ZEISS Xradia Versa User's Guide

July 2016

Xradia Versa®
High-Resolution 3D X-ray Imaging Systems
U.S. Patent Nos. 7,800,072, 7,130,375, 7,400,704, 9,110,004, and 9,128,584.

Original Instructions
Can be translated to another language on request

Carl Zeiss X-ray Microscopy, Inc.
4385 Hopyard Rd, Ste 100
Pleasanton, CA 94588 USA
1 (888) 497-2342 (T)
1 (925) 730-4952 (F)
www.zeiss.com/xrm

Document Name:	ZEISS Xradia Versa User's Guide
Document Part Number and Revision:	A003030, Rev. B
Software Version:	11.*x*
Effective from:	July 2016

Contents

Safety

This section provides guidelines and information for safely using and operating the ZEISS® Xradia Versa®:

- Safety Guidelines
- EMO Shutdown
- Enclosure Covers and Access Doors
- Potential Hazards and Safety Precautions – Personnel
- Potential Hazards and Safety Precautions – Equipment
- Safety Labels
- Safety Lockout
- Decommissioning and Disposal

Safety Guidelines

Observe and follow these safety guidelines when using the Xradia Versa:

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

⚠WARNING Failure to observe and follow these guidelines is in violation of product use and warranty, and puts you at risk of serious injury. ZEISS is not liable for personal injury or damage to the Xradia Versa caused by misuse.

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

- Use the Xradia Versa only for applications and uses for which it is designed.
- Use only the components and/or machine accessories prescribed or provided by ZEISS.
- Use the Xradia Versa within environmental conditions specified in Appendix H, "Specifications."
- Do **not** use the Xradia Versa with objects or raw materials other than those for which it is intended.
- If the Xradia Versa is covered by a ZEISS field service contract, do **not** attempt to maintain, service, repair, or modify the Xradia Versa because these tasks must be performed only by trained ZEISS service personnel.
- Turn OFF the X-ray source before opening the access doors. Do **not** open the access doors while X-rays are being generated.

NOTICE If the access doors do not completely close or are damaged, turn OFF the Xradia Versa and contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

– Do **not** intentionally defeat the access door safety interlocks. Keep the access doors closed when the X-ray source is turned ON.

– In the event of a personal safety or Xradia Versa emergency, press an **EMO** button to turn OFF power to the Xradia Versa.

NOTICE The EMO shutdown process (pressing of an **EMO** button) leaves the Xradia Versa stage positions and other system components in undefined states and can adversely affect the computer workstation and/or optional storage server, potentially causing data loss – use only in the event of a personal safety or equipment emergency. Refer to “Loss of Data Due to EMO Shutdown,” for how to recover lost data.

NOTE Use of the non-emergency shutdown procedure is recommended in non-emergency events. (Refer to “Shutting Down the Xradia Versa in a Non-Emergency Event,” on page 174 in Appendix C.)

– Connect the Xradia Versa to a properly rated and grounded AC power outlet, on an electrical circuit that is not shared by any other equipment, as specified in Appendix J, “Electrical Documentation.”

– All users should be sufficiently trained regarding how to use the Xradia Versa by ZEISS service personnel.

– 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 any motorized component(s) within the Xradia Versa.

– Maintain the operating temperature range at an ambient room temperature, between 10 to 25°C, with a variation of less than 2°C, for optimum image quality.

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

EMO Shutdown

NOTICE The EMO shutdown process (pressing of an **EMO** button) leaves the Xradia Versa stage positions and other system components in undefined states and can adversely affect the computer workstation and/or optional storage server, potentially causing data loss – use only in the event of a personal safety or equipment emergency. Refer to “Loss of Data Due to EMO Shutdown,” for how to recover lost data.

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

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

One **EMO** button is located on the front panel of the enclosure, within easy reach. A second **EMO** button is located on the back of the Xradia Versa enclosure, below the rear access doors. The **EMO** button used, as well as its locations on the Xradia Versa, are shown in the figure below.

EMO Button – Front of Xradia Versa (Xradia 520 Versa Shown)

To shut down the Xradia Versa in an emergency event

1. Firmly press an **EMO** button to immediately turn OFF power to the Xradia Versa.

   After the emergency is resolved, all personnel are safe, and all appropriate safety conditions are satisfied, proceed to "Turning ON the Xradia Versa," on page 176 in Appendix C.

Enclosure Covers and Access Doors

⚠WARNING Do **not** remove any covers or baffles, or intentionally defeat the access door safety interlocks. Doing so will expose personnel to harmful X-ray radiation, which can result in serious injury.

⚠WARNING If the access doors do not completely close or are damaged, or if any part of the enclosure is damaged, turn OFF the Xradia Versa and contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.) Failure to do so can result in fatal injuries.

⚠WARNING Do **not** modify any part of the enclosure. Doing so can result in fatal injuries.

The Xradia Versa is fully enclosed within a steel enclosure, which includes access doors and protective covers that provide a safety and environmental barrier. The steel and lead-lined enclosure covers and access doors:

– Provide protection from X-ray beams and high voltage generated by the X-ray source

– Maintain the Xradia Versa at operating temperature

The access doors include a fail-safe (safety) interlock. The X-ray source will turn ON only if the access doors are CLOSED. Turn OFF the X-ray source before opening the access doors. Do **not** open the access doors while X-rays are being generated.

NOTICE Do **not** open the access doors while X-rays are being generated. Doing so automatically terminates X-ray generation and causes a fault condition, thereby preventing further operation until the fault is reset. Refer to "Interlock Sequence of Operation," on page 334 in Appendix J for further explanation and method of recovery. Method of recovery is also provided in Table A-9, "Troubleshooting Light Tower Electrical Issues," on page 165 in Appendix A.

For personal and equipment safety:

– Do **not** remove any bolted-down covers or doors.

– Ensure that the access doors are completely closed and not damaged nor blocked in any way.

– Do **not** intentionally defeat the access door safety interlocks. Keep the access doors closed when the X-ray source is turned ON.

Potential Hazards and Safety Precautions – Personnel

The Xradia Versa is designed to be safe for standard operator 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 Xradia Versa. Severe or catastrophic injury to personnel, or damage to the equipment or facility can result if the prescribed procedures are not followed.

The Xradia Versa uses a broad energy range of 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 personnel include:

– Hazardous Materials

– High Voltage

– Ionizing Hazard

– Electrical Shock Hazard

– Magnetic Field

– Pinch Hazards

Each potential hazard is described in the sections that follow.

Hazardous Materials

The Xradia Versa contains one or more components that are known to be hazardous to health and/or the environment. For further details, contact Carl Zeiss X-ray Microscopy Product Marketing.

NOTE Safety Data Sheets are available from ZEISS on request.

⚠CAUTION Should you need to decommission and dispose of the Xradia Versa, refer to “Decommissioning and Disposal.”

High Voltage

NOTICE Press an **EMO** button to shut down the Xradia Versa in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

The X-ray source generates dangerous high voltages that can be present if the safety interlocks are defeated and/or cabling is disconnected, cut, or damaged.

The risk level is low for standard use, due to safety interlocks, protective cable insulation, and tool-to-remove cable connection.

The X-ray source and some motion components require high voltage of up to 160 kV. The high-voltage power is located within the High Voltage Power supply located within the enclosure.

Observe the following safety guidelines:

- Do **not** attempt to defeat the access door safety interlocks. Keep the access doors 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 or by ZEISS service personnel.
- Do **not** remove any GROUND connections.

Potential Damage Severe to catastrophic injuries can result from electric shock by the high-voltage source. Minor to moderate injuries can result from electric shock by hazardous voltage sources.

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

Ionizing Hazard

⚠WARNING Do **not** modify any part of the enclosure. Doing so can result in fatal injury.

NOTICE Press an **EMO** button to shut down the Xradia Versa in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

The X-ray source generates X-rays within the enclosure that can expose personnel to dangerous X-rays if the safety interlocks are defeated and the access doors are OPENED, protective covers are removed, or the enclosure is damaged.

The risk level is low for standard use, due to safety interlocks and the protective enclosure.

The Xradia Versa uses a broad energy range of X-rays to image samples and collect references.

Observe the following safety guidelines:

– Do **not** intentionally defeat the access door safety interlocks. Keep the access doors closed when the X-ray source is turned ON.

– Do **not** remove the enclosure panels or any protective covers.

– Do **not** operate the X-ray source if the access doors do not close, any portion of the enclosure appears damaged, or the interlock switches appear to be damaged. Turn OFF the X-ray source and contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

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 Xradia Versa is fully enclosed by a steel and lead-lined enclosure that incorporates safety interlocks, which together protect personnel from harmful X-ray radiation. To ensure the enclosure's integrity, ZEISS service personnel perform a radiation survey on installation and during regularly scheduled service every six months, for Xradia Versa units under warranty or service packages.

For questions concerning radiation safety, contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

Electrical Shock Hazard

⚠WARNING The Xradia Versa must remain properly grounded and connected to a grounded AC power source, as installed by ZEISS service personnel. Failure to do so can cause electric shock, which can result in fatal or near-fatal injuries.

NOTICE Press an **EMO** button to shut down the Xradia Versa in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

If the Xradia Versa is not connected to a grounded AC power source, there is a high risk of electrical shock.

There should be no problem with improper grounding when the Xradia Versa is properly connected to a grounded power source, per specifications. Refer to Appendix J, "Electrical Documentation," for grounding specifications.

Observe the following safety guideline:

– Ensure that the power cord from the Xradia Versa (located on the back of the instrument) is connected to a grounded power outlet.

Magnetic Field

The Xradia Versa includes several motors that generate low levels of magnetic field. The Xradia Versa might also include power supplies that can incorporate transformers and/or inductors that generate low-level magnetic fields.

The risk level is low for standard use, due to the protective enclosure.

Potential Damage The magnetic field strength is extremely low. Personal injury 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

– Is holding objects sensitive to magnetic fields, such as a floppy disk, external hard disk drive, credit card, hotel key card

Pinch Hazards

The radiation-shielding enclosure, which includes the access doors, 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; therefore, the risk level is low.

There is also a pinch hazard associated with movement of stages within the enclosure. The risk is low due to the slow speed of motion.

Although unlikely, it is also possible to be pinched by the screw or spring clamp sample holder provided with the Xradia Versa.

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

Hazard Control Pay attention when opening or closing the access doors.

Keep your hands clear of the stages when a stage is in motion.

Keep your fingers free of the part of the screw or spring clamp sample holder that closes on the sample.

If a body part is caught in a closing access door

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

If a hand is caught in a stage

1. Reverse the motion controller that moved the stage onto the hand.

If a finger is caught in a sample holder

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

Potential Hazards and Safety Precautions – Equipment

The Xradia Versa 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 Xradia Versa. 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:

- Improper Grounding
- Loss of Data Due to EMO Shutdown
- Collision of Moving Parts

Improper Grounding

⚠WARNING The Xradia Versa must remain properly grounded and connected to a grounded AC power source, as installed by ZEISS service personnel. Failure to do so can cause electric shock, which can result in fatal or near-fatal injuries.

NOTICE Press an **EMO** button to shut down the Xradia Versa in a personal safety or equipment emergency. Refer to "EMO Shutdown," for further details.

There should be no problem with improper grounding when the Xradia Versa is properly connected to a grounded power source, per specifications. Refer to Appendix J, "Electrical Documentation," for proper grounding.

Observe the following safety guideline:

- Ensure that the three-prong power connector (located at the back of the Xradia Versa) is connected to a grounded 230V AC Nominal (160 to 286V AC range, Single Phase, 50/60 Hz, 15A) power source

Loss of Data Due to EMO Shutdown

NOTICE The EMO shutdown process (pressing of the **EMO** button) leaves the Xradia Versa stage positions and other system components in undefined states and can adversely affect the computer workstation and/or optional storage server, potentially causing data loss – 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 drives.

Hazard Control Use the EMO shutdown process only in the event of a personal safety or equipment emergency. If possible, use the process described in "Shutting Down the Xradia Versa in a Non-Emergency Event," on page 174 in Appendix C, instead.

To recover lost data

- If a backup copy of the data files that were lost is available, copy or restore the files back to the affected hard disk drive
- Contact your Information Technology (IT) department for assistance
- Contact the ZEISS Support Team for assistance (refer to "Technical Support," on page 348 in Appendix L)

NOTE To help protect data files created by the Xradia Versa, it is recommended that you install a backup program, or other backup process that is required by your IT department, on the Xradia Versa.

Collision of Moving Parts

NOTE Tips for troubleshooting collision and imminent collision are described more fully in "Troubleshooting Scout-and-Scan Control System Sample Issues," on page 140 in Appendix A.

The risk level is low for standard use.

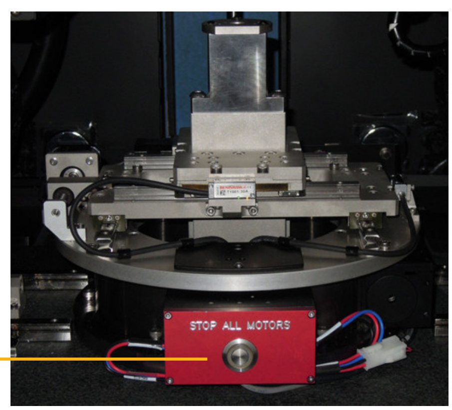
Collision Detection Xradia Versa Version 11.*x* software has a collision detection feature that protects against collision of motorized components. However, it does **not** protect the sample from colliding with other components when the sample, detector, and/or X-ray source are moved. Collisions, should they occur, are likely due to moving the sample, detector, and/or X-ray source too close to one another. In most cases, equipment damage would be minor.

Potential Damage Collisions can cause misalignment and, in more severe cases, damage to subcomponents. Should the Xradia Versa require realignment, contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

STOP ALL MOTORS Button The Xradia Versa is equipped with one **STOP ALL MOTORS** button (inside the enclosure, sample stage base) for use in case of emergency. (Refer to the figure below.) Press the button to immediately stop all moving motors. Press the button again to release the button before starting any moves.

STOP ALL MOTORS Button

Inside the enclosure, at the base of the sample stage



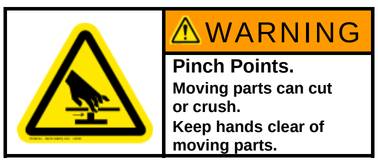
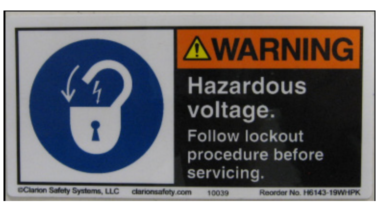
Observe the following safety guideline:

– Ensure that the *sample holder assembly* is correctly loaded on the sample stage (flat edge facing front, tungsten balls on the stage aligned with the sample holder base)

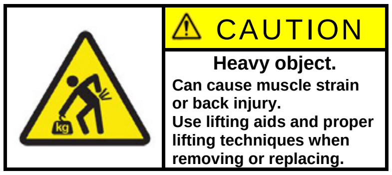
Safety Labels

The following table lists and describes a sampling of the **WARNING** and **CAUTION** safety labels located inside and/or outside the Xradia Versa enclosure.

Safety Labels

<table>
<tr><th>Label</th><th>Description and Location in/on Xradia Versa</th></tr>
<tr><td>
</td><td>Warns ZEISS service personnel to turn OFF and lock out Xradia Versa power prior to attempting to service the Xradia Versa.
Adhered to the top of the Power Distribution Unit (PDU). Visible when the PDU is pulled out by ZEISS service personnel, for servicing.</td></tr>
<tr><td>
</td><td>Warns you that moving parts can cut or crush, keep hands clear of moving parts to avoid being pinched.
Adhered near the sample stage, visible inside the front and back of the Xradia Versa.</td></tr>
<tr><td>
</td><td>Warns you that the access doors can cut or crush, keep hands clear when closing the access doors to avoid being pinched.
Adhered on the front and back access doors, on the lip of the doors.</td></tr>
<tr><td>
</td><td>Warns ZEISS service personnel to follow lockout procedures before servicing the Xradia Versa.
Adhered under the front left access panel, on the high-voltage power supply.</td></tr>
<tr><td>
</td><td>Warns you to read and understand this guide and other documentation before operating the Xradia Versa.
Adhered under the front left access panel, on the high-voltage power supply.</td></tr>
<tr><td>
</td><td>Warns you not to lift or move the Xradia Versa without assistance.
Adhered under the front left access panel, on the high-voltage power supply.</td></tr>
</table>

Safety Labels (Continued)

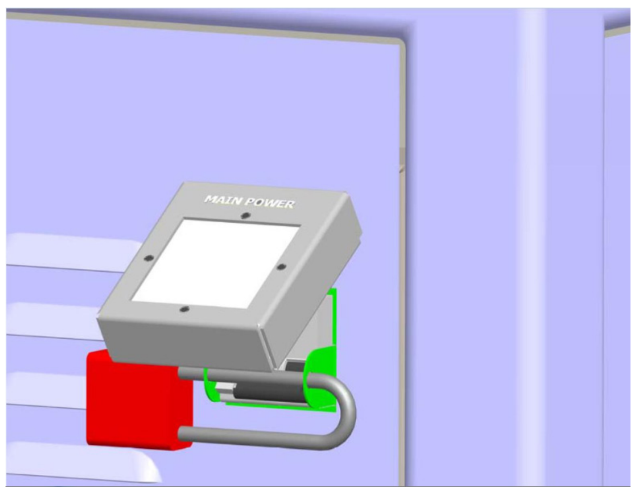
<table>
<tr><th>Label</th><th>Description and Location in/on Xradia Versa</th></tr>
<tr><td>
</td><td>Cautions you that the Xradia Versa is a heavy object, and to use lifting aids and appropriate lifting techniques to avoid muscle strain and/or back injury.
Adhered under the front left access panel, on the high-voltage power supply.</td></tr>
<tr><td>
</td><td>Cautions you to not remove any parts of the enclosure to protect yourself and others from harmful X-ray radiation.
Adhered to the baffles or covers that are bolted to the Xradia Versa.</td></tr>
<tr><td>
</td><td>Cautions you to turn OFF the X-ray source before opening the access doors to protect yourself and others from harmful X-ray radiation.
Adhered to the front of the Xradia Versa, on an access door.</td></tr>
<tr><td>
</td><td>Cautions you that the Xradia Versa is a heavy object, and to use lifting aids and appropriate lifting techniques to avoid muscle strain and/or back injury.
Adhered under the front left access panel, under the PDU.</td></tr>
<tr><td>
</td><td>Cautions you to not touch the hot surface of the X-ray source. To avoid possible skin burns, disconnect and lockout power to the Xradia Versa and allow the X-ray source’s surface to cool before servicing.
Adhered to the X-ray source.</td></tr>
</table>

Safety Lockout

WARNING This safety lockout method described here is the is the only approved method to use for the Xradia Versa. Use of a lockable cover on the power cord does **not** put the Xradia Versa in a safe power-down state. The Xradia Versa's internal Uninterruptible Power Supply (UPS) continues to generate hazardous voltage, even when power to the Xradia Versa is disconnected. The main power disconnect terminates input power to the Xradia Versa and disables output of the UPS.

Safety Lockout can be accomplished using a padlock with approximately a 7.62-cm shackle (American Lock #A1107KAREG or equivalent). The padlock can be applied to the main power disconnect circuit breaker, located on the back of the Xradia Versa enclosure, as shown in the following figure.

Safety Lockout Using a Padlock



Decommissioning and Disposal

Should you need to decommission and dispose of the Xradia Versa, contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

THIS PAGE INTENTIONALLY LEFT BLANK

Preface

The guide covers use of the Scout-and-Scan™ Control System on all ZEISS® Xradia Versa® instruments. In addition, any references to the instruments encompass the current **Xradia Versa** family composed of the Xradia 520 Versa, Xradia 510 Versa, and Xradia 410 Versa.

Some features are optional and not included with every system. Your particular system might not include optional components if these were not purchased. No differentiation is made in the user's guide about which features and components are optional or standard. ZEISS reserves the right to redefine the standard product configuration and available options.

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 Xradia Versa.
- Chapter 1, “Overview,” provides an overview of the technology used by the Xradia Versa, as well as the main components, programs, and processes used to generate and view tomographic data.
- Chapter 2, “Acquiring Tomographies with the Scout-and-Scan Control System,” describes how to acquire tomographies using the Scout-and-Scan Control System. Also includes instructions for setting up and using a recipe with variable angle tomography (Xradia 520 Versa only) and a secondary reference.
- Chapter 3, “Manually Reconstructing a Tomography Dataset,” describes how to use Reconstructor to manually reconstruct a tomography dataset.
- Chapter 4, “Viewing and Editing Tomographies,” describes how to use XM3DViewer to view and edit 2D reconstructed slices and 3D reconstructed volume datasets for use in reports and movies.
- Appendix A, “Troubleshooting,” describes how to resolve common issues that might be encountered when using the Xradia Versa.
- Appendix B, “Files and File Storage,” describes the file types unique to the Xradia Versa programs, recommended file handling, and file storage.
- Appendix C, “Shutting Down and Restarting the Xradia Versa,” describes how to shut down and restart the Xradia Versa, and then home all motorized axes to predefined initialization positions.
- Appendix D, “User Interface and Software Control Features,” describes the Scout-and-Scan Control System, Reconstructor, and XM3DViewer user interfaces.
- Appendix E, “Mounting, Loading, and Removing Samples,” describes how to mount a sample, load the sample holder assembly on the sample stage, and remove the sample from the Xradia Versa after use.

– Appendix F, “Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa,” describes how to manually install a source filter on the X-ray source (Xradia 510 Versa and Xradia 410 Versa only), as well as how to remove a source filter that is already installed.

– Appendix G, “Advanced Features,” discusses features that would typically be used by more-advanced Xradia Versa users.

– Appendix H, “Specifications,” lists the Xradia Versa component and facility requirement specifications.

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

– Appendix K, “CE Declaration of Conformity,” provides a copy of the ZEISS CE Declaration of Conformity.

– Appendix L, “License, Warranty, and Service Information,” provides the software license agreement, limited warranties, service and maintenance information, and ZEISS Support Team information.

– Appendix M, “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 sequence 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**.

- Settings to be typed or selected (if more than one selection is available) are *italicized*. For example:

  Type *1* in the **Exposure (sec)** text box.

- File name extensions and partial file names are *italicized*. For example:

  Each **.txrm* file contains multiple images.

- Terms that are being defined or also known by another name are *italicized*. For example:

  Also referred to as an *output reconstruction file*.

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

  amber, **blue**, **gold**, **gray**, **green**, **orange**, **red**, **yellow**

NOTE The same color is used for both **gold** and **yellow**.

- First capping is used in some cases for OPEN, CLOSED, ON, OFF, CLOCKWISE, and COUNTERCLOCKWISE.

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, and in some cases, subsection. For example, if you are reading text in Chapter 1, and the referenced text is in Chapter 3, the reference mentions the Chapter number and includes a page number.

User Interface Terminology

Select and click are used as follows:

- **Select**

  Move the mouse pointer to select/highlight an item for use. For example:

  - Select a high-resolution objective (whichever best matches the sample size) from the **Objective** drop-down list box
  - Select the **Acquisition** tab

- **Click**

  Click the left- (default) or right-mouse button (as instructed) to select a button, check box, or other item that incurs an action that issues a command or sets a parameter value. For example:

  - Click **OK**
  - Click  to proceed to the next tabbed view

Warnings, Cautions, Notices, and Notes

Warnings, Cautions, Notices, and Notes appear throughout the guide. Examples of format and content are provided below. For Warnings, Cautions, and Notices, it is particularly important to read and understand each so that you are sufficiently aware of the possible hazards that can be encountered when using the Xradia Versa.

If the Warning, Caution, or Notice indicates “contact the ZEISS Support Team,” stop using the Xradia Versa, and then contact ZEISS at the number provided in “Technical Support,” on page 348 in Appendix L.

⚠WARNING Used when information is critical to avoid personal injury.

⚠CAUTION Used when information is important to personal safety.

NOTICE Used when information is critical to avoid device or equipment damage, or to avoid severely impacting processing.

NOTE Used when information is sufficiently important to require attention.

Assumptions

This guide assumes that you have:

- Been sufficiently trained by ZEISS service personnel in basic use of the Xradia Versa
- Experience using Microsoft Windows 7 (or previous versions of Windows) and a basic working knowledge of 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, main components, and programs used by the ZEISS® Xradia Versa® to generate and view tomographic data. A definition of the axes is included as well.

Technology Overview

The following provides a brief overview of how the Xradia Versa is used as an analytical tool, how the Xradia Versa works, and the current **Xradia Versa** family.

X-ray Microscopy

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

While medicine and dentistry remain the most common usages of X-rays, it is also widely used in other applications, from airport security to industrial inspection and quality control systems. Computed Tomography (CT) 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 on the X-rays transmitted by the sample. Where the sample absorbs more X-rays, the image is darker; where it transmits more X-rays, the image is brighter. Absorption increases with density and thickness, and is also generally higher for elements with a higher atomic number in the periodic table.

Magnification in X-ray microscopes is typically achieved either by using a projection geometry with a point source (as in the Xradia Versa), or by using optical elements similar to a regular visible light microscope (as in the Xradia Ultra®).

In most X-ray microscopes (unlike electron microscopes), the sample is generally at normal atmospheric pressure. Environmental conditions such as temperature, pressure, humidity, or gas atmosphere can be adjusted, as necessary, within certain limits. Samples, including semiconductor packages and various other materials, can be imaged under real operating conditions or while subject to mechanical forces.

How Computed Tomography Works

In X-ray CT, the sample is imaged from different directions, ideally across an angular range of at least 180°. A single image at one particular angle is referred to as a *projection*. Computer algorithms can be used to reconstruct the internal, 3-dimensional (3D) structure of the sample from a series of projections. The reconstructed volume can be visualized in different ways; for example *slice by slice* (also referred to as *virtual cross-sectioning)*, or by rendering a 3D view of individual internal features.

Xradia Versa Family

This guide describes the use of CT technology for the **Xradia Versa** family. The Xradia Versa is the latest generation in a leading class of 3D X-ray microscopy (XRM) solutions optimized for non-destructive micro tomography. The Xradia Versa's new X-ray source technology and high-resolution detector provide unmatched submicron resolution for large and small samples.

What the Xradia Versa Does

ZEISS advanced X-ray computed tomography (CT) products help promote innovation in science and industry. ZEISS 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. For the following applications, the Xradia Versa offers:

- In Life Science Research

  The Xradia Versa enables imaging of hard and soft tissue with an unmatched combination of resolution and sample size. ZEISS 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 Material Research and Development

  The ZEISS 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.

– In Semiconductor Package Development and Failure Analysis

Engineers use the **Xradia Versa** family to verify micron-sized defects, without the need for physical delayering or cross-sectioning, thus maintaining the integrity of the samples.

– In Geomaterials Physics Modeling and Oil and Gas Exploration

Digital rock analysis combines 3D images of reservoir rock pore networks with fluid flow simulation to estimate and optimize well performance. ZEISS 3D X-ray microscopes provide high-resolution images of pore structures that enable accurate and statistically meaningful simulation models. They also provide a unique, high-resolution imaging platform for *in situ* multi-phase fluid flow experiments to confirm those models. Solutions are available for sandstone, carbonate, tight gas sand, and oil shale.

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 Versa Hardware and Software

The Xradia Versa includes the hardware and software needed to create and view tomography images.

Hardware Components

This section describes the Xradia Versa major hardware components.

Major External and Internal Hardware Components

Figure 1-1 provides visual internal and external views of a typical Xradia Versa (Xradia 520 Versa shown) with the access doors OPEN and CLOSED. Table 1-1 lists the major internal and external hardware components as they relate to Figure 1-1.

NOTICE The Xradia Versa includes extremely sensitive mechanical, optical, and electronic components. Do **not** touch anything within the enclosure except for the following components, unless instructed otherwise by ZEISS service personnel:

- Sample stage, while loading the sample holder assembly
- X-ray source, when installing a source filter

Figure 1-1 External and Internal Views (Xradia 520 Versa Shown)

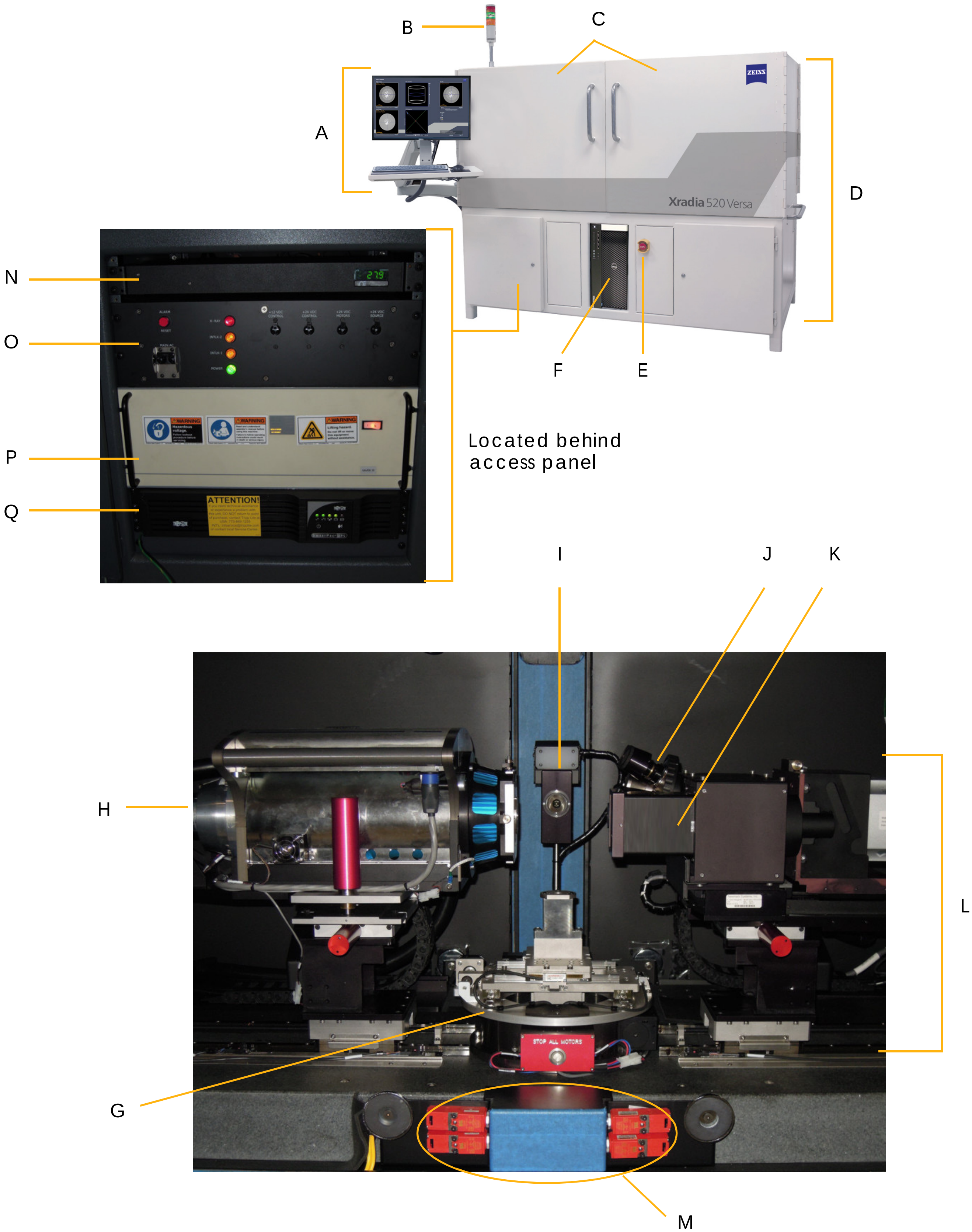


Table 1-1 Major Components Shown in Figure 1-1

<table>
<tr><th>Reference Designator</th><th>Part</th><th colspan="2">Description</th></tr>
<tr><td>A</td><td>Ergonomic Station</td><td colspan="2">User console for controlling the Xradia Versa for data acquisition and analysis.
Refer to “Ergonomic Station,” for further details.</td></tr>
<tr><td rowspan="9">B</td><td rowspan="9">Light Tower</td><td colspan="2">Indicator located on top of the Xradia Versa that visually reports the following status conditions.</td></tr>
<tr><td>Light Tower Indicator Status</td><td>Description</td></tr>
<tr><td>All lights OFF</td><td>Power to the Xradia Versa is turned OFF.</td></tr>
<tr><td>Red light ON (top)</td><td>X-ray source is turned ON and X-rays are present within the enclosure.</td></tr>
<tr><td>Red light OFF (top)</td><td>X-ray source is turned OFF and X-rays are not present within the enclosure.</td></tr>
<tr><td>Amber light ON (center)</td><td>Access doors are CLOSED.</td></tr>
<tr><td>Amber light OFF (center)</td><td>Access doors are OPEN.</td></tr>
<tr><td>Green light ON (bottom)</td><td>Power to the Xradia Versa is turned ON.</td></tr>
<tr><td>Green light OFF (bottom)</td><td>Power to the Xradia Versa is turned OFF.</td></tr>
<tr><td>C</td><td>Access Doors</td><td colspan="2">Part of the enclosure. Closes off the X-ray source, providing protection from harmful X-ray radiation. The Xradia Versa has four access doors – two on the front (shown in the figure), and two on the back (not shown), of the enclosure.
Typically, only the front access doors need to be opened to access the Xradia Versa interior. Using the door handles, pull an access door toward you to OPEN, or push an access door toward the Xradia Versa to CLOSE.</td></tr>
<tr><td>D</td><td>Enclosure</td><td colspan="2">Insulated steel and lead-lined framework that covers the Xradia Versa exterior and provides protection from harmful X-ray radiation.</td></tr>
<tr><td>E</td><td>EMO Buttons</td><td colspan="2">Emergency OFF. Used to shut down (power OFF) the Xradia Versa in a personal safety or equipment emergency. To restore power, release the EMO button by twisting it CLOCKWISE, move the PDU’s (reference designator O in Figure 1-1) power breaker switches to their OFF (DOWN) position, press the UPS’ (reference designator Q in Figure 1-1) Power button, and then move the PDU’s power breaker switches to their ON (UP) position.
A second EMO button is located on the back of the Xradia Versa enclosure, below the rear access doors (not shown).</td></tr>
<tr><td>F</td><td>Computer Workstation</td><td colspan="2">Windows 7-based computer included with the Xradia Versa. Must be powered ON by pressing its Power button.</td></tr>
</table>

Table 1-1 Major Components Shown in Figure 1-1 (Continued)

Reference Designator	Part	Description
G	Sample Stage	Platform on which the sample holder assembly (with a mounted sample) is secured and positioned for microscopy. Includes a **STOP ALL MOTORS** button. Refer to "Sample Stage" for further details. Information related to use of its **STOP ALL MOTORS** button is provided in "Collision of Moving Parts," on page xxii in Safety.

H	X-ray Source	Mechanism that generates X-rays, used by the Xradia Versa to image samples and collect references. Includes an filter holder.
		The following details the voltage levels available with the Xradia Versa, by model number:
		– **Xradia 520 Versa and Xradia 510 Versa –** 30 to 160 kV (10W maximum)
		– **Xradia 410 Versa**
		  – 20 to 90 kV (8W maximum)
		  – 40 to 150 kV (10W maximum)
		  – 40 to 150 kV (30W maximum)
		Refer to "X-ray Source," and Appendix J, "Electrical Documentation," for further details.

I	Visual Light Camera	Supplies images to the **Visual Light Camera** image display (right side of the Scout-and-Scan Control System, as well as the image display in the Scout-and-Scan Control System's **Load** view). Located behind the sample stage, at the rear of the enclosure. Used for positioning the sample, detector, and X-ray source. Located above and behind the sample stage, along the back wall of the enclosure.

J	Turret and Objectives	Part of the detector/detector assembly. Holds up to five objectives (magnification lenses). The objective located at the lowest point on the turret is used to focus on the sample. Located between the 0.4X objective and back wall of the enclosure.
		The following details the objective magnification levels included with the Xradia Versa, by model number:
		– **Xradia 520 Versa and Xradia 510 Versa**
		  – **Standard objectives** – 0.4X, 4X, 20X
		  – **Optional objective (available on request)** – 40X
		– **Xradia 410 Versa**
		  – **Standard objectives** – 0.4X, 4X, 10X, 20X
		  – **Optional objective (available on request)** – 40X
		Refer to "Detector Assembly," for further details.

K	0.4X Objective	Part of the detector assembly. Square objective that provides a second beam line for imaging with a larger field of view (FOV) than the other objectives, at a lower magnification. The 0.4X objective is mounted **beside** the turret. Refer to "Detector Assembly," for further details.

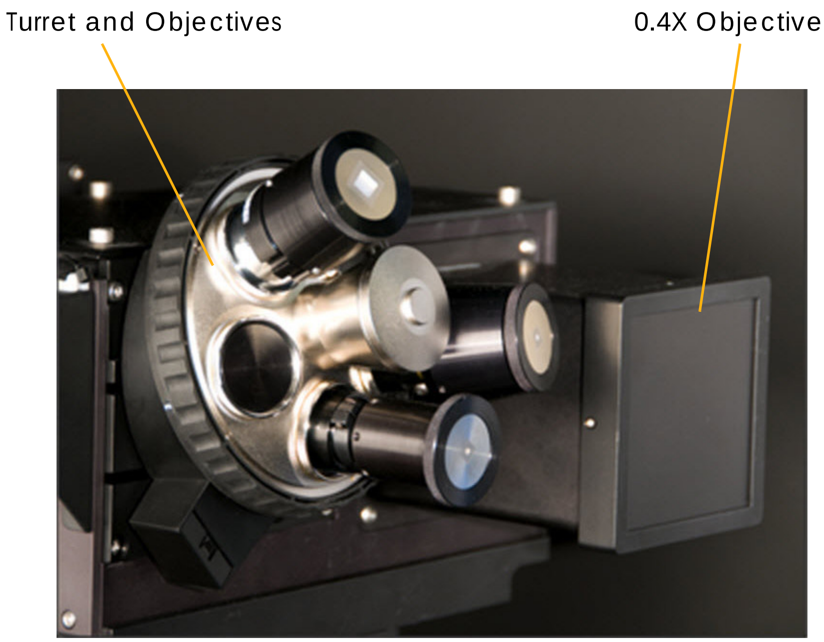
Table 1-1 Major Components Shown in Figure 1-1 (Continued)

Reference Designator	Part	Description
L	Detector Assembly (Detector)	Assembly that collects X-rays to present images of the sample. Includes the turret and 0.4X objective. Refer to "Detector Assembly," for further details.
M	Safety Interlocks	Turn OFF the X-ray source when the access doors are OPENED. ⚠WARNING **If any of the safety interlocks are damaged, DO NOT OPERATE THE XRADIA VERSA. Turn OFF the X-ray source, and then contact the ZEISS Support Team for assistance. DO NOT TAMPER WITH THE SAFETY INTERLOCKS.** Refer to Appendix J, "Electrical Documentation," for further details. Refer to "Technical Support," on page 348 in Appendix L if you need to contact the ZEISS Support Team.
N	Enclosure Temperature Control Unit	Regulates input temperature of air entering the enclosure.
O	Power Distribution Unit (PDU)	Distributes and controls power to the electrical Xradia Versa components.
P	High-Voltage Power Supply	Provides high-voltage power to the X-ray source and battery-supplied power to allow a soft shutdown of the Xradia Versa in case of a power outage.
Q	Uninterruptible Power Supply (UPS)	Regulates the incoming AC voltage and provides battery-supplied power to the Xradia Versa for approximately 15 minutes in case of a power outage.

Detector Assembly

The detector assembly (“detector”) picks up X-ray images of the sample. The objectives, with the exception of the 0.4X objective, look similar to one another, and are all mounted on a motorized turret (in a manner similar to how an optical microscope has different objectives). The turret can hold up to five objectives. The 0.4X objective, however, looks square and boxy, and is mounted next to the turret. Figure 1-2 provides a view of how the objectives are mounted on the detector assembly.

Figure 1-2 Detector Assembly Objective-Mount Configuration



X-ray Source

The Xradia Versa is available with either a 160 kV (Xradia 520 Versa and Xradia 510 Versa) or 90 or 150 kV (Xradia 410 Versa) X-ray source. Figure 1-3 provides a view of the 160 kV X-ray source. Table 1-2 lists the minimum and maximum voltage and power settings, by X-ray source.

The Xradia 510 Versa and Xradia 410 Versa X-ray source includes a holder for installing a source filter. The Xradia Versa *source filters* are materials that improve reconstructed image quality by removing low-energy X-rays (that passed through the sample) that do not provide useful information. The process of installing a source filter is described in Appendix F, "Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa."

NOTE The Xradia 520 Versa includes an automatic filter changer, and therefore does not require manual installation or removal of source filters. Source filters are available in a ZEISS filter kit.

NOTE The X-ray source must go through an initial warm-up process, referred to as *X-ray source aging*. For the Xradia 520 Versa and Xradia 510 Versa, the aging process occurs every 23 hours and takes approximately 3 minutes. For the Xradia 410 Versa, the aging process occurs every 8 hours and takes approximately 20 minutes.

Figure 1-3 160 kV X-ray Source – Xradia 520 Versa and Xradia 510 Versa (Xradia 520 Versa Shown)

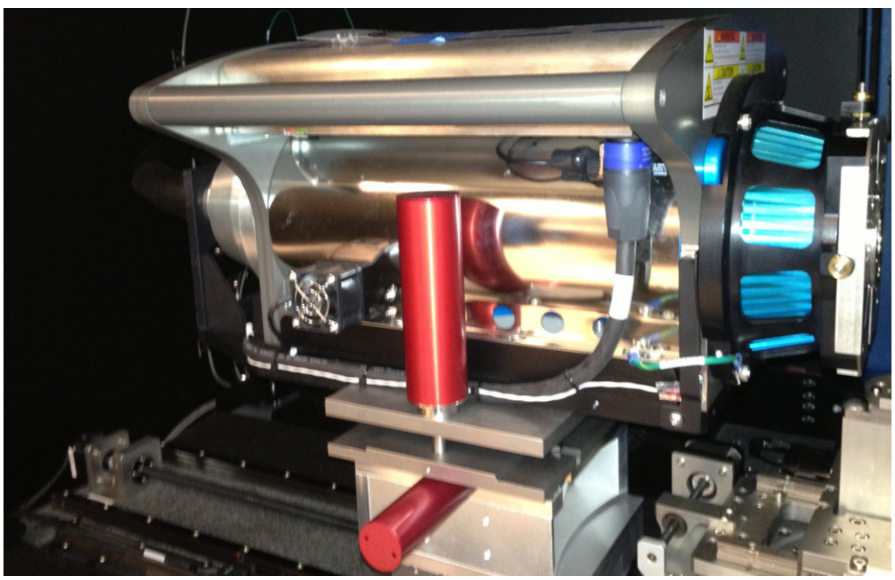


Table 1-2 X-ray Source Voltage and Power Settings

Model	X-ray Source	Voltage (kV)	Power (W)	
		Maximum	Minimum	Maximum
Xradia 520 Versa Xradia 510 Versa	160 kV (10W maximum)	110 to 160	1	10
		100	1	9
		90	1	8
		80	1	7
		70	1	6
		60	1	5
		50	1	4
		40	1	3
		30	1	2
Xradia 410 Versa	90 kV (8W maximum)	40 to 90	1	8
		30	1	4.5
		20	1	2
	150 kV (10W maximum)	40 to 150	1	10
	150 kV (30W maximum)	60 to 150	1	30
		50	1	25
		40	1	20

Sample Stage

The sample stage (refer to Figure 1-4) is the platform on which the sample holder assembly (with a mounted sample) is secured and positioned for microscopy.

When loading the sample holder assembly on the sample stage, you must align the flat edges of the assembly and stage (facing the front of the Xradia Versa; refer to Figure 1-6), and match the slotted grooves on the underside of the assembly with the three tungsten alignment balls (circled in Figure 1-5) on the sample stage.

NOTICE Use extreme caution when loading the sample holder assembly on the sample stage.

NOTE Information related to use of the **STOP ALL MOTORS** button shown in Figure 1-4 is provided in "Collision of Moving Parts," on page xxii in Safety.

Figure 1-4 Sample Stage and **STOP ALL MOTORS** Button

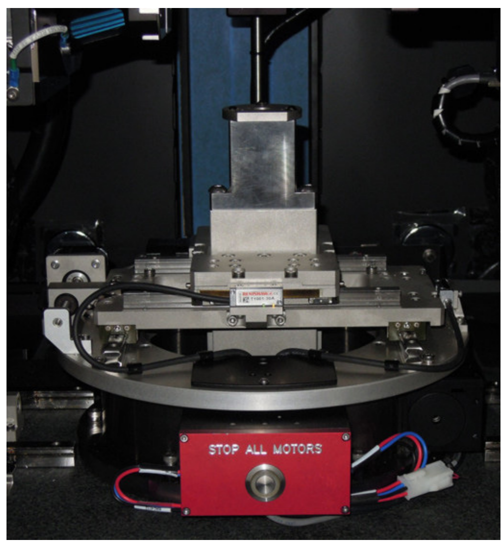


Figure 1-5 Sample Stage, with Tungsten Alignment Balls Highlighted

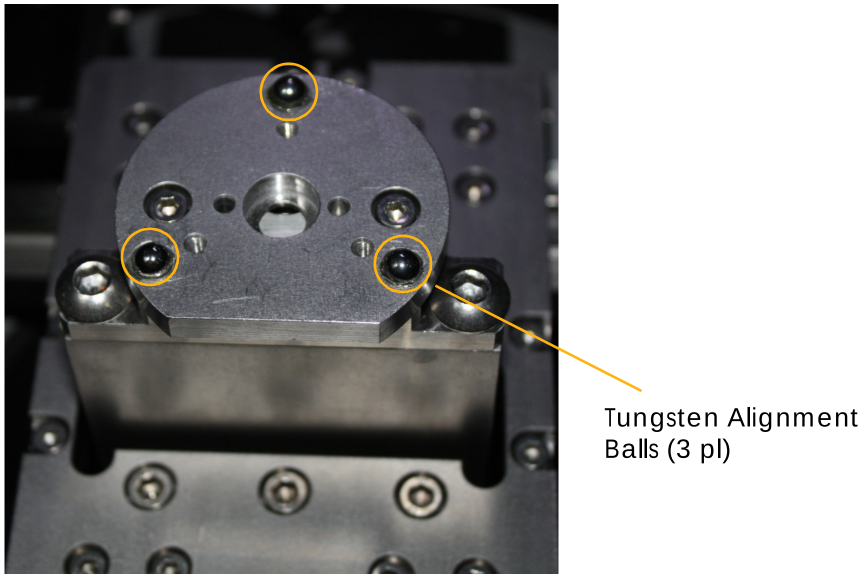
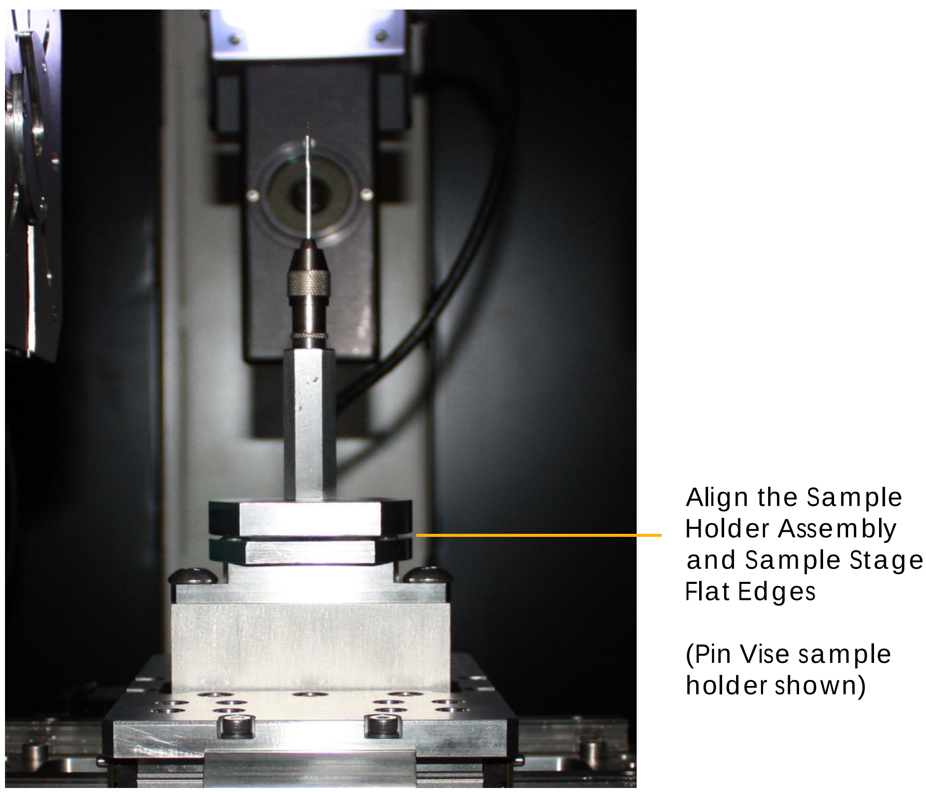


Figure 1-6 Sample Holder Assembly Loaded on Sample Stage, with Flat Edges Aligned, Facing Front of Xradia Versa)



Ergonomic Station

The ergonomic station is the console used for controlling the Xradia Versa. Table 1-3 lists the station's major components.

Table 1-3 Ergonomic Station Components

Component	Description
Monitor (Display)	Used to interface with the Xradia Versa programs. Must be powered ON by pressing its **Power** button.
Mouse	Three-button pointing device used to interface with programs used on the Xradia Versa. The device's position is visible on the monitor. The mouse button functions are dependent on 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.
Wrist Pad	Ergonomic wrist rest.
Keyboard	Standard QWERTY computer keyboard.

Software Control

The following three programs are used to control the Xradia Versa:

– Scout-and-Scan Control System

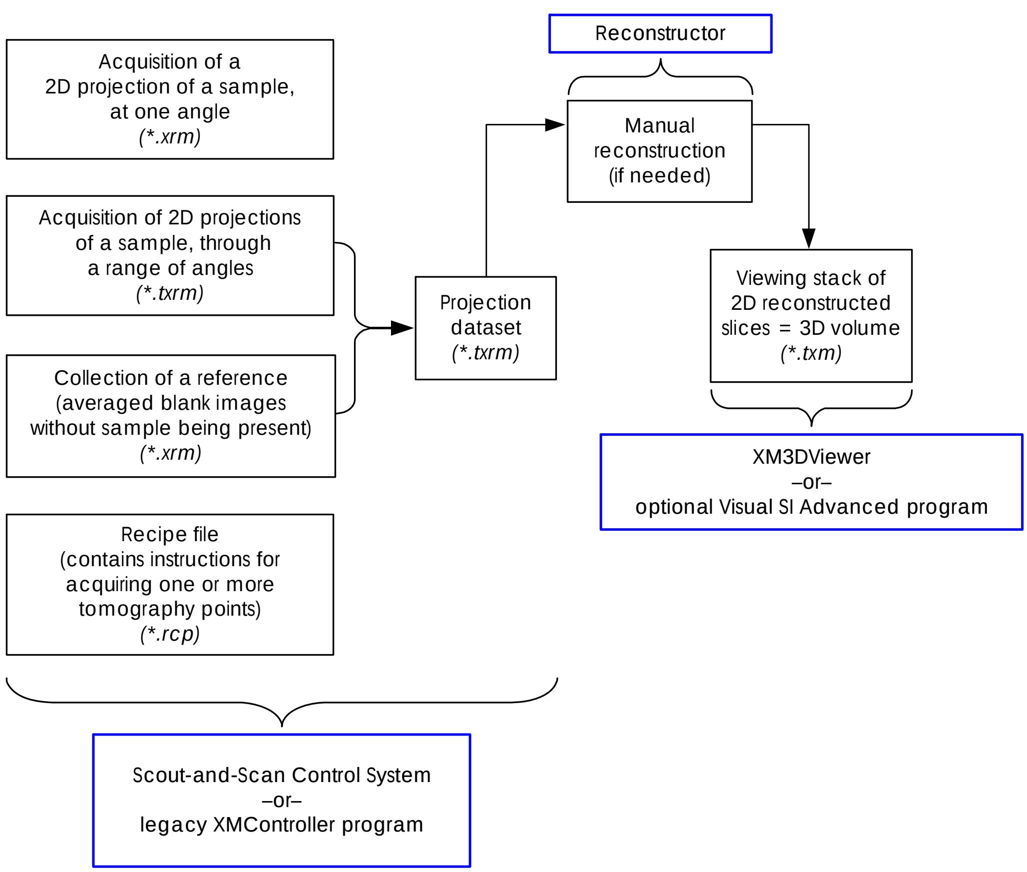
– Reconstructor

– XM3DViewer

Figure 1-7 shows the relationship between the three programs, as well as the legacy XMController and optional Visual SI Advanced programs, and the data, processes, and files created by each. The three programs are briefly described in the sections that follow. For further details, refer to Appendix D, "User Interface and Software Control Features."

NOTE Although this guide occasionally mentions the legacy XMController program, the program is primarily used by ZEISS service personnel. Complete instructions for the program's use are provided in Chapter 2 and Appendix D of the legacy *VersaXRM-500 User's Guide*.

Figure 1-7 Data, Processes, and Files

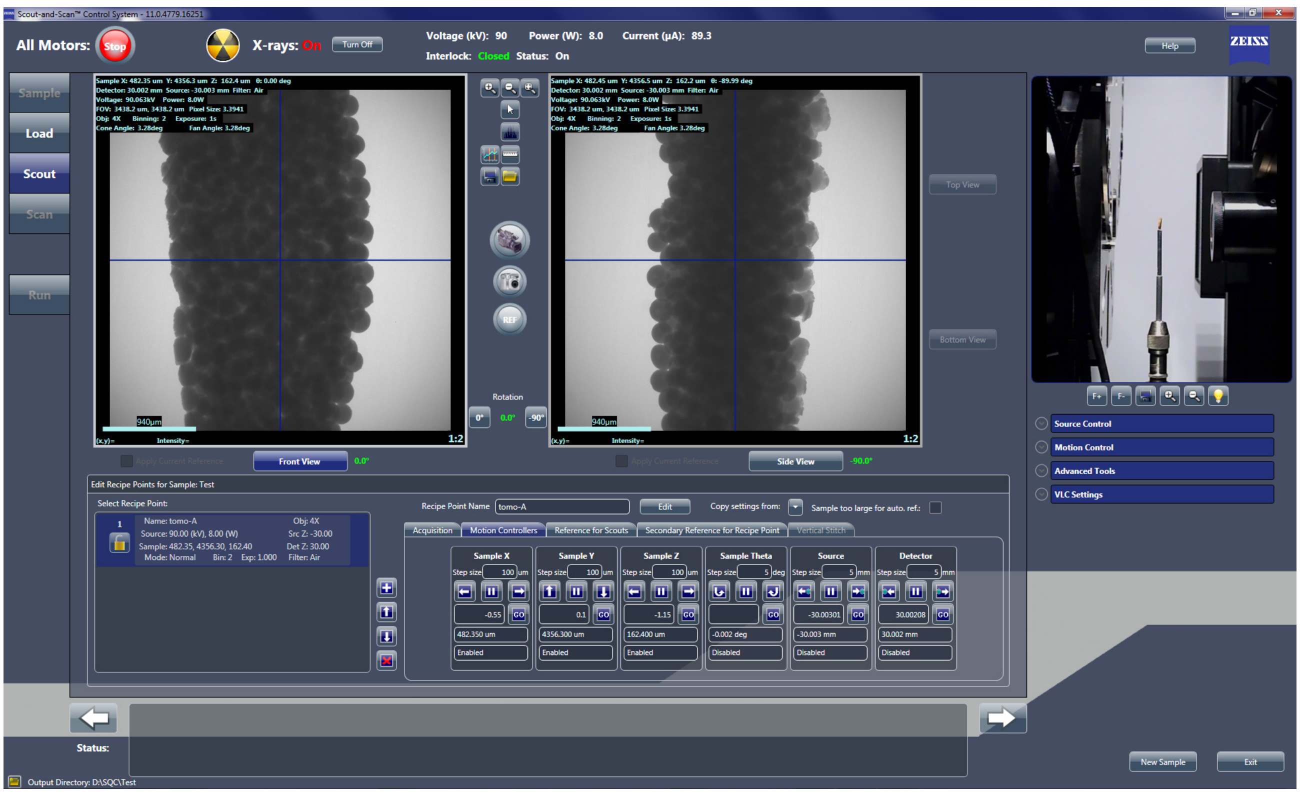


Scout-and-Scan Control System

The Scout-and-Scan Control System (Figure 1-8) is the program used to manage the data acquisition process, from setting up the sample to the data acquisition. Use of the Scout-and-Scan Control System is described in Chapter 2, “Acquiring Tomographies with the Scout-and-Scan Control System.”

NOTE For in-depth information that describes each user interface control and feature, refer to “Scout-and-Scan Control System User Interface,” on page 182 in Appendix D.

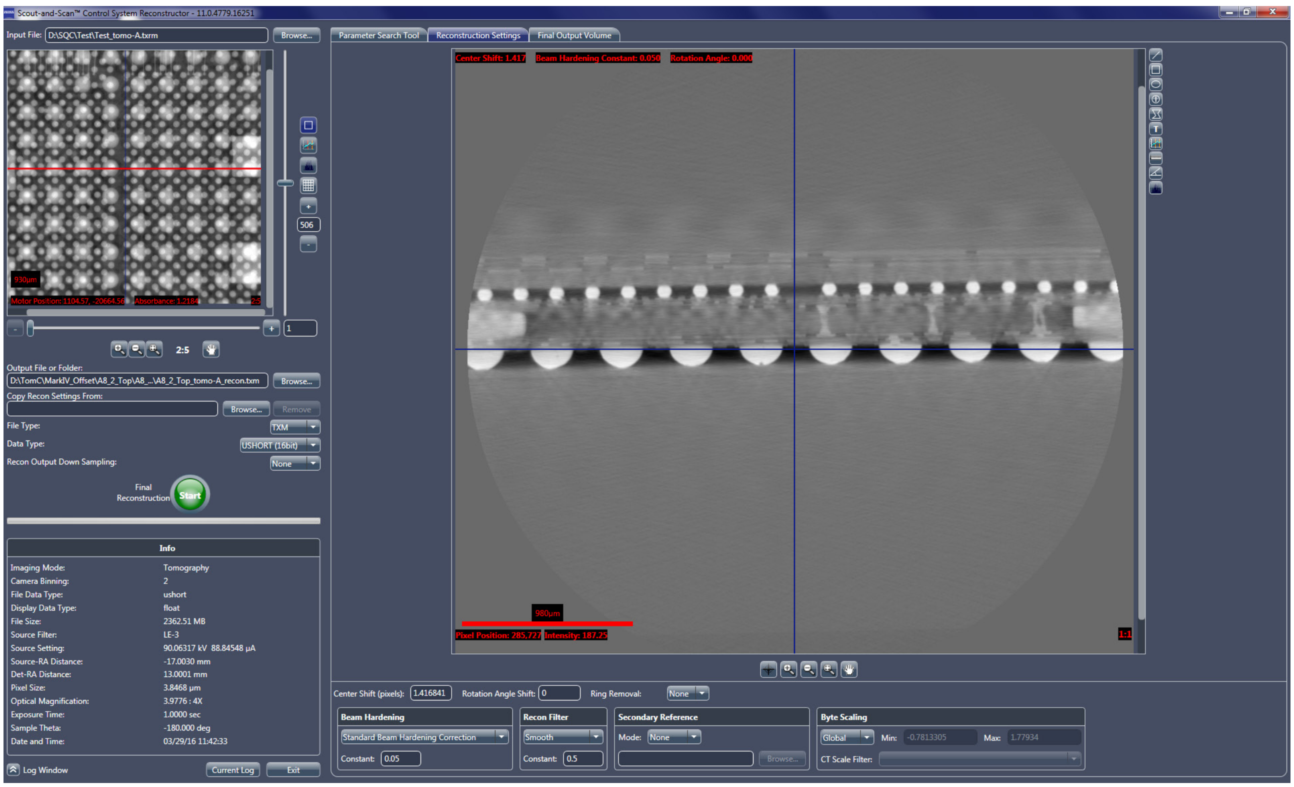
Figure 1-8 **Scout-and-Scan Control System** Main Window (**Scout** View Shown)



Reconstructor

The Reconstructor Scout-and-Scan Control System program (Reconstructor) (refer to Figure 1-9) is used to “manually” reconstruct the 2D images (projections) that are acquired during data acquisition/tomography to create a 3D reconstructed volume. Automatic reconstruction can be requested in the Scout-and-Scan Control System, which makes manual reconstruction necessary only when automatic reconstruction fails.

Figure 1-9 Typical **Reconstructor** Main Window with **Reconstruction Settings** Tab Active



Manual Reconstruction is necessary when any of the following conditions exist:

– Recipe was run with *Manual* selected from the **Recon Type** drop-down list box on the **Advanced Acquisition** tab within **Scan** view in the Scout-and-Scan Control System

– Recipe was run with *Auto* (default) selected from the **Recon Type** drop-down list box on the **Advanced Acquisition** tab within **Scan** view, but automatic reconstruction failed during tomography data acquisition within **Run** view in the Scout-and-Scan Control System

– 3D reconstructed images are unacceptable due to Scout-and-Scan Control System reconstruction parameter values that are **not** optimal

Use of Reconstructor is described in Chapter 3, "Manually Reconstructing a Tomography Dataset."

NOTE For in-depth information that describes most user interface controls and features, refer to "Reconstructor User Interface," on page 225 in Appendix D.

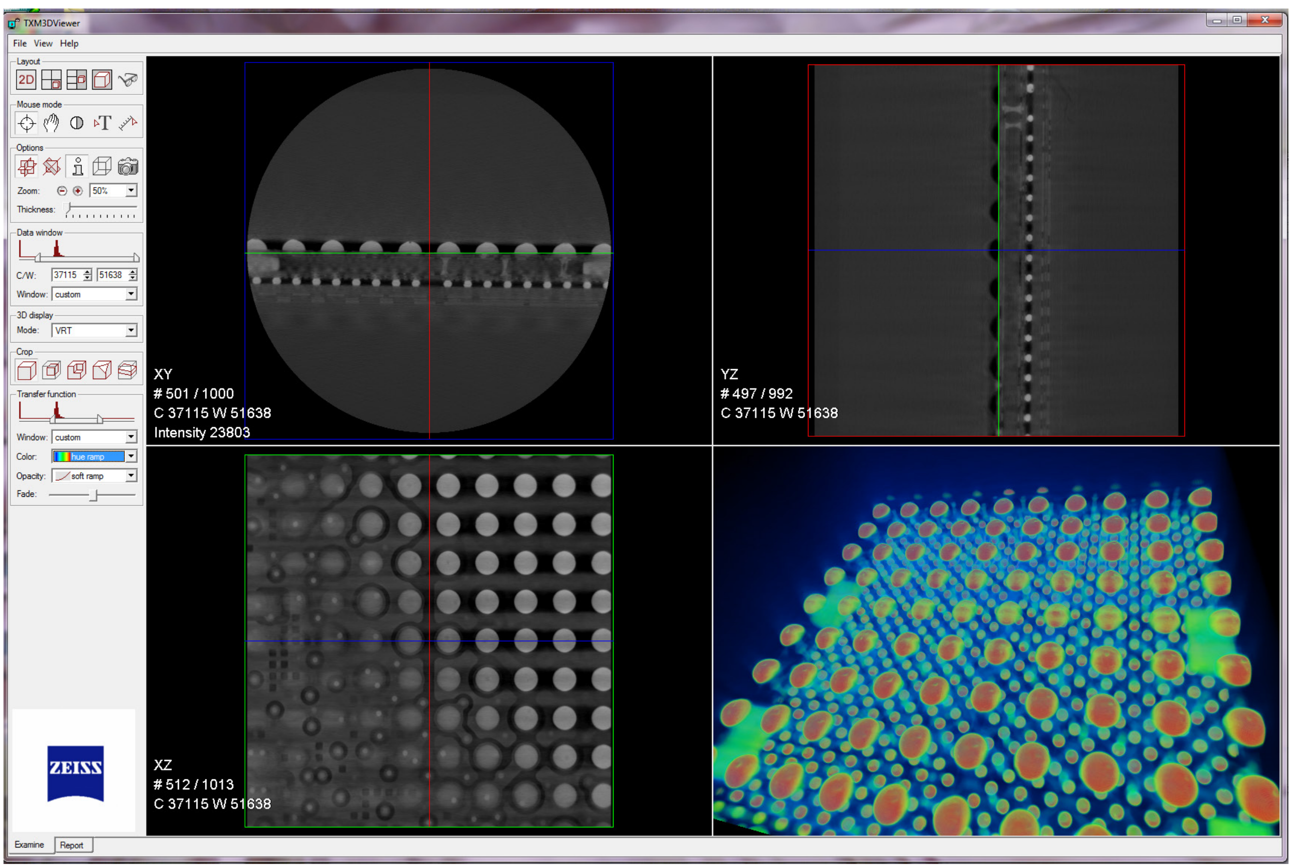
XM3DViewer

After reconstruction, a file containing the 3D image volume is saved to the hard disk drive. That file can then be loaded into XM3DViewer (refer to Figure 1-10) for viewing. Use of XM3DViewer is described in Chapter 4, “Viewing and Editing Tomographies.”

NOTE In its main window title bar, XM3DViewer appears as “**TXM3DViewer**,” rather than as “**XM3DViewer**”. Additionally, the main window bars and tools change, depending on which **Layout** icon is selected.

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 “XM3DViewer User Interface,” on page 237 in Appendix D, as well as the *Xradia ExamineRT Workstation 1.1 User’s Manual*, available under XM3DViewer’s **Help** menu.

Figure 1-10 Default **XM3DViewer** Main Window – **Examine** Tab



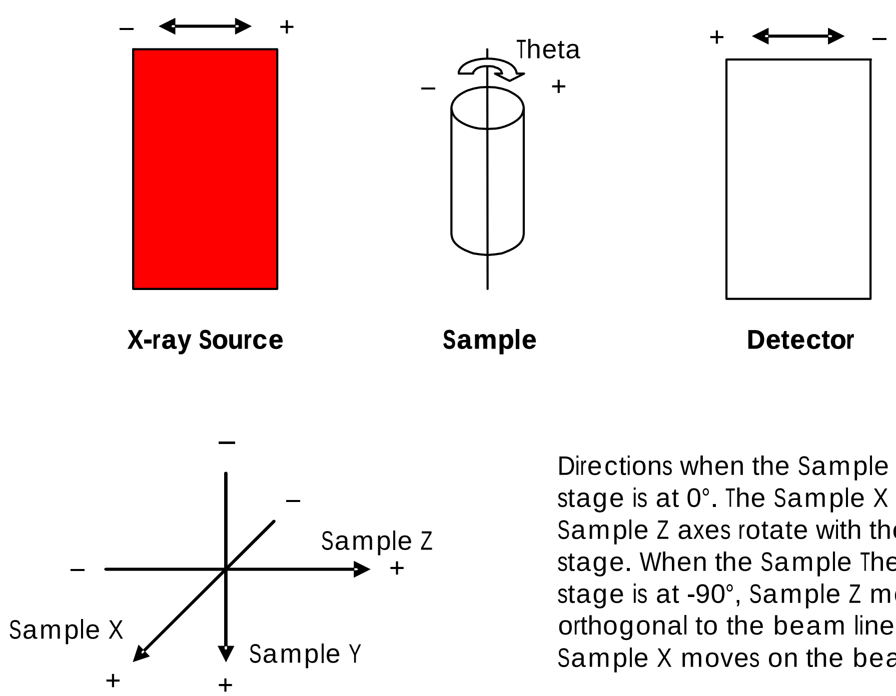
Axis Definitions

Throughout this guide, directions Sample X, Y, Z, and Theta are mentioned. Table 1-4 describes, and Figure 1-11 shows, the directions used when moving the sample, detector, and X-ray source.

Table 1-4 Sample, Detector, and X-ray Source Movement Directions

Direction (Axis)	Sample Theta Position	Movement	Movement From User's Perspective
Sample X	0°	Toward and away orthogonal to the beam line from the X-ray source to the detector	IN and OUT
	-90°	Toward and away on the beam line from the X-ray source to the detector	
Sample Y	0°, -90°	From top to bottom of the enclosure	UP and DOWN
Sample Z	0°	Beam line from the X-ray source to the detector	LEFT and RIGHT
	-90°	Orthogonal to the beam line from the X-ray source to the detector	
Sample Theta	–	Circular angle	CLOCKWISE and COUNTERCLOCKWISE

Figure 1-11 Axis Definitions of X-ray Source, Sample, and Detector



Directions when the Sample Theta stage is at 0°. The Sample X and Sample Z axes rotate with the stage. When the Sample Theta stage is at -90°, Sample Z moves orthogonal to the beam line and Sample X moves on the beam line.

THIS PAGE INTENTIONALLY LEFT BLANK

2 Acquiring Tomographies with the Scout-and-Scan Control System

This chapter describes how to acquire tomographies using the Scout-and-Scan Control System. Instructions are provided for the following use cases:

- Creating and Running a New Recipe
- Loading and Running an Existing Recipe or Recipe Template

NOTE For in-depth information that describes each user interface control and feature, refer to "Scout-and-Scan Control System User Interface," on page 182 in Appendix D.

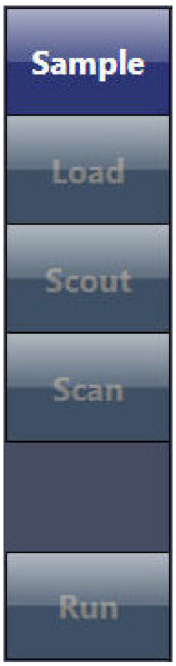
NOTE From this point on, the processes assume that the Xradia Versa is already powered ON and warmed up. If the Xradia Versa is turned OFF, use the processes described in Appendix C, "Shutting Down and Restarting the Xradia Versa," to restart the Xradia Versa and home all motorized axes to their predefined initialization positions.

NOTICE Do **not** open the access doors while X-rays are being generated. Doing so automatically terminates X-ray generation and causes a fault condition, thereby preventing further operation until the fault is reset. Refer to "Interlock Sequence of Operation," on page 334 in Appendix J for further explanation and method of recovery. Method of recovery is also provided in Table A-9, "Troubleshooting Light Tower Electrical Issues," on page 165 in Appendix A.

Creating and Running a New Recipe

The process of creating and running a new recipe is composed of five steps, each of which is represented in one of the five **Scout-and-Scan Control System** workflow-based tabbed views, as listed in Table 2-1. Each view provides the tools to complete the required operations for each step.

Table 2-1 Creating and Running a New Recipe Steps

Scout-and-Scan Control System View Tabs[a]	Step	Operation
	Step 1 – Sample	Set the **Sample**'s data folder. Initiate the creation of a new recipe.
	Step 2 – Load	Use the Visual Light Camera to **Load** and roughly position the sample.
	Step 3 – Scout	Use X-ray images to **Scout** the sample to locate the sample's region of interest (ROI) and field of view (FOV), and set imaging parameter values.
	Step 4 – Scan	Set up the recipe's 3D **Scan** acquisition and auto reconstruction parameter values.
	Step 5 – Run	**Run** the recipe and acquire the tomographies.

a. After  is clicked to access the next view, you can click the tabbed item to move between the active views.

Step 1 – Sample

This process describes how to use **Sample** view to set the sample's data folder and initiate creation of a new recipe. (Refer to Figure 2-1.)

NOTE For in-depth information that describes **Sample** view, refer to "Sample View," on page 195 in Appendix D.

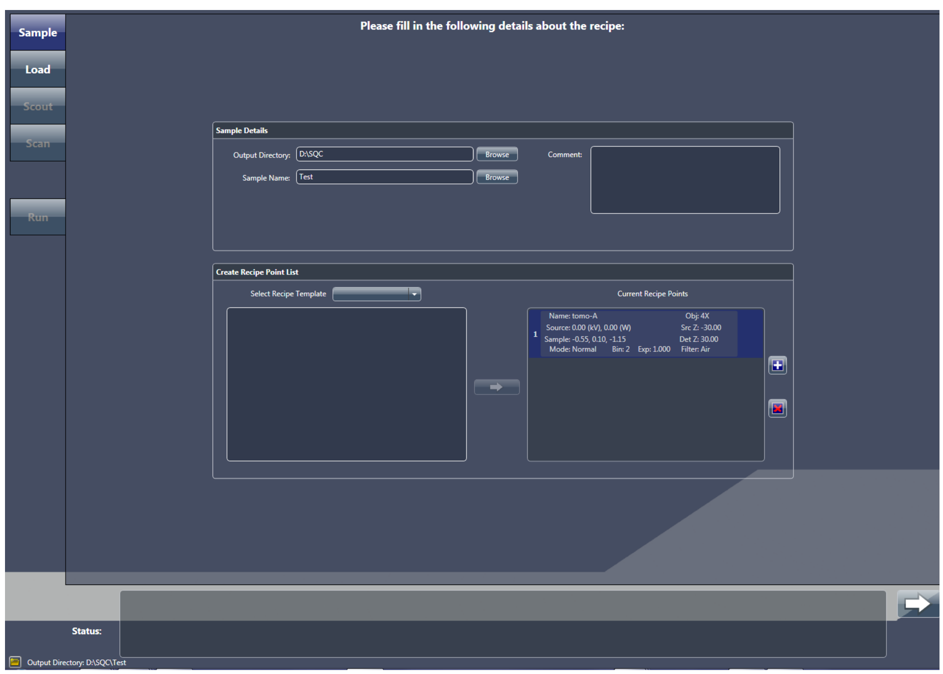
To set the sample's data folder and initiate a recipe

1. On the Windows taskbar **Start** menu, select **All Programs**, **Carl Zeiss X-ray Microscopy**, **Xradia Versa 11.*x***, and then **Scout-and-Scan Control System 11.*x***. The Scout-and-Scan Control System opens to the first tabbed view – **Sample** view.

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

NOTE The screen capture provided below is partially filled in. Although a generic name is being used for the sample name, it is recommended that you use a name that better identifies the sample in use.

Figure 2-1 Typical **Sample** View



2. Click **Browse**, and then browse to and select the output directory (folder) in which to store the sample's data.

3. Type a name in the **Sample Name** text box (new sample) –or– click **Browse** (existing sample), and then browse to and select the sample name to be used.

   A subfolder is automatically created under the selected output directory (folder), in which all acquired data will be stored.

4. **Optional** – Type a comment in the **Comment** text box.

5. Click  in the **Create Recipe Point List** panel to add a recipe point and initiate a new recipe.

NOTE Multiple recipe points can be added if you want to acquire multiple tomographies for the sample. Simply click  again to create another recipe point.

6. Click  to proceed to the next tabbed view (**Load**).

   Proceed to "Step 2 – Load."

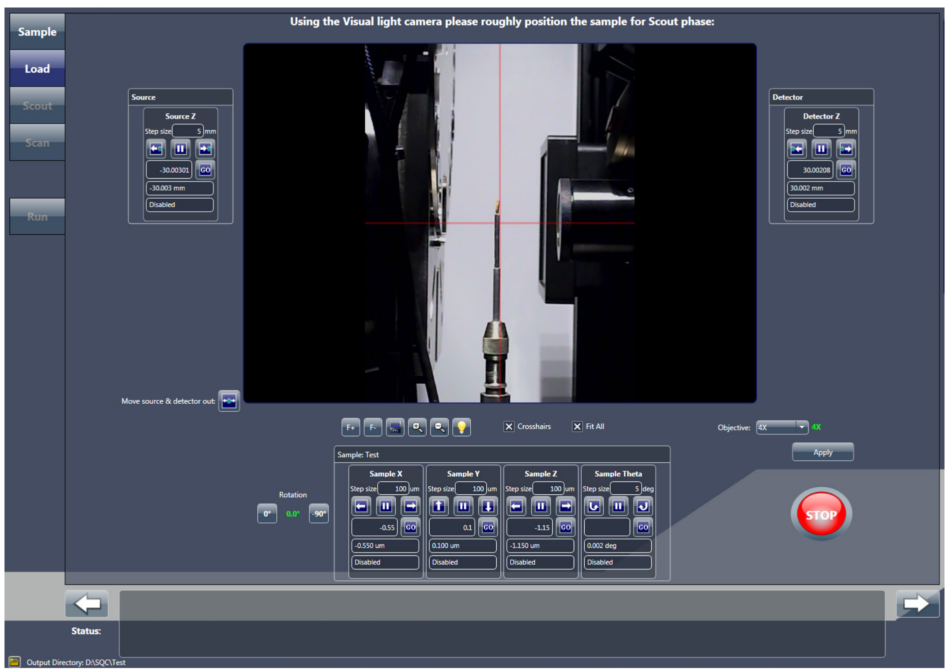
Step 2 – Load

This process describes how to use the visual light camera in **Load** view (refer to Figure 2-2) to load and roughly position the sample on the axis of rotation and position the X-ray source and detector.

NOTICE If collision is imminent at any time during this process, click Stop (**All Motors**, upper left view) to immediately stop all motors, –or– ⏸ within a motion controller to halt movement for the axis associated with that motion controller.

NOTE For in-depth information that describes **Load** view, refer to “Load View,” on page 198 in Appendix D.

Figure 2-2 Typical **Load** View



To load and roughly position the sample

1. If needed, click to move the X-ray source and detector away from the sample stage. This should provide sufficient room in which to load the sample holder assembly on the sample stage. If not, click again until there is sufficient room.

2. Load the sample holder assembly on the sample stage.

NOTE Instructions for mounting the sample on the sample holder are provided in "Mounting a Sample in or on a Sample Holder," on page 241 in Appendix E. Instructions for loading the sample holder assembly (sample mounted on sample holder) on the sample stage are provided in "Loading a Sample Holder Assembly on the Sample Stage," on page 248 in Appendix E.

NOTE The Xradia Versa's collision avoidance system is designed to protect against collisions between the sample holder base and X-ray source or detector.

3. **Optional** – Click and hold to completely zoom out of the image.

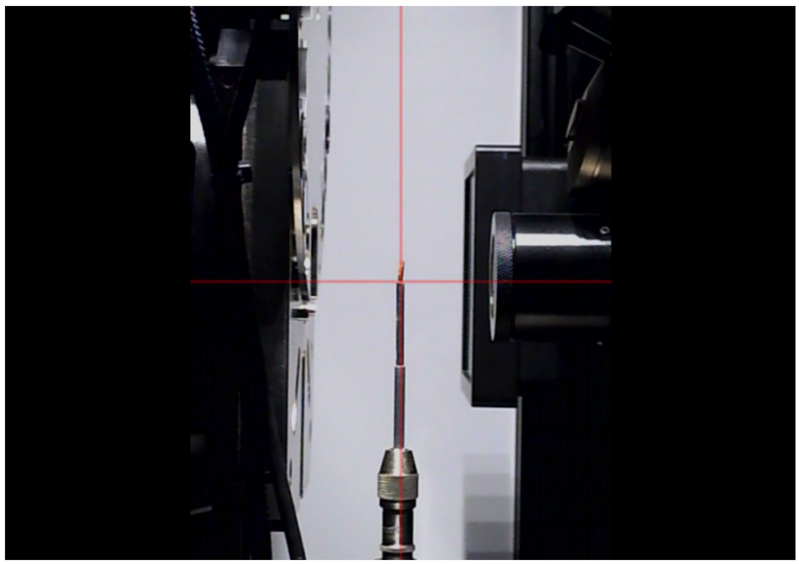
4. Click to rotate the sample (**Sample Theta** axis) to 0°. Ensure that the detector and X-ray source are a sufficient distance from the sample to avoid collision when the sample is rotated.

5. With Sample Theta at 0°, under the **Sample** panel, use the **Sample Y** and **Sample Z** motion controllers to align the sample –or– its feature of interest with the **red** crosshairs on the **Visual Light Camera** image display (refer to Figure 2-3):

   – Click and/or (**Sample Y**) to vertically align the sample

   – Click and/or (**Sample Z**) to horizontally align the sample

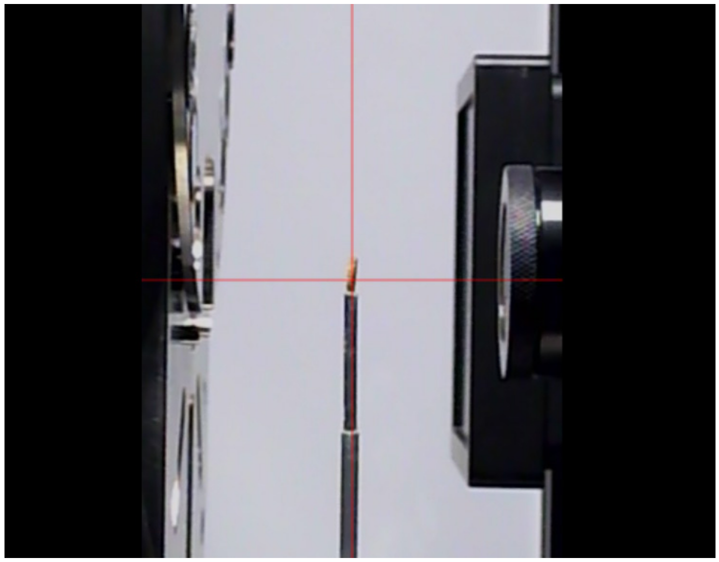
Figure 2-3 Sample Coarsely Aligned with **Red** Crosshairs in **Load** View



6. Click to rotate the sample (**Sample Theta** axis) to -90°. Ensure that the detector and X-ray source are a sufficient distance from the sample to avoid collision when the sample is rotated.
7. With Sample Theta at -90°, under the **Sample** panel, use the **Sample X** motion controller to align the sample –or– its feature of interest with the **red** crosshairs on the **Visual Light Camera** image display. (Refer to Figure 2-3.) Click and/or to horizontally align the sample.

8. Click and hold  to zoom in on the image. Repeat steps 4 through 7 to fine align the sample –or– its feature of interest with the **red** crosshairs on the **Visual Light Camera** image display with Sample Theta at both 0° and -90°. (Refer to Figure 2-4.)

Figure 2-4 Sample Finely Aligned with **Red** Crosshairs in **Load** View



9. Click  to proceed to the next tabbed view (**Scout**).

   Proceed to "Step 3 – Scout."

Step 3 – Scout

This process describes how to use X-ray images in **Scout** view (refer to Figure 2-5) to scout the sample – locate the sample's ROI and FOV, and set imaging parameter values.

The Scout phase consists of the following processes:

a. Scout – Find and Center the ROI at Low Magnification

b. Scout – Fine-Tune the ROI at High Magnification

c. Scout – Set X-ray Source and Detector Positions

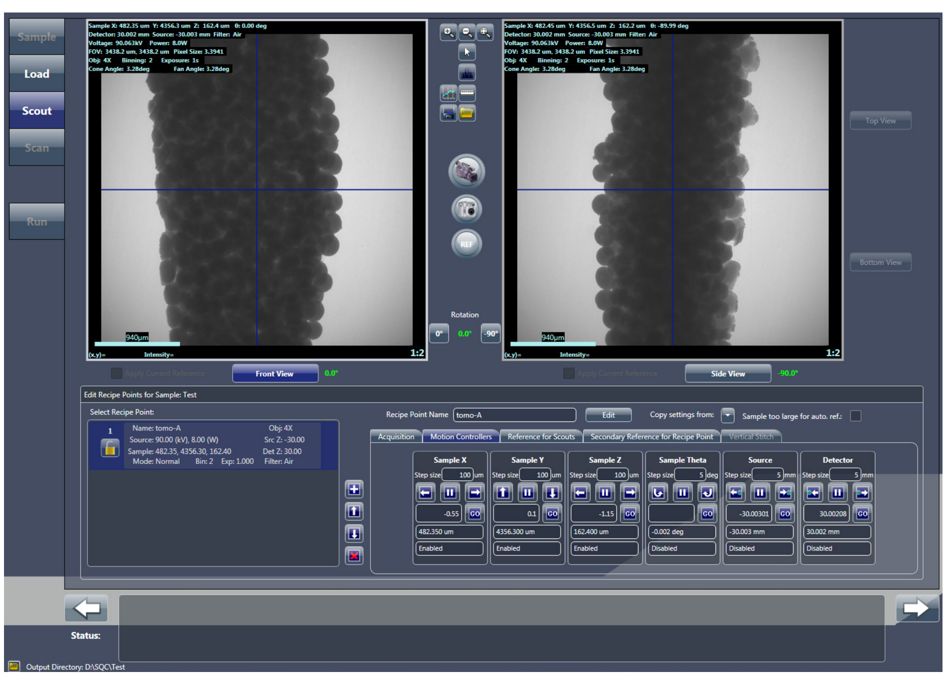
d. Scout – Select Appropriate Source Filter and Voltage

e. Scout – Determine Acquisition Time

NOTICE If collision is imminent at any time during this process, click  (**All Motors**, upper left view) to immediately stop all motors, –or–  within a motion controller to halt movement for the axis associated with that motion controller.

NOTE For in-depth information that describes **Scout** view, refer to "Scout View," on page 200 in Appendix D.

Figure 2-5 Typical **Scout** View



Scout – Find and Center the ROI at Low Magnification

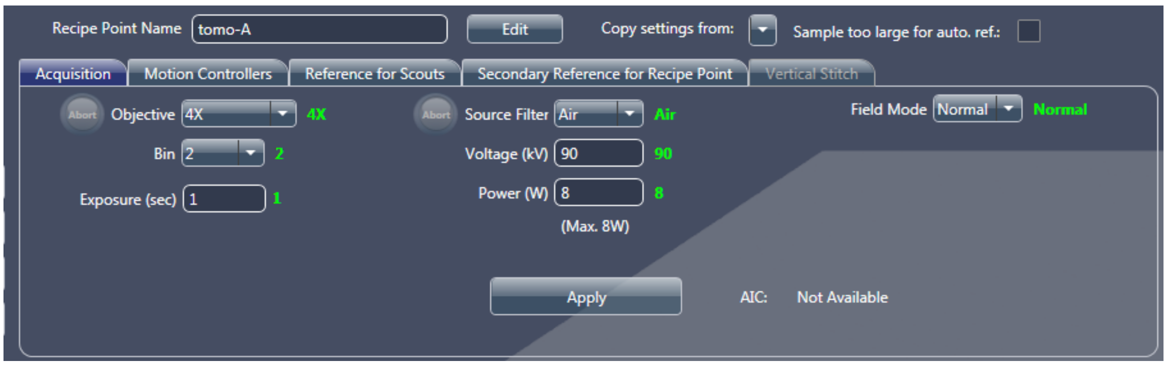
This process uses X-rays to help you to locate and roughly center the sample's ROI. The **Sample X**, **Y**, and **Z** axes are adjusted, using the **Acquisition** tab within **Scout** view's **Edit Recipe Points for Sample** panel.

NOTE For details regarding axes directional movement, refer to "Axis Definitions," on page 21 in Chapter 1.

To find and center the ROI at low magnification

1. Select the **Acquisition** tab within the **Edit Recipe Points for Sample** panel. (Refer to Figure 2-6.)

Figure 2-6 Typical **Acquisition** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel



2. Follow steps a through e below to set up the acquisition settings:

   a. Select an objective from the **Objective** drop-down list box:

      – Samples larger than 4 mm – Select *0.4X*

      – Samples smaller than 4 mm – Select *4X*

   b. Type the X-ray source voltage and power in the **Voltage (kV)** and **Power (W)** text boxes, using the following guidelines:

      – *80 kV/7W* for thin or low-density samples

      – *140 kV/10W* for thick or high-density samples

NOTE For details regarding X-ray source voltage and power, refer to Table 1-2, "X-ray Source Voltage and Power Settings," on page 12 in Chapter 1.

   c. Type *1* in the **Exposure (sec)** text box.

   d. Select *2* from the **Bin** drop-down list box.

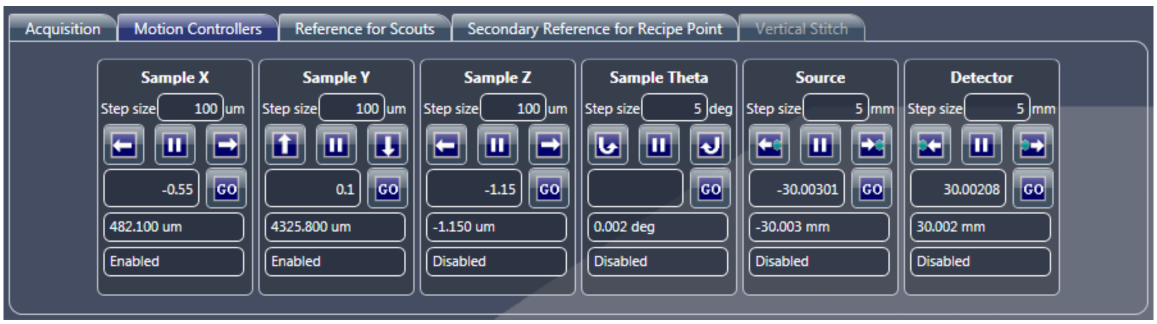
   e. Click **Apply** to set the Xradia Versa to the specified settings.

3. Click  to rotate the sample (**Sample Theta** axis) to 0° and activate the **Front View** image display.

4. Click  to start continuous imaging. The button changes to .

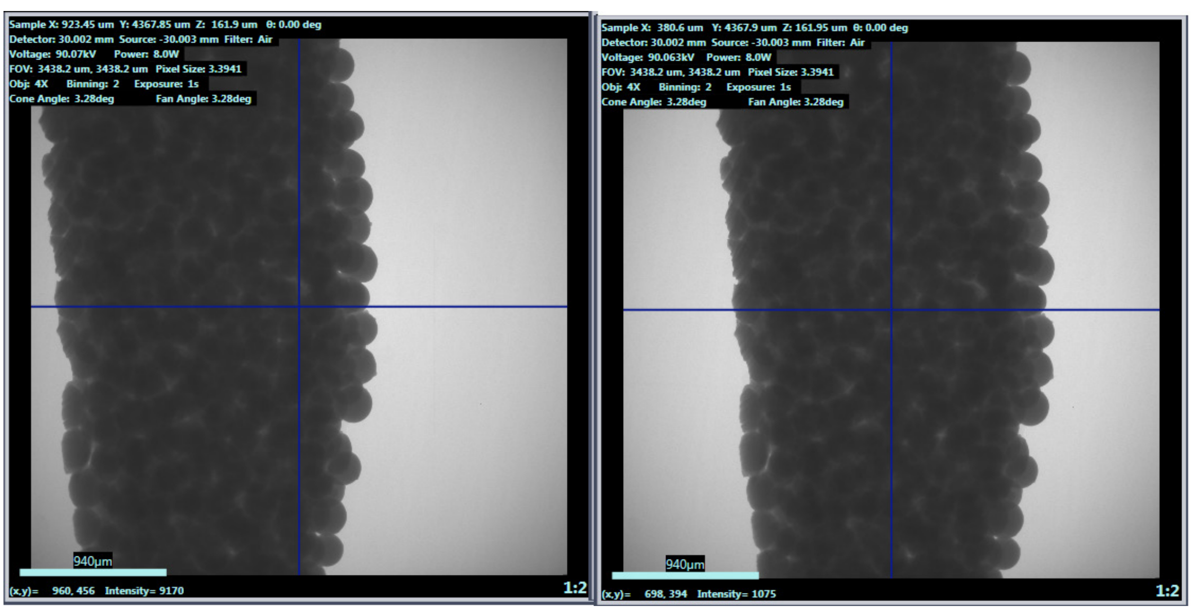
NOTE If you need to increase the FOV, use the **Motion Controllers** tab to move the detector (**Detector** motion controller) closer to the sample and/or the X-ray source (**Source** motion controller) away from the sample. (Refer to Figure 2-7.)

Figure 2-7 Typical **Motion Controllers** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel



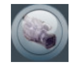
5. Double-click the center of the sample –or– its feature of interest within the **Front View** image display to automatically roughly center the ROI for the **Sample X** and **Y** axes. (Refer to Figure 2-8.)

Figure 2-8 ROI Prealignment and Roughly Centered for **Sample X** and **Y** Axes



Prealignment,
ROI Not Centered

Aligned,
ROI Centered

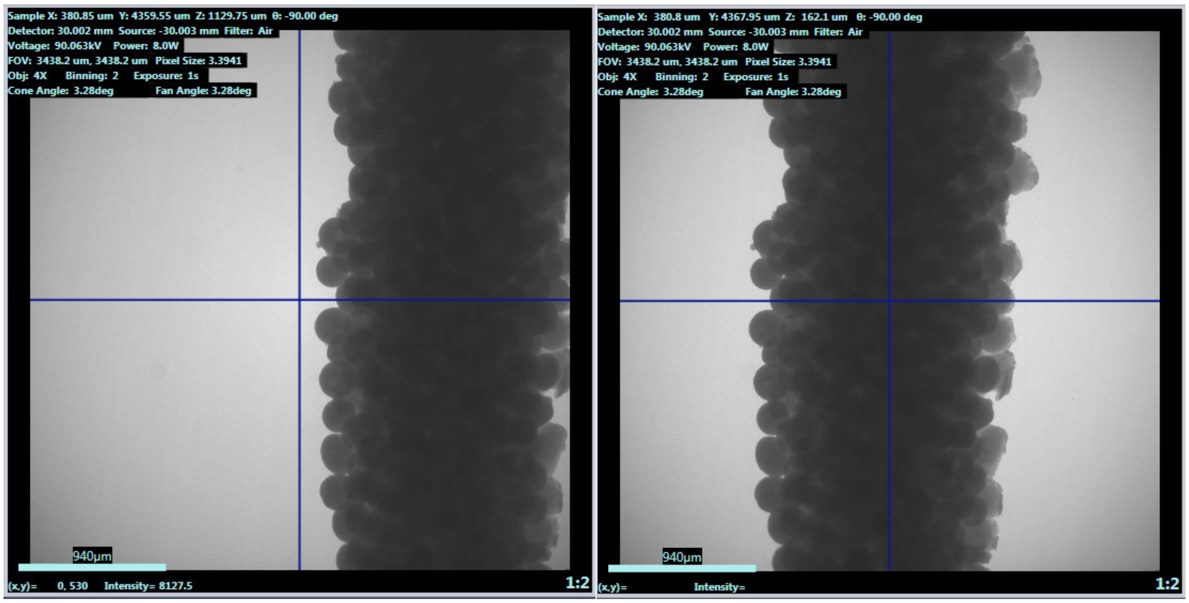
6. Click  to halt continuous imaging. The button changes back to .

7. Click  to rotate the sample (**Sample Theta** axis) to -90° and activate the **Side View** image display.

8. Click  to start continuous imaging. The button changes to .

9. Double-click within the **Side View** image display to automatically roughly center the ROI for the **Sample Z** axis. (Refer to Figure 2-9.)

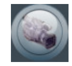
Figure 2-9 ROI Prealignment and Roughly Centered for **Sample Z** Axis



Prealignment,
ROI Not Centered

Aligned,
ROI Centered

NOTE The message **Image different from recipe point** might appear on the **Side View** image display. This is okay. It simply indicates that the stage has been repositioned and is different than it is for the **Front View** image display.

10. Click  to halt continuous imaging. The button changes back to .

Proceed to "Scout – Fine-Tune the ROI at High Magnification."

Scout – Fine-Tune the ROI at High Magnification

This process uses the **Acquisition** tab within **Scout** view's **Edit Recipe Points for Sample** panel to fine-tune the sample's ROI at a higher magnification.

To fine-tune the ROI at high magnification

1. In the **Acquisition** tab, select a high-resolution objective (whichever best matches the sample voxel size) from the **Objective** drop-down list box if it is different than the objective currently in use.

NOTE *Voxel* (sometimes referred to as *nominal resolution* or *detail detectability*) is a geometric term that contributes to, but does not determine, resolution, and is provided here only for comparison. ZEISS specifies on spatial resolution, the true overall measurement of instrument resolution.

Table 2-2 Objective Selection, by Voxel Size

Objective	Voxel Size (µm) with Binning = 2[a]	
	Xradia 520 Versa Xradia 510 Versa	Xradia 410 Versa
0.4X	55 to 5	55 to 6
4X	5 to 0.7	6 to 3
10X[b]	–	2.4 to 1.8
20X[a]	0.9 to 0.5	1.2 to 0.9
40X[a c]	0.5 to 0.3	0.6 to 0.5

a. **20X and 40X Objectives** – Change binning to 4 to acquire a clearer image.
b. **10X Objective** – Xradia 410 Versa only.
c. **40X Objective** – Optional, available on request.

2. Perform steps 2b through 10 of "Scout – Find and Center the ROI at Low Magnification," on page 32 to fine-tune the sample position at the higher magnification selected in step 1.

NOTE For quick X-ray source and detector movement, you can click within the **Front View** (Sample Theta is at 0°) or **Side View** (Sample Theta is at -90°) image display, and then roll the mouse wheel away from you to zoom in on, or toward you to zoom out of, the image.

NOTE If the selected high-resolution objective results in zooming in so closely that you cannot see detail and/or the image display shows what looks like noise, repeat steps 1 through 2, but with a lower-resolution objective.

If the lower-resolution objective is the same objective that was selected in "Scout – Find and Center the ROI at Low Magnification," on page 32, repeat steps 1 through 2, but with the X-ray source and detector moved closer to the sample (by way of the **Motion Controllers** tab).

NOTE If you need to increase the FOV, use the **Motion Controllers** tab to move the detector (**Detector** motion controller) closer to the sample and/or the X-ray source (**Source** motion controller) away from the sample.

Proceed to "Scout – Set X-ray Source and Detector Positions."

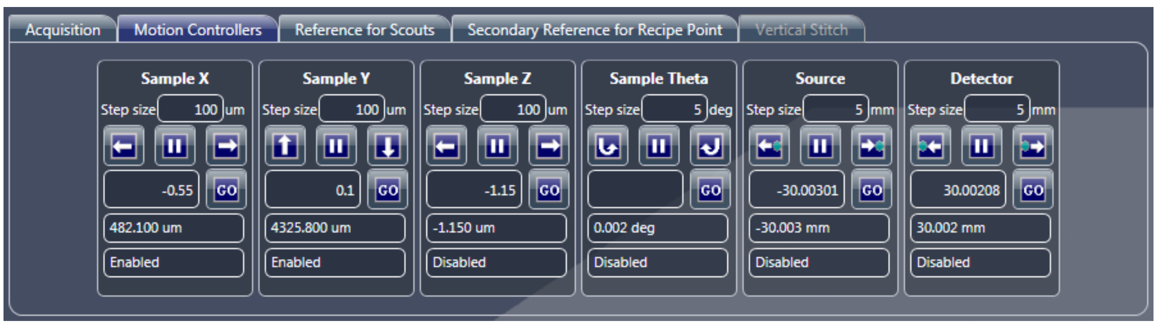
Scout – Set X-ray Source and Detector Positions

This process uses the **Motion Controllers** tab within **Scout** view's **Edit Recipe Points for Sample** panel to set the X-ray source and detector positions. The process differs, by model, as noted below.

To set the X-ray source and detector positions – Xradia 520 Versa and Xradia 510 Versa

1. Select the **Motion Controllers** tab within **Scout** view's **Edit Recipe Points for Sample** panel. (Refer to Figure 2-10.)

Figure 2-10 Typical **Motion Controllers** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel



NOTE If necessary, click  to halt motion for the selected motion controller (**Detector** or **Source** for **Detector Z** and **Source Z**, respectively, or **Sample Theta**).

2. Using the **Sample Theta** motion controller and **Visual Light Camera** image display, click  and  to rotate the sample between -180° and +180° (using the step size, such as the 5° indicated in Figure 2-10) to determine the angle at which the sample is closest to the X-ray source.

NOTE You can also type the angle in the text box below those buttons, and then click 

.

3. Using the **Source** motion controller and **Visual Light Camera** image display, click  and  to position the X-ray source as close to the sample as possible, at the angle determined in step 2.

NOTE While moving the X-ray source closer to the sample, start with small step sizes (such as 5 mm) to be safe. If the distance between the X-ray source and sample is large, you can use larger step sizes (such as 10 mm). The **blue** dot in the buttons represents the sample.

4. Using the **Sample Theta** motion controller and **Visual Light Camera** image display, click  and  to rotate the sample between -180° and +180° (using the step size, such as the 5° indicated in Figure 2-10) to determine the angle at which the sample is closest to the detector.

NOTE You can also type the angle in the text box below those buttons, and then click .

5. Using the **Detector** motion controller and **Visual Light Camera** image display, click  and  to position the detector as close to the sample as possible (for fastest scan), at the angle determined in step 4.

NOTE While moving the detector closer to the sample, start with small step sizes (such as 5 mm) to be safe. If the distance between the detector and sample is large, you can use larger step sizes (such as 10 mm). The **blue** dot in the buttons represents the sample.

NOTE For the 0.4X and 4X objectives, ensure that the distance between the X-ray source and detector is not less than that indicated in the table below. For example, if the position noted for **Detector Z** is 10 mm, for the 4X objective, the X-ray source should be positioned no closer than -(65 - 10) = -55 mm from the sample. If this process is not correctly followed for the lower-resolution objectives, the X-ray source aperture might be seen within the FOV.

Objective	Minimum Distance between Source Z and Detector Z
0.4X	135 mm
4X	13 mm

6. If a particular voxel size is needed, move the detector closer to or farther from the sample to decrease or increase, respectively, the geometrical magnification. Use Table 2-2 on page 35 as guidance for the resolution range for each objective.

NOTE For best resolution, it is ideal to minimize geometrical magnification when using the higher-resolution objectives. Exceeding the geometrical magnification for a particular objective (other than the 0.4X) to achieve smaller voxel sizes than indicated within the range listed in Table 2-2 on page 35 can potentially lead to X-ray source spot blurring.

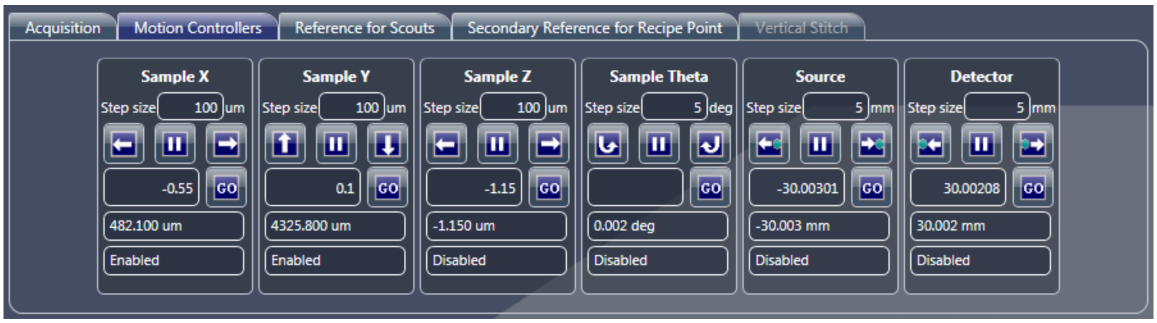
7. Using the **Sample Theta** motion controller and **Visual Light Camera** image display again, click  and  to rotate the sample between -180° and +180° to verify that the sample does not collide with the detector or X-ray source.

Proceed to “Scout – Select Appropriate Source Filter and Voltage.”

To set the detector and X-ray source positions – Xradia 410 Versa

1. Select the **Motion Controllers** tab within **Scout** view's **Edit Recipe Points for Sample** panel. (Refer to Figure 2-11.)

Figure 2-11 Typical **Motion Controllers** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel



NOTE If necessary, click  to halt motion for the selected motion controller (**Detector** or **Source** for **Detector Z** and **Source Z**, respectively, or **Sample Theta**).

2. Using the **Sample Theta** motion controller and **Visual Light Camera** image display, click  and  to rotate the sample between -180° and +180° (using the step size, such as the 5° indicated in Figure 2-11) to determine the angle at which the sample is closest to the X-ray source.

NOTE You can also type the angle in the text box below those buttons, and then click .

3. Using the **Detector** motion controller and **Visual Light Camera** image display, click  and  to position the detector near the sample at the angle determined in step 2.

NOTE While moving the detector closer to the sample, start with small step sizes (such as 5 mm) to be safe. If the distance between the detector and sample is large, you can use larger step sizes (such as 10 mm). The **blue** dot in the buttons represents the sample.

4. Move the X-ray source toward the sample, using the following guidelines:

   - **10X, 20X, and 40X objectives** – Move the X-ray source as close to the sample as possible, while avoiding collision, such that the distance between the X-ray source and detector follows the ratio listed in Table 2-3.

   - **0.4X and 4X objectives** – Move the X-ray source near the sample such that the distance between the X-ray source and detector follows the distance requirements listed in Table 2-3.

Table 2-3 Distance Needed between X-ray Source and Detector Guidelines, by Objective

Objective	Source:Detector Distance (Ratio)[a]	Minimum Distance between Source Z and Detector Z
0.4X	–	135 mm
4X	1:1	13 mm
10X[b]	2:1 to 3:1	–
20X	4:1 to 5:1	–
40X[c]	6:1 to 7:1	–

a. Ratio of the X-ray source position to the detector position, relative to the sample (that is, if the X-ray source is at 50 mm and the detector is at 10 mm, the ratio is 5:1).
b. **10X Objective** – Xradia 410 Versa only.
c. **40X Objective** – Optional, available on request.

NOTE For the 0.4X and 4X objectives, ensure that the distance between the X-ray source and detector is not less than that indicated in Table 2-3. For example, if the position noted for **Detector Z** is 10 mm, for the 4X objective, the X-ray source should be positioned no closer than -(65 - 10) = -55 mm from the sample. If this process is not correctly followed for the lower-resolution objectives, the X-ray source aperture might be seen within the FOV.

5. If a particular voxel size is needed, move the detector closer to or farther from the sample to decrease or increase, respectively, the geometrical magnification. Use Table 2-2 on page 35 as guidance for the resolution range for each objective.

NOTE For best resolution, it is ideal to minimize geometrical magnification when using the higher-resolution objectives. Exceeding the geometrical magnification for a particular objective to achieve smaller voxel sizes than indicated within the range listed in Table 2-2 on page 35 can potentially lead to X-ray source spot blurring.

Proceed to "Scout – Select Appropriate Source Filter and Voltage."

Scout – Select Appropriate Source Filter and Voltage

This process uses the **Acquisition** tab within **Scout** view's **Edit Recipe Points for Sample** panel to select an appropriate source filter and voltage to use for the sample.

NOTE For cylindrical samples, the angle used for this process is **not** important. For high-aspect ratio samples, use a 45° to 60° angle to perform this process. For irregularly shaped samples, rotate the sample for the thickest part of the sample.

To select an appropriate source filter and voltage

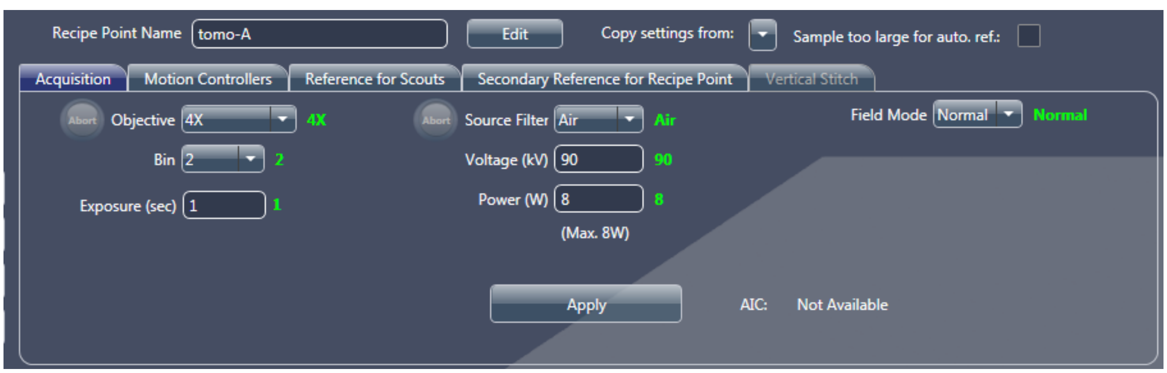
1. Select the **Acquisition** tab within **Scout** view's **Edit Recipe Points for Sample** panel. (Refer to Figure 2-12.)
2. Set up the source filter, as follows:

   – **Xradia 520 Versa** – Select *Air* from the **Source Filter** drop-down list box

   – **Xradia 510 Versa and Xradia 410 Versa** – Select *Air* from the **Source Filter** drop-down list box, –and– ensure that a source filter is **not** physically present

NOTE **Xradia 510 Versa and Xradia 410 Versa** – If a source filter is physically present, use the process described in Appendix F, "Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa," steps 1 through 3a and 4, to remove the source filter.

Figure 2-12 Typical **Acquisition** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel



3. Click  to rotate the sample (**Sample Theta** axis) to 0° and activate the **Front View** image display.
4. Type *1* in the **Exposure (sec)** text box, and then click **Apply** to set the Xradia Versa to the new settings.

5. Click  to acquire a single image in the **Front View** image display.

   The button changes to  and then back to  after the image is acquired.

6. Position the mouse pointer at the center of the ROI or feature of interest, and then verify that the image's **Intensity** value (light saturation; lower left **Front View** image display) is approximately 5000.

NOTE Exposure time scales linearly with the intensity.

7. Click  to collect and apply a reference to the **Front View** image display. The button changes to  and then back to  after the reference is collected.

NOTE The default direction for moving a sample out of the FOV to collect an air reference is *Sample Y+* (sample moves down). If the sample is too tall to move out of the FOV, the reference direction can be changed to *Sample Z+*, *Sample Z-*, *Sample X+*, or *Sample X-*. If you see that the sample is **not** moving out the FOV for a reference, such as shown in Figure 2-13, change the reference collection direction in the **Reference for Scouts** tab (refer to Figure 2-14) and then click  again to update the reference.

Figure 2-13 Change Reference Axis Direction If the Sample Is Unable to Completely Move Out of the FOV (as Shown in **Front View** Image Display), Changing the Direction to Sample X+ Enabled Collection of a Correct Auto Reference

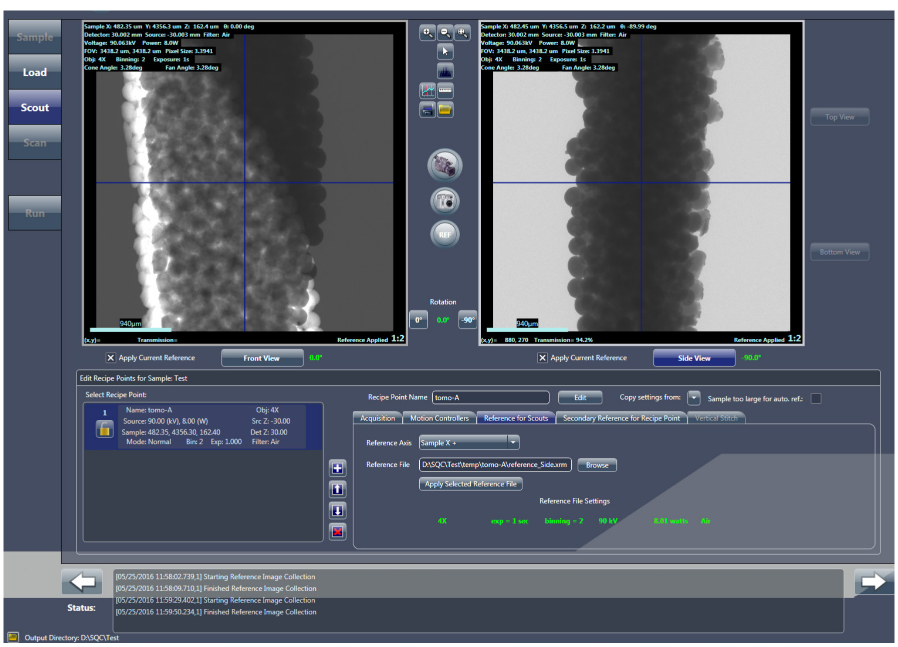
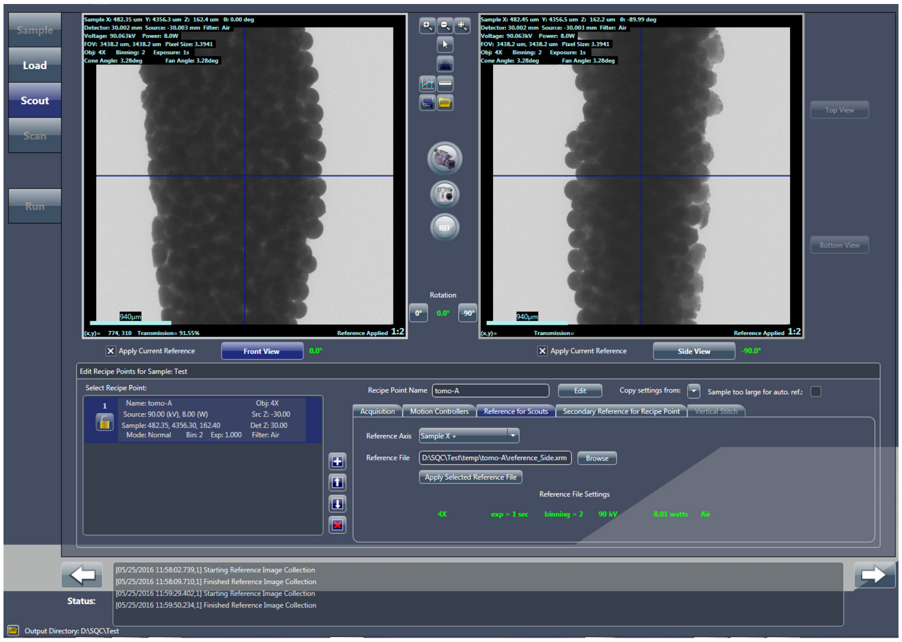
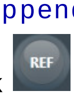


Figure 2-14 Previously Collected Reference Can Be Applied to Images Acquired at Different Sample Theta Positions



NOTE A new reference does **not** need to be collected after rotating the sample. You can apply the collected reference by clicking **Apply Selected Reference File** in the **Reference for Scouts** tab. (Refer to Figure 2-14.) A new reference **must** be collected, however, after acquiring a new image with a different voltage value, power value, X-ray source position, detector position, and/or objective.

NOTE If the sample is too large to be moved out of the FOV in any direction, manually remove the sample holder from the sample stage, following the processes described in "Removing a Sample after Use," steps 1 through step 4, on page 250 in Appendix E, close the access doors, turn ON the X-ray source, and then click  again to update the reference.

NOTE If the sample is too large for an automatic reference, select **Scout** view's **Sample too large** check box. This will enable the user interface to go through steps that guide you to remove and then replace the sample for manual reference collection after you start the scan.

8. Follow steps a through c below to select and apply the source filter:

    a. Center the mouse pointer over the ROI or feature of interest in the **Front View** image display to view the **Transmission** value (lower left, same location that previously indicated the **Intensity** value), which is identified as a number between 1 and 100.

NOTE *Transmission value* is the ratio of X-rays through the sample versus the ratio of X-rays without the sample being present.

NOTE If the entire sample is of interest, determine an approximate average of several **Transmission** values throughout the image.

    b. Use the **Transmission** value determined in step a and Table 2-4, “0.4X and 4X Source Filter Selection,” on page 46 –or– Table 2-5, “10X, 20X, and 40X Source Filter Selection,” on page 47 to determine which source filter to use.

    c. Select the source filter determined in step b from the **Acquisition** tab’s **Source Filter** drop-down list box.

NOTE **Xradia 520 Versa** – Step c is used to change the source filter on the automated filter changer.

Xradia 510 Versa and Xradia 410 Versa – Step c logs the correct source filter into the recipe.

NOTE If you selected *Air* (no filter) in step c, proceed directly to “Scout – Determine Acquisition Time,” on page 49.

    d. **Xradia 510 Versa and Xradia 410 Versa** – Manually install the source filter (determined in step b) on the X-ray source.

NOTE **Xradia 510 Versa and Xradia 410 Versa** – Use the process described in Appendix F, “Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa,” to install the source filter.

NOTICE **Xradia 510 Versa and Xradia 410 Versa** – Do **not** open the access doors while X-rays are being generated. Doing so automatically terminates X-ray generation and causes a fault condition, thereby preventing further operation until the fault is reset. Refer to “Interlock Sequence of Operation,” on page 334 in Appendix J for further explanation and method of recovery. Method of recovery is also provided in Table A-9, “Troubleshooting Light Tower Electrical Issues,” on page 165 in Appendix A.

e. Click **Apply** in the **Acquisition** tab.

NOTE **Xradia 520 Versa** – Clicking **Apply** in step e changes the filter to the source filter selected in step c.

Xradia 510 Versa and Xradia 410 Versa – Clicking **Apply** in step e includes the correct information and scan parameter value in the recipe for future overview.

Table 2-4 0.4X and 4X Source Filter Selection

<table>
<tr><th>Transmission at 80 kV
(For Thin Samples
and/or Low Z Materials)[a]
(%)</th><th>Transmission at 140 kV
(For Thick Samples
and/or High Z Materials)[b]
(%)</th><th>Filter</th></tr>
<tr><td>> 74</td><td rowspan="7">Recheck at 80 kV</td><td>No Filter (Air)</td></tr>
<tr><td>74 – 58</td><td>LE1</td></tr>
<tr><td>58 – 46</td><td>LE2</td></tr>
<tr><td>46 – 36</td><td>LE3</td></tr>
<tr><td>36 – 28</td><td>LE4</td></tr>
<tr><td>28 – 20</td><td>LE5</td></tr>
<tr><td>20 – 12</td><td>LE6</td></tr>
<tr><td rowspan="6">Recheck at 140 kV</td><td>32 – 20</td><td>HE1</td></tr>
<tr><td>20 – 12</td><td>HE2</td></tr>
<tr><td>12 – 08</td><td>HE3</td></tr>
<tr><td>08 – 05</td><td>HE4</td></tr>
<tr><td>05 – 03</td><td>HE5</td></tr>
<tr><td>< 03</td><td>HE6</td></tr>
</table>

a. Low Z materials are typically biological or polymeric.
b. High Z materials are typically metallic or contain metallic structures (such as semiconductor samples).

Table 2-5 10X[a], 20X, and 40X[b] Source Filter Selection

Transmission at 80 kV (For Thin Samples and/or Low Z Materials)[c] (%)	Transmission at 140 kV (For Thick Samples and/or High Z Materials)[d] (%)	Filter
> 63	Recheck at 80 kV	No Filter (Air)
63 – 44		LE1
44 – 34		LE2
34 – 28		LE3
28 – 21		LE4[b]
21 – 14		LE5
14 – 12		LE6
Recheck at 140 kV	30 – 18	HE1
	18 – 08	HE2
	08 – 06	HE3
	06 – 04	HE4
	04 – 03	HE5
	< 03	HE6

a. **10X Objective** – Xradia 410 Versa only.
b. **Optional 40X Objective** – If the required filter is identified as LE #4 or higher (such as LE #5 or any HE filters), scan the sample with 20X instead. This indicates a relatively high absorption for the sample, and it is unlikely that 40X will provide better resolution than 20X.
c. Low Z materials are typically biological or polymeric.
d. High Z materials are typically metallic or contain metallic structures (such as semiconductor samples).

9. Follow steps a through d below to adjust the X-ray source voltage value until the **Transmission** value is within the range of 22 to 35:

   a. Click  to acquire a single image in the **Front View** image display.

      The button changes to  and then back to  after the image is acquired.

   b. Click  to collect and apply the new reference to the **Front View** image display.

   c. Move the mouse pointer to the **Front View** image display to view the updated **Transmission** value.

   d. Adjust the X-ray source voltage value in the **Voltage (kV)** text box, and then click **Apply**.

NOTE If the **Transmission** value is higher than 35, decrease the voltage by 20 kV If the **Transmission** value is lower than 22, increase the voltage by 20 kV.

   e. Repeat steps a through d until the **Transmission** value is within the range of 22 to 35.

NOTE **Low-density materials** – Decreasing the voltage might not bring the **Transmission** value within the required range. In this case, you can decrease the voltage by 40 kV.

NOTE If bringing the **Transmission** value within the required range is **not** possible by changing the **Voltage (kV)** value, use the **Power (W)** that brings the **Transmission** value closest within the required range.

Proceed to "Scout – Determine Acquisition Time."

Scout – Determine Acquisition Time

This process uses the **Acquisition** tab within **Scout** view's **Edit Recipe Points for Sample** panel to help you determine the tomography's acquisition time.

NOTE The acquisition time is a parameter value that becomes part of the recipe.

To determine the acquisition time

1. Type *1* in the **Acquisition** tab's **Exposure (sec)** text box, and then click **Apply**.

2. Click to acquire a single image in the **Front View** image display. The button changes to and then back to after the image is acquired.

NOTE Step 2 assumes that Sample Theta is still at 0°. However, if you moved Sample Theta to -90°, the **Side View**, rather than the **Front View**, image display is updated with the new image.

3. Position the mouse pointer at the center of the **blue** crosshairs, and then make note of the **Intensity** value (lower left **Front View** image display).

NOTE For full FOV scans, ensure that the **Intensity** values of the air surrounding the sample are less than 60000. Also, for high aspect ratio samples, rotate the sample to the direction in which air is within the FOV (if applicable) to ensure that the **Intensity** values surrounding the sample are less than 60000.

4. Repeat steps 1 through 3, increasing the exposure time until the **Intensity** value at the center of the **blue** crosshairs is greater than 5000. The exposure time that resulted in increasing the **Intensity** value to approximately 5000 is the acquisition time.

NOTE Exposure time scales linearly with the **Intensity** value.

5. Click to proceed to the next tabbed view (**Scan**).

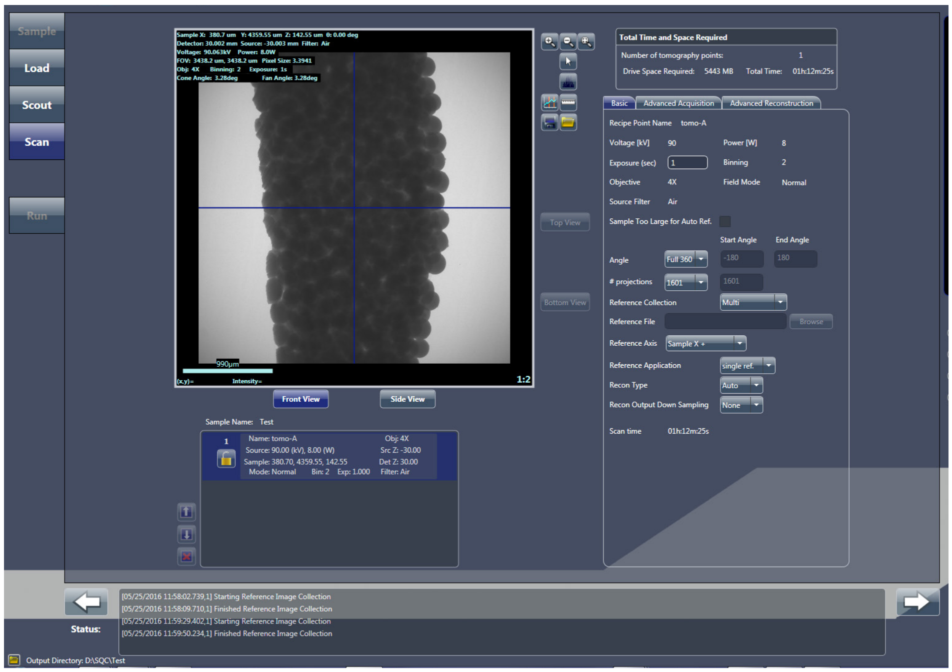
   Proceed to "Step 4 – Scan."

Step 4 – Scan

This process describes how to use **Scan** view to set up the recipe's 3D scan parameters.

NOTE For in-depth information that describes **Scan** view, refer to "Scan View," on page 210 in Appendix D.

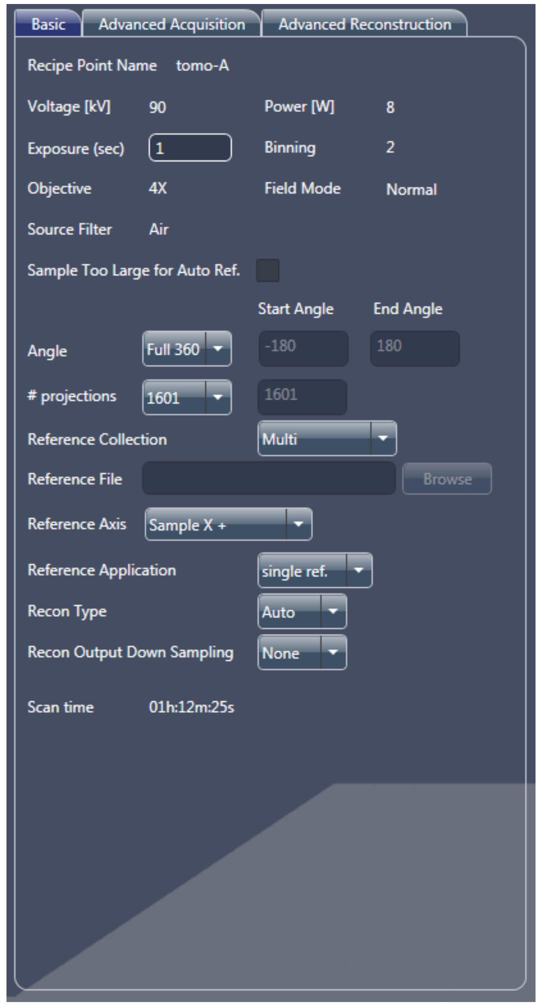
Figure 2-15 Typical **Scan** View



To set up the 3D scan parameters

1. Follow steps a and b below to set up the **Basic** tab parameter values. (Refer to Figure 2-16.)

Figure 2-16 Typical Basic Tab within **Scan** View



a. For high image quality, select *1601* from the **# projections** drop-down list box for samples that fit within the FOV. For interior tomographies, select *Custom*, and then type *2001* in the text box.

b. Leave all other parameters at their default values.

2. Click  to proceed to the next tabbed view (**Run**).

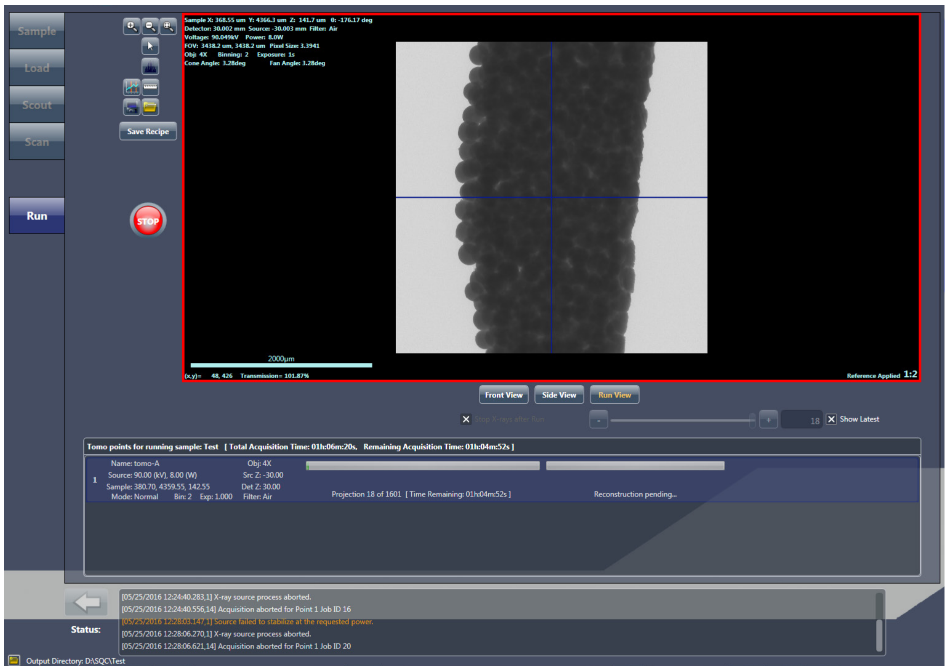
Proceed to “Step 5 – Run.”

Step 5 – Run

This process describes how to use **Run** view to run the recipe and acquire tomographies.

NOTE For in-depth information that describes **Run** view, refer to "Run View," on page 221 in Appendix D.

Figure 2-17 Typical **Run** View



To run the recipe and acquire tomographies

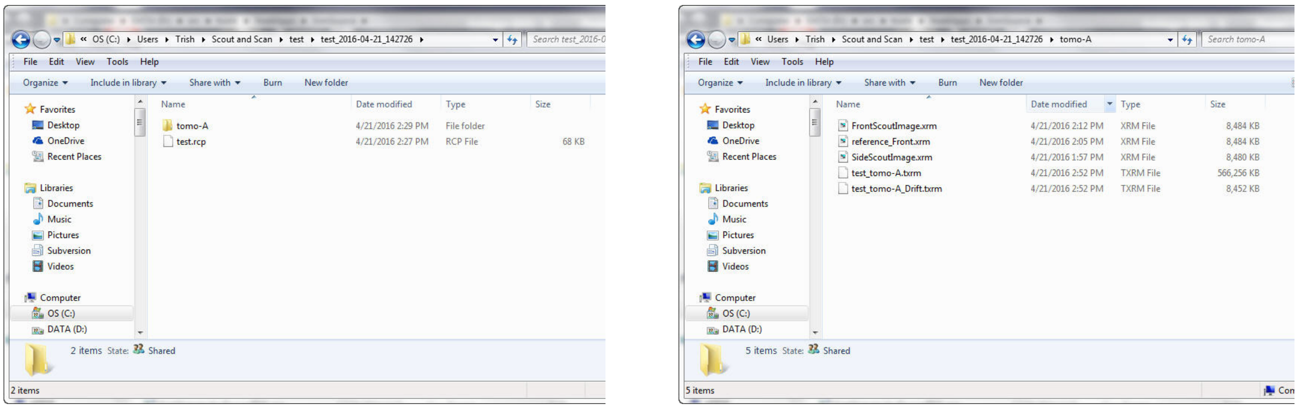
1. Click  to begin tomography acquisition. The button changes to .

   The projection and auto reconstruction (default) progress bars appear and then indicate status throughout the recipe run. (Auto reconstruction occurs in parallel to acquiring the tomographies; refer to Figure 2-17.) After the scans and reconstructions successfully complete, the progress bars change to solid **green** and the button changes back to .

NOTE A partially **red** reconstruction progress bar after tomography data acquisition completes indicates that **reconstruction failed**. Should this occur, you will need to manually reconstruct the tomography dataset, as described in Chapter 3, "Manually Reconstructing a Tomography Dataset."

A date- and time-stamped folder is created in the **Sample** folder specified in “Step 1 – Sample,” step 2, on page 26. In this example, the sample name is **test**. A folder named **test-Date_Time** is created, and a **tomo-A** subfolder is created for the recipe point. A copy of the recipe, **Sample Name.rcp**, is also created within the **Sample** folder. (Refer to Figure 2-18.)

Figure 2-18 Typical Folder Hierarchy Created when Running a Recipe



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

– **Run another recipe** – Click **New Sample**, and then proceed with the tomography collection process described in “Step 1 – Sample,” on page 25 (new recipes) –or– “Step 1 – Sample,” on page 55 (existing recipes or recipe templates)

– **Automatic reconstruction failed** – Use Reconstructor to manually reconstruct the tomography dataset, as described in Chapter 3, “Manually Reconstructing a Tomography Dataset”

– **View and edit tomography data** – Use XM3DViewer to view and edit 2D reconstructed slices and 3D reconstructed volume datasets, for use in reports and movies, as described in Chapter 4, “Viewing and Editing Tomographies”

NOTE Visual SI Advanced, available from ZEISS, is an optional program that can be used instead of XM3DViewer.

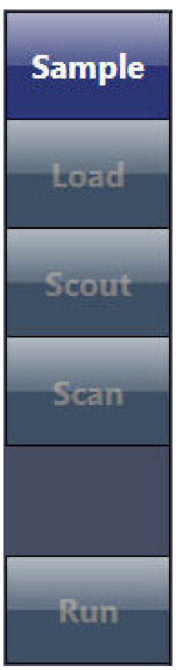
Loading and Running an Existing Recipe or Recipe Template

NOTE Take care when using existing recipes. Sample size and material dictate the X-ray source and detector positions, voltage, filter, and exposure time. Be sure to use the correct recipe to avoid problems such as collisions, or poor image quality due to insufficient **Intensity** or **Transmission** values.

An existing recipe or recipe template can be reused if the imaging and scan parameter values are suitable for the selected sample. In this case, only the sample position needs to be adjusted to set up the recipe**.**

Creating and running an existing recipe or recipe template requires four steps that are represented by four of the five **Scout-and-Scan Control System** workflow-based tabbed views, as listed in Table 2-6. Each view provides the tools that are needed to complete the required operations for each step.

Table 2-6 Loading and Running an Existing Recipe or Recipe Template Steps

Scout-and-Scan Control System View Tabs[a]	Step	Operation
	Step 1 – Sample	Set the **Sample**'s data folder. Load an existing recipe or recipe template.
	Step 2 – Load	Use the Visual Light Camera to **Load** and roughly position the sample.
	Step 3 – Scout	**Scout** the sample to locate the desired ROI and FOV. Imaging parameter setup is skipped because the parameter values are loaded from the existing recipe or recipe template.
	Step 4 – Scan	***Not used.*** The **Scan** step is skipped because scan parameter values are loaded from the existing recipe or recipe template.
	Step 5 – Run	**Run** the recipe and acquire the tomographies.

a. After  is clicked to access the next view, you can click the tabbed item to move between the active views.

Step 1 – Sample

This process describes how to use **Sample** view (refer to Figure 2-19) to set the sample’s data folder and load an existing recipe or recipe template.

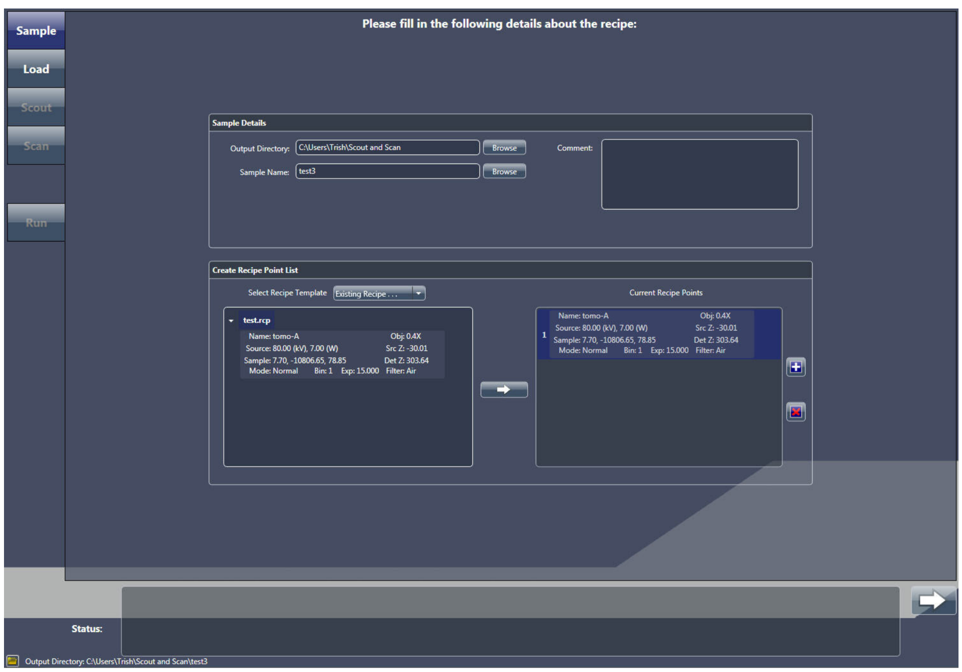
NOTE For in-depth information that describes **Sample** view, refer to “Sample View,” on page 195 in Appendix D.

To set the sample’s data folder and load an existing recipe or recipe template

1. Start the Scout-and-Scan Control System, if it is not already running. The program opens, defaulted to **Sample** view.

NOTE The screen capture provided below is partially filled in. Although a generic name is being used for the sample name, it is recommended that you use a name that better identifies the sample in use.

Figure 2-19 Typical **Sample** View with Existing Recipe Selected



2. Click **Browse**, and then browse to and select the output directory (folder) in which to store the sample’s data.

3. Type a name in the **Sample Name** text box (new sample) –or– click **Browse** (existing sample), and then browse to and select the sample name to be used.

   A subfolder is automatically created under the selected output directory (folder), in which all acquired data will be stored.

4. **Optional** – Type a comment in the **Comment** text box.

5. Select **Existing Recipe** from the **Select Recipe Template** drop-down list box. An **Open** dialog box opens.

6. Click the recipe –or– recipe template to load from the **Open** dialog box, and then click **Open**.

7. Select the recipe, recipe template, and/or specific recipe points to be run (refer to Figure 2-20):

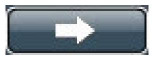
   – **Select the recipe or recipe template** – From the recipe(s) –or– recipe templates displayed, click the recipe or recipe template to be run, and then click  to add the recipe to the **Current Recipe Points** list.

Figure 2-20 Select Recipe, Recipe Template, and/or Recipe Points to Be Run

Recipe – Click the recipe or recipe template to be run, and then click  to add the recipe to the **Current Recipe Points** list

Recipe Points – Click  (left of recipe), click the recipe point(s) to add, and then click  to add each clicked recipe point to the **Current Recipe Points** list

   – **Select recipe point(s) within a recipe** – Click  to the left of the recipe, click the recipe point to be run, and then click  to add the recipe point to the **Current Recipe Points** list. Add as many recipe points as needed.

8. Click  to proceed to the next tabbed view (**Load**).

   Proceed to “Step 2 – Load.”

Step 2 – Load

This process describes how to use the visual light camera in **Load** view (refer to Figure 2-21) to load and roughly position the sample on the axis of rotation and position the X-ray source and detector.

NOTICE If collision is imminent at any time during this process, click  (**All Motors**, upper left view) to immediately stop all motors, –or–  within a motion controller to halt movement for the axis associated with that motion controller.

NOTE For in-depth information that describes **Load** view, refer to "Load View," on page 198 in Appendix D.

NOTE This process is identical to the Load process discussed earlier in this chapter, in "Step 2 – Load," on page 27. The process is repeated here for your convenience.

Figure 2-21 Typical **Load** View

To load and roughly position the sample

1. If needed, click  to move the X-ray source and detector away from the sample stage. This should provide sufficient room in which to load the sample holder assembly on the sample stage. If not, click  again until there is sufficient room.

2. Load the sample holder assembly on the sample stage.

NOTE Instructions for mounting the sample on the sample holder are provided in “Mounting a Sample in or on a Sample Holder,” on page 241 in Appendix E. Instructions for loading the sample holder assembly (sample mounted on sample holder) on the sample stage are provided in “Loading a Sample Holder Assembly on the Sample Stage,” on page 248 in Appendix E.

NOTE The Xradia Versa’s collision avoidance system is designed to protect against collisions between the sample holder base and X-ray source or detector.

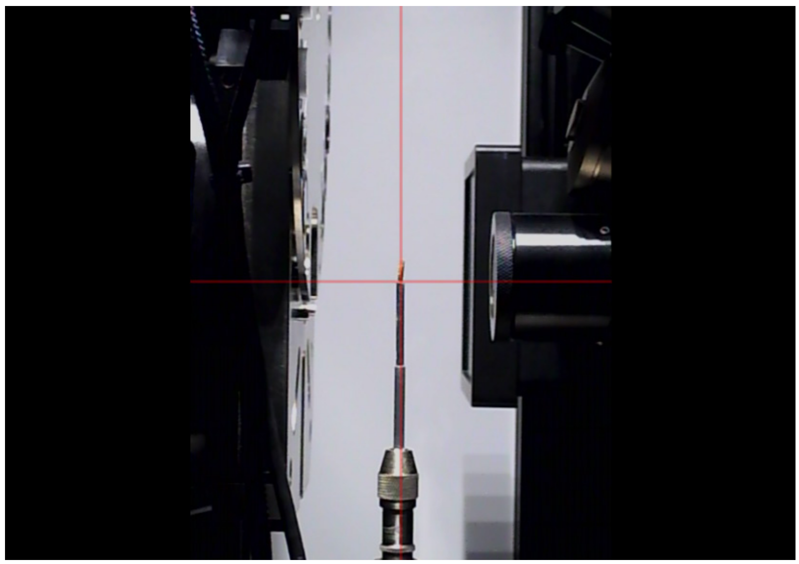
3. **Optional** – Click and hold  to completely zoom out of the image.

4. Click 

to rotate the sample (**Sample Theta** axis) to 0°. Ensure that the detector and X-ray source are a sufficient distance from the sample to avoid collision when the sample is rotated.

5. With Sample Theta at 0°, under the **Sample** panel, use the **Sample Y** and **Sample Z** motion controllers to align the sample –or– its feature of interest with the **red** crosshairs on the **Visual Light Camera** image display (refer to Figure 2-22):
   - Click and/or (**Sample Y**) to vertically align the sample
   - Click and/or (**Sample Z**) to horizontally align the sample

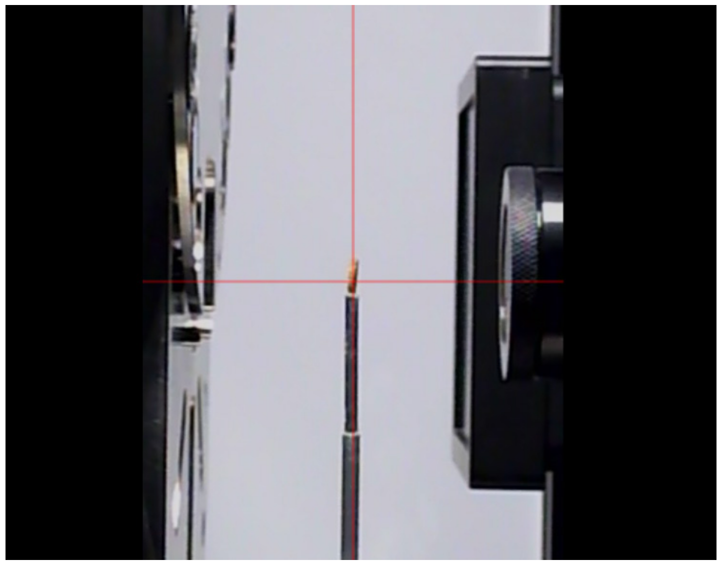
Figure 2-22 Sample Coarsely Aligned with **Red** Crosshairs in **Load** View



6. Click to rotate the sample (**Sample Theta** axis) to -90°. Ensure that the detector and X-ray source are a sufficient distance from the sample to avoid collision when the sample is rotated.
7. With Sample Theta at -90°, under the **Sample** panel, use the **Sample X** motion controller to align the sample –or– its feature of interest with the **red** crosshairs on the **Visual Light Camera** image display. (Refer to Figure 2-22.) Click and/or to horizontally align the sample.

8. Click and hold  to zoom in. Repeat steps 4 through 7 to fine align the sample –or– its feature of interest with the **red** crosshairs on the **Visual Light Camera** image display with Sample Theta at both 0° and -90°. (Refer to Figure 2-23.)

Figure 2-23 Sample Finely Aligned with **Red** Crosshairs in **Load** View



9. Click  to proceed to the next tabbed view (**Scout**).

   Proceed to "Step 3 – Scout."

Step 3 – Scout

This process describes how to use X-ray images in **Scout** view (refer to Figure 2-24) to scout the sample – locate the sample's ROI and FOV. It is unnecessary to determine new imaging parameter values because the parameter values are loaded from the existing recipe or recipe template.

The Scout phase, after loading an existing recipe or recipe template, consists of the following processes:

a. Scout – Lock Recipe (Optional)

b. Scout – Find and Center the ROI at Low Magnification

c. Scout – Fine-Tune the ROI at High Magnification

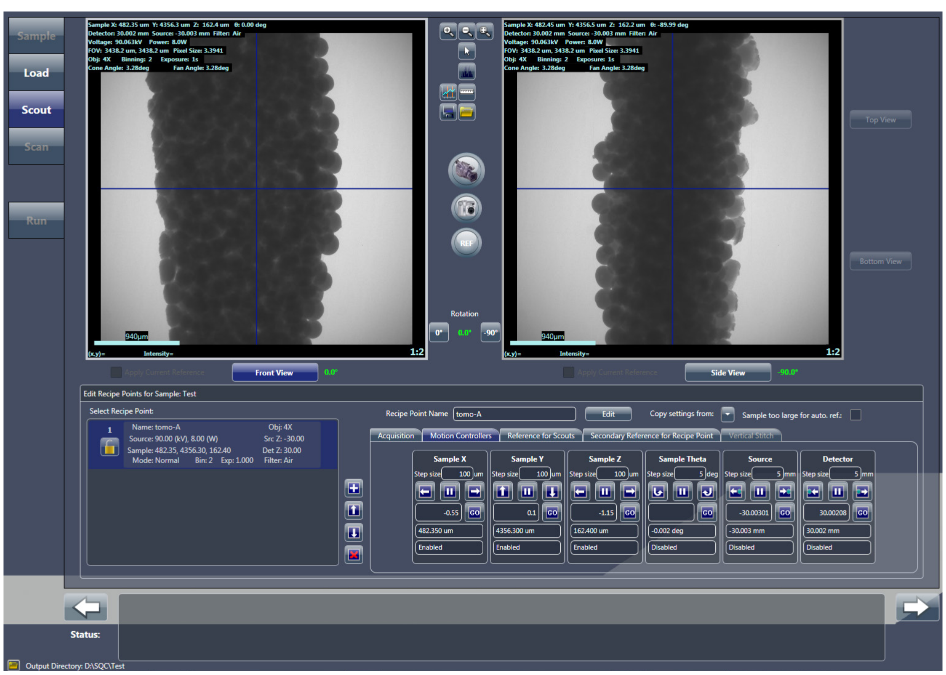
d. Scout – Save Positions to Recipe (Optional)

NOTICE If collision is imminent at any time during this process, click 

(**All Motors**, upper left view) to immediately stop all motors, –or–  within a motion controller to halt movement for the axis associated with that motion controller.

NOTE For in-depth information that describes **Scout** view, refer to "Scout View," on page 200 in Appendix D.

Figure 2-24 Typical **Scout** View



Scout – Lock Recipe (Optional)

This optional process locks the recipe, which prevents the recipe from being changed. The recipe should remain locked until the sample positions are set.

To lock the recipe

1. Click  within the recipe listed in the **Select Recipe Point** area to lock the recipe that was loaded in “Step 2 – Load,” on page 57. The button changes to .

   Proceed to “Scout – Find and Center the ROI at Low Magnification.”

Scout – Find and Center the ROI at Low Magnification

This process uses X-rays to help you to locate and roughly center the sample’s ROI. The **Sample X**, **Y**, and **Z** axes are adjusted, using the **Acquisition** tab within **Scout** view’s **Edit Recipe Points for Sample** panel.

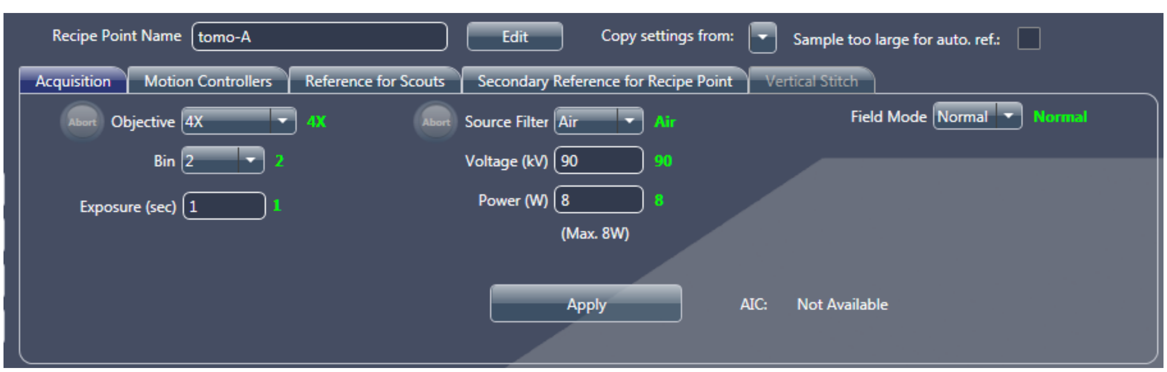
NOTE For details regarding axes directional movement, refer to “Axis Definitions,” on page 21 in Chapter 1.

To find and center the ROI at low magnification

1. Select the **Acquisition** tab within the **Edit Recipe Points for Sample** panel. (Refer to Figure 2-25.)

   The values displayed are those for the current recipe.

Figure 2-25 Typical **Acquisition** Tab within **Scout** View’s **Edit Recipe Points for Sample** Panel



2. Follow steps a through c below to set up the acquisition settings:

   a. Select an objective from the **Objective** drop-down list box:

      – Samples larger than 4 mm – *0.4X*

      – Samples smaller than 4 mm – Select *4X*

NOTE If the currently selected objective provides the best magnification, do **not** select a different objective.

   b. Type *1* in the **Exposure (sec)** text box.

NOTE Reducing the exposure time speeds up sample positioning, but does **not** affect the locked recipe's exposure time.

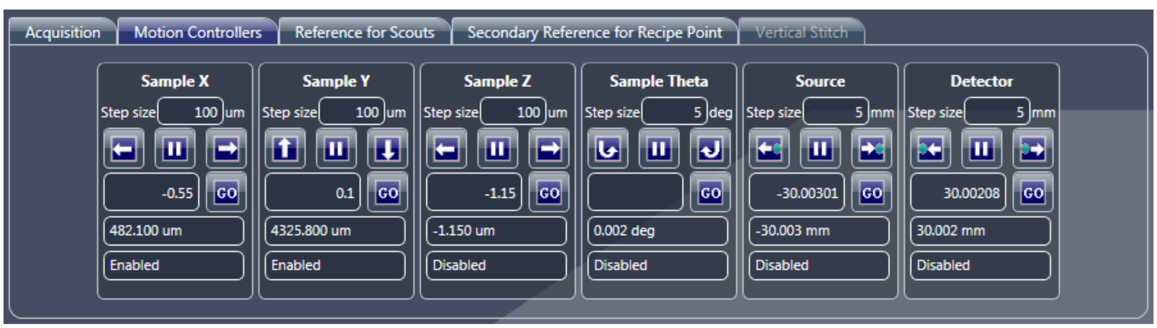
   c. Click **Apply** to set the Xradia Versa to the new settings.

3. Click  to rotate the sample (**Sample Theta** axis) to 0° and activate the **Front View** image display.

4. Click  to start continuous imaging. The button changes to .

NOTE If you need to increase the FOV, use the **Motion Controllers** tab to move the detector (**Detector** motion controller) closer to the sample and/or the X-ray source (**Source** motion controller) away from the sample. (Refer to Figure 2-26.)

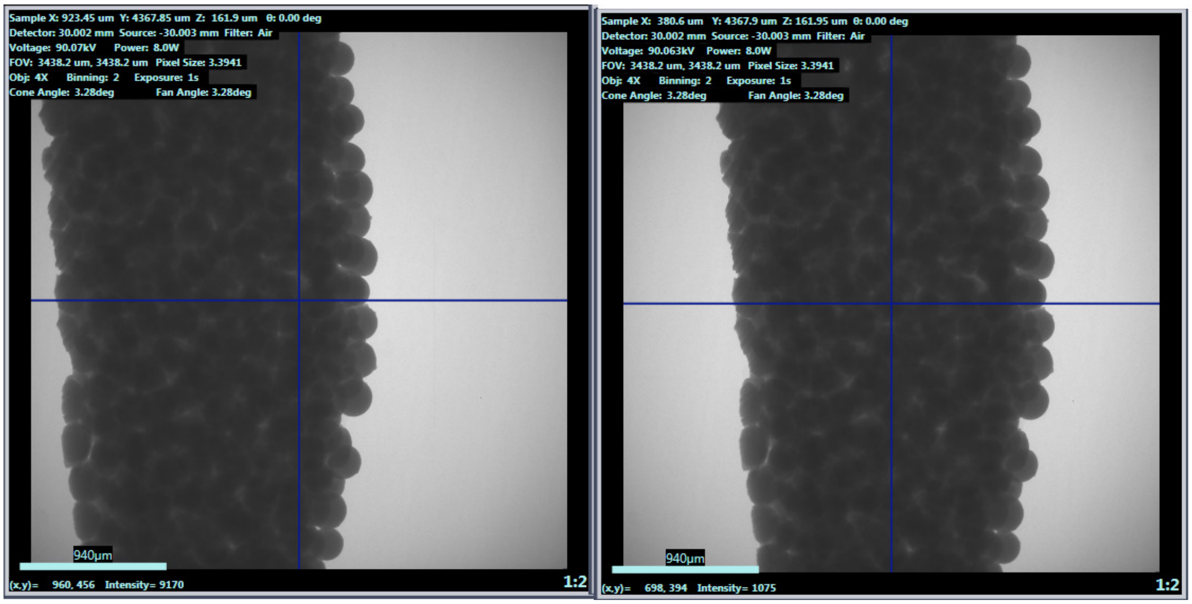
Figure 2-26 Typical **Motion Controllers** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel



5. Double-click the center of the sample –or– its feature of interest within the **Front View** image display to automatically roughly center the ROI for the **Sample X** and **Y** axes. (Refer to Figure 2-27.)

NOTE The message **Image different from recipe point** might appear on the **Front View** image display. This is expected when the recipe is locked and the stage is repositioned differently than its past position.

Figure 2-27 ROI Prealignment and Roughly Centered for **Sample X** and **Y** Axes

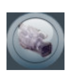


Prealignment, ROI Not Centered

Aligned, ROI Centered

6. Click  to halt continuous imaging. The button changes back to .

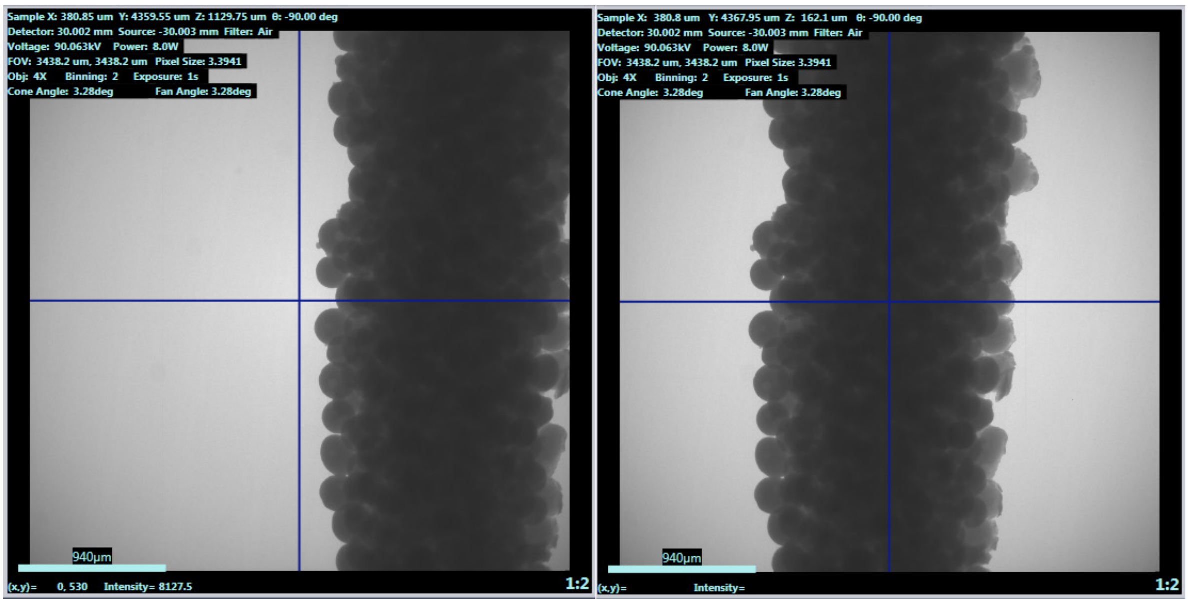
7. Click  to rotate the sample (**Sample Theta** axis) to -90° and activate the **Side View** image display.

8. Click  to start continuous imaging. The button changes to .

9. Double-click within the **Side View** image display to automatically roughly center the ROI for the **Sample Z** axis. (Refer to Figure 2-28.)

NOTE The message **Image different from recipe point** might appear on the image. This is expected when the recipe is locked and the stage is repositioned differently than its past position.

Figure 2-28 ROI Prealignment and Roughly Centered for **Sample Z** Axis



Prealignment,
ROI Not Centered

Aligned,
ROI Centered

10. Click 

to halt continuous imaging. The button changes back to .

Proceed to "Scout – Fine-Tune the ROI at High Magnification."

Scout – Fine-Tune the ROI at High Magnification

This process uses the **Acquisition** tab within **Scout** view's **Edit Recipe Points for Sample** panel to fine-tune the sample's ROI at a higher magnification.

To fine-tune the ROI at high magnification

1. In the **Acquisition** tab, select the same high-resolution objective that is used in the recipe from the **Objective** drop-down list box if it is different than the objective currently in use.

NOTE The objective used by the recipe is listed in the recipe details within the **Select Recipe Point** area.

2. Perform steps 2b through 10 of "Scout – Find and Center the ROI at Low Magnification," on page 62 to fine-tune the sample position at the higher magnification selected in step 1.

NOTE For quick X-ray source and detector movement, you can click within the **Front View** (Sample Theta is at 0°) or **Side View** (Sample Theta is at -90°) image display, and then roll the mouse wheel away from you to zoom in, or toward you to zoom out, of the image.

NOTE If the selected high-resolution objective results in zooming in so closely that you cannot see detail and/or the image display shows what looks like noise, repeat steps 1 and 2, but with a lower-resolution objective.

If the lower-resolution objective is the same objective that was selected in "Scout – Find and Center the ROI at Low Magnification," on page 62, repeat steps 1 and 2, but with the X-ray source and detector moved closer to the sample (by way of the **Motion Controllers** tab).

NOTE If you need to increase the FOV, use the **Motion Controllers** tab to move the detector (**Detector** motion controller) closer to the sample and/or the X-ray source (**Source** motion controller) away from the sample.

Proceed to "Scout – Save Positions to Recipe (Optional)."

Scout – Save Positions to Recipe (Optional)

This optional process unlocks the recipe, and then saves the new detector, X-ray source, and sample positions to the recipe.

To unlock the recipe and save the new detector, X-ray source, and sample positions

1. Click  within the recipe listed in the **Select Recipe Point** area to unlock the recipe that was loaded in "Step 2 – Load," on page 57.

   The button changes to .

NOTE Prior to unlocking the recipe, the sample positions and exposure time (parameter values) are likely listed in **red** because they do **not** match the scouted images. The new parameter values are saved in the next step.

2. In the **Acquisition** tab, click **Apply** to set the Xradia Versa to the new settings.

3. Click  to rotate the sample (**Sample Theta** axis) to 0° and activate the **Front View** image display.

4. Click  to acquire a single image to the **Front View** image display.

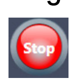
   The button changes to  and then back to  after the image is acquired.

   The new sample positions are updated in the recipe.

NOTE The **Exp** (exposure) value might still be listed in **red** because it does not match the scouted image in the **Side View** image display.

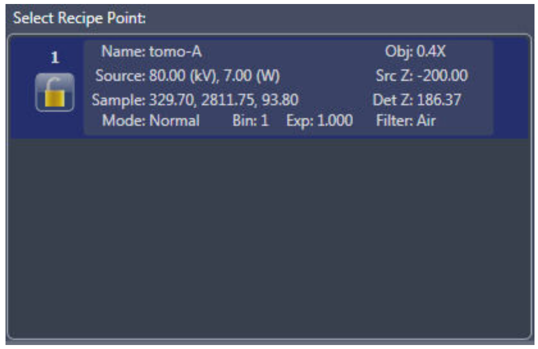
5. Click  to rotate the sample (**Sample Theta** axis) to -90° and activate the **Side View** image display.

6. Click  to acquire a single image to the **Side View** image display.

   The button changes to  and then back to  after the image is acquired.

   All recipe parameter values should now match the scouted images, and any previously mismatched values are no longer listed in **red**, such as shown in Figure 2-29.

Figure 2-29 All Recipe Parameter Values Should Now Match the Scouted Images, with No Mismatched **Red** Values



7. Click  within the recipe listed in the **Select Recipe Point** area to lock the recipe. The button changes to .

   All the recipe parameter values are identical to the original recipe. Only the sample positions have been updated. The recipe is now ready to run.

8. Click  twice to proceed to the next view for this process (**Run**).

NOTE **Scan** view is skipped because the scan parameter values are already loaded from the existing recipe or recipe template.

Proceed to "Step 5 – Run."

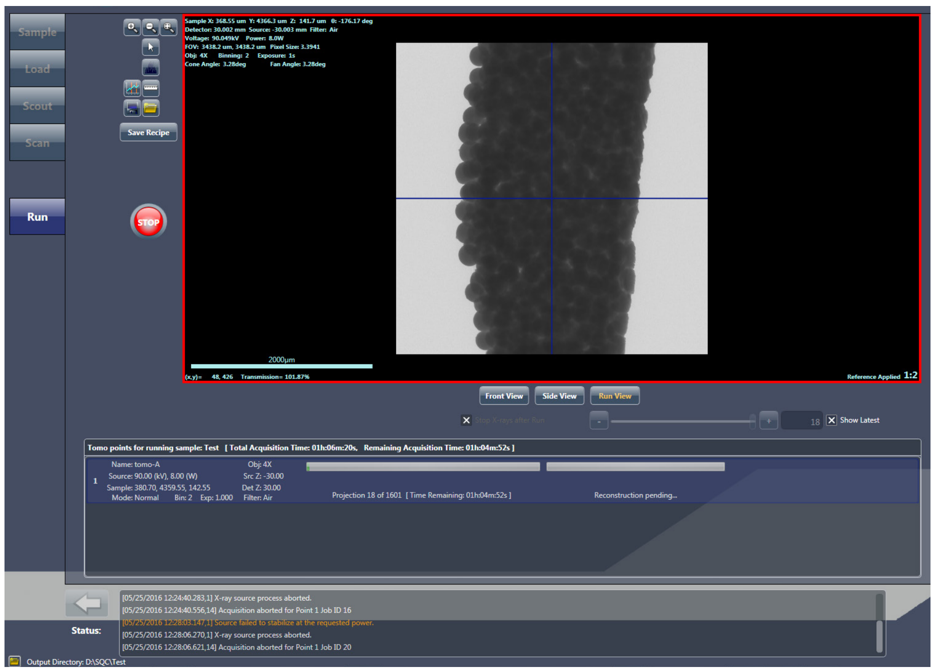
Step 5 – Run

This process describes how to use **Run** view to run the recipe and acquire tomographies.

NOTE For in-depth information that describes **Run** view, refer to "Run View," on page 221 in Appendix D.

NOTE This process is identical to the Run process discussed earlier in this chapter, in "Step 5 – Run," on page 52. The process is repeated here for your convenience.

Figure 2-30 Typical **Run** View



To run the recipe and acquire tomographies

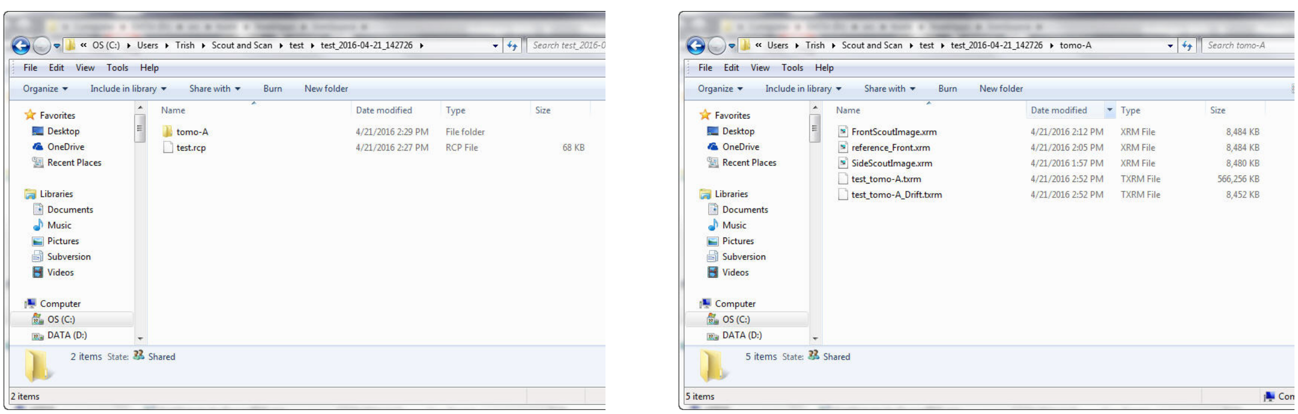
1. Click  to begin tomography acquisition. The button changes to .

   The projection and auto reconstruction (default) progress bars appear and then indicate status throughout the recipe run. (Auto reconstruction occurs in parallel to acquiring the tomographies; refer to Figure 2-30.) After the scans and reconstructions successfully complete, the progress bars change to solid **green** and the button changes back to .

NOTE A partially **red** reconstruction progress bar after tomography data acquisition completes indicates that **reconstruction failed**. Should this occur, you will need to manually reconstruct the tomography dataset, as described in Chapter 3, "Manually Reconstructing a Tomography Dataset."

   A date- and time-stamped folder is created in the **Sample** folder specified in "Step 1 – Sample," step 2, on page 55. In this example, the sample name is **test**. A folder named **test-Date_Time** is created, and a **tomo-A** subfolder is created for the recipe point. A copy of the recipe, **Sample Name.rcp**, is also created within the **Sample** folder. (Refer to Figure 2-31.)

Figure 2-31 Typical Folder Hierarchy Created when Running a Recipe



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

- **Run another recipe** – Click **New Sample**, and then proceed with the tomography collection process described in “Step 1 – Sample,” on page 25 (new recipes) –or– “Step 1 – Sample,” on page 55 (existing recipes or recipe templates)
- **Automatic reconstruction failed** – Use Reconstructor to manually reconstruct the tomography dataset, as described in Chapter 3, “Manually Reconstructing a Tomography Dataset”
- **View and edit tomography data** – Use XM3DViewer to view and edit 2D reconstructed slices and 3D reconstructed volume datasets, for use in reports and movies, as described in Chapter 4, “Viewing and Editing Tomographies”

NOTE Visual SI Advanced, available from ZEISS, is an optional program that can be used instead of XM3DViewer.

THIS PAGE INTENTIONALLY LEFT BLANK

3 Manually Reconstructing a Tomography Dataset

This chapter describes how to use the Reconstructor Scout-and-Scan Control System program (Reconstructor) to manually reconstruct a tomography dataset when any of the following conditions exist:

- Recipe was run with *Manual* selected from the **Recon Type** drop-down list box on the **Advanced Acquisition** tab within **Scan** view in the Scout-and-Scan Control System

- Recipe was run with *Auto* (default) selected from the **Recon Type** drop-down list box on the **Advanced Acquisition** tab within **Scan** view, but automatic reconstruction failed during tomography data acquisition within **Run** view in the Scout-and-Scan Control System

NOTE In **Run** view, a partially **red** reconstruction progress bar after tomography data acquisition completes indicates that **reconstruction failed**.

- 3D reconstructed images are unacceptable due to Scout-and-Scan Control System reconstruction parameter values that are **not** optimal

Tomographic reconstruction is the process of mathematically combining the 2D projection images acquired over several angles during a tomography data acquisition to create a 3D image volume.

NOTE For in-depth information that describes the Reconstructor user interface, refer to "Reconstructor User Interface," on page 225 in Appendix D.

NOTE Reconstructor can only be used to reconstruct images that are reference corrected.

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

Process Overview

The process of manually reconstructing a tomography dataset is composed of the following subprocesses:

1. Preparing for Reconstruction.
2. Finding the Center Shift.
3. Finding the Beam Hardening Constant.
4. **Optional** – Changing the Rotation Angle.
5. Reconstructing the Tomography Data.

Each of these steps is described in the sections that follow.

Preparing for Reconstruction

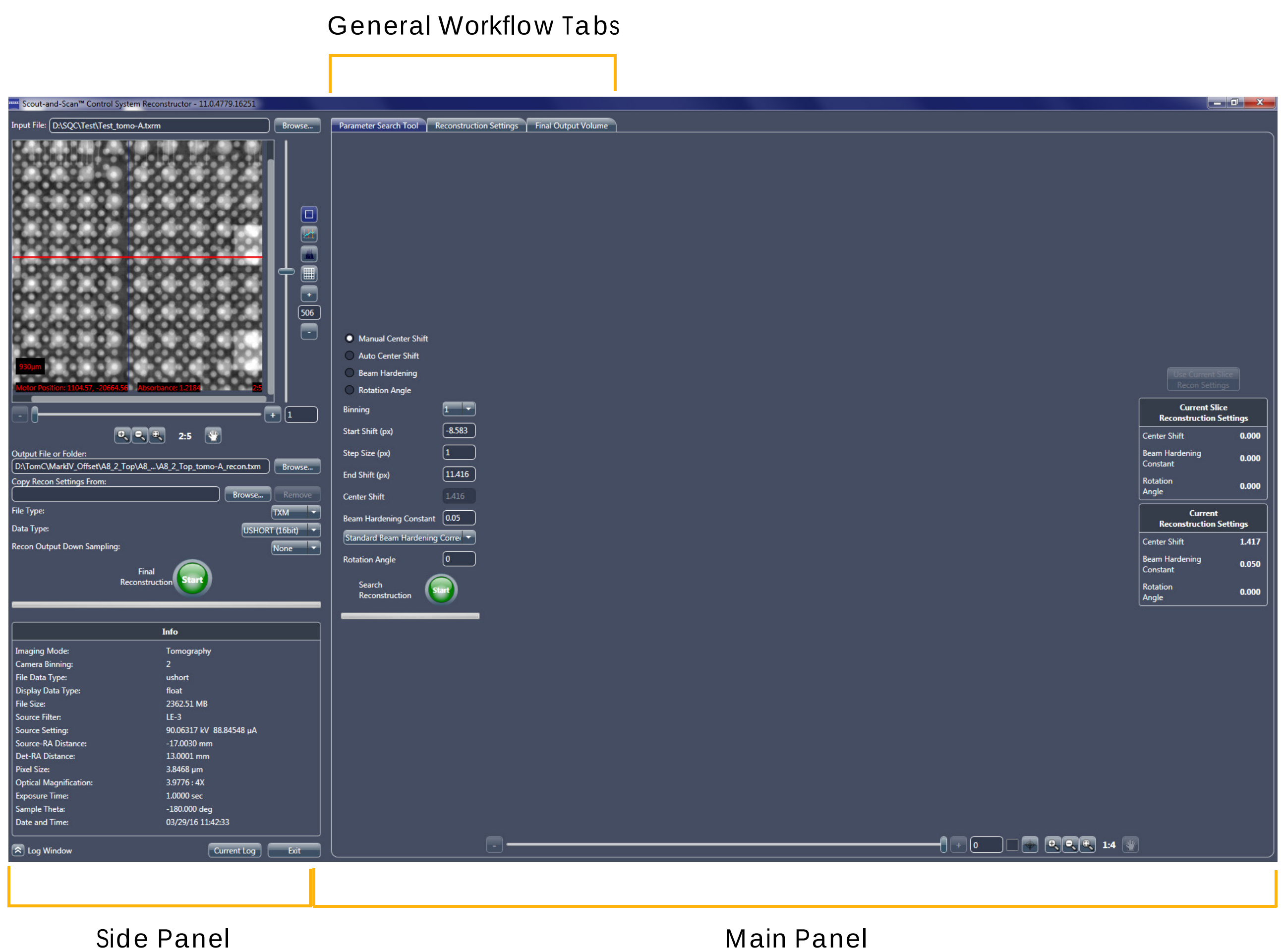
This process describes how to start Reconstructor, load the data, and then define the initial parameter values.

To prepare for reconstruction

1. On the Windows taskbar **Start** menu, select **All Programs**, **Carl Zeiss X-ray Microscopy**, **Xradia Versa 11.*x***, and then **Reconstructor Scout-and-Scan 11.*x***. The **Reconstructor** main window opens.

NOTE “x” is the program’s current version number.

Figure 3-1 **Reconstructor** Main Window after Loading a File



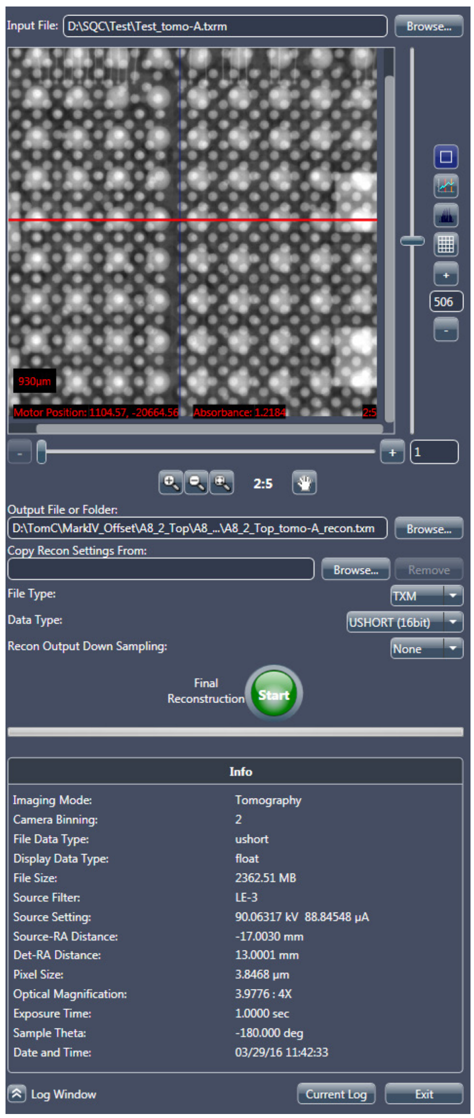
2. Follow steps a through c below to load the file to be reconstructed:

   a. Click **Browse** (right of the **Input File** text box). The **Input File** dialog box opens.

   b. Browse to the file path of the raw tomography dataset (**.txrm* file) to be reconstructed.

   c. Select the file, and then click **Open**. The file's path and name appear in the **Input File** text box, and the raw tomography dataset is shown in the **Projection Dataset** image display. (Refer to Figure 3-2.)

Figure 3-2 Preparation for Reconstruction



NOTE If the “The file may be opened by other programs. Please close any open copies of this file before continuing.” **File Access Problem** warning dialog box opens (refer to Figure 3-3, image to the left), click **OK**, close the file in the other program, and then reload the file as instructed in step 2.

NOTE If the “Invalid file for reconstruction. Only reference corrected files supported. The file header indicates the original data is not reference corrected, and there is no seperate reference data available.” **Invalid Input File** warning dialog box opens (refer to Figure 3-3, image to the right), the tomography file has **not** been reference corrected yet. Click **OK**, collect and apply a reference to the file (according to the process described in “Scout – Select Appropriate Source Filter and Voltage,” on step 7, on page 43 in Chapter 2), and then reload the tomography file as instructed in step 2.

Figure 3-3 Reconstructor Warning Dialog Boxes – **File Access Problem** and **Invalid Input File**

3. Follow steps a through d below to set up the output reconstruction file name and location (refer to Figure 3-2):

   a. Click **Browse** (right of the **Output File or Folder** text box). The **Output File** dialog box opens.

   b. Browse to the destination file path to which you want to save the output **.txm* file.

   c. Type the output reconstruction file name in the **File name** text box.

NOTE A suggested file name is to use the same name as the input file specified in step 2 with *_recon* appended to the file name.

   d. Click **Save**. The file path and file name appear in the **Output File or Folder** text box.

4. **Optional** – Follow steps a through c below to copy previously used reconstruction parameter values such as Center Shift, Beam Hardening Constant, Rotation Angle, Recon Filter, and/or Byte Scaling (refer to Figure 3-2):

NOTE Suggested use cases are manual reconstruction of datasets collected for vertical stitching.

   a. Click **Browse** (right of the **Copy Recon Settings From** text box). The **Input File** dialog box opens.

   b. Browse to the file path of the raw tomography dataset or reconstructed output (**.txrm* or **.txm* file, respectively) to be copied.

   c. Select the file, and then click **Open**. The file's path and name appear in the **Copy Recon Settings From** text box.

NOTE Should you decide that you do **not** want to copy the reconstruction parameter values from the selected file, click **Remove** (right of the **Copy Recon Settings From** text box).

5. Select the file type from the **File Type** drop-down list box – *txm* (default; ZEISS proprietary), *dicom*, *tiff*, or *bin*. (Refer to Figure 3-2.)

NOTE **.txm* files can be opened **only** in Reconstructor's **Final Output Volume** tab, the legacy XMController program, and XM3DViewer.

6. Select the data type from the **Data Type** drop-down list box – *ushort* (16 bit, default; unsigned, Scout-and-Scan Control System **Intensity** value ranges from 0 to 65535), *ushort* (8 bit, Scout-and-Scan Control System **Intensity** value ranges from 0 to 255), or *float* (32 bit). (Refer to Figure 3-2.)

7. Select the downsampling value from the **Recon Output Down Sampling** drop-down list box – *None* (recommended), *2*, or *4*. (Refer to Figure 3-2.)

   Proceed to "Finding the Center Shift."

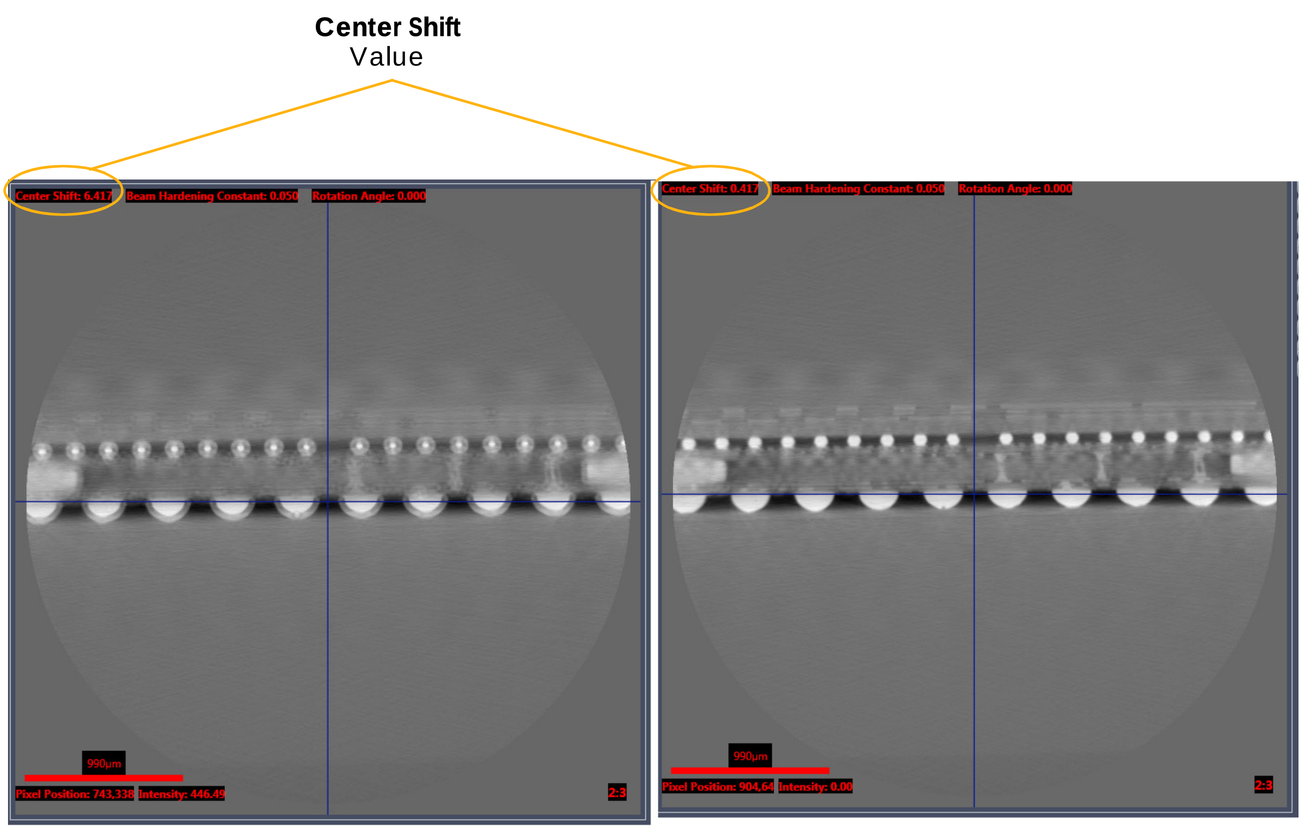
Finding the Center Shift

This process describes how to find the center shift. The **Center shift** value (upper left **Reconstructed Slice** image display within the main panel) is the amount, in pixels, that the axis of rotation is offset from the detector's center column.

Images with incorrect center shift are unfocused and blurry. Images with correct center shift are focused and clear, with clean edges and crisp features.

For example, in Figure 3-4, the scans are performed using projections that range 360°. For these types of scans, the out-of-focus features have double-lined edges, such as those visible in the image to the right (image with incorrect center shift). The image to the left is that of a focused image (image with correct center shift).

Figure 3-4 Incorrect and Correct Center Shift – Sample Image Scans Performed Using Projections that Range 360°

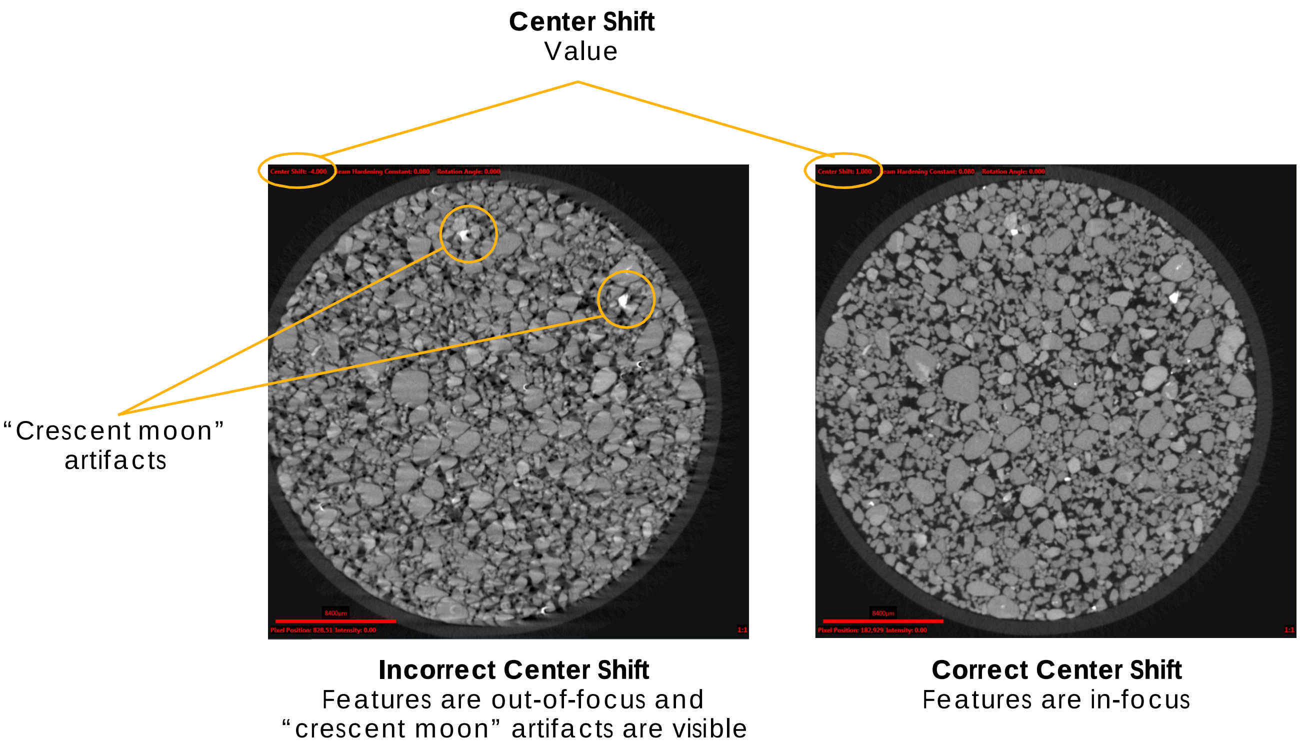


Incorrect Center Shift
Features are out-of-focus and have double-lined edges

Correct Center Shift
Features are in-focus

For example, in Figure 3-5, the scans are performed using projections that do not range 360°. For these types of scans, the out-of-focus features have artifacts that look like “crescent moons,” such as those visible in the image to the right (image with incorrect center shift). The image to the left is that of a focused image (image with correct center shift).

Figure 3-5 Incorrect and Correct Center Shift – Sample Image Scans Performed Using Projections that Do Not Range 360°



Center shift can be found using either of the following methods:

– Auto Center Shift (recommended)

– Manual Center Shift (used when the **Center Shift** value determined by Auto Center Shift looks incorrect (image in the **Reconstructed Slice** image display is unfocused and blurry)

Both methods are described in the sections that follow.

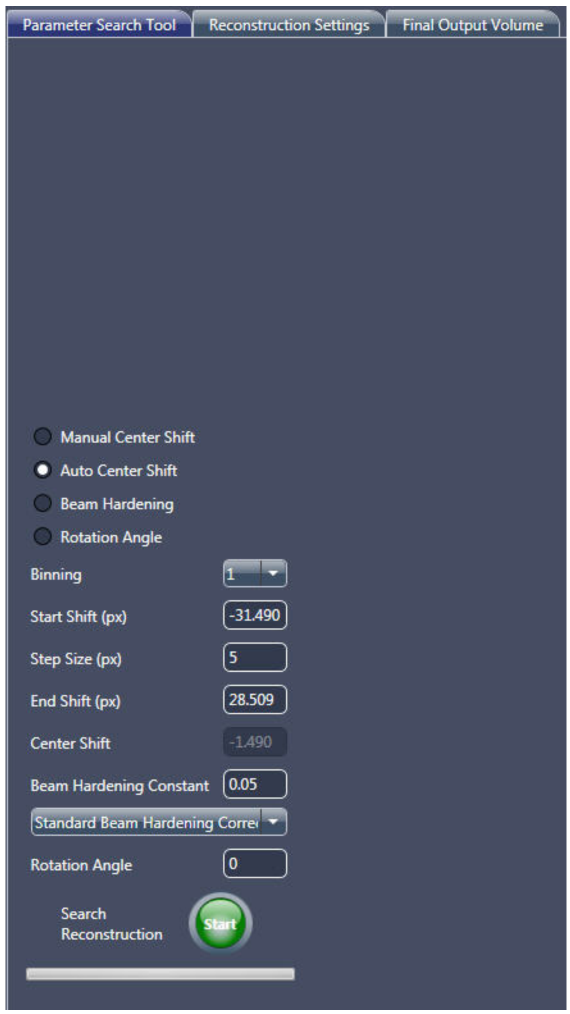
Auto Center Shift

This process describes how to automatically find center shift.

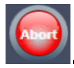
*To automatically find center shift for the open *.txrm file*

1. In the **Parameter Search Tool** tab within the main panel, select **Auto Center Shift**. (Refer to Figure 3-6.)

Figure 3-6 Typical Partial **Parameter Search Tool** Tab within Reconstructor Main Panel – **Auto Center Shift** Selected



2. Use the default **Start Shift (px)**, **Step Size (px)**, and **End Shift (px)** values that appear (defaults vary, depending on the sample's reconstruction parameter values). (Refer to Figure 3-6.)

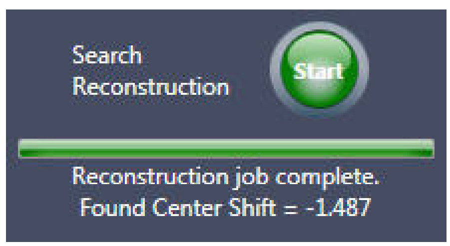
3. Click  (**Search Reconstruction**, lower main panel **Parameter Search Tool** tab) to begin the Center Shift Find process. The button changes to . After the image finishes center-shifting through the specified range, the:

   – Button changes to ,

   – Images in the **Reconstructed Slice** image display indicate the **Center Shift** value (refer to Figure 3-4; upper left image display), and

   – **Parameter Search Tool** tab displays the center shift value and **Reconstruction job complete** status (refer to Figure 3-7)

Figure 3-7 Auto Center Shift – Typical **Parameter Search Tool** Tab Found Center Shift Results



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

– If the **Center Shift** value determined in the **Reconstructed Slice** image display looks incorrect (image is unfocused and blurry; refer to Figure 3-4 and Figure 3-5, images to the left), proceed to "Manual Center Shift," to manually find center shift

– If the **Center Shift** value determined in the **Reconstructed Slice** image display looks correct (image is focused, crisp, and clear; refer to Figure 3-4 and Figure 3-5, images to the left), proceed to "Finding the Beam Hardening Constant"

Manual Center Shift

This process describes how to manually find the center shift when the **Center Shift** value determined by Auto Center Shift looks incorrect (image in the **Reconstructed Slice** image display is unfocused and blurry).

The process of manually finding center shift is a two-step process:

1. Coarse Focusing to Find an Approximately Focused Image.
2. Fine Focusing to Find the Best-Focused Image.

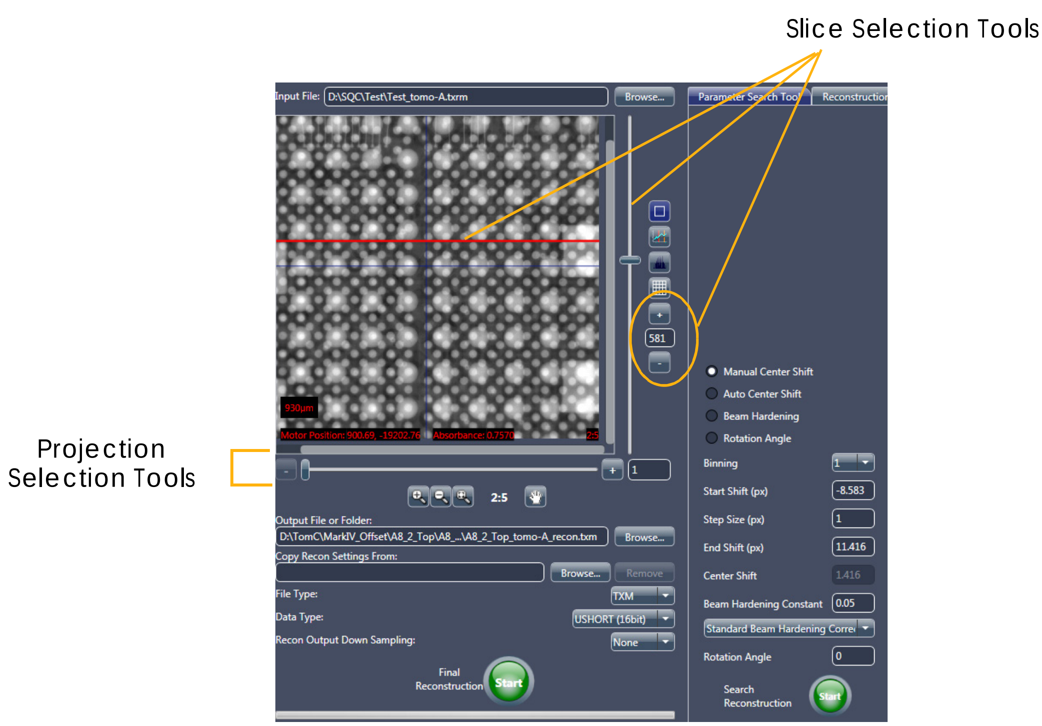
Both steps are described in the sections that follow.

Coarse Focusing to Find an Approximately Focused Image

To use coarse focusing to find an approximately focused image

1. **Optional** – In the side panel **Projection Dataset** image display, click and drag the **red** slice selection line to change the slice to cross a high-contrast feature, if present. (Refer to Figure 3-8.)

Figure 3-8 Slice Selection and Partial **Parameter Search Tool** Tab within Reconstructor Main Panel – **Manual Center Shift** Selected

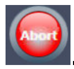


2. In the **Parameter Search Tool** tab within the main panel, select **Manual Center Shift**. (Refer to Figure 3-8.)

3. Use the default **Start Shift (px)**, **Step Size (px)**, and **End Shift (px)** values (-*10*, *1*, and +*10* pixels, respectively). (Refer to Figure 3-8.)

NOTE If prior sample knowledge is available, you can change to the known parameter values; otherwise, use the default values.

4. Click 

(**Search Reconstruction**, lower main panel **Parameter Search Tool** tab) to begin the Center Shift Find process. The button changes to 

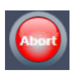
.

   The **Reconstructed Slice** image display within the **Parameter Search Tool** tab shows a series of 2D reconstructed slices with increasing center shift being created, as follows:

   – Starting from the shift specified in the **Start Shift (px)** text box,

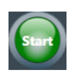
   – Increasing in intervals according to the value specified in the **Step Size (px)** text box, and

   – Ending in the shift specified in the **End Shift (px)** text box.

NOTE Click 

if you need to abort the Center Shift Find process before the process completes.

   After the image finishes center-shifting through the specified range, the:

   – Button changes back to 

,

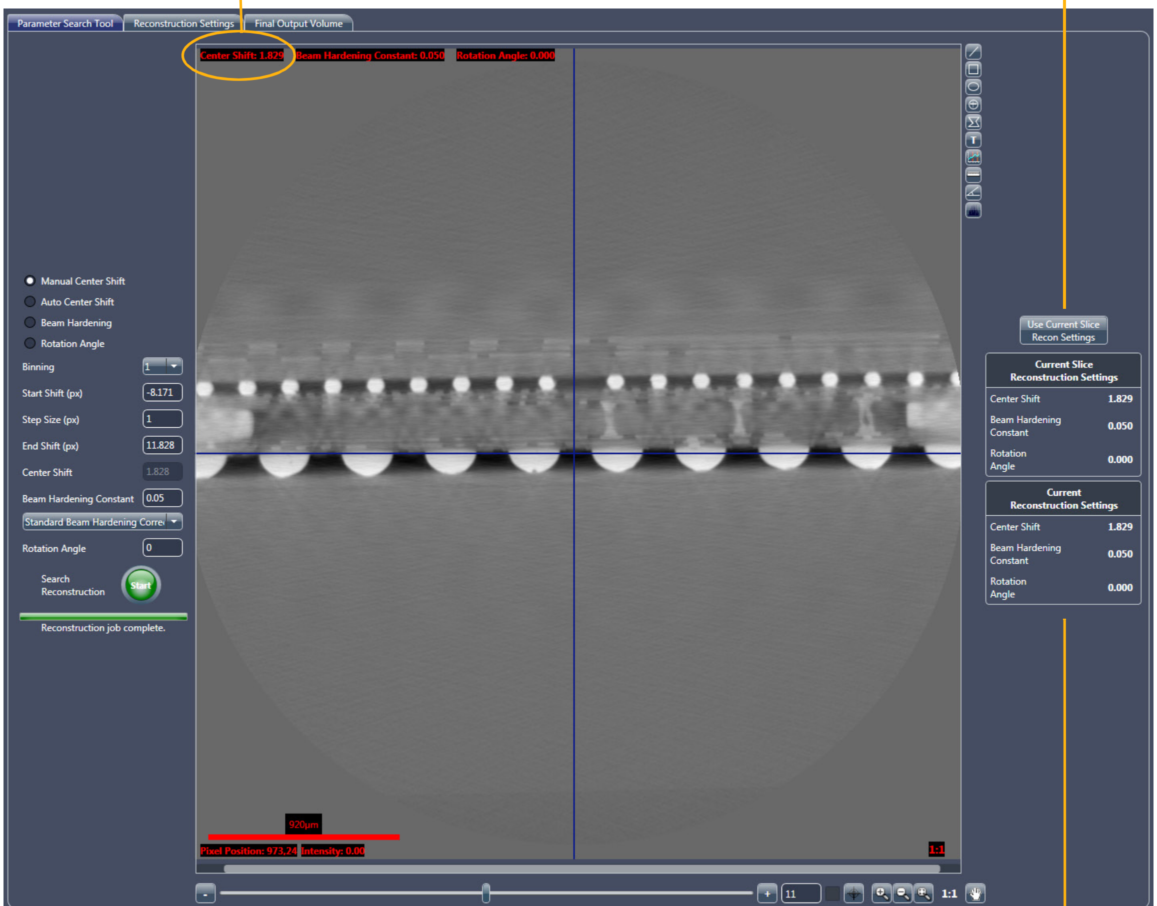
   – Images in the **Reconstructed Slice** image display indicate the **Center Shift** value (refer to Figure 3-9; upper left image display), and

   – **Parameter Search Tool** tab status changes to **Reconstruction job complete** (refer to Figure 3-9)

Figure 3-9 **Parameter Search Tool** Tab with 2D Reconstructed Slice in **Reconstructed Slice** Image Display

Center Shift Value

Current Slice Reconstruction Settings Parameter Values



Scroll Bar and Image Number Indicator
Use These Controls to Scroll through the Images in the **Reconstructed Slice** Image Display

Tomography's **Current Reconstruction Settings** Parameter Values

NOTE The scroll bar and Image number controls are the same as those used in the Scout-and-Scan Control System.

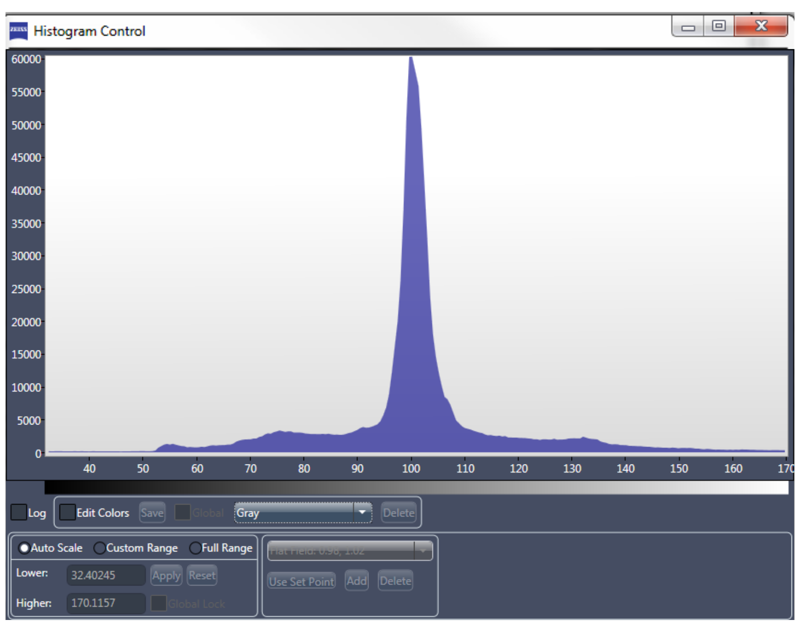
5. Scroll through the images in the **Reconstructed Slice** image display, using the slider in the scroll bar –or– the image number control (click the **–** or **+** symbols; lower main panel) to locate and identify the image with the crispest features (sharpest focus). (Refer to Figure 3-4 and Figure 3-5.) Typically, the features will go in and out of focus as you scroll through the images.

6. Note the **Center Shift** value (upper left **Reconstructed Slice** image display; refer to Figure 3-9) of the image with the sharpest focus. This value is the coarse center shift value.

NOTE If a correct **Center Shift** value is **not** found within the specified **Start** and **End Shift (px)** range, repeat steps 1 through 6, but change the **Start** and/or **End Shift (px)** value in step 3 to search over a different range. The step 3 settings can also be changed to look at finer or coarser shift intervals. Continue to change values until the image is at its sharpest.

7. In cases where there are areas on the image that are all **white** or **black**, use the Histogram Control tool (refer to Figure 3-10) to adjust image contrast and brightness, such that detailed features within the all **white/black** areas can be observed.

Figure 3-10 Histogram Control Tool



NOTE A complete description of how to use the Histogram control is provided in "Histogram Control Tool," on page 316 in Appendix G. Instructions specific to adjusting the image's contrast and brightness are provided in "Histogram Scaling," on page 321 in Appendix G.

Follow steps a through d below to adjust image contrast and brightness:

a. Click (right of **Reconstructed Slice** image display). The Histogram Control tool opens.

b. Select **Custom Range**.

c. Within the main chart, click a start range (minimum value), and then drag to an end range (maximum value) to adjust image contrast and brightness in the image that is shown in the **Reconstructed Slice** image display, as needed.

d. After you have sufficiently adjusted image contrast and brightness, click to close the tool.

NOTE Although **Auto Scale** can be selected to automatically estimate the best image contrast and brightness, the results might not provide desired results; therefore, use of **Custom Range** is recommended.

Fine Focusing to Find the Best-Focused Image

NOTE This process assumes that **Manual Center Shift** is still selected in the **Parameter Search Tool** tab.

To use fine focusing to find the best-focused image

1. In the **Start Shift (px)** and **End Shift (px)** text boxes, type input values that are within approximately ±2 to 3 pixels of the coarse center shift value determined in “Coarse Focusing to Find an Approximately Focused Image,” step 6, on page 86. For example, if the coarse center shift number determined was 0, the **Start Shift (px)** parameter could be 0 - 3 = -2 or -3, and the **End Shift (px)** parameter could be 0 + 3 = 2 or 3.

   For this example, type the following values for fine center shift determination.

Parameter	Setting
Start Shift (px)	*-3*
End Shift (px)	*3*

2. Type *0.2* in the **Step Size (px)** text box.

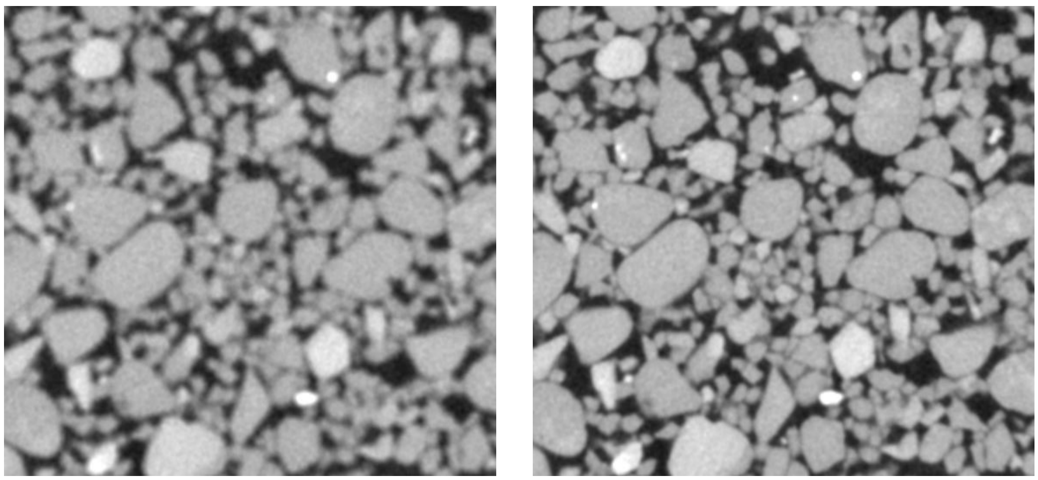
3. Click  (**Search Reconstruction**, lower main panel **Parameter Search Tool** tab) to begin the Center Shift Find process.

4. When the search is complete, scroll through the images in the **Reconstructed Slice** image display, using the slider in the scroll bar –or– the image number control (click the **–** or **+** symbols; lower main panel)

   to locate and identify the image with the best focus. Click  to zoom in on the slices to clearly see the features.

For example, the images in Figure 3-11 are zoomed in with a ratio of 2:1. The image to the left was reconstructed with a **Center Shift** value of 1. The image to the right was reconstructed with a **Center Shift** value of 2. Despite being reconstructed with a center shift difference of only one pixel, the difference in focus between the two images is significant. The image to the right should be selected as the one with the correct center shift.

Figure 3-11 Sample Image Scans Performed Using Projections that Range 360°



Incorrect Center Shift
Image is out-of-focus

Correct Center Shift
Image is in-focus

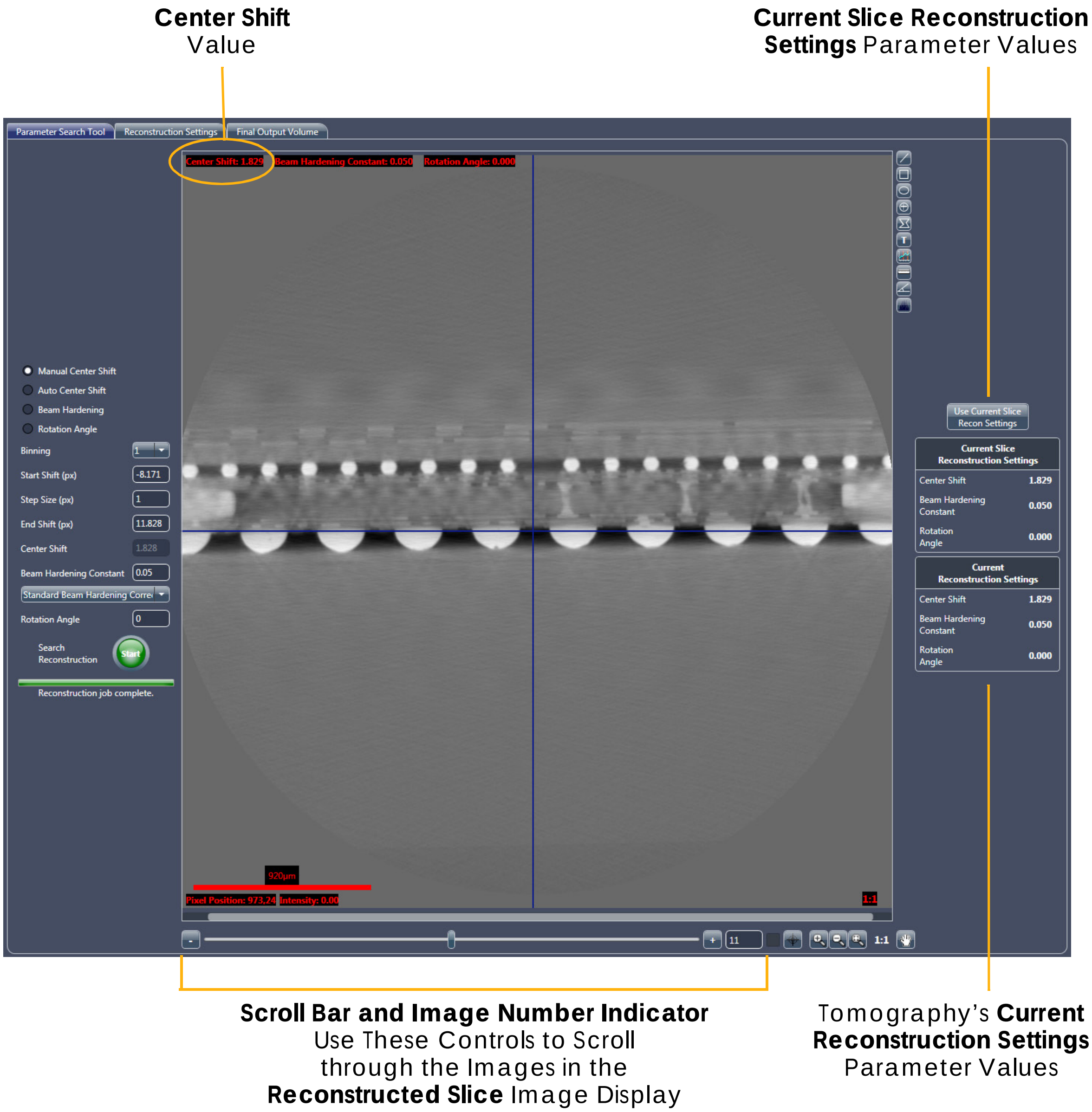
5. Note the **Center Shift** value (upper left **Reconstructed Slice** image display) of the image with the best focus. This value is the fine center shift number. (Refer to Figure 3-12.)

   The main panel displays the following:

   – **Current Slice Reconstruction Settings** – Parameter values used to reconstruct the current slice displayed in the **Reconstructed Slice** image display

   – **Current Reconstruction Settings** – Displays parameter values that will be used for the tomography data's final reconstruction

Figure 3-12 **Parameter Search Tool** Tab with 2D Reconstructed Slice in **Reconstructed Slice** Image Display



6. Click **Use Current Slice Recon Settings** (upper right tab) to update the **Current Reconstruction Settings** parameter values to match the **Current Slice Reconstruction Settings** parameter values.

   Proceed to "Finding the Beam Hardening Constant."

Finding the Beam Hardening Constant

This process describes how to find the beam hardening constant.

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 within the same material).

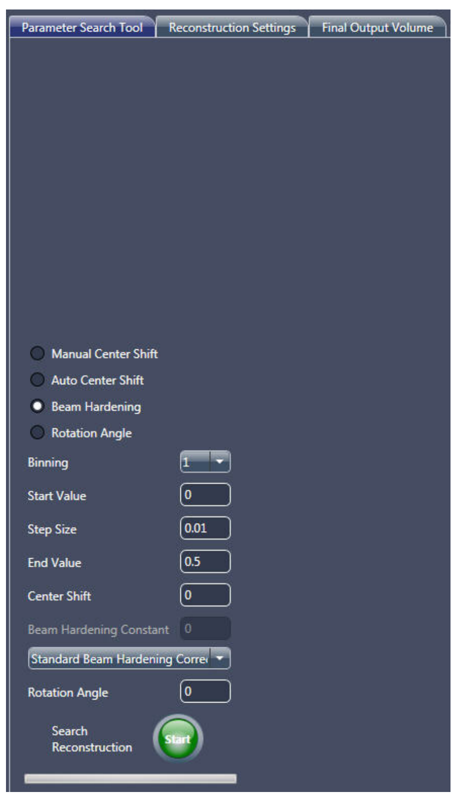
NOTE The typical beam hardening constant value is usually within the range of 0.01 to 0.2 if the correct X-ray source filter is used for Full field of view scans. For interior tomographies, the value can be *0*.

NOTE The Beam Hardening Correction Constant Find process should be performed on a focused image. It is assumed at this step that you have previously completed the Center Shift Find process for the given raw data and successfully found an in-focus image with correct center shift.

*To identify beam hardening correction in the open *.txrm file*

1. In the **Parameter Search Tool** tab within the main panel, select **Beam Hardening**. (Refer to Figure 3-13.)

Figure 3-13 Partial **Parameter Search Tool** Tab within Reconstructor Main Panel – **Beam Hardening** Selected

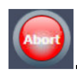


2. Use the following default beam hardening parameter values. (Refer to Figure 3-13.)

Parameter	Default Value
Binning	*1*
Start value	*0*
Step Size	*0.01*
End value	*0.5*
Center Shift	**Center Shift found automatically** – Center shift noted in "Auto Center Shift," step 3, on page 82
	Center Shift found manually – Center shift noted in "Fine Focusing to Find the Best-Focused Image," step 5, on page 89
File (label not shown)	*Standard Beam Hardening Correction*

NOTE If prior sample knowledge is available, you can change to the known parameter values; otherwise, use the default values.

3. Click 

(**Search Reconstruction**, lower main panel **Parameter Search Tool** tab) to begin the Beam Hardening Correction Constant Find process. The button changes to 

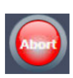
.

   The **Reconstructed Slice** image display within the **Parameter Search Tool** tab shows a series of 2D reconstructed slices with increasing beam hardening correction constants being created, as follows:

   – Starting from the setting specified in the **Start Value** text box,

   – Increasing in intervals according to the value specified in the **Step Size** text box, and

   – Ending in the setting specified in the **End Value** text box.

NOTE Click 

if you need to abort the Beam Hardening Correction Constant Find process before the process completes.

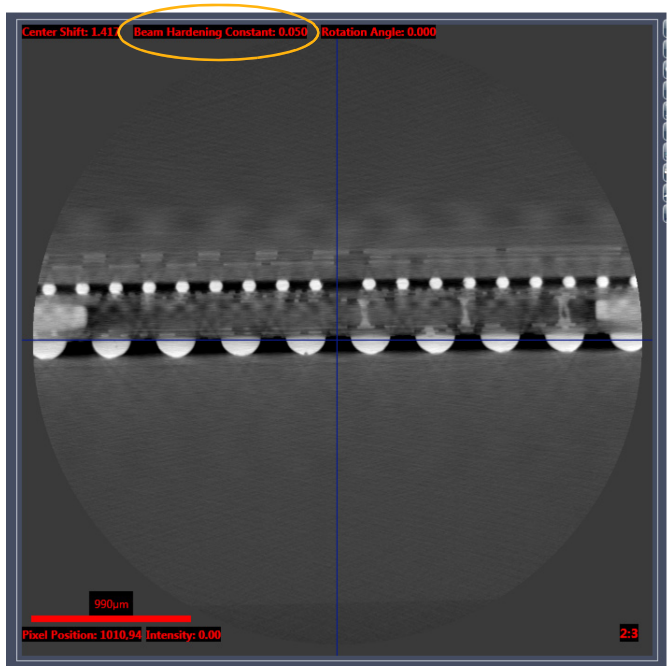
After the image finishes correcting for beam hardening through the specified range, the:

– Button changes back to ,

– Images in the **Reconstructed Slice** image display indicate the **Beam Hardening Constant** value (refer to Figure 3-14; upper center image display), and

– **Parameter Search Tool** tab status changes to **Reconstruction job complete**

Figure 3-14 **Beam Hardening Constant** Value in **Reconstructed Slice** Image Display



4. If necessary, use the Histogram Control tool, , to adjust image contrast and brightness, as described in “Coarse Focusing to Find an Approximately Focused Image,” step 7, on page 86.

NOTE A complete description of how to use the Histogram Control tool is provided in “Histogram Control Tool,” on page 316 in Appendix G. Instructions specific to adjusting the image’s contrast and brightness are provided in “Histogram Scaling,” on page 321 in Appendix G.

5. Click  (right of **Reconstructed Slice** image display) to enable the Line Graph annotation tool.

6. Within the **Reconstructed Slice** image display, draw a **yellow** line across the 2D reconstructed slices by using the mouse pointer to click the line's start point, and then drag to the line's endpoint. The line should span materials of similar density. (Refer to Figure 3-15, horizontal **yellow** line across center of image display.) The **Line Graph Window** opens. (Refer to Figure 3-16.)

Figure 3-15 Typical **Reconstructed Slice** Image Display with **Yellow** Annotation Line

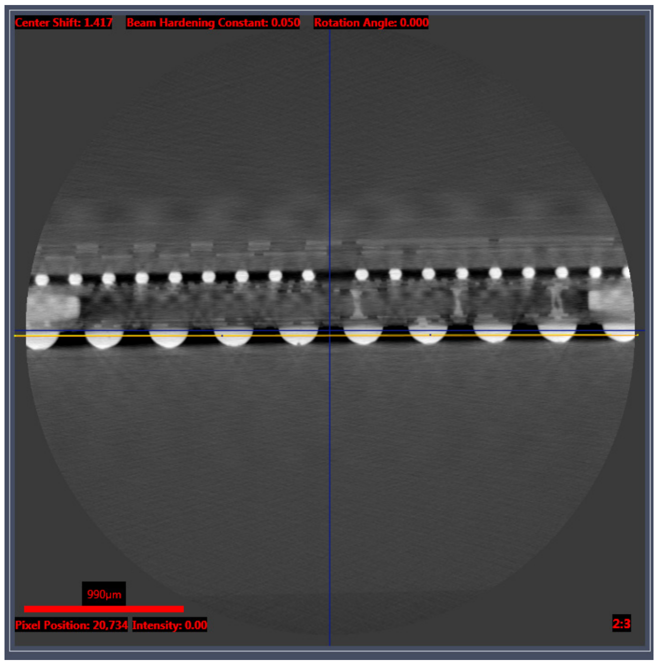
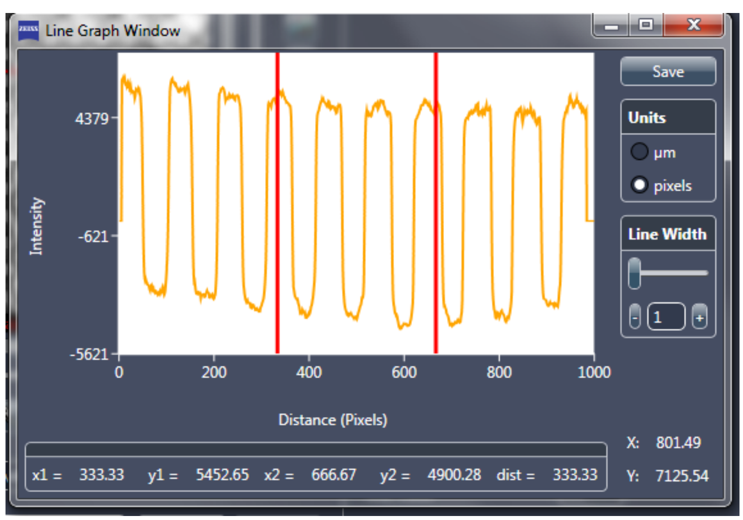


Figure 3-16 Typical **Line Graph Window**, Indicating Plot of Line Profile across Image



7. To widen the graph line width and reduce noise on the plot (by averaging more lines, and thereby smoothing out the graph), drag the slider in the **Line Width** scroll bar –or– click the **Line Width –** or **+** symbols to indicate a value between 10 and 100 pixels (maximum). (Refer to Figure 3-16.)

8. In the **Reconstructed Slice** image display, use the slider in the scroll bar –or– the image number control (click the **–** or **+** symbols; lower main panel) to scroll through the 2D reconstructed slices. As you scroll, watch the graph in the **Line Graph Window**. The slice with the optimum **Beam Hardening Constant** value in the **Reconstructed Slice** image display will have the flattest graph (BH = *0.08* in the Figure 3-17 example) in the **Line Graph Window**.

NOTE Optimum beam hardening is indicated when the line profile drawn across the images is as flat as possible, with little to no curvature. Of the three images shown in Figure 3-17, the center image has the flattest line profile.

Figure 3-17 Understanding the **Beam Hardening Constant** Value

9. If necessary, return to the image selected with the optimum **Beam Hardening Constant** value in step 8. Click **Use Current Slice Recon Settings** (upper right tab) to update the **Current Reconstruction Settings** parameter values to match the **Current Slice Reconstruction Settings** parameter values.

10. Click ☒ to close the **Line Graph Window**.

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

    – If a specific slice orientation within the axial plane is needed, proceed to "Changing the Rotation Angle."

    – If a specific slice orientation within the axial plane is **not** needed and you are ready to reconstruct the dataset, proceed to "Reconstructing the Tomography Data."

Changing the Rotation Angle

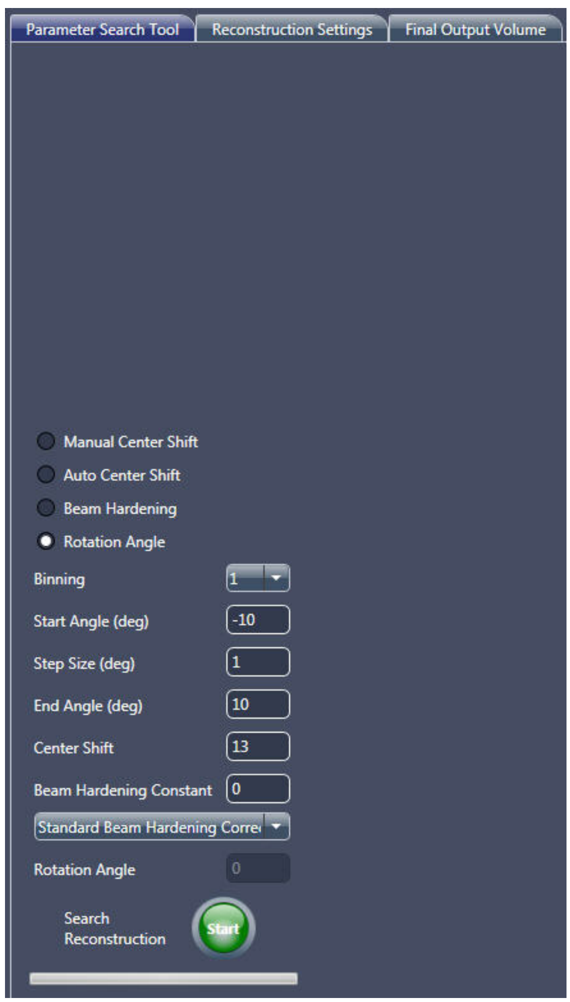
This optional process describes how to change the rotation of the axial slices (looking at the sample from the top and then down) within the tomography data.

NOTE Sample rotation is useful when a specific slice orientation within the axial plane is needed. This is especially useful when dealing with flat samples to increase slice orthogonality.

To change slice rotations within the axial orientation

1. In the **Parameter Search Tool** tab within the main panel, select **Rotation Angle**. (Refer to Figure 3-18.)

Figure 3-18 Partial **Parameter Search Tool** Tab within Reconstructor Main Panel – **Rotation Angle** Selected

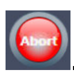


2. Use the following default rotation angle parameter values. (Refer to Figure 3-18.)

Parameter	Default Value
Binning	*1*
Start Angle (deg)	*-10*
Step Size (deg)	*1*
End Angle (deg)	*10*
Center Shift	**Center Shift found automatically** – Center shift noted in "Auto Center Shift," step 3, on page 82
	Center Shift found manually – Center shift noted in "Fine Focusing to Find the Best-Focused Image," step 5, on page 89
Beam Hardening Constant	Beam hardening constant noted in "Finding the Beam Hardening Constant," step 8, on page 95 **NOTE** Value is limited to a single digit. For example, if the beam hardening constant is 0.08, the value to be entered here is *0*.
File (label not shown)	*Standard Beam Hardening Correction*

NOTE If prior sample knowledge is available, you can change to the known parameter values; otherwise, use the default values.

3. Click 

(**Search Reconstruction**, lower main panel **Parameter Search Tool** tab) to begin the Rotation Angle Find process. The button changes to 

.

   The **Reconstructed Slice** image display within the **Parameter Search Tool** tab shows a series of 2D reconstructed slices with different rotation angles being applied, as follows:

   – Starting from the setting specified in the **Start Angle (deg)** text box,

   – Increasing in intervals according to the value specified in the **Step Size (deg)** text box, and

   – Ending in the setting specified in the **End Angle (deg)** text box.

NOTE Click 

if you need to abort the Rotation Angle Find process before the process completes.

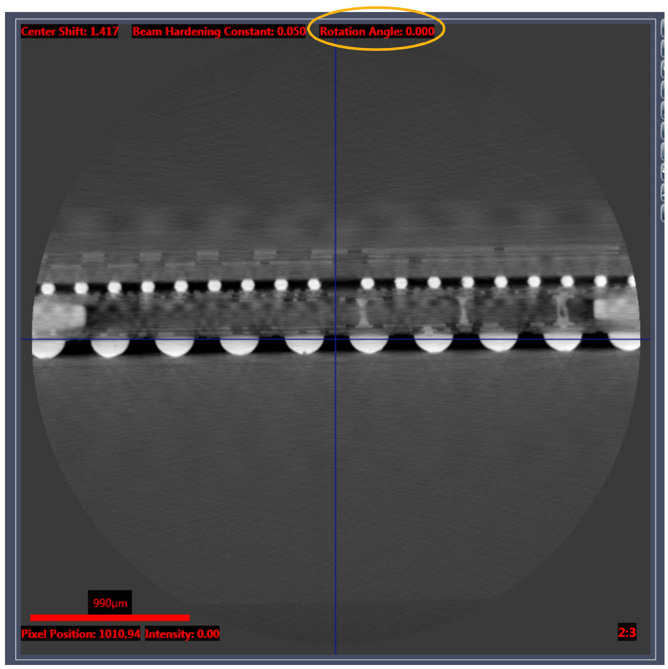
After the image finishes rotating through the specified range, the:

- Button changes back to ,

- Images in the **Reconstructed Slice** image display indicate the **Rotation Angle** value (refer to Figure 3-19; upper right image display), and

- **Parameter Search Tool** tab status changes to **Reconstruction job complete**

Figure 3-19 **Rotation Angle** Value in **Reconstructed Slice** Image Display



4. In the **Reconstructed Slice** image display, use the slider in the scroll bar –or– the image number control (click the **–** or **+** symbols; lower main panel) to scroll through the 2D reconstructed slices. Select the image with the desired orientation. (Refer to Figure 3-20.) For flat samples, select the rotation such that the plane of the sample orthogonality is increased. (Refer to Figure 3-21.)

Figure 3-20 Rotation to Achieve Desired Orientation

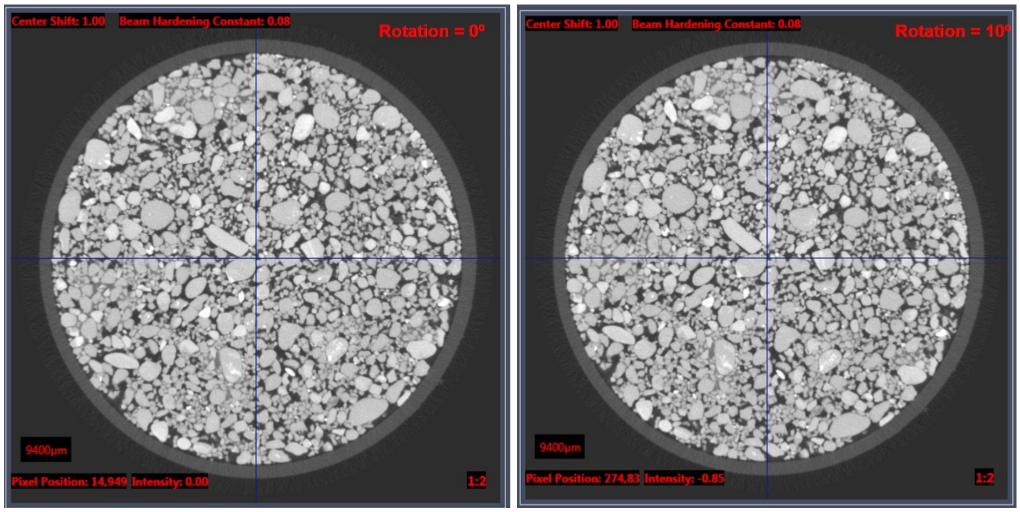
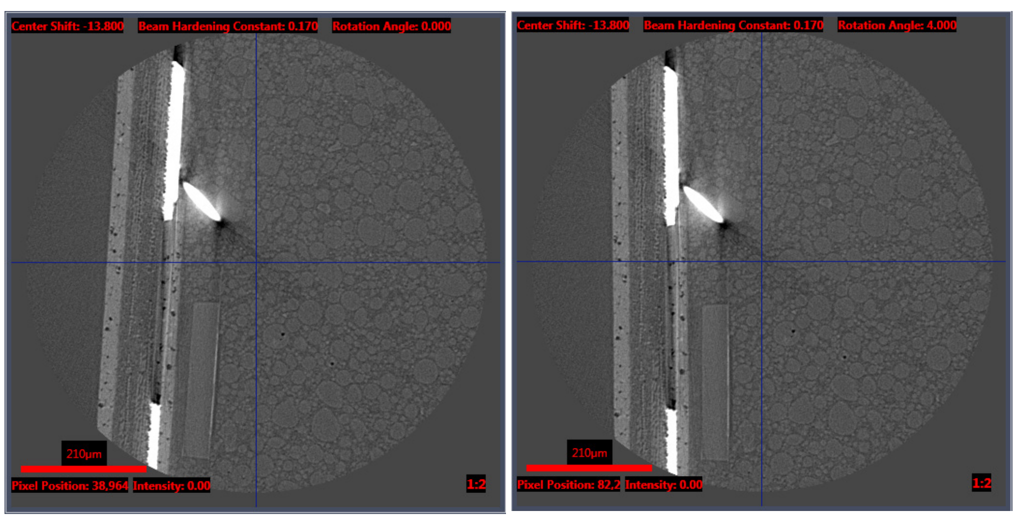


Figure 3-21 Rotation to Make Axial Plane Flat to Axis



5. **Optional** – Repeat step 2 with different settings to look at smaller and/or larger rotation angle ranges with finer and/or coarser rotation angles.

NOTE The **Angle** tool can be used to calculate the required sample rotation. To use the tool, click . Within the **Reconstructed Slice** image display, click where you want the angle vertex to appear, and then click two points to create the angle.

6. If necessary, return to the image selected in step 4 or 5. Click **Use Current Slice Recon Settings** (upper right tab) to update the **Current Reconstruction Settings** parameter values to match the **Current Slice Reconstruction Settings** parameter values.

   Proceed to "Reconstructing the Tomography Data."

Reconstructing the Tomography Data

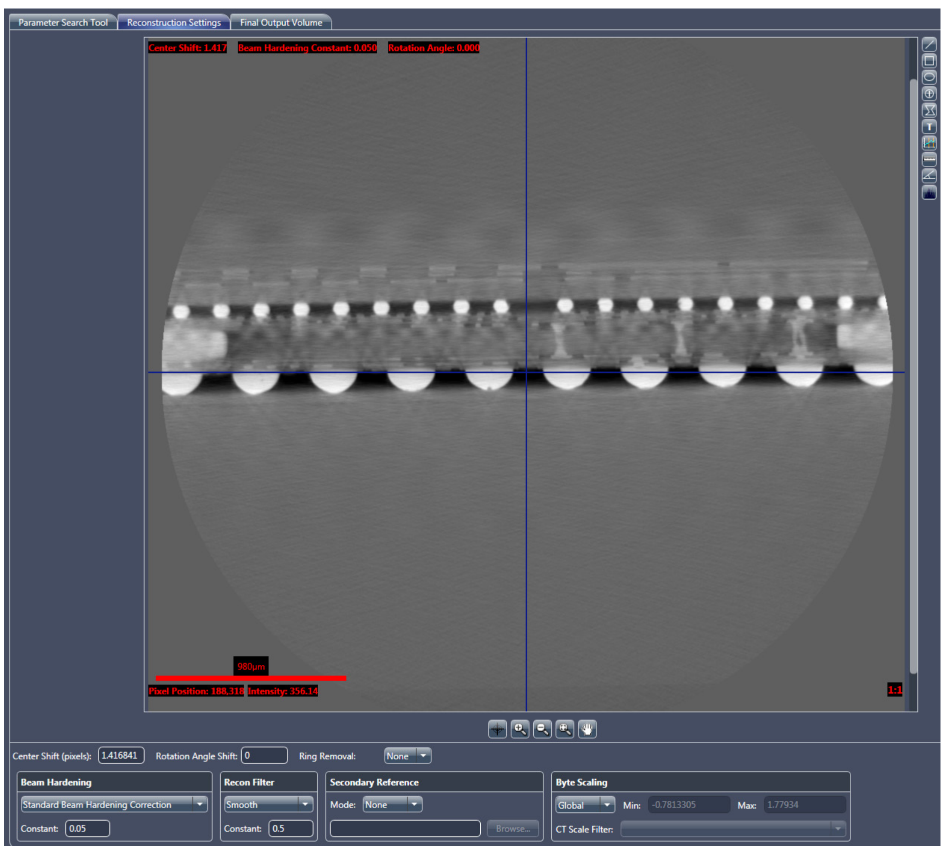
This process describes how to reconstruct the tomography data after finding the center shift, beam hardening constant, and rotation angle.

To reconstruct the open *.txrm file

1. Within the main panel, select the **Reconstruction Settings** tab. (Refer to Figure 3-22.)

   If you have previously clicked **Use Current Slice Recon Settings** in the **Parameter Search Tool** tab –or– manually input parameter values during the Center Shift Find, Beam Hardening Correction Constant Find, or Angle Rotation processes, those parameter values are prepopulated in this tab.

Figure 3-22 **Reconstruction Settings** Tab within Reconstructor Main Panel



2. Select one of the following parameter values from the **Ring Removal** drop-down list box.

Value	Usage
None	Use when Dynamic Ring Removal (DRR) is enabled. No rings will be removed.
Low contrast	When DRR is disabled, apply 8-section ring removal for bone, rock, plastic, carbon composite, or composite material samples.
High contrast	When DRR is disabled, apply 3-section ring removal for high-contrast samples, such as semiconductors, or if the other two parameter values do not apply.

NOTE Select *None* for all but rare cases in which DRR is off during tomography acquisition. Neither of the ring removal corrections is necessary for most scans.

NOTE DRR is automatically enabled, by default, in the Scout-and-Scan Control System's **Scan** view **Advanced Acquisition** tab. For further details, refer to "Advanced Acquisition Tab," on page 215 in Appendix D.

NOTE The *High contrast* ring removal option sometimes add rings when regularly repeating high-contrast features are present in the sample.

3. Select a software filter from the **Recon Filter** drop-down list box.

NOTE *Smooth* (Kernel Size = *0.5*) is recommended for **Binning** = *2* acquisitions. *Smooth* (Kernel Size = *0.7*) is recommended for **Binning** = *1* acquisitions.

NOTE The **Recon Filter** value is objective- and sample-dependent. Determine which software filter provides the most satisfactory balance between image resolution and noise (through your own experience). Using the correct software filter provides for significant noise reduction, but has a minimal impact on resolution.

NOTE **Do not use the Sharp (Shepp-Logan) recon filter option.**

4. If a secondary reference was previously collected, select the secondary reference, as indicated below:

   – Select *Embedded* from the **Mode** drop-down list box in the **Secondary Reference** panel if the secondary reference was collected and embedded in the dataset as part of the sample setup or sample run process

   – Select *Use File* from the **Mode** drop-down list box in the **Secondary Reference** panel, and then click **Browse** to browse to and select the secondary reference collected after scan completion

NOTE The process of collecting a secondary reference is described in "Using a Filtered Secondary Reference for Ring Artifact Reduction," on page 276 in Appendix G. If you selected *Use File*, browse to and select the **.xrm* file saved in "Collecting a Secondary Reference," step 2, on page 284 in Appendix G.

5. Leave *Global* (default) as selected from the **Byte Scaling** drop-down list box, unless this is a special case. Special cases include the following:

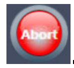
   – Select *Custom* from the **Byte Scaling** drop-down list box **only** if the global minimum and maximum byte scaling values are known from a prior similar sample, such as when manually reconstructing datasets acquired for vertical stitching (scan acquired at the same settings (objective, binning, exposure time, X-ray source power, detector and X-ray source distances, and number of projections)). Type the minimum and maximum byte scaling values in their respective text boxes.

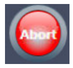
   – Dataset is to be CT-scaled and CT scaling calibration is complete. Select *Apply CT Scale* from the **Byte Scaling** drop-down list box, and then select the correct software filter from the **CT Scale Filter** drop-down list box.

NOTE Refer to "Vertical Stitching," on page 287 in Appendix G for details related to manually reconstructing vertically stitched datasets.

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

6. Click  (**Final Reconstruction**, lower side panel) to begin the Final Reconstruction process and reconstruct the tomography data.

   The button changes to .

NOTE Click  if you need to abort the Final Reconstruction process before the process completes.

   The progress bar in the side panel's progress bar indicates reconstruction progress. After the reconstruction process is complete, the:

   – Button changes back to , and

   – Side panel reconstruction progress bar is solid **green** (refer to Figure 3-23), and

   – Side panel indicates **Reconstruction job complete** status (refer to Figure 3-23)

Figure 3-23 Final Reconstruction Job Is Complete

   The tomography is now reconstructed and ready for viewing under the **Final Output Volume** tab. The resulting file is a *.*txm* file.

NOTE The **Final Output Volume** tab is described in "Final Output Volume Tab," on page 236 in Appendix D.

   Proceed to Chapter 4, "Viewing and Editing Tomographies."

4 Viewing and Editing Tomographies

This chapter describes how to use XM3DViewer to view and edit 2D reconstructed slices and 3D reconstructed volume datasets, for use in reports and movies. This is typically done after acquiring and automatically or manually reconstructing the tomography dataset, as described in Chapter 2, “Acquiring Tomographies with the Scout-and-Scan Control System,” and Chapter 3, “Manually Reconstructing a Tomography Dataset.”

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 “XM3DViewer User Interface,” on page 237 in Appendix D, as well as the *Xradia ExamineRT Workstation 1.1 User’s Manual*, available under XM3DViewer’s **Help** menu.

Process Overview

The process of viewing tomographies is composed of the following subprocesses:

1. Starting XM3DViewer.

2. Using XM3DViewer:

   – Adjusting and Navigating 2D Reconstructed 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 Reconstructed Volumes

   – Correcting Problems with the Reconstructed File

NOTE Unlike earlier chapters of this guide, most processes described within this chapter can be performed out of sequence unless indicated otherwise.

Starting XM3DViewer

This process describes how to start XM3DViewer and open a reconstructed file for viewing.

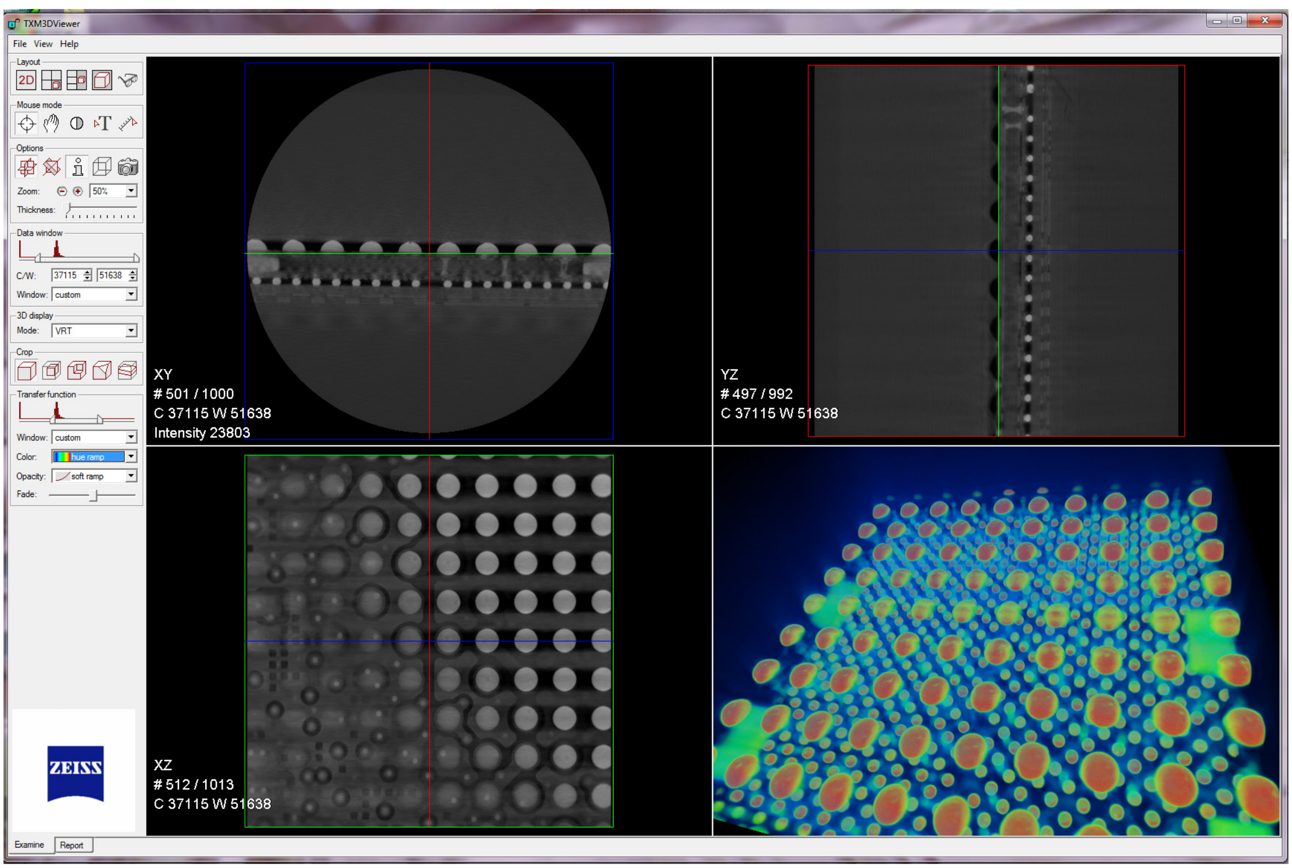
To start XM3DViewer

1. On the Windows taskbar **Start** menu, select **All Programs**, **Carl Zeiss X-ray Microscopy**, **Xradia Versa 11.*x***, and then **XM3DViewer 1.*x***. The **XM3DViewer** main window opens. (Refer to Figure 4-1.)

NOTE “x” is the program’s current version number.

NOTE In its main window title bar, XM3DViewer appears as “**TXM3DViewer**”, rather than as “**XM3DViewer**”. Additionally, the main window bars and tools change, depending on which **Layout** icon is selected.

Figure 4-1 Typical **XM3DViewer** Main Window – **Examine** Tab



2. On the **File** menu, click **Open**. An **Open File** dialog box opens.

3. Browse to the destination file path, and then locate the reconstructed file that you want to open (*_Recon* is appended to the original **.txm* file name).

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, and then browse to and select the correct drive and destination file path.

4. Select the file name, and then click **Load** to open the file. A status window opens, displays the file upload status, and then closes when the upload is complete.

NOTE If the file is very large, a dialog box opens providing you with the following options (refer to the first dialog box in Figure 4-2):

- **Out-of-core mode** – Must be used when the workstation's RAM is less than approximately 4X the dataset file size.

  A large file to be used for displaying the 3D data will be written to the hard disk drive.

  During Out-of-core mode, XM3DViewer creates two files – **.txm-exm* and **.txm-exm-ooc*. These files are accessed during viewing of reconstructed results in XM3DViewer. These files can be quite large (on the order of a few gigabytes), and should be deleted after generating reports and creating movies.

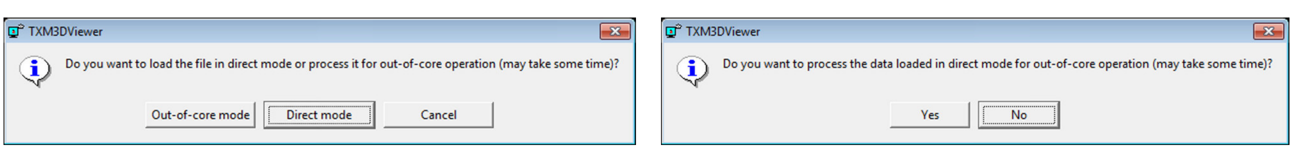
- **Direct mode** (recommended) – Used on newer workstations and can be used when the file size is much less than the dataset file size.

  The file will be loaded into Xradia Versa memory and not require hard disk drive space.

It is strongly recommended to use Direct mode, which keeps the hard disk drive free of unnecessary large files.

When the dialog box opens, click **Direct mode**. A second dialog box opens, providing you with a final opportunity to load the file in Out-of core mode. Click **No** to proceed with Direct mode loading. (Refer to the second dialog box in Figure 4-2.)

Figure 4-2 Out-of-core Mode/Direct Mode-Related Dialog Boxes



Adjusting and Navigating 2D Reconstructed Slices

After the processing is complete, images appear in each of the four views within the default **XM3DViewer** main window. (Refer to Figure 4-1 on page 107.)

The processes described in this section provide general guidelines for gaining familiarity with XM3DViewer:

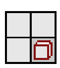
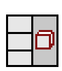
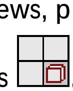
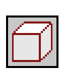
- Adjusting Contrast and Brightness in the 2D Reconstructed Slice Views
- Navigating the XM3DViewer Main Window

NOTE If it is obvious that something is not right, proceed directly to "Correcting Problems with the Reconstructed File."

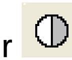
NOTE The guidelines provided in this section relate to the default layout of the main window – three equally sized 2D reconstructed slice views and one 3D volume view. (Refer to Figure 4-1 on page 107.) The layouts are described in Table 4-1. All **four** layouts are located in the **Layout** icon toolbar.

NOTE The main window bars and tools change, depending on which **Layout** icon is selected.

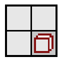
Table 4-1 **XM3DViewer** Main Window Layout Options

Icon	Description
	Click to display three equally sized 2D reconstructed slice views and one 3D volume view. This is the default window layout.
	Click to display a single 2D reconstructed slice view. Click multiple times to cycle through the orientation of the slice in the 2D reconstructed slice view. When clicked, adds **Cine controls** to the main window (left side, below the other icon toolbars and tools).
	Click to display three equally sized 2D reconstructed slice views, plus one larger 3D volume view. Displays the same four images as .
	Click to display a single 3D volume view (not used for 2D reconstructed slices).

Adjusting Contrast and Brightness in the 2D Reconstructed Slice Views

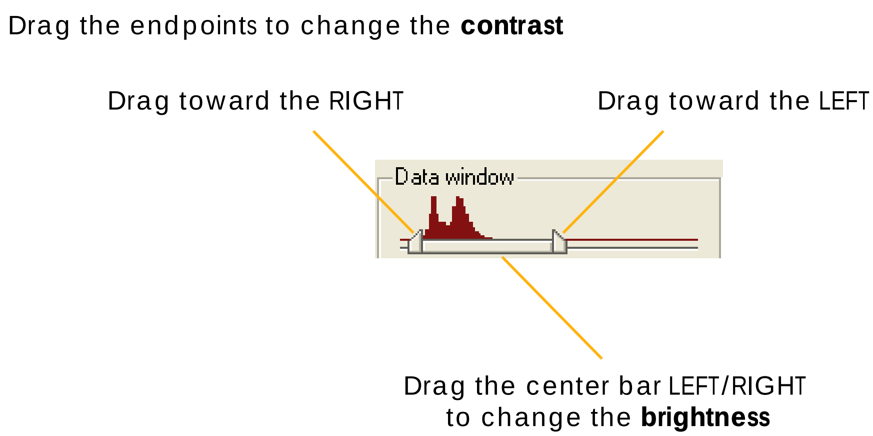
This process describes how to use the **Data window** slider or  **Mouse mode** icon to adjust 2D reconstructed slice view contrast and brightness.

To adjust 2D reconstructed slice view contrast and brightness

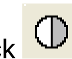
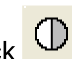
1. Click  in the **Layout** icon toolbar.
2. On the **View** menu, click **2D bilinear filter** to turn ON the 2D bilinear filter. This provides for less pixelated views.
3. Use the **Data window** slider to adjust the contrast and brightness of the 2D reconstructed slices (upper and lower left and upper right views), using the following processes.

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, respectively, 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 4-3 Using the **Data window** Slider



Changes in contrast and brightness can also be achieved within any of the three 2D reconstructed slice views, using the following processes.

Adjustment Needed	Process
Contrast	Click  in the **Mouse mode** icon toolbar, and then use the mouse pointer to click and drag UP or DOWN within any of the 2D reconstructed slice views to change the contrast (window width).
Brightness	Click  in the **Mouse mode** icon toolbar, and then use the mouse pointer to click and drag LEFT or RIGHT within any of the 2D reconstructed slice views to change the brightness (window center).

NOTE In the **Data window** Tools, leave *custom* selected from the **Window** drop-down list box to avoid potential problems. For example, if you select *CT Default* from the **Window** drop-down list box, all 2D reconstructed slices 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 2D reconstructed slice's contrast and brightness, and change the **Window** drop-down list box 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

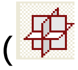
1. Use the navigation crosshairs (colored lines) in the 2D reconstructed slice views to change position in all the 2D reconstructed slice views. (Refer to Figure 4-1 on page 107.)

   For example, move the **green** line in the upper left view to locate the region of interest (ROI) in the bottom left view (**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 ROI lies.

NOTE **Green** = X/Z, **blue** = X/Y, and **red** = Y/Z.

2. Use the **Zoom** and **Pan** controls,  and , to make the complete slice visible within the 2D reconstructed slice views.

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 toolbar. With the center-mouse button pressed, use the mouse pointer to click and drag UP and DOWN to zoom IN and OUT, respectively, within any 2D reconstructed slice view. You can also click and hold the left-mouse button, and then drag LEFT and RIGHT to pan.

3. Orthogonal Slicing mode ( in the **Options** icon toolbar) orthogonally positions the crosshairs – this is the default slicing mode.

   If the region of interest is not on the orthogonal plane, click  in the **Options** icon toolbar to use Oblique Slicing mode. This places the region of interest on one plane, allowing you to rotate the **green**, **blue**, or **red** crosshairs to line the planes up with the region of interest. Use the left-mouse button to click the vertical or horizontal line, and then drag to rotate the plane.

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 view (lower right view). 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 virtual slice with larger “pixel” thickness.

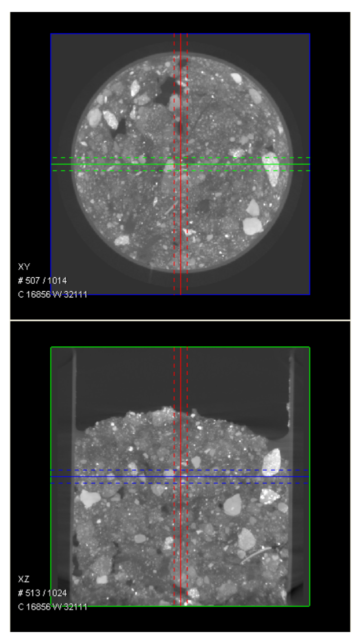
   The slice’s thickness is indicated by dashed lines in the 2D reconstructed slice views. Use the mouse pointer to click and drag the **Thickness** slider to the LEFT to reduce the pixel thickness.

Figure 4-4 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 contrast and/or brightness, follow the processes described in “Adjusting Contrast and Brightness in the 2D Reconstructed Slice Views,” step 3, on page 110.

   When the 2D reconstructed slices look as they should, proceed to the next process:

   – If you have already located the region(s) of interest, proceed to “Collecting Images (or Pictures) for a Report”

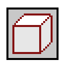
   – If you want to work with 3D rendering, proceed to “Creating 3D Volume Renderings”

Creating 3D Volume Renderings

This process describes how to create a 3D volume rendering that can be used in reports or movies. In the default view, after a reconstructed **.txm* file is loaded, images appear in each of the four views within the **XM3DViewer** main window. In this view, the 3D volume view is the lower right view of the main window. (Refer to Figure 4-1.)

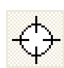
NOTE Resolution on the 3D volume rendering is reduced, compared to the 2D reconstructed slices, because the rendering is loaded into memory that is insufficiently sized to contain the full resolution in 3D.

To create a 3D volume rendering

1. Click  in the **Layout** icon toolbar to open the single 3D volume view.

2. The **3D display** mode should be defaulted to VRT (volume rendering technique). If another mode is selected, 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.

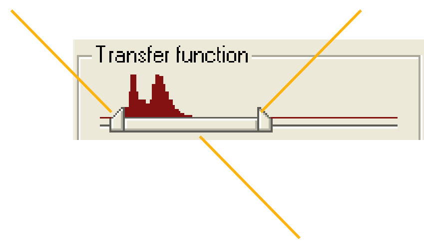
3. Click  or  in the **Mouse mode** icon toolbar to enable and use the following mouse functions.

Mouse Function	Process
Rotate the image	With the left-mouse button pressed, use the mouse pointer to click and drag within the 3D volume view.
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 view.
Pan	With the center-mouse button pressed, use the mouse pointer to click and drag within the 3D volume view.

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	With the left-mouse button pressed, use the mouse pointer to click and drag the endpoints of the bar to the LEFT or RIGHT to change the contrast.
Brightness	With the center-mouse button pressed, 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 4-5 Using the **Transfer function** Slider



Changes in contrast and brightness can also be achieved in the 3D volume view, using the following processes.

Adjustment Needed	Process
Contrast	Click  in the **Mouse mode** icon toolbar, and then use the mouse pointer to click and drag UP or DOWN within the 3D volume view to change the **contrast** (window width).
Brightness	Click  in the **Mouse mode** icon toolbar, and then use the mouse pointer to click and drag LEFT or RIGHT within the 3D volume view 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 *custom* selected from the **Window** drop-down list box to avoid potential problems. For example, if you select *CT Default* from the **Window** drop-down list box, 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 3D volume's contrast and brightness, and change the **Window** drop-down list box 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.

NOTE Using the **Fade** slider can cause low-contrast features to disappear; use care to not inadvertently hide details in the dataset; otherwise, avoid adjusting the fade level.

NOTE A recommended approach to using the **Fade** slider is to start with a hard fade (all the way to the left), and then bring up the left **Transfer function** threshold until the noise disappears. Just after the outside air noise vanishes, bring up the right **Transfer function** slider until the material is sufficiently bright, making the surface features visible. Fade can now be slid slightly to the right to reveal internal structure. Cropping (refer to step 8) can also be used in conjunction with fade control to provide best viewing of internal structures.

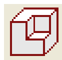
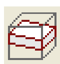
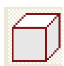
6. Alternate using the mouse pointer to click and drag the **Transfer function** (contrast and brightness) and **Fade** sliders to obtain a desirable 3D rendering.

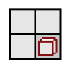
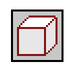
7. Select a different opacity and color from the **Opacity** and **Color** drop-down list boxes, respectively, and then repeat step 6 to obtain the optimum effect with the newly selected opacity and color.

NOTE **Opacity** typically affects only **Fade** slider behavior. Two of the available false **Color** palettes are **Organic** and **Hue ramp**. **Organic** provides good viewing results for many samples. **Hue ramp** is useful for highlighting density differences within the sample.

NOTE Use colors other than **black** and **white** to better view dark features against the black background.

8. Isolate the region of interest within the 3D reconstructed volume by clicking  in the **Crop** icon toolbar 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 cropped area within the 3D reconstructed volume.
	Click to enable creating a parallel cropped slice within the 3D reconstructed volume.
	No crop (default). Click to omit any previously applied cropping.

NOTE To adjust the crop volume, click  in the **Layout** icon toolbar, and then click and drag the **orange** lines to obtain the effect that you want. If you want to return to the single 3D volume view, click  in the **Layout** icon toolbar.

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 that you will collect depends on what is needed to be known/reported.

If you are not the sample's owner, ask the owner to identify what information is needed for the report. For example, if the purpose of imaging is to identify a crack within a particular area of the sample, the images that you collect for the report should highlight the crack's presence and location.

The collection process differs, depending on whether you are processing cross-sectional 2D reconstructed slices and/or 3D reconstructed volumes:

– Visualize, Measure, and Capture Internal Structure on 2D Reconstructed Slices

– Visualize, Measure, and Capture Internal Structure on 3D Reconstructed Volumes

Visualize, Measure, and Capture Internal Structure on 2D Reconstructed Slices

This process describes how to create images from 2D reconstructed slices to indicate the region of interest within a sample for use in a report.

To visualize, measure, and capture the internal structure on 2D reconstructed slices

1. Click 

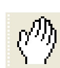
in the **Layout** icon toolbar to display the single 2D reconstructed slice view.

2. Click 

again, once per plane, to scroll through the **green**, **blue**, and **red** 2D planes to see different views of each slice.

3. Use the **Zoom** and **Pan** controls, 

and , to zoom and pan within the 2D reconstructed slice views.

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 toolbar. With the center-mouse button pressed, use the mouse pointer to click and drag UP and DOWN to zoom IN and OUT, respectively, within any 2D reconstructed slice view. You can also click and hold the left-mouse button, and then drag LEFT and RIGHT to pan.

4. On the **View** menu, click **Scale bar**. This inserts a scale at the bottom of the view, which provides a reference for the size of the region shown.

5. Use the keyboard's **UP** and **DOWN** arrow keys to scroll through the different slices and identify a 2D reconstructed slice of interest.

6. If you want to add a measurement line, click  in the **Mouse mode** icon toolbar to enable Measurement mode. In the 2D reconstructed slice view, at the slice's region of interest, click once to define the start point for measuring, and then again to define the endpoint for measuring.

NOTE To remove an erroneous measurement line, click the line to select it (line color changes from **blue** to **yellow**), and then press the **Delete** key on the ergonomic station's keyboard.

If Measurement mode is not the active mode, click  to enable it, and then proceed with the removal process described above.

7. If you want to apply arrow and text annotations, click  in the **Mouse mode** icon toolbar to enable Annotation mode, and then apply the annotations.

Annotation	Process
Arrow	Click within the 2D reconstructed slice view at the point you want to start the arrow, and then click again at the point you want to end the arrow. The arrowhead is drawn on the second end point.
Text associated with the arrow	Double-click the arrow, and then type the text you want to add.

NOTICE Switching to a new slice automatically removes all annotations. To save the current slice, proceed to step 8.

NOTE To remove an erroneous annotation, click the annotation to select it (annotation color changes from **blue** to **yellow**), and then press the **Delete** key on the ergonomic station's keyboard.

If Annotation mode is not the active mode, click  to enable it, and then proceed with the removal process described above.

8. After isolating and marking the region(s) of interest in the selected slice, click  in the **Options** icon toolbar, move the mouse pointer to the 2D reconstructed slice view, and then left-click to take a picture (snapshot) of the slice. This saves a picture of the 2D reconstructed slice on the **Snapshots** panel of the **Report** tab. (Refer to Figure 4-6, lower left corner of the **XM3DViewer** main window.)

NOTE The screen captures are automatically captured at screen resolution and then scaled to fit on the page. This can result in difficult-to-read scale bars, measurements, and annotations when the window is very large during capture. To make the text more readable, resize the **XM3DViewer** main window to a smaller size before taking a picture of the 2D reconstructed slice.

9. Repeat steps 1 through 8 for all 2D reconstructed slices that are of interest.

   When finished, proceed to the next process:

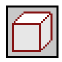
   – If you want to take pictures of 3D reconstructed volume data before generating a report, proceed to “Visualize, Measure, and Capture Internal Structure on 3D Reconstructed Volumes”

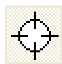
   – If you want to generate a report with only 2D reconstructed slice data, proceed to “Generating a Report”

Visualize, Measure, and Capture Internal Structure on 3D Reconstructed Volumes

This process describes how to create images from a 3D volume to indicate the region of interest within a sample for use in a report.

To visualize, measure, and capture the internal structure on 3D reconstructed volumes

1. Click  in the **Layout** icon toolbar to display the single 3D volume view.

2. Click  or  in the **Mouse mode** icon toolbar to enable and use the following mouse functions.

Mouse Function	Process
Rotate the image	Use the mouse pointer to left-click and drag within the 3D volume view.
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 view.
Pan	With the center-mouse button pressed, use the mouse pointer to click and drag within the 3D volume view.

3. Follow steps a and b below if you want to include a distance reference:

   a. On the **View** menu, remove the check mark from **3D perspective** selection. This causes the image in the 3D volume view to appear with a linear distance scaling, which is necessary when including a distance reference or scale bar.

   b. On the **View** menu, click **Scale bar** to insert a scale bar at the bottom of the 3D volume view, which provides a size reference. Ensure that **3D perspective** is **not** selected.

4. Follow steps a through c below if you want to add a measurement line:

   a. On the **View** menu, remove the check mark from **3D perspective** selection (if you did not already do so in step 3a). This causes the image in the 3D volume view to appear out of perspective, which is necessary when adding a measurement line.

   b. Click  in the **Mouse mode** icon toolbar to enable Measurement mode.

   c. In the 3D volume view, at the region of interest, left-click once to define the start point for measuring, and then again to define the endpoint for measuring.

NOTE To remove an erroneous measurement line, click the line to select it (line color changes from **blue** to **yellow**), and then press the **Delete** key on the ergonomic station's keyboard.

If Measurement mode is not the active mode, click  to enable it, and then proceed with the removal process described above.

5. If you want to apply arrow and text annotations, click  in the **Mouse mode** icon toolbar to enable Annotation mode, and then apply the annotations.

Annotation	Process
Arrow	Left-click within the 3D volume view at the point you want to start the arrow, and then click again at the point you want to end the arrow. The arrowhead is drawn on the second end point.
Text associated with the arrow	Double-click the arrow, and then type the text you want to add.

⚠CAUTION Switching to a new slice automatically removes all annotations. To save the current slice, proceed to step 6.

NOTE To remove an erroneous annotation, click the annotation to select it (annotation color changes from **blue** to **yellow**), and then press the **Delete** key on the ergonomic station's keyboard.

If Annotation mode is not the active mode, click  to enable it, and then proceed with the removal process described above.

6. After isolating and marking the region(s) of interest, left-click  in the **Options** icon toolbar, move the mouse pointer to the 3D volume view, and then left-click to take a picture (snapshot) of the 3D volume. This saves a picture of the 3D volume on the **Snapshots** panel of the **Report** tab. (Refer to Figure 4-6.)

NOTE The screen captures are automatically captured at screen resolution and then scaled to fit on the page. This can result in difficult-to-read scale bars, measurements, and annotations when the window is very large during capture. To make the text more readable, resize the **XM3DViewer** window to a smaller size before taking a picture of the 3D volume.

7. Repeat steps 1 through 6 for all 3D reconstructed volumes that are of interest.

   When finished, proceed to one of the next processes:

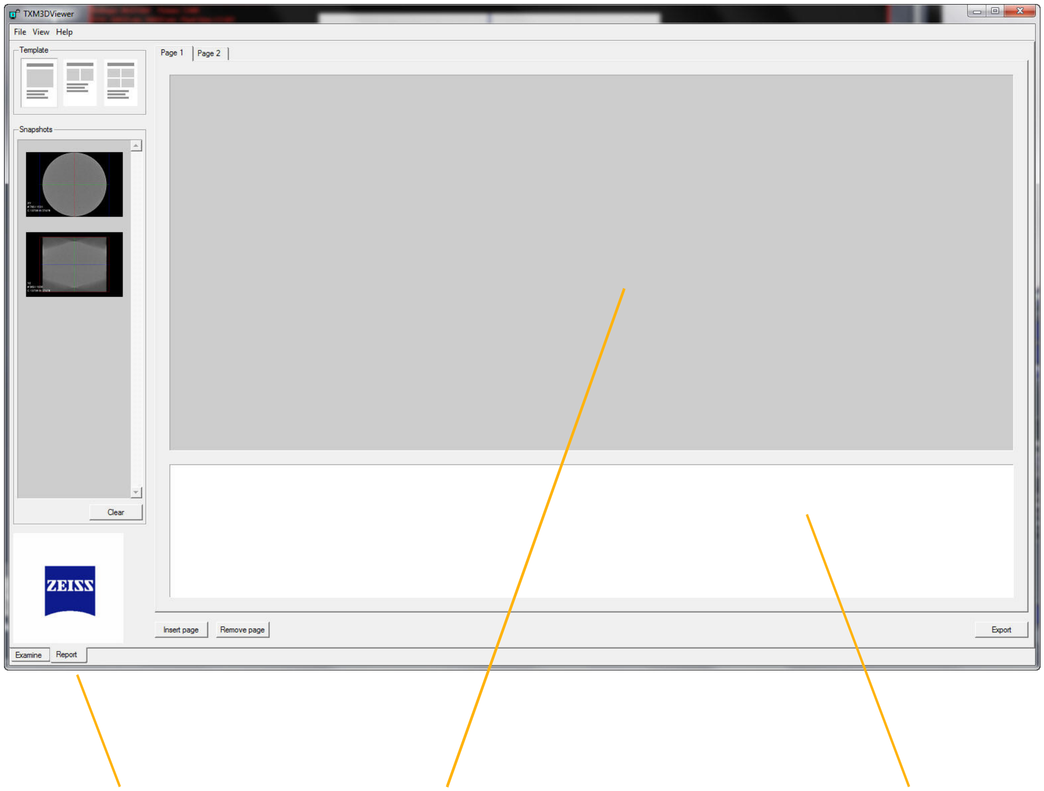
   – “Visualize, Measure, and Capture Internal Structure on 2D Reconstructed Slices”

   – “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 4-6 **XM3DViewer** Main Window – **Report** Tab



Report tab

Drag snapshots here

Add comments here

To generate a report

1. Click the **Report** tab (lower left corner of **XM3DViewer** main window).
2. In the **Template** panel, click the report layout that you want to use. That layout opens in the selected **Page *x*** tab.
3. Use the mouse pointer to click and drag snapshots to the **Page *x*** tab, according to the selected layout.

NOTE Screenshots are automatically captured at screen resolution, and then scaled to fit on the page. This can result in difficult-to-read scale bars, measurements, and annotations when the window image is large. To make the text more readable, resize the **XM3DViewer** main window to a smaller size before performing a screen capture.

4. To add comments, type the comment text in the bottom panel (white space) of the page.
5. To add a page, click **Insert page**. Repeat steps 3 and 4, as needed.

NOTE To remove a page that is not needed in the report, select the page's **Page x** tab, and then click **Remove page**.

6. When you are finished creating the report data, click **Export** to export and save the report as a formatted **.doc* Microsoft Word document.

   The final report includes a title page, the exported information, and closes the report with "Sincerely, RADIOLOGIST".

NOTE Report files are automatically saved in **C:\Program Files\Carl Zeiss X-ray Microscopy\Xradia Versa\11.*x*\3DViewer\share\examine_report**. To save the report file to a different location, on the Microsoft Word **File** menu, click **Save As**.

NOTE Images exported in the report file can be copied at full screen resolution into other types of documents, such as a Microsoft PowerPoint presentation or Excel spreadsheet.

NOTE After all required movies and reports are generated, delete the **.txm-exm* and **.txm-exm-ooc* files created by XM3DViewer if Out-of-core mode was used when XM3DViewer first opened the reconstructed file.

Creating Movies of Cross-Sectional 2D Reconstructed Slices and 3D Reconstructed Volumes

This process describes how to create an animation (movie) of captured data, using the **Cine controls**. The instructions differ, depending on whether you are processing 2D reconstructed slices or 3D reconstructed volumes:

– Creating Movies of 2D Reconstructed Slices

– Creating Movies of 3D Reconstructed Volumes

Creating Movies of 2D Reconstructed Slices

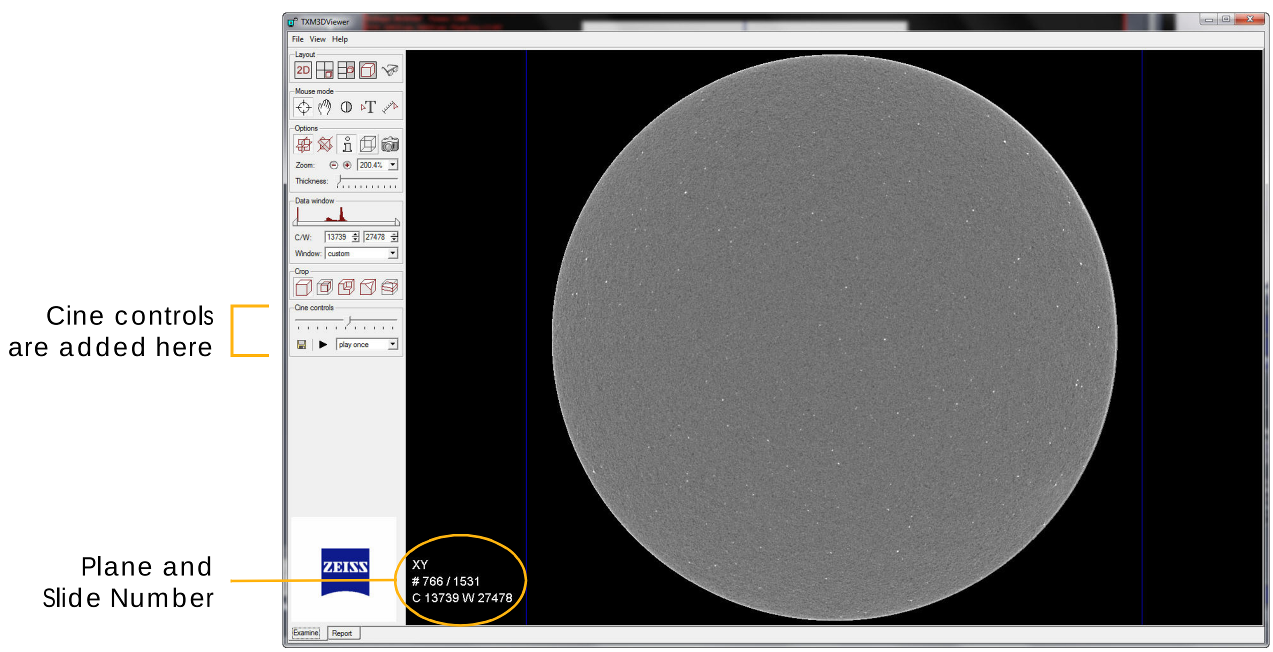
This process describes how to use the **Cine controls** to create a 2D reconstructed slice movie.

To create a 2D reconstructed slice movie

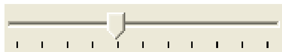
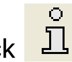
1. Click  in the **Layout** icon toolbar. **Cine controls** appears below the **Crop** icon toolbar area.

NOTE If the **Cine controls** are not visible, it is possible that the window size is too small. If this occurs, maximize the window size. **Cine controls** should now be visible.

Figure 4-7 **Cine controls** (Added to **XM3DViewer** Main Window)



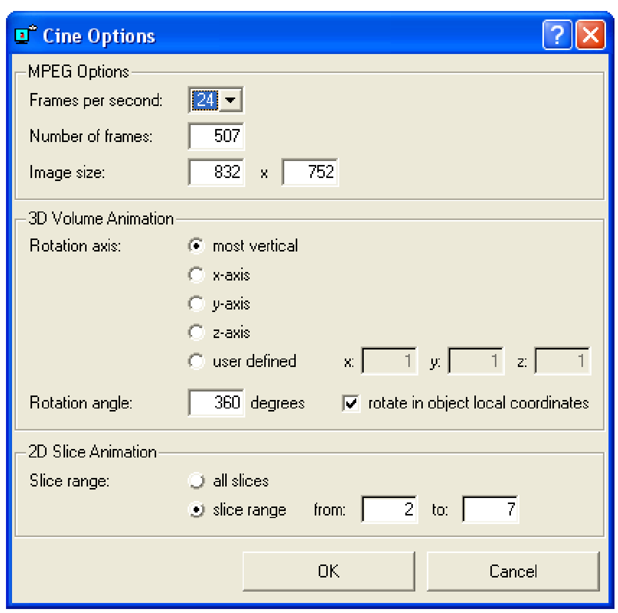
2. Use the following cine controls to identify slices of interest, and set up how often to play them in the movie.

Control	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  in the **Options** icon toolbar to display them). Note the beginning and ending slice numbers to be saved as the movie. These values are 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.

NOTE Image size changes with the viewing window's size. To make a movie that naturally occupies a specific screen size, resize the window as needed, and then click  under **Cine controls** to generate a movie with that screen size.

Figure 4-8 **Cine Options** Dialog Box



4. Select and/or type the cine option parameter values.

Parameter	Value
Frames per second	*24* is a good value to use. Number of frames × Frames per second = Movie time length.
Number of frames	Use the default value.
Image size	Use the default value. Changes with the viewing window's size. To make a movie that naturally occupies a specific screen size, resize the window as needed, and then click  under **Cine controls** to generate a movie with that screen size.
3D Volume Animation	N/A
2D Slice Animation **Slice range**	Select **slice range**, and then type the beginning and ending slice numbers (noted in step 2) in the **from** and **to** text boxes, respectively.

5. Click **OK**. A **Choose filename for movie file** dialog box opens, defaulted to the *MPEG movie (.mpg)* file type.

6. Browse to the destination file path, type the new file name in the **File name** text box, and then click **Save**.

NOTE XM3DViewer automatically scrolls through the included 2D reconstructed slices and generates the movie. The window cannot be minimized, and you cannot open any other windows (from within XM3DViewer or another program), until movie rendering is complete.

7. When the movie completes, an **Info** dialog box opens with the message "MPEG file successfully written". Click **OK** to close the dialog box.

NOTE After all required movies and reports are generated, delete the **.txm-exm* and **.txm-exm-ooc* files created by XM3DViewer if Out-of-core mode was used when XM3DViewer first opened the reconstructed file.

Creating Movies of 3D Reconstructed Volumes

This process describes how to use the **Cine controls** to create a 3D reconstructed volume movie.

To create a 3D reconstructed volume movie

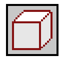
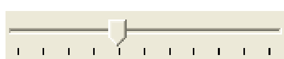
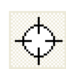
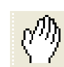
1. Click  in the **Layout** icon toolbar. **Cine controls** appears below **Transfer function** area.

Figure 4-9 **Cine controls**

2. Use the following cine controls to preview a 360° view, and set up how often to play the 3D volume in the movie.

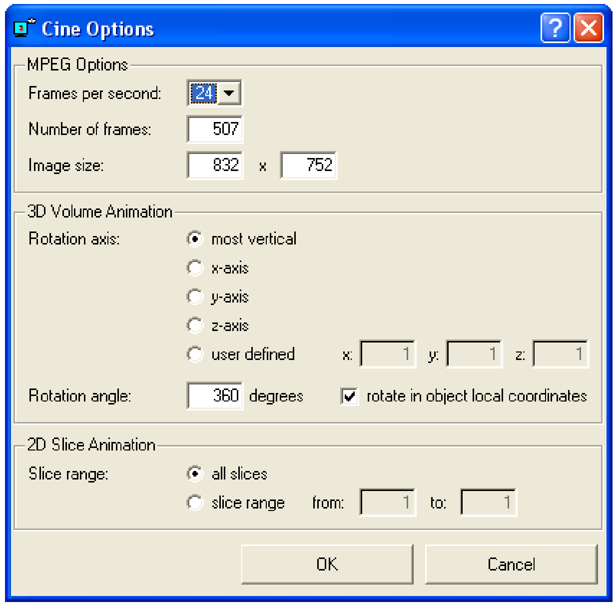
Control	Description
	Use the slider to preview a 360° view. If the sample is not centered about the rotation axis, use the **Pan** control to center the sample within the view by clicking  or  in the **Mouse mode** icon toolbar. With the center-mouse button pressed, use the mouse pointer to click and drag within the 3D volume view.
	From the drop-down list box, select whether to play the 3D volume movie once (*play once*; default) or *continuously* in a loop.

NOTE Check the center of rotation before saving the movie by playing the movie from the window first. This minimizes any undesirable wobble in the final movie.

To do this, play a small portion of the movie, and then use the **Pan** control to recenter the volume when it starts to rotate off-axis (orbit about a point). Continue doing this until the movie rotates about the desired axis location.

3. Click  under **Cine controls**. The **Cine Options** dialog box opens.

Figure 4-10 **Cine Options** Dialog Box



4. Select and/or type the cine option parameter values.

Parameter	Value
Frames per second	*24* is a good value to use. Number of frames × Frames per second = Movie time length.
Number of frames	Use the default value.
Image size	Use the default value. Changes with the viewing window's size. To make a movie that naturally occupies a specific screen size, resize the window as needed, and then click  under **Cine controls** to generate a movie with that screen size.
3D Volume Animation Rotation axis	Can be changed, as needed. If allowed to default (**most vertical**), the movie is taken with the sample rotated about the vertical axis.
3D Volume Animation Rotation angle	Use the default value.
2D Slice Animation	N/A

5. Click **OK**. A **Choose filename for movie file** dialog box opens, defaulted to the *MPEG movie (.mpg)* file type.

6. Browse to the destination file path, type the new file name in the **File name** text box, and then click **Save**.

NOTE XM3DViewer automatically scrolls through the 3D volume and generates the movie. The window cannot be minimized, and you cannot open any other windows (from within XM3DViewer or another program), until movie rendering is complete.

7. When the movie completes, an **Info** dialog box opens with the message "MPEG file successfully written". Click **OK** to close the dialog box.

NOTE After all required movies and reports are generated, delete the **.txm-exm* and **.txm-exm-ooc* files created by XM3DViewer if Out-of-core mode was used when XM3DViewer first opened the reconstructed file.

Correcting Problems with the Reconstructed File

NOTE Troubleshooting tips specific to contrast and brightness is described in "Troubleshooting Contrast, Brightness, and Intensity Value Issues," on page 149 in Appendix A.

This section provides troubleshooting information for how to handle specific problems with reconstructed data:

– Table 4-2 lists "show stopper" problems, with probable cause and solutions

– Table 4-3 lists solutions to problems that require manual reconstruction

– Table 4-4 lists solutions to problems that require reimaging

Table 4-2 Show Stoppers

Problem	Probable Cause	Solution
Reconstruction failed (no reconstructed file)	Insufficient hard disk drive memory (depends on the size of the acquired file before reconstruction).	Clean up the available space on the hard disk drive, and 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 tomography (projection) dataset's file size.
Blank file	Sample fell off the sample stage due to incorrect positioning or motor failure (check for errors in the **Scout-and-Scan Control System** Status bar).	Reposition sample, detector, and X-ray source, and then reacquire the data. If the problem is due to motor failure, contact the ZEISS Support Team.[a]

a. Refer to "Technical Support," on page 348 in Appendix L.

Table 4-3 Solutions to Problems that Require Manual Reconstruction

Problem	Solution
There are streaks or blurring in the image.	Correct the center shift (refer to “Finding the Center Shift,” on page 79 in Chapter 3), and 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 the beam hardening constant (refer to “Finding the Beam Hardening Constant,” on page 91 in Chapter 3), and then reconstruct the file.
Regions of the image are blurred. Reconstruction filter kernel is too large.	Repeat “Reconstructing the Tomography Data,” on page 101 in Chapter 3, but in step 3, select a recon filter with a smaller kernel size.
Image is too noisy. Areas that should be smooth contain large intensity (light saturation) variations over short length scales, on the order of the pixel size. Reconstruction filter kernel is too small.	Repeat “Reconstructing the Tomography Data,” on page 101 in Chapter 3, but in step 3, select a recon filter with a larger kernel size.
Too many rings are obscuring the region of interest.	Repeat “Reconstructing the Tomography Data,” on page 101 in Chapter 3, but in step 2, select a different ring removal option.

Table 4-4 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.
Too many rings are obscuring the region of interest and DRR (dynamic ring removal) was not enabled.	Select **Enable DRR (Dynamic Ring Removal)** (default) for the recipe in the **Advanced Acquisition** tab within the Scout-and-Scan Control System's **Scan** view, and then repeat the scan.[a]
Region of interest has streaks (sample might have moved during imaging).	Securely mount the sample on the sample holder[b] and/or reposition the detector and X-ray source so that they do not collide with the sample[c], and then repeat the scan.
	Sample drift can occur with any amount of temperature shift; however, it does not cause visible artifacts if the drift is sufficiently small. Sample drift correction can be used to correct for this.[d]

a. Refer to “Advanced Acquisition Tab,” on page 215 in Appendix D.
b. Refer to “Mounting a Sample in or on a Sample Holder,” on page 241 in Appendix E.
c. Refer to “Step 2 – Load,” on page 27 (new recipe) –or– “Step 2 – Load,” on page 57 (existing recipe or template) in Chapter 2.
d. Refer to “Correcting for System-Related Drift,” on page 310 in Appendix G.

A Troubleshooting

This appendix describes how to resolve common issues that might be encountered when using the Xradia Versa:

– Issues that Require Technical Support

– Troubleshooting Scout-and-Scan Control System Sample Issues

– Troubleshooting Contrast, Brightness, and Intensity Value Issues

– Troubleshooting XM3DViewer Issues

– Troubleshooting X-ray Source Issues

– Troubleshooting Xradia Versa Power-Related Issues

– Troubleshooting Light Tower Issues

If the suggested solutions do not resolve the problem, contact the ZEISS Support Team for assistance. (Refer to “Technical Support,” on page 348 in Appendix L.)

Issues that Require Technical Support

Table A-1 and Table A-2 list hardware and software issues, respectively, that must be referred to the ZEISS Support Team for resolution. (Refer to “Technical Support,” on page 348 in Appendix L.)

⚠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.

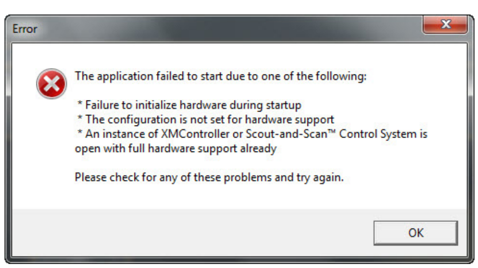
Table A-1 Hardware Problems that Require Technical Support

Symptom(s)	Problem
The Scout-and-Scan Control System indicates that the X-ray source is turned ON; however, the X-ray source turns OFF almost immediately and the PDU’s **red** **ALARM/RESET** push-button switch is lit.	Light tower is malfunctioning. Refer also to “Troubleshooting Light Tower Issues.”
Light tower’s **red** (top) light does **not** turn ON.	X-ray source does not turn ON after closing the access doors and clicking the **Apply** button (**Source Control** panel or **Acquisition** tab in **Scout** view). Refer also to “Troubleshooting Light Tower Issues.”
Light tower’s **amber** (center) light does **not** turn ON when the access doors are closed.	Safety interlock is malfunctioning.
Light tower’s **amber** (center) light is ON; however, the **Interlock** indicator in the **X-ray Source** dialog box indicates **OPEN**.	
Turret-mounted objective was selected; however, the turret does not rotate the selected objective into position.	Turret is malfunctioning.
Homing Status dialog box indicates homing errors: – “… followed out on coarse home” – “… followed out on fine home”	One or more axes (**Sample X**, **Y**, **Z**, and/or **Theta**, **Detector Z**, **CCDZ**, **CCDX**, and/or **Source Z**) will not move or cannot be changed/homed.
Axis does not move after clicking  within a motion controller.	

Table A-1 Hardware Problems that Require Technical Support

<table>
<tr><th>Symptom(s)</th><th>Problem</th></tr>
<tr><td>One or more of the axes (Sample X, Y, Z, and/or Theta, Detector Z, CCDZ, CCDX, and/or Source Z) does not move, moves erratically, or vibrates when moving.</td><td rowspan="3">Xradia Versa motion control(s) or motor(s) are malfunctioning.</td></tr>
<tr><td>Program running on the Xradia Versa issues an “Unable to communicate with the (motion or source) controller” message.</td></tr>
<tr><td>Red Warning message appears at the bottom of the Scout-and-Scan Control System display.</td></tr>
<tr><td>X-ray source tube errors</td><td>Refer to Table A-5, “X-ray Source Tube Error Messages that Require Technical Support,” on page 154.</td></tr>
</table>

Table A-2 Software Problems that Require Technical Support

<table>
<tr><th>Symptom(s)</th><th>Problem</th></tr>
<tr><td>Image quality is not the same quality as achieved in prior acquisitions that used the same settings.</td><td>Imaging components, such as the detector and/or X-ray source, have malfunctioned.</td></tr>
<tr><td>Errors in a window or dialog box indicate a problem that cannot be easily user-remedied.</td><td>System hardware components, such as the motors, have malfunctioned.</td></tr>
<tr><td>X-ray source reports that it is unable to reach the requested voltage or power.</td><td>If the requested voltage and power is within the supported range, this indicates that the X-ray source might require calibration by ZEISS service personnel. Contact the ZEISS Support Team for assistance.</td></tr>
<tr><td>Starting the Scout-and-Scan Control System generated the following error message(s).

</td><td>An instance of the Scout-and-Scan Control System is likely already running. If this is not the case, try shutting down and restarting the Xradia Versa[a], and then restart the Scout-and-Scan Control System. If the error persists, contact the ZEISS Support Team for assistance.</td></tr>
</table>

a. Refer to Appendix C, “Shutting Down and Restarting the Xradia Versa.”

Troubleshooting Scout-and-Scan Control System Sample Issues

This section provides tips for troubleshooting the following sample-related issues that you might experience when using the Scout-and-Scan Control System:

- Sample Is Unstable
- Sample Is Not Visible within the Front or Side View Image Display
- 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

Symptom Sample is wobbly (unstable) on the sample stage or in/on the sample holder; acquired images are blurry and unfocused and/or include drifts.

Problem Sample is not properly mounted or loaded.

Solution ***To stabilize the sample***

1. Ensure that the flat edges of the sample holder and sample stage are aligned. (Refer to Figure E-7, “Sample Holder Assembly Loaded on Sample Stage, with Flat Edges Aligned, Facing Front of Xradia Versa),” on page 249 in Appendix E.)

2. Ensure that the tungsten balls on the sample stage are fitted into the indentations on the underside of the sample holder. (Refer to Figure E-6, “Sample Stage, with Tungsten Alignment Balls Highlighted,” on page 249 in Appendix E.)

3. Ensure that the sample is securely mounted in/on the sample holder.

4. Ensure that the sample is stable, such that it does not move nor vibrate in response to gently tapping the sample holder.

5. Follow steps a through d below if the sample must be repositioned in/on the sample holder:

   a. Turn OFF the X-ray source and remove the sample holder from the sample stage, following the processes described in “Removing a Sample after Use,” on page 250 in Appendix E.

   b. Adjust the sample’s position in/on the sample holder, based on the criteria identified in steps 3 and 4, following the processes described in “Mounting a Sample in or on a Sample Holder,” on page 241 in Appendix E.

   c. Load the sample holder assembly back on the sample stage, following the processes described in “Loading a Sample Holder Assembly on the Sample Stage,” on page 248 in Appendix E.

   d. Repeat steps 1 through 4.

   If you resume the process in which you determined there was an issue and the issue persists, contact the ZEISS Support Team for assistance. (Refer to “Technical Support,” on page 348 in Appendix L.)

Sample Is Not Visible within the Front or Side View Image Display

Symptom Sample is not visible within the Scout-and-Scan Control System **Front** or **Side View** image display.

Problem Sample is not properly installed; sample is out of the field of view (FOV).

Solution ***To make the sample visible within the Scout-and-Scan Control System Front or Side View image display***

1. With the access doors closed, use the visual light camera to verify that the:

   – Sample is securely mounted in/on the sample holder, and has not slid from view, and that its region of interest (ROI) is:

     – Located above the top surface of the holder

     – Positioned so that the least amount of material will be penetrated by X-ray

NOTE Refer to "Mounting a Sample in or on a Sample Holder," on page 241 in Appendix E for mounting instructions.

   – Sample holder assembly is properly loaded on the sample stage

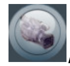
NOTE Refer to "Loading a Sample Holder Assembly on the Sample Stage," on page 248 in Appendix E for loading instructions.

   – X-ray source is positioned near the sample without colliding with the sample:

     – **Xradia 520 Versa and Xradia 510 Versa** – Position the X-ray source as close to the sample as possible

     – **Xradia 410 Versa** – Position the X-ray source at an appropriate distance from the sample

   – Detector is situated as close to the sample as possible without colliding with the sample

– Sample is visible after clicking /applying continuous X-rays. If not, do one of the following:

  – Ensure that the **Sample X** and **Sample Z** axes are at 0°, –or–

  – Change the objective to a lower magnification to enable seeing a larger FOV. Move the detector closer to the sample. If the image becomes saturated (**Intensity** value is greater than 50000), lower the exposure time –or– increase the binning, and then click  again to apply continuous X-rays.

NOTE Move the sample up, as needed, until you see the sample within the **Front** or **Side View** image display.

2. Repeat “Step 2 – Load,” on page 27 (new recipe) –or– “Step 2 – Load,” on page 57 (existing recipe or template) in Chapter 2.

   If you resume the process in which you determined there was an issue and the issue persists, contact the ZEISS Support Team for assistance. (Refer to “Technical Support,” on page 348 in Appendix L.)

Sample Region of Interest Is Not Visible

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. Repeat “Step 2 – Load,” on page 27 (new recipe) –or– “Step 2 – Load,” on page 57 (existing recipe or template) in Chapter 2.
2. Repeat “Step 3 – Scout,” on page 31 (new recipe) –or– “Step 3 – Scout,” on page 61 (existing recipe or template) in Chapter 2.

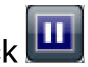
   If you resume the process in which you determined there was an issue and the issue persists, contact the ZEISS Support Team for assistance. (Refer to “Technical Support,” on page 348 in Appendix L.)

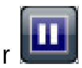
Sample and Detector Collision Is Imminent

Symptom While using the Scout-and-Scan Control System and moving the sample or detector, the sample and detector are coming too close to one another.

Problem The sample and detector are so close that they might collide with one another.

Solution ***To prevent the sample and detector from colliding***

1. If you just clicked  within a motion controller, click  for that motion controller to immediately halt movement.

NOTICE Always position the mouse pointer over  after clicking  **(within the same motion controller)**, so you can quickly halt movement if collision with the sample is imminent.

2. Review the safety guidelines provided in “Collision of Moving Parts,” on page xxii in Safety.

3. Move the Detector away from the sample. In the **Detector** motion controller, type a value greater than the current Detector position, in increments of 5 mm or less, in the **Detector** text box, and then click .

   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 the Scout-and-Scan Control System, the detector and sample are positioned such that they are touching one another, or the sample holder assembly 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  (**All Motors**, upper left view).
2. **If the detector is damaged** – Contact the ZEISS Support Team for assistance. (Refer to "Technical Support," on page 348 in Appendix L.)
3. Review the safety guidelines provided in "Collision of Moving Parts," on page xxii in Safety.
4. **If the sample holder assembly fell off the sample stage** – Load the sample holder assembly back on the sample stage, following the processes described in "Loading a Sample Holder Assembly on the Sample Stage," on page 248 in Appendix E.
5. **If the sample is damaged** – Follow steps a through c below to replace the sample:
   a. Turn OFF the X-ray source and remove and discard the sample, following the processes described in "Removing a Sample after Use," on page 250 in Appendix E.
   b. Mount a new sample in/on the sample holder, following the processes described in "Mounting a Sample in or on a Sample Holder," on page 241 in Appendix E.
   c. Position and scan the new sample, following the processes described in Chapter 2, "Acquiring Tomographies with the Scout-and-Scan Control System."

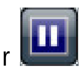
Sample and X-ray Source Collision Is Imminent

Symptom While using the Scout-and-Scan Control System and moving the sample or X-ray source, the sample and X-ray source are coming too close to one another.

Problem The sample and X-ray source are so close that they might collide with one another.

Solution ***To prevent the sample and X-ray source from colliding***

1. If you just clicked  within a motion controller, click  for that motion controller to immediately halt movement.

NOTICE Always position the mouse pointer over  after clicking  **(within the same motion controller)**, so you can quickly halt movement if collision with the sample is imminent.

2. Review the safety guidelines provided in "Collision of Moving Parts," on page xxii in Safety.

3. Move the X-ray source away from the sample. In the **Source** motion controller, type a value more negative than the current X-ray source position, in increments of 5 mm or less, in the **Source** text box, and then click .

   Repeat this step, as necessary, until the detector does not touch the sample, but is still sufficiently close to it.

Sample and X-ray Source Collided

Symptom While using the Scout-and-Scan Control System, the X-ray source and sample are positioned such that they are touching one another, or the sample holder assembly 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 

(**All Motors**, upper left view).

2. **If the X-ray source is damaged** – Contact the ZEISS Support Team for assistance. (Refer to "Technical Support," on page 348 in Appendix L.)

3. Review the safety guidelines provided in "Collision of Moving Parts," on page xxii in Safety.

4. **If the sample holder assembly fell off the sample stage** – Load the sample holder assembly back on the sample stage, following the processes described in "Loading a Sample Holder Assembly on the Sample Stage," on page 248 in Appendix E.

5. **If the sample is damaged** – Follow steps a through c below to replace the sample:

   a. Turn OFF the X-ray source and remove and discard the sample, following the processes described in "Removing a Sample after Use," on page 250 in Appendix E.

   b. Mount a new sample in/on the sample holder, following the processes described in "Mounting a Sample in or on a Sample Holder," on page 241 in Appendix E.

   c. Position and scan the new sample, following the processes described in Chapter 2, "Acquiring Tomographies with the Scout-and-Scan Control System."

Troubleshooting Contrast, Brightness, and Intensity Value Issues

Contrast, brightness, and **Intensity** value (light saturation) adjustments are typically process-specific. Table A-3 lists processes in the guide that describe how to adjust contrast, brightness, and/or **Intensity** value, within the context of those processes.

Table A-3 Processes that Adjust Contrast, Brightness, and/or **Intensity** Value, by Program

Program	Processes that Adjust Contrast, Brightness, and/or Intensity Value
Scout-and-Scan Control System	"Scout – Select Appropriate Source Filter and Voltage," steps 4 and 5, on page 43 in Chapter 2
	"Scout – Determine Acquisition Time," step 1, on page 49 in Chapter 2
	"Histogram Scaling," on page 321 in Appendix G
Reconstructor	"Finding the Center Shift," step 7, on page 86 in Chapter 3
	"Finding the Beam Hardening Constant," step 4, on page 93 in Chapter 3
	"Histogram Scaling," on page 321 in Appendix G
XM3DViewer	"Adjusting Contrast and Brightness in the 2D Reconstructed Slice Views," on page 110 in Chapter 4
	"Creating 3D Volume Renderings," step 4, on page 116 in Chapter 4
	"Creating 3D Volume Renderings," step 6, on page 117 in Chapter 4

Troubleshooting XM3DViewer Issues

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 134 in Chapter 4.

Additional troubleshooting, with respect to contrast and brightness, is also provided earlier in this appendix, in "Troubleshooting Contrast, Brightness, and Intensity Value Issues."

Troubleshooting X-ray Source Issues

This section provides tips for troubleshooting the following X-ray source-related issues that you might experience when using the Xradia Versa and/or Scout-and-Scan Control System:

- X-ray Source Status
- Troubleshooting X-ray Source Tube Error Messages
- Troubleshooting X-ray Source Power Failure
- Troubleshooting 0.4X or 4X Objective Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View

Tips for troubleshooting X-ray source-related issues with respect to the sample are described earlier in this appendix:

- “Sample and X-ray Source Collision Is Imminent,” on page 147
- “Sample and X-ray Source Collided,” on page 148

X-ray Source Status

The X-ray source goes through the following X-ray source tube state sequence when it receives a voltage or power command:

1. Stabilizing Voltage and Power.
2. Centering.
3. Stabilizing Voltage and Power.
4. On.

Table A-4 lists and describes the general and error states associated with the X-ray source tube. If the state is an error state, the table also includes troubleshooting tips.

Table A-4 X-ray Source Tube States

State	Troubleshooting Needed/Error[a]	Description
Aging		The X-ray source is undergoing aging, a required initial warm-up process that is required for optimum tube performance. For the Xradia 520 Versa and Xradia 510 Versa, the aging process occurs every 23 hours and takes approximately 3 minutes. For the Xradia 410 Versa, the aging process occurs every 8 hours and takes approximately 20 minutes. The aging process automatically starts when the X-ray source is powered ON. After aging is complete, the X-ray source tube automatically goes through its standard sequence to achieve the requested voltage and power. The X-ray source voltage and current increase up to their maximum levels in a predetermined manner during warm-up.
Initializing		Communication with the X-ray source has been initiated. This state is usually not displayed on the user interface because initialization of communication with the tube completes before the Scout-and-Scan Control System user interface is displayed.
Lost Communication with the source	✔	To resolve the error, refer to "Lost Communication with the source.," in Table A-6 on page 155.
Off		The tube is powered OFF.
Off – Arc	✔	The tube high voltage has arced and the high-voltage power supply has automatically been turned OFF. The tube is in an error state. Using the Scout-and-Scan Control System, check the rectangular **white** status area in the Source Control Drop-Down Panel for an error message, –or– click **Current Log** in the Advanced Tools Drop-Down Panel to access the error's description. To reset the error, click the Source Control Drop-Down Panel, and then click **Error Reset**. If this does not reset the error, contact the ZEISS Support Team for assistance.[b]
On		The tube is powered ON and working normally. It has reached the requested voltage and power.

Table A-4 X-ray Source Tube States (Continued)

State	Troubleshooting Needed/Error[a]	Description
`On – Error`	✔	The X-ray source is powered ON and in an error state. The tube might not be at the requested power or voltage. Using the Scout-and-Scan Control System, check the rectangular **white** status area in the Source Control Drop-Down Panel for an error message, –or– click **Current Log** in the Advanced Tools Drop-Down Panel to access the error's description. To reset the error, click the Source Control Drop-Down Panel, and then click **Error Reset**. If this does not reset the error, contact the ZEISS Support Team for assistance.[b]
`Centering`		The tube is centering the electron beam to optimize tube performance. Whenever the tube is powered ON or the voltage and/or power settings are changed, the tube goes through the Fast Centering process. Fast Centering takes less time than Slow. The tube always attempts to do Fast Centering first. If the tube cannot reach the requested power, only then will it go through the Slow Centering process.
`Stabilizing Voltage and Power`		The tube is waiting for the requested voltage and power to be reached and stabilized.
`Tube Error – Press Error reset`	✔	The tube has malfunctioned and is in an error state. Using the Scout-and-Scan Control System, check the rectangular **white** status area in the Source Control Drop-Down Panel for an error message, –or– click **Current Log** in the Advanced Tools Drop-Down Panel to access the error's description. To reset the error, click the Source Control Drop-Down Panel, and then click **Error Reset**. If this does not reset the error, contact the ZEISS Support Team for assistance.[b]

a. Specific X-ray source error messages and their resolutions are described in "Troubleshooting X-ray Source Tube Error Messages," on page 153.
b. Refer to "Technical Support," on page 348 in Appendix L.

Troubleshooting X-ray Source Tube Error Messages

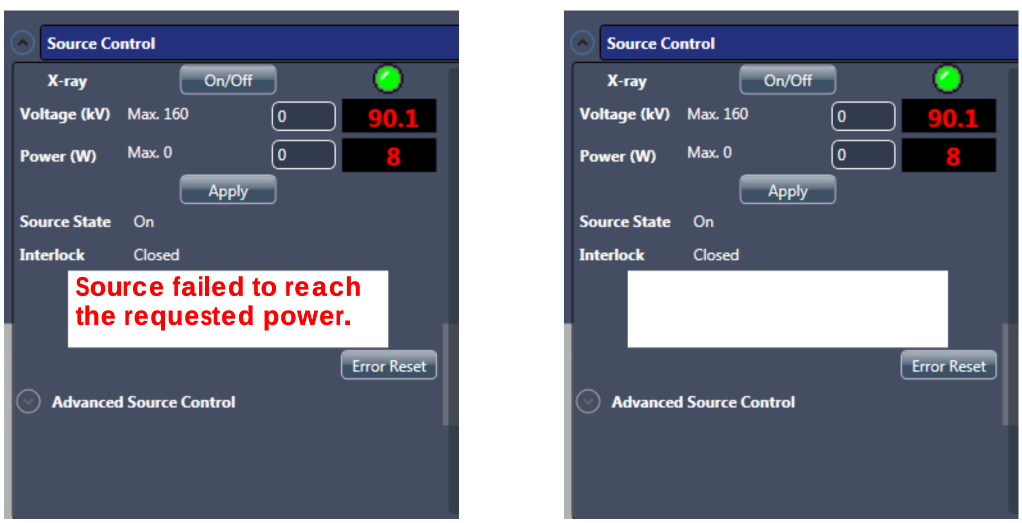
This section provides instructions for recovering from X-ray source tube errors. Table A-5 lists X-ray source tube error messages that must be referred to the ZEISS Support Team for resolution. Table A-6 lists X-ray source tube error messages that you can typically troubleshoot and resolve without having to contact the ZEISS Support Team.

If an X-ray source tube error occurs, the error must be cleared before troubleshooting can begin. For error messages listed in Table A-5, it is recommended that you wait until after contacting the ZEISS Support Team to perform this action. For error messages listed in Table A-6, you will need to instruct the Xradia Versa to clear the error before performing the recommended solution.

To clear an X-ray source tube error

1. Click the **Source Control** drop-down list box. The **Source Control** drop-down panel opens with a status error message displayed. (Refer to Figure A-1, image to the left.)

Figure A-1 **Source Control** Drop-Down Panel, with Typical Error Message Shown and then Cleared



Error message(s) will appear within the white box when the X-ray source tube is in an error state

X-ray source tube is operational and **not** in an error state

2. Click **Error Reset**. The error message should clear after clicking **Error Reset**.

Table A-5 X-ray Source Tube Error Messages that Require Technical Support[a]

X-ray Source Tube Error Message	Problem
`X-ray 56V fault. Contact ZEISS support.`	Internal X-ray source error.
`X-ray cache error. Contact ZEISS support.`	Internal X-ray source error.
`X-ray centering coil ramp failure.`	Internal X-ray source error.
`X-ray file access error. Contact ZEISS support.`	Internal X-ray source error.
`X-ray focusing coil ramp failure. Contact ZEISS support.`	Internal X-ray source error.
`X-ray tube current ramp failure. Contact ZEISS support.`	Internal X-ray source error.
`X-ray tube error reset failed.`	Internal X-ray source error.
`X-ray tube filament failed. Contact ZEISS support.`	Internal X-ray source error.
`X-ray tube unknown fault. Contact ZEISS support.`	Internal X-ray source error.
`X-ray tube Vacuum is bad. Contact ZEISS support.`	The X-ray source tube's vacuum level has degraded and is above the acceptable level. The tube does not turn ON when the vacuum level is outside the supported range.
`X-ray tube voltage ramp failure. Contact ZEISS support.`	Internal X-ray source error.
`X-ray uamp ramp failure. Contact ZEISS support.`	Internal X-ray source error.
`X-ray uamps lost. Turn tube off and then back on.`	Internal X-ray source error.
`X-ray undefined PSU. Contact ZEISS support.`	Internal X-ray source error.
`X-ray vacuum pump fault. Contact ZEISS support.`	Internal X-ray source error.
`X-ray vacuum sensor failure. Contact ZEISS support.`	Internal X-ray source error.
`X-ray warmup script failed to load. Contact ZEISS support.`	Internal X-ray source error.
`Error when changing spot size.`	**Xradia 410 Versa only** This error message applies only when the Xradia 410 Versa has the 150 kV (30W maximum) X-ray source. This occurs if the command to change the source spot size failed to complete.

a. Refer to "Technical Support," on page 348 in Appendix L.

Table A-6 X-ray Source Tube Error Message Troubleshooting Tips

X-ray Source Tube Error Message	Problem	Recommended Solution
`Aging failed to complete.`	X-ray source aging failed to complete successfully. The X-ray source tube is turned OFF when this occurs. Aging can fail to complete if the tube's vacuum level is too high.	1. Turn ON the X-ray source. Aging should restart. 2. If aging continues to fail, exit the Scout-and-Scan Control System and start XMController.[a] 3. Turn ON the X-ray source. At this point, aging should commence and successfully complete. 4. If aging successfully completed, exit XMController and restart the Scout-and-Scan Control System. The X-ray source should now turn ON without aging. 5. If aging continues to fail, contact the ZEISS Support Team.[b]
`Cannot set source to requested voltage and power because the source is aging.`	X-ray source aging is in-progress and the X-ray source tube cannot be set to the requested voltage and power until aging completes.	1. Wait for aging to complete. 2. Turn ON the X-ray source at the requested voltage and power.
`Fast Centering failed. Trying Slow centering.`	This occurs if the X-ray source tube was unable to center correctly using fast centering.	The tube should automatically run slow centering. No action is required
`High voltage arc occurred in the X-ray tube. Turn the source back on to recover.`	A high voltage arc occurred. The high-voltage power supply was automatically turned OFF.	1. Turn ON the X-ray source. 2. If a high-voltage arc continues to occur, contact the ZEISS Support Team.[b]
`Interlock Open.`	The safety interlocks on one or more of the Xradia Versa's four enclosure access doors are OPEN.	1. Check that all four of the access doors are securely CLOSED. 2. If the error persists, contact the ZEISS Support Team.[b]
`Lost Communication with the source.`	The Scout-and-Scan Control System has lost communication with the X-ray source. This can be caused by a disconnected cable, or the Scout-and-Scan Control System simply needs to be restarted.	1. Exit and restart the Scout-and-Scan Control System. 2. If the error persists, contact the ZEISS Support Team.[b]

Table A-6 X-ray Source Tube Error Message Troubleshooting Tips (Continued)

<table>
<tr><th>X-ray Source Tube Error Message</th><th>Problem</th><th>Recommended Solution</th></tr>
<tr><td><code>Requested Power value is outside the allowed range.</code></td><td>The requested power is outside the supported range for the requested voltage.</td><td>1. Consult Table 1-2, “X-ray Source Voltage and Power Settings,” on page 12 in Chapter 1 for the allowable power for the requested voltage.
2. Change the power to be within the supported range for the requested voltage.</td></tr>
<tr><td><code>Requested Voltage value is outside the allowed range.</code></td><td>The requested voltage is outside the supported range for the requested power.</td><td>1. Consult Table 1-2, “X-ray Source Voltage and Power Settings,” on page 12 in Chapter 1 for the allowable voltage for the requested power.
2. Change the voltage to be within the supported range for the requested power.</td></tr>
<tr><td><code>Source failed to reach the requested power.</code></td><td>The X-ray source failed to reach the requested power.</td><td rowspan="2">1. Turn OFF the X-ray source.
2. Turn ON the X-ray source at the requested voltage and power.
3. If the X-ray source fails to reach the requested power, reduce the power by 1W and retry.
4. If the error persists, contact the ZEISS Support Team.[b]</td></tr>
<tr><td><code>Source failed to reach the requested voltage.</code></td><td>The X-ray source failed to reach the requested voltage.</td></tr>
<tr><td><code>Source failed to stabilize at the requested power.</code></td><td>The X-ray source failed to stabilize at the requested power.</td><td>1. Turn OFF the X-ray source.
2. Turn ON the X-ray source at the requested voltage and power.
3. If the X-ray source fails to stabilize at the requested power, allow the X-ray source to warm up for approximately 15 minutes.
4. If the error persists, contact the ZEISS Support Team.[b]</td></tr>
</table>

Table A-6 X-ray Source Tube Error Message Troubleshooting Tips (Continued)

X-ray Source Tube Error Message	Problem	Recommended Solution
`Target Power too high.`	The X-ray source power has exceeded its allowable limit. The X-ray source is automatically turned OFF. This can occur during centering.	1. Turn ON the X-ray source at the requested voltage and power. 2. If the error reoccurs, try setting the X-ray source at a lower power. 3. If the error persists, contact the ZEISS Support Team.[b]
`X-ray tube centering failed. No peak found.`	Centering failed to successfully complete.	
`X-ray tube current lost during warm up. Turn tube back on.`	Internal X-ray source error.	
`X-ray kV power supply failed to turn on.`	The high-voltage power supply failed to turn ON. This can occur if a high-voltage arc occurred.	Retry turning ON the X-ray source at the requested voltage and power.
`X-ray kv ramp error. Contact ZEISS support.`	Internal X-ray source error.	
`X-ray source failed to turn on.`	The X-ray source failed to turn ON.	
`X-ray source turned off by user. X-ray source request aborted.`	This message is displayed if your turned OFF the X-ray source before it finished stabilizing after submitting a voltage and power request. This is not an error.	No error. Turn ON the X-ray source.

a. Refer to "Starting XMController and Loading the Sample Holder Assembly onto the Sample Stage" on page 35 in Chapter 2 of the legacy *VersaXRM-500 User's Guide*.
b. Refer to "Technical Support," on page 348 in Appendix L.

Troubleshooting X-ray Source Power Failure

This section provides tips for troubleshooting an X-ray source power failure.

Symptom X-ray does not turn ON after OPENING and then CLOSING an access door.

Problem X-ray source was turned ON when an access door was OPENED. An access door's safety interlocks turned OFF power to the X-ray source.

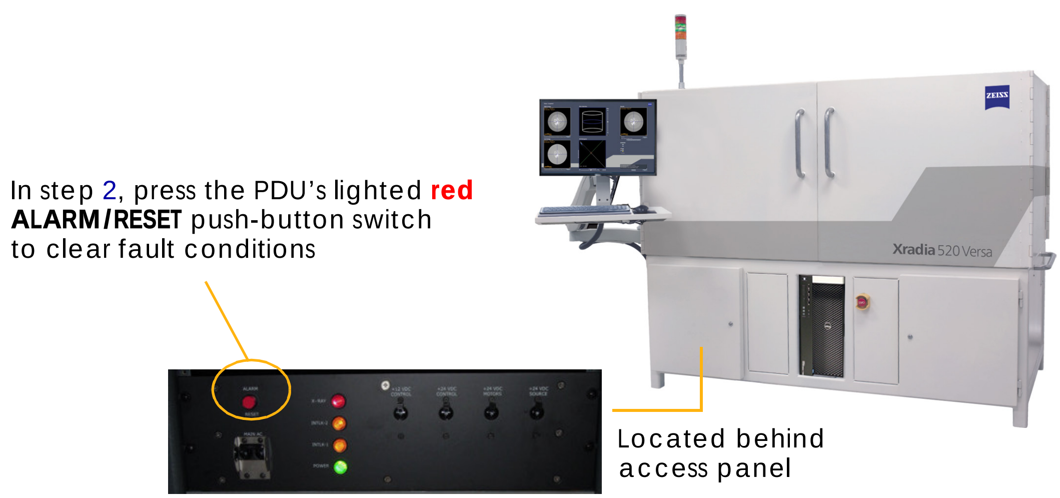
Solution ***To restore power to the X-ray source***

1. Open the access door on the bottom left front of the Xradia Versa enclosure.

2. Press the PDU's lighted **red ALARM/RESET** push-button switch (located behind the front access panel; refer to Figure A-2) to restore X-ray source power.

   If the X-ray source does not turn ON, contact the ZEISS Support Team for assistance. (Refer to "Technical Support," on page 348 in Appendix L.)

Figure A-2 Press the PDU's Lighted **Red ALARM/RESET** Push-Button Switch to Restore X-ray Source Power (Xradia 520 Versa Shown)



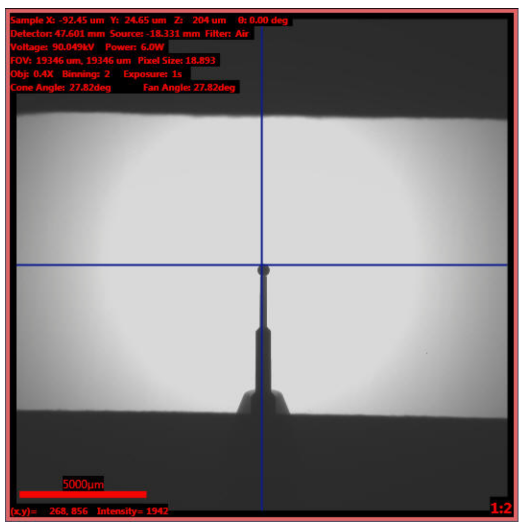
Troubleshooting 0.4X or 4X Objective Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View

It is important to keep the X-ray source aperture out of the field of view (FOV) for the 0.4X and 4X objectives.

Symptom X-ray source aperture is visible in image scans.

Problem Corner clipping of images acquired with the 0.4X or 4X objective occurs due to the objective being too close to the X-ray source aperture. A ring artifact is visible in the image and the image's upper and lower edges are jagged.

Figure A-3 Example of Image with X-ray Source Aperture within FOV (Indicated by Ring Artifact and Jagged Edges) – Image Acquired with 0.4X Objective, with X-ray Source at -18.331 mm and Detector at 47.601 mm



NOTE Use the guidelines listed in Table A-7 when moving the X-ray source and detector near the sample. For the 0.4X and 4X objectives, the minimum distance indicated between **Source Z** and **Detector Z** prevents the X-ray source aperture from appearing within the FOV.

Table A-7 Distance Needed between X-ray Source and Detector Guidelines, by Objective

Objective	Source:Detector Distance (Ratio)[a]	Minimum Distance between Source Z and Detector Z
0.4X	–	135 mm
4X	1:1	13 mm

a. Ratio of the X-ray source position to the detector position, relative to the sample (that is, if the X-ray source is at 50 mm and the detector is at 10 mm, the ratio is 5:1).

Solution ***To remove the X-ray source aperture from the image***

1. Move the X-ray source away from the sample, using the guidelines listed in Table A-7. In the **Source** motion controller, type a value more negative than the current X-ray source position, in increments of 5 mm or less, in the **Source** text box, and then click 

.

   –or–

   Move the detector away from the sample. In the **Detector** motion controller, type a value greater than the current Detector position, in increments of 5 mm or less, in the **Detector** text box, and then click 

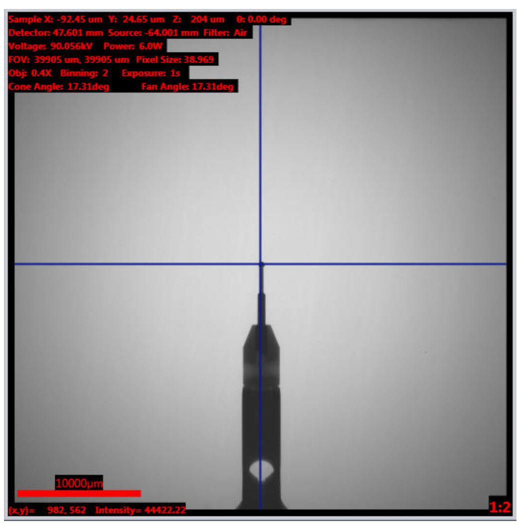
.

   The end result should resemble Figure A-4.

NOTICE Always position the mouse pointer over  after clicking 

(within the same motion controller), so you can quickly halt movement if collision with the sample is imminent.

Figure A-4 Example of Image with X-ray Source Aperture out of the FOV, after Moving the X-ray Source – Image Acquired with 0.4X Objective, with X-ray Source at -64.001 mm and Detector at 47.601 mm



Troubleshooting Xradia Versa Power-Related Issues

This section provides tips for troubleshooting the following power-related issues that you might experience when using the Xradia Versa:

- Troubleshooting PDU Power Breaker Switch in OFF (DOWN) Position
- Troubleshooting Xradia Versa Power-Related Failures

Troubleshooting PDU Power Breaker Switch in OFF (DOWN) Position

Symptom The PDU's power breaker switches are usually in the ON (UP) position, indicating that power is being applied to the Xradia Versa. If there is a power-related malfunction within the Xradia Versa, one or more of the PDU power breaker switches might trip to the OFF (DOWN) position.

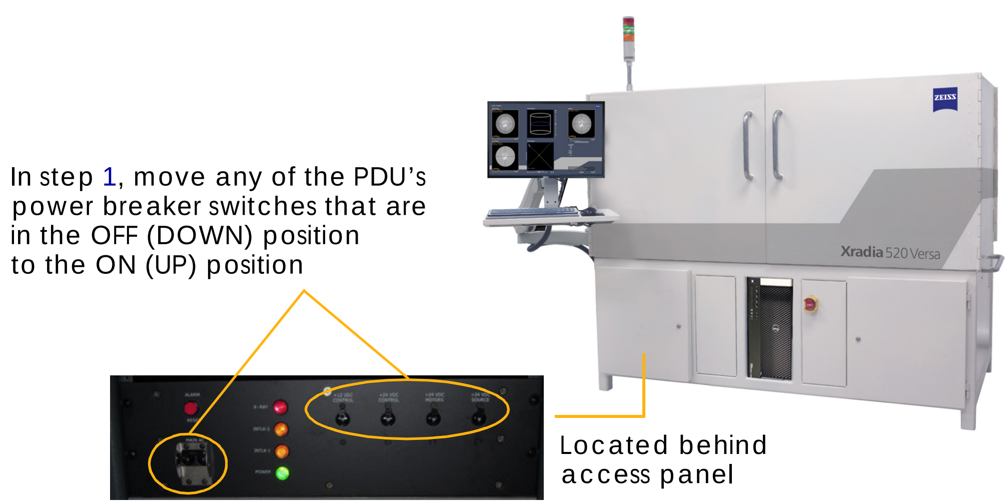
Problem A PDU power breaker switch has tripped due to a power-related malfunction within the Xradia Versa.

Solution ***To troubleshoot a PDU power breaker switch in the OFF (DOWN) Position***

1. Reset the power breaker switch by moving it to the ON (UP) position, as shown in Figure A-5.

   If the power breaker switch trips again, contact the ZEISS Support Team for assistance. (Refer to "Technical Support," on page 348 in Appendix L.)

Figure A-5 Resetting PDU Power Breaker Switches (Xradia 520 Versa Shown)



Troubleshooting Xradia Versa Power-Related Failures

This section provides tips for troubleshooting Xradia Versa power-related failures.

Symptom Light tower lights do not turn ON; entire Xradia Versa and/or computer workstation does not turn ON; ergonomic station monitor does not turn ON.

Problem One or more components within the Xradia Versa is not receiving power.

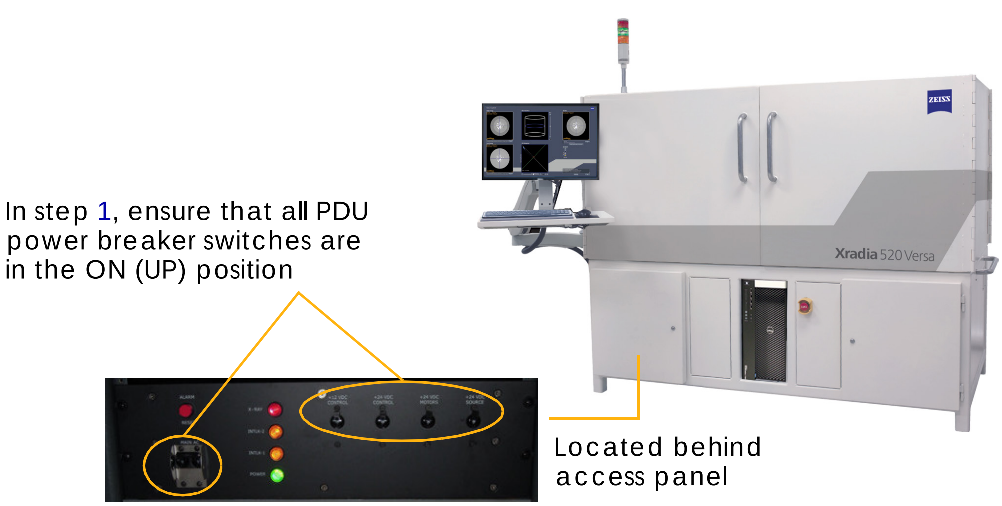
Solution ***To troubleshoot Xradia Versa power-related failures***

1. Verify that the Xradia Versa's three-prong power connector is connected to a grounded 230V AC Nominal (160 to 286V AC range, Single Phase, 50/60 Hz, 15A) power source. If the Xradia Versa is not connected to a grounded power source, plug it in, and then proceed to step 6.

   However, if using an uninterruptible power source (UPS), line conditioner, surge protector, or similar device, ensure that the Xradia Versa is connected to the device, and that the device's power connector is connected to a grounded 230V AC Nominal (160 to 286V AC range, Single Phase, 50/60 Hz, 15A) power source. If the device's power connector is not connected to a grounded power source, plug it in, and then proceed to step 6.

2. Open the cabinet door on the lower left side of the Xradia Versa. Verify that all PDU power breaker switches are in the ON (UP) position, and that none of the switches are tripped (in the OFF (DOWN) position).

Figure A-6 Resetting PDU Power Breaker Switches (Xradia 520 Versa Shown)



WARNING If a power breaker switch is tripped, refer to “Troubleshooting PDU Power Breaker Switch in OFF (DOWN) Position,” on page 161 to resolve the issue.

3. Verify that the component’s (computer workstation and/or ergonomic station monitor) **Power** button is lit. If the component’s **Power** button is not lit, press the button again.

   If Xradia Versa power is still failing, proceed to step 4. Otherwise, this process is complete.

4. Shut down the Xradia Versa, following the processes described in “Shutting Down the Xradia Versa in a Non-Emergency Event,” on page 174 in Appendix C.

5. Verify that the power source is working by plugging another electrical item into the power source, or testing the power source 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 Xradia Versa, following the processes described in “Turning ON the Xradia Versa,” on page 176 in Appendix C.

   If you resume the process in which you determined there was an issue and the issue persists, contact the ZEISS Support Team for assistance. (Refer to “Technical Support,” on page 348 in Appendix L.)

Troubleshooting Light Tower Issues

Table A-8 describes the behavior of each light (status indicator) in the light tower. Figure A-7 shows a sample light tower status combination. Table A-9 provides tips for troubleshooting light tower electrical issues. If any status indicators are not functioning as described, contact the ZEISS Support Team for assistance. (Refer to “Technical Support,” on page 348 in Appendix L.)

Table A-8 Light Tower Lights (Status Indicators)

Light Tower Indicator Status	Description
All lights OFF	Power to the Xradia Versa is turned OFF.
Red light ON (top)	X-ray source is turned ON and X-rays are present within the enclosure.
Red light OFF (top)	X-ray source is turned OFF and X-rays are not present within the enclosure. Refer also to Table A-9 for troubleshooting electrical issues.
Amber light ON (center)	Access doors are CLOSED.
Amber light OFF (center)	Access doors are OPEN.
Green light ON (bottom)	Power to the Xradia Versa is turned ON.
Green light OFF (bottom)	Power to the Xradia Versa is turned OFF.

Figure A-7 Typical Light Tower Status Combination

Red light OFF – X-ray source is turned OFF, X-rays are not present within the enclosure

Amber light ON – Access doors are CLOSED

Green light ON – Power to the ZEISS Xradia Versa is turned ON

Table A-9 Troubleshooting Light Tower Electrical Issues[a]

Symptom(s)	Problem	Solution
Red (top) light is burned out (OPEN) or shorted	Latching relay LR1 (FAULT) is set in response to X-ray source ON, indicating a fault condition.	Press the PDU's lighted **red ALARM/RESET** push-button switch (located behind the front access panel; refer to Figure A-8), and then contact the ZEISS Support Team[b] to repair the light.
	An access door was OPENED while X-rays were being generated.	CLOSE the access door, and then press the PDU's lighted **red ALARM/RESET** push-button switch. (Refer to Figure A-8.)

a. For further details, including the interlock schematic, refer to "Interlock Sequence of Operation," on page 334 in Appendix J.

b. Refer to "Technical Support," on page 348 in Appendix L.

Figure A-8 Press the PDU's Lighted **Red ALARM/RESET** Push-Button Switch to Clear Fault Conditions (Xradia 520 Versa Shown)

THIS PAGE INTENTIONALLY LEFT BLANK

B Files and File Storage

This appendix describes the file types unique to the Xradia Versa programs, recommended file handling, and file storage:

– File Types

– File Structure

– File Storage (Hard Disk Drives)

File Types

The Scout-and-Scan Control System controls the Xradia Versa hardware during setup and data acquisition. The control system can also be used for 2D-image viewing for ZEISS-specific images. The Scout-and-Scan Control System is primarily used for acquiring tomography datasets, using user-created **.rcp* files, which are a collection of 2D images (projections) acquired at different angles around the axis of rotation in the Xradia Versa. Datasets that contain a collection of projection images are saved as **.txrm* files. Each **.txrm* file contains multiple images. In contrast, **.xrm* files contain only one image.

When used, Reconstructor manually 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 that is oriented in the X/Z plane. Slices generated from each **.txrm* file are stored in a **.txm* file. A **.txm* file contains a collection of 2D slices that make up the 3D 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 created by Reconstructor is also referred to as an *output reconstruction file*. These files can be viewed with XM3DViewer or the optional Visual SI Advanced program.

If Out-of-core mode was selected when using XM3DViewer, two large files were created – **.txm-exm* and **.txm-exm-ooc*. These files should be deleted after generating reports and creating movies.

Table B-1 summarizes the file name extensions used for files used by the Xradia Versa, and their associated programs. The check mark (✓) indicates that the file type is opened and/or processed by the program.

Table B-1 ZEISS File Name Extensions and Related Programs

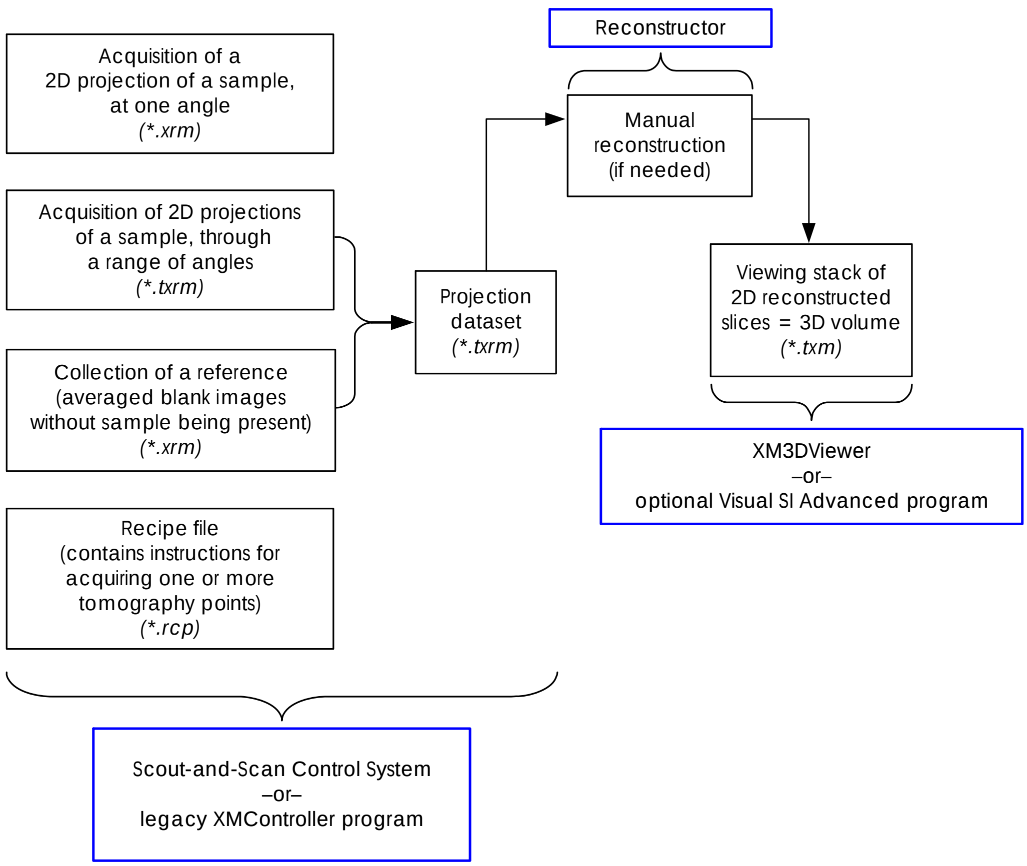
File Name Extension	Description	Scout-and-Scan Control System –or– XMController[a]	Reconstructor	XM3DViewer –or– Visual SI Advanced[b]
.rcp	Contains Xradia Versa parameter values to acquire one or more recipe points.	✓		
.txrm	Collection of 2D projection images acquired using the Scout-and-Scan Control System –or– legacy XMController program. Also referred to as a *tomography dataset*.	✓	✓	
.xrm	Image acquired with Single and Continuous acquisition modes and saved, using the Scout-and-Scan Control System –or– legacy XMController program.	✓		
.txm	3D tomography volume dataset file in proprietary ZEISS format. Contains a stack of 2D reconstructed images, saved as a contiguous volume. Also referred to as an *output reconstruction file*.	✓	✓	✓
.txm-exm	Created by XM3DViewer if Out-of-core mode was used; should be manually removed after generating reports and creating movies.			✓
.txm-exm-ooc				✓

a. Although this guide occasionally mentions the legacy XMController program, XMController is primarily used by ZEISS service personnel. Complete instructions for XMController's use are provided in Chapter 2 and Appendix D of the legacy *VersaXRM-500 User's Guide*.

b. Visual SI Advanced, available from ZEISS, is an optional program that can be used instead of XM3DViewer.

Figure B-1 shows the relationship between the Scout-and-Scan Control System, legacy XMController, Reconstructor, XM3DViewer, and the optional Visual SI Advanced programs, and their data, processes, and file types.

Figure B-1 Data, Processes, and Files



File Structure

Figure B-2 and Figure B-3 show a typical folder hierarchy that is created when running a recipe.

Figure B-2 Typical Folder Hierarchy Created when Running a Recipe – 1 of 2

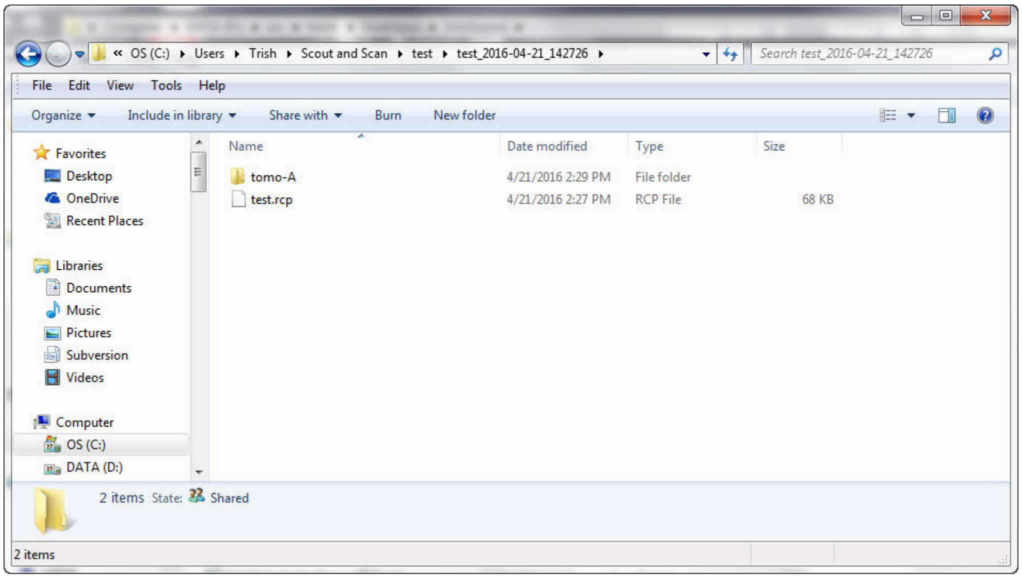
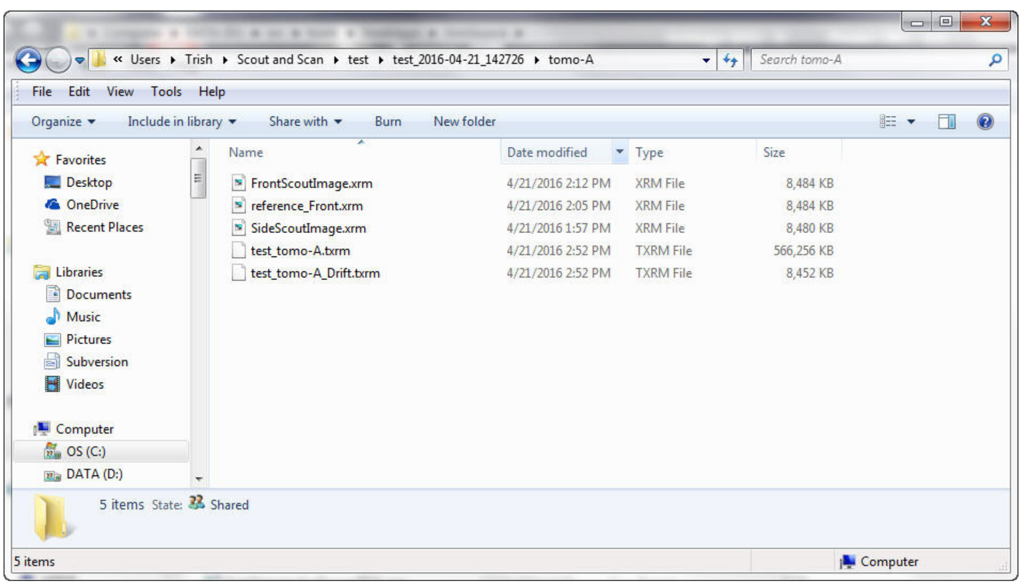


Figure B-3 Typical Folder Hierarchy Created when Running a Recipe – 2 of 2



File Storage (Hard Disk Drives)

The Xradia Versa computer workstation has two internal hard disk drives:

- Drive C
- Drive D, which is a RAID-5 array hard disk drive with fast read/write speed

The amount of disk space available on hard disk Drives C and D varies because it is dependent on the computer workstation model available at the time of shipment/purchase.

An optional storage server is also available from ZEISS. If included with the Xradia Versa, the server is networked to the computer workstation as an additional hard disk drive.

NOTE Redundant Array of Independent Disks (RAID) provides redundant (mirrored copies) fail-safe storage for all programs and data stored on hard disk Drives C and D.

NOTE The desktop folder path is typically **C:\Documents and Settings*[Your Windows User Login Name]*\Desktop**.

NOTE It is recommended that you periodically back up hard disk Drives C and D, and remember to empty the Recycle Bin after deleting files.

NOTE During reconstruction with Reconstructor, the amount of free space required on the selected hard disk drive must be at least 1 GB more than the tomography (projection) dataset's file size.

NOTE **Out of Core mode** – After all required movies and reports are generated, delete the **.txm-exm* and **.txm-exm-ooc* files created by XM3DViewer when the reconstructed **_recon.txm* file is first opened within XM3DViewer.

C Shutting Down and Restarting the Xradia Versa

This appendix describes how to shut down and restart the Xradia Versa, and then home all motorized axes to predefined initialization positions:

NOTE The EMO shutdown process (pressing of an **EMO** button), used in the event of a personal safety or equipment emergency, is described in "EMO Shutdown," on page xii in Safety.

Shutting Down the Xradia Versa in a Non-Emergency Event

This process describes how to shut down the Xradia Versa in a non-emergency event, such as when troubleshooting a problem that requires resetting the instrument, or if the instrument is not going to be used for a long period of time (such as during a holiday closure).

To shut down the Xradia Versa in a non-emergency event

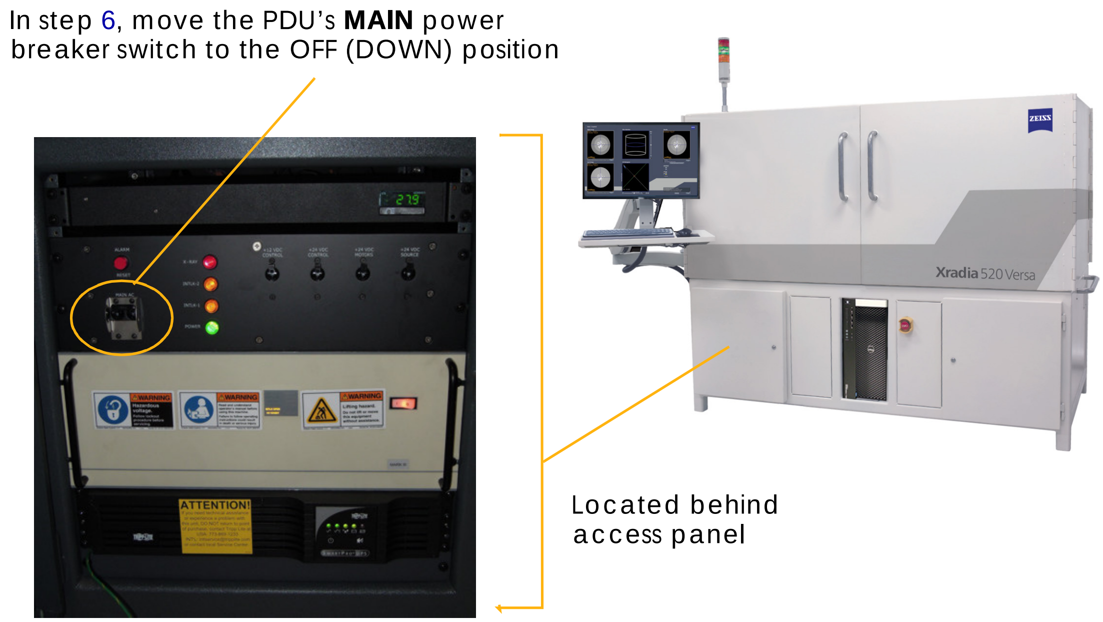
1. Close any programs that are running on the Xradia Versa.
2. On the Windows taskbar **Start** menu, select **Shut Down**.
3. **If the Xradia Versa has a storage server** – Refer to the provided storage server manufacturer's product documentation for the server's shutdown instructions.
4. When prompted, select **Shut Down** to shut down the Xradia Versa's computer workstation.

   Follow the instructions as they appear on screen.
5. Open the front left access panel to gain access to the PDU. (Refer to Figure C-1.)
6. Move the PDU's **MAIN** power breaker switch to the OFF (DOWN) position. (Refer to Figure C-1.)

NOTE This removes all power from the Xradia Versa, but allows the UPS battery to maintain a charge.

When ready to turn ON the Xradia Versa, proceed to "Turning ON the Xradia Versa."

Figure C-1 Move the PDU's **MAIN** Power Breaker Switch to the OFF (DOWN) Position (Xradia 520 Versa Shown)



Turning ON the Xradia Versa

This process describes how to turn ON the Xradia Versa if it has been shut down (turned OFF).

To turn ON the Xradia Versa

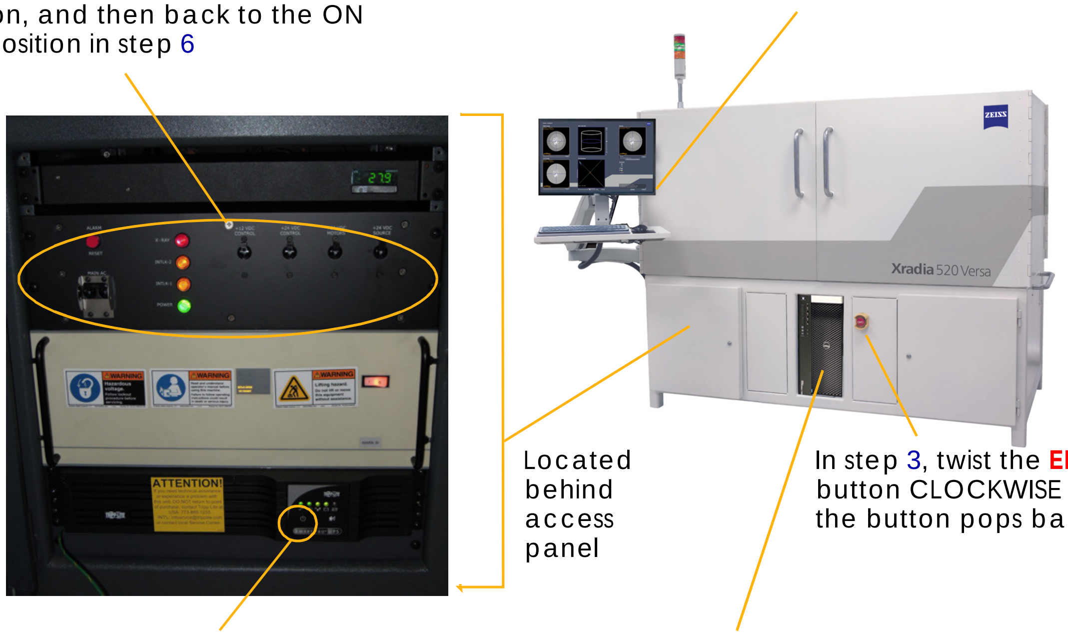
1. Ensure that the three-prong power connector (located at the back of the Xradia Versa) is connected to a connected to a grounded 230V AC Nominal (160 to 286V AC range, Single Phase, 50/60 Hz, 15A) power source.

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

2. **If restarting the Xradia Versa after an emergency event** – Verify that the emergency is resolved, all personnel are safe, and all appropriate safety conditions are satisfied.

3. **If restarting the Xradia Versa after an emergency event** – Twist the **EMO** button (that was previously pressed to shut down the Xradia Versa) CLOCKWISE until the button pops back out. (Refer to Figure C-2.)

Figure C-2 Turning ON the Xradia Versa (Xradia 520 Versa Shown)



4. Move the PDU’s power breaker switches to the OFF (DOWN) position. (Refer to Figure C-2.)

5. Press the UPS’ **Power** button to turn ON the Xradia Versa. (Refer to Figure C-2.)

6. Move the PDU’s power breaker switches to the ON (UP) position. (Refer to Figure C-2.) The **green** (bottom) light on the light tower turns ON. If the access doors are closed, satisfying all safety interlocks, the **amber** (center) light on the light tower also turns ON. (Refer to Figure C-3.)

NOTE At this point in the process, it is okay to have the access doors OPEN. If the **amber** (center) light does not turn ON, the access doors are **not** securely CLOSED. To securely close the access doors, OPEN and then RECLOSE the doors.

Figure C-3 Typical Light Tower Status Combination

7. **If the Xradia Versa has a storage server** – Refer to the provided storage server manufacturer’s product documentation for the server’s power-on instructions.

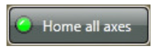
8. Press the Xradia Versa’s computer workstation’s **Power** button to turn ON the workstation. (Refer to Figure C-2.)

9. Press the ergonomic station monitor’s **Power** button to turn ON the monitor. The standard Windows 7 desktop should be(come) visible. (Refer to Figure C-2.)

Proceed to “Homing the Axes.”

Homing the Axes

This process describes how to use the Scout-and-Scan Control System to home the motorized sample (**Sample X, Y, Z, and Theta**), detector (**Detector Z, CCDZ, CCDX**), and X-ray source (**Source Z**) axes to their predefined initialization positions in preparation for acquiring tomographic data.

NOTE The axes must be homed whenever the Xradia Versa is restarted after a shutdown. It is usually unnecessary to home the axes at any other time unless instructed otherwise by the Technical Support. If you need to home the axes on your own, click 

to in the **Homing Status** tab in the **Motion Control** drop-down panel.

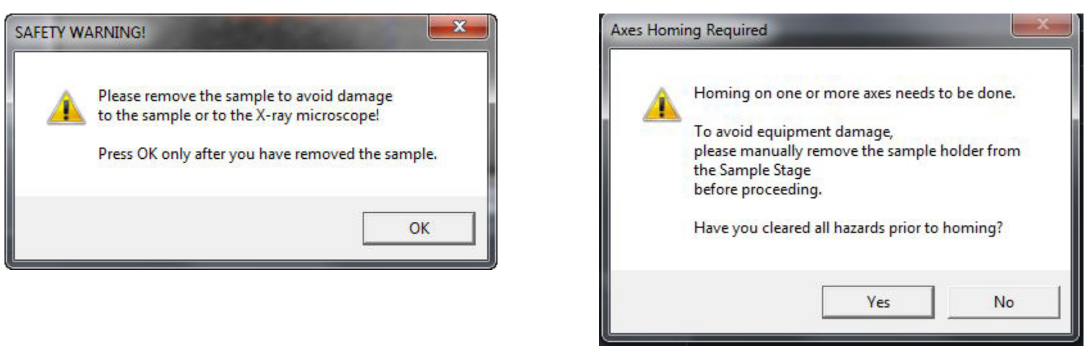
To home all axes

1. Start the Scout-and-Scan Control System if it is not already running.

2. If the Xradia Versa has previously been turned OFF, just prior to starting the Scout-and-Scan Control System, the **Axes Homing required** dialog box opens. (Refer to Figure C-4.) Click **Yes** to home all motorized axes.

NOTICE **WARNING** dialog boxes also open, asking you to remove the sample, if present, before proceeding, or whether it is safe to proceed. **If a sample is present**, turn OFF the X-ray source and remove the sample, following the instructions provided in “Removing a Sample after Use,” on page 250 in Appendix E. Click **OK** or **Yes**, as appropriate, to continue homing the axes.

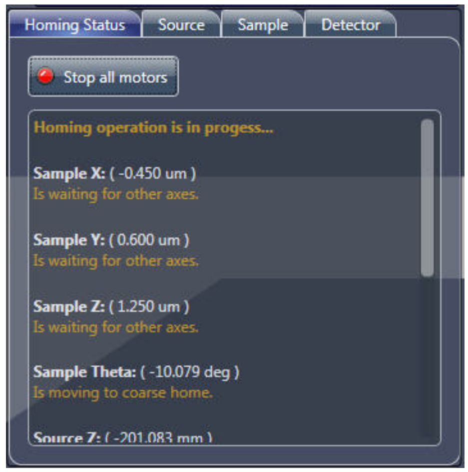
Figure C-4 **WARNING** Dialog Boxes Related to Manual Axes Homing



3. Open the **Motion Control** drop-down panel, and then select the **Homing Status** tab.

   During the homing process, the **Homing Status** tab indicates real-time homing status for each axis. (Refer to Figure C-5.) This process can take several minutes.

Figure C-5 **Homing Status** Tab in the **Motion Control** Drop-Down Panel – Homing In-Progress



Axes homing is complete and successful when the **Homing operation is complete** message appears at the top of the **Homing Status** tab within the **Motion Control** drop-down panel. (Refer to Figure C-6.)

Figure C-6 Final Homing Status – All Axes Successfully Homed

4. **If homing was successful** – Proceed to Chapter 2, "Acquiring Tomographies with the Scout-and-Scan Control System," to prepare the Xradia Versa for acquiring data.

   If homing was unsuccessful – The **Homing Status** tab within the **Motion Control** drop-down panel indicates homing errors. Contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

D User Interface and Software Control Features

This appendix describes how to use the following:

– Scout-and-Scan Control System User Interface

– Reconstructor User Interface

– XM3DViewer User Interface

Scout-and-Scan Control System User Interface

This section describes the function of each button, icon, and field within the Scout-and-Scan Control System user interface. The user interface consists of five workflow-based tabbed views that lead you through the steps required to set up and collect tomographic scans.

Topics within this section are organized as follows:

- Basic Controls
- Visual Light Camera Controls
- Advanced Options
- Workflow-Based Tabbed Views
  - Sample View
  - Load View
  - Scout View
  - Scan View
  - Run View

NOTE Tasks that use the Scout-and-Scan Control System are discussed in Chapter 2, "Acquiring Tomographies with the Scout-and-Scan Control System."

Basic Controls

The Scout-and-Scan Control System streamlines the workflow of collecting single- or multi-point tomography datasets. Several controls that are common to most of the Scout-and-Scan Control System views are shown in Figure D-1 and described in Table D-1. Table D-2 describes additional common controls that are used for navigating the Scout-and-Scan Control System.

Figure D-1 Controls Common to Most Scout-and-Scan Control System Views

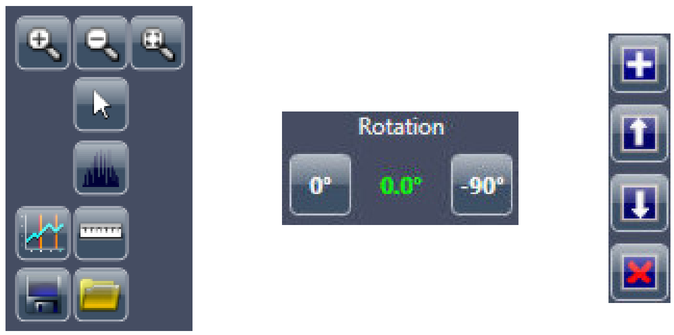


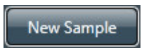
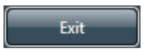
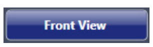
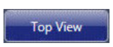
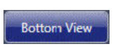
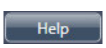
Table D-1 Controls Common to Most Scout-and-Scan Control System Views

Control	Description
	Click and hold to zoom in on the active image display. Release when the image display is at the desired level of zoom.
	Click to zoom out of the active image display. Click and hold to completely zoom out of the active image display.
	Click to fit the entire image within the active image display.
	Click to select the Arrow tool (standard navigation). When using this tool, you can double-click a position within the active image display to bring that position to the center of the active image display.
	Click to open the Histogram Control tool. Functionality and use is the same as Reconstructor's Histogram Control tool. (Refer to "Histogram Control Tool," on page 316 in Appendix G.)
	Click to open the Line Graph tool, which enables you to draw a line on the image and display a graph that compares intensity versus position along a linear path. While holding down the mouse button, click a graph start point and endpoint within the active image display.
	Click to open the Measurement tool, which enables you to annotate the active image display with a line of measured tick marks. While holding down the mouse button, click a line start point and endpoint within the active image display. Hold down the mouse button while pressing SHIFT to draw a vertical or horizontal line.

Table D-1 Controls Common to Most Scout-and-Scan Control System Views (Continued)

Control	Description
	Click to save the image in the active image display to the hard disk drive.
	Click to open a **.bmp*, **.gif*, **.jpg*, **.png*, or **.xrm* file from the hard disk drive.
	Provides the option to orient the sample for alignment in the X/Y or Z/Y directions, respectively. Also displays the Sample Theta stage's current angle of orientation, in **green**, relative to the visual light camera. The angle blinks **red** when the Sample Theta stage is rotating. – Click  to activate the **Front View** image display and move Sample Theta to 0° for X/Y direction alignment – Click  to activate the **Side View** image display and move Sample Theta to -90° for Z/Y direction alignment
	Click after clicking a recipe point to add and append a copy of that recipe point to the recipe.
	Click after clicking a recipe point to move that recipe point UP within the list, to change the sequence in which the recipe point will run within the recipe. **NOTE** Typically **unavailable** when only one recipe point is listed.
	Click after clicking a recipe point to move that recipe point DOWN within the list, to change the sequence in which the recipe point will run within the recipe. **NOTE** Typically **unavailable** when only one recipe point is listed.
	Click after clicking a recipe point to remove the selected recipe point from the recipe. **NOTE** Typically **unavailable** when only one recipe point is listed.

Table D-2 Common Scout-and-Scan Control System Navigation Controls

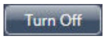
Tool	Description
	Click to navigate forward within the Scout-and-Scan Control System workflow. This button becomes active when processing within the current view is complete.
	Click to navigate backward within the Scout-and-Scan Control System workflow. This button becomes active when processing within the current view is complete.
	Click to clear all currently listed sample-related data and start over in Sample view.
	Click to exit (close) the Scout-and-Scan Control System. Anything created for the recipe (up to the point that you clicked the button) is saved to the path specified in **Sample** view's **Output Directory** text box.
	Click to select the left image display to be populated with the next image to be acquired. Activated after clicking  .
	Click to select the right image display to be populated with the next image to be acquired. Activated after clicking  .
	Click to select the active image display to be populated with the Top Y Position image when acquiring an image with vertical stitching enabled.
	Click to select the active image display to be populated with the Bottom Y Position image when acquiring an image with vertical stitching enabled.
	Click to access online help.

The main status/control bar (refer to Figure D-2; top of each Scout-and-Scan Control System view) also provides the following:

– **All Motors** 

button, which can be clicked to stop all motion when a motion controller starts moving to an unexpected location and/or collision is imminent

– X-ray emission status (On or Off)

– X-ray source 

button

NOTE The X-ray source does **not** have a corresponding **Turn On** button. X-rays are turned ON after setting up the X-ray source voltage and power and clicking **Apply** in **Scout** view's **Acquisition** tab.

– X-ray source voltage, power, and current

– Access door interlock status (Open or Closed)

– X-ray source status (On or Off)

Figure D-2 Main Status/Control Bar

A status bar containing system notifications, either status indicators or error notifications, is also provided. (Refer to Figure D-3; lower left of each Scout-and-Scan Control System view.)

Figure D-3 Status Bar with Typical Status Indicators

Visual Light Camera Controls

The Scout-and-Scan Control System's visual light camera image display (refer to Figure D-4) enables you to see what the camera sees from within the enclosure. Table D-3 describes each visual light camera control.

Figure D-4 Visual Light Camera Image Display and Controls

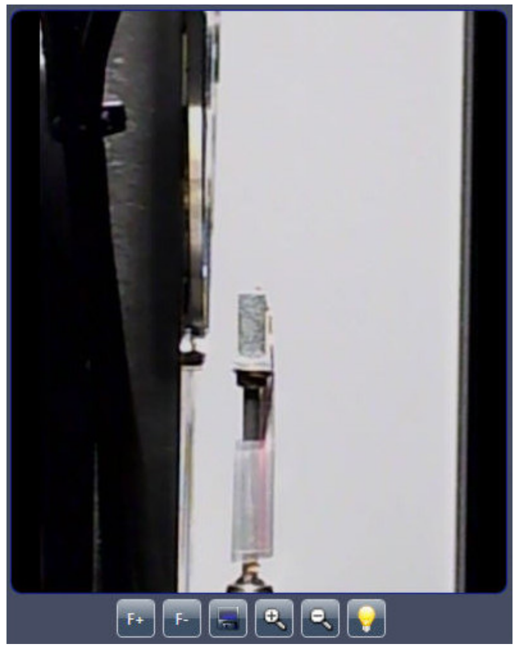


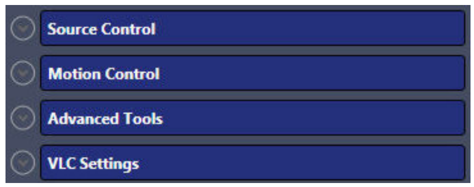
Table D-3 Visual Light Camera Controls

Control	Description
	Click to set the focal plane to objects closer to the visual light camera.
	Click to set the focal plane to objects farther away from the visual light camera.
	Click to save the visual light camera image to a **.jpg* file.
	Click to increase the visual light camera image's zoom level (zoom IN).
	Click to decrease the visual light camera image's zoom level (zoom OUT).
	Click to toggle the visual light camera's light ON/OFF (default is ON).

Advanced Options

The Scout-and-Scan Control System also provides control over instrument parameter values and image acquisition modes that are not part of the standard imaging workflow. These options (refer to Figure D-5) are available on the right of each Scout-and-Scan Control System view.

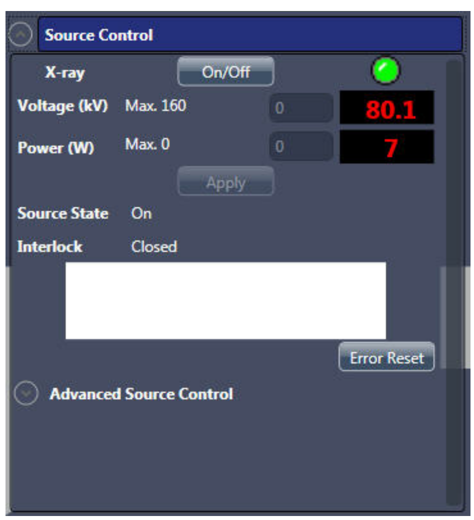
Figure D-5 Advanced Xradia Versa Scout-and-Scan Control System Controls



Source Control Drop-Down Panel

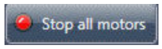
The **Source Control** drop-down panel (refer to Figure D-6) allows you to control the X-ray source settings, including turning X-ray source components On or Off, viewing alarms, resetting errors, and viewing the current access door (interlock) status. Details regarding these settings are beyond the scope of this guide. Should you need further details, contact the ZEISS Support Team. (Refer to “Technical Support,” on page 348 in Appendix L.)

Figure D-6 **Source Control** Drop-Down Panel



Motion Control Drop-Down Panel

The **Motion Control** drop-down panel (refer to Figure D-7) allows you to control all available axes. Each tab within the panel provides absolute motion, relative motion, and a status readout for its associated axis. Table D-4 describes the various controls available in the motion control-related tabs.

The 

button, available within each tab, works the same as the **All Motors** 

button (all Scout-and-Scan Control System views, upper left).

NOTE Within the Scout-and-Scan Control System workflow, the motion controls included in **Load**, **Scout**, and **Scan** view are usually sufficient for most tasks.

Figure D-7 **Motion Control** Drop-Down Panel Tabs – **Homing Status**, **Source**, **Sample**, and **Detector**

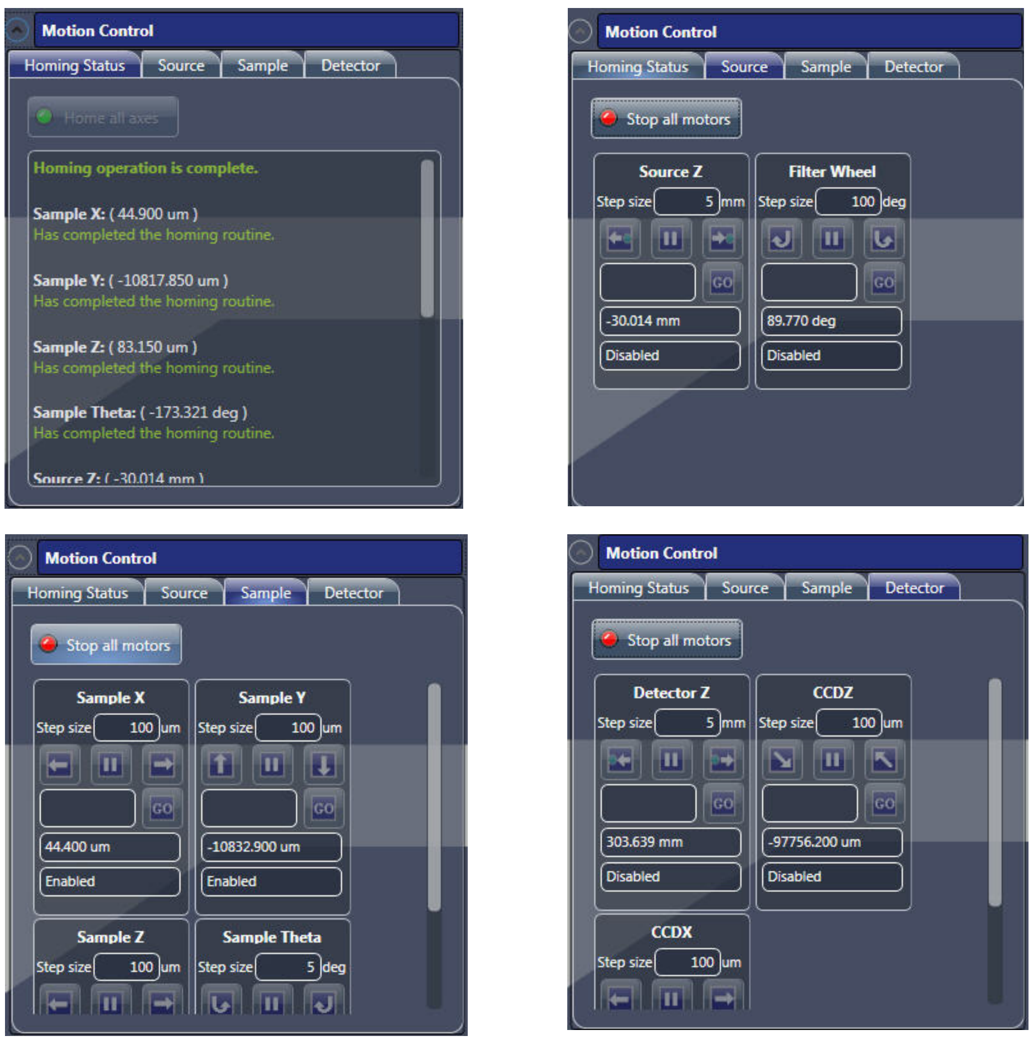


Table D-4 Scout-and-Scan Control System **Motion Control** Drop-Down Panel Controls

Control	Description
	Text box used to define the step size for relative motion associated with the currently selected axis (that is, motion relative to the axis' current position).
	Click to halt movement associated with the currently selected axis.
	Interface for absolute motion (that is, for moving to a specific location). Type a location in the text box, and then click  .
	Status field that indicates the axis' current position.
	Status field that indicates the axis' current status (Enabled or Disabled).
	Initiates motion in the positive direction for the **Sample X** axis. – Click once and release to jog the sample stage toward the access doors when Sample Theta is at 0° by the value indicated in the **Step size** text box – Click and hold to continuously move the sample stage toward the access doors when Sample Theta is at 0°, and then release the hold to stop sample stage movement
	Initiates motion in the positive direction for the **Sample Z** axis. – Click once and release to jog the sample stage toward the X-ray source when Sample Theta is at 0° by the value indicated in the **Step size** text box – Click and hold to continuously move the sample stage toward the X-ray source when Sample Theta is at 0°, and then release the hold to stop sample stage movement
	Initiates motion in the negative direction for the **Sample X** axis. – Click once and release to jog the sample stage away from the access doors when Sample Theta is at 0° by the value indicated in the **Step size** text box. – Click and hold to continuously move the sample stage away from the access doors when Sample Theta is at 0°, and then release the hold to stop sample stage movement.
	Initiates motion in the positive direction for the **Sample Z** axis. – Click once and release to jog the sample stage away from the X-ray source when Sample Theta is at 0° by the value indicated in the Step size text box – Click and hold to continuously move the sample stage away from the X-ray source when Sample Theta is at 0°, and then release the hold to stop sample stage movement

Table D-4 Scout-and-Scan Control System **Motion Control** Drop-Down Panel Controls (Continued)

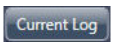
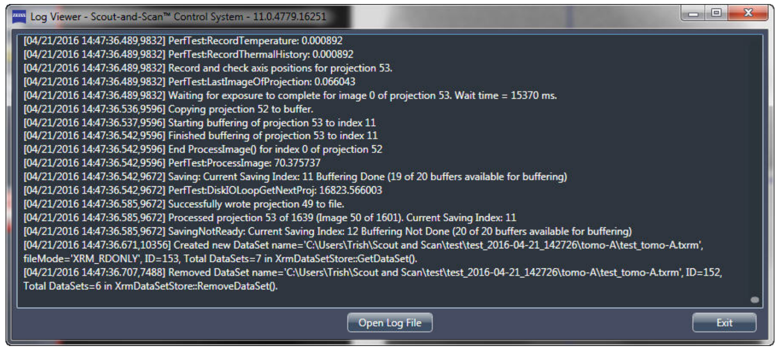
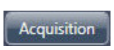
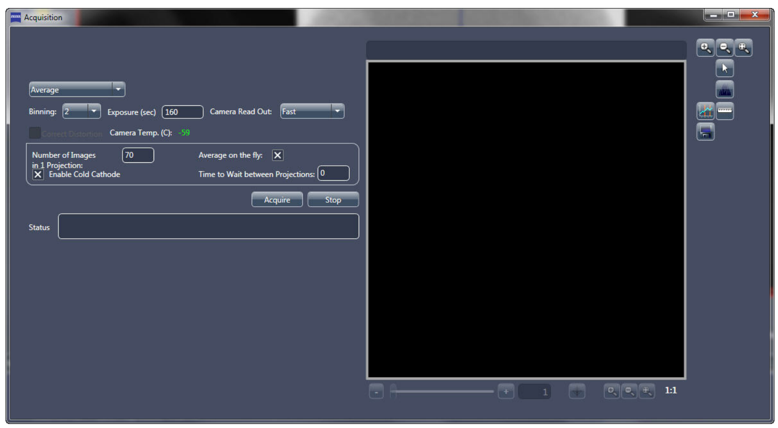
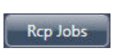
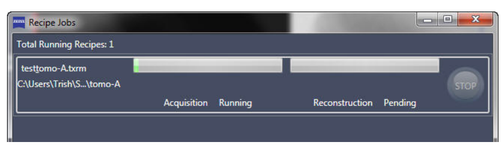
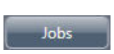
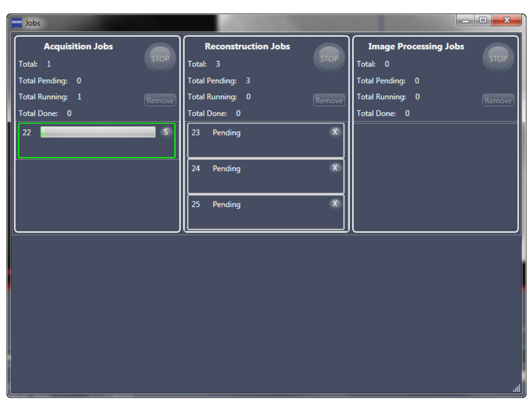
Control	Description
	Initiates motion in the negative direction for the **Sample Y** axis. – Click once and release to jog the sample stage UP (toward the top of the enclosure) by the value indicated in the **Step size** text box – Click and hold to continuously move the sample stage UP, and then release the hold to stop sample stage movement
	Initiates motion in the positive direction for the **Sample Y** axis. – Click once and release to jog the sample stage DOWN (toward the bottom of the enclosure) by the value indicated in the **Step size** text box – Click and hold to continuously move the sample stage DOWN, and then release the hold to stop sample stage movement
	Initiates COUNTERCLOCKWISE motion for the **Sample Theta** axis. – Click once and release to jog the sample stage COUNTERCLOCKWISE by the value indicated in the **Step size** text box – Click and hold to continuously move the sample stage COUNTERCLOCKWISE, and then release the hold to stop sample stage movement
	Initiates CLOCKWISE motion for the **Sample Theta** axis. – Click once and release to jog the sample stage CLOCKWISE by the value indicated in the **Step size** text box – Click and hold to continuously move the sample stage CLOCKWISE, and then release the hold to stop sample stage movement
	Initiates motion in the negative direction for the **Detector Z** axis. – Click once and release to jog the detector to the LEFT (toward the sample, represented by the **blue** dot in the button) by the value indicated in the **Step size** text box – Click and hold to continuously move the detector to the LEFT, and then release the hold to stop detector movement
	Initiates motion in the positive direction for the **Detector Z** axis. – Click once and release to jog the detector to the RIGHT (away from the sample, represented by the **blue** dot in the button) by the indicated in the **Step size** text box – Click and hold to continuously move the detector to the RIGHT, and then release the hold to stop detector movement
	Initiates motion in the positive direction for the **Source Z** axis. – Click once and release to jog the X-ray source to the LEFT (away from the sample, represented by the **blue** dot in the button) by the value indicated in the **Step size** text box – Click and hold to continuously move the X-ray source to the LEFT, and then release the hold to stop detector movement
	Initiates motion in the negative direction for the **Source Z** axis. – Click once and release to jog the X-ray source to the RIGHT (toward the sample, represented by the **blue** dot in the button) by the indicated in the **Step size** text box – Click and hold to continuously move the X-ray source to the RIGHT, and then release the hold to stop detector movement

Advanced Tools Drop-Down Panel

The **Advanced Tools** drop-down panel (refer to Figure D-8) provides control over various other Xradia Versa features. Use of these features is uncommon, but nevertheless provided for specialized circumstances. Table D-5 describes use of the **Current Log**, **Acquisition**, **Rcp Jobs**, and **Jobs** buttons. Should you need further details regarding these features or others not described in the table, contact the ZEISS Support Team. (Refer to “Technical Support,” on page 348 in Appendix L.)

Figure D-8 **Advanced Tools** Drop-Down Panel

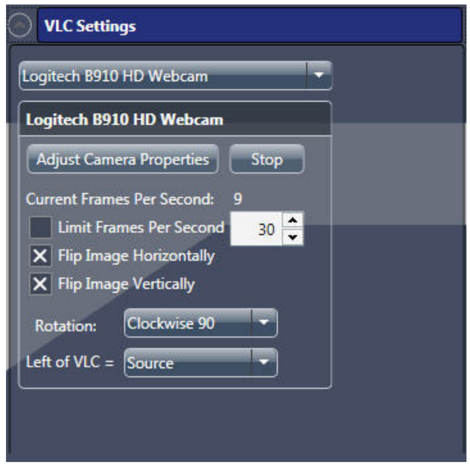
Table D-5 Scout-and-Scan Control System **Advanced Tools** Drop-Down Panel Controls

<table>
<tr><th>Tool</th><th>Description</th></tr>
<tr><td>
</td><td>Click to display the current user software log, which describes the Xradia Versa behavior.

</td></tr>
<tr><td>
</td><td>Click to enable manual image acquisition, similar in functionality to the Scout-and-Scan Control System's automatic image acquisition.

</td></tr>
<tr><td>
</td><td>Click to view the recipe-related jobs that are currently running.

</td></tr>
<tr><td>
</td><td>Click to view the status of jobs that are currently running.

</td></tr>
</table>

VLC Settings Drop-Down Panel

The **VLC Settings** drop-down panel (refer to Figure D-9) provides control over the visual light camera. Use of these features is uncommon. Should you need details regarding these features, contact the ZEISS Support Team. (Refer to “Technical Support,” on page 348 in Appendix L.)

Figure D-9 **VLC Settings** Drop-Down Panel



Workflow-Based Tabbed Views

The Scout-and-Scan Control System includes five workflow-based tabbed views that are used for acquiring tomographies:

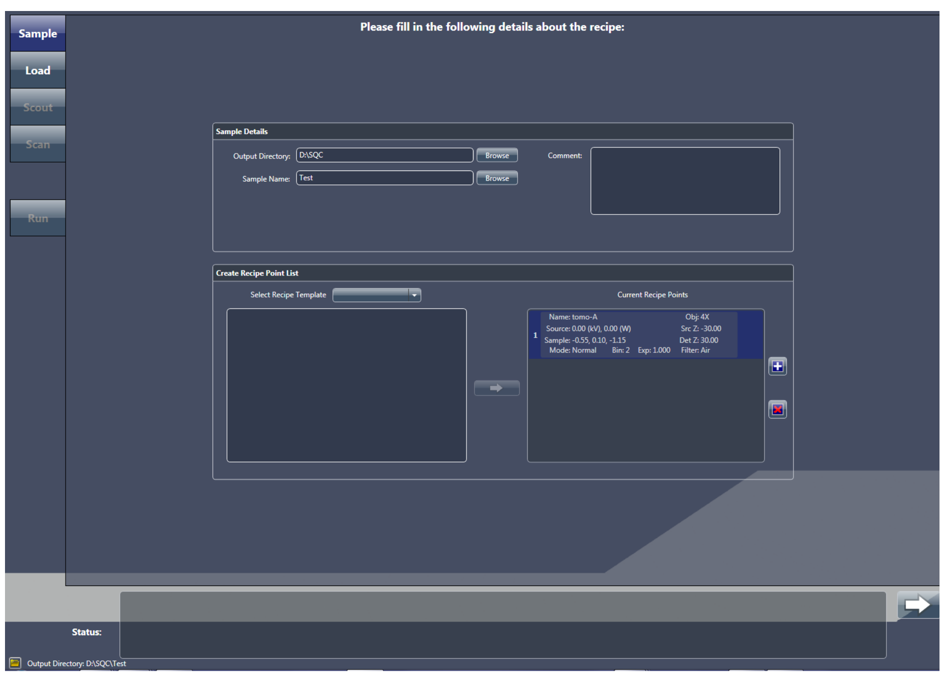
- Sample View
- Load View
- Scout View
- Scan View
- Run View

Sample View

NOTE Use of **Sample** view in the tomography collection process is described in “Step 1 – Sample,” on page 25 (new recipes) and “Step 1 – Sample,” on page 55 (existing recipes or recipe templates) in Chapter 2.

When the Scout-and-Scan Control System is started, the first view displayed is **Sample** view. (Refer to Figure D-10.) **Sample** view directs you to initialize the scan by defining the output directory, base file naming convention, and recipe points.

Figure D-10 Typical **Sample** View



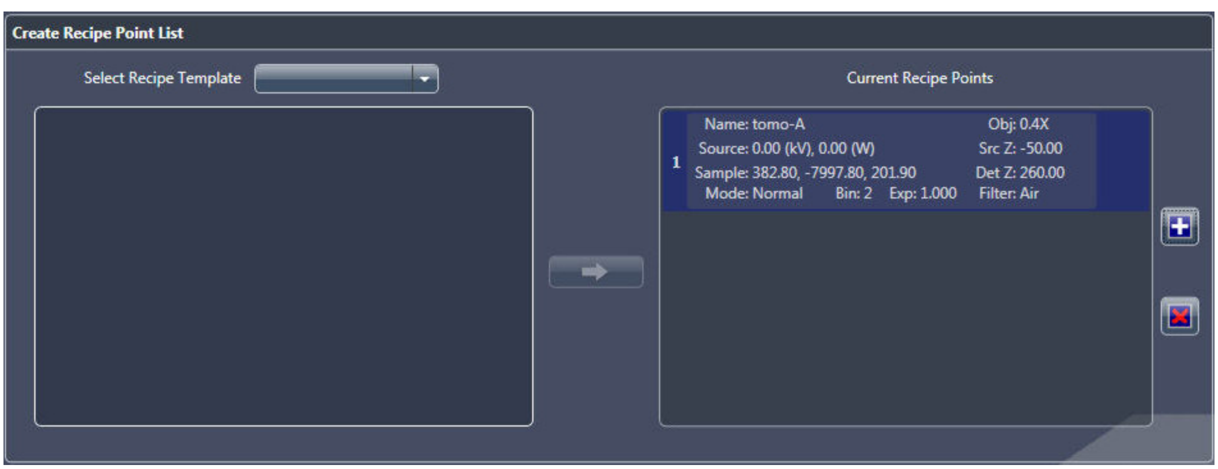
The **Sample Details** panel (refer to Figure D-11) within this view has two text boxes that accept user input:

- **Output Directory** – Defines the output directory (data folder) in which to store all scan data for the current recipe.
- **Sample Name** – Specifies the base file name to use for all recipe points within the recipe. A folder with this name will be created as a subfolder under the output directory (data folder).
- **Comment** – **Optional**. You can type general sample-related comments in this text box.

Figure D-11 **Sample Details** Panel in **Sample** View, Populated with Recipe-Related Information

The **Create Recipe Point List** panel within this view (refer to Figure D-12) allows you to create the initial recipe point(s), –or– open an existing recipe.

Figure D-12 **Create Recipe Point List** Panel, in Which You Can Create New Recipe Points –or– Import an Existing Recipe or Recipe Template



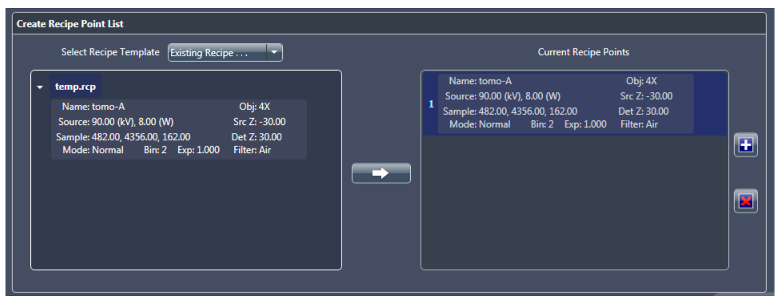
NOTE To proceed with the Scout-and-Scan Control System workflow, the recipe **must** include at least one recipe point.

- **Select Recipe Template** (optional) – This drop-down list box allows you to open a general template, the last edited recipe, or an existing recipe (*.*rcp* file) (refer to Figure D-13):
  - **General Templates** – Lists recipes that you can predefine for routine scan operations. This is not commonly used.
  - **Existing Recipe** – Opens an **.rcp* recipe file, from which individual recipe points can be imported.
  - **Last Edited Recipe** – Opens the last recipe that was edited in the Scout-and-Scan Control System.

Figure D-13 Importing Recipe Points from an Existing Recipe

Recipe – Click the recipe or recipe template to be run, and then click [arrow button] to add the recipe to the **Current Recipe Points** list

Recipe Points – Click [expand icon] (left of recipe), click the recipe point(s) to add, and then click [arrow button] to add each clicked recipe point to the **Current Recipe Points** list



- **Recipe point selection** (if a recipe template is selected above; refer to Figure D-13)) – Opening a recipe template lists all recipe points included in that recipe or recipe template.
  - To add all recipe points (entire recipe) to the recipe for the current scan, click the recipe or recipe template to be run (*.*rcp* file at the top of the list), and then click [arrow button]
  - To add one or more recipe points to the recipe for the current scan, click [expand icon] (left of recipe) to expand the list, click the recipe point(s) to add, and then click [arrow button]

Clicking [next button] (lower right of the view) advances to the next step in the process, Load View.

Load View

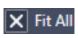
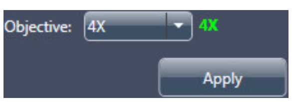
NOTE Use of **Load** view in the tomography collection process is described in "Step 2 – Load," on page 27 (new recipes) and "Step 2 – Load," on page 57 (existing recipes or recipe templates) in Chapter 2.

Load view (refer to Figure D-14) allows you to use visible light to coarsely position the sample on the rotation axis. To do this, you will change the position of the Sample Theta stage to align the coordinate system of the visual light camera to match that of the sample stage, which aligns the sample to the rotation axis in both the X ("front view") and Z ("side view") directions.

The visual light camera controls function the same as those described in Table D-3 on page 187. The motion control-related panels function the same as those described in Table D-4 on page 190. Table D-6 describes the remaining **Load** view controls.

Figure D-14 Typical **Load** View

Table D-6 **Load** View Controls

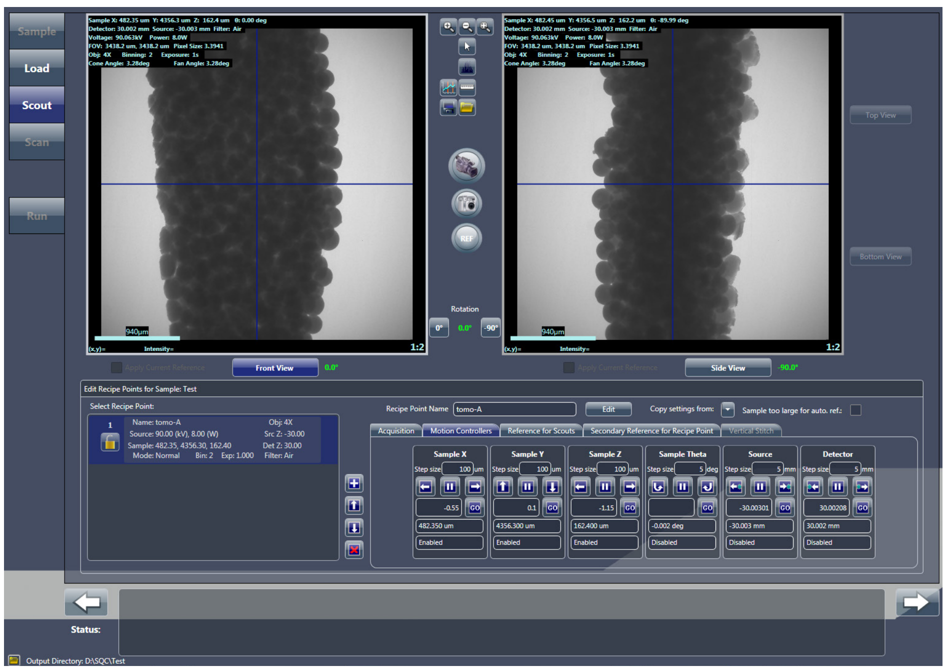
Control	Description
	**Note** The **blue** dot in the button represents the sample. Click to move the X-ray source and detector away from the sample stage. This should provide sufficient room in which to load the sample holder assembly on the sample stage. If not, click again until there is sufficient room. **NOTE** Useful when loading/removing the sample holder assembly on to/from the sample stage.
	– Select the check box to toggle ON the **red** crosshairs within the **Visual Light Camera** image display (default) – Clear the check box to toggle OFF the **red** crosshairs within the **Visual Light Camera** image display
	– Select the check box to adjust the **Visual Light Camera** image display to show the maximum vertical area (default). **NOTE** Useful during sample positioning, because the sample base is visible within the display. – Clear the check box adjust the **Visual Light Camera** image display to show a zoomed view of the X-ray source, sample FOV, and detector.
	From the drop-down list box, select the objective with which to focus on the sample. Click **Apply** to rotate the selected objective (with the exception of the 0.4X objective, which is stationary) to the lowest point on the motorized turret. The currently selected objective appears in **green**, and blinks **red** when the selected objective is being moved into position.
	Clicked to stop all motion when a motion controller starts moving to an unexpected location and/or collision is imminent.

Scout View

NOTE Use of **Scout** view in the tomography collection process is described in "Step 3 – Scout," on page 31 (new recipes) and "Step 3 – Scout," on page 61 (existing recipes or recipe templates) in Chapter 2.

After the ROI is coarsely identified in **Load** view, the next step is to finely align the ROI and determine the necessary imaging parameter values in **Scout** view. (Refer to Figure D-15.) Individual options are explained in the subsections that follow.

Figure D-15 Typical **Scout** View



Front, Side, Top, and Bottom View Image Displays

The **Front** and **Side View** image displays (refer to Figure D-15) collect and display scouted sample image data. The displays are used when centering the sample's ROI and FOV on the **Sample X** and **Y** axes. When performing a vertical stitch, click [Top View] and [Bottom View] to toggle between the **Top** and **Bottom View** display images, respectively, within the **Front** and **Side View** display images (Sample Theta is at 0° or -90°, respectively.

Table D-7 lists the image display controls.

Table D-7 **Scout** View Image Display Controls

Control	Description
	Click to start continuous imaging at the current Sample Theta position in the active image display. **NOTE** The button changes to  during imaging, which can be clicked to halt imaging.
	Click to acquire a single image at the current Sample Theta position in the active image display. **NOTE** The button changes to  during imaging, which can be clicked to halt imaging.
	Click to collect a reference at the current Sample Theta position in the active image display. **NOTE** The button changes to  during imaging, which can be clicked to halt imaging.
☒ Apply Current Reference	Activated after collecting a reference at the current Sample Theta position in the active image display (0° for **Front View** or -90° for **Side View**). – Select to apply the current reference to the appropriate active image display on-the-fly – Clear to **not** apply the reference to an image display **NOTE** This option can be used to see the effect of a reference on the acquired image in the active display by selecting and clearing the check box. **NOTE** Selecting this option does **not** save the reference or apply reference correction. The option simply collects measurements and lets you see the effect of a reference on the acquired image.

Select Recipe Point Area

The **Select Recipe Point** area (refer to Figure D-16) allows you to select a recipe point to scout within the recipe. When a recipe point is selected, its name appears The selected point's name appears in the **Recipe Point Name** text box. Table D-8 lists the **Select Recipe Point** area controls.

NOTE When parameter values for the image displayed in the active image display differ from those in the recipe, the differing values appear in **red** within the listed recipe point.

NOTE Each recipe point within a recipe must have a unique name. Typically, each recipe point will already have a unique name.

Figure D-16 **Select Recipe Point** Area

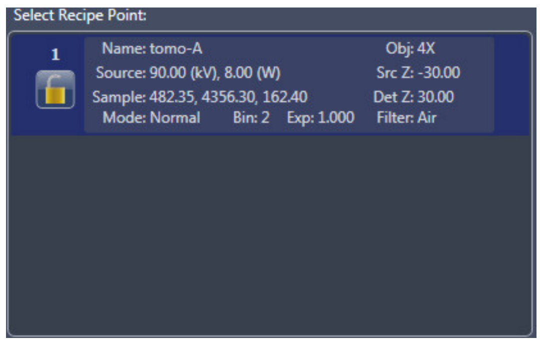
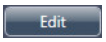
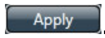
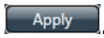
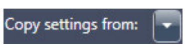
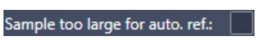


Table D-8 **Scout** View **Select Recipe Point** Area Controls

Control	Description
	Lists the currently selected recipe point.
	Click if the recipe point's name is not unique (that is, the name appears in **red**), –or– if you want to change the recipe point's name. The button label changes to  . Type a new name in the **Recipe Point Name** text box, and then click  . The new recipe point name appears in the **Recipe Point Name** text box, as well as in the **Select Recipe Point** area.
	Click after clicking a recipe point to lock the selected recipe point and protect its parameter values from being changed. **NOTE** The button changes to  after the recipe point is locked, which can be clicked to unlock the recipe point. **NOTE** A lock watermark appears behind a recipe point to indicate that the recipe point is locked.
	After clicking a recipe point, click the drop-down list box to select the sequence number of the recipe point whose parameter values you want to copy. All parameter values are copied, including the copied recipe point's **Scan** view parameter values (existing recipes and recipe templates only).
	Select the check box if the sample is too large to be moved out of the FOV when collecting a reference. When selected, you will be prompted to remove the sample, and a reference will be collected before starting a tomography. **NOTE** All recipe points within the recipe must use the same objective when this check box is selected.

Acquisition Tab

The **Acquisition** tab (refer to Figure D-17) provides the ability to change the recipe point's objective, binning, exposure time, X-ray source's filter, voltage, and power, and field mode. Table D-9 defines each **Acquisition** tab parameter and control.

NOTE For general-purpose imaging applications, it is recommended to use an exposure time that produces an **Intensity** value of at least 5000 throughout the sample. Increasing the binning value (for example, from *1* to *2*) increases the **Intensity** value per pixel by the square of the binning increase. Increasing the binning value also increases the pixel size by a factor equal to the binning increase, thereby potentially reducing spatial resolution. To test imaging parameter values or imaging modes, set up the desired parameter values in the **Acquisition** tab, click **Apply**, and then use single and/or continuous image acquisition to test the result.

NOTE Current parameter values appear in **green** and blink **red** after clicking **Apply** while the updated parameter value is being applied to the recipe. Wait until the parameter value stops blinking and changes back to **green** before attempting to proceed to the next workflow task.

Figure D-17 Typical **Acquisition** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel

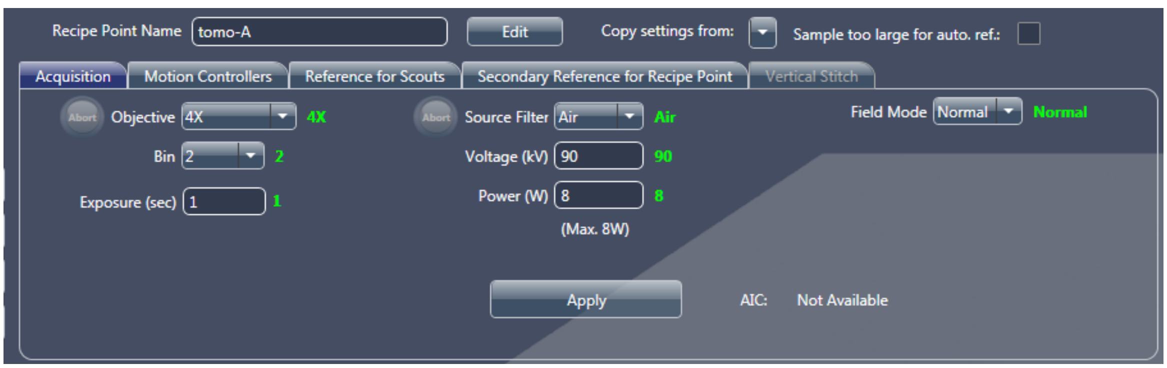


Table D-9 **Scout** View **Acquisition** Tab Parameters/Controls

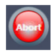
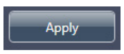
Parameter/ Control	Description
Objective	From the drop-down list box, select the objective to use for the selected recipe point. **NOTE**  is enabled when the objective is being changed. Click to immediately halt the motorized turret from rotating if the turret and/or one of its objectives looks like it is about to collide with another object.
Bin	From the drop-down list box, select the binning value (*1*, *2*, *4*, or *8*) for the detector to apply to the selected recipe point. For example, when binning is set to *2*, a tile of four native pixels is summed. The number of pixels in the acquired image will then be reduced by a factor of 4.
Exposure (sec)	In the text box, type a length of time (typically 10 or less, in units of seconds) for which you want to expose the selected recipe point to light.
Source Filter	From the drop-down list box, select the source filter to be used/in use. – **Xradia 520 Versa** – Filter selection changes the filter on the automated filter changer (after clicking **Apply**) when the recipe is run. – **Xradia 510 Versa and Xradia 410 Versa** – Filter selection logs the correct filter into the recipe, for future reference/informational purposes only. You must manually place the filter in front of the X-ray source to use the correct filter. **NOTE** Table 2-4, "0.4X and 4X Source Filter Selection," on page 46 and Table 2-5, "10X, 20X, and 40X Source Filter Selection," on page 47 provide guidelines for source filter selection, based on the scouted image's **Transmission** value. **NOTE** **Xradia 510 Versa and Xradia 410 Versa –** Instructions for replacing the source filter are provided in Appendix F, "Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa." **NOTE** **Xradia 520 Versa –**  is enabled when the source filter is being changed. Click to immediately halt the automated filter changer from rotating if the automated filter changer and/or one of its filters looks like it is about to collide with another object.
Voltage (kV)	In the text box, type the X-ray source voltage to use for the selected recipe point, using the following guidelines: – *80 kV* Use for thin or low-density samples – *140 kV* For thick or high-density samples
Power (W)	**Xradia 520 Versa and Xradia 510 Versa –** It is recommended to always use the maximum power available for the given voltage. Power can be calculated as follows: – W = (kV / 10) - 1 Use for 30 to 110 kV – *10W* Use for 120 to 160 kV **Xradia 410 Versa –** For highest throughput, the maximum power available is recommended. For high resolution scans (less than 2 µm), sometimes the use of lower power (6W) can help with image quality.

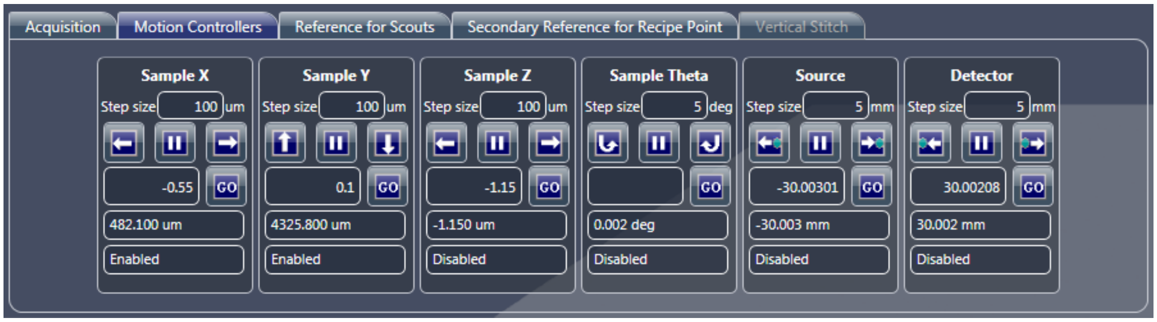
Table D-9 **Scout** View **Acquisition** Tab Parameters/Controls (Continued)

Parameter/ Control	Description
Field Mode	From the drop-down list box, select the field mode: – *Normal* Use for Normal Field mode (default) – *Wide* Use for Wide Field mode (refer to “Wide Field Mode,” on page 271 in Appendix G for details) – *Stitch* Use for Vertical Stitch Field mode (refer to “Vertical Stitching,” on page 287 in Appendix G for details) – *Wide Stitch* Use for Wide Stitch Field mode (refer to “Setting up Vertical Stitch Tomographies,” step 8, on page 300 in Appendix G for details)
	Click to confirm and apply the **Scout** view selections. **NOTE** This button **must** be clicked prior to collecting the first scouted image, even if the default parameter values are to be accepted.

Motion Controllers Tab

The **Motion Controllers** tab (refer to Figure D-18) provides positioning capabilities for the **Sample X**, **Y**, **Z**, and **Theta**, **Source**, and **Detector** axes. The motion control-related panels function the same as those described in Table D-4 on page 190.

Figure D-18 In the **Motion Controllers** Tab, Absolute Motion Control Fields are Populated with the Motor Positions that Correspond to the Region of Interest; Clicking **GO** for Each Axis Drives the Motors to Center the Selected Region of Interest



Reference for Scouts Tab

The **Reference for Scouts** tab (refer to Figure D-19) defines the auto reference collection and reference application parameter values. Table D-10 defines each **Reference for Scouts** tab parameter and control.

NOTE Use of the **Reference for Scouts** tab is described in "Selecting the Correct Source Filter to Use for the Secondary Reference," step 2, on page 280 in Appendix G.

Figure D-19 Typical **Reference for Scouts** Tab within **Scout** View

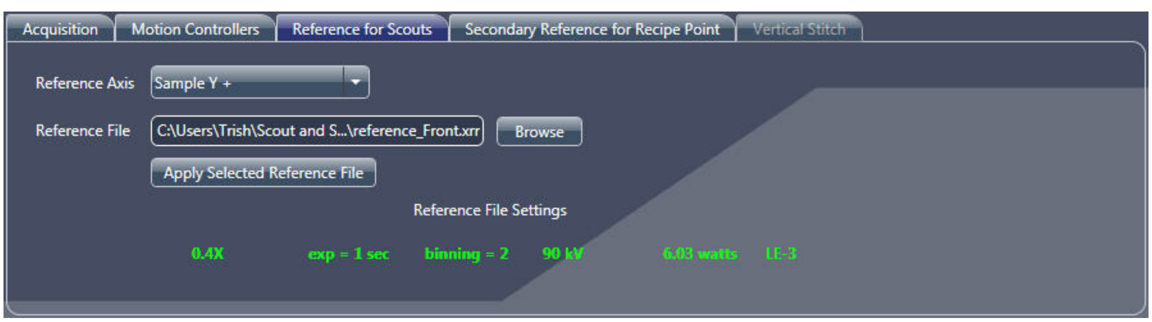
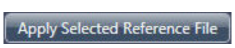


Table D-10 **Scout** View **Reference for Scouts** Tab Parameters/Controls

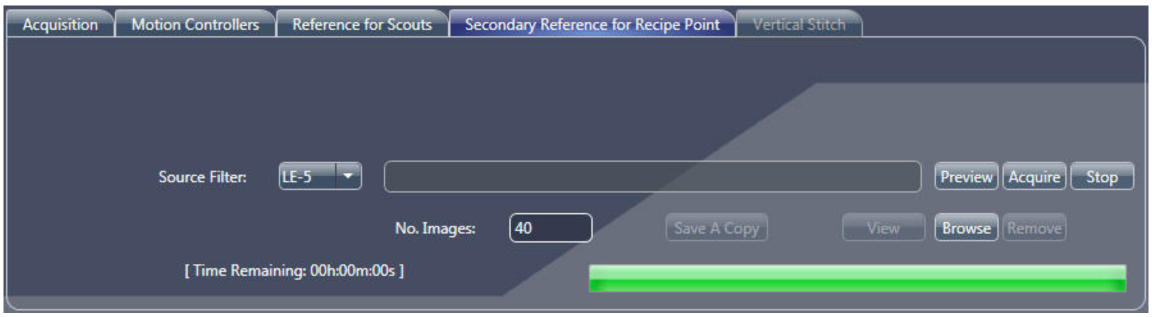
Parameter/Control	Description
Reference Axis	From the drop-down list box, select to where the selected sample axis should move while collecting a reference: – *Sample X+* Moves the **Sample Theta** axis to 0°, and then moves the **Sample X** axis to its positive limit. Useful for large samples in which the height above the ROI is greater than the travel available to the Sample Y stage. – *Sample X-* Moves the **Sample Theta** axis to 0°, and then moves the **Sample X** axis to its negative limit. Useful for large samples in which the height above the ROI is greater than the travel available to the Sample Y stage. – *Sample Y+* Moves the **Sample Y** axis to the positive (“most downward”) limit. Useful for ROIs that are far from the tip of the sample. – *Sample Z-* Moves the **Sample Theta** axis to -90°, and then moves the **Sample Z** axis to its negative limit. Useful for large samples in which the height above the ROI is greater than the travel available to the Sample Y stage. – *Sample Z+* Moves the **Sample Theta** axis to -90°, and then moves the **Sample Z** axis to its positive limit. Useful for large samples in which the height above the ROI is greater than the travel available to the Sample Y stage.
Reference File	This text box is populated with the automatically collected reference file name. **NOTE** If a previous reference exists, it can be specified here by clicking **Browse** and then browsing to and selecting that reference file.
	If a reference has been collected and the displayed image has been updated (but the previous reference is still valid), click to apply the reference listed in the **Reference file** text box to the active image display.

Secondary Reference for Recipe Point Tab

The **Secondary Reference for Recipe Point** tab (refer to Figure D-20) helps you select a source filter that matches the sample's beam hardening effects and then acquire a secondary reference.

NOTE Use of the **Secondary Reference for Recipe Point** tab is described in "Selecting the Correct Source Filter to Use for the Secondary Reference," step 3, on page 281 and "Collecting a Secondary Reference," on page 283 in Appendix G.

Figure D-20 Typical **Secondary Reference for Recipe Point** Tab within **Scout** View

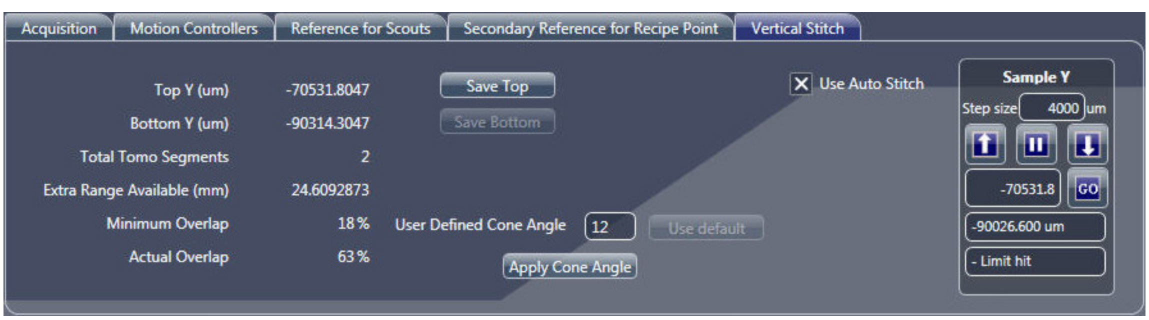


Vertical Stitch Tab

The **Vertical Stitch** tab (refer to Figure D-21) guides you through the vertical stitch process.

NOTE Use of the **Vertical Stitch** tab is described in "Vertical Stitching," on page 287 in Appendix G.

Figure D-21 Typical **Vertical Stitch** Tab within **Scout** View

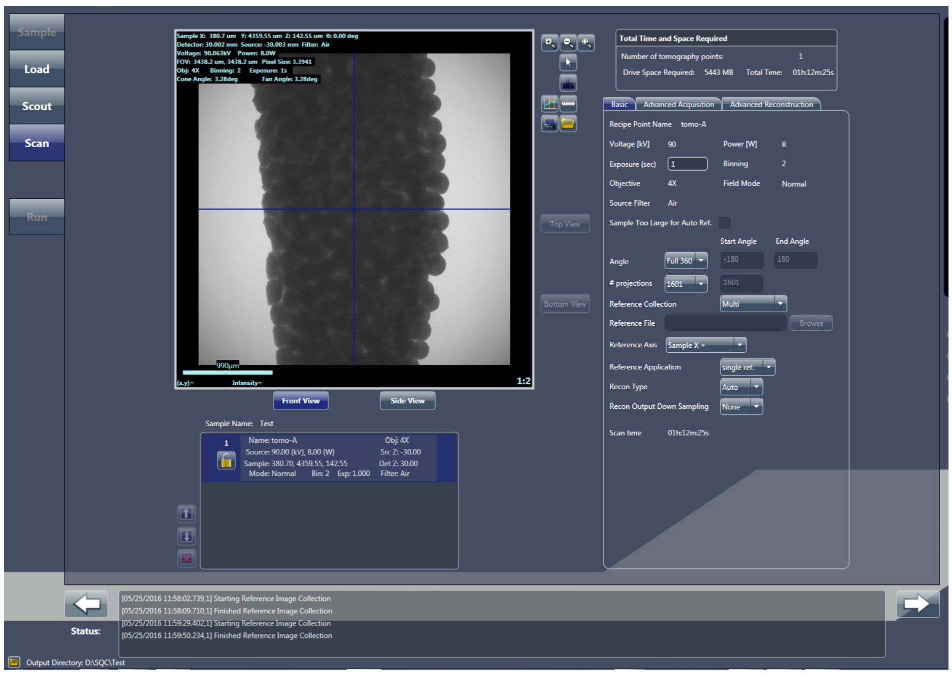


Scan View

NOTE Use of **Scan** view in the tomography collection process is described in “Step 4 – Scan,” on page 50 (new recipes only).

While **Scout** view is used to set up the exposure parameters for each image within each tomography, **Scan** view (refer to Figure D-22) is used to set up the general acquisition parameter values.

Figure D-22 Typical **Scan** View



Front, Side, Top, and Bottom View Image Displays

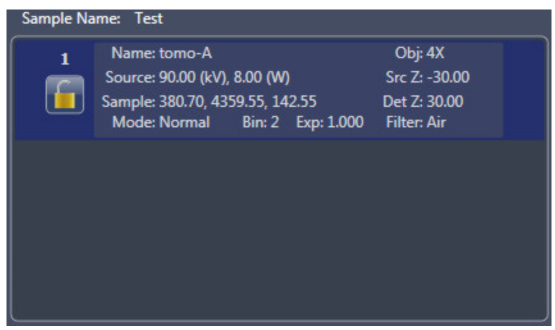
The **Scan** view image display contains the front and side view images (and top and bottom view, if performing a vertical stitch), stored from **Scout** view.

Click Front View and Side View to toggle between the **Front** and **Side View** display images, respectively. When performing a vertical stitch, click Top View and Bottom View to toggle between the **Top** and **Bottom View** display images, respectively, within the **Front** and **Side View** display images (Sample Theta is at 0° or -90°, respectively.

Recipe List Panel

Click each recipe point within the **Recipe List** panel (refer to Figure D-23), and then individually set up the point's settings in the Basic Tab, and **optionally** in the Advanced Acquisition Tab and Advanced Reconstruction Tab, as needed. Note that each recipe point is set up, by default, with the default Acquisition mode's settings and might benefit from changing the parameter values.

Figure D-23 **Recipe List** Panel in **Scan** View

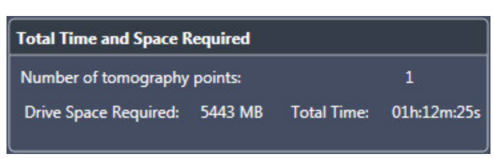


Total Time and Space Required Panel

The **Total Time and Space Required** panel (refer to Figure D-24) displays the total time and hard disk drive space required to complete data acquisition for all tomography (recipe) points within the recipe.

NOTE The time and space values do **not** include Reconstruction time when **Recon Type** = *Auto* in the Basic Tab.

Figure D-24 **Total Time and Space Required** Panel Summarizes the Time and Space Needed for the Entire Recipe



Basic Tab

The **Basic** tab (refer to Figure D-25) includes basic scan parameters that can be applied to unlocked recipe points. Table D-11 defines the editable **Basic** tab parameters.

NOTE The **Voltage [kV]**, **Power [W]**, **Binning**, **Objective**, **Field Mode**, **Source Filter**, and **Sample too Large for Auto Ref.** parameters are informational only (that is, the parameters are **not** editable). If their values need adjustment, adjust the parameters in Scout View. **Scan Time**, although not editable, changes on-the-fly, based on the selected parameter values.

Figure D-25 Typical **Basic** Tab within **Scan** View

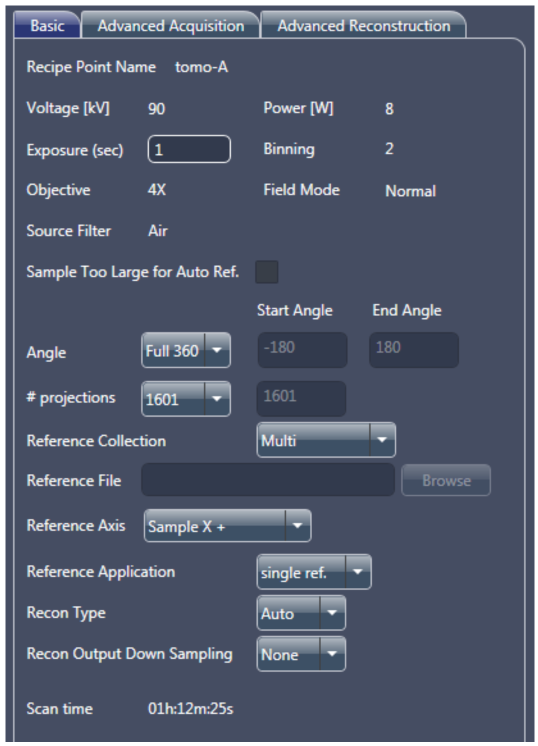


Table D-11 Editable **Scan** View **Basic** Tab Parameters

Parameter	Description/Function
Exposure (sec)	In the text box, type an exposure time, in seconds. Use the same exposure time previously specified in **Scout** view, or type a new time value.
Angle	From the drop-down list box, select the type of angle to scan: – *Full 360* Sets the start and end angles to *-180* and *180*, respectively – *180+ fan* Sets the start and end angles to *-90+fan* and *90+fan*, respectively **NOTE** Fan angle is determined by the objective currently in use and the X-ray source and detector positions. Produces the fewest views needed for reconstruction to be completed without creating artifacts due to missing projections. – *Custom* Type the start and end angles in their respective text boxes.
# projections	From the drop-down list box, select the number of projections to collect: – *201* – *1601* – *401* – *3201* – *801* – *Custom* If you select *Custom*, type a number in the text box. **NOTE** When using *Custom*, it is recommended that the value be a multiple of 20 plus 1 so that AMC can be acquired. For example, for interior tomographies, the recommended number of projections to collect is *2001*, allowing AMC to be acquired at every 100th projection, as follows: $(2001 - 1) / 20 = 100$
Reference Collection	From the drop-down list box, select the type of reference to collect: – *None* – *Single* – *Use File* – *Multi* If you select *Use File*, an **Open** dialog box opens from which you can select a previously saved **.xrm* reference file.
Reference File	Click **Browse** and then browse to and select a previously saved **.xrm* reference file. Enables you to select a reference file to use and/or change the reference file previously selected *Use File* from the **Reference Collection** drop-down list box.
Reference Axis	From the drop-down list box, select to where the selected sample axis should move while collecting a reference: – *Sample X+* – *Sample Z-* – *Sample X-* – *Sample Z+* – *Sample Y+* **NOTE** Same function as described in Table D-10 on page 208.

Table D-11 Editable **Scan** View **Basic** Tab Parameters (Continued)

Parameter	Description/Function
Reference Application	From the drop-down list box, select the Reference Application mode: – *no ref.* – *single ref.* – *multi-ref.*
Recon Type	From the drop-down list box, select the type of reconstruction: – *Auto* Reconstruction is automatically run on the recipe point after data collection is complete, as part of the recipe run process – *Manual* Select if you need to use Reconstructor to manually reconstruct the tomography dataset later
Recon Output Down Sampling	Enabled when **Recon Type** = *Auto*. From the drop-down list box, select the downsampling (binning) value to use during reconstruction: – *None* (recommended) – *2* – *4*

Advanced Acquisition Tab

The **Advanced Acquisition** tab (refer to Figure D-26) includes optional advanced scan parameters that can be applied to unlocked recipe points. Table D-12 defines the editable **Advanced Acquisition** tab parameters.

NOTE Use of the **Advanced Acquisition** tab is featured throughout Appendix G, "Advanced Features."

NOTE **Scan Time** changes on-the-fly, based on the selected parameter values.

Figure D-26 Typical **Advanced Acquisition** Tab within **Scan** View

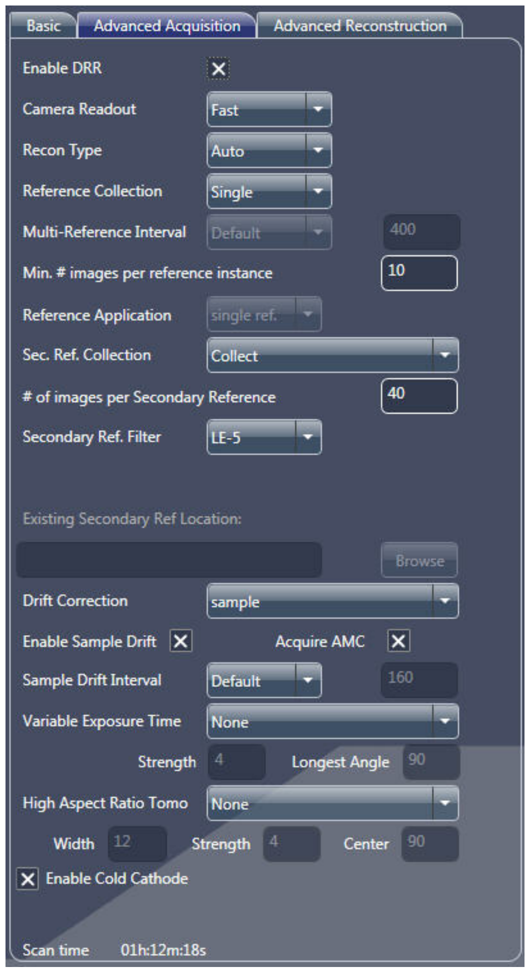


Table D-12 Editable **Scan** View **Advanced Acquisition** Tab Parameters

Parameter	Description/Function
Enable DRR	Select the check box to enable Dynamic Ring Removal (DRR; recommended), which reduces the number of rings around the image ROI. Useful when too many rings obscure the image ROI.
Camera Readout	From the drop-down list box, select the camera readout speed: – *Fast* (recommended) – *Precision*
Recon Type	Same function as in Basic Tab.
Reference Collection	Same function as in Basic Tab.
Multi-Reference Interval	From the drop-down list box, select the number of projections between references being collected: – *Default* (25% of the total number of projections) – *Custom* If you select *Custom*, type a number in the text box.
Min. # images per reference instance	In the text box, type a number of references to average.
Reference Application	Same function as in Basic Tab.
Sec. Ref. Collection[a]	From the drop-down list box, select whether to collect a secondary reference: – *None* – *Use file* – *Collect*
# of images per Secondary Reference[a]	Type a number of secondary references to collect (*40* or more). Enabled when **Sec. Ref. Collection** = *Collect*.
Secondary Ref. Filter[a]	From the drop-down list box, select the source filter to use for the secondary reference if it is not already selected. Enabled when **Sec. Ref. Collection** = *Collect*.
Existing Secondary Ref Location[a]	Click **Browse** and then browse to and select a previously saved **.xrm* secondary reference file. Enabled when **Sec. Ref. Collection** = *Use file*.
Drift Correction[b]	From the drop-down list box, select the type of drift correction to apply: – *none* – *sample* – *source* – *temperature* – *Adaptive Motion Compensation*
Enable Sample Drift[b]	The check box is selected by default to enable sample drift collection.
Acquire AMC[b]	The check box is selected by default to enable AMC collection.

Table D-12 Editable **Scan** View **Advanced Acquisition** Tab Parameters (Continued)

Parameter	Description/Function
Sample Drift Interval[b]	From the drop-down list box, select the sample drift interval: – *Default* (every 10% of the total number of projections) – *Custom* If you select *Custom*, type an interval in the text box.
Variable Exposure Time	From the drop-down list box, select the variable exposure time: – *None* – *Custom* – *Default* – *Browse* If you select *Custom*, type strength and longest angle parameter values in their respective text boxes. Useful for high aspect ratio samples, such as for HART. This parameter increases the exposure along the sample's long axis, and reduces the exposure along the sample's thin side.
High Aspect Ratio Tomo[c]	**Xradia 520 Versa only** – From the drop-down list box, select whether to enable HART: – *None* – *Default* – *Custom* If you select *Custom*, type width, strength, and center parameter values in their respective text boxes.
Enable Cold Cathode	The check box is selected by default (recommended), which enables an Cold Cathode mode, an X-ray source mode of operation that increases the X-ray source's life span.

a. **Secondary reference-related parameters** – Refer to "Using a Filtered Secondary Reference for Ring Artifact Reduction," on page 276 in Appendix G for further details.
b. **Drift-related parameters** – Refer to "Correcting for System-Related Drift," on page 310 in Appendix G for further details.
c. **HART-related parameters** – Refer to "High Aspect Ratio Tomography – Xradia 520 Versa," on page 258 in Appendix G for further details.

Advanced Reconstruction Tab

The **Advanced Reconstruction** tab (refer to Figure D-27) is enabled when **Recon Type** = *Auto* in the Basic Tab. Table D-13 defines the **Advanced Reconstruction** tab parameters as they relate to auto reconstruction.

NOTE Use of the **Advanced Reconstruction** tab is featured in "Adding the Secondary Reference to the Recipe," on page 285 in Appendix G.

Figure D-27 Typical **Advanced Reconstruction** Tab within **Scan** View

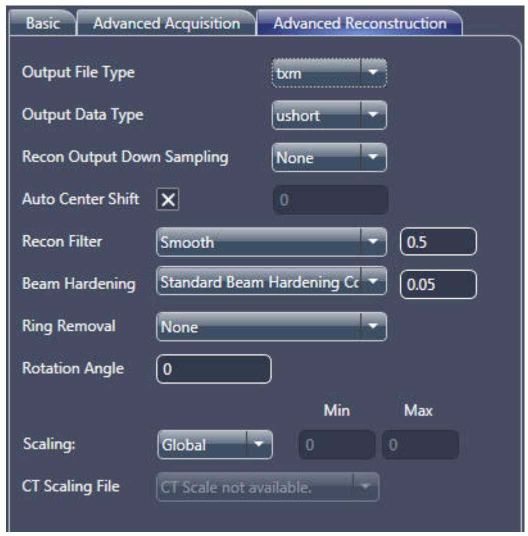


Table D-13 **Scan** View **Advanced Reconstruction** Tab Parameters

Parameter	Description/Function
Output File Type	From the drop-down list box, select the output file type: – *txm* (default; ZEISS proprietary) – *dicom* – *tiff* – *bin*
Output Data Type	From the drop-down list box, select the output data type: – *uchar* 8 bit – *ushort* 16 bit (default) – *float* 32 bit
Recon Output Down Sampling	Same function as in Basic Tab.

Table D-13 **Scan** View **Advanced Reconstruction** Tab Parameters (Continued)

Parameter	Description/Function
Auto Center Shift	Select to enable automatic center shift, –or– clear and then type a center shift value in the text box.
Recon Filter[a]	From the drop-down list box, select *Smooth*. In the text box, type a kernel size of *0.5* or *0.7*, as follows: – *0.5* is recommended for **Binning** = *2* acquisitions – *0.7* is recommended for **Binning** = *1* acquisitions **NOTE** The **Recon Filter** value is objective- and sample-dependent. Determine which software filter provides the most satisfactory balance between image resolution and noise (through your own experience). Using the correct software filter provides for significant noise reduction, but has a minimal impact on resolution. **NOTE** **Do not use the Sharp (Shepp-Logan) recon filter option.**
Beam Hardening	From the drop-down list box, select the type of beam hardening to apply and then type the beam hardening (BH) constant (typically a value between 0 and 0.5 for most samples) in the text box. – *9.x Standard Beam Hardening Correction* – *Standard Beam Hardening Correction* (default BH constant is 0.5) – *Beam Hardening Correction for very low transmission*
Ring Removal	From the drop-down list box, select the type of ring removal to apply: – *None* Use when Dynamic Ring Removal (DRR) is enabled. No rings will be removed. – *Low contrast* When DRR is disabled, apply 8-section ring removal for bone, rock, plastic, carbon composite, or composite material samples. – *High contrast* When DRR is disabled, apply 3-section ring removal for high-contrast samples, such as semiconductors, or if the other two parameter values do not apply. **NOTE** Select *None* for all but rare cases in which DRR is off during tomography acquisition. Neither of the ring removal corrections is necessary for most scans. **NOTE** The *High contrast* ring removal option sometimes adds rings when regularly repeating high-contrast features are present in the sample.
Rotation Angle[b]	In the text box, type an angle at which you want to view the rotation of the axial slices (looking at the sample from the top and then down) within the tomography data. *0* (0°) is the default. **NOTE** Sample rotation is useful when a specific slice orientation within the axial plane is needed. This is especially useful when dealing with flat samples to increase slice orthogonality.

Table D-13 Scan View **Advanced Reconstruction** Tab Parameters (Continued)

Parameter	Description/Function
Scaling	From the drop-down list box, select the type of byte scaling to apply: – *Global* – *Custom* If you select *custom*, type min and max values in their respective text boxes.
CT Scaling File	Available when scaling is setup for this acquisition. A drop-down list box will appear with available scalings.

a. **Recon Filter drop-down list box and text box –** The Gaussian Smooth filter reduces high-frequency image noise by convolving the image with a 3D Gaussian function. There is typically a corresponding reduction in image detail or resolution; however, most high-resolution images acquired using the 20X or optional 40X objective have more than one pixel per spatial resolution element. Therefore, the reduction in resolution is minimal, with significant improvements in noise when the image is Gaussian-smoothed with a standard deviation between 0.5 and 1.

b. "Changing the Rotation Angle," on page 96 in Chapter 3, in its description of changing the angle during the manual reconstruction process, provides more in-depth information related to rotation angle.

Run View

NOTE Use of **Run** view in the tomography collection process is described in "Step 5 – Run," on page 52 (new recipes) and "Step 5 – Run," on page 69 (existing recipes or recipe templates) in Chapter 2.

After the scan settings are all defined, **Run** view (refer to Figure D-28) is used to start (run) the scan. **Run** view lists all the recipe points within the recipe. Table D-14 lists and describes most **Run** view controls.

Figure D-28 Typical **Run** View

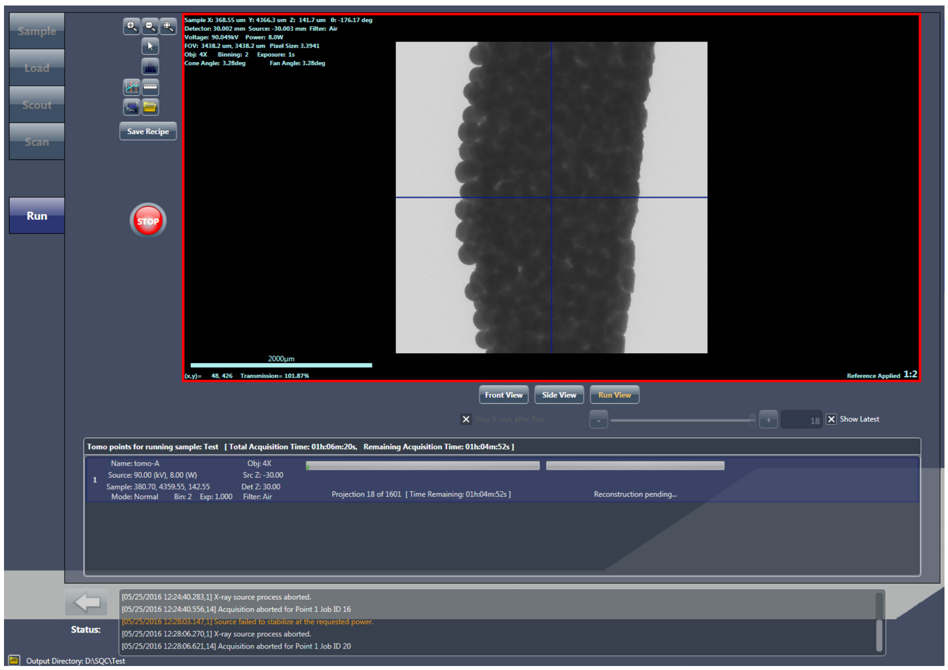


Table D-14 **Run** View Controls

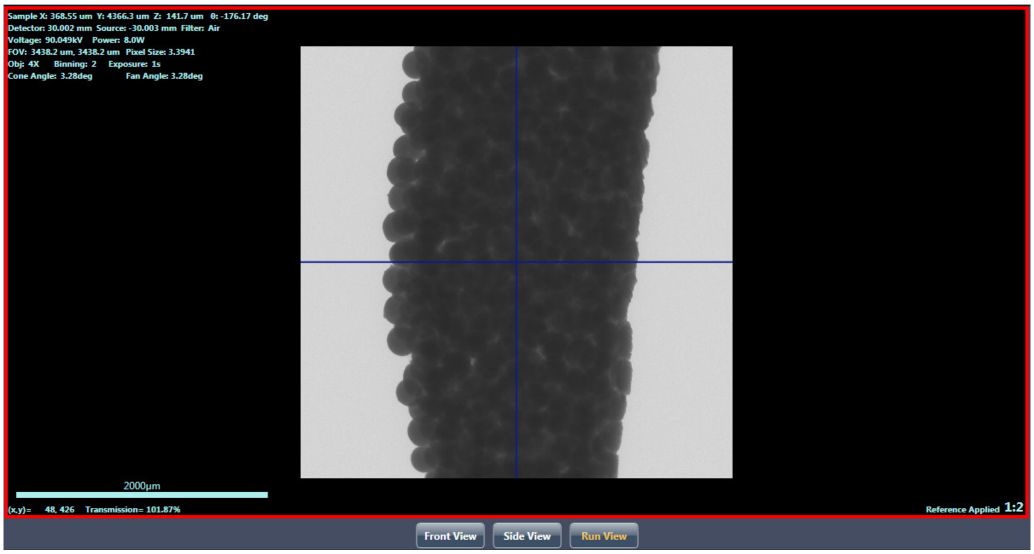
Option	Description
	Saves the recipe so that it can be run again at a later date.
	Starts the recipe with the first recipe point that is listed in the **Tomo points for running sample** panel.R
	Immediately stops data acquisition. Available only after starting a scan.
	Select the check box to automatically turn OFF the X-ray source after the recipe finishes running. Useful to help extend the life of the X-ray source, or conserve power if the X-ray source is not needed for an extended period of time after running the recipe. **NOTE** **Unavailable** after the recipe starts running.
Refer to Figure D-29	The **Projection Navigation** slider allows you to navigate the acquisition in-progress. By default, the **Show Latest** check box is selected. Clearing the **Show Latest** check box allows you to use the slider to navigate the acquired projections.

Figure D-29 **Run** View **Projection Navigation** Slider and **Show Latest** Check Box

Front, Side, and Run View Image Display

The image display shows the projection currently being acquired for the currently selected recipe point, by default, in Run View. You can also see the previously scouted projection with Sample Theta at 0° and -90°in Front View and Side View, respectively.

Figure D-30 **Run** View Image Display, Defaulted to **Run View**



Tomo points for running sample Panel

The **Tomo points for running sample** panel indicates the following status for each tomo (recipe) point:

- Tomography acquisition
- Auto reconstruction (when auto reconstruction is enabled)
- Stitching status (when Stitch or Wide Stitch Field mode is selected)

Select a recipe point to view its scouted and acquired projection images in the active image display. If the recipe is currently running, each projection can be viewed as it is acquired, when 

(default) is selected as the active image display. (Refer to Figure D-30.) Previously acquired projections can also be viewed after the recipe finishes running, by clicking the recipe point.

Figure D-31 shows both an in-progress status (upper image) and complete status (lower image) for multiple recipe points. After the scans, reconstructions, and stitches successfully complete, the progress bars change to solid **green**.

NOTE Prior to clicking 

, the **[Total Acquisition Time]** for the entire recipe is listed in brackets (upper left panel). The **Acquisition Pending [Estimated Time]** is listed for each recipe point, under a status bar that will indicate the recipe point's acquisition progress. After 

is clicked, **[Total Acquisition Time, Remaining Acquisition Time]** for the entire recipe is listed in brackets (upper left panel). **Projection *x* of *y*** and **[Time Remaining]** are listed for each recipe point, under a status bar that indicates the recipe point's acquisition progress.

NOTE A partially **red** reconstruction progress bar after tomography data acquisition completes indicates that **reconstruction failed**. Should this occur, you will need to manually reconstruct the tomography dataset, as described in Chapter 3, "Manually Reconstructing a Tomography Dataset."

Figure D-31 Typical **Tomo points for running sample** Panels, In-Progress and Complete

Reconstructor User Interface

NOTE Tasks that use Reconstructor are discussed in Chapter 3, "Manually Reconstructing a Tomography Dataset."

The Scout-and-Scan Control System Reconstructor program (Reconstructor) is an interface that allows you to manually reconstruct raw tomography files obtained from the **Xradia Versa** family.

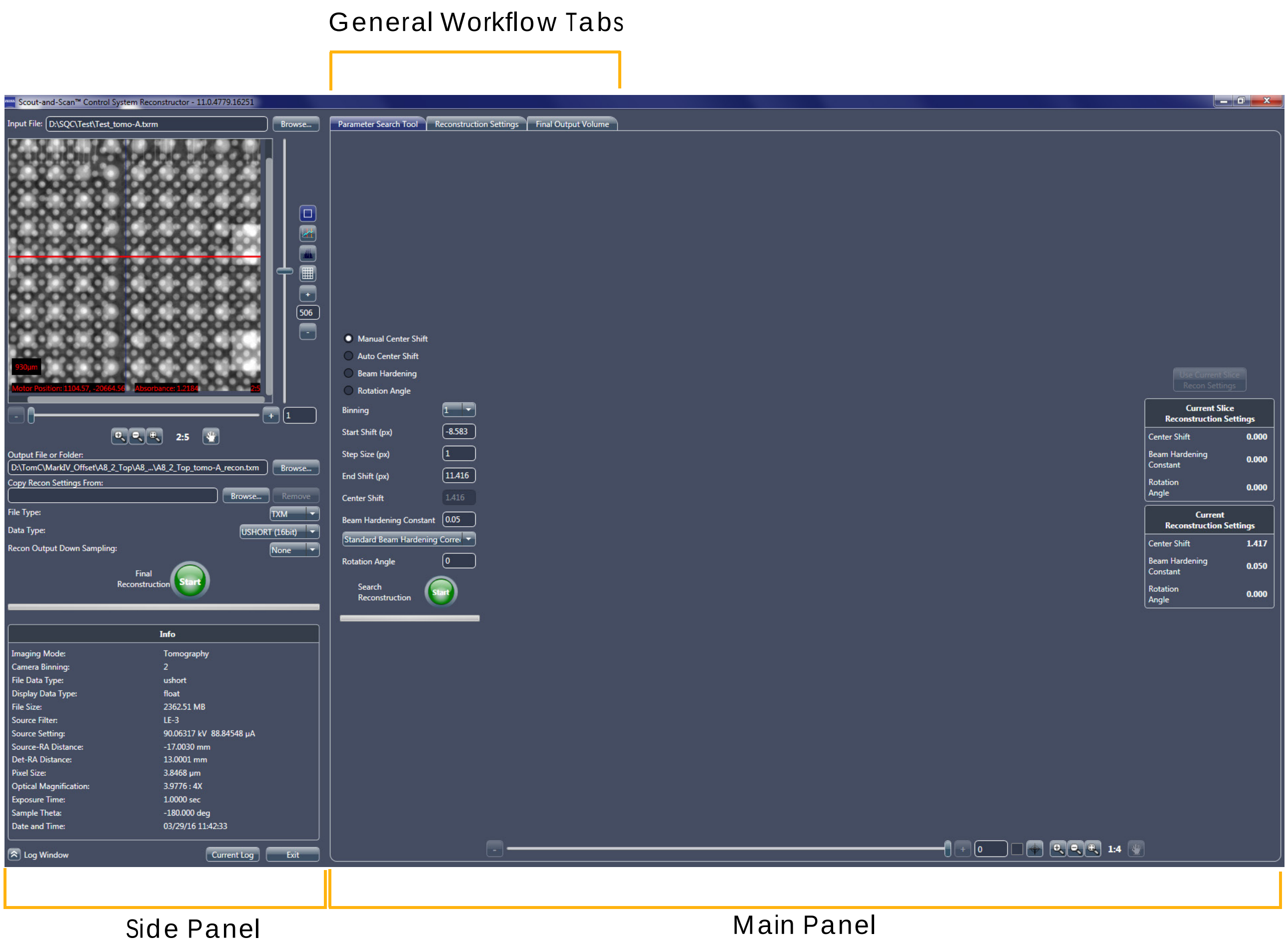
The **Reconstructor** main window is composed of two panels (refer to Figure D-32):

– Side Panel

– Main Panel

Both panels are described in the sections that follow.

Figure D-32 **Reconstructor** Main Window after Loading a File



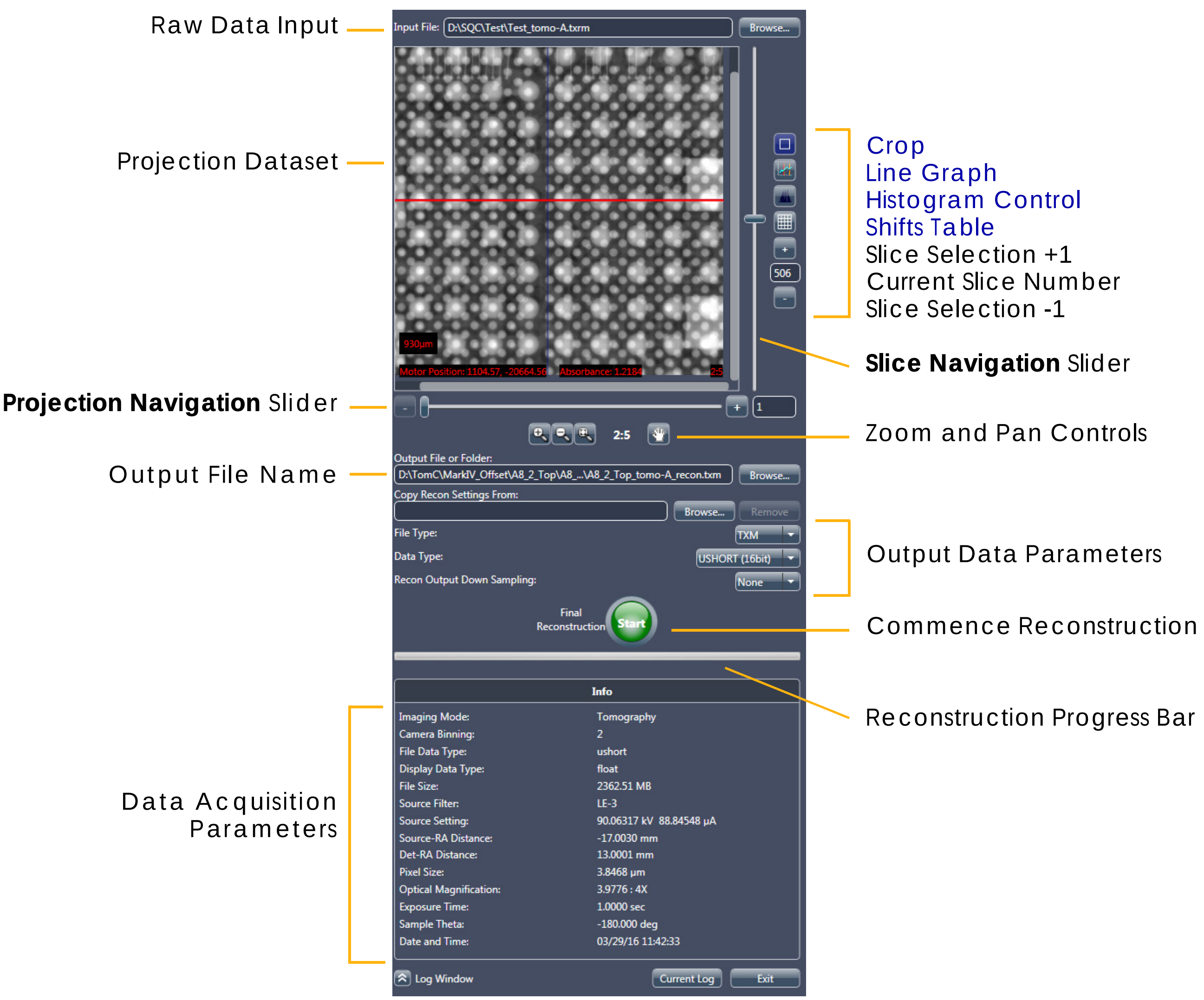
Side Panel

The Reconstructor side panel is used to prepare a raw tomography dataset (**.txrm* file) for reconstruction. Process tasks include selecting the input file, and naming the output file and selecting its data. (Refer to Figure D-33.)

Information detailing the raw tomography dataset's data acquisition parameter values is listed in the **Info** area (lower side panel).

Most side panel parameters are discussed as they are used in the reconstruction workflow in Chapter 3, "Manually Reconstructing a Tomography Dataset." Two optional tools available in the side panel are Crop and Shifts Table. Both are described in the sections that follow. Another optional tool is the Histogram Control, available in both the side and main panels. (Refer to "Histogram Control Tool," on page 316 in Appendix G.)

Figure D-33 **Reconstructor** Main Window Side Panel – Overview



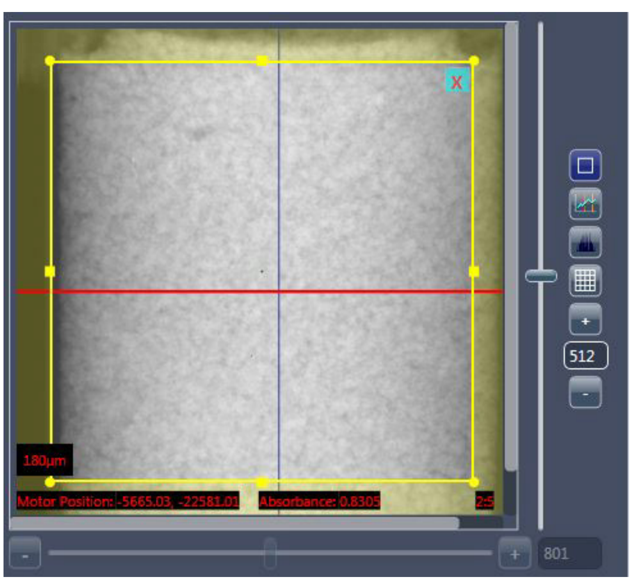
Crop

Reconstructor's Crop tool, , enabled by default, can be used if you need to indicate only a portion of the raw tomography dataset to be reconstructed during the reconstruction process.

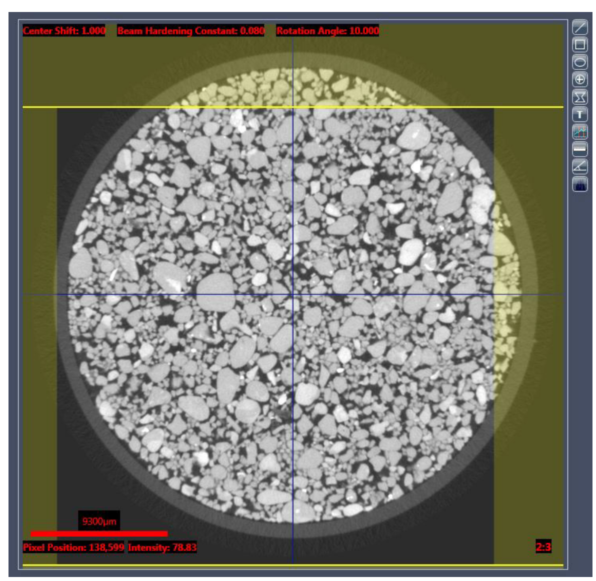
Table D-15 Reconstructor Crop Tool Tasks

Task	Process
Crop a portion of the raw tomography dataset to be reconstructed	Left-click within the **Projection Dataset** image display at the box's upper left corner, and then drag to the box's lower right corner to annotate the crop area boundary. (Refer to Figure D-34.) Only the region within the crop area boundary will be reconstructed during the reconstruction process. For cropping in the third plane, select the **Reconstruction Settings** tab, and then drag in the yellow lines displayed in the top and bottom of the reconstructed slice, as shown in Figure D-34. **NOTE** Cropping within the third plane is enabled only **after** the cropping region is drawn within the **Projection Dataset** image display.
Delete the crop	Click (upper right crop area boundary).
Disable editing capabilities of the crop area boundary	Click .

Figure D-34 Use the **Reconstructor** Main Window Side Panel's Crop Tool to Crop a Region of Interest



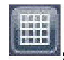
Typical Cropping



Cropping within the Third Plane

Shifts Table

NOTE Data can be reconstructed with only one shift table applied at a time.

Reconstructor's Shifts Table tool, , provides the ability to manipulate the raw tomography dataset:

- Select the **Select Projections** check box to determine the number of projections to incorporate for the reconstruction. (Refer to Figure D-35.) Common use cases include:
  - Simulate scans that run faster than the original time (for example, skipping every second projection simulates the quality of scan achieved by running the scan approximately twice as fast)
  - Convert a 360° scan to a 180°+ fan angle in cases where too much motion was observed at the beginning and/or end of the scan to try and obtain a reconstruction with fewer motion artifacts

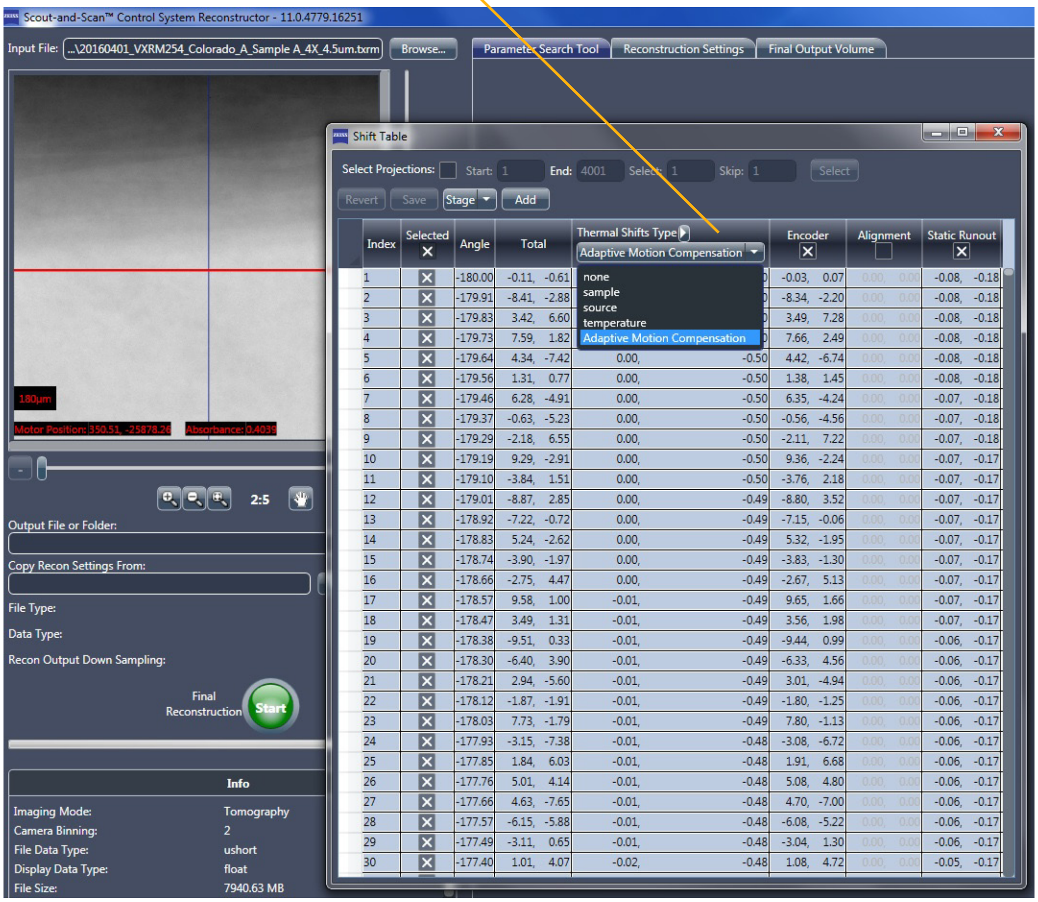
NOTE Clearing the **Selected** check box for random projections (**Index** items) might lead to visible artifacts in the reconstruction.

- Change shifts between AMC, sample drift (if collected), and thermal shift if large sample drifts are noticed in the scan. These are particularly recommended for high resolution scans to enable reconstruction with fewer motion-related artifacts. (Refer to Figure D-35.)
- Add user-defined shift tables when available. (Refer to Figure D-35.)

NOTE For further details regarding the Shifts Table tool and how the information within it is created, refer to "Correcting for System-Related Drift," on page 310 in Appendix G.

Figure D-35 **Reconstructor** Main Window Side Panel – **Shifts Table** Window

Use this drop-down list box to change the applied drift



Main Panel

The Reconstructor main panel is composed of three general workflow tabs (refer to Figure D-32), used in the sequence listed:

1. Parameter Search Tool Tab – Used to find values for the three main reconstruction parameters – Center Shift, Beam Hardening Correction, and Rotation Angle.

2. Reconstruction Settings Tab – Used to set up and finalize reconstruction parameter values.

3. Final Output Volume Tab – After reconstruction, the reconstructed 3D image volume can be visualized as a virtual stack of axial 2D image slices.

Each main panel tab is described in the sections that follow.

Parameter Search Tool Tab

The first step in the reconstruction workflow, the **Parameter Search Tool** tab (refer to Figure D-36), is used to determine the search ranges and best values for finding the Center Shift, Beam Hardening Correction, and optional Rotation Angle. In addition to the annotation tools, the tab has three main controls:

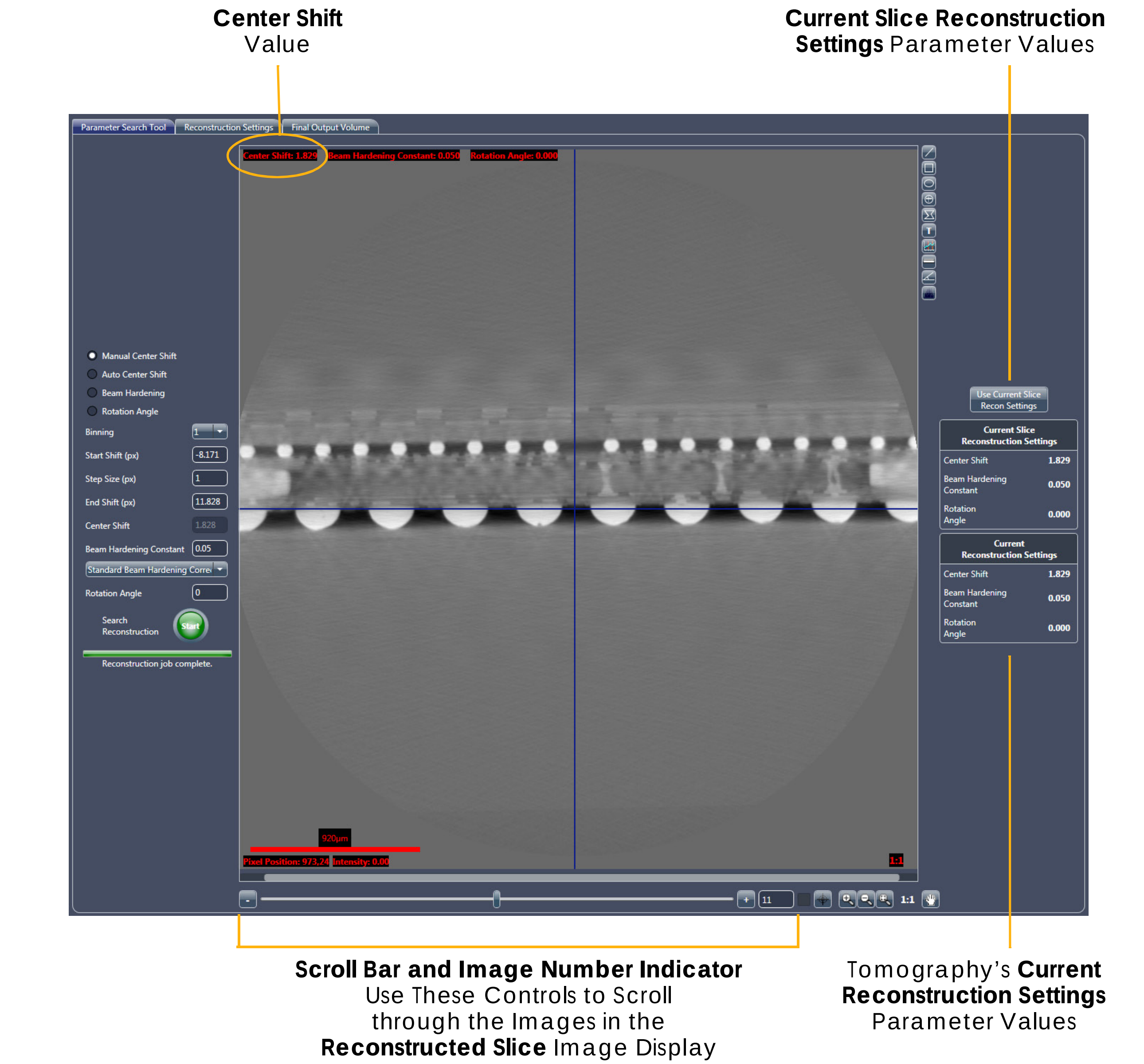
– Parameter Determination and Search Ranges

– Reconstructed Slice Image Display

– Reconstruction Settings Summary

Each is described in the sections that follow.

Figure D-36 Typical **Parameter Search Tool** Tab



Parameter Determination and Search Ranges

These controls are used for finding the Center Shift (automatically or manually), Beam Hardening Correction, and optional Rotation Angle. First you select the find process that you want to run, and then its start and end ranges and step size (settings). You may also accept the default settings for the selected process. Then, click  to begin the process, and the resulting images will appear in the **Reconstructed Slice** image display.

Reconstructed Slice Image Display

The slices reconstructed for the specified search are shown in the **Reconstructed Slice** image display. Use the scroll bars to scroll through the images, using the slider in the scroll bar –or– the image number control (click the **–** or **+** symbols; lower main panel) to find the best-suited parameter values for the selected find process.

Annotation and Control Tools

The annotation and control tools are used to manipulate the images shown in the **Reconstructed Slice** image display. The remainder of the tools are generic (lower edge of tab) and are the same as those used for the Scout-and-Scan Control System).

Table D-16 **Reconstructor** Main Panel Annotation and Control Tools

Button	Function	Description
	Line	Draws a line on the image. Click the button, and then click a start point and endpoint within the **Reconstructed Slice** image display, while holding down the mouse button. Hold down SHIFT and the mouse button to draw a vertical or horizontal line.
	Square/Rectangle	Draw a square or rectangle on the image. Click the button, and then click within the reconstructed slice image display at the shape's upper left corner and then drag to its lower right corner to form the square or rectangle.
	Circle/Ellipses	Draw a circle or ellipsis on the image. Click the button, and then click a start and end side (diameter width) within the reconstructed slice image display to form the circle or ellipsis.
	Crosshair	Draw a crosshair at the selected location on the image.

Table D-16 **Reconstructor** Main Panel Annotation and Control Tools (Continued)

Button	Function	Description
	Polygon	Draw a closed polygon on the image. Click the button, and then click multiple points within the **Reconstructed Slice** image display. Double click to end the polygon.
	Note	Annotate the image with text at specific areas. Click the button, and then type text at locations of interest within the **Reconstructed Slice** image display.
	Line Graph	Draw a line on the image and display a graph that compares intensity versus position along a linear path. Click the button, and then while holding down the mouse button, click a graph start point and endpoint within the **Reconstructed Slice** image display.
	Measurement	Add a line of measured tick marks. Click the button, and then while holding down the mouse button, click a line start point and endpoint within the **Reconstructed Slice** image display. Hold down the mouse button while pressing SHIFT to draw a vertical or horizontal line. The distance between the two points is added to the window.
	Angle	Measure angles on the image. Click the button to activate. Then, within the **Reconstructed Slice** image display, click where you want the angle vertex to appear, and then click two points to create the angle.
	Histogram Control	Click to control and adjust image contrast and brightness and/or apply false coloring. A complete description of how to use the Histogram Control tool is provided in "Histogram Control Tool," on page 316 in Appendix G.

Reconstruction Settings Summary

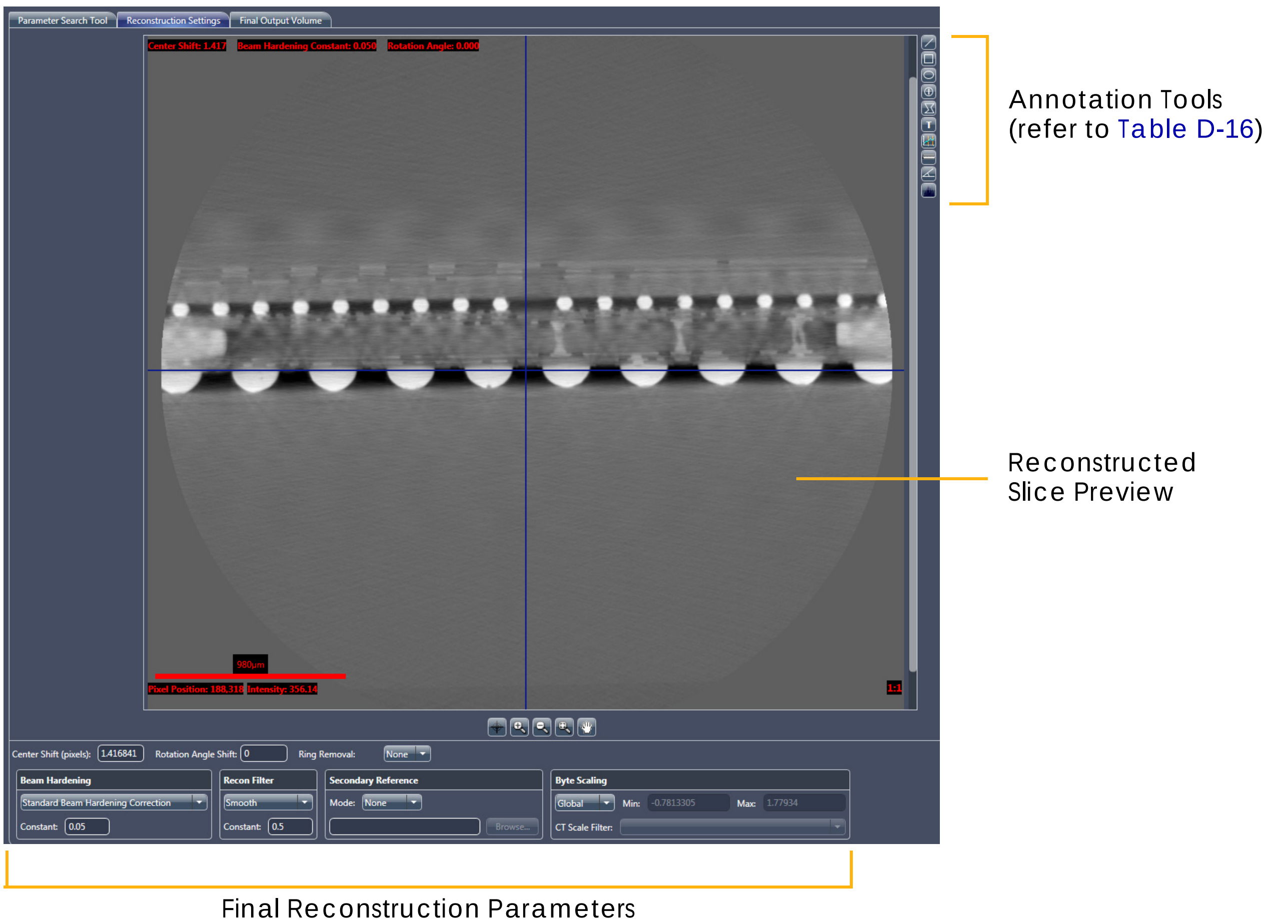
The Reconstruction Settings Summary is composed of two sets of parameters for the Center Shift, Beam Hardening Constant, and optional Rotation Angle:

- **Current Slice Reconstruction Settings** – Parameters used to reconstruct the slice currently displayed in the **Reconstructed Slice** image display.
- **Current Reconstruction Settings** – Displays parameters that will be used for the tomography data's final reconstruction. These parameter values are populated when you:
  - Click **Use Current Slice Recon Settings**, which copies parameter values listed in the **Current Slice Reconstruction Settings** area to the **Current Reconstruction Settings** area
  - Set up values in the **Reconstruction Settings** tab
  - Set up a file in the side panel's **Copy Recon Settings From:** text box, which displays parameter values used to reconstruct the selected file

Reconstruction Settings Tab

After using the **Parameter Search Tool** tab to find the Center Shift, Beam Hardening Correction, and optional Rotation Angle, use this tab to preview the reconstructed slice in the **Reconstructed Slice** image display. (Refer to Figure D-37.) This tab can also be used to fine-tune the final reconstruction parameter values. The annotation tools provided are the same as those used in the **Parameter Search Tool** tab. (Refer to "Annotation and Control Tools," on page 232.)

Figure D-37 Typical **Reconstruction Settings** Tab

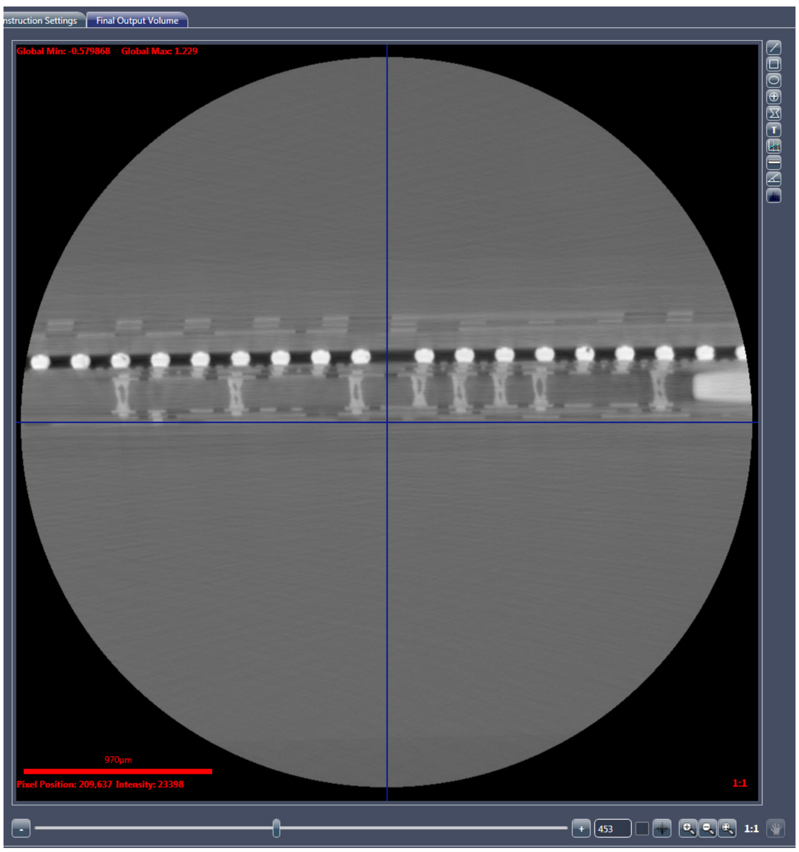


Final Output Volume Tab

This tab can be used to visualize the reconstructed tomography dataset as a virtual stack of 2D axial slices. (Refer to Figure D-38.) Use the scroll bars to scroll through the reconstructed slices to ensure that the slices look as desired before opening the slices in XM3DViewer or the optional Visual SI Advanced program. The annotation tools provided are the same as those used in the **Parameter Search Tool** tab. (Refer to "Annotation and Control Tools," on page 232.)

NOTE XM3DViewer can be used for further detailed visualization. Use of XM3DViewer is described in Chapter 4, "Viewing and Editing Tomographies."

Figure D-38 Typical **Final Output Volume** Tab Displaying Reconstructed Tomography Data



XM3DViewer User Interface

This section provides instructions for using the **XM3DViewer** main window's user interface icons. (Refer to Figure D-39 and Table D-17.)

NOTE Tasks that use XM3DViewer are discussed in Chapter 4, "Viewing and Editing Tomographies." This guide provides basic information for using XM3DViewer to view tomographic data after reconstruction. For further details regarding the program's use (beyond what is provided in Chapter 4 and this appendix), refer to the *Xradia ExamineRT Workstation 1.1 User's Manual*, available under XM3DViewer's **Help** menu.

NOTE In its main window title bar, XM3DViewer appears as "**TXM3DViewer**", rather than as "**XM3DViewer**". Additionally, the main window bars and tools change, depending on which **Layout** icon is selected.

Figure D-39 Default **XM3DViewer** Main Window – **Examine** Tab, with Descriptions of Each View

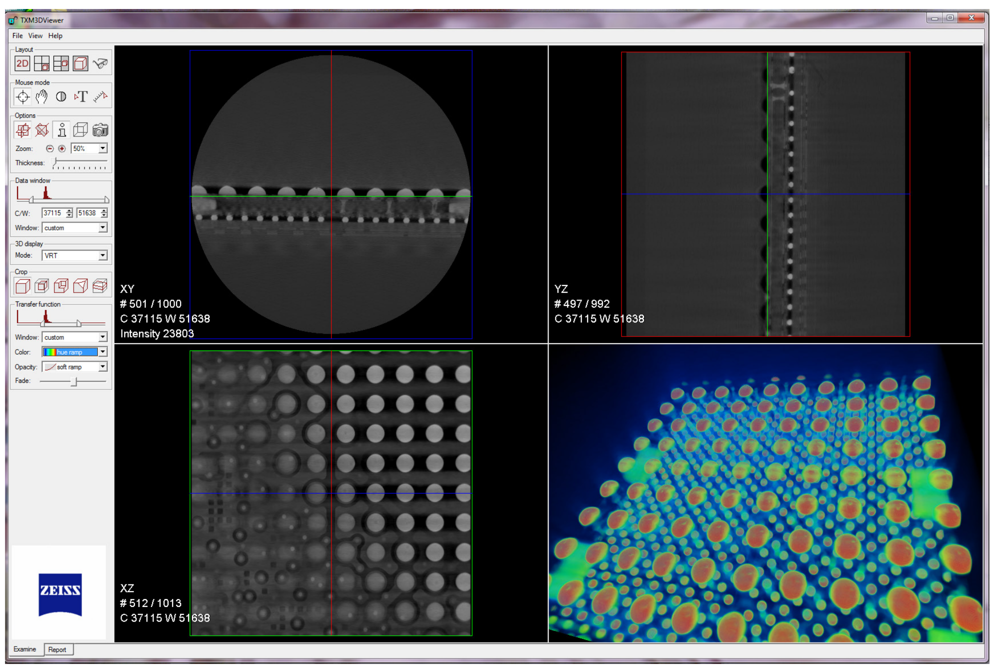


Table D-17 XM3DViewer User Interface Icons[a]

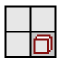
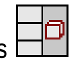
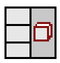
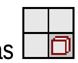
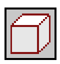
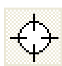
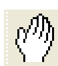
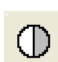
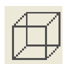
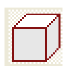
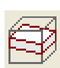
Type	Icon	Description
Layout		Click to display a single 2D reconstructed slice view. Click multiple times to cycle through the orientation of the slice in the 2D reconstructed slice view. When clicked, adds **Cine controls** to the main window (left side, below the other icon toolbars and tools).
		Click to display four equally sized views (default) – three 2D reconstructed slice views plus one 3D volume view. Displays the same four images as . In Figure D-39, the white text in each view identifies the type of image shown in that view.
		Click to display three equally sized 2D reconstructed slice views, plus one larger 3D volume view. Displays the same four images as .
		Click to display a single 3D volume view (not used for 2D reconstructed slices).
Mouse mode		Standard navigation mode (default). Enables selecting and moving navigation lines (crosshairs) in the 2D reconstructed slice and 3D volume views. 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 on whether it is used in a 2D reconstructed slice or 3D volume view, as follows: – **2D reconstructed slice view** – Enables panning and zooming – **3D volume view** – Enables image rotation, panning, and zooming
		Click to enable Window/Level mode. Behaves differently, depending on whether it is used in a 2D reconstructed slice or 3D volume view, as follows: – **2D reconstructed slice view** – Enables interactive adjustment of image contrast and brightness by changing the Data window's width and center, respectively. – **3D volume view** – Enables interactive adjustment of image contrast and brightness by changing the Transfer function's width and center, respectively.
		Click to enable Annotation mode. You can add arrows and text annotations: – **Arrow** – Click within a 2D reconstructed slice or 3D volume view at the point you want to start the arrow, and then click again at the point you want to end the arrow. – **Text associated with an arrow** – Double-click the arrow, and then type the text you want to add.
		Click to enable Measurement mode. In the 2D reconstructed slice or 3D volume view, at the region of interest (ROI), click once to define the start point for measuring, and then again to define the endpoint for measuring.

Table D-17 XM3DViewer User Interface Icons[a] (Continued)

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

a. Complete details regarding mouse use for these functions is included in the process steps in which they are used, in Chapter 4, “Viewing and Editing Tomographies.”

THIS PAGE INTENTIONALLY LEFT BLANK

E Mounting, Loading, and Removing Samples

This appendix describes the following processes:

Mounting a Sample in or on a Sample Holder

NOTE The processes that use these instructions appear in "Step 2 – Load," on page 27 and "Step 2 – Load," on page 57 in Chapter 2.

This process describes how to mount samples on the sample holders used with the Xradia Versa:

In general, samples should be mounted on their sample holders in such a manner that the sample's ROI (the focus of the data acquisition) is:

- 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

Table E-1 lists the various types of samples that the Xradia Versa can image, and their corresponding holders. Use and mounting procedures for each holder type are described in the sections that follow. Table E-2 lists the recommended maximum solid sample thickness, by objective.

For specific sample applications, contact the ZEISS Support Team. (Refer to "Technical Support," on page 348 in Appendix L.)

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

NOTE 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.

Table E-1 Sample Types and Corresponding Sample Holders

Sample Holder[a]	Sample Type
Screw Clamp	Semiconductor; flat. Sample should be no thicker than 10 mm.
Spring Clamp	Semiconductor; flat; rigid material. Sample should be thin and flat, no thicker than 5 mm. **NOTE** When using a spring clamp, the sample is likely to **not** be rigidly held, and therefore can potentially angle the sample.
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 samples.

a. The screw clamp, spring clamp, and pin vise sample holders are permanently mounted on 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 on the sample stage. The stand-alone sample base is also used as a sample holder.

Table E-2 Recommended Maximum Solid Sample Thickness, by Objective

Objective	Recommended Maximum Thickness of Solid Material
0.4X	100 mm
4X	50 mm
10X[a]	30 mm
20X	10 mm
40X[b]	5 mm

a. **10X Objective –** Xradia 410 Versa only.
b. **40X Objective –** Optional, available on request.

Mounting a Sample on a Screw Clamp

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

To mount a semiconductor or flat sample in a screw clamp

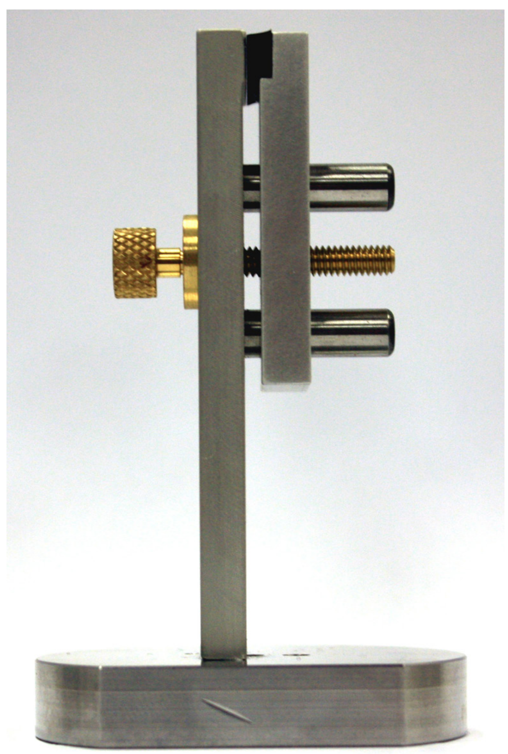
1. Turn the thumbscrew COUNTERCLOCKWISE on the clamp lever to OPEN the clamp region.

2. Position the sample within the clamp. Ensure that the sample's ROI is clearly visible, and not covered by the clamp's edges.

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

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

Figure E-1 Sample Holder – Screw Clamp



Mounting a Sample on a Spring Clamp

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

NOTE When using a spring clamp, the sample is likely to **not** be rigidly held, and therefore can potentially angle the sample.

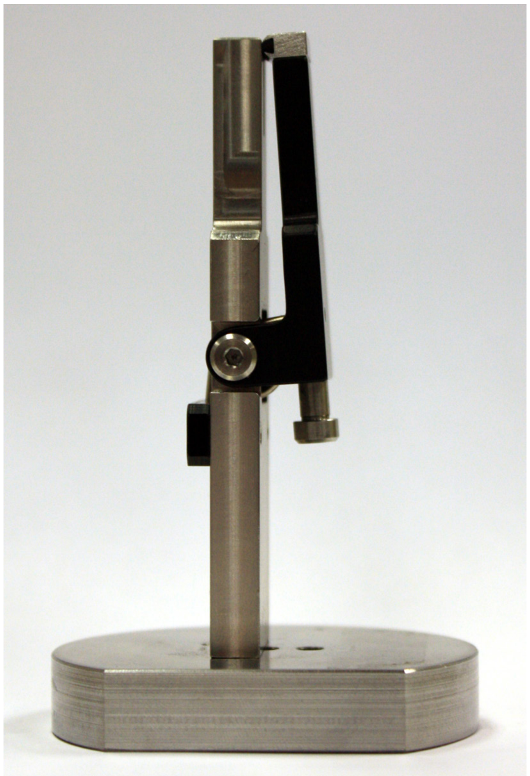
To mount a semiconductor, flat, or rigid material sample in a spring clamp

1. Push down on the clamp to OPEN it.
2. Position the sample between the clamp's pincers. Ensure that the sample's ROI is clearly visible, and not covered by the clamp's edges.

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

3. Release the spring clamp to close.

Figure E-2 Sample Holder – Spring Clamp



Mounting a Sample on a Pin Vise

This process describes how to mount a sample in a 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 hold an Al rod with the sample epoxied on top of 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 rod holding the sample into the vise.

2. Position the sample in the vise.

   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.

Figure E-3 Sample Holder – Pin Vise

Mounting a Sample on a Sample Base

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

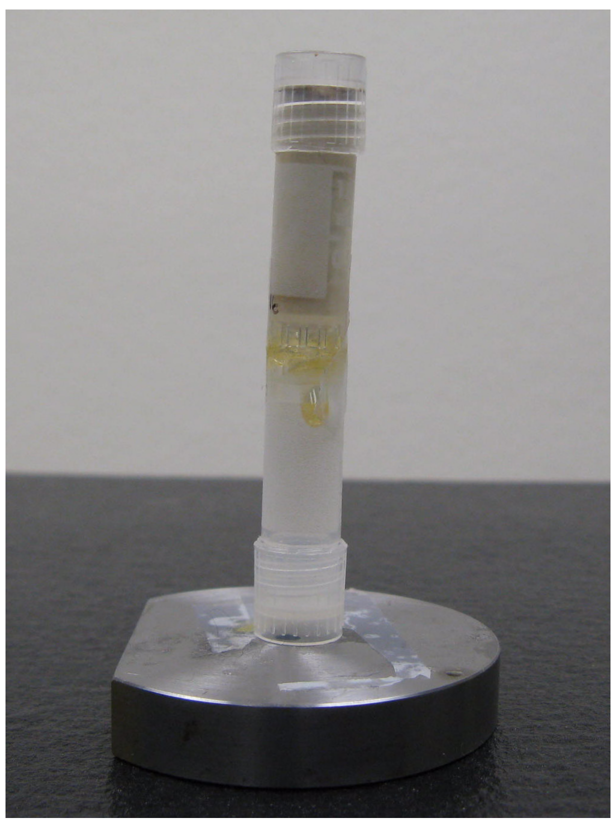
NOTE The sample must be securely packed within the tube.

To mount a soft biological sample on 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 to the sample base, as per the epoxy manufacturer's instructions.

⚠CAUTION Follow the epoxy manufacturer's safety guidelines.

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



Loading a Sample Holder Assembly on the Sample Stage

This process describes how to load the sample holder assembly. To do this, the detector and X-ray source must be moved away from the sample stage to allow access to the sample stage. After the detector and X-ray source are moved, the sample holder assembly (sample plus sample holder) can be loaded on the sample stage.

The processes that use these instructions appear in "Step 2 – Load," on page 27 and "Step 2 – Load," on page 57 in Chapter 2.

To load the sample holder assembly on the sample stage

1. In **Load** view, click  to move the X-ray source and detector away from the sample stage to their **-Limit** and **+Limits**, respectively.

2. Click **Turn Off** to turn OFF the X-ray source. The X-ray status changes to **X-rays: Off**.

Figure E-5 X-rays Are Turned **OFF**

NOTICE Do **not** open the access doors while X-rays are being generated. Doing so automatically terminates X-ray generation and causes a fault condition, thereby preventing further operation until the fault is reset. Refer to "Interlock Sequence of Operation," on page 334 in Appendix J for further explanation and method of recovery. Method of recovery is also provided in Table A-9, "Troubleshooting Light Tower Electrical Issues," on page 165 in Appendix A.

3. Open the access doors.

NOTICE Use extreme caution when loading the sample holder assembly on the sample stage.

4. Load the sample holder assembly on the sample stage, with the flat edges of the assembly and sample stage aligned, facing the front of the Xradia Versa. (Refer to Figure E-7.) The slotted grooves on the assembly should match and help seat the assembly on the three tungsten alignment balls (circled in Figure E-6) on the sample stage.

Figure E-6 Sample Stage, with Tungsten Alignment Balls Highlighted

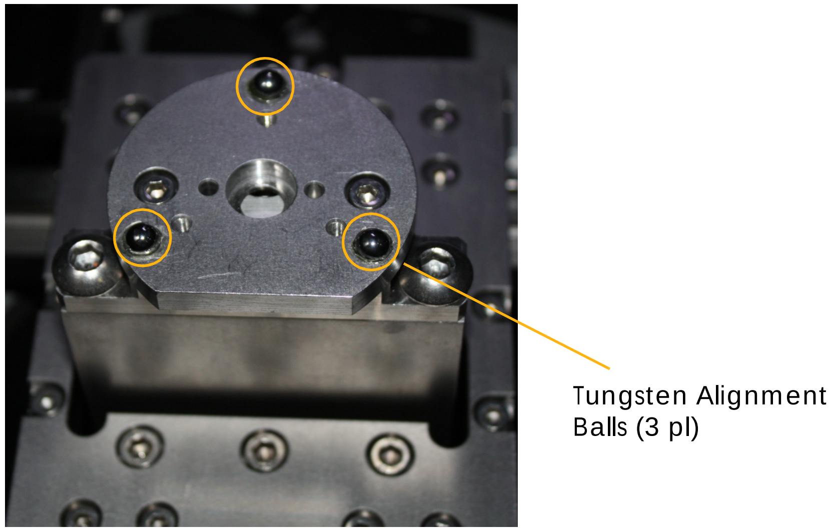
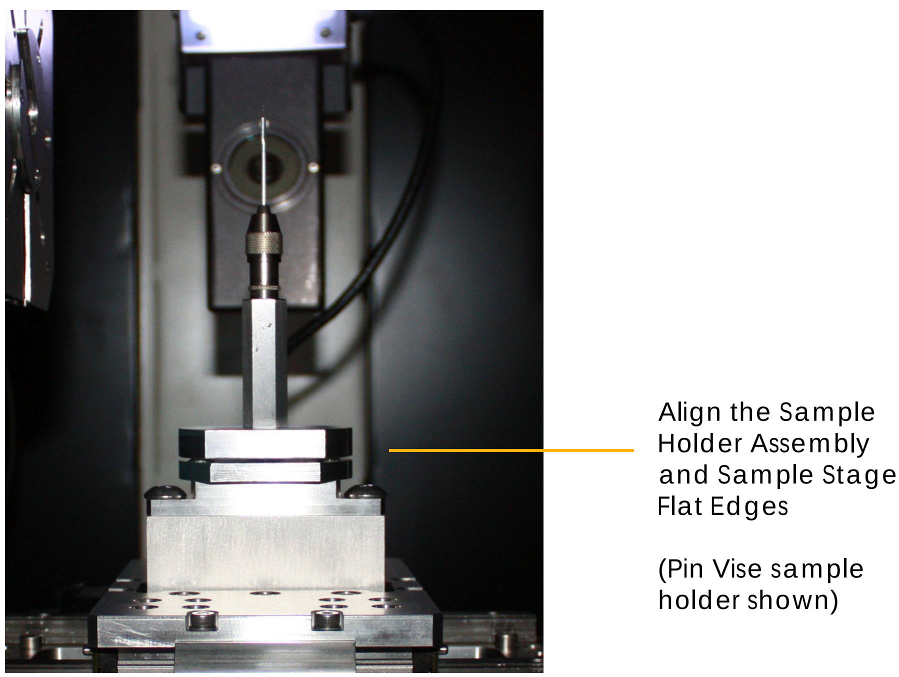


Figure E-7 Sample Holder Assembly Loaded on Sample Stage, with Flat Edges Aligned, Facing Front of Xradia Versa)



5. Close the access doors. The **Interlock** indicator in the **X-ray Source** dialog box indicates **CLOSED**. The **amber** (center) light on the light tower turns ON.

6. Click **Apply** in the **Acquisition** tab to turn ON the X-ray source.

Removing a Sample after Use

This process describes how to remove the sample from the Xradia Versa 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. Click  to move the X-ray source and detector away from the sample stage to their **-Limit** and **+Limits**, respectively.

2. Click **Turn Off** to turn OFF the X-ray source. The X-ray status changes to **X-rays: Off**.

Figure E-8 X-rays Are Turned **OFF**

NOTICE Do **not** open the access doors while X-rays are being generated. Doing so automatically terminates X-ray generation and causes a fault condition, thereby preventing further operation until the fault is reset. Refer to "Interlock Sequence of Operation," on page 334 in Appendix J for further explanation and method of recovery. Method of recovery is also provided in Table A-9, "Troubleshooting Light Tower Electrical Issues," on page 165 in Appendix A.

3. Open the access doors.

NOTICE Use extreme caution when removing the sample holder assembly from the sample stage.

4. Remove the sample holder assembly from the sample stage.

5. Remove the sample from the sample holder assembly, using one of the following processes.

Sample Holder Type	Process
Screw Clamp	While holding the sample, loosen the clamp thumbscrew COUNTERCLOCKWISE, and then remove the sample from the clamp.
Spring Clamp	While holding the sample, push down on the clip to OPEN the clamp, and then remove the sample from the clamp.
Pin Vise	Rotate the outer section of the vise COUNTERCLOCKWISE, and 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.

6. Store the sample in a safe location that is free from contaminants, for future use, or dispose of properly, per site-specific requirements.

7. Close the access doors. The **Interlock** indicator in the **X-ray Source** dialog box indicates **CLOSED**. The **amber** (center) light on the light tower turns ON.

THIS PAGE INTENTIONALLY LEFT BLANK

F Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa

This appendix describes how to manually install a source filter on the X-ray source used by the Xradia 510 Versa and Xradia 410 Versa. The instructions also include how to remove a source filter that is already installed.

NOTE The Xradia 520 Versa includes an automatic filter changer, and therefore does **not** require manual installation or removal of source filters.

NOTE A typical process for determining which source filter to use is described in "Scout – Select Appropriate Source Filter and Voltage," step 8, on page 45 in Chapter 2.

To install a source filter on the X-ray source

1. Click **Turn Off** to turn OFF the X-ray source. The X-ray status changes to **X-rays: Off**.

Figure F-1 X-rays Are Turned **OFF**

NOTICE Do **not** open the access doors while X-rays are being generated. Doing so automatically terminates X-ray generation and causes a fault condition, thereby preventing further operation until the fault is reset. Refer to "Interlock Sequence of Operation," on page 334 in Appendix J for further explanation and method of recovery. Method of recovery is also provided in Table A-9, "Troubleshooting Light Tower Electrical Issues," on page 165 in Appendix A.

2. Open the access doors.

3. Follow steps a through c below to install the source filter that you selected in the Scout-and-Scan Control System:

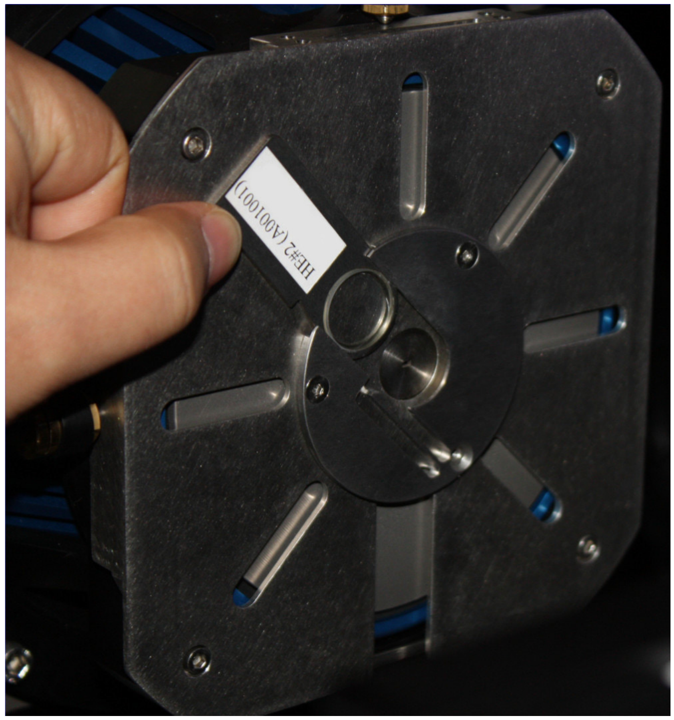
   a. **If a source filter other than the one you selected is already installed** – Holding the metal tab at the top of the filter, and, taking care to not touch the filter, gently slide the filter out of the filter holder. (Refer to Figure F-2 for handling.) Store the filter in a safe location (such as its storage box).

   b. **New source filter** – Holding the metal tab at the top of the filter and taking care to not touch the filter, gently slide the filter into the filter holder, at the front of the X-ray source, with the thickest part of the filter facing toward the sample. (Refer to Figure F-2 for handling and placement.)

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

NOTICE If the sample stage is near the X-ray source, take care to **not** scratch the source filter during the filter's installation. If necessary, move the X-ray source **away** from the sample stage.

Figure F-2 Typical Source Filter Installation
(HE2 Source Filter Shown, Used with 160 kV X-ray Source)



4. Click **Apply** in the **Acquisition** tab to turn ON the X-ray source.

THIS PAGE INTENTIONALLY LEFT BLANK

G Advanced Features

This appendix discusses the following features that would typically be used by more-advanced Xradia Versa users:

High Aspect Ratio Tomography – Xradia 520 Versa

This section describes the High Aspect Ratio Tomography (HART) technique, available for use with the Xradia 520 Versa in the Scout-and-Scan Control System (v10.6 and higher). HART can be used to improve image quality and reduce scanning time for high-aspect-ratio samples. HART allows you to acquire higher angular density projections for long views, while preserving the total number of projections. Theoretical background and operational procedures are described. Two use cases are discussed – improve image quality and reduce scan time.

Introduction

HART is designed to provide better imaging of samples that are thin and wide, such as semiconductor packages. Normal tomography uses evenly distributed projections along the rotation angles. However, many features could be obscured due to a low signal-to-noise (SNR) ratio and streak artifacts along the long views, which are critical for visualization. HART allows you to acquire more projections for long views than short views so that these features, such as bump cracks, are better visualized. In addition, various artifacts (primarily streak artifacts) are largely reduced because of the increased number of long views.

Streak artifacts are often present in X-ray tomography images of high aspect ratio samples, particularly in high-throughput scans. Streaks typically result from undersampling in angular spaces along the long views. HART is useful to reduce this type of artifact.

The main advantages of using HART, as compared to normal tomography imaging, include the following:

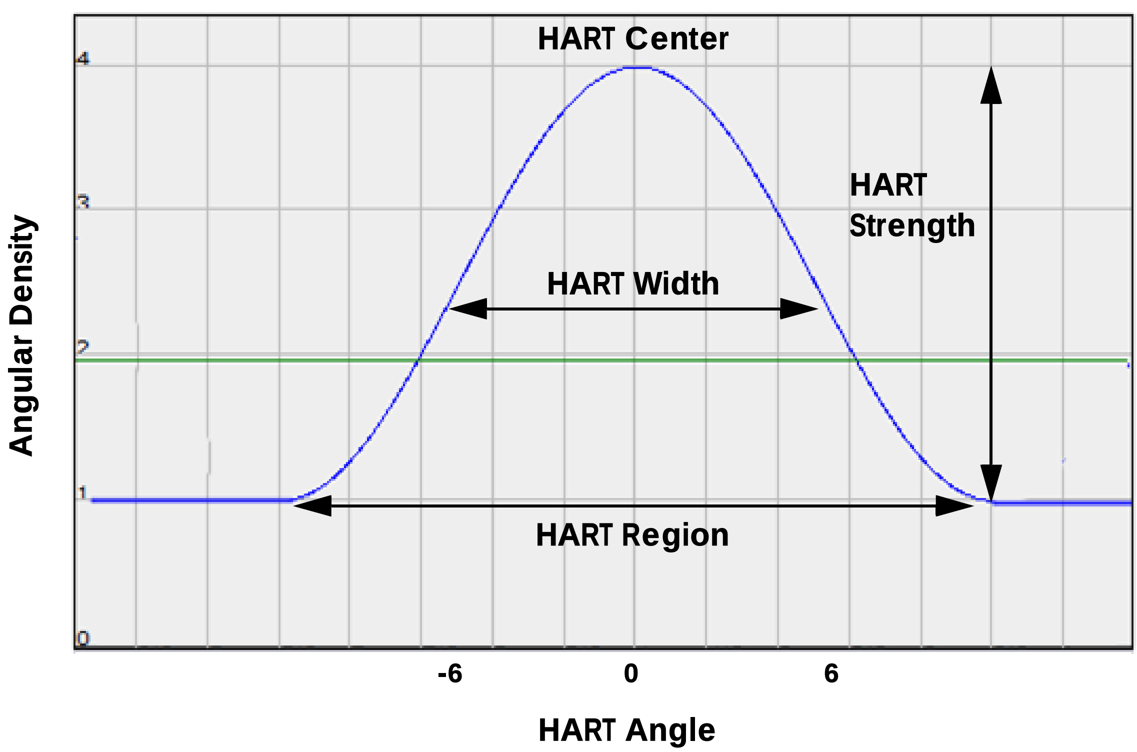
– Improve image quality for the same scan time

– Generate equal or better results for a shorter scan time

HART-Specific Terminology

- **HART center** – Angle at which the Sample Theta stage's angular speed is minimized (long-view angle; refer to Figure G-1)
- **HART strength** – Multiplicative factor over the standard angle increment for each angle that reduces the Sample Theta stage's rotation by this factor (refer to Figure G-1)
- **HART width** – Angular span of Gaussian-shaped HART curve (refer to Figure G-1)
- **Long view** – Projection image through the longer beam path along the sample
- **Long-view transmission** – **Transmission** value through the long views
- **Short view** – Projection image through the shorter beam path along the sample
- **Short-view transmission** – **Transmission** value through the short views

Figure G-1 Sample Theta Stage Slows Down in the HART Region and Reaches the Minimum Defined by the HART Strength at the HART Center Angle



HART Theory of Operation

During acquisition setup, the Scout-and-Scan Control System calculates new angles for each projection based on user-selected HART parameter values. Each projection can have a unique angular span. When applying a reference, compensation is **not** needed for the different angles because the exposure time does **not** change. During auto or manual reconstruction, the Scout-and-Scan Control System or Reconstructor, respectively, automatically compensates for any input angular distribution. No other corrections need to be made.

NOTE Use of the Scout-and-Scan Control System is featured in Chapter 2, "Acquiring Tomographies with the Scout-and-Scan Control System." Use of Reconstructor is featured in Chapter 3, "Manually Reconstructing a Tomography Dataset."

Figure G-1 illustrates how the Sample Theta stage's angular speed can be adjusted to achieve variable angle scans. In Gaussian-shaped HART, the HART region is composed of projections with variable angular spans. The angular density increases to full strength at the HART center, long-view angles. Both single- and double-HART regions within a tomography are supported.

HART Procedures

Use of HART follows these basic steps:

1. Determine whether the sample is suitable for HART.
2. Select parameter values and run HART.
3. Reconstruct and analyze HART data.

Each step is described in the sections that follow.

Determining Whether a Sample Is Suitable for HART

HART is suitable only for flat samples in which the sample's ROI is best viewed by a long views. Symmetrical specimens, such as a cylinder or cube-shaped sample, are **not** suitable for HART.

This section describes how to use the Scout-and-Scan Control System to determine whether a sample is suitable for HART. Note that HART's image quality improvements are strongly dependent on other factors, such as ROI (such as defect types), **Transmission** value, and other imaging parameter values. A successful HART application should be satisfied with the following:

– **Transmission** value in the short view is more than 4X that of the long view

– **Transmission** value is at least 1% at the long view

To determine whether a sample is suitable for HART

1. Mount a flat sample, either parallel to the beam path (0° as long views), –or– perpendicular to the beam path (0° as short views).

2. **Scout** – Locate and align the ROI with the desired objective.

3. **Scout** – Move the X-ray source and detector to an appropriate distance from the sample.

4. **Scout** – Select a source filter and set a voltage and power appropriate to the sample.

NOTE Rotate Sample Theta to 45° when selecting a source filter and determining the power parameter value.

5. **Scout** – Follow steps a through c below to obtain **Transmission** values at long and short views.

NOTE If the image acquired in step a is the long view, the image acquired in step b is the short view, depending on the sample's orientation. Likewise, if the image acquired in step b is the long view, the image acquired in step a is the short view.

a. Click 0° to rotate Sample Theta to 0°, click to acquire a single image with an exposure time that results in an **Intensity** value of at least 5000 through the ROI, and then click REF to collect and apply a reference to the **Front View** image display.

The Scout-and-Scan Control System automatically acquires a proper reference and calculates the **Transmission** value. Move the mouse pointer to the ROI and make note of the **Transmission** value.

b. Click -90° to rotate Sample Theta to -90°, click to acquire a single image with an exposure time that results in an **Intensity** value of at least 5000 through the ROI, and then click REF to collect and apply a reference to the **Side View** image display.

The Scout-and-Scan Control System automatically acquires a proper reference and calculates the **Transmission** value. Move the mouse pointer to the ROI and make note of the **Transmission** value.

c. Divide the short view's **Transmission** value by the long view's **Transmission** value.

If the **Transmission** value at the long view is less than 1%, –or– the **Transmission** value at the short view is less than 4X the **Transmission** value at the long view, it is recommended to perform a normal (non-HART) tomography because the advantages of using HART may not be fully realized in this sample.

If the **Transmission** value at the long view is greater than 1%, –or– the **Transmission** value at the short view is greater than 4X the **Transmission** value at the long view, proceed to "Setting up and Running HART Parameters."

Setting up and Running HART Parameters

This section describes how to use the Scout-and-Scan Control System to set up the HART parameters and then run the recipe using the HART parameter values.

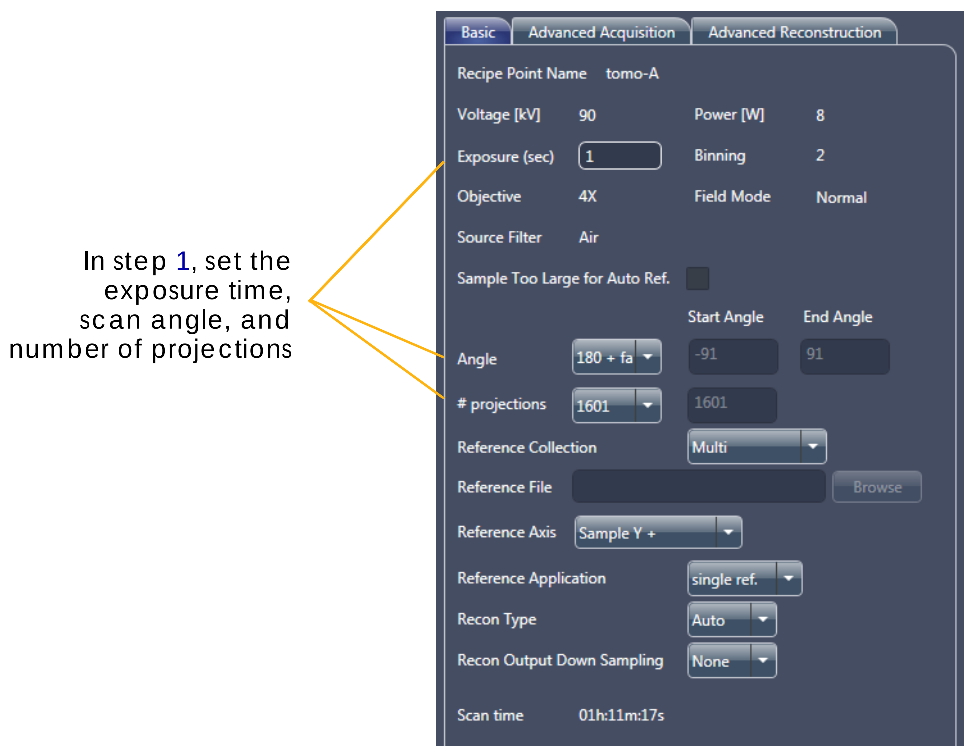
To set up and run HART parameters

1. **Scan** – In the **Basic** tab, set the exposure time, scan angle, and number of projections. (Refer to Figure G-2.)

NOTE It is recommended to select *180+fan* from the **Angle** drop-down list box for high aspect ratio samples.

NOTE Select *1601* from the **# projections** drop-down list box for samples that fit within the FOV. For interior tomographies, select *Custom*, and then type *2001* in the text box.

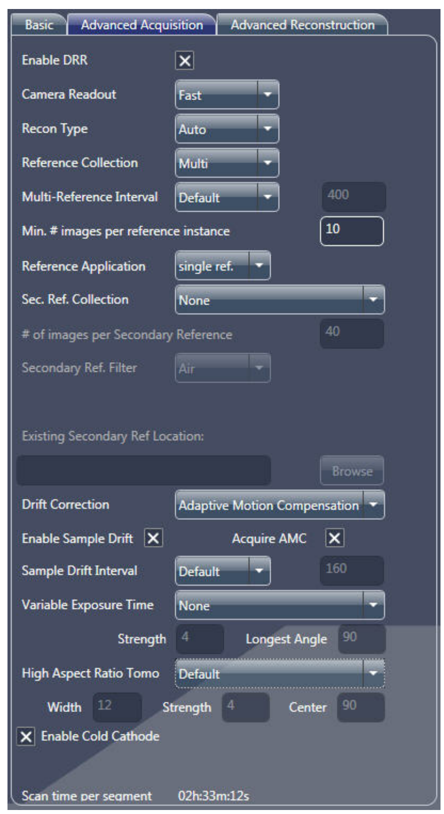
Figure G-2 Set up the Basic Scan Parameters



2. **Scan** – In the **Advanced Acquisition** tab, select one of the following three values from the **High Aspect Ratio Tomo** drop-down list box, based on the high aspect ratio sample's needs. Leave all other parameters at their default values. (Refer to Figure G-3.)

Value	Description
Default	Default HART parameter values that provide a good starting point for imaging a new sample: – **Width** – *12* (half the HART region) – **Strength** – *4* (Multiplicative factor) – **Center** – *90* (long view angle) **NOTE** For a 180+fan angle scan, a center angle of *90* means that two HART regions will be created at 90° and -90°. A center angle of *0* for a 180+fan scan means that a single HART region will be created at 0°.
Custom	Allows you to set custom HART **Width**, **Strength**, and **Center** parameter values.

Figure G-3 Set up the Advanced Acquisition Scan Parameters



In step 2, select *Default* –or– *Custom* (and then type values)

3. **Run** – Run the recipe.

Proceed to "Verifying the Angular Span Change."

Analyzing HART Data

Using initial scans of a new sample, this section will help you understand the benefit of a HART scan over a normal scan through use of the legacy XMController program (XMController). The analysis is also useful for further optimizing imaging quality.

The two main advantages of the HART technique are as follows:

- Improve image quality for the same scan time
- Generate equal or better results with reduced scan time

The two advantages, as well as verifying the angular span change, are discussed in the sections that follow.

Verifying the Angular Span Change

This step helps validate whether the **Sample Theta** axis movement complies with the HART scan.

To verify the angular span change

1. On the Windows taskbar **Start** menu, select **All Programs**, **Carl Zeiss X-ray Microscopy**, **Xradia Versa 11.*x***, and then **XMController**.

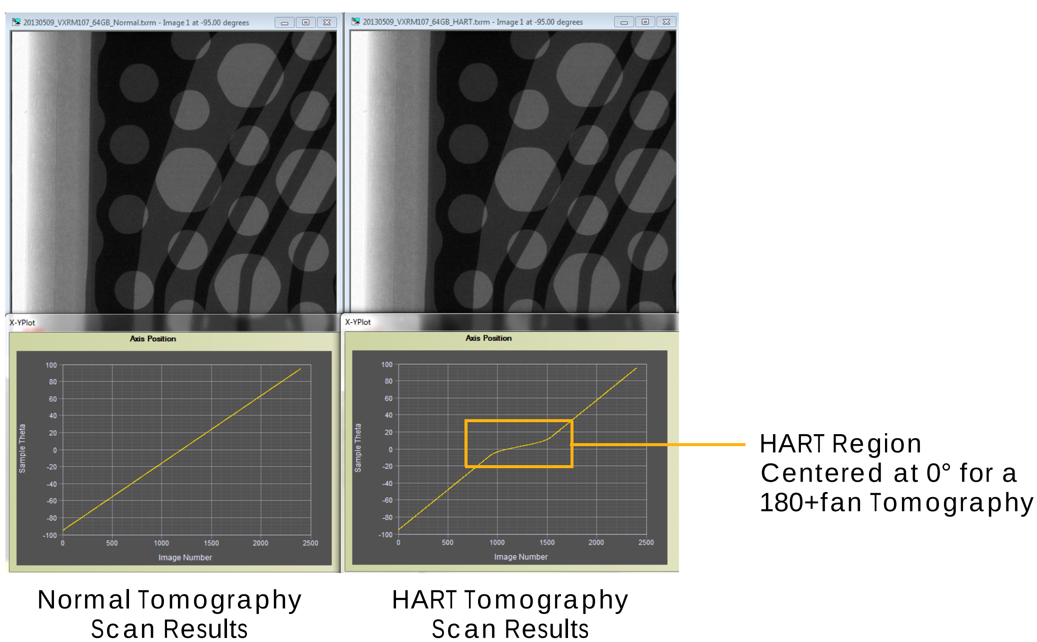
2. On the **File** menu, select **Open**, and then open the raw projection **.txrm* file acquired by HART in “Setting up and Running HART Parameters,” step 3, on page 264.

3. On the **View** menu, select **Image Control**, the **Axis Positions** tab, and then **Sample Theta** from the drop-down list box.

4. Click **Plot Graph**. A plot of **Sample Theta** axis position opens. (Refer to Figure G-4.)

   If *180+fan* scan angle was chosen in **Scan** view (Scout-and-Scan Control System) and the HART center is *0* (Sample Theta is at 0°), one HART region is shown (refer to Figure G-4, image to the right, **yellow** boxed/highlighted area). If *180+fan* scan angle was chosen and the HART center is *90* (Sample Theta is at -90°), two HART regions will be shown.

Figure G-4 **Sample Theta** Axis versus **Image Number** Plot Shows No change of Angular Density Change in a Normal Tomography Scan (Left), and Angular Density Change for HART Scan (Right)



HART Use Case Analysis 1 – Improving Image Quality With the Same Scan Time

To compare HART data with normal tomography data, the scan conditions must be kept the same. This includes FOV, objective, pixel size, voltage, power, reference, exposure time, and number of projections. For this use case comparison, the only difference is that HART uses variable angular spanned projections while the normal tomography uses equivalent angular spacing.

To visualize the HART data

1. On the XMController **File** menu, select **Open**, and then open the reconstructed HART and normal tomography **.txm* files.

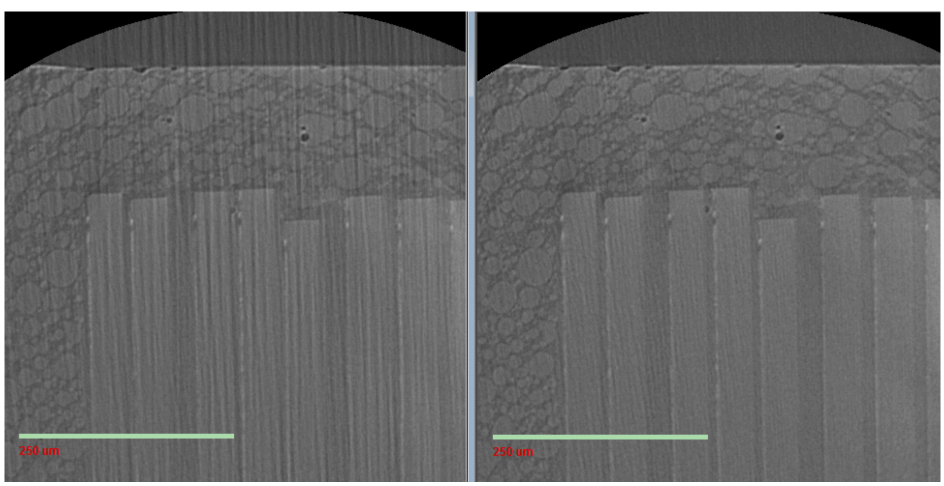
2. Locate the same features within both **.txm* files by looking at the same slice number.

3. **Optional** – Use the Histogram Control tool to adjust the histogram, if needed, to highlight the desired feature within the ROI.

4. Follow steps a and b below to compare the results.

    a. Visually check for streak artifact reduction (often parallel to the long views) within the HART image. (Refer to Figure G-5.) HART is successful when streak artifacts are significantly reduced.

Figure G-5 Normal versus HART Image Results Showing Streak Artifact Reduction When Scanned for the Same Length of Time



Normal Tomography Scan Results after 2-Hour Scan, with Streak Artifacts

HART Tomography Scan Results after 2-Hour Scan, with Reduced Streak Artifacts

For example, in Figure G-5, a microSD card was scanned for 2 hours, for both a normal tomography (image to the left) and a tomography using HART (image to the right). The scan parameter values were 4X objective, 1.1 µm pixel size, 60 kV voltage, 5W power, 5s exposure time, 1200 projections, beam hardening constant of 0, and Gaussian 0.7 filter during auto reconstruction. The HART parameter values used were width 12, strength 4, and center 0. The resulting HART image has much less-pronounced streaks than the non-HART image.

b. Visualize the clarity of the feature(s) of interest. If the HART image reveals better visibility on the structures than the normal tomography image, HART is useful for this type of sample.

   For example, one feature of interest in Figure G-5 is the die spacing. The die spacing in the normal tomography is obscured by streak artifacts (image to the left). The die spacing in the HART tomography (image to the right) is easier to visualize.

HART Use Case Analysis 2 – Generating Equal or Better Results with Reduced Scan Time

To compare HART data with normal tomography data, the scan conditions must be kept the same. This includes FOV, objective, pixel size, voltage, power, reference, and exposure time. For this use case comparison, the only difference is that HART uses fewer projections (and thus a shorter scan time) than the normal tomography.

To visualize the HART data

1. On the XMController **File** menu, select **Open**, and then open the reconstructed HART and normal tomography **.txm* files.

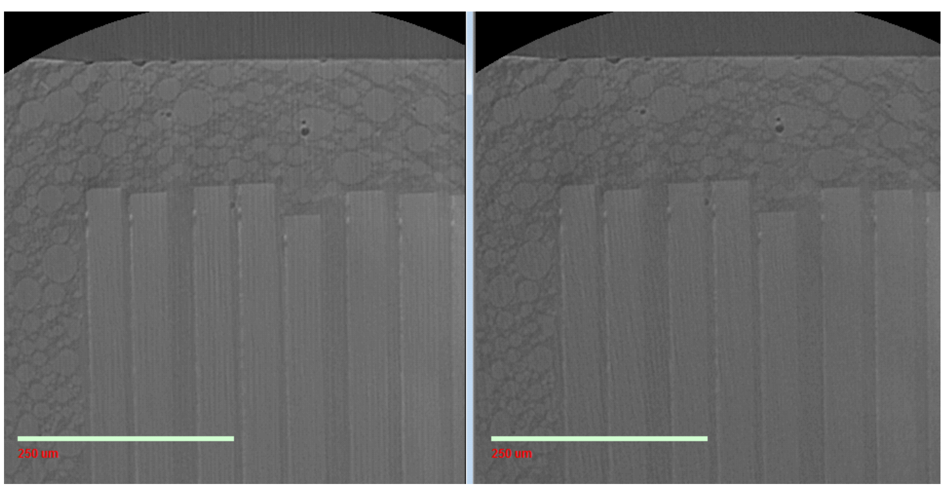
2. Locate the same features within both **.txm* files by looking at the same slice number.

3. **Optional** – Use the Histogram Control tool to adjust the histogram, if needed, to highlight the desired feature within the ROI.

4. Follow steps a and b below to compare the results.

   a. Visually check for the streak artifact presence within both images. (Refer to Figure G-6.) If the streak artifact intensity in the HART tomography (image to the right) is less than or equal to the normal tomography (image to the left), HART was successful.

Figure G-6 Normal versus HART Image Results Showing Equal or Better Image Quality at 50% of the Scan Time



Normal Tomography Scan Results after 4-Hour Scan

HART Tomography Scan Results after 2-Hour Scan, with Equal or Better Image Quality

For example, in Figure G-6, the same microSD card from Use Case 1 was scanned with the same scan parameter values, but for 4 hours (normal) versus 2 hours (HART). The streaks in the HART tomography (image to the right) appear to have similar but lower intensity and abundance to the normal tomography (image to the left).

b. Visualize the clarity of the feature(s) of interest. If the HART image reveals equal or better results on the structures than the normal tomography image, HART is useful for this type of sample.

For example, one feature of interest in Figure G-6 is the spacing between dies. The HART tomography (image to the right) appears much better than the normal tomography (image to the left) for visualizing the die space (the die space in the normal tomography becomes obscured due to the presence of streak artifacts).

5. Scan the sample again with further-reduced imaging time, as needed, for additional result improvement.

Wide Field Mode

NOTE Wide Field mode is available on the Xradia 520 Versa for the 0.4X and 4X objectives, and on the Xradia 510 Versa and Xradia 410 Versa for the 0.4X objective.

Wide Field mode allows you to acquire and horizontally stitch together two FOVs. The mode can be used to acquire a tomography with a smaller voxel size and at a higher resolution for the same field of view, –or– almost double the FOV with the same voxel size provided by Normal Field mode.

A set of two tomographies are collected for each recipe point. Two datasets are horizontally stitched together at the end of data collection to form a single tomography, at approximately:

– 2K × 2K × 1K voxels for a dataset with a binning value of 2, –or–

– 4K × 4K × 2K voxels for a dataset with a binning value of 1

The reconstruction process (such as finding center shift and the beam hardening constant) is the same as that used for Normal Field mode datasets. The sample stage is moved and also slightly rotated at each angle during acquisition to calculate angles from the X-ray source for each image acquisition.

NOTE If the X-ray source and detector are placed near the sample for Normal Field mode acquisition, ensure that at least a 1-mm gap exists between the X-ray source and sample, and between the detector and sample, to allow for the additional motion necessary in Wide Field mode.

To set up and use a Wide Field mode recipe

NOTE The process described here references the steps described in "Creating and Running a New Recipe."

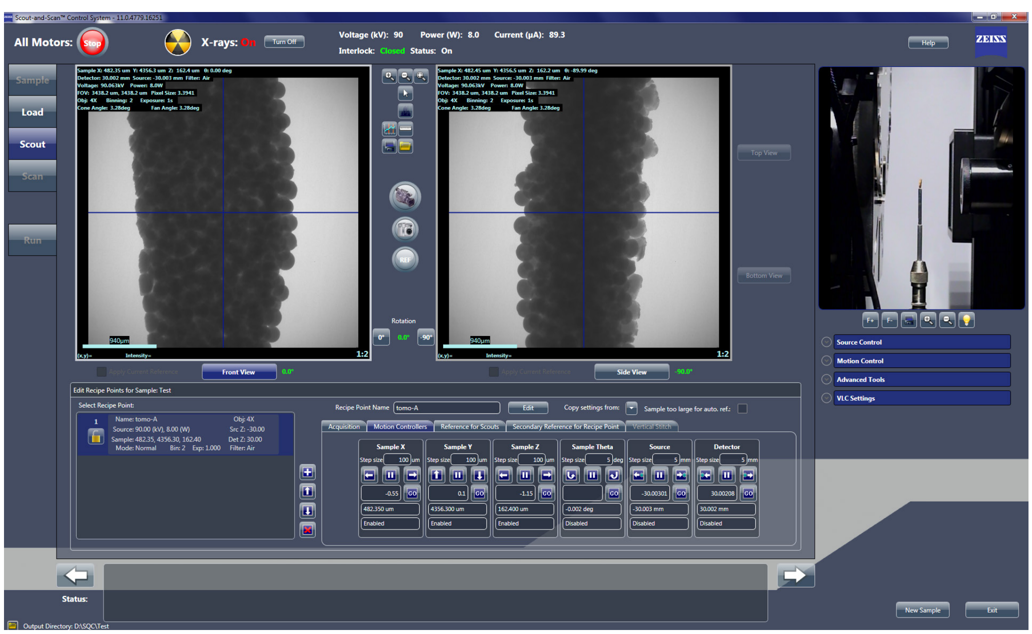
1. **Sample** – Complete "Step 1 – Sample," on page 25.
2. **Load** – Follow steps a and b below to load and roughly position the sample with the Visual Light Camera. (Refer to "Step 2 – Load," on page 27.)

   a. If the sample is large, move the X-ray source and detector distances to *-100 mm* and *100 mm* (or farther, if necessary), respectively, to ensure that the X-ray source and/or detector do not collide with the sample.

   b. Ensure that the sample is roughly positioned within the center of the field of view (FOV) with Sample Theta at both 0° and -90° in the **Front** and **Side View** image displays, respectively.

3. **Scout** – Follow the steps provided in the one of the two possible use cases identified in this step to establish the Wide Field mode FOV. (Refer to "Step 3 – Scout," on page 31.)

Figure G-7 Typical **Scout** View – Normal Field Mode (Before Changing to Wide Field Mode)



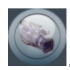
Use Case 1 – To almost double the FOV from the current Normal Field mode setting

a. In Normal Field mode (refer to Figure G-7), center the required ROI with Sample Theta at both 0° and -90° (**Front** and **Side View** image displays, respectively). Adjust the X-ray source and detector distances so that the scouted image at 0° now covers approximately 50% of the required horizontal FOV.

b. In the **Acquisition** tab within the **Edit Recipe Points for Sample** panel, select *Wide* from the **Field Mode** drop-down list box, and then click **Apply**.

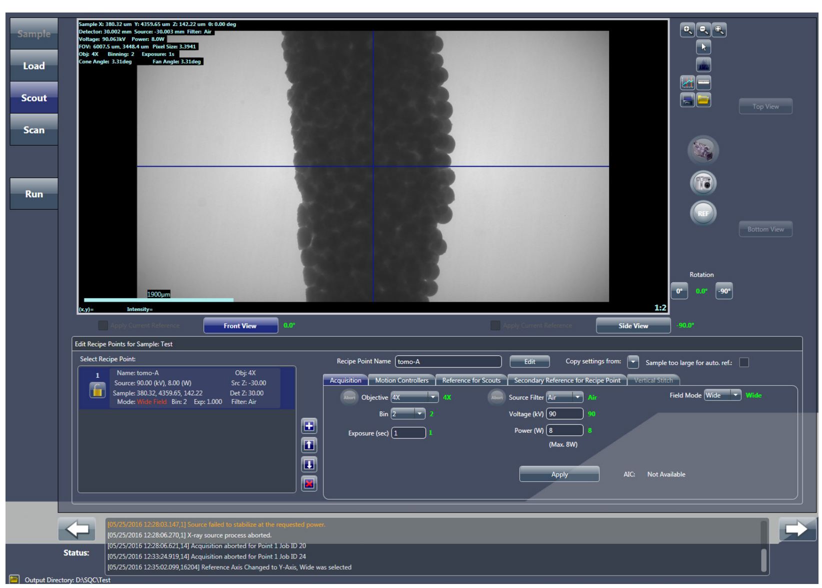
c. Click  to acquire a single image in the combined **Front** and **Side View** image displays. (Refer to Figure G-8.) The button changes to 

, and then back to  after the image is acquired. The horizontal FOV will now be approximately 1.8X the original FOV.

NOTE Continuous imaging, , is **not** supported by Wide Field mode.

NOTE In Normal Field mode, the image appears in two image displays (**Front** and **Side View**). In Wide Field mode, the image appears in a combined **Front** and **Side View** image display. (Refer to Figure G-8.)

Figure G-8 Typical **Scout** View – Wide Field Mode

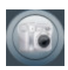


Use Case 2 – To almost double the resolution in the horizontal FOV shown in the current Normal Field mode setting

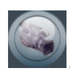
a. In Normal Field mode (refer to Figure G-7), center the ROI with Sample Theta at both 0° and -90° (**Front** and **Side View** image displays, respectively). Adjust the X-ray source and detector distances so that the scouted image at 0° now covers the desired horizontal FOV.

b. To achieve almost 2X the resolution in this current FOV, increase the geometrical magnification by moving the X-ray source closer (only if collision is **not** imminent) and detector farther away from the sample to achieve a little more than half the voxel size from the original voxel size that was indicated in the Normal Field mode image. (For example, if the original voxel size is 20 µm in Normal Field mode, move the X-ray source and detector to achieve a 10 µm voxel size).

c. In the **Acquisition** tab within the **Edit Recipe Points for Sample** panel, select *Wide* from the **Field Mode** drop-down list box, and then click **Apply**.

d. Click  to acquire a single image in the combined **Front** and **Side View** image displays. (Refer to Figure G-8.) The button changes to 

, and then back to  after the image is acquired.

NOTE Continuous imaging, , is **not** supported by Wide Field mode.

NOTE The X-ray source and detector should be approximately 160 mm apart. This is particularly important when using the 0.4X objective to avoid seeing the X-ray source aperture within the FOV. To decrease the FOV. "Troubleshooting 0.4X or 4X Objective Too Close to the X-ray Source – Keeping the X-ray Source Aperture out of the Field of View," on page 159 in Appendix A provides instructions for ensuring that the X-ray source aperture does **not** appear within the FOV when using the 0.4X objective.

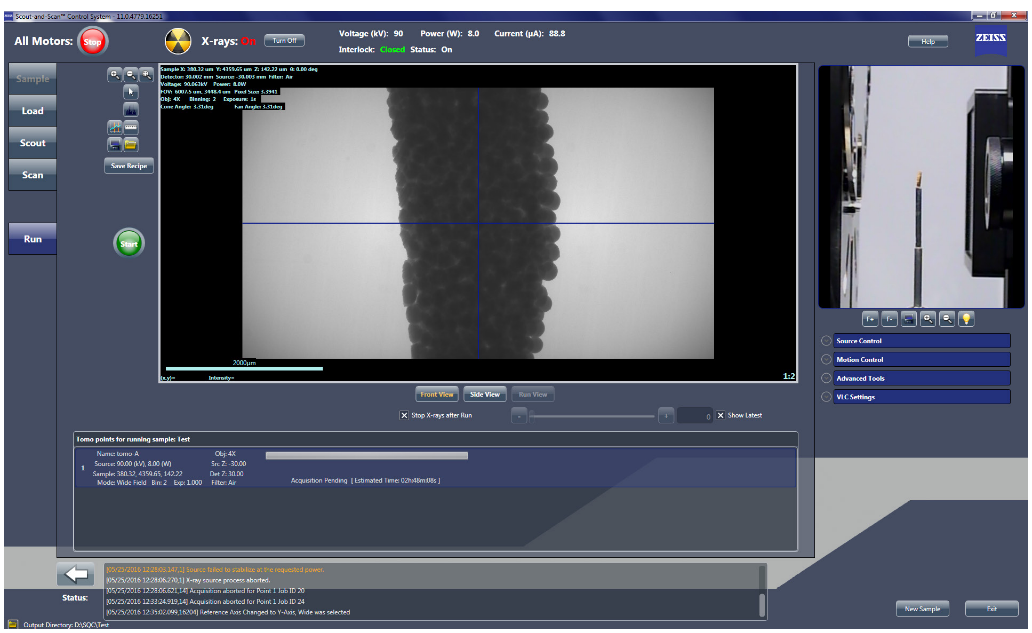
NOTE The following table compares the voxel size (X µm) and the FOV (Y mm × Y mm) obtained in Normal Field mode versus the two Wide Field mode use cases identified in step 3:

- **Use Case 1 (achieving a larger horizontal FOV)** – You can increase the FOV by 1.8X that of the Normal Field mode FOV while maintaining the same the voxel size as Normal Field mode.
- **Use Case 2 (achieving better resolution in the same horizontal FOV as in Normal Field mode)** – You can increase the resolution by almost 2X while reducing the voxel size to half that of Normal Field mode. However, the vertical FOV would be reduced to half the height of the original Normal Field mode image.

Scan	Voxel Size (µm)	Field of View (mm)
Normal Field Mode (NFM)	X	Y × Y
Wide Field Mode (WFM)	X	1.8Y × Y
Wide Field Mode High Res (WFM HighRes)	0.5X	Y × 0.5Y

4. **Run** – Run the recipe. (Refer to Figure G-9 and “Step 5 – Run,” on page 52.)

Figure G-9 Typical **Run** View – Wide Field Mode

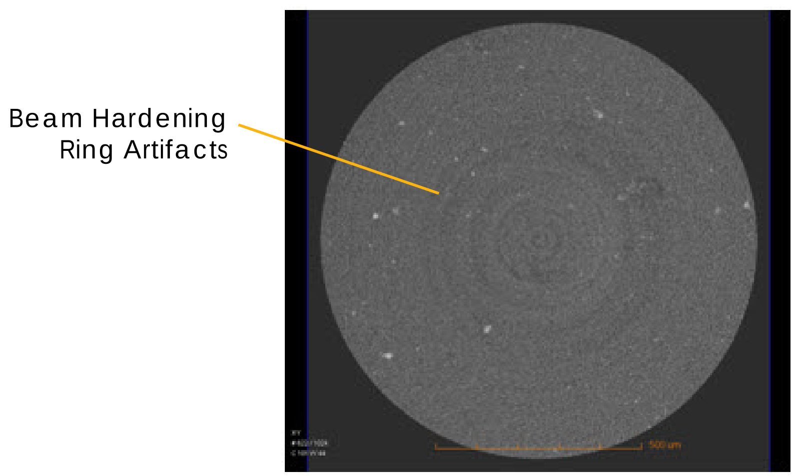


Using a Filtered Secondary Reference for Ring Artifact Reduction

When a reference contains beam hardening effects that differ from the scanned sample image, the result can appear as diffuse ring artifacts within the reconstructed data. This phenomenon is most prominent when no filter (Air) is used for the original tomography or beam hardening artifacts (such as Kossel lines or X-ray source spots) are present in the Xradia Versa. Figure G-10 is an example of a reconstructed slice that shows this type of ring artifact.

Filtering with a physical filter (referred to as a *source filter* in the Scout-and-Scan Control System processes) is recommended during the original scan to modify the beam for both the reference and tomography. Images acquired using a physical filter are less susceptible to diffuse ring artifacts than images acquired without using a physical filter. However, in some cases, it is necessary to minimize the filtering effect applied by a physical filter to maximize overall image contrast. Therefore, additional filtering of the reference during manual reconstruction might be needed to reduce beam hardening ring artifacts within an image. Beam hardening ring artifacts can be significantly reduced by collecting a correctly filtered secondary reference, and then applying that secondary reference to the data.

Figure G-10 Beam Hardening Ring Artifacts Visible in Reconstructed Image



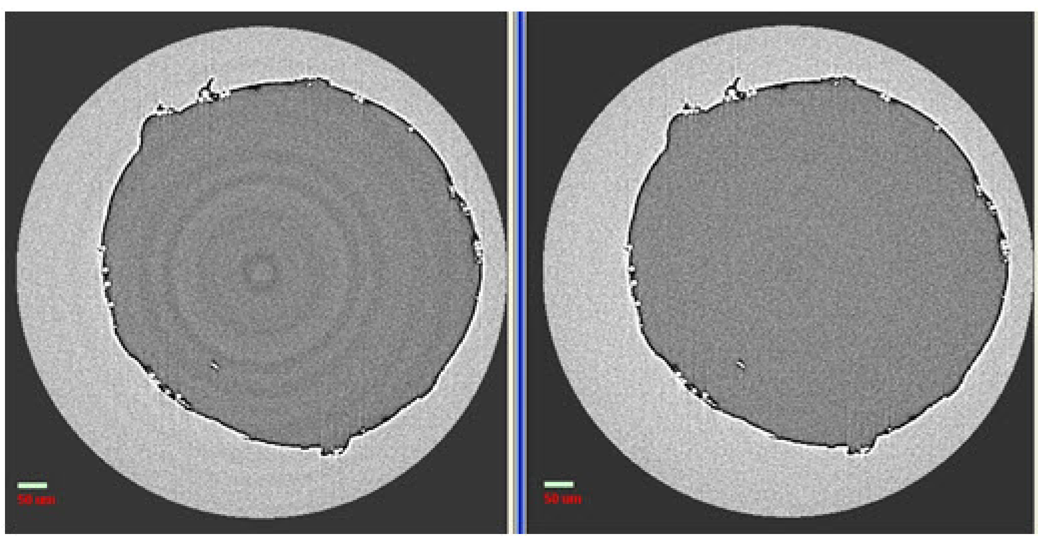
Collection and application of a filtered secondary reference follows these five basic steps**:**

1. Select the correct source filter to use for the secondary reference(s).
2. Collect the secondary reference(s).
3. Verify and select the secondary reference(s).
4. Run the recipe as usual.
5. **Optional** – Apply the secondary reference during manual reconstruction.

The fourth step is described in “Step 5 – Run,” on page 52 (new recipes) and “Step 5 – Run,” on page 69 (existing recipes or recipe templates). The optional fifth step is performed using Reconstructor during the manual reconstruction process described in “Reconstructing the Tomography Data,” step 4, on page 103 in Chapter 3. (The last two steps are mentioned at the end of the third step.)

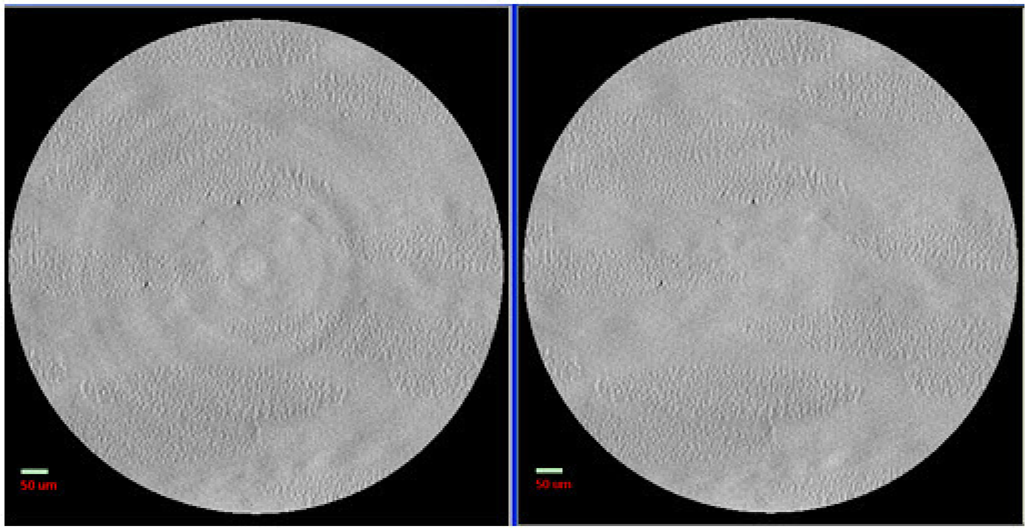
Figure G-11 through Figure G-13 show three examples of 2D reconstructed slices, before and after applying a secondary reference.

Figure G-11 2D Reconstructed Slices of a Bubble in Wax, before and after Applying a Secondary Reference



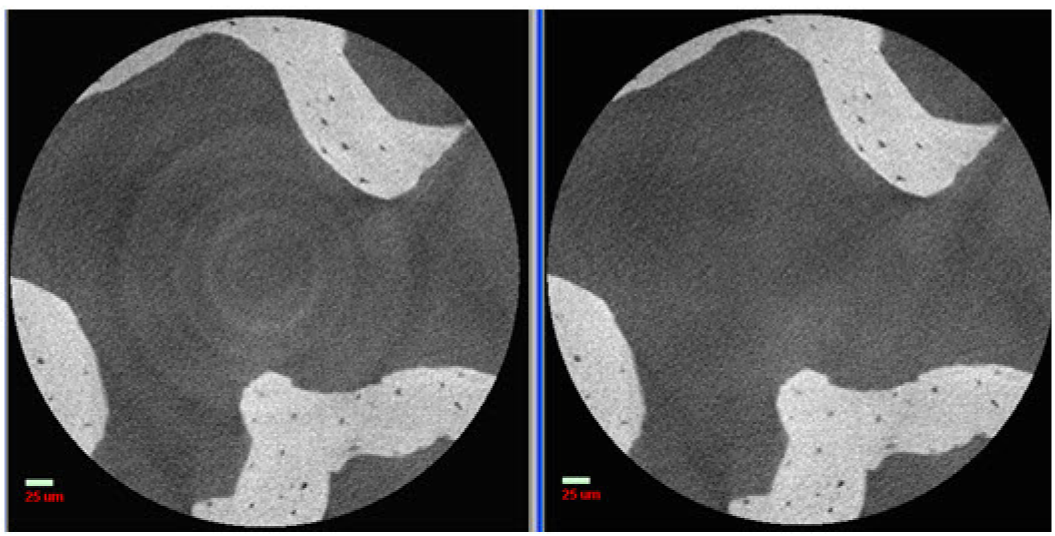
Before Applying Secondary Reference **After Applying Secondary Reference**

Figure G-12 2D Reconstructed Slice of a High Aspect Ratio Composite Material, before and after Applying a Secondary Reference



Before Applying Secondary Reference **After Applying Secondary Reference**

Figure G-13 2D Reconstructed Slice of a High Resolution Bone, before and after Applying a Secondary Reference



Before Applying Secondary Reference **After Applying Secondary Reference**

Selecting the Correct Source Filter to Use for the Secondary Reference

This process describes how to select a source filter that matches the sample's beam hardening effects.

NOTE It is best to collect the secondary reference immediately after acquiring the original tomography, **without moving the X-ray source or detector**, to maximize the secondary reference's effectiveness.

NOTE The original image acquisition and secondary reference collection parameter values **must be the same** for a secondary reference to work correctly.

To select the correct source filter to use for the secondary reference

1. **Scout** – Follow steps a and b below to determine the sample's average **Intensity** value:

   a. Using the parameter values previously determined for tomography acquisition, click  to acquire a single image in the **Front** or **Side View** image display (Sample Theta is at 0° or -90°, respectively).

   The button changes to  and then back to  after the image is acquired.

   b. Within the updated **Front** or **Side View** image display (Sample Theta is at 0° or -90°, respectively), position the mouse pointer at the center of the image, and then make note of the **Intensity** value (lower left of the updated image display). **This is the sample's average Intensity value that you are aiming to match within approximately 20% when the secondary filter is in place.**

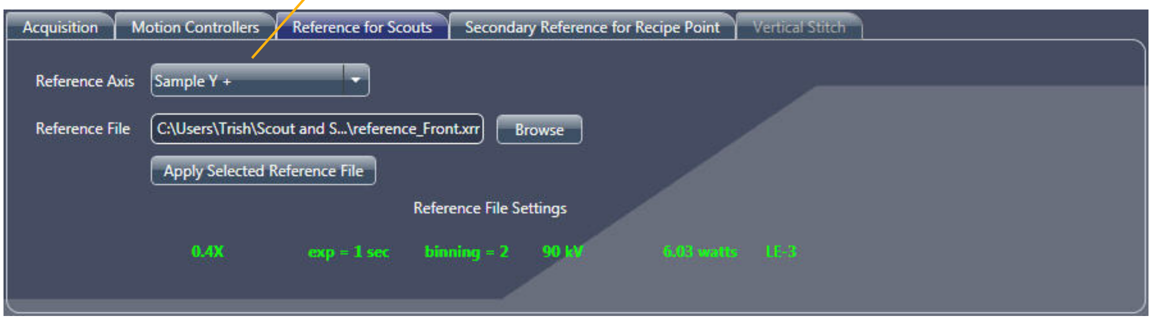
NOTE For samples with high-aspect ratios (that is, samples that are wider than thick), select a 2D projection that is at least 45° to the normal (Sample Theta at ±45°) to obtain values that better represent the entire tomography.

2. **Scout** – Select the **Reference for Scouts** tab within the **Edit Recipe Points for Sample** panel, and then select the reference axis on which to position the sample during reference collection from the **Reference Axis** drop-down list box. (Refer to Figure G-14.)

NOTE The default reference axis is *Sample Y+*. For most samples, selecting Sample Y+ will sufficiently move the sample below the beam line and out of the FOV.

Figure G-14 Use **Reference for Scouts** Tab within **Scout** View's **Edit Recipe Points for Sample** Panel to Indicate Reference Axis

In step 2, select the reference axis on which to position the sample during reference collection.



3. **Scout** – Select the **Secondary Reference for Recipe Point** tab within the **Edit Recipe Points for Sample** panel, and then select a source filter from the **Source Filter** drop-down list box that is *N*+2 higher than the source filter that was used to acquire the original tomography.

   For example (refer to Figure G-15):

   – If a source filter was not used during acquisition, select *LE2*

   – If the LE3 source filter was used during acquisition, select *LE5*

Figure G-15 Select the Source Filter and Preview the Secondary Reference

In step 3, select a source filter that is *N*+2 higher than the source filter that was used to acquire the original tomography.

In step 4, click **Preview** to preview the secondary reference.

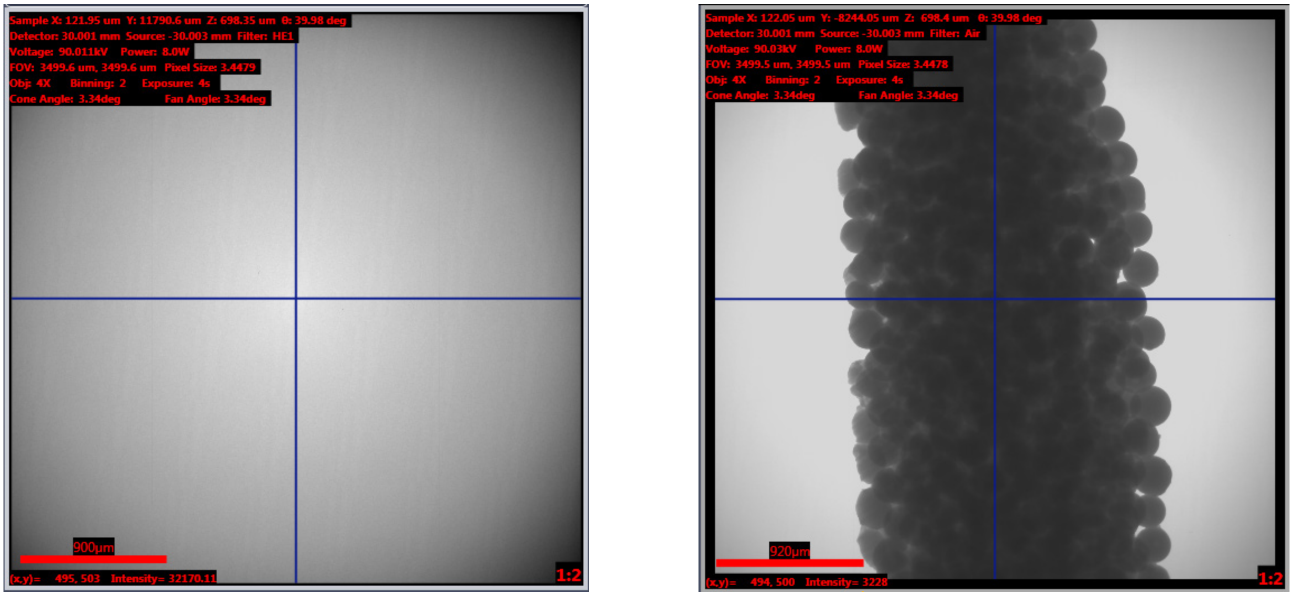
NOTE **Xradia 510 Versa and Xradia 410 Versa** – Manually install the source filter that you selected in step 3 on the X-ray source, using the process described in Appendix F, "Installing a Source Filter – Xradia 510 Versa and Xradia 410 Versa."

4. **Scout** – Click **Preview** to verify that the sample is out of the FOV. An **Image: Scout Page Reference Acquisition** window opens, displaying the filtered secondary reference preview. (Refer to Figure G-16, image on left.)

NOTE If the sample is too tall for the default Sample Y+ axis set up in step 2, –or– the sample is still within the FOV, repeat steps 2 through 4 with *Sample X-* or *Sample X+* selected in step 2 instead.

NOTE When you are finished viewing the window(s) opened in step 4, click ☒ in each window to close the window(s).

Figure G-16 Typical **Image: Scout Page Reference Acquisition** Window, Displaying the Filtered Secondary Reference Preview – Compare the Preview Reference's **Intensity** Value against the Original Tomography's **Intensity** Value



In step 5, compare the **Intensity** value against the original tomography's **Intensity** value.

5. Position the mouse pointer over the center of the newly filtered image preview to display the **Intensity** value. (Refer to Figure G-16; lower left image). Verify that the **Intensity** value is within approximately 20% of the **Intensity** value of the sample image collected in step 1**.**

   Proceed to "Collecting a Secondary Reference."

NOTE If the **Intensity** value is too high or low, select a different source filter, as appropriate, and then repeat steps 3 through 5:

- **Secondary reference's Intensity value is too high** – Select a stronger source filter (for example, if you selected *LE5* in step 3, select *LE6* instead)
- **Secondary reference's Intensity value is too low** – Select a weaker source filter (for example, if you selected *LE5* in step 3, select *LE4* instead)

Collecting a Secondary Reference

NOTE Secondary reference collection is automatically done after every scan on an Xradia 520 Versa. However, you may follow this procedure if you forgot to collect a secondary reference during acquisition. For the Xradia 520 Versa, skip this process and proceed directly to "Adding the Secondary Reference to the Recipe."

This process describes how to collect the secondary reference after selecting the correct source filter and previewing the reference.

For the Xradia 510 Versa and Xradia 410 Versa, if you have more than one tomography point in the recipe that use different objectives, the secondary reference collection sequence changes. **Do not change the objective between the tomography acquisition and secondary reference collection.** Consider the following scenarios:

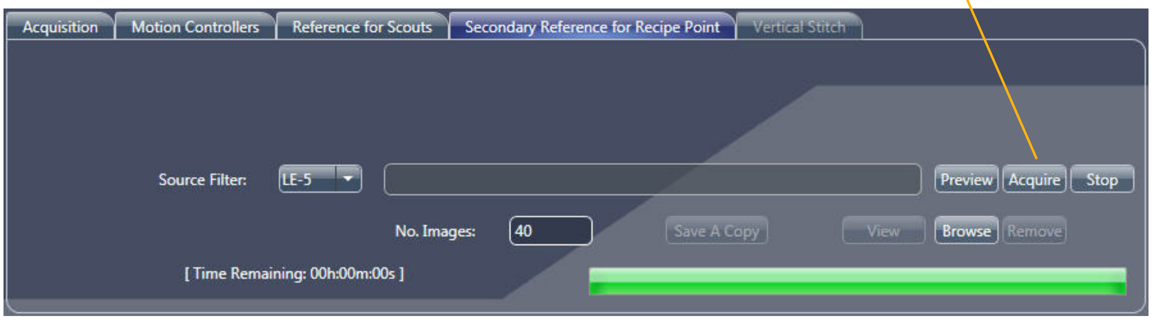
– **Recipe has two tomography points, and both use a different objective** – Use the process described in this section to collect the secondary reference for the **first** tomography point before starting tomography acquisition. After all the parameter values are finalized, run the recipe in **Run** view. After tomography acquisition is complete, use the process described in this section to collect the secondary reference for the **second** tomography point.

– **Recipe has three tomography points, and each uses a different objective** – Use the process described in this section to collect the secondary reference for the **first** tomography point and save that **.xrm* file to use later during manual reconstruction. Run the recipe in **Run** view. Immediately after the tomography acquisition is complete, use the process described in this section to collect the secondary reference for the **third** tomography point. After acquisition for the **third** tomography point is complete, apply the parameter values used during the second tomography point in **Scout** view's **Acquisition** tab. Finally, use the process described in this section to collect the secondary reference for the **second** tomography point.

1. **Scout** – Click **Acquire** to collect a secondary reference. (Refer to Figure G-17.) A **Save As** dialog box opens.

Figure G-17 Collect the Secondary Reference

In step 1, click **Acquire** to collect the secondary reference.



2. Accept the default file name –or– type a new file name, and then click **Save** to save the secondary reference. For example, save the file using a name that identifies the filter number and that the file is a secondary reference, such as *LE5_sec_ref.xrm*, –or– *Sec Ref.xrm*.

   An **Image: Scout Page Reference Acquisition** window opens, displaying the filtered secondary reference(s).

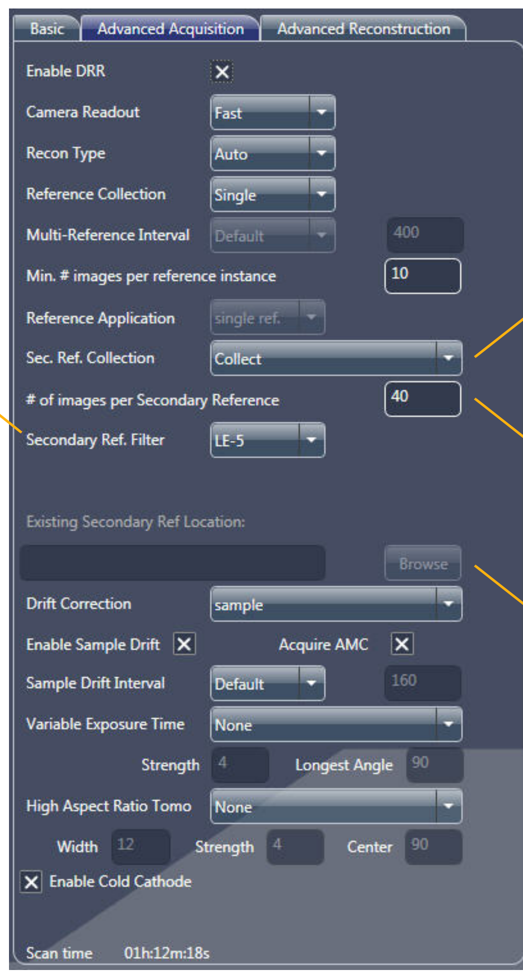
Adding the Secondary Reference to the Recipe

This process describes how to add the selected reference to the recipe.

1. **Scan** – Select the **Advanced Acquisition** tab, and then follow steps a through c below to review or apply the secondary reference's settings (refer to Figure G-18):

   a. **Xradia 520 Versa** – The source filter to use for collecting the secondary reference should already be selected, by default. Ensure that the **Secondary Ref. Filter** drop-down list box correctly indicates the source filter selected in "To select the correct source filter to use for the secondary reference," step 3, on page 281, –or– step 5, on page 282, if you had to select a different source filter to adjust the **Intensity** value.

Figure G-18 Secondary Reference Collection Parameter Values Indicated in **Advanced Acquisition** Tab (Partial Shown) within **Scan** View



Xradia 520 Versa – In step 1a, ensure that the **Secondary Ref. Filter** drop-down list box lists the correct source filter.

Xradia 520 Versa – In step 1b, select *Collect* from the **Sec. Ref. Collection** drop-down list box.

Xradia 510 Versa and Xradia 410 Versa – In step 1b, select *Use file* from the **Sec. Ref. Collection** drop-down list box.

In step 1c, verify that the number listed in the **# of images per Secondary Reference** text box is *40* or higher.

Xradia 510 Versa and Xradia 410 Versa – In step 1b, click **Browse** and then browse to and select a previously saved **.xrm* secondary reference file.

b. **Xradia 520 Versa** – Verify that **Sec. Ref. Collection** = *Collect*.

Xradia 510 Versa and Xradia 410 Versa – Select *Use file* from the **Sec. Ref. Collection** drop-down list box, click **Browse**, and then browse to and select a previously saved **.xrm* secondary reference file. The selected file appears in the **Existing Secondary Ref. Location** text box.

c. Verify that the number listed in the **# of images per Secondary Reference** text box is *40* or higher.

Run – When finished, **run** the recipe as usual, as described in "Step 5 – Run," on page 52 (new recipes) and "Step 5 – Run," on page 69 (existing recipes or recipe templates).

Xradia 520 Versa – Secondary references automatically collected during tomography acquisition will be automatically embedded in the raw tomography file for reconstruction.

Xradia 510 Versa and Xradia 410 Versa – Secondary references applied using the **Sec. Ref. Collection** = *Use file* in the **Advanced Acquisition** tab will be embedded, by default, in the raw tomography for reconstruction. Secondary references manually collected after tomography acquisition, however, must be selected in Reconstructor, as described in "Reconstructing the Tomography Data," step 4, on page 103 in Chapter 3.

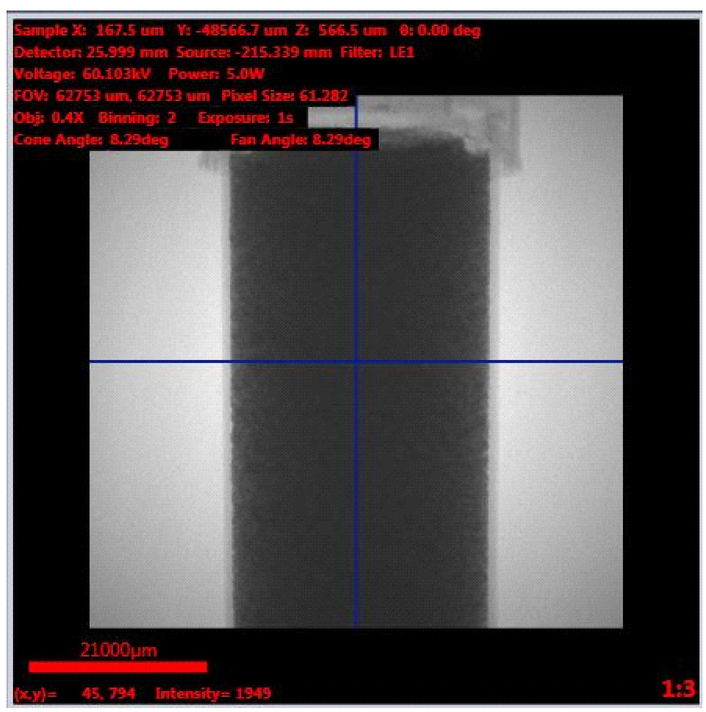
Vertical Stitching

Vertical stitching is a technique that allows you to combine multiple datasets that have an offset only in the Y (vertical) direction. This section describes how to obtain and stitch together multiple reconstructed volumes that are offset in the vertical direction, collected along a sample's length. The resulting volume has a larger field of view while maintaining the desired higher resolution.

A 3D tomography's FOV is determined by the pixel size and number of pixels used. For a single scan, a larger FOV results in larger pixel size, which creates images with lower resolution. For example, in Figure G-19, the entire 70-mm-long tube is too large to be accommodated within one FOV. Without stitching, the best pixel resolution that can be achieved is 30 µm (**Binning** = *1*) while imaging a 62-mm portion of the sample's length. However, by collecting and then stitching three datasets, you can obtain a much higher resolution of 40 µm (20 µm by using **Binning** = *1*) over the sample's entire length.

NOTE For extremely uniform samples (such as optically perfect glass rods), features must added to the outside of the sample for successful vertical stitching. Hand-torn masking tape attached to the sample's outer edge has been used with success.

Figure G-19 Unless Vertical Stitching Is Used, the Maximum FOV Possible to Image of a 70-mm Tube Is a 60-mm Portion, with the Highest Resolution Achievable Being 20 µm (**Binning** = *1*)



Two methods of vertical stitching are available:

- **Auto stitching**

  Auto stitching is enabled for every stitch tomography, by default. After defining the stitch's endpoints, the Scout-and-Scan Control System calculates the number of segments needed to cover the vertical FOV. After a tomography is complete, reconstruction automatically starts while the next scan is in-progress. When two tomographies are reconstructed, a stitch begins in parallel to the next scan and/or reconstruction. This process of scanning, reconstructing, and stitching automatically continues until all segments are complete.

- **Manual stitching**

  Manual stitching is used for stitching together individual tomographies that have been reconstructed. The stitch setup is the same as for auto stitching, with slightly varied process steps to complete the task.

Instructions for selecting both vertical stitching methods are provided in the sections that follow.

Setting up Vertical Stitch Tomographies

This section describes how to set up a vertical stitch tomography.

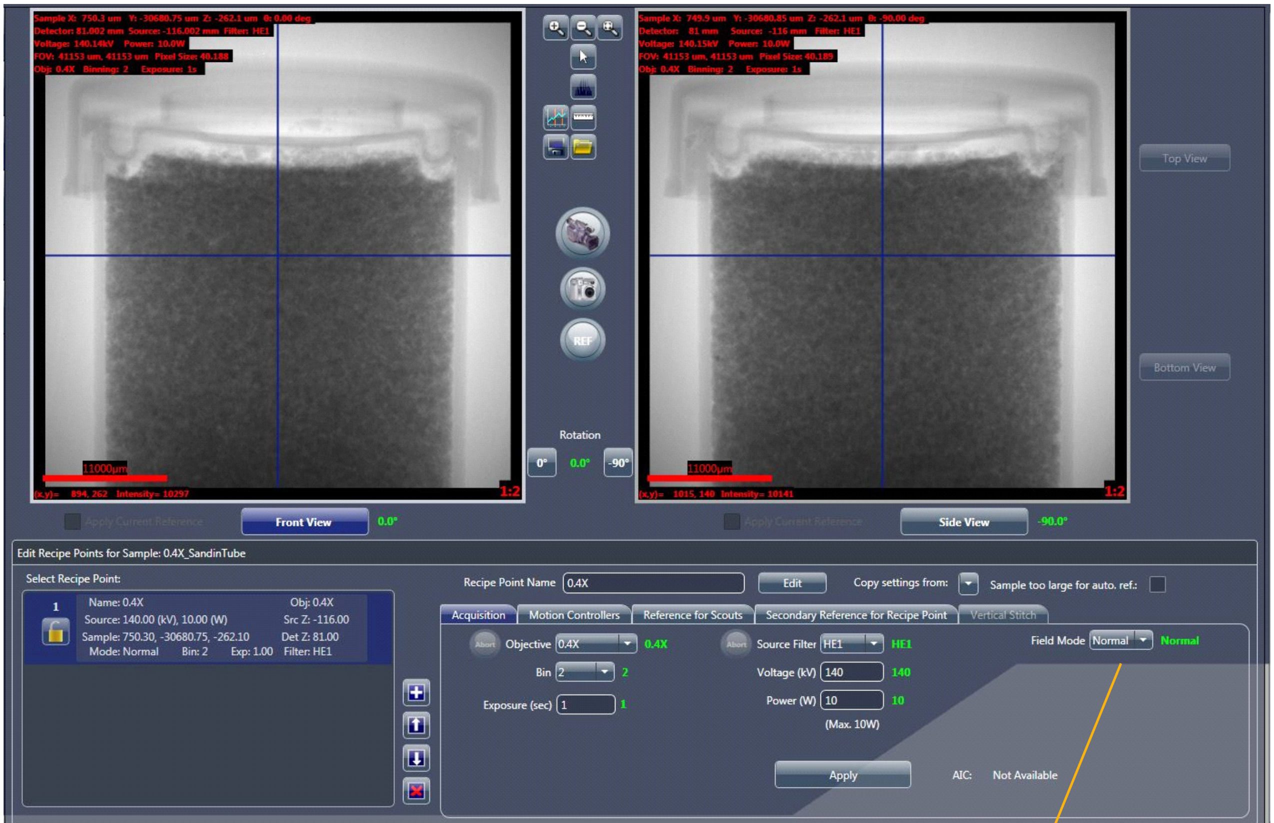
To set up a vertical stitch tomography

1. Use the Scout-and-Scan Control System **Scout** view to establish the sample's scanning parameter values, such as FOV, X-ray source voltage and power, acquisition time, source filter, **Field Mode** = *Normal*, and so forth. Ensure that the sample is mounted as vertically as possible and centered in the 0° and -90° planes (**Front** and **Side View** image displays, respectively). (Refer to Figure G-20.)

NOTE Use of **Scout** view in the tomography collection process is described in "Step 3 – Scout," on page 31 (new recipes) and "Step 3 – Scout," on page 61 (existing recipes or recipe templates) in Chapter 2.

NOTE For vertical stitching using Wide Field mode, set up the sample first for the Wide Field mode scan. After the correct centering and X-ray source and detector positions are selected (refer to "Wide Field Mode," on page 271), for ease of setup, follow the next steps for stitching as if setting up the stitch for Normal Field mode first.

Figure G-20 In **Scout** View, Use the **Acquisition** and **Motion Controllers** Tabs and Normal Field Mode to Set up the Scan as Usual



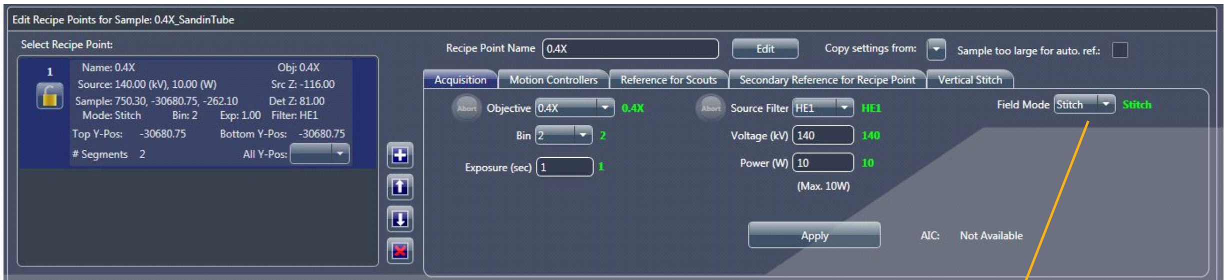
In step 1, ensure that *Normal* is selected from the **Field Mode** drop-down list box.

NOTE To help ensure efficient stitching, mount the sample as straight as possible. Each individual tomography will have the same X and Z position for accurate stitching; thus, any sample that is not vertically aligned might not be fully scanned.

2. In the **Acquisition** tab within the **Edit Recipe Points for Sample** panel in **Scout** view, select *Stitch* from the **Field Mode** drop-down list box.

3. Click **Apply** to enable vertical stitching, the **Vertical Stitch** tab, and the **Top View** and **Bottom View** buttons. (Refer to Figure G-21, Figure G-23, and Figure G-24, respectively.)

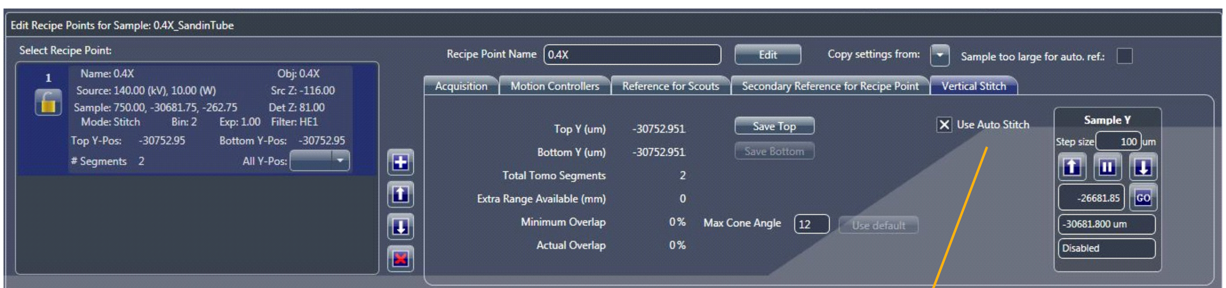
Figure G-21 Select *Stitch* as the Field Mode to Enable Vertical Stitching in the **Acquisition** Tab in **Scout** View



In step 2, select *Stitch* from the **Field Mode** drop-down list box.

4. Select the **Vertical Stitch** tab within the **Edit Recipe Points for Sample** panel in **Scout** view, and then verify that the **Use Auto Stitch** check box is selected (default). (Refer to Figure G-22.)

Figure G-22 Setting up a Stitch from the **Vertical Stitch** Tab in **Scout** View



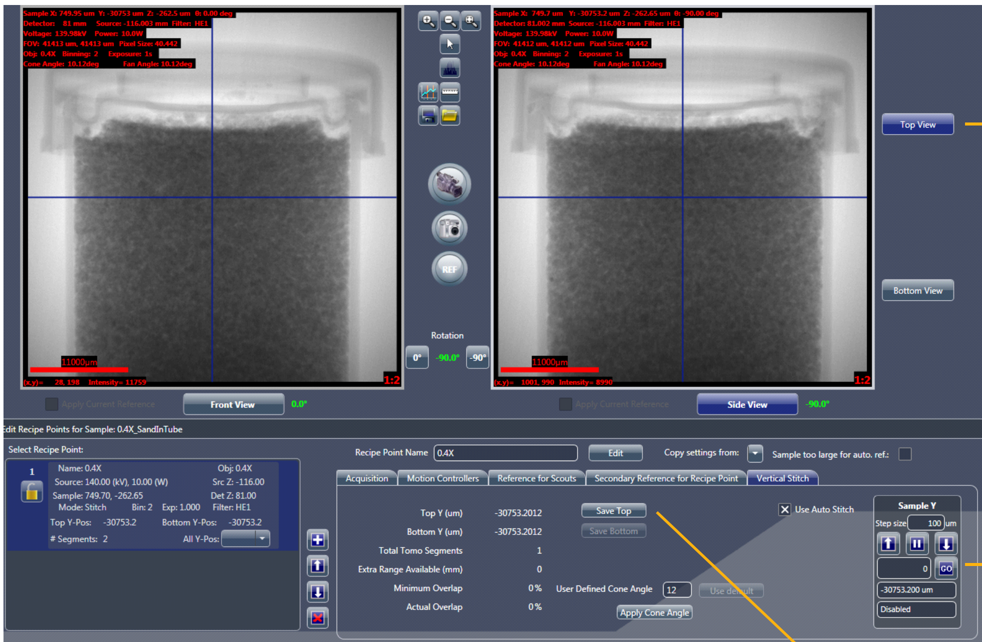
In step 4, verify that the **Use Auto Stitch** check box is selected (default).

NOTE The **Use Auto Stitch** check box is selected, by default. **Leave this check box selected unless you do not want to perform auto stitching.**

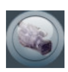
NOTE Only when the **Use Auto Stitch** check box is cleared can the reconstruction type be changed to *Manual* from the **Recon Type** drop-down list box in the next view (**Scan** view's **Basic** tab).

5. Follow steps a through e below to save the top view. (Refer to Figure G-23.)

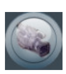
Figure G-23 Saving the Vertical Stitch's Top View



a. Click **Top View** (right of **Side View** image display).

b. Click  to start continuous imaging. The button changes to .

c. Use the **Sample Y** motion controller to move the sample until you have positioned the top of the sample or desired ROI within the FOV.

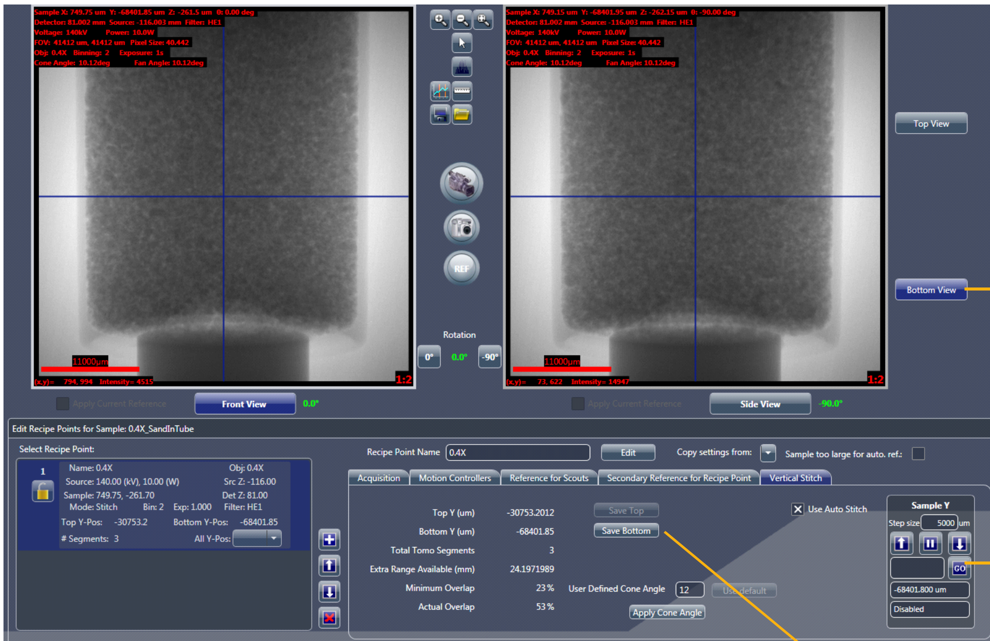
d. Click  to halt continuous imaging. The button changes back to . The **Front** or **Side View** image display (Sample Theta is at 0° or -90°, respectively) updates to show the new image.

e. In the **Vertical Stitch** tab, click **Save Top** to lock in the Top Y position.

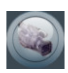
NOTE An image (either single or continuous) must be acquired after any changes are made to the scan parameter values (such as the objective, Sample X or Sample Z positions, X-ray source or detector positions), or the recipe will **not** be updated. Simply acquiring an image, however, does **not** update the saved Top Y position in the recipe. You must click **Save Top** again to update the recipe

6. Follow steps a through e below to save the bottom view. (Refer to Figure G-24.)

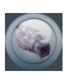
Figure G-24 Saving the Vertical Stitch's Bottom View



a. Click **Bottom View** (right of **Side View** image display).

b. Click  to start continuous imaging. The button changes to .

c. Use the **Sample Y** motion controller to move the sample until you have positioned the bottom of the sample or desired ROI within the FOV.

d. Click  to halt continuous imaging. The button changes back to . The **Front** or **Side View** image display (Sample Theta is at 0° or -90°, respectively) updates to show the new image.

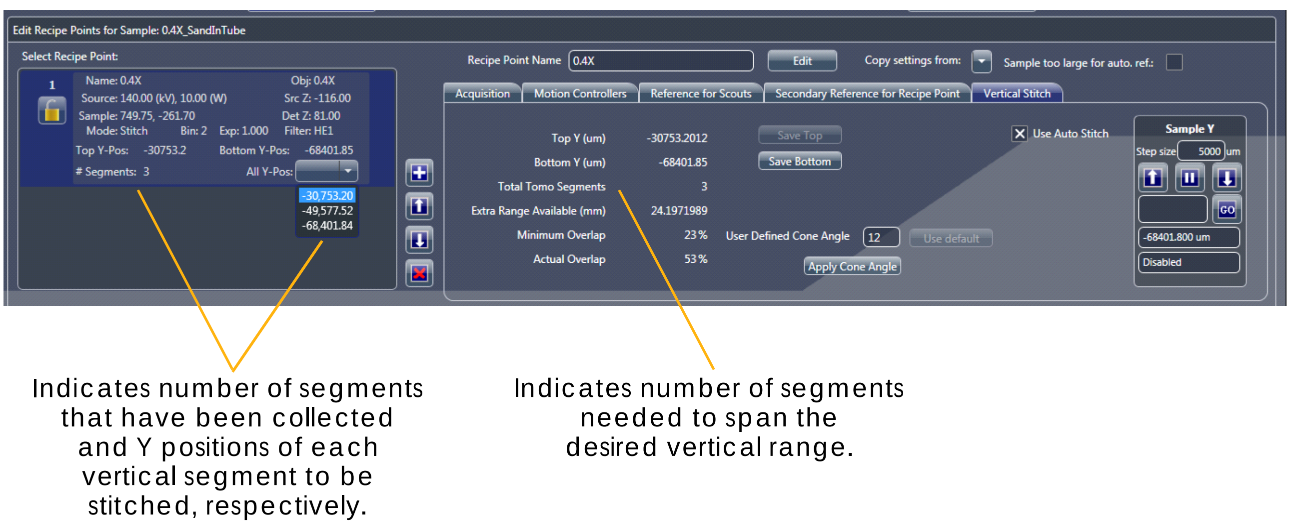
NOTE During continuous image acquisition, the **Total Tomo Segments** parameter changes as you move the sample to indicate the number of stitch points (segments) that are needed to span the desired vertical range. (Refer to Figure G-25.)

e. In the **Vertical Stitch** tab, click **Save Bottom** to lock in the Bottom Y position.

NOTE An image (either single or continuous) must be acquired after any changes are made to the scan parameter values (such as the objective, Sample X or Sample Z positions, X-ray source or detector positions), or the recipe will **not** be updated. Simply acquiring an **image**, however, does **not** update the saved Bottom Y position in the recipe. You must click **Save Bottom** again to update the recipe.

In the **Select Recipe Point** area, **# Segments** indicates the number of segments that have been collected and the **All Y-Pos** drop-down list box lists the Y positions of each vertical segment to be stitched. (Refer to Figure G-25.)

Figure G-25 Vertical Stitch Segment-Related Information



NOTE If you acquire another image after locking in (saving) the Top and/or Bottom Y positions to the recipe, the **Total Tomo Segments** in the **Vertical Stitch** tab will differ from the **# Segments** number listed in the **Select Recipe Point** area unless you click **Save Top** and/or **Save Bottom** after acquiring the additional image.

For example, in Figure G-26, after saving the Top (-30,753.20) and Bottom (-68,401.84) Y positions (as shown in the **Select Recipe Point** area), the sample's Top Y position was moved to -34401.402 and then a third image was acquired (as shown in the **Vertical Stitch** tab). Moving the sample changed the remainder of the other **Vertical Stitch** tab parameter values as well. The new **Vertical Stitch** tab parameter values will be used (that is, saved to the recipe) **only** if you click **Save Top** before proceeding to the next step.

Figure G-26 Mismatched **Select Recipe Point** Area and **Vertical Stitch** Tab Top Y Positions

At this point, auto stitching setup is complete. You can either proceed to step 7 to reduce the overlapping region for a more-efficient vertical stitch –or– proceed to step 9.

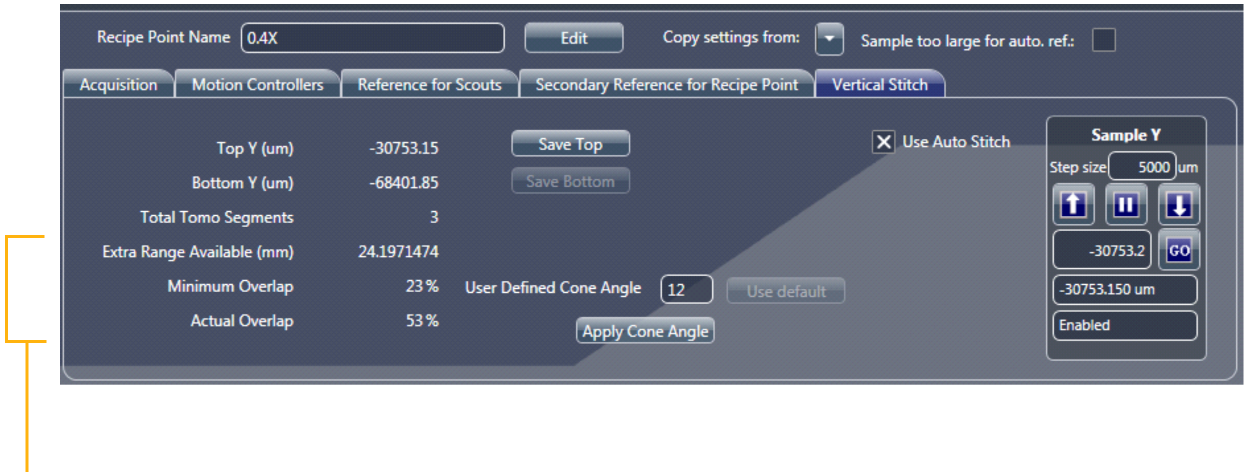
7. **Optional** – Optimize the overlapping region. (Refer to Figure G-27.)

   Depending on the geometric configuration (objective, cone angle, and so forth), the Scout-and-Scan Control System calculates the **Minimum Overlap** value (Vertical Stitch tab). The **Minimum Overlap** value indicates the ideal overlapping region required for a clean vertical stitch.

   The **Actual Overlap** value is calculated from the current Top and the Bottom Y positions (listed in the **Vertical Stitch** tab) region, and provides information regarding the overlapped region. The **Extra Range Available (mm)** value indicates the amount of extra range, in millimeters, that is available on the Y axis.

NOTE The most efficient (highest throughput) stitch occurs when the **Extra Range Available (mm)** value is approximately 0.05 mm (which allows for small stage motions), and the **Actual Overlap** value is approximately equal to the **Minimum Overlap** value.

Figure G-27 For a More-Efficient Vertical Stitch, Change the Vertical Stitch Recipe Parameter Values to Reduce Excess Overlap between Tomography Segments



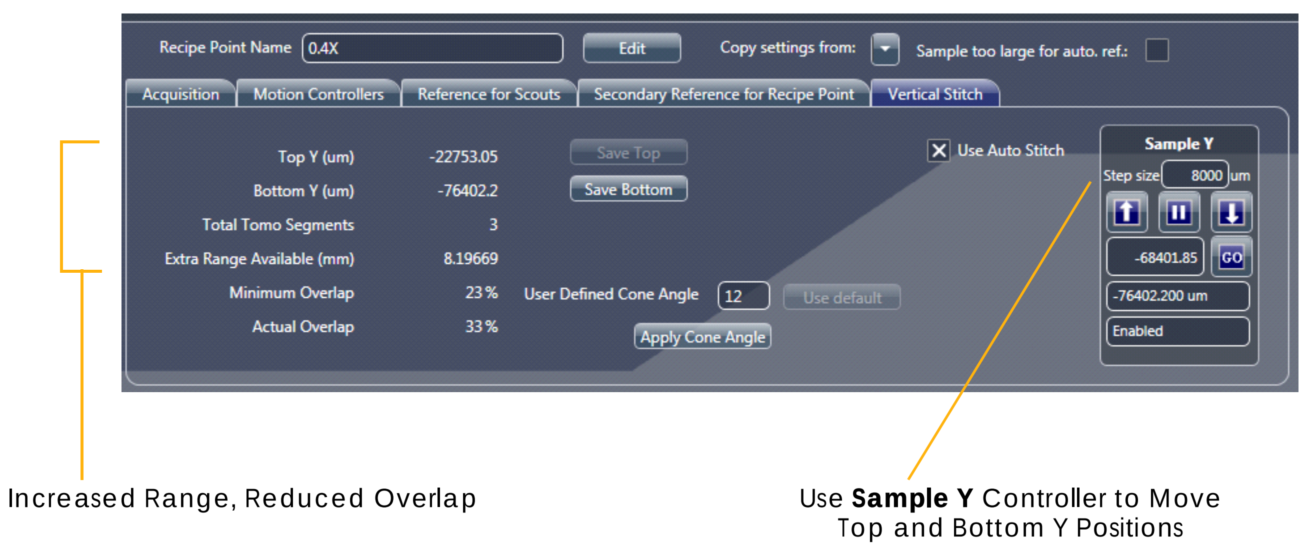
Depending on the amount of excess overlapping to be applied, you can do one of four things (refer to Figure G-27):

– **Make no changes** – This option leads to using the “extra overlap” as the total overlapping region, thereby enabling a higher quality of overlap in terms of signal-to-noise ratio. For example, in Figure G-27, the actual overlap is significantly more than the minimal required overlap.

– **Change the Top and/or Bottom Y positions to increase the range** – As shown in Figure G-28, of the 24 mm of extra range available (shown initially in Figure G-27), 16 mm were used to increase the stitch’s vertical range by using the Sample Y controller to add 8 mm (8000 µm) to each end of the range. If you use this method, be sure to click **Save Top** and **Save Bottom** after changing the Top and Bottom Y positions, respectively.

NOTE The additional range can be applied in differing lengths to the Top and/or Bottom Y positions. For example, the 16 mm of additional vertical range could be applied as 6 mm to the Top Y position and 10 mm to the Bottom Y position –or– any combination that equals 16 mm.

Figure G-28 To Reduce the Overlapping Region (Extra Range Available), You Can Move the Top and/or Bottom Y Positions to Increase the Vertical Stitched Range

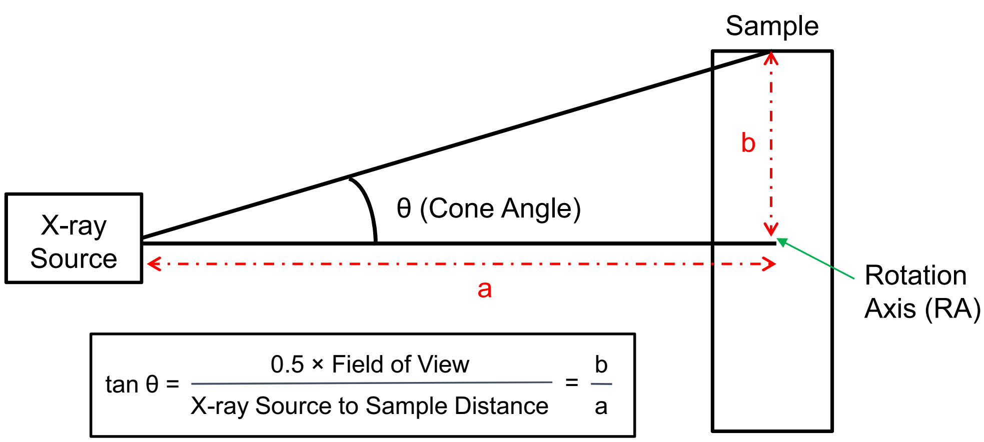


– **Change the Top and/or Bottom Y positions to reduce the range** – If there is room for flexibility within the selected vertical range, and the percentage of actual overlap is large, you can decrease the range just enough to reduce the number of segments needed by 1. If you use this method, be sure to click **Save Top** and **Save Bottom** after changing the Top and Bottom Y positions, respectively.

– **Optional** – **Change the cone angle (Advanced User option)** – The cone angle (CA) θ can be calculated as shown in Figure G-29. If you need to perform stitching at a particular angle, type the desired angle in the **User Defined Cone Angle** text box, and then click **Apply Cone Angle** to save the angle change to the recipe.

For example, in Figure G-30, the CA default of *12* (refer to Figure G-27) was changed to *8*, which increased the overlapping region because slices at cone angles greater than 8° were excluded from the stitch.

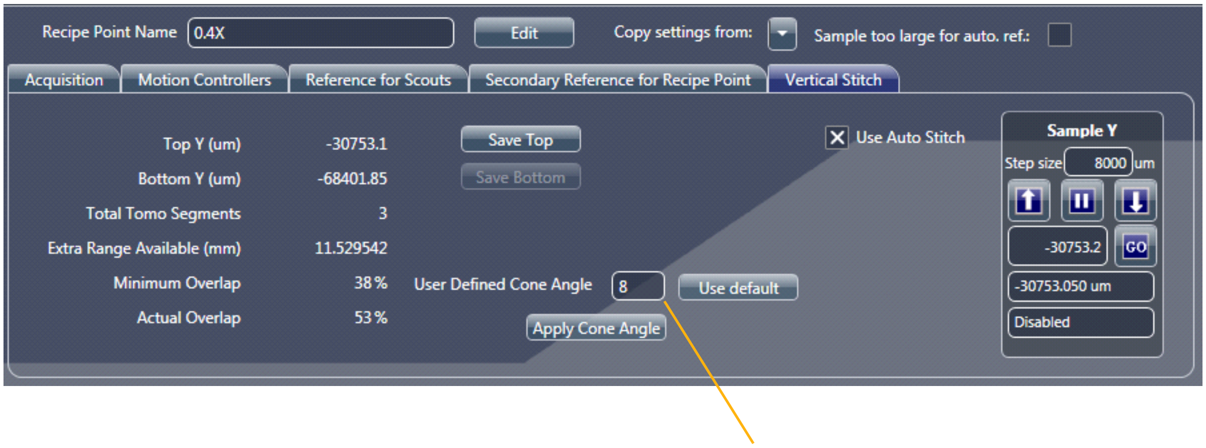
Figure G-29 Cone Angle Definition



NOTE The user-defined cone angle defines the cone angle at which the segments are vertically stitched. Changing the **User Defined Cone Angle** value does **not** change the scan's physical cone angle, which is defined by the objective, X-ray source – rotation axis, and detector – rotation axis distances.

NOTE Changing of the cone angle is an optional step to be used only by advanced users who determine that the stitch's cone angle needs to be changed.

Figure G-30 Set up a **User Defined Cone Angle** Value to Change the Vertical Stitch's Cone Angle



The default 12° cone angle ensures that you will **not** see cone angle artifacts (that is, cone angle streaks at the tops and bottoms of the image volume) at angles greater than 12°. This is done at the cost of extra overlap, however, that can cause the need for additional segments to span the desired vertical range. If you want to try to acquire fewer segments (which results in faster throughput), the cone angle can be adjusted up to 17°, but only if the actual scanning cone angle is 17° (for example, the actual scanned cone angle, as seen in the figures provided in this section, is 12°; the math will **not** go beyond 12°, even if you set up a larger value). The typical method to change the actual cone angle is to change the X-ray source and detector positions. Increasing the cone angle from 12° will, however, lead to more cone angle artifacts in the vertical stitch. **It is therefore highly recommended that you do not set the instrument (X-ray source/ detector) to cone angles greater than 12°.**

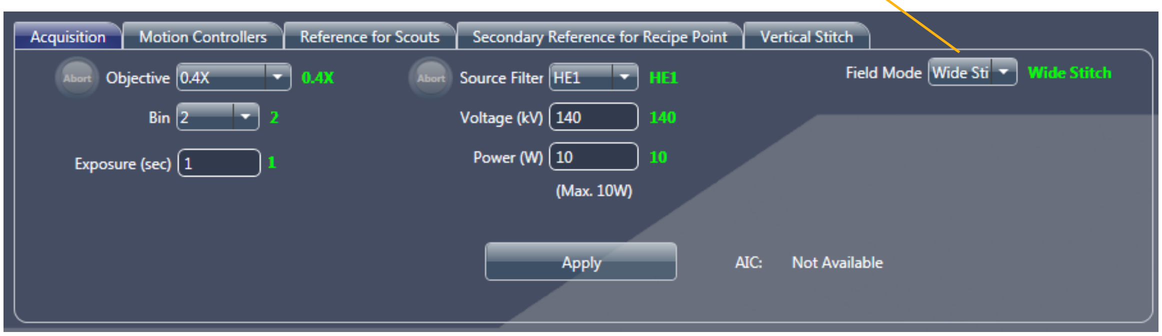
If you want a higher-quality stitch with fewer cone angle artifacts, you can reduce the maximum stitch cone angle. However, this will result in greater overlap and possibly additional segments. Although the minimum cone angle is 3°, going below 6° has diminishing returns and can be unnecessary.

8. **Wide Field Mode Stitch Setup** – If Wide Stitch Field mode was intended, set up the sample first for a Wide Field mode scan. After the correct centering and X-ray source and detector positions are selected (refer to “Wide Field Mode,” on page 271), for ease of setup, follow the next steps for stitching as if setting up the stitch for Normal Field mode first.

    a. After the Y coordinates for the stitch are decided, in the **Acquisition** tab within the **Edit Recipe Points for Sample** panel in **Scout** view, select *Wide Stitch* from the **Field Mode** drop-down list box, and then click **Apply** to enable wide stitching. (Refer to Figure G-31.)

Figure G-31 Selection of Wide Stitch Field Mode

In step 8a, select *Wide Stitch* from the **Field Mode** drop-down list box.



    b. Click **Top View** (right of **Side View** image display), and then select the **Vertical Stitch** tab within the **Edit Recipe Points for Sample** panel in **Scout** view. The Y coordinate for the top view scan appears in the **Sample Y** motion controller text box. Click  to move the sample to the Y coordinate. Click  to acquire a single image in the **Front** or **Side View** image display (Sample Theta is at 0° or -90°, respectively).

    c. In the **Vertical Stitch** tab within the **Edit Recipe Points for Sample** panel in **Scout** view, click **Save Top** to lock in the Top Y position.

    d. Repeat steps b and c, but for the Bottom Y position.

    e. Proceed to **Scan** view to setup the stitch.

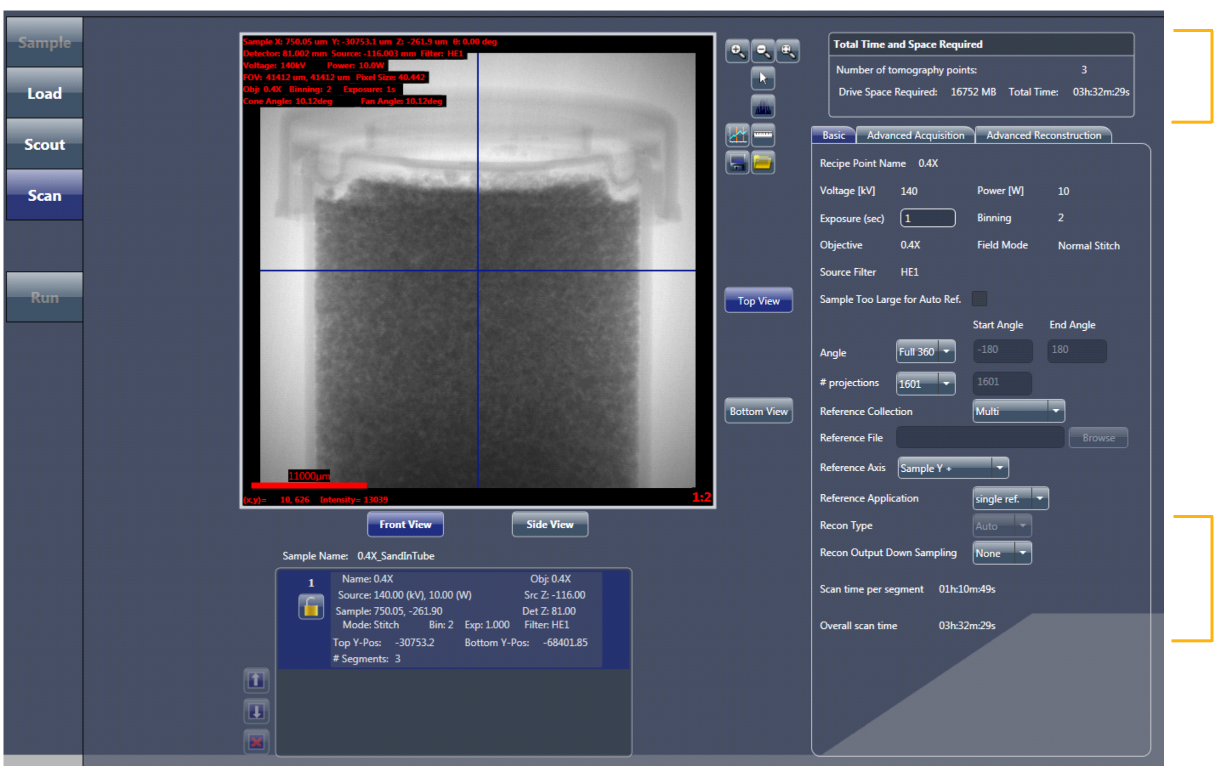
9. Auto stitching setup with overlapping region optimization is complete. Proceed to the next process, depending on what needs to be done next:

   – **Scan** – Set up the recipe's 3D scan parameter values (refer to "Step 4 – Scan," on page 50)

     In **Scan** view, **Scan Time per segment** (lower right) indicates the estimated time to acquire one segment, and **Overall Scan Time** (lower right) indicates the estimated total time for all segments within the stitch recipe point to complete acquisition. The **Total Time** parameter in the **Total Time and Space Required** panel (upper right) indicates the total time for acquiring all recipe points within the recipe. (Refer to Figure G-32.)

     Additionally, because the **Use Auto Stitch** check box was selected in the **Scout** view **Vertical Stitch** tab (default), automatic reconstruction is enabled, by default, for all segments. As a result, **Recon Type** = *Auto* (by default and not changeable) in the **Basic** tab. (Refer to Figure G-32.)

Figure G-32 **Scan** View Timings for Individual Sections and Total Stitched Recipe Points



– **Run** – Run the recipe to acquire the tomographies (refer to “Step 5 – Run,” on page 69)

After you click  to begin acquisition, the auto reconstruction and auto stitch progress bars appear. and then indicate status throughout the recipe run. (Auto reconstruction and stitching occur in parallel to acquiring the tomographies; refer to Figure G-33.) After the scans, reconstructions, and stitches successfully complete, the progress bars change to solid **green**. (Refer to Figure G-34.)

Figure G-33 Individual Progress Bars for Auto Reconstruction and Stitching Appear (If Enabled) in **Run** View

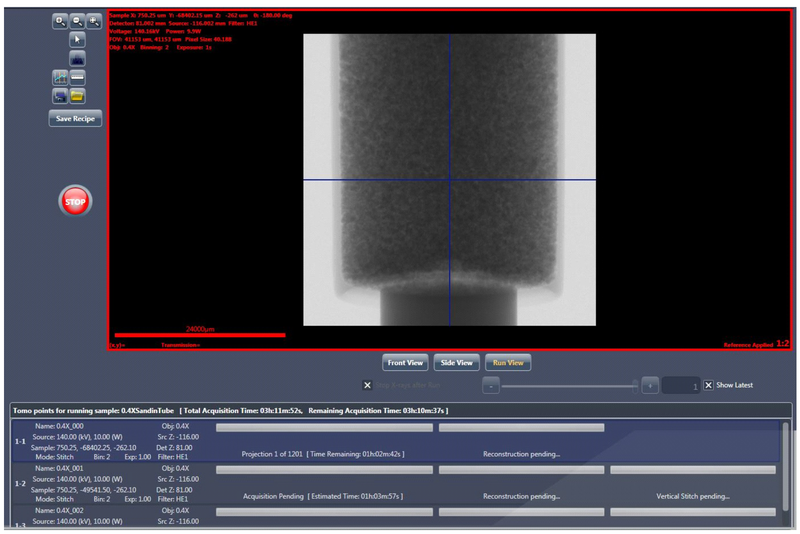
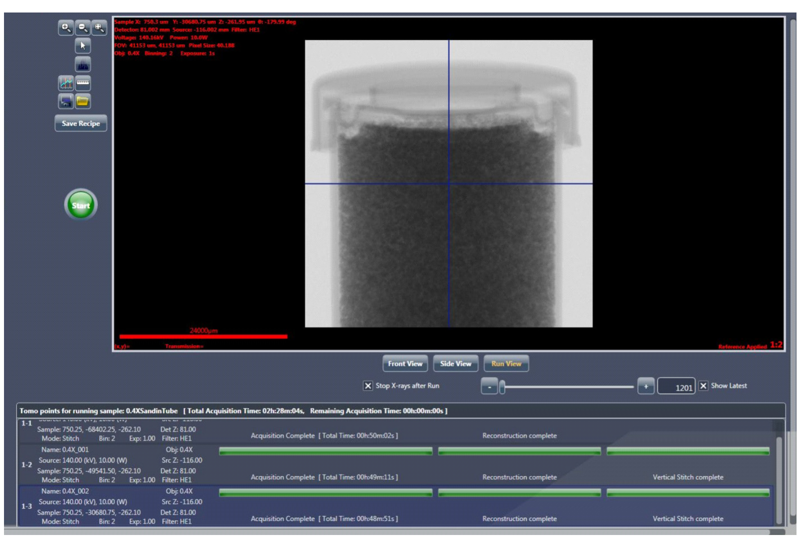


Figure G-34 **Run** View Green Progress Bars Denote Successful Task Completions



Each tomography segment scan will be automatically labeled using numbers – **_000* for the first scan, **_001* for the second scan, and so forth. At the successful completion of data collection, reconstruction, and stitching, a file named **_Stitch.txm* will also be present in the **Sample** folder set up in **Sample** view, which contains the vertically stitched 3D volume dataset for the entire vertical range scanned on the sample. This stitched dataset can be viewed with XM3DViewer (refer to Chapter 4, "Viewing and Editing Tomographies") or the optional Visual SI Advanced program. (Refer to Figure G-35.)

NOTE Because several tomographies are being collected, the overall amount of data may be quite large, especially if collecting data using a binning value of 1 or Wide Field mode. (Refer to "Wide Field Mode," on page 271.) The stitched dataset will be much larger than any individual segment. In the auto stitching example described in this section, which uses a binning value of 2 for its datasets, the stitched file size is approximately 4 GB.

Figure G-35 Typical **Sample** Folder Contents after Successfully Running a Recipe in Auto Reconstruction and Auto Stitching Modes

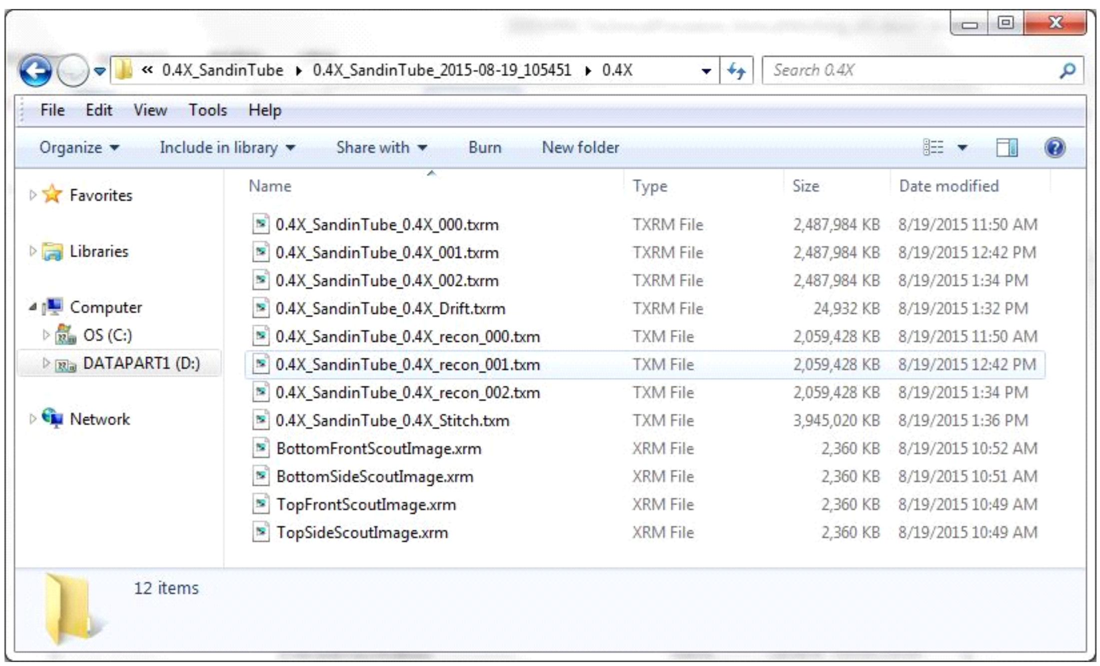
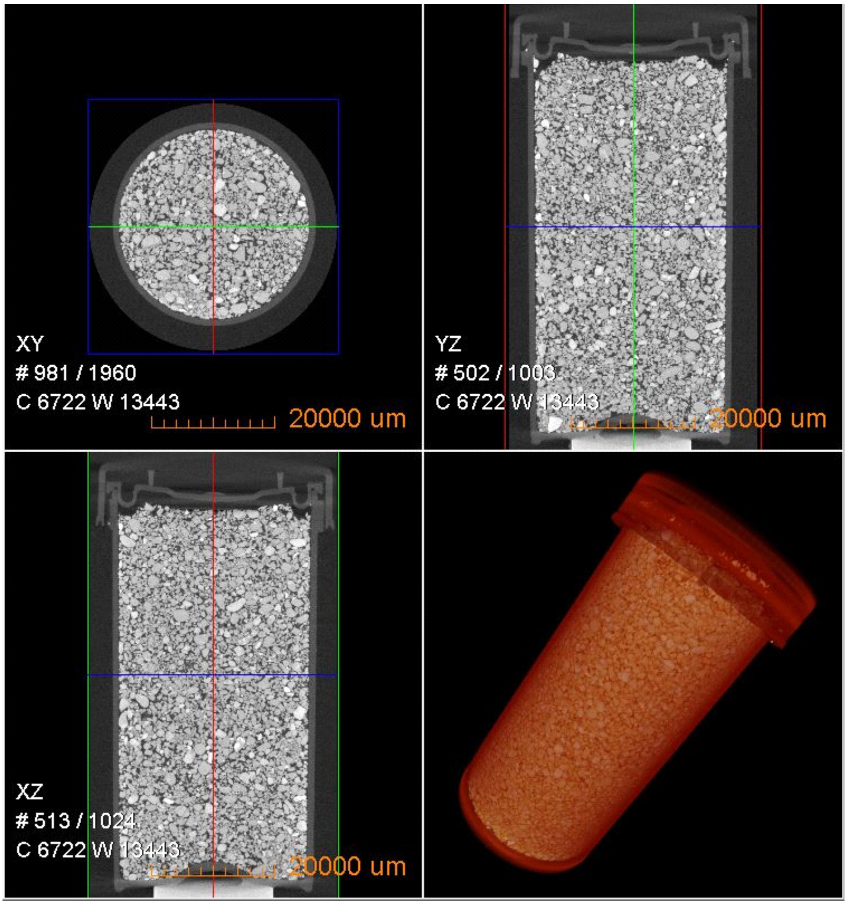


Figure G-36 illustrates an example of a vertically stitched dataset.

Figure G-36 Visualization of the Vertically Stitched Datasets Using XM3DViewer

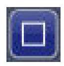


Manual Stitching

The need for manual stitching usually occurs when one or more scans did not automatically reconstruct well. In the case of unsatisfactory center shift or beam hardening constant values used for auto stitch, manual reconstruction of the individual datasets followed by manual stitching should be performed. Manual stitching requires that each tomography is reconstructed with the same byte scaling, beam hardening, and filter settings. Copying these settings from the first reconstruction to all additional reconstructions is the best and easiest method of manual stitching setup.

NOTE For use cases in which the Beam Hardening constant or global scaling is not ideal, or you decide to disable auto stitching, manual stitching **must** be used instead of auto stitching.

NOTE Do **not** use the Angle tool, , to rotate the images.

Do **not** use the Crop tool, , to crop images in the projection dataset image display if you intend to stitch the images together later.

To manually reconstruct and stitch together datasets spanning a range of vertical length along a sample's length

1. Open the *_recon_000.txrm* file (located in the **Sample** folder set up in **Sample** view) in the Reconstructor Scout-and-Scan Control System program (Reconstructor).

NOTE Instructions for using Reconstructor are provided in Chapter 3, "Manually Reconstructing a Tomography Dataset."

2. Find the center shift and the beam hardening constant.

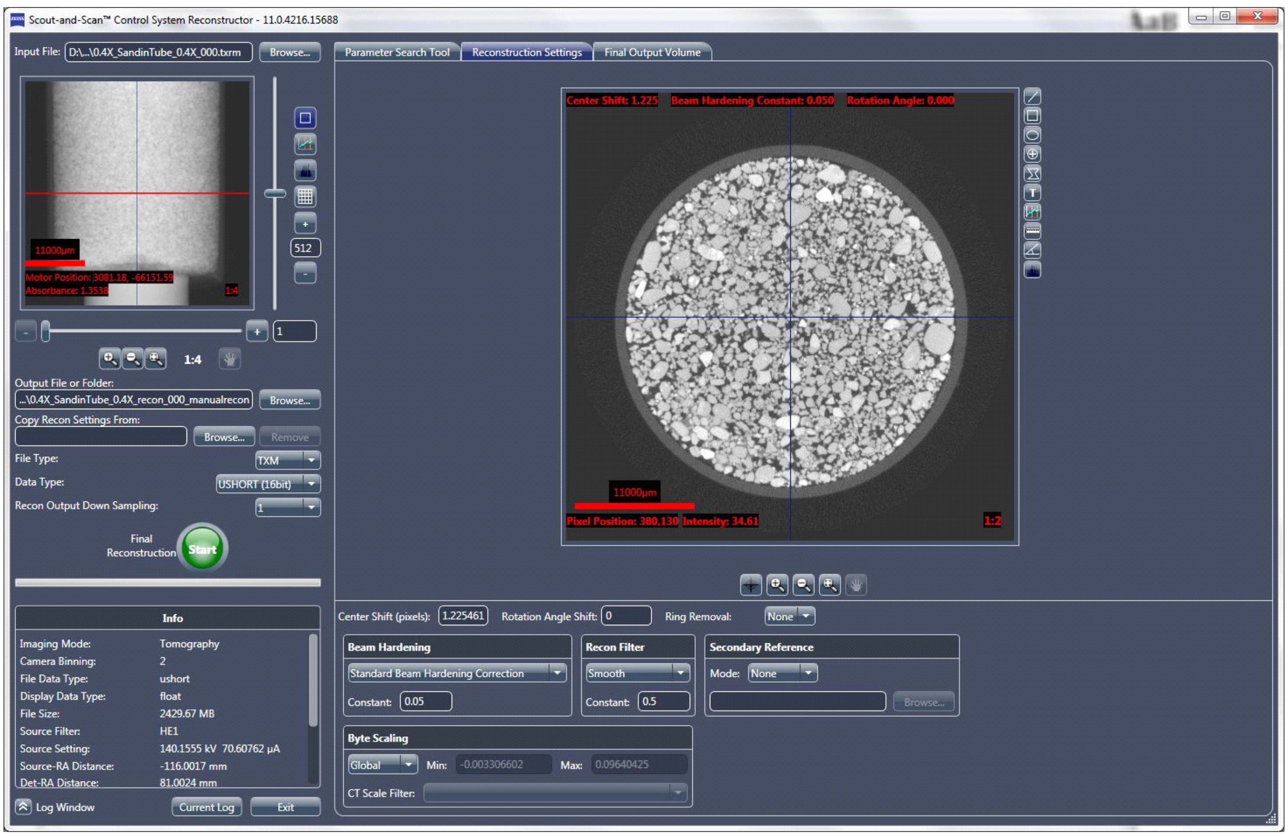
NOTE Instructions for manually finding the center shift and the beam hardening constant are provided in "Finding the Center Shift," on page 79 and "Finding the Beam Hardening Constant," on page 91 in Chapter 3, respectively.

3. Select *Global* from the **Byte scaling** drop-down list box to allow for the global minimum and maximum byte scaling calculation. (Refer to Figure G-37.)

4. Click Start to reconstruct the tomography data. The button changes to Abort and then back to Start when the reconstruction task is complete.

NOTE You can either change the file name set up in the **Output File or Folder** text box (such as to *_recon_000_manualrecon.txm*, as shown in Figure G-38), –or– leave the file name as is and overwrite the auto-reconstructed *_recon_000.txm* file.

Figure G-37 Manual Reconstruction of the First Recipe Point, using Reconstructor



5. After reconstruction is complete, open the next segment (*_recon_001.txrm* file) in Reconstructor.

6. Follow steps a through c below to copy the previously used reconstruction settings (Center Shift, Beam Hardening Constant, Rotation Angle, Recon Filter, and Byte Scaling). These are the values that you will use to reconstruct all segments for the complete vertical stitch.

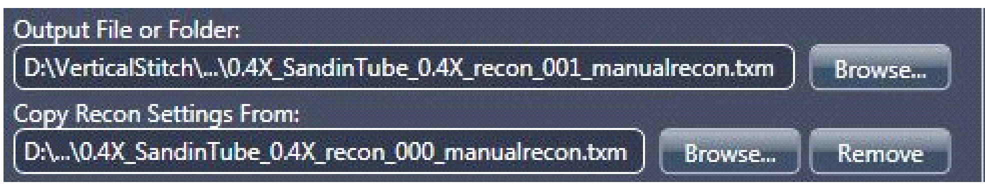
NOTE The center shift between the segments may be slightly different. You should find center shift for each individual segment. All other parameter values (beam hardening correction, global scaling, and recon filter), however, **must** be identical for each segment that is to be vertically stitched.

   a. Click **Browse** (right of the **Copy Recon Settings From** text box). (Refer to Figure G-37.) The **Input File** dialog box opens.

   b. Browse to the file path of the first raw tomography dataset or reconstructed output (for example, the **_recon_000.txrm* or **_recon_000_manualrecon.txm* file, respectively) to be copied.

   c. Select the file, and then click **Open**. The file's path and name appear in the **Copy Recon Settings From** text box. (Refer to Figure G-38.)

Figure G-38 Recon Parameter Values Are Copied from the Selected Dataset Using the **Copy Recon Settings From** Tab



7. Click 

to reconstruct the tomography data. The button changes to 

and then back to 

when the reconstruction task is complete.

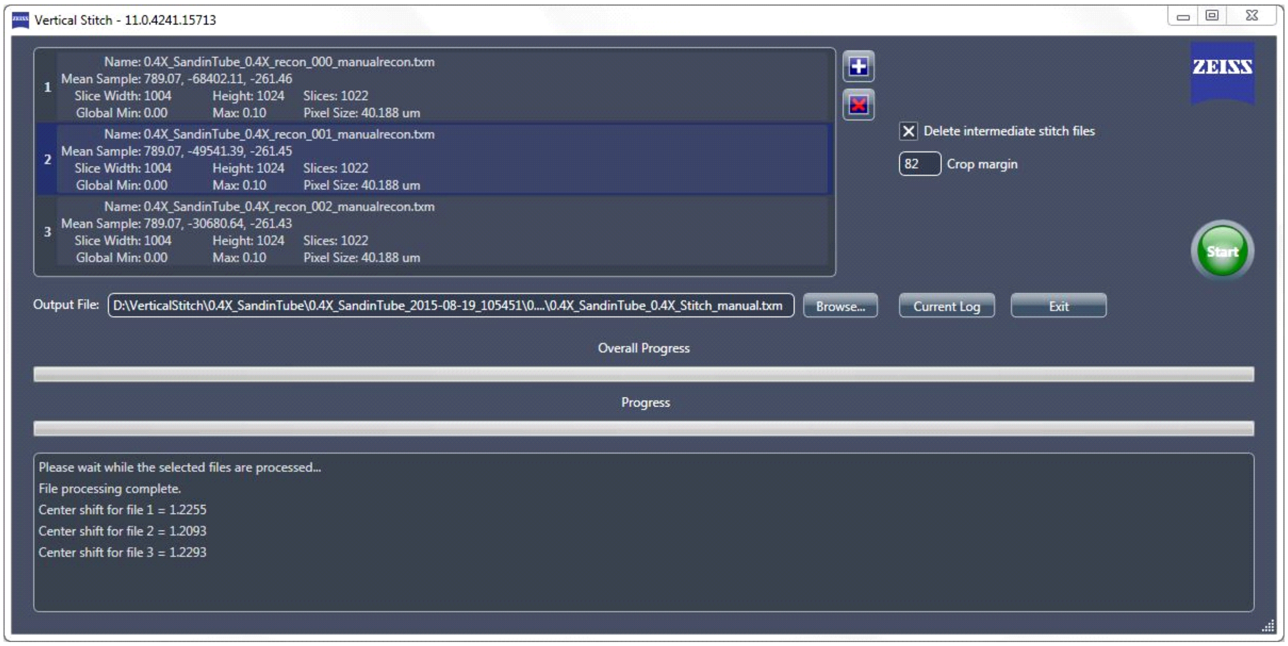
8. Repeat steps 5 through 7 for any remaining segments to be reconstructed, in file-number sequence (for example, **_recon_002.txrm*, **_recon_003.txrm*, and so forth).

9. On the Windows taskbar **Start** menu, select **All Programs**, **Carl Zeiss X-ray Microscopy**, **Xradia Versa 11.*x***, and then **Manual Stitcher Scout-and-Scan 11.*x***. The **Manual Stitcher** main window opens.

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

10. Click [button], press **SHIFT**, select the *_recon_###_manualrecon.txm* files to be vertically stitched to add the files to the stitching queue. (Refer to Figure G-39.)

Figure G-39 Select the Reconstructed Files to Be Stitched and Provide an Output File Name in the **Manual Stitcher** Main Window



11. Follow steps a through c below to set up the output *.txm* file name (refer to Figure G-39):

    a. Click **Browse** (right of the **Output File** text box). The **Output File** dialog box opens.

    b. Browse to the file path of the input files set up in step 6.

    c. Type the file name (such as **Stitch_manual.txm*), and then click **Save**. The file's path and name appear in the **Output File** text box.

12. **Optional** – Clear the **Delete intermediate stitch files** check box if you want to keep the intermediate files.

13. Click [Start] to initiate the vertical stitch. The button changes to [Abort].

The **Progress** bar (lower window) indicates individual vertical stitch status. The **Overall Progress** bar (lower window) indicates overall vertical stitch progress. The status area (lower window) lists calculations being performed on the current stitch. (Refer to Figure G-40.)

After the vertical stitch successfully completes, both progress bars change to solid **green** and the button changes back to . (Refer to Figure G-41.) This stitched dataset can be viewed with XM3DViewer (refer to Chapter 4, "Viewing and Editing Tomographies") or the optional Visual SI Advanced program.

Figure G-40 Overall Vertical Stitch Progress Is Shown as a Progress Bar

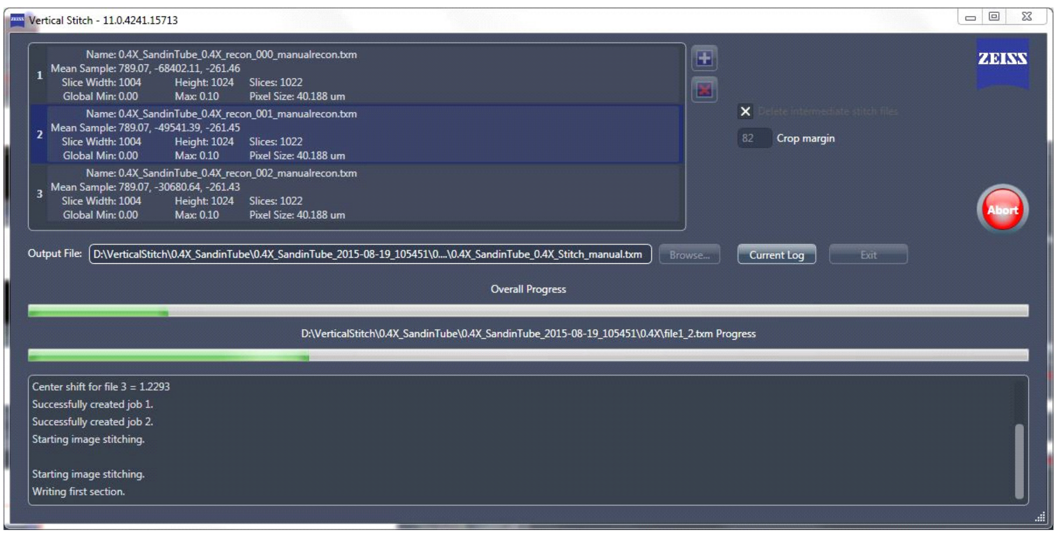
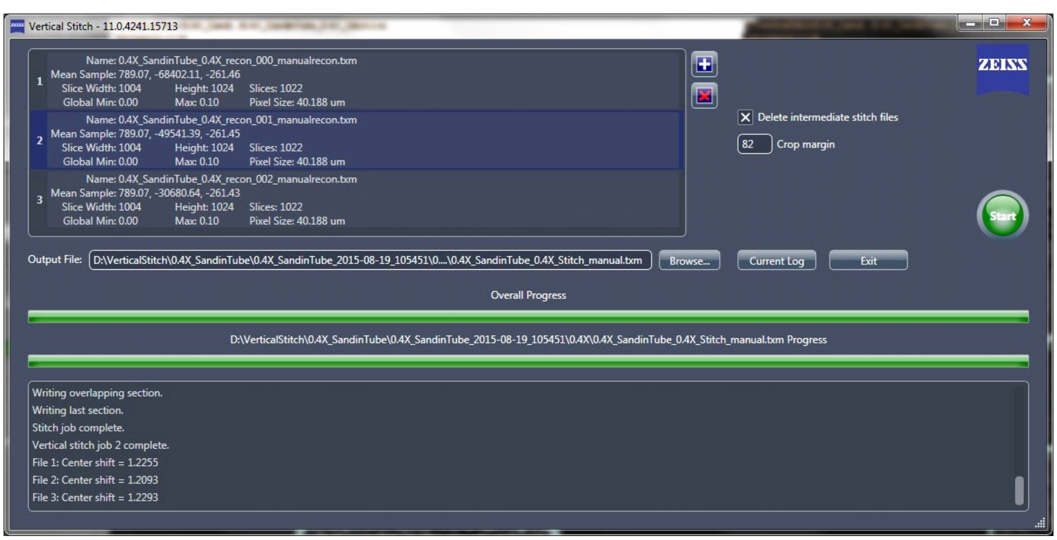


Figure G-41 Solid **Green** Progress Bars Indicate a Successfully Completed Vertical Stitch



Correcting for System-Related Drift

All micro and nano CT X-ray systems have thermal shifts and mechanical drifts that cause unwanted system motion, which results in unwanted drifts within the scanned images.

Drifts can also be caused if the sample moves slightly during imaging; however, the Scout-and-Scan Control System cannot completely correct for this type of drift. Therefore, precise and stable sample mounting is critical.

NOTE Sample mounting and loading instructions are provided in Appendix E, “Mounting, Loading, and Removing Samples.” Troubleshooting instructions related to sample movement are provided in “Sample Is Unstable,” on page 141 in Appendix A.

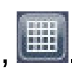
The Scout-and-Scan Control System provides the ability to correct for three types of drift:

– Adaptive Motion Compensation

– Sample Drift

– Thermal Shifts

NOTE Thermal shift correction is available only on the Xradia 520 Versa and Xradia 510 Versa.

The Scout-and-Scan Control System collects corrections for each of the three types of drift correction, by default. Drift corrections can be applied only one at a time, by way of the Shifts Table tool, . Each type is discussed in the sections that follow.

Adaptive Motion Compensation

NOTE Adaptive Motion Compensation (AMC) is supported only in Normal and Stitch Field modes.

AMC is new for Scout-and-Scan Control System v11.*x*. AMC corrects for **Sample X**, **Sample Y**, and **Sample Z** stage drifts, X-ray source and detector drifts, and any rectilinear drifts of the sample.

AMC is image-based; therefore, sample projections must have distinct features for the correction to register.

When compared to sample drift, AMC can reduce warm-up times by up to half.

AMC drift is collected and applied by default if the original tomography has the number of projections (**Scan** view **# projections** parameter) set correctly as a multiple of 20 + 1.

If AMC fails to register, the drift collection defaults to thermal shift. Reasons for AMC failures include:

- Original image and corresponding AMC image differ by 30% in brightness
- AMC image has drifted by more than 25% of the original FOV
- Stage-axis of the original image versus the corresponding AMC image differ by more than the predefined tolerances

Method

After the tomography is complete, 21 projections are taken along the angle range selected for the original scan.

Images taken at the same angles (in the original scan and the AMC scan) are registered and the drifts are calculated and embedded in the raw **.txrm* file, correcting drifts in all directions.

Use Cases

AMC is particularly useful for flat samples in which the long views are at 0° and sample drift correction would not be effective.

Sideways (**Sample X** and **Sample Z** axes) sample movements are better handled by AMC than sample drift.

Sample Drift

Sample drift (SD) primarily corrects for **Sample X** and **Sample Y** stage drifts.

SD is image-based; therefore, sample projections must have distinct features for the correction to register.

Method

During tomography acquisition, the sample is rotated to 0° after every 10% of the total number of projections (default drift collection interval) and an image in the XY plane is acquired.

These images are grouped together into a *filename_drift.txrm* file and saved in the same folder as the original scan.

These time lapse images are registered to one another and the drifts are calculated and embedded in the raw **.txrm* file. The images can be visualized to understand the sample movement through the scan.

Use Cases

SD works well for scans that have sufficient warm-up scans (30 minutes for low-resolution scans and up to 2 hours for high-resolution scans).

Using SD is a good alternative if other drift correction options fail to correct the drift.

Use SD when AMC is disabled for scans that have either of the following parameters selected:

– **Sample too large for auto ref.** check box (**Scout** view **Edit Recipe Points for Sample** panel)

– *Wide* selected from the **Field Mode** drop-down list box (**Scout** view **Acquisition** tab)

Thermal Shifts

NOTE Thermal shift correction is available only on the Xradia 520 Versa and Xradia 510 Versa.

Thermal shifts correct for basic thermal motions of the stages and warmed-up X-ray source.

Method

Thermistors are placed at components known to expand and/or contract due to temperature changes within the Xradia Versa enclosure.

Temperature changes throughout the scans are recorded and the associated shifts are calculated and embedded in the raw **.txrm* file.

Use Cases

Thermal shifts work well for scans that have sufficient warm-up scans (30 minutes for low-resolution scans and up to 2 hours for high-resolution scans).

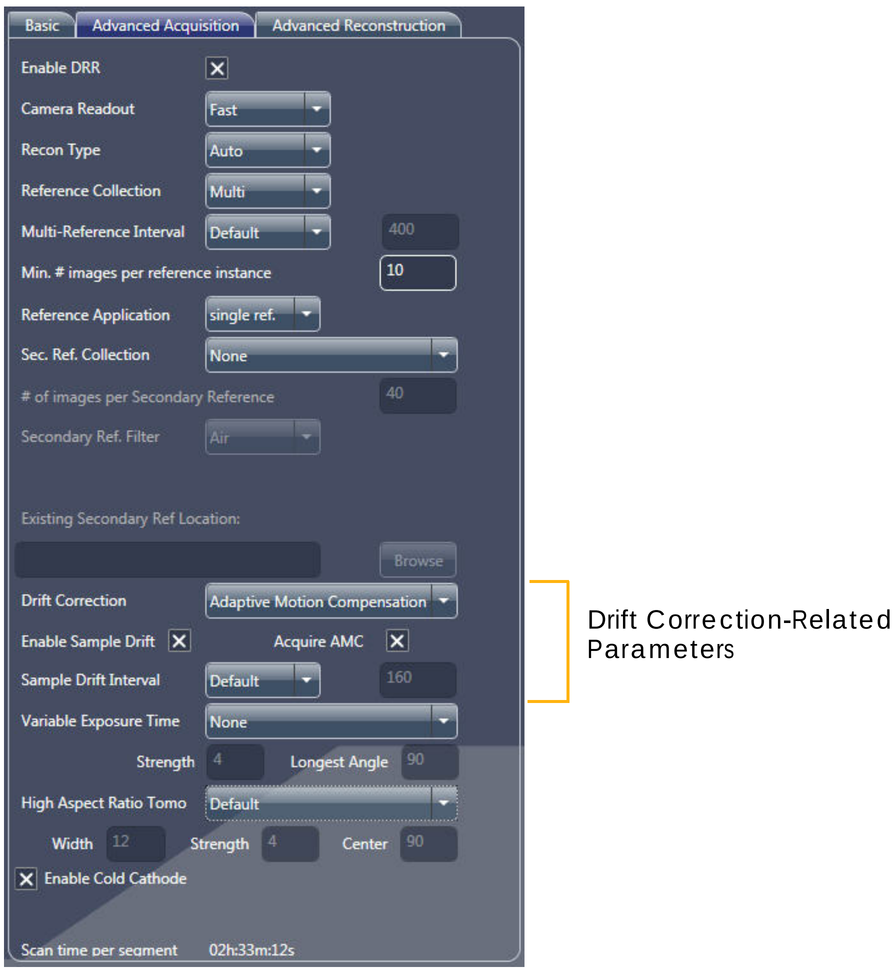
Thermal shift is the only available option that can be used when scanning featureless samples that cannot support image registration, such as the interior of a defect-free uniform glass rod.

Automatically Applying Drift Correction during Scanning

In the Scout-and-Scan Control System's **Advanced Acquisition** tab in **Scan** view (refer to Figure G-42), you can enable/disable collection of AMC and/or SD. Thermal shift is always collected. To apply any of the collected drifts, select the desired drift correction from the **Drift Correction** drop-down list box.

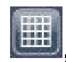
NOTE Only one drift correction can be applied at a time. This is because each type of drift takes into account the same or more components and would lead to overcorrections if used in combination.

Figure G-42 Use the Scout-and-Scan Control System's **Advanced Acquisition** Tab in **Scan** View to Set Drift Correction-Related Parameter Values



Applying Drift Correction during Manual Reconstruction

NOTE Refer also to "Reconstructor User Interface," on page 225 in Appendix D.

Reconstructor's Shifts Table tool, , provides the ability to manipulate the raw tomography dataset:

– Change shifts between AMC, sample drift (if collected), and thermal shift (Xradia 520 Versa and Xradia 510 Versa only) if large sample drifts are noticed within the scan. These are particularly recommended for high-resolution scans to enable reconstruction with fewer motion-related artifacts. (Refer to Figure G-43.)

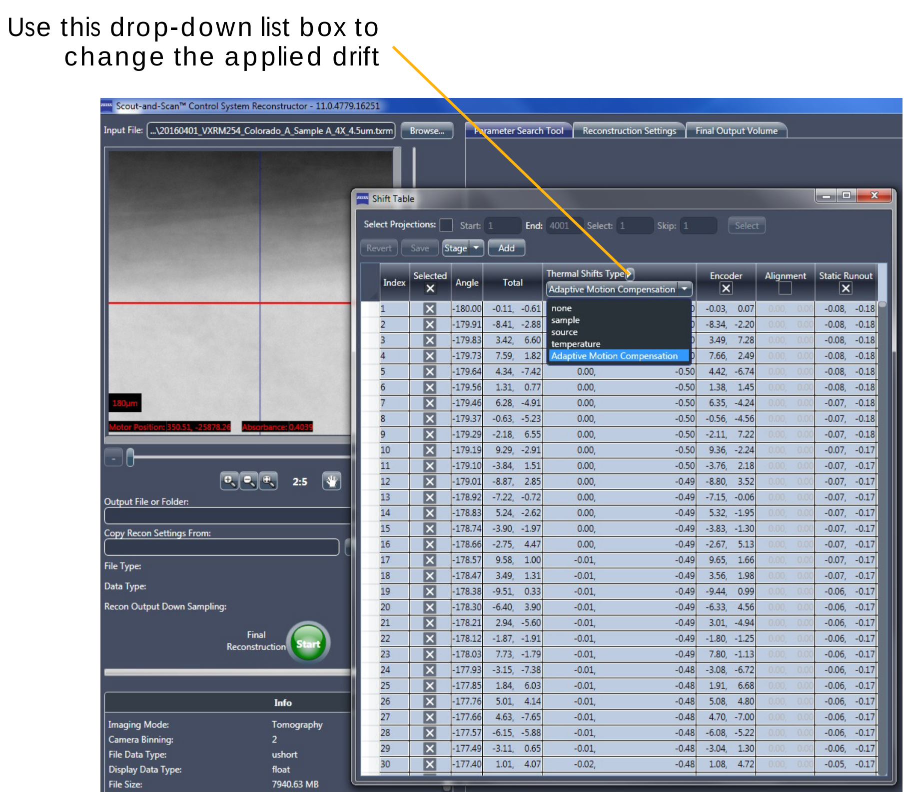
– Add user-defined shift tables when available. (Refer to Figure G-43.)

– Save any changes applied to the Shifts Table tool.

NOTE Data can be reconstructed with only one shift table applied at a time.

NOTE If the reconstruction has motion artifacts, reconstruct using a different drift type and compare all, choosing the one that works the best.

Figure G-43 **Reconstructor** Main Window Side Panel – **Shifts Table** Window

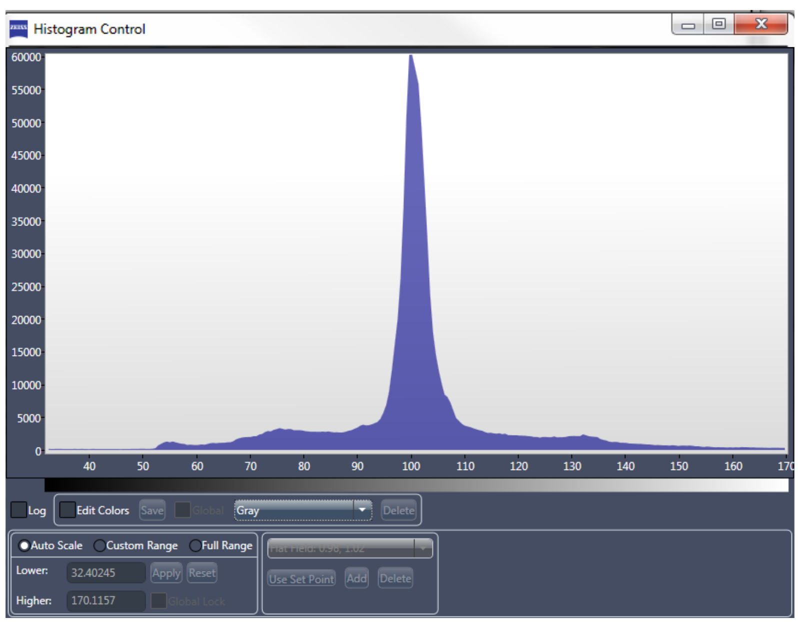


Histogram Control Tool

Reconstructor's Histogram Control tool (refer to Figure G-44), available by clicking [icon] in the side or main panel, enables you to adjust an image's contrast and brightness. This is required, for example, if there are large regions within the reconstructed image that are all black or all white, or to highlight features within a narrow part of the dynamic range of the image. The tool also provides the ability to apply false coloring to the reconstructed image. This section describes the Histogram Control tool's functionality.

Figure G-44 displays the histogram of image intensities. The Y axis indicates the number of image pixels with corresponding intensities along the X axis. The Y axis is auto-scaled to fit the maximum value over the range of X values. The default number of *histogram buckets* (that is, X axis values) is 256.

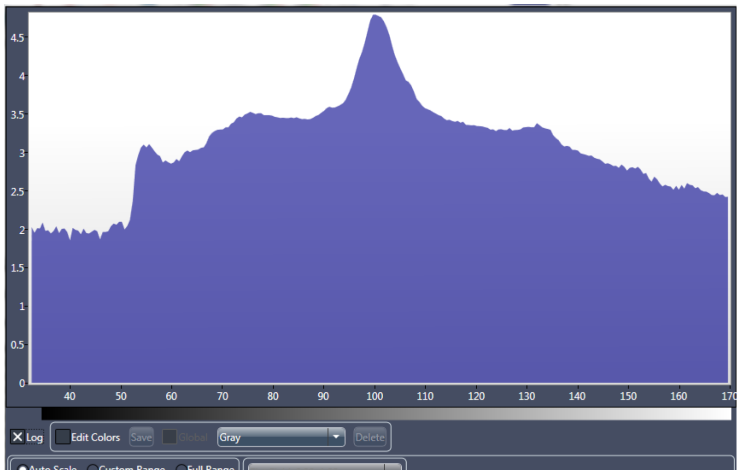
Figure G-44 Histogram Control Tool



Histogram Log

Selecting the **Log** check box displays the histogram log (refer to Figure G-45), which can be used to emphasize the lower-intensity pixel distribution.

Figure G-45 Histogram Log Emphasizes Lower-Intensity Pixel Distribution

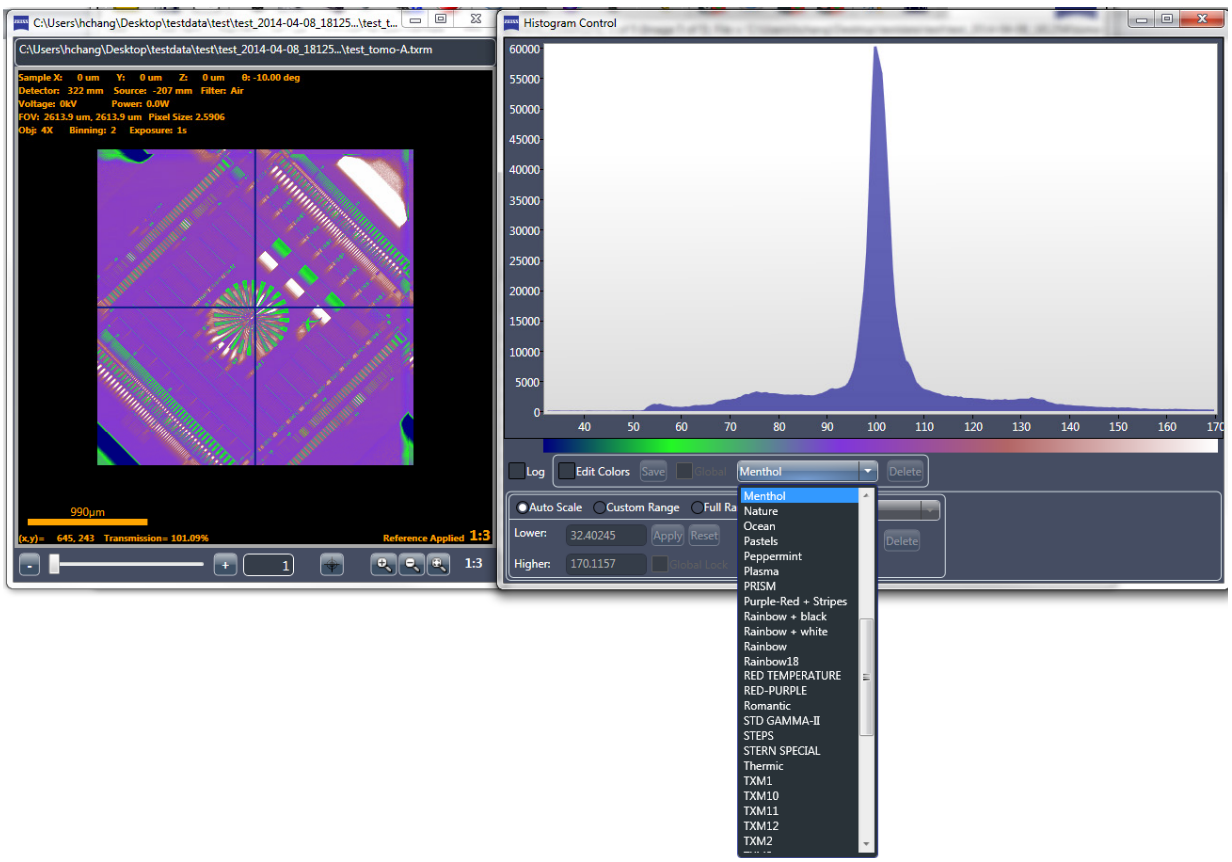


Histogram Color Palette

The color palette can be used to apply false coloring to the image. (Refer to Figure G-46.) The default palette is *Gray* (8-bit grayscale). The **Color** drop-down list box (not labeled; right of the **Edit Colors** check box) lists the available color palettes.

NOTE When the **Edit Colors** check box is cleared, the histogram can be exported as a **.txt* text file. To do this, right-click the main chart and then select **Export Histogram**.

Figure G-46 Sampling of Available Color Palettes and How They Look when Applied to an Image



There are two types of color palettes – generic and custom. Generic palettes are provided with the Histogram tool and cannot be deleted. Custom palettes are user-generated and can be deleted. As such, **Delete** is enabled only for custom palettes and **not** enabled for generic palettes.

To generate a custom color palette, select **Edit Colors**. The main chart displays three overlapping lines – **red**, **green**, and then **blue**. (Refer to Figure G-47.) Each line can be used to adjust the intensity of its associated color to create the desired coloring for different intensity pixels. Table G-1 lists color palette-related tasks, including how to create a new color palette.

Figure G-47 Initial Color Line Positions in the Main Chart when Creating a Custom Color Palette after Selecting **Edit Colors**

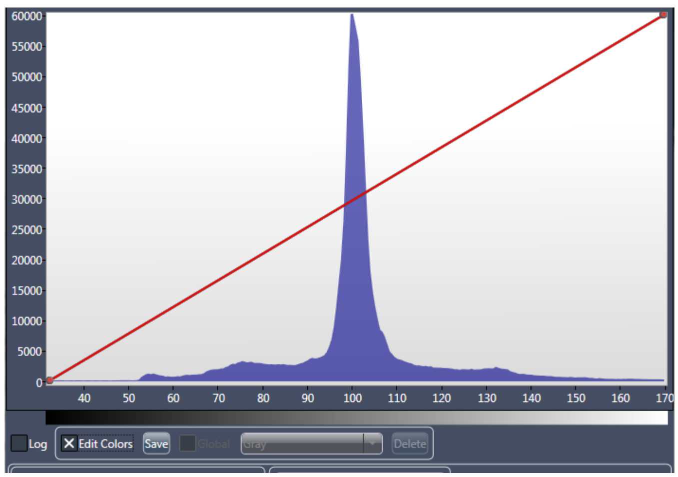


Figure G-48 Image and Main Chart after Adjusting Color Lines to Define a Custom Color Palette

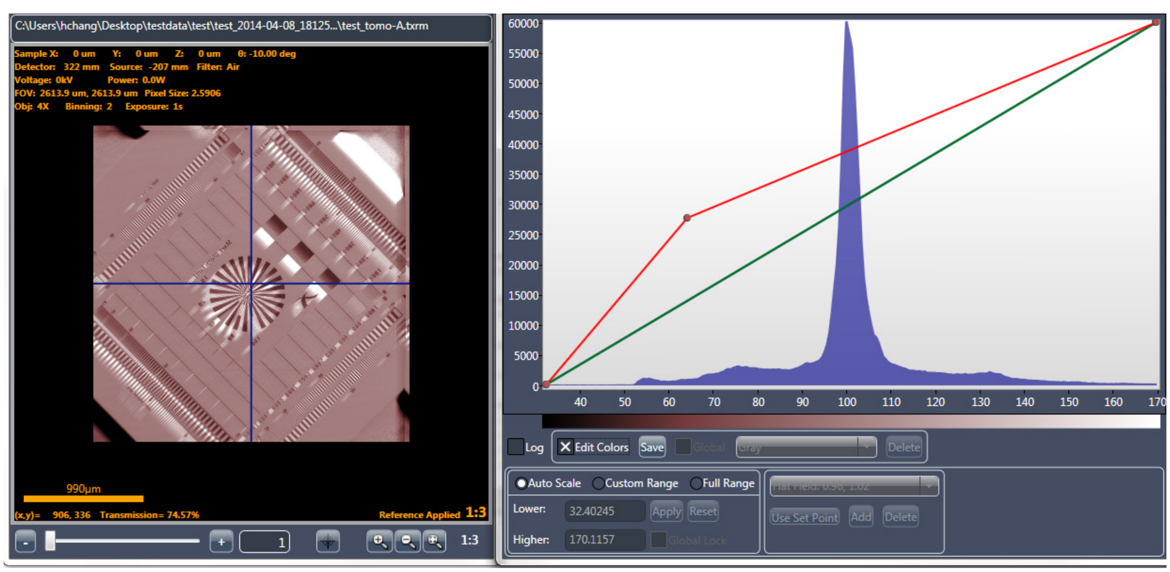
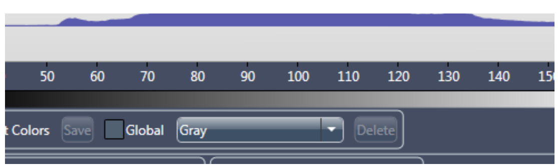


Table G-1 Histogram Control Tool Color Palette Tasks

Task	Process
Create a color line point	Click any location along one of the color lines. (Refer to Figure G-48.)
Create a new color	Click and drag a color line point anywhere within the main chart. The color map and image update after the drag action is complete. (Refer to Figure G-48.)
Remove a color line point	Right click a point, and then select **Remove Color Point**.
Reset a color line to its original position	Right click a line, and then select **Reset Selected Color Line**.
Reset all color lines to their original positions	Right click within the main chart, and then select **Reset Color Lines**.
Save a custom color palette	Click **Save**. A **Please provide a new name for the palette** dialog box opens. Type a unique color palette name in the text box, and then click **OK**. Both the palette and lines will be saved in files under the name provided. If the color palette name you entered already exists as a custom palette, a dialog box opens, asking whether you want to overwrite the existing files. **NOTE** If the color palette name you entered already exists as a generic palette, the Histogram Control will not allow you to save the palette by that name. **NOTE** If you clear the **Edit Colors** check box before saving the custom color palette, the Histogram Control will ask whether you want to save the palette.
Delete a custom color palette	Select the custom color palette that you want to delete from the **Color** drop-down list box, and then click **Delete**.

Figure G-49 Histogram Control Tool with Color Palette



Histogram Scaling

The Histogram Control tool's scaling-related panels (lower left) controls histogram scaling, which controls contrast and brightness in the reconstructed image that is shown in the **Reconstructed Slice** image display, as needed. New histograms open with **Auto Scale** automatically selected unless the **Global Lock** check box is selected.

Figure G-50 Histogram Control Tool Scaling-Related Panels

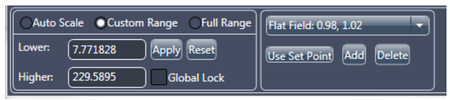


Table G-2 Histogram Control Tool Scaling Tasks

Parameter	Description
Auto Scale	Select to remove the lowest 2% and highest 4% pixels, based on intensity, and then squeeze the remaining distribution to cover 67%. (Refer to Figure G-51.) **NOTE** Although **Auto Scale** can be selected to automatically estimate the best image contrast and brightness, the results might not provide desired results; therefore, use of **Custom Range** is recommended. **NOTE** **Auto Scale** can be used as a "redo" feature to reset the scale.
Custom Range	Select and then set up the desired histogram minimum and maximum values, using one of the following methods: – Type values in the **Lower** and **Higher** text boxes, respectively, and then click **Apply**. (Refer to Figure G-52, left image.) – Within the main chart, click a start range (minimum value), and then drag to an end range (maximum value). The selected region will be highlighted in **blue**. (Refer to Figure G-52, right image.) – Click **Use Set Point** to apply the selected set point from the **Set Points** drop-down list box (not labeled) as the histogram minimum and maximum values. (Refer to Figure G-53.) **NOTE** Click **Add** to add the current histogram minimum and maximum values to the **Set Points** drop-down list box. (The add operation will fail if the name or the set point values already exist as a set point.) Click **Delete** to remove the current selected set point from the **Set Points** drop-down list box. **NOTE** To remove the custom range and display the histogram with full range scaling, click **Reset**, –or– right-click the main chart and then select **Reset Histogram**. **NOTE** **Apply** and **Reset** are enabled only when **Custom Range** is selected.
Full Range	Select to show the image's entire histogram intensity range. (Refer to Figure G-54.)

Figure G-51 Image and Main Chart with **Auto Scale** Scaling Enabled

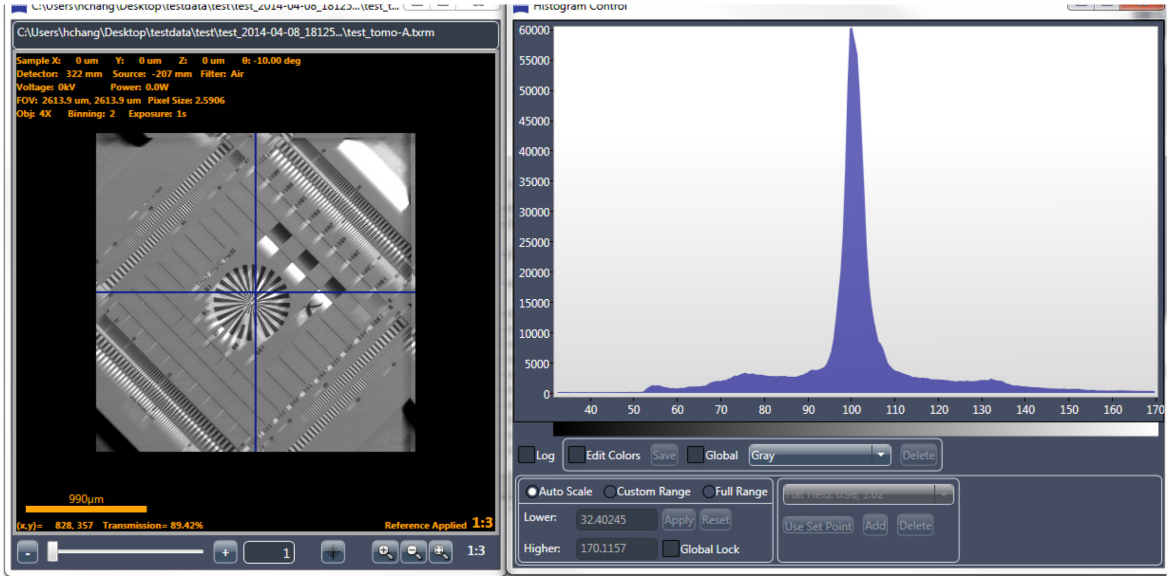
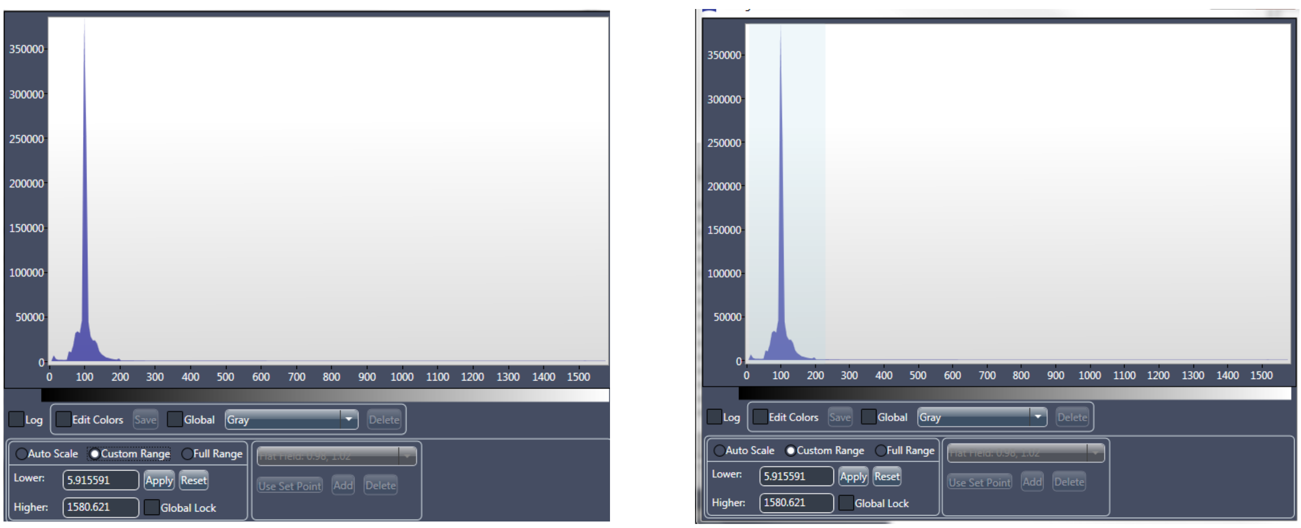


Figure G-52 Main Chart with **Custom Range** Scaling Enabled



Custom Range Scaling Applied by way of **Lower** and **Higher** Text Boxes

Custom Range Scaling Applied by Clicking and Dragging Range Area within Main Chart

Figure G-53 Histogram Range Can Also Be Set by Selecting from a List of Predetermined Set Points

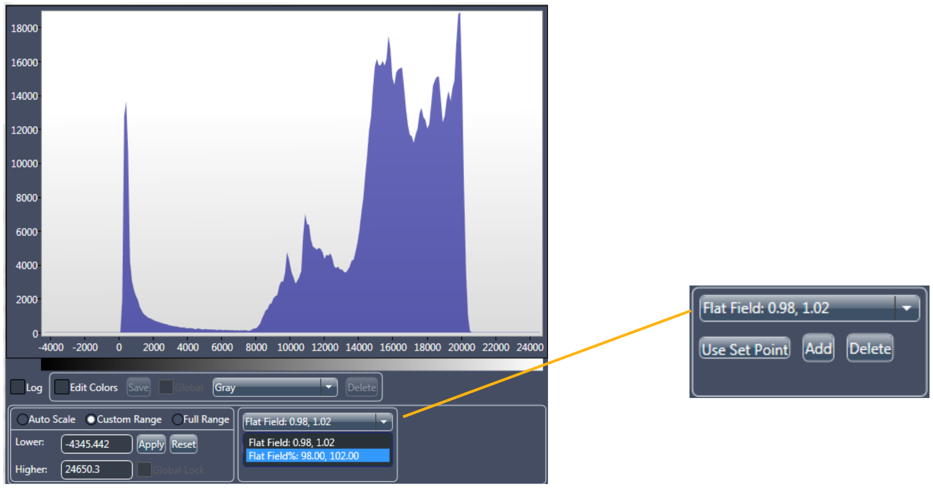
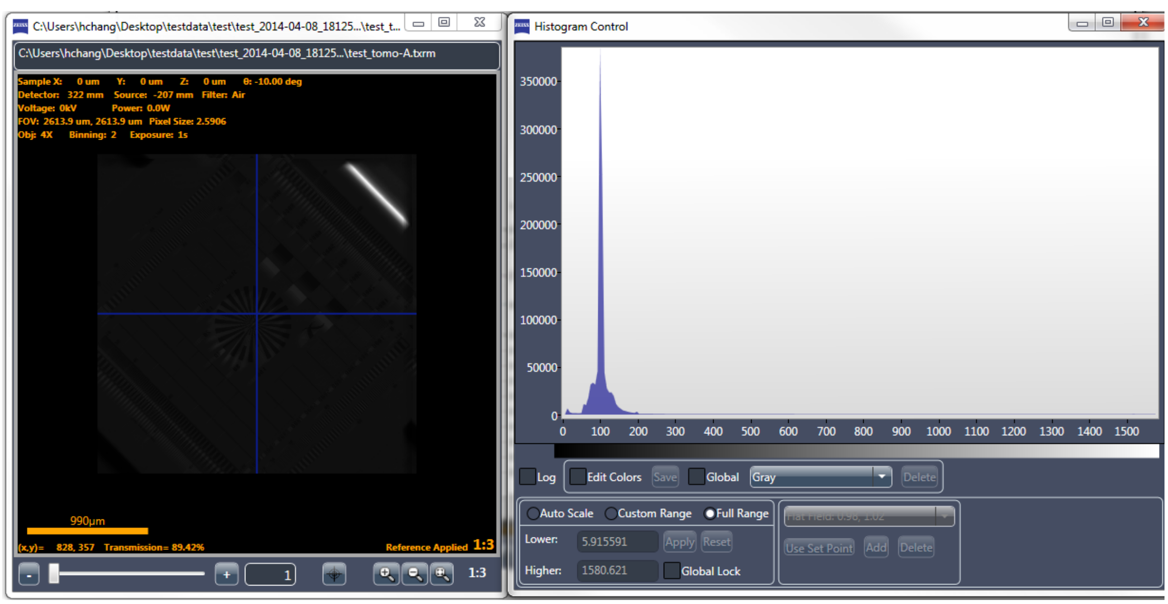


Figure G-54 Image and Main Chart with **Full Range** Scaling Enabled



THIS PAGE INTENTIONALLY LEFT BLANK

H Specifications

This appendix lists the Xradia Versa specifications.

NOTE Contact the ZEISS Support Team for specific questions related to maintenance, or for any specifications that might not be included in this guide at the time of publication. (Refer to "Technical Support," on page 348 in Appendix L.)

NOTE All data presented is subject to change. Consult ZEISS for the most current information. (Refer to "Technical Support," on page 348 in Appendix L.)

Table H-1 Imaging

Category	Xradia Versa Model		
	520	**510**	**410**
Spatial Resolution (ZEISS resolution target)[a]	0.7 µm	0.7 µm	0.9 µm
Resolution at a Distance (RaaD™) (at 50 mm working distance)[b]	1.0 µm	1.0 µm	1.5 µm
Minimum Achievable Voxel (voxel size at sample at maximum magnification)[c]	70 nm	70 nm	100 nm

a. Spatial resolution measured with ZEISS 2D resolution target, Normal Field mode, with optional 40X objective.
b. RaaD working distance is defined as clearance about the axis of rotation.
c. *Voxel* (sometimes referred to as *nominal resolution* or *detail detectability*) is a geometric term that contributes to, but does not determine, resolution, and is provided here only for comparison. ZEISS specifies on spatial resolution, the true overall measurement of instrument resolution.

Table H-2 Contrast-Optimized Detectors

Category	Xradia Versa Model		
	520	510	410
0.4X Objective	Standard	Standard	Standard
Spatial Resolution	20 µm	20 µm	20 µm
Maximum 3D FOV	50 mm	50 mm	50 mm
Wide Field Mode, Maximum 3D FOV	90 mm	90 mm	90 mm
Recommended Maximum Solid Sample Thickness	100 mm	100 mm	100 mm
4X Objective	Standard	Standard	Standard
Spatial Resolution	1.9 µm	1.9 µm	5 µm
Maximum 3D FOV	6.5 mm	6.5 mm	6.5 mm
Wide Field Mode, Maximum 3D FOV	11 mm	–	–
Recommended Maximum Solid Sample Thickness	50 mm	50 mm	50 mm
10X Objective	–	–	Standard
Spatial Resolution	–	–	2.5 µm
Maximum 3D FOV	–	–	2.6 mm
Recommended Maximum Solid Sample Thickness	30 mm	30 mm	30 mm
20X Objective	Standard	Standard	Standard
Spatial Resolution	0.9 µm	0.9 µm	1.5 µm
Maximum 3D FOV	1.3 mm	1.3 mm	1.3 mm
Recommended Maximum Solid Sample Thickness	10 mm	10 mm	10 mm
40X Objective	Optional	Optional	Optional
Spatial Resolution	0.7 µm	0.7 µm	0.9 µm
Maximum 3D FOV	0.7 mm	0.7 mm	0.7 mm
Recommended Maximum Solid Sample Thickness	5 mm	5 mm	5 mm

Table H-3 X-ray Source

Category	Xradia Versa Model		
	520	510	410
Architecture	Sealed	Sealed	Sealed
Target Mechanism	Transmission	Transmission	Reflection
Target Material	Tungsten (W)	Tungsten (W)	Tungsten (W)
Minimum Aging Time (approximate)	Cycle: every 23 hours Duration: approximately 3 minutes	Cycle: every 23 hours Duration: approximately 3 minutes	Cycle: every 8 hours Duration: approximately 20 minutes
Tube Voltage Range, Standard	30 to 160 kV	30 to 160 kV	20 to 90 kV
Maximum Output, Standard	10W	10W	8W
Maximum Tube Current, Standard	90 µA	90 µA	200 µA
Tube Voltage Range, High-Energy Option	–	–	40 to 150 kV
Maximum Output, High-Energy Option	–	–	10W
Maximum Tube Current, High-Energy Option	–	–	250 µA
Tube Voltage Range, High-Power Option	–	–	40 to 150 kV
Maximum Output, High-Power Option	–	–	30W
Maximum Tube Current, High-Power Option	–	–	500 µA

Table H-4 Source Filters

Category	Xradia Versa Model		
	520	510	410
Automated Filter Changer	Standard	–	–
Filter Capacity	24	Single	Single
Filters, Standard	Range of 12	Range of 12	Range of 12
Filters, Custom	Available[a]	Available[a]	Available[a]

a. Available by special order.

Table H-5 X-ray Source Voltage and Power Parameter Values

Model	X-ray Source	Voltage (kV)	Power (W)	
		Maximum	Minimum	Maximum
Xradia 520 Versa Xradia 510 Versa	160 kV (10W maximum)	110 to 160	1	10
		100	1	9
		90	1	8
		80	1	7
		70	1	6
		60	1	5
		50	1	4
		40	1	3
		30	1	2
Xradia 410 Versa	90 kV (8W maximum)	40 to 90	1	8
		30	1	4.5
		20	1	2
	150 kV (10W maximum)	40 to 150	1	10
	150 kV (30W maximum)	60 to 150	1	30
		50	1	25
		40	1	20

Table H-6 Charge-Coupled Device

Category	Xradia Versa Model		
	520	510	410
Pixel Array	2,048 x 2,048	2,048 x 2,048	2,048 x 2,048
Pixel Size	13.5 µm	13.5 µm	13.5 µm
Temperature	< -50°C	< -50°C	< -50°C

Table H-7 Control Workstation

Category	Xradia Versa Model		
	520	510	410
Operating System	Microsoft Windows 7 Pro	Microsoft Windows 7 Pro	Microsoft Windows 7 Pro
Central Processing Unit (CPU)	Dual Eight Core	Dual Eight Core	Dual Eight Core
Graphics Processing Unit (GPU)	Dual CUDA-enabled 3D GPU	Single CUDA-enabled 3D GPU	Single CUDA-enabled 3D GPU
Hard Disk Drive Physical Capacity	8 TB (4 x 2 TB)	8 TB (4 x 2 TB)	8 TB (4 x 2 TB)
Hard Disk Drive Configuration (Drive D)	RAID-5	RAID-5	RAID-5
Memory	32 GB	32 GB	32 GB
Display Monitor	24-inch LCD	24-inch LCD	24-inch LCD

Table H-8 Instrument Software

Category	Xradia Versa Model		
	520	510	410
System Control and Tomography Acquisition	Scout-and-Scan Control System	Scout-and-Scan Control System	Scout-and-Scan Control System
	XMController (legacy)	XMController (legacy)	XMController (legacy)
Reconstruction	Reconstructor	Reconstructor	Reconstructor
3D Viewer	XM3DViewer	XM3DViewer	XM3DViewer
	Visual SI Advanced (optional)	Visual SI Advanced (optional)	Visual SI Advanced (optional)

Table H-9 GPU-Accelerated Reconstruction Performance

Category	Xradia Versa Model		
	520	510	410
1004 slices from 1601 projections (1K × 1K)	1.2 minutes	1.2 minutes	1.2 minutes
2044 slices from 3201 projections (2K × 2K)	11.6 minutes	13.7 minutes	13.7 minutes

Table H-10 Stage Motions

Category	Xradia Versa Model		
	520	510	410
Sample Stage, Load Capacity	15 kg	15 kg	15 kg
Sample Stage Travel, X Direction	45 mm	45 mm	45 mm
Sample Stage Travel, Y Direction	100 mm	100 mm	100 mm
Sample Stage Travel, Z Direction[a]	50 mm	50 mm	50 mm
Sample Stage Travel, Rotation	360°	360°	360°
X-ray Source Travel, Z Direction[a]	190 mm	190 mm	350 mm
Detector Travel, Z Direction[a]	290 mm	290 mm	290 mm

a. Z direction is defined along the X-ray beam path.

Table H-11 Advanced Modes

Category	Xradia Versa Model		
	520	510	410
High Aspect Ratio Tomography	Standard	–	–
Wide Field Mode	0.4X 4X	0.4X	0.4X
Vertical Stitching	Scout-and-Scan Control System	Scout-and-Scan Control System	Scout-and-Scan Control System

Table H-12 Advanced Analysis Tools

Category	Xradia Versa Model		
	520	510	410
Dual-Scan Contrast Visualizer, including Dual Energy visualization and analysis	Standard	–	–

Table H-13 *In Situ* Compatibility

Category	Xradia Versa Model		
	520	510	410
In Situ Interface Kit	Optional	Optional	Optional
Integrated *in situ* recipe control for Deben	Standard	Standard	Standard

Table H-14 X-ray Radiation Safety

Category	Xradia Versa Model		
	520	510	410
Safety Standards Compliance	UL/CSA 61010-1 SEMI S2-0712 SEMI S8-0712 CE Mark[a]	UL/CSA 61010-1 SEMI S2-0712 SEMI S8-0712 CE Mark[a]	UL/CSA 61010-1 SEMI S2-0712 SEMI S8-0712 CE Mark[a]
Radiation Safety, measured 25 mm above enclosure surface	<< 1 μS/hr	<< 1 μS/hr	<< 1 μS/hr

a. A copy of the CE Declaration of Conformity is provided in Appendix K.

Table H-15 Facilities[a]

Category	Xradia Versa Model		
	520	510	410
Standard Dimensions, including handles and ergonomic arm bracket (L x W x H)	217 x 119 x 209 cm	217 x 119 x 209 cm	217 x 119 x 209 cm
Standard Weight	2,468 kg	2,461 kg	2,430 kg
Electrical Requirements	230V AC Nominal 160 to 286V AC range, Single Phase, 50/60 Hz, 15A SCCR: 10K Amps	230V AC Nominal 160 to 286V AC range, Single Phase, 50/60 Hz, 15A SCCR: 10K Amps	230V AC Nominal 160 to 286V AC range, Single Phase, 50/60 Hz, 15A SCCR: 10K Amps
Climate Requirements	10 to 25°C < 2°C variation RH < 70%	10 to 25°C < 2°C variation RH < 70%	10 to 25°C < 2°C variation RH < 70%

a. Consult the latest *Xradia Versa Facilities Guide* for the most up-to-date information.

THIS PAGE INTENTIONALLY LEFT BLANK

J Electrical Documentation

This appendix provides electrical documentation specific to the Emergency Off (EMO) system and safety interlocks.

EMO

The Xradia Versa's EMO circuit consists of two mushroom-style push-button switches (**EMO** button) and an auxiliary switch attached to the main power disconnect circuit breaker. All three switches have normally CLOSED contacts and are connected in a serial manner to the EMO circuit in the Uninterruptible Power Supply (UPS). If either **EMO** button is pressed, –or– if the main disconnect circuit breaker is tripped or switched OFF, the contacts OPEN, and then the UPS immediately terminates output power to the entire Xradia Versa.

⚠CAUTION The two **EMO** buttons should be used only to shut down (power OFF) the Xradia Versa in a personal safety or equipment emergency.

NOTE Use of the non-emergency shutdown procedure is recommended in non-emergency events. (Refer to "Shutting Down the Xradia Versa in a Non-Emergency Event," on page 174 in Appendix C.)

Interlock Sequence of Operation

The interlock electronics are located within the Power Distribution Unit (PDU), and are intended to serve as a safety circuit that protects the operator from exposure to X-rays. Because there are two different manufacturers of X-ray sources used within the **Xradia Versa** family, the PDU produces interlock signals for both. Each X-ray source has input for two independent interlock signals – Interlock-1 and Interlock-2. Both interlocks prevent X-ray generation.

The light tower located on top of the Xradia Versa provides equipment status to the operator, as listed in Table J-1.

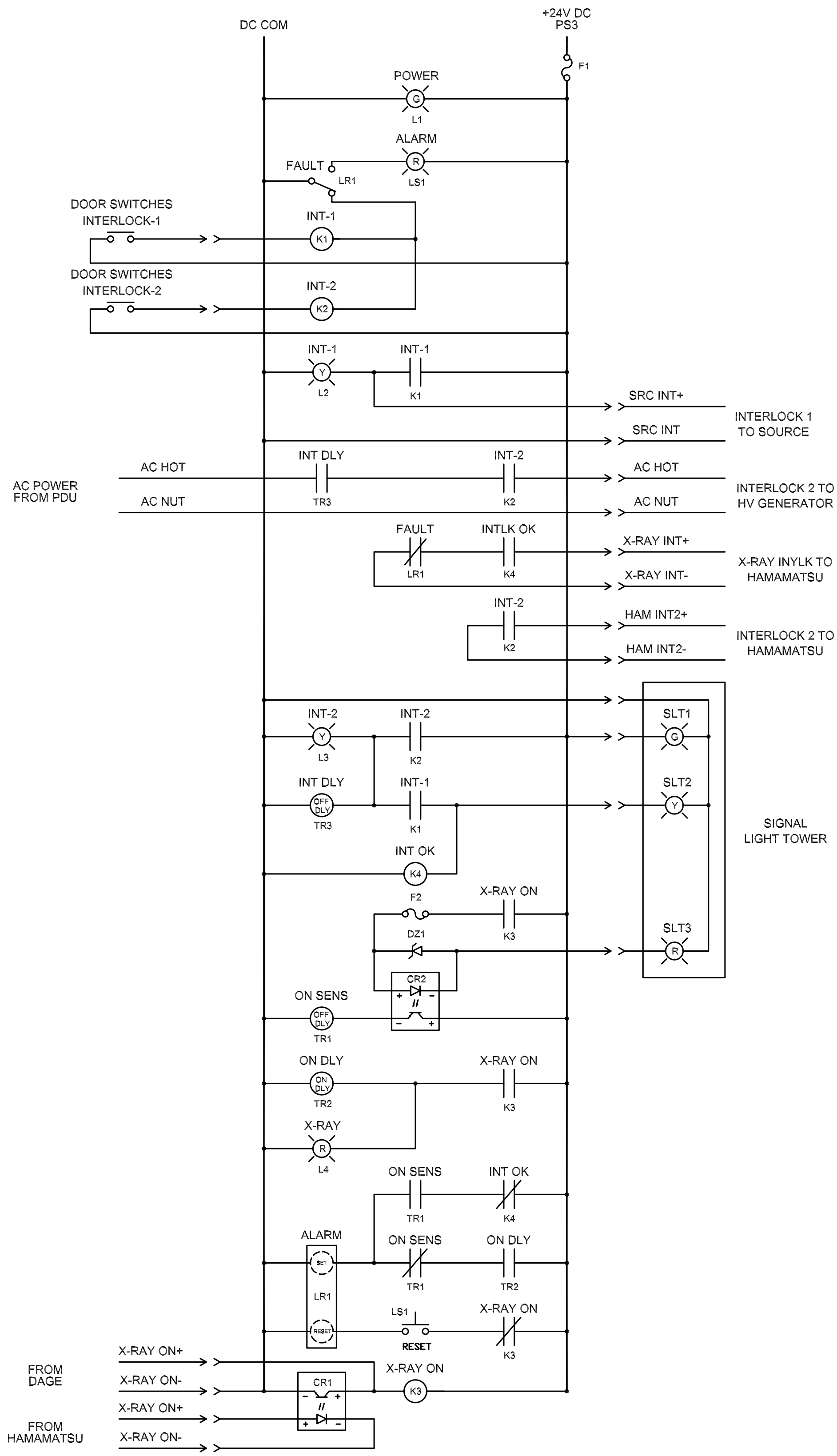
Table J-1 Light Tower Indicator Status

Light Tower Indicator Status	Description
All lights OFF	Power to the Xradia Versa is turned OFF.
Red light ON (top)	X-ray source is turned ON and X-rays are present within the enclosure.
Red light OFF (top)	X-ray source is turned OFF and X-rays are **not** present within the enclosure.
Amber light ON (center)	Access doors are CLOSED.
Amber light OFF (center)	Access doors are OPEN.
Green light ON (bottom)	Power to the Xradia Versa is turned ON.
Green light OFF (bottom)	Power to the Xradia Versa is turned OFF.

There are four access doors located on the Xradia Versa's enclosure. Each door has two normally closed dual-contact switches. Contacts from one switch on each door are connected in series and serve Interlock Circuit 1, and the other four switches are likewise connected in series and serve Interlock Circuit 2. If any of the four access doors are OPENED, both interlock circuits OPEN.

In Figure J-1, door interlocks are represented as a single switch, one representing the serial circuit for Interlock-1 and the other for Interlock-2. The switches are shown in the OPEN state, representing any of the four access doors being OPEN. When all four access doors are CLOSED, interlock relays K1 (INT-1) and K2 (INT-2) are both energized, provided that latching relay LR1 (FAULT) is **not** active. If interlock relays INT-1 and INT-2 are both energized, the **amber** (center) light on the light tower is turned ON and relay K4 (INTLK OK) is energized.

Figure J-1 Safety Interlock Electrical Diagram



Contacts from K2 and K4 produce the two interlock signals for both types of X-ray sources that are used in the **Xradia Versa** family.

When both Interlocks are energized, the X-ray source is capable of producing X-rays in response to software requests from the operator by way of the Scout-and-Scan Control System. If the X-ray source is generating X-rays, it sends a signal that energizes K3 (X-RAY ON). X-RAY ON relay contacts are used to power the light tower's **red** (top) light.

Additional components monitor current to the light tower's **red** X-RAY ON indicator. Therefore, if the **red** (top) light is burned out (OPEN) or shorted, latching relay LR1 (FAULT) is set in response to X-RAY ON, indicating a fault condition. This fault condition can be cleared only by pressing the PDU's lighted **red** **ALARM/RESET** push-button switch (located behind the front access panel; refer to Figure J-2) and then repairing the X-RAY ON light (contact the ZEISS Support Team to repair the light). (Refer to "Technical Support," on page 348 in Appendix L.) A fault condition (LR1) is also set when an access door is OPENED while X-rays are being generated. The fault can be cleared by CLOSING the access door and then pressing the PDU's lighted **red** **ALARM/RESET** push-button switch (refer to Figure J-2).

Figure J-2 Press the PDU's Lighted **Red** **ALARM/RESET** Push-Button Switch to Clear Fault Conditions (Xradia 520 Versa Shown)

K CE Declaration of Conformity

This appendix provides a copy of the ZEISS CE Declaration of Conformity.

DECLARATION OF CONFORMITY

Manufacturer's Name and Address:

Carl Zeiss X-ray Microscopy, Inc.
4385 Hopyard Road
Suite 100
Pleasanton, CA 94588
USA

Phone: +1.925.701.3600
Fax: +1.925.730.4952
E-mail: micro@zeiss.com

TYPE OF EQUIPMENT: High Resolution X-ray 3D Computed Tomography Microscope

REGULATORY MODEL:
TRADE/BRAND NAME: ZEISS
SERIAL NUMBER:

Carl Zeiss X-ray Microscopy, Inc. as the responsible party for regulatory compliance, declare under our sole responsibility that the described product fulfills all relevant provisions of EC directive 2006/42/EC (Machine Directive) and EMC directive 2014/30/EU.

The described product has been assessed and determined compliant with the following standards:

SAFETY: EN/UL/IEC 61010-1:2010 (3rd edition)
EN ISO13849-1:2008
SEMI S2-0712 including X-ray

EMC: EN 61326-1:2013
EN 55011:2009/A1:2010
EN 61000-4-2, -3, -4, -5, -6, -8, -11

SUPPLEMENTARY INFORMATION: This product has been tested and found to comply with the electromagnetic compatibility (EMC) limits for a **Class A** digital device pursuant to the listed directives, regulations and standards. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a business environment. The equipment was tested in a typical configuration.

Person located in the EU: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

Pleasanton, California, USA	
Place of Issuance	Signature
April 2016	**Thomas Murman**
Date of Issuance	Full Printed Name
G001103	**Director, Manufacturing Operations**
Document Control Tracking Number	Position/Title

G001103 Rev. D

Carl Zeiss X-ray Microscopy, Inc. erklärt als in alleiniger Verantwortung für die Einhaltung der Bestimmungen verantwortliche Partei, dass das beschriebene Produkt alle relevanten Vorschriften der EU-Richtlinie 2006/42/EG (Maschinenrichtlinie) und die EMV-Richtlinie 2014/30/EU erfüllt.

Das beschriebene Produkt wurde beurteilt und als kompatibel mit den folgenden Normen befunden:

SICHERHEIT: EN/UL/IEC 61010-1:2010 (3. Auflage)
EN ISO13849-1:2008
SEMI S2-0712 einschließlich Röntgenstrahlung

EMV: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

ZUSÄTZLICHE INFORMATIONEN: Dieses Produkt wurde getestet und entspricht den Grenzwerten für elektromagnetische Verträglichkeit (EMV) für ein digitales Gerät der **Klasse A** gemäß den genannten Richtlinien, Bestimmungen und Normen. Diese Grenzwerte sind dazu bestimmt, angemessenen Schutz gegen schädliche Störungen beim Betrieb in einem Geschäftsumfeld zu bieten. Das Gerät wurde in einer typischen Konfiguration getestet.

Bevollmächtigte Person in der EU: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

Carl Zeiss X-ray Microscopy, Inc., como parte responsable del cumplimiento normativo, declara bajo su responsabilidad exclusiva que el producto descrito cumple todas las disposiciones aplicables de la Directiva 2006/42/CE (directiva relativa a las máquinas) y de la Directiva CEM 2014/30/UE.

A tenor de la evaluación del producto descrito, se ha confirmado su conformidad con las siguientes normas:

SEGURIDAD: EN/UL/IEC 61010-1:2010 (3ª edición)
EN ISO13849-1:2008
SEMI S2-0712, incluidos rayos X

CEM: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

INFORMACIÓN ADICIONAL: los ensayos realizados en este producto han demostrado que se ajusta a los límites de compatibilidad electromagnética (CEM) para un dispositivo digital de **Clase A** conforme a las directivas, reglamentos y normas mencionados anteriormente. Dichos límites se han fijado para proporcionar una protección razonable contra interferencias nocivas al utilizar los equipos en un entorno profesional. Los ensayos se realizaron con una configuración típica en los equipos.

Contacto en la UE: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

G001103 Rev. D

Som den overensstemmelsesansvarlige erklærer Carl Zeiss X-ray Microscopy, Inc., med eneansvar, at det beskrevne produkt lever op til alle relevante bestemmelser i EF direktiv 2006/42/EF (Maskindirektiv) og EMC direktiv 2014/30/EU.

Det beskrevne produkt er blevet vurderet og fundet værende i overensstemmelse med følgende standarder:

SIKKERHED: EN/UL/IEC 61010-1:2010 (3. udgave)
EN ISO13849-1:2008
SEMI S2-0712 inklusive X-ray (røntgen)

EMC: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

YDERLIGERE INFORMATION: Dette produkt er blevet testet og fundet værende i overensstemmelse med elektromagnetisk kompatibilitets (electromagnet compatibility, EMC) -grænseværdierne for en **Klasse A** digital enhed i overensstemmelse med de nævnte direktiver, forordninger og standarder. Disse grænseværdier er beregnet til at sikre rimelig beskyttelse mod skadelig interferens, når udstyret anvendes i et forretningsmiljø. Udstyret er testet i en repræsentativ konfiguration.

Person baseret i EU: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

Carl Zeiss X-ray Microscopy, Inc. vakuuttaa ainoana sääntelyvaatimusten noudattamisesta vastuussa olevana tahona, että kuvattu tuote täyttää kaikki kyseeseen tulevat konedirektiivin 2006/42/EY ja EMC-direktiivin 2014/30/EU määräykset.

Kuvattu tuote on arvioitu ja se on määritysten mukaan seuraavien standardien mukainen:

TURVALLISUUS: EN/UL/IEC 61010-1: 2010 (3. painos)
EN ISO13849-1:2008
SEMI S2-0712, myös röntgen

EMC: EN 61326-1: 2013
EN 55011/A2: 2007
EN 55011: 2009/A1: 2010

LISÄTIETOJA: Tämä tuotteen on testauksessa osoitettu olevan **luokan A** digitaalisille laitteille annettujen sähkömagneettisen yhteensopivuuden (EMC) rajoitusten mukainen, sellaisina kuin ne on määritelty mainituissa direktiiveissä, määräyksissä ja standardeissa. Rajoitukset on suunniteltu siten, että laitetta liiketoimintaympäristössä käytettäessä saadaan aikaan kohtuullinen suojaus haitalliselta interferenssiltä. Laite testattiin tyypillisiä asetuksia käyttäen.

EU-alueen edustaja: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

G001103 Rev. D

La société Carl Zeiss X-ray Microscopy, Inc., en qualité de partie responsable de la conformité réglementaire, déclare sous sa seule responsabilité que le produit décrit respecte l'ensemble des dispositions applicables de la directive CE 2006/42/CE (directive machines) et de la directive 2014/30/UE (directive CEM).

Le produit décrit a été évalué et déclaré conforme aux normes suivantes :

SÉCURITÉ : EN/UL/IEC 61010-1:2010 (3e édition)
EN ISO13849-1:2008
SEMI S2-0712 comprenant les rayons X

CEM : EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

INFORMATIONS SUPPLÉMENTAIRES : cet appareil a été testé et déclaré conforme aux limites de compatibilité électromagnétique (CEM) des appareils numériques de **Classe A** en vertu des directives, règlements et normes cités. Ces limites ont été déterminées pour assurer une protection raisonnable contre les interférences nuisibles lorsque l'appareil est utilisé dans un environnement professionnel. L'appareil a été testé dans une configuration habituelle.

Mandataire dans l'UE : Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

Carl Zeiss X-ray Microscopy, Inc. in qualità di parte responsabile per il rispetto delle normative, dichiara sotto la sua sola responsabilità, che il prodotto descritto rispetta tutte le disposizioni relative contenute nella direttiva CE 2006/42/CE (Direttiva Macchine) e la direttiva CEM 2014/30/UE.

Il prodotto descritto è stato esaminato e dichiarato conforme ai seguenti standard:

SICUREZZA: EN/UL/IEC 61010-1:2010 (3ª Edizione)
EN ISO13849-1:2008
SEMI S2-0712 incluso Raggi X

CEM: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

INFORMAZIONI SUPPLEMENTARI: Questo prodotto è stato testato e giudicato conforme ai limiti di compatibilità elettromagnetica (CEM) richiesti ad una apparecchiatura digitale di **Classe A** secondo le direttive, i regolamenti e gli standard elencati. Questi limiti sono progettati per assicurare una ragionevole protezione contro interferenze dannose quando l'apparecchiatura è usata in un ambiente di lavoro. L'apparecchiatura è stata testata nella sua configurazione tipica.

Soggetto con sede nell'UE: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

G001103 Rev. D

Carl Zeiss X-ray Microscopy, Inc., als de verantwoordelijke partij voor naleving van de wet- en regelgeving, verklaart geheel onder eigen verantwoordelijkheid dat het beschreven product voldoet aan alle relevante bepalingen van EG-richtlijn 2006/42/EG (de machinerichtlijn) en EMC-richtlijn 2014/30/EU.

Men heeft het beschreven product beoordeeld en bepaald dat het voldoet aan de volgende normen:

VEILIGHEID: EN/UL/IEC 61010-1:2010 (3e versie)
EN ISO13849-1:2008
SEMI S2-0712 inclusief röntgen

EMC: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

AANVULLENDE INFORMATIE: Dit product is getest en voldoet aan de limieten voor elektromagnetische compatibiliteit (EMC) voor digitale toestellen **Klasse A** overeenkomstig de vermelde richtlijnen, voorschriften en normen. Deze limieten zijn ontworpen om redelijke bescherming te bieden tegen schadelijke storing wanneer de apparatuur wordt gebruikt in een commerciële omgeving. De apparatuur is getest in een normale configuratie.

Contactpersoon in de EU: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

Carl Zeiss X-ray Microscopy, Inc. jako strona odpowiedzialna za zgodność z przepisami, deklaruje z pełną odpowiedzialnością, że opisywany produkt spełnia wszystkie odpowiednie postanowienia dyrektywy UE 2006/42/WE (dyrektywa maszynowa) oraz dyrektywy 2014/30/UE w sprawie zgodności elektromagnetycznej.

Opisany produkt został poddany ocenie i ustalono, że jest zgodny z następującymi normami:

NORMY DOTYCZĄCE BEZPIECZEŃSTWA:
EN/UL/IEC 61010-1:2010 (wyd. III)
EN ISO13849-1:2008
SEMI S2-0712 w tym urządzenia rentgenowskie

NORMY DOTYCZĄCE ZGODNOŚCI ELEKTROMAGNETYCZNEJ:
EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

INFORMACJE DODATKOWE: Produkt został poddany badaniom i uznany za zgodny z ograniczeniami dotyczącymi zgodności elektromagnetycznej (EMC) dla urządzeń cyfrowych klasy A zgodnie z podanymi dyrektywami, rozporządzeniami i normami. Ograniczenia te mają na celu zapewnienie odpowiedniej ochrony przed szkodliwymi zakłóceniami, gdy sprzęt jest eksploatowany w środowisku gospodarczym. Urządzenie było testowane w typowej konfiguracji.

Osoba znajdująca się w UE: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

G001103 Rev. D

Carl Zeiss X-ray Microscopy, Inc. como a parte responsável pela conformidade regulamentar, declara sob exclusiva responsabilidade que o produto se encontra em conformidade com a diretiva CE 2006/42/CE (Diretiva Máquinas) e a diretiva EMC 2014/30/EU.

O produto descrito foi avaliado e determinado em conformidade com as seguintes normas:

SEGURANÇA: EN/UL/IEC 61010-1:2010 (3ª edição)
EN ISO13849-1:2008
SEMI S2-0712 incluindo Raio-X

EMC: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

INFORMAÇÃO COMPLEMENTAR: Este produto foi testado e considerado em conformidade com os limites eletromagnéticos de compatibilidade (EMC) para um dispositivo digital de **Classe A** de acordo com as diretivas, regulamentações e normas listadas. Estes limites são concebidos de modo a garantirem proteção razoável contra interferências nocivas num ambiente de trabalho. O equipamento foi testado numa configuração típica.

Pessoa na UE: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

Noi, Carl Zeiss X-ray Microscopy, Inc., în calitate de parte responsabilă pentru conformitatea de reglementare, declarăm pe proprie răspundere că produsul descris îndeplinește cerințele aplicabile ale directivei CE 2006/42/EC (Directiva privind utilajele) și ale directivei CEM 2014/30/EU.

Produsul descris a fost evaluat și s-a constatat că este în conformitate cu următoarele standarde:

SIGURANȚĂ: EN/UL/IEC 61010-1:2010 (Ediția 3)
EN ISO13849-1:2008
SEMI S2-0712 inclusiv razele X

CEM: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

INFORMAȚII SUPLIMENTARE: Acest produs a fost testat și s-a constatat că este în conformitate cu limitele de compatibilitate electromagnetică (CEM) pentru un dispozitiv digital de **Clasa A**, în baza directivelor, reglementărilor și standardelor menționate. Aceste limite sunt stabilite pentru a furniza o protecție rezonabilă împotriva interferenței dăunătoare atunci când echipamentul este folosit într-un mediu comercial. Echipamentul a fost testat într-o configurație uzuală.

Persoana cu sediul în UE: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

G001103 Rev. D

Carl Zeiss X-ray Microscopy, Inc., som ansvarig part för regelefterlevnad, tillkännager under eget ansvar att den beskrivna produkten uppfyller alla relevanta bestämmelser i EG-direktiv 2006/42/EG (maskindirektivet) och EMC-direktivet 2014/30/EU.

Den beskrivna produkten har bedömts och fastställts uppfylla följande krav:

SÄKERHET: EN/UL/IEC 61010-1:2010 (3:e utgåvan)
EN ISO13849-1:2008
SEMI S2-0712 inklusive röntgen

EMC: EN 61326-1:2013
EN 55011/A2:2007
EN 55011:2009/A1:2010

KOMPLETTERANDE INFORMATION: Denna produkt har testats och befunnits överensstämma med gränserna för elektromagnetisk kompatibilitet (EMC) för digitala enheter av **Klass A** i enlighet med angivna direktiv, förordningar och standarder. Gränserna är utformade för att ge rimligt skydd mot skadliga störningar när utrustningen används i företagsmiljö. Utrustningen testades i en typisk konfiguration.

Kontaktperson i EU: Rainer Haerle
Carl Zeiss Microscopy GmbH, Zeiss Group
Carl-Zeiss-Straße 22
73447/ Oberkochen/ Germany

G001103 Rev. D

L License, Warranty, and Service Information

This appendix provides the software license agreement, limited warranties, service and maintenance information, and ZEISS Support Team information.

Software License Agreement

All Software obtained by Purchaser from ZEISS is proprietary to ZEISS and its licensors and is subject to copyrights, other intellectual property rights and moral rights owned by ZEISS 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. ZEISS 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 ZEISS. 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 Product(s) with the Software or for which the Software was supplied, and then, only if these same licensing terms and limitations are agreed and adhered to by the sublicensee, assignee, or transferee. Purchaser acknowledges that the Software incorporates valuable trade secrets of ZEISS and agrees not to copy, decompile, disassemble, reverse engineer, or modify any Software provided by ZEISS or its suppliers. This license granted herein is effective upon delivery of the Software to Purchaser.

Other terms and conditions regarding licensing might also be defined in the formal sales contract between the user and ZEISS. If any terms or conditions described here are deemed to be in conflict with the sales contract, the sales contract takes precedence.

Limited Warranties

a) Hardware Warranty – ZEISS 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, ZEISS shall, in its sole discretion, either repair or replace such Product, without charge to Purchaser, provided that: i) ZEISS 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 an RMA number from ZEISS prior to returning the nonconforming Product to ZEISS at the Ex Works point, freight prepaid. ZEISS cannot warrant the product if: (i) Customer modifies the hardware component, (ii) improper use of the hardware component, or (iii) the hardware operating environment is outside of the ZEISS stated operating environment.

b) Software Warranty – ZEISS warrants to Purchaser that during the Warranty Period the Software will perform substantially in accordance with its user documentation and specifications. ZEISS 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, ZEISS shall correct the nonconforming Software so that it performs as warranted at no charge to Purchaser, provided that: i) ZEISS 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. Customer modifications to this Software will void the warranty.

c) ZEISS 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, unauthorized or improper installation, unauthorized repair, improper testing, unusual physical or electrical stress, or environmental conditions outside the operating parameters specified by ZEISS, ii) software or firmware not supplied by ZEISS, or iii) Purchaser's failure to follow operating or corrective instructions provided by ZEISS.

d) ZEISS shall have a reasonable time to repair or replace nonconforming Product(s) or correct nonconforming Software. ZEISS 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) ZEISS warrants to Purchaser that, at the time title to the Products passes to Purchaser, ZEISS 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 ZEISS service personnel, for customers with field service contracts. Should the Xradia Versa require service outside the contracted maintenance schedule, contact the ZEISS Support Team to schedule a service visit.

Technical Support

If you need assistance with the Xradia Versa, contact your local ZEISS Support Team. Contact details can be found at www.zeiss.com.

M Glossary

3D reconstructed volume End result of tomography. 3D digital representation of the sample volume obtained by tomographically reconstructing a series of projections acquired over a range of viewing angles. Virtual cross-sections can be extracted from the 3D reconstructed volume.

access doors Part of the enclosure. Close(s) off the X-ray source, providing protection from harmful X-ray radiation. The Xradia Versa enclosure has four safety-interlocked access doors – two on the front and two on the back. Typically, the front access doors are used to access the Xradia Versa's interior. Keep all four access doors closed, whenever possible, to maintain temperature stability.

Adaptive Motion Compensation Refer to AMC.

AMC Image-based drift correction that corrects for **Sample X**, **Sample Y**, and **Sample Z** stage drifts, X-ray source and detector drifts, and any rectilinear drifts of the sample.

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 within the same material).

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 into 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 **C**harge-**C**oupled **D**evice. 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.

centering Procedure that adjusts the centering currents of the X-ray tube's electron beam to optimize tube performance.

center shift Amount, in pixels, that the axis of rotation is offset from the detector's center column.

computer workstation Windows 7-based computer included with the Xradia Versa.

CT **C**omputed **T**omography. Method used to generate 3D volumetric data from a range of angular 2D images (projections), typically using X-rays.

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. ZEISS uses the unsigned short data format; therefore, ZEISS CT scaling scales air to 0 and water to 1,000.

detector/detector assembly Assembly that collects X-rays to present images of the sample. Includes the turret and 0.4X objective.

drifts Blur in scanned images caused by thermal shifts and mechanical drifts that cause unwanted system motion. System-related drift correction is discussed in "Correcting for System-Related Drift," on page 310 in Appendix G. Refer also to AMC, SD, and thermal shifts.

Dynamic Ring Removal Refer to DRR.

DRR **D**ynamic **R**ing **R**emoval. ZEISS proprietary method to remove ring artifacts in reconstructed slices and volumes (available in the Scout-and-Scan Control System's **Advanced Acquisition** tab within **Scan** view).

EMO button **Em**ergency **O**ff button. **Used to turn OFF power to the entire Xradia Versa in a personal safety or equipment emergency**. The Xradia Versa has two **EMO** buttons – one on the enclosure's front panel and the other on the enclosure's back panel (below the rear access panels).

enclosure Insulated steel and lead-lined framework that covers the Xradia Versa exterior and provides protection from harmful X-ray radiation.

enclosure temperature control unit Regulates input temperature of air entering the enclosure.

ergonomic station User console for controlling the Xradia Versa for data acquisition and analysis.

exposure time Amount of time that the CCD is exposed to light when acquiring an image. Typically expressed in seconds.

field of view Refer to FOV.

FOV **F**ield **o**f **V**iew. Area imaged by the Xradia Versa.

HART High Aspect Ratio Tomography. **Xradia 520 Versa Only.** Provides better imaging of samples that are thin and wide, such as semiconductor packages. Enables you to acquire more projections for long views than short views so that the features oriented primarily along long views, such as bump cracks, are better visualized. In addition, various artifacts (primarily streaks) are reduced because of the decreased angular step along the long views. Use of this feature is discussed in "High Aspect Ratio Tomography – Xradia 520 Versa," on page 258 in Appendix G.

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 and/or safety of personnel.

High Aspect Ratio Tomography Refer to HART.

high-voltage power supply Provides high-voltage power to the X-ray source and battery-supplied power to allow a soft shutdown of the Xradia Versa in case of a power outage.

Histogram control Reconstructor tool that enables you to adjust an image's contrast and brightness, and to apply false coloring to the image.

histogram buckets X axis values in Reconstructor's Histogram control.

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 -1,000 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).

intensity Pixel light saturation values, indicated as **Intensity** (Scout-and-Scan Control System, lower left **Front** or **Side View** image display).

ionizing hazard Hazard caused by exposure to X-ray radiation.

kernel size Number of pixels sampled as a unit during image manipulation.

light tower Indicator located on top of the Xradia Versa that visually reports status conditions. For further details, refer to Table A-8, "Light Tower Lights (Status Indicators)," on page 164 in Appendix A.

Modulation Transfer Function Refer to MTF.

motion controller hardware Embedded microprocessor-based system that drives and controls all Xradia Versa motors and other Xradia Versa features. The Motion Controllers communicate to the computer workstation over a dedicated network cable, and interface with the Scout-and-Scan Control System.

MTF **M**odulation **T**ransfer **F**unction. In imaging systems, 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 intensity variation within images produced by the different imaging system components.

objective Magnification lenses used for imaging the sample. Part of the detector/detector assembly.

PDU **P**ower **D**istribution **U**nit. Distributes and controls power to the electrical Xradia Versa components.

Power Distribution Unit Refer to PDU.

power supply Refer to high-voltage power supply.

projection 2D images acquired during data acquisition/tomography using the Scout-and-Scan Control System.

reconstruction Process of using all the projections acquired during data acquisition/tomography to create a 3D volume, either automatically by way of the Scout-and-Scan Control System or manually by way of Reconstructor.

Reconstructor Program used to manually reconstruct 2D projections into 3D reconstructed volumes. Use of this program is featured in Chapter 3, “Manually Reconstructing a Tomography Dataset.” Refer also to reconstruction.

reference Blank image acquired with the sample out of the FOV. Used to normalize images acquired with the sample in the FOV.

region of interest Refer to ROI.

ROI **R**egion **O**f **I**nterest. Data acquisition area of focus.

safety interlocks Devices that prevent X-ray source operation when the access doors are open.

sample base Rounded base with a flat edge that lines up with the sample stage when the sample holder assembly is loaded on the sample stage.

sample drift Refer to SD.

sample holder Device used to hold the sample in place. Sample holders used with Xradia Versa are screw clamps, spring clamps, pin vises, and sample bases. Sample holders are described in “Mounting a Sample in or on a Sample Holder,” on page 241 in Appendix E.

sample holder assembly Sample mounted on a sample holder.

sample stage Platform on which the sample holder assembly (with a mounted sample) is secured and positioned for microscopy.

SCCR **S**hort **C**ircuit **C**urrent **R**ating.

scintillator Device used for detecting and counting scintillations produced by ionizing radiation.

Scout-and-Scan Control System Program used for controlling the Xradia Versa and acquiring tomographies. Use of this program is featured in Chapter 2, “Acquiring Tomographies with the Scout-and-Scan Control System.”

scout the sample Use of X-ray images to locate the sample’s ROI and FOV, and set imaging parameter values (new recipes only).

SD Image-based drift correction that corrects for corrects for **Sample X** and **Sample Y** stage drifts

Signal-to-Noise Ratio Refer to SNR.

slice Scout-and-Scan Control System automatically or Reconstructor manually reconstructs images stored in each **.txrm* file to form a set of reconstructed slices, which are 2D sections of the 3D reconstructed volume. Slices generated from each **.txrm* file are stored in a **.txm* file, which contains a collection of 2D slices that make up the 3D 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 filter Material (available in a ZEISS filter kit) that improves reconstructed image quality by removing low-energy X-rays (that passed through the sample) that do not provide useful information. Table 2-4, "0.4X and 4X Source Filter Selection," on page 46 and Table 2-5, "10X, 20X, and 40X Source Filter Selection," on page 47 provide guidelines for source filter selection, based on a scouted image's Transmission value.

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. Stitching vertically increases the scan volumes, which allows you to image and analyze larger volumes.

tomography Technique that allows virtual cross-sectioning or delayering, which enables you to look at the interior of a sample without destroying the sample.

thermal shifts Drift correction that corrects for basic thermal motions of the stages and warmed-up X-ray source.

Transmission value Ratio of X-rays through the sample versus the ratio of X-rays without the sample being present.

turret Part of the detector/detector assembly. Holds up to five objectives (magnification lenses). The objective located at the lowest point on the turret is used to focus on the sample.

uninterruptible power supply Refer to UPS.

UPS Uninterruptible **P**ower **S**upply. Regulates the incoming AC voltage and provides battery-supplied power to the Xradia Versa for approximately 15 minutes in case of a power outage.

visual light camera Supplies images to the **Visual Light Camera** image display (right side of the Scout-and-Scan Control System, as well as the image display in the Scout-and-Scan Control System's **Load** view). Located behind the sample stage, at the rear of the enclosure. Used for positioning the sample, detector, and X-ray source.

Volume Rendering Technique Refer to VRT.

voxel Geometric term that contributes to, but does not determine, resolution. (Also referred to as *nominal resolution* or *detail detectability*.) Basic unit of computed tomography reconstruction, represented as a pixel in the **Front** and **Side View** image displays. ZEISS specifies on spatial resolution, the true overall measurement of instrument resolution.

VRT **V**olume **R**endering **T**echnique. Default XM3DViewer **3D display** mode that is used to compute a color and transparency mapping of a 3D reconstructed volume.

XM3DViewer Program used to view ROIs in reconstructed tomographic data as a 3D volume. Use of this program is featured in Chapter 4, "Viewing and Editing Tomographies."

XMController Legacy program used prior to the creation of the Scout-and-Scan Control System to manage the data acquisition process, from setting up the sample to data acquisition. Was also used to acquire images, and monitor and control the microscope's hardware components.

X-ray source Mechanism that generates X-rays, from 30 to 160 kV. Used by the Xradia Versa to image samples and collect references.

X-ray source aging Required initial X-ray source warm-up process that is required for optimum tube performance. For the Xradia 520 Versa and Xradia 510 Versa, the aging process occurs every 23 hours and takes approximately 3 minutes. For the Xradia 410 Versa, the aging process occurs every 8 hours and takes approximately 20 minutes. The aging process automatically starts when the X-ray source is powered ON. After aging is complete, the X-ray source tube automatically goes through its standard sequence to achieve the requested voltage and power.

X-ray source aperture Piece of tungsten with a hole in the center of it that is bolted to the front of the X-ray source. Blocks X-rays that do not contribute to imaging.

XRM **X**-**R**ay **M**icroscope.

Z material, Low or High Low Z materials are typically biological or polymeric. High Z materials are typically metallic or contain metallic structures (such as semiconductor samples).