

Technical Publication

**Direction 5158821-100
Revision 3**

**GE Healthcare
eXplore Locus SP Service Guide**

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Revision History

Revision History		
Effective Date	Revision	Nature of Change
March 19/05	0	Previously released under <i>eXplore Locus SP Service & Installation Guide (2407687)</i> .
March 24/06	1	Updates to FRUs, Calibration & Troubleshooting. Reflects latest software release.
Apr. 2/07	2	Changes to calibration procedures. Addition of Calibration Worksheets. Addition of electrical block diagram. Changes to Registry back up. Addition of Registry Restore procedure. Addition of Calibration Values Restore procedure. Addition of Acquisition Computer Replacement procedures (Dell to HP) Major changes to Preventive Maintenance chapter.
Sept 26/07	3	Minor changes to calibration procedures. Remove lexan collimator window if present. Live animal handling prohibition.

Before You Begin *This Guide documents how to service GE's eXplore Locus SP scanner. It is only intended for use by GE qualified personnel who have received training on its operation. The eXplore Locus SP may be not be used or serviced in a manner outside manufacturer specifications.*

This Guide is periodically updated. Please ensure you are using the most current version by checking the Common Documentation Library (CDL) at:

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Chapter 1

Introduction

Purpose: This chapter informs the reader about important precautions and safety considerations. It also provides publication conventions so that the reader can identify safety and general material that is considered important by its format.

Please become familiar with this chapter before proceeding.

Section 1.1

Important Precautions

1.1.1 Language

- WARNING**
- This service manual is available in english only.
 - If a customer's service provider requires a language other than english, it is the customer's responsibility to provide translation services.
 - Do not attempt to service the equipment unless this service manual has been consulted and is understood.
 - Failure to heed this warning may result in injury to the service provider, operator or patient from electric shock, mechanical or other hazards.

AVERTISSEMENT

- **CE MANUEL DE MAINTENANCE N'EST DISPONIBLE QU'EN ANGLAIS.**
- **SI LE TECHNICIEN DU CLIENT A BESOIN DE CE MANUEL DANS UNE AUTRE LANGUE QUE L'ANGLAIS, C'EST AU CLIENT QU'IL INCOMBE DE LE FAIRE TRADUIRE.**
- **NE PAS TENTER D'INTERVENTION SUR LES ÉQUIPEMENTS TANT QUE LE MANUEL SERVICE N'A PAS ÉTÉ CONSULTÉ ET COMPRIS.**
- **LE NON-RESPECT DE CET AVERTISSEMENT PEUT ENTRAÎNER CHEZ LE TECHNICIEN, L'OPÉRATEUR OU LE PATIENT DES BLESSURES DUES À DES DANGERS ÉLECTRIQUES, MÉCANIQUES OU AUTRES.**

WARNUNG

- DIESES KUNDENDIENST-HANDBUCH EXISTIERT NUR IN ENGLISCHER SPRACHE.
- FALLS EIN FREMDER KUNDENDIENST EINE ANDERE SPRACHE BENÖTIGT, IST ES AUFGABE DES KUNDEN FÜR EINE ENTSPRECHENDE ÜBERSETZUNG ZU SORGEN.
- VERSUCHEN SIE NICHT, DAS GERÄT ZU REPARIEREN, BEVOR DIESES KUNDENDIENST-HANDBUCH NICHT ZU RATE GEZOGEN UND VERSTANDEN WURDE.
- WIRD DIESE WARNUNG NICHT BEACHTET, SO KANN ES ZU VERLETZUNGEN DES KUNDENDIENSTTECHNIKERS, DES BEDIENERS ODER DES PATIENTEN DURCH ELEKTRISCHE SCHLÄGE, MECHANISCHE ODER SONSTIGE GEFAHREN KOMMEN.

AVISO

- ESTE MANUAL DE SERVICIO SÓLO EXISTE EN INGLÉS.
- SI ALGÚN PROVEEDOR DE SERVICIOS AJENO A GEMS SOLICITA UN IDIOMA QUE NO SEA EL INGLÉS, ES RESPONSABILIDAD DEL CLIENTE OFRECER UN SERVICIO DE TRADUCCIÓN.
- NO SE DEBERÁ DAR SERVICIO TÉCNICO AL EQUIPO, SIN HABER CONSULTADO Y COMPRENDIDO ESTE MANUAL DE SERVICIO.
- LA NO OBSERVANCIA DEL PRESENTE AVISO PUEDE DAR LUGAR A QUE EL PROVEEDOR DE SERVICIOS, EL OPERADOR O EL PACIENTE SUFRAN LESIONES PROVOCADAS POR CAUSAS ELÉCTRICAS, MECÁNICAS O DE OTRA NATURALEZA.

ATENÇÃO

- ESTE MANUAL DE ASSISTÊNCIA TÉCNICA SÓ SE ENCONTRA DISPONÍVEL EM INGLÊS.
- SE QUALQUER OUTRO SERVIÇO DE ASSISTÊNCIA TÉCNICA, QUE NÃO A GEMS, SOLICITAR ESTES MANUAIS NOUTRO IDIOMA, É DA RESPONSABILIDADE DO CLIENTE FORNECER OS SERVIÇOS DE TRADUÇÃO.
- NÃO TENHA TENTADO REPARAR O EQUIPAMENTO SEM TER CONSULTADO E COMPREENDIDO ESTE MANUAL DE ASSISTÊNCIA TÉCNICA.
- O NÃO CUMPRIMENTO DESTA AVISO PODE POR EM PERIGO A SEGURANÇA DO TÉCNICO, OPERADOR OU PACIENTE DEVIDO A CHOQUES ELÉTRICOS, MECÂNICOS OU OUTROS.

AVVERTENZA

- IL PRESENTE MANUALE DI MANUTENZIONE È DISPONIBILE SOLTANTO IN INGLESE.
- SE UN ADDETTO ALLA MANUTENZIONE ESTERNO ALLA GEMS RICHIEDE IL MANUALE IN UNA LINGUA DIVERSA, IL CLIENTE È TENUTO A PROVVEDERE DIRETTAMENTE ALLA TRADUZIONE.
- SI PROCEDA ALLA MANUTENZIONE DELL'APPARECCHIATURA SOLO DOPO AVER CONSULTATO IL PRESENTE MANUALE ED AVERNE COMPRESO IL CONTENUTO.
- NON TENERE CONTO DELLA PRESENTE AVVERTENZA POTREBBE FAR COMPIERE OPERAZIONI DA CUI DERIVINO LESIONI ALL'ADDETTO ALLA MANUTENZIONE, ALL'UTILIZZATORE ED AL PAZIENTE PER FOLGORAZIONE ELETTRICA, PER URTI MECCANICI OD ALTRI RISCHI.

警告

このサービスマニュアルには英語版しかありません。

GEMS以外でサービスを担当される業者が英語以外の言語を要求される場合、翻訳作業はその業者の責任で行うものとさせていただきます。

このサービスマニュアルを熟読し理解せずに、装置のサービスを行わないで下さい。

この警告に従わない場合、サービスを担当される方、操作員あるいは患者さんが、感電や機械的又はその他の危険により負傷する可能性があります。

注意

本维修手册仅存有英文本。

非 GEMS 公司的维修员要求非英文本的维修手册时，客户需自行负责翻译。

未详细阅读和完全了解本手册之前，不得进行维修。
忽略本注意事项会对维修员，操作员或病人造成触电，机械伤害或其他伤害。

Section 1.2 Safety & Hazard Information

1.2.1 Text and Character Representation

Different paragraph and character styles are used to indicate potential hazards. Paragraph prefixes, such as hazard, caution, danger and warning, are used to identify important safety information. Text (Hazard) styles are applied to the paragraph contents that is applicable to each specific safety statement.

EXAMPLES OF HAZARD STATEMENTS USED

CAUTION
Pinch Points
Loss of Data
Sharp Objects

Caution is used when a hazard exists that can or could cause minor injury to self or others if instructions are ignored. They include for example:

- Loss of critical patient data
- Crush or pinch points
- Sharp objects

DANGER
EXCESSIVE
VOLTAGE
CRUSH
POINT

DANGER IS USED WHEN A HAZARD EXISTS THAT WILL CAUSE SEVERE PERSONAL INJURY OR DEATH IF INSTRUCTIONS ARE IGNORED. THEY CAN INCLUDE:

- **ELECTROCUTION**
- **CRUSHING**
- **RADIATION**

WARNING
ROTATING
EQUIPMENT
BARE WIRES

WARNING IS USED WHEN A HAZARD EXISTS WHICH COULD OR CAN CAUSE SERIOUS PERSONAL INJURY OR DEATH IF INSTRUCTIONS ARE IGNORED. THEY CAN INCLUDE:

- Potential for shock
- Exposed wires
- Failure to Tag and lockout system power could allow for un-command motion.

NOTICE
Equipment
Damage
Possible

Notice is used when a hazard is present that can cause property damage but has absolutely no personal injury risk. They can include:

- Disk drive will crash
- Internal mechanical damage, such as to the x-ray tube
- Coasting the rotor through resonance.

It's important that the reader not ignore hazard statements in this document.

1.2.2 Standard Hazard Icons

Several different graphical icons (symbols) are used to make you aware of specific types of hazards that could possibly cause harm.

ELECTRICAL



LASER



MECHANICAL



HEAT



RADIATION



PINCH



Some others make you aware of specific procedures that should be followed.

AVOID STATIC ELECTRICITY



TAG AND LOCK OUT



WEAR EYE PROTECTION



1.2.3 Lockout / Tagout (LOTO)

NOTICE
Equipment must be locked out during servicing and parts replacement

All energy sources for equipment on which work will be performed and on which injury could occur due to unexpected energization, startup or release of stored energy shall be deactivated. This includes opening electrical circuits, closing and bleeding pressurized hydraulics and pneumatics, blocking springs or counterweights and discharging capacitors (for example).

1. LOTO indicates that the energy source is Locked Out and that an Authorized Employee is actively working on the machine, equipment, process, or circuit. LOTO is limited to one shift or the amount of time the person is actively working on the system. If the job is not finished and the system is not ready to be put back in use, the authorized person shall apply the Transition LOTO or the Out of Service LOTO, whichever is appropriate for the situation.
2. When applying LOTO the following six step process (which is described in detail in the training) must be followed:
 - a. Prepare for shutdown.
 - b. Shutdown machine or equipment.
 - c. Isolate machine or equipment.
 - d. Apply lockout and tagout device.
 - e. Isolate stored energy.

- f. Verify Isolation
3. Temporary removal of LOTO and re-energization of a machine or equipment may be performed when power is needed for testing or positioning. When testing you must:
 - a. Ensure the machine is operationally intact.
 - b. Notify all Authorized or Affected Employees who are working on the equipment or are in the area that the equipment is going to be tested and to move to a safe area.
 - c. Verify controls are in the "off" position.
 - d. Remove LOTO Locks and tags.
 - e. Energize and proceed with testing.
 - f. After testing, de-energize, verify system isolation, and re-apply LOTO Locks and Tags.
4. When removing Lockout/Tagout the following steps must be followed:
 - a. Communicate to all Affected Employees.
 - b. Verify the safety of the area.
 - c. Ensure the safety devices and guards are in place.
 - d. Return system functions.
 - e. Remove your lock and tag.
 - f. Communicate system re-energization.
 - g. Re-energize and test equipment.

1.2.4 Certified Electrical Contractor Statement

All electrical Installations that are preliminary to positioning of the equipment at the site prepared for the equipment shall be performed by licensed electrical contractors. In addition, electrical feeds into the Power Distribution Unit shall be performed by licensed electrical contractors. Other connections between pieces of electrical equipment, calibrations and testing shall be performed by qualified GE Medical personnel. The products involved (and the accompanying electrical installations) are highly sophisticated, and special engineering competence is required. In performing all electrical work on these products, GE will use its own specially trained field engineers. All of GE's electrical work on these products will comply with the requirements of the applicable electrical codes. The purchaser of GE equipment shall only utilize qualified personnel (i.e., GE's field engineers, personnel of third-party service companies with equivalent training, or licensed electricians) to perform electrical servicing on the equipment.

1.2.5 Important... X-Ray Protection

CAUTION



X-ray equipment if not properly used may cause injury. Accordingly, the instructions herein should be thoroughly read and understood by everyone who will use the equipment before you attempt to place this equipment in operation. The General Electric Company, Medical Systems Group, will be glad to assist and cooperate in placing this equipment in use.

Although this apparatus incorporates a high degree of protection against x-radiation other than the useful beam, no practical design of equipment can provide complete protection. Nor can any practical design compel the operator to take adequate precautions to prevent the possibility of any persons carelessly exposing themselves or others to radiation.

It is important that anyone having anything to do with x-radiation be properly trained and fully acquainted with the recommendations of the National Council on Radiation Protection and Measurements as published in NCRP Reports available from NCRP Publications, 7910 Woodmont

Avenue, Room 1016, Bethesda, Maryland 20814, and of the International Commission on Radiation Protection, and take adequate steps to protect against injury.

The equipment is sold with the understanding that the General Electric Company, Medical Systems Group, its agents, and representatives have no responsibility for injury or damage which may result from improper use of the equipment.

Various protective materials and devices are available. It is urged that such materials or devices be used.

1.2.6 Live Animal Handling Prohibition

Live animal handling for installation, testing, or service of equipment is NOT permissible. Live animal handling must remain in control of the customer.



Section 1.3 Publication Conventions

1.3.1 General Paragraph and Character Styles

Prefixes are used to highlight important non-safety related information. Paragraph prefixes (such as Purpose, Example, Comment and Note) are used to identify important but non-safety related information. Text styles are also applied to text within each paragraph modified by the specific prefix.

EXAMPLES OF PREFIXES USED FOR GENERAL INFORMATION

Purpose: Introduces and provides meaning as to the information contained within the chapter, section or subsection, such as used at the beginning this chapter for example.

Note: Conveys information that should be considered important to the reader.

Example: Used to make the reader aware that the paragraph(s) that follow are examples of information possibly stated previously.

Comment: Represents "additional" information that may or may not be relevant.

1.3.2 General Installation Safety Measures

GENERAL RULES

- Only qualified service personnel with proper training can perform installation and servicing.
- Personal Protection Equipment (PPE) is required and must be worn (safety glasses, gloves, proper shoes, etc.).
- Follow the Lockout/Tagout safety procedures.
- All fasteners must be tightened according to their torque specification.
- Dispose of the wastes from the installation properly.
- Push any one of the Emergency Stop button during an emergency.
- Report any existing or potential safety issues to GE Healthcare.
- Handling of live animals during servicing is prohibited.

1.3.3 Omissions, Errors & Suggested Improvements

Contacting GE Healthcare:

Toll Free: 1-800-526-3593

Email: PCIServiceEngineering@ge.com

Mail: GE Healthcare
1-1510 Woodcock Street
London, ON
Canada N6H 5S1

Chapter 2

Theory & Components

Section 2.1

Basic Concepts

This section describes the basic components of the x-ray assembly, and explains how they work together to produce a projection. It describes some concepts that will help you to understand the choices that are available to you when you set up and perform a scan.

2.1.1 Parts of a CT Scanner

The tube emits x-rays. The current affects the intensity of the x-ray beam, and the voltage affects the peak of the x-ray energy spectrum of the beam and the distribution of x-rays across energies. If the x-ray beam were light, the current would affect the brightness of the light, and the voltage would affect the color.

The filter controls the energy spectrum of the x-rays. The metal filters in the micro CT scanner are like the colored filters used in cameras which block certain components of white light. When the x-ray beam passes through it, the filter preferentially blocks lower-energy x-rays from the beam, allowing a more uniform beam to pass through.

The shutter controls the length of time of each exposure. The shutter in the Micro CT assembly has the same function as the shutter on a camera. In a camera, the shutter interval determines how long the film is exposed to the light, and a correct shutter interval prevents the film from becoming over-or under-exposed. In the eXplore Micro CT scanner, the shutter interval determines how long the detector is exposed to the x-ray beam in each interval of data acquisition.

The specimen is the object that is being imaged. In a film camera, light bounces off the object, comes through the aperture, and exposes the film to create an image. In a micro CT scanner, the x-rays come out of the x-ray tube, go through the object, and act on the scintillator to create a radiographic projection, which is a map of the beam attenuation properties of different areas of the object. The projection is recorded by the camera.

The detector is like the film in a camera. The eXplore Micro CT system's detector has two components, a scintillator and a CCD camera, which are connected with fiber optics. The scintillator is a thin screen of cesium iodide, which luminesces when exposed to x-rays. The camera behind it records the image that is projected onto the scintillator. The projection is saved in digital format.

2.1.2 Definitions of Basic Concepts

The following sections describe some basic concepts related to creating a projection of a specimen using x-rays.

ATTENUATION

The attenuation coefficient can be understood as the x-ray stopping power of an object.

When x-rays pass through an object, the object attenuates the beam. This means that the beam of x-rays is reduced in intensity as individual photons are absorbed or scattered by the object. The process is similar to the way that light passes through a translucent object. If light is shone through glass, most of the light comes through to the other side. Very little is absorbed or scattered by glass. If light is shone through thick fabric, only a small amount of light will come through. The rest will be reflected back, absorbed, or scattered.

Different materials have different **attenuation properties**. Bone, a dense material, has a high attenuation coefficient. X-rays will lose a great deal of intensity when they pass through bone. Fat, a low density material, has a low attenuation coefficient. X-rays will not lose much intensity when they pass through fat.

Attenuation varies directly with the atomic weight of the substance being subjected to x-rays. The atomic weight is generally related to material density.

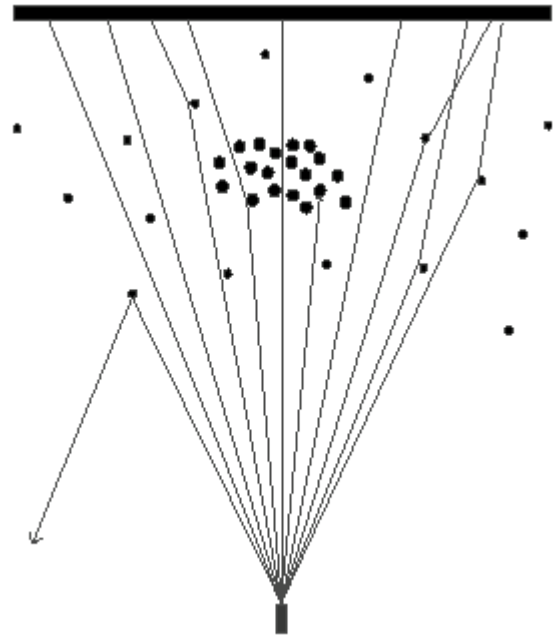
SCATTER

In the eXplore Micro CT scanner, the x-ray beam does not travel through a vacuum, devoid of any matter except the specimen. Both the air in the scanner and any water in the specimen vial are in the path of the x-ray beam.

The x-ray beam, the specimen, and the medium surrounding the specimen all consist of particles. These particles interact in a manner similar to billiard balls on a table. The x-ray particles are moving in a straight line, and the object particles fixed in position. When the x-rays go towards the object, some of the x-ray particles miss and pass through empty space, some of them hit object particles and are deflected slightly, and some of them hit object particles and bounce back. The x-ray particles that pass through are detected. The particles that hit and are deflected are also detected, but they are a form of noise that we call *scatter*.

Every micro CT projection contains a small amount of scatter noise.

Particles in the specimen and in the surrounding medium can deflect x-rays. Notice how some x-rays pass through the particles directly, some are deflected slightly, and some are deflected considerably.



2.1.3 Image Creation Basics

This section introduces you to the basic concepts behind digital imaging. Understanding these concepts will help you to make useful choices when you are setting up scans and reconstructing volumes.

It is important to understand that both the projection that is created with the GE eXplore Locus SP scanner and the reconstructed volume that is created using the eXplore Reconstruction Interface *are representations* of the structure that the x-ray beam passed through; *they are not the structure itself*. It is therefore important that you understand how both projections and reconstructions are created, so that you can choose the optimal settings.

In the GE eXplore system, the user is given a high degree of control over the signal-to-noise ratio, which affects the resolution of both the originally acquired data and the reconstructed volume. The user controls the signal-to-noise ratio by adjusting parameters like frame averaging, the total number of views taken, error correction, and the energy and intensity of the x-ray beam.

ANALOG VS. DIGITAL

One difference between a CT scanner and a conventional clinical x-ray machine is the detector. A clinical x-ray setup uses a film screen as a detector. The x-rays pass through the object, hit the film, and create a projection. Each photon that hits the film causes an effect on that film. The degree of exposure of the film is directly related to the sum of the energies of the x-rays that hit the film at that point. The projection created on film is a photo-chemical representation of the object, and the brightness of the film can have a continuous range of values.

In digital image creation, each photon hits a detector, which is divided into discrete receptor units. It is useful to think of each unit as a sort of bucket which slowly becomes filled with the photons emitted by the x-ray tube. The energy of the photons in each of these buckets is measured, and a numerical value is assigned to that energy. Because of the inability of the computer equipment to deal with a continuous range of values, the values are digitized. The projection that is created is a representation of the object as numerical data.

ADUs, CT NUMBER AND HOUNSFIELD UNITS

When the first projections are created, the values of the pixels are given in ADUs. ADU stands for Arbitrary Digital Units, and it is a scale that is particular to the eXplore Micro CT system. The same material may be given a different ADU value in a different scan, because the scale is particular to each scan and changes depending on the materials scanned and on the strength and intensity of the x-ray beam.

When a volume is first reconstructed, the ADUs are converted to CT values. The CT value is a number that represents the attenuation coefficient of a particular voxel in the reconstruction. CT values should be given in Hounsfield Units (HU), but the Hounsfield scale has specific known values for air and water, and the scale must be calibrated properly, using actual air and water (or equivalents) in a specific scan as reference points.

THE HOUNSFIELD SCALE

- Air is -1000 HU
- Water is 0 HU
- Fat is approximately -150 HU
- Compact bone is approximately 3000-4000 HU
- Ethyl alcohol is -700 HU

Until the scale is properly calibrated, the CT numbers are not given in HU.

PIXELS AND VOXELS

A **pixel** is a **picture element**. It is a single element in a two-dimensional image. Images are made up of an array of individual pixels. Each pixel has a numerical value. In MicroView, each pixel is represented by a shade of gray.

A **voxel** is a **volume element**. It is a single element in a three-dimensional image. As with pixels, each voxel has a numerical value. In MicroView, each voxel is represented by a shade of gray on the screen.

RESOLUTION

The resolution of an image refers to the smallest structure that can be discretely represented. If the resolution of an image is 25 microns (μm), then any structure smaller than 25 μm will not be distinguishable.

It is important to note that resolution and pixel/voxel size are separate. Pixel/voxel size is defined as the amount of space represented by each pixel or voxel. Resolution is limited by pixel size, but many factors will cause resolution to be larger than pixel/voxel size.

Factors that affect resolution include the pixel/voxel size, the signal-to-noise ratio, the immobility of the subject during scanning, and the x-ray tube properties.

SIGNAL-TO-NOISE RATIO (SNR)

Signal is useful information, and noise is non-useful information. In general, the SNR can be positively affected by choosing a higher binning setting, using a filter, and performing some frame averaging.

With digital imaging, considerable control is given to the user to affect the SNR.

To understand how the SNR in the micro CT system is affected by scanning parameters, let the number of x-ray photons collected by each detector pixel for an image be **n**. Signal strength in the image increases linearly with **n**, while noise in the image generally increases with the square root of **n**. Therefore, in order to increase the SNR by a factor of two, **n** must be increased by a factor of four. This can be accomplished by increasing the binning by a factor of two in each direction (e.g.,

from 2x2 to 4x4), by averaging four frames together, or by increasing the current by a factor of four, although this latter technique is generally not feasible.

BINNING

Binning is a process of adding the values of neighboring pixels together to produce a new pixel in a reduced-resolution image.

Binning is sometimes called *pixel ganging*. Using this technique improves the signal-to-noise ratio. In general, noise is scattered evenly throughout an image, but signal is concentrated in specific areas. By adding pixel values together, the effect of noise on the pixel values is reduced, and the effect of signal is increased.

In the above example, the bin mode 2x2 is chosen. In the case of a 2x2 bin, 4 pixels are ganged together and considered as a unit ("2 x 2" refers to the dimensions of the matrix).

The CT numbers of the 4 pixels opposite are 5, 2, 8, and 4. In 1x1 mode, 4 pieces of data would be stored. In the 2x2 mode shown, only one piece of data, the sum of the 4 pixels, is stored. The values of the 4 pixels are added together (not averaged) and this sum is recorded as a single piece of data. The value of the 2x2 matrix shown is 19.

5	2
8	4

FRAME AVERAGING

Frame averaging is a process whereby several frames are averaged into a single file. The effect is similar to that of a film camera when a long shutter interval is used in combination with slow film.

Frame averaging is one method for improving the SNR. In general, noise is scattered evenly throughout an image, but signal is concentrated in specific areas. By increasing the total number of photons used to create a single view, a more reliable image is created.

Section 2.2 Hardware & Software Components

2.2.1 Hardware

There are several components to the GE eXplore Locus SP. The following pages will describe the location and function of each.

EXTERNAL FEATURES

The main components of the eXplore Locus SP are the cabinet, the console, and the control boxes. **The cabinet** contains the x-ray tube and the detector, and it is where you place the specimen to be scanned.

The console is a desktop PC. Use the console to control all aspects of the scanning process and to perform reconstruction of volumes.

The control boxes allow you to monitor and manually control the current and voltage, turn the x-rays on and off, and monitor the temperature of the detector.

X-RAY ASSEMBLY

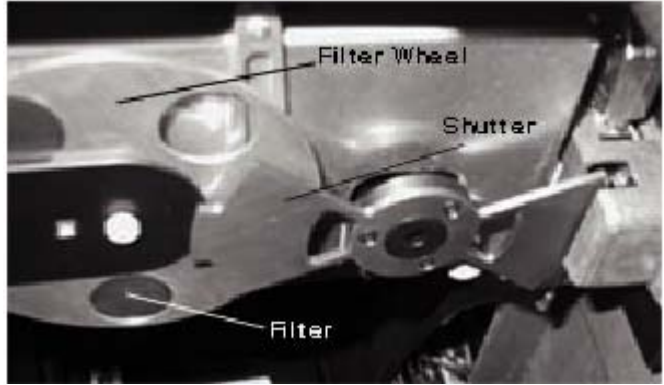
Shutter The shutter rotates at a constant rate and chops the x-ray beam into segments. Each segment of the beam creates a single projection, or frame.

Filter Wheel The filter wheel contains 4 filters and one empty hole. The filter preferentially removes the lower intensity photons from the x-ray beam so that the specimen does not act as a filter itself.

Bed The bed holds the specimen and allows it to be precisely positioned and then immobilized.

X-Ray Source The x-ray source transmits x-rays through the selected filter, towards the specimen, and onto the detector.

Detector The detector detects x-rays. It consists of the following: a scintillator, which is a screen of cesium iodide that converts the x-rays to light; an optical taper, which concentrates the light on to the camera; and a CCD camera, which records the image.



2.2.2 Software

The following describes the software components of the GE eXplore Locus SP that are needed to control the scanner, acquire projections, and reconstruct a volume.

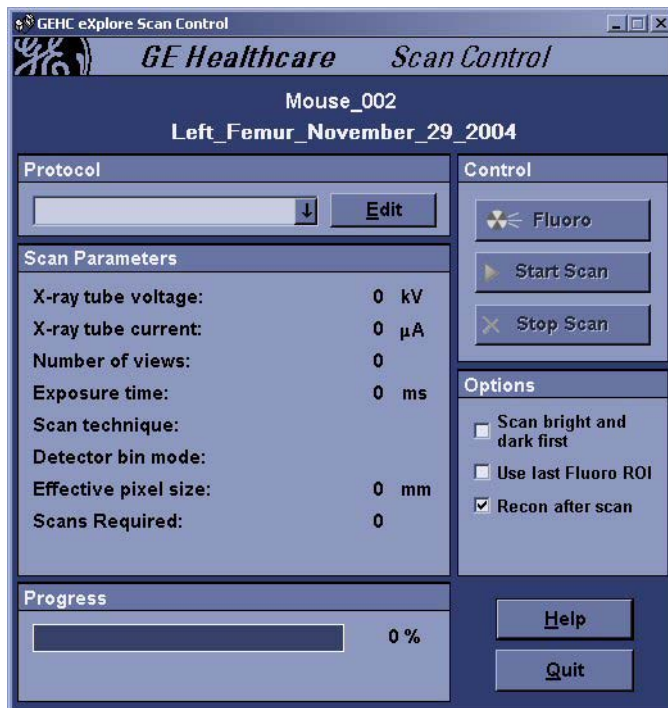
EXPLORE WARM-UP APPLICATION

The X-Ray Warm-Up application is used to control the power of the x-ray tube during the warm-up phase of a scan.



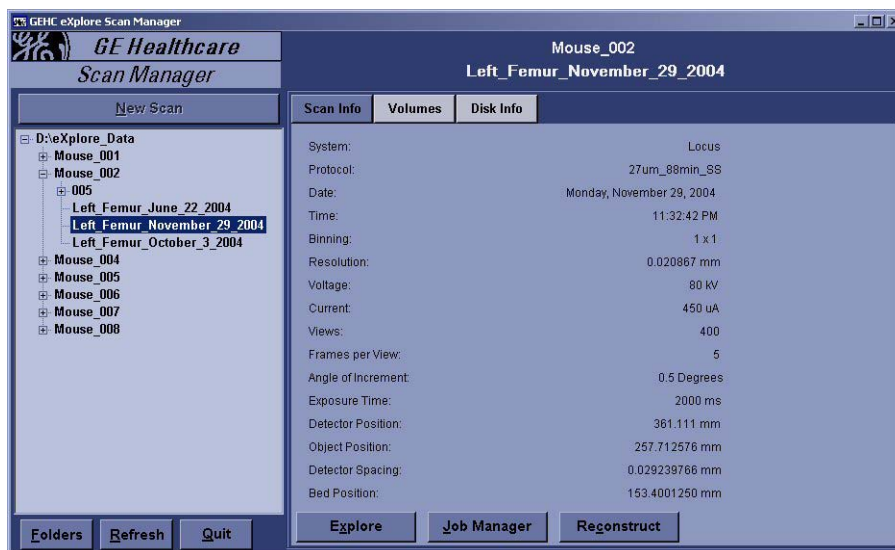
EXPLORE SCAN CONTROL

Use eXplore Scan Control to specify the scan protocol (which determines the hardware and software settings of the scan), control the scanning process, and start a scan.



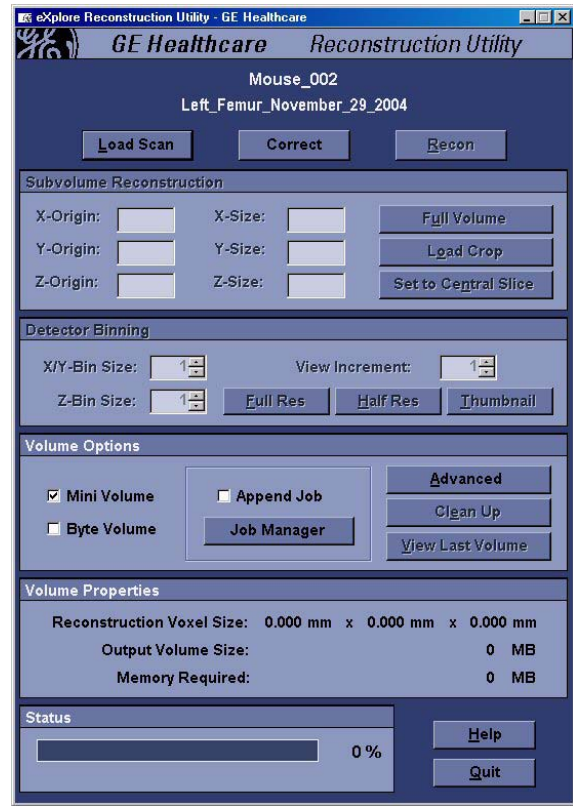
EXPLORE SCAN MANAGER

Use eXplore Scan Manager to view and manage your scan data. It is also used to launch the eXplore Reconstruction Utility when you wish to reconstruct a scan.



EXPLORE RECONSTRUCTION UTILITY

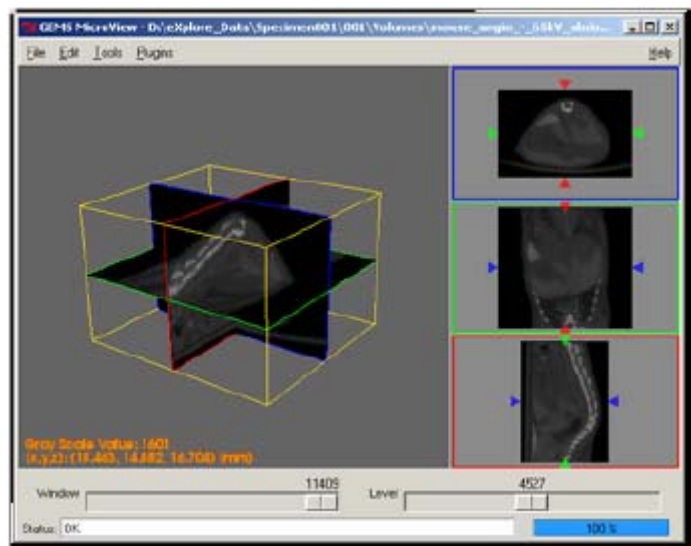
The eXplore Reconstruction Utility is used for reconstructing three-dimensional volumes from a series of two-dimensional projections. It converts all the single-projection files that are created during the scanning phase (acquisition), it corrects imperfections in the data, and it reconstructs the data into a three-dimensional volume.



MICROVIEW

MicroView is the free, open source viewing application available from GE Healthcare. MicroView can display files of single projections that were created during the acquisition phase, and it can also view the three-dimensional volume or the transverse slices that were created during the reconstruction phase.

MicroView has many features that are discussed at length in the full eXplore MicroView Software User Guide, available from GE Healthcare.



Section 2.3 Managing Files

The process of acquiring data files, correcting them, and constructing volumetric data files sometimes creates thousands of files.

The following will explain:

- where applications are kept
- what file types are created by the scanning and reconstruction processes
- strategies for minimizing the amount of hard drive space needed.

2.3.1 File Locations

When the software for the eXplore Locus SP is installed for the first time, the default directories are as follows.

eXplore Evolver is located in:

C:\Program Files\GE Medical Systems\Xplore Utilities\Evolver.exe

The eXplore Reconstruction Utility is located in:

C:\Program Files\GE Medical Systems\Xplore Utilities ReconInterface.exe

MicroView is located in:

C:\Program Files\GE Healthcare\Imaging Applications\Microview.exe

2.3.2 Files Created During the Acquisition Process

PROJECTION FILES

What: Projection files are the files created during the acquisition process. They are in VFF format, which is an image format that can be read by MicroView. Each file in the scan directory represents a single projection. If you have used projection averaging, then each file represents the number of projections that were averaged.

Scan directories can be 100 MB to 12 GB in size, depending on the protocol parameters. Before starting a scan, be sure there is enough space on the primary data drive.

Where: Each scan is given its own numbered directory. Projection files are found in the following directory: Storage Drive:\EVS_Data\SubjectName\Scan_001

BRIGHT AND DARK FIELD FILES

What: A single VFF file is created for each of the bright and dark fields. These files are used as reference points so that outlier correction can take place.

Where: The bright and dark field files are located inside the scan directory.

2.3.3 Files Created During the Reconstruction Process

CORRECTED FILES

What: When the projection files are corrected, another set of VFF files is created. There is one corrected VFF file for each original projection file.

To correct the projection files again, delete the Corrected directory and re-load the scan in the eXplore Reconstruction Utility.

Where: The Corrected directory is located inside the scan directory.

VOLUMES

What: Reconstructed volumes are the large files that are created from the several small VFF files in the Corrected directory. When reconstructed volumes are viewed in MicroView, they are represented as three-dimensional images.

Volumes can be full volumes, which are given their own name, or mini volumes. All mini volumes are saved as mini_vol.vff. If a second mini volume is created, it will overwrite the previous mini_vol.vff. Only one mini_vol.vff will exist in the Volumes directory at one time.

Full volumes are called ScanName.vff, for example.

You should have at least 10GB of free space available on the hard drive where you are storing volumes.

Where: The Volumes directory is located inside the scan directory.

2.3.4 Removing Unnecessary Scan Data

After you have corrected your data, you can free disk space by deleting the following files from the scan directory:

- acq*.vff
- bright.vff
- dark.vff
- transform

After deleting these files, you will still be able to reconstruct your scan, but you will not be able to re-correct it. DO NOT delete the files in the Corrected directory if you want to be able to reconstruct the scan again.

Chapter 3

Troubleshooting

Section 3.1

Overview

3.1.1 Avoiding Common Errors

Wrong filter: When a low density filter is used in combination with a high density specimen, beam hardening can occur. Beam hardening occurs because the beam is not filtered before it goes through a material with high attenuation.

When a high density filter is used in combination with soft tissue, the signal-to-noise ratio can be such that resolution is reduced considerably. When a dense filter is used in combination with soft tissue (tissue with low variation in the CT values of the different structures), the combination of the energetic, filtered beam with the low density, low variation tissue results in an image in which the structures are very hard to distinguish from each other.

Current too high: When the current is too high, the resulting projection appears similar to a film camera image that has been overexposed.

Current too low: When the current is too low, the resulting projection appears similar to a film camera image that was taken in low light. The resolution is very low.

Voltage too high: When the voltage is too high, the resolution can be low, and high dynamic range errors can occur. A high dynamic range error appears as a dark spot in the midst of a bright area which is not accounted for by the structure that was scanned.

Voltage too low: When the voltage is too low, a great deal of the beam is absorbed instead of penetrating the material. The resulting projection shows low resolution, high noise, and sometimes beam hardening.

Exposure time too long: When the exposure time is too long, too many photons appear on the same exposure. The result is similar to the current being too high. If you need to use a long exposure time, compensate by decreasing the current and voltage.

Exposure time too short: When the exposure time is too low, the signal-to-noise ratio is low. This in turn reduces resolution. If you need to use a short exposure time, compensate by using frame averaging to increase the number of frames used in each final projection file.

Bubbles in suspension medium: Bubbles in the suspension medium cause several problems. They can be a distracting visual element in the final images. Also, because they unevenly change the density of the suspension medium, they can compromise the usability of the final data.

Tube not warmed up: When the x-ray tube is not warmed up, it emits an x-ray beam that is uneven. The projection that is created looks similar to the projections that result when the voltage and current are low.

Section 3.2 Troubleshoot the System

3.2.1 Visualization

Visualization		
Problem	Possible Cause	Suggested Recovery/Solution
MicroView crashes	Image file > 700MB	Image file should be <700MB total.
		Use SliceView if the image is too big to downsample in MicroView.
Large 2D slice loaded but shows up blank	Video card texture memory exceeded	Adjust maximum texture size in: HKLM\software\GEMS\MicroView\MaximumTextureSize
Isosurface tool crashes		Reduce complexity of surface (memory issue) and try again.
"Unauthorized" plugin	Need to purchase license	Some plugins are not free (they are authorized by MicroView.cfg file). Contact sales to purchase a license.
Plugin (that was purchased) stopped working	Need to switch network cards	Switch network cards. If network cards were switched, requires a new MicroView.cfg file.

3.2.2 System Wide Failure

System Wide Failure		
Problem	Possible Cause	Suggested Recovery/Solution
Applications will not start		Ensure Microsoft.NET version 1.1 is installed (VB.NET app will not run without it). Check "Add/Remove Programs" in the control panel.
		Check that system is ON.
		Check the blue heat serial interface card seating.
		Check the frame grabber interface card seating.
		Frequent BSOD - run memory check.

3.2.3 Reconstruction Cluster

Cluster		
Problem	Possible Cause	Suggested Recovery/Solution
Power failed		<ol style="list-style-type: none"> 1. Turn on the Master node. 2. Wait 2 minutes. 3. Turn on the Slave nodes (wait 20 seconds between each to avoid excessive power surges). 4. Check http://192.168.12.1/gems/webmon/sysinfo.php?command=server_status
Master node does not boot		Insert eXplore cluster rescue disk. Boot from the CD.
Master node boots, but slave nodes do not		Hook up monitor and keyboard to diagnose. Ensure Ethernet cables are plugged in to the correct network port on each slave.

Cluster		
Problem	Possible Cause	Suggested Recovery/Solution
		Check that MAC address is listed in /etc/dhcpd.conf (edit with Webmin Tool).
		Ensure the gigabit network switch is powered and is showing link lights for each machine.
All recon fails		Check that all machines are booted.
		Check lamboot can run: 1. Log onto master node (username=evs) 2. Run 'lamboot-v' and make sure this is successful.
		Check authorization for each node, including master.
Every other recon works		Ensure slave nodes have booted correctly.
R:\drive on acquisition computer does not exist		Remap drive (map \\192.168.12.1\data to R:\ drive, username=evs, password=EvS8899)

3.2.4 Reconstruction

Reconstruction		
Problem	Possible Cause	Suggested Recovery/Solution
No correction (access denied)		Check authorization (run authchk.exe) 1. Check: network plugged in/active? 2. Unauthorized: request license.reg file.
		Check the amount of free disk space available.

Reconstruction		
Problem	Possible Cause	Suggested Recovery/Solution
		If correction completes but ReconInterface dies at the very end of correction: <ul style="list-style-type: none"> • problem with automatic centre-of-rotation, COR, determination code - ignore • restart ReconInterface and manually adjust COR.
ReconInterface fails "cannot find server"		Check process list for ReconServer.exe. If ReconServer.exe does not exist: <ol style="list-style-type: none"> 1. Run 'net start reconsvr' to restart (or GEMS control applet to restart). 2. Check system service is setup to run in automatic mode.
ReconInterface loads properly, but network neighbourhood is empty		Ensure Reconsrvr.exe is running (see above).
ReconInterface loads properly, but cluster is not present in recon server list		Check network connection.
		Check cluster is booted (check webpage http://192.168.12.1)
		Check ReconServer.pyc is running on cluster.
		Check network broadcast is set correctly in regs on console: <ul style="list-style-type: none"> • HKLM\Software\GEMS\ReconServer\BroadcastAddr0
ReconInterface starts, hangs, then fails		Check authorization: <ul style="list-style-type: none"> • C:\Program Files\GE Medical Systems\Explore Utilities\Logs\REconServer.log on win32 • /var/log/reconsvr.log on cluster (via Web Tool) • Unauthorized: request license.reg/ license.dat file.

Reconstruction		
Problem	Possible Cause	Suggested Recovery/Solution
		<p>Check log files for 'negative offset detected' error:</p> <ul style="list-style-type: none"> adjust centre of rotation value and try again set 'filter by convolution' method if all else fails, use DOS-box recon.
ReconInterface with a cluster fails every other reconstruction		<p>Check slave nodes on cluster (likely not properly booted)</p> <ul style="list-style-type: none"> check http://192.168.12.1 -> queue manager
ReconInterface fails in some other way		<p>Check log files:</p> <ul style="list-style-type: none"> C:\Program Files\GE Medical Systems\eXplore Utilities\Logs\ReconServer.log with win32 /var/log/reconsvr.log on cluster (via Web Tool)
ReconInterface daemon non-responsive		<ol style="list-style-type: none"> Stop ReconInterface. Change port number with control panel applet. Restart daemon.
DOS box ReconInterface - image has a discontinuity half-way through image		<p>Known problem. Image does not auto-calibrate between chunked sections. Do not use, or determine water/air/bone values independently.</p>
ReconInterface works but pixel size is wrong		<p>Check protocol file.</p>
		<p>Check calibration settings.</p>
Wisps	Incorrect centre of rotation	<p>Change the centre of rotation (see Chapter 7 - Calibration)</p>
	Beam hardening	<p>Due to dense object filtering the beam.</p> <ul style="list-style-type: none"> Use a harder filter. Use a higher voltage setting.
Blurry Images	Movement during scanning	<p>Movement can be caused by machine vibration, specimen movement inside a vial, or frozen object thawing.</p>
	Poor signal-to-noise ratio	<p>Ensure correct filtering is used. Frame averaging can improve SNR if using low intensity beam on soft tissue. Adjust pixel binning.</p>

Reconstruction		
Problem	Possible Cause	Suggested Recovery/Solution
Rings	Failure to correct acquisition data for long-term trends	Bright & dark field files are used to correct long-term trends.
Bright spots around objects with high attenuation	Failure to use the correction option High Dynamic Range when scanning high-density or high-attenuation materials	Select High Dynamic Range when correcting acquisition data from scan containing high attenuation coefficient.
Reconstruction different shape from original	Width truncation	Ensure Fluoro region of interest is wide enough to encompass object (ROI should encompass vial walls).
	Incorrect centre of rotation	Adjust centre of rotation (see Chapter 7 - Calibration).

3.2.5 Scan Manager

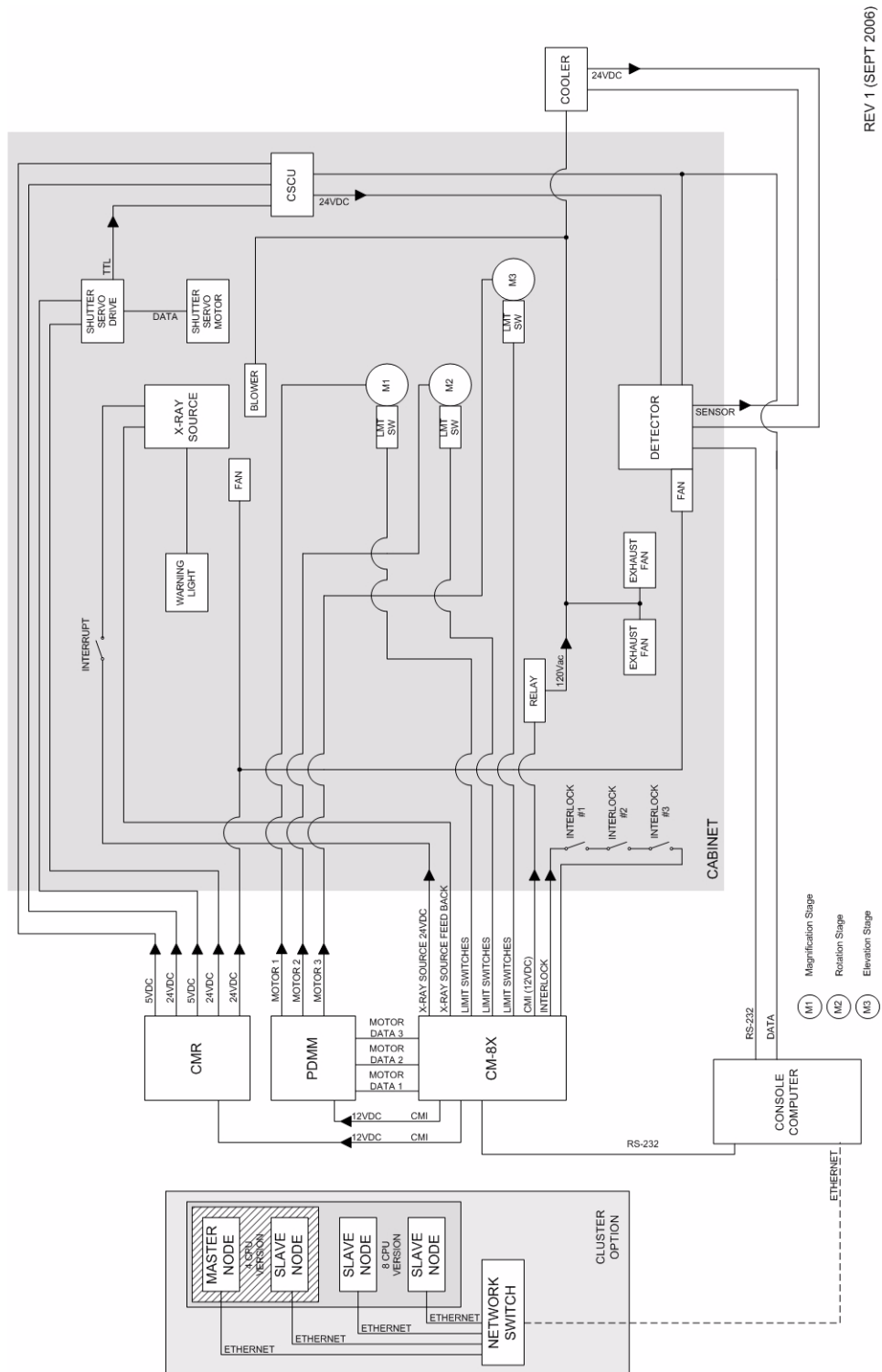
Scan Manager		
Problem	Possible Cause	Suggested Recovery/Solution
Scan Control problem		Check protocol files (most problems will occur in the protocol files). <ul style="list-style-type: none"> Ensure tabs exist in protocol, not spaces.
		Protocol files are missing in drop-down menu: <ul style="list-style-type: none"> Check protocols directory exists and has *.protocol files: C:\Program Files\GE Medical Systems\eXplore Utilities\Protocols
Scan Manager problem		Check for sufficient data storage on D:\ or R:\ drive.

3.2.6 Fluoroscopy

Fluoroscopy		
Problem	Possible Cause	Suggested Recovery/Solution
No Fluoro		Are Fluoro Window/Level slide bars correctly set? If not, adjust slide bars or check filter.
		Are X-Rays on? If not, turn on X-Ray Source. If X-Ray Source can not be turned on, check whether eXplore Locus SP has mis-configured jumpers. If jumpers are not mis-configured, check X-Ray tube operation.
		Is shutter working? Open the lid and observe if there is a flashing red LED. If not, check for 'ShutterServer.exe in the process list. If ShutterServer.exe does not exist, restart shutter ('net stop shtrsvr', 'net start shtsvr'). If shutter is still not working, restart the scanner and restart the computer.
		Is computer hung? Is computer is hung, reboot computer.
	Possible hardware connection problem	Check frame-grabber cable.
	Possible protocol mismatch to hardware	Check for mismatch (i.e. edge trigger protocols vs. internal trigger protocols).
		Error message 'cannot connect to camera': <ul style="list-style-type: none"> • Check whether the scanner is powered. • Check power supply (fuses). • Check serial connection between PC and detector.

3.2.7 eXplore Locus SP Electrical Block Diagram

The following provides an electrical block diagram that may be used when troubleshooting the eXplore Locus SP.



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Chapter 4

Functional Checks

Section 4.1 Overview

4.1.1 Purpose

This Chapter describes how to test the functionality of certain equipment on the eXplore Locus SP. After troubleshooting a problem, a functional check may be required to determine whether a piece of equipment is faulty. Should a functional check indicate the piece of equipment is defective, see **Chapter 6 - Field Replaceable Units**.

Section 4.2 Perform Functional Checks

4.2.1 X-Ray Source

The functionality of the X-Ray Source is checked through the diagnosis **X-Ray and Motor Controller** software.

4. Ensure all interlocks and the interrupt are closed.
5. Access the **X-Ray and Motor Controller** software and adjust the tube voltage and tube current to the following settings:
kV: 70
μA: 20
6. Click on the *Turn X-Ray On* button.

Note: A buzz will sound for approximately 8 seconds, X-Ray indicator lights will be illuminated. The **X-Ray and Motor Controller** software also reports that the x-ray tube is turned on and displays approximately 70kVp and 20μA under Power Status.
The CM LED will display 70kVp and 20μA.

4.2.2 Detector

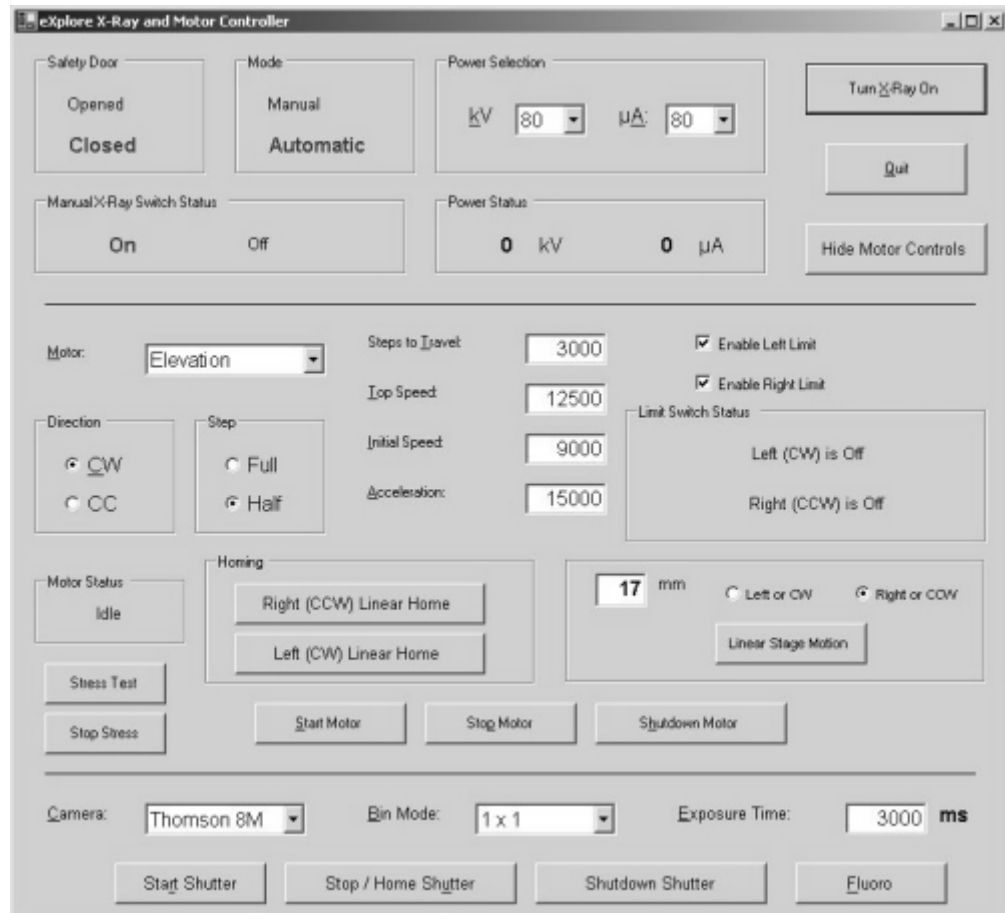
1. Mount the bebe grid on the detector using small white nylon screws and washers.
2. Ensure the filter wheel setting is set to 4.
3. Install the Interlock Jumper (only required if the outer cabinet is removed).
4. Warm-up the X-Ray Source using the **System Warm-Up** application as follows:
 - double-click the Warm-Up icon (located beside the clock at the bottom of the screen)

- right-click the icon and select *System Idle* from the list of options
- right-click the icon again and select the *<=10 Minutes to Scan* option
- once the cycle has finished (approximately 14 minutes), right-click on the icon again and select **Exit**.

The **System Warm-Up** application can be re-initialized by double-clicking on WarmupApp.exe in C:\Program Files\GE Medical Systems\Explore Utilities\

5. Access the **X-Ray and Motor Controller** software.
6. Ensure the fields below are set to the following settings:

Camera: Thomson 8M
Bin Mode: 1 x 1
Exposure Time: 3000 ms
kV: 80
µA: 80



7. Ensure the X-Ray switch on the unit is ON and the red *Reset* button is not lit.
8. Click on the *Start Shutter* button on the **X-Ray and Motor Controller** screen.
9. Click on the *Turn X-Ray On* button.
10. Click on the **Fluoro** button, then:
 - select *OK* when the warning pop-up appears.

- select *OK* when the text concerning placement of the specimen appears.
- 11. Press **w** to bring up the Window and Level controls in **Fluoro**.
- 12. Adjust Window and Level in **Fluoro** to obtain the centring bebe projection.
The Window and Level values control the image's contrast and brightness. These values are adjusted using either the slide bars at the bottom of the **MicroView** window, or by right-clicking on either slide bar to display a pop-up window where you enter a specific value.
- 13. Adjust the Level and Window slide bars until the babes disappear into the extreme levels.

4.2.3 Limit Switch

Most limit switches can be checked through the the diagnostic **X-Ray and Motor Controller** software.

1. Verify that nothing is blocking the sensor of the limit switch.
2. Access the **X-Ray and Motor Controller** software and verify that sensor indicates it is clear.
3. Trip the sensor and verify that software is registering the trigger.

4.2.4 Comair Rotron Fan FS12B3 (Detector Fan)

1. Visually inspect that fan is running at correct speed.
2. Listen to verify that fan is not making extra noise (grinding or clicking).
If fan is not running:
3. Disconnect the fan and measure the pins on the input and verify a reading of 12VDC.

4.2.5 Comair Fan 2.0625 (Fan under X-ray Source)

1. Visually inspect that fan is running at correct speed.
2. Listen to verify that fan is not making extra noise (grinding or clicking).
If fan is not running:
3. Disconnect the fan and measure the voltage on the terminal block and verify a reading of 12VDC.

4.2.6 Shutter Drive Motor

1. Verify that shutter disk is clear of obstacles.
2. Access the **X-Ray and Motor Controller** software and press the **Start Shutter** button.
3. Verify that the shutter initializes.
4. Set speed of shutter and visually verify speed.
If unable to initialize:
 - a. Verify connections on Micro Mo drive unit.
 - b. Verify voltage on connections on Micro Mo unit.
 - c. Verify connection to CSCU.
 - d. Verify connection on Motor (inside X-Ray Source Shielded Housing).

4.2.7 X-Ray Indicator Light, Small

1. Visually inspect the X-Ray Indicator Light.
2. Verify that X-Ray Source is working.

4.2.8 Comair Blower

A Comair Blower is used to cool the X-ray tube. When the main cabinet is powered, the center part of the Blower spins.

4.2.9 Ventilator Hose (PVC, 1"IDX1.21"OD)

A PVC hose provides a ventilating path from the Comair Blower to the x-ray tube. Any damage to the hose can be found through a visual check.

4.2.10 Interlock, D4DS Series

There are 3 interlock switches installed inside the main cabinet. When the system is first powered on, or when the enclosure door has been opened, the red Reset button on CM-8X control box is illuminated.

After pressing the Reset button the Reset button is no longer illuminated and the **X-Ray and Motor Controller** software should indicate that the Safety Door is Closed (i.e. the sliding door and both ends of the main cabinet are properly closed).

If the Safety Door on the **X-Ray and Motor Controller** indicates Opened, at least one of the three interlock switches is not closed properly. The x-ray tube only can be operated if the Safety Door indicates Closed and the *Reset* button is not illuminated.

IF SAFETY DOOR READS "OPENED"

An electronic wiring check of the interlock can be obtained using a multi-meter. When all three interlocks are closed, pin 10 and pin 11 of connector 2 on the electronic flange should be a short circuit. If the outer cabinet is removed from the system and all three interlocks are closed, pin 1 and pin 2 of the disconnect of interlock cable on the enclosure should be short circuit.

4.2.11 Interrupt Switch, 4600B

This switch is mounted on the sliding door and is needed to control the generation of an x-ray. Only when the sliding door is closed properly is the x-ray tube able to generate x-ray.

ELECTRONIC WIRING CHECK

An electronic wiring check of the interlock can be obtained using a multi-meter. When the enclosure is on the system and the door is closed properly, pin 11 and pin 13 of connector 1 on the electronic flange should be a short circuit. When the outer cabinet is removed from the system and the door is closed properly, then pin 3 and pin 4 of the disconnect of interlock cable should be a short circuit.

Chapter 5

Software Set Up / Back Up

Section 5.1

Computer Hard Drive

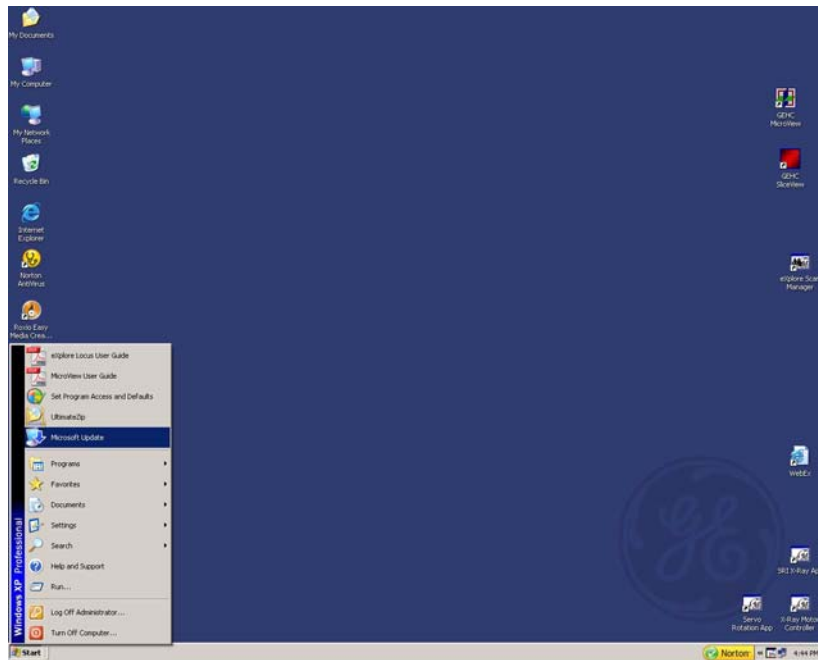
5.1.1 Ghost an Image on C Drive & Update Software

1. Enter the computer BIOS by pressing **F2** at initial computer boot up.
 - a. Set boot sequence as follows: DVD, floppy, Hard drive
 - b. Insert the ghost image DVD, ensuring correct version for the machine before exiting BIOS
 - c. Exit BIOS
 - d. Click on any key to boot from DVD (Wait for "Boot from DVD" prompt).
2. Ghost the screen as follows:
 - a. Hit **OK** for first 2 prompts
 - b. Continue with marking drives > **OK**
 - c. Local > disk > from image
 - d. Look in drives and change to DVD
 - e. Open (Alt+O)
 - f. Select the first drive (default) small one
 - g. Destination? Click **OK**
 - h. Proceed? Click **YES**
 - i. The message Clone completed successfully appears. Choose to continue
 - j. Quit
 - k. Click on **YES**.
3. Remove the ghost image DVD from the computer and restart.

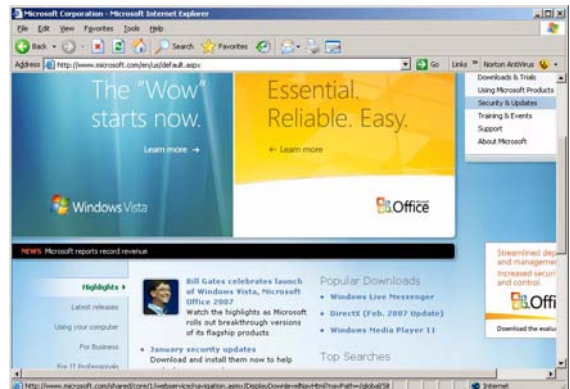
Note: *The next 2 steps require the system to be connected to the Internet.*

4. Perform Windows Update, as described below.

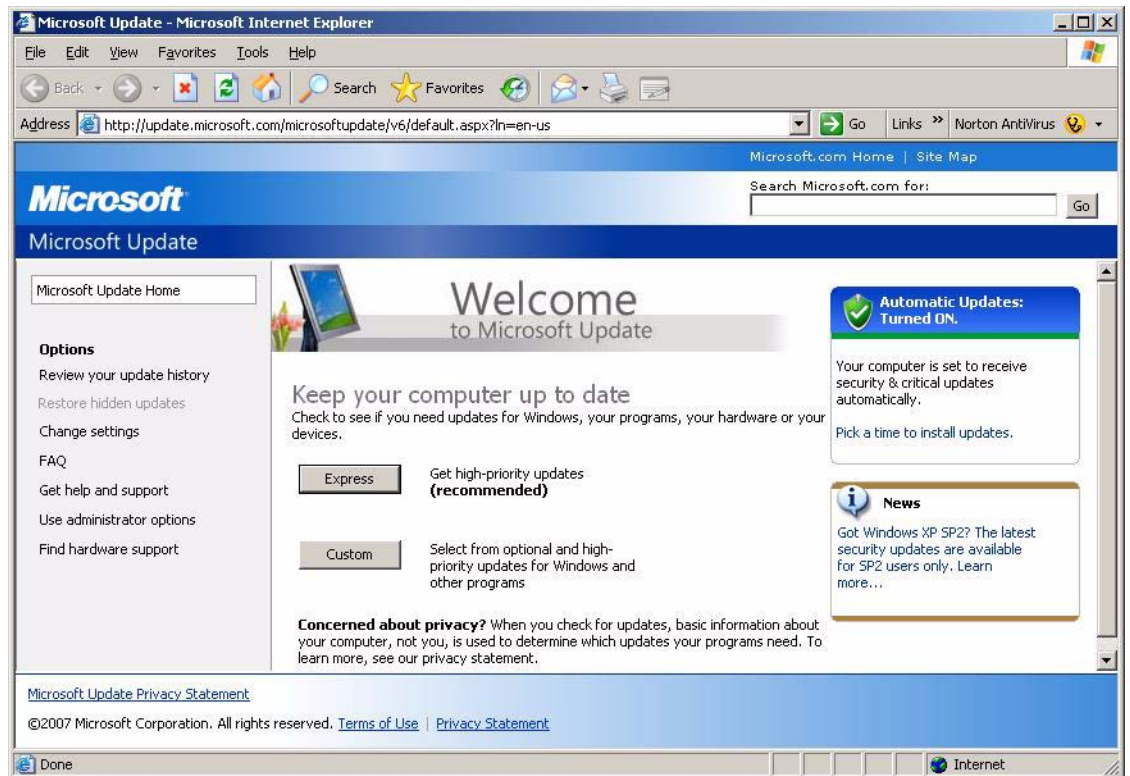
- a. Click on Start -> **Microsoft Update**



Alternatively, if Microsoft Update is not on the Start menu, go to www.microsoft.com, click on 'Security & Updates'. Then click on **Microsoft Updates**.



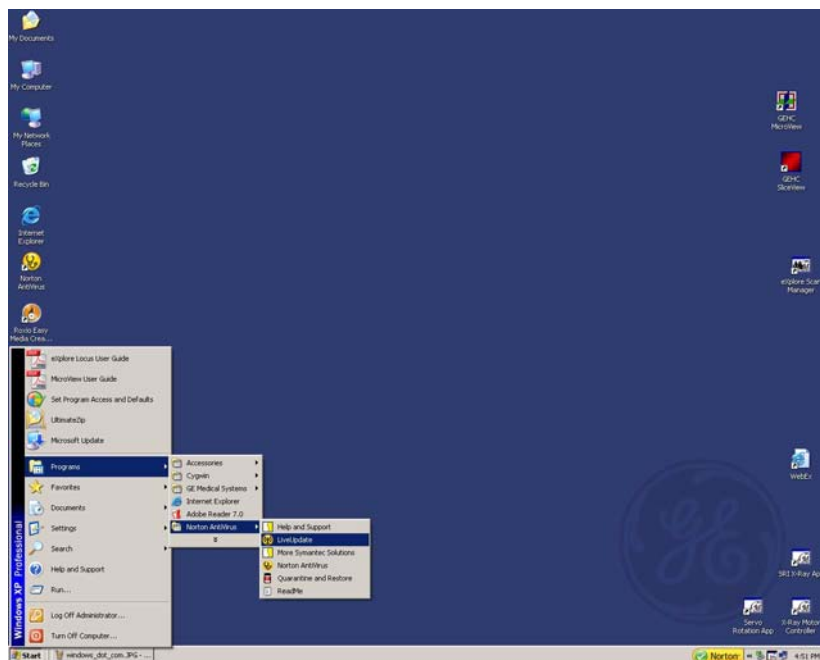
b. Click on **Express**.



c. Follow instructions from the website (install updates if needed, restart if prompted, etc.).

5. Update Norton AntiVirus software:

a. Start -> Programs -> Norton AntiVirus -> **Live Update**



- b. Click on **Next**.



- c. Click on **Next**, to install.
d. When complete, restart the computer if needed.

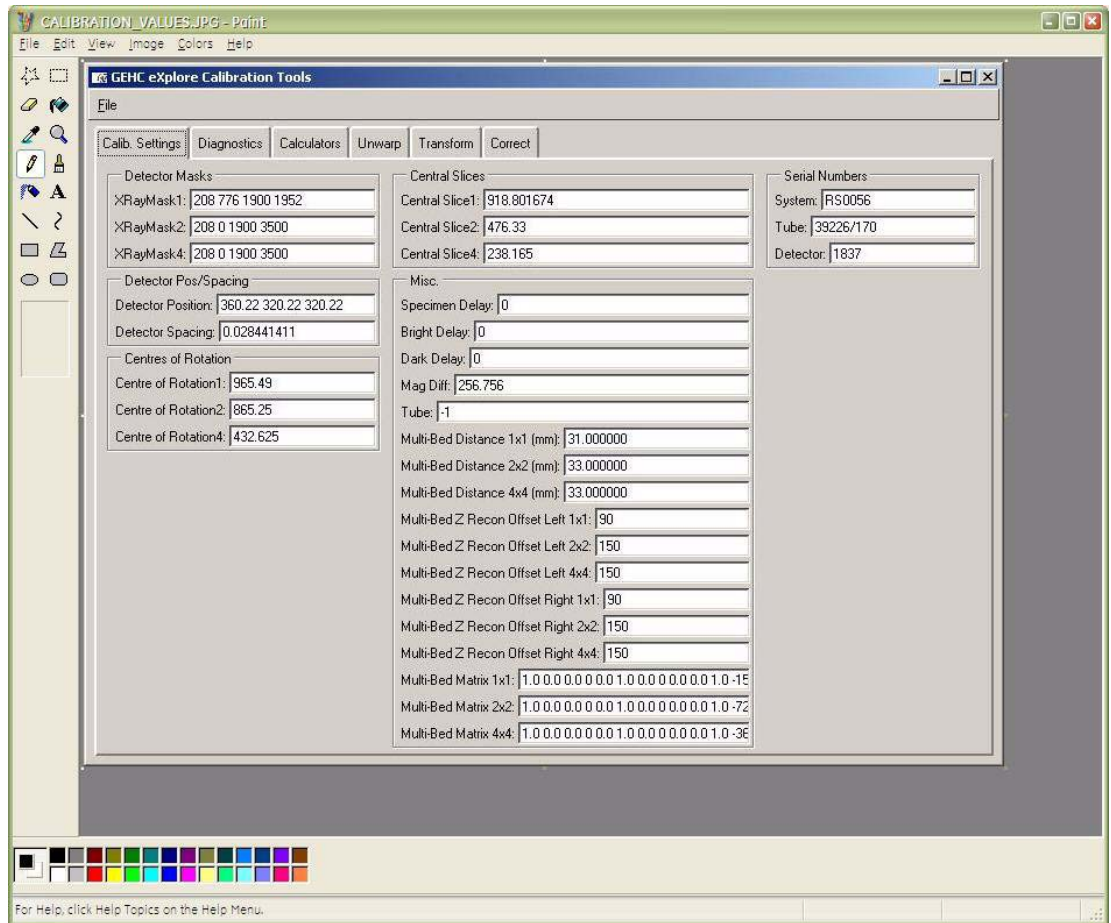
Section 5.2 Back Up & Restore

5.2.1 Back Up Calibration and Registry Settings

SAVE CALIBRATION SETTINGS

1. Capture a screen shot of the *Calib. Settings* tab in **Calibration Tools**.
2. Call this file *calibration_values.jpg*

3. Save the document to both C: and D: drives.



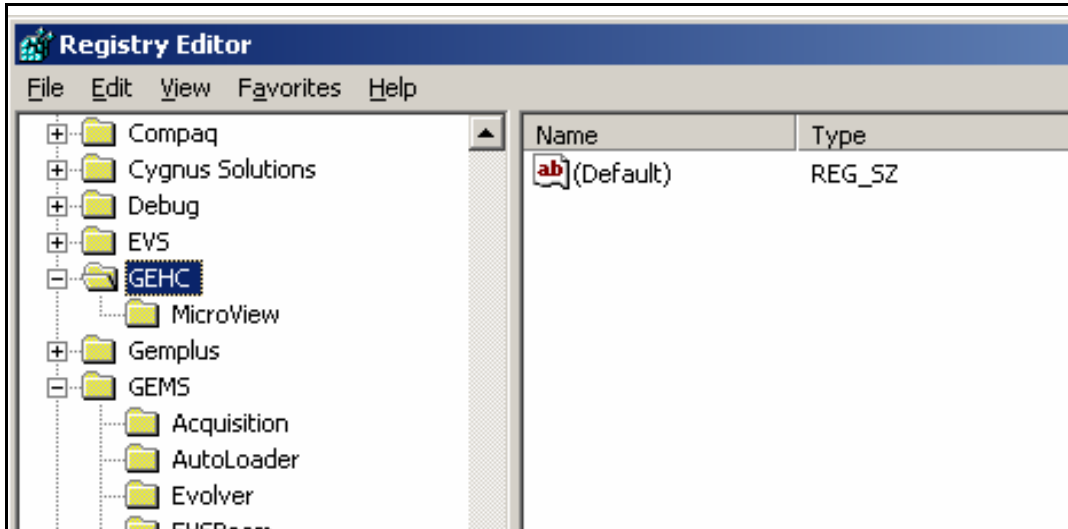
4. Copy D:\calib folder to C: drive.
5. Copy C:\translations1 to D: drive.

BACK UP REGISTRY

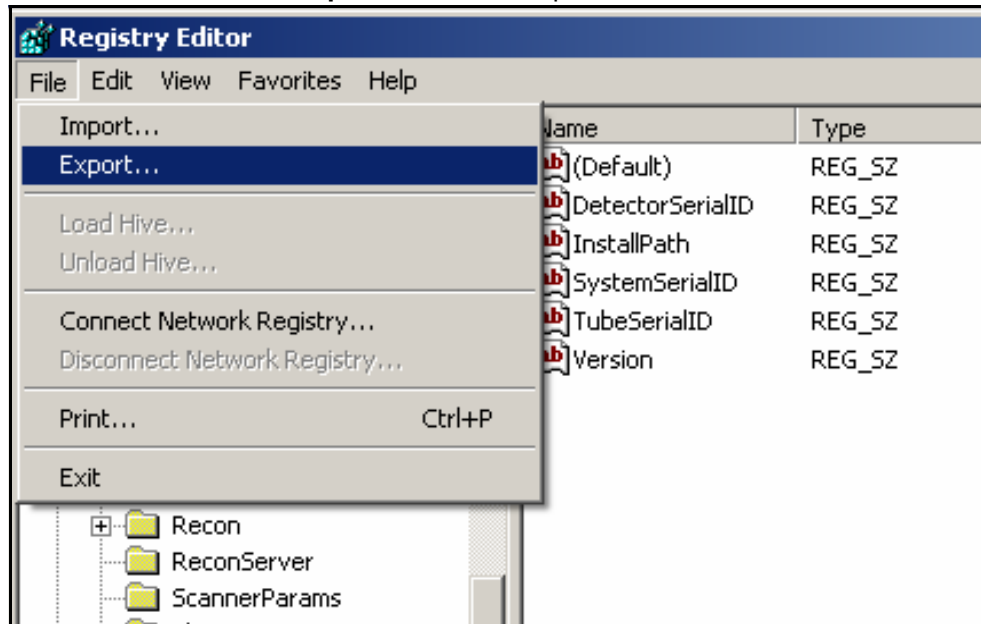
6. If needed, add the following folder to the C: drive: **Registry Backup**
7. Create a sub-folder under Registry Backup and label the folder with "today's date" e.g. yymmdd
8. Click on the Microsoft **start** button in the bottom right corner of the screen, and choose **Run...**
9. Enter the following in the text box, then click OK: **regedit**



10. Once the Microsoft Registry Editor opens, click on the **GEHC** folder.

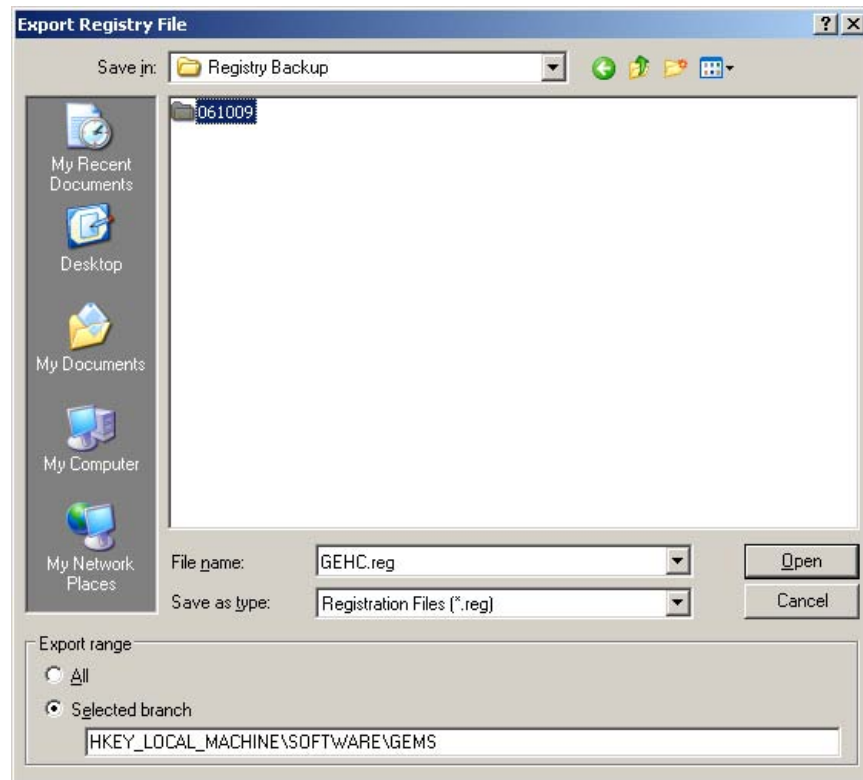


11. Click on **File**, then choose **Export...** from the drop-down list.



12. Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.

- Under File name, enter **GEHC.REG** then click on the **Save** button.



- Next select the **GEMS** folder under the Registry Editor.
- Click on **File**, then choose **Export...** from the drop-down list.
- Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
- Under File name, enter **GEMS.REG** then click on the **Save** button.
- In Windows Explorer, rename the file to **GEMS.GER**.

This is done to protect the file so that it is not accidentally opened which would rewrite the registry.

DISABLE TEST PROTOCOLS

- Disable the test protocols by changing the 1x1wire.protocol, 2x2wire.protocol and 4x4wire.protocol files to:

1x1wire.txt

2x2wire.txt

4x4wire.txt

Files are located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols\

BACK UP CRITICAL FILES TO DVDs

- Copy the following files to a DVD:
 - C:\translations1

- all the transform and transform.dat files found in D: drive
 - the D:\calib folder and the D:\detector folder
 - the C:\Program Files\GE Medical Systems folder
 - the newly created *calibration_values.jpg* file
 - all saved volumes (e.g. 1x1_wire_cs_360)
 - the C:\Registry Backup folder.
2. Label the DVD with the name *Calibration Values*, and include the system serial number and date.
 3. Create zip files containing the acquired images and support files created for each of the 3 wire scans. Call the zip files *1x1.zip*, *2x2.zip* and *4x4.zip*. There is no need to backup the 'Volumes' or 'Corrected' folder.
 4. Save the zip files on to a separate DVD and label the DVD with the name *Wire Scans*. Include the system serial number and date.
 5. Make two copies of each DVD. File one set of DVDs in the system's Device History Record folder located on the back of the system, and send the other to Service Engineering.

Service Engineering
Attn: Janice Chu
1510 Woodcock Street, Unit #7
London, ON N6H 5S1
Canada

5.2.2 Restore Registry

The following describes how to perform a registry restore using the backed up values on the C: drive. A registry restore may also be performed from a DVD.

1. In Windows Explorer, open the following folder: **C:\Registry Backup**
2. Open the sub-folder labelled with the appropriate date (i.e. the sub-folder containing the registry values you wish to restore).
3. In Windows Explorer, rename the file GEHC.GER to **GEHC.REG**.
4. Double-click on the **GEHC.REG** file.
5. Click **Yes** when asked if you want to add the information to the registry.



6. Double-click on the **GEMS.REG** file.
 7. Click **Yes** when asked if you want to add the information to the registry.
- The registry is restored.

5.2.3 Restore Calibration Values

From the DVD:

1. Copy the following files from the DVD, overwriting the existing files:
 - **translations1** to the C: drive
 - **calib folder** and **detector folder** to the D: drive
 - GE Medical Systems\Explore Utilities**Protocols folder** to C:\Program Files\GE Medical Systems\Protocols folder
 - GE Medical Systems\Explore Utilities**Parameters folder** to C:\Program Files\GE Medical Systems\Parameters folder

Once the files are restored, ensure the restored files are not "read-only":

2. Right-click on each restored file and folder.
3. Choose **Properties** from the drop-down menu.
4. Ensure the "Read-only" field is not checked off.

5.2.4 Acquisition Computer Replacement - Transfer Critical Data

The following describes how to move calibration and registry data from a Dell 650 acquisition computer to the HP XW200, should the Dell 650 require replacement. The HP XW200 runs Windows XP.

WARNING *Prior to performing the procedures below, ensure all registry and calibration data is backed up.*

The new HP computer is completely configured except for the absence of the calibration data, and the Frame Grabber and Blue Heat serial cards. The calibration data will be copied from the existing Dell computer to the new HP computer. The HP computer also contains two files on the desktop named **directories.reg** and **recon.reg**.

COPY GEMS REGISTRY KEY FROM DELL TO HP

1. On the Dell's Windows taskbar, click Start, choose Run... and type **regedit**.
2. Click the **Ok** button. A pop-up called "Registry Editor" appears.
3. On the left pane of the "Registry Editor", navigate to the key "HKEY_LOCAL_MACHINE\SOFTWARE\GEMS".
Make sure GEMS is highlighted.
4. Click on File and choose **Export...** to open the Export Registry File window.
5. On the left-hand side of the Export Registry File window click on the Desktop Icon.
6. Type **gems.reg** in the File name field and click on the **Save** button.
7. Copy the new file called **gems.reg** to the HP's desktop.

8. On the HP desktop double-click **gems.reg** to import it into the registry.

COPY THE PARAMETERS DIRECTORY FROM DELL TO HP

9. Copy the directory "C:\Program Files\GE Medical Systems\Explore Utilities\Parameters" from the Dell to the "C:\Program Files\GE Medical Systems\Explore Utilities\" directory on the HP.

IMPORT THE FOLLOWING KEYS INTO THE HP REGISTRY

10. Double-click the file **recon.reg** on the HP's Desktop
11. Double-click the file **directories.reg** on the HP's Desktop

SWAP FRAME GRABBER AND BLUE HEAT SERIAL CARDS

12. Shut down the Dell and the HP computers.
13. Put on a grounded ESD wristband.
14. Remove the computer covers from both the Dell and HP.
15. Remove the Frame Grabber board from Slot 1 of the Dell computer and put it in Slot 1 of the HP Computer.
16. Take the Blue Heat board from Slot 2 of the Dell computer and put it in Slot 2 of the HP computer.

VERIFY TRANSFER

17. Reboot the HP computer.
18. Verify that the new HP computer scans and reconstructs as expected.
19. Back up the following files from the HP desktop:
 - gems.reg
 - recon.reg
 - directories.reg.

Chapter 6

Field Replaceable Units

Section 6.1 Overview

Detailed instructions for removing and replacing eXplore Locus SP components and assemblies appear in this chapter.

6.1.1 Lockout / Tagout (LOTO) Instructions

NOTICE
The equipment must be locked out for most procedures in this chapter.

All energy sources for equipment on which work will be performed and on which injury could occur due to unexpected energization, startup or release of stored energy shall be deactivated. This includes opening electrical circuits, closing and bleeding pressurized hydraulics and pneumatics, blocking springs or counterweights and discharging capacitors (for example).

1. LOTO indicates that the energy source is Locked Out and that an Authorized Employee is actively working on the machine, equipment, process, or circuit. LOTO is limited to one shift or the amount of time the person is actively working on the system. If the job is not finished and the system is not ready to be put back in use, the authorized person shall apply the Transition LOTO or the Out of Service LOTO, whichever is appropriate for the situation.
2. When applying LOTO the following six step process (which is described in detail in the training) must be followed:
 - a. **Prepare for shutdown.**
 - b. **Shutdown machine or equipment.**
 - c. **Isolate machine or equipment.**
 - d. **Apply lockout and tagout device.**
 - e. **Isolate stored energy.**
 - f. **Verify Isolation.**
3. **Temporary removal of LOTO** and re-energization of a machine or equipment may be performed when power is needed for testing or positioning. When testing you must:
 - a. **Ensure the machine is operationally intact.**
 - b. **Notify all Authorized or Affected Employees who are working on the equipment or are in the area that the equipment is going to be tested and to move to a safe area.**
 - c. **Verify controls are in the "off" position.**
 - d. **Remove LOTO Locks and tags.**
 - e. **Energize and proceed with testing.**
 - f. **After testing, de-energize, verify system isolation, and re-apply LOTO Locks and Tags.**
4. When removing Lockout/Tagout the following steps must be followed:
 - a. **Communicate to all Affected Employees.**

- b. Verify the safety of the area.
- c. Ensure the safety devices and guards are in place.
- d. Return system functions.
- e. Remove your lock and tag.
- f. Communicate system re-energization.
- g. Re-energize and test equipment.

6.1.2 Left Access Panel Removal

The left access panel needs to be removed for many of the procedures shown in this section. Instructions follow.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

Machine locked out. See 6.1.1 for details.

REMOVE

1. Using Phillips screwdriver, remove eleven screws and washers securing left panel to unit.



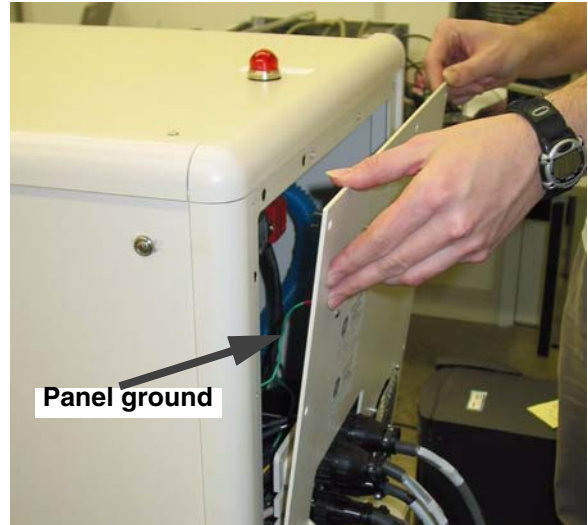
2. Disconnect ground cable to panel.
Remove panel.

REPLACE

1. Reverse of removal.

FOLLOW-ON PROCEDURES

None



6.1.3 Right Access Panel Removal / Replacement

INTRODUCTION

The right access panel needs to be removed for many of the procedures in this section. Instructions follow.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

Machine locked out. See 6.1.1 for details.

REMOVE

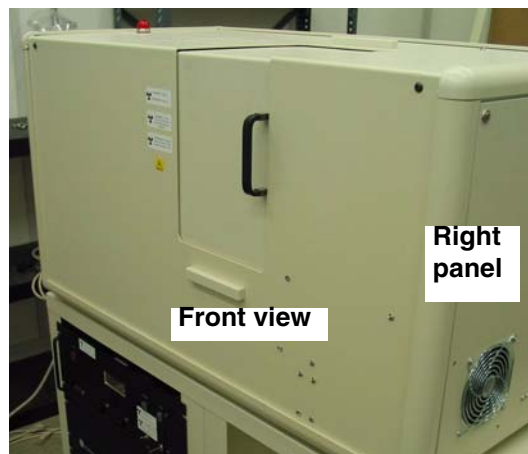
1. Using Phillips screwdriver remove twelve screws and washers from right panel.
2. Disconnect ground cable to panel.
3. Remove panel from top. Lift up panel to right to remove.

REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

None



6.1.4 Case Removal / Replacement

INTRODUCTION

Removing the case is necessary to access and service some internal components.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

- X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.
- The case weighs over 100 lbs. Two or three people are needed to safely lift it out of the way.

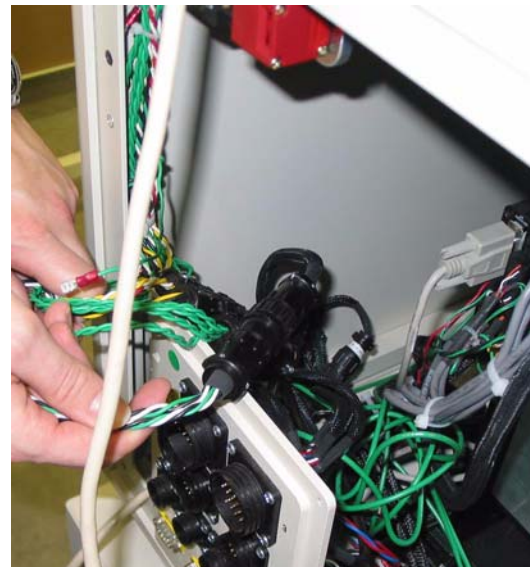


PRECONDITIONS

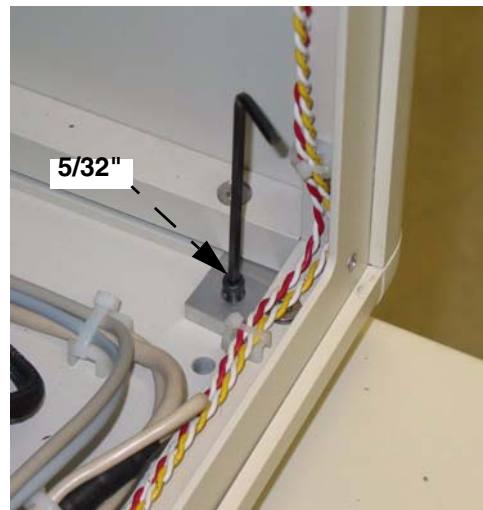
- Machine locked out. See 6.1.1 for details.
- Left and right access panels removed. See 6.1.2 and 6.1.3 for details
- Camera cable (frame grabber cable) bundled and stowed inside the unit.

REMOVE

1. Disconnect the four cables from the case. (These are all unique and cannot be inserted incorrectly).

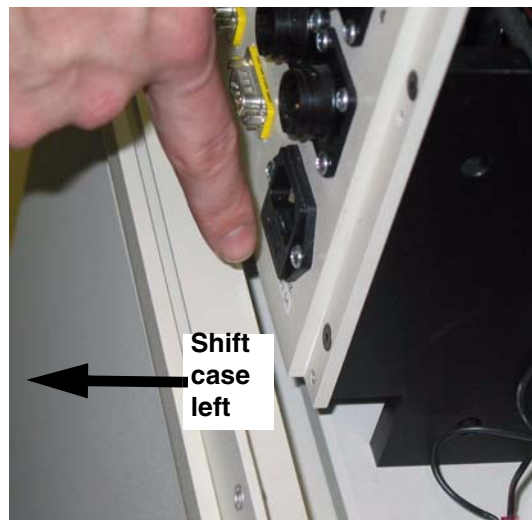


- Using 5/32" hex key, remove four screws, lockwashers and hold-down brackets securing case to base.
- Access to the hold-down bracket behind the electrical flange is restricted. Loosen the four flat head cap screws on the flange brackets. (3/32" hex key) as required to improve access.



Comment: Door side of the cased is heavier of the two.

- Remove case: Slide case left at least 2" to clear electrical flange, tilt forward about 1" for door shielding to clear rear shielding and then shift right to clear the detector. Continue lifting up and over while being careful not to hit anything.

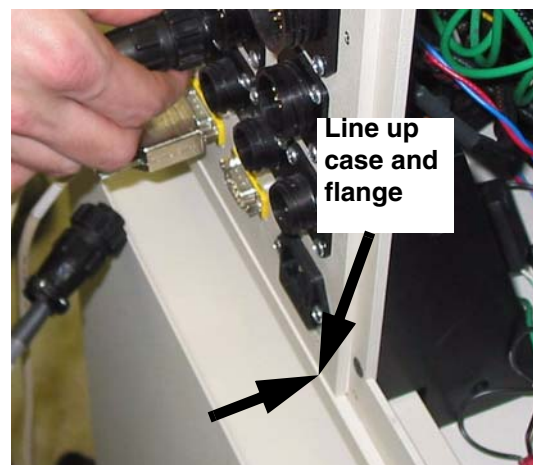


REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

- Ensure that case is centred on the base plate.
- Check that four corner hold-down brackets are fully engaged, and that case and electrical flange are properly aligned.
- Perform an "abridged" calibration (see Case/ Shielding Removal in Chapter 7)



6.1.5 X-Ray Shield Removal / Replacement

INTRODUCTION

Shields must be removed to access the detector, source and stage. Typically, back shield is removed first.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

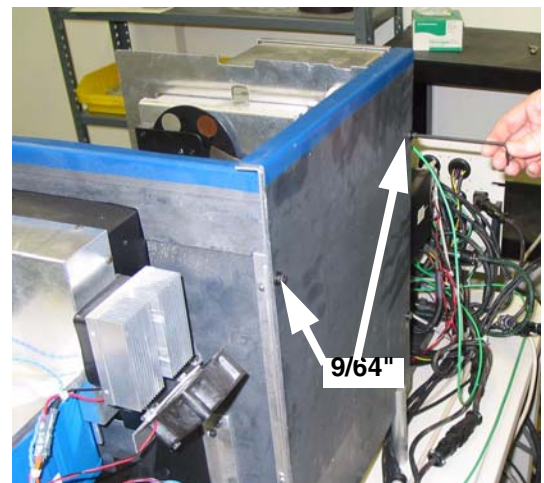
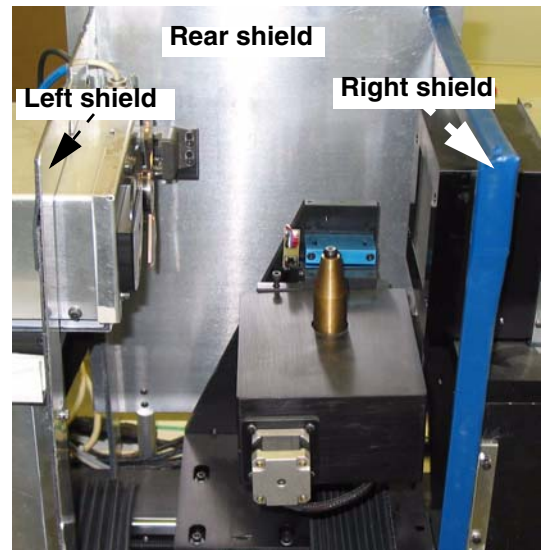
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

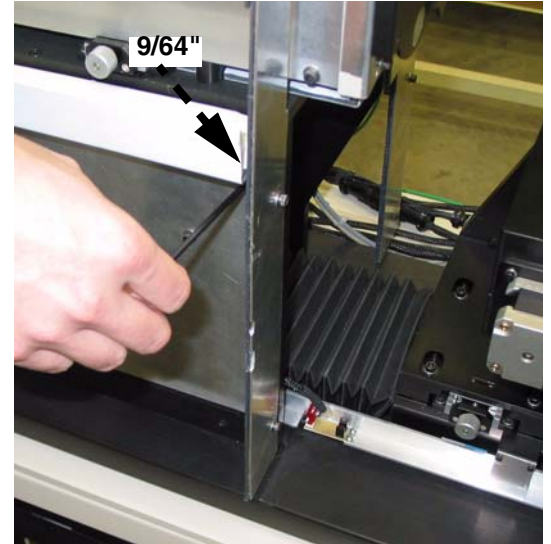
- Machine locked out. See 6.1.1 for details.
- Left and right access panels, case removed. See 6.1.2, 6.1.3 and 6.1.4 for details.

REMOVE

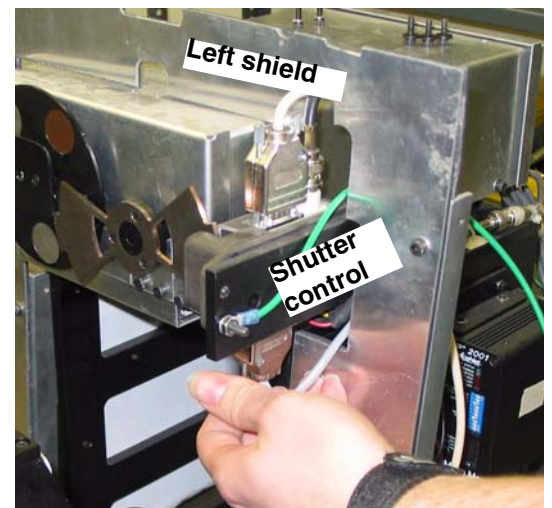
1. Using 9/64" hex key, remove four screws and flatwashers securing back shield to right and left shields. Set shield aside.



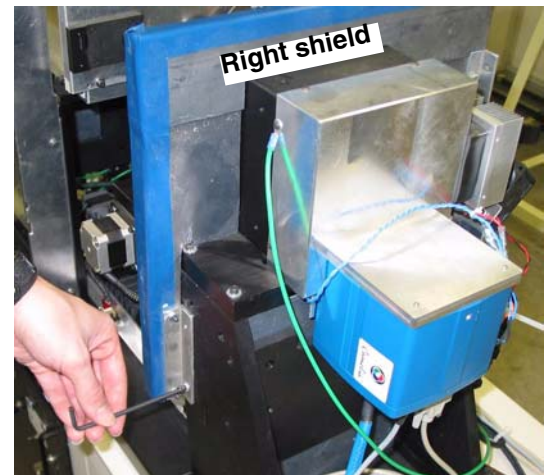
- Using 9/64" hex key remove two screws securing left-hand shield to source stand.



- Remove cable to bottom of shutter control as required to remove shield.



- Using 9/64" hex key, remove two screws from front and back of right shield. Lift shield up and away from unit.



REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

- Perform an "abridged" calibration (see Case/ Shielding Removal in Chapter 7)

Section 6.2 Remove / Replace FRUs

6.2.1 Comair Blower and Hose Removal / Replacement

The blower is located behind the left panel assembly.

TOOL LIST

Standard toolkit

SUPPLIES

Lockwashers

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out See 6.1.1 for details..
- Left access panel removed. See 6.1.2 for details.

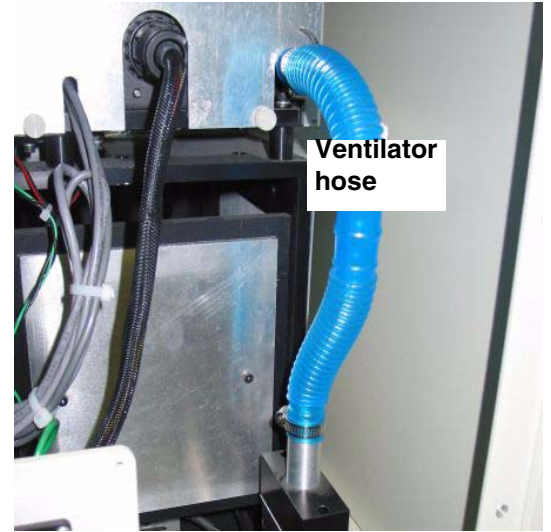
REMOVE

1. Disconnect power cable from blower.
2. Using slotted screwdriver loosen clamp securing ventilator hose to blower.
3. Using 5/32" hex key, remove two screws and lockwashers securing blower mounting bracket to unit base. Remove blower, discard lockwashers.
4. Using Phillips screwdriver remove two screws and flatwashers securing mounting bracket to blower.
5. Using 9/64" hex key, remove blower manifold from blower.



REPLACE

1. Reverse of removal.
2. Torque screws securing blower to bottom of case.



FOLLOW-ON PROCEDURES

- Observe the blower operating with the power on.
- Replace left access panel.

6.2.2 Right Comair Fan Removal / Replacement

INTRODUCTION

The unit is equipped with two fans, located on the rear panel, and provide fresh/cooling air to unit. A slightly different procedure is required for each fan.

TOOL LIST

Standard toolkit

SUPPLIES

None.

SAFETY CONSIDERATIONS

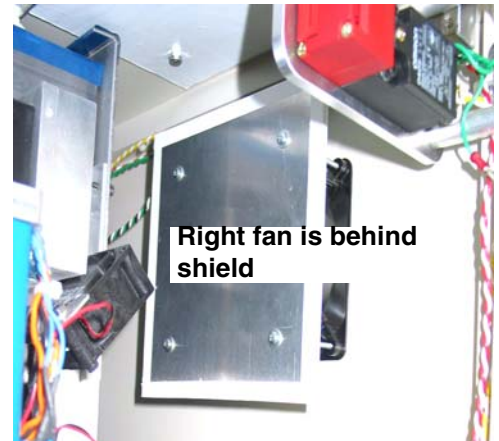
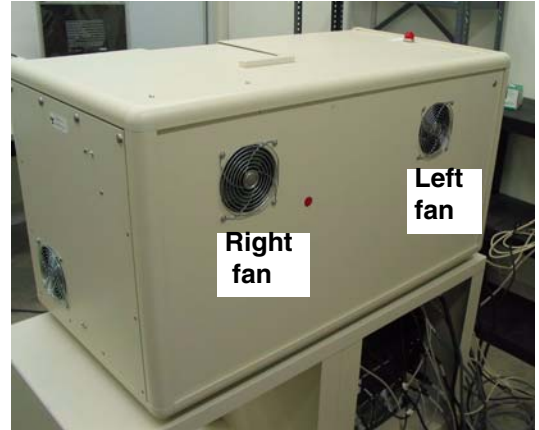
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Remove right access panel. See 6.1.3 for details.

REMOVE

1. Using Phillips screwdriver, remove four screws, flatwashers, and finger guard securing fan to panel.
2. Using slotted screwdriver, disconnect ground wire, and unplug power wires from fan.



3. Remove lead shield from fan.

REPLACE

1. Reverse of removal.
2. Install fan so that air flow is out of unit.
3. Fan power cables are not polarized.
4. Use small adjustable wrench as required to hold standoffs while tightening fan.

FOLLOW-ON PROCEDURES

Observe fans operating with system power on.



6.2.3 Left Comair Fan Removal / Replacement

INTRODUCTION

The left fan is located on the rear panel, and blows air out of the unit.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Remove left access panel. See 6.1.2 for details.

REMOVE

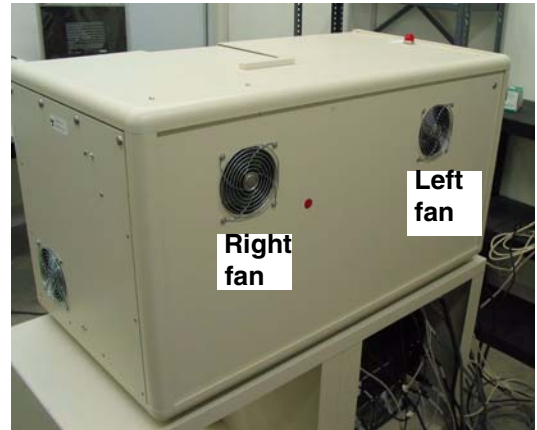
1. Using Phillips screwdriver, remove four screws, flatwashers, and finger guard securing fan to rear panel.
2. Using slotted screwdriver, disconnect ground wire, and unplug power wires from fan.

REPLACE

1. Reverse of removal.
2. Ensure that air flows out of unit.
3. Power wires to fan are not polarized.

FOLLOW-ON PROCEDURES

Observe that the fans operate with the system power on.



6.2.4 Interlock Removal / Replacement

INTRODUCTION

The unit has three interlocks: on right and left panel and on the sliding door.

The left and right interlocks are identical, and this procedure applies to both. See Section 6.2.19 for details on the door interlock procedure.

TOOL LIST

Standard toolkit

SUPPLIES

Lockwashers

SAFETY CONSIDERATIONS

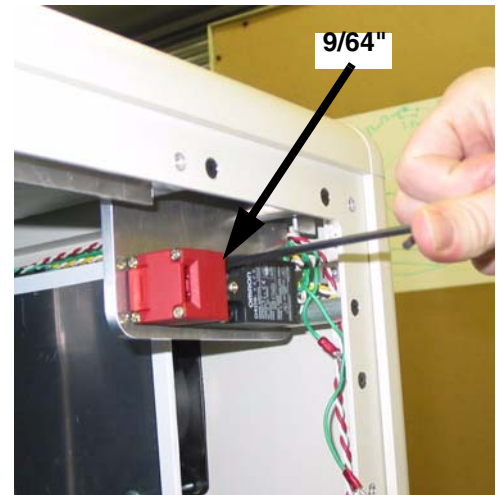
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Left or right access panel removed, as required. See 6.1.2 and 6.1.3 for details.

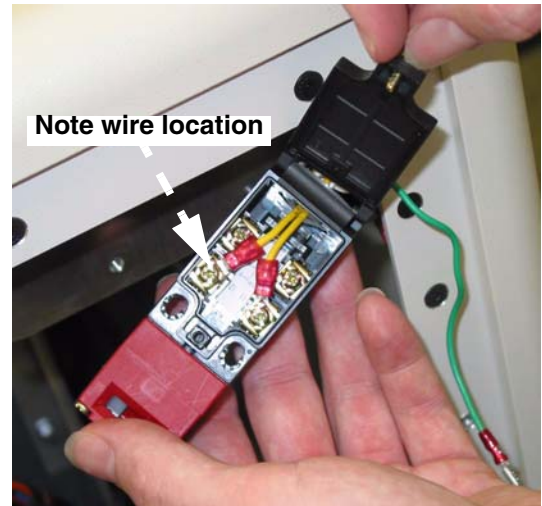
REMOVE

1. Using 9/64" hex key, remove two screws and internal tooth lockwashers securing interlock to bracket. Discard lockwashers.



1. Using Phillips screwdriver open access cover.

2. Using Phillips screwdriver, loosen and remove two wires from interlock body. **Wire polarity is not important, but terminal location is.**



REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

None

6.2.5 X-Ray Indicator Light Removal / Replacement

INTRODUCTION

The light illuminates when x-rays are being generated.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Left access panel removed. See 6.1.2 for details.

REMOVE

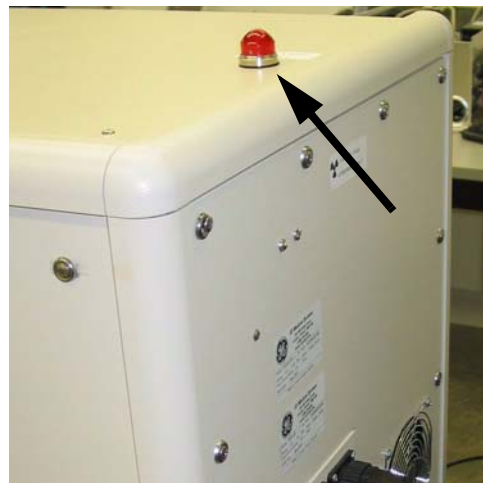
1. Using 1 1/8" open end or adjustable wrench, remove nut and internal tooth lockwasher securing light to case.
2. Using slotted screwdriver, remove two wire from terminals. Note location for later re-installation - yellow is positive.

REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

Power-up unit, turn x-rays on to confirm proper operation of indicator light.



6.2.6 Temperature Controller Removal / Replacement

INTRODUCTION

The temperature controller is the metal blue box, usually located in storage area.

TOOL LIST

None

SUPPLIES

None

SAFETY CONSIDERATIONS

n/a

PRECONDITIONS

Machine locked out. See 6.1.1 for details.

REMOVE

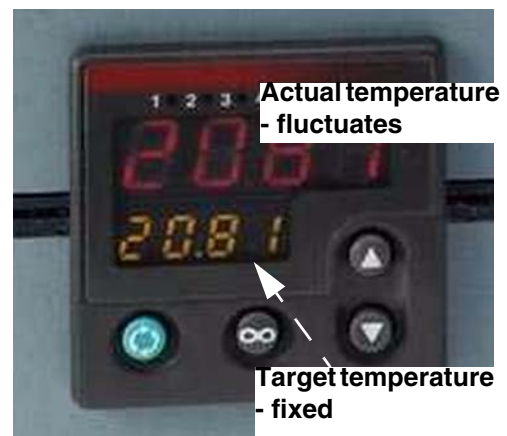
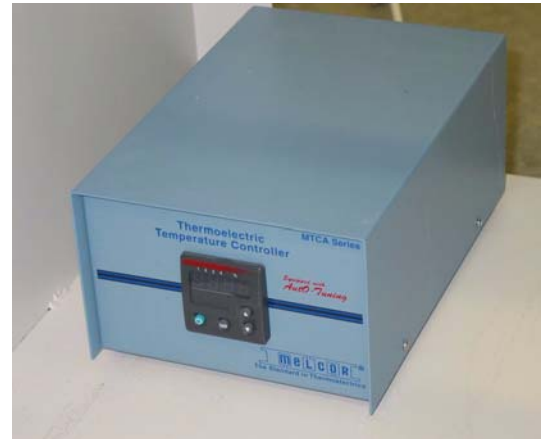
1. Disconnect three cables from back of temperature controller.

REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

- Temperature controller should be programmed prior to shipment to site.
- Target temperature is 12.98. See set-up procedure, below.



6.2.6.1 Set-Up Temperature Controller

1. Plug in and run the Temperature Controller.
2. Press the Green button on the left of the control panel to scroll to the first setting. **Pcnt** should appear in green at the bottom of the display screen.
3. Ignore the **Pcnt** setting and press the green button again until **PBI** appears in green on the bottom of the display.
4. Enter the values below as you scroll through the settings, pressing the green button after each entry. Use the up and down arrow buttons on the right of the panel to enter values.

Setting	Value
PB1	2.99
1t1	7.00
dE1	0.98
Pb2	6.26
1t2	7.00
dE2	0.98
AtLI	100.0
AtL2	100.0
ILSP	0.00
ILA	50%
ILb	50%
A3Lo	1.00
A3h1	22.00
A-77	AUTO

Table 6-1 Settings

5. Press the middle button °° upon completion.
6. Enter the temperature setting of 12.98 in the bottom part of the display.

6.2.7 Specimen Stage, Short Limit Switch Removal / Replacement

INTRODUCTION

Two limit switches limit vertical travel of the specimen stage and prevent it from colliding with the bracket. One is mounted to the top left of the specimen slide, the other directly below it on a common bracket.

TOOL LIST

- Standard toolkit
- 9/64" t-handle allen wrench

SUPPLIES

None

SAFETY CONSIDERATIONS

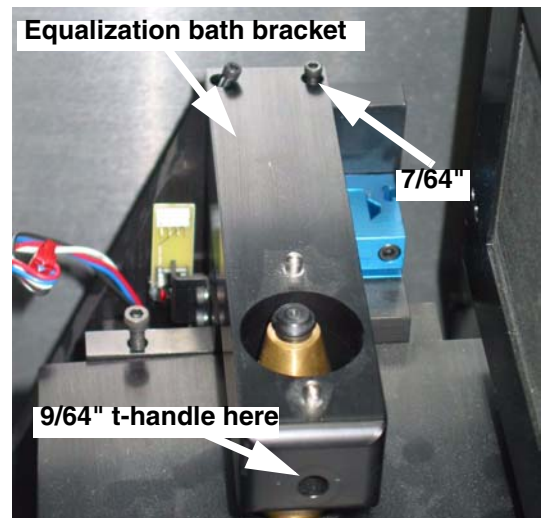
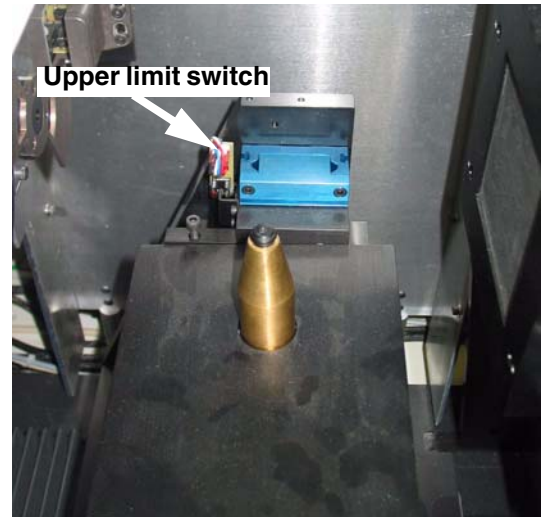
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Fully retract brass cone to allow equalization bath bracket to be removed.
- Machine locked out. See 6.1.1 for details.
- Door opened.
- Equalization bath bracket removed.

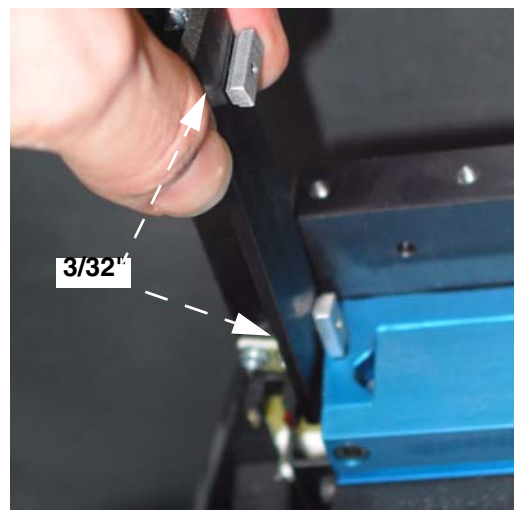
EQUALIZATION BATH BRACKET REMOVAL

1. Using 7/64" hex key, remove two socket head cap screws from end of equalization bath bracket.
2. Insert t-handle, 9/64" hex driver through hole in front of equalization bath bracket loosen screw. Remove bracket.



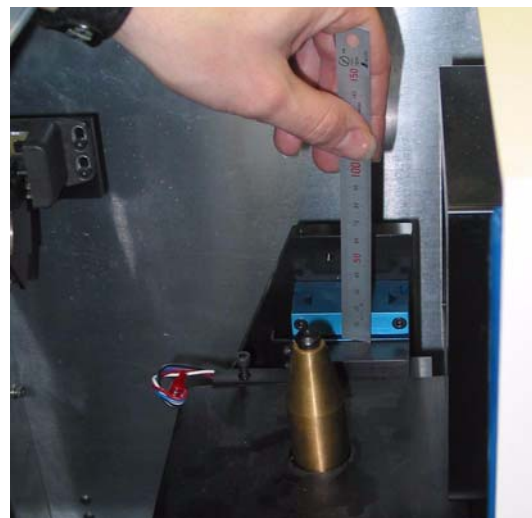
LIMIT SWITCH REMOVAL

1. Unplug wire connectors to limit switches.
2. Using 3/32" hex key, loosen two screws, and slide limit switch bracket up and out of the t-slot in the specimen slide.
3. Using small Phillips screwdriver, remove two screws and lockwashers securing limit switch to bracket.



REPLACE

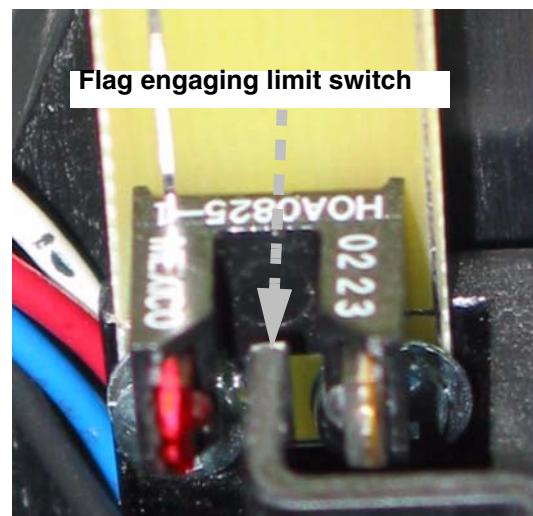
1. Ensure that the gap between the specimen slide and the rotation stage is 2mm. This can be adjusted manually by turning the lead screw located behind the stage.



2. Position limit switch bracket so that the flag is slightly above the centre limit switch sensor.
3. Tighten bracket.
4. Hook up connectors to limit switches and ensure that the wires run down behind the bracket (so they don't interfere with the movement of the stage).

FOLLOW-ON PROCEDURES

- Run the X-Ray Motor Controller application and verify that the limit switches are communicating with the software and that the stage/slide does not crash.
- Stage Replacement calibration is required. See Chapter 7.



6.2.8 Magnification Stage Limit Switches Removal / Replacement

INTRODUCTION

The magnification stage is equipped with two limit switches, located along the outside of the limit switch bracket.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Door open.

REMOVE

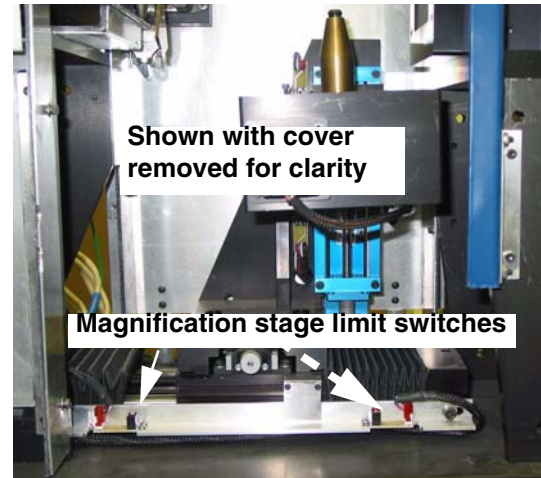
1. Unplug cable connector from limit switches.
2. Using small Phillips screwdriver, remove screw and lockwashers securing limit switch to bracket.

REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

Run the X-Ray Motor Controller application and verify that the limit switches are communicating with the software and that the stage/slide does not crash.



6.2.9 Filter Wheel Assembly Removal / Replacement

INTRODUCTION

The filter wheel assembly is secured to the front of the x-ray source by a cover.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

None

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Door open.

REMOVE

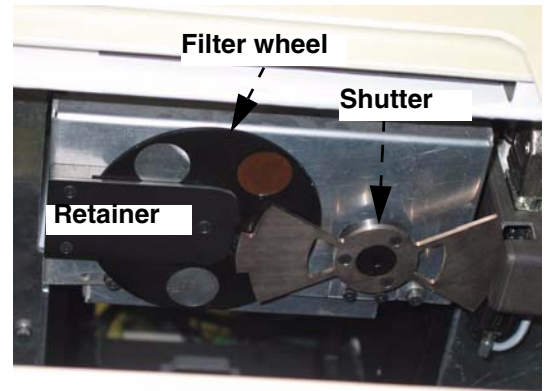
1. Rotate shutter to better access filter wheel.
2. Using 1/16" hex key, remove three hex screws securing filter wheel retainer to filter wheel mount base. Support wheel while removing last screw.

REPLACE

1. Ensure filter numbers on front of wheel are visible.
2. Place filter wheel onto shaft.
3. Secure filter wheel retainer with three screws and 1/16" hex key. Ensure wheel can rotate easily.

FOLLOW-ON PROCEDURES

None



6.2.10 Module Servicing

INTRODUCTION

The system is equipped with three control modules. These are mounted to the table and secured with four Phillips screws and countersunk washers. Modules are simply removed and replaced as required for servicing, including fuse replacement. Note - It may be necessary to remove upper and middle module to remove lower module.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

None

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Depending on how and where the machine is situated it may be possible to access the rear of the unit and unplug the cables from the module from the back.

REMOVE

1. Using Phillips screwdriver, remove four screws and countersunk shoulder washers securing module to table. Slide module out.
2. Unplug cables from rear of module while noting their location. Cables and connectors are labelled to facilitate re-installation.

REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

None



6.2.11 Rotary Stage Removal / Replacement

INTRODUCTION

The rotary stage is secured to the gear box slide spacer with four screws and two dowels. It pivots on the dowels for calibration and is secured by the screws.

TOOL LIST

Standard toolkit

SUPPLIES

Cable ties

Lockwashers

SAFETY CONSIDERATIONS

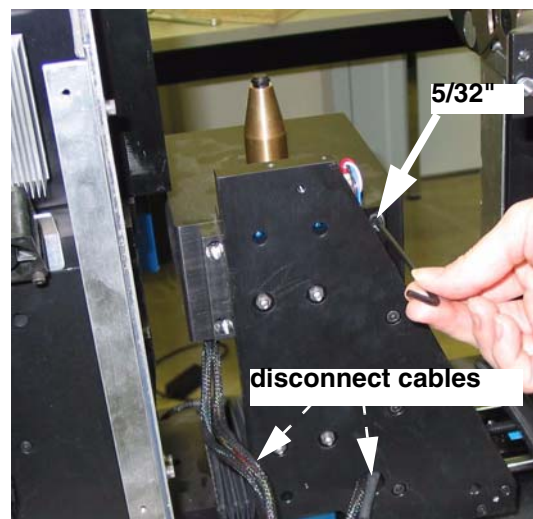
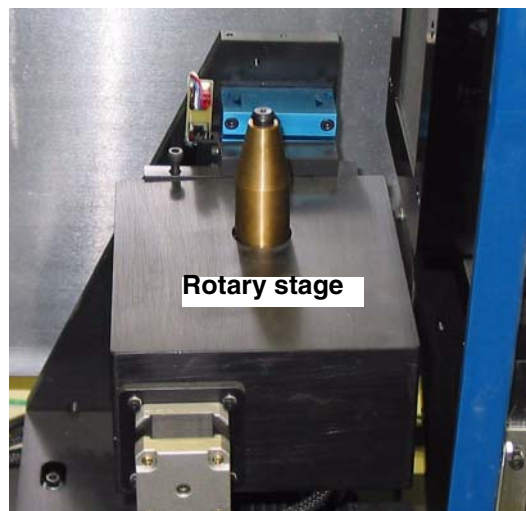
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Left access panel removed. See 6.1.2 for details.

REMOVE

1. Using 7/64" hex key, remove equalization support bracket from top of stage.
2. Use 9/64" t-handle allen wrench, remove screw from front of bracket.
3. Cut cable ties securing two cables to rotary stage. Disconnect cables to rotary stage.
4. Using 5/32" hex key, remove four screws and lockwashers from back of rotary stage. Discard lockwashers.



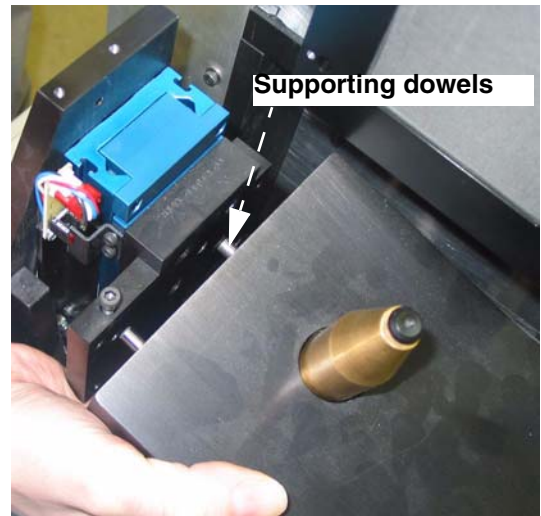
- Using 5/32" hex ball driver remove lower right screw (looking from the front) and remove rotary stage from gear box slide spacer. Support weight of stage as the last screw is removed.



- The stage is supported on two short dowels.

REPLACE

- Reverse of removal.
- Insert rotary stage dowels, and support it while inserting four screws.
- SNUG - DO NOT TIGHTEN THE SCREWS PRIOR TO CALIBRATION!**, (or damage to the equipment may result when calibration is attempted).
- Use cable ties to secure cables.



FOLLOW-ON PROCEDURES

Stage Replacement calibration is needed. See Chapter 7.

6.2.12 Specimen Slide Removal / Replacement

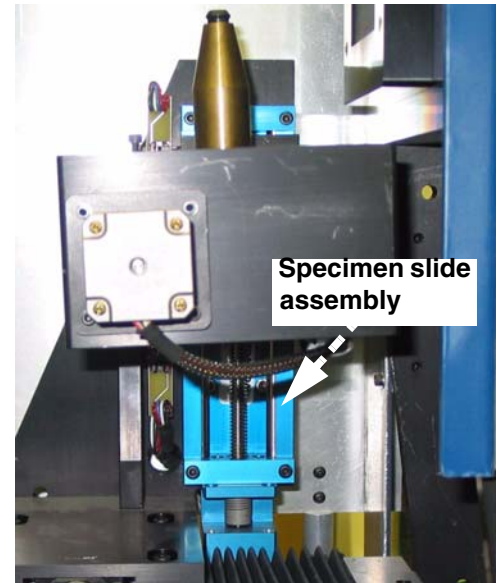
INTRODUCTION

The specimen slide controls the vertical position of the specimen relative to the x-ray source.

There are 2 methods of removing the specimen slide:

- A.) Remove rotary stage first, then only remove the specimen slide, OR*
- B.) Remove the entire rotary stage and specimen slide assembly (together), and then separate the specimen slide from the rotary stage (this method may be easier than separating the specimen slide from the rotary stage in the small confines of the open door).*

Both methods are described below.



TOOL LIST

Standard toolkit

SUPPLIES

Cable ties

SAFETY CONSIDERATIONS

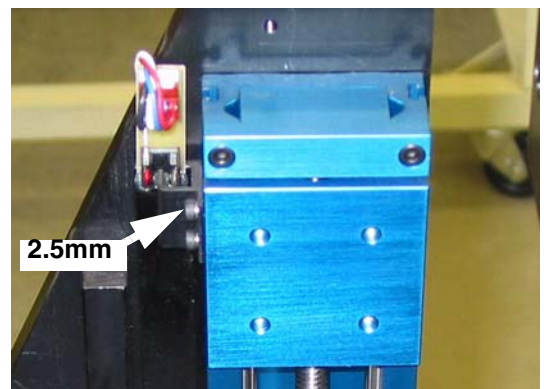
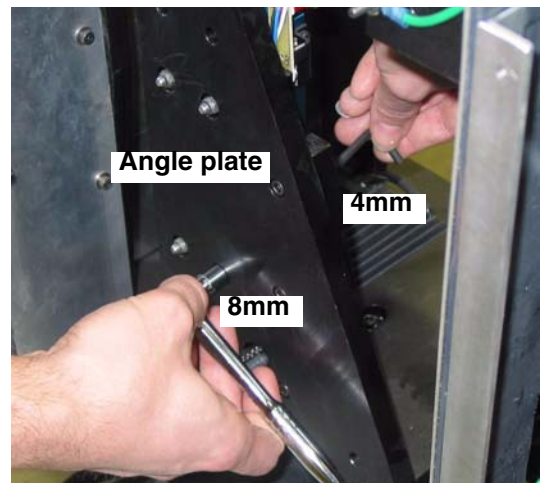
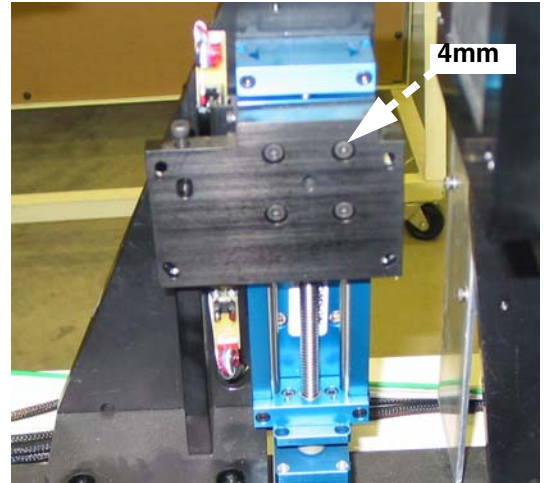
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Left access panel removed. See 6.1.2 for details.
- Equalization bath bracket removed. See 6.2.7 for details.
- Rotary stage removed OR entire rotary stage and specimen slide assembly.

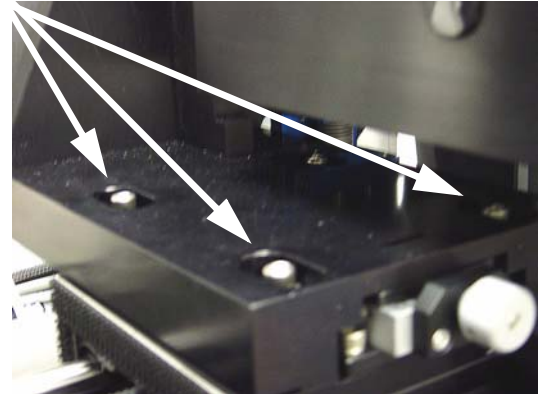
A) REMOVE ROTARY STAGE FIRST, THEN SPECIMEN SLIDE

1. Disconnect cables (4) to specimen slide.
2. Using 4mm hex key, remove four screws securing gear box slide spacer to specimen slide.
3. Using the 4mm hex key ball driver and 8mm socket, remove four screws and nuts securing specimen slide to angle plate.
4. Using 2.5mm hex key remove two screws and lockwashers securing limit finger to specimen slide.
5. Using 3/32" hex key remove limit switch bracket from specimen slide.

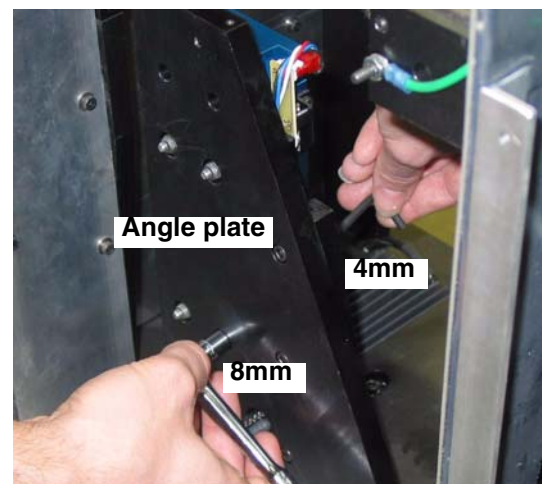
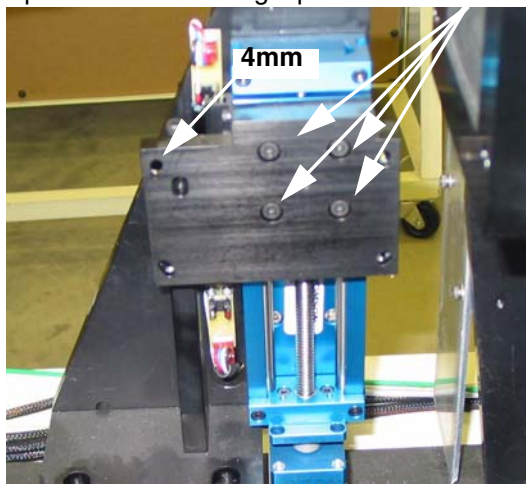


B) REMOVE ENTIRE ASSEMBLY, THEN SEPARATE

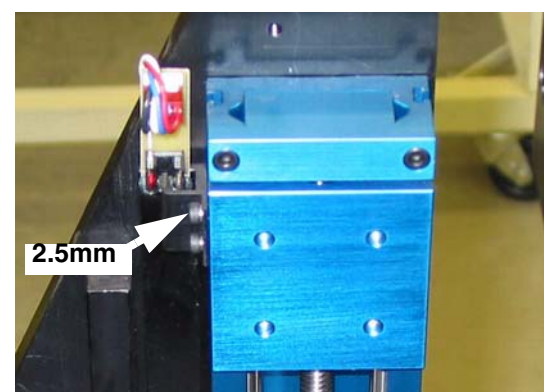
1. Disconnect cables (4) to specimen slide.
2. Using 4mm hex key, remove the stage retaining screws.
3. Remove entire rotary stage and specimen slide assembly.
4. Separate the rotary stage from specimen slide:



Using 4mm hex key ball driver and 8mm socket, remove four screws and nuts securing specimen slide to angle plate.



5. Using 2.5mm hex key remove two screws and lockwashers securing limit finger to specimen slide.
6. Using 3/32" hex key remove limit switch bracket from specimen slide.



REPLACE

1. Reverse of removal.
2. Attach limit switch bracket to specimen slide.
3. Attach limit finger to specimen slide.
4. Attach specimen slide to angle plate.
5. Attach gear box slide spacer to specimen.
6. Use cable ties to secure cables.

FOLLOW-ON PROCEDURES

- Replace rotary stage, perform calibration and secure. Stage Replacement calibration is found in Chapter 7.
- Re-calibrate limit switches.
- Replace shielding, case and covers, and perform an "abridged" calibration (see Chapter 7).

6.2.13 X-Ray Source Removal / Replacement

INTRODUCTION

The x-ray source is located under a shielded aluminum box at the left-side of the unit. It is attached to an adjusting plate by four screws.

TOOL LIST

Standard toolkit

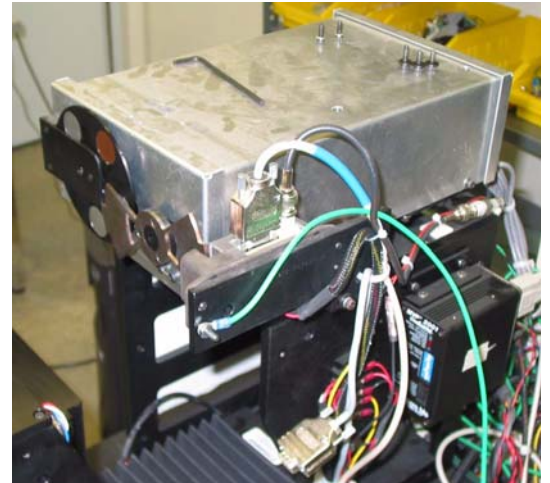
SUPPLIES

Cable ties

Lockwashers

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.



PRECONDITIONS

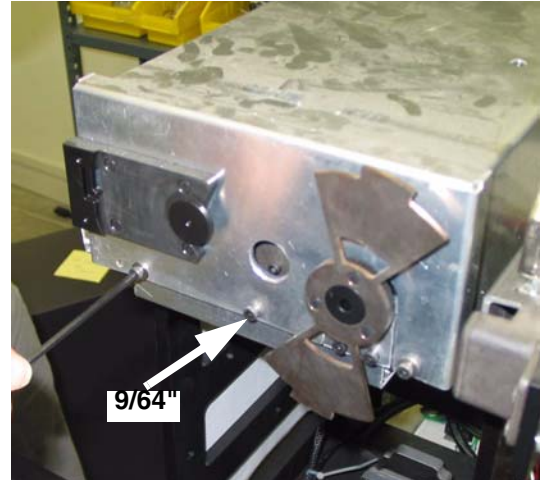
- Machine locked out. See 6.1.1 for details.
- Left and right access panels, case removed. See 6.1.2, 6.1.3 and 6.1.4 for details.
- Equalization bath bracket removed. See 6.2.7 for details
- Remove filter wheel. See 6.2.9 for details.

Note: *The x-ray source may be removed without taking off the right cover or case. In order to do this, a shortened hex key will be needed to access the 4 screws on the top of the X-ray source shield.*

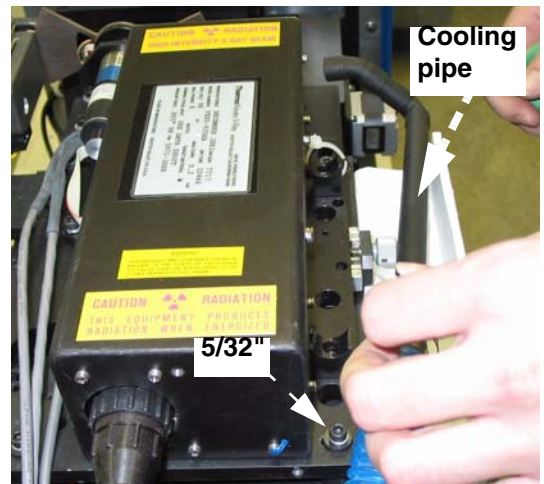
REMOVE

1. Loosen and remove rear source shielding using thumbscrews. Set aside.

- Using 9/64" hex key, remove 3 hex screws and flatwashers securing front source shielding. Set shield aside.
- Similarly, remove 4 screws and flatwashers securing source top shielding from source. Support shield as last screw is being removed to prevent it from dropping.



- Cut cable ties and remove cooling pipe. Set pipe aside.
- Using 5/32" hex key, remove four hex screws, lockwashers and flatwashers securing base and source to adjusting plate.
- Disconnect main cable from rear of x-ray source.

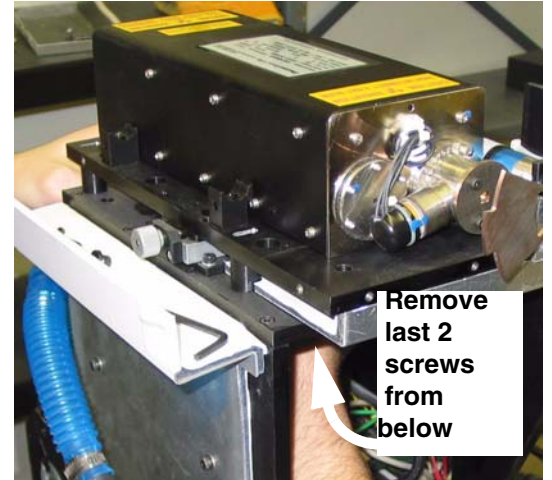


- Using 9/64" hex key, remove 2 front screws securing x-ray source to adjusting plate. Loosen back two screws.



- Using 9/64" ball driver, remove back two screws **from below**. Remove source.
- Remove the collimator from the old source and install it on the new source - 3 hex screws need to be removed.

WARNING *There are 3 washers on each screw separating the tube from the collimator. They may fall out as you are removing the collimator. These washers must be properly replaced in the new source - the 3 washers separating tube from collimator provide the needed spacing for cooling. This prevents tube damage and early failure.*



LEXAN COLLIMATOR WINDOW The lexan collimator window that is found between the source and the collimator should be discarded if it is present. It gets yellow and brittle, and may affect image quality.

REPLACE

- Place source on adjusting plate.
- With plate flat, insert and tighten two rear screws into adjusting plate from below.
- Tilt adjusting plate, insert and tighten two front screws.
- Re-grease top of four posts as required.
- Locate and place adjusting plate onto two dowels.
- Insert and loosely tighten four screws, lockwashers and flatwashers.
- SNUG - DO NOT TIGHTEN THE TWO SCREWS BENEATH THE COOLING TUBE.** These are inaccessible after the cooling tube has been replaced.

FOLLOW-ON PROCEDURES

Replace shields, case and panels. X-Ray Source calibration is required (see Chapter 7).

Two back screws need to be tightened after calibration using t-handle through top of shield.

Note: *When calibrating, the collimator may need to be filed down should black spots appear on the edges in Fluoro (NOT black edges as seen before masking). This is due to the different cone angles for each source.*

6.2.14 Shutter Drive Motor Assembly Removal / Replacement

INTRODUCTION

The shutter drive motor is located next to the x-ray source under a lead-shielded aluminum box at the left-side of the unit.

TOOL LIST

Standard toolkit

SUPPLIES

Cable ties

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

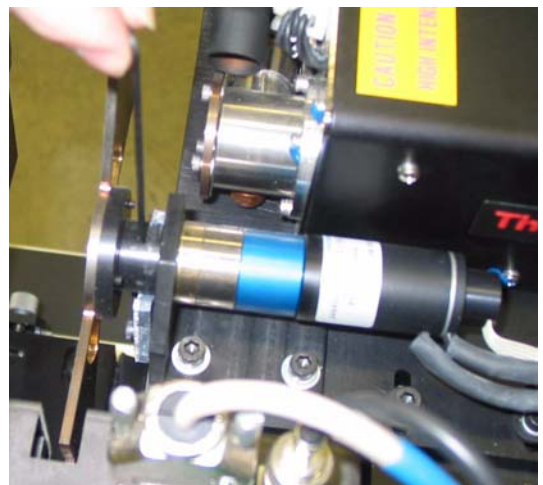
PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Left access panel removed. See 6.1.2.
- X-ray source shielding removed. See 6.2.13 for details.
- Filter wheel removed. See 6.2.9 for details.

Note: *The x-ray source may be removed without taking off the right cover or case. In order to do this, a shortened hex key will be needed to access the 4 screws on the top of the X-ray source shield.*

REMOVE

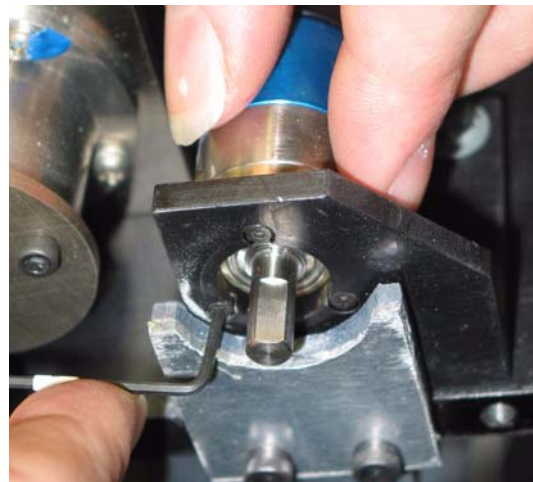
1. Using 5/64" hex key, loosen two set screws securing shutter arbor to shutter motor shaft. Remove arbor and set aside.
2. Disconnect cables and ground from shutter motor at shutter motor controller.



3. Using 1.5mm hex key, remove 3 screws securing shutter motor to bracket.

REPLACE

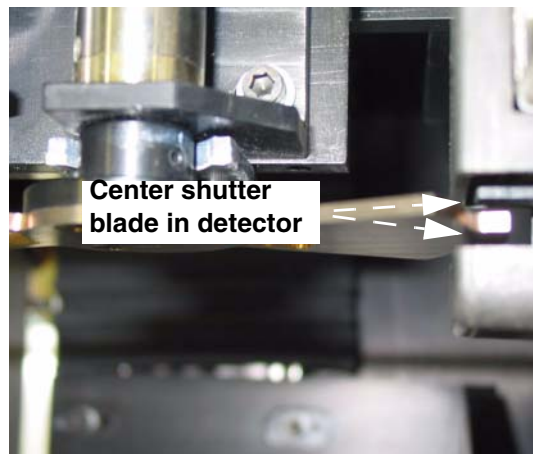
1. Reversal of removal.
2. Ensure that set screw is seated on flat of shaft.



3. Ensure that shutter blades are centered in shutter control assembly upon installation.

FOLLOW-ON PROCEDURES

Replace all shielding, covers, case and panels, and perform an "abridged" calibration (see Chapter 7).



6.2.15 Collimator Window Removal

INTRODUCTION

The collimator window is a thin Lexan shield located at the front of the x-ray source, behind the bronze-coloured metal collimator. The window can be accessed through the sliding door, with the case on.

This window, if present, should be discarded. It gets yellow and brittle, and may affect image quality.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

The X-ray source opening contains beryllium. Do not touch it.

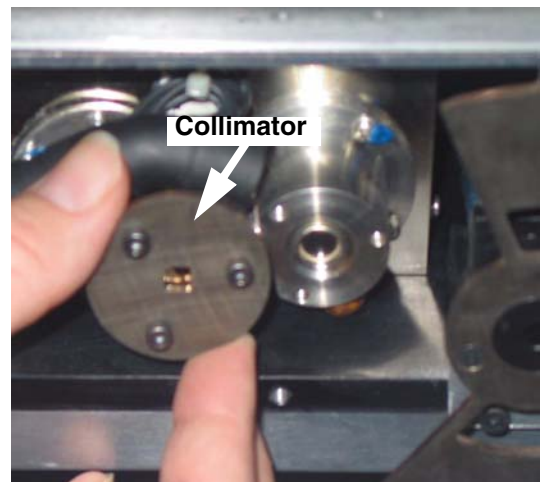
WARNING
DO NOT
TOUCH THE
OPENING OF
THE X-RAY
SOURCE WITH
COLLIMATOR
REMOVED.

PRECONDITIONS

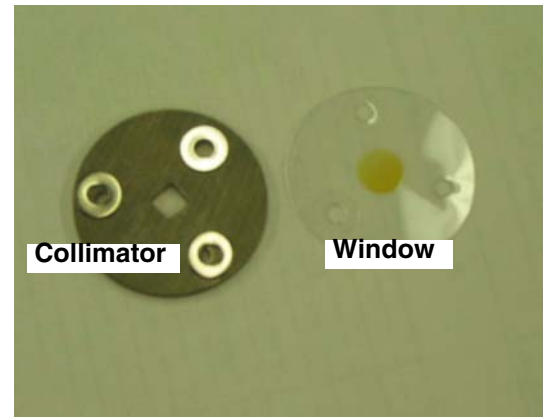
- Machine locked out. See 6.1.1 for details.
- Filter wheel assembly removed. See 6.2.9 for details.
- X-ray source front shielding removed. See 6.1.5 for details.

REMOVE

1. Using 9/64" hex key, remove three screws from collimator. Note position of collimator for later re-installation.

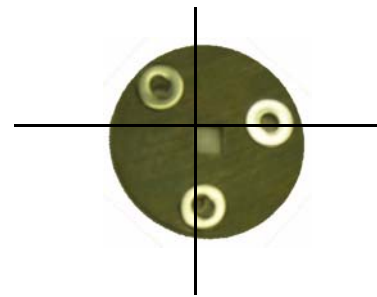


2. Window, that is to be discarded, is located behind the collimator. Washer is between window and collimator.



RE-INSTALL COLLIMATOR

1. Ensure that collimator is re-installed so that opening is 'square', and not on an angle.



FOLLOW-ON PROCEDURES

None

6.2.16 Detector Removal / Replacement

INTRODUCTION

The detector is bolted to the stand with four screws and lockwashers.

TOOL LIST

Standard toolkit

SUPPLIES

- Cable ties
- Lockwashers

SAFETY CONSIDERATIONS

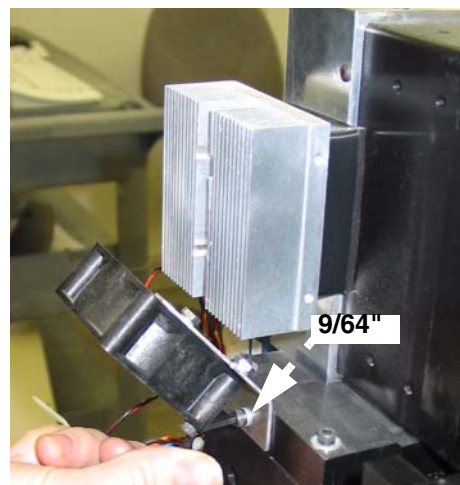
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

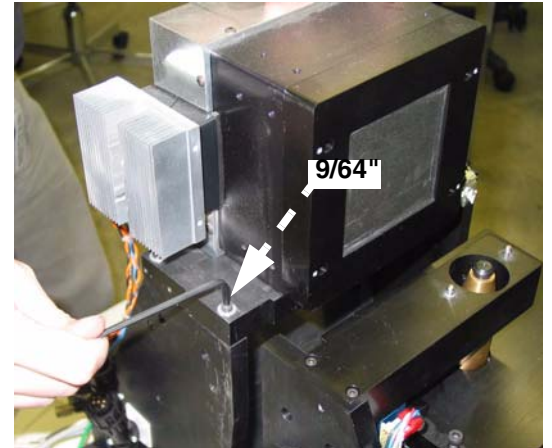
- Machine locked out. See 6.1.1 for details.
- Right access panel removed. See 6.1.3 for details.
- Equalization bath bracket removed. See 6.2.7 for details.

REMOVE

1. Using 9/64" hex key, remove two screws and lockwashers securing cooling fan to back of detector.
2. Remove cable ties from fan cable.
3. Loosen and disconnect 3 cables to bottom of detector



4. Using 5/64" hex key, remove the ground cable from detector.
5. Using 9/64" hex key, remove four screws and lockwashers securing detector to stand. Support detector while removing. Set aside.



REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

Detector Replacement calibration is required (see Chapter 7).

6.2.17 Fan 2.0625 (Below X-Ray Source)

INTRODUCTION

This fan is located below and to the rear of the x-ray source. It can be removed from the left-hand side and through the door with the case in place.

TOOL LIST

Standard toolkit

SUPPLIES

Mirror

SAFETY CONSIDERATIONS

None

PRECONDITIONS

- Machine locked out. See 6.1.1 for details.
- Left access panel removed. See 6.1.2 for details.
- Left x-ray shield removed. See 6.1.5 for details.

REMOVE

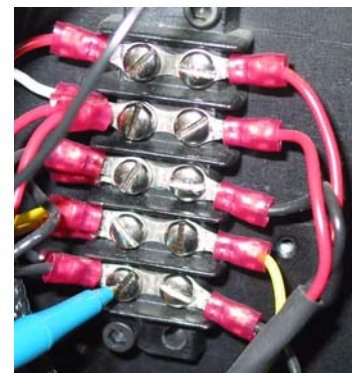
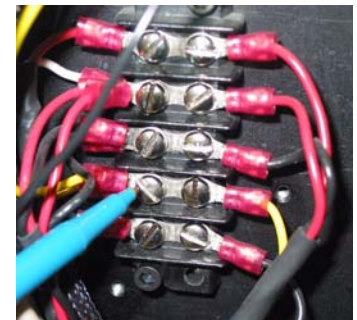
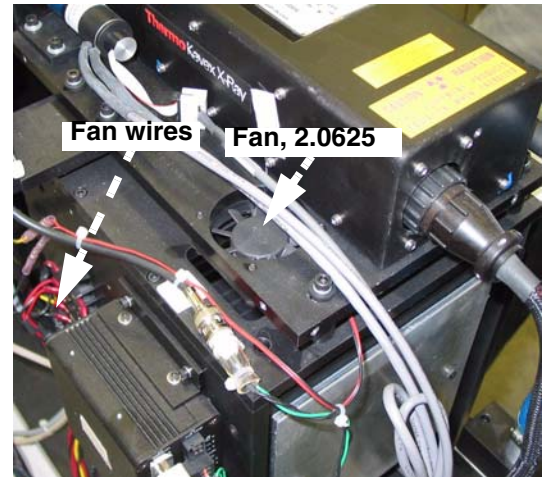
1. Using 9/64" hex key, remove four hex screws and lockwashers and flatwashers securing fan to adjusting plate. Fan will pull down through the hole once the wires are free.
2. Cut cable ties securing fan wires
3. Using mirror and small slotted screwdriver, locate and remove fan wires from terminal. Note the wire location.

REPLACE

1. Insert and secure fan into place and feed wires out to rear of unit. Fan must be blowing down and away from x-ray source.
2. Attach fan wires and secure to terminal block with slotted screwdriver.

FOLLOW-ON PROCEDURES

None



6.2.18 Shutter Control Assembly Removal / Replacement

INTRODUCTION

The shutter control assembly. can be removed with the case on, through the door and with the left panel removed.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

- Machine locked out. See 6.1.2 for details.
- Left access panel removed. See 6.1.2 for details.

REMOVE

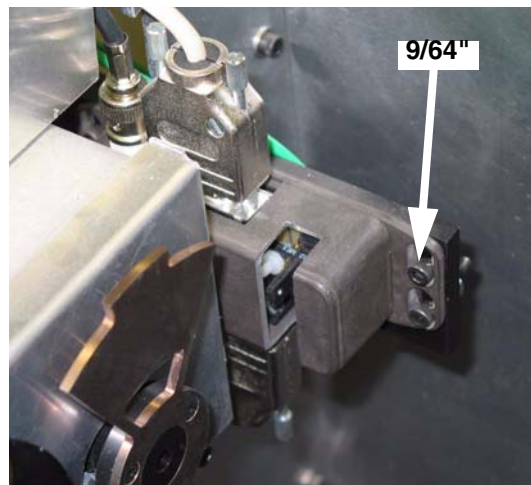
1. Remove four cables to shutter control assembly – two above, two below.
2. Using 11/32" socket, remove nut and green ground wire from (long screw) at rear of control assembly.
3. Using 9/64" hex key remove four screws securing shutter control to bracket.

REPLACE

1. Reverse of removal.
2. Line up control assembly so that the sensor is aligned with the centre of the shutter and will not interfere with rotating shutter.

FOLLOW-ON PROCEDURES

None



6.2.19 Door Interlocks Removal / Replacement

INTRODUCTION

The sliding door is equipped with an interlock and an interrupt.

TOOL LIST

Standard toolkit

SUPPLIES

None

SAFETY CONSIDERATIONS

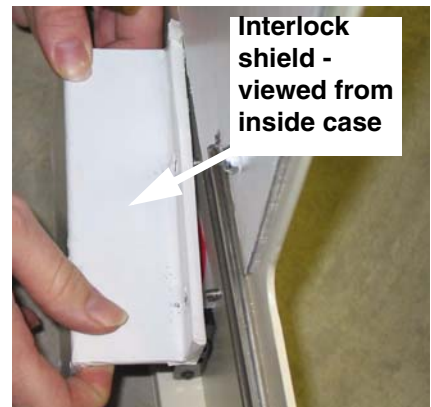
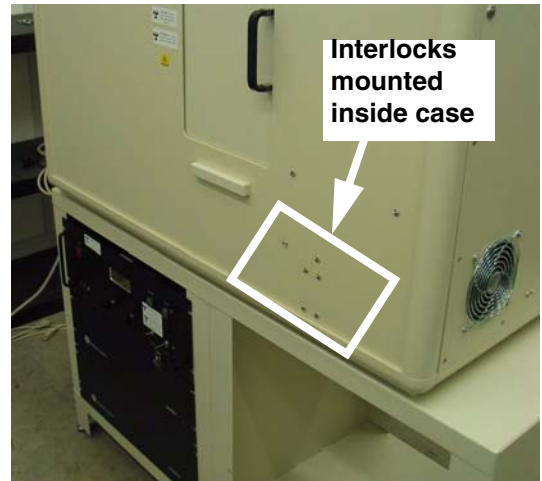
X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

PRECONDITIONS

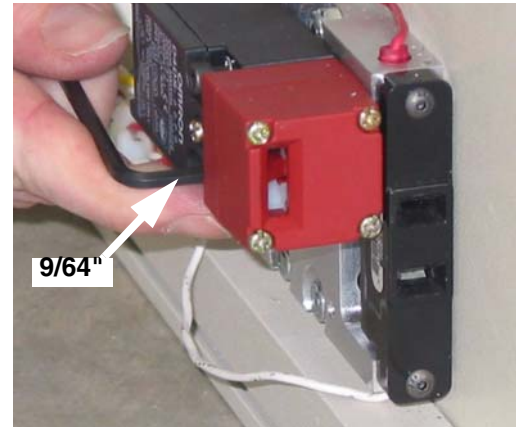
Machine locked out. See 6.1.1 for details.

REMOVE

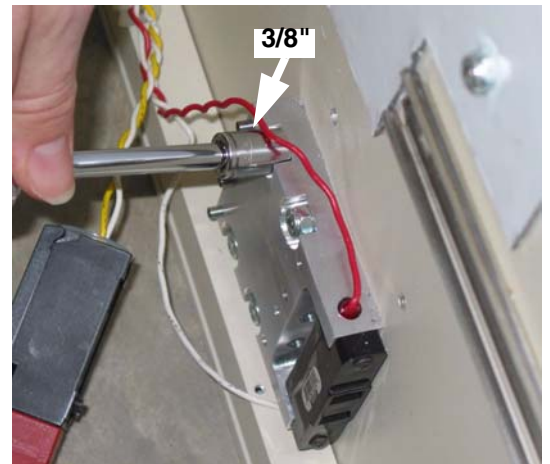
1. Using 3/8" socket, remove two screws securing shield from interlocks. Shield has tamper-proof screws on outside.



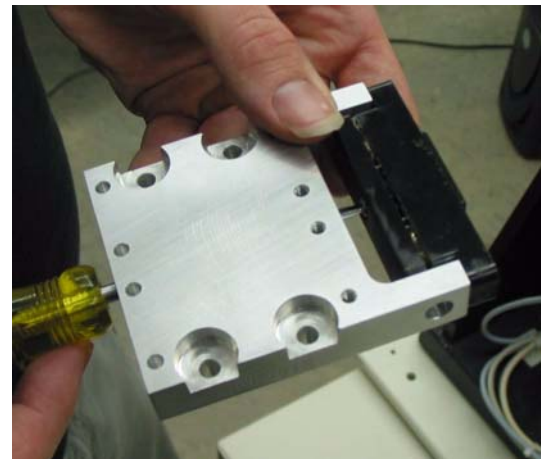
2. Using 9/64" hex key, remove two screws securing interlock to bracket.
3. Using Phillips screwdriver, open access cover and remove wires.



4. Using 3/8" socket, remove the four tamper-proof screws securing the switch mounting block to the case.
5. Using a narrow slotted screwdriver, loosen the cover on back of switch.



6. Using slotted screwdriver, loosen two terminals and remove wires from terminal and through holes in block.
7. Remove switch from mounting block to replace.
8. Disconnect wires into switch.



9. Remove switch from mounting block with 5/64" hex key.

REPLACE

Reverse of removal.

FOLLOW-ON PROCEDURES

None



Chapter 7

Calibration

Section 7.1

Overview

7.1.1 Purpose

This Chapter describes how to calibrate the eXplore Locus SP. The calibration procedures differ depending on which component is being replaced.

- **Detector Replacement** (see Section 7.2)
Detector replacement calibration involves: Mechanically Adjust Detector, Find X-Ray Mask Values, Start Transform1 File Creation, Complete Transform1 File Creation, Create Transform2 and Transform4 Files, Calculate Central Slice of X-Ray Source, Verify Stage Alignment, Centre the Stage, Calculate Source to Detector Distance, Edit Calibration Settings, Calculate & Edit Magnification Difference, Perform Verification Scans, Follow Up.
- **Stage Replacement** (see Section 7.3)
Stage replacement calibration involves: Mechanically Align the Stage, Centre the Stage, Perform Verification Scans.
- **X-Ray Source Replacement** (see Section 7.4)
Source replacement calibration involves: Centre the X-Ray Source, Centre the Stage, Calculate Central Slice of X-Ray Source, Verify Stage Alignment, Calculate Source to Detector Distance, Edit Calibration Settings, Calculate & Edit Magnification Difference, Perform Verification Scans, Follow Up.
- **Abridged Calibration** (see Section 7.5)
Each time the case/shielding is removed from the SP Locus, or the system is re-located, the following calibration steps are performed: Centre the Stage, Perform Verification Scans, Edit Calibration Settings, Follow Up.

Since the major calibration steps (e.g. Centre the Stage) may vary slightly depending on the sequence of calibration, all major steps are repeated within the various sections for ease of use.

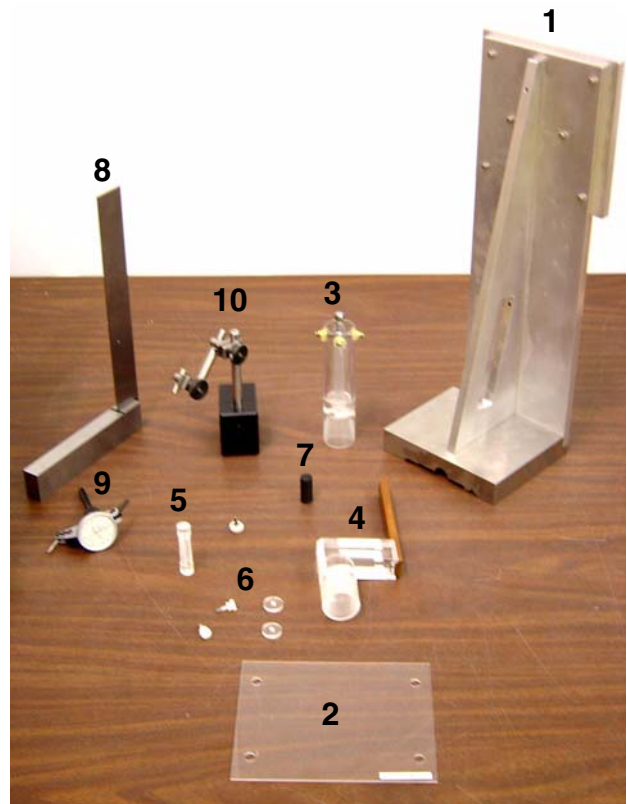
NOTICE *These calibration procedures are proprietary and confidential. Access to these procedures are restricted to GE Technical Service personnel only.*

NOTICE *Refer to the Lockout & Tagout procedure in Chapter 1 before servicing the system.*

7.1.2 Calibration Kits

eXplore Locus SP Calibration Kits contain the following items:

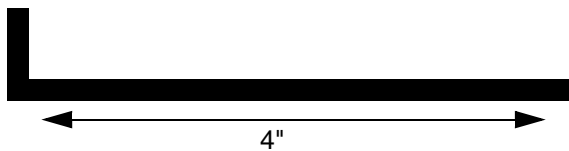
- Detector Alignment Plate 1
- Bebe Grid 2
- X,Y Ball Centring tool and adjustment key 3
- Distance tool 4
- Wire Phantom 5
- White nylon screws & washers 6
- Measured Plastic dowel (value is indicated on storage tube) 7
- 9" Square 8
- Precision Dial Indicator 9
- Dial Indicator Mount 10



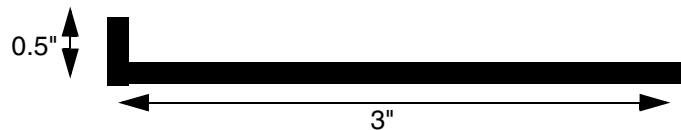
Additional tools required include:

- Shims
- 8mm socket and ratchet
- T-Allen 5/32"
- Personal radiation dosimeter
- *custom* Allen keys -

The *Centre the Source* procedure requires an Allen (or hex) key that fits a 9/64" socket, and has a maximum length of 4";



The *Centre the Stage* procedure requires an Allen (or hex) key that fits a 5/32" socket, and has a length of 3" and a head of only 0.5";



- Calibration Worksheets which are found in the Appendix, Chapter 99 (use a printed copy for recording calibration values and calculations).

Section 7.2 Detector Replacement Calibration

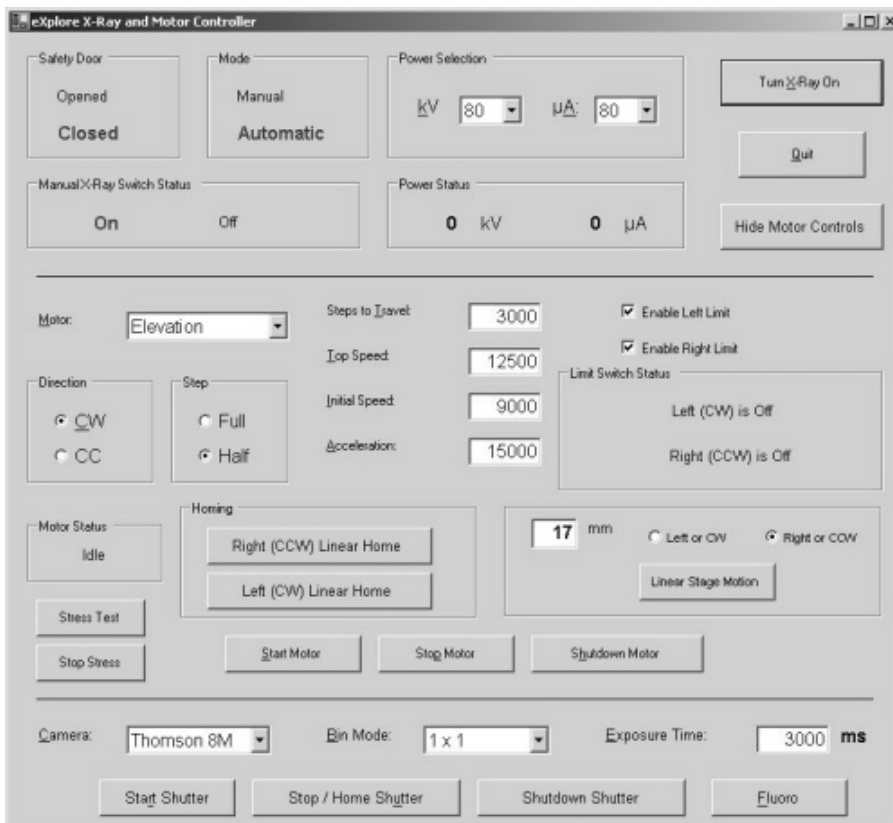
The procedures below use the following applications:

- **System Warm-Up** (C:\Program Files\GE Medical Systems\Explore Utilities\WarmupApp.exe)
- **Calibration Tools** (C:\Program Files\GE Medical Systems\Explore Utilities\Calibration.exe)
- **X-Ray and Motor Controller**. The **X-Ray and Motor Controller** (C:\Program Files\GE Medical Systems\Explore Utilities\X-Ray_Controller.exe)
- **transgen** program (C:\Program Files\GE Medical Systems\Explore Utilities\Calibration\transgen.exe)

7.2.1 Mechanically Adjust Detector

This mechanical adjustment ensures the detector and stage are correctly positioned. To perform a detector adjustment:

1. Access the **X-Ray and Motor Controller** program.

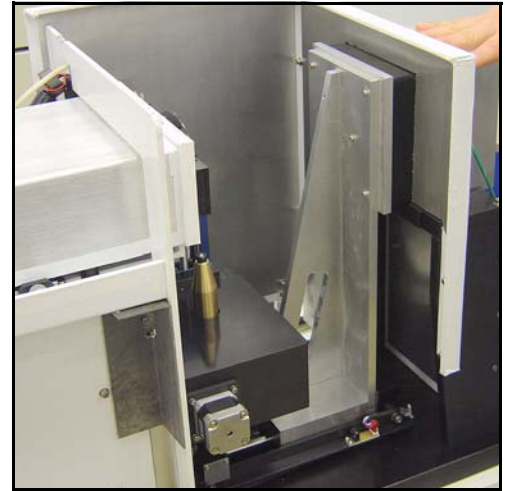


2. Ensure the fields below are set to the following settings:
Enable Left Limit: checked off
Enable Right Limit: checked off
Camera: Thomson 8M
Bin Mode: 1 x 1
Exposure Time: 3000 ms

kV: 80

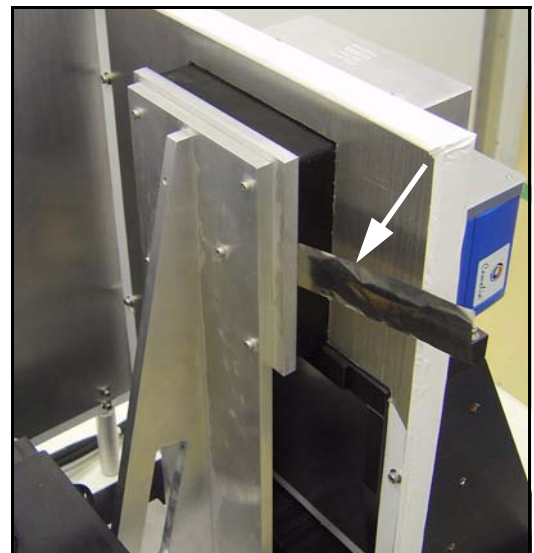
μ A: 80

3. Find the motor limit switch (this ensures that the limit switches will never be triggered):
 - select *Magnification* from the drop down menu in the Motor field
 - press the *Left (CW) Linear Home* button to move the stage toward the detector
 - enter **2** in the mm field, click on the *right or CCW* radio button, then press the *Linear Stage Motion* button to offset the "home" position by 2 mm.
4. Move the stage **140mm** to the right.
5. Use the Detector Alignment Plate to position the detector so that it is precisely parallel and perpendicular to the magnification rail.

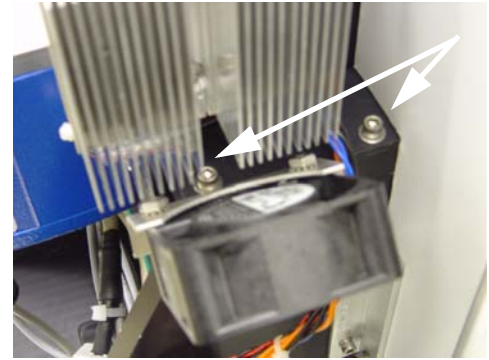
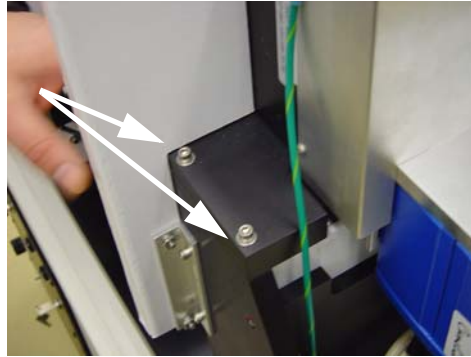


Note: *The difference in the gap between the Detector Alignment Plate and the detector should be no more than .001" on any given side.*

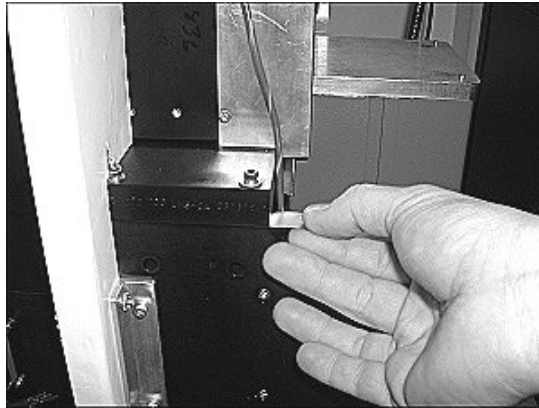
The feel of the shim as it moves between the detector and the Detector Alignment Plate is what will indicate any spatial difference in the gap between the detector and all four sides. All four sides should be flush. The corners will typically feel slightly tighter than the sides.



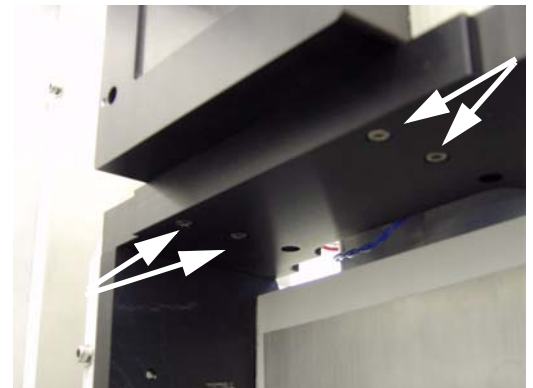
6. Loosen the 4 detector mounting bolts to adjust the detector alignment first.



7. Shim the detector mounting bracket to adjust the elevation and twist the detector while the bolts are loose to adjust the azimuth.



8. If the alignment can not be accomplished with this adjustment, loosen and adjust using the 4 bottom detector mounting bolts.



7.2.2 Find X-Ray Mask Values

WHY DO THIS?

Mask files capture the usable part of the detector so only that area is displayed in **Fluoro**.

The Locus SP CCD (Charge Coupled Device) contains an array of 2300 by 3500 pixels. Due to the size and variance between fiber optic tapers, there are a limited number of the CCD's pixels that will actually receive photons from the x-ray tube. It is for this reason that the screen is masked.

Masking is the ability of the camera to only save the detection of photons for a specified range (i.e. same idea as cropping a picture). We want to avoid including pixels which will not receive photons because pixels that do not receive light have no value but they will increase file size, correction and assembly time.

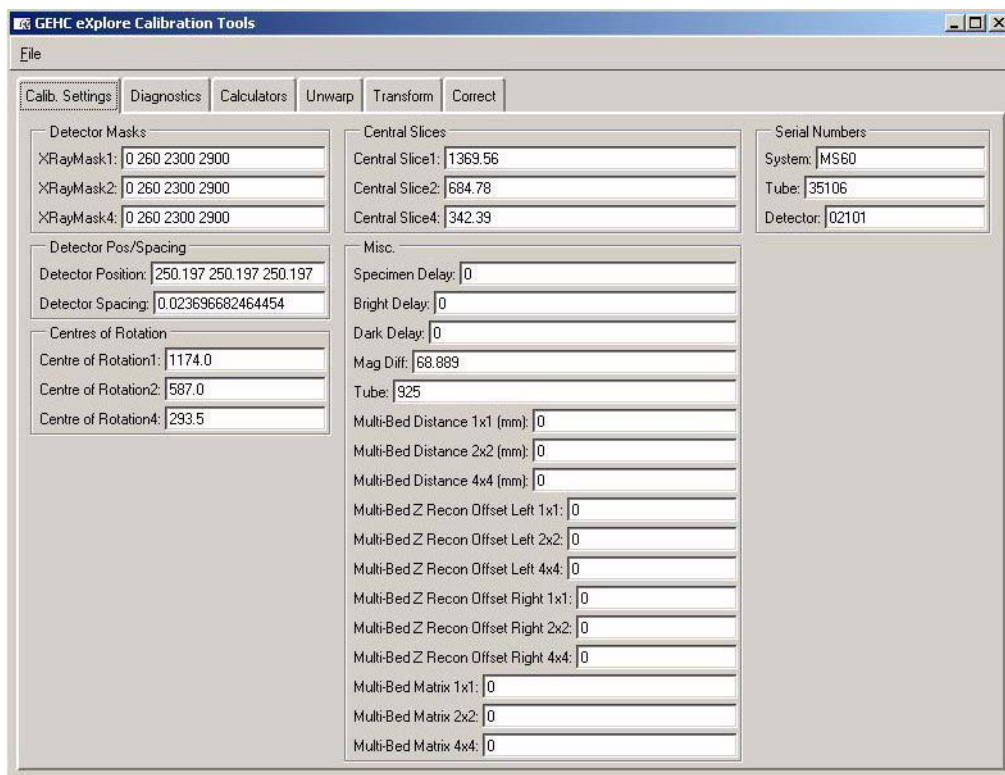
1. Open **Windows Explorer** and navigate to D:/. Copy the *calib* folder and rename it *original_calib*. Navigate to C:/ and copy the *translations* folder and rename it *original_translations*
2. Install the Bebe grid using the white nylon screws and washers, and ensure the filter wheel setting is set to 4. Don't tighten the screws on the bebe grid too much as it will distort the image. Tighten it just so that the grid does not move. Centre the grid on the detector.



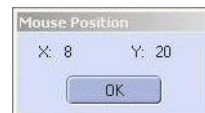
3. Warm-up the X-Ray Source using the **System Warm-Up** application as follows:
 - right-click the Warm-Up icon in the task bar and select the *<=10 Minutes to Scan* option
 - once the cycle has finished (approximately 14 minutes), right-click the icon again and select *Scan Mode*.

The **System Warm-Up** application can be re-initialized by double-clicking on *WarmupApp.exe* in C:\Program Files\GE Medical Systems\Explore Utilities\

- Open the **Calibration Tools** program, click *OK* when the warning pop-up is displayed, then choose the *Calib. Settings* tab. **Calibration Tools** is located in C:\Program Files\GE Medical Systems\Xplore Utilities\Calibration\.



- Click *File* and choose *Read Registry Values* from the drop-down menu.
- Change the values in the XRayMask1, XRayMask2, and XRayMask4 fields to: **0 0 2300 3500** (be sure to include the spaces)
- Click *File* and choose *Write Registry Values* from the drop-down menu.
When prompted for a password, enter: **EvS8899**
- Ensure the X-Ray switch on the unit is ON and the red Reset button is not lit.
- Click the *Start Shutter* button on the **X-Ray and Motor Controller** screen.
- Click the *Turn X-Ray On* button.
- Click the *Fluoro* button, then:
 - select *OK* when the warning pop-up appears.
 - select *OK* when the text concerning placement of the specimen appears.
- Press *m* in **Fluoro** to display the mouse position window.



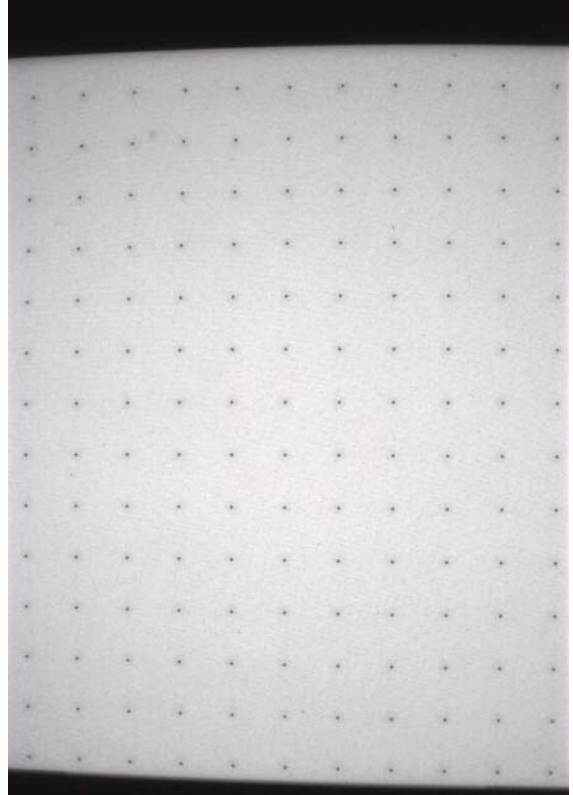
The usable area of the detector appears as the grey area in **Fluoro** - it is usually bounded by black borders at the top and bottom of the screen (unusable area).

The objective is to determine the coordinates of the largest rectangle possible within the grey area of the screen that encompasses 11 x 14 bebes.

If not all the 11 x 14 bebes appear, turn off the X-Ray Source and physically move the grid so all 11 x 14 bebes are visible. Only complete rows and columns of bebes can appear on the screen. If necessary, fewer than 11 x 14 bebes will work in extreme cases

Ensure that there is equal spacing between all 4 outside edges and the 4 outermost bebe rows/columns.

13. Using the mouse pointer, determine the following 4 values (which must be multiples of 4):
 - The lowest x value in the usable rectangle (usually 0)
 - The top of the y axis boundary (e.g. 320)
 - The highest x axis boundary (usually 2300)
 - The lowest y boundary minus the top y boundary (e.g. 2850)



14. Make note of these values in the Worksheet (e.g. 0 320 2300 2850) and exit **Fluoro**.
15. Access **Calibration Tools** and choose the *Calib. Settings* tab.
16. Click *File* and choose *Read Registry Values* from the drop-down menu.
17. Change the values in the three XRayMask1, XRayMask2, and XRayMask4 fields to reflect your new values e.g. 0 320 2300 2850 (be sure to include the spaces between the numbers). All three fields should contain the same values.
18. Click *File* and choose *Write Registry Values* from the drop-down list. When prompted for a password, enter: **EvS8899**
19. Click the *Fluoro* button.
20. Confirm that only the grey, usable area of the detector appears on the screen (i.e. no black borders).

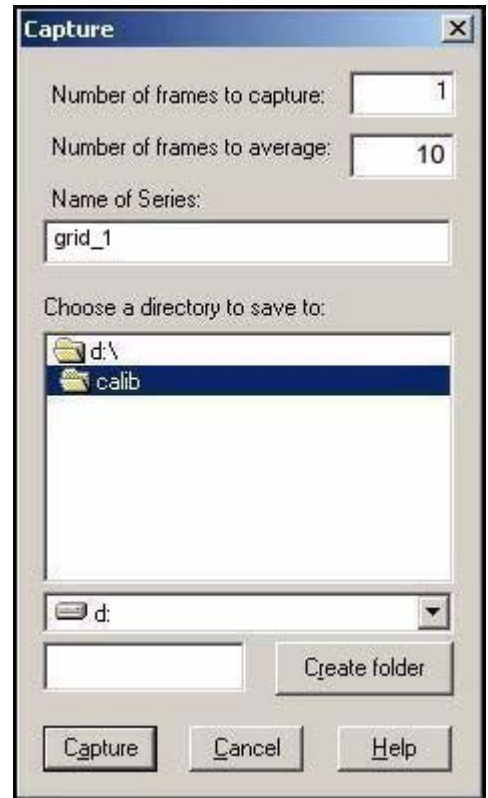
If black borders still appear on the screen exit **Fluoro** and the **X-Ray and Motor Controller**, and repeat the steps needed to read and re-write the registry values until only the usable area of the detector is visible. The mouse position values, in this case, are only valid if you are viewing the full screen (e.g. 0 0 2300 3500).

Capture an Image:

21. Capture an image in **Fluoro** as follows:

- click *Menu* at the top of the **Fluoro** screen and choose *Capture* from the drop-down menu
- once the Capture pop-up is displayed, enter **1** in the Number of Frames to Capture field
- enter **10** in the Number of Frames to Average field
- name the file *grid_1* in the Name of Series field
- save the file to the directory: D:\calib
- click the *Capture* button.

The progress of capture is shown in the Fluoro's title bar as *[saving...]*. Wait until the image is captured.



- 22. Turn off the X-Ray Source.
- 23. Capture a dark image in **Fluoro**, and call this image *dark*.
- 24. Remove the bebe grid.
- 25. Turn the X-rays back on and wait a few minutes for the Source to stabilize.
- 26. Capture a bright image in Fluoro and call this image *bright*.

Keep X-Ray Source warm by leaving it on.

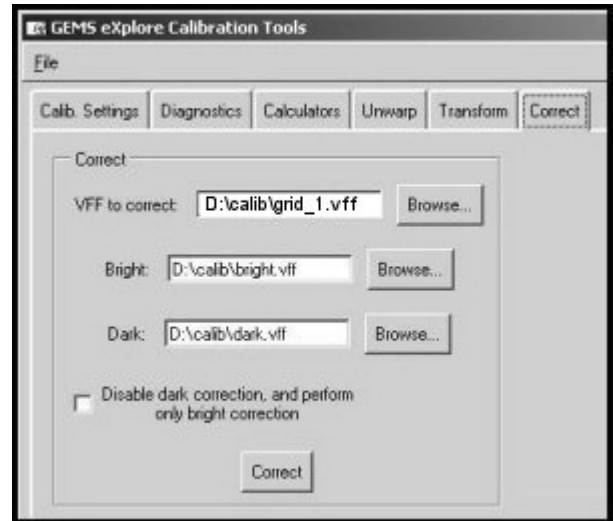
7.2.3 Start Transform1 File Creation

WHY DO THIS?

The goal here is to remove the distortion caused by the fiber optic taper. This is accomplished by capturing a raw image of the bebe grid which is a known standard (equally spaced bebes). Using the Transgen program, we can specify the distance between pixels on the detector - therefore, when we unwarp an acquired image, the corresponding pixels will be properly represented in MicroView. The end result means that when we unwarp the acquired bebe grid, it will be an accurate representation of the actual (physical) grid.

To start the Transform1 file creation:

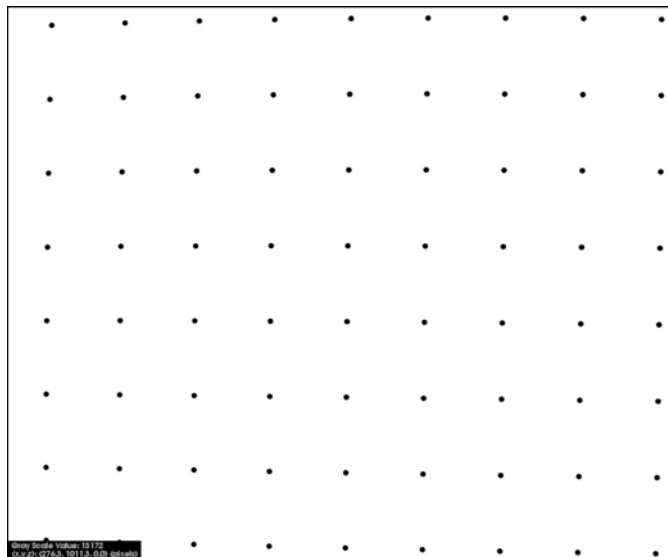
1. Correct the grid image using the **Calibration Tools** program as follows:
 - click on the *Correct* tab
 - in the VFF to Correct field, find the newly captured image
 - use the *Browse* buttons to find the *bright* and *dark* files created earlier
 - click the *Correct* button (the corrected file is named *corrected.vff* and it is stored in the same folder in which the captured imaged was stored)



2. Double-click on *corrected.vff* in **Windows Explorer** to load the image into **MicroView** and confirm that the grid has been corrected (image looks cleaner with less noise in between the bebes).
3. Double-click on the W and L parameters in the lower right of the screen. Change the Update mode to *Delayed updates*. This only needs to be changed once.



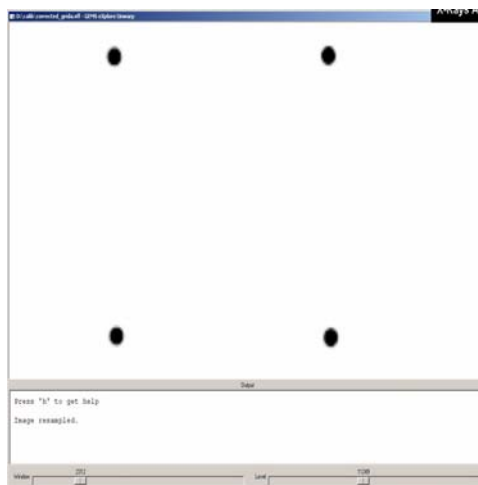
4. Close **MicroView** upon completion.
5. Use **Windows Explorer** to rename the corrected image to *corrected_grid.vff*
6. Run the **transgen** program. The **transgen** program is located in C:\Program Files\GE Medical Systems\Explore Utilities\Calibration\.
7. Load the *corrected_grid* file into the **transgen** program.



8. Adjust the *Window* (e.g. 2300) and *Level* (e.g. remove graininess) until there are minimal pixels visible except for the grid's bebes. Make the bebes as big and round as possible, zooming in on individual bebes to check their roundness and the surrounding area for visible stray pixels.

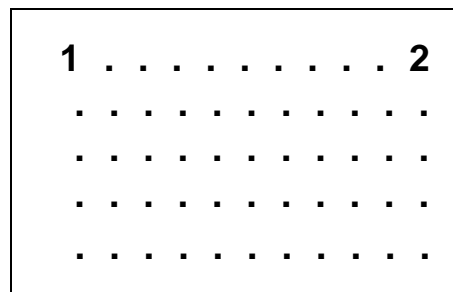
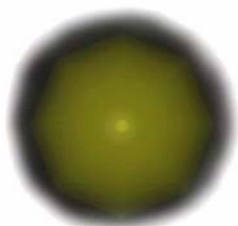
Not getting the *Window* and *Level* right may affect the centroid calculations.

To Pan, move the mouse while pressing Shift plus the left mouse button simultaneously. To Zoom, move the mouse up (to magnify) or down (to zoom out) while pressing the right mouse button.



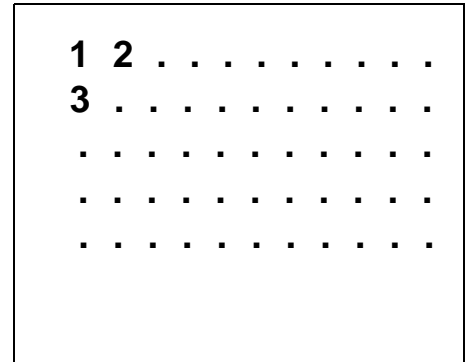
Note: *If stray pixels touch or are close to any bebe, take a new image.*

9. Place the cursor over the centre of the first bebe on the top left of the grid and press **1**.



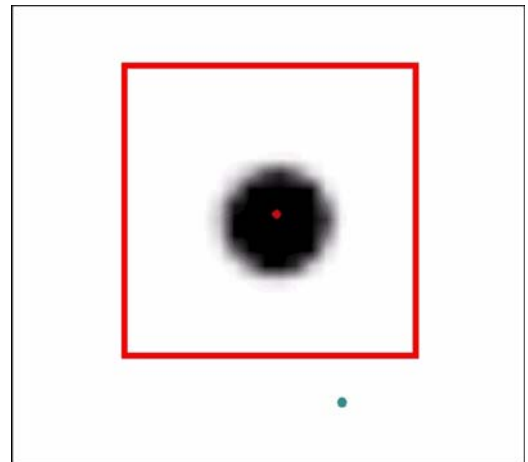
10. Place the cursor over the centre of the last bebe on the top right of the grid and press **2**.
11. Determine how many pixels there are between 1 and 2 (marker 2's x position minus marker 1's x position) and record in the Worksheet.

12. Manually divide this number by the number of spaces between the bebes (this number will be 10 if all bebes are visible). This is the average distance between the bebes. Make a note of this value (approximately 213) in the Worksheet. Round the number to the nearest whole number.
13. Press a lowercase **s** to display spacing.
14. Enter the x, y coordinates of bebe 1 (e.g. $x = 37.5$, $y = 83.5$) and record in the Worksheet. Next enter the average distance between the bebes as calculated earlier - enter this average twice e.g. 37.5 83.5 213 213 (be sure to include a space between each number). This tells the system the average spacing between bebes and where you want the system to start (from bebe 1).
15. Move the mouse to the bebe positioned to the right of number 1 and press **2**.
16. Move the mouse to the bebe directly below bebe 1 and press **3**.
17. Press **b** and enter the box size number (start at 33), and record it in the Worksheet.
18. Press **l** (lowercase L) to draw red boxes around each bebe.
Use the Pan and Zoom features to examine every bebe. Ensure that a red box appears around each bebe and that the red dot (centroid) appears approximately in the middle of the bebe.



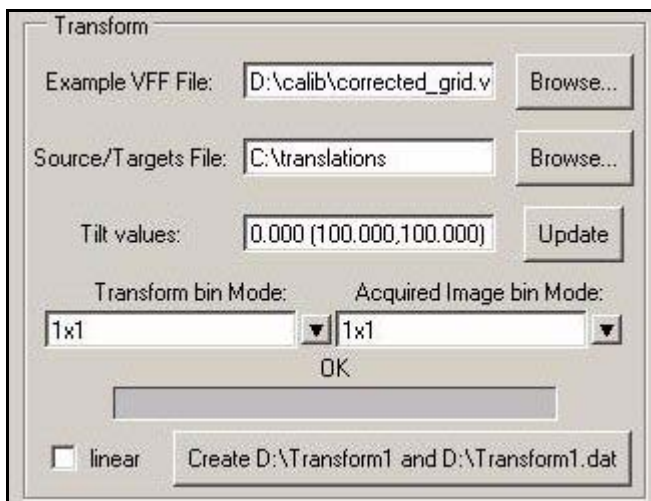
Note: *Bebes cannot appear outside the red boxes, nor can boxes appear outside the field of view. If they do, exit the program and start again by running the **transgen** program and repeating steps 14 through 18, but enter a different box size in step 17.*

19. Press **f** to write the output file to C:\translations (overwriting the existing file).
20. Return to the **transgen** program and press **t**.
The system repositions the bebes into a perfect grid and displays the bebe centroids as blue dots.
Check all the blue dots to ensure all 11x14 appear in the field of view (blue dots do not need to be in the red box). If not, exit the program and start again by running the **transgen** program and reentering the coordinates (the spacing value or origin must change).



21. Calculate the detector spacing by dividing 5 by the average spacing (e.g. $5 \div 213$) and make note of this value in the Worksheet (e.g. 0.023474178) to 9 decimal places.
22. Exit the **transgen** program.

23. Access **Calibration Tools** and click the *Transform* tab.



24. Complete the Example VFF File field using *Browse* to find the *corrected_grid.vff* file.
 25. Ensure the Source/Targets File field is set to *C:\translations*
 26. Leave the Tilt values field as zeros.

Note: If not zeros, click the *Calculators* tab and press *Reset* under Tilt Calculator, then press *Update*. Return to the *Transform* tab and press the *Update* button.

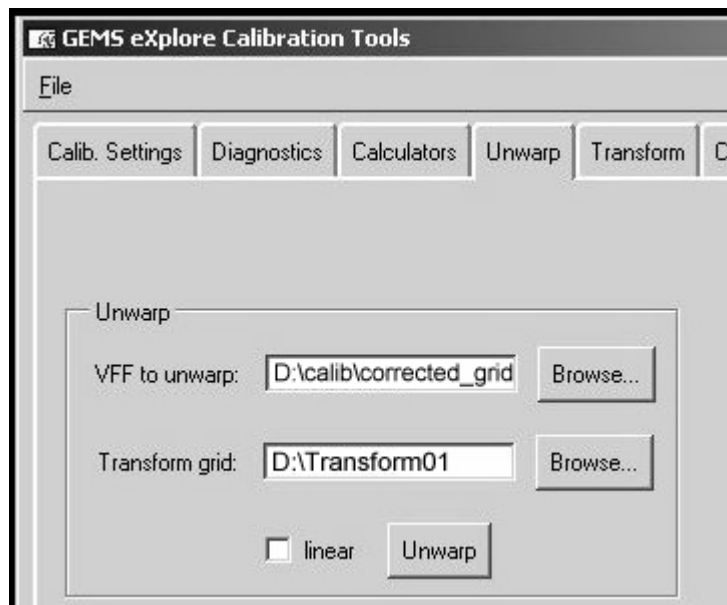
27. Ensure 1x1 appears in the Transform bin Mode field and Acquired Image bin Mode field.
 28. Press the *Create D:\Transform1 and Transform1.dat* button at the bottom of the window.
 29. Use **Windows Explorer** to rename the *Transform1* file and the *Transform1.dat* files to *Transform01* and *Transform01.dat*.

30. Access **Calibration Tools** and click the *Unwarp* tab and complete the fields as follows:
 VFF to unwarp: *D:\calib\corrected_grid*
 Transform grid: *D:\Transform01*

31. Click the *Unwarp* button.
 32. Call the file *D:\zz* when prompted to name the file, then click *OK*.

The *zz* file will be used as a temporary file for unwarping. Continue to overwrite this file whenever unwarping.

33. Double-click *zz* in **Windows Explorer** to load the unwarped *corrected_grid* file into **MicroView**.



34. Check that the unwarped corrected_grid file is straight by dragging another window edge over the rows and columns of bebes. Use the window's edge as a ruler to ensure the bebes are perfectly aligned both vertically and horizontally.

If bebes are not aligned, repeat the creation of transform files.

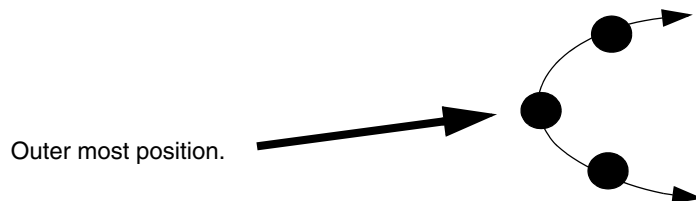
7.2.4 Complete Transform1 File Creation

This set of procedures determines the tilt angle of the installed bebe grid and generates a new Transform file to compensate for the angle.

To calculate the tilt:

1. Turn off X-Ray Source and position the X,Y Centring Ball tool on the cone.
2. Turn on the X-Ray Source.
3. Open **Fluoro** and press **m** to display the mouse position on the **Fluoro** screen.
4. Use the **X-Ray and Motor Controller** to elevate the stage until one small bebe appears in the middle y axis of the display screen.
5. Rotate the tool until the bebe is on the left side of the screen (approximately 250 pixels from the outside of the screen). To get the bebe 250 pixels from the outside, adjust the magnification (approximately 40mm away from the detector).

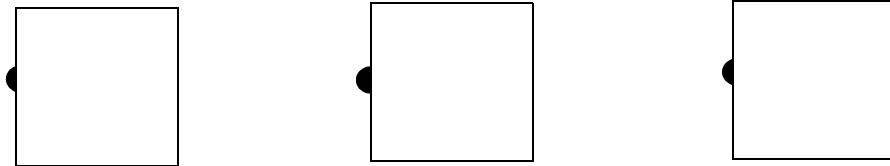
Note: *The next few steps attempts to find the value of the bebe's outer most position during the bebe's rotation arc. Using the mouse window as a reference point, the tool is **slightly** rotated in each direction until the outer most position is determined.*



- Place the mouse position window over the bebe (to use the lines of the window as a reference point).



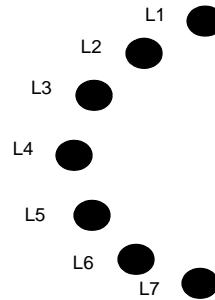
- Rotate the stage in both directions to determine the bebe's outer most position. As the bebe is rotated, the bebe moves out from under the mouse position window.



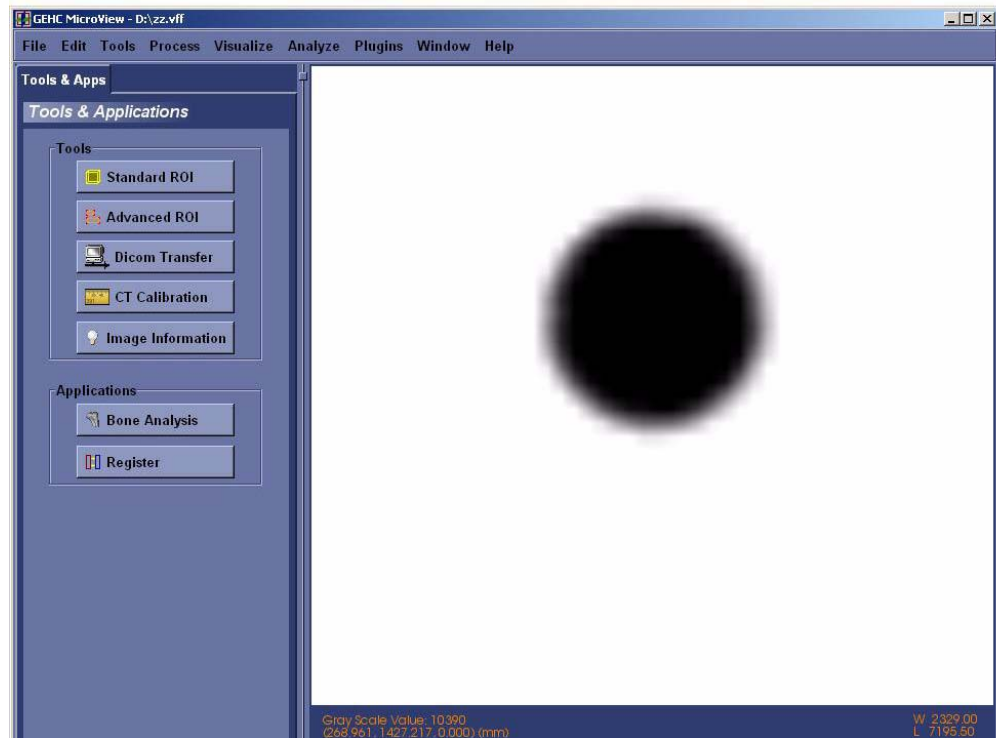
Note: *Once the outer most position is found, images will be captured. Save the images in D:\calib. The objective is to capture an image of the outer most position plus 3 images on either side of this position. To do this:*

- Rotate until the bebe is in its outer most position.
- Rotate 3 degrees past the outer most position and capture the image. Name the image *L1*. Record the x and y positions of L1, and the others below, in the Worksheet.
- Rotate 1 degree back toward the outer most position and capture the image. Name the image *L2*.
- Rotate 1 degree toward the outer most position again and capture the image. Name the image *L3*.
- Rotate 1 degree in the same direction and capture the image. Name the image *L4*. This should be your outer most position in **Fluoro**.
- Continue to rotate 1 degree and capture the image. Name the image *L5*.
- Rotate another 1 degree and capture the image. Name the image *L6*.

15. Rotate another 1 degree and capture the image. Name the image *L7*. Your captured images should approximate the following:

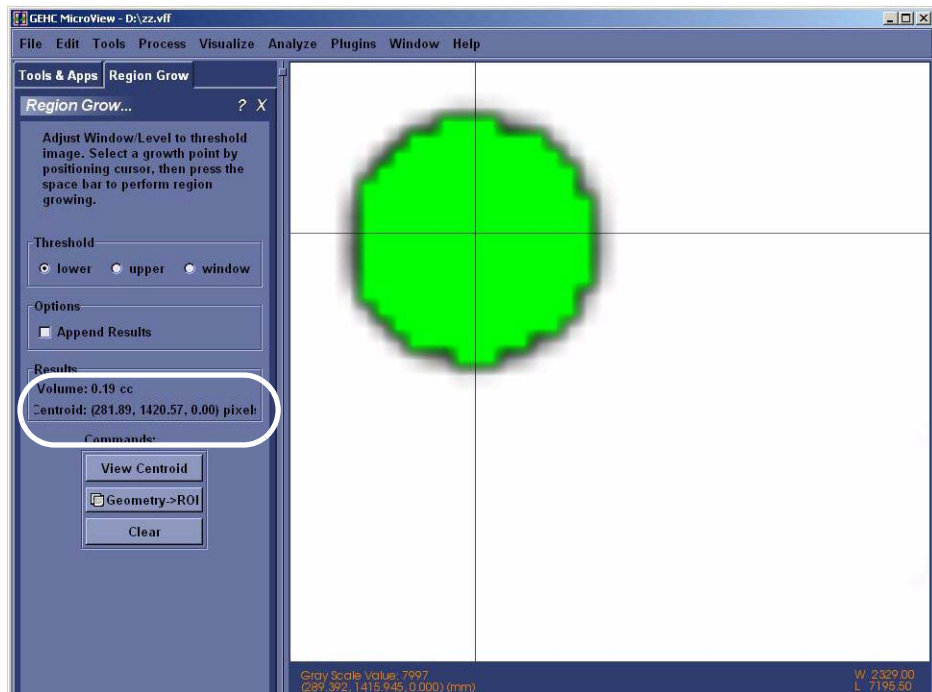


16. Rotate the bebe to the right side of the screen and repeat steps 6 to 15, naming each file *R1* through *R7*. Record the x and y positions in the Worksheet.
17. Determine the real outer bebe by examining the images. Starting with L1, correct the file, and unwarped it (using *Transform01*).
18. Load the corrected and unwarped file into **MicroView**.
19. Zoom in on the bebe that appears in the centre of the Y axis and find the centre of the bebe. Adjust the Window and Level to make the bebe as round as possible.



20. In **MicroView**, choose *Tools>Region Grow*.
21. Select *Lower* in the Threshold field.
22. Place the mouse over the bebe and press the Spacebar (the bebe's solid centre turns green).

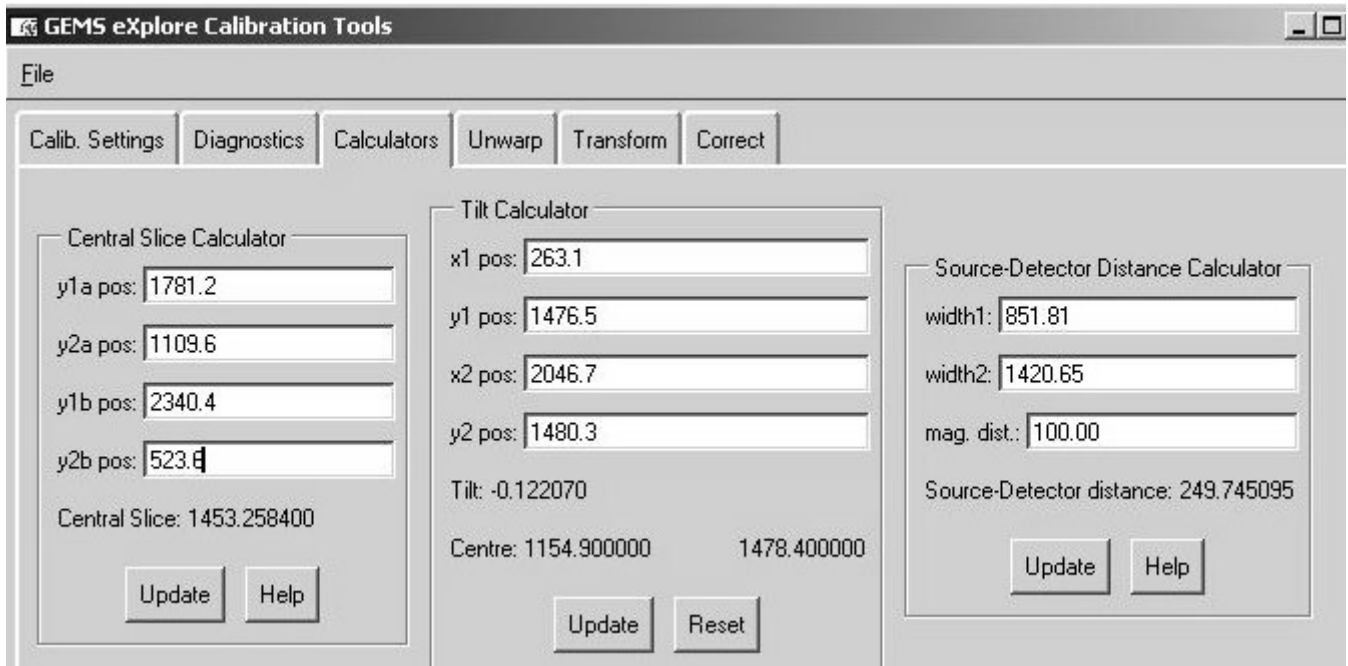
23. Record the centroid value (x & y coordinates). If desired, press the *View Centroid* button to view the calculated actual centre. You may have to Pan and Zoom to see the cross hairs.



24. Repeat the last 7 steps (starting with correct & unwarp file) for each of the files L2 through L7 and R1 through R7.

Once all the coordinates are noted:

25. Examine all 7 coordinates from the left side of the screen and find the **SMALLEST** x value. Note both the x and y values from that coordinate in the Worksheet.
26. Examine all 7 coordinates from the right side of the screen and find the **LARGEST** x value. Note both the x and y value from that coordinate in the Worksheet.
27. Access **Calibration Tools** and choose the *Calculators* tab.
28. Enter the noted x and y coordinates (from steps 25 and 26) for the outer most bebe positions for both the left and right sides of the screen, as follows under *Tilt Calculator*:
- x1 pos: enter the x coordinate value for the left side of the screen
- y1 pos: enter the y coordinate value for the left side of the screen
- x2 pos: enter the x coordinate value for the right side of the screen
- y2 pos: enter the y coordinate value for the right side of the screen



29. Press the *Update* button under Tilt Calculator. The Tilt value changes (value is usually less than 1 degree and can be either positive or negative.).
30. Select the *Transform* tab. The settings should reflect those entered during Start Transform1 File Creation (if blank, see steps 24-27 in Section 7.2.3).
31. Press the *Update* button next to the Tilt values. The system loads the calculated tilt angle.
32. Click the *Create Transform1 and D:\Transform1.dat* button. This often takes a few minutes. At the end of this process the system creates the Transform1 file which, when run, will correct the distortion caused by the detector's taper assembly and compensate for the tilt angle of the grid in 1x1 mode.
33. Correct and Unwarp the 2 outermost babes using Transform1 and find the centroid (these are the 2 outer-most L and R babes determined earlier in steps 25 and 26). Record in the Worksheet.

The y value should be the same for both babes (within 0.2 pixels) and should approximately equal the **second** number that appears beside *Centre:* under Tilt Calculator (e.g. 1478.4).

7.2.5 Create Transform2 & Transform4 Files

1. Access **Calibration Tools** and click the *Transform* tab.
2. Check the values of the following fields:
Example VFF File: D:\calib\corrected_grid.vff
Source/Targets File: C:\translations
Tilt values: (should reflect the same tilt angle used when creating the Transform1 file)
Acquired Image bin Mode: 1x1
3. Change the following field:
Transform bin Mode:2x2

Note: *The Acquired Image bin Mode field remains 1x1.*

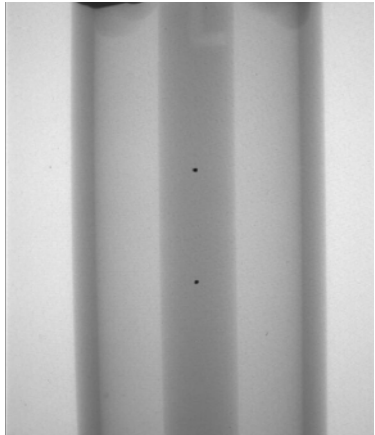
4. Press the *Create D:\Transform2 and D:\Transform2.dat* button. The Transform2 file is created.
5. Return to the Transform bin Mode field and choose *4x4* from the drop-down menu.

Note: *The Acquired Image bin Mode field remains 1x1.*

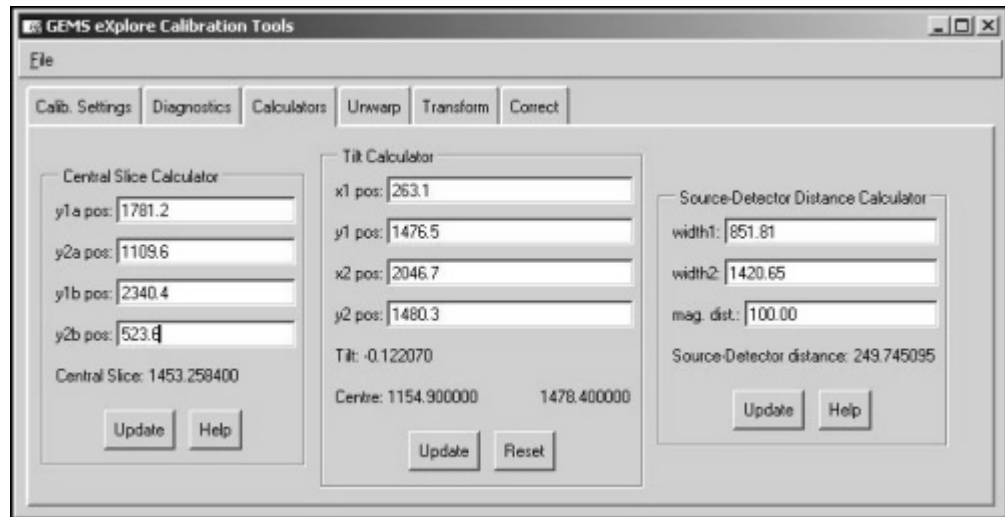
6. Press the *Create D:\Transform4 and D:\Transform4.dat* button. The Transform4 file is created.

7.2.6 Calculate Central Slice of X-Ray Source

This procedure calculates the Central Slice of the X-ray. With the X,Y Centring Ball tool still mounted and the system warmed up:

1. Move the stage back toward the detector using the **X-Ray and Motor Controller**.
 2. Elevate and rotate the tool until both bebes appear in the centre of the screen in **Fluoro**.
- 
3. Capture the image and name it *CS1*.
 4. Move the tool 120mm toward the X-Ray Source and capture an image. Name the image *CS2*.
 5. Correct the CS1 image, unwarped it and load it into **MicroView**. Determine the y coordinates of both bebes using the Region Grow tool in **MicroView**.
 6. Make note of the CS1 file's two y coordinates in the Worksheet.
 7. Correct the CS2 image, unwarped it and load it into **MicroView**. Determine the y coordinates of both bebes.

8. Make note of the CS2 file's two y coordinates in the Worksheet.
9. Access **Calibration Tools** and select the *Calculators* tab.
10. Enter the 4 following values under Central Slice Calculator in the order below:
 - y1a pos: enter the CS1 file's top bebe's y coordinate
 - y2a pos: enter the CS1 file's bottom bebe's y coordinate
 - y1b pos: enter the CS2 file's top bebe's y coordinate
 - y2b pos: enter the CS2 file's bottom bebe's y coordinate
11. Press the *Update* button under Central Slice Calculator.

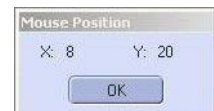


12. Make note of the Central Slice value (e.g. 1453.25) in the Worksheet.

7.2.7 Verify Stage Alignment

VERIFY STAGE TILT (FRONT-TO-BACK MOVEMENT):

1. Turn off X-rays and adjust the X,Y Centring Ball tool so that the bebes are facing the detector.
2. Turn x-rays back on and wait a few minutes for the Source to stabilize.
3. Move the stage (using **X-Ray and Motor Controller**) 120mm back toward the detector.
4. Access **Fluoro** and press *m* to display the mouse position window.
5. Rotate the tool until the top bebe appears in the centre of the x axis of the screen.
6. Adjust the elevation using the **X-Ray and Motor Controller** program so that the top bebe moves downward and appears within 200 pixels of the bottom of the screen.
7. Capture an image in **Fluoro** and name it *shim1*.
8. Adjust the elevation, so that the top bebe moves upward and appears within 200 pixels of the top of the screen (approximately 50mm).



9. Capture an image in **Fluoro** and name it *shim2*.
10. Correct the shim1 file and unwarp it (using Transform1).
11. Load the corrected and unwarped file into **MicroView**.
12. Use the Worksheet to make a note of the x value of the centre of the bebe using **MicroView's** Region Grow tool.
13. Repeat steps 11 and 12 above (correct, unwarp & load into MicroView) for the *shim2* file. Use the Worksheet to make a note of the x value of the centre of the bebe using **MicroView's** Region Grow tool.

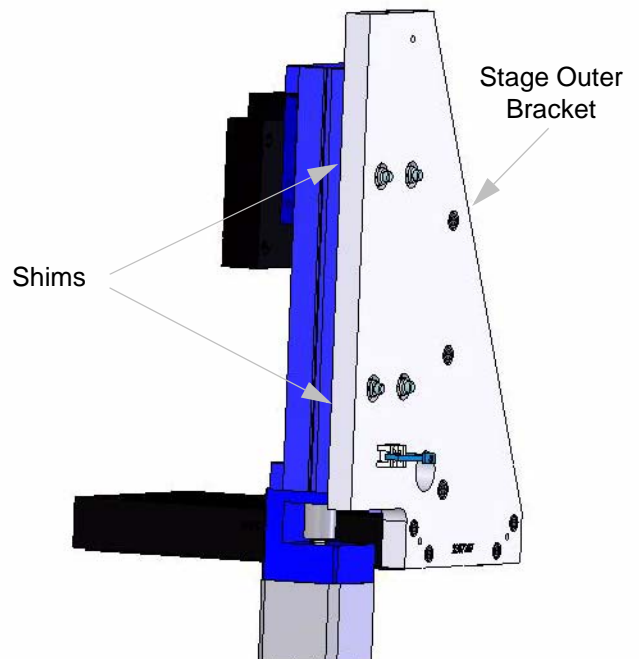
Note: *The x values must be within 2 pixels of each other (e.g. if one value is 1140, the other must be within 1138 to 1142).*

If the values **ARE NOT** within 2 pixels of each other:

14. Place shims behind the elevation rail (loosen stage bolts, etc.). Tighten the screws to a torque setting of 25 in/lbs.

Note: *One pixel is approximately .002" in shims. If the x value of the top bebe in **Fluoro** is less than the x value of the bottom bebe, the shim goes on the bottom of the stage. If the x value of the top bebe is higher, the shim goes at the top of the stage.*

The shims are placed close to the mounting bolts. Larger adjustments (more than 0.004") will require shims at both the top *and* the bottom to allow the stage to tip once it is tightened (e.g. large shim on the bottom and small shim on the top). This is because flat surfaces are bolted together.

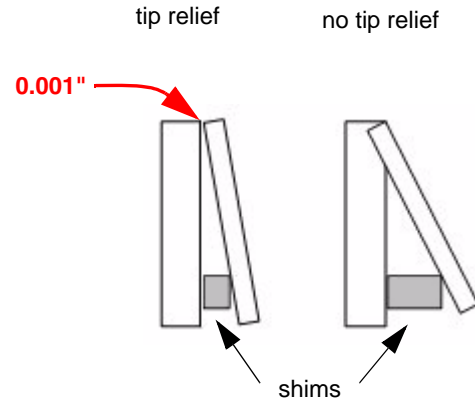


NOTICE
Equipment
Damage
Possible

Failure to provide a tip relief will cause the rail assembly to bend when the bolts are tightened. There should be at least 0.001" clearance at the tip end.

If you have to shim the stage, re-check the stage tilt mechanically using the 9" Square.

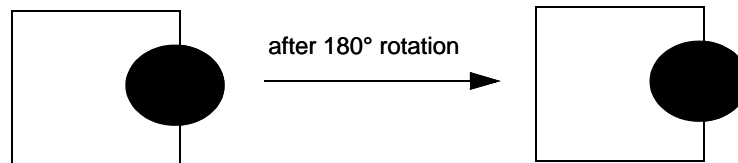
Repeat steps 5 to 13 until the values are within + or - 2 pixels.



VERIFY STAGE TIP (SIDE-TO-SIDE MOVEMENT):

1. Move the ball toward the X-Ray Source (**140mm right**).
2. Elevate and rotate the tool until the top bebe appears in the centre of the screen.
3. Use the mouse pointer window as a reference guide and rotate the bebe 180°.

The goal here is to have the bebe return to the same x axis after the 180° rotation.



4. Continue to reposition the bebe until it is close to returning to the same x axis.

It may be necessary to rotate the bebe less than 0.1 degree to get it in the exact centre. To make movements that are finer than 0.1 degree, access the **X-Ray and Motor Controller** and adjust the *Steps to Travel* field (e.g. 50) which are steps in the stepper motor. Adjust the Direction and press the *Start Motor* button.

The next goal is to confirm that, at the X-Ray Source end, the y values at 0 and 180 degree rotation are within 2 pixels of each other AND within 2 pixels of the Central Slice, AND the y axis at the Detector end is within 2 pixels of the Central Slice.

5. Once the bebe is properly positioned in the x direction, capture the image, correct and unwarp it. Open the image in **MicroView** and determine the y axis of the bebe using the Region Grow tool in **MicroView**. Record it in the Worksheet. This y axis must be the same as the Central Slice value (within 2 pixels) that was calculated earlier.

If the y axis is not the same value as the Central Slice (within 2 pixels):

6. Continue to adjust the elevation - capturing, correcting, unwarping, and viewing the images in **MicroView** - until the y axis is within 2 pixels of the Central Slice value. Use the *Steps to Travel* field within **X-Ray and Motor Controller** to make movements finer than 1mm.

Once the y axis equals the value at the Central Slice (within 2 pixels):

7. Rotate the tool 180° and capture, correct, unwarp and view the image in **MicroView**. The value of this y axis must be within 2 pixels of the previous value before rotation (i.e. the value determined in step 6). For example, if the previous y axis was 1428, this y axis may have a value between 1426 and 1430. Also, the x value must be within 5 pixels of each other.

If not within 2 pixels, verify the Central Slice position before making any adjustments, as follows.

Verify the Central Slice position:

- rotate the tool back 180 degrees
- move the stage 140mm toward the detector
- capture an image, correct and unwarp it
- load the image into **MicroView** and check that the y position is the same within 2 pixels. If the y position is not at the Central Slice at the detector end, the Central Slice calculation will need to be redone.

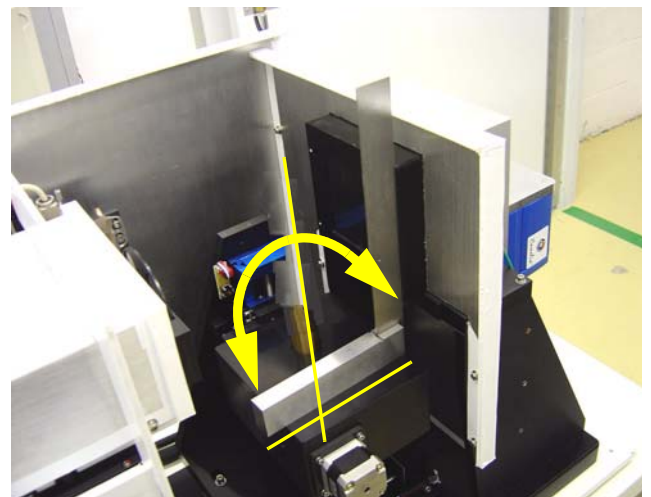
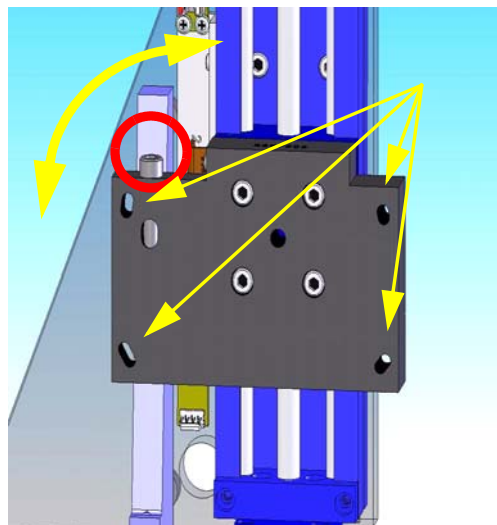
Verify all values before redoing the Central Slice calculation.

If the y axis at 180° is not within 2 pixels of the previous value (determined in step 6) AND the Central Slice calculation has been verified, do the following:

- Move the stage back 140mm toward the Source
- Mechanically adjust the stage using the stage levelling screws (capturing, correcting, unwarping and viewing an image after each adjustment). Move the stage to the centre (70 mm toward the detector) in order to mechanically adjust the stage.

The 4 stage levelling screws sit in slanted, slotted holes (see diagram on the left) so, when loosened, allow for movement in the direction shown below.

Note: *You may need to tighten or loosen the locking screw at the top of the bracket in order to get the stage aligned (see red circle in the left diagram).*



- Continue to adjust the stage and view the results until the y axis is within 2 pixels of the previous value (determined in step 6) after 180° of rotation. Use the Worksheet to record values.

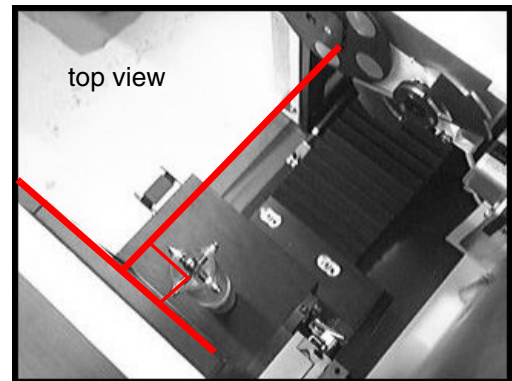
The end result is that at the Source end the y values at 0 and 180 degree rotation are within 2 pixels of each other and within 2 pixels of the Central Slice, AND the y axis at the detector end is within 2 pixels of the Central Slice.

8. Once the values are within 2 pixels of each other, capture and save an image after each rotation and call the files *Tip1* and *Tip2*.

7.2.8 Centre the Stage

This procedure is used to centre the stage between the X-Ray Source and the detector. With the X,Y Centring Ball tool still mounted :

1. Click on the *Turn X-Ray Off* button, then physically rotate the X,Y Centring Ball tool so that 2 of the 4 adjustment screws are exactly perpendicular to the detector (i.e. not at an angle).
2. Elevate the tool using the Elevation feature in **X-Ray and Motor Controller** until the ball appears in the centre of the **Fluoro** display.
3. Move the stage 70mm toward the detector so that it is positioned in the middle between the Source and detector.
4. Mount the Dial Indicator Mount and Precision Dial Indicator.
5. Adjust the tip on the Precision Dial Indicator to strike the equator of the ball. Make sure the Indicator is not pegged (i.e. the small needle on the gauge, near the centre of the Dial Indicator, is around the halfway mark).



Note: *The Precision Dial Indicator is very sensitive and care should be taken not to lean or touch any part of the system while adjusting the Indicator or the X,Y Centring Ball tool.*

6. Zero the Precision Dial Indicator.

Note: *For fine measurements, the Precision Dial Indicator may not be accurate until after the first movement.*

7. Use the *Rotation* setting in **X-Ray and Motor Controller** to rotate the ball 180°, then rotate the ball again 180° (so the ball rotates 360°). Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged. Re-zero the Dial Indicator, if necessary.

Centre the Ball:

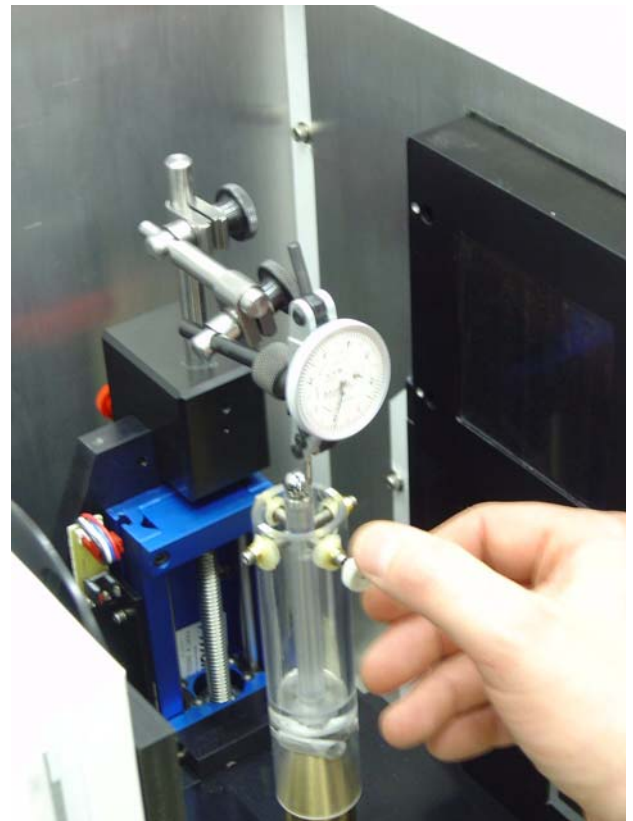
8. Use the *Rotation* setting to rotate the ball 180°.
9. Watch the Precision Dial Indicator as the ball rotates. Note the reading of the Precision Dial Indicator after 180° of rotation (e.g. .0004").
The objective is to adjust the ball so that, after the adjustment, the Dial Indicator reads half of the original reading (e.g. .0002").

To do this:

10. Use the tool's adjustment key to carefully turn the 2 adjustment screws that are aligned with the Dial Indicator - turn the screws until the Dial Indicator reads half of the original reading.

The tool is extremely delicate. Fine adjustments are required. DO NOT overtighten the screws. One screw turns clockwise and the other turns counter clockwise. Turn the screws in tandem using as little torque as possible (i.e. 5° at a time).

11. Once adjusted, rotate the ball 180° and check the Dial Indicator reading. It should match the reading taken after the adjustment in the previous step (e.g. .0002").
12. Re-zero the Dial Indicator.
13. Use the rotation setting to rotate the ball 360° (rotating 180° at a time). Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged. Re-zero the Dial Indicator, if necessary.
14. Rotate the ball 180° and confirm the Dial Indicator reads zero.
15. Rotate the ball 90°.
16. Carefully adjust the 2 screws that are aligned with the Dial Indicator until the Dial Indicator reads zero.
17. Rotate the ball 180° and verify that the Dial Indicator still reads zero.



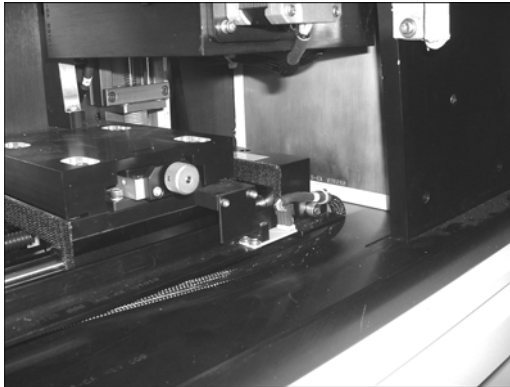
NOTICE
Equipment
Damage
Possible

NOTICE
Equipment
Damage
Possible

Note: *Fine tuning may be required. Continue to make adjustments until the ball can rotate 360° without the Dial Indicator reading moving more than .0002".*

18. Once the ball has been centred, remove the Dial Indicator Mount and Precision Dial Indicator.
19. Select *Magnification* in the Motor field in the **X-Ray and Motor Controller** window and move the ball 70mm toward the detector. This should be 2mm from the limit switch.
20. Warm up the x-rays without using the **System Warm-up** application to avoid moving the stage. To do this, use the **X-Ray and Motor Controller** program and do the following:
 - a. Set the kV field to 80
 - b. Set the μ A field to 10
 - c. Press the **Turn X-Rays** on button
 - d. Wait 2 minutes
 - e. Press the **Turn X-Rays** off button
 - f. Set the kV and μ A field to the next value in list below, and repeat steps c to e:

- wait 2 minutes @ 80kV, 45 μ A
- wait 10 minutes @ 80kV, 80 μ A



21. Capture the image in **Fluoro** and name it *capture*.
22. Correct and unwarp the captured image using **Calibration Tools**.

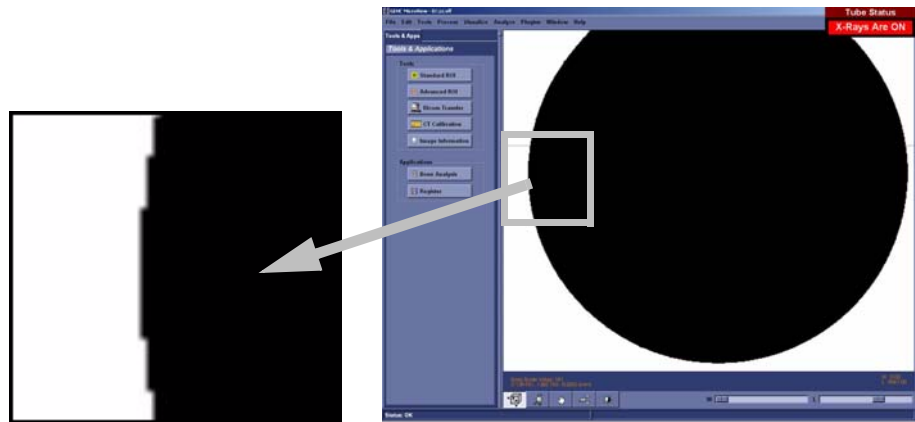
Find the Geometric Centre of the Ball at Detector End:

Note: *To find the geometric centre of the ball, determine the x value on the right and left side of the ball. Add the values together and divide by 2. To find the geometric centre as follows.*

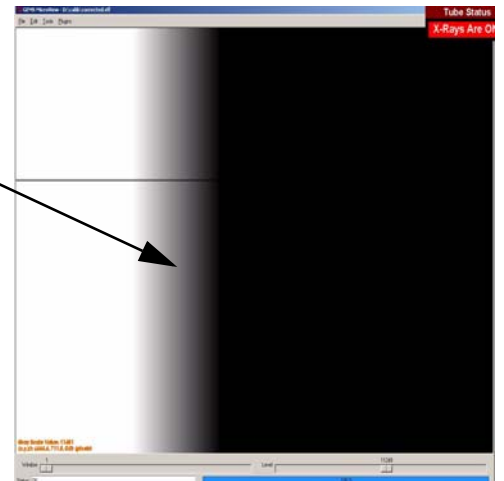
23. Use the Pan and Zoom features in **MicroView** to get the ball in the desired area of the screen.

Note: *To Pan, move the mouse while pressing Shift plus the left mouse button simultaneously. To Zoom, move the mouse up (to magnify) or down (to zoom out) while pressing the right mouse button.*

24. Threshold the image by sliding the *Window* slide bar to the left until it reads 0 and sliding the *Level* slide bar until the edges of the ball appears with the maximum amount of square edges.



25. Zoom in on the outer left most side of the ball.
26. Place the mouse in the middle of the gray band that appears to the left of the black area. Make note of the x coordinate and round the coordinate to the nearest .5 pixel. Record in the Worksheet.



27. Zoom out and move to the right outer most side of the ball. Zoom in on the edge. **DO NOT** re-adjust the *Window* and *Level* slide bars.
28. Place the mouse in the middle of the gray band that appears to the right of the black area. Make note of the x coordinate in the Worksheet.
29. Add the 2 x values together and then divide by 2. This value is the ball's geometric centre. Make note of this value in the Worksheet.

30. Use the **X-Ray and Motor Controller's Magnification** setting to move the ball toward the X-Ray Source 140mm.
31. Capture the image calling the file *capture*.
32. Correct the image.
33. Unwarp the image calling the file D:\zz.
34. Double-click on zz in **Windows Explorer** to load the unwarped, corrected file into **MicroView**.
35. Find the geometric centre of the ball at the X-Ray Source end by making note of the x values on the outer most left and right side of the ball and dividing this value by 2. Use the Worksheet to record values.



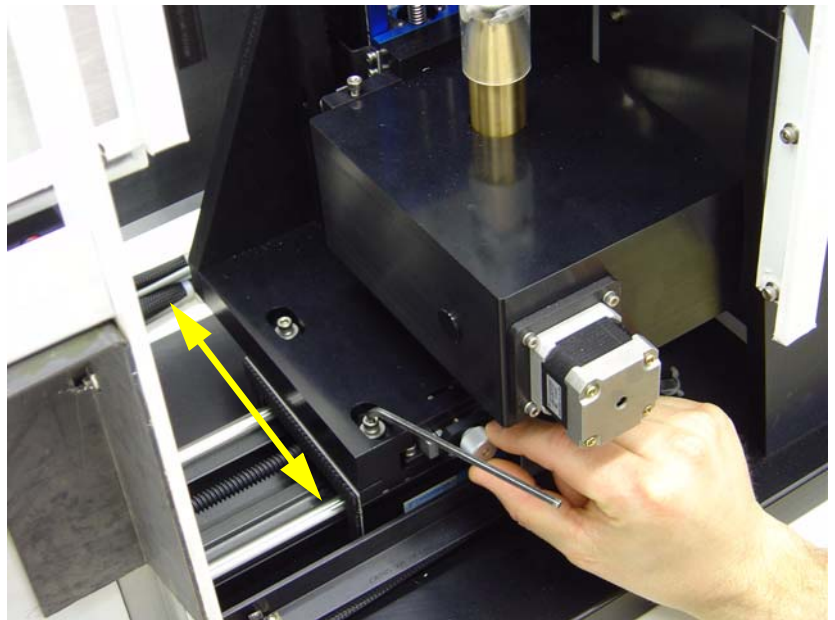
Note: *This value must eventually equal the ball's geometric centre at the detector end, plus or minus 1 pixel.*

IF NOT, adjust the geometric centre values until they are within 1 pixel of each other as follows:

- a. Turn off the X-Ray Source.
- b. Loosen the 4 stage retaining bolts.

- c. Manually adjust the stage using the stage's adjustment wheel (see Note below). This moves the stage perpendicular to the rail as shown here in the diagram.

- d. Continue to determine the value of the ball's geometric centre at both the detector end and the X-Ray Source end - manually adjusting the stage's adjustment wheel in between - until the values are equal, plus or minus 1 pixel.



Note: *Small movements of the adjustment wheel are required. One pixel will equal a few (1 to 5 degrees) turn of the wheel.*

The adjustment will change the ball's geometric centre value 3 times faster when the stage is at the X-Ray Source end compared to an adjustment when the stage is at the detector end.

If the value at the X-Ray Source is larger than the value at the detector end, turning the adjustment wheel clockwise reduces the values.

Once confirmed (i.e. the values of the 2 geometric centres are the same + or - 1 pixel):

36. Carefully tighten the 4 bolts (snug only) once the values are close. Make the bolts sufficiently tight so that the adjustment wheel will operate but is difficult to turn. Tightening the bolts may change the value of the geometric centres.
37. Complete the tightening of the 4 bolts and then verify the results at both ends. The bolts may need to be loosened and retightened as you use the adjustment wheel to align the 2 values.

Once the 2 figures are again within 1 pixel of each other, the geometric centre of the ball (the value of its x axis) is now the CENTRE OF ROTATION. Make note of this value in the Worksheet.

38. Save a captured image at both the detector end and the X-Ray Source end. Name the image closest to the detector *smallball.vff* and the image closest to the X-Ray Source *largeball.vff*.

7.2.9 Calculate Source to Detector Distance

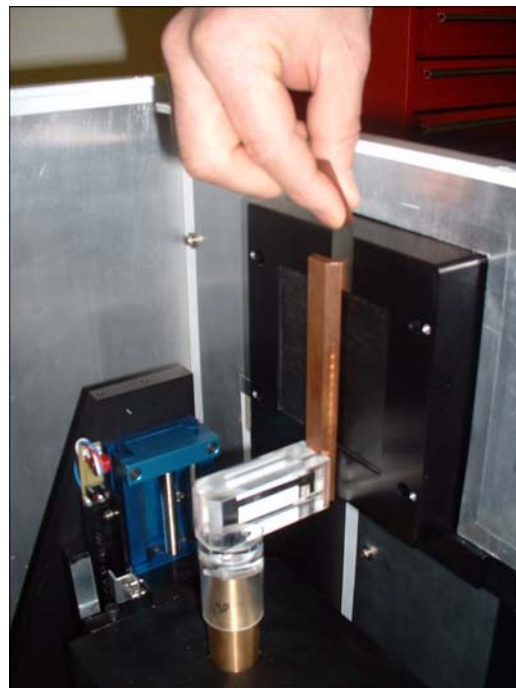
NOTICE
Equipment
Damage
Possible

1. Move the stage 40mm from the detector and mount the Distance tool. Make sure that the tool covers the height of the detector. Remove the tool each time you move the stage.

Do not move the stage with the tool in place. If care is not taken, this procedure can break the tool, move the stage out of alignment and damage the detector.

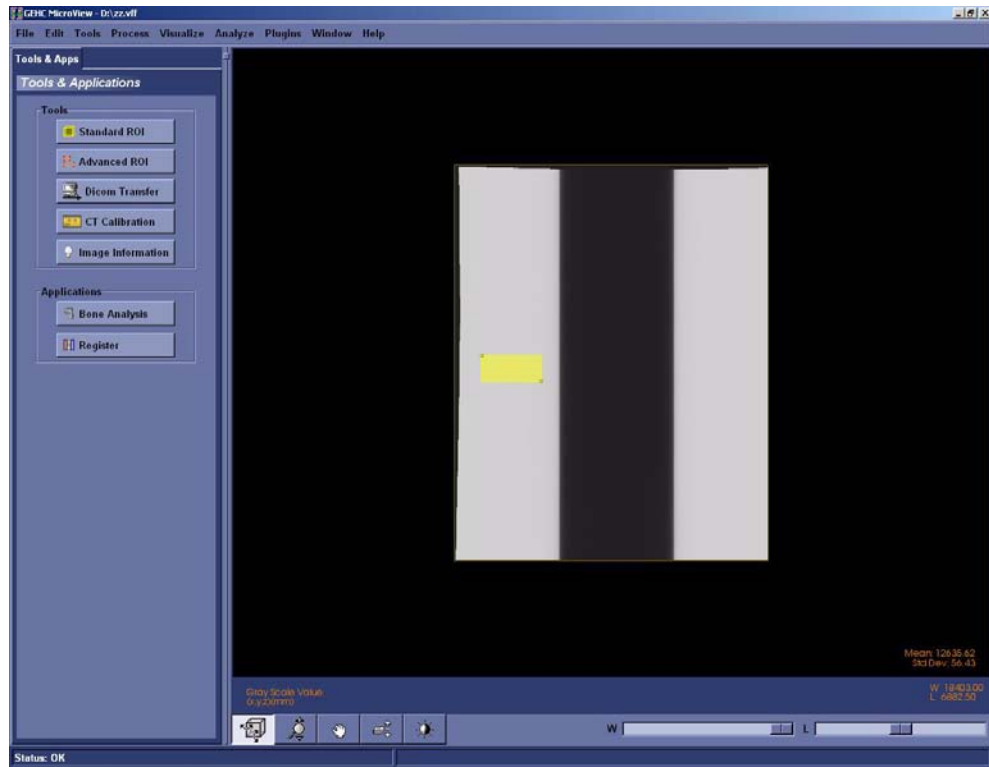
2. Use the **X-Ray and Motor Controller** to move the tool toward the detector until it is 0.025" from the detector.

Movements finer than 1mm will be required! The X-Ray and Motor Controller application will accept movements as fine as 0.1mm.

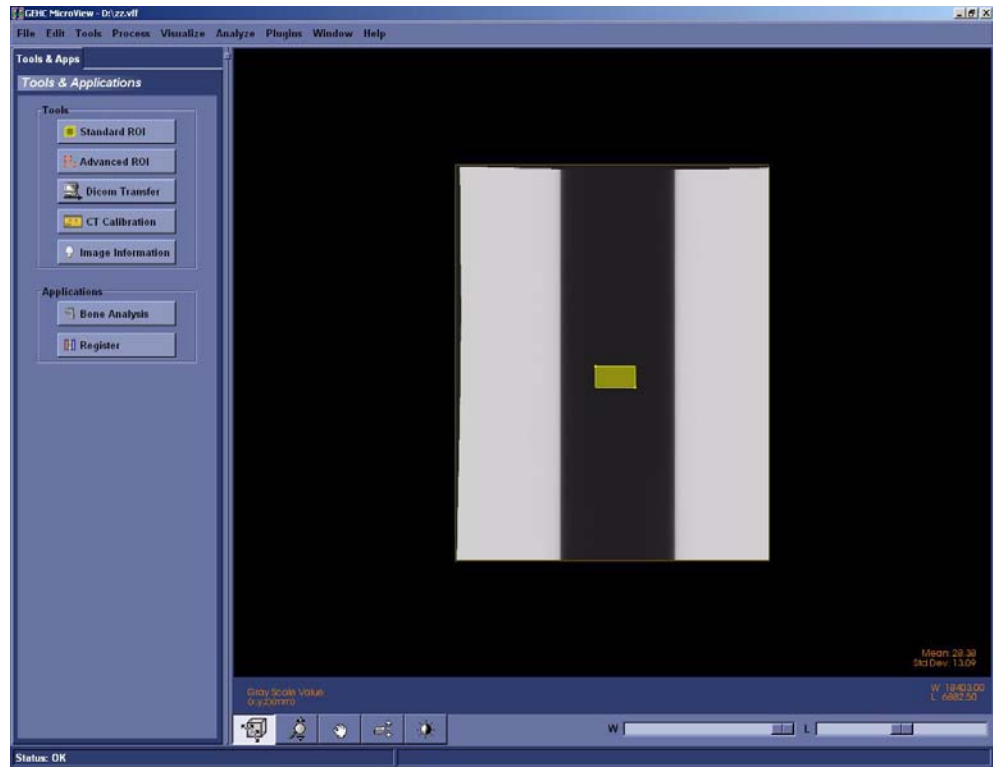


3. Turn on the X-Ray Source using the **X-Ray and Motor Controller**. Wait a few minutes for the X-Ray Source to stabilize.

4. Capture an image and name it *D1*.
5. Move the tool back 100mm **TO THE RIGHT** (toward the X-Ray Source).
6. Capture an image and name it *D2*.
7. Turn off the X-Ray Source and remove Distance tool from the scanner.
8. Turn the X-Ray Source back on to keep it warm.
9. Correct and unwarp the D1 image and load it into **MicroView**.
10. Draw an ROI (Region Of Interest) in **MicroView** in the middle of the white area:
 - Position cursor in the white area, near the centre, and press the 7 key. This draws the top left corner of the ROI.
 - Move cursor to the right and down and press the 8 key to complete the ROI. A yellow box represents the ROI.
 - Press small **m** (no caps).
The mean value is displayed in the bottom right corner of the window. Make a note of this value in the Worksheet.



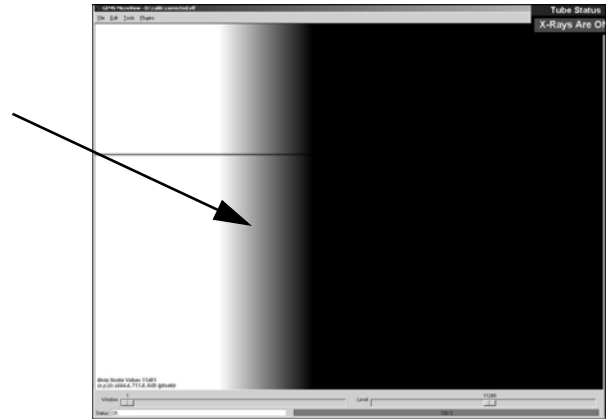
- Repeat the above step in the black area of the screen. Note this value in the Worksheet.



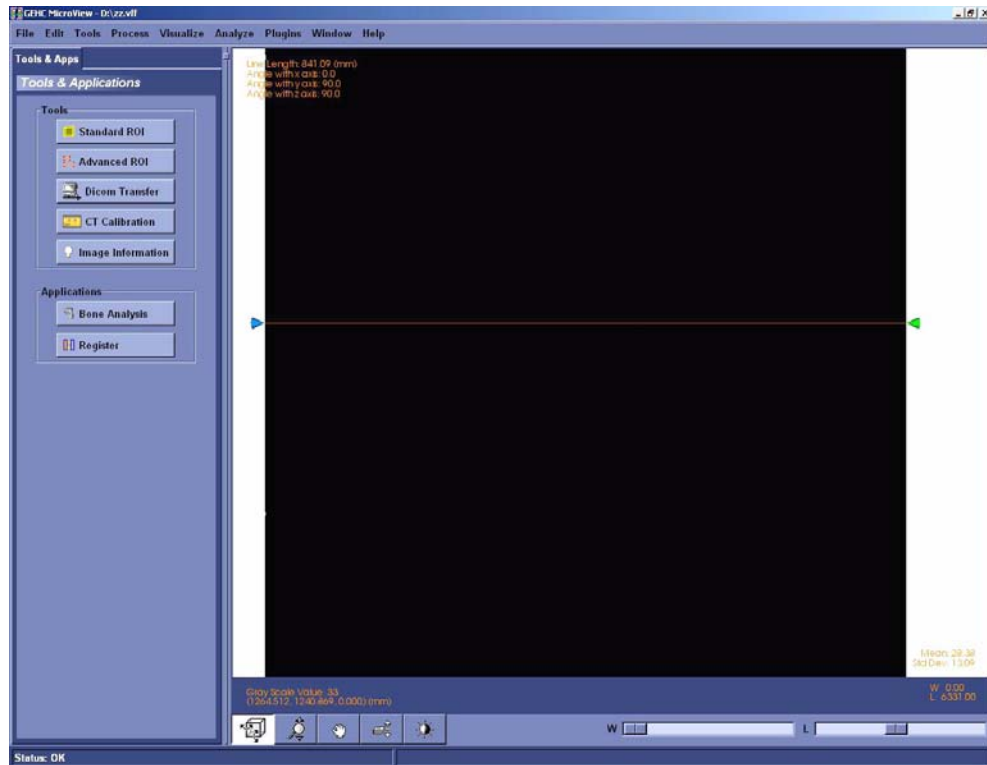
- Add the two mean values determined in the above 2 steps.
- Divide this value by 2 to determine the Half Maximum value. Note this value in the Worksheet.
- In **MicroView**, slide the *Window* slide bar left until it reads 0.
- Double-click on the W and L parameters in the lower right of the screen. Enter the Half Maximum value calculated in step 13 in the Level field.



16. Zoom in on the left edge of the image and position the cursor until the y axis equals the value of the Central Slice (determined earlier) and the x position is in the centre of the grey region.
17. Press **1**.
18. Zoom out and pan across to the right edge of the image. Zoom in on the right edge and position the cursor until the y axis equals the value of the Central Slice (determined earlier) and the x position is in the centre of the grey region.



19. Press **2** to draw a line between 1 and 2.
20. Record the line length (appears in the top left of the screen). Make a note of this value in the Worksheet.

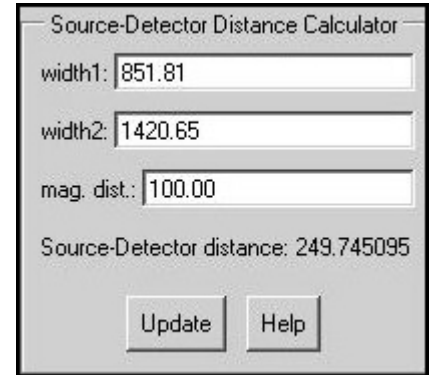


21. Repeat the above steps 9 to 20 for the D2 image using the Worksheet to record values. Make note of its line length in the Worksheet.

22. Access the *Calculators* tab in **Calibration Tools** and enter the following in the Source-Detector Distance Calculator:

width1: enter line length of D1
width2: enter line length of D2
mag. dist.: enter the distance the tool was moved back (i.e. 100mm).

23. Press the *Update* button. The system provides the Source-Detector distance.



Source-Detector Distance Calculator

width1: 851.81

width2: 1420.65

mag. dist.: 100.00

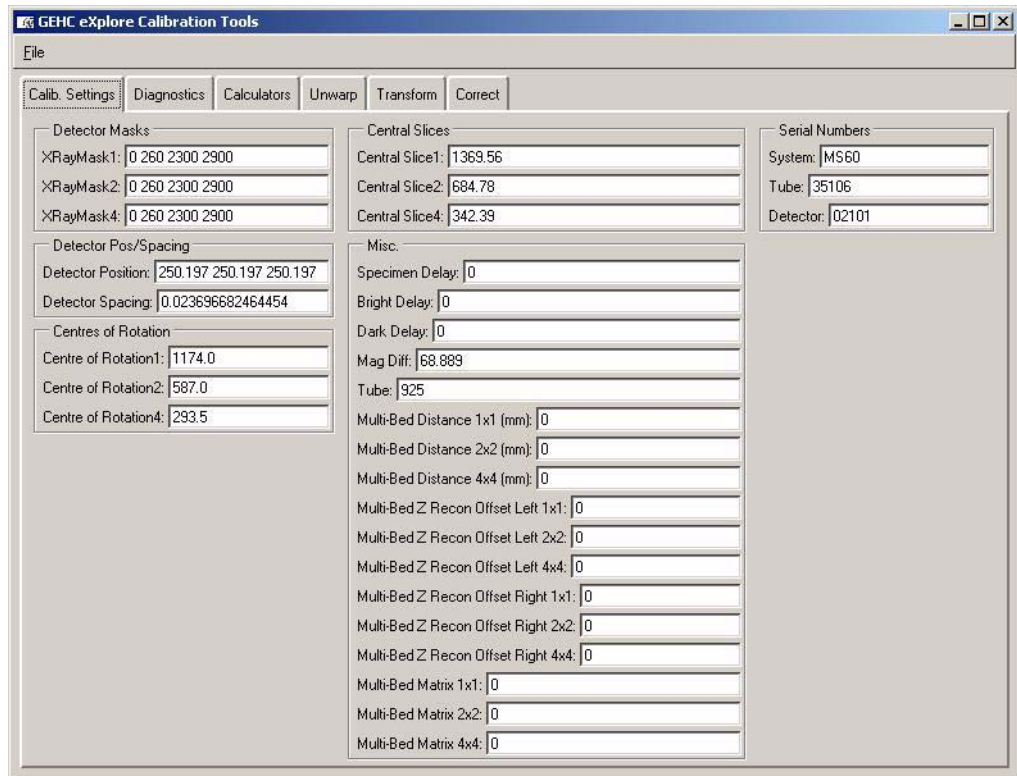
Source-Detector distance: 249.745095

Update Help

Make note of this value (should be approximately 250) in the Worksheet.

7.2.10 Edit Calibration Settings

1. Access **Calibration Tools** and click the *Calib. Settings* tab.
2. Click *File* and choose *Read Registry Values* from the drop-down list.
3. Using the Worksheet, enter the Source-Detector distance in the Detector Position field three times for each binning mode (1x1, 2x2, 4x4), separating each with a space (e.g. 249.74 249.74 249.74). See topic 7.2.9, step 23.
4. Complete the Detector Spacing field with the detector spacing value (include nine decimal places (e.g. 0.023474178). See topic 7.2.3, step 12.
5. Complete the Centres of Rotation fields as follows (see topic 7.2.8, step 37):
 - Centre of Rotation1: enter the Centre of Rotation as determined during the Centre the Stage procedure
 - Centre of Rotation2: enter $\frac{1}{2}$ of the Centre of Rotation value
 - Centre of Rotation4: enter $\frac{1}{4}$ of the Centre of Rotation value.
6. Complete the Central Slices fields as follows (see topic 7.2.6, step 12):
 - Central Slice1: enter the Central Slice value
 - Central Slice2: enter $\frac{1}{2}$ the Central Slice value
 - Central Slice4: enter $\frac{1}{4}$ the Central Slice value
7. Complete the Serial Numbers fields as follows:
 - Detector: enter the new detector's serial number (e.g. 01872)



8. Click *File* and choose *Write Registry Values* from the drop-down list (and enter the password **EvS8899** when prompted).
9. Use **Windows Explorer** to find the following Transform files in D:\
 - Transform1
 - Transform2
 - Transform4
 - Transform1.dat
 - Transform2.dat
 - Transform4.dat

Copy these transform files to:

C:\Program Files\GE Medical Systems\Explore Utilities\Parameters\

10. Enable test protocols. Change 1x1wire.txt, 2x2wire.txt and 4x4wire.txt to *1x1wire.protocol*, *2x2wire.protocol* and *4x4wire.protocol*.

Files are located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols\.

7.2.11 Calculate & Edit Magnification Difference

This calculation is done to accurately display measurements on the screen in millimeters.

1. Install the Measured Plastic dowel into the small specimen tube and secure the dowel with foam. Make note the size of the dowel (e.g. 11.684) in the Worksheet.
2. Mount the small specimen tube.
3. Ensure the filter wheel is set to 4.

Note: *Details concerning the following steps are found in the **eExplore Locus SP User Guide**. Refer to it for particulars.*

4. Turn off the **X-Ray and Motor Controller** application if it is still on.
5. Warm up the X-Ray Source, if needed.
6. Once warm, launch **eExplore Scan Manager** by double-clicking on the desktop icon.
7. Click *Scan New Subject* and name the subject *pixel_size*.
8. Enter *mag_diff* in the Scan Description field.
9. The **Scan Control** window opens. Choose *2x2wire* from the Protocol drop-down menu.

10. Select the *Scan bright and dark first*, *Recon after scan* and *Home all stages* checkboxes under Options.

11. Click on the **Fluoro** button. When prompted, place specimen in the scanner and press **OK**.

12. Click **Menu** in **Fluoro** and choose *Position Stages* from the drop-down menu.

13. Adjust the elevation until the plastic dowel is in the mid section of the **Fluoro** screen, then Exit **Fluoro**.

If the width of the small specimen tube does not fit in the field of view, calibration will need to be repeated.

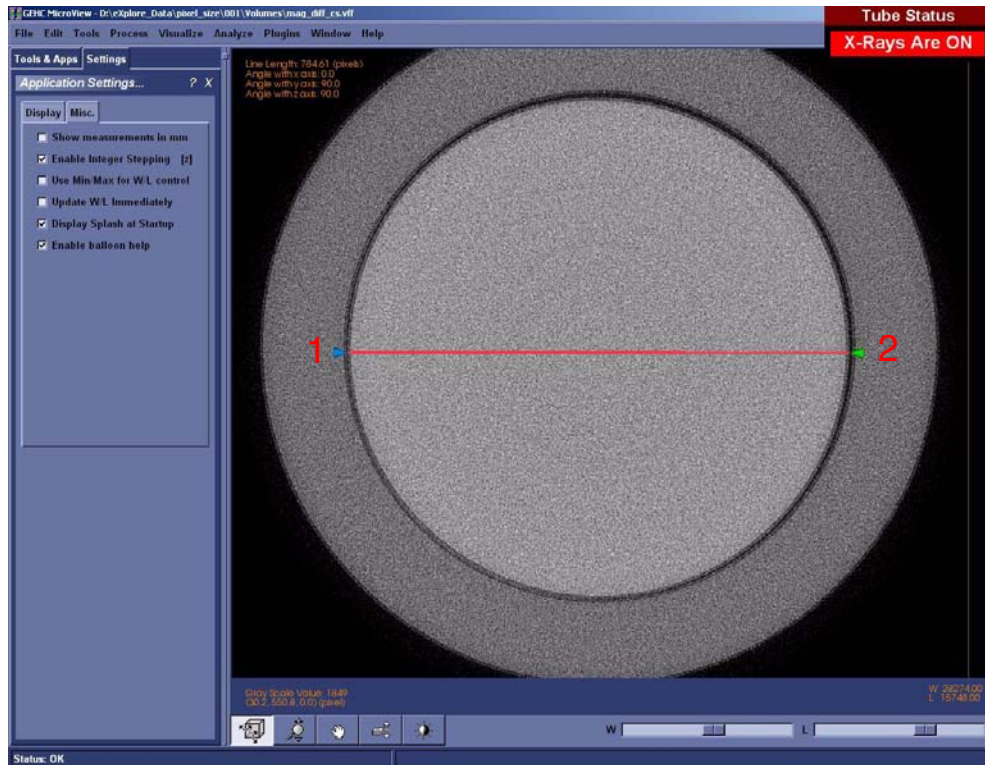


14. Press the **Start Scan** button (the scan takes approximately 30 minutes). When prompted, remove specimen from scanner. Bright and dark scans are scanned. When prompted, place specimen back in scanner.

eExplore Reconstruction Utility is automatically launched once the scan is complete.

15. Click the *Set to Central Slice* button.
16. Click the *Full Res* button.

17. Change the Z-Size value to 1.
18. Click on the *Recon* button.
19. View the reconstructed image in **MicroView**.
20. Change the **MicroView** settings to display measurements in pixels:
 - select Edit>Application Settings
 - select the Miscellaneous tab
 - de-select *show measurements in mm*
21. *Find the widest point* by plotting a line from one side of the plastic dowel to the other:
 - zoom in on the left side, place your mouse on the furthest edge of the plastic dowel, and press **1**
 - pan over to the right side's furthest edge and press **2** (*you may need to press 2 repeatedly at different points until you find the widest point or the maximum number of pixels*)



22. Determine the maximum number of pixels from one side of the plastic dowel to the other (diameter) and note value in the Worksheet.
23. Calculate the measured pixel size using the following equation (and record in Worksheet):

$$\text{measured pixel size} = \text{Measured Plastic dowel size} \div \text{diameter in pixels}$$

24. Calculate the true object position using the following equation (and record in Worksheet):

$$\text{true object position} = (\text{measured pixel size} \times \text{detector position}) \div (\text{detector spacing} \times \text{bin mode}^* \text{ of the scan})$$

**bin mode will be either 1, 2 or 4.*

Note: *The detector position, spacing, and current Mag_Diff values are found in the Calib. Settings tab of **Calibration Tools**. OBJ_POS can be found by opening the 2x2wire.protocol file in Notepad. This file is located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols*

25. Calculate the Mag_Diff using the following equation (Mag_Diff should be approximately 70):

$$\text{Mag_Diff} = \text{true object position} - (\text{OBJ_POS in the protocol} - \text{current Mag_Diff in registry})$$

For example:

$$\text{Mag_Diff} = 85.47 - (80 - 65)$$

$$\text{Mag_Diff} = 70.47$$

Record values in Worksheet.

26. Return to the *Calib. Settings* tab.
27. Click *File* and choose *Read Registry Values* from the drop-down menu.
28. Change the Mag_Diff field to the newly calculated magnification difference.
29. Click *File* and choose *Write Registry Values* from the drop-down menu.
When prompted for a password, enter: **EvS8899**

7.2.12 Perform Verification Scans (1x1, 2x2 & 4x4 Modes)

The following procedure is used to verify the calibration settings.

Note: *The ambient temperature in the room must be stable to perform this procedure i.e. the room temperature should not change even by 1 degree during the scanning process.*

First perform verification scans for 1x1 mode using the procedure below, then repeat the procedure in order to perform verification scans for 2x2 and 4x4 modes.

FIND THE IDEAL CENTRE OF ROTATION AT CENTRAL SLICE:

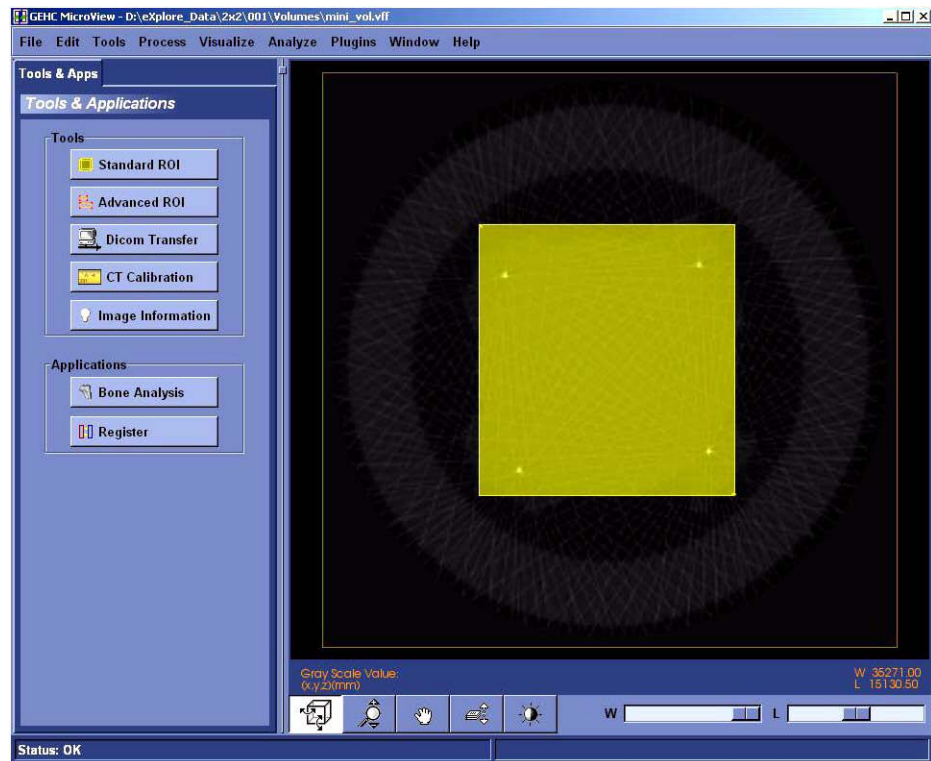
1. Place the wire phantom in the small specimen tube, secure the wire phantom with foam, and mount the tube.
2. Ensure the filter wheel is set to **4** (or set to **1** if doing 4x4 mode).

Note: *Details concerning the following steps are found in the **eExplore Locus SP User Guide**. Refer to it for particulars.*

3. Warm up the X-Ray Source.
4. Once warmed up, launch **eExplore Scan Manager**.
5. Click *Scan New Subject* and name the subject *1x1* (or *2x2* or *4x4* depending on which verification scans are being performed).
6. Enter *1x1wire* in the Scan Description field (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
7. The **Scan Control** window opens. Select *1x1wire* from the Protocol drop-down list (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
8. Select the *Scan bright and dark first, Recon after scan* and *Home all stages* checkboxes under Options.
9. Start **Fuoro**.
10. Click *Menu* and choose *Position Stages* from the drop-down list.
11. Adjust the elevation until the wires of the center section of the wire phantom extend from the top to the bottom of the screen.
12. Exit **Fuoro**.
13. Press the *Start Scan* button (the scans takes approximately 45 minutes) and follow the prompts to place and remove the specimen from the scanner for the bright and dark scans.
The **eExplore Reconstruction Utility** launches automatically when the scan is complete.
14. Click the *Set to Central Slice* button.
15. Click the *Thumbnail* button.
16. Change the Z-Size field to **5**.
17. Press the *Recon* button on the **Reconstruction Utility** window.
18. View the image in **MicroView**. Draw a line from the wire on the left side of the screen to the wire on the top using the 1 and 2 keys, and note the angle displayed in the top left of the screen in the Worksheet.
19. Exit **MicroView**.
20. Press the *Advanced* button on the **Reconstruction Utility** window and select the *Reconstruction* tab.
21. Enter the approximate angle of the 4 wires noted above in the Angle field.
22. Record the existing air, water and HU calibration values. Enter **-1** (minus one) values for each field in the Worksheet.



23. Select *Short Scan*. This looks at the first 200 views instead of all 360 views. It will emphasize any errors in calibration. Click OK.
24. Press the *Recon* button in the **Reconstruction Utility** window.
25. View the image in **MicroView** upon completion. The 4 wires should appear "square" to the screen.
26. Select a region of interest that encompasses all 4 wires using the 7 and 8 keys in **MicroView**.

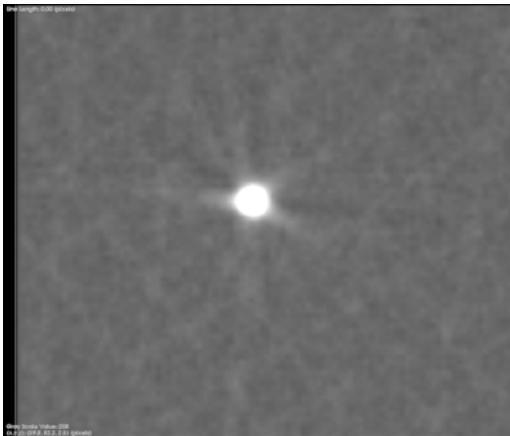


27. Select File>Save crop coordinates.
28. Exit **MicroView**.
29. Click the *Load Crop* button on the **Reconstruction Utility** window.
30. Press the *Recon* button. View the image in **MicroView** and verify the image is cropped properly, then exit **MicroView**.
31. Change the Z-Size field on the Reconstruction Utility screen to **1**.
32. Click the *Full Res* button. De-select the *Mini-volume* field. This allows you to name the resulting reconstructed volume.
33. Press the *Recon* button. Name the file *1x1wire_cs_ss.vff* (or *2x2wire_cs_ss.vff* or *4x4wire_cs_ss.vff* depending on which verification scans are being performed).

34. View the cropped area in **MicroView** upon completion.



35. Zoom in on individual wires. All 4 wires should be as round as possible.



Round Wire



Skewed Wire

If all of the wires are not round, the Centre of Rotation needs to be adjusted as follows:

- Exit **MicroView**.
- Click the *Advanced* button in the **Reconstruction Utility** window.
- Click the *Reconstruction* tab.
- Change the Centre of Rotation field. Make only small, incremental changes to this number (e.g. change 1150 to 1150.5) then click *OK*.
- Click the *Recon* button in the **Reconstruction Utility** window.
- View the image in **MicroView** upon completion. If the image is improved, continue to change the Centre of Rotation in the same direction (e.g. change 1150.5 to 1151). If the image is worse, change the Centre of Rotation in the opposite direction (e.g. change 1150.5 to 1149.5).
- Continue to adjust the Centre of Rotation until the wires are as round as possible (although all 4 wires are unlikely to be equally round).
- Make a note of this value in the Worksheet. This is the ideal Centre of Rotation at the Central Slice.

If the wires appear square, ensure that the interpolation is on:

- Go to Edit->Application Settings
- Ensure a checkmark appears next to "Use Image Interpolation".

36. Click the *Advanced* button in the **Reconstruction Utility** window, and choose the *Reconstruction* tab.
37. De-select the Short Scan field and click *OK*.
38. Click the *Recon* button in the **Reconstruction Utility** window.
39. Name the file *1x1_wire_cs_360* (or *2x2_wire_cs_360* or *4x4_wire_cs_360* depending on which verification scans are being performed),
40. Confirm the wires are still round in **MicroView**. The wires should appear even rounder. Exit **MicroView**.

Note: *If the wires appear hollow (like a ring) in the 360 degree reconstruction, then the Centre of Rotation needs to be adjusted as described above. Also, verify that the HU calibration values are set to -1.*

This process has determined the ideal Centre of Rotation of the wire phantom at the Central Slice. The following steps check the Centre of Rotation of the image at either end of the wire phantom.

VERIFY CENTRE OF ROTATION AT EACH END (FOR 1X1 MODE ONLY):

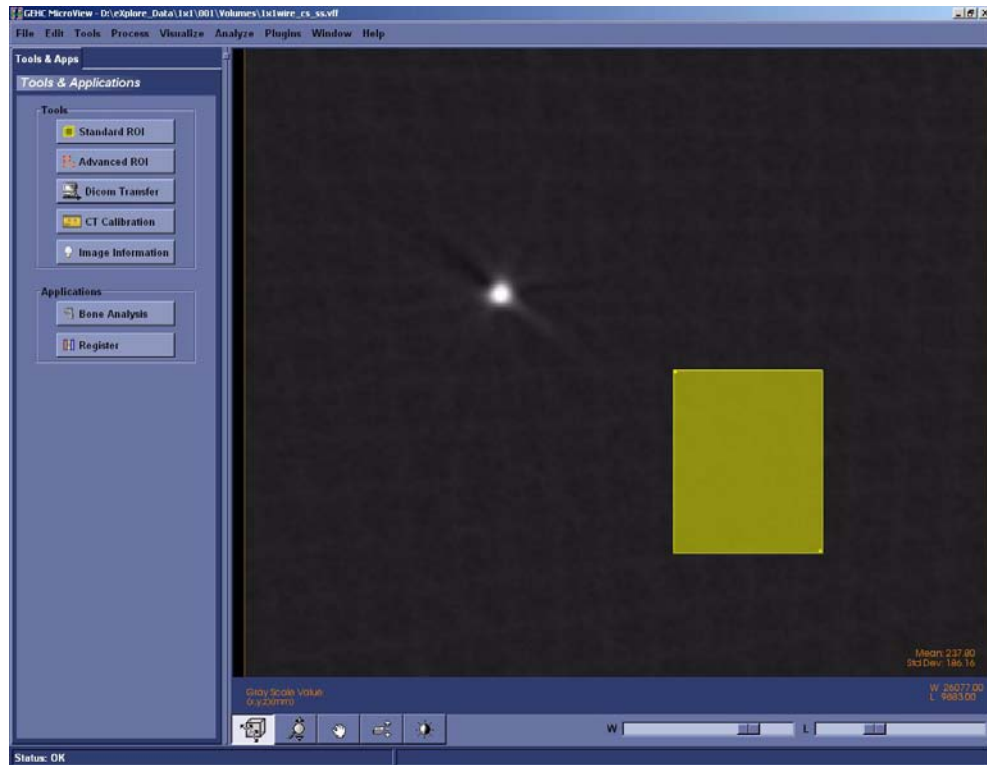
1. Change the Z-Origin field on the **Reconstruction Utility** window to *200*. This represents one end of the wire phantom.
2. Click the *Advanced* button, then choose the *Reconstruction* tab.
3. Re-select Short Scan, then click *OK*.
4. Click the *Recon* button. Name the file *1x1wire_-end_ss*
5. View the image in **MicroView**. The wires should appear as round as possible.
If the wires are not round, the Centre of Rotation needs to be adjusted as described above.
6. Upon completion, make note of the difference between this Centre of Rotation and the ideal Centre of Rotation at the Central Slice.

Note: *The value of the Centre of Rotation at either end of the wire phantom may only differ from the ideal Centre of Rotation at the Central Slice by 1.5 pixels. The Short Scan option in **Reconstruction Utility** must be used for this test to be valid.*

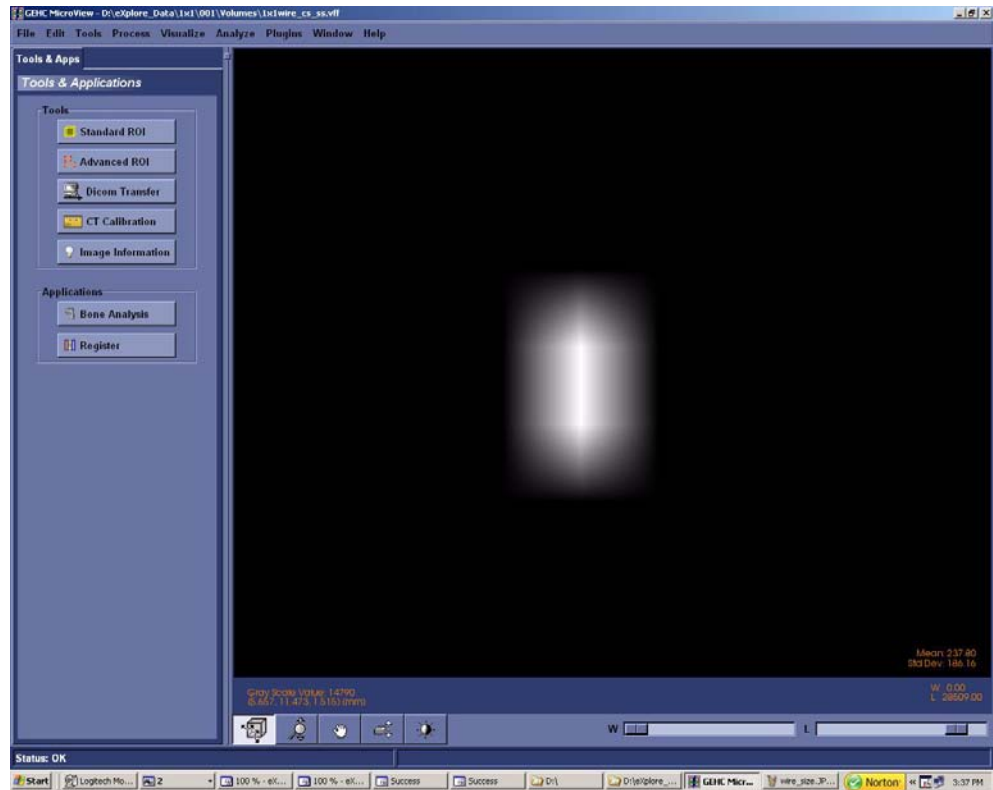
7. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_-end_360*. Verify that the wires appear round.
8. Move to the other end of the wire phantom by changing the Z-Origin to *2600*. Re-select the Short Scan field. Name the file *1x1wire_+end_ss*
9. Click the *Recon* button and view the image in **MicroView**. The wires should appear as round as possible. If the wires are not round, adjust the Centre of Rotation until the wires appear as round as possible.

Note: *If the Centre of Rotation at either end of the wire phantom differs by more than 1.5 pixels from the ideal Centre of Rotation at the Central Slice (e.g. the total difference is greater than 3 pixels), the tilt angle of the grid is likely incorrect and you must re-calibrate from that point (see Complete Transform1 File Creation).*

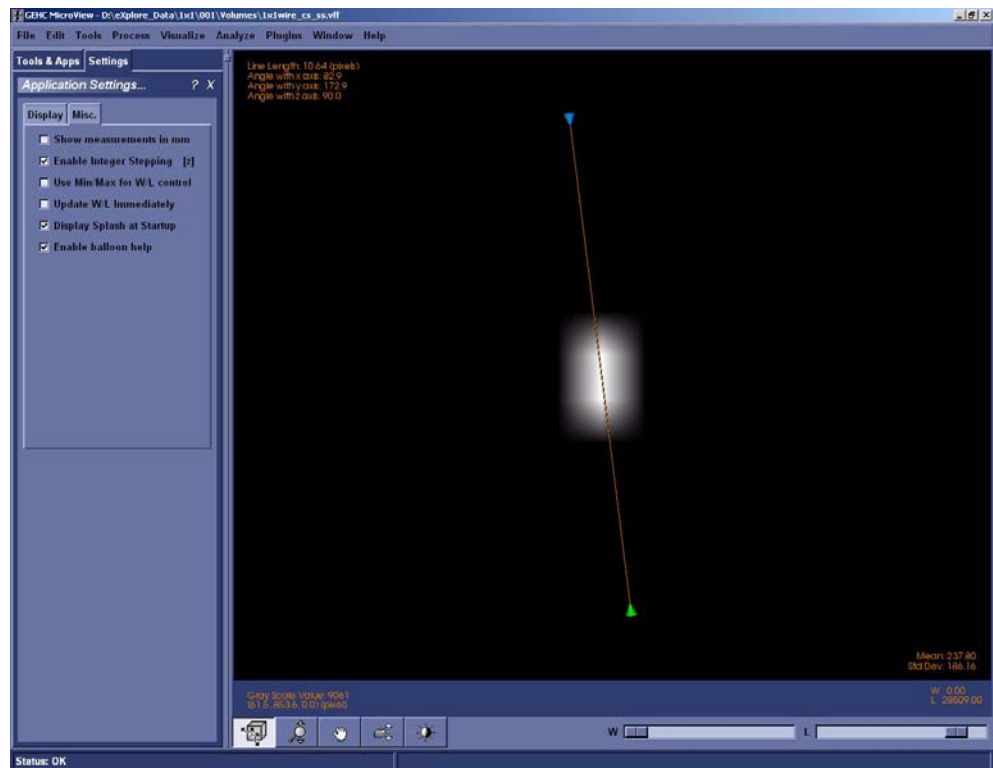
10. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_+end_360*. Verify that the wires appear round.
11. Once successful, click the *Set to Central Slice* button on the **Reconstruction Utility** window.
12. Click the *Advanced* button and choose the *Reconstruction* tab.
13. Select Short Scan.
14. Click the *Recon* button on the **Reconstruction Utility** window.
15. View the image in **MicroView** and zoom in on the wire that appears least round to be measured.
16. Select a region of interest within the phantom housing near the wire being measured. Press **m** to calculate the mean value of the plastic area selected. Record in Worksheet.



17. Zoom in on the wire. Adjust the Window and Level to allow only two pixels to be visible.



18. Plot a line across the wire's two brightest pixels using the 1 and 2 keys in MicroView.



The next step is to find the Full Width Half Maximum value of this wire in pixels.

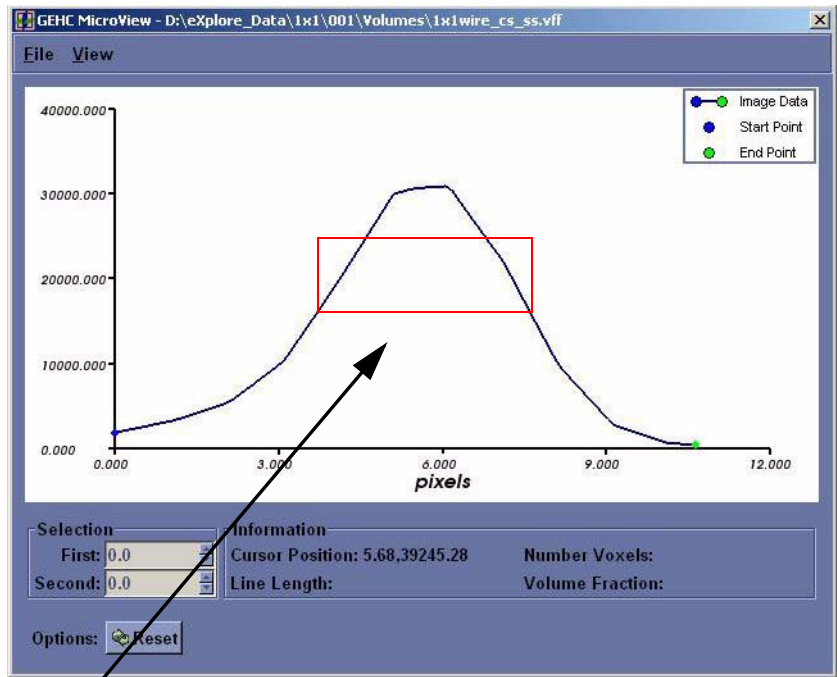
Note: *All 4 wires must be symmetrical, but not necessarily completely round. How the wires appear may give you a clue about a possible problem.*

If, for example, 2 wires in diagonal corners look good but the other 2 do not, the centring of the stage is not correct. If 3 of the wires look good and one looks bad, a possible error was made calculating the distance between the X-Ray Source and the detector or the Detector Spacing under the Calib. Settings tab is incorrect.

19. Press **p** to view the plot.

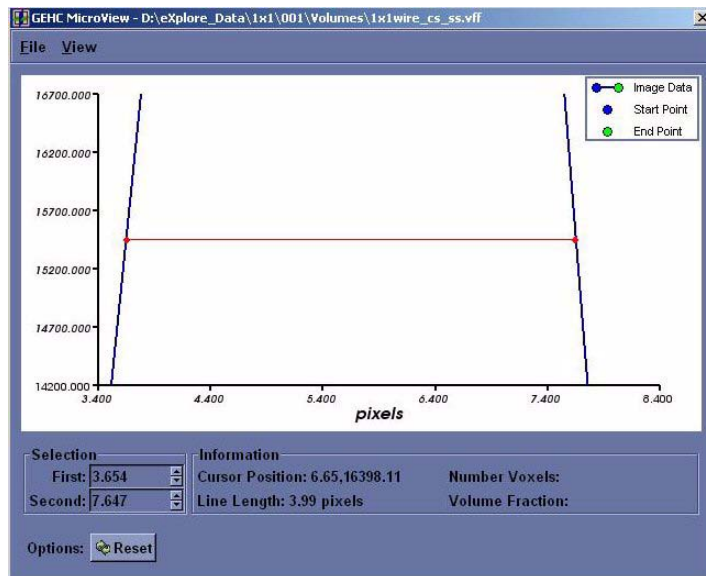
If the resulting plot is a straight line, exit Microview and repeat reconstruction but change z-size to 5.

20. Use the mouse pointer to find the number at the top of the peak (e.g. 30000). Record in Worksheet.
21. Add the mean value calculated above in step 16 to the peak value (determined in the last step) and then divide the result by 2. This is the Full Width Half Maximum value. Record value in Worksheet.



22. Zoom in (left-click and drag the mouse) so that the middle area of the peak is highlighted.
23. Move the mouse to the left line (side) and press **1** at the Full Width Half Maximum value point (e.g. 15000).

24. Move the mouse to the right line (side) and press **2** at the Full Width Half Maximum value point to draw a line from one side to the other.
25. Make note of the line length in pixels, in the Worksheet.
26. In **eExplore Scan Manager**, navigate to the 1x1 wire scan. Note the resolution value displayed on the right-hand side of the window in the Worksheet.
27. Divide .025mm (which is the size of the wire in the wire phantom) by the resolution value and then add 2 to the result. This value is the target value, in pixels, of the wire scan.



Example:

$$.025 \div .007634 = 3.274 \text{ (target value)}$$

$$3.274 + 2 = 5.274 \text{ (maximum value)}$$

Record values in the Worksheet.

28. Verify that the line length calculated in step 25 is less than the maximum value calculated in step 27. If not, calibration will need to be restarted.
29. Repeat steps 15 to 28 for the remaining 3 wires, recording appropriate values in the Worksheet.
30. Exit the plot, then exit **MicroView**.

Upon completion:

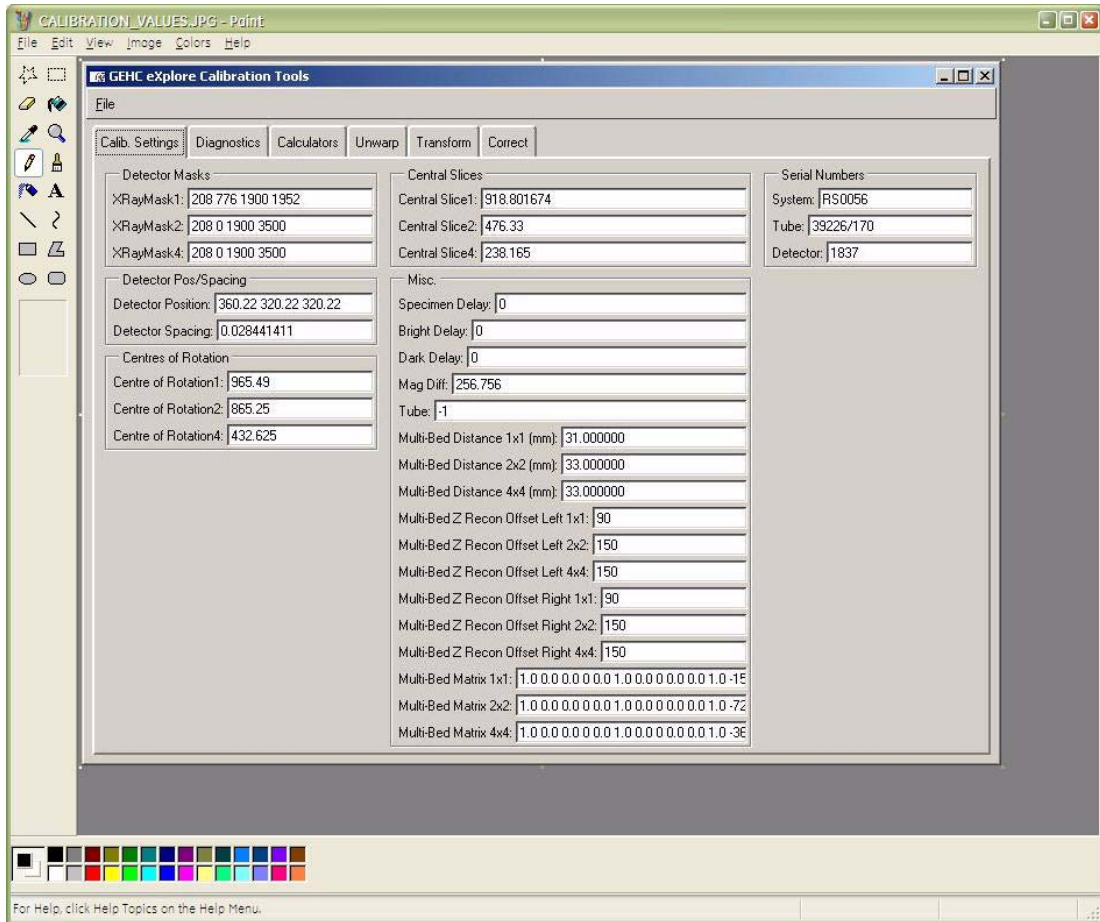
In the **Reconstruction Utility**, press the Advanced button. Go to the Recon tab. Re-enter the noted air, water and bone HU calibration values into each field for all three scans (1x1, 2x2 and 4x4) Inform the customer that they may need to re-calibrate their HU values.

7.2.13 Follow Up

Upon completion, back up calibration values.

SAVE CALIBRATION SETTINGS

1. Capture a screen shot of the calibration values found under the *Calib. Settings* tab in **Calibration Tools**.
2. Call the file *calibration_values.jpg*
3. Save the document to both C: and D: drives.

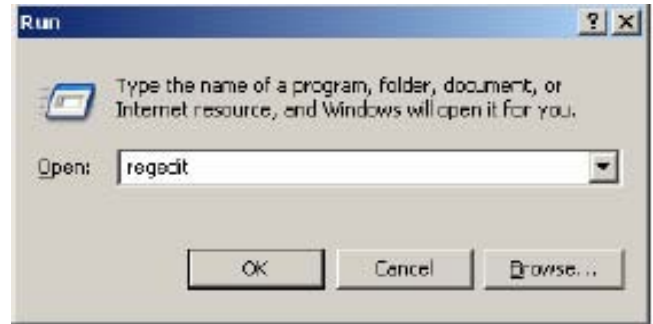


4. Copy D:\calib folder to C: drive.
5. Copy C:\translations1 to D: drive.

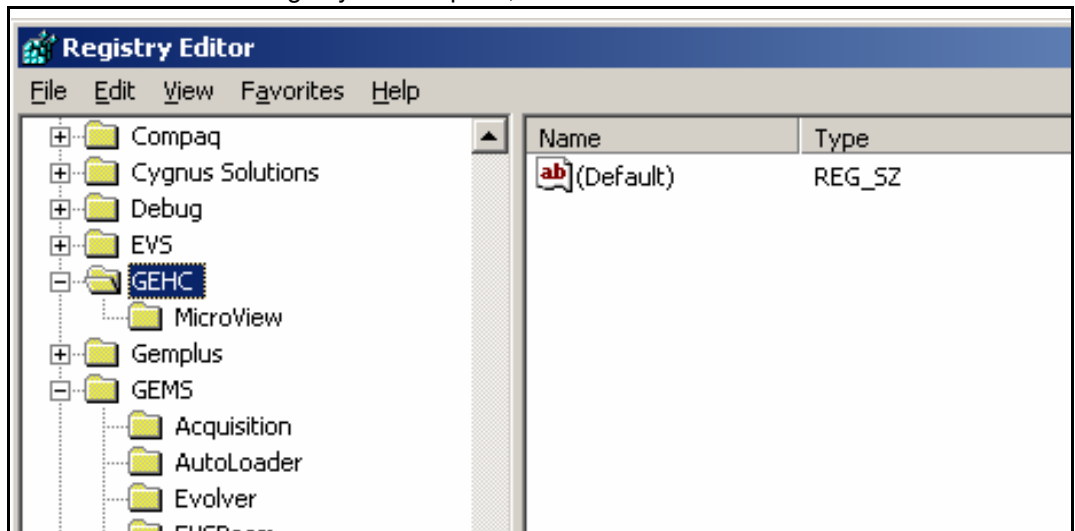
BACK UP REGISTRY

6. If needed, add the following folder to the C: drive: **Registry Backup**
7. Create a sub-folder under Registry Backup and label the folder with "today's date" e.g. yymmdd
8. Click on the Microsoft **start** button in the bottom right corner of the screen, and choose **Run...**

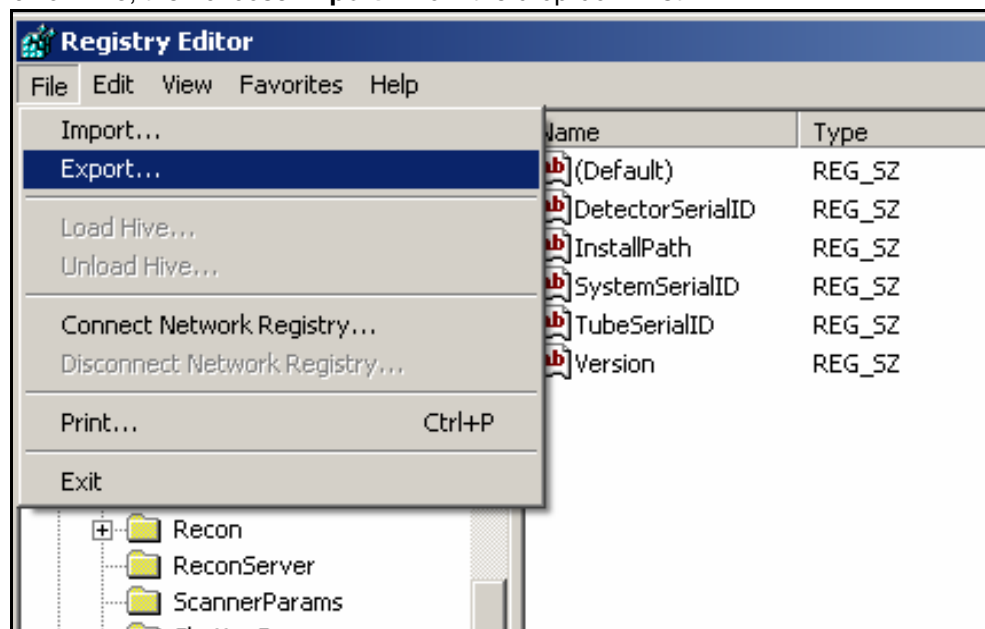
9. Enter the following in the text box, then click OK: **regedit**



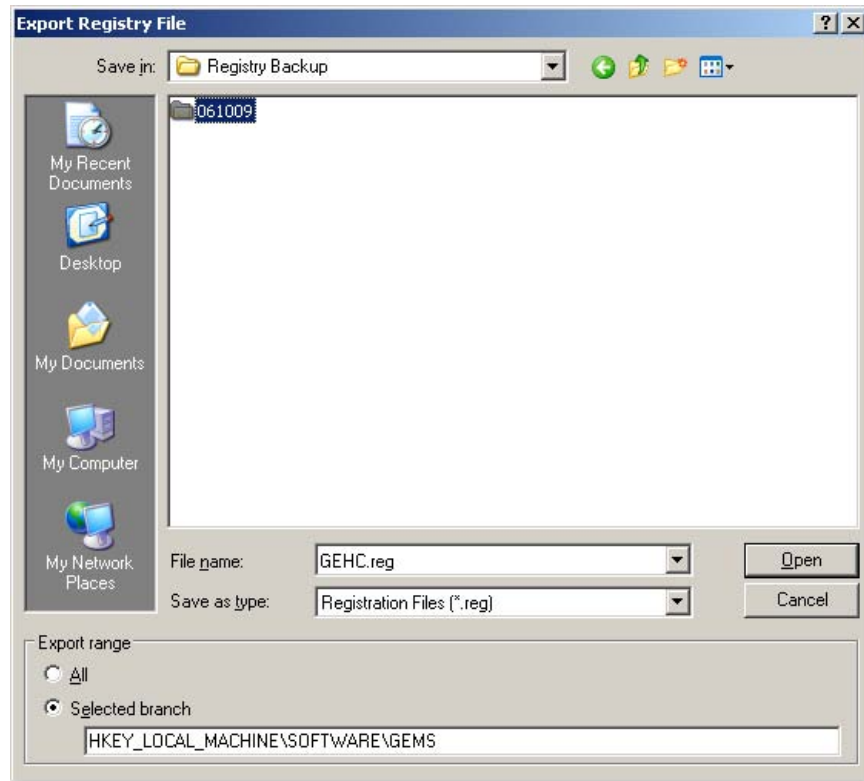
10. Once the Microsoft Registry Editor opens, click on the **GEHC** folder.



11. Click on **File**, then choose **Export...** from the drop-down list.



12. Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
13. Under File name, enter **GEHC.REG** then click on the **Save** button.



14. Next select the **GEMS** folder under the Registry Editor.
15. Click on **File**, then choose **Export...** from the drop-down list.
16. Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
17. Under File name, enter **GEMS.REG** then click on the **Save** button.
18. Using Windows Explorer, rename the file: **GEMS.GER**

This is done to protect the file so that it is not accidentally opened which would rewrite the registry.

DISABLE TEST PROTOCOLS

19. Disable the test protocols by changing the 1x1wire.protocol, 2x2wire.protocol and 4x4wire.protocol files to:

1x1wire.txt

2x2wire.txt

4x4wire.txt

Files are located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols\

BACK UP CRITICAL FILES TO DVDs

1. Copy the following files to a DVD:
 - C:\translations1
 - all the transform and transform.dat files found in D: drive
 - the D:\calib folder and the D:\detector folder
 - the C:\Program Files\GE Medical Systems folder
 - the newly created *calibration_values.txt* file
 - all saved volumes (e.g. 1x1_wire_cs_360)
 - the C:\Registry Backup folder.
2. Label the DVD with the name *Calibration Values*, and include the system serial number and date.
3. Create zip files containing the acquired images and support files created for each of the 3 wire scans. Call the zip files *1x1.zip*, *2x2.zip* and *4x4.zip*. There is no need to backup the 'Volumes' or 'Corrected' folder.
4. Save the zip files on to a separate DVD and label the DVD with the name *Wire Scans*. Include the system serial number and date.
5. Make two copies of each DVD. File one set of DVDs in the system's Device History Record folder located on the back of the system, and send the other to Service Engineering.

Service Engineering
Attn: Janice Chu
1510 Woodcock Street, Unit #7
London, ON N6H 5S1
Canada

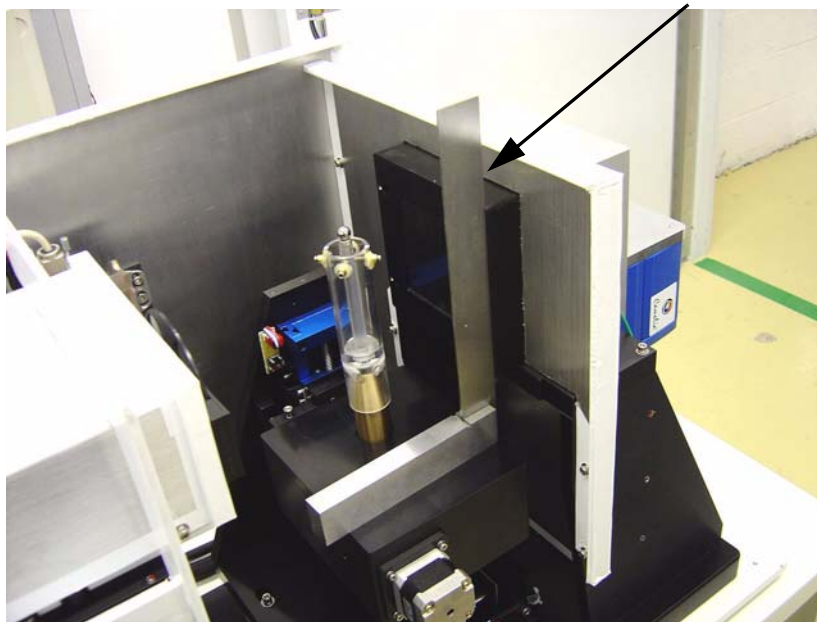
Section 7.3 Stage Replacement Calibration

The following describes the calibration procedures performed each time the stage is replaced. The procedures below use the following applications:

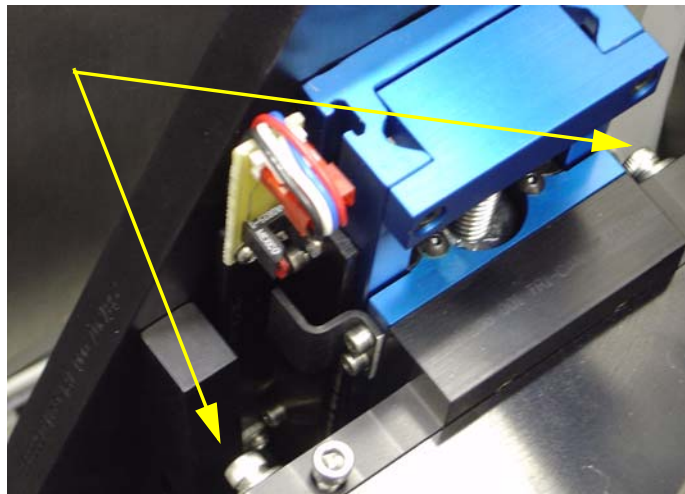
- **System Warm-Up** (C:\Program Files\GE Medical Systems\Explore Utilities\WarmupApp.exe)
- **Calibration Tools** (C:\Program Files\GE Medical Systems\Explore Utilities\Calibration.exe)
- **X-Ray and Motor Controller**. The **X-Ray and Motor Controller** (C:\Program Files\GE Medical Systems\Explore Utilities\X-Ray_Controller.exe)

7.3.1 Mechanically Align the Stage

1. Open **Windows Explorer** and navigate to D:/. Copy the *calib* folder and rename it *original_calib*.
2. Place the 9" Square tool on the stage with one edge flat against the detector.

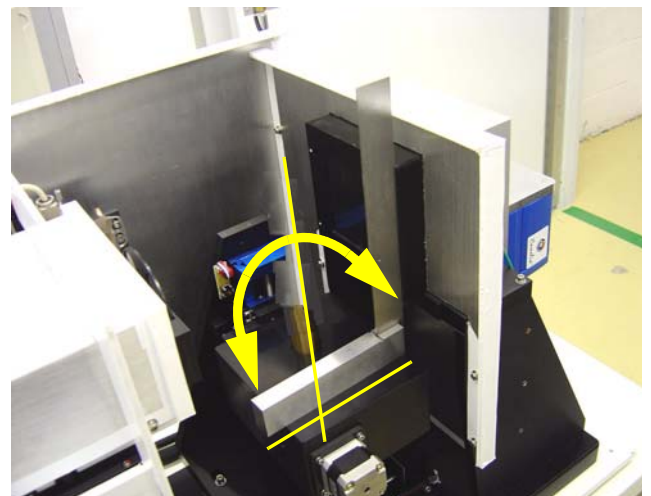
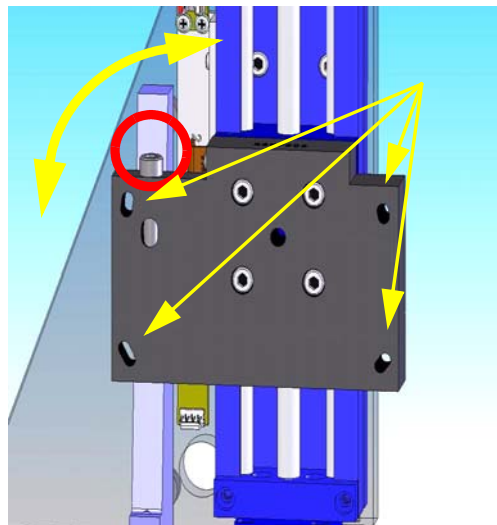


- Use the 4 stage levelling screws to tilt the stage until the 9" Square is flush against the detector and stage (this provides a rough stage alignment).



The 4 stage levelling screws sit in slanted, slotted holes (see diagram below, left) so, when loosened, allow for movement in the direction shown below.

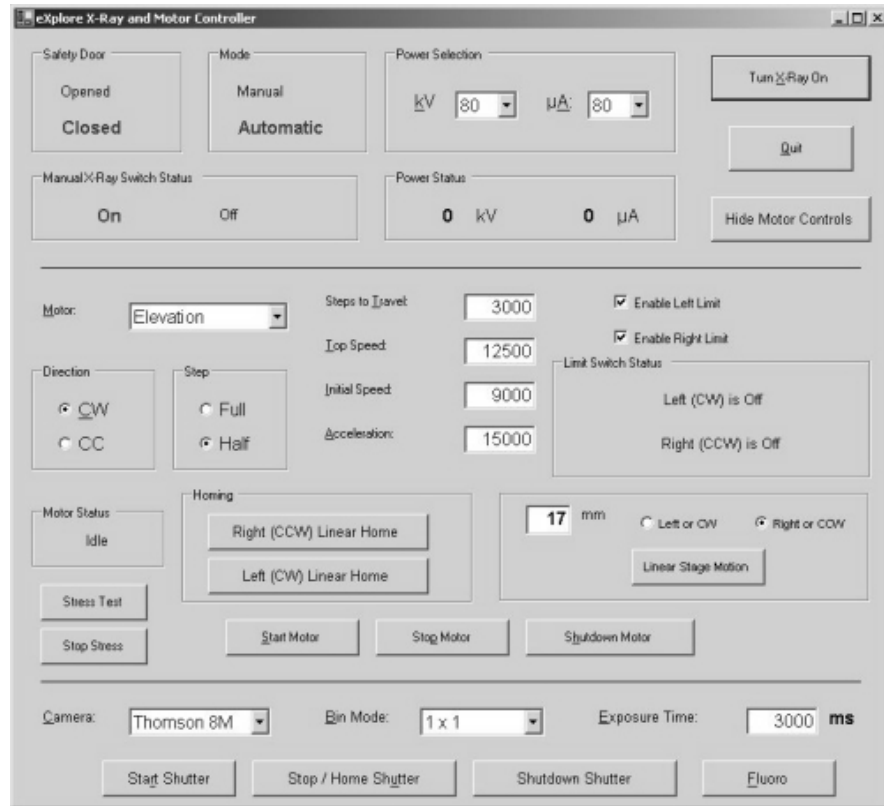
Note: *You may need to tighten or loosen the locking screw at the top of the bracket in order to get the stage aligned (see red circle in the left diagram).*



- Turn the unit ON using the key, and press the red *Reset* button.
- Warm-up the X-Ray Source using the **System Warm-Up** application as follows:
 - right-click the Warm-Up icon in the task bar and select the *<=10 Minutes to Scan* option
 - once the cycle has finished (approximately 14 minutes), right-click the icon again and select *Scan Mode*.The **System Warm-Up** application can be re-initialized by double-clicking on *WarmupApp.exe* in C:\Program Files\GE Medical Systems\Explore Utilities\
 - Access the **X-Ray and Motor Controller** program.

7. Ensure the fields below are set to the following settings:

Enable Left Limit: checked off
Enable Right Limit: checked off
Camera: Thomson 8M
Bin Mode: 1 x 1
Exposure Time: 3000 ms
kV: 80
 μ A: 80



8. Find the motor limit switch (this ensures that the limit switches will never be triggered):
- select *Magnification* from the drop down menu in the Motor field
 - press the *Left (CW) Linear Home* button to move the stage toward the detector
 - enter **2** in the mm field, click on the *right or CCW* radio button, then press the *Linear Stage Motion* button to offset the "home" position by 2 mm.
9. Click the *Start Shutter* button.
10. Click the *Turn X-Ray On* button.
11. Click the *Fluoro* button, then:
- select *OK* when the warning pop-up appears.
 - select *OK* when the text concerning placement of the specimen appears.

Capture an Image:

12. Capture an image in **Fluoro** as follows:
 - click *Menu* at the top of the **Fluoro** screen and choose *Capture* from the drop-down menu
 - once the Capture pop-up is displayed, enter **1** in the Number of Frames to Capture field
 - enter **3** in the Number of Frames to Average field
 - name the file *bright* in the Name of Series field
 - save the file to the directory: D:\calib
 - click the *Capture* button.

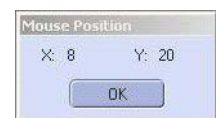
The progress of capture is shown in the Fluoro's title bar as *[saving...]*. Wait until the image is captured.

13. Turn off the X-Ray Source and capture a dark image in Fluoro. Call this image *dark*.
14. Move the stage 70mm toward the X-Ray Source, so that is positioned in the centre between the Source and the detector.



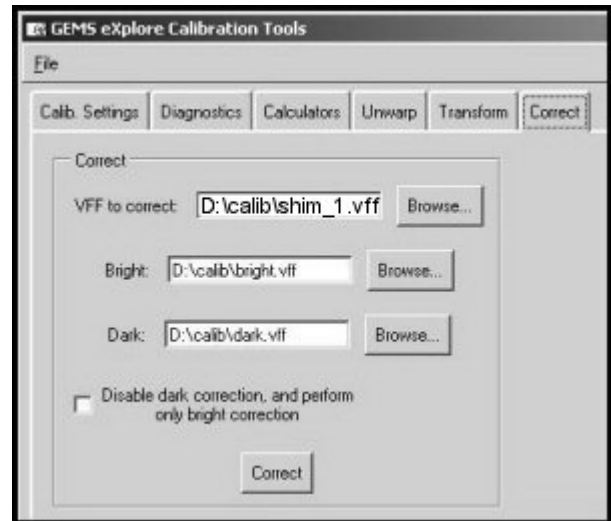
VERIFY STAGE TILT (FRONT-TO-BACK MOVEMENT)

15. Attach the X, Y Ball Centring tool with the bebe facing toward the detector.
16. Move the stage back 70mm toward the detector.
17. Turn the X-Ray Source back on and wait 2 minutes to let the Source stabilize.
18. Access **Fluoro**. and press *m* to display the mouse position window.
19. Rotate the tool until the top bebe appears in the centre of the x axis of the screen.
20. Adjust the elevation using the **X-Ray and Motor Controller** program so that the top bebe moves downward and appears within 200 pixels of the bottom of the screen. Capture an image in **Fluoro** and name it *shim1*.
21. Adjust the elevation, so that the top bebe moves upward and appears within 200 pixels of the top of the screen (approximately 50mm).
22. Capture an image in **Fluoro** and name it *shim2*.



Correct the First Image:

23. Correct the captured image as follows:
 - access the **Calibration Tools** program (located in C:\Program Files\GE Medical Systems\Explore Utilities\Calibration)
 - click the *Correct* tab
 - in the VFF to correct field, find the newly captured image (e.g. *shim_1*)
 - use the *Browse* buttons to find the files called *bright* and *dark*
 - click the *Correct* button (the corrected file is named *corrected.vff* and it is stored in the same folder in which the captured imaged was stored)

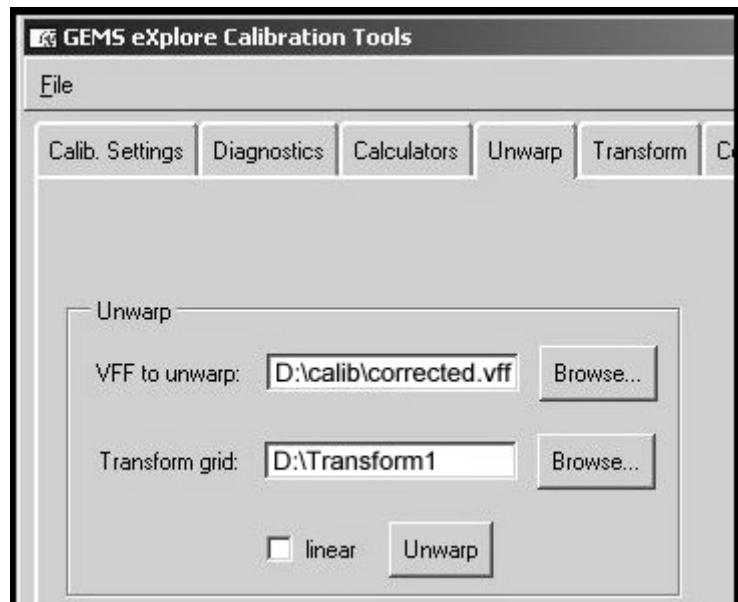


Unwarp the Image:

24. Click the *Unwarp* tab in **Calibration Tools** and complete the fields as follows:
 - in the VFF to unwarp: field use the *Browse* button to find the file D:\calib\corrected.vff
 - in the Transform grid: field, use the *Browse* button to find the D:\Transform1 file.
25. Click the *Unwarp* button.
26. Call the file D:\zz when prompted to name the file, then click *OK*.

The zz file will be used as a temporary file for unwarping. Continue to overwrite this file whenever unwarping.

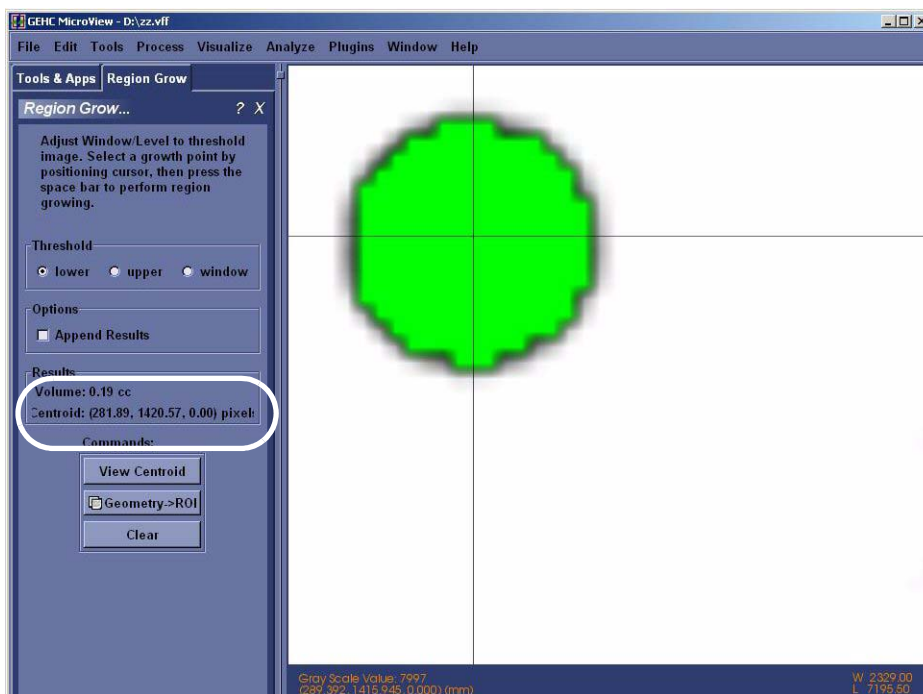
27. Double-click on zz in **Windows Explorer** to load the image into **MicroView**.



28. Double-click on the W and L parameters in the lower right of the screen. Change the Update mode to *Delayed updates*. This only needs to be changed once.



29. Make a note of the x value of the centre of the bebe using **MicroView's** Region Grow tool:
- In **MicroView**, choose *Tools>Region Grow*.
 - Select *Lower* in the Threshold field.
 - Place the mouse over the bebe and press the Spacebar (the bebe's solid centre turns green).
 - Record the centroid value (x & y coordinates) in the Worksheet. If desired, press the *View Centroid* button to view the calculated actual centre. You may have to Pan and Zoom to see the cross hairs.



30. Repeat the steps above (Correct the Image, and Unwarp the Image) for the *shim2* file. Use the Worksheet and make a note of the x value of the centre of the bebe using **MicroView's** Region Grow tool.

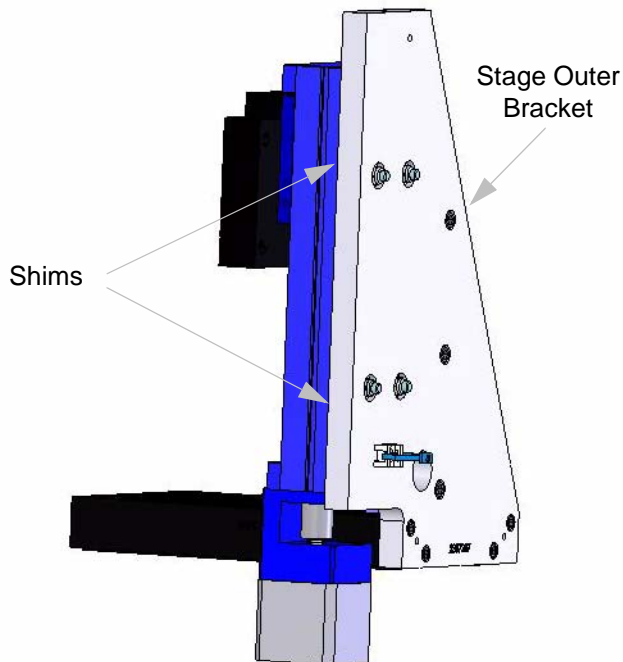
Note: *The x values must be within 2 pixels of each other (e.g. if one value is 1140, the other must be within 1138 to 1142).*

If the values **ARE NOT** within 2 pixels of each other:

31. Place shims under the elevation rail (loosen stage bolts, etc.).

Note: *One pixel is approximately .002" in shims. If the x value of the top bebe in **Fluoro** is less than the x value of the bottom bebe, the shim goes on the bottom of the stage. If the x value of the top bebe is higher, the shim goes at the top of the stage.*

The shims are placed close to the mounting bolts. Larger adjustments (more than 0.004") will require shims at both the top *and* the bottom to allow the stage to tip once it is tightened (e.g. large shim on the bottom and small shim on the top). This is because flat surfaces are bolted together.

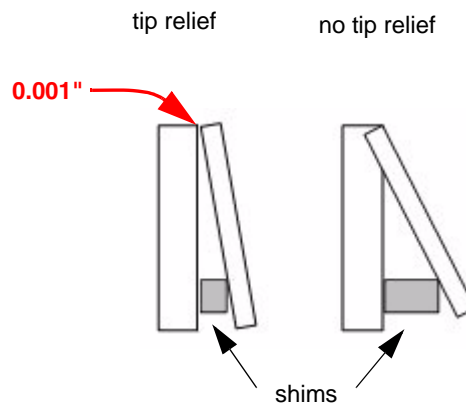


NOTICE
Equipment
Damage
Possible

Failure to provide a tip relief will cause the rail assembly to bend when the bolts are tightened. There should be at least 0.001" clearance at the tip end.

If you have to shim the stage, re-check the stage tilt mechanically using the 9" Square.

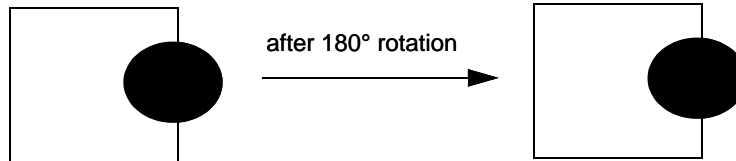
Repeat steps 18 to 29 until the values are within + or - 2 pixels.



VERIFY STAGE TIP (SIDE-TO-SIDE MOVEMENT)

32. Move the ball toward the X-Ray Source (*140mm right*).
33. Elevate and rotate the tool until the top bebe appears in the centre of the screen.
34. Use the mouse pointer window as a reference guide and rotate the bebe 180°.

The goal here is to have the bebe return to the same x axis after the 180° rotation.



35. Continue to reposition the bebe until it is close to returning to the same x axis.
It may be necessary to rotate the bebe less than 0.1 degree to get it in the exact centre. To make movements that are finer than 0.1 degree access the **X-Ray and Motor Controller** and adjust the *Steps to Travel* field (e.g. 50) which are steps in the stepper motor. Adjust the Direction and press the *Start Motor* button.

The next goal is to confirm that, at the X-Ray Source end, the y values at 0 and 180 degree rotation are within 2 pixels of each other AND within 2 pixels of the Central Slice, AND the y axis at the Detector end is within 2 pixels of the Central Slice.

36. Once the bebe is properly positioned in the x direction, capture the image, correct and unwarped it. Open the image in **MicroView** and determine the y axis of the bebe using the Region Grow tool in **MicroView**. Record value in Worksheet. This y axis must be the same as the Central Slice value (within 2 pixels).

To find the calculated Central Slice, in **Calibration Tools**, click on the *Calib. Settings* tab. Click *File* and choose *Read Registry Values* from the drop-down menu. The calculated Central Slice value is found beside Central Slice1.

If the y axis position is not the same value as the Central Slice (within 2 pixels):

37. Continue to adjust the elevation - capturing, correcting, unwarping, and viewing the images in **MicroView** - until the y axis is within 2 pixels of the Central Slice value. Use the *Steps to Travel* field within **X-Ray and Motor Controller** to make movements finer than 1mm.

Once the y axis position equals the value as the Central Slice (within 2 pixels):

38. Rotate the tool 180° and capture, correct, unwarped and view the image in **MicroView**. The value of this y axis position must be within 2 pixels of the previous value before rotation. For example, if the previous y axis was 1428, this y axis position may have a value between 1426 and 1430. Also, verify the x value are within 5 pixels of each other.

Note: *If not within 2 pixels, verify the Central Slice position before making any adjustments, as follows.*

Verify the Central Slice position:

- rotate the tool back 180 degrees
- move the stage 140mm toward the detector
- capture an image, correct and unwarp it
- load the image into **MicroView** and check that the y position is the same within 2 pixels. If the y position is not at the Central Slice at the detector end, the Central Slice calculation will need to be redone.

Verify all values before redoing the Central Slice calculation.

If the y axis is not within 2 pixels of the previous value and the Central Slice calculation is verified:

- Move the stage back 140 mm toward the Source.
- Mechanically adjust the stage using the stage levelling screws (capturing, correcting, unwarping and viewing an image after each adjustment). Move the stage to the centre (70mm toward the detector) in order to mechanically adjust the stage.
- Continue to adjust the stage and view the results until the y axis is within 2 pixels of the previous value after 180° of rotation.

The end result is that at the Source end the y values at 0 and 180 degree rotation are within 2 pixels of each other and within 2 pixels of the Central Slice, AND the y axis at the detector end is within 2 pixels of the Central Slice.

39. Once the values are within 2 pixels of each other, capture and save an image after each rotation and call the files *Tip1* and *Tip2*.

7.3.2 Centre the Stage

This procedure is used to centre the stage between the X-Ray Source and the detector. With the X,Y Centring Ball tools still mounted and the X-Ray Source on:

1. Click on the *Turn X-Ray Off* button, then physically rotate the X,Y Centring Ball tool so that 2 of the 4 adjustment screws are exactly perpendicular to the detector (i.e. not at an angle).
2. Elevate the tool using the Elevation feature in **X-Ray and Motor Controller** until the ball appears in the centre of the **Fluoro** display. Move the stage 70mm toward the detector so that it is positioned in the middle between the Source and detector.



3. Mount the Dial Indicator Mount and Precision Dial Indicator.
4. Adjust the tip on the Precision Dial Indicator to strike the equator of the ball. Make sure the Indicator is not pegged (i.e. the small needle on the gauge, near the centre of the Dial Indicator, is around the halfway mark).

Note: *The Precision Dial Indicator is very sensitive and care should be taken not to lean or touch any part of the system while adjusting the Indicator or the X,Y Centring Ball tool.*

5. Zero the Precision Dial Indicator.

Note: *For fine measurements, the Precision Dial Indicator may not be accurate until after the first movement.*

6. Use the *Rotation* setting in **X-Ray and Motor Controller** to rotate the ball 360° (180° at a time). Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged. Re-zero the Dial Indicator, if necessary.

Centre the Ball:

7. Use the *Rotation* setting to rotate the ball 180°.
8. Watch the Precision Dial Indicator as the ball rotates. Note the reading of the Precision Dial Indicator after 180° of rotation (e.g. .0004") in the Worksheet.
The objective is to adjust the ball so that, after the adjustment, the Dial Indicator reads half of the original reading (e.g. .0002").

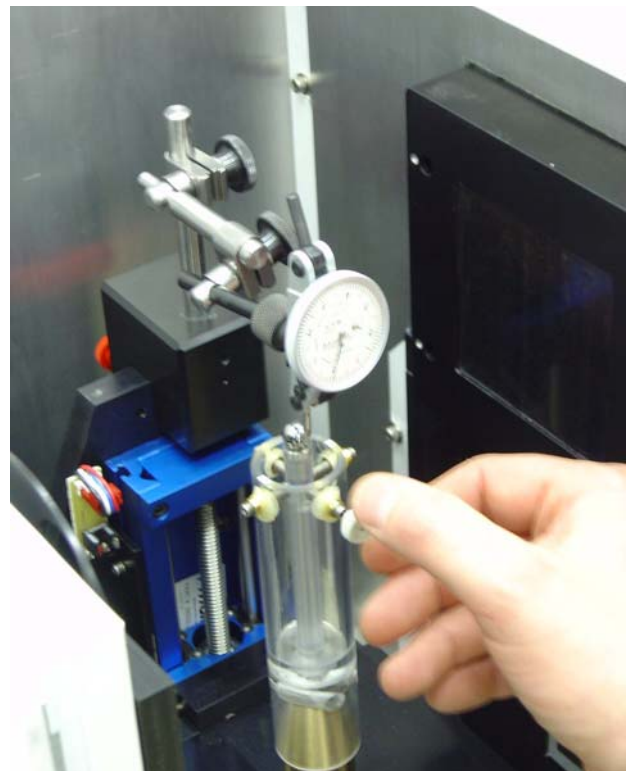
To do this:

9. Use the tool's adjustment key to carefully turn the 2 adjustment screws that are aligned with the Dial Indicator - turn the screws until the Dial Indicator reads half of the original reading.

NOTICE
Equipment
Damage
Possible

The tool is extremely delicate. Fine adjustments are required. DO NOT overtighten the screws. One screw turns clockwise and the other turns counter clockwise. Turn the screws in tandem using as little torque as possible (i.e. 5° at a time)

10. Once adjusted, rotate the ball 180° and check the Dial Indicator reading. It should match the reading taken after the adjustment in the previous step (e.g. .0002").
11. Re-zero the Dial Indicator.
12. Use the rotation setting to rotate the ball 360° (180° at a time). Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged. Re-zero the Dial Indicator, if necessary.



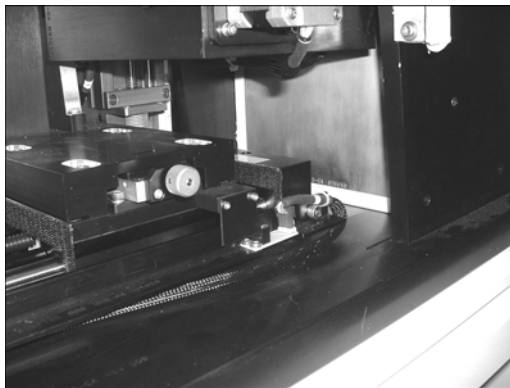
NOTICE
Equipment
Damage
Possible

13. Rotate the ball 180° and confirm the Dial Indicator reads zero.
14. Rotate the ball 90°.
15. Carefully adjust the 2 screws that are aligned with the Dial Indicator until the Dial Indicator reads zero.
16. Rotate the ball 180° and verify that the Dial Indicator still reads zero.

Note: *Fine tuning may be required. Continue to make adjustments until the ball can rotate 360° without the Dial Indicator reading moving more than .0002".*

17. Once the ball has been centred, remove the Dial Indicator Mount and Precision Dial Indicator.
18. Select *Magnification* in the Motor field in the **X-Ray and Motor Controller** window and move the ball 70 mm toward the detector. This should be 2mm from the limit switch.
19. Warm up the x-rays without using the **System Warm-up** application to avoid moving the stage. To do this, use the **X-Ray and Motor Controller** program and do the following:
 - a. Set the kV field to 80
 - b. Set the μ A field to 10
 - c. Press the **Turn X-Rays** on button
 - d. Wait 2 minutes
 - e. Press the **Turn X-Rays** off button
 - f. Set the kV and μ A field to the next value in list below, and repeat steps c to e:

- wait 2 minutes @ 80kV, 45 μ A
- wait 10 minutes @ 80kV, 80 μ A



20. Capture the image in **Fluoro** and name it *capture*.
21. Correct and unwarped the captured image using **Calibration Tools**.

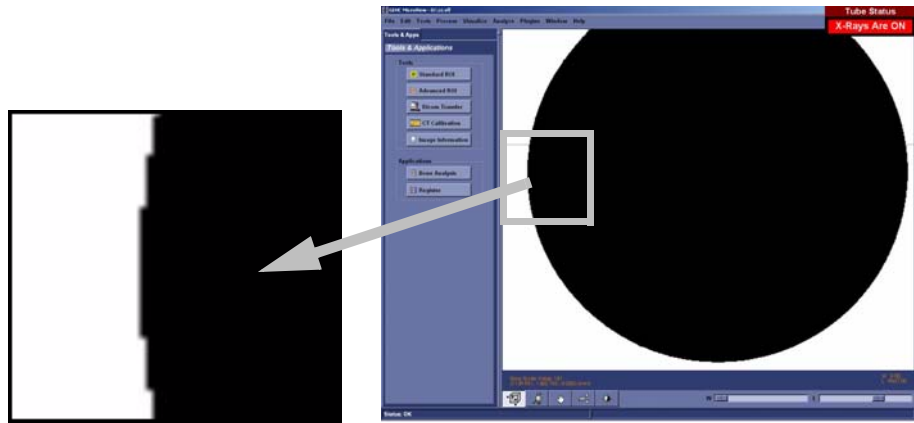
Find the Geometric Centre of the Ball at Detector End:

Note: *To find the geometric centre of the ball, determine the x value on the right and left side of the ball. Add the values together and divide by 2. To find the geometric centre as follows.*

22. Use the Pan and Zoom features in **MicroView** to get the ball in the desired area of the screen.

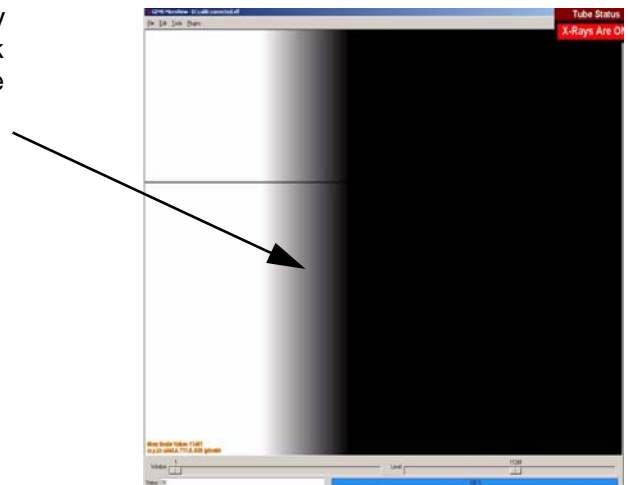
Note: *To Pan, move the mouse while pressing Shift plus the left mouse button simultaneously. To Zoom, move the mouse up (to magnify) or down (to zoom out) while pressing the right mouse button.*

23. Threshold the image by sliding the *Window* slide bar to the left until it reads 0 and sliding the *Level* slide bar until the edges of the ball appears with the maximum amount of square edges.



24. Zoom in on the outer left most side of the ball.

25. Place the mouse in the middle of the gray band that appears to the left of the black area. Use the Worksheet and make note of the x coordinate and round the coordinate to the nearest .5 pixel.



26. Zoom out and move to the right outer most side of the ball. Zoom in on the edge. **DO NOT** re-adjust the *Window* and *Level* slide bars.

27. Place the mouse in the middle of the gray band that appears to the right of the black area. Make note of the x coordinate in the Worksheet.

28. Add the 2 x values together and then divide by 2. This value is the ball's geometric centre. Make note of this value in the Worksheet.
This value should be close to the centre of rotation in the registry. Open **Calibration Tools** (located in C:\Program Files\GE Medical Systems\Explore Utilities\Calibration\). Click on Calb. settings tab. Click File, and choose Read Registry Values from the drop-down menu. The Centre of Rotation equals the value in Centre of Rotation1.
29. Use the **X-Ray and Motor Controller's Magnification** setting to move the ball toward the X-Ray Source 140mm.
30. Capture the image calling the file *capture*.
31. Load the corrected and unwarped image into **MicroView**.
32. Find the geometric centre of the ball at the X-Ray Source end by making note of the x values on the outer most left and right side of the ball and dividing this value by 2. Note values in the Worksheet.



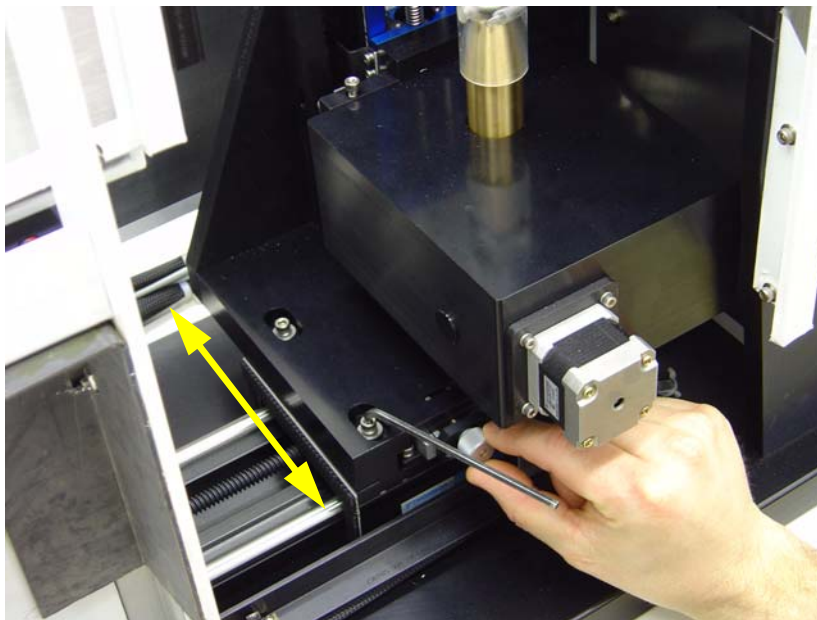
Note: *This value must eventually equal the ball's geometric centre at the detector end, plus or minus 1 pixel.*

IF NOT, adjust the geometric centre values until they are within 1 pixel of each other as follows:

- a. Turn off the X-Ray Source.
- b. Loosen the 4 stage retaining bolts.
- c. Manually adjust the stage using the stage's adjustment wheel (see following Note).

This moves the stage perpendicular to the rail as shown here in the diagram.

- d. Continue to determine the value of the ball's geometric centre at both the detector end and the X-Ray Source end - manually adjusting the stage's adjustment wheel in between - until the values are equal, plus or minus 1 pixel.



Note: *The adjustment will change the ball's geometric centre value 3 times faster when the stage is at the X-Ray Source end compared to an adjustment when the stage is at the detector end. If the value at the X-Ray Source is larger than the value at the detector end, turning the adjustment wheel clockwise reduces the values. Small movements of the adjustment wheel are required. One pixel will equal a few (1 to 5 degrees) turns of the wheel.*

Once confirmed (i.e. the values of the 2 geometric centres are the same + or - 1 pixel):

33. Carefully tighten the 4 bolts (snug only) once the values are close. Make the bolts sufficiently tight so that the adjustment wheel will operate but is difficult to turn. Tightening the bolts may change the value of the geometric centres.
34. Complete the tightening of the 4 bolts and then verify the results at both ends. The bolts may need to be loosened and retightened as you use the adjustment wheel to align the 2 values.

Once the 2 figures are again within 1 pixel of each other, the geometric centre of the ball (the value of its x axis) is now the CENTRE OF ROTATION. Make note of this value in the Worksheet.

35. Save a captured image at both the detector end and the X-Ray Source end. Name the image closest to the detector *smallball.vff* and the image closest to the X-Ray Source *largeball.vff*.
36. Turn off the X-Ray Source and exit **X-Ray and Motor Controller**.

7.3.3 Perform Verification Scans (1x1, 2x2, & 4x4 Modes)

The following procedure is used to verify the calibration settings.

Note: *The ambient temperature in the room must be stable to perform this procedure i.e. the room temperature should not change even by 1 degree during the scanning process.*

First perform verification scans for 1x1 mode using the procedure below, then repeat the procedure in order to perform verification scans for 2x2 and 4x4 modes.

FIND THE IDEAL CENTRE OF ROTATION AT CENTRAL SLICE:

1. Place the wire phantom in the small specimen tube, secure the phantom with foam, and mount the tube.
2. Ensure the filter wheel is set to **4** (or choose **1** for 4x4 mode).

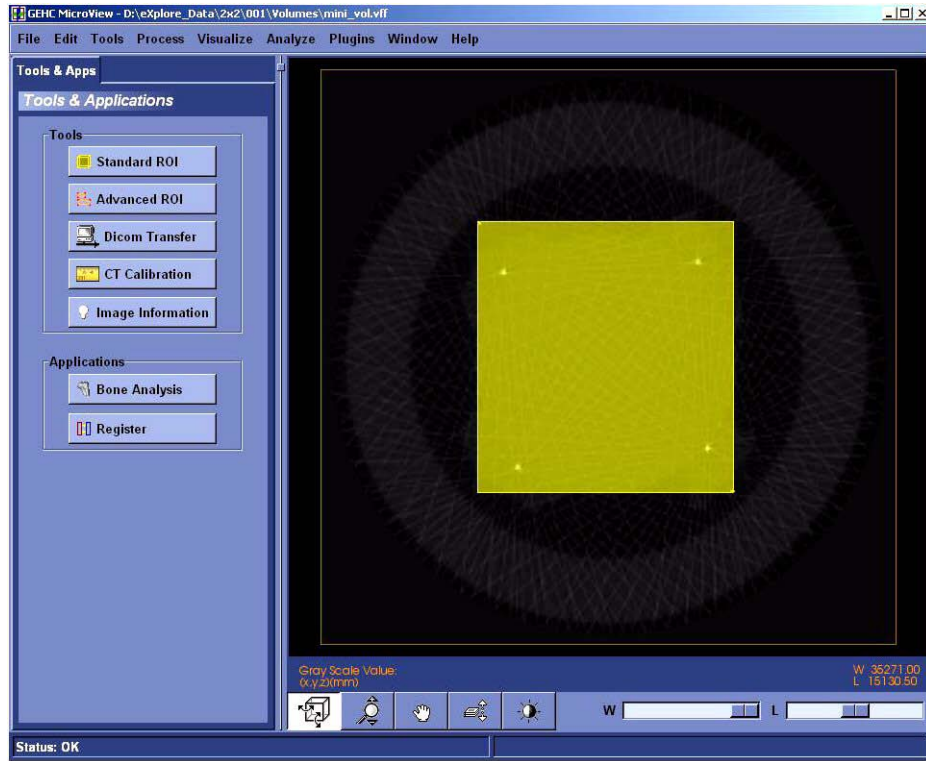
Note: *Details concerning the following steps are found in the **eExplore Locus SP User Guide**. Refer to it for particulars.*

3. Warm up the X-Ray Source, if needed.
4. Once warmed up, launch **eExplore Scan Manager**.
5. Click *Scan New Subject* and name the subject *1x1* (or *2x2* or *4x4* depending on which verification scans are being performed).

6. Enter *1x1wire* in the Scan Description field (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
7. The **Scan Control** window opens. Select *1x1wire* from the Protocol drop-down list (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
8. Select the *Scan bright and dark first*, *Recon after scan* and *Home all stages* checkboxes under Options.
9. Start **Fuoro**.
10. Click *Menu* and choose *Position Stages* from the drop-down list.
11. Adjust the elevation until the wires of the center section of the wire phantom extend from the top to the bottom of the screen.
12. Exit **Fuoro**.
13. Press the *Start Scan* button (the scan takes approximately 45 minutes) and follow the prompts to place and remove the specimen from the scanner for the bright and dark scans.
The **eXplore Reconstruction Utility** launches automatically when the scan is complete.
14. Click the *Set to Central Slice* button.
15. Click the *Thumbnail* button.
16. Change the Z-Size field to **5**.
17. Press the *Recon* button on the **Reconstruction Utility** window.
18. View the image in **MicroView**. Draw a line from the wire on the left side of the screen to the wire on the top using the 1 and 2 keys, and note the angle displayed in the top left of the screen, in the Worksheet.
19. Exit **MicroView**.
20. Press the *Advanced* button on the **Reconstruction Utility** window and select the *Reconstruction* tab.
21. Enter the approximate angle of the 4 wires noted above in the Angle field, then click *OK*.
22. Record the existing air, water and HU calibration values in the Worksheet. Enter **-1** (minus one) values for each field.
23. Select *Short Scan*. This looks at the first 200 views instead of all 360 views. It will emphasize any errors in calibration. Click *OK*.
24. Press the *Recon* button in the **Reconstruction Utility** window.
25. View the image in **MicroView** upon completion. The 4 wires should appear "square" to the screen.

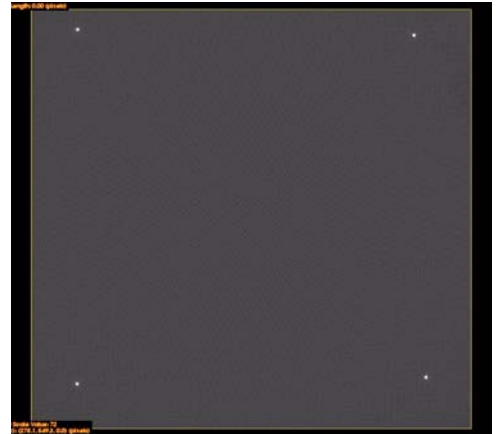


26. Select a region of interest that encompasses all 4 wires using the 7 and 8 keys in **MicroView**.

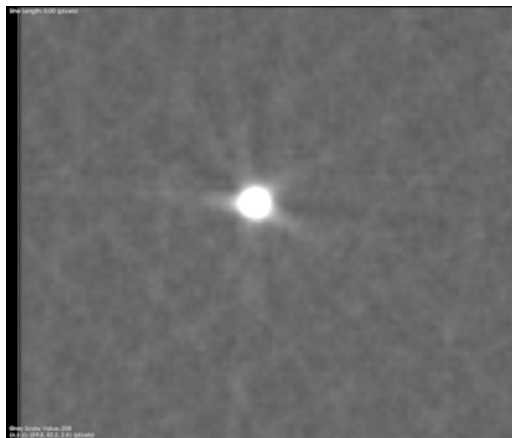


27. Select File>Save crop coordinates.
28. Exit **MicroView**.
29. Click the *Load Crop* button on the **Reconstruction Utility** window.
30. Press the *Recon* button. View the image in **MicroView** and verify the image is cropped properly, then exit **MicroView**.
31. Click the *Full Res* button. De-select the Mini-volume field. This allows you to name the resulting reconstructed volume.
32. Change the Z-Size field to 1.
33. Press the *Recon* button. Name the file *1x1wire_cs_ss.vff* (or *2x2wire_cs_ss.vff* or *4x4wire_cs_ss.vff* depending on which verification scans are being performed).

34. View the cropped area in **MicroView** upon completion.



35. Zoom in on individual wires. All 4 wires should be as round as possible.



Round Wire



Skewed Wire

If all of the wires are not round, the Centre of Rotation needs to be adjusted as follows:

- a. Exit **MicroView**.
- b. Click the *Advanced* button in the **Reconstruction Utility** window.
- c. Click the *Reconstruction* tab.
- d. Change the Centre of Rotation field. Make only small, incremental changes to this number (e.g. change 1150 to 1150.5) then click *OK*.
- e. Click the *Recon* button in the **Reconstruction Utility** window.
- f. View the image in **MicroView** upon completion. If the image is improved, continue to change the Centre of Rotation in the same direction (e.g. change 1150.5 to 1151). If the image is worse, change the Centre of Rotation in the opposite direction (e.g. change 1150.5 to 1149.5).
- g. Continue to adjust the Centre of Rotation until the wires are as round as possible (although all 4 wires are unlikely to be equally round).
- h. Make a note of this value in the Worksheet. This is the ideal Centre of Rotation at the Central Slice.

If the wires appear square, ensure that the interpolation is on:

- a. Go to Edit->Application Settings
- b. Ensure a checkmark appears next to "Use Image Interpolation".

36. Click the *Advanced* button in the **Reconstruction Utility** window, and choose the *Reconstruction* tab.
37. De-select the Short Scan field and click *OK*.
38. Click the *Recon* button in the **Reconstruction Utility** window.
39. Name the file *1x1_wire_cs_360* (or *2x2_wire_cs_360* or *4x4_wire_cs_360* depending on which verification scans are being performed)
40. Confirm the wires are still round in **MicroView**. The wires should appear even rounder. Exit **MicroView**.

Note: *If the wires appear hollow (like a ring) in the 360 degree reconstruction, then the Centre of Rotation needs to be adjusted as described above. Also, verify that the HU calibration values are set to -1.*

This process has determined the ideal Centre of Rotation of the wire phantom at the Central Slice. The following steps check the Centre of Rotation of the image at either end of the wire phantom.

VERIFY CENTRE OF ROTATION AT EACH END (ONLY FOR 1X1 MODE):

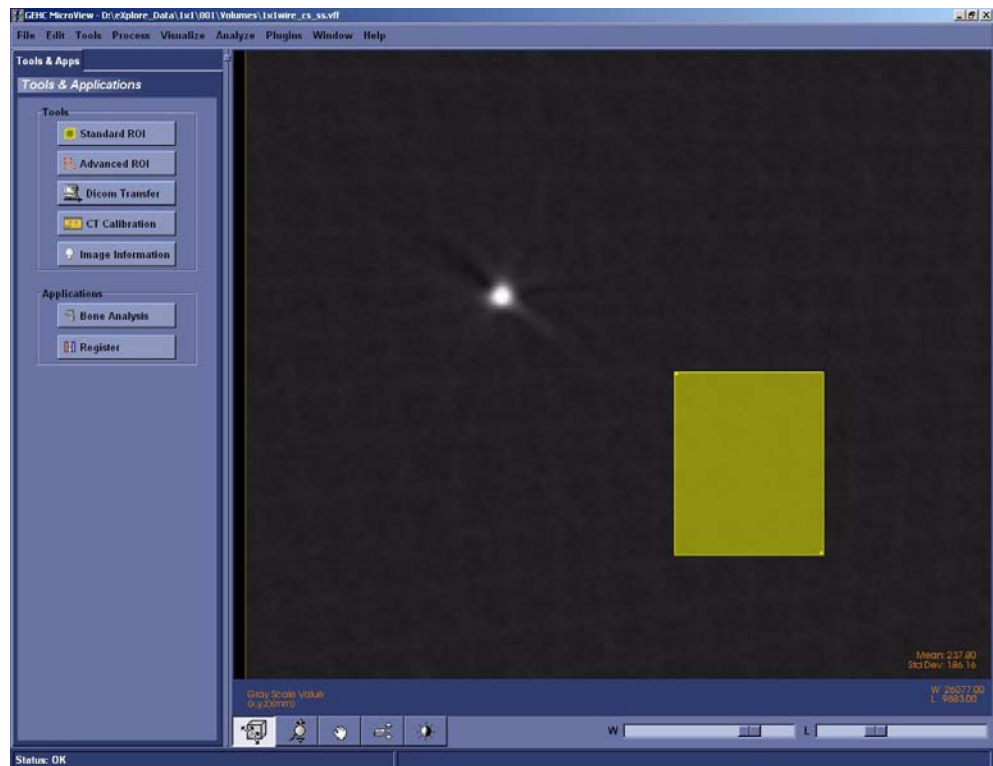
1. Change the Z-Origin field on the **Reconstruction Utility** window to *200*. This represents one end of the wire phantom.
2. Click the *Advanced* button, then choose the *Reconstruction* tab.
3. Re-select Short Scan, then click *OK*.
4. Click the *Recon* button. Name the file *1x1wire_-end_ss*
5. View the image in **MicroView**. The wires should appear as round as possible.
If the wires are not round, the Centre of Rotation needs to be adjusted as described above.
6. Upon completion, make note of the difference between this Centre of Rotation and the ideal Centre of Rotation at the Central Slice in the Worksheet.

Note: *The value of the Centre of Rotation at either end of the wire phantom may only differ from the ideal Centre of Rotation at the Central Slice by 1.5 pixels. The Short Scan option in **Reconstruction Utility** must be used for this test to be valid.*

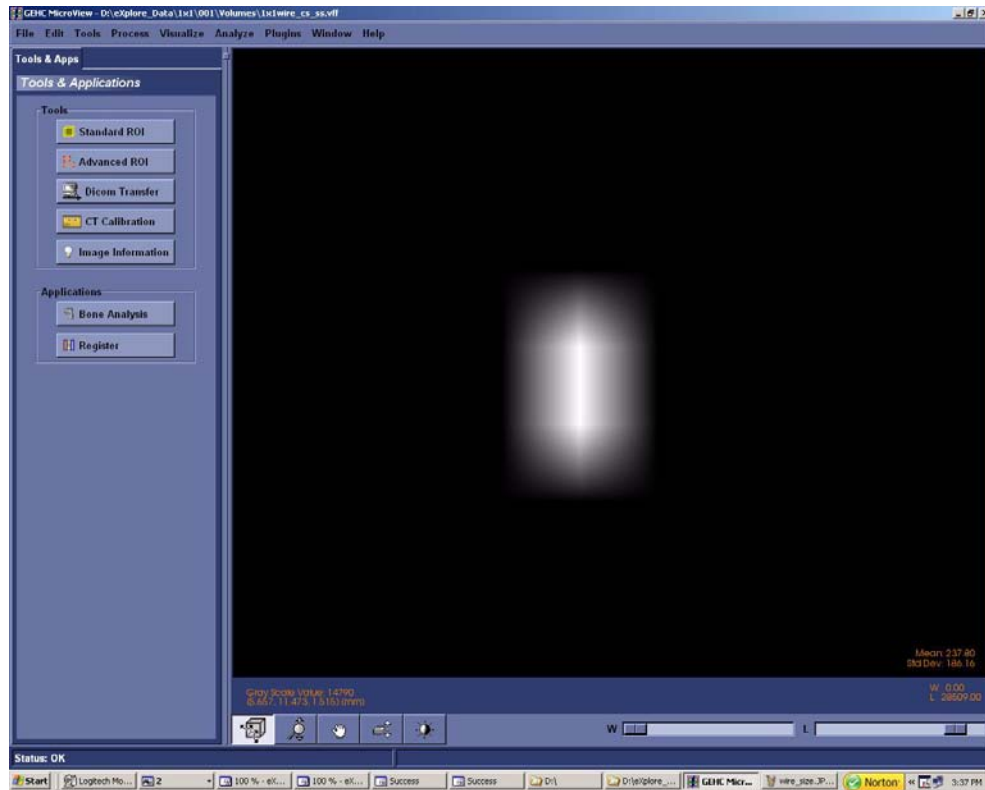
7. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_-end_360*. Verify that the wires appear round.
8. Move to the other end of the wire phantom by changing the Z-Origin to *2600*. Re-select the Short Scan field. Name the file *1x1wire_+end_ss*
9. Click the *Recon* button and view the image in **MicroView**. The wires should appear as round as possible. If the wires are not round, adjust the Centre of Rotation until the wires appear as round as possible.

Note: *If the Centre of Rotation at either end of the wire phantom differs by more than 1.5 pixels from the ideal Centre of Rotation at the Central Slice (e.g. the total difference is greater than 3 pixels), the tilt angle of the grid is likely incorrect and you must re-calibrate from that point (see Complete Transform1 File Creation).*

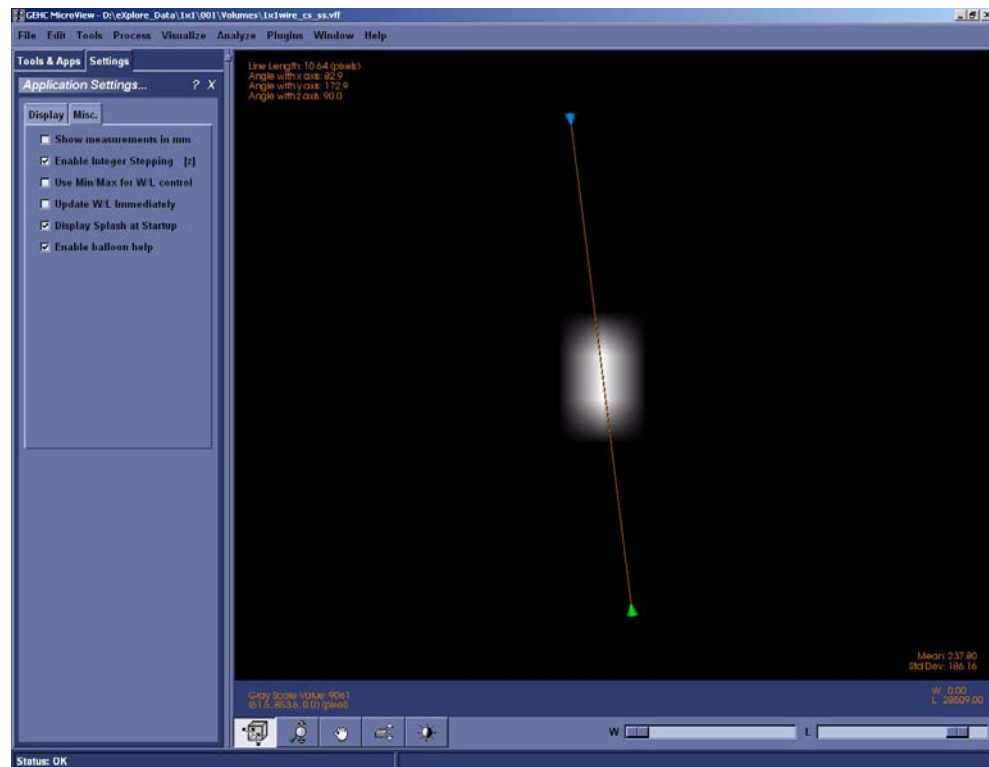
10. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_+end_360*. Verify that the wires appear round.
11. Once successful, click the *Set to Central Slice* button on the **Reconstruction Utility** window.
12. Click the *Advanced* button and choose the *Reconstruction* tab.
13. Change the Centre of Rotation field back to the value of the ideal Centre of Rotation at the Central Slice, then click *OK*.
14. Click the *Recon* button on the **Reconstruction Utility** window.
15. View the image in **MicroView** and zoom in on the wire that appears least round to be measured.
16. Select a region of interest within the phantom housing near the wire being measured. Press **m** to calculate the mean value of the plastic area selected. Record in Worksheet.



- Zoom in on the wire. Adjust the Window and Level to allow only two pixels to be visible.



- Plot a line across the wire's two brightest pixels using the 1 and 2 keys in MicroView.



The next step is to find the Full Width Half Maximum value of this wire in pixels.

Note: *All 4 wires must be symmetrical, but not necessarily completely round. How the wires appear may give you a clue about a possible problem.*

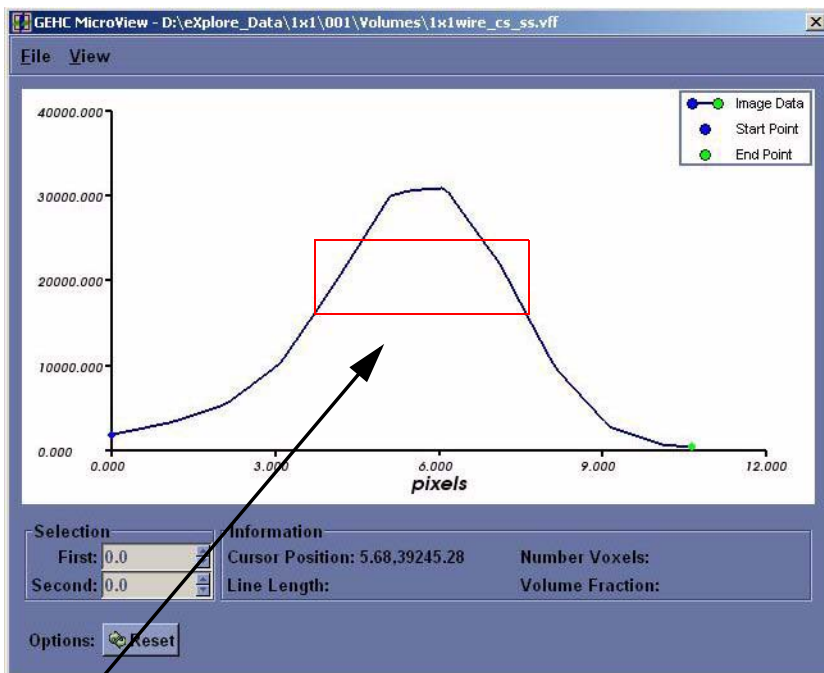
If, for example, 2 wires in diagonal corners look good but the other 2 do not, the centring of the stage is not correct. If 3 of the wires look good and one looks bad, a possible error was made calculating the distance between the X-Ray Source and the detector or the Detector Spacing under the Calib. Settings tab is incorrect.

- Press **p** to view the plot.

If the resulting plot is a straight line, exit Microview and repeat reconstruction but change z-size to 5.

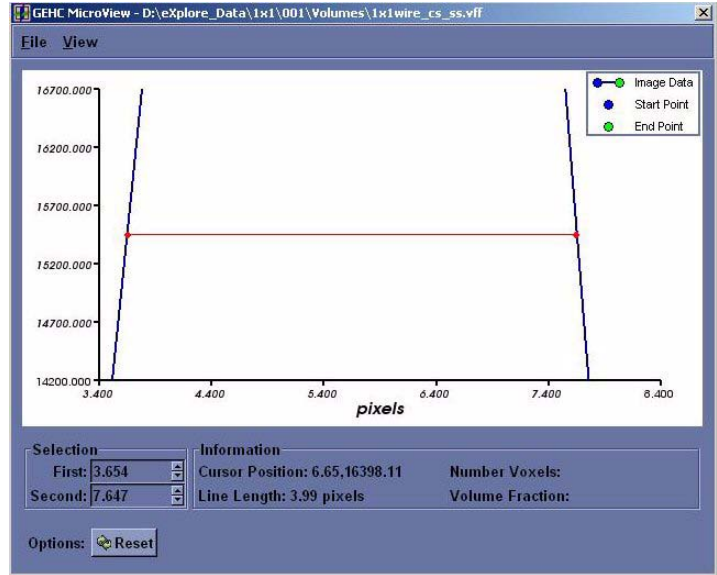
- Use the mouse pointer to find the number at the top of the peak (e.g. 30000). Record in Worksheet.

- Add the mean value calculated above in step 16 to the peak value (determined in the last step) and then divide the result by 2. This is the Full Width Half Maximum value. Record in Worksheet.



- Zoom in (left-click and drag the mouse) so that the middle area of the peak is highlighted.
- Move the mouse to the left line (side) and press **1** at the Full Width Half Maximum value point (e.g. 15000).

24. Move the mouse to the right line (side) and press **2** at the Full Width Half Maximum value point to draw a line from one side to the other.
25. Make note of the line length in pixels, in the Worksheet.
26. In **eExplore Scan Manager**, navigate to the 1x1 wire scan. Note the resolution value displayed on the right-hand side of the window, in the Worksheet.
27. Divide .025mm (which is the size of the wire in the wire phantom) by the resolution value and then add 2 to the result. This value is the target value, in pixels, of the wire scan. Record in Worksheet.



Example:

$$.025 \div .007634 = 3.274 \text{ (target value)}$$

$$3.274 + 2 = 5.274 \text{ (maximum value)}$$

28. Verify that the line length calculated in step 25 is less than the maximum value calculated in step 27. If not, calibration will need to be restarted.
29. Repeat steps 15 to 28 for the remaining 3 wires.
30. Exit the plot, then exit **MicroView**.

Upon completion:

In the **Reconstruction Utility**, press the Advanced button. Go to the Recon tab. Re-enter the noted air, water and bone HU calibration values into each field for all three scans (1x1, 2x2 and 4x4) Inform the customer that they may need to re-calibrate their HU values.

Section 7.4 Source Replacement Calibration

The following describes the calibration procedures performed each time the X-Ray Source is replaced. The procedures below use the following applications:

- **System Warm-Up** (C:\Program Files\GE Medical Systems\Explore Utilities\WarmupApp.exe)
- **Calibration Tools** (C:\Program Files\GE Medical Systems\Explore Utilities\Calibration.exe)
- **X-Ray and Motor Controller**. The **X-Ray and Motor Controller** (C:\Program Files\GE Medical Systems\Explore Utilities\X-Ray_Controller.exe)

7.4.1 Centre X-Ray Source

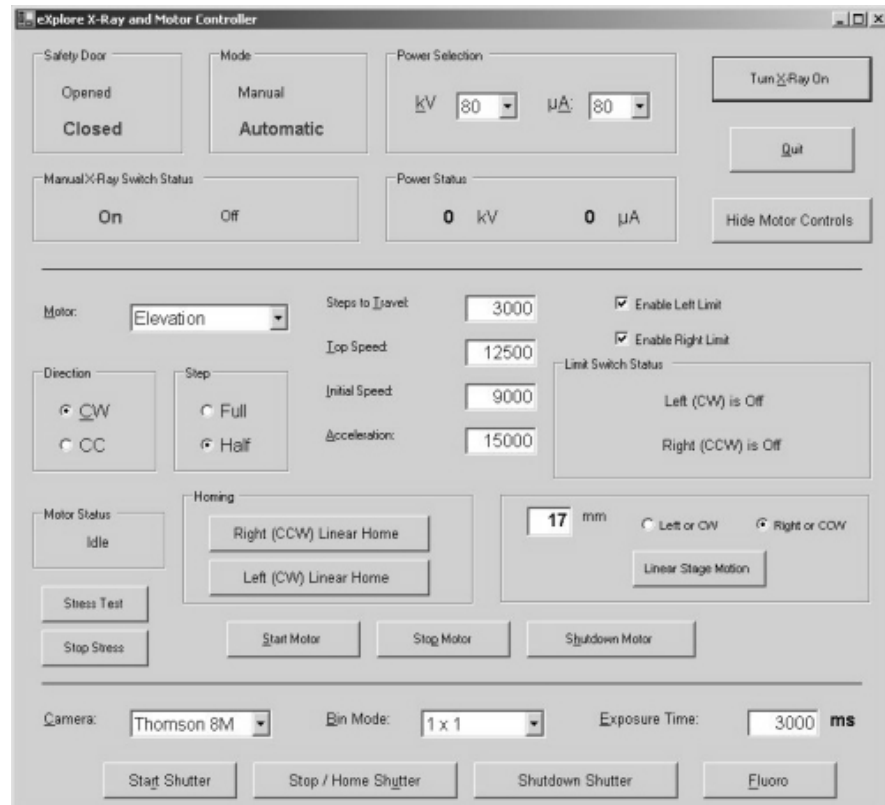
This adjustment properly positions the X-Ray Source. To adjust the X-Ray Source:

1. Open **Windows Explorer** and navigate to D:/. Copy the *calib* folder and rename it *original_calib*.
2. Turn the unit ON using the key, and press the red *Reset* button.
3. Warm-up the X-Ray Source using the **System Warm-Up** application as follows:
 - right-click the Warm-Up icon in the task bar and select the *<=10 Minutes to Scan* option
 - once the cycle has finished (approximately 14 minutes), right-click the icon again and select *Scan Mode*.

The **System Warm-Up** application can be re-initialized by double-clicking on *WarmupApp.exe* in C:\Program Files\GE Medical Systems\Explore Utilities\

4. Access the **X-Ray and Motor Controller** program.
5. Ensure the fields below are set to the following settings:

Enable Left Limit: checked off
Enable Right Limit: checked off
Camera: Thomson 8M
Bin Mode: 1 x 1
Exposure Time: 3000 ms
kV: 80
µA: 80



6. Find the motor limit switch (this ensures that the limit switches will never be triggered):
 - select *Magnification* from the drop down menu in the Motor field
 - press the *Left (CW) Linear Home* button to move the stage toward the detector
 - enter **2** in the mm field, click on the *right or CCW* radio button, then press the *Linear Stage Motion* button to offset the "home" position by 2 mm.
7. Ensure X-ray switch on the unit is on and the red reset button is not lit.
8. Click the *Start Shutter* button.
9. Click the *Turn X-Ray On* button.
10. Click the *Fluoro* button, then:
 - select *OK* when the warning pop-up appears.
 - select *OK* when the text concerning placement of the specimen appears.

Capture an Image:

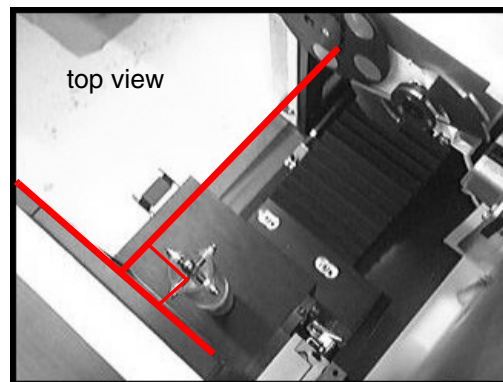
11. Capture an image in **Fluoro** as follows:
 - click *Menu* at the top of the **Fluoro** screen and choose *Capture* from the drop-down menu
 - once the Capture pop-up is displayed, enter **1** in the Number of Frames to Capture field
 - enter **10** in the Number of Frames to Average field
 - name the file *bright* in the Name of Series field
 - save the file to the directory: D:\calib
 - click the *Capture* button.

The progress of capture is shown in the Fluoro's title bar as *[saving...]*. Wait until the image is captured.

12. Turn off the X-Ray Source and capture a dark image in Fluoro. Call this image *dark*.



13. Mount the X,Y Centring ball tool on the stage cone. Physically rotate the X,Y Centring Ball tool so that 2 of the 4 adjustment screws are exactly perpendicular to the detector (i.e. not at an angle).

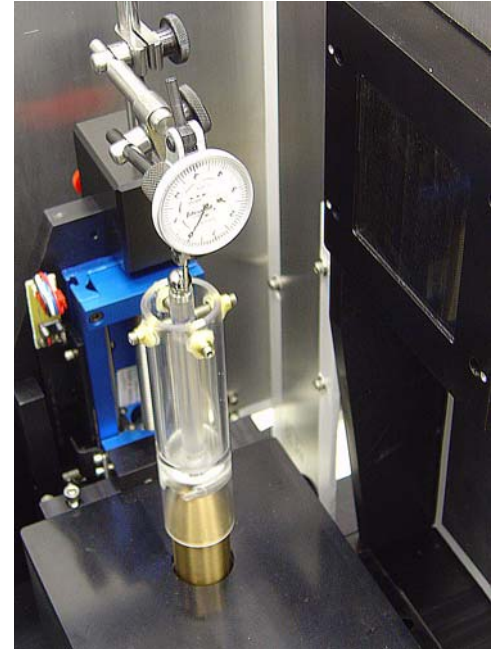


14. Using the **X-Ray and Motor Controller** program, click the *Turn X-Ray On* button.
15. Use **X-Ray and Motor Controller** to elevate the X,Y Ball Centring tool until the ball appears in the middle of the **Fluoro** display screen. Move the stage 70mm toward the Source (right) so that it is in the middle between the Source and detector.
16. Turn off the X-Ray Source.

17. Mount the Dial Indicator Mount and Precision Dial Indicator.
18. Adjust the tip of the Precision Dial Indicator to strike the equator of the ball. Make sure the indicator is not pegged (i.e. the small needle on the gauge near the centre of the Dial Indicator is around the halfway mark).

The Precision Dial Indicator is very sensitive and care should be taken not to lean or touch any part of the system while adjusting the indicator or X,Y Ball Centring tool.

19. Zero the Precision Dial Indicator.



Note: *For fine measurements, the Precision Dial Indicator may not be accurate until after the first movement.*

20. Return to the **X-Ray and Motor Controller** window.
21. Use the *Rotation* setting to rotate the ball 360° (180° at a time). Re-zero the Dial Indicator, if necessary. Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged.

Center the Ball:

22. Use the *Rotation* setting to rotate the ball 180°.
23. Watch the Precision Dial Indicator as the ball rotates. Note the reading of the Precision Dial Indicator after 180° of rotation (e.g. .0004").
The objective is to adjust the ball so that, after the adjustment, the Dial Indicator reads half of the original reading (e.g. .0002").

To do this:

24. Use the tool's adjustment key to carefully turn the 2 adjustment screws that are aligned with the Dial Indicator - turn the screws until the Dial Indicator reads half of the original reading.

NOTICE
Equipment
Damage
Possible

The tool is extremely delicate. Fine adjustments are required. DO NOT overtighten the screws. One screw turns clockwise and the other turns counter clockwise. Turn the screws in tandem using as little torque as possible (i.e. 5° at a time).



25. Once adjusted, rotate the ball 180° and check the Dial Indicator reading. It should match the reading taken after the adjustment in the previous step (e.g. .0002").
26. Re-zero the Dial Indicator.
27. Use the *Rotation* setting to rotate the ball 360° (180° at a time). Re-zero the Dial Indicator, if necessary. Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged.
28. Rotate the ball 180° and confirm the Dial Indicator reads zero.
29. Rotate the ball 90°.
30. Carefully adjust the 2 screws that are aligned with the Dial Indicator until the Dial Indicator reads zero.
31. Rotate the ball 180° and verify that the Dial Indicator still reads zero.

NOTICE
Equipment
Damage
Possible

Note: *Fine tuning may be required. Continue to make adjustments until the ball can rotate 360° without the Dial Indicator moving more than .0002".*

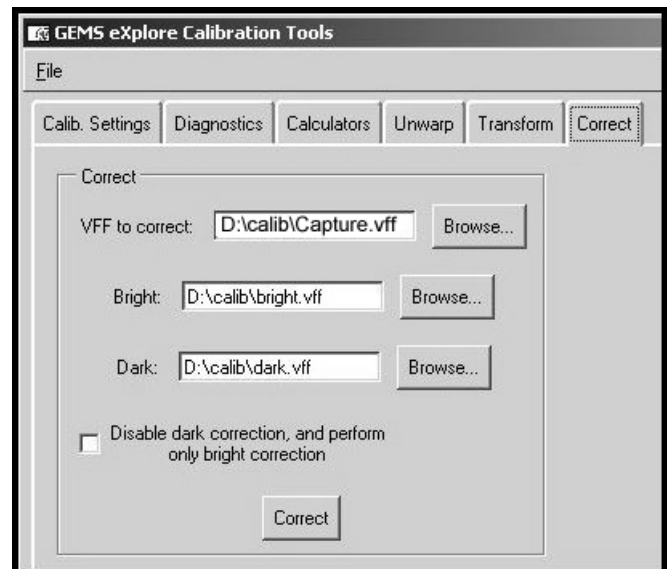
32. Once the ball has been centred, remove the Dial Indicator Mount and Precision Dial Indicator.
33. Select *Magnification* in the Motor field and move the ball 70mm toward the X-Ray Source.



34. Click the *Turn X-Ray On* button in the **X-Ray and Motor Controller** window and let the X-Ray Source warm up.
35. Capture an image in **Fluoro** as follows:
 - click *Menu* at the top of the **Fluoro** screen and choose *Capture* from the drop-down menu
 - once the Capture pop-up is displayed, enter **1** in the Number of Frames to Capture field
 - enter **3** in the Number of Frames to Average field
 - name the file *ball* in the Name of Series field
 - save the file to the directory: D:\calib
 - click the *Capture* button.

36. Correct the captured image using the **Calibration Tools** program as follows:

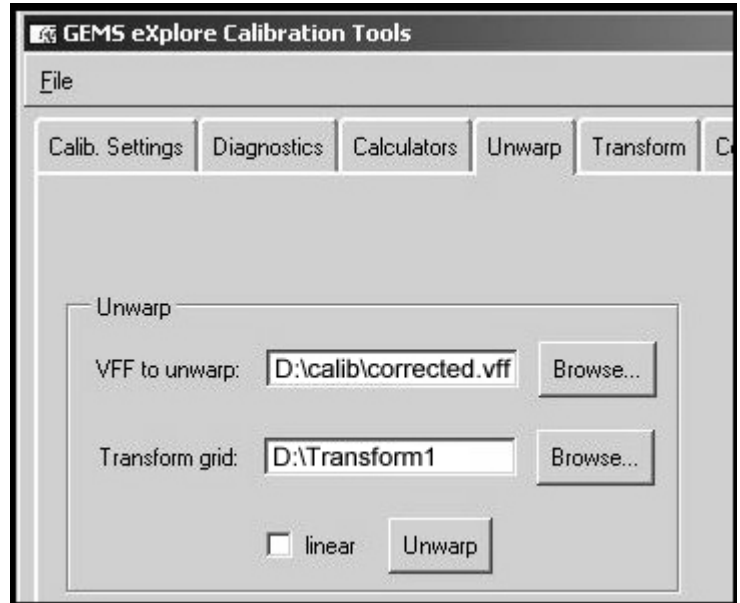
- click the *Correct* tab
- in the VFF to correct field, find the newly captured image (e.g. *capture*)
- use the *Browse* buttons to find the files called *bright* and *dark* created earlier
- click the *Correct* button (the corrected file is named *corrected.vff* and it is stored in the same folder in which the captured image was stored)



Unwarp the Image:

37. Click the *Unwarp* tab in **Calibration Tools** and complete the fields as follows:
 - in the VFF to unwarp: field use the *Browse* button to find the file D:\calib\corrected.vff
 - in the Transform grid: field, use the *Browse* button to find the D:\Transform1 file.
38. Click the *Unwarp* button.
39. Call the file D:\zz when prompted to name the file, then click *OK*.

The zz file will be used as a temporary file for unwarping. Continue to overwrite this file whenever unwarping.



40. Double-click on zz in **Windows Explorer** to load the image into **MicroView**.

41. Double-click on the W and L parameters in the lower right of the screen. Change the Update mode to *Delayed updates*. This only needs to be changed once.



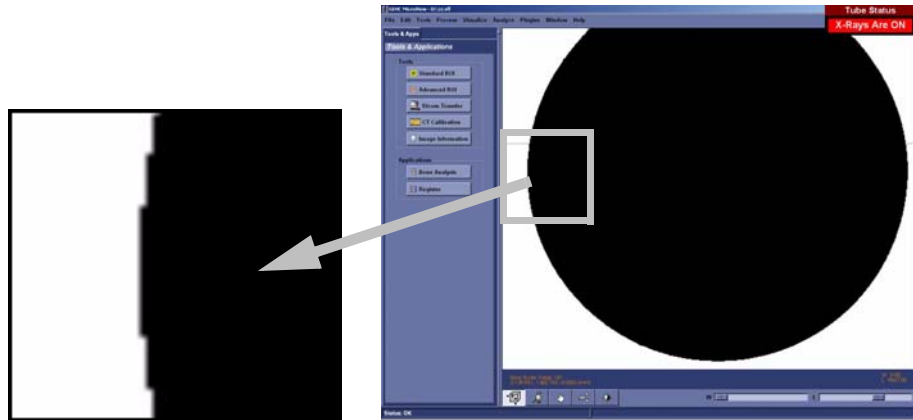
Find the Geometric Centre of the Ball:

Note: *To find the geometric centre of the ball determine the x value on the right and left side of the ball. Add the values together and divide by 2. To find the geometric centre perform the following steps.*

42. Use the Pan and Zoom features to get the ball in the desired area of the screen.

Note: *To Pan, move the mouse while pressing Shift plus the left mouse button simultaneously. To Zoom, move the mouse up (to magnify) or down (to zoom out) while pressing the right mouse button.*

43. Threshold the image. Slide the *Window* slide bar to the left until it reads 0 and slide the *Level* slide bar until the ball appears with the maximum amount of square edges.

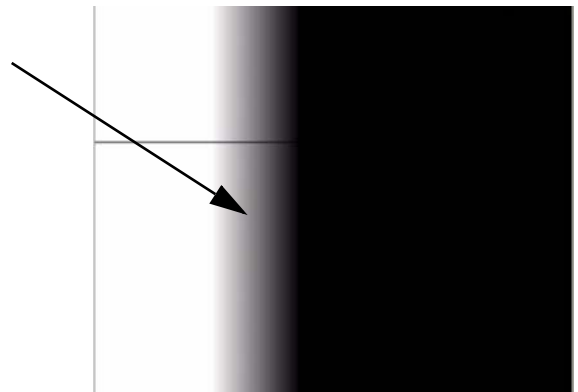


The *Window* and *Level* values control the image's contrast and brightness. These values are adjusted using either the slide bars at the bottom of the **MicroView** window, or by right-clicking on either slide bar to display a pop-up window where you enter a specific value.

44. Zoom in on the outer right most side of the ball.
45. Place the mouse in the middle of the gray band that appears to the right of the black area. Make note of the x coordinate in the Worksheet.
46. Zoom out and move to the left outer most side of the ball. Zoom in on the edge.

Note: **DO NOT** re-adjust *Window* and *Level* slide bars.

47. Place the mouse in the middle of the gray band that appears to the left of the black area. Make note of the x coordinate in the Worksheet.

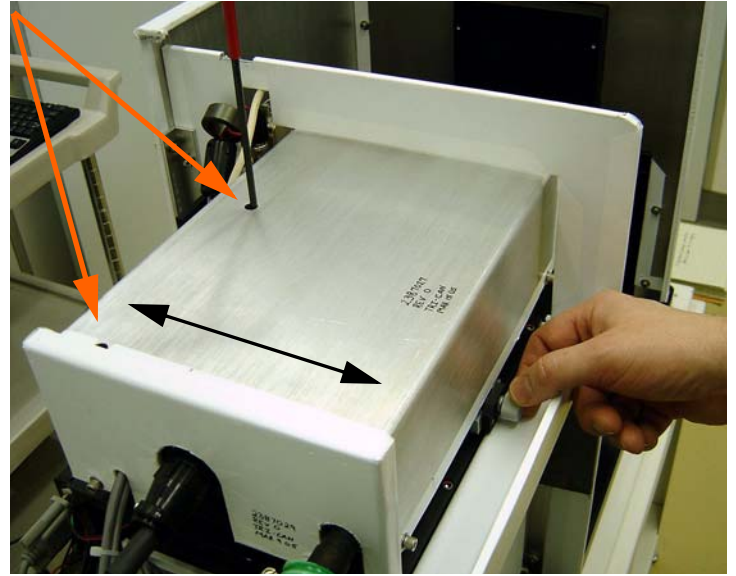


48. Add the 2 x values together and divide by 2. This value is the ball's geometric centre. Make note of this value in the Worksheet.

The x value must eventually equal the centre of rotation in the registry (within 5 pixels). Open **Calibration Tools** (located in C:\Program Files\GE Medical Systems\eXplore Utilities\Calibration\). Click on *Calib. Settings* tab. Click *File*, and choose *Read Registry Values* from the drop-down menu. The Centre of Rotation equals the value in Centre of Rotation1. This positioning puts the ball in the centre of the detector.

To reach the correct x value:

- a. Turn off the X-Ray Source.
- b. Loosen the 2 screws on the top of the Source and move the Source using the Source adjustment wheel. This moves the Source along the x-axis as shown in the diagram.
- c. Repeat steps 34 to 48 until the x value equals the same value that appears in the registry (within 5 pixels). Use the Worksheet to record values.



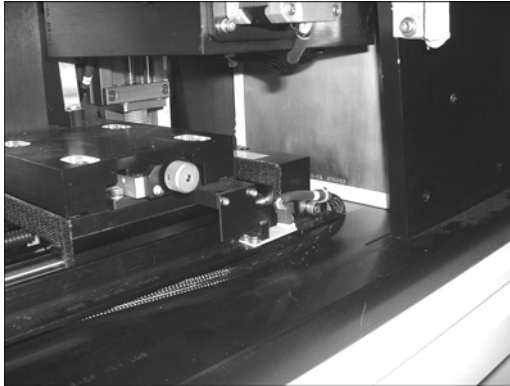
Once the ball is in the centre of the detector:

49. Tighten the screws on the top of the X-Ray Source.
50. Tightening the screws may change the value of the ball centre. Turn X-rays back on, and verify the setting by repeating steps 34 to 48.

7.4.2 Centre the Stage

This procedure is used to centre the stage between the X-Ray Source and the detector. With the X,Y Centring Ball tool still mounted and the system warmed up:

1. Use the **X-Ray and Motor Controller's** Magnification setting to move the stage 140mm toward the detector.

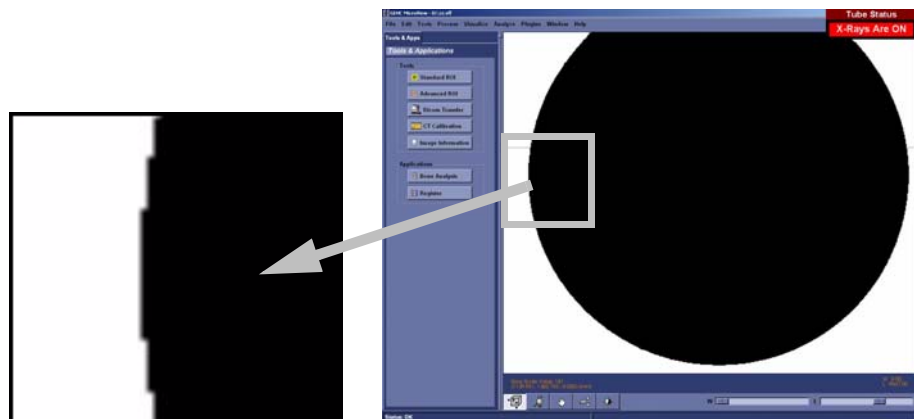


2. Capture the image in **Fluoro** and name it *capture*.
3. Correct and unwarpage the captured image using **Calibration Tools**.

Find the Geometric Centre of the Ball at Detector End:

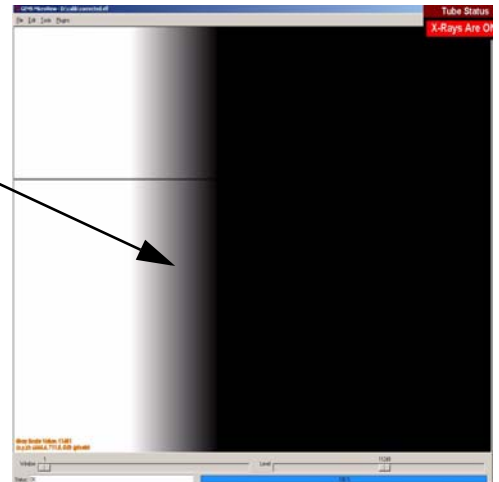
Note: *To find the geometric centre of the ball, determine the x value on the right and left side of the ball. Add the values together and divide by 2. To find the geometric centre as follows.*

4. Use the Pan and Zoom features in **MicroView** to get the ball in the desired area of the screen.
5. Threshold the image by sliding the *Window* slide bar to the left until it reads 0 and sliding the *Level* slide bar until the edges of the ball appears with the maximum amount of square edges.



6. Zoom in on the outer left most side of the ball.

7. Place the mouse in the middle of the gray band that appears to the left of the black area. Make note of the x coordinate and round the coordinate to the nearest .5 pixel. Record in Worksheet.



8. Zoom out and move to the right outer most side of the ball. Zoom in on the edge. **DO NOT** re-adjust the *Window* and *Level* slide bars, which may be recorded in the Worksheet.
9. Place the mouse in the middle of the gray band that appears to the right of the black area. Make note of the x coordinate in the Worksheet.
10. Add the 2 x values together and then divide by 2. This value is the ball's geometric centre. Make note of this value in the Worksheet.
11. Use the **X-Ray and Motor Controller's Magnification** setting to move the ball toward the X-Ray Source 140mm.
12. Capture the image calling the file *capture*.
13. Load the corrected and unwarped image into **MicroView**.
14. Find the geometric centre of the ball at the X-Ray Source end by making note of the x values on the outer most left and right side of the ball and dividing this value by 2. Make note values in the Worksheet.



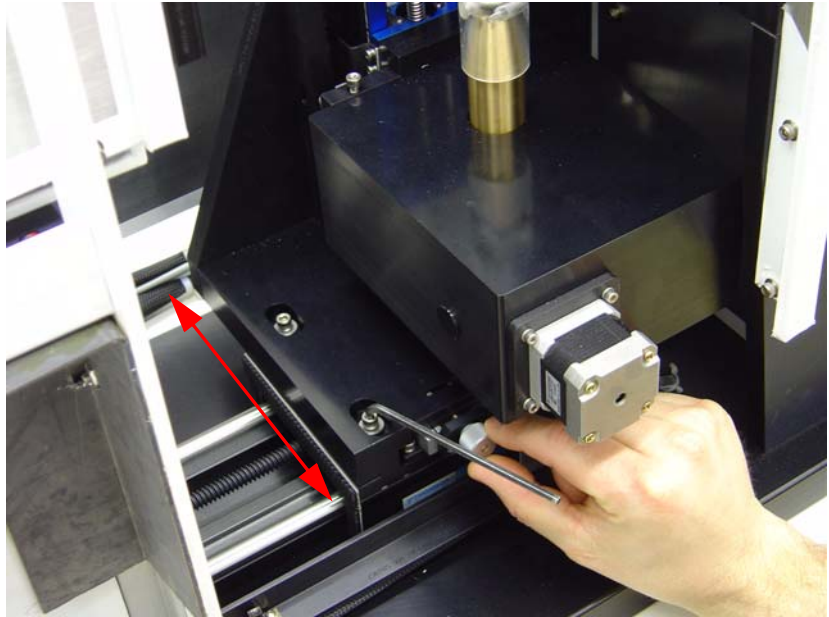
Note: *This value must eventually equal the ball's geometric centre at the detector end, plus or minus 1 pixel.*

IF NOT, adjust the geometric centre values until they are within 1 pixel of each other as follows:

- a. Turn off the X-Ray Source.
- b. Loosen the 4 stage retaining bolts.

- c. Manually adjust the stage using the stage's adjustment wheel (see Note below).

This moves the stage perpendicular to the rail as shown here in the diagram.



- d. Continue to determine the value of the ball's geometric centre at both the detector end and the X-Ray Source end - manually adjusting the stage's adjustment wheel in between - until the values are equal, plus or minus 1 pixel.

Note: *The adjustment will change the ball's geometric centre value 3 times faster when the stage is at the X-Ray Source end compared to an adjustment when the stage is at the detector end. If the value at the X-Ray Source is larger than the value at the detector end, turning the adjustment wheel clockwise reduces the values. Small movements of the adjustment wheel are required. One pixel will equal a few (1 to 5 degrees) turn of the wheel.*

Once confirmed (i.e. the values of the 2 geometric centres are the same + or - 1 pixel):

15. Carefully tighten the 4 bolts (snug only) once the values are close. Make the bolts sufficiently tight so that the adjustment wheel will operate but is difficult to turn. Tightening the bolts may change the value of the geometric centres.
16. Complete the tightening of the 4 bolts and then verify the results at both ends. The bolts may need to be loosened and retightened as you use the adjustment wheel to align the 2 values.

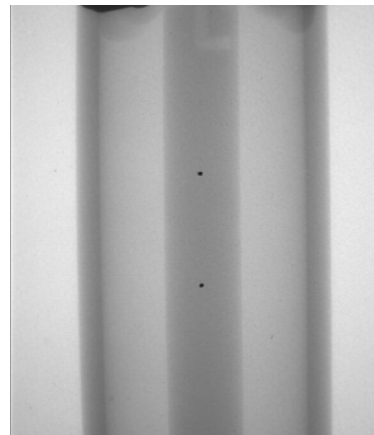
Once the 2 figures are again within 1 pixel of each other, the geometric centre of the ball (the value of its x axis) is now the CENTRE OF ROTATION. Make note of this value in the Worksheet.

17. Save a captured image at both the detector end and the X-Ray Source end. Name the image closest to the detector *smallball.vff* and the image closest to the X-Ray Source *largeball.vff*.

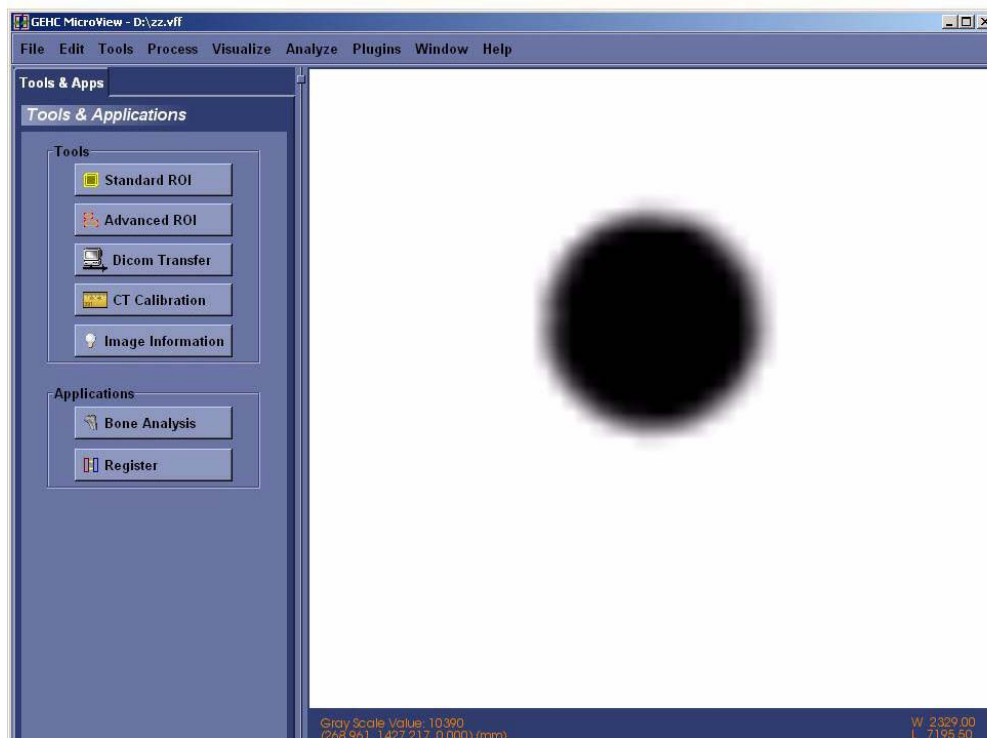
7.4.3 Calculate Central Slice of X-Ray Source

This procedure calculates the Central Slice of the X-ray. With the X,Y Centring Ball tool still mounted and the system warmed up:

1. Move the stage back toward the detector using the **X-Ray and Motor Controller**.
2. Elevate and rotate the tool until both bebes appear in the centre of the screen in **Fluoro**.
3. Capture the image and name it **CS1**.
4. Move the tool 120mm toward the X-Ray Source and capture an image. Name the image **CS2**.
5. Correct the CS1 image, unwarped it and load it into **MicroView**.

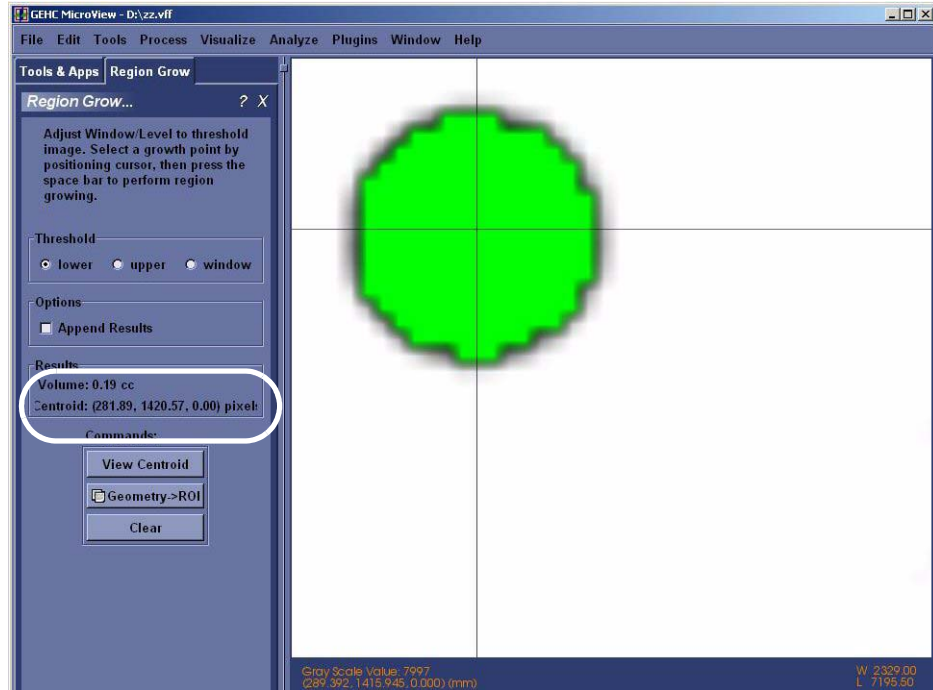


6. Determine the y coordinates of both bebes using the Region Grow tool in **MicroView**, as follows:
 - a. Zoom in on the top bebe and find the centre of the bebe. Adjust the Window and Level to make the bebe as round as possible. Record Window and Level in Worksheet.



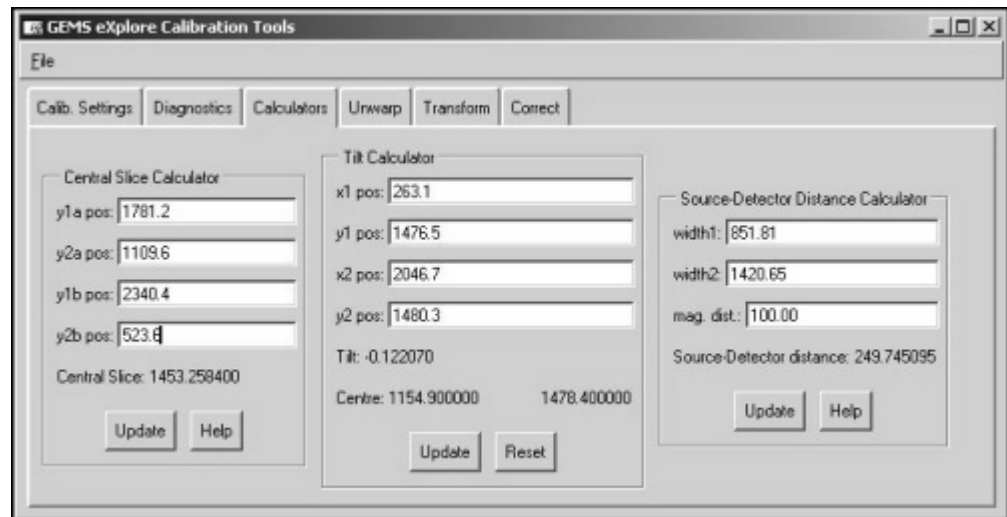
- b. In **MicroView**, choose *Tools>Region Grow*.
- c. Select *Lower* in the Threshold field.

- d. Place the mouse over the bebe and press the Spacebar (the bebe's solid centre turns green).
- e. Record the centroid value (y coordinate only). If desired, press the *View Centroid* button to view the calculated actual centre (see below). You may have to Pan and Zoom to see the cross hairs.



7. Make note of the CS1 file's two y coordinates (top and bottom bebe) in the Worksheet.
8. Correct the CS2 image, unwarped it and load it into **MicroView**. Determine the y coordinates of both bebes using MicroView's Region Grow tool.
9. Make note of the CS2 file's two y coordinates (top and bottom bebe) in the Worksheet.
10. Access **Calibration Tools** and select the *Calculators* tab.
11. Enter the 4 following values under Central Slice Calculator in the order below:
 - y1a pos: enter the CS1 file's top bebe's y coordinate
 - y2a pos: enter the CS1 file's bottom bebe's y coordinate
 - y1b pos: enter the CS2 file's top bebe's y coordinate
 - y2b pos: enter the CS2 file's bottom bebe's y coordinate

- Press the *Update* button under Central Slice Calculator.

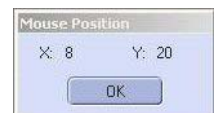


- Make note of the Central Slice value (e.g. 1453.25) in the Worksheet.

7.4.4 Verify Stage Alignment

VERIFY STAGE TILT (FRONT-TO-BACK MOVEMENT):

- Turn off x-rays and adjust the X,Y Centring Ball tool so that the bebes are facing the detector.
- Turn x-rays back on and wait a few minutes for the Source to stabilize.
- Move the stage (using **X-Ray and Motor Controller**) 120mm back toward the detector.
- Access **Fluoro.** and press *m* to display the mouse position window.
- Rotate the tool until the top bebe appears in the centre of the x axis of the screen.
- Adjust the elevation using the **X-Ray and Motor Controller** program so that the top bebe moves downward and appears within 200 pixels of the bottom of the screen.
- Capture an image in **Fluoro** and name it *shim1*.
- Adjust the elevation, so that the top bebe moves upward and appears within 200 pixels of the top of the screen (approximately 50mm).
- Capture an image in **Fluoro** and name it *shim2*.
- Correct the Shim1 file and unwarp it (using Transform1).
- Load the corrected and unwarped file into **MicroView**.
- Use the Worksheet and make a note of the x value of the centre of the bebe using **MicroView's** Region Grow tool.



13. Repeat steps 11 and 12 above (correct, unwarped & load into MicroView) for the *shim2* file.
14. Make a note of the x value of the centre of the bebe using **MicroView's** Region Grow tool, in the Worksheet.

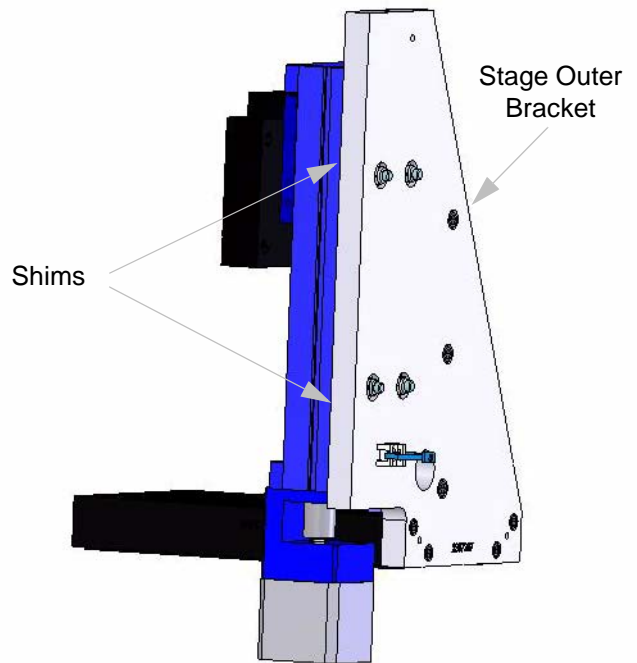
Note: *The x values must be within 2 pixels of each other (e.g. if one value is 1140, the other must be within 1138 to 1142).*

If the values **ARE NOT** within 2 pixels of each other:

15. Place shims behind the elevation rail (loosen stage bolts, etc.). Tighten the screws to a torque setting of 25 in/lbs.

Note: *One pixel is approximately .002" in shims. If the x value of the top bebe in **Fluoro** is less than the x value of the bottom bebe, the shim goes on the bottom of the stage. If the x value of the top bebe is higher, the shim goes at the top of the stage.*

The shims are placed close to the mounting bolts. Larger adjustments (more than 0.004") will require shims at both the top *and* the bottom to allow the stage to tip once it is tightened (e.g. large shim on the bottom and small shim on the top). This is because flat surfaces are bolted together.

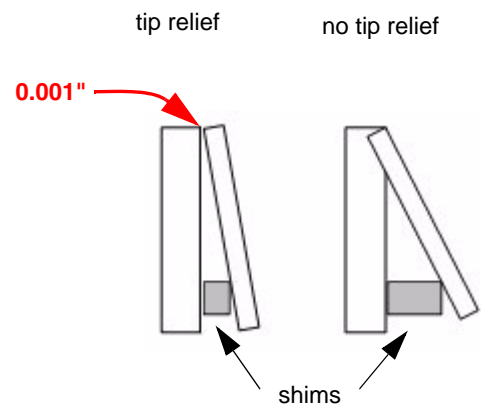


NOTICE
Equipment
Damage
Possible

Failure to provide a tip relief will cause the rail assembly to bend when the bolts are tightened. There should be at least 0.001" clearance at the tip end.

If you have to shim the stage, re-check the stage tilt mechanically using the 9" Square.

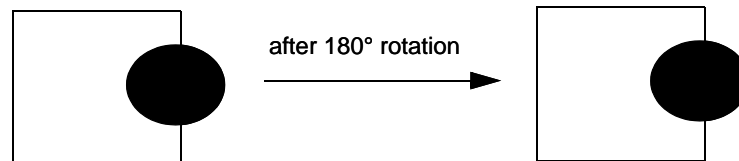
Repeat steps 3 to 13 until the values are within + or - 2 pixels.



VERIFY STAGE TIP (SIDE-TO-SIDE MOVEMENT):

1. Move the ball toward the X-Ray Source (**140mm right**).
2. Elevate and rotate the tool until the top bebe appears in the centre of the screen.
3. Use the mouse pointer window as a reference guide and rotate the bebe 180°.

The goal here is to have the bebe return to the same x axis after the 180° rotation.



4. Continue to reposition the bebe until it is close to returning to the same x axis.
It may be necessary to rotate the bebe less than 0.1 degree to get it in the exact centre. To make movements that are finer than 0.1 degree access the **X-Ray and Motor Controller** and adjust the *Steps to Travel* field (e.g. 50) which are steps in the stepper motor. Adjust the Direction and press the *Start Motor* button.

The goal here is that, at the Source end, the y values at 0 and 180 degree rotation are within 2 pixels of each other and within 2 pixels of the Central Slice, AND the y axis at the detector end is within 2 pixels of the Central Slice.

5. Once the bebe is properly positioned in the x direction, capture the image, correct and unwarp it. Open the image in **MicroView** and determine the y axis of the bebe using the Region Grow tool in **MicroView**. This y axis must be the same as the Central Slice value (within 2 pixels) calculated earlier. Use Worksheet to record values.

If the y axis is not the same value as the Central Slice (within 2 pixels):

6. Continue to adjust the elevation - capturing, correcting, unwarping, and viewing the images in **MicroView** - until the y axis is within 2 pixels of the Central Slice value. Use the *Steps to Travel* field within **X-Ray and Motor Controller** to make movements finer than 1mm.

Once the y axis equals the value as the Central Slice (within 2 pixels):

7. Rotate the tool 180° and capture, correct, unwarp and view the image in **MicroView**. The value of this y axis must be within 2 pixels of the previous value before rotation (i.e. the value determined in step 6). For example, if the previous y axis was 1428, this y axis may have a value between 1426 and 1430. Also, the x value must be within 5 pixels of each other. Use Worksheet to record values.

If not within 2 pixels, verify the Central Slice position before making any adjustments, as follows.

Verify the Central Slice position:

- rotate the tool back 180 degrees
- move the stage 140mm toward the detector

- capture an image, correct and unwarpage it
- load the image into **MicroView** and check that the y position is the same within 2 pixels. If the y position is not at the Central Slice at the detector end, the Central Slice calculation will need to be redone.

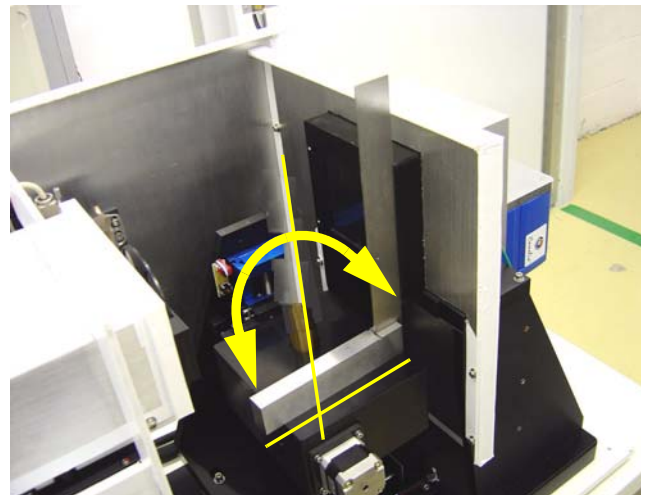
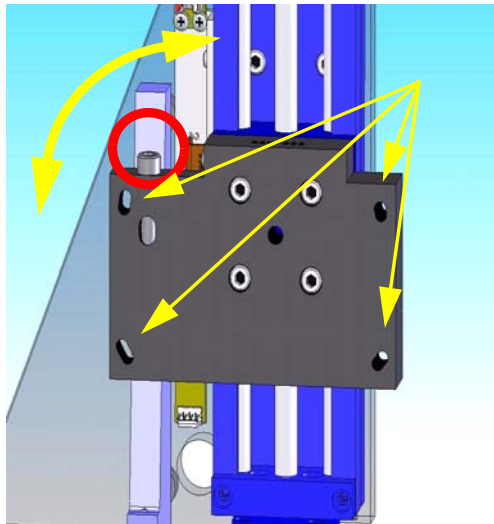
Verify all values before redoing the Central Slice calculation.

If the y axis at 180° is not within 2 pixels of the previous value (determined in step 6) AND the Central Slice calculation has been verified, do the following:

- Move the stage back 140mm toward the Source
- Mechanically adjust the stage using the stage levelling screws (capturing, correcting, unwarpage and viewing an image after each adjustment). Move the stage to the centre (70 mm toward the detector) in order to mechanically adjust the stage.

The 4 stage levelling screws sit in slanted, slotted holes (see diagram on the left) so, when loosened, allow for movement in the direction shown below.

Note: *You may need to tighten or loosen the locking screw at the top of the bracket in order to get the stage aligned (see red circle in the left diagram).*



- Continue to adjust the stage and view the results until the y axis is within 2 pixels of the previous value (the value determined in step 6) after 180° of rotation.

The end result is that at the Source end the y values at 0 and 180 degree rotation are within 2 pixels of each other and within 2 pixels of the Central Slice, AND the y axis at the detector end is within 2 pixels of the Central Slice.

8. Once the values are within 2 pixels of each other, capture and save an image after each rotation and call the files *Tip1* and *Tip2*.

Note: ***IF anything gets adjusted during Verify Stage Alignment, the Centre the Stage calibration must be repeated!***

9. Turn off x-rays and remove the X,Y Centring Ball tool.
10. Move stage so that it is 40 mm from the detector.

7.4.5 Calculate Source to Detector Distance

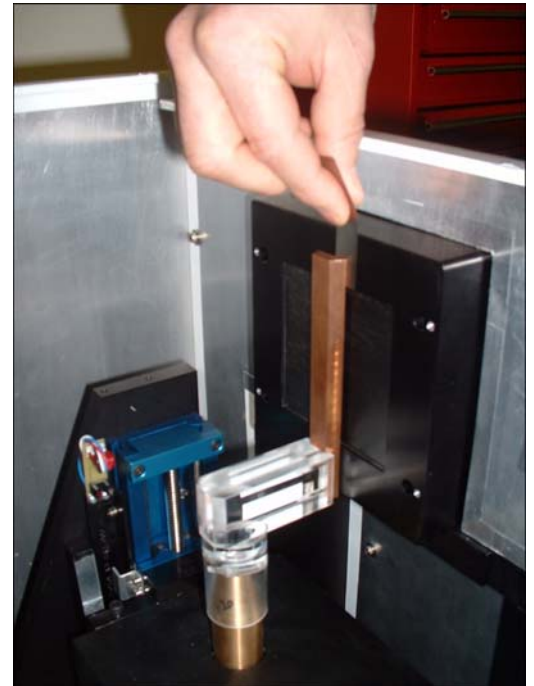
NOTICE
Equipment
Damage
Possible

1. Mount the Distance tool. Make sure that the tool covers the height of the detector. Remove the tool each time you move the stage.

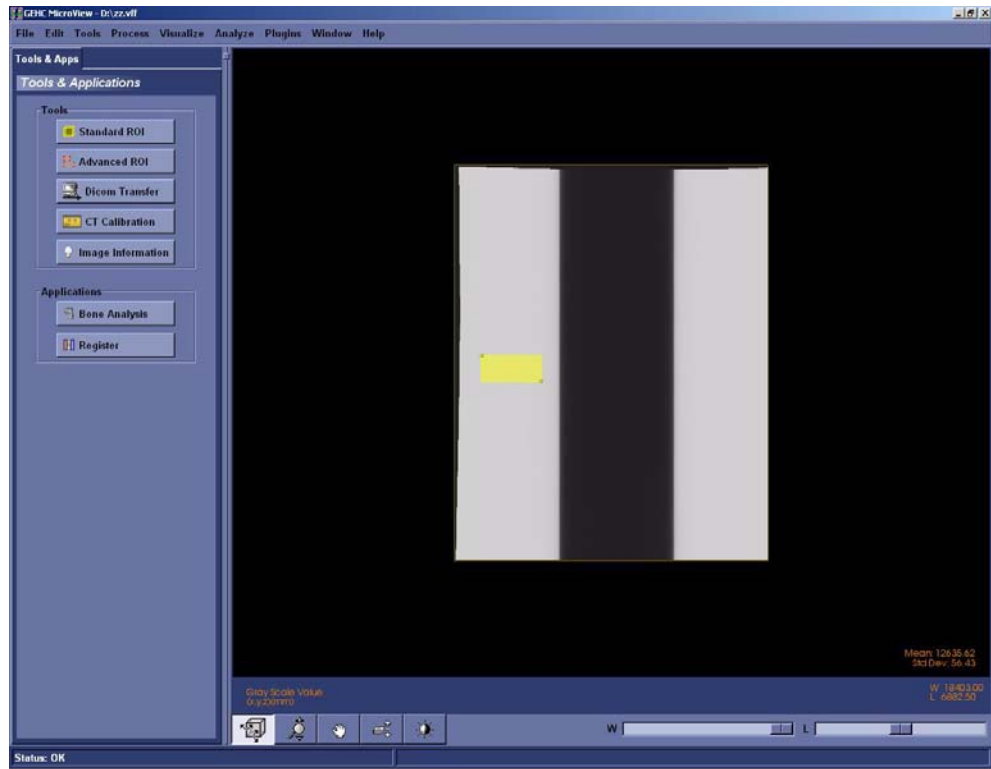
Do not move the stage with the tool in place. If care is not taken, this procedure can break the tool, move the stage out of alignment and damage the detector.

2. Use the **X-Ray and Motor Controller** to move the tool toward the detector until it is 0.025" from the detector.

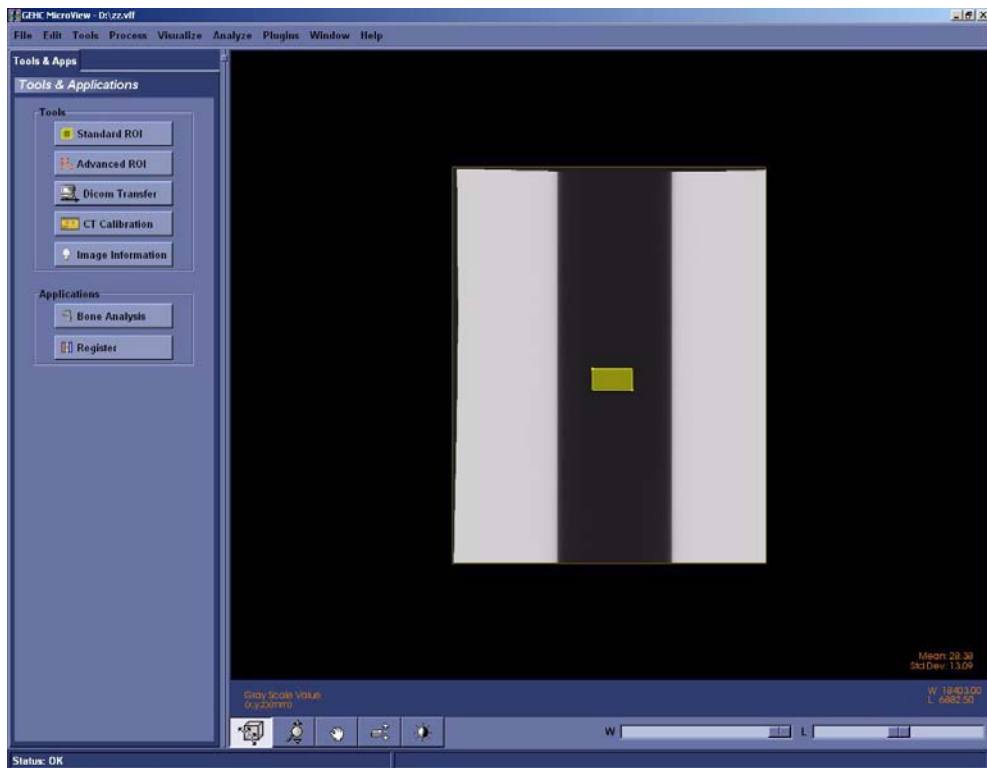
Movements finer than 1mm will be required! The X-Ray and Motor Controller application will accept movements as fine as 0.1mm.



3. Turn on the X-Ray Source using the **X-Ray and Motor Controller**. Wait a few minutes for the X-Ray Source to stabilize.
4. Capture an image and name it *D1*.
5. Move the tool back 100mm **TO THE RIGHT** (toward the X-Ray Source).
6. Capture an image and name it *D2*.
7. Turn off the X-Ray Source and remove Distance tool from the scanner.
8. Turn the X-Ray Source back on to keep the Source warm.
9. Correct and unwrap the *D1* image and load it into **MicroView**.
10. Draw an ROI (Region Of Interest) in **MicroView** in the middle of the white area:
 - Position cursor in the white area near the centre and press the 7 key. This draws the top left corner of the ROI.
 - Move cursor to the right and down and press the 8 key to complete the ROI. A yellow box represents the ROI.
 - Press small **m** (no caps).
The mean value is displayed in the bottom right corner of the window. Make a note of this value in the Worksheet.



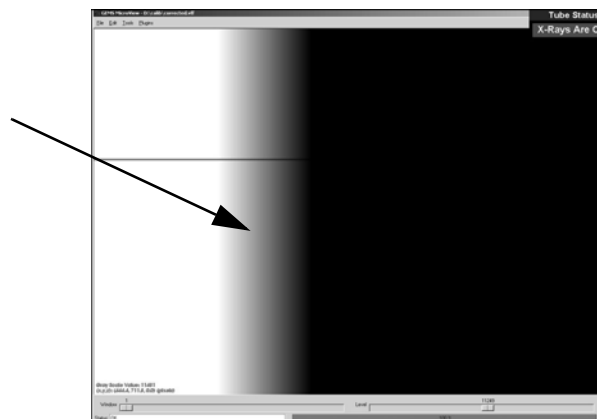
11. Repeat the above step in the black area of the screen and record value in the Worksheet.



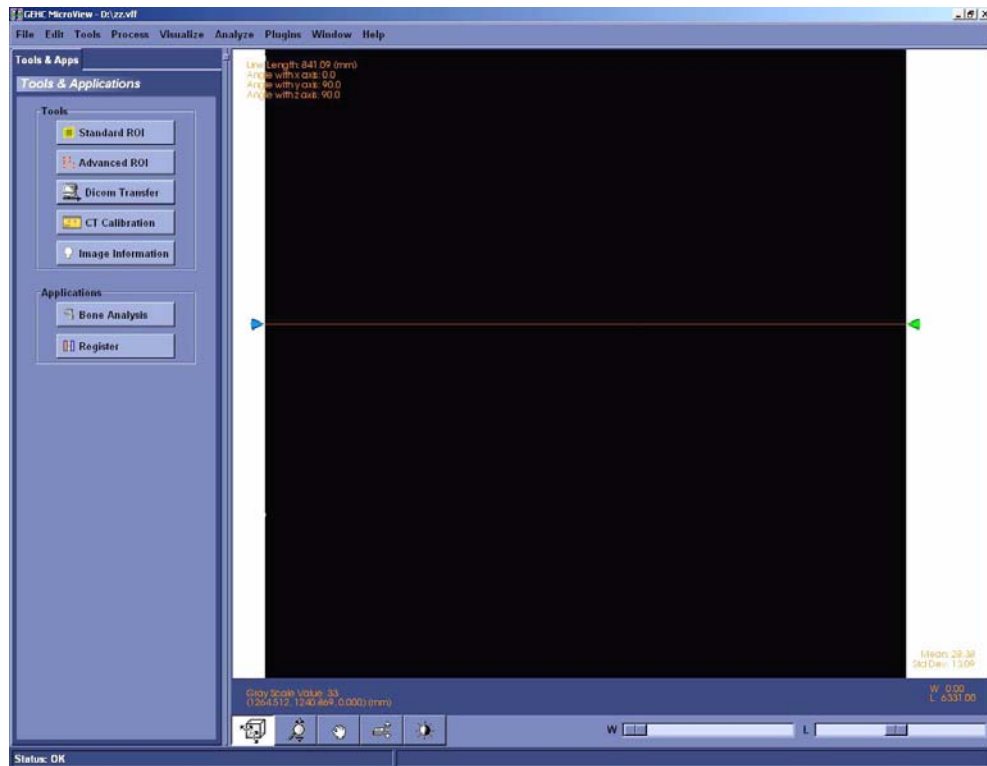
12. Add the two mean values determined in the above 2 steps.
13. Divide this value by 2 to determine the Half Maximum value. Note this value in the Worksheet.
14. In **MicroView**, slide the *Window* slide bar left until it reads 0.
15. Double-click on the W and L parameters in the lower right of the screen. Enter the Half Maximum value calculated in step 13 in the Level field.



16. Zoom in on the left edge of the image and position the cursor until the y axis equals the value of the Central Slice (determined earlier) and the x position is in the centre of the grey region.
17. Press **1**.
18. Zoom out and pan across to the right edge of the image. Zoom in on the right edge and position the cursor until the y axis equals the value of the Central Slice (determined earlier) and the x position is in the centre of the grey region.
19. Press **2** to draw a line between 1 and 2.



20. Record the line length (appears in the top left of the screen). Make a note of this value in the Worksheet.



21. Repeat the above steps 9 to 20 for the D2 image, recording values in the Worksheet. Make note of its line length in the Worksheet.

22. Access the *Calculators* tab in **Calibration Tools** and enter the following in the Source-Detector Distance Calculator:

width1: enter line length of D1
width2: enter line length of D2
mag. dist.: enter the distance the tool was moved back (i.e. 100mm).

Source-Detector Distance Calculator

width1:

width2:

mag. dist.:

Source-Detector distance: 249.745095

23. Press the *Update* button. The system provides the Source-Detector distance.

Make note of this value (should be approximately 250) in the Worksheet.

7.4.6 Edit Calibration Settings

1. Access **Calibration Tools** and click the *Calib. Settings* tab.
2. Click *File* and choose *Read Registry Values* from the drop-down list.
3. Using the Worksheet, enter the Source-Detector distance in the Detector Position field three times for each binning mode (1x1, 2x2, 4x4), *separating each with a space* (e.g. 249.74 249.74 249.74).
4. Complete the Centres of Rotation fields as follows:
 Centre of Rotation1: enter the Centre of Rotation as determined during the Centre the Stage procedure
 Centre of Rotation2: enter $\frac{1}{2}$ of the Centre of Rotation value (note value in Worksheet)
 Centre of Rotation4: enter $\frac{1}{4}$ of the Centre of Rotation value (note value in Worksheet).
5. Complete the Central Slices fields as follows:
 Central Slice1: enter the Central Slice value
 Central Slice2: enter $\frac{1}{2}$ the Central Slice value (note value in Worksheet)
 Central Slice4: enter $\frac{1}{4}$ the Central Slice value (note value in Worksheet)
6. Complete the Serial Numbers fields as follows:
 Tube: enter the new X-Ray Source's serial number (e.g. 35106) and note number in Worksheet

The screenshot shows the 'Calib. Settings' tab in the 'GEHC eXplore Calibration Tools' application. The interface includes a menu bar with 'File' and a set of tabs: 'Calib. Settings', 'Diagnostics', 'Calculators', 'Unwarp', 'Transform', and 'Correct'. The 'Calib. Settings' tab is selected and contains the following fields:

- Detector Masks:** XRayMask1, XRayMask2, XRayMask4 (all containing '0 260 2300 2900')
- Detector Pos/Spacing:** Detector Position (250.197 250.197 250.197), Detector Spacing (0.023696682464454)
- Centres of Rotation:** Centre of Rotation1 (1174.0), Centre of Rotation2 (587.0), Centre of Rotation4 (293.5)
- Central Slices:** Central Slice1 (1369.56), Central Slice2 (684.78), Central Slice4 (342.39)
- Serial Numbers:** System (MS60), Tube (35106), Detector (02101)
- Misc.:** Specimen Delay (0), Bright Delay (0), Dark Delay (0), Mag Diff (68.889), Tube (925), and various Multi-Bed Distance and Matrix fields (all 0).

7.4.7 Calculate & Edit Magnification Difference

This calculation is done to accurately display measurements on the screen in millimeters.

1. Install the Measured Plastic dowel into the small specimen tube, secure the dowel with foam, and note the size of the dowel (e.g. 11.684) in the Worksheet.
2. Mount the small specimen tube.
3. Ensure the filter wheel is set to 4.

Note: *Details concerning the following steps are found in the **eExplore Locus SP User Guide**. Refer to it for particulars.*

4. Turn off the **X-Ray and Motor Controller** application if it is still on.
5. Warm up the X-Ray Source.
6. Once warm, launch **eExplore Scan Manager** by double-clicking on the desktop icon.
7. Click *Scan New Subject* and name the subject *pixel_size*.
8. Enter *mag_diff* in the Scan Description field.
9. The **Scan Control** window opens. Choose *2x2wire* from the Protocol drop-down menu.

10. Select the *Scan bright and dark first*, *Recon after scan* and *Home all stages* checkboxes under Options.

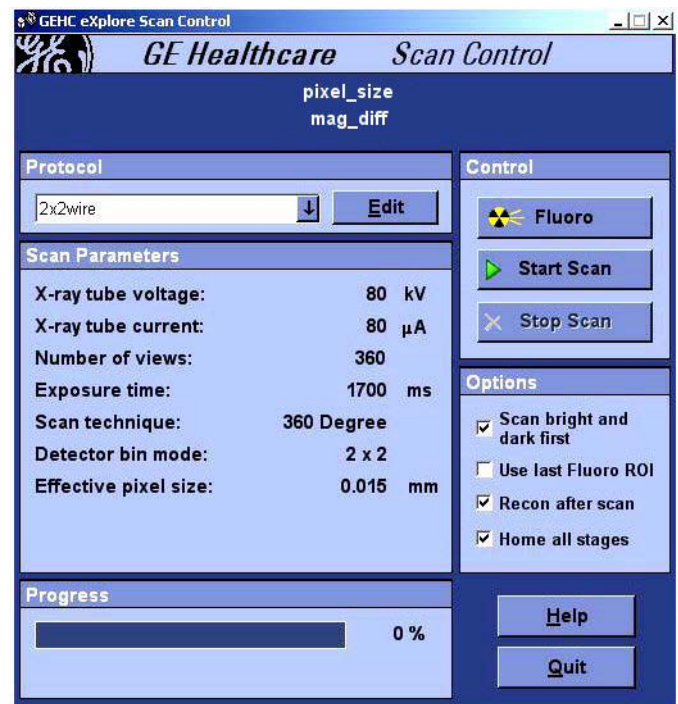
11. Click on the **Fluoro** button. When prompted, place specimen in the scanner and press **OK**.

12. Click **Menu** in **Fluoro** and choose *Position Stages* from the drop-down menu.

13. Adjust the elevation until the plastic dowel is in the mid section of the **Fluoro** screen, then Exit **Fluoro**.

If the width of the small specimen tube does not fit in the field of view, calibration will need to be repeated.

Verify all values before restarting calibration.

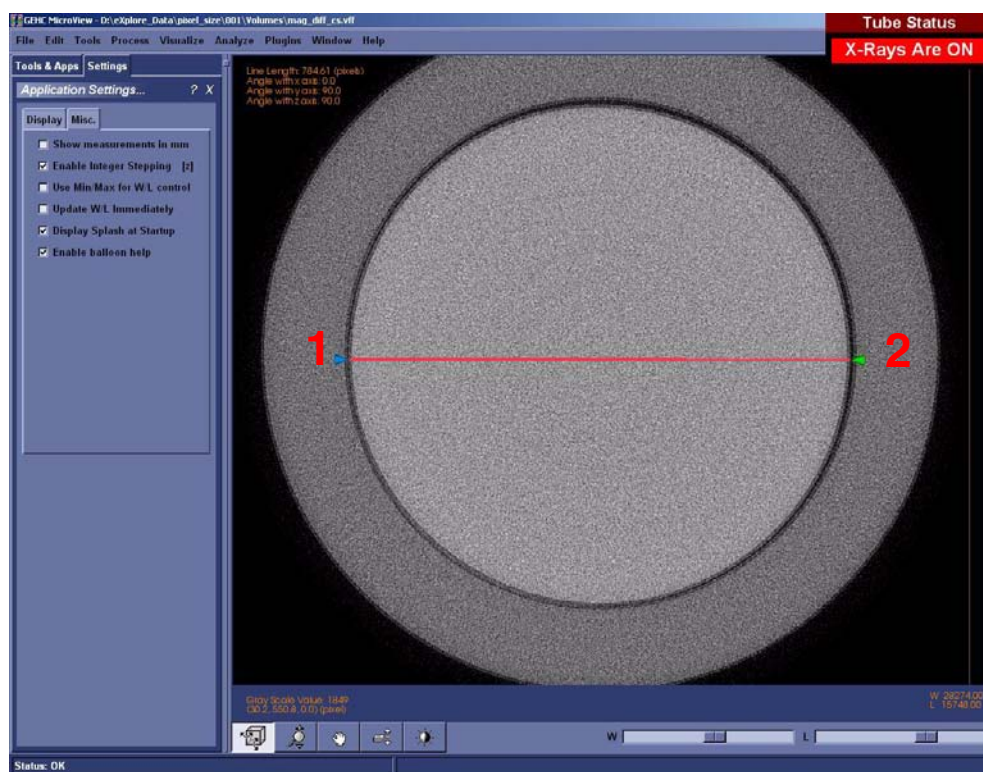


14. Press the *Start Scan* button (the scan takes approximately 30 minutes). When prompted, remove specimen from scanner. Bright and dark scans are scanned. When prompted, place specimen back in scanner.

eExplore Reconstruction Utility is automatically launched once the scan is complete.

15. Click the *Set to Central Slice* button.
16. Click the *Full Res* button.

17. Change the Z-Size value to 1.
18. Click on the *Recon* button.
19. View the reconstructed image in **MicroView**.
20. Change the **MicroView** settings to display measurements in pixels:
 - select Edit>Application Settings
 - select the Miscellaneous tab
 - de-select *show measurements in mm*
21. *Find the widest point* by plotting a line from one side of the plastic dowel to the other:
 - zoom in on the left side, place your mouse on the furthest edge of the plastic dowel, and press **1**
 - pan over to the right side's furthest edge and press **2** (you may need to press 2 repeatedly at different points until you find the widest point or the maximum number of pixels).



22. Determine the maximum number of pixels from one side of the plastic dowel to the other (diameter) and note the number in the Worksheet.
23. Calculate the measured pixel size using the following equation, and record in Worksheet:

$$\text{measured pixel size} = \text{Measured Plastic dowel size} \div \text{diameter in pixels}$$

24. Calculate the true object position using the following equation, and record in Worksheet:

true object position = (measured pixel size x detector position) ÷ (detector spacing x bin mode* of the scan)

*bin mode will be either 1, 2 or 4.

Note: *The detector position, spacing, and current Mag_Diff values are found in the Calib. Settings tab of **Calibration Tools**. OBJ_POS can be found by opening the 2x2wire.protocol file in Notepad. This file is located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols.*

25. Calculate the Mag_Diff using the following equation (Mag_Diff should be approximately 70):

Mag_Diff = true object position - (OBJ_POS in the protocol - current Mag_Diff in registry)

For example:

Mag_Diff = 85.47 - (80 - 65)

Mag_Diff = 70.47

Record values in the Worksheet.

26. Return to the *Calib. Settings* tab.
27. Click *File* and choose *Read Registry Values* from the drop-down menu.
28. Change the Mag_Diff field to the newly calculated magnification difference.
29. Click *File* and choose *Write Registry Values* from the drop-down menu.
When prompted for a password, enter: **EvS8899**

7.4.8 Perform Verification Scans (1x1, 2x2, & 4x4 Modes)

The following procedure is used to verify the calibration settings.

Note: *The ambient temperature in the room must be stable to perform this procedure i.e. the room temperature should not change even by 1 degree during the scanning process.*

First perform verification scans for 1x1 mode using the procedure below, then repeat the procedure in order to perform verification scans for 2x2 and 4x4 modes.

FIND THE IDEAL CENTRE OF ROTATION AT CENTRAL SLICE:

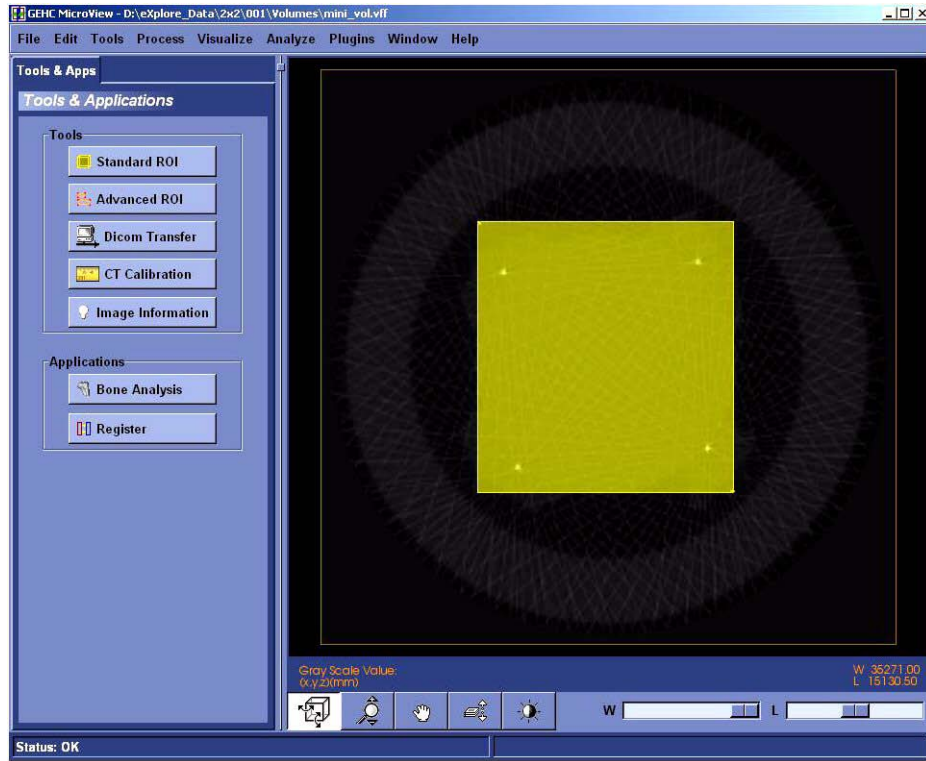
1. Place the wire phantom in the small specimen tube, secure the phantom with foam, and mount the tube.
2. Ensure the filter wheel is set to **4** (or **1** for 4x4 mode).

Note: *Details concerning the following steps are found in the **eExplore Locus SP User Guide**. Refer to it for particulars.*

3. Warm up the X-Ray Source.
4. Once warmed up, launch **eExplore Scan Manager**.
5. Click *Scan New Subject* and name the subject *1x1* (or *2x2* or *4x4* depending on which verification scans are being performed).
6. Enter *1x1wire* in the Scan Description field (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
7. The **Scan Control** window opens. Select *1x1wire* from the Protocol drop-down list (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
8. Select the *Scan bright and dark first*, *Recon after scan* and *Home all stages* checkboxes under Options.
9. Start **Fluoro**.
10. Click *Menu* and choose *Position Stages* from the drop-down list.
11. Adjust the elevation until the wires of the center section of the wire phantom extend from the top to the bottom of the screen.
12. Exit **Fluoro**.
13. Press the *Start Scan* button (the scan takes approximately 45 minutes) and follow the prompts to place and remove the specimen from the scanner for the bright and dark scans.
The **eExplore Reconstruction Utility** launches automatically when the scan is complete.
14. Click the *Set to Central Slice* button.
15. Click the *Thumbnail* button.
16. Change the Z-Size field to **5**.
17. Press the *Recon* button on the **Reconstruction Utility** window.
18. View the image in **MicroView**. Draw a line from the wire on the left side of the screen to the wire on the top using the 1 and 2 keys, and note the angle displayed in the top left of the screen in the Worksheet.
19. Exit **MicroView**.
20. Press the *Advanced* button on the **Reconstruction Utility** window and select the *Reconstruction* tab.
21. Enter the approximate angle of the 4 wires noted above in the Angle field.
22. Record the existing air, water and HU calibration values in the Worksheet. Enter **-1** (minus one) values for each field.
23. Select *Short Scan*. This looks at the first 200 views instead of all 360 views. It will emphasize any errors in calibration. Click OK.
24. Press the *Recon* button in the **Reconstruction Utility** window.
25. View the image in **MicroView** upon completion. The 4 wires should appear "square" to the screen.



26. Select a region of interest that encompasses all 4 wires using the 7 and 8 keys in **MicroView**.

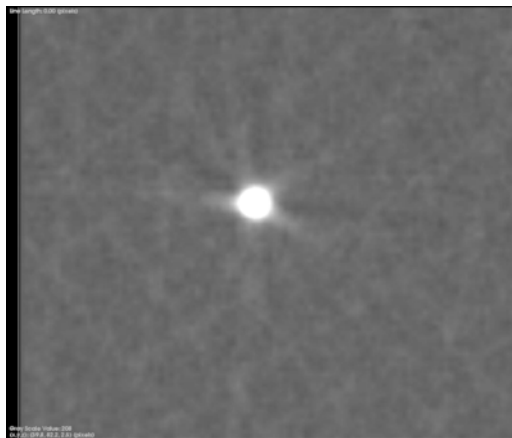


27. Select File>Save crop coordinates.
28. Exit **MicroView**.
29. Click the *Load Crop* button on the **Reconstruction Utility** window.
30. Press the *Recon* button. View the image in **MicroView** and verify the image is cropped properly, then exit **MicroView**.
31. Click the *Full Res* button. De-select the Mini-volume field. This allows you to name the resulting reconstructed volume.
32. Change the Z-Size field to 1.
33. Press the *Recon* button. Name the file *1x1wire_cs_ss.vff* (or *2x2_cs_ss.vff* or *4x4wire_cs_ss.vff* depending on which verification scans are being performed).

34. View the cropped area in **MicroView** upon completion.



35. Zoom in on individual wires. All 4 wires should be as round as possible.



Round Wire



Skewed Wire

If the wires are not round, the Centre of Rotation needs to be adjusted as follows:

- a. Exit **MicroView**.
- b. Click the *Advanced* button in the **Reconstruction Utility** window.
- c. Click the *Reconstruction* tab.
- d. Change the Centre of Rotation field. Make only small, incremental changes to this number (e.g. change 1150 to 1150.5) then click *OK*.
- e. Click the *Recon* button in the **Reconstruction Utility** window.
- f. View the image in **MicroView** upon completion. If the image is improved, continue to change the Centre of Rotation in the same direction (e.g. change 1150.5 to 1151). If the image is worse, change the Centre of Rotation in the opposite direction (e.g. change 1150.5 to 1149.5).
- g. Continue to adjust the Centre of Rotation until the wires are as round as possible (although all 4 wires are unlikely to be equally round).
- h. Make a note of this value in the Worksheet. This is the ideal Centre of Rotation at the Central Slice.

If the wires appear square, ensure that the interpolation is on:

- a. Go to Edit->Application Settings
- b. Ensure a checkmark appears next to "Use Image Interpolation".

36. Click the *Advanced* button in the **Reconstruction Utility** window, and choose the *Reconstruction* tab.
37. De-select the Short Scan field and click *OK*.
38. Click the *Recon* button in the **Reconstruction Utility** window.
39. Name the file *1x1_wire_cs_360* (or *2x2_wire_cs_360* or *4x4_wire_cs_360* depending on which verification scans are being performed).
40. Confirm the wires are still round in **MicroView**. The wires should appear even rounder. Exit **MicroView**.

Note: *If the wires appear hollow (like a ring) in the 360 degree reconstruction, then the Centre of Rotation needs to be adjusted as described above. Also, verify that the HU calibration values are set to -1.*

This process has determined the ideal Centre of Rotation of the wire phantom at the Central Slice. The following steps check the Centre of Rotation of the image at either end of the wire phantom.

VERIFY CENTRE OF ROTATION AT EACH END (FOR 1X1 MODE ONLY):

1. Change the Z-Origin field on the **Reconstruction Utility** window to *200*. This represents one end of the wire phantom.
2. Click the *Advanced* button, then choose the *Reconstruction* tab.
3. Re-select Short Scan, then click *OK*.
4. Click the *Recon* button. Name the file *1x1wire_-end_ss*
5. View the image in **MicroView**. The wires should appear as round as possible.
If the wires are not round, the Centre of Rotation needs to be adjusted as described above.
6. Upon completion, make note of the difference between this Centre of Rotation and the ideal Centre of Rotation at the Central Slice in the Worksheet.

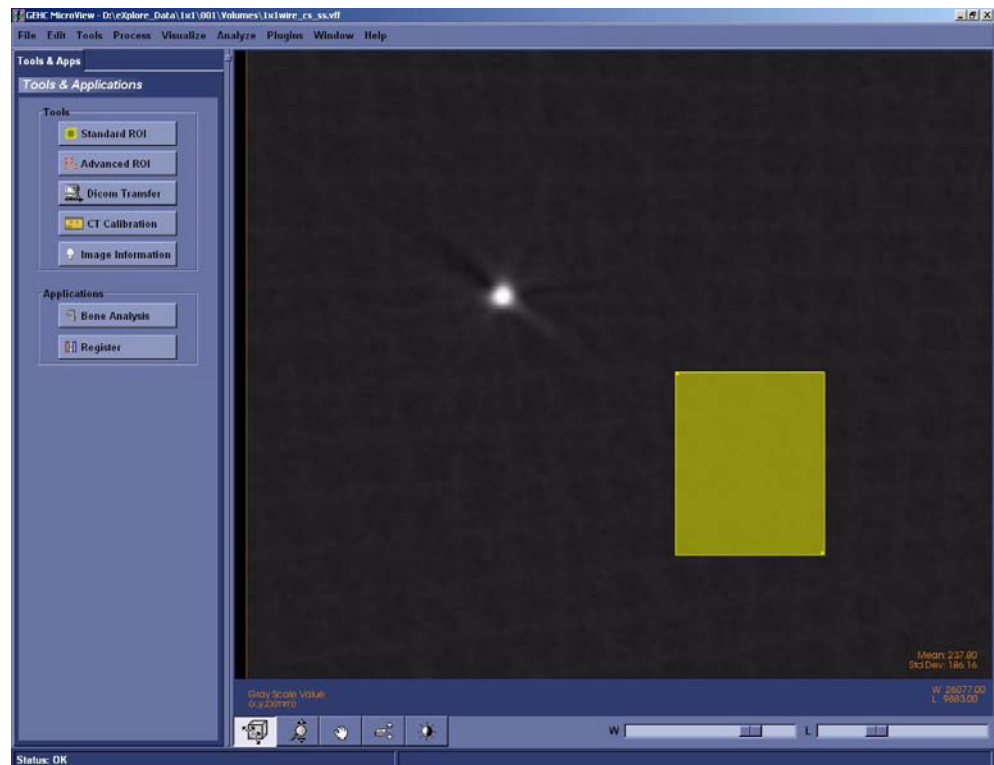
Note: *The value of the Centre of Rotation at either end of the wire phantom may only differ from the ideal Centre of Rotation at the Central Slice by 1.5 pixels. The Short Scan option in **Reconstruction Utility** must be used for this test to be valid.*

7. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_-end_360*. Verify that the wires appear round.
8. Move to the other end of the wire phantom by changing the Z-Origin to *2600*. Re-select the Short Scan field. Name the file *1x1wire_+end_ss*
9. Click the *Recon* button and view the image in **MicroView**. The wires should appear as round as possible. If the wires are not round, adjust the Centre of Rotation until the wires appear as round as possible.

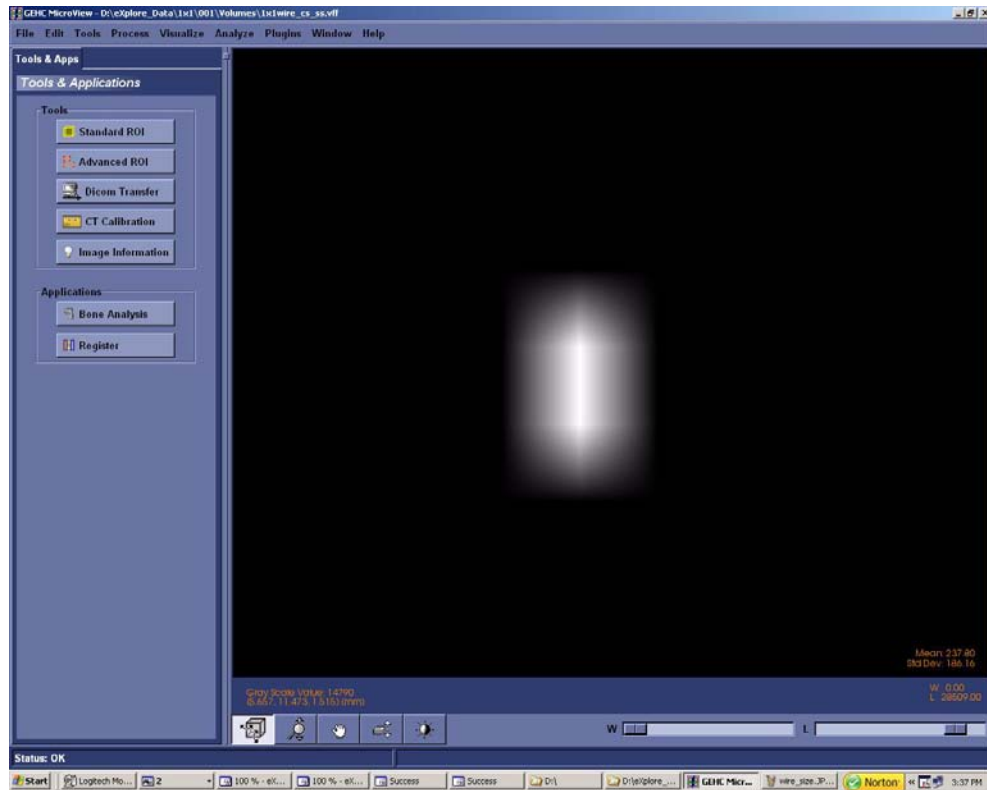
Note: *If the Centre of Rotation at either end of the wire phantom differs by more than 1.5 pixels from the ideal Centre of Rotation at the Central Slice (e.g. the total difference is greater than 3 pixels), the tilt angle of the grid is likely incorrect and you must re-calibrate from that point (see Complete Transform1 File Creation).*

10. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_+end_360*. Verify that the wires appear round.
11. Once successful, click the *Set to Central Slice* button on the **Reconstruction Utility** window.
12. Select Short Scan.
13. Click the *Recon* button on the **Reconstruction Utility** window.
14. View the image in **MicroView** and zoom in on the wire that appears least round to be measured.
15. Select a region of interest within the phantom housing near the wire being measured.

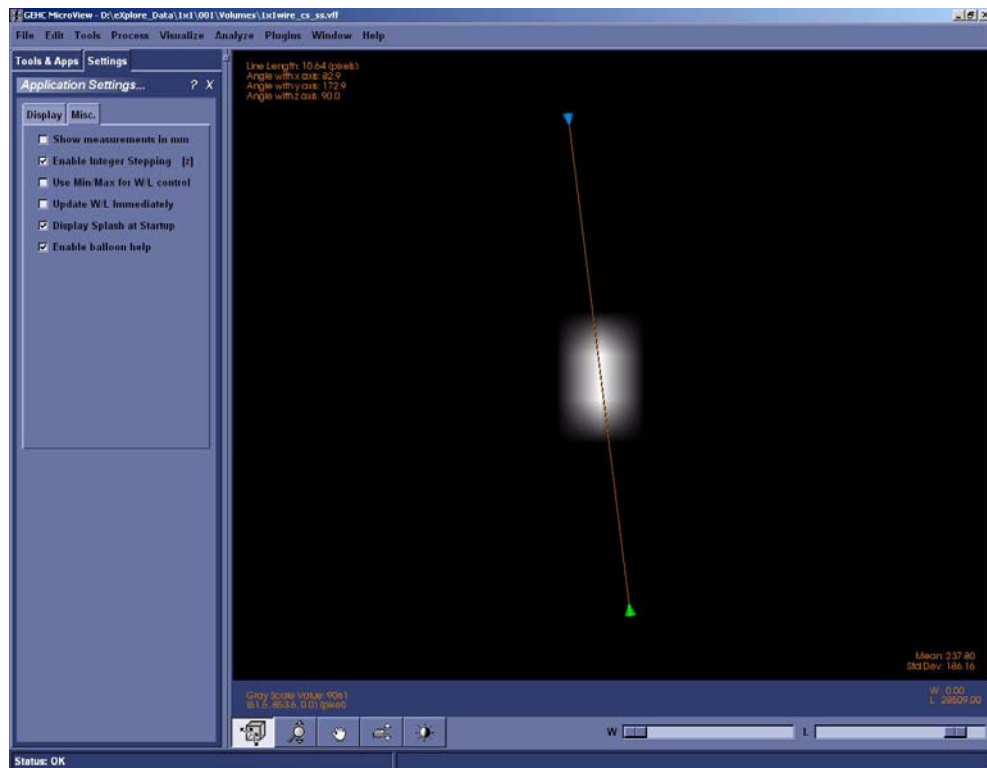
Press **m** to calculate the mean value of the plastic area selected and record in Worksheet.



16. Zoom in on the wire. Adjust the Window and Level to allow only two pixels to be visible.



17. Plot a line across the wire's two brightest pixels using the 1 and 2 keys in MicroView.



The next step is to find the Full Width Half Maximum value of this wire in pixels.

Note: *All 4 wires must be symmetrical, but not necessarily completely round. How the wires appear may give you a clue about a possible problem.*

If, for example, 2 wires in diagonal corners look good but the other 2 do not, the centring of the stage is not correct. If 3 of the wires look good and one looks bad, a possible error was made calculating the distance between the X-Ray Source and the detector or the Detector Spacing under the Calib. Settings tab is incorrect.

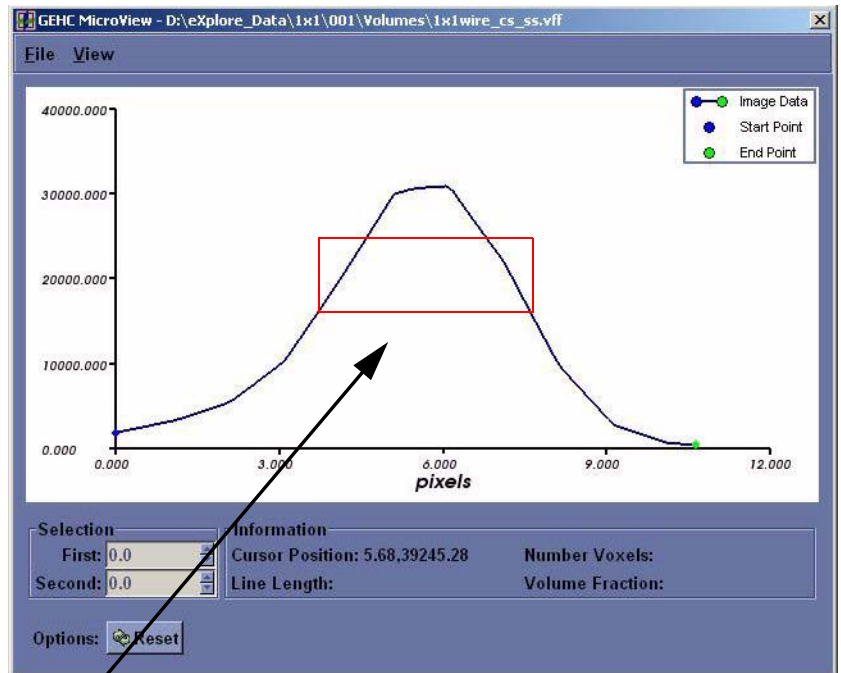
- 18. Press **p** to view the plot.

If the resulting plot is a straight line, exit Microview and repeat reconstruction but change z-size to 5.

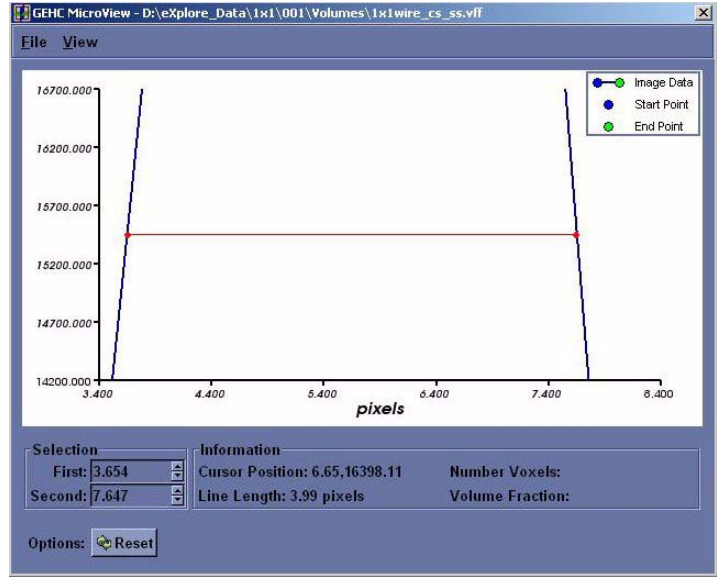
- 19. Use the mouse pointer to find the number at the top of the peak (e.g. 30000). Record in Worksheet.

- 20. Add the mean value calculated above in step 16 to the peak value (determined in the last step) and then divide the result by 2. This is the Full Width Half Maximum value. Record in Worksheet.

- 21. Zoom in (left-click and drag the mouse) so that the middle area of the peak is highlighted.
- 22. Move the mouse to the left line (side) and press **1** at the Full Width Half Maximum value point (e.g. 15000).



23. Move the mouse to the right line (side) and press **2** at the Full Width Half Maximum value point to draw a line from one side to the other.
24. Make note of the line length in pixels, in the Worksheet.
25. In **eXplore Scan Manager**, navigate to the 1x1 wire scan. Note the resolution value displayed on the right-hand side of the window, in the Worksheet.
26. Divide .025mm (which is the size of the wire in the wire phantom) by the resolution value and then add 2 to the result. This value is the target value, in pixels, of the wire scan.



Example:

$$.025 \div .007634 = 3.274 \text{ (target value)}$$

$$3.274 + 2 = 5.274 \text{ (maximum value)}$$

Record values in the Worksheet.

27. Verify that the line length calculated in step 25 is less than the maximum value calculated in step 27. If not, calibration will need to be restarted.
28. Repeat steps 15 to 28 for the remaining 3 wires. Use the Worksheet to record values, as appropriate.
29. Exit the plot, then exit **MicroView**.

Upon completion:

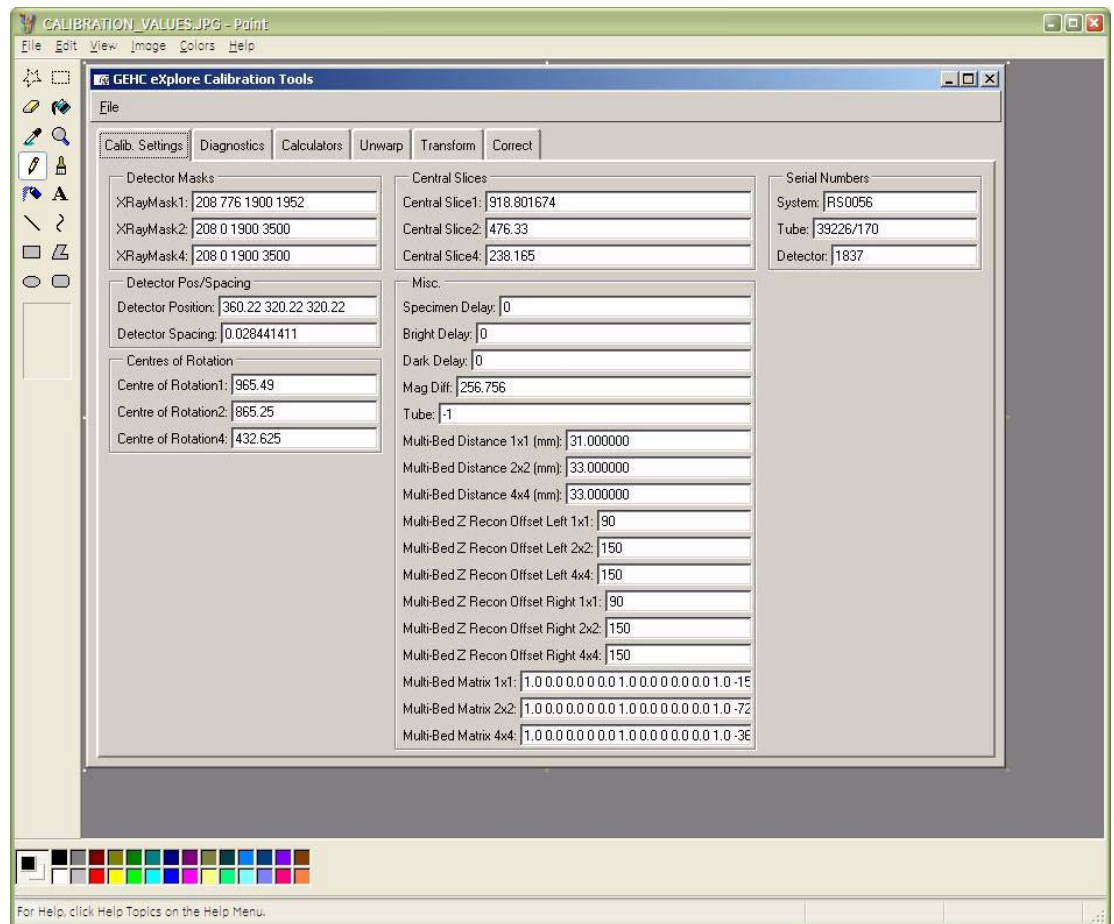
In the **Reconstruction Utility**, press the *Advanced* button. Go to the Recon tab. Re-enter the noted air, water and bone HU calibration values into each field for all three scans (1x1, 2x2 and 4x4). Inform the customer that they may need to re-calibrate their HU values.

7.4.9 Follow Up

Upon completion, back up calibration values.

SAVE CALIBRATION SETTINGS

1. Capture a screen shot of the calibration values found under the *Calib. Settings* tab in **Calibration Tools**.
2. Call the file *calibration_values.jpg*
3. Save the document to both C: and D: drives.

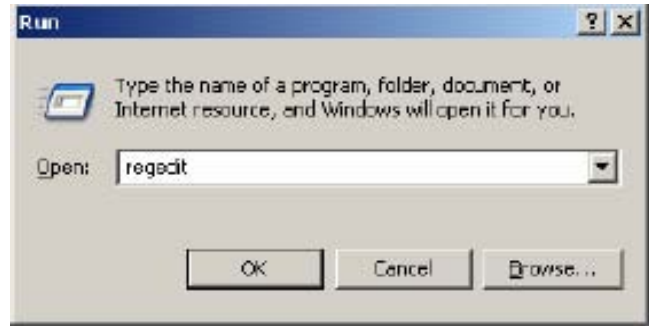


4. Copy D:\calib folder to C: drive.
5. Copy C:\translations1 to D: drive.

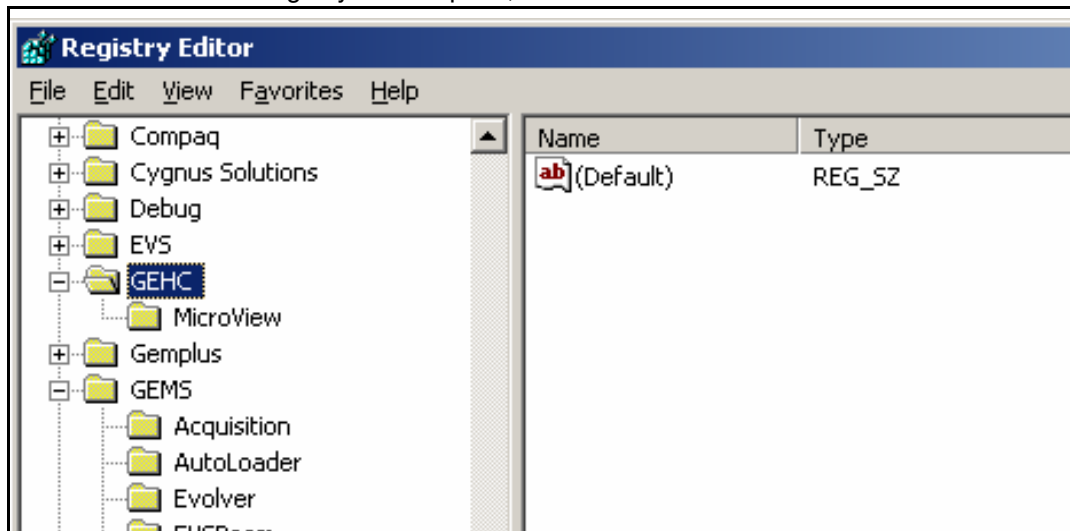
BACK UP REGISTRY

6. If needed, add the following folder to the C: drive: **Registry Backup**
7. Create a sub-folder under Registry Backup and label the folder with "today's date" e.g. yymmdd
8. Click on the Microsoft **start** button in the bottom right corner of the screen, and choose **Run...**

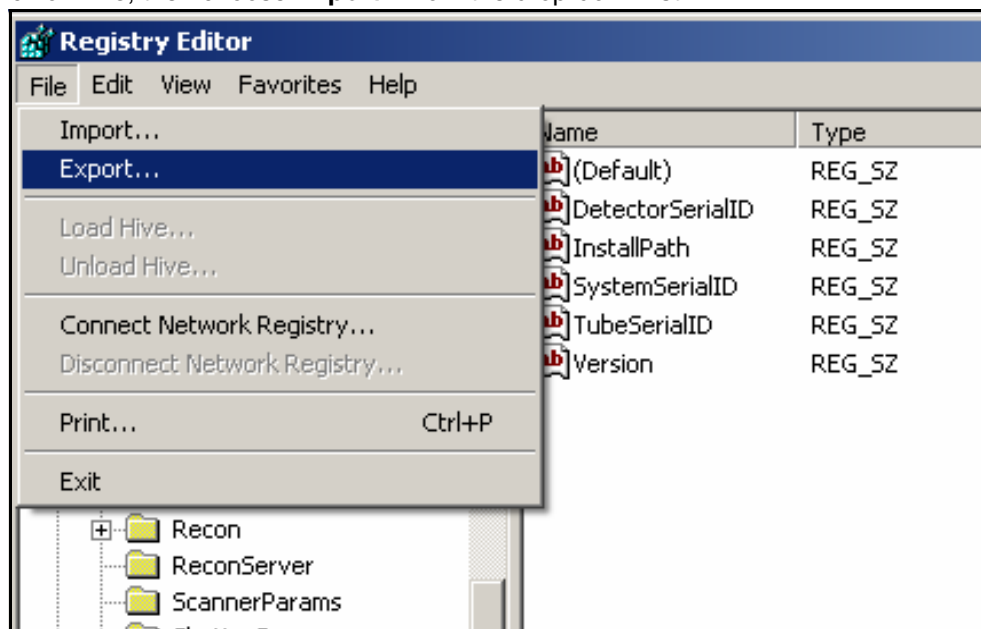
9. Enter the following in the text box, then click OK: **regedit**



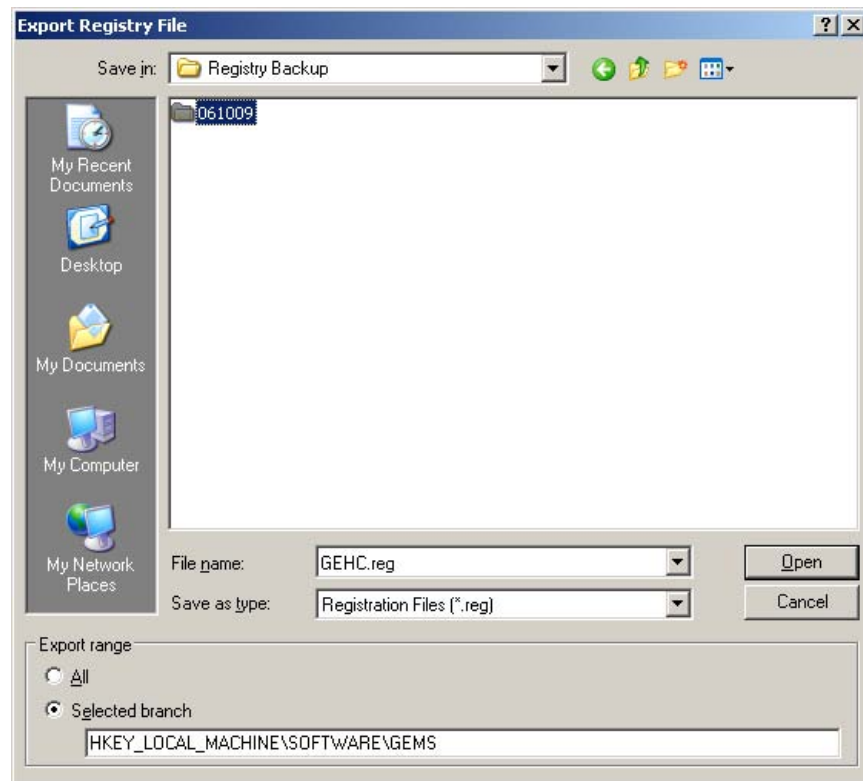
10. Once the Microsoft Registry Editor opens, click on the **GEHC** folder.



11. Click on **File**, then choose **Export...** from the drop-down list.



12. Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
13. Under File name, enter **GEHC.REG** then click on the **Save** button.



14. Next select the **GEMS** folder under the Registry Editor.
15. Click on **File**, then choose **Export...** from the drop-down list.
16. Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
17. Under File name, enter **GEMS.REG** then click on the **Save** button.
18. Using Windows Explorer, rename the file: **GEMS.GER**

This is done to protect the file so that it is not accidentally opened which would rewrite the registry.

DISABLE TEST PROTOCOLS

19. Disable the test protocols by changing the 1x1wire.protocol, 2x2wire.protocol and 4x4wire.protocol files to:

1x1wire.txt

2x2wire.txt

4x4wire.txt

Files are located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols\

BACK UP CRITICAL FILES TO DVDs

1. Copy the following files to a DVD:
 - C:\translations1
 - all the transform and transform.dat files found in D: drive
 - the D:\calib folder and the D:\detector folder
 - the C:\Program Files\GE Medical Systems folder
 - the newly created *calibration_values.txt* file
 - all saved volumes (e.g. 1x1_wire_cs_360)
 - the C:\Registry Backup folder.
2. Label the DVD with the name *Calibration Values*, and include the system serial number and date.
3. Create zip files containing the acquired images and support files created for each of the 3 wire scans. Call the zip files *1x1.zip*, *2x2.zip* and *4x4.zip*. There is no need to backup the 'Volumes' or 'Corrected' folder.
4. Save the zip files on to a separate DVD and label the DVD with the name *Wire Scans*. Include the system serial number and date.
5. Make two copies of each DVD. File one set of DVDs in the system's Device History Record folder located on the back of the system, and send the other to Service Engineering.

Service Engineering
Attn: Janice Chu
1510 Woodcock Street, Unit #7
London, ON N6H 5S1
Canada

Section 7.5 Case/Shielding Removal "Abridged" Calibration

When the case or x-ray shielding is removed from the Locus SP, an "abridged" calibration is performed which consists of centring the stage, performing verification scans, editing calibration settings, and follow up. This is also performed whenever the system is moved. The procedures below use the following applications:

- **System Warm-Up** (C:\Program Files\GE Medical Systems\Explore Utilities\WarmupApp.exe)
- **Calibration Tools** (C:\Program Files\GE Medical Systems\Explore Utilities\Calibration.exe)
- **X-Ray and Motor Controller**. The **X-Ray and Motor Controller** (C:\Program Files\GE Medical Systems\Explore Utilities\X-Ray_Controller.exe)
- **transgen** program (C:\Program Files\GE Medical Systems\Explore Utilities\Calibration\transgen.exe)

7.5.1 Centre the Stage

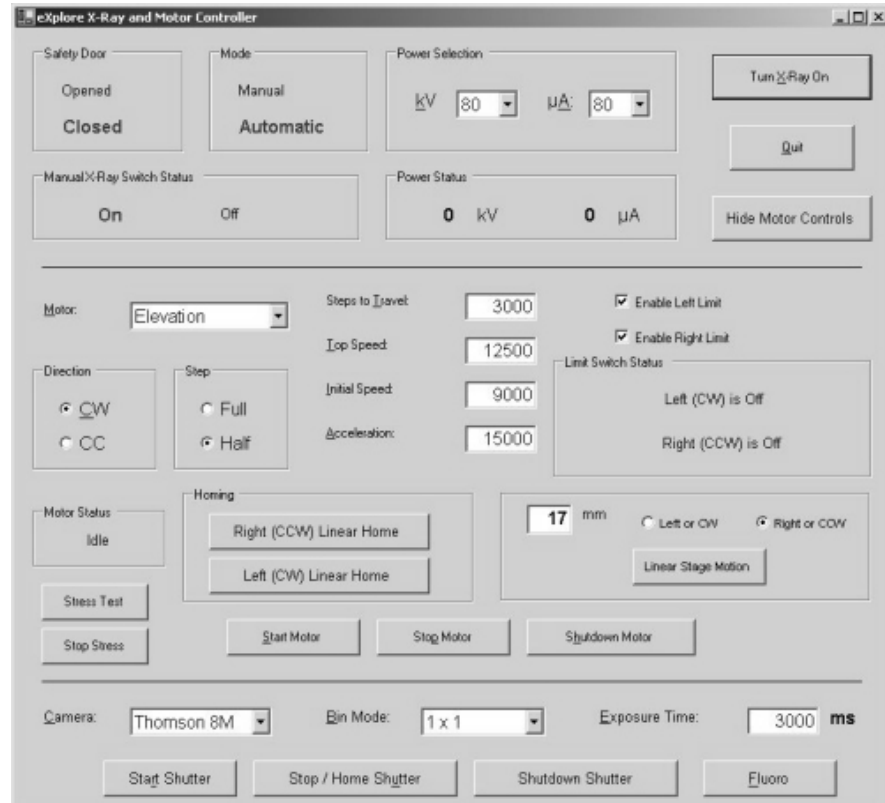
This procedure is used to centre the stage between the X-Ray Source and the detector.

1. Open **Windows Explorer** and navigate to D:/. Copy the *calib* folder and rename it *original_calib*.
2. Turn the unit ON using the key, and press the red *Reset* button.
3. Warm-up the X-Ray Source using the **System Warm-Up** application as follows:
 - right-click the Warm-Up icon in the task bar and select the *<=10 Minutes to Scan* option
 - once the cycle has finished (approximately 14 minutes), right-click the icon again and select *Scan Mode*.

The **System Warm-Up** application can be re-initialized by double-clicking on *WarmupApp.exe* in C:\Program Files\GE Medical Systems\Explore Utilities\

4. Access the **X-Ray and Motor Controller** program.
5. Ensure the fields below are set to the following settings:

Enable Left Limit: checked off
Enable Right Limit: checked off
Camera: Thomson 8M
Bin Mode: 1 x 1
Exposure Time: 3000 ms
kV: 80
µA: 80



6. Find the motor limit switch (this ensures that the limit switches will never be triggered):
 - select *Magnification* from the drop down menu in the Motor field
 - press the *Left (CW) Linear Home* button to move the stage toward the Source
 - enter **2** in the mm field, click on the *right or CCW* radio button, then press the *Linear Stage Motion* button to offset the "home" position by 2 mm.
7. Click the *Start Shutter* button.
8. Click the *Turn X-Ray On* button.
9. Click the *Fluoro* button, then:
 - select *OK* when the warning pop-up appears.
 - select *OK* when the text concerning placement of the specimen appears.

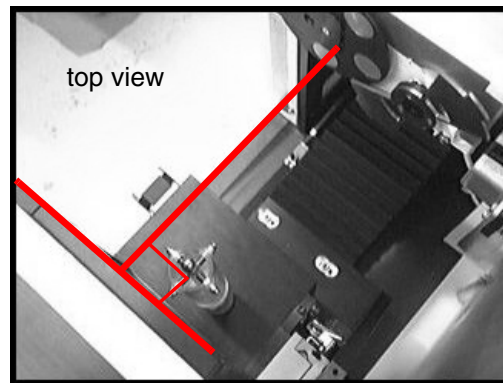
10. Capture an image in **Fluoro** as follows:
 - click *Menu* at the top of the **Fluoro** screen and choose *Capture* from the drop-down menu
 - once the Capture pop-up is displayed, enter **1** in the Number of Frames to Capture field
 - enter **10** in the Number of Frames to Average field
 - name the file *bright* in the Name of Series field
 - save the file to the directory: D:\calib
 - click the *Capture* button.

The progress of capture is shown in the Fluoro's title bar as *[saving...]*. Wait until the image is captured.

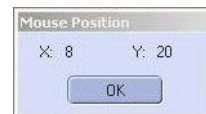


11. Turn off the X-Ray Source and capture a dark image in Fluoro. Call this image *dark*.

12. Mount the X,Y Centring ball tool on the stage cone. Physically rotate the X,Y Centring Ball tool so that 2 of the 4 adjustment screws are exactly perpendicular to the detector (i.e. not at an angle).



13. Turn the X-rays back on and wait a few minutes for the Source to stabilize, then re-start **Fluoro**.
14. Press *m* in **Fluoro** to display the mouse position window.



15. Elevate the tool using the Elevation feature in **X-Ray and Motor Controller** until the ball appears in the centre of the **Fluoro** display. The stage should be close to the detector. Move the stage 70 mm toward the Source so that it is positioned approximately halfway between the Source and detector.
16. Click the *Turn X-Ray Off* button.
17. Mount the Dial Indicator Mount and Precision Dial Indicator.

- Adjust the tip on the Precision Dial Indicator to strike the equator of the ball. Make sure the Indicator is not pegged (i.e. the small needle on the gauge, near the centre of the Dial Indicator, is around the halfway mark).

Note: *The Precision Dial Indicator is very sensitive and care should be taken not to lean or touch any part of the system while adjusting the Indicator or the X,Y Centring Ball tool.*

- Zero the Precision Dial Indicator.

Note: *For fine measurements, the Precision Dial Indicator may not be accurate until after the first movement.*

- Use the *Rotation* setting in **X-Ray and Motor Controller** to rotate the ball 360° (180° at a time). Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged. Re-zero the Dial Indicator, if necessary.

Centre the Ball:

- Use the *Rotation* setting to rotate the ball 180°.

- Watch the Precision Dial Indicator as the ball rotates. Note the reading of the Precision Dial Indicator after 180° of rotation (e.g. .0004").

The objective is to adjust the ball so that, after the adjustment, the Dial Indicator reads half of the original reading (e.g. .0002").

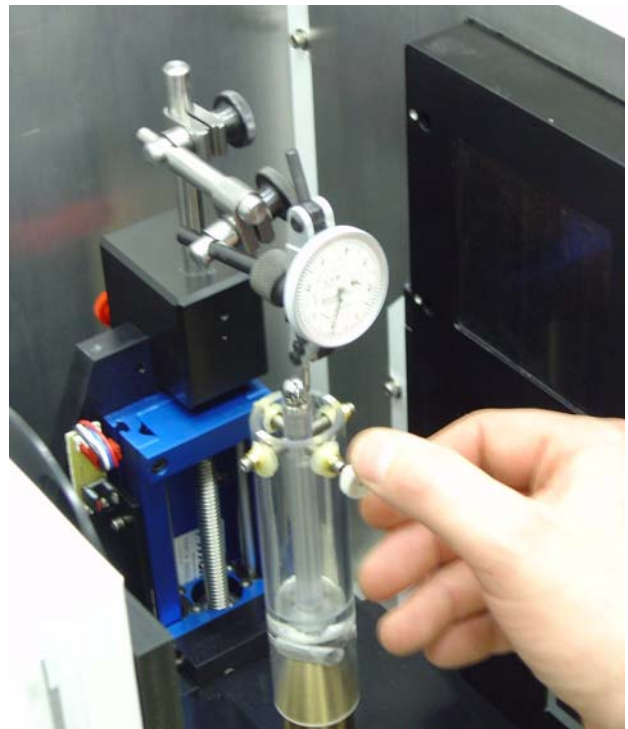
To do this:

- Use the tool's adjustment key to carefully turn the 2 adjustment screws that are aligned with the Dial Indicator - turn the screws until the Dial Indicator reads half of the original reading.

NOTICE Equipment Damage Possible

The tool is extremely delicate. Fine adjustments are required. DO NOT overtighten the screws. One screw turns clockwise and the other turns counter clockwise. Turn the screws in tandem using as little torque as possible (i.e. 5° at a time).

- Once adjusted, rotate the ball 180° and check the Dial Indicator reading. It should match the reading taken after the adjustment in the previous step (e.g. .0002").
- Re-zero the Dial Indicator.



26. Use the rotation setting to rotate the ball 360° (180° at a time). Watch as the ball is rotating to ensure that the tip of the Precision Dial Indicator is touching the ball at all points of rotation and that it is not pegged. Re-zero the Dial Indicator, if necessary.
27. Rotate the ball 180° and confirm the Dial Indicator reads zero.
28. Rotate the ball 90°.

NOTICE
Equipment
Damage
Possible

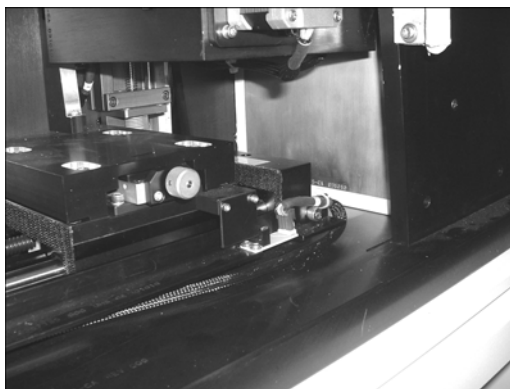
29. Carefully adjust the 2 screws that are aligned with the Dial Indicator until the Dial Indicator reads zero.
30. Rotate the ball 180° and verify that the Dial Indicator still reads zero.

Note: *Fine tuning may be required. Continue to make adjustments until the ball can rotate 360° without the Dial Indicator reading moving more than .0002".*

31. Once the ball has been centred, remove the Dial Indicator Mount and Precision Dial Indicator.
32. Select *Magnification* in the Motor field in the **X-Ray and Motor Controller** window and move the ball 70mm toward the detector. This should be 2mm from the limit switch.
33. Warm up the x-rays without using the **System Warm-up** application to avoid moving the stage. To do this, use the **X-Ray and Motor Controller** program and do the following:
 - a. Set the kV field to 80
 - b. Set the μ A field to 10
 - c. Press the **Turn X-Rays on** button
 - d. Wait 2 minutes
 - e. Press the **Turn X-Rays off** button
 - f. Set the kV and μ A field to the next value in list below, and repeat steps c to e:

- wait 2 minutes @ 80kV, 45 μ A

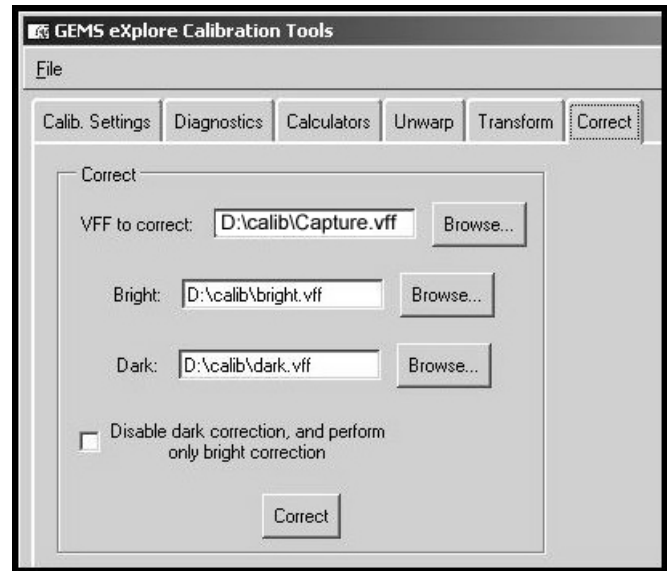
- wait 10 minutes @ 80kV, 80 μ A



34. Capture the image in **Fluoro** and name it *capture*.

Correct the Image:

35. Correct the captured image as follows:
 - access the **Calibration Tools** program (located in C:\Program Files\GE Medical Systems\Explore Utilities\Calibration)
 - click the *Correct* tab
 - in the VFF to correct field, find the newly captured image (e.g. *capture*)
 - use the *Browse* buttons to find the files called *bright* and *dark*
 - click the *Correct* button (the corrected file is named *corrected.vff* and it is stored in the same folder in which the captured image was stored)

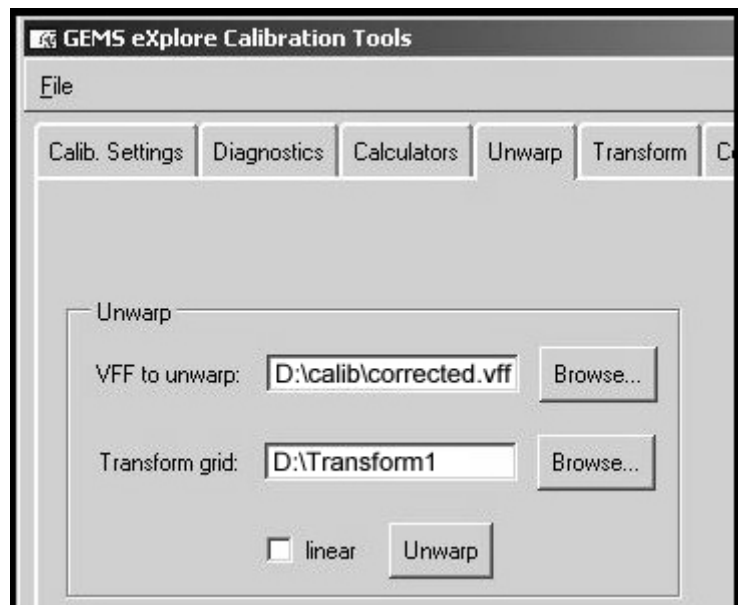


Unwarp the Image:

36. Click the *Unwarp* tab in **Calibration Tools** and complete the fields as follows:
 - in the VFF to unwarp: field use the *Browse* button to find the file D:\calib\corrected.vff
 - in the Transform grid: field, use the *Browse* button to find the D:\Transform1 file.
37. Click the *Unwarp* button.
38. Call the file D:\zz when prompted to name the file, then click *OK*.

The zz file will be used as a temporary file for unwarping. Continue to overwrite this file whenever unwarping.

39. Double-click on zz in **Windows Explorer** to load the image into **MicroView**.



40. Double-click on the W and L parameters in the lower right of the screen. Change the Update mode to *Delayed updates*. This only needs to be changed once.



Record Window and Level in the Worksheet.

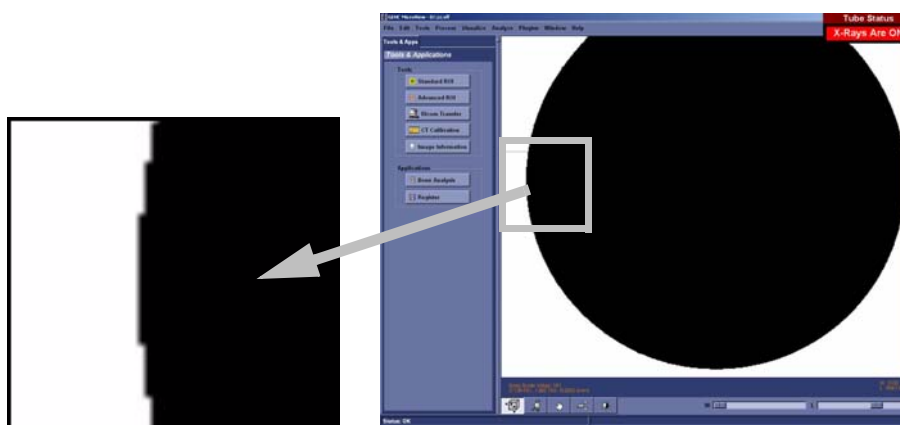
Find the Geometric Centre of the Ball at Detector End:

Note: *To find the geometric centre of the ball, determine the x value on the right and left side of the ball. Add the values together and divide by 2. To find the geometric centre as follows.*

41. Use the Pan and Zoom features in **MicroView** to get the ball in the desired area of the screen.

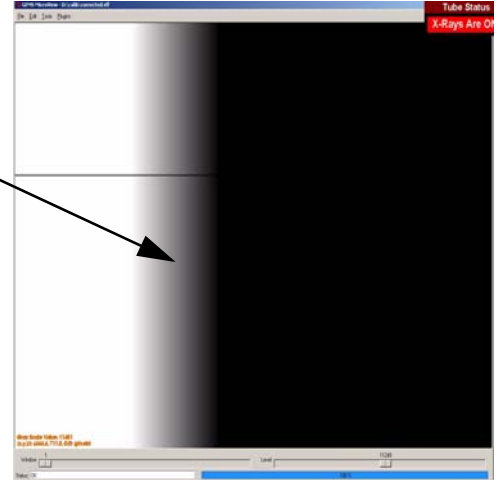
Note: *To Pan, move the mouse while pressing Shift plus the left mouse button simultaneously. To Zoom, move the mouse up (to magnify) or down (to zoom out) while pressing the right mouse button.*

42. Threshold the image by sliding the *Window* slide bar to the left until it reads 0 and sliding the *Level* slide bar until the edges of the ball appears with the maximum amount of square edges.



43. Zoom in on the outer left most side of the ball.

44. Place the mouse in the middle of the gray band that appears to the left of the black area. Use the Worksheet to make note of the x coordinate and round the coordinate to the nearest .5 pixel.



45. Zoom out and move to the right outer most side of the ball. Zoom in on the edge. **DO NOT** re-adjust the *Window* and *Level* slide bars.
46. Place the mouse in the middle of the gray band that appears to the right of the black area. Make note of the x coordinate in the Worksheet.
47. Add the 2 x values together and then divide by 2. This value is the ball's geometric centre. Make note of this value in the Worksheet.
48. Use the **X-Ray and Motor Controller's Magnification** setting to move the ball toward the X-Ray Source 140mm.
49. Capture the image calling the file *capture*.
50. Correct the image.
51. Unwarp the image calling the file D:\zz.
52. Double-click on zz in **Windows Explorer** to load the unwarped, corrected file into **MicroView**.
53. Find the geometric centre of the ball at the X-Ray Source end by making note of the x values on the outer most left and right side of the ball and dividing this value by 2. Make note of values in Worksheet.



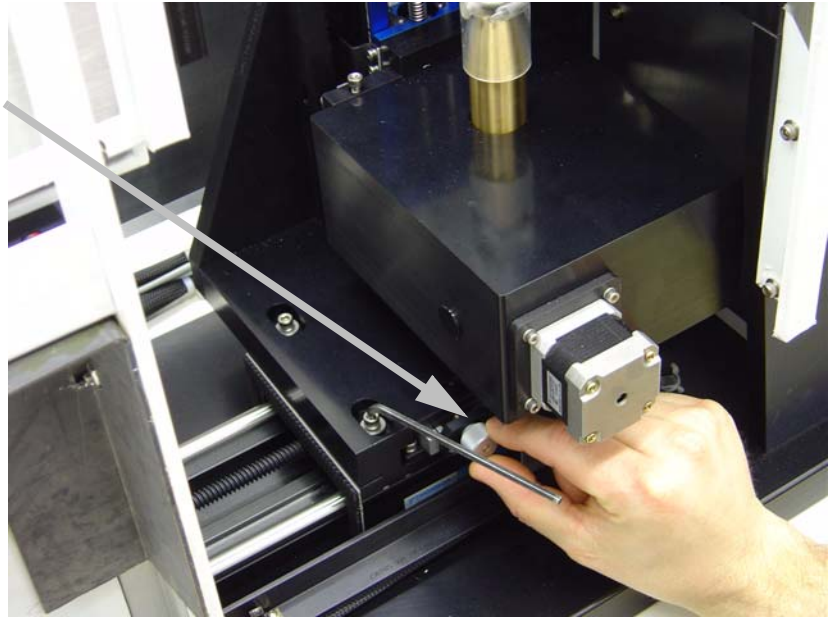
Note: *This value must eventually equal the ball's geometric centre at the detector end, plus or minus 1 pixel.*

IF NOT, adjust the geometric centre values until they are within 1 pixel of each other as follows:

- a. Turn off the X-Ray Source.
- b. Loosen the 4 stage retaining bolts.

- c. Manually adjust the stage using the stage's adjustment wheel (see Note below).

- d. Continue to determine the value of the ball's geometric centre at both the detector end and the X-Ray Source end - manually adjusting the stage's adjustment wheel in between - until the values are equal, plus or minus 1 pixel.



Note: *Small movements of the adjustment wheel are required. One pixel will equal a few (1 to 5 degrees) turn of the wheel.*
The adjustment will change the ball's geometric centre value 3 times faster when the stage is at the X-Ray Source end compared to an adjustment when the stage is at the detector end.
If the value at the X-Ray Source is larger than the value at the detector end, turning the adjustment wheel clockwise reduces the values.

Once confirmed (i.e. the values of the 2 geometric centres are the same + or - 1 pixel):

54. Carefully tighten the 4 bolts (snug only) once the values are close. Make the bolts sufficiently tight so that the adjustment wheel will operate but is difficult to turn. Tightening the bolts may change the value of the geometric centres.
55. Complete the tightening of the 4 bolts and then verify the results at both ends. The bolts may need to be loosened and retightened as you use the adjustment wheel to align the 2 values.

Once the 2 figures are again within 1 pixel of each other, the geometric centre of the ball (the value of its x axis) is now the CENTRE OF ROTATION. Make note of this value in the Worksheet.

56. Save a captured image at both the detector end and the X-Ray Source end. Name the image closest to the detector *smallball.vff* and the image closest to the X-Ray Source *largeball.vff*.
57. Turn off the X-Ray Source.
58. Enable test protocols. Change *1x1wire.txt*, *2x2wire.txt* and *4x4wire.txt* to *1x1wire.protocol*, *2x2wire.protocol* and *4x4wire.protocol*.

Files are located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols\.

7.5.2 Perform Verification Scans (1x1, 2x2 & 4x4 Modes)

The following procedure is used to verify the calibration settings.

Note: *The ambient temperature in the room must be stable to perform this procedure i.e. the room temperature should not change even by 1 degree during the scanning process.*

First perform verification scans for 1x1 mode using the procedure below, then repeat the procedure in order to perform verification scans for 2x2 and 4x4 modes.

FIND THE IDEAL CENTRE OF ROTATION AT CENTRAL SLICE:

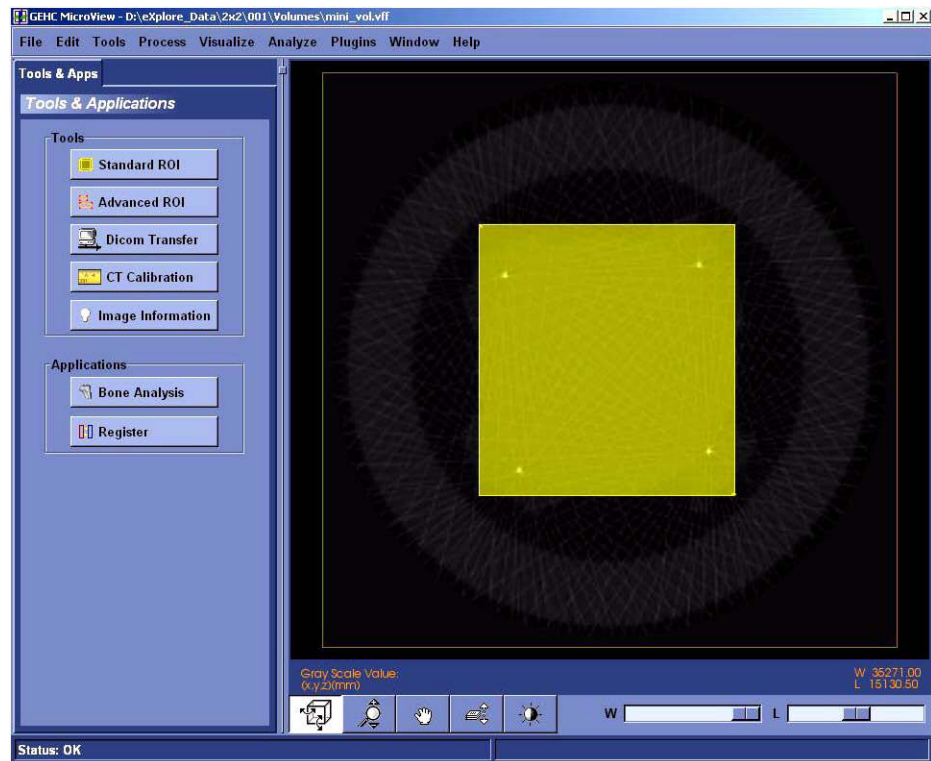
1. Place the wire phantom in the small specimen tube, secure the phantom with foam, and mount the tube.
2. Ensure the filter wheel is set to **4** (or **1** for 4x4 mode)

Note: *Details concerning the following steps are found in the **eExplore Locus SP User Guide**. Refer to it for particulars.*

3. Warm up the X-Ray Source.
4. Once warmed up, launch **eExplore Scan Manager** by double-clicking on the desktop icon.
5. Click *Scan New Subject* and name the subject *1x1* (or *2x2* or *4x4* depending on which verification scans are being performed).
6. Enter *1x1wire* in the Scan Description field (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
7. The **Scan Control** window opens. Select *1x1wire* from the Protocol drop-down list (or *2x2wire* or *4x4wire* depending on which verification scans are being performed).
8. Select the *Scan bright and dark first*, *Recon after scan* and *Home all stages* checkboxes under Options.
9. Start **Fluoro**.
10. Click *Menu* and choose *Position Stages* from the drop-down list.
11. Adjust the elevation until the wires of the center section of the wire phantom extend from the top to the bottom of the screen.
12. Exit **Fluoro**.
13. Press the *Start Scan* button (the scan takes approximately 45 minutes) and follow the prompts to place and remove the specimen from the scanner for the bright and dark scans.
The **eExplore Reconstruction Utility** launches automatically when the scan is complete.
14. Click the *Set to Central Slice* button.
15. Click the *Thumbnail* button.
16. Change the Z-Size field to **5**.

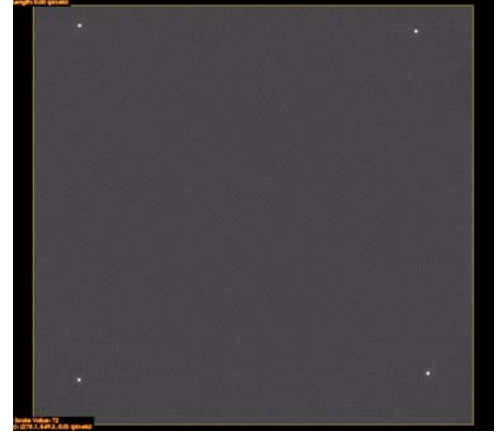


17. Press the *Recon* button on the **Reconstruction Utility** window.
18. View the image in **MicroView**. Draw a line from the wire on the left side of the screen to the wire on the top using the 1 and 2 keys, and note the angle displayed in the top left of the screen in the Worksheet.
19. Exit **MicroView**.
20. Press the *Advanced* button on the **Reconstruction Utility** window and select the *Reconstruction* tab.
21. Enter the approximate angle of the 4 wires noted above in the Angle field.
22. Record the existing air, water and HU calibration values in the Worksheet. Enter -1 (minus one) values for each field.
23. Select *Short Scan*. This looks at the first 200 views instead of all 360 views. It will emphasize any errors in calibration. Click OK.
24. Press the *Recon* button in the **Reconstruction Utility** window.
25. View the image in **MicroView** upon completion. The 4 wires should appear "square" to the screen.
26. Select a region of interest that encompasses all 4 wires using the 7 and 8 keys in **MicroView**.

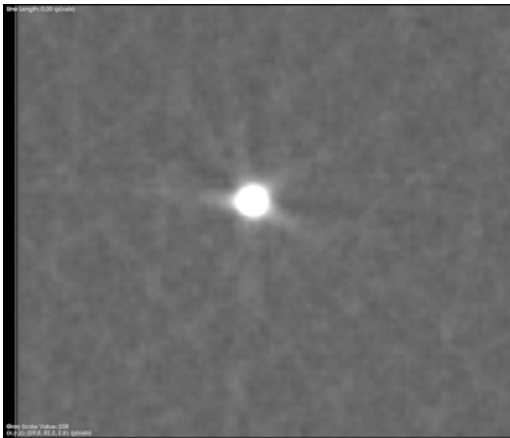


27. Select File>Save crop coordinates.
28. Exit **MicroView**.
29. Click the *Load Crop* button on the **Reconstruction Utility** window.
30. Press the *Recon* button. View the image in **MicroView** and verify the image is cropped properly, then exit **MicroView**.
31. Change the Z-Size field on the Reconstruction Utility screen to **1**.

32. Click the *Full Res* button. De-select the *Mini-volume* field. This allows you to name the resulting reconstructed volume.
33. Press the *Recon* button. Name the file *1x1wire_cs_ss.vff* (or *2x2wire_cs_ss.vff* or *4x4wire_cs_ss.vff* depending on which verification scans are being performed)
34. View the cropped area in **MicroView** upon completion.



35. Zoom in on individual wires. All 4 wires should be as round as possible.



Round Wire



Skewed Wire

If all of the wires are not round, the Centre of Rotation needs to be adjusted as follows:

- a. Exit **MicroView**.
- b. Click the *Advanced* button in the **Reconstruction Utility** window.
- c. Click the *Reconstruction* tab.
- d. Change the Centre of Rotation field. Make only small, incremental changes to this number (e.g. change 1150 to 1150.5) then click *OK*.
- e. Click the *Recon* button in the **Reconstruction Utility** window.
- f. View the image in **MicroView** upon completion. If the image is improved, continue to change the Centre of Rotation in the same direction (e.g. change 1150.5 to 1151). If the image is worse, change the Centre of Rotation in the opposite direction (e.g. change 1150.5 to 1149.5).
- g. Continue to adjust the Centre of Rotation until the wires are as round as possible (although all 4 wires are unlikely to be equally round).

- h. Make a note of this value in the Worksheet. This is the ideal Centre of Rotation at the Central Slice.
36. Click the *Advanced* button in the **Reconstruction Utility** window, and choose the *Reconstruction* tab.
37. De-select the Short Scan field and click *OK*.
38. Click the *Recon* button in the **Reconstruction Utility** window.
39. Name the file *1x1_wire_cs_360* (or *2x2_wire_cs_360* or *4x4_wire_cs_360* depending on which verification scans are being performed)
40. Confirm the wires are still round in **MicroView**. The wires should appear even rounder. Exit **MicroView**.

Note: *If the wires appear hollow (like a ring) in the 360 degree reconstruction, then the Centre of Rotation needs to be adjusted as described above. Also, verify that the HU calibration values are set to -1.*

This process has determined the ideal Centre of Rotation of the wire phantom at the Central Slice. The following steps check the Centre of Rotation of the image at either end of the wire phantom.

VERIFY CENTRE OF ROTATION AT EACH END (FOR 1X1 MODE ONLY):

1. Change the Z-Origin field on the **Reconstruction Utility** window to *200*. This represents one end of the wire phantom.
2. Click the *Advanced* button, then choose the *Reconstruction* tab.
3. Re-select Short Scan, then click *OK*.
4. Click the *Recon* button. Name the file *1x1wire_-end_ss*
5. View the image in **MicroView**. The wires should appear as round as possible.
If the wires are not round, the Centre of Rotation needs to be adjusted as described above.
6. Upon completion, make note of the difference between this Centre of Rotation and the ideal Centre of Rotation at the Central Slice, in the Worksheet.

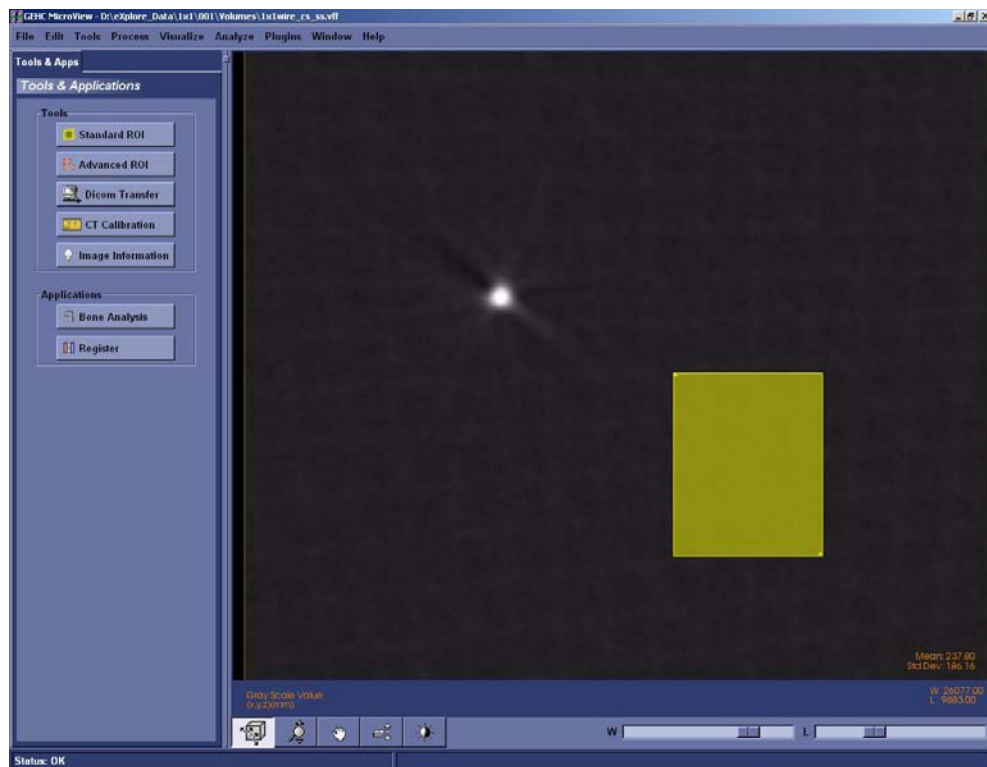
Note: *The value of the Centre of Rotation at either end of the wire phantom may only differ from the ideal Centre of Rotation at the Central Slice by 1.5 pixels. The Short Scan option in **Reconstruction Utility** must be used for this test to be valid.*

7. Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_-end_360*. Verify that the wires appear round.
8. Move to the other end of the wire phantom by changing the Z-Origin to *2600*. Re-select the Short Scan field. Name the file *1x1wire_+end_ss*

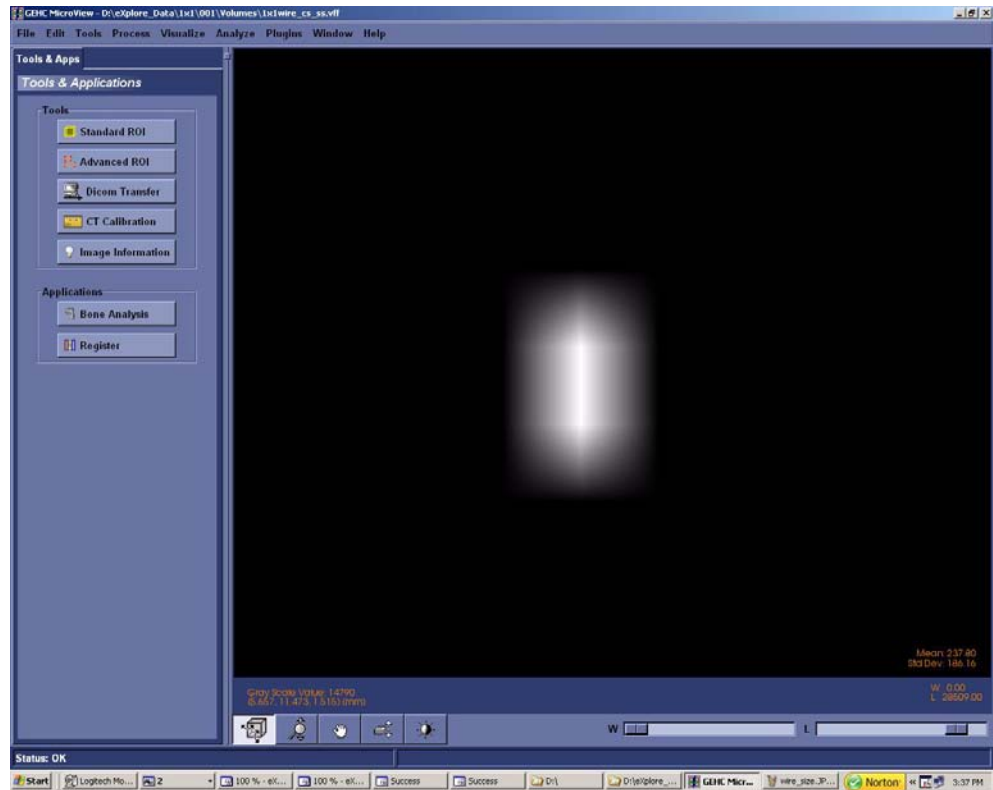
- Click the *Recon* button and view the image in **MicroView**. The wires should appear as round as possible. If the wires are not round, adjust the Centre of Rotation until the wires appear as round as possible.

Note: *If the Centre of Rotation at either end of the wire phantom differs by more than 1.5 pixels from the ideal Centre of Rotation at the Central Slice (e.g. the total difference is greater than 3 pixels), the tilt angle of the grid is likely incorrect and you must re-calibrate from that point (see Complete Transform1 File Creation).*

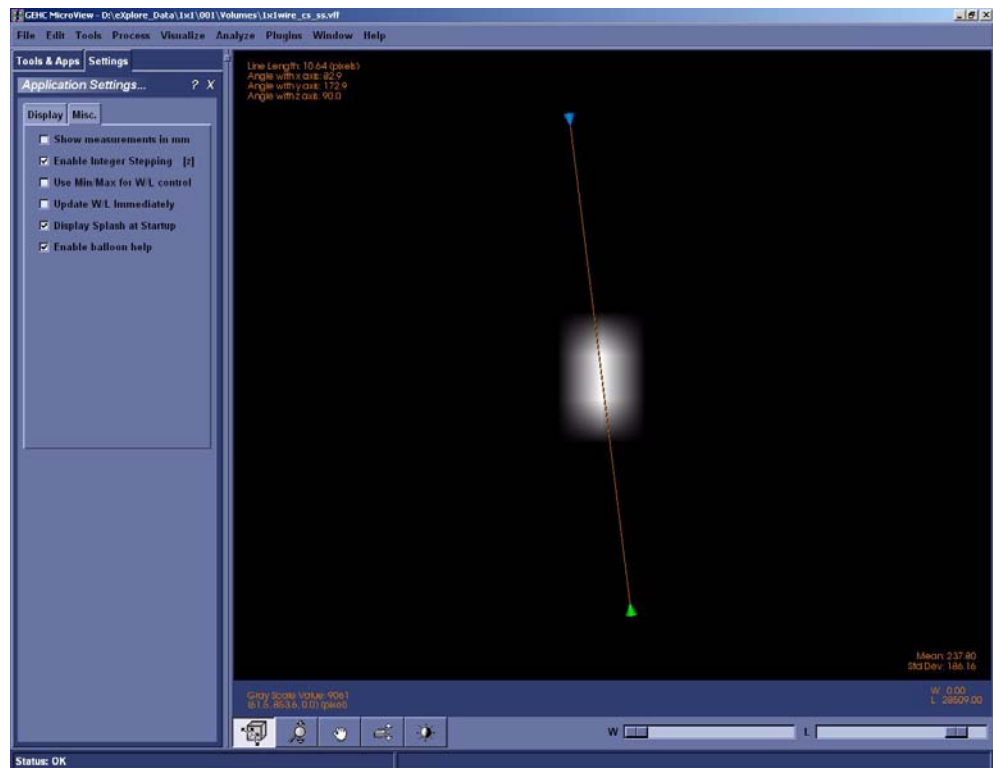
- Change the centre of rotation back to the ideal found at the Central Slice and repeat the reconstruction with all 360 views (de-select the Short Scan field). Name the file *1x1wire_+end_360*. Verify that the wires appear round.
- Once successful, click the *Set to Central Slice* button on the **Reconstruction Utility** window.
- Click the *Advanced* button and choose the *Reconstruction* tab.
- Select Short Scan.
- Click the *Recon* button on the **Reconstruction Utility** window.
- View the image in **MicroView** and zoom in on the wire that appears least round to be measured.
- Select a region of interest within the phantom housing near the wire being measured. Press **m** to calculate the mean value of the plastic area selected and record in the Worksheet.



17. Zoom in on the wire. Adjust the Window and Level to allow only two pixels to be visible.



18. Plot a line across the wire's two brightest pixels using the 1 and 2 keys in MicroView.



The next step is to find the Full Width Half Maximum value of this wire in pixels.

Note: *All 4 wires must be symmetrical, but not necessarily completely round. How the wires appear may give you a clue about a possible problem.*

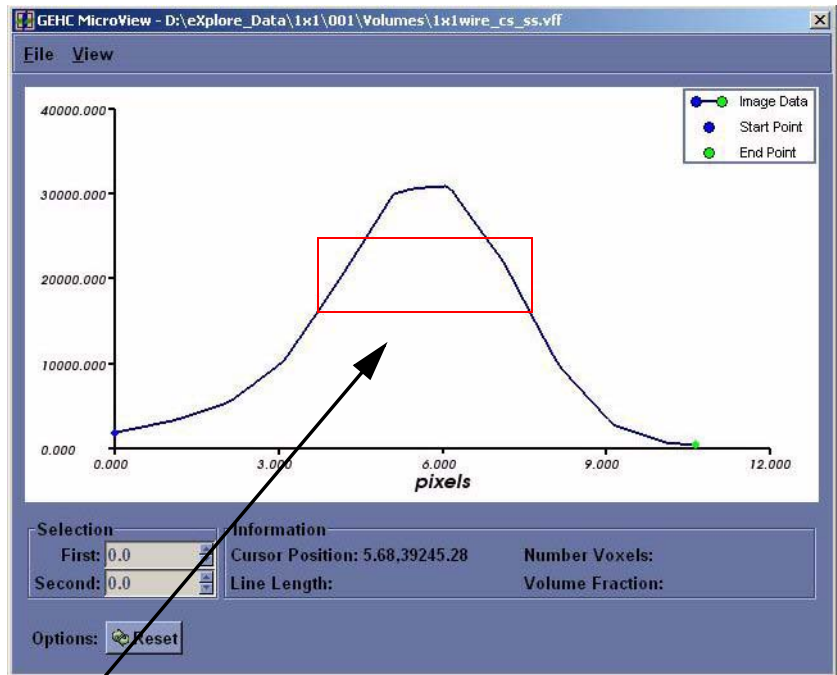
If, for example, 2 wires in diagonal corners look good but the other 2 do not, the centring of the stage is not correct. If 3 of the wires look good and one looks bad, a possible error was made calculating the distance between the X-Ray Source and the detector or the Detector Spacing under the Calib. Settings tab is incorrect.

19. Press **p** to view the plot.

If the resulting plot is a straight line, exit Microview and repeat reconstruction but change z-size to 5.

20. Use the mouse pointer to find the number at the top of the peak (e.g. 30000), and record in the Worksheet.

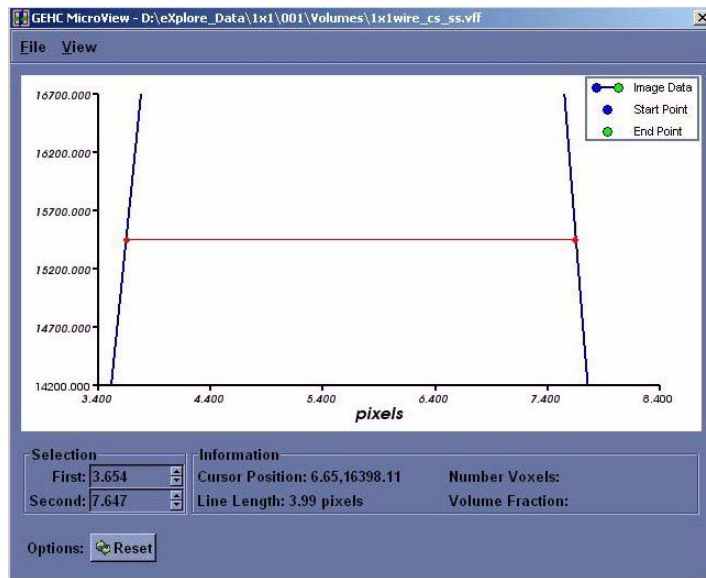
21. Add the mean value calculated above in step 16 to the peak value (determined in the last step) and then divide the result by 2. This is the Full Width Half



Maximum value. Record value in the Worksheet.

22. Zoom in (left-click and drag the mouse) so that the middle area of the peak is highlighted.
23. Move the mouse to the left line (side) and press **1** at the Full Width Half Maximum value point (e.g. 15000).

24. Move the mouse to the right line (side) and press **2** at the Full Width Half Maximum value point to draw a line from one side to the other.
25. Make note of the line length in pixel, in the Worksheet.
26. In **eExplore Scan Manager**, navigate to the 1x1 wire scan. Note the resolution value displayed on the right-hand side of the window, in the Worksheet.
27. Divide .025mm (which is the size of the wire in the wire phantom) by the resolution value and then add 2 to the result. This value is the target value, in pixels, of the wire scan.



Example:

$$.025 \div .007634 = 3.274 \text{ (target value)}$$

$$3.274 + 2 = 5.274 \text{ (maximum value)}$$

Record values in the Worksheet.

28. Verify that the line length calculated in step 25 is less than the maximum value calculated in step 27. If not, calibration will need to be restarted.
29. Repeat steps 15 to 28 for the remaining 3 wires. Record appropriate values in the Worksheet.
30. Exit the plot, then exit **MicroView**.

Upon completion:

In the **Reconstruction Utility**, press the *Advanced* button. Go to the Recon tab. Re-enter the noted air, water and bone HU calibration values into each field for all three scans (1x1, 2x2 and 4x4). Inform the customer that they may need to re-calibrate their HU values.

7.5.3 Edit Calibration Settings

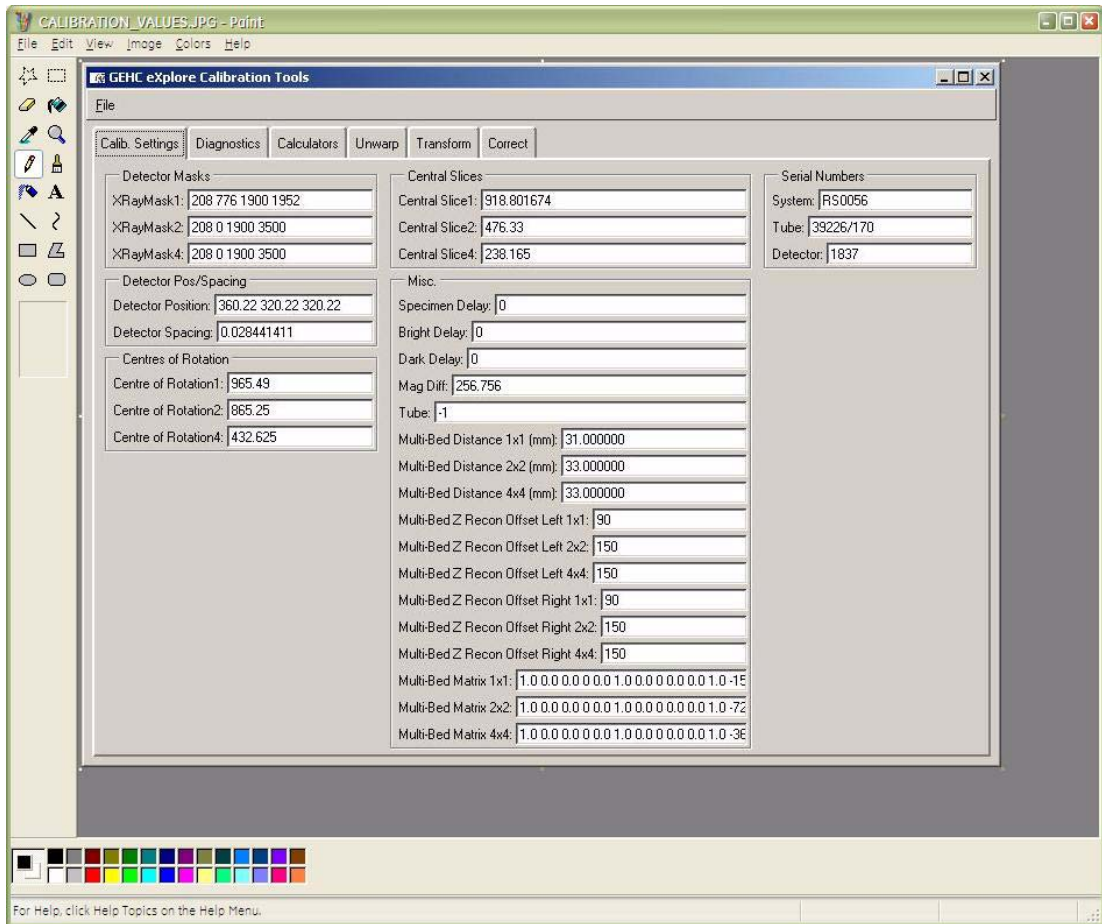
1. Access **Calibration Tools** and click the *Calib. Settings* tab.
2. Click *File* and choose *Read Registry Values* from the drop-down list.
3. Complete the Centres of Rotation fields as follows:
Centre of Rotation1: enter the Centre of Rotation as determined during the Centre the Stage procedure
Centre of Rotation2: enter 1/2 of the Centre of Rotation value
Centre of Rotation4: enter 1/4 of the Centre of Rotation value.

7.5.4 Follow Up

Upon completion, back up calibration values.

SAVE CALIBRATION SETTINGS

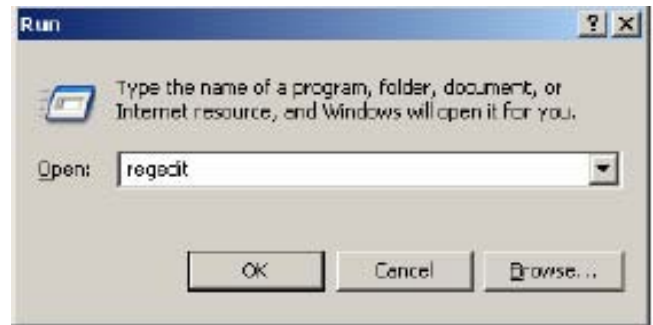
1. Capture a screen shot of the calibration values found under the *Calib. Settings* tab in **Calibration Tools**.
2. Call the file *calibration_values.jpg*
3. Save the document to both C: and D: drives.



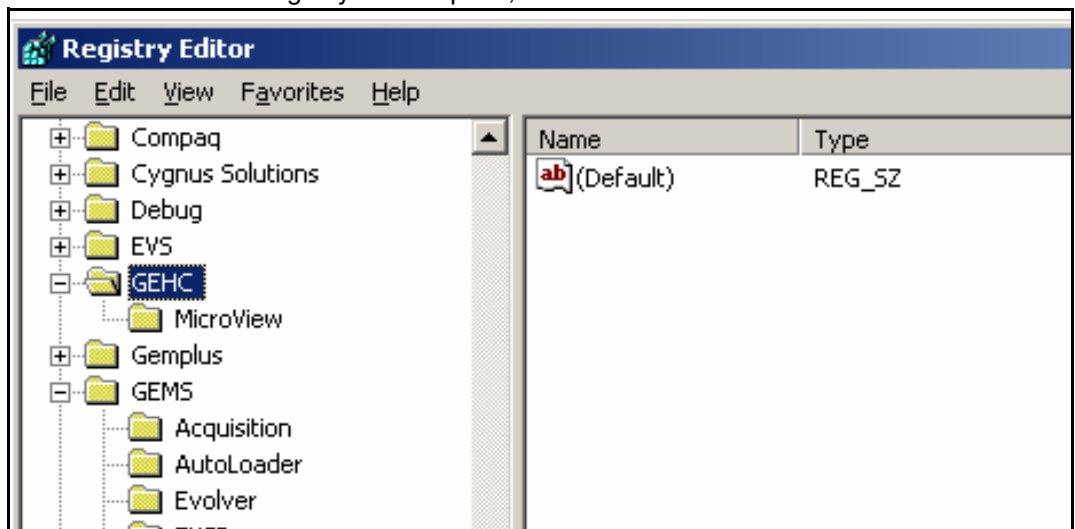
4. Copy D:\calib folder to C: drive.
5. Copy C:\translations1 to D: drive.

BACK UP REGISTRY

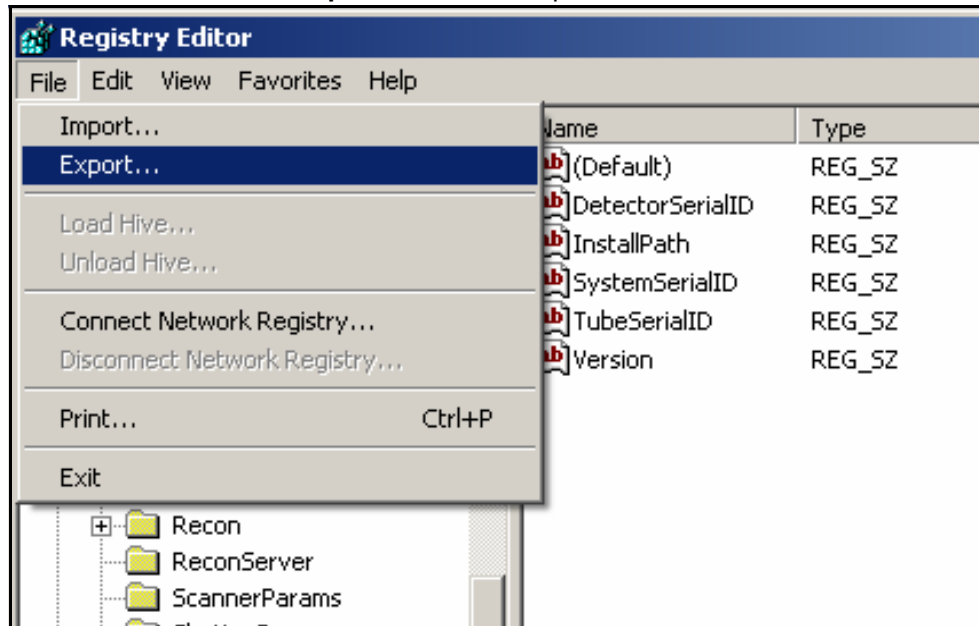
6. If needed, add the following folder to the C: drive: **Registry Backup**
7. Create a sub-folder under Registry Backup and label the folder with "today's date" e.g. yymmdd
8. Click on the Microsoft **start** button in the bottom right corner of the screen, and choose **Run...**
9. Enter the following in the text box, then click OK: **regedit**



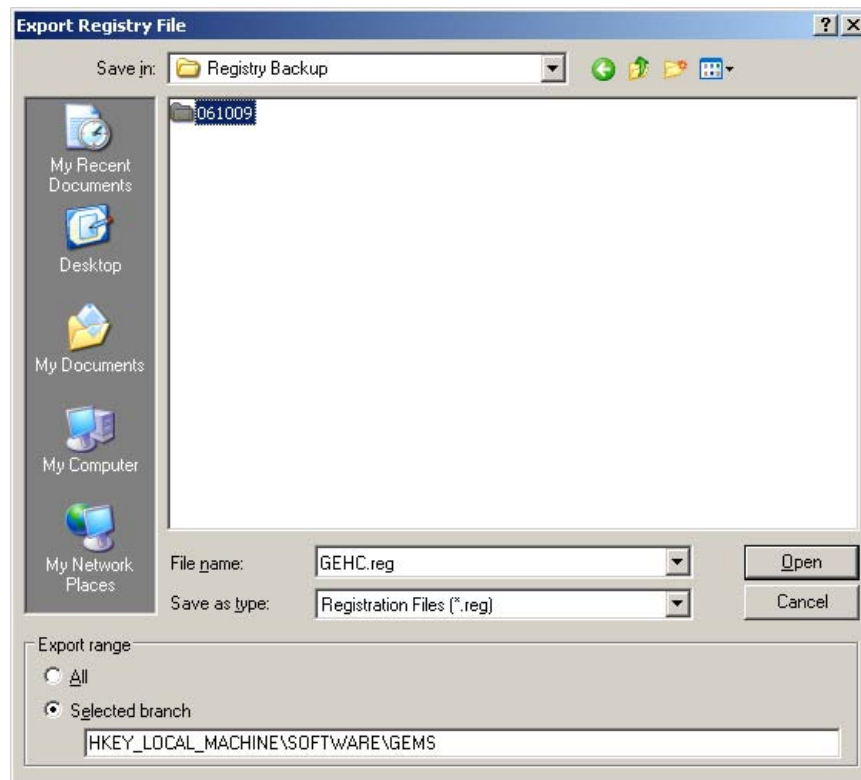
10. Once the Microsoft Registry Editor opens, click on the **GEHC** folder.



- Click on **File**, then choose **Export...** from the drop-down list.



- Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
- Under File name, enter **GEHC.REG** then click on the **Save** button.



- Next select the **GEMS** folder under the Registry Editor.
- Click on **File**, then choose **Export...** from the drop-down list.

16. Under Save in, find the Registry Backup folder, then select the sub-folder labelled with today's date.
17. Under File name, enter **GEMS.REG** then click on the **Save** button.
18. Using Windows Explorer, rename the file: **GEMS.GER**

This is done to protect the file so that it is not accidentally opened which would rewrite the registry.

DISABLE TEST PROTOCOLS

19. Disable the test protocols by changing the 1x1wire.protocol, 2x2wire.protocol and 4x4wire.protocol files to:

1x1wire.txt

2x2wire.txt

4x4wire.txt

Files are located in C:\Program Files\GE Medical Systems\Explore Utilities\Protocols\

BACK UP CRITICAL FILES TO DVDs

1. Copy the following files to a DVD:
 - C:\translations1
 - all the transform and transform.dat files found in D: drive
 - the D:\calib folder and the D:\detector folder
 - the C:\Program Files\GE Medical Systems folder
 - the newly created *calibration_values.txt* file
 - all saved volumes (e.g. 1x1_wire_cs_360)
 - the C:\Registry Backup folder.
2. Label the DVD with the name *Calibration Values*, and include the system serial number and date.
3. Create zip files containing the acquired images and support files created for each of the 3 wire scans. Call the zip files *1x1.zip*, *2x2.zip* and *4x4.zip*. There is no need to backup the 'Volumes' or 'Corrected' folder.
4. Save the zip files on to a separate DVD and label the DVD with the name *Wire Scans*. Include the system serial number and date.
5. Make two copies of each DVD. File one set of DVDs in the system's Device History Record folder located on the back of the system, and send the other to Service Engineering.

Service Engineering
Attn: Janice Chu
1510 Woodcock Street, Unit #7
London, ON N6H 5S1
Canada

Chapter 8

Preventive Maintenance

Section 8.1

Preventive Maintenance (PM) Introduction

8.1.1 Why Do Preventive Maintenance?

A preventive maintenance program monitors the equipment and guarantees the best results from good equipment performance.

Ensuring quality assurance includes:

- strict installation procedures (parts are designed to be installed a certain way)
- a pre-shipment Radiation Survey which ensures compliance with the United States' Radiation Control for Health and Safety Act and the Canadian RED Regulations C.R.C.
- itemized torque settings that prevent damage to items that come loose and avoid deformations caused through over tightening
- software systems which run under a designed set of tolerances
- regularly scheduled preventive maintenance.

8.1.2 Record Keeping

Accurate record keeping is a vital part of preventive maintenance and quality control. Maintaining accurate records which includes a well maintained history of the unit assists Service Technicians with their system diagnosis should problems occur. It also makes the scheduled maintenance of the system easier.

System records are maintained as follows:

- A calibration history is stored electronically in the systems D:\calib directory
- A hardcopy Device History Record folder is maintained for each system. It contains:
 - results of each Radiation Survey performed on the system
 - a history of all service calls and replacement parts, Preventive Maintenance Performance Checklists, and tracks updates to both the hardware and software.

8.1.3 Scheduling Preventive Maintenance

Performing periodic minor maintenance lengthens the time needed between major maintenance. Performing periodic major maintenance lengthens the time between the occurrence of any serious problems. Scheduling preventive maintenance gives Service Technicians:

- the opportunity to inspect and verify that the system is running under normal parameters

- the opportunity to ensure the system is being used correctly
- the chance to verify calibration
- the chance to clean the unit.

Major preventive maintenance (such as inspecting the wear components, cleaning the unit, and performing an "abridged calibration") occurs on a yearly basis.

8.1.4 Tools & Supplies

TOOLS

- Standard toolkit 2409483
- ESD Compliant Vacuum (e.g. Product code 9808T25 from McMaster-Carr www.mcmaster.com)

SUPPLIES

- Locus SP Preventive Maintenance kit 5177260
- Teflon Lubricating Oil (e.g. Tri-Flow Lubricant from McMaster-Carr www.mcmaster.com 1202K41)

8.1.5 SAFETY CONSIDERATIONS

Live animal handling is prohibited during installation, testing, or service of equipment.

X-RAY SHIELDING

X-ray shielding contains lead and lead compounds, chemicals known (to the State of California) to cause cancer and other reproductive harm. Wear gloves when handling shielding and wash hands after handling.

BLOOD BOURNE PATHOGENS PROCEDURE

The following procedure is documented in "Blood Bourne Pathogens Procedure" (SER-01-0001).

Note: *This procedure may be periodically updated, therefore, see the latest version of the document in the GE Medical Systems files.*

Before any equipment is returned to GEMS or before equipment is serviced, the following criteria must be met:

- Equipment returned from use in a clinical or laboratory setting must be clean and free of any blood and other infectious substances.
- *Customers are responsible for the sanitary condition of the equipment.* The suggested equipment clean-up procedure for cleaning any fluids or matter discovered inside the equipment is as follows:
 - Wear personal protective equipment.
 - Wear proper Nitrile gloves.

- Before cleanup take note of sharp corners or objects that could cut the gloves. If gloves tear, remove, wash hands thoroughly and re-glove.
- Use cloth or paper towels along with cleaner, taking care not to splash the material.
- Sanitize the area using common bleach diluted 10:1 or a product listed under Approved Cleaning Products below. Clean any tools that came in contact with a body fluid.
- Since viruses require moisture to remain active, dry the entire area using a heat gun or hair dryer.
- When confident the area is clean and dry, place used cleaning materials in a red biohazard bag.
- Remove gloves, turning them inside out, and put gloves in the biohazard plastic bag. Seal and give the bag to appropriate personnel for proper disposal.

Approved Cleaning Products:

- Common household bleach - dilute 10:1
- Fullsan 128 Neutral Germicidal Detergent - dilute 1 oz to 1 gal Fuller Brush Company: phone number 1-800-438-5537
- Wavecide 6 Disinfectant Spray - use full strength Edwards Medical: phone number 1-800-837-7000

Section 8.2 Preventive Maintenance Procedures

8.2.1 X-Ray Source

1. Access the **X-Ray and Motor Controller** software and adjust tube voltage and current to:
kV: **70**
 μ A: **20**
2. Click on the *Turn X-Ray On* button. A buzz will sound for approximately 8 seconds, X-Ray indicator lights will be illuminated.

The **X-Ray and Motor Controller** software reports that the x-ray tube is turned on and displays approximately 70 kVp and 20 μ A under Power Status.

The CM LED will display 70 kVp \pm 0.2kVP and 20 μ A.

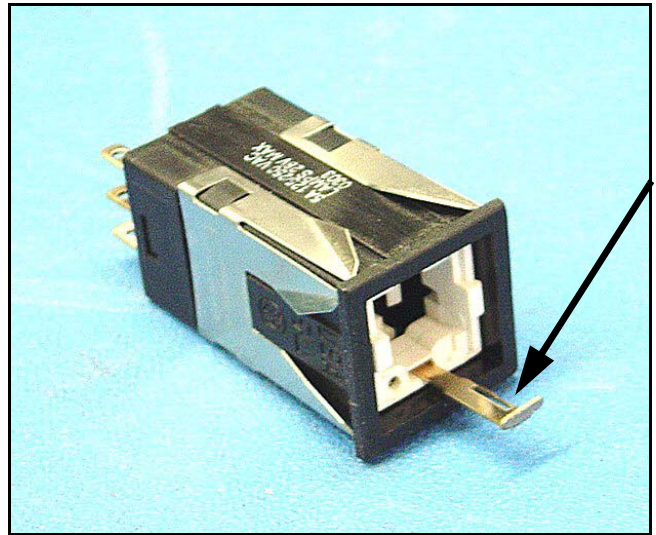


8.2.2 X-Ray Indicator Light

1. Visually inspect the X-ray Indicator Light.
2. Verify that when the X-Ray source is on, light is on.
3. Verify that a buzz sounds for approximately 8 seconds

8.2.3 Reset Switch Light

1. Remove the red button cover on the reset switch on the CM-8X Control Box.
2. Pull out the golden tab release (see picture).
3. Pull out the LED lamp from the socket.
4. Replace LED lamp.
5. Replace the button cover.



8.2.4 Interlock Body

The unit has four interlocks: one on the right and left panels and two on the sliding door.

1. Access **X-Ray and Motor Controller** software.
2. Power on system - Red reset button on the CM-8X control box is illuminated.
3. Press the *reset* button and it should no longer be illuminated.



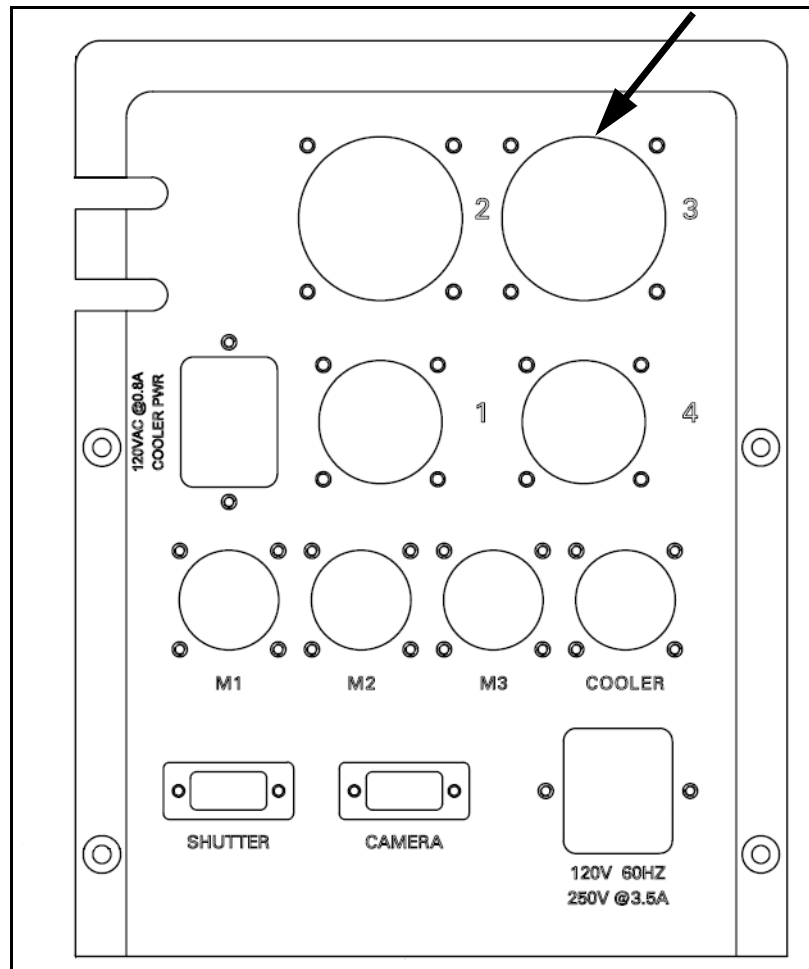
X-Ray and Motor Controller software should indicate that the Safety Door is closed.



If **X-Ray and Motor Controller** indicates Safety door is opened, at least one of the four interlock switches is not closed properly.

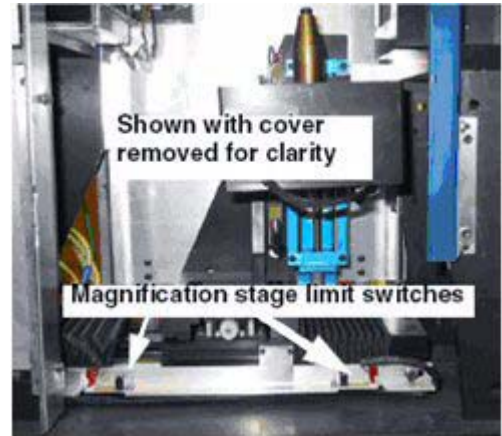
Check the electronic wiring of the interlock using a multi-meter:

When all four interlocks are closed, pin 10 and pin 11 of connector 3 on the electronic flange should be a short circuit.

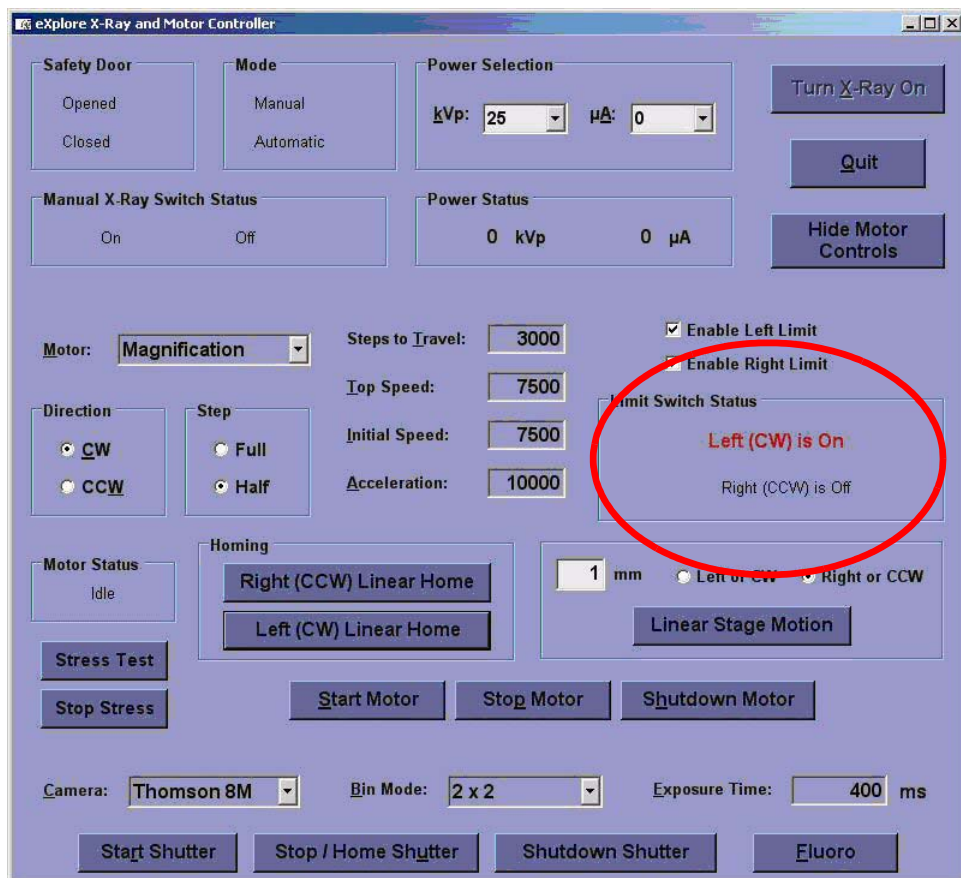


8.2.5 Limit Switches on Magnification Stage

1. Visually inspect each limit switch and verify that nothing is blocking the sensor of the limit switch.
2. Access the **X-ray and Motor Controller** software and verify that sensor indicates it is clear.
3. Select *Magnification* from the drop down menu in the Motor field. Press the *Left (CW) Linear Home* button to move the stage toward the detector. Verify that the software is registering the trigger - displays 'Left (CW) is ON' in the Limit Switch Status.



4. Press the *Right (CCW) Linear Home* button to move the stage toward the source. Verify that 'Right (CCW) is ON' is displayed in the Limit Switch Status.



8.2.6 Specimen Slide

1. Access the **X-ray and Motor Controller** software.
2. Select *Elevation* from the drop down menu in the Motor field. Press the *Left (CW) Linear Home* button to move the stage up. Listen for any abnormal noises.
3. Use a Teflon lubricating oil to lubricate the slide rails.

8.2.7 Limit Switches On Specimen Stage

1. Visually inspect each limit switch and verify that nothing is blocking the sensor of the limit switch.
2. Access the **X-ray and Motor Controller** software and verify that sensor indicates it is clear.
3. Select *Elevation* from the drop down menu in the Motor field. Press the *Left (CW) Linear Home* button to move the stage up. Verify that the software is registering the trigger - displays 'Left (CW) is ON' in the Limit Switch Status.
4. Press the *Right (CCW) Linear Home* button to move the stage down. Verify that 'Right (CCW) is ON' is displayed in the Limit Switch Status.

8.2.8 Rotary Stage Assembly

1. Access X-Ray and Motor Controller software and Select Rotation from the drop down menu in the Motor field.
2. Rotate, and listen for any abnormal noises.

8.2.9 Filter Wheel Assembly

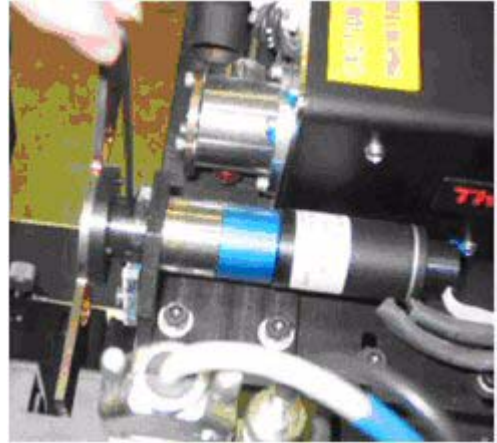
1. Visually inspect the filter wheel assembly for any defects.
2. Verify that the filter wheel can turn to each setting. Ensure that there is clearance between the shutter and the filter wheel assembly.

8.2.10 Shutter Drive Motor

1. Verify that the shutter disk is clear of obstacles.
2. Access the **X-Ray and Motor Controller** software and press the *Start Shutter* button.
3. Verify that the shutter initializes.

If shutter is unable to initialize:

- Verify connections on Micro Mo drive unit.
- Verify voltage on connections on Micro Mo Unit.
- Verify connection to CSCU.
- Verify connection on Motor (inside X-Ray Source Shielded Housing).



4. Vary the exposure time and verify the shutter moves accordingly. The shorter the exposure time, the faster the shutter should move.
5. Stop shutter, and verify that the shutter stops in home position

8.2.11 Rear Exhaust Fans

1. Visually inspect that fan is running and blowing out.
2. Feel for any abnormal vibration.
3. Listen to verify that fan is not making extra noise (grinding or clicking).
4. Clean the fan (with the system turned off) by vacuuming the area.



8.2.12 Fan Under X-ray Source

1. Visually inspect that fan is running and blowing out.
2. Feel for any abnormal vibration.
3. Listen to verify that fan is not making extra noise (grinding or clicking).
4. If fan is not running, disconnect the fan and measure the pins on the input and verify a reading of 12VDC. To measure the voltage, remove the left panel, and test at the terminal block.

8.2.13 Fan Behind The Detector

1. Visually inspect that fan is running and blowing out.
2. Feel for any abnormal vibration.
3. Listen to verify that fan is not making extra noise (grinding or clicking).
4. If fan is not running, disconnect the fan and measure the pins on the input and verify a reading of 12VDC. To measure the voltage, remove the left panel, and test at the terminal block.
5. Clean the fan and heatsink using vacuum.

8.2.14 Comair Blower

Used to cool the X-ray tube.

1. Power up the system, verify that the centre part of the Blower spins.
2. Feel for any abnormal vibration.
3. Listen to verify that the fan is not making extra noise (grinding or clicking).
4. If fan is not running, disconnect the fan and measure the pins on the input and verify a reading of 120VDC. To measure the voltage, remove the left panel, and test at the terminal block.

8.2.15 Ventilator Hose

1. Visually inspect any damage to the hose. This hose provides a ventilating path from the Comair Blower to the X-ray tube.

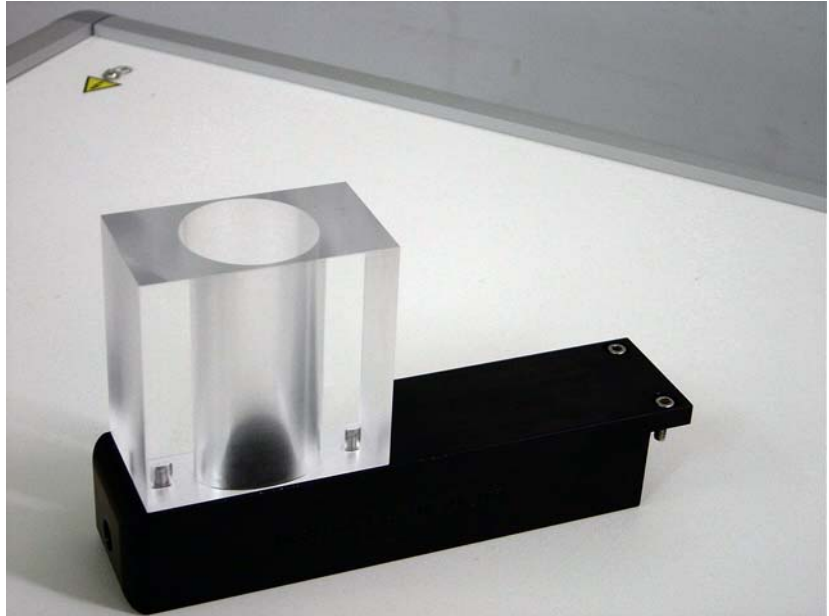
8.2.16 Fan Filters

There are two filters, each located behind the fans on the left and right panels.

1. Remove and replace filters by removing the left and right panels.

8.2.17 Equalization Bath

1. Inspect the equalization bath and specimen holder and check for any cracking or discoloration.



8.2.18 Temperature Controller

1. Verify that the system is running at approximately 12.98.

The number on the bottom LED display (green) on the temperature controller should read 12.98. The number displayed in the top LED display (red) should be approximately 13.

Note: This is a resistance number and not a degrees setting.



8.2.19 Cables

1. Check external cables and ensure they are neatly arranged (i.e. not tangled, and are not pinched by the any surrounding objects).

8.2.20 Gantry

1. Check all internal cables are neatly secured with tie wraps.
2. Vacuum the interior.
3. Wipe system covers with a damp cloth (alcohol or detergent water) and dry immediately with a dry cloth.

8.2.21 Control Modules

1. Clean the module interior:
 - open up all control module boxes (CM-8X, CMR8X, PDMM8X) and vacuum the interior.

8.2.22 Acquisition Computer

CLEAN MOUSE

1. If an optical mouse, wipe optical mouse lens or blow lens free of dust.
2. If a ball mouse, take the ball out of the mouse, and clean with alcohol.



CHECK FAN OPERATION

1. Check that the fans in the rear of the computer are operational (no grinding or excessive noise).

GENERAL CLEANING

1. Using the anti-static vacuum with soft brush, carefully clean the interior, inlets and fan exhaust ports.

Note: *If the amount of dust is thick, remove it from the screens and fans by hand.*

2. Vacuum the following (using care not to disturb wiring or bump any adjustments):
 - rear computer exhaust
 - front computer air intake
 - rear fans
 - front
 - tower fan and front.
3. Wipe the flat panel screen gently with a soft dry cloth (microfiber cloths such as those used to clean eyeglasses are excellent for use with LCDs).
4. If any marks remain, moisten the cloth with LCD cleaner (e.g. 50/50 isopropyl alcohol and water mixture), and then gently stroke the cloth across the display in one direction, moving from the top of the display to the bottom.

Note: *Do not use any of the following chemicals or any solutions that contain them: acetone, ethyl alcohol, toluene, ethyl acid, ammonia, or methyl chloride. Using any of these chemicals may cause permanent damage to the flat panel screen. Some commercial window cleaners contain ammonia and are therefore unacceptable.*

Be sure the flat panel screen is dry before using the computer.

5. Vacuum the keyboard to remove an debris that settles.
6. Visually inspect the following items for wear:
 - all cable connectors should be tight to the touch
 - inspect the desktop, keyboard top and their supports for damage and tightness.

COMPUTER MAINTENANCE

1. Open windows **Explorer** and record free space available on Hard drives (C: and D:) on the Preventive Maintenance Performance Checklist.
2. Run System Analyzer for defragment on C: and D:
 - Start-> Programs-> Accessories->System tools-> *Disk Defragmenter*If the system suggests a defragment, continue with the defragment.
3. Check System Logs:
 - Desktop->Right click on my Computer, select *Manage*
 - System Tools-> Event Viewer->*System*.
 - Check if there are any 'Critical errors'. Note them down in the PM Checklist if any appear.
 - Go to Performance Logs and Alerts
 - Check if there are any alerts. Note them in the PM Checklist if any appear.

8.2.23 Perform Periodic Abridged Calibration

PERFORM ABRIDGED CALIBRATION

- Verify Stage Alignment (see topic 7.4.4)
- Perform Abridged Calibration (see topics 7.5.1 Centre the Stage, Perform Verification Scans 7.5.2, Edit Calibration Settings 7.5.3, Follow Up 7.5.4).

Section 8.3 Preventive Maintenance Checklist

8.3.1 Completing and Filing the Checklist

1. Copy the *Preventive Maintenance Performance Checklist* on the following 2 pages.
2. Check off each task completed.
3. Sign and date the form.
4. Provide a copy of the form to the client.
5. Make a photocopy and send to Service Engineering:
Service Engineering
Attn: **Janice Chu**
1510 Woodcock Street, Unit #7
London, ON N6H 5S1
Canada

8.3.2 Preventive Maintenance Performance Checklist

Refer to Topic	Perform PM Tasks	Completed ✓
8.2.1	Verified X-Ray Source Operational	
8.2.2	Confirmed X-Ray Indicator Light Operational	
8.2.3	Replaced Reset Switch LED	
8.2.4	Verified Four Interlocks Operational	
8.2.5	Confirmed Limit Switches on Magnification Stage Working	
8.2.6	Checked Specimen Slide & Lubricated Slide Rails	
8.2.7	Confirmed Limit Switches on Specimen Stage Working	
8.2.8	Verified Rotary Stage Assembly Operational	
8.2.9	Inspected Filter Wheel Assembly	
8.2.10	Verified Shutter Drive Motor Operational	
8.2.11	Inspected & Cleaned Rear Exhaust Fans	
8.2.12	Verified Fan Under X-Ray Source Operational	
8.2.13	Verified Fan Behind Detector Operational & Cleaned Fan and Heatsink	
8.2.14	Confirmed Comair Blower Working	
8.2.15	Inspected Ventilator Hose	
8.2.16	Replaced Fan Filters	
8.2.17	Inspected Equalization Bath & Specimen Holder	
8.2.18	Verified Temperature Controller Operational	
8.2.19	Checked External Cables	
8.2.20	Inspected & Cleaned Gantry	
8.2.21	Cleaned Control Module Boxes' Interior	
8.2.22	Acquisition Computer: <i>Cleaned Mouse</i>	
8.2.22	Acquisition Computer: <i>Checked Fan is Operational</i>	
8.2.22	Acquisition Computer: <i>Inspected & Performed General Cleaning</i>	

Refer to Topic	Perform PM Tasks	Completed <input checked="" type="checkbox"/>
8.2.22	Acquisition Computer: <i>Computer Maintenance</i> List Available Free Space C: & D: _____ List Any Critical Errors/Alerts: _____ _____ _____ _____ _____ _____ _____ _____ _____	
8.2.23	Performed Abridged Calibration	
Additional Comments: 		

Print Client Name: _____ **Date:** _____

FE Signature: _____

(Servicing Field Engineer: print name and sign above)

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Chapter 99

Appendix

Purpose: This chapter provides support information and blank forms helpful when servicing the eXplore Locus SP.

Section 99.1

Calibration Worksheets

The following blank Worksheets may be used when calibrating the eXplore Locus SP. There are different sets of Worksheets depending on whether you are performing the following:

- Detector Replacement Calibration
- Stage Replacement Calibration
- X-Ray Source Replacement Calibration, or
- an Abridged Calibration.

Prior to performing the calibration, print off the appropriate Worksheet pages. Use the Worksheet pages to record the values and calculations that are needed during calibration

99.1.1 Detector Replacement Calibration Worksheets

TOPIC 7.2.2 FIND X-RAY MASK VALUES:

<i>Parameter Description</i>	<i>Parameter Value</i>
Lowest X value in usable rectangle	LX=
Top of the Y axis boundary	TY=
Highest X axis boundary (actual is 4 more than displayed)	HX=
Lowest Y boundary	LY=
Lowest Y boundary minus top Y boundary	LY-TY=

TOPIC 7.2.3 START TRANSFORM1 FILE CREATION:

<i>Parameter Description</i>	<i>Parameter Value</i>
BB #1 X axis position	A=
BB #2 X axis position	B=
How many pixels between BB #1 and #2	B-A= =(P)
Number of spaces between bebes	S=
Average distance between bebes	P/S= =(D)
X, Y coordinates of 1 (to 1 decimal place)	X= Y=
Box size number (must be odd number)	B=
Detector spacing (to 9 decimal places)	5/D=

TOPIC 7.2.4 COMPLETE TRANSFORM1 FILE CREATION:

<i>Parameter Description</i>	<i>Centroid X pos.</i>	<i>Centroid Y pos.</i>
L1		
L2		
L3		
L4		

DETECTOR REPLACEMENT CALIBRATION WORKSHEET

DETECTOR REPLACEMENT CALIBRATION WORKSHEET

L5		
L6		
L7		
<i>Parameter Description</i>	<i>Centroid X pos.</i>	<i>Centroid Y pos.</i>
R1		
R2		
R3		
R4		
R5		
R6		
R7		
<i>Parameter Description</i>		<i>Parameter Value</i>
Tilt Calculator X1 pos. for left side		
Tilt Calculator Y1 pos. for left side		
Tilt Calculator X2 pos. for right side		
Tilt Calculator Y2 pos. for right side		
Left centroid Y value		
Right centroid Y value		

TOPIC 7.2.6 CALCULATE CENTRAL SLICE OF X-RAY SOURCE:

<i>Parameter Description</i>	<i>Parameter Value</i>
CS1 top bebe Y1a coordinate	
CS1 bottom bebe Y2a coordinate	
CS2 top bebe Y1b coordinate	
CS2 bottom bebe Y2b coordinate	
Central Slice Calculator - Central Slice	

TOPIC 7.2.7 VERIFY STAGE ALIGNMENT:

<i>Parameter Description</i>		<i>Parameter Value</i>
Shim1 X value of center of top bebe		
Shim2 X value of center of top bebe		
Y axis of top bebe		
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
Top bebe (after 180° rotation)	Y axis	X axis
X axis of top bebe		

TOPIC 7.2.8 CENTRE THE STAGE:

<i>Parameter Description</i>		<i>Parameter Value</i>
Ball left side X coordinate		
Ball right side X coordinate		
Ball geometric center X coordinate (near detector)		
Ball left side X coordinate		
Ball right side X coordinate		
Ball geometric center X coordinate (near source)		
Center of rotation X coordinate (1x1)		
Center of rotation X coordinate (½ of 1x1)		
Center of rotation X coordinate (½ of 1x1)		

DETECTOR REPLACEMENT CALIBRATION WORKSHEET

TOPIC 7.2.9 CALCULATE SOURCE TO DETECTOR DISTANCE:

<i>Parameter Description</i>	<i>Parameter Value</i>
D1 white area mean value	
D1 black area mean value	
D1 Half Maximum Value (see formula)	
D1 line length	
D2 white area mean value	
D2 black area mean value	
D2 Half Maximum Value (see formula)	
D2 line length	
Source–Detector Distance	

TOPIC 7.2.11 CALCULATE & EDIT MAGNIFICATION DIFFERENCE:

<i>Parameter Description</i>	<i>Parameter Value</i>
Marked diameter of dowel in mm	
Max. numbers of pixels across dowel dia.	
Measured pixel size (see formula)	
True object position (see formula)	
OBJ_POS in the protocol	
Current Mag_diff in registry	
Calculated Mag_Diff (see formula)	

TOPIC 7.2.12 PERFORM VERIFICATION SCANS FOR 1X1 MODE:

DETECTOR REPLACEMENT CALIBRATION WORKSHEET

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	
VERIFY CENTER OF ROTATION AT EACH END	
<i>Parameter Description</i>	<i>Parameter Value</i>
Mean value of plastic	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	
Resolution value	
Target value	
Maximum value	
Mean value of plastic	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	
Resolution value	
Target value	
Maximum value	
Mean value of plastic	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	

DETECTOR REPLACEMENT CALIBRATION WORKSHEET

Resolution value	
Target value	
Maximum value	
Mean value of plastic	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	
Resolution value	
Target value	
Maximum value	

TOPIC 7.2.12 PERFORM VERIFICATION SCANS FOR 2X2 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

TOPIC 7.2.12 PERFORM VERIFICATION SCANS FOR 4X4 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

DETECTOR REPLACEMENT CALIBRATION WORKSHEET

Date calibration was finished: _____

Engineer doing calibration: _____

Locus SP serial number: _____

Customer: _____

99.1.2 Stage Replacement Calibration Worksheets

TOPIC 7.3.1 MECHANICALLY ALIGN THE STAGE:

<i>Parameter Description</i>	<i>Parameter Value</i>
Shim1 centroid value of bebe X axis	
Shim1 centroid value of bebe Y axis	
Shim2 centroid value of bebe X axis	
Shim2 centroid value of bebe Y axis	

TOPIC 7.3.2 CENTRE THE STAGE:

<i>Parameter Description</i>	<i>Parameter Value</i>
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Precision Dial reading after 180° rotation	
Left side of ball X- value	
Right side of ball X- value	
Ball geometric center X-value	
Left side of ball X- value	
Right side of ball X- value	

STAGE REPLACEMENT CALIBRATION WORKSHEET

Ball geometric center X-value	
Center of Rotation X axis	

TOPIC 7.3.3 PERFORM VERIFICATION SCANS FOR 1X1 MODE:

STAGE REPLACEMENT CALIBRATION WORKSHEET

FIND THE IDEAL CENTER OF ROTATION AT CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Angle of wires	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	
VERIFY CENTER OF ROTATION AT EACH END	
- end Center Of Rotation (adjusted)	
+ end Center Of Rotation (adjusted)	
Mean value of black area (WIRE # 1)	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	
Resolution (on right side of Scan Mgr Window)	
Target value in pixels of wire scan	
Mean value of black area (WIRE # 2)	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	
Resolution (on right side of Scan Mgr Window)	
Target value in pixels of wire scan	
Mean value of black area (WIRE # 3)	
Value at top of peak	

STAGE REPLACEMENT CALIBRATION WORKSHEET

Full Width Half Maximum Value	
Line length in pixels	
Resolution (on right side of Scan Mgr Window)	
Target value in pixels of wire scan	
Mean value of black area (WIRE # 4)	
Value at top of peak	
Full Width Half Maximum Value	
Line length in pixels	
Resolution (on right side of Scan Mgr Window)	
Target value in pixels of wire scan	

TOPIC 7.3.3 PERFORM VERIFICATION SCANS FOR 2X2 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

TOPIC 7.3.3 PERFORM VERIFICATION SCANS FOR 4X4 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

STAGE REPLACEMENT CALIBRATION WORKSHEET

Date calibration was finished: _____

Engineer doing calibration: _____

Locus SP serial number: _____

Customer: _____

99.1.3 X-Ray Source Replacement Calibration Worksheets

TOPIC 7.4.1 CENTRE X-RAY SOURCE:

X-RAY SOURCE REPLACEMENT CALIBRATION WORKSHEET

<i>Parameter Description</i>	<i>Parameter Value</i>
Right side of ball X axis	R=
Left side of ball X axis	L=
Geometric center of ball X axis	$(L+R)/2=$
Right side of ball X axis	R=
Left side of ball X axis	L=
Geometric center of ball X axis	$(L+R)/2=$
Right side of ball X axis	R=
Left side of ball X axis	L=
Geometric center of ball X axis	$(L+R)/2=$
Right side of ball X axis	R=
Left side of ball X axis	L=
Geometric center of ball X axis	$(L+R)/2=$
Right side of ball X axis	R=
Left side of ball X axis	L=
Geometric center of ball X axis	$(L+R)/2=$
Right side of ball X axis	R=
Left side of ball X axis	L=
Geometric center of ball X axis	$(L+R)/2=$

X-RAY SOURCE REPLACEMENT CALIBRATION WORKSHEET

TOPIC 7.4.4 VERIFY STAGE ALIGNMENT:

<i>Parameter Description</i>		<i>Parameter Value</i>
Shim1 X value of center of top bebe		X1=
Shim2 X value of center of top bebe		X2=
Difference between X1 and X2 (near detector)		X1 and X2 Diff=
Y axis center of BB (near detector)		Y=
Difference between Y axis center & Central Slice		Diff=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
Top bebe (after 180° rotate)	Y axis=	X axis=
0° Y value (near source)		0° Y=
180° Y value (near source)		180° Y=
Central Slice Y value (p.178 step 13)		C.S. Y=
Y axis center (near detector)		Y=
Central Slice Y value (near detector) (p.178 step 13)		C.S.=

TOPIC 7.4.5 CALCULATE SOURCE TO DETECTOR DISTANCE:

<i>Parameter Description</i>		<i>Parameter Value</i>
D1 Mean value of white area		W=
D1 Mean value of black area		B=
D1 Half Maximum Value		(W+B)/2=
D1 Line length		

X-RAY SOURCE REPLACEMENT CALIBRATION WORKSHEET

D2 Mean value of white area	W=
D2 Mean value of black area	B=
D2 Half Maximum Value	(W+B)/2=
D2 Line length	
Source-Detector Distance	

TOPIC 7.4.6 EDIT CALIBRATION SETTINGS:

<i>Parameter Description</i>	<i>Parameter Value</i>
½ of Center Of Rotation	
¼ of Center Of Rotation	
½ of Central Slice	
¼ of Central Slice	
New X-ray tubes serial number	

TOPIC 7.4.7 CALCULATE & EDIT MAGNIFICATION DIFFERENCE:

<i>Parameter Description</i>	<i>Parameter Value</i>
Marked diameter of dowel in mm	
Max. numbers of pixels across dowel dia.	
Measured pixel size (see formula)	
Detector Position (from Calib. Tools)	
Detector Spacing (from Calib. Tools)	
True object position (see formula)	
OBJ_POS in the protocol	
Current Mag_diff in registry	
Calculated Mag_Diff (see formula)	

TOPIC 7.4.8 PERFORM VERIFICATION SCANS FOR 1X1 MODE:

X-RAY SOURCE REPLACEMENT CALIBRATION WORKSHEET

<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	
VERIFY CENTER OF ROTATION AT EACH END	
- end Center Of Rotation (adjusted)	
+ end Center Of Rotation (adjusted)	
MEASURE THE WIRES AT CENTRAL SLICE	
Mean value of plastic (WIRE # 1)	M=
Value at top of peak	T=
Full Width Half Maximum Value	(M+T)/2=
Line length in pixels	
Resolution value	R=
Target value in pixels	(.025/R)=
Maximum value (Target value + 2)	
Mean value of plastic (WIRE # 2)	M=
Value at top of peak	T=
Full Width Half Maximum Value	(M+T)/2=
Line length in pixels	
Resolution value	R=
Target value in pixels	(.025/R)=
Maximum value (Target value + 2)	
Mean value of plastic (WIRE # 3)	M=
Value at top of peak	T=
Full Width Half Maximum Value	(M+T)/2=
Line length in pixels	

X-RAY SOURCE REPLACEMENT CALIBRATION WORKSHEET

Resolution value	R=
Target value in pixels	$(.025/R)=$
Maximum value (Target value + 2)	
Mean value of plastic (WIRE # 4)	M=
Value at top of peak	T=
Full Width Half Maximum Value	$(M+T)/2=$
Line length in pixels	
Resolution value	R=
Target value in pixels	$(.025/R)=$
Maximum value (Target value + 2)	

TOPIC 7.4.8 PERFORM VERIFICATION SCANS FOR 2X2 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

TOPIC 7.4.8 PERFORM VERIFICATION SCANS FOR 4X4 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	

Ideal Center of Rotation at Central Slice	
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X-RAY SOURCE REPLACEMENT CALIBRATION WORKSHEET

Date calibration was finished: _____

Engineer doing calibration: _____

Locus SP serial number: _____

Customer: _____

ABRIDGED CALIBRATION WORKSHEET

Resolution value	R=
Target value in pixels	$(.025/R)=$
Maximum value (Target value + 2)	
Mean value of plastic (WIRE # 2)	M=
Value at top of peak	T=
Full Width Half Maximum Value	$(M+T)/2=$
Line length in pixels	
Resolution value	R=
Target value in pixels	$(.025/R)=$
Maximum value (Target value + 2)	
Mean value of plastic (WIRE # 3)	M=
Value at top of peak	T=
Full Width Half Maximum Value	$(M+T)/2=$
Line length in pixels	
Resolution value	R=
Target value in pixels	$(.025/R)=$
Maximum value (Target value + 2)	
Mean value of plastic (WIRE # 4)	M=
Value at top of peak	T=
Full Width Half Maximum Value	$(M+T)/2=$
Line length in pixels	
Resolution value	R=
Target value in pixels	$(.025/R)=$
Maximum value (Target value + 2)	

TOPIC 7.5.2 PERFORM VERIFICATION SCANS FOR 2X2 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	

Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

TOPIC 7.5.2 PERFORM VERIFICATION SCANS FOR 4X4 MODE:

FIND THE IDEAL CENTER OF ROTATION AT THE CENTRAL SLICE	
<i>Parameter Description</i>	<i>Parameter Value</i>
Line angle	
Existing air calibration value	
Existing water calibration value	
Existing HU calibration value	
Ideal Center of Rotation at Central Slice	

ABRIDGED CALIBRATION WORKSHEET

Date calibration was finished: _____

Engineer doing calibration: _____

Locus SP serial number: _____

Customer: _____