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eXplore SpeCZT CT 120 Service Guide

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Revision History

Revision History		
Effective Date	**Revision**	**Nature of Change**
February 12, 2008	0	Draft
October 9, 2008	1	Draft - "Vision" removed from system name. Calibration updated.
November, 2008	2	Significant updates to FRU and Calibration chapters. Added schematic chapter. Other changes throughout.
April 2009	3	Minor changes in Chapter 4. SPECT and CT calibration procedure updates (Chapter 7).
August 2009	4	Changed CZT detector and X-ray tube replacement instructions (Chapter 5). Changed disabling bad pixels instructions, CT calibration & verification instructions, scan planes calibration instructions and landmark offset calibration instructions (Chapter 7). Change to gen. cal. procedure (Chapter 8)
October 4, 2010	5	Added FRU for cradle height sensor (Chapter 5). Changed CT verification scans procedure, revised septa alignment procedure, added pinhole procedures and made miscellaneous changes. (Chapter 7). Added facsimile of collimator bar codes and service notes about analog saturation and filter detector replacement to Chapter 10. Revised Chapter 4 troubleshooting, Chapter 6,and Chapter 9. Also, miscellaneous updates throughout.

Before You Begin *This Guide documents how to service GE's eXplore speCZT system. It is only intended for use by GE qualified personnel who have received training on its operation. No part of the eXplore speCZT may be used in a manner not specified by the manufacturer.*

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

"http://apps.gehealthcare.com/servlet/ClientServlet?REQ=Enter+Documentation+Library"

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

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Chapter 1 Introduction

Section 1.1 Publication Conventions

Please become familiar with this chapter before proceeding.

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 TENTE REPARAR O EQUIPAMENTO SEM TER CONSULTADO E COMPREENDIDO ESTE MANUAL DE ASSISTÊNCIA TÉCNICA.
- O NÃO CUMPRIMENTO DESTE 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。

1.1.2 Text and Character Representation

Different paragraph and character styles are used to indicated 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.

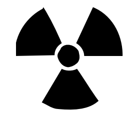
1.1.3 Standard Hazard Icons

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

ELECTRICAL

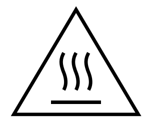
MECHANICAL

RADIATION

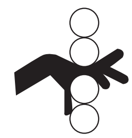


LASER

HEAT

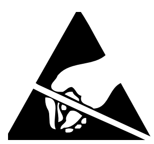


PINCH

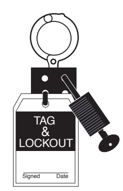


Some others make you aware of specific procedures that should be followed.

AVOID STATIC ELECTRICITY



TAG AND LOCK OUT



WEAR EYE PROTECTION

1.1.4 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

Section 1.2
Hardware & Software Components

1.2.1 Hardware

SPECT'S STATIONARY GANTRY

The SPECT system consists of a stationary Gantry (located in front of the CT scanner). It employs a Septa and Cadmium Zinc Telluride (CZT) detector ring with a rotating collimator. Different sized collimators accommodate the 3 geometric modes, plus a pinhole collimator provides for the requirements of isotropic resolution both axially and in-plane, as well as for small field of view applications.

Two types of stationary detector rings are available:

- dual ring detector (for larger axial views)
- single ring detector

The SPECT system supports at least two sizes of bore diameters (opening clearance) to accommodate a mouse and rat, which are 34mm for a mouse, and 90mm for a rat.

CT'S ROTATING GANTRY

The CT scanner assembly consists of an x-ray generator and tube, and an x-ray detector with data acquisition electronics. The CT scanner's x-ray tube is available in:

- 35 to 80 kV maximum tube voltage (standard), or
- 120 kV maximum tube voltage (premium).

X-Ray Generator

The premium 120 kV maximum tube voltage system comes with an X-Ray Generator that is positioned beside the speCZT system. Refer to the documentation that accompanies the X-Ray Generator for instructions on its care and use.

SPECIMEN TABLE & CRADLE

The table, integral to the eXplore speCZT CT 120 system, provides for the precise positioning of specimens. The table travels the length of the eXplore speCZT CT 120 system to accomplish both SPECT and CT scanning.

Two types of interchangeable cradles are provided (e.g. mouse cradle and rat cradle) that employ a quick release mechanism for cradle interchange. The table is designed to support tubing management, animal physiological monitor leads, and animal life supporting systems such as a heated bed.

Tableside Controller

User controlled table motion (versus automated motion driven by the system) is available via a tableside controller, whereby a single person can start or stop a scan while in a position to perform animal handling requirements.

OPERATOR CONSOLE

All scan acquisition and analysis functions (both SPECT and CT) are controlled from the Operator Console. The Operator Console consists of 2 LCD display monitors and a host computer.

1.2.2 Optional Components

COLLIMATORS

Additional collimators are available depending on the Field Of View, resolution, and sensitivity requirements.

PCI ANALYSIS WORKSTATION & DESK

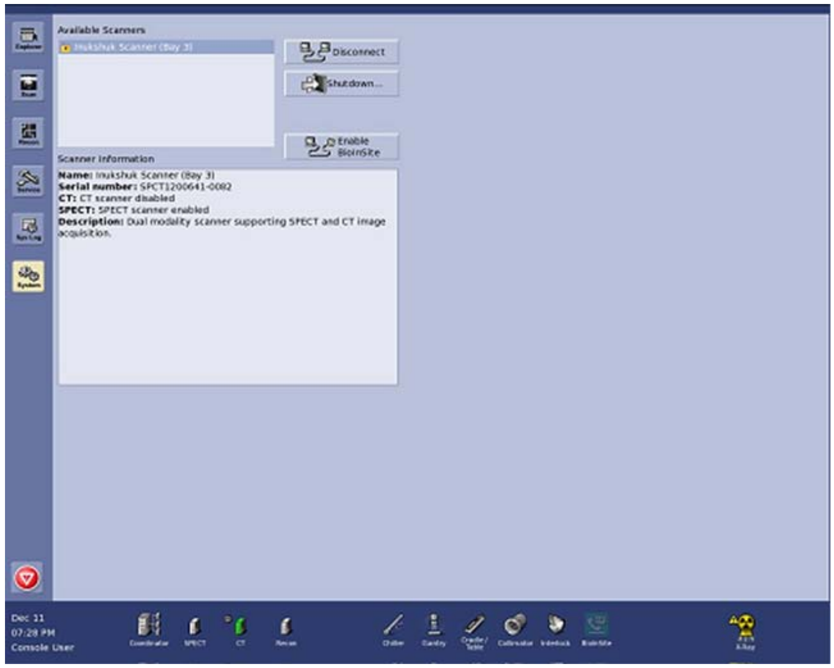
A PCI analysis workstation is available for user's applications (separate from the Console) The functionality on the PCI analysis workstation includes the following:

- Registration/fusion display;
- Region of interest (ROI)/volume of interest (VOI) analysis;
- Segmentation analysis;
- Oblique image reformatting;
- Volume rendering;
- Input/Output (I/O) of DICOM;
- Image post-reconstruction filtering such as Gauss.

1.2.3 Software

The following describes the software components of the GE eXplore speCZT CT 120 system needed to control the scanners, acquire projections, reconstruct and view the results.

HOST CONSOLE INTERFACE

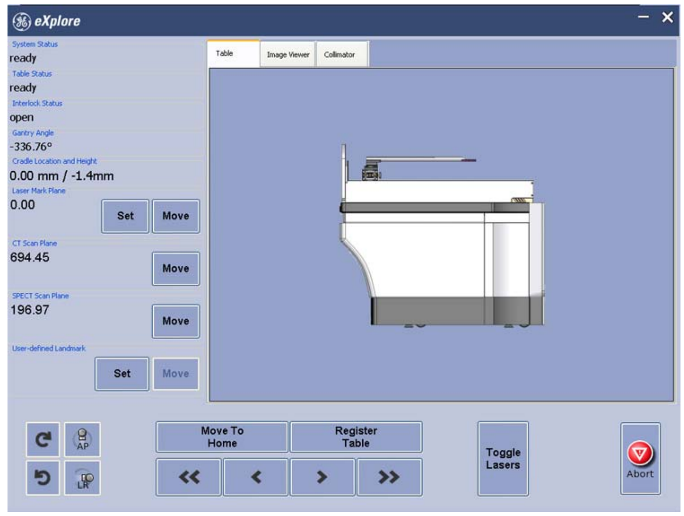


The Host Console Interface is used to:

- Login.
- Manage your Projects, exams & specimens
- Design and manage your Protocols & Sequences
- Perform scans using the CT scanner and the SPECT scanner.
- Launch eXplore MicroView.
- Archive data and restore data.
- Transfer data to (optional) PCI Analysis Workstation.
- Logoff and shutdown the system.

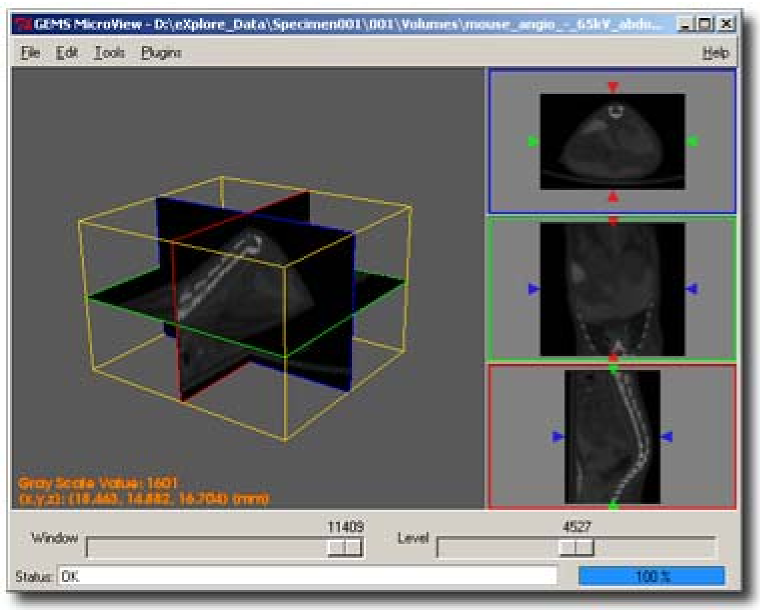
TABLESIDE CONTROLLER

The Tableside Controller is the touch screen monitor positioned on the front of the SPECT Gantry, just above the Table. This interface is used to control the positioning of the specimen cradle, set landmarks, and turn on/off the alignment lasers.



EXPLORE MICROVIEW

eXplore MicroView is an open source viewing application available from GE Healthcare. eXplore 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.



eXplore MicroView has many features that are discussed at length in the full *eXplore MicroView Software User Guide*, available from GE Healthcare. The *eXplore speCZT User Guide* will discuss only the features of eXplore MicroView that allow the user to view slices and view three-dimensional reconstructed volumes.

Section 1.3
Principles/Theory of Operation

1.3.1 Specimen Table & Cradle

OVERVIEW

The function of the Table and Cradle system is to move the specimen into the SPECT and CT units with controlled positioning and speed.

MOTION CONTROL

The Table utilizes a motion control system, to which the cradle stage is mounted. The motion control system is driven by the Table Real Time Bus (RTB), which will lock out motion if interlocks and interrupts are activated. This prevents the cradle from advancing while:

- service is being performed
- the Table Shield is left open
- the cradle and collimator types are not matched, or
- the cradle height is not sufficient to allow it to pass through the gantry.

Table motion is also stopped by a limit switch at either end of the motion control system's travel, preventing the stage from coming within 75 mm of either end of the table.

CRADLE

Each cradle type (rat or mouse) has a unique ID built into a board. When attached to the stage, an A/D converter interprets the code and passes it to the Table Computer. The result is displayed by hovering the mouse over the Cradle icon on the main Console screen. Cradle height is manually adjusted by a knob on the stage and the height is displayed on the Tableside Touch Screen.

PDU

The Main Power Distribution Unit (PDU) takes facility power (208 VAC) and provides power to all electrical components distributed throughout the machine. This includes all computers, peripherals, monitors, fans and motors.

TABLE COMPUTER

The Table Computer interfaces with the RTB (to disable the table motion control system and the X-Ray controller when interlocks are activated), the cradle and the Tableside Touch Screen. Through the Internet Switch, it also communicates with the SPECT, CT and Console computers, and has access to the Internet.

1.3.2 SPECT System

OVERVIEW

The SPECT system houses all components necessary to provide specimen images from injected isotopes. The major components are:

- CZT detector panels
- Septa and Drive
- Collimator and Drive
- Chiller

- SPECT Computer
- Barcode Reader
- Landmark Lasers

DETECTOR

The detector is comprised of ten CZT detector panels arranged in a ring. The panels are connected to a Ring board by ribbon cables. A rectangular Adaptor board, which is mounted and connected to the Ring board, powers the detector panels via separate low voltage and high voltage power supplies and passes their signals to the SPECT computer for processing.

CHILLER

The detector panels are maintained at a constant temperature of 17°C by the Chiller, which passes coolant through a Cooling Ring. This ensures a constant signal to noise ratio from the detector panels, which are mounted to the rear side of the Cooling Ring. The Chiller coolant temperature is monitored by the SPECT computer and displayed on the Chiller screen on the Service pages (Console).

SEPTA

The Septa surrounds the specimen, and divides the radiation from the isotope in the specimen into "slices". The septa motor and linkage ensures the Septa is positioned accurately and consistently along the z-axis. It is positioned over the detector panels during image acquisition ("calibrated" position) and retracted safely to a "home" position during Collimator changes. This prevents hardware collisions between the Septa and the Collimator. The septa motor is under the control of the SPECT computer.

COLLIMATOR

The Collimator is rotated by a Collimator Drive Motor, which is mounted to the Collimator Support. The Collimator Support swings down to allow a Collimator change (for different specimen types such as rat and mouse), but is locked closed by a solenoid until the Septa is "home".

The Collimator is a cylinder which surrounds the specimen and is of a smaller diameter than the Septa. The rotation of the Collimator inside the Septa allows an image "slice" through the specimen to be constructed by progressively exposing single detector pixels in any single slice to the isotope. The CZT crystal in the detector panels react to the istope particles by emitting photons, which in turn activate specific detector pixels.

Collimator rotation speed, acceleration and number of degrees of total rotation are set in the Service pages using the Collimator screen. The SPECT computer implements the motion by controlling the Collimator Amplifier, which drives the Collimator Drive Motor.

BARCODE READER

A Barcode Reader is mounted just in front of the detector ring. By selecting the Scan For Collimator button on the Collimator screen, the Reader will identify the type of Collimator installed. This information is displayed on the screen, and is also used to determine whether or not the correct Cradle is attached to the Table stage.

LASERS

Lasers can be toggled on and off from the Tableside Touch Screen. These create landmarks which help set a starting position for the specimen along the z-axis. This allows precise positioning of the specimen in the SPECT and CT scanning regions.

SPECT COMPUTER

As noted previously, the SPECT computer controls the main SPECT components. This includes detector data acquisition, Collimator rotation, Septa axial positioning and reading of the Chiller temperature and Barcode Reader output.

1.3.3 CT Gantry & X-Ray Generator

OVERVIEW

CT images are created by rotating an x-ray source around a specimen and measuring the attenuation of x-rays through the specimen at various angles, using a detector on the opposite side of the specimen. A "slice" through the specimen can be constructed by combining multiple angular snapshots. By advancing the cradle through the gantry, a number of slices along the length of the specimen can be captured. By reconstructing the slices in a separate computer, a full 3D representation of the specimen can be created.

DISC ELECTRONICS

The x-ray source and detector are mounted on a disc, along with a detector Cooler, a Disc Power Box and cooling fans for the source and detector. The high power version described in this manual (speCZT CT 120) uses a separate X-Ray Generator (Dunlee) which is a standalone unit located near the CT cabinet. Alternately, the low power version (speCZT CT 80) has an SRI Control Box mounted on the disc. All connections to the disc electronics pass through the Energy Chain Cable Track, which is a chain-like cable conduit that winds and unwinds from a take-up reel on the reverse side of the disc as it rotates.

DISC POWER BOX

Power is provided by this box to the detector, the detector Cooler and cooling fans for the x-ray source and detector.

SRI CONTROL BOX (SPECZT CT 80)

Under the control of the CT Computer and Generator Control Box, the SRI Control Box initiates firing of the x-ray source and turns on the x-ray warning lights. It also locks out the x-ray source, under the control of the Interlock Box.

DUNLEE TUBE GENERATOR (SPECZT CT 120)

Due to the higher power requirements of the Dunlee x-ray tube, a standalone generator must be used. Located near the CT cabinet, the Generator is hard-wired to a 208-230V 100 Amp single-phase breaker. It is triggered by the Generator Control Box through a DB25 cable. Triggering is also enabled/prevented by the Interlock Box through a DB15 cable.

CT PDU

The CT Power Distribution Unit derives its power input from the Main PDU on the Table. In turn, it provides power to all electronic assemblies in the CT unit, including the Disc Power Box and roof fans.

INTERLOCK BOX

Through the CT Real Time Bus, the Interlock Box locks out the x-ray source in the event that interlocks and interrupts indicate a cabinet door or Table shield opening. In the high power version only (speCZT CT 120), this Box turns on the x-ray warning lights and enables the external X-Ray Generator through a DB15 cable.

GENERATOR CONTROL BOX

Under the control of the CT Computer, this Box allows either the SRI Control Box or the external X-Ray Generator to energize the respective x-ray source. It can also be locked out by the Real Time Bus or the Interlock Box if interlocks or interrupters are opened.

CT INTERFACE BOARD

In conjuction with the CT Computer and the Real Time Bus, this Board allows the Servo Motor to rotate the disc, as long as interlocks (ie. cabinet doors) are not activated.

SERVO MOTOR DRIVE

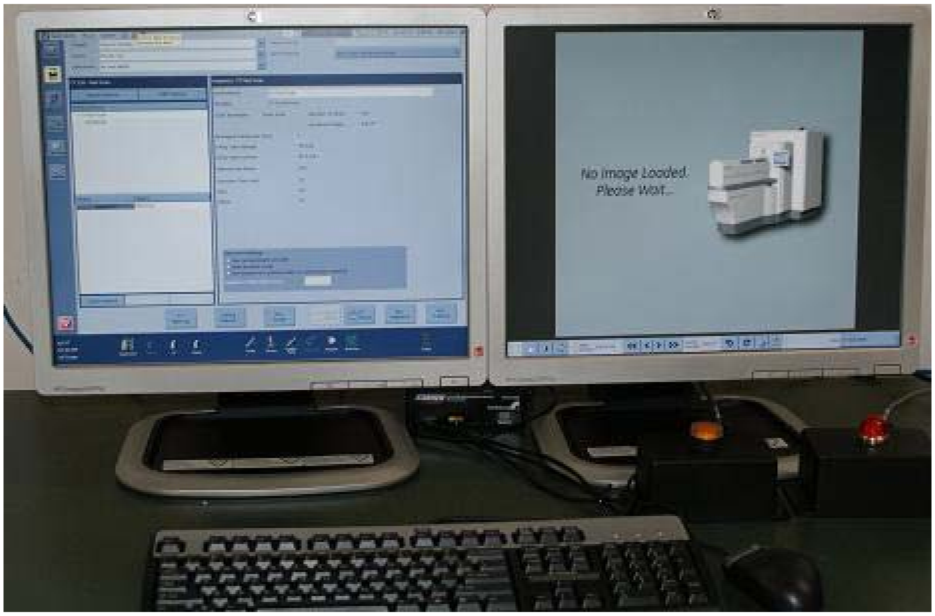
This assembly provides power to the Servo Motor, under the control of the CT Computer and the CT Interface Board.

CT COMPUTER

Disc rotation and energizing of the x-ray source is under the control of the CT Computer, in conjunction with interlock signals and interrupters located throughout the machine. The Computer is also tasked with acquisition of data from the detector and monitoring the detector Cooler temperature.

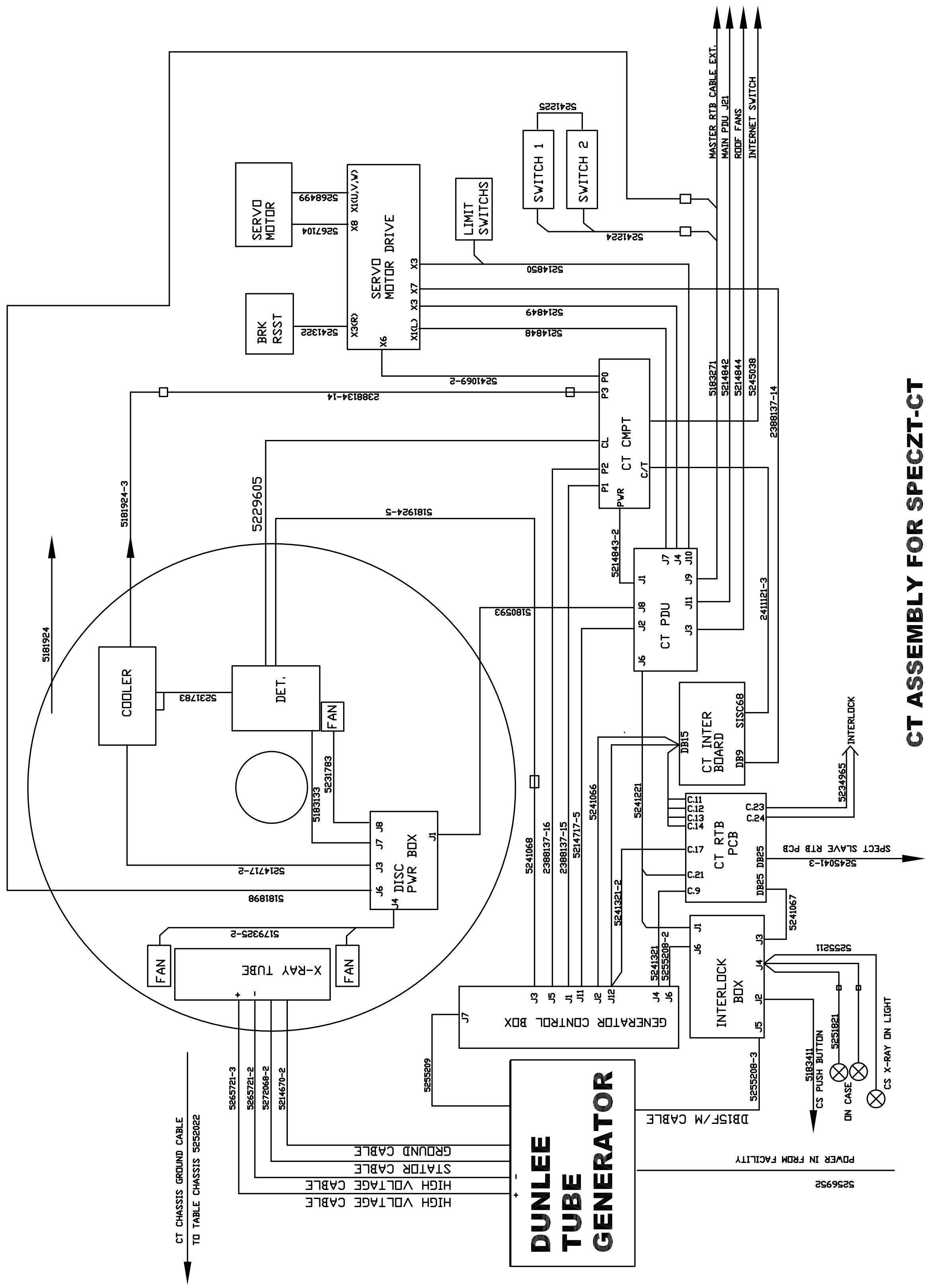
1.3.4 Operator Console

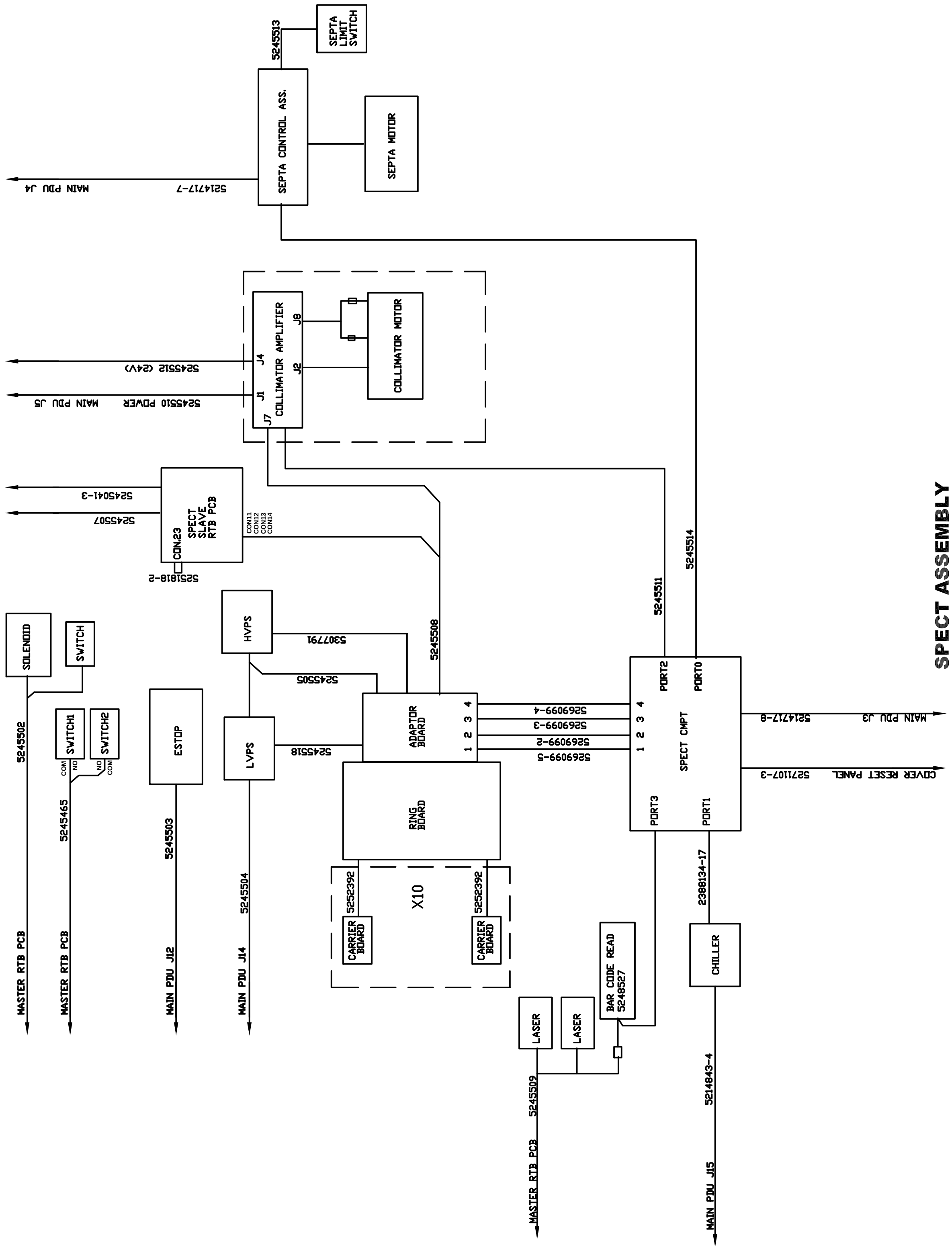
All scan acquisition and analysis functions (both SPECT and CT) are controlled from the Operator Console. The Operator Console consists of 2 LCD display monitors and a host computer.



Both monitors display the Host Console Interface. Use the left monitor to operate the control functions. The right monitor acts primarily as a "viewer" displaying data output, images, etc.

1.3.5 System Interconnects





SPECT ASSEMBLY

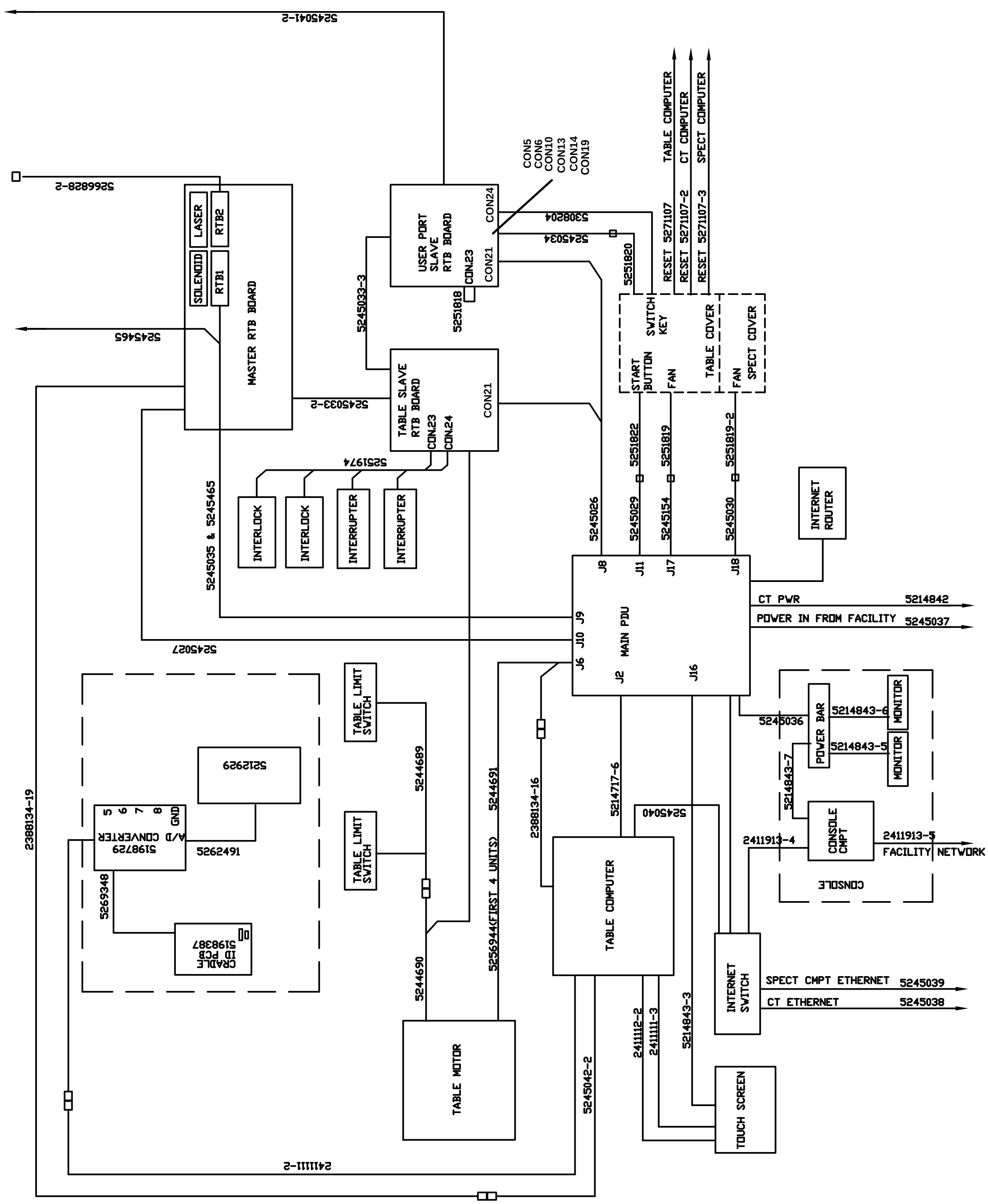


TABLE ASSEMBLY

Chapter 2
Service Safety Measures

Section 2.1
Safety Information & Precautions

2.1.1 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 Healthcare 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.

2.1.2 IMPORTANT! X-RAY PROTECTION

DANGER

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

It is important that everyone having anything to do with x-radiation be 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 Ave., Bethesda, MD 20814, and of the International commission on Radiation Protection, and take adequate steps to ensure protection against injury.

RADIATION SAFETY

The GE speCZT CT utilizes a radiation emitting x-ray source and complies with US and Canadian cabinet x-ray standards (as detailed above) which allow the system to be safely operated without additional x-ray shielding.

The rotating tungsten anode x-ray source is capable of operating in continuous mode at a maximum tube potential of 120kVp and a tube current of 125mA. The source and scanning area is completely shielded during x-ray operation.

The system is manufactured with redundant mechanical and electronic safety systems that prevent x-ray output any time the scanning door is opened. X-rays cannot be generated at anytime during access to the specimen tube or scanning area.

The x-ray tube power may only be switched on from the acquisition computer console. X-rays may only be generated if the scanner door is closed and the x-ray reset button has been reset.

Radiation measurements have been taken from the scanner at the time of manufacture and installation to confirm that the maximum exposure level 5 cm from any accessible surface is less than or equal to 0.5 mR/h.

2.1.3 Electrical Safety

CAUTION This unit has more than one power supply. To avoid electric shock, disconnect all supplies before servicing.

For bonding, a one-way safety screw is used to securely bond the outer casing of the unit to earth ground. This screw should not be removed as it provides protection in the event of component or equipment failure. Removing this screw will not provide access to internal components.

2.1.4 Protective Conductor Terminals

The protective conductor terminal is a one-way safety screw used to securely bond the outer casing of the unit to earth ground. This screw should not be removed as it provides protection in the event of component or equipment failure. Removing this screw will not provide access to internal components.

2.1.5 General 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.

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

Section 2.2 Before Servicing the System

2.2.1 Lockout / Tagout (LOTO)

NOTICE Equipment must be locked out during servicing and parts replacement

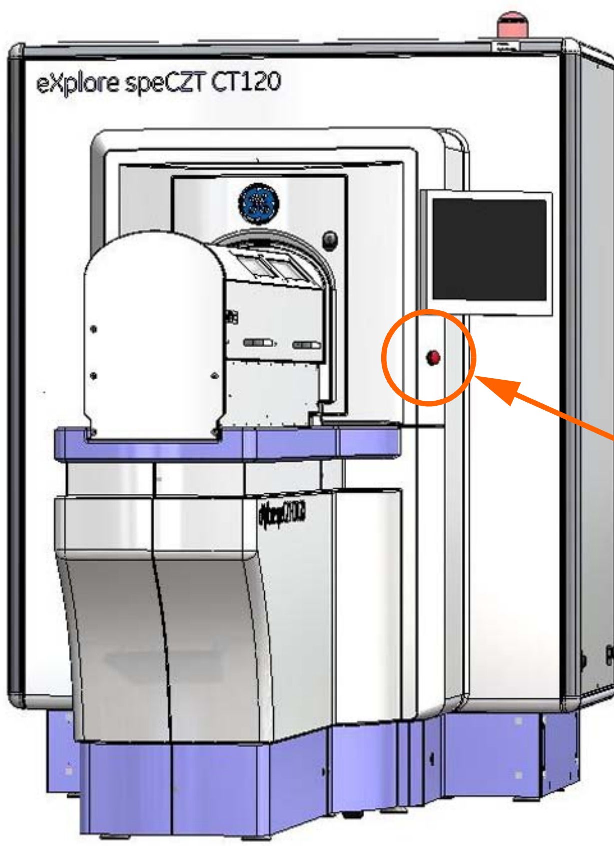
All energy sources for equipment on which work will be performed and on which injury could occur due to unexpected energization, startup or release of stored energy shall be deactivated. This includes opening electrical circuits, closing and bleeding pressurized hydraulics and pneumatics, blocking springs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

2.2.2 Emergency Stop Buttons

An **Emergency Stop** (E-Stop) button is found on the front right side of the SPECT Gantry. As well, the **Abort** button on the Tableside Controller acts in the same manner as the Emergency Stop button.

Use the Emergency Stop (or Abort button on the Tableside Controller) to immediately stop all scanner activity and abort a scan in the case of an emergency. All power to the speCZT system is shut off.



AFTER PRESSING THE EMERGENCY STOP BUTTON

Once the **Emergency Stop** button is pressed, the user must ensure that the button is in the "out" position before restarting scanner. This is done by turning the **Emergency Stop** button to the right until it pops out. Once reset, the scanner may be restarted by pressing the **Start** button on the side of the specimen table.

2.2.3 Safety Interlocks

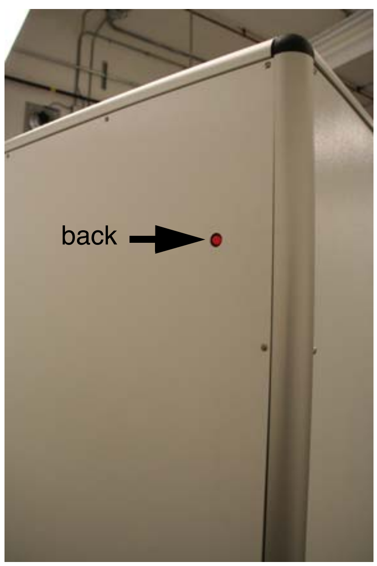
For safety purposes, the speCZT CT system comes with "interlocks". An interlock is a device that, once tripped, precludes radiation exposure by preventing x-rays from firing. The interlocks on the speCZT ensure that the specimen table cover is both closed and is in its forward position over the cradle *before* x-rays fire.

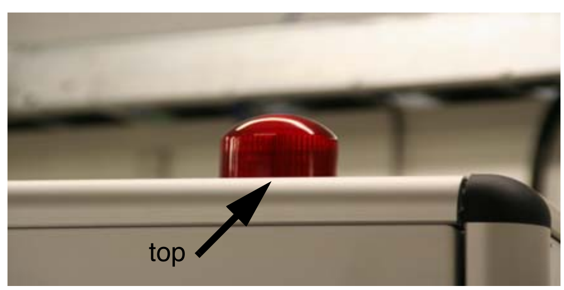
Each time an interlock is tripped (i.e. the specimen table cover is opened or the cover is moved from its forward position), the user must return the cover to its proper position and then press the **X-Ray Enable** button next to the keyboard (which resets the Interlocks.)

The X-Ray Enable button appears bright yellow any time the interlocks are tripped.

2.2.4 X-Rays ON Warning Lights

speCZT has three x-ray ON warning lights. When x-rays are firing, these lights appear bright red. One light appears at the top cover of the CT scanner, another is located on the back cover of the system, and the other is commonly located near the Host Console Interface (although it may be mounted in another location such as outside the door to the scanning room).





Section 2.3 Cleaning Equipment Prior to Servicing

2.3.1 Cleaning Instructions

The device does not require any customer performed maintenance other than cleaning as described below. All other maintenance must be performed by trained and qualified technicians.

GENERAL CLEANING INSTRUCTIONS

The device should be located in a relatively clean, low dust, laboratory environment. Typically, no cleaning should be required other than removing excess dust from the exterior of the device and control units.

Cleaning the device should be performed with a soft cloth, lightly dampened with water if desired, carefully wiping the surfaces required. DO NOT under any circumstances use domestic or industrial cleaning products and DO NOT spray any liquid, including water, onto any surface of the control units, scanner or into the interior of the scanner.

CLEAN EQUIPMENT (BIO HAZARD)

CAUTION **Blood Bourne Pathogens Procedure**

Before any equipment is serviced or returned to GE Healthcare, the following criteria must be met:

- Equipment used 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 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

Chapter 3
Using the Service Module

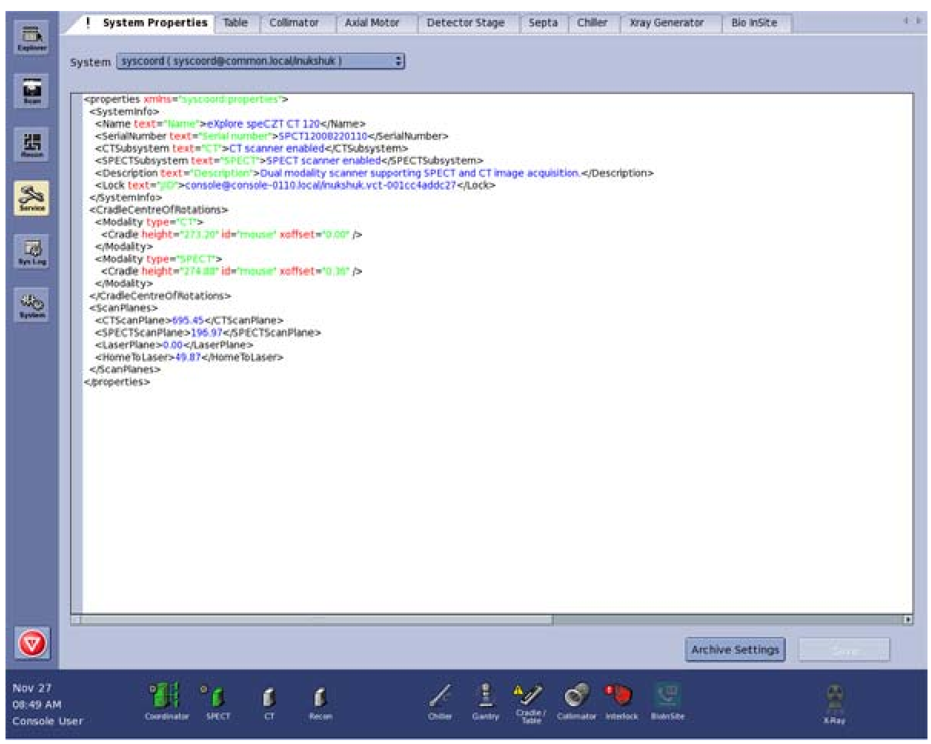
Section 3.1
Host Console Interface's Service Module

3.1.1 Accessing the Service Module

The Host Console Interface's Service module is available to FE's when servicing the speCZT system. The Service module is used when diagnosing problems, troubleshooting issues, and setting/initializing parameters.

After logging on to the Host Console Interface in "service mode", click on the Service icon on the left of the screen.

The following screen is presented :



3.1.2 Table

The Table page is the next tab available in the Service module. Like many of the service pages, this screen is organized around:

- Setup
- Movement Control
- Table Status

Use this service page when servicing the speCZT table, diagnosing problems, or setting table parameters.

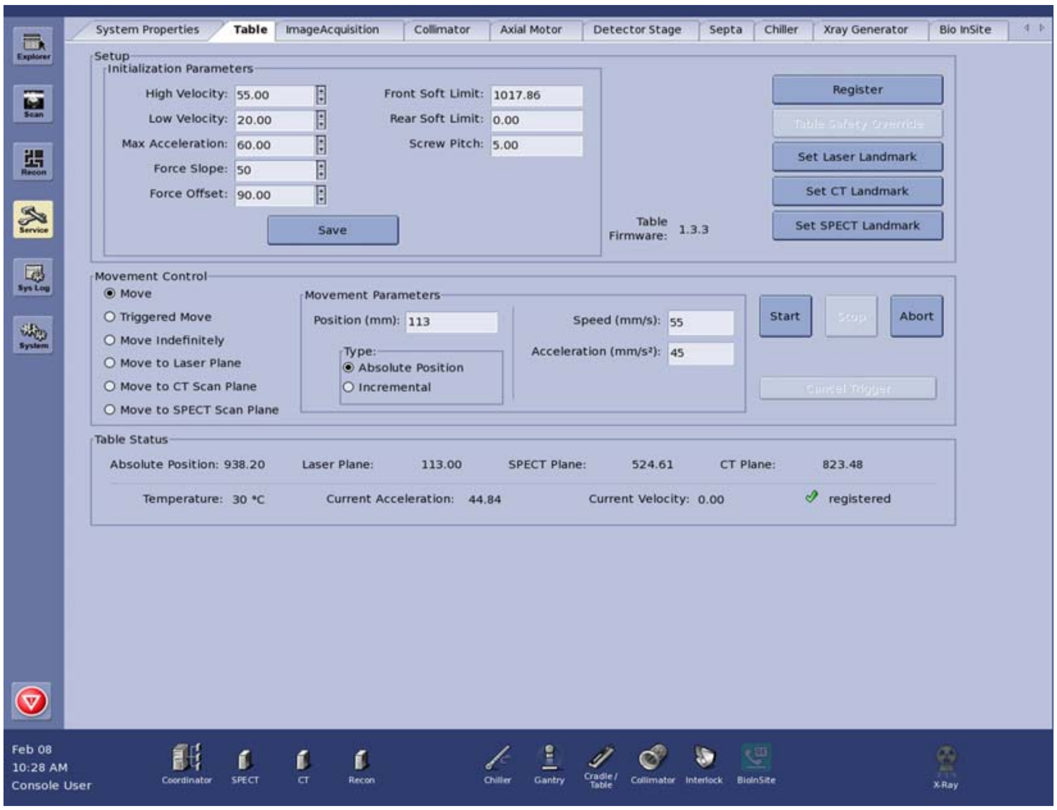


TABLE Fields/Buttons	Definitions
SETUP:	
Save button	This button is used to send new initialization parameters to the table (see below).
Initialization Parameters: High Velocity	This field indicates the speed the table travels (in mm per second) when the double arrow buttons (fast) are pressed on the Tableside Controller.

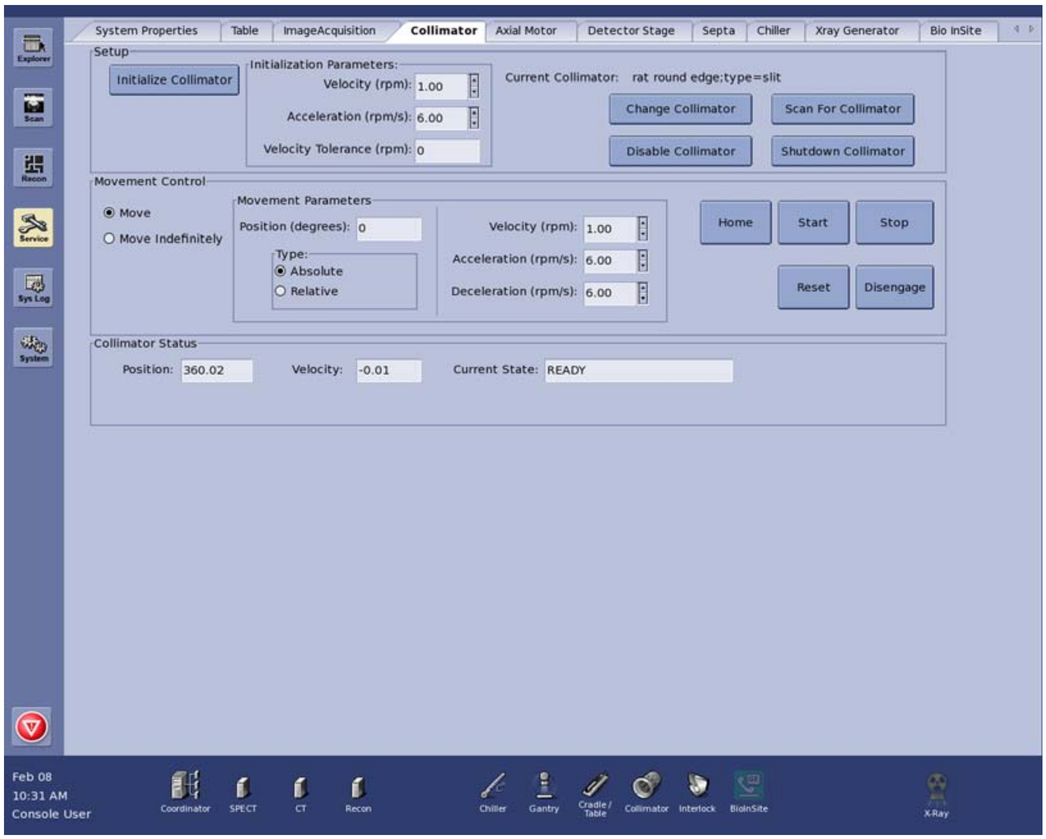
TABLE Fields/Buttons	Definitions
Initialization Parameters: Low Velocity	This field indicates the speed the table travels (in mm per second) when the single arrow buttons (slow) are pressed on the Tableside Controller.
Initialization Parameters: Max Acceleration	This is the maximum acceleration or "ramp up" acceleration in mm per second squared.
Initialization Parameters: Force Slope	Represents the additional force required to move the table at a given velocity, according to the equation $F = k*v + C$, where F is force, k is force slope, v is velocity and C is force offset.
Initialization Parameters: Force Offset	The minimum force required to start table motion.
Initialization Parameters: Front Soft Limit	This is the software's limit (in mm) on how far the table may travel toward the scanner before it stops.
Initialization Parameters: Rear Soft Limit	This is the software's limit (in mm) on how far the table may travel away from the scanner before it stops.
Initialization Parameters: Screw Pitch	Another means of controlling the speed of the table. The larger the pitch, the faster the table moves.
Register button	This button will register the table. The table should be registered before asking the table to move.
Set Laser Landmark button	When pressed, the *current* table position will be set as the specimen landmark.
Set CT Landmark button	This is a fine adjustment that tells the table where the actual CT scan plane is (in mm).
Set SPECT Landmark button	This is a fine adjustment that tells the table where the actual SPECT scan plane is (in mm).
MOVEMENT CONTROL:	
Move	Once a value is entered in the Position field, choosing this option moves the table to the position entered, after the Start button is selected.

TABLE Fields/Buttons	Definitions
Triggered Move	N/A
Move Indefinitely	If this option is selected, the Start button changes to "Move". By holding down the Move button, the table moves as long as the button is held down.
Move to Laser Plane	If this option is selected, the table moves to the Laser Landmark Plane position once the Start button is selected.
Move to CT Scan Plane	If this option is selected, the table moves to the CT Scan Plane position once the Start button is selected.
Move to SPECT Scan Plane	If this option is selected, the table moves to the SPECT Scan Plane position once the Start button is selected.
Movement Parameters: Position (mm)	If the Move option is selected and the Start button pushed, the table moves to the position entered here.
Type	Absolute Position: Choose absolute to move the table to the exact position indicated in the Position field. Incremental: Choose this option if you wish to move the table the distance indicated in the Position field .
Speed (mm/s)	Enter the speed you wish the table to travel at during the move (in mm per second).
Acceleration (mm/s^2)	Enter the acceleration you wish to use during the move (in mm per second squared).
Start button	Click on this button to begin moving the table according to the instructions entered above.
Stop button	Click on this button to stop table movement.
TABLE STATUS:	
Absolute Position	Displays the table’s current absolute position.

TABLE Fields/Buttons	Definitions
Laser Plane	Displays the table's current specimen landmark position setting.
SPECT Plane	Displays the table's current SPECT plane position setting.
CT Plane	Displays the table's current SPECT plane position setting.
Temperature	Displays the current temperature of the table's motor.
Current Acceleration	While accelerating, this field displays the table's current acceleration speed.
Current Velocity	While traveling, this field indicates the table's current speed.
registered not registered	Indicates whether or not the table is currently registered.

3.1.3 Collimator

Each time the collimator is changed, the **Current Collimator** field must be updated to reflect the newly installed collimator. This page is also used to adjust initialization parameters and to troubleshoot collimator movement issues.



COLLIMATOR Fields/Buttons	Definitions
SETUP:	
Initialize Collimator button	When selected, this button fills in the Initialization Parameters with the current settings.
Initialization Parameters: Velocity (rpm)	This field sets the default collimator's speed in revolutions per minute.

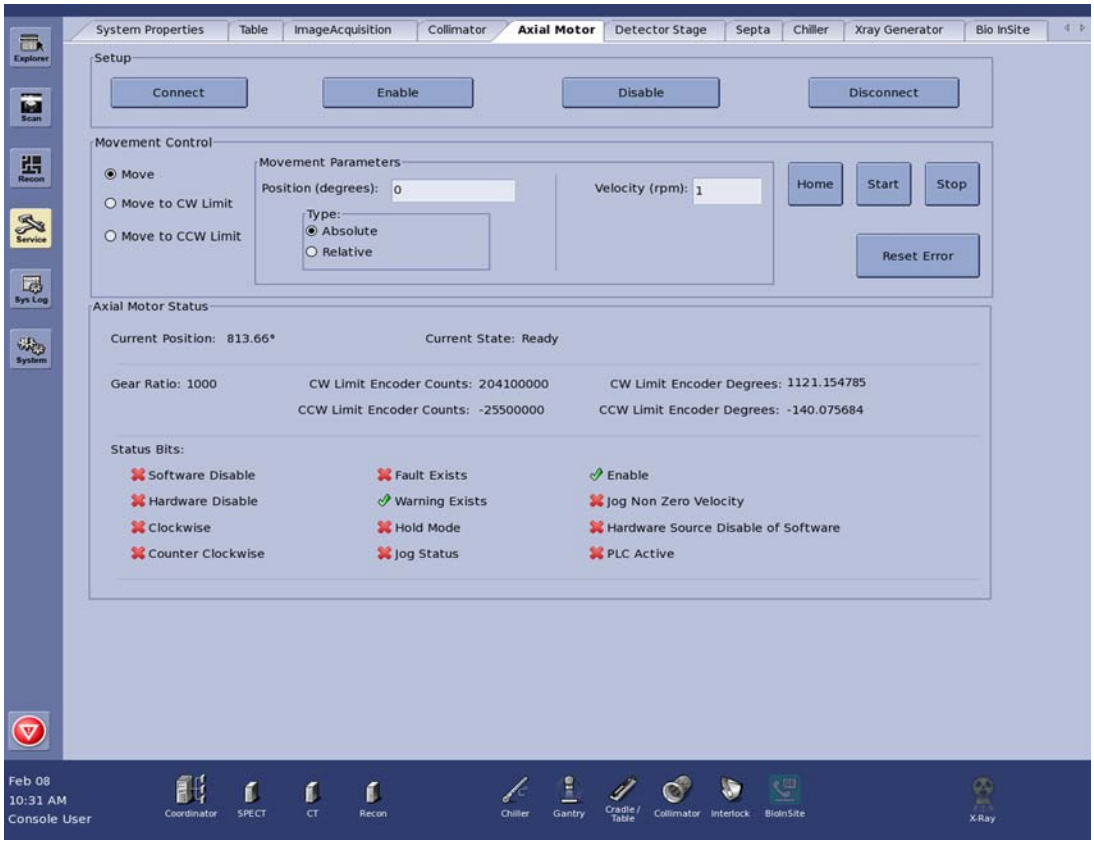
COLLIMATOR Fields/Buttons	Definitions
Initialization Parameters: Acceleration (rpm/s)	This field controls the acceleration of the collimator in revolutions per minute/second.
Initialization Parameters: Velocity Tolerance (rpm)	This field controls the rotational speed of the collimator in revolutions per minute.
Current Collimator	This field indicates the *type* of collimator currently installed.
Change Collimator	This button unlocks the collimator support plate to allow the collimator to be changed.
Scan for Collimator	This button starts the bar code reader and rotates the collimator until its bar code is detected.
Disable Collimator	This button allows a scan to proceed without a collimator in place. NOTE: This function should be used with care, as hardware collisions may occur if a collimator *is* installed.
Shutdown Collimator button	Use this button to remove all power to the collimator - used in emergency stop situations only. If used, the user must restart the system to restore power to the collimator.
MOVEMENT CONTROL:	
Move	Once a value is entered in the Position field, choosing this option moves the collimator to the position entered, after the Start button is selected.
Move Indefinitely	If this option is selected, the Start button changes to "Move". By holding down the Move button, the collimator moves as long as the button is held down.
Movement Parameters: Position (degrees)	Enter the location, in degrees, of where the collimator is to move (assuming the "Move" option is selected above). If you enter 90, the collimator moves 90 degrees in either absolute terms (i.e. from its 0° position), or it moves relative to where the collimator is currently positioned.

COLLIMATOR Fields/Buttons	Definitions
Movement Parameters: Type	Absolute: Choose this option if you wish to move the collimator (the number of degrees appearing in the Position field) starting from its ’home" position. Relative: Choose this option if you wish to move the collimator (the number of degrees appearing in the Position field) starting from its *current* position.
Movement Parameters: Velocity (rpm)	Indicate how fast you wish the collimator to move, in revolutions per minute. Entering *0* here tells the system to use the default value.
Movement Parameters: Acceleration (rpm/s)	During movement, indicate how fast you wish the collimator to accelerate in revolutions per minute/second. Entering *0* here tells the system to use the default value.
Movement Parameters: Deceleration (rpm/s)	During movement, indicate how slowly you wish the collimator to decelerate in revolutions per minute/second. Entering *0* here tells the system to use the default value.
Home button	Choosing this button moves the collimator to its "home" position (0°).
Start button	Use this button to begin collimator movement.
Stop button	Use this button to halt collimator movement.
Reset button	Should an error occur, use this button to reset the controls.
Disengage button	Use this button to disengage the collimator motor (so the collimator may be moved by hand).

COLLIMATOR Fields/Buttons	Definitions
COLLIMATOR STATUS:	
Position	Provides the current collimator position, in degrees from its "home" position.
Velocity	Provides the collimator's current velocity or speed setting in revolutions per minute.
Current State	Provides the current state of the collimator, e.g. homing, moving, error, etc.

3.1.4 Axial Motor

Use this screen when troubleshooting axial motor movement issues.



AXIAL MOTOR Fields/Buttons	Definitions
SETUP:	
Connect button	Use this button to connect to the axial motor (connection does not enable axial motor motion).
Enable button	This button is used to enable the axial motor for motion.
Disable button	This button disables the axial motor for motion.

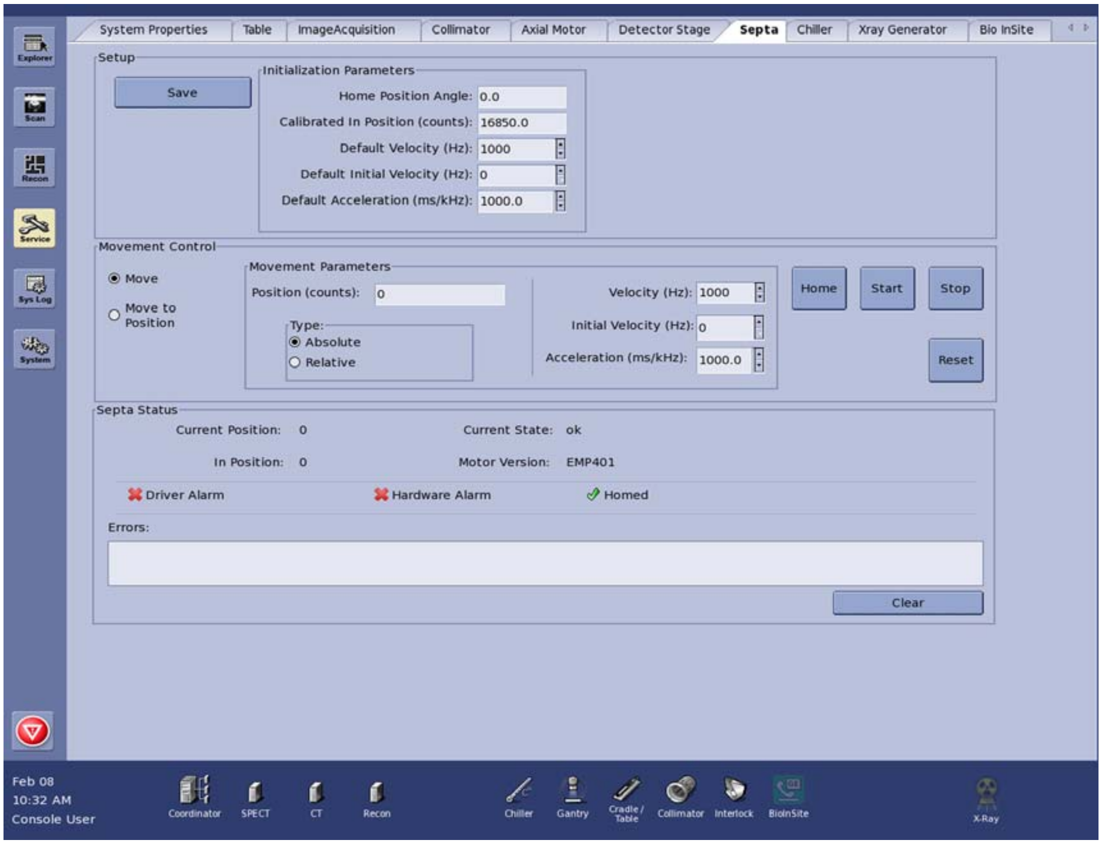
AXIAL MOTOR Fields/Buttons	Definitions
Disconnect button	This button shuts down the connection to the axial motor.
MOVEMENT CONTROL:	
Move	Once a value is entered in the Position field, choosing this option moves the axial motor to the position entered in degrees, after the Start button is selected.
Move to CW Limit	Use this option if you wish to move the axial motor clockwise to its utmost limit.
Move to CCW Limit	Use this option if you wish to move the axial motor counter clockwise to its utmost limit.
Movement Parameters: Position (degrees)	Enter the location in degrees of where the axial motor is to move (assuming the "Move" option is selected above). If you enter 400, the axial motor moves 400 degrees in either absolute terms (i.e. from its 0 position), or relative to where the motor is currently positioned.
Movement Parameters: Type	Absolute: Choose this option if you wish to move the axial motor (the number of degrees appearing in the Position field) starting from its "home" position. Relative: Choose this option if you wish to move the axial motor (the number of degrees appearing in the Position field) starting from its *current* position.
Movement Parameters: Velocity	Indicate how fast you wish the axial motor to move in revolutions per minute.
Home button	When you press this button it "homes" the gantry.
Start button	Hit this button to begin moving the axial motor according to the settings entered above.
Stop button	Use this button to stop axial motor movement.

AXIAL MOTOR Fields/Buttons	Definitions
Reset Error button	If an error is encountered, use this button reset the controls.
AXIAL MOTOR STATUS:	
Current Position	Provides the current position of the axial motor, in degrees from its "home" setting.
Current Status	Provides the axial motor's current status, e.g. homing, etc.
Gear Ratio	Fixed at 1000:1
CW Limit Encoder Counts	Provides the clockwise limit position in motor encoder counts.
CW Limit Encoder Degrees	Provides the clockwise limit position in degrees, which may be more convenient or useful than encoder counts.
CCW Limit Encoder Counts	Provides the counter clockwise limit position in motor encoder counts.
CCW Limit Encoder Degrees	Provides the counter clockwise limit position in degrees, which may be more convenient or useful than encoder counts

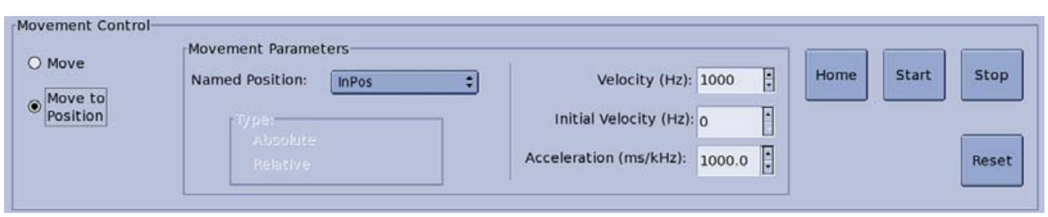
AXIAL MOTOR Fields/Buttons	Definitions
Status Bits:	A checkmark indicates the following motor status bits are applicable or engaged: Software Disable: software error exists. Hardware Disable: hardware error exists. Clockwise: motor moving clockwise. Counter Clockwise: motor moving counter clockwise. Fault Exists: motor error exists. Warning Exists: problem exists but motor still working. Hold Mode: motor in hold mode and will not move. Jog Status: motor is being controlled by Flex Plus software, located on Table computer Enable: motor is enabled. Jog Non Zero Velocity: motor is being controlled by Flex Plus software and is set to other than zero velocity. Hardware Source Disable of Software: PLC Active: motor is being controlled by Flex Plus software, which is in PLC mode.
Errors	Any errors encountered by the axial motor appear here.
Refresh button	Use this button to retrieve the current status of the axial motor and update the status fields.

3.1.5 Septa

Use the Septa screen to adjust the septa motor's initialization parameters, and/or troubleshoot issues surrounding the septa motor. This screen is also used to move the septa out of the way before physically switching collimators.



SEPTA Fields/Buttons	Definitions
SETUP:	
Save button	If initialization parameters are changed, use this button to update the settings.
Initialization Parameters: Home Position Angle	This field indicates the angle of the septa motor arms that determines the septa's "out" or outermost position (i.e. the collimator is outside of the septa).
Initialization Parameters: Calibrated in Position	This field indicates the step count from home position of the septa motor that determines the septa's "in" or innermost position.
Initialization Parameters: Default Velocity (Hz)	This field indicates the default speed of the septa motor in counts per second (Hertz).
Initialization Parameters: Default Initial Velocity (Hz)	Use this field to indicate the default initial speed of the septa motor in counts per second (Hertz).
Initialization Parameters: Default Acceleration (ms/kHz)	Use this field to indicate the default acceleration of the septa motor in milliseconds (ms) per thousand counts per second (kiloHertz).
MOVEMENT CONTROL:	
Move	Use this option if you wish to move the septa motor to the number of step counts indicated in the Position field.
Move to Position	Choose this option if you wish to move the septa motor to a pre-defined Named Position (see below). Position (counts) in Movement Parameters changes to Named Position.
Movement Parameters: Position (counts)	Enter the location in "step counts" of where the septa motor is to move (assuming the "Move" option is selected above). The septa will move in either absolute terms (i.e. from its "home" position), or relative to where the septa's is currently positioned.

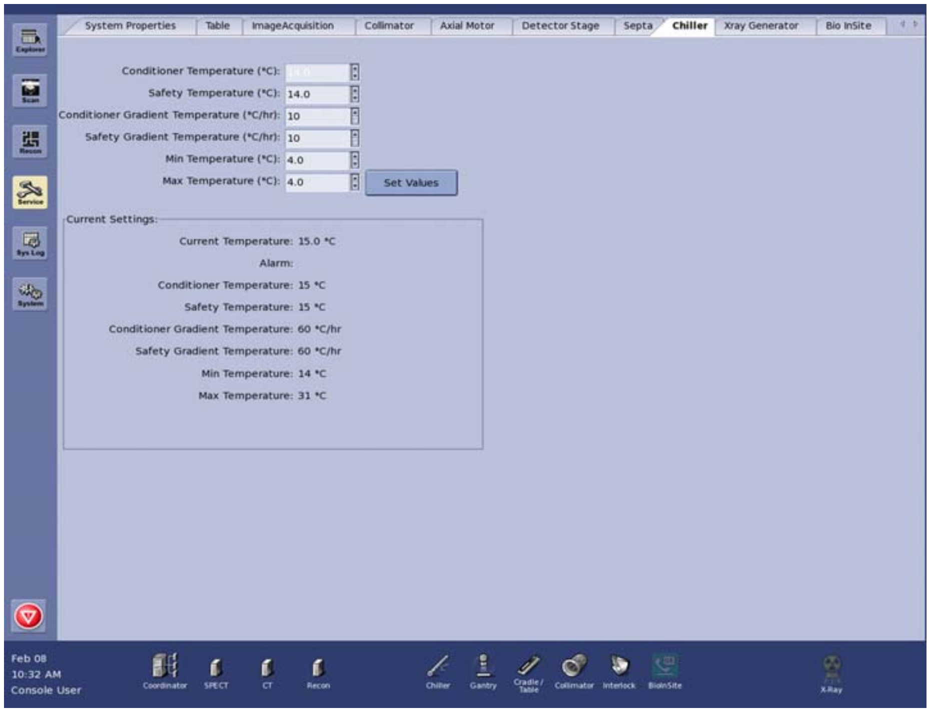


SEPTA Fields/Buttons	Definitions
Movement Parameters: Named Position	Choose from one of three options: In Position, Pinhole Collimator or Home. These are available only if Move to Position radio button is selected.
Movement Parameters: Type	Absolute: Choose this option if you wish to move the septa motor (the number of counts appearing in the Position field) starting from its "home" or outermost position. Relative: Choose this option if you wish to move the septa motor (the number of motor counts appearing in the Position field) starting from its *current* position.
Movement Parameters: Velocity (Hz)	Indicate the speed you wish the septa motor to move in counts per second (Hertz). 0 entered here tells the system to use the default velocity.
Movement Parameters: Initial Velocity (Hz)	Indicate the initial speed you wish the septa motor to move in counts per second (Hertz). 0 entered here tells the system to use the default initial velocity.
Movement Parameters: Acceleration (ms/kHz)	Indicate the acceleration you wish to use in milliseconds (ms) per thousand counts per second (kiloHertz). 0 entered here tells the system to use the acceleration default.
Home button	Use this button to move the septa motor to its "home" or outermost position.
Start button	Use the Start button to begin moving the septa motor according to the settings above.
Stop button	Use the Stop button to stop septa motor movement.
Reset button	Should errors be encountered, use the Reset button to reset the controls.

SEPTA Fields/Buttons	Definitions
SEPTA STATUS:	
Current Position	Displays the current position of the septa motor in "step counts" from its home or outermost position.
Current State	Displays the current state or status of the septa motor.
In Position	A count matching the Calibrated In Position count indicates the septa motor is in its "in" or innermost position.
Motor Version	Displays the septa motor's version.
Driver Alarm	A checkmark here indicates the septa motor software is reporting an error or warning.
Hardware Alarm	A checkmark here indicates the septa motor hardware is reporting an error or warning.
Homed	A checkmark here indicates the septa motor is in its "home" or outermost position.
Errors	Errors encountered by the septa motor are displayed here.
Clear button	Use the Clear button to clear errors from the Error field.

3.1.6 Chiller

The Chiller page is used to view current chiller settings and adjust those settings, if needed.



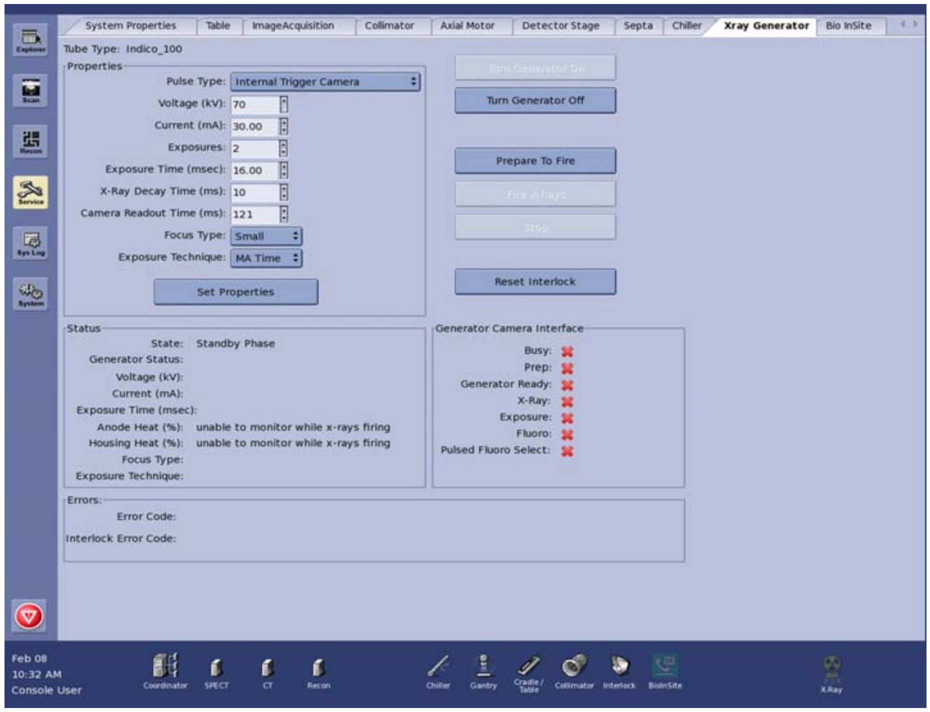
CHILLER Fields/Buttons	Definitions
Conditioner Temperature	This field sets the chiller's conditioner temperature that is to be maintained when the system is actively interacting with the chiller. The default is 17°C and is typically the same as the Safety Temperature.
Safety Temperature	This field sets the chiller's safety temperature that is to be maintained when the chiller is idle. The default is 17°C and is typically the same as the Conditioner Temperature.

CHILLER Fields/Buttons	Definitions
Conditioner Gradient Temperature	If the conditioner temperature is changed, this field sets the rate of acceptable temperature change (i.e. the maximum degree change per hour). 60° per hour is the default.
Safety Gradient Temperature	If the safety temperature is changed, this field sets the rate of acceptable temperature change (i.e. the maximum degree change per hour). 60° per hour is the default.
Min Temperature	This is the minimum temperature the chiller may reach before an alarm goes off. The default is 16.9°C.
Max Temperature	This is the maximum temperature the chiller may reach before an alarm is sounded. The default is 17.1°C.
Set Values button	If parameters for the chiller are changed, use this button to update the settings.

CHILLER Fields/Buttons	Definitions
Current Settings	The chiller's current settings are displayed here: Current Temperature - chiller's present temperature Alarm - No Alarm, Low Alarm (temperature is too low), or High Alarm (temperature is too high) Conditioner Temperature - chiller's default conditioner temperature setting Safety Temperature - chiller's default safety temperature setting. Conditioner Gradient Temperature - chillers default rate of conditioner temperature change (in degrees per hour) Safety Gradient Temperature - chiller's default rate of safety temperature change (in degrees per hour) Min Temperature - chiller's current minimum temperature setting. Max Temperature - chiller's current maximum temperature setting.

3.1.7 Xray Generator

Use this screen to adjust X-ray Generator properties or settings, and/or troubleshoot issues with the X-ray Generator.



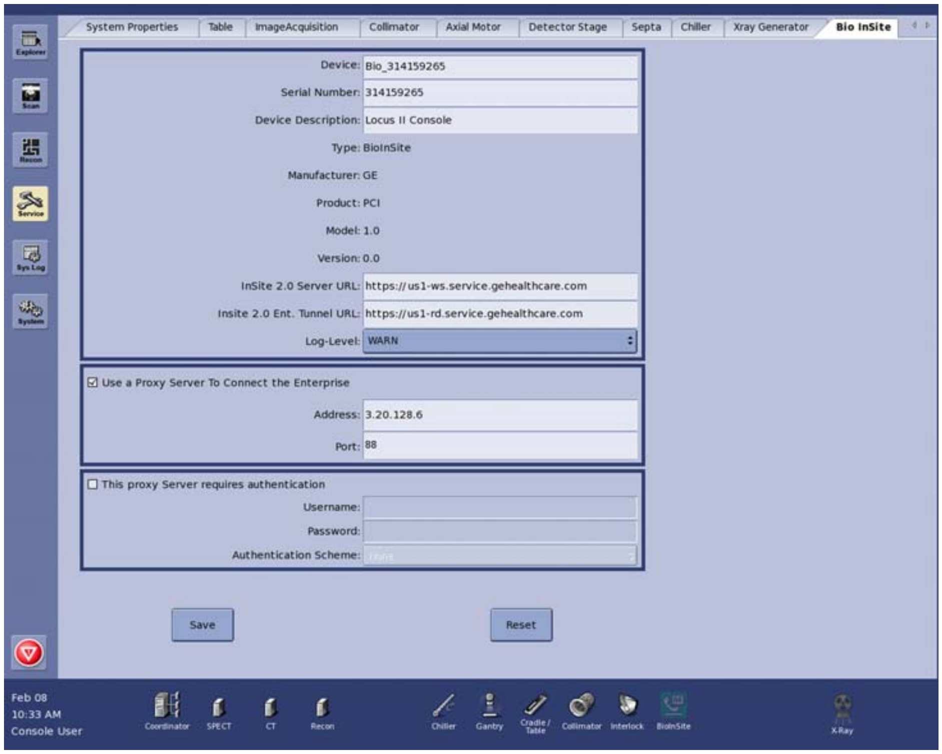
XRAY GENERATOR Fields/Buttons	Definitions
PROPERTIES:	
Pulse Type	This field indicates the type of pulse the generator uses: *External Trigger Camera +Tube* - Both camera and tube are triggered simultaneously by an event external to the machine *External Trigger Camera* - Only the camera is triggered by an event external to the machine in order to obtain a "dark" image *Internal Trigger Camera +Tube* - Both camera and tube are triggered simultaneously by the machine *Internal Trigger Camera* - Only the camera is triggered by the machine in order to obtain a "dark image"

XRAY GENERATOR Fields/Buttons	Definitions
Voltage (kV)	This field controls the energy of the x-ray beam by controlling the tube anode voltage in kiloVolts delivered by the generator during a scan.
Current (mA)	This field controls the intensity of the x-ray beam by controlling indicates the current in milliAmps delivered by the generator during a scan.
Exposures	This field indicates the number of projections that will be acquired during a scan.
Exposure Time (ms)	Exposure time is the amount of time, measured in milli seconds, that the camera will be exposed to the x-rays. If effects the speed of the shutter.
X-Ray Decay Time (ms)	This field controls the ramp-down time at the end of an x-ray pulse.
Camera Readout Time (ms)	This field indicates to the generator control box how much time is required to read out the detector at the selected bin mode. This value may be adjusted to increase the delay between exposures.
Focus Type	Either a small or large focal spot of the x-ray tube may be chosen.
Exposure Technique	The method used by the generator to calculate exposure may be chosen. Default is MA_Time, which means current and exposure time are specified separately.
Set Properties button	If the above properties or settings are changed, use this button to update the settings.
Turn Generator On button	Use this button to turn on the x-ray generator.
Turn Generator Off button	Use this button to turn off the x-ray generator.

XRAY GENERATOR Fields/Buttons	Definitions
Prepare To Fire button	Use this button to warm up the x-ray tube. Once pressed, x-rays must be fired within 30 seconds. Press the Reset Interlock button prior to using this button.
Fire X-Rays button	Use this button to fire up the x-rays according to the above settings. Must be pressed within 30 seconds of pressing the Prepare To Fire button.
Stop button	Use this button to stop x-rays from firing.
Reset Interlock button	Use this button to release the Interlock. Must be released prior to selected the Prepare To Fire button.
STATUS:	
State	The current state of the generator
Generator Status	Internal Generator status code
Voltage (kV)	The voltage value read back from the Generator
Current (mA)	The current value read back from the Generator
Exposure Time (msec)	The length of time the detector is exposed to X-rays
Anode Heat (%)	The X-ray tube's anode heat represented as a percentage of maximum
Housing Heat (%)	The X-ray tube's housing heat represented as a percentage of maximum
Focus Type	The current focal spot size (Large or Small)
Exposure Technique	This will always be MA-TIME, meaning exposure is set with time in milliseconds

XRAY GENERATOR Fields/Buttons	Definitions
GENERATOR CAMERA INTERFACE:	
Generator Camera Interface:	A checkmark next to the fields below indicate that the particular item is engaged or active: Busy - camera communication status Prep - camera is in preparation mode Generator Ready - generator is ready for firing X-Ray - x-rays are on Exposure - exposure is being generated Fluoro - mode is selected Pulsed Fluoro Select - mode is selected
Errors	Any errors encountered by the x-ray generator are reported here.

3.1.8 Bio Insite



BIO INSITE Fields/Buttons	Definitions
Device	This field indicates the scanner ID
Serial Number	This field indicates the serial number unique to the scanner
Device Description	This field provides the model name of the scanner
Type	Read-only field identifies the Bio InSite software
Manufacturer	Read-only field identifies the manufacturer of the Bio InSite software

BIO INSITE Fields/Buttons	Definitions
Product	Read-only field identifies the Bio InSite software product name
Model	Read-only field identifies the Bio InSite software model number
Version	Read-only field identifies the Bio InSite software version number
Insite 2.0 Server URL	This field lists the URL of the Bio Insite server: https://us1-ws.service.gehealthcare.com/
Insite 2.0 Ent. Tunnel URL	This field lists the URL of the Bio Insite Tunnel: https://us1-rd.service.gehealthcare.com/
Log Level	Choice of WARN or CRITICAL
Address	This field indicates the IP address of the customer's proxy server.
Port	This field indicates the port number associated with the customer's proxy server.
Username	If the customer's proxy server requires authentication, the customer-supplied username is entered here.
Password	If the customer's proxy server requires authentication, the customer-supplied password is entered here.
Authentication Scheme	Choice of encryption scheme: None, 128 bit, etc.
Save button	This button saves information entered in all fields.
Reset button	This button clears information entered in all fields.

Chapter 4
Functional Checks & Troubleshooting

Section 4.1
Functional Checks

Functional checks ensure that the system will basically produce SPECT and CT scans. They are typically performed by the FE after installation of a new system has been completed, but can be performed fairly quickly during any site visit to ensure ongoing customer satisfaction. If any of these checks do not produce the desired results, they provide the FE with the opportunity to troubleshoot further.

CAUTION In order to perform functional checks, a power up sequence must have already been performed as in Section 4.3 Test Power and Functionality in the eXplore speCZT CT Installation and Training Guide. In particular, make sure that the gantry break is fully released. Also, it is assumed that all software has been loaded into the computers at the factory, and that the system is connected to facility power.

4.1.1 Emergency Stop

1. Start the system by pushing the green button on the side of the Table (Figure 4-1 left).
2. Press the emergency stop button below the Touch Screen (Figure 4-1 right).
3. Verify that the system shuts down. The emergency stop button should remain depressed. To reset the emergency stop button, turn it counter-clockwise.

Figure 4-1

4.1.2 Table

1. Power up the console computer by pushing on the power button.
2. Start the system by pushing the green button on the side of the Table, and allow all computers to boot.
3. Log on to the host computer. The user name is **vct** and the password is **vct@pci**.
4. Click on the GE icon to launch the Host Console Interface.
5. Highlight the desired scanner in the Available Scanners window. Note, it will take approximately 5 minutes from the time you press the green button to the time when the scanner appears in the Available Scanners window. (Figure 4-2).
6. Click the Connect button. It will take several minutes for the system to start.
7. Check the icons on the bottom of the screen. Active icons will light up. Icons will also indicate specific problems if they occur.

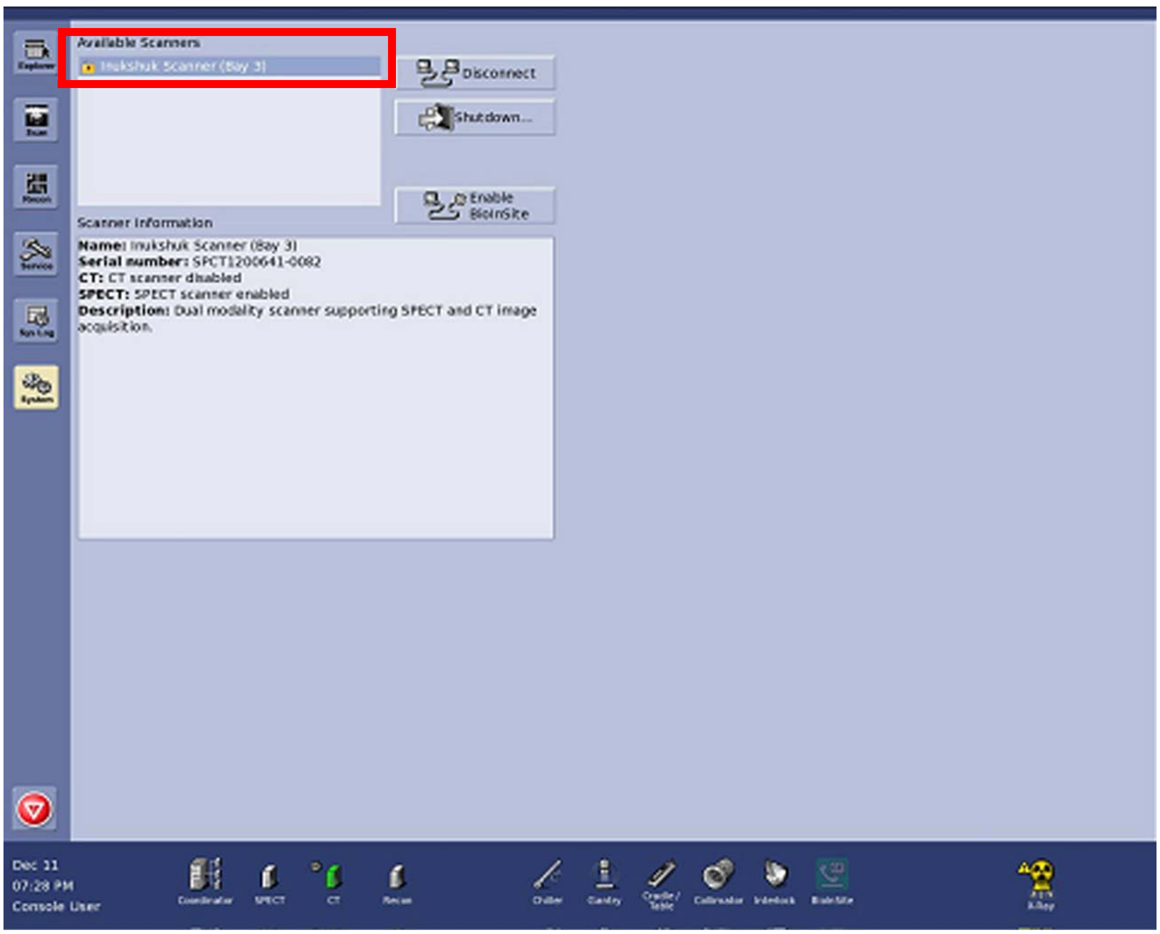


Figure 4-2

NOTICE Equipment Damage Possible *Be prepared to push the emergency stop if the stage moves close to either end of the bed.*

8. Remove the cradle from the stage assembly if one is present (Figure 4-3 top left).
9. Register the table. The stage should stop approximately 75 mm from the end of the bed (Figure 4-3 top right) and (Figure 4-4).
10. Use the Touch Screen to carefully advance the stage to the other end of the bed, where it should stop within 75 mm from the end (Figure 4-3 bottom left) and (Figure 4-5).
11. Adjust the limit switches if necessary (Figure 4-3 bottom right).

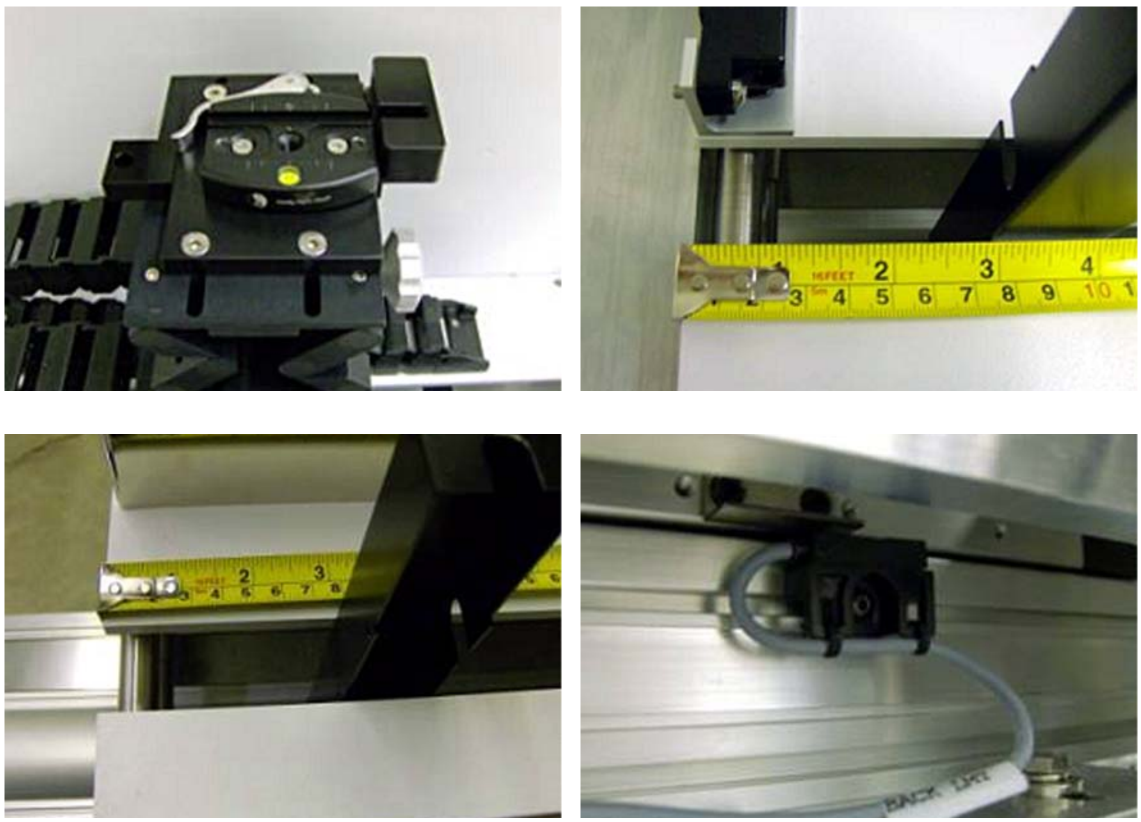


Figure 4-3

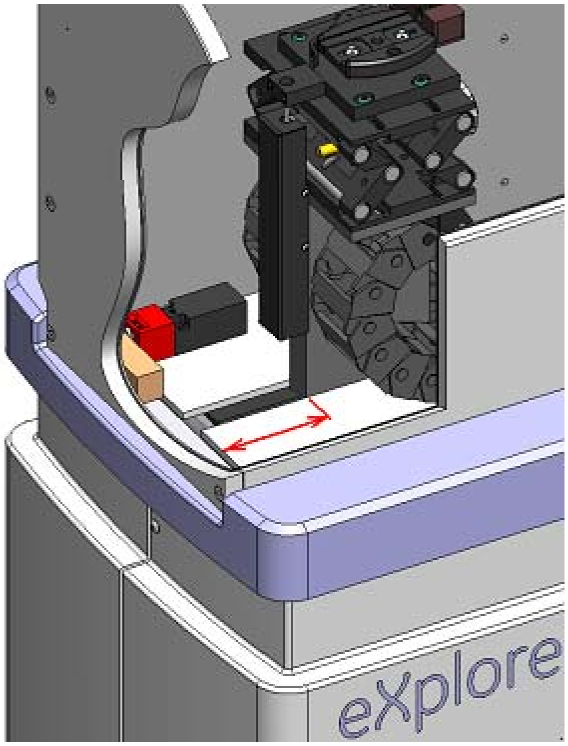


Figure 4-4

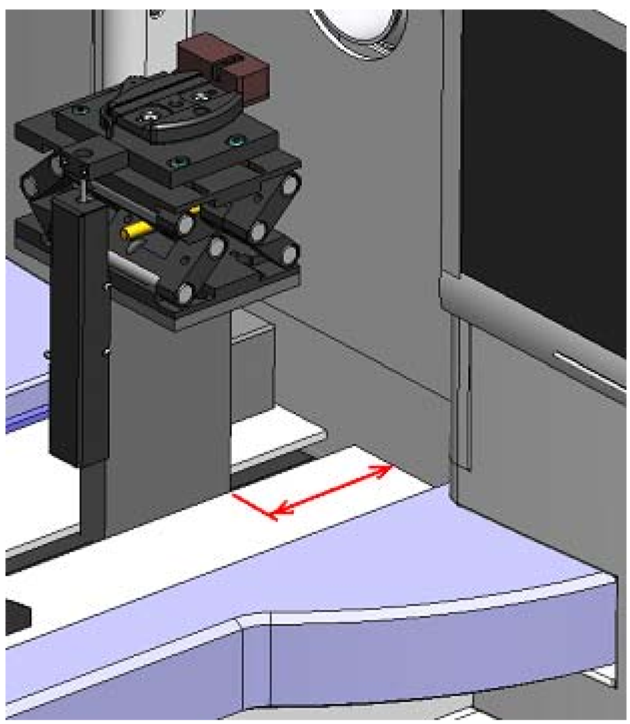


Figure 4-5

12. Reduce the Force Offset and save the value.(Figure 4-6)
13. Attempt to register the table.
14. Continue to reduce the Force Offset until the table will not register.
15. Set the Force Offset to approximately 10 above the value where the table will register and save the settings.

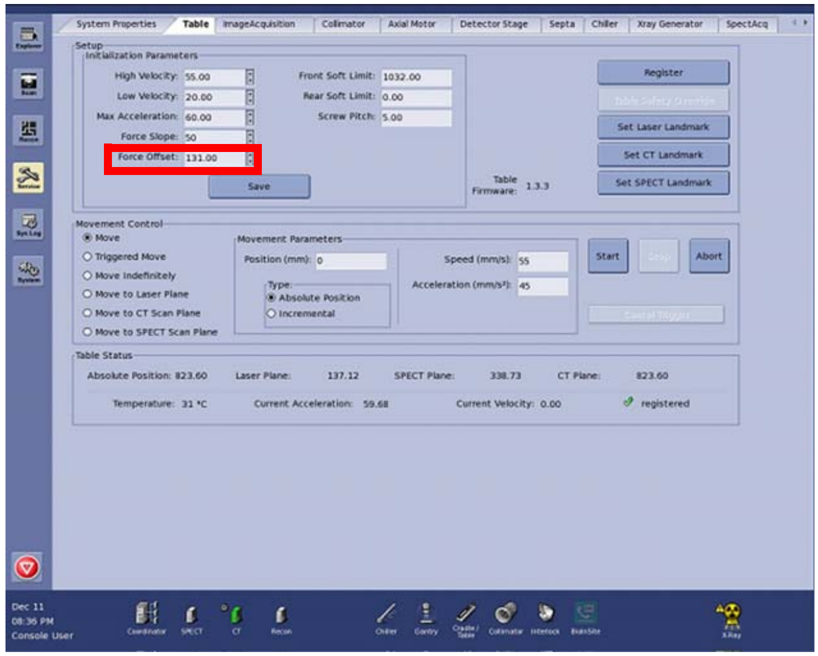


Figure 4-6

16. Toggle the lasers from the Touch Screen and verify that both lasers are working (Figure 4-7).
17. Adjust the cradle height adjustment knob and verify that the height indication changes on the Touch Screen.

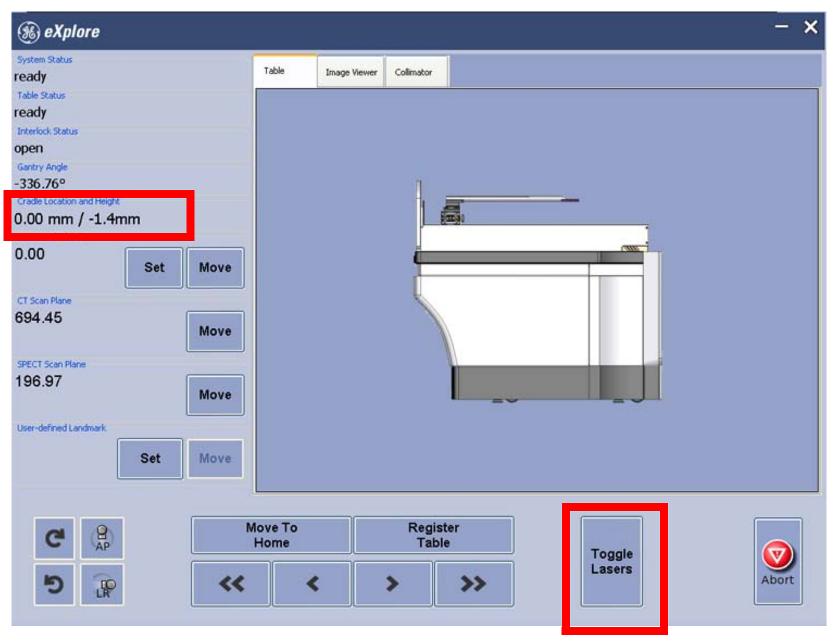


Figure 4-7

18. Install the rat and mouse cradles in sequence. Verify that both cradles are identified correctly on the screen.
19. Hover the mouse over the icon on the main screen to display the cradle installed. (Figure 4-8)
20. Remove the cradle.

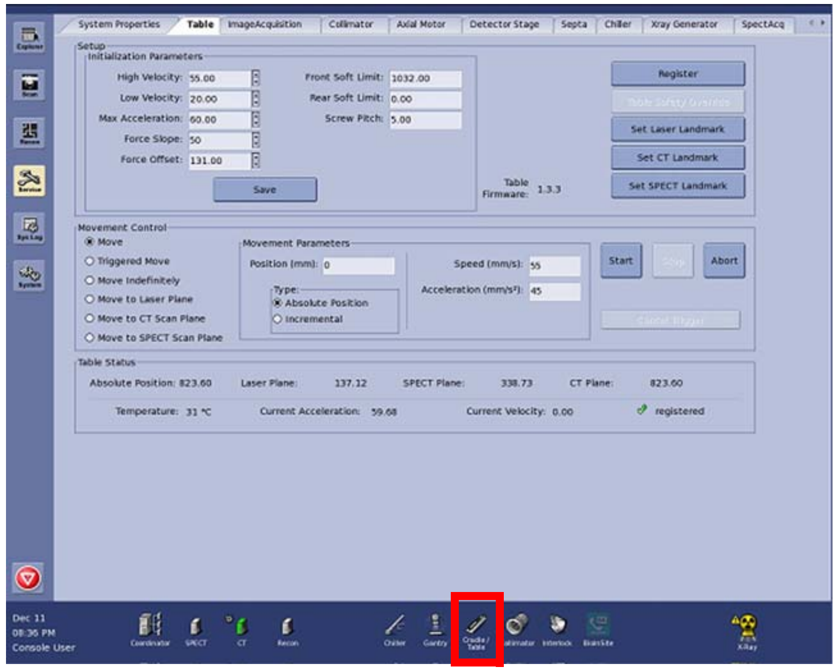


Figure 4-8

4.1.3 SPECT

Note: Removal of the SPECT covers and radiation shields may be necessary when performing function checks. Refer to Section 5 of this Guide for removal and replacement instructions.

CHILLER

1. Select the Service icon on the left side of the screen.
2. Select the Chiller tab.
3. Verify that the Chiller temperature is displayed on the Service page.

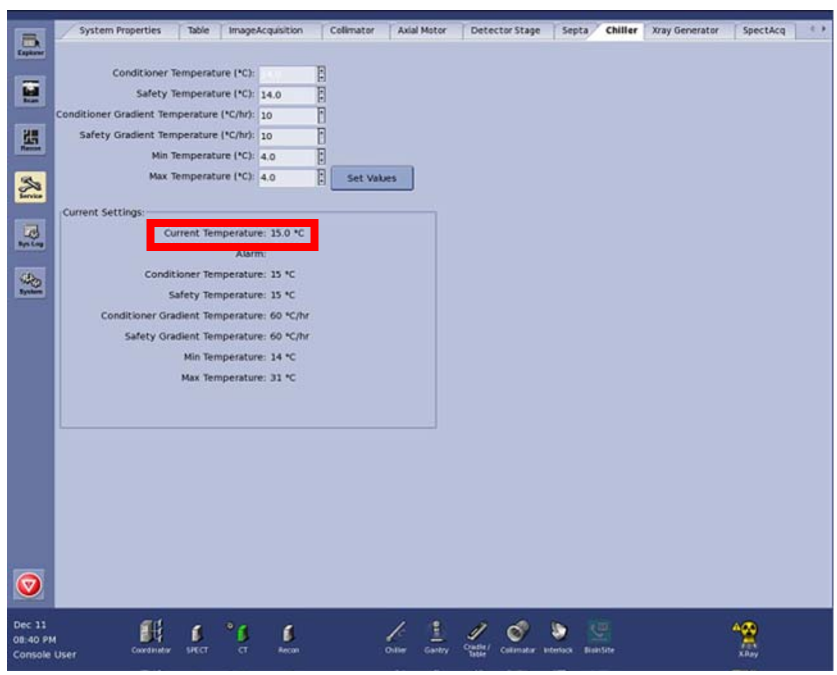


Figure 4-9

COLLIMATOR

1. On the Service pages, click the Collimator tab, then Change Collimator. This will release the lock securing the collimator support flange.
2. Access the collimator drive by opening the Front Cover door, unlatching the collimator support flange assembly and lowering it.

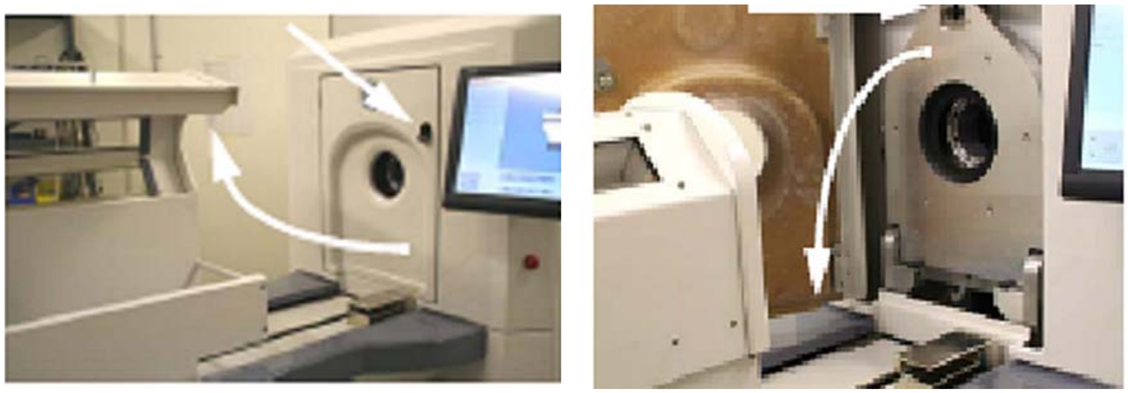


Figure 4-10

3. Note the orientation of the collimator drive plate.
4. Attempt to rotate the collimator drive by hand. If it is not possible, power is still available to the collimator drive and the safety switches are not working. If the collimator can be rotated by hand, this verifies that the safety switches are working.
5. Close the collimator support assembly.
6. Verify that the solenoid has locked the collimator support assembly in place. Adjust the solenoid latch as necessary.
7. From the Service page (Figure 4-11), rotate the collimator drive. Verify that it has moved the desired number of degrees. The collimator must rotate clockwise when viewed from the front.

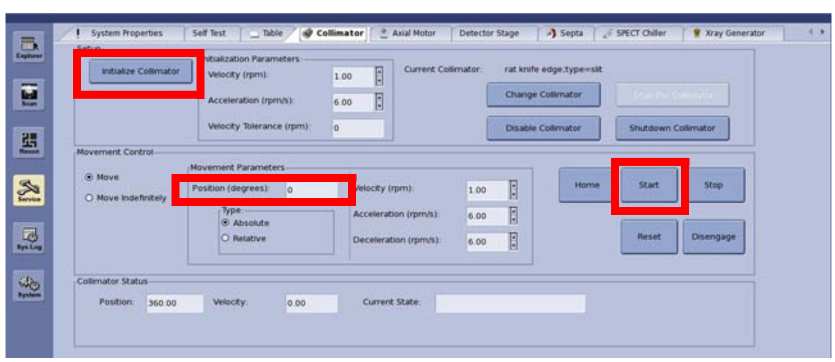


Figure 4-11

8. Select Scan For Collimator (Figure 4-12).The bar code reader will light up.

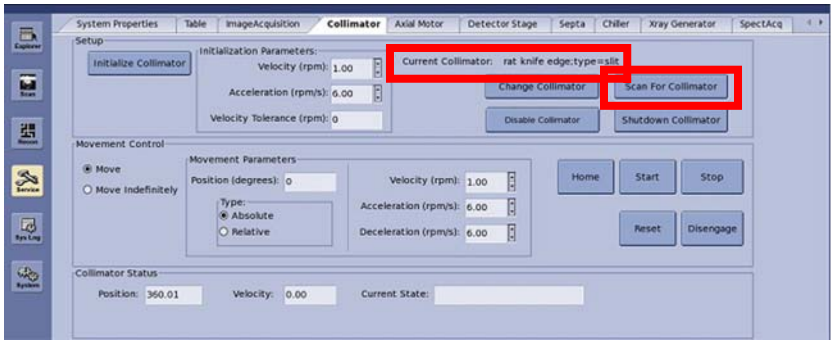
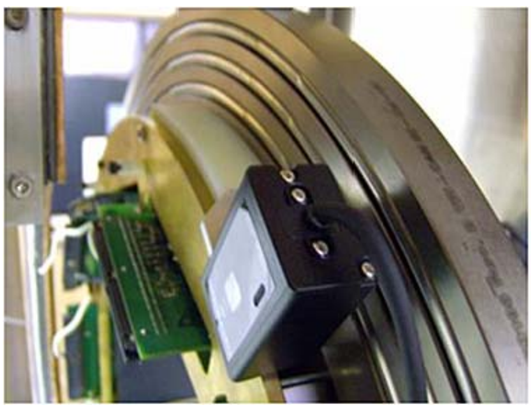


Figure 4-12

9. If the collimator was removed or if the collimator is in but not recognized, a paper barcode may have to be used instead. Remove the collimator as needed and place a paper printout of the bar code in front of the reader (Figure 4-13). The lights of the bar code reader will turn off when the bar code is read.



1001

Figure 4-13

10. Verify that the proper collimator is displayed on the screen. (Figure 4-12)

SEPTA

1. Move the septa toward its home position by clicking the Move radio button, entering a relative position amount and clicking Start. (Figure 4-14)
2. Continue to move the septa toward home. Home position is indicated by the LED on the optical switch (Home Flag) lighting up. (Figure 4-15)
3. Adjust the micro switch to activate at the septa home position.

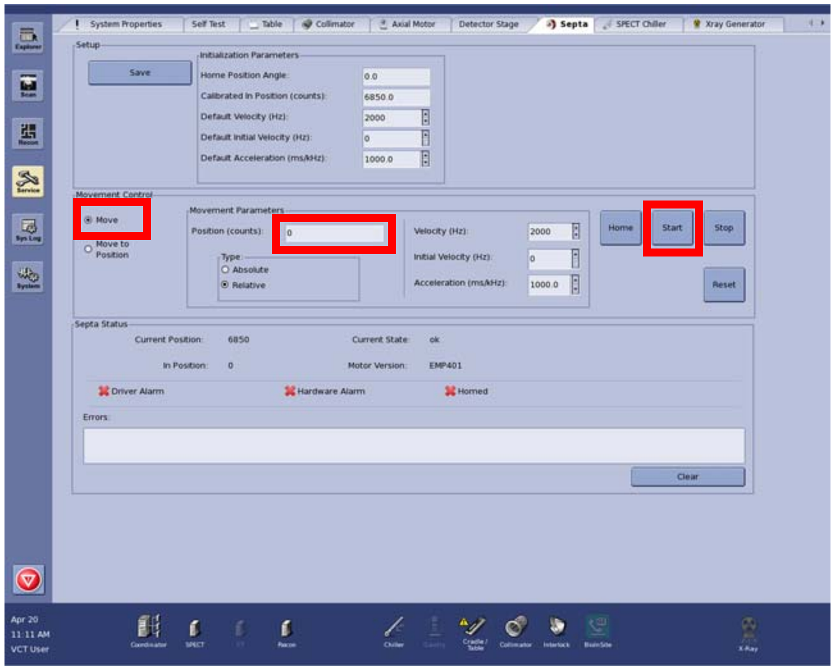


Figure 4-14

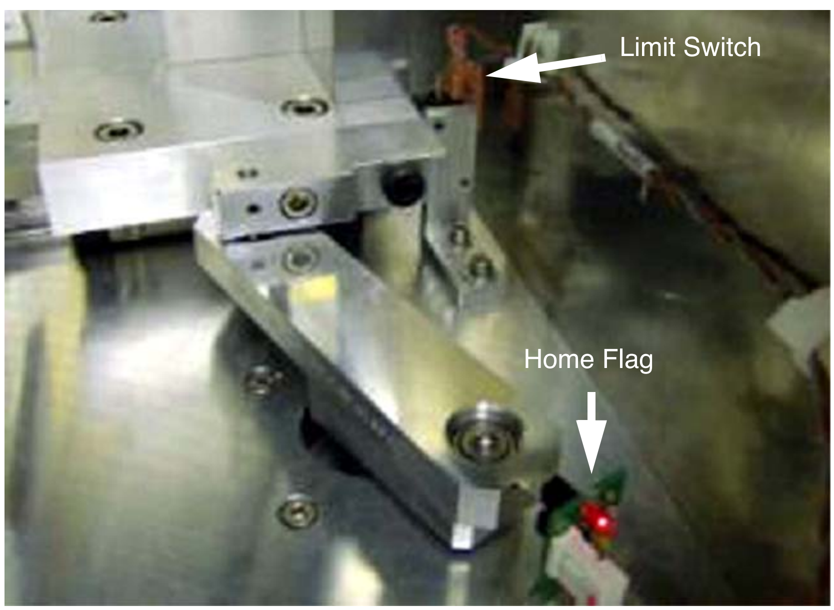


Figure 4-15

4. Move the septa away from the home position using the Septa Service page.
5. Select the Home button on the Service page and verify that the septa returns to the home position.
6. Select Change Collimator from the Collimator Service page (Figure 4-16) or Change Collimator from the Collimator tab on the Tableside Touch Screen. The solenoid lock should release.

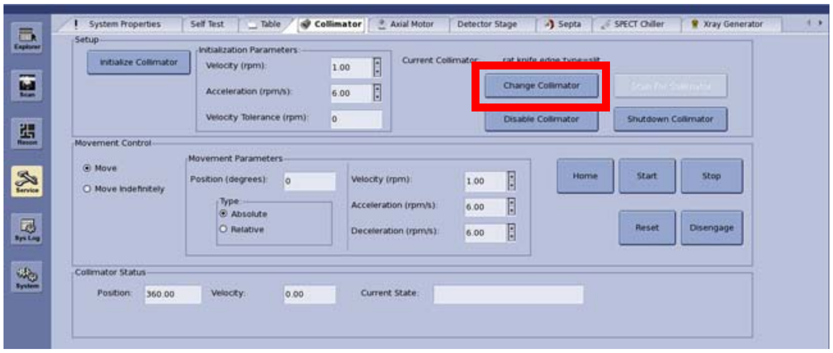


Figure 4-16

7. Open the collimator support assembly.
8. Access the Septa Service page. Write down the current value in the Calibrated In Position field. With the collimator support open, attempt to move the septa toward the scanning plane by clicking the Move to Position button, selecting InPos from the Named Position drop-down list, entering 10,000 in the Calibrated In Position field and clicking Start (Figure 4-17). The septa must not move.

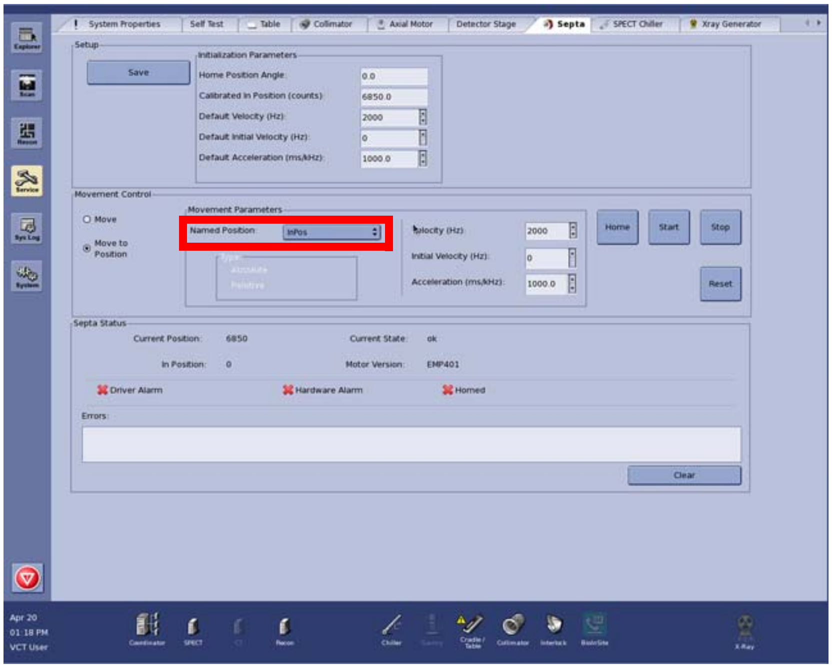


Figure 4-17

9. Close the collimator support assembly.

10. Move the septa further away from its home position using the Service page.

NOTICE Equipment Damage Possible

Take care not to damage the septa. If the lock has failed and the collimator support assembly is swung forward far enough, the collimator will collide with the septa and damage its individual sheets.

11. Verify that the solenoid lock has locked the collimator support in position.
12. Access the Collimator Service page and click Change Collimator. The septa must return to its home position. Once there, the solenoid lock should release. Verify that the collimator support assembly can be opened.
13. Restore the Calibrated In Position field to the value recorded in step 8.

DETECTORS

1. Click the Scan icon.
2. Click on the SPECT Fluoro button (Figure 4-18).

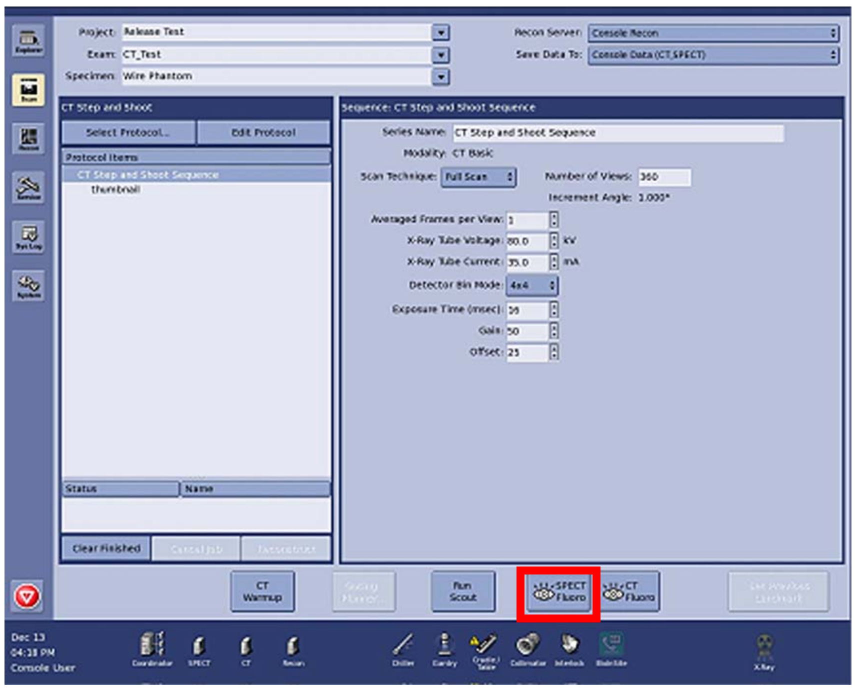


Figure 4-18

3. Select Reset SPECT Viewer (Figure 4-19).

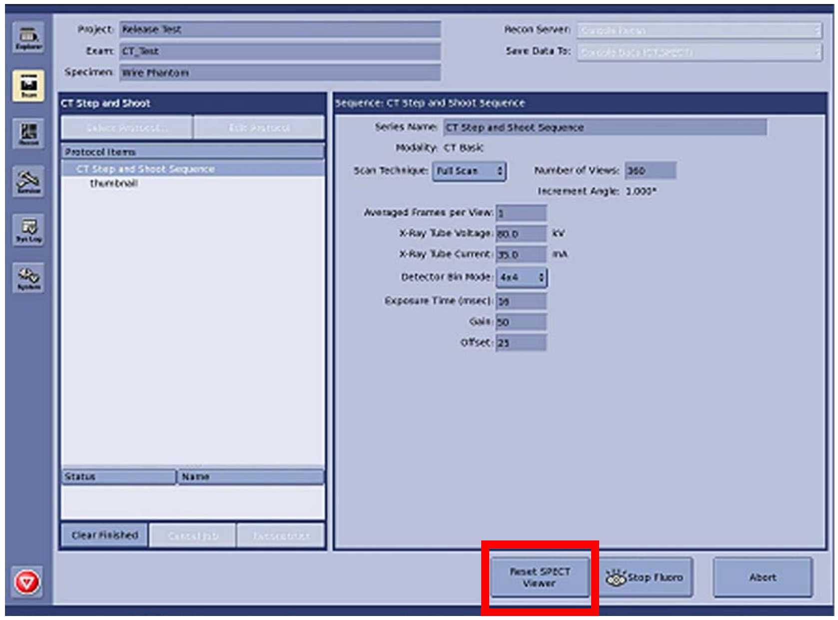


Figure 4-19

4. Observe the live SPECT image (Figure 4-20) . This will confirm whether or not all ten detector panels are working.

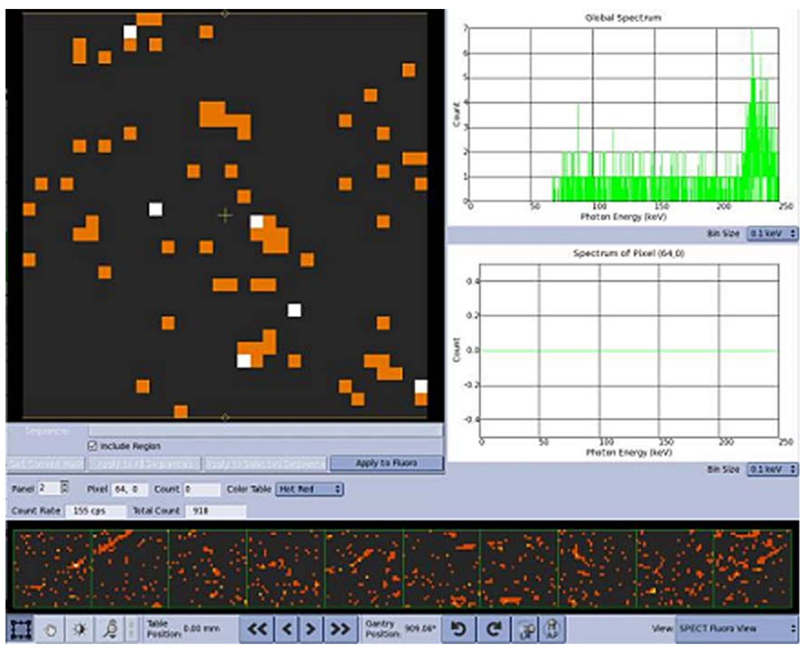


Figure 4-20

5. Select Stop Fluoro to turn Fluoro off.

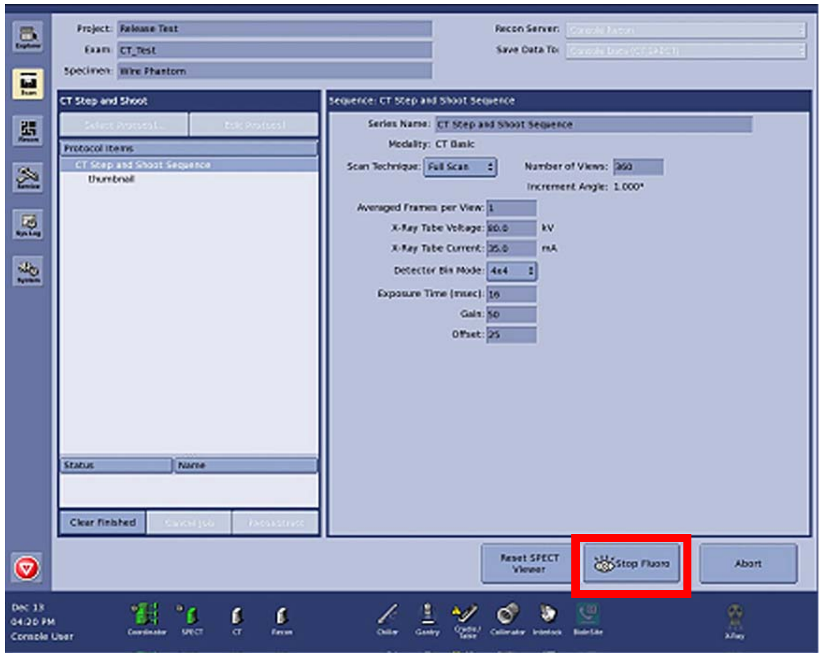


Figure 4-21

4.1.4 CT

Note: Removal of the CT covers may be necessary when performing function checks. Refer to Section 5 of this Guide for removal and replacement instructions.

1. Click the Absolute radio button and enter a number of degrees in the Movement Parameters field. (Figure 4-22)
2. Click Start.
3. Verify that the gantry moved to the selected position by looking at the Current Position field under Axial Motor Status.

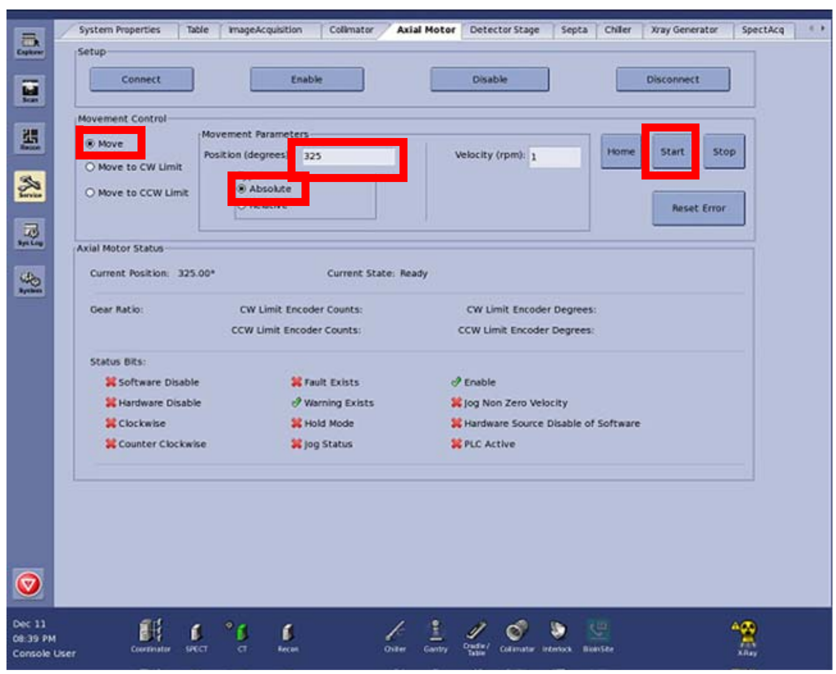


Figure 4-22

4. If lit, push the interlock reset button (inset on Figure 4-23), located next to the Console keyboard until the button is not lit.
5. If the Xray generator is off, click the Turn Generator On button from the Xray Generator Service page.
6. Set the Pulse Type to Internal Trigger Camera + Tube.
7. Set the Voltage (kV) to 80 and the Current (mA) to 25.
8. Set Exposures to 5.
9. Click Set Properties.
10. Click Reset Interlock

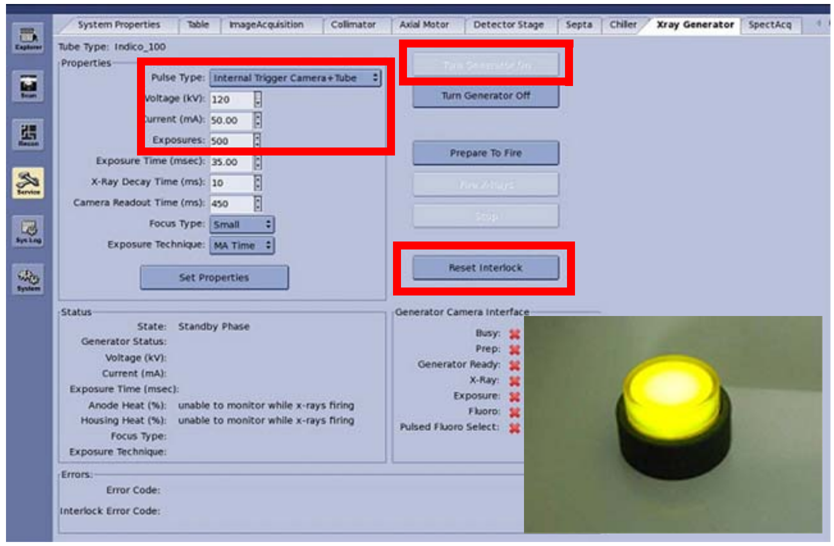


Figure 4-23

11. Click the Prepare to Fire button. (Figure 4-24)

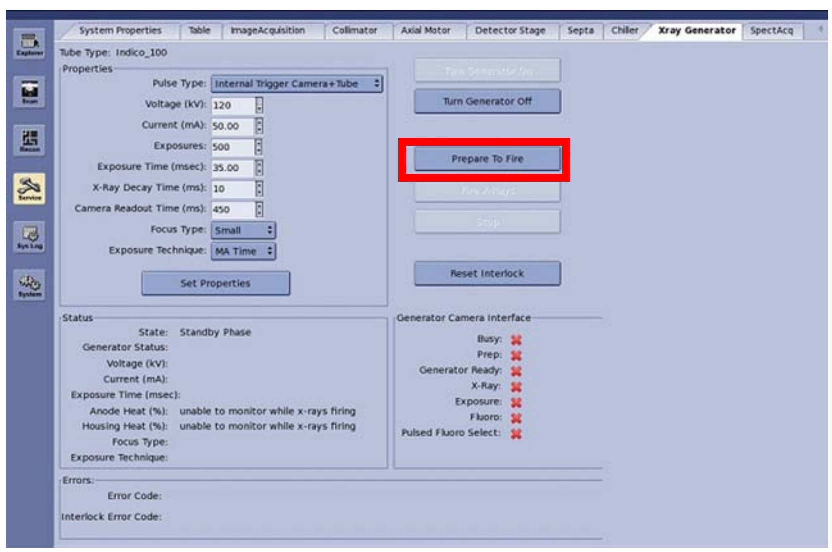


Figure 4-24

12. Verify that the three (3) X-Ray indicator lamps light. (Figure 4-25)

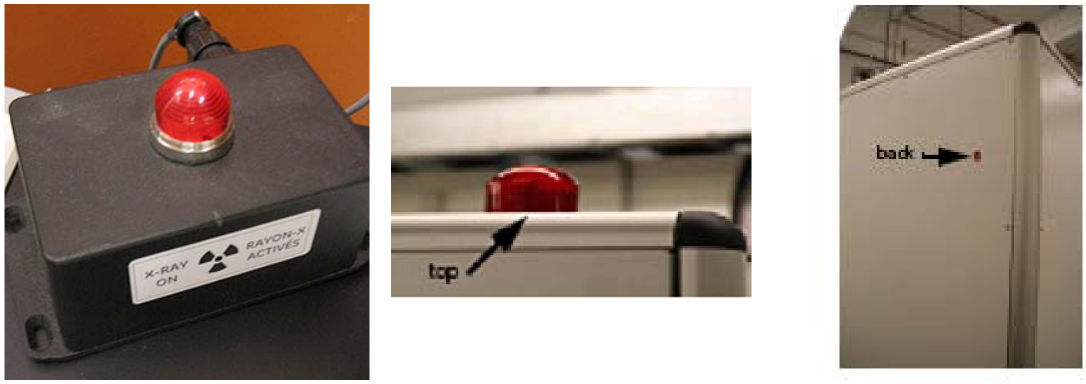


Figure 4-25

13. Click the Fire X-Rays button (Figure 4-26). Listen for the X-Ray generator firing sounds.

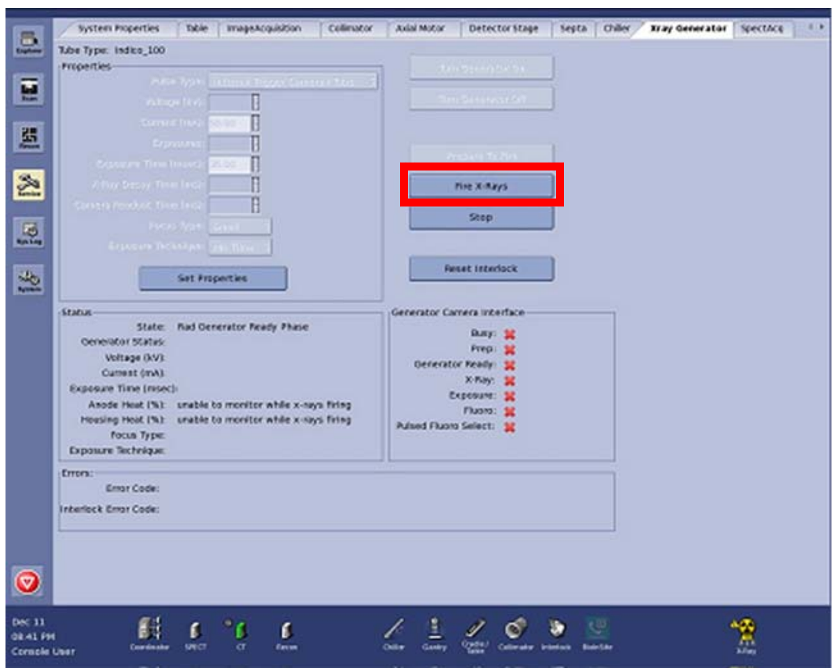


Figure 4-26

14. Verify that opening each access panel will turn the interlock reset lamp on and will not reset with the an access panel open .(Figure 4-27).

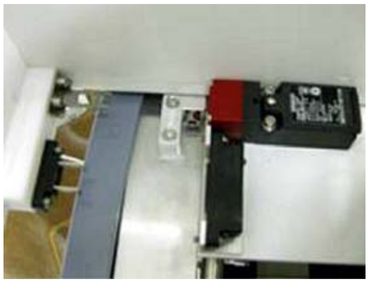


Figure 4-27

15. Verify that X-rays will not fire with any of the access panels open.
16. Test each of the interrupts individually with a jumper (Figure 4-28). Verify that X-rays will not fire with either jumper removed.

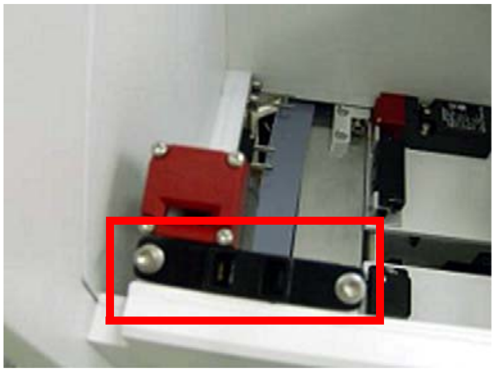
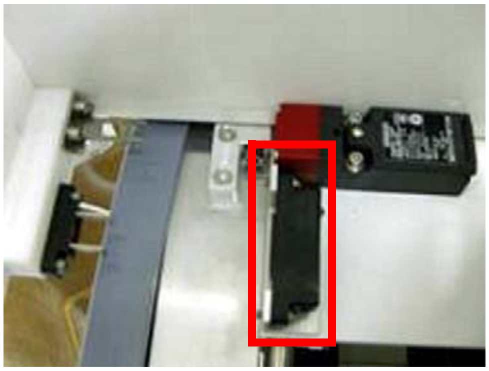



Figure 4-28

17. Click on the Scan icon on the left side of the screen. (Figure 4-29)

18. Click on the CT Fluoro button.

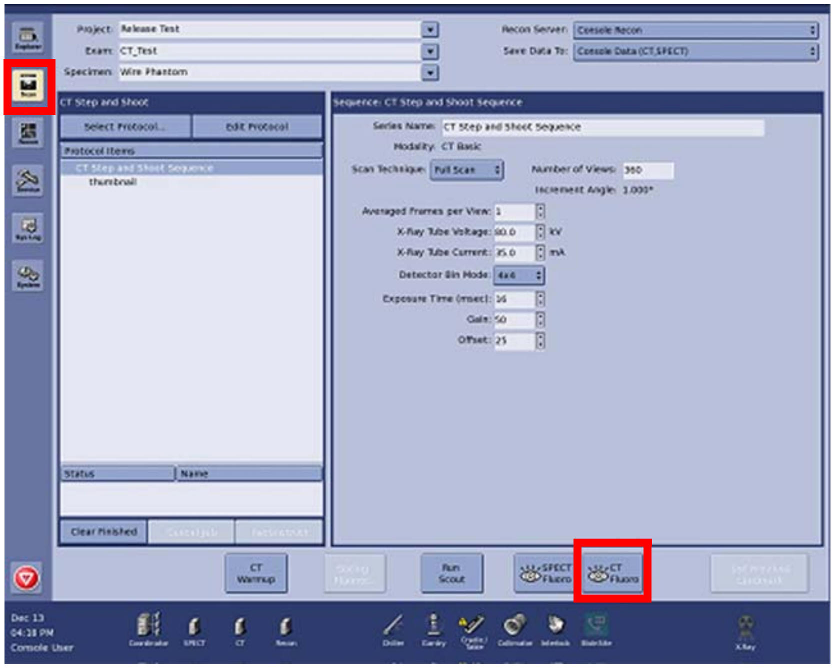


Figure 4-29

19. Observe the live CT image (Figure 4-30). This will confirm that the detector is working.

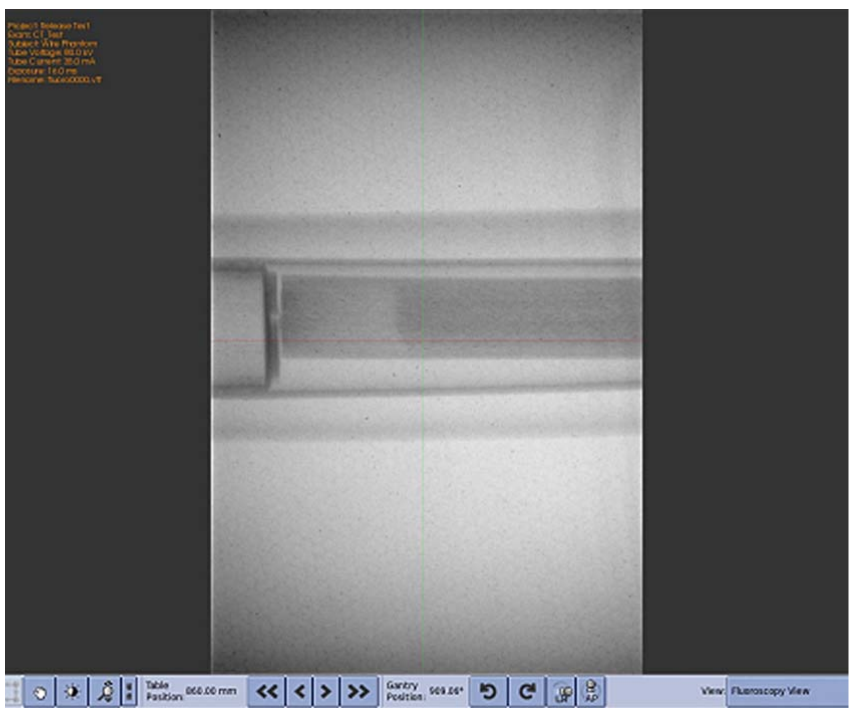


Figure 4-30

20. Click on the Stop X-Rays button to turn Fluoro off.

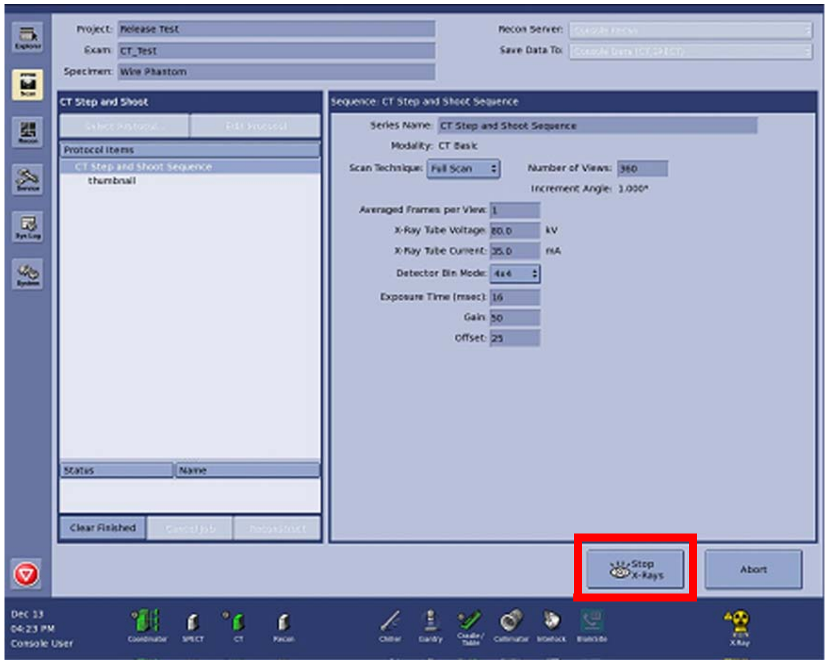


Figure 4-31

21. Shut down the machine.

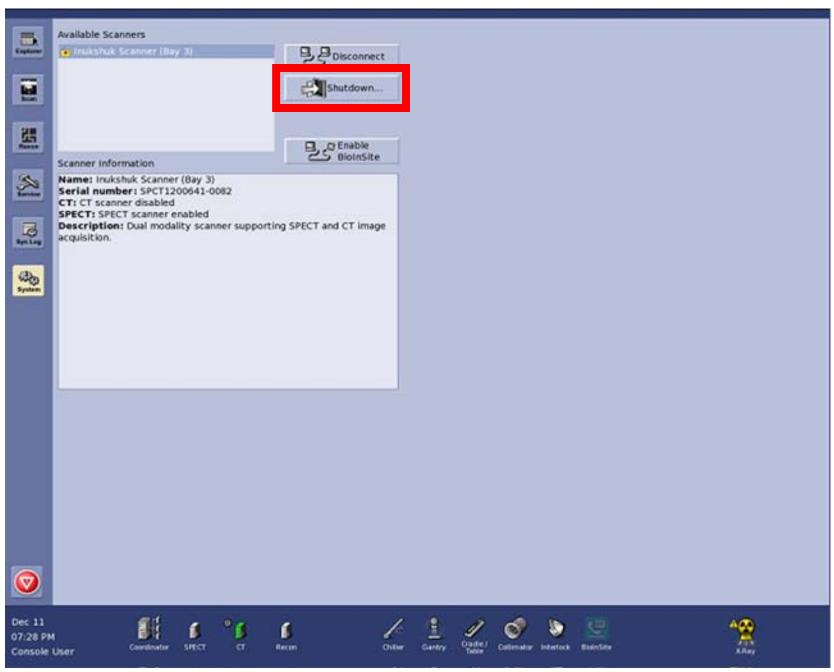


Figure 4-32

Section 4.2 Troubleshooting

Note: The table at the end of this chapter was used in the past to troubleshoot. Eventually, the content from this table will follow the proceeding format.

4.2.1 How To Use The Troubleshooting Information

This chapter is intended to assist you in diagnosing and solving problems with eXplore speCZT/ CT120. The material has been organized into 5 sections:

1. **System**: this section describes issues that seem general in nature - such as, **"**the system does not power up when the green button is pressed".
2. **Console**: in this section you will find a list of issues that seem to originate from the console computer, its operating system, or the application software that is installed on it.
3. **Common**: here you will find a description of issues related to hardware that is common to all scanner configurations (except issues covered by the console). These include issues with the common computer, the touch-screen, the realtime bus, etc.
4. **CT**: this section only applies if a CT120 acquisition subsystem is part of the scanner. As the name implies, it covers the issues related to acquisition of CT images.
5. **SPECT**: this section only applies if a speCZT acquisition subsystem is part of the scanner. As the name implies, it covers the issues related to the acquisition of SPECT images.

Table 4-1 Troubleshooting Summary Table, on page 80, consists of a number of columns - one for each of the sections described above. The remaining rows of each column list subsections or topics, which further categorize the issues. If you try to match the issue you have with the available categories, you will be able to more quickly arrive at the solution to your problem. Clicking on the subsection page number in the table will take you to a page that lists the issues that fall within that category of problems.

Each issue is presented in a standard format:

- **"One line summary"**: a statement that describes the issue. Try to match the symptoms that you observe with one of these summaries.
- **"Description":** more detail about the issue. This will help you confirm that this is what you are looking for.
- **"Conditions"**: for any particular issue, there may be more than one set of circumstances under which the symptoms arise (i.e., scenario). Furthermore, each scenario may require different investigative/remedial actions. So, look through the conditions, if there are more than one, and find the scenario that matches your particular problem.
    * Tests and actions: for each condition, there will be a list of tests to be performed and actions to be taken, based on the results of the test. The test and actions are references to procedures that are documented at the end of the trouble shooting chapter.
- Once you find the scenario that matches your problem, click on the references to the tests and follow the detailed procedure.

Note: There may be times when you need assistance from engineering with resolving system issues. For such cases, you may be asked to connect the system to a VPN that allows engineering staff to access the scanner remotely. See the OpenVPN section for more information (page 84)

Table 4-1 Troubleshooting Summary Table

System	Console	Common	CT	SPECT
Power page 81	Console	Table	Gantry	Rio Driver
Network	Data Storage page 82	Real Time Bus	Detector	Collimator
Connectivity page 81	Reconstruction page 82	Cradle	X-ray Generator page 83	Chiller
		Touch-Screen	X-ray Control Box	Calibration Files
			X-ray Tube	Acquisition Storage
			Cooler	
			Calibration Files	
			Interlock	
			Scanning page 82	

4.2.2 System Issues

POWER

The Scanner does not Fully Power Up

When the green button is pressed to power up the scanner, the common computer starts (you know this because the touch-screen display comes up), but the CT and/or SPECT subsystems do not fully power up. CT is not visible at all, and the SPECT subsystem appears, but many of its components report communication errors. Similarly, the table also reports a communications error (serial port time-out).

Conditions:

- "The scanner has power, evidenced by the fact that you can hear the fans and the touch-screen display appears. However, not all the subsystems start. If you examine the statuses of the various bots that do appear, using an XMPP client like gajim, you will see communication errors reported.

Tests:

1.) Check the COM Port Settings for the Common Computer.(page 86)
   a.) COM port settings are incorrect: Perform the Setup Common COM Ports procedure.(page 97)
   b.) COM port settings are correct: continue with #2.
2.) Check the USB to serial cable.
   a.) Cable is defective, replace cable.
   b.) Cable is working properly continue with #3.
3.) Check the fuse on the Realtime bus board.
   a.) Fuse needs replacing: Perform the Realtime Bus Fuse Replacement procedure.
   b.) Fuse is okay: contact GMI for further assistance.

CONNECTIVITY

No Scanner Appears in Scanner List on the System Page

Even though the scanner is powered up and the touch-screen indicates that the system is ready for use, when one goes to the System page of the console application, the scanner is not listed as a scanner that can be locked.

Conditions:

- Scanner is powered up and ready for use but the console application doesn't “see” the scanner.

Tests:

1.) Confirm network connectivity.(page 87)
   a.) Console and Common computer are connected: continue with #2
   b.) Console and Common computer are not connected: Perform the Console/ Common Computer Network Setup procedure.
2.) Confirm XMPP Federation is Working. (page 87)
   a.) XMPP servers are federated: Perform XMPP Roster Restore. (page 94)
   b.) XMPP servers are not federated: Perform the XMPP Server Setup procedure.(Chapter 6, step 6, Launch Firefox, page 237)

4.2.3 Console Issues

DATA STORAGE

Raid Error Reported by Console Application

The console computer monitors RAID failures and reports failures to GE service via email. Furthermore, the console application will display an error box when there are issues with the RAID hardware.

Conditions:

- The console application displays the error message: RAID hardware attached to this machine is running in degraded mode. Data integrity is at risk. Please contact GE service.

Tests:

1.) Check Health of Console Computer RAID (page 90)

a.) RAID is in degraded mode: Perform the Fixing A Degraded RAID procedure.(page 95)

b.) RAID is not in degraded mode: contact engineering

RECONSTRUCTION

It is Impossible to Add Jobs to the Recon Queue

Under some conditions, the reconstruction queue appears empty and unresponsive. For example, after renaming the console, the queue is unusable. The same is true if there has been a significant change in the XMPP server due to a software upgrade.

Conditions:

- From the recon page of the console application, the recon queue always remains empty, even after submitting reconstruction jobs.

Tests:

1.) There are no tests to confirm if the recon queue is the problem. So, if the queue becomes unresponsive after a console rename or after a software upgrade:

a.) Perform the Recon Queue Reset procedure(page 93).

b.) If the problem persists try rebooting the console computer.

4.2.4 CT Subsystem Issues

SCAN ISSUES

CT Continuous Scan Does Not Work

When a continuous rotation CT sequence is run from the console, the acquisition components enter the acquisition phase, the gantry rotates, but no x-rays are fired. Eventually, the generator throws an EL018 latching error because it has been in the prep phase for too long.

Conditions:

- The failure rate for continuous rotation acquisitions is 100%.
- CT fluoro does work, meaning that it is possible to fire x-rays.

Tests:

1.) Verify Encoder Device Name in CT Properties is Correct (page 88) a.) Mismatch exists: Perform the Specifying the Encoder Device Name in the CT Properties procedure.(page 94)

b.) No mismatch exists: Continue with test #2.

2.) Check the encoder connection from the CT computer to the x-ray control box (page 92).

a.) The connections were loose, retry the CT fast scan

b.) Continue with #3

3.) Contact engineering for further support.

X-RAY GENERATOR ISSUES

EL018 Error When Scanning

The EL018 error code is reported by the generator when there is a preparation time out error. Before firing x-rays, the generator must be put into a prep phase, but this phase can only be held for 30 seconds. If an x-ray fire trigger is not received before 30 seconds has passed, the generator will return to standby and issue the EL018 error.

Conditions:

- The error occurs only when a continuous rotation acquisition is attempted

Tests:

1.) Verify Encoder Device Name in CT Properties is Correct.(page 88)

a.) Mismatch exists: Perform the Specifying the Encoder Device Name in the CT Properties procedure.(page 94)

b.) No mismatch exists: Continue with #2.

2.) Check the encoder connection from the CT computer to the x-ray control box (page 92).

a.) The connections were loose, retry the CT fast scan

b.) Continue with #3.

3.) Contact engineering for further support.

Conditions:

- The error occurs during a CT gated acquisition.

Tests:

1.) Check the input from the animal monitoring system.

a.) No signal generated: fix the animal monitoring system.

b.) Signal received: continue with #2.

2.) Check input to the x-ray control box.

a.) No signal received at the x-ray control box: contact engineering.

b.) Signal received at the x-ray control box: continue with #3.

3.) Check the output from the x-ray control box.

a.) No signal generated by the x-ray control box: continue with #4

b.) Signal generated by the x-ray control box: contact engineering.

4.) Verify the firmware version on the x-ray control box.

a.) Correct version installed: continue with #5.

b.) Incorrect version installed: contact engineering.

5.) Contact engineering for further support.

Section 4.3
OpenVPN

OpenVPN is an SSL/TLS-based open-source VPN solution that runs on multiple platforms and can use either UDP or TCP packets to form networks. It is used as a backup VPN solution to GMI because it can tunnel over https requests, and so is often usable behind corporate firewalls, even through web proxies. When the scanner is built, the necessary software is installed on the console. This section describes various ways that you can connect to the VPN from a console computer.

Method 1 - from Gnome System Menus

- Select Applications --> System Tools --> GEHC Start OpenVPN.
- If prompted for the administrative password via a dialog box, enter 'operator', then hit the 'OK' button.
- A text console will appear:
  - When prompted for a user name, you have a choice:
    - either enter your GMI-provided single sign on user name (the same user name used to access the GMI wiki web site), then when prompted, enter your password, or,
    - enter 'guest', then when prompted for a password, enter the password given to you by GMI Engineering. This password will be a one-time password http://en.wikipedia.org/wiki/One-time_password that works for a short period of time (currently set to expire 1, 4 or 24 hours after creation). The guest account password can be generated by creating a ticket on the http://london.gm-ideas.com/trac/vpn

Method 2 - from a Console Window

- Launch a terminal (Applications --> System Tools --> Terminal) (Figure 4-33)
- Run:

  su
- If prompted for a password enter 'operator' then hit return
- Next, run:

  /sbin/service openvpn start
- When prompted for a user name, you have a choice:
  - either enter your GMI-provided single sign on user name (the same user name used to access the GMI wiki web site), then when prompted, enter your password, or,
  - enter 'guest', (Figure 4-34) then when prompted for a password, enter the password given to you by GMI Engineering. This password will be a one-time password http://en.wikipedia.org/wiki/One-time_password that works for a short period of time (currently set to expire 1, 4 or 24 hours after creation). The guest account password can be generated by creating a ticket on the http://london.gm-ideas.com/trac/vpn.

Figure 4-33

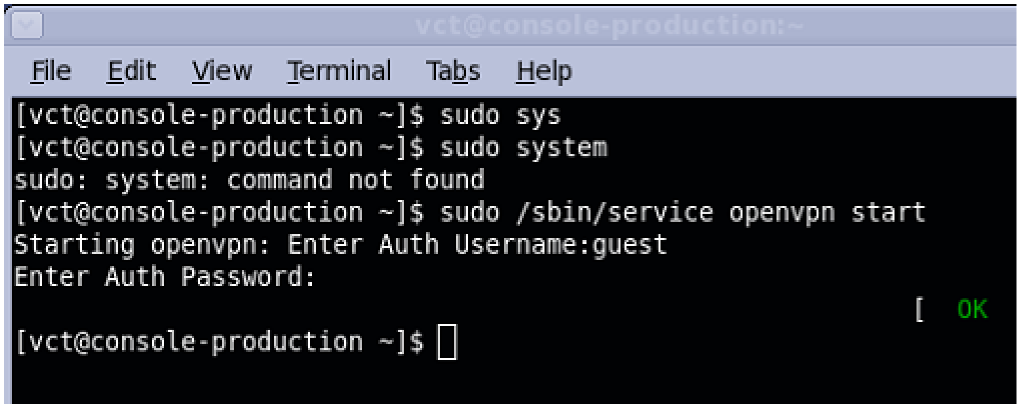


Figure 4-34

Method 3 - from a Console Window (with Debugging)

If for some reason OpenVPN fails to make a connection, and you'd like to debug why, it's best to run openvpn from a command console so that you can view the extended logging. To do so:

- Launch a terminal (Applications --> System Tools --> Terminal), as described above.
- Run

  `su`
- If prompted for a password enter 'operator' then hit return.
- Next, run:

  `cd /etc/openvpn; /usr/sbin/openvpn --config gmi-guest-user.conf`
- As before, you have a variety of user name/password options, as described above.

Section 4.4
Test Procedures

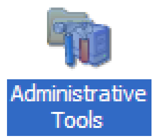
CHECK THE COM PORT SETTINGS FOR THE COMMON COMPUTER

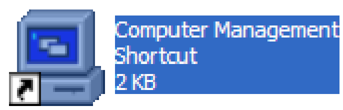
1. Open a terminal window on the console computer and create a VNC connection to the common computer by typing:

   ```
   vncviewer common.local
   ```

   When prompted for a password, enter "debug".

2. When the common computer's desktop appears, bring up the Start menu (the key combination CTRL+ESC will make the task bar appear), and select the Control Panel entry from the menu.

3. Double click on 

to open the *Administrative Tools* folder, and from there, double click on 

to start the Computer Management

4. Select the *Device Manager* tool and expand the Ports entry in the associated tree control:

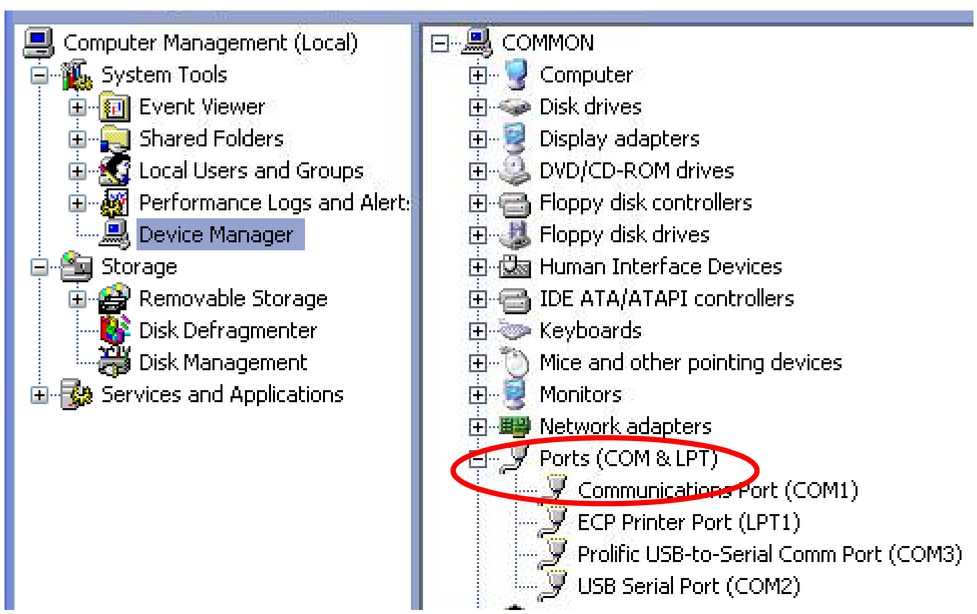


Figure 4-35

5. For each of the ports - COM1, COM2, and COM3 - select the corresponding entry under *Ports* and click on the *Properties* toolbar button  . A properties dialog will appear. Examine the Location property for each COM port:

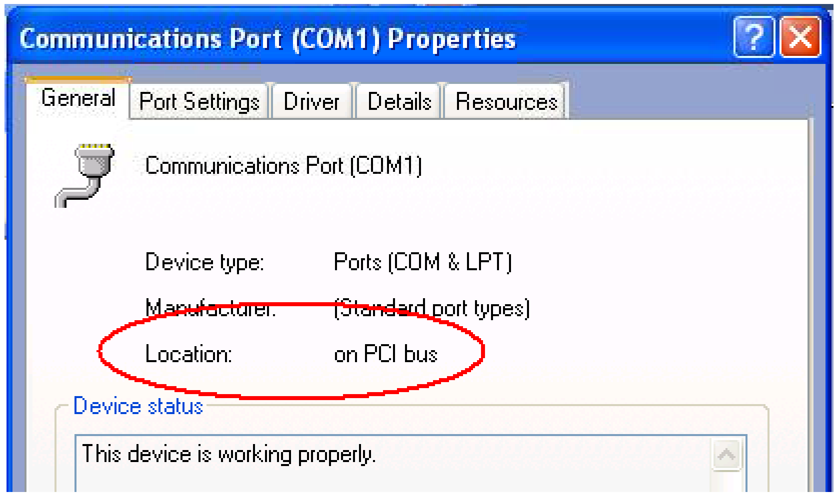


Figure 4-36

If the COM ports are set up correctly, the ports will be mapped to locations as follows:

COM1 - PCI bus

COM2 - USB Serial Converter

COM3 - USB Serial Controller

CONFIRM NETWORK CONNECTIVITY (CONSOLE TO COMMON)

1. Open a terminal window on the console computer and verify that common.local can be reached by ICMP ping packets by typing:

```
ping 192.168.12.100
```

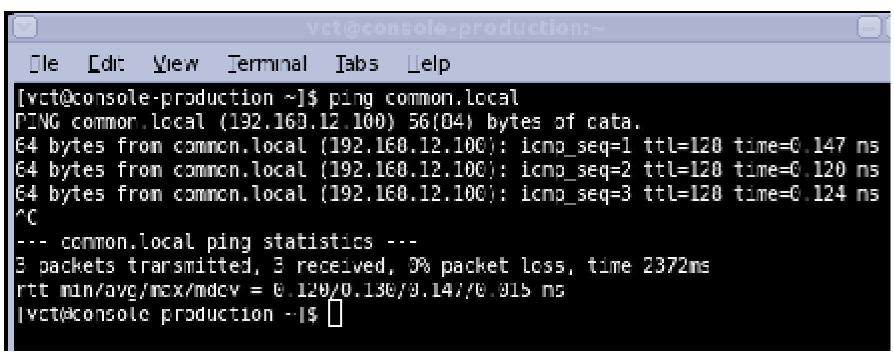


Figure 4-37

If the two machines are properly connected, you will seem messages indicating that bytes have been received from 192.168.12.100. If they are not, you will seem messages indicating that 192.168.12.100 is unreachable.

CONFIRM XMPP FEDERATION IS WORKING

1. If common.local is reachable, verify that the console and common computers are federating via Jabber, by checking the http://192.168.12.100:9090 system administration service page
2. If Jabber federation appears to be working, check common.local's openfire system administration page to verify that bots are actually logged in.
3. If the two systems are federating, and bots are logged in on common.local, but are still not visible on the console's jabber roster, a roster cleanup is required.

VERIFY ENCODER DEVICE NAME IN CT PROPERTIES IS CORRECT

1. The name of the encoder device is defined using the National Instruments Measurement & Automation application. This application runs on the CT computer; so, you will have to VNC to that machine. Open a terminal window on the console computer and type:

```
vncviewer ct.local
```

   When prompted for the password, enter "debug".
2. The CT computer desktop will appear. Use the start menu to launch the Measurement & Automation application, as shown below.

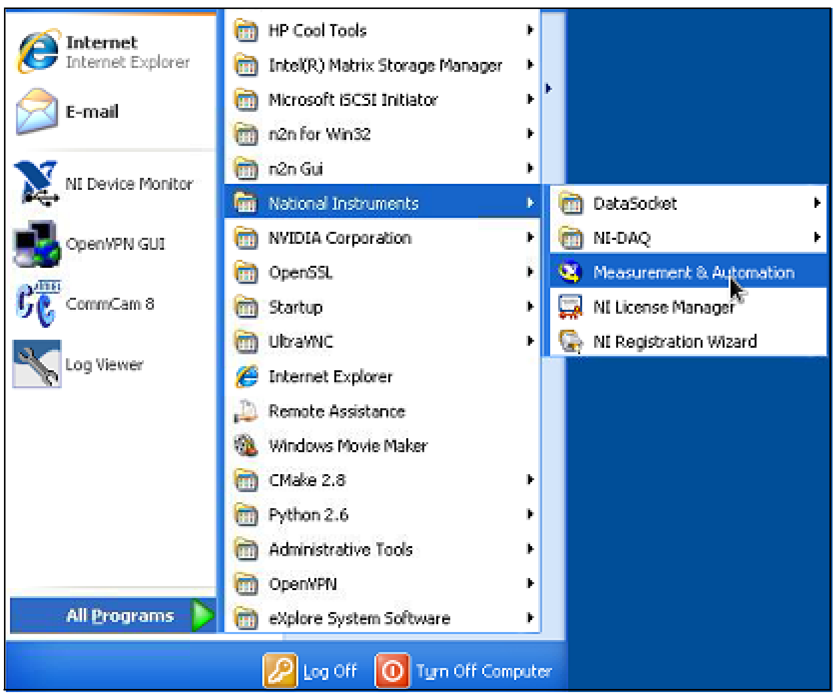


Figure 4-38

3. Expand the configuration tree, as shown below:

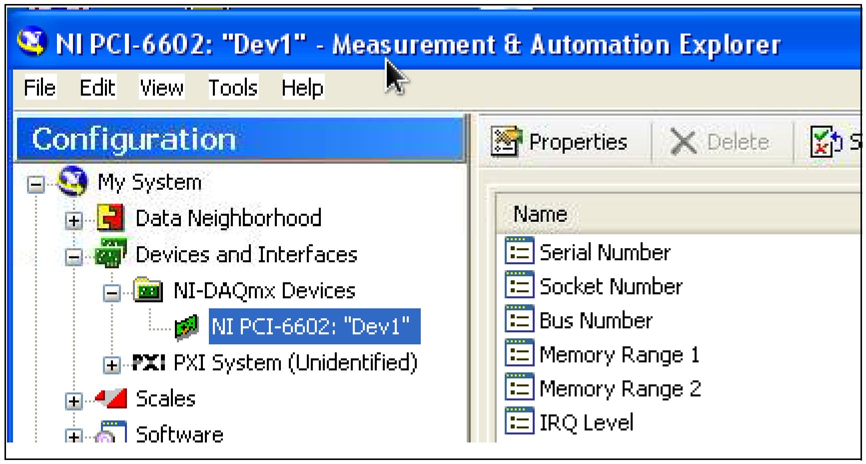


Figure 4-39

The name of the device appears in quotes after the device type description. In this example, the device name is “Dev1”. If a replacement has occurred, you will likely see another device defined - even though there is only one 6602 device in the computer.

4. The name of the encoder device is also recorded in the CT settings (available from the Service panel - System Properties tab of the console application; select ct from the drop-down). This is a reference to the name of the device defined by the Measurement & Automation application. So the two must match in order for the encoder to be programmed properly for a continuous rotation acquisition. Open the CT properties from the console application and verify that the two device names match. If the names do not match, this test fails. Make note of the device name as displayed in the Measurements & Automation application. You will have to fix the name in the CT properties.

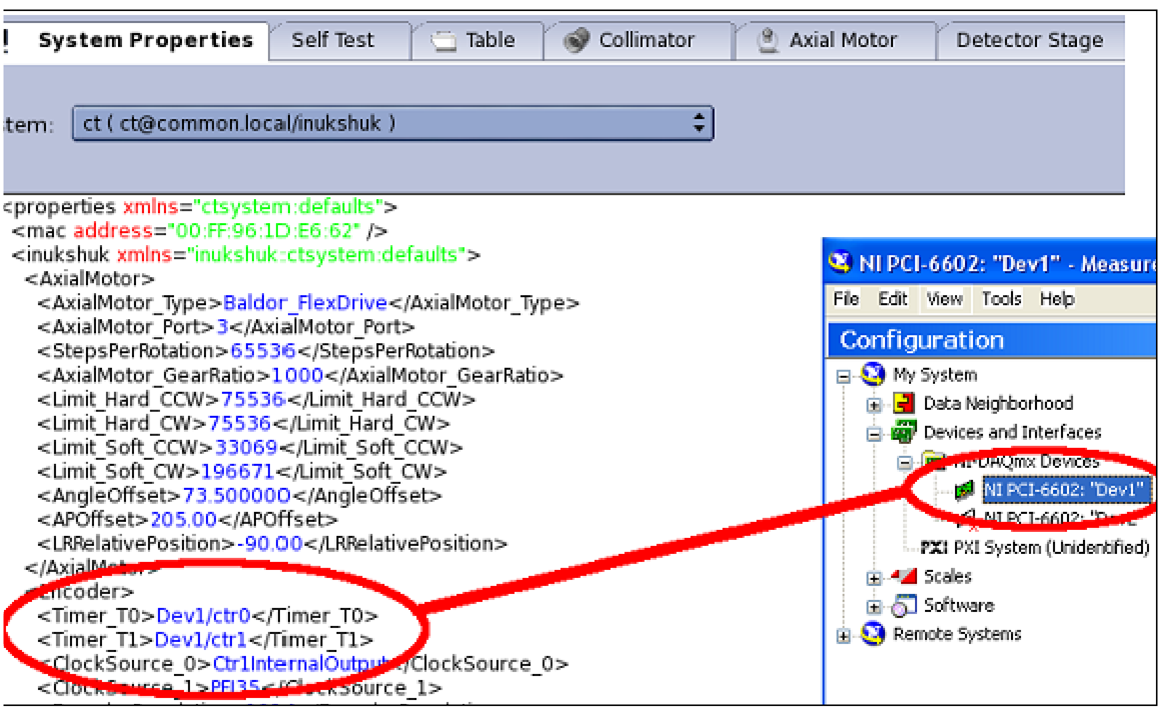


Figure 4-40

CHECK HEALTH OF CONSOLE COMPUTER RAID

Background

RAID

A **Redundant Array of Inexpensive Disks** or RAID, is a technology that allowed computer users to achieve high levels of storage reliability from low-cost and less reliable PC-class disk-drive components, via the technique of arranging the devices into arrays for redundancy.

eXplore Console Specifics

Hardware Layout

The console computer contains 5 SATA hard disks. The first hard disk is typically an 80 GB capacity drive that contains the operating system and application software that boots the computer. The remaining 4 500 GB drives form a data storage pool on to which end-user scan data resides. Using standard linux device name conventions, the low level devices are:

```
/dev/sda    - 80 GB boot disk
/dev/sdb    - 500 GB data drive
/dev/sdc    - 500 GB data drive
/dev/sdd    - 500 GB data drive
/dev/sde    - 500 GB data drive
```

Each of the data drives contains one partition, marked as a software RAID device:

```
/dev/sdb1
/dev/sdc1
/dev/sdd1
/dev/sde1
```

Two software RAID-1 (mirrored) virtual devices are formed out of the collection of data devices:

```
/dev/md0    - /dev/sdb1, /dev/sdc1
/dev/md1    - /dev/sdd1, /dev/sde1
```

Finally, the two software RAID-1 devices, /dev/md0 and /dev/md1 are striped across (using software called LVM), to form the final data drive:

```
/dev/mapper/VolGroup01-data_disk    - /dev/md0 and /dev/md1
```

The final data device /dev/mapper/VolGroup01-data_disk functions much the same way as a software or hardware RAID-10 device (e.g. a striped collection of mirrored disks), but has some management advantages -- it can be extended in a slightly more flexible fashion across additional devices.

Checking for SCSI/SATA drives

SATA drives, under Linux, appear to the system as SCSI disks, and so have device names like `/dev/sda1, /dev/sdb1` etc. To get a listing of all SATA and SCSI disks that are currently visible to the system, do the following:

1. Open a terminal window on the console computer.
2. Type in the terminal window:

   `cat /proc/scsi/scsi`

   below is the output that follows:

```
[root@console-production vct]# cat /proc/scsi/scsi
Attached devices:
Host: scsi0 Channel: 00 Id: 00 Lun: 00
  Vendor: ATA      Model: ST380815AS       Rev: 3.CH
  Type:   Direct-Access                    ANSI  SCSI revision: 05
Host: scsi1 Channel: 00 Id: 00 Lun: 00
  Vendor: ATA      Model: ST3500620AS      Rev: HP12
  Type:   Direct-Access                    ANSI  SCSI revision: 05
Host: scsi2 Channel: 00 Id: 00 Lun: 00
  Vendor: ATA      Model: ST3500620AS      Rev: HP12
  Type:   Direct-Access                    ANSI  SCSI revision: 05
Host: scsi3 Channel: 00 Id: 00 Lun: 00
  Vendor: ATA      Model: ST3500620AS      Rev: HP12
  Type:   Direct-Access                    ANSI  SCSI revision: 05
Host: scsi4 Channel: 00 Id: 00 Lun: 00
  Vendor: ATA      Model: SAMSUNG HD502IJ  Rev: 1AA0
  Type:   Direct-Access                    ANSI  SCSI revision: 05
Host: scsi8 Channel: 00 Id: 00 Lun: 00
  Vendor: ATAPI    Model: DVD A  DH16A3L   Rev: 8H3D
  Type:   CD-ROM                           ANSI  SCSI revision: 00
```

3. Examine the result and determine the health of the RAID. The screen-shot, below, shows a console session where the RAID status is healthy. Notice the presence of `[UU]` on the status output for both `/dev/md0` and `/dev/md1`:

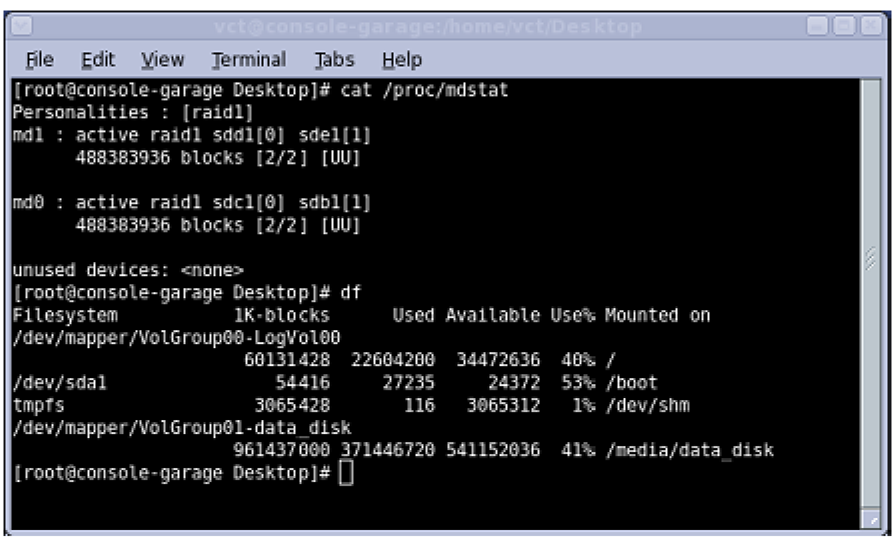


Figure 4-41

The next screen-shot shows a console session where the RAID status is degraded. Notice the presence of `[U_]` on the status output for `/dev/md0`. This indicates that the `device /dev/sdb1` has been marked as failed. This doesn't necessarily indicate a hardware failure - first one should re-initialize the drive, then monitor for subsequent failures. In most cases, the drive is not physically defective and can be successfully reinserted into the RAID array.

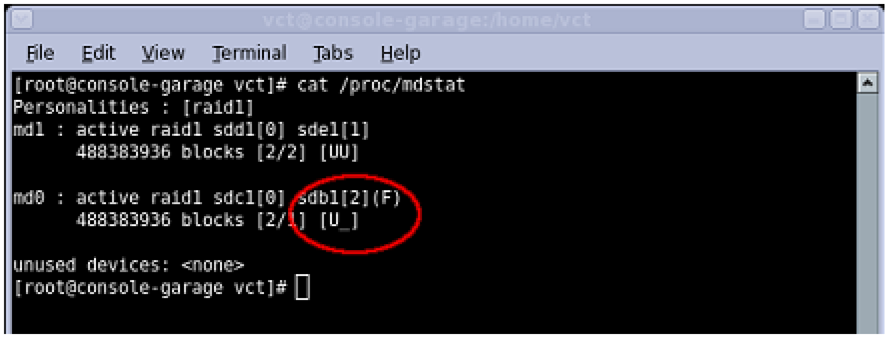


Figure 4-42

CHECKING THE ENCODER CONNECTION FROM THE CT COMPUTER TO THE X-RAY CONTROL BOX.

1. Open the side panel of the CT gantry to reveal the CT computer.
2. Examine the SCSI-type cable connecting the CT computer to the x-ray control box. Make sure it is connected (Figure 4-43).
3. Open the back panel of the CT gantry to reveal the CT connection box at the bottom of the gantry assembly (next to the CT PDU).
4. Verify that the SCSI-type cable is connected firmly to the board at the top of the unit (Figure 4-44)

Figure 4-43

Figure 4-44

Section 4.5
Solutions

RECON QUEUE RESET PROCEDURE

The recon queue, after the console is renamed, will appear empty and non responsive. This occurs because the queue must be recreated using the new console name. To reset the queue, follow the steps below.

1. Start the Gajim chat client on the console. This is done by moving the mouse to the top of the left monitor and selecting Applications --> Internet --> Gajim Instant Messenger.

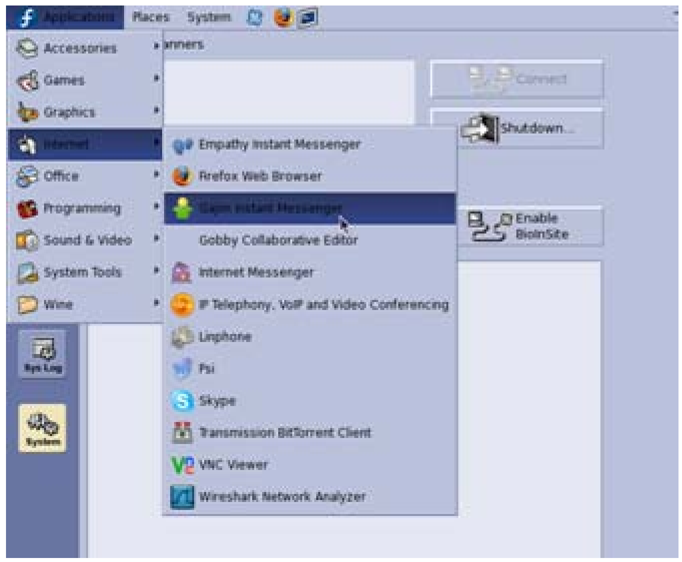


Figure 4-45

2. To log into the console using Gajim, right click on the console account and select the Status --> Available.

Figure 4-46

3. Once the chat client is logged in, find the recon server entry and right click selecting “Chat”. If you have more than one recon server listed, let the mouse hover over the entry to find out the console it is running on; it can be determined by examining the tool-tip that appears.

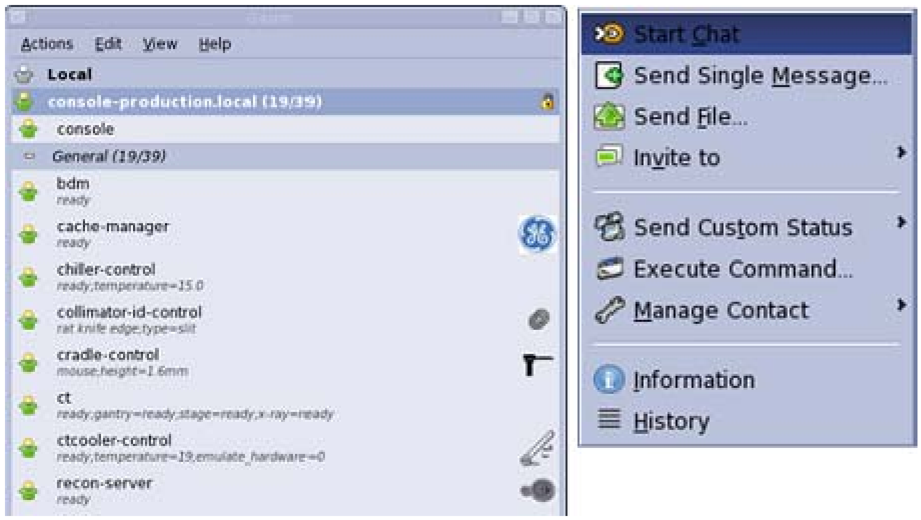


Figure 4-47

4. In the chat window type “help” and press enter to get a list of commands. Next, type “delete pubsub” and press enter. Finally, type “create pubsub” and press enter. Close the chat window and Gajim client application, once you are done.
5. Restart the console application (not the console computer): disconnect from the scanner and shutdown the console application; then, start the eXplore Console using the desktop icon.

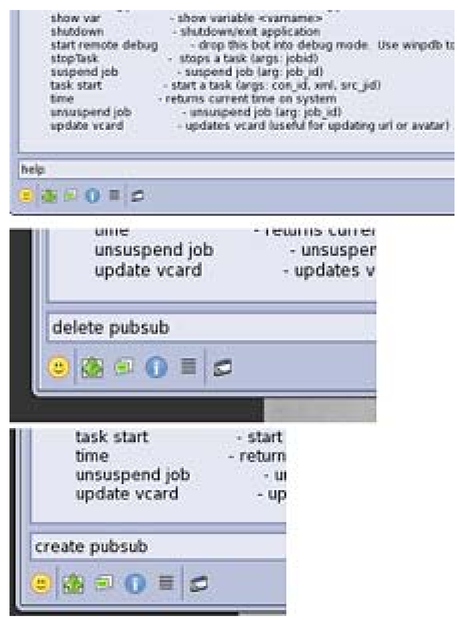


Figure 4-48

XMPP JABBER ROSTER RESTORE

1. Start the gajim XMPP client and select all bots that are in a 'hung' state (see Test: Confirm XMPP Federation is Working).
2. Remove them from the console's roster by hitting the delete key.
3. Restart the console application - a number of roster request messages will appear on the console -- you can ignore these.

SPECIFYING THE ENCODER DEVICE NAME IN THE CT PROPERTIES

1. From the console application, navigate to the Service Panel - System Properties tab. Select ct from the drop-down to display the CT properties.
2. Find the Encoder element; it will contain a Timer_T0 and Timer_T1 element. These elements specify a device and counter name, in the format:

   device/counter
3. Change the device portion of the name to match what is defined by the Measurements & Automation application (see the test: Verify Encoder Device Name in CT Properties is Correct on page -88).
4. Click the Save button and restart the scanner.

FIXING A DEGRADED RAID

Using the above hardware failure, we can fix it by following steps 1-5 (Figure 4-49)

1. Open a terminal window on the console computer and become root user by typing

   `su`

   Enter the password “operator” when prompted.
2. Check status of RAID and determine which drive needs synchronization by typing:

   `cat /proc/mdstat`
3. Determine which raw device has failed (e.g., `/dev/sdb1`), and remove it from the corresponding RAID device (e.g., `/dev/md0`):

   `/sbin/mdadm --manage /dev/md0 --remove /dev/sdb1`

Note: Replace `md0` and `sdb1` with the device and raw device names that you have determined are causing the issue.

Note: This step may not be necessary if you don't see all 4 raw drives in the contents of `/proc/mdstat`

4. Add the raw device back to the RAID array as a hot spare by typing:

   `/sbin/mdadm --manage /dev/md0 --add /dev/sdb1`

Note: Replace `md0` and `sdb1` with the device and raw device names that you have determined are causing the issue.

5. Monitor recovery progress

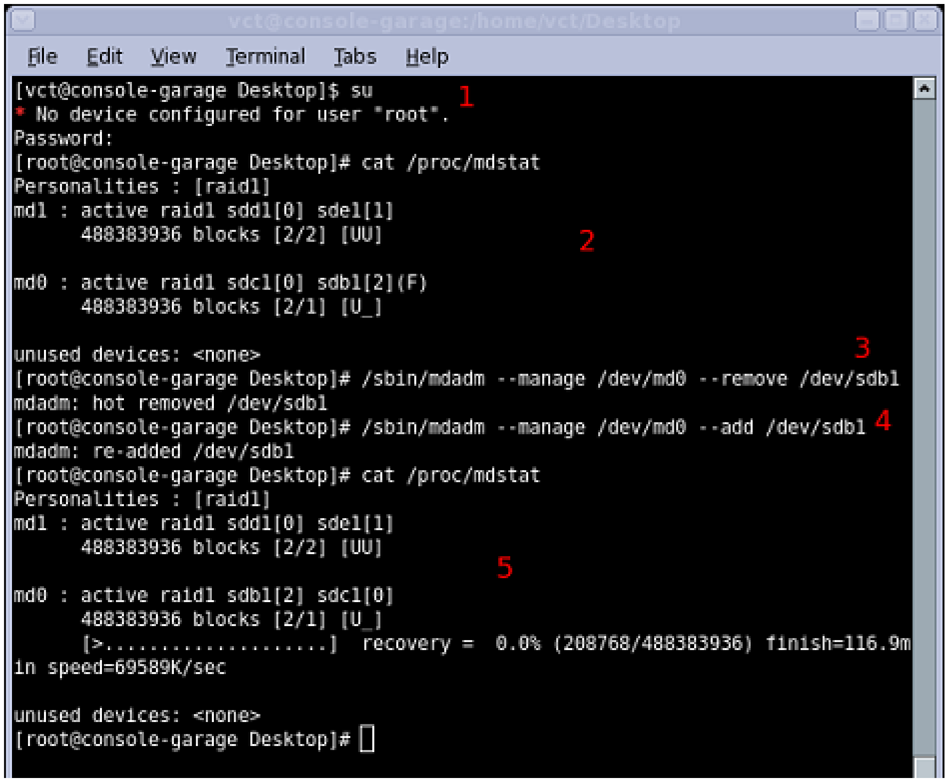


Figure 4-49

6. If the recovery process is successful, exit this procedure now.
7. If the raw device cannot be re-inserted into the RAID, you will have to acquire a new drive and replace the defective drive.

Note: These instructions apply if the RAID is being completely replaced (i.e. customer has backed up data and understands RAID is being reformatted).

8. As root user, `edit /etc/fstab`. Use `gedit` to edit the file. Look for the line that looks like this:

```
/dev/VolGroup01/data_disk /media/data_disk      ext4     defaults        1 0
```

and put a comment mark as the first character in this line, e.g.:

```
#/dev/VolGroup01/data_disk /media/data_disk      ext4     defaults        1 0
```

Note: It may say 'ext3' rather than 'ext4' as above, but that's okay. The point here is the comment-out the line telling the computer to automatically mount the data drive at boot time. Otherwise, when you remove the 4 drives in step 2, the machine won't boot fully and will require manual intervention

9. Shut down console computer. Once powered off, replace all 4 drives with new drives. Turn computer power back on.
10. Log in as usual (vct user).
11. Close the console application so you can see the desktop.
12. Look on the right hand side to see if disks have been automatically mounted (if they arrived unformatted this won't happen - if they came with a VFAT file system they may automatically mount -- see note in step 8).
13. On any data disk icons you see, right click on each icon, select “unmount” from popup menu.

14. Open a terminal window and type:

    `su` (password: operator)

15. Type:

    `/sbin/mkdatadisk`

16. Monitor the command output for errors.
17. Edit `/etc/fstab` again, and uncomment (i.e. remove leading '#' character) the data disk line (same line you edited before).
18. Reboot the console computer

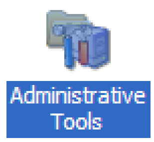
SETUP COMMON COM PORTS

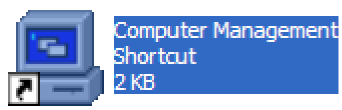
1. Open a terminal window on the console computer and create a VNC connection to the common computer by typing:

    `vncviewer common.local`

    When prompted for a password, enter "debug".

2. When the common computer's desktop appears, bring up the Start menu (the key combination CTRL+ESC will make the task bar appear), and select the Control Panel entry from the menu.

3. Double click on 

to open the *Administrative Tools* folder, and from there, double click on 

to start the Computer Management

4. Select the *Device Manager* tool and expand the Ports entry in the associated tree control:

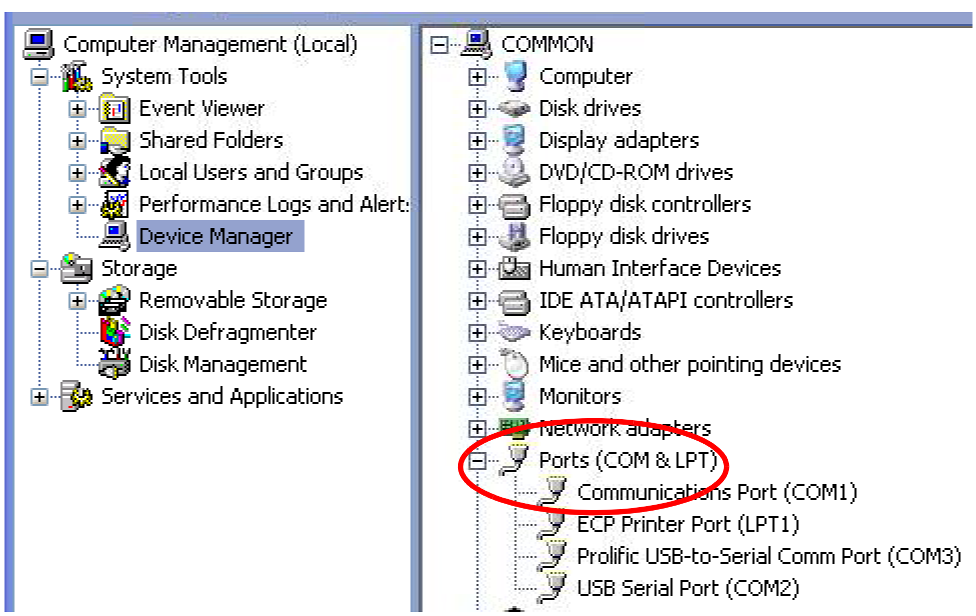


Figure 4-50

For each of the ports - COM1, COM2, and COM3 - select the corresponding entry under *Ports* and click on the *Properties* toolbar button  . A properties dialog will appear. Examine the Location property for each COM port:

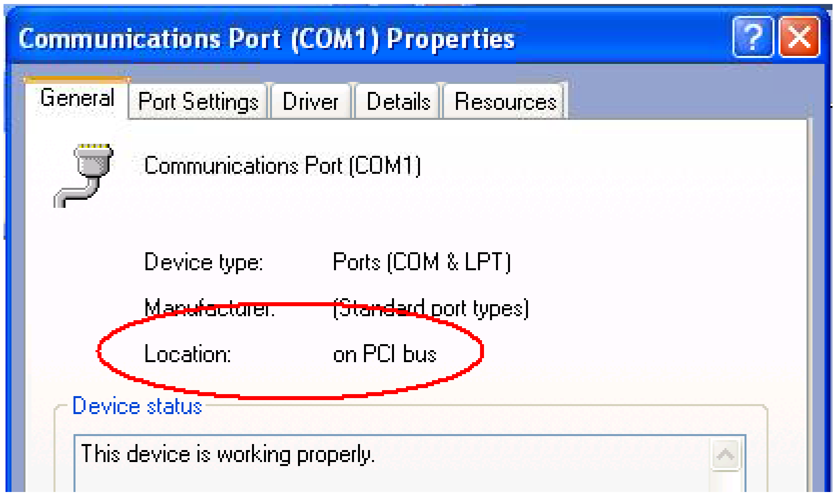


Figure 4-51

5. Make note of the current COM port/location pairings. They should be as shown below, but make note of the mismatches.

COM1 - should be PCI bus, but is ________________.

COM2 - should be USB Serial Converter, but is ___________________.

COM3 - should be USB Serial Controller, but is ___________________.

6. For each of the mismatched COM ports, activate the Port Settings tab and click the Advanced button:

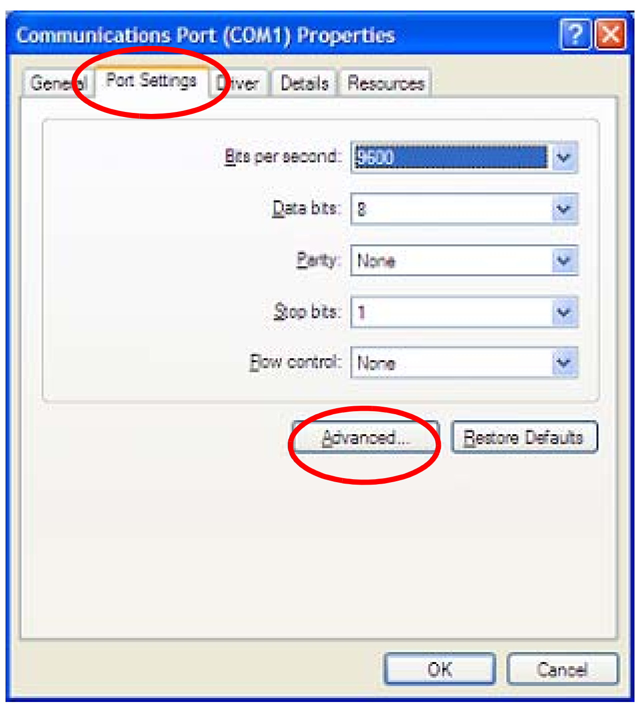
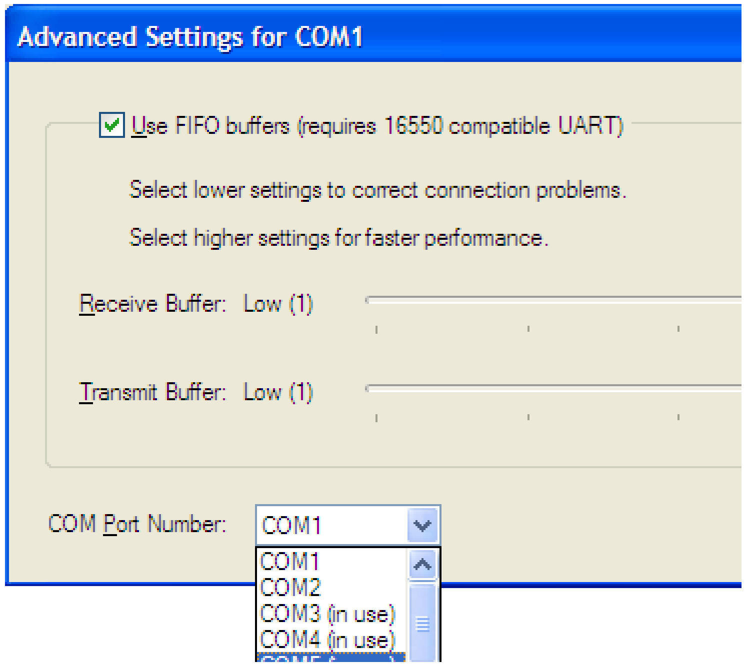


Figure 4-52

7. The Advanced Settings dialog will appear. Use the COM Port Number drop-down to select the correct port number according to the information gathered in step 5.



For example, if COM3 has a location setting of PCI bus, then change it to be COM1, as this is the COM port that should be associated with that location.

8. After all the COM port settings are corrected, close the Computer Management application and the Administrative Tools folder. Close the VNC window for the common computer
9. Power cycle the scanner and confirm that a normal power up occurs.

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
TABLE	Touch Screen display does not start	Table Computer failed	Check breaker at J2 on Main (Table) PDU	Reset breaker if tripped
			Ping or vnc from Console to check computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration. Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
		Power to Touch Screen failed	Check power cord at rear of Touch Screen	Push firmly in place
			Check breakers on Main (Table) PDU	Reset breaker if tripped
	Touch Screen display available but not responsive to touch	USB connection on Touch Screen	Check USB cable at both ends	Push connectors in firmly

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
TABLE	Table icon greyed out on Console	Table Computer failed	Check breaker at J2 on Main (Table) PDU	Reset breaker if tripped
			Ping or vnc from Console to check computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration. Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
			Minimize Touch Screen display & check computer for errors on dialog box	

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
TABLE	Table icon greyed out on Console	Serial Port Assignments	Check Properties on Console for Port assignments Minimize Touch Screen display & check port assignments under Properties on dialog box Use Instant Messenger to check Port assignments	Reset assignments as needed

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
TABLE	Scanner (CT or SPECT) available but not responsive	Table Computer failed	Check breaker at J2 on Main (Table) PDU	Reset breaker if tripped
			Ping or vnc from Console to check computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration. Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
			Minimize Touch Screen display & check computer for errors on dialog box	

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
TABLE	Stage/Cradle will not move	Table Computer failed	Check breaker at J2 on Main (Table) PDU	Reset breaker if tripped
			Ping or vnc from Console to check computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration. Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
			Minimize Touch Screen display & check computer for errors on dialog box	

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
TABLE	Stage/Cradle will not move or is noisy	Motion Control System failed	Check connections to servo motor	Replace servo motor. Use SmartMotor interface on Table Computer to set up new motor.
			Check for binding in the linear positioner	Replace linear positioner
	Table Shield does not slide easily or is noisy	Drawer Slide(s) failed	Remove Table Shield and check each Drawer Slide individually	Replace Drawer Slide(s)
	Cable Track binds or is noisy	Link on Cable Track failed	Visually inspect for fault	Replace link
	Table Shield hard to open or noisy	Broken Torsion Spring	Visually inspect for broken Torsion Spring(s)	Replace broken Torsion Spring(s)
		Hinge failed	Visually inspect for damage to Hinge components	Replace damaged Hinge components

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	SPECT appears to be scanning (progress bar advances) but counts are not increasing	SPECT Computer failed	Check breaker at J3 on Main (Table) PDU	Reset breaker if tripped
			Ping or vnc from Console to check computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration, maps (energy & uniformity) & stackograms (geometry). Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
			Minimize Touch Screen display & check computer for errors on dialog box	
		Run out of disk space	Check disk space on SPECT Computer	Delete old files with customer permission

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Chiller icon greyed out	SPECT Computer failed	Check breaker at J3 on Main (Table) PDU	Reset breaker if tripped
			Ping or vnc from Console to check computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration, maps (energy & uniformity) & stackograms (geometry). Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
			Minimize Touch Screen display & check computer for errors on dialog box	

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Chiller slow to reach operating temperature (15°C nominal)	Coolant level low	Check Chiller Service page on Console for error message	Add coolant. Check for leaks on Chiller lines and tighten fittings/replace as necessary.
			Remove left cover at base of SPECT and look for "Coolant Low" indication on display on top of Chiller	
		Chiller failed	Check breaker at J15 on Main (Table) PDU	Reset breaker if tripped
			Remove SPECT left side cover and check if display on top of Chiller active	Toggle power switch on Chiller off then on. If Chiller fails to start, replace Chiller.

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Fluid on floor below SPECT unit	Detector coolant leak	Check chiller lines and fittings for leaks	Tighten fittings or replace Chiller lines as required. Top up coolant.
			Check Cooling Ring for signs of corrosion or cracks. This will require removal of radiation shields.	Replace Cooling Ring
	Landmark Lasers not functioning	Master RTB board failed	Attempt to set relays in System Monitor program from Instant Messenger	If unresponsive, replace Master RTB board

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Cannot find Collimator	SPECT Computer does not recognize Barcode Scanner	Reboot SPECT Computer. Ping or vnc SPECT Computer from Console to ensure it is healthy.	Replace computer if diagnosis indicates Computer unresponsive. Load software. Load configuration. Reassign serial ports.
		Barcode Scanner failed	Check if barcode lights illuminated	If lights off, check connection to SPECT computer. If OK, replace Barcode Scanner.
			Check with paper barcode in front of Scanner	If lights fail to go off, replace Barcode Scanner.
		Barcode label on Collimator missing or damaged	Inspect Collimator	Replace label or Collimator

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Cannot find Collimator	Mismatch between Table and Collimator	Check that Cradle and Collimator are of same type (rat or mouse)	Change Cradle or Collimator until types match
		Optical Reader for Cradle non-functional	Change Cradle and hover the computer mouse over Cradle icon	If Cradle not recognized, ensure Optical Reader is clean and unobstructed. If so, replace Reader.
	One area of SPECT flood scan is black	CZT Module failed	Check ribbon cable between suspect CZT Module and Ring PCB	If connectors properly seated and ribbon not broken, replace CZT Module & perform SPECT cal. procedures

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	One area of SPECT flood scan is black	Faulty ribbon cable between CZT Module and Ring PCB	Inspect ribbon cable for wire breaks	Replace ribbon cable
		Firmware in SPECT Computer needs updating	In the c:\Inukshuk\executables, double click “EEPROM_2.2.exe”	If firmware update does not resolve problem, replace CZT Module & perform SPECT cal. procedures
			Go to “SPI” tab	
			1.Type the chip index number that corresponds to the firmware that needs updating	
			2.Type “9D” SPI command to read module serial number (lower part)	
			3.Type “9E” SPI command to read module serial number (higher part)	
			4.Type “86” SPI command to read module firmware version	
			Refer to V40 CZT user manual for all other SPI commands	

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	SPECT image poor	Septa damaged	Remove SPECT side covers and radiation shields. Inspect Septa for bent plates	Replace Septa if damaged. Recalibrate for alignment.
		Play in Septa linkage	Remove SPECT Side covers and radiation shields. Inspect linkage for wear and play.	Replace Septa linkage if worn. Recalibrate for alignment.
SPECT	Septa fails to move	Stepper Motor failed	Check breaker at J4 on Main (Table) PDU	Reset breaker if tripped
		Septa program failed	If Septa tab greyed out on Service Pages, enter System Monitor program on Instant Messenger	Restart program
		Serial Port Assignments	Use Instant Messenger to check Port assignments	Reassign serial ports. If Motor still fails to respond, replace Motor. Recalibrate for alignment.

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Bad SPECT reconstructions	Play in Servoring Motor	Collimator must not exhibit play when rotated by hand	Replace Servoring. Flash with new firmware using Copley Motion Explorer software (located on SPECT Computer). Verify that collimator rotates clockwise when viewed from front of machine.
		Replacement Servoring rotates in wrong direction	Check that collimator rotates clockwise when viewed from the front of the machine.	Flash the firmware for the replacement Servoring using Copley Motion Explorer software located on SPECT computer

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
SPECT	Collimator noisy when rotating	Faulty Servoring	Verify that noise is from Servoring	Replace Servoring. Flash with new firmware using Copley Motion Explorer software located on SPECT Computer. Verify that collimator rotates clockwise when viewed from front of machine.
	Collimator Support drops quickly when opened	Faulty Gas Shock(s)	Remove and check Shocks individually	Replace faulty Shock(s)

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CT	CT Scanner available but not working	CT Computer failed	Check breaker at J1 on CT PDU	Reset breaker if tripped
			Ping or vnc from Console to check CT computer status	Replace computer if diagnosis indicates Computer unresponsive. Load software. Reassign serial ports.
			Reboot computer from Reset switch on Table cover	
			Completely power down system and restart	
			Use Instant Messenger to check computer status and status of control software components	
			Minimize Touch Screen display & check computer for errors on dialog box	

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CT	Interlock Button stays on	Table Shield not closed and in position	Inspect Table Shield	Ensure shield is locked down and in place (closest to SPECT unit)
		Cabinet doors not closed	Inspect CT cabinet doors	Ensure doors are securely latched or bolted closed
		Real Time Bus Slave Board failed	Use Instant Messenger to check if Real Time Bus functional	Replace Slave Board
		One or more interlocks failed	Use Instant Messenger to check status of interlocks through Real Time Bus	Check all interlocks and replace failed interlock
	X-Ray lights go on but CT images are not created. No noise heard from X-Ray Generator (speCZT CT120 & eXplore CT 120 only)	Generator Control Box failed	Check breaker at J2 on CT PDU	Reset breaker if tripped
			If power available, scope input and output of box to determine whether or not it responds	Replace Generator Control Box if unresponsive
		Dunlee or SRI tube failed	Check tube manuals for troubleshooting procedures	Replace tube if faulty or suspect
		X-Ray Generator failed	Check X-Ray Generator manual for troubleshooting procedures	Per X-Ray Generator Manual

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CT	X-Ray lights go on but CT images are not created.	Transfer Bot failed	Use Instant Messenger to check status of Transfer Bots.	Use Instant Messenger to restart Transfer Bot software or restart system
		Run out of disk space	Check disk space on CT Computer	Delete old files with customer permission
		Encoder in Axial Servo Motor failed	N/A	Replace Servo Motor
	Missing scan files in CT scan ("jumps" in the image)	Encoder in Axial Servo Motor failed	N/A	Replace Servo Motor
	CT Scanner indicates it is homing on Gantry icon on Console Computer, but never finishes	Poor coupling between Servo Motor and Baldor gearbox	Observe disc rotation while under software control	If no rotation, replace Servo Motor and/or Baldor Gearhead
	CT Scanner hits a limit with limited or no disc rotation	Broken or dusty servo limit switch	Inspect servo limit switch	Clean or replace servo limit switch

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CT	Loud noises from CT cabinet during disc rotation	Timing Belt - 40 DP broken	Open rear CT cabinet cover and doors, remove Hard-Soft Stop Shield and look for Timing Belt around Hard-Soft Stop Assembly pulley. Extensive damage to Energy Chain & cabling may have occurred.	Replace Timing Belt. Replace Energy Chain and re-cable as necessary.
		Hard-Soft Stop Assembly failed	Check connections to Hard-Soft Stop Assembly	If connections OK, replace Hard-Soft Stop Assembly. Replace Energy Chain and re-cable as necessary.
		Faulty Energy Chain Pulley	Inspect each Pulley guiding the Energy Chain	Replace noisy Pulley and/or Pulley Mount
		Link on Energy Chain failed	Visual inspection of links	Replace Link

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CT	Indexer/Rotating Lock fails to lock disc motion	Teeth on Indexer/Rotating Lock or Belt Gear Drive stripped	Visual inspection of both	Replace Indexer/Rotating Lock or Belt Gear
	No images or noisy images	Temperature Controller failed	Check Console to see if Controller temperature is in range. If not, check that it has power from Disc Power Box.	Replace Temperature Controller if power available but not maintaining temperature. Check Detector for heat damage. Replace and recalibrate Detector if required.
		Detector	Visually inspect Detector for heat damage. Check that fan filter is unobstructed and Temperature Controller functioning.	Replace Detector. Ensure cooling systems (Temp. Controller & Fan) are functioning. If not, replace them before restarting system. Recalibrate Detector.

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CT	No X-Ray lights or images	Interlock Box failed (speCZT CT 120 or eXplore 120)	Check if Box is receiving power from PDU (J6 on CT PDU or J1 on Interlock Box). Check that it responds to Generator Control Box signals	Replace Interlock Box
		SRI Control Box failed (speCZT CT 80 or eXplore 80)	Check if Box is receiving power from Disc Power Box. Check that it responds to Generator Control Box signals	Replace SRI Control Box

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
X-RAY GENERATOR	Unable to enter Prep state	EL006 indicated on error log (Rotor Fault). Low Speed Starter (and proximity) fuses possibly blown.	Replace fuses if blown. Check impedance of rotor vs. spec sheet.	If impedance of rotor is correct and fuses continue to blow, replace Low Speed Starter Board.
		EL007 indicated on error log (Filament Fault). Filament board fuses (F1 and F2) possibly blown.	Replace fuses and disconnect J5 (output of board). If fuses do not blow, test impedance of filament circuits on tube.	If either filament is open circuit, replace tube. If filaments are good and error continues, replace filament board.
		EL022 indicated on error log (Door Interlock). Possible problem with Room Interface Board.	Check interlock connection on Room Interface Board (TB4 - pins 4 and 5).	Tighten connections. Note: on eXplore CT 120, these pins are jumpered, along with pins 8 and 9. If 8 and 9 are open, EL020 will result.

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
X-RAY GENERATOR	Scan aborted by generator after 1-2 minutes.	EL008 indicated on error log (kV/mA Fault).	Disable all output relays on generator using Receptor Setup in Genware, in order to listen for arcing. Listen for repeatable ticking sound originating from base of generator during exposure. Do not run exposures for more than 30 seconds, with a 2 minute break between each series of exposures.	Replace generator immediately (before catastrophic failure).
	Failure after first exposure of sequence.	EL011 indicated on error log. (High mA Fault)	Re-run sequence with shorter exposure time.	Continue running sequence with shorter exposure time.

MAJOR ASM	SYMPTOM	POSSIBLE CAUSE(S)	DIAGNOSIS/PRELIMINARY CHECK	CORRECTIVE ACTION
CONSOLE	Cannot find scanner on Console	Console Computer failed	Ping or vnc Table, SPECT and CT Computers. Reboot system (including Console).	If unresponsive, reverse Ethernet cable locations on rear of Console Computer Replace computer if Ethernet cable reversal ineffective. Load software. Load configuration. Reassign serial ports. Ensure Openfire is running on Console and/or Table Computer.
	Images are not being displayed during fluoro, scout or scanning	Transfer Bot has failed	Use Instant Messenger to check status of Transfer Bots.	Use Instant Messenger to restart Transfer Bot software or restart system

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Chapter 5
Field Replaceable Units (FRUs)

Section 5.1
Before You Begin

5.1.1 Safety

NOTICE ***REFER TO CHAPTER 1 FOR SAFETY AND HAZARD INFORMATION (PLUS SERVICE SAFETY MEASURES) PRIOR TO SERVICING AND REPLACING PARTS ON THE EXPLORE SPECZT CT.***

CAUTION ***Equipment MUST be locked out during servicing and parts replacement.***
See topic 2.2.1 for details.

LOCKING THE ROTATING BASE

When working on the Gantry, servicing procedures require that the rotating base is locked into position by engaging the Rotating Lock. To access the Lock, removal of the CT Rear Cover will be required.

Turning the Rotating Lock clockwise locks the rotating base. Turning the Lock counterclockwise disengages the Lock. (Figure 5-1)

Figure 5-1

PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Safety shoes*
- Safety glasses*
- Gloves
- LOTO Kit (part of Field Engineers' Tool Kit)*
- Hearing Protection*
- 6' & 8 ' Step ladder

* These PPE items are absolutely required during servicing, with NO exceptions.

Note: *Other items needed to service the system often include paint, masking tape, cleaners, towels, utility knife, Kim Wipes, and other materials needed to service the system.*

WARNING *When servicing the specimen bed, be sure to follow the* ***Blood Borne Pathogens Procedure****.*

When Replacing a Field Replaceable Unit (FRU) please double check all connections to the FRU you just replaced.

5.1.2 Avoid Equipment Damage

NOTICE Gantry bolts ***All bolts used on the Gantry need to be properly torqued. All bolts must be secured with either Loctite or a spring lock washer.***

TORQUE CHART

Size	NM	in-lbs.
M3	0.8	7.1
M4	2.3	20.4
M5	5.0	44.0
M6	7.9	70.0
M8	22.0	195.0
M10	38.4	340.0
M12	66.0	584.0
M14	106.0	938.0
M16	160.0	1416.0

Torque Chart

NOTICE Loose fasteners ***When replacing any parts or assemblies in the eXplore SPECZT CT 120, be extremely cautious with loose fasteners. Due to the nature of the equipment, any loose fasteners may cause damage to the system. Make sure that all screws, washers, etc. are accounted for when working on the equipment.***

ELECTRIC CABLES

For ease of assembly, all electric cables are labeled with a part number and referenced to the corresponding connection to be made.

Section 5.2
Accessing the System & Cover Replacement

Refer to Figure 5-2 and Figure 5-3. Descriptions are provided on the pages following the illustrations for removal and replacement of the covers.

Procedures for removal and replacement of FRUs, once the appropriate covers have been removed, are outlined in Section 5.3.

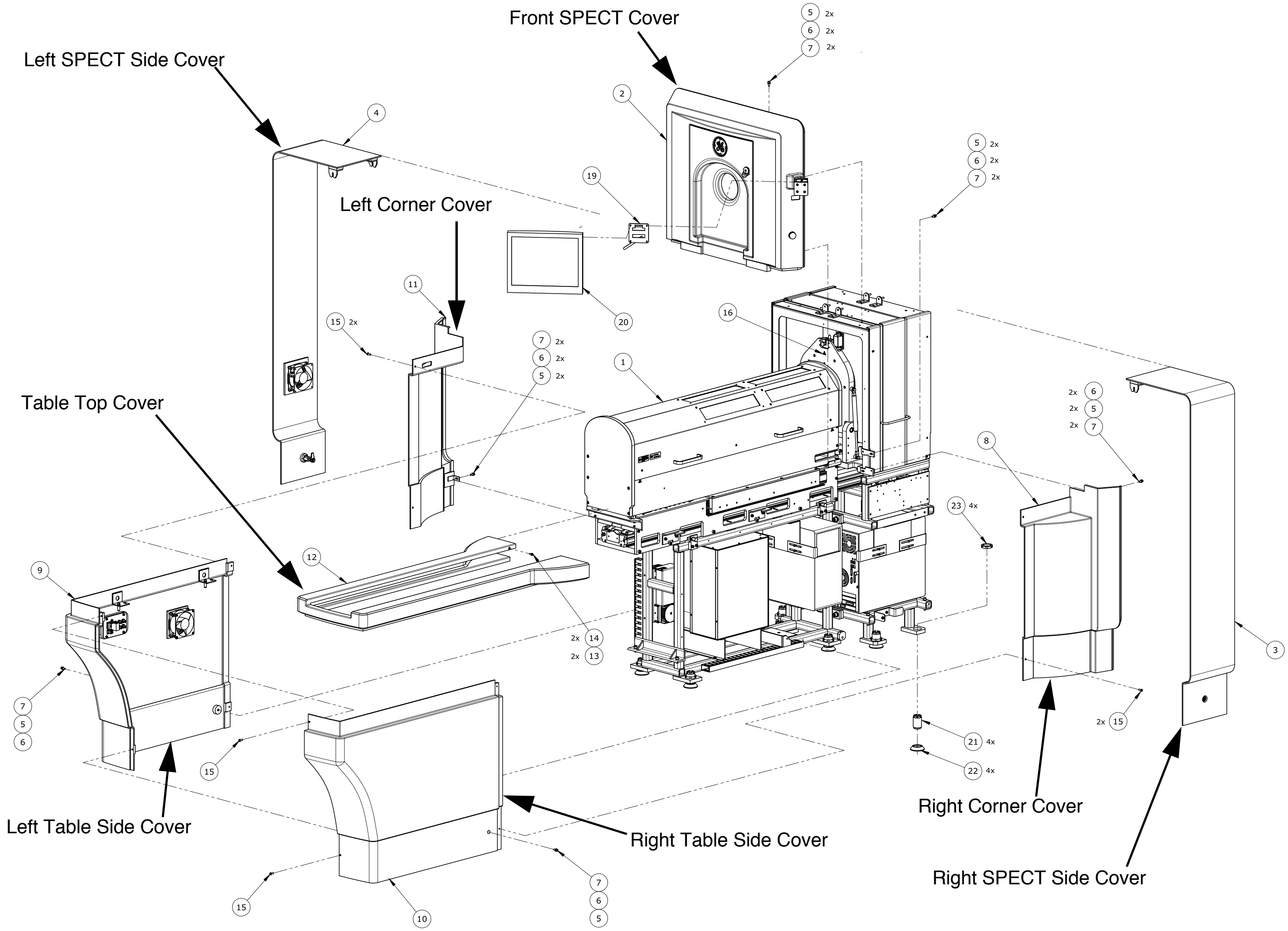


Figure 5-2 SPECZT - Table/SPECT Unit (Long Table)

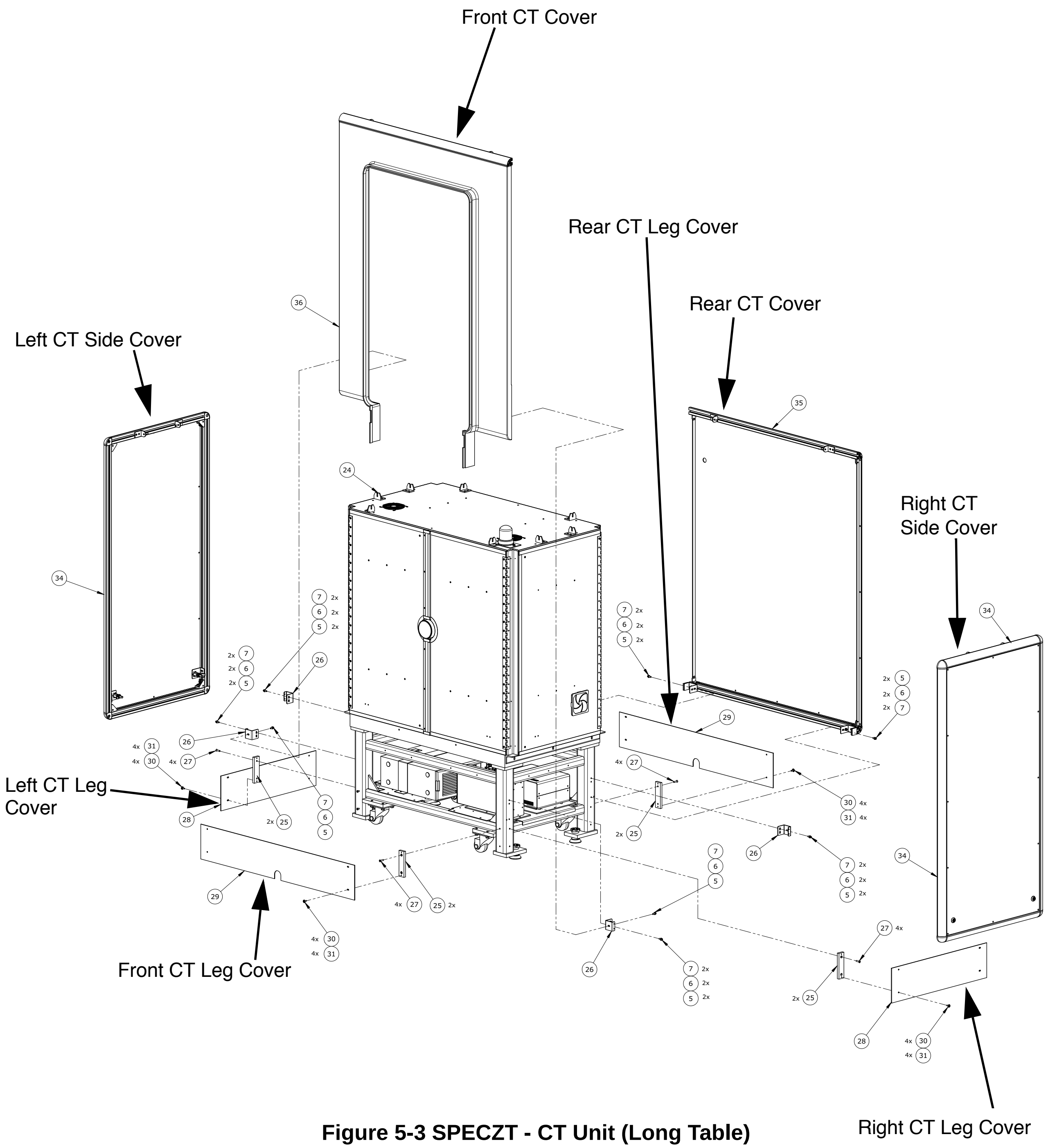


Figure 5-3 SPECZT - CT Unit (Long Table)

5.2.1 Remove Tableside Controller Touch Screen

If access to FRUs inside the SPECT, removal of the touch screen will be necessary.

1. Remove the Power, USB and Signal cables from the rear of the touch screen.
2. While someone supports the touch screen, unfasten the hardware holding the touch screen wall mount to the bracket and set touch screen and hardware aside.

5.2.2 Remove Covers

NOTICE Possible Equipment Damage

The covers are very heavy and awkward. Use extreme care when handling.

The weight of the covers is great enough that the covers will crash to the floor if not supported when the attachment screws are loosened.

REMOVE SPECT UNIT COVERS

The SPECT unit covers should be removed in the following sequence:

1. Using an Allen key, turn the lock at the base of each of the Left Side Cover (5255219, Item 4 in Figure 5-2) and Right Side Cover (5261000, Item 3 in Figure 5-2) one quarter turn counterclockwise. Lift until the brackets un-hook at the top. On the Left Side Cover, disconnect the fan cable. Carefully set covers aside.
2. From the top of the SPECT unit, remove two (2) M6 socket screws (2109867-13), lock washers (2109880-3) and flat washers (2109878-3) holding down the brackets on the SPECT Upper Front Cover (5195387, Item 2 on Figure 5-2). Also remove two (2) M6 socket screws (2109867-13), lock washers (2109880-3) and flat washers (2109878-3) holding the cover to the SPECT unit through brackets on either side of the base of the unit. See Figure 5-2, Items 5,6 and 7 for hardware locations. Lift cover higher than the Table shield and carry to a safe storage location.

REMOVE TABLE UNIT COVERS

Removing the Table unit covers will provide access to the Table base assembly and all Table electronics. See Figure 5-2.

1. Remove two (2) screws (2109872-7, Item 15) from each of the Left Corner Cover (5192474, Item 11) and the Right Corner Cover (5192473, Item 8).
2. Remove two (2) M6 socket screws (2109867-13, Item 7), lock washers (2109880-3, Item 6) and flat washers (2109878-3, Item 5) holding the rear brackets of the covers in step 1. to the SPECT unit and set aside. Carefully set covers aside.
3. Starting with the Table Right Side Cover (5261388, Item 10), remove two (2) screws (2109872-7, Item 15) from the front edge and set aside. Remove one (1) M6 socket screw (2109867-13, Item 7), lock washer (2109880-3, Item 6) and flat washer (2109878-3, Item 5) and set aside. Carefully set cover aside.
4. From the Table Left Side Cover (5261389, Item 9), remove one (1) M6 socket screw (2109867-13, Item 7), lock washer (2109880-3, Item 6) and flat washer (2109878-3, Item 5) and set aside. Disconnect inline connectors from switch panel and fan. Carefully set cover aside.

5. Move Table Shield back until M5 socket screws (2390619-2, Item 14) are visible at the gantry end of the Table Top Cover (5192465, Item 12). Remove them (2 locations) along with two (2) flat washers (2109878-7, Item 13) and set aside. Slide cover away from the gantry and carefully set aside.

REMOVE CT UNIT COVERS

See Figure 5-3.

1. Using an Allen key, turn the two (2) locks near the base of each CT Side Cover (5237776, Item 34) counterclockwise until the bottom of each cover is free of the CT unit. Unhook each cover from the top of the CT unit and lift away.
2. The hardware securing the bottom of the CT Rear Cover (5237777, Item 35) is now accessible. Remove two (2) M6 socket screws (2109867-13, Item 7), lock washers (2109880-3, Item 6) and flat washers (2109878-3, Item 5) holding each of the brackets on the cover to the CT unit base and set aside. Unhook the cover from the top of the CT unit and lift away.
3. Remove one (1) M6 socket screw (2109867-13, Item 7), lock washer (2109880-3, Item 6) and flat washer (2109878-3, Item 5) holding the CT Front Cover (5237778, Item 3) to each of the brackets on the CT unit base and set aside. Using a person on either side of the unit, unhook the cover from the top of the CT unit and carefully carry the cover all the way to the end of the Table unit. Store flat to avoid damage.

5.2.3 Replace Covers

When installing covers where a screw, lock washer and flat washer are used, ensure that the lock washer is always placed on the screw first so that it is between the screw head and the flat washer.

REPLACE SPECT UNIT COVERS

Replacing the SPECT Unit Covers is the same procedure as "Remove SPECT Unit Covers", but in reverse.

REPLACE TABLE UNIT COVERS

Replacing the Table Unit Covers for the Long Table is the same procedure as "Remove Table Unit Covers (Long Table)", but in reverse.

REPLACE CT UNIT COVERS

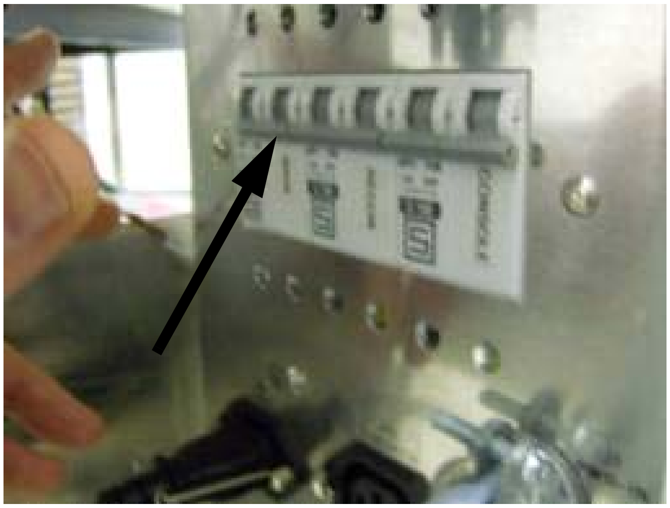
Replacing the CT Unit Covers for the Long Table (SPECT-CT) is the same procedure as "Remove CT Unit Covers (Long Table)", but in reverse.

5.2.4 Replace Tableside Controller Touch Screen

Replacing the Tableside Controller Touch Screen is the same procedure as "Remove Tableside Controller Touch Screen", but in reverse.

5.2.5 Power Down System

Before proceeding with removal and replacement of FRUs, power down the system by switching off the main breaker on the PDU.



Section 5.3
SpeCZT CT 120 (5169192) Table Component FRUs

5.3.1 Table Computer (5251975)

Preconditions

- The Table side and corner covers are removed.
- The machine is powered OFF using the main breaker on the PDU.

Refer to Figure 5-4.

Removal

1. Unplug all cables from the rear panel of the computer (Item 6), noting their locations.
2. Remove two (2) 6mm socket screws (2109867-12, Item 18) and set aside with two (2) flat washers (2109879-2, Item 20) and two (2) lock washers (2109880-3, Item 19).
3. Set aside computer bracket assembly (Items 7&8). Carefully slide computer out from its shelf

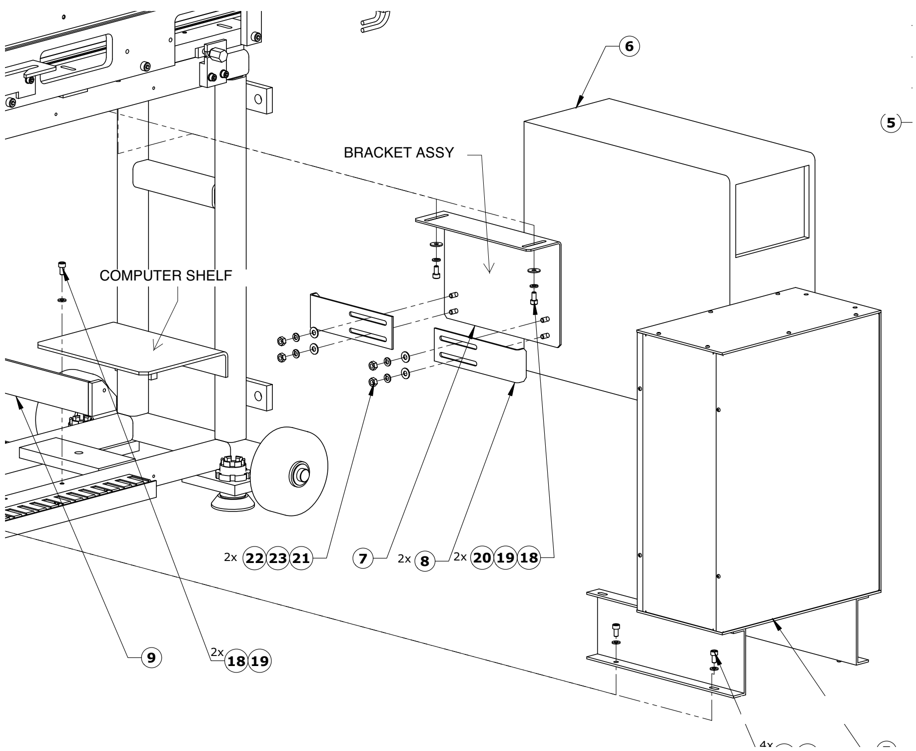


Figure 5-4

Replacement

1. Slide computer onto shelf with front panel oriented as shown in the illustration.
2. Adjust the slide brackets to fit firmly against the computer. Tighten the four nuts.
3. Add lock washer then flat washer to socket screws set aside during removal and fasten to table base. Torque to 70 in-lb (Figure 5-5 left).
4. Reconnect all cables to rear panel of computer and secure.

NOTICE 5. **Check the switch on the back of the computer** and verify that it is set to 230V (Figure 5-5 right).

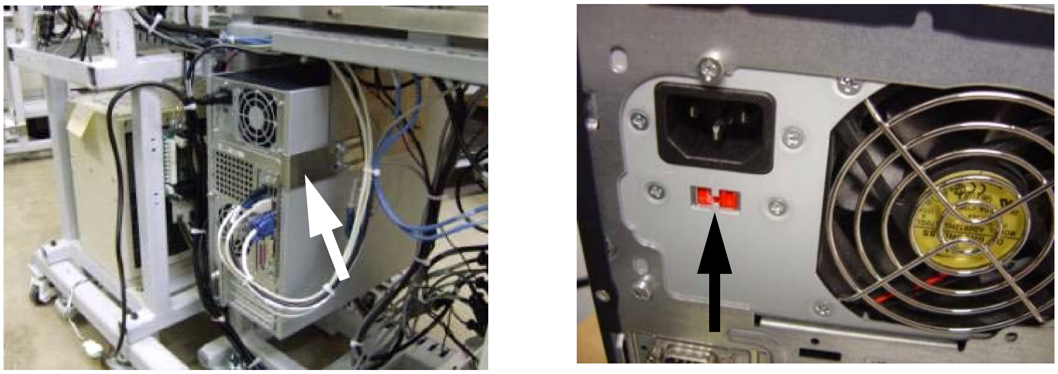
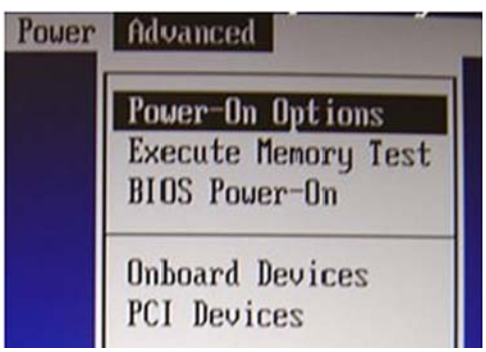
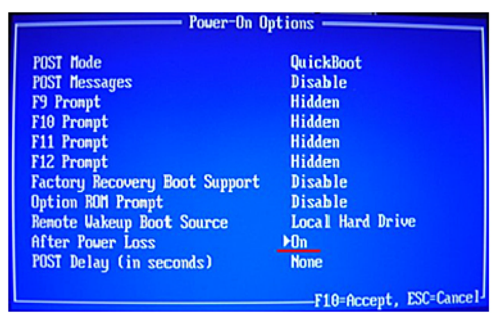


Figure 5-5

Follow Up

1. Power the Table (common) Computer on and press F10 to boot into BIOS. Select Storage/ Boot Order and select Broadcom Ethernet Controller.





2. Select Advanced/Power-On Options and select After Power Loss.
3. Select File/Save Changes and Exit and turn the Computer off.

4. On the Console computer, select **"Application – System Tools – Enable Remote Installation"**. Enter the password: **operator.** (Figure 5-6). Note that the password dialog box may not appear. In this case, the system caches the password, so it is not needed to continue.

5. On the Console computer, select **"Application - System Tools - Terminal"** to launch a terminal window. (**Figure 5-7**)

6. In the terminal window type in command:***sudo tail-f/var/ log/messages <enter>***

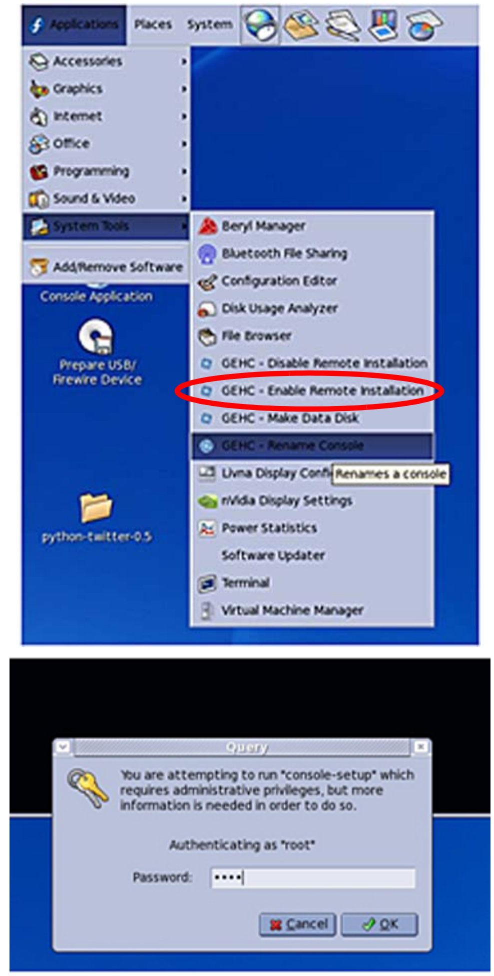


Figure 5-6

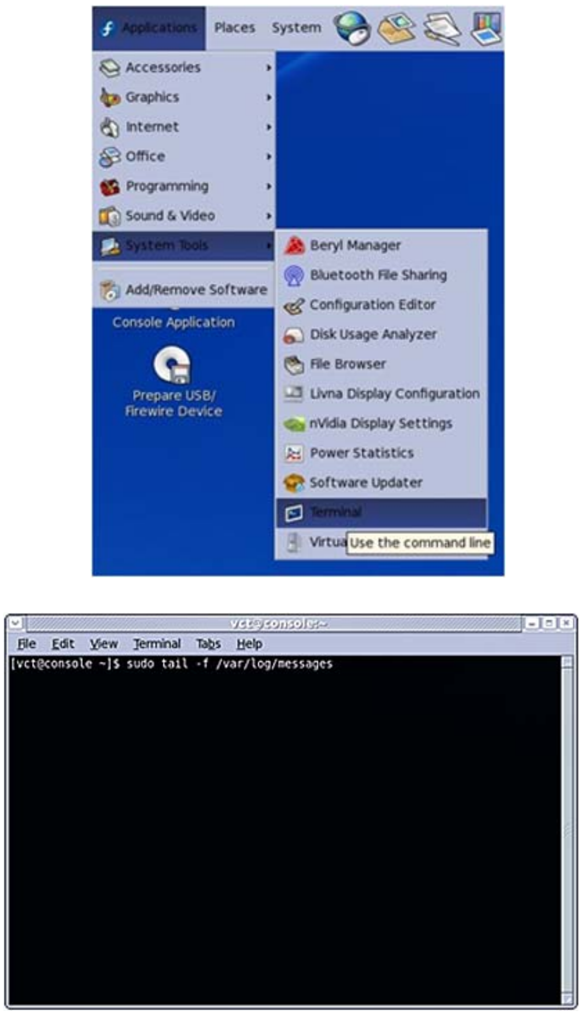


Figure 5-7

7. Turn on the Table Computer and wait for it to boot. Note the last IP address indicated in the "tail" terminal window (Figure 5-8).

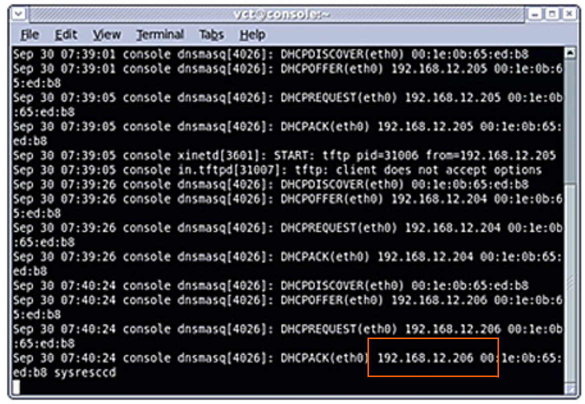


Figure 5-8

8. See Figure 5-9. Launch another terminal window on the Table Computer. Type in the command ***slogin root@<IP Address> <enter>*** using the IP Address in Figure 5-8.
Type in "***yes***" if you see the question "Are you sure you want to continue connecting?"Type in "***operator***" as password. Type in the command ***./restore_common.sh***
Type ***"yes"*** to continue connecting. Enter the password ***"vct"***.

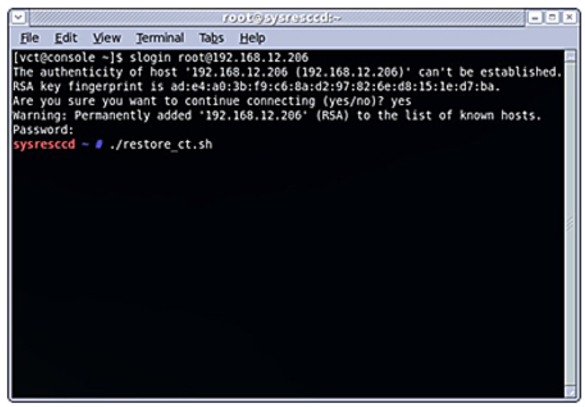
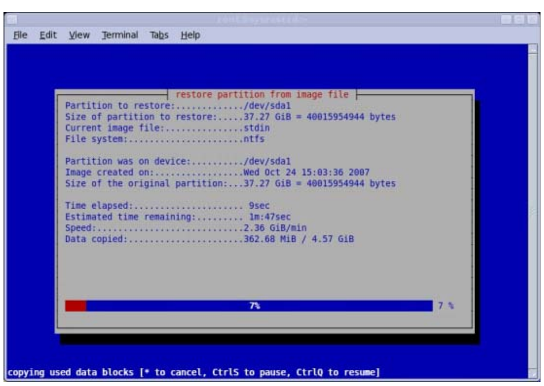
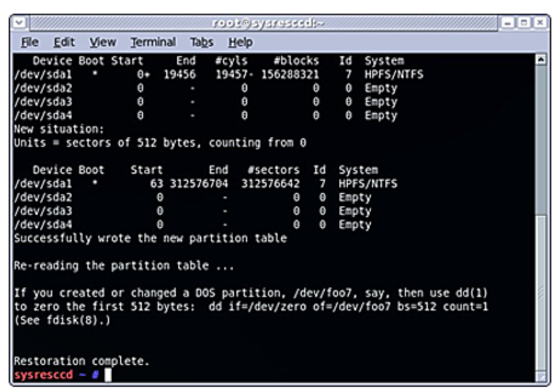


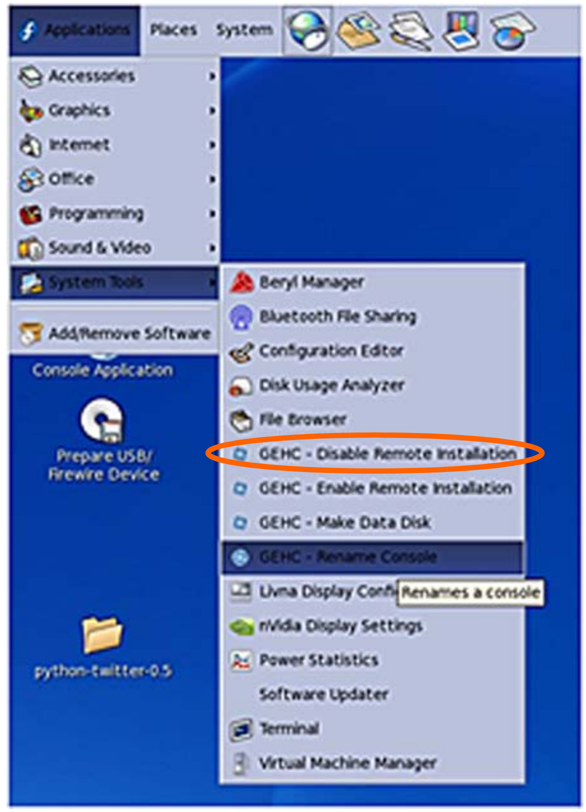
Figure 5-9

9. Allow the software restore to finish.





10. On Console computer, Select **"Application – System Tools – Disable Remote Installation "** (Figure 5-10)



11. In the terminal window logged into the Table Computer, type in command ***reboot -f <enter>.*** Wait a few minutes to allow the computer to reboot. *(*Figure 5-10**)**

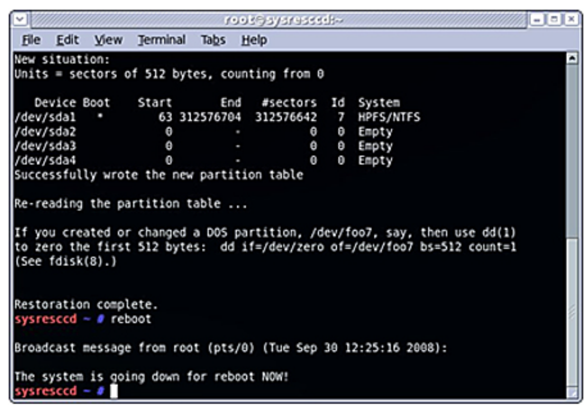


Figure 5-10

12. Establish a VNC connection to the Table Computer. On the Console computer, Select **"Application – System Tools – Terminal"** to launch a terminal window. Type ***vncviewer common.local***

13. Type in the password ***debug .***

14. The Table (common) Computer should boot into Windows. Exit the system monitor on the common computer.
15. Go to Control Panel and select Device Manager. Ensure that COM1 = Table Motor, COM2 = USB for cradle height (115,200 bps) and COM3=RTB (9600 bps).
16. Shut the Computer down.

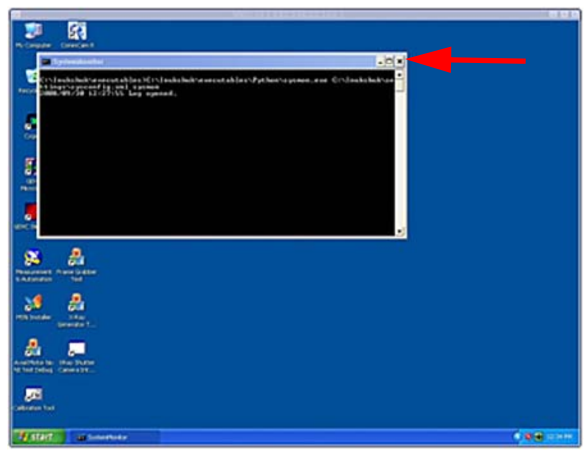
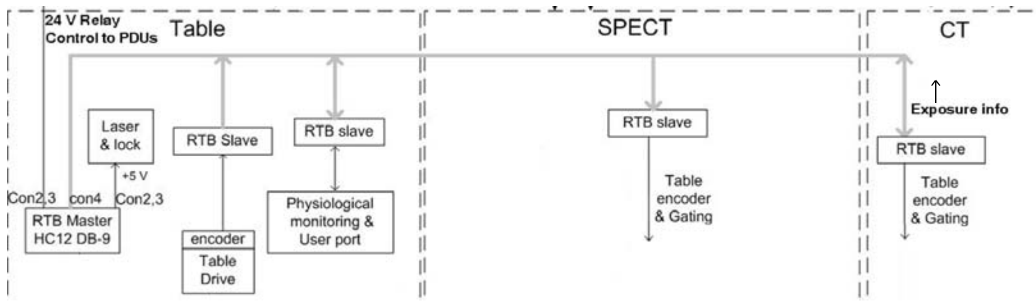


Figure 5-11

5.3.2 Real Time Bus Slave Board ASM (5220979)

Preconditions

- The Table side covers are removed.
- The machine is powered OFF using the main breaker on the PDU.



Real Time Bus Architecture

Removal

1. See Figure 5-12. Remove RTB Slave Cover (5252403, Item 5) by removing four (4) 4mm socket screws (2109867-2, Item 8) and four (4) lock washers (2109880-2, Item 9). Set aside.

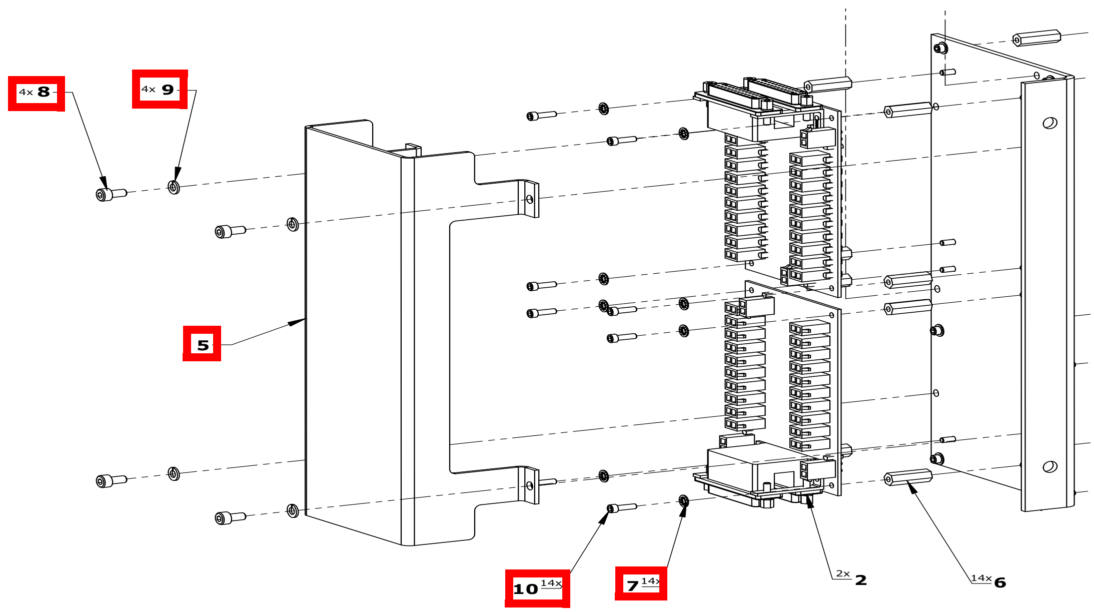


Figure 5-12

2. There are two Slave Boards. Determine which Board(s) needs replacement, then unplug all cables from the appropriate Board(s), noting their locations. The tags on the cables correspond to the silk screen markings on the boards.
3. Remove four (4) #4-40 socket screws (46-260789P11, Item 10) and four (4) internal tooth lock washers (2390666-2, Item 7) for each Slave Board that is to be removed. Set hardware aside. Do not remove standoffs from Assembly.

Replacement

1. Place replacement Slave Board(s) on standoffs with same orientation as in the illustration.
2. Align standoffs with holes in boards and thread screws with internal tooth lock washers set aside during board removal. Hand tighten.

Note: Do not over-torque screws, as damage to board may result.

3. Reconnect all cables to assembly and secure. Re-assemble RTB Slave Cover to Assembly using hardware set aside earlier.

5.3.3 Real Time Bus Master PCB ASM (5224161)

Preconditions

- The Table side covers are removed.
- The machine is powered OFF using the main breaker on the PDU.

See Figure 5-12 to Figure 5-15.

Removal

1. See Figure 5-12. Remove RTB Slave Cover (5252403, Item 5) as described in 5.3.2.
2. Unplug all cables that would interfere with the removal of the RTB assembly from the Table, noting their locations.
3. Remove two (2) 6mm socket screws (2109867-12, Item 18) and set aside with two (2) flat washers (2109880-3, Item 19). See Figure 5-13.

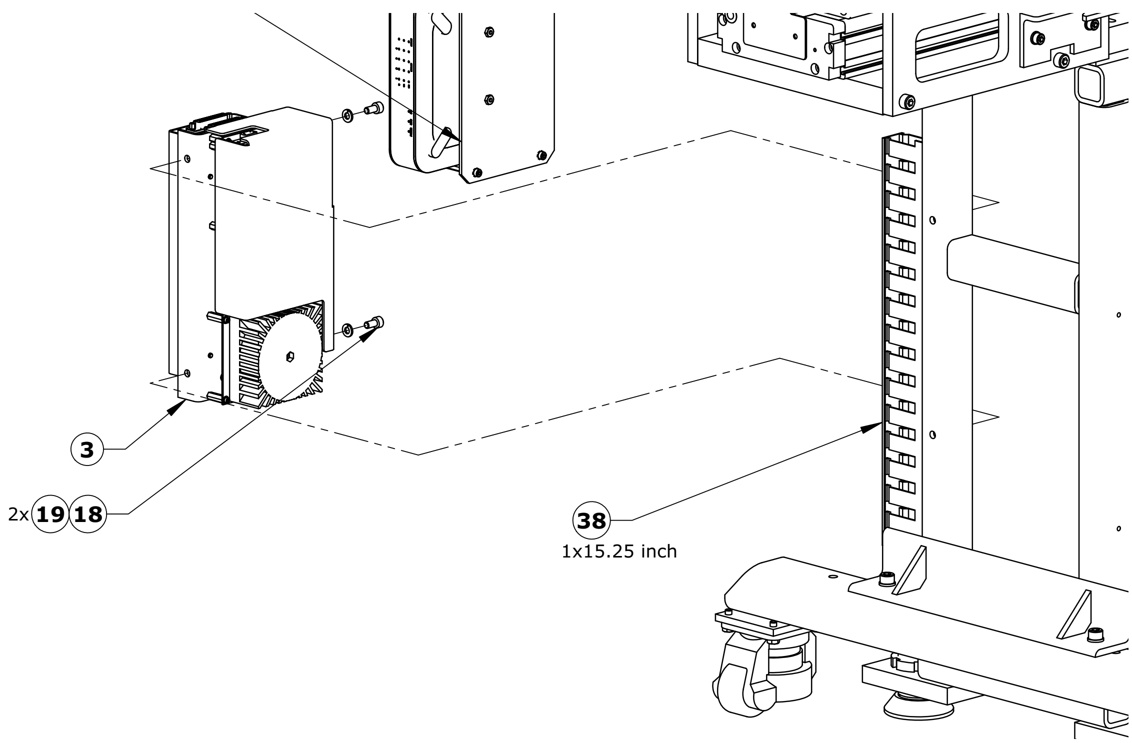


Figure 5-13

4. Move Assembly to a bench (shown in photo with RTB Slave Cover still attached).

5. See Figure 5-14. Remove RTB Master Cover (5252402, Item 4) by removing two (2) 4mm socket screws (2109867-2, Item 8) and two (2) lock washers (2109880-2, Item 9) from the Real Time Bus Board Support (5194639, Item 1). Set aside.

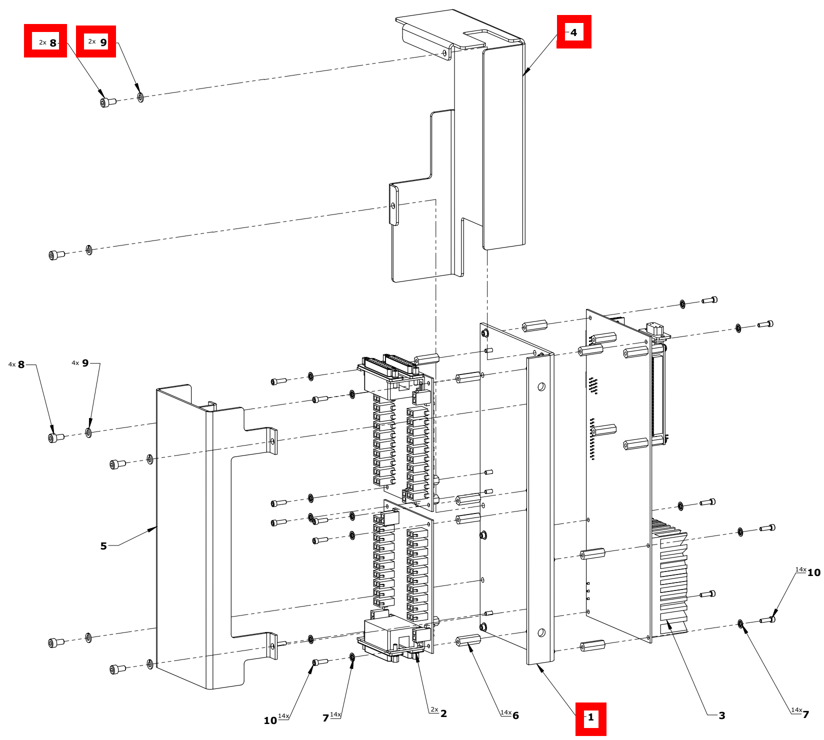


Figure 5-14

6. See Figure 5-15. Remove six (6) #4-40 socket screws (46-260789P11, Item 10) and six (6) internal tooth lock washers (2390666-2, Item 7) for each. Set hardware aside. Do not remove standoffs from Assembly. Remove defective Real Time Bus Master PCB (Item 3).

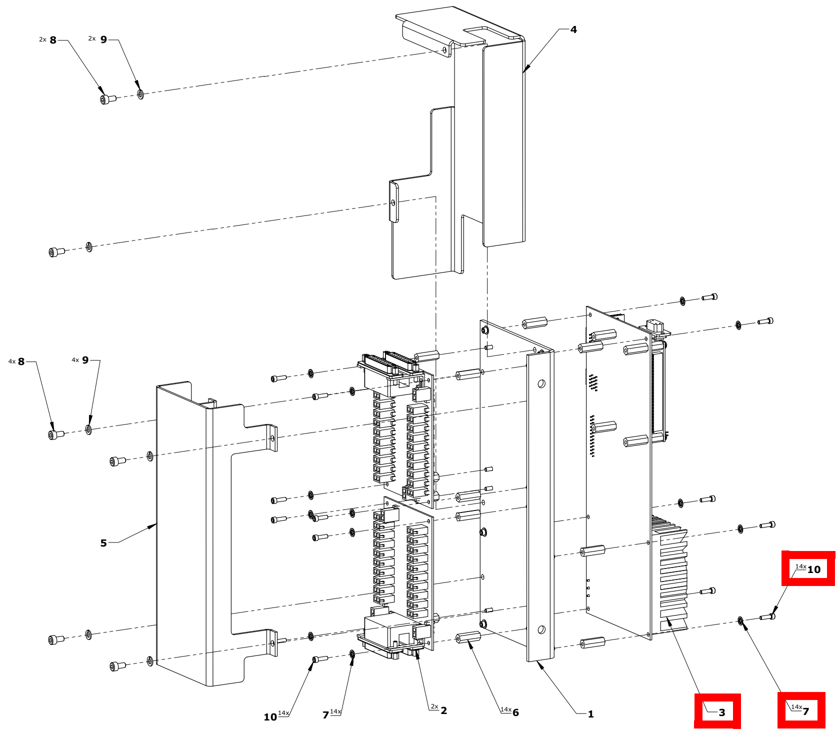


Figure 5-15

Replacement

1. Place replacement PCB on standoffs with same orientation as in the illustration.
2. Align standoffs with holes in boards and thread screws with internal tooth lock washers set aside during board removal. Hand tighten.

Note: Do not over-torque screws, as damage to board may result.

3. Re-assemble RTB Master Cover to Assembly using hardware set aside earlier.
4. Mount Assembly as shown in Figure 5-13 using two screws and flat washers set aside earlier.
5. Reconnect all cables to assembly and secure.
6. Re-assemble RTB Slave Cover to Assembly using hardware set aside earlier.

5.3.4 Shielding Lid Assembly, SPECT-CT Long Table (5241206)

NOTICE Possible Equipment Damage

The Table Shielding Lid is very heavy and awkward. Use extreme care when handling.

The weight of the Lid is great enough that it will crash to the floor if not supported when the attachment screws are loosened. At least ***three*** *personnel will be required to perform procedures involving removal and replacement of this assembly.*

In order to remove and replace certain FRUs on the Table Shielding assembly, it will be necessary to remove the Shielding Lid Assembly. See Figure 5-16.

Removal

1. With two persons holding the Lid (Item 4) in place, eight (8) M6 countersunk head screws (2109884-14, Item 26) can be removed by a third person along the hinge side, and set aside.
2. Ensure that Safety Lid Lock (5231941, Item 11) is released and lift the Lid away from the Table (three persons).

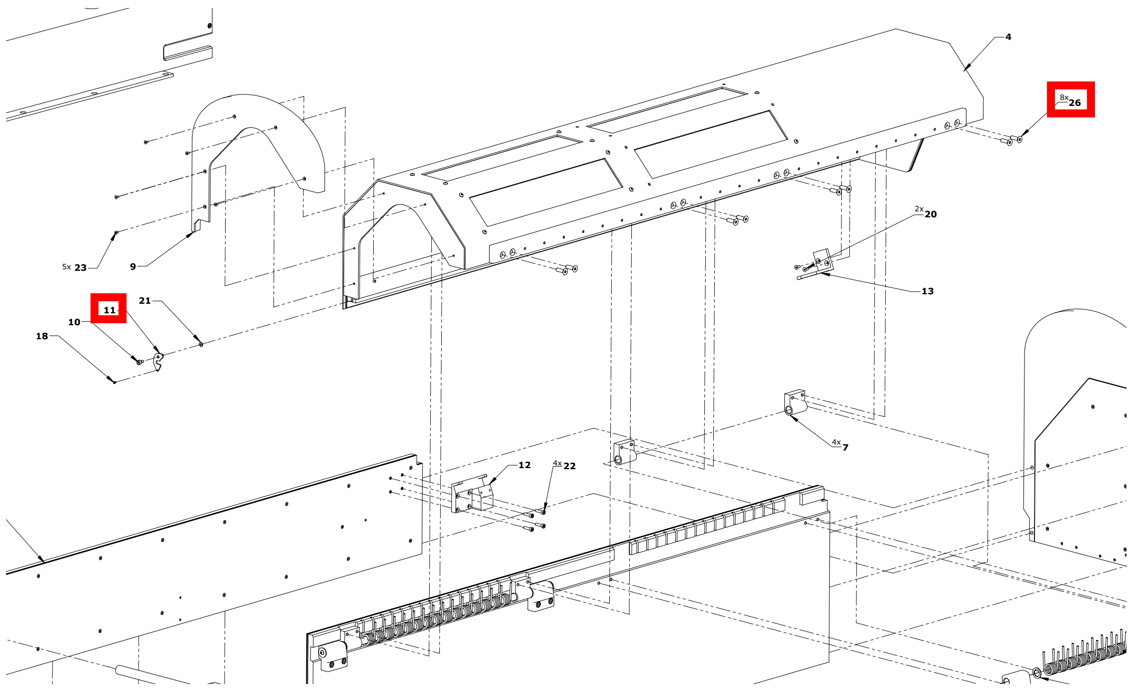


Figure 5-16

Replacement

1. Re-assemble Lid to Table Shielding assembly with eight (8) M6 cap screws set aside during removal and torque to 70 in-lb.

5.3.5 Fixed Hinge Seat, Table Shielding (5231864)

See Figure 5-17.

NOTICE Possible Equipment Damage

The Table Shielding Assembly is very heavy and awkward. Use extreme care when handling.

The weight of the Lid is great enough that it will crash to the floor if not supported when the attachment screws are loosened. At least ***three*** *personnel will be required to perform procedures involving removal and replacement of this assembly.*

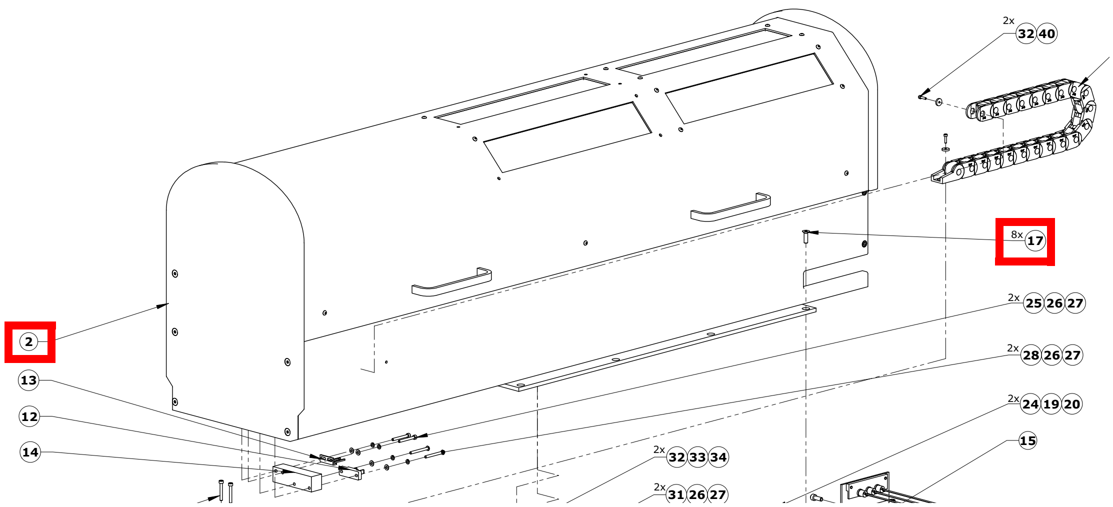


Figure 5-17

Removal

1. Remove four (4) M6 cap screws (2109884-14, Item 17 Figure 5-17) holding down each side of the Table Shielding Assembly (5241211, Item 2 Figure 5-17). Set hardware aside. Lift Table Shielding Assembly away (minimum three persons) and carefully set with Shielding Lid upside down. Block up the Left Side Panel (photo) so that it is parallel to the work surface. This orientation will relieve tension in the Torsion Springs.

2. Refer to Figure 5-18 (shown oriented normally). From the end of the Hinge Shaft (5231866-2, Item 16) where the Seat to be removed is located, remove an M4 cap screw (2109872-2, Item 17) and flat washer (2390635-16, Item 15) and set aside.
3. Remove two (2) M6 socket screws (2109867-14, Item 14) holding the Fixed Hinge Seat (Item 8) to the Left Side Panel (5241209, Item 2). Set hardware aside.
4. Slide the Seat off the Hinge Shaft.

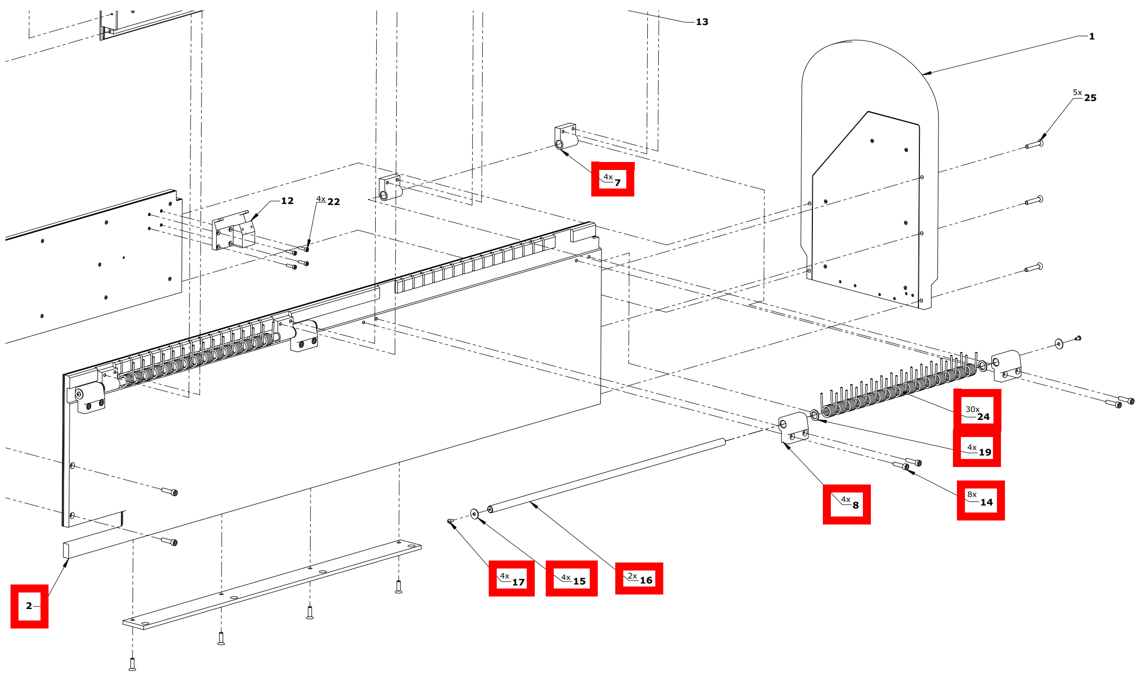


Figure 5-18

Replacement

1. Slide the replacement Seat on the Hinge Shaft with the orientation shown in the illustration.
2. Thread the M4 cap screw with washer set aside earlier onto the end of the Hinge Shaft. Torque to 20 in-lb.
3. Fasten the Fixed Hinge Seat to the Left Side Panel with the M6 screws set aside earlier. Torque to 70 in-lb.

5.3.6 Lid Hinge Seat, Table Shielding (5231865)

See Figure 5-18.

Removal

1. Remove an M4 cap screw (2109872-2, Item 17) and flat washer (2390635-16, Item 15) from one end of the Hinge Shaft. Unthread two M6 countersunk head screws (2109884, Item 26 in Figure 5-16) from the Shielding Lid Assembly. Set screws aside.
2. Slide the Hinge Shaft out as far as needed to remove the Lid Hinge Seat. The nylon washer (2390667-3, Item 19) and adjacent Lid Hinge Seat (Item 7) can be removed. Set the washer aside.

Replacement

1. Attach the replacement Lid Hinge Seat with the orientation shown in Figure 5-18 to the Shielding Lid Assembly with the M6 screws set aside earlier. Torque to 70 in-lbs.
2. Slide a nylon washer onto the Shaft in the correct location and slide Shaft completely into position. Secure shaft end with hardware set aside earlier. Torque to 20 in-lb.

5.3.7 Hinge Shafts, Long Tables (5231866-2)

See Figure 5-18.

Removal

1. From both ends of the Hinge Shaft (5231866-2, Item 16), remove an M4 cap screw (2109872-2, Item 17) and flat washer (2390635-16, Item 15) and set aside.
2. Slide the Shaft through the Hinge Seats and the Torsion Springs. Set aside the two (2) nylon washers that separate the Fixed and Lid Hinge Seats.

Replacement

1. Slide the replacement shaft through the Hinge Seats and Torsion Springs, ensuring that a nylon washer is placed between each of the Fixed and Lid Hinge Seats. Thread cap screws and washers onto each end of shaft and torque both cap screws to 20 in-lb.

5.3.8 Torsion Spring, Table Shielding (5257418)

See Figure 5-18.

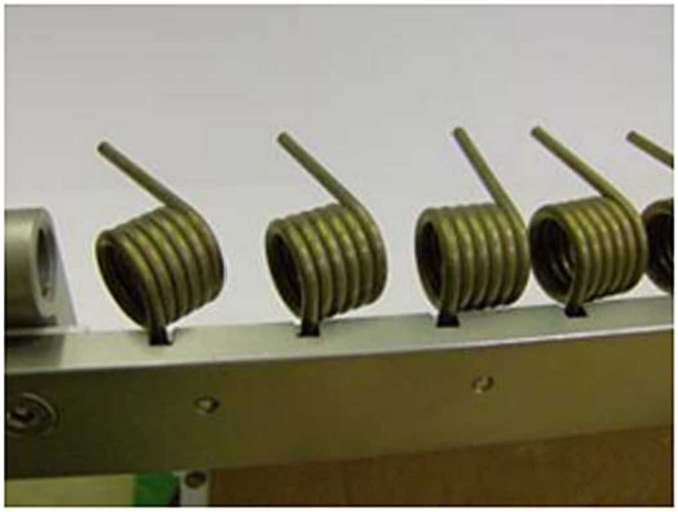
Removal

1. From one end of each Hinge Shaft (5231866-2, Item 16), remove an M4 cap screw (2109872-2, Item 17) and flat washer (2390635-16, Item 15) and set aside.
2. Slide the Shafts through the Hinge Seats and the Torsion Springs. Set aside the two (2) nylon washers that separate the Fixed and Lid Hinge Seats.
3. Move the Left Side Panel (5241209, Item 2) away from the Shield to allow the Torsion

Spring(s) to be removed.

Replacement

1. Place the replacement Spring(s) in the Shield, oriented as shown in the photo. Re-position the Left Side Panel so that all Torsion Springs can be guided into slots on the Panel.
2. Slide the Hinge Shafts through the Hinge Seats and Torsion Springs, ensuring that a nylon washer is placed between each of the Fixed and Lid Hinge Seats. Thread cap screws and washers onto the end of each shaft and torque both cap screws to 20 in-lb.



5.3.9 Safety Lid Lock (5231941)

See Figure 5-19.

Removal

1. On the Shielding Lid Assembly, remove Shoulder Bolt (5231936, Item 10), Safety Lid Lock (Item 18 -arrow) and Flat Washer (2390667-4, Item 21) and set aside.

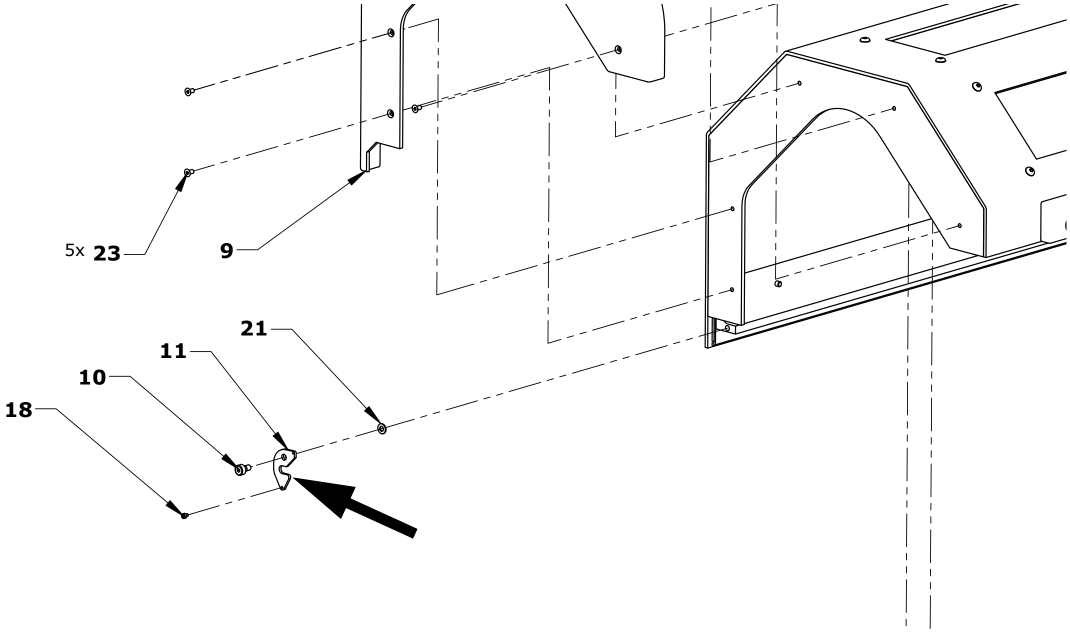


Figure 5-19

Replacement

1. Assemble replacement Safety Lid Lock to Shielding Lid Assembly as shown in the illustration, using the hardware set aside after removal. See also photo below.

5.3.10 Leaded Glass, 8mm (5231778)

See Figure 5-20.

Removal

1. From the bottom side of the Shielding Lid, loosen six (6) button head screws (2109872-3, Item 7) around the Leaded Glass panel that is to be replaced, while supporting it from the underside. Lower the two (2) Window Spacers (5262719, Item 3) and the Leaded Glass (Item 2). Set screws and Spacers aside.

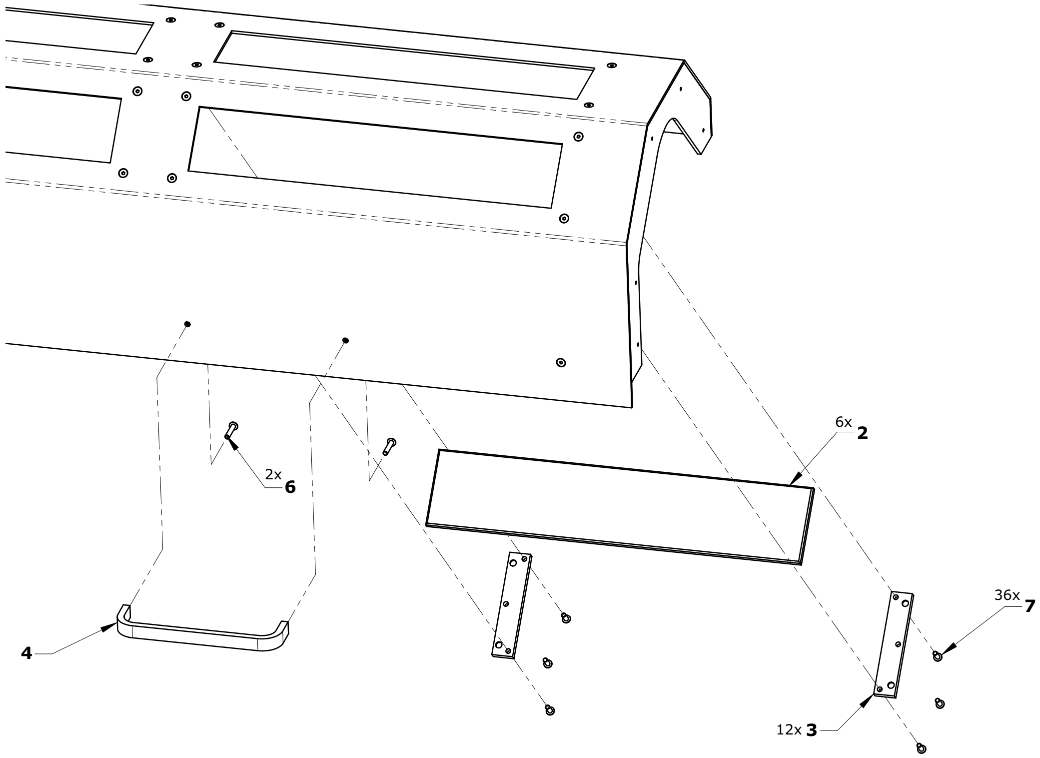


Figure 5-20

Replacement

1. Place the Leaded Glass panel into the recesses in the Shielding Lid.

NOTICE **Ensure replacement panel overlaps the lead layer along all sides.**

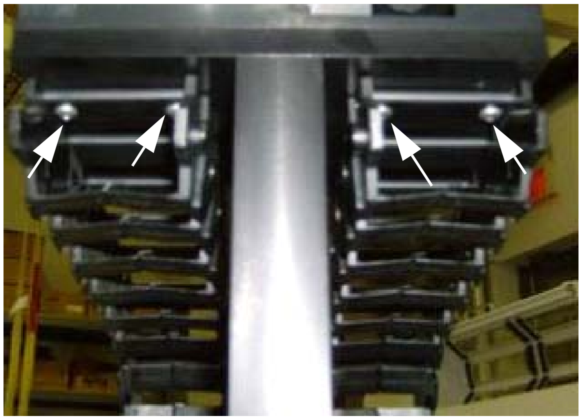
2. Align the Window Spacer holes with the Shielding Lid holes and thread six button head screws from the bottom. Torque to 20 in-lb.

5.3.11 Cable Track (5260777)

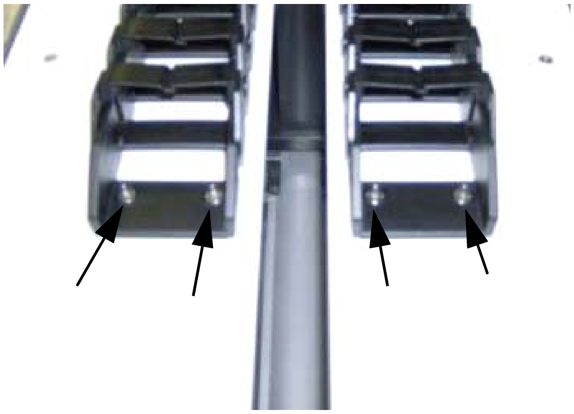
See Figure 5-21.

Removal

1. Ensure all tubing and cabling has been removed from the Cable Track (Item 12).
2. Remove four (4) M4 cap screws (2109872-2, Item 35) from the underside of the Height Adjustment assembly (5261012, Item 3) and set aside.



3. Remove two (2) M4 countersunk screws (2109884, Item 34) from each of 5197716, Item 7 and 5147235, Item 16 and set aside.



4. Remove Cable Track.

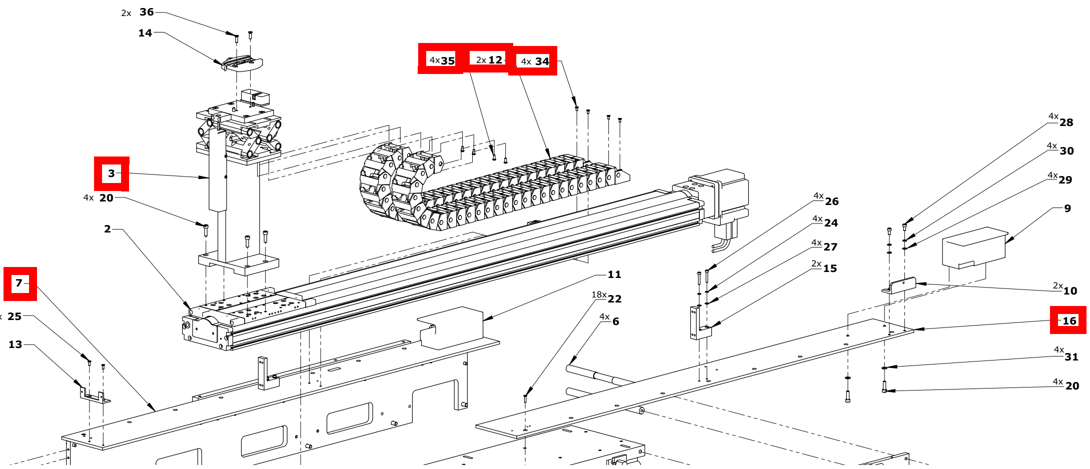


Figure 5-21

Replacement

1. Noting the orientation of the Cable Track in the illustration, fasten the replacement Cable Track in place using the hardware set aside during removal. Torque to 20 in-lb.

5.3.12 Height Adjustment Assembly Sensor (Potentiometer)

See Figure 5-22.

Note: **Ensure system is powered OFF.**

Removal

1. Remove two (2) M3 cap screws (2390622, Item 15) and washers (Item 13) from Potentiometer Cover (5215053, Item 9) and set aside Cover and hardware.
2. See Figure 5-23. Remove red, blue and black wires from terminal block by loosening appropriate screws.
3. See Figure 5-22. Back off two (2) Hex Nuts (46-252318P5, Item 19) above and below Potentiometer Mounting Block (5199964, Item 5). Remove top nut. Remove Linear Potentiometer (5215335, Item 6) by removing four (4) M2 Pan Head Screws (2355910, Item 14). Set all hardware aside.

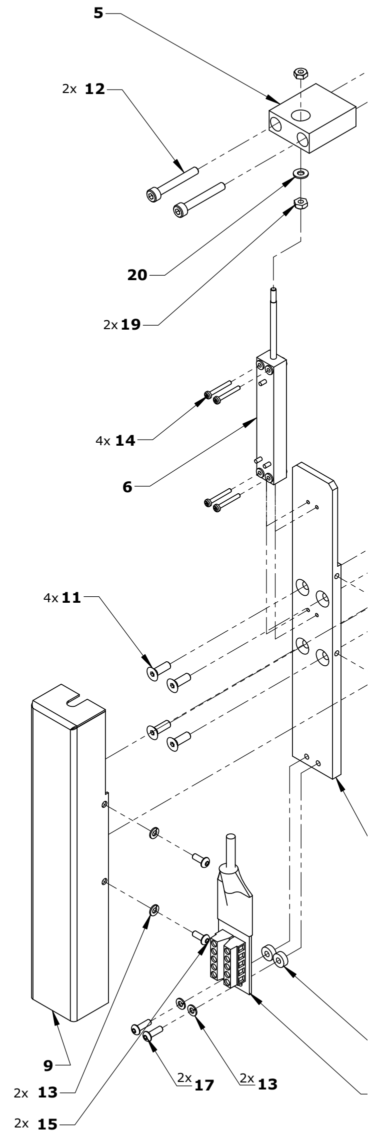


Figure 5-22

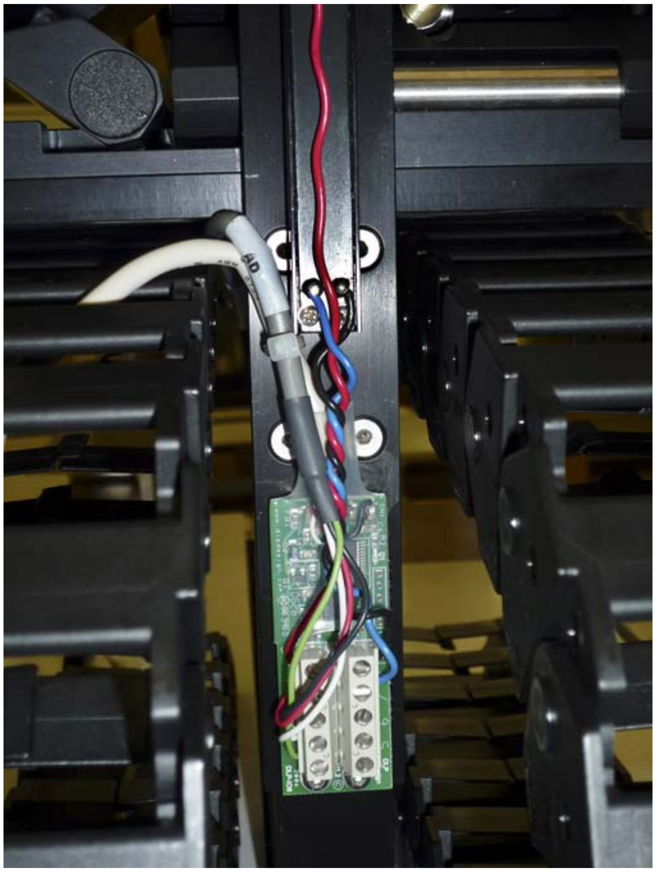


Figure 5-23

Replacement

Replacement is the reverse of removal, but the position at which the potentiometer shaft is fastened to the mounting block must be set carefully. Calibration steps are as follows:

1. Attach target laser block (P/N 5197806) to the cradle positioner. (Figure 5-25)

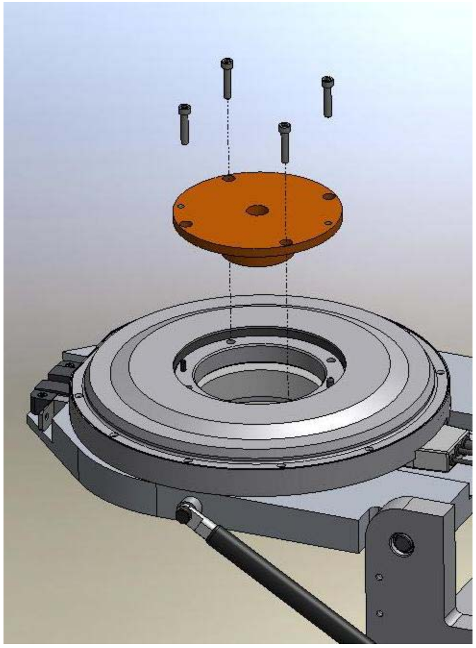


Figure 5-24

2. Pull the Table shield toward the rear to allow the collimator mounting plate on the SPECT unit to tilt down. Attach Laser Holder Disc, SPECT Alignment Tool (P/N 5306188) to the collimator drive flange (Figure 5-24) using four (4) M6 x 20 socket head cap screws (2109867-14).

Figure 5-25

3.) Place the MG 2000 laser transmitter (P/N 5212073) in the Holder Disc (Figure 5-26) and switch on. The light beam should appear on the face of the target laser block (Figure 5-27). Change the height of the block using the cradle positioner height adjustment until the beam falls along the horizontal score line on the block.

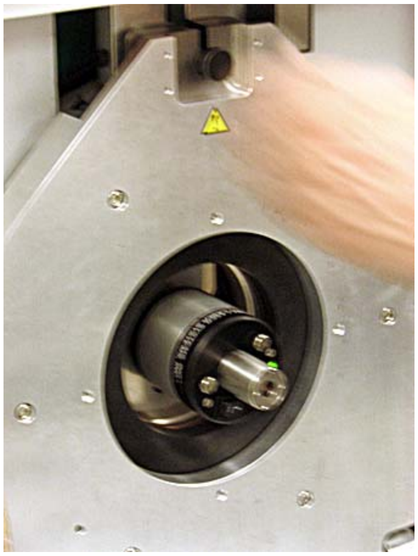


Figure 5-26

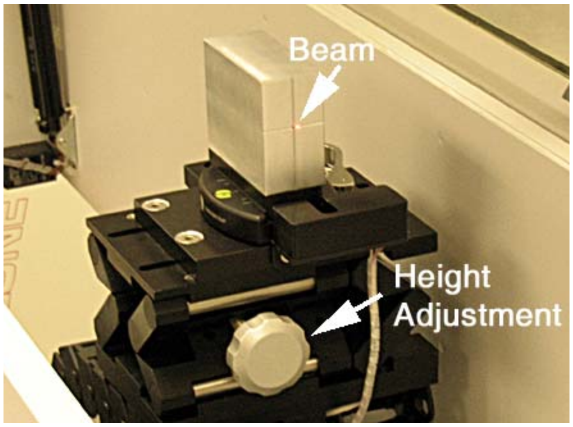


Figure 5-27

Note: **Ensure that the Laser is firmly seated, as the fit is not always tight.**

4.) Rotate the laser mount in 90 degree steps on the collimator drive flange and check the beam at each step. Adjust the height until the beam is closest to the horizontal line for all four positions. Height adjustment is now optimized, and must NOT be changed again.

5. Refer back to Figure 5-22. Mount the replacement potentiometer with the hardware set aside during removal. Add nut and flat washer to shaft. Place shaft through Potentiometer Mounting Block, being careful not to change the cradle positioner height. Add nut to top of shaft and tighten both nuts until the shaft is secure to the Potentiometer Mounting Block.

6. Check that the laser is still centered on the laser block. If not, readjust.

7. Remove laser and laser mount from SPECT collimator drive flange.

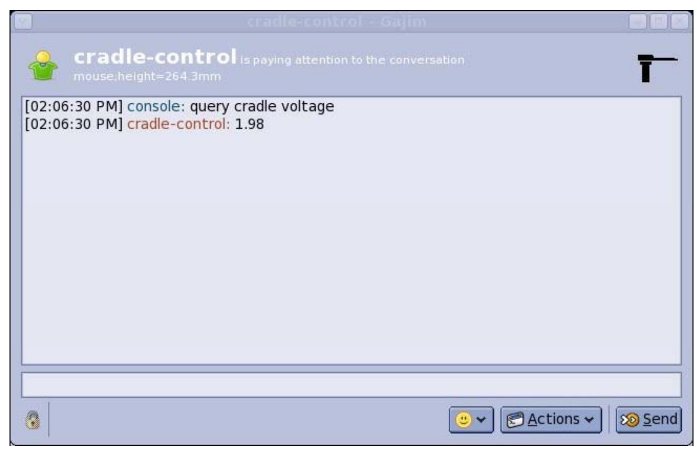
8. Make connections from potentiometer to terminal block in same order that they were removed.

9. Power up the system.

10.) Check the cradle height on the touch panel. If it is not zero, the system will need to be recalibrated for cradle height.

11. Use a caliper to measure cradle height and zero it.

12. On the Console computer, select Applications/Internet/Gajim Instant Messenger to launch Gajim.



13. Type the password 'vct'.

14. Right click on console.local, select Status/Available to change status to online.

15. Find contact cradle-control and double click on it to open a chat window to it.

16. Change the cradle height to its lowest position and measure the height in millimeters. It will be a negative number.

17. Open the cradle height spread sheet stored on the console. Enter the measurement value into cell B2.

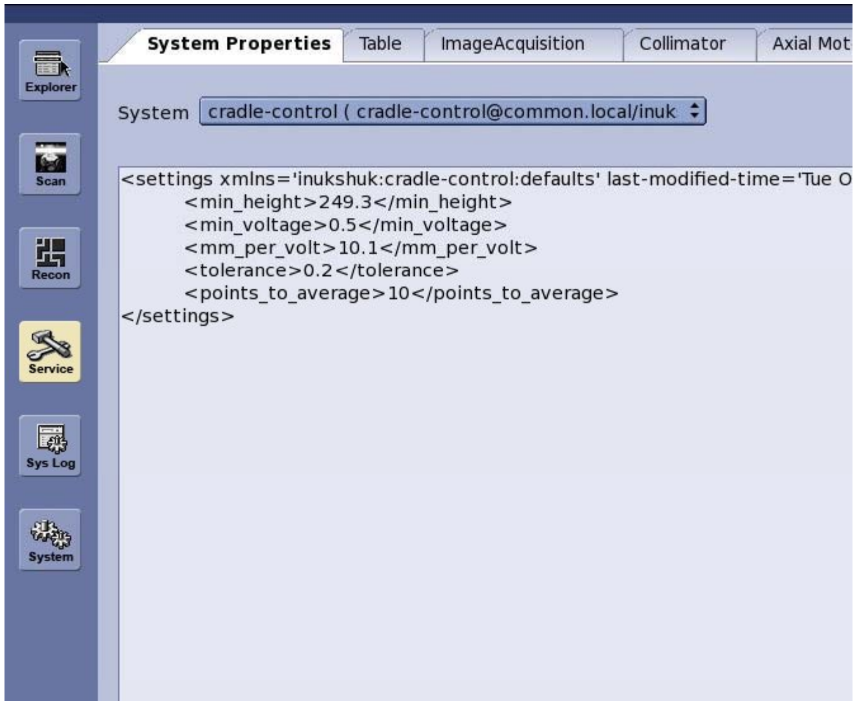
18. In the chat window, type in command "query cradle voltage" to get the voltage value, and fill into cell B4.

19. Change the table to highest position, measure the height, and fill the value into cell L2.

20. In chat window, type in command "query cradle voltage" to get the voltage value, and fill into cell L4.

21. Refer to values in C2 ~ K2, change the cradle height, at each position, record actual height values into C3 ~ K3, and query the voltage values into C4 ~ K4.

22. In the Locus Console application, select “Service/System Properties”, and select “ cradle-control (cradlecontrol@common.local/inukshuk)” from the Systemdropdown.



23. Replace min_height with value in B2, min_voltage with value in B4, and mm_per_volt with value in B5, and click on “Save” button.
24. Go to the System panel, shutdown the system, and restart the system.

5.3.13 Dual Mount Drawer Slide (5191238)

See Figure 5-28.

NOTICE Possible Equipment Damage

The Table Shielding Assembly is very heavy and awkward. Use extreme care when handling.

The weight of the Lid is great enough that it will crash to the floor if not supported when the attachment screws are loosened. At least three personnel will be required to perform procedures involving removal and replacement of this assembly.

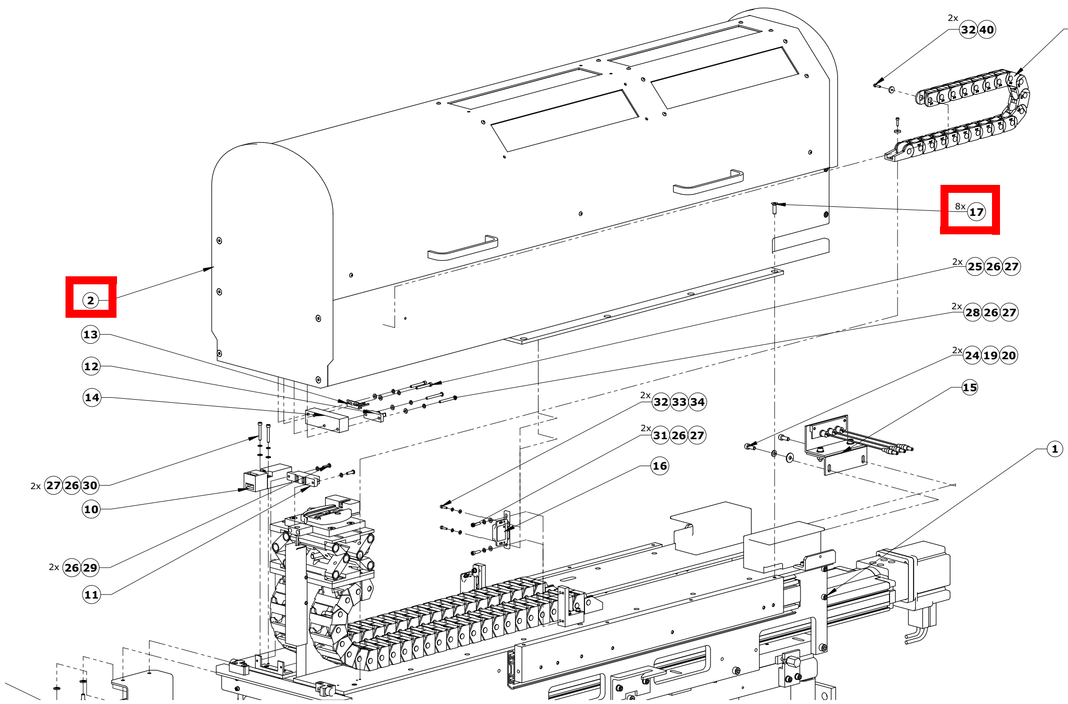


Figure 5-28

Removal

1. Remove four (4) M6 cap screws (2109884-14, Item 17 Figure 5-28) holding down each side of the Table Shielding Assembly (5241211, Item 2 Figure 5-28) to the Table Cover Mounting Blocks (5191858, Item 3 in Figure 5-29 and 4 in Figure 5-30). Set hardware aside. Lift Table Shielding Assembly up (minimum three persons) and carefully set on blocks above the Table. Drawer Slides should be free to slide.
2. Extend the Drawer Slide on either side of the Table and remove six (6) screws (2109872-7, Item 6 in Figure 5-29 and Item 5 in Figure 5-30). Set hardware aside and place both Drawer Slide/Table Cover Mounting Block assembly (or assemblies if replacing both) on a flat surface.
3. Remove seven (7) M6 button head screws (2109872-8, Item 5 in Figure 5-29 and Item 6 in Figure 5-30) holding each Drawer Slide to a Table Cover Mounting Block, and set hardware and Block aside.

Replacement

1. Place the replacement Drawer Slide on the Table Cover Mounting Block in the same orientation as the Drawer Slide that was removed. Torque the seven (7) M6 button head screws (2109872-8) set aside during removal to 70 in-lb.
2. Align the Drawer Slide/Table Cover Mounting Block assembly with holes on the Table Side

Plate (refer to Figure 5-29 for the left side and Figure 5-30 for the right side). Thread the six (6) screws (2109872-7) starting with the two holes closest together (near the end of the wide section of the slide). Torque to 70 in-lb.

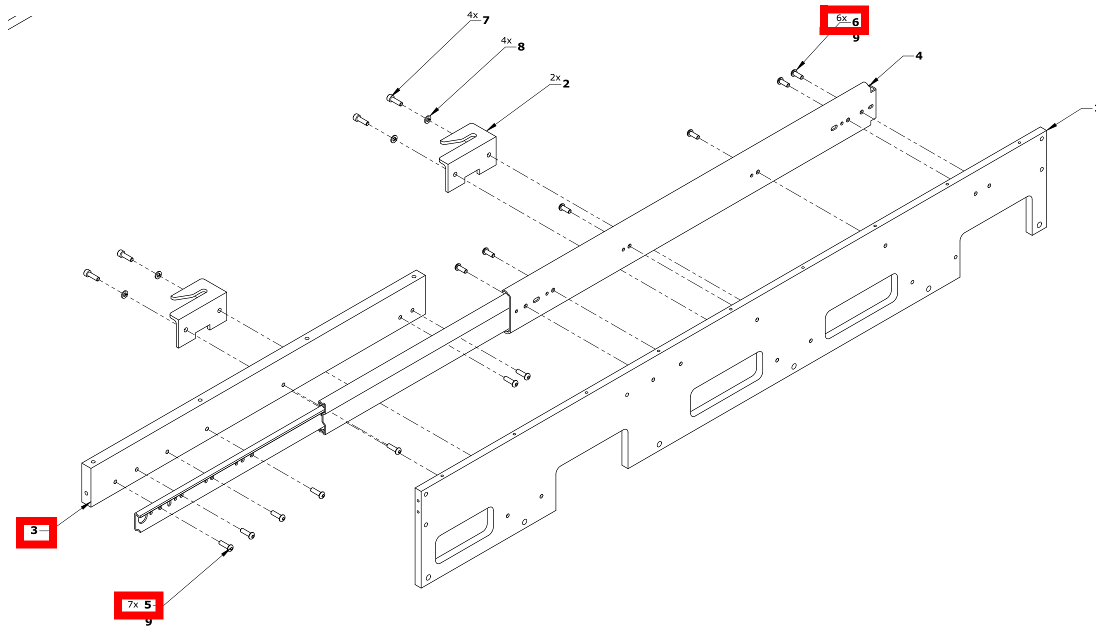


Figure 5-29

3. Using at least three persons, lift the Table Shielding Assembly off temporary blocks and move Drawer Slides until the holes in the Assembly line up with those on the Table Cover Mounting Blocks. Fasten each side with four (4) M6 cap screws (2109884-14) and torque to 70 in-lb.

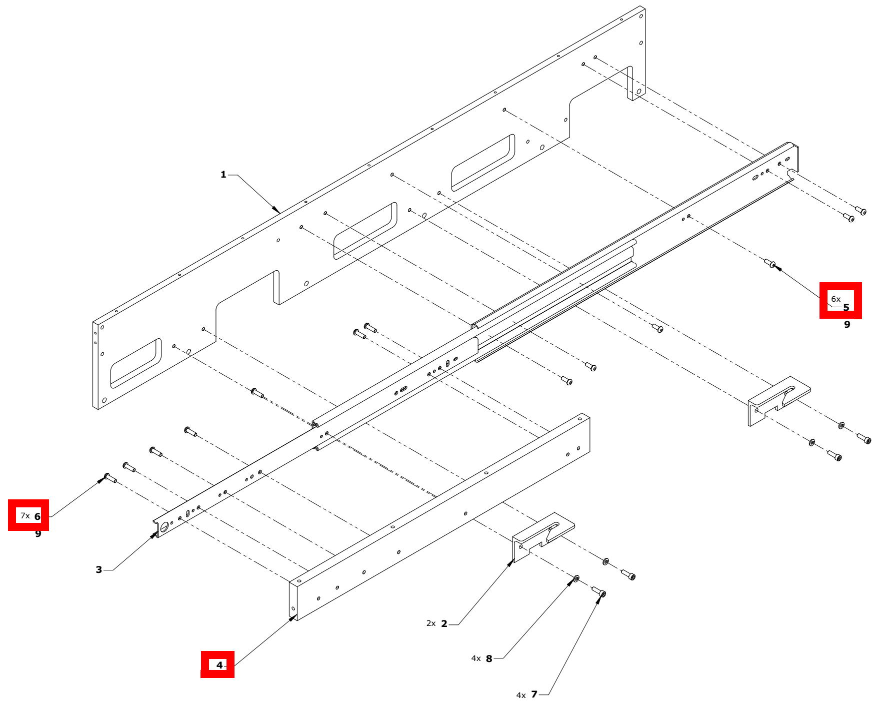


Figure 5-30

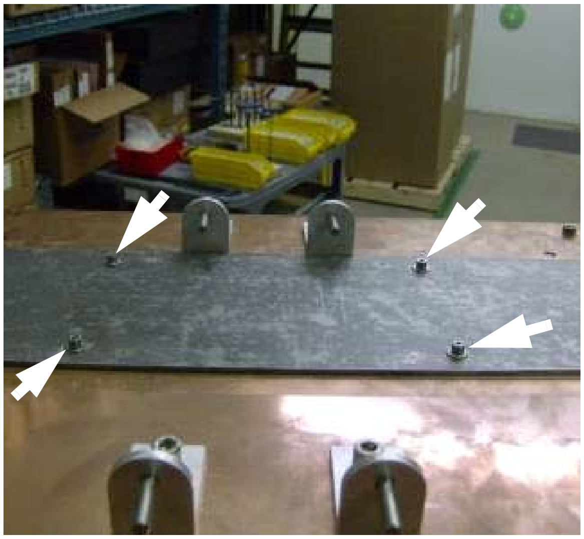
Section 5.4
SpeCZT CT 120 (5169192) SPECT Component FRUs

SPECT SIDE AND RADIATION SHIELD REMOVAL & REPLACEMENT

In order to access a number of components in this section, it will be necessary to remove the radiation shields. Refer to Figure 5-31 for their locations.

Removal

1. Remove four (4) M6 socket screws (2109867-14, Item 20), lock washers (2109880-3, Item 5) and flat washers (2109878-3, Item 19) from each of the SPECT Left Side Shield (5257577, Item 17) and SPECT Right Side Shield (5257577-2, Item 18) and set hardware aside.
2. Remove four (4) M4 socket screws (2109867-7, item 14), lock washers (2109880-2, item 9), flat washer (2109879, item 11) from the top shield and set aside (photo).



3. Slide out External Radiation Shields (Items 12, 13, 15 & 16) and set aside.

Replacement

1. Slide External Radiation Shields back into their respective slots. Note that the front shields have circular cutouts and the rear shields have decagon-shaped cutouts. Refer to the illustration for orientation. The seams between each pair of shields needs to be as tight as possible. Bend the shields as necessary to achieve the best possible fit.
2. Re-attach the SPECT Left and Right Side Shields and the External Radiation Shields using the hardware set aside in steps 1. and 2. in **Removal**. Place the lock washers on the screws before the flat washers.

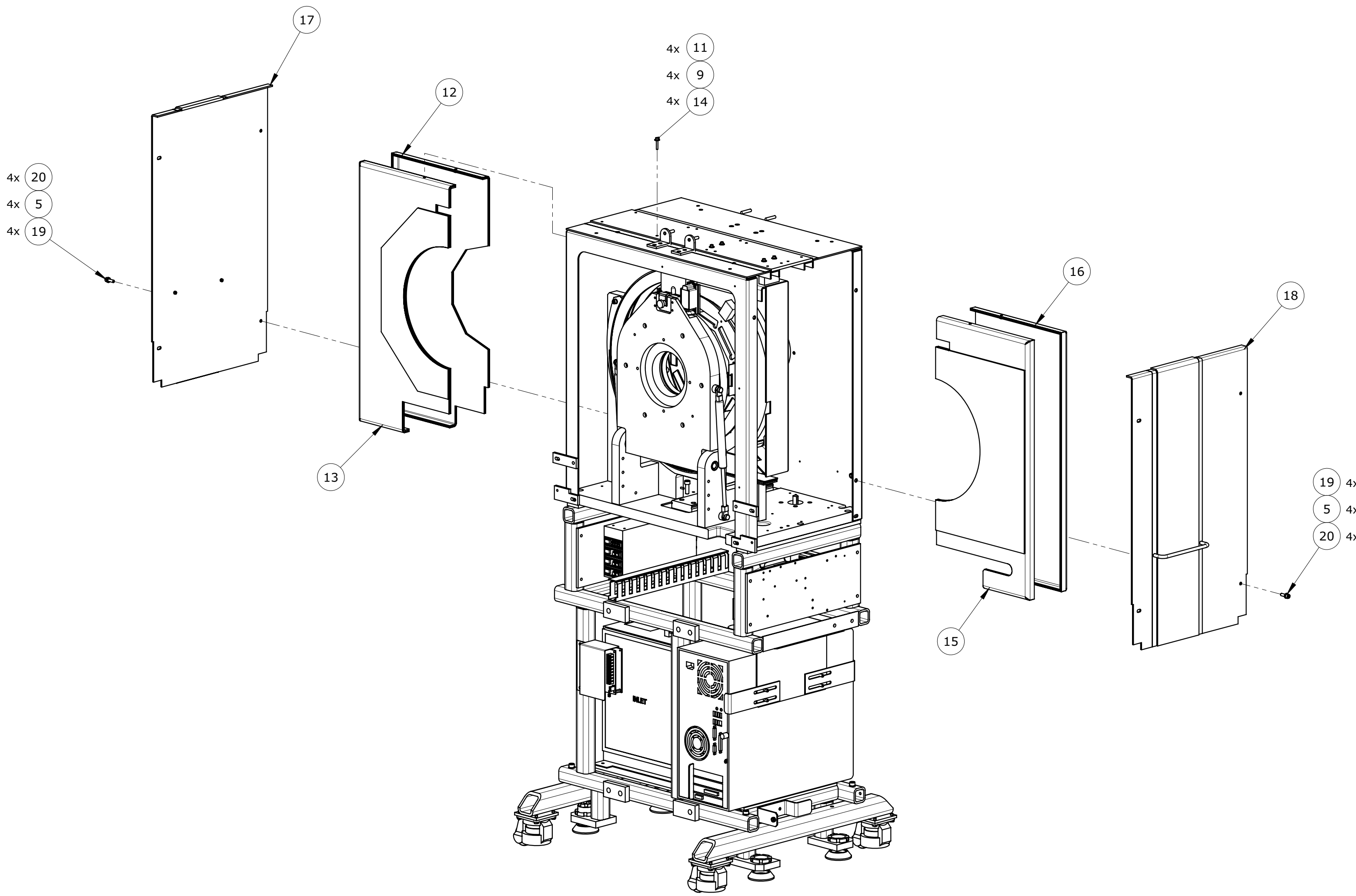


Figure 5-31

5.4.1 SPECT Computer (5271920)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The SPECT and Table side and corner covers are removed.

Removal

See Figure 5-32.

1. From right side of the SPECT Unit, unplug all cables from the rear panel of the computer (Item 12), marking their locations.
2. Remove two (2) 6mm socket screws (2109867-13, Item 31) and set aside with two (2) flat washers (2109879-2, Item 36) and two (2) lock washers (2109880-3, Item 29).
3. Set aside table computer bracket assembly (Items 13 &14). Carefully slide computer out from its shelf.

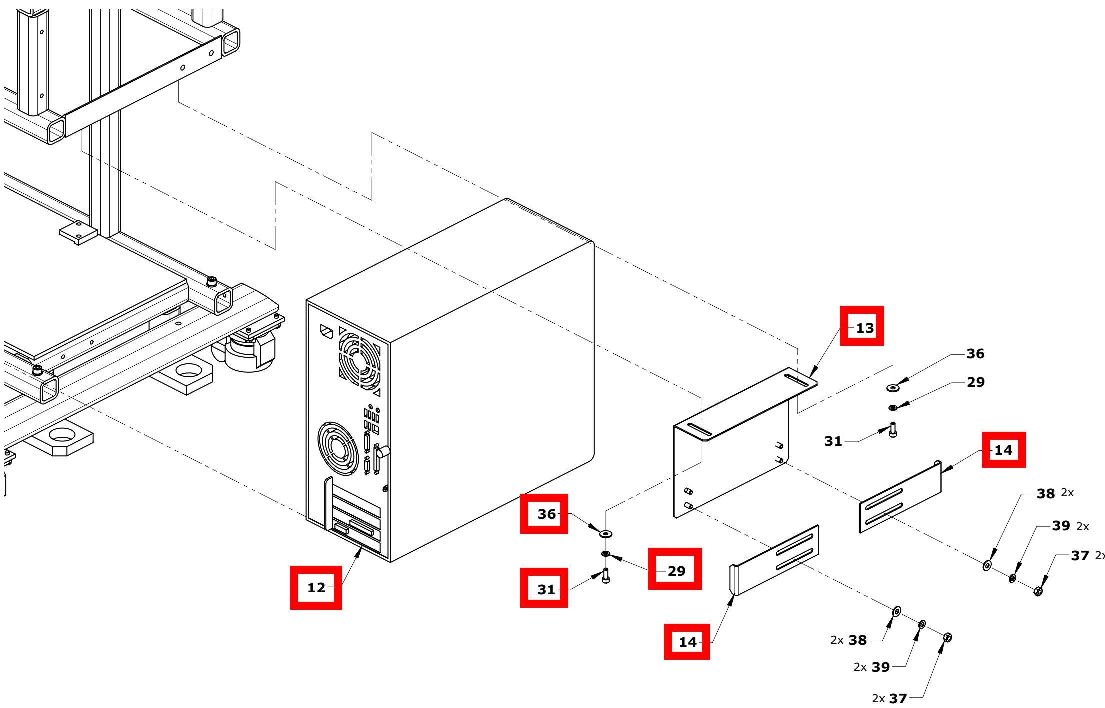


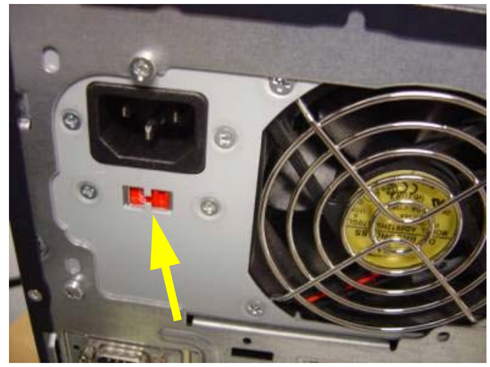
Figure 5-32

Replacement

1. Slide computer onto shelf with rear panel oriented as shown in the illustration.
2. Adjust the slide brackets to fit firmly against the computer. Tighten the four nuts.
3. Add lock washer then flat washer to socket screws set aside during removal and fasten to table base. Torque to 70 in-lb.
4. Reconnect all cables to rear panel of computer and secure.

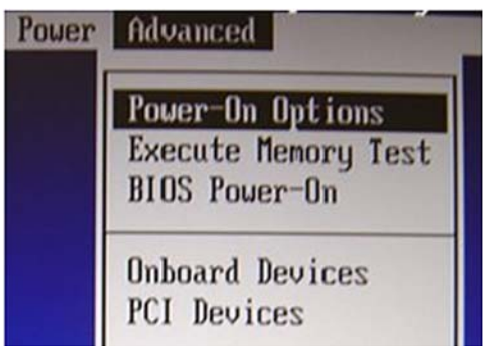
NOTICE Equipment Damage Possible

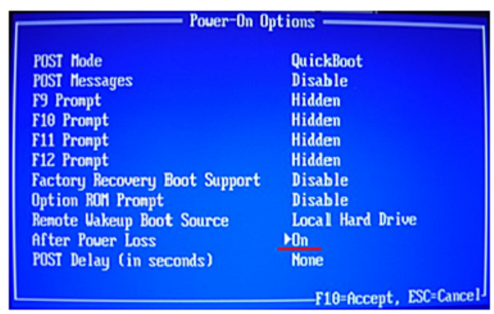
Ensure that the 110/220V switch on the Computer is set to 220V



Follow Up

1. Power the SPECT Computer on and press F10 to boot into BIOS. Select Storage/Boot Order and select Broadcom Ethernet Controller.





2. Select Advanced/Power-On Options and select After Power Loss.
3. Select File/Save Changes and Exit and turn the Computer off.

4. On the Console computer, select **“Application – System Tools – Enable Remote Installation”**. Enter the password: **operator.** (Figure 5-33). Note that the password dialog box may not appear. In this case, the system caches the password, so it is not needed to continue.

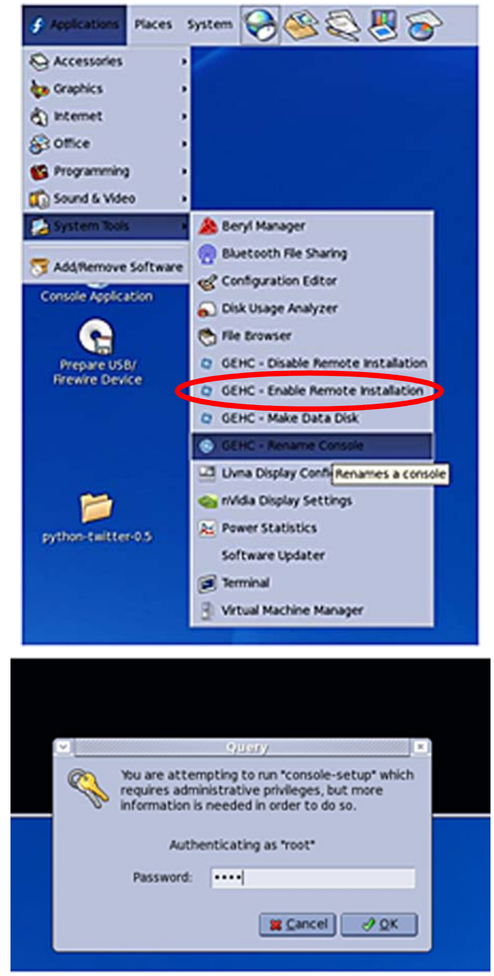


Figure 5-33

5. On the Console computer, select **"Application - System Tools - Terminal"** to launch a terminal window. (**Figure 5-34**)

6. In the terminal window type in command:***sudo tail-f/var/log/messages <enter>***

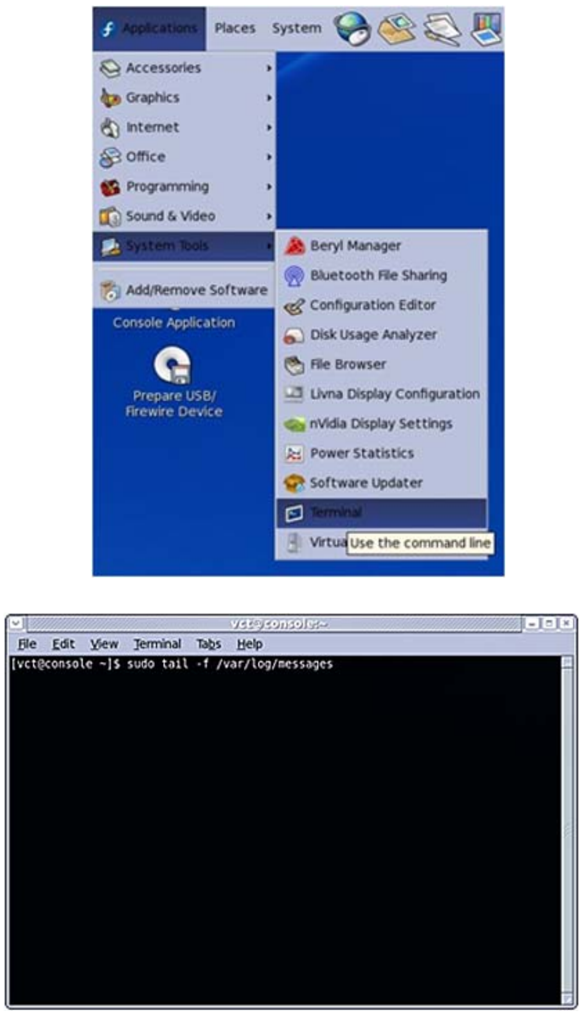


Figure 5-34

7. Turn on the SPECT Computer and wait for it to boot. Note the last IP address indicated in the "tail" terminal window (Figure 5-35).

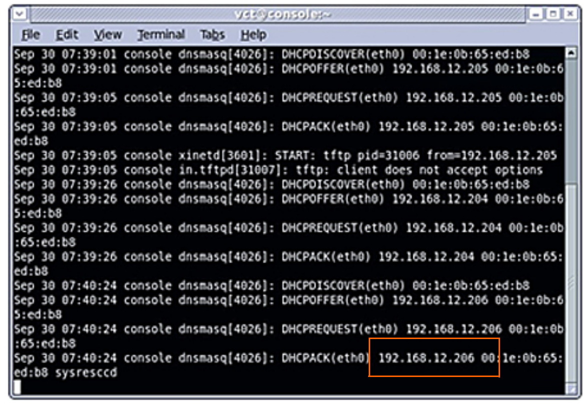
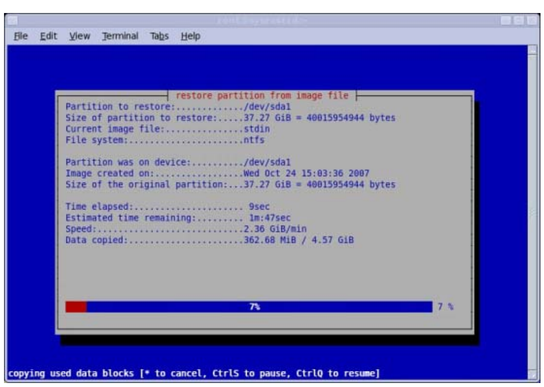


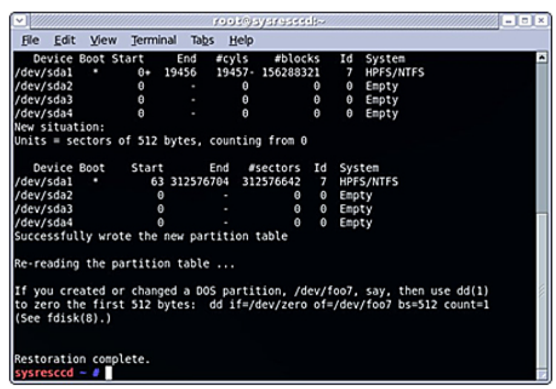
Figure 5-35

8. See Figure 5-36. Launch another terminal window on the SPECT Computer. Type the command ***slogin root@<IP Address> <enter>*** using the IP Address in Figure 5-35. Type in "***yes***" if you see the question "Are you sure you want to continue connecting?"Type in "***operator***" as password. Type in the command ***./restore_spect.sh***
Type ***"yes"*** to continue connecting. Enter the password "***vct***".

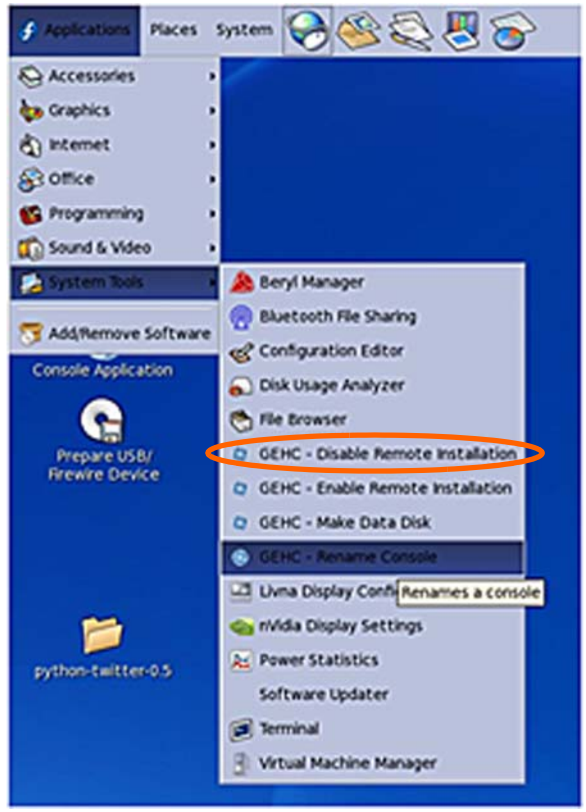
Figure 5-36

9. Allow the software restore to finish.





10. On the Console computer, Select **“Application – System Tools – Disable Remote Installation "** (Figure 5-37)



11. In the terminal window logged into the SPECT Computer, type in command ***reboot -f <enter>.*** Wait a few minutes to allow the computer to reboot. *(*Figure 5-37**)**

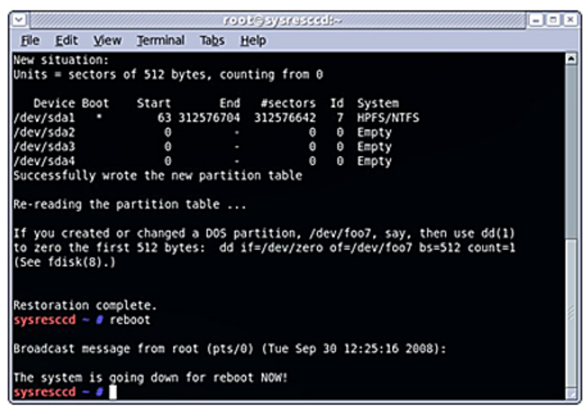


Figure 5-37

12. Establish a VNC connection to the SPECT Computer. On the Console computer, Select **“Application – System Tools – Terminal”** to launch a terminal window. Type ***vncviewer spect.local***

13. Type in the password ***debug .***

14. The SPECT Computer should boot into Windows. Exit the system monitor on the SPECT computer.
15. Shut the Computer down.

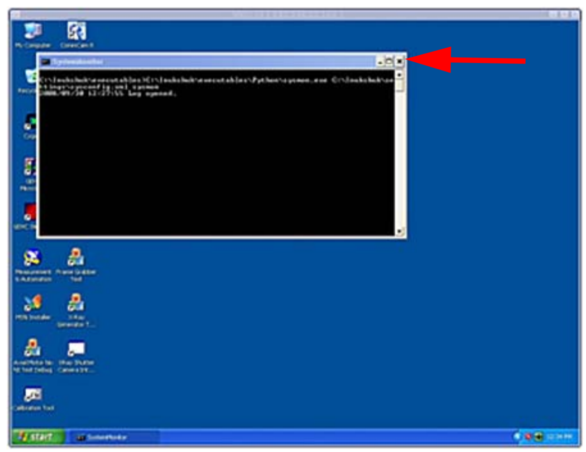


Figure 5-38

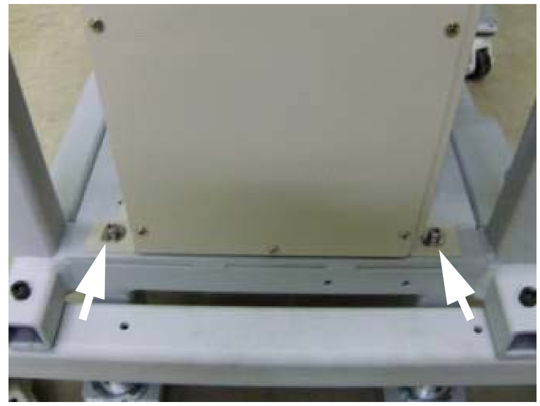
5.4.2 Chiller (5257328)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The SPECT side covers, Table side covers and corner covers are removed.

Removal

See Figure 5-39.



1. Remove power cord and serial cable from Chiller.
2. See photo at right. Remove two (2) M6 socket screws (2109867-13, Item 31) and lock washers (2109880-3, item 29) from the base of the Chiller and set aside. These are located at the left end of the SPECT unit base.
3. Grasp the top handle and carefully slide the Chiller out of the left hand end of the SPECT unit base. If necessary, back off the screws holding down the Chiller retainer blocks at the right hand end of the Chiller. Chiller line length will allow the unit to come out just far enough to disconnect the lines from Chiller (Item 23) inlet and outlet (circled).
4. Drain X-Ray Detector Coolant from Chiller, Cooling Rings and Cooling Lines.

.

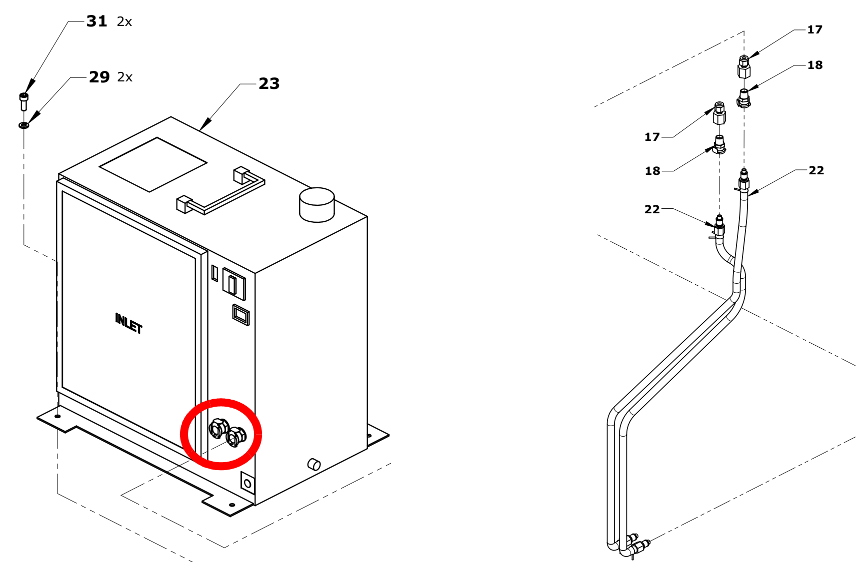
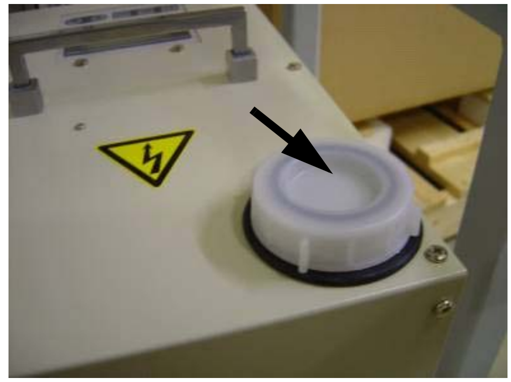


Figure 5-39

Replacement

1. Orient the replacement Chiller such that the inlet & outlet will be in the center of the SPECT unit base and face the table when installed. Slide the unit onto the base until the Chiller retainer brackets slide under the two retainer blocks. Loosen the screws holding the retainer blocks. Position the Chiller so that the holes in the left end of the retainer bracket align with threaded holes in the base. Tighten retainer block screws.
2. Add lock washers to socket screws set aside earlier. Insert into SPECT base through remaining holes in retainer bracket. Torque to 70 in-lb.
3. Re-connect Cooling Lines to inlet and outlet.

4. Unscrew coolant cap from chiller (photo at right) and add X-Ray Detector Coolant (2352900, Item 50 - not shown) to 2 inches below O-ring level. Replace cap and tighten.



5. Plug in power cord and start the Chiller. Coolant should be noted flowing in the Cooling Lines. Look for leaks and shut off the Chiller immediately if any are found. Let the Chiller run for 1 minute, then switch off. Check Coolant level again and add more as required until level is 2 inches below O-ring.
6. See following photos. Start Chiller and ensure firmware version GC 1.00 appears on the display for the first 5 seconds. Ensure PV<17.0 °C appears. After running for about 10 minutes, SV should approach 17 °C.

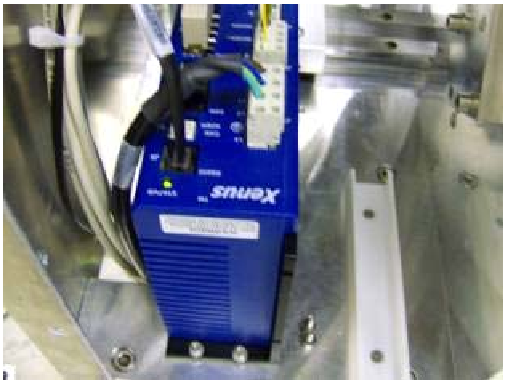
5.4.3 Amplifier for Collimator Drive Motor (5165454)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The left side SPECT cover and left side shields are removed.

See Figure 5-40.

Removal



1. Remove all cable connections to Amplifier (Item 7). Note their locations for re-connection (see photo at right).
2. Remove four (4) M4 socket screws (2109867-3, Item 33), lock washers (2109880-2, Item 32) and flat washers (2381270-5, Item 34) securing the Amplifier to the SPECT Mounting Plate. Set hardware aside.

Replacement

1. Position replacement Amplifier on the Mounting Plate per the illustration.
2. Fasten to the Plate using the hardware set aside during removal.
3. Re-connect all cables.

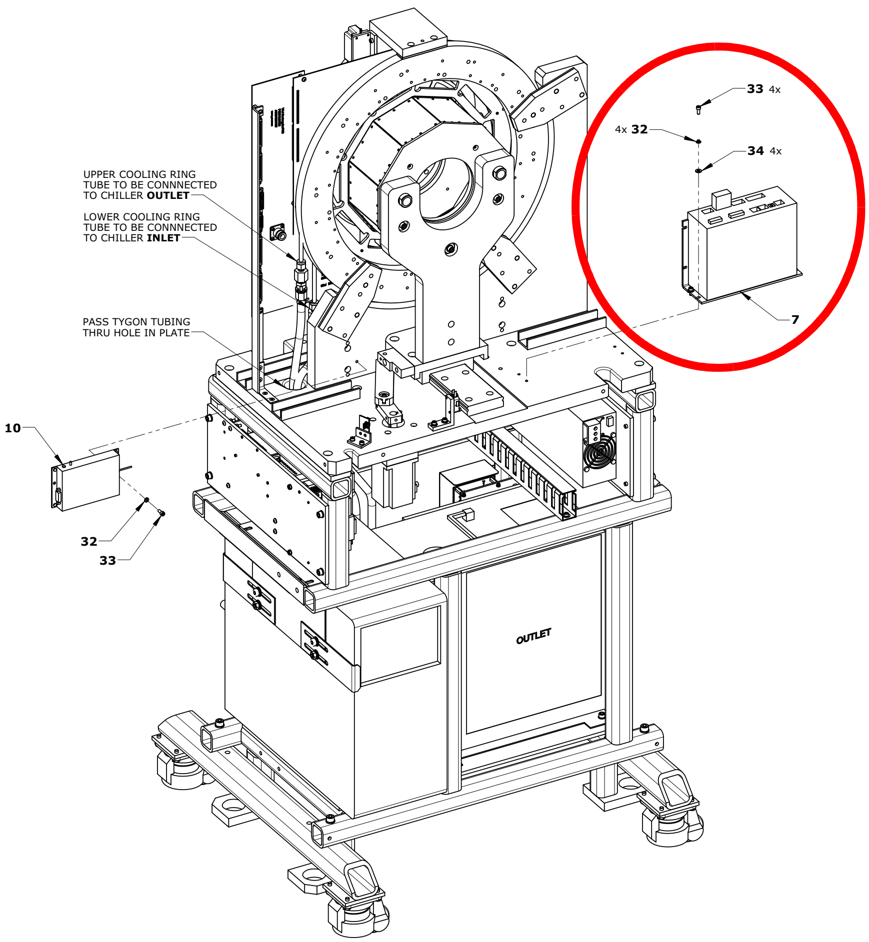
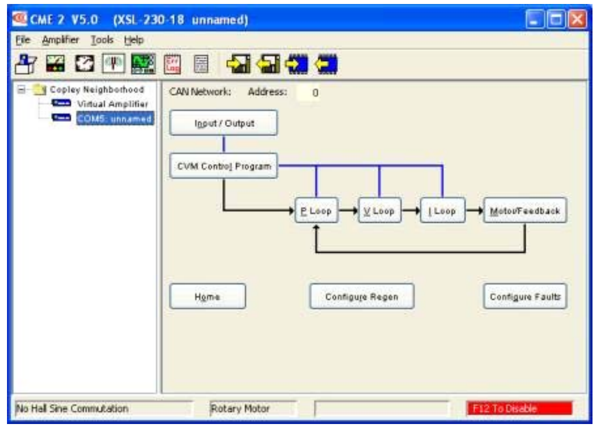


Figure 5-40

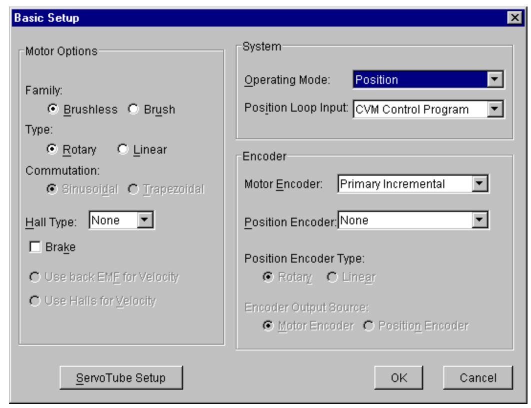
Follow Up

To program the new amplifier:

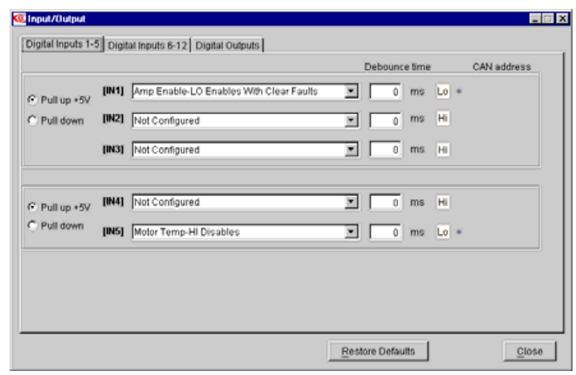
1. On SPECT computer, run the CME2 application on the desktop.



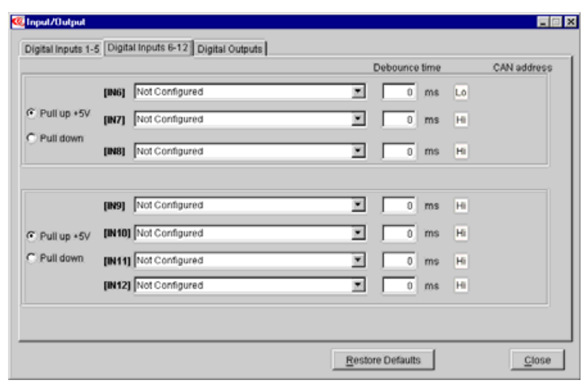
2. Click on Amplifier/Basic Setup.



3. Verify settings displayed in the picture at right and change if necessary. Click OK to save.
4. Click 'Input/Output' button on the main application (top picture).

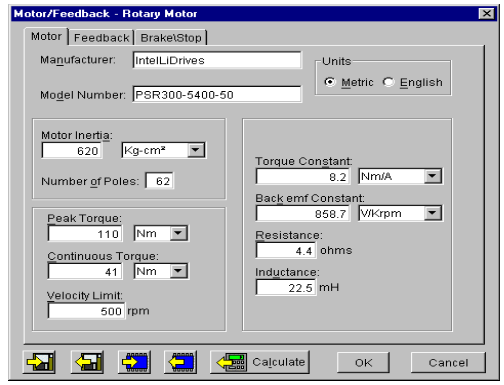


5. Verify settings displayed under 'Digital Inputs 1-5' tab. Change if necessary.

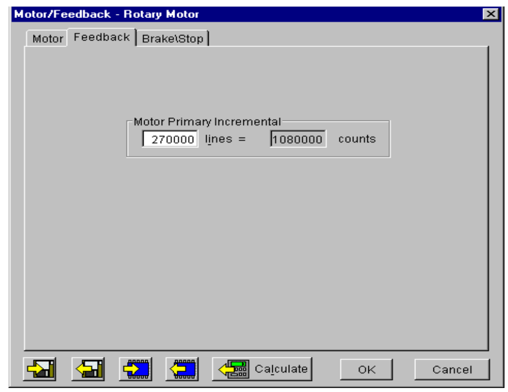


6. Click on 'Digital Inputs 6-12' tab. Verify settings are the same. Change if necessary.

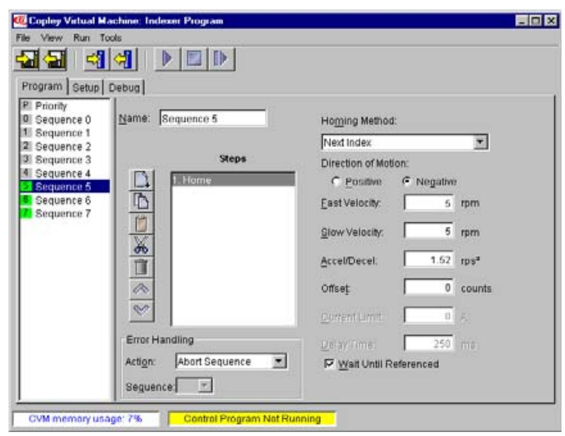
7. Click 'Close' to save and exit.
8. Click 'Motor/Feedback" button on main application.



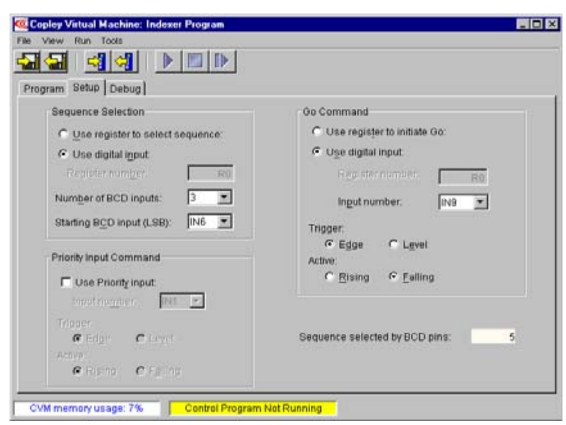
9. Under 'Motor' tab, verify settings. Change if necessary and press OK to save.



10. Click on 'Feedback' tab and verify settings. Change if necessary and press OK to save and exit.
11. Click on 'CVM Control program" button on main application

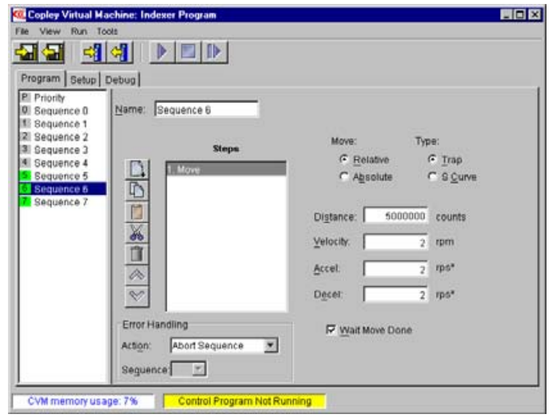


12. Under 'Program' tab, for Sequence 5 verify settings. Change if necessary.

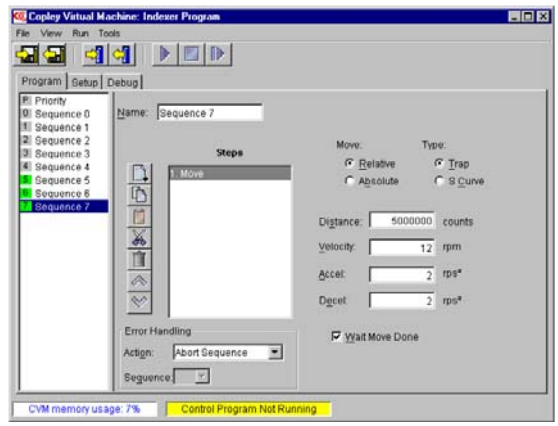


13. Click on the "Setup" tab and verify settings. Change if necessary

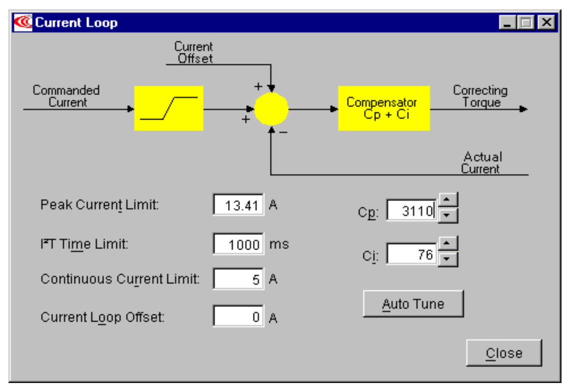
14. Click on the "Program" tab, and on Sequence 6 on the left. Verify the settings and change if necessary.



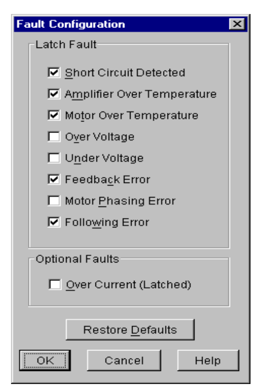
15. Click on Sequence 7 on the left, and verify the settings. Exit.



16. Click on the "I loop" button on the main application.
17. Verify settings and change if necessary. Click 'Close'.



18. Click on 'Configure Faults' on the main application
19. Verify settings.



5.4.4 Septa Electronics Subassembly (5195188)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The right side SPECT cover is removed.

See Figure 5-41.

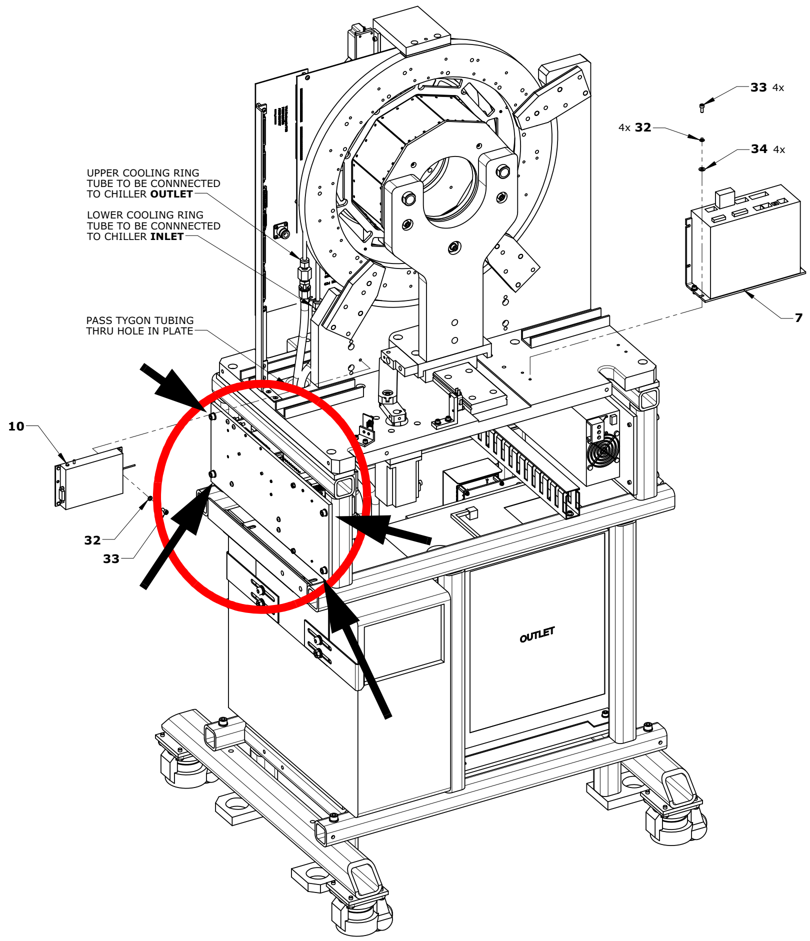


Figure 5-41

Removal

1. Remove four M6 hex screws and washers (arrows) holding the Septa Electronics to the SPECT frame and set aside.
2. Unplug the AC power cord.
3. Clip ty-raps as necessary.
4. Tilt the Septa Electronics out and unplug all connectors, noting their locations. Lift assembly away from the frame.

Replacement

1. Replacement is the reverse of installation. Torque screws to 70 in-lb.

5.4.5 Low Voltage Power Supply Assembly (5195194)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The left and right side SPECT covers and right side shield are removed.

See Figure 5-42.

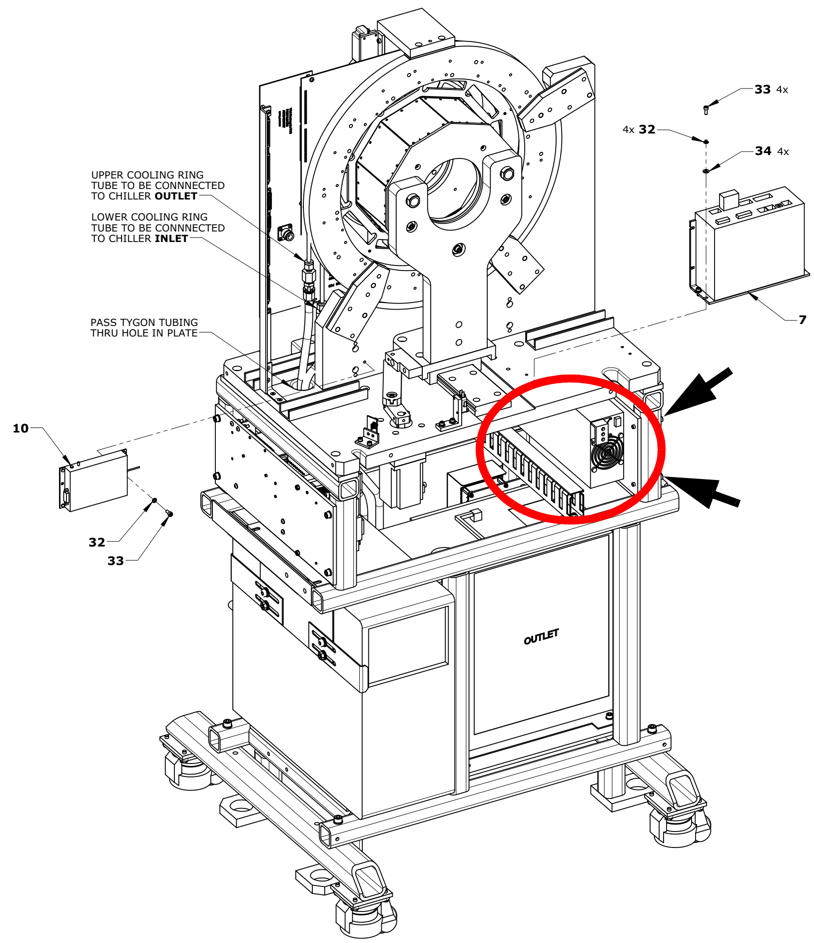


Figure 5-42

Removal

1. Remove four M6 hex screws and washers (arrows) holding the Power Supply to the SPECT frame and set aside.
2. Unplug the AC power cord from the rear of the Power Supply.
3. Carefully unplug the DC cable (5245518) from the Rectangular Board.
4. Tilt the Power Supply away from the frame and remove.

Replacement

1. Replacement is the reverse of installation. Torque screws to 70 in-lb.

5.4.6 Collimator Drive Motor (5327503)

Preconditions

- The machine is powered off using the main breaker on the PDU.
- The Table Shield is pulled back completely.
- Through the Service pages, the septa is retracted to the home position and the Collimator Support (5162668, Item 2 in Figure 5-43) is unlocked.
- The thumbscrew is unlocked and the Collimator Support is lowered. If a collimator is mounted, remove it.

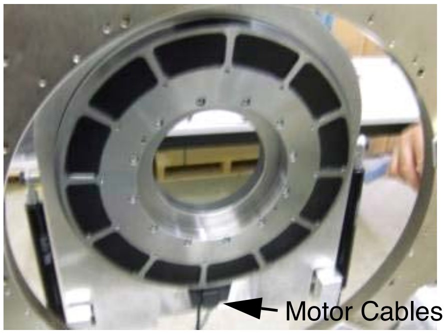
Removal

1. See Figure 5-43. Remove ten (10) 6-32 flat head socket screws (2390659-1, Item 43) holding Front Shield (5314267, Item 42) and set all aside.
2. Remove six (6) M5 socket head cap screws (2390619, Item 41) holding Front Shield Mounting Bracket (5314269, Item 40) and set all aside.
3. Mark the Drive Flange position relative to the Collimator Drive Motor. Remove twelve (12) M4 socket cap screws (2109884-2, Item 21) from Drive Flange (5165217, Item 23). Set Flange and hardware aside.

NOTICE Possible Equipment Damage

Two persons will be required to remove and replace the Collimator Drive Motor - one to support it and another to loosen the mounting screws.

4. Disconnect Collimator Drive Motor (5327503, Item 46) motor cables (photo). Tilt Collimator Support to access six (6) M6 socket cap screws (2109867-15, Item 25) from the front side. Loosen screws while an assistant supports the Drive Motor. The Drive Motor is positioned by guide pins. Pull the Drive Motor straight out and set aside with hardware.



Replacement

1. Aligning guide pins with holes, put replacement Collimator Drive Motor in recess on back side of Collimator Support with wires at bottom, as shown in illustration. Thread six M6 cap screws set aside earlier through the front of the Collimator Support and torque to 70 in-lb.
2. Align Drive Flange to rear of Collimator Drive Motor using the marks made before removal. Fasten with twelve M4 screws set aside earlier. Torque screws to 20 in-lb.
3. Reconnect cables to Amplifier.
4. Attach Front Shield Mounting Bracket to Collimator, then Front Shield to Front Shield Mounting Bracket, using hardware set aside earlier.

Follow Up

1. Perform geometry and unformity calibration for each collimator that the customer is using. See Chapter 7, SPECT Calibration.

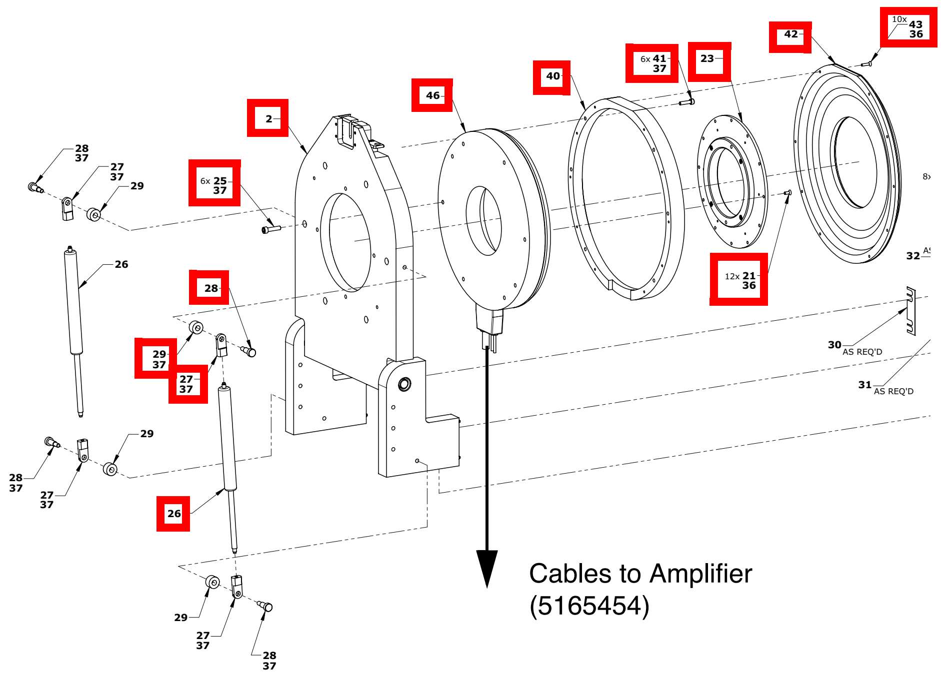


Figure 5-43

5.4.7 Gas Shock (5162335)

See Figure 5-43.

Removal

1. Ensure Collimator Plate is in its upright position and the locking thumbscrew is secured.
2. Place a wedge under the bottom end of the Shock to prevent it from extending while removing bolt. Remove Socket Shoulder Bolt (46-328419P2, Item 28) from each end of the faulty Gas Shock (5162335, Item 26). Set Bolts and two (2) Spacers (5162331, Item 29) aside.
3. Remove the Eyelet (2412084, Item 27) from each end of the Gas Shock and set aside.

Replacement

1. Thread an Eyelet (set aside earlier) on each end of the Gas Shock.
2. Place a Spacer between each Eyelet and the mounting holes on the Collimator Support and

the Mounting Plate, and fasten with the Shoulder Bolts. Torque to 195 in-lb.

5.4.8 Stepper Motor (5154899)

Preconditions

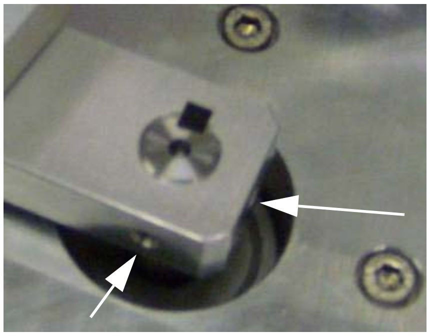
- The machine is powered off using the main circuit breaker on the PDU.
- The right side SPECT cover and right side shield are removed.

See Figure 5-44.

Removal

1. Detach Septa Retraction Linkage (5241220, Item 7) from Septa Assembly (5195199, Item 5) by removing Shoulder Bolt (46-328419P5, Item 33) and M6 socket screw (2109867-17, Item 34). See photo at right. Set hardware aside.

2. Loosen the two set screws on the Septa Retraction Linkage at the Stepper Motor (Item 17) shaft and lift the Linkage off the shaft. See photo at right. Set hardware aside.



3. Unplug Stepper Motor cable from the Septa Electronics board. Loosen four (4) M5 cap screws (2381227-6, Item 16) holding the Stepper Motor to the Mounting Plate while holding the motor. Set screws aside.

Replacement

1. Orient replacement Stepper Motor with its cable facing the left side of the SPECT unit (facing away from the Septa Electronics).
2. Using the M5 cap screws set aside earlier, thread through the Mounting Plate into the Motor. Torque to 44 in-lb.
3. Place motor end of Septa Retraction Linkage on Motor shaft. Completely remove the two set screws. Adjust the Linkage until it is flush with the Motor shaft end. Thread in the set screws and hand tighten them.
4. Re-attach the Linkage to the Septa Assembly, first with the Shoulder Bolt, then the M6 screw.

Torque the Shoulder Bolt to 195 in-lb and the screw to 70 in-lb.

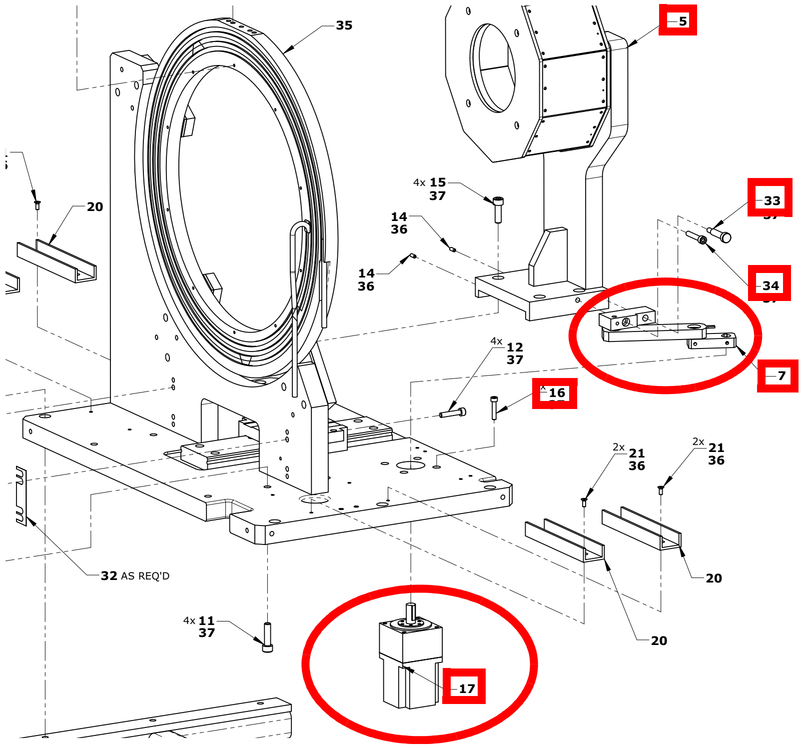


Figure 5-44

5.4.9 Ring PCB (5224341)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The SPECT covers are removed.

See Figure 5-45.

Removal

CAUTION *Printed circuit board components are vulnerable to electrostatic damage. Ensure that a wrist strap, grounded to a metal frame on the machine, is worn when handling boards. Use an antistatic bag to store boards when not installed.*

CAUTION *Connections to the V4.0 Rectangular PCB (5231767, Item 40) are fragile. Use care when removing or making connections.*

1. Remove all cable connections at the rear side of the Rectangular Board.
2. Remove three (3) #6-32 screws (2390639-13, Item 44) with internal tooth lock washers (2390666, Item 43) holding the Rectangular Board to the Rectangular PCB Brace (5248116, Item 41) nylon standoffs and set aside.
3. Remove three (3) #6-32 screws (2390639-13, Item 44) with internal tooth lock washers (2390666, Item 43) holding the Rectangular Board to the Ring PCB (Item 39) standoffs and set aside.
4. Gently pull Rectangular PCB away from the Ring PCB and place in an antistatic bag.

5. Loosen ten (10) #6-32 screws (2390639-13, Item 44) with internal tooth lock washers (2390666, Item 43) from the front side of the Ring PCB. Note that the screw at the 7 o'clock position secures a Cable Tie Mount (2388013, Item 16). Support the Ring PCB while removing the last screws. Remove three (3) Nylon standoffs (2390049-3, Item 48) from the Ring PCB by removing #6-32 screws (Item 44) with internal tooth lock washers (Item 43) from the rear side. Set hardware aside.

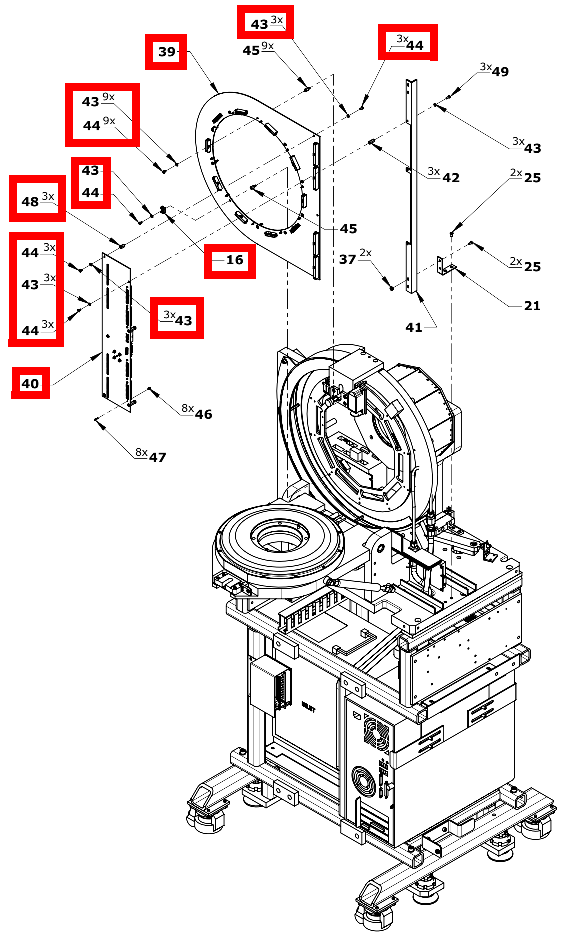


Figure 5-45

Replacement

1. Add the three (3) Nylon Standoffs (Item 48) to the replacement Ring PCB using the #6-32 screws and internal tooth lock washers set aside earlier.
2. Place replacement Ring PCB over nylon standoffs on Front Sensor Shield, oriented as shown in the illustration. Connectors must face the front of the machine. Fasten with ten (10) #6-32 screws and internal tooth washers set aside earlier, remembering to secure the Cable Tie Mount at the 7 o'clock position. Hand tighten these bolts only. Over-torquing may damage the Ring PCB.
3. Carefully plug the V4.0 Rectangular PCB set aside earlier into the Ring PCB connectors. Fasten the Rectangular PCB to the Ring PCB in three places (at the Nylon Standoffs) with #6-32 screws and internal tooth washers set aside earlier. Also fasten the Rectangular PCB to the Rectangular PCB Brace with three (3) #6-32 screws (Item 44) with internal tooth lock washers (Item 43) set aside earlier, threading through the front of the PCB into the nylon standoffs.
4. Re-connect cables to the Rectangular PCB.

5.4.10 Cooling Ring (5159196)

The likelihood of failure of the Cooling Ring is low. Removal and replacement with subsequent alignment is a very involved process that is beyond the scope of normal field service.

If a failure is encountered, contact GE Healthcare for guidance.

5.4.11 Septa (5159198)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The SPECT covers and shields are removed.

Removal

1. Disconnect the Septa Retraction Linkage from the Septa Assembly as described in 5.4.8 Stepper Motor (5154899) "Removal". Set hardware aside.
2. Slide Linear Motion Guide carriage (5147989) toward rear of machine to move the Septa safely clear of the detector ring.

CAUTION *Support the Septa or have an assistant hold the Septa during removal.*

3. See Figure 5-46. Remove M6 socket screw (2109867-12, Item 5), lock washer (2109880-3, Item 4) and flat washer (2381270-7, Item 3) and set aside.
4. Remove M6 socket screws (2109867-17, Item 6), flat washers (2381270-7, Item 3) and Compression Springs (5237384, Item 8) at two locations and set aside.
5. Using a 6mm socket, loosen M6 nuts (2109875-3, Item 7). Remove nut, lock washer (2109880-3, Item 4) and flat washer (2109878-3, Item 9) at both locations and set aside.
6. Carefully remove Septa (Item 2).

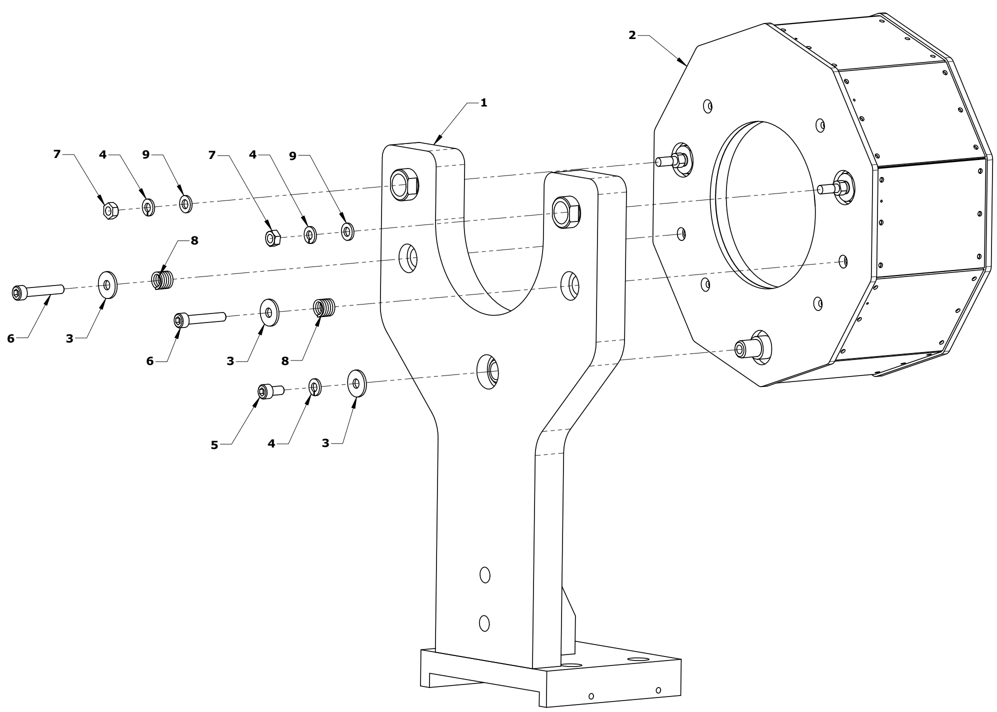


Figure 5-46

Replacement

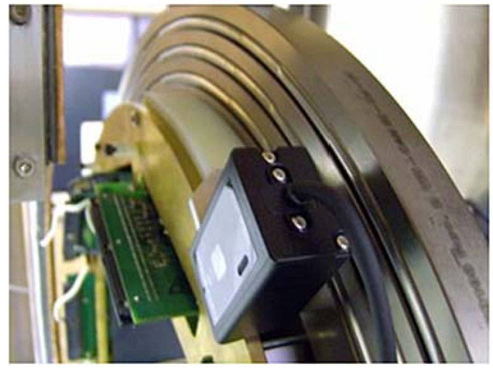
CAUTION *The Septa is fragile. Have an assistant available to hold the Septa during installation.*

1. Mount the Septa into the holes in the Septa Support (Item 1) from the front side, as shown in Figure 5-46.
2. Place a flat washer (Item 9), lock washer (Item 4) and a nut (Item 7) set aside earlier on each of the top two (2) threaded ball joint links (on the Septa) through the holes in the Support. A special tool will be required to stop the ball joint links from rotating while the nut is tightened.
3. Fasten M6 socket screw (Item 5), lock washer (Item 4) and flat washer (Item 3) set aside earlier through bottom hole in the Support and into the adjustment shaft in the Septa. Torque to 70 in-lb.
4. Loosely fasten two (2) M6 socket screws (2109867-17, Item 6), flat washers (2381270-7, Item 3) and Compression Springs (5237384, Item 8) set aside earlier to the Septa through remaining holes in the Support. Tighten only until they are snug. These will be adjusted during Septa alignment.

Follow Up

1. Full SPECT calibration will be required. See 7.2.1 SPECT Calibration.

5.4.12 Barcode Reader (5316863)



Preconditions

- The Front SPECT cover is removed.
- The front door of the SPECT unit is open and the collimator support unlocked and lowered.

See Figure 5-47.

Removal

1. Unplug the Barcode Reader cable from the SPECT Computer.
2. Cut any cable ties securing the Barcode Scanner cable.
3. Remove M2 socket head cap screw (46-260789P21, Item 63) and lock washer (2381267, Item 62) holding Barcode Reader (Item 58) to Barcode Reader Mounting Bracket (5290068, Item 57). Set screw and lock washer aside.

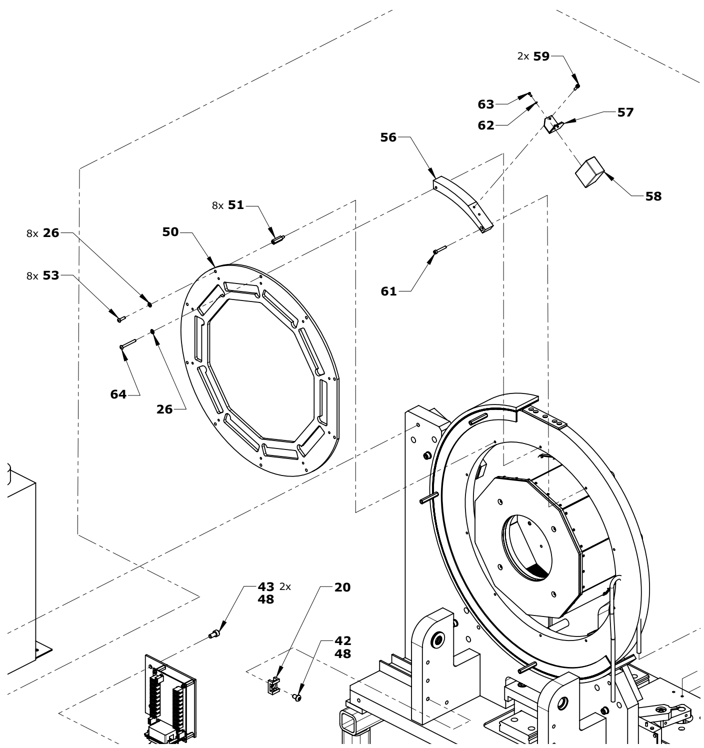


Figure 5-47

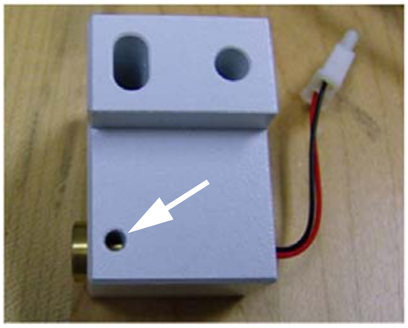
Replacement

1. Mount replacement Barcode Reader to Barcode Reader Mounting Bracket using the screw and lock washer set aside earlier.
2. Secure Barcode Reader cable to Cooling Ring tube with Cable Ties.
3. Plug the cable into the SPECT computer in the same port from which the original cable was removed.

5.4.13 Landmark Lasers (5307786)

Preconditions

- Open access door on SPECT front cover.
- Close collimator support and lock with thumbscrew.



Removal

See Figure 5-48.

1. Unplug the laser (vertical or horizontal) that is to be replaced (Item 2). The vertical laser in its mounting bracket is shown in the photo at right.
2. For the vertical laser, loosen M4 nylon tip set screw (arrow in photo; 46-311853P9, Item 10) until laser is free to slide upward out of its mounting bracket. For the horizontal laser, loosen the set screw and pull the laser out sideways.

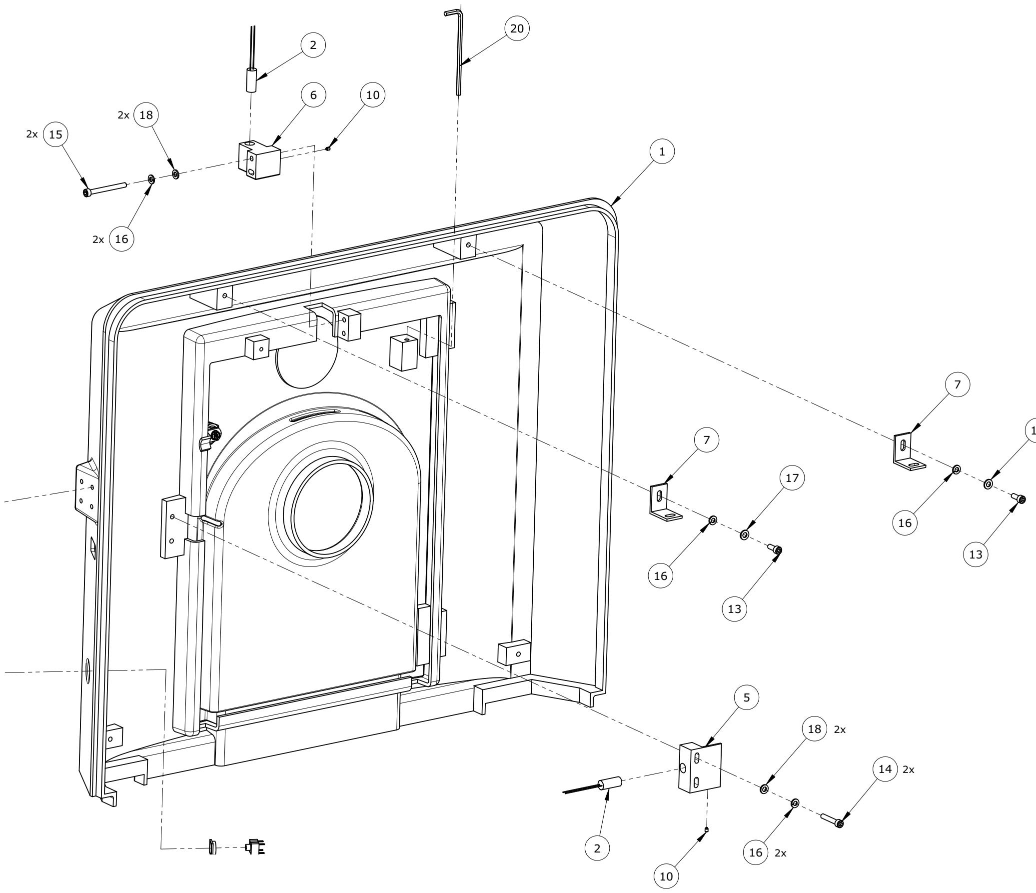


Figure 5-48

Replacement

1. Slide laser into its mounting block until it extends 5 mm past the block. Tighten the set screw slightly to keep it in position. Plug in the laser.
2. Set laser target block (5197806) on the cradle and adjust cradle height until 0 mm is indicated

on the Touch Screen. Move the cradle close to the collimator support.

3. Toggle lasers on.
4. For the horizontal laser, rotate its barrel until the beam is level on the face of the collimator support, using bolt heads as a reference. The beam should also pass through the horizontal groove on the laser target block. Tighten the set screw to secure the laser, but don't overtighten.
5. For the vertical laser, use a square on the table to ensure the beam is vertical.
6. Toggle lasers off.

5.4.14 CZT Detector, Dual Row (5252277-2)

Preconditions

- Use the service page (Septa tab) to home the septa.
- Remove the collimator.
- Shut down the system from the Console.
- Power the system off using the main circuit breaker on the PDU.
- Remove the SPECT side covers (Remove SPECT Unit Covers on page 132) and shields (SPECT Side and Radiation Shield Removal & Replacement on page 160).
- Remove the touch screen and place in a safe location.

CAUTION

Shields are heavy. Use caution when handling to avoid injury from pinching.

NOTICE Equipment Damage Possible

Wear static protection when handling the CZT detector panels.

Removal

1. Disconnect all cables from the rear of the Rectangular Adapter Board (photo at right), noting their locations.
2. See circled aluminum angle plate in Figure 5-49. Remove the three allen screws attaching the plate to the Rectangular Adapter Board. (Note that the middle 1.5mm screw is longer than the other two 2.5mm screws). Remove the four (4) remaining 2mm allen screws and set aside.
3. See Figure 5-49. Remove Side Shielding (5314272, Item 7) by removing four (4) M4 hex cap screws (2109867-6, Item 10), lock washers (2109880-2, Item 9) and flat washers (2109879, Item 11) from the top of the unit. Set hardware and Shielding aside.
4. Remove four (4) #6-32 flat head screws (2390659-5, Item 6) from Rear Shield (5314265, Item 2). Slide the Shield out of the side of the machine and set aside with screws.
5. Remove three (3) screws from each of Left Side Bottom Shield (5314271, Item 3) and Right Side Bottom Shield (5314354, Item 4) and set aside with Covers.

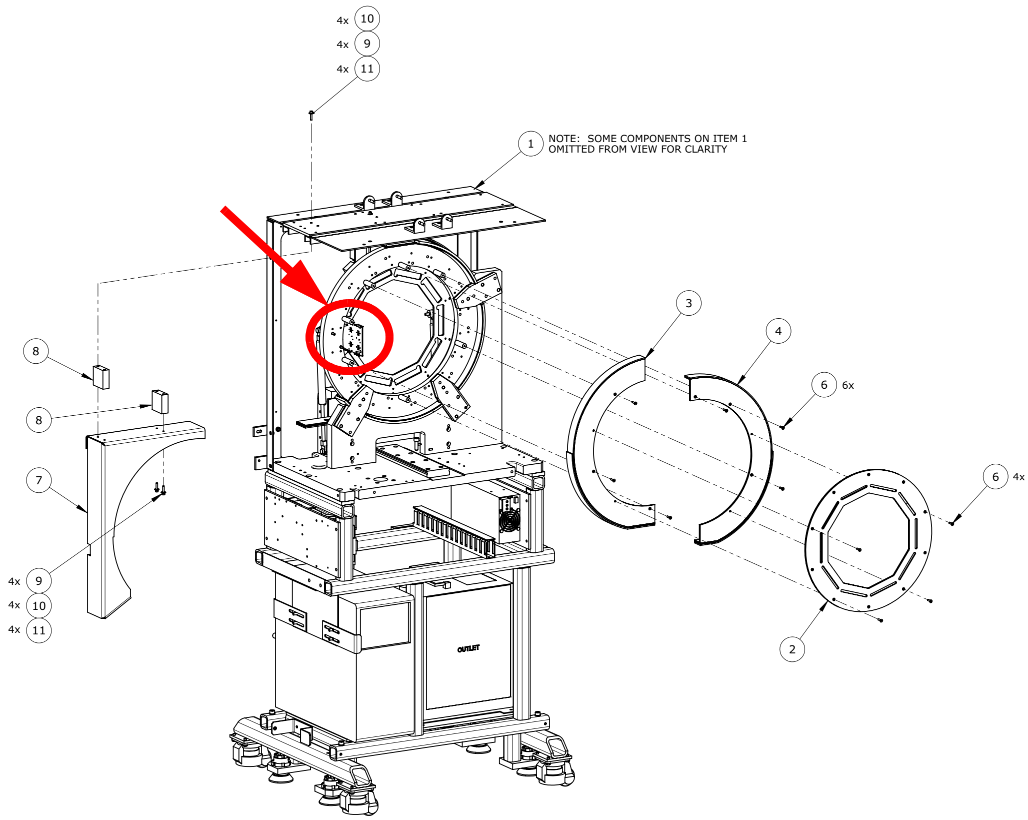


Figure 5-49

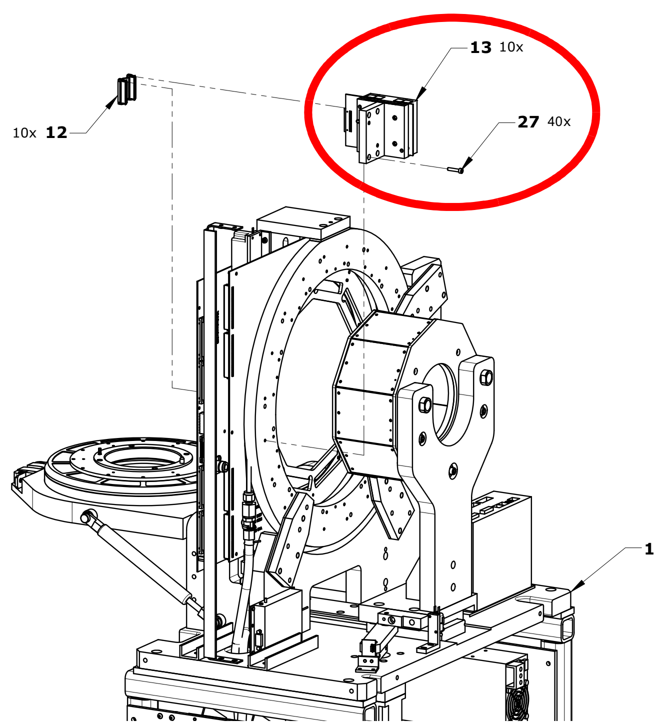
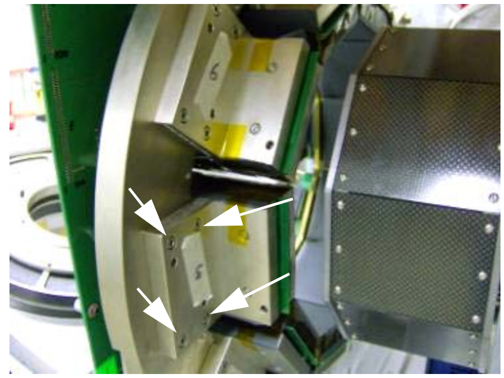


Figure 5-50

6. See Figure 5-50. For the Detector panel being replaced (Item 13), unplug one end of the Ribbon Cable (5252392, Item 12) at the panel end, and unplug the white high voltage cable from the Ring PCB.

Note: For reference, the panels are numbered in counterclockwise fashion as viewed from the Table, starting at 9 o'clock position (Panel "0").



7. While supporting the panel, remove four (4) M4 socket screws (2109867-6, Item 27) from the rear side of the Cooling Ring (see photo). Carefully move the panel toward the rear until it is clear of the ring. Set hardware aside.

Replacement

1. Orient the replacement Detector panel as shown, and from the rear of the Cooling Ring, pass it through the opening in the Front Sensor Shield.
2. Thread the four M4 screws set aside earlier through the panel into the Cooling Ring and torque to 21 in-lb.
3. Connect the Ribbon Cable to the Detector.
4. Connect the white high voltage cable to the Ring PCB and position cable so that it doesn't cause mechanical interference.
5. Install the Left and Right Side Bottom Shields with the hardware set aside earlier.
6. Install the Rear Shield (copper side facing front of system) by sliding it into position form the side and fastening with hardware set aside earlier.
7. Install Side Shielding by fastening through the top with hardware set aside earlier.
8. Restore connnections to the rear of the Rectangular Board.

Follow Up

1. Full SPECT calibration will be required. See 7.2.1 SPECT Calibration.

Section 5.5
SpeCZT CT 120 (5169192) CT Component FRUs

CAUTION

Failure to lock the rotating base prior to removing components may lead to Gantry motion which can strike a person causing injury or death.

CT UNIT SHIELDS AND TOP SHIELD

Most components in the CT Gantry can be accessed by swinging the hinged X-Ray shields open on the rear and the sides. See Figure 5-51 for shield locations.

For removal of the X-Ray tube, it will be necessary to rotate the disc until the tube is at the top, then apply the gantry lock. If the top shield is removed, a hoist and sling can be used to safely remove and replace it.

Opening and Closing of Left and Right Side Shields

1. Remove two (2) M6 cap screws (2109867-13, Item 41) and flat washers (2109878-3, Item 42) from top and bottom of each of the Left Side Shield (5224529, Item 16) and the Right Side Shield (5224528, Item 15) and set aside. Shields are now free to swing open.
2. Secure Shields with hardware set aside during opening to secure the Shields closed. Torque to 70 in-lb.

Opening and Closing of Rear Shields

1. Remove two (2) M6 cap screws (2109867-13, Item 41) and flat washers (2109878-3, Item 42) from top and bottom of the Left Rear Shield (5224526, Item 28). Shields are now free to swing open.
2. Secure Shields with hardware set aside during opening to secure the Shields closed. Torque to 70 in-lb.

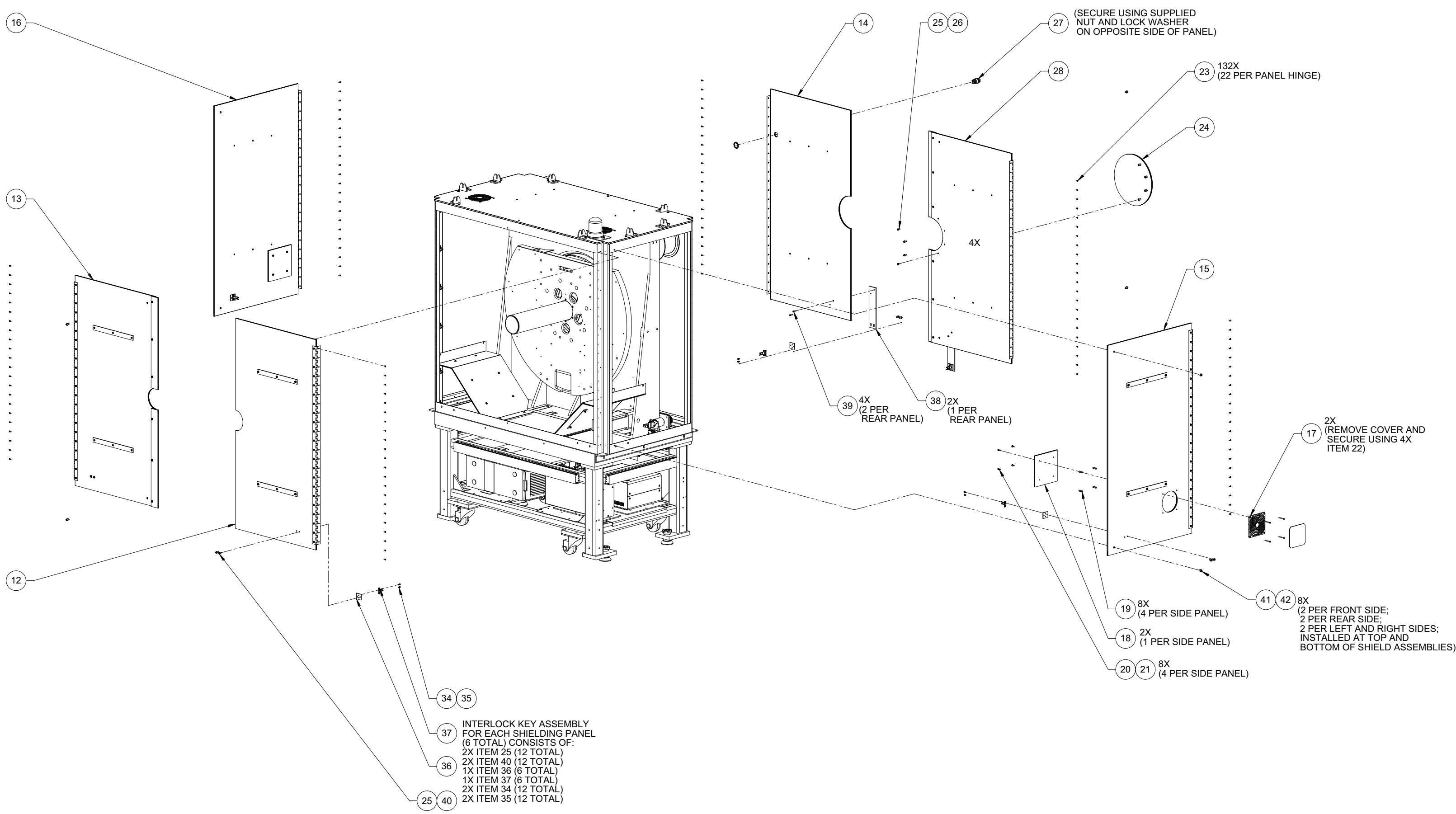

16
13
12
14
25
26
27
(SECURE USING SUPPLIED NUT AND LOCK WASHER ON OPPOSITE SIDE OF PANEL)
28
23
132X (22 PER PANEL HINGE)
24
4X
15
39
4X (2 PER REAR PANEL)
38
2X (1 PER REAR PANEL)
17
2X (REMOVE COVER AND SECURE USING 4X ITEM 22)
41
42
8X (2 PER FRONT SIDE; 2 PER REAR SIDE; 2 PER LEFT AND RIGHT SIDES; INSTALLED AT TOP AND BOTTOM OF SHIELD ASSEMBLIES)
19
8X (4 PER SIDE PANEL)
18
2X (1 PER SIDE PANEL)
20
21
8X (4 PER SIDE PANEL)
34
35
37
INTERLOCK KEY ASSEMBLY FOR EACH SHIELDING PANEL (6 TOTAL) CONSISTS OF:
2X ITEM 25 (12 TOTAL)
2X ITEM 40 (12 TOTAL)
1X ITEM 36 (6 TOTAL)
1X ITEM 37 (6 TOTAL)
2X ITEM 34 (12 TOTAL)
2X ITEM 35 (12 TOTAL)
36
40

Figure 5-51

5.5.1 CT Computer (5262167)

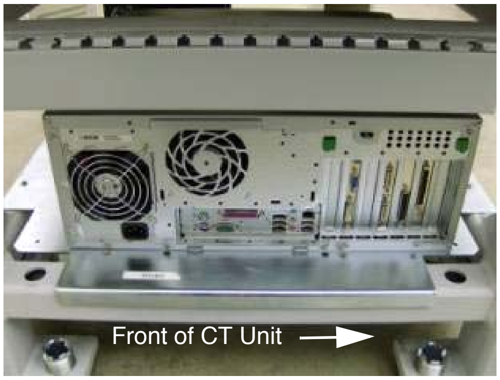
Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The left side CT cover and rear cover are removed.
- The left side corner cover and Table side covers are removed.

See Figure 5-52.

Removal

1. Disconnect all cables from the rear panel of the CT Computer (Item 66). Note cable locations.
2. Remove two (2) M6 cap screws (2109867-13, Item 29), lock washers (2109880-3, Item 18) and flat washers (2109878-3, Item 33) from Computer Location Plate (5241219, Item 49) and set aside.
3. Remove one (1) M6 cap screw (2109867-13, Item 29), lock washer (2109880-3, Item 18) and flat washer (2109878-3, Item 33) from each side of the Computer Hold Down Strap (5241215, Item 48) and set hardware and Strap aside.
4. Slide CT Computer off CT Table Lower Shelf.



Replacement

1. Slide replacement CT Computer into left side of Gantry base, oriented as shown in the illustration.
2. Align Location Plate holes with holes in the Lower Shelf and fasten with hardware set aside earlier. Adjust the Computer location until its front panel aligns with the Location Plate.
3. Fasten Hold Down Strap to the Lower Shelf with hardware set aside earlier. Torque to a maximum of 70 in-lb.
4. Reconnect cables to rear panel of Computer in the order noted during removal.

NOTICE Equipment Damage Possible **Ensure that the 110/220V switch on the Computer is set to 220V**

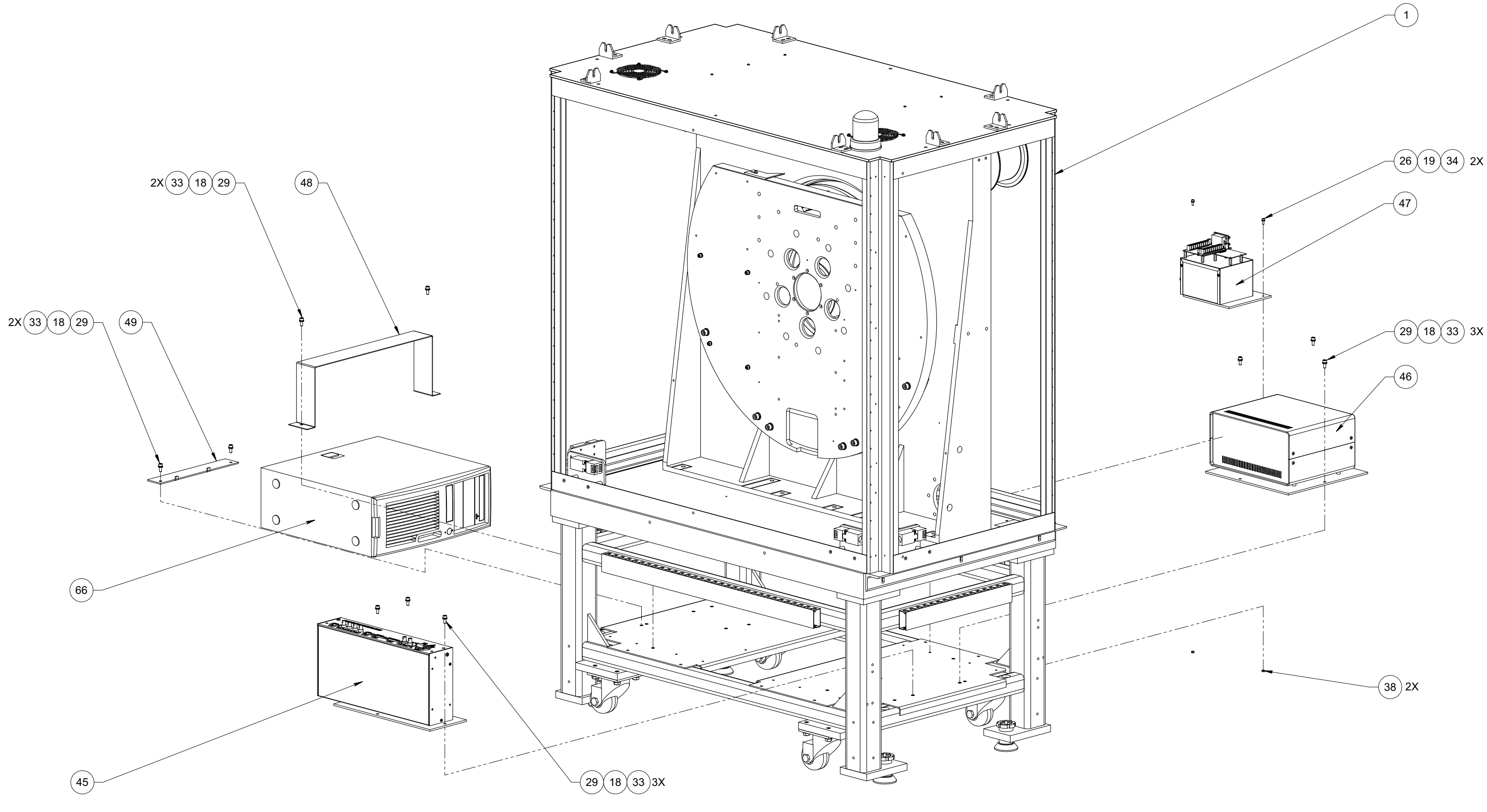
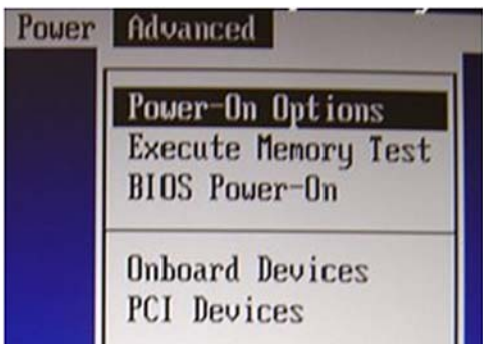
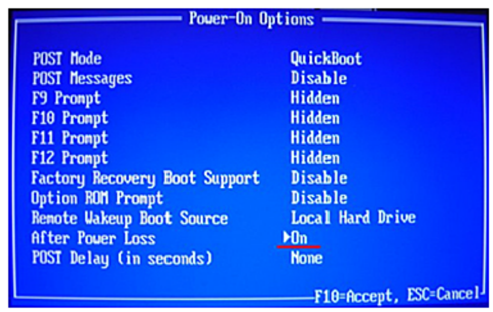

1
2X 33 18 29
48
2X 33 18 29
49
26 19 34 2X
47
29 18 33 3X
46
66
45
29 18 33 3X
38 2X

Figure 5-52

Follow Up

1. Power the Computer on and press F10 to boot into BIOS. Select Storage/Boot Order and select Broadcom Ethernet Controller.





2. Select Advanced/Power-On Options and select After Power Loss.
3. Select File/Save Changes and Exit and turn the Computer off.

4. On the Console computer, select **“Application – System Tools – Enable Remote Installation”**. Enter the password: **operator.** (Figure 5-53). Note that the password dialog box may not appear. In this case, the system caches the password, so it is not needed to continue.

5. On the Console computer, select **"Application - System Tools - Terminal"** to launch a terminal window. (**Figure 5-54**)

6. In the terminal window type in command:***sudo tail-f/var/log/messages <enter>***

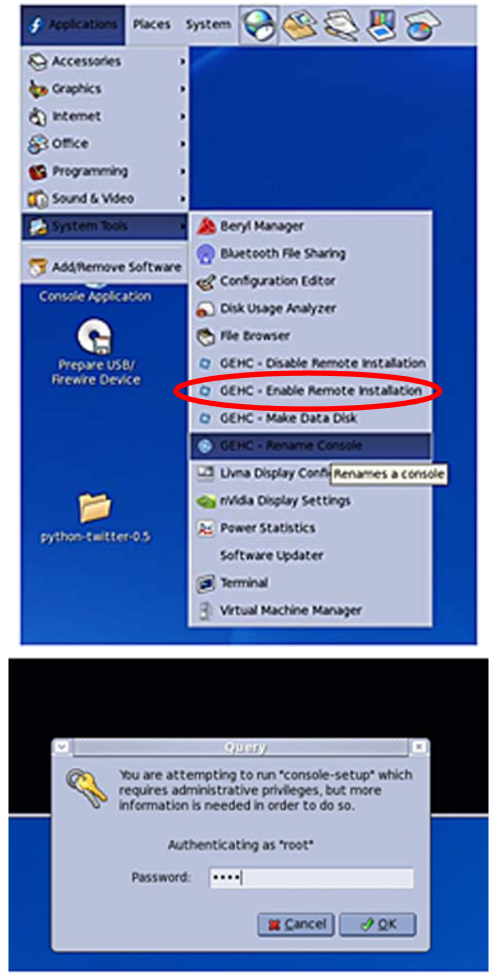


Figure 5-53

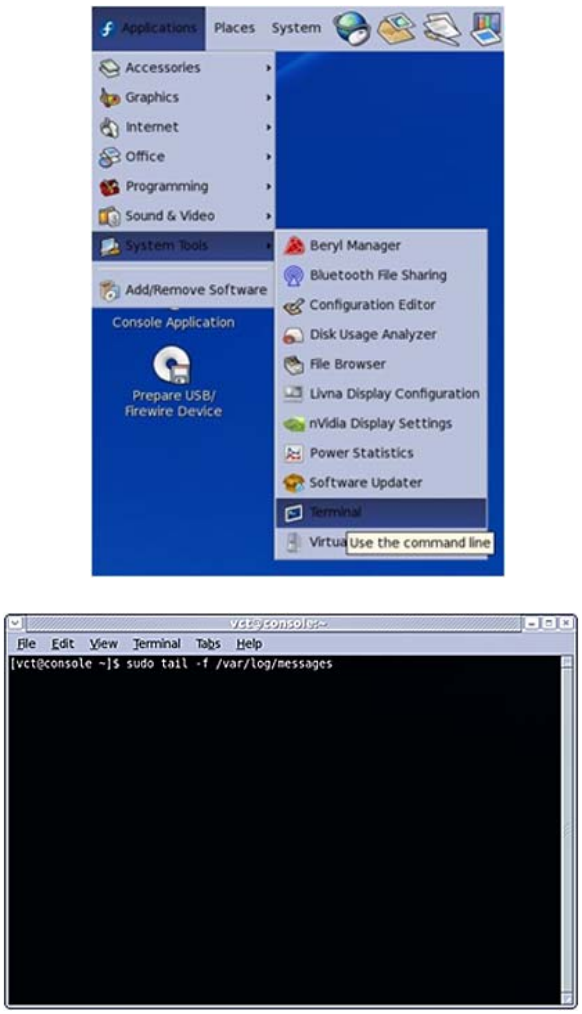


Figure 5-54

7. Turn on the CT Computer and wait for it to boot. Note the last IP address indicated in the "tail" terminal window (Figure 5-55).

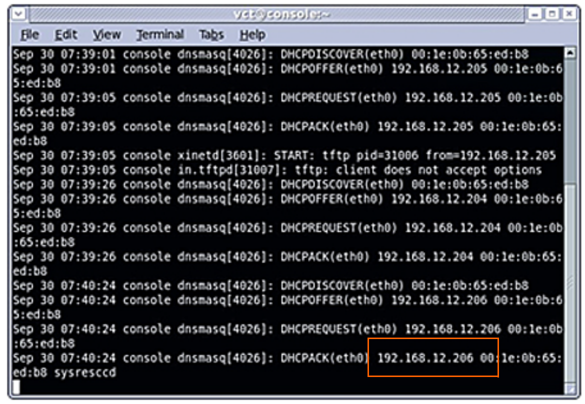
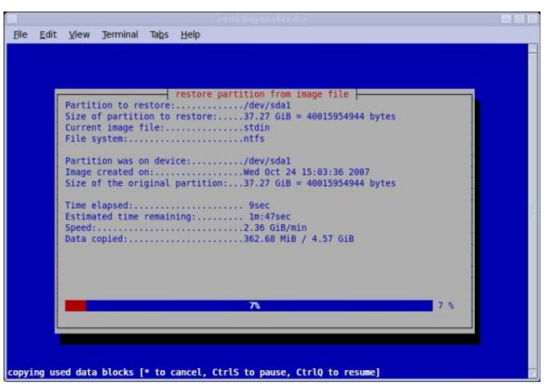


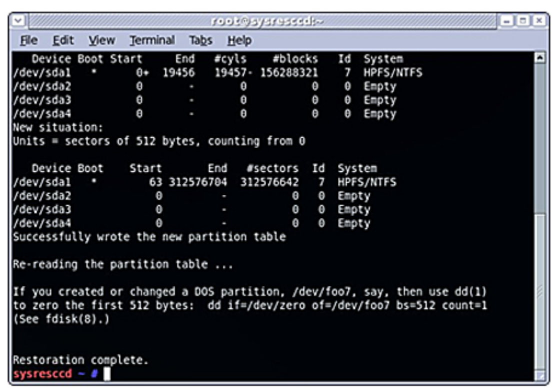
Figure 5-55

8. See Figure 5-56. Launch another terminal window on the CT Computer. Type in the command ***slogin root@<IP Address> <enter>*** using the IP Address in Figure 5-55. Type in "***yes***" if you see the question "Are you sure you want to continue connecting?"Type in "***operator***" as password. Type in the command ***./restore_ct.sh*** Type ***"yes"*** to continue connecting. Enter the password ***"vct@pci"***.

Figure 5-56

9. Allow the software restore to finish.





10. On the Console computer, Select **"Application – System Tools – Disable Remote Installation "** (Figure 5-57)

11. In the terminal window logged into the CT Computer, type in command ***reboot -f <enter>.*** Wait a few minutes to allow the computer to reboot. *(*Figure 5-57**)**

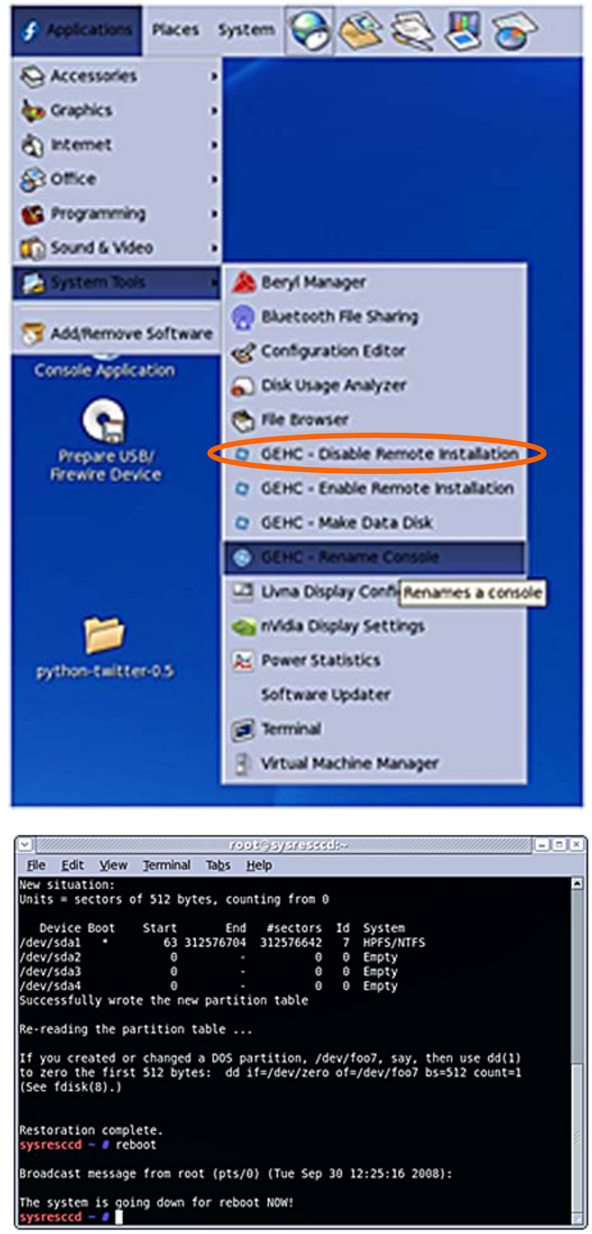


Figure 5-57

12. Establish a VNC connection to the CT Computer. On the Console computer, Select **“Application – System Tools – Terminal”** to launch a terminal window. Type ***vncviewer ct.local***

13. Type in the password ***debug .***

14. The CT Computer should boot into Windows. Exit the system monitor on the CT computer.

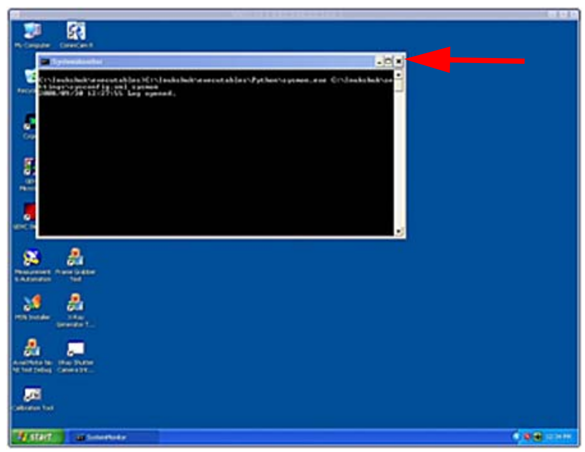
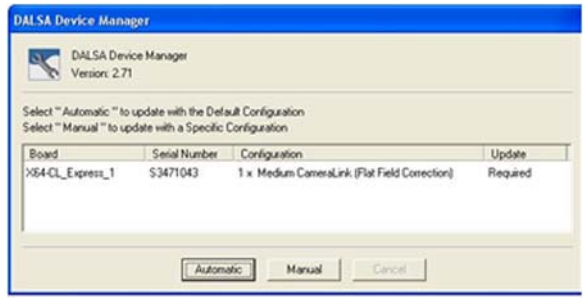
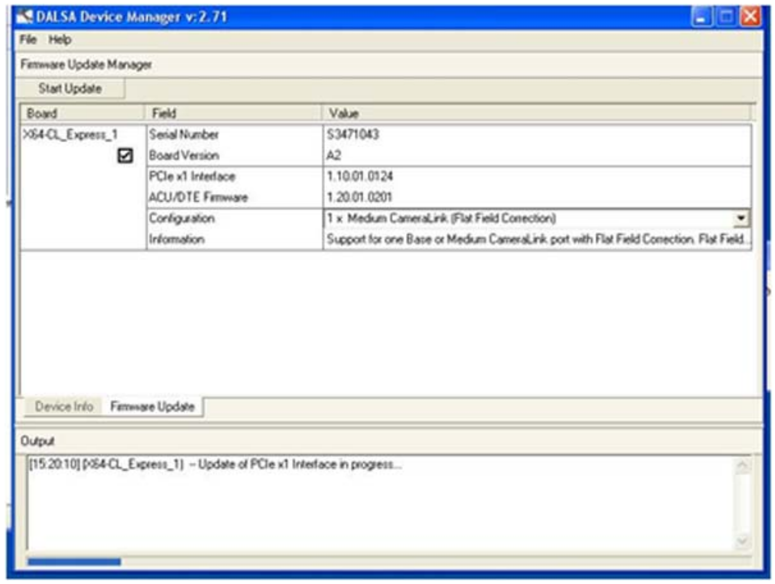


Figure 5-58



15. The Frame Grabber requires a configuration file the first time it is used. If configuration is required, the DALSA Device Manager will open automatically. Select Automatic. Do not change any of the settings shown. Select Yes when the upgrade successfully completes.



16. Shut down the computer when finished.

5.5.2 PDU Control Box (5257567)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The right side CT cover is removed.
- The right side corner cover and Table side covers are removed.

Refer back to Figure 5-52.

Removal

1. Remove connections from the PDU Control Box (Item 46) and note cable locations.
2. Remove three (3) M6 cap screws (2109867-13, Item 29), lock washers (2109880-3, Item 18) and flat washers (2109878-3, Item 33) from the base of the Control Box.
3. Remove Control Box from rear of Gantry base.

Replacement

1. Position replacement PDU Control Box on CT Table Lower Shelf, oriented as shown. Align with mounting holes.
2. Using hardware set aside earlier, fasten the Control Box to the Lower Shelf. Torque screws to 70 in-lb.
3. Reconnect cables in the order noted during removal.

5.5.3 Generator Control Box (5257564)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The right side CT cover is removed.
- The right side corner cover and Table side covers are removed.

Refer back to Figure 5-52.

Removal

1. Remove connections from the Generator Control Box (Item 45) and note cable locations.
2. Remove three (3) M6 cap screws (2109867-13, Item 29), lock washers (2109880-3, Item 18) and flat washers (2109878-3, Item 33) from the base of the Control Box.
3. Remove Control Box.

Replacement

1. Position replacement Generator Control Box on CT Table Lower Shelf, oriented as shown. Align with mounting holes.
2. Using hardware set aside earlier, fasten the Control Box to the Lower Shelf. Torque screws to 70 in-lb.
3. Reconnect cables in the order noted during removal.

5.5.4 Temperature Controller (5252283)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The right side CT cover is removed.
- The rear CT cover is removed.
- The right side and rear radiation shields are open.

WARNING • **LOCK THE ROTATING BASE.**

See Figure 5-59.

Removal

1. Remove connections from the Temperature Controller (Item 6 and photo at right) and note cable locations.
2. Cut Cable Tie (46-208758P1, Item 41) from Cable Tie Mount (2388013-2, Item 39).
3. Remove four (4) M6 socket screws (2109867-14, Item 23), lock washers (2109880-3, Item 18) and flat washers (2109878-3, Item 33) holding controller to disc and set Controller and hardware aside.

Replacement

1. Mount replacement Temperature Controller to disc as illustrated, using hardware set aside earlier. Torque to 70 in-lb.
2. Reconnect cables in the order noted during removal.
3. Loop a Cable Tie (Item 41) through the Cable Tie Mount and re-secure the cable.

5.5.5 Disc Power Box Assembly (5192794)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The left side CT cover is removed.
- The rear CT cover is removed.
- The left side and rear radiation shields are open.

WARNING • **LOCK THE ROTATING BASE.**

Refer to Figure 5-59.

Removal

1. Unplug all cables from the box, noting their locations.
2. Loosen four (4) M6 hex cap screws (2109867-14, Item 23) holding the box to the disc.
3. While supporting the box, remove the screws along with lock washers (2109880-3, Item 18) and flat washers (2109878-3, Item 33). Set hardware aside.

Replacement

1. Mount replacement box with hardware set aside earlier. Orient the box as shown in the illustration, and assemble hardware in the order shown.
2. Re-attach cables in the locations noted earlier.

5.5.6 Interlock Box Assembly (5257563)

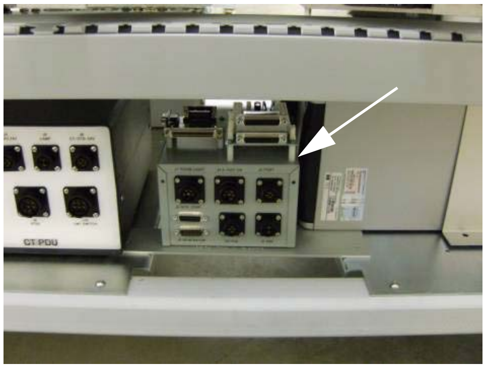
Refer back to Figure 5-52.

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- Both side CT covers are removed.
- The rear CT cover is removed.

Removal

1. Remove connections from the Interlock Box ASM (item 47 and photo at right) and note cable locations.
2. Remove two (2) M4 socket screws (2109867-4, Item 26), lock washers (2109880-2, item 19), and flat washers (2109878-2, item 34) holding the interlock box to the base and set box and hardware aside.



Replacement

1. Mount replacement Interlock Box ASM to disc as illustrated, using hardware set aside earlier. Torque to 20 in-lb.
2. Reconnect cables in the order noted during removal.

5.5.7 Dunlee Tube (5192695)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT covers are removed.
- The side and rear radiation shields are open.
- If no hoist is available, two people will be required to lift the tube (26kg) in and out of its place. All CT covers (except the rear cover) will need to be removed and side shields opened.

See Figure 5-59.

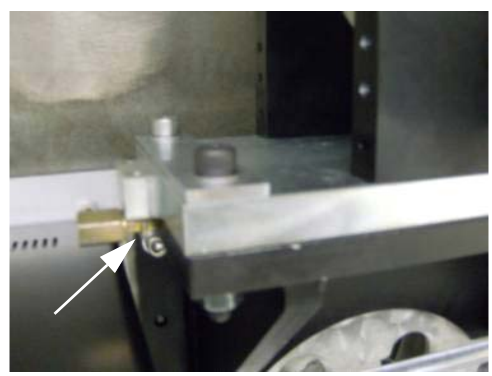
Removal

1. Manually rotate the gantry so that the X-Ray source is at the 12 o'clock position. Manually lock the gantry.

WARNING ***Failure to lock the rotating disc (gantry) prior to removing components may lead to Gantry motion which can strike a person causing injury or death.***

2. Disconnect the cables to the two fans from the PDU side. Remove the eight (4) screws (2390619, item 31) and flat washers (2109878-7, item 36) and place fan assembly and hardware aside.
3. Unlock the gantry and rotate it manually until the tube is at the 9 o'clock position.
4. Remove the ground strap.
5. Remove high voltage connections.
6. Place each high voltage cable in individual plastic bags and twist ties or ty-raps to keep the cable ends clean and free from dust.
7. Remove stator connections from the Dunlee Tube (Item 71) and note their locations (photos below).

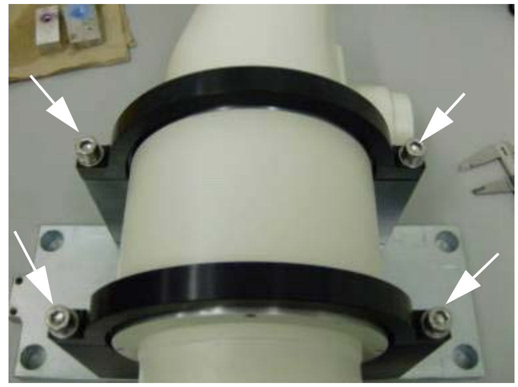
8. Remove the <u>top</u> two (2) M10 mounting bolts (2109867-28, Item 24), two (2) lock washers (2109880-4, Item 17), four flat washers (2109878-4, Item 32), nuts (2109875-4, Item 37) and retainer plate (5168177, item 14). Set hardware aside.
9. Rotate the gantry manually until the tube is at the 10 o'clock position. Lock the gantry.
10. Loosen the set screw (2120094, Item 16). Remove the adjuster block (2148597, item 15 and photo at right) by removing two (2) screws (2109867-16, Item 25), lock washers (2109880-3, item 18) and flat washers (2109878-7, item 33). Set parts and hardware aside.
11. Remove remaining two sets of mounting bolts, lock washers, flat washers, nuts and retainer plate as detailed in step 8. above, and set aside.
12. Mark the tube position for future reference.



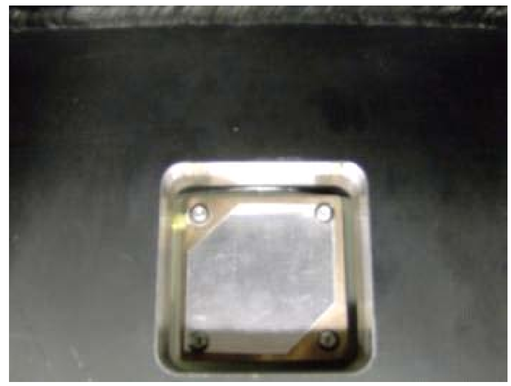
CAUTION ***The X-ray tube assembly is heavy. Use two (2) persons to remove it.***

13. Remove the tube assembly and place on a bench.

14. Remove the four (4) screws (2109867-26, item 30 and photo at right), flat washers (2109878-4, item 32), and lock washers (2109880-4, item 17) securing the two (2) upper cradle brackets (5168518, item 70).



15. Rotate the tube in the cradle so that the tube opening is pointing up.
16. See photo at right. Remove the aluminum cover (5268141, item 75) and collimator (5197990, item 72) (note the orientation of each) by removing the four (4) screws (2390639, item 69), flat washers (2390635-3, item 61) and lock washers (46-260800P6, item 68). Lift tube out of assembly and set aside.



Replacement

1. Place replacement tube in the mounting cradle brackets so that the opening is pointing up. Remove the protective cover over the tube opening (and stick it on the old tube). Make sure that no dust or debris is in the X-ray tube opening. Any dirt or debris will be trapped by the collimator cover and must be removed before the cover is installed.
2. Replace the collimator and aluminum cover in the same orientation as noted during removal. Secure with hardware removed earlier.
3. Rotate the tube until the opening is pointing down.
4. Attach the upper cradle brackets using the hardware set aside earlier. Leave the brackets loose enough to allow the X-ray source to rotate.
5. Remove the stator cable that is attached to the X-ray source. Remove the nuts and screw holding the four wires in place. Reinstall the 3 nuts and screws. They will be needed when the system is wired.
6. Using the source alignment spacer tool, properly position the X-ray tube to obtain equal spacing on each side. Tighten the four bolts in sequence in gradual steps. The gaps on the cradle brackets must be equal. Once all four gaps on the cradle brackets are equal, torque the bolts to 340 in-lb. Use the spacer tool to confirm that the X-ray tube is properly positioned.

CAUTION ***Ensure gantry is still locked in the 10 o'clock position.***

7. Lift the X-ray tube into place. Check to see that the X-ray tube can move freely from side to side on the mounting plate. Position the X-ray tube assembly in the middle of its side to side movement.
8. Re-install the four (4) sets of mounting bolts, flat washers, lock washers and nuts, and two retainer plates removed earlier with the hardware set aside.
9. Re-install the adjuster block with hardware set aside earlier.
10. Unlock and manually rotate the gantry until the tube is at 12 o'clock. Lock the gantry.
11. Restore connections to the Tube in the order noted during removal.
12. Re-install fans with hardware set aside earlier. The fans should blow toward the X-ray source.

Restore connections from fans to the PDU.

13. Unlock the gantry.

Note: After changing the tube or detector you may need to change the aluminum filter for the x-ray tube. Follow the procedure outlined in the Appendix in Chapter 10.3 page 416

You may also have to adjust CT protocols for saturation. Follow the procedure outlined in the Appendix in Chapter 10.3 page 417

Follow Up

1. Perform generator calibration. See X-Ray Generator Calibration on page 364.
2. The CT calibration procedure will be required. Start at Generate Transform1 Files with Tilt Angle on page 315.

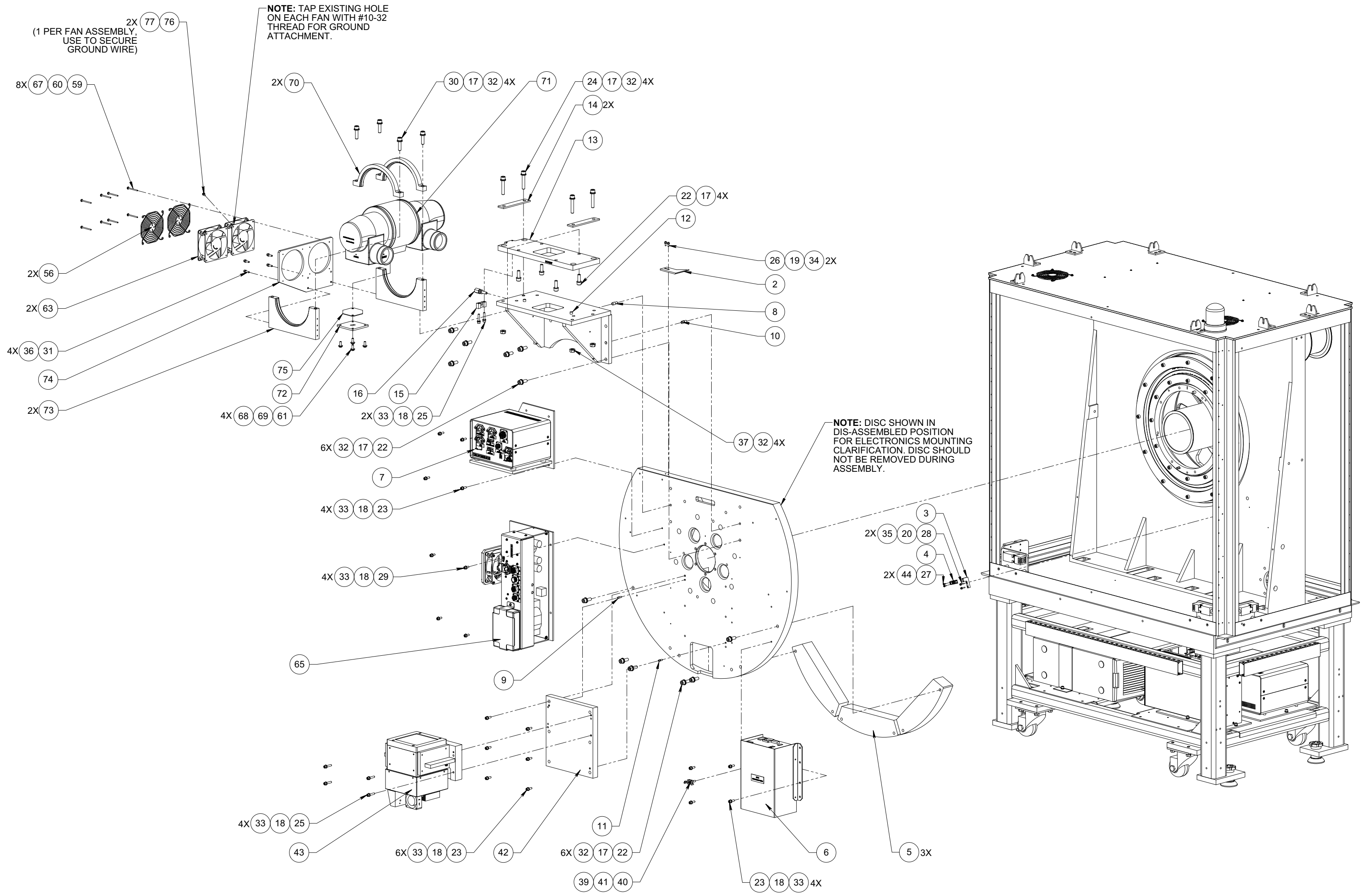

NOTE: TAP EXISTING HOLE ON EACH FAN WITH #10-32 THREAD FOR GROUND ATTACHMENT.
2X 77 76 (1 PER FAN ASSEMBLY, USE TO SECURE GROUND WIRE)
8X 67 60 59
2X 70
30 17 32 4X
71
24 17 32 4X
14 2X
13
22 17 4X
12
26 19 34 2X
2
8
10
2X 56
2X 63
4X 36 31
74
2X 73
75
72
4X 68 69 61
16
15
2X 33 18 25
6X 32 17 22
37 32 4X
7
4X 33 18 23
NOTE: DISC SHOWN IN DIS-ASSEMBLED POSITION FOR ELECTRONICS MOUNTING CLARIFICATION. DISC SHOULD NOT BE REMOVED DURING ASSEMBLY.
3
2X 35 20 28
4
2X 44 27
4X 33 18 29
65
9
4X 33 18 25
43
6X 33 18 23
42
11
6X 32 17 22
39 41 40
23 18 33 4X
6
5 3X

Figure 5-59

5.5.8 Detector, Fixed 24V (5252104-2)

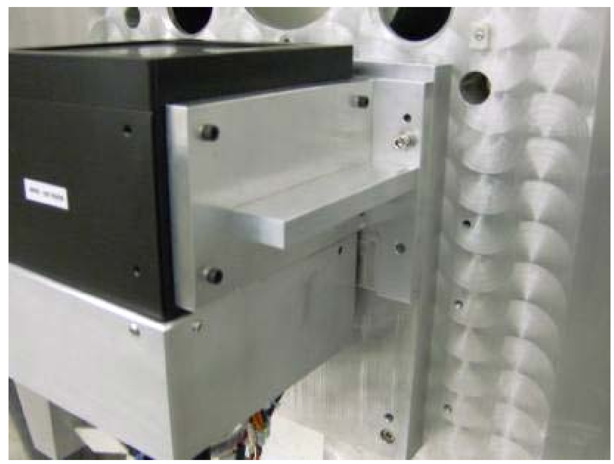
Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side covers are removed.
- The side radiation shields are open.
- The P-tube is removed.

WARNING • **LOCK THE ROTATING BASE.**

See Figure 5-59.

Removal



1. Disconnect Detector (Item 43) power and Camera Link cables from the Detector. Cut all cable ties that secure them.
2. Remove four (4) M6 cap screws (2109867-16, Item 25), lock washers (2109880-3, Item 18) and flat washers (2109878-3, Item 33) securing the Detector to the mounting plate on the disc.

Replacement

1. Mount replacement Detector to mounting plate as illustrated, using hardware set aside earlier. Torque to 70 in-lb.
2. Reconnect Detector cables and secure with cable ties. Re-install the P-tube.

Note: After changing the tube or detector you may need to change the aluminum filter for the x-ray tube. Follow the procedure outlined in the Appendix in Chapter 10.3 page 416

Follow Up

1. Calibrate the Detector. See 7.2.3 CT Calibration.

5.5.9 Energy Chain Cable Track (5270755)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The rear radiation shields are open.

See Figure 5-60.

Removal

1. Rotate gantry clockwise (as viewed from rear of machine) to unwind Cable Track from the take-up reel.

WARNING

Failure to lock the rotating base prior to removing components may lead to Gantry motion which can strike a person causing injury or death.

2. Disconnect all cables in the Cable Track (Item 10) from both ends, noting all connection locations. Cut all cable ties holding them.
3. Remove two (2) M5 cap screws (5135959, Item 20) from E-Chain Mount Bracket (5192985, Item 9) and set aside. Carefully pull as much of the Cable Track as possible over Bracket and lower the end of the Cable Track.
4. Remove four (4) M4 socket screws (2109867-4, Item 19) and flat washers (2109878-2, Item 15) holding the Cable Track to the Cable Support Weldment (take-up reel) and set aside. Some cable track covers may need to be removed to access the screws.
5. Carefully pull the cables through the holes in the disc and remove entire Cable Track.

Replacement

1. Place the end of the replacement Cable Track that is to be attached to the E-Chain Mount Bracket over the top pulleys.
2. Pull the Cable Track and cables so that it loops under the vertical pulley and up to the Mount Bracket. Thread cables over the Mount Bracket and into the CT cabinet. Fasten the Cable Track to the Mount Bracket using the M5 cap screws set aside earlier. Torque to 44 in-lb.

Note: Link covers <u>cannot</u> be added to the first 38 sections in the Cable Track (counted starting from E-Chain Mount Bracket end.

3. The other end of the Cable Track will wind in a counterclockwise direction around the Cable Support Weldment. Fasten the Cable Track to the Cable Support Weldment using the M4 hardware set aside earlier. Torque to 20 in-lb. It may be necessary to temporarily remove some cable track covers to access the mounting holes.
4. Insert the cables through the disc. The disc/stator power cables, low voltage cables and each

high voltage cable go through their own holes in the disc. With the X-Ray source at the 12 o'clock position, and looking at the disc from the front of the unit, the disc/stator and low voltage cables pass through the left holes while the High Voltage anode (with the red band) and the High Voltage cathode pass through the right holes. Place two cable ties around the cable bundle, between the disc and the drive gear.

5. Reconnect all cables as noted during removal of the Cable Track. Secure with cable ties as before.

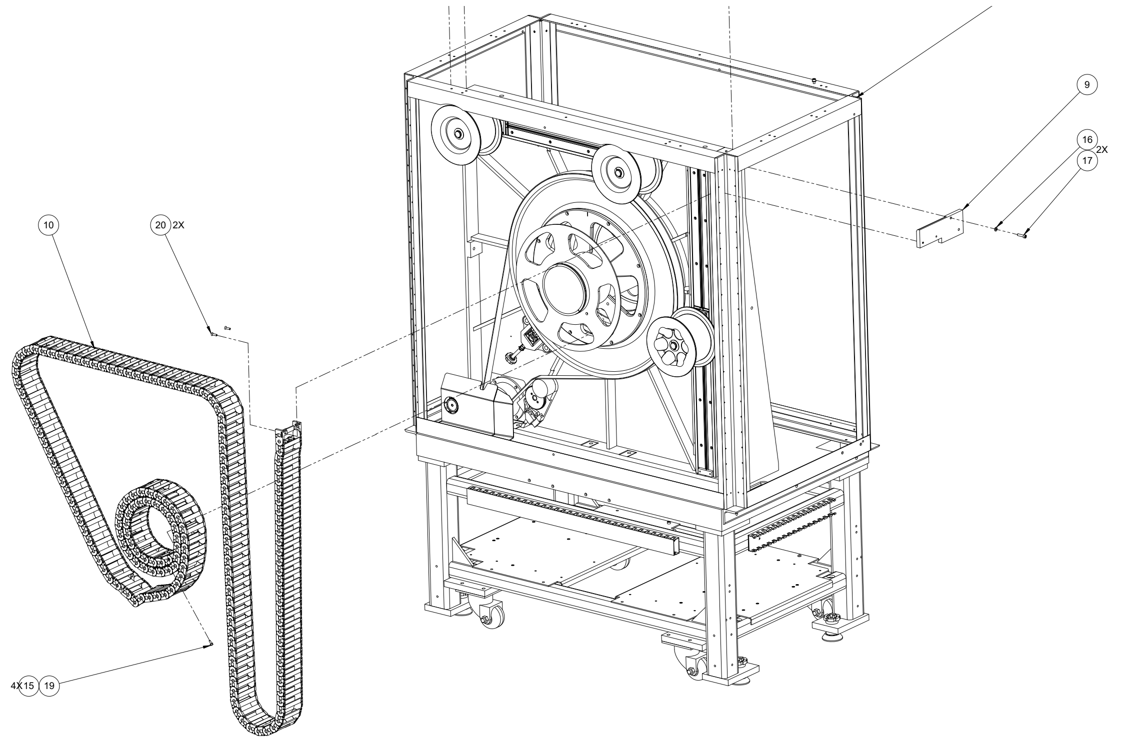


Figure 5-60

5.5.10 Pulley Return Cord (5257183)

Preconditions

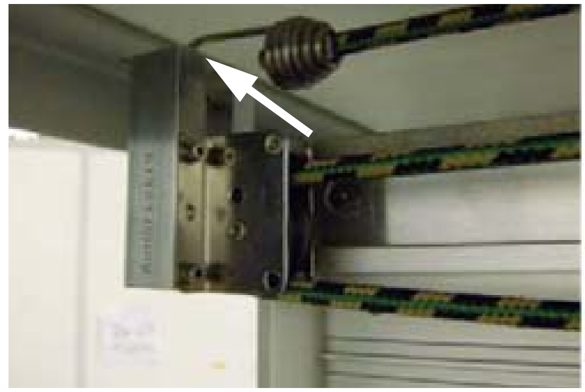
- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The rear radiation shields are open.

Removal

1. Rotate gantry clockwise (as viewed from rear of machine) to unwind Cable Track from the take-up reel until the Cable Track is loosely draped over the top pulleys.

WARNING

Failure to lock the rotating base prior to removing components may lead to Gantry motion which can strike a person causing injury or death.



2. Unhook the Pulley Return Cord (photo at right). This will allow the top left E-Chain Pulley to slide.
3. Temporarily support the Energy Train Cable Track near the Pulley so that the Pulley can be removed.
4. See Figure 5-61. Remove the Pulley (5172379, Item 16) by removing the External Retaining Ring (5193167, Item 17) and one (1) Thrust Washer (5193158, Item 15). Remove the remaining Thrust Washer. Set all parts aside.
5. Slide the loop in the end of the Cord off the Pulley Mount (5171793, Item 18).
6. Untie the loop in the cord, and pull it through pulley (in above photo), then through pulley on opposite side (in photo at right).

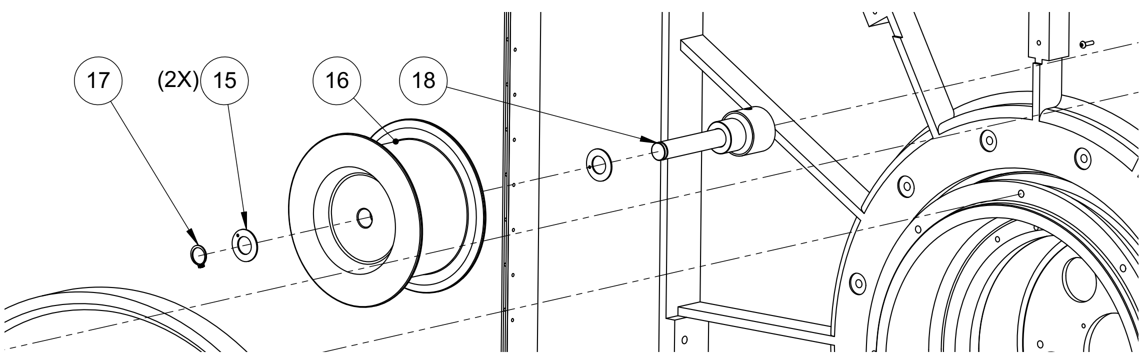


Figure 5-61

Replacement

1. Hook the replacement Pulley Return Cord as shown in the first photo under **Removal**. Thread the Cord over the pulleys as shown in Figure 5-62.

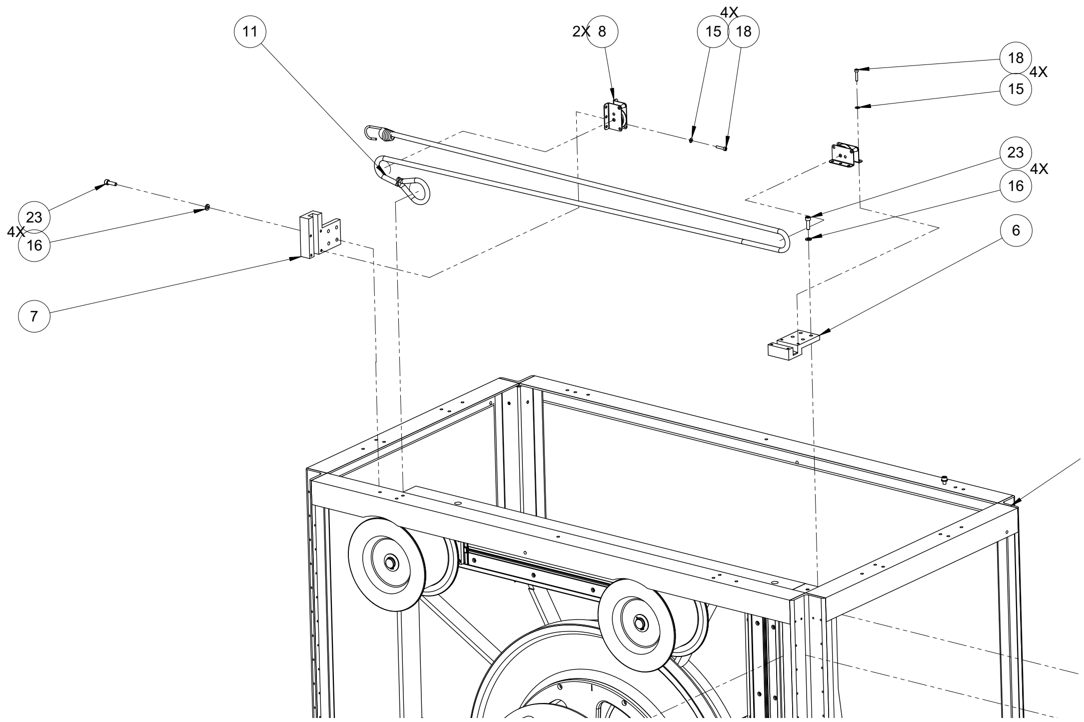


Figure 5-62

2. Make a loop in the free end of the Cord 8 inches long.

3. Make a knot in the loop and tighten.

4. The loop should be 1.5 inches long. Cut off excess Cord and tape the end.
5. Slide the loop onto the Pulley Mount (Item 18 in Figure 5-61).
6. Replace the E-Chain Pulley and hardware in the order shown in Figure 5-61.
7. Place the Energy Chain Cable Track back on the E-Chain Pulley and rotate the gantry counterclockwise until the slack is removed in the Cable Track.

5.5.11 Fixed E-Chain Pulley Mount (5171793)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The rear and side CT covers are removed.
- The side and rear radiation shields are open.

See Figure 5-63.

Removal

1. Remove Energy Chain Cable Track as outlined in 5.5.9 Energy Chain Cable Track (5270755).
2. Remove External Retaining Ring (5193167, Item 17) and Thrust Washer (5193158, Item 15) from front of E-Chain Pulley (5172379, Item 16). Remove Pulley and second Thrust Washer (Item 15) from Fixed E-Chain Pulley Mount (Item 16). Set all items aside.
3. Remove M12 cap screw (2390619-10, Item 20) and flat washer (2109878-9, Item 19) from the front side of the Machined Cast Upright while an assistant supports the Pulley Mount. Set hardware aside.

Replacement

1. Fasten replacement Pulley Mount to Machined Cast Upright using M12 screw and flat washer set aside earlier. Torque to 584 in-lb.
2. Add one Thrust Washer, the E-Chain Pulley, and a second Thrust Washer to the Pulley Mount and fasten with the External Retaining Ring set aside earlier.
3. Replace the Energy Chain Cable Track.

5.5.12 Indexer/Rotating Lock (2181221-2)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The rear and side CT covers are removed.
- The side and rear radiation shields are open.

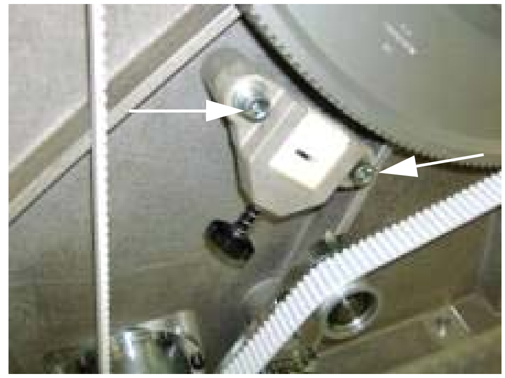
See Figure 5-63.

Removal

CAUTION

Removal of the rotating lock may lead to Gantry motion which can strike a person causing injury or death. Ensure that personnel are clear of the Gantry before removing the lock.

1. Remove two (2) M12 cap screws (2390619-11, Item 31) and four (4) flat washers (2109878-9, Item 19) holding Rotating Lock (Item 30) and set aside.



Replacement

1. Mount replacement Rotating Lock as illustrated with hardware set aside earlier. Torque to 584 in-lb.

5.5.13 Timing Belt - 40DP (5177391)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The side and rear radiation shields are open.

NOTICE Equipment Damage Possible

Disconnect the ethernet cable from the CT computer.

See Figure 5-64.

Removal

1. Remove three (3) M6 cap screws (2109867-11, Item 45) and flat washers (2109878-3, Item 22) holding Hard-Soft Stop Shield (5192796, Item 44) to Machined Cast Upright and set aside.
2. Place a mark on each of the Timing Belt (Item 43), the Hard-Soft Timing Belt Pulley (5177816, Item 38), and the pulley on the Hard-Soft Stop Assembly (5176364, Item 41).
3. Loosen three (3) M6 socket screws (2109867-14, Item 29) holding down the Hard-Soft Stop Assembly.
4. Timing Belt (Item 43) may now be removed.

Replacement

1. Loop replacement Timing Belt around Hard-Soft Stop Assembly pulley and Hard-Soft Timing Belt Pulley (5177816, Item 38), aligning mark on the Belt with those on the pulleys.
2. Adjust position of Hard-Soft Stop Assembly until Belt sits squarely in both pulleys and the belt has tension. Tighten the socket screws (Item 29) holding down the Assembly. Torque to a maximum of 70 in-lb.
3. Re-attach Hard-Soft Stop Shield with hardware set aside earlier.

Follow Up

1. ***Ensure ethernet cable is disconnected from the CT computer before turning the system power back on.***
2. Perform CT Servo Limits Adjustment (see 5.5.18).

5.5.14 Hard-Soft Stop Timing Belt Pulley (5177816)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The side and rear radiation shields are open.

NOTICE Equipment Damage Possible ***Disconnect the ethernet cable from the CT computer.***

See Figure 5-64.

Removal

1. Remove Hard-Soft Stop Shield and Timing Belt as described in 5.5.13 Timing Belt - 40DP (5177391). Ensure a mark is also placed on the 26 Tooth Pulley (5175750, Item 37), aligned with the one on the Timing Belt Pulley.
2. Remove M8 cap screw (2381232-4, Item 40) and lock washer (2381267-8, Item 39), and remove Hard-Soft Stop Timing Belt Pulley (Item 38). Set hardware aside.

Replacement

1. Attach replacement Timing Belt Pulley to Baldor Planetary Gearhead (Item 35) shaft using hardware set aside earlier. Ensure marks on the 26 Tooth Pulley and Timing Belt Pulley are aligned. Torque to 195 in-lb.
2. Adjust position of Hard-Soft Stop Assembly until Belt sits squarely in both pulleys and the belt has tension. Tighten the socket screws (Item 29) holding down the Assembly. Torque to 70 in-lb.
3. Re-attach Hard-Soft Stop Shield with hardware set aside earlier.

Follow Up

1. ***Ensure ethernet cable is disconnected from the CT computer before turning the system power back on.***
2. Perform CT Servo Limits Adjustment (see 5.5.18).

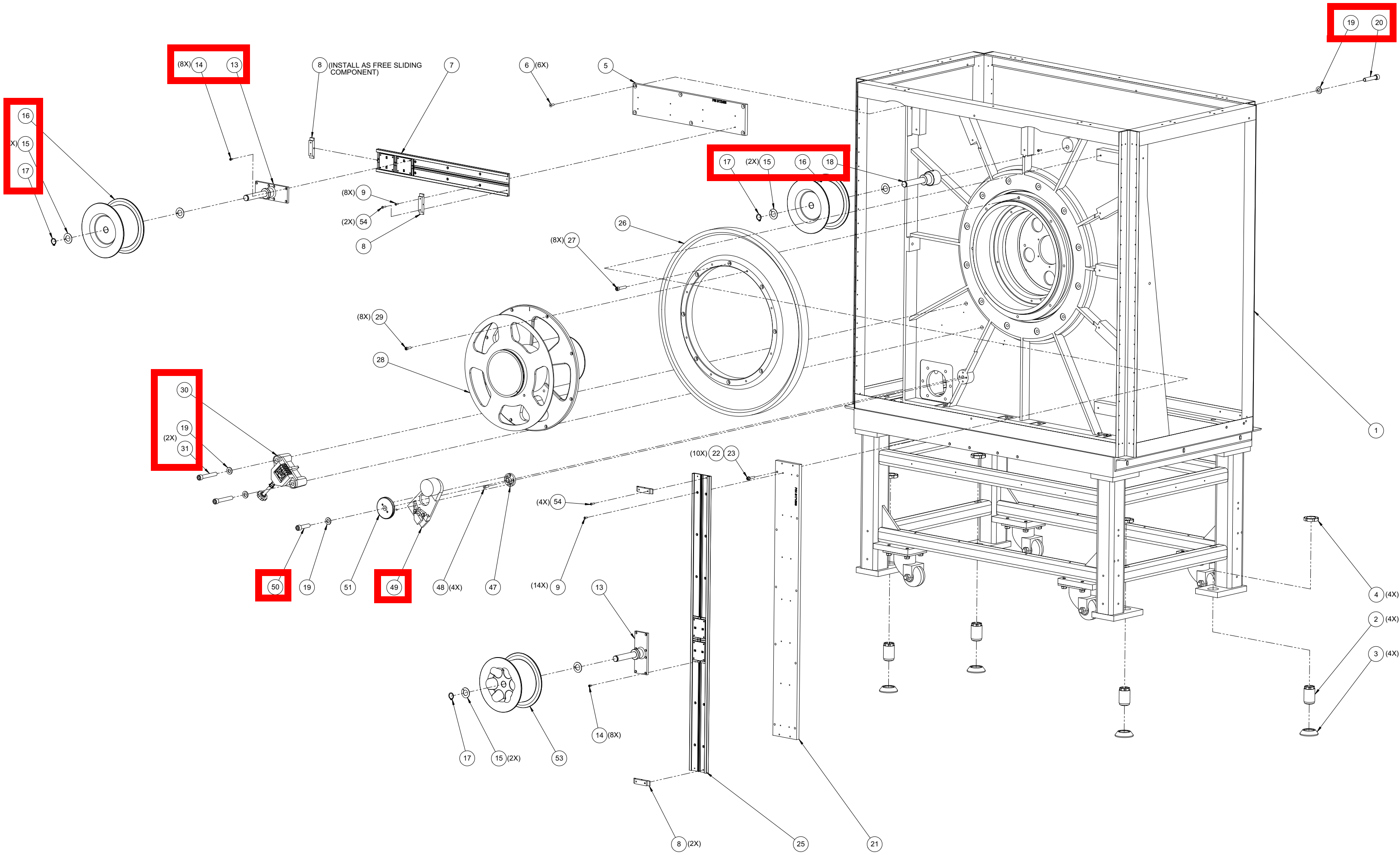


Figure 5-63

5.5.15 Hard-Soft Stop Assembly (5176364)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The side and rear radiation shields are open.

NOTICE Equipment Damage Possible ***Disconnect the ethernet cable from the CT computer.***

Refer to Figure 5-64.

Removal

1. Mark the Timing Belt, Timing Belt Pulley and the pulley on the Hard-Soft Stop Assembly.
2. Loosen three (3) M6 socket screws (2109867-14, Item 29), flat washers (2109878-3, item 22), and lock washers (xxxxxxx, item xx) holding down the Hard-Soft Stop Assembly (5176364, Item 41) and un-loop the Timing Belt (Item 43) from its pulley.
3. Un-plug electrical connections to the Assembly.
4. Remove the socket screws and flat washers (2109878-3, Item 22) and set aside, and remove the Assembly.

Replacement

1. Position the replacement Assembly as illustrated and loop the Timing Belt over its pulley. Align all three marks made during removal.
2. Thread hardware set aside earlier loosely through the Assembly into the Machine Cast Upright.
3. Adjust position of Hard-Soft Stop Assembly until Belt sits squarely in both pulleys and the belt has tension. Tighten the three socket screws (Item 29) holding down the Assembly. Torque to 70 in-lb.
4. Re-attach electrical connections.

Follow Up

1. ***Ensure ethernet cable is disconnected from the CT computer before turning the system power back on.***
2. Perform CT Servo Limits Adjustment (see 5.5.18).

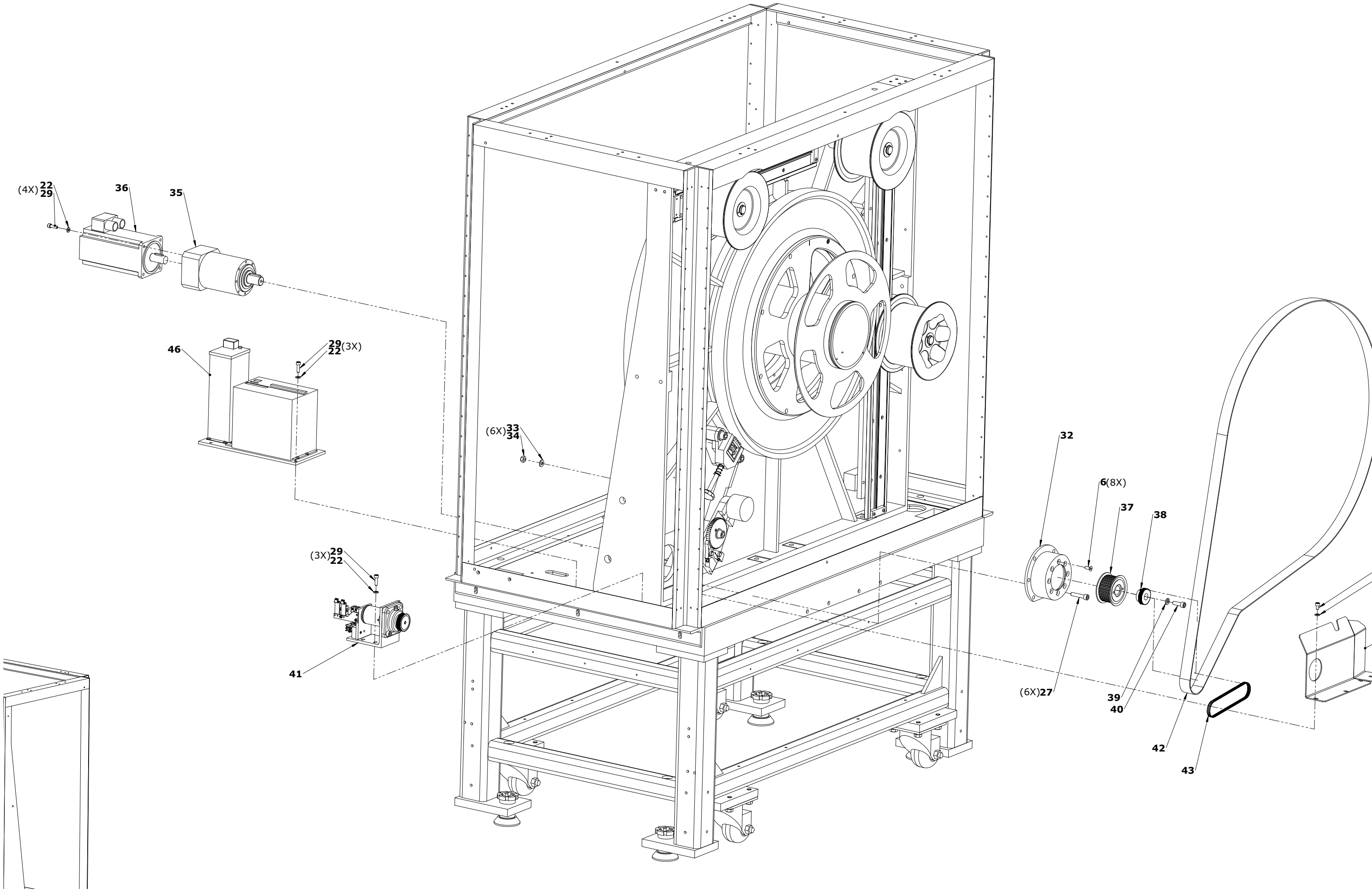

(4X) 22 29
36
35
46
29 22 (3X)
(6X) 33 34
(3X) 29 22
41
32
6 (8X)
37
38
45 22 (3X)
44
(6X) 27
39
40
42
43

Figure 5-64

5.5.16 Servo Motor, 230V, Resolver (5177575)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The side and rear radiation shields are open.

NOTICE Equipment Damage Possible ***Disconnect the ethernet cable from the CT computer.***

Removal

1. Refer to Figure 5-65. Remove Table Shield (5268546, Item 10) covering the Servo Motor on the right side of the unit (arrow). Set Shield and

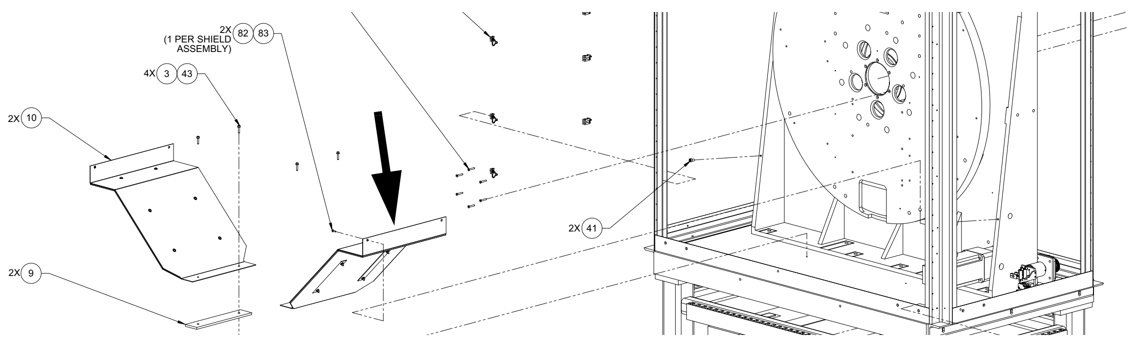
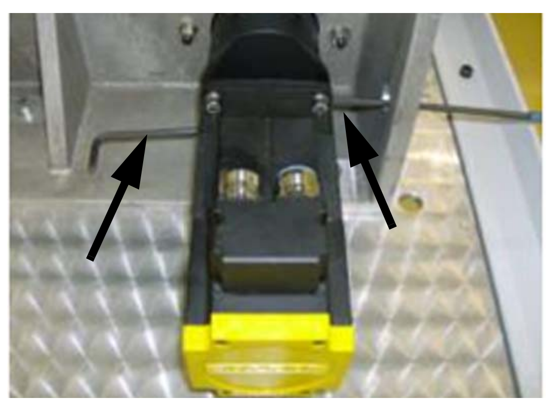


Figure 5-65



2. Refer back to Figure 5-64. Remove connections from top side of Servo Motor (Item 36 and photo at right).
3. Loosen the coupler bolts on the gear box. The gantry may need to be rotated to access both coupler bolts. Insert a T-handle hex key through the hole in the casting (right arrow in photo at right) to access one bolt, and a hex key into the other bolt (left arrow).
4. Remove four (4) M6 socket screws (2109867-14, Item 29) and flat washers (2109878-3, Item 22) while supporting the Servo Motor. Pull Motor away from Baldor Planetary Gearhead (Item 35) and set hardware aside.

Replacement

1. Align the replacement Servo Motor key with the keyway in the Planetary Gearhead and push them together. Electrical connections must face up. Align holes in the Motor flange with holes in the Gearhead and thread in the M6 socket screws with flat washers set aside earlier. Torque to 70 in-lb.
2. Re-attach electrical connections. Tighten the two coupler bolts on the gear box.

Follow Up

1. ***Ensure ethernet cable is disconnected from the CT computer before turning the system power back on.***
2. Perform CT Servo Limits Adjustment (see 5.5.18).

5.5.17 Baldor Planetary Gearhead (5176320)

Preconditions

- The machine is powered off using the main circuit breaker on the PDU.
- The CT side and rear covers are removed.
- The side and rear radiation shields are open.

NOTICE Equipment Damage Possible

Disconnect the ethernet cable from the CT computer.

See Figure 5-64.

Removal

1. Remove Servo Motor as described in 5.5.16 Servo Motor, 230V, Resolver (5177575).
2. Mark the Timing Belt-40DP (Item 43), the HTD Timing Belt (Item 44), the Hard-Soft Timing Belt Pulley (Item 38) and the 26 Tooth Pulley (Item 37).
3. Remove Hard-Soft Stop Shield (Item 44), Timing Belt-40DP(Item 43) and Hard-Soft Stop Timing Belt Pulley (Item 38) as described in 5.5.13 Timing Belt - 40DP (5177391) and 5.5.14 Hard-Soft Stop Timing Belt Pulley (5177816) and set aside.
4. Refer back to Figure 5-63. Loosen M12 cap screw (2390619, Item 50) enough to allow the Drive Belt Tensioner (Item 49) to rotate and relieve tension on the HTD Timing Belt (Item 42 in Figure 5-64). Un-loop Belt from 26 Tooth Pulley (5175750, Item 37).
5. Using a gear puller or similar tool, pull the 26 Tooth Pulley (5175750, Item 37) from the Baldor Planetary Gearhead (Item 35) shaft and set aside.
6. Remove eight (8) M6 countersunk screws (2109884-13, Item 6) from Baldor Gearbox Mounting Bracket (Item 32) while supporting the Planetary Gearhead. Remove Gearhead and set hardware aside.

Replacement

1. Mount replacement Planetary Gearhead with M6 screws set aside earlier. Ensure housing of Gearhead is oriented as shown in Figure 5-64, with the Servo Motor mounting flange square to the base. Torque screws to 70 in-lb.
2. Heat the 26 Tooth Pulley (Item 37) in an oven, align its keyway with the key on the shaft, then tap it onto the Gearhead shaft with a block of wood.
3. Loop HTD Timing Belt (Item 42) around Pulley, aligning the marks made earlier, and over the top of the Tensioner pulley. Rotate Tensioner until Belt is taut and tighten M12 cap screw (Item 50) to 584 in-lb.
4. Align Pulley and Belt marks made earlier and re-mount Hard-Soft Stop Timing Belt Pulley (Item 38), Timing Belt (Item 43) and Hard-Soft Stop Shield (Item 44) as described in 5.5.14 Hard-Soft Stop Timing Belt Pulley (5177816) and 5.5.13 Timing Belt - 40DP (5177391).
5. Re-mount Servo Motor (Item 36) as described in 5.5.16 Servo Motor, 230V, Resolver (5177575).

Follow Up

1. ***Ensure ethernet cable is disconnected from the CT computer before turning the system power back on.***
2. Perform CT Servo Limits Adjustment (see 5.5.18).

5.5.18 CT Servo Limits Adjustment

Preconditions

- The CT side and rear covers are removed.
- The side and rear radiation shields are open.

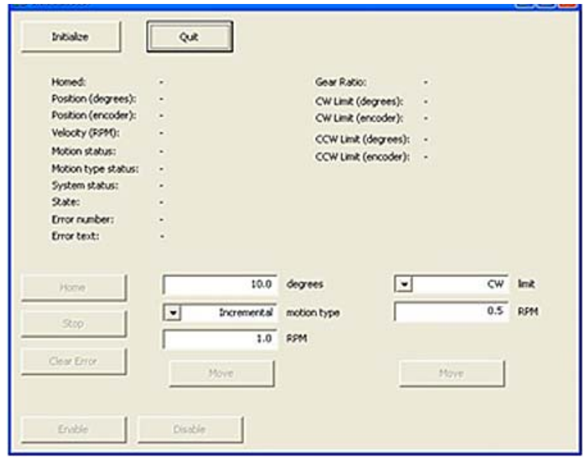
NOTICE Equipment Damage Possible ***Disconnect the ethernet cable from the CT computer.***

NOTICE Equipment Damage Possible ***Be prepared to remove power from the Baldor servo controller if the gantry does not stop when the Cable Track is fully wound.***

Procedure

1. Connect a keyboard and monitor directly to the CT Computer.
2. Go to System Monitor and close it.

3. Open the Axial Motor program and press the Initialize button.
4. Set motion type to Incremental. Enter a small angle increment (5°) and press the Move button. Verify that the gantry rotates counterclockwise as viewed from the rear of the unit. If necessary, place a negative sign in front of the angle value.

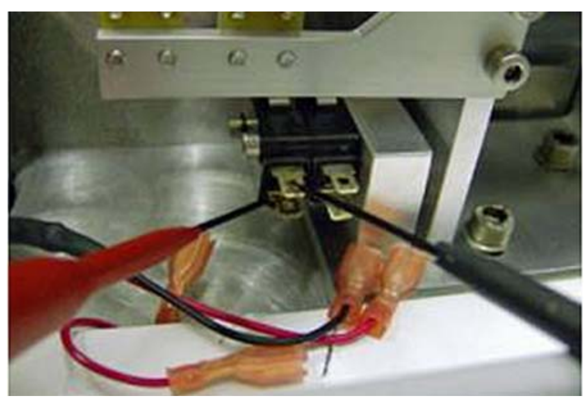


5. Wind the Cable Track up completely. The top left Pulley (as viewed from the rear of the unit) should be at or near the end of its travel, and there should be a small amount of slack in the track.

6. Change the angle increment to -1° and press Move until the Cable Track is completely tight.
7. Back off the tension by rotating the gantry clockwise (as viewed from rear) by 10°, in positive 1° steps.

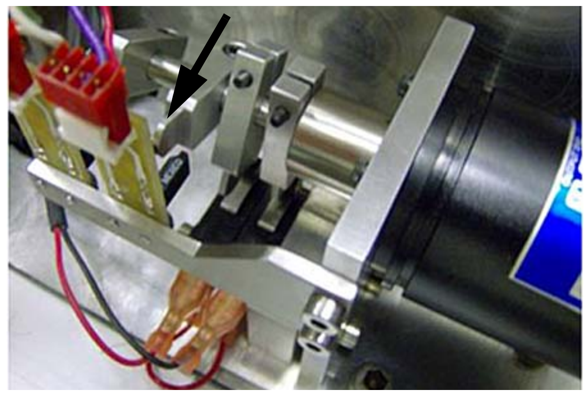
NOTICE Equipment Damage Possible ***Ensure the gantry is unwinding the cable track and not winding it up.***

8. Connect an ohmmeter to the fully wound mechanical limit switch terminals as shown in the photo.
9. Set the mechanical limit switch (second from the speed reducer) for the fully wound position by adjusting the limit switch finger until the normally-closed switch opens.
10. Unwind the Cable Track in 1° steps. The switch should close in less than 10°. If not, adjust the finger until it does. Wind up the Cable Track by incrementing in -1° steps until the limit switch opens. Hard limit is now set for the fully wound position. Plug a jumper into the harness terminals.

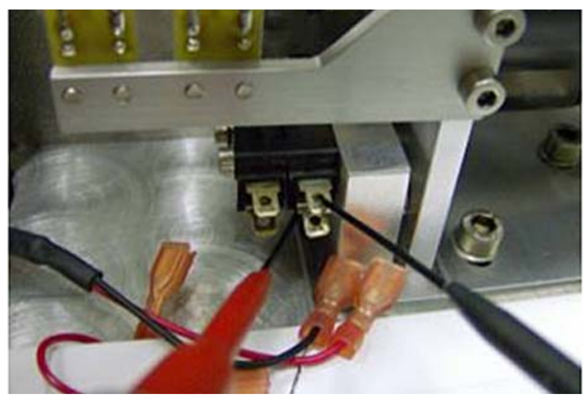


11. Unwind the Cable Track by 10° (clockwise). The Baldor display should show "I-". If not, adjust the optical switch finger (furthest from speed reducer) until it does. Soft limit is now set for the fully wound position.

12. Completely unwind the Cable Track by entering 1260° (positive number). This is 3.5 turns of the gantry. Unwind the gantry an additional 20° beyond this point. The optical switch finger for the fully unwound soft limit may need to be adjusted to allow the gantry to rotate (arrow in photo at right).

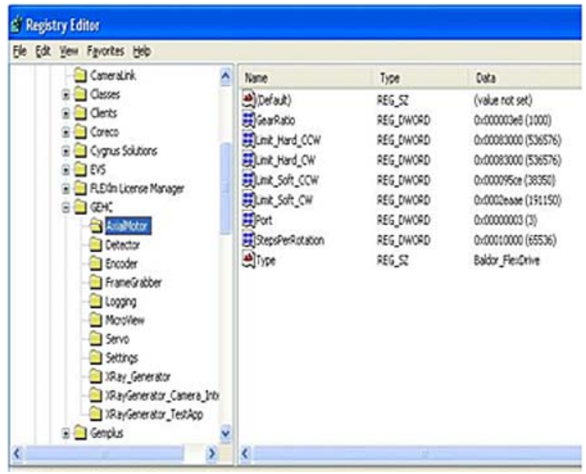


13. Connect an ohmmeter to the fully unwound mechanical limit switch terminals (closest to the speed reducer). Adjust the switch finger until the normally-closed switch opens.
14. Rotate the gantry in -1° increments to wind the Cable Track until the switch closes. This should occur in less than 10°. Readjust the finger if necessary. Unwind the Cable Track by incrementing in 1° steps until the limit switch opens. Hard limit is now set for the fully unwound position. Plug a jumper into the harness terminals.



15. Wind the Cable Track by 10° (counterclockwise). The Baldor display should show "-I". If not, adjust the optical switch finger until it does. Soft limit is now set for the fully wound position.
16. Use the Axial Motor program to rotate the gantry 360° counterclockwise (to wind up the Cable Track), exit the program and remove power from the Baldor controller. Remove the jumpers and plug the wiring harness back onto the limit switches.

17. Restore power to the controller. Restart the Axial Motor program, press the Initialize button then the Home button. This starts counterclockwise rotation toward the fully wound soft limit, then a clockwise rotation to the Home flag. The Home flag is 140° from the fully wound hard limit switch, and is mounted on the disc. Turn the gantry 140° counterclockwise again until it encounters the soft limit. Clear the error in the Axial Motor program if it occurs.
18. Move (unwind) the gantry clockwise by 3°.
19. Read the encoder position in counts. Round it up so that it is only six digits. Open the Registry Editor. Edit the Limit_Soft_CCW file to match the encoder counts divided by 1,000. Do not enter a negative sign in front of this value.



20. There should be approximately 1260° between the fully wound soft limit and the fully unwound soft limit. Rotate the gantry 1262° clockwise and read the encoder position in counts. Divide this value by 1,000 and edit the Limit_Soft_CW value to match it. Do not enter a negative sign in front of this value.

21. Quit the Axial Motor program.
22. Remove power from the Baldor controller for at least 5 seconds and restart the Axial Motor program.
23. Press Initialize, then Home. The gantry will be 140° from the fully wound position.
24. Rotate the gantry -140° until it is fully wound.
25. Rotate the gantry 1260° to verify the Cable Track fully unwinds, and -1260° to verify it fully winds.
26. Turn on the System Monitor from the CT Computer.
27. Go to the Console. Enter Service pages and click the System Properties tab. Edit the Limit_Soft_CCW and Limit_Soft_CW values to match the values entered in the Axial Motor program (box in Figure 5-66). Save the file.

28. Reconnect the CT Computer Ethernet connection and reboot the Console.

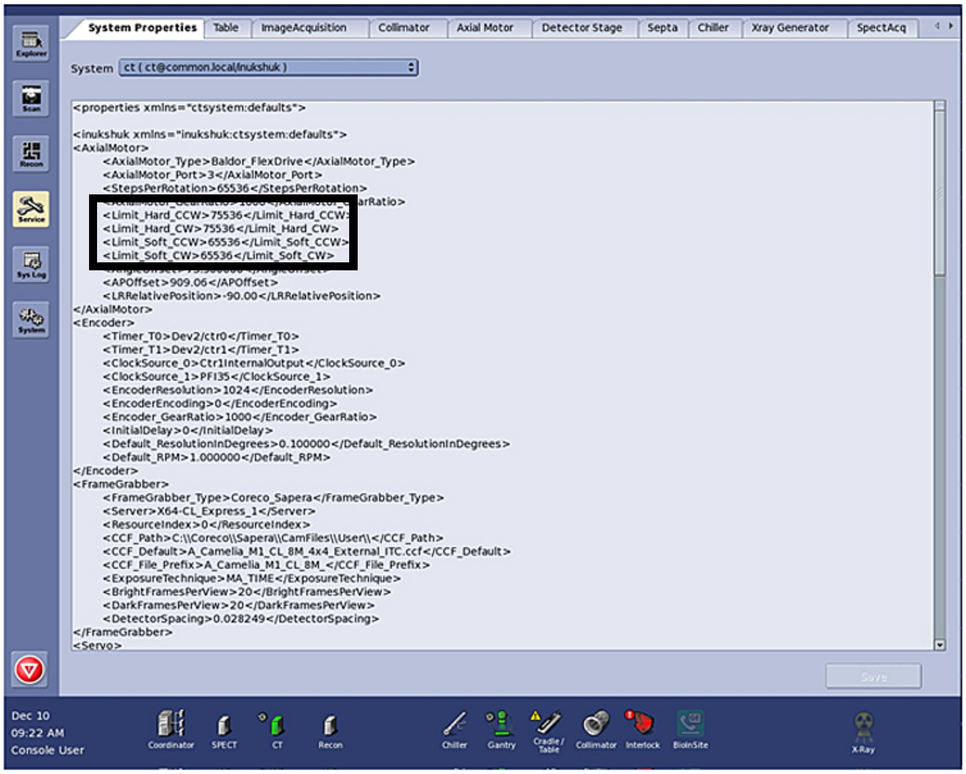


Figure 5-66

Section 5.6 Complete Parts List

Table 5-1 CT PARTS

PART NUMBER	PART DESCRIPTION
G5231841	INTEGRATED SERVOMOTOR
G5330251	MUFFIN XL AC FAN, 220 230 VAC
G5330245	COMAIR BLOWER
G5330236	COMAIR ROTRON FAN
G5271636	SYSTEM CONTROL, ACQUISITION COMPUTER
G5271208	MUFFIN XL AC FAN, 220 230 VAC, 17 WATTS, 115 CFM
G5270755	LOCUS II ENERGY CHAIN CABLE TRACK (LARGE TUBE)
G5269921	DIGITAL INTERFACE, RS232, SRI X-RAY SOURCE CONTROLLER
G5268406	SRI X-RAY TUBE, 50 MICRON FOCAL SPOT, 35-80 kVp
G5268094	SERVO MOTOR, 230V, RESOLVER
G5262167	CT COMPUTER ASM
G5261385	CPI INDICO 100 X-RAY GENERATOR
G5257567	PDU CONTROL BOX ASM
G5257564	GENERATOR CONTROL BOX
G5257563	INTERLOCK BOX ASM
G5257118	PCB ASM, SEPTA RETRACTION OPTICAL BOARD
G5255307	ENERGY CHAIN CABLE TRACK, LOCUS II (SMALL TUBE)
G5252283	TEMPERATURE CONTROLLER ASM
G5252104-2	DETECTOR ASM, FIXED, 24V FAN
G5252103	PDU W-BRACKETS, LOCUS II TABLE
G5224161	RTB MASTER PCB ASM
G5220979	RTB SLAVE ASSEMBLY
G5215329	DISC POWER BOX ASSEMBLY WITH MOUNTING
G5213206	CRADLE ID ASM
G5212929	LINEAR POTENTIONMETER, ETI SYSTEMS NO. LCP12
G5198729	DLP -IO8 8- CHANNEL DATA ACQUISITION BOARD
G5195240	PROSAFE 8 PORT GIGABIT ETHERNET DESKTOP SWITCH
G5194972	SWITCH, EMERGENCY STOP OMRON # A165E-S-01
G5194869	LASER MODULE

Table 5-1 CT PARTS

PART NUMBER	PART DESCRIPTION
G5194788	ACRYLIC P-TUBE
G5194356	TOUCH SCREEN MONITOR
G5192695	DUNLEE TUBE
G2395833-5	END OF TRAVEL LIMIT PROXIMITY SENSORS
G2395833-2	INTEGRATED SERVOMOTOR PACKAGE, 24VDC-48VDC INPUT POWER
G2105871	ADJUSTER, LEVELING PAD
G5176364	HARD-SOFT STOPASSEMBLY, LOCUS II
G5176320	BALDOR PLANETARY GEARHEAD
G2387786	FAN FILTER
G2106207	LOCK RING
G2105872	LEVELING PAD
G2412434-2	CLAMP, B2 LLR II, QUICK RELEASE, MULTI-MODALITY
G2386194	INTERLOCK KEY, 90 DEG
G2382720	RESOLUTION & CT VALUE CAL PHANTOM
G5270099	19 IN MONITOR WITH LABELS
G5263548	BLUEHEAT SERIAL I/O CARD
G5261132	LOCUS CAMERALINK FRAME GRABBER BOARD

Table 5-2 SPECT PARTS

PART NUMBER	PART DESCRIPTION
G2352900	32 OUNCE BOTTLE OF COOLANT FOR MAMMO
G5316863	BARCODE READER ASM
G5271920	SPECT COMPUTER ASM
G5257328	CHILLER
G5257171	COOLING LINE ASM, INUKSHUK
G5252277-2	CZT DETECTOR ARRAY ASM, DUAL ROW, INUKSHUK
G5245450	SERVO CONTROLLER ASM
G5231767	V4.0 RECTANGULAR PCB ASM
G5224583	SWITCH, MINITURE SNAP-ACTION, OMRON NO. VX-5-1A3
G5224578	POWER SUPPLY, ASTEC MP4-1C-1D-1D-NQE-00
G5224341	V4.0 RING PCB ASM
G5212735	ELECTRIC CABINET LOCK
G5195216	DRIP TRAY, INUKSHUK
G5195188	SEPTA ELECTRONICS SUB-ASM
G5182385	SEPTA PROTECTION TUBE, INUKSHUK
G5162764	PLANAR SERVORING ROTARY TABLE, INTELLIDRIVE MODEL # PSR300
G5162335	GAS SHOCK
G5159198	SEPTA ASM
G5154899	STEPPER MOTOR WITH 50:1 GEARHEAD AND DRIVER, 24VDC 0.0072 DEG RESOLUTION

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Chapter 6
Software Installation/Updates

Section 6.1
Back Up & Restore

6.1.1 Hard Drive Images

1. Select from the console's system menu:
   'Applications->System Tools->GEHC - Enable Remote Installation'.
2. Power up the computer.
3. Slogin to the computer by the command: slogin root@192.168.12.xxx. Password is **operator**.
   - IP address for each computer:
     * Common - 192.168.12.100
     * Spect - 192.168.12.101
     * CT - 192.168.12.102
4. Procedure for backup:
   Run './backup_XXX.sh' where XXX='ct','spect' or 'common'.
   When prompted for a password, type: 'vct@pci'
5. Procedure for restore:
   Run './restore_XXX.sh' where XXX='ct','spect' or 'common'.
   When prompted for a password, type: 'vct@pci'

6.1.2 Back Up Calibration & Registry Settings

1. Run console.
2. Connect to scanner.
3. Select Service page.
4. Select 'System Properties' tab.
5. Hit '"Archive Settings" button.
6. Wait up to a minute. Calibration data, including CT registry values, will be written to /media/data_disk in a file named according to the scanner name and date.
7. Record the current Bio Insite settings.

6.1.3 Restore Registry

1. In Windows Explorer, look for a file with the .reg extension.
2. Double click on the file to restore the registry.

6.1.4 Restore Bio Insite settings

Take the values that you recorded in 6.1.2. step 7 (page 227) and reapply them to the Bio Insite Page.

6.1.5 Restore Calibration Values

Whenever there is a software update for the eXplore speCZT/CT120 scanners, the calibration information for the scanner will be overwritten. So, before a software update, it is necessary to archive the current settings (Section 6.1.2 on page 227). The archive will be stored on the RAID drive, which is not touched by a software update. This document describes how to extract from the archive the appropriate system settings and restore them to the system. Many of the steps include commands that are entered at the command-line. Take care when entering the commands – details, such as spacing, slashes, and upper vs. lower-case, are important. Many of the command-lines include a sample taken from a terminal window to show you exactly what the text should look like.

RESTORATION STEPS

1. Start up the console application if it is not already started and connect to the eXplore scanner.(Figure 6-1)

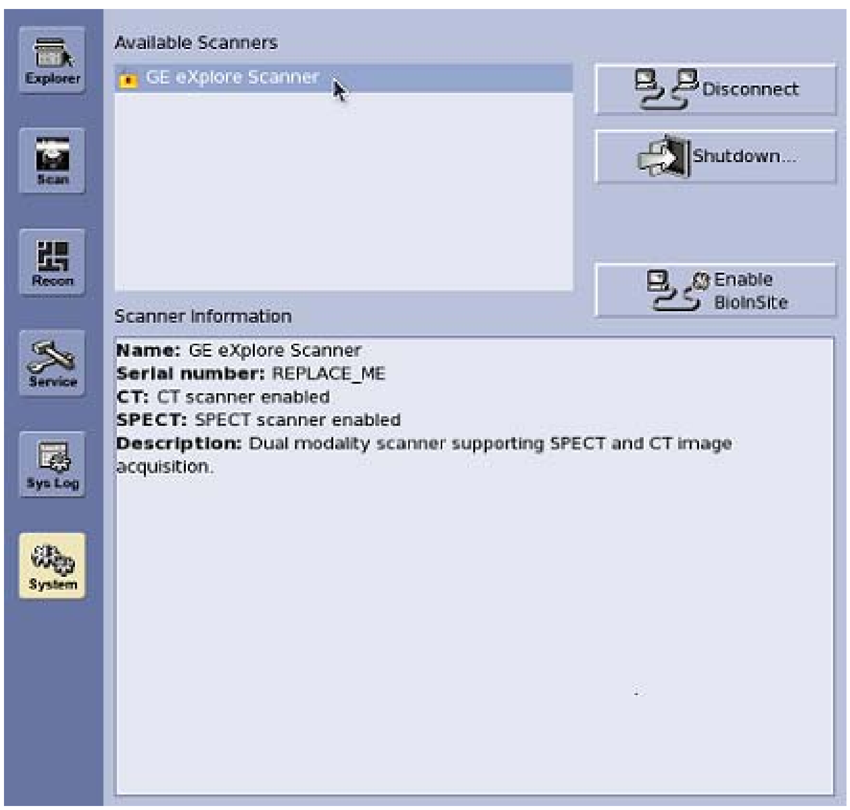


Figure 6-1

2. Open a terminal window. Much of the restoration work will be done from the command line. For convenience, open the terminal window on another workspace. To select another workspace, move the mouse cursor to the top of the screen of the left-hand monitor. A task bar will appear. Click on an empty workspace icon:(Figure 6-2)

Figure 6-2

When you have a new workspace, you can either right-click in the middle of the screen and select the "Open In Terminal" menu option, or you can reveal the task bar, as described above, and select Applications --> System Tools--> Terminal. A terminal window will appear (Figure 6-3):

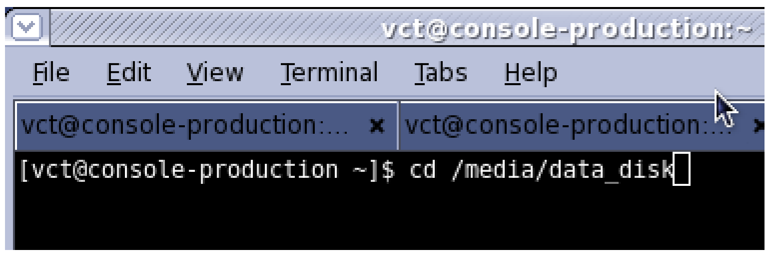


Figure 6-3

3. Change to the folder containing the archives by typing:

   cd /media/data_disk

4. Determine the archive from which to restore. List the available archives by typing:

   ls *.zip

   You will see a listing that looks similar to this- the actual file names will vary (Figure 6-4):

```
[vct@console-production data_disk]$ ls *.zip
archive-CT1200849-0115 (GE Warehouse)-Tue_Jan_27_15-49-59_2009.zip
archive-REPLACE_ME-Fri_Jan__9_10-53-55_2009.zip
archive-REPLACE_ME-Mon_Mar__2_16-39-49_2009.zip
archive-REPLACE_ME-Thu_Dec__4_11-27-21_2008.zip
```

Figure 6-4

From the listing, determine the file name of the archive you want. Notice that the date that the archive was created is part of the file name. In most cases, you will want the most recent archive.

5. Create a temporary folder in which to unzip the archive, and then unzip the archive. Type

   mkdir tmp

   Change to the new folder by typing: **cd tmp** and pressing enter. Finally, unzip the archive by typing:

   unzip ../<name-of-archive>

   where <name-of-archive> is the name you selected in step 4. For example(Figure 6-5):

```
[vct@console-production data_disk]$ mkdir tmp
[vct@console-production data_disk]$ cd tmp
[vct@console-production tmp]$ unzip ../archive-CT1200849-0115\ \(GE\ Warehouse\)
-Tue_Jan_27_15-49-59_2009.zip
```

Figure 6-5

You'll see the progress of unzip reported to the screen (Figure 6-6):

Figure 6-6

6. Display a listing of all the settings files (Figure 6-7) by typing:

   `ls *.xml`

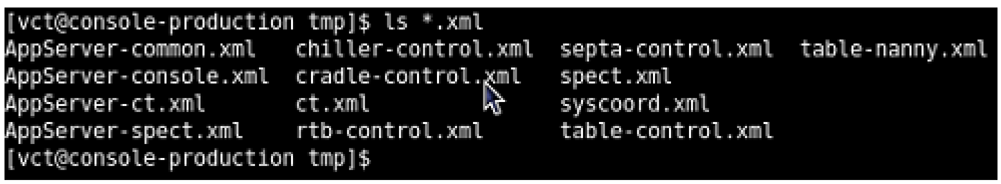


Figure 6-7

Unless otherwise instructed, ignore all the settings files that begin with "AppServer". For the other files: chiller-control.xml, cradle-control.xml, ct.xml, rtb-control.xml septa-control.xml, spect.xml, syscoord.xml, table-control.xml, and table-nanny.xml; you will perform the next five steps (steps 7 – 11).

7. Edit the contents of the settings file, using gedit. For example, the first setting file to be handled is chiller-control.xml:

   `gedit chiller-control.xml`

8. Select all the text in the settings file and copy it. There are multiple ways you can do this. Either use the Edit -> Select All menu option or type control+A. The text in the editor will be highlighted. Copy the highlighted text by clicking on the "Copy" button on the toolbar (Figure 6-8).

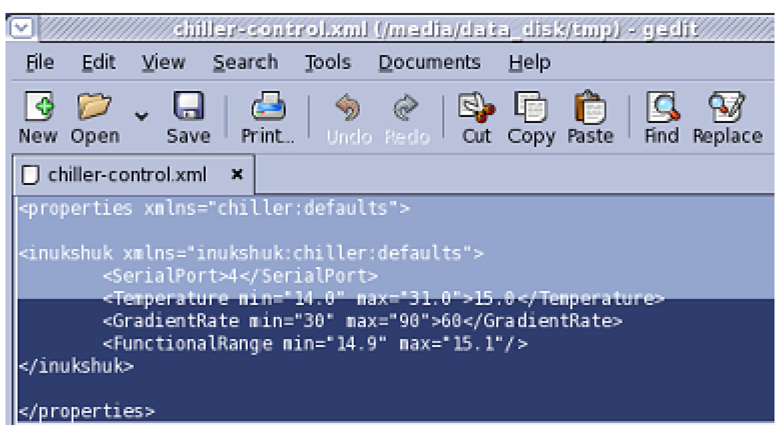


Figure 6-8

9.

a. Switch back to the console application, which you left running in another workspace. As before, move the mouse cursor to the top of the left-hand screen, revealing the task bar. Click on the workspace that contains the console application

b. Go to the “Service” panels and select the “System Properties” page. From the drop-down list, select the appropriate “System” component. The following table shows the mapping from settings file to system component.

Table : Settings and Components

Settings File	System Component
chiller-control.xml[a]	chiller-control
cradle-control.xml	cradle-control
ct xml[b]	ct
rtb-control.xml	rtb-control
septa-control.xml[a]	septa-control
spect.xml[a]	spect
syscoord.xml	syscoord
table-control.xml	table-control
table-nanny.xml	table-nanny

a. Present only if there is a "SPECT" subsystem
b. Present only if there is a "CT" subsystem

When you have selected the appropriate system component, the current settings for that component will appear in the edit window.

10. Replace the current settings. Highlight (select) the current content in the edit window: Now, either press delete to remove the settings or right click in the edit window to bring up the context menu and select “Delete”. The edit window should be blank. Now paste in the archive settings by either pressing control+V or right clicking in the edit window to bring up the context menu and select “Paste”. You will now see the archive settings

11. Save the archive settings, making them a permanent part of the system state. To do this, you just click the “Save” button at the bottom of the panel. If this button is disabled, it is due to a defect in the edit window. Simply click on the text in the edit window and move the edit cursor using the keyboard cursor keys.

12. For the next three steps, you will need to become the super-user. From the terminal window, type “su” and press enter. When prompted for a password, enter “operator”: You will no longer be in the same folder. So, you must change back to the temporary folder you created earlier. Type:

```
cd /media/data_disk/tmp
```

13. Restore the reconstruction license. From the terminal window, type:

```
cp Console/license.dat /etc/GEHC/license.dat
```

14. Restore the external network configuration. From the terminal window, type:

```
cp Console/ifcfg-eth1 /etc/sysconfig/network-scripts/ifcfg-eth1
```

15. Restore the MicroView configuration. From the terminal window, type:

Note: Even though this spans two lines in the document, it is all one line in the terminal window.

```
cp Console/MicroView.cfg /opt/GEHC/lib/python2.4/site-packages/MicroView/
MicroView.cfg
```

16. Restore the protocol-related files. GE provided files go into /usr/share/GEHC and generally don't need to be restored. User-defined protocols, sequences and energywindows are written to /var/lib/GEHC.

   a. Type:

   ```
   cp var/lib/GEHC/protocols/* /var/lib/GEHC/protocols
   ```

   If prompted to overwrite a file, reply ‘y’ for yes.

   b. Type:

   ```
   cp var/lib/GEHC/sequences/* /var/lib/GEHC/sequences
   ```

   If prompted to overwrite a file, reply ‘y’ for yes.

   c. Typically the user-defined energywindow.xml file won't have been modified. If it has, restore it by typing:

   ```
   cp var/lib/GEHC/energywindows/* /var/lib/GEHC/energywindows
   ```

   If prompted to overwrite a file, reply ‘y’ for yes.

CAUTION **As of 2.0.8.16, new tags are required in this file, so you'll need to add "phCosPower" tags everywhere if you're restoring a user-defined energy window xml file. See the contents of /usr/share/GEHC/energywindows/EnergyWindows.xml for guidance.**

17. Revoke your super-user privileges. There are risks to being the super-user; so, you will return to being the vct user. From the terminal window, type:

```
exit
```

NOTICE **Perform steps 18-24 only if there is a CT subsystem present.**

18. Establish a connection to the CT computer by typing in the terminal window:

Note: (You may want to open a separate terminal window to do this, as you will not be able to use the terminal window for other purposes, until the connection to the CT computer is broken)

```
vncviewer ct.local
```

You will be prompted to enter a password, which is “debug”. You should then see the desktop of the CT computer.

19. Open a “cygwin terminal window” on the CT computer. To do this, you will be operating in the desktop window shown by VNC. From the Window’s task bar select Start --> All Programs --> Cygwin --> Cygwin Bash Shell: The “cygwin terminal window” will appear.

20. Change to the Inukshuk/settings folder. To do this, in the “cygwin terminal window”, type:

```
cd c:
```

Then, type:

```
cd Inukshuk/settings/
```

21. Restore the transform files. From the “cygwin terminal window”, type:

```
scp vct@192.168.12.89:/media/data_disk/tmp/CT/transform* .
```

You will be prompted for a password, which is “vct@pci”. Type this and press enter to continue. You will see the progress as the transform files are copied to the CT machine.

22. Copy the registry settings for the CT computer. From the “cygwin terminal window”, type:

```
scp vct@192.168.12.89:/media/data_disk/tmp/CT/CT_registry.reg .
```

When prompted, enter the same password as before.

23. Start the Window’s registry editor. From the “cywin terminal window”, type:

```
regedt32
```

The registry editor window will appear: From the registry editor’s menu, select File --> Import. A file selection dialog will appear. Navigate to the “c:\Inukshuk\settings” folder and select the “CT_registry.reg” file and click “Open”. You will see a confirmation dialog, which you can dismiss. Close the registry editor and then close the cygwin window and then close the vnc window.

24. You are now going to restore the SPECT settings. However, before you do so, you will need to determine the scan ID of the most recent SPECT scan. From the console terminal window, type:

```
ls /media/data_disk/SPECT
```

This will produce a listing of all the folders created for SPECT scans. Find the highest numbered scan, and make note of the number, as you will use this information in a moment.

NOTICE **Perform Step 25-29 only if a SPECT subsystem is present**

25. Establish a connection to the SPECT computer by typing in the terminal window:

Note: (You may want to open a separate terminal window to do this, as you will not be able to use the terminal window for other purposes, until the connection to the SPECT computer is broken)

```
vncviewer spect.local
```

You will be prompted to enter a password, which is “debug”. You should then see the desktop of the SPECT computer.

26. Click on the "Start" menu on the Windows desktop that you see, and click on the "Run" option. A dialog will appear, prompting you to enter an application name. Type: `regedit` in the entry field (Figure 6-9).

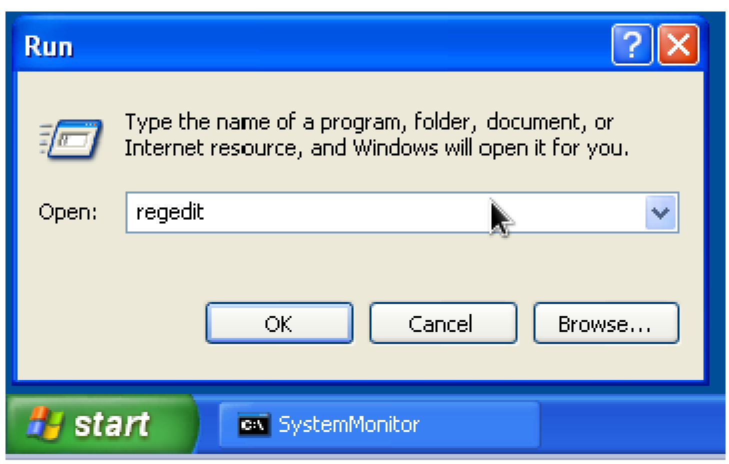


Figure 6-9

The registry editor will appear. In the registry tree, find HKEY_LOCAL_MACHINE/SOFTWARE/GEHC/PCI-SPECT, as illustrated below (Figure 6-10).

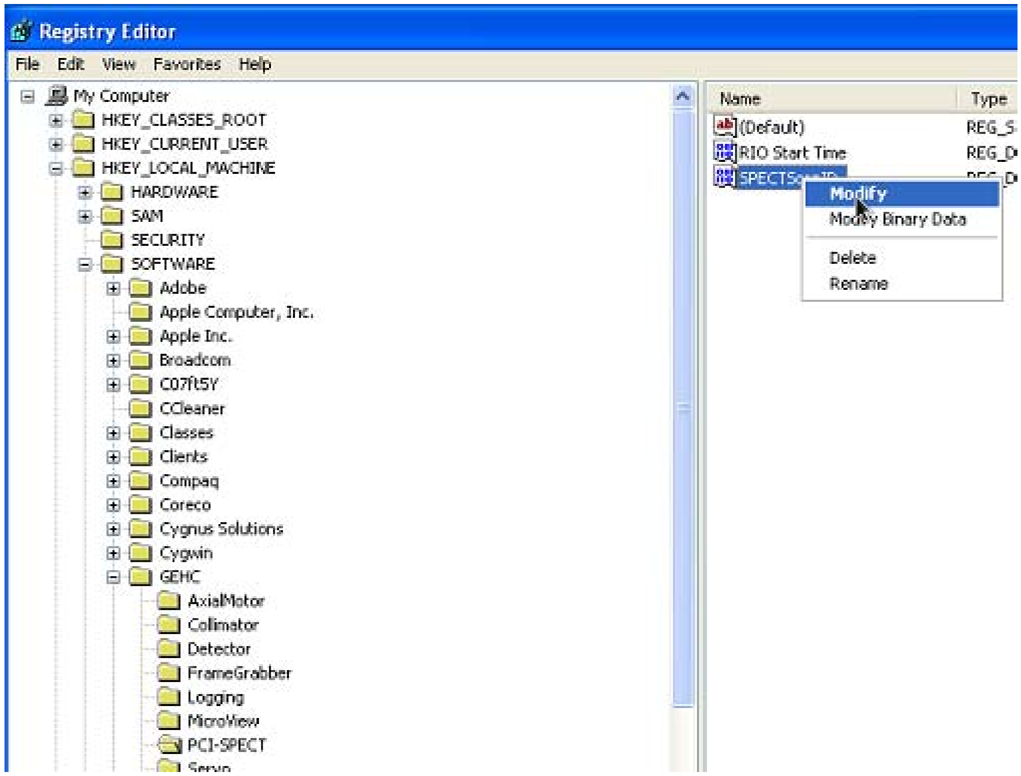


Figure 6-10

Right-click on "SPECTScanID" to bring up the context menu and select the "Modify" option. A dialog will appear, which you can use to change the value of this entry. Click on the "Decimal" radio button to switch to decimal numbers and in the "Value data" entry field, enter the scan ID that you recorded in step 24 (Figure 6-11).

Click "OK" to save the change. Then, close the regedit application.

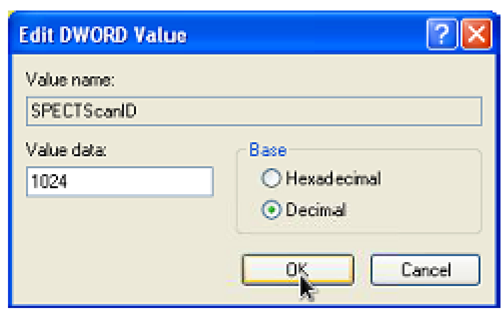


Figure 6-11

27. Open a “cygwin terminal window” on the SPECT computer. To do this, you will be operating in the desktop window shown by VNC. From the Window’s task bar select Start --> All Programs --> Cygwin --> Cygwin Bash Shell: The “cygwin terminal window” will appear.

28. Change to the Inukshuk/settings folder. To do this, in the “cygwin terminal window”, type:

    ```
    cd c:
    ```

    Then, type:

    ```
    cd Inukshuk/settings/
    ```

29. Restore the archived SPECT settings. This is done in two steps. First, type in the “cygwin terminal window” :

    ```
    scp vct@192.168.12.89:/media/data_disk/tmp/SPECT/*.dat .
    ```

When prompted for the password, enter “vct@pci”.

Next, change to the “EcorMaps” folder by typing:

```
cd EcorMaps/
```

And then, type:

```
scp vct@192.168.12.89:/media/data_disk/tmp/SPECT/EcorMaps/* .
```

Again, enter the password when prompted: Once the file copy is complete, close the cygwin window and close the SPECT vnc viewer.

30. Restart the scanner. Return to the console application. Go to the “System” panel and click the “Shutdown” button: You will be prompted to confirm your decision:
    * Click the “Yes” button. You may also be prompted to move the table before shutting down:
    * Click “No”. The scanner will shutdown in a few minutes.

At this point you should also reboot the console computer. From the System menu, select the Shutdown option (Figure 6-12).

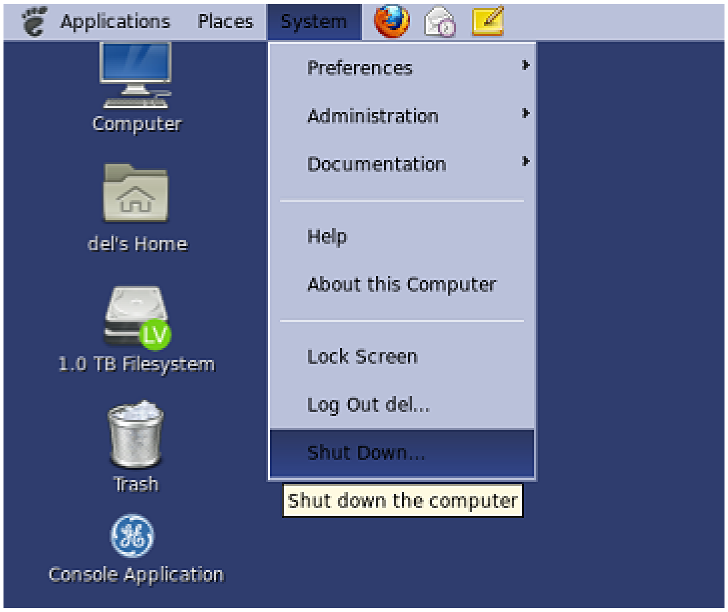


Figure 6-12

Click the Restart button on the dialog that appears, and the console will reboot (Figure 6-13).

Figure 6-13

Once the scanner and console have restarted, you must register the table. This is necessary because the table maintains a file that is used to track the last known position of the table. Because the software image was applied to the common computer, the file is no longer valid. Click the Register Table button on the touch-screen.

Section 6.2
Rename the Console Computer

Each console computer is named to reflect the serial number of the scanner with which it is paired. After a software upgrade, however, the name has been overwritten and must be restored. You will find the scanner serial number recorded on a label attached to a side cover. Please make note of it, as you will need this information to complete this procedure.

1. From the console desktop, select Applications -->System Tools -->GEHC Rename Console.(Figure 6-14)
2.) If prompted for a password, enter 'operator' then hit enter key.
3.) When prompted, edit console name, then select 'OK". Rename the console to reflect the serial number of the system. Use the last four digits of the system serial number-xxxx. (i.e.CT120yyww-xxxx)

`console-0111.local`

Figure 6-15

Figure 6-14

4.) Allow the script to complete.

Note: The password dialog box may not appear, the system caches the password and in this case it is not needed to continue.

5.) The Openfire server needs to be adjusted to reflect the new console name. First, make sure that Openfire is running by restarting the service:

* Select from the Gnome menu: System --> Administration --> Services. (Figure 6-16)
* Scroll down in the left-hand list box until you find the 'openfire' service.(Figure 6-17)

-
-
-
-
-
-
-
-
-

Figure 6-16

* Restart the Openfire service by hitting the Restart button on the services application..

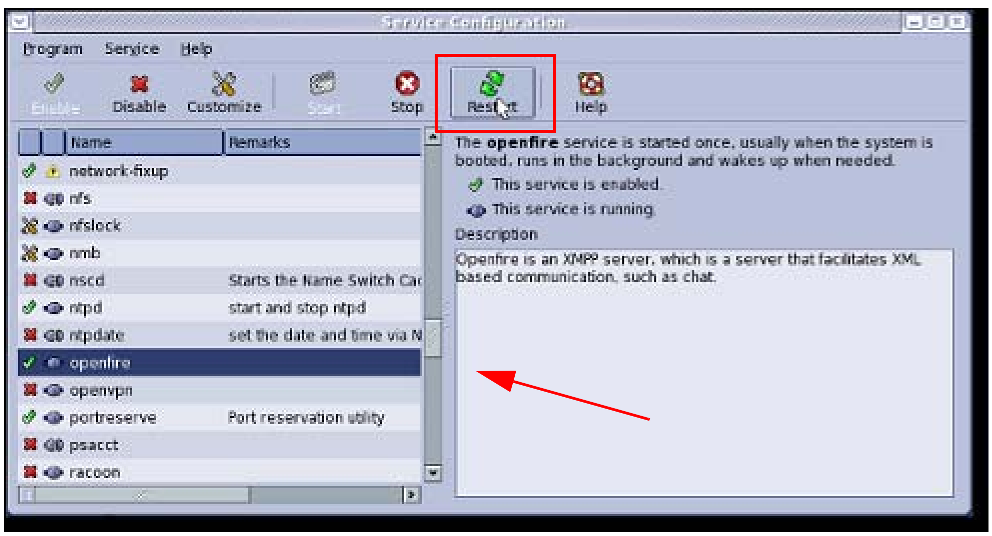


Figure 6-17

* Wait 20 seconds for Openfire server to start up.

6.) Launch Firefox (Applications-->Internet-->Firefox Web Browser).

7.) Open URL: http://localhost:9090/

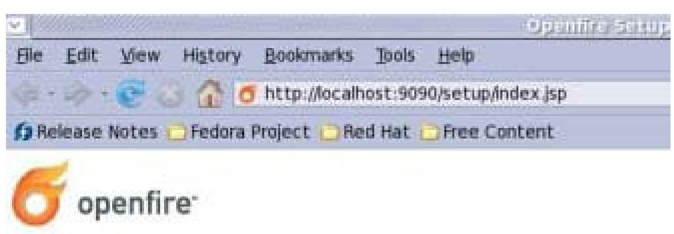


Figure 6-18

8.) Select **continue** for server settings.

Figure 6-19

9.) Select **continue** for database settings.

Figure 6-20

10.) Enter the new password as "Admin" and select **continue.**

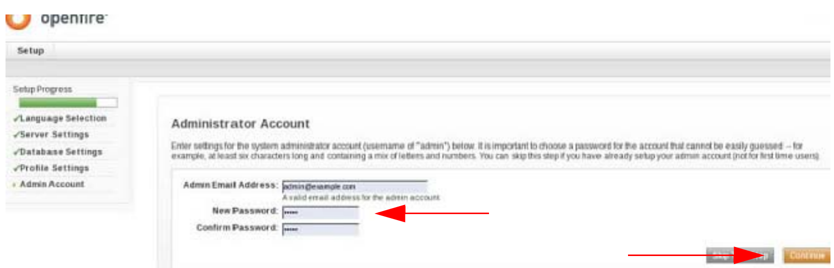


Figure 6-21

11.) Select : **Login to admin controls.**

Figure 6-22

12.) Enter the password: **admin**.

Figure 6-23

13.) Select **Not now** to remember password.

Figure 6-24

14.) Verify that the server ports are indicated. Exit the web browser by clicking on Exit properties..

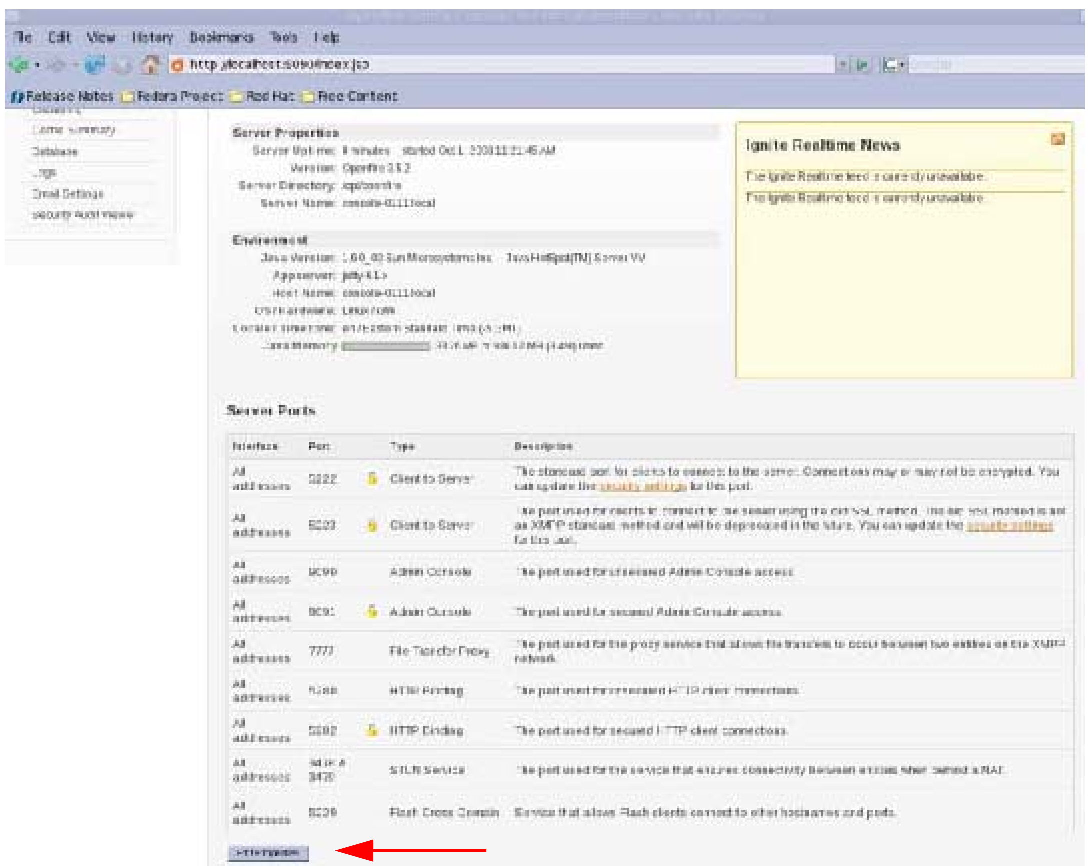


Figure 6-25

15.) Restart Openfire.(This is required because there seems to be a bug in Openfire later than 3.6.4).

Note: The following instructions should be followed to ensure that RSA and DSA certificates for the openfire server are generated with the correct server name in them.

Note: Follow these instructions if you've renamed a console (e.g. from console-production.local to something like console-xxxx.local), but the openfire server isn't correctly configured.

16.) Log on to openfire web server (`firefox http://localhost:9090`).

17.) If prompted for username/password, enter a username of `admin` and a password of `admin`.

18.) If instead, a setup wizard is presented, accept all default settings and when prompted to give the system a username/password pair, give it `admin` and `admin`, then log in to the server.

19.) Click on the top-most 'Server' button, then select 'Server Information', then hit 'Edit Properties' button.

20.) Adjust 'Server Name' field to correct the value, based on the console computer name. (e.g. `console-0115.local`) Then, hit the 'Save Properties' button.

21.) Follow the recommendation to restart the openfire server after a name change: `su -c "/etc/rc.d/init.d/openfire restart"`.

22.) Log back in to the server after it restarts (refresh the firefox page).

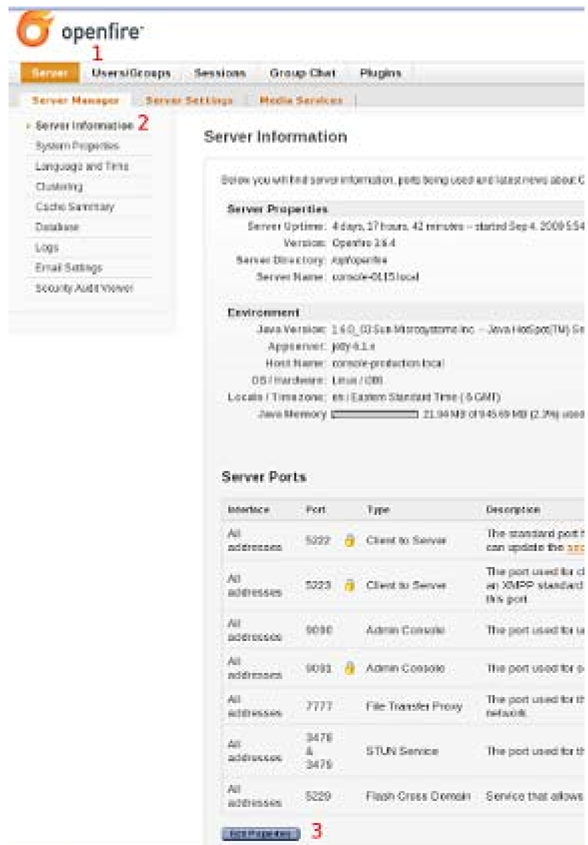


Figure 6-26

23.) Create new certificates for the machine:

A.) Click on the top-most 'Server' button, then select 'Server Settings', then select 'Server Certificates'.

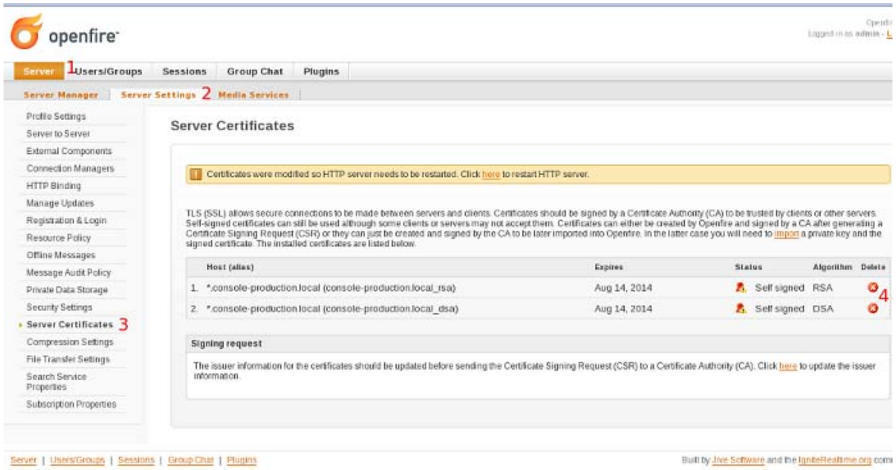


Figure 6-27

B.) Delete existing DSA and RSA certificates.

C.) Click the 'here' link to restart http server.

D.) Log back in to openfire server.

E.) Click the 'here' link to generate new self-signed certificates for the server with the new server name.

F.) Verify that the certificate names match the openfire server name, which in turn matches the console name.

- After a console has been renamed, the recon server queue will become unresponsive because it is misconfigured. This is addressed in it's own service note :Recon Queue Reset Procedure on page -93 in Chapter 4.
- After a console has been renamed, the roster state can get into a bad state with respect to federation between console and scanner Openfire servers. This is addressed in it's own service note: XMPP Jabber Roster Restore on page -94 in Chapter 4.

Section 6.3
Set the Timezone

The console computer uses http://www.ntp.org/ to adjust it's time. However, the timezone/locale must still be set on the console during final steps of installation for the correct time to be displayed.

Instructions:

1. Go to the System page and Click on date and time button, at the top right of the screen, to open up calender settings.

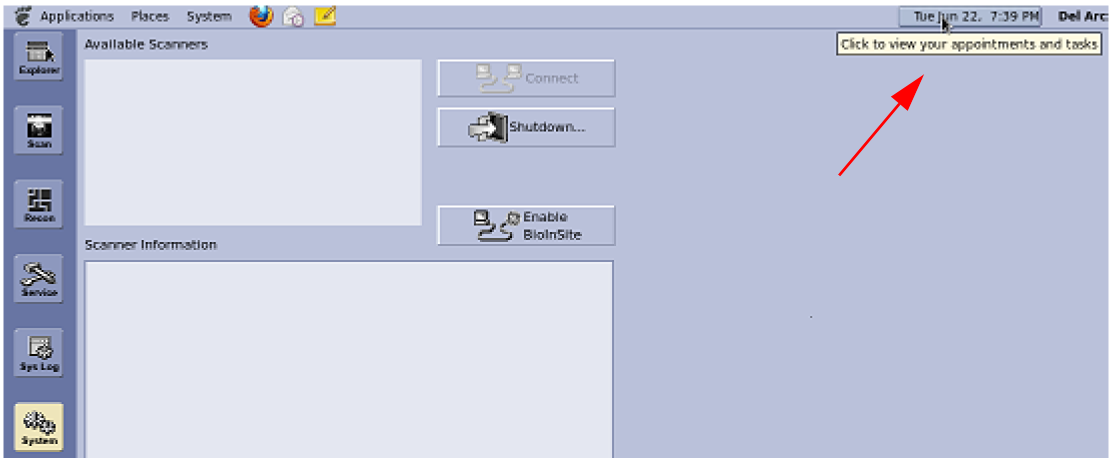


Figure 6-28

2.) Click on Edit, and then Click on Add, to edit the location.

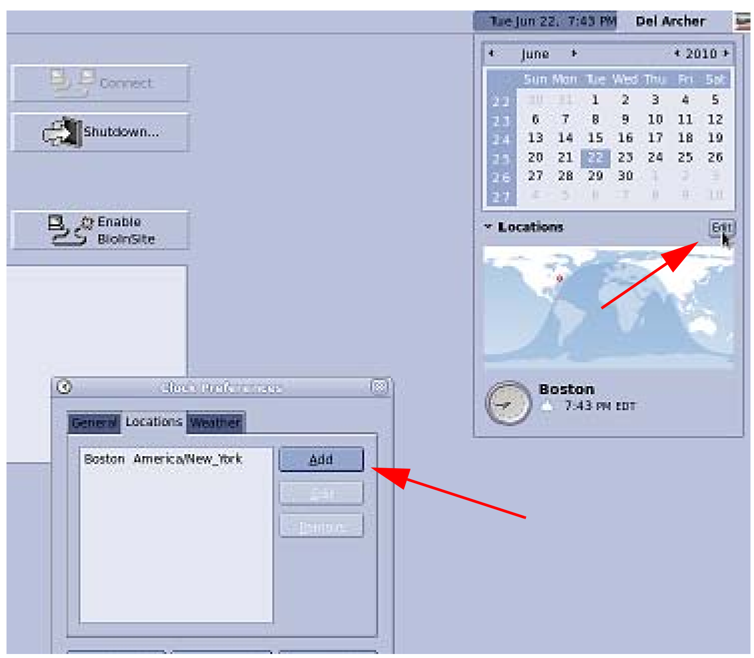


Figure 6-29

3.) Type in a location in the "Choose a location window" and then select a match from the pop-up. Select OK.

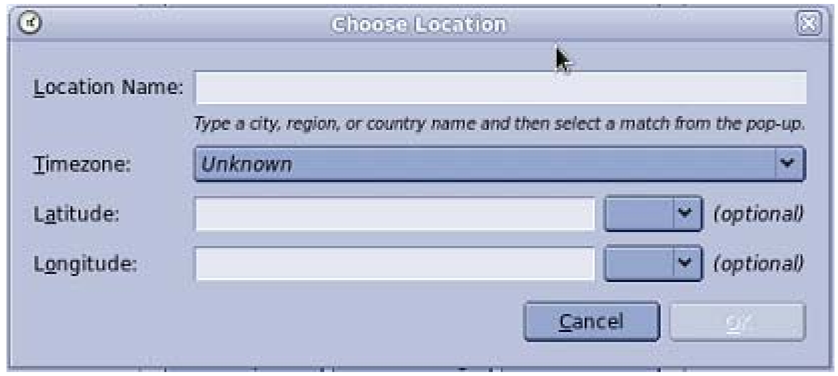


Figure 6-30

4.) Click on the Close button to close the Clock preferences dialog box.

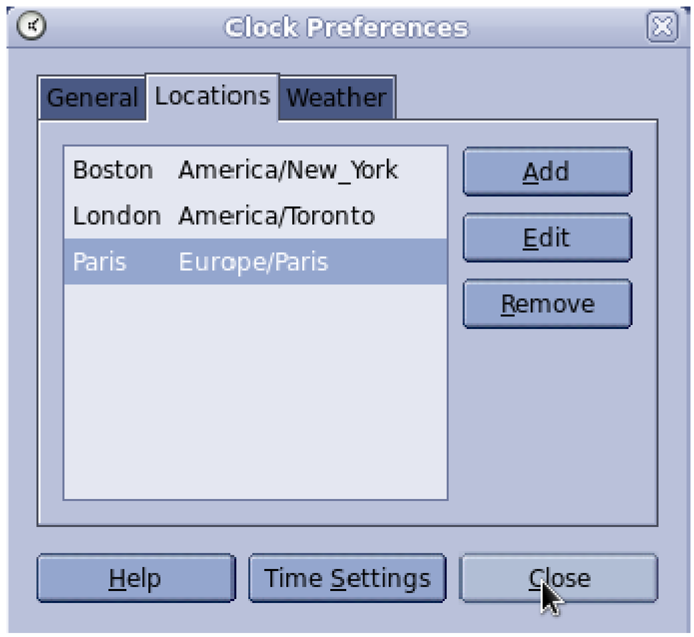


Figure 6-31

5.) Set the location as the current location by clicking on the set button.

Figure 6-32

Chapter 7
Calibration

Section 7.1
Overview

7.1.1 When to Calibrate?

Calibration should be performed:

- After replacement of SPECT or CT detectors or components thereof.
- After replacement of a septa or an x-ray source.
- After physical separation of the Table/SPECT unit and the CT unit. In this case, laser alignment must first be performed (see eXplore speCZT Installation and Training Guide).

Verification should be performed:

- Upon initial installation of the system (see eXplore speCZT CT 120 Installation and Training Guide).

7.1.2 Calibration Kit

Tools:

- Allen key set

Calibration Kit:

- SPECT alignment jig
- Line isotope tube
- BB Grid for CT detector calibration
- 4-Coil QA Phantom
- Elliptical Calibration Phantom
- 4 Wire Phantom (mouse and rat)

Customer supplied items:

- Co-57 point source
- Co-57 line source
- Am-241 line source
- Ultra-Micro Hot Spot Phantom (include resolution insert)
- Co-57 or Tc-99 for Ultra-Micro Hot Spot phantom
- Neoprene or nitrile gloves (powder-free)

Section 7.2
Calibration Procedures

7.2.1 SPECT Calibration

The purpose of SPECT calibration is to gather data that will be used to compute compensation parameters to correct the variations in uniformity & energy response of detector pixels. This data will also be used for geometric calibration of detector panels and collimators.

The parameters which are measured during calibration are:

- Uniformity map
- Energy map
- Geometry of collimator and detector panel

Before shipment of the system, and before acceptance by the customer, these parameters plus background noise (without an isotope present), linearity, uniformity, sensitivity and resolution must be verified.

On a daily basis, the user must also perform a QA test of background noise.

DISABLING BAD PIXELS

It is expected that at least some pixels in each detector panel will be faulty. A noisy pixel will present itself as a bright spot on a flood scan with no isotope present. To prevent these pixels from skewing calibration results, it is strongly advised that they be disabled before proceeding with calibration.

1. Ensure a collimator is not installed (see collimator removal procedure in the next few pages).
2. On the Console desk computer top menu bar, click the Applications button, System Tools and Terminal.
3. On the Terminal screen:
    a. Type: vncviewer spect.local
    b.) Type password:debug
4.) On the SPECT computer:
    a.) Exit the RIO Driver application by clicking on the Stop button on the Control tab.
    b. Close the system monitor application.
    c.) Open Windows Explorer and navigate to c:\inukshuk\executables
    d.) Double click on Host_CZT40.exe (4.0 CZT version) or IH_36.exe (3.5 CZT version).

The Inukshuk Receiver screen appears. (Figure 7-1 andFigure 7-2)

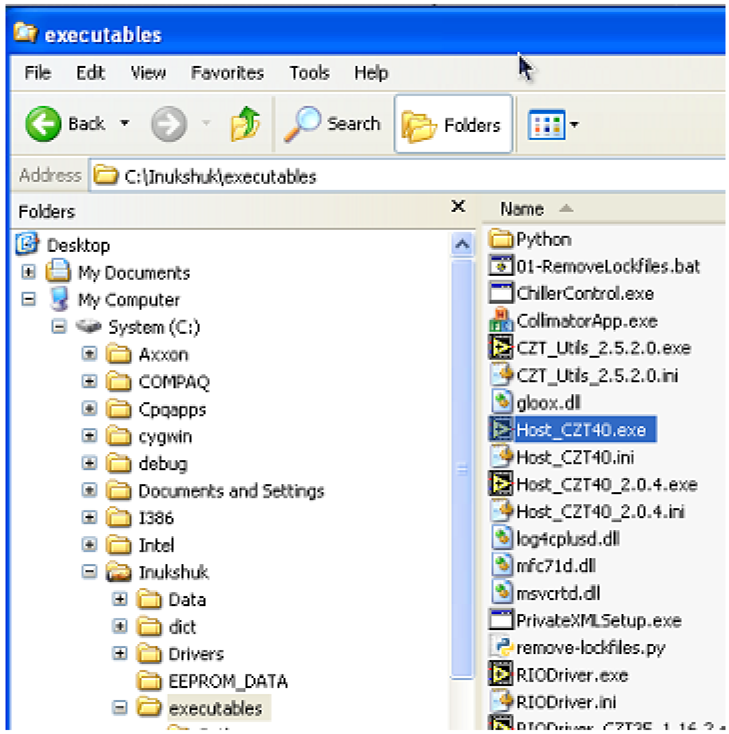


Figure 7-1

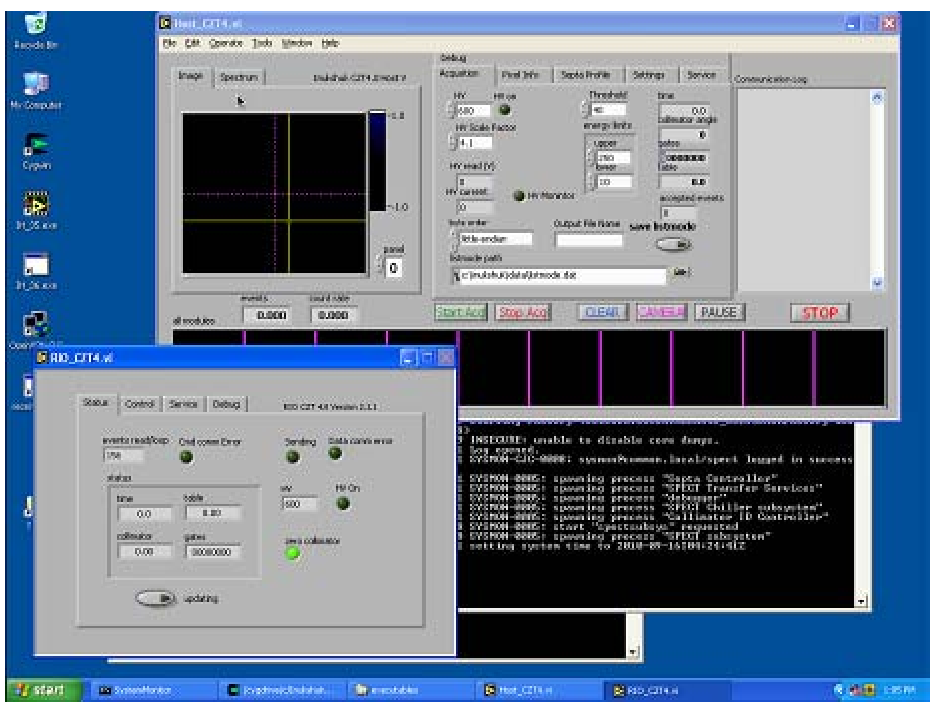


Figure 7-2

4.0 CZT Software

A.) Click the Acquisition tab (circled in Figure 7-3).

B.) To set high voltage you click on the green LED, it lights RED when high voltage is on.

C.) Set the Threshold to 40 KeV. Set the Energy window high value to 250 KeV and the low value to 40 KeV.

D.) Press the Start Acq button.

E.) Click on the Pixel Info tab. Click on bright pixels (those having a value greater than 100) and click the Disable button. If a pixel is disabled by mistake, press the Enable button (circled buttons in Figure 7-4). You will have to do this for each panel.

F.) Click on the CLEAR button to refresh the display.

G.) Continue this procedure until all noisy pixels are disabled.

H.) When complete, press Stop Acq.

I.) Save the bad pixel information by pushing the Update Setup button (Figure 7-4)

Note: Check in the communication log to make sure there is not an SPI bus error. If this error is present the disabled pixels were not saved. You will have to restart the program or even shut down the system and power up again to ensure that an SPI bus error is not present.

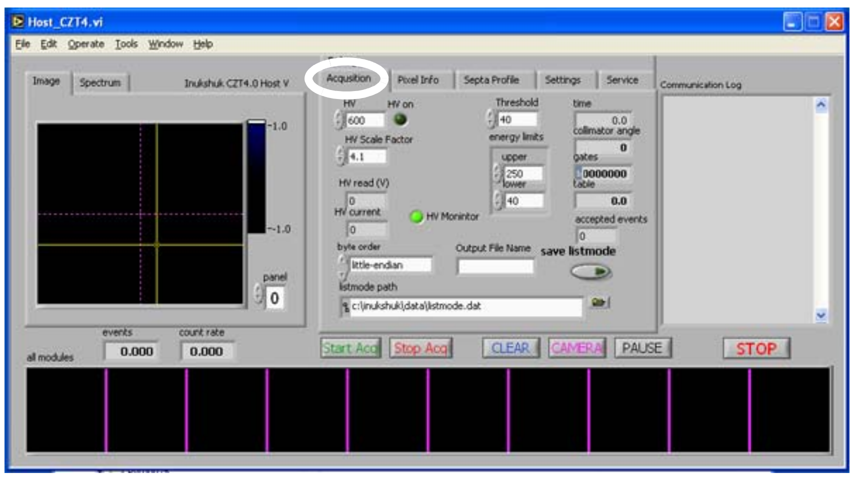


Figure 7-3

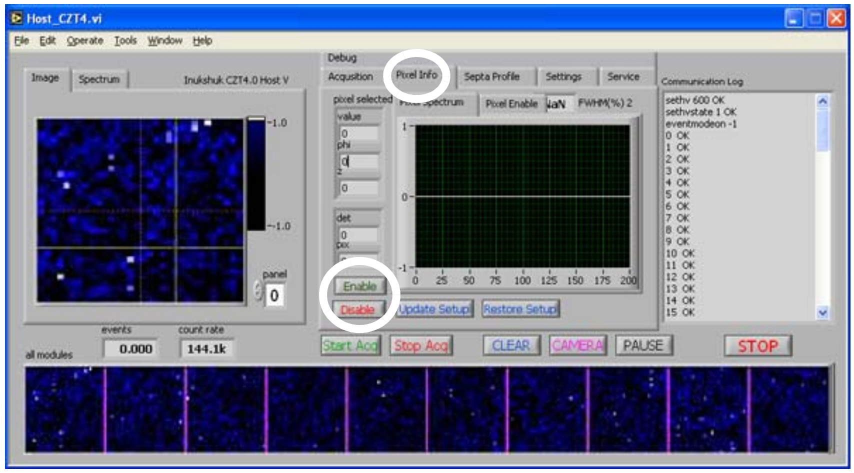


Figure 7-4

Note: Look in the communication log for status and error messages. Disabled pixel=1, enabled=0.

3.5 CZT Software

A.) Click on the calibration tab (Figure 7-5)

B.) Change lower energy limit to 50 KeV

C.) Change V cal and frequency to 0

D.) Change threshold to 8000

E.) Set HV to 600. Turn the HV on by pressing the red "LED". This starts the acquisition.

F.) Change to the pixel enable tab (Figure 7-6).

G.) Click on one of ten panels (at the bottom of the screen) in which a pixel needs to be disabled

H.) Click on each green square in the detector section to select a specific module for the currently selected panel

I.) Move the mouse in the red pixel map area and position the cross-hairs on the bad pixel in the left panel view.

J.) Once the desired pixel is centered on the cross-hairs, right mouse click on the pixel map area to disable this pixel.

K.) Hit CLEAR to refresh the view.

L.) Hit STOP to end acquisition.

Note: Do not hit the SAVE button as the pixels are disabled at the hardware level

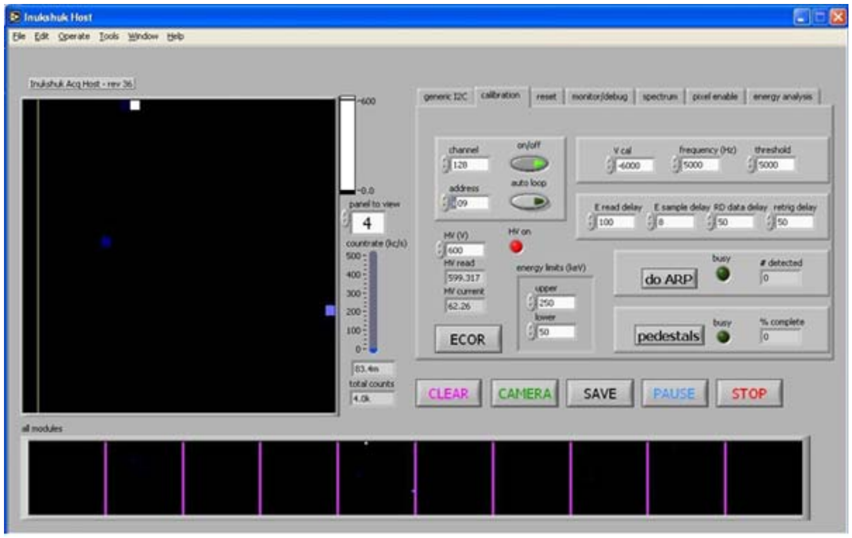


Figure 7-5

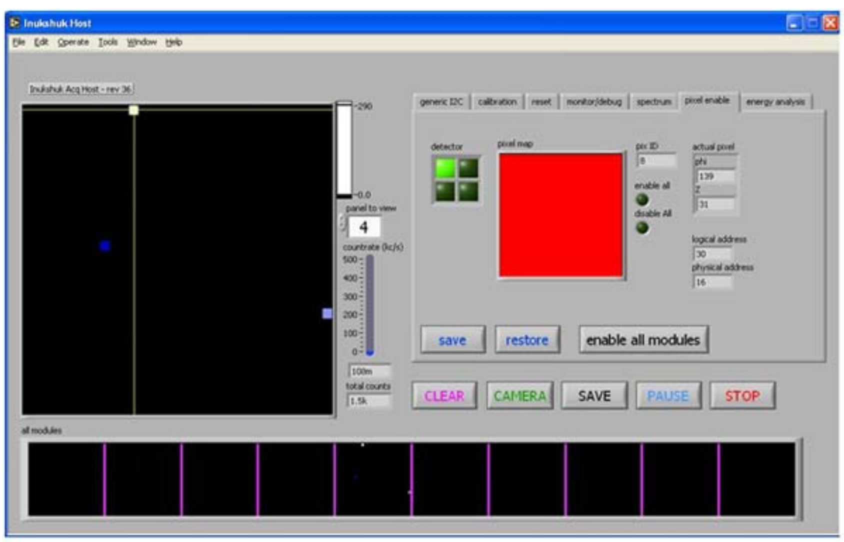


Figure 7-6

ENABLING ALL PIXELS

It may be necessary to undo the disabling procedure just described and start again. The procedure depends on the Inukshuk Receiver software version. Repeat steps 1 to 4 on page 246.

4.0 CZT Software

1. Put a line source in the jig (See page 264 for this procedure).
2. Click the Start Acq button on the Acquisition tab. This will create a flood scan. Dark pixels are the ones that have been disabled.
3. Click the Stop Acq button and click on the Pixel Info tab (Figure 7-4).
4. Re-enable pixels on each panel one at a time by clicking the Enable button.
5. Click the Update Setup button
6. Click Start Acq again to confirm that all pixels are active.

3.5 CZT Software

1. Click the enable all modules button (Figure 7-6) on pixel enable tab to re-enable all pixels simultaneously.

SEPTA ALIGNMENT

The septa provides 32 discrete axial slices by creating "channels" through which individual rows of detector panel pixels will be illuminated by the isotope without interfering with adjacent pixels (Figure 7-7). Septa alignment with the pixel rows must be completed before the three calibrations listed above can be performed. (Figure 7-8)

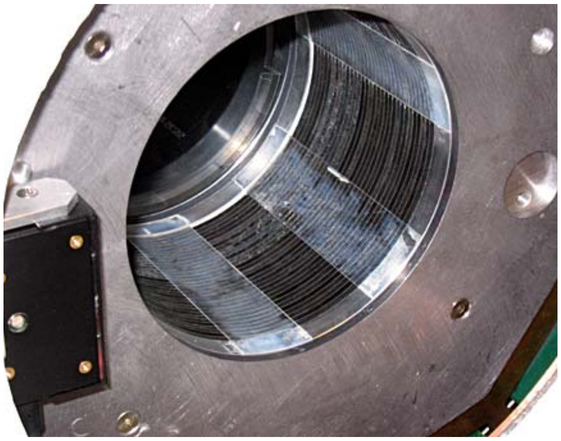


Figure 7-7

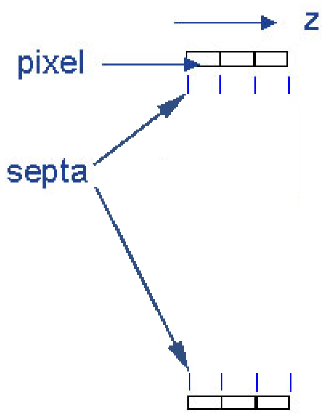


Figure 7-8

Septa alignment is therefore critical to optimal image quality and sensitivity. By placing a point source isotope close to the septa and aligning it exactly in the center of a septa opening (channel), for example, the illumination of the centered pixel and the adjacent two pixels (in the z direction) can be observed. Ideal alignment of the septa and the pixels is achieved when the centered pixel is strongly illuminated and little or no illumination is observed in the adjacent pixels. Misalignment can be created in several ways:

- A particular detector panel may be misaligned with the septa, while the panel on the opposite side of the septa is perfectly aligned.
- A panel may be twisted such that its pixel rows are not aligned with the septa "channels".
- The septa is manufactured with uneven spacings.
- The septa is not mounted perpendicular to the z-axis.
- Combinations of the above.

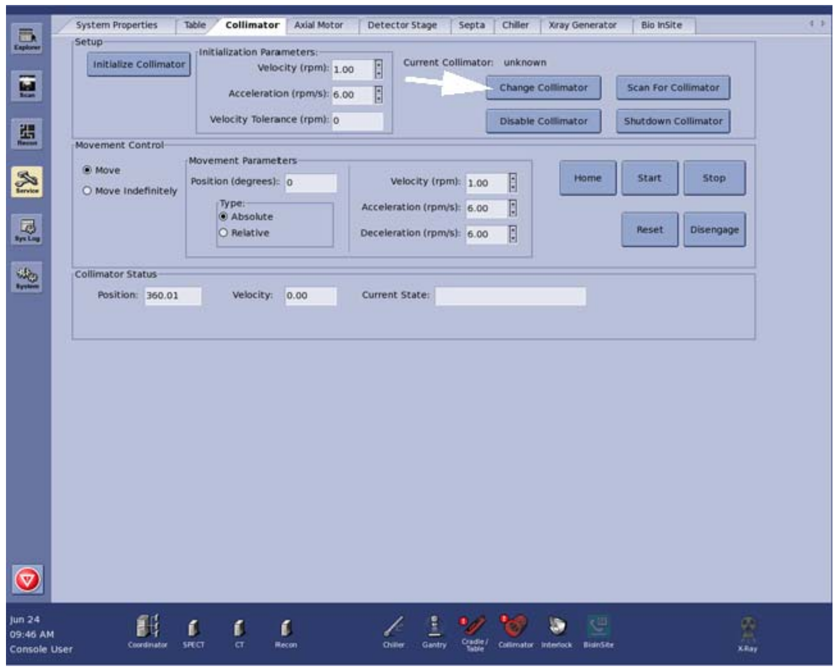


Figure 7-9

For septa alignment, a collimator must NOT be installed.The removal procedure is as follows:

Collimator Removal Using the Tableside Touch Screen

1. Touch the Collimator tab (circled in Figure 7-10).

Figure 7-10

2. Follow the instructions in the dialog box (Figure 7-11).

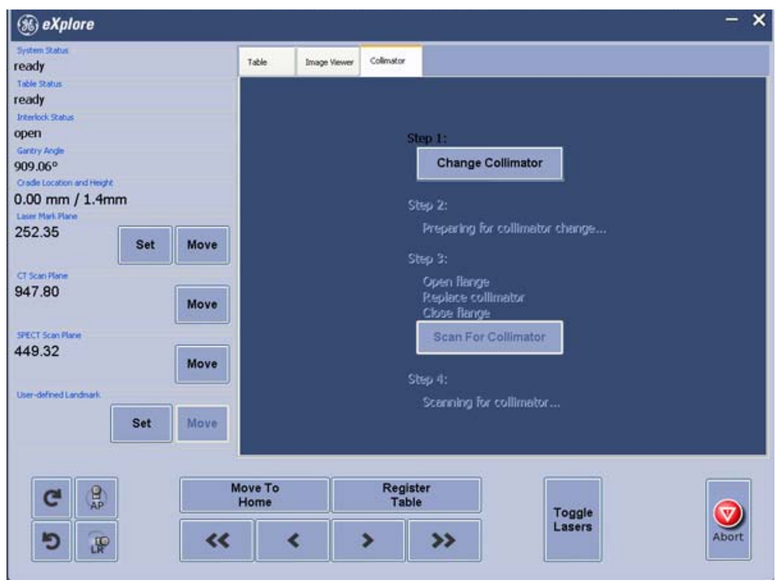


Figure 7-11

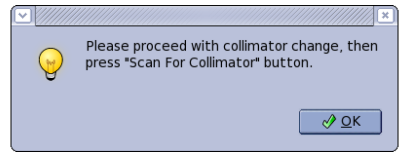
3. Skip to step 3 on page 254.

Alternate Collimator Removal Using Service Pages

1.) 

Enter the Service pages on the Console, click the Collimator tab, then Change Collimator (Figure 7-9). A dialog box appears, warning the user that the septa and table are about to move. If the Yes button is clicked, this will release the collimator mounting plate lock.

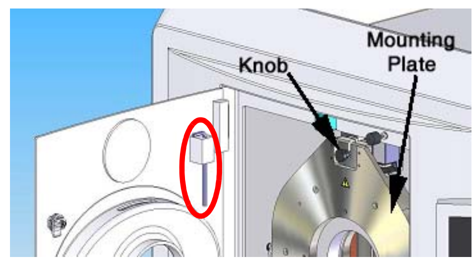
2.) A dialog box informs the user that collimator change is permitted. Click OK. If the box does not appear, there is a system error. Move the mouse over the Cradle/Table icon (bottom row in Figure 7-9) and check for a Table error.



Note: If an error cannot be resolved, restart the system.

CAUTION For the next step, be careful to lift the collimator straight up in order to avoid shearing the alignment pins.

3.) Move the Table shield completely back. Unlatch and open the door, undo the knurled knob and swing the mounting plate (flange) down. Unscrew four (4) allen screws using the tool (circled at right), holding down the collimator. Remove collimator (Figure 7-12). Swing the plate up and lock in position with the knurled knob.



.

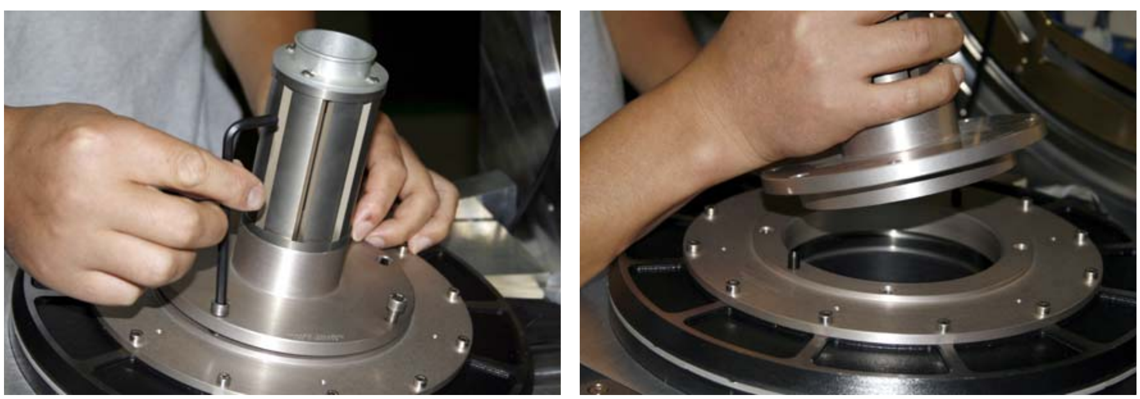
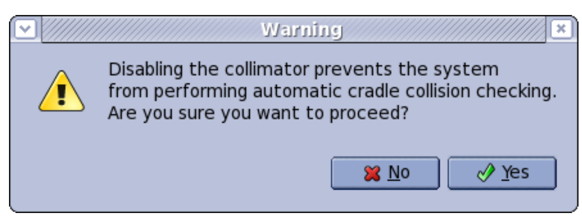


Figure 7-12

Disable Collimator

1.) Click the Disable Collimator button on the Collimator Service page (Figure 7-13). A dialog box appears, warning the user that automatic cradle collision checking is disabled. If Yes is clicked, this allows the procedure to continue without a collimator



present If the collimator is successfully disabled, "Type=Slit; emulate hardware =1" will appear on the Collimator Service page after "Current Collimator:".

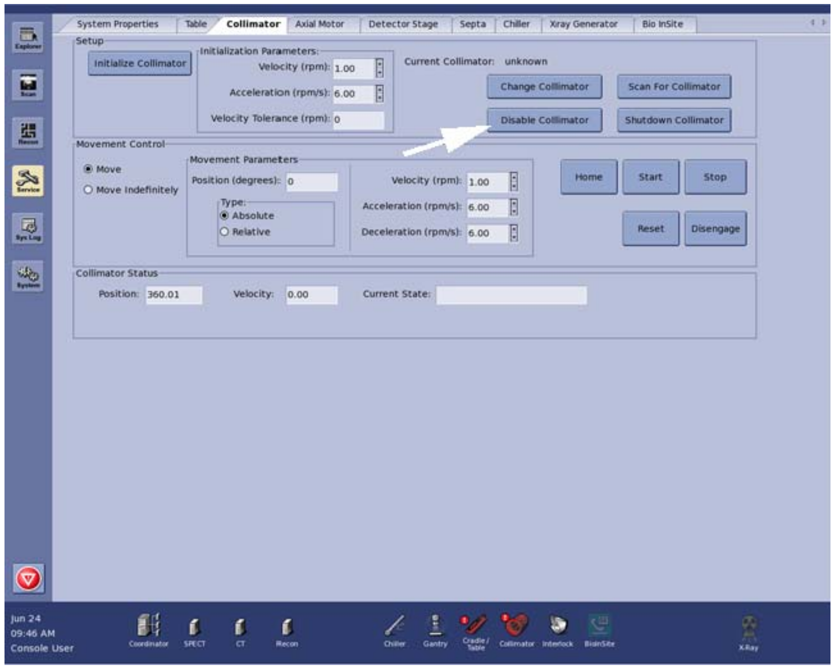


Figure 7-13

Alternate Method to Disabling Collimator

If the collimator cannot be disabled with the Disable Collimator button:

1. On the Collimator Service page hit the Scan for Collimator button.

2. Select Yes when a warning that the collimator is about to move appears.

3. Place the paper barcode (available in the Appendix to this guide) where the collimator barcode is normally located (Figure 7-14). The red barcode laser should be visible on the paper. Move the barcode around so that it is under the laser and about the same angle as the laser beam. When the barcode is read, the beam will be turned off. On the console, the collimator will be recognized.

Figure 7-14

Septa Alignment Procedure

1. The septa must be moved to its nominal aligned position. From the septa service page, click on the "Move to Position" radio button and select "InPos" from the named position drop-down list. Click the "Start" button and wait for the septa to stop moving. (Figure 7-15). I.

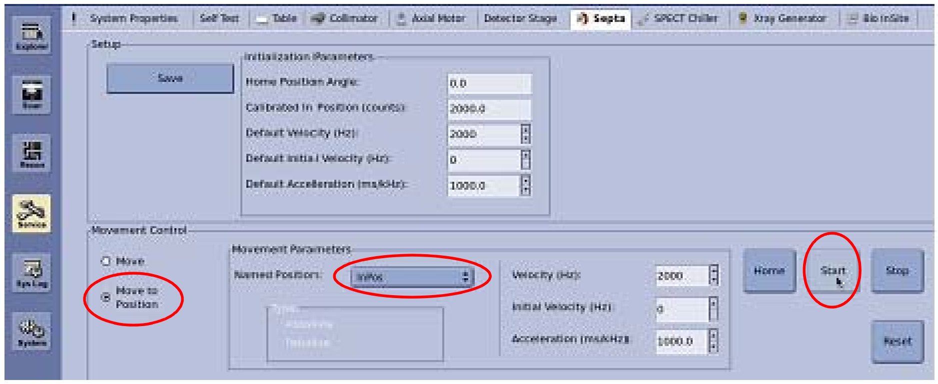


Figure 7-15

2.) Place the point source isotope (Co-57) on the mouse cradle and tape it down.

3.) From the Tableside touch screen (Figure 7-16), hit Toggle Lasers. Red laser beams will turn on. By touching and holding the 

button, the cradle will move continuously. Release once the point source isotope position approaches the laser crosshairs. Step the cradle in 1mm steps by tapping the 

button until the isotope position is perfectly aligned with the crosshairs. Lock in the laser landmark location by touching Set in the Laser Mark Plane area of the screen. Ensure the Cradle Location, Laser Mark Plane and CT Scan Plane values all changed after touching the Set button. Move the cradle to the scan plane by touching the Move button in the SPECT Scan Plane area of the screen.

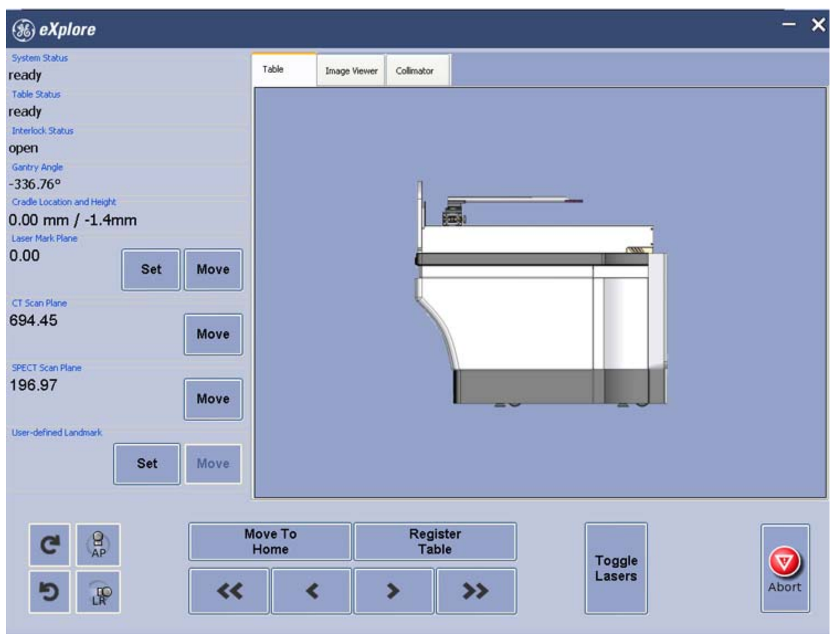


Figure 7-16

Note: If the lasers do not come on, unplug the USB cable from the back of the touch screen then plug it in again. If this procedure does not correct it, reboot the entire system.

4.) Adjust the cradle height so that the isotope is on the center of rotation of the septa (ie. on the Z-axis). (Figure 7-17)

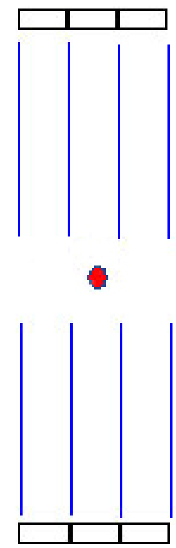


Figure 7-17

To Connect Remotely to the SPECT Computer:

A.) On the Console desk computer top menu bar, click the Applications button, System Tools and Terminal.

B.) On the Terminal screen:

e.) Type: vncviewer spect.local

f.) Type password:debug

Note: If connection to the SPECT computer fails, reboot the entire system.

5.) On the SPECT computer:

a.) Exit the RIO Driver application by clicking on the Stop button on the Control tab.

b.) Open Windows Explorer and navigate to c:\inukshuk\executables

c.) Double click on Host_CZT40.exe (4.0 CZT version) or IH_36.exe (3.5 CZT version). The Inukshuk Receiver screen appears.

4.0 CZT Software

1. Click the Start Acq button.

2.) Click the Septa Profile tab and check the symmetry of all detector panels by clicking on each and observing the Profile window. Figure 7-18 shows the profiles of two panels.

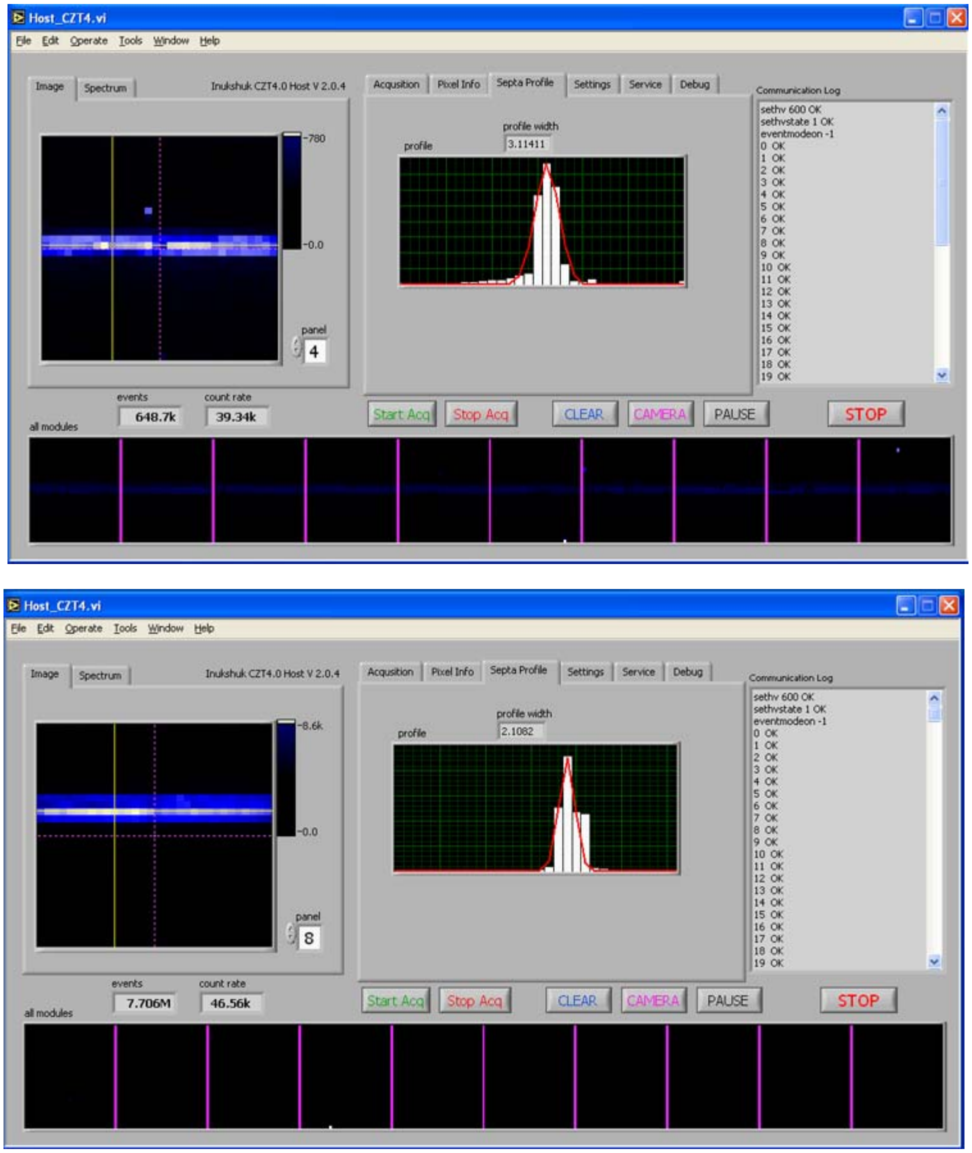
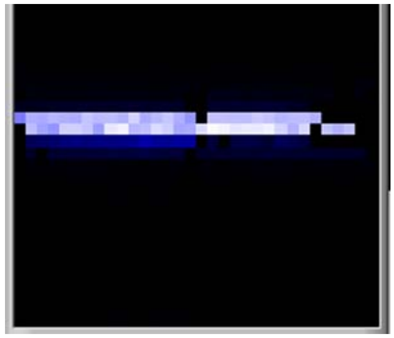
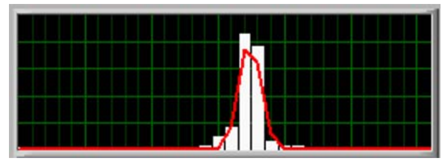


Figure 7-18

3.) If necessary, fine tune the isotope position along the Z axis by using the Console Service pages or the  or  buttons on the Tableside touch screen (in 1mm steps) until the point source is centered over an opening in the septa. To refresh the display after the Table is moved, click on 1) Stop Acq then 2) Clear and then 3) Start Acq. When correct, one row of pixels will be much brighter than its adjacent rows, as seen in the Profile window for each panel. Figure 7-18 shows good centering on both panels. Following are the image plot and profile showing an example of poor alignment between source and septa, resulting in lack of symmetry.





Note: If the profile looks like the one above, the source is not aligned close to the center of a channel in the septa. Move the table 1.23 mm to improve the symmetry.

Note: If most panels show good symmetry, then the alignment is considered acceptable.

4.) Click the "pixel Info" tab on the Inukshuk Receiver screen. Click on the most active row in the left hand window in Figure 7-19 and note the row data (Z value). Adjust the isotope position along the Z axis by moving the table, if necessary, to ensure it is closest to row 16. To refresh the display after the Table is moved, click on 1) Stop Acq then 2) Clear and then 3) Start Acq. .

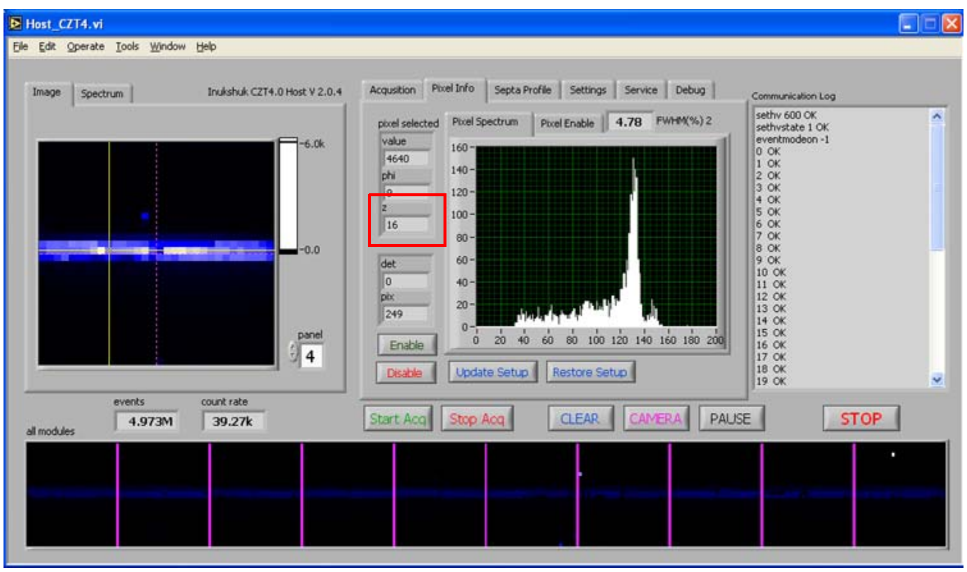


Figure 7-19

5.) As shown in Figure 7-20, septa misalignment with the pixel rows will cause illumination of adjacent rows (white = maximum, black=minimum). If symmetry in the previous step cannot be obtained, step the septa by adjusting the Movement Parameters / Position (counts) value in Figure 7-21. First, send the septa to its Home position, and increment the position count by 50 to 16850. Hit Start and examine the Profile.

6.) Repeat steps 3 to 5, sending the septa Home again, incrementing the position count by another 50 to 16900 and hitting Start. Repeat this process until the most symmetrical illumination on the Profile window for each panel is achieved.

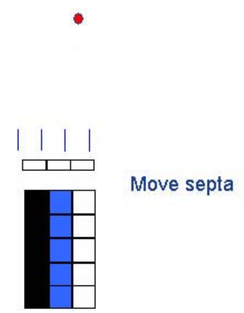


Figure 7-20

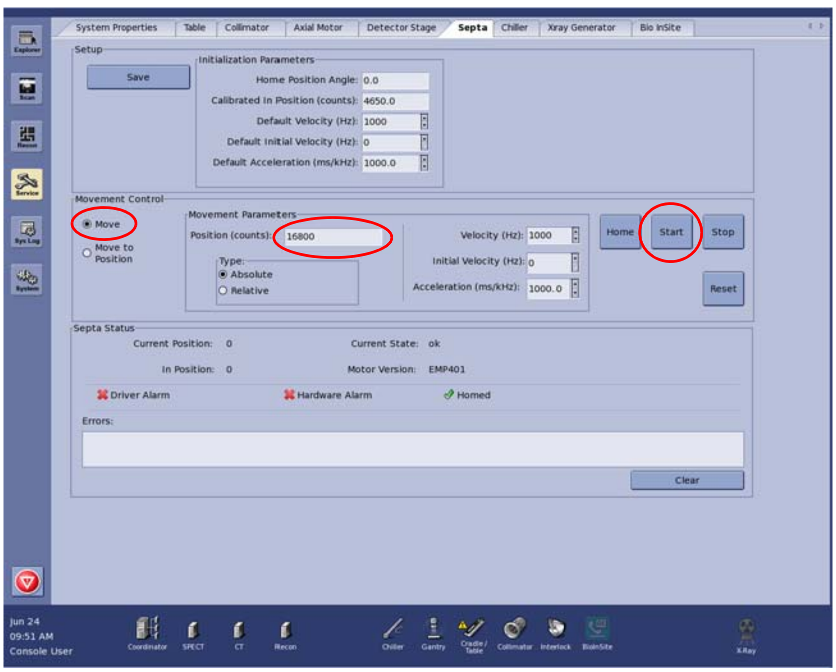


Figure 7-21

Note: Not all rows on all panels will achieve perfect symmetry, but if the septa must be moved by more than 500 counts to achieve reasonable results, there may be a problem with the septa or a panel.

7.) Choose another location for the point source by moving the cradle by multiples of 2.46 mm using the console Service pages or the Tableside touch screen. Note the pixel row by clicking the "pixel Info" tab on the Inukshuk Receiver screen and clicking on the most active row on the left hand window. Move the septa again and determine whether or not the septa location in step 5 is still optimal by observing the Profile window. If not, record the difference in the stepper motor count.

8.) Repeat this process for other point source locations and determine an optimal stepper motor count for best overall septa alignment. This will become the septa "calibrated" position.

9.) Go to the Service pages (highlighted page button at right) and click the Septa tab. Enter the actual stepper motor count into the Calibrated in Position (counts) field in the Installation Parameters area and click the Save button.

10.) Shut down and re-start the system to save the settings:

a.) Click the System button on the console screen "page" section (arrow in illustration at right).

b.) Select Shut Down.

c.) When the Tableside touch screen shuts off, press and release the red button (near the touch screen). Wait 15 seconds.

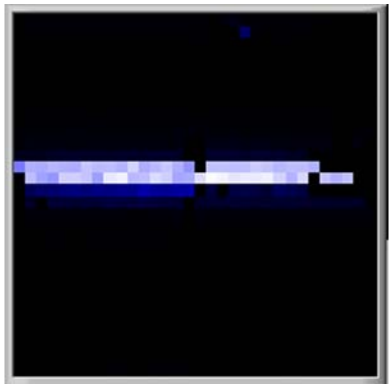
d.) Power up the system using the green button on the left side of the Table.

e.) On the console screen, double click the GE Console Application icon, choose the Inukshuk scanner then click the Connect button.

f.) Wait for all components to finish booting.

3.5 CZT Software

If the 3.5 version of the software is installed, repeat the process for the 4.0 version. The difference is that a Septa Profile is not available in the 3.5 version. Use the left window on the Inukshuk Receiver to evaluate symmetry. The left image in Figure 7-22 shows poor symmetry, while the right image is acceptable.



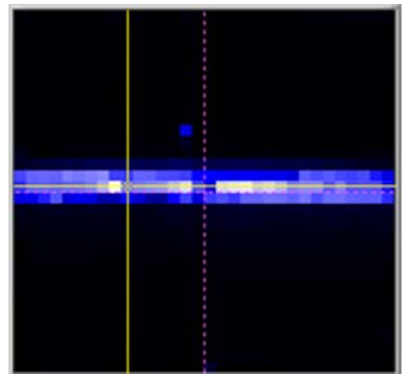


Figure 7-22

Note: The pixel row data can be read from the "z" field on the pixel enable tab on the 3.5 version Inukshuk Receiver.

ENERGY CORRECTION

Energy correction starts with the collection of data on the energy spectral response of each pixel. The energy peak location in keV depends on the isotope used, but response to the isotope is different for each pixel. This data is used to produce an energy map, which provides linear gain and offset values for each pixel. Two different isotopes, Co-57 and Am-241, will be used (customer supplied). The energy map is shared among all collimators.

Note: The customer may supply other isotopes. Use the same procedure for these isotopes until step 8 on page 266. If this is the case, use the peak value specified for the given isotope in the table below.(Table 1) The threshold for all isotopes will be 30 keV .

Table 1: Energy Characteristics of Commonly Used Isotopes

Isotope	Min (keV)	Max (keV)	Peak (keV)
Co-57	110	140	122.1
I-123	143	175	159
I-125	30	40	35.5
In-111	154	188	171.3
Tc-99	125	150	140.5
Se-75	120	150	136
Xe-133	65	100	81
Am-241	50	80	59.5
Tl-201	60	80	70.8

Preparation for Energy Correction

WARNING

1.) Ensure the cradle is removed using the quick-release clamp.

2.) Ensure the collimator is NOT installed. Refer to the removal procedure on page 254 if a collimator is installed.

3.) Ensure the septa is in its calibrated position. From the septa service page, click on the "Move to Position" radio button and select "InPos" from the named position drop-down list. Click the "Start" button and wait for the septa to stop moving. (Figure 7-15).

4.) Press the Scan button 

. Press the Select Protocol button. Select the SPECT Flood Scan protocol. When clicking on the recon, ensure that the Energy Correction and Uniformity Correction boxes are checked. Set the protocol for an average photon count per pixel of 100,000 (102.4 Megacounts for all pixels) by entering 102400000 into the Counts field.

5. For Co-57, set the energy threshold to 60 KeV, the energy window to 110-140 KeV, the Step Count to 1, the Increment Angle to 0.5 degrees, and set energy correction to none as shown in Figure 7-23.

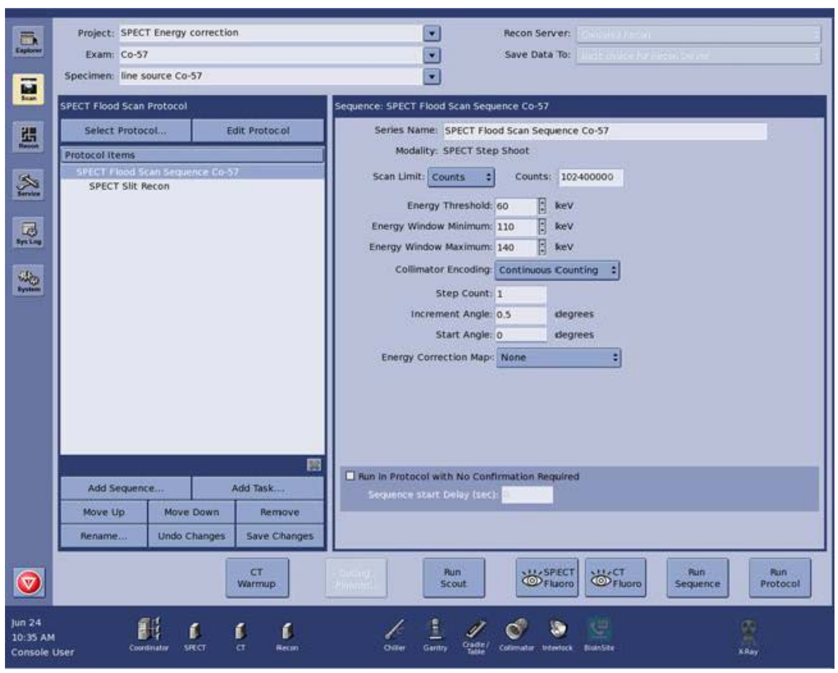
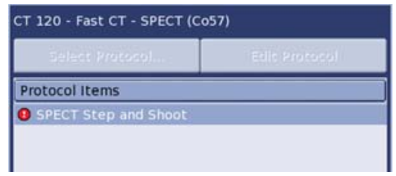


Figure 7-23

Note: If the Run Protocol or Run Sequence buttons are not enabled, a landmark may need to be set, the table may need to be registered, or a recon is missing or wrong.

- If a recon is mismatched to the collimator, a red alert symbol will appear next to the recon. Click Edit Protocol, select the incorrect recon (ie. SPECT Pinhole Recon at right) and click Remove. Click on Add Task and select the SPECT slit recon.

- If a recon is missing (as shown at right), click Edit Protocol/ Add Task and select SPECT Slit Recon.



- If a landmark needs to be set, a yellow alert symbol will appear next to the Cradle/Table icon. Hover the mouse over the icon and a message will confirm whether or not a landmark needs to be set. If so, go to the Service page/Table tab, move the Table to an absolute position of 300 and click 

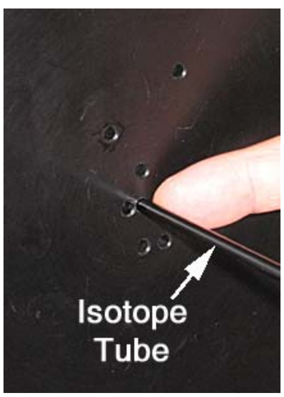
. If the table needs to be registered, click the Register button before setting the landmark.

CAUTION

Energy Correction Procedure

1.) Orient the jig until the largest of the four holes near the edge of the jig is at the 9 o'clock position (Figure 7-24).

Note that the jig is now supplied in clear plastic (below) and does note have a larger hole. Line up the jig as shown.



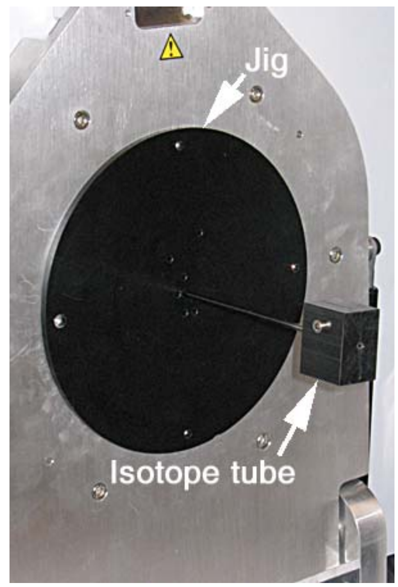


Figure 7-24

Note: Isotope will slide in the isotope tube when the tube is tilted. TRY TO KEEP THE TUBE AS LEVEL AS POSSIBLE OR SLIGHLTY TILTED DOWNWARD AT THE OPPOSITE END TO THE BLOCK AT ALL TIMES.

Note: Although the procedure refers to Co-57 and Am-241, the customer may supply different isotopes. If this is the case use: Table 1: Energy Characteristics of Commonly Used Isotopes, on page 262, to look up the appropriate energy values.

2.) Load the Co-57 line source isotope (500 uCi) into the end of the isotope tube at the block end. Ensure the isotope tube is placed in the center hole of the special jig and the isotope tube block (arrow in Figure 7-24) is pushed flush against the jig. Ensure the end of the isotope is at the far end of the tube, using a wire if necessary to push it. CAUTION - Latex gloves must be worn when handling an isotope, and properly disposed of afterward.

3. Verify that the line source covers the whole FOV by using SPECT fluoro. The line source might need to be adjusted in or out (z-position) by adjusting the source holder tube position. Loosen the clamping allen screw in the white holding block and adjust the position.

4.) Confirm that the septa is in its calibrated position by going to the Service page/Septa tab and then check the current position. Start the data acquisition by clicking Run Sequence. Duration will be approximately ten minutes. As a second check, look at the counting rate, which should be approximately 20,000. If not, the system will need to be re-booted.

5.) After the scan has successfully completed, a folder will be generated and named automatically by the system in the form "Scan_xxxx" and stored in the Console at /media/data_disk/SPECT. To determine the assigned folder number while in this directory, type:

ls -l

where the first and last characters are lower case L. This lists the scans along with their time/ date stamp. The most recent is the current scan number. A file called SPECTAcq.dat will be stored in this new folder.

6.) Cover the tube opening at the block end when removing the tube from the jig to prevent the isotope from sliding out. Re-load the isotope tube with Am-241 (200 μCi) using the same precautions as in step 1. Change the Series Name field in the Scan page to reflect the different isotope. Change the energy threshold to 40 KeV and the energy window to 40-80 KeV, as shown in Figure 7-25, and start data acquisition (approximately 90 minutes). Check the Count Rate box on the right screen after the scan is started. For 4.0 CZT, count rate cannot be higher than 500 kcps. For 3.5 CZT, count rate cannot be higher thatn 200 kcps. Use less activity if the count rate is higher than the limit. A new folder will be generated and stored in the form "Scan_yyyy", where yyyy is the next number in the naming sequence. A file called SPECTAcq.dat will be stored in this new folder.

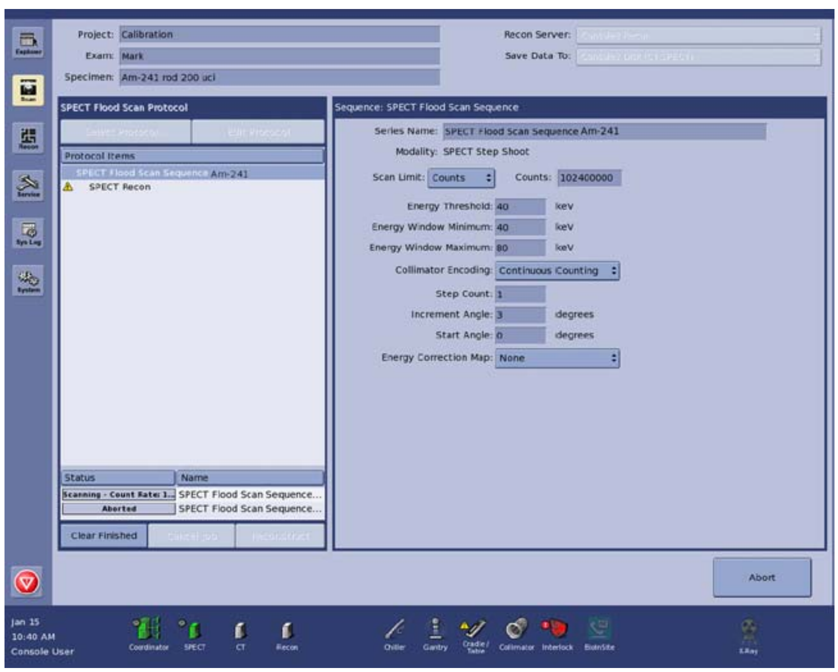


Figure 7-25

Note: Opening scan.xml with a text editor will verify the correct scan number against the Series Name.

7.) Create a new directory into which the two acquisition files will be copied and renamed:

a.) On the Console desk computer, click Applications, System Tools and Terminal.

b.) Type: cd /media/data_disk/SPECT

c.) Type: ls

The first character is a lower case L. Check if a CorrMaps folder already exists. If it does, skip step d. If not:

d.) Type: mkdir CorrMaps

e.) Type: cd CorrMaps

f.) Type: cp ../Scan_xxxx/SPECTAcq.dat SPECTAcq_1.dat
cp ../Scan_yyyy/SPECTAcq.dat SPECTAcq_2.dat

where Scan_xxxx is the folder generated for the Co-57 scan and Scan_yyyy is the folder generated for the Am-241 scan. These are now copied into the CorrMaps directory under new filenames SPECTAcq_1.dat & SPECTAcq_2.dat, respectively.

g.) Verify that the files have been copied by listing the files. Type: ls -l

8.) Generate an energy map:

Note: **If you are using isotopes other than Co-57 or Am-241 than you must change the energy peak values in the command line below. See (Table 1: Energy Characteristics of Commonly Used Isotopes, on page 262)**

a.) Type:
goEcor SPECTAcq_1.dat xxxx 122.1 50 250 SPECTAcq_2.dat yyyy 59.5 50 250
where xxxx and yyyy correspond to the original folder names generated after the scans."122.1" represents the Co-57 energy peak at 122 KeV and "50 250" represents a 50-250 KeV energy window. "59.5" represents the Am-124 energy peak at 59 KeV and "50 250" represents a 50-250 KeV energy window.

The software will ask you for the system serial number (e.g., SPCT1200846-0112) This is located on the gantry side panel.

b.) An energy map file will be generated as "EnergyMap_xxxx_yyyy.vff". Make a copy of this file and name it EnergyMap.dat
Type: cp EnergyMap_xxxx_yyyy.vff EnergyMap.dat

c.) Rename the generated file as "EcorGainOffset.vff".
Type: mv EnergyMap_xxxx_yyyy.vff EcorGainOffset.vff

Note: If renaming the file fails, list the contents of the folder and verify that EnergyMap_xxxx_yyyy.vff is present. If not go back to step 7a)

The dual Console screens in Figure 7-26 show an example of flooding all pixels with a line source (Co-57), with the collimator removed. One detector panel is shown magnified on the right hand screen.

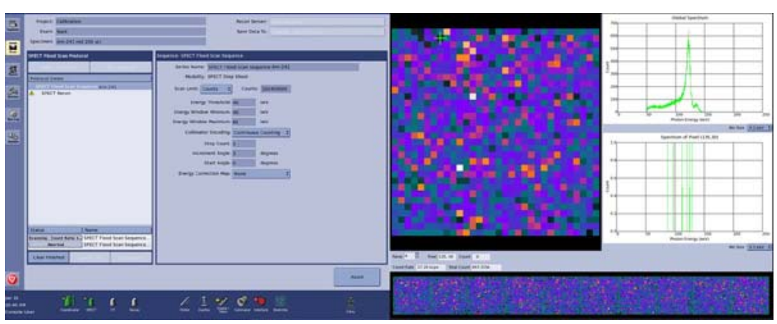


Figure 7-26

UNIFORMITY CORRECTION FOR SLIT COLLIMATORS

Note: **The following uniformity correction steps are for slit collimators only. Please refer to a separate procedure to do uniformity correction for pinhole collimators. All slit collimators share the same uniformity map. But the maps are given different file names for different slit collimators.**

In order to correct for differences in sensitivity between pixels, all pixels must be flooded by the isotope, then photon counts made for each over the long term. If all pixels are flooded equally, counts theoretically should be the same for all pixels.

The uniformity map provides a correction factor for each pixel based on the difference in counts. The map also takes into account the intrinsic geometric falloff in sensitivity expected in pixels that are not at the center of each detector panel, because the pixels are on a flat rather than a circular surface.

Note: If energy correction has been performed using Co-57 with the collimator removed, it will NOT be necessary to repeat the scan for uniformity correction. Copy the acquisition file (../Scan_xxxx/SPECTAcq.dat) into the CorrMaps folder and rename as SPECTAcq_3.dat using the general procedure in step 7 on page 266, then skip to step 2 on page 267.

Uniformity correction depends on energy correction. With any change to the energy map, we need to redo uniformity correction.

Preparation for Uniformity Correction

Perform ”Preparation for Energy Correction” (page 263).

Uniformity Correction Procedure

CAUTION Perform Steps 1 to 4 of ”Energy Correction Procedure” (page 264), then:

1.) Copy the acquisition file into the CorrMaps folder and rename it:
   a.) On the Console desk computer, click Applications, System Tools and Terminal.
   b.) Type: cd /media/data_disk/SPECT
   c.) Type: ls
   Check if a CorrMaps folder already exists. If it does not, complete Steps 6 to 8 of the Energy Correction Procedure on page -264 first.
   d.) Type: cd CorrMaps
   e.) Type: cp ../Scan_zzzz/SPECTAcq.dat SPECTAcq_3.dat
   where Scan_zzzz is the folder generated for the Co-57 scan. This is now copied into the CorrMaps directory under new filename SPECTAcq_3.dat.
2.) Create a uniformity map:
   a.) Type: SPECTCalibApp 10
   This will create a file called UniformityMap.dat, which sets all pixel values to 1.

Note: The following command line assumes the use of Co-57. If you are using a different isotope, replace the "1100" and "1400" with the appropriate values that you will find in Table 1: Energy Characteristics of Commonly Used Isotopes, on page 262. These are the min and max values multipied by 100.

   b.) Type: SPECTCalibApp 7 SPECTAcq_3.dat . 1 01100 01400 0.5 2.0
   Note the space-period-space after "dat". Type it exactly as shown. The "1" after the space-period-space uses the energy correction map for the uniformity calculation. "1100" represents 110 KeV and "1400" represents 140 KeV. This is the energy window.
3.) The system will generate a file called UniformityMaps_01100_01400.dat. Rename this file as UniformityMap.dat by over-writing the existing file or deleting it:
   Type: mv UniformityMaps_01100_01400.dat UniformityMap.dat

4. View the UniformityMap.dat to verify that it does not have any major faults. You are looking for patterns of pixels that are all bright or all dark or that all have a constant value. If you see such a block of pixels then contact engineering. Save the Map and mail it to engineering.

5.) Log in to the SPECT computer:

a.) On the Terminal screen:

Type: vncviewer spect.local

Type password:debug

6.) Copy the energy and uniformity maps to the SPECT computer:

a.) From the SPECT computer, open a Cygwin terminal window (icon on the desktop).

b.) To copy the existing uniformity map into the Inukshuk/settings directory, type:
cd c:\Inukshuk\settings

cp UniformityMap.dat UniformityMap_dd_mm_yy.dat
(Note: dd_mm_yy should be the current date)

scp vct@192.168.12.89:/media/data_disk/SPECT/CorrMaps/UniformityMap.dat .
A prompt for a password appears. Type : vct@pci

c. Copy the uniformity map to each of the new file names (one for each collimator):

```
mouse-UniformityMap.dat
rat-UniformityMap.dat
rat_knife_edge-UniformityMap.dat
rat_round_edge-UniformityMap.dat
```

Note: You create these files using the cp command. For example:

cp uniformityMap.dat mouse-UniformityMap.dat

After you have created all the files, confirm that all were created successfully by listing the contents of the folder by typing :

```
ls *.dat
```

You should see all four files.

Note: The latter two collimators are no longer available for new systems.

d.) Go to the EcorMaps directory by typing:
cd EcorMaps

To copy the energy map to the EcorMaps directory, type:
scp vct@192.168.12.89:/media/data_disk/SPECT/CorrMaps/EcorGainOffset.vff .
A prompt for a password appears. Type : vct@pci

e. Verify that the copy was successful by confirming that scp displays file copy progress and reports that 100% of the file was copied. If instead you see an error message recheck the command line you typed in step c. Note: the "." at the end of the command line is required and must be separated from the rest of the command line by a space.

7.) EcorNone.vff should be in "c:\Inukshuk\settings\EcorMaps". If not, contact GE Healthcare.

GEOMETRY CALIBRATION FOR SLIT COLLIMATORS

This procedure characterizes the following parameters:

- Distance from center of rotation (COR) to collimator slits. This is the radius from the isotope point source to each slit.
- Collimator slit angle offset. This is the difference between the theoretical and manufactured angle for each slit.
- Distance from center of rotation (COR) to the point on each detector panel where the radius line intersects the panel at a right angle. See Figure 7-27.
- Detector center of view (COV) offset. See Figure 7-27. If a detector panel is not, at its geometric center, perfectly at a right angle to the radius from the center of rotation (COR), the point on the panel at which it *is* at a right angle is offset by a particular distance (d) from the geometric center.

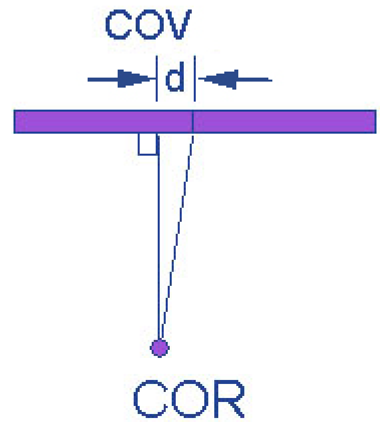


Figure 7-27

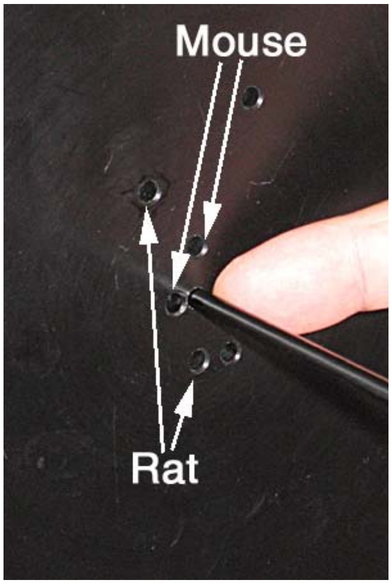


Figure 7-28

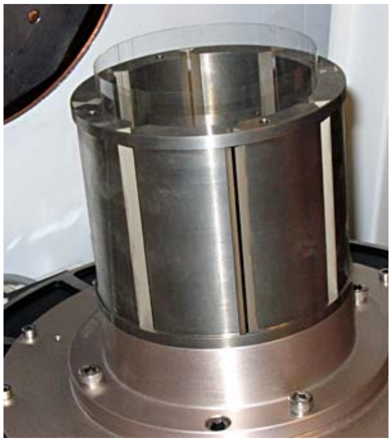


Figure 7-29

For geometry calibration, use the alignment jig in Figure 7-28 mounted on the outside of the collimator mounting plate.

The jig has holes into which an isotope holder tube is pushed (Figure 7-28). The block on the end of the tube ensures that the isotope is centered over the detector panels when pushed flush against the jig. This ensures all 32 slices are axially covered.

The center hole (with isotope tube inserted into it on jig as shown in Figure 7-28) is normally used only for energy and uniformity correction. The other holes, however, will be used for geometry correction. For mouse and rat specimens, the choice of holes will be different, as marked in the photo.

A slit collimator is required for this procedure and each collimator needs to be calibrated separately. Two types are available, with:

* 8 longtitudinal slits (rat and mouse) (Figure 7-29), arranged at 45 degrees apart around its circumference. As two parameters will be measured for each slit (distance from center of rotation and slit offset angle), 16 parameters in total will be measured. The collimator must be mounted as shown for geometry calibration, using 4 allen screws.
* 5 longtitudinal slits (rat) , arranged at 72 degrees apart. 10 parameters in total will be measured. It mounts the same way as the 8-slit collimator.

There are 10 detector panels formed in a ring. Each panel measures 78 mm x 78 mm. (Figure 7-30)

Two parameters are measured for each detector panel: offset distance from center of view (COV) and distance to the center of rotation (COR). Since there are 10 panels in the detector ring, there are 20 parameters total that must be measured.

The total number of parameters for both the detectors and the collimator is therefore 36 for the 8-slit collimator and 30 for the 5-slit collimator.

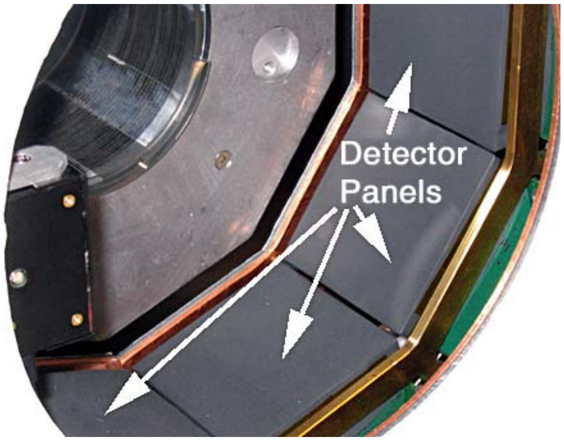


Figure 7-30

WARNING

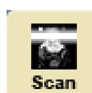
Preparation for Geometry Calibration

1.) Install a collimator. Refer to the collimator removal procedure on page 254 for general guidelines.

2.) Press 

on the Service page/Collimator tab.

3.) Ensure the cradle is removed using the quick-release clamp, and ensure one of the two available collimators is installed.

4.) Press the Scan 

button. Press the Select Protocol button (Figure 7-31). Select the

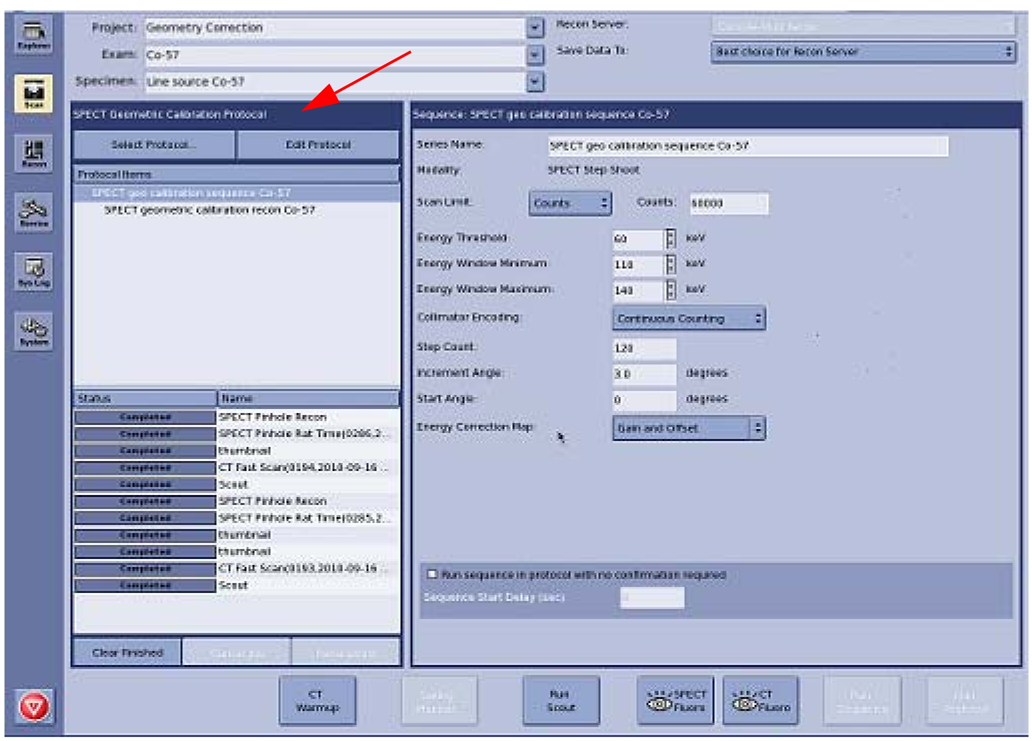


Figure 7-31

"SPECT Geometric Calibration Protocol". Set the protocol for a total count of 60,000.

5.) For Co-57, set the energy threshold to 60 KeV, the energy window to 110-140 KeV, the Step Count to 120, the Increment Angle to 3.0 degrees, and the energy correction map to "gain and offset", as shown in Figure 7-31.

CAUTION **Geometry Calibration Procedure**

1.) Load Co-57 line source into the isotope tube. Ensure the isotope tube is placed in one of the holes designated for the appropriate type of specimen (rat or mouse) as shown in Figure 7-28, and the isotope tube block is flush with the jig. (Figure 7-32)

2. Use SPECT flouro to check the line source position to be sure it covers FOV from top to bottom.

Note: A mouse collimator should only be used with the mouse holes on the jig. Similarly, only use rat collimators with the rat holes on the jig.

3.) Start the data acquisition by clicking Run Protocol. A file will be generated and named automatically by the system in the form "Scan_aaaa" and stored in the Console at /media/data_disk/SPECT. The scan is approximately 30 minutes long for an isotope activity of 1 mCi.

4.) To determine the assigned folder number while in this directory, type:

ls -l

where the first and last characters are lower case L. This lists the scans along with their time/date stamp. The most recent is the current scan number. A file called SPECTAcq.dat will be stored in this new folder.

5.) Move the isotope tube to the second hole designated for the specimen, and click Run Protocol. A new file will be generated and stored in the form "Scan_bbbb", where bbbb is the next number in the naming sequence.

6.) On the Console desk computer, click Applications, System Tools and Terminal.

a.) Type: cd media/data_disk/SPECT

Figure 7-32

7.) Generate a stackogram for each of the two files:

a.) Type: SPECTSlitRecon -f 0 -i Scan_aaaa/SPECTAcq.dat -x Scan_aaaa/scan.xml -o Scan_aaaa -c Scan_aaaa
Type it exactly as shown. Note that the "0" after "-f" denotes that a stackogram is required.

b.) Type: ls Scan_aaaa
Verify that there is a file Projection.dat generated. If not, repeat the previous step and check that it is entered exactly as shown.

c.) Type: SPECTSlitRecon -f 0 -i Scan_bbbb/SPECTAcq.dat -x Scan_bbbb/scan.xml -o Scan_bbbb -c Scan_bbbb

d.) Type: ls Scan_bbbb
Verify that there is a file Projection.dat generated. If not, repeat the previous step and check that it is entered exactly as shown.

8.) Change to the CorrMaps directory and save each stackogram under a different name:

a.) Type: cd CorrMaps

b.) Rename the recons to correspond with the collimator names (ie. rat & mouse). Type:
cp ../Scan_aaaa/Projection.dat rat1.dat
cp ../Scan_bbbb/Projection.dat rat2.dat
OR
cp ../Scan_aaaa/Projection.dat mouse1.dat
cp ../Scan_bbbb/Projection.dat mouse2.dat

9.) Send the two renamed files to a GE Healthcare facility capable of running MatLab optimization code. The output will be 20 detector parameters and either 16 (for 8-slit collimator) or 10 (for 5-slit collimator) slit parameters.

10.) Repeat entire Preparation and Procedure for another collimator, if available.

11.) Figure 7-33 shows a typical screen during data acquisition. The line image at the top left portion of the screen (created by the collimator) is a magnified version of one of the detector panel outputs at the bottom of the screen.

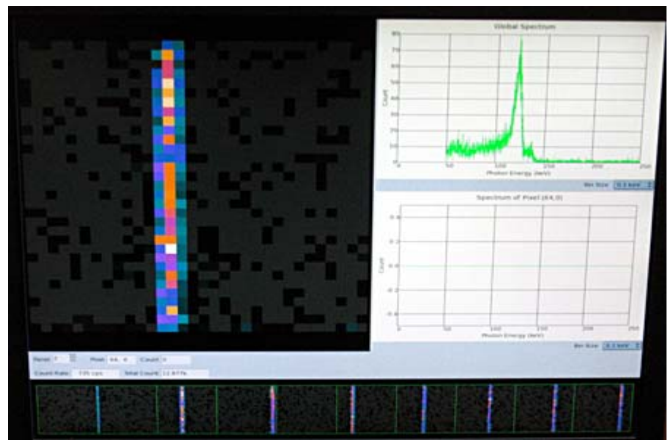


Figure 7-33

12.) From the System Properties page select SPECT(spect@common.local/Inukshuk) from the dropdown and enter the Slit Data numbers, obtained from GE Healthcare in step 9, in the code found under the System Properties tab on the Service page (circled in Figure 7-34). If the parameters for the collimator being used are not listed, contact GE Healthcare for an XML template. Enter this code after the </Collimator> tag (arrow in Figure 7-34).

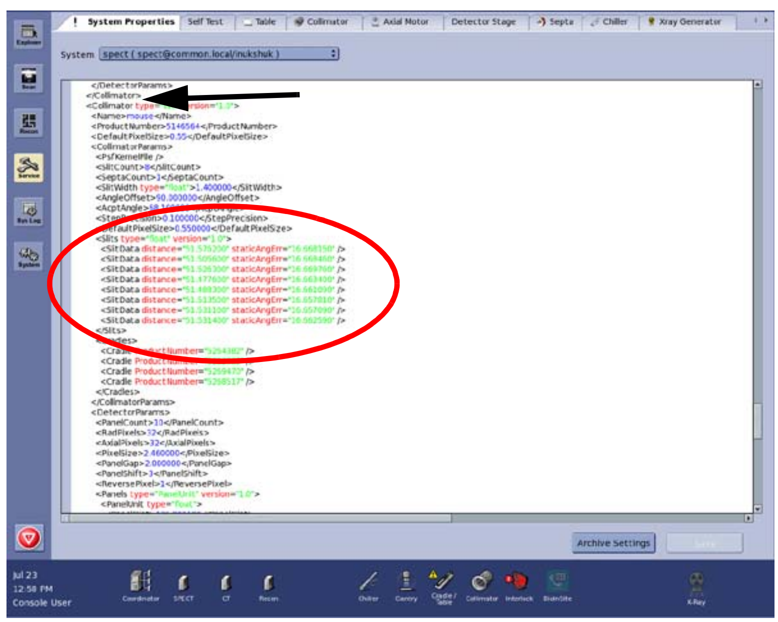


Figure 7-34

13.) Enter the ten pairs of detector parameters, obtained from GE Healthcare in step 9, after <DetectorParams> in System Properties (boxed area in Figure 7-35).

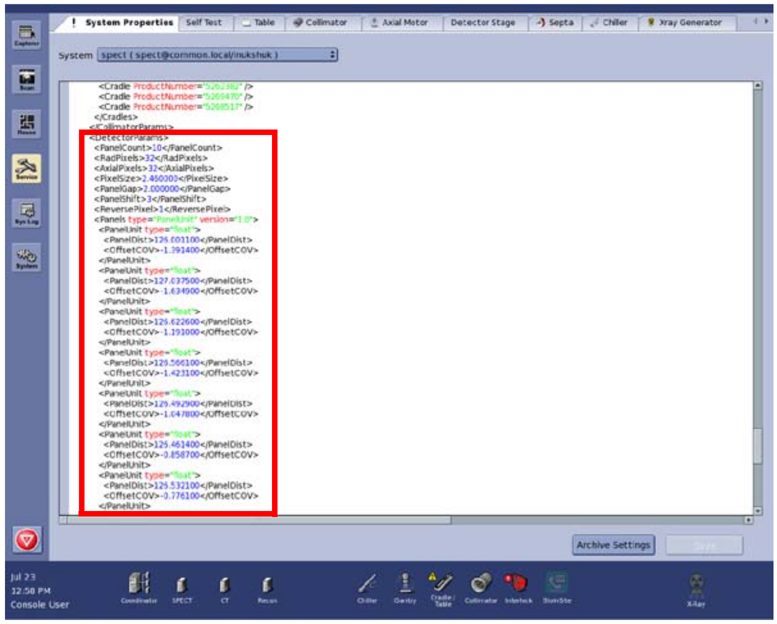


Figure 7-35

14.) Hit Save. Reboot as per the procedure on page 261, item 10.

SEPTA PINHOLE POSITION

With slit collimators, the septa is positioned directly above the detectors to provide discrete axial slices. With pinhole collimators, the septa is instead used to provide additional shielding from external radiation. To do this, the septa must be positioned so that the front of the septa aligns with the rear edge of the CZT detector ring This is called the 'pinhole position' for the septa. Typically a value of 5150 works well; so start with that by navigating to the "septa service page" and manually move the septa as shown in (Figure 7-36).

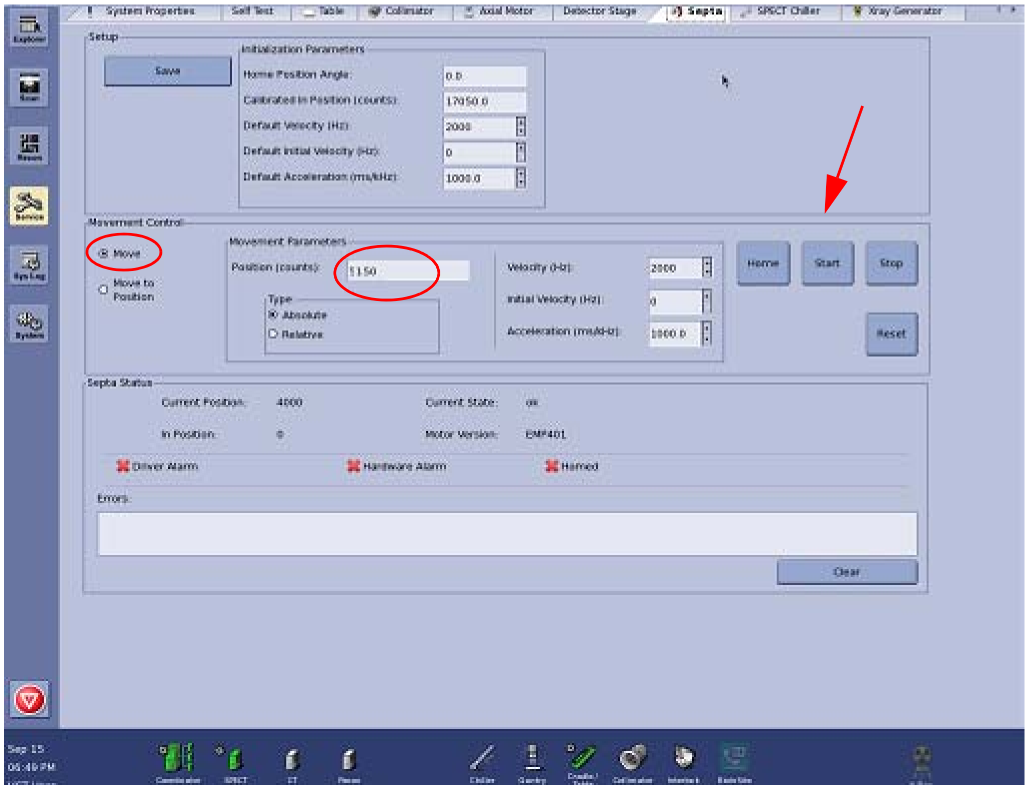


Figure 7-36

Then visually inspect the position of the septa and adjust its position (from the septa service page) until the front edge of the septa is aligned with the rear edge of the CZT detectors (Figure 7-37).

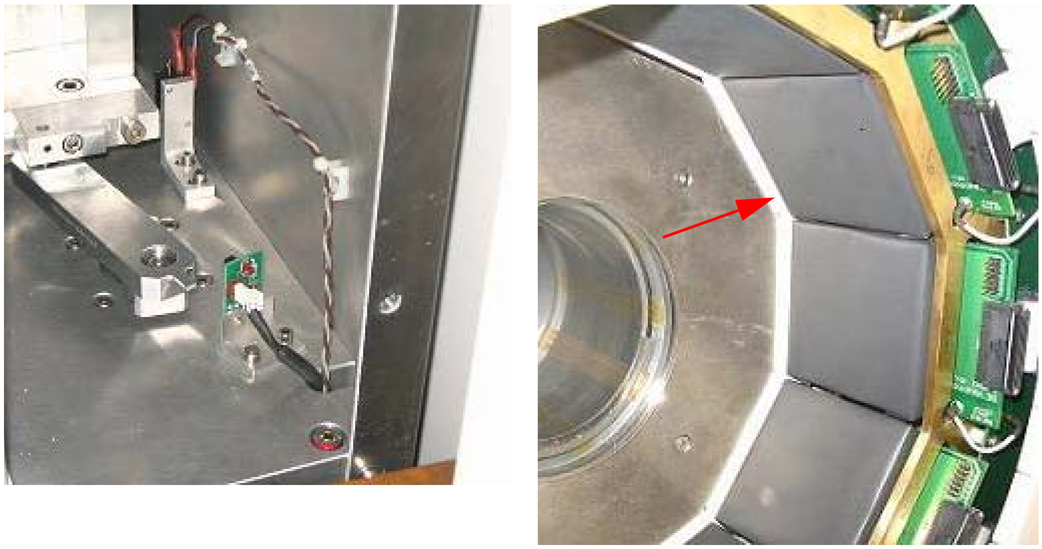


Figure 7-37

Once you are satisfied with the position, save this as the 'pinhole position' in the septa settings

UNIFORMITY CORRECTION FOR PINHOLE COLLIMATORS

Note: Before performing uniformity correction you must complete the procedure for Septa Pinhole Position on page -275.

The uniformity correction scan is done with a pinhole collimator in place. Each type of pinhole collimator has a different uniformity map.

Pinhole Uniformity Correction Procedure

1. Acquire the correction image data
   a. Install the pinhole collimator. In this example we will begin with the mouse 7 pinhole collimator.

b. Mount the alignment jig(the same jig that was used for the slit collimator geometry calibration) on the outside of the collimator mounting plate (Figure 7-38 .).

c. Put the line source (with isotope tube inserted into it on jig as shown above) at the central hole of the jig. Use the Co-57 line source specified in the site preparation guide, if available. Otherwise, use a Tc-99m line source of about 5mCi(no more than 10mCi).

d. Load the protocol “SPECT Pinhole Uniformity Correction”, making sure it has fixed time, 144 steps and a 2.5 degree increment

e. Select proper Energy Map. Energy correction should be done before this calibration. If two isotopes are used to generate the energy map (using application goEcor), then select “Gain and Offset”. If only one isotope is used to generate the energy map (using application SPECTCalibApp), then select “Gain Only"

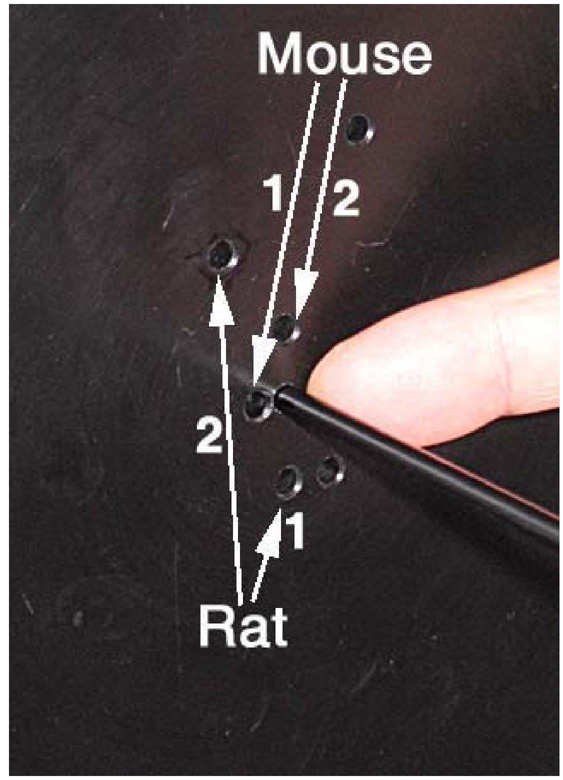


Figure 7-38

f. Start SPECT fluoro. Adjust the axial position of the rod to make sure that the rod covers all rows of the detectors.

g. Use SPECT fluoro to determine the time per step. Pick a hot spot on a rod in the 10 panel display. Click on "Reset SPECT Fluoro" button on scan page. Count the number of seconds when the picked pixel reaches 100 counts. Set time per step to no less than this number of seconds. Check the pixel spectrum to avoid picking a noisy pixel. A normal hot pixel should peak around the expected energy peak of the isotope while a noisy pixel tends to concentrate on the lower part of the spectrum without any obvious peak.

h. Verify that the septa has moved to the pinhole position by navigating to the septa service page and verifying that its current position matches the septa pinhole position.

i. Click the "Run Protocol" button and wait for the SPECT acquisition to complete

2. Reframe the dataset and generate a projection in VFF format

a. Go to the scan directory, Scan_xxxx. To do this, navigate to the explorer page, select the SPECT data set and find the most recent result. Right click on the acquisition in the details list and choose “Open in Terminal” from the menu (Figure 7-39). A console terminal window will appear.

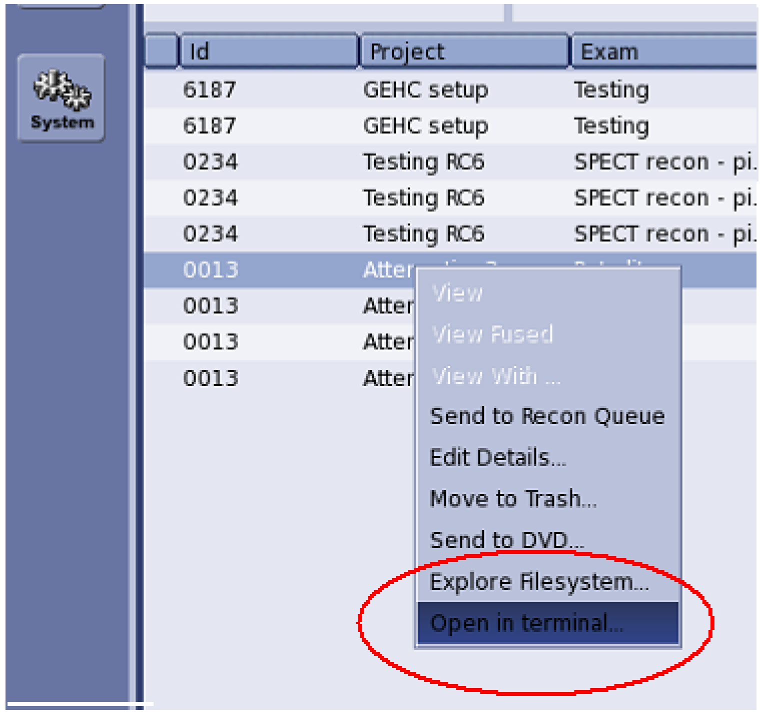


Figure 7-39

In the terminal window type:

```
runReframer
```

The normal completion messages are like this --

```
vct@console99 Scan_6162]$ runReframer
    lo: eth0: virbr0: tap0: Empty EnergyWindows in XML, use default 25 keV ~ 250
    keV
    System BadCellMap: 503 badcells
    Estimated number of events to read is 1729368
    Average angle creep = 0.234998, sampleAngleOffset=0.000000, calculated
    startAngleAdj = 0.234998
    Step count statistics for EnergyWin[0]: mean=25733.859375, stdDev=3953.926270
    Step time statistics(seconds per step): mean=29.874, stdDev=0.123
    Finish whole acquisition of 150050 ticks, and 1304227 events,
    with 1298948 reframed, 1286693 in energy window 1, 1286693.000000 weighted.
    Recon time = 0.040000, all time = 1.440000 seconds .
```

Here are the error messages when nx, ny or nz is set to 0 in the scan.xml --

```
    lo: eth0: virbr0: tap0: Empty EnergyWindows in XML, use default 25 keV ~ 250
    keV
    Reframer: 50, 8, 10, 32, 2.460000
    Reframer: 128, 128, 0, 1, 1 catch zero dimension exception in Reframer
```

This shows nz=0. Edit the scan.xml file by typing:

```
gedit scan.xml
```

Search for nz. Then set the value of nz to 128 (Figure 7-40). Save the file, exit the editor, and rerun the command.

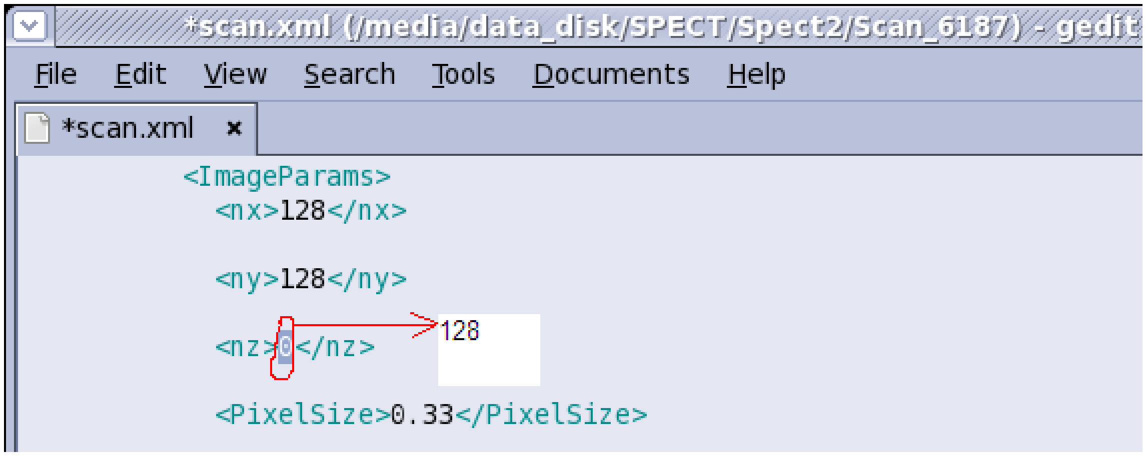


Figure 7-40

b. Once the previous command completes, type:

```
SPECTPinholeRecon -i Projection.dat -j CollimatorTablePos.dat -u
UniformityMap.dat -o . -x scan.xml
```

Note: All the text is typed on one line even though it spans multiple lines here. Also in '-o .', '.' is part of the command line. There is a space between '-o' and '.', and another space between '.' and '-x' (Figure 7-41).

Figure 7-41

c. Reconstruction does not need to finish here. Use Ctrl+C to terminate SPECTPinholeRecon once you see the message "Calculating System Matrix"; otherwise, the process will run for about 20 minutes.

d. Type: `ls -l Projection.dat.vff` to confirm that the projection VFF file is generated.

3. Run CreateUniformityMap application to generate uniformity map

   a. Copy Rod360Projection.vff to the scan directory by typing:

```
cp /usr/share/spect-recon/Rod360Projection.vff .
```

Note: The final '.' is part of the command line (Figure 7-42)

Figure 7-42

b. After the copy completes, type:

`CreateUniformityMap Rod360Projection.vff 75 Projection.dat.vff 144 UniformityMap.dat`

The normal completion message is like this:

`The scanner has 131 total bad pixels`

c. Type: `ls -l UniformityMap.dat` to confirm that the map is generated.

4. Copy the created UniformityMap.dat to spect.local computer.

a. Type: `vncviewer spect.local` to go to SPECT computer.

b. Launch a cygwin terminal on SPECT computer.

c. If you are calibrating a mouse pinhole collimator, type the command (on one line, even if it appears on multiple lines in this document):

```
scp vct@192.168.12.89:/media/data_disk/SPECT/Scan_xxxx/
UniformityMap.dat /cygdrive/c/Inukshuk/settings/mouse_7_pinhole-
UniformityMap.dat
```

You will be prompted for a passphrase which is vct@pci

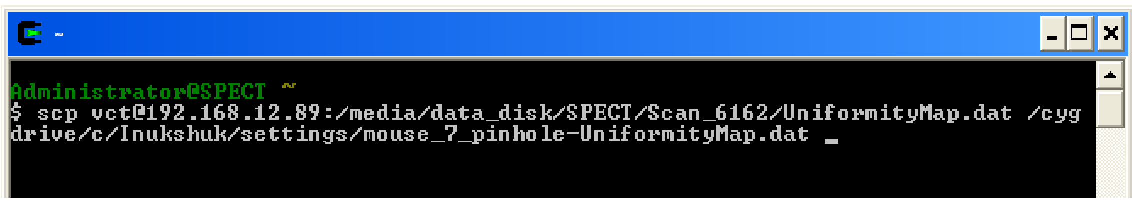


Figure 7-43

If it is a rat pinhole collimator that you are calibrating, type the command (on one line, even if it appears on multiple lines in this document)

```
scp vct@192.168.12.89:/media/data_disk/SPECT/Scan_xxxx/
UniformityMap.dat /cygdrive/c/Inukshuk/settings/rat_5_pinhole-
UniformityMap.dat
```

You will be prompted for a passphrase which is vct@pci

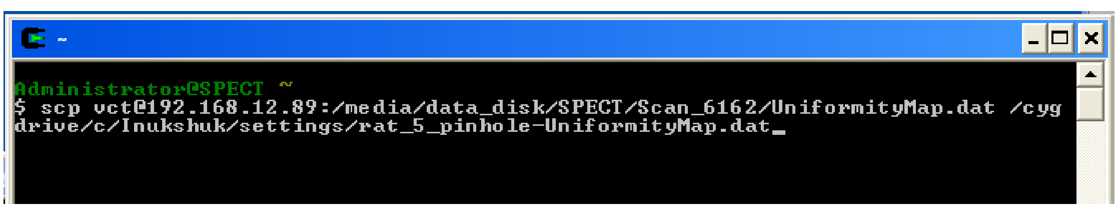


Figure 7-44

5. Restart the scanner, and the new pinhole uniformity map shall take effect

PINHOLE POSITION AUTOMATIC CALIBRATION

Note: Energy Correction must be done before this procedure

1. Do the calibration scan.

   a. Put a point source at the centre of the FOV. Use the Co-57 point source specified in the site preparation guide if available. Otherwise, use a Tc-99m point source of about 0.75mCi(0.1mCi~1.5mCi). The point source shall have a diameter of no more than 3mm. The stronger the activity in the point source, the quicker the scan. For positioning the source, use the calibration jig and point source holder, if available. If CT is available, use CT fluoro to help. See the following screenshot of CT fluoro. Click the "LR" button to check if the source is centered in Y. Click the "AP" button to check if the source is centered in X. (Figure 7-45).

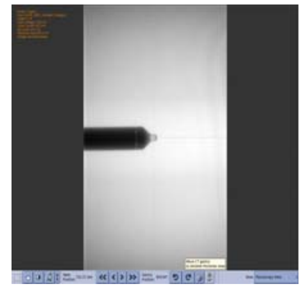


Figure 7-45

   Make sure that the point source is within 5mm radius from the centre in XY plane. Do a SPECT fluoro to verify the source positioning. For the mouse 7-pinhole collimator, we should see 7 bright dots evenly distributed across the 10 panels. Adjust the table position to avoid positioning the source exactly at the central rows, number 15 or 16. Instead, put it near row number 13 or 18.

   b. Load the “SPECT Pinhole Position Calibration” protocol and confirm that there are 300 steps with a 1.2 degree angle increment.

   c. Select a proper Energy Map, based on the kind of isotope you are using. If two isotopes are used to generate the energy map (using application goEcor), then select “Gain and Offset”. If only one isotope is used to generate the energy map (using application SPECTCalibApp), then select “Gain Only”.

   d. Use SPECT fluoro to determine the time per step. Pick the hottest spot of the point source in the 10 panel display. Click on "Reset SPECT Fluoro" button on the scan page. Count the number of seconds when the picked pixel reaches 400 counts. Set the time per step to no less than this number of seconds. Check the pixel spectrum to avoid picking a noisy pixel. A normal hot pixel should peak around the expected energy peak of the isotope while a noisy pixel tends to concentrate on the lower part of the spectrum without any obvious peak. Run SPECT fluoro. Click the stop button. Then on the septa service page verify that the septa is at the calibrated pinhole position.

   e. Click the "Run Protocol" button and wait for the SPECT acquisition to complete.

2. Reframe the dataset.

   a. Follow instructions for step 2 a) page 277.

   b. Edit CollimatorTablePos.dat by typing:

```
gedit CollimatorTablePos.dat
```

Make sure that the value of the first line is 0. (If not change it to 0 and save the file). Make sure you get 300 steps by looking at the first column of the third line to the end of the file. So go to the end of the file and confirm that '299' is in the first column. If it isn't, contact engineering staff.

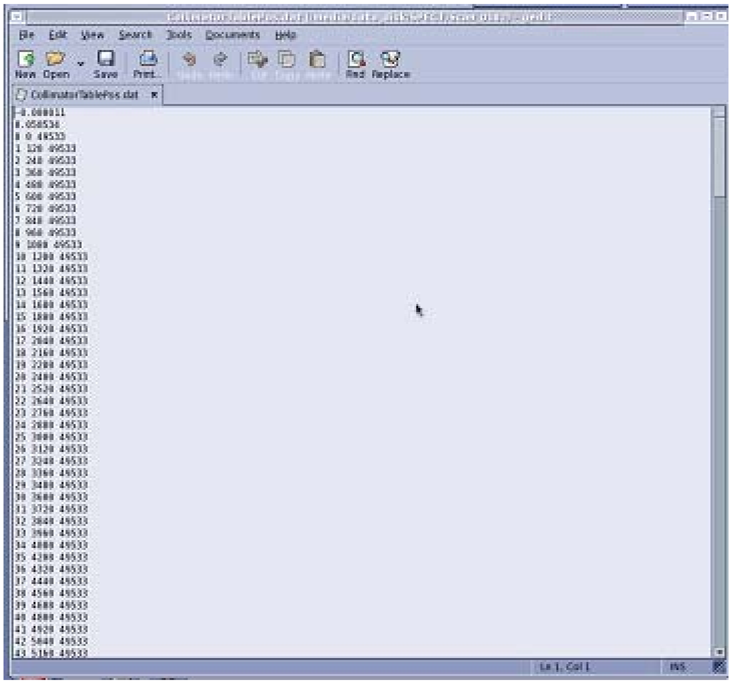


Figure 7-46

c. Type: `ls -l Projection.dat` to confirm that the projection file is generated.

3. Run pinhole position calibration tool to calculate the calibrated values.

   a. For mouse 7 pinhole collimator, inside the scan folder, type:

      `cp Projection.dat mousePH.dat`

      And then, type:

      `run_CalibPinholePositionMouse.sh /opt/MATLAB/MATLAB_Compiler_Runtime/v78 -90`

   b. For rat 5 pinhole collimator, inside the scan folder, type:

      `cp Projection.dat ratPH.dat`

      And then, type:

      `run_CalibPinholePositionRat.sh /opt/MATLAB/MATLAB_Compiler_Runtime/v78 -90`

   c. A projection image will be displayed. Maximize the display window to check for any noisy pixels on the image. Skip the next two steps if no noisy pixels are found.

   d. Select the "Zoom In" button on the toolbar. On the image panel, zoom in on the bad pixel area by pressing the left button of the mouse and drag a rectangle. When the bad pixels are big enough, select "Data Cursor". Click on one bad pixel and the location will be displayed on a tooltip. See the following screenshot.

   e. In the console terminal, click on the menu: "File/Open Tab" to open a new tab. In the new tab, edit the BadPixels text file by typing:

      `gedit BadPixels`

      Put one bad pixel on each line. Count the panel index from left to right in the image window. Write the panel index on the first column; then, write the X index in the second column. An example is illustrated in (Figure 7-47). In this example, the panel index is 6 and X is 1. This bad pixel is added in the BadPixels file as “6 1”.

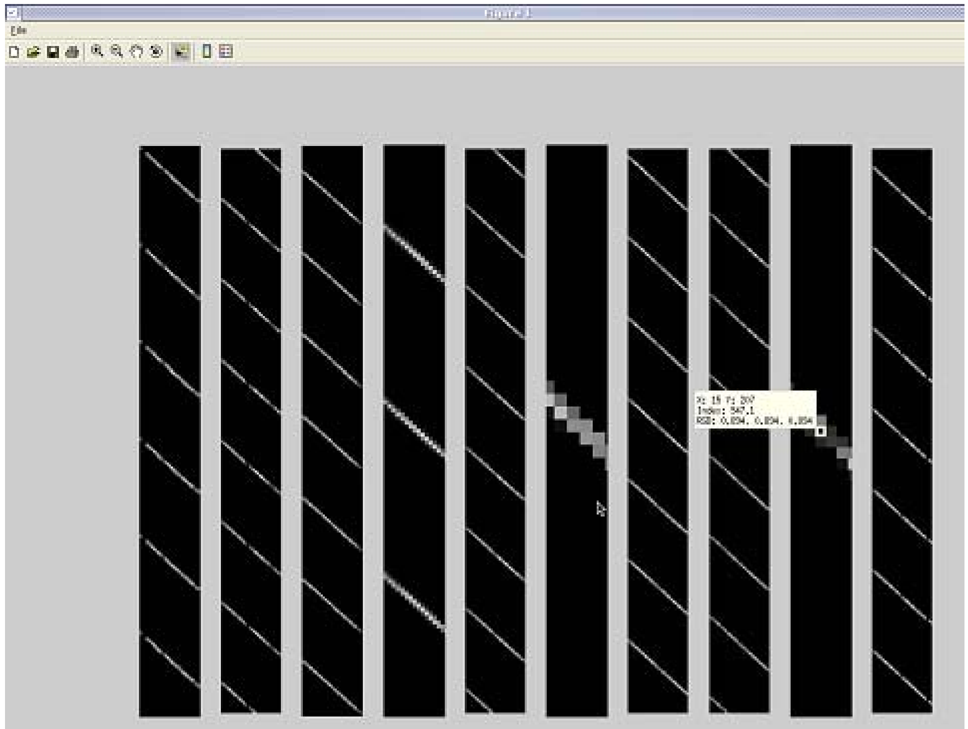


Figure 7-47

f. After adding all bad pixels, save the file and exit the editor. Then close the projection image window.

g. Now, the terminal running the calibration tool is brought back to the front. Press “enter” key on the keyboard to continue the calculation. The tool should print out rmsError line by line while doing the calculation. After about 2 minutes, the calculation will finish with printed output and a colored projection image (Figure 7-48).

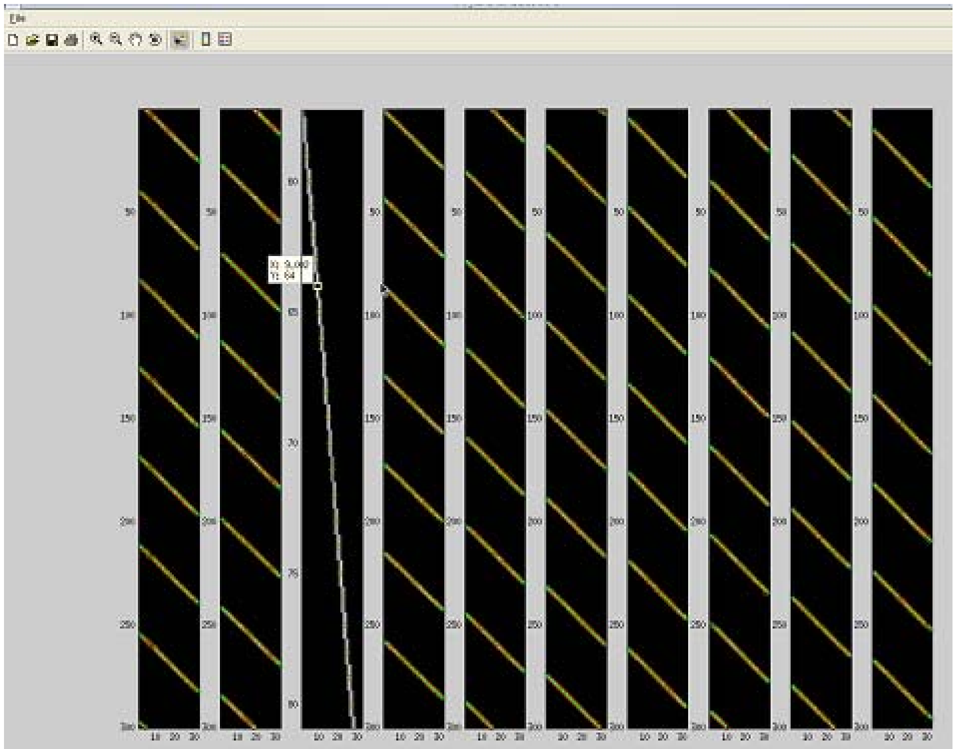


Figure 7-48

The calibration result will be saved in GeomParamsMousePH.xml or GeomParamsRatPH.xml, depending on the kind of pinhole collimator in use. Zoom by clicking on the zoom gui and then, use the up/down arrow keys.

Note: If any new bad pixels are added to BadPixels, you need to go back to step a) or b) to re-run the script.

h. Maximize the projection image to check the result. Estimated projections are shown as green crosses, while the centroids from real projections are shown as red circles. The two should closely match each other. (Figure 7-49):

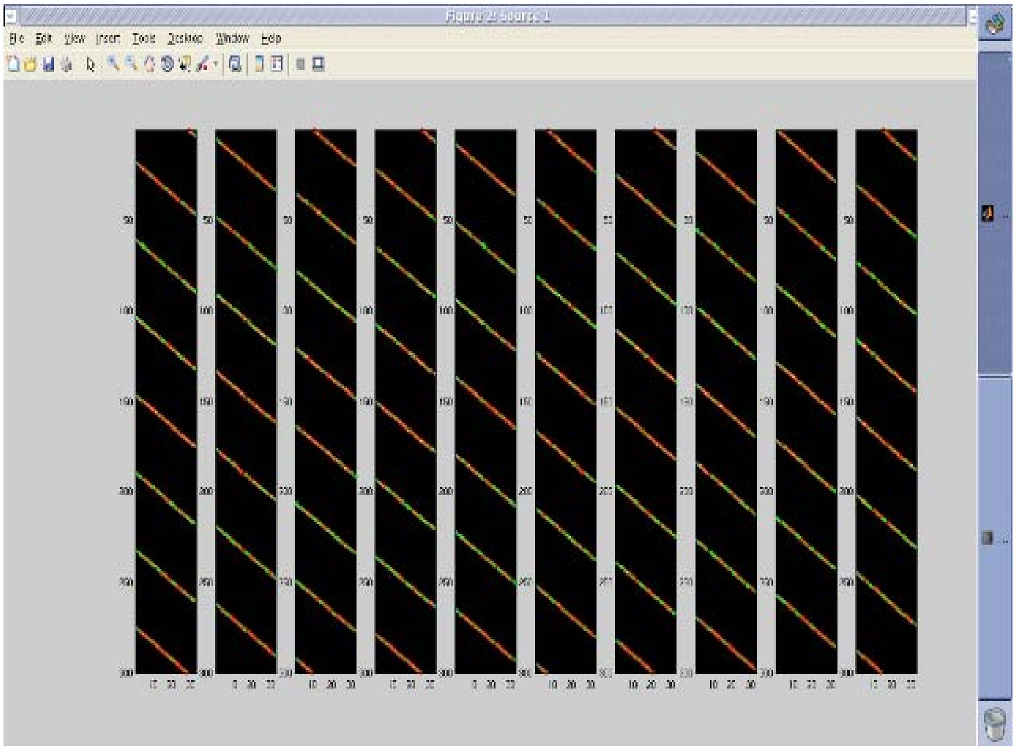


Figure 7-49

4. Put the calibrated pinhole positions into XML.

   a. Copy scan.xml to calib.xml. Edit Calib.xml by typing:

   ```
   cp scan.xml calib.xml
   gedit calib.xml
   ```

   Copy and paste the CollimatorParams/Pinholes element and DetectorParams/Panels element from GeomParamsRatPH.xml or GeomParamsMousePH.xml to calib.xml.

   b. In OsemParams, set subsets to 6 and Iterations to 3. Set AnglesPerTooth and NumbersOfAngles to 42 for mouse 7 pinhole collimator, and to 60 for rat 5 pinhole collimator.

   c. Do another recon with calib.xml. Type:

   ```
   SPECTPinholeRecon -I Projection.dat -j CollimatorTablePos.dat -u
   UniformityMAp.dat -o . -x calib.xml
   ```

   d. Then view by typing:

   ```
   MicroView SPECT_Pinhole_Recon.vff
   ```

e. You should see a nice image of a point source.(Figure 7-50)

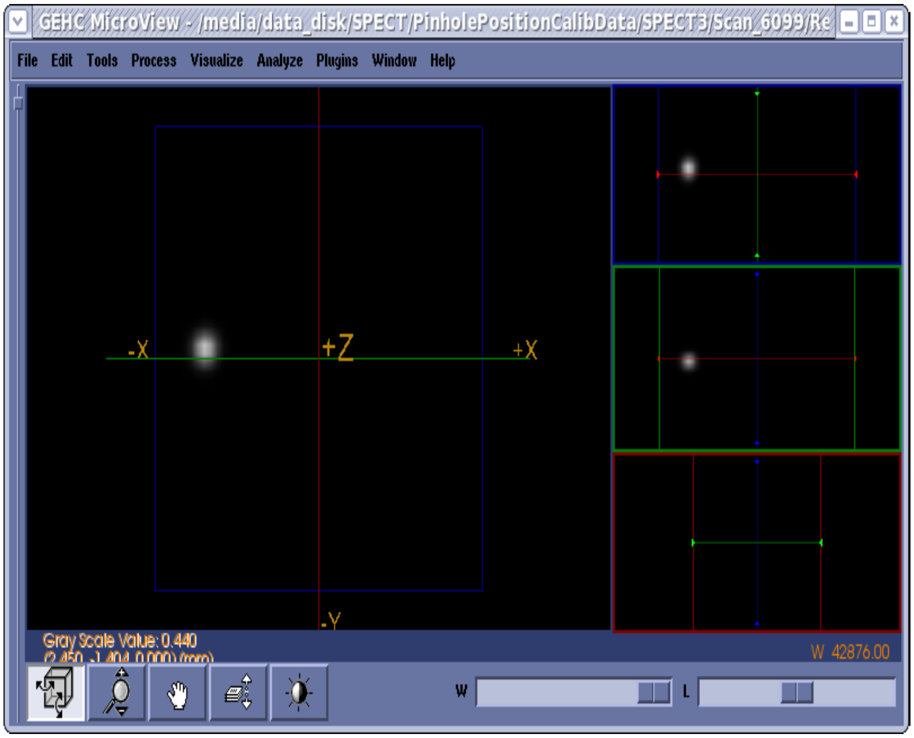


Figure 7-50

5. Update the system

Return to the Console application and navigate to the “Service Pages”. Select the “System Properties” tab and choose “SPECT subsystem” from the drop-down. Go to the proper section for the calibrated collimator; update the parameters for all pinholes and the parameters for all detector panels with those in calib.xml (see the following screenshot). Then click the "Save" button. Finally, restart the scanner to finish the update. (Figure 7-51).

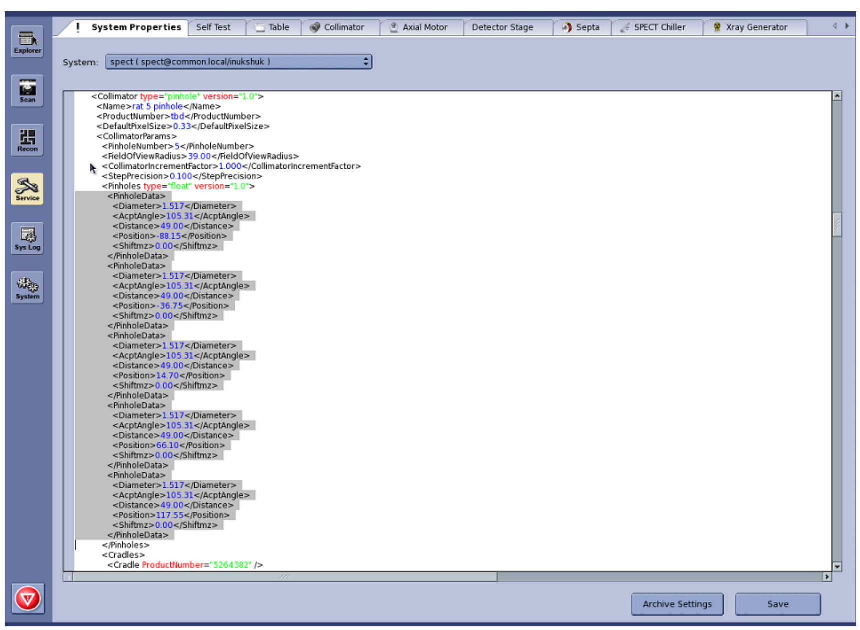


Figure 7-51

6. Repeat the procedure for the other pinhole collimator.
7. Click "Archive Settings"when done.

SPECT IMAGE SCALAR

This procedure is for quantitative SPECT. The goal is to scale the SPECT image properly so that the total value of a given region of interest in the image is exactly the radioactivity (Bq) of that region. The reconstruction already models most geometric and physical characteristics of the scanner, and even without this procedure, the image values are not far from our goal of quantitative SPECT. Taking into account detector efficiency and other known factors, this procedure will make the image value more precise.

For each collimator to be used, perform the following steps to calibrate the image scalar:

Procedure to Calibrate Spect Image Scalar

1. Install the collimator to be calibrated
2. Scan a source of known activity
   - **About the isotope**: While the scanner's sensitivity changes with the energy of the source. For most applications, a single calibration value will suffice. Tc-99m is recommended as the standard source for this calibration, but the operator has the option to calibrate the image scalar with some other isotope. This would be done if the energy value of the isotope to be used in an acquisition is far from Tc-99m, or if the operator desires more precision. Usually, such a calibration would be performed just before the animal scan; the operator would take care to record the Tc-99m setting, replace it, and then restore it after the experiment.
   - Make sure the active region of the source is within the field of view (FOV) for the collimator. With pinhole collimators, consider the FOV of a circular scan without any table movement. Use SPECT fluoro to help position the source, if necessary. It is recommended that you use a point source near the centre of the FOV.
   - **About source activity**: The optimal counting rate for the detector is about 200 kps, with a maximum of 500 kps. Considering the range of sensitivities of the available collimators, 200 kps translates to a highly-concentrated liquid source of about 10 mCi. A source with activity that is too low will require a longer scan time for a good result. Depending on availability and convenience, a source with 1 mCi to 10 mCi is recommended.
   - Use the standard step-and-shoot protocol for the acquisition, adjusting counts/step or time/step according to the source activity (a source with high activity will require less scan time).
3. Reconstruct the dataset and measure the activity in the image
   - Choose reconstruction parameters properly to make sure that the iterative recon converges without introducing too much noise. For a point source or a line source, select subsets and iterations so that Total Interations = Subset * Iteration and is in the range of 30 to 50.
   - Load the reconstructed image in MicroView. Create a standard ROI to include the whole active region of the source. Be careful to exclude the noise usually present near the FOV boundaries. Then, take the total value of the ROI as the measured activity.
4. Calculate the ratio of SensitivityCalibrationFactor
   - Define the ratio as Sensitivity Calibration Factor = Known Activity / Measured Activity. Be careful to take decay into account for Known Activity.
5. Save SensitivityCalibrationFactor and update scanner
   - From the console application, go to ServicePage/SystemProperties/"SPECT subsystem"

to save SensitivityCalibrationFactor for all calibrated collimators.

- To update the scanner with the new calibrated parameters, power down the whole scanner and power it up again.

7.2.2 SPECT Verification

Before releasing the SPECT system for customer use, uniformity, resolution, linearity, background noise and sensitivity must be measured and compared with specification. These values are recorded in the Acceptance Form. Measuring these five parameters provides verification that septa alignment, energy correction, uniformity correction and geometry calibration were performed correctly, and that the scanner meets or exceeds specification.

UNIFORMITY

This parameter quantifies the difference in photon counts received by each pixel when exposed equally to an isotope source. This is essentially the same preparation and procedure used to produce Uniformity maps. See “Uniformity Correction For Slit Collimators” on page 267.

The uniformity correction procedure has generated maps which have now been applied to the system, such that the sensitivity differences between pixels should now be eliminated during data acquisition. The following procedure verifies the effectiveness of the map.

Preparation

1.) Ensure a collimator is installed. (See “Geometry Calibration for Slit Collimators” on page 269.)
2.) Ensure the septa is in its calibrated position.This can be determined from the "Current Position" in the "Septa Status" area on the Septa tab screen in the Service pages (Figure 7-15). This must match the "Calibrated in Position (counts)" field in the "Installation Parameters" area.

Note: If a combined uniformity and resolution phantom is available, only one scan needs to be performed for both uniformity verification and resolution verification.

3.) Press the Scan 

page button. Press the Select Protocol button (Figure 7-52). Select the "SPECT Geometric Calibration Verification - 5 Slit" protocol if using a 5-slit collimator (top screen) and the "SPECT Geometric Calibration Verification - 8 Slit" protocol if using an 8-slit collimator (bottom screen). If Tc-99 liquid isotope is available, set the energy threshold to 50 KeV and the energy window to 120 to 160 KeV. For an 8-slit collimator, set the Counts to 1,000,000, the Step Count to 45 and Increment Angle to 1.0 degree. For a 5-slit collimator, set the Counts to 600,000, the Step Count to 72 and Increment Angle to 1.0 degree.

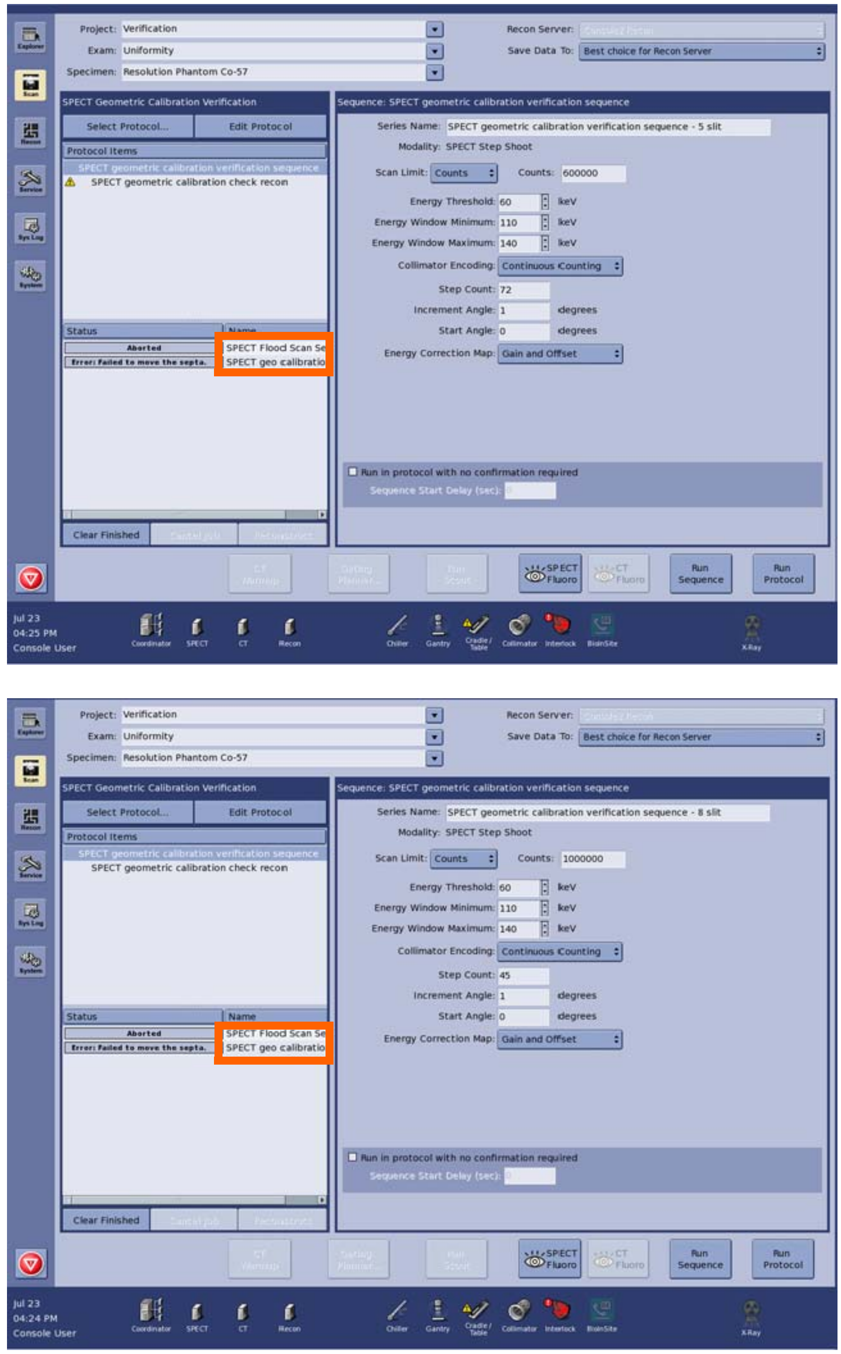


Figure 7-52

4.) If the customer only has Co-57 available, set the protocol to 600,000 counts for a 5-slit collimator or 1,000,000 for an 8-slit collimator, an energy threshold of 60 KeV and an energy window of 110 to 140 KeV. For an 8-slit collimator, set the Step Count to 45 and Increment Angle to 1.0 degree. For a 5-slit collimator, set the Step Count to 72 and Increment Angle to 1.0 degree.

Note: The recon type in Figure 7-52 must match the collimator type. If not:

a.) Click Edit Protocol and remove the wrong recon

b.) Add a task, select the slit recon and click on OK c.) Select the recon name. The parameters panel (right side of screen) changes to recon parameters.

d.) Adjust Energy Window parameters to match the isotope type in use (refer to recon parameters below)

e.) Click on the protocol under Protocol Items (Figure 7-52). Select the appropriate number of subsets from the drop-down box (15 for 8 slits and 24 for 5 slits).

Ensure the Recon parameters have been set as follows:

- Image Size: 128 x 128 x32
- Pixel size (x and y): 0.55mm for rat and 0.4mm for mouse; (z): 2.46mm
- Energy window: 110 to 140 keV (Co-57)
  120 to 160 keV (Tc-99)
- Subset: 15 (8-slit mouse collimator)
  9 (5-slit rat collimator)
- Iteration: 5 for mouse, 9 for rat
- Energy correction: Yes
- Uniformity Correction: Yes
- Use Resolution Recovery Filter: Yes

Procedure

1.) Thread the Ultra-Micro Hot Spot Phantom to the special jig and mount the jig to the collimator mounting plate (Figure 7-53). Ensure the resolution insert is removed, if possible, and fill the phantom with a customer-supplied liquid isotope (Tc-99). If the customer cannot supply Tc-99, ensure that an Ultra-Micro Hot Spot Phantom prefilled with Co-57 is provided.

2.) Change the Scan page headings:
Project: SPECT Verification
Exam: Uniformity
Specimen: Ultra Micro Hot Spot Phantom

3.) Start the data acquisition by clicking Run Sequence.

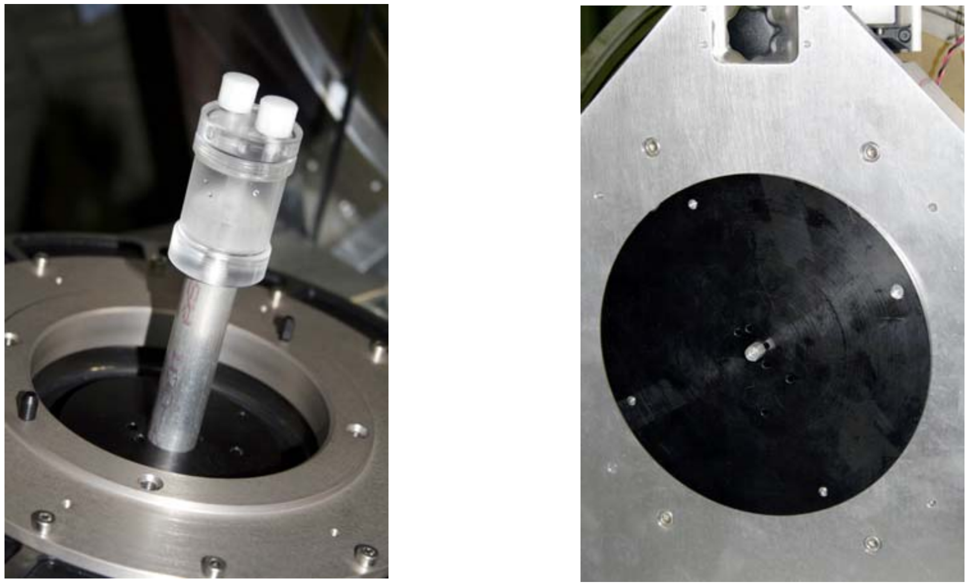


Figure 7-53

4.) The typical global spectrum and pixel map on the Console’s right hand screen are shown in Figure 7-54 .

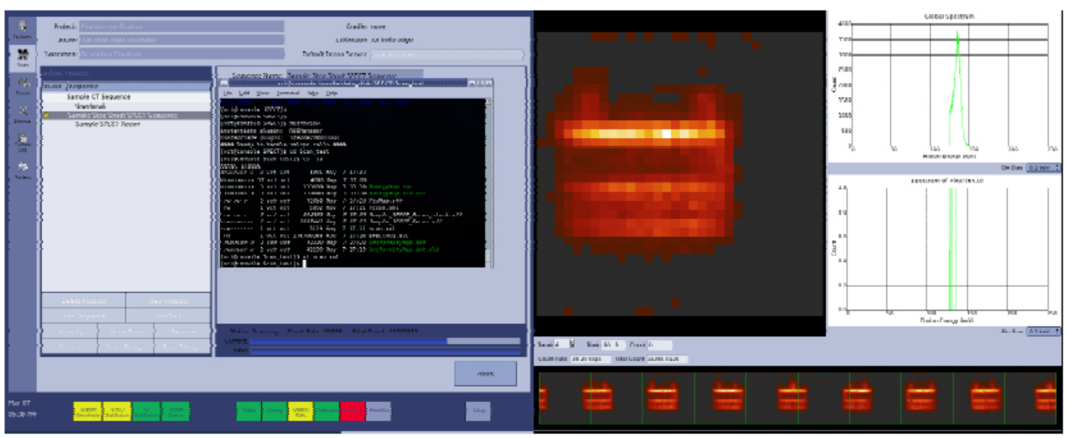


Figure 7-54

5.) After the scan is complete, and acquisition data is completed and saved, recon will start automatically. When complete, click on the recon Name (boxed areas in Figure 7-52) and click the View button when enabled. MicroView opens and loads the recon image as shown in Figure 7-55.

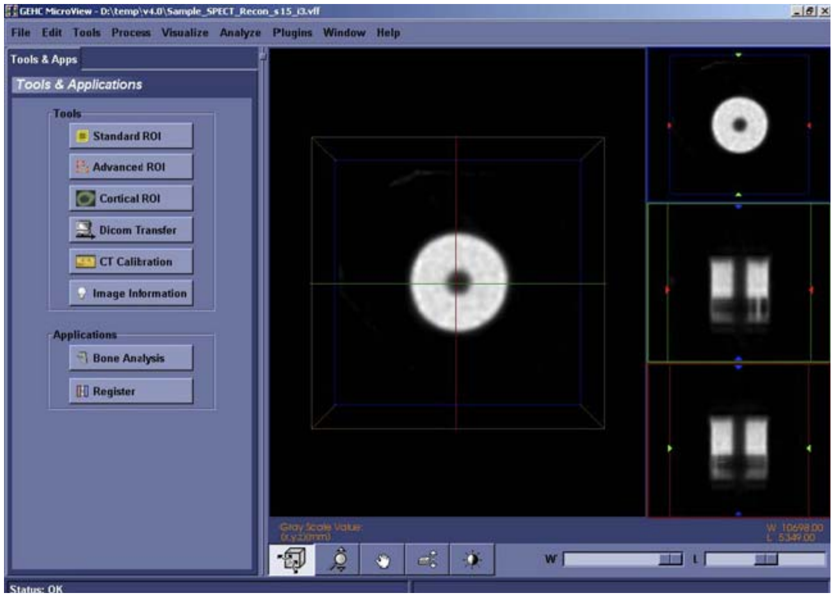


Figure 7-55

6.) Click the Standard ROI button in MicroView. See Figure 7-56. Under Tool Selection, click the Cylinder radio button. Use the ROI Size sliders to draw a cylinder around the region of interest (ROI) of dimensions X=18, Y=18 and Z=24. Adjust the ROI Center sliders until the crosshairs are at the center of the phantom.

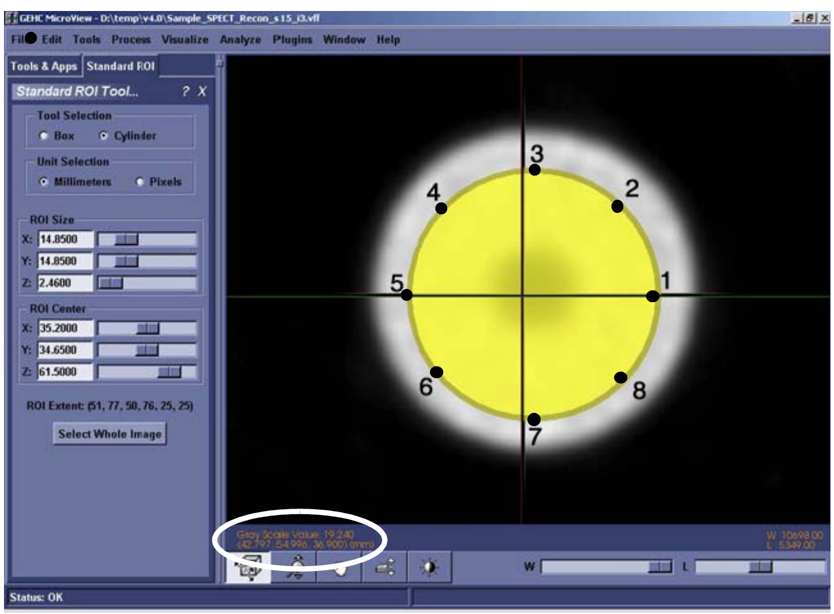


Figure 7-56

7.) Move the mouse over the 8 locations and read the Gray Scale Value for each (circled in Figure 7-56). Use the following formulas to get the mean and standard deviation for this data:

$$Mean = \frac{\left(\sum_{1}^{8} X_i\right)}{8}$$

$$Std = \sqrt{\frac{\sum_{1}^{8}(Xi \,?\, Mean)^2}{8}}$$

8.) Divide the *Std* by the *Mean.* The result must be </=5%.

RESOLUTION

The energy correction procedure has generated maps which have now been applied to the system, such that the spectral response differences between pixels should now be eliminated during data acquisition. This procedure verifies the effectiveness of the map.

The same Preparation for Uniformity Correction and Uniformity Correction Procedure (page 267) are used for resolution verification, with the exception that the resolution insert must be installed in the phantom for the Tc-99 isotope. If the customer cannot provide Tc-99, ensure than an Ultra-Micro Hot Spot Phantom with resolution insert, prefilled with Co-57, is provided. This is shown in Figure 7-53.

Note: If a combined uniformity and resolution phantom was used for the uniformity verification, a scan does not need to be repeated for resolution verification. On the Scan page, click on the appropriate recon Name, click the View button, and MicroView will open the image. Then, skip to step 4.

Preparation

If a scan is required, set the scan parameters as shown in Figure 7-52, depending on which collimator is used.

Ensure the Recon parameters have been set as follows:

- Image Size: 128 x 128 x 32
- Pixel size (x and y): 0.55mm for rat and 0.4mm for mouse; (z): 2.46mm
- Energy window: 110 to 140 keV (Co-57)
  120 to 160 keV (Tc-99)
- Subset: 15 (8-slit)
  9 (5-slit)
- Iteration: 5 for mouse, 9 for rat
- Energy correction: Yes
- Uniformity Correction: Yes
- Use Resolution Recovery Filter: Yes
- Normalize Image Values: Yes
- Change Exam to Resolution

Procedure

1.) The typical global spectrum and pixel map on the Console's right hand screen are shown in Figure 7-57 .

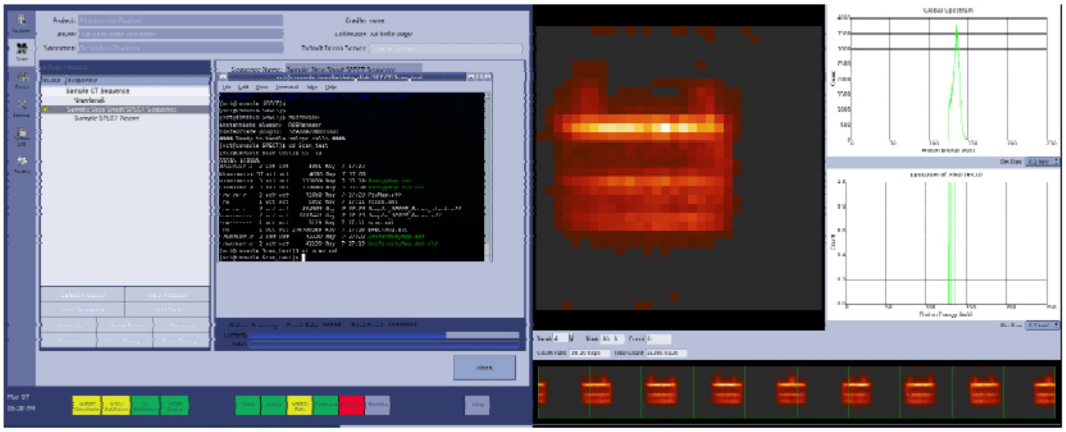


Figure 7-57

2.) After the scan is complete, and acquisition data is completed and saved, recon will start automatically.

3.) After recon is complete, MicroView is used to load the recon image as shown in Figure 7-58.

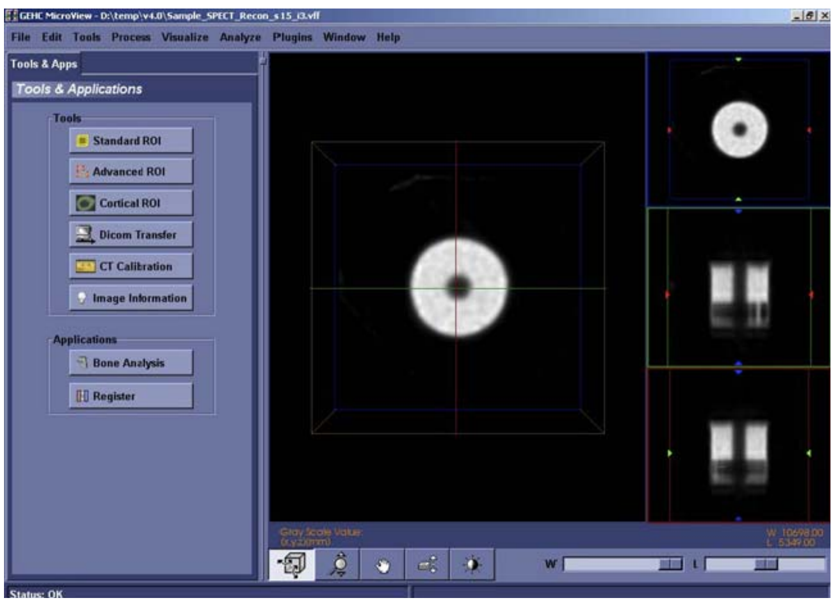


Figure 7-58

4.) The purpose is to determine whether the hot rods (6 x 1.7 mm group for rat and 8 x 1.35 mm for mouse shown in Figure 7-59) can be differentiated from each other. Quantitatively, MicroView is used for analysis by drawing a line across the centers of the rods, then plotting a profile. To plot a profile:

a.) Mouse to the center of the phantom and hit 1 on the keyboard.

b.) Mouse to the outside of the phantom and hit 2 on the keyboard.

Note: Ensure that the line passes through the centers of the rods.

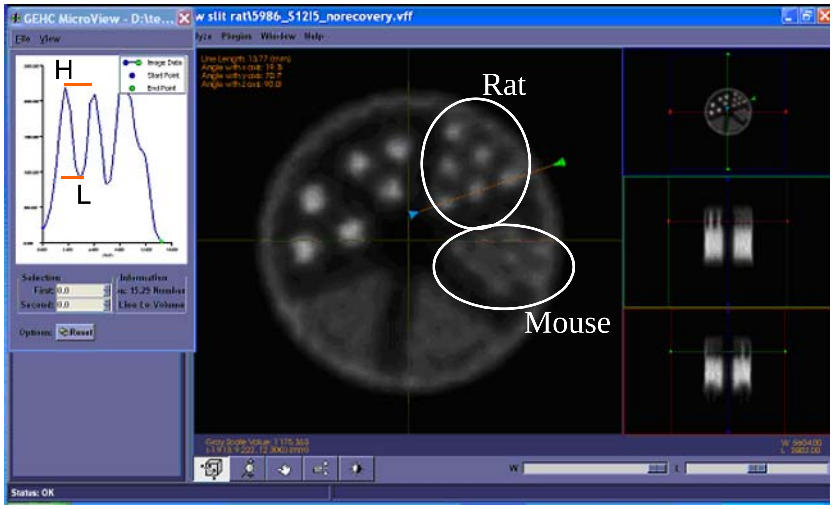


Figure 7-59

c. Hit P on the keyboard to obtain the plot shown in Figure 7-59. Place the cursor on the curve and read the peak and valley values from the Information block.

Note: Use the appropriate areas of the resolution phantom depending on whether a rat or mouse collimator is used, as shown in Figure 7-59.

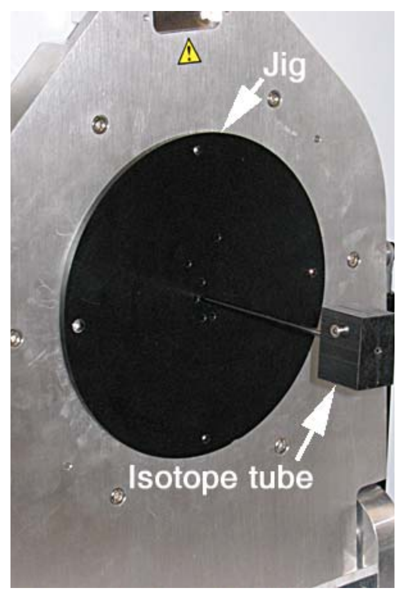
5.) Note on the Acceptance Form and Worksheet (Appendix) the values of H and L and the ratios H/L for various peaks. The minimum ratio should be >/= 1.2:1.

LINEARITY

This parameter provides the relationship between isotope intensity and the grey scale output provided by the SPECT detector.

Three pre-measured isotope line sources of the same chemical element with different activity levels are placed in the scanner sequentially, and detector outputs are compared with expected outputs. If only two isotopes are available, zero values will be used in place of the third isotope.

A mouse collimator is used for this procedure.

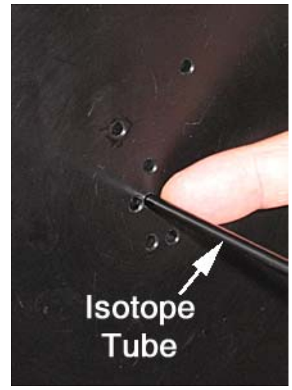


Preparation

1.) Ensure the cradle is NOT installed.

2.) Ensure a mouse collimator is installed.

3.) Ensure the septa is in its calibrated position.



4.) Load the line source into the center hole of the jig.

5.) Press the Scan  page button.

a.) Press the Select Protocol button. Choose the appropriate SPECT Step Shoot protocol for the isotope currently being used.

b.) Set the Scan Limit to 200,000 counts per step.

c.) Set an energy threshold of 60 KeV and an energy window of 110 to 140 KeV.

Note: If an isotope other than Co-57 is used, the above two settings must change. Contact GE Healthcare for values.

d.) For an 8-slit collimator, set the Step Count to 45 and Increment Angle to 1.0 degree. For a 5-slit collimator, set the Step Count to 72 and Increment Angle to 1.0 degree.

e.) Set the Start Angle to 0 degrees.

f.) Set the Energy Correction Map to Gain and Offset.

g.) Set the Exam field to Linearity and the Specimen to reflect the specific source used in each case.

6.) Press the recon name under the currently selected protocol sequence, and set the recon parameters.

a.) Image size: 128 x 128 x 32

b.) Pixel size (x & y): 0.4 mm

c.) Energy Window: 110 to 140 KeV

d.) Subset: 15 (8-slit)

e.) Iteration: 3

f.) Energy Correction: Yes

g.) Uniformity Correction: Yes

h.) Normalize Image Values: Off

Procedure

After the scan is finished and acquisition data is transferred and saved, the recon will initiate immediately.

1.) After recon is completed, MicroView is used to load the recon image as shown in Figure 7-60.

2.) Click on the completed recon name, then click the View button to launch MicroView.

3.) Go to “Tools” and select “Region grow”.

a.) Move the mouse to the center of the line source image

b.) Press “space”. A green region is formed

c.) Press Geometry > ROI button. A yellow ROI is then formed

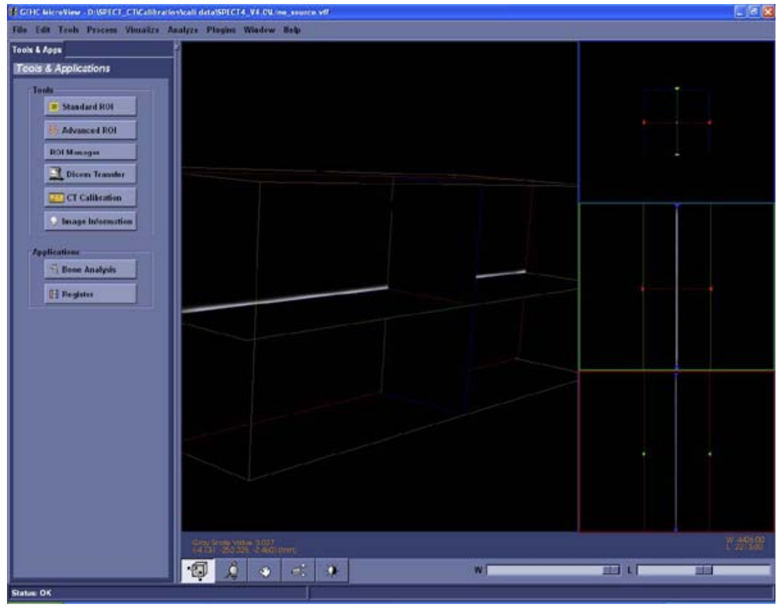


Figure 7-60

Note: The entire source should be uniformly yellow. If so, skip to step 8. If it is not, complete the following steps:

4.) Click the Standard ROI button, then click the Cylinder radio button under Tool Selection.

5.) Use the ROI Size sliders to set X=8 pixels, Y=8 pixels and Z=49.2 pixels.

6.) Adjust the ROI Center sliders as needed to center the cylinder over the source image.

7.) Record the ROI Size and ROI Center values so that they can be used for other sources.

8.) Press “m” to get mean and standard deviation values as shown by the arrow in Figure 7-62.

9.) Record the mean (M) and standard deviation values. Standard deviation serves as an indicator that the data may be suspect if its value is high, but only the mean is used in the linearity calculation. Total value (found to the right of mean and standard deviation) can also be used instead of mean.

10.) Obtain the line source activity in μCi (C) by calculation, or by using an isotope supplier’s web site tools such as the one shown in Figure 7-61.

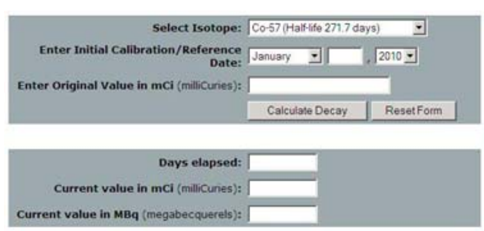


Figure 7-61

11.) Repeat for other line sources, using exactly the same ROI.

12.) Calculate linearity error as follows

a.) Get the trend line equation M=*a x C + b* by linear fit of the measured mean values (M_1, C_1), (M_2,C_2) and (M_3,C_3) in step 9.

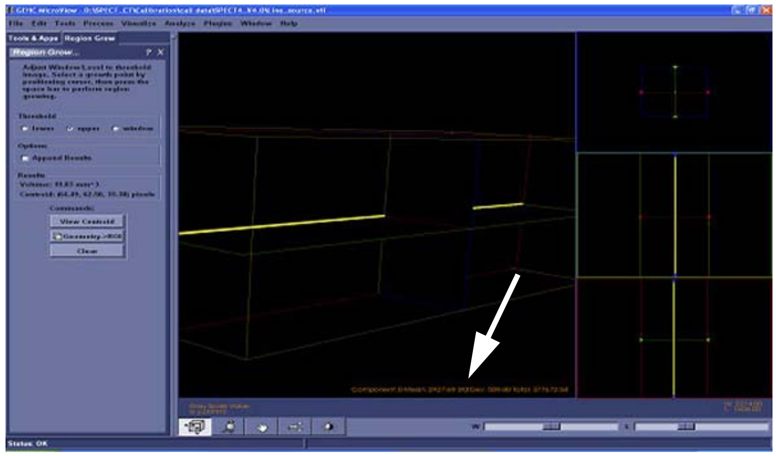


Figure 7-62

b.) Open Excel.

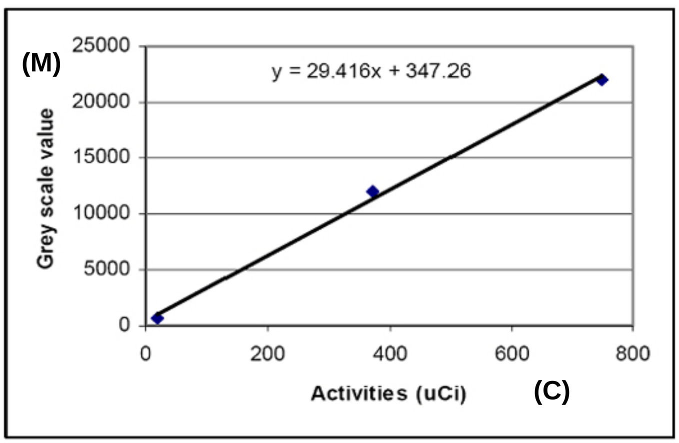
1.) Enter the three sets of values in two columns. If only two isotope sources were available, enter a zero in each column for the third set of values.

2.) Highlight the data and choose Insert/Chart from the menu. Choose XY Scatter.

3.) To add a trendline, from the menu choose Chart/Add Trendline.

4.) Double click on the trendline and check the option "Display equation on chart".

5.) Parameters *a* and *b* can be read from the equation



c.) Linearity error (in %) can be calculated by:

$$err = \max[1-Mi/(a*Ci+b)] \text{x } 100\%$$

where i=1,2,3

Acceptance criteria is *err*</= 5%. If this value is exceeded and steps 4. to 7. were skipped (Cylinder ROI), try using the method in these steps. Contact GE Healthcare for other options if this value is still exceeded.

BACKGROUND NOISE

To establish the SPECT system's noise floor, a scan must be performed without an isotope present. Photon counts from all pixels are made, and a total count is determined.

Preparation

1.) Install the 5 slit collimator. (refer back to "Alternate Collimator Removal Using Service Pages" (page 254)). Close the table cover.

2.) Ensure the septa is in its calibrated position.(See "Septa Alignment" on page 251.)

3.) Access the SPECT 5 Slit Rat Collimator Protocol screen. Set the following parameters:

- Scan Limit: time
- Time: 120 seconds
- Threshold: 60 KeV
- Energy Window Minimum: 60 KeV
- Energy Window Maximum: 250 KeV
- Collimator Encoding: Continuous Counting
- Step Counts: 1
- Incremental Angle: 3
- Start Angle: 0
- Energy Correction Map: None

4.) Ensure no isotope is in or near the machine.

5.) Change the Exam field to Background Noise and Specimen to None.

Procedure

1.) Click Run Sequence.

2.) Observe the Console's right hand screen (Figure 7-63). Distribution from 60 KeV to 250 KeV should be even and all 10 panels should light up equally. Note the minimum and maximum values in the Count field and record the values on the Acceptance Form or Worksheet (Appendix). The maximum value should be less than or equal to 150 counts per second.

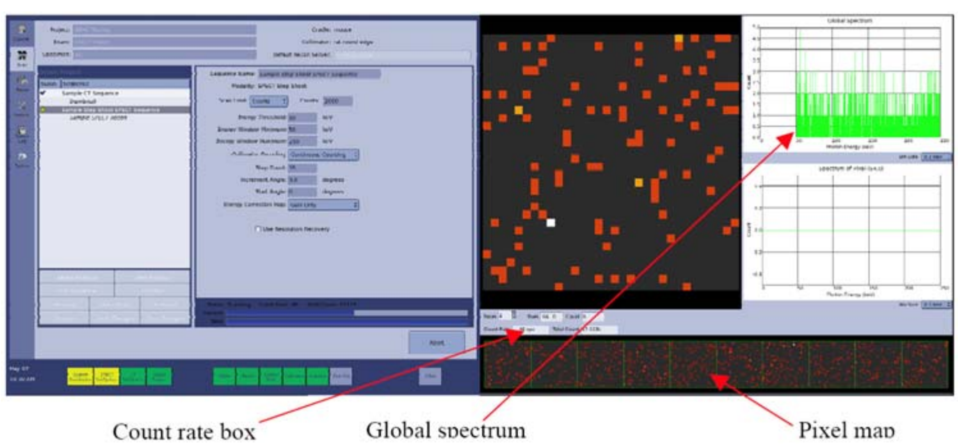


Figure 7-63

SENSITIVITY

Sensitivity measures the rate at which events are detected in the presence of radioactive sources. The test is made by loading a standard flood Co-57 line source carefully positioned in the center of the field of view and emission data is collected for a prescribed time. The reframer is to sum all events together to determine the observed count rate from this known activity density. The result reported is directly dependent on the accuracy of the activity measurement so special care should be taken with this measurement.

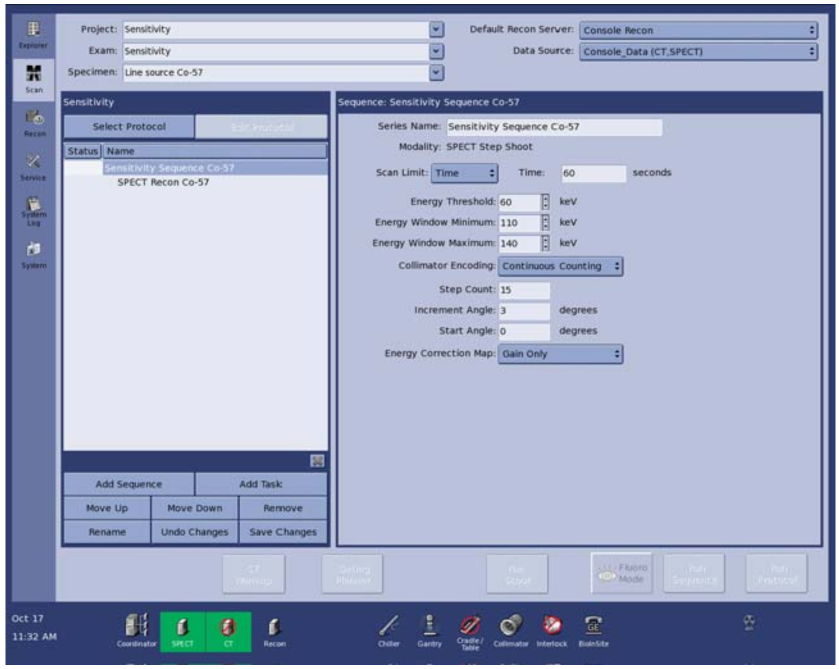
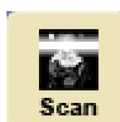


Figure 7-64

Note: If available, the scatter fraction should be entered for the calculation of this test to obtain true sensitivity.

Preparation

WARNING

1.) Ensure the cradle is removed using the quick-release clamp.
2.) Ensure that the 5 slit rat collimator to be measured is installed.
3.) Press the Scan page 

button (See Figure 7-64).
   a.) Choose the static SPECT Step Shoot protocol.
   b.) Set the Scan Limit to Time.
   c.) Set the Time to 60 seconds.
   d.) Set an energy threshold of 250 keV and an energy window of 110 to 140 KeV.
   e.) Set the Collimator Encoding to Continuous Counting.
   f.) Set the Step Count to 24 and Increment Angle to 3 degrees.
   g.) Set the Start Angle to 0 degrees.
   h.) Set the Energy Correction Map to Gain and Offset.
   i.) Change the Exam field to Sensitivity and the Specimen field to name the isotope in use (ie. Co-57).

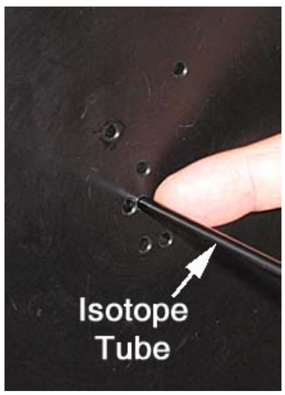
4.) Press the recon name and set the recon parameters.

a.) Image size: 128 x 128 x 32
b.) Pixel size (x & y): 0.55 mm for rat / 0.4 mm for mouse
c.) Energy Window: 110 to 140 KeV
d.) Subset: 3 (8-slit)
3 (5-slit)
e.) Iteration: 5
f.) Energy Correction: Yes
g.) Uniformity Correction: Yes

Procedure

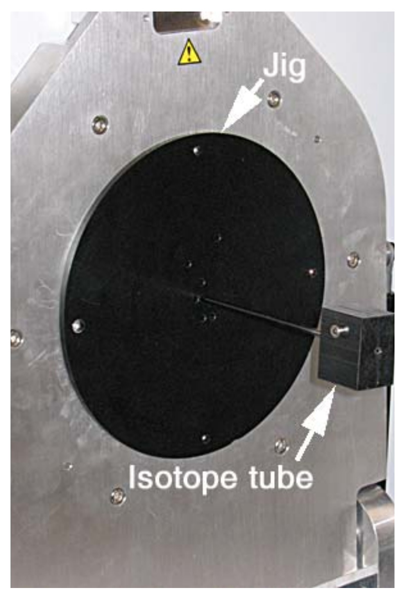
Note: Isotope will slide in the isotope tube when the tube is tilted. TRY TO KEEP THE TUBE AS LEVEL AS POSSIBLE OR SLIGHLTY TILTED DOWNWARD AT THE OPPOSITE END TO THE BLOCK AT ALL TIMES.

CAUTION



1.) Load the Co-57 line source isotope into the end of the isotope tube. Orient the jig until the largest of the four holes near the edge of the jig is at the 9 o'clock position (photo next page). Ensure the isotope tube is placed in the center hole of the special jig (photo at left) and the isotope tube block is pushed flush against the jig. Ensure the isotope end is at the far end of the tube, using a wire if necessary to push it.
CAUTION - Latex gloves must be worn when handling an isotope, and properly disposed of afterward.

2.Use SPECT fluoro to verify that the line source is in position and that it covers the full field of view.



3.) Start the data acquisition by clicking Run Sequence. Duration will be approximately 15 to 20 minutes. Confirm that the septa is in its calibrated position by clicking on the Septa tab in the Service pages. If not, the system will need to be re-booted.

4.) To find the total counts after the scan is finished:

a.) On the Console desk computer, click Applications, System Tools and Terminal.
b.) Type: cd /media/data_disk/SPECT
c.) A folder will be generated and named automatically by the system in the form "Scan_xxxx" and stored in this directory. To determine the assigned folder number while in this directory, type:
ls -l
where the first and last characters are lower case L. This lists the scans along with their time/date stamp. The most recent is the current scan number. A file called SPECTAcq.dat will be stored in this new folder.
d.) Type: SPECTSlitRecon -f 0 -i Scan_xxxx/SPECTAcq.dat -x Scan_xxxx/scan.xml -o Scan_xxxx -c Scan_xxxx -s

e.) The system generates output of the form:
"Finish whole acquisition of wwwwwww ticks, and xxxxxxxx events, with yyyyyyyy reframed, zzzzzzz in energy window ..." where the number represented by zzzzzzz is the total number of counts.(Figure 7-65)

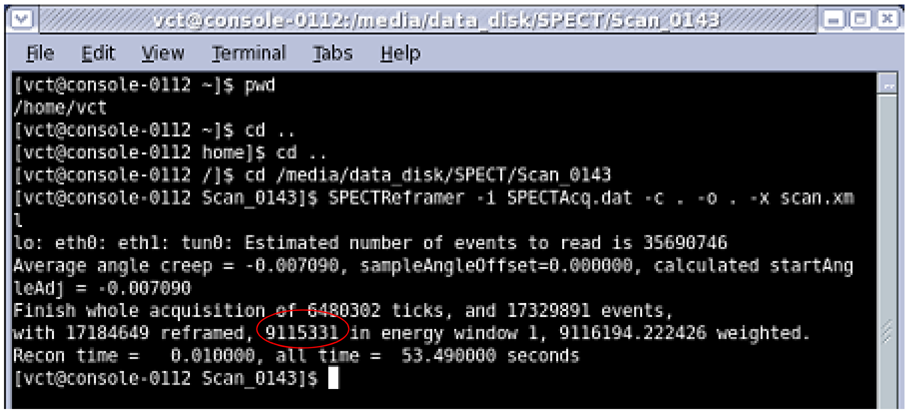


Figure 7-65

5.) Sensitivity is calculated by:

a.) Count rate=total counts/(60 x 15) (cps) for an 8-slit collimator OR
Count rate=total counts/(60 x 24) (cps) for a 5-slit collimator

b.) Source activity=μCi x 3.7 x 10^4 (cps). The activity in μCi can be obtained by calculation, or using an isotope supplier's web site tools as shown in Figure 7-66. The formula converts μCi to MBq. If the activity is available directly in MBq, then use this value for source activity.

c.) Sensitivity= Count rate/Source activity x 1,000,000 (cps/MBq)

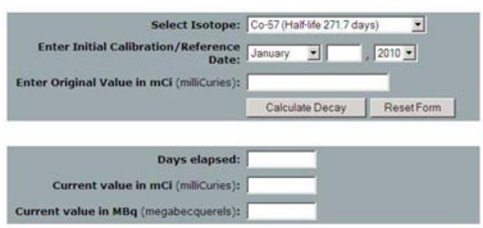


Figure 7-66

6.) Percentage is calculated by dividing counts per second by the isotope intensity and multiplying by 100:
%=cps/MBq x 100

7.) Acceptance criteria:

a.) Rat slit collimator: >/= 200cps

b.) Mouse slit collimator: >/= 450 cps $\pm$ 10%

7.2.3 CT Calibration

GENERATE THE CORRECTED GRID FILE

WHY DO THIS?

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

Preparation for Image Acquistion

1.) Remove left side cover from CT unit.
2.) Open the left side shield.

Image Acquisition Procedure

1.) Enter the Service pages and click on the Axial Motor tab. Use the Axial Motor Program to rotate the Gantry to absolute position 180^{o} (6 o'clock).
2.) Inspect the detector to ensure it is parallel to the base of the unit. If not, repeat step 1. using another absolute position (189° typically works better than 180°). Use judgement to determine the best value.
3.) Install the BB grid on the detector using two plastic screws and flat washers (Figure 7-67). Insert the screws with washers through the smaller holes on the detector, and TURN BY HAND ONLY UNTIL THEY ARE JUST HOLDING THE GRID IN PLACE.
4.) Close the side shield on the CT unit.

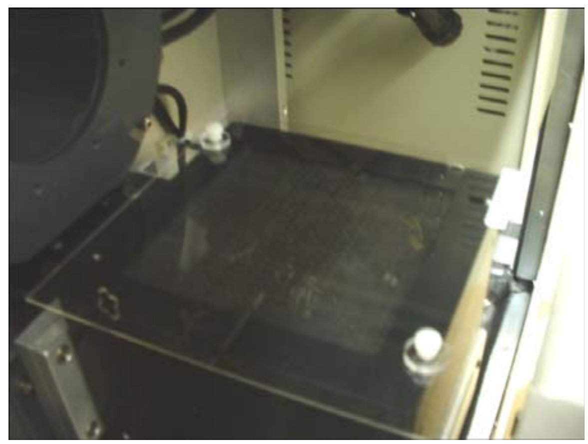


Figure 7-67

Note: If the P tube is installed, the plastic screw closest to the right side of the unit can only be accessed by removing the right side cover and opening the right side shield.

Note: DO NOT OVERTIGHTEN the screws on the BB grid, as it will distort the image. Tighten it just so that the grid does not move. Center the grid on the detector.

Note: The grid must be oriented with its longest dimension at a right angle to the Z-axis (Table axis).

5.) Remove the cradle.

6.) From the Scan page, click the CT Warmup button and wait for the warmup to finish (Figure 7-68). For the SRI tube this period is typically 7 minutes and for the Dunlee tube, approximately 5 minutes. X-rays should fire and lights should be on. If not, check that the side shield is properly closed or that an interlock key is in place.

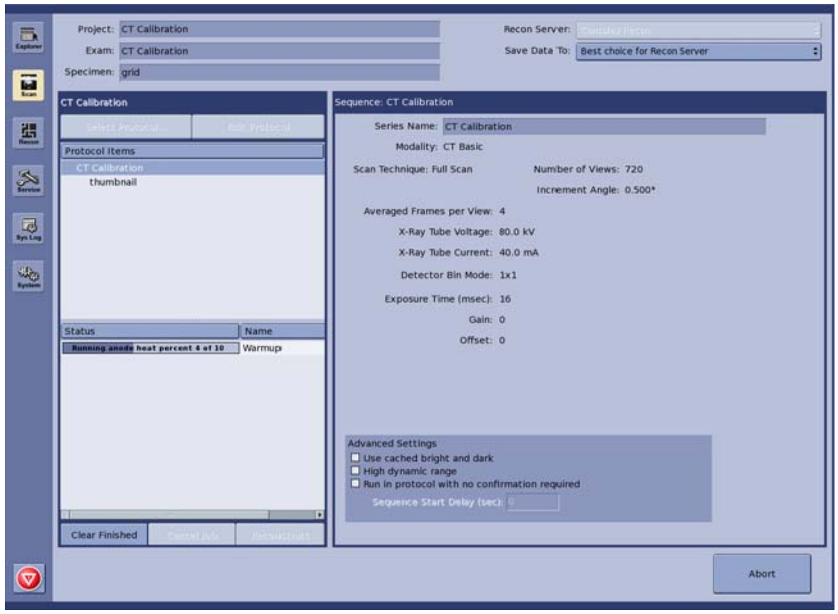


Figure 7-68

7.) Click on the Select Protocol button and select the CT Calibration protocol from the list.

8.) Enter the Project and Exam as "CT Calibration" and the Specimen as "grid".

9.) Click on the CT Fluoro button. The button changes to Stop X-Rays.

10.) Click on Stop X-Rays after a few images have been acquired on the right screen of the Console.

11.) Ensure the image includes an array of at least 10x20 BBs. Examine the image. If it is crooked, adjust the grid slightly and re-run the CT Fluoro.

To Connect Remotely to the CT Computer

A.) On the Console desk computer top menu bar, click the Applications button, Systems Tools and Terminal.

B.) On the Terminal screen:

a.) Type: vncviewer ct.local

b.) Type password:debug

Note: The response of the system is slow when using vnc into the CT computer. Wait for the image to appear.

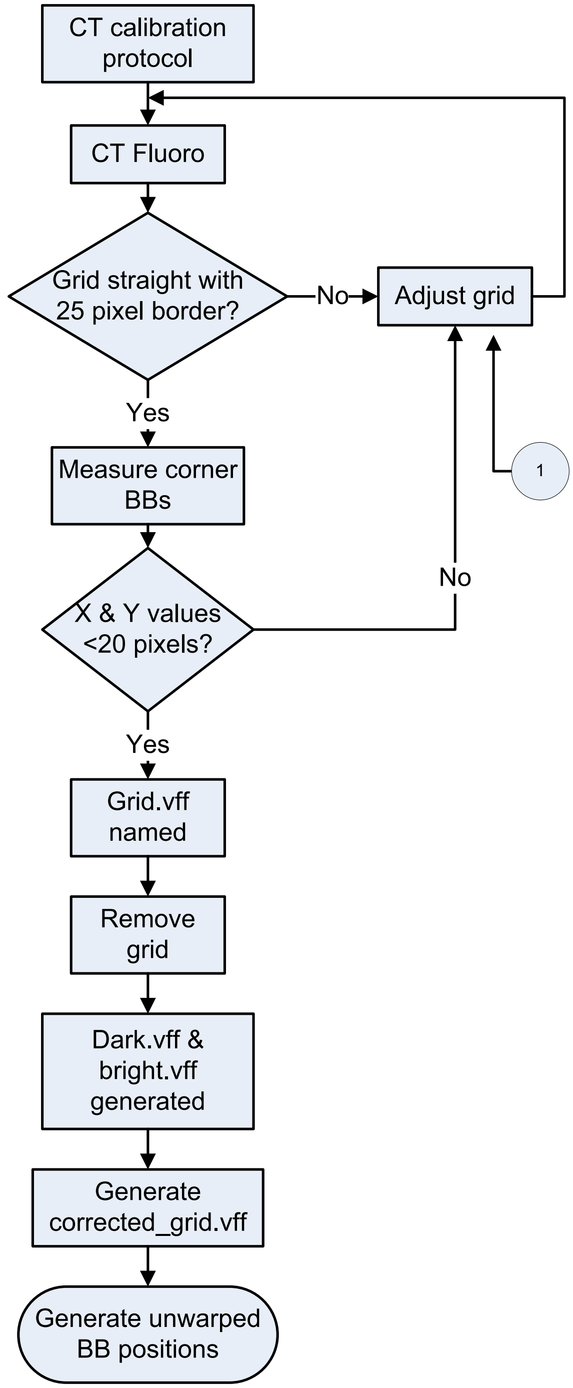


Figure 7-69 Generate Corrected Grid

12.) When an acceptable image is obtained find the .vff file generated in fluoro next to "Filename" on the right hand Console screen (arrow in Figure 7-70).

13.) Navigate on the CT computer to C:\Inukshuk\data\fluoro and double click on the file name found in Figure 7-70 to open MicroView.

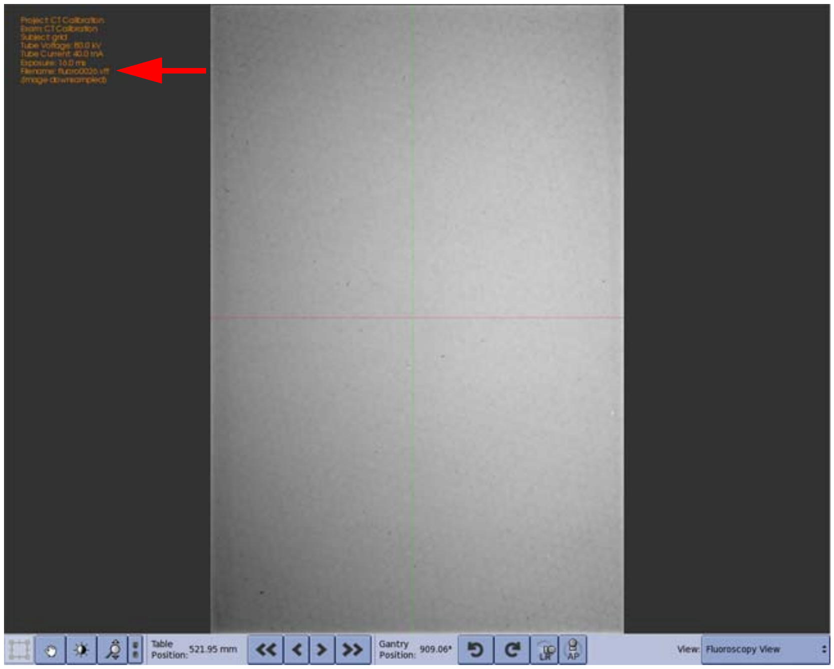


Figure 7-70

14.) The objective is to center 13x20 BBs (or 10x20 minimum) on the detector, with roughly 50 pixels between the BBs and the edge of the screen. The BBs cannot be clipped at the edge of the screen. An example of such an acquired image (fluoroxxxx.vff) is shown in Figure 7-71.

NOTE: The orientation is different between the Fluoro and MicroView displays (Figure 7-72). Keep this in mind when adjusting the grid.

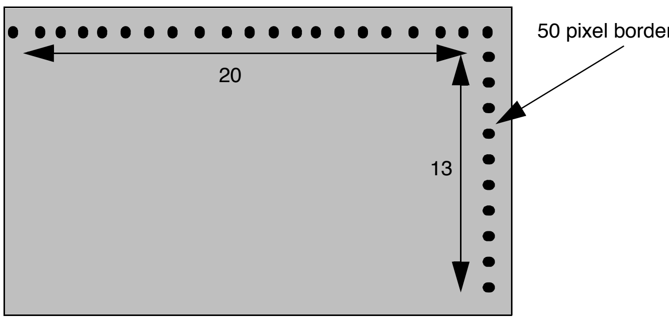


Figure 7-71

NOTE: In MicroView, click on Edit\Application Settings\Misc and click on the Show Measurements in Pixels radio button.

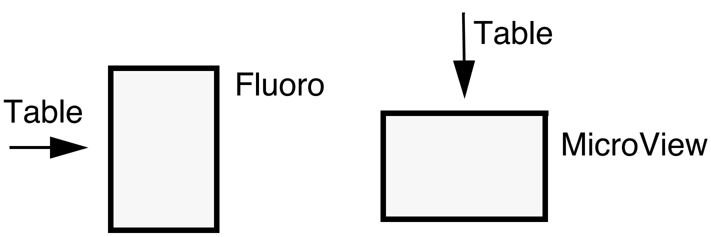


Figure 7-72

15.) In MicroView, hold the mouse over the center of the BBs in each corner. The difference in X and Y values between BBs must be 20 pixels or less.

16.) If the BBs are not within this 20 pixel difference, then physically move the grid on the detector and repeat steps 9 to 15 for image acquisition and viewing. Note that each time, the new file fluoroxxxx.vff (where xxxx corresponds to the view acquired) must be reviewed.

17.) Once grid centering is achieved, copy the last file acquired (fluoroxxxx.vff) to C:\Images and rename to **grid.vff.** Delete all other files in C:\Images.

18.) Remove the grid.

19.) On the Scan page, name the scan and the sequence then click on the Run Sequence button. The button changes to Abort. First dark, then bright images will be displayed in MicroView.

20.) Hit the Abort button. Copy the dark and bright images from C:\Inukshuk\data\Scan_xxxx as **dark.vff** and **bright.vff**, respectively, to C:\Images. Look for the most recent scan using the date/time stamp.

To start the Transform file creation, correct the captured image using the **Calibration Tools** program. To open **Calibration Tools**, on the CT computer, hit Start\All Programs\GE Healthcare\Explore Utilities\calibration\Calibration Tool

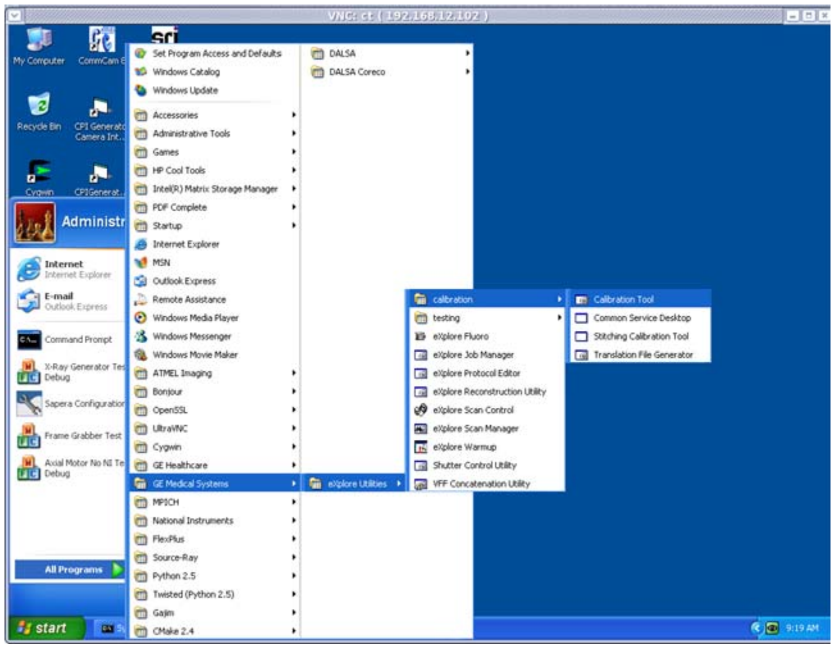


Figure 7-73

1.) Click the *Correct* tab

2.) In the “VFF to Correct” field, find the newly captured "grid.vff" image using the *Browse* button

3.) Use the *Browse* button to find the "bright" and "dark" files created earlier

4.) Click the *Correct* button (the corrected file is named "corrected.vff" and is stored in the same folder in which the captured image was stored)

5.) Double-click the "corrected.vff" file in **Windows Explorer** to load the image into **MicroView**.

6.) Confirm that the grid has been corrected (the image looks cleaner with less noise in between the BBs).

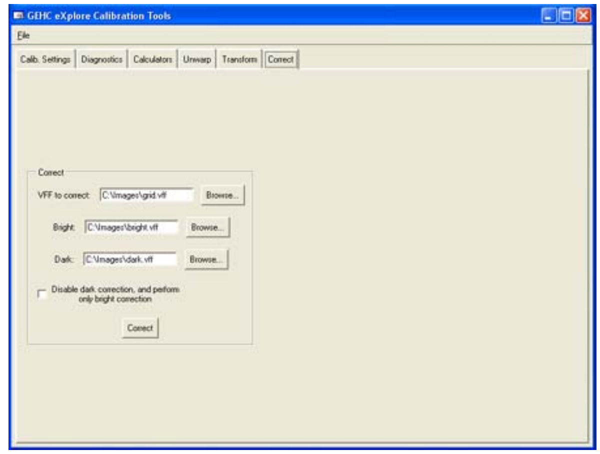


Figure 7-74

7.) Use **Windows Explorer** to rename the image "corrected_grid.vff".

GENERATE UNWARPED BB POSITIONS

1. Run the **transgen** program (Browse to the Start button, and GE Healthcare, eXplore Utilities, calibration, Translation File Generator)

2.) Load the "corrected_grid" file into the **transgen** program.

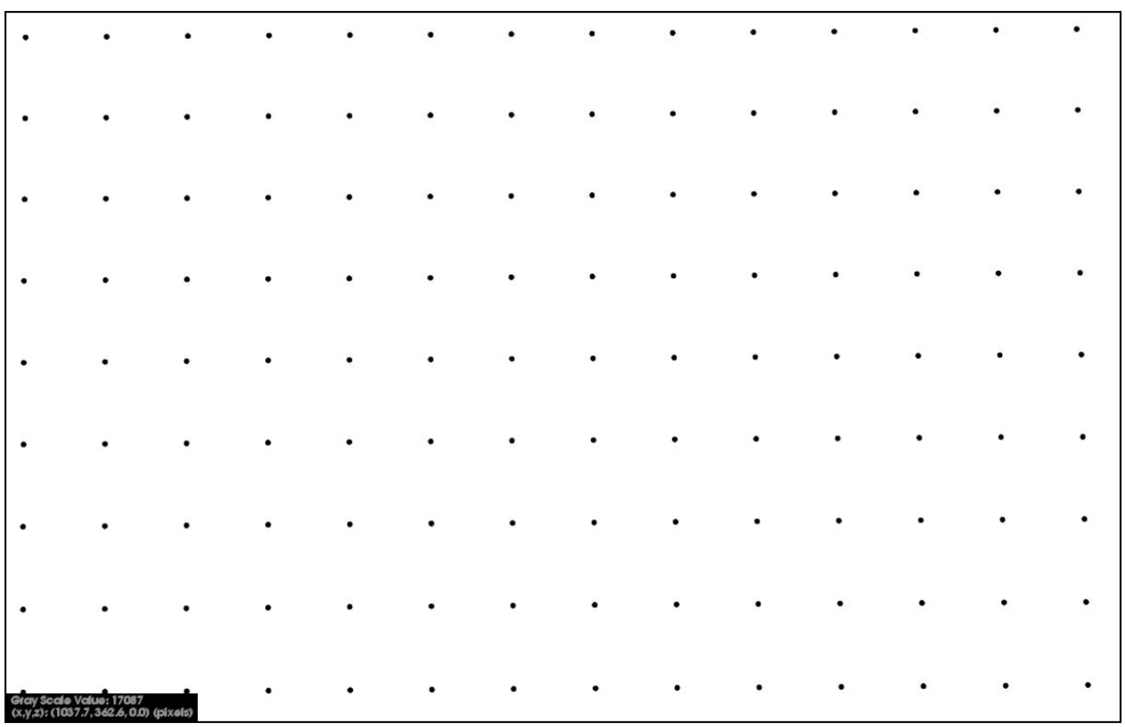


Figure 7-75

Note: **If clicking on the image without pressing Shift, the image will rotate. Close transgen and restart from step 1**

Note: Image will initially appear black until Window and Level sliders are adjusted. These sliders will be visible after the screen is maximized.

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

3.) Adjust the *Window* (e.g. 700) and *Level* (e.g. remove graininess) sliders until there are minimal pixels visible except for the grid's BBs (Figure 7-75). Make the BBs as big and round as possible, zooming in on individual BBs to check their roundness and the surrounding area for visible stray pixels (Figure 7-76). Not getting the Window and Level right may affect the centroid calculations. The background must be white (no grey).

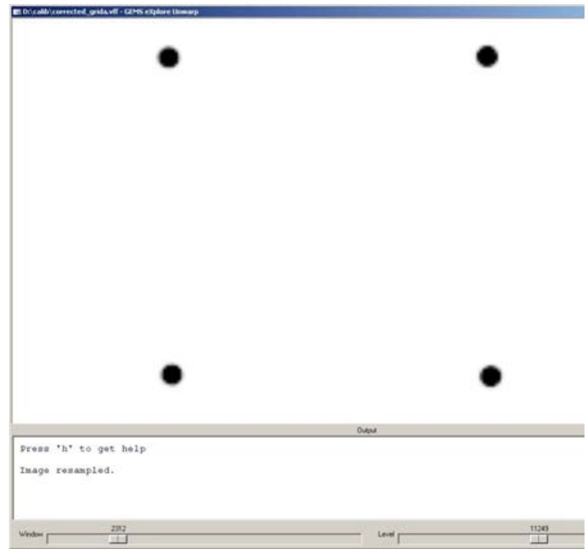
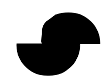


Figure 7-76

Note: Some shearing in the y-direction in **Fluoro** is allowable on some of the BBs - to a maximum of 1/4 of a BB. This shearing is due to internal characteristics of the optic fiber taper.



4.) Write down the *Window* and *Level* value.

5.) Zoom in on the first BB on the top left of the grid, place the cursor in the center of the BB and press **1**.

6.) Zoom in on the last BB on the top right of the grid, place the cursor in the center of the BB, and press **2 (**Figure 7-77**)**.

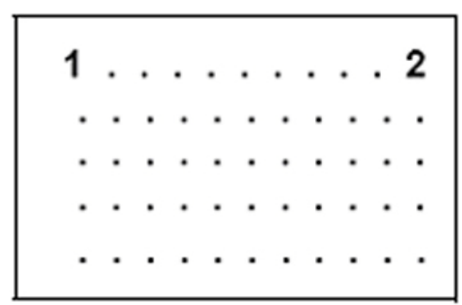


Figure 7-77

Note: *The coordinates of both BB 1 and 2 will appear at the bottom of the screen. Record these values in the Worksheet.*

7.) Determine how many pixels there are between **1** and **2** by subtracting marker **2**'s x position from marker **1**'s x position. E.g. if marker **1** is 3402.5 and marker **2** is 46.4, subtract 46.4 from 3402.5 to get 3356.1 Record in the Worksheet. Note that the value between **1**'s y and **2**'s y should be very small (<20 pixels).

8.) Manually divide the x position difference by the number of spaces between the BBs (e.g. 20 or 19) and make a note of this value (acceptable range is 176 to 177) on the Worksheet. This is the average pixel spacing between the BBs. If the value exceeds 177, contact GE Healthcare.

Note: If the screen displays 21 BBs, divide by 20. If the screen displays 20 BBs, divide by 19.

9.) Press a lowercase **s** to display spacing.

10.) Enter the x and y coordinates of BB 1 (e.g. x= 37.5, y = 38.1). Next enter the average distance between the BBs as calculated earlier (Figure 7-78). Enter this average twice e.g. 37.5 38.1 176.0 176.0 (be sure to include the space between each number). This tells the system the average spacing between BBs and where you want the system to start (from BB 1).

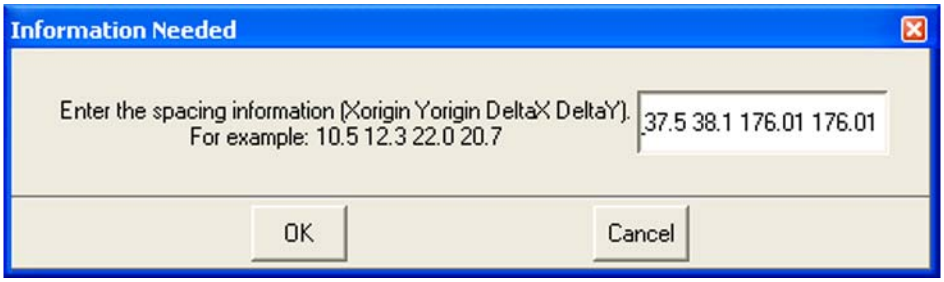


Figure 7-78

11.) Move the mouse to the BB positioned to the right of number 1 and press **2**.(Figure 7-79)

12.) Move the mouse to the BB directly below 1 and press **3**. (Figure 7-79)

13.) Press **b** and enter the box size number 29.

14.) Press **l** (lowercase L) to draw red boxes around each BB.

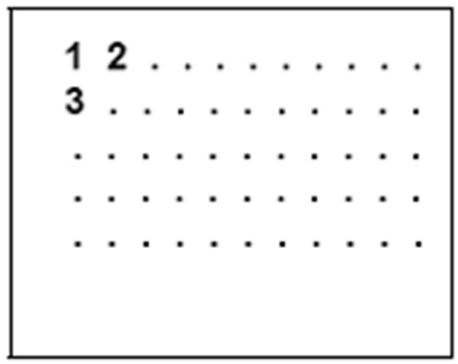


Figure 7-79

Use the pan and zoom features to examine every BB. Ensure that a red box appears around each BB and that the red dot (the BB's centroid) appears in the middle of the BB (Figure 7-80).

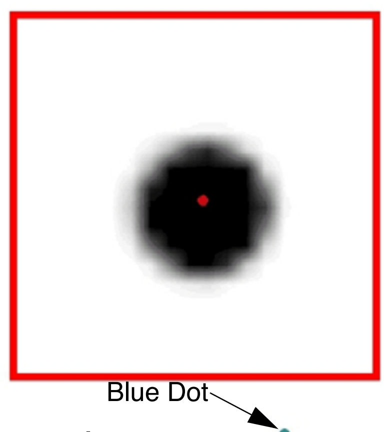


Figure 7-80

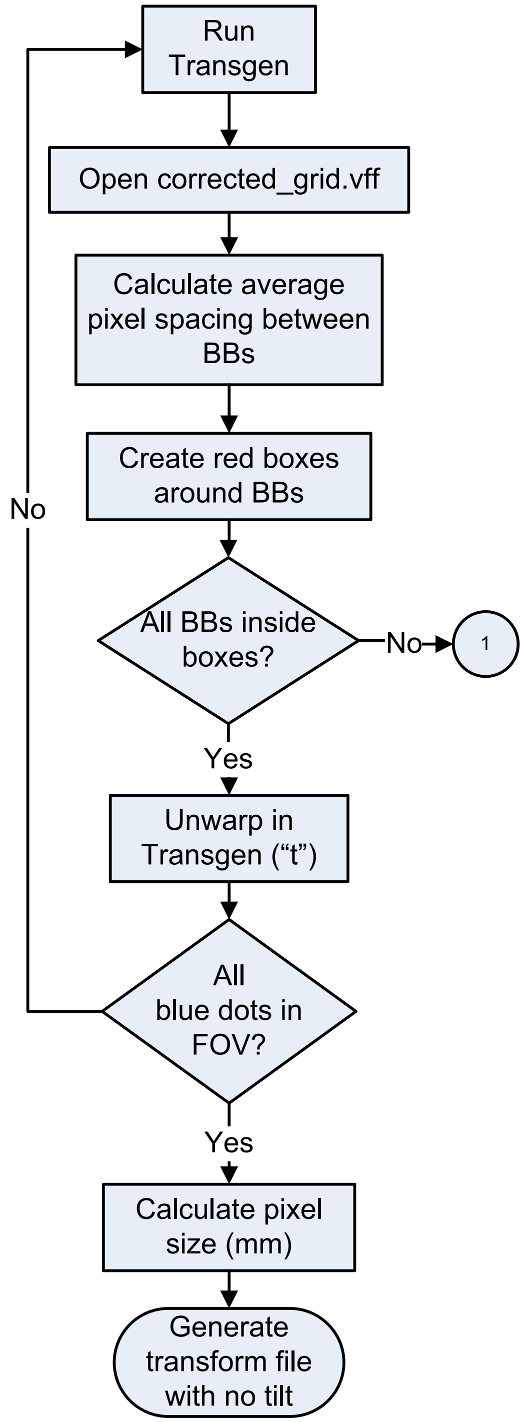


Figure 7-81 Generate Unwarped BB Positions

Note: *If any of the BBs are outside of the red boxes, the image is unacceptable. The screws on the BB grid may be too tight, resulting in a distorted grid. If this is the case, adjust the screws and repeat the procedure starting at step 9 on page 304.*

15.) Press **f** to write the output file to C:\translations.

16.) Rename the "translations" file to "translations1" and move it to C:\Images.

17.) Return to the **transgen** window and press **t**.

The system repositions the BBs into a perfect grid and displays the BB centroids as blue dots. *The blue dot is now the actual unwarped representation of the BB's centroid.*

Check all blue dots to ensure all 13x20 appear in the field of view (the 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 re-entering the coordinates (the spacing value or origin must change).

Note: Blue dots, as shown in Figure 7-80, may take some time to appear.

18.) Calculate the detector spacing by dividing 5 by the number calculated in step 8 (average spacing). For example: 5 ÷ (176.0)

Note: Here, 5.0 corresponds to 5.0mm which is the distance between two BBs and 176.0 corresponds to the number of pixels on the detectors between the BBs. Therefore, detector spacing is 5.0/176.0 mm.Make note of this detector spacing value (e.g. 0.028409090) to 9 decimal places in the Worksheet.

19.) Exit the **transgen** program.

GENERATE TRANSFORM FILE WITH NO TILT

1. Access **Calibration Tools** and click the *Transform* tab (Figure 7-82). If a pop-up warning box appears, click on OK and continue.

2.) Complete the Example VFF File field using *Browse* to find the "corrected_grid.vff" file. Ensure the Source/Targets File is set to C:\Images\translations1.

3.) Leave Tilt values as zeros. If not zeros, click the *Calculators* tab and press *Reset*, then press *Update*. Return to the *Transform* tab and press *Update*.

4.) Ensure 1x1 appears in the Transform bin Mode and Acquired Image bin Mode fields.

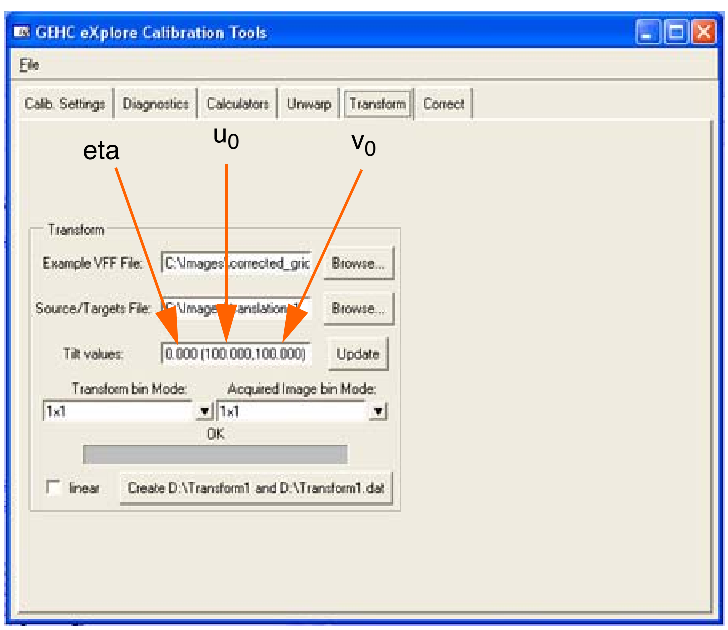


Figure 7-82

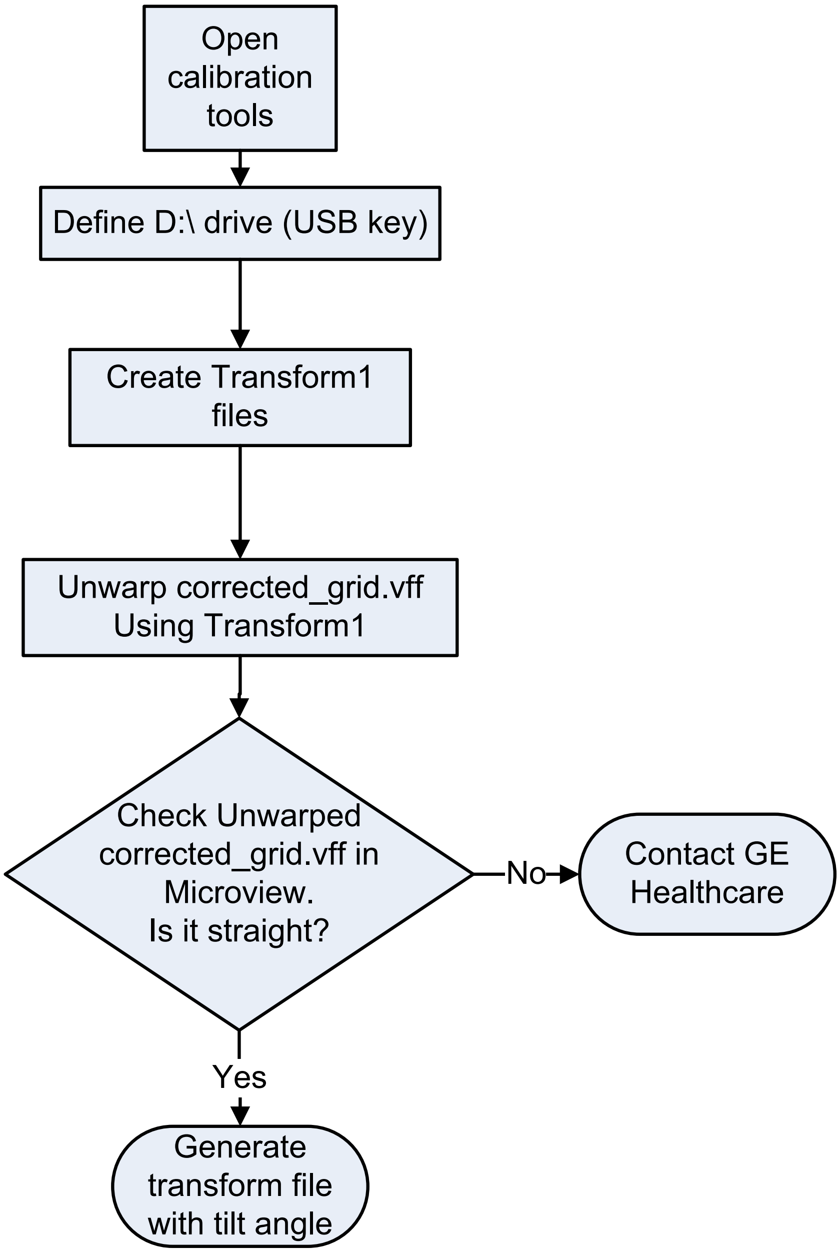


Figure 7-83 Generate Transform File with No Tilt

5.) A drive D: needs to be defined. It can be either an external hard drive or a USB key. If either the drive or key do not automatically assign as D:, they will need to be changed. On the CT computer, go to Control Panel\Administration Tools\Computer Management\Storage\Disk Management. Click on the external drive or USB key, right click, then choose Change Drive Letter and Paths. Change the drive letter to D:.

Note: If D: is currently in use, re-map the drive using D: to another drive letter first.

6.) Press the *Create D:\Transform1 and Transform1.dat* button at the bottom of the window.

7.) Access **Calibration Tools,** click the *Unwarp* tab (Figure 7-84) and complete the fields as follows:

- VFF to unwarp: C:\Images\corrected_grid.vff
- Transform grid: D:\Transform1

8.) Click the *Unwarp* button.

9.) Call the file D:\zz when prompted what to name the file, then click *OK*.

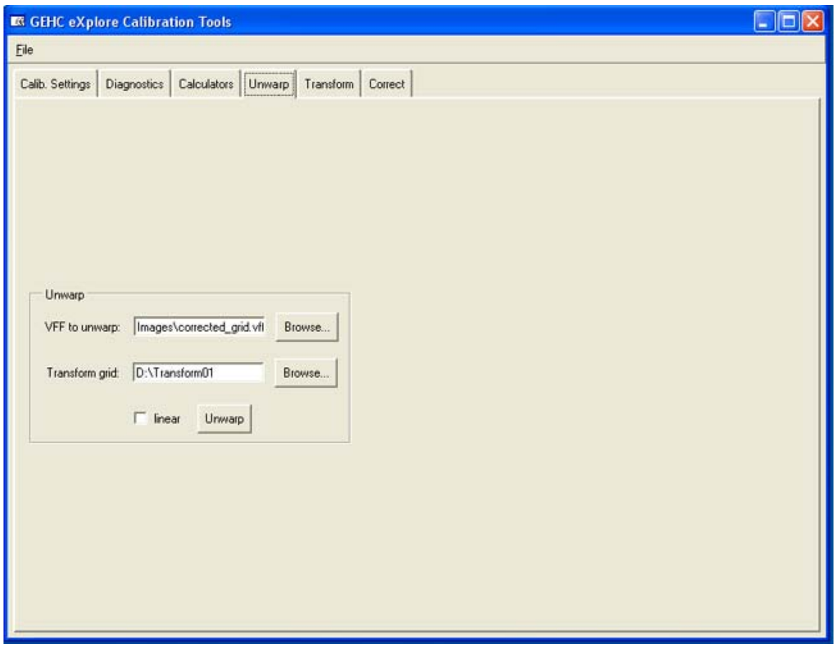


Figure 7-84

The zz file will be used as a temporary file for unwarping.Continue to overwrite this file whenever unwarping, because saving the unwarped files is unnecessary.

10. From the Console, on the CT computer open cygwin and:
type: cd D:/
type: scp zz.vff vct@192.168.12.89:/media/data_disk/CT/.
When prompted, type the user name **vct** and password **vct@pci**.
This copies zz.vff to the CT directory on the Console computer.

11.) In **File Browser** on the Console**,** locate and double-click zz.vff under /media/data_disk/CT. When prompted for a user name, type: **vct**. For password, type: **vct@pci**. This loads the unwarped "corrected_grid" file into **MicroView**.

12.) Check that the unwarped "corrected_grid" file is straight by dragging another window's edge over the rows and columns of the BBs. Use the window's edge as a ruler to ensure the BBs are perfectly aligned horizontally and vertically. If not, contact GE Healthcare. Black lines along the border are acceptable.

GENERATE TRANSFORM1 FILES WITH TILT ANGLE

1.) Copy Transform1 and Transform1.dat from D: to the CT computer under:
C:\Inukshuk\settings

2.) Open the console window and load the CT Calibration protocol.
  * For the Dunlee tube: CT 120 - Calibration
  * For the SRI tube: CT 80 - Calibration

Change the Specimen field name to Elliptical Phantom.

3.) Place the calibration phantom on the table. Fasten the thumbscrew of the phantom (arrow in exploded view in Figure 7-85) tightly so that the phantom is stable. See also Figure 7-86.

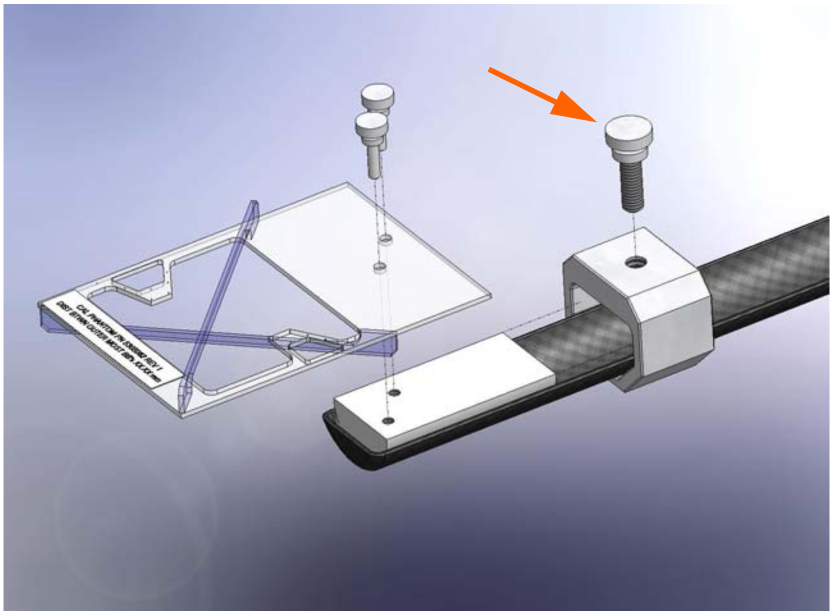


Figure 7-85

Note: It is very important that the phantom is stable and does not move during the scan (while the gantry is rotating). The phantom may also be positioned back toward the cradle as needed, as long as the cradle is not within the field of view of the BBs.

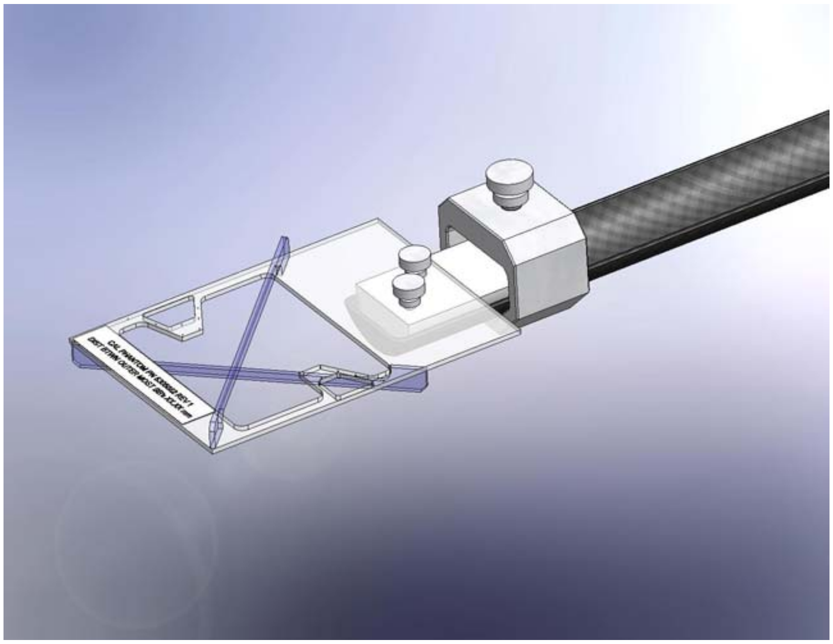


Figure 7-86

4.) With the lasers toggled on, position the table such that the laser passes through the center of the phantom. On the Tableside Controller touch screen, set the table landmark at this position by touching the Set button (Figure 7-87).

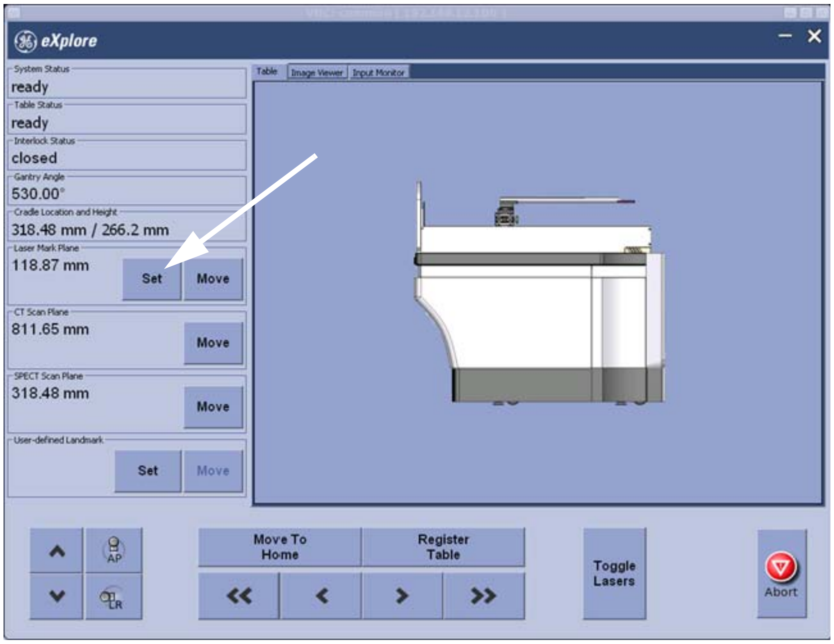


Figure 7-87

5.) From the Scan page, click the CT Warmup button. (Highlighted in Figure 7-88). Wait for the warmup to complete.

6.) Perform a CT Fluoro (button highlighted in Figure 7-88) and position the table such that the central BB is almost at the center of the detector (aligned with the cross-hairs on the Console screen).

7.) While the fluoro is running, rotate the gantry by -400° (relative) and ensure that all BBs are visible on the screen. Otherwise, the calibration will be unsuccessful.

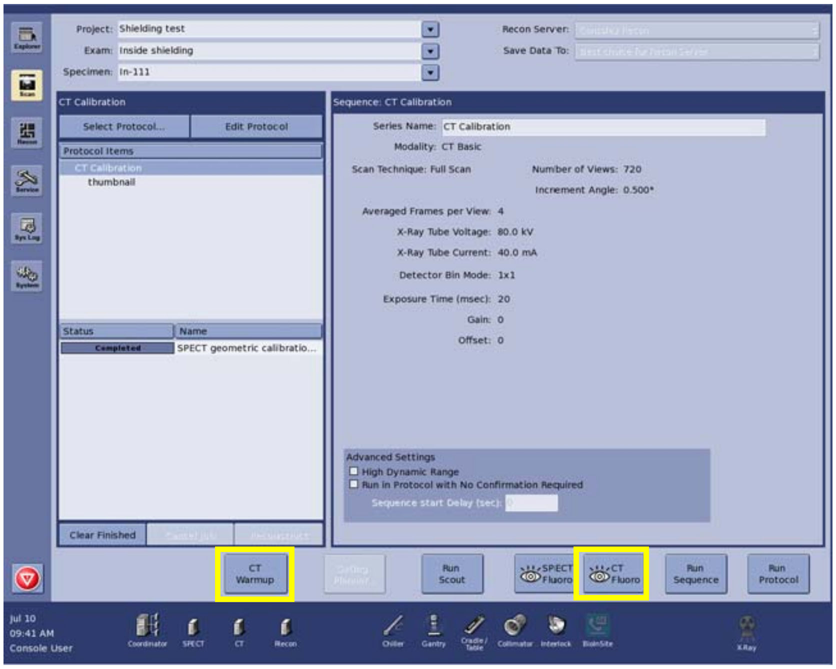


Figure 7-88

Note: If a gantry rotation error message appears, it may be possible to reset it on the Service page.

8. If all BBs are not visible, move the table in and out using:

   a.) the buttons on the bottom of the right Console screen

   b.) the Service page, or

   the Tableside Controller touch screen
   OR move the cradle up or down manually using the knob on the cradle.
   Repeat step 7.

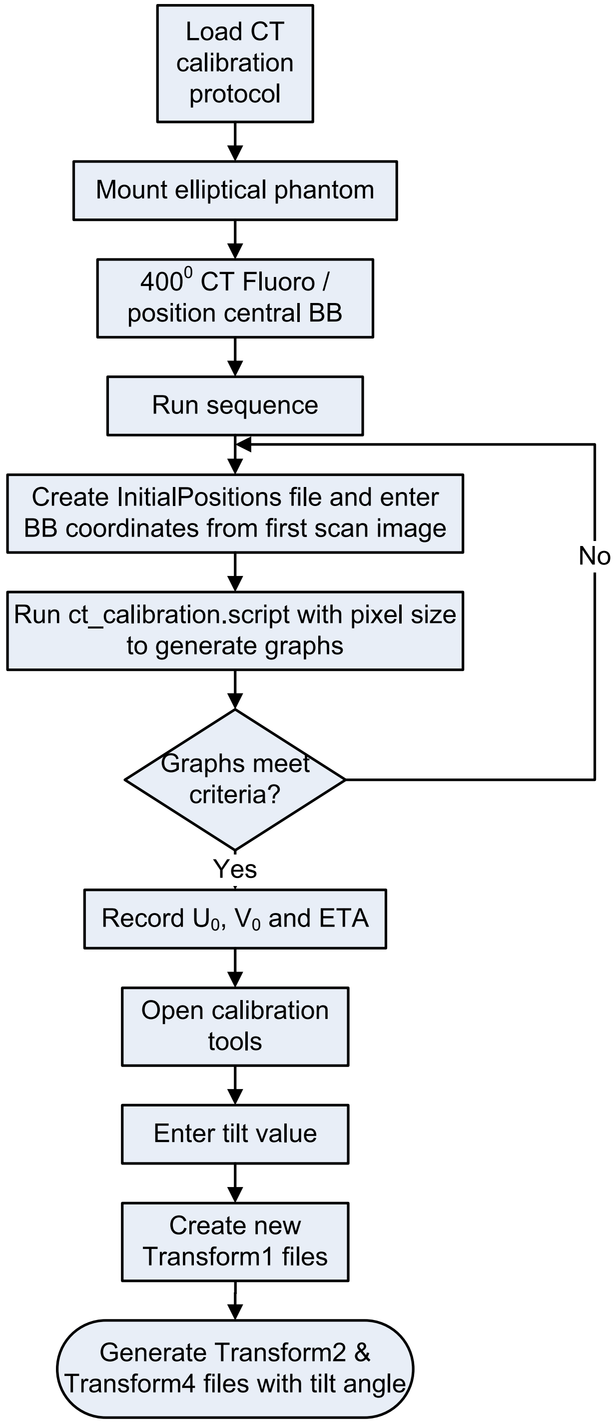


Figure 7-89 Generate Transform1 File with Tilt Angle

9.) Take a scan by clicking the Run Sequence or Run Protocol buttons. Duration is approximately 45 minutes.

10. Look at bright.vff. If part of the phantom is visible in the image, abort the scan and:

a. Go to the Service pages, System Properties tab, and select syscoord (Figure 7-90).

b. Write down the value following the <Home To Laser> tag (box in Figure 7-90).

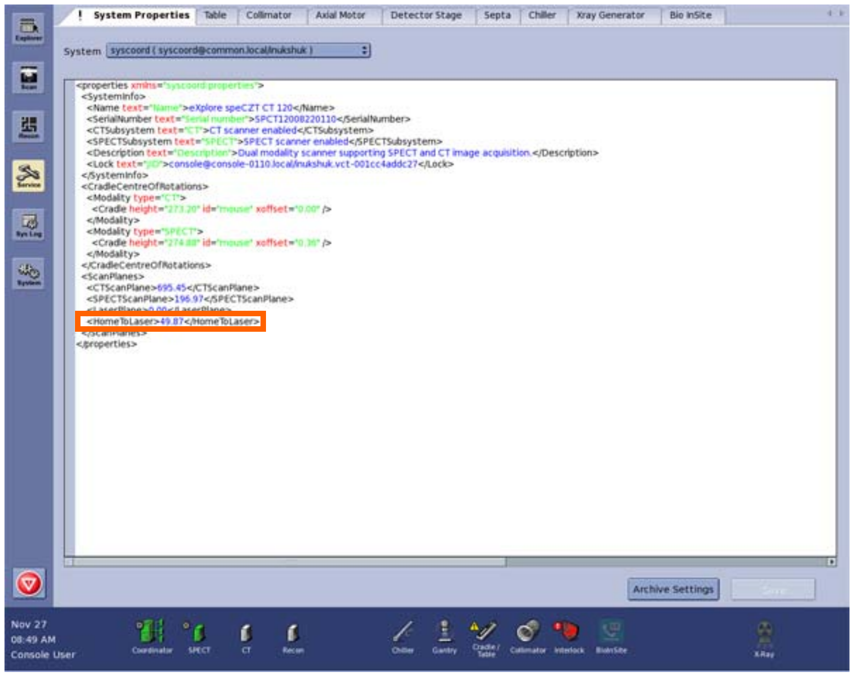


Figure 7-90

c. Change the value to be 20 less than the current value.

d. Reboot the scanner and re-run the bright image. Confirm the phantom is not visible.

e. Run a CT Fluoro and confirm that the landmark was set correctly (central BB aligned with cross-hairs)

f. Run Sequence.

11.) A new scan directory will be generated on the Console computer:
/media/data_disk/CT/Scan_xxxx

12.) Browse to the terminal session that is already open (Applications/System Tools/Terminal) and type cd /media/data_disk/CT/

Note: The Applications toolbar opens by moving the cursor to the top of the Console screen.

13.) Type: ls –l –t lmore and then type q.
The first line on this terminal shows the directory of the new scan. It is called “Scan_xxxx”, where xxxx corresponds to the scan number.

14.) Type: cd Scan_xxxx
A directory called Corrected should be visible. Change directory (cd) to Corrected and make a new directory:
cd Corrected
mkdir DataAnalysis
cd DataAnalysis

15.) While the scan is running (60 minutes) type:

MicroView ../uwarp-00-0000.vff

The first image collected will be visible. Using the left mouse button, click Edit then Application Settings. Click on the Misc tab and uncheck the "Show Measurements in mm" radio button. When the mouse is on the MicroView image, values are shown in pixels.

16.) Create a file called InitialPositions using any editor, such as vi or gedit. To enter gedit from a terminal screen -

type: gedit InitialPositions

Hover the mouse over the center of each BB. Starting from the bottom-most BB (BB0), read and record the x and y coordinates. Repeat for all BBs, naming them:

0 x y
1 x y
2 x y
.
.
.
12 x y

for a 13-BB phantom. Wait for the scan to finish.

Note: These positions are approximate, and can vary by up to ± 20 pixels.

17. Save the InitialPositions file in the DataAnalysis directory.

18.) Run the ct_calibration.script file by typing:

run_CTcalibration.sh /opt/MATLAB/MATLAB_Compiler_Runtime/v78/ 0.029412 /media/data_disk/CT/Scan_xxxx/Corrected/uwarp-00-

where 0.029412 is detector spacing, calculated on page 312.

19.) Once the code finishes, many graphs will be plotted. An elliptical trajectory for each BB will be generated, for a total of 15 graphs.

DO NOT respond to the Yes/No message until the graphs have been viewed.

a.) Graphs 1, 2, 12 and 13 should be perfect ellipses (Figure 7-91). If not, the threshold value may have to be changed. Contact GE Healthcare.

b.) Graph 6 is a bumpy ellipse, but is acceptable as long as the ellipse is within ±5 pixels vertically on the graph (Figure 7-92).

c.) Graph 14 should be an oblique straight line (Figure 7-93).

d.) Graph 15 should be a vertical line with a points spread of ± 1.5 pixels (Figure 7-94).

20. Write down values for twist angle (same as tilt angle), center of rotation and central slice on the worksheet as listed in Figure 7-94 or from the terminal from which the run_CTcalibration command was performed.

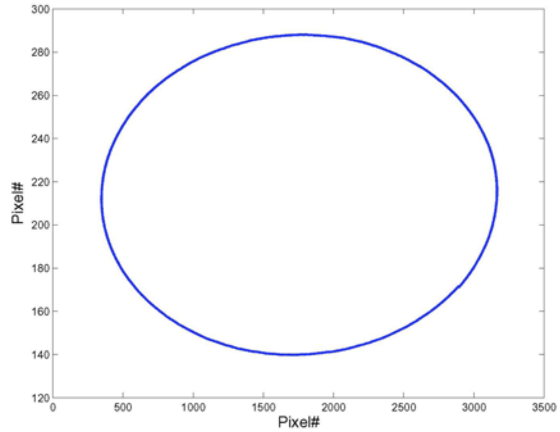


Figure 7-91

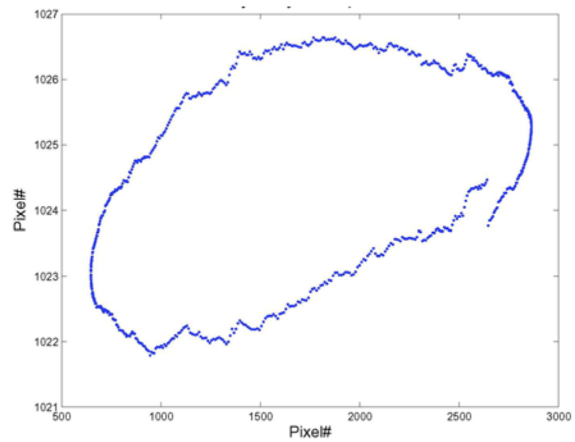


Figure 7-92

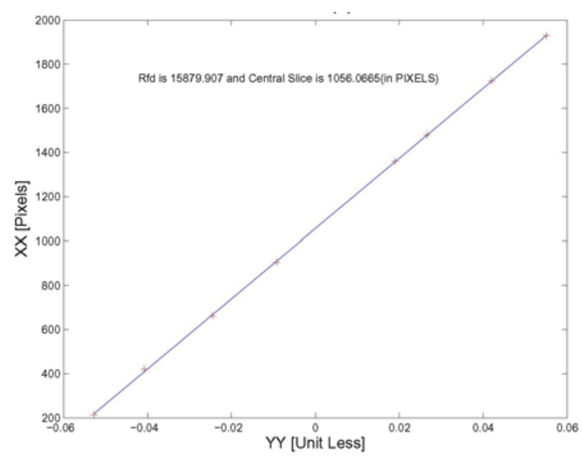


Figure 7-93

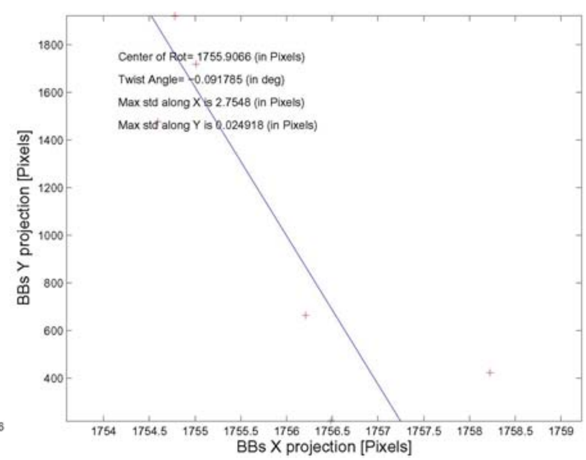


Figure 7-94

21.) To view the graphs again, type:
cd /media/data_disk/CT/Scan_xxxx/Corrected/Data Analysis/GraphsPlotted/
Type: ls (lower case L) to list all graph names.
Then type: evince graphname.pdf, where graphname is the name of the desired graph

22.) If the ellipses do not meet this criteria, repeat this procedure starting at step 16 (InitialPositions). Use Region Grow to get more accurate center coordinates:

- In MicroView, click on *Tools/ Region Grow* (Figure 7-95)
- Select *Lower* in the Threshold field
- Place the mouse over the BB and press the Spacebar (the BB's solid center turns green)
- Record the centroid value (x & y coordinates). If desired, press the *View Centroid* button to view the calculated actual center. It may be necessary to Pan and Zoom to see the cross-hairs.

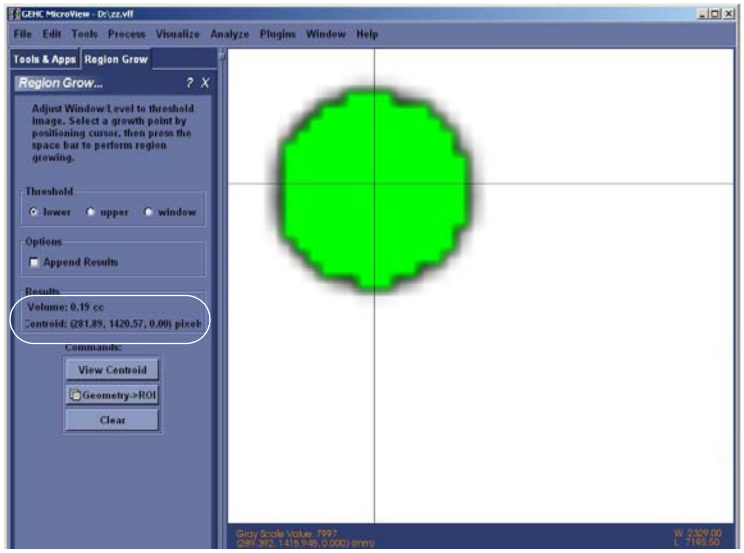


Figure 7-95

If this is unsuccessful, contact GE Healthcare.

23.) As a result of running ct_calibration.script, write separately the values of:

u_0 (center of rotation)

v_0 (central slice)

eta (tilt angle - usually less than 1°)

24.) Starting back at Step 1 on page 312, enter the new tilt values just detemined from ct_calibration.script in the Tilt values field of the Calibration Tools screen, in the form eta(u_0,v_0). Create new transform1 and transform1.dat files.

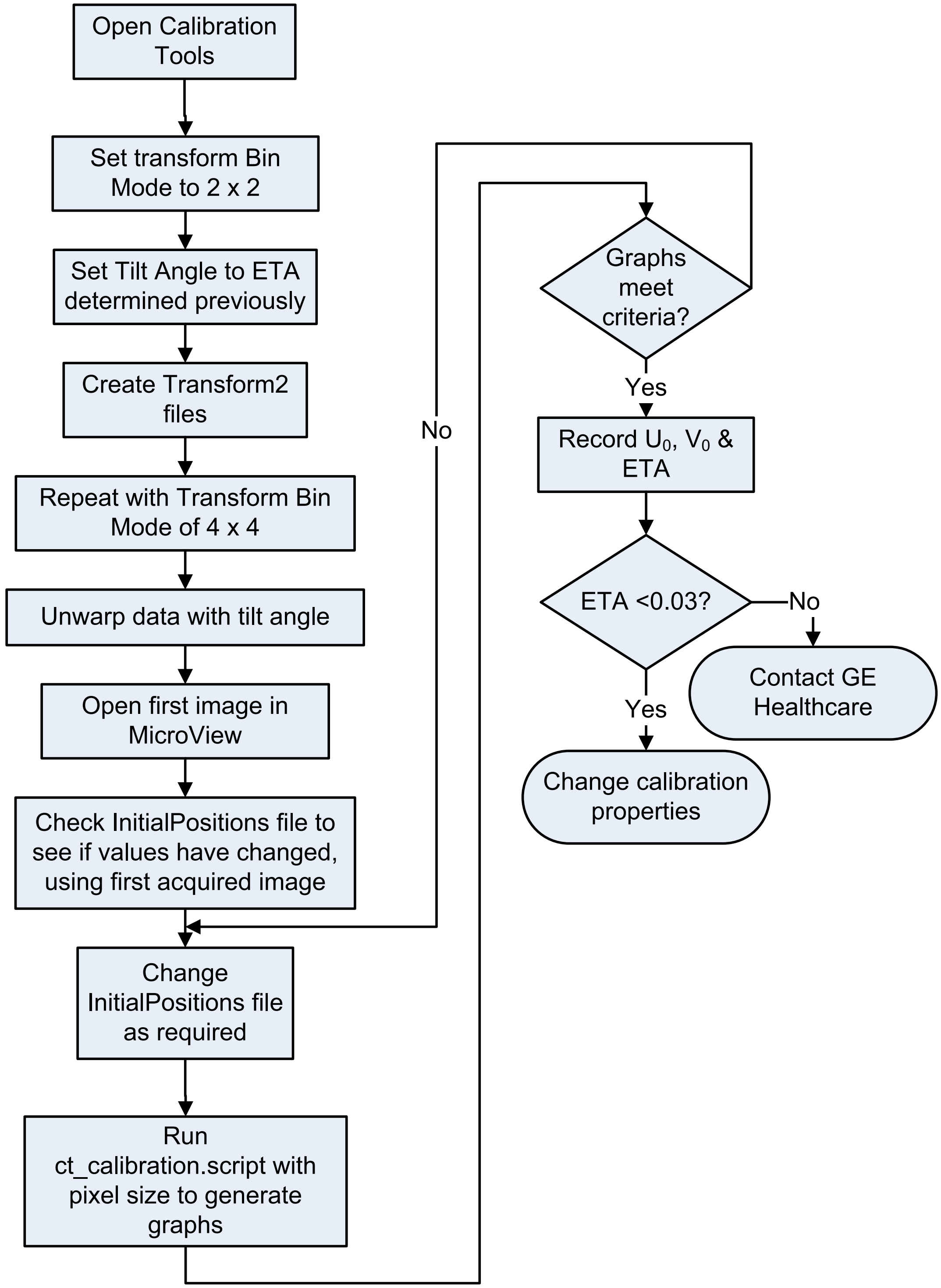


Figure 7-96 Generate Transform2 and Transform4 Files with Tilt Angle

GENERATE TRANSFORM2 AND TRANSFORM4 FILES WITH TILT ANGLE

The following duplicates the **transform1** creation procedure for 2x2 and 4x4 binning modes:

1.) Access **Calibration Tools** and click the *Transform* tab.

2.) Check the values of the following fields:
   * Example VFF File: C:\Images\corrected_grid.vff
   * Source/Targets File: C:\translations1
   * 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 at 1x1.*

4.) Press the *Create D:\Transform2 and D:\Transform2.dat* button. The "Transform2" file is created.

5.) Check the file sizes of the transform files in D:\. Transform1 should be approximately 80 Kb and Transform2 should be approximately 20 Kb.

6.) Repeat step 3 with Transform Bin Mode: 4x4

7.) Press the *Create D:\Transform4 and D:\Transform4.dat* button. The "Transform4" file is created, and its size should be approximately 5Kb.

Place the transform files in the appropriate location so that the scanner can access them.

8. Move D:\Transform1, D:\Transform1.dat, D:\Transform2, D:\Transform2.dat, D:\Transform4, and D:\Transform4.dat to C:\Inukshuk\settings on the CT computer. If these files exist, then overwrite them.

9.) On the CT computer:
Open cygwin
type: cd C:/Inukshuk/settings
type: scp transform1* vct@192.168.12.89:/media/data_disk/CT/Scan_xxxx/
A prompt for a password appears. Type: vct@pci

10.) On the Console computer, type:

```
cd /media/data_disk/CT/Scan_xxxxx
mv Corrected CorrectedNoTilt
mkdir Corrected
cd /media/data_disk/CT/Scan_xxxx
ct_correct -i acq-00-%04d.vff -o Corrected/uwarp-00-%04d.vff
```

This last step will unwarp the data with tilt angle

11.) Type

```
cd Corrected
mkdir DataAnalysis
cd DataAnalysis
```

Now repeat step 18 on page 320 to step 24 on page 322 using values from the first unwarped image from step 10. Change the InitialPositions file if values have changed. An eta of less than 0.03 should now be achieved.

Note: If this value is not achieved, do not proceed further. Contact GE Healthcare for assistance.

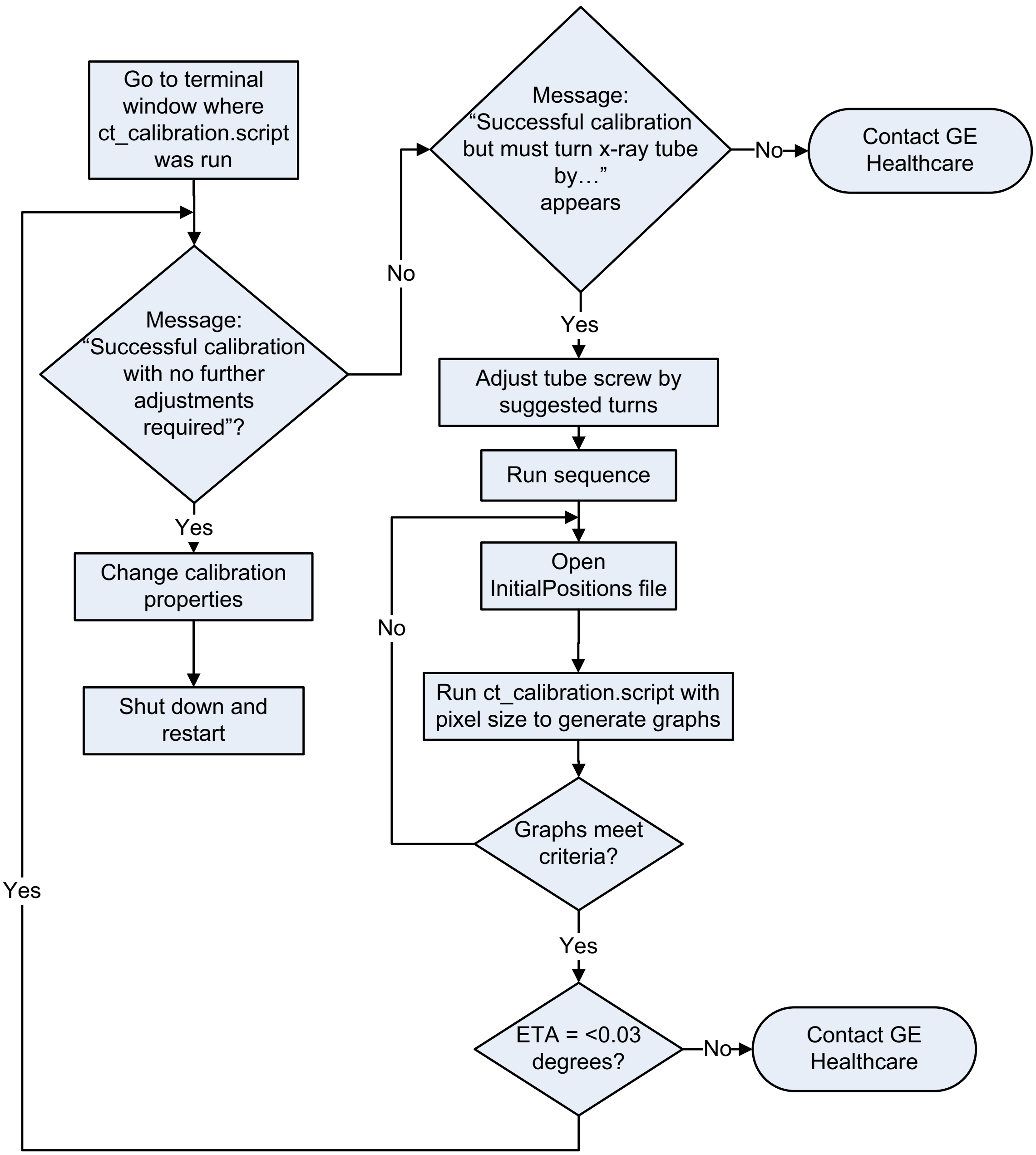


Figure 7-97 Change Calibration Properties

CHANGE CALIBRATION PROPERTIES

1.) Once calibration is finished, check the terminal at which "/usr/bin/ct_calibration.script" is run. The command "CALIBRATION PROTOCOL FINISHED" should be noted. This statement is followed by one of three possible messages: "Successful Calibration with no further adjustments required","Successful Calibration, but must turn X-ray tube by x.x turns to the left (or right) and repeat calibration procedure" or "Calibration failure".
2.) If "Calibration failure" appears, contact GE Healthcare for assistance.
3.) If the tube needs adjustment, first take the freeplay out of the adjusting screw and shift the tube by the required number of turns. To make the adjustment, refer to Figure 7-98. Loosen four M10 bolts (two shown by arrows). Adjust the set screw as needed (circled), then tighten bolts to 340 in.-lb.

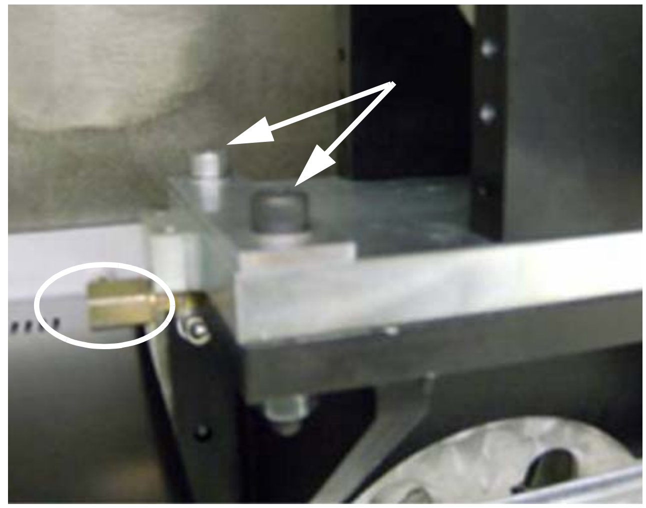


Figure 7-98

NOTICE Equipment Damage Possible Tube adjustment should only be carried out by trained personnel.

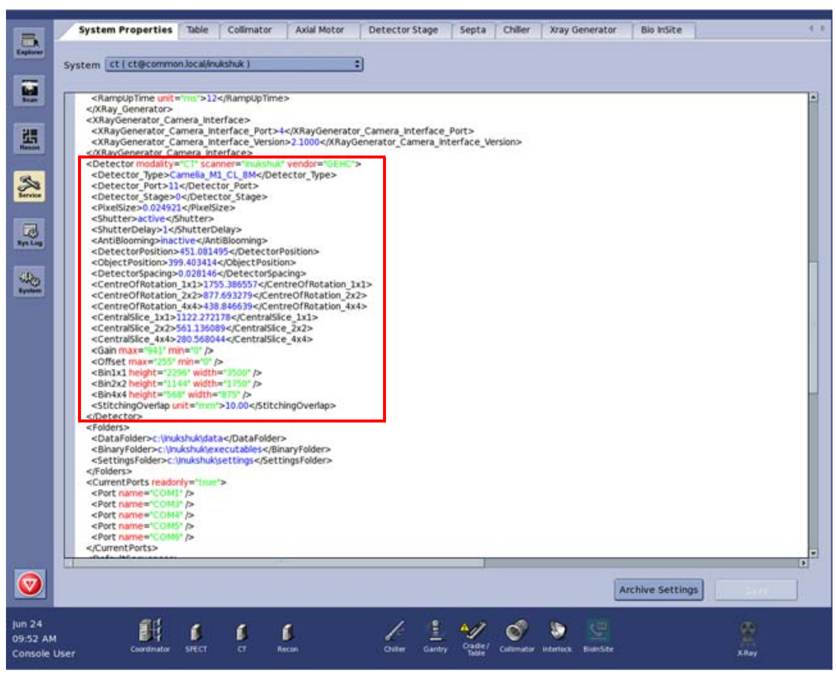


Figure 7-99

4.) Repeat step 1 on page 315 to step 11 on page 324.
5.) The message should now change to "Successful Calibration with no further adjustments required" and the tilt angle should be less than 0.03°. Parameters are now located in this same terminal screen.
6.) Use these parameters to change the ten <Detector> properties in the System Properties for the CT subsystem on the Service page. (Figure 7-99).

* Detector spacing is calculated as described in Step 18 on page 312.
* Detector Position in pixels is the same as the larger of two numbers in XRay Focal Spot - Detector Distance
* Object Position in pixels is the same as the smaller of two numbers in XRay Focal Spot - Detector Distance
* Pixel size in mm is calculated by multiplying Object Position by Detector Spacing and dividing by Detector Position
* For parameters with 2x2 in their name, use the 1x1 values in the ScannerParameters file and divide by 2.
* For parameters with 4x4 in their name, use the 1x1 values in the ScannerParameters file and divide by 4.

Note: Ensure USB is now removed from the CT computer.

7. Re-enter the value for the <Home To Laser> tag, previously recorded in Step 10 on page 319.
8.) Click Save. Shutdown the system and restart OR restart the System Monitor on the Table (common) computer, and then on the CT computer.

PERFORM VERIFICATION SCANS

WHY DO THIS?

The following procedure is used to verify the calibration settings as well scanner stability.

Perform 4 wires Verification Scans Procedure:

Note: Perform scans with both the 30mm and 50mm 4 wire phantoms.

1.) Place the 30mm 4 wire phantom onto the bed and take a fluoro image. Make sure that phantom is inside the field of view.

2. Set the Exam field to Verification and Specimen to 4 Wire Phantom.
3.) Take a scan using CT InVitro High Resolution Protocol.
4.) On the Scan page, click on the scan name and click the Reconstruct button.
5.) Reconstruct three images at different Z positions, naming each accordingly:
    * Change the Output Name, enter Z=300 in the Offset field and Z=3 in the Size field and click the Submit Recon button.
    * Again, click on the scan name, and the last submitted recon parameters will be displayed. Change the Output Name. Enter Z=central slice in the Offset field (use value from System Properties in Figure 7-99) and click the Submit Recon button. Z should still be 3 in the Size field.
    * Click on the scan name, and the last submitted recon parameters will be displayed. Change the Output Name. Enter Z=1900 in the Offset field and click Submit Recon. Z should still be 3 in the Size field.

Note: Console must be connected to the scanner to see recon parameters.

6.) On the Console computer, type:

cd /media/data_disk/CT/Scan_xxxx/Volumes
{where Scan_xxxx is the scan number which can be found on the scan page (near the progress bar) or on the Explorer page}
ls [lower case L]

Open the three images in MicroView by typing:

MicroView "Output Name"

Each wire should be as round as possible.

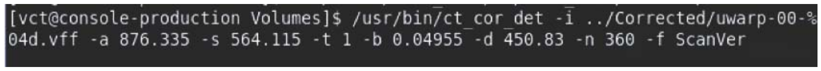


Figure 7-100

7.) Run /usr/bin/ct_cor_det -i ../Corrected/uwarp-00-%04d.vff -a [ ] -s [ ] -t [ ] -b [ ] -d [ ] -f [ ] -n [ ] (example in Figure 7-100) where:

* **-a** is center of rotation (u_0), from System Properties (Figure 7-99)
* **-s** is central slice (v_0), from System Properties (Figure 7-99)
* **-t** is angle increment. This is the same as "Increment Angle" on the Scan page (Figure 7-88)
* **-b** is voxel size from image properties in Microview. Open any corrected value from this acquisition and click on Image Information button
* **-d** is detector position from System Properties (Figure 7-99)
* **-f** is a new output file name of the user's choice
* **-n** is number of angles. This is the same as "Number of Views" on the Scan page (Figure 7-88)

Note: Square brackets are not part of the syntax

8.) Open file:

gnuplot
plot ["new file name of user's choice from previous step"]

A graph is displayed. Variation should be $\leq \pm 2$. If greater than ± 2, contact GE Healthcare.

Perform Quality Assurance Phantom Verification Scans Procedure:

1.) Place the QA phantom (Figure 7-101 or Figure 7-102) on the rat cradle with the 4 coils (visible from one end of the phantom) facing toward the rear of the table.

2.) Manually position the phantom (with the lasers toggled on) so that the transaxial or slice positioning laser lines up with the copper alignment wire.

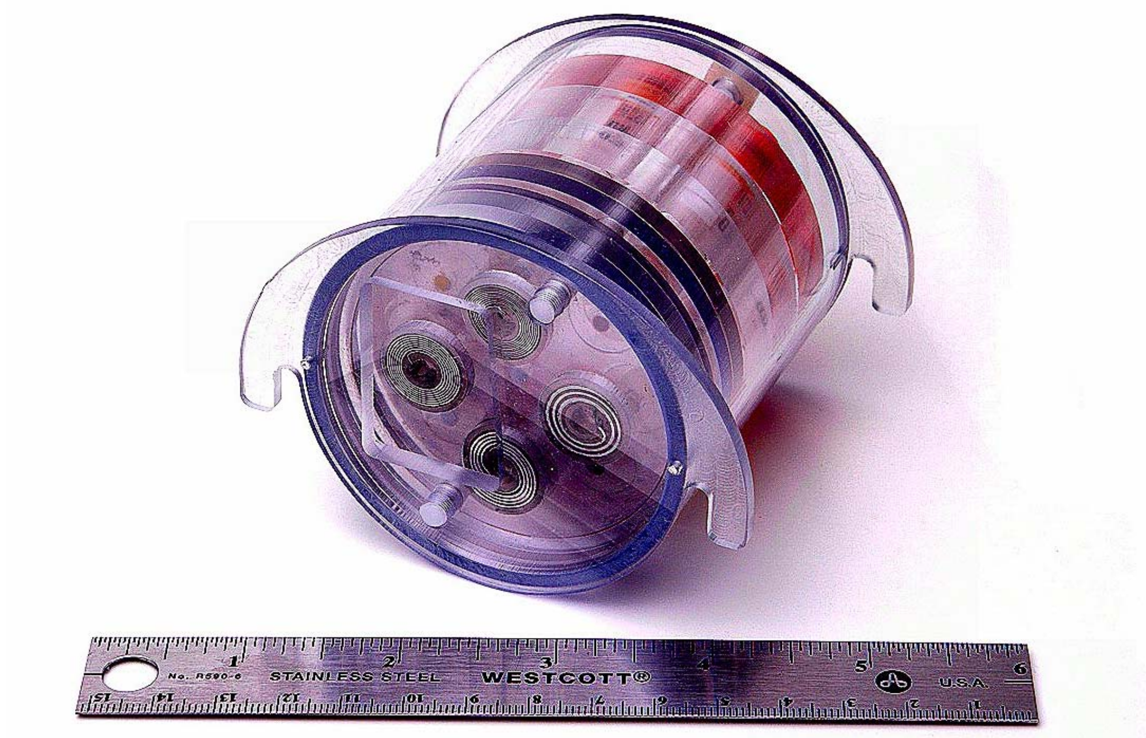


Figure 7-101

Figure 7-102

3.) Use tape (Figure 7-103) to secure the phantom to the cradle (ensure the tape does not cover the copper alignment wire on the geometric accuracy plate).

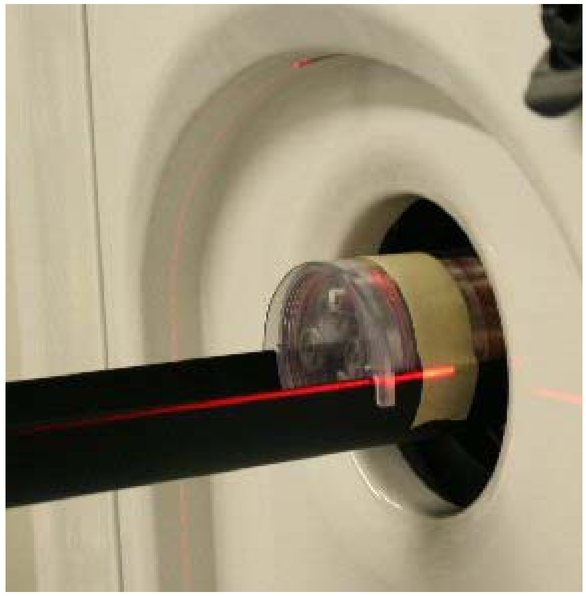


Figure 7-103

Note: The Tableside Controller may also be used to help line up the transaxial or slice-positioning laser with the copper alignment wire.

4.) Press the **Set** button for the laser plane on the Tableside Controller touch screen.

5.) Open the QA Phantom protocol by clicking "Select Protocol" and choosing from the list..

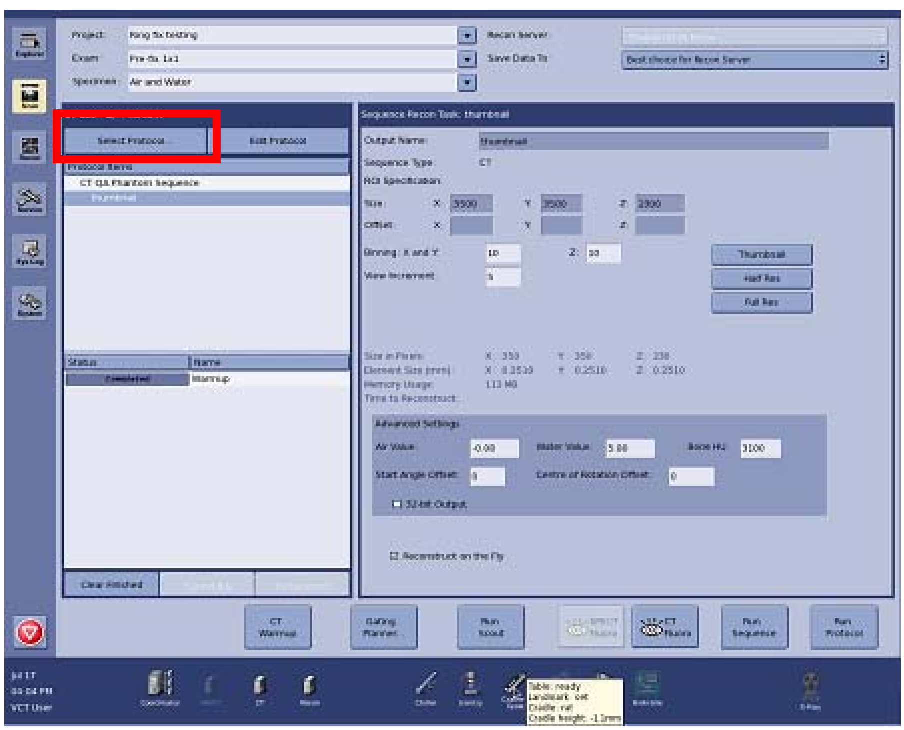


Figure 7-104

6.) Click the CT Fluoro button and ensure the copper alignment wire is aligned with the cross-hairs. Adjust cradle position if necessary. When satisfied, press stop x-ray button. If prompted to set the landmark to the current bed position, click 'yes'.

7.) Click Run Scout to get an image of the entire phantom. Select a region of interest (ROI) on the thumbnail to include the entire phantom.

8.) Click Run Sequence or Run Protocol. (This will take approximately 45 minutes to run)

9.) Open the thumbnail in MicroView by clicking on "thumbnail" under Name in Figure 7-105. Click the View button in the bottom left area of the Scan page.

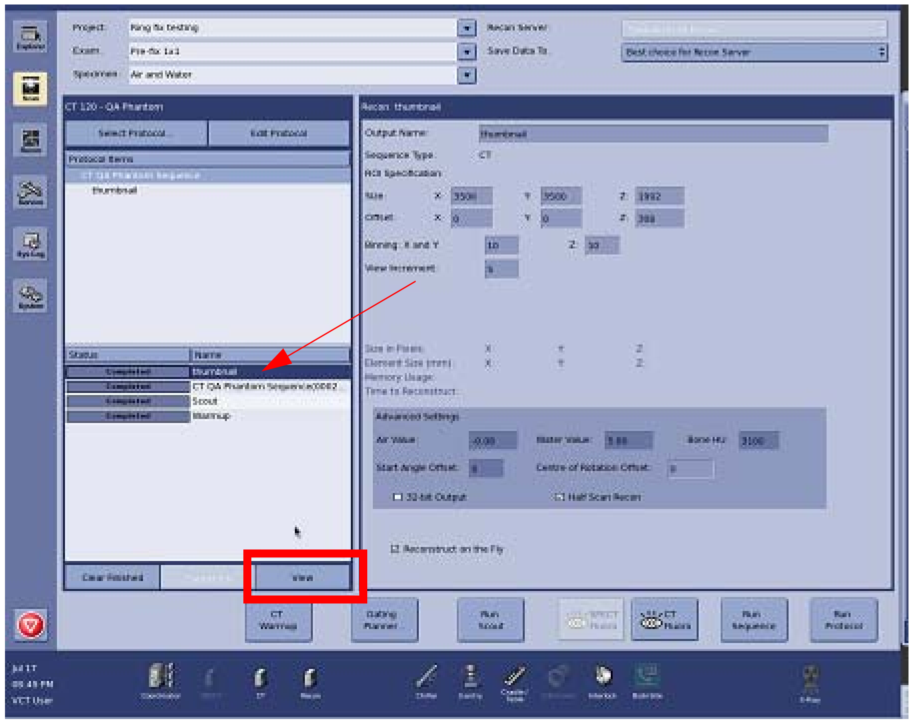


Figure 7-105

10.) In MicroView, click the fourth button from the left as shown by the arrow in Figure 7-106 and "drag" the viewing plane in the image with the mouse to find the BBs (as they appear in Figure 7-110).

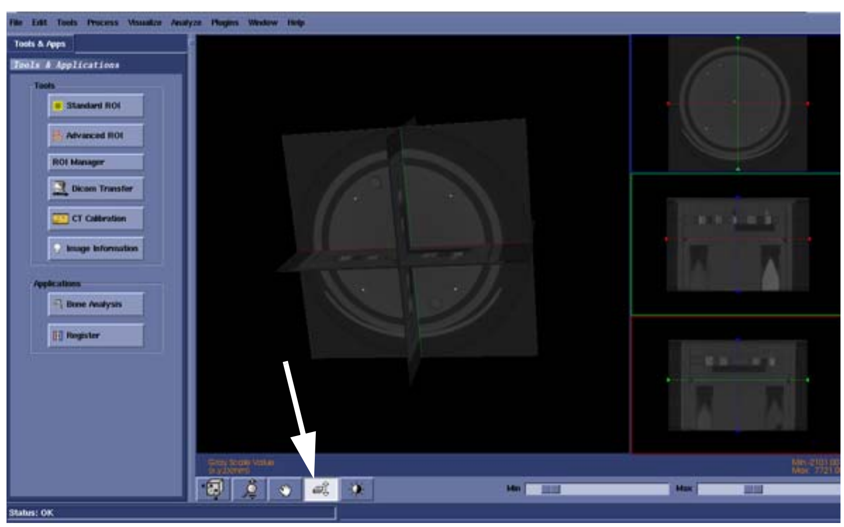


Figure 7-106

11.) Click the Standard ROI button in MicroView and use the sliders (in highlighted area in Figure 7-107) for x,y and z until a rectangular volume covers all 5 BBs (50 slices).

12. When you are satisfied with the ROI press the 's' key to save. (You can also select Save/ Crop Coordinates from the file menu).

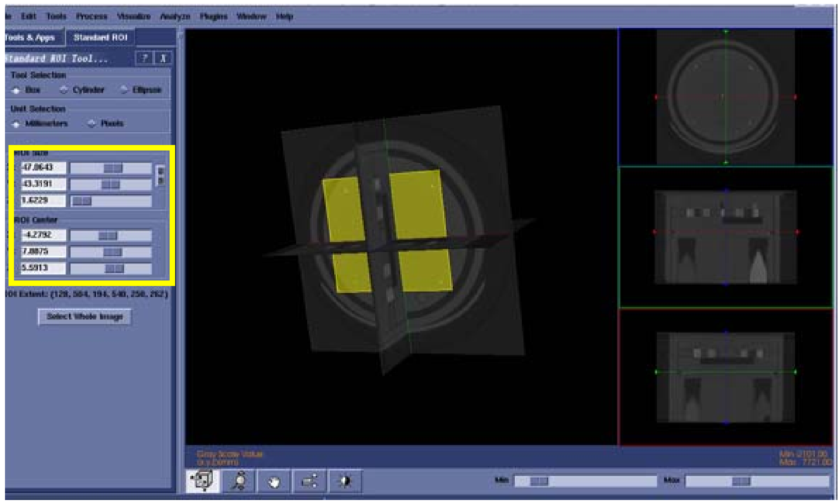


Figure 7-107

13.) Use Explorer to locate the QA scan. Select the uwarp scan and click on the Send to Recon button. Click on the Recon page button and select the unassigned recon.

14.) Reconstruct the selected ROI using full resolution (click Full Res button on the Recon page) and change output name to be: Geometric Accuracy Recon. (Figure 7-108). Click the Load ROI button ,and then click the Submit Recon button. Geometric Accuracy Recon now appears in the Recon queue (circled in Figure 7-109).

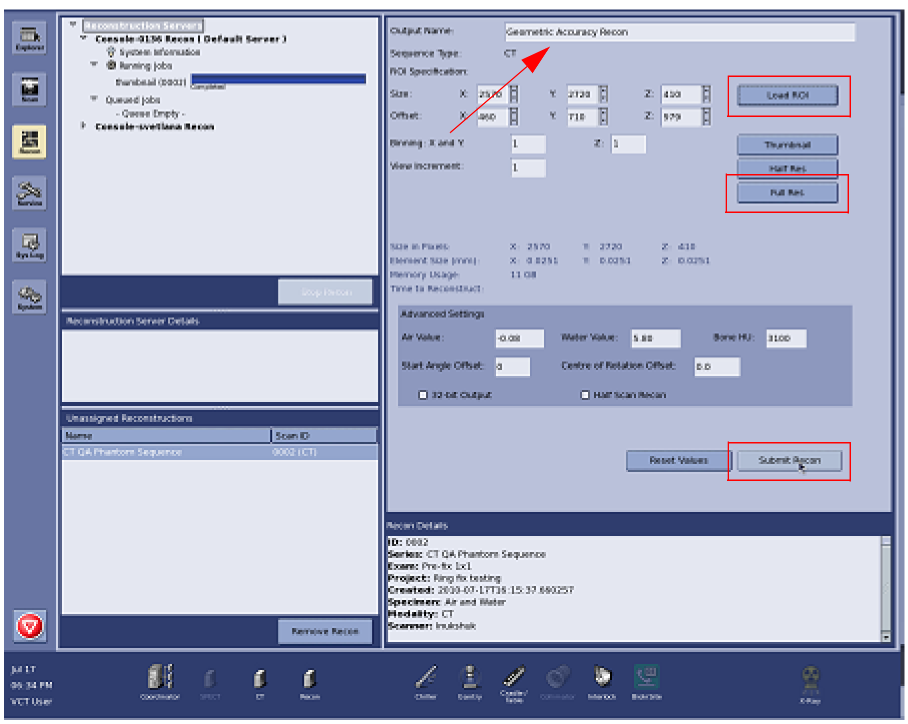


Figure 7-108

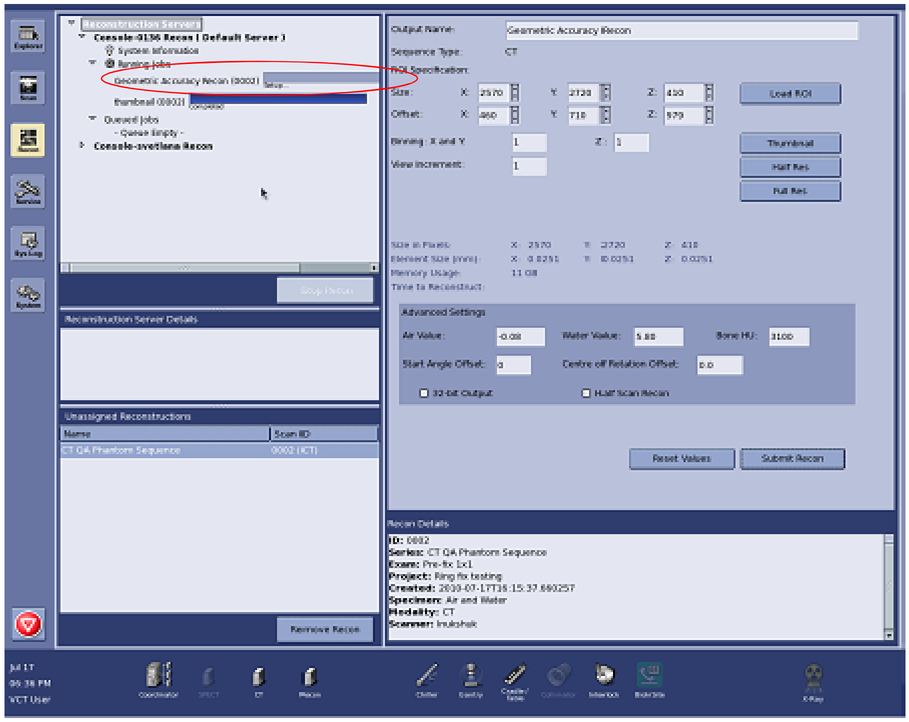


Figure 7-109

15.) From thumbnail of the Phantom, choose a 50-slice ROI. Go to the plane that shows all four coils. Adjust the ROI to select the finest coil (Figure 7-111).

16.) Reconstruct the selected ROI using full resolution and change the output name to be: SpatialResolution (refer to step 14).

Geometric Accuracy Test:

1.) Load the Geometric Accuracy Recon.vff file into Microview by double clicking its "Name" on the Scan page.
2.) Find the centroid of each BB using the full Region Grow feature. This is outlined in step 22 on page 322. Zoom into the top left BB, mouse over it and press the spacebar. The centroid is expressed in pixels.
3.) Measure the distances in voxels from the centroid of each BB to the centroid of all neighbouring BBs, using the Image Information button in Microview, and record. Alternately, simply calculate the distances from the centroid values.
4.) Multiply these distances by Voxel size (in mm) and compare these values to the ideal ones shown in Figure 7-110 using:
$d=(\Delta x^2+\Delta y^2+\Delta z^2)^{1/2}$ x Voxel Size
    * Voxel size can be found in Microview under Tools/Image Information.
    * These distances should be the values shown in Figure 7-110 ±1%.

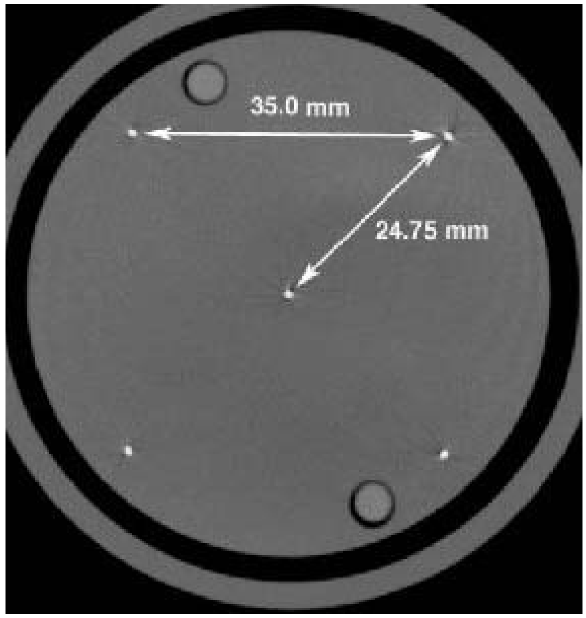


Figure 7-110

Spatial Resolution Test:

1.) Load the SpatialResolution.vff file into Microview by double clicking the file Name on the Scan page.
2.) Zoom into the finest coil using Shift+right mouse button. It should be easily resolved by simply changing the window level. This is done by double clicking on the W and L area in the bottom right hand corner of the MicroView screen (highlighted on Figure 7-112), choosing Window Level radio button from the dialog box and using the W and L sliders to change contrast.
3.) Select a ROI whose size is X=Y=1.5mm and Z=1.2mm.
4.) Change the location of the ROI center until you reach the finest resolution coil.

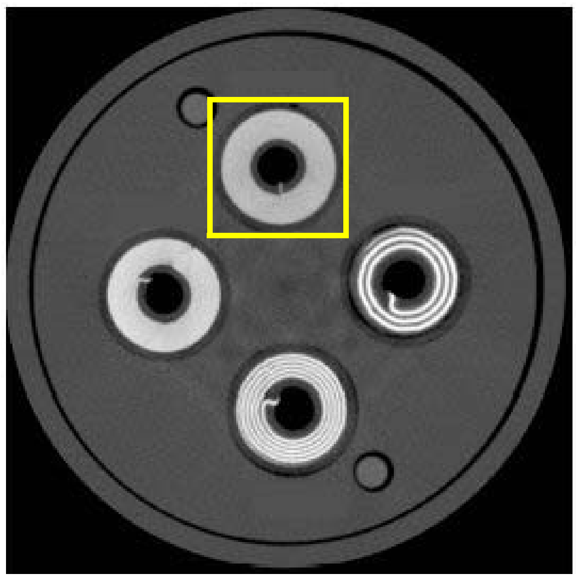


Figure 7-111

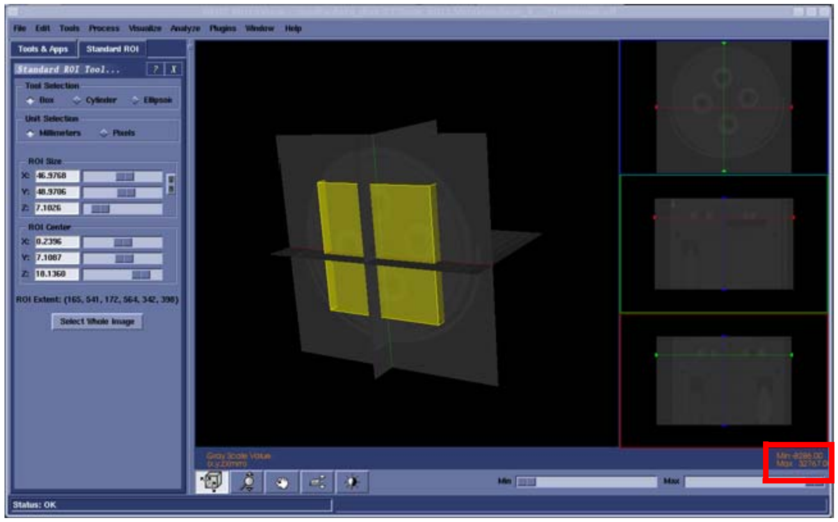


Figure 7-112

5.) At the four locations (top, right, bottom, left) on each coil, place ROIs (Figure 7-113). Ensure that each ROI is completely within coil pattern, especially the Z-direction.

6.) Find the Mean (M_i, i=1->4) and Std (σ_i, i=1,4) in each region, by pressing m.

7.) Change the location of ROIs to a place where there are no coils, but still within the volume and measure the standard deviation found in this region (σ_0).

8.) Now calculate $\sum_{i=1}^{4}(\sigma_i^2 - \sigma_0^2)^{1/2} / \sum_{i=1}^{4} M_i$

9. Alternately, in each ROI, divide each value of σ_i by its corresponding M_i .

Using either method, all results should be larger than 15%.

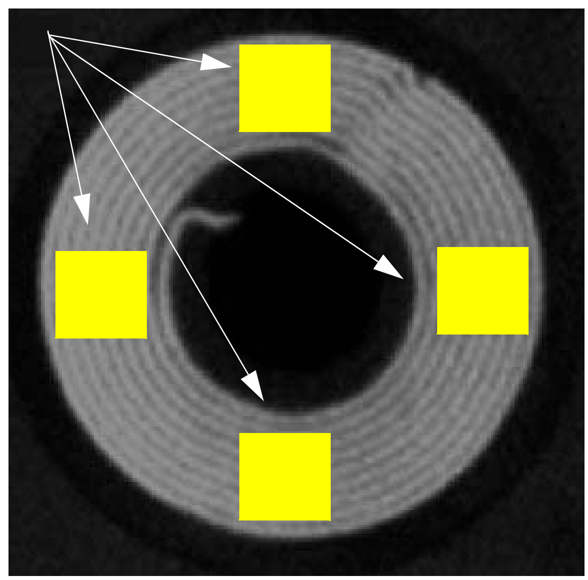


Figure 7-113

Section 7.3
Scan Planes Calibration

The procedures for calibrating the X-Ray tube rotational position, the Table home-to-laser position, SPECT scan plane and CT scan plane are outlined in this section. In addition, determination and correction of offsets between centers of rotation of the SPECT and CT scan planes is also described.

7.3.1 Gantry A-P / L-R Calibration

INTRODUCTION

For CT scans, it is important to be able to move the gantry to the A-P position (x-ray tube at 12 o'clock) and the L-R position (X-Ray tube at 3 o'clock). When service is performed, the home position may not be at either of these two locations, so, an A-P gantry location must be recorded as one of the CT settings.That is the purpose of this procedure.

Note: *A prerequisite for this calibration is the proper alignment of the table and SPECT/CT. See Section 4 of the eXplore speCZT CT Installation and Training Guide.*

Steps

1. Move the table to home, gantry to home, and turn on the lasers (Toggle Lasers button) using the Tableside Controller touch screen (Figure 7-114).

Perform the following steps while next to the scanner. The touch screen may be used to control the position of the table:

2. Place the mouse wire phantom on the cradle, securing it with tape.
3. Position the phantom so that the wires line up with the laser cross-hairs.
4. Set the laser landmark (arrow in Figure 7-114).
5. Close the scanner lid.

Perform the following steps from the console:

6. Ensure the interlock button is dim. Press it if it is lit up.
7. Ensure the console is connected to the scanner. Navigate to the system page and connect, if it is not currently connected.

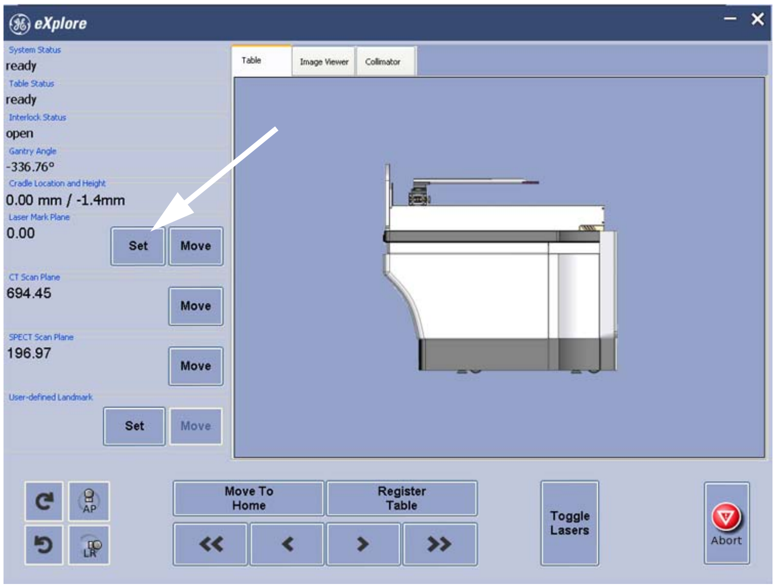


Figure 7-114

8. Navigate to the scan page (Figure 7-115).

9. Click the CT Fluoro button (highlighted in Figure 7-115) to begin a fluoroscopic scan. If the CT Fluoro button is disabled, check the interlocks.

10. When it appears, click the Start X-rays button.

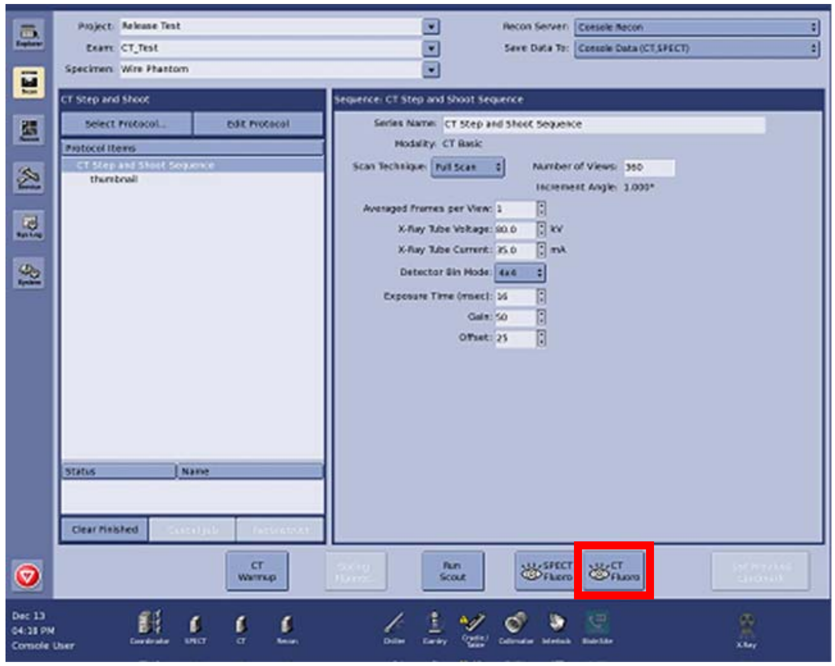


Figure 7-115

Images will appear on the console viewer. If the wire phantom does not appear in the image, adjust the table position until the phantom is visible. Use either the table motion buttons at the bottom of the viewer, or click on the table position indicator at the bottom of the viewer and enter an absolute table position (mm). Once the wire phantom is in the CT field of view, rotate the gantry until the cradle appears below the phantom and the wires are lined up so that from above there appear to be only three wires, instead of four. The top-most wire will hide the bottom-most. The gantry angle can be controlled with either the gantry buttons at the bottom of the viewer or by clicking on the gantry position indicator at the bottom of the viewer and entering an absolute gantry angle. Once the correct A-P gantry position has been determined, stop the fluoroscopic scan by clicking the Stop X-rays button.

11. Navigate to the service page and click the *System Properties* tab. Select *ct* from the drop down list to display the properties for the CT subsystem (Figure 7-116).

12. Find the *APOffset* element: <APOffset>42.50</APOffset>

13. Replace the value with the current gantry position and click the *Save* button to make the changes permanent. Navigate to the system page and shutdown the system. Power it back up and confirm the A-P and L-R positions by:

    a. Touching the A-P button on the Tableside Controller and starting a CT Fluoro.
    b. Confirming from the fluoroscan that only two wires are visible.
    c. Touching the L-R button on the Tableside Controller.
    d. Confirming from the fluoroscan that only two wires are visible.

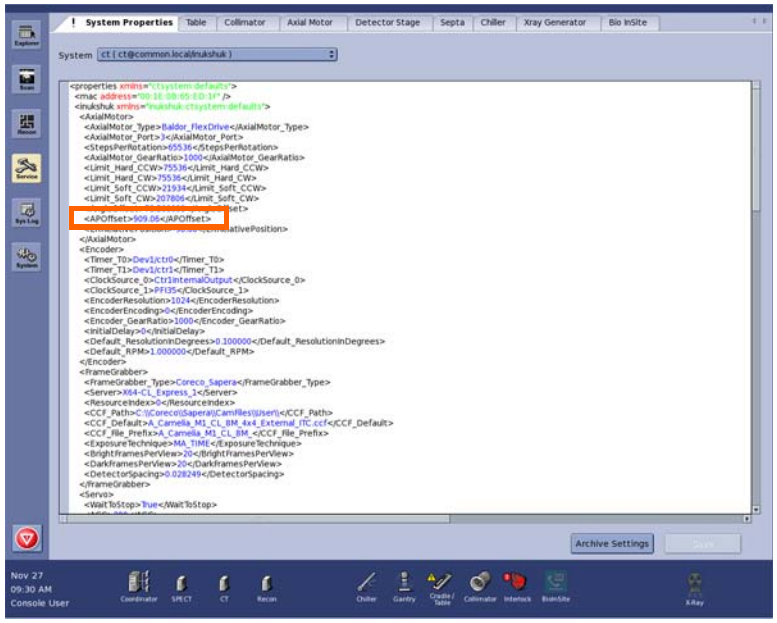


Figure 7-116

7.3.2 Table Scan Planes Calibration

INTRODUCTION

In order to map a landmark set using the landmark laser, the SPECT fluoroscan, or the CT fluoroscan, the system must know the relative distances between the landmark and each of the SPECT scan plane and the CT scan plane. Additionally, successful acquisition of CT scouts requires knowing the table location that places the tip of the cradle at the laser landmark.

Steps

1. Attach the mouse cradle and turn on the landmark laser (Toggle Lasers button in Figure 7-114).
2. Place the Co-57 line source near the tip of the cradle.
3. Using the touch screen controls, position the line source so that the end is at the laser cross-hairs.
4. On the touch screen, locate the Laser Mark Plane group and click the Set button (arrow in Figure 7-114). This will define a laser landmark at the current table position. Setting a laser landmark will automatically define the landmark positions at the SPECT and CT scan planes.

For the following steps, go to the console:

5. Navigate to the scan page and click the CT Fluoro button (Figure 7-115). The cradle will automatically be positioned in the CT scan plane. Click the Start X-Rays button to begin collecting CT images.These will appear on the viewer displayed on the rightmost monitor (Figure 7-117).

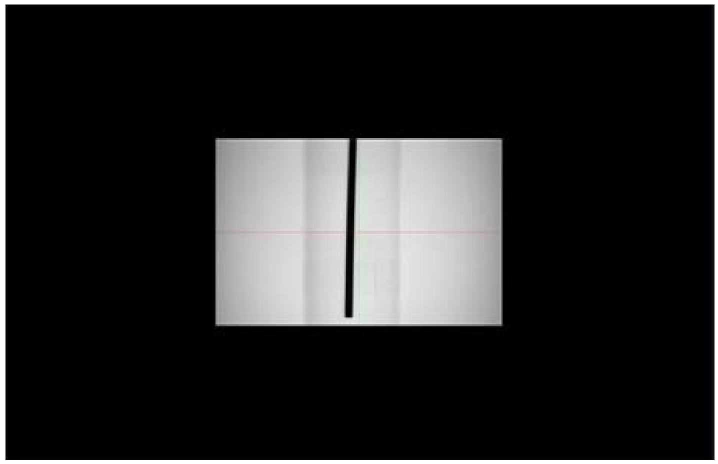


Figure 7-117

6. For a properly calibrated system, the tip of the line source will be exactly at the center of the CT field of view, denoted by a vertical green line in the viewer. If this is the case, the CT scan plane needs no adjustment. More likely, though, the cradle will need to be moved either forward or backward. Make note of the current table position. Use the table motion buttons buttons at the bottom of the viewer to position the cradle so that the tip of the cradle is located at the center of the field of view. These motion buttons work just like the ones on the touch-screen. Once positioning of the cradle is complete, make note of the table position. The difference between this position and the starting position is the amount the CT scan plane distance must be adjusted.
7. Click the Stop X-rays button to end the CT fluoroscopic scan. If the table was moved, a prompt to set a new landmark will appear. **DO NOT** do this. Click No to leave the landmark settings as they are. If a new landmark is accidentally set, go back to step 1.
8. Click the SPECT Fluoro button (refer back to Figure 7-115) to start a SPECT scan. Again, the table will move automatically. This time, it is moving to the SPECT scan plane. As it moves into the SPECT field of view, the image displayed on the viewer will be smeared. Once the table stops moving, click the Reset SPECT Viewer button.
9. The viewer will show the position of the line source (Figure 7-118). On a properly calibrated system, the tip of the line source is at the midway point (vertically) of the SPECT viewer. Make note of the current table position. Use the table motion buttons at the bottom of the viewer to reposition the line source. Whenever the table is moved, click the Reset SPECT Viewer button to clear away the old image information. Once the table position is satisfactory, make note of the new table position. The difference between this position and the starting position is the amount the SPECT scan plane distance must be adjusted.

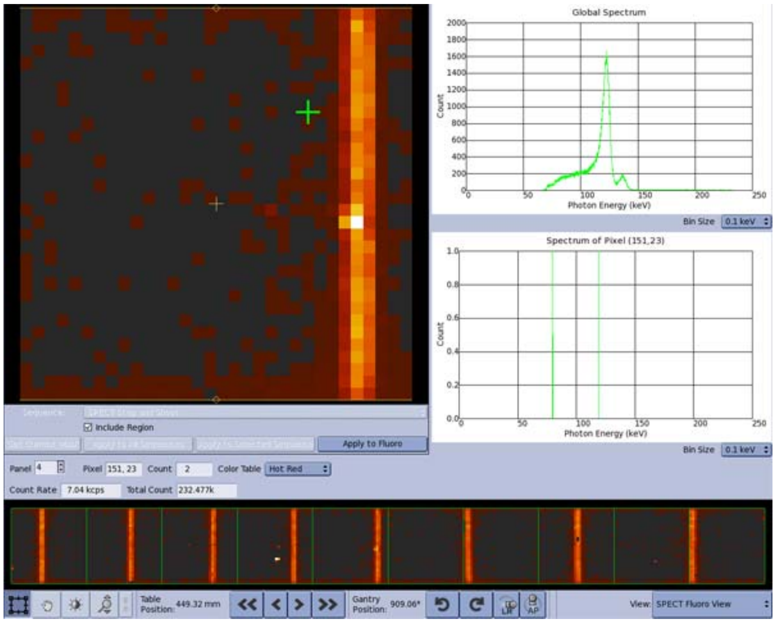


Figure 7-118

10. Click the Stop Fluoro button to end the SPECT scan. As before, there will be a prompt to set a new landmark, if the table position has changed. Click No to leave the current landmark settings as they are.
11. Navigate to the service page and select the System Properties tab. From the drop down list, select the syscoord entry.The current system coordinator properties will be displayed. Within the properties, find the ScanPlanes element:
<ScanPlanes>
<CTScanPlane>500.12</CTScanPlane>
<SPECTScanPlane>200.50</SPECTScanPlane>
<LaserPlane>0.00</LaserPlane>
<HomeToLaser>82.75</HomeToLaser>
</ScanPlanes>
Adjust the CT Scan Plane value by the difference calculated above (step 7). Similarly, adjust the SPECT Scan Plane value with the difference calculated above (step 10). The Laser Plane value remains unchanged at zero.
12. Click the Save button to make the changes permanent.
13. Navigate to the system page and shut down the system. Restart the system and test the new settings by repeating this procedure from step 4. Further table adjustments should not be necessary. If they are, repeat the whole calibration.
14. To test the home to laser calibrated distance, follow the Scout Position Calibration procedure for HomeToLaser Adjustment in Section 7.3.3 on page 341.

7.3.3 Scout Position Calibration (HomeToLaser Adjustment)

Introduction

For acquisitions, the system is guaranteed to have a total scannable region of 25 cm. Under CT, it is possible to plan such acquisitions using the CT scout. However, in an un-calibrated system, some of this 25 cm region may be past the tip of the cradle. To adjust for this, there is a calibration setting called HomeToLaser. This value is used in determining at which table position to begin the scout acquisition.

Steps

Note: Before proceeding, ensure that the scanner is on, the console application is started, and the scanner has been locked (connected).

1. From the scan page, click the CT Scout button 

and acquire an initial scout image. You will use this image to determine how much the HomeToLaser value needs to be adjusted.
2. Examine the resulting scout image. If there is a gap between the tip of the cradle and the top of the scout image, the HomeToLaser value must be increased. If, on the other hand, the table extends beyond the top of the image, the HomeToLaser value must be decreased.

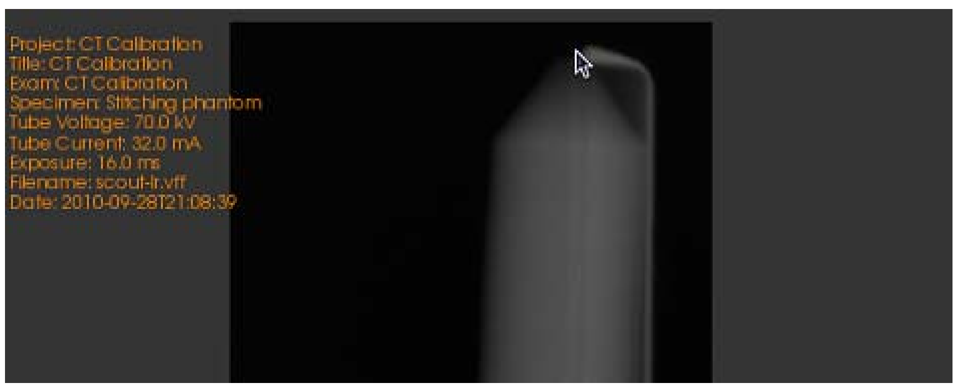


Figure 7-119

3. Move the mouse so that it hovers over the tip of the cradle in the scout image, as shown in Figure 7-19. At the bottom of the scout image, you will see the corresponding table components displayed. In particular, you want to make note of the z-axis position, which is circled in Figure 7-120 below.

Figure 7-120

4. Now move the mouse to the top edge of the scout image. Again, you will want to make note of the z-axis position of the table, as displayed at the bottom of the scout image (Figure 7-121) .

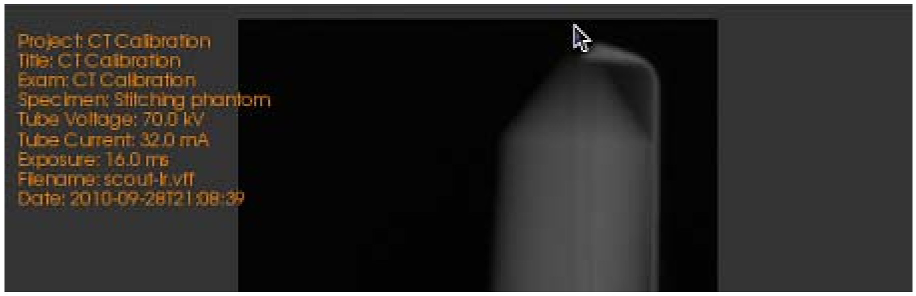


Figure 7-121

5. Subtract the first table position from the second table position (e.g., 270.752 - 266.661). The result is the amount that the HomeToLaser value will be adjusted.

Figure 7-122

6. Navigate to the Service panels and activate the System Properties tab. From the System drop-down, select the syscoord entry. The system coordinator's properties will be displayed. Find the HomeToLaser element and adjust its value according to the result from step 5.

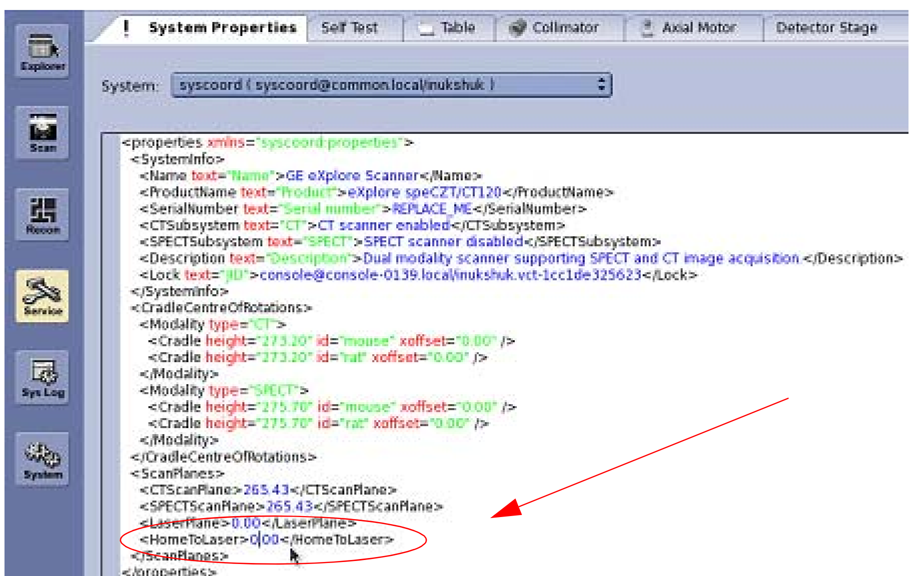


Figure 7-123

7. Click the save button 

and then power cycle the scanner (i.e.,shut down and restart it). The change in the settings will not take affect until this is done.

8. When the scanner is available, connect and run a confirmation scout scan to verify the new HomeToLaser setting. The result should look like the scout image in (Figure 7-124).

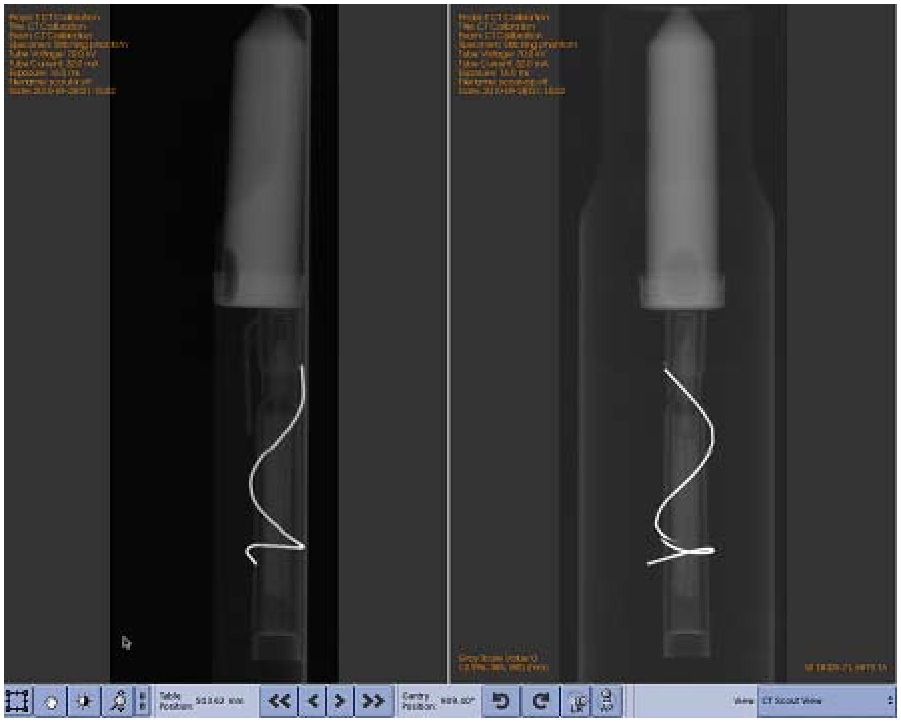


Figure 7-124

7.3.4 Landmark Offset Calibration

Introduction

In order to fuse CT and SPECT images, it is necessary to map the generated images to the physical world. This means that for a given physical location in the scanable area of one modality, it must be possible to map that point to a location in the scanable area of the other modality. Clearly, there is a difference in the axial location of the imaging planes, but there may also be transaxial differences as well.

The difference in the axial direction is accounted for by the calibration values that specify the distance between the scan planes for CT and SPECT and the laser landmark plane. These values were recorded in a previous calibration. The purpose of this calibration is to set the relative differences in x and y directions between the CT and SPECT scan planes (Figure 7-125).

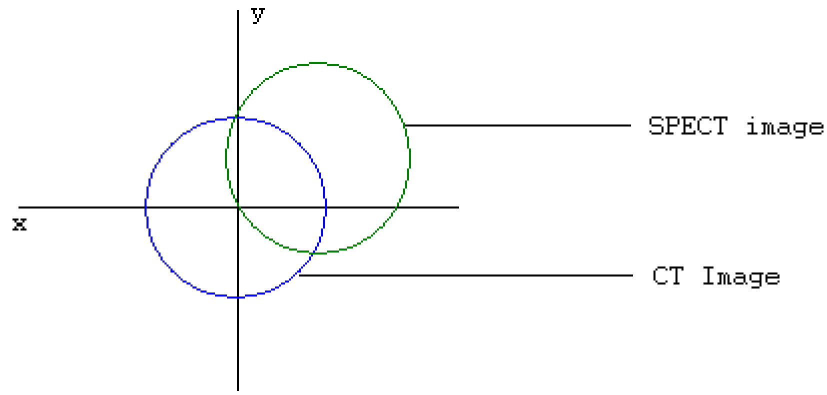


Figure 7-125

Consider the figure above. The CT image is given as the lower circle and the SPECT image is given as the upper circle. The difference in the z-axis (axial) direction has been accounted for. However, because of differences in the alignment and height of the acquisition hardware for the two modalities, the images are still not perfectly aligned. The calibration steps below will determine the offsets that need to be applied in order to get the images to be aligned.

Note: *A prerequisite for this calibration is the proper calibration of the scan planes and laser landmark plane*

Steps

1. Move the table to the home position, rotate the gantry to the L-R position and turn on the landmark laser.

Perform the following steps while next to the scanner. The touch screen can be used to control the position of the table and the setting of the laser landmark (Figure 7-114).

2. Replace the current cradle with the mouse cradle, if necessary.
3. Place the mouse wire phantom near the end of the cradle.
4. Use the touch screen table motion control buttons to position the phantom under the laser. The middle of the phantom should be hit by the laser (approximately).
5. Click the Set button for the laser landmark on the touch screen.

For the next steps, go to the Console:

6. Navigate to the scan page and click the CT Fluoro button to start a fluoroscopic scan. The table will move the phantom to the CT scan plane, and after a few seconds, images of the phantom will appear.

7. The image of the phantom is from the L-R position. Ideally, the red, horizontal line on the fluoro display will be running laterally through the center of the phantom. If it is not, perform step 8; otherwise, move on to step 9.

8. It will be necessary to move the cradle either up or down in order to get the center of the phantom at the center of the fluoro display. By hovering the mouse over the image, a measurement (in millimeters) of the phantom position can be obtained. Use this information to determine approximately how far off the cradle height is. Stop the fluoro scan using either the Abort or Stop X-Rays (preferred) buttons and go to the table and adjust the cradle height, accordingly.The height of the cradle is displayed on the touch screen. Once the height has been set, go back to step 6.

9. Make note of the cradle height. This must be recorded in the properties for the system coordinator (syscoord).

10. Remove the mouse phantom from the cradle, replacing it with the Co-57 line source.

11. Navigate to the scan page (Figure 7-126) and open the CT 120-Fast CT-SPECT (Co-57) protocol. For project, enter "Calibration", for exam, enter "Landmark offset", and for specimen, enter "Co-57 line source".

12. Again, use the CT fluoro scan to position the line source so that it all fits in the CT field of view. Stop fluoro when the position of the phantom is satisfactory. If the console prompts you to set the landmark, click OK to set a new landmark.

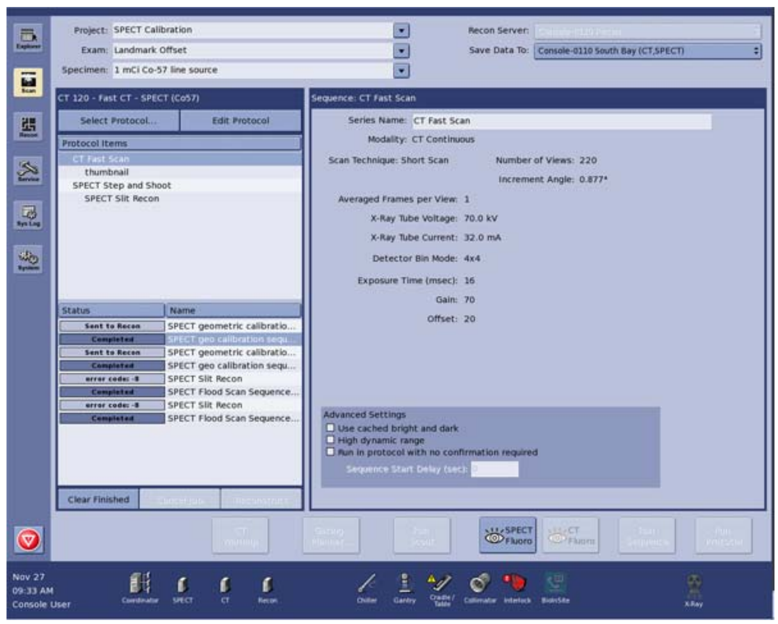


Figure 7-126

13. Click the Run Protocol button. The CT scan will occur first. When it is complete, click the Confirm Next Sequence button to proceed with the SPECT scan.

14. See Figure 7-127 (line source on cradle). In a properly calibrated system, the two images would automatically overlap each other perfectly (as in this example). Use the Register tool to determine the x offset for the two images (mm).That is, determine how much the SPECT image has to move in order to overlap the CT image. This is done by:
    a. On the Explorer page, click on the SPECT image name and click View.
    b. On the Explorer page, click on the CT image name and click View.

c. On the Explorer page, click on View Fused.
d. In Microview, click on the center of one of the images and hit 1 on the keyboard.
e. Click on the center of the second image and hit 2 on the keyboard.
f. The line length can be read from the Microview screen.

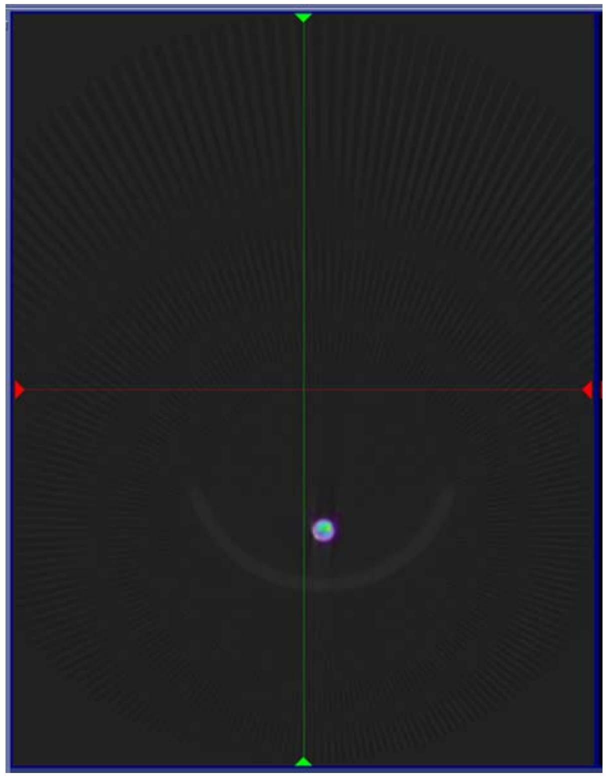


Figure 7-127

15. Make note of this value. Close MicroView.

16. Return to the Console and navigate to the service page. Click the System Properties tab and select syscoord from the drop down list (Figure 7-128). Within the system coordinator's properties, find the Cradle Center Of Rotations element:
<CradleCenterOfRotations>
<Modality type="CT">
<Cradle id="mouse" height="273.50"xoffset="0.00"/>
<Cradle id="rat" height="271.00"xoffset="0.00"/>
</Modality><Modality type="SPECT">
<Cradle id="mouse" height="275.00"xoffset="1.25"/>
<Cradle id="rat" height="272.50"xoffset="2.36"/></Modality>
</CradleCenterOfRotations>
Adjust the height values (in mm) of all the mouse cradle entries to match the values measured above. Then, adjust the x-offsets of the SPECT mouse cradle entry to match the value determined by the MicroView register tool. Click the Save button to make the changes permanent.

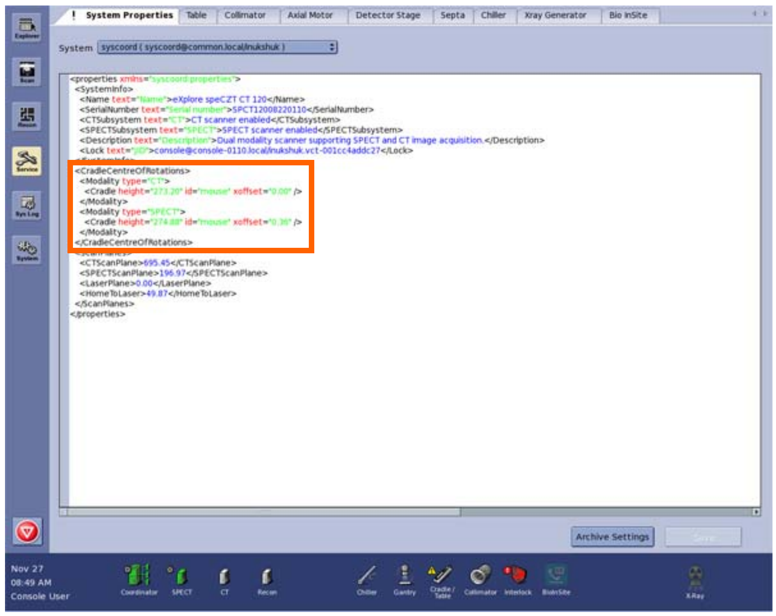


Figure 7-128

17. Repeat steps 1 through 17 for the rat cradle.

18. Navigate to the system page and shut down the system. Restart the system once power down is complete. Run a SPECT/CT small animal scan of the Co-57 line source to confirm that SPECT and CT images are automatically registered correctly. If the two images do not properly overlap, repeat this calibration.

Section 7.4
Table Calibrations

While the table registration procedure provides an automatic calibration of the table motor travel limits, there are other calibrations that must be performed manually. These include the calibration of the table height measurement and the cradle/collimator pairings (table-nanny properties).

7.4.1 Cradle/Collimator Pairings

INTRODUCTION

Because the cradle height can be adjusted, there exists the possibility of a collision between the cradle and the collimator if the cradle is either too high or too low to pass through the collimator opening. The system is able to identify both the cradle and the collimator. So, it is possible for the system to identify the potential for a collision, if the cradle/collimator pairings are propertly calibrated. Basically, you will be specifying the minimum and maximum height for any given cradle when combined with any given collilmator.

Steps

1. Navigate to the service page and click the *System Properties* tab. Select *table-nanny* from the drop down list to display the properties for the process that monitors for table collision hazards.
2. Define the collimator cradle combinations as per Figure 7-129.

```
<properties xmlns="inukshuk:table-nanny:properties">
  <limits>
    <limit collimator="mouse"           cradle="rat"   min="1000.00" max="-1000.00" table_max="0.00"/>
    <limit collimator="mouse"           cradle="mouse" min="0.00"    max="33.00"    table_max="0.00"/>
    <limit collimator="mouse 7 pinhole" cradle="rat"   min="1000.00" max="-1000.00" table_max="0.00"/>
    <limit collimator="mouse 7 pinhole" cradle="mouse" min="0.00"    max="33.00"    table_max="0.00"/>
    <limit collimator="no collimator"   cradle="mouse" min="0.00"    max="68.00"    table_max="0.00"/>
    <limit collimator="no collimator"   cradle="rat"   min="0.00"    max="25.00"    table_max="0.00"/>
    <limit collimator="rat"             cradle="rat"   min="0.00"    max="24.00"    table_max="0.00"/>
    <limit collimator="rat"             cradle="mouse" min="0.00"    max="57.00"    table_max="0.00"/>
    <limit collimator="rat 5 pinhole"   cradle="rat"   min="0.00"    max="24.00"    table_max="0.00"/>
    <limit collimator="rat 5 pinhole"   cradle="mouse" min="0.00"    max="57.00"    table_max="0.00"/>
  </limits>
</properties>
```

Figure 7-129

Chapter 8
Planned Maintenance

Section 8.1
Overview

8.1.1 Why Do Planned Maintenance?

A planned maintenance program monitors the equipment and guarantees the best results from good equipment performance.

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 planned maintenance and quality control. Maintaining accurate records which includes a well maintained history of the unit assists Field Engineers 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, Planned Maintenance Performance Checklists, and tracks updates to both the hardware and software.

8.1.3 Scheduling Planned 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 planned maintenance gives Field Engineers:

- 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 opportunity to verify calibration

- the opportunity to clean the unit

Major planned maintenance (such as an inspecting the wear components, cleaning the unit, and performing an "abridged calibration") occurs on a yearly basis. The Planned Maintenance Performance Checklist is used to record the results of this activity. A copy of this document is included at the end of this Chapter. One completed copy must remain with the system as part of the Device History Record.

8.1.4 Tools & Supplies

TOOLS

- Standard toolkit 2409482
- ESD Compliant Vacuum (e.g. Product code 9808T25 from McMaster-Carr www.mcmaster.com)

NOTICE Possible Equipment Damage

Be sure to use an anti-static vacuum, as using vacuum hose near electronic equipment may cause equipment damage due to static.

SUPPLIES

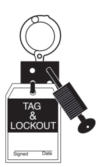
- Teflon Lubricating Oil (e.g. Tri-Flow Lubricant from McMaster-Carr www.mcmaster.com 1202K41)
- cleaning solution
- can of compressed air (Aero-Duster)
- lint free wipes (Kim Wipes)
- ADNOK-C grease (#46-297932P1) or Polyrex (2347076)
- neoprene or nitrite gloves (powder-free)
- Fan filters for CT cabinet (2387786, Qty 2)

WARNING

Always wear eye protection to avoid eye injury when using compressed air.

8.1.5 Safety Considerations

CAUTION



Be sure to tag and lockout the system when indicated. When cleaning the equipment, use neoprene or nitrite gloves to protect against any blood or other infectious substances.

Section 8.2
Planned Maintenance Procedures

8.2.1 Check Emergency Stop Buttons

1. If the system is not powered up, do so by pressing the green start button located on the side of the scanner (fig 8-1 left).
2. Using the Tableside Touch Screen, advance the specimen cradle about 2 feet from the Gantry.
3. On the Tableside Touch Screen locate the **Home** button and **Abort** button. First, touch the **Home** button; the cradle will move away from the gantry. Now, press the **Abort** and confirm that the cradle stops moving.
4. Locate the **Emergency Stop** mushroom button (fig 8-1 right), which is found on the gantry cover, just below the Tableside Touch Screen. Press the button down; confirm that the scanner immediately powers off. Also, confirm that the mushroom button remains depressed when released.
5. Wait for 10 seconds and then reset the **Emergency Stop** button by turning it counter-clockwise. Then, power up the system by pressing the green start button located on the side of the scanner. Note: typical start up time is about 15 minutes..

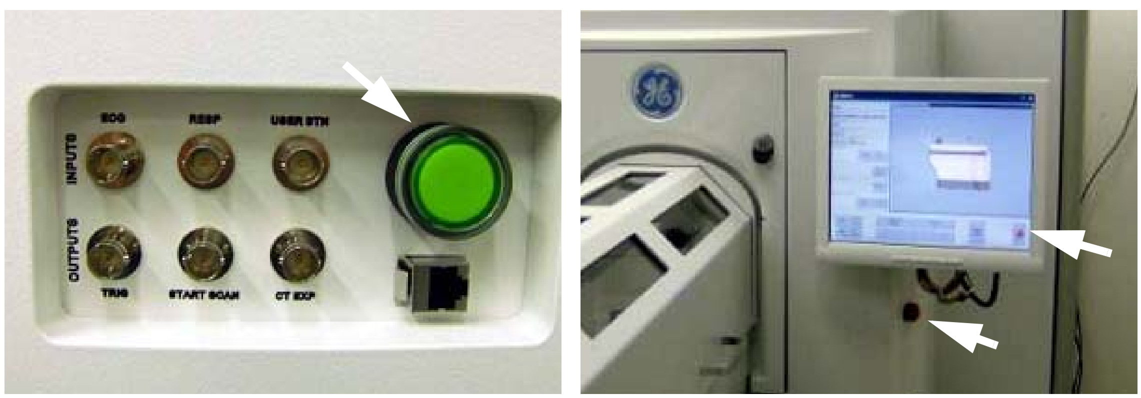


Figure 8-1

8.2.2 Specimen Table & Cradles

Remove the Table covers as outlined in Chapter 5.

CAUTION Be sure to wear neoprene or nitrite gloves when removing animal waste.

VACUUM INTERNAL TABLE

1. Use Lockout/Tagout procedures before proceeding.
2. Open the Table Shield.
3. Using an anti-static vacuum, vacuum inside the table. Be sure to vacuum the area just below where the specimen Cradle moves back and forth.

INSPECT AND CLEAN TABLE

1. Inspect the Table Shield for cracks and damage, especially around mounting hardware.
2. Inspect the Shield for loose or missing hardware.
3. Clean the Shield and Table interior with a lint-free cloth lightly dampened with soap water or denatured alcohol. Be sure to clean all animal waste. Check the edges and top of Table for contaminates.
4. Inspect, clean and grease Shield hinges as necessary.
5. Inspect and clean Shield slides. Grease *only* as necessary.

CHECK SPECIMEN CRADLE AND STAGE

1. Unlatch the Cradle from the quick release clamp.
2. Clean the Height Adjustment Stage and Cradle(s) with a lint-free cloth lightly dampened with soap water or denatured alcohol. Be sure to clean all animal waste from the Stage and Cradle(s). Grease the Stage scissor jack components. (Figure 8-2)
3. Ensure the Cradle ID optical sensor on the Stage is clean.
4. Inspect the bottom of the Cradle for cracks, tape, and residue.

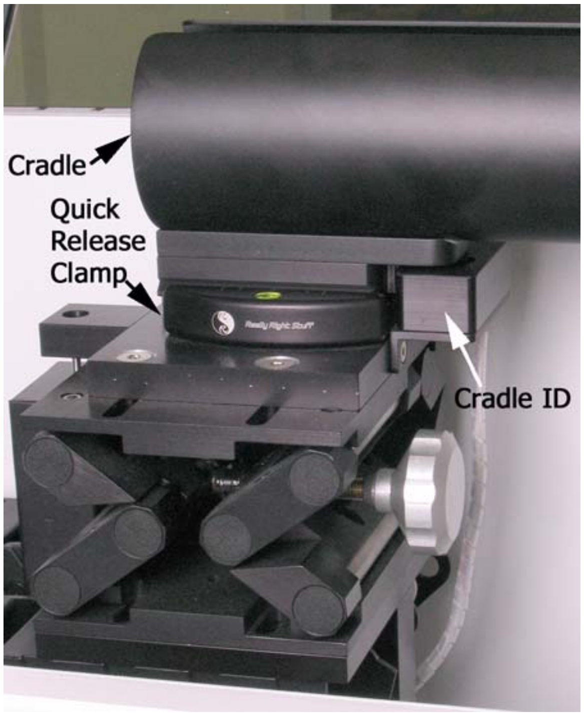


Figure 8-2

INSPECT AND VERIFY TABLE OPERATION

1. Inspect the limit switches and activation bracket/flags for damage. (Figure 8-3)
2. Restore power.
3. Use the Touch Screen to drive the Cradle along its full length of travel and ensure adequate clearances between the limit switch activation bracket/flag and the limit switches.
4. Verify that the Cradle moves smoothly along its full length of travel without noise or erratic motion. Check that limit switches are operational. See Functional Checks on the Table in Chapter 4 if more information is needed.

Figure 8-3

INSPECT AND CLEAN TABLE COMPUTER

1. Check that the fans in the rear of the computer are operational (no grinding or excessive noise) when running. Power down system.
2. Remove the Table Computer from Table, as described in Chapter 5, and remove the cover.
3. Using the anti-static vacuum with soft brush, carefully clean the interior, inlets and fan exhaust ports.

Note: *If the dust is thick, remove it from the screens and fans by hand.*

4. Vacuum the following (using care not to disturb wiring or bump any components):
   - rear computer exhaust
   - rear fans
   - front computer air intake
   - tower fan and front.
5. Reinstall and reconnect the computer.

TABLE COMPUTER MAINTENANCE

1. Power up the system. From the Console, access the Table (Common) Computer using **vncviewer**. Open windows **Explorer** and record initial free space available on the Table Computer hard drive on the Planned Maintenance Performance Checklist.
2. Run System Analyzer for defragmenting the hard drive:
   - Start-> Programs-> Accessories->System tools-> *Disk Defragmenter*

   If the system suggests defragmenting, continue with the defragmentation.
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 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.
   - If you see a critical error or alert, they are OS related. Consult the OS trouble shooting guide.
4. *With customer permission*, remove old files from the data directory to create additional free space.

8.2.3 SPECT Unit

CAUTION ***Except where noted, planned maintenance on the SPECT Unit involves removing the SPECT Unit covers and radiation shields and performing lockout/tagout procedures:***

- ***Follow topic 2.2.1 for lockout/tagout procedures***
- ***See Chapter 5 for instructions on removing the covers and accessing the SPECT Unit.***

INSPECT AND CLEAN SPECT COMPUTER

CAUTION Do not use lockout/tagout procedures or remove radiation shields at this time.

1. Check that the fans in the rear of the computer are operational (no grinding or excessive noise) when running. Power down system.
2. Remove the SPECT Computer from the base of the SPECT unit, as described in Chapter 5, and remove the cover.
3. Using the anti-static vacuum with soft brush, carefully clean the interior, inlets and fan exhaust ports.

Note: *If the dust is thick, remove it from the screens and fans by hand.*

4. Vacuum the following (using care not to disturb wiring or bump any components):
   - rear computer exhaust
   - rear fans
   - front computer air intake
   - tower fan and front.
5. Reinstall and reconnect the computer.

SPECT COMPUTER MAINTENANCE

1. Power up the system. From the Console, access the SPECT Computer using **vncviewer**. Open windows **Explorer** and record initial free space available on the SPECT Computer hard drive on the Planned Maintenance Performance Checklist.
2. Run System Analyzer for defragmenting the hard drive:
   - Start-> Programs-> Accessories->System tools-> *Disk Defragmenter*

   If the system suggests defragmentation, continue with the defragmentation.
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 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.
   - If you see a critical error or alert, they are OS related. Consult the OS trouble shooting guide.
4. *With customer permission*, remove old files from the data directory to create additional free space.

INSPECT AND CLEAN CHILLER

Ensure system power is OFF.

1. Inspect the Chiller screen (Figure 8-4 left). Vacuum to remove accumulated dust. Remove thicker debris by hand.
2. Check X-Ray Detector Coolant level, and top up as necessary (Figure 8-4 right). Coolant must be 2 inches below the O-ring level under the cap.
3. Check for leaks from the Chiller or hoses.

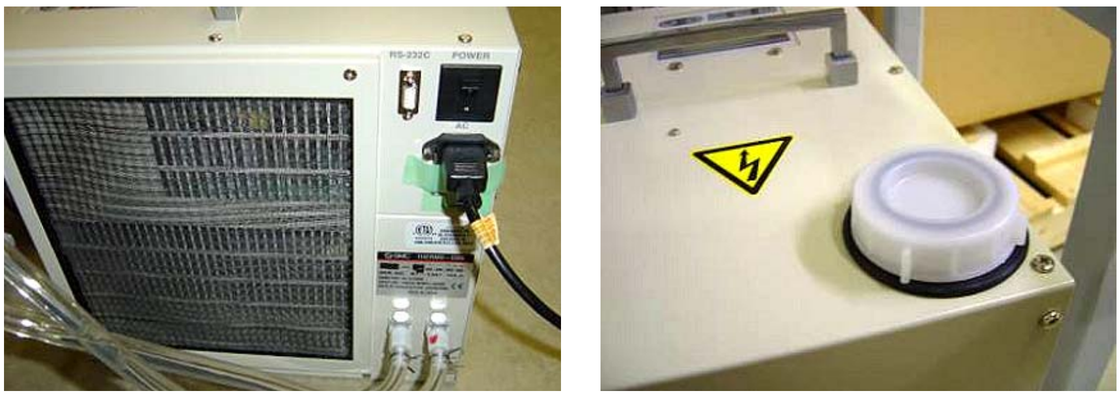


Figure 8-4

4. Verify that the LCD display on the chiller matches what the console is reporting. Hover the mouse over the chiller icon.

INSPECT COLLIMATOR AND SERVORING

1. Ensure a collimator is installed.
2. Power up the system and access the Collimator Service Page.
3. Press Scan for Collimator and ensure that Current Collimator shows the correct type. (Figure 8-5)
4. Visually check bar codes on all collimators to ensure they are clear and are not cracking or peeling. Replace labels as necessary.
5. Rotate the collimator and listen for abnormal noises coming from servoring. This is a non-serviceable item and will require replacement if faulty. Refer to Chapter 5 for service instructions..

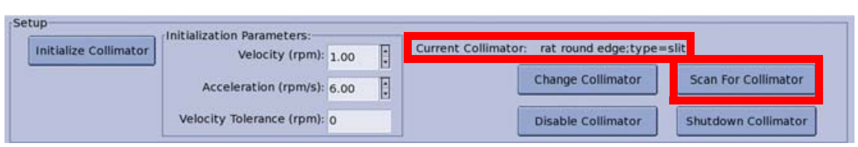


Figure 8-5

INSPECT SEPTA MOVEMENT

1. Access the Septa Service Page.
2. Choose the Move to Position radio button. (Figure 8-6)
3. If the septa is in its home position (retracted fully from the detector ring), choose InPos from the Named Position pull down and click Start. Listen to and observe the septa movement. Select Home from the Named Position pull down and click Start. Listen to and observe the septa movement. If movement in either direction is abnormally noisy or erratic, clean and grease the linear motion guide and linkages.

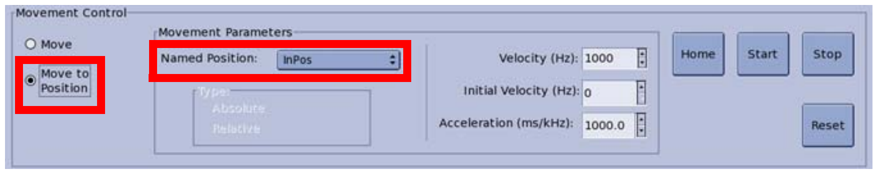


Figure 8-6

4. If the noise or erratic movement is not resolved, the Stepper Motor may need replacement. Refer to Chapter 5 for service instructions.
5. Move the septa to InPos and power down the system.

CLEAN SPECT MOUNTING PLATE

CAUTION

1. Lockout and tag the system.
2. Remove radiation shields as described in Chapter 5.

NOTICE Equipment Damage Possible

3. *Carefully* vacuum the SPECT Mounting Plate (on which the septa linkage and motion guide are mounted) and SPECT unit interior. DO NOT contact the septa with the vacuum wand.

CLEAN SEPTA PROTECTION ("P") TUBE

1. Carefully remove four nylon set screws holding the tube to the drip tray on the SPECT unit rear panel.
2. Remove the tube and thoroughly clean it.
3. Clean the drip tray.
4. Reassemble the tube to the drip tray.

8.2.4 CT Unit

CAUTION ***Except where noted, planned maintenance on the CT Unit involves removing the CT Unit covers and performing lockout/tagout procedures:***

- ***Follow topic 2.2.1 for lockout/tagout procedures***
- ***See Chapter 5 for instructions on removing the covers and accessing the CT Unit.***

INSPECT AND CLEAN CT COMPUTER

1. Do not perform lockout/tagout procedures at this time. Power up the system.
2. Check that the fans in the rear of the computer are operational (no grinding or excessive noise) when running.
3. Remove the CT Computer from the base of the CT unit, as described in Chapter 5, and remove the cover.
4. Using the anti-static vacuum with soft brush, carefully clean the interior, inlets and fan exhaust ports.

Note: *If the dust is thick, remove it from the screens and fans by hand.*

5. Vacuum the following (using care not to disturb wiring or bump any components):
   - rear computer exhaust
   - front computer air intake
   - rear fans
   - tower fan and front.
6. Reinstall and reconnect the computer.

CT COMPUTER MAINTENANCE

1. Power up the system. From the Console, access the CT Computer using **vncviewer**. Open windows **Explorer** and record initial free space available on the CT Computer hard drive on the Planned Maintenance Performance Checklist.
2. Run System Analyzer for defragmenting the hard drive:
   - 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.
   - If you see a critical error or alert, they are OS related. Consult the OS trouble shooting guide.

4. *With customer permission*, remove old files from the data directory to create additional free space.

VACUUM CT UNIT BASE

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Using an anti-static vacuum, vacuum the base of the CT unit where dust and lint may collect.

CLEAN "P" TUBE

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Remove "P" tube from disc by removing six (6) 4mm bolts from the front side of the disc.
3. Clean the tube thoroughly.
4. Reassemble the tube to the disc and torque the screws to a maximum of 20 in-lb.

CLEAN AIR INTAKE AREA & CHANGE FILTER ON LEFT AND RIGHT SIDE SHIELDS

The air intake filter (Figure 8-7) consists of 3 pieces: the filter mount (left), a porous filter (middle), and a fan shield on the inside (right). The filter has a friction fit on the filter mount.

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Snap the filter off the filter mount.
3. Using an anti-static vacuum, vacuum the filter mount and around the fan shield.
4. Place a new filter on the filter mount by snapping it into place.

Figure 8-7

CLEAN GENERATOR CONTROL BOX

NOTICE Equipment Damage Possible Once the Box is opened, there are exposed PCBs. Do not use a vacuum on the box interior.

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Access the Box interior by removing four screws and lifting off the cover.
3. Judiciously or quickly dust the box using a can of compressed air.
4. Replace the cover.

CLEAN COLLIMATOR AND X-RAY TUBE OPENING

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Turn the disc by hand until the tube is in a position for convenient access.
3. Remove screws holding the the collimator and filter over the tube opening, remove and clean.
4. *Carefully* vacuum the tube opening.
5. Replace the filter and collimator and fasten with the same screws.

CLEAN TUBE FANS & FAN GUARDS

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Turn the disc by hand until the tube is at 12 o'clock. The heat exchanger is mounted on the left side of the tube and has 2 large black fans mounted directly to it.
3. Using an anti-static vacuum, vacuum the guard that is exposed opposite to the fans.
4. Once the power is restored to the system, check to see if there is airflow from the fans and that the fans are not making any abnormal noises (clicks or grinding).

CLEAN DETECTOR HEAT SINKS AND FAN

NOTICE Possible Equipment Damage *Take extra caution when performing the following due to delicate parts.*

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Turn the disc by hand for easy access to the Detector. There are two heat sinks mounted on the back side of the Detector, which, in turn, have a single fan mounted next to them.
3. Using an anti-static vacuum, vacuum around the heat sinks and the fan.
4. Once the power is restored to the system, check to see if there is airflow from the fan and that the fan is not making any abnormal noises (clicks or grinding).

CHECK/CLEAN DETECTOR SCAN WINDOW

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Check the scan window for any scratches or dirt, and any physical damage to the window or sealing rubber.
3. Clean the scan window using a lint-free wipe and cleaning solution.

CHECK DETECTOR TEMPERATURE AND OPERATION OF COOLER

Detector temperature and cooler status can be checked using the "Chiller" icon at the bottom of the user interface. Holding the mouse over this icon will bring up a tooltip listing the status ("OK") and temperature (should be 19 degrees C while the scanner is running).

INSPECT GENERATOR & HIGH VOLTAGE CABLES

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Rotate the Gantry until you have easy access to the Generator.
3. Inspect the high voltage cable receptacles for any oily residue.
4. If a leak exists, determine whether any damage exists.
5. If no damage exists, replace the oil in the cable receptacles and tighten the connections.

INSPECT CABLE JACKETS IN ENERGY CHAIN

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Look for chafing, tearing or cracking in the jackets (outer sheaths) of all cables in the Energy Chain Cable Track. This will involve hand rotation of the disc and removal of clips from the Cable Track to enable inspection. Identify any damaged cables in the PM Chart.
3. Replace the cable if available, or schedule a service call for a later time.

INSPECT CLIPS ON ENERGY CHAIN

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Ensure that all clips are secure on the Energy Chain Cable Track

INSPECT THE DRIVE BELT

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Visually inspect the Drive Belt looking for frayed edges, cracks, etc.
3. Replace the Belt as necessary.

Note: *Check the entire length of the Drive Belt by manually rotating the disc two rotations.*

INSPECT THE TIMING BELT

CAUTION

1. Use Lockout/Tagout procedures before proceeding.
2. Remove the Hard-Soft Stop Shield as described in Chapter 5.
3. Visually inspect the Drive Belt looking for frayed edges, cracks, etc.
4. Replace the Belt as outlined in Chapter 5, if necessary, and replace the Hard-Soft Stop Shield.

CHECK AND CLEAN TOP FANS

1. Once the system is powered up, check the 2 fans on the top of the unit.
2. Ensure there is airflow coming off of the fans and that the fans are not making any abnormal noises (clicking or grinding). Additionally, when the fans are properly balanced, they should not be vibrating excessively.
3. Shut off the system and vacuum the fan grills.

CHECK AND CLEAN HARD-SOFT STOP LIMIT SWITCH

1. Through the Axial Motor Service Page, set up the disc to rotate to a limit.
2. Activate the Hard-Soft Stop limit switch to verify that it stops the Axial Motor rotation.

CHECK AND CLEAN HARD-SOFT STOP OPTICAL SENSOR

TBD

GREASE MAIN BEARING

1. Grease main bearing approximately every 1.5 million revolutions. Add 1 cartridge (25cc) of grease every 1.5 million revolutions. Use only ANDOK-C grease or Polyrex.

LISTEN TO THE MAIN BEARING AND BALDOR GEARBOX

1. Once the system is powered up, listen for clicking or grinding emanating from the main bearing or gearbox.
2. Ensure that noise is not emanating from the Energy Chain Cable Track.
3. If the gearbox is at fault, replace as outlined in Chapter 5.
4. If the main bearing is at fault, replacement is an involved process. Note the failure on the PM Checklist and schedule a service appointment

CHECK CONNECTORS ON DISC AND STATIONARY BASE

1. Ensure that all cable connectors are securely locked in place. Pay special attention to all connectors on the disc, as they are most likely to loosen.

REPLACE LIGHT BULBS

1. Replace light bulbs in the two cabinet X-Ray On lights and the X-Ray Warning Light Box.

8.2.5 X-Ray Generator Calibration

1. Power up the system. Wait for all computers to boot.
2. Access the CT computer from the Console by typing vncviewer.ct.local in a terminal window. In the Start menu, look for Genware Utilities and click on Genware generator utilities.
3. Select “Setup” from the top menu bar and Tube selection as in Figure 8-8. Select PX1483 0.3/1.0 and then press “download”.
    - * The information should pop-up “data is successfully written to generator".
    - * Tube name becomes “ PX1483 0.3/1.0 Revision 1.0” on the top of center window.

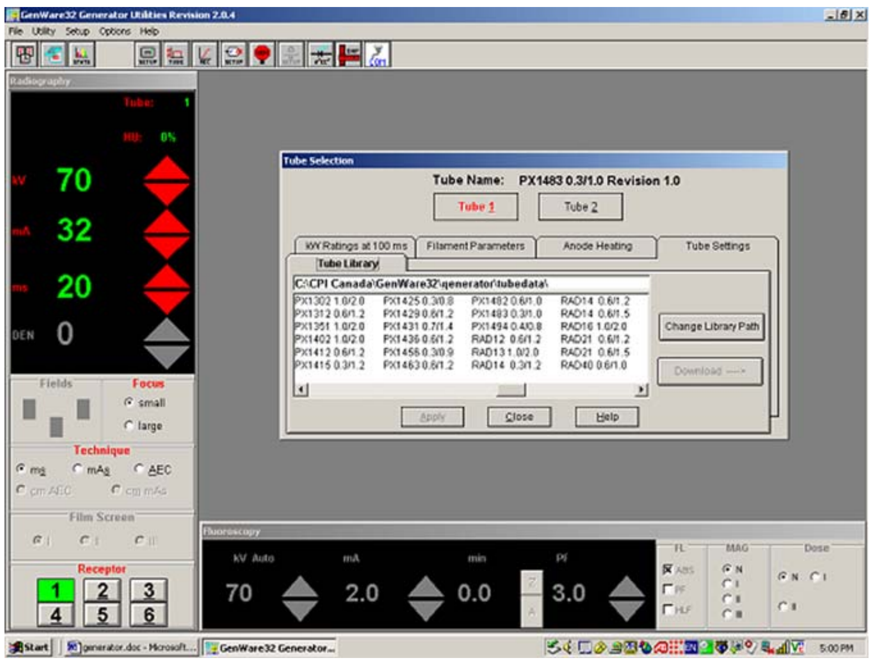


Figure 8-8

4. Checking the settings to ensure they are the same as in the following screens:

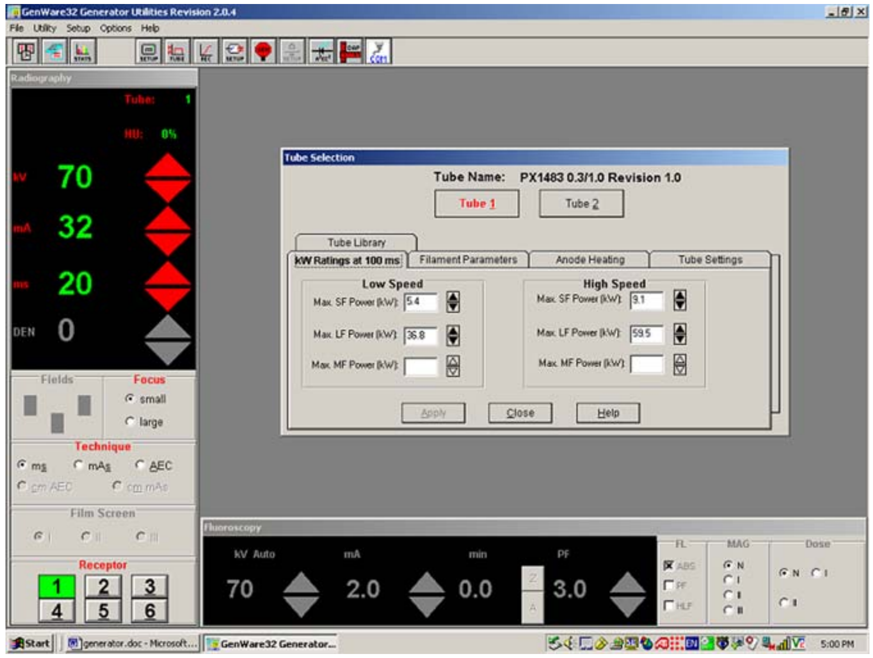


Figure 8-9

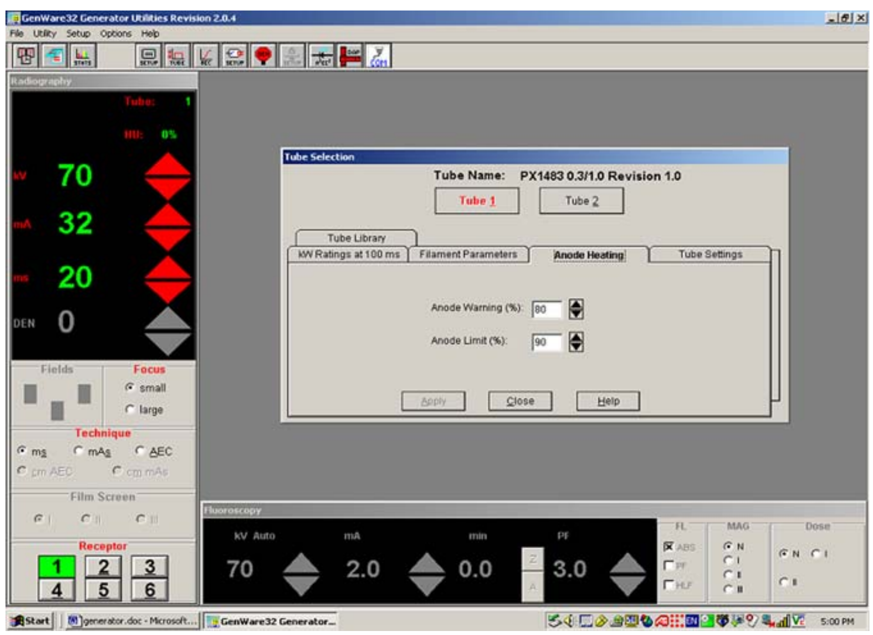


Figure 8-10

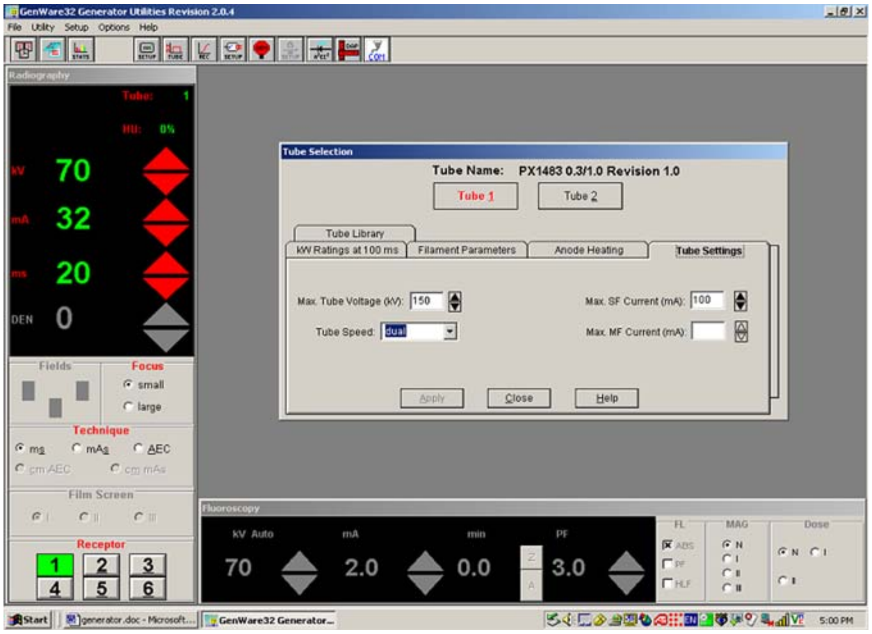


Figure 8-11

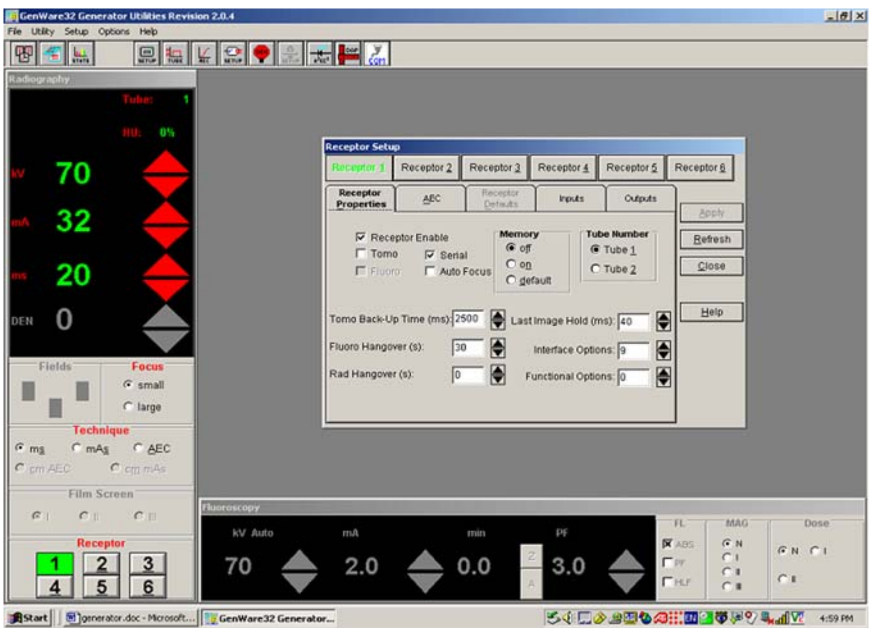


Figure 8-12

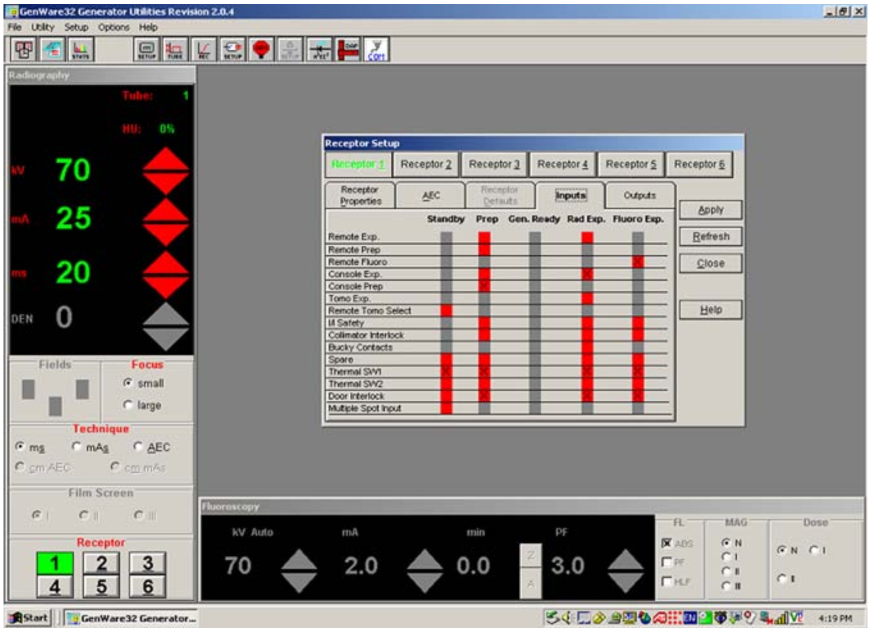


Figure 8-13

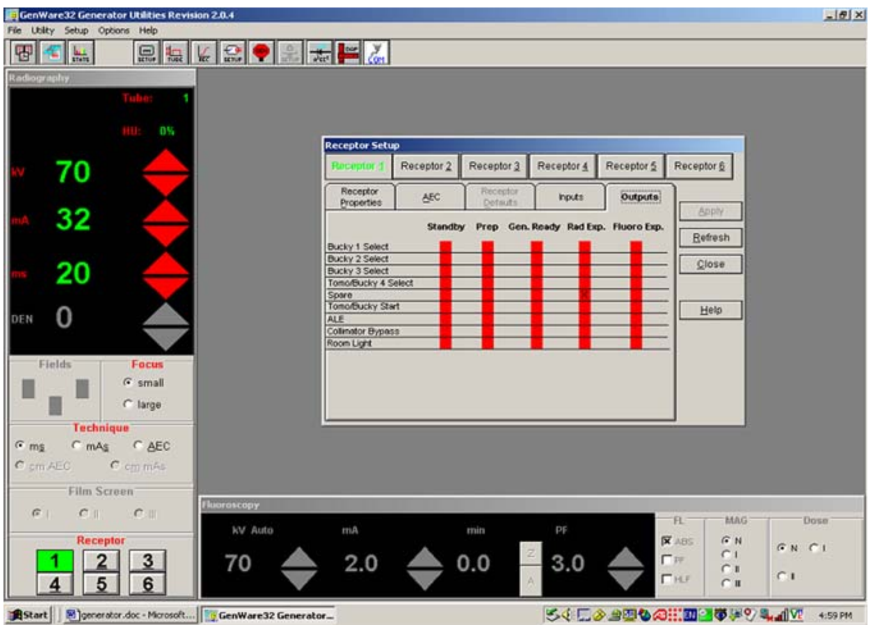


Figure 8-14

5. Double-click the icon labeled “CPIGeneratorCameraInterface.exe” on the windows desktop. (Figure 8-15)

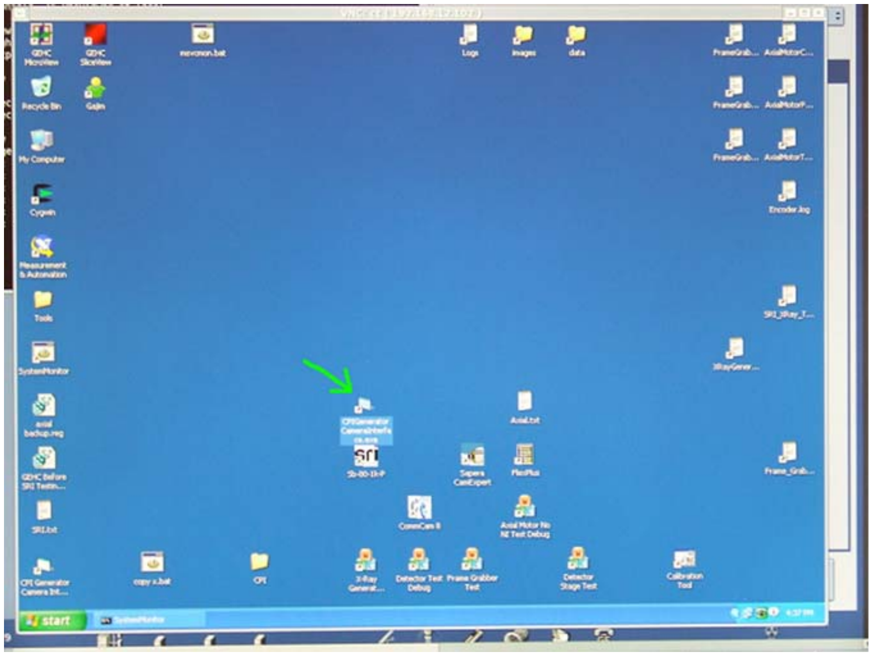


Figure 8-15

6. Click “Generator On” to turn on the CPI generator. (Figure 8-16)
7. Wait 2 minutes for the generator to power up.

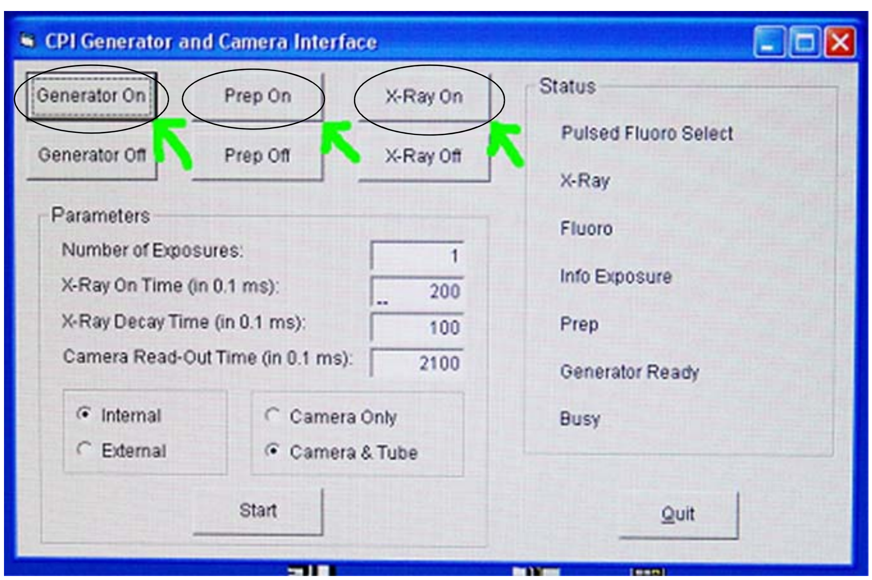


Figure 8-16

8. Select Auto Tube Calibration from the Setup menu. (Figure 8-17)
9. Choose “Tube 1” and “Focus: Small”. (Figure 8-17)

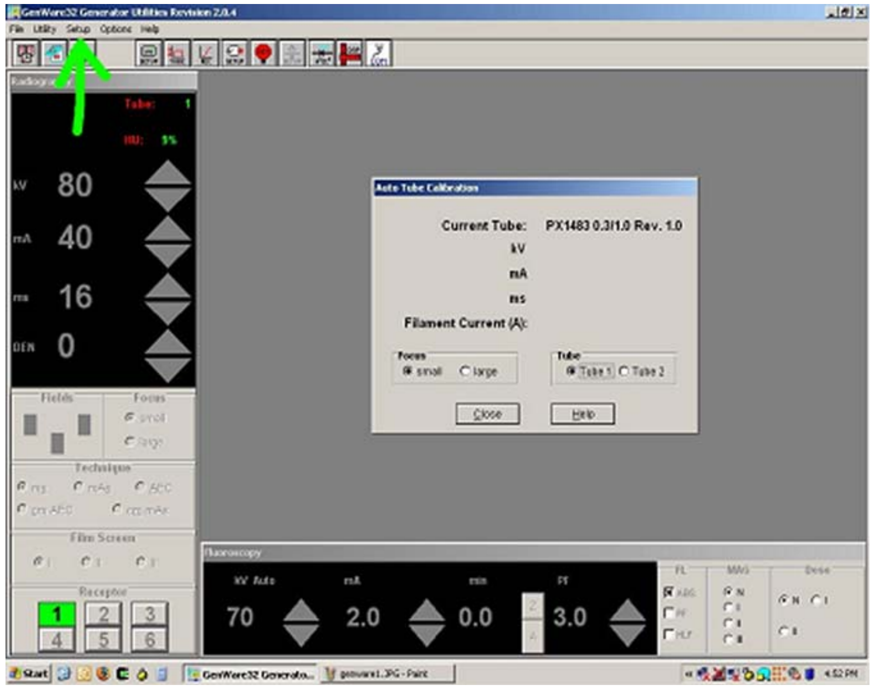


Figure 8-17

10. At the Console computer, click “Prep On” and “X-Ray On” in the CPIGeneratorCameraInterface.exe window (within the VNC window). (Figure 8-16)
11. Wait 5 minutes for the completion of the auto calibration procedure (the “ticking” sound from the generator will cease, and the x-ray logo in the Genware window will stop flashing).
12. Click on “Prep Off” and “X-Ray Off” in the CPIGeneratorCameraInterface.exe window.
13. Click on “Focus: Large”, then repeat steps 10 to 12.

The calibration procedure is now complete.

8.2.6 Console Computer

CLEAN MOUSE

1. If an optical mouse is used, wipe optical mouse lens or blow lens free of dust.
2. If a ball mouse is used, 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. Remove the computer cover.
2. Using the anti-static vacuum with soft brush, carefully clean the interior, inlets and fan exhaust ports.

Note: *If the dust is thick, remove it from the screens and fans by hand.*

3. Vacuum the following (using care not to disturb wiring or bump any components):
   - rear computer exhaust
   - front computer air intake
   - rear fans
   - tower fan and front.
4. Wipe the Tableside Touch Screen gently with a soft dry cloth (microfiber cloths such as those used to clean eyeglasses are excellent for use with LCDs).
5. 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.

6. Vacuum the keyboard to remove any debris that settles.
7. 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.
8. Install cover and power up the computer.

COMPUTER MAINTENANCE

1. Open windows **Explorer** and record initial free space available on Hard drives (C: and D:) on the Planned Maintenance Performance Checklist.
2. Go to c:\inukshuk\data. *With customer permission*, delete old data files to free up additional space.
3. Run System Analyzer for defragment on C: and D:
   - Start-> Programs-> Accessories->System tools-> *Disk Defragmenter*

   If the system suggests defragmentation, continue with the defragment.
4. 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.

ADJUST MONITOR

1. Press the auto adjustment button on the bottom right of each monitor.

8.2.7 Verify Energy & Intensity of X-ray Source

The following describes how to verify the X-ray Source, which includes two tests:

- energy (kV) verification, and
- intensity verification.

Equipment

- PMX-I CD kVp/time meter

Verification Method

Energy (kV) Verification:

Use the kVp meter to measure the energy (kVp) of the x-ray beam, and compare with the setting value to verify whether the energy (kVp) control (including the feedback resistor and closed-loop control) works properly.

Intensity Verification:

Take bright images at different setting intensities (mA). From the images measure the gray scale values of certain detector points, compare the measured values with the reference values, and check if the error is within 20% range (thus verifying the intensity control of the X-ray Source and the sensitivity of detector).

Energy (kV) Verification Procedure

1. Turn on the kVp meter, move it into the FOV, and ensure the sensor appears at the center of FOV.
2. Select the protocol and sequence:

   Protocol: X-source calibration

   Sequence: Collimator_test_20mm, (non filter)
3. At the service laptop, open the worksheet "X-ray Source" in the file **Ironman Calibration.xls** (released as a service tool or available in the Common Documentation Library).
4. Take the following scans:
   - 70 kV, 20 mA
   - 80 kV, 20 mA
   - 90 kV, 20 mA
   - 100 kV, 20 mA
   - 110 kV, 20 mA
   - 120 kV, 20 mA
   - 130 kV, 20 mA
   - 140 kV, 20 mA

5. For each scan, read the kV value from the meter and insert the value into the worksheet (which will calculate the relative error).
6. Pass criterion: relative error ≤10%

Intensity (mA) Verification Procedure

7. Remove the kVp meter from the FOV.
8. Select the protocol and sequence:
   Protocol: X-source calibration
   Sequence: Collimator_test_100mm, (non filter)
9. Take the following scans:
   - 80 kV, 10 mA
   - 80 kV, 20 mA
   - 80 kV, 30 mA
   - 80 kV, 40 mA
   - 80 kV, 50 mA
   - 80 kV, 60 mA
   - 80 kV, 70 mA
   - 80 kV, 80 mA

10. After each scan, import the image into MicroView:
    Filename Template: /vol/data/vct/date_time_user_protocol_sequence/Prep
    Import: acqxxxx.dat
11. In MicroView, define the size of the ROI and measure the mean gray scale value (GSV):
    a. Go to standard ROI
    b. Select the ROI size: x=8, y=8, z=1 in pixels
    c. Define the center of the ROI (x, y, z) in pixel
    d. Move the cursor to the ROI, and press **M** to measure the mean GSV
12. Measure the mean GSV at following center points: (x, y) in pixels
    (300, 300), (500, 500), (700,700)
13. Insert the measured GSV into the worksheet, which will calculate the relative error.

Pass criterion: relative error ≤ 20%

8.2.8 Perform Periodic Abridged Calibration

See “Perform Verification Scans” on page 327.

Section 8.3
Planned Maintenance Checklist

8.3.1 Complete and File the Checklist

1. Copy the *Planned Maintenance Performance Checklist* on the following three pages.
2. Check off each task completed.
3. Note any numerical results or comments (ie. future service date scheduled) in the appropriate column.
4. Sign and date the form.
5. Provide a copy of the form to the client.
6. 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 Planned Maintenance Performance Checklist

Refer to Topic	PM Task	Result/Comment	Completed √

Refer to Topic	PM Task	Result/Comment	Completed √
8.2.2 8.2.3 8.2.4 8.2.6	Table Computer: *Computer Maintenance* List Available Free Space C: & D: ____________________ List Any Critical Errors/Alerts: ____________________ ____________________ SPECT Computer: *Computer Maintenance* List Available Free Space C: & D: ____________________ List Any Critical Errors/Alerts: ____________________ ____________________ CT Computer: *Computer Maintenance* List Available Free Space C: & D: ____________________ List Any Critical Errors/Alerts: ____________________ ____________________ Console Computer: *Computer Maintenance* List Available Free Space C: & D: ____________________ List Any Critical Errors/Alerts: ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________ ____________________		
8.2.8	Performed Abridged Calibration		

Refer to Topic	PM Task	Result/Comment	Completed √
Additional Comments:			

Print Client Name:_________________________ **Date:**________

FE Signature:____

(*Servicing Field Engineer: print name and sign above*)

Chapter 9
Schematic Diagrams

This section contains schematics for specific subassemblies. These are for reference only, and are not supported by descriptions elsewhere in this Guide.

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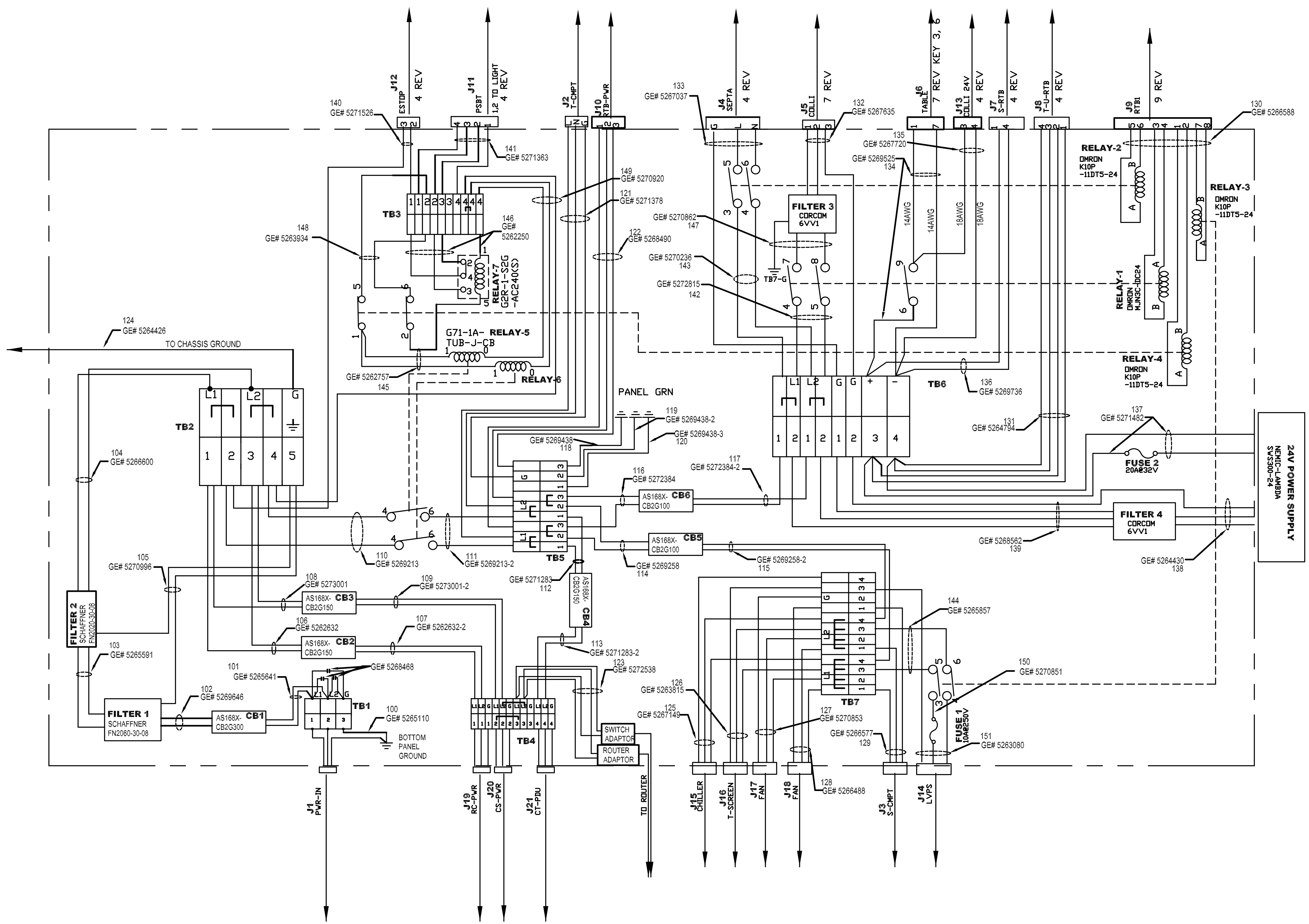

Figure 9-1 Main PDU Schematic

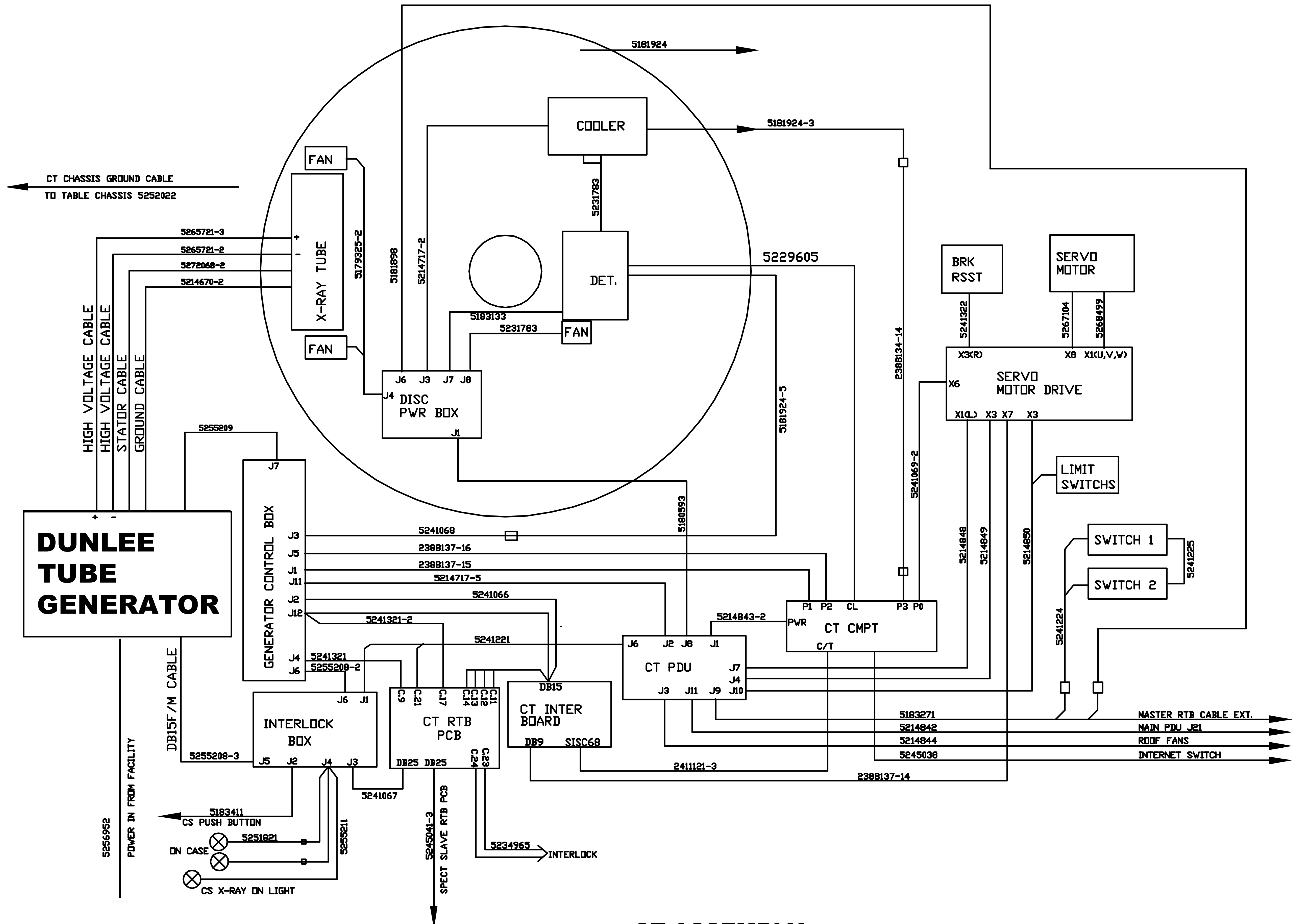

Figure 9-2 CT Interconnect

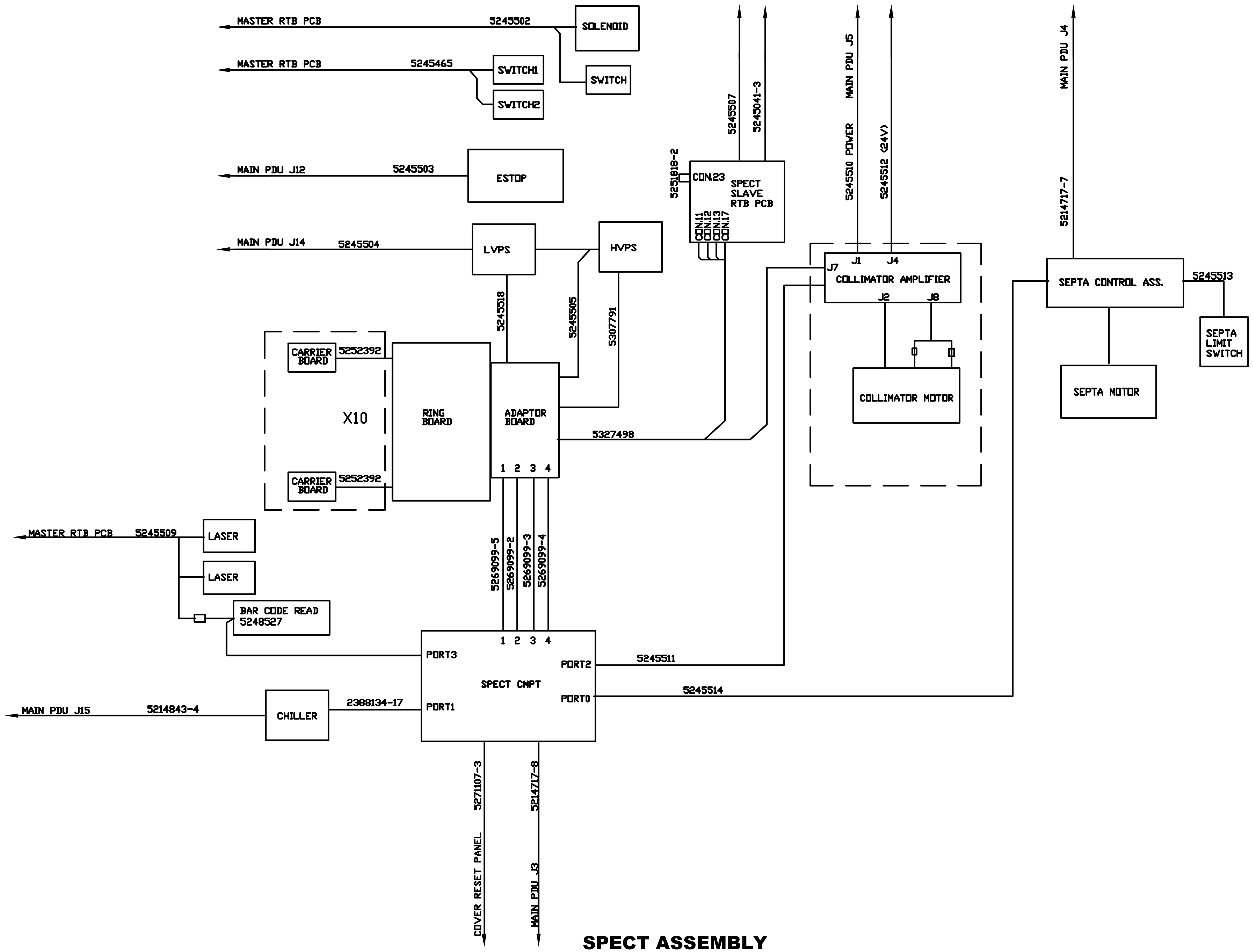

Figure 9-3 SPECT Interconnect

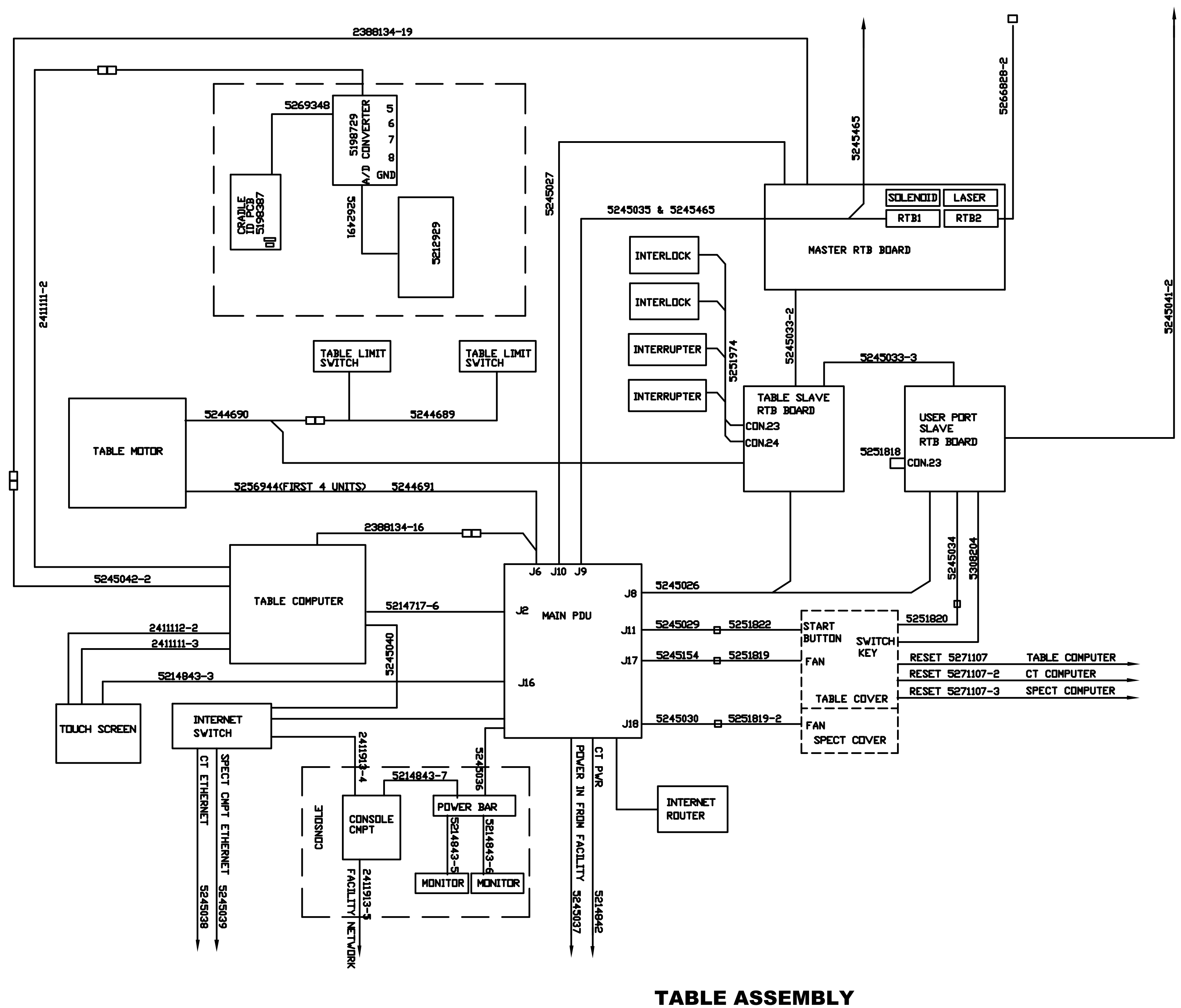

Figure 9-4 Table Interconnect

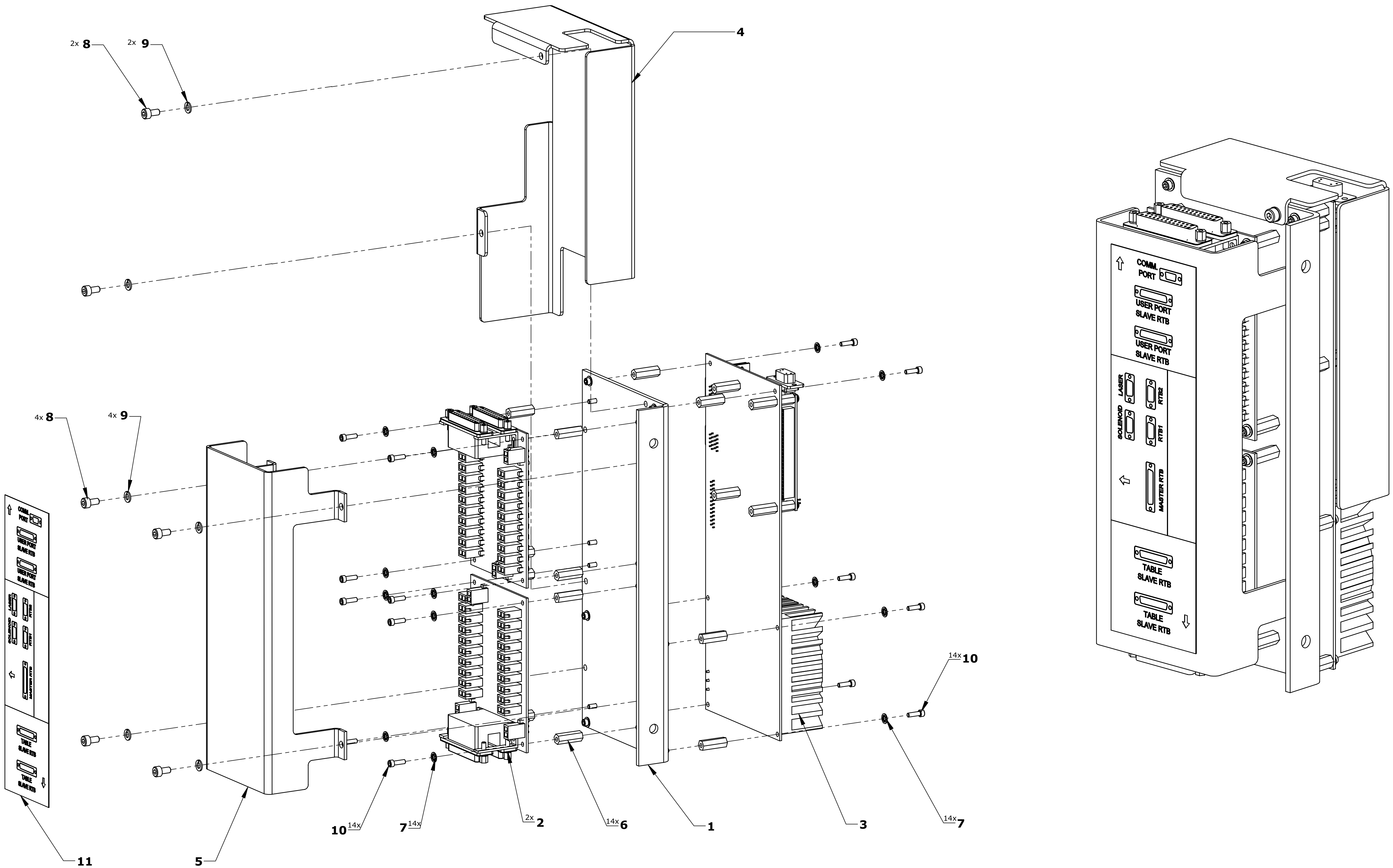

Figure 9-5 Real Time Bus Assembly

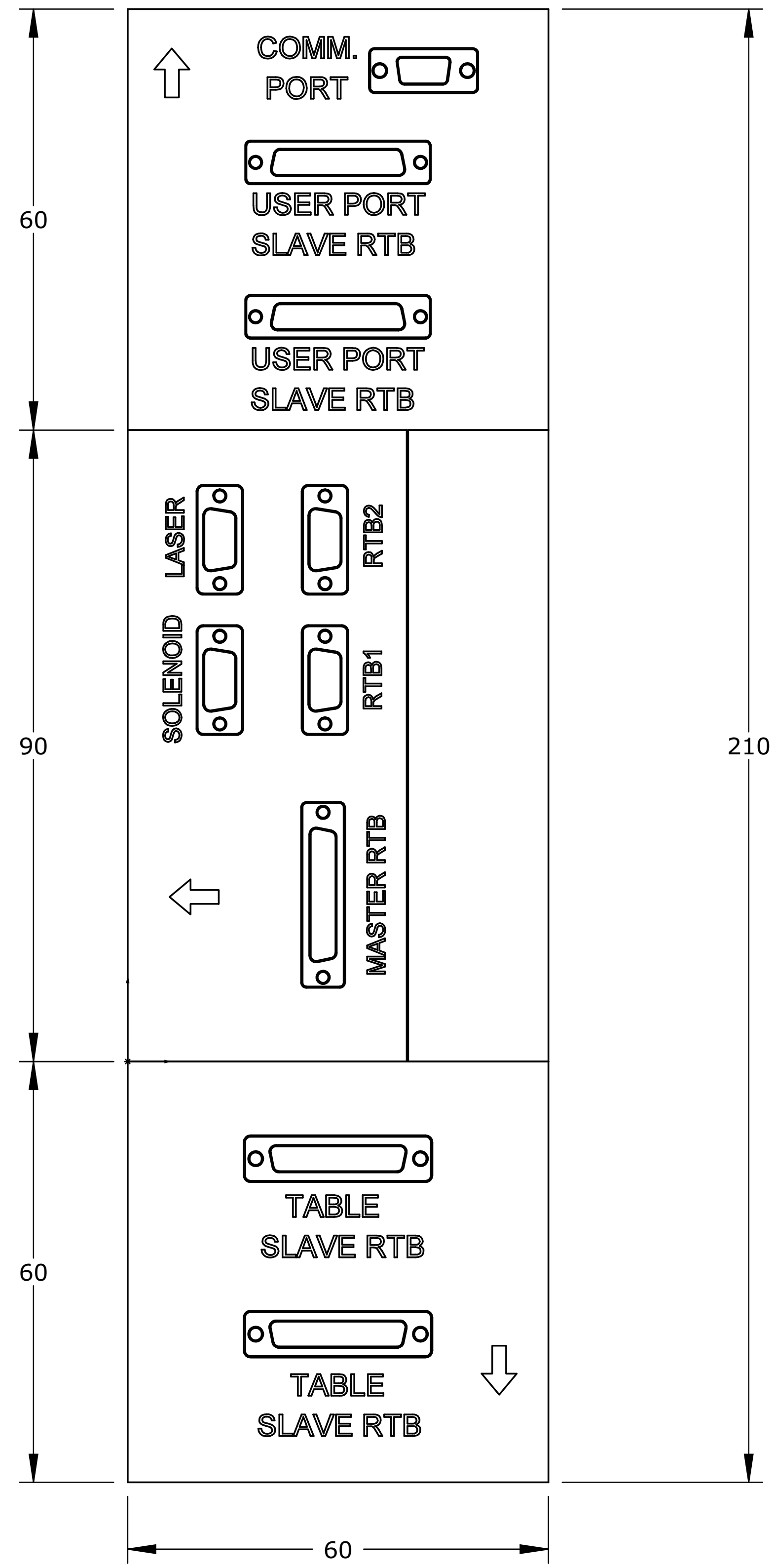

Figure 9-6 Real Time Bus Connections

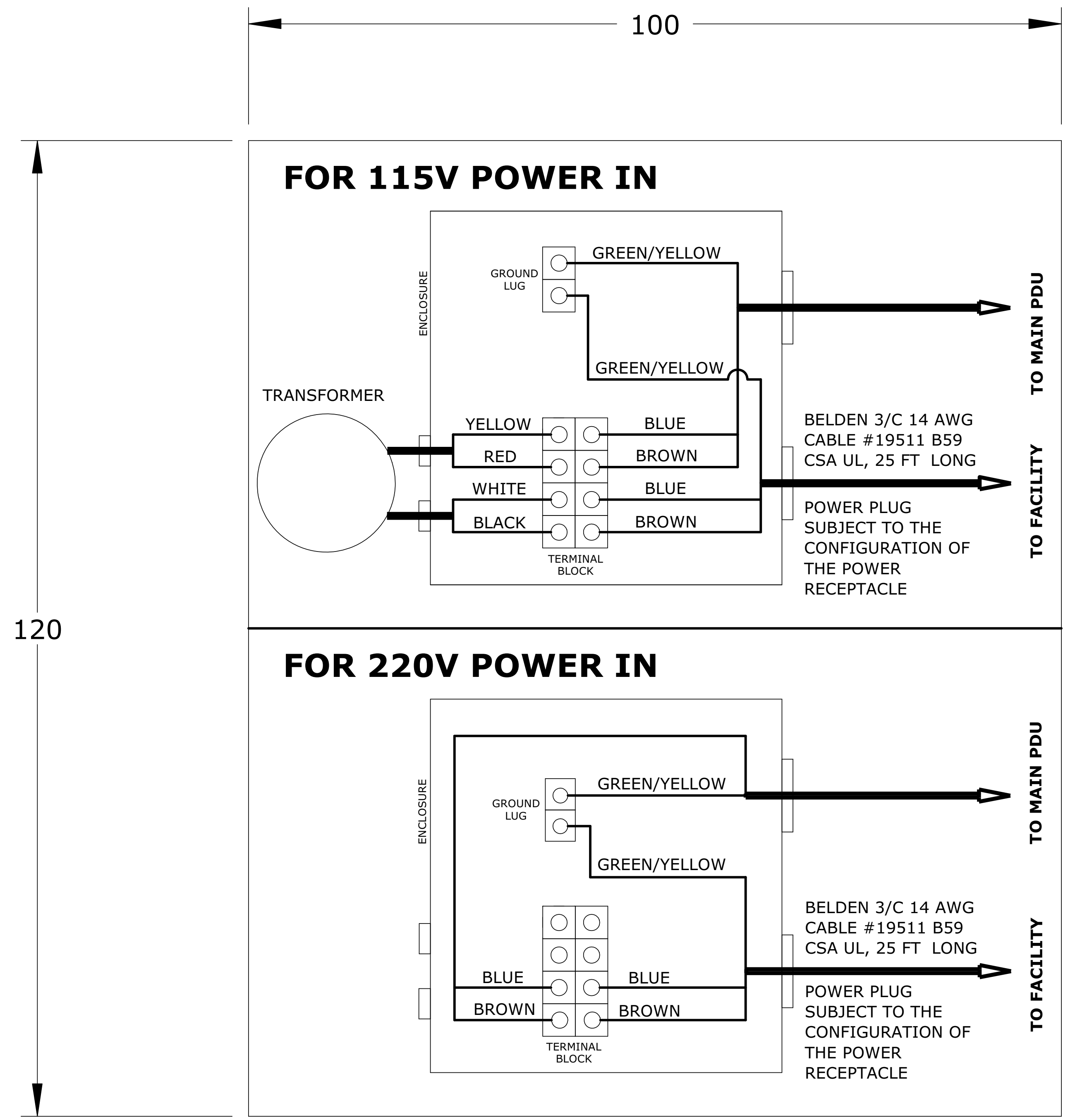

Figure 9-7 Junction Box

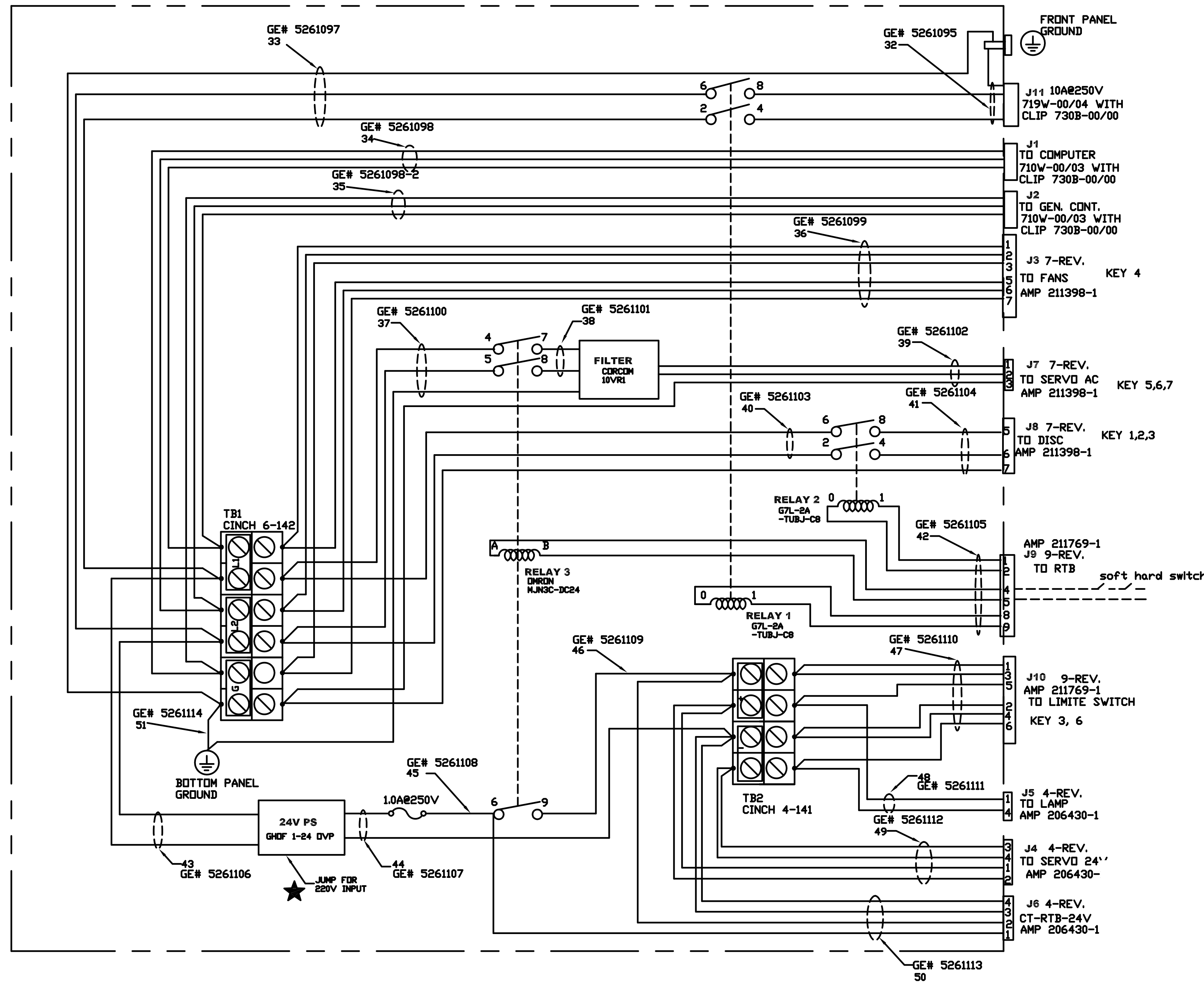

Figure 9-8 CT PDU Schematic

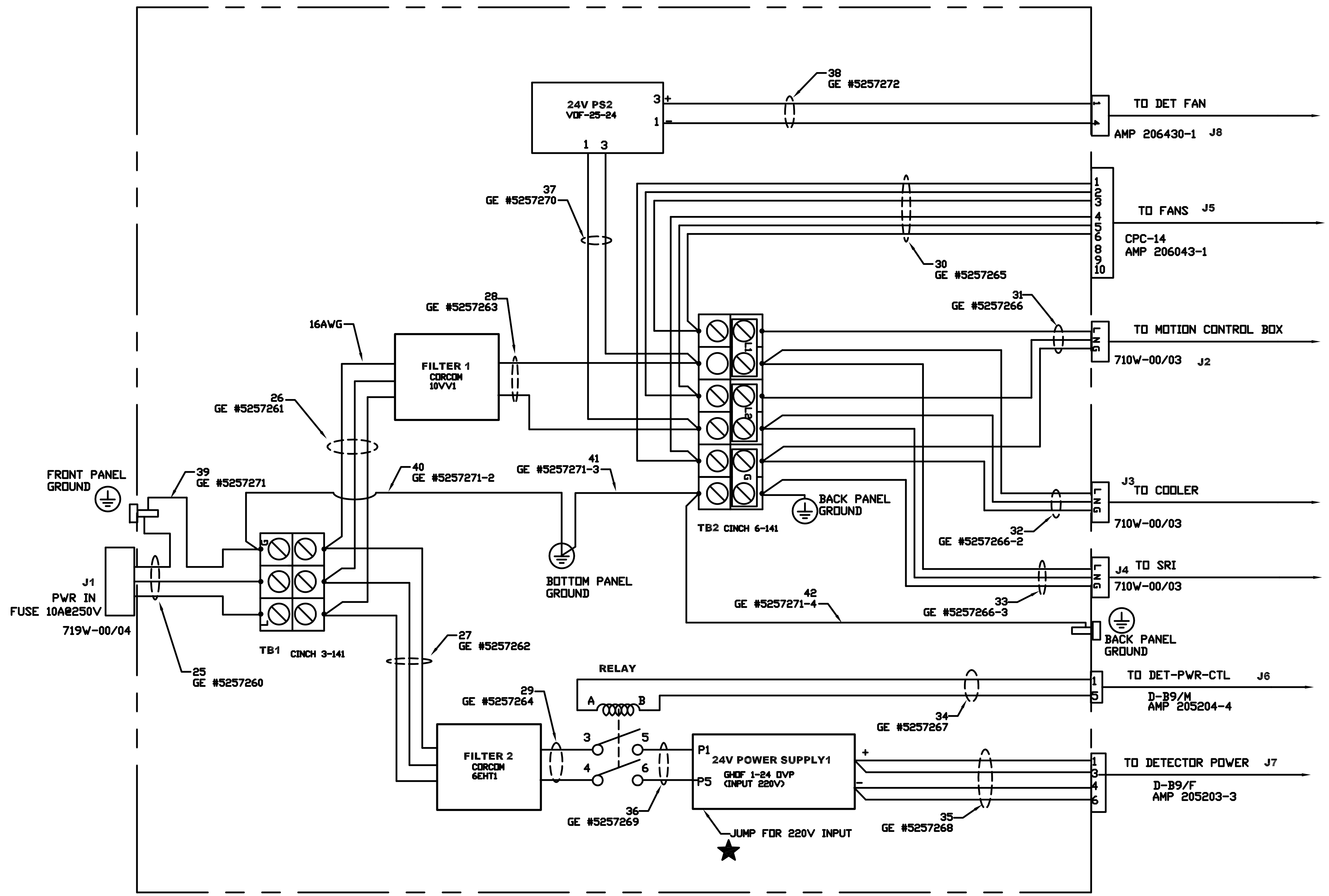

Figure 9-9 Disc Power Box Schematic

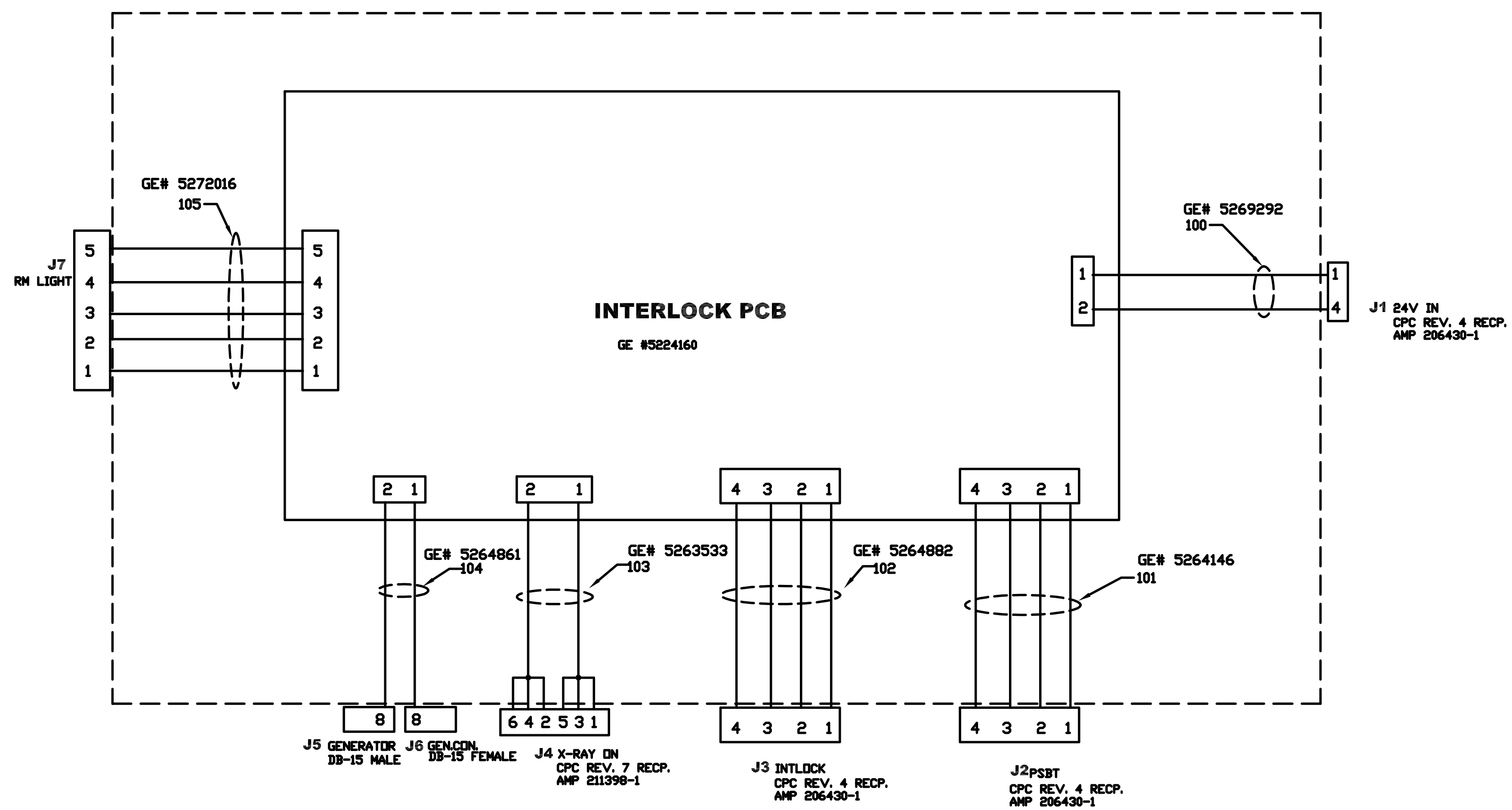

Figure 9-10 CT Interlock Control Box

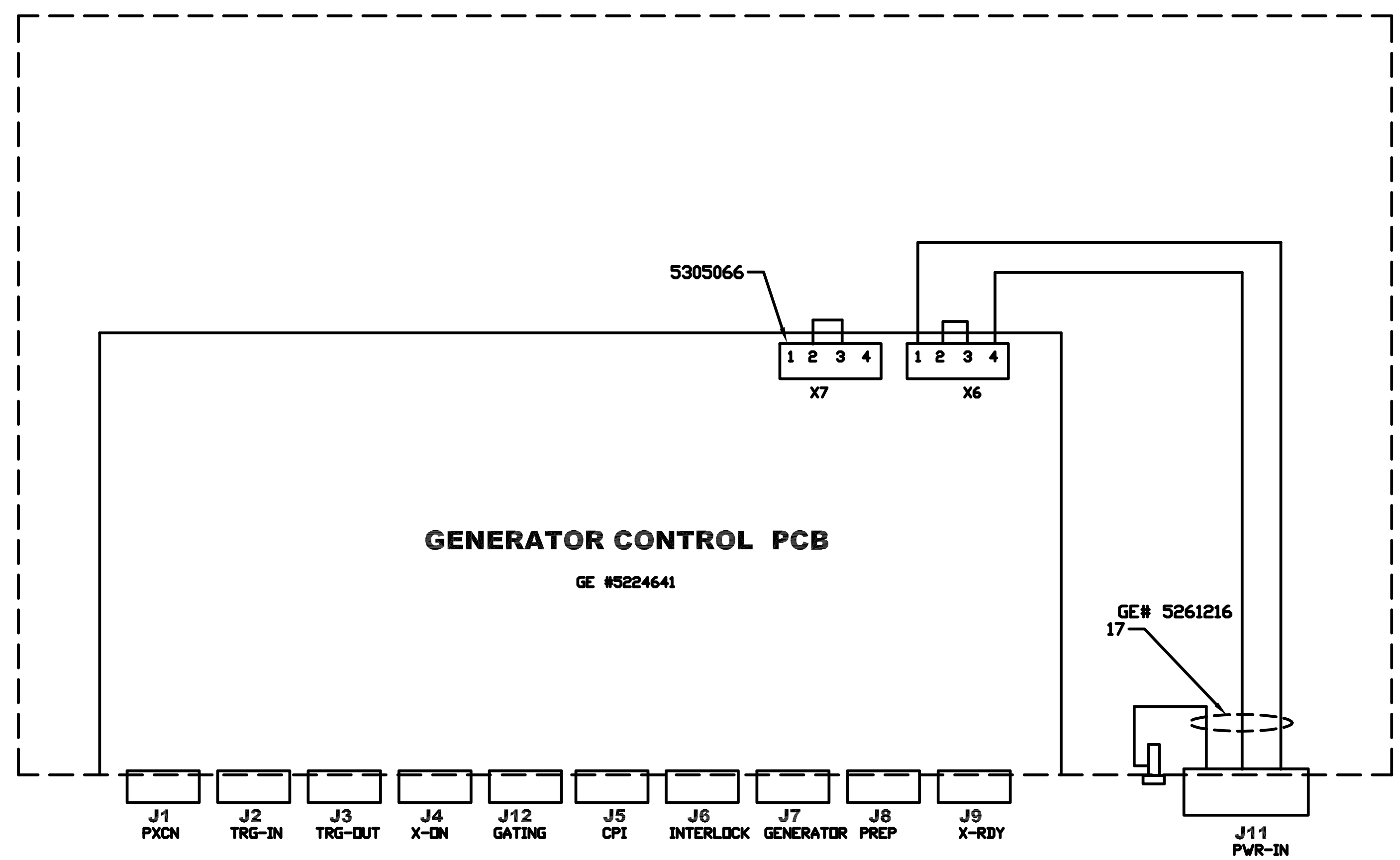

Figure 9-11 CT Generator Control Box

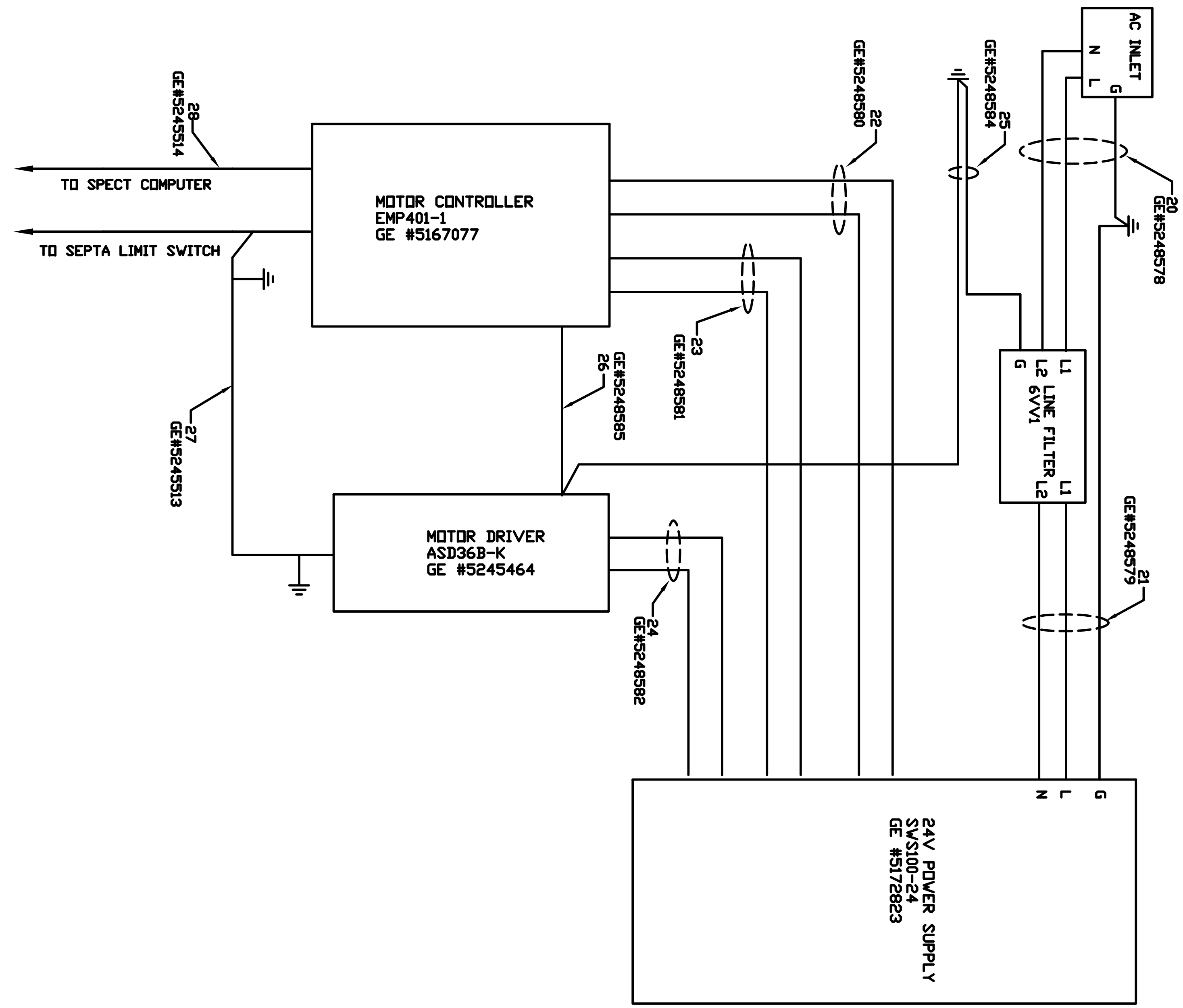

Figure 9-12 SPECT Septa Control ASM

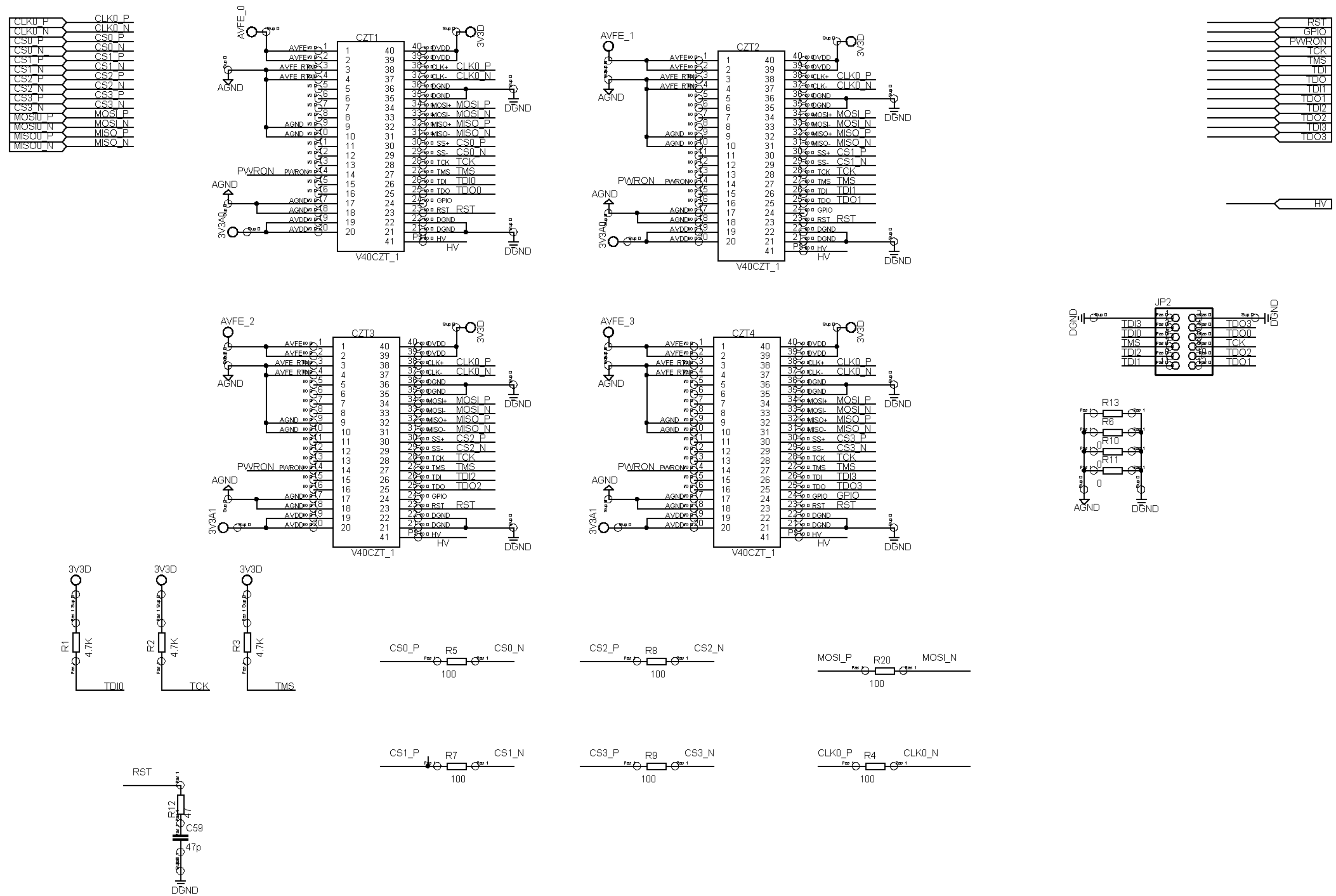

Figure 9-13 SPECT Carrier Board 1/3

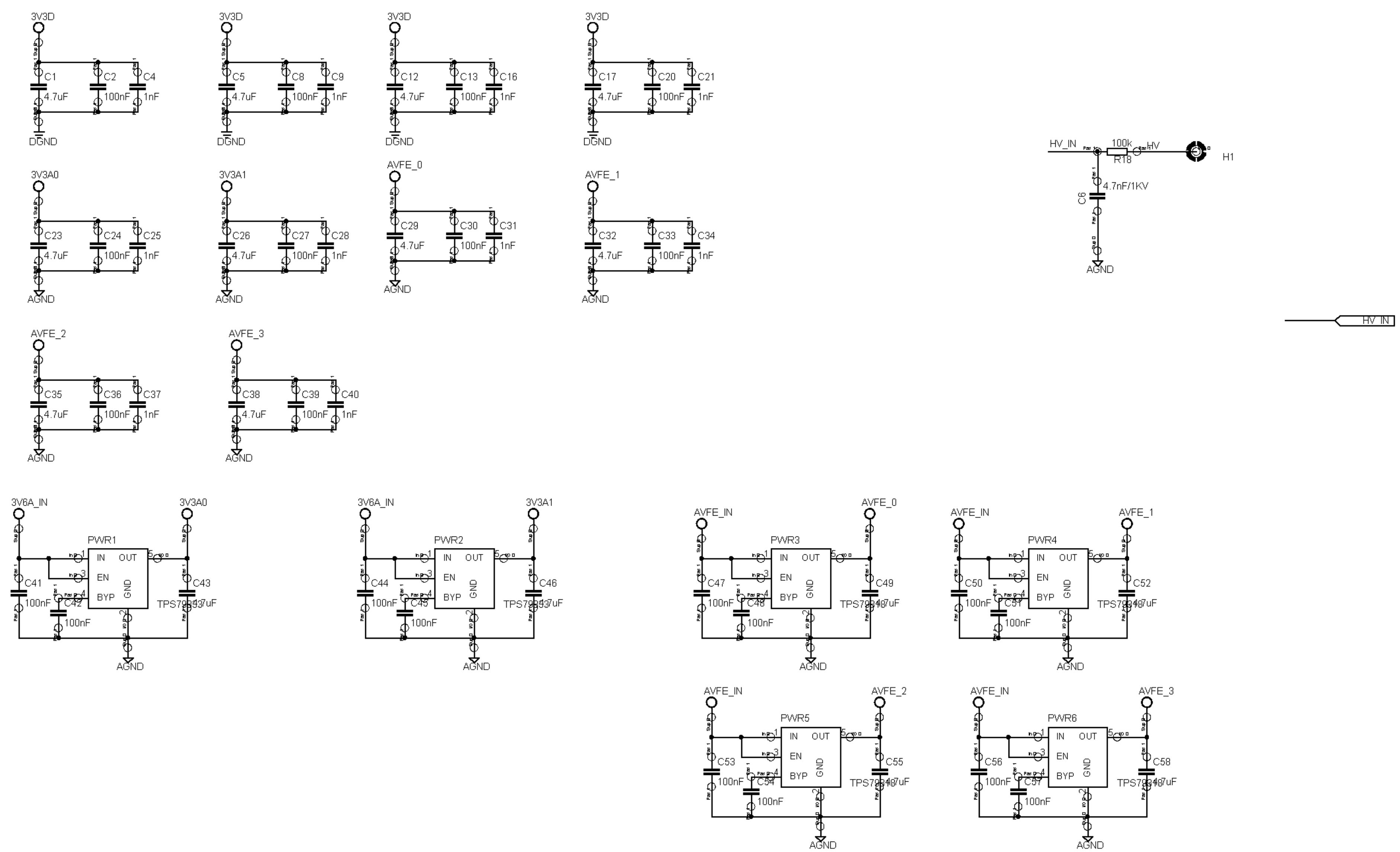

Figure 9-14 SPECT Carrier Board 2/3

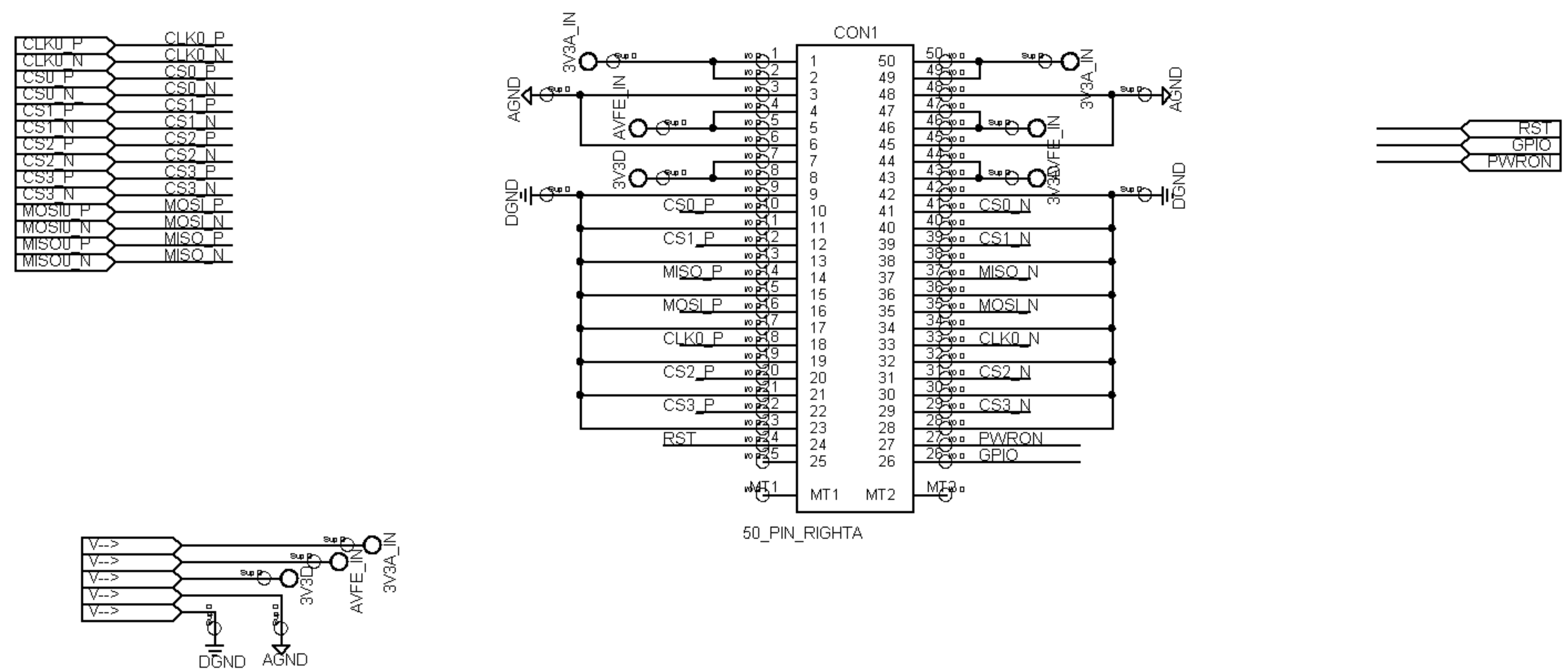

Figure 9-15 SPECT Carrier Board 3/3

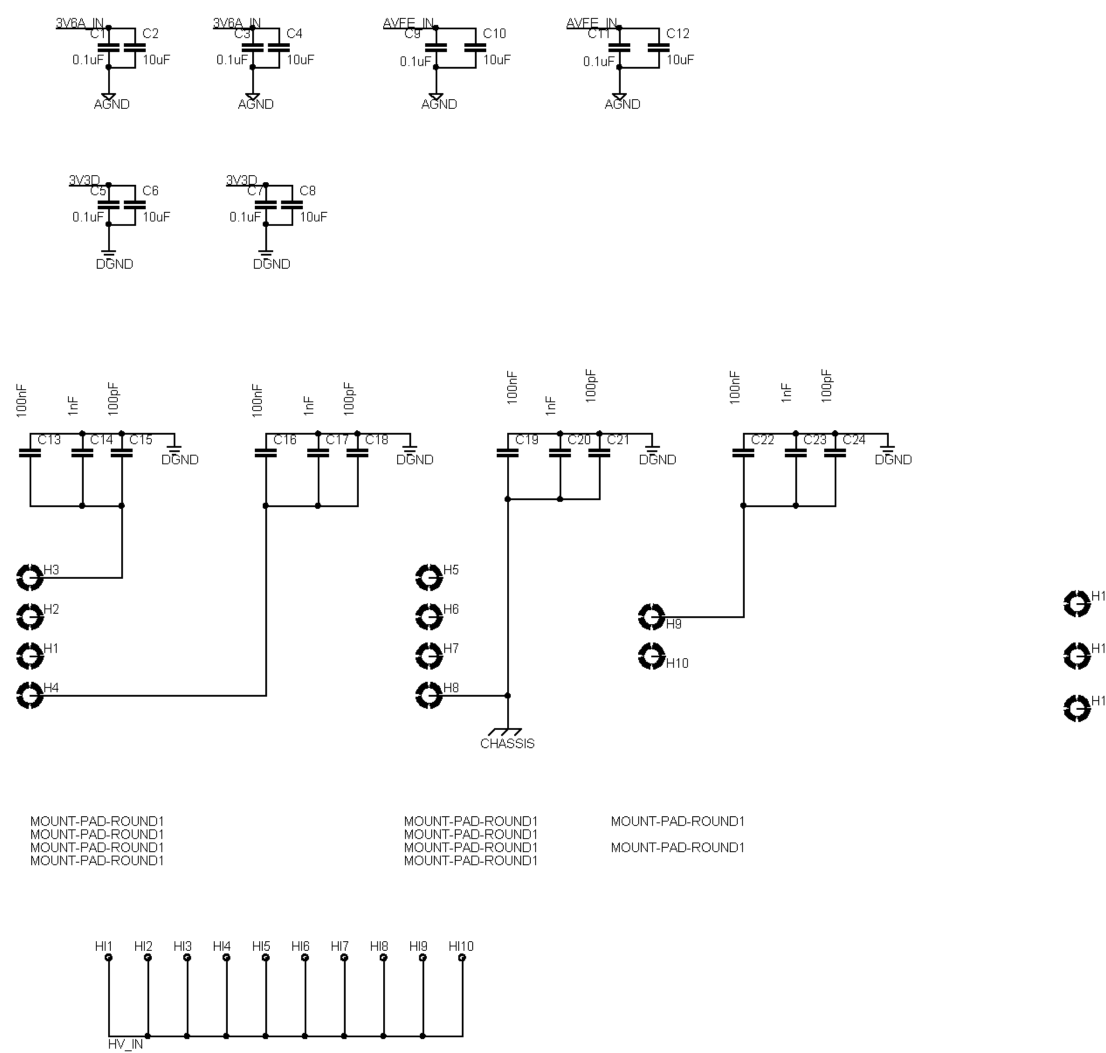

Figure 9-16 SPECT Ring PCB 1/4

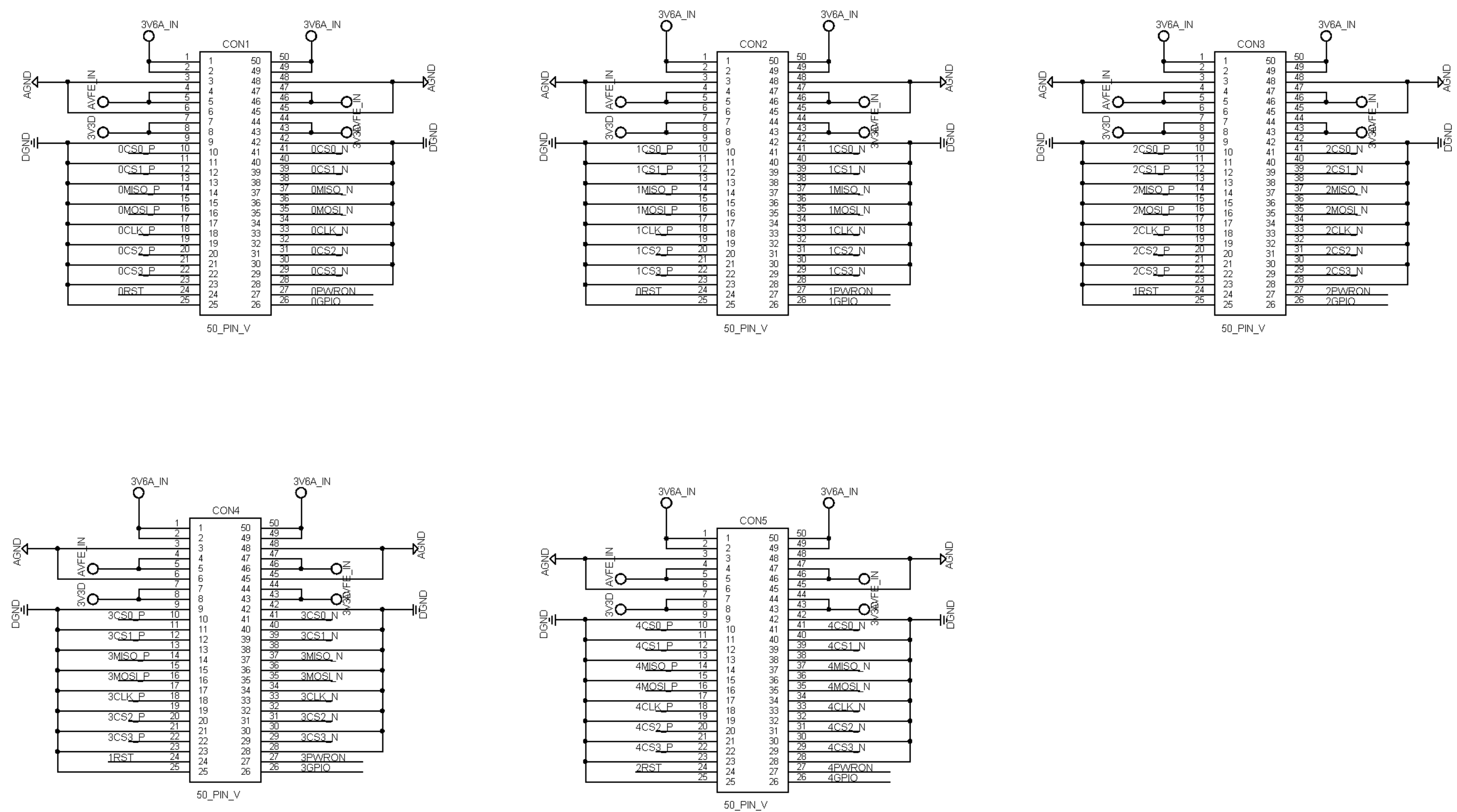

Figure 9-17 SPECT Ring PCB 2/4

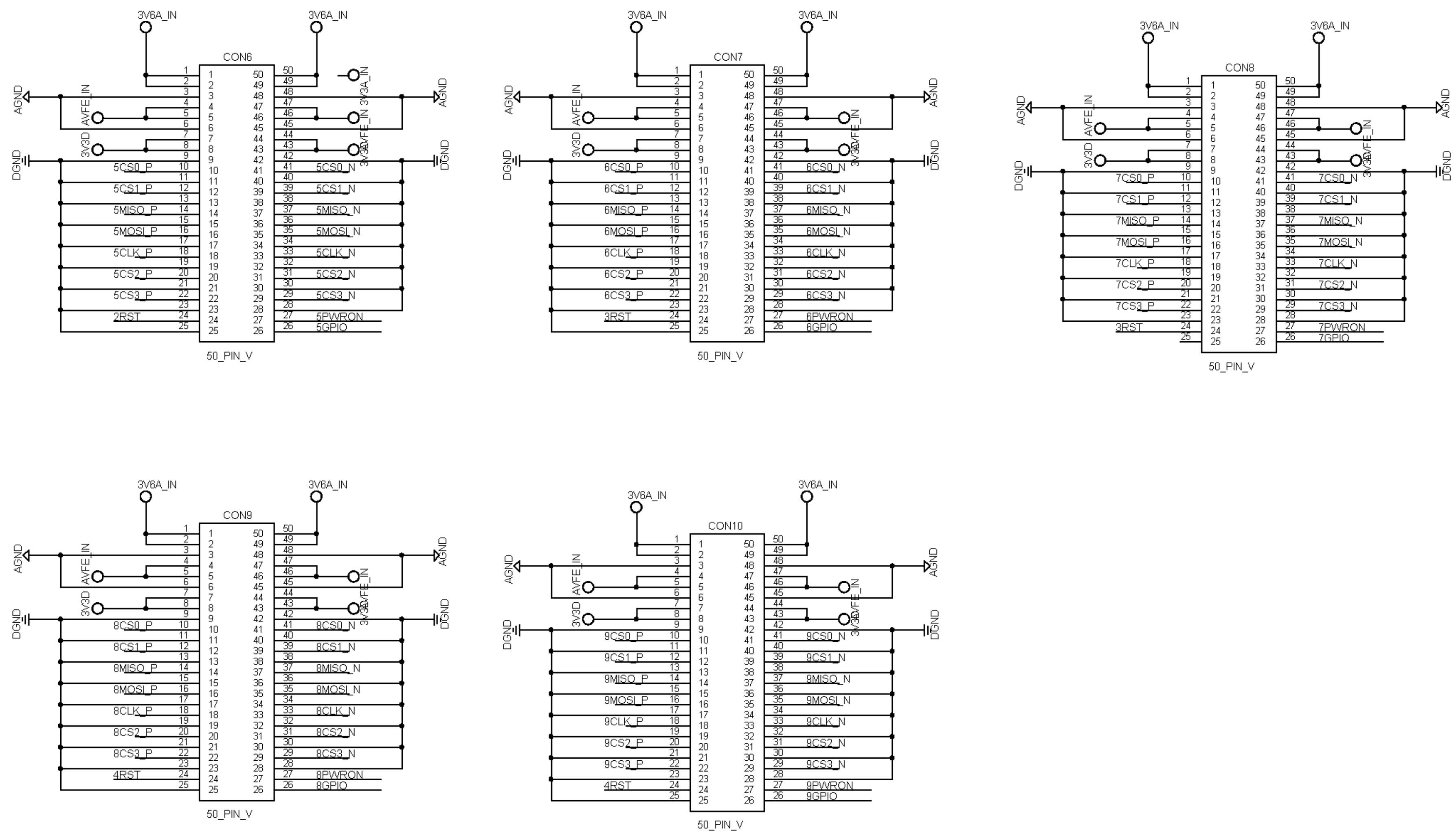

Figure 9-18 SPECT Ring PCB 3/4

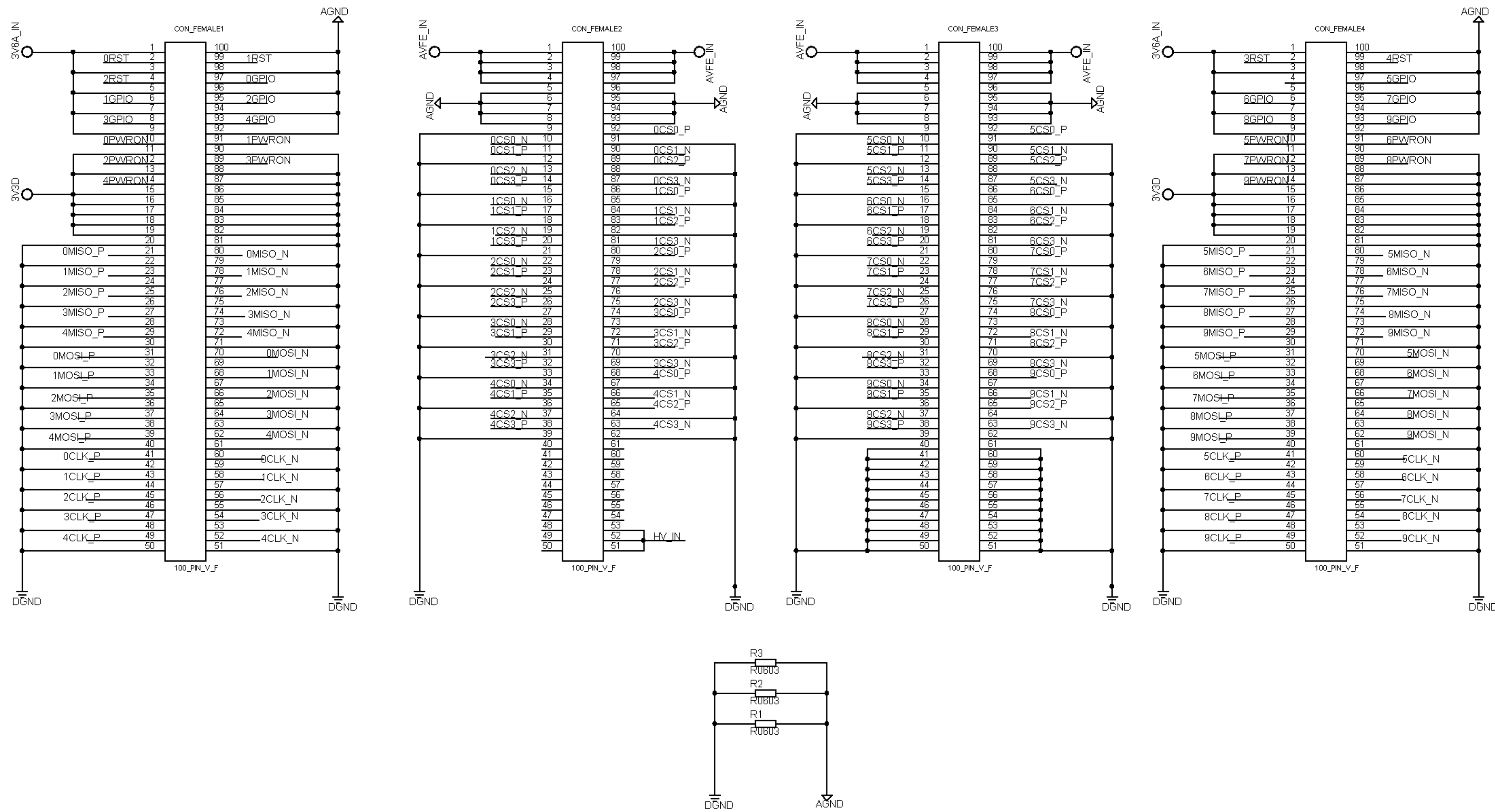

Figure 9-19 SPECT Ring PCB 4/4

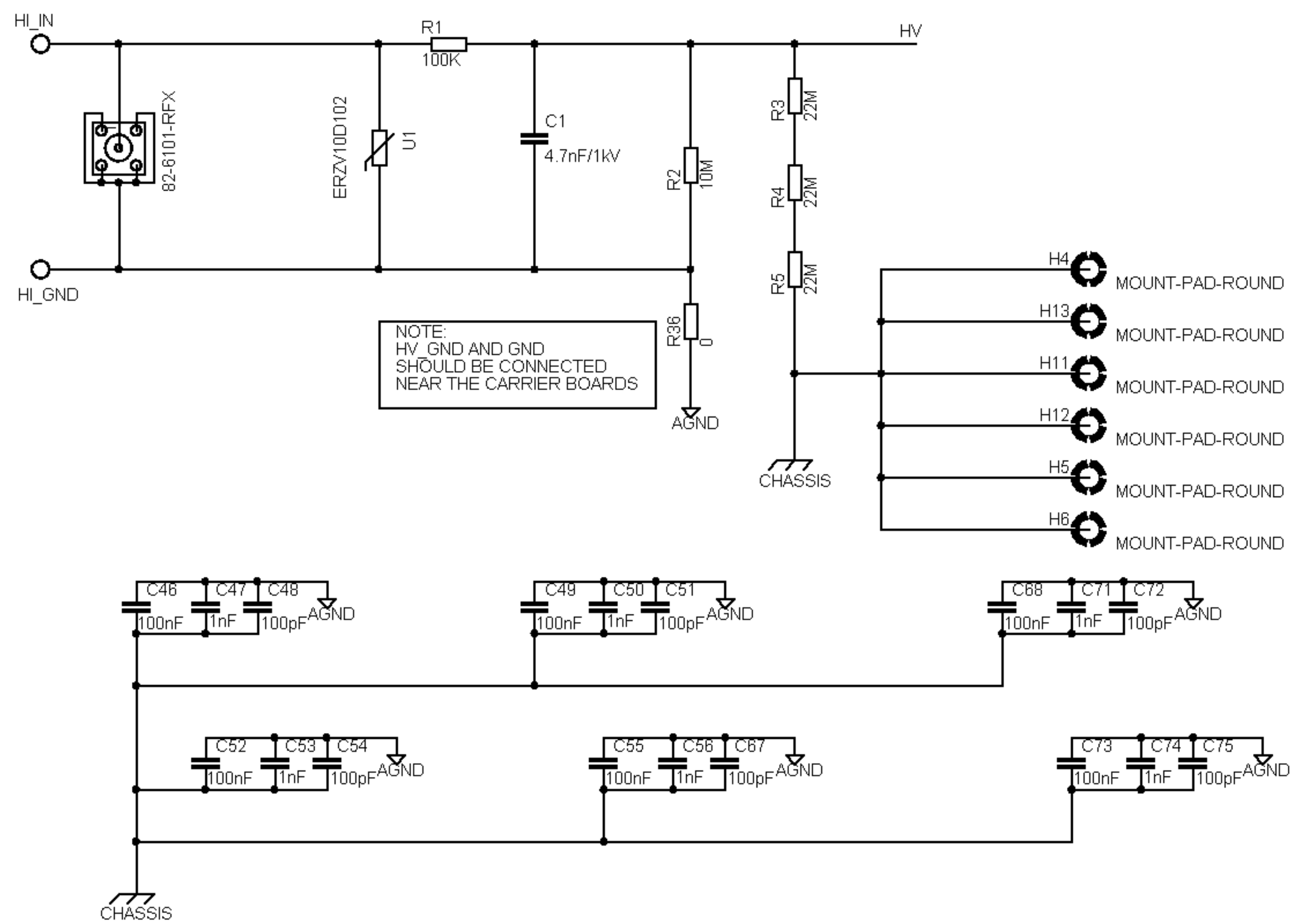

Figure 9-20 SPECT Adapter Board1/6

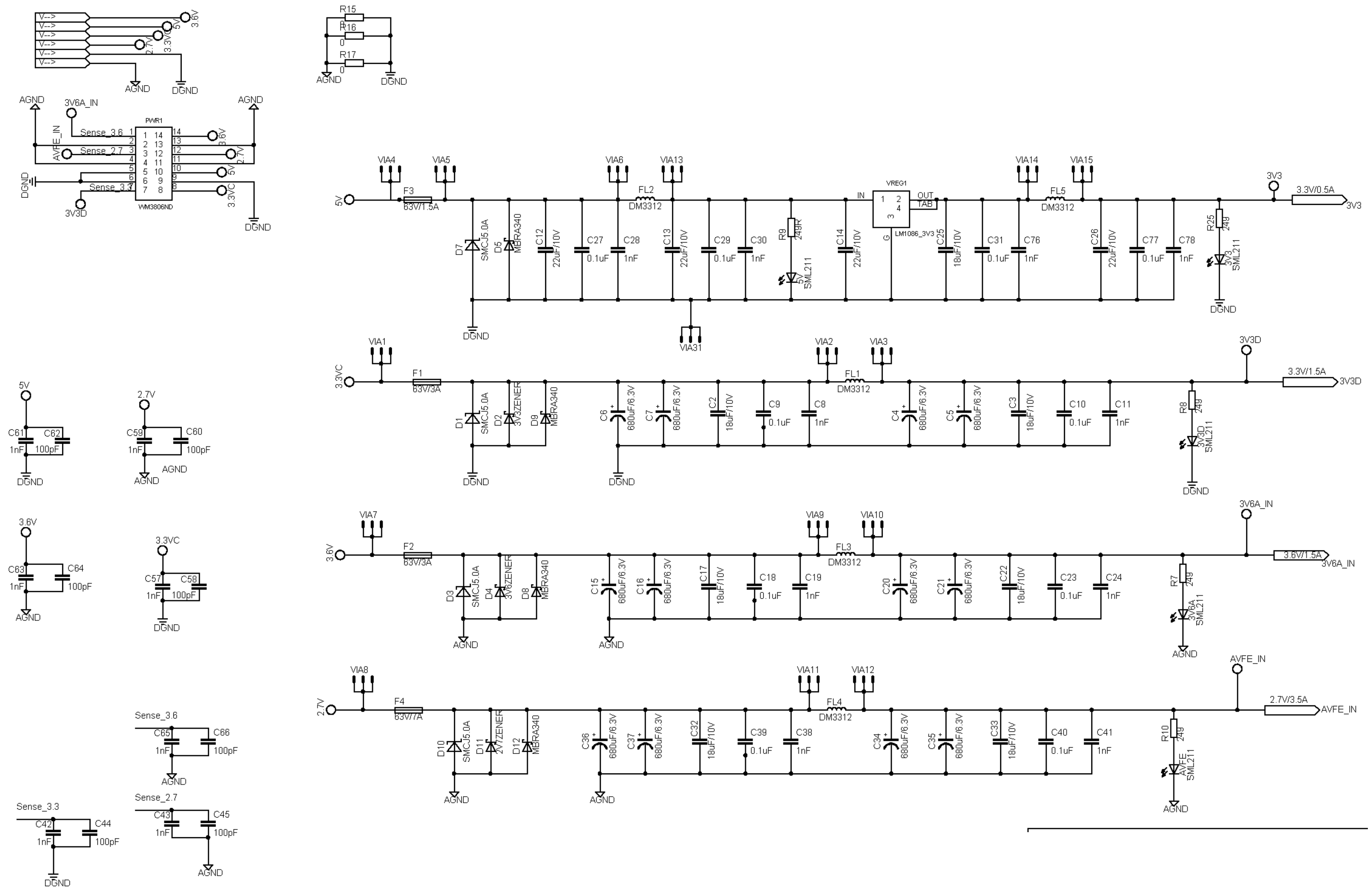

Figure 9-21 SPECT Adapter Board 2/6

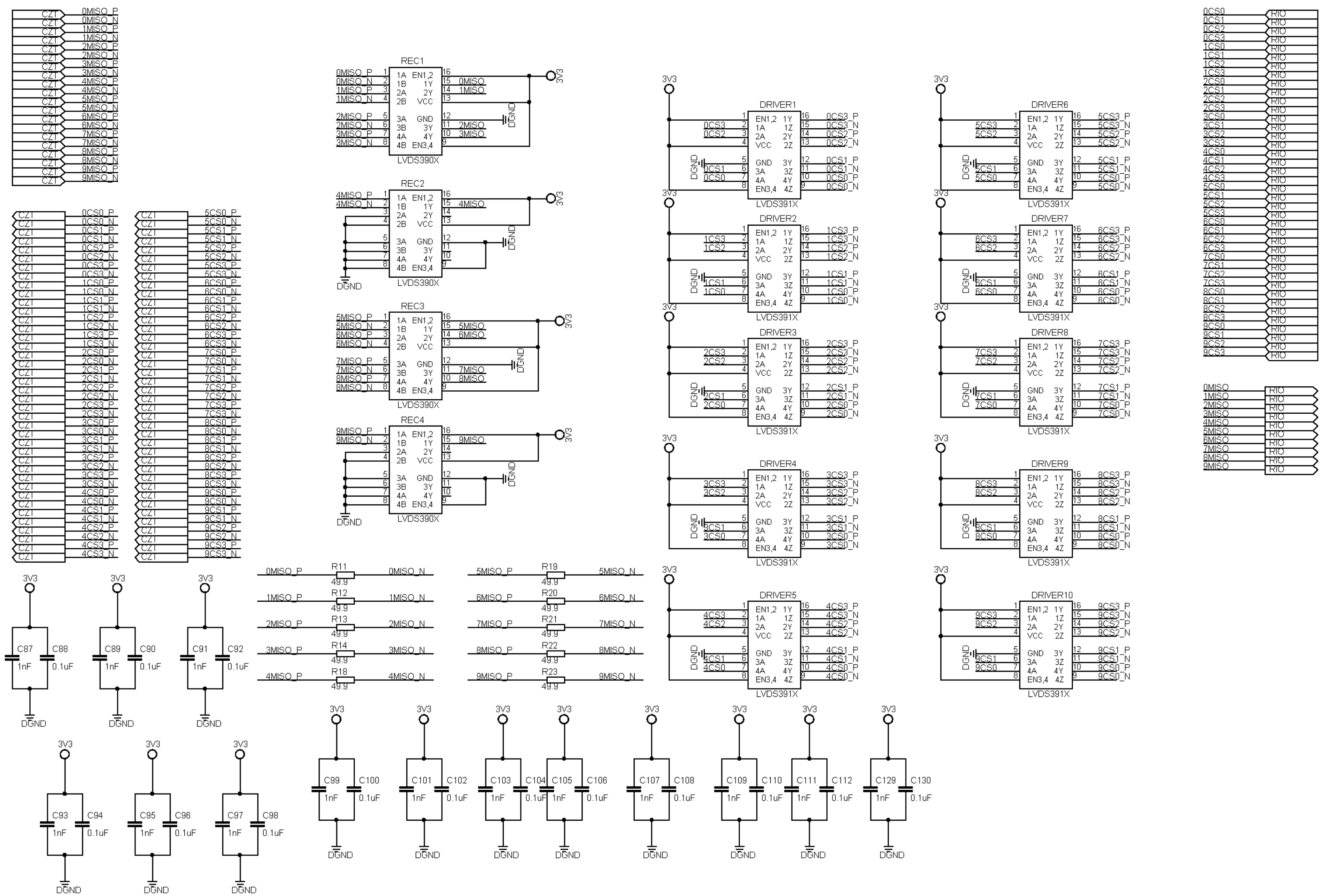

Figure 9-22 SPECT Adapter Board 3/6

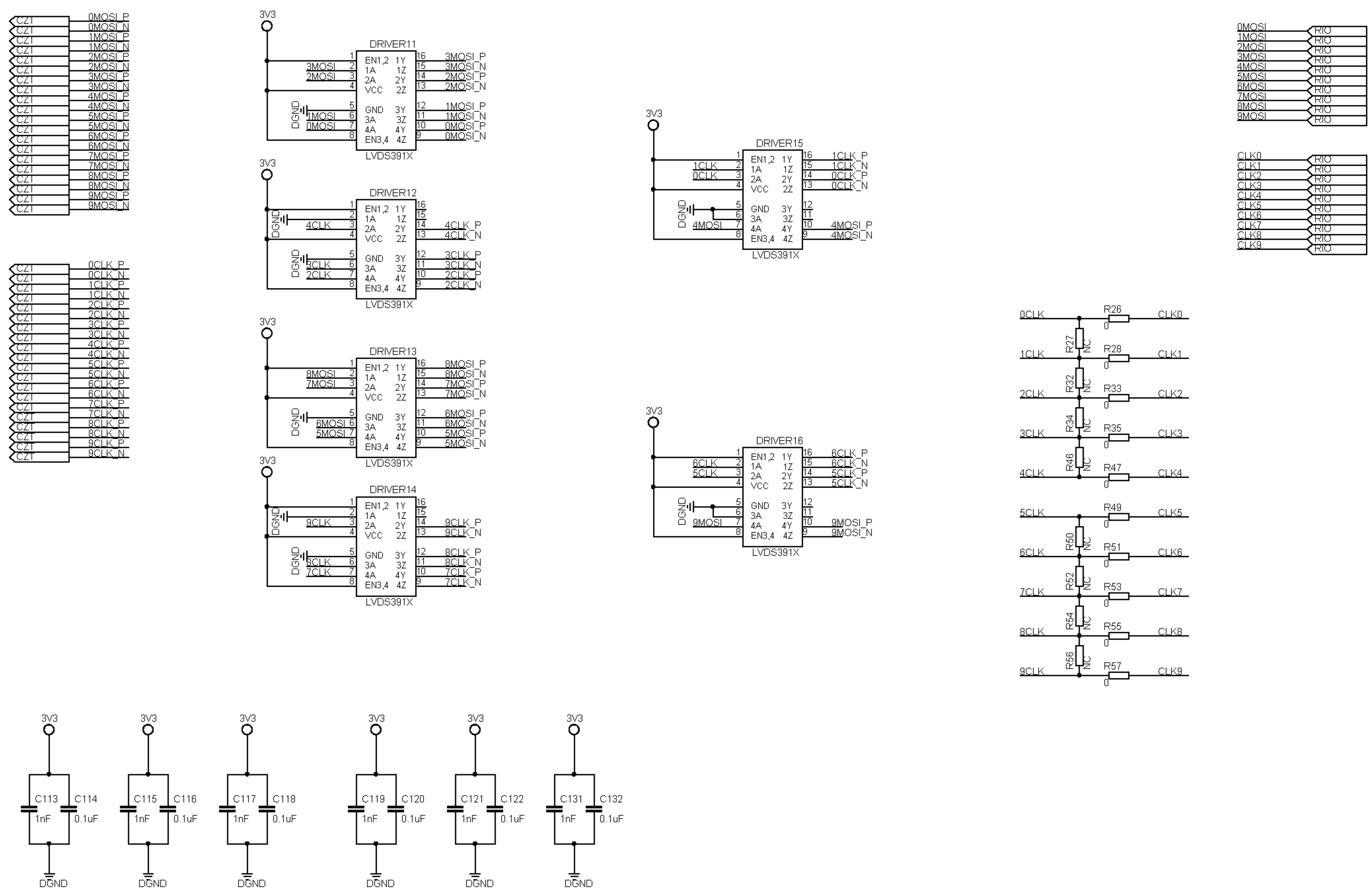

Figure 9-23 SPECT Adapter Board 4/6

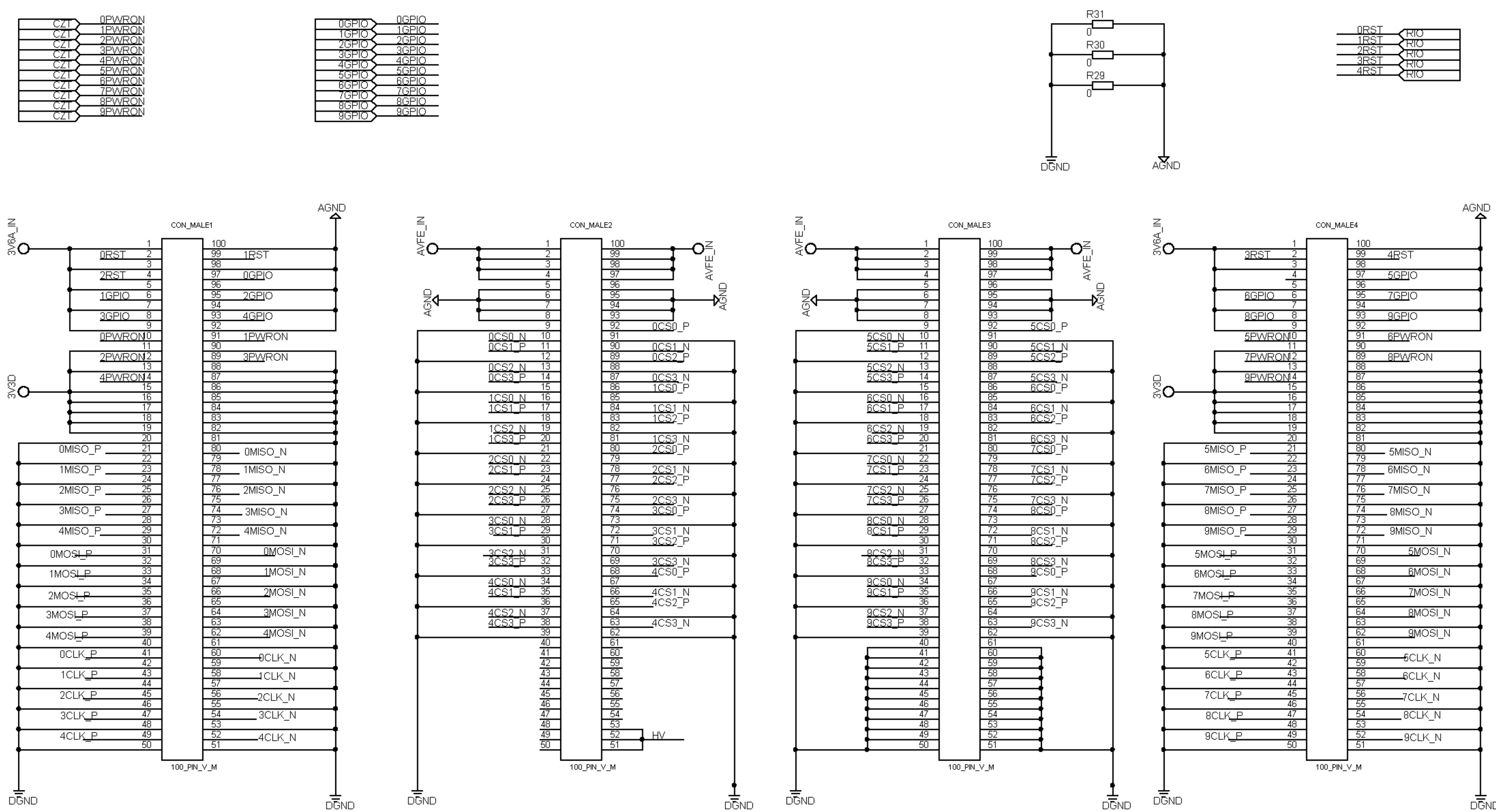

Figure 9-24 SPECT Adapter Board 5/6

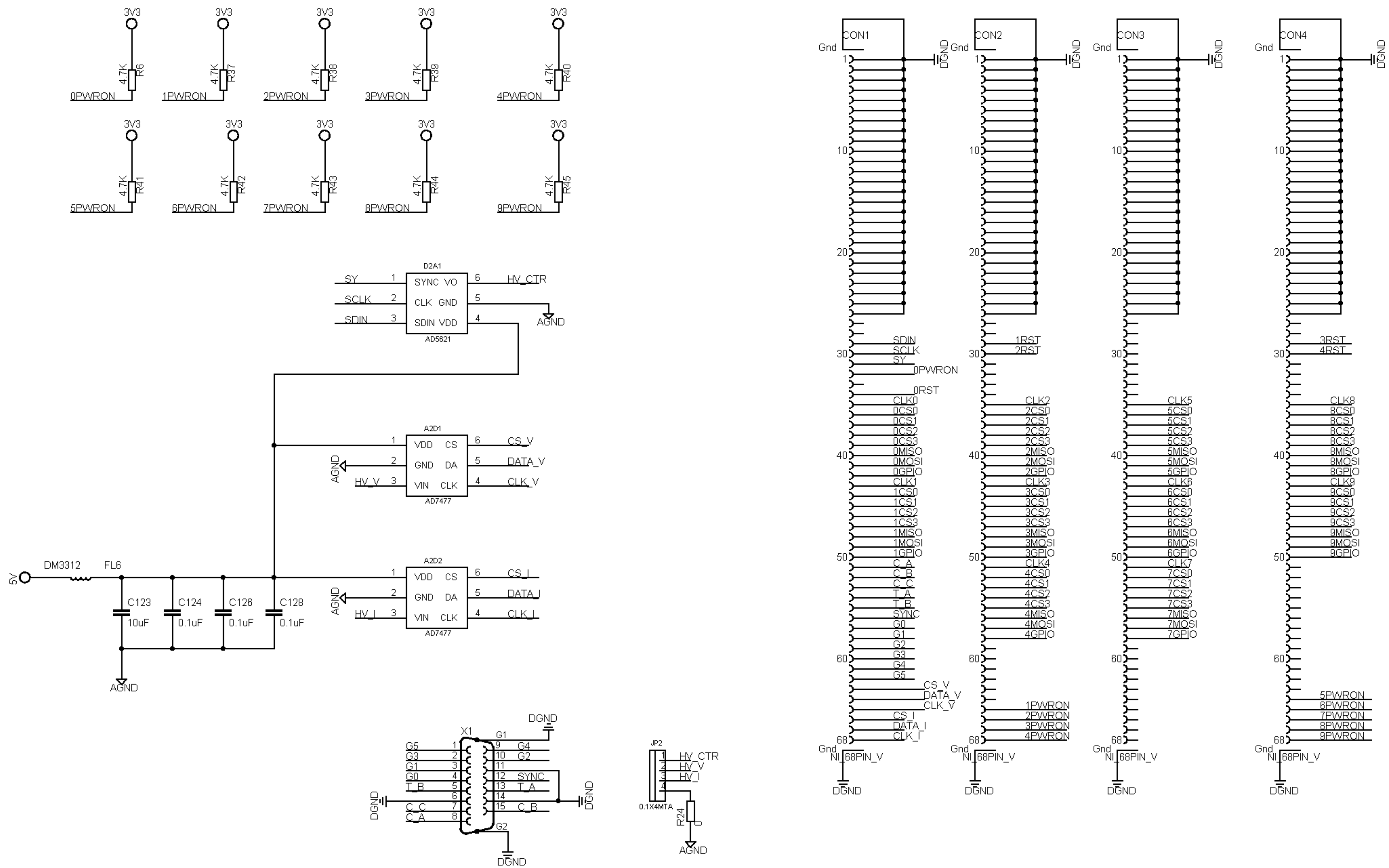

Figure 9-25 SPECT Adapter Board 6/6 88

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Chapter 10 Appendix

Section 10.1 Worksheet

Item	Page	Value
Write down the current value in the Calibrated In Position field	page 70	
Note the values of H and L and the ratios H/L for various peaks	page 295	H_1= L_1=
		H_1/L_1=
		H_2= L_2=
		H_2/L_2=
Record the ROI Size and ROI Center values so that they can be used for other sources	page 297	ROI Size= ROI Center=
Record the mean (M) and standard deviation values	page 297	M_1= Std Dev_1= C_1=
		M_2= Std Dev_2= C_2=
		M_3= Std Dev_3= C_3=
Calculate Linearity Error for all three sources	page 298	err_1=
		err_2=
		err_3=
Record min. and max. values in the Count field (≤150 cps)	page 299	min= max=
Count Rate (cps)	page 302	
Source Activity (MBq)	page 302	

Item	Page	Value
Calculate Sensitivity=Count Rate/Source Activity x 10^6 (cps/MBq)	page 302	
Calculate Percentage=cps/MBq x 100	page 302	
Record Window and Level values	page 309	
Record BB1 coordinates	page 309	x_1= y_1=
Record BB2 coordinates	page 309	x_2= y_2=
Record X position difference	page 309	x_2-x_1=
Record Y position difference	page 309	y_2-y_1=
Divide X difference by # of BBs	page 310	
Calculate detector spacing	page 312	
Record Home to Laser value	page 319	
Record BB coordinates	page 320	x_0= y_0=
Record twist angle, center or rotation & central slice	page 320	TA= COR= CS=
Record Centroid values from Region Grow	page 322	x= y=
Record u_0, v_0 & eta	page 322	u_0= v_0= eta=
Distances betwen centroids	page 334	d=

Item	Page	Value
Record cradle height	page 345	
Record line length	page 346	

Section 10.2 Collimator Bar Code Facsimile

1001 1001 1001

1001 1001 1001

1001 1001 1001

1001	1001	1001
1001	1001	1001
1001	1001	1001

Section 10.3 Service Notes

ANALOG SATURATION DETECTION

Introduction

The CT-120 detector uses a CsI detector coupled with a CCD. The CCD collects the charge from the detector into discrete wells, which will be digitized to get the final image. However, the wells have a finite capacity, and it is possible to saturate them. This is called analog saturation. Even if there is analog saturation, it is possible that after digitalization, the final image will not show saturation, which means a visual inspection of the final image is not sufficient for analog saturation detection.

Steps:

Note: Before proceeding, ensure that the scanner is on, the console application is started, and the scanner has been locked (connected).

1. From the scan page, click "Select Protocol" and open the "CT-120 Calibration" protocol. This protocol has detector settings (gain/offset) of zero.

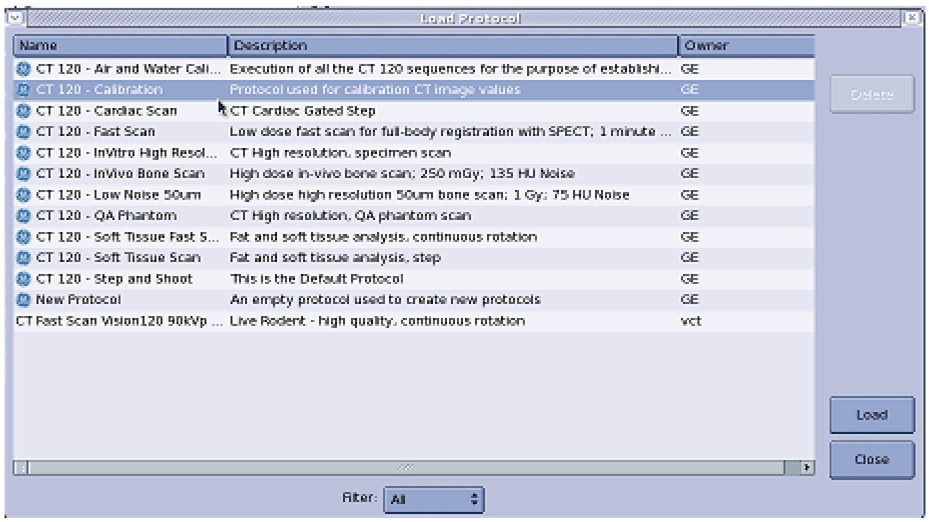

Figure 10-1

2. Remove the cradle from the table. Then, click the "CT Fluoro" button 

to start the acquisition of fluoroscopic images.

3. You will see CT fluoroscopic images appear on the image viewer panel. Use the image information found at the top, left corner of the image display to determine when enough images have been collected. Make sure that at least 15 images have been acquired.

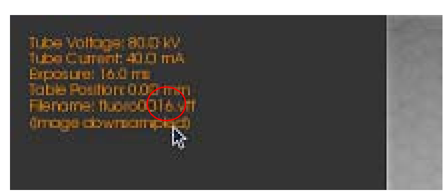

Figure 10-2

4. Click the "Stop X-rays" button 

, and when prompted to set the landmark, click "No".

Figure 10-3

5. From the system's Application menu, select "System Tools" and then "File Browser" to open the file browsing application.

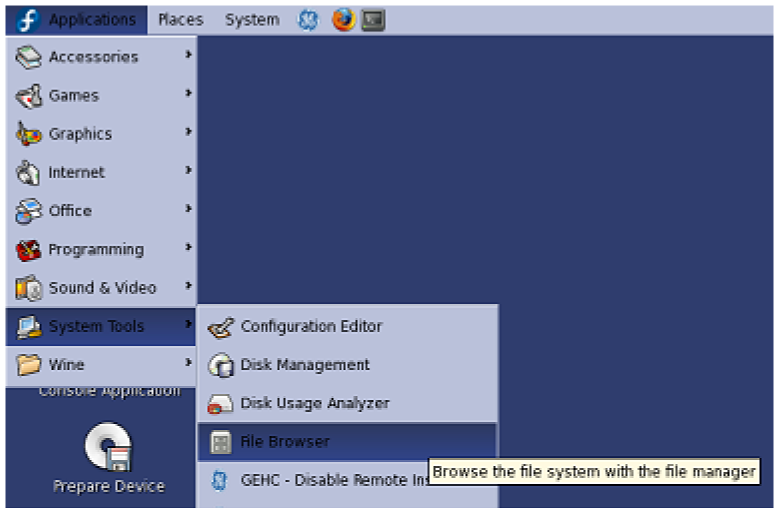

Figure 10-4

6. When the file browser appears, enter:
   `smb://ct.local/inukshuk/Data/fluoro`
   in the "Location entry field and press the *enter* key.

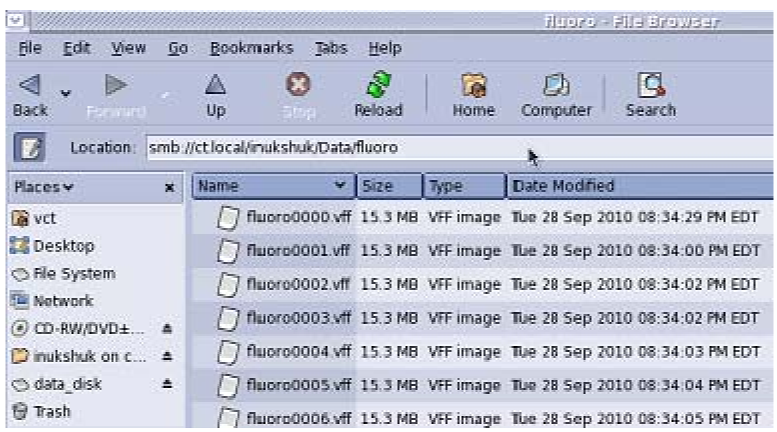

Figure 10-5

The file display will show the recently acquired fluoroscopic images.

7. Select two of the images (e.g., fluoro0014.vff and fluoro0015.vff) and drag them to the desktop.

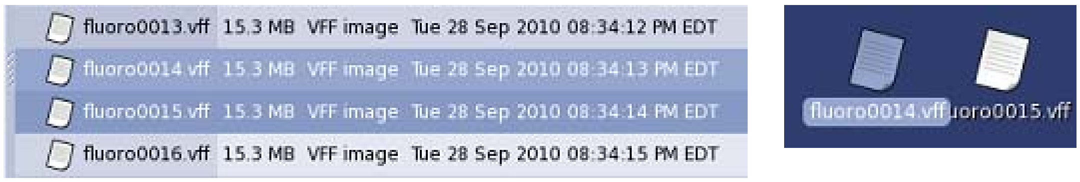

Figure 10-6 fluoro0015.vff and fluoro0015.vff selected (left) and (right) on desktop

8. Open a terminal window and type:

   `cd ~/Desktop`

   and press the enter key. This will take you to the Desktop folder, which contains the two images you dragged over from the CT computer. Type:

   `ls`

   and press the enter key to confirm that the files are there.

Figure 10-7

9. Run the image subtraction program, vffSubtract by typing:

   `vffSubtract fluoro0014.vff fluoro0015.vff subtract.vff 0 0 0`

   and press the enter key. This will subtract the first fluoro image from the second, producing a new image named, *subtract.vff*.

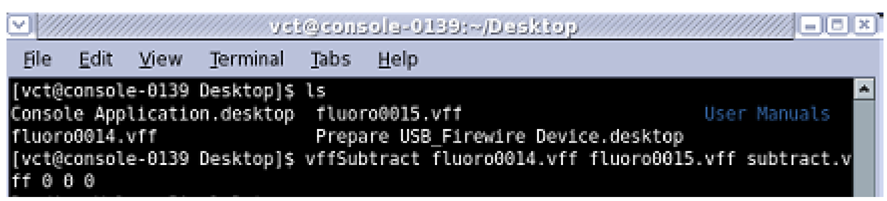

Figure 10-8

10. Start MicroView in order to view the result of the image subtraction by typing:

    `MicroView subtract.vff`

    and press the enter key. In a moment, the MicroView application will appear.

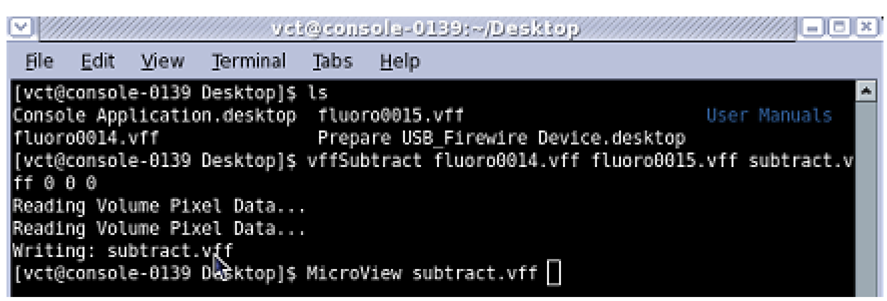

Figure 10-9

11. Examine the image. If there is no analog saturation, the image will appear to be completely random noise. On the other hand, a saturated image will have regions that are clearly distinct from the others. The regions will appear duller or flatter than the rest.

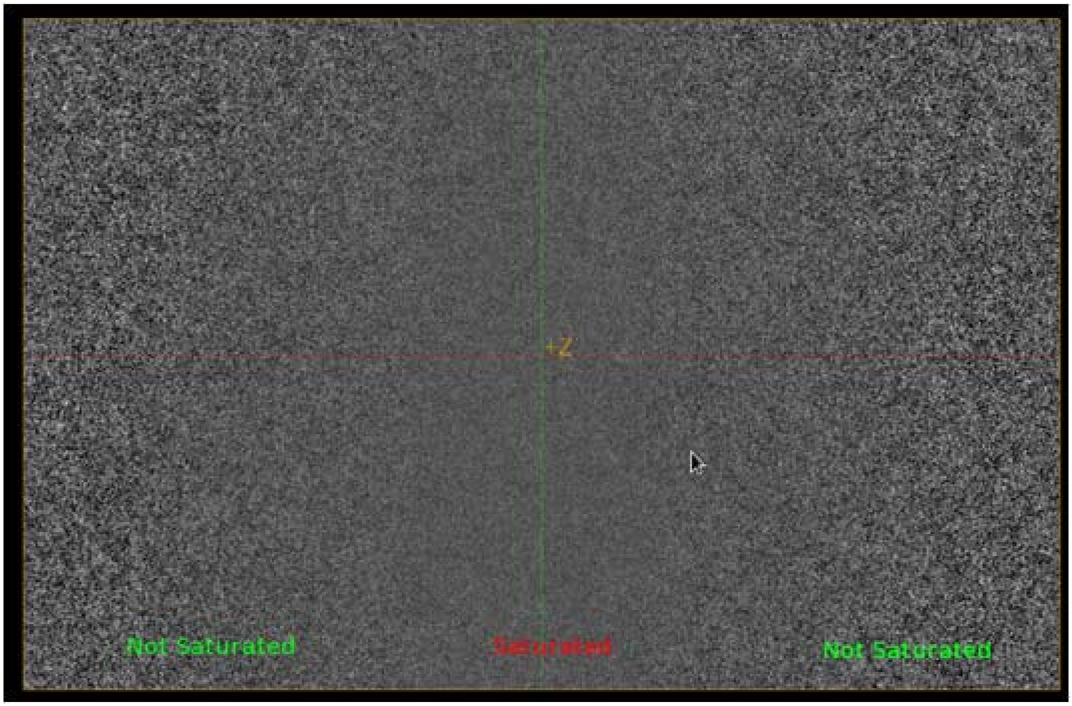

Figure 10-10 Analog Saturation

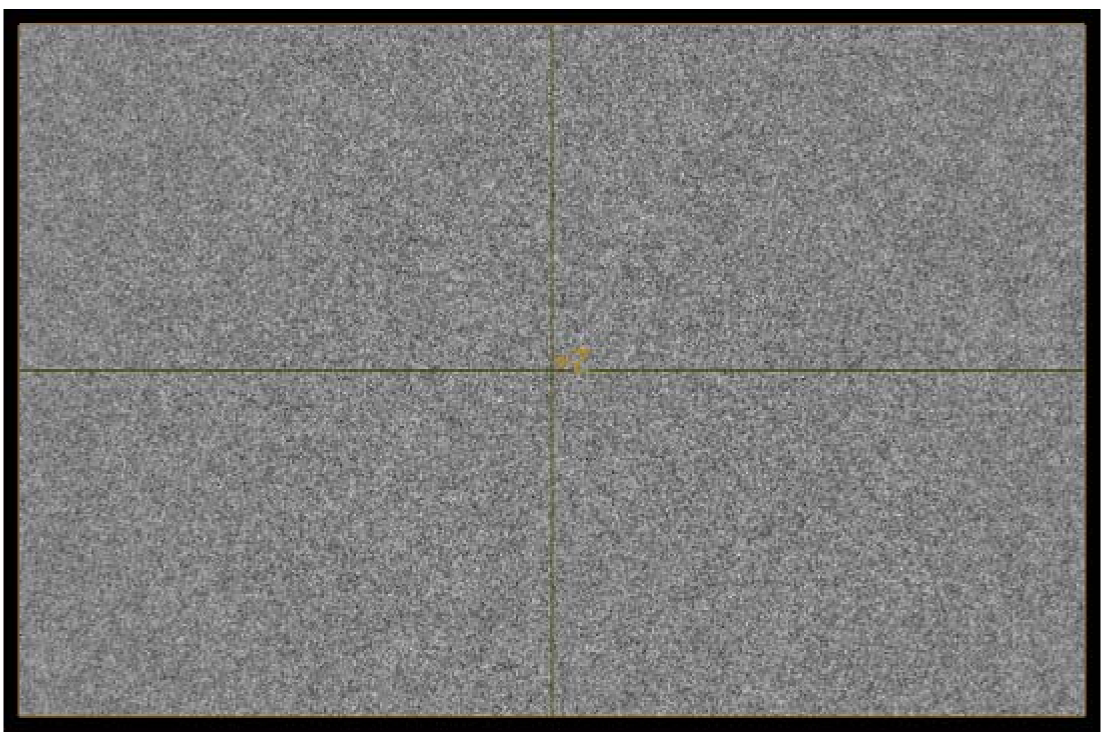

Figure 10-11 No Saturation

CT120 FILTER KIT FOR DETECTOR REPLACEMENT

Purpose:

The purpose of this kit is to adjust the intensity of the x-ray beam in order to account for variability in detector gain from unit to unit. Without filter adjustment, previously-functioning protocols may saturate the detector (detector gain increase) or fail to meet factory noise specifications (detector gain decrease).

Materials

The kit includes this service note, as well as the following filters:

4118561	1.0 mm Al filter
5268141	1.5 mm Al filter
4118559	2.0 mm Al filter
4118315	2.5 mm Al filter
4118560	3.0 mm Al filter

The following tools are required:

8 mm Allan key (removing side cover)

5 mm Allan key (opening side door)

4 mm Allan key (removing filters)

Procedure:

1. Perform ”Analog saturation detection” (page 412). If saturation is detected, the system requires more filtration, and you will continue with step 2 (page 416). If no saturation is detected, then you are finished with this procedure.
2. Remove the side cover of the CT120, whichever side is more easily accessible.
3. Open the shielding door, allowing access to the inside of the scanner.
4. Using the service software, rotate the gantry so that the tube is at the 6:00 position.
5. Remove the four screws and associated hardware, as indicated by the drawing (mark numbers 61, 68 and 69) (Figure 10-12)
6. Remove the aluminum filter, and replace with a thicker or thinner filter, depending on the results of step 3.
7. Replace the screws and associated hardware, and secure the side door.
8. Repeat steps 1-9 until no analog saturation is detected.

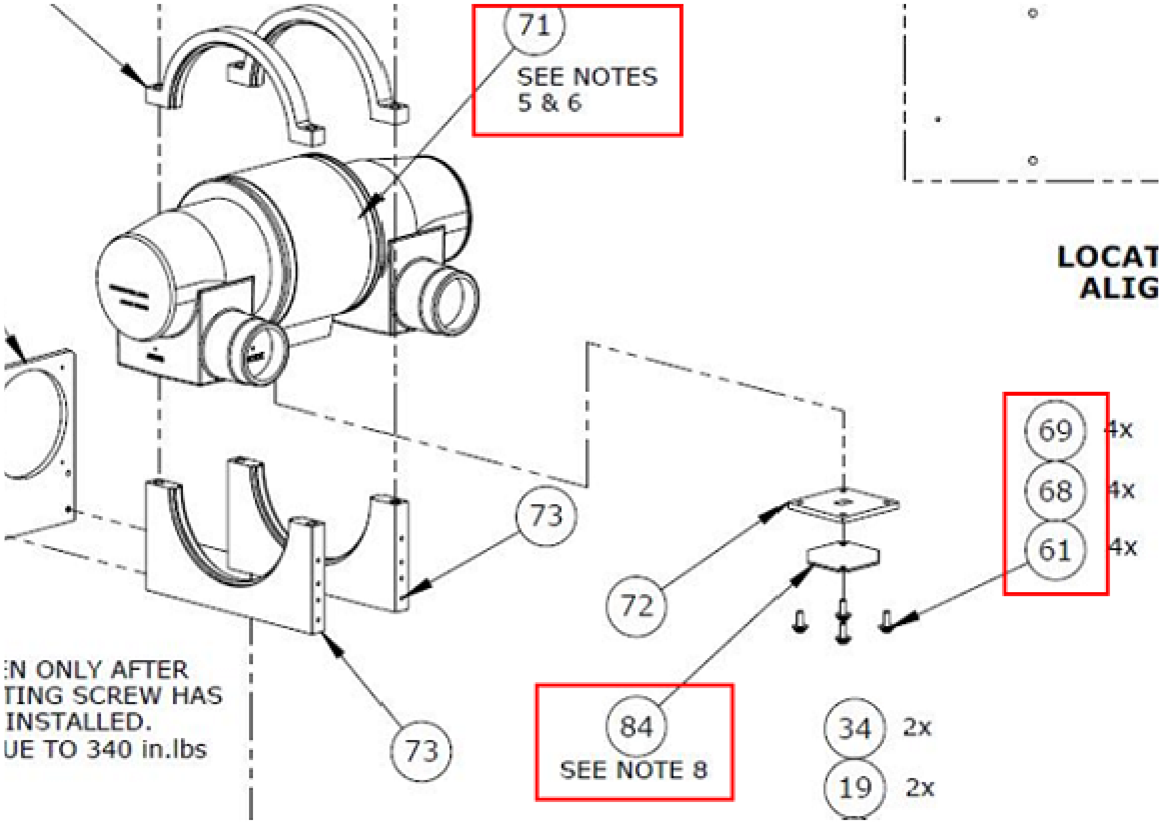

Figure 10-12

ADJUSTING CT PROTOCOLS FOR IMAGE SATURATION

Background

When the scanners are manufactured, the protocols are tuned for optimal use of the dynamic range available from the detector. However, if the detector and/or x-ray tube is replaced, this tuning may have to be repeated. In particular, after a tube/detector change, the CT protocols may cause image saturation of the detector. This occurs because the detector is now over-exposed. Fortunately, each protocol has a detector gain and detector offset value that can be adjusted (in this case lowered). This procedure describes how to adjust the detector gain and detector offset of a protocol in order to eliminate image saturation.

1. Load the CT protocol that results in image saturation

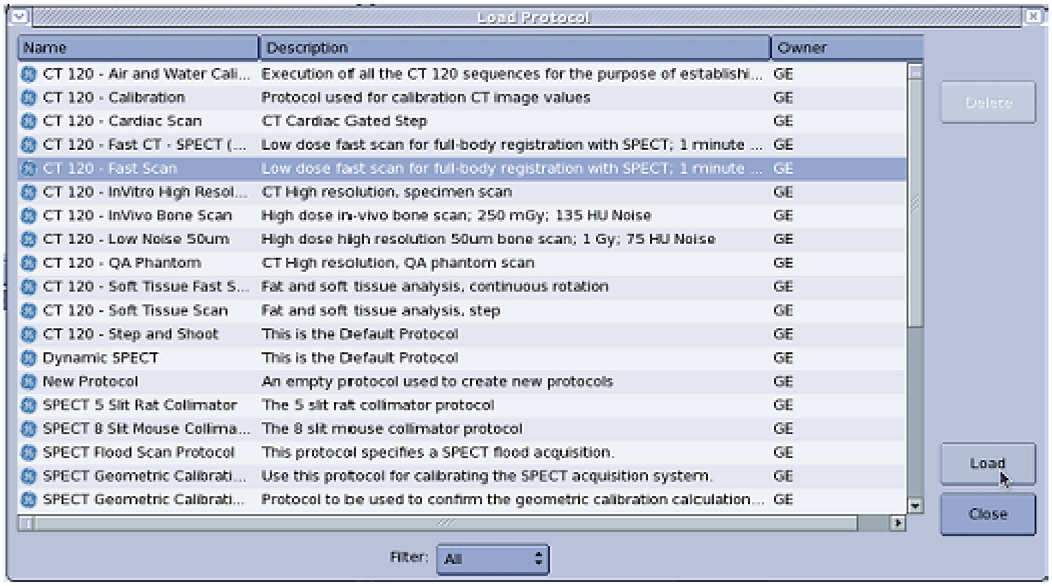

Figure 10-13

2. Select each sequence in turn and run CT Fluoro. Look for image saturation in the fluoro window (a red banner appears if image is saturated)

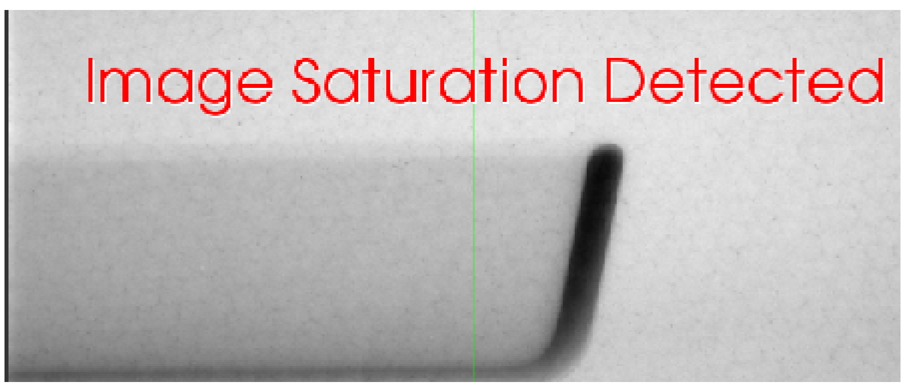

Figure 10-14

3. For each sequence/protocol that is saturated:

   a. Open a terminal window.

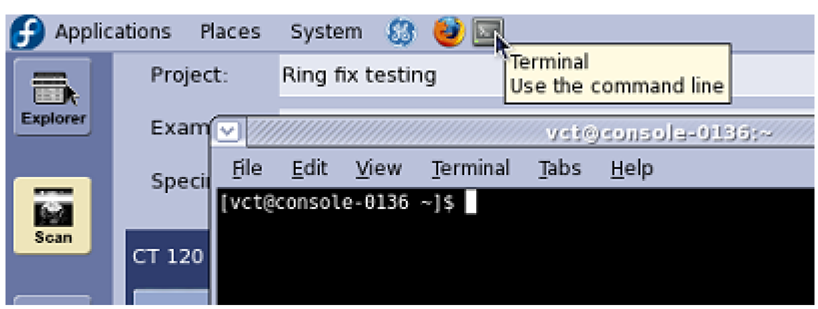

Figure 10-15

   b. Change to the protocol folder by typing:

   `/usr/share/GEHC/protocols`

c. Switch to superuser by typing: `su` (password is operator)

d. Edit the protocol with gedit. gedit <protocol_name>

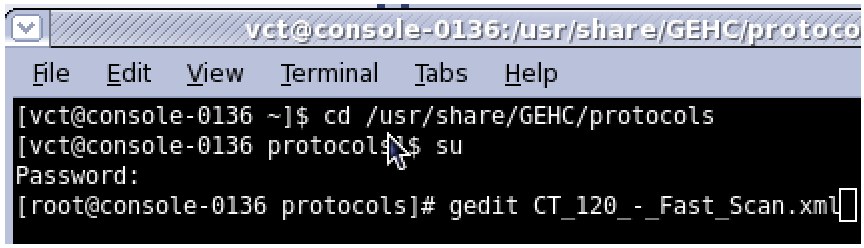

Figure 10-16

e. If this is the first time you are changing the gain and offset for this protocol, change the name by adding a "2" at the end.

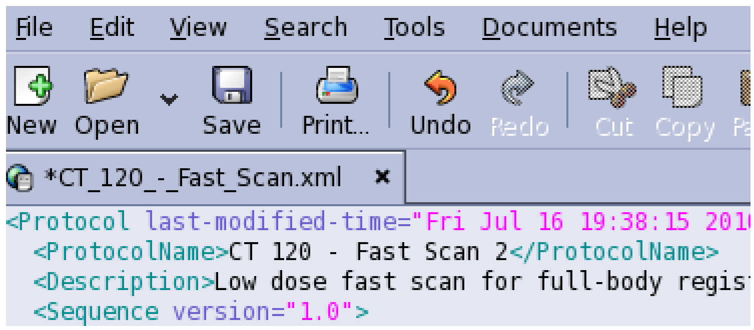

Figure 10-17

f. Lower Gain and Offset values. Note, Gain has a greater effect on saturation than offset.

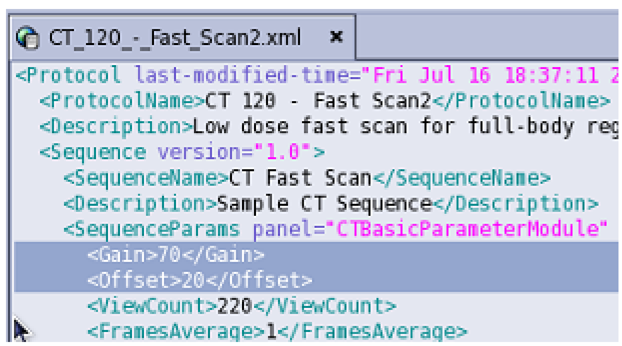

Figure 10-18

g. Save protocol/sequence.

h. Close gedit.

i. Reload the protocol you just modified. Click the load button.

Because you have modified the protocol outside fo the eXplore software, expect to see a warning (Figure 10-19). Click OK.

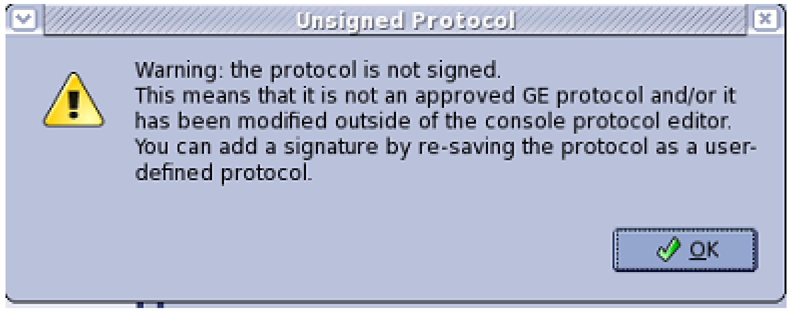

Figure 10-19

j. Check for saturation by running CT Fluoro.

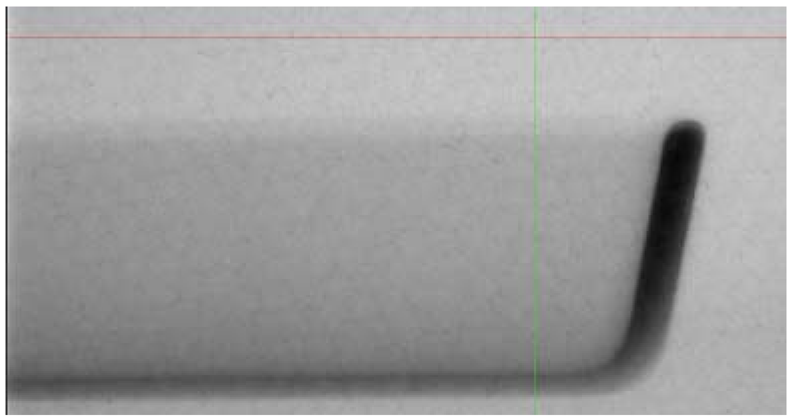

Figure 10-20

k. If the protocol is still saturated redo the procedure starting at step c.

l. Once there is no image saturation, save the protocol from the scan page by clicking "edit protocol", then clicking "save changes".

m. When the save dialog appears remove the "2" from the protocol name so that it is the same as the original name. Click OK.

n. The protocol has been saved in the customer protocol folder; you need to move it to the GE protocol folder. In the terminal window, type:

```
mv /var/lib/GEHC/protocols/<protocol_file> ./<protocol_file>
```

Where <protocol_file> is the name of the protocol file you are working with. When prompted to overwrite the file, type 'y'.

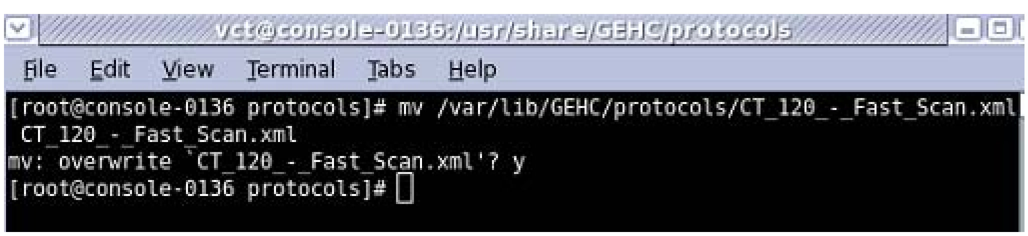

Figure 10-21

o. Close terminal window.

p. Confirm that the protocol has the correct signature by selecting it one more time from the scan page. There should be no warning dialog.