Quantum FX μCT Imaging System User's Manual

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PerkinElmer Health Sciences

68 Elm Street

Hopkinton, MA 01748

Telephone: (508) 435-9761 or (508) 435-9500

FAX: 508) 435-9761

E-mail: Global.Techsupport@PerkinElmer.com

Website: WWW.PerkinElmer.com

Contents

1 Welcome

1.1 About This Manual

Welcome to the *Quantum FX µCT Software User's Manual*. The software controls the Quantum FX µCT instrument, a micro-computed tomography (µCT) scanner which provides high-resolution, high-speed radiographic imaging of small animals and reconstruction of 3D volumetric data.

Please see the *Quantum FX µCT System Manual* (part no. 128059_Rev0A) for information on the Quantum FX µCT instrument.

Figure 1.1 Quantum FX µCT Instrument

1.2 What's New in the Quantum Fx µCT Software

- Acquire images with respiratory or cardiac gating.
- Preset scan conditions: FOV40–std and FOV40–fine.
- 4.5 minute acquisition time for FOV20, FOV24, FOV40, FOV60, and FOV73.
- Ability to search the database.
- Automatically export images from the database.

1.3 Quantum FX µCT Help

To view a tooltip about a button function, put the mouse cursor over the button.

1.4 Additional Important Documentation

Table 1.1 lists other important documentation related to the use of the Quantum FX µCT instrument.

Table 1.1 Documentation for the Quantum FX µCT instrument

Document Name	Description	Part No.
Quantum FX µCT System Manual	Provides detailed instructions on the safe operation and maintenance of the Quantum FX µCT instrument.	128059
Safe Operating and Emergency Procedures for the Operation of the Quantum FX µCT Cabinet X-Ray System	Provides detailed instructions on the safety features, operating procedures, and emergency procedures for the Quantum FX µCT instrument.	128054 128634 (Canada)
Mouse Imaging Shuttle Instructions	Explains how to install and use the optional Mouse Imaging Shuttle that can be used to contain the subject during optical and CT imaging. The Mouse Imaging Shuttle enables imaging and transfer of subjects between imaging platforms without disrupting the subject position. As a result, 3D optical and 3D volumetric data can be precisely registered.	127820_RevA
Quick Start Guide: Aquiring Images on the Quantum µFX CT Instrument	Quick reference guide for image acquisition.	

1.5 Technical Support

For technical support, please contact us at:

Telephone	800-762-4000 (US)
	+1 203-925-4602
E-mail	Global.TechSupport@PERKINELMER.COM
Fax	+1 203-944-4904
Mail	PerkinElmer
	US Corporate Headquarters
	940 Winter Street
	Waltham
	Massachusetts 02451
	USA

2 Getting Started

2.1 Workflow Overview

Table 2.1 presents an overview of acquiring CT data on the Quantum FX μCT scanner.

Table 2.1 Workflow overview

Step	See Page
1. Start the Quantum FX μCT control software (click the ⬛ icon on the desktop).	See below
2. Warm up the Quantum FX μCT scanner (click the ⬛ button in the Control Panel).	17
3. Create or select a database.	8, 9
4. Create or select a sample and study where the image data (series) will be saved.	18
5. Set the scan conditions.	19
6. Place the subject in the sample chamber and center the subject in the Xcapture window.	19
7. Start the CT scan.	26
8. View and analyze the 3D reconstruction.	35

2.2 System Startup Procedure

1. Turn on the Quantum FX μCT workstation.

> **NOTE:** This also powers on the Quantum FX μCT scanner.

2. Double-click the ⬛ icon on the desktop to start the Quantum FX μCT software, .

The Control Panel and Database window appear (Figure 2.1).

Figure 2.2 shows an overview of the Control panel functions.

All image data are saved to a database. See Chapter 3 on page 8 for more details about databases.

> **NOTE:** The user ID "CTadmin" has administrator privileges.

If you have any concerns during the startup procedure, please contact PerkinElmer technical support (see page 3) for assistance.

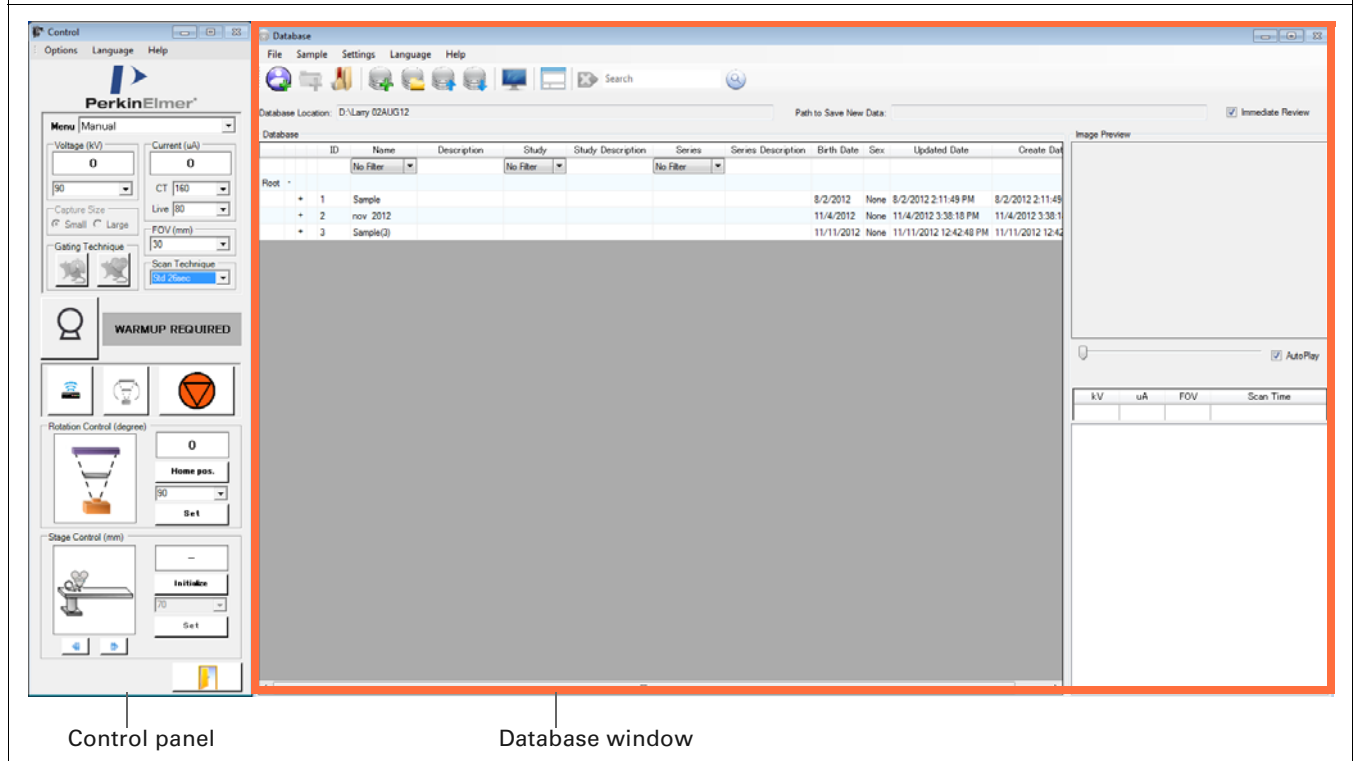**Figure 2.1** Control Panel and Database Window at Startup

Control panel   Database window

Figure 2.2 Control Panel

Scan Settings

Choose a pre-set or custom scan configuration from this drop-down list (see page 19 for more on preset configurations or page 21 for details on custom configuration set up)

X-Ray Tube Status

Actual voltage and current of the X-ray tube

Scan Parameters

Scan parameter values specified by the selected scan setting. Scan settings can be edited here, but the changes are not saved to the system.

Cardiac or respiratory gating options (see page 28)

Available scan configurations (see Table 4.3 on page 20)

Scanner status

Actual degree of gantry rotation

Returns the gantry to the 0 degree rotation position

Warm-up button

Starts the X-ray tube warm-up. When warm up is complete, this button becomes the Live Mode button (shown below).

To manually rotate the gantry prior to a scan, select the degrees of rotation from the drop-down list or enter a value, and click **Set**.

Live Mode button

This button appears after warm up is complete. Click the Live Scan button to view the subject in real time. Live Mode automatically times out after 150 minutes.

Actual z-axis position of the sample bed into or out of the bore

Moves the sample bed to the "0" position and initiates manual control of the sample bed.

CT Scan button

Starts the CT scan.

To move the sample bed in/out of the bore, select a distance (mm) from the drop-down list or enter a value, and click **Se**

Emergency Stop button

Aborts the current operations, for example, the CT scan.

Closes the control software and, if open, the Database window.

2.3 System Shut Down Procedure

PerkinElmer does not recommend power cycling the Quantum FX µCT (turning the system components on and off). If it is necessary to shut down the scanner for any reason, it is important to follow the procedure below.

1. Make sure that all processes are finished. Confirm that the gantry and sample bed are not moving.

2. Close the Control panel and Database window. If prompted, save any data.

3. Turn off the computer using the standard Windows® shut down procedure.

   This also shuts down the Quantum FX µCT scanner.

4. Turn off the power to the other system components and power surge protection devices.

If you have any concerns during the shut down procedure, please contact PerkinElmer technical support (see page 3) for assistance.

NOTE: The Emergency Stop button is not intended as a main X-ray source control and should not be used to turn the X-ray function ON or OFF on a routine basis. It should only be used in the unlikely situation where the X-ray source must be immediately turned OFF.

# 3 Managing Databases

3.1 Creating a Database

All image data (*series*) are saved to a local database. Each scan is stored in the folder D:\Data and the raw acquisition data are stored in Computer\Data (D:)*. The database facilitates interacting with and managing data sets.

To create a database:

1. Open the Database window by starting the Quantum FX μCT software (click the ![icon] icon on the desktop.
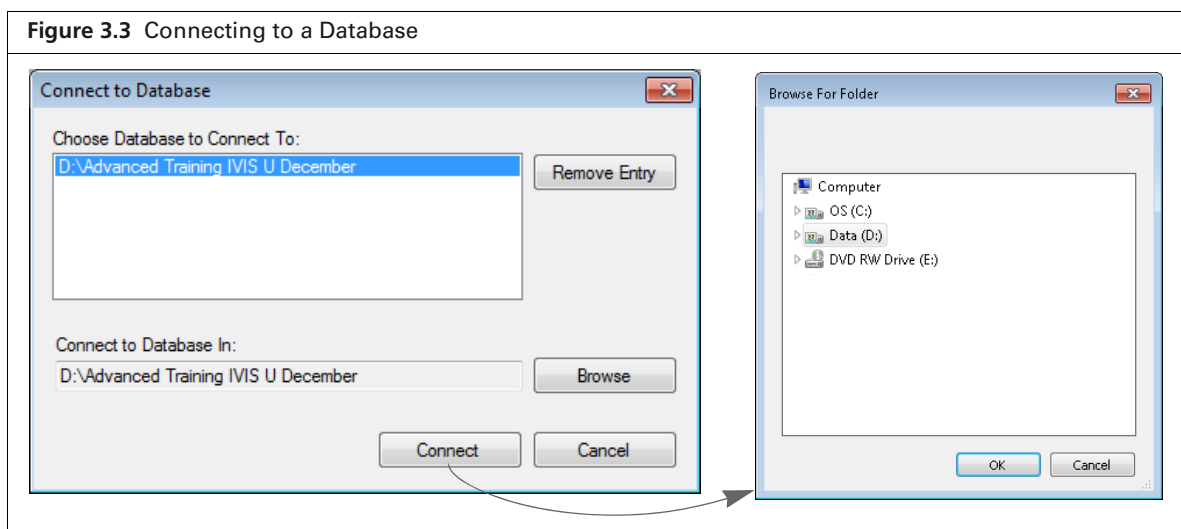

Figure 3.1 Database Window
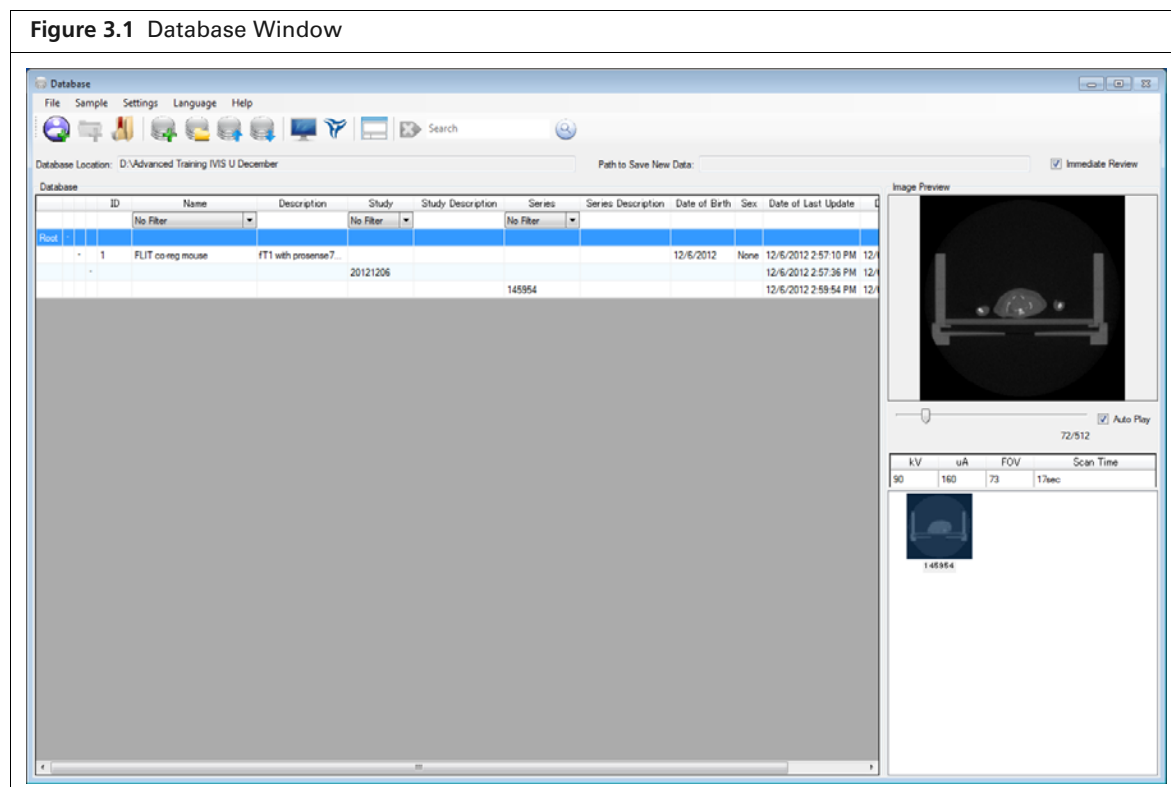
2. Click the New Database button ![icon] in the Database window. Alternatively, select **File → New Database** on the menu bar.

3. In the dialog box that appears:

    a. Enter a name for the new database (Figure 3.2).

b. Click **Browse**, and in the dialog box that appears, navigate to the drive where the database will be saved and click **OK**.

c. Click **Create**.

The new database appears in the Database window.

Figure 3.2 Creating a New Database
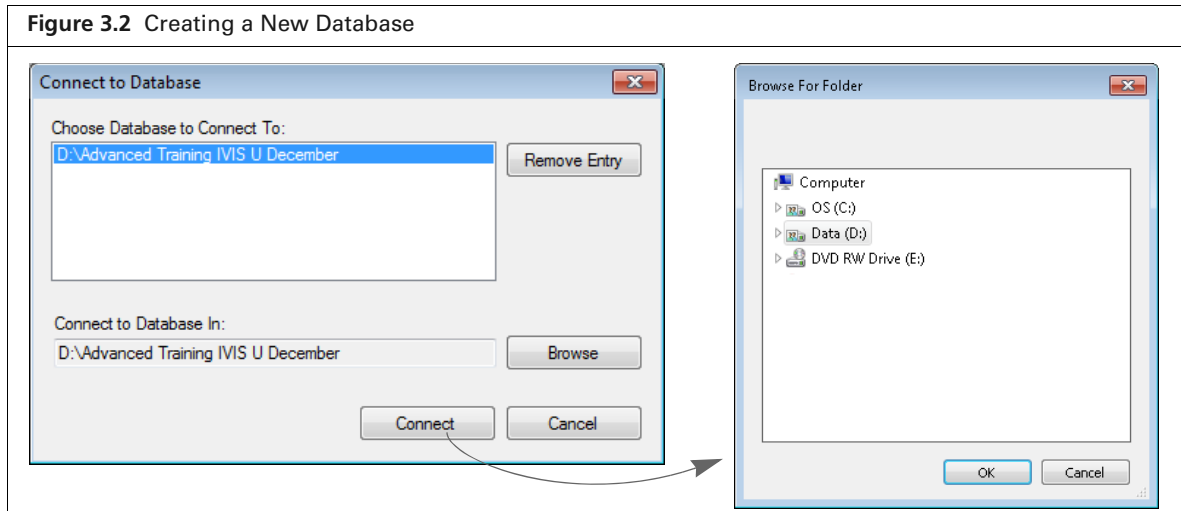
3.2 Connecting to a Database

1. Click the Connect to Database button in the Database window.

2. If the database name is listed the dialog box that appears, double-click the name. Alternatively, select the database name and click **Connect** (Figure 3.3).

If the database name is not listed in the dialog box:

a. Click **Browse**

b. Select a database in the dialog box that appears and click OK.

c. Click **Connect**.

Figure 3.3 Connecting to a Database

3.3 Data Organization

The image data (series) in a database are associated with a study and a sample (Figure 3.4). A sample may include multiple studies and a study may include one or more series.

Figure 3.4 Database Window

Samples

A sample includes one or more studies. This example shows two samples. Sample_1 has one studies and Sample_2 has five studies.

Studies

A study includes one or more series. For example, study "20100806" under Sample_1 includes two series.

Series (image data)

Customizing the Database View

You can select particular columns and data to display in the Database window.

To hide/show columns:

1. Right-click a column header in the Database window (Figure 3.5).

2. Select **Configure Display Columns** on the shortcut menu that appears.

3. In the dialog box that appears, remove or add a check mark next to a column name that you want hide or show. Click OK.)

Figure 3.5 Select Database Columns
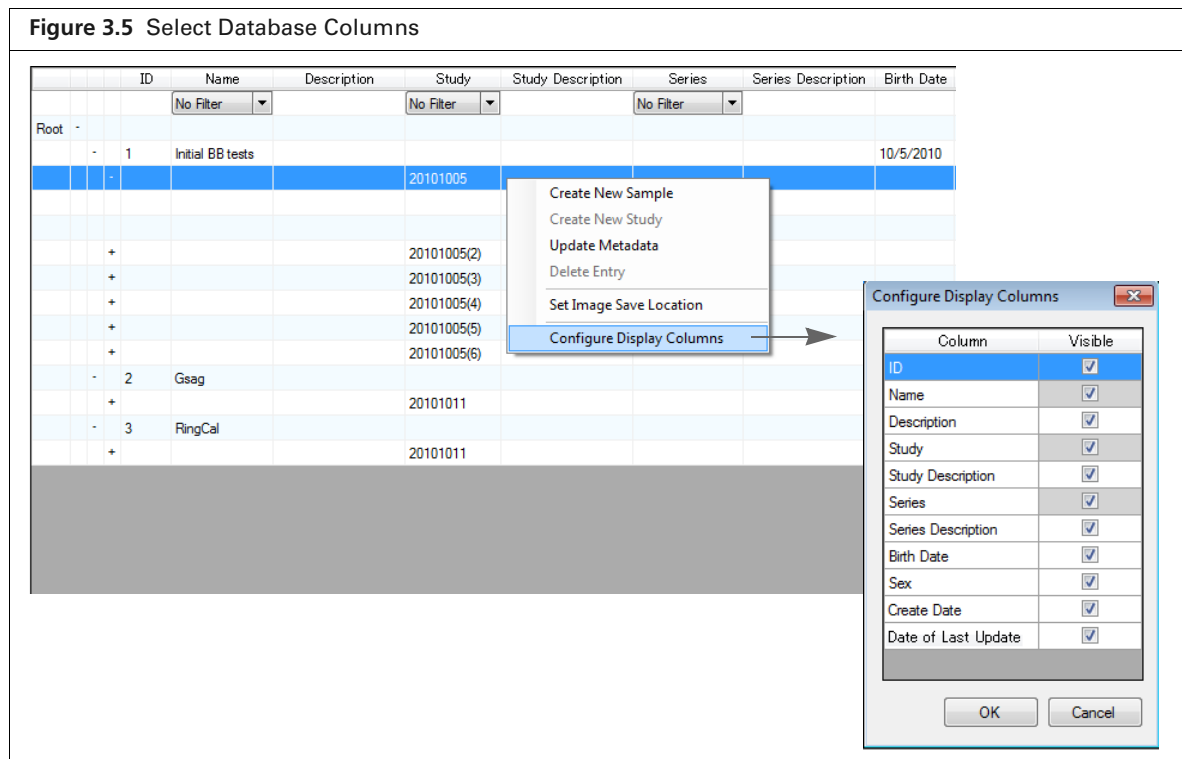
To filter the data:

Select a filter from the Name, Study, and/or Series drop-down list.

Figure 3.6 Database Filters
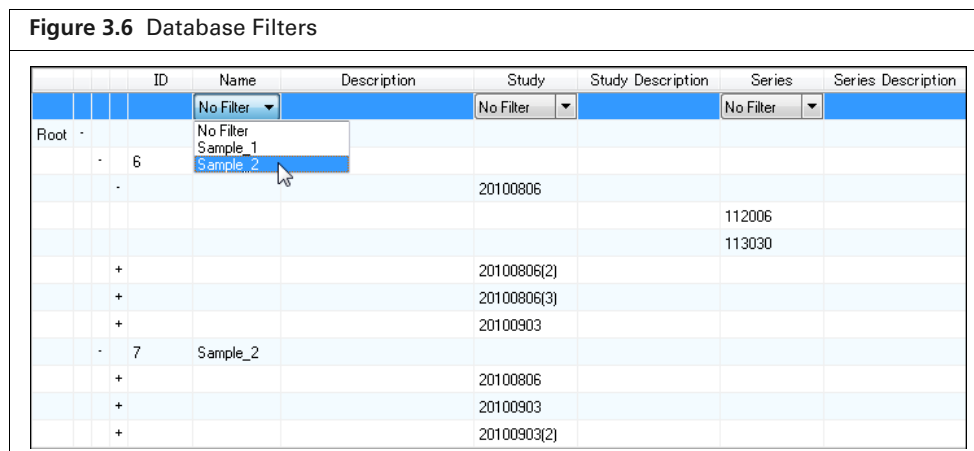
3.4 Managing Data

Reconstructed image data (*.vox) can be imported between databases or exported from the database to another location such as the desktop.

Importing Data

1. Select a save location (sample and study) for the data in the Database window. See for instructions on selecting a save location.

2. Click the ⬚ toolbar button. Alternatively, select **File → Import File** on the menu bar.

3. Select the data (*.vox) for import in the dialog box that appears, and click **Open**.

   The imported series appears in the Database window. The original data name is listed in the Series Description.

Exporting Data

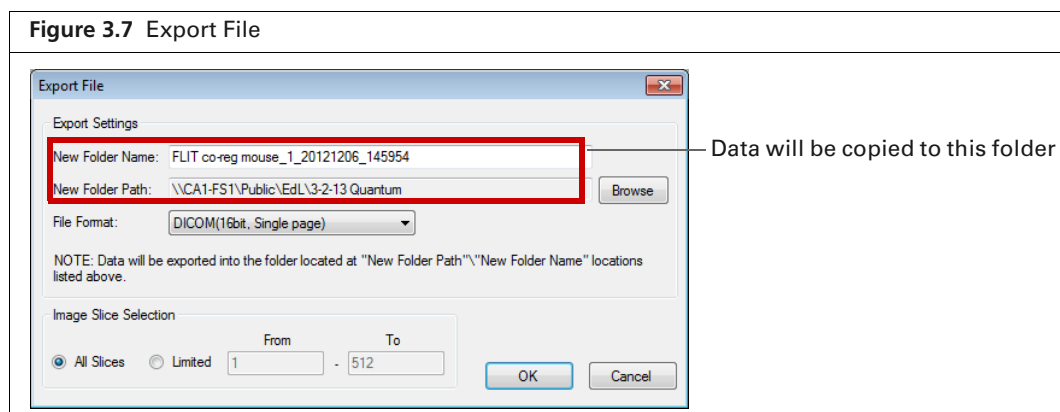1. Select the series for export in the Database window.

2. Click the 🗄 toolbar button. Alternatively, select **File → Export File** on the menu bar.

3. In the dialog box that appears (Figure 3.7), confirm the default name or enter a different name for the new folder where the data will be copied.

Figure 3.7 Export File

Data will be copied to this folder

4. To change the folder path, click **Browse** and select a location in the dialog box that appears.

5. Select a file format from the drop-down list.

File Format	Description
CT image with a SimpleViewer	Exports the 3D reconstruction (.vox) along with the SimpleViewer. See page 48 for more details on the SimpleViewer.
DICOM (16bit, Single page) Tiff (16, Multi page) JPEG Bitmap PNG	Exports individual slices in a file formats common for medical imaging. Exporting to DICOM format creates a folder of .dcm files, one file per slice. Exporting to Tiff format creates a single file which includes all of the slices.
AVI	Exports the selected images in a video file format.

6. To export only a subset of the slices contained in an image, choose the "Limited" option and enter a range of slice numbers. Click **OK**.

Deleting Data

✎ **NOTE:** Only the system administrator can delete a database (includes the associated studies and series), study (includes the associated series), or series only. See page 15 for instructions on system administrator login/logout.

⚠️ **CAUTION:** Deleting data removes all reconstructed and raw images from the system. The images cannot be recovered once the delete process is initiated.

1. Select a sample, study, or series in the Database window.
2. Right-click the row and select **Delete Data** on the shortcut menu.
3. Click **Yes** in the confirmation message that appears.

Figure 3.8 Deleting Data
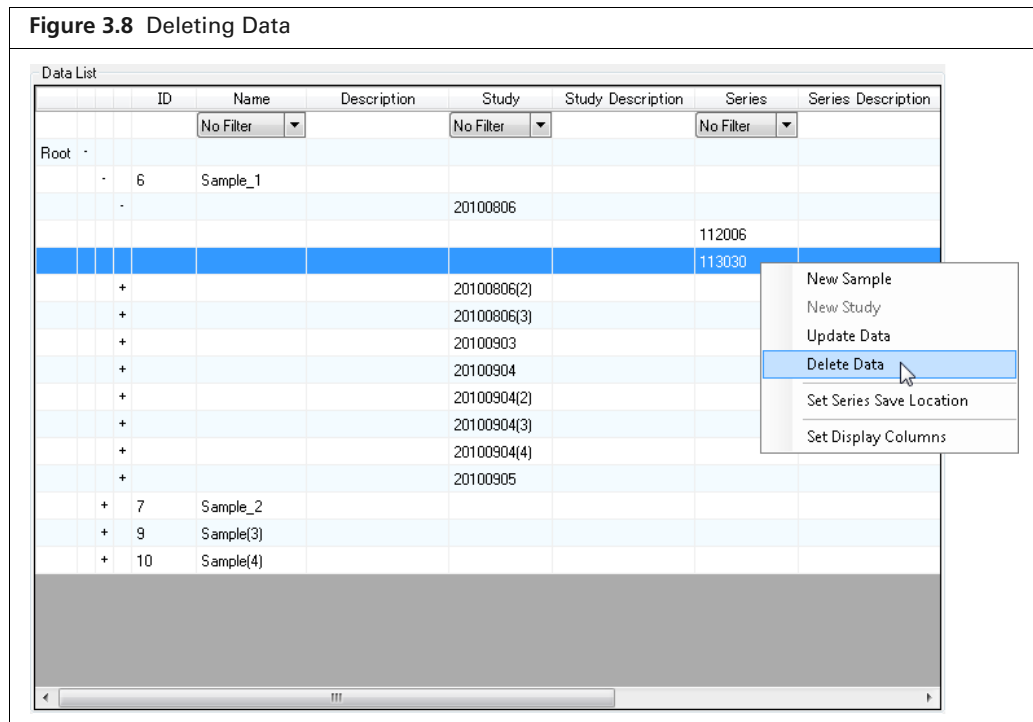
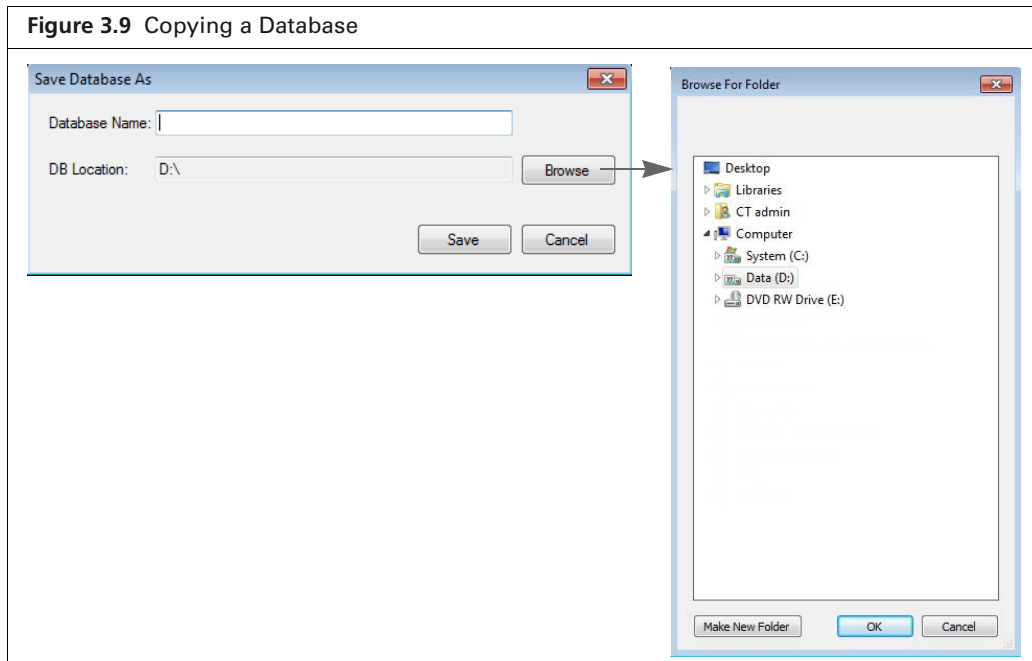

3.5 Managing Databases

Copying a Database

Copying a database provides a convenient way to share data.

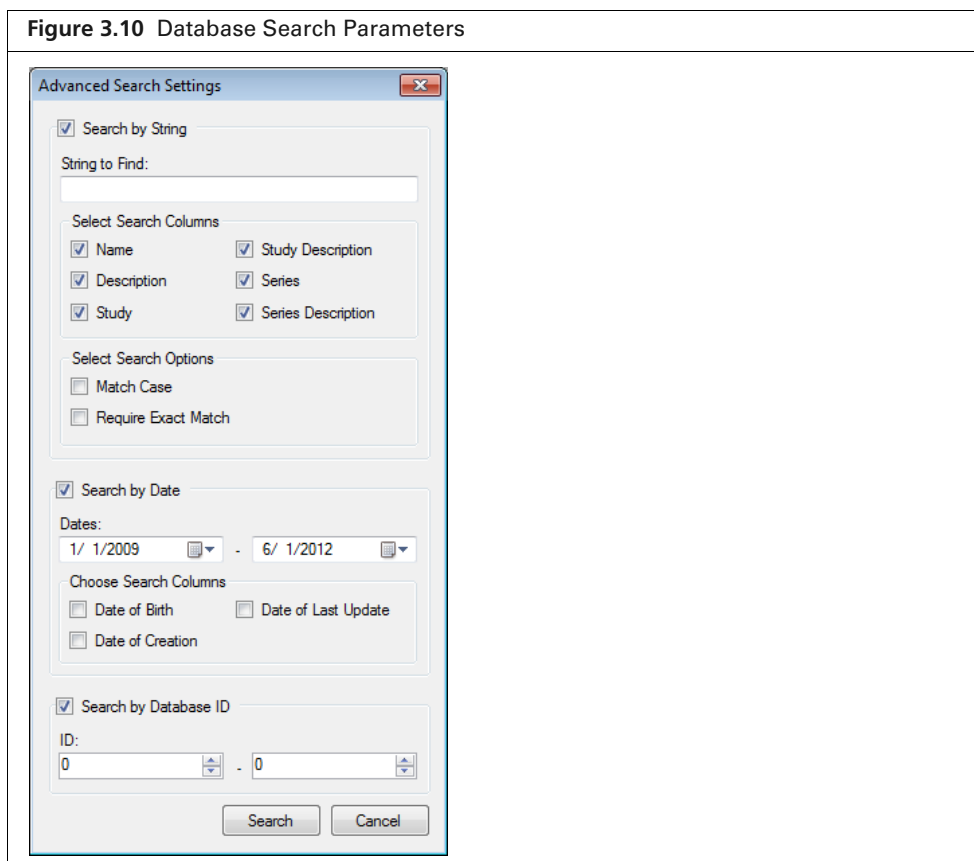✏️ **NOTE:** Only the system administrator can copy a database. See page 15 for instructions on system administrator login/logout.

1. Connect to the database that you want to copy. (See page 9 for details on connecting to a database.)
2. Select **File** → **Save Database as** on the menu bar.
3. Enter a name for the new database in the dialog box that appears.
4. To change the save location:
   a. Click **Ref** (Figure 3.9).
   b. Select a folder in the dialog box that appears, and click **OK**.
5. Click **Save**.

Figure 3.9 Copying a Database

Searching a Database

1. Click the 🔍 toolbar button.

2. Enter a text string, choose the search options, and click **Search**.

Figure 3.10 Database Search Parameters

Reconstructing a Database

In the rare event that a database is corrupted, it is possible to reconstruct the database from the .xml files in the CT image folders.

To reconstruct a database:

1. Select **File → Rebuild Database** on the menu bar.

2. Select the database for reconstruction in the dialog box that appears and click **OK**.

Deleting a Database

NOTE: Only the system administrator can copy a database. See page 15 for instructions on system administrator login/logout. Do not delete a database using Windows Explorer.

CAUTION: Deleting a database removes all reconstructed and raw images from the system. The images cannot be recovered once the delete process is initiated.

1. Connect to the database to be deleted:

   a. Click the Connect to Database button in the Database window.

   b. Select the database in the dialog box that appears.

2. Select **File → Delete Database** on the menu bar.

3. Click **OK** In the confirmation messages that appears.

3.6 System Administrator Login/Logout

1. Select **Settings → Login/Logout** as Administrator on the menu bar.

2. Enter the administrator password in the dialog box that appears.

   The default password is *ctadmin*.

3. Click **Login** (or **Logout** if logging out).
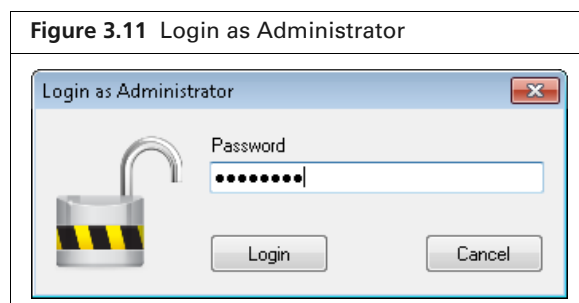
Figure 3.11 Login as Administrator

4 Image Acquisition
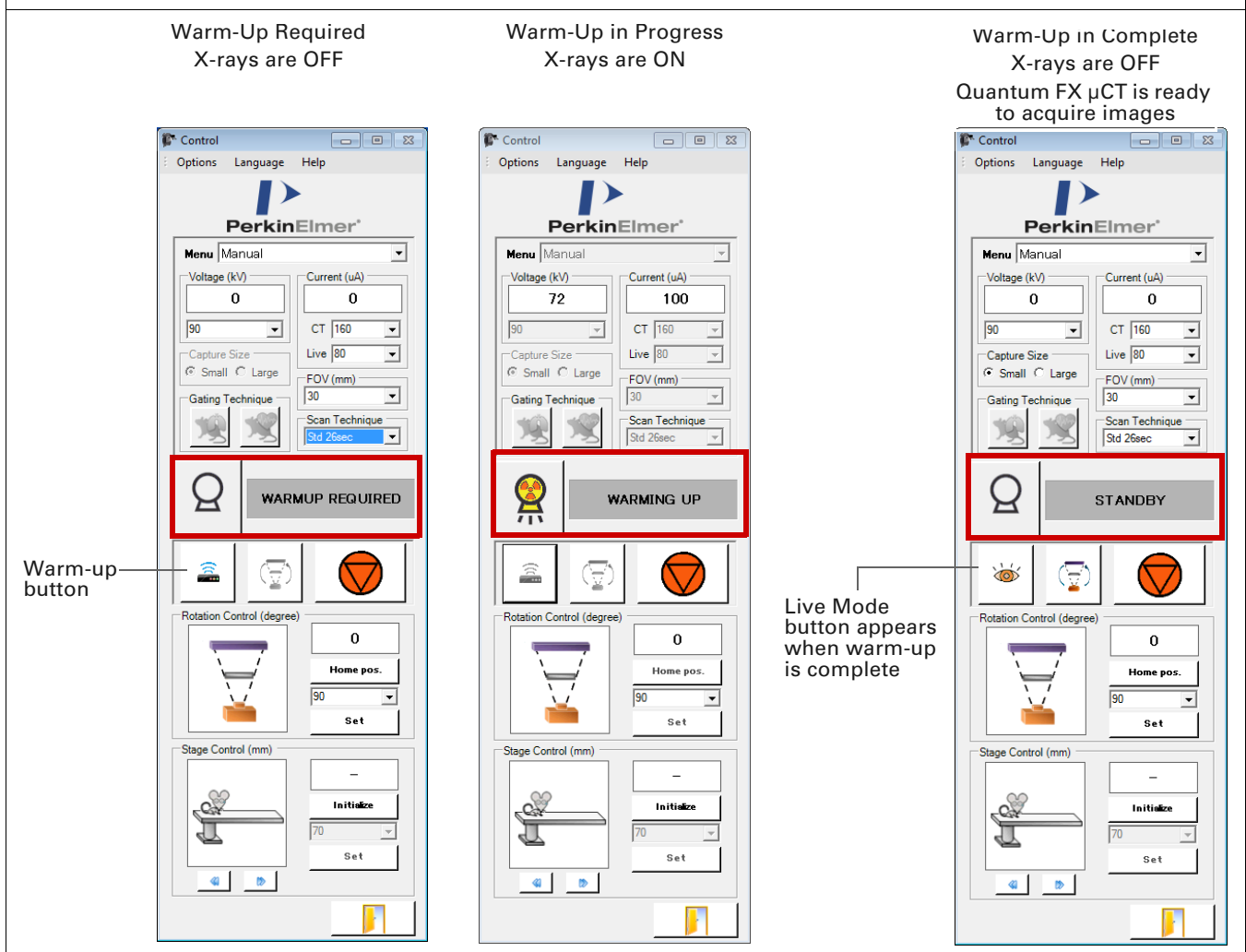
4.1 Instrument Warm-Up

Check the Control panel to see if the instrument requires warm-up (Figure 4.1). (If the Control panel is not open, click the ![icon] icon on the desktop).

Figure 4.1 Control Panel

To warm-up the instrument:

1. Confirm that the sample chamber is empty (no subject or sample bed is inside the sample chamber).

2. Close the instrument door.

> **NOTE:** The Quantum FX ìCT instrument does not generate X-rays unless the door is properly closed and the safety interlock is engaged. There is an audible "click" when the safety interlock properly engages as the door is closed.

3. Click the Warm-up button [icon] in the control panel.

4. Click OK the warning message that appears (Figure 4.2).

Figure 4.2 Warm-Up Warning Message
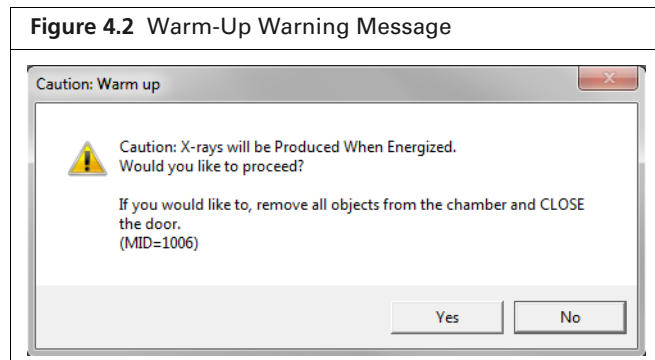
> **CAUTION: Do not open the instrument door when X-rays are being produced (the control panel displays "XRAY ON" and the X-ray indicator [icon] is flashing). Opening the door terminates the X-rays and aborts the warm-up process.**

The X-ray tube begins the warm-up process and generates X-rays. The time required for warm-up depends on how long it has been since the instrument was last used (Table 4.1). When warm-up is completed, the X-ray tube status is "STANDBY" (Figure 4.1).

Table 4.1 Estimated Time Required for Warm-Up

Duration of Instrument Disuse	Approximate Time Required for Warm-Up
8 hours to one month	15 min
One to three months	40 min
More than three months	120 min

4.2 Select a Save Location

All image data (series) are saved to a database where the data are organized by sample and study (sample:study:series). See page 10 for more details on data organization. Before image acquisition, select a database and specify the sample and study where the series will be saved. You can save a series to a new or existing sample and a new or existing study within the sample.

> **NOTE:** The selected database drive must have at least 10GB free disk space available. If this requirement is not met, the scan will not proceed

Set the Save Location:

1. Connect to a database or create a new database. (See Managing Databases page 9 for details).

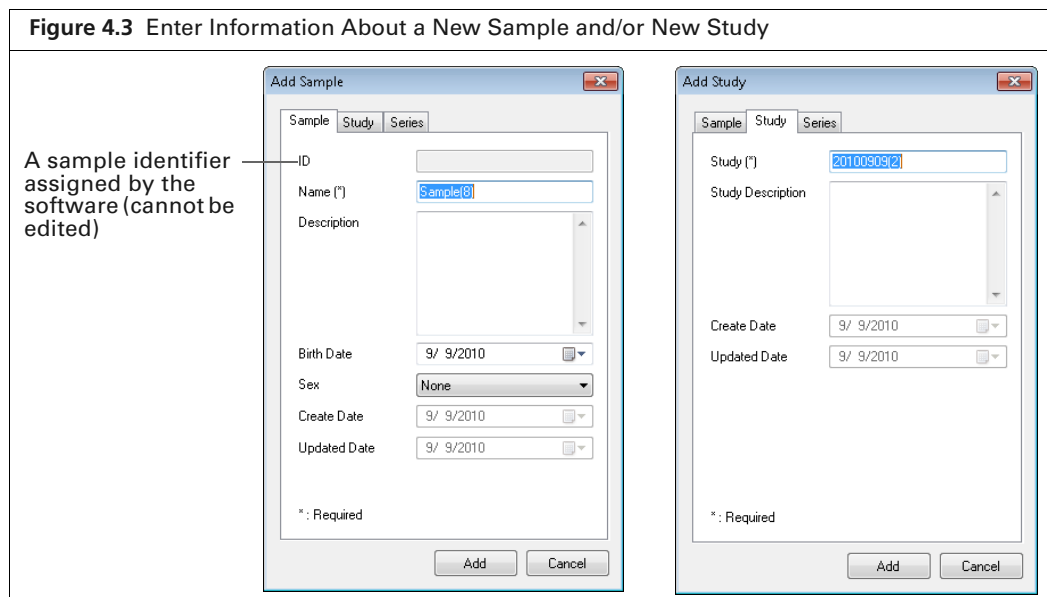**2.** Follow the instructions in Table 4.2 to select a sample and study for the series.

Table 4.2 Setting the Save Location in the Database window

To Save the Series to a:	Do One of the Following:
New sample and new study	Click the 🔵 toolbar button. or Right-click the Database window and select **New Sample** on the shortcut menu. or Select **Sample → New Sample** on the menu bar.
Existing sample and new study	Select the sample row and click the 🔨 toolbar button. or Right-click the sample row and select New Study on the shortcut menu. or Select the sample row and select **Sample → New Study** on the menu bar.
Existing sample and existing study	Select the study row and click the 🔨 toolbar button. or Right-click the study row and select **Set Series Save Location** on the shortcut menu.

3. Enter the sample and/or study information in the dialog box that appears. Click **Add**.

For example, edit the default sample name and enter a description of the sample.

> 🖊 **NOTE:** Depending on the method used to select the save location, the Add Sample or Add Study dialog box may not automatically appear. To display them, right-click a selected sample or study in the Database window and choose **Update Data** on the shortcut menu.

Figure 4.3 Enter Information About a New Sample and/or New Study

A sample identifier assigned by the software (cannot be edited)

4.3 Set Up Automatic Image Export

After acquisition, DICOM images can be automatically exported to a user-selected location.

1. Select Setting **Automatic → DICOM Export Settings** in the Database window.
2. Put a check mark next to "Export DICOM file after each scan" in the dialog box that appears.
3. Choose the File path or VOX folder option and click the Browse button to select a folder. Click **OK**.

Figure 4.4 Automatic DICOM Export Settings

4.4 Set the Scan Conditions

To set the scan conditions, choose a:

■ Preset scan condition or specify custom scan parameter conditions in the control panel.
■ Gating option if performing a gated CT scan.

Preset Scan Conditions

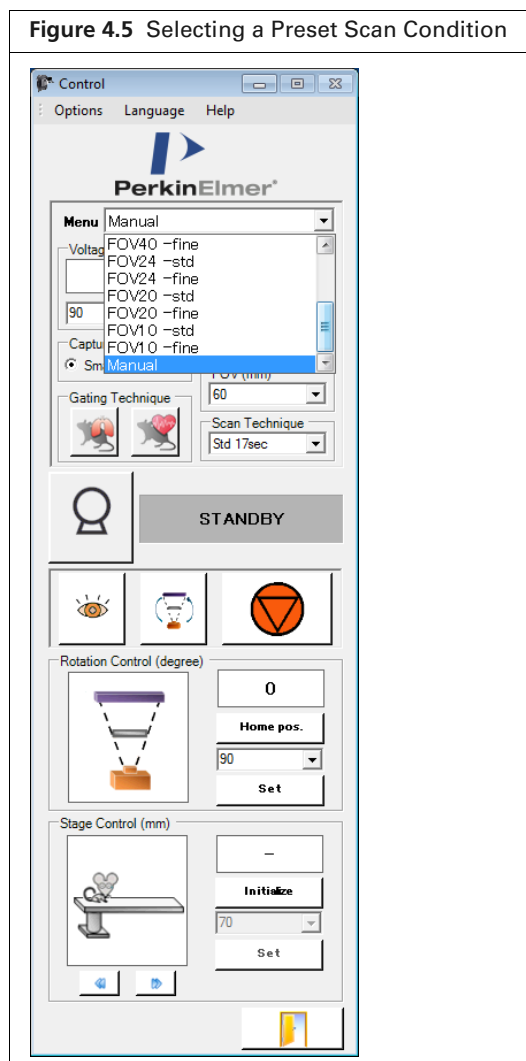1. Make a selection from the Mode drop-down list (Figure 4.5).

Figure 4.5 Selecting a Preset Scan Condition

Table 4.3 Preset Scan Configurations

Preset Scan Condition	kV	CT μA	Live μA	FOV (mm)	Length (mm)	Scan Time (sec)	Image Pixel Size (μm)	Dynamic Scan Available	Bore Cover
FOV73—std	90	160	80	73	60	17	148	yes	L, M, S
FOV73—fine	90	160	80	73	60	120	148	yes	L, M, S
FOV60—std	90	160	80	60	60	17	118	yes	L, M, S
FOV60—fine	90	160	80	60	60	120	118	yes	L, M, S
FOV30—std	90	160	80	30	30	26	59	no	L, M, S
FOV30—fine	90	160	80	30	30	180	59	no	L, M, S
FOV40—std	90	160	80	40	40	17	80	no	M, S
FOV40—fine	90	160	80	40	40	120	80	no	M, S
FOV24—std	90	160	80	24	20	17	50	no	S

Table 4.3 Preset Scan Configurations (continued)

Preset Scan Condition	kV	CT µA	Live µA	FOV (mm)	Length (mm)	Scan Time (sec)	Image Pixel Size (µm)	Dynamic Scan Available	Bore Cover
FOV24—fine	90	160	80	24	20	120	50	no	S
FOV20—std	90	160	80	20	20	17	40	no	S
FOV20—fine	90	160	80	20	20	120	40	no	S
FOV10—std	90	160	80	10	10	26	20	no	S
FOV10—fine	90	160	80	10	10	180	20	no	S

Table 4.4 Scan Parameters

Parameter	Description
kV	The voltage requested from the X-ray tube.
CT µA	The current requested from the X-ray tube.
Live µA	The current requested from the X-ray tube during fluoroscopy/Live Mode scan.
FOV (mm)	The field of view.
Scan Time	The time that the gantry requires to rotate 360 degrees during image acquisition.

Custom Scan Conditions

There are two ways to set custom scan conditions:

- Edit the scan parameters in the Control panel (see below). These changes are not saved to the system.

  or

- Create and save a scan condition in the Menu Settings table (see). The custom scan condition will be available in the Menu drop-down list of the Control panel

Editing Scan parameters in the Control Panel

1. Select "Manual" from the Menu drop-down list
2. Enter a custom voltage and current in the Control panel (Figure 4.6).
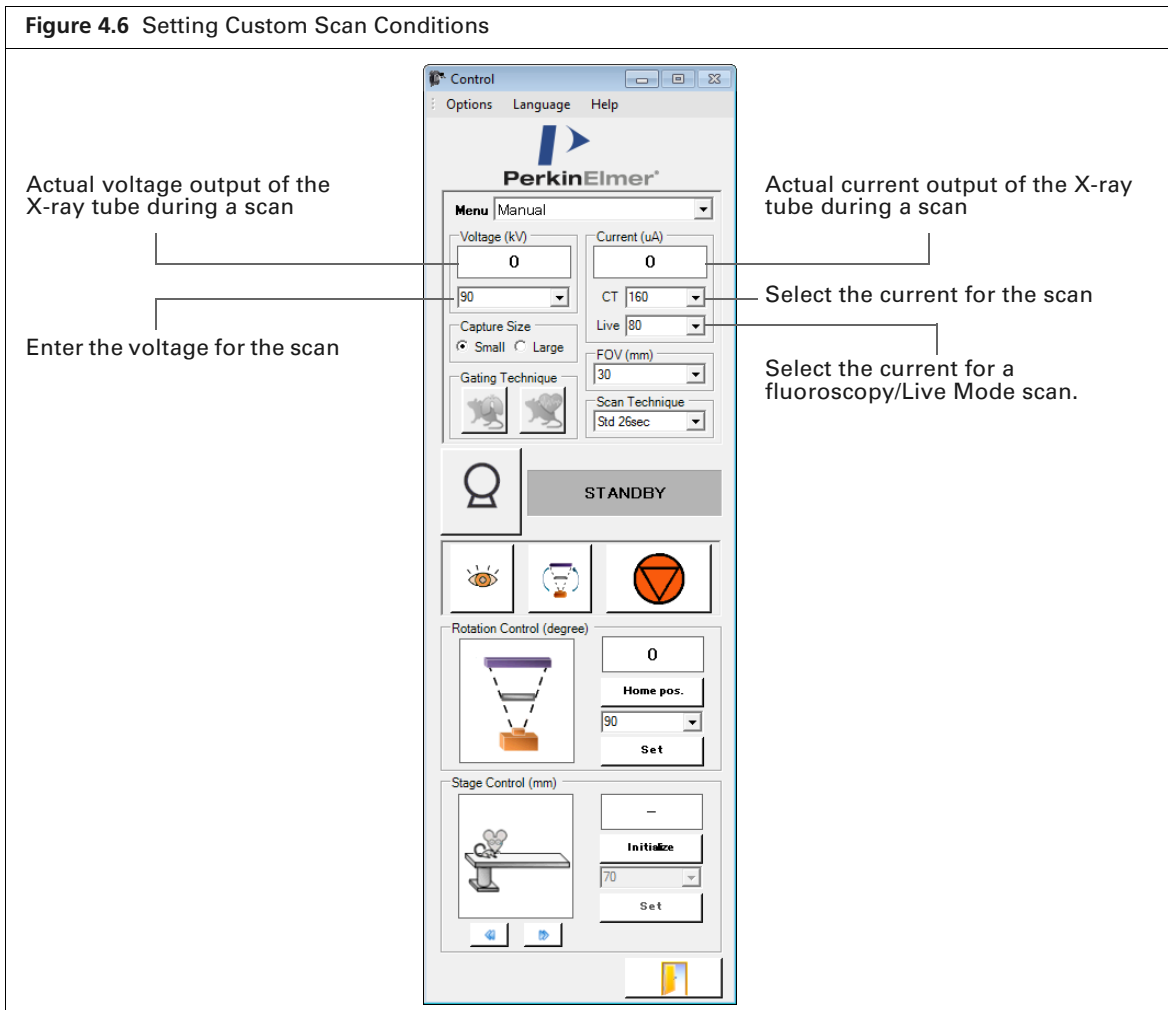3. Select a Preview Size, FOV, and Scan Technique. See Table 4.5 for more details on these parameters.

Figure 4.6 Setting Custom Scan Conditions

Actual voltage output of the X-ray tube during a scan

Enter the voltage for the scan

Actual current output of the X-ray tube during a scan

Select the current for the scan

Select the current for a fluoroscopy/Live Mode scan.

Table 4.5 Control Panel Acquisition Parameters

Parameter	Description
Voltage	The voltage affects the potential of the electron beam between the cathode and anode, and therefore, the energies in the X-ray spectrum that is generated.
Current	The current affects the amount of X-rays that are generated, and therefore, the dose. CT – The current setting for a scan. Live – The current setting for a fluoroscopy/Live Mode scan.
Capture Size — Large or Small	Size options for the Xcapture window.
FOV	The field of view (mm).
Scan Technique	Std – A common scan configuration. These scans typically require 17 or 25 seconds. Fine – A scan mode that reduces image noise. These scans typically require 2 or 3 minutes. Dyn..*..– A scan configuration that performs two scans and stitches them together to increase the axial field of view. After the first scan, the bed moves into the bore and the second scan is completed. The software uses the images from both scans to generate the 3D reconstruction (.vox).

Creating a Custom Scan Condition

Create a custom scan condition by editing an existing scan condition or creating a new scan condition.

1. Select **Options** → **Preset Modes** on the Control panel menu bar

The Menu Settings table appears. It lists the available scan conditions and their parameter settings.

Figure 4.7   Preset Mode Settings
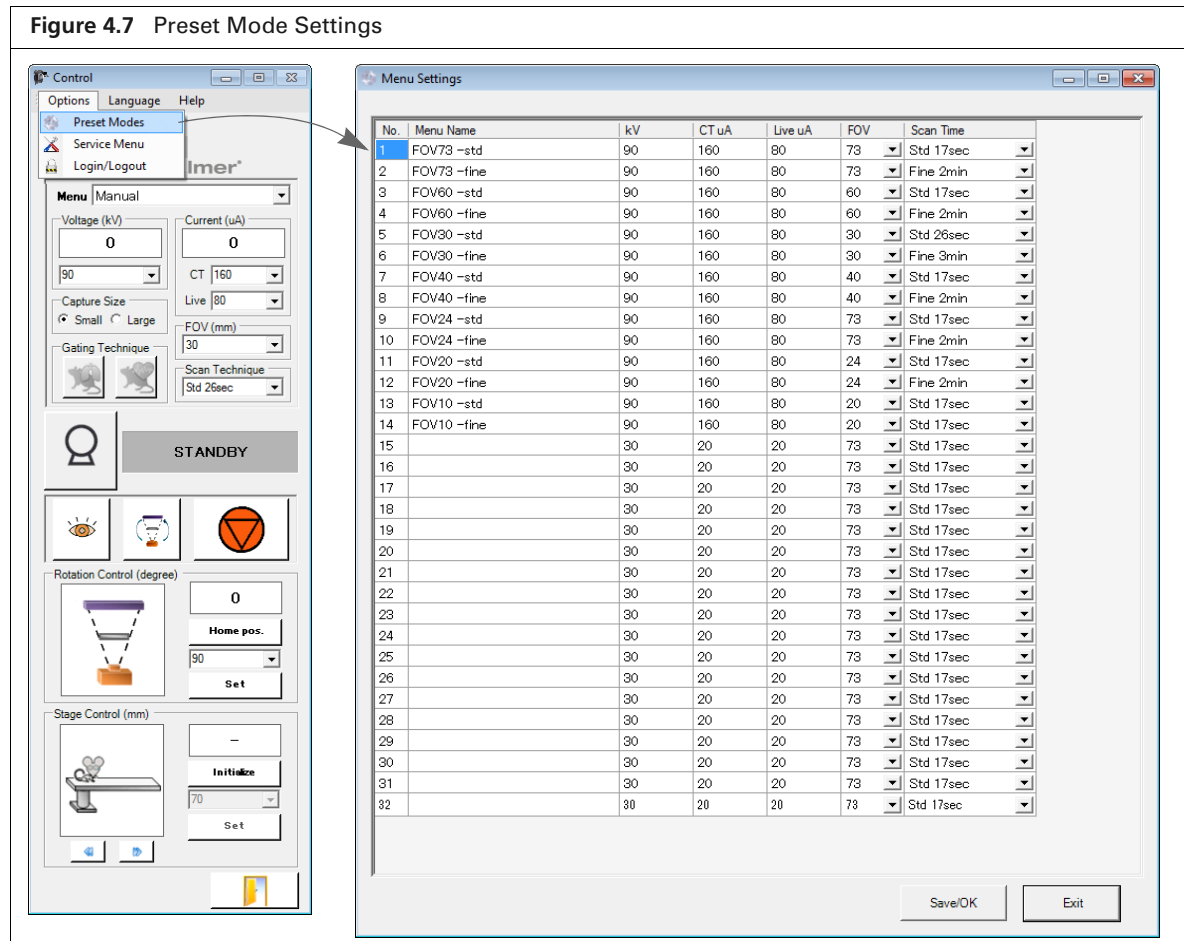
2. To create a custom scan condition:
  a. Enter a name (under the "Menu Name" column header).
  b. Enter values for kV, CT μA, and Live μA.
  c. Make a selection from the FOV and Scan Time drop-down lists.
  d. Click **Save/OK**.
      The scan condition appears in the Mode drop-down list in the Control panel.
3. To edit an existing scan condition:
  a. Double-click a table cell and enter a new value.
  b. Select a new value from a parameter drop-down list.
  c. Click **Save/OK**.
      The changes are saved to the system.
4. Select the scan condition from the Mode drop-down list in the Control panel.

4.5 Place a Subject in the Sample Chamber

The Quantum FX µCT is ready to acquire images after instrument warm-up is complete. (See page 16 for more details on instrument warm-up.)

1. Install the appropriate bore cover. See Table 4.3 on page 20.

2. Place the anesthetized subject on the sample bed. See the *Quantum FX µCT System Manual* (part no. 128059) for instructions.

   If using the Mouse Imaging Shuttle, place the shuttle with the anesthetized subject on the sample bed. If needed, connect the gas anesthesia tubing. See the *Mouse Imaging Shuttle Instructions* (part no. 127820) for details on the Mouse Imaging Shuttle.

3. Push the sample table into the bore and slide the instrument door closed so that the interlock properly engages.

4. Turn on Live Mode by clicking the 👁 button in the Control panel.

   The Xcapture window appears and shows the subject in real time (Figure 4.8).

   > 📝 **NOTE:** Only the image data inside the bounding box are used to reconstruct the 3D volume.

Figure 4.8 Xcapture Window
Respiratory gating is selected in this example.

Image data bounding box
Image data outside the bounding box are not used in the reconstruction.

Gating bounding box positioned around the diaphragm
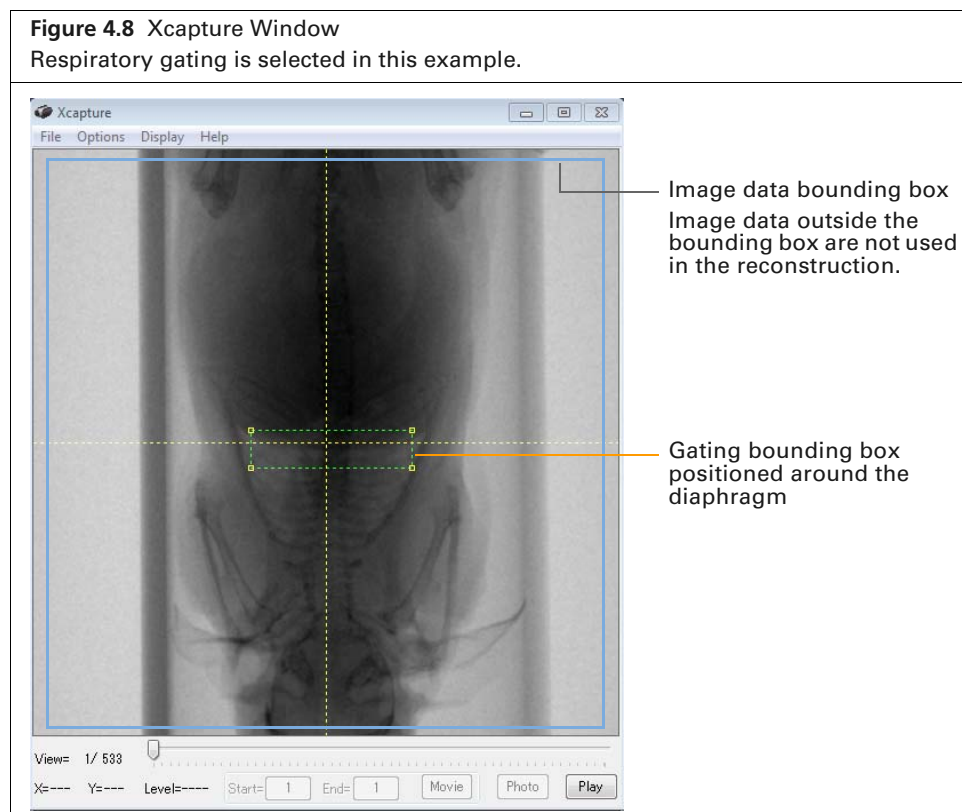
5. Move the sample bed into the bore using any of the following methods:
   - Use the stage Z-axis controls on the front panel of the instrument to move the sample bed into the bore. To do this, press and hold the Fast button while you press the Z-axis left or right arrow (Figure 4.9).

Figure 4.9 Quantum FX μCT Front Panel
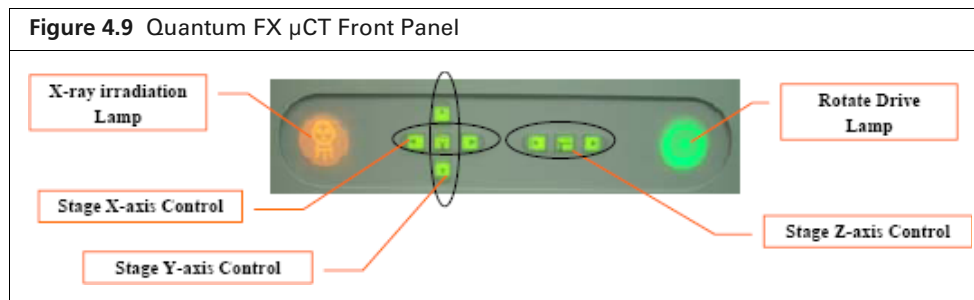
- Use the stage control arrows [icon] [icon] in the control panel (Figure 4.10)
- Move the sample bed a specific distance:
    1) Click **Initialize** (Figure 4.10).
    2) Enter a distance (in mm) and click **Set**.

Figure 4.10 Control Panel

Gantry position set to 0 degrees

Use these controls to move the sample bed in or out of the bore

Gantry position set to 90 degrees
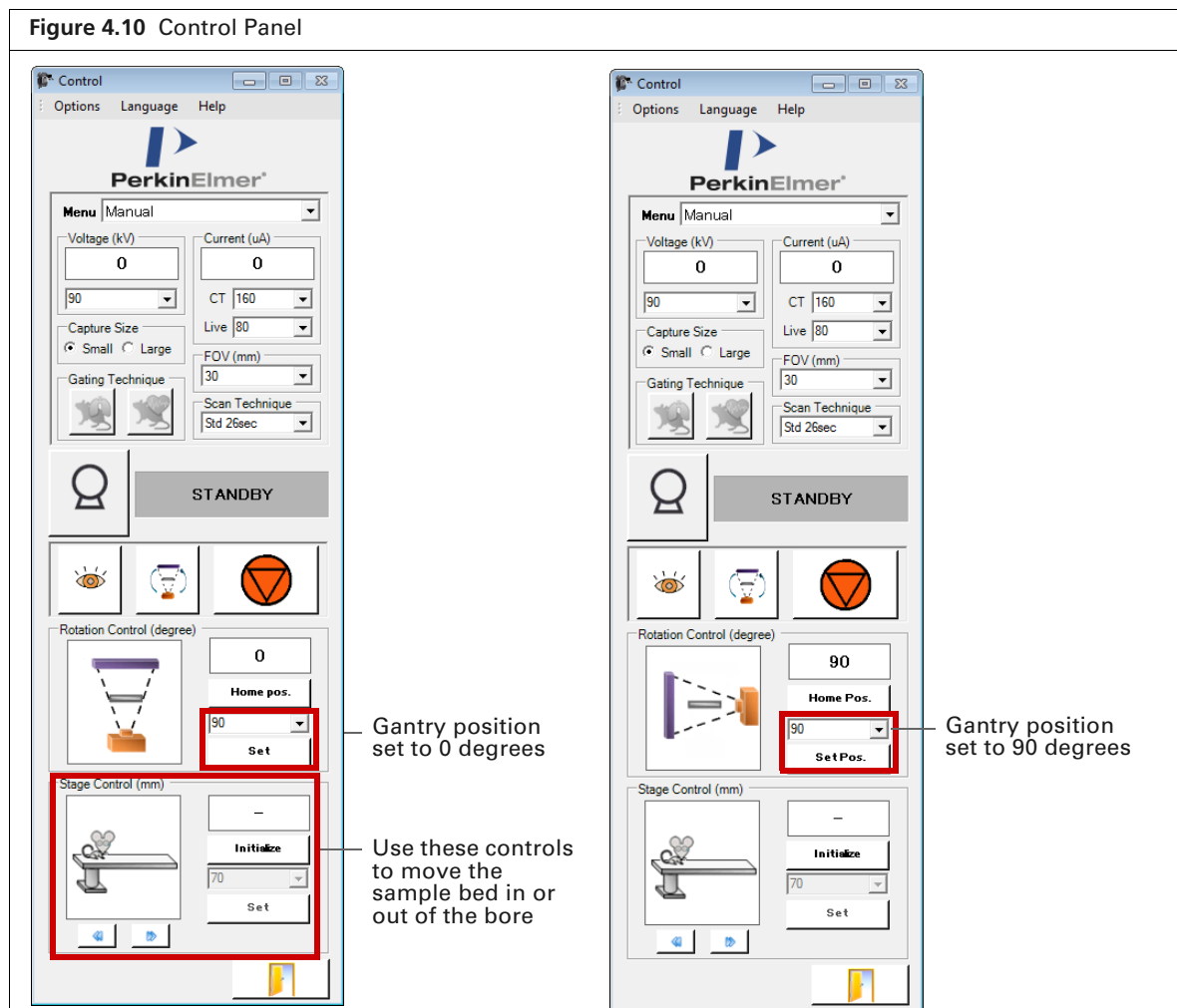
6. Check the subject position in the Xcapture window at the 0 degree gantry position:
   a. Select "0" from the Rotation Control drop-down list.
   b. Click **Set** (Figure 4.10).
   c. If necessary, use the stage X-axis controls on the instrument front panel to center the subject in the Xcapture window (Figure 4.10).

7. Check the subject position in the Xcapture window at the 90 degree gantry position:

   a. Select "90" from the Rotation Control drop-down list and click **Set** (Figure 4.10).

   b. If necessary, use the stage Y-axis controls on the instrument front panel to center the subject in the Xcapture window (Figure 4.9).

8. Click the 👁 button to turn off Live Mode and close the Xcapture window

> ✏ **NOTE:** Live Mode automatically times out after 150 seconds.

4.6 Perform a CT Scan

This section explains how to perform a:

- *CT Scan Without Gating*
- *CT Scan With Respiratory Gating* on page 28
- *CT Scan With Cardiac Gating* on page 30

CT Scan Without Gating

> ❗ **IMPORTANT:** Click the emergency stop 🔻 button in the control panel to abort acquisition and stop X-ray generation.

1. Click the CT Scan button ⏳ to begin the scan.

2. Click Yes in the confirmation message that appears (Figure 4.11).

X-rays are energized as indicated by the blinking voltage icon and the instrument status box (Figure 4.12). The Xcapture window opens, then gantry rotation and image acquisition begin.

The 3D reconstruction automatically proceeds after acquisition is complete. The AutoViewer displays the 3D reconstruction (Figure 4.13). See Chapter 5 on page 35 for more information on viewing 3D reconstructions.

Figure 4.11 CT Scan Confirmation Message
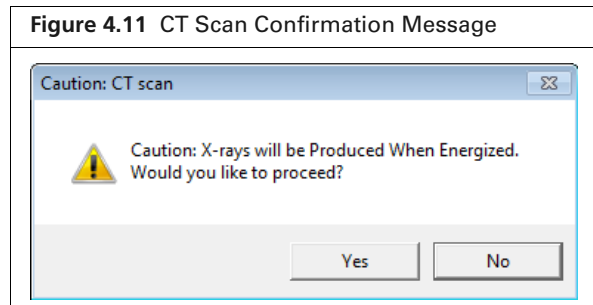
Figure 4.12 Control Panel and Xcapture Window During a Scan

X-ray tube status = ON

X-ray tube status = ON

Gantry position
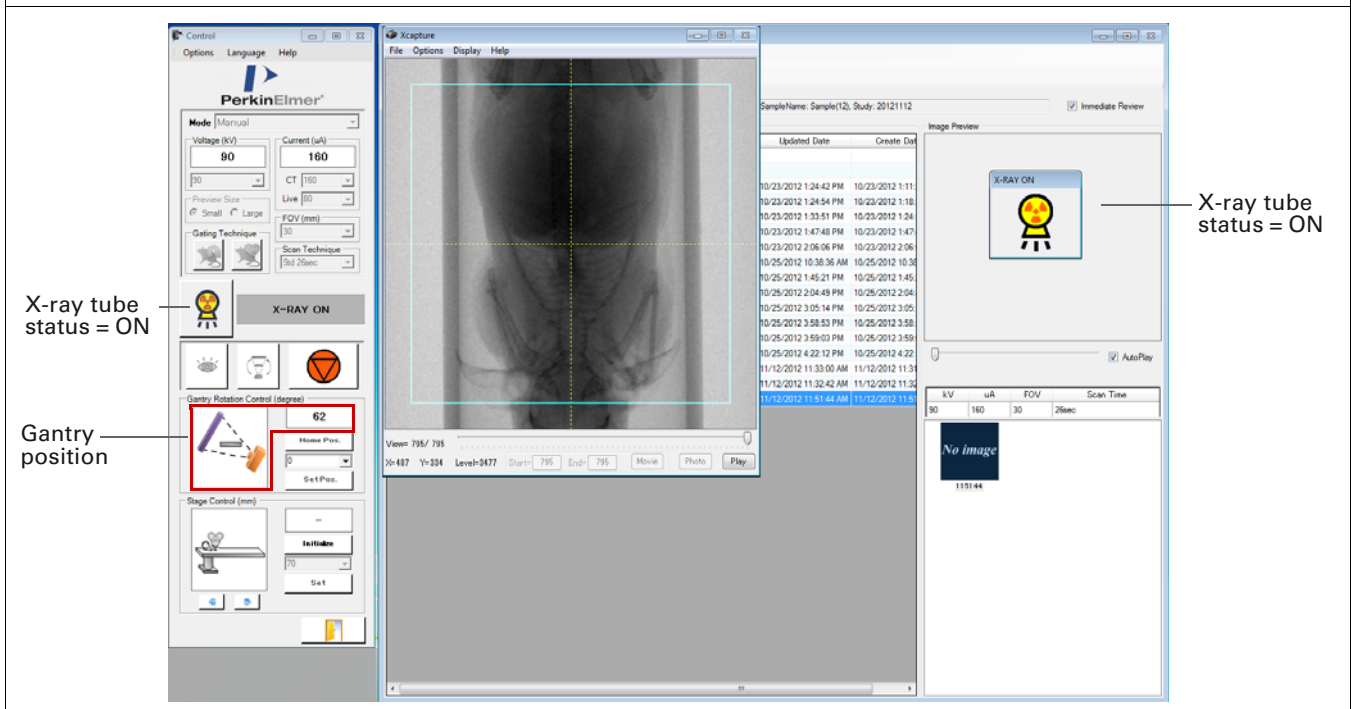
3. Remove the subject from the sample chamber when the Quantum FX μCT is in Standby mode.

⚠️ **CAUTION: Do not remove or change the bore cover until the Quantum FX μCT is in standby mode and the CT scan button 🔘 becomes available.**

Figure 4.13 AutoViewer
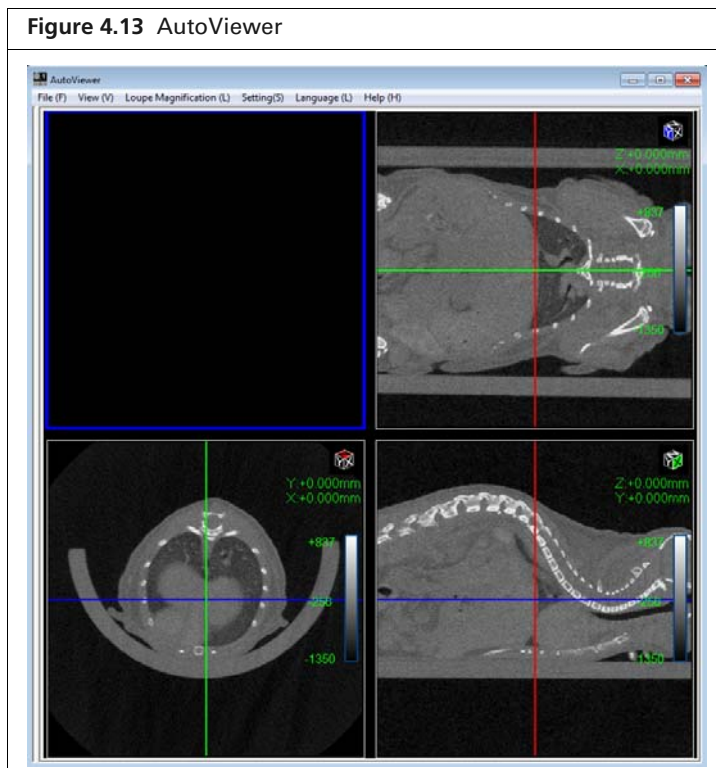
> 🖊 **NOTE:** If the AutoViewer does not automatically appear, confirm that the AutoView option is selected in the Database window.

CT Scan With Respiratory Gating

> ❗ **IMPORTANT:** Click the emergency stop 🔻 button in the control panel to abort acquisition and stop X-ray generation.

1. Click the respiratory 🐭 gating button.
2. Turn on Live Mode by clicking the 👁 button in the Control panel.

   The Xcapture window appears and shows the subject in real time (Figure 4.14).

Figure 4.14 Xcapture Window
Respiratory gating is selected in this example.

Image data bounding box
Image data outside the bounding box are not used in the reconstruction.

ROI positioned over the diaphragm

Start the scan after the breath rate is stable and greater than 1000 ms
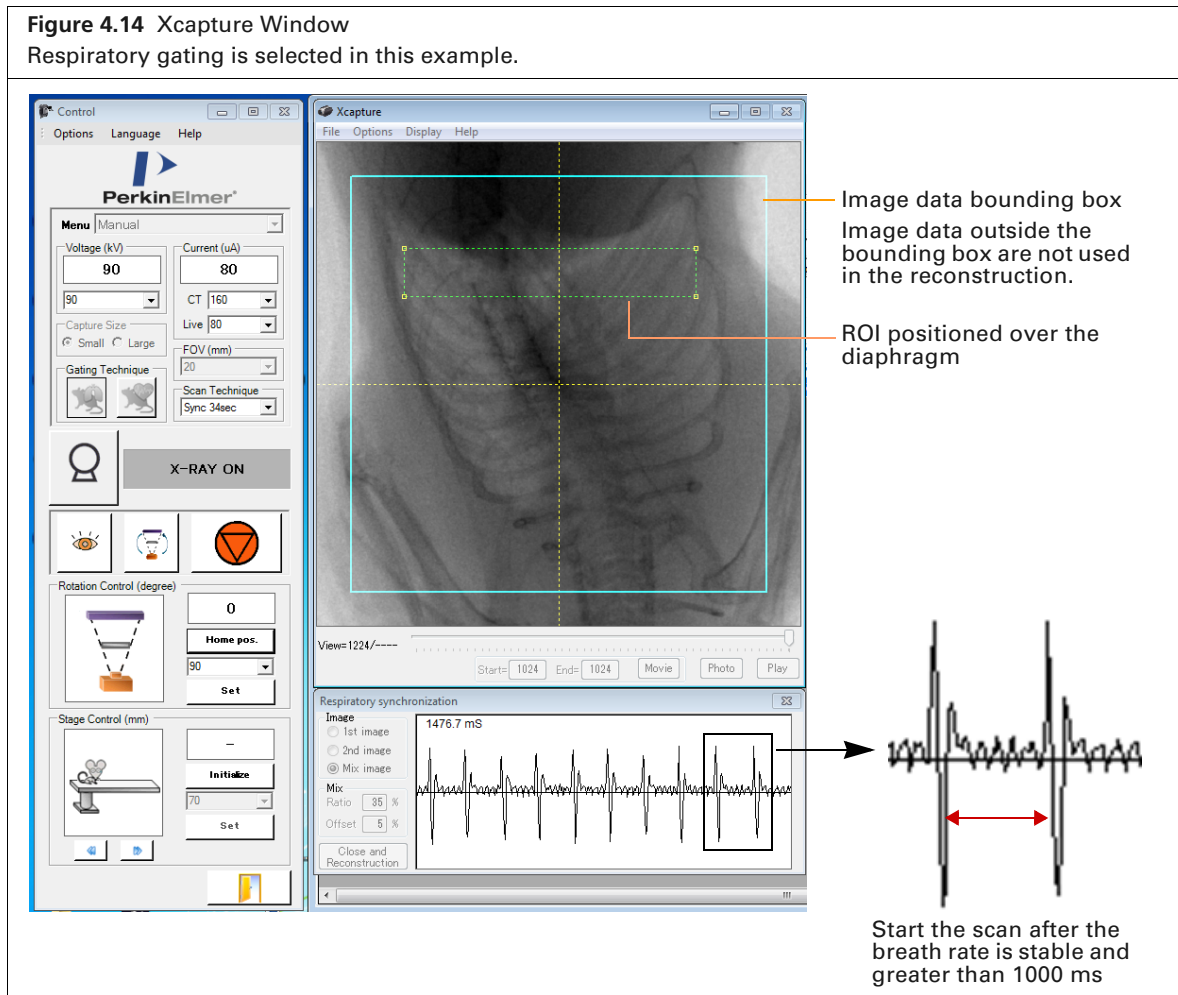
3. In the Xcapture window, adjust the ROI dimensions to position it over the diaphragm.
4. Rotate the gantry 90 degrees. Ensure that the subject is within the filed of view and the ROI is correctly positioned over the diaphragm.
5. Rotate the gantry back to 0 degree position.
6. Check the respiratory signal trace in the Respiratory synchronization window (Figure 4.14).

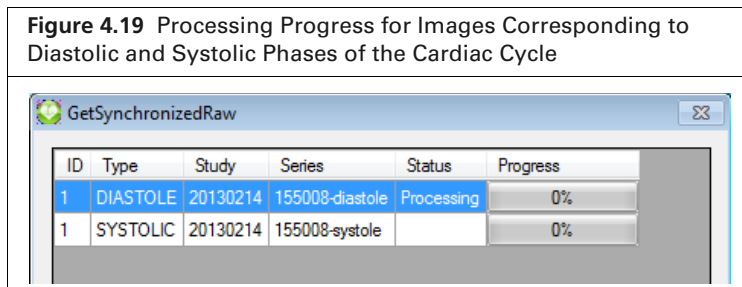Trace spikes represent diaphragm movements. Wait for the breath rate to stabilize with longer than 1000 ms ±1 sec between breaths (Figure 4.14).

7. Click the CT Scan button to begin the scan.

8. Click Yes in the confirmation message that appears (Figure 4.11).

X-rays are energized as indicated by the blinking voltage icon and the instrument status box (Figure 4.12). The Xcapture window opens, then gantry rotation and image acquisition begin.

Figure 4.15 CT Scan Confirmation Message
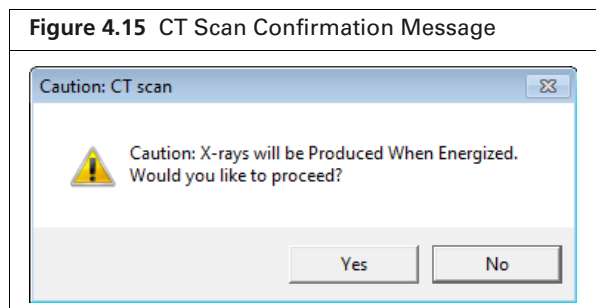
9. Review the Mix Image results in the Respiratory Synchronization window (Figure 4.16).

The goal is to achieve a trace that is as flat as possible. If necessary, adjust the Ratio or Offset (see Table 4.6).

Figure 4.16 Respiratory Synchronization Window – Example Mix Image
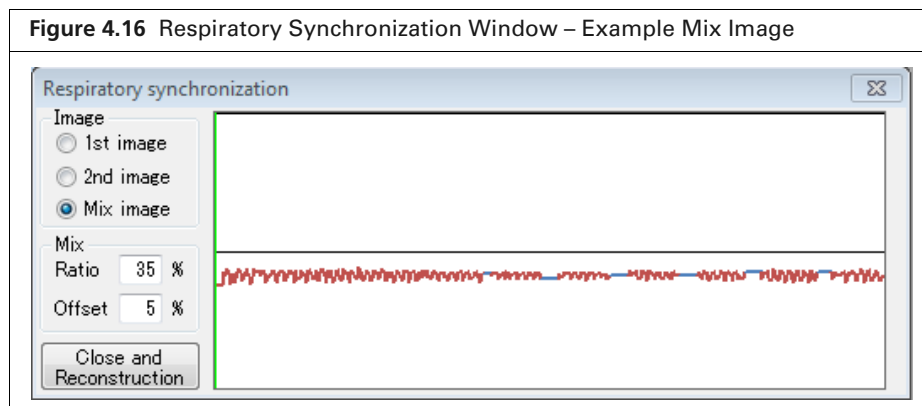
Table 4.6 Respiratory Synchronization

Item	Description
1st image	Image acquired during the first gantry rotation.
2nd image	Image acquired during the second gantry rotation.
Mix image	Image produced by combining and smoothing the first and second images.
Ratio	The width of a single breath relative to the interval between breaths.
Offset	A measure of how far to shift the breath center relative to the peak center.
Close and Reconstruction	Click to close the XCapture window and reconstruct the image.

10. Click **Close and Reconstruction** after obtaining a satisfactory Mix Image result.

The 3D reconstruction proceeds. The AutoViewer displays the 3D reconstruction (Figure 4.13). See Chapter 5 on page 35 for more information on viewing 3D reconstructions.

CT Scan With Cardiac Gating

> **!** **IMPORTANT:** Click the emergency stop ⬇ button in the control panel to abort acquisition and stop X-ray generation.

1. Click the cardiac 🐭 gating button.

2. Turn on Live Mode by clicking the 👁 button in the Control panel.

   The Xcapture window appears and shows the subject in real time (Figure 4.14).

Figure 4.17 Xcapture Window

Image data bounding box
Image data outside the bounding box are not used in the reconstruction.

Position the ROI over the apex of the heart and diaphragm

Diaphragm motion signals   Cardiac motion signals

---
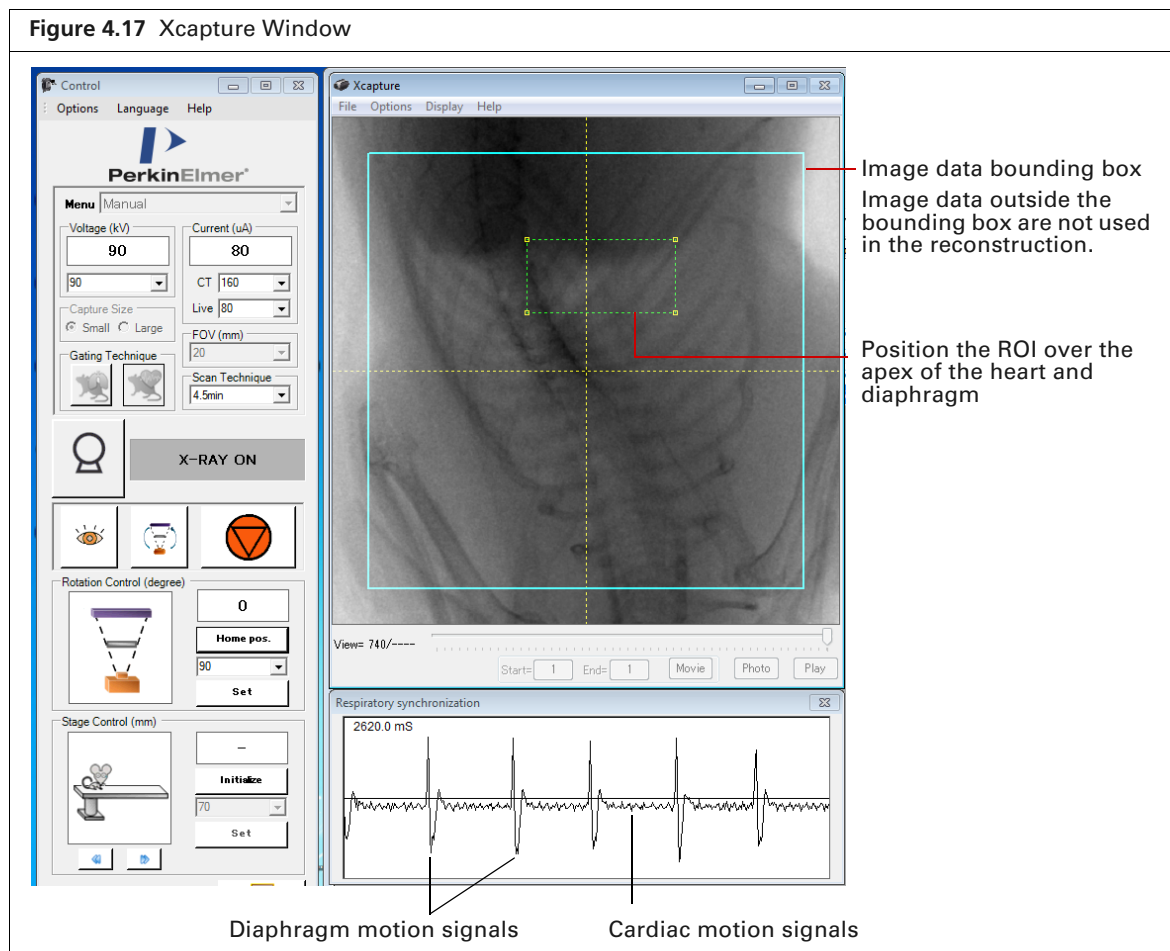
3. In the Xcapture window, adjust the ROI dimensions to position it over the apex of the heart and diaphragm.

4. Rotate the gantry 90 degrees. Ensure that the subject is within the filed of view and the ROI is correctly positioned.

5. Rotate the gantry back to 0 degree position.

6. Check the respiratory and cardiac signal trace in the Respiratory synchronization window (Figure 4.14).

   The large trace spikes represent diaphragm movement. The smaller spikes in between represent cardiac movement. Ensure that the cardiac signal is as visible as possible (Figure 4.17). It may be possible to improve the signal visibility by adjusting the ROI position.

   Wait for the breath rate to stabilize with longer than 1000 ms ±1 sec between breaths

7. Click the CT Scan button 🔄 to begin the scan.

8. Click Yes in the confirmation message that appears (Figure 4.11).

   X-rays are energized as indicated by the blinking voltage icon and the instrument status box (Figure 4.12). The Xcapture window opens, then gantry rotation and image acquisition begin.

Figure 4.18 CT Scan Confirmation Message
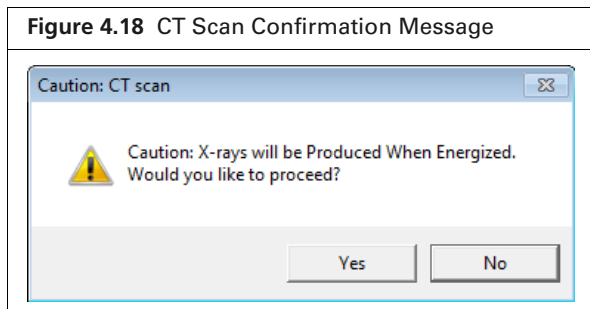
Progress indicators for image processing appear (Figure 4.19). The AutoViewer displays the 3D reconstruction (Figure 4.13) after processing is complete. See Chapter 5 on page 35 for more information on viewing 3D reconstructions.

Figure 4.19 Processing Progress for Images Corresponding to Diastolic and Systolic Phases of the Cardiac Cycle

Ring Reduction

The ring reduction algorithm helps reduce image artifacts and is turned on by default. Figure 4.20 shows example images of before and after ring reduction.

Figure 4.20 Images With Example Ring Artifacts
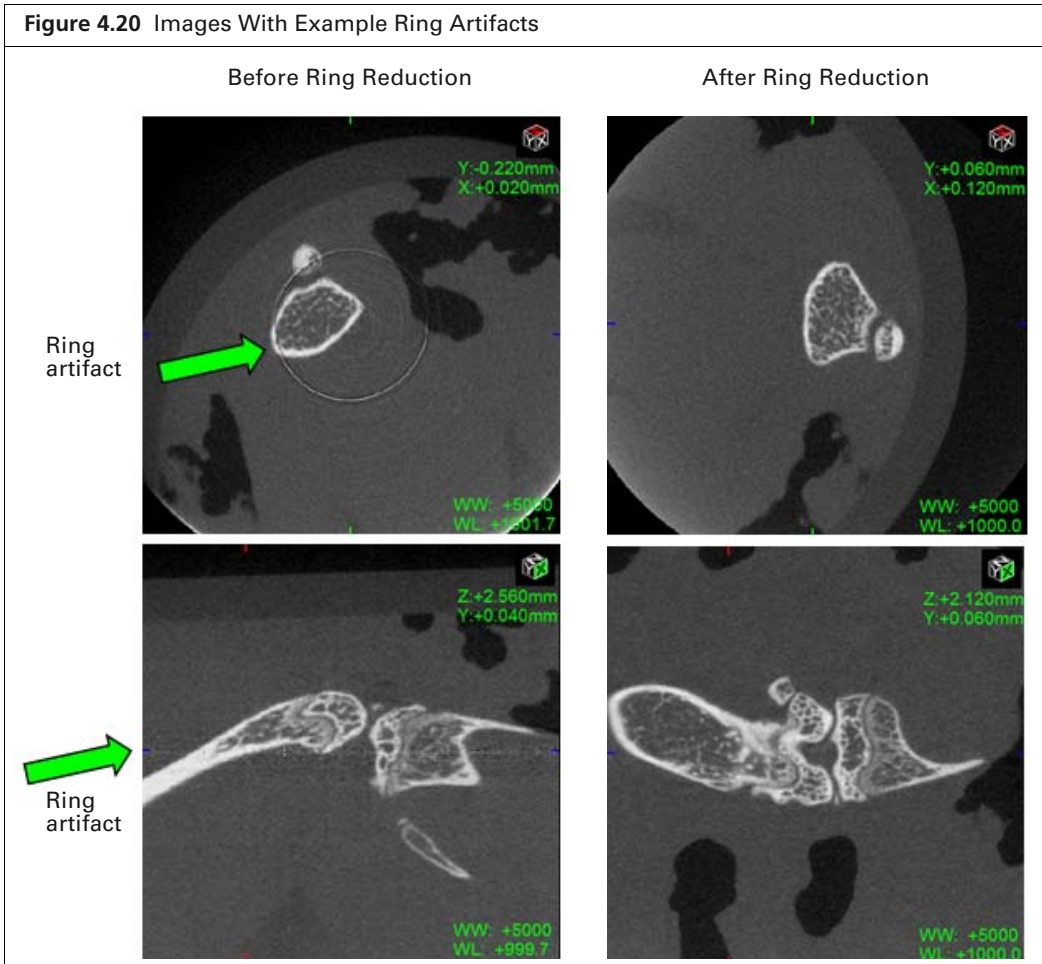
Sometimes ring reduction may result in image artifacts (Figure 4.21). The artifacts are usually minor. However, if they are unacceptable, you can turn off ring reduction and repeat the acquisition.

Figure 4.21 Example Image Artifacts Resulting From Ring Reduction
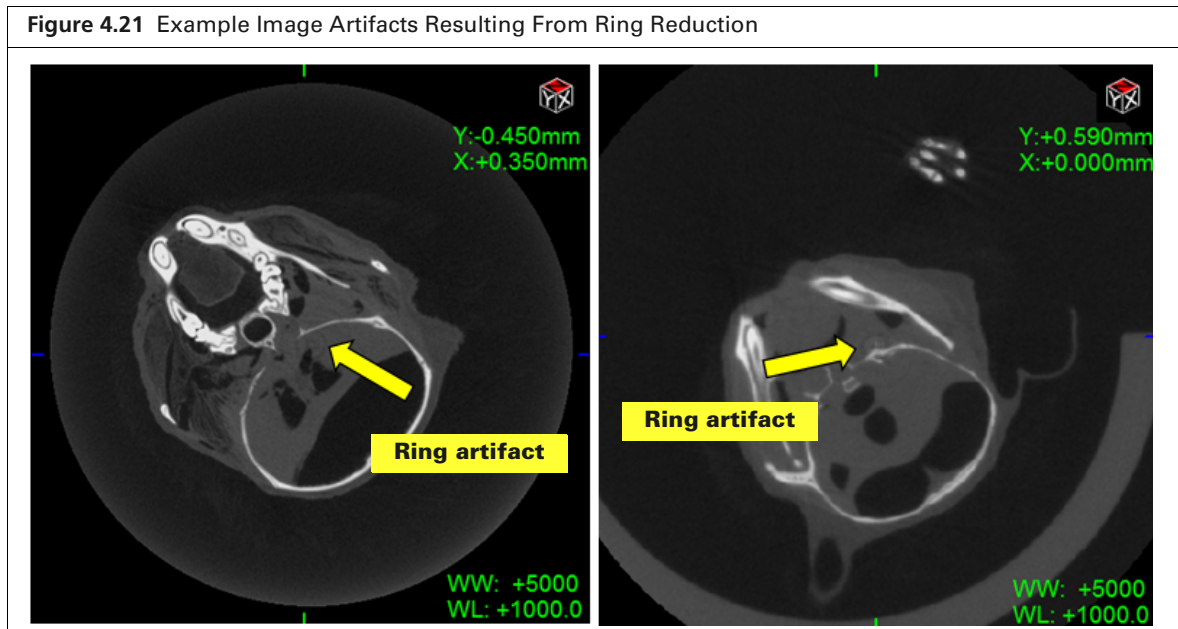
To turn off ring reduction:

1. Select **Options → Ring Reduction Settings** in the Control Panel (Figure 4.22).

2. Remove the check mark next to the scan technique that was used during acquisition and click **OK**.

Figure 4.22 Turning Off Ring Reduction
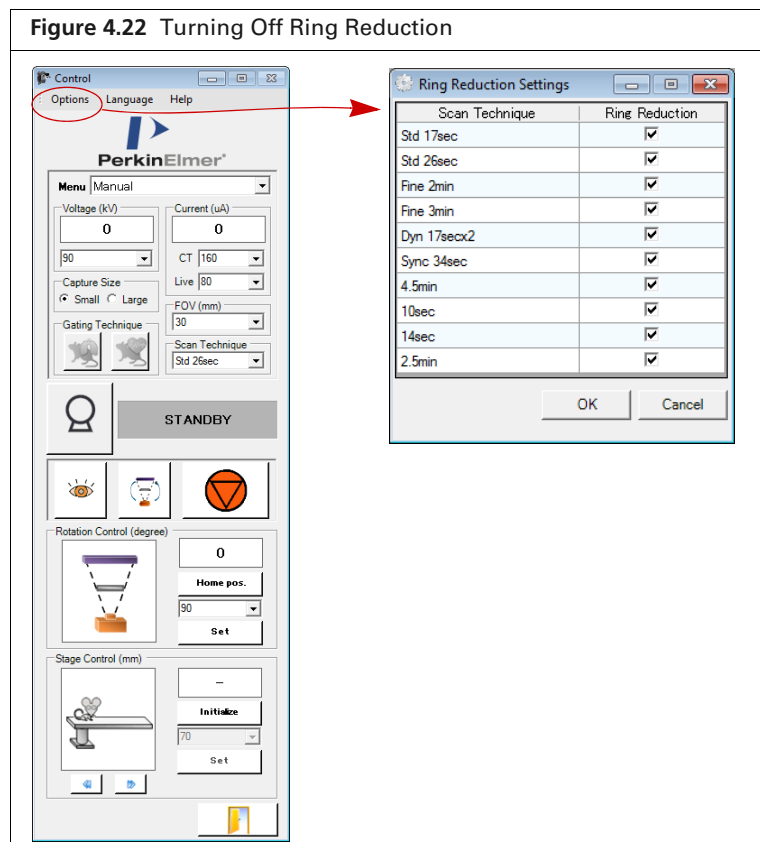
4.7 Perform Acquisition in Fluoroscopy Mode

In fluoroscopy mode, a range of user-selected frames can be viewed as a movie (scrolling through 2D images) and stored in the image database.

1. Confirm the current save location or select a new save location (see page 17 for details).
2. Place the subject in the sample chamber and set the scan conditions. See *Set the Scan Conditions,* *page 19* and *Set the Scan Conditions, page 19* for more details.
3. In the X-Capture window, move the slider to the first frame of the movie and click **Start** (Figure 4.23). Move the slider to the last frame of the movie and click **End**.
4. Click **Play** to scroll through the selected frames.
5. Click **Movie** to save the frames as a video.

   The movie is saved to the current save location.

Figure 4.23 Xcapture Window and Options for Acquisition and Viewing
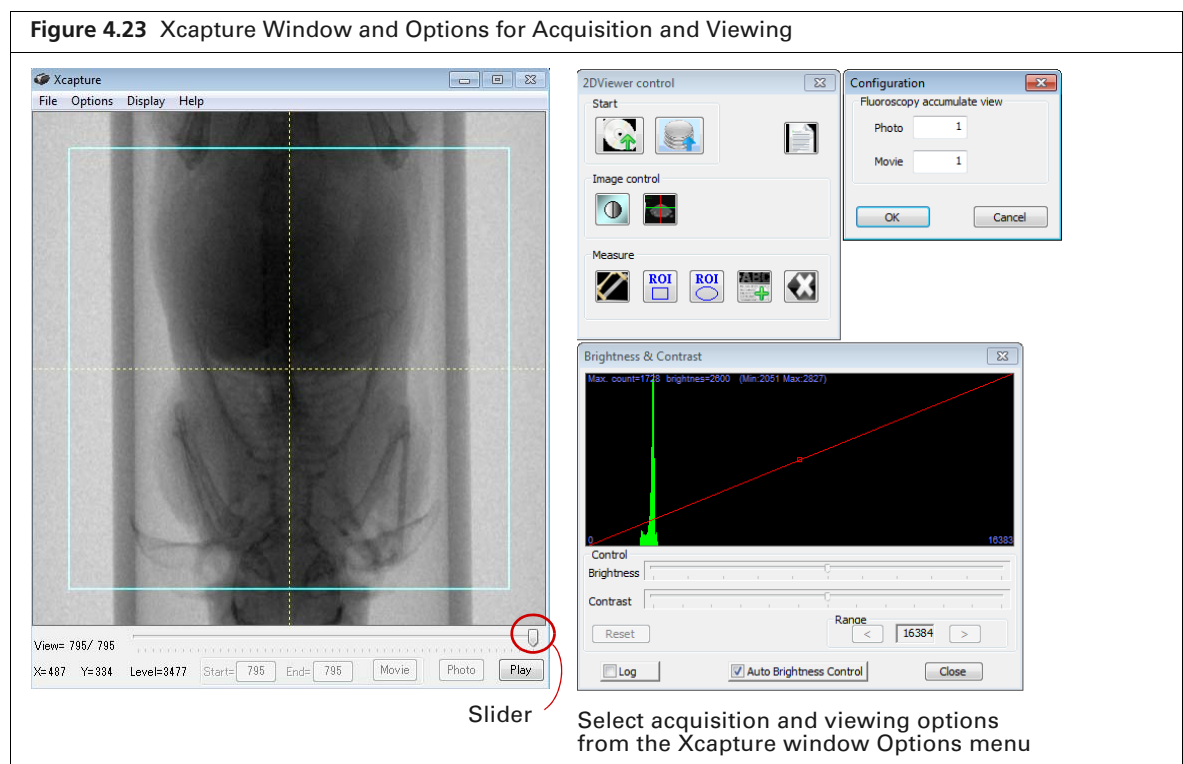
Saving an Image

A single frame in the Xcapture window can be saved as a "snapshot" and stored in the database.

1. Select a frame using the slider in the Xcapture window.
2. Click **Photo**.

   The snapshot is saved to the current save location.

5 Viewing Images

5.1 Previewing Data

The Database window provides previews of 3D reconstructions.

Table 5.1 Previewing Data in the Database Window

Select:	To Preview:
Sample	The series from all studies under the sample (Figure 5.1).
Study	All series in the study.
Series	Series

Figure 5.1 Previewing Data in the Database Window

Select the Immediate Review option to automatically display a 3D reconstruction in the AutoViewer after acquisition. See page 36 for more details on the Autoviewer.

Choose the AutoPlay option to view a playback of the slices in the 3D reconstruction.

Uncheck the AutoPlay option and move the slider to view a particular slice.

Scan conditions for the selected series

Thumbnail of the series in the selection. If there are multiple series in the selection, click one of the thumbnails to display in the preview pane above.

5.2 CT Viewers

View the data using one of the CT viewers (Table 5.2).

Table 5.2 CT Viewers

Viewer Name	Description	See Page
AutoViewer	The AutoViewer automatically appears after a scan and 3D reconstruction are completed. The Autoviewer enables you to: ■ View 2D images (slices) in the x, y, or z-planes. ■ Select other image data (.vox) for viewing. ■ Print the current AutoViewer display.	Below
Viewer	An optional plugin that displays 2D image data. Double-click a series in the Database window to open the data in the Viewer. Alternatively, select a series and click the Run Viewer toolbar button 🖥. Use this viewer to visualize the 3D anatomical planes and perform basic 2D measurements.	37
3D Viewer	An optional plugin that enables rendering of a 3D reconstruction (classifying the data).	41
SimpleViewer	Used to view image data that have been exported from a database. This viewer is used to interact with the 3D anatomical planes and make basic 2D measurements. Additional plugins (for example, the optional 3D Viewer) will not be accessible.	48

5.3 Autoviewer

> 🖊 **NOTE:** If the AutoViewer does not automatically appear after reconstruction, confirm that the Immediate Review option is selected in the Database window (Figure 5.1).

Figure 5.2 AutoViewer

Drag the crosshairs to select a slice location in the x, y, and z-axis planes. Alternatively, use the middle mouse button to scroll through the slices within a viewing plane.
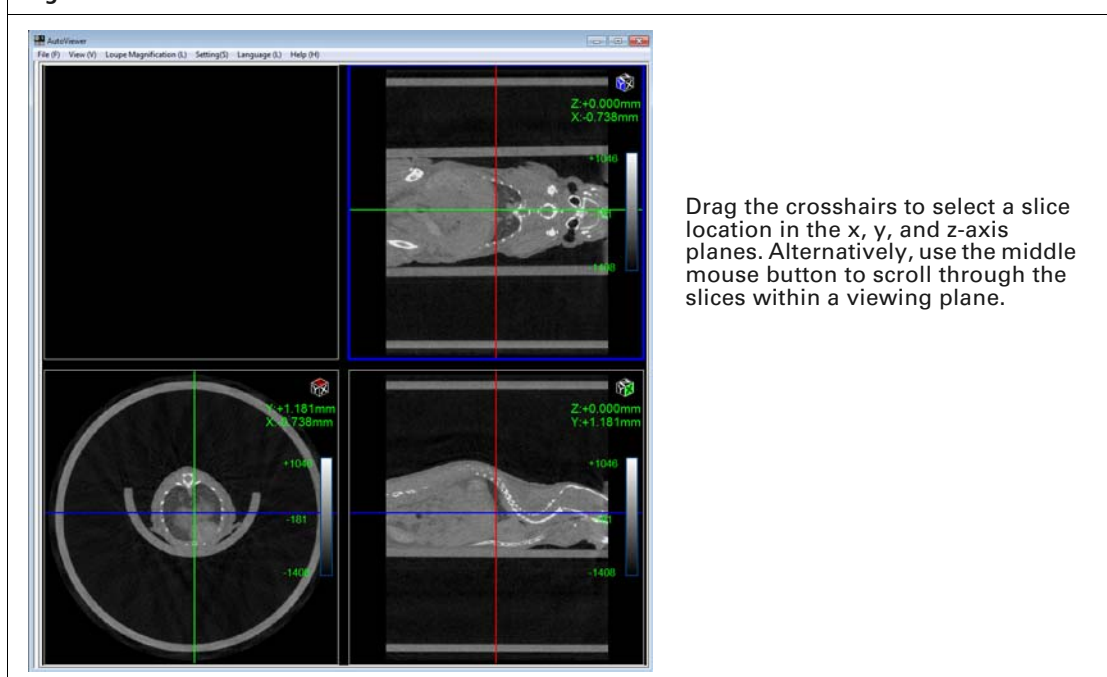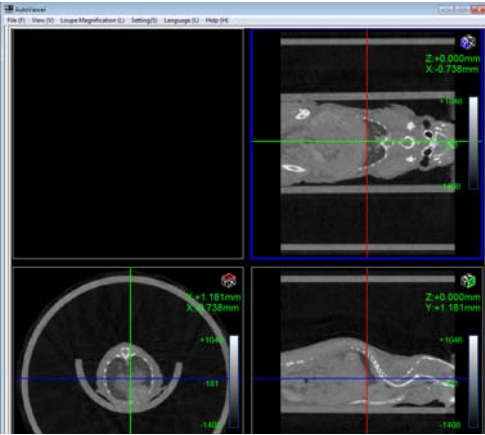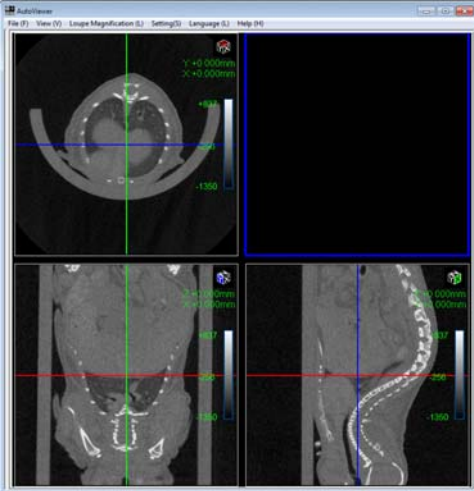
Table 5.3 AutoViewer Menu Commands

Menu Command	Description
File → Import	Opens a dialog box that enables you to select another .vox file for viewing.
File → Print	Opens a dialog box that enables you to print the current AutoViewer display.
Setting → CT number adjustment	Opens a dialog box that enables you to calibrate the Hounsfield Unit scale.
Setting → System Configuration	Choose this option to view the function key associations for quickly changing the window and level settings for image viewing.
View → Status Bar	Choose this option to show the x, y-coordinates of the mouse arrow in the AutoViewer window as well as the opacity value ("VAL").
View → Horizontal View	Displays the x and y-axis views in a vertical orientation.
View → Vertical View	Displays the x and y-axis views in a horizontal orientation.

Viewer (Optional Plugin)

The Viewer provides tools for 2D image display and analysis.

To open data in the Viewer, double-click a thumbnail or series row in the Database window. Multiple series can be open in the Viewer at the same time.

Figure 5.3 Viewer Window
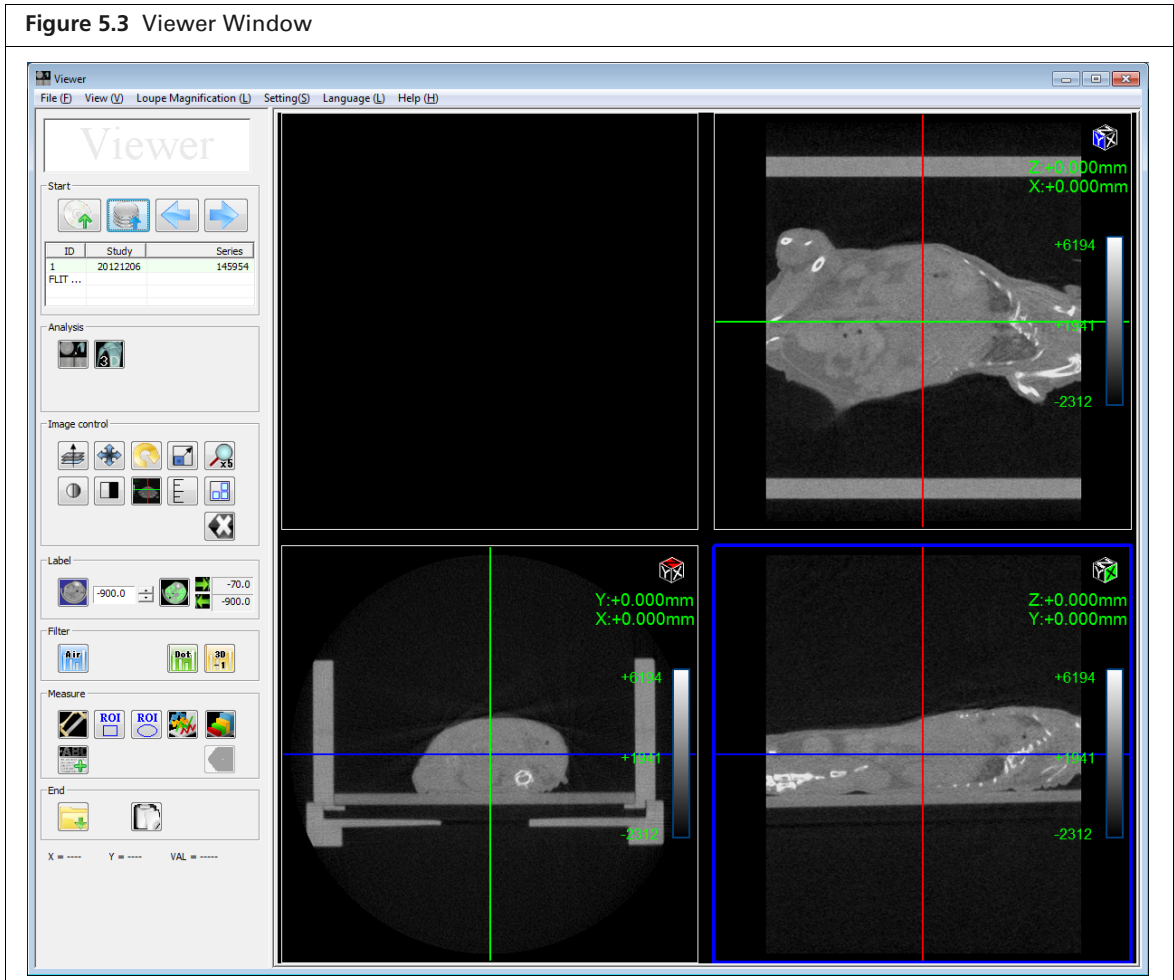
Table 5.4 Viewer Functions

Item	Function
Start	
	Click to import other CT data (*.vox) into the Viewer.
	Opens the Database window.
	Switches between images in the database. Click [→] to open the next database image in the same instance of the Viewer. Click [←] to open the previous database image in the same instance of the Viewer.
Analysis	
	Opens the SimpleViewer.
	Opens the optional 3D Viewer plugin.
Image Controls	
	Scrolls through slice images in a windowpane using the mouse wheel.

Table 5.4 Viewer Functions (continued)
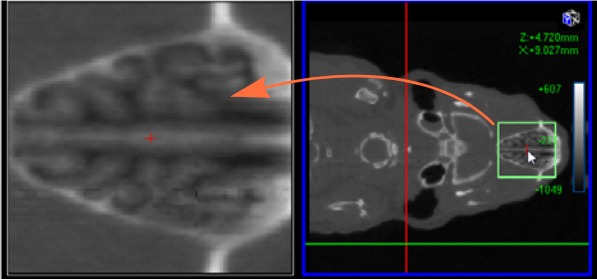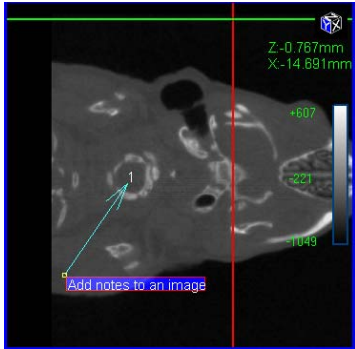
Item	Function
	Translates the slice image in the windowpane.
	Rotates the slice image (within a plane).
	Scales the slice image.
 2x, 5x, or 10x	Magnifies a selected area of the slice image. Right-click to select a different magnification (2x, 5x, or 10x). Alternatively, click the button the to change magnification. Magnified image area — Area within the bounding box is magnified.
	Changes the window and level settings to change the image display. Use the keyboard up or down arrows. Alternatively, press and hold the mouse button while you drag the mouse up or down in a windowpane.
	Reverses the gray scale color table. Click the button again to return to the default gray scale color table.
	Show or hide the x and y-axis crosshairs.
	Show or hide a scale bar in the windowpanes.
	Toggles between a horizontal or vertical slice orientation.
	Resets to the default slice view or the default display if the image has been rotated, translated, or scaled
Label	
	Masks all voxels with gray scale value below the threshold value entered in the field. Click the button to turn the mask off or on.
	Specifies a range of grayscale values for image display. Modify the range by editing the values in the fields. Click the button to turn the feature off or on.
Filter	
	When a mask is applied using the button (generates a purple mask), click the button to mask additional voxels at the edges of the mask. This can help sharpen visualization at edges such as around the animal skin.
	When a mask is applied using the button (generates a green mask), click the button to remove single pixel noise from the thresholded mask.
	Enables you to select a 3D filter that removes noise by combining pixels and displaying the average intensity of the selected pixels: ORIGINAL – Does not apply a filter. SOFT – Applies a 3 x 3 x 3 averaging filter. SMOOTH – Applies a 5 x 5 x 5 averaging filter.
Measure	

Table 5.4 Viewer Functions (continued)

Item	Function
	Click and drag to draw a measurement cursor on an image. Right-click a measurement cursor to delete the selected cursor or all cursors.
	Draws a rectangular ROI on an image. Right-click an ROI to delete the selected ROI or all ROIs.
	Draws a circular ROI on an image.
	Displays a line graph of pixel intensities along a line segment drawn on an image. 1. Select a slice view. 2. Click the ![button] button. The Line Profile window appears. 3. Press and hold the mouse button while drawing a line segment on the image. The Line Profile graph shows the pixel intensities along the line segment. 4. Drag either end of the line segment to resize or reposition the line segment. The graph is automatically updated. 5. Click the ![button] button again to turn off and close the line profile graph.
	Opens a dialog box that enables you to insert a comment on an image. To add a comment to an image: 1. Select a slice view. 2. Click the ![button] button. 3. Enter text and click **OK** in the dialog box that appears. 4. To resize or reposition the arrow, drag the arrow tip or the arrow end. To move the arrow, drag the entire arrow. 5. To delete a comment or all comments, right-click a comment and select a delete option from the shortcut menu.
End	
	Opens a Save As dialog box that enables export of the 3D reconstruction (.vox).
	Copies the image to the system clipboard.
X =	Cross hair location in the X-plane.
Y =	Cross hair loation in the Y-plane.
VAL =	Grayscale value at the crosshair location.

5.4 3D Viewer (Optional Plugin)

The 3D Viewer is an optional plugin that provides tools for rendering 3D reconstructions (classifying the image data and visualization) and viewing the 3D reconstruction from different perspectives. The volume rendering controls provide a histogram-based method for classifying the 3D reconstruction.

To open the 3D Viewer:

1. Double-click a thumbnail or series row in the Database window.
2. Click the ![button] button in the Viewer that appears,
   The Volume Rendering Control panel and 3DViewer window appears (Figure 5.4).

Figure 5.4 Volume Rendering Control Panel and 3DViewer
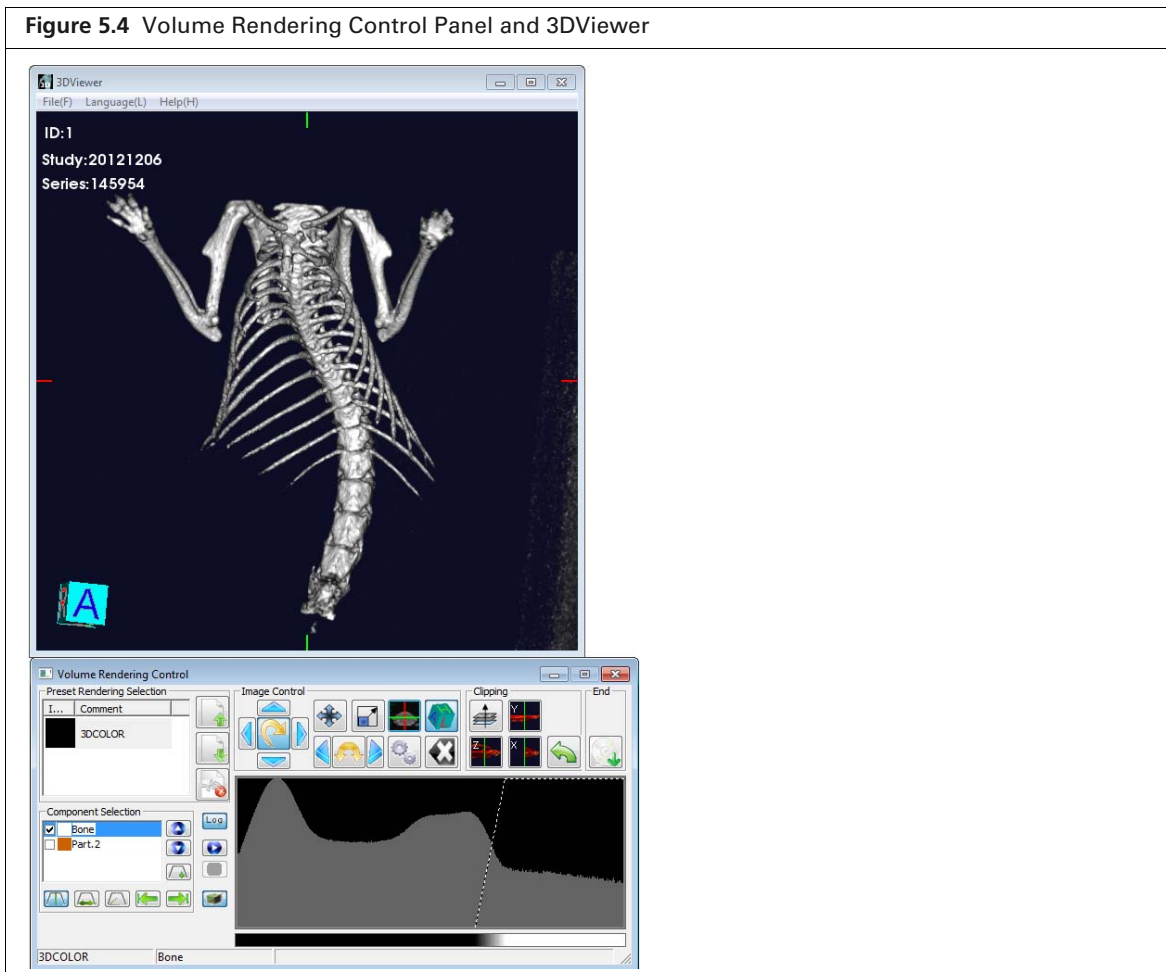
Table 5.5 Volume Rendering Controls
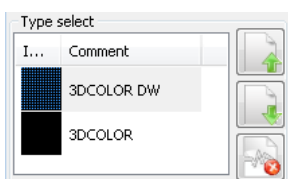
Item	Function
Present Rendering Selection 	Allows the use of custom color tables.

Table 5.5 Volume Rendering Controls (continued)
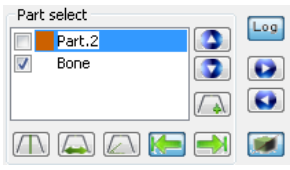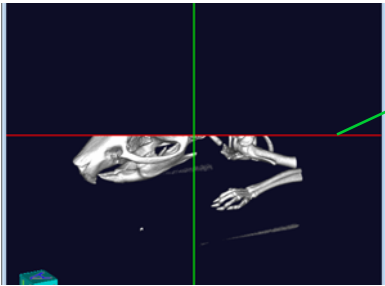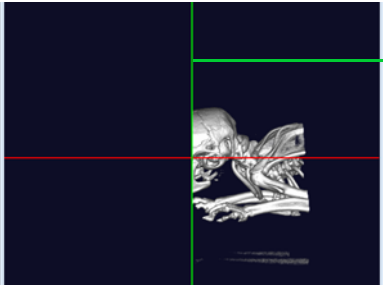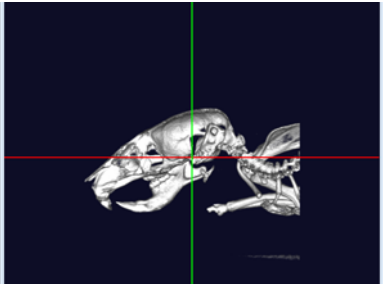
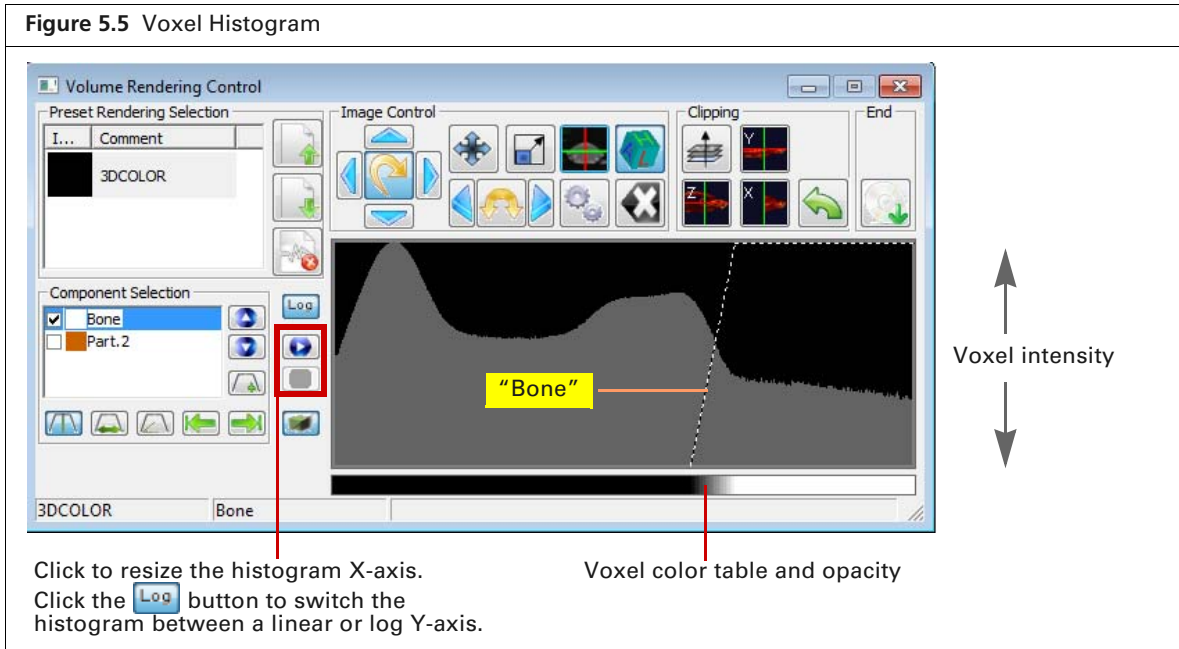| Item	Function
Component Selection *Part select* Part.2 Bone	Tools for classifying the image data. See for more details.
Image Control	Click a blue arrow to rotate the 3D reconstruction 90° about the x, y, or z-axis. To freely rotate the 3D reconstruction about the x or y-axis: 1. Click the [ ] button. 2. In the 3DViewer, press and hold the mouse button while dragging the mouse.
	Click an arrow to rotate the 3D reconstruction about the z-axis. To freely rotate about the Z-axis: 1. Click the [ ] arrow, then click an image. 2. Press and hold the mouse key while moving the mouse.
	Translates the slice image in the windowpane. Click the [ ] button to return to the default view.
	Scales the slice image.
	Show or hide the x and y-axis crosshairs.
	Show or hide the perspective indicator in the 3D Viewer.
	Opens the Tool Box with controls for setting shading parameters and the level of details in static and moving images in the optional 3D Viewer. See for more details on the Tool Box.
	Resets to the default slice view or the default display if the image has been rotated, translated, or scaled
Cut	Use these controls to "cut" the 3D reconstruction and remove voxels from the
	Hides all voxels above the y-axis crosshair. Y-axis crosshair

Table 5.5 Volume Rendering Controls (continued)

Item	Function
	Hides all voxels to the left of the x-axis crosshair.
	Hides all voxels that are above the intersection of the x and y-axes.
	Adds/removes voxels to the display after it has been cut using the , , or button. After the 3D reconstruction has been cut in the x, y, or z-plane, click the Slice button . To add or remove voxels from the display, click and hold the mouse button while dragging the mouse across the image.
	Undo button that reverses the "cuts" that were made (unhides the voxels). Performs the undo action in a step-by-step reverse order (the last cut is the first reversed, and so on).
End	
	Opens a dialog box that enables you to export the 3DViewer display to a graphic file or a movie.

Classifying Image Data Using the 3D Viewer

The 3DViewer initially displays image data with a default air-noise boundary that identifies bone. Use the volume rendering controls to create and visualize additional intensity ranges or "parts", for example, a particular type of soft tissue.

The histogram in the volume rendering controls represents the distribution of voxel intensities in the 3D reconstruction and their color-opacity values. The goal of classification is to set color and opacity values for different intensity ranges so that regions of the volume that are of interest appear opaque and unimportant regions are hidden (the voxels are transparent).

Figure 5.5 Voxel Histogram

Click to resize the histogram X-axis.

Click the [Log] button to switch the histogram between a linear or log Y-axis.

Voxel color table and opacity

To classify a part of the data:

1. Click the Add Part button [icon] (Figure 5.6).

A new partition appears in the histogram. The new part name is added to the part list.

Figure 5.6 Adding a Part to the Histogram

Part list

Partition tools

Click to add a partition   New "Part 2"

---
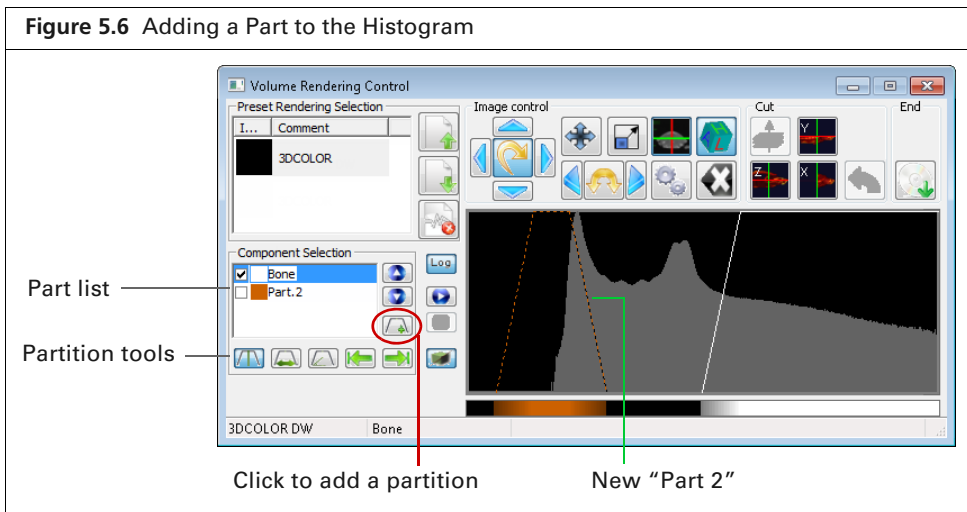
2. Modify the partition to visualize the tissue of interest using the tools partition tools (Table 5.6). To use a tool:

   a. Click the button, then click the histogram.

   b. Press and hold the mouse button while dragging the mouse left/right or up/down
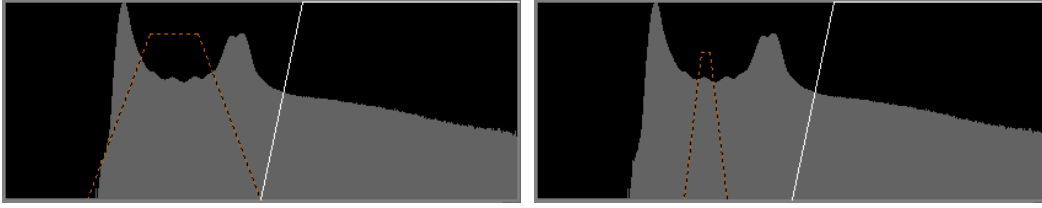
Table 5.6 Partition Tools
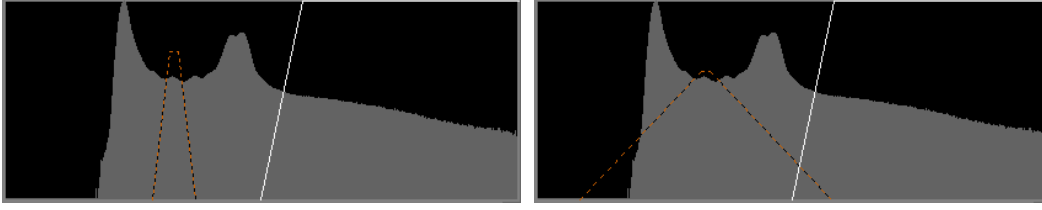
Tool	Functions
[icon]	Moves (translates) the partition up/down or left/right on the histogram.

Table 5.6 Partition Tools (continued)

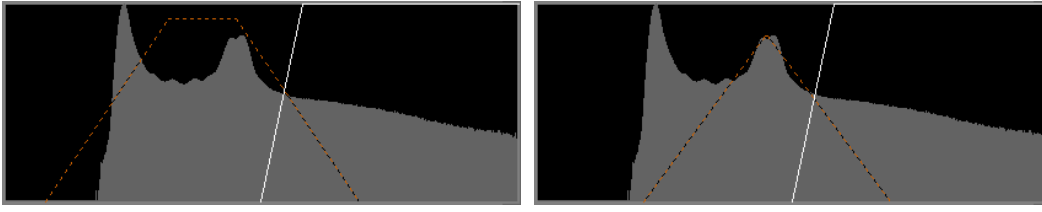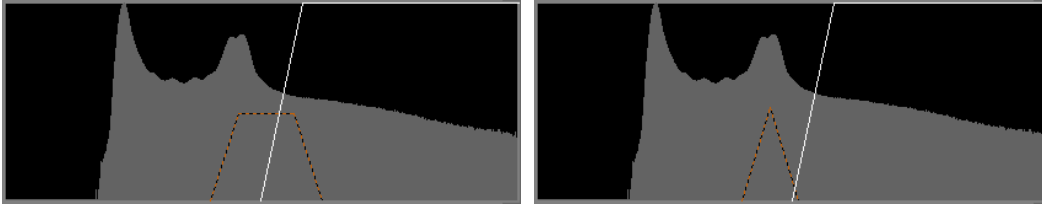| Tool	Functions
	Adjusts the angle of the left and right portions of the partition. If the top of the partition is narrow, this can result in partition forming a point (as shown). For example:
	Adjusts the partition height. Adjusts the width at the bottom only. For example:
	Adjusts the partition height and moves the left side of the partition. For example:
	Adjusts the partition height and moves the right side of the partition. For example:

Managing Classified Data

You can edit the color table and name that are assigned to different parts of the data, and change the display order of multiple, overlapping data parts. For example, if there are two data parts that overlap, the 3DViewer displays the first part in the list on top of the second part.

To change the color table for particular data:

1. Double-click the part name and select **Color** on the shortcut menu.,

2. Select a color or define a custom color in the Color Palette that appears. Click **OK**.

Figure 5.7 Selecting a Color Table
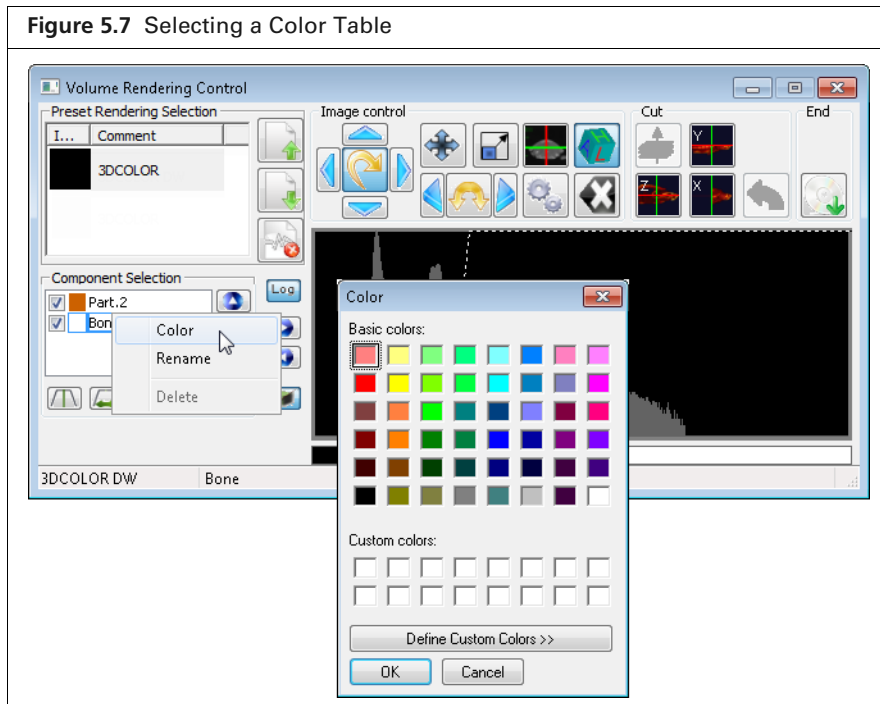
To edit a part name:

1. Double-click the part name and select **Rename** on the shortcut menu.
2. Enter a name in the dialog box that appears. Click **OK**.

To show/hide or delete parts:

1. To hide a part, remove the check mark next to the part name.
2. Put a check mark next to the name to show the part (Figure 5.8).
3. To delete a part, double-click the name and select **Delete** on the shortcut menu that appears.

Figure 5.8 Select Parts to Show or Hide

Select the parts to display in the 3DViewer
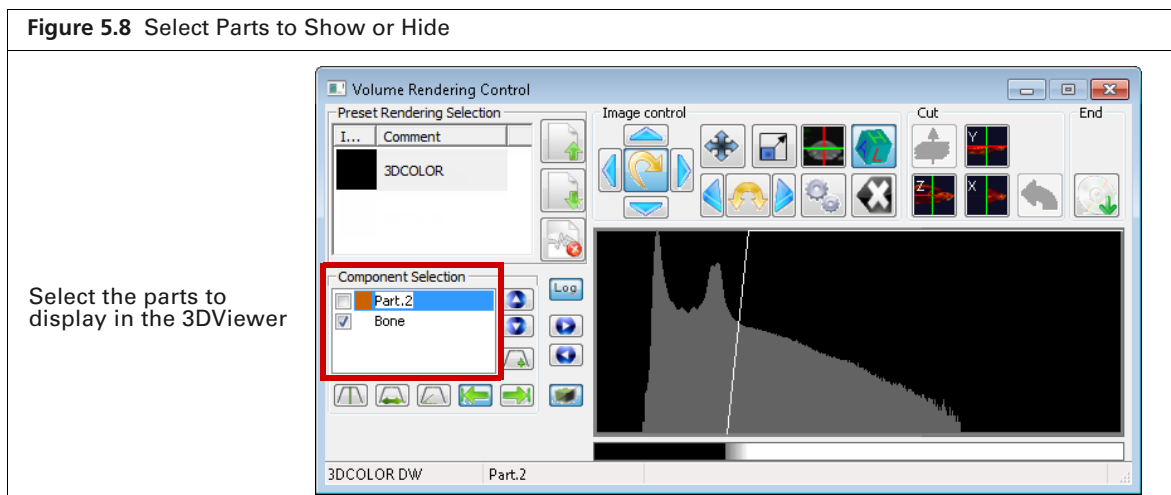
3DViewer Display Options

You can adjust the detail level and shading that is used to render the 3D reconstruction in the 3DViewer.

1. Click the button to access the tools for setting shading and detail level.
2. Adjust the settings using the sliders.

   Changing shade settings automatically updates the 3DViewer display.

Table 5.7 Tool Box Settings

Item	Description
Shader Setting	
Ambient	Controls the intensity of the 'ambient light" that is applied to the rendering. Setting range: 0.0 to 1.0, dim to bright
Diffuse	Sets the level of "focus' of the simulated light on the rendering. Setting range: 1 = most focused, resulting in the brightest rendering; 0 = the dimmest.
Specular	Affects the lens that is used for light in the rendering. Setting range: 0 to 1.0, dim to bright.
Specular Power	Affects the "lens" used for the visual rendering. Setting range: 0 to 50. The results are dependent on the 'Specular' setting.
Level of Detail	
Still Level of Detail	Sets the quality of the visual rendering that is 'still' (not moving). Highest quality = 1.0. Decreasing this number reduces the quality of the rendering and also reduces the computational burden.
Moving Level of Detail	Sets the quality of the visual rendering during rotation, translation or zooming. The highest quality is set relative to the 'still' quality. Decreasing this number will reduce the quality of the rendering during movement and can be used to speed up reformatting of the rendering.

5.5 SimpleViewer

The SimpleViewer is included with image data that has been exported from a database. It provides tools for 2D image display and analysis.

To view data in the SimpleViewer:

1. Open the folder with the exported image data.

2. Double-click the file "SimpleViewer.exe".

   The SimpleViewer appears and displays the image data. The Image Control, Label, Filter and Measure options in the SimpleViewer are identical to those in the Viewer. See Table 5.4 on page 38 for details.

Figure 5.9 SimpleViewer