xradia™
insight in 3D

MicroXCT-200 and MicroXCT-400

User's Guide

April, 2010

Xradia, Inc.
5052 Commercial Circle
Concord, CA 94520 USA

Telephone	1 (888) 497-2342
	1 (925) 771-8093
Fax	1 (925) 243-8788
Email	service@xradia.com
Website	http://www.xradia.com/products/support.php

Document Part Number: G000408, Rev. A
Version 7.0, Revision 1.5
April, 2010

Contents

THIS PAGE INTENTIONALLY LEFT BLANK

Safety

This section provides guidelines and information for safely using and operating the MicroXCT™:

Safety Guidelines

Observe and follow these safety guidelines when using the MicroXCT:

WARNING Electrical and X-ray hazard present. Use the MicroXCT as cautioned herein, to avoid personal injury and/or damage to the MicroXCT.

WARNING Failure to observe and follow these guidelines is in violation of product use and warranty, and puts you at risk of serious injury. Xradia® is not liable for personal injury nor damage to the MicroXCT caused by misuse.

WARNING In the rare event that you or someone working with the MicroXCT is injured as a result of using the MicroXCT, and the injury requires immediate medical attention, follow the emergency procedures established by your work site.

- Use the MicroXCT only for applications and uses for which it is designed.
- Use only the components and/or machine accessories prescribed or provided by Xradia.
- Use the MicroXCT within environmental conditions specified in Appendix G, "Specifications."
- Do not use the MicroXCT with objects nor raw materials other than those for which it is intended.
- If the MicroXCT is covered by an Xradia field service contract, do not attempt to maintain, service, repair, nor modify the MicroXCT, because these tasks must be performed only by trained Xradia personnel.
- Although the X-ray source automatically turns OFF when the access door(s) is (are) open, ensure that the access door(s) is (are) completely closed and not damaged nor blocked in any way.

WARNING If the access door(s) does (do) not completely close or is (are) damaged, turn OFF the MicroXCT and contact the Xradia Support Team.

– Do not intentionally defeat the access door safety interlocks.

– In the event of a personal safety or MicroXCT emergency, use the **EMO** button to turn OFF power to the MicroXCT.

WARNING The EMO shutdown process (pressing of the **EMO** button) can damage the MicroXCT, particularly the workstation and/or optional storage server, potentially causing data loss and/or irreversible damage – use only in the event of a personal safety or equipment emergency.

NOTE Use of the non-emergency shutdown is recommended in non-emergency events. (Refer to "Shutting Down the MicroXCT in a Non-Emergency Event," on page 246.)

– Use only a grounded AC power outlet.

– Use the MicroXCT on an electrical circuit that is not shared by any other equipment.

– All users should be sufficiently trained regarding how to use the MicroXCT, by trained Xradia personnel.

– Use of the MicroXCT by children is prohibited.

– Keep hands and other body parts, as well as other objects, away from hardware mechanisms (such as the sample stage, detector, and X-ray source) when moving the sample, detector, and X-ray source axes.

– Keep the operating temperature range at an ambient room temperature, between 18 to 25°C, with a variation of less than 2°C, for optimum image quality.

– Avoid operating the MicroXCT in areas where spray or liquids can enter or adhere to it.

EMO Shutdown

WARNING Risk level is HIGH.

WARNING The EMO shutdown process (pressing of the **EMO** button) can damage the MicroXCT, particularly the workstation and/or optional storage server, potentially causing data loss and/or irreversible damage – use only in the event of a personal safety or equipment emergency. Refer to "Loss of Data and/or Irreversible Damage Due to EMO Shutdown," for how to recover lost data, or what to do if there is irreversible damage.

Pressing the Emergency Off (**EMO**) button turns OFF:

- All hazardous energy sources, including the X-ray source and high-voltage power supply
- All moving parts within the MicroXCT, such as the motor control modules
- The workstation, and if included, the optional storage server

The **EMO** button is located on the front panel (and back panel, MicroXCT-400 only) of the enclosure, within easy reach. The **EMO** button, as well as the **RESET** button, are illustrated in the following figure.

EMO and **RESET** Buttons

MicroXCT-200

MicroXCT-400

To shutdown the MicroXCT in an emergency event

1. Firmly press the **EMO** button, to immediately turn OFF power to the MicroXCT.

   After the emergency event has passed, proceed to "Turning ON the MicroXCT," on page 247.

Enclosure Covers and Access Door(s)

WARNING Do not remove any baffles within or covers on the MicroXCT. Removal will expose personnel to harmful X-ray radiation, which can result in fatal injuries.

WARNING If the access door(s) does (do) not completely close or is (are) damaged, turn OFF the MicroXCT and contact the Xradia Support Team.

WARNING If any part of the enclosure is damaged, turn OFF the MicroXCT and contact the Xradia Support Team.

WARNING Do **not** modify any part of the enclosure.

The steel and lead-lined enclosure covers and access door(s):

- Provide protection from X-ray beams and high voltage generated by the MicroXCT
- Maintain the MicroXCT at operating temperature

The access door(s) include(s) a fail-safe (safety) interlock. The X-ray source will turn ON only if the access door(s) is (are) closed. The X-ray source automatically turns OFF when the access door(s) is (are) opened.

NOTE Although the X-ray source automatically turns OFF when the access door(s) is (are) opened, it is recommended that the X-ray source first be turned OFF, prior to opening the access door(s).

NOTE Instructions for turning OFF the X-ray source are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 6, on page 45. Instructions for turning ON the X-ray source are provided in "Turning on the X-ray Source," on page 58.

For personal and equipment safety:

- Do not remove any bolted-down covers or doors
- Ensure that the access door(s) is (are) completely closed and not damaged nor blocked in any way
- Do not intentionally defeat the access door safety interlocks

Potential Hazards and Safety Precautions – Personnel

The MicroXCT is designed to be safe for customer use. However, potential hazards do exist. This section describes the potential hazards to personnel, such as radiation and high voltage, and methods to isolate and control the hazards.

Read and understand all the safety information and follow the procedures when using the MicroXCT. Severe or catastrophic injury to personnel, or damage to the equipment or facility can result if the prescribed procedures are not followed.

The MicroXCT uses 20 to 90 kV (90 kV X-ray source) or 40 to 150 kV (150 kV X-ray source) X-rays for imaging. A high-voltage power supply is required to generate the high-energy radiation, and a shielding enclosure is required to contain the radiation. The potential hazards to the personnel include:

– High Voltage

– Ionizing Hazard

– Pinch Hazards

– Magnetic Field

– Hazardous Materials

Each is described in the sections that follow.

High Voltage

WARNING Risk level is High.

CAUTION Press the **EMO** button to shut down the MicroXCT in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

The X-ray source and some motion components require high voltage of up to 90 kV (90 kV X-ray source) or 150 kV (150 kV X-ray source) in normal operation. The high-voltage power is located within the X-ray source, within the enclosure.

Observe the following safety guidelines:

- Do not attempt to defeat the access door safety interlocks, and keep the access door(s) closed when the X-ray source is turned ON
- Do not remove the enclosure panels
- Do not touch any parts inside the enclosure, unless instructed to do so by this guide

Potential Damage Severe to catastrophic injuries can result from electrocution by the high-voltage source. Electric shock from hazardous voltage sources can result in minor to moderate injuries.

Hazard Control All high-voltage sources are sealed. Electrical faults are shorted to ground. **Do not touch anything within the MicroXCT unless instructed to do so otherwise within this guide or by Xradia personnel. Firmly press the EMO button in an emergency, to shut down the MicroXCT.**

Ionizing Hazard

WARNING Do **not** modify any part of the enclosure.

CAUTION Risk Level is LOW due to equipment protections in place.

CAUTION Press the **EMO** button to shut down the MicroXCT in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

The X-ray source generates X-rays, from 20 to 90 kV (90 kV X-ray source) or 40 to 150 kV (150 kV X-ray source), used by the MicroXCT to image samples and reference images.

Observe the following safety guidelines:

– Do not attempt to defeat the access door safety interlocks, and keep the access door(s) closed when the X-ray source is turned ON

– Do not remove the enclosure panels

Potential Damage Exposure to X-ray radiation causes moderate to severe illness to personnel, mostly in the form of soft tissue damage, or cancer in severe cases, or death due to radiation poisoning.

Hazard Control The enclosure, with its safety interlocks and lead shielding, protects users from harmful X-ray radiation. To ensure the enclosure's integrity, Xradia personnel performs a radiation survey during regularly scheduled service every six months, for MicroXCT units under warranty or service packages.

Pinch Hazards

CAUTION Risk level is LOW.

The radiation-shielding enclosure, which includes the access door(s), is made of steel and lead plates that are extremely heavy. Placing body parts in the path of a closing access door can cause bodily injury. Minor injuries can occur in rare occasions, and serious injuries are extremely unlikely.

Although unlikely, it is also possible to be pinched by the clamp or clip sample holder provided with the MicroXCT.

Potential Damage Physical pain or minor injuries can result from the pinch.

Hazard Control Pay attention when opening or closing the enclosure access door(s). Air dampers slow the movement of the door(s) during the last inch or so of travel, to avoid slamming of the door(s).

Keep your fingers free of the part of the clamp or clip sample holder, that closes onto the sample, to avoid being pinched.

If a body part is caught in a closing access door

1. Reverse the motion of the access door(s), to free the body part(s).

If a finger is caught in a sample holder

1. Reverse the motion that closed the sample holder onto your finger.

Magnetic Field

CAUTION Risk level is LOW.

The MicroXCT includes several motors that generate low levels of magnetic field.

Potential Damage The magnetic field strength is extremely low. Injury to personnel or damage to equipment is extremely unlikely.

Hazard Control Be aware of the presence of the magnetic field around the motors.

Exercise caution if

– A person near the motors uses a pacemaker

– A person near the motors is holding objects sensitive to magnetic fields, such as a floppy disk, external hard disk drive, credit card, hotel key card, and so forth

Hazardous Materials

CAUTION The materials listed here are not customer-accessible, and should only be accessed by trained Xradia personnel.

CAUTION Be aware of the presence of these hazardous materials. Contact Xradia prior to decommissioning and disposing of the MicroXCT for special cautions, instructions, and possible recycling of parts.

The MicroXCT contains the following hazardous materials:

- **Beryllium** – A beryllium window is used on the X-ray source. The total quantity of beryllium is approximately 4g.
- **Thallium-doped Cesium Iodide** – This material is used as the scintillator and is integrated into the detector. The quantity of thallium is approximately 2.5 mg. The thallium content is approximately 1% of the weight of the cesium iodide.
- **Lead** – This material prevents X-rays from escaping the enclosure and exposing personnel to X-ray radiation. The interior of the steel enclosure contains 6-mm-thick lead sheets on all sides, top, and bottom. The right side contains an additional 3 mm of lead sheet, for a total of 9 mm. The lead sheets are covered by steel sheets or paint.

Potential Hazards and Safety Precautions – Equipment

The MicroXCT is designed to be safe for customer use. However, potential hazards do exist.

Read and understand all the safety information and follow the procedures when using the MicroXCT. Severe or catastrophic injury to personnel, or damage to the equipment or facility can result if the prescribed procedures are not followed.

Potential hazards to equipment include:

- Loss of Data and/or Irreversible Damage Due to EMO Shutdown
- Collision of Moving Parts
- Improper Grounding

Each is described in the sections that follow.

Loss of Data and/or Irreversible Damage Due to EMO Shutdown

WARNING Risk level is HIGH.

WARNING The EMO shutdown process (pressing of the **EMO** button) can damage the MicroXCT, particularly the workstation and/or optional storage server, potentially causing data loss and/or irreversible damage – use only in the event of a personal safety or equipment emergency.

Potential Damage If you used the EMO Shutdown process, it is possible that there will be data loss on the hard disk drive(s), and/or irreversible damage to the MicroXCT.

Hazard Control Use the EMO shutdown process only in the event of a personal safety or equipment emergency. If possible, to avoid damage to the MicroXCT, use the process described in “Shutting Down the MicroXCT in a Non-Emergency Event,” on page 246, instead.

To recover lost data

– If a backup copy of the data files that were lost is available, copy or restore the files back onto the hard disk drive

– Contact your Information Technology (IT) department for assistance

– Contact the Xradia Support Team for assistance

NOTE To help protect data files generated by the MicroXCT, you are welcome to install a backup program, or other backup process that is required by your IT department, on the MicroXCT.

If there is irreversible damage to the MicroXCT

– Contact the Xradia Support Team for resolution

Collision of Moving Parts

CAUTION Risk level is LOW.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE Tips for troubleshooting collision and imminent collision are described more fully in "Troubleshooting Sample Issues in XMController," on page 210.

Motorized components (sample and detector and/or sample and X-ray source) can collide when they are moved during normal operation, if you are not careful. Collisions are likely due to moving the sample, detector, and/or X-ray source too close to one another. In most cases, should collision occur, damage to equipment will be minor.

Potential Damage Collisions can cause misalignment and, in more severe cases, damage to subcomponents. Should the MicroXCT require realignment, contact the Xradia Support Team.

Hazard Control Use caution when moving motors, particularly the sample, detector, and/or X-ray source components.

Guidelines for reducing collision risk

– Ensure that the sample holder is correctly loaded onto the sample stage (flat part facing front, tungsten balls on the stage aligned with the sample holder base).

– Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box. This will enable you to quickly click it and stop movement, if collision is imminent.

– Whenever moving the detector and X-ray source, use small increments when moving toward the sample.

Improper Grounding

WARNING Risk level is High.

CAUTION Press the **EMO** button to shut down the MicroXCT in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

NOTE The MicroXCT should already be connected to power, at installation.

There should be no problem with improper grounding when the MicroXCT is properly connected to a grounded power source, per specifications.

Observe the following safety guidelines:

- Ensure that the three-prong power connector (located at the back of the MicroXCT) is connected to a grounded 100 to 240 VAC, 12A power source

- If using an uninterruptible power source (UPS), line conditioner, surge protector, or similar device, ensure that the MicroXCT is connected to the device, and that the device's power connector is connected to a grounded 100 to 240 VAC, 12A power source

Safety Labels

The following table illustrates and describes the **WARNING** and **CAUTION** safety labels, located in/on the MicroXCT.

Safety Labels

Icon	Description and Location in/on MicroXCT
	Warns Xradia service personnel to turn OFF and lock out MicroXCT power prior to attempting to service the MicroXCT. Adhered to the top of the Power Distribution Unit (PDU).
	Warns you to **not** remove the enclosure, to protect yourself and others from harmful X-ray radiation. Adhered to the baffles or covers bolted onto the MicroXCT.
	Warns you to turn OFF the X-ray source before opening the access door(s), to protect yourself and others from harmful X-ray radiation. Adhered to the front of the MicroXCT.
	Warns you to not place your hands on the ledge, because the door rolls over the ledge when it is being opened. Adhered to the right side of the MicroXCT-200, beside the access door. It is visible only when the access door is closed.

Preface

This user's guide provides information for using the Xradia® MicroXCT™-200 and MicroXCT™-400 High-Resolution 3D X-ray Imaging Systems. It describes the features, functions, and use of these products.

The following details document organization and conventions, and assumptions.

Document Organization

The process tasks described in each chapter follow a typical workflow. Additional information is provided in the appendices.

This guide is organized as follows:

– Safety provides guidelines and information for safely using and operating the MicroXCT.

– Chapter 1, "Overview," provides an overview of the technology used by the MicroXCT, as well as the main components, programs, and processes used to generate and view tomographic data.

– Chapter 2, "Setting Up for Data Acquisition," describes the pre-data acquisition procedures, including (but not limited to) mounting, loading, and coarse positioning of the sample using XMController, and turning on the X-ray source.

– Chapter 3, "Selecting the First Tomography Point," how to use XMController to select the first tomography point for a tomography dataset, and for use later, when running a recipe.

– Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)," how to use XMController to record the tomography point selected in Chapter 3, select the remaining tomography points for tomography datasets, and run an automatic recipe.

– Chapter 5, "Manually Acquiring Images and Tomographic Data," describes how to use XMController to acquire images and tomographic data using Continuous, Single, Averaging, and Mosaic acquisition modes, and how to create and apply a reference image.

– Chapter 6, "Manually Reconstructing a 3D Dataset," describes how to use XMReconstructor to manually reconstruct 3D tomography datasets when a dataset is manually acquired, a dataset is automatically acquired but not reconstructed, the center shift is incorrect, or the automatic reconstruction had problems.

– Chapter 7, "Viewing Tomographies," describes how to use XM3DViewer to view and edit 2D reconstructed slices and 3D volume datasets for use in reports and movies.

– Appendix A, "Troubleshooting," describes how to resolve common issues that may be encountered when using the MicroXCT, and provides Xradia Support Team contact information.

– Appendix B, "MicroXCT Files and File Storage," describes the file types unique to the MicroXCT programs, recommended file handling, and how to export the files to graphic formats.

– Appendix C, "Shutting Down and Restarting the MicroXCT," describes how to shutdown and restart the MicroXCT, and then home all motorized axes to pre-defined initialization positions.

– Appendix D, "Visual Light Camera Monitor Brightness Controls," describes how to change the brightness, to reduce image glare, on the visual light camera monitor that has icon control buttons.

– Appendix E, "Removing the Sample after Use," describes how to remove the sample from the MicroXCT, after you have finished imaging the sample.

– Appendix F, "Determining Whether the MicroXCT is 360°-Enabled," describes how to determine whether the MicroXCT is 180° or 360°-enabled.

– Appendix G, "Specifications," lists the MicroXCT-200 and MicroXCT-400 specifications that are of use to customers.

– Appendix H, "Electrical Documentation," provides electrical documentation specific to the Emergency Off (EMO) system and safety interlocks.

– Appendix J, "License, Warranty, and Service Information," provides the software license agreement, limited warranties, service and maintenance information, and Xradia contact information.

– Appendix K, "Glossary," describes terms used within this guide.

Document Conventions

The following sections contain descriptions of the document conventions applied in this guide.

Instructions and Information

Instructions and information are conveyed as follows:

– Numbered steps denote tasks performed in the order listed

– Bulleted lists denote information that does not need to be processed in sequence

Special Text Formats

Special text formats use the following conventions:

– Critical information, menu names, and text displayed on-screen appear in **bold**. For example:

Click **OK**.

– Values to be typed are in *italics*. For example:

Type *130* in the **Source Z** text box.

– Generic references to a specific item or task are in *italics*. For example:

Select the appropriate *save option*.

– The following colors, when used to reference an item that is that color, appear in bold and the specified color:

blue, **green**, **orange**, **red**, **yellow**

Cross-References

Cross-references (chapters, appendices, headings, step numbers, and so forth) appear in blue. This information is hyperlinked, and if you use the pointer tool in a PDF, you can "jump" to the referenced text.

Page numbers are included with the referenced subheadings, if the text appears outside the current main section. For example, if you are reading text in Chapter 1, and the referenced text is in Chapter 3, the reference includes a page number.

Terminology

Graphical user interface (GUI) terms, select and click, are used as follows:

- **Select**

  Choose/highlight an item for use. For example:

  - Select a *file type* from the **Files of type** drop-down list box
  - Select **Microscope > Motion Controller…**

- **Click**

  Select a button, box, or other item that incurs an action that issues a command or sets an option. For example:

  - Click **OK**
  - Click  in the icon bar

Notes, Cautions, and Warnings

Notes, Cautions, and Warnings appear throughout the guide. Examples of format and content are provided below. For Cautions and Warnings, it is particularly important to read and understand each, and the possible dangers that can be encountered when using the MicroXCT.

NOTE Used when information is sufficiently important to require attention.

CAUTION Used when information is critical to avoid device or equipment damage, or to avoid severely impacting processing. If the caution indicates "contact the Xradia Support Team," stop using the MicroXCT, then contact Xradia at the number provided in "Contacting the Xradia Support Team (Technical Support)," on page 231.

WARNING Used when information is critical to avoid personal injury or severe equipment damage. If the warning indicates "contact the Xradia Support Team," stop using the MicroXCT, then contact Xradia at the number provided in "Contacting the Xradia Support Team (Technical Support)," on page 231.

Assumptions

This guide assumes that you have:

- Been sufficiently trained by Xradia personnel in basic use of the MicroXCT
- Experience using Microsoft Windows XP (or previous versions of Windows) and a basic working knowledge of how to use its user interface, including browsing for data paths and files, using the mouse pointer to click and drag, and closing open windows and dialog boxes, opening, saving, and closing files, and so forth

1 Overview

This chapter provides an overview of the technology used by the Xradia® MicroXCT™-200 and MicroXCT™-400, as well as the main components, programs, and processes used to generate and view tomographic data.

Technology Overview

The following provides a brief overview of how the Xradia MicroXCT is used as a diagnostic tool, how the MicroXCT works, and the current MicroXCT product family.

X-ray Microscopy

When used together, microscopy enables observation of features smaller than those visible to the naked eye, and X-ray enables observation of features internal to structures.

While medicine and dentistry remain the most common usages of X-ray, it is also widely used in other applications, from airport security to industrial inspection and quality control systems. CAT scanning, or X-ray tomography, has made it possible to use X-rays to create three-dimensional (3D) representations of structures as complex as the internals of the human body.

How X-ray Microscopy Works

X-ray microscopes form images, based upon the X-rays transmitted by the sample. Where the sample absorbs more X-rays, the image is darker; where it transmits more, the image is brighter. Absorption increases with density and thickness, and it is also generally higher for elements with a higher atomic number in the periodic table.

In X-ray microscopes (unlike electron microscopes), the sample is generally at normal atmospheric pressure. It can be heated or cooled, as necessary. Wet samples are mounted between X-ray transparent windows or in thin-walled capillaries. X-rays are not affected by factors such as electric nor magnetic fields; therefore, samples, including semiconductor packages and various other materials, can be imaged under real operating conditions, or while subject to mechanical forces.

What Xradia MicroXCT Does

Xradia's advanced X-ray computed tomography (CT) products help advance innovation in science and industry. Xradia's CT technology has been used by scientists and engineers to provide insight in 3D, into the internal structure of samples in a large variety of applications.

– In life science research, Xradia's MicroXCT enables imaging of hard and soft tissue with an unmatched combination of resolution and sample size. Xradia's proprietary detector technology, as well as phase contrast imaging, provides the unique ability to image soft tissue with good contrast, even in combination with calcified tissue and bone structures.

– In advanced materials research and development, Xradia's multi-length scale solution enables the development of a full model of the material, from millimeter down to nanometer scale. Material defects, such as cracks and voids, can be visualized at these length scales.

– Semiconductor package development and failure analysis engineers use the MicroXCT product family to verify micron-sized defects, without the need for physical delayering or cross-sectioning, thus maintaining the integrity of the samples.

– CT technology can be used in rock physics modeling, and for drilling feasibility analysis in oil and gas exploration.

Key to effective imaging is the ability to use a succession of increasing resolutions, combined with smaller and smaller fields of view that allow "zooming" into the particular region of interest. As product and sample complexity increases, 3D-imaging modalities are required, to fully understand the 3D intricacies of structures.

Xradia MicroXCT Product Family

This guide describes use of CT technology, for the following models within the MicroXCT product family:

– **MicroXCT-200** – A flexible and easy-to-use system for general-purpose imaging at sub-1 micron pixel resolution, for samples up to 100 mm in diameter, 150 mm in height, and 1 kg in weight.

– **MicroXCT-400** – A large system ideal for in-situ studies. The imaging resolution is identical to the MicroXCT-200; however, the sample size can be up to 500 mm in diameter, 400 mm in height, and 15 kg in weight.

MicroXCT Hardware and Software

The MicroXCT includes the hardware and software needed to create tomography images and to view them.

Hardware Description

This section describes the MicroXCT major hardware components.

Major External and Internal Hardware Components

Figure 1-1 and Figure 1-2 provide a visual **external** view of the MicroXCT-200 and MicroXCT-400, respectively. Table 1-1 lists the major external hardware components, as they relate to Figure 1-1 and Figure 1-2.

Figure 1-3 and Figure 1-4 provide a visual **internal** view of the MicroXCT-200 and MicroXCT-400, respectively, with the access door(s) open. Table 1-2 lists the major internal hardware components, as they relate to Figure 1-3 and Figure 1-4.

WARNING Do not touch anything within the enclosure, except for the following:

- Sample stage, while loading the sample holder assembly,
- X-ray source, when installing a source filter, and
- Non-motorized turret (if MicroXCT unit does not include a motorized turret), when manually selecting a non-Macro magnification lens,

unless instructed to do so by Xradia personnel. Otherwise, you will violate the product warranty.

Figure 1-1 MicroXCT-200 External View, with Access Door Open, and Lower Doors Removed

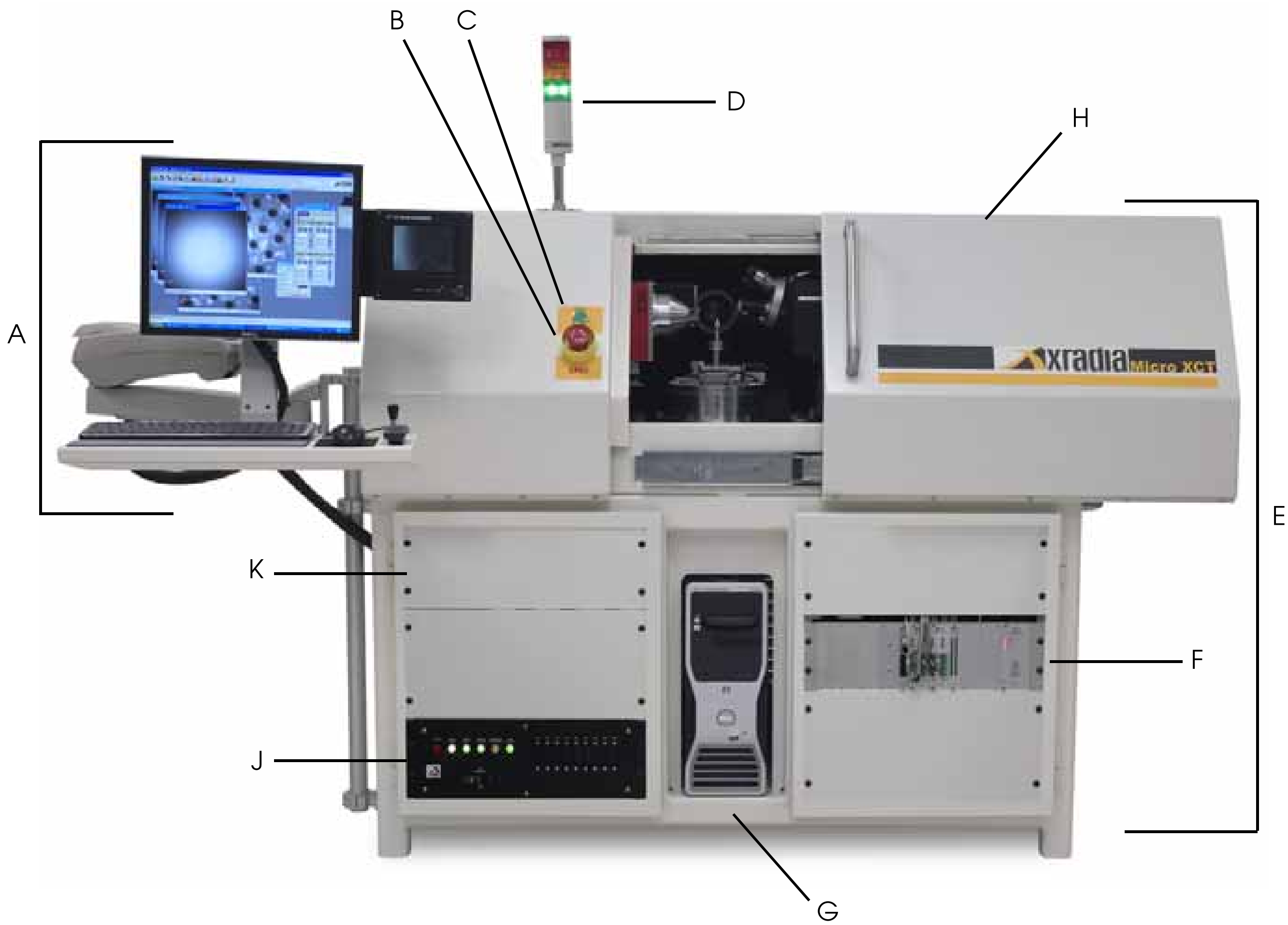


Figure 1-2 MicroXCT-400, External View, with Lower Doors Removed

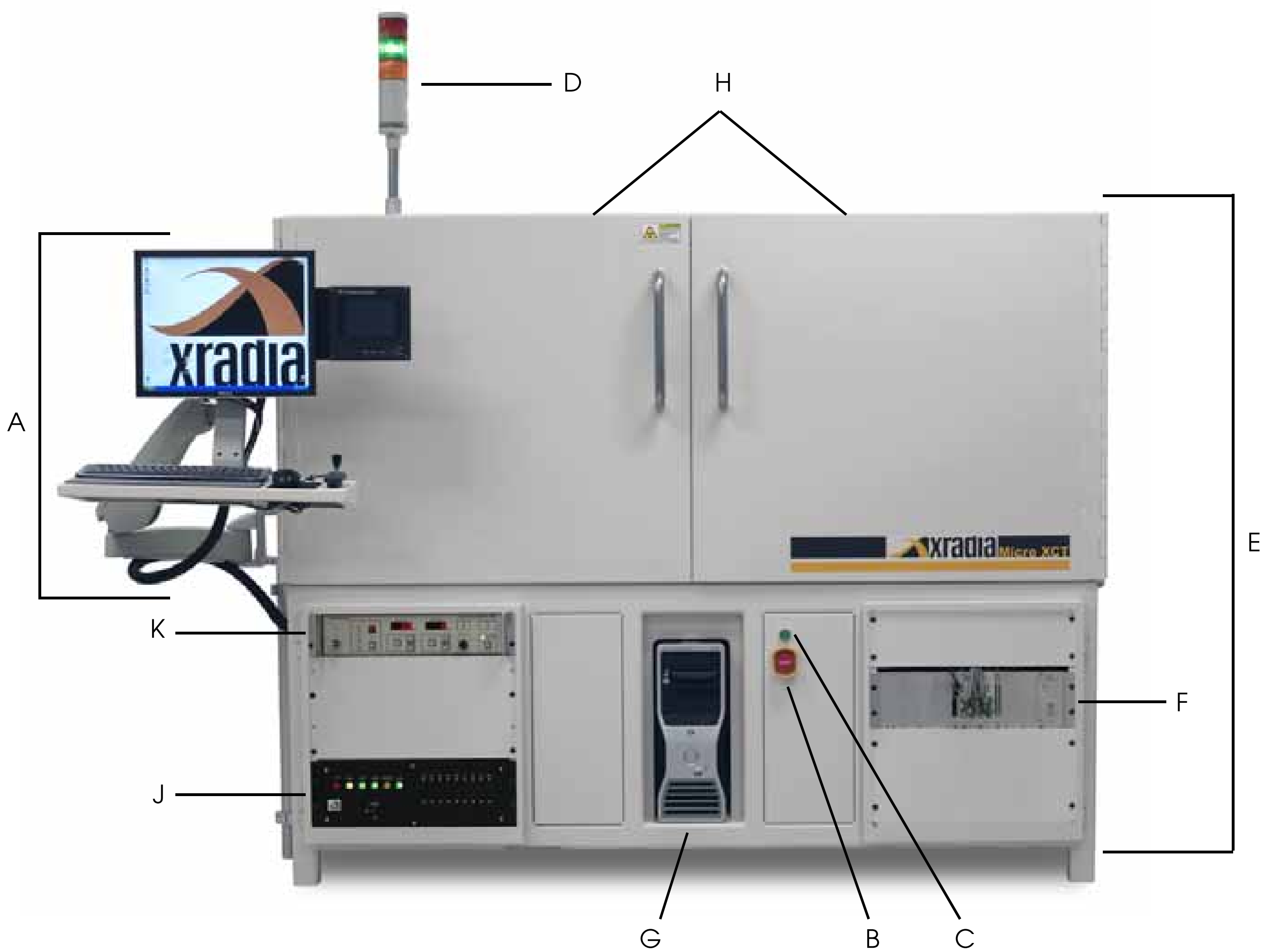


Table 1-1 MicroXCT-200 and MicroXCT-400 – Major External Components, Illustrated in Figure 1-1 and Figure 1-2

Callout Letter	Part	Description
A	Ergonomic Station	User console for controlling the MicroXCT for data acquisition and analysis. Refer to "Ergonomic Station," for further details.
B	**EMO** Button	Emergency OFF. Turns OFF power to the entire MicroXCT in an emergency, as well as in non-emergency events. Release to enable the **RESET** button, when starting the MicroXCT. Refer to "Safety" Appendix C, "Shutting Down and Restarting the MicroXCT," and Appendix H, "Electrical Documentation," for further details. **MicroXCT-400 only** – A second **EMO** button is located on the back panel, below the rear access doors (not shown).
C	**RESET** Button	Resets MicroXCT power after a shutdown; use the EMO reset procedure. Also used when starting the MicroXCT. Refer to Appendix C, "Shutting Down and Restarting the MicroXCT," for further details. **MicroXCT-400 only** – A second **RESET** button is located on the back panel, below the rear access doors (not shown).
D	Light Tower	Indicator located on top of the MicroXCT, that visually reports status conditions: – **All lights OFF** – Power to the MicroXCT is OFF – **Red light ON** (top) – X-ray source is ON, and X-rays are present within the enclosure – **Red light OFF** (top) – X-ray source is OFF, and X-rays are not present within the enclosure – **Yellow light ON** (center) – Access door(s) is (are) closed – **Yellow light OFF** (center) – Access door(s) is (are) open – **Green light ON** (bottom) – Power to the microscope is ON – **Green light OFF** (bottom) – Power to the microscope is OFF Refer to Appendix H, "Electrical Documentation," for further details.
E	Enclosure	Insulated steel and lead-lined framework that covers the exterior of the MicroXCT, providing protection from harmful X-ray radiation. Refer to "Enclosure Covers and Access Door(s)," on page xiii for further details.
F	Motion Controller Hardware	Provides the interface between the workstation and all motors. Located in the right cabinet. **DO NOT TOUCH.**
G	Workstation	Windows XP-based computer included in the MicroXCT. Must be powered ON, by pressing its **Power** button.

Table 1-1 MicroXCT-200 and MicroXCT-400 – Major External Components, Illustrated in Figure 1-1 and Figure 1-2 (Continued)

Callout Letter	Part	Description
H	Access Door(s)	Part of the enclosure. Closes off the X-ray source, providing protection from harmful X-ray radiation. The door(s) differ, by model: – **MicroXCT-200** – Single sliding door to the right, with a door handle. To open the door, using the door handle, slide to the RIGHT to OPEN, to the LEFT to CLOSE. There is also a sliding door to the left, which is bolted shut and is not needed for use. This other door is not mentioned elsewhere in the guide. – **MicroXCT-400** – Two hinged doors on the front. To open either door, using the door handles, pull toward you to open, and push toward the MicroXCT-400 to close. You can have both doors open simultaneously; however, if opening only one door, open the door on the right. There are also two hinged doors located at the back of the MicroXCT-400 (not shown). These doors can also be opened to access the sample stage, from the opposite side of the MicroXCT-400. These doors provide easier access to set up additional equipment, such as load cells on the sample stage. For the most part, these additional two doors on the back are not mentioned elsewhere in the guide.
J	Power Distribution Unit (PDU)	Distributes power to electrical components. The PDU is located inside the enclosure, behind a cabinet door, on the lower left side of the MicroXCT. Typically, you do not need to do anything with this part. **WARNING** If either of the following occur, contact the Xradia Support Team: – **Alarm** button is lit, indicating a light tower malfunction. – Any of the PDU's power breakers are tripped (in the DOWN position). **DO NOT RESET THE BREAKER.**
K	Source Controller Hardware	Provides the interface between the workstation and X-ray source. Included only with the 150 kV X-ray source. Located in the left cabinet. (Location shown only in Figure 1-2.) **DO NOT TOUCH.**
–	Storage Server	Optional data storage. Networked to the workstation, if included, and recognized as an additional hard disk drive. (Not shown in either figure.) Located inside the enclosure, beside the workstation.

Figure 1-3 MicroXCT-200 Internal View, with Access Door Open

Figure 1-4 MicroXCT-400 Internal View, with Access Doors Open

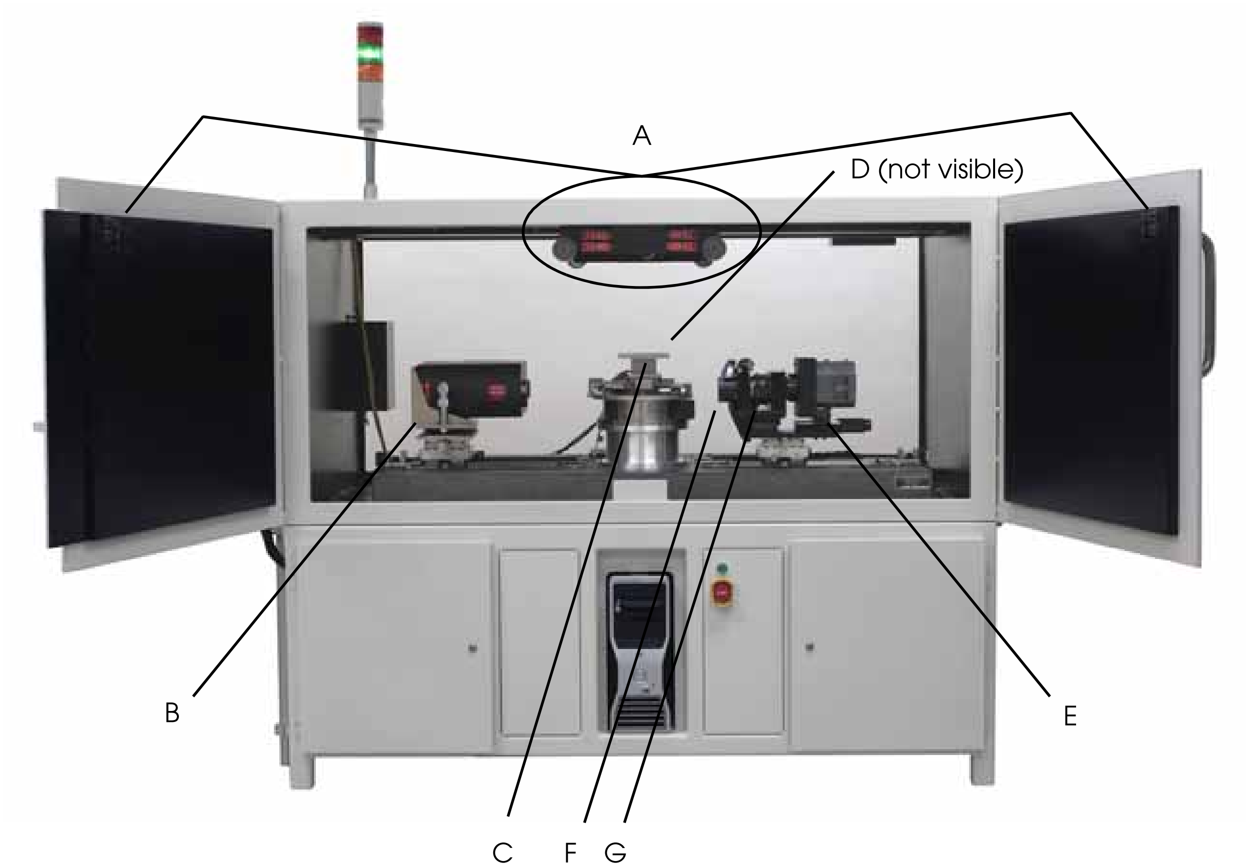


Table 1-2 MicroXCT-200 and MicroXCT-400 – Major Internal Components, Illustrated in Figure 1-3 and Figure 1-4

Callout Letter	Part	Description
A	Safety Interlocks	When the access door(s) is (are) opened, the safety interlocks turn OFF the X-ray source. Refer to Appendix H, "Electrical Documentation," for further details.
B	X-ray Source	Mechanism that generates X-rays, from 20 to 90 kV (90 kV X-ray source) or 40 to 150 kV (150 kV X-ray source; shown in both figures), used by the MicroXCT to image samples and create reference images. Includes a source filter holder. Refer to "X-ray Source," and Appendix H, "Electrical Documentation," for further details.
C	Sample Stage	Platform upon which the sample (imaging target), mounted on a sample base, is secured for microscopy.
D	Visual Light Camera	Supplies images to the visual light camera monitor. Located behind the sample stage, at the rear of the enclosure. Used for positioning the sample, detector, and X-ray source.
E	Detector Assembly (Detector)	Assembly that picks up X-ray images of the sample. Refer to "Detector Assembly," for further details.
F	Turret	Part of the detector assembly. Holds up to six lenses. The lens located at the lowest point on the turret is used to focus on the sample. Turret lens selection is controlled by the drop-down arrow to the right of the XMController  icon. Refer to "Detector Assembly," for further details. – **Standard lenses (included with every MicroXCT)** – 4X, 10X, 20X – **Optional lenses (available upon request)** – 1X, 2X[a, b], 40X
G	Macro Lenses	Optional square (Macro-70) or round (Macro-55 (0.5X)[b, c, d]) lenses that provide a second beam line for imaging with a larger field of view (FOV) than the other lenses, at a lower magnification. There can only be one Macro lens in each MicroXCT. If included, the Macro lens is mounted **beside** the turret. Macro lens selection is controlled by the drop-down arrow to the right of the XMController  icon. For further details regarding use of this icon, refer to Table 1-7.

a. The 2X lens is not available when the MicroXCT has an optional Macro lens.
b. The Macro-55 (0.5X) and 2X lenses have a round FOV. Therefore, their 3D FOV range is the diameter of the FOV.
c. The Macro-55 (0.5X) lens is obsolete, and was replaced by the Macro-70 as an option. The lens is still in use in some MicroXCT units.
d. MicroXCT-400 only.

X-ray Source

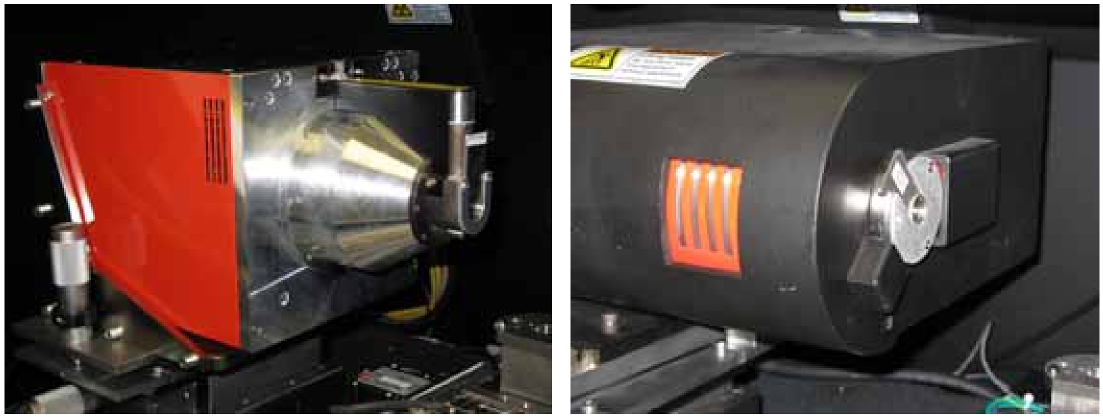
The X-ray source generates X-rays, from 20 to 90 kV (90 kV X-ray source) or 40 to 150 kV (150 kV X-ray source), used by the MicroXCT to image samples and create reference images. The type of X-ray source is determined at the time of purchase. The 90 kV X-ray source is typically used for imaging softer materials (lower density). The 150 kV X-ray source is typically used for large and/or harder materials (high density). Both are illustrated in Figure 1-5. Table 1-3 lists the minimum and maximum voltage and power settings, by X-ray source.

The X-ray source includes a holder for installing a source filter – material (available in a filter kit from Xradia) that improves reconstructed image quality, by removing low-energy X-rays that do not provide useful information through the sample.

NOTE If MicroXCT power or the X-ray source has been turned OFF for more than eight hours, the X-ray source must go through an initial warm-up process, called **X-ray source aging**. This process can take 30 minutes or more, depending upon the length of time that the X-ray source was turned OFF.

NOTE 15 minutes is the minimum warm-up period, if the X-ray source has been turned OFF for more than 15 minutes, for optimal X-ray source stability during scans.

Figure 1-5 90 kV and 150 kV X-ray Sources



90 kV X-ray Source 150 kV X-ray Source

Table 1-3 Minimum and Maximum Voltage and Power Settings, by X-ray Source

X-ray Source	Voltage (kV)		Power (W)	
	Minimum	Maximum	Minimum	Maximum
90 kV	20	90	1	8
150 kV	40	150	4	10

Detector Assembly

The detector assembly ("detector") picks up X-ray images of the sample. "Lens" and "detector" are sometimes used interchangeably. The 1X through 40X magnification lenses look similar and are all mounted on a turret, similar to optical microscopes that have different objectives (lenses).
In most MicroXCT installations, the turret is motorized. (Refer to Figure 1-6.) The turret can hold up to six lenses.

Table 1-4 lists the magnification level, and spatial resolution and field of view (FOV) ranges for each magnification lens.

Figure 1-6 Detector Assembly

Table 1-4 Spatial Resolution and FOV Ranges, by Magnification Level

Magnification Level/Lens	Resolution Range (μm)	3D FOV Range (mm)
Standard Lenses (included with every MicroXCT)		
4X	5.0 – 6.0	2.4 – 6.0
10X	2.5 – 3.0	2.0 – 2.7
20X	1.5	1.3
Optional Lenses (available upon request)		
Macro-70[a]	20.0 – 50.0	17.0 – 50.0
Macro-55 (0.5X)[a, b, c, d]	14.0 – 40.0	14.0 – 40.0
1X	9.0 – 22.0	4.0 – 15.0
2X[c, e]	6.0 – 13.0	4.0 – 13.0
40X	1.0	0.7

a. The Macro lens, if included, provides a second beam line for imaging, and is mounted beside, rather than on, the turret.
b. The Macro-55 (0.5X) lens is obsolete, and was replaced by the Macro-70 as an option. The lens is still in use in some MicroXCT units.
c. The Macro-55 (0.5X) and 2X lenses have a round FOV. Therefore, their 3D FOV range is the diameter of the FOV.
d. MicroXCT-400 only.
e. The 2X lens is not available when the MicroXCT has an optional Macro lens.

Ergonomic Station

Figure 1-7 provides a visual view of the MicroXCT ergonomic station. Table 1-5 lists the station's major components.

Figure 1-7 Ergonomic Station

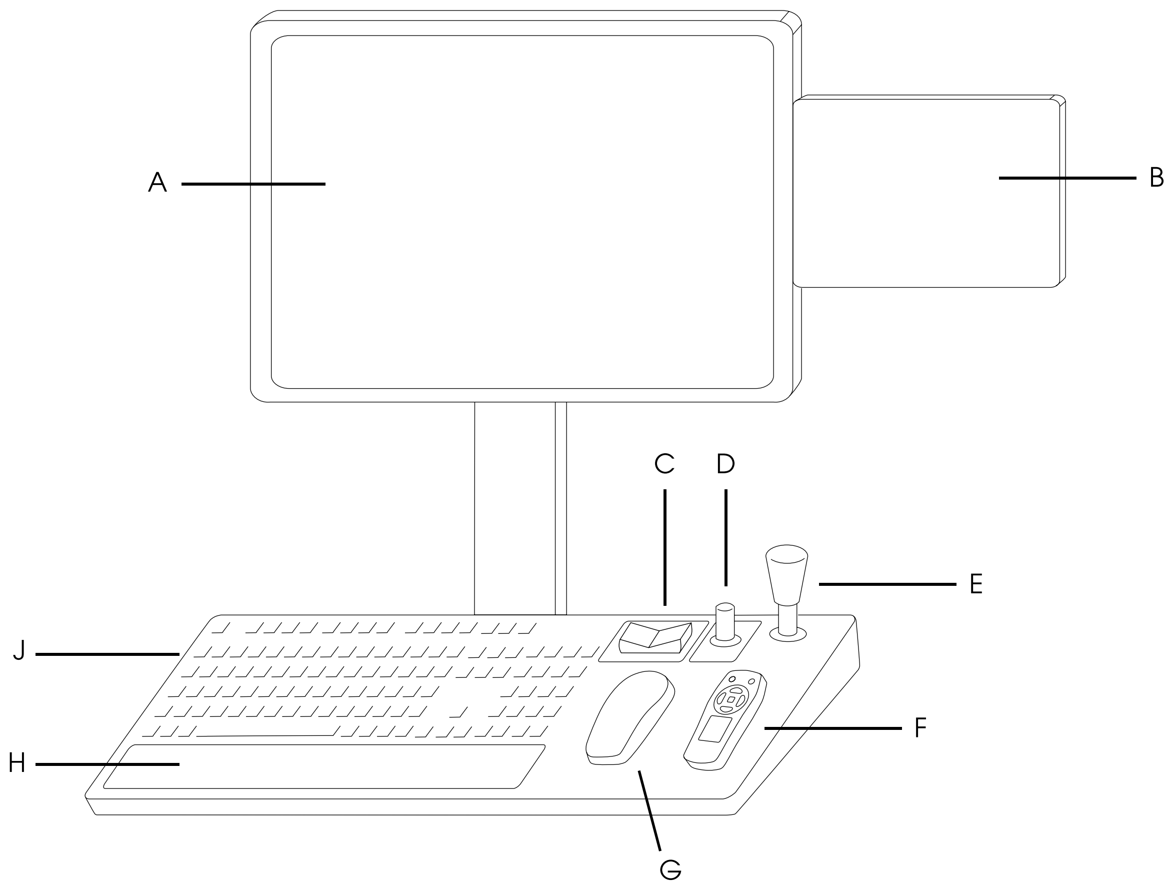


Table 1-5 MicroXCT Ergonomic Station – Major Components Illustrated in Figure 1-7

Callout Letter	Part	Description
A	Workstation Monitor	Display. Used to interface with the MicroXCT programs. Must be powered ON, by pressing its **Power** button. Refer to "XMController," "XMReconstructor," and "XM3DViewer," for further details.
B	Visual Light Camera Monitor	Displays images as seen by the visual light camera. Must be powered ON, by pressing its **Power** button. Two models of visual light camera monitors are currently in use. One has self-descriptive control buttons, and the other has control buttons represented by icons. Instructions for using the latter to adjust monitor glare are provided in Appendix D, "Visual Light Camera Monitor Brightness Controls."
C	Shortcut Keys for -90° and 0°	– LEFT button rotates Sample Theta to -90° – RIGHT button rotates Sample Theta to 0° – Pressing the same button again, during rotation, immediately stops the selected rotation
D	Visual Light Camera Light Switch	– UP position turns interior light ON – DOWN position turns interior light OFF
E	Joystick for Visual Positioning	– Pushing the joystick forward (away from you) moves the sample stage DOWN, while pulling the joystick backward (toward you) moves the sample stage UP – With Sample Theta at 0°, pushing the joystick LEFT and RIGHT moves the sample in the NEGATIVE and POSITIVE Z directions, respectively – With Sample Theta at -90°, pushing the joystick LEFT and RIGHT moves the sample in the NEGATIVE and POSITIVE X directions, respectively Refer to Figure 2-5, "Axis Definitions of X-ray Source, Sample, and Detector," on page 40 for an illustration of the X and Z axis directions.
F	Visual Light Camera Controller	Handset used for controlling the visual light camera. Refer to "Visual Light Camera Controller," for further details.
G	Mouse	Three-button pointing device used to interface with the programs used on the MicroXCT. The device's position is visible on the workstation monitor. The mouse button functions are dependent upon the program and function in which the mouse is being used. Unless stated otherwise in this guide, all references to mouse clicks are to the left-mouse button.
H	Wrist Pad	Ergonomic wrist rest.
J	Keyboard	Standard computer keyboard, in QWERTY layout.

Visual Light Camera Controller

The visual light camera allows visual positioning of the detector and X-ray source, in relation to the sample, by using the visual light camera controller.

Figure 1-8 Visual Light Camera Controller

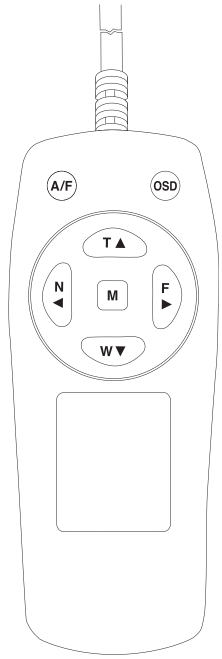


Table 1-6 Visual Light Camera Controller Button Functions

Button	Description
A/F	Press to enable autofocus.
OSD	Press to enable On-Screen Display mode focusing functions.
M	Press to enable Menu mode.
N ◄ F ►	Press to adjust the focus in On-Screen Display mode. In Menu mode, can also be used to switch between modes, in the directions indicated by the arrows.
T ▲	Press to zoom IN on the image displayed in the visual light camera monitor. In Menu mode, can also be used to switch between modes, in the direction indicated by the arrow.
W ▼	Press to zoom OUT from the image displayed in the visual light camera monitor. In Menu mode, can also be used to switch menu modes in the direction indicated by the arrow.

Software Control

MicroXCT uses the following three programs to control the Xradia tomography process:

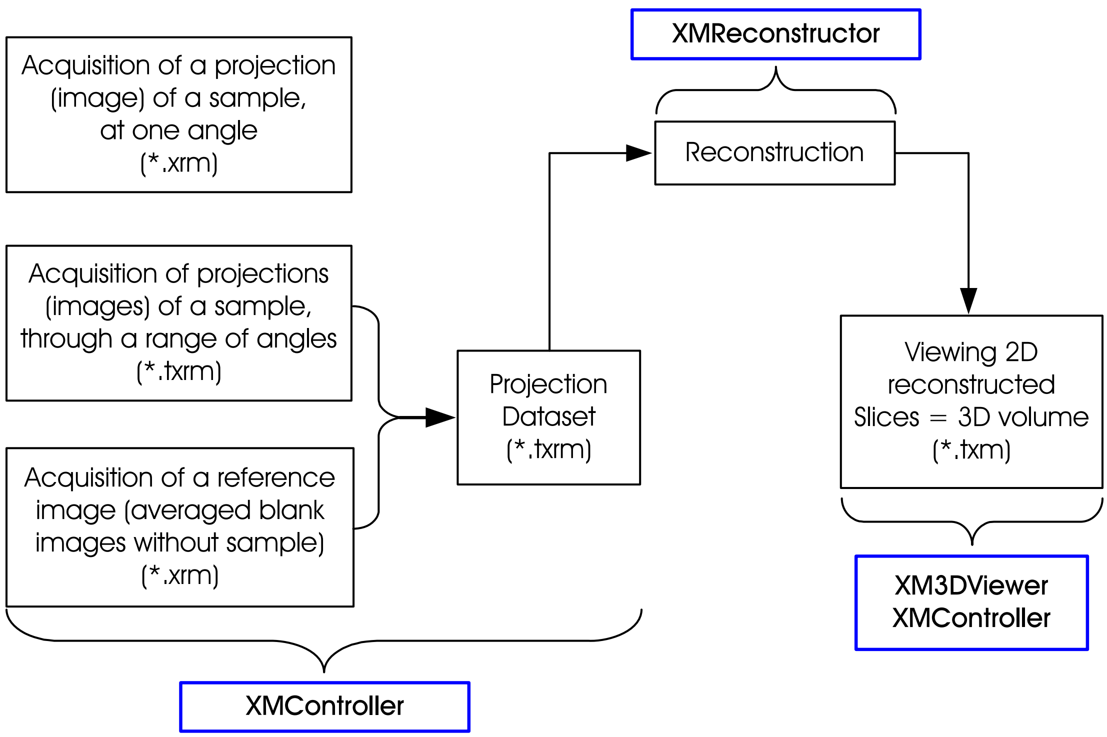
– XMController

– XMReconstructor

– XM3DViewer

Figure 1-9 illustrates the relationship between the three programs, and the data, processes, and files generated by each. Each program is described in the sections that follow.

Figure 1-9 MicroXCT Data, Processes, and Files



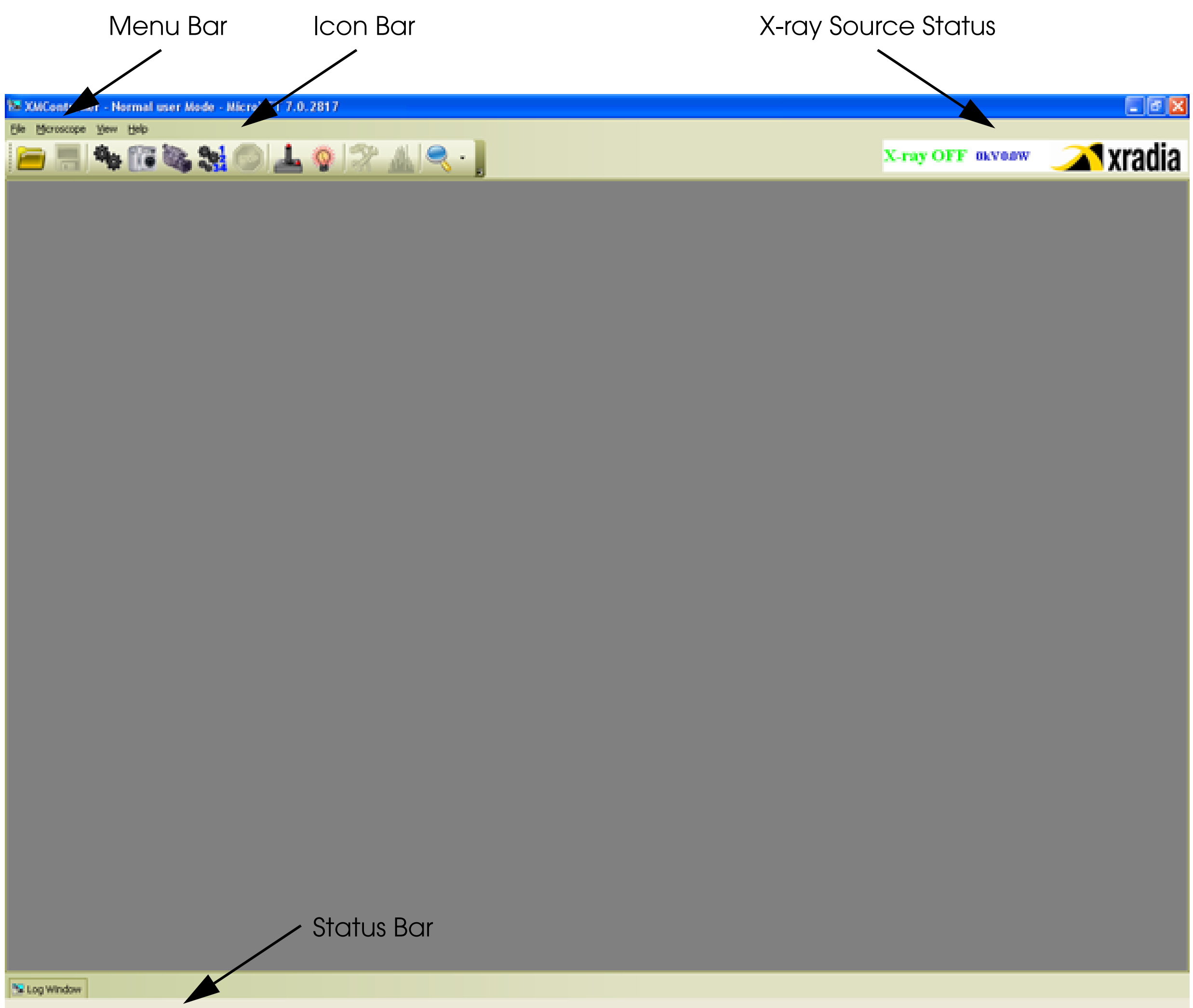
XMController

XMController is the program used to manage the data acquisition process, from setting up the sample to the acquisition of data, either manually or through the automatic Recipe. It is also used to acquire X-ray images, and monitor and control the microscope's hardware components. Use of XMController is described in Chapter 2 through Chapter 5.

Figure 1-10 illustrates the default **XMController** main window, and Table 1-7 describes the user interface icons.

NOTE The main window's menu bar changes, during use, to also include **Process** and **Window** menus.

Figure 1-10 Default **XMController** Main Window



NOTE If an icon is highlighted orange in the icon bar, its associated dialog box is already open, and clicking the icon closes, rather than opens, the dialog box.

Table 1-7 XMController User Interface Icons

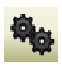
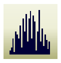
Icon	Description
	Click to select the file to be opened/used. Opens the **Open File** dialog box. Same as selecting **File > Open…**.
	Click to save the currently open file. Opens the **Save File** dialog box. Same as selecting **File > Save**.
	Click to set the acquisition parameters (mode, exposure time, binning, and mode-dependent settings) and start acquisition process. Opens the **Acquisition Setting** dialog box. Same as selecting **Microscope > Settings**.
	Click to acquire a single image, using the current acquisition settings. Same as selecting **Microscope > Acquire one Image**.
	Click to acquire continuous images, using the current acquisition settings, until stopped. Used in the sample positioning process. Same as selecting **Microscope > Continuous acquisition**.
	Click to automatically run and reconstruct 3D dataset tomographies. Opens the **Recipe** dialog box. Same as selecting **Microscope > Recipes…**.
	Click to stop image acquisition. Closes the **Acquisition Status** message box. Same as selecting **Microscope > Abort**.
	Click to position the sample, and the X-ray source and detector in relation to the sample. Opens the **Motion Controller** dialog box, with **Sample**, **Source**, and **Detector** tabs. Same as selecting **Microscope > Motion Controller…**.
	Click to control the X-ray source – turn the X-ray source ON/OFF, and set the X-ray source voltage and power. Opens the **Xray Source** dialog box. Same as selecting **Microscope > Source Controller…**.
	Click to access tools for manipulating the acquired image. Opens the **Image Controls** dialog box. Tabs include **Annotation**, **Info**, **Axis positions**, **Reference**, and **Notes**. Same as selecting **View > Image Controls**.

Table 1-7 XMController User Interface Icons (Continued)

<table>
<tr><th>Icon</th><th>Description</th></tr>
<tr><td></td><td>Click to control and adjust image contrast and brightness.
Same as selecting View > Histogram tool.</td></tr>
<tr><td></td><td>Click the drop-down arrow to the right of the icon to select the magnification lens and/or see which magnification lens is selected (indicated with a check mark (✓)).
When selecting a lens, the icon functions differently, depending upon whether the MicroXCT has a motorized or non-motorized turret and/or optional Macro lens:
<table>
<tr><th>Turret</th><th>Optional Macro Lens</th><th>Icon Function</th></tr>
<tr><td>Motorized</td><td>No</td><td>Click the drop-down arrow to the right of the icon, then select the magnification lens you want to use.</td></tr>
<tr><td>Motorized or Non-Motorized</td><td>Yes</td><td>Click the drop-down arrow to the right of the icon, then select the magnification lens you want to use. If you selected the optional Macro lens, the Waiting… dialog box opens. When the dialog box’s title changes to Done!, click Done.</td></tr>
<tr><td>Non-Motorized</td><td>No</td><td>After manually moving the turret to the magnification lens you want to use, click the drop-down arrow to the right of the icon, then verify that the lens is marked as selected (indicated with a check mark (✓)).</td></tr>
</table>
Lenses listed in the drop-down list are dependent upon which lenses are installed:
– Standard lenses (included with every MicroXCT) – 4X, 10X, 20X
– Optional lenses (available upon request) – Macro-70, Macro-55 (0.5X)[a, b, c], 1X, 2X[b, d], 40X</td></tr>
</table>

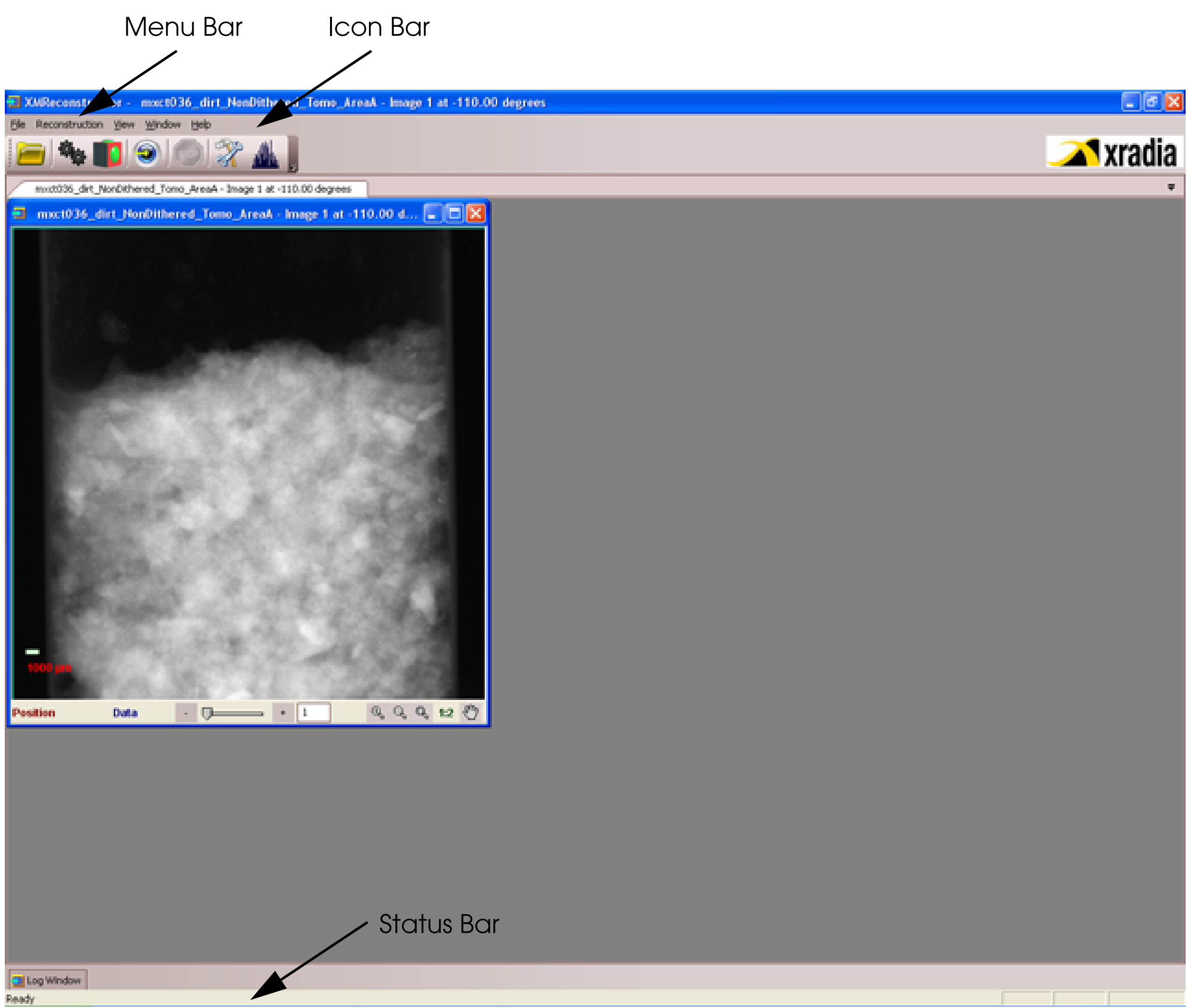
a. The Macro-55 (0.5X) lens is obsolete, and was replaced by the Macro-70 as an option. The lens is still in use in some MicroXCT units.
b. The Macro-55 (0.5X) and 2X lenses have a round FOV. Therefore, their 3D FOV range is the diameter of the FOV.
c. MicroXCT-400 only.
d. The 2X lens is not available when the MicroXCT has an optional Macro lens.

XMReconstructor

XMReconstructor is the program used to reconstruct all the 2D images (projections) acquired during data acquisition/tomography, to create a 3D reconstructed volume. Use of XMReconstructor is described in Chapter 6, “Manually Reconstructing a 3D Dataset.”

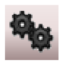
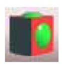
Figure 1-11 illustrates the main window, and Table 1-8 describes the user interface icons.

Figure 1-11 Default **XMReconstructor** Main Window (Opened File Shown for Reference Only)



NOTE If an icon is highlighted orange in the icon bar, its associated dialog box is already open, and clicking the icon closes, rather than opens, the dialog box.

Table 1-8 XMReconstructor User Interface Icons

Icon	Description
	Click to select the file to be opened/used. Opens the **Open File** dialog box. Same as selecting **File > Open…**.
	Click to set the reconstruction parameters and start the reconstruction process. Opens the **Reconstruction Setting** dialog box. Same as selecting **Reconstruction > Reconstruction Setting…**.
	Click to reconstruct the tomography data. Opens the **Reconstruction Status** window. Same as selecting **Reconstruction > Start Reconstruction**.
	Click to identify and correct center shift and beam hardening. Opens the **Rotation Center / Beam Hardening** dialog box. Same as selecting **Reconstruction > Find Center Shift**.
	Click to abort the center shift find, beam hardening correction find, and reconstruction processes. Same as selecting **Reconstruction > Abort**.
	Click to access tools for manipulating the projection images or reconstructed image while finding the center shift or beam hardening correction constant. Opens the **Image Controls** dialog box. Tabs include **Annotation**, **Info**, and **Navigation**. Same as selecting **View > Image Controls**.
	Click to control and adjust image contrast and brightness. Same as selecting **View > Histogram tool**.

XM3DViewer

After acquiring, referencing, and reconstructing the tomography dataset, the end result is a ready-to-load 3D reconstruction of the region(s) of interest that can be viewed in XM3DViewer. Use of XM3DViewer is described in Chapter 7, "Viewing Tomographies."

NOTE In its main window title bar, XM3DViewer appears as "**TXM3DViewer**," rather than as "**XM3DViewer**".

NOTE This guide provides basic information for using XM3DViewer to view tomographic data after reconstruction. For further details regarding the program's use (beyond what's provided here, and in Chapter 7, "Viewing Tomographies"), refer to the *Xradia ExamineRT Workstation 1.1 User's Manual*, available under XM3DViewer's **Help** menu.

Figure 1-12 illustrates the main window, and Table 1-9 describes the user interface icons.

Figure 1-12 Default **XM3DViewer** Main Window – **Examine** Tab, with Descriptions of Each Quadrant

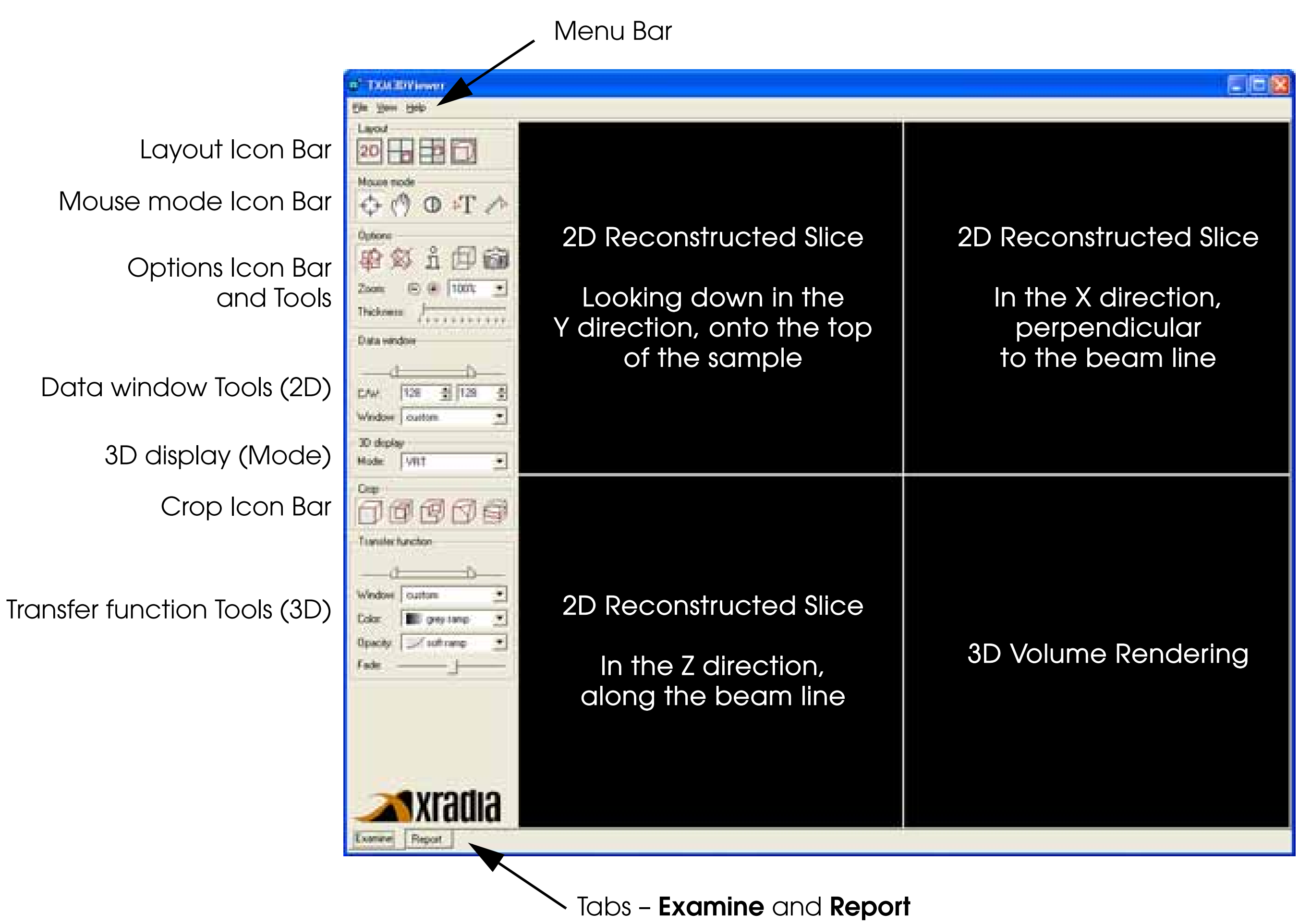


Table 1-9 XM3DViewer User Interface Icons[a]

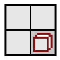
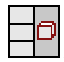
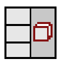
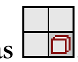
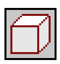
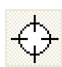
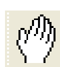
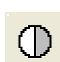
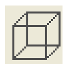
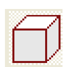
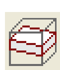
Type	Icon	Description
Layout		Click to display a single 2D reconstructed slice window. Click multiple times to cycle through the orientation of the slice in the 2D reconstructed slice window. When clicked, adds **Cine controls** to the main window (left side, below the other icon bars and tools).
		Click to display four equally sized windows (default) – three 2D reconstructed slice windows plus one 3D volume window. Displays the same four images as . In Figure 1-12, the white text in each quadrant window identifies specifically what appears in each window.
		Click to display three equally sized 2D reconstructed slice windows, plus one larger 3D volume window. Displays the same four images as .
		Click to display a single 3D volume window (not used for 2D reconstructed slices).
Mouse mode		Standard navigation mode (default). Enables selecting and moving navigation lines (cross-hairs) in the 2D reconstructed slice and 3D volume windows. If it is not the current mode, click to enable. **Navigation line (plane) colors** – **green** = X/Z, **blue** = X/Y, and **red** = Y/Z.
		Click to enable Zoom/Translate mode. Behaves differently, depending upon whether it is used in a 2D reconstructed slice or 3D volume window, as follows: – **2D reconstructed slice window** – Enables panning and zooming – **3D volume window** – Enables image rotation, panning, and zooming
		Click to enable Window/Level mode. Behaves differently, depending upon whether it is used in a 2D reconstructed slice or 3D volume window, as follows: – **2D reconstructed slice window** – Enables interactive adjustment of contrast and brightness, by changing the width and center, respectively, of the Data window. – **3D volume window** – Enables interactive adjustment of contrast and brightness, by changing the width and center, respectively, of the Transfer function.
		Click to enable Annotation mode. You can add arrows and text annotations: – **Arrow** – Click within a 2D reconstructed slice or 3D volume window at the point you want to start the arrow, then click again at the point you want to end the arrow. – **Text associated with an arrow** – Double-click the arrow, then type the text you want to add.
		Click to enable Measurement mode. In the 2D reconstructed slice or 3D volume window, at the region of interest, click once to define the start point for measuring, then again to define the endpoint for measuring.

Table 1-9 XM3DViewer User Interface Icons[a] (Continued)

Type	Icon	Description
Options		Click to enable Orthogonal Slicing mode (default). Restricts the slice orientation in 2D reconstructed slice windows to the reconstruction plane (X/Z plane of the MicroXCT).
		Click to enable Oblique Slicing mode. All three planes are orthogonal to one another; however, they are not orthogonal to the reconstruction plane.
		Click to enable Dataset information mode. Toggles the display of dataset information text in the 2D reconstructed slice and 3D volume windows.
		Click to enable Bounding box mode. Toggles the display of a wire frame of the bounding box in the 3D volume windows.
		Click to enable Snapshot mode. Changes the mouse cursor to a camera. Click the icon, move the mouse onto the image, then click to take a picture (snapshot) of the image. This saves the entire image in the **Snapshots** panel.
Crop		No crop (default). Click to omit any previously applied cropping.
		Click to focus on the region of interest within the 3D reconstructed volume, by isolating a region smaller than the complete image.
		Click to enable cropping a corner within the 3D reconstructed volume.
		Click to enable creating a diagonal area within the 3D reconstructed volume.
		Click to enable creating a parallel slice within the 3D reconstructed volume.

a. Complete details regarding mouse use for these functions, is included in the process steps in which they are used, in Chapter 7, “Viewing Tomographies.”

Process Overview

Figure 1-13 (“automatic” processes) and Figure 1-14 (“manual” processes) provide an overall view of the MicroXCT process flow.

Figure 1-13 Overall MicroXCT Process Flow – Automated Processes

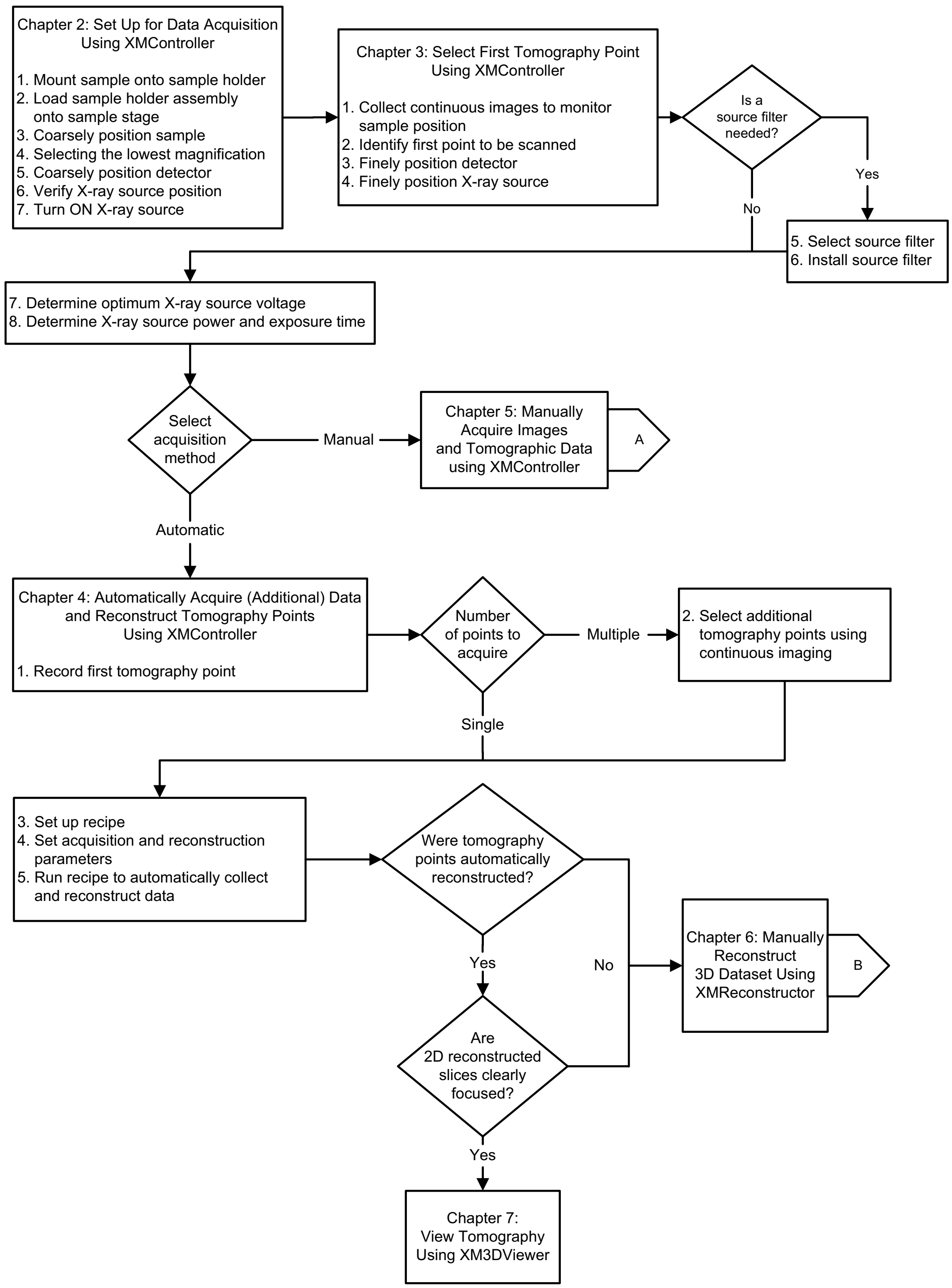
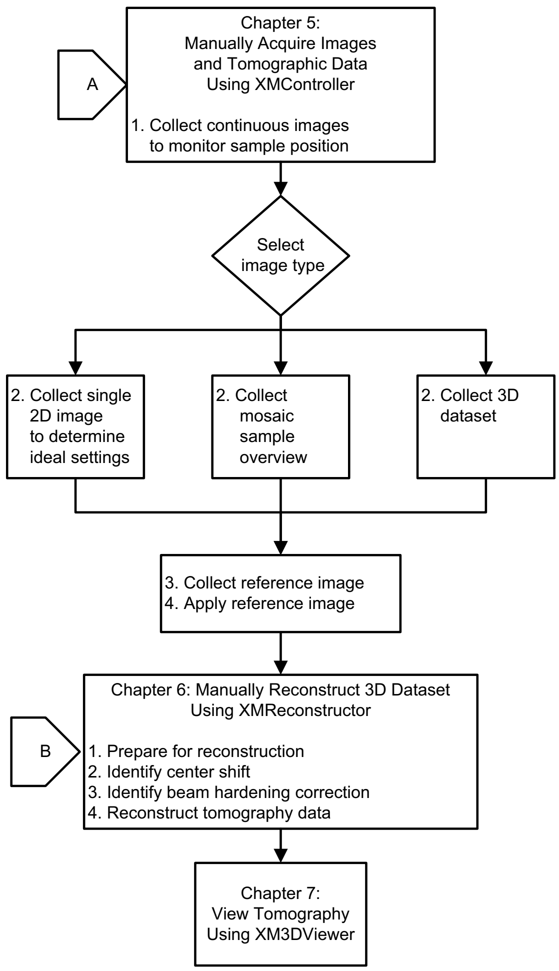


Figure 1-14 Overall MicroXCT Process Flow – Manual Processes



THIS PAGE INTENTIONALLY LEFT BLANK

2 Setting Up for Data Acquisition

This chapter describes the pre-data acquisition procedures, including (but not limited to) mounting, loading, and coarse positioning of the sample using XMController, and turning on the X-ray source. Before setting up the MicroXCT to take images or tomographies, the precautions and steps provided in this chapter should be taken to minimize collisions between the sample and the detector and X-ray source.

WARNING Failure to follow these precautions could increase camera, X-ray source, and lens depreciation, and/or potentially cause damage to magnification lenses and motors, MicroXCT alignment, and can potentially cause the MicroXCT to fail.

CAUTION Troubleshooting tips regarding imminent collision appear throughout this chapter. For more complete collision-related troubleshooting tips, refer to "Troubleshooting Sample Issues in XMController," on page 210.

Process Overview

The process of setting up for data acquisition is comprised of the following subprocesses:

1. Mounting the Sample in/on a Sample Holder.
   - Mounting Using a Clamp
   - Mounting Using a Clip
   - Mounting Using a Pin Vise
   - Mounting Using a Sample Base
2. Installing the Sample.
   a. Loading the Sample Holder Assembly onto the Sample Stage.
   b. Coarsely Positioning the Sample.
   c. Selecting the Lowest Magnification.
   d. Coarsely Positioning the Detector.
   e. Verifying the X-ray Source's Position.
3. Turning on the X-ray Source.

Each is described in the sections that follow.

Mounting the Sample in/on a Sample Holder

This process describes how to mount a sample in or on a sample holder. The sample holder assembly (sample plus sample holder) can then be loaded onto the MicroXCT's sample stage, for imaging of the sample.

In general, samples should be placed in/on their sample holders in such a manner that the region of interest in the sample (the focus of the data acquisition) is:

- Facing up
- Located above the top surface of the holder
- Positioned so that the least amount of material is penetrated by X-ray

Additionally, the sample must be:

- Securely mounted in/on the holder
- Stable, such that it does not move nor vibrate in response to gentle tapping on the holder

CAUTION Follow the safe sample handling procedures established by your work site.

CAUTION A properly mounted sample should not move during data acquisition. Any movement, however small, will compromise image resolution and create streak artifacts in reconstructed 2D slices and 3D volume data.

NOTE Instructions for removing the sample from the sample holder, after you are finished using the sample, are provided in Appendix E, "Removing the Sample after Use."

Table 2-1 lists the various types of samples that can be imaged with the MicroXCT, and their corresponding holders. The use and mounting procedures for each holder type is described in the sections that follow. Table 2-2 lists the sample diameter/width and height limitations, by MicroXCT model.

The processes for mounting samples, for each sample holder type, is described in the sections that follow.

For specific sample applications, contact Xradia directly.

Table 2-1 Sample Types and Corresponding Sample Holders

Sample Holder[a]	Sample Type
Clamp	Semiconductor; flat. Sample should be no thicker than 10 mm.
Clip	Semiconductor; flat; rigid material. Sample should be thin and flat, no thicker than 5 mm.
Pin Vise	Solid material (such as rock core samples, or thin, long pieces of material). Sample (or toothpick or rod) should be 3 mm or less in diameter.
Sample Base	Soft biological material that fits within a tube.

a. The clamp, clip, and pin vise sample holders are permanently mounted onto a sample base, which is the rounded base with a flat edge that lines up with the sample stage when the sample holder assembly (sample plus sample holder) is loaded onto the sample stage. The stand-alone sample base is also used as a sample holder.

Table 2-2 Sample Diameter/Width and Height Limitations

Model	Diameter/Width Limitations (Centered on Axis of Rotation)	Height Limitations
MicroXCT-200	100 mm	150 mm
MicroXCT-400	500 mm	400 mm

Mounting Using a Clamp

This process describes how to mount a sample, using the clamp sample holder. The clamp is primarily used for semiconductor or flat samples.

To mount a semiconductor or flat sample in a clamp

1. Turn the thumbscrew COUNTERCLOCKWISE on the clamp lever, to open the clamp region.

2. Position the sample in the clamp. Ensure that the region of interest is clearly visible, and not covered by the edges of the clamp.

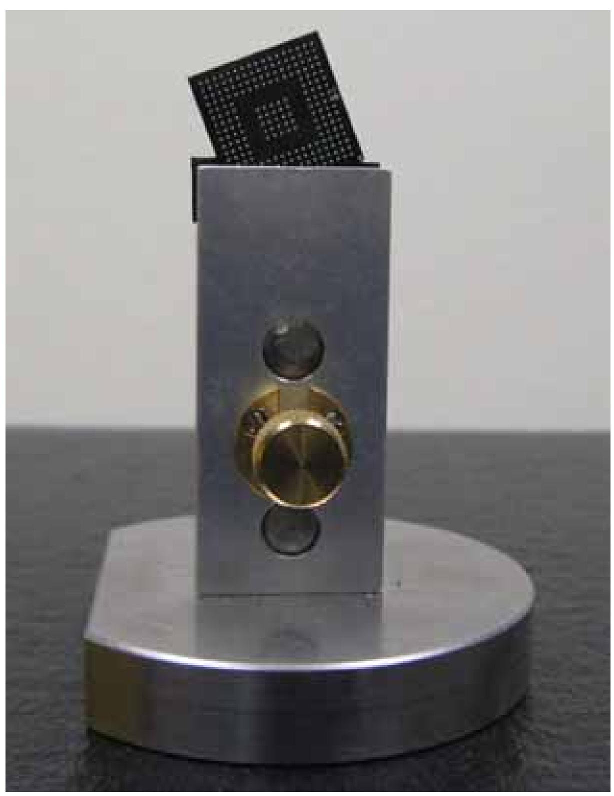
CAUTION Keep your fingers free of the part of the clamp that closes onto the sample, to avoid being pinched.

NOTE Semiconductor samples are usually mounted at a slight tilt (as illustrated in Figure 2-1) so that the horizontal traces can be properly reconstructed.

3. Gently tighten the clamp thumbscrew CLOCKWISE, to hold the sample in place.

   Proceed to “Installing the Sample.”

Figure 2-1 Sample Holder – Clamp with Semiconductor Sample



Mounting Using a Clip

This process describes how to mount a sample, using the clip sample holder. The clip is used for semiconductor or flat samples, as well as for rigid material, such as a tooth.

To mount a semiconductor, flat, or rigid material sample in a clip

1. Push down on the clip to open it.
2. Position the sample between the clip's pincers. Ensure that the region of interest is clearly visible, and not covered by the edges of the clip.

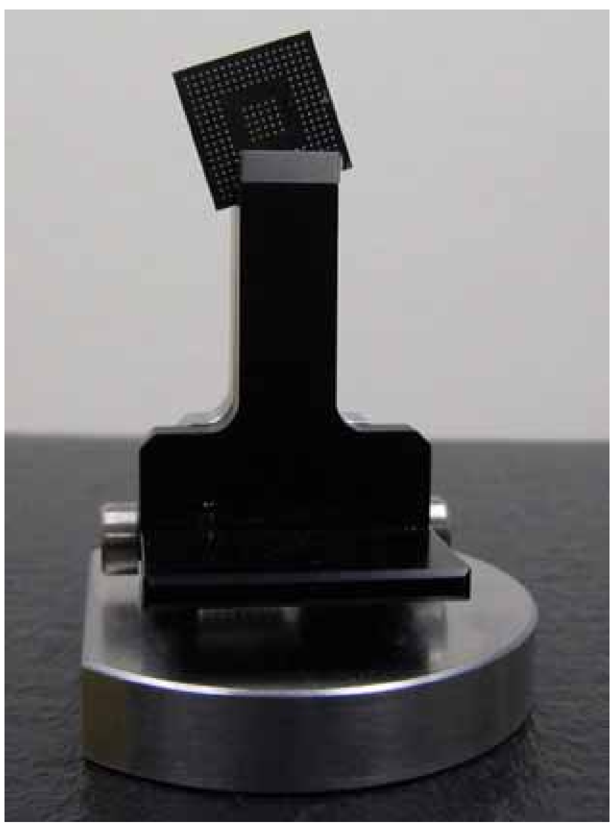
CAUTION Keep your fingers free of the part of the clip's pincers, to avoid being pinched.

NOTE Semiconductor samples are usually mounted at a slight tilt (as illustrated in Figure 2-2) so that the horizontal traces can be properly reconstructed.

3. Release the clip to close.

Proceed to "Installing the Sample."

Figure 2-2 Sample Holder – Clip with Semiconductor Sample



Mounting Using a Pin Vise

This process describes how to mount a sample, using the pin vise sample holder. The pin vise is used for solid material, such as rock core samples, or thin, long pieces of material. The pin vise can directly hold the sample, or it can hold a toothpick or thin rod, with the sample epoxied on top of the toothpick or thin rod.

To mount a solid or thin, long material sample in a pin vise

1. Rotate the outer section of the vise to sufficiently narrow (CLOCKWISE) or widen (COUNTERCLOCKWISE) the pin opening, for inserting the sample (or toothpick or rod) into the vise.

2. Position the sample in the vise.

   If using a toothpick or rod, place the end opposite from the sample, into the vise.

3. Rotate the outer section of the vise CLOCKWISE, to gently tighten the gripping section.

   Proceed to "Installing the Sample."

Figure 2-3 Sample Holder – Pin Vise with Sample on Thin Rod

Mounting Using a Sample Base

This process describes how to mount a sample directly onto a sample base sample holder. The sample base is used for soft biological samples. The sample is loaded into a plastic tube, then epoxied onto the sample base, using 5-minute epoxy.

NOTE The sample must be securely packed within the tube.

To mount a soft biological sample onto a sample base

1. So that the sample base can be reused, apply cellophane tape to its top surface, prior to applying the epoxy.
2. Load the biological sample into a plastic tube, packing firmly so that the sample does not move within the tube.
3. Epoxy the tube onto the base, as per the epoxy manufacturer's instructions.

CAUTION Follow the epoxy manufacturer's safety guidelines.

Proceed to "Installing the Sample."

Figure 2-4 Sample Holder – Sample Base with Sample in Plastic Tube

Installing the Sample

The process of installing the sample is comprised of the following subprocesses:

1. Loading the Sample Holder Assembly onto the Sample Stage.
2. Coarsely Positioning the Sample.
3. Selecting the Lowest Magnification.
4. Coarsely Positioning the Detector.
5. Verifying the X-ray Source's Position.

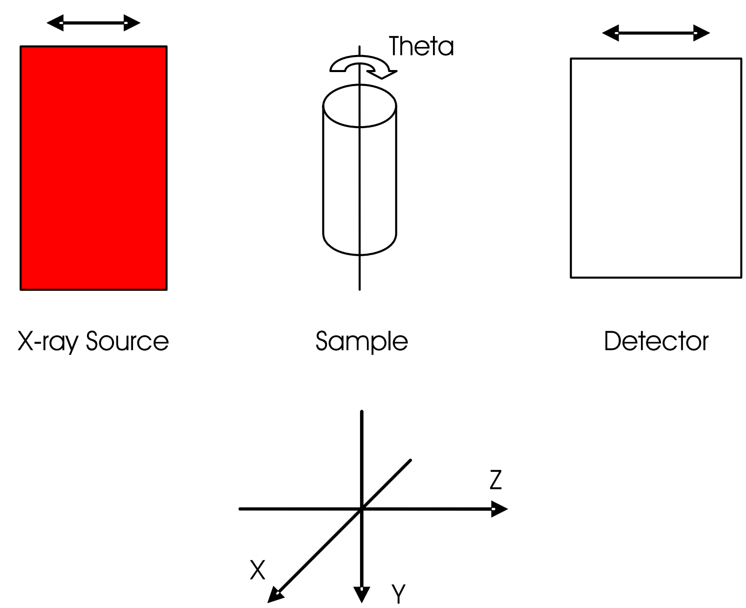
Each is described in the sections that follow.

Throughout this chapter, and the remainder of this guide, directions X, Y, Z, and Theta are mentioned. Table 2-3 describes, and Figure 2-5 illustrates, the directions used when moving the sample, detector, and X-ray source, in relation to the visual light camera (located behind the sample stage).

Table 2-3 Sample, Detector, and X-ray Source Movement Directions

Direction (Axis)	Movement	Movement From User's Perspective
X	Toward and away from visual light camera	IN and OUT
Y	From top to bottom of the enclosure	UP and DOWN
Z	Beam line from X-ray source to detector	LEFT and RIGHT
Theta	Circular angle	CLOCKWISE and COUNTERCLOCKWISE

Figure 2-5 Axis Definitions of X-ray Source, Sample, and Detector



Loading the Sample Holder Assembly onto the Sample Stage

This process describes how to open XMController, and load the sample holder assembly. The latter involves moving the X-ray source and detector away from the sample stage, to allow access to the sample stage. After the X-ray source and detector are moved, the sample holder assembly (sample plus sample holder) can be loaded onto the sample stage.

NOTE From this point on, the processes assume that the MicroXCT is already turned ON. If it is not ON, use the processes described in Appendix C, “Shutting Down and Restarting the MicroXCT,” to restart MicroXCT and home all motorized axes to pre-defined initialization positions.

NOTE Instructions for removing the sample holder from the sample stage, after you are finished using the sample, are provided in Appendix E, “Removing the Sample after Use.”

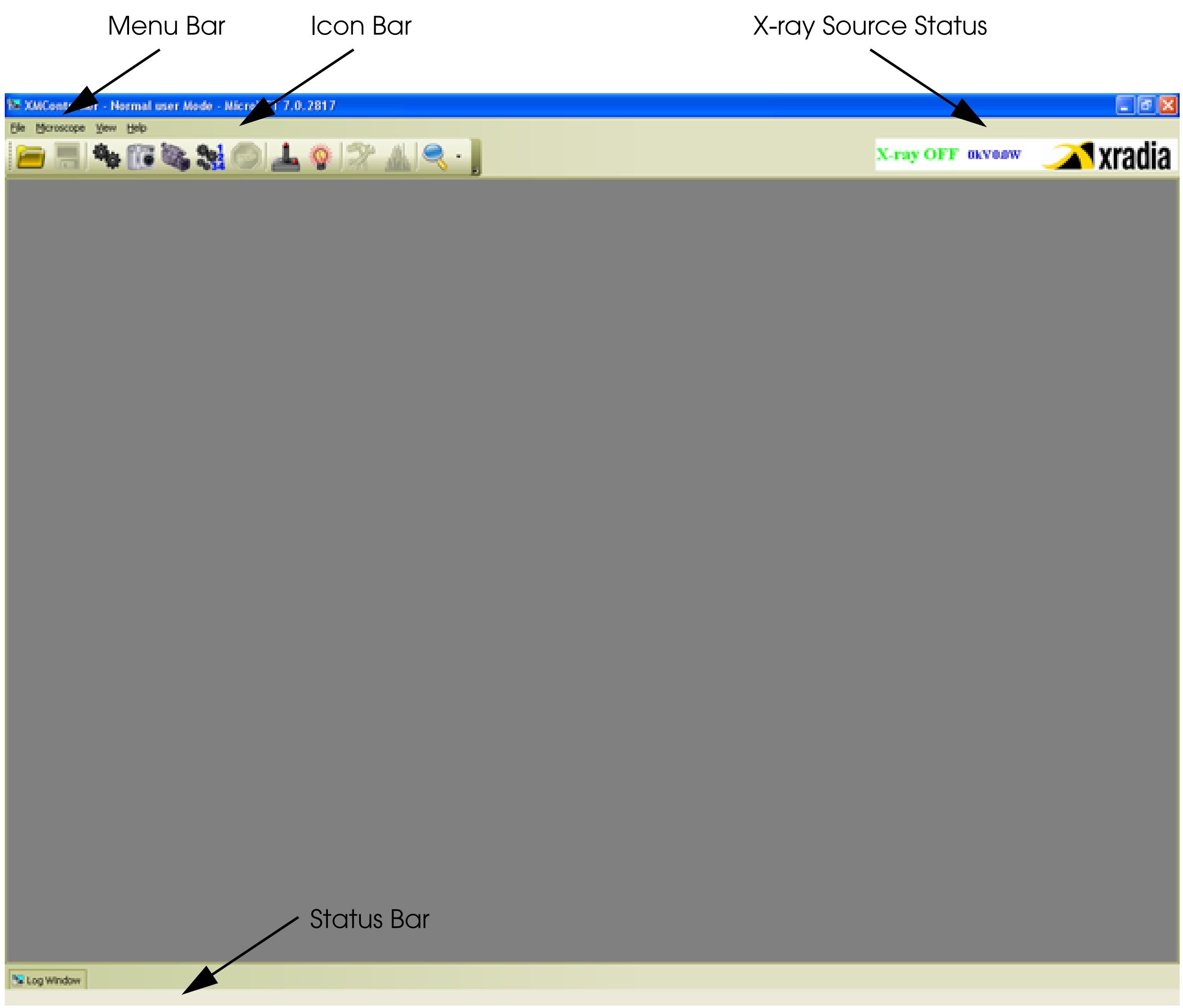
To load the sample holder assembly onto the sample stage

1. Start XMController, if it is not already running. Select **Start > All Programs > Xradia > MicroXCT 7.*x* > XMController 7.*x***. The **XMController** main window opens.

NOTE "x" is the program's current version number.

NOTE The main window's menu bar changes, during use, to also include **Process** and **Window** menus.

Figure 2-6 Default **XMController** Main Window



2. Open the **Motion Controller** dialog box, using one of the following methods:

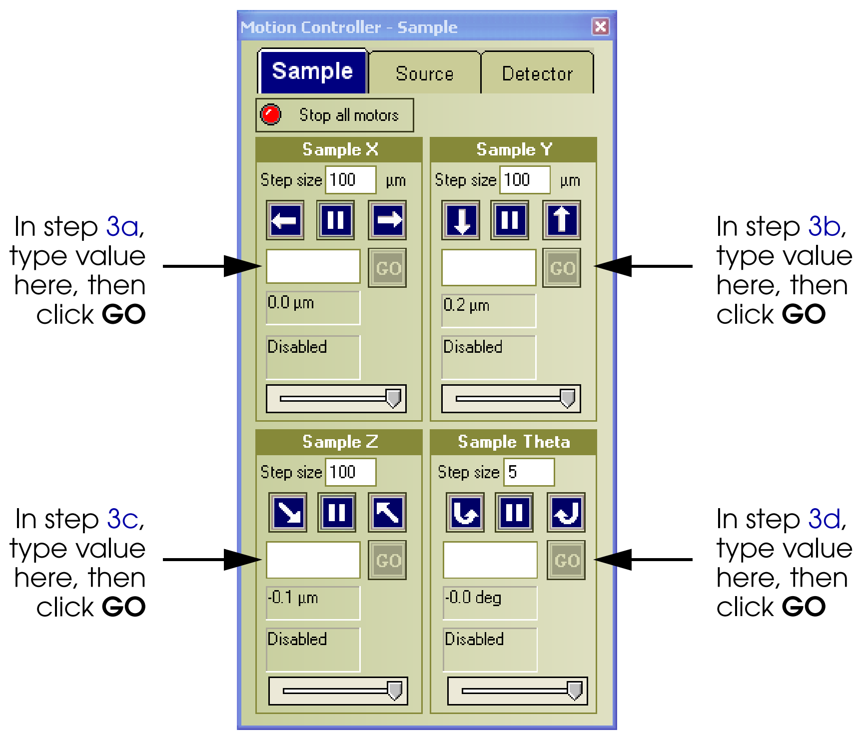
   – Select **Microscope > Motion Controller…**

   – Click  in the icon bar

   The dialog box opens, defaulted to the **Sample** tab.

NOTE If  is highlighted orange in the icon bar, the **Motion Controller** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted orange icon, then click the non-highlighted icon, as described above.

Figure 2-7 **Motion Controller** Dialog Box – **Sample** Tab



3. Follow steps a through d to bring the sample stage to the center of the axis of rotation. (Refer to Figure 2-7.) This ensures that the axes on the sample stage are centered, so that the sample, when loaded into the MicroXCT, is also centered.

   a. In the **Sample X** panel, type *0* in the **Sample X** text box, then click **GO**.

   b. In the **Sample Y** panel, type *0* in the **Sample Y** text box, then click **GO**.

   c. In the **Sample Z** panel, type *0* in the **Sample Z** text box, then click **GO**.

   d. In the **Sample Theta** panel, type *0* in the **Sample Theta** text box, then click **GO**.

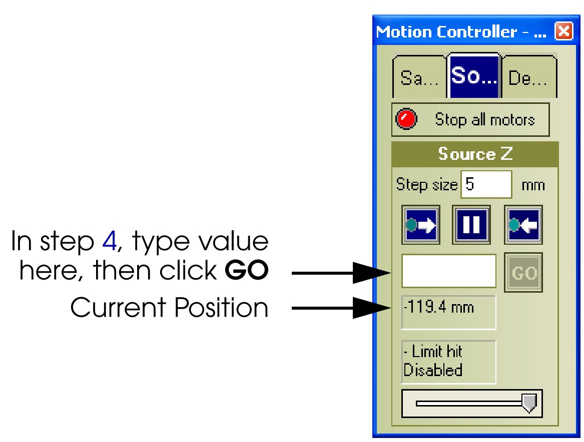
CAUTION Always position the mouse pointer over the pause button, **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

4. Click the **Source** tab. The **Current Position** status indicates the *current Source Z position*. Type *-130* in the **Source Z** text box, then click **GO**.

   The source retracts from the sample stage. When complete, the Source Z **Current Position** status indicates **-130 mm**, or the Source Z axis negative limit (**-Limit hit**) for your MicroXCT.

NOTE The **Source** and **Detector** tab labels are not fully visible when those tabs are selected in the **Motion Controller** dialog box; they are, however, fully visible when the **Sample** tab is selected.

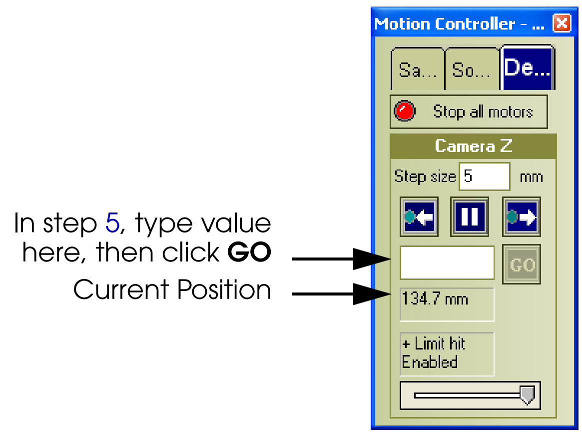
Figure 2-8 **Motion Controller** Dialog Box – **Source** Tab



5. Click the **Detector** tab. The **Current Position** status indicates the *current Camera Z position*. Type *130* in the **Camera Z** text box, then click **GO**.

   The detector retracts from the sample stage. When complete, the Camera Z **Current Position** status indicates **130 mm**, or the Camera Z axis positive limit (**+Limit hit**) for your MicroXCT.

Figure 2-9 **Motion Controller** Dialog Box – **Detector** Tab



6. At this point, the X-ray source should be OFF, because you have not yet turned it ON. However, before proceeding, **you must ensure that the X-ray source is turned OFF**. The X-ray source is ON if the **red** light on the light tower (top light) is illuminated.

NOTE Refer to Table 1-1, "MicroXCT-200 and MicroXCT-400 – Major External Components, Illustrated in Figure 1-1 and Figure 1-2," on page 7, for information regarding status of the light tower indicators.

   Follow steps a and b to turn OFF the X-ray source:

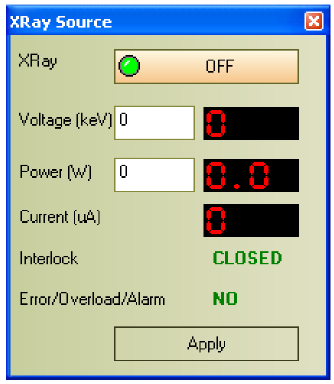
   a. Open the **XRay Source** dialog box, using one of the following methods:

      – Select **Microscope > Source Controller…**

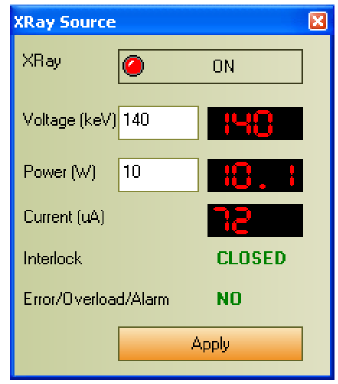
      – Click  in the icon bar

NOTE If  is highlighted **orange** in the icon bar, the **Xray Source** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted **orange** icon, then click the non-highlighted icon, as described above.

Figure 2-10 **XRay Source** Dialog Box – X-Ray Source OFF and ON (150 kV Source Shown for "ON")



X-ray Source is turned OFF



X-ray Source is turned ON

b. If the **Xray** button label indicates green **OFF**, the X-ray Source is already turned OFF. Proceed to step 7.

If the **Xray** button label indicates red **ON**, click the button to turn OFF the X-ray source. The label changes to green **OFF**, the red light on the light tower turns OFF, and the red dialog box values automatically change to 0.

NOTE There is no safety issue if the access door(s) is (are) opened without first turning OFF the X-ray source, because it automatically turns OFF when the access door(s) is (are) opened; however, it is better for the MicroXCT if the X-ray source is turned OFF by the software.

7. Open the access door. The **Interlock** indicator in the **XRay Source** dialog box indicates **OPEN**.

8. Place the sample holder assembly on the sample stage, with the flat edges of the assembly and sample stage aligned, facing the front of the MicroXCT. (Refer to Figure 2-12.) The dips on the assembly should match and help seat the assembly onto the three tungsten alignment balls (circled in **red**, in Figure 2-11) on the sample stage.

9. Close the access door(s). The **Interlock** indicator in the **XRay Source** dialog box indicates CLOSED. The yellow light on the light tower turns ON.

NOTE If you can see yourself on the visual light camera monitor, the access door(s) is (are) still open.

Proceed to "Coarsely Positioning the Sample."

Figure 2-11 Sample Stage, with Tungsten Alignment Balls Highlighted

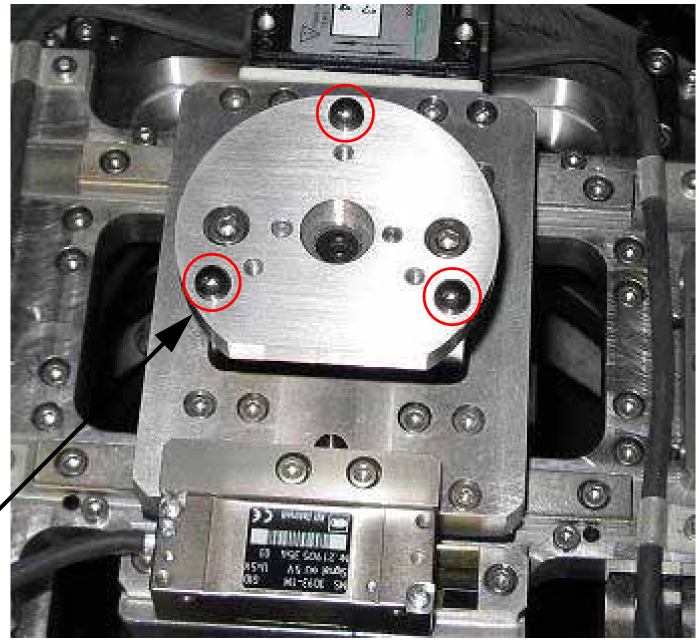
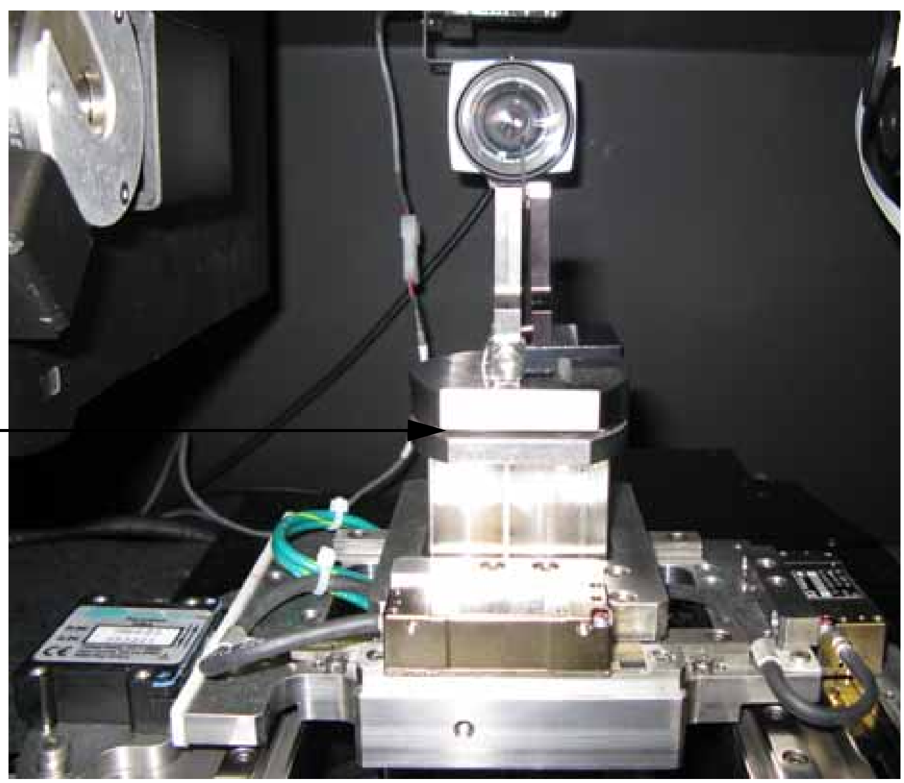


Figure 2-12 Sample Holder Assembly Loaded onto the Sample Stage, with Flat Edges Aligned, Facing the Front of the MicroXCT (Clip Sample Holder Shown)



Coarsely Positioning the Sample

Now that the sample is in place, it is necessary to ensure that the region of interest in the sample is clearly in view. This process describes how to coarsely position the sample, using the visual light camera and motion controller.

To coarsely position the sample

1. If the interior light is turned OFF, turn it ON, by moving the visual light camera light switch (D on Figure 1-7, "Ergonomic Station," on page 16) to the UP (ON) position.

   The sample is now visible on the visual light camera monitor.

NOTE If it is difficult to see the image due to glare, use the monitor's brightness control to reduce the glare, until the sample is visible.

Two models of visual light camera monitors are currently in use. One has self-descriptive control buttons, and the other has control buttons represented by icons. Instructions for using the latter to adjust monitor glare is provided in Appendix D, "Visual Light Camera Monitor Brightness Controls."

2. Open the **Motion Controller** dialog box, if it is not already open, by clicking  in the icon bar.

NOTE If  is highlighted orange in the icon bar, the **Motion Controller** dialog box is already open.

3. Select the **Sample** tab, if it is not already selected.

4. Change the sample rotation to -90° (COUNTERCLOCKWISE), using one of the following methods:

   – Press the -90° shortcut key (left green key) on the ergonomic station (C on Figure 1-7, “Ergonomic Station,” on page 16)

   – In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *-90* in the **Sample Theta** text box, then click **GO**

   When complete, the Sample Theta **Current Position** status indicates **-90.0 deg**.

CAUTION If collision is imminent, press the -90° shortcut key again to stop the sample rotation.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

5. Use the processes described in the following table, to coarsely center (by rough estimate) the sample’s region of interest at -90° in the visual light camera monitor. The sample’s region of interest should fill the entire display area, when the visual light camera is zoomed IN.

Tool	Process
Joystick	Use the joystick to move the sample in the X (LEFT and RIGHT) and Y (UP and DOWN) directions. (Refer to E on Figure 1-7, “Ergonomic Station,” on page 16.)
Visual light camera controller	Use the visual light camera controller to zoom IN/OUT, focus with the visual light camera, and monitor positioning progress. (Refer to F on Figure 1-7, “Ergonomic Station,” on page 16, and Table 1-6, “Visual Light Camera Controller Button Functions,” on page 18.)

In the **Sample X** and **Sample Y** panels, the **Current Position** status changes to indicate the *current Sample X and Sample Y positions*, respectively.

The sample is now coarsely positioned in the X and Y directions. The next two steps coarsely position the sample in the Z direction.

6. Change the sample rotation to 0°, using one of the following methods:

   – Press the 0° shortcut key (right green key) on the ergonomic station (C on Figure 1-7, “Ergonomic Station,” on page 16)

   – In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *0* in the **Sample Theta** text box, then click **GO**

   When complete, the Sample Theta **Current Position** status indicates **0 deg**.

CAUTION If collision is imminent, press the 0° shortcut key again to stop the sample rotation.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

7. Use the processes described in the following table, to coarsely center (rough estimate) the sample’s region of interest at 0° in the visual light camera monitor. The region of interest should fill the entire display area, when the visual light camera is zoomed IN.

Tool	Process
Joystick	Use the joystick to move the sample in the Z (LEFT and RIGHT) direction. (Refer to E on Figure 1-7, “Ergonomic Station,” on page 16.)
Visual light camera controller	Use the visual light camera controller to zoom IN/OUT, focus with the visual light camera, and monitor positioning progress. (Refer to F on Figure 1-7, “Ergonomic Station,” on page 16, and Table 1-6, “Visual Light Camera Controller Button Functions,” on page 18.)

In the **Sample Z** panel, the **Current Position** status changes to indicate the *current Sample Z position*. The sample is now coarsely positioned in the Z direction.

The sample is now coarsely positioned in the X, Y, and Z directions. Proceed to “Selecting the Lowest Magnification.”

Selecting the Lowest Magnification

This process describes how to select the lowest magnification lens, to visualize the sample at the largest field of view (FOV) available on the your MicroXCT. Using a low magnification lens enlarges the FOV. Therefore, the lower the magnification, the larger the FOV for the region of interest (that is, you can see more of the sample).

The selection process varies, depending upon whether your MicroXCT has a motorized or non-motorized turret and/or optional Macro lens.

To select the lowest magnification level – MicroXCT has a motorized turret, but does not have an optional Macro lens

1. Click the drop-down arrow to the right of  in the icon bar, then select the *lowest magnification level* (smallest number) listed in the drop-down list.

   The turret rotates to the selected magnification lens position.

   Proceed to "Coarsely Positioning the Detector."

To select the lowest magnification level – MicroXCT has a motorized turret and an optional Macro lens

1. Click the drop-down arrow to the right of  in the icon bar, then select the *optional Macro lens*. The **Waiting…** dialog box opens.
2. When the dialog box's title changes to **Done!**, click **Done**.

   Proceed to "Coarsely Positioning the Detector."

To select the lowest magnification level – MicroXCT has a non-motorized turret

1. Turn OFF the X-ray source if it is ON.

NOTE The process for turning OFF the X-ray source is described in "Loading the Sample Holder Assembly onto the Sample Stage," step 6.

2. Open the access door, if it is closed.

3. Slowly turn the turret (CLOCKWISE or COUNTERCLOCKWISE), until the *lens with the lowest magnification* clicks into place, at the bottom position (lowest point) of the turret.

4. Close the access door.

NOTE If you can see yourself on the visual light camera monitor, the access door is still open.

5. If you turned OFF the X-ray source in step 1, turn it back ON.

NOTE The process for turning ON the X-ray source is described in "Turning on the X-ray Source."

6. Click the drop-down arrow to the right of  in the icon bar, and verify that the correct lens is selected (marked with a check mark (✓)). If it is not selected, repeat steps 1 through 6.

   Proceed to "Coarsely Positioning the Detector."

Coarsely Positioning the Detector

This process describes how to coarsely position the detector, using the visual light camera and motion controller. For fastest imaging, shortest exposure time, and greatest intensity in the X-ray image, the detector should be coarsely positioned near the sample, but not so close that the sample collides with the detector, in the Z direction.

To coarsely position the detector

1. Zoom OUT with the visual light camera, by pressing W▼ on the visual light camera controller, until the entire sample and holder are visible on the visual light camera monitor.

2. While viewing the sample with the visual light camera monitor, rotate the sample to -90° (COUNTERCLOCKWISE), using one of the following methods:

   – Press the -90° shortcut key (left **green** key) on the ergonomic station

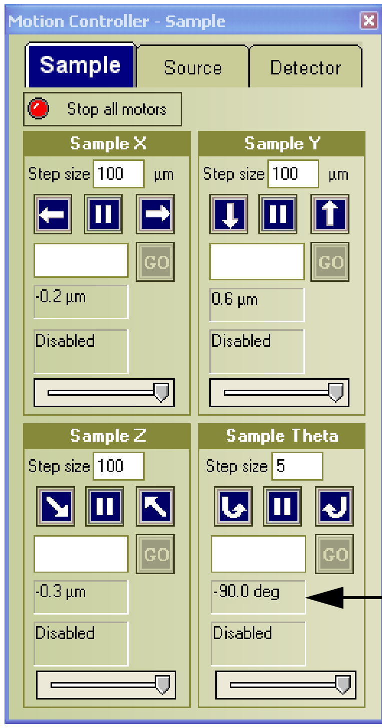
   – In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *-90* in the **Sample Theta** text box, then click **GO**

   When complete, the Sample Theta **Current Position** status indicates **-90.0 deg**.

CAUTION If collision is imminent, press the -90° shortcut key again to stop the sample rotation.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

Figure 2-13 **Motion Controller** Dialog Box – **Sample** Tab



Current Position status changes to **-90.0 deg**

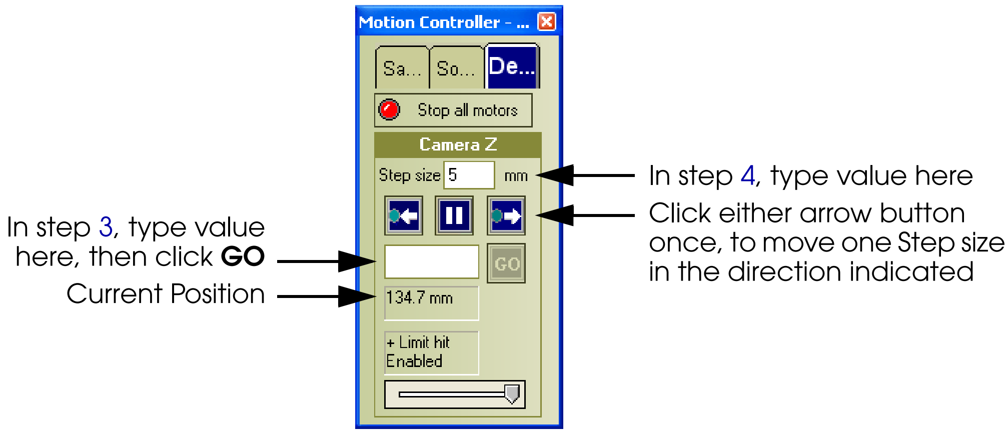
3. In the **Motion Controller** dialog box, select the **Detector** tab, type a number from *20* to *120* mm in the **Camera Z** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE The Camera Z value indicates the distance (in mm) between the center of the region of interest in the sample and front of the detector. The smaller the number, the closer the detector is to the sample. Type a number that is close to the sample's overall dimensions.

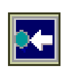
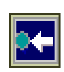
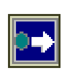
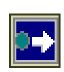
For example, if the sample is 25-mm wide, type *25* to start and adjust. The adjustment process is described in the next step.

Figure 2-14 **Motion Controller** Dialog Box – **Detector** Tab



4. Continue to change the value in the **Camera Z** text box, by typing decreased values, in small increments.

   You can also use the processes described in the following table to move the detector, using the **Step size** text box and the buttons indicated. The default Step size is 5 mm; therefore, if a smaller Step size is needed, type a smaller value in the text box.

Button	Process
	Click  once in the **Detector** tab, to move the detector **closer to** the sample by one step size.
	Click  once in the **Detector** tab, to move the detector **farther away from** the sample by one step size.

   The smaller the **Current Position** value, the closer the detector is to the sample. The center of rotation is at 0 mm. Keep track of the detector's position in the visual light camera monitor, to ensure that the detector does not collide with nor touch the sample. Leave a gap of at least 5 mm between the sample and detector.

5. Zoom IN with the visual light camera, by pressing 

 on the visual light camera controller, until the gap between the sample and detector is clearly visible.

6. Change the sample rotation back to 0°, using one of the following methods:

   – Press the 0° shortcut key (right **green** key) on the ergonomic station

   – In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *0* in the **Sample Theta** text box, then click **GO**

CAUTION If collision is imminent, press the 0° shortcut key again to stop the sample rotation. Repeat step 3, but move Camera Z to a larger ***Current Position*** *value*, to increase the clearance between the sample and detector by at least 5 mm. Press the 0° shortcut key to continue rotating to 0°.

CAUTION If collision is imminent, click in the **Sample Theta** panel to pause the rotation. Select the **Detector** tab, then repeat step 3, but move Camera Z to a larger ***Current Position*** *value*, to increase the clearance between the sample and detector by at least 5 mm. Return to the **Sample** tab, type *0* in the **Sample Theta** text box, then click **GO** to continue rotating to 0°.

When complete, the Sample Theta **Current Position** status indicates **0 deg**.

Keep track of the detector's position in the visual light camera monitor, to ensure that the detector does not collide with nor touch the sample.

Proceed to "Verifying the X-ray Source's Position."

Verifying the X-ray Source's Position

This process describes how to ensure that the X-ray source is at -130 mm or its negative limit (**-Limit**). The X-ray source must be at this position before proceeding to the next process.

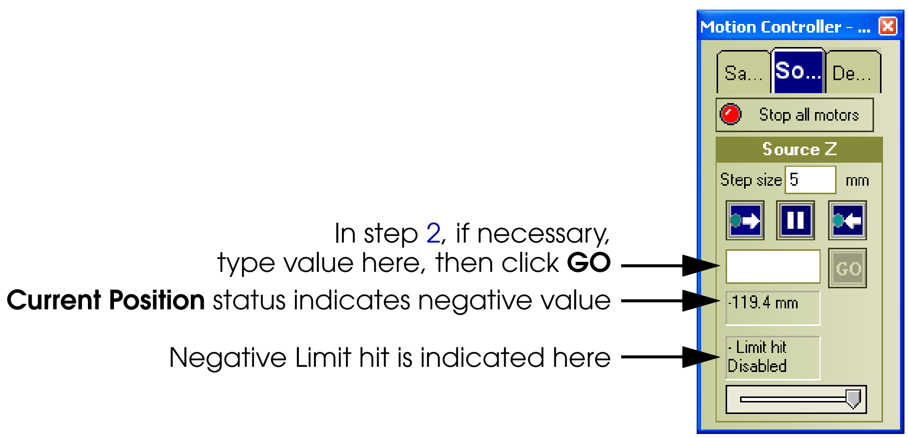
To verify the X-ray source's position

1. In the **Motion Controller** dialog box, select the **Source** tab.
2. The Source Z **Current Position** status should indicate -130 mm or the negative limit. If it does not, type *-130* in the **Source Z** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

Proceed to "Turning on the X-ray Source."

Figure 2-15 **Motion Controller** Dialog Box – **Source** Tab



Turning on the X-ray Source

This process describes how to turn ON the X-ray source, after the sample is installed and the access door(s) is (are) closed. The X-ray source must be ON for the X-ray source to accept user input.

NOTE If MicroXCT power or the X-ray source has been turned OFF for more than eight hours, the X-ray source must go through an initial warm-up process, called **X-ray source aging**. This process can take 30 minutes or more, depending upon the length of time that the X-ray source was turned OFF.

To turn ON the X-ray source

1. If the access door(s) is (are) open, close the door(s). The yellow light on the light tower turns ON.

NOTE If you can see yourself on the visual light camera monitor, the access door(s) is (are) still open.

2. Open the **XRay Source** dialog box, using one of the following methods:
   - Select **Microscope > Source Controller…**
   - Click  in the icon bar

NOTE If  is highlighted orange in the icon bar, the **Xray Source** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted orange icon, then click the non-highlighted icon, as described above.

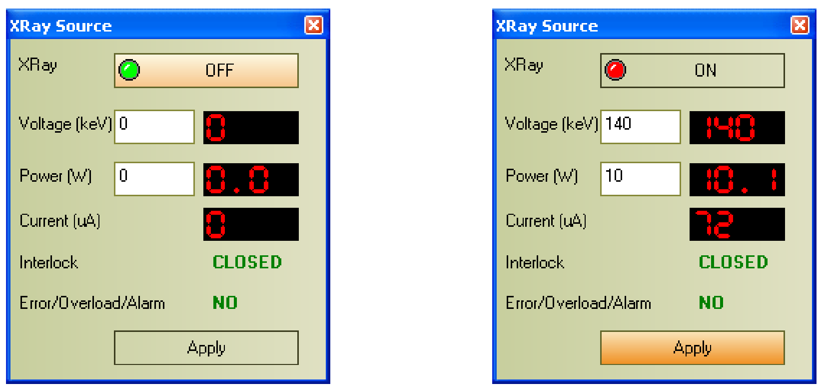
3. **Click the Xray button (green OFF), to turn ON the X-ray source or start the X-ray source warm-up process.**

NOTE If the X-ray source has been turned OFF for more than eight hours, it must go through a warm-up process called X-ray source aging. (Refer to the Note at the beginning of this process). When the aging is complete, the X-ray source turns itself OFF, the **Xray** button is **green** and the **red** light on the light tower is OFF. Click the **Xray** button (**green OFF**) again, to turn ON the X-ray source.

When the X-ray source turns ON, the Xray button label changes to red ON, the red light on the light tower turns ON, and the red dialog box values automatically change to the previously set voltage and power values. The green and yellow lights on the light tower remain ON.

WARNING If the **red** and **yellow** lights on the light tower are not turned ON, the source is not turning ON. Contact the Xradia Support Team.

Figure 2-16 **XRay Source** Dialog Box – X-Ray Source OFF and ON (150 kV Source Shown for "ON")



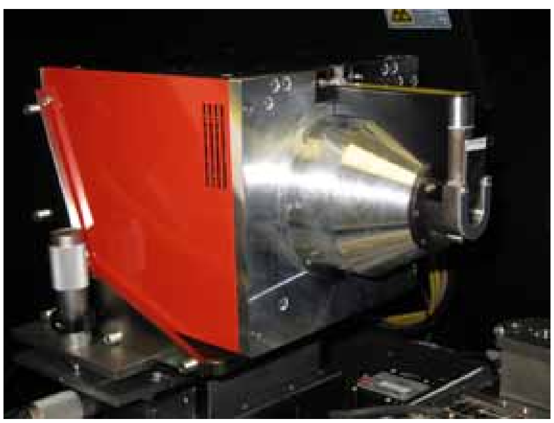
X-ray Source is turned OFF X-ray Source is turned ON

4. Type the appropriate *voltage and power values* in the **Voltage (kV)** and **Power (W)** text boxes, respectively, for the corresponding X-ray source and sample material type. (Refer to Table 2-4 and Figure 2-17.)

Table 2-4 **XRay Source** Dialog Box, **Voltage** and **Power** Settings by X-ray Source and Sample Material Type

X-ray Source	Sample Material Type	Voltage (kV)	Power (W)
90 kV	–	80	8
150 kV	High density (such as semiconductor)	140	10
	Low density (such as biological)	80	10

Figure 2-17 90 kV and 150 kV X-ray Sources



90 kV X-ray Source

150 kV X-ray Source

5. Click **Apply**.

One or more **Wait** message boxes briefly open and close, and the **red** values in the **Xray Source** dialog box change to indicate the actual voltage and power.

Proceed to Chapter 3, "Selecting the First Tomography Point."

3 Selecting the First Tomography Point

This chapter describes how to use XMController to select the first tomography point for a tomography dataset. Tomography points are used later, by the Recipe process, to collect and reconstruct tomographic data.

CAUTION Troubleshooting tips regarding imminent collision appear throughout this chapter. For more complete collision-related troubleshooting tips, refer to "Troubleshooting Sample Issues in XMController," on page 210.

NOTE Additional tomography points, if needed, are selected in Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)."

Process Overview

The process of selecting the first tomography point is comprised of the following subprocesses:

1. Collecting Continuous Images.
2. Identifying the First Point.
3. Finely Positioning the Detector.
4. Finely Positioning the X-ray Source.
5. Selecting the Source Filter.
6. Installing the Selected Source Filter.
7. Determining the Optimum X-ray Source Voltage.
8. Determining the X-ray Source Power and Exposure Time.

Each is described in the sections that follow.

Collecting Continuous Images

This process describes how to set up the correct parameters to acquire continuous images, using Continuous acquisition mode, that you can double-click later to set the sample position.

To collect continuous images

1. Follow steps a through c to take continuous images of the sample:

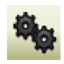
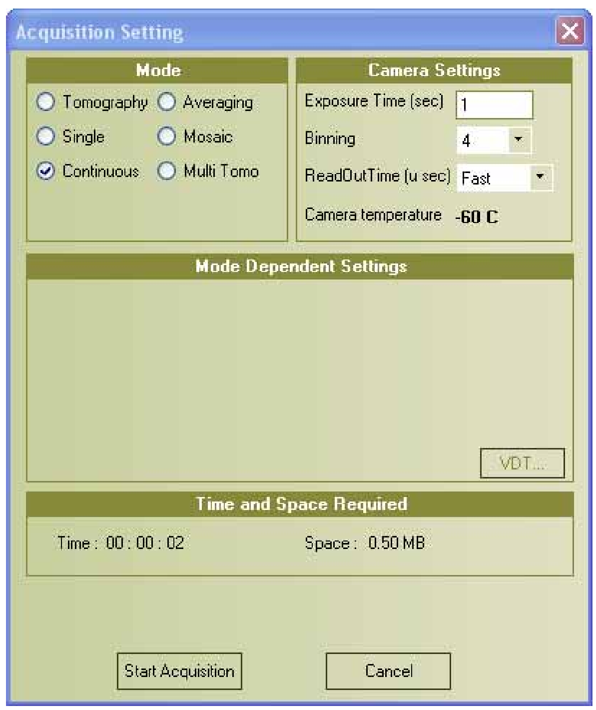
    a. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 3-1 **Acquisition Setting** Dialog Box – Settings Applied for Continuous Acquisition Mode



b. Select and/or type the *acquisition setting values*:

Option	Setting Value
Mode	*Continuous*
Exposure Time (sec)	*1*
Binning	*4*
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

c. Click **Start Acquisition** to acquire the image. An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click 

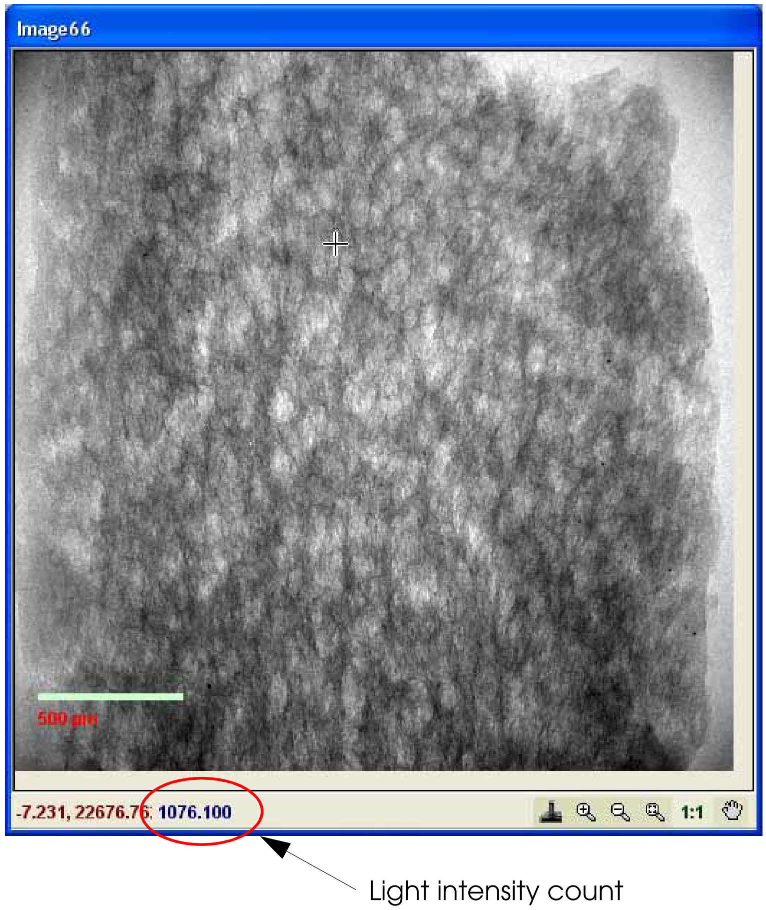
in the icon bar, then repeat steps 1a through 1c with different settings.

The **Acquisition Status** message box closes when you click 

in the icon bar to abort continuous imaging.

NOTE To continue collecting images using the same acquisition setting values, click  in the icon bar. If you need to specify an exposure time value other than 1 second or binning value other than 4, change the values in the **Acquisition Setting** dialog box.

Figure 3-2 **Image** Window Showing Light Intensity Count



2. Move the mouse pointer over the image and look at the region of interest's light intensity counts. Resolve any issues with the image being *too bright or dark*:

Issue with Image	Process
Image is too bright	Depending upon the sample density, image saturation can occur, with light intensity counts higher than 60,000. If this occurs anywhere in the image, you must reduce the voltage and power values. In the **XRay Source** dialog box, type the *minimum voltage and power values* (refer to Table 3-1) in the **Voltage (kV)** and **Power (W)** text boxes, respectively, click **Apply**, then repeat step 1.
Image is still too bright	Click  in the icon bar, then repeat step 1, with the exposure time *reduced to 0.5* or binning *reduced to 2*.
Image is too dark	Click  in the icon bar, then repeat step 1, with the exposure time *increased to 2 or higher*.

NOTE There is no upper limit to the length of exposure time; however, it should be more than 0.2 seconds.

NOTE The refresh rate significantly decreases when the exposure time is increased.

Table 3-1 Minimum and Maximum Voltage and Power Settings, by X-ray Source

X-ray Source	Voltage (kV)		Power (W)	
	Minimum	Maximum	Minimum	Maximum
90 kV	20	90	1	8
150 kV	40	150	4	10

Proceed to "Identifying the First Point."

Identifying the First Point

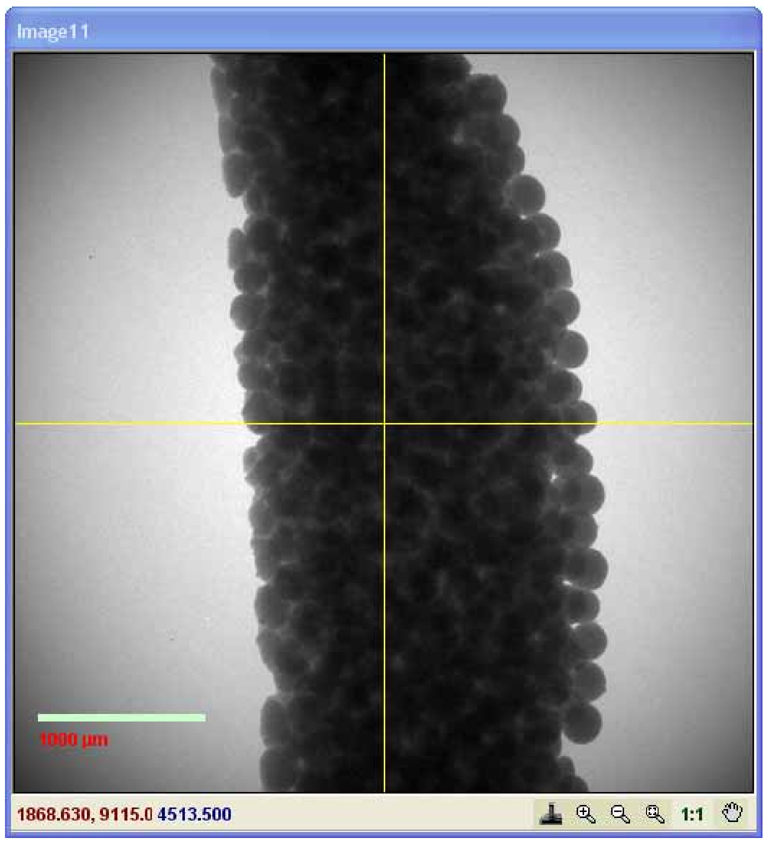
This process describes how to position the sample, using the continuous images created in the previous section, to focus on the first point to be scanned. In real-work events, up to 26 points can be collected in Version 7.*x*.

NOTE In the next XMController version release, there will be no limitation on the number of points that can be collected.

To identify the first point

1. Select **View > Highlight Center of FOV**. Yellow cross-hairs highlighting the center of the FOV are added to the current **Image** window.

Figure 3-3 Example Current **Image** Window, with Cross-Hairs Added



2. Click in the icon bar to open the **Motion Controller** dialog box, if it is not already open. The dialog box opens, defaulted to the **Sample** tab.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE If is highlighted orange in the icon bar, the **Motion Controller** dialog box is already open.

3. In the **Sample** tab, verify that **Sample Theta** is at 0°. If Sample Theta is not at 0°, type *0* in the **Sample Theta** text box, then click **GO** to rotate Sample Theta to 0°.

4. In the **Image** window, locate the *region of interest* and double-click it, using the mouse pointer, to move the *region of interest* to the center of the cross-hairs.

NOTE The center of the yellow FOV cross-hairs (for the X and Y axes) automatically move to the clicked location. Use the mouse pointer to adjust the region of interest, as necessary.

5. In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *90* in the **Sample Theta** text box, then click **GO** to rotate Sample Theta to +90°.

CAUTION If collision with the detector is imminent, click in the **Sample Theta** panel. Next, select the **Detector** tab, type a value in the **Camera Z** text box that is *at least 5 mm greater than the current value*, then click **GO**. Return to the **Sample** tab, type *90* in the **Sample Theta** text box, then click **GO** to continue rotating Sample Theta to +90°.

6. With Sample Theta at +90°, double-click along the horizontal yellow cross-hair, to center the region of interest in the FOV cross-hairs, for the Z axis.

7. Click the drop-down arrow to the right of in the icon bar, then select the *magnification lens you want to use*, based upon the required resolution. (Refer to Table 3-2.)

   The **Waiting…** dialog box might open, and then close. Click **Done** when complete.

NOTE If the MicroXCT has a non-motorized turret, use the process described in "To select the lowest magnification level – MicroXCT has a non-motorized turret," on page 52, to manually select the magnification lens.

Table 3-2 Spatial Resolution and FOV Ranges, by Magnification Level

Magnification Level/Lens	Resolution Range (µm)	3D FOV Range (mm)
Standard Lenses (included with every MicroXCT)		
4X	5.0 – 6.0	2.4 – 6.0
10X	2.5 – 3.0	2.0 – 2.7
20X	1.5	1.3
Optional Lenses (available upon request)		
Macro-70[a]	20.0 – 50.0	17.0 – 50.0
Macro-55 (0.5X)[a, b, c, d]	14.0 – 40.0	14.0 – 40.0
1X	9.0 – 22.0	4.0 – 15.0
2X[c, e]	6.0 – 13.0	4.0 – 13.0
40X	1.0	0.7

a. The Macro lens, if included, provides a second beam line for imaging, and is mounted beside, rather than on, the turret.
b. The Macro-55 (0.5X) lens is obsolete, and was replaced by the Macro-70 as an option. The lens is still in use in some MicroXCT units.
c. The Macro-55 (0.5X) and 2X lenses have a round FOV. Therefore, their 3D FOV range is the diameter of the FOV.
d. MicroXCT-400 only.
e. The 2X lens is not available when the MicroXCT has an optional Macro lens.

8. At the new magnification setting, follow steps a and b to verify that the region of interest is still visible in the FOV, at Sample Theta = +90° and 0°:

   a. Currently, Sample Theta is at +90°. Double-click the region of interest, to bring it to the center of the FOV (intersection of the yellow cross-hairs).

   b. In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *0* in the **Sample Theta** text box, then click **GO** to rotate Sample Theta to 0°. Double-click the region of interest, to bring it to the center of the FOV.

9. If you do not see the region of interest at the selected resolution, repeat step 7, but reduce the magnification level by one step (for example, from 10X to 4X), then repeat steps 2 through 8. A new **Image** window opens as a result of selecting a different magnification level.

10. When the region of interest is visible at the selected resolution,

    click  in the icon bar, to abort imaging.

    Proceed to “Finely Positioning the Detector.”

Finely Positioning the Detector

This process describes how to use the motion controller to position the detector as close to the sample as possible, while avoiding collision, for the shortest scan time.

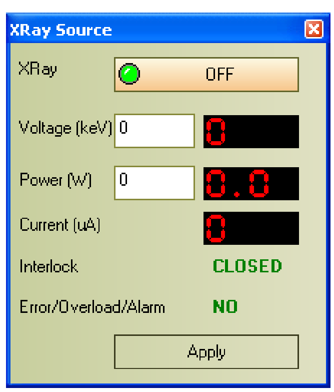
To finely position the detector

1. Open the **XRay Source** dialog box, using one of the following methods:
   - Select **Microscope > Source Controller…**
   - Click  in the icon bar

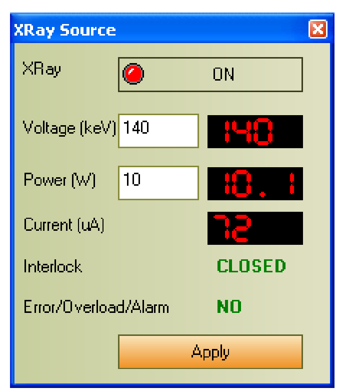
NOTE If  is highlighted orange in the icon bar, the **Xray Source** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted orange icon, then click the non-highlighted icon, as described above.

2. Click the **Xray** button (**red ON**), to turn OFF the X-ray source. The button label changes to **green OFF**, the **red** light on the light tower turns OFF, and the **red** dialog box values automatically change to 0.

Figure 3-4 **XRay Source** Dialog Box – X-Ray Source OFF and ON (150 kV Source Shown for "ON")



X-ray Source is turned OFF



X-ray Source is turned ON

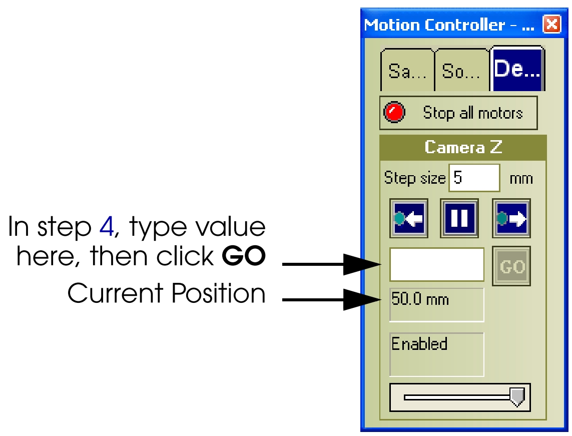
3. Open the access door.

4. In the **Motion Controller** dialog box, select the **Detector** tab, type a *value smaller than the current Camera Z position*, in steps of 5 mm or less, in the **Camera Z** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE The Camera Z value indicates the distance (in mm) between the center of the region of interest in the sample and front of the detector. The smaller the number, the closer the detector will be to the sample. Type a number that is close to the sample's overall dimensions.

Figure 3-5 **Motion Controller** Dialog Box – **Detector** Tab



5. To position the detector as close to the sample as possible, or until the status indicates **-Limit hit**, continue to change the value in the **Camera Z** text box by typing *decreased values, in 1-mm steps*, and clicking **GO**.

   Keep track of the detector's position in the visual light camera monitor and/or through the open access door, to ensure that the detector does not collide with nor touch the sample.

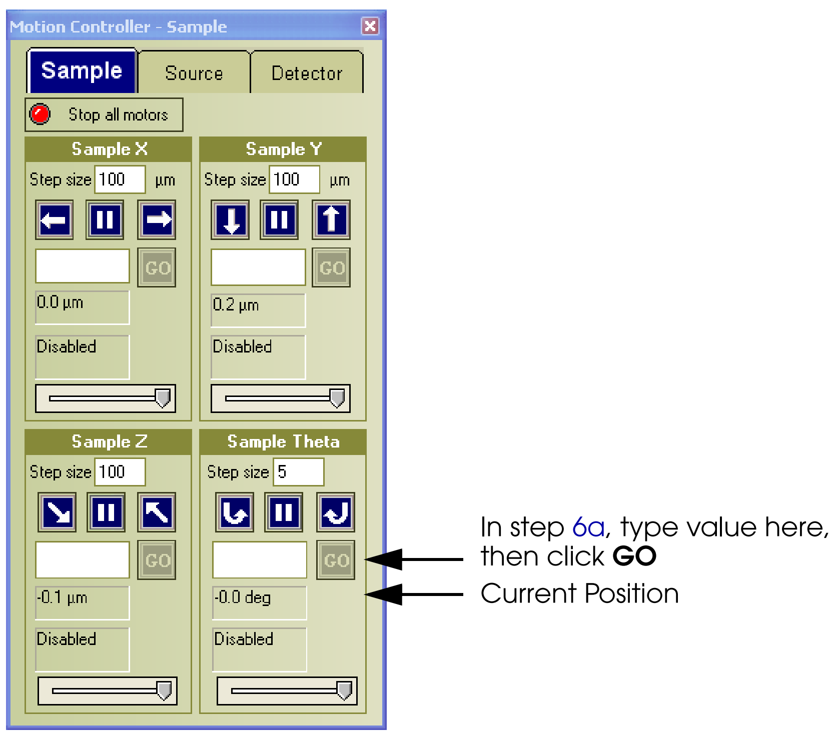
6. Follow steps a through c to verify the tomographic angle range, to ensure that the detector does not collide with nor touch the sample:

NOTE On the detector, the collision point is between the sample and the face of the bottom magnification lens (flat area) on the turret.

a. In the **Motion Controller** dialog box, select the **Sample** tab. In the **Sample Theta** panel, type the *negative limit of the Sample Theta tomographic angle range* (*-90* or *-180*, per Table F-1, “Sample Types and Sample Theta Tomographic Angle Ranges,” on page 259) in the **Sample Theta** text box, then click **GO**.

NOTE If the negative limit of the Sample Theta tomographic angle range is determined to be -180, but the MicroXCT is only 180°-enabled, type *-90*; otherwise, type *-180*. If you do not know whether the MicroXCT is 180°- or 360°-enabled, refer to Appendix F for further details.

Figure 3-6 **Motion Controller** Dialog Box – **Sample** Tab



b. Keep track of the sample's position in the visual light camera monitor and/or through the open access door, to ensure that the sample does not collide with nor touch the detector.

c. If the sample collides with the detector, or looks like it will collide with or touch the detector, click  in the **Sample Theta** panel to stop the movement. Select the **Detector** tab, type a *value slightly greater than the current Camera Z position* in the **Camera Z** text box, then click **GO**.

Continue repeating steps 6a through 6c, until the sample and detector do not collide with nor touch one another, and the Sample Theta **Current Position** status indicates the *negative limit of the Sample Theta tomographic angle range* (**-90 deg** or **-180 deg**, per Table F-1, "Sample Types and Sample Theta Tomographic Angle Ranges," on page 259).

7. Repeat steps 6a through 6c for the *positive limit of the Sample Theta tomographic angle range* (**+90 deg** or **+180 deg**, per Table F-1).

8. **If data is to be automatically reconstructed (using instructions documented in** Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)"**) and the tomographic angle range is -90 to +90** – Repeat steps 6a through 6c, to check for collision with the detector, *at angles up to Sample Theta = +170°*.

9. Note the *current Camera Z position* in the **Motion Controller** dialog box **Detector** tab. This value can be used later, to calculate Source Z positions in "Finely Positioning the X-ray Source."

Proceed to "Finely Positioning the X-ray Source."

Finely Positioning the X-ray Source

This process describes how to use the motion controller to position the X-ray source appropriately, for imaging with the chosen magnification lens:

- **10X, 20X, and 40X lenses** – The X-ray source is placed as close to the sample as possible, while avoiding collision.

- **Macro, 1X, 2X, and 4X lenses** – The X-ray source is placed such that the distance between the X-ray source and detector is not less than that indicated in Table 3-3. The distance between the X-ray source and detector is equal to Camera Z - Source Z.

  For example, if the value noted for Camera Z in "Finely Positioning the Detector," step 9, is 10 mm, then for a 4X lens, the X-ray source should be positioned no closer than -(65 - 10) = -55 mm from the region of interest in the sample. That is, Source Z can be at a more negative value than -55 mm – -60 mm will work; however, -50 mm will not.

NOTE If this process is not correctly followed for the Macro, 1X, 2X, and 4X lenses, the X-ray source aperture might be seen in the field of view (FOV). Refer to "Troubleshooting Magnification Lens Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View," on page 224, for resolution.

Table 3-3 Minimum Distance between X-ray Source and Detector for Macro, 1X, 2X, and 4X Lenses

Lens	MicroXCT With an Optional Macro Lens	MicroXCT Without an Optional Macro Lens
Macro-70[a]	135 mm	–
Macro-55 (0.5X)[a, b, c]	80 mm	–
1X	33 mm	160 mm
2X[d]	–	92 mm
4x	13 mm	65 mm

a. The Macro lens, if included, provides a second beam line for imaging, and is mounted beside, rather than on, the turret.
b. The Macro-55 (0.5X) lens is obsolete, and was replaced by the Macro-70 as an option. The lens is still in use in some MicroXCT units.
c. MicroXCT-400 only.
d. The 2X lens is not available when the MicroXCT has an optional Macro lens.

To finely position the X-ray source

1. In the **Motion Controller** dialog box, select the **Sample** tab, then rotate Sample Theta back to 0°, by typing *0* in the **Sample Theta** text box and clicking **GO**.

2. Zoom OUT with the visual light camera, by pressing W▼ on the visual light camera controller, until the entire sample and holder are visible on the visual light camera monitor.

3. **10X, 20X, and 40X lenses** – Skip this step.

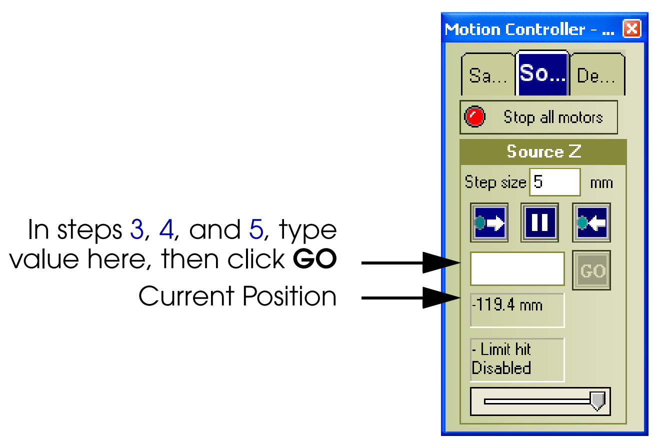
   Macro, 1X, 2X, and 4X lenses – Follow steps a through c to position Source Z:

NOTE If steps a through c are not followed correctly, the X-ray source aperture might be seen in the field of view (FOV). Refer to "Troubleshooting Magnification Lens Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View," on page 224, for resolution.

   a. Subtract the value of Camera Z noted in "Finely Positioning the Detector," step 9, from the value indicated for the lens and MicroXCT type in Table 3-3.

   b. In the **Motion Controller** dialog box, select the **Source** tab.

Figure 3-7 **Motion Controller** Dialog Box – **Source** Tab



c. In the **Source Z** text box, type the *negative value of the value calculated in step a*, then click **GO**.

Proceed to step 6.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

4. **10X, 20X, and 40X lenses** – Follow steps a and b to position Source Z (refer to Figure 3-7):

a. In the **Motion Controller** dialog box, select the **Source** tab.

b. In the **Source Z** text box, type a *negative value greater than the current Source Z position*, in increments of about 10 to 20 mm, then click **GO**.

For example, if Source Z is currently at -130 mm, type *-110* in the **Source Z** text box, then click **GO**, to bring the X-ray source closer to the sample. This will bring the X-ray source 20 mm closer to the sample.

5. **10X, 20X, and 40X lenses** – Continue to position the X-ray source as close to the sample as possible, or until the Source Z **Current Position** status indicates **+Limit hit**, by typing *increased negative values*, in small increments, and clicking **GO**. (Refer to Figure 3-7.)

Keep track of the X-ray source's position in the visual light camera monitor and/or through the open access door, to ensure that the X-ray source does not collide with nor touch the sample.

WARNING At this point, the sample is very close to the detector, and if the X-ray source collides with the sample, the detector can be damaged.

CAUTION For more complete troubleshooting tips regarding imminent collision, as well as for collision, refer to "Troubleshooting Sample Issues in XMController," on page 210.

6. Follow steps a through c to verify the tomographic angle range, to ensure that the X-ray source does not collide with nor touch the sample:

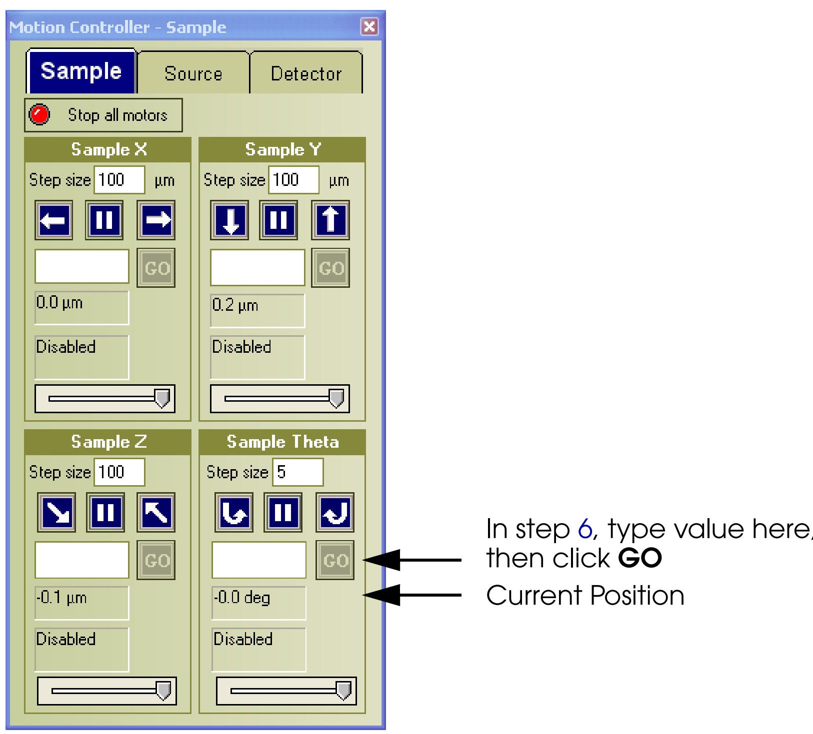
NOTE The collision point varies, by X-ray source:

– **90 kV X-ray source** – Between the source filter holder and sample
– **150 kV X-ray source** – Between the sample base and bottom of the X-ray source

a. In the **Motion Controller** dialog box, select the **Sample** tab. In the **Sample Theta** panel, type the value of the *negative limit of the Sample Theta tomographic angle range* (-90° or -180°, per Table F-1, "Sample Types and Sample Theta Tomographic Angle Ranges," on page 259) in the **Sample Theta** text box, then click **GO**.

NOTE If the negative limit of the Sample Theta tomographic angle range is determined to be -180, but the MicroXCT is only 180°-enabled, type *-90*; otherwise, type *-180*. If you do not know whether the MicroXCT is 180°- or 360°-enabled, refer to Appendix F for further details.

Figure 3-8 **Motion Controller** Dialog Box – **Sample** Tab



b. Keep track of the sample's position in the visual light camera monitor and/or through the open access door, to ensure that the sample does not collide with nor touch the source.

c. If the sample collides with the source, or looks like it will collide with or touch the source, click  in the **Sample Theta** panel to stop the movement. Select the **Source** tab, type a *negative value slightly less than the current Source Z position* in the **Source Z** text box, then click **GO**.

   For example, if the X-ray source is currently at -40 mm, type *-45* in the **Source Z** text box, to move the X-ray source away from the sample by 5 mm.

   Continue to repeat steps 6a through 6c, until the sample and X-ray source do not collide with nor touch one another, and the Sample Theta **Current Position** status indicates the *negative limit of the Sample Theta tomographic angle range* (**-90 deg** or **-180 deg**, per Table F-1, "Sample Types and Sample Theta Tomographic Angle Ranges," on page 259).

7. Repeat steps 6a through 6c for the *positive limit of the Sample Theta tomographic angle range* (**+90 deg** or **+180 deg**, per Table F-1).

8. **If data is to be automatically reconstructed (using instructions documented in** Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)"**) and the angle range is -90° to +90°** – Repeat steps 6a through 6c to check for collision with the X-ray source, *at angles up to Sample Theta = +170°*.

   Proceed to "Selecting the Source Filter."

Selecting the Source Filter

Source filters are materials that improve reconstructed image quality, by removing low-energy X-rays that do not provide useful information through the sample, also known as *hardening the X-ray*, thus reducing the effects of beam hardening.

This process describes how to determine whether a source filter is needed, and if so, which source filter to use, based upon the transmission value and magnification lens in use. The *transmission value* is the ratio of X-rays through the sample versus the X-rays without the sample present:

Transmission Value = Image with Sample / Image without Sample

NOTE Source filters are available in a filter kit from Xradia.

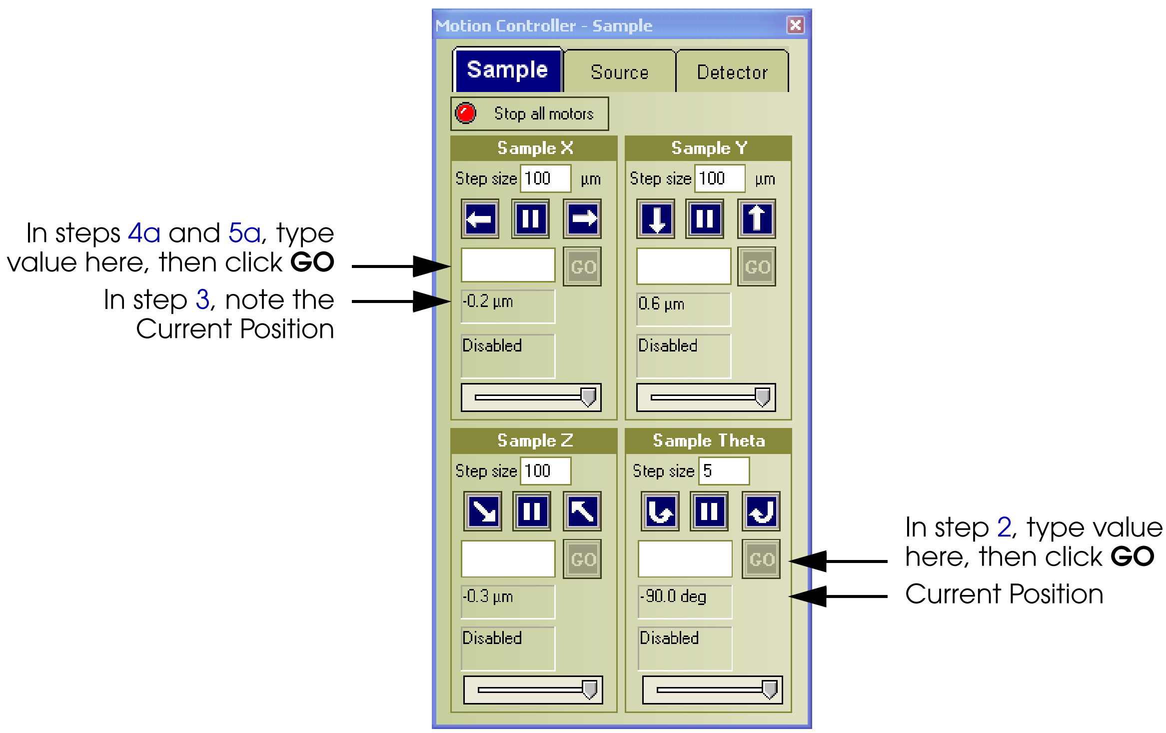
To select the source filter

1. Turn ON the X-ray source, following the process described in "Turning on the X-ray Source," on page 58.

2. In the **Motion Controller** dialog box, select the **Sample** tab. In the **Sample Theta** panel, if the current Sample Theta position is not **0 deg**, type *0* in the **Sample Theta** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

Figure 3-9 **Motion Controller** Dialog Box – **Sample** Tab



3. In the same dialog box and tab, note the *current Sample X position*. (Refer to Figure 3-9.) This value is used later, in step 5, as well as in other processes that appear later in this chapter.

4. **Image without sample** – Follow steps a through f to take a single image, with the sample out of the field of view (FOV):

   a. Move the sample out of the FOV. In the **Sample X** panel of the **Motion Controller** dialog box **Sample** tab, type *60,000* in the **Sample X** text box, then click **GO**. (Refer to Figure 3-9.)

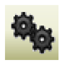
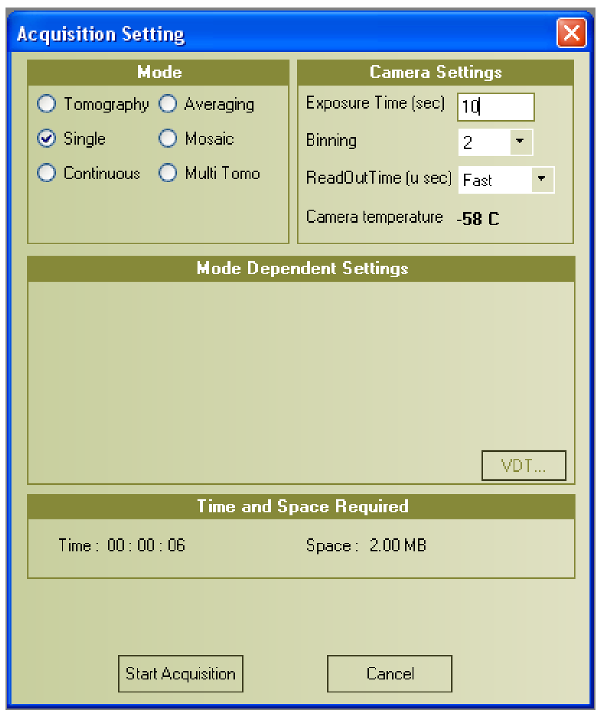
   b. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 3-10 **Acquisition Setting** Dialog Box – Settings Applied for Single Acquisition Mode



c. Select and/or type the *acquisition setting values*:

Option	Setting Value
Mode	*Single*
Exposure Time (sec)	*10*
Binning	*2*
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

d. Click **Start Acquisition** to acquire the image. An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click STOP in the icon bar, then repeat steps 4b through 4d with different settings.

The **Acquisition Status** message box closes when acquisition is complete, or when you click STOP in the icon bar to abort imaging.

e. Resolve any issues with the image being *too bright or dark*:

Issue with Image	Process
Image is too bright	Depending upon the X-ray source to detector distances and magnification lens used, image saturation can occur, with light intensity counts higher than 60,000. If this occurs anywhere in the image, you must reduce the power value. In the **XRay Source** dialog box, type the *minimum power value* (*1* for the 90 kV X-ray source; *4* for the 150 kV X-ray source) in the **Power (W)** text box, click **Apply**, then repeat steps 4b through 4d.
Image is still too bright	Repeat steps 4b through 4d, with the exposure time *reduced to 1*.
Image is too dark	Repeat steps 4b through 4d, with the exposure time *increased to a value higher than 10* (such as 20).

NOTE There is no upper limit to the length of exposure time; however, it should be more than 0.2 seconds.

f. Note the *image name* in the top left corner of the final **Image** window's title bar. This value is used later, as *Input b* in step 6d.

NOTE To collect another image using the same acquisition setting values, click  in the icon bar. If you need to specify an exposure time other than 10 seconds or binning other than 2, change the values in the **Acquisition Setting** dialog box.

NOTE If the X-ray source is visible on the image, use the troubleshooting tips provided in "Troubleshooting Magnification Lens Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View," on page 224, for resolution.

5. **Image with sample** – Follow steps a through c to take a second image, with the sample in the FOV:

   a. Move the sample back into the FOV. In the **Sample X** panel of the **Motion Controller** dialog box **Sample** tab, type the *Sample X position value*, noted earlier in step 3, in the **Sample X** text box, then click **GO**. (Refer to Figure 3-9.)

NOTE In cases where the sample is significantly thinner in one dimension than the others, rotate Sample Theta to an angle that will reflect and average transmission between projection images at ***different*** Sample Theta angles. For example, for a semiconductor sample that has minimal thickness but larger width and height, rotate Sample Theta to -70° to acquire the image with the sample. Note the sample theta value. Always rotate Sample Theta back to 0° before trying to move the sample out of the FOV (by moving Sample X).

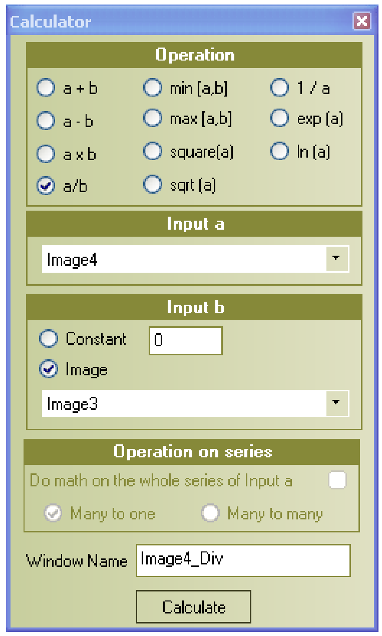
   b. Click  in the icon bar, to acquire a single image with same *acquisition settings* selected in step 4.

   c. Note the *image name* in the top left corner of the final **Image** window's title bar. This value is used later, as *Input a* in step 6c.

6. Follow steps a through f to calculate the transmission value, which is determined by dividing the second image (with sample) by the first image (without sample):

   a. Select **Process > Image Calculator**. The **Calculator** dialog box opens.

Figure 3-11 **Calculator** Dialog Box – **a/b** Operation



   b. Select *a/b* operation.

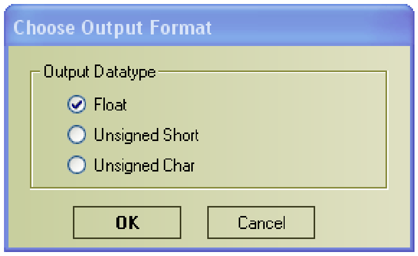
   c. Select the *image acquired in step 5* ("image with sample," using the *image name noted in step 5c*), from the **Input a** drop-down list box.

   d. Select the *image acquired in step 4* ("image without sample," using the *image name noted in step 4f*), from the **Input b** drop-down list box.

NOTE The window name that appears in the **Window Name** text box is automatically derived, based upon the selected operation. You can leave it as is, or rename it.

e. Click **Calculate**. The **Choose Output Format** dialog box opens.

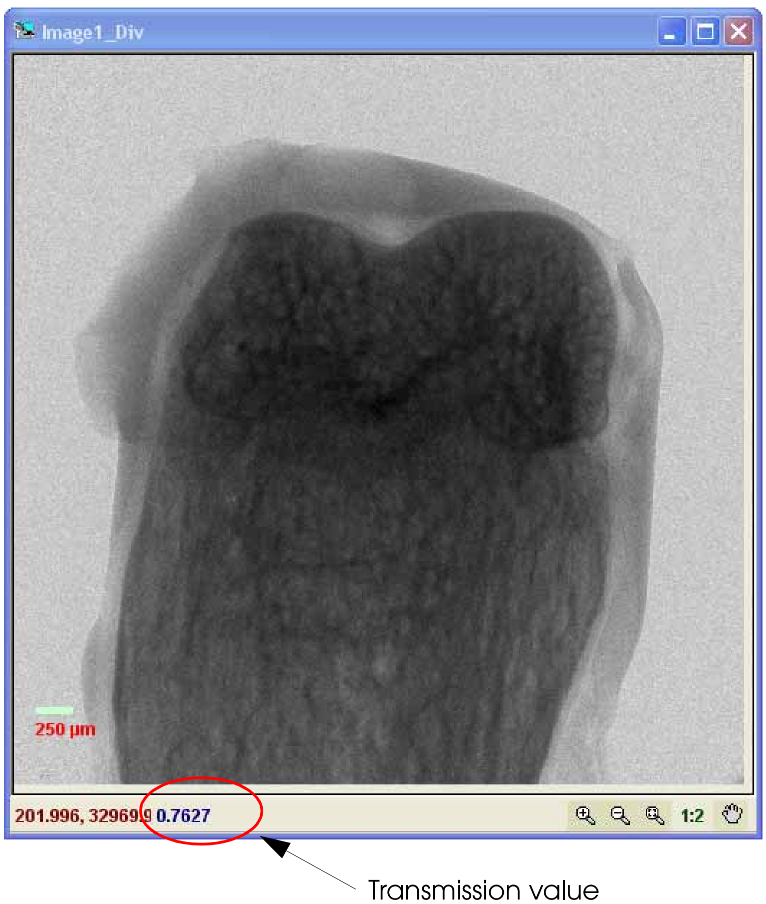
Figure 3-12 **Choose Output Format** Dialog Box



f. Click **OK** to select the *Float* output datatype (default). An **Image*x*_Div** window opens, with the transmission value indicated in **blue** (lower left status bar of the window), on a scale of 0 to 1.

NOTE If the transmission value is greater than 1, you divided the blank image by the sample image. Repeat steps 6c through 6f to divide the sample image by the blank image.

Figure 3-13 **Image*x*_Div** Window Resulting from Calculation



7. Using the value determined in step 6, determine the appropriate source filter thickness to be used, in "Installing the Selected Source Filter":

   – **10X, 20X, or 40X lenses** – Select the appropriate value from Table 3-4

   – **Macro, 1X, 2X, or 4X lenses** – Select the appropriate value from Table 3-5

NOTE In most cases, the region of interest can contain different materials, with different transmission values. If this is the case, estimate an average transmission value to select a source filter.

To estimate an average, hover the mouse over the region of interest, look at the **blue** numbers, then roughly estimate the average value.

Proceed to the next process:

– If Table 3-4 or Table 3-5 indicates that a source filter is needed, proceed to "Installing the Selected Source Filter"

– If Table 3-4 or Table 3-5 indicates that a source filter is **not** needed, proceed to "Determining the Optimum X-ray Source Voltage"

Table 3-4 Source Filter Selection for 10X, 20X, and 40X Lenses, by X-ray Source

Transmission @ 80 kV (90 kV X-ray Source)	Transmission @ 140 kV (150 kV X-ray Source)	Source Filter
> 0.63	–	No Filter
0.44 – 0.63	–	LE #1
0.34 – 0.44	–	LE #2
0.28 – 0.34	–	LE #3
0.21 – 0.28	–	LE #4
0.14 – 0.21	–	LE #5
0.08 – 0.14	–	LE #6
–	0.18 – 0.30	HE #1
–	0.08 – 0.18	HE #2
–	0.06 – 0.08	HE #3
–	0.04 – 0.06	HE #4
–	0.03 – 0.04	HE #5
–	< 0.03	HE #6

Table 3-5 Source Filter Selection for Macro, 1X, 2X, and 4X Lenses, by X-ray Source

Transmission @ 80 kV (90 kV X-ray Source)	Transmission @ 140 kV (150 kV X-ray Source)	Source Filter
> 0.740	–	No Filter
0.58 – 0.74	–	LE #1
0.46 – 0.58	–	LE #2
0.36 – 0.46	–	LE #3
0.28 – 0.36	–	LE #4
0.20 – 0.28	–	LE #5
0.12 – 0.20	–	LE #6
–	0.20 – 0.32	HE #1
–	0.12 – 0.20	HE #2
–	0.08 – 0.12	HE #3
–	0.05 – 0.08	HE #4
–	0.03 – 0.05	HE #5
–	< 0.03	HE #6

Installing the Selected Source Filter

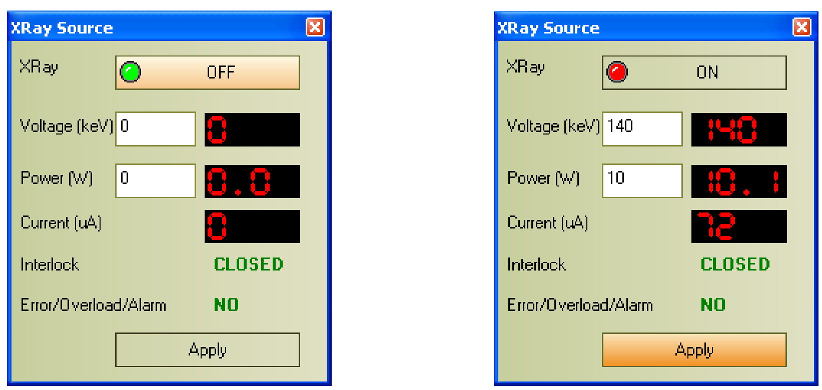
This process describes how to manually install the source filter selected in "Selecting the Source Filter."

NOTE If "Selecting the Source Filter," step 7, indicated that a source filter is not needed, proceed directly to "Determining the Optimum X-ray Source Voltage."

To install the selected filter

1. If the **Xray Source** dialog box is not already open from a previous process, click  in the icon bar.
2. In the **Xray Source** dialog box, click the **Xray** button (**red ON**), to turn OFF the X-ray source. The button label changes to **green OFF**, the **red** light on the light tower turns OFF, and the **red** dialog box values automatically change to 0.

Figure 3-14 **XRay Source** Dialog Box – X-Ray Source OFF and ON (150 kV Source Shown for "ON")



X-ray Source is turned OFF   X-ray Source is turned ON

3. Open the access door.

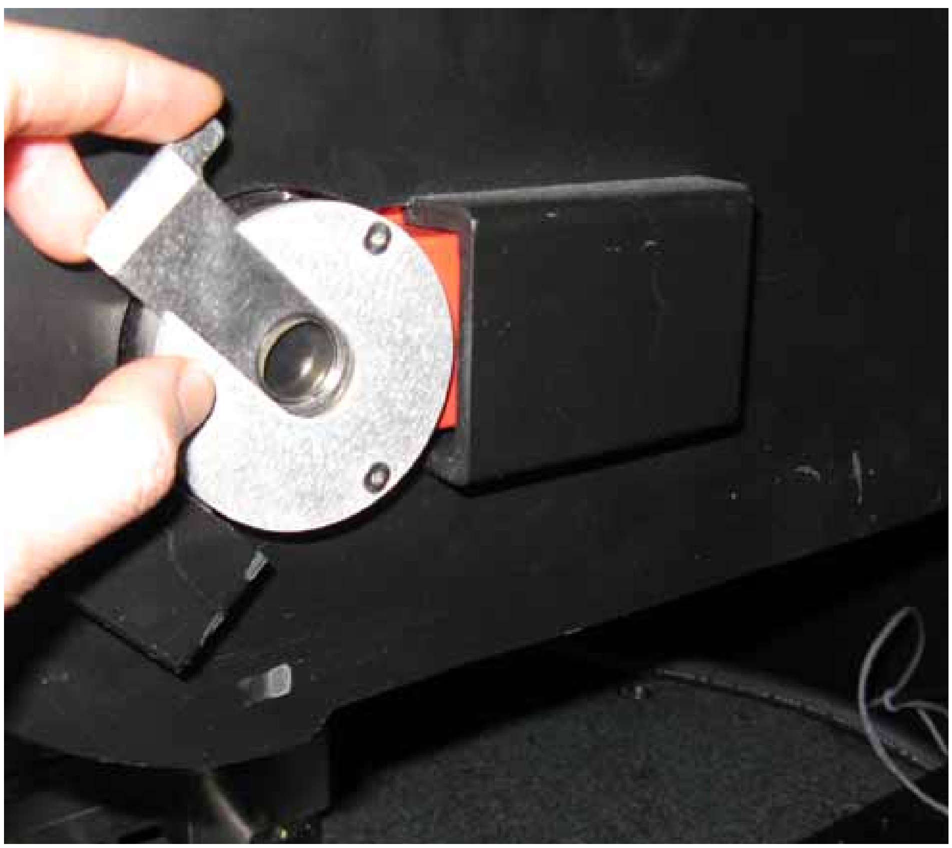
4. Follow steps a and b to install the source filter selected in "Selecting the Source Filter," step 7.

   a. Holding the metal tab at the top of the source filter and taking care not to touch the filter, gently slide the filter into the source filter holder, at the front of the X-ray source, with the thickest part of the filter facing outward, toward the sample. (Refer to Figure 3-15 for handling and placement.)

   b. Ensure that the lower edge of the source filter is firmly seated in the source filter holder.

CAUTION The sample might be very close to the X-ray source at this point. Take care not to scratch the source filter when installing.

Figure 3-15 Source Filter Installation (150 kV X-ray Source Shown)



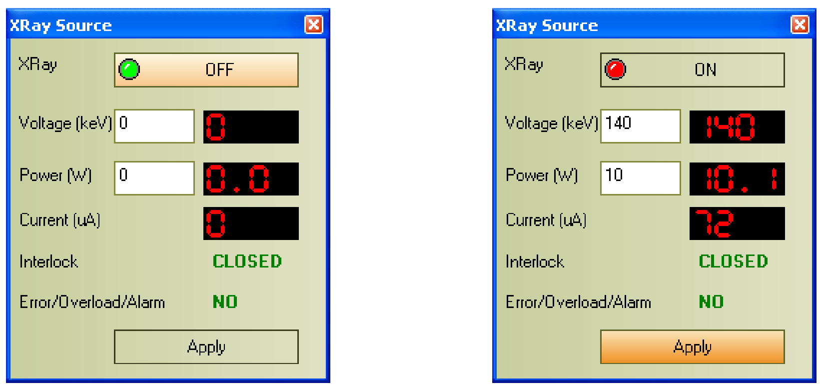
5. Close the access door.

NOTE If you can see yourself on the visual light camera monitor, the access door(s) is (are) still open.

6. In the **XRay Source** dialog box, click the **Xray** button (green **OFF**), to turn ON the X-ray source. The button label changes to **red** **ON**, the **red** light on the light tower turns ON, and the **red** dialog box values automatically change to the previously set voltage and power values. The **green** and **yellow** lights on the light tower remain ON.

   Proceed to “Determining the Optimum X-ray Source Voltage.”

Figure 3-16 **XRay Source** Dialog Box – X-Ray Source OFF and ON (150 kV Source Shown for “ON”)



X-ray Source is turned OFF | X-ray Source is turned ON

Determining the Optimum X-ray Source Voltage

This process describes how to determine the modified transmission value after installing a source filter, and identify which X-ray source voltage to use, to acquire images with minimal beam-hardening artifacts.

NOTE If a source filter is not required, the initial transmission value is already known from "Selecting the Source Filter," step 7. Proceed directly to step 6 of this process, to adjust the X-ray source voltage to achieve the ideal transmission value.

To determine the optimum X-ray source voltage

1. In the **Sample X** panel of the **Motion Controller** dialog box **Sample** tab, type the *Sample X position* previously noted in "Selecting the Source Filter," step 3, in the **Sample X** text box, then click **GO**.

NOTE If you applied a Sample Theta angle other than 0° in "Selecting the Source Filter," step 5, rotate Sample Theta to that angle **before** moving Sample X to the value noted in "Selecting the Source Filter," step 3.

2. **Image with sample** – Follow steps a through c to take a single image, with the sample in the FOV:

    a. Click  in the icon bar. A new **Image** window opens after the acquisition is complete.

    b. **If the image is too dark, with light intensity counts of less than 500** – In the **XRay Source** dialog box, type the *maximum power value* (*8* for the 90 kV X-ray source; *10* for the 150 kV X-ray source) in the **Power (W)** text box, click **Apply**, then click  in the icon bar to acquire another single image. If the image is still too dark, increase the exposure time to *2 times (2x) the current value* in the **Acquisition Setting** dialog box for Single acquisition mode, then click **Start Acquisition**. A new **Image** window opens after the acquisition is complete.

    c. Note the *image name* in the top left corner of the final **Image** window's title bar. This value is used later, as *Input a* in step 4c.

3. **Image without sample** – Follow steps a through d to take a single image, with the sample out of the FOV:

   a. In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, ensure that the current Sample Theta position is **0 deg**. If not, type *0* in the **Sample Theta** text box, then click **GO** to rotate Sample Theta to 0°.

   b. Move the sample out of the FOV. In the **Sample X** panel of the **Motion Controller** dialog box **Sample** tab, type *60,000* in the **Sample X** text box, then click **GO**.

   c. Click  in the icon bar. A new **Image** window opens after the acquisition is complete.

   d. Note the *image name* in the top left corner of the final **Image** window's title bar. This value is used later, as *Input b* in step 4d.

4. Follow steps a through f to determine the transmission value:

   a. Select **Process > Image Calculator**. The **Calculator** dialog box opens. (Refer to Figure 3-11.)

   b. Select *a/b* operation.

   c. Select the *image acquired in step 2* ("image with sample," using the *image name noted in step 2c*), from the **Input a** drop-down list box.

   d. Select the *image acquired in step 3* ("image without sample," using the *image name noted in step 3d*), from the **Input b** drop-down list box.

NOTE The window name that appears in the **Window Name** text box is automatically derived, based upon the selected operation. You can leave it as is, or rename it.

   e. Click **Calculate**. The **Choose Output Format** dialog box opens.

   f. Click **OK** to select the *Float* output datatype (default). An **Imagex_Div** window opens, with the transmission value indicated in **blue** (lower left status bar of the window), on a scale of 0 to 1.

NOTE The ideal transmission value should be between 0.23 and 0.35.

NOTE If the transmission value is greater than 1, you divided the blank image by the sample image. Repeat steps 4c through 4f to divide the sample image by the blank image.

5. If the transmission value is not within the specified range, use the processes described in the following table to adjust the value (refer to Table 3-6 for the minimum and maximum voltage values, by X-ray source).

Transmission Value	Process
< 0.23	In the **XRay Source** dialog box, type an *increased source voltage value* (for example, in steps of 20 kV) in the **Voltage (kV)** text box, click **Apply**, then repeat steps 1 through 4.
> 0.35	In the **XRay Source** dialog box, type a *reduced source voltage value* (for example, in steps of 20 kV) in the **Voltage (kV)** text box, click **Apply**, then repeat steps 1 through 4.

NOTE If you have repeated step 5 several times, and the transmission value still does not fall within the specified range, proceed directly to "Determining the X-ray Source Power and Exposure Time."

Table 3-6 Minimum and Maximum Voltage, by X-ray Source

X-ray Source	Voltage (kV)	
	Minimum	Maximum
90 kV	20	90
150 kV	40	150

6. At this point, there are many open **Image** windows within the **XMController** main window. Select **Window > Close All…**, then click **No to All** to **not** save any of the images and to close all the open **Image** windows.

Proceed to "Determining the X-ray Source Power and Exposure Time."

Determining the X-ray Source Power and Exposure Time

This process describes how to adjust the X-ray source power and exposure time used, to achieve the optimum light intensity counts per projection image.

To determine the source power and exposure time

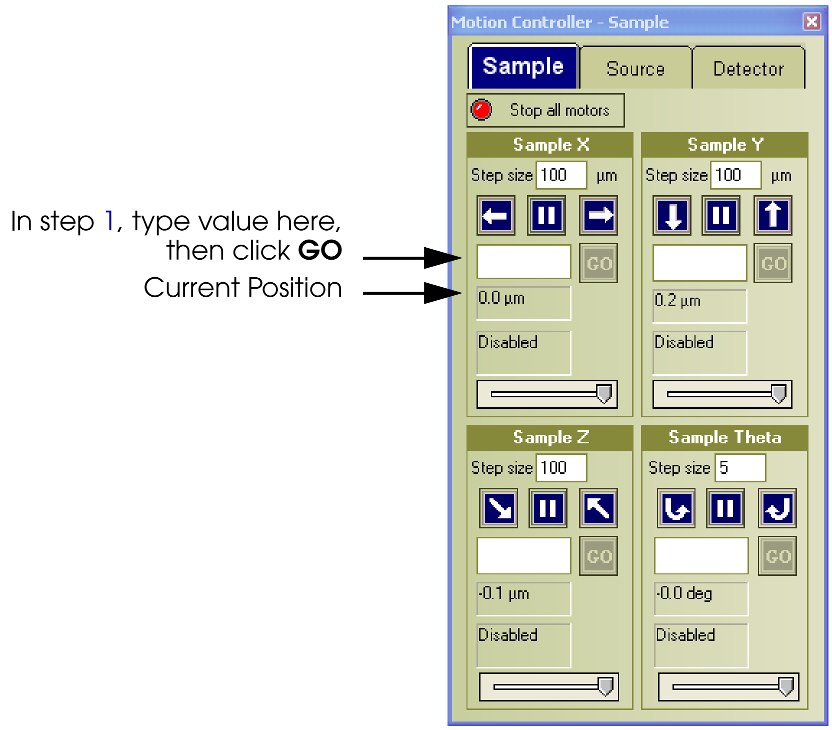
1. In the **Sample X** panel of the **Motion Controller** dialog box **Sample** tab, type the *Sample X position* previously noted in "Selecting the Source Filter," step 3, in the **Sample X** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE If you applied a Sample Theta angle other than 0° in "Selecting the Source Filter," step 5, rotate Sample Theta to that angle **after** moving Sample X to the value noted in "Selecting the Source Filter," step 3.

NOTE Step 1 is also referenced as part of the multi-tomography point collection process, documented in Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)." If collecting multi-tomography points, type the *Sample X position previously noted* in "Selecting Additional Tomography Points, Using Continuous Imaging," step 8, on page 108, in the **Sample X** text box instead, then click **GO**.

Figure 3-17 **Motion Controller** Dialog Box – **Sample** Tab



2. Use the processes described in the following table to set the *power*.

Magnification Lens	Process
10X, 20X, and 40X	In the **XRay Source** dialog box, type *4* in the **Power (W)** text box, then click **Apply**. Ensure that **Current** remains at a value that is less than or equal to 100 µA.
Macro, 1X, 2X, and 4X	In the **XRay Source** dialog box, type the *maximum power value* (*8* for the 90 kV source; *10* for the 150 kV source) in the **Power (W)** text box, then click **Apply**.

3. Follow steps a through c to adjust the exposure time, to acquire at least 5,000 light intensity counts, but no more than 30,000. Note the required exposure time to achieve a sufficient quantity of counts within this range.

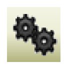
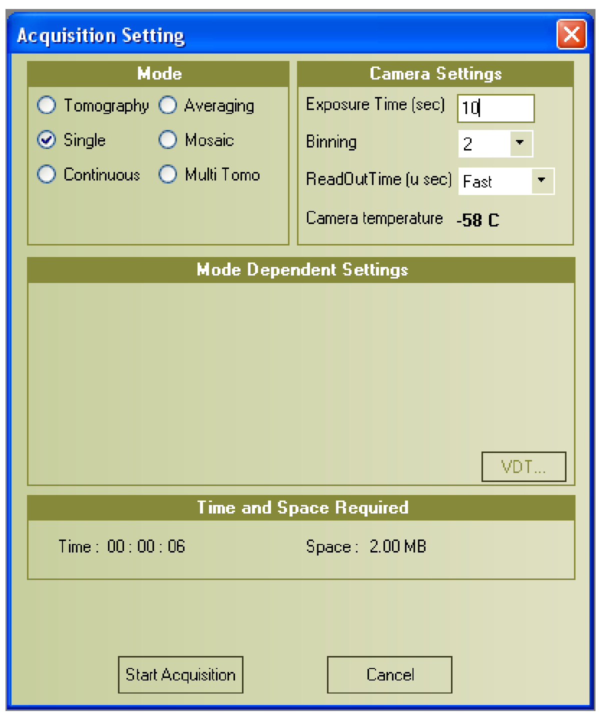
   a. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 3-18 **Acquisition Setting** Dialog Box – Settings Applied for Single Acquisition Mode



b. Select and/or type the ***acquisition setting values***:

Option	Setting Value
Mode	*Single*
Exposure Time (sec)	*10*
Binning	*2*
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

c. Click **Start Acquisition** to acquire the image. An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click  in the icon bar, then repeat steps 3a through 3c with different settings.

The **Acquisition Status** message box closes when acquisition is complete, or when you click  in the icon bar to abort imaging.

4. If the light intensity counts are not at least 1,000, or are significantly higher than 5,000, at the region of interest, repeat step 3, adjusting the exposure time, as needed, to be as close to 5,000 counts as possible. For example, if the number of light intensity counts is 10,000 and the exposure time is 10 seconds, reducing the exposure time to 5 seconds decreases the number of counts to 5,000.

NOTE Ideally, light intensity counts at the region of interest should be higher than 5,000, but less than 30,000; however, anything greater than 1,000 is acceptable.

The last image acquired is used in "Recording the First Selected Tomography Point (Region of Interest)," on page 103.

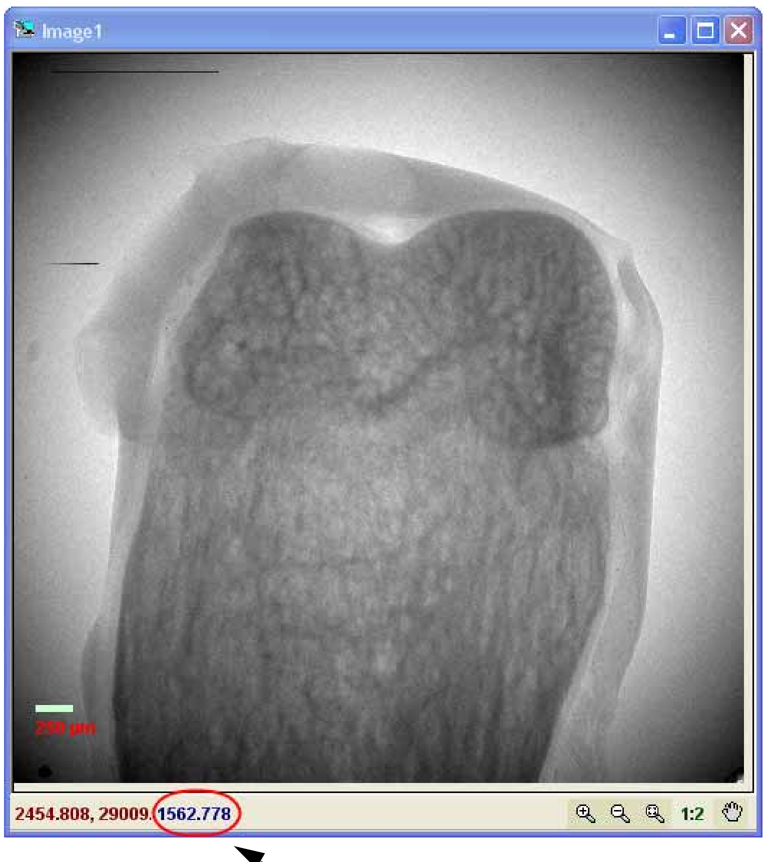
5. Note the exposure time required. This value is used later, as input to acquiring the tomography dataset in Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)," and Chapter 5, "Manually Acquiring Images and Tomographic Data."

6. In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *0* in the **Sample Theta text** box, then click **GO** to rotate Sample Theta to 0°.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE There is no upper limit to the length of exposure time; however, it should be more than 0.2 seconds. If the exposure time has been reduced to the minimum, and the intensity is still to high, reduce the *Source power value*, by way of the **Xray Source** dialog box.

Figure 3-19 **Image** Window Showing Light Intensity Count



Light intensity count

After you have located a point with the appropriate X-ray source and detector positions, source filter (if needed), source voltage (kV) and power (W), and exposure time, proceed to the next process:

– If you want to automatically acquire tomography of that point with a recipe, record the point, and set up the recipe, proceed to Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)"

– If you want to acquire tomography of that point, by manually collecting a 3D (tomography) dataset, proceed to Chapter 5, "Manually Acquiring Images and Tomographic Data"

– If you want to continue to collect points, to be automatically imaged with a recipe, proceed to Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)"

4 Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)

This chapter describes how to use XMController to record the tomography point selected in Chapter 3, select the remaining tomography points for tomography datasets, and run an automatic recipe. Recipes are used to automatically collect and reconstruct tomographic data. This is useful for repeated scanning of common areas on many samples, or of several areas on a single sample. The end result is a ready-to-load, 3D reconstructed volume of the region(s) of interest.

CAUTION Troubleshooting tips regarding imminent collision appear throughout this chapter. For more complete troubleshooting tips regarding imminent collision, as well as for collision, refer to "Troubleshooting Sample Issues in XMController," on page 210.

NOTE The process for selecting the first tomography point is described in Chapter 3, "Selecting the First Tomography Point." If you have not yet collected the first tomography point, proceed directly to Chapter 3, "Selecting the First Tomography Point."

NOTE If you need to manually acquire and reconstruct images, refer to Chapter 5, "Manually Acquiring Images and Tomographic Data," and Chapter 6, "Manually Reconstructing a 3D Dataset," respectively.

Process Overview

The process of automatically acquiring additional data and reconstructing tomography point(s) is comprised of the following subprocesses:

1. Recording the First Selected Tomography Point (Region of Interest).
2. Selecting Additional Tomography Points, Using Continuous Imaging.
3. Setting up a Recipe.
   – Tour of the Recipe Dialog Box
   – Opening the Recipe Dialog Box and Editing Collected Points
4. Setting Acquisition and Reconstruction Parameters.
5. Running a Recipe.

Each is described in the sections that follow.

Recording the First Selected Tomography Point (Region of Interest)

This process describes how to record the first tomography point that you identified in Chapter 3, "Selecting the First Tomography Point." This tomography point is used later, by the recipe, and appears first in the **Recipe** dialog box's **Tomography Locations** panel.

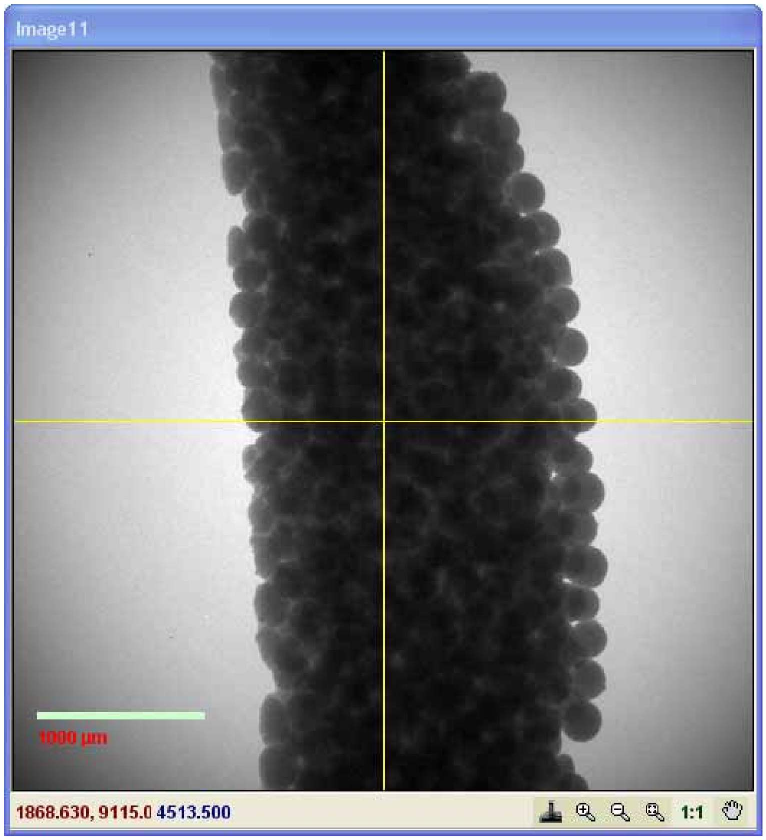
NOTE Use of this tomography point and the **Tomography Locations** panel is described later, in "Opening the Recipe Dialog Box and Editing Collected Points."

To record the first acquired tomography point

1. Click the ***Image window*** of the last "image with sample" acquired in "Determining the X-ray Source Power and Exposure Time," step 4, on page 98, to make it the active window (that is, bring it to the front of any other open windows).

2. Select **View > Highlight Center of FOV**. Yellow cross-hairs highlighting the center of the FOV are added to the current **Image** window.

Figure 4-1 Example **Image** Window, with **Yellow** Cross-Hairs Added



3. Click  in the icon bar. The **Image Controls** dialog box opens.

NOTE If  is highlighted **orange** in the icon bar, the **Image Controls** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted **orange** icon, then click the non-highlighted icon, as described above.

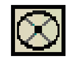
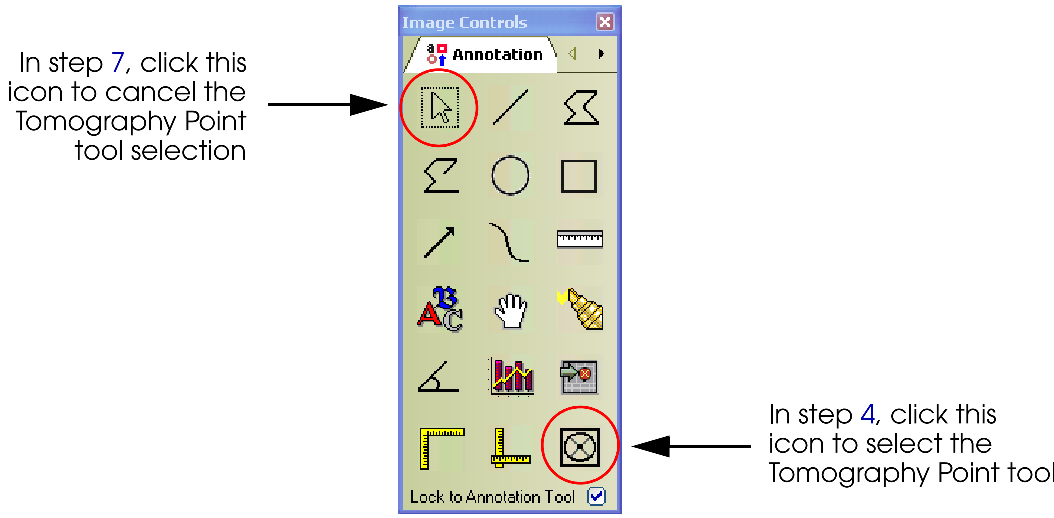
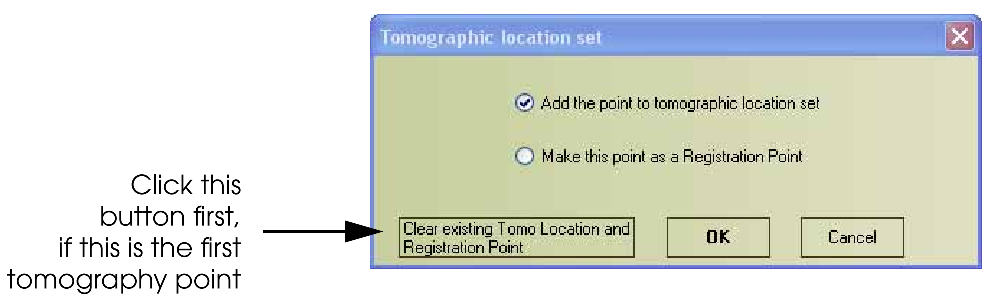
4. Select the **Annotation** tab, then click  to access the Tomography Point tool.

Figure 4-2 **Image Controls** Dialog Box – **Annotation** Tab



5. Click the center of the **Image** window, at the intersection of the **yellow** cross-hairs. (The **red** bounding box indicating the FOV should also be visible.) The **Tomographic location set** dialog box opens, defaulted to **Add the point to tomographic location set**.

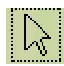
Figure 4-3 **Tomographic location set** Dialog Box



6. Use the processes described in the following table to complete this step, dependent upon whether this is the first or subsequent tomography point.

First or Subsequent Tomography Point	Process
First	Click **Clear existing Tomo Location and Registration Point**, then click **OK**. The image created will be labeled with a letter *A* (upper left corner).
Subsequent	Click **OK**. The image created will be labeled with a letter *B* for the second point, *C* for the third point, and so forth (upper left corner).

NOTE Do **not** select **Make this point as a Registration Point**.

7. In the **Annotation** tab, click  to cancel the Tomography Point tool selection for the image. (Refer to Figure 4-2.)

Proceed to the next process:

– If you need to collect additional tomography points (for the recipe that you will be running later), proceed to "Selecting Additional Tomography Points, Using Continuous Imaging"

– If you do not need to collect additional tomography points, proceed to "Setting up a Recipe"

Selecting Additional Tomography Points, Using Continuous Imaging

This process describes how to use Continuous acquisition mode to select additional tomography points, when you need to collect tomography data for more than one point.

NOTE If you need to generate tomography on a single point only, proceed directly to "Setting up a Recipe."

NOTE If you are just beginning to use the MicroXCT, it is recommended that you try running a few recipes with a single tomography point, to familiarize yourself with the overall process. To do this, proceed directly to "Setting up a Recipe," run a few practice recipes, then return to this process when you are ready to run recipes with multiple points.

NOTE Because most of the process steps for this process are described earlier in the guide, they are cross-referenced, rather than repeated.

To select additional tomography points, using continuous imaging

1. Open the **Motion Controller** dialog box, if it is not already open, by clicking  in the icon bar. The dialog box opens, defaulted to the **Sample** tab.

NOTE If  is highlighted orange in the icon bar, the **Motion Controller** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted orange icon, then click the non-highlighted icon, as described above.

2. Follow steps a and b to move the detector and X-ray source, respectively, away from the sample stage, to ensure that they do not collide with nor touch the sample:

   a. Select the **Motion Controller** dialog box **Detector** tab, type a *value that is 20 mm greater than the current Camera Z position* in the **Camera Z** text box, then click **GO**.

   b. Select the **Motion Controller** dialog box **Source** tab, type *-130* in the **Source Z** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

3. Click the drop-down arrow to the right of  in the icon bar, then select the *lowest magnification*.

NOTE Instructions for selecting the lowest magnification are provided in "Selecting the Lowest Magnification," on page 51.

4. Click  in the icon bar to start Continuous acquisition mode, using the same *exposure time* and *binning* values used when the first tomography point was collected, as described in "Collecting Continuous Images," steps 1 and 2, starting on page 63.

5. Identify an additional single point, using the same process described in "Identifying the First Point," on page 67.

6. Position the detector and X-ray source as close to the sample as possible, without collision or touching, through the tomographic angle ranges, using the same processes described in "Finely Positioning the Detector," on page 71, and "Finely Positioning the X-ray Source," on page 75, respectively.

7. In the **Motion Controller** dialog box, select the **Sample** tab. In the **Sample X** panel, note the *current Sample X position*. This value is used in the next step.

8. Determine the *optimum voltage*, using the same process described in "Determining the Optimum X-ray Source Voltage," on page 92. When finished, use the *Sample X position* noted in step 7 to move the sample back into the FOV.

9. Determine the *power settings* and note the *exposure time required*, using the same process described in "Determining the X-ray Source Power and Exposure Time," on page 95.

10. Record the *selected point identified in step 5* (*Point B* if second point, *Point C* if third point, and so forth), using the same process described in "Recording the First Selected Tomography Point (Region of Interest)."

11. Repeat steps 2 through 10 for *each additional tomography point to be acquired* (Point C, and if needed, additional points).

The tomographic point selection process is now complete. Proceed to "Setting up a Recipe."

Setting up a Recipe

This process describes how to set up a recipe, which is run to automatically collect and reconstruct tomography data, using the information and processes described in the following sections:

- Tour of the Recipe Dialog Box
- Opening the Recipe Dialog Box and Editing Collected Points

Figure 4-4 provides an overall view of the **Recipe** dialog box. Table 4-1 describes the **Recipe** dialog box panels and boxes – what information you must supply and what is automatically entered.

Tour of the Recipe Dialog Box

This section describes the **Recipe** dialog box. The **Recipe** dialog box has several panels, some of which are automatically filled in, and others that require manual text entry. The two most important dialog box panels for recipe generation are:

– **Navigation** – Contains settings specific to each tomographic point

– **Tomography Locations** – Contains points where tomographies will be acquired

Figure 4-4 provides a view of the **Recipe** dialog box. Table 4-1 briefly describes the dialog box's panels, each panel's function, and whether the information is automatically or manually entered/selected.

Figure 4-4 **Recipe** Dialog Box – Navigation and Tomography Locations Panels Highlighted

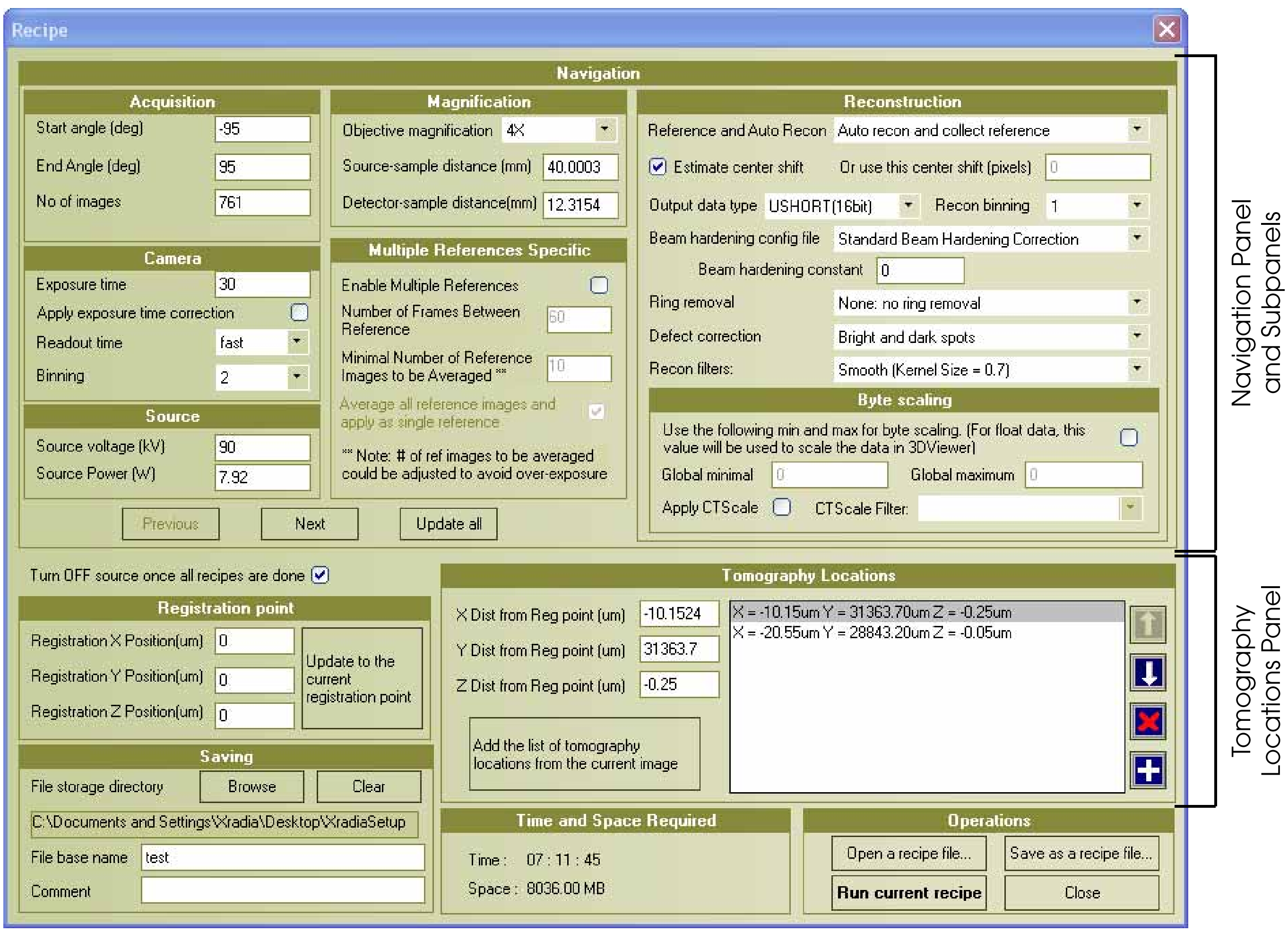


Table 4-1 **Recipe** Dialog Box – Panel and Subpanel Descriptions

<table>
<tr><th rowspan="2">Panel</th><th rowspan="2">Subpanel of</th><th colspan="2">Data Entry Method</th><th rowspan="2">Description</th></tr>
<tr><th>Automatic</th><th>Manual</th></tr>
<tr><td>Acquisition</td><td rowspan="6">Navigation</td><td>✓</td><td>✓</td><td>Defines the starting and ending angles, and number of 2D images (projections) to be acquired per tomography point.[a]</td></tr>
<tr><td>Camera</td><td></td><td>✓</td><td>Defines the exposure time required per projection, and the binning value. Leave Readout time as Fast. Select Apply exposure time correction only if you are running a semiconductor sample. The standard exposure time table will increase the exposure time at higher angles, up to eight times (8x) its setting at 0°, at Sample Theta = ±90°.</td></tr>
<tr><td>Source</td><td>✓</td><td></td><td>Indicates the X-ray source voltage and power values. These values are automatically entered, based upon the images from which the tomography points were selected and should not be altered.</td></tr>
<tr><td>Magnification</td><td>✓</td><td></td><td>Indicates the lens magnification and Source-to-Sample and Detector-to-Sample distances. These values are also automatically entered based upon the images from which the tomography points were selected and should not be altered.</td></tr>
<tr><td>Multiple References Specific</td><td></td><td>✓</td><td>Select Enable Multiple References to acquire reference images with specific parameters during tomography. This reduces artifacts due to variations in X-ray source spot and intensity, but is unnecessary if Dynamic Ring Removal (DRR) is enabled. The process for filling in the remaining text boxes is described in “Setting Acquisition and Reconstruction Parameters,” step 6.</td></tr>
<tr><td>Reconstruction</td><td></td><td>✓</td><td>Defines reference image collection and reconstruction parameters.</td></tr>
<tr><td>Byte scaling</td><td>Navigation and Reconstruction</td><td></td><td>✓</td><td>Used to set the global minimum and maximum byte scaling value for reconstruction, when stitching is required. Also provides support for CT scaling.[b]</td></tr>
<tr><td colspan="2">Turn OFF source once all recipes are done</td><td>✓</td><td></td><td>Select to turn OFF the X-ray source after tomography for all tomography points in this recipe have been collected (default).</td></tr>
</table>

Table 4-1 **Recipe** Dialog Box – Panel and Subpanel Descriptions

Panel	Subpanel of	Data Entry Method		Description
		Automatic	Manual	
Registration point			✓	Set to 0, 0, 0 (X, Y, Z coordinates), by default. Use only for repeated samples with a well-defined fiducial[c] point; the samples must be identically mounted.[d]
Tomography Locations			✓	Lists tomography points at which tomographic data will be acquired.
Saving			✓	Specifies the location and file name for saving the output tomography dataset for this recipe.
Time and Space Required		✓		Indicates the total amount of time and hard disk drive space required for all the tomography points in this recipe.
Operations			✓	Select the next action to be taken – **Open**, **Save**, **Run the current recipe**, or **Close**.

a. Start and end angles are automatically calculated for a range of 180° plus fan angle. The angles must be manually entered for tomographic angle ranges of -180 to +180 for MicroXCT that are 360°-enabled. Instructions for determining whether the MicroXCT is 360°-enabled are provided in Appendix F, “Determining Whether the MicroXCT is 360°-Enabled.”
b. Refer to *CT Scaling Instructions* (G000135), included with the MicroXCT product documentation, for details related to CT scaling.
c. Fixed basis of reference or comparison.
d. Sample mounting options are discussed in “Mounting the Sample in/on a Sample Holder,” on page 33.

Opening the Recipe Dialog Box and Editing Collected Points

This process describes how to set up the recipe. When the recipe is run, data is collected from the previously selected and recorded tomography points.

NOTE This process assumes that you still have the **Image** window(s) open from the "Recording the First Selected Tomography Point (Region of Interest)" and "Selecting Additional Tomography Points, Using Continuous Imaging" processes.

To open the recipe dialog box and edit the collected points

1. Open the **XRay Source** dialog box, using one of the following methods:

   – Select **Microscope > Source Controller...**

   – Click  in the icon bar

NOTE If  is highlighted orange in the icon bar, the **Xray Source** dialog box is already open.

2. Ensure that the X-ray source has been turned ON for more than 15 minutes.

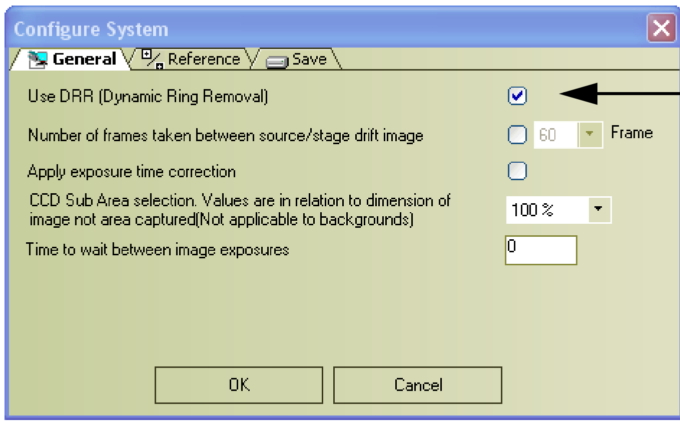
NOTE 15 minutes is the minimum warm-up period, if the X-ray source has been turned OFF for more than 15 minutes, for optimal X-ray source stability during scans.

NOTE The X-ray source should already be at the correct voltage and power settings for the selected sample, after completing the setup processes described in in Chapter 2, "Setting Up for Data Acquisition," and Chapter 3, "Selecting the First Tomography Point."

3. Follow steps a through c to enable DRR, so that the reconstructed images will be free of ring artifacts:

   a. Select **Microscope > Configure System**. The **Configure System** dialog box opens, defaulted to the **General** tab.

Figure 4-5 **Configure System** Dialog Box – **General** Tab, with **Use DRR** Selected



In step 3b, select this option to enable DRR

   b. Select **Use DRR (Dynamic Ring Removal)**.

   c. Click **OK**.

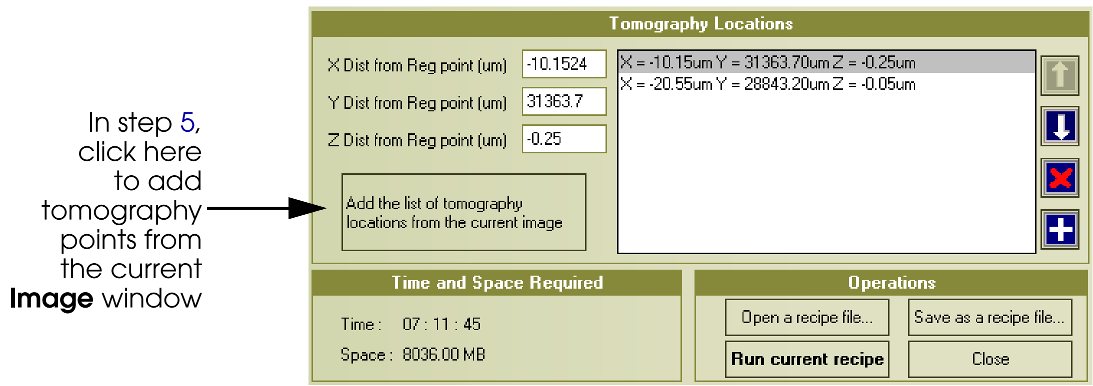
4. Open the **Recipe** dialog box (refer to Figure 4-4), using one of the following methods:

   – Select **Microscope > Recipes**...

   – Click  in the icon bar

5. In the **Tomography Locations** panel, click **Add the list of tomography locations from the current images**. The tomography points selected earlier are added to the panel.

Figure 4-6 **Recipe** Dialog Box – **Tomography Locations** Panel, with Previously Selected Tomography Points Added



6. You can manipulate the listed tomography points, using the information provided in Table 4-2.

   Entering/editing of the tomography locations is complete.
   Proceed to "Setting Acquisition and Reconstruction Parameters."

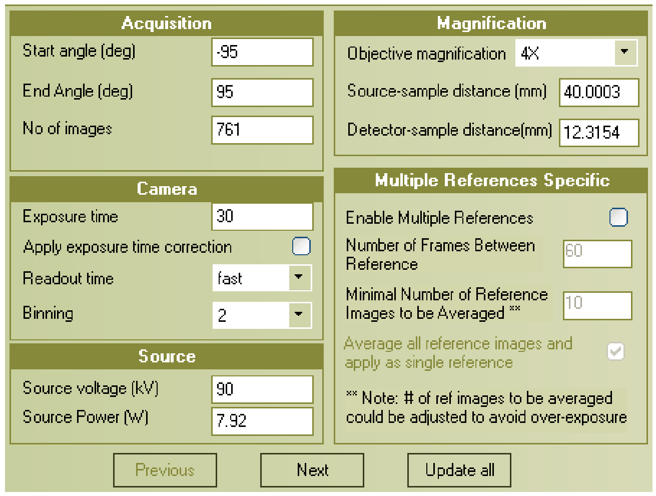
Table 4-2 Tomography Locations Panel (Icon) Buttons

Button	Function	Process
	Move UP	Select the *tomography point*, then click to move the point UP in the list.
	Move DOWN	Select the *tomography point*, then click to move the point DOWN in the list.
	Delete	Select the *tomography point*, then click to remove the point from the list.
	Add	Click to add a 0, 0, 0 (X, Y, Z) tomography point to the list. Change the point's location, by editing the X, Y, and Z coordinates in the **X/Y/Z Dist. from Reg Point (um)** text boxes (left side of panel).

Setting Acquisition and Reconstruction Parameters

This process provides the opportunity to enter information in the **Recipe** dialog box that is not automatically filled in by XMController in the **Acquisition**, **Camera**, **Source**, **Magnification**, and **Multiple References Specific** panels.

Figure 4-7 **Recipe** Dialog Box – **Acquisition**, **Camera**, **Source**, **Magnification**, and **Multiple References Specific** Panels, with Buttons



To set the acquisition and reconstruction parameters, for each tomography location

1. Select the *first tomography point* listed in the **Tomography Locations** panel.

NOTE When this process is repeated, as described in step 8, select each tomography point, in turn, to alter its acquisition and reconstruction settings.

2. In the **Acquisition** panel, the start and end angles are defaulted to include the fan angle for 180° + fan angle tomography, which is required for good reconstruction of that particular tomography point. Use the processes described in the following two bullets to determine and apply the appropriate angle option:

   – **180° + fan angle tomography** – Use this setting for flat samples, such as semiconductor samples. This angle range is automatically calculated and displayed for each point. In the text box, type the *total number of images* to collect. It is recommended to acquire *at least two per degree*. Calculate the number of images to collect as:

   *((End Angle - Start Angle) * n) +1*

   where *n* = number of images per degree

   – **360° tomography** – Set **Start angle** = *-180*

   Set **End angle** = *180 - 1/n*

   Set **No. of Image** = *(360 * n) +1*

   where *n* = number of images per degree

3. In the **Camera** panel, select and/or type the following *camera setting values*:

Option	Setting Value
Exposure Time	*Type the exposure time noted for each point previously collected in "Determining the X-ray Source Power and Exposure Time," step 3, on page 97*
Apply exposure time correction	*Do not select*
Readout Time	*Fast* (default)
Binning	*2*

NOTE If the binning value is 1 (instead of 2), use an exposure time that is four times (4x) the values noted for each point previously collected during the single- and multiple-point "Recording the First Selected Tomography Point (Region of Interest)" processes.

4. In the **Source** panel, the **Source Voltage** and **Power** values are already set. **Do not change these values.**

5. In the **Magnification** panel, the **Source-sample distance** and the **Detector-sample distance** are already set. **Do not change these values.**

6. In the **Multiple References Specific** panel, select and/or type the following *setting values*:

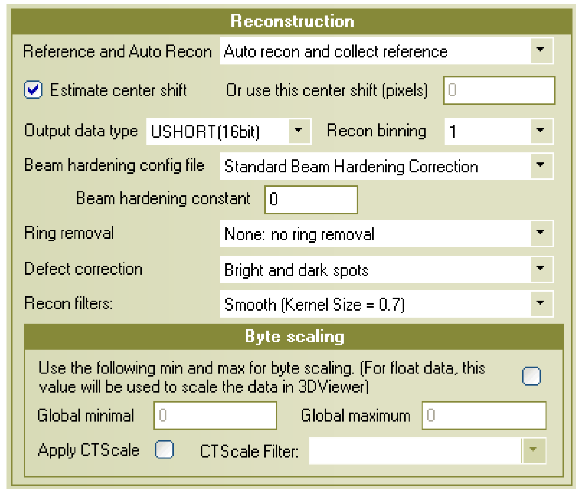
Option	Setting Value
Enable Multiple References	*Select, if you need to acquire multiple reference images*
Number of Frames Between Reference	*100*
Minimal Number of Reference Images to be Averaged	*10*
Average all reference images and apply as single reference	*Select*

NOTE If **Enable Multiple References** is not selected, but **Collect Reference** is selected in the **Reconstruction** panel, an averaged reference of 10 images will be acquired at the beginning of the recipe's data acquisition.

NOTE If the sample is too large and cannot be automatically moved out of the FOV, do **not** enable Multiple References.

7. Follow steps a through g to specify the **Reconstruction** panel settings (upper right corner of the dialog box):

Figure 4-8 **Recipe** Dialog Box – **Reconstruction** Panel and **Byte Scaling** Subpanel



a. Select one of the following *options* from the **Reference and Auto Recon** drop-down list box:

Option	Usage
Auto recon and collect reference	Use this option only if the sample will not collide with nor touch the detector and X-ray source between Sample Theta at -10° and +170°. Automatically reconstructs and collects the reference image for this tomography point.
Collect reference but no auto recon	Use this option if the sample will collide with the detector and X-ray source, between Sample Theta at -10° and +170°. Collects the reference image for this tomography point, but does not automatically reconstruct the dataset.
Do not auto recon or collect reference	Use this option if the sample is too large to automatically move out of the FOV. Collects only the projections for this tomography point. You must later remove the sample from the FOV and manually collect the reference image, per processes described in "Collecting a Reference Image," on page 143.

b. **Estimate center shift** is selected only if **Auto recon and collect reference** is also selected. The MicroXCT takes two projection images of the sample, one at Sample Theta = -10° and Sample Theta = +170°, to estimate the center shift before acquiring the tomography dataset.

NOTE If the center shift is known (rarely), type the *center shift value* in the **Or use this center shift (pixels)** text box, then cancel the **Estimate center shift** selection.

c. Select and/or type the following *reconstruction setting values*:

Option	Setting Value
Output data type	*USHORT(16bit)* (default) Provides grayscale over a range of 0 to 65,535.
Recon binning	*1* (default; recommended)
Beam hardening config file	*Standard Beam Hardening Correction* (default)
Beam hardening constant	*If the beam hardening correction constant is known for the sample (rarely, unless similar samples have been run before), type its value, to be used in auto-reconstruction*

d. Select one of the following *options* from the **Ring removal** drop-down list box:

Option	Usage
None: No Ring Removal	Use this option if DRR is enabled.
Low contrast – 8-section RR	Use this option if DRR is disabled, for bone, rock, plastic, carbon composite, or composite material samples.
High contrast – 3-section RR	Use this option if DRR is disabled, for high-contrast samples, such as semiconductors.

NOTE 3-section ring removal is known to sometimes add rings when there are regularly repeating high-contrast features.

e. Select one of the following *options* from the **Defect correction** drop-down list box:

Option	Usage
Bright and dark spots	Use this option if DRR is disabled, to remove both bright and dark defects on the projections. If these defects are not removed, intense rings might be observed in the reconstruction.
Bright spots only	Use this option if the **Bright and dark spots** option seems to add more artifacts than are desirable to the reconstruction.
Disable	Use this option in Version 7.*x* when DRR is enabled, to disable defect correction.

NOTE Defect calibration must be completed before the **Defect correction** options are functional. (The defect calibration process must be performed by trained Xradia personnel, and is typically done during install or during a preventive maintenance session.) If defect calibration is not completed, an error message is issued during image reconstruction.

f. Select a *software filter* from the **Recon Filters** drop-down list box. The minimum is Smooth (Kernel Size = 0.5); if unsure, start with *Smooth (Kernel Size = 0.7)*.

NOTE The **Recon Filters** value is magnification lens- and sample-dependent.

NOTE Determine which software filter value provides the most satisfactory balance between image resolution and noise (through your own experience); the correct software filter value provides for significant noise reduction, but has a minimal impact on resolution.

NOTE Do **not** use **None** nor **Sharp (Shepp-Logan)**.

g. In the **Byte Scaling** subpanel of the **Reconstruction** panel, apply byte scaling only if either of the following conditions is true:

Apply Byte Scaling When True	Process
Global minimum and maximum byte scaling values are known from a prior similar sample (scan acquired at the same settings (X-ray source power, detector and X-ray source distances, number of projections, exposure times, binning, and magnification)).	Select **Use the following min and max...**, then type the *global minimum and maximum byte scaling values* in the **Global minimum** and **Global maximum** text boxes, respectively.
Dataset is to be CT-scaled and CT scaling calibration is complete.	Select **Apply CT Scale**, then select the correct *software filter* from the **CTScale Filter** drop-down list box.

NOTE Refer to *CT Scaling Instructions* (G000135), included with the MicroXCT product documentation, for details related to CT scaling.

8. Select the next *tomography point* in the **Tomography Locations** panel, then repeat steps 2 through 7, until all parameters are set up for all tomography points.

9. Follow steps a through d to save the recipe file:

   a. Click **Save as a recipe file...** (lower right corner of the dialog box). A **Save File** dialog box opens.

   b. Browse to the *destination file path*.

   c. Type the *new file name* in the **File name** text box.

   d. Click **Save**.

Recipe acquisition and reconstruction parameter setup is complete. Proceed to "Running a Recipe."

Running a Recipe

This process describes how to run a recipe, to automatically collect and reconstruct the previously set-up tomographic data.

NOTE XMController internally calls XMReconstructor to reconstruct the dataset.

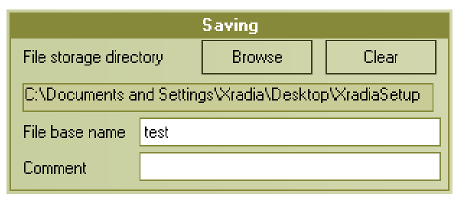
NOTE The amount of free space required on the hard disk drive must be at least 1 GB more than the file size of the tomography (projection) dataset.

To run a recipe

1. Turn OFF the interior light, by moving the visual light camera light switch (D on Figure 1-7, "Ergonomic Station," on page 16) to the DOWN (OFF) position.

2. Click **Browse** on the **Recipe** dialog box **Saving** panel (lower left corner of the dialog box), to locate the *destination file path*.

Figure 4-9 **Recipe** Dialog Box – **Saving** Panel



3. Type a *base file name* in the **File base name** text box.

NOTE XMController collects 2D images, known as projection or data files. XMReconstructor creates reconstructed images or slices from these files.

NOTE The projection file from the first tomography point has *Tomo_Area A* appended to the file name. The projection file from the second tomography point has *Tomo_Area B* appended to the file name, and so forth. The X, Y, and Z of the actual point(s) appear(s) in the **Recipe** dialog box **Tomography Locations** panel, as described in "Setting up a Recipe."

4. Click **Run current recipe** on the **Recipe** dialog box **Operations** panel, to begin running the recipe. An **Acquisition Status** message box opens (lower right corner) for each tomography point. When all data has been acquired, the **Acquisition Status** message box closes.

Figure 4-10 **Recipe** Dialog Box – **Operations** Panel

After the recipe finishes running, proceed to the next process:

- If the tomography point was automatically and successfully reconstructed (the option **Auto recon and collect reference** was selected in "Setting Acquisition and Reconstruction Parameters," step 7a), proceed to Chapter 7, "Viewing Tomographies," to open the file in XM3DViewer and view the 3D volume reconstruction
- If the center shift is incorrect, proceed to Chapter 6, "Manually Reconstructing a 3D Dataset," to manually repeat the reconstruction
- If the tomography point was not automatically reconstructed, proceed to Chapter 6, "Manually Reconstructing a 3D Dataset," to manually reconstruct the dataset

5 Manually Acquiring Images and Tomographic Data

This chapter describes how to use XMController to acquire images and tomographic data using Continuous, Single, Mosaic, Tomography, and Averaging acquisition modes, and how to create and apply a reference image.

CAUTION Troubleshooting tips regarding imminent collision appear throughout this chapter. For more complete troubleshooting tips regarding imminent collision, as well as for collision, refer to "Troubleshooting Sample Issues in XMController," on page 210.

NOTE The automatic process for acquiring and reconstructing tomographic data is described in Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)."

NOTE The processes in this chapter assume that XMController is already running. If you need to start XMController, refer to "Loading the Sample Holder Assembly onto the Sample Stage," step 1, on page 42, for instructions.

NOTE The processes within this chapter assume that the sample is loaded into the MicroXCT, and that the detector, X-ray source, and sample are properly aligned, according to the processes described in Chapter 2, "Setting Up for Data Acquisition," and Chapter 3, "Selecting the First Tomography Point."

Process Overview

The process of manually acquiring images and tomographic data is comprised of the following subprocesses:

1. Acquiring Images.
   - Collecting Continuous Images
   - Collecting a Single 2D Image
   - Collecting a Mosaic Image
   - Manually Collecting a 3D (Tomography) Dataset
   - Collecting a Reference Image
2. Applying the Reference Image.

Each is described in the sections that follow.

Acquiring Images

After the sample is installed and the X-ray source is turned ON (described in Chapter 2, “Setting Up for Data Acquisition”), you can use XMController to manually acquire images.

The following processes are used for acquiring images:

- Collecting Continuous Images
- Collecting a Single 2D Image
- Collecting a Mosaic Image
- Manually Collecting a 3D (Tomography) Dataset
- Collecting a Reference Image

Each is described in the sections that follow.

Collecting Continuous Images

This process describes how to locate the region of interest in a sample, and to move the region of interest to the center of the FOV by double-clicking.

Double-clicking to move the sample is allowed only in Continuous acquisition mode. For description of how this is used in positioning the sample, refer to "Identifying the First Point," on page 67.

To collect continuous images

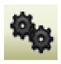
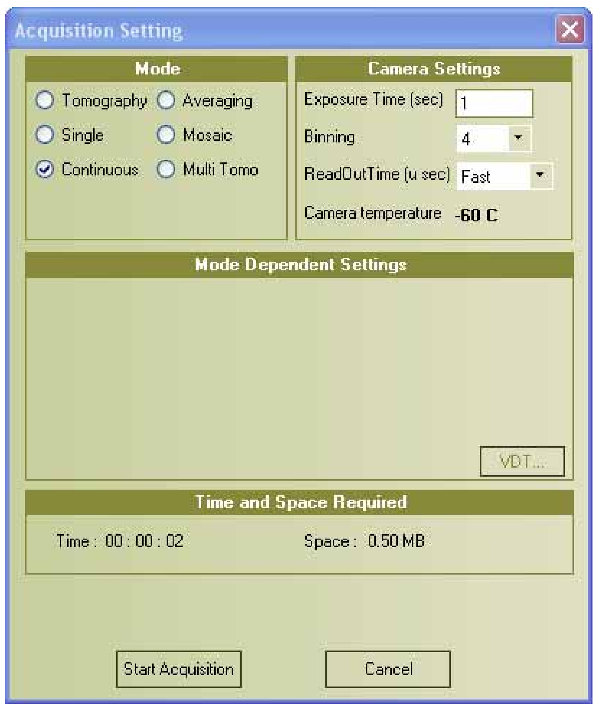
1. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 5-1 **Acquisition Setting** Dialog Box – Settings Applied for Continuous Acquisition Mode



2. Select and/or type the *acquisition setting values*:

Option	Setting Value
Mode	*Continuous*
Exposure Time (sec)	*1*
Binning	*4*
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

3. Click **Start Acquisition** to acquire the image. An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click  in the icon bar, then repeat steps 1 through 3 with a different value for exposure time. The minimum value that should be used for exposure time is 0.2 seconds.

The **Acquisition Status** message box closes when you click  in the icon bar to abort continuous imaging.

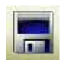
NOTE To continue collecting images using the same acquisition setting values, click  in the icon bar. If you need to specify an exposure time other than 1 second or binning other than 4, change the values in the **Acquisition Setting** dialog box.

NOTE If image contrast and/or brightness requires adjustment, refer to the troubleshooting tips referenced in "Troubleshooting Image Contrast, Brightness, and Light Intensity Count Issues," on page 226.

4. Because continuous imaging is typically used only for sample positioning, these images are not typically saved.

   Follow steps a through e if you want to save the images after acquisition is complete:

   a. If you collected more than one set of continuous images, click the ***Image*** *window of an image you want to save*.

   b. Click  in the icon bar. The **Save File** dialog box opens.

   c. Browse to the *destination file path*.

   d. Type the *new file name* in the **File name** text box.

   e. Click **Save**.

   Repeat steps a through e for each continuous image to be saved.

   Proceed to the next process, depending upon what needs to be done next:

   – If you need to determine the most ideal settings for a particular sample, proceed to “Collecting a Single 2D Image”

   – If you need to view an overview of the sample, proceed to “Collecting a Mosaic Image”

   – If you need to create a 3D volume dataset, to be manually reconstructed later to create a 3D reconstructed volume, proceed to “Manually Collecting a 3D (Tomography) Dataset”

Collecting a Single 2D Image

This process describes how to collect a single image, using Single acquisition mode, which can be used to determine the most ideal settings for a particular sample.

To collect a single 2D image

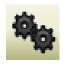
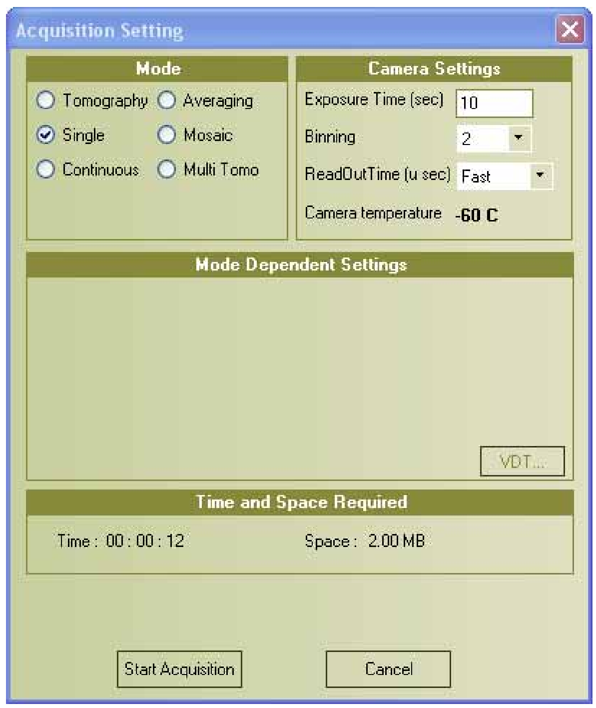
1. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 5-2 **Acquisition Setting** Dialog Box – Settings Applied for Single Acquisition Mode



2. Select and/or type the *acquisition setting values*:

Option	Setting Value
Mode	*Single*
Exposure Time (sec)	*10*
Binning	*2*
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

3. Click **Start Acquisition** to acquire the image. An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. The acquisition will complete after the required exposure time, or you can click 

in the icon bar to stop acquisition before completion.

The **Acquisition Status** message box closes when acquisition is complete, or when you click 

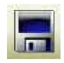
in the icon bar to abort imaging.

NOTE To collect another image using the same acquisition setting values, click  in the icon bar. If you need to specify an exposure time other than 10 seconds or binning other than 2, change the values in the **Acquisition Setting** dialog box.

NOTE If image contrast and/or brightness requires adjustment, refer to the troubleshooting tips referenced in "Troubleshooting Image Contrast, Brightness, and Light Intensity Count Issues," on page 226.

4. After acquisition is complete, follow steps a through e to save the image:

    a. If you collected more than one single image, click the ***Image** window of the image you want to save*.

    b. Click  in the icon bar. The **Save File** dialog box opens.

    c. Browse to the *destination file path*.

    d. Type the *new file name* in the **File name** text box.

    e. Click **Save**.

    Repeat steps a through e for each single image to be saved.

    Proceed to "Collecting a Reference Image."

NOTE When acquiring a reference image, the exposure time, detector and X-ray source positions, camera binning, and X-ray voltage and power settings should match the settings used for the actual tomography, or other images collected with different acquisition modes. Take note of the above settings, before proceeding to "Collecting a Reference Image."

Collecting a Mosaic Image

This process describes how to collect a mosaic image, using Mosaic acquisition mode. A mosaic is one large image that is created by scanning the sample, and then tiling the individual images acquired at each scanned X, Y location, to provide an overview of the sample.

NOTE A mosaic can only be collected when Sample Theta = 0°. In a future release, a mosaic can be collected at Sample Theta = ±90° as well.

To collect a mosaic image

1. Click  in the icon bar to open the **Motion Controller** dialog box, if it is not already open. The dialog box opens, defaulted to the **Sample** tab.

NOTE If  is highlighted orange in the icon bar, the **Motion Controller** dialog box is already open.

2. In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, type *0* in the **Sample Theta** text box, then click **GO** to rotate Sample Theta to 0°.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

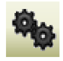
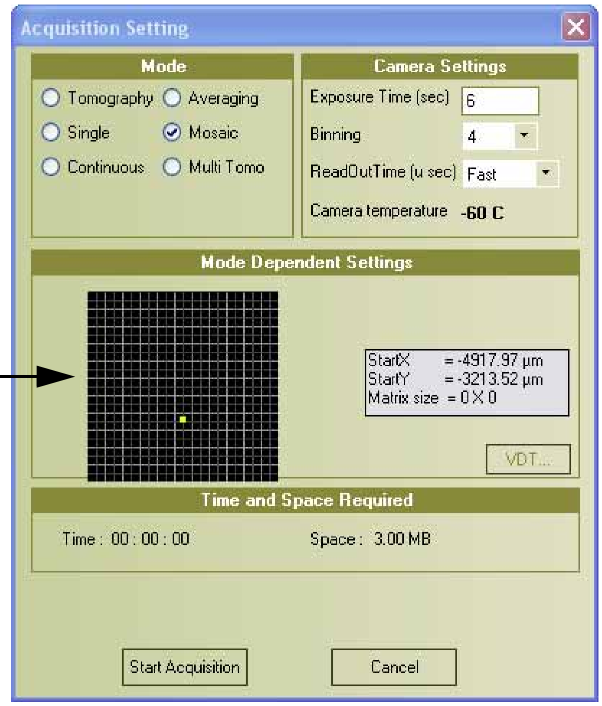
3. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 5-3 **Acquisition Setting** Dialog Box – Settings Applied for Mosaic Acquisition Mode

In step 5, use the mouse pointer to click and drag within the grid-lined black square, to select the region of interest to image



4. Select and/or type the *acquisition setting values*:

Option	Setting Value
Mode	*Mosaic*
Exposure Time (sec)	*Between 5 and 20*
Binning	*4 (or less, for higher resolution)*
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

5. Select the region to image (and establish the **Mode Dependent Settings**). Use the mouse pointer to click and drag within the grid-lined black square, to select the region to image. (Refer to Figure 5-3.) The small yellow square indicates the current sample location. Each white square is a single FOV.

6. Click **Start Acquisition** to acquire the image. An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click  in the icon bar, then repeat steps 3 through 6 with different settings.

The **Acquisition Status** message box closes when acquisition is complete, or when you click  in the icon bar to abort imaging.

7. After acquisition is complete, follow steps a through d to save the image:

   a. Click  in the icon bar. The **Save File** dialog box opens.

   b. Browse to the *destination file path*.

   c. Type the *new file name* in the **File name** text box.

   d. Click **Save**.

   Proceed to "Collecting a Reference Image."

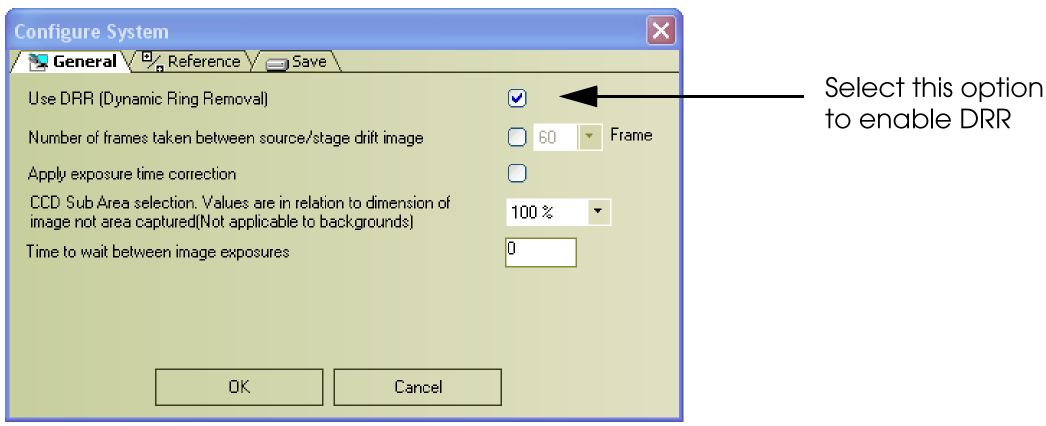
NOTE When acquiring a reference image, the exposure time, detector and X-ray source positions, camera binning, and X-ray voltage and power settings should match the settings used for the actual tomography, or other images collected with different acquisition modes. Take note of the above settings, before proceeding to "Collecting a Reference Image."

Manually Collecting a 3D (Tomography) Dataset

This process describes how to collect a 3D tomography dataset, using Tomography acquisition mode. In this collection process, a series of 2D images (also called *projections*) between specific starting and ending angles (Sample Theta) are acquired. These projections are later reconstructed by XMReconstructor (in Chapter 6, "Manually Reconstructing a 3D Dataset") to create the 3D reconstructed volume.

NOTE If you want to acquire ring-artifact-free reconstruction, use Dynamic Ring Removal (DRR). Select **Microscope > Configure System** to open the **Configure System** dialog box. In the **General** tab (default), select **Use DRR (Dynamic Ring Removal)**, then click **OK** to enable DRR.

Figure 5-4 **Configure System** Dialog Box – **General** Tab, with **Use DRR** Selected



To manually collect a 3D (tomography) dataset

1. Turn OFF the interior light, by moving the visual light camera light switch (D on Figure 1-7, “Ergonomic Station,” on page 16) to the DOWN (OFF) position.

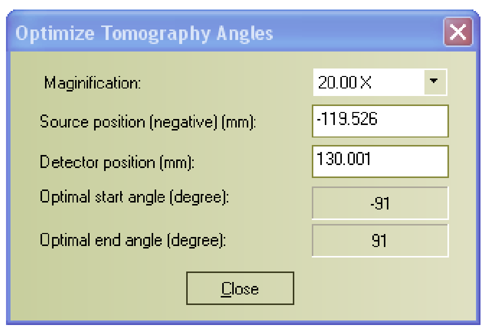
2. Determine whether MicroXCT is 360°-enabled, using Method 1, as described in Appendix F, “Determining Whether the MicroXCT is 360°-Enabled.” This information is used later, in the steps that follow.

3. **MicroXCT is not 360°-enabled or imaging a flat sample (such as a semiconductor sample)** – Follow steps a and b to determine the angle range for 180 + fan.

    a. Select **Microscope > Calculate Optimal Tomography Angles…**. The **Optimize Tomography Angles** dialog box opens.

    The **Magnification**, **Source position** (Source Z), and **Detector position** (Camera Z) indicate the current MicroXCT state.

Figure 5-5 **Optimize Tomography Angles** Dialog Box



    b. Note the **Optimal start** and **end angle (degree)** values, then click **Close**. These values are used later, in step 6.

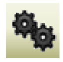
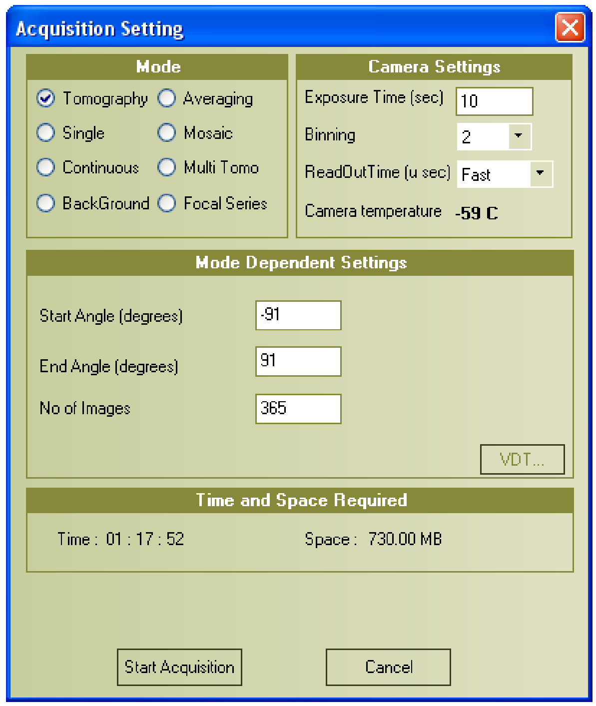
4. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 5-6 **Acquisition Setting** Dialog Box – Settings Applied for Tomography Acquisition Mode



5. Select and/or type the following *acquisition setting values*:

Option	Setting Value
Mode	*Tomography*
Exposure Time (sec)	*Between 5 to 60, or the value noted in "Determining the X-ray Source Power and Exposure Time," step 5, on page 98*
Binning	*2* (refer to Note below)
ReadOut Time (u sec)	*Fast* (default)

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

NOTE If using a binning value of 1 instead of 2, use an exposure time that is four times (4x) the value noted for this point in "Determining the X-ray Source Power and Exposure Time," step 5, on page 98.

6. Type the *start* and *end angle values* in their associated text boxes, based upon the MicroXCT capability or sample type:

MicroXCT Capability or Sample Type[a]	Start Angle (degrees)	End Angle (degrees)
MicroXCT is 360°-enabled (n = number of images per degree; n should be at least 2)	*-180*	*180 - 1/n*
MicroXCT is not 360°-enabled or imaging a flat sample (such as a semiconductor sample)	*Values noted in step 3*	

a. Instructions for determining whether the MicroXCT is 180°- or 360°-enabled (referenced in step 2) are provided in Appendix F, "Determining Whether the MicroXCT is 360°-Enabled."

7. Type the *number of images to collect* in the **No. of Images** text box, using the processes described in the following bullets to determine the value:

– **MicroXCT is 360°-enabled** – Set **No. of Images** to *(360 * n) +1*, where n = number of images per degree.

For example, for n = 2:

No. of Images = (360 * 2)+1 = 721

– **MicroXCT is not 360°-enabled or imaging a flat sample (such as a semiconductor sample)** – It is recommended to acquire at least two images per degree. Calculate the number of images to collect as *((End Angle - Start Angle) * n) +1*, where n = number of images per degree.

For example, for n = 2, **End Angle** = 91, and **Start Angle** = -91:

No. of Images = ((91 - (-91)) * 2) + 1 = 365

8. Click **Start Acquisition** to acquire the image. The **Save File** dialog box opens. Follow steps a through c to save the file, and continue.

   a. Browse to the *destination file path*.

   b. Type the *new file name* in the **File name** text box.

   c. Click **Save**.

   An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

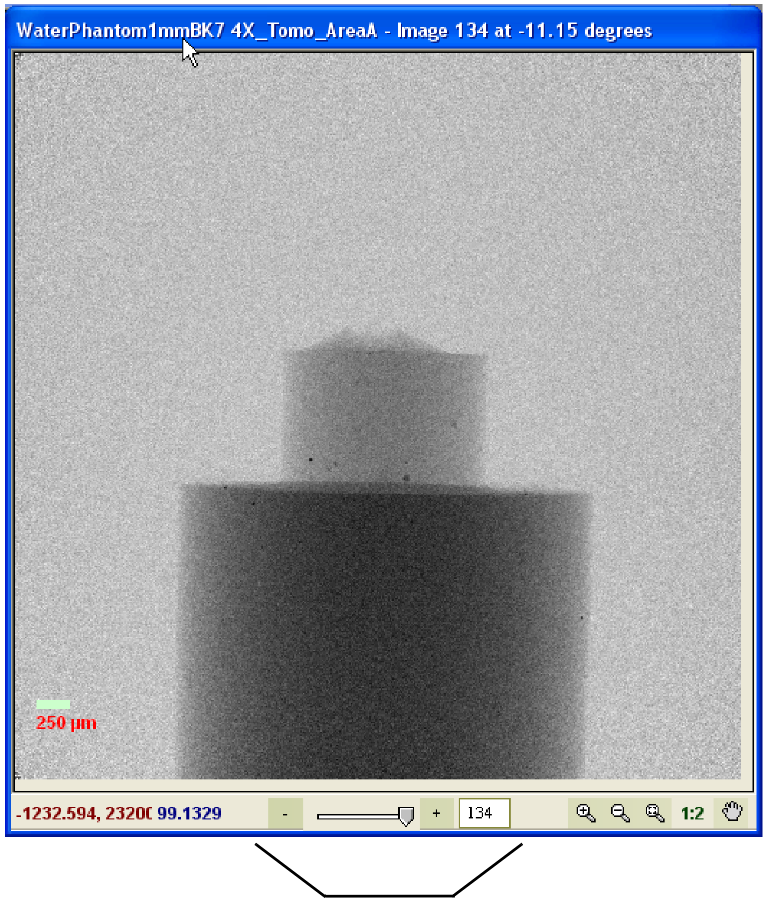
NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click in the icon bar, then repeat steps 4 through 8 with different settings.

The MicroXCT rotates the sample to the starting angle, and automatically acquires images at evenly spaced angles, between the starting and ending angles indicated in step 6, based upon the total number of images indicated in step 7. Each individual image is saved to disk and displayed in the **Image** window.

With tomography files, which contain a series of 2D images (projections), the **Image** window has a scroll bar and an image number indicator showing which image is currently displayed.

The **Acquisition Status** message box closes when acquisition is complete, or when you click in the icon bar to abort imaging.

Figure 5-7 Example Tomography File **Image** Window, with Scroll Bar and Image Number Indicator Shown



Scroll Bar and Image Number Indicator –
Use these controls to scroll through the images

After collecting the 3D (tomography) dataset, you need to collect a reference image, which must be applied to the tomography dataset before you can reconstruct the dataset.

Proceed to "Collecting a Reference Image."

NOTE When acquiring a reference image, the exposure time, detector and X-ray source positions, camera binning, and X-ray voltage and power settings should match the settings used for the actual tomography, or other images collected with different acquisition modes. Take note of the above settings, before proceeding to "Collecting a Reference Image."

Collecting a Reference Image

This process describes how to collect a reference image, using Averaging (on-the-fly) acquisition mode. A reference image (image acquired with the sample out of the FOV) is used to normalize the images acquired with the sample in the FOV. Applying a reference translates the intensity of the sample image to a percentage of X-ray transmission between 0% and 100%.

For this process, the exposure time, detector and X-ray source positions, camera binning, and X-ray voltage and power settings should match the settings used for the actual tomography, or other images collected with different acquisition modes.

To collect a reference image

1. Follow steps a through c, to move the sample out of the FOV:

   a. Click  in the icon bar. The **Motion Controller** dialog box opens, defaulted to the **Sample** tab.

   b. In the **Sample Theta** panel of the **Motion Controller** dialog box **Sample** tab, ensure that the current Sample Theta position is **0 deg**. If not, type *0* in the **Sample Theta** text box, then click **GO** to rotate Sample Theta to 0°.

   c. In the **Sample X** panel of the **Motion Controller** dialog box **Sample** tab, type *60,000* in the **Sample X** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

NOTE If  is highlighted **orange** in the icon bar, the **Motion Controller** dialog box is already open.

NOTE If the sample is too large and cannot be fully moved out of the FOV by moving Sample X, turn OFF the X-ray source, open the access door, manually remove the sample holder assembly from the sample stage, close the access door, then turn ON the X-ray source.

Instructions for turning OFF the X-ray source are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 6, on page 45. Instructions for turning ON the X-ray source are provided in "Turning on the X-ray Source," on page 58.

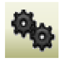
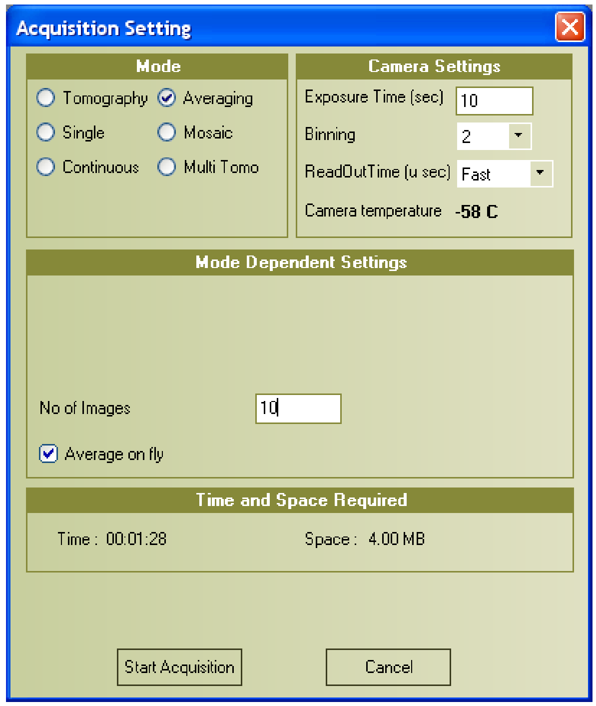
2. Click  in the icon bar. The **Acquisition Setting** dialog box opens.

Figure 5-8 **Acquisition Setting** Dialog Box – Settings Applied for Averaging Acquisition Mode



3. Select and/or type the *acquisition setting values*:

Option	Setting Value
Mode	*Averaging*
Exposure Time (sec)	*Same as the exposure time used for the image that is being reference corrected*
Binning	*Same value used when acquiring the tomography*
ReadOut Time (u sec)	*Fast* (default)
No. of Images	$\geq$ *10*
Average on fly	*Selected*

CAUTION **Camera temperature** should be < -55°C. Contact the Xradia Support Team if the temperature is higher.

NOTE Generally, the total time for the reference image (individual image time * number of images) should be greater than or equal to 10 times (10x) the length of time for one exposure in the tomography (for example, if the exposure time for each projection is 10 seconds, the reference image should be 10 images averaged with 10 seconds per image).

NOTE Exposure time for the reference image can be equal to that of a single tomography image, unless the intensity of the image produced from that exposure time oversaturates the image (the light intensity count is greater than 64,000 per pixel, indicative of a bright region in the center of the image).

If the image is saturated, reduce the exposure time for the reference image so that the counts are somewhere in the 30,000 range, and increase the number of images such that the time to acquire the reference image is about 10 times (10x) the length of time needed for one exposure in the images that need to be referenced corrected.

4. Click **Start Acquisition** to begin acquiring the reference image. The **Save File** dialog box opens.

5. Follow steps a through c to save the image:

   a. Browse to the *destination file path*.

   b. Type the *new file name* in the **File name** text box.

   c. Click **Save**.

   An **Acquisition Status** message box opens, indicating real-time acquisition status, and an **Image** window opens, showing the image being updated, with light intensity counts indicated in **blue** (lower left status bar of the window).

NOTE **Acquisition Setting** dialog box values cannot be changed until acquisition is stopped. If you need to abort the acquisition and change the values, click  in the icon bar, then repeat steps 2 through 5 with different settings.

The **Acquisition Status** message box closes when acquisition is complete, or when you click  in the icon bar to abort imaging.

After acquisition is complete, proceed to "Applying the Reference Image."

Applying the Reference Image

This process describes how to apply the reference image (collected in "Collecting a Reference Image"), which normalizes images taken with the sample visible (in the FOV), including tomography images, to a percentage value of the X-ray transmission.

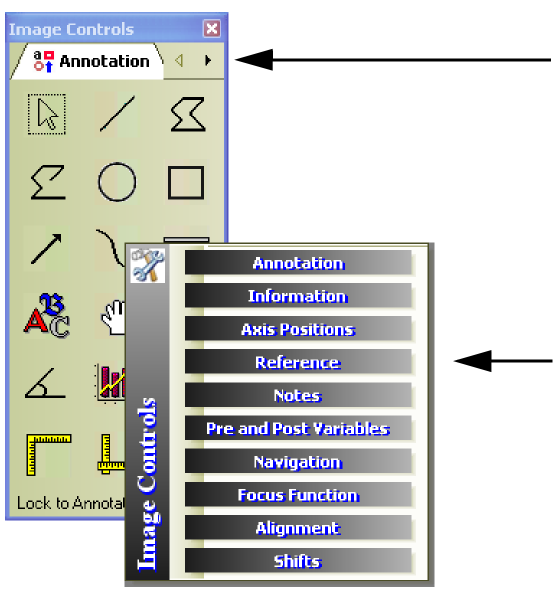
To apply the reference image

1. Click the ***Image** window that you want reference corrected*, to make it the active window (that is, bring it to the front of all other windows/ dialog boxes).

2. Click  in the icon bar. The **Image Controls** dialog box opens, defaulted to the **Annotation** tab.

NOTE If  is highlighted orange in the icon bar, the **Image Controls** dialog box is already open, and clicking the icon closes, rather than opens, the dialog box. If the dialog box is hidden behind other windows or dialog boxes, click the highlighted orange icon, then click the non-highlighted icon, as described above.

Figure 5-9 **Image Controls** Dialog Box – **Annotation** Tab, Selecting the **Reference** Tab



In step 3, click the arrow icons to scroll through the available tabs, until the **Reference** tab is visible, –or–

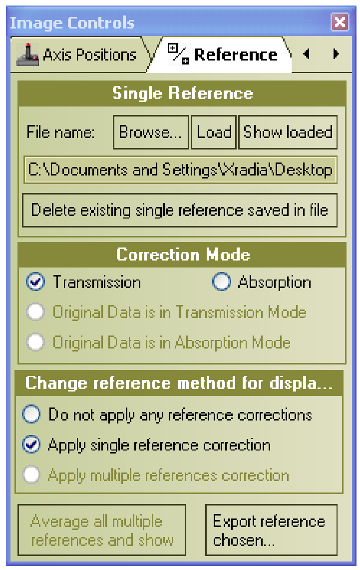
In step 3, right-click within the main body of the **Image Controls** dialog box, then select **Reference** from the list of available tabs

3. Select the **Reference** tab, using one of the following methods (refer to Figure 5-9):

   – Scroll through the available tabs, by clicking the or arrow icon, until the **Reference** tab is visible

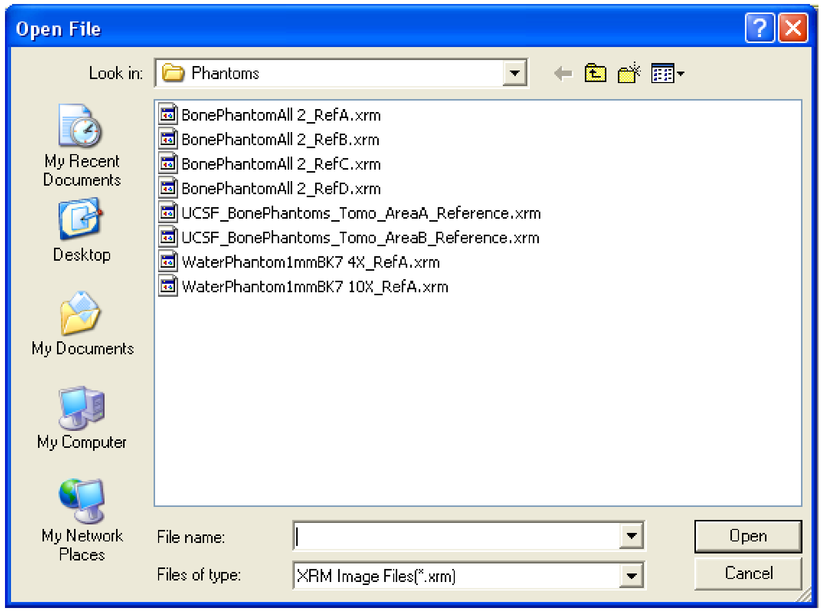
   – Right-click within the **Image Controls** dialog box, then select **Reference**

Figure 5-10 **Image Controls** Dialog Box – **Reference** Tab



4. Click **Browse…**. The **Open File** dialog box opens.

Figure 5-11 **Open File** Dialog Box



5. Browse to the *destination file path*, then select the *reference file* created in “Collecting a Reference Image,” step 5, for this tomography dataset or “image with sample.”

6. Click **Apply Correction** to correct the sample image with the reference image. The light intensity counts change to indicate percentage transmission upon applying the reference correction.

   Proceed to the next step:

   – **Image with sample that is a tomography dataset** – The file is automatically saved, and includes the reference image. Proceed to step 8.

   – **Image with sample that is a not a tomography dataset** – Proceed to step 7 to save the file.

7. **Image with sample that is not a tomography dataset –**
   Follow steps a through d to save the file created in step 6:

   a. Click in the icon bar. The **Save File** dialog box opens.

   b. Browse to the *destination file path*.

   c. Type the *new file name* in the **File name** text box.

   d. Click **Save**.

8. Close the file (click , top right corner).

   To create a viewable 3D volume, you must reconstruct the tomography dataset. Proceed to Chapter 6, "Manually Reconstructing a 3D Dataset."

6 Manually Reconstructing a 3D Dataset

This chapter describes how to use XMReconstructor to manually reconstruct 3D tomography datasets when:

– A dataset is manually acquired, as described in “Manually Collecting a 3D (Tomography) Dataset,” on page 137, or

– A dataset is automatically acquired, but not reconstructed in Chapter 4, “Automatically Acquiring Additional Data and Reconstructing Tomography Point(s),” or

– The center shift is incorrect, or

– The automatic reconstruction had problems

Reconstruction is the process of using all the projections acquired during a tomography data acquisition, to create a 3D volume.

XMReconstructor can only be used to reconstruct images that have been reference corrected. (Refer to “Collecting a Reference Image,” on page 143, and “Applying the Reference Image,” on page 147.)

NOTE The automatic process for acquiring and reconstructing tomographic data is described in Chapter 4, “Automatically Acquiring Additional Data and Reconstructing Tomography Point(s).”

NOTE During reconstruction with XMReconstructor, the amount of free space required on the hard disk drive must be at least 1 GB more than the file size of the tomography (projection) dataset.

Process Overview

The process of manually reconstructing a 3D dataset is comprised of the following subprocesses:

1. Preparing for Reconstruction.
2. Identifying Center Shift.
3. Identifying Beam Hardening Correction.
4. Reconstructing the Tomography Data.

Each is described in the sections that follow.

Preparing for Reconstruction

This process describes how to open XMReconstructor, and ensure that the tomography dataset to be reconstructed is not in use by another program.

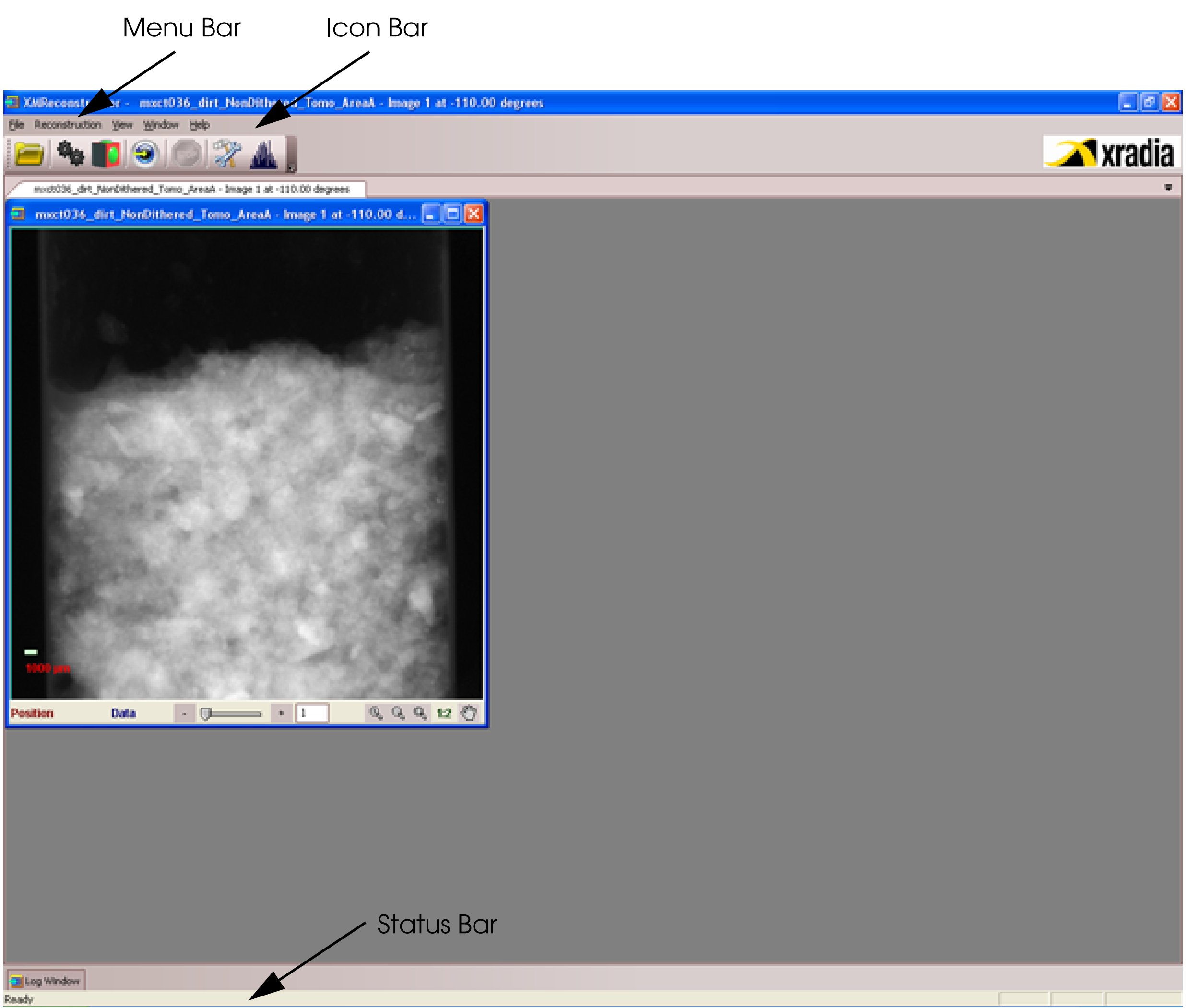
To prepare for reconstruction

1. Select **Start > All Programs > Xradia > MicroXCT 7.*x* > XMReconstructor 7.*x***. The **XMReconstructor** main window opens.

NOTE "x" is the program's current version number.

NOTE When using XMReconstructor, if an icon is highlighted orange in the icon bar, its associated dialog box is already open, and clicking the icon closes, rather than opens, the dialog box.

Figure 6-1 Default **XMReconstructor** Main Window (Opened File Shown for Reference Only)

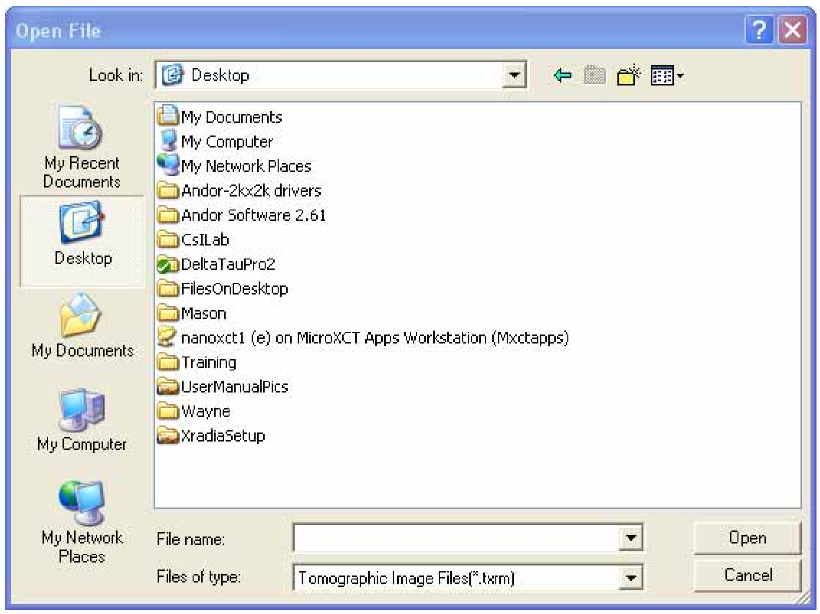


2. Open the **Open File** dialog box, using one of the following methods:

   – Select **File > Open...**

   – Click  in the icon bar

Figure 6-2 **Open File** Dialog Box



3. Browse to the *destination file path* of the tomography dataset (**.txrm* file) to be opened.

4. Select the *file*, then click **Open**.

NOTE If the "This file is open on another machine" **Warning** dialog box opens, click **OK**, close the file in the other program, then repeat steps 2 through 4.

NOTE If the "Only reference corrected file supported..." **Warning** dialog box opens, the tomography file has not been reference corrected yet. Click **OK**, then apply a reference image to the file, according to the process described in "Applying the Reference Image," on page 147. If a reference image has not been collected, collect one according to the processes described in "Collecting a Reference Image," on page 143, and apply it to the tomography file. Upon completing either or both tasks, repeat steps 2 through 4.

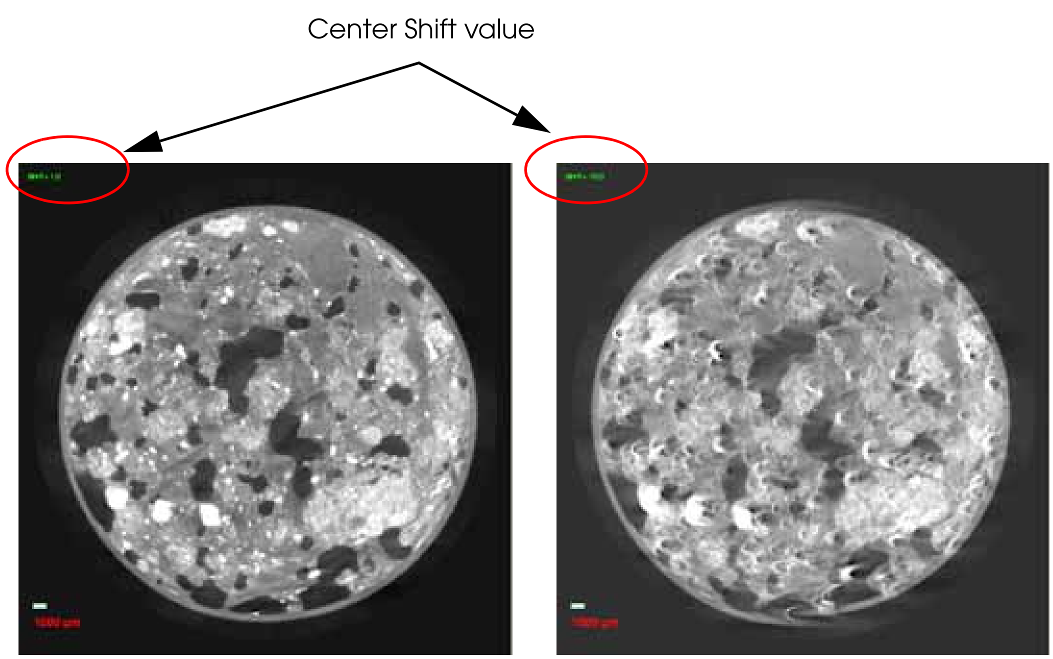
Proceed to "Identifying Center Shift."

Identifying Center Shift

This process describes how to identify the center shift value. Center shift is the amount, in pixels, that the axis of rotation is offset from the center column of the detector. This value is used later, when determining the beam hardening correction value and when reconstructing the data.

Images with good center shift are focused and clear, while images with bad center shift are unfocused and blurry. (Refer to Figure 6-3.)

Figure 6-3 Comparison between Good and Bad Center Shift Results



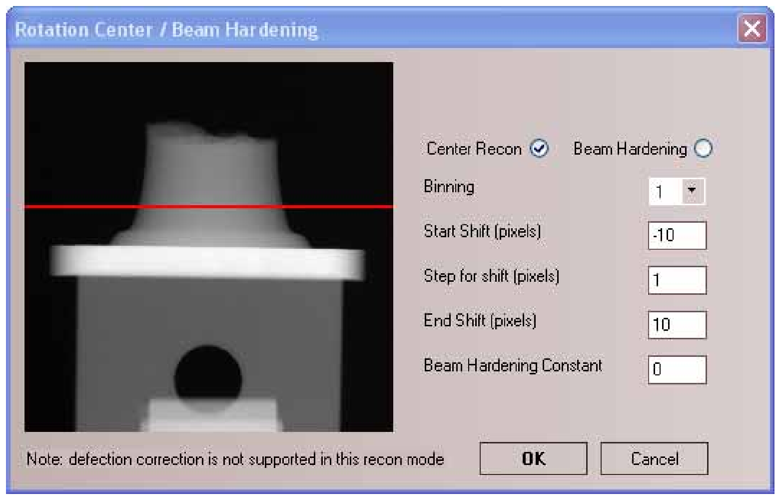
Good Center Shift
Image is clear and focused

Bad Center Shift
Image is blurry and unfocused

*To identify center shift in the open *.txrm file*

1. Click  in the icon bar. The **Rotation Center / Beam Hardening** dialog box opens.

Figure 6-4 **Rotation Center/Beam Hardening** Dialog Box – **Center Recon** Option Selected



2. Select and/or type the *center shift setting values* (refer to Figure 6-4):

Option	Setting Value
Center Recon	*Selected*
Binning	*1*

Leave all other values at their defaults on the first attempt to determine the center shift.

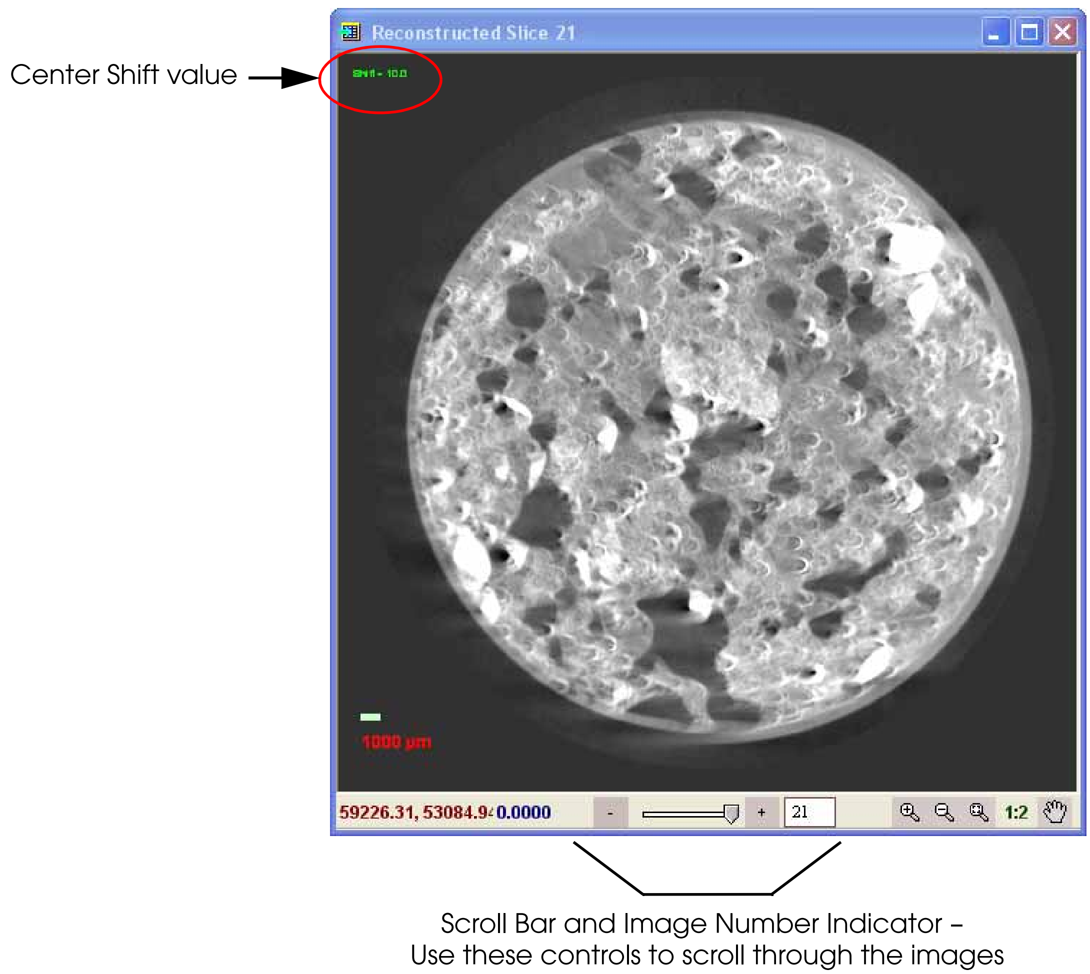
3. Click **OK**. A **Reconstruction Status** message box opens, indicating real-time reconstruction status, and a **Reconstructed Slice Image** window opens.

NOTE If you need to abort the center shift find process before it completes, click  in the icon bar.

The **Reconstructed Slice Image** window shows a series of 2D reconstructed slices with increasing center shift being created, starting from the shift range specified in the **Rotation Center / Beam Hardening** dialog box **Start Shift (pixels)** text box, increasing in intervals, according to **Step to shift**, and ending in the shift specified in the **End Shift (pixels)** text box. The amount that each image is shifted is indicated in **green** (upper left corner).

Wait while the image finishes center-shifting through the range. The **Reconstruction Status** message box closes at the end of the process.

Figure 6-5 Reconstructed Slice Image Window



4. In cases where there are areas on the image that are all white or black, image contrast and brightness should be adjusted such that detailed features within the all white/black areas can be observed. Follow steps a and b to adjust contrast and brightness:

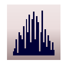
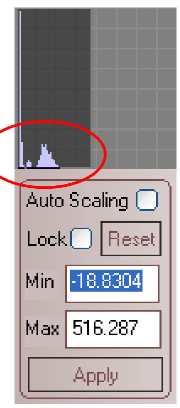
   a. Click  in the icon bar. The **Histogram** panel opens and pins itself in the **XMReconstructor** main window (upper right corner).

Figure 6-6 **Histogram** Panel

In step 4b, to adjust contrast and brightness of the image in the **Reconstructed Slice Image** window, use the mouse pointer to click and drag to the RIGHT and/or LEFT within the gray area of the **Histogram** panel



   b. Use the following instructions to *maintain or adjust image contrast and brightness*:

Contrast and Brightness	Process
Maintain for all images	Select **Lock**.
Adjust for all images	Click **Reset**. Next, use the mouse pointer to click and drag to the RIGHT and/or LEFT within the gray area of the **Histogram** panel, to adjust contrast and brightness. (The panel is light gray until the mouse is dragged on it. The area in which the mouse is dragged turns dark gray.) After you have sufficiently adjusted the contrast and brightness in the **Reconstructed Slice Image** window, select **Lock**.

NOTE The **Auto-Scaling** option can be selected to automatically estimate the best contrast and brightness for the image; however, the results may not provide the results you want; therefore, manual adjustment is recommended.

5. Scroll through the images in the **Reconstructed Slice Image** window, using the slider in the scroll bar or the image number control (click the **–** or **+** symbols) at the bottom of the window, to locate and identify the image with the crispest features (sharpest focus).

6. Note the ***center shift value*** of the image with the sharpest focus (indicated in **green**, top left corner of the **Reconstructed Slice Image** window). This value is used later, in "Identifying Beam Hardening Correction," step 2.

NOTE If a good center shift is not found with the specified Start and End Shift range, repeat steps 1 through 6, but in step 2 change the *Start and/or End Shift value to search over a different range*. The step values in step 2 can also be changed to look at finer or coarser shift intervals.

Proceed to "Identifying Beam Hardening Correction."

Identifying Beam Hardening Correction

This process describes how to identify the beam hardening correction value. This value is used later, along with the center shift value, when reconstructing the data.

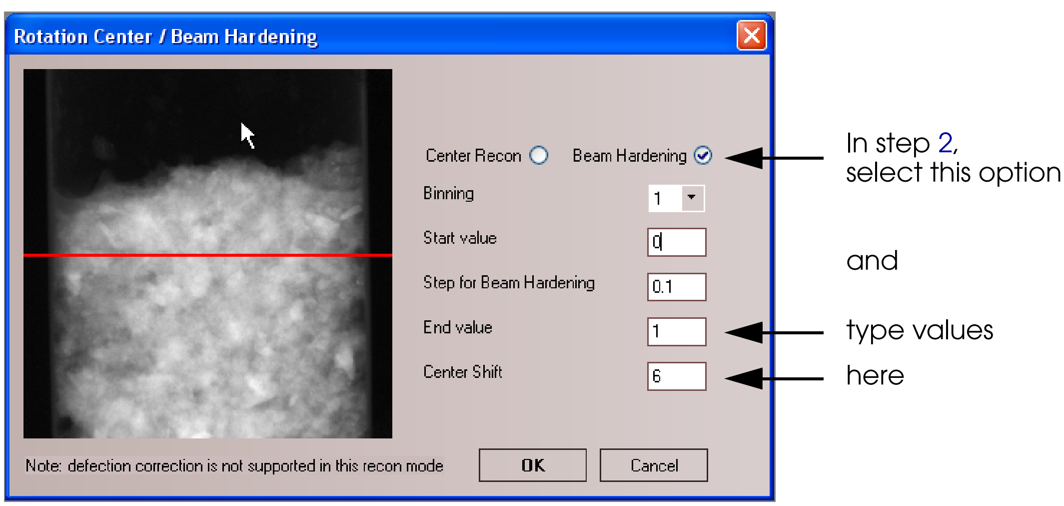
Beam hardening is the result of the change in spectrum characteristic as the X-rays pass through the sample, where the sample density remains the same, but the light changes – one area is darker than another.

NOTE The typical beam hardening correction value is 0.2 to 0.4, if the correct source filter is used.

To identify beam hardening correction in the open *.txrm file

1. Click  in the icon bar. The **Rotation Center / Beam Hardening** dialog box opens.

Figure 6-7 **Rotation Center / Beam Hardening** Dialog Box – **Beam Hardening** Option Selected



2. Select and/or type the *beam hardening setting values* (refer to Figure 6-7):

Option	Setting Value
Beam Hardening	*Selected*
Binning	*1*
Start value	*0* (default)
Step for Beam Hardening	*0.1* (default)
End value	*1*
Center Shift	*Center shift value noted in "Identifying Center Shift," step 6*

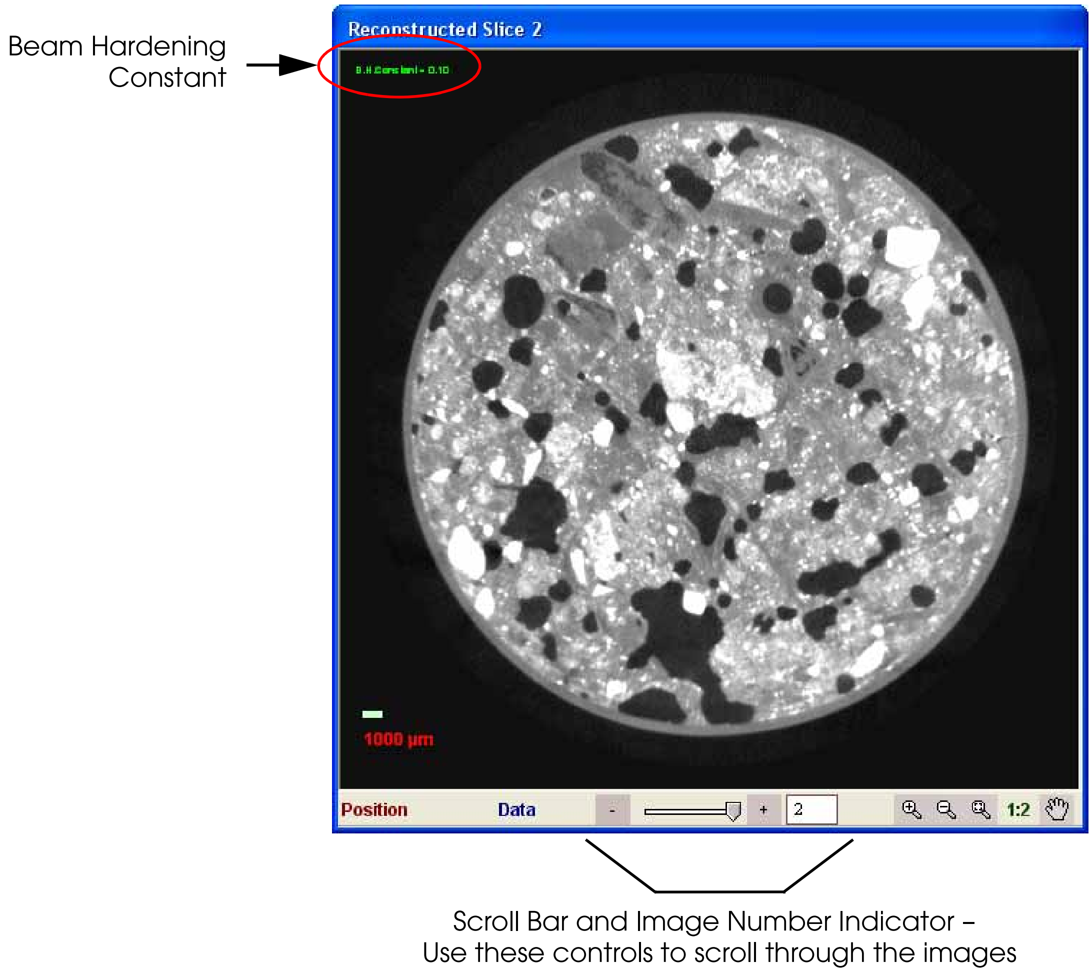
3. Click **OK**. A **Reconstruction Status** message box opens, indicating real-time reconstruction status, and a **Reconstructed Slice Image** window opens.

NOTE If you need to abort the beam hardening correction find process before it completes, click  in the icon bar.

The **Reconstructed Slice Image** window shows a series of 2D reconstructed slices with increasing beam hardening correction being created, starting from the value specified in the **Rotation Center** / **Beam Hardening** dialog box **Start value** text box, increasing in intervals, according to **Step for Beam Hardening**, and ending in the value specified in the **End value** text box. The amount that each slice is corrected is indicated in **green** (identified as a *B.H. Constant*, upper left corner).

Wait while the image finishes correcting for beam hardening through the range. The **Reconstruction Status** message box closes at the end of the process.

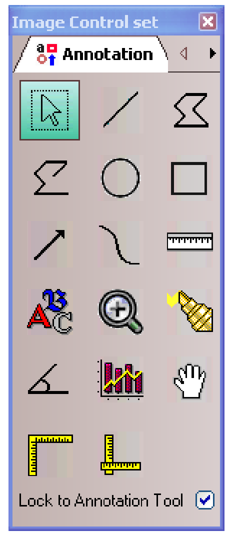
Figure 6-8 **Reconstructed Slice Image** Window

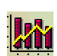


4. Adjust *image contrast and brightness* using the **Histogram** tool, if necessary, as described in "Identifying Center Shift," step 4.

5. Click  in the icon bar. The **Image Control set** toolbox opens.

Figure 6-9 **Image Control set** Toolbox



6. Click  to enable the Line Plot annotation tool.

7. Draw a line across the 2D reconstructed slice, by using the mouse pointer to click and drag within the **Reconstructed Slice Image** window. The line should span materials of similar density. The **Reconstructed Slice *x*-Line Plot** dialog box opens.

Figure 6-10 Reconstructed Slice Image Window with Annotation Line

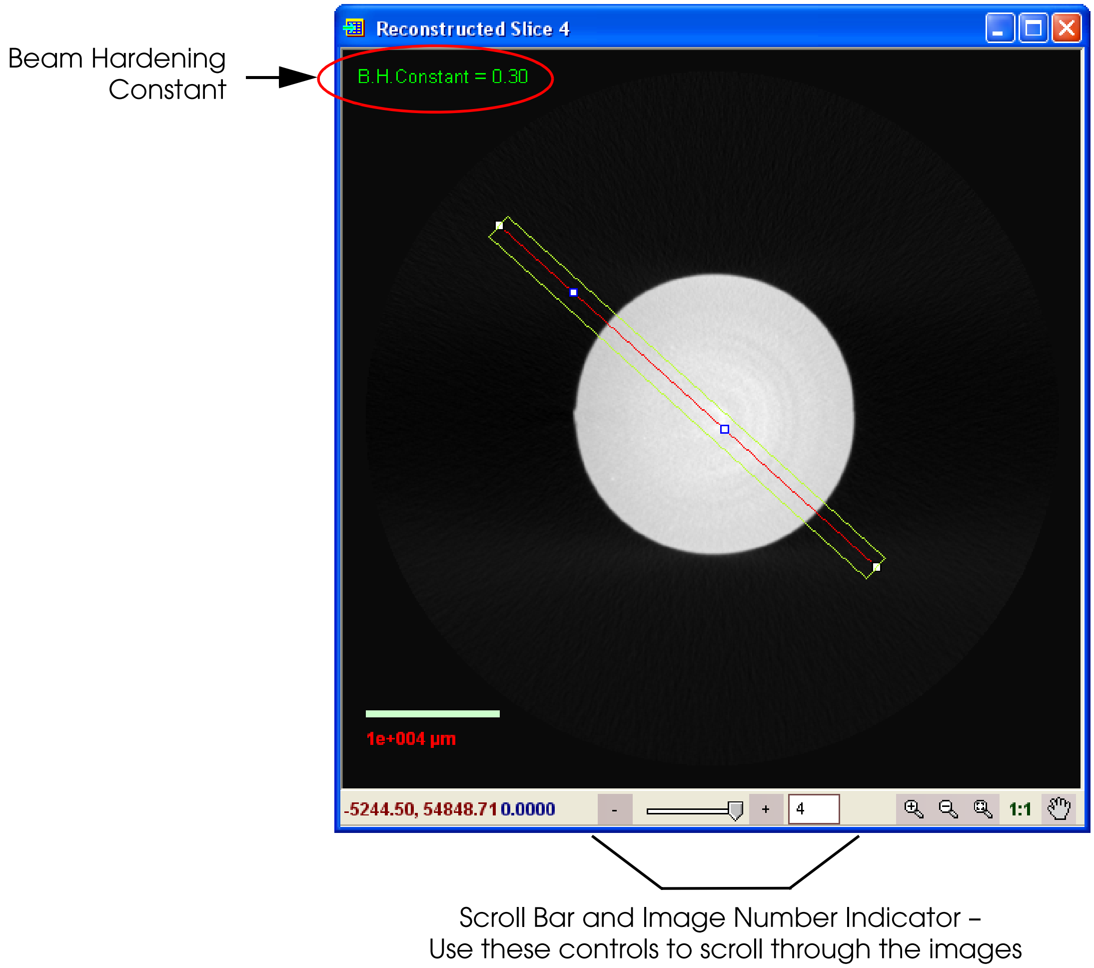
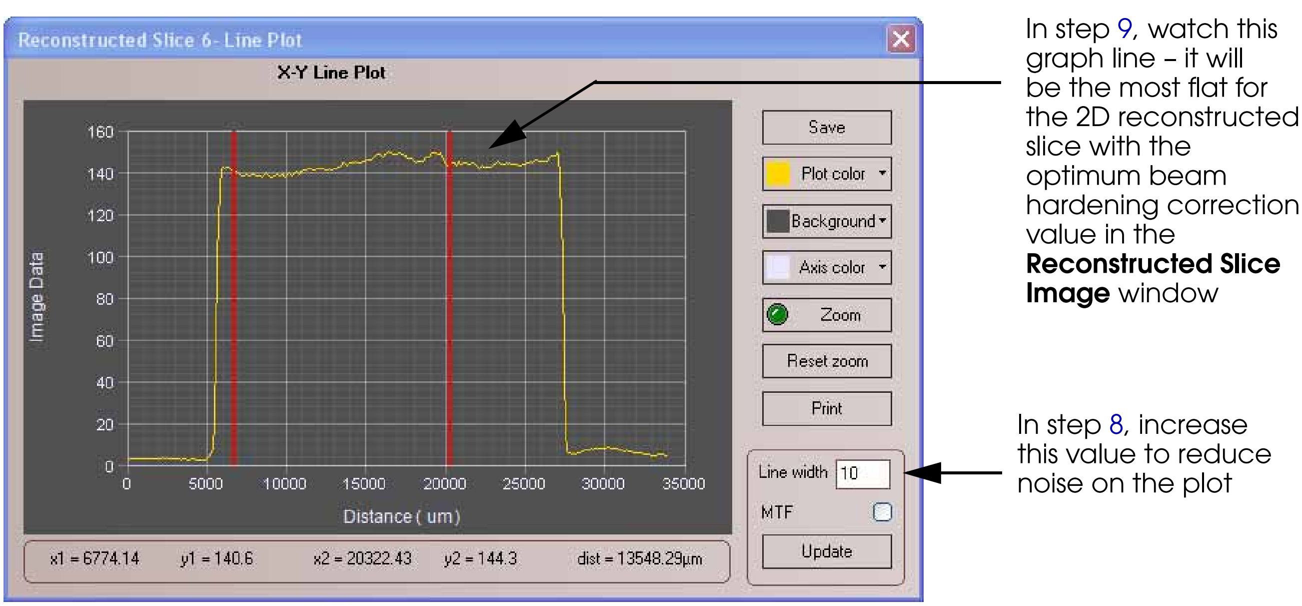


Figure 6-11 Reconstructed Slice *x*-Line Plot Dialog Box



8. To reduce noise on the plot (by averaging more lines, and thereby smoothing out the graph), widen the graph line width by typing a value between *10* and *64* (maximum) in the **Line Width** text box, then click **Update**. (Refer to Figure 6-11.)

9. In the **Reconstructed Slice Image** window, use the slider to scroll through the 2D reconstructed slices. As you scroll, watch the graph in the **Reconstructed Slice *x*-Line Plot** dialog box. The slice with the optimum beam hardening correction value in the **Reconstructed Slice Image** window will have the flattest graph in the **Reconstructed Slice *x*-Line Plot** dialog box. (Refer to Figure 6-11.)

10. Note the *beam hardening correction value* (indicated in **green**, identified as a *B.H. Constant*, upper left corner of the **Reconstructed Slice Image** window). This value is used later, in "Reconstructing the Tomography Data," step 3.

11. Close the **Reconstructed Slice Image** window and **Reconstructed Slice *x*-Line Plot** dialog box (click , top right corner).

NOTE Finer intervals can be used for **Step for Beam Hardening**, in step 2, if the beam hardening correction must be more precise. Repeat steps 1 through 11, but in step 2, *narrow the range around the best beam hardening correction found during the previous attempt*, and change **Step for Beam Hardening** to a *smaller value*.

Proceed to "Reconstructing the Tomography Data."

Reconstructing the Tomography Data

This process describes how to reconstruct the tomography data, after the center shift and beam hardening correction values are known.

*To reconstruct the open *.txrm file*

1. Open the **Reconstruction Setting** dialog box, using one of the following methods:

   – Select **Reconstruction > Reconstruction Setting…**

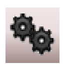
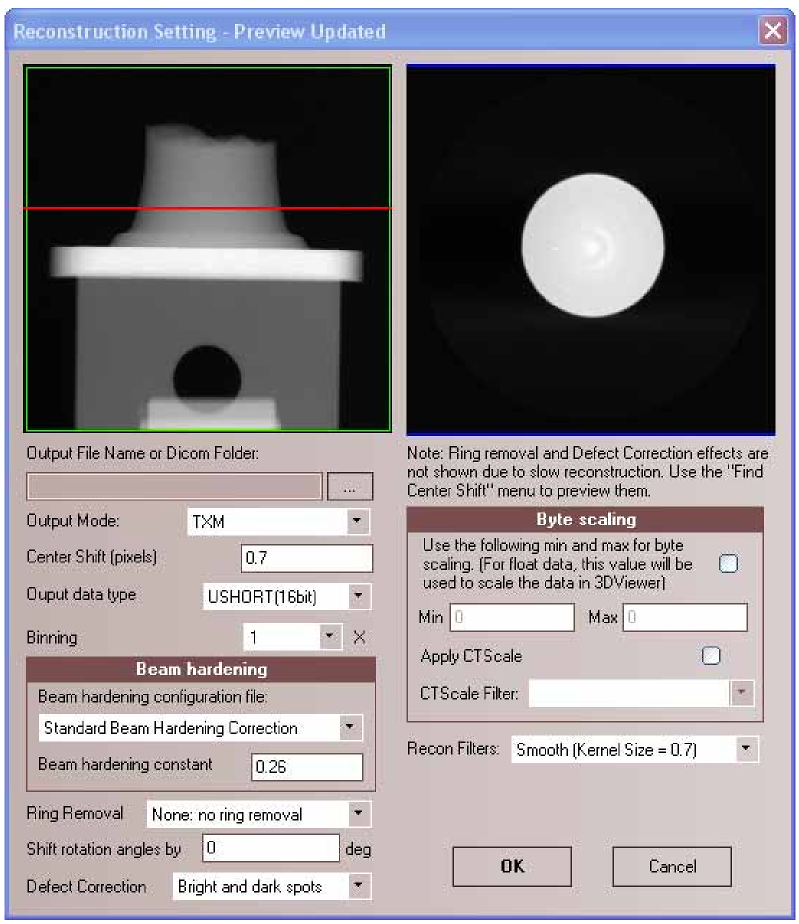
   – Click  in the icon bar

Figure 6-12 **Reconstruction Setting** Dialog Box – Settings Applied in Subsequent Steps



2. Follow steps a through c to assign the output reconstruction file name:

   a. Click **...** (to the right of the **Output File Name or Dicom Folder** text box), then browse for the *destination file path*.

   b. Type an *output reconstruction file name* in the **File name** text box.

   c. Click **OK**. The path and file name appear in the **Output File Name or Dicom Folder** text box.

3. Select and/or type the following *reconstruction setting values*:

Option	Setting Value
Output Mode	*TXM* (default)
Center Shift (pixels)	*Center shift value identified in "Identifying Center Shift," step 6*
Output data type	*USHORT(16bit)* (default)
Binning	*1* (refer to Note)
Beam hardening configuration file	*Standard Beam Hardening Correction* (default)
Beam hardening constant	*B.H. correction value identified in "Identifying Beam Hardening Correction," step 9*
Shift rotation angles by	*0 deg* (default)
Defect correction	– *None if using DRR in Version 7.x* – *Bright and dark spots* (default) *if **not** using DRR*

NOTE Because the acquisition binning for tomography is usually 2, reconstruction binning is 1.

4. Select one of the following *options* from the **Ring Removal** drop-down list box:

Option	Usage
None: No Ring Removal	Use this option if DRR is enabled.
Low contrast – 8-section RR	Use this option if DRR is disabled, for bone, rock, plastic, carbon composite, or composite material samples.
High contrast – 3-section RR	Use this option if DRR is disabled, for high-contrast samples, such as semiconductors, or if the other two options do not apply.

NOTE 3-section RR is known to sometimes add rings when there are regularly repeating high-contrast features.

5. Select a *software filter* from the **Recon Filters** drop-down list box. The minimum is Smooth (Kernel Size = 0.5); if unsure, start with *Smooth (Kernel Size = 0.7)*.

NOTE The **Recon Filters** value is magnification lens- and sample-dependent.

NOTE Determine which software filter value provides the most satisfactory balance between image resolution and noise (through your own experience); the correct software filter value provides for significant noise reduction, but has a minimal impact on resolution.

NOTE Do **not** use **None** nor **Sharp (Shepp-Logan)**.

6. Use the **Byte scaling** option only if either of the following conditions is true:

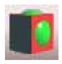
Apply Byte Scaling When True	Process
Global minimum and maximum byte scaling values are known from a prior similar sample (scan acquired at the same settings (X-ray source power, detector and X-ray source distances, number of projections, exposure times, binning, and magnification)).	Select **Use the following min and max for byte scaling**, then type the *global minimum and maximum byte scaling values* in the **Min** and **Max** text boxes, respectively.
Dataset is to be CT-scaled and CT scaling calibration is complete.	Select **Apply CT Scale**, then select the correct *software filter* from the **CTScale Filter** drop-down list box.

NOTE Refer to *CT Scaling Instructions* (G000135), included with the MicroXCT product documentation, for details related to CT scaling.

7. Click **OK** to close the **Reconstruction** dialog box.

8. Reconstruct the tomography data, using one of the following methods:

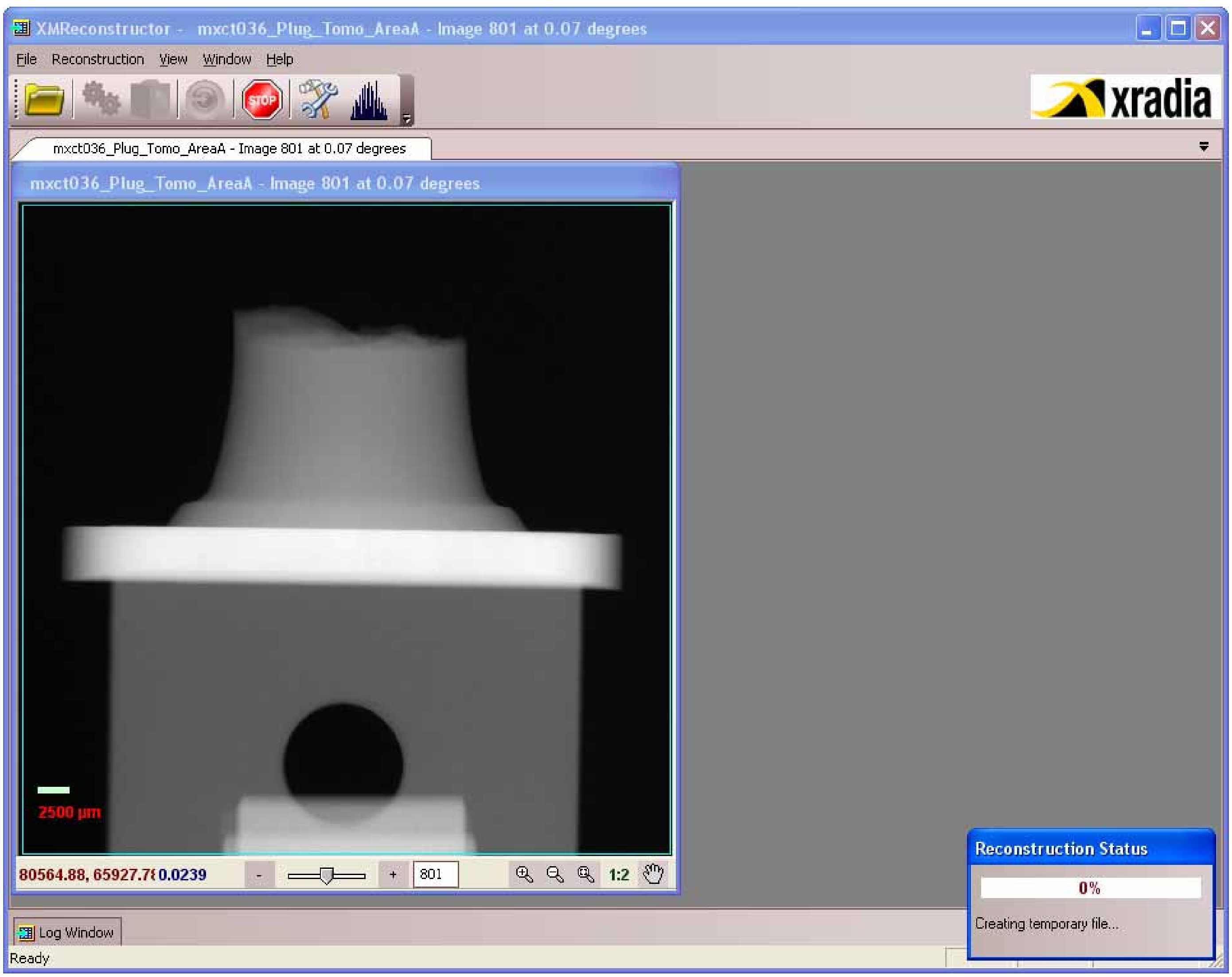
   – Select **Reconstruction > Start Reconstruction**

   – Click  in the icon bar

   The **Reconstruction Status** window opens, indicating real-time reconstruction progress (lower left status bar of the window).

NOTE If you need to abort the reconstruction process before it completes, click  in the icon bar.

Figure 6-13 Reconstruction Window



9. When reconstruction is complete, the **Reconstruction Status** window closes and a **Message** dialog box opens, indicating the total reconstruction time. Click **OK** to close the dialog box.

   The tomography is now reconstructed, and ready for viewing with XM3DViewer. Proceed to Chapter 7, “Viewing Tomographies.”

7 Viewing Tomographies

This chapter describes how to use XM3DViewer to view and edit 2D reconstructed slices and 3D volume datasets for use in reports and movies. This is typically done after acquiring, referencing, and reconstructing the tomography dataset (all the processes described in the previous chapters).

NOTE This chapter provides basic information for using XM3DViewer to view tomographic data after reconstruction. For further details regarding the program's use, refer to the *Xradia ExamineRT Workstation 1.1 User's Manual*, available under XM3DViewer's **Help** menu.

Process Overview

The process of viewing tomographies is comprised of the following subprocesses:

1. Checking a Large Reconstructed File.
2. Starting XM3DViewer.
3. Using XM3DViewer:
   - Adjusting and Navigating the Reconstructed 2D Slices
   - Creating 3D Volume Renderings
   - Collecting Images (or Pictures) for a Report
   - Generating a Report
   - Creating Movies of Cross-Sectional 2D Reconstructed Slices and 3D Volumes
   - Correcting Problems with the Reconstructed File

NOTE Unlike earlier chapters of this guide, most processes described in this chapter can be performed out of sequence.

Each is described in the sections that follow.

Checking a Large Reconstructed File

This process describes how to check a large reconstructed file with XMController (before using XM3DViewer), which must be done if the reconstructed file generated in:

- Chapter 4, "Automatically Acquiring Additional Data and Reconstructing Tomography Point(s)," or
- Chapter 6, "Manually Reconstructing a 3D Dataset"

is larger than the memory available on the graphics adapter (~ 0.25 GB or greater), and you suspect that the file has a problem.

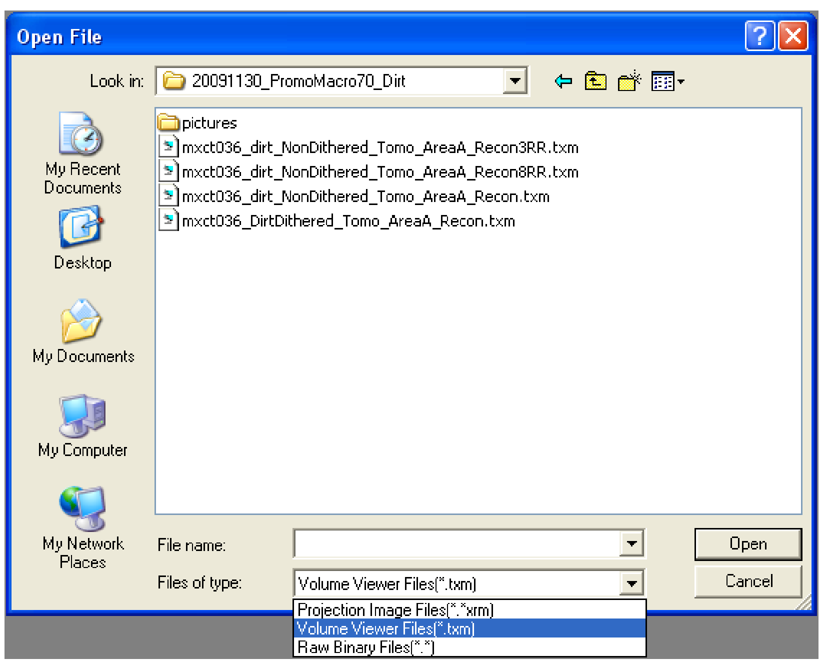
To check a large reconstructed file

1. Start XMController, if it is not already running.

NOTE Instructions for starting XMController are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 1, on page 42.

2. Select **File > Open...**. The **Open File** dialog box opens.

Figure 7-1 **Open File** Dialog Box

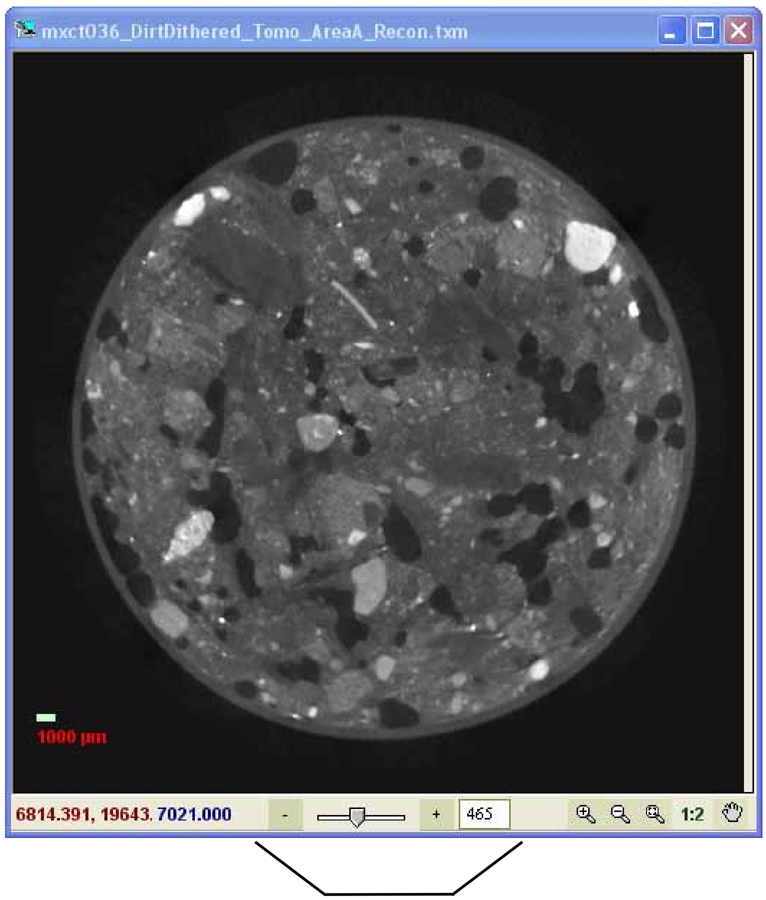


3. Select *Volume Viewer File (*.txm)* from the **Files of type** drop-down list box.

4. Browse to the *destination file path*.

5. Select the *reconstructed file to be checked*, then click **Open**. An **Image** window opens with the series of reconstructed slices.

Figure 7-2 **Image** Window with Slider Shown



Scroll Bar and Image Number Indicator –
Use these controls to scroll through the images

6. Scroll through the images, using the slider in the scroll bar or the image number control (click the **–** or **+** symbols) at the bottom of the window, to navigate to the middle slices and look for potential problems, such as streaks, blurriness, and other problems that affect image quality.

   Proceed to the next process:

   – If there are no problems with the file, close the file, then proceed to “Starting XM3DViewer.”

   – If there is a problem with the file, proceed to “Correcting Problems with the Reconstructed File,” at the end of this chapter.
   After identifying the problem and taking steps to remedy it, close the file.

NOTE Instructions for removing the sample, after you are finished using it, are provided in Appendix E, “Removing the Sample after Use.”

Starting XM3DViewer

This process describes how to start XM3DViewer and open a reconstructed file for viewing.

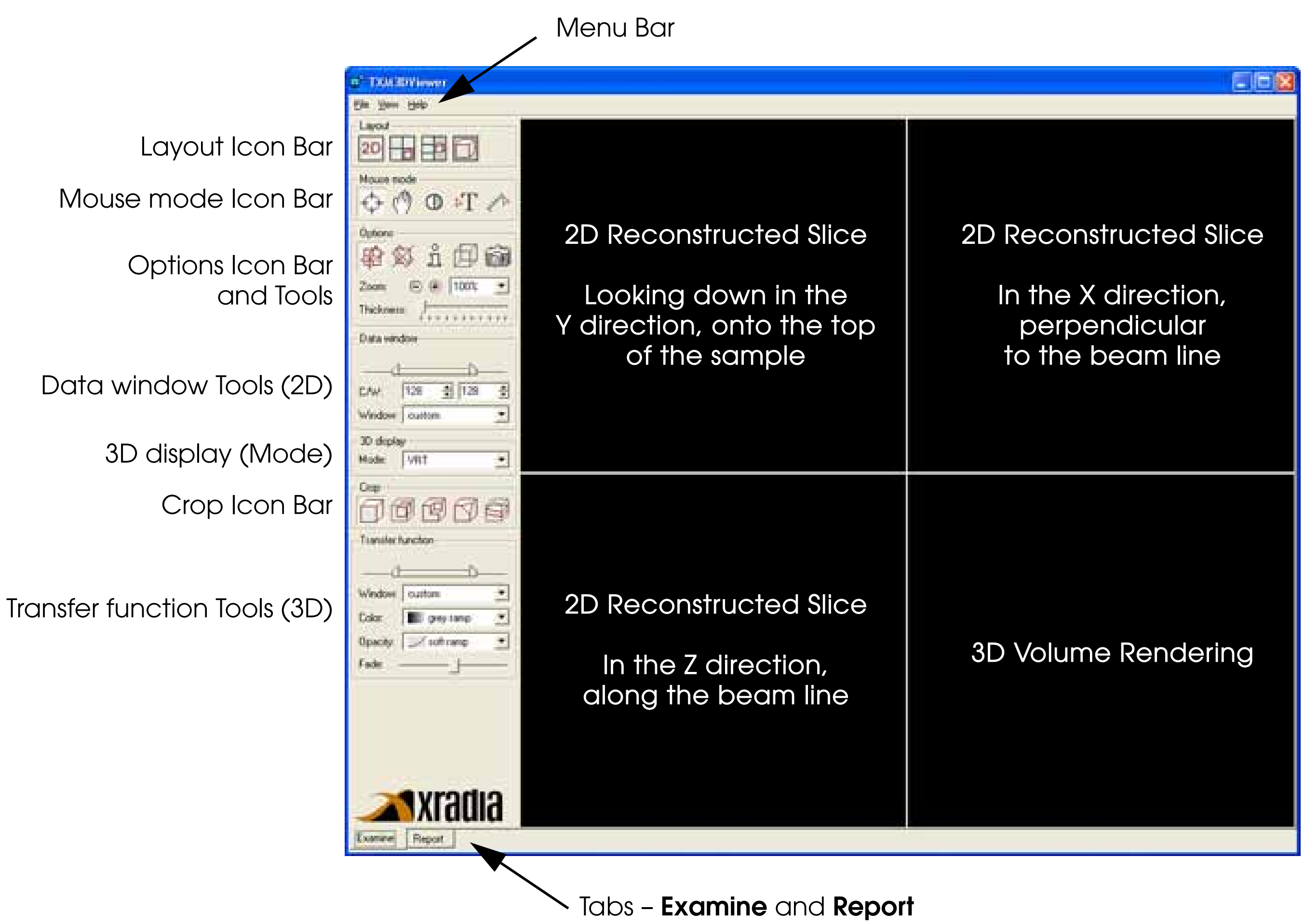
To start XM3DViewer

1. Select **Start > All Programs > Xradia > MicroXCT 7.*x* > XM3DViewer 1.*x***. The **XM3DViewer** main window opens.

NOTE "x" is the program's current version number.

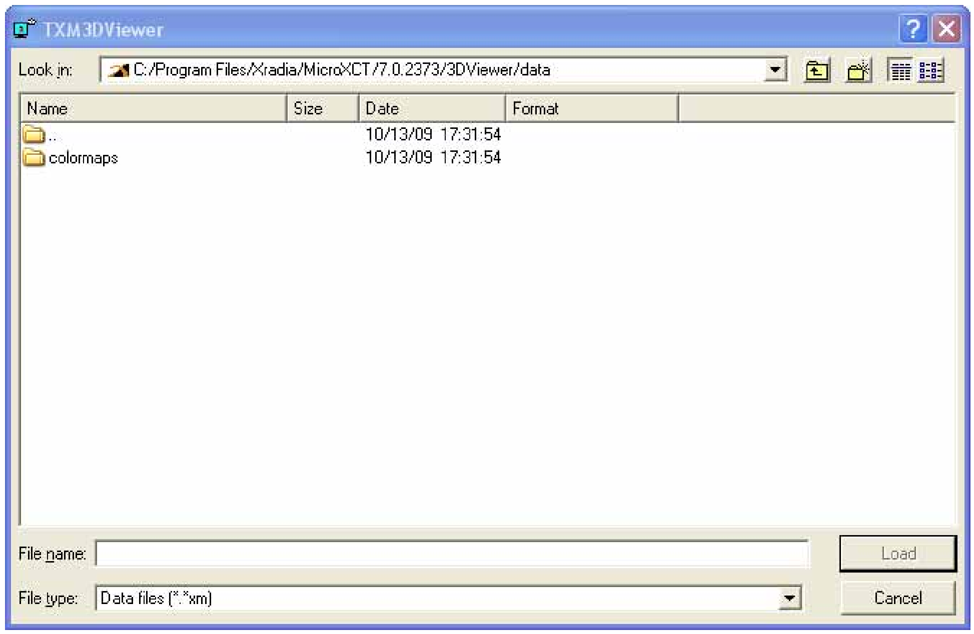
NOTE In its main window title bar, XM3DViewer appears as "**TXM3DViewer**," rather than as "**XM3DViewer**".

Figure 7-3 Default **XM3DViewer** Main Window – **Examine** Tab, with Descriptions of Each Quadrant



2. Select **File > Open…**. The **Open File** dialog box opens.

Figure 7-4 **Open File** Dialog Box



3. Browse to the *destination file path*, then locate the *reconstructed file that you want to open* (*_Recon.txm* is appended to the output file names of the Recipe function).

NOTE If you saved the reconstructed file to the desktop, the file is located in the **C:/Documents and Settings/*(Your Windows User Login Name)*/Desktop** path. In this file path, you will see only the files created with that Login Name.

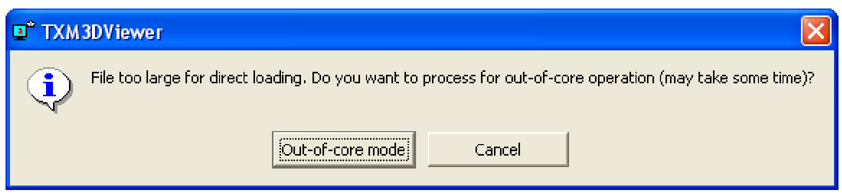
NOTE If you saved the reconstructed file to another hard disk drive, click the **Look in** drop-down list box, then browse to and select the *correct drive and destination file path*.

4. **Double-click the *file name* to open the file. A status window opens, statusing the file upload, then closes when the file upload is complete.**

NOTE If the file is too large for the graphics adapter memory (larger than the available memory (RAM) capacity on the workstation), a dialog box opens, requesting for the file to be processed out-of-core. If this occurs, click **Out-of-core mode** to continue loading the file. An **XM3DViewer** status window opens, indicating the out-of-core operation's progress.

During this process, XM3DViewer generates two files – **.txm-exm* and **.txm-exm-ooc* – whenever you open a **.txm* file that is larger than the available memory (RAM) capacity on the workstation. These files are accessed during viewing of reconstructed results on the XM3DViewer. These files can be quite large (on the order of a few gigabytes), and should be deleted after generating reports and creating movies.

Figure 7-5 "**Out-of-core mode**" Dialog Box



Adjusting and Navigating the Reconstructed 2D Slices

After the processing is complete, images appear in each of the four panels in the **XM3DViewer** main window. (Refer to Figure 7-3.)

The processes described in this section provide general guidelines for gaining familiarity with XM3DViewer:

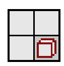
– Adjusting Contrast and Brightness in the 2D Reconstructed Slice Windows

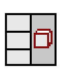
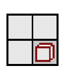
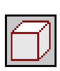
– Navigating the XM3DViewer Main Window

Each is described in the sections that follow.

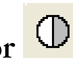
NOTE If it is obvious that something is not right, proceed directly to "Correcting Problems with the Reconstructed File."

NOTE Unlike earlier chapters of this guide, these processes can be performed out of sequence.

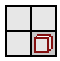
NOTE The guidelines provided in this section relate to the default layout of the main window, three equally sized 2D reconstructed slice windows and one 3D volume window, . (Refer to Figure 7-3.) The other layouts are listed below. All **four** are located in the Layout icon bar.

Icon	Description
	Click to display a single 2D reconstructed slice window. Click multiple times to cycle through the orientation of the slice in the 2D reconstructed slice window. When clicked, adds **Cine controls** to the main window (left side, below the other icon bars and tools).
	Click to display three equally sized 2D reconstructed slice windows, plus one larger 3D volume window. Displays the same four images as .
	Click to display a single 3D volume window (not used for 2D reconstructed slices).

Adjusting Contrast and Brightness in the 2D Reconstructed Slice Windows

This process describes how to adjust contrast or brightness in the 2D reconstructed slice windows, using the **Data window** slider or  **Mouse mode** icon.

To adjust contrast and brightness in the 2D reconstructed slice windows

1. Click  in the **Layout** icon bar.
2. Select **2D bilinear filter** from the **View** drop-down menu, to turn ON the 2D bilinear filter. This provides for less noisy 2D reconstructed slice images.
3. Use the **Data window** slider to adjust the contrast and brightness of the reconstructed slices (2D reconstructed slices on the top and bottom left and top right quadrants), using the processes described in the following table.

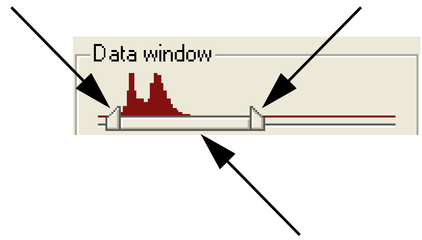
Adjustment Needed	Process
Contrast	Use the mouse pointer to click and drag the endpoints of the bar to the LEFT or RIGHT, to change the minimum and maximum contrast values of the *Data window* range.
Brightness	Use the mouse pointer to click and drag the center bar to the LEFT or RIGHT to change the *Data window* position along the histogram values, and thereby change the brightness.

Figure 7-6 Using the **Data window** Slider

Drag the endpoints to change the **contrast**

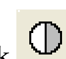
Drag toward the RIGHT

Drag toward the LEFT



Drag the center bar LEFT/RIGHT
to change the **brightness**

Changes in contrast and brightness can also be achieved within any of the three 2D reconstructed slice windows, using the processes described in the following table.

Adjustment Needed	Process
Contrast	Click  in the **Mouse mode** icon bar, then use the mouse pointer to click and drag UP or DOWN within any of the 2D reconstructed slice windows, to change the contrast (window width).
Brightness	Click  in the **Mouse mode** icon bar, then use the mouse pointer to click and drag LEFT or RIGHT within any of the 2D reconstructed slice windows, to change the brightness (window center).

NOTE In the **Data window** Tools, leave the **Window** option selected as *custom* to avoid potential problems. For example, if you changed the **Window** option to *CT Default*, all the 2D reconstructed slices will turn white, and you will not be able to see the slices. If this occurs, use the mouse pointer to click and drag the right endpoint on the **Data window** slider to the RIGHT, to improve the contrast and brightness of the 2D reconstructed slice. The **Window** option will change back to *custom*.

Navigating the XM3DViewer Main Window

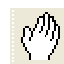
This process describes how to navigate the **XM3DViewer** main window, by walking you through common tasks.

To navigate the XM3DViewer main window

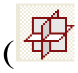
1. Use the navigation cross-hairs in the 2D reconstructed slice sections (colored lines), to change position in all the 2D reconstructed slice windows. (Refer to Figure 7-3.)

   For example, move the **green** line in the upper left quadrant to locate the region of interest in the bottom left quadrant (**green** frame). Do the same with the **blue** line and corresponding **blue** frame, and then the **red** line and corresponding **red** frame, to identify the layers in which the region of interest lies.

NOTE Green = X/Z, blue = X/Y, and red = Y/Z.

2. Use the **Zoom** controls,  and , described in the following table, to make the complete slice visible within the 2D reconstructed slice windows.

Zoom Control	Description
	Click to Zoom OUT.
	Click to Zoom IN.
	Select a *zoom percentage* from the drop-down list box.
	Click this icon in the **Mouse mode** icon bar, then, with the center-mouse button pressed, use the mouse pointer to click and drag UP and DOWN, within any 2D reconstructed slice window, to zoom IN and OUT, respectively.

3. Orthogonal Slicing mode ( in the **Options** icon bar) positions the cross-hairs orthogonally – this is the default slicing mode.

   If the region of interest is not on the orthogonal plane, click  in the **Options** icon bar to use *Oblique Slicing mode*. This places the region on one plane, rotating the **green**, **blue**, or **red** cross-hairs to line the planes up with the region of interest.

NOTE Use of Oblique Slicing mode reduces image resolution.

4. Select **MPR** (Multi-Planar Rendering) from the **3D display** mode drop-down list box, to display the 2D reconstructed slices as planes in 3D space within the 3D volume window (lower right quadrant). This can help you to better observe the spatial interrelations of the three planes (**green**, **blue**, and **red**).

5. Under **Options**, use the mouse pointer to click and drag the **Thickness** slider to the RIGHT, to sum the slices between the dashed lines and produce a less-noisy image.

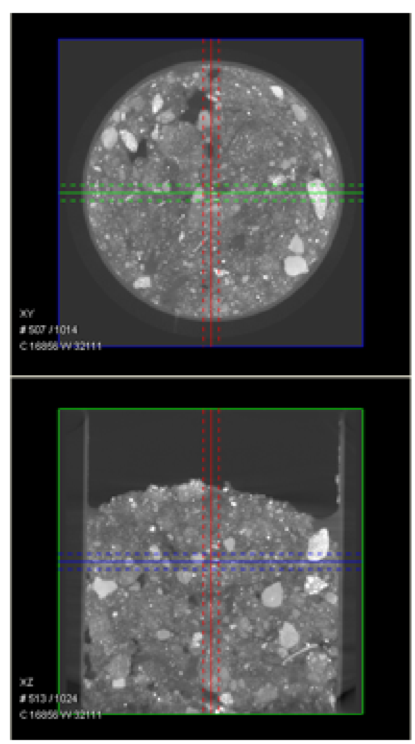
   The thickness of the slice is illustrated by dashed lines in the **Slice** areas. Use the mouse pointer to click and drag the **Thickness** slider to the LEFT to reduce the thickness.

Figure 7-7 Increasing the Thickness of 2D Reconstructed Slices

The slices between the two dashed, horizontal **blue** lines (B, center of image) are summed to create the image shown on the **blue** plane (A, entire image)

A

B



6. If you need to adjust the image contrast and/or brightness, follow the processes described in "Adjusting Contrast and Brightness in the 2D Reconstructed Slice Windows," step 3.

   When the 2D reconstructed slice images look as they should, per your requirements, proceed to the next process:

   – If you have already located the region(s) of interest, proceed to "Collecting Images (or Pictures) for a Report"

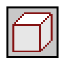
   – If you want to work with 3D rendering, proceed to "Creating 3D Volume Renderings"

Creating 3D Volume Renderings

This process describes how to create a 3D volume rendering that can be used in reports or movies. After a reconstructed file (**.txm*) is loaded, images appear in each of the four panels in the **XM3DViewer** main window. In the default view, the 3D volume window is the lower right quadrant of the main window. (Refer to Figure 7-3.)

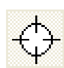
NOTE Unlike earlier chapters of this guide, this process can be performed out of sequence.

To create a 3D volume rendering

1. Click the  in the **Layout** icon bar to open the single 3D volume window.

2. The **3D display** mode should be defaulted to VRT (volume rendering technique). If it is not defaulted to VRT, select *VRT* from the **Mode** drop-down list box.

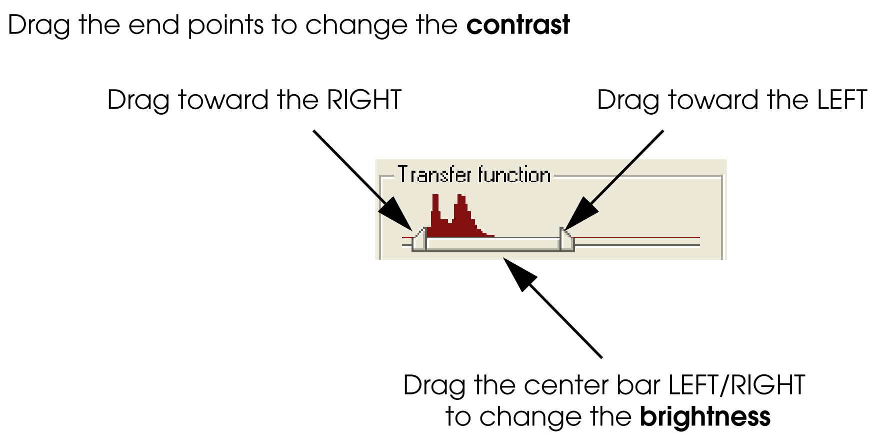
NOTE VRT is the only 3D display mode that is described in this guide. For information regarding the other 3D display modes, refer to the *Xradia ExamineRT Workstation 1.1 User's Manual*, available under XM3DViewer's **Help** menu.

3. Use the  or , available in the **Mouse mode** icon bar, to tilt the 3D volume, by using the mouse pointer to click and drag within the 3D volume window.

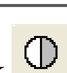
4. Use the **Transfer function** slider to adjust the contrast and brightness of the 3D volume, using the processes described in the following table. Use of these processes changes the mapping from actual input data values to display output values.

Adjustment Needed	Process
Contrast	Use the mouse pointer to click and drag the endpoints of the bar to the LEFT or RIGHT, to change the contrast.
Brightness	Use the mouse pointer to click and drag the center bar to the LEFT or RIGHT, to change the *Transfer function* along the histogram values, and thereby change the brightness.

Figure 7-8 Using the **Transfer function** Slider



Changes in contrast and brightness can also be achieved in the 3D volume window/quadrant, using the processes described in the following table.

Adjustment Needed	Process
Contrast	Click  in the **Mouse mode** icon bar, then use the mouse pointer to click and drag UP or DOWN within the 3D volume window, to change the contrast (window width).
Brightness	Click  in the **Mouse mode** icon bar, then use the mouse pointer to click and drag LEFT or RIGHT within the 3D volume window, to change the brightness (window center).

NOTE Steps 5 through 7 reference tasks that use additional **Transfer function** controls.

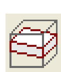
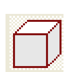
NOTE In the **Transfer function** Tools, leave the **Window** option selected as *custom* to avoid potential problems. For example, if you changed the **Window** option to *CT Default*, the 3D volume becomes a white cube, and you will not be able to see the 3D volume data. If this occurs, use the mouse pointer to click and drag the right endpoint on the **Transfer function** slider to the RIGHT, to improve the contrast and brightness of the 3D volume. The **Window** option will change back to *custom*.

5. Use the mouse pointer to click and drag the **Fade** slider LEFT or RIGHT, to adjust the fade level, to make internal features visible.

6. Alternate using the mouse pointer to click and drag the **Transfer function** (contrast and brightness) and **Fade** sliders, to obtain a desirable 3D rendering.

7. Select different **Color** and **Opacity** drop-down list box *options*, then repeat step 6 to obtain the optimum effect with the newly selected options.

8. Isolate the region of interest within the 3D reconstructed volume, by clicking  in the **Crop** icon bar to isolate a region smaller than the complete volume. Use the remaining **Crop** icons, as needed, to obtain the effect that you want.

Icon	Description
	Click to enable cropping a corner within the 3D reconstructed volume.
	Click to enable creating a diagonal area within the 3D reconstructed volume.
	Click to enable creating a parallel slice within the 3D reconstructed volume.
	No crop (default). Click to omit any previously applied cropping.

NOTE For further details regarding these cropping functions, refer to the *Xradia ExamineRT Workstation 1.1 User's Manual*, available under XM3DViewer's **Help** menu.

Collecting Images (or Pictures) for a Report

This process describes how to collect images (or pictures) of the sample, to be used in "Generating a Report." The information you will collect depends upon what is needed to be known/reported.

If you are not the owner of the sample, ask the owner to identify what information is needed. For example, if the purpose of imaging is to identify a crack in a particular area of the sample, the images that you collect for the report should highlight the presence and location of the crack.

The processes are different, depending upon whether you are processing cross-sectional 2D reconstructed slices or 3D volumes:

- Visualize, Measure, and Capture Internal Structure on 2D Reconstructed Slices
- Visualize, Measure, and Capture Internal Structure on 3D Volumes

Each is described in the sections that follow.

NOTE Unlike earlier chapters of this guide, these processes can be performed out of sequence.

Visualize, Measure, and Capture Internal Structure on 2D Reconstructed Slices

This process describes how to create images from 2D reconstructed slices, to illustrate the region of interest in a sample, for use in a report.

To visualize, measure, and capture the internal structure on 2D reconstructed slices

1. Click  in the **Layout** icon bar to display the single 2D reconstructed slice window.

2. Click  again, once per plane, to scroll through the **green**, **blue**, and **red** 2D planes, to see different views of each slice.

3. Select to **View > Scale bar**. This inserts a scale at the bottom of the window, which provides a reference for the size of the region shown.

4. Use the keyboard's **UP** and **DOWN** arrow keys to scroll through the different slices, to identify a 2D reconstructed slice of interest.

5. If you want to add a measurement line, click  in the **Mouse mode** icon bar to enable Measurement mode. In the 2D reconstructed slice window, at the slice's region of interest, click once to define the start point for measuring, then again to define the endpoint for measuring.

NOTE To remove an erroneous measurement line, click the line to select it (line changes from **blue** to **yellow**), then press the **Delete** key on the workstation keyboard.

If Measurement mode is not the active mode, click  to enable it, then proceed with the removal process described above.

6. If you want to apply arrow and text annotations, click in the **Mouse mode** icon bar, to enable Annotation mode and apply the annotations:

Annotation	Process
Arrow	Click within the 2D reconstructed slice window at the point you want to start the arrow, then click again to at the point you want to end the arrow.
Text associated with the arrow	Double-click the arrow, then type the text you want to add.

NOTE To remove an erroneous annotation, click the annotation to select it (annotation changes from **blue** to **yellow**), then press the **Delete** key on the workstation keyboard.

If Annotation mode is not the active mode, click to enable it, then proceed with the removal process described above.

7. After isolating and marking the region(s) of interest in the selected slice, click in the **Options** icon bar, move the mouse onto the 2D reconstructed slice, then click to take a picture (snapshot) of the slice. This saves a picture of the 2D reconstructed slice in the **Snapshots** panel of the **Report** tab. (Refer to Figure 7-9.)

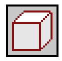
8. Repeat steps 1 through 7 for all 2D reconstructed slices that are of interest.

   When finished, proceed to "Generating a Report."

Visualize, Measure, and Capture Internal Structure on 3D Volumes

This process describes how to create images from a 3D volume, to illustrate the region of interest in a sample, for use in a report.

To visualize, measure, and capture the internal structure on 3D volumes

1. Click  in the **Layout** icon bar to bring up the single 3D volume rendering window.

2. Click  in the **Mouse mode** icon bar, to enable and use the following *mouse functions:*

Function	Process
Rotate the image	Use the mouse pointer to click and drag within the 3D volume window.
Zoom IN and OUT	With the left- and center-mouse buttons simultaneously pressed, use the mouse pointer to click and drag UP and DOWN, respectively, within the 3D volume window.
Pan	With the center-mouse button pressed, use the mouse pointer to click and drag within the 3D volume window.

3. Follow steps a and b if you want to include a distance reference:

   a. Cancel the **3D perspective** selection under **View** menu. This causes the image in the 3D volume window to appear out of perspective, which is necessary when including a distance reference.

   b. Select **View > Scale bar** to insert a scale bar at the bottom of the 3D volume window, to provide a size reference.

4. Follow steps a through c if you want to add a measurement line:

   a. Cancel the **3D perspective** selection under **View** menu (if you did not already cancel it in step 3a). This causes the image in the 3D volume window to appear out of perspective, which is necessary when adding a measurement line.

   b. Click  in the **Mouse mode** icon bar, to enable Measurement mode.

c. In the 3D volume window, at the region of interest, click once to define the start point for measuring, then again to define the endpoint for measuring.

NOTE To remove an erroneous measurement line, click the line to select it (line changes from **blue** to **yellow**), then press the **Delete** key on the workstation keyboard.

If Measurement mode is not the active mode, click  to enable it, then proceed with the removal process described above.

5. If you want to apply arrow and text annotations, click  in the **Mouse mode** icon bar, to enable Annotation mode and apply the annotations:

Annotation	Process
Arrow	Click within the 3D volume window at the point you want to start the arrow, then click again at the point you want to end the arrow.
Text associated with the arrow	Double-click the arrow, then type the text you want to add.

NOTE To remove an erroneous annotation, click the annotation to select it (annotation changes from **blue** to **yellow**), then press the **Delete** key on the workstation keyboard.

If Annotation mode is not the active mode, click  to enable it, then proceed with the removal process described above.

6. After isolating and marking the region(s) of interest, click  in the **Options** icon bar, move the mouse onto the 3D volume, then click to take a picture (snapshot) of the 3D volume. This saves a picture of the 3D volume in the **Snapshots** panel of the **Report** tab. (Refer to Figure 7-9.)

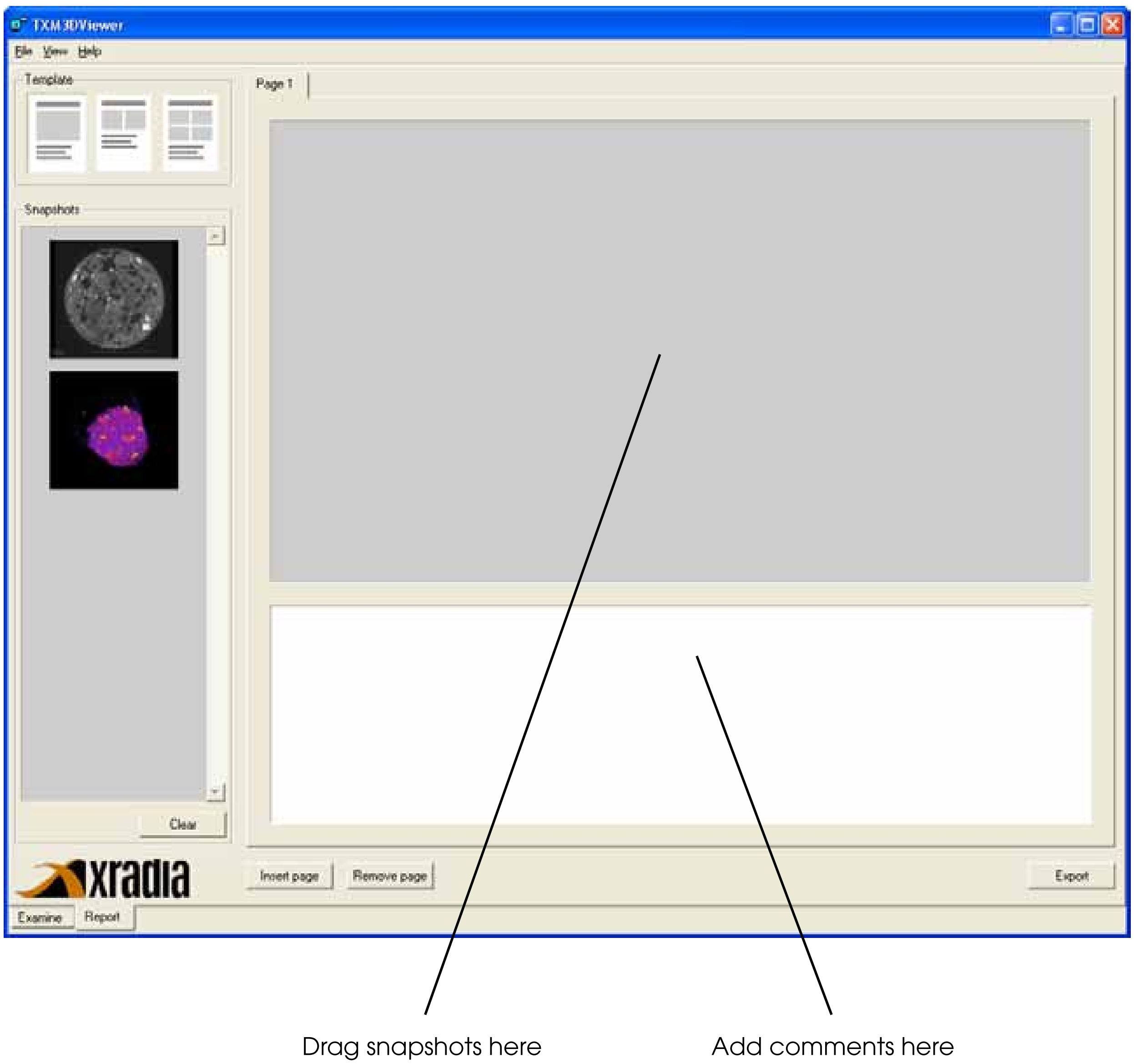
7. Repeat steps 1 through 6 for all 3D reconstructed volumes that are of interest.

When finished, proceed to "Generating a Report."

Generating a Report

This process describes how to generate a report, using the images that you created and modified in "Collecting Images (or Pictures) for a Report."

Figure 7-9 **XM3DViewer** Main Window – **Report** Tab



To generate a report

1. Click the *report layout that you want to use* from **Template**. That layout opens in the report screen, in the selected **Page *x*** tab.

2. Use the mouse pointer to click and drag snapshots onto the **Page *x*** tab, according to the chosen layout.

3. To add comments, type the comment text in the bottom panel (white space) of the page.

4. To add a page, click **Insert page**.

5. To remove a specific page, select the appropriate ***Page x*** tab, then click **Remove page**.

6. When you have finished combining the captured data that you want to include in the report, click **Export** to export and save the file as a formatted Microsoft Word **.doc* document, to a specific *destination path*.

   You can open and edit the file as you typically would a Word document.

NOTE The Word document includes a title page, the exported information, and closes the report with "Sincerely, RADIOLOGIST".

NOTE The images exported in the document can be copied into other types of documents, such as a Microsoft PowerPoint presentation or Excel spreadsheet.

Creating Movies of Cross-Sectional 2D Reconstructed Slices and 3D Volumes

This process describes how to create an animation (movie) of captured data, using the **Cine controls**. The instructions are slightly different, depending upon whether you are processing cross-sectional 2D reconstructed slices or 3D reconstructed volumes:

- Creating Movies of 2D Reconstructed Slices
- Creating Movies of 3D Reconstructed Volumes

Each is described in the sections that follow.

NOTE Unlike earlier chapters of this guide, these processes can be performed out of sequence.

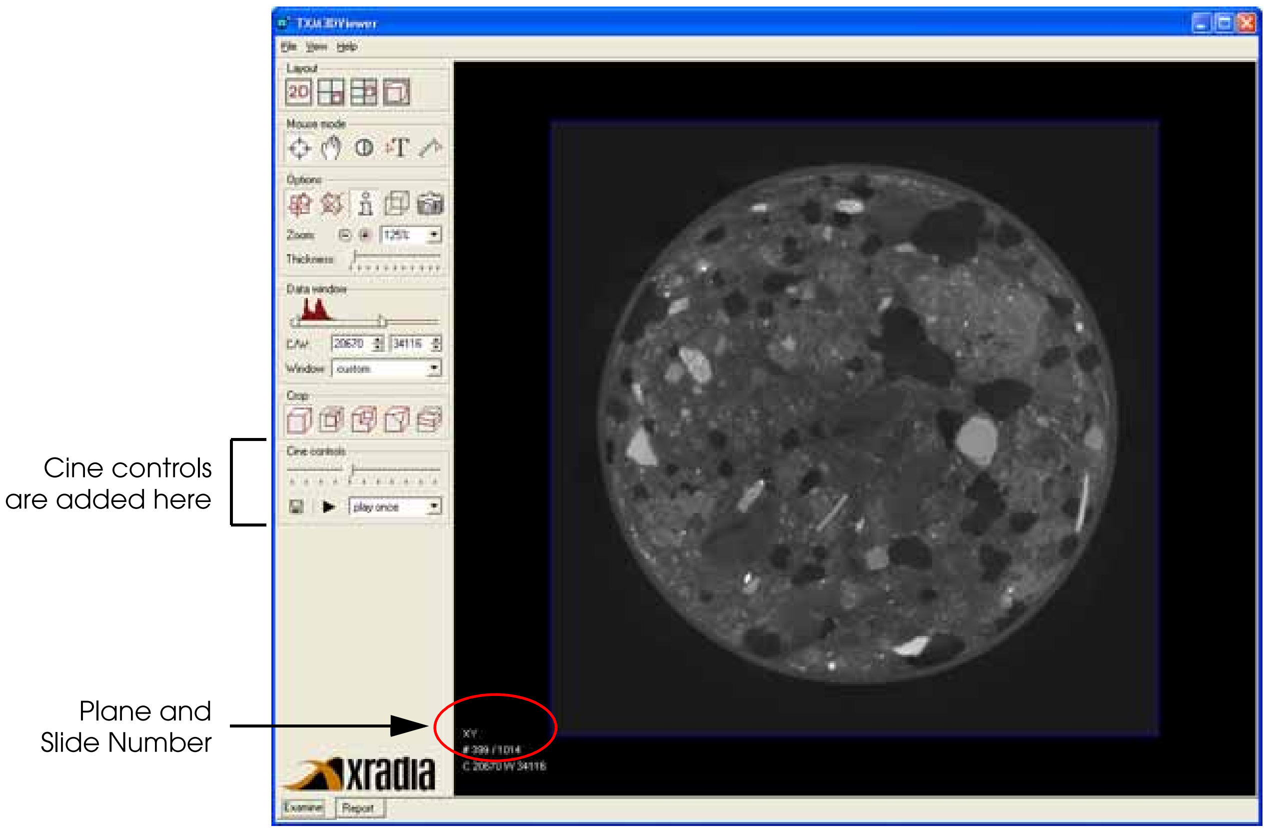
Creating Movies of 2D Reconstructed Slices

This process describes how to create a movie of 2D reconstructed slices, using the **Cine controls**.

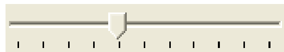
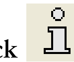
To create a movie of 2D reconstructed slices

1. Click 2D in the **Layout** icon bar. **Cine controls** appear below the **Crop** icon bar area.

Figure 7-10 **Cine controls** (Added to **XM3DViewer** Main Window)

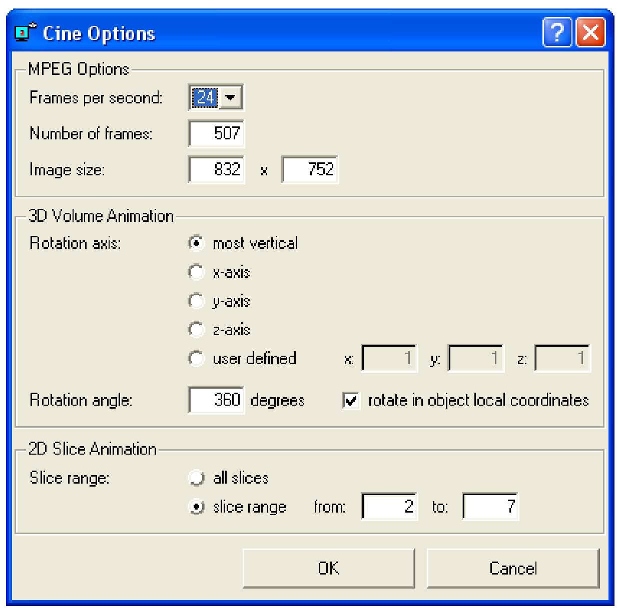


2. Use the following *Cine controls* to identify slices of interest, and specify how often to play them in the movie:

Option	Description
	Use the slider to scroll through the 2D reconstructed slices, to identify slices of interest (the slice numbers appear in the bottom left of the screen, indicated in white; if the slice numbers are not visible, click  to display them). Note the *beginning and ending slice numbers* to be saved as the movie. This information is used later, in step 4.
	From the drop-down list box, select whether to scroll through the 2D reconstructed slices once (*play once*; default) or *continuously*, in a loop.

3. Click  under **Cine controls**. The **Cine Options** dialog box opens.

Figure 7-11 **Cine Options** Dialog Box

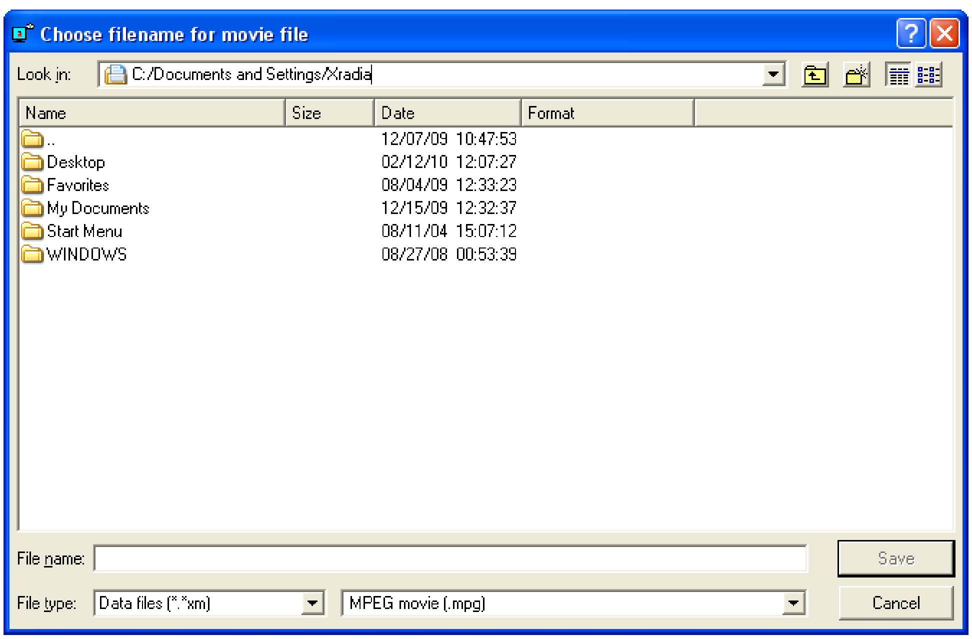


4. Select and/or type the following *cine option setting values*:

Option	Setting Value
Frames per second	*24* is a good value to use
Number of frames	*Allow to default*
Image size	*Allow to default*
3D Volume Animation	*N/A*
2D Animation	*Slice Range* Type the *beginning and ending slice numbers* noted in step 2, in the **from** and **to** text boxes, respectively

5. Click **OK**. The **Choose filename for movie file** dialog box opens, defaulted to the *MPEG movie (.mpg)* file type.

Figure 7-12 **Choose filename for movie file** Dialog Box



6. Browse to the *destination file path*; type the *new file name* in the **File name** text box, then click **Save**.

NOTE The program automatically scrolls through the included 2D reconstructed slices and creates the movie. The window cannot be minimized and you cannot open another window until the movie completes.

7. When the movie completes, an **Info** message box opens with the message "MPEG file successfully written". Click **OK** to close the message box.

NOTE Instructions for removing the sample, after you are finished using it, are provided in Appendix E, "Removing the Sample after Use."

Creating Movies of 3D Reconstructed Volumes

This process describes how to create a movie of 3D reconstructed volumes, using the **Cine controls**.

To create a movie of a 3D reconstructed volume

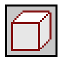
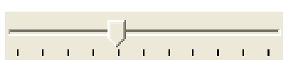
1. Click  in the **Layout** icon bar. **Cine controls** appear below **Transfer function**.

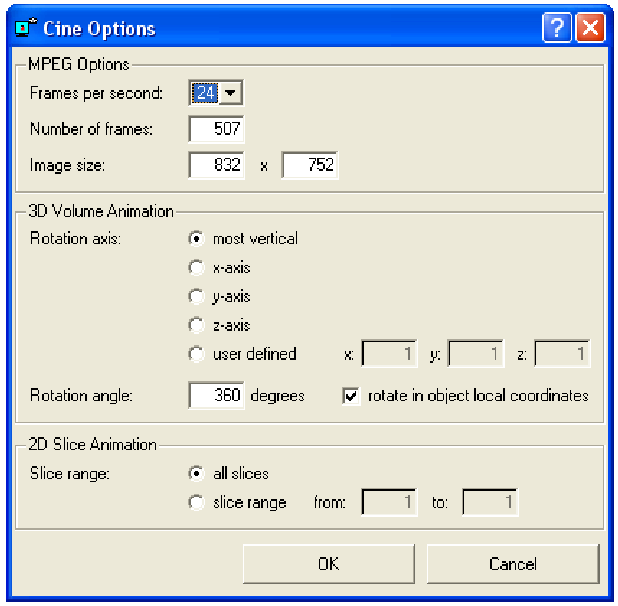
Figure 7-13 Cine controls

2. Use the following *Cine controls* to preview a 360° view, and specify how often to play the 3D volume in the movie:

Option	Description
	Use the slider to preview a 360° view.
	From the drop-down list box, select whether to play the 3D volume move once (*play once*; default) or *continuously*, in a loop.

3. Click  under **Cine controls**. The **Cine Options** dialog box opens.

Figure 7-14 **Cine Options** Dialog Box

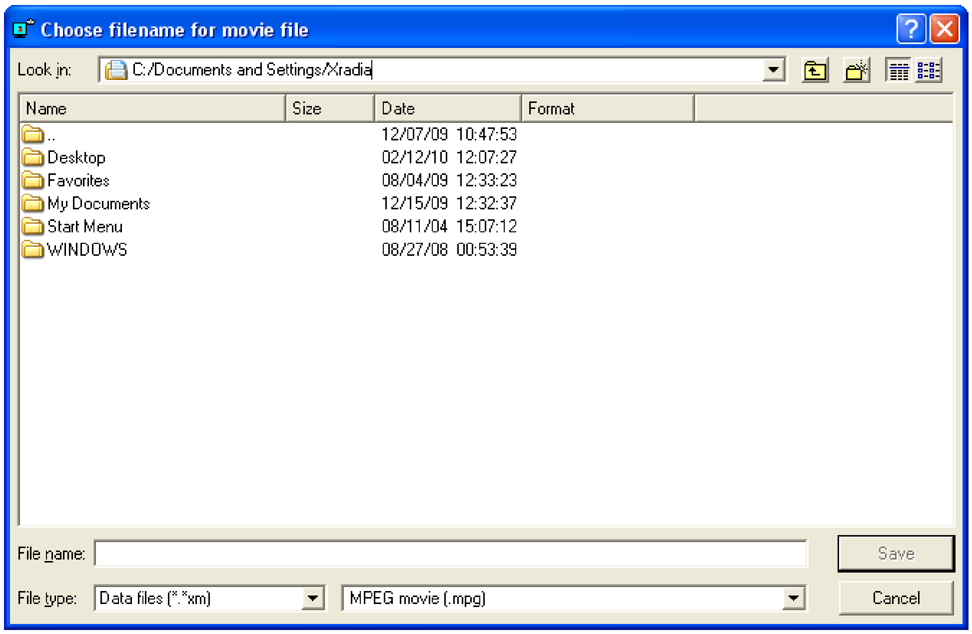


4. Select and/or type the following *cine option setting values*:

Option	Setting Value
Frames per second	*24* is a good value to use
Number of frames	*Allow to default*
Image size	*Allow to default*
Rotation axis	*Can be changed, as needed* If allowed to default (most vertical), the movie will be taken with the sample rotated about the vertical axis.
Rotation angle	*Allow to default*
2D Animation	*N/A*

5. Click **OK**. The **Choose filename for movie file** dialog box opens, defaulted to the *MPEG movie (.mpg)* file type.

Figure 7-15 **Choose filename for movie file** Dialog Box



6. Browse to the *destination file path*; type the *new file name* in the **File name** text box, then click **Save**.

NOTE XM3DViewer automatically scrolls through the 3D volume and creates the movie. The window cannot be minimized and you cannot open another window until the movie completes.

7. When the movie completes, an **Info** message box opens with the message “MPEG file successfully written”. Click **OK** to close the message box.

NOTE Instructions for removing the sample, after you are finished using it, are provided in Appendix E, “Removing the Sample after Use.”

Correcting Problems with the Reconstructed File

NOTE Unlike earlier chapters of this guide, this process can be performed out of sequence.

NOTE Troubleshooting tips specific to image contrast and brightness is described in "Troubleshooting Image Contrast, Brightness, and Light Intensity Count Issues," on page 226.

This section provides troubleshooting information for how to handle specific problems with reconstructed data:

– Table 7-1 lists "show stopper" problems, with probable cause and solutions

– Table 7-2 lists solutions to problems that require manual reconstruction

– Table 7-3 lists solutions to problems that require reimaging

Table 7-1 Show Stoppers

Problem	Probable Cause	Solution
Reconstruction failed (no reconstructed file)	Insufficient hard disk drive memory (depends upon the size of the acquired file before reconstruction).	Clean up the available space on the hard disk drive, then reconstruct the file again. The amount of free space required on the hard disk drive must be at least 1 GB more than the file size of the tomography (projection) dataset.
Blank file	Sample fell off the sample stage due to incorrect positioning or motor failure (check for errors in the **XMController** main window Status bar).	Reposition sample, detector, and X-ray source, then re-acquire the data. If the problem is due to motor failure, contact the Xradia Support Team.

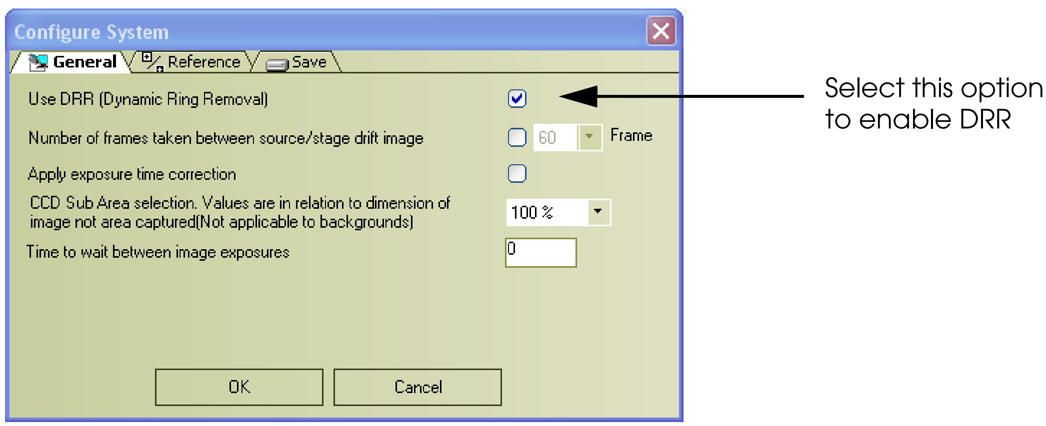
Table 7-2 Solutions to Problems that Require Manual Reconstruction

Problem	Solution
There are streaks or blurring in the image.	Correct the center shift (refer to "Identifying Center Shift," on page 155), then reconstruct the file.
The outer part of the sample looks more dense than the inside, and the sample is all the same material.	Correct Beam Hardening (refer to "Identifying Beam Hardening Correction," on page 160), then reconstruct the file.
Regions of the image are blurred.	Reconstruction filter kernel is too large. Repeat "Reconstructing the Tomography Data," on page 166, but in step 5, select a *Recon Filter with a smaller kernel size*.
Image is too noisy. Areas that are supposed to be smooth contain very large intensity variations over short lengthscales on the order of the pixel size.	Reconstruction filter kernel is too small. Repeat "Reconstructing the Tomography Data," on page 166, but in step 5, select a *Recon Filter with a larger kernel size*.

Table 7-3 Solutions to Problems that Require Reimaging

Problem	Solution
Magnification is insufficient – cannot see fractures or other flaws down to a sufficiently fine detail.	Repeat scan at a higher magnification, if it has not already been done.
There are too many rings and DRR (dynamic ring removal) was not turned ON.	Select **Microscope** > **Configure System**, select **Use DRR (Dynamic Ring Removal)** in the **General** tab (default), click **OK**, then repeat the scan. (Refer to Figure 7-16.)
Region of interest has streaks (sample may have moved during imaging).	Securely mount the sample on the sample holder; reposition the X-ray source and detector so that they do not collide with nor touch the sample. (Refer to "Finely Positioning the Detector," on page 71, and "Finely Positioning the X-ray Source," on page 75.) Repeat the scan.

Figure 7-16 **Configure System** Dialog Box – **General** Tab, with **Use DRR** Selected



THIS PAGE INTENTIONALLY LEFT BLANK

A Troubleshooting

This appendix describes how to resolve common issues that may be encountered when using the MicroXCT:

- Issues that Require Xradia Assistance
- Troubleshooting Sample Issues in XMController
- Troubleshooting Magnification Lens Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View
- Troubleshooting Image Contrast, Brightness, and Light Intensity Count Issues
- Troubleshooting Issues with XM3DViewer
- Troubleshooting MicroXCT Power Failures
- Troubleshooting Light Tower Issues

as well as Xradia Support Team contact information. If the suggested solutions do not resolve the problem, refer to "Contacting the Xradia Support Team (Technical Support)."

Issues that Require Xradia Assistance

Table A-1 and Table A-2 list hardware and software issues, respectively, that must be referred to the Xradia Support Team for resolution.

WARNING Do not attempt to troubleshoot these issues on your own, because doing so will violate the product warranty and/or cause potential physical harm.

Table A-1 Hardware Problems that Require Xradia Support Team Assistance

<table>
<tr><th>Symptom(s)</th><th>Problem</th></tr>
<tr><td>Source Controller in XMController indicates that the X-ray source turns ON, but then turns OFF almost immediately and the Alarm button on the front of the PDU is lit.</td><td>Light tower is malfunctioning. Refer also to “Troubleshooting Light Tower Issues.”</td></tr>
<tr><td>One or more PDU power breakers are tripped (in the DOWN position).
DO NOT RESET THE BREAKER.</td><td>Power to one or more of the MicroXCT components is turned OFF and/or the MicroXCT is malfunctioning.</td></tr>
<tr><td>Xray button label does not change to red ON when turning ON the X-ray source.</td><td rowspan="2">X-ray source does not turn ON after closing the access door(s) and clicking the green OFF Xray button in the Xray Source dialog box. Refer also to “Troubleshooting Light Tower Issues.”</td></tr>
<tr><td>Light tower’s red light does not turn ON.</td></tr>
<tr><td>Light tower’s yellow light does not turn ON when the access door(s) are closed.</td><td rowspan="2">Safety interlock is malfunctioning.</td></tr>
<tr><td>Light tower’s yellow light is ON; however, the Interlock indicator in the Xray Source dialog box indicates OPEN.</td></tr>
<tr><td>Non-Macro magnification lens was selected, but the motorized turret does not rotate the selected lens into position.</td><td>Motorized turret is malfunctioning.</td></tr>
<tr><td>Homing Status dialog box indicates homing errors:
– “… followed out on coarse home”
– “… followed out on fine home”</td><td rowspan="2">One or more of the axes (Source Z, Camera Z, Sample X, Y, Z, and/or Theta) will not move or cannot be changed/homed.</td></tr>
<tr><td>Axis does not move after clicking GO in any one of the Motion Controller dialog box tabs.</td></tr>
</table>

Table A-1 Hardware Problems that Require Xradia Support Team Assistance (Continued)

<table>
<tr><th>Symptom(s)</th><th>Problem</th></tr>
<tr><td>Any axis (Source Z, Camera Z, Sample X, Y, Z, and/or Theta) does not move, moves erratically, or vibrates when moving.</td><td rowspan="3">MicroXCT motion controller or motor(s) are malfunctioning.

NOTE If the MicroXCT has just completed manual or automatic axis homing, it is normal for the red Error message bar to appear. To resolve this, click the drop-down arrow to the right of  in the icon bar, select a magnification lens, then click the red Error message bar to close the message bar.</td></tr>
<tr><td>Program running on the MicroXCT issues an “Unable to communicate with the (motion or source) controller” message.</td></tr>
<tr><td>Red Error message bar appears at the bottom of the XMController main window. Click or hover the mouse pointer over the Log Window label (bottom left corner of the XMController main window), then scroll through the acquisition log to locate error lines in red. The errors listed can indicate Error FATAL or Error Warning.</td></tr>
<tr><td>XMController Acquisition Setting dialog box indicates the camera temperature is $\geq$ -55°C.</td><td>CCD does not reach operating temperature, $<$ -55°C.</td></tr>
</table>

Table A-2 Software Problems that Require Xradia Support Team Assistance

Symptom(s)	Problem
Image quality is not the same quality as achieved in prior acquisitions that used the same parameters.	Image quality is degraded.
Errors indicate a problem that cannot be easily user-remedied.	Status window or dialog box indicates severe errors.

Troubleshooting Sample Issues in XMController

This section provides tips for troubleshooting the following sample-related issues that you might experience when using XMController:

- Sample Is Unstable
- Sample Is Not Visible on the Visual Light Camera Monitor
- Sample Region of Interest Is Not Visible
- Sample and Detector Collision Is Imminent
- Sample and Detector Collided
- Sample and X-ray Source Collision Is Imminent
- Sample and X-ray Source Collided

Sample Is Unstable

NOTE Mounting and installation of the sample are discussed in "Mounting the Sample in/on a Sample Holder," on page 33, and "Installing the Sample," on page 39, respectively. If you need to remount or install the sample, refer to the relevant processes described in those sections.

Symptom Sample is wobbly (unstable) on the sample stage or in its holder; acquired images are blurry and unfocused.

Problem Sample is not properly mounted or installed.

Solution ***To stabilize the sample***

1. In XMController, open the **Motion Controller** dialog box. In the **Source** tab, note the *current Source Z position*. In the **Detector** tab, note the *current Camera Z position*. These values are used later, in step 8.

2. Follow the processes described in "Loading the Sample Holder Assembly onto the Sample Stage," steps 3 through 7, starting on page 44, to move the X-ray source and detector away from the sample stage, turn OFF the X-ray source, and open the access door.

3. Ensure that the flat edges of the sample holder and sample stage are aligned. (Refer to Figure 2-12, "Sample Holder Assembly Loaded onto the Sample Stage, with Flat Edges Aligned, Facing the Front of the MicroXCT (Clip Sample Holder Shown)," on page 47.)

4. Ensure that the tungsten balls on the sample stage are fitted into the indentations on the underside of the sample holder. (Refer to Figure 2-11, "Sample Stage, with Tungsten Alignment Balls Highlighted," on page 47.)

5. Ensure that the sample is securely mounted in/on the sample holder.

6. Ensure that the sample is stable, such that it does not move nor vibrate in response to gentle tapping on the sample holder.

7. Follow steps a through d if the sample must be repositioned in/on the sample holder:

   a. Remove the sample holder from the sample stage.

   b. Adjust the sample's position in the sample holder, based upon the criteria identified in steps 5 and 6.

NOTE The sample mounting instructions vary by sample holder type. Instructions for each holder type is provided in Chapter 2, starting at "Mounting the Sample in/on a Sample Holder," on page 33.

   c. Load the sample holder back onto the sample stage, using the processes described in "Loading the Sample Holder Assembly onto the Sample Stage," on page 41.

   d. Repeat steps 3 through 6.

8. Follow steps a and b to move the X-ray source and detector back to their original positions noted in step 1:

   a. In the **Motion Controller** dialog box **Source** tab, type the *original current Source Z position* in the **Source Z** text box, then click **GO**.

   b. In the **Motion Controller** dialog box **Detector** tab, type the *original current Camera Z position* in the **Camera Z** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

9. Follow the processes described in "Turning on the X-ray Source," steps 1 through 3, starting on page 58, to close the access door and then turn ON the X-ray source.

   If you resume the process in which you determined there was an issue, and the issue still exists, contact the Xradia Support Team for assistance.

Sample Is Not Visible on the Visual Light Camera Monitor

NOTE Mounting and installation of the sample are discussed in "Mounting the Sample in/on a Sample Holder," on page 33, and "Installing the Sample," on page 39, respectively. If you need to remount or install the sample, refer to the relevant processes described in those sections.

Symptom Sample is not visible on the visual light camera monitor.

Problem Interior light might be turned OFF; sample is not properly installed; sample is out of the field of view (FOV).

Solution ***To make the sample visible on the visual light camera monitor***

1. Ensure that the visual light camera monitor is turned ON.

NOTE When the visual light camera monitor is turned ON, you should see the sample stage (if the access door(s) is (are) closed) or yourself (if the access door(s) is (are) open). If you do not see anything on the monitor, press its **Power** button, to turn ON the monitor. If the visual light monitor remains blank after ensuring that the monitor is turned ON, contact the Xradia Support Team for assistance.

2. Ensure that the visual light camera light switch (D on Figure 1-7, "Ergonomic Station," on page 16) is in the UP (ON) position, and that the interior light is ON.

NOTE If the switch is in the ON position, and the light is **not** ON, contact the Xradia Support Team.

3. With the access door(s) closed, visually verify that the:
   - Sample is securely mounted in/on the sample holder, and has not slid from view, and that its region of interest is:
     - Facing up
     - Located above the top surface of the holder
     - Positioned so that the least amount of material is penetrated by X-ray
   - Sample holder is properly loaded onto the sample stage (refer to "Loading the Sample Holder Assembly onto the Sample Stage," on page 41)
   - Detector and X-ray source are situated as close as possible to the sample, without colliding with nor touching the sample

4. **If it is difficult to see the sample due to glare, use the monitor's brightness control to reduce the glare, until the sample is visible.**

NOTE Two models of visual light camera monitors are currently in use. One has self-descriptive control buttons, and the other has control buttons represented by icons. Instructions for using the latter to adjust monitor glare is provided in Appendix D, "Visual Light Camera Monitor Brightness Controls."

If you resume the process in which you determined there was an issue, and the issue still exists, contact the Xradia Support Team for assistance.

Sample Region of Interest Is Not Visible

NOTE Mounting and installation of the sample are discussed in "Mounting the Sample in/on a Sample Holder," on page 33, and "Installing the Sample," on page 39, respectively. If you need to remount or install the sample, refer to the relevant processes described in those sections.

Symptom Region of interest (the focus of the data to be acquired) is not visible.

Problem Sample is not properly mounted nor installed, or is out of the field of view (FOV).

Solution ***To make the sample region of interest visible***

1. Try reducing the magnification level by one step at a time, until the region of interest is visible. In XMController, click the drop-down arrow to the right of  in the icon bar, then select a *lower magnification level* from the drop-down list. Follow the processes described in "Identifying the First Point," steps 2 through 8, on page 68, to center the region of interest within the FOV of the selected magnification lens.
   If you do not see the region of interest, even at the lowest available magnification, proceed to step 2.

NOTE If the MicroXCT has a non-motorized turret, open the access door (if it is closed), slowly turn the turret CLOCKWISE or COUNTERCLOCKWISE, until the *lower magnification lens you want to use* clicks into place, at the bottom position (lowest point) of the turret, then close the access door. **Follow standard procedures for turning the X-ray source OFF and ON, prior to opening and closing the access door, respectively.**

2. Follow steps a through d to reposition the sample, using the visual light camera:

   a. Open the **Motion Controller** dialog box. In the **Source** tab, note the *current Source Z position*. In the **Detector** tab, note the *current Camera Z position*. These values are used later, in step 4.

   b. In the **Motion Controller** dialog box **Detector** tab, type *a more positive value than the current Camera Z position*, in the **Camera Z** text box, then click **GO**. This will provide more space for manipulating the sample.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

c. In the **Motion Controller** dialog box **Source** tab, type *a more negative value than the current Source Z position*, in the **Source Z** text box, then click **GO**. This will provide more space for manipulating the sample.

d. Estimate the location of the region of interest, and reposition it within the center of the visual light camera monitor, using the processes described in “Coarsely Positioning the Sample,” on page 48. Proceed to step 3.

3. Follow steps a through c to search for the region of interest, starting at the lowest magnification level:

   a. Center the region of interest on the field of view (FOV), using the processes described in “Identifying the First Point,” steps 2 through 7, on page 68, but *increase the magnification by one level* in step 7.

   b. Repeat the processes described in “Identifying the First Point,” steps 2 through 6.

   c. Continue iterating “Identifying the First Point,” steps 2 through 7, increasing the magnification by one level at a time, until optimum magnification is achieved for the region of interest.

4. Follow steps a and b to move the X-ray source and detector back to their original positions noted in step 2a:

   a. In the **Motion Controller** dialog box **Source** tab, type the *original current Source Z position* in the **Source Z** text box, then click **GO**.

   b. In the **Motion Controller** dialog box **Detector** tab, type the *original current Camera Z position* in the **Camera Z** text box, then click **GO**.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

5. Follow steps a and b to verify that the sample does not collide with either the detector or X-ray source, by rotating Sample Theta through the tomographic angle range:

   a. Follow the processes described in “Finely Positioning the Detector,” steps 6 through 8, starting on page 73, to ensure that the sample does not collide with the detector.

   b. Follow the processes described in “Finely Positioning the X-ray Source,” steps 6 through 8, starting on page 78, to ensure that the sample does not collide with the source.

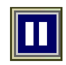
   If you resume the process in which you determined there was an issue, and the issue still exists, contact the Xradia Support Team for assistance.

Sample and Detector Collision Is Imminent

Symptom While using XMController and moving the sample or detector, the two are coming too close to one another.

Problem The sample and detector are so close that they might collide or touch one another.

Solution ***To prevent the sample and detector from colliding***

1. If you have just clicked **GO** within any axis panel, within any tab of the **Motion Controller** dialog box, click , **in the same axis panel**, to immediately stop movement.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

2. Review the safety guidelines provided in “Collision of Moving Parts,” on page xxii.

3. Move the Detector away from the sample. Select the **Motion Controller** dialog box **Detector** tab, type a *value greater than the current Camera Z position*, in steps of 5 mm or less, in the **Camera Z** text box, then click **GO**.

   Repeat this step, as necessary, until the detector does not touch the sample, but is still sufficiently close to it.

Sample and Detector Collided

Symptom While using XMController, the detector and sample are positioned such that they are touching one another, or the sample holder fell off the sample stage when the sample and detector collided.

Problem While moving the sample or detector, the two collided with one another.

Solution ***To resolve the problems caused by the collision***

1. Click **Stop all motors** in any tab within the **Motion Controller** dialog box.
2. **If the detector is damaged** – Contact the Xradia Support Team for assistance.
3. Review the safety guidelines provided in "Collision of Moving Parts," on page xxii.
4. **If the sample holder fell off the sample stage** – Follow steps a through e to load the sample holder back onto the sample stage:
   a. Open the **Motion Controller** dialog box **Detector** tab. Type a *value 5 mm (or more) greater than the current Camera Z position*, in the **Camera Z** text box, then click **GO** to move the detector away from the sample.
   b. Follow the process described in "Loading the Sample Holder Assembly onto the Sample Stage," steps 6 and 7, starting on page 45, to turn OFF the X-ray source, and then open the access door.
   c. Load the sample holder back onto the sample stage, using the process described in "Loading the Sample Holder Assembly onto the Sample Stage," step 8, on page 46.
   d. Follow the processes described in "Finely Positioning the Detector," on page 71, to position the detector as close to the sample as possible, through the tomographic angle range, without touching or colliding with the sample.

      Repeat this step, as necessary, until the detector is sufficiently close to the sample, without touching it.
   e. Follow the processes described in "Turning on the X-ray Source," steps 1 through 3, starting on page 58, to close the access door and then turn ON the X-ray source.

5. **If the sample is damaged** – Follow steps a through c to replace the sample:

    a. Follow the processes described in Appendix E, “Removing the Sample after Use,” to remove and discard the sample.

    b. Mount a new sample in/on the sample holder, following the processes described in “Mounting the Sample in/on a Sample Holder,” on page 33.

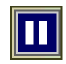
    c. Follow the processes described earlier in this guide, starting from Chapter 2, to position and scan the new sample.

Sample and X-ray Source Collision Is Imminent

Symptom While using XMController and moving the sample or X-ray source, the two are coming too close to one another.

Problem The sample and X-ray source are so close that they might collide or touch one another.

Solution ***To prevent the sample and X-ray source from colliding***

1. If you have just clicked **GO** within any axis panel, within any tab of the **Motion Controller** dialog box, click , **in the same axis panel**, to immediately stop movement.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

2. Review the safety guidelines provided in "Collision of Moving Parts," on page xxii.

3. In the **Motion Controller** dialog box, select the **Source** tab, type a *value more negative than the current Source Z position*, in steps of 5 mm or less, in the **Source Z** text box, then click **GO**.

   Repeat this step, as necessary, until the X-ray source does not touch the sample, but is still sufficiently close to it.

Sample and X-ray Source Collided

Symptom While using XMController, the X-ray source and sample are positioned such that they are touching one another, or the sample holder fell off the sample stage when the sample and X-ray source collided.

Problem While moving the sample or X-ray source, the two collided with one another.

Solution ***To resolve the problems caused by the collision***

1. Click **Stop all motors** in any tab within the **Motion Controller** dialog box.

2. **If the X-ray source or detector is damaged** – Contact the Xradia Support Team for assistance.

3. Review the safety guidelines provided in "Collision of Moving Parts," on page xxii.

4. **If the sample holder fell off the sample stage** – Follow steps a through e to load the sample holder back onto the sample stage:

   a. Open the **Motion Controller** dialog box **Source** tab. Type a *value 5 mm or more negative than the current Source Z position*, in the **Source Z** text box, then click **GO** to move the source away from the sample.

   b. Follow the process described in "Loading the Sample Holder Assembly onto the Sample Stage," steps 6 and 7, starting on page 45, to turn OFF the X-ray source, and then open the access door.

   c. Load the sample holder back onto the sample stage, using the process described in "Loading the Sample Holder Assembly onto the Sample Stage," step 8, on page 46.

   d. Follow the processes described in "Finely Positioning the X-ray Source," on page 75, to position the X-ray source as close to the sample as possible, through the tomographic angle range, without touching or colliding with the sample.

      Repeat this step, as necessary, until the X-ray source is sufficiently close to the sample, without touching it.

   e. Follow the processes described in "Turning on the X-ray Source," steps 1 through 3, starting on page 58, to close the access door and then turn ON the X-ray source.

5. **If the sample is damaged** – Follow steps a through c to replace the sample:

   a. Follow the processes described in Appendix E, “Removing the Sample after Use,” to remove and discard the sample.

   b. Mount a new sample in/on the sample holder, following the processes described in “Mounting the Sample in/on a Sample Holder,” on page 33.

   c. Follow the processes described earlier in this guide, starting from Chapter 2, to position and scan the new sample.

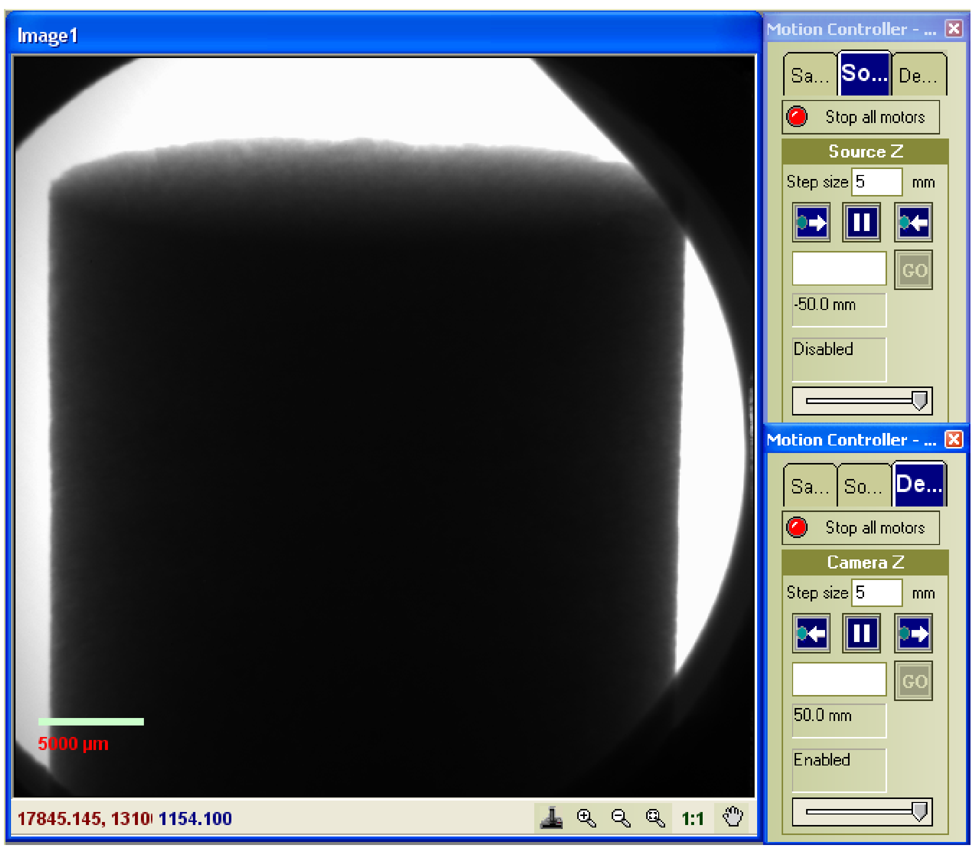
Troubleshooting Magnification Lens Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View

It is important to keep the X-ray source aperture out of the field of view (FOV) for the Macro, 1X, 2X, and 4X lenses. If the separation between the X-ray source and detector is less than the amount specified in Table 3-3, “Minimum Distance between X-ray Source and Detector for Macro, 1X, 2X, and 4X Lenses,” on page 75, the X-ray source aperture will be visible in the FOV.

Symptom X-ray source aperture is visible in image scans.

Problem Corner clipping of the images taken with Macro-70, 1X, and 4X lenses and reduction in area of the round FOV in the Macro-55 (0.5X) and 2X lenses occur due to the X-ray source aperture.

Figure A-2 Example of Image with Source Aperture in FOV of Macro-70 Lens – Image taken with X-ray Source at -50 mm and Detector at 50 mm



Solution ***To remove the X-ray source aperture from the image***

1. In the **Motion Controller** dialog box **Source** tab, type a *value 5 mm more negative than the current Source Z position* in the **Source Z** text box, then click **GO**, to move the X-ray source away from the sample.

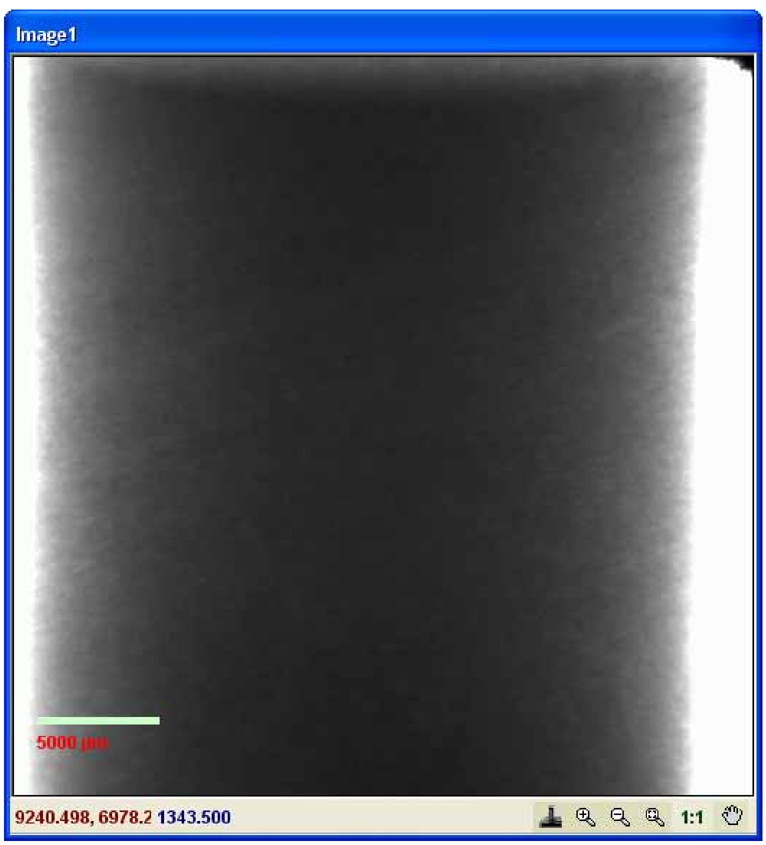
   –or–

   In the **Motion Controller** dialog box **Detector** tab, type a *value 5 mm greater than the current Camera Z position* in the **Camera Z** text box, then click **GO**, to move the detector away from the sample.

   The end result should resemble Figure A-3.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

Figure A-3 Example of Core Sample Filling FOV for Macro-70 , without X-ray Source Aperture Showing



Troubleshooting Image Contrast, Brightness, and Light Intensity Count Issues

Image contrast, brightness, and light intensity count (saturation) adjustments are typically process-specific. Table A-3 lists processes in the guide that describe how to adjust image contrast, brightness, and/or light intensity counts, within the context of those processes.

Table A-3 Processes that Apply Contrast, Brightness, and/or Light Intensity Count (Saturation) Adjustments, by Program

Program	Processes that Apply Contrast, Brightness, and/or Light Intensity Count (Saturation) Adjustments
XMController	"Collecting Continuous Images," step 2, on page 66
	"Selecting the Source Filter," step e, on page 83
	"Determining the Optimum X-ray Source Voltage," step 2b, on page 92
	"Collecting a Reference Image," step 3, on page 145, Exposure time-related Note
XMReconstructor	"Identifying Center Shift," step 4, on page 158
	"Identifying Beam Hardening Correction," step 4, on page 163
XM3DViewer	"Adjusting Contrast and Brightness in the 2D Reconstructed Slice Windows," on page 180
	"Creating 3D Volume Renderings," step 4, on page 186
	"Creating 3D Volume Renderings," step 6, on page 187

Troubleshooting Issues with XM3DViewer

NOTE This guide provides basic information for using XM3DViewer to view tomographic data after reconstruction. For further details regarding the program's use, refer to the *Xradia ExamineRT Workstation 1.1 User's Manual,* available under XM3DViewer's **Help** menu.

Because XM3DViewer is a third-party product, its troubleshooting is described separately, in "Correcting Problems with the Reconstructed File," on page 203.

Additional troubleshooting, with respect to image contrast and brightness, is also provided in earlier in this appendix, in "Troubleshooting Image Contrast, Brightness, and Light Intensity Count Issues."

Troubleshooting MicroXCT Power Failures

This section provides tips for troubleshooting MicroXCT power failures.

Symptom Light tower lights do not turn ON; entire MicroXCT and/or workstation does not turn ON; visual light camera monitor and/or workstation monitor does not turn ON.

Problem One or more components within the MicroXCT is not receiving power.

Solution ***To troubleshoot MicroXCT power failures***

1. Verify that the MicroXCT's three-prong power connector is connected to a grounded 100 to 240 VAC, 12A power source. If it is not, plug it in, then proceed to step 6.

   However, if using an uninterruptible power source (UPS), line conditioner, surge protector, or similar device, ensure that the MicroXCT is connected to the device, and that the device's power connector is connected to a grounded 100 to 240 VAC, 12A power source. If it is not, plug it in, then proceed to step 6.

2. Open the cabinet door on the lower left side of the MicroXCT. Verify that all PDU power breakers are in the UP position, and that none are tripped (in the DOWN position). (Refer to item J in Figure 1-1 on page 5 (MicroXCT-200) or Figure 1-2 on page 6 (MicroXCT-400).)

WARNING Do **not** reset a power breaker if it is tripped. Contact the Xradia Support Team for assistance.

3. Verify that the component's (workstation, visual light camera monitor, and/or workstation monitor) **Power** button is lit. If it is not lit, press its **Power** button again.

   If MicroXCT power is still failing, proceed to step 4. Otherwise, this process is complete.

4. Shut down the MicroXCT, following the processes described in "Shutting Down the MicroXCT in a Non-Emergency Event," on page 246.

5. Verify that the power source is working, by plugging another electrical item into it, or testing it with an electrical outlet tester.

NOTE Contact your Facilities or Maintenance Department if another electrical item does not work when plugged into the power source. Either the electrical receptacle must be replaced, or the power source's circuit breaker is tripped.

6. Turn ON the MicroXCT, following the processes described in “Turning ON the MicroXCT,” on page 247.

   If you resume the process in which you determined there was an issue, and the issue still exists, contact the Xradia Support Team for assistance.

Troubleshooting Light Tower Issues

Table A-4 describes the behavior of each light (status indicator) in the light tower. Figure A-5 illustrates a sample light tower status combination. If any status indicators are not functioning as described, contact the Xradia Support Team for assistance.

Table A-4 Light Tower Lights (Status Indicators)

Light Tower Indicator Status	Description
All lights OFF	Power to the MicroXCT is OFF.
Red light ON (top)	X-ray source is ON, and X-rays are present within the enclosure.
Red light OFF (top)	X-ray source is OFF, and X-rays are not present within the enclosure.
Yellow light ON (center)	Access door(s) is (are) closed.
Yellow light OFF (center)	Access door(s) is (are) open.
Green light ON (bottom)	Power to the microscope is ON.
Green light OFF (bottom)	Power to the microscope is OFF.

Figure A-5 Sample Light Tower Status Combination

Red light OFF – X-ray source is OFF, X-rays are not present within the enclosure
Yellow light ON – Access door(s) is (are) closed
Green light ON – Power to the microscope is ON

Contacting the Xradia Support Team (Technical Support)

If you need assistance with the MicroXCT, contact the Xradia Support Team, using one of the following methods:

Email:	service@xradia.com
Telephone:	1 (888) 497-2342 1 (925) 771-8093
Mail:	Xradia, Inc. 5052 Commercial Circle Concord, CA 94520 USA

THIS PAGE INTENTIONALLY LEFT BLANK

B MicroXCT Files and File Storage

This appendix describes the file types unique to the MicroXCT programs, recommended file handling, and how to export the files to graphic formats, as well as file storage:

- File Types
- Exporting Files
  - Exporting *.xrm Files or Single Images on XMController
  - Exporting *.txrm and *.txm Files
- File Storage (Hard Disk Drive(s))

File Types

XMController controls the MicroXCT hardware during setup and data acquisition. It can also be used for general image processing and 2D-image viewing for Xradia-specific images. XMController is primarily used for acquiring tomography datasets, which are a collection of 2D images (projections) acquired at different angles around the axis of rotation in the MicroXCT. Datasets that contain a collection of projection images are saved with the extension *.txrm*. Each **.txrm* file contains multiple images. In contrast, files with the extension *.xrm* contain only one image.

XMReconstructor reconstructs images stored in each **.txrm* file, to form a set of reconstructed slices. A slice is a 2D section of the 3D reconstructed volume, oriented in the X/Z plane. Slices generated from each **.txrm* file are stored in a file with the extension *.txm*. A **.txm* file contains a collection of slices that make up the reconstructed volume. If no specific region is selected during reconstruction, the number of slices is equal to the height of each projection image in the original **.txrm* file.

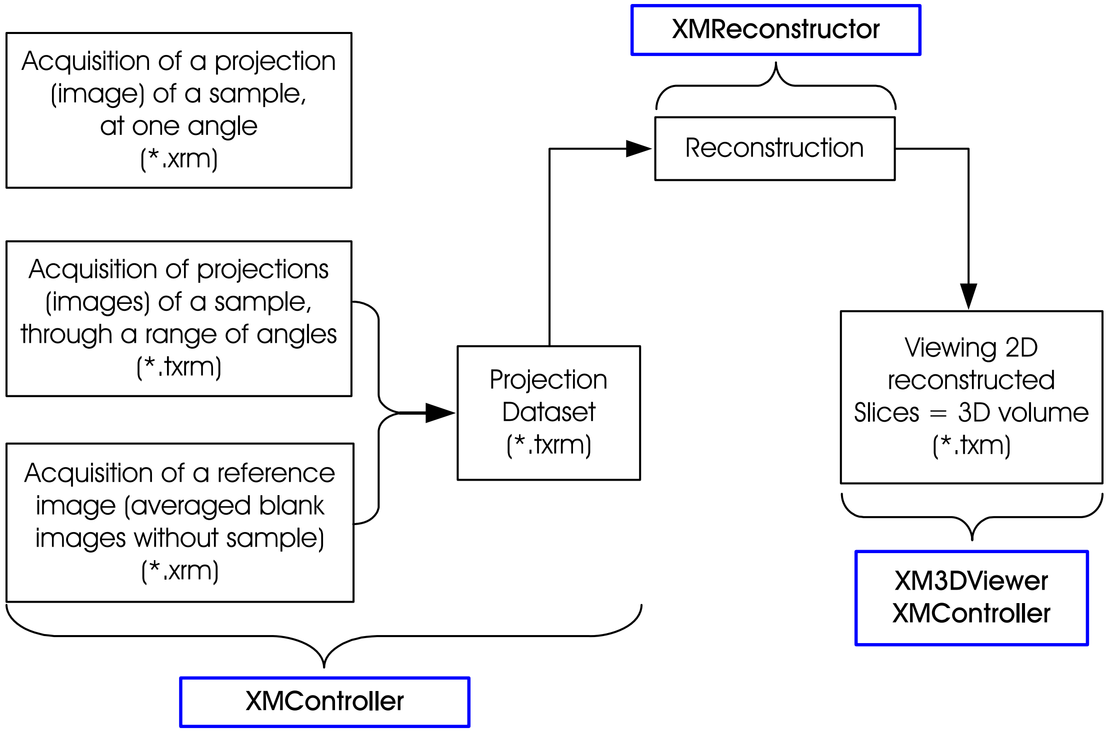
A **.txm* file generated by XMReconstructor is also referred to as a *volume viewer file*. These files can be viewed with XM3DViewer. XMController can also open and process **.txm* files.

Table B-1 summarizes the file extensions used for files used by the MicroXCT, and their associated programs. The check mark (✓) indicates that the file type is opened and/or processed by the program. Figure B-1 illustrates the relationship between the XMController, XMReconstructor, and XM3DViewer programs, and the data, processes, and files generated by each.

Table B-1 File Extensions and Related Programs

File Description	File Extension	XMController	XMReconstructor	XM3DViewer
Collection of 2D projection images acquired using XMController. Also referred to as a *tomography dataset*.	*.txrm*	✓	✓	
Image acquired with Single, Averaging (on-the-fly), Continuous, and Mosaic acquisition modes and saved, using XMController.	*.xrm*	✓		
Collection of 2D reconstructed slices created by XMReconstructor. Also referred to as a *volume viewer file*.	*.txm*	✓	✓	✓

Figure B-1 MicroXCT Data, Processes, and Files



Exporting Files

NOTE XM3DViewer can be used to export Word documents (**.doc*) and MPEG movies (**.mpg*). For details, refer to "Generating a Report," on page 193 and "Creating Movies of Cross-Sectional 2D Reconstructed Slices and 3D Volumes," on page 195, respectively.

XMController can be used to export images acquired and/or reconstructed by the MicroXCT programs, into the following graphic file formats:

– 8-bit tiff (*.tif*)

– bitmap (*.bmp*)

– JPEG (*.jpg*)

– 16-bit raw tiff (*.tiff*)

– binary (*.bin*)

– single image (*.xrm*)

Images exported as 8-bit tiff, bitmap, and JPEG files can be viewed by standard graphics programs, such as Microsoft Paint, Adobe Photoshop, and others, and can be inserted into documents, such as Microsoft Word and PowerPoint files. JPEG files can also be viewed in web browsers.

16-bit tiffs can only be viewed with specialized image software, such as MATLAB and ImageJ.

Binary images are accompanied by header files (**Header.txt*) – simple text files that indicate the parameters required to read these images. An example of a binary header file is provided in Figure B-2.

Multiple images in **.txrm* and **.txm* files can be exported as single-image **.xrm* files, that XMController can read and display. Although available, this export option is not often needed/used.

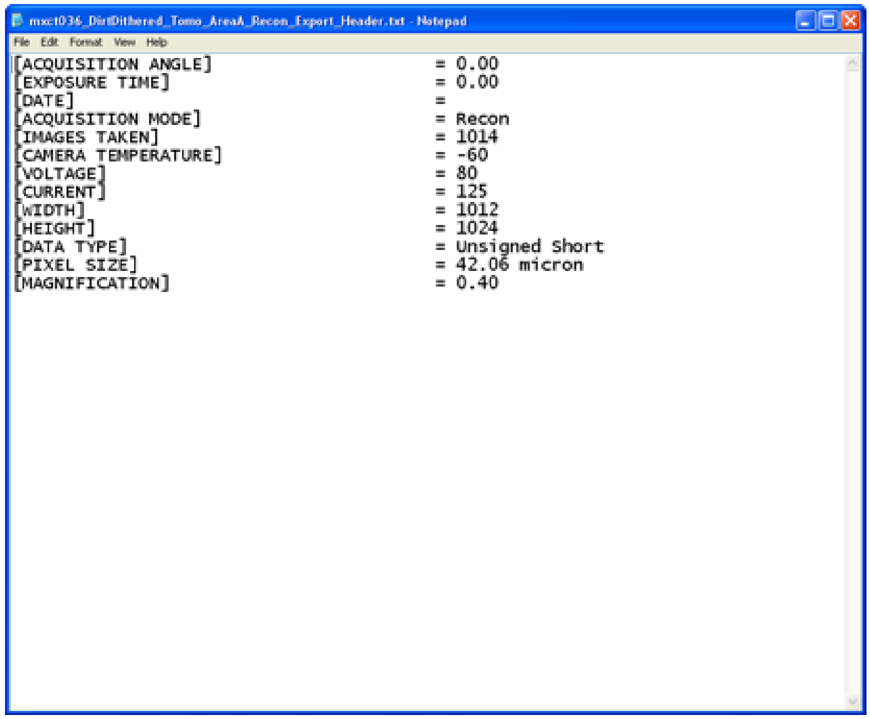
The export process varies, dependent upon the original file type:

– Exporting *.xrm Files or Single Images on XMController

– Exporting *.txrm and *.txm Files

Each is discussed in the sections that follow.

Figure B-2 Header File that Accompanies Exported Binary File(s)


mxct036_DirtDithered_Tomo_AreaA_Recon_Export_Header.txt - Notepad

File Edit Format View Help

```
[ACQUISITION ANGLE]                        = 0.00
[EXPOSURE TIME]                            = 0.00
[DATE]                                     =
[ACQUISITION MODE]                         = Recon
[IMAGES TAKEN]                             = 1014
[CAMERA TEMPERATURE]                       = -60
[VOLTAGE]                                  = 80
[CURRENT]                                  = 125
[WIDTH]                                    = 1012
[HEIGHT]                                   = 1024
[DATA TYPE]                                = Unsigned Short
[PIXEL SIZE]                               = 42.06 micron
[MAGNIFICATION]                            = 0.40
```

Exporting *.xrm Files or Single Images on XMController

**.xrm* files are single image files acquired using XMController. This process describes how to export **.xrm* files or any single images from XMController to the various formats previously described.

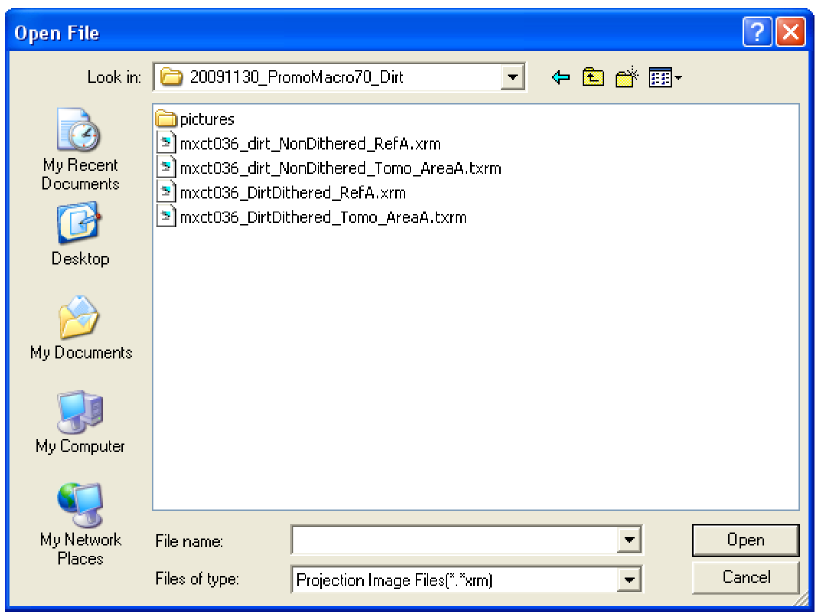
*To export *.xrm files*

1. Start XMController, if it is not already running.

NOTE Instructions for starting XMController are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 1, on page 42.

2. If the file or image to be exported is already open, proceed to step 6; otherwise open the file by selecting **File > Open...**. The **Open File** dialog box opens.

Figure B-3 **Open File** Dialog Box



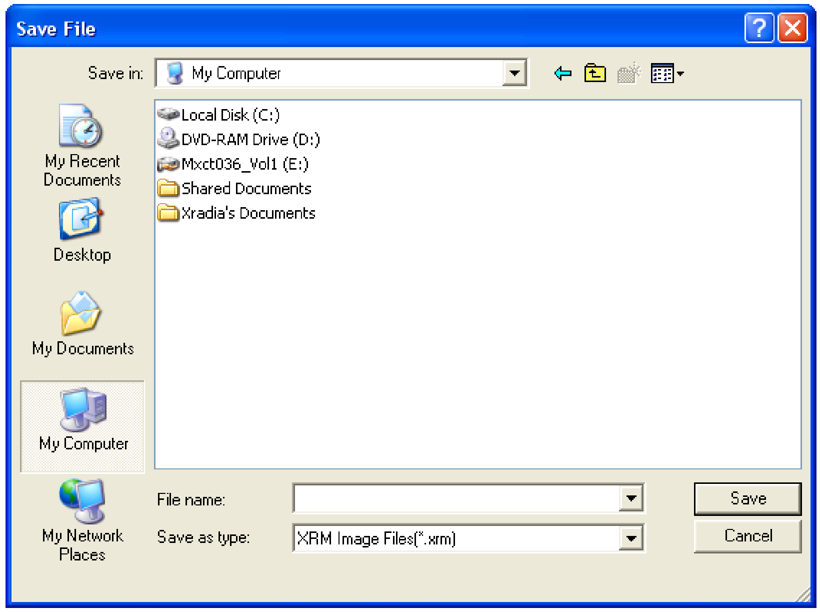
3. Browse to the *file's path*.

4. Select **Projection Image Files (*.xrm)** from the **Files of type** drop-down list box.

5. Select the **.xrm file* to be exported, then click **Open**. A **.xrm* file window opens within the **XMController** main window.

6. Select **File > Export…**. The **Save File** dialog box opens.

Figure B-4 **Save File** Dialog Box



7. Browse to the *destination file path*.

8. Type the *new file name* in the **File name** text box.

9. Select the *export file format* from the **Save as type** drop-down list box.

10. Click **Save** to export the file to the selected format.

Exporting *.txrm and *.txm Files

**.txrm* files contain projection images acquired during a tomography. **.txm* files contain 2D reconstructed slices output from XMReconstructor. This process describes how to export **.txrm* and **.txm* files to the various formats previously described.

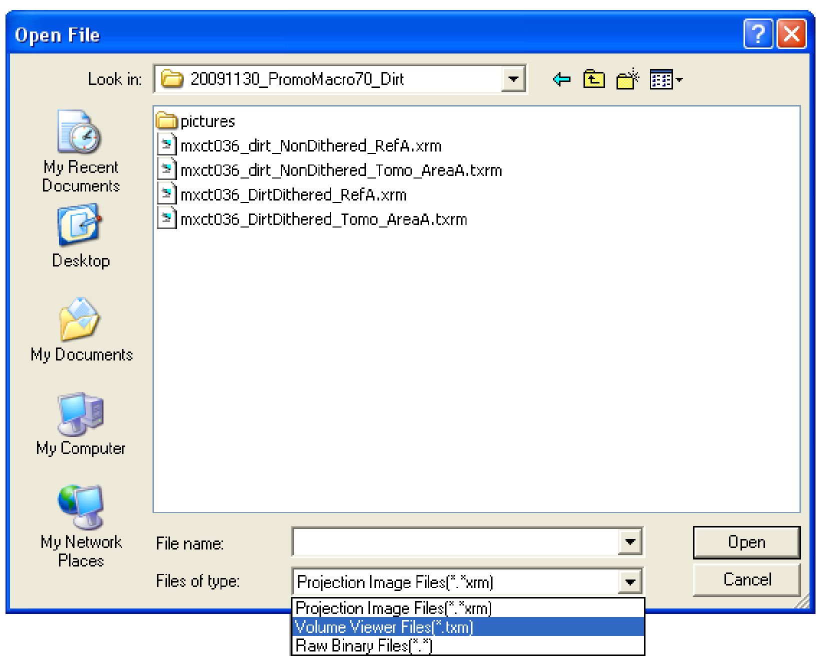
*To export *.txrm and *.txm files*

1. Start XMController, if it is not already running.

NOTE Instructions for starting XMController are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 1, on page 42.

2. If the file or image to be exported is already open, proceed to step 6; otherwise open the file by selecting **File > Open...**. The **Open File** dialog box opens.

Figure B-5 **Open File** Dialog Box



3. Browse to the *file's path*.

4. Select the **.*xrm* or **.txm file type* from the **Files of type** drop-down list box.

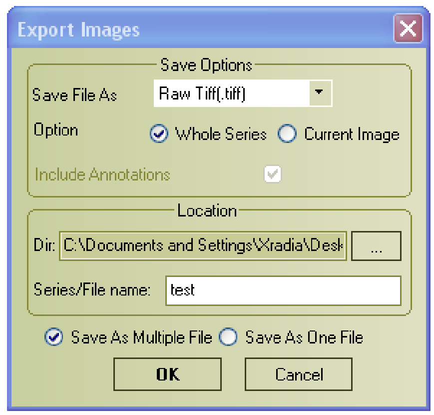
5. Select the **.txrm* or **.txm file* to be exported, then click **OK**. A **.txrm* or **.txm* file window opens within the **XMController** main window.

6. **If you are planning to export the entire file** – Proceed to step 7.

   If you are planning to export only a single image from the file – Scroll through the images in the *file's window*, using the slider in the scroll bar or the image number control (click the **–** or **+** symbols) at the bottom of the window, to locate and identify the image to be exported in step 9.

7. Select **File > Export…**. The **Export Images** dialog box opens.

Figure B-6 **Export Images** Dialog Box



8. Select the *export file format* from the **Save as type** drop-down list box.

9. Select the *save options*:

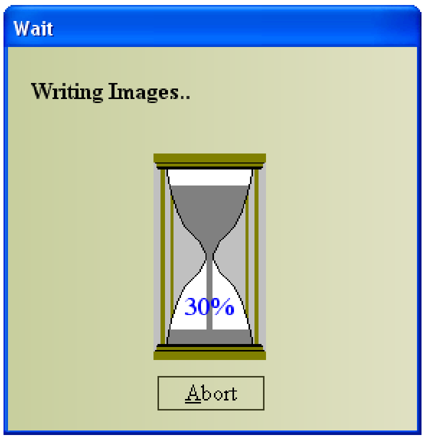
Option	Setting Value
Option	Select one of the following options: – **Whole Series** – Exports all images from the **.txrm* or **.txm* file – **Current Image** – Exports only the currently displayed image selected in step 6
	If you selected **Whole Series**, select one of the following options: – **Save as Multiple File** – Exports the images individually. The file name of each image will have four digits appended to it, in increasing numbers, starting from 0001, corresponding to the image sequence in the original **.txrm* or **.txm* file. – **Save as One File** – Exports all images in a single file.
Include Annotations	Select to include, in the exported image, the scale bar, and any annotations that were applied. This option is **not** available for binary and raw tiff format.

10. Select the *location options*:

Option	Setting Value
Dir	Click **...**, then browse to the *destination file path*.
Series/File name	Type the *new file name* for the exported file(s) in this text box.

11. Click **OK**. If exporting multiple images, a **Wait** message box opens, showing the export progress, then closes when the file is finished exporting.

Figure B-7 **Wait** Message Box



NOTE If you need to cancel the export before the file completes the export process, click **Abort**.

File Storage (Hard Disk Drive(s))

The MicroXCT workstation has one internal hard disk drive – drive C, which is a RAID-5 array hard disk drive with fast read/write speed. The amount of disk space available on drive C varies, because it is dependent upon the workstation model available at the time of shipment/purchase.

An optional storage server is also available from Xradia. If included with your MicroXCT, it is networked to the workstation, and as an additional hard disk drive.

NOTE RAID (redundant array of independent disks) provides redundant (mirrored copies) fail-safe storage for all programs and data stored on drive C.

NOTE The desktop folder path is typically **C:/Documents and Settings/*(Your Windows User Login Name)*/Desktop**.

NOTE It is recommended that you periodically backup drive C, and remember to empty the Recycle Bin after deleting files.

NOTE During reconstruction with XMReconstructor, the amount of free space required on the hard disk drive must be at least 1 GB more than the file size of the tomography (projection) dataset.

THIS PAGE INTENTIONALLY LEFT BLANK

C Shutting Down and Restarting the MicroXCT

This appendix describes how to shutdown and restart the MicroXCT, and then home all motorized axes to pre-defined initialization positions:

- Shutting Down the MicroXCT in a Non-Emergency Event
- Turning ON the MicroXCT
- Homing the Axes

NOTE The EMO shutdown process (pressing of the **EMO** button), used in the event of a personal safety or equipment emergency, is described in "EMO Shutdown," on page xii.

Shutting Down the MicroXCT in a Non-Emergency Event

This process describes how to shut down the MicroXCT in a non-emergency event, such as when troubleshooting a problem that requires resetting the MicroXCT, or if the MicroXCT is not going to be used for a long period of time (such as during a holiday closure).

To shut down the MicroXCT in a non-emergency event

1. On the workstation, close any programs that are running.
2. Select **Start > Shut Down**.
3. **If the MicroXCT has a storage server** – Refer to the provided storage server manufacturer's product documentation for its shutdown instructions.
4. When prompted, select **Shut Down** to shut down the workstation.

   Follow the instructions as they appear onscreen.
5. After the workstation is shut down, firmly press the **EMO** button (located on the front panel of the enclosure (and back panel, MicroXCT-400 only); refer to Figure C-1), to turn OFF power to the MicroXCT.

   Proceed to "Turning ON the MicroXCT."

NOTE For specific **EMO** and **RESET** button locations, refer to Figure 1-1, "MicroXCT-200 External View, with Access Door Open, and Lower Doors Removed," on page 5, and Figure 1-2, "MicroXCT-400, External View, with Lower Doors Removed," on page 6.

Figure C-1 **EMO** and **RESET** Buttons

MicroXCT-200

MicroXCT-400

Turning ON the MicroXCT

This process describes how to turn ON the MicroXCT if it has been shut down (turned OFF).

To turn ON the MicroXCT

1. Ensure that the three-prong power connector (located at the back of the MicroXCT) is connected to a grounded 100 to 240 VAC, 12A power source.

NOTE The MicroXCT should already be connected to power, at installation.

NOTE If using an uninterruptible power source (UPS), line conditioner, surge protector, or similar device, ensure that the MicroXCT is connected to the device, and that the device's power connector is connected to a grounded 100 to 240 VAC, 12A power source.

2. **If restarting the MicroXCT after an emergency event** – Verify that the emergency has passed, all personnel are safe, and all appropriate safety conditions are satisfied.

3. Turn the **EMO** button (refer to Figure C-1) CLOCKWISE, until it pops upward. This releases the **EMO** button and enables use of the **RESET** button.

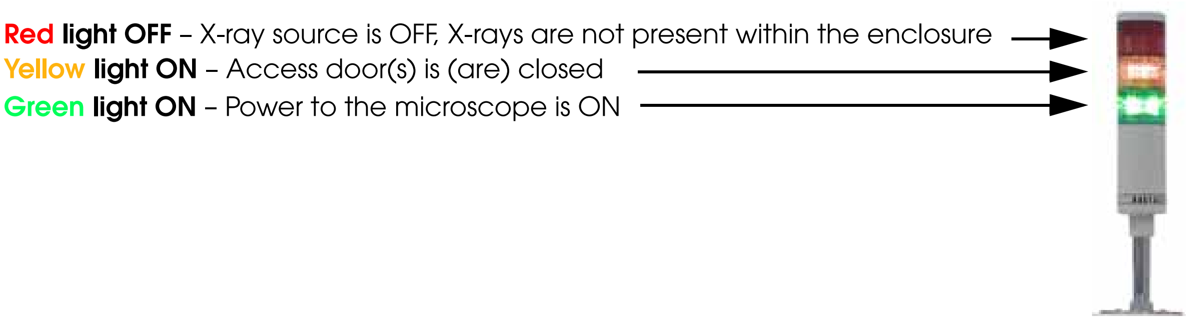
4. Press the **RESET** button (located above the **EMO** button) to turn ON the MicroXCT.

   The **green** light on the light tower (bottom light) turns ON. If the access door(s) is (are) closed, satisfying all safety interlocks, the **yellow** light on the light tower (middle light) also turns ON.

NOTE If pressing the **RESET** button does not power-on the MicroXCT, repeat step 3, to ensure that the **RESET** button is enabled.

NOTE At this point, it is okay to have the access door(s) open. If the yellow light does not turn ON, the access door(s) is (are) not securely closed. To securely close the access door(s), open and then reclose the door(s).

Figure C-2 Light Tower



5. **If the MicroXCT has a storage server** – Refer to the provided storage server manufacturer's product documentation for its power-on instructions.

6. Press the workstation's **Power** button, to turn ON the MicroXCT workstation.

7. Press the workstation monitor's **Power** button, to turn ON the monitor. The standard Windows XP desktop should be(come) visible.

8. Turn ON the interior light, by moving the visual light camera light switch (D on Figure 1-7, "Ergonomic Station," on page 16) to the UP (ON) position.

9. Press the visual light camera monitor's **Power** button, to turn ON the monitor.

NOTE When the visual light camera monitor is turned ON, you should see the sample stage (if the access door(s) is (are) closed), as well as yourself (if the access door(s) is (are) open). If you do not see anything on the monitor, press its **Power** button again, to turn ON the monitor.

If you plan to use XMController, proceed to "Homing the Axes."

Homing the Axes

This process describes how to use XMController to home all motorized axes to their pre-defined initialization positions – set the Sample X, Y, Z, and Theta values of the sample stage to 0, and the X-ray source and detector to their negative (**-Limit**) and positive (**+Limit**) limits, respectively – in preparation for acquiring tomographic data.

Typically, the axes are automatically homed, as described in "Automatically Homing the Axes." However, if it is necessary to manually home the axes, instructions for doing so are provided in "Manually Homing the Axes."

NOTE The axes must be homed whenever the MicroXCT is restarted after a shutdown. It is usually not necessary to home the axes at any other time, unless instructed to do otherwise by the Xradia Support Team.

Automatically Homing the Axes

This process describes how to automatically home all motorized axes to their pre-defined initialization positions.

To automatically home all axes

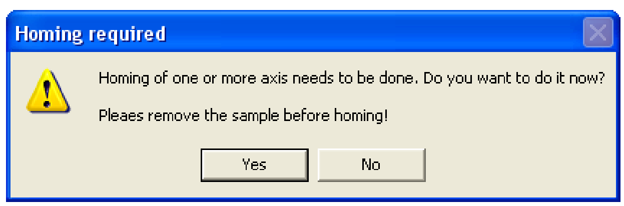
1. Start XMController, if it is not already running.

NOTE Instructions for starting XMController are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 1, on page 42.

2. If the MicroXCT has previously been turned OFF, just prior to starting XMController, the **Homing required** dialog box opens. Click **Yes** to home all motorized axes. Follow the instructions as they appear.

WARNING If you accidentally clicked **No** in the **Homing required** dialog box, you must manually home all axes. Proceed directly to "Manually Homing the Axes."

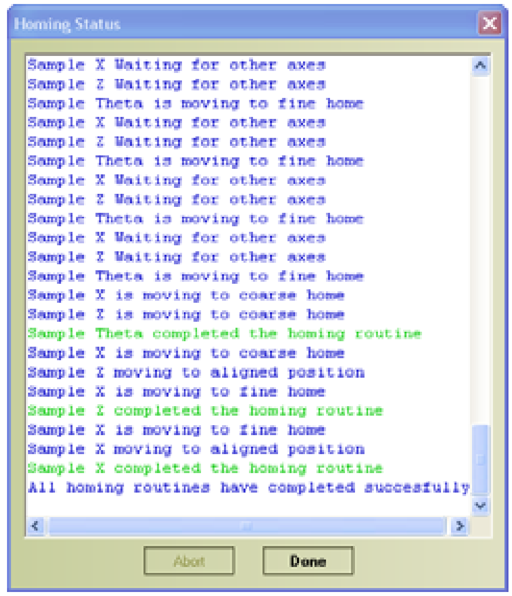
Figure C-3 **Homing required** Dialog Box



During the homing process, the **Homing Status** dialog box opens, indicating the status in real time. This process can take several minutes.

Axis homing is complete and successful when the "All homing routines have completed successfully" message and the **Done** button appear in the **Homing Status** dialog box.

Figure C-4 Final **Homing Status** Dialog Box – All Axes Successfully Homed

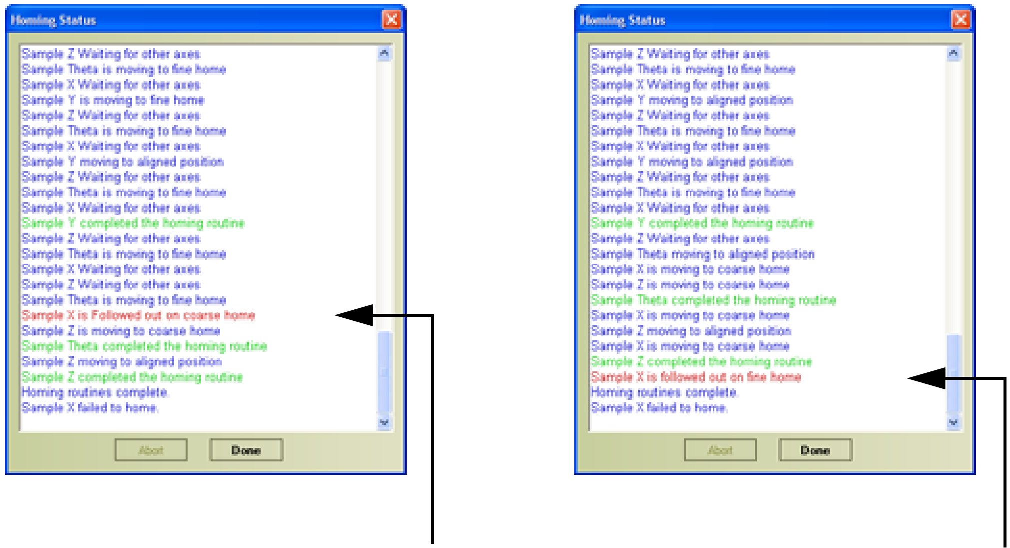


WARNING For each axis, the two homing errors illustrated in Figure C-5 (indicated in **red**) can occur during:

- Coarse home, when the axis fails to move to its limit
- Fine home, when the axis fails to move to the predetermined offset

If there are homing errors, the message "… failed to home" also appears in the **Homing Status** dialog box, at the end of the message list. Locate the homing status error(s), scrolling up through the messages, as necessary, then contact the Xradia Support Team for assistance.

Figure C-5 Final **Homing Status** Dialog Box – Homing Errors

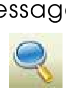


Error – Followed out on coarse home

Error – Followed out on fine home

3. **If homing was successful** – Click **Done**, then proceed to Chapter 2, "Setting Up for Data Acquisition," to prepare the MicroXCT for acquiring data.

   If homing was unsuccessful (that is, the Homing Status dialog box indicates homing errors) – Contact the Xradia Support Team.

NOTE If the MicroXCT has just completed axis homing, it is normal for the **red** Error message bar to appear. To resolve this, click the drop-down arrow to the right of  in the icon bar, select a *magnification lens*, then click the **red** Error message bar to close the message bar.

Manually Homing the Axes

This process describes how to manually home all motorized axes to their pre-defined initialization positions. Use this process only if you clicked **No** in "To automatically home all axes," step 2, or if you need to manually home all axes.

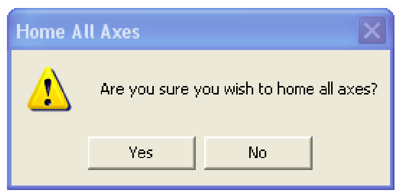
To manually home all axes

1. Start XMController, if it is not already running.

NOTE Instructions for starting XMController are provided in "Loading the Sample Holder Assembly onto the Sample Stage," step 1, on page 42.

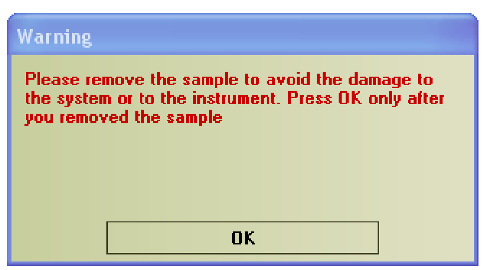
2. Select **Microscope > Home all axes...**. The **Home All Axes** dialog box opens.

Figure C-6 **Home All Axes** Dialog Box



3. Click **Yes** to home all axes. A **Warning** dialog box opens, indicating the sample must be removed before proceeding. The warning appears regardless of whether a sample is physically present.

Figure C-7 **Warning** Dialog Box – Sample Present



4. **If a sample is present** – Follow steps a through c to remove the sample:

   a. Open the access door.

   b. Remove the sample holder assembly from the sample stage.

   c. Close the access door.

NOTE If you can see yourself on the visual light camera monitor, the access door is still open.

5. Click **OK**.

   During the homing process, the **Homing Status** dialog box opens, indicating the status in real time. This process can take several minutes.

   Axis homing is complete and successful when the "All homing routines have completed successfully" message and the **Done** button appear in the **Homing Status** dialog box. (Refer to Figure C-4.)

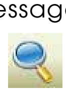
WARNING For each axis, the two homing errors illustrated in Figure C-5 (indicated in **red**) can occur during:

- Coarse home, when the axis fails to move to its limit
- Fine home, when the axis fails to move to the predetermined offset

If there are homing errors, the message "... failed to home" also appears in the **Homing Status** dialog box, at the end of the message list. Locate the homing status error(s), scrolling up through the messages, as necessary, then contact the Xradia Support Team for assistance.

6. **If homing was successful** – Click **Done**, then proceed to Chapter 2, "Setting Up for Data Acquisition," to prepare the MicroXCT for acquiring data.

   If homing was unsuccessful (that is, the Homing Status dialog box indicates homing errors) – Contact the Xradia Support Team.

NOTE If the MicroXCT has just completed axis homing, it is normal for the **red** Error message bar to appear. To resolve this, click the drop-down arrow to the right of  in the icon bar, select a *magnification lens*, then click the **red** Error message bar to close the message bar.

D Visual Light Camera Monitor Brightness Controls

This appendix describes how to change the brightness, to reduce image glare, on the visual light camera monitor that has icon control buttons. (Refer to Figure D-1.)

NOTE The brightness control buttons on the other visual light camera monitor used by some MicroXCTs are self-explanatory.

Figure D-1 Visual Light Camera Monitor with Icon Control Buttons

NOTE The image in Figure D-1 is provided to illustrate the button layout only, and does not represent the type of glare being adjusted on the monitor.

To adjust the visual light camera monitor brightness

1. Access Menu mode, by pressing the **Menu** button, . **Brightness** with a brightness level number appears on the monitor.

2. Press ▲ or ▼ to adjust brightness, until image glare is no longer visible on the monitor.

   The word **Brightness** disappears from the monitor after approximately 5 seconds of non-use.

3. At this point, you can also or scroll through other menu options – **Color**, **Contrast**, and **Tint** – by pressing to access each, until you reach the last option and exit Menu. These other menu options can be adjusted, using the same ▲ or ▼ method described in step 2.

E Removing the Sample after Use

This appendix describes how to remove the sample from the MicroXCT, after you have finished imaging the sample.

CAUTION Follow the safe sample handling procedures established by your work site.

To remove the sample after use

1. Follow the processes described in "Loading the Sample Holder Assembly onto the Sample Stage," steps 3 through 7, starting on page 44, to move the X-ray source and detector away from the sample stage, turn OFF the X-ray source, and open the access door.

2. Remove the sample holder from the sample stage.

3. Remove the sample from the sample holder, as described in the following table.

Holder Type	Process
Clamp	While holding the sample, loosen the clamp thumbscrew COUNTERCLOCKWISE, then remove the sample from the clamp.
Clip	While holding the sample, push down on the clip to open the clip, then remove the sample from the clip.
Pin Vise	Rotate the outer section of the vise COUNTERCLOCKWISE, then remove the sample (or toothpick or rod) from the vise.
Sample Base	While holding the sample, remove the cellophane tape from the sample base surface.

4. Store the sample in a safe place that is free from contaminants, for future use, or dispose of properly, per site-specific requirements.

THIS PAGE INTENTIONALLY LEFT BLANK

F Determining Whether the MicroXCT is 360°-Enabled

This appendix describes how to determine whether the MicroXCT is 180° or 360°-enabled.

Some older MicroXCT models are 180°-enabled; others are 360°-enabled. If the MicroXCT is not 360°-enabled, use the -90 to +90 tomographic angle range, when a tomographic angle range is requested.

Table F-1 lists the sample types and their corresponding Sample Theta tomographic angle ranges.

Table F-1 Sample Types and Sample Theta Tomographic Angle Ranges

Sample Type	Sample Theta Tomographic Angle Range
Semiconductor, flat	-90 to +90 (180°; half circle) (appear as **-90 deg** and **+90 deg** in **Sample Theta** panel)
Rigid biological material	-180 to +180 (360°; full circle) (appear as **-180 deg** and **+180 deg** in **Sample Theta** panel)
Soft biological material that fits within a tube	
Solid material	

There are two methods for determining whether the MicroXCT has 180° or 360° capability.

Method 1

1. In the **Motion Controller** dialog box, select the **Sample** tab.

2. In the **Sample Theta** panel, type *180* in the **Sample Theta text** box, then click **GO**.

   If the Sample Theta **Current Position** status indicates **+Limit** before Sample Theta rotates to **180 deg**, the MicroXCT is not 360°-enabled.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

Method 2

1. In the **Motion Controller** dialog box, select the **Sample** tab.

2. In the **Sample Theta** panel, type *-180* in the **Sample Theta text** box, then click **GO**.

   If the Sample Theta **Current Position** status indicates **-Limit hit** before Sample Theta rotates to **-180 deg**, the MicroXCT is not 360°-enabled.

CAUTION Always position the mouse pointer over , **in the same axis panel**, after clicking **GO** in the **Motion Controller** dialog box, so that movement can be quickly stopped (by clicking the button) if collision is imminent.

G Specifications

This appendix lists the MicroXCT-200 and MicroXCT-400 specifications that are of use to customers.

NOTE Contact the Xradia Support Team for specific questions related to maintenance, or for any specifications that may not be included in this guide at the time of publication.

NOTE All specifications are subject to change. Consult Xradia for current specifications.

MicroXCT-200 Specifications

This appendix provides the following MicroXCT-200 specifications:

– Spatial Resolution

– Components

– Facility Requirements

Spatial Resolution

Table G-1 Spatial Resolution – MicroXCT-200

Magnification Level/ Lens	Best Resolution at 10% MTF[a] (μm)	Detector Pixel Size[b] (μm)	Sample Width Limit (mm)
Standard Lenses (included with every MicroXCT)			
4X	5.0	3.4	50
10X	2.5	1.4	50
20X	1.5	0.7	30
Optional Lenses (available upon request)			
Macro-70[c]	20.0	34.0	100
1X	9.0	13.5	50
2X[d, e]	6.0	6.8	50
40X[f]	1.0	0.3	20

a. MTF (Modulation Transfer Function) measured using Xradia's standard 2D resolution target.
b. Pixel size on the face of the detector; Detector Area = 2,048 * Detector Pixel size, except 1X; Detector Area for 1X = 1,024 x Detector Pixel Size.
c. The Macro lens, if included, provides a second beam line for imaging, and is mounted beside, rather than on, the turret.
d. The 2X lens has a round FOV. Therefore, its 3D FOV range is the diameter of the FOV.
e. The 2X lens is not available when the MicroXCT has an optional Macro lens.
f. Spatial Resolution Limit for 40X is 0.7 μm.

Components

Table G-2 Sample Stage – MicroXCT-200

	X Axis	Y Axis	Z Axis[a]	Rotation
Travel	90 mm	50 mm	10 mm	360°[b]
Load Capacity	1 kg			

a. The Z direction is defined as being along the X-ray beam path.
b. Some older MicroXCT models are 180°-enabled. All current models are 360°-enabled. To determine the rotation capability of your MicroXCT, refer to Appendix F, "Determining Whether the MicroXCT is 360°-Enabled."

Table G-3 Sample Diameter/Width and Height Limitations – MicroXCT-200

Diameter/Width Limitations (Centered on Axis of Rotation)	Height Limitations
100 mm	150 mm

Table G-4 X-ray Source Minimum Warm-Up Time, and Minimum and Maximum Voltage and Power Settings – MicroXCT-200

X-ray Source	Minimum Warm-Up Time Prior to Use[a]	Voltage (kV)		Power (W)	
		Minimum	Maximum	Minimum	Maximum
90 kV	15 minutes	20	90	1	8
150 kV	15 minutes	40	150	4	10

a. 15 minutes is the minimum warm-up period, if the X-ray source has been turned OFF for more than 15 minutes, for optimal X-ray source stability during scans.

Table G-5 Detector and X-ray Source Axes Travel Limits – MicroXCT-200

Detector Axis	X-Ray Source Axis
120 mm	85 mm

Table G-6 Detector – MicroXCT-200

Category	Specification
Pixel Array	2,048 x 2,048
Turret Lens Capacity	6

Table G-7 Charge-Coupled Device – MicroXCT-200

Category	Specification
Operating Temperature	< -55°C **CAUTION** Contact the Xradia Support Team if the XMController **Acquisition Setting** dialog box indicates a temperature > -55°C.

Table G-8 Workstation (Computer, Quad Core) – MicroXCT-200

Category	Specification
Operating System	Windows XP Pro
Hard Disk Drive Space – Drive C	Varies, dependent upon the workstation model available at the time of shipment/purchase
RAM	4 GB
Monitor	19-inch LCD

Table G-9 Tomography Software – MicroXCT-200

Category	Specification
Reconstruction Time	1,024 slices (8-bit) from 181 projections (GPU accelerated) < 3 minutes

Facility Requirements

Table G-10 Facility Requirements – MicroXCT-200

Category	Specification[a]
Electrical[b]	90 to 240 VAC, 15A, 50/60 Hz Isolated circuit (not shared by other equipment)
Footprint (w x d)[c, d]	1.64 m x 0.9 m Flat surface (0° angle)
Height[e]	1.78 m
Weight	1,361 kg
Radiation Safety	<1 μS/hr
Operating Temperature	18 to 25°C, with < 2°C variation
Exterior Clearance	**Front** – 1.2 m **Left** – 1 m **Right** – 1 m **Back** – 0.9 m

a. Length measurements are rounded.
b. Refer to Appendix H, “Electrical Documentation,” for information specific to the EMO system and safety interlocks.
c. Includes handle and ergonomic workstation arm bracket.
d. Refer to Figure G-1 and Figure G-2.
e. Includes light tower.

Figure G-1 Footprint – MicroXCT-200

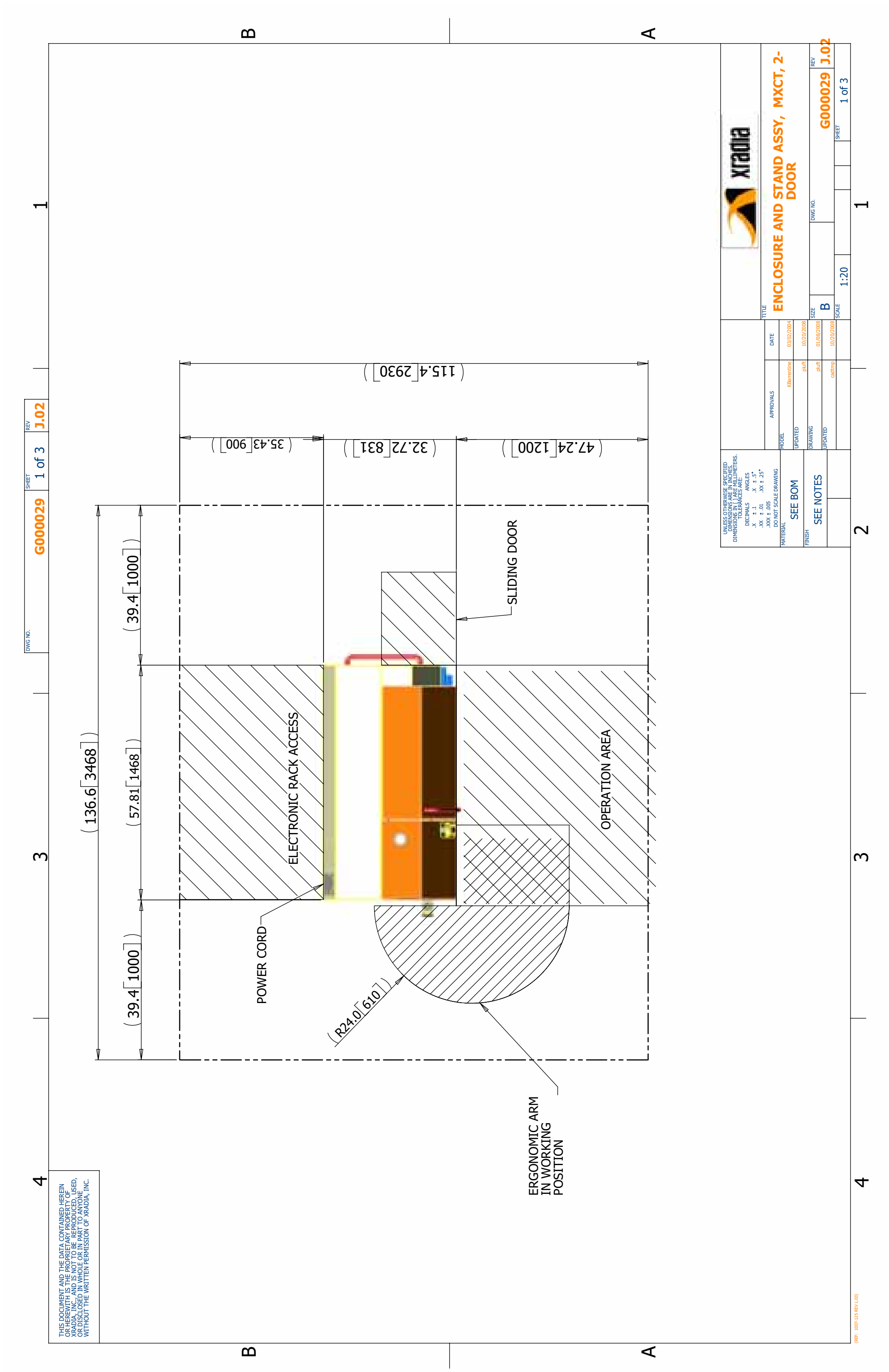
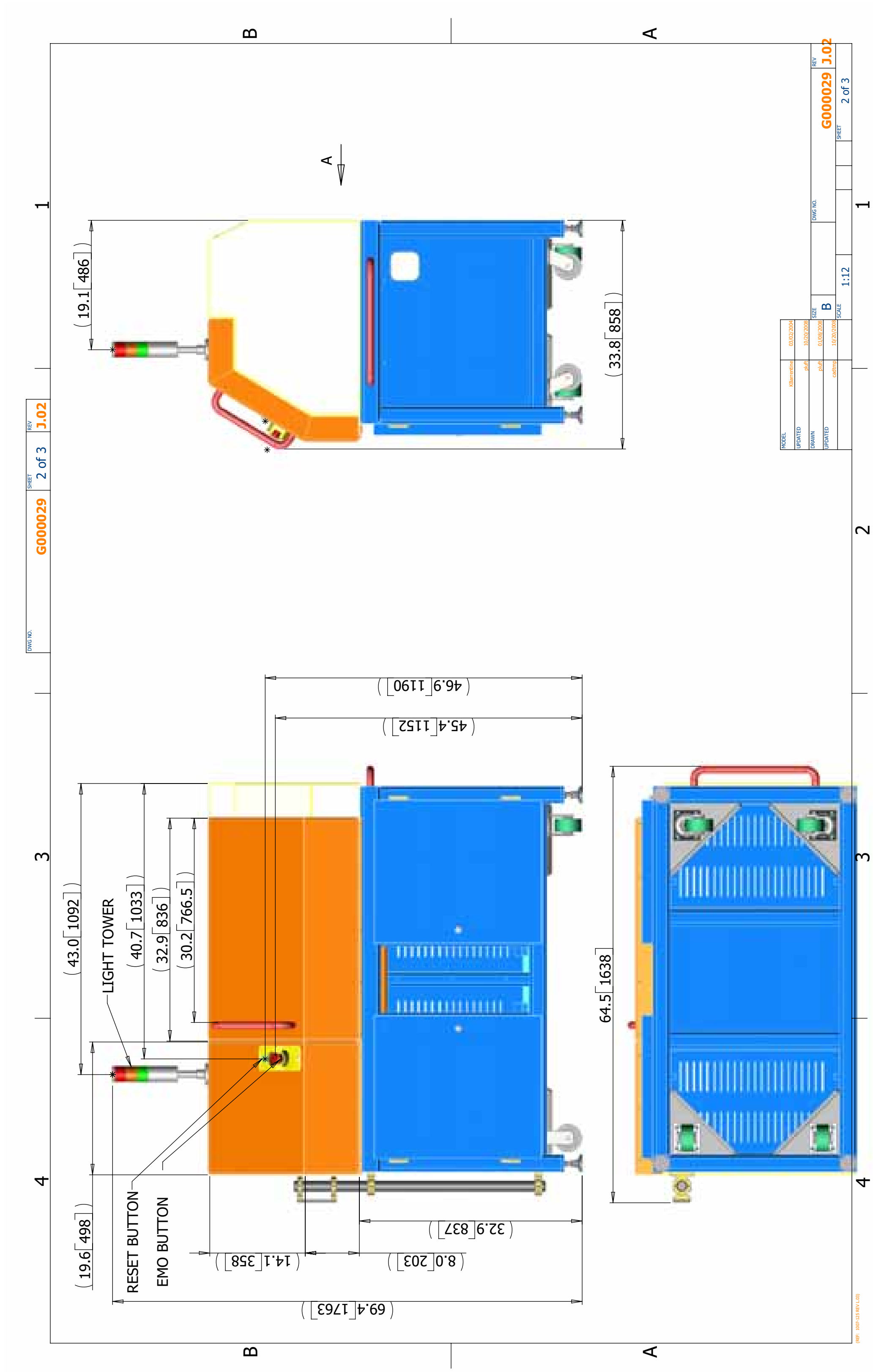


Figure G-2 Dimensions – MicroXCT-200



MicroXCT-400 Specifications

This appendix provides the following MicroXCT-400 specifications:

- Spatial Resolution
- Components
- Facility Requirements

Spatial Resolution

Table G-11 Spatial Resolution – MicroXCT-400

Magnification Level/ Lens	Best Resolution at 10% MTF[a] (μm)	Detector Pixel Size[b] (μm)	Sample Width Limit (mm)
Standard Lenses (included with every MicroXCT)			
4X	5.0	3.4	100
10X	2.5	1.4	50
20X	1.5	0.7	30
Optional Lenses (available upon request)			
Macro-70[c]	20.0	34.0	100
Macro-55 (0.5X)[c, d, e]	16.0	27.0	100
1X	9.0	13.5	50
2X[e, f]	6.0	6.8	50
40X[g]	1.0	0.3	20

a. MTF (Modulation Transfer Function) measured using Xradia's standard 2D resolution target.
b. Pixel size on the face of the detector; Detector Area = 2,048 * Detector Pixel size, except 1X; Detector Area for 1X = 1,024 x Detector Pixel Size.
c. The Macro lens, if included, provides a second beam line for imaging, and is mounted beside, rather than on, the turret.
d. The Macro-55 (0.5X) lens is obsolete, and was replaced by the Macro-70 as an option. The lens is still in use in some MicroXCT units.
e. The Macro-55 (0.5X) and 2X lenses have a round FOV. Therefore, their 3D FOV range is the diameter of the FOV.
f. The 2X lens is not available when the MicroXCT has an optional Macro lens.
g. Spatial Resolution Limit for 40X is 0.7 μm.

Components

Table G-12 Sample Stage – MicroXCT-400

	X Axis	Y Axis	Z Axis[a]	Rotation
Travel	45 mm	100 mm	50 mm	360°[b]
Load Capacity	15 kg			

a. The Z direction is defined as being along the X-ray beam path.
b. Some older MicroXCT models are 180°-enabled. All current models are 360°-enabled. To determine the rotation capability of your MicroXCT, refer to Appendix F, "Determining Whether the MicroXCT is 360°-Enabled."

Table G-13 Sample Diameter/Width and Height Limitations – MicroXCT-400

Diameter/Width Limitations (Centered on Axis of Rotation)	Height Limitations
500 mm	400 mm

Table G-14 X-ray Source Minimum Warm-Up Time, and Minimum and Maximum Voltage and Power Settings – MicroXCT-400

X-ray Source	Minimum Warm-Up Time Prior to Use[a]	Voltage (kV)		Power (W)	
		Minimum	Maximum	Minimum	Maximum
90 kV	15 minutes	20	90	1	8
150 kV	15 minutes	40	150	4	10

a. 15 minutes is the minimum warm-up period, if the X-ray source has been turned OFF for more than 15 minutes, for optimal X-ray source stability during scans.

Table G-15 Detector and X-ray Source Axes Travel Limits – MicroXCT-400

Detector Axis	X-Ray Source Axis
300 mm	400 mm

Table G-16 Detector – MicroXCT-400

Category	Specification
Pixel Array	2,048 x 2,048
Turret Lens Capacity	6

Table G-17 Charge-Coupled Device – MicroXCT-400

Category	Specification
Operating Temperature	< -55°C **CAUTION** Contact the Xradia Support Team if the XMController **Acquisition Setting** dialog box indicates a temperature > -55°C.

Table G-18 Workstation (Computer, Quad Core) – MicroXCT-400

Category	Specification
Operating System	Windows XP Pro
Hard Disk Drive Space – Drive C	Varies, dependent upon the workstation model available at the time of shipment/purchase
RAM	4 GB
Monitor	19-inch LCD

Table G-19 Tomography Software – MicroXCT-400

Category	Specification
Reconstruction Time	1,024 slices (8-bit) from 181 projections (GPU accelerated) < 3 minutes

Facility Requirements

Table G-20 Facility Requirements – MicroXCT-400

Category	Specification[a]
Electrical[b]	90 to 240 VAC, 15A, 50/60 Hz Isolated circuit (not shared by other equipment)
Footprint (w x d)[c, d]	2.17 m x 1.2 m Flat surface (0° angle)
Height[e]	2.09 m
Weight	2,722 kg
Radiation Safety	<1 μS/hr
Operating Temperature	18 to 25°C, with < 2°C variation
Exterior Clearance	**Front** – 1.2 m **Left** – 1.34 m **Right** – 1.1 m **Back** – 1.2 m

a. Length measurements are rounded.
b. Refer to Appendix H, "Electrical Documentation," for information specific to the EMO system and safety interlocks.
c. Includes handle and ergonomic workstation arm bracket.
d. Refer to Figure G-3 and Figure G-4.
e. Includes light tower.

Figure G-3 Footprint – MicroXCT-400

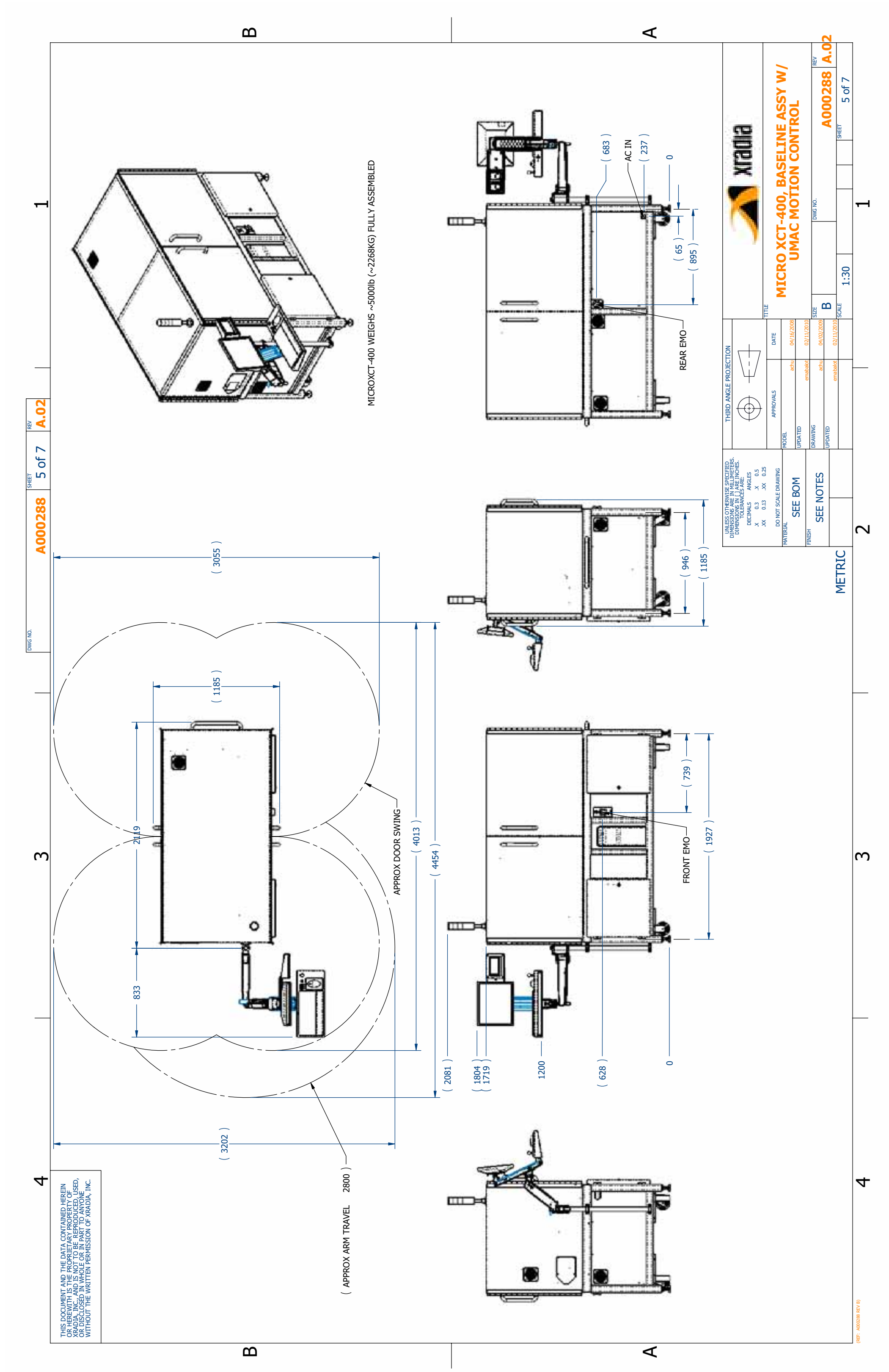
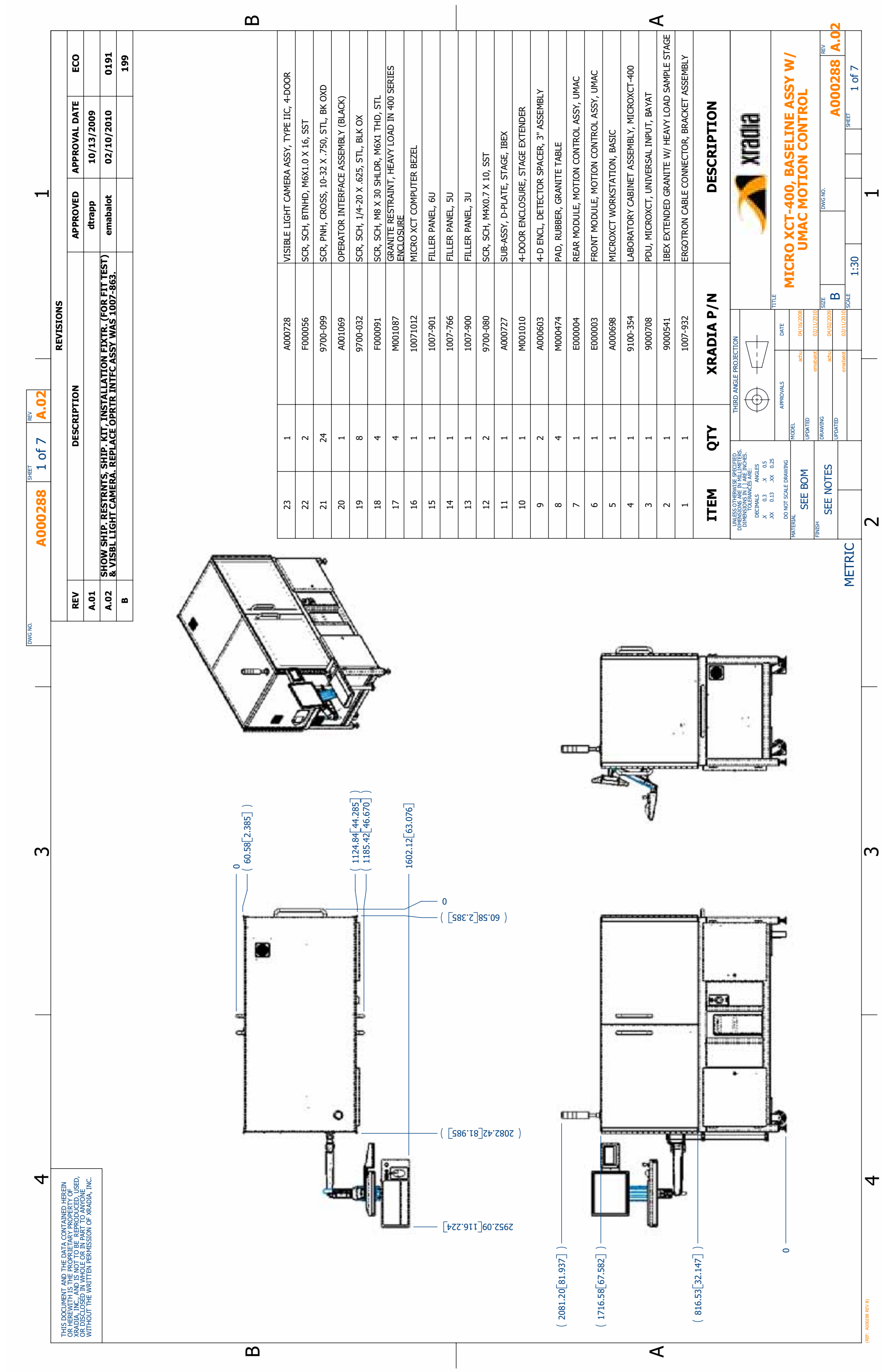


Figure G-4 Dimensions – MicroXCT-400



REVISIONS

REV	DESCRIPTION	APPROVED	APPROVAL DATE	ECO
A.01		dtrapp	10/13/2009	
A.02	SHOW SHIP. RESTRNTS, SHIP. KIT, INSTALLATION FIXTR. (FOR FIT TEST) & VISBL LIGHT CAMERA. REPLACE OPRTR INTFC ASSY WAS 1007-863.	emabalot	02/10/2010	0191
B				199

ITEM	QTY	XRADIA P/N	DESCRIPTION
23	1	A000728	VISIBLE LIGHT CAMERA ASSY, TYPE IIC, 4-DOOR
22	2	F000056	SCR, SCH, BTNHD, M6X1.0 X 16, SST
21	24	9700-099	SCR, PNH, CROSS, 10-32 X .750, STL, BK OXD
20	1	A001069	OPERATOR INTERFACE ASSEMBLY (BLACK)
19	8	9700-032	SCR, SCH, 1/4-20 X .625, STL, BLK OX
18	4	F000091	SCR, SCH, M8 X 30 SHLDR, M6X1 THD, STL
17	4	M001087	GRANITE RESTRAINT, HEAVY LOAD IN 400 SERIES ENCLOSURE
16	1	10071012	MICRO XCT COMPUTER BEZEL
15	1	1007-901	FILLER PANEL, 6U
14	1	1007-766	FILLER PANEL, 5U
13	1	1007-900	FILLER PANEL, 3U
12	2	9700-080	SCR, SCH, M4X0.7 X 10, SST
11	1	A000727	SUB-ASSY, D-PLATE, STAGE, IBEX
10	1	M001010	4-DOOR ENCLOSURE, STAGE EXTENDER
9	2	A000603	4-D ENCL, DETECTOR SPACER, 3" ASSEMBLY
8	4	M000474	PAD, RUBBER, GRANITE TABLE
7	1	E000004	REAR MODULE, MOTION CONTROL ASSY, UMAC
6	1	E000003	FRONT MODULE, MOTION CONTROL ASSY, UMAC
5	1	A000698	MICROXCT WORKSTATION, BASIC
4	1	9100-354	LABORATORY CABINET ASSEMBLY, MICROXCT-400
3	1	9000708	PDU, MICROXCT, UNIVERSAL INPUT, BAYAT
2	1	9000541	IBEX EXTENDED GRANITE W/ HEAVY LOAD SAMPLE STAGE
1	1	1007-932	ERGOTRON CABLE CONNECTOR, BRACKET ASSEMBLY

THIS PAGE INTENTIONALLY LEFT BLANK

H Electrical Documentation

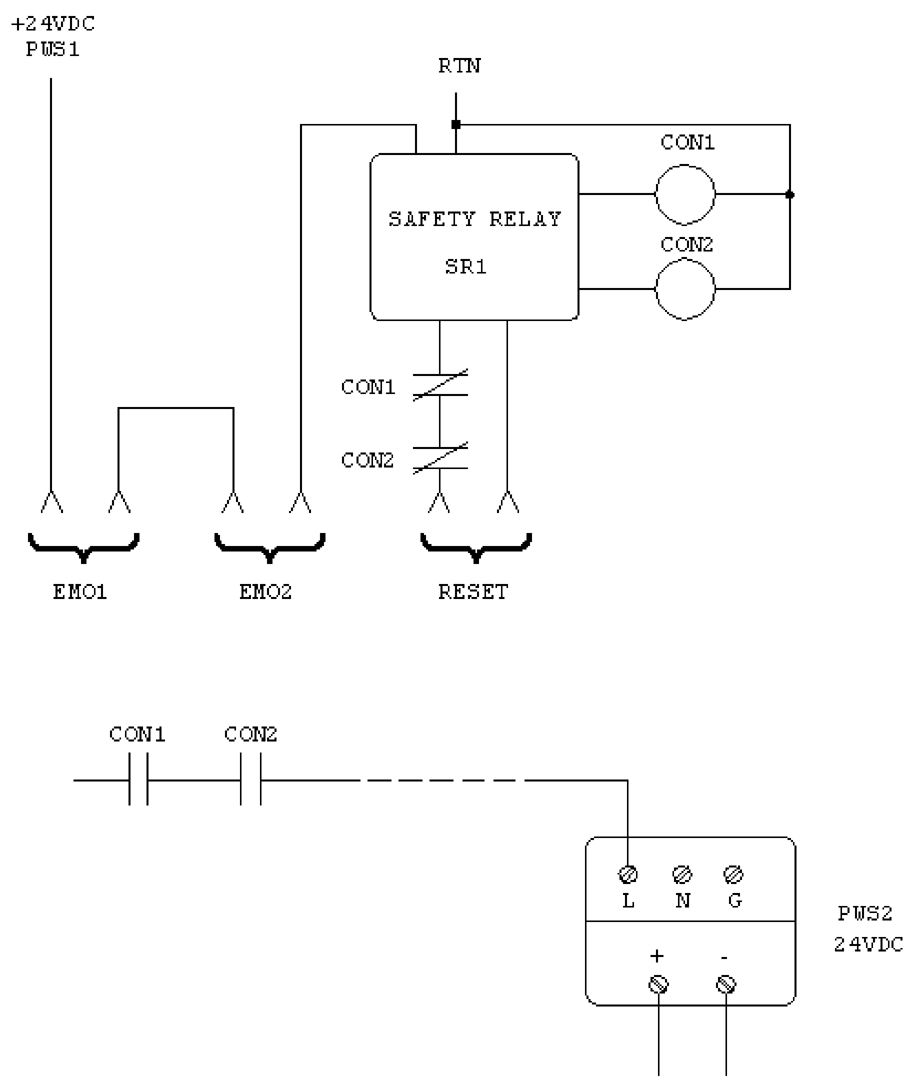
This appendix provides electrical documentation specific to the Emergency Off (EMO) system and safety interlocks.

EMO Sequence of Operation

The Safety Relay SR1 is powered through the EMO1 and EMO2 circuits, from the primary 24 VDC power supply, PWS1. If the **EMO** button is not activated (its normally CLOSED contacts are CLOSED) and 24 VDC has been supplied from PWS1, pressing the **RESET** button energizes the CON1 and CON2 contactors, whose contacts close and provide the power for the secondary 24 VDC power supply, PWS2. If **EMO** button is activated, the Safety Relay SR1 turns OFF, CON1 and CON2 immediately de-energize, and PWS2 is cut off from power. The normal condition can be restored when the **EMO** button is released (de-activated) and **RESET** button pressed. (Refer to Figure H-1.)

NOTE EMO2 is used only by the MicroXCT-400; in the MicroXCT-200 circuit, EMO2 is shorted.

Figure H-1 EMO Electrical Diagram



Interlock Sequence of Operation

NOTE Elsewhere in this guide, the "signal light tower" is referred to as the "light tower," and its lights are referred to as "lights," rather than "LEDs." The technical terminology (signal light tower and LED) are used only within this appendix.

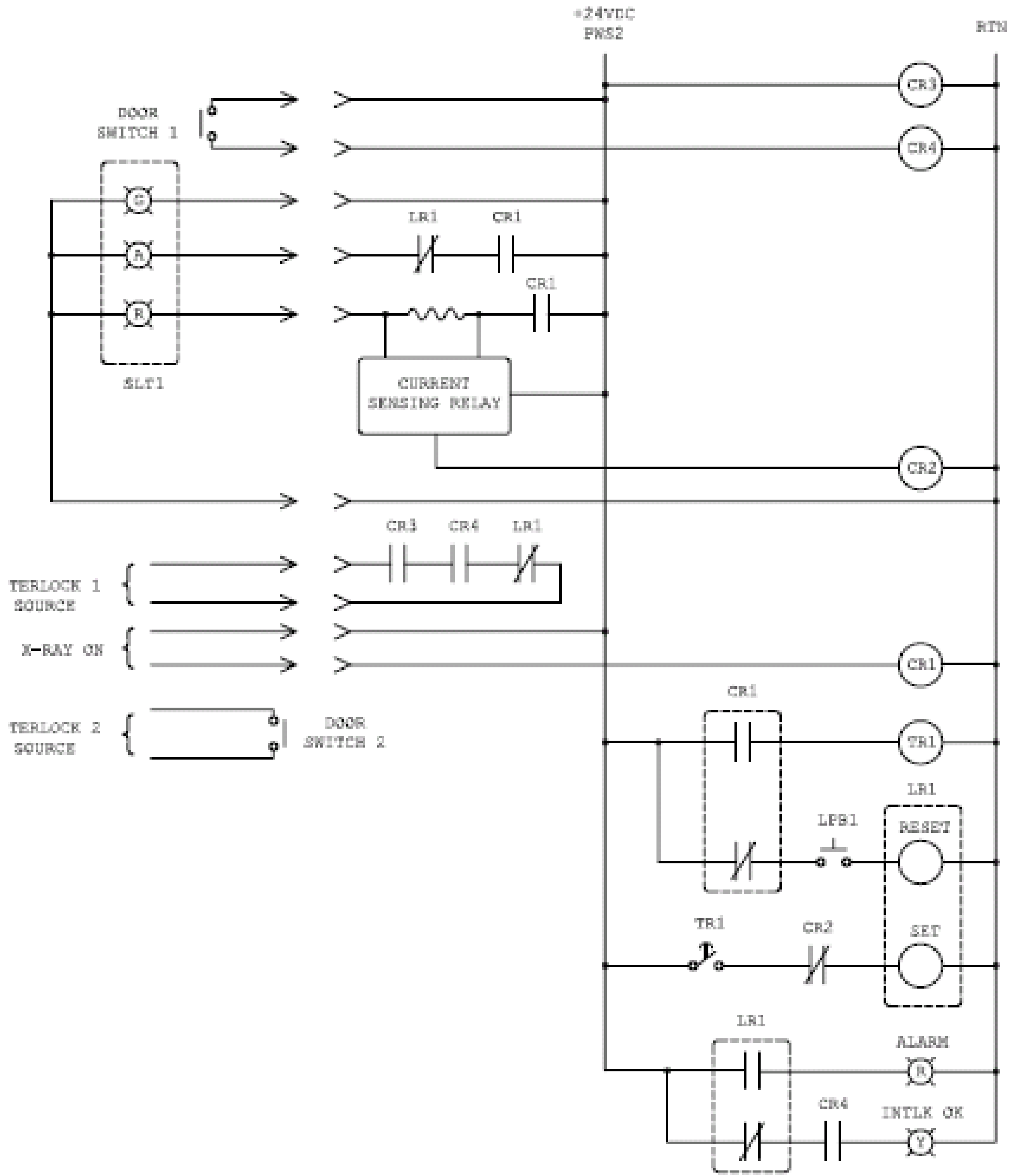
When PWS2 is powered up (EMO OK), the relay CR3 is energized and the (signal) light tower's (SLT1) **green** LED turns ON. When the access door(s) is (are) closed, both door interlocks are made (Door Interlock switch 2 is connected directly to the Interlock 2 input of the X-ray source; refer to Figure H-2), the relay CR4 becomes energized and the light tower's (SLT1) **yellow** LED turns ON. At this condition, the X-ray source is enabled (unless LR1 is energized). Failure on any interlock circuit (1 or 2) disables the X-ray source.

When the X-ray source turns ON, the relay CR1 becomes energized. The Normally OPEN contact of CR1 turns ON the light tower's (SLT1) **red** LED, indicating that the X-ray source is ON. CR2 becomes energized from the current sensing relay, which monitors the current flowing through the light tower's (SLT1) **red** LED.

At the same time CR1 turns ON, the time delay relay TR1 becomes energized and, after a short delay, its contact closes in the latching relay LR1 SET coil circuit. However, LR1 SET is not energized, because the normally CLOSED contact CR2 (which is in series with LR1 SET coil) becomes OPEN before the delay times out.

If the light tower's (SLT1) **red** LED turns OFF while the X-ray source is ON (LED failure, broken wire, or other electrical-related problem), the relay CR2 turns OFF. The LR1 becomes SET and disables the X-ray source, and the PDU's **ALARM** light turns ON. Normal conditions can be restored, if the light tower's (SLT1) **red** LED circuit is fixed prior to activating alarm reset LPB1.

Figure H-2 Safety Interlock Electrical Diagram



J License, Warranty, and Service Information

This appendix provides the software license agreement, limited warranties, service and maintenance information, and Xradia contact information.

Software License Agreement

All Software obtained by Purchaser from Xradia is proprietary to Xradia and its licensors and is subject to copyrights, other intellectual property rights and moral rights owned by Xradia and its licensors. Any references to "purchases" of Software signify only the purchase of a license to use the Software in question pursuant to the terms of the following software license. Xradia grants to Purchaser a non-exclusive license to use, according to its intended use, any software or firmware incorporated in or provided to operate with the Products, together with any modifications or enhancements to such software or firmware supplied to Purchaser by Xradia. Except as expressly set forth herein, no other rights are granted to or acquired by Purchaser with respect to Software. Purchaser may not sublicense, assign or otherwise transfer its rights to use Software except upon a transfer of any Products with or for which the Software was supplied and then only if these same licensing terms and limitations are applicable to the sublicensee, assignee or transferee. Purchaser acknowledges that the Software incorporates valuable trade secrets of Xradia and agrees not to copy, decompile, disassemble, reverse engineer, or modify any software provided by Xradia or its suppliers. This license granted herein will take effect upon delivery of the Software to Purchaser at the Ex works Point.

Limited Warranties

a) Hardware Warranty – Xradia warrants to Purchaser that the hardware component of the Products will be free from defects in material and workmanship and will conform to applicable specifications or documentation for a period of twelve (12) months from the date of delivery to Purchaser (the “Warranty Period”) when given normal, proper and intended usage and care. If, during the Warranty Period, the hardware component of any Product fails to conform to the foregoing warranty, Xradia shall, in its sole discretion, either repair or replace such Product, without charge to Purchaser, provided that: i) Xradia is promptly notified in writing by Purchaser (not later than thirty (30) days after discovery of the nonconformity or thirty (30) days after expiration of the Warranty Period, whichever occurs first) that the Product does not conform to the foregoing warranty, and ii) Purchaser obtains a Return Material Authorization (“RMA”) and a RMA number from Xradia prior to returning the nonconforming Product to Xradia at the Ex works Point, freight prepaid.

b) Software Warranty – Xradia warrants to Purchaser that during the Warranty Period the Software will perform substantially in accordance with its user documentation and specifications. Xradia does not warrant that the Software will operate in combination with other software or firmware which may be selected for use by Purchaser. If, during the Warranty Period, the Software fails to conform to the foregoing warranty, Xradia shall correct the nonconforming Software so that it performs as warranted at no charge to Purchaser, provided that: i) Xradia is promptly notified in writing by Purchaser (not later than thirty (30) days after discovery of the nonconformity or thirty (30) days after expiration of the Warranty Period, whichever occurs first) that the Product does not conform to the foregoing warranty.

c) Xradia shall have no responsibility with respect to defects in the Products or performance problems occurring in whole or part by reason of i) accident, misuse, neglect, alteration, improper installation, unauthorized repair, improper testing, unusual physical or electrical stress, or other conditions outside the operating parameters specified by Xradia, ii) software or firmware not supplied by Xradia, or iii) Purchaser’s failure to follow operating or corrective instructions provided by Xradia.

d) Xradia shall have a reasonable time to repair or replace nonconforming Product(s) or correct nonconforming Software. Xradia will pay standard freight for shipment of the repaired or replacement Product to Purchaser. Each repaired or replacement Product will be warranted for a period equal to the remainder of the original warranty period for the returned Product or ninety (90) days from the date of shipment of the repaired or replacement Product to Purchaser, whichever is longer.

e) Xradia warrants to Purchaser that, at the time title to the Products passes to Purchaser, Xradia has good and marketable title to the Products and that they are free and clear of all liens and encumbrances.

f) THE WARRANTIES STATED HERE ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, WHETHER EXPRESS, IMPLIED, OR STATUTORY, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE REMEDIES STATED HERE ARE EXCLUSIVE WITH RESPECT TO ANY DEFECTS OR DEFICIENCIES IN THE PRODUCTS.

Service and Maintenance

All service and maintenance is to be performed by trained Xradia personnel for customers with field service contracts. Should the MicroXCT require service outside the contracted maintenance schedule, contact Xradia to schedule a service visit.

Contact Information

Xradia, Inc.
5052 Commercial Circle
Concord, CA 94520 USA

Phone:	1 (888) 497-2342
	1 (925) 771-8093
Fax:	1 (925) 243-8788
Email:	service@xradia.com
Website:	http://www.xradia.com/products/support.php

K Glossary

access door(s) Part of the enclosure. Closes off the X-ray source, providing protection from harmful X-ray radiation.

artifacts Features that exist in an image that are not part of the sample, but are introduced by the imaging system.

baffle Part of the interior shielding within the enclosure, designed to deflect and/or absorb X-rays.

beam hardening Result of the change in spectrum characteristic as the X-rays pass through the sample, where the sample density remains the same, but the light changes – one area is darker than another.

beam line Imaging X-ray/light path consisting of the X-ray source, sample, and detector.

binning Process of combining charges from adjacent pixels in a CCD during readout. The two primary benefits of binning are improved signal-to-noise ratio (SNR) and the ability to increase frame rate, albeit at the expense of reduced spatial resolution. A binned pixel can be referred to as a *super pixel*, because charges of the binned pixels are combined to one. To ensure that dark current noise does not lower SNR during binning, it is essential that the CCD be sufficiently cooled, to reduce the dark current noise to a negligible level relative to the read noise.

CCD Charge-Coupled Device. A device for the movement of electrical charge, usually from within the device to an area where the charge can be manipulated. Technically, CCDs are implemented as shift registers. Often the device is integrated with a sensor, such as a photoelectric device to produce the charge that is being read, used where the conversion of images into a digital signal is required. CCDs are widely used in professional, medical, and scientific applications where high-quality image data is required.

center shift Amount, in pixels, that the axis of rotation is offset from the center column of the detector.

counts, light intensity Refer to light intensity counts.

CT Computed Tomography.

CT scale, CT scaling Process by which the tomography images produced have the appropriate Hounsfield Units (HU), in which air and water have values of -1,000 and 0, respectively. Xradia uses the unsigned short data format; therefore, Xradia CT scaling scales air to 0 and water to 1,000.

detector assembly Assembly that picks up X-ray images of the sample.

Dynamic Ring Removal Refer to DRR.

DRR Dynamic Ring Removal. Xradia proprietary method to remove ring artifacts in reconstructed slices and volume (available by selecting **Microscope > Configure System**).

EMO button Emergency Off button. Used to shut down the MicroXCT in emergency and non-emergency events.

enclosure Insulated steel and lead-lined framework that covers the exterior of the MicroXCT, providing protection from harmful X-ray radiation.

ergonomic station User console for controlling the MicroXCT for data acquisition and analysis.

exposure time Amount of time that the CCD is exposed to light when acquiring an image.

fiducial Fixed basis of reference or comparison.

field of view Refer to FOV.

FOV Field of View. Size of the area imaged by the system.

hardening the X-ray Using a source filter to remove lower-energy X-rays, to reduce the effects of beam hardening.

hazardous material Dangerous or toxic substance that is a biological, chemical, or physical agent (or a combination of agents), whose presence or use in the workplace can endanger the health or safety of a worker.

Hounsfield Units (HU) Scale in which the radiodensity of distilled water at standard pressure and temperature (STP) is defined as zero HU, while the radiodensity of air at STP is defined as -1000 HU. These standards are universally available references and are suited to the imaging of the internal anatomy of living creatures based on organized water structures and mostly living in air. The scale was established by Sir Godfrey Newbold Hounsfield, one of the principal engineers and developers of computed axial tomography (CAT, or CT scans).

ionizing hazard Hazard caused by exposure to X-ray radiation.

kernel size Number of pixels sampled as a unit during image manipulation.

light intensity counts Pixel intensity values, indicated in **blue**, in the lower left status area of an **Image** window.

light tower Indicator located on top of the MicroXCT that visually reports status conditions.

mosaic One large image that is created by scanning the sample and tiling the individual images acquired at each scanned X/Y location.

motion controller hardware Provides the interface between the workstation and all motors.

MTF **M**odulation **T**ransfer **F**unction. In imaging systems, it describes the response of an optical system to an image decomposed into sine waves. MTF represents the Bode plot of an imaging system (such as a microscope or the human eye), and thus depicts the filtering characteristic of the imaging system.

noise Random variation in intensity, in images produced by the different components of the imaging system.

PDU **P**ower **D**istribution **U**nit. Distributes power to the electrical MicroXCT components.

Power Distribution Unit Refer to PDU.

projection 2D images acquired during data acquisition/tomography using XMController.

reconstruction Process of using all the projections acquired during data acquisition/tomography, to create a 3D volume. This process requires the use of XMReconstructor.

reference image Blank image acquired with the sample out of the FOV.

region of interest Data acquisition area of focus.

RESET button Button used to reset MicroXCT power after a shutdown.

safety interlocks Device applied to two or more moveable parts that allows the operation of the X-ray source, only when the parts are locked in a pre-determined position. For the MicroXCT, the safety interlocks turn OFF the X-ray source when the access door(s) is (are) opened.

sample holder assembly Sample mounted on a sample holder.

sample holder Device used to hold the sample in place. Sample holders used with MicroXCT are clamps, clips, pin vises, and sample bases. Sample holders are described in "Mounting the Sample in/on a Sample Holder," on page 33.

sample stage Platform upon which the sample (imaging target), mounted on a sample base, is secured for microscopy.

scintillator Device used for detecting and counting scintillations produced by ionizing radiation.

slice XMReconstructor reconstructs images stored in each **.txrm* file to form a set of reconstructed slices. A slice is a 2D section of the 3D reconstructed volume. Slices generated from each **.txrm* file are stored in a file with the extension *.txm*. A **.txm* file contains a collection of slices that make up the reconstructed volume. If no specific region is selected during reconstruction, the number of slices is equal to the height of each projection image in the original **.txrm* file.

SNR **S**ignal-to-**N**oise **R**atio. Describes the quality of a measurement. In CCD imaging, SNR refers to the relative magnitude of the signal compared to the uncertainty in that signal on a per-pixel basis. Specifically, it is the ratio of the measured signal to the overall measured noise (frame-to-frame) at that pixel. High SNR is particularly important in applications that require precise light measurement.

source aperture Tungsten piece with a hole in the center of it, that is bolted onto the front of the X-ray source.

source controller hardware Provides the interface between the workstation and X-ray source. Included only with the 150 kV X-ray source.

source filter Material (available in a filter kit from Xradia) that improves reconstructed image quality, by removing low-energy X-rays that do not provide useful information through the sample.

stitching Process in which two volumes are merged at a common plane, to become a single volume. The two volumes must be reconstructed at the same byte scaling, to provide identical grayscale levels for both volumes.

tomography Technique that allows virtual cross-sectioning or de-layering, which enables you to look at the interior of the sample, without destroying the sample.

transmission value Ratio of X-rays through the sample versus the X-rays without the sample present.

turret Part of the detector assembly. Holds up to six lenses. The lens located at the lowest point on the turret is used to focus on the sample.

visual light camera Supplies images to the visual light camera monitor. Located behind the sample stage, at the rear of the enclosure.
Used for positioning the sample, detector, and X-ray source.

VRT **V**olume **R**endering **T**echnique. Default **3D display** mode in XM3DViewer that is used to compute a color and transparency mapping of a 3D reconstructed volume.

workstation Windows XP-based computer included in the MicroXCT.

XM3DViewer Program used to view regions of interest in reconstructed tomographic data as a 3D volume.

XCT **X**-ray **C**omputed **T**omography.

XMController Program used to manage the data acquisition process, from setting up the sample to the acquisition of data, either manually or through the automatic Recipe. Also used to acquire X-ray images, and monitor and control the microscope’s hardware components.

XMReconstructor Program used to reconstruct 2D projections into 3D reconstructed volumes. Refer also to reconstruction.

X-ray source Mechanism that generates X-rays, from 20 to 90 kV (90 kV X-ray source) or 40 to 150 kV (150 kV X-ray source), used by the MicroXCT to image samples and reference images.

X-ray source aging Required X-ray source warm-up process that lasts up to 30 minutes or longer, after the X-ray source has been turned OFF for more than 8 hours. The X-ray source voltage and current increase up to their maximum levels in a pre-determined fashion during warm-up.