VARIAN
medical systems

TrueBeam™
TrueBeam STx™
Technical Reference Guide

Volume 1

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Abstract

The *TrueBeam Technical Reference Guide* (P/N 100034031-02) provides reference information and procedures for using the TrueBeam™ system, version 1.0.

This document was originally published in English (P/N 100034031-02).

This manual can be printed on any printer capable of printing .pdf documents.

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If you want the source code for RealVNC software, a copy will be sent to you at your request. This offer is valid for a period of three years from the date on which you first received the TrueBeam system from Varian. You will be charged a fee for fulfilling this request. Please contact your Varian service representative for more information and to obtain the request form.

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EU REACH SVHC Disclosure

The link to the current EU REACH SVHC disclosure statement is http://www.varian.com/us/corporate/legal/reach.html.

HIPAA

Varian's products and services are specifically designed to include features that help our customers comply with the Health Insurance Portability and Accountability Act of 1996 (HIPAA). The software application uses a secure login process, requiring a user name and password, that supports role-based access. Users are assigned to groups, each with certain access rights, which may include the ability to edit and add data or may limit access to data. When a user adds or modifies data within the database, a record is made that includes which data were changed, the user ID, and the date and time the changes were made. This establishes an audit trail that can be examined by authorized system administrators.

CAUTION: US Federal law restricts this device to sale by or on the order of a physician.

Trademarks

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Contents

Chapter 1 Introduction

This reference guide describes how to configure, test, and maintain the Varian Medical Systems radiotherapy TrueBeam.

This chapter describes:

- Who should use this guide.
- Visual cues (such as Warnings and Cautions) used in this guide.
- Related publications.
- Electrical and environmental specifications for all models of Varian medical linear accelerators.
- Customer support information.

Who Should Read This Guide

This guide is written for advanced users of Varian Medical Systems' medical linear accelerators—physicists, dosimetrists, and authorized service personnel. It provides instructions for obtaining fast and comprehensive access to machine operations and conditions.

If you are new to Varian's medical linear accelerators, you can find basic information on how to operate them in the *TrueBeam Instructions for Use*.

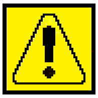
WARNING: Incorrect use of a radiotherapy linear accelerator can cause serious injury or death. Only trained personnel under the supervision of a licensed physician should be authorized by the hospital or owner to operate a clinical linear accelerator. Each operator should also be required to be fully familiar with the emergency and safety procedures described in the *TrueBeam Safety Guide*.

Varian Medical Systems manufactures high-energy medical linear accelerators that feature different groups of X-ray and electron energies, as well as low-energy accelerators with a single X-ray energy. In addition, some Varian accelerator options and software are installed and configured for your specific clinical setting. Therefore, your options and software screens may differ slightly from those shown in this guide.

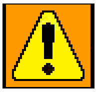
Visual Cues

This reference guide uses the following visual cues to help you find information:

Note: *Describes actions or conditions that can help the user obtain optimum performance from the equipment or software.*



CAUTION: Describes actions or conditions that can result in minor or moderate injury or can result in damage to equipment.



WARNING: Describes actions or conditions that can result in serious injury or death.

Related Publications

The following Varian Medical Systems publications provide additional information about TrueBeam medical linear accelerators and related equipment:

- *TrueBeam Safety Guide*, PN 100020440-02
- *TrueBeam Instructions for Use*, PN 100020438-02

Warnings and Precautions: EMI and RF Interference

WARNING: This equipment can interfere with the operation of other electrical devices, resulting in equipment damage or injury to patients or personnel. Safe use of medical equipment requires special precautions regarding electromagnetic interference (EMI) and electromagnetic compatibility (EMC) with other devices.

In general:

- **Portable and mobile radio frequency (RF) communications devices (such as mobile phones) can affect medical electrical equipment.**
- **The use of accessories, transducers, or cables other than those specified by Varian or manufactured by Varian may result in increased radiation emissions or decreased immunity of the equipment to EMI.**

To prevent damage or injury due to EMI:

- **Avoid use of unnecessary electrical devices near the accelerator.**
- **Use only cables and accessories listed in the Varian Data Book.**
- **Do not use this equipment adjacent to, or stacked with, other equipment. If such use is necessary, test the equipment in the configuration in which it will be used to make sure it operates normally before delivering treatment.**

WARNING: Ionizing radiation and EMI from the accelerator may affect electronic medical devices such as:

- **Infusion pumps, such as ambulatory or pole-mounted IV pumps**
- **Implanted devices, such as cochlear implants or pacemakers.**

In addition, EMI from other equipment, such as microwave hyperthermia or diathermy equipment, can interfere with the accelerator's integrated dose counters, resulting in incorrect doses to patients.

To prevent damage to equipment and injury to patients or personnel:

- **Assess patients for risk prior to treatment**
- **Report any observed malfunctions of medical devices to the patient's health care provider.**

For detailed information about the interaction of EMI or ionizing radiation with any device, consult the device manufacturer.
For technical information about the electromagnetic compatibility of this equipment, see the *TrueBeam Instructions for Use*.

Electrical and Environmental Specifications

Before operating the accelerator, you should be familiar with the following specifications. For detailed safety information, refer to the *TrueBeam Safety Guide*.

Electrical operating specifications:

- Type of protection against electric shock: Class I
- Degree of protection against electric shock: Type B,
- Operation: The TrueBeam is classified as being suitable for continuous connection to the supply main in the standby state and for specified permissible loadings.
- TrueBeam is not for use in the presence of flammable anesthetic mixtures.

Electrical requirements:

TrueBeam input voltage: 200 to 240 Vac 50 or 60 Hz 125 Amps max @ 208V; or 360 to 440 Vac 50 or 60 Hz 65 Amps max @ 400V.

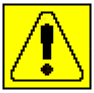
Environmental operating requirements:

- Humidity range: 15% to 80% relative humidity, non-condensing.
- Temperature range: 60°F to 80°F (16°C to 27°C).

Symbols Used on Equipment Labels

Table 1 depicts symbols you will find on labels applied to the accelerator, and their meanings.

Table 1 Symbols on Labels

Icon	Description
	Caution: Indicates potential injury or damage to equipment. Observe safety precautions.
	Caution: Laser Radiation. Do not stare into beam; observe laser safety precautions.
	Type B applied part: This part complies with the specified requirements of EN 60601-1 to provide protection against electric shock, particularly regarding allowable leakage current.
	Equipment manufacturer. This symbol appears adjacent to the name and address of the equipment manufacturer.
	This equipment has been designated as electrical and electronic equipment (EEE) that is not to be disposed of at the end of its life as unsorted municipal waste. EEE contains substances that may present hazards to human health and to the environment. It must be recovered, reused, recycled, or otherwise treated, and properly disposed of.
SN	Serial Number: This symbol appears adjacent to the manufacturer's serial number.

Customer Support

If you cannot find information in this user guide, you can contact Varian in several ways.

For Help Desk support, contact:

- North American toll-free support: 1.888.827.4265.
- Global telephone support:1.702.938.4807.
- Global telephone support, Treatment Planning: 1.702.938.4712.

To order additional documents, contact:

- From North America: 1.800.535.5350 and press 1 for “Parts” on your touch-tone phone.
- Globally: 1.702.938.4700.

If you have access to the Internet, point your browser to Oncology Systems: http://www.varian.com and then select Support.

By e-mail, contact:

- Information Management Systems, Digital Imaging Management Systems, and Delivery Systems: onc.helpdesk@varian.com.
- Treatment Planning Systems: tps.support@us.varian.com.
- Brachytherapy Systems: brachy.support@varian.com.

By United States mail, contact:

Varian Medical Systems Medical Systems, Inc.
3100 Hansen Way
Palo Alto, CA 94304-1030, USA

For the European representative, contact:

Varian Medical Systems Medical Systems, UK Ltd.
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Chapter 2 Overview of the TrueBeam System

The TrueBeam system delivers, according to the purchased configuration and the patient treatment plan selected, image-guided stereotactic radiosurgery and precision radiotherapy for lesions, tumors, and conditions anywhere in the body where radiation treatment is indicated.

The TrueBeam system features:

- A waveguide accelerator that can generate any energy between 6 MV and 20 MV (22 MeV for an electron beam) with improved beam stability and performance over previous generations of accelerators.
- Digital controls that provide dynamic, reliable, and automatic delivery of dose throughout a treatment cycle, to include control of motion axes (servoing) and rapid tuning.
- An integrated control system that digitally controls all machine and treatment functions, thus improving calibration, initialization, and service. The system provides machine state and performance data, complete fault and interlock reporting, and automated system startup and morning checkout.

Physical Layout

A typical TrueBeam installation occupies two separate rooms—a treatment room in which patients receive radiation doses, and a console area or room in which therapists control the radiation delivery.

Treatment Room Layout

The TrueBeam gantry, Stand, and the patient couch are located in the treatment room. The room is shielded to prevent radiation exposure to technicians. The TrueBeam modulator may be in the treatment room or in a separate room. Cameras, lasers, and in-room monitors complete a typical installation. Figure 1 on page 8 shows a typical treatment room installation.

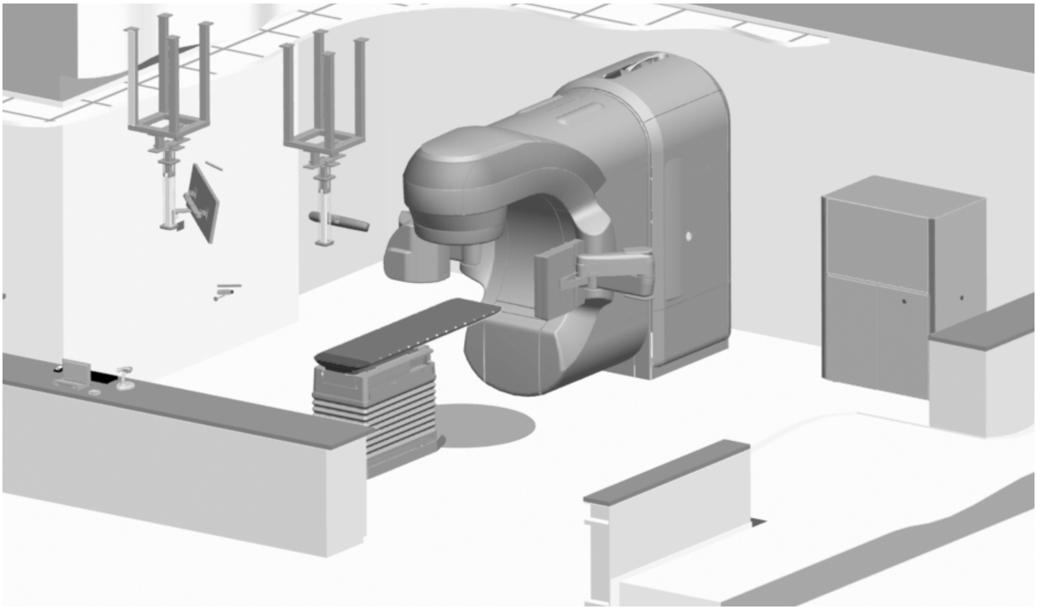


Figure 1 Typical Treatment Room Installation

The treatment room may also contain closed-circuit television (CCTV) cameras so the technician can view the patient and check for mechanical clearances, and an optical guidance camera for respiratory gating.

The two in-room monitors, controlled by the in-room computer, display machine status information to the technician during patient setup. This information includes patient data, setup photos, plan information, motion axes status, and any interlocks.

Wall lasers enable the technician to position the patient precisely.

Console Area Layout

The console area contains the control console that allows the operator to activate the beam for treatment and imaging. It also contains a computer, with a standard alphanumeric keyboard and mouse, two monitors, one showing treatment details, the other showing patient positioning and imaging details. Electronics cabinets house the computers that control the treatment, service, imaging, and other TrueBeam applications.

Figure 2 shows a typical console area installation.

Figure 2 Typical Console Area Installation

In addition, typically, the console area contains the CCTV monitors to display video images taken by the in-room cameras.

System Components

The basic components of the TrueBeam system are controlled through an integrated control system.

Console area or room—Contains the control console, computers, monitors, and the printer that allow users to implement the treatment plan and deliver patient treatments.

Figure 3 on page 10 shows the following components.

Gantry—Contains the parts of the TrueBeam that deliver and shape the beam. The gantry can rotate around the treatment couch to deliver beam from any angle.

Stand—Supports the gantry and contains the components that produce the high levels of radio-frequency (RF) energy required for beam generation.

Modulator—Contains the components that transform AC electricity into the required high-voltage electricity, and distribute it to the primary and support systems of the accelerator.

Treatment couch—Provides precise patient positioning for imaging and treatment.

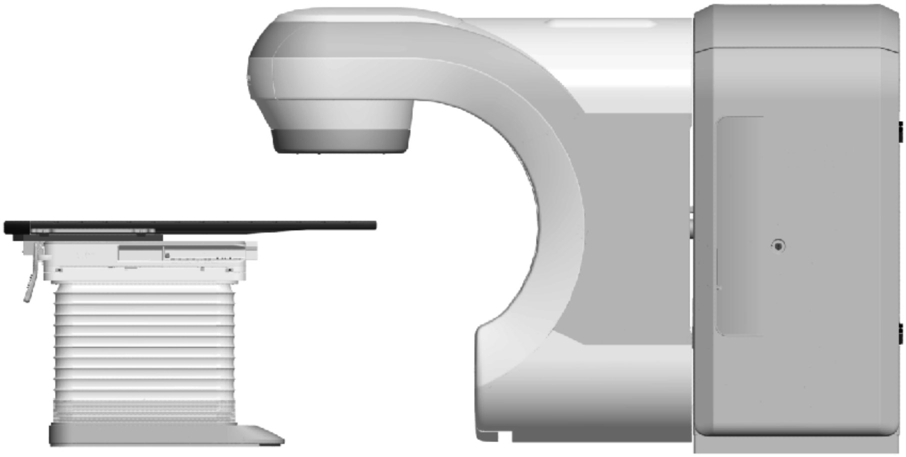


Figure 3 Couch, Gantry, and Stand

Console Area

The console area or room includes the control console, console computers and monitors, and electronics cabinet.

Control Console

The control console (Figure 4 on page 11) provides function and Motion Enable buttons that allow users to start and stop treatments and obtain images. The control console is attached directly to the Stand controller, and it sends keystrokes to the TrueBeam through the control network.

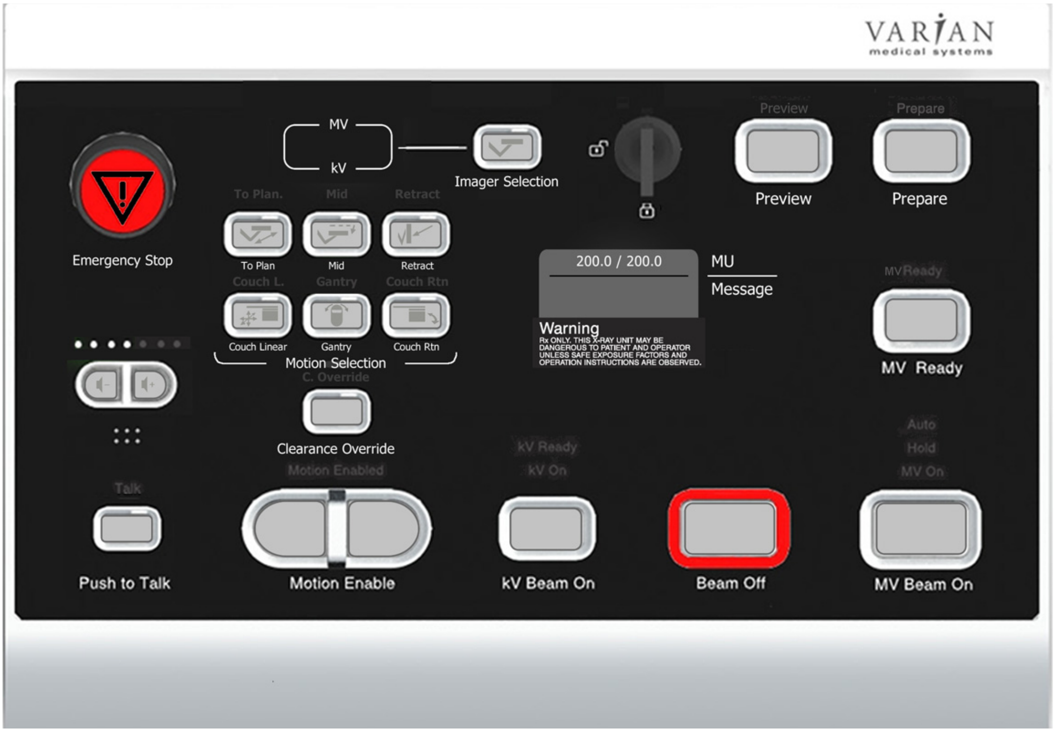


Figure 4 Control Console

Console Workstation

From the console workstation, authorized users operate the treatment delivery and patient verification software, control imagers, and calibrate, tune, and troubleshoot the system. The operator has access to hospital patient records, treatment plans, and other functions.

The console workstation provides treatment controls such as selecting a patient to be treated, and viewing the treatment field plan against actual axis positions. A subsystem of the TrueBeam control system, the console workstation interacts with hospital patient information systems to transfer treatment plans, treatment histories, and radiological images.

Three main applications run on the workstation: the Treatment, Service, and Imaging applications. Additional supporting applications assist in configuration and diagnostics, including the System Administration application and Daily QA mode.

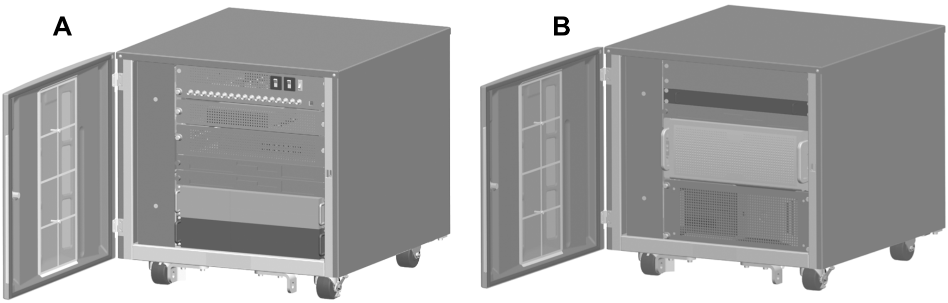
The console workstation is connected to the imaging subsystem with a high speed, 1-gigabit per second Ethernet network to provide real-time image transfer. The workstation is directly connected to the Supervisor to exchange beam information and motion axis targets dictated by the plan.

Approximately every 250 ms, the system Supervisor sends machine status updates and asynchronous event messages (such as control console and pendant keystrokes) to the console workstation.

The two workstation monitors display accelerator operations, treatment software, images, and the gating system, and provide a direct, closed-circuit video image of the patient.

Electronics Cabinets

The electronics cabinets contain the computers that operate the Treatment and Imaging applications, plus computers that provide additional functions (Figure 5). The computers in the control cabinet operate the Treatment application and provide communication with the TrueBeam control system. The computers in the imaging cabinet operate the Imaging application.



A Control cabinet. **B** Imaging cabinet.

Figure 5 Electronics Cabinets

Treatment and imaging—During normal operation, a treatment session begins by loading a plan. The Treatment application verifies the parameters on the system against the plan and shows which axes are moving (arrows).

Once the treatment plan has been verified, the information is passed on to the Supervisor, which activates and monitors the subsystems to carry out the treatment.

The Imaging application acquires and displays patient images to verify that the patient is in the correct position for treatment. The system computes plan corrections based on comparison between reference and verification images, providing plan corrections as needed. In addition, the Imaging application coordinates selection, editing, setting up, and executing additional imaging for dynamic treatment, for offline verification, and for other specialized purposes.

In-room monitors—The in-room monitors are controlled by a separate computer located in the electronics cabinet, providing patient and plan data to the technician during patient set-up.

CBCT Reconstructor—This specialized computer enables cone-beam images to be rendered in three dimensions, providing real-time CT images for treatment or planning.

Gantry

Located in the treatment room, the gantry contains the parts of the system that generate and shape the beam for treatments (Figure 6).

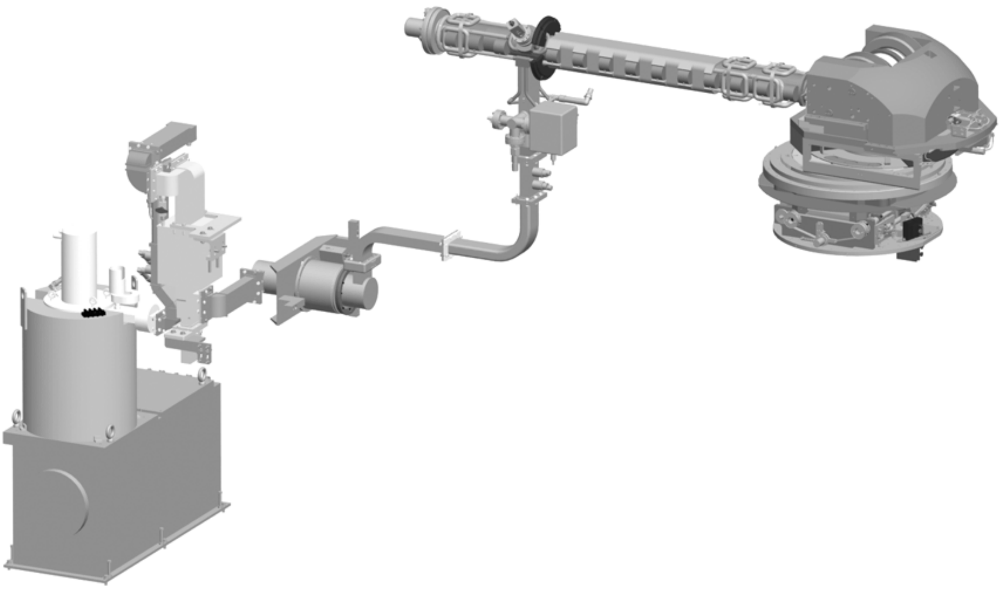


Figure 6 Beam Generation Components

And it supports the imaging arms that provide kV and MV images. The gantry is connected to the Stand and is rotated as a unit. The gantry can be rotated from –185° to 185° in either direction from IEC 0 (gantry up, beam vertically down, for a total range of 370°) at speeds between 1° per second and 6° per second.

The gantry contains these elements:

- Electron gun that controls dose rate and injects a stream of electrons into the accelerator.
- Linear accelerator that maintains optimal bunching for different acceleration conditions and transports the standing waves of the energy beam.
- Energy Switch mounted on the accelerator that varies the coupling between guide sections for varying X-ray energies.
- Automatic frequency control system (AFC) that senses the operating frequency of the accelerator structure and varies the operating frequency of the radio-frequency driver and microwave power tube to maintain constancy of radiation output.
- Vacuum system that maintains the high vacuum needed for operation of the accelerator structure and electron gun.
- Bend magnet that directs the path of the electron beam around 270° from its incoming orientation.
- Electromagnetic steering coils over the accelerator that control the beam within the structure, ensuring precise beam symmetry irrespective of the gantry angles used.
- Collimator, which shapes the beam into the required geometry for treating a tumor.
- MV and kV imagers that acquire images to verify the patient's position for treatment, evaluate treatment results, and prepare for offline review. They consist of the MV source arm and the kV source and detector arms, also called positioning units. The *TrueBeam Technical Reference Guide–Volume 2: Imaging* describes these imagers in detail.

Beam Generation

The accelerator (also called a guide or a waveguide) is the physical container and accelerator of the electron beam.

Electrons emitted by the electron gun are accelerated through the cavities of the accelerator, with the beam controlled by the buncher, position, and angle steering coils (and for high electron energies, the trim coil). The beam emerging at the far end of the accelerator is rotated 270° by a bending magnet. Then the beam enters the air, and either impacts one of four targets (to produce X-rays) or passes though an empty slot (to continue as an electron beam).

The beam then passes through the carousel located at the head of the gantry. The carousel rotates to bring into position the proper filter (to flatten an X-ray beam) or foil (to scatter an electron beam). It can also position an empty slot for treatments that do not use a flattening filter.

The beam then passes through ion chambers which monitor the beam for symmetry and dose.

Finally the beam is truncated into the desired column shape (collimated) and delivered to the treatment location in the patient.

Collimation

The collimator subassembly, located at the end of the gantry, controls size and shape of the treatment beam. The collimator contains two sets of tungsten metal blocks, called X and Y jaws, that open and close to form the basic treatment field and limit it to a specific size. Each jaw can be moved independently along its designated axis. The jaws create the treatment field as specified in the plan.

The beam then passes through the multileaf collimator (MLC), which consists of two banks of 60 narrow lead bars, or *leaves*, that can be positioned individually to shape the X-ray beam to conform to the precise geometry of a defined treatment area. Each leaf can be moved independently of the other leaves. The MLC creates the precise shape of the treatment beam to protect healthy tissue and critical organs from radiation.

The treatment plan can change the collimation dynamically during treatment—the collimator rotates, the jaws open and close as directed, and the MLC changes the shape of the treatment beam.

The collimator has attachments that accept wedge filters, shadow block trays, compensating filters, electron applicators, and other accessories to modify the treatment beam further.

MV and kV Imagers

Supporting the MV and kV imagers are positioning units consisting of three arms—MV detector, kV source, and kV detector. The kV source and detector arms are positioned 90° from the treatment axis. All three arms are attached to the gantry and rotate in unison when the gantry rotates.

Each positioning unit arm consists of a number of mechanical assemblies connected by motorized axes. Feedback devices measure the position of each axis. Based on these values, the TrueBeam control system calculates the position of the arm in space.

Stand: Water and Gas Systems and Indicators

The Stand is the stationary welded steel structure at the back of the TrueBeam that supports the gantry (Figure 7). The Stand contains the high-power microwave tube (klystron) which produces RF energy, amplifies it, and supplies it to the linear accelerator in the gantry through the waveguide system.

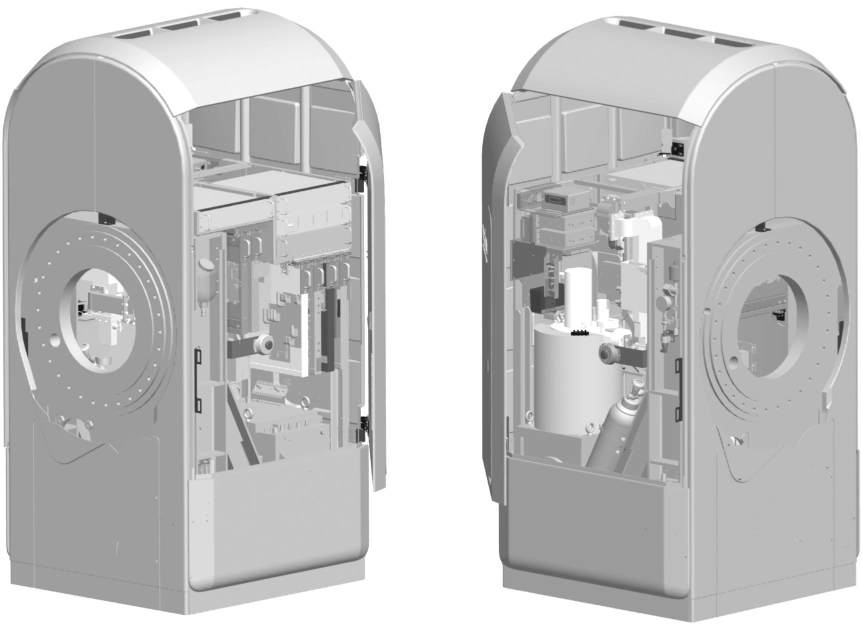


Figure 7 Stand Components

The Stand also houses the assemblies for the power distribution controller, the cooling system, SF_6 gas controller, treatment room signal interface, and the interface to the control console. In addition, the Stand contains the lower couch controller and the Stand controller boards.

Modulator Power Controls

The modulator cabinet contains the components that transform AC electricity into the required high voltage, and distribute it to the primary and support systems of the accelerator.

The modulator cabinet contains main power controls, system circuit breakers, and other controls and indicators.

WARNING: Except for the Start and Emergency Off buttons, the controls and indicators in the modulator cabinet should be used only by authorized personnel. Unauthorized use can result in serious injury or damage to equipment.

To access these controls, open the front door of the modulator cabinet.

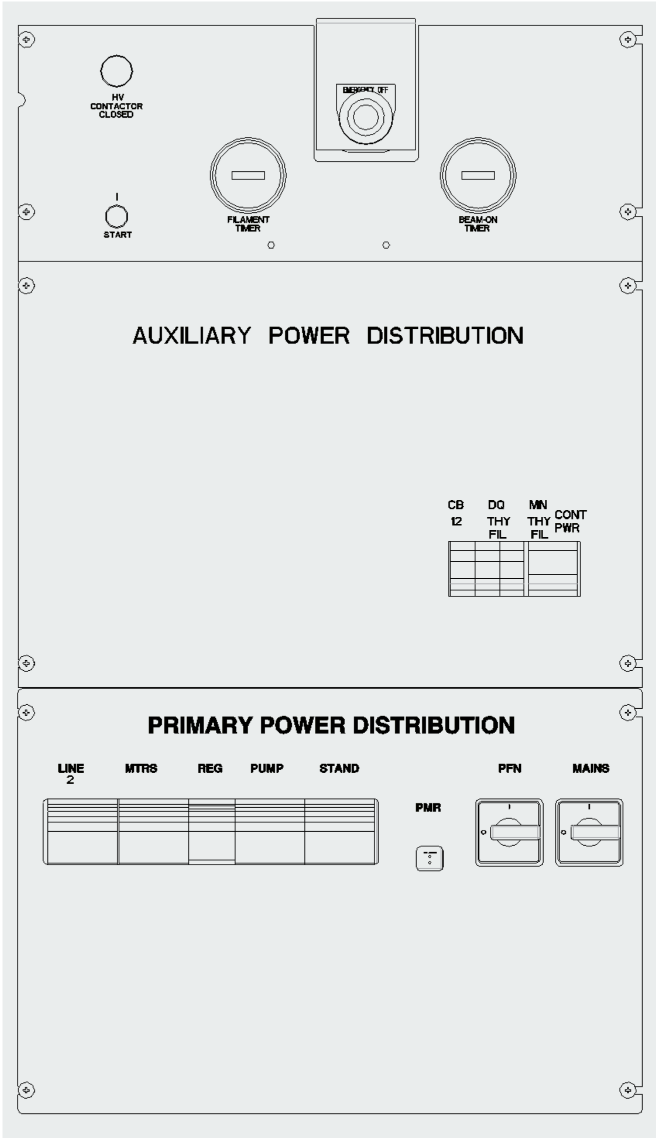


Figure 8 Modulator Front Panel

Table 2 lists functions of some of the controls and indicators in the modulator cabinet.

Table 2 Controls and Indicators in the Modulator Cabinet

Control	Description
Start button and indicator	Used to restore power to the accelerator after complete shutdown or power failure. Lights when the accelerator is powered on.
Emergency Stop button	Stops all motions of gantry, collimators, couch, and imager arms. To reset, pull the button out.
Line 2 breaker	Protects the power circuits to the console power supply and control power.
Motors breaker	Protects the primary power circuit to the DC motor circuits.
Regulator breaker	Protects main and D-Qing thyratron, klystron, gun filaments, high-voltage power supplies, and Stand fans.
Pump breaker	Protects the pump motor. If the Pump breaker is open (tripped), the Pump interlock is active.
Stand Power breaker	Protects power circuits to the klystron tube, solenoid, and bend magnet power supplies. If the Stand power breaker is open (tripped), BMAG and KSOL interlocks are active.
PMR	Phase monitor. Detects problems in the incoming power and prevents Power On if issues, such as a missing phase, exist.
PFN	Pulse-Forming Network circuit breaker
MAINS	This is the main circuit breaker for the accelerator.

Treatment Couch

The treatment couch is a patient-positioning platform which provides a travel range to accommodate a wide variety of treatment fields. The couch provides smooth motion in the following planes:

- Lateral: Right and left in relation to the accelerator.
- Longitudinal: Toward and away from the base of the accelerator.
- Vertical: Up and down.
- Rotation: Swinging in a clockwise or counterclockwise direction in a flat circle in relation to the accelerator.

TrueBeam Control System

The TrueBeam is controlled by a sophisticated network of control boards (modules) coordinated by a Supervisor module, providing integrated control of the entire system.

This section provides information about:

- Control system architecture
- System network
- System communications

Control System Architecture

Figure 9 shows a diagram of the control system and its subsystems, along with system networks and communications.

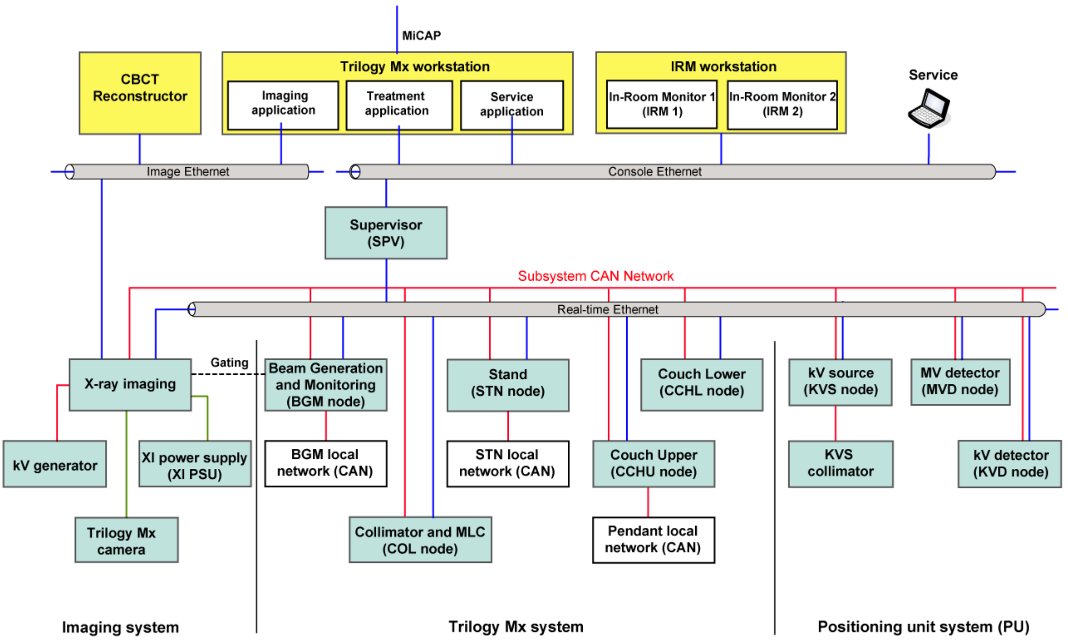


Figure 9 Overview of TrueBeam Control System

Ancillary systems provide safety loops to ensure that beam, motion, and power are enabled only when the entire system has been verified.

The control system is divided into nodes, or subsystems, each responsible for controlling a portion of the machine. The subsystems are linked through the Supervisor, the central control node (this main control node is abbreviated SPV). The nodes provide logical modules (imaging system, respiratory gating and tracking, detector arms, couch, Stand, beam generation, and collimation) to provide detailed control and monitoring of subordinate functions.

Supervisor

The Supervisor node is the central node in the system, coordinating and monitoring the other nodes. The Supervisor signals the other nodes every 10 ms, and it receives status and other information in response.

The Supervisor coordinates:

- Beam delivery by creating motion requests and dose delivery requests every 10 ms based on treatment plan control points.
- Imaging procedures.

It also provides logic control for the pendant, side panels, and control console.

The system nodes generally only communicate with the Supervisor.

X-Ray Imaging

The X-ray Imaging subsystem (XI) is responsible for image acquisition in the TrueBeam system. Other components of this subsystem include the Positioning Unit (PU) subsystem, CBCT Reconstructor for reconstructing CT slices into 3D CBCT scans, and the Imaging Gating and Tracking subsystem.

The XI subsystem is fully integrated into the TrueBeam system, interfacing directly with the Imaging application on the workstation for fast image transfer (up to 10 frames per second).

XI subsystem provides a standard interface for access to real-time image data (used for gating and tracking).

Image acquisition is coordinated by the Supervisor. Images can be acquired during treatment, to coordinate imaging functions with treatment beaming.

Positioning Unit—This subsystem is part of the XI subsystem. It consists of three components (MVD, kVD, kVS) to control the position of the MV detector, kV detector and kV source imaging arms. The TrueBeam pendant also controls imaging arms.

Gating and Tracking—Also part of the XI subsystem, the gating and tracking subnode allows respiratory gating during imaging. It receives real-time image data from the imaging subsystem.

CBCT Reconstructor

This workstation assembles projections from the kV imaging system into the 3D volumetric datasets that comprise a CBCT (cone beam computer tomography) image.

Couch

The couch subsystem controls the four couch axes. It interfaces with pendants and side panels, and routes the status information to the Supervisor for processing.

Stand

The Stand subsystem performs these functions:

- Coordinates power in the system, including emergency stop, to keep controllers running in case of a power outage.
- Controls the cooling system, monitoring water flow and temperature.
- Controls the gantry axis, monitoring gantry position as part of the motion control system.
- Interfaces with the control console through the controller area network (CAN) bus, and routes status information to the Supervisor for processing

Beam Generation and Monitoring

The beam generation and monitoring system (BGM) controls beam generation, provides trigger signals, controls power to the bending magnet, controls the electron gun, and interfaces with the modulator. In addition, the BGM system:

- Measures the delivered dose, using independent ion chamber sensors.
- Controls beam servo systems, including steering servo, dose servo, and AFC servo.

The BGM system is divided into subnodes to control specific functions:

- Electron gun (EGN) to initiate and control the electron gun which creates electrons to be accelerated.
- Modulator (MOD) monitors and controls the high-voltage power created by the modulator and klystron.
- Radio frequency source and power supply (RFSPS) controls the RF driver and power supplies to the bend magnet, accelerator solenoid, and the klystron solenoid.
- Position (POS) controls the carousel, target drive, and the Energy Switch.
- Pulse-width modulator (PWM) controls the beam-steering coils that guide the beam along the accelerator and through the bend magnet.

Collimation

The collimation subsystem controls collimator rotation, the upper and lower jaws, and the MLC, to determine the final beam shape.

The collimation subsystem also monitors accessories and provides status information to the Supervisor for processing.

System Networks

The TrueBeam system includes four types of networks with specific functions:

- Real-time Ethernet network connects the Supervisor and the nodes for cyclical (UDP, 10 ms) message exchange, providing status and command flow. (User or Universal Data Protocol enables computer applications to send messages (datagrams) to other hosts on an Internet Protocol network without requiring prior communications to set up special transmission channels or data paths.)

- Workstation Ethernet network connects the workstation, in-room computers, and the Supervisor for non-real-time data exchange (plans, histories, imaging procedures) and for status information of the controller (about 250 ms).
- Imaging network connects the XI application and the workstation for fast real-time image data exchange (10 frames per second) and for configuring the imaging system.
- Subsystem Network connects the nodes for fast (about 1 ms) peer-to-peer communication using the controller area network (CAN). Communication includes dedicated synchronization pulses, beam pulses, and safety loops.

The system checks that each component is operating with compatible software and firmware versions.

Communications

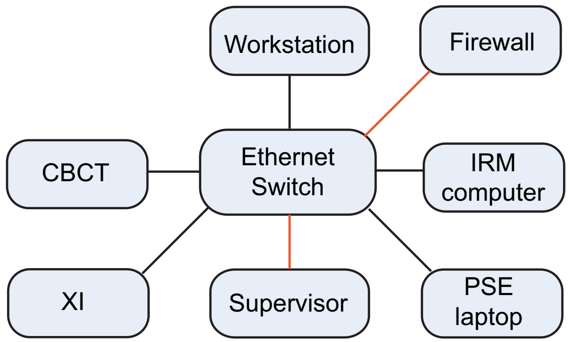
Communications between the parts of the system are provided by two types of networks—Ethernet and controller area network (CAN). The Ethernet provides high capacity data communications; the CAN network supports very fast communications in smaller packets.

Ethernet Networks

Connection from the TrueBeam console workstation to the control system is through three major Ethernet networks. The workstation is connected to:

- The hospital system through a 100-megabit per second (MBps) firewall.
- The CBCT Reconstructor and the XI node, and separately to the in-room computer, using a 1-gigabit-per-second (Gbps) Ethernet, the fastest industry-standard desktop connection.
- The Supervisor and its subnodes, through a 100 MBps connection.

The TrueBeam Ethernets are wired in a star topology (see Figure 10 on page 25). Each device has a direct (nonshared) cable connection to the Ethernet switch at the center.



Red: 100 MBps connection speed. **Black:** 1 Gbps connection speed.

Figure 10 Ethernet Star Topology

This configuration isolates network traffic, essentially making data going between two ports invisible at any other port.

Controller Area Network (CAN)

A CAN is a network protocol and bus standard that allows microcontrollers and devices to communicate with each other without using a host computer.

The major subnodes in the TrueBeam system are connected with a CAN bus, as shown in Figure 11. The CAN bus facilitates very low latency communications—for example, for beam gating.

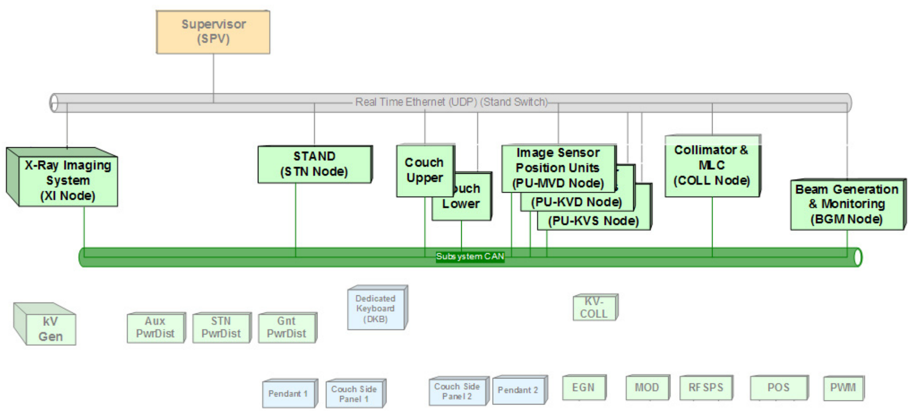


Figure 11 Subsystem CAN bus

The smaller subnodes and controllers in the TrueBeam system also use CAN bus connections, as shown in Figure 12.

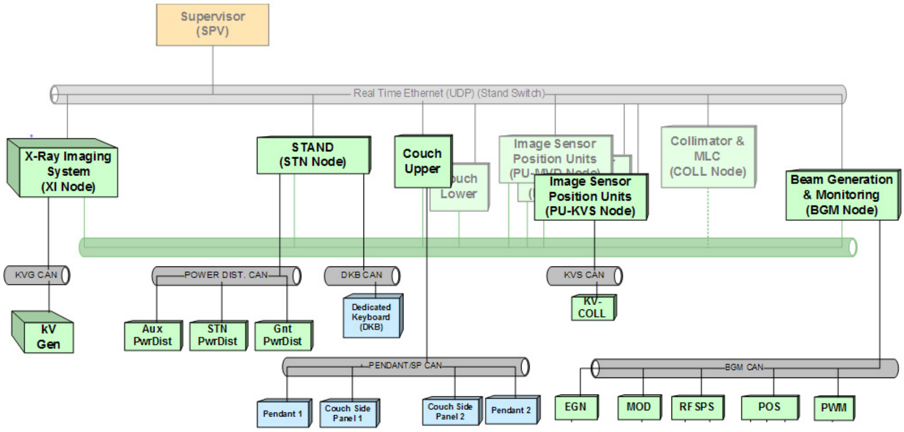


Figure 12 Local Cell CAN buses

The CAN busses provide real-time data transmission with bit-timing and synchronization. The CAN is wired as a bus. In comparison with the Ethernet star topology, a CAN network is linear: a terminator is required at each end. CAN data rates are higher on shorter buses, and lower on the longer busses.

The subsystem CAN network connecting the Stand, gantry and the X-ray imaging console operates at 500 kbps. The CAN networks running in the treatment room (BGM, power, pendant) may operate as fast as 1 Mbps.

Chapter 3 System Safety

Normal and safe TrueBeam operation is monitored by a safety system that targets potentially hazardous failures involving machine axis movements, beam generation, radiation, electricity, and data communication.

The TrueBeam safety system includes internal mechanisms, such as system communications, self-checking software, and safety interlocks; external mechanisms, such as warning lights, audio alerts, and motion controls; and treatment room monitoring devices, such as an intercom system and live camera feedback.

Safety procedures concerning patients are in the *TrueBeam Instructions for Use*. For more information on safety procedures for service and maintenance personnel, refer to the *TrueBeam Safety Guide*.

System Hazards

Table 1 lists examples of major system hazards and preventive actions taken by the safety system.

Table 1 Major System Hazards

Potential Failure	Hazard	Automatic Action
Mechanical:		
Damaged drive	Motor runs at full speed.	Software checks velocity and removes drive power.
Damaged position sensor	Axis in wrong position.	Software checks axis position and removes drive power.
Beam Generation:		
Problems with dose symmetry and flatness	Radiation is out of specification.	Beam Enable safety loop is opened; beam generation and monitoring controller prevents beam generation.

Table 1 Major System Hazards

Potential Failure	Hazard	Automatic Action
Software:		
Subsystem	Treatment is out of specification	Main controller disables system; all subsystem outputs are switched to inactive state.
Supervisor	Treatment is out of specification	Operator monitors workstation display and prevents treatment.
Data Communication:		
Interruption between subsystem and main controller	Treatment is out of specification	Subsystem opens safety loops to prevent beam generation and axis motion.
Interruption between workstation and main controller	Inaccurate data on workstation display and in-room monitors.	Main controller stops treatment.
Data Transfer:		
Corrupt data from treatment plan program to workstation	Treatment is incorrect for patient.	Treatment software prevents treatment.

Second Channel Integrity Checks (SCIC)

When a patient plan is approved in an ARIA version supporting SCIC, SCIC calculates a signature value that is stored with the plan. If SCIC is enabled in the TrueBeam system, when the patient plan is loaded the system calculates a signature and compares it with the value in the plan. If the signatures match, the patient plan is loaded.

If the two signature values do not match, the plan data may be incorrect. The system prompts a SCIC failure, and the patient plan is not opened. Contact Varian customer service for assistance in determining whether the plan data is corrupted.

Enable or disable SCIC in the System Administration mode, under Treatment preferences.

System Communications

The TrueBeam safety system actually consists of two independent systems, the main system and the safety system. The safety system independently checks the safe functioning of the main system.

Two communication systems reporting normal operation ensure that no single failure can cause a hazardous failure in the TrueBeam. Because the two systems are independent, the safety system cannot be disabled by the main system.

Each safety system has these independent communication channels for communicating system hazards (Figure 1 on page 29):

- Main system, which consists of network communications (Ethernet, controller area network or CAN).
- Safety system, which consists of safety loops controlling power enable, motion enable, kV beam enable and MV beam enable.

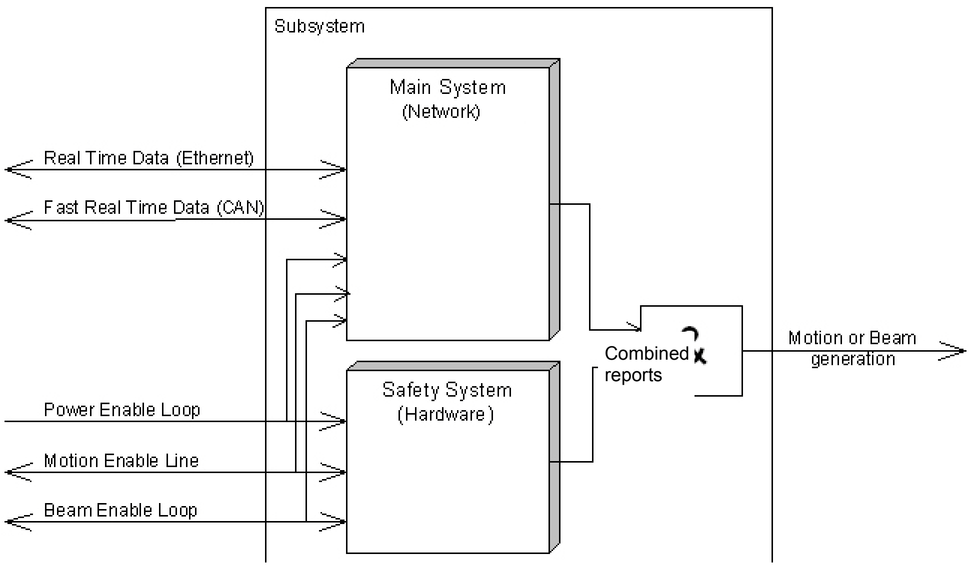


Figure 1 System Communications

In a safety loop, command signals travel from a central controller board—such as the BGM-CONT or the Supervisor—to a device such as the electron gun or couch lift motor. Feedback signals from the device travel back to the controller and inform the controller that beam generation or couch motion has occurred. Safety adjustments are made to the command signals as necessary.

Safety System Components

Safety system components include operator actions (Table 2). Additional safety system components include safety interlocks and safety loops, described in the section “Power Safety” on page 37.

Table 2 Operator Actions

Action	Components	Section in This Chapter
Prevent unauthorized use of TrueBeam.	Control console keyswitch	“Control Console Lockout” on page 30
Visually monitor treatment room.	Cameras, intercom system, Live View window, and optional pan-tilt-zoom cameras and audio.	“Treatment Room Monitoring” on page 31
Visually monitor beam on.	Treatment room and control console warning lights	“Warning Lights” on page 32
Aurally monitor beam on, dose delivery.	Control console audio alert	“Audio Alerts” on page 32
Visually monitor beam delivery.	Control console monitor units backup counter	“Dose Monitoring” on page 34
Immediately shut off beam.	Control console Beam Off button Door interlock switches	“Beam Off Button” on page 34
Immediately shut off power.	Emergency Stop buttons, Emergency Disconnect Switch	“Power Safety” on page 37

Control Console Lockout

The control console can be locked to prevent unauthorized use of the TrueBeam. Turning the control console key to the locked (off) position disables safety loops and shuts off power for beam generation and axis motions from the control console.

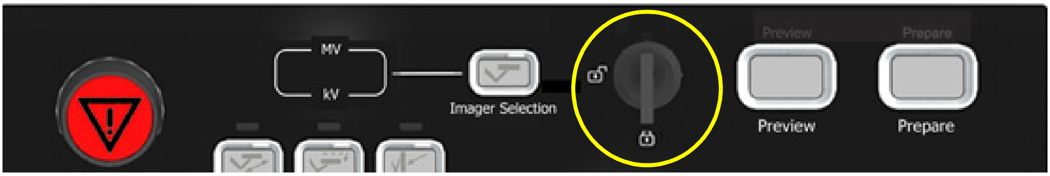


Figure 2 Control Console Keyswitch

After the TrueBeam is placed in Power Saver mode, operators can follow owner procedures for removing the key and storing it in a secure enclosure.

Treatment Room Monitoring

An intercom system, cameras, and the Live View window enable you to monitor the treatment room. Warnings lights and audio sounds alert operators to unsafe and other conditions.

Monitoring System

The monitoring system includes:

- A two-way intercom system (speakers and microphones), connected between the treatment room and the console area, that enables therapists in the console area to always communicate with other therapists in the treatment room.
- Optional pan-tilt-zoom, closed-circuit-television (CCTV) cameras in the treatment room that are mounted to a wall or to the ceiling. CCTV cameras enable radiotherapists to monitor the room from the control console.
- One fixed-position, radiation-hard camera focused on the patient whose image appears on the Treatment application screen.
- Live View window (in Treatment mode) that provides live feedback from cameras inside the treatment room. Animated arrows in the Live View window show the direction that TrueBeam parts will move (see Figure 3 on page 32).

For recommendations on mounting monitoring devices, see the *Varian Installation Data Package*.

Figure 3   Movement Direction Arrows in Live View

Warning Lights

Warning lights alert an operator to unsafe conditions. The TrueBeam provides outputs for various warning lights. Inside and outside the treatment room, lights blink when a beam is on.

In addition, in the console area lights include:

- Depending on local codes, a ready light
- Separate X-ray-on and generator-on lights.
- On the control console, a Beam Off light. See “Beam Off Button” on page 34 for more information.

Audio Alerts

The control console emits sounds to signal different events, alert you to notice the state of the TrueBeam machine, and signal that the machine is ready to operate. In addition, a completed alert sounds when the last field of a treatment plan has completed.

The control console emits a beep alert when:

- kV or MV beams are on.
- Couch is in a float position.
- A full monitor unit has been delivered.
- The kV beam radiograph has been delivered. Continuous alerts sound during kV Beam On for fluroscopy and cone beam computed tomography (CBCT) modes.
- Modes for kV Beam On for fluoroscopy and CBCT are running.
- The Prepare button on the control console is pressed. The sound plays for 2 seconds.

The control console emits notice alert sounds in the following cases:

- A collision is detected.
- An interlock is activated and all interlocks have been previously cleared.
- An operator's motion request is denied.
- The TrueBeam is exiting the Power Saver state.
- The couch is in free-float position. An alert sounds 5 seconds after the couch is placed in Float mode and plays every 5 seconds.
- When TrueBeam is in Treatment mode and you switch to kV high level fluoroscopy in the Imaging application, the beep becomes higher pitched.
- The kV fluoroscopy timer has expired. A warning alert sounds every 3 seconds.

You are also alerted when the TrueBeam is OK and ready to operate:

- All collisions have cleared.
- Imager arm positions have been reached.
- Machine warmup is complete.
- Plan and actual parameters agree.
- All interlocks have been cleared.

Dose Monitoring

The monitor unit (MU) backup counter on the control console enables a radiotherapist to monitor the delivered dose of radiation. The backup counter (Figure 4 on page 34) is a liquid crystal display that shows:

- Delivered MU and the total planned MU of the current field or last field treated, for example, 20/200 as shown in Figure 4.
- Last MU until a new MU is delivered.

Figure 4 Monitor Unit Backup Counter

The counter is continuously updated to show accurate MU data. It does not have a battery, but continues to display data for at least 30 minutes if power is lost or shut off.

Beam Off Button

The Beam Off button on the control console terminates treatment, for example, when a patient has moved out of position.

Pressing the Beam Off button (Figure 5 on page 35) immediately shuts off the treatment beam.

Beam Off is also activated by the following conditions:

- In the modulator cabinet: a door is open, the Pulse Forming Network (PFN) Disconnect Switch S1 is open, or the Crowbar control switch is deactivated.
- A treatment room door is open or not securely closed.
- A control system is activated by a fault interlock.
- Actual and planned parameters in a treatment plan do not match.

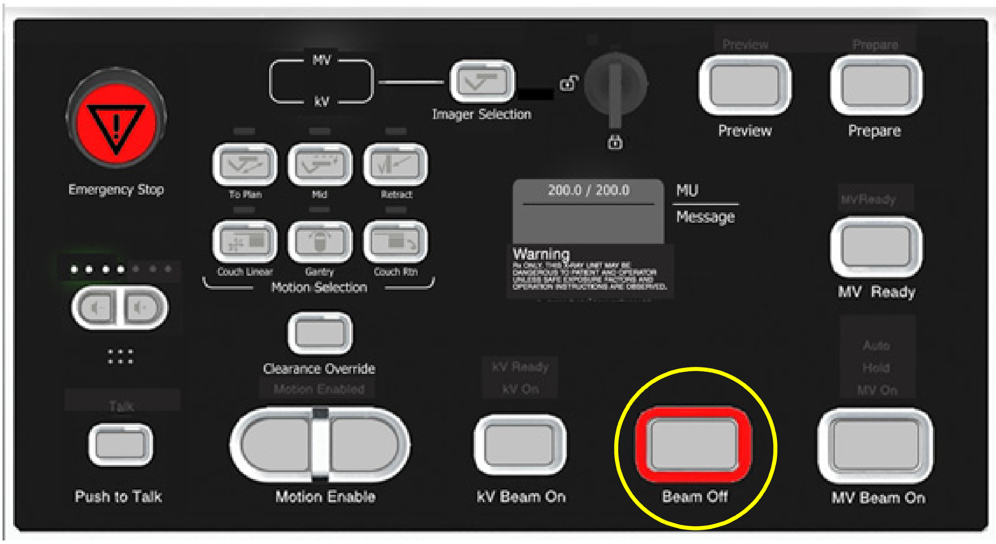


Figure 5 Beam Off Button

Motion Control

When a beam is on, TrueBeam motions stop if an operator presses the Beam Off button or the Emergency Stop button on the control console. Other conditions described in this section also affect motion.

Go To Targets

When a treatment field is loaded, Go To positions for geometric axes are sent to the main controller in the TrueBeam. If moving an axis does not require pressing a Motion Enable button or bar, the axis moves automatically to the target position on pressing the Prepare button.

Accessories

Whenever an accessory is inserted in an accessory mount but is not recognized by the accessory subsystem, the collimator and gantry cannot be moved remotely or during treatment. (The exception is if the TrueBeam is in Service mode; for more information, see “Moving Axes” on page 58.)

For non-Varian accessories, refer to the documentation provided for those accessories.

Remote Control

Control of remote motion of the gantry and couch depends on which application (also known as the operational mode) issues instructions.

Service Mode—When the treatment room door is open, remote-control motion is possible.

System Administration Mode—Operators can disable remote-controlled motion before servicing the TrueBeam, during the first day of treatment for a new patient, or for any reason that they consider necessary.

Treatment Mode—Remote motions for treatment are controlled by tolerance tables during the treatment planning stage. Tolerance tables determine whether remote motions are permitted for each axis. When the TrueBeam is in Treatment mode, you can see the values associated with the current table by clicking the Information button (the circled “i”) next to the Tol. Table field.

Motion Enable Loop

When the TrueBeam control system detects a fault or interlock in motion controls, the Motion Enable loop is opened to stop all axis motions. Motion controllers then execute a controlled stop.

Input Device Motion Control Hierarchy

Pendants and couch side panels have higher priority for moving machine axes (such as imager arms and the gantry) than do the control console or Service application.

If a motion direction is made from a higher priority device and motion is in progress, the TrueBeam interrupts its current motion and executes the new motion directed by the higher priority device. If a motion direction is made from a device that has equal or lower priority, the TrueBeam ignores the new motion direction.

Power Safety

The TrueBeam power safety system includes Emergency Stop buttons, door interlock switches, safety loops, and an Emergency Disconnect Switch in the main circuit breaker panel.

Owner-supplied Emergency Stop buttons and switches inside and outside the treatment room supplement the TrueBeam power safety system.

Two-Layer Protection

Emergency Stop switches consist of two layers of disconnects (Figure 6) to ensure that no single failure can defeat the safety system.

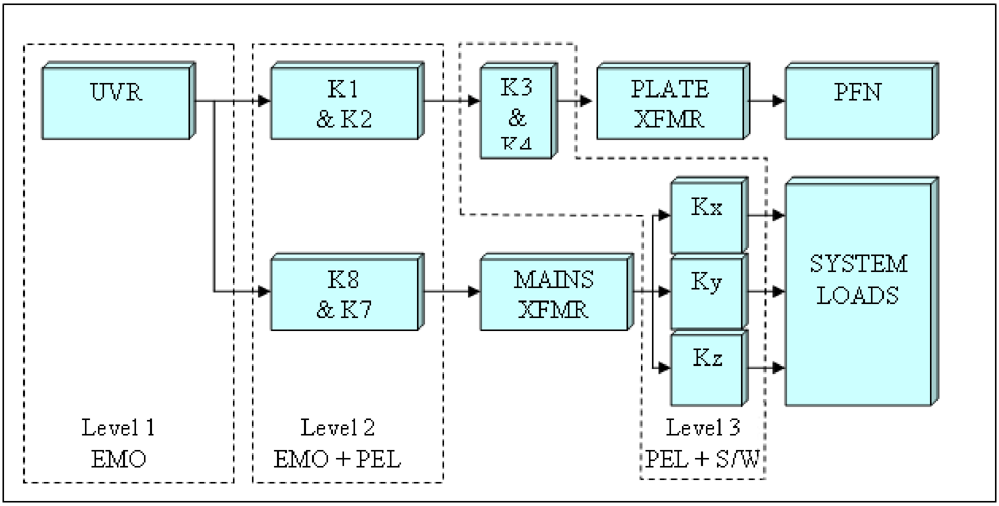


Figure 6 Power Safety System

For emergency machine off (EMO) circuits, all primary power for all transformers and system loads is cut upstream. When an EMO circuit is open, it can be closed only by manually starting the sequence to reset the under voltage relay.

As shown in Figure 6, the Power Enable loop (PEL) also consists of two layers of disconnects. For PEL, power is removed via relays (in the modulator and in power distribution boards in the stand and gantry) that are upstream of all major system AC loads. Figure 6 represents these relays as Kx, Ky, and Kz.

Door Interlock Switches

Door interlock switches ensure that the treatment room doors (including neutron doors) are closed during TrueBeam operation. Until a door is securely closed, the TrueBeam safety system prevents beam generation.

Safety Loops

Safety loops are routed through subsystems and local networks (such as the beam generation and monitoring system and the power system). These loops allow the various power distribution boards to inhibit beam and motion if the TrueBeam is not ready for beam generation and axis motion.

For more information on safety loops, see Appendix D, "Safety Loops," on page 283.

Emergency Stop

Emergency Stop buttons are red, two-position, push buttons that are provided by Varian and labeled with an emergency icon (Figure 2). The buttons are used to disconnect energy sources and shut off power to the TrueBeam system. The EMO system (which includes components in the Stand, couch side panels, modulator, control console, and console cabinets) detects and identifies the status of Emergency Stop buttons.

Figure 7 Emergency Stop Icon

Emergency Stop buttons can be used by operators during hazardous situations, such as an unsafe motion by a machine axis or a fire in the console or treatment area. Automatic activation of the Emergency Stop system occurs when power to the TrueBeam is interrupted.

Unsafe axis motions can occur when an axis controller detects unwanted or excessive motions, a mismatch occurs in the position feedback devices, or motor current is excessive. If unwanted motions continue after Emergency Stop is pressed, the control system de-energizes the motors contactor to interrupt AC power to motor axes.

Power interruption can occur when a power failure at an owner's site causes loss of AC power to motors; an operator opened circuit breakers; or excessive current tripped the motor or mains circuit breakers. In the latter case, the mains contactor is de-energized to open if the main transformer temperature exceeds safe operating conditions.

Button Locations

Emergency Stop buttons complement owner-supplied Emergency Stop buttons and switches that are mounted on walls inside and outside the treatment room.

Emergency Stop buttons are located on these TrueBeam components:

- Control console
- Stand
- Couch
- Modulator cabinet

TrueBeam emergency circuitry includes owner-supplied Emergency Stop buttons and switches. The TrueBeam system can show the location of switches for up to four of these external Emergency Stop buttons.

Treatment Versus Service Operation

Operation of Emergency Stop differs, depending on whether the TrueBeam is in Treatment mode or in Service mode. The main difference is whether the external 24-volt power supply for operation of the multiple printed circuit boards remains operating.

Treatment Mode Operation—While the TrueBeam is in Treatment mode, Emergency Stop activation does *not* disconnect the 24-volt power supply from incoming power.

In Treatment mode, pressing Emergency Stop immediately shuts off:

- High-voltage input power to the modulator, which stops any motion or beam.
- All AC power to the treatment room.
- AC fans.

Power remains on:

- At the TrueBeam workstation computer.
- (24V) To closed-circuit television (CCTV) displays, control console, and throughout the TrueBeam for use as control power (for example, for couch emergency controls).
- To some fans.

To run Treatment mode, click the Daily QA or Treatment button in the Select Major Mode menu; then enter your user name and password.

Service Mode—Pressing Emergency Stop shuts off all power to:

- Most TrueBeam components including the 24V power supplies. Inside the imaging cabinet, the main circuit breaker opens and power is still provided to the kilovolt (kV) detector.
- The TrueBeam from the treatment room.
- Cooling fans.

Power remains on to Emergency Stop power supplies.

See Chapter 4, “Introduction to Service,” for more information on Service mode.

Circuit Testing

Varian recommends that EMO circuits in the Emergency Stop system be tested at least once every three months to ensure patient safety and safe operation of the TrueBeam.

To test circuits, you can use the Service application. In Service mode, pressing any Emergency Stop button deenergizes controllers, AC power, and vacion power. See Chapter 4, “Introduction to Service,” for more information on Service mode.

Emergency Disconnect Switch

The Emergency Disconnect switch (or button) is used to completely shut off the TrueBeam. Use the Emergency Disconnect switch during an emergency, such as a fire, smoke in the TrueBeam, or any catastrophic situation.

The Emergency Disconnect switch is located in the main circuit breaker panel on a wall inside or outside the treatment room. It is installed on one of the circuit breaker panels with the CB2 and CB3 circuit breakers. The Emergency Disconnect switch is not in the Emergency Stop direct network.

CAUTION: The Emergency Disconnect Switch (or button) shuts off all power to the TrueBeam. Use the switch only during an emergency. Otherwise, use the proper shutdown procedure to turn off power to the TrueBeam. To test the switch, shut off all computers to prevent data corruption and damage to the computer operating system. DO NOT test the Emergency Disconnect Switch when computers are on.

In Service and Treatment modes, the Emergency Disconnect switch is the only way to shut off all power.

The switch removes power upstream of the uninterrupted power supply (UPS) in the console monitor and interface printed circuit board (ConMan), which controls EMO circuits. Pressing the switch shuts off power to:

- The UPS and all incoming power to the TrueBeam, including the main circuit breaker.
- All components such as console computers, firewall devices, in-room monitors, and the radiation-hard camera.

Recovering from an Emergency

The TrueBeam safety system provides the following utilities for recovering from an emergency.

Operator Instructions—If there is communication failure between the TrueBeam control system and the workstation, the control console displays operator instructions on how to proceed.

System Event Log—These logs contain information for diagnosing events, which are generated each time a fault interlock is activated. Logs are stored on the system for operators and service personnel to read and archive.

Monitor Unit Backup Counter—After an emergency stop, the MU Backup Counter on the control console displays the cumulative number of monitor units that were delivered during treatment (see "Dose Monitoring" on page 34). Operators can record the data.

Collision Detection and Prevention

WARNING: To avoid exposure to excessive leakage current, do not touch the connector and circuits in touch detectors on the back of the kilovolt (kV) and megavolt (MV) imaging arms.

The TrueBeam includes various mechanical, electrical, and software features to detect collisions as well as prevent contact with obstacles and possible injury to the patient or operator. You can also override and clear potential collisions.

Collision Detection

Collision detection structures, to detect contact with obstacles in the travel path, are both mechanical and electrical.

Touch detectors—Are safety sensors that interrupt machine motion when they touch anything. These devices prevent collisions between TrueBeam machine parts, as well as between machine parts and patients and operators. Touch detectors are located on the MV and kV source and imaging arms, at the isocenter of the electron applicators, and on the accessories rack. If the electron applicator touches a patient, all external axes stop.

Virtual TrueBeam software—Includes the Live View window. Live View enables an operator to see the positions of the TrueBeam and thereby avoid collisions.

A collision model—Simulates the movement of machine parts and detects potential collisions. If machine parts move closer than a set distance, all external axes motions and beam generation stop.

Collision Prevention

The TrueBeam includes software monitoring and simulation features to prevent collisions.

Dry Run—Is a dose-less, practice run of a treatment plan that enables an operator to check machine movements for a possible collision or other problems. An operator in the treatment room can move the imager arms, the collimator, couch, and gantry according to a treatment plan without any generated radiation. Dry Run is used for high risk situations (such as complex treatments or inexperienced therapists) to help assure clearance.

Clearance Check—Acts as an advanced collision detection. It is a dose-less, practice run of planned machine movements that are selected by an operator in the treatment room. Using a pendant and in-room monitors, an operator can select targets and check target-to-target transitions within a treatment plan for clearance.

Motion Rules—Prevent remote motions and some targeted motions in regions where potential collisions exist. For example, motion rules prevent remote gantry motion on the same side as a rotated couch. Motion rules have a trigger threshold of 2 cm.

Collision Override and Clearance Override

The Collision Override button on the gantry and couch side panels enables you to move axes away from the direction of a potential collision. During collision override, motion speed is reduced.

To use the Collision Override button, hold down the button while simultaneously moving a thumbwheel on the side panel or pendant.

When you consider remote motions to be safe (for example, moving an axis away from a restricted zone), use the Clearance Override button to permit remote motions that would be prevented by motion rules.

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Chapter 4 Introduction to Service

The Service application enables you to monitor, record, and view information handled by the control system. This chapter describes the purpose of the Service mode, user rights, Service mode navigation and controls, and how to use the Service mode to configure the TrueBeam system.

The Service application allows performing such basic servicing as:

- Monitoring machine parameters, faults, and interlocks.
- Viewing, editing, manipulating, and saving configuration files.
- Acknowledging and overriding faults.
- Loading and executing automated service routines.
- Loading beam templates.
- Setting up, tuning, and calibrating the TrueBeam, initializing axes, and running diagnostic tests.
- Servicing the TrueBeam from the in-room monitor for tasks that are best performed inside the treatment room using the couch pendants and side panels.
- Saving tuning parameters.
- Acquiring machine performance data.

Viewing and Editing Service Data

For most clinical users, the Service application displays read-only information on the system, gives access to some basic tools, and provides a window into the various functions of the TrueBeam. Advanced users with Varian Service Training, including physicists and Varian service personnel, can perform more advanced operations—depending on user rights—such as diagnosis, beam tuning, and calibration.

Editable parameters appear as white data boxes; read-only parameters have a gray background.

User Rights

User rights affect the type of operations that the user can perform. TrueBeam owners can perform essential service operations. Varian employees have proprietary access to advanced factory service routines and operations.

Three general categories of users can perform operations; Table 3 compares user rights.

Basic User—Does not have service training. He or she has read-only rights, can navigate the Service screen, exit Service mode, perform basic treatment or quality assurance operations, and may have to relay information to a Varian service engineer while troubleshooting on the telephone. A radiotherapist is a basic user.

Intermediate Service—Has access to fundamental tools that enables the user to calibrate the TrueBeam, but has not been fully trained to service the machine. These include physicists who perform machine calibrations.

Advanced Service—Has had Varian Service Training. These include physicists carrying out diagnosis or research, as well as all Varian service personnel.

Other Advanced categories include Advanced Proprietary Service, for Varian personnel only, and Manufacturing, for Varian factory routines only. For information on clinical user rights, see the *TrueBeam Instructions for Use*.

Table 3 User Rights

Operation	Basic	Intermediate	Advanced
Open a plan.	Yes	Yes	Yes
Control positions of imager arms, the couch, collimator, and gantry.	Yes	Yes	Yes
Acknowledge faults.	Yes	Yes	Yes
Reboot nodes and subnodes.	Yes	Yes	Yes
Override faults and interlocks.	No	Yes	Yes
Calibrate the TrueBeam—axes.	No	No	Yes

Starting Service

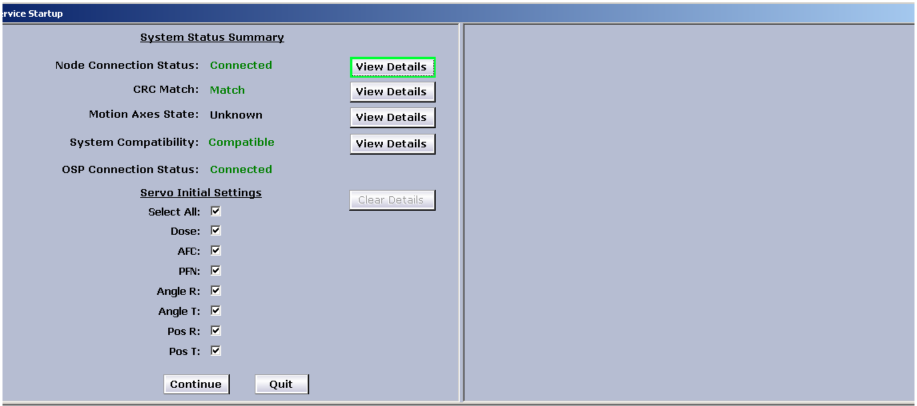
To start Service:

1. At the TrueBeam workstation, click **Service** in the Select Major Mode menu.

   You use the Select Major Mode screen (the main menu) to start the TrueBeam applications.

2. In the Oncology System Platform (OSP) login window, enter your user name and password.
3. In the Login window, enter your user name and password.

   The Service Startup window appears.



The Service Startup window summarizes the connection status of the TrueBeam hardware and software. Green indicators show that a node is connected or files are compatible; red indicators mean nodes or configuration files are not connected or incompatible.

For details on this display and information on synchronizing incompatible files, see "Viewing and Synchronizing System Status" on page 52.

4. To run the TrueBeam in Service mode, click **Continue**.

The Service screen appears; see Figure 8 on page 49.

About the Service Screen

The Service screen (Figure 8 on page 49) consists of three main sections—Fault and Routine Interlocks, Machine controls, and tabs—as well as a Utilities bar, Power button, taskbar, and other controls.

A Fault and Routine Interlocks. **B** Power button. **C** Machine data and controls.
D Utilities bar. **E** Tabs. **F** Subtabs.
G Subsystems. **H** Taskbar.

Figure 8 Service Screen (Default View)

Fault and Routine Interlocks—Are multicolored buttons that identify groups of TrueBeam parameters. These group buttons enable you to see, clear, and override fault interlocks and routine interlocks in the TrueBeam. For more information, see “About Fault and Routine Interlocks” on page 54.

Power button—Shows whether the TrueBeam is turned on or in Power Saver (Standby) mode. Clicking this button turns on the TrueBeam or sets the TrueBeam to the Power Saver (Standby) state.

Utilities bar—Includes the Status indicator, Load Plan menu, Event Log and Alerts buttons, and the Axis Positions or Meter Readouts toggle button. For more information, see “Using the Utilities Bar” on page 60.

Machine controls—Enable you to control the power state of the TrueBeam, view a status summary of the machine, and configure beam parameters and axis positions. By default, Service mode displays Meter Readouts data; the view toggles to editable axis positions. For more information, see “Using Machine Controls” on page 55.

This section also includes a GoTo menu for working with motion axes and the MLC; see Appendix A, “Service Screens,” for more information.

Safe Mode Status window—An additional window, Safe Mode Status, opens in the Machine Controls area under certain unsafe conditions or during simulation. When Radiation Safe Mode is enabled or during simulation of TrueBeam software, the Safe Mode Status window appears to indicate that the beam will be delivered without MUs, for testing purposes in the treatment room. Collision Model appears if an axis becomes uninitialized, for example, after a power loss. Motion Safe appears if, for example, if the console key is removed.

Tabs, Subtabs, and Subsystems—Show communications from TrueBeam components; subtabs show additional subsystem information. Subtabs change depending on the tab selected, to display information and parameters about the selected subsystem. For more information, see “Using Subsystems Tabs” on page 62.

Taskbar—Has controls for saving configuration changes and exiting the Service application. Depending on the tab selected, the taskbar also may display the power status of nodes; controls to turn the calibration check on or off; retrieve results from the ion charge capacity calibration; saturate the bend magnet; and perform calculations.

About Service Controls

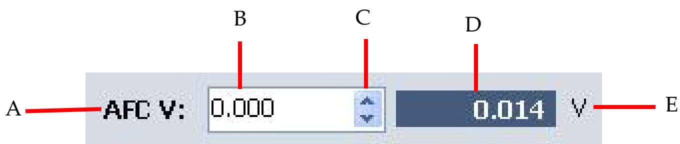
Service controls include buttons, check boxes, text boxes, drop-down menus, tuning arrows, and locks. indicators show connection, power and installation status; they also alert you about errors, warnings, and interlocks.

Buttons

An option button is filled or an indicator turns green when it is on or selected. An empty option button or gray indicator shows that the control is off.

Check Boxes—Clicking a check box selects a control.

Text and Data Boxes—Use text boxes to manually type parameters. In data boxes, click arrows to enter parameters, or to increase or decrease parameter values.



A Label. **B** Programmable parameter. **C** Arrows.
D Actual parameter. **E** Unit of measure.

Figure 9 Parameter Boxes

Drop-down Menus—Use drop-down menus (Figure 10) to select specific energies, template plans, meter ranges, statistics, configuration files, and Service screens.

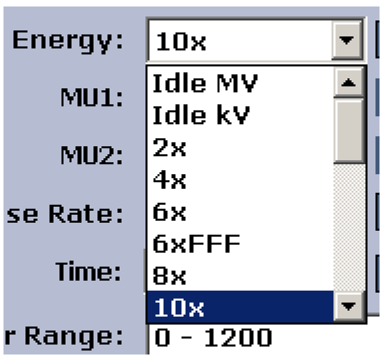


Figure 10 Drop-down Menu

Locks

To allow or deny access to a control, click the lock button.
An unlocked control (left) can be used; a locked control (right) is unavailable.

Indicators

Indicator colors have the following meanings:

System or subsystem is connected or installed; control is activated; or power is on.

Warning.

Major warning. Flashing indicator means that a condition requires special attention and action.

System or subsystem is not connected or installed; control is not activated; or power is off.

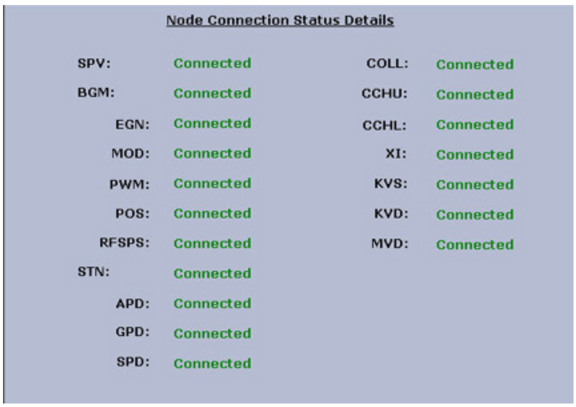
Viewing and Synchronizing System Status

The Service Startup screen displays the connection status of TrueBeam hardware and software, and additional related information. You can use this screen to synchronize incompatible files, if you have the appropriate user rights. This screen appears when you start the Service application.

To view system status:

- In the Network-Conn Status tab of the Service application, click the **View Details** button next to the corresponding status field to view additional information, as described in this section.

The Node Connection Status Details screen appears on the right of the display.



To synchronize incompatible files:

1. In the Network/Conn Status tab of the Service application, click the check box next to the incompatible node.
2. Click the **Synch Config** button to match node configuration files with workstation configuration files.

Node Connection Status—Shows whether all, some, or no nodes are connected.

CRC Match—Shows the result of the cyclic redundancy check (CRC) on configuration files in nodes and configuration files on the workstation. CRC verifies the compatibility (redundancy) between node and workstation configuration files. The result is a complete, partial, or no match between files.

Motion Axis State—Shows whether motion axes have been initialized.

System Compatibility—Shows complete, partial, or no compatibility of configuration files for the TrueBeam, Supervisor, multileaf collimator (MLC), and couch.

OSP Connection Status—Shows complete, partial, or no connection between the Oncology System Platform (OSP) workstation and the TrueBeam server.

Servo Initial Settings—Allows running an automatic beam tuning servo, when its check box is selected.Tuning servos perform these functions:

- Dose regulates that the proper dose rate is delivered at any given time.
- Automatic Frequency Control (AFC) regulates RF driver resonant frequency.
- PFN (Pulse Forming Network) regulates PFN voltage to have the maximum dose output.
- Angle R, Angle T, Pos R, and Pos T respectively adjust the radial and transverse angles and radial and transverse positions of a beam during beam steering to maintain beam symmetry.

About Fault and Routine Interlocks

A blinking group button at the top of the Service screen indicates the existence of fault interlocks and routine interlocks. Clicking a Fault Group button opens a Details window, similar to a dictionary of information that describes the fault interlocks or routine interlocks in the group. For example, clicking a blinking COOL button displays the fault interlocks in the cooling system.

Three additional buttons (Clear All, Fault Interlocks, and Routine Interlocks) enable you to see information about interlocks and also clear and override interlocks.

For more information on fault interlocks and routine interlocks, see "Troubleshooting" on page 83.

Using Machine Controls

Machine controls appear in the top third of the Service screen (Figure 11). They control turning on the TrueBeam or setting it to Power Saver mode (Standby); configuring a treatment beam and selecting beam templates; monitoring power; and moving axes.

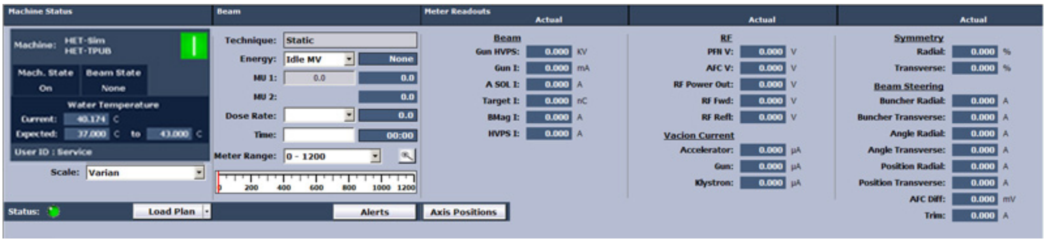


Figure 11 Machine Controls

The Machine Controls area is separated into four areas: status and beam on the left; meter readouts (or axis positions) on the right; and the Utilities bar at the bottom. The following sections describe these areas.

For those without Advanced Service rights, with the exception of axis positions, this area is read-only. (Service technicians and others with appropriate user rights can load beams, generate event logs and view alerts.)

Machine Status

The Machine Status section lets you turn on the TrueBeam or set it to the Power Saver (Standby) state, by clicking the Power button. This section also identifies the TrueBeam and shows its operational status in these fields:

Machine—Shows the machine name and machine serial number of the TrueBeam.

Mach. State—Displays the operating state of the TrueBeam (PowerOff, Standby, On, Ready, BeamOn) on clicking the control.

Beam State—Displays the status of the treatment beam:

- None means no beam is loaded.
- Loaded means a beam is loaded.
- Authorized indicates that the loaded beam has been authorized and is ready to be sent.
- Treating means the authorized beam is being sent.
- Paused indicates that the beam is paused after Beam Off was pressed.

Water temperature—Shows the actual and expected water temperatures in the TrueBeam.

User ID—Displays the log-in name of the TrueBeam operator.

Scale—Shows the display scale. Selections include IEC1217, VarianIEC, and (for Service mode only) Varian.

Beam

This section of Machine controls has options for tuning a treatment beam. A default beam is loaded when the Service application opens.

Technique—Shows the beam template that is loaded. The default template is Static.

Energy—Displays photon energies (such as 2x, 4x, and 6x) and electron energies (such as 4e, 6e, and 9e) that can be selected for the machine. The default setting is Idle MV.

MU1—Specify monitor units of radiation that are measured by the primary dosimetry channel.

MU2—Shows the monitor units of radiation that are measured by the secondary (backup) dosimetry channel.

Dose Rate—Allows specifying the rate of monitor units delivered per minute.

Time—Enables specifying the duration of the beam (using the planned MU, dose rate +10%).

Meter range—Is a simulated analog meter that shows the range of the beam. Clicking the magnifying glass icon zooms in and out of the meter.

Meter Readouts

These readouts show the actual voltages and currents in dark blue status boxes for beam components, radio frequency components, vacuum pumps, and beam steering coils. Actual percentages of a symmetry are shown. To change this default view, click the Axis Positions button (which then changes to Meter Readouts); the two views are toggles.

Axis Positions

This area of Machine controls toggles between Meter Readouts (the default) and Axis Positions. To view axis position data, click the Axis Positions button (which then changes to Meter Readouts) to show axes data.

The Axis Positions section has editable Program text boxes for entering target positions for the gantry, accessories, couch, and imager arms, which enables you to move the axes. This section of the Service screen also lets you add accessories. For more information, see “Moving Axes” on page 58.

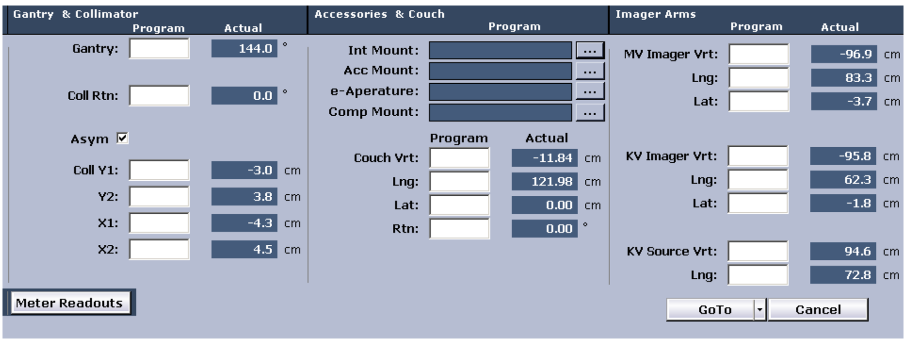


Figure 12 Axis Positions

Readouts include actual (current) positions of gantry and collimator, accessories and couch, and imager arms motion axes. Also shown are radio frequency components, vacuum pumps, and beam steering coils. Actual percentages of a symmetry are shown. Angular parameters are shown in degrees. Linear parameters are shown in centimeters.

Moving Axes

You can move axes using the Service application for diagnostic and other purposes. As part of treatment, you can also move axes using the Treatment application or pendant or couch side panel controls in the treatment room; for more information, see *TrueBeam Instructions for Use*.

In Service mode in the Axis Positions section, there are two ways to move an axis: using a beam template or manually moving an axis. You can also add accessories and manually move axes during beam on or off. Motion rules restrict motion under certain circumstances.

To move an axis with a beam template:

1. On the Service screen in the Utilities bar, click the **Load Plan** button and then choose **Open Standard Template Beam** from the menu.
2. Select a beam template and click **Open** to load the template. Parameters are automatically loaded into the Program fields.

To manually move an axis in the default plan:

1. In the Axis Positions section of the Service screen, click a **Program** text box for the axes you want to move.

   To display the asymmetrical parameters for the upper (Y2) and lower (X2) collimator axes, check the Asym box in the Gantry & Collimator section of the Axis Positions area.
2. Position the pointer over the corresponding Actual data box to see a range of acceptable values. Enter a parameter in the text box.
3. To move the axis to a programmed target position, click the **GoTo** button as you simultaneously press the **Motion Enable** bars or button on the pendant or control console.

To add an accessory:

1. On the Service screen in the Axis Positions section, display a list of accessories by clicking the **Browse** button next to an accessory, such as Int Mount in the Accessories & Couch section of Axis Positions area.

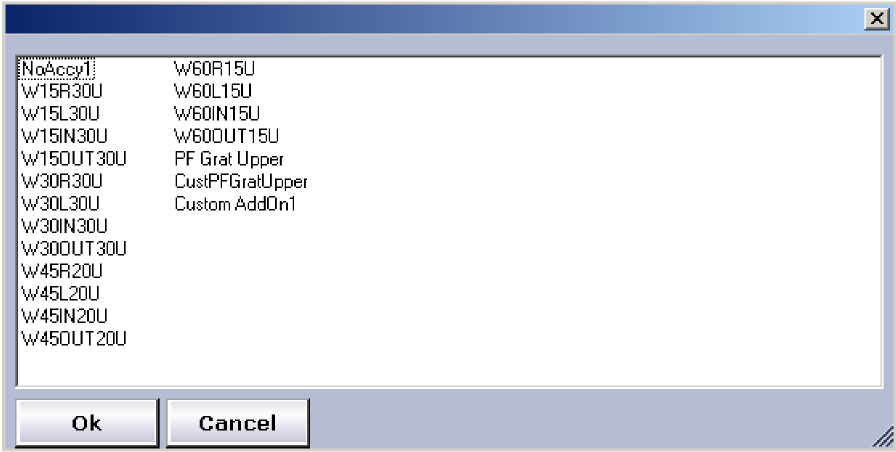


Figure 13 Int Mount Accessories

2. Select an accessory by clicking its name in the list; then **OK**.

The accessory is automatically loaded into the Program data box.

During Beam On, a Manual Motion axis panel appears in the Accessories & Couch section. (Figure 14). Use the panel to position axes.

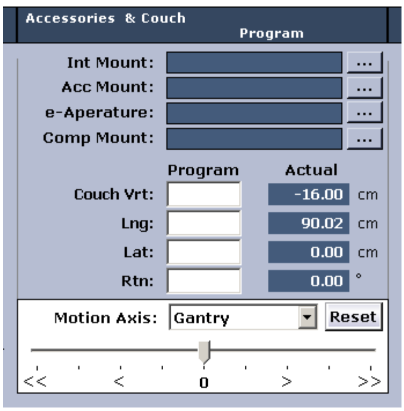


Figure 14 Manual Motion Axis Panel

To position axes:

1. In the manual motion axis panel, click the Motion Axis drop-down arrow and select an axis:
   - Gantry
   - Collimator
   - X and Y, X1 and X2, and Y1 and Y2
   - Couch vertical, longitudinal, latitudinal, and rotation
2. During Beam On, move an axis by pressing a **Motion Enable** bar or button and, in the Manual Motion Axis panel, simultaneously dragging the pointer along the slider scale.

   Arrows beneath the slider indicate an increase or decrease in the speed of axis movement, with single brackets (< >) indicating slower movement and double brackets (<< >>) indicating faster movement. Axis motions are reflected in the Actual meter readouts.
3. To stop axis motion, release a Motion Enable bar or button. Clicking the Reset button resets the pointer to zero; the axis position is not affected.

Using the Utilities Bar

The Utilities bar enables you to view the status of the data in the Service screen, load plans, generate event logs, view system alerts, view and program axis positions, and view meter readouts of power signals.

Status

The Status indicator in the Utilities bar shows the status of activity from the Supervisor (main controller). Indicator colors have these meanings:

- Green means status messages are being received from the Supervisor and information from the control system is current. The data shown in the Service screen is current and valid.
- Red Status indicator means no status messages are being received from the Supervisor. The displayed information is outdated and may not accurately reflect the state of the TrueBeam.

Loading Plans

A treatment plan must be loaded before Beam On is possible. The Service screen opens with the default treatment plan loaded and without values for the axes. You use the Load Plan button in the Utilities bar to load a plan. Beam templates cannot be changed or saved.

To load a plan:

1. Click the arrow next to the Load Plan button in the Utilities bar to display a menu of beam templates.
2. Choose from the following options:
   - Choose **Open Standard Template Beam** to open the Beam Template window. Select a template from the list; then click Open.

     Beam templates include static plans in which there is no machine motion, and dynamic and ARC plans in which the gantry moves.
   - Choose **Set Default Beam** to reset the treatment plan with these default settings: Energy: Idle MV; MU1: 0; Dose Rate: 0.

Generating Event Logs

To generate an event log, click the **Event Log** button in the Utilities bar. Select the nodes for which you will generate the log, and then click **Generate**.

Viewing Alerts

Clicking the Alerts button in the Utilities bar opens a window with a list of messages about critical and noncritical conditions in the TrueBeam. If messages are truncated in the Alerts window, drag the column separator to the right of the Message column to expand the window.

When there are critical conditions, such as the detection of a collision, in the TrueBeam, the Alerts button flashes orange. Examples of noncritical conditions include a beam that cannot be loaded or a disconnected node.

Using Subsystems Tabs

Subsystems are represented by tabs that show system communications data and provide access to TrueBeam controls and monitoring parameters. Subsystem tabs are grouped by task and in order of workflow. Clicking a tab opens a screen with status indicators, readouts, and control buttons for monitoring and configuring components in the subsystem.

Figure 15 on page 62 shows the default (Network) tab.

Figure 15   Service–Network Tab

For more information on Service screens and subsystem, see Appendix A, “Service Screens,” on page 209.

Calibrating and Initializing Manually

The TrueBeam performs many calibration and axis initialization routines automatically. You can also perform some axis initialization and system calibration operations manually inside the treatment room, using the Service application on the in-room computer, and a pendant.

System Calibration

You can view system parameters on the in-room monitor.

To calibrate the system manually, you use a pendant and another device, such as an oscilloscope. See Appendix A, “Service Screens,” for more information on calibration options in the corresponding subsystem tabs.

Axis Initialization

Axis initialization involves setting up equipment and then using the Initialization Assistant wizard to initialize axes, including the:

- Collimator.
- X1, X2, Y1, and Y2 jaws.
- Multileaf collimator.
- kV and MV imagers.
- Other machine axes.

Before initializing axes, make sure that:

- The gantry is in the up position (0° in IEC1217 and VarianIEC display scales; 180° in Varian display scale).
- The couch longitudinal axis is fully extended.

  To move machine axes away from the gantry before starting initialization, use a pendant.

To initialize axis:

1. In the main menu, click **Initialize** to open the Initialization Assistant.
2. Click **Start Initialization**.
3. During initialization, press the motion enable buttons or bars.
4. After axes are initialized, click **Change Mode** to exit the Initialization Assistant.

Saving and Undoing Configuration Changes

Clicking the Save Configuration button in the taskbar at the bottom of the Service application preserves your system changes. This command saves only subsystem configuration changes. Save Configuration does not apply to application-generated files such as imaging calibration data.

Clicking Undo Edits discards configuration changes and reverts to the original saved configuration. You may want to revert to the original after completing tasks for tuning and troubleshooting, when it is sometimes necessary to edit service parameters, and monitor the performance of the machine.

Exiting Service

Clicking Close exits the Service mode. In the Closing Service Mode window, clicking Yes returns you to the main screen. Clicking No enables you to continue using Service.

Chapter 5 Basic Procedures

Basic procedures include starting and shutting down the TrueBeam, setting system-wide options, and performing some system quality assurance checks.

Starting the TrueBeam System

If your site has set the TrueBeam system to start automatically, you do not need to start it at the beginning of the treatment day. To configure the system to turn on automatically each morning, use the System Administration application; see "Setting System and User Preferences" on page 71 for more information.

If you plan to start your system manually, at the end of each treatment day, you should park the TrueBeam system in the four o'clock position to prevent water from getting into the cassette in case of a water leak. At the beginning of the next treatment day, you transition the system from Standby to On.

You can manually start up the TrueBeam in either Treatment mode or in Service mode

Starting the TrueBeam in Treatment Mode

To start the TrueBeam in Treatment mode from the Power Saver (Standby) state:

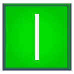
1. If the workstation monitors have been turned off, turn them on
1. At the TrueBeam console workstation, click **Treatment** in the Select Major Mode menu.
2. Enter your user ID and password; then click **OK** to enter the Treatment mode.
3. Click the **Tools** button.
4. Click **Power Saver (Standby)**.
5. Turn the key switch on the control console to the On (unlocked) position.

Starting the TrueBeam in Service Mode

To start the TrueBeam in Service mode from Power Saver (Standby):

1. If the workstation monitors have been turned off, turn them on.
2. Start the Service application. For complete instructions, see “Starting Service” on page 47.
3. On the Service screen, click the orange Power Saver button.

The Mach. State area displays On, and the Power button changes to green to indicate Power On.



4. Turn the key switch on the control console to the On (unlocked) position.

Clearing Fault Interlocks

After the TrueBeam is on, clear any fault interlocks. This section describes the Treatment mode and Service mode procedures for acknowledging (clearing) fault interlocks. You must first examine a fault interlock before clearing it.

To clear a fault interlock in Treatment mode:

1. In the orange window above the Tools button, mouse-over a fault interlock to see an explanation of the fault interlock and a corrective action.
2. After taking any necessary corrective action, click **Acknowledge** to clear the fault.
3. If applicable, enter your user ID and password in the prompt window, then click **OK**.

To clear or override a fault interlock in Service mode:

1. Click the **Fault Interlocks Group** button to display the Fault Interlock Details window, and read the information.
2. In the Fault Interlock Details window, click a fault interlock to select it.

3. Take any necessary corrective action.
4. Right-click anywhere on the fault interlock, and then click **Acknowledge** to clear the fault.

Note: *Only trained Varian service personnel should override a fault interlock.*

5. Close the Fault Interlock Details window.

See Chapter 6, “Troubleshooting,” for more information on fault interlocks.

Initializing Motion Axes

Initialization verifies the travel range of an axis. TrueBeam components that require axis initialization include the carousel, collimator and imaging jaws, collimator rotation, multileaf collimator, and imaging arms.

Axes are initialized on machine restart or after the TrueBeam was shut down (for example, due to machine servicing or an emergency stop). For instructions on initializing axes manually using the Service application, see “Calibrating and Initializing Manually” on page 62.

To initialize jaw axes:

1. Start the Service application. For complete instructions, see “Starting Service” on page 47.
2. On the Service screen, click the **Axis** tab. Then click the **Jaws** button to display the Jaws subtab.
3. In the Jaws screen, click **Initialize X Jaws**; then click the **Initialize Y Jaws** button.

To initialize the collimator:

1. On the Service screen, click the **Axis** tab. Then click the **Jaws** button to display the Jaws subtab.
2. Click the **Gantry/Coll** button to display the Gantry and Collimator Rotation subtab.
3. In the Collimator Rotation section, click **Initialize** and simultaneously hold down the **Motion Enable** buttons or bars.

Note: *Pressing the Motion Enable buttons or bars is required when initializing all external axes, including collimator rotation and imaging arms.*

To initialize carousel axes:

1. On the Service screen, click the **Carousel** tab.
2. Click the **Init Axis** button and simultaneously hold down the **Motion Enable** buttons or bars.
3. Select the **Commands** option.
4. Choose an option:
   - If all carousel axes require initialization, click **Initialize All**.
   - If only specific axes require initialization, click **Initialize** for those axes.

To initialize multileaf collimator axes:

1. On the Service screen, click the **MLC** tab.
2. Select the **Commands** option.
3. Click **Initialize**.

To see information about the state of the multileaf collimator and bank A and bank B carriages, select the **Initialization Details** checkbox.

Performing Daily QA

Daily QA mode enables you to run a series of mechanical and beam tests to ensure the consistent and proper functioning of the TrueBeam system. Tests that represent modern daily and weekly quality assurance checks recommended by international guidelines are detailed in the *TrueBeam Instructions for Use*.

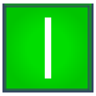
In addition to these tests, as part of daily QA, you can include tests to evaluate the MLC. Intensity modulated radiation therapy (IMRT) relies on the ability of the MLC leaves to provide dynamic, complex field shaping. Various MLC tests can evaluate the positional accuracy of the leaves, the kinectic properties of the MLC (such as leaf speed stability and the effects of leaf acceleration), and accuracy of fractional dose delivery.

See “MLC Tab” on page 232 for more information on performance and diagnostic tests. In addition, DMLC QA Test Patterns and Procedures, available from Varian, describes various MLC test procedures.

Powering Down to Standby

Varian Medical Systems recommends that the TrueBeam system be left on overnight, but in the Power Saver, Standby state. This powered down state allows Varian service technicians to perform troubleshooting remotely, if needed. Follow this procedure to put the system in Standby state.

To power down the TrueBeam to Standby:



1. On the Service screen, click the green **Power On** button.

   The Power button changes to the orange Power Saver button.

2. Click **Close** to exit the Service mode.
3. Turn off the monitors.
4. Turn the control console keyswitch to the locked position, and, if necessary, remove the key and store it in a secure place.

Power Failure

If a power failure lasts more than 5 minutes, you must initialize the TrueBeam system, including the multileaf collimator, before you can start or resume treatment. If an emergency stop caused the power failure, follow the Emergency Stop Restart procedure described in the *TrueBeam Instructions for Use*.

To initialize the TrueBeam system after a power loss:

1. Choose **Initialize** from the Select Major Mode screen.
2. Make sure that the gantry is at 0° IEC; then click **Start Initialization**, and follow the onscreen instructions.
3. When the initialization has finished, click **Change Mode**. Then select **Treatment** on the Select Major Mode screen to start the Treatment application.

   If a treatment session was interrupted, the Treatment application automatically opens a recovery session and loads the last treatment session in progress.

4. Continue the treatment from this point, or close the session to save any plan changes and record the treatment history available from the interrupted session.

For instructions on delivering a partial treatment and restarting after a power loss or an Emergency Stop, see the *TrueBeam Instructions for Use*.

Starting Treatment Mode

To run Treatment mode, click **Treatment** on the Select Major Mode menu, and sign on with your user name and password at the prompt.

When the TrueBeam is in Treatment mode, you can perform various actions, some only in the console area and some only in the treatment room.

In the console area, you can:

- Observe the current status of the TrueBeam including axes positions and interlocks, and move various axes.
- Retrieve schedules, treatment plans, treatment histories, and radiographic images.
- Run treatment plans that are imported into the TrueBeam from an information system, such as ARIA or IMPAC, and save histories of such treatments back to the information system. You can also run treatment plans that are loaded from DICOM plan files, and save their treatment histories as a DICOM file.
- Select a patient to be treated; and define, modify, and run treatment plans.

Note: *In the console area, you can also perform Daily QA routines, by choosing Daily QA from the Select Major Mode menu. For instructions, refer to the TrueBeam Instructions for Use.*

In the treatment room, you can:

- View the Machine in-room to monitor the current status of the TrueBeam, including axes positions and interlocks, as well as the status of planned accessories.
- Use the couch pendants and side panels to start auto moves or manual motions of the various axes.
- Detect potential collisions by performing a treatment dry run.

- Compare the planned axis position for a treatment field and the actual axis position.
- During a dry run, advance to the next treatment field or display patient notes and pictures.
- Position a patient.
- Use the Patient in-room monitor to display field photos and setup notes for the patient.

Setting System and User Preferences

Use the System Admin mode (or System Administration application) to configure TrueBeam user settings and preferences for the current TrueBeam system, including for the Treatment and Service applications, and to display system information. You will be prompted to save and describe any changes you make before exiting the System Administration application.

Some options described in this section are available and visible only to users who log on with advanced rights.

To start the System Administration application:

1. At the TrueBeam console workstation, click **System Admin** in the Select Major Mode menu.
2. Enter your user ID and password; then click **OK** to enter the System Admin mode.

About the System Administration Screen

The System Administration screen contains three areas: machine and user information (top), configuration tabs (middle, described in the sections that follow), and taskbar buttons (bottom). The top and bottom areas are permanent and appear in all System Administration screens.

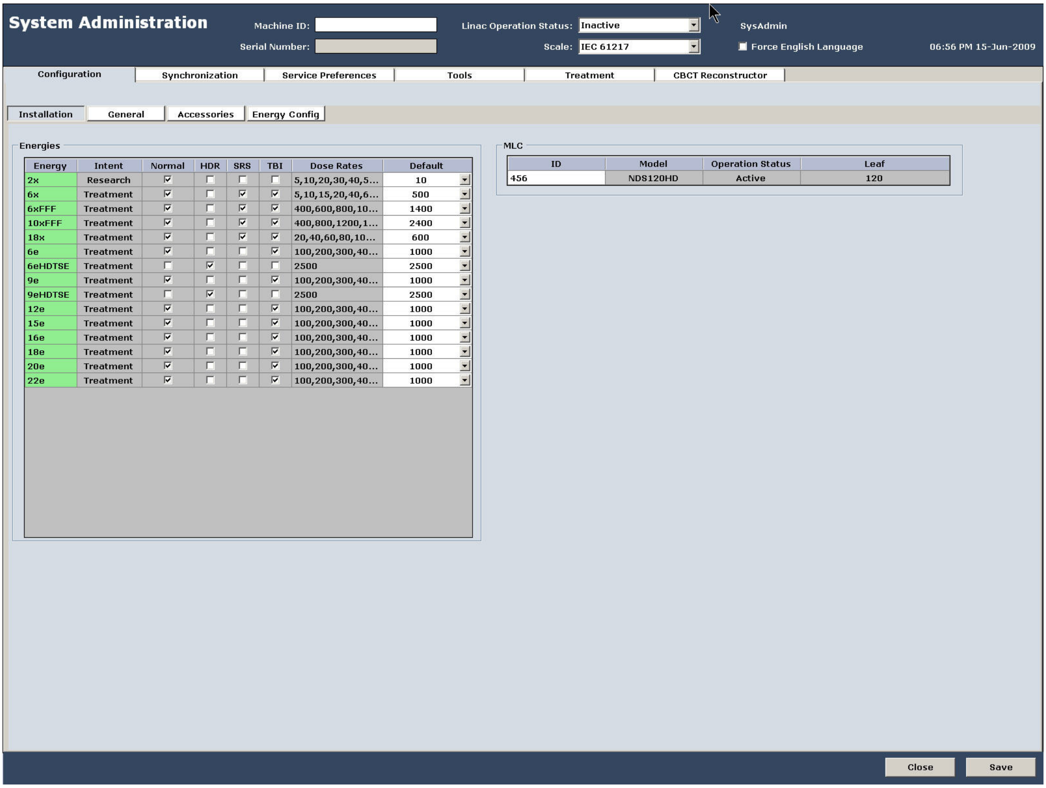


Figure 16 System Administration Screen

Machine and User Information—Use the text boxes for identifying the machine and selecting the operation status of the linear accelerator and the display scale. A read-only data box shows the serial number.

Additional machine and user information includes the user log-in name and a check box for forcing the local language to U.S. English. This option is useful for customers to take screen shots for troubleshooting, that they can send to Varian. The current date and time are also shown.

Taskbar Buttons—Use the Close and Save buttons to exit the System Admin mode or save changes to machine configuration.

Configuration Tabs—Use the tabs to set configurations and preferences. The tabs are described in the following sections.

Synchronization

The Synchronization tab contains three subtabs: Backup, Export, and Restore. Clicking a subtab button displays controls for specifying the TrueBeam configuration files that you want copied (backed up), exported, and restored. File formats include WOX (Web Objects in XML) and XML (Extensible Markup Language). Using Export, you can export the current machine configuration file to the RadOnc Management system (ARIA software).

Common to all Synchronization subtabs is a Browse (**...**) button for opening a browser window to navigate to backup, export, and restore destinations for files. Each subtab also has a progress window for copy, export, and restore file operations.

Service Preferences

The Service Preferences tab contains two areas: Custom User Settings and AutoStartTime. Changing a parameter in this tab also affects both Service and Treatment applications.

In Custom User Settings, you can customize the date and time format and the size of records or you can select the default settings. In AutoStartTime, you can specify the time and days for the TrueBeam to automatically start; the machine will transition from Standby to On.

Tools

The Tools tab contains four subtabs.

Flash Tools—These tools can be used only by Varian service technicians.

Services—Start, stop, and restart the Varian TrueBeam Model Service. Only Varian service technicians can stop and restart Axeda services.

General—This subtab contains sections for the IRM, duplicate treatment room access, enabling research application, keyboard shortcuts, and automatically updating the local time. In IRM, clicking the button reboots the in-room computer, which runs the in-room monitors. Duplicate Access in Treatment Room, when enabled, launches the virtual network computing (VNC) viewer on the IRM computer and allows remote access to the workstation; the IRM computer can then perform all functions as if done at the console workstation. Research Application allows use of a research application with the TrueBeam. Keyboard Shortcuts allows using Windows shortcuts with the Service application (see Appendix B, "Shortcuts," on page 277). In the IP Address section, you can browse to and load the simple time server address, to automatically update the time display for the local time zone. The Progress window shows activity during rebooting; click Clear to clear the display.

Node Config—Displays the configuration for the selected node in the System Admin application. Select a node from the Nodes menu, and then click **View Configuration**.

Treatment

The Treatment tab contains two subtabs: Clinical and Advanced.

Clinical

The Clinical subtab contains five sets of options, arranged in columns:

- General Preferences
- Couch Correction Sign-Off Thresholds and Couch Correction Remote Motion Thresholds
- Film Imaging Preferences
- Setup Notes.

General Preferences—In this column, you can:

- Allow field grouping for automation.
- Require sign-off before closing a session after a patient has been treated.
- Commission the use of EDW treatments.
- Set a tolerance for when the megavolt energy can be overridden.
- Require sign-off when activating or deactivating a field.
- Allow operators to add an unplanned treatment.
- Check the integrity of the second channel plan.
- Allow operators to load an unapproved plan.

- Allow verifying a custom accessory manually.
- Set the alert monitor unit (MU) level in case a treatment field does not have accessories.
- Allow validating the dynamic MLC shape.

Couch Correction–Sign-off Thresholds—Allow setting vertical, longitudinal, lateral, and rotational limits for couch correction. If an operator exceeds the set limits, sign-off is required.

Couch Correction–Remote Motion Thresholds—Allow remote motion and setting vertical, longitudinal, lateral, and rotation limits for couch correction. If corrections are within the thresholds, the user can move the couch remotely using the control console. If couch corrections exceed the thresholds, the user can set up the couch only from within the treatment room.

Film Imaging Preferences—For port film, lets you set the best energy for image quality, the maximum MU limit, default MU, and default dose rate.

Setup Notes—Displays predefined Setup notes and allows defining the size of the Setup Note field.

Advanced

The Advanced area contains three columns: ADI Preferences, DICOM Preferences, and Tools.

ADI Preferences—Displays the Analog Devices Incorporated (ADI) port number of the installed ADI device. You can also identify and describe the ADI device.

DICOM Preferences—Displays the Digital Imaging and Communications in Medicine (DICOM) server:

- Client application entity (AE) title
- Client port number
- Server AE title
- Server port number
- Server IP address.

Clicking the button in this column tests the connection of the DICOM server. Varian service personnel can edit the preferences, for example, to customize and IP address.

Tools—Clicking the button in this column clears session recovery data.

CBCT Reconstructor

The CBCT Reconstructor tab includes nine areas, described in this section.

Reconstructor Service—Starts and stops the Reconstructor service. Use this control to overcome a persistent error on the server.

Reconstructor Workstation—Restarts and shuts down the Reconstructor workstation.

Disk Fragmentation—Runs a disk fragmentation analysis on the Reconstructor workstation and defragments the disk. A progress bar shows activity during disk fragmentation analysis and disk defragmentation.

Status—Displays the operational status of the Reconstructor service and Reconstructor workstation and check free disk space. Green Status indicators respectively show that the server is running, the workstation is accessible, or free disk space is above its set warning limit. Red Status indicators show that the server is not running, the workstation is inaccessible, or free disk space is below its set error limit. When the Status indicator for free disk space is yellow, free disk space is below its set warning limit and above its set error limit.

Information—Displays the uptime (running time) of the Reconstructor service and workstation, server memory consumption, and free disk space and total disk space on the Reconstructor workstation. If the server is not running or the Reconstructor workstation is inaccessible, data boxes are empty.

Versions—Displays a table showing all CBCT Reconstructor components and component versions. If the Reconstructor workstation is inaccessible, the table is empty.

Settings—Displays current information, in editable data and text boxes, on the Reconstructor service including the Logging Level (the level for collecting log data), Disk Space Warning Limit, Disk Space Error Limit, and Scan Lifetime (the period for retaining scan data—raw projections and related calibrations—before data is automatically deleted). If the Reconstructor service is not running, the text boxes are empty.

You can change the amount of detail displayed by adjusting the logging level; click the data box arrow and select a level (Error, Warning, Info, Debug, or Verbose). You can change the remaining settings by typing a value in the text boxes. To update the Reconstructor with these settings, click **Apply**.

Scans—Displays information on acquired scans. The table format includes scan identification, acquisition date and time, and the associated acquisition mode. If the Reconstructor service is not running, the table is empty.

To change the scan export directory, type a new path in the Directory data box; or click the Browse (**...**) button, and navigate to the desired directory. If the Reconstructor workstation is inaccessible, the data box and Browse (**...**) button are not usable.

To export scans to the selected directory, click the Export button (the button changes to Abort). A progress bar shows activity. To stop an export in progress, click Abort. If the directory does not exist, an error message appears. If the Reconstructor workstation is inaccessible, the Export button is not usable.

Configuration and Calibration—Displays a directory for copying and restoring the configuration and calibration file.

To back up the current configuration and calibration file, enter a directory pathname or click the Browse (**...**) button and navigate to the desired directory; then click the Back Up button to copy the file to the selected directory. The Reconstructor workstation must be accessible, and no file restoration can be pending. If the directory does not exist, an error message appears.

To retrieve a previously saved configuration and calibration file from a selected directory, select the directory, and then click the Restore button. The Reconstructor workstation must be accessible, and no file backup can be pending. If the directory does not exist, an error message appears.

DICOM Stream Service

The DICOM Stream Service caches reference and acquired DICOM objects to the local file system. The tab includes three areas for changing customer settings: Server Settings, Service, and DICOM Protocol Settings.

Server Settings—Displays and allows changing the port number and host name. Selecting the Store To Session Folder option saves all acquired session data in its own session folder named with the date and time.

Service—Start and stop the Varian DICOM Stream Service.

DICOM Protocol Settings—View and change:

- SCP (service class provider) Local Host address
- SCP Local Port number
- SCP Local AE Title
- SCP Remote Host address
- SCP Remote Port number
- SCP Remote AE Title
- Process Timeout
- Read Timeout
- Send Timeout
- SCU (service class user) Max Retrieve Sessions
- SCU Max Store Sessions
- Implementation Class UID (unique identifier).

PVA

The PVA tab includes three areas: Imaging, Automatic Workflow Management, and General.

Imaging Sources—Contains three subareas: X-Ray Imaging Sources, CBCT Reconstructor, and Unused Imager Position.

In X-ray Imaging System, click the check boxes to enable or disable the X-Ray Imaging System, the MV and kV imaging sources, and the Gating Camera.

In CBCT Reconstructor, click the check box to enable or disable the CBCT Reconstructor.

In Unused Imager Position, define the behavior of an unused imager arm. Controls in this area include a Send Targets check box and three option buttons: Mid, Retracted, and Based on Actuals. Deselecting Send Targets means that no target positions will be sent for an unused imager arm; the unused arm can remain at its current position. Selecting Send Targets allows choosing one of three behaviors for the imager arm:

- **Midrange** moves an unused imager arm to the mid-range position.
- **Retracted** retracts the imager arm.
- **Based on Actuals** moves the imager arm to the target position depending on its actual (current) position, which could be extended, mid-range, or retracted.

Automatic Workflow Management—Automatic workflow management guides an operator through the entire imaging process by automatically activating or deactivating the appropriate workspaces. Check boxes enable you to turn on or off the following workflows:

- Paired Acquisition: Automatically selects the next image to be acquired.
- Topogram Acquisition: After the topogram has been acquired, automatically activates the CBCT acquisition workspace.
- 3D-3D Match: After the CBCT has been acquired, automatically activates the 3D3D Match workspace.
- 2D-2D Match: After the two orthogonal images have been acquired, automatically activates the 2D2D Match workspace.
- 2D Match Plan Procedure: After the image of the plan procedure has been acquired, automatically activates the 2D Match workspace.
- 2D Match Beam Procedure: After the image of the beam procedure has been acquired, automatically activates the 2D Match workspace.
- Marker Match: After the two orthogonal images have been acquired, automatically activates the Marker Match workspace.

General—This area includes the Use Object Related Settings option, which stores volatile object-related settings. Storing settings can streamline processes, such as defining the window or level setting for images. It also allows using 6DoF for matching.

Configuration

The Configuration tab contains four subtabs: Installation, General, Accessories, and Energy Config.

Installation—This subtab has two areas: Energies, where you view beam energies and dose rates, and MLC, where you can enter an ID for the multileaf collimator. The MCL ID is an alphanumeric field that matches the corresponding ID in the RadOnc Management system. To enter the ID, double-click the ID column and type.

General—This subtab includes two areas: Geometric Parameters and Couch Positions.

In Geometric Parameters, you can select AutoSetup and AutoGoTo motion permissions for moving blades, the gantry, collimator and collimator jaws, and the couch. (These features are not available for the imager arms.) AutoSetup and AutoGoTo motion permissions include:

- Instant: As soon as target positions are set, axes immediately move; an operator does not have to use pendants, side panels, or the control console.
- Remote: Axes can be moved (with pendants or side panels) inside the treatment room or (with the control console) from the console area.
- InRoom: Axes can be moved only with pendants or side panels.
- None: Moving axes requires using thumbwheels and Motion Enable buttons.

In Couch Positions, you can change the values for couch longitudinal settings by double-clicking the Value column.**Accessories—**This subtab includes four areas where you can view information about wedges, applicators, other accessories (such as apertures and custom add-ons), and slots.

Energy Config—This parameter can be used only by Varian Service to display the factory configuration settings and copy the energy tuning parameters.

Saving System Configuration Changes

You can save system configuration changes made in the System Administration application, and get information about your TrueBeam.

Clicking Save opens a MachineConfig window in which you must briefly describe changes that you made to the system configuration. If you try to close System Administration without saving changes, you will be prompted to do so.

For audit purposes, the TrueBeam system makes a log entry for each critical configuration item that you changed. A critical configuration item is a change that could impact treatment, for example, changing the MU limit.

Each log entry contains the following information:

- Machine identification
- Identification of the user who made the changes
- Time stamp
- Identification of the configuration item
- Old configuration value
- New configuration value.

Getting System Information

Various utilities in the TrueBeam software provide information about your system.

- In Treatment mode, positioning the cursor over an information icon displays information about the TrueBeam and Varian contact information.
- In Service mode, subsystem tabs provide diagnostic information.
- Tool tips provide brief explanations of areas within the TrueBeam graphical user interface (GUI). To display tool tips, position the cursor over text and icons in the interface.

Maintenance

To ensure TrueBeam reliable performance, the system must be checked regularly for operational safety, accuracy, and quality. Service and maintenance should be done only by authorized personnel trained to work on the TrueBeam. Work by unqualified personnel can result in poor performance, damage to the TrueBeam, or serious and possibly fatal injuries.

The frequency of checks normally is based on the professional judgment of the person in charge and the requirements of the existing quality assurance regulations.

Varian recommends that you keep records of the performed checks, to include recording Daily QA observations about operational problems, testing Emergency Stop circuits, and checking all fasteners.

Recording Observations—Should be done daily in a log book when you perform the Daily QA procedure as well as throughout the treatment day. Note unusual TrueBeam operation or other observations.

Testing Emergency Stop Circuits—Should be performed at least once every three months to ensure proper functioning.

Checking Fasteners—For tightness should be done at least semiannually.

For more TrueBeam maintenance procedures, see the “Service and Maintenance Guidelines” in the *TrueBeam Safety Guide*.

Chapter 6 Troubleshooting

The TrueBeam provides an array of troubleshooting features, including fault messages, system and event logs, and records for motion, beam, and power.

This chapter describes troubleshooting tools available in the TrueBeam system. Information about specific issues for specific subsystems appear in the individual chapters.

Interlocks

An interlock prevents the system from operating until a particular condition is resolved. There are two kinds of interlocks: fault interlocks and routine interlocks.

The TrueBeam system asserts a fault interlock whenever the machine is not operating correctly. A fault message that identifies the issue is displayed for each fault interlock. Each fault interlock must be acknowledged (cleared) by an operator before the machine will function.

The TrueBeam system asserts a routine interlock when a condition exists that prevents the machine from operating—such as an open door. A routine interlock is automatically cleared when the triggering condition no longer exists. For example, the Door Open interlock is asserted whenever the door to the treatment room is open. When the door is closed, the Door Open interlock clears.

If a routine interlock fails to clear when the issue is apparently resolved, a fault message about the problem will also appear.

This chapter describes how to handle fault and routine interlocks in Service mode; for information on handling them in Treatment mode, refer to the *TrueBeam Instructions for Use*.

Fault Interlocks

Control systems in the TrueBeam generate faults and provide fault messages that identify the reasons for the fault. Figure 17 shows the Fault Interlock message display in Service mode.

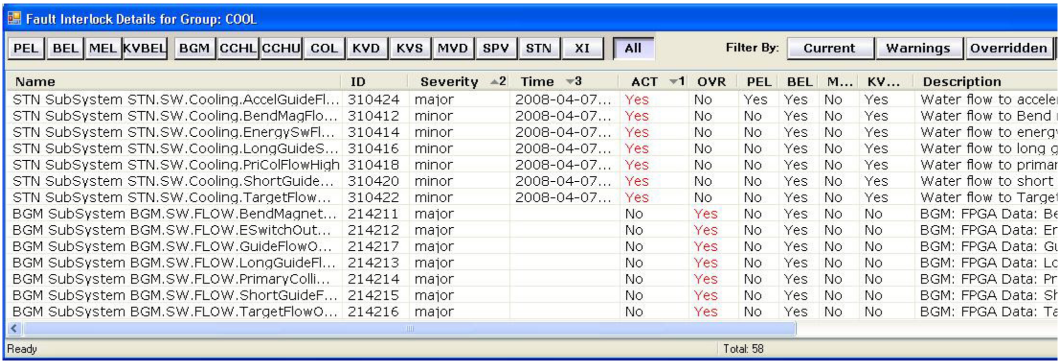


Figure 17 Fault Interlock Messages

The status bar at the bottom of the Fault Interlock Details window shows Ready, indicating that the fault interlock details have been loaded and the window is ready to use. The total number of faults and warnings is also shown.

Fault Details

Fault message information includes more than a dozen items. Some of the fields (such as Notes) show up only if Varian service personnel have logged in, and not if customers log in.

Name—Is the technical identifier of the fault interlock message, showing the node that is reporting the fault.

ID—Is the fault interlock identification number.

Severity—Identifies the seriousness of the fault—major, minor, or warning.

Time—Includes the date and time that the fault interlock occurred.

Act—Indicates whether the fault interlock is active or inactive.

OVR—Shows whether the fault interlock is currently overridden.

PEL—Indicates whether the fault interlock affects the Power Enable loop.

BEL—Indicates whether the fault interlock affects the MV Beam Enable loop.

MEL—Indicates whether the fault interlock affects the Motion Enable loop.

kVBEL—Indicates whether the fault interlock affects the kV Beam Enable loop.

Description—Displays the description of the fault interlock.

Cause—Provides likely reasons that the fault interlock has been asserted. If a fault cannot be easily pinpointed, this field indicates that there may be multiple potential causes.

Suggestions—Provides possible ways to resolve the problem. In many cases, the final suggestion is to notify Varian service, as the machine may need professional troubleshooting.

Notes—Give additional details about the problem, including some diagnostic suggestions for technicians servicing the machine.

Fault Severity Levels

Fault interlocks are one of three severities: major, minor, or warning.

Warnings are generated when a condition exists that will require attention at some future time. Typically, the control system has detected a condition that does not fall within an optimum range, but which has not passed a threshold that requires immediate attention. A warning does not affect motion, beam, or power, so the control system continues to allow motion and irradiation.

A minor fault interlock impacts machine motion or beam delivery, but may not cause the system to stop operating.

A major fault interlock causes the system to go into Standby state, and thereby to stop operating until the fault is fixed. A major fault may impact machine motion, beam delivery, or power.

Any fault that impacts power also impacts beam delivery and machine motion. Any fault that impacts machine motion, also impacts beam delivery.

Routine Interlocks

A routine interlock is a condition that routinely happens during treatment and is detected by the control system. Some interlocks require action by an operator to be cleared; for example, a Door interlock requires that the operator close the door. Other interlocks—for example, the carousel is rotating into position—clear automatically after some internal process has completed. Examples of routine interlocks include:

- Door. The door to the treatment room is open.
- Position. An axis position is not set up within tolerance of the required treatment positions.
- Pendant. A pendant is not properly hanging on the couch.
- Accessory. An accessory is not properly installed or the installed accessory does not match the planned accessory.
- Delay. An internal process is under way at the control system and must be completed before treatment can proceed.
- Beam. No energy is programmed.
- Key. The key on the control console is in the Off position.
- Couch. The couch emergency brake is overridden.

Handling Fault Interlocks

Fault messages are grouped at the top of the Service screen (Figure 18).

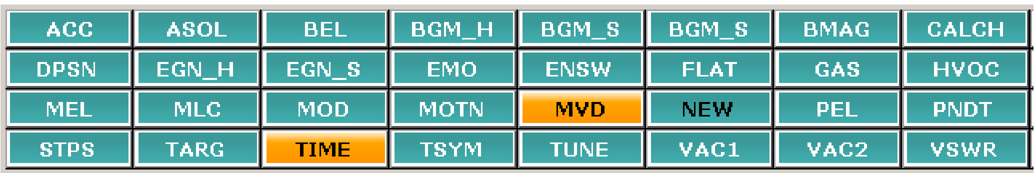


Figure 18 Fault Interlock Group Buttons

Clicking a group button opens a window that details the fault interlocks in that group. For example, clicking the BEL button displays all beam enable loop faults.

At the top right of the screen, three buttons provide general controls for fault interlocks.

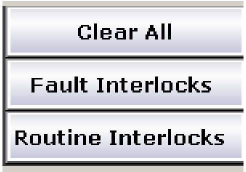


Figure 19 Fault Interlock General Controls

Clear All—automatically acknowledges all faults in the TrueBeam. This is an unusual action. Typically, you inspect and take action on faults in individual groups.

Fault Interlocks—opens a window that displays all active fault interlock messages.

Routine Interlocks—opens a window that displays all active routine interlocks.

Group Button Colors

The fault interlock group buttons may be blue-green, red, or yellow:

Blue-green—There are no active fault interlocks in the group.

Red—There is at least one active fault interlock in the group.

Orange—There are only warnings in the group.

The text on the fault interlock group buttons may be white or black, to indicate whether a fault interlock has been overridden; or blinking, to indicate an active fault.

White text—Means that no interlocks in the group have been overridden.

Black text—Indicates at least one interlock in the group has been overridden.

Blinking text—Indicates the group has at least one active fault interlock.

The text color works in combination with the button color. Here are the meanings of the different color and text combinations:

Blue-green, white text—The group has no active fault interlocks, and no fault interlocks are overridden.

Blue-green, black text—The group has no active fault interlocks, but at least one fault interlock is overridden.

Red, blinking white text—The group has at least one active fault interlock, and no fault interlocks are overridden.

Red, nonblinking black text—The group has at least one active fault interlock, and at least one overridden fault interlock.

Orange, nonblinking white text—The group has only warnings; no fault interlocks are overridden.

Orange, blinking white text—The group has **only** warnings, but it also has at least one active fault interlock.

Orange, black text—The group has only warnings, but at least one fault interlock has been overridden.

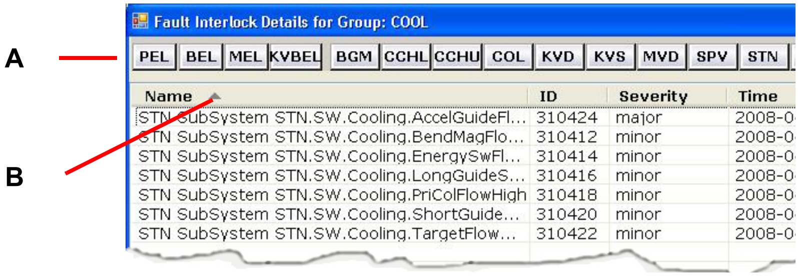
Looking at Fault Interlock Messages

The Fault Interlock Details window provides ways to sort and filter the fault interlock messages so that you can manage them.

Column Sorting

Current faults are at the top of columnar lists. By default, faults are sorted in ascending order in the Severity column, and in descending order in the Time column and Active (ACT) column.

You can change the sort order of columns by clicking a column heading to display an arrow next to the heading name. Clicking the Up arrow sorts the columnar data in ascending order. Clicking the Down arrow sorts the data in descending order.



A Fault group button. **B** Details listed in ascending order.

Figure 20 Fault and Interlock Details

Filtering

You can filter for details for any group, or you can show details for all groups.

- To show details for any group, click the appropriate button.
- To show details for all fault interlocks, click the All button.
- To display details for selected categories, use the Filter By buttons. You can display details for only current faults, only warnings, or only overridden warnings and faults; or you can display all warnings and faults.

Overriding Fault Interlocks

You can override a fault interlock so that you can test or operate the machine temporarily.

To override a fault interlock:

1. At the top of the Service screen, click the fault group button to open its Fault Interlock Details window.
2. Click **Current**, then select the fault that you want to override.

   To override more than one fault, press the **Ctrl** key while selecting multiple faults.
3. Right-click the fault interlock message, and from the context menu choose **Override**.

   The text in the Ovr column changes to Pen . . . (pending change).

The fault is cleared from the Current or Warnings list and transferred to the Overridden list. A red YES appears in the OVR column.

To cancel a fault interlock override:

1. Select the fault interlock message. Ctrl-click to select multiple faults.
2. Right-click and choose **Cancel Override** from the menu.

Clearing Fault Interlocks

When you have resolved the problem that caused the fault interlock to be asserted, you clear (acknowledge) the fault interlock.

To clear a fault interlock:

1. At the top of the Service screen, click the fault group button to open its Fault Interlock Details window.
2. Click **Current**; then select the fault that you want to override.
3. Right-click the fault interlock message and choose **Clear**.

   The fault is cleared from the Current list and transferred to the Cleared list.

Changing Overrides on Groups of Faults

You can override, clear, or cancel the overrides for all the faults in a group.

1. Right-click the fault group button at the top of the Service screen.
2. Choose the action you want from the context menu.

Basic Troubleshooting

Faults can generally be divided into software or hardware faults. A problem may be caused by a machine part failure, or it may be caused by a software setting.

The software is designed to respond to any problem with an informational message. A fault interlock message may provide a suggestion that a specific fault is associated with hardware or software.

In many cases, several fault interlocks will be asserted at the same time, or within a brief period of time. Reviewing all the fault messages and checking the event log can provide clues to the origin of the faults. Determining the originating or initial fault is addressed in Varian technical training, and is typically the responsibility of Varian Service technicians.

To request circuit diagrams, component part lists, descriptions, calibration instructions, and other information that will assist service personnel to repair those parts of TrueBeam that are repairable by service personnel, contact Varian Service.

System, Event, and Dynamic Treatment Logs

TrueBeam logs are troubleshooting tools that provide detailed information about machine states when a fault interlock is asserted. Events, for example, are generated each time a fault interlock is asserted. You can use the Event log to isolate the system state just prior to the fault interlock.

System Logs

The System log keeps an ongoing record of everything the machine does. It can be a valuable resource when a problem occurs. Its main drawback is that it contains megabytes of information, on thousands of lines of text.

Event Logs

The Event log tracks “events,” which include all faults that occur during Beam On, major faults that occur during Beam Off, faults that occur during initialization and calibration checks, and other nonroutine events.

Part of the Event log viewer is a tool to home in on the system log during the time a particular event occurred. It presents the state of the Service application at the time the event occurred, plus the System log at that time.

Event Log Data

The event log contains the following information:

Machine parameters—Includes event status (monitor units, time, dose rate, accessory installed, if applicable), machine status (for example, Beam On), settings (mode, energy, MU), and axis position for all axes (primary and secondary readouts).

Interlock status—Includes fault and interlock status at the time of the event, including the effect on MEL, PEL, BEL, and kVBEL.

Accessory information—If applicable, shows status and any error conditions for installed accessories.

Dynamic Beam summary—If applicable, provides a summary of the dynamic treatment log for the event.

Dynamic Treatment Log

The Dynamic Treatment log records information about all axes and beam dose during each dynamic beam delivery. Treatment setup information includes the treatment type, energies used, and monitor units delivered. It also lists information related to enhanced dynamic wedge or dynamic arc treatments.

Dynamic beam statistics shows total dose delivered, and position and deviation information for axes used during the treatment.

Dynamic Treatment logs are created during each dynamic treatment, and during the morning checkout procedure.

Working with Technical Services

When you encounter a problem with the TrueBeam, you need to keep careful records so that you can provide important information to a technician.

You will always need to provide the product code and the machine serial number. They both appear on the machine serial number plate, and on the login screen for Service mode.

Gathering Fault Information

It is critically important to record the time when a problem occurs. Given the time of the fault, it is possible to view the machine state information when the fault was asserted.

If you log problem information, you will be able to follow up on faults that prove recalcitrant. If you can provide adequate records, a technician can more quickly track down problems that recur.

For each fault interlock, you should provide the following information:

- Your name and phone number
- The fault number
- User name
- Date
- Time encountered
- Feature used
- Software version
- Modes being used (for example, Treatment, or Daily QA)
- Steps followed that preceded the problem
- Steps followed to try to clear the problem
- Filename of a screenshot that shows the machine data
- Person notified
- Comments.

System Snapshots

When a machine is first installed, the installation technicians print screenshots that show the state of the machine when it begins service.

These printouts serve as “snapshots” of the system parameters and provide a baseline for subsequent troubleshooting and tuning.

Technicians performing routine maintenance typically create similar snapshots of the system, to show the state of the machine at specific dates in its history.

Such records provide information that a technician can use to track a problem. A technician can observe the parameters that existed when the machine was performing correctly, and can compare the current state of the machine with them. Discrepancies provide clues to current problems.

To capture a screenshot, you can use the PrintScreen key on your keyboard. Screenshots are stored at this path:

C:\VMSOS\Log\Application\TDS\PrintScreen

System Records

The TrueBeam system stores data for motion, power, beam, and node functioning. Similar to system log files, system records have much more detailed information, and the information can be displayed or exported to analyze relationships.

For example, system records track the amount of electrical current used during rotation at each position. So the data will enable the graphic display of rotation compared to current. If current spikes, the data will show the location of the axis when that spike occurred (and thus help locate the binding or blockage).

System records are stored at this path:

C:\VMSOS\AppData\TDSService\Records

Chapter 7 Motion Control

Motion subsystems control the movements of the TrueBeam machine. These subsystems consist of the various motion axes that move the machine and support the delivery of the beam—the couch, gantry, collimator, positioning unit arms for the MV and kV imagers, and even the beam (in its motion aspect, as a one-directional mover of electrons).

Motors move the axes based on monitoring from sensors that are part of the feedback system used to initiate and monitor the movement and positioning of axes.

Motion either is manually initiated through the pendant or couch side panel while setting up the patient, or is automatically initiated by the Supervisor during targeted motion or a dynamic treatment. In Service mode, test applications can operate axes for testing. Which device has priority for moving axes follows a hierarchy described in “Input Device Motion Control Hierarchy” on page 36.

The TrueBeam Supervisor dynamically synchronizes the dose delivery while simultaneously moving any of the required axes—the gantry, collimator rotation, collimator X and Y jaws, the two MLC banks and each MLC leaf. The Supervisor sends commands for all these motions to the control boards for each of the axes and receives status every 10 ms.

Topics in this chapter cover how TrueBeam and the Supervisor control motion, including the use of motors that drive motion axes and sensors for feedback. The chapter includes an overview of the calibration process to set reference points for the motion axes, the initialization process to verify axis positions, and troubleshooting information.

Supervisor Control of Motion Axes

The Supervisor manages the motion control system. The Supervisor (SPV) communicates with the other nodes every 10 ms, on the system sync signal. The system sync pulse is maintained by the Stand node (STN).

Based on information from the treatment plan, the Supervisor determines the required positions of each of the axes and the dose to be delivered. The Supervisor exchanges information about the treatment plan, treatment history, and machine status with the Treatment application and in-room monitors.

The Supervisor also coordinates image acquisition (for example, with the kV and the MV imagers).

Control Sequence

The Supervisor manages control of the motion axes in the following sequence:

1. When the treatment plan is loaded, the Supervisor calculates the trajectory for each of the moving axes (the sequence, speed, and duration of motion). It also calculates the amount of dose to be delivered at each point in the sequence of movements.
2. After calculating the trajectory for each node, it creates the appropriate instructions for each node that will realize the treatment.
3. When treatment begins, the Supervisor sends the appropriate instructions to each motion axis and the beam generation system every 10 ms.

   Each instruction tells the node where its axis must be in 10 ms and in 20 ms. Providing two instructions (one for the position in 10 ms and one for the position at 20 ms) makes it possible for an axis to operate successfully even if an instruction is dropped. See Figure 21 on page 97.
4. When it receives a trajectory instruction, each node carries out the instruction.

   The node generates detailed instructions for the axis it is controlling. The node operates much faster than 10 ms, and it provides the multitude of instructions to operate the axis to realize the overall trajectory instructions provided by the Supervisor. For example, the beam is generated as often as every 2.5 ms, so the BGM calculates and delivers four pulses for every instruction it receives from the Supervisor.

Communication Between Supervisor and Axis Nodes

At each system sync pulse, the Supervisor and nodes exchange information. The Supervisor issues instructions, and each node provides status information to the Supervisor about its axis (which includes positions, capabilities, faults, interlocks, and safety loop status).

During the 10 ms interval between sync pulses, each node receives and evaluates position information from the sensors in its axis. If the axis position deviates from the trajectory calculated by the SPV (outside of the specified range), the node issues a motion fault and the treatment stops.

On receiving the information from the node, the Supervisor verifies axis positions (or delivered dose) reported in the status message, and calculates two new positions (P1 and P2) to be reached by the following second and third sync signals. See Figure 21.

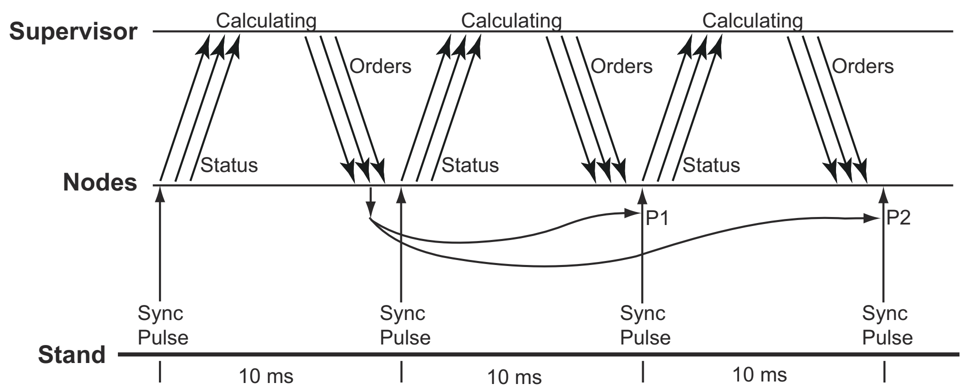


Figure 21 Supervisor Communication on the System Sync Pulse

If a node does not receive two instructions in a row, or if the Supervisor doesn't receive two status replies from a node, the system considers communication between the node and the Supervisor interrupted. The system issues a communication fault interlock, and stops treatment.

Motor Drive Operation

Motion axes (with the exception of the MLC) are moved by direct-current motors; brushless, these motors are notable for high efficiency, reliability, quiet operation, and overall reduction in electromagnetic interference. These motors are efficiently cooled by airflow to the outside of the motor. The motor's internals are entirely enclosed and protected from dirt and other foreign matter.

Feedback Systems

Feedback to the node is provided in most cases by a primary and a secondary sensor, either a resolver or encoder.

Resolvers—Comprise most sensors. Resolvers provide information about the location of the sensor relative to a physical location (the axis hard stop). A resolver is a type of rotary electrical transformer that measures degrees of rotation.

Encoders—Provide absolute location information. An encoder is a device used to convert the angular position of a shaft into a digital signal.

Primary sensors—Are used to confirm the position of an axis during treatment. The primary sensor location is calibrated against an axis hard stop, so that the axis never reaches the hard stop in normal operation.

Secondary sensors—Also evaluate the axis position, providing a backup value to confirm the work of the primary sensor.

Servoing

The motion axes and the beam-generation system are servoed (controlled by a servomechanism), using the error-detecting capabilities of the sensors to initiate adjustments to correct the position, trajectory, speed, and dose.

Each motion control node constantly receives axis position data from the primary resolver location. The node compares the actual position to the position commanded by the Supervisor. The node then sends a signal to adjust the axis position as needed.

Figure 22 shows how the Collimator controller adjusts the collimator axes in a test environment.

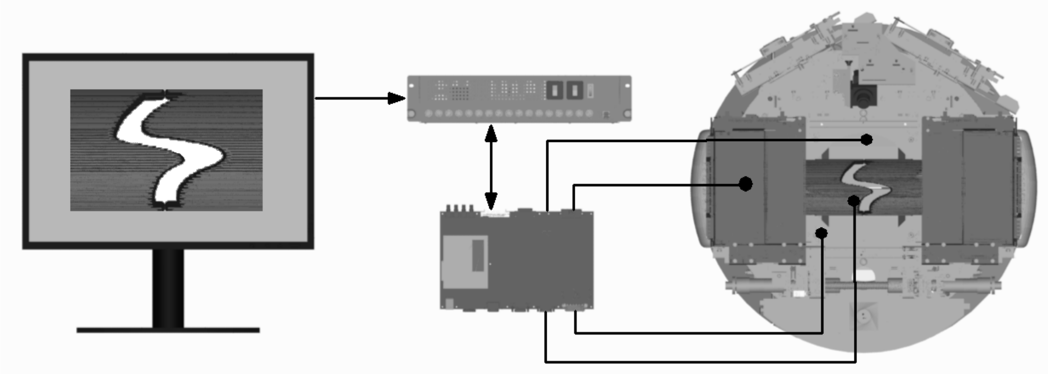


Figure 22 Servoing the Collimator

Description of Motors

Table 4 shows the location, design, sensor type, and sensor location of the different motors in the TrueBeam system. In the table, P identifies the primary sensor, S identifies the secondary sensor, T identifies the tertiary sensor, and "pot" is short for "potentiometer."

Table 4 Motor Descriptions

Motor	Location	Design	Sensor Type	Sensor Location
Collimator Rotation	Gantry head	Brushless	P = Resolver S = Resolver	P = Motor S = Gantry head
X jaws	Lower Collimator	Brushless	P = Resolver S = Resolver	P = Motor S = X-jaw belt
Y jaws	Upper Collimator	Brushless	P = Resolver S = Resolver	P = Motor S = Y-jaw gear rack
MLC Carriage drives	MLC	Brush	P = Magnetic encoder S = Optical encoder	P = Motor S = Optical mount

Table 4 Motor Descriptions

Motor	Location	Design	Sensor Type	Sensor Location
Carousel Rotation	Carousel Y-stage plate	Brushless	P = Resolver S = Resolver	P = Motor S = Rotation belt idler
Carousel Y-stage	Carousel Y-stage	Brushless	P = Resolver S = Resolver	P = Motor S = Y-Stage gear rack
Target drive	Target drive	Brushless	P = Resolver S = Resolver	P = Motor S = Target gear rack
Ion Chamber drive	Carousel Ion Chamber drive	Brushless	P = Resolver S = Resolver	P = Motor S = Ion Chamber drive gear rack
Gantry	Stand	AC sync brushless	P = Digital absolute S = Digital absolute	P = RF joint S = motor
Couch	Lift	AC sync brushless	P = 2x digital string pots absolute S = digital absolute	P = Lower couch base S = Lower couch base T = At motor
MLC Carriage drives	MLC	Brush	P = Magnetic encoder S = Optical encoder	P = Motor S = Optical mount
MLC full leaf	MLC carriage	Brush	P = Magnetic S = Linear pot	P = Motor S = Soft pot
MLC half leaf	MLC marriage	Brush	P = Magnetic S = Linear pot	P = Motor S = Soft pot
MLC quarter leaf	HD MLC marriage	Brush	P = Magnetic S = Linear pot	P = Motor S = Soft pot
Energy switch	Energy switch drive	Brushless	P = Resolver S = None	P = Motor S = None

Calibration and Initialization

Once the motion axes have been calibrated, initialization verifies that the calibration data is valid, and places each axis at a known starting point for treatment.

Calibration

This process establishes a specific relationship between position sensor readouts (which are relative) and positions which are permanently affixed to a system structure, such as a limit switch. End-of-travel switches, hard stops, and collision sensors are used to determine travel limits and to calibrate position sensors, depending on the specific mechanics of an axis. All collimation axes, except for the Y jaws can be automatically calibrated. The mechanics of the Y jaws require that an external positioning pin be used for calibration.

Calibration is performed at initial installation and when needed thereafter. The results of initial calibration are stored as part of the encoded configuration files on the workstation. The checkout routine takes key measurements of axis position, and those results are compared by the control node with the calibration data that is obtained from the workstation. If the values don't agree to within configured tolerances, a fault is raised that system calibration data is not valid.

The home position is a verifiable reference point from which axis motion is tracked. A limit switch or hard stop is typically used for finding the home position. The process of doing this is referred to as homing.

To calibrate motion axes:

Use the appropriate tab in the Service application:

- To calibrate the target, ion chamber, or the carousel, choose Carousel > Init Axis and select the Commands checkbox.
- To calibrate the gantry or the collimator, choose Axis > Gantry/Coll.
- To calibrate the MLC, choose MLC > Positions, and select the Commands checkbox.

Initialization

This process prepares the system for operation, by verifying that the axes are moving as expected and are set to a known location. The initialization process uses checkout routines to ensure that calibration data is accurate. If valid calibration data is available from a previous calibration, then calibration is skipped. If valid calibration is not available, then a calibration can be performed under operator control.

Troubleshooting

The Service application offers various information about the axes to use in interpreting fault interlock messages and for reporting problems to Varian Service. Troubleshooting motion faults typically involves interpreting the fault message and examining the axis involved.

The Service application displays specific information about voltage and current flow to the axes (Table 5), and about actual and planned positions (Table 6).

Table 5 Voltage and Current Flow to Axes

Axis	Tab > Subtab	Provides
Couch	Axis > Couch PCBs	Voltage and current to couch motors, sensors, brakes.
MLC	MLC > Currents	Actual current load for each leaf.
Jaws	Axis > Jaws	Actual current to each jaw.

Table 6 Actual and Planned Positions for Axes

Axis	Tab > Button	Provides
All	Axis Positions	Program and actual positions for gantry, collimator, jaws, couch, and imager arms
Couch	Axis > Couch	Actual positions for couch.
MLC	MLC > Positions	Positions for each leaf.

Slipping Faults

If a fault message indicates that the axis motor is slipping, it means that the motor is operating, but the axis is not moving. Something is intervening in the axis motion.

Typically, you would check for blockage somewhere in the axis, then check the axis motor.

Deviating from Standstill Position Faults

If a fault message indicates that the axis motor is deviating from its standstill position, it means that the axis was instructed to hold its position in standstill, but has moved or is out of balance. These faults show the position expected and the current position (in degrees for a rotational axis, and millimeters in a linear axis).

Such faults can indicate a problem with the servoing mechanism or with the sensor. Typically, the first step would be to check the brake. It is also possible that a chain drive chain may be stretched.

Deviating from Requested Position Faults

If a fault message indicates that the axis motor is deviating from its requested position, it means that the axis is not correctly following the trajectory calculated by the Supervisor. Such faults show the position expected and the current position (in degrees for a rotational axis or millimeters in a linear axis).

Essentially, these faults indicate that the axis is moving at the wrong speed, or not moving at all. The axis is not following the order to move, or it is late following that order. Large electro-mechanical deviations indicate a broken wire or a major obstruction. Small deviations indicate the need for lubrication or other maintenance.

Axis ID Numbers

Some fault messages identify an axis by an ID number, as shown in Table 7 on page 104. (For more information on the imaging system axes, see the *TrueBeam Technical Reference Guide—Volume 2: Imaging*.)

Table 7 Axis ID Numbers

ID Number	Axis
1	Gantry rotation
2	Collimator rotation
3	Couch vertical
4	Couch lateral
5	Couch longitudinal
6	Couch rotation
7	Lower jaw X1
8	Lower jaw X2
9	Upper jaw Y1
10	Upper jaw Y2
11	Multileaf collimator
12	Multileaf collimator, external
13	MV detector shoulder
14	MV detector elbow
15	MV detector wrist
16	MV detector hand
17	kV detector shoulder
18	kV detector elbow
19	kV detector wrist
20	kV detector hand
21	kV source shoulder
22	kV source elbow
23	kV source wrist
24	kV source hand

Chapter 8 Beam Generation and Monitoring

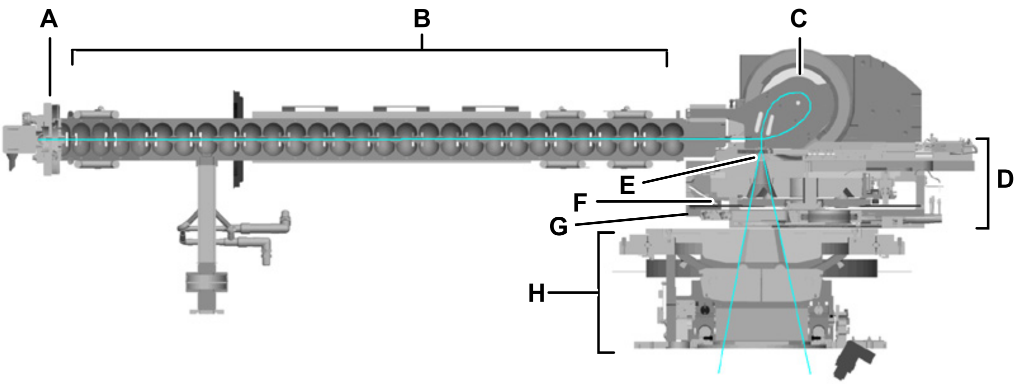
The TrueBeam system generates the beam by activating an electron gun, bunching the released electrons, accelerating them, and then steering them through a 270° bend magnet. Servo mechanisms automatically steer the beam in response to measurements of beam symmetry.

To create an X-ray (photon) beam, the electron beam is directed at a target, which releases photons. The photons are collimated and shaped, including with filters that flatten the beam, into the required geometry for treatment.

To create an electron beam, the target is withdrawn, and the electron beam itself is used for treatment. The electron beam is collimated and shaped for treatment, including with foils to scatter the beam.

Filters and foils arranged in the carousel are rotated into position to affect the beam.

The X-ray or electron beam passes through an ion chamber in the carousel, where the beam generation control node (BGM node) monitors the dose, beam flatness, and symmetry.



A Gun. **B** Accelerator. **C** Bend magnet. **D** Carousel.
E Target. **F** Foils and filters. **G** Ion chamber **H** Collimator.

Figure 23 Accelerator and Beam Diagram

The beam triggers, the electron gun, power supplies for accelerating the beam, and steering—are all controlled by the beam generation and monitoring (BGM) system together with its subsystems.

The BGM node is in constant cyclical communication with the system Supervisor, exchanging dose delivery orders every 10 ms.

The BGM node communicates directly with BGM subnodes through the control area network (CAN).

Beam Generation Basics

The BGM system sets the operating values for all beam generation components, including positioning the target, the Energy Switch, and the appropriate foil or filter. It also programs the current for the accelerator, the klystron solenoid, and the bend magnet.

As part of its beam generation function, the BGM system generates modulator, RF, and electron gun trigger pulses. As well, the BGM system controls:

- The dose servoing system.
- The beam steering servo system.
- The AFC (automatic frequency control) servo system.
- The PFN (pulse-forming network) servo system.
- Any required beam-hold using the BGM system network CAN bus.

As part of its beam monitoring functions, the BGM system:

- Measures dose and dose distribution (symmetry and flatness) at the ion chamber.
- Monitors vacion pumps to ensure vacuum in the accelerator.

In addition, the BGM system monitors the operating environment, including machine temperature, water flow, and power supply to the BGM subnodes.

Beam Generation System (BGM)

The BGM system consists of a central controller board (BGM-CONT) and five subnode boards—EGN, MOD, RFSPS, POS and PWM—which connect and communicate through a local CAN network. See Figure 24.

The BGM controller node (BGM-CONT, or just BGM) controls the BGM subnodes. It takes commands at 10 ms intervals from the Supervisor and implements all beam generation functions. The BGM-CONT board monitors all beam generation functions to ensure they remain within tolerance limits, and interlocks the beam if the machine is outside these limits. This board is primarily a task manager and monitor, keeping all the parameters in control. It is the master for the local BGM network, a CAN bus implementation, which it uses to control and monitor certain BGM subnode parameters.

All subnodes have a digital signal processing (DSP) chip to run firmware. The firmware controls the sequence of preparing (or "moding up") the energy and turning the beam on and off.

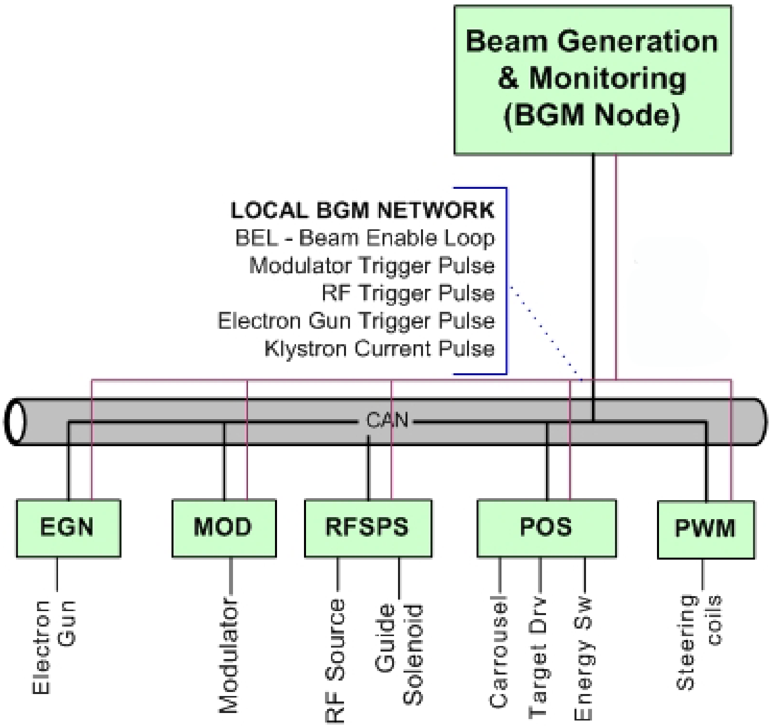


Figure 24 BGM System with Its Five Subsystems

Generating the Beam

The BGM system controls the parameters that affect the generation of the beam. When the user prepares an energy, the Supervisor sends an order to the BGM with the requested energy and dose rate. To have the requested energy and dose rate delivered, the BGM system configures the machine in this sequence:

1. Sets all subnodes to the Ready state (if they are not yet in that state).
2. Loads the configuration for the given energy.
3. Sets the steering coils to 0 A and saturates the bend magnet.

   To saturate the bend magnet, the BGM sets the bend magnet current to the maximum value for at least 6 seconds. Saturating the bend magnet is required to avoid hysterisis in the magnetic field. (Hysterisis is, roughly, resistance to a change in magnetization.)
4. Issues commands to drive the target, the Energy Switch, and the carousel to their appropriate, energy-specific positions.
5. While saturating the bend magnet and moving motion axes:
   - Starts configuration of other parameters, such as RF Driver voltage, AFC voltage, and the accelerator solenoid current.
   - Initiates the calibration check test (Cal Check), which verifies the dosimetry system.
6. After the bend magnet is saturated, programs the bend magnet to its energy-specific value.
7. Sets up the trigger timing in FPGA, which controls generation of MOD, GUN, and RF Driver triggers.
8. Sets all servo control parameters and dosimetry limits.
9. On receiving the Beam Ready command from the Supervisor, drives all the subnodes to the Active state and enables the modulator pulse-forming network (PFN) high-voltage power supply (HVPS).
10. On receiving the Beam On command from the Supervisor and each subnode has closed its beam loop switch, the BGM system generates the triggers to deliver the beam.

BGM EGN

The BGM-EGN subnode controls the electron gun driver. It also controls the accelerator and Gun vacion pump, monitoring current and voltage to the pump. The BGM-EGN subnode performs these functions:

- Programs the gun grid voltage, and gun HVPS for each energy level, based on parameters received from the BGM controller.
- When an energy is moded up, enables the hotdeck by closing the AC relay; enables the gun HVPS; and closes the crowbar.

  The hotdeck is the part of the gun driver where the bias voltage and grid pulse are produced and applied to the grid of the electron gun and where heater power is applied to the filament.

  The crowbar is a safety relay in the TrueBeam that, when closed, immediately removes high voltage.
- Receives the gun trigger signal from the BGM controller and, when the Beam Enable loop (BEL) is closed, sends it to the gun.
- Monitors the actual voltage outputs to ensure they are operating within an acceptable range.
- When requested, sends diagnostic information to the Service application.

BGM RFSPS

The BGM-RFSPS subnode is the radio frequency source and power supply subsystem. The RFSPS subsystem controls the RF driver and power supplies to the bend magnet, accelerator solenoid, and the klystron solenoid. The RFSPS subnode performs these functions:

- Receives parameters from the BGM controller to program power supplies for each energy level in the bend magnet, accelerator solenoid, and the klystron solenoid.
- Monitors the power supply outputs to ensure they are operating within an acceptable range. The actual current and voltage are sampled into RFSPS every 10 ms.
- Monitors RF driver power for every beam pulse.
- When requested, sends diagnostic information to the Service application.

RF Driver

The BGM interfaces with the RF driver through the BGM-RFSPS subnode and sets its RF driver power and frequency when an energy is prepared. The frequency of RF driver pulse is adjusted by the AFC servo during beam on.

The BGM controller monitors a passive AFC circuit to detect and maintain the RF frequency from the RF driver at the resonant frequency of the accelerator guide, to minimize reflected power from the guide.

Bend Magnet

The BGM-RFSPS subnode controls final beam energy selection in the bend magnet. The bend magnet contains fixed energy slits at the point of maximum dispersion. These slits block the unwanted highest and lowest energy spectra.

The current to the bend magnet coils determines the trajectory of a particular beam energy through the magnet; adjusting this current thus adjusts energy selection. The bend magnet power supply provides a programmed level of current to the bend magnet for each energy level.

Accelerator Solenoid and Klystron Solenoid Power Supplies

The accelerator solenoid focuses the electron beam as it travels the length of the accelerator structure. The accelerator solenoid power supply provides a programmed level of current to the accelerator focusing coil for each energy level.

The klystron solenoid provides the necessary magnetic field to keep the klystron electron beam well-collimated and working at maximum efficiency. The klystron solenoid power supply, programmed to a constant value, provides a set level of current for the klystron focusing coil.

BGM PWM

The BGM pulse width modulator subnode (BGM-PWM) controls the coils that steer the beam:

- Radial and transverse Buncher steering coils, on the accelerator.
- Radial and transverse Position steering coils, on the accelerator.
- Radial and transverse Angle steering coils, located in the bend magnet.
- The Trim coil, located in the bend magnet.

In addition, the BGM-PWM subnode performs these functions:

- Receives parameters from the BGM-CONT board to set the steering coil currents for each coil for each energy level. Settings are applied when the energy is loaded.
- Monitors the current that flows through the coils, ensuring that the actual current matches the requested current.

  When steering servoing is enabled, the system adjusts the current as needed during Beam On. The current is adjusted during every beam pulse.
- Monitors power supply outputs to ensure they are operating within the acceptable range, and when requested, sends diagnostic information through the Service application.

BGM POS

The BGM positioning subnode (BGM-POS) controls the position of the following motion axes and monitors their actual position to ensure they are operating within the acceptable range:

- Energy Switch
- Target
- Carousel Rotation: Transversal
- Foils and filters
- Carousel: Y-stage (longitudinal motion)
- Carousel ion chamber.

In addition, the BGM-POS subnode performs these functions:

- Receives parameters from the BGM-CONT board to set the positions for each axis as required by a plan. Calibration sets the travel range and distance of limit switches.
- Checks the secondary position against the preset expected position.
- Monitors the motor drive current for these motors, and when requested, sends diagnostic information through the Service application.

Energy Switch

The BGM-POS system controls and positions the Energy Switch to energy and mode-specific locations. The Energy Switch is inserted to reduce the electric field for low X-ray energies. It is withdrawn for electron beam treatments. The Energy Switch positions are set at the factory.

The Energy Switch drives a plunger to a precise location into one of the accelerator side cavities located about one-third the length of the accelerator from the gun end; little acceleration then occurs in the remaining 2/3 of the accelerator. This causes a predetermined reduction in centerline electric field in the remaining section of the accelerator. A much higher power level can thus be applied to an effectively shorter accelerator. The net result is an output beam energy that not only is at the required reduced value (for example, 6 MeV) but also with a beam that retains a narrow energy spectrum, so that high-output dose rate is possible (up to 600 MU/min from the 6 MeV beam), after transit through the bend magnet.

Target

The BGM-POS node positions the target to energy and mode-specific locations.

The target is located in the beam path at the exit of the bend magnet. X-ray radiation is emitted if the target is hit by electrons. Separate targets are placed in the electron beam path, according to selection of X-ray (photon) beam energy.

For an electron beam, the target is retracted from the beam path. The target is positioned by a servo-driven mechanism.

Foils and Filters

The BGM-POS node controls the placement of the X-ray filter (for X-ray energies) or the electron foil (for electron energies). Filters and foils are placed in the beam path to achieve the desired field distributions for the selected energy and mode. For an X-ray beam, the filter attenuates the beam so that it is flattened. For an electron beam, the foil scatters the beam.

The carousel arranges the filters and foils and rotates them into position (Figure 25). For beam treatments that do not use a flattening filter (flattening-filter-free beam treatments), the carousel rotates an empty filter location into the beam path.

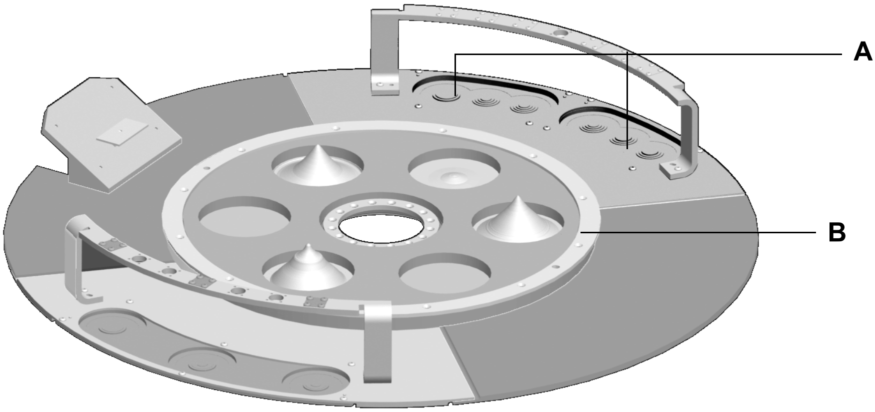


Figure 25 Foils (A) and Filters (B)

Carousel Y-Stage

The BGM-POS node positions the carousel Y-stage axis, providing longitudinal motion for the carousel. The Y-stage axis drive (Figure 26) moves the target out of the way when electron mode energies are used; positions foils and filters; and adjusts the field light mirror for proper focus.

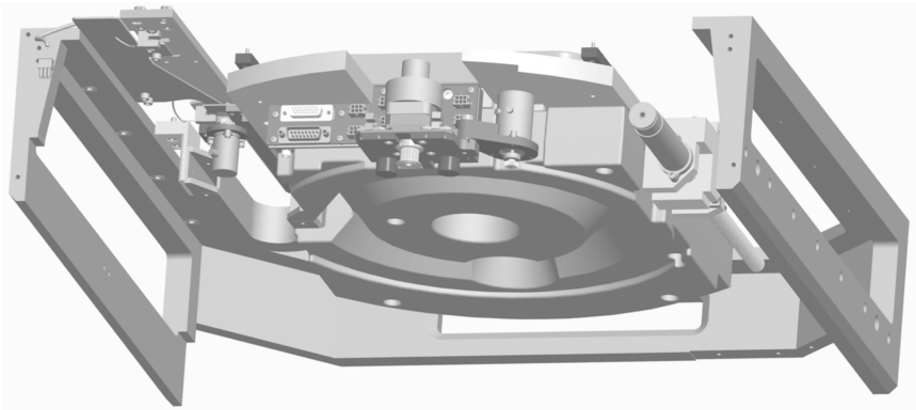


Figure 26 Y-stage Axis

Carousel Ion Chamber

Located at the end of the carousel closest to the collimator, the ion chamber (Figure 27) is intercepts the radiation beam after it has passed through the X-ray filter or electron foil. The BGM-POS subnode positions the ion chamber into the path of the beam.

The ion chamber monitors the radiation treatment beam to provide feedback to the BGM controller on actual dose rate, symmetry, and flatness.

Based on spatial distribution, the BGM generates corrective signals for radial and transverse angle and position steering servo systems.

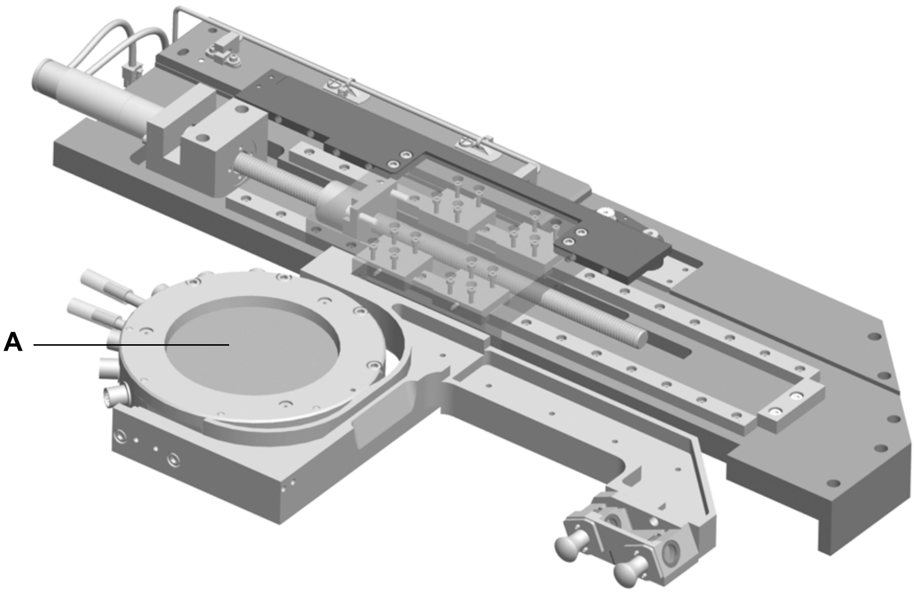


Figure 27 Ion Chamber Axis (A)

Measuring the Dose Rate

The ion chamber contains two independent plate sets, metal disks that are sensitive to radiation. Each plate set contains five plates in the radial plane (ion plates A, B, E, F, and I) and five in the transverse plane (ion plates C, D, G, H, and J) as shown in Figure 28. These plates charge proportionally to dose and time, to measure the dose rate and integrated dose.

The dose rate and integrated dose is measured by a primary dose measurement system on the radial plane (ion plates A, B, E, F, and I), and additionally by the independent secondary dose measurement system on the transverse plane (ion plates C, D, G, H, and J).

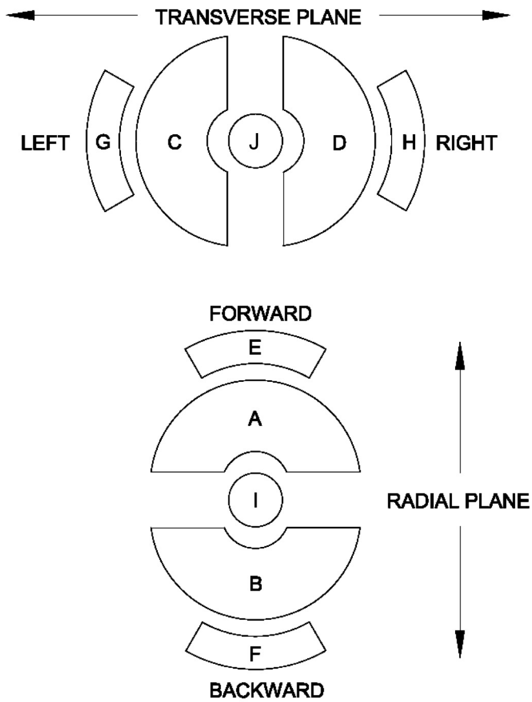


Figure 28 Ion Chamber Diagram

The dose measurement system integrates each ion plate signal over one beam pulse and samples them. The BGM controller monitors dose per pulse, accumulated dose, symmetry, and flatness; and servos the beam as needed.

Field Light

The BGM-POS subnode controls the position of the field light. The field light is used to position the patient and has two bulbs, one of which is used 80% of the time, the other serving as a backup.

The field light and the ion chamber are on the same axis. The mechanism retracts the ion chamber when the field light is required.

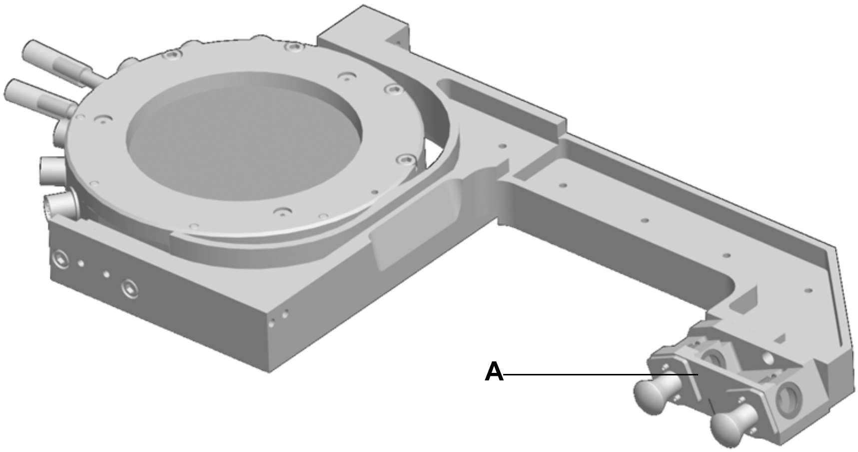


Figure 29 Field lights (A) and Shared Assembly with the Ion Chamber

The field lights behave in this way:

- When no energy is prepared, the field light turns on and off by pressing the field light buttons on the pendant and the couch side panel in the treatment room. These buttons are toggles.
- When an energy is prepared, the carousel automatically drives the ion chamber into position; the field lights no longer turn on or off by pressing the pendant or couch side panel buttons.

  This behavior can be overridden in Service mode by selecting the Mimic Treatment Room Field Light option on the Carousel/Field Light tab. You can then turn the field light on or off with the pendant or side panel buttons, as if the treatment door were open.

BGM MOD

The BGM modulator node (BGM MOD) interfaces with the modulator and the klystron, and performs these functions:

- Controls the modulator high voltage and current.
- Enables modulator voltage during Beam On, disables modulator voltage during Beam Off.
- When an energy is prepared, receives parameters from the BGM controller to program the pulse forming network (PFN) in the modulator.
- Sets the voltage and selects the power mode (A, B, None).
- When PFN servo is enabled, adjusts the PFN programming voltage for every beam pulse during Beam On.
- Monitors PFN voltage and HVPS current.
- Monitors klystron current and voltage.
- Controls the klystron vacion pump, monitoring current and voltage to the pump.
- Generates klystron trigger signals (using klystron current edge) that are used as the external trigger reference by the BGM controller.

When requested, the BGM MOD sends diagnostic information through the Service application.

Dosimetry

The Beam Tuning tab in the Service application contains the controls that allow you to make dosimetry adjustments. The subtabs include:

Preset—For monitoring and programming electrical power; adjusting pulse widths; and when the local trigger is enabled during Beam Off, for adjusting trigger frequencies.

RF Process—For monitoring and adjusting peak radio frequency power, configuring the primary dose rate, and monitoring and adjusting AFC triangular wave generation power and frequencies.

AFC—For monitoring and adjusting automatic frequency control sweep.

Energy Switch—For adjusting the switch position.

Preliminary—For monitoring, programming, and adjusting radial and transverse balances, radial and transverse axes in the carousel, and local triggers in the electron gun, RF, and modulator.

Dose Cal—For monitoring and configuring dosimetry calibration.

Symmetry Cal—For monitoring and calibrating beam symmetry.

Flat Cal—For monitoring and calibrating beam flatness.

Dose Diag—For monitoring calibration check, ion charge capacity and offsets, and nominal beam data.

Gun Diag—For monitoring the electron gun and its power supply.

Limits—For adjusting and calibrating servo limits for the treatment dose, AFC, pulse forming network (PFN), RF, and radial and transverse angles and positions.

For details on these subtabs, see Appendix A on page 217.

Cal Check Cycle

Before each treatment and each time the beam is prepared, the BGM system checks the dosimetry circuit to ensure that it functions properly. This calibration check cycle (Cal Check) includes cable connectivity and dosimetry interlocks. If the beam is out of specifications, the BGM system opens the Beam Enable loop (BEL), which prevents beam generation.

The hardware Beam Enable loop is not tested during Cal Check. It is tested after the user selects Beam On. See Appendix D "Safety Loops," for details on the Beam Enable loop (BEL).

Cal Check tests cable connections; dosimetry-related circuits as well as field programmable gate arrays and BGM software; and the ion chamber power supply.

Cable Connection Test

Because test current pulses generated at the BGM node do not flow through the ion chamber, the connectivity of the ion chamber is tested separately from the other tests. Cal Check tests ion chamber connections, including the ion chamber power supply cable and both ion chamber signal cables.

The BGM system checks connectivity by applying a voltage step change (50 V amplitude) to the ion chamber power supply. If the power supply cable is disconnected, then all ion chamber readings are zero. If any ion chamber cable is not connected, the reading for the disconnected ion plate is zero.

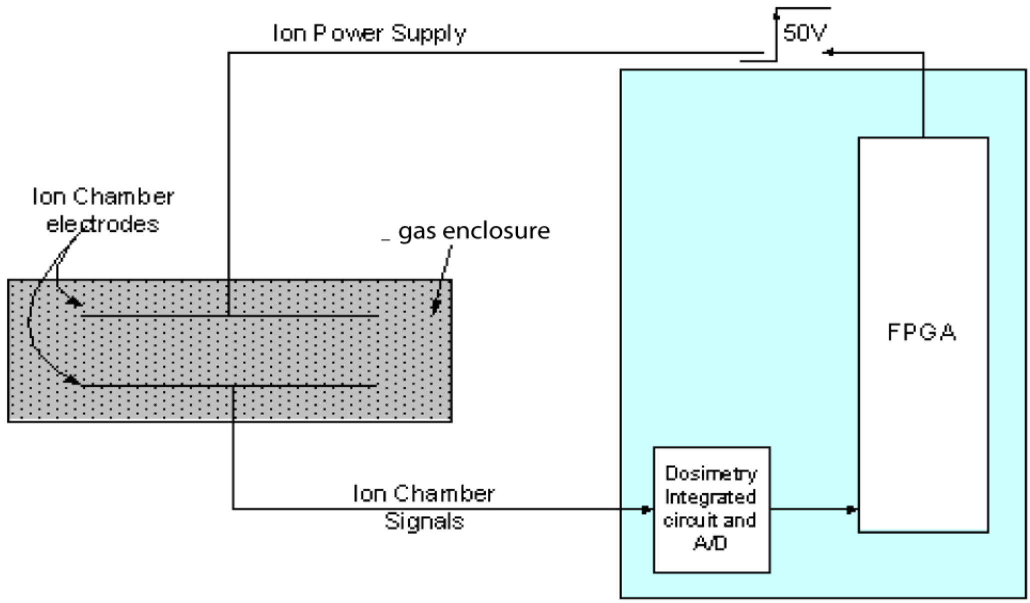


Figure 30 Ion Chamber Cable Connections

Dosimetry-Related Circuitry Tests

To test functioning of the dosimetry-related circuit, the BGM system injects test current pulses into the integration circuitry. These pulses can be configured individually to represent each ion plate and target current. The raw data is checked against the known expected charge values. Accumulated dose, dose rate, number of beam pulses, and Beam On time are checked as well.

The check also tests the dosimetry system in the field-programmable gate array, to calculate the correct accumulated dose, current dose rate, number of beam pulses generated, and beam on time.

The BGM system uses different combinations of test pulse configurations to test symmetry, flatness measurement, and any interlocks defined in BGM software.

Ion Chamber Power Supply

The ion chamber power supply provides 500V DC bias to the ion chamber plates. The power supply on the BGM controller printed circuit board and the actual voltage on the plates are monitored.

Troubleshooting

Dosimetry fault interlocks are asserted based on any of these factors:

- Any mismatch between primary and secondary accumulated dose.
- Mismatch between actual and requested accumulated dose.
- Over-dose fault or under-dose fault (includes dose per pulse, each ion plate and target current).
- Dose tracking error.
- Beam symmetry or beam flatness in radial and transverse planes.
- Ion chamber 500 VDC power supply out of range.

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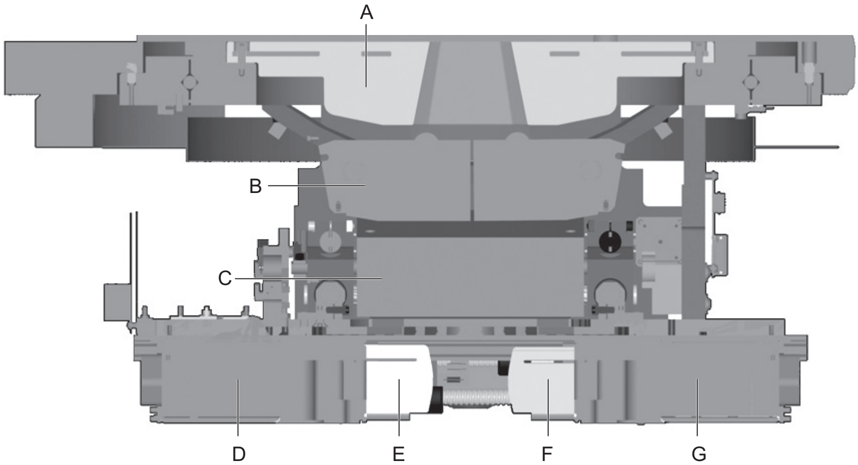
Chapter 9 Collimation

By controlling the collimator and its accessories, the Collimation subsystem determines the final beam shape delivered to the treatment location. The Collimation subsystem has these major components:

- The collimator controller (COL), a single control node that controls and monitors the collimator components.
- The collimation head, which contains all of the collimation components. The head rotates around an axis that is fixed to the gantry, thereby rotating all of the collimation components.
- The Y jaws, a pair of motorized tungsten blocks that constrain the beam in the Y direction. The Y jaws are also called the upper jaws, as they are the uppermost jaws when the gantry is at the top.
- The X jaws, a pair of motorized tungsten blocks that constrain the beam in the X direction. The X jaws are also called the lower jaws, as they are the lowermost jaws when the gantry is at the top.
- The multileaf collimator (MLC), an array of smaller motorized blocks that shape the beam to more complex geometries than the jaws alone.
- Accessories, which are modifying devices used to further shape the beam.

Figure 31 on page 124 shows the physical location of the components.



A Collimator shielding **B** Y (upper) jaws. **C** X (lower) jaws. **D** MLC Carriage A.
E MLC Carriage B. **F** MLC leaf bank A. **G** MLC leaf bank B.

Figure 31 Collimation Components

Collimator Controller

Figure 32 shows how the collimator control system is integrated into the TrueBeam control system.

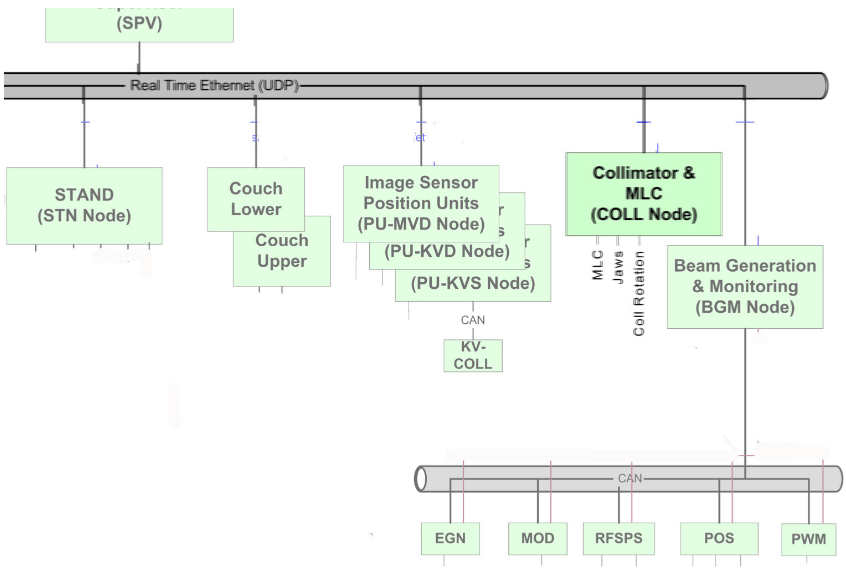


Figure 32 Collimator and MLC Node Diagram

The collimator controller has an embedded PC that contains the node software. The controller monitors the motion and position of all axes within the collimator during treatment, treatment setup, and servicing, and performs these functions:

- Calibrates and initializes all motion axes, when necessary, including the MLC.
- Controls and reports the motion and position of the collimator head and the two Y jaws (upper) and two X jaws (lower).
- Verifies the MLC configuration and controls and verifies the motion and positions of MLC carriages and leaves.
- Monitors and reports the status of the collision sensor (also called a touch guard) and the collision override button.
- Reads and reports any installed accessory configuration.
- Monitors critical subsystem temperatures and supply voltages.
- Maintains cyclical communication with the Supervisor by exchanging positioning orders and positioning status of all axes every 10 ms.

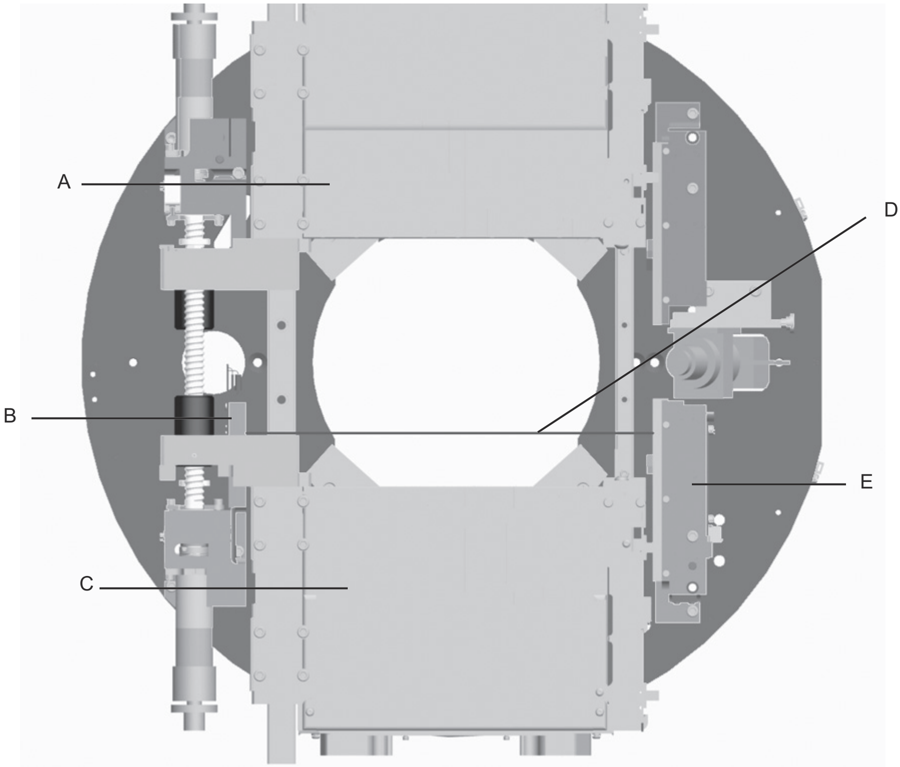
MLC

The TrueBeam MLC consists of two opposing banks of moveable tungsten leaves. Each bank is configured with 60 leaves, 120 leaves in all, providing complex beam geometries.

Carriage and individual leaf positioning are under the control of the collimation controller node. Each leaf motor is given motion commands every 2.875 µsec.

The banks and leaves are moved along the same axis as the X jaws. MLC positions can be static or dynamic during treatment.

A single optical beam, located 56 mm from the MLC centerline, initializes the carriage and leaves. During initialization, locator tabs on the carriages interrupt the beam to establish carriage positions, and the leaves interrupt the beam to establish leaf positions (see Figure 33 on page 126).



A Leaf bank A. **B** Emitter assembly. **C** Leaf bank B. **D** Calibration beam. **E** Receiver board.

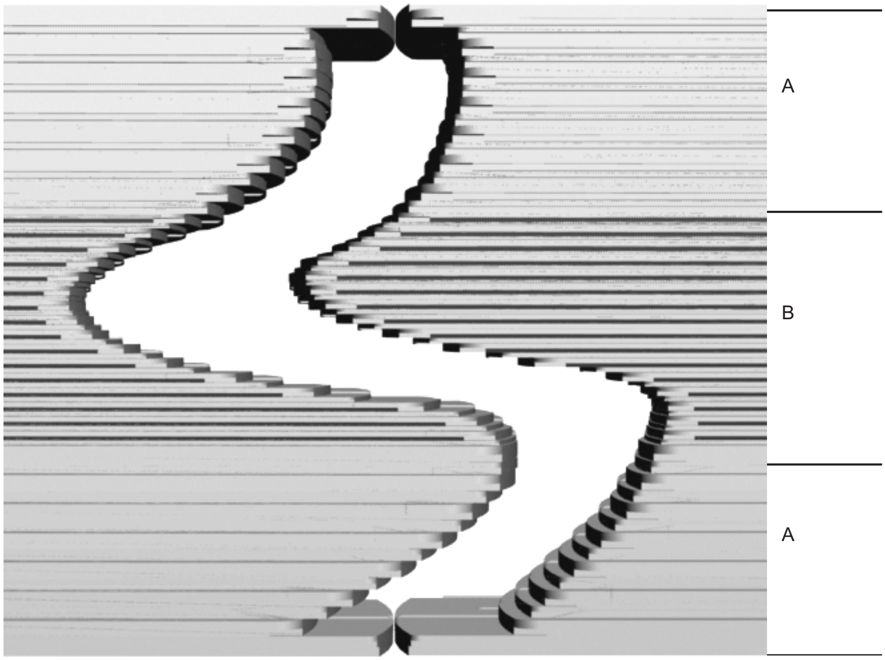
Figure 33 Single Beam Optics for MLC Initialization and Calibration

The TrueBeam is installed with a customer-specified choice of MLCs—the 120 MLC, intended for radiation oncology (VOS), and the HD 120™, a high-definition version for surgical, stereotactic radiotherapy (VSS).

120 MLC—Radiation Oncology Version—<This standard leaf design has 5 mm leaf thickness projected at isocenter (over 20 cm of the treatment plan) and 10 mm leaf thickness projected at isocenter over the peripheral 10 cm on each side region.

HD 120™—High-Definition MLC—Compared to the oncology version, the HD 120 MLC has thinner and deeper leaves, to provide a smaller overall field size. This high-definition multileaf collimator provides twice the leaf resolution at isocenter, 2.5 mm, for stereotactic and radiosurgery (SRS) and stereotactic body radiosurgery (SBRT) applications. Figure 34 on page 127 shows this leaf pattern for the HD 120 MLC:

- 32 quarter leaves (1.25 mm thick, stepping to 2.5 mm at isocenter) distributed in an 8-cm wide central region.
- 28 half leaves (2.5 mm thick, stepping to 5 mm at isocenter) distributed over the peripheral 7 cm on each side region.



A 14 half leaves, 5 mm at isocenter. **B** 32 quarter leaves, 2.5 mm at isocenter.

Figure 34 HD MLC Leaf Arrangement

MLC Collision Safeguards

Individual leaves do not have collision sensors, and opposing leaves can come into contact with one another during operation (zero leaf gap). A variety of safeguards have been implemented to prevent damage to leaves or leaf motion mechanisms:

- Software monitors individual leaf trajectories for potential collisions.
- Primary and secondary position sensors detect a potential zero gap.
- Each leaf's mechanical mounting is spring-loaded, allowing a few millimeters of retraction if excessive force is applied to the leaf face.
- Each leaf has a mechanical fuse on its drive screw, which breaks the mechanical drive link if excessive motion resistance is encountered.
- Dynamic operation is restricted to a leaf gap no smaller than 0.25 mm. Leaf gap is a relative position.

Displaying MLC Information

MLC data and status are displayed various ways. In Service mode, you can view data on the positions of the MLC carriages and leaves, current and pulse width (driving force) to the leaves, and communications. You can graphically display the leaves and X and Y jaw positions.

You can select control points to view more information on a leaf, as well as select one or more control points and play their sequence of movement. You can also perform a dry run of an MLC plan.

A control point is a position on an MLC leaf relative to the rest of the system as identified by its primary or secondary sensors and reported to the Supervisor. The MLC sends information on one control point at a time.

You can view this MLC data:

- The status of the MLC initialization, power to the MLC and communications, appear on the right side of all Service/MLC tabs with the exception of the MLC Diagnostics screen. Initialization states are Not Initialized, Settling at Position, No Substate, and

Ready (Powered, Maintains Position). LimSw refers to the limit switch that marks the end or home position for the carriage. Also displayed is the installed MLC model.

- By default, Service > MLC > Positions shows the current position in machine internal scale of the two carriage banks, their leaves, and the PRO (primary sensory readout) position of the selected leaf.
- In the MLC > Positions tab, select **Show Plan Position** to view the plan and actual values.
- Hardware Positions shows the clinical values from the Supervisor, which is the leaf value at the leaf plane in relation to the isoplane, with offset for some curvature due to the physical design of the leaf and how it blocks the beam. To view this information, In the Service application, click the MLC tab; then click the **Positions** button and choose **Hardware Positions** from the menu.
- MLC Display (MLC > MLC Display) graphically shows control point positions in relation to the X and Y jaws.

Loading an MLC Plan

You can load an MLC plan and its related information, to perform diagnostics and simulate MLC movement.

To load an MLC plan:

1. Start the Service application. For instructions, see "Starting Service" on page 47.
2. On the right side of the Service screen, click the **GoTo** button, and choose **Cycle MLC** from the menu.
3. In the MLC AutoCycle dialog box that appears, click **Open** to browse to and select an MLC plan and its related information.

   The selected plan appears in the Current MLC Plan box.

Simulating an MLC Plan

You can display MLC information dynamically, using the AutoCycle MLC command. This feature is useful for simulating the plan movement of the MLC leaves and collecting information for charting, which Varian Service personnel use for diagnostic purposes. You can select one or more control points and cycles to simulate.

The AutoCycle Motion Axis test lets you specify the start and end position for the motion axis—not just MLC—and how many times the movement will be repeated. The information is collected for charting, which Varian Service technicians use for diagnostic purposes. Click **Start** to begin the selected motion.

You can also perform an MLC dry run, to simulate the movement of the MLC leaves during plan delivery, but without delivering a dose.

To cycle through the MLC plan:

1. Load the MLC plan you want to simulate. For instructions, see “Loading an MLC Plan” on page 129.
2. On the Service screen, click the **GoTo** button on the right side. Then choose **AutoCycle MLC** from the menu.
3. Choose the control point or points you want to cycle through. You can select one or multiple points; click **Select All** to select all of the plan control points.

   To clear the display, click **Clear All**.
4. Specify how many times to repeat the cycle count. Then click the **Start** button to begin the simulation.
5. When you have finished, click the **Close** button.

To perform an MLC dry run:

1. Load the MLC plan you want to simulate. For instructions, see “Loading an MLC Plan” on page 129.
2. Move the axes to the initial plan positions.
3. On the right side of the Service screen, click the **GoTo** button. Then choose **MLC Dry Run** from the menu.
4. In the MLC Dry Run dialog box, click the **Enable Dry Run** button.
5. Using the control console, prepare the beam.
6. In the treatment room using the pendant, hold down the **Motion Enable** bars; then press the **Enter** button to start the dry run.

   To cancel the dry run in progress, press the **Cancel Dry Run** button on the pendant.

Moving to Targets

On pressing the control console Prepare button, two MLC GoTo commands move the collimator axis automatically to the target position of the currently loaded motion axes:

- The **GoTo** menu command, on the right side of the Machine Controls area in the Service application, always moves to the first control point of the plan and matches the actual position with the plan.
- The **GoTo Plan** button, in the taskbar at the bottom of the Service/MLC screen, goes to whatever control point is selected in the MLC table. The MLC table displayed is for the current MLC, unless you load a different table (see “Loading an MLC Plan” on page 129 for instructions)

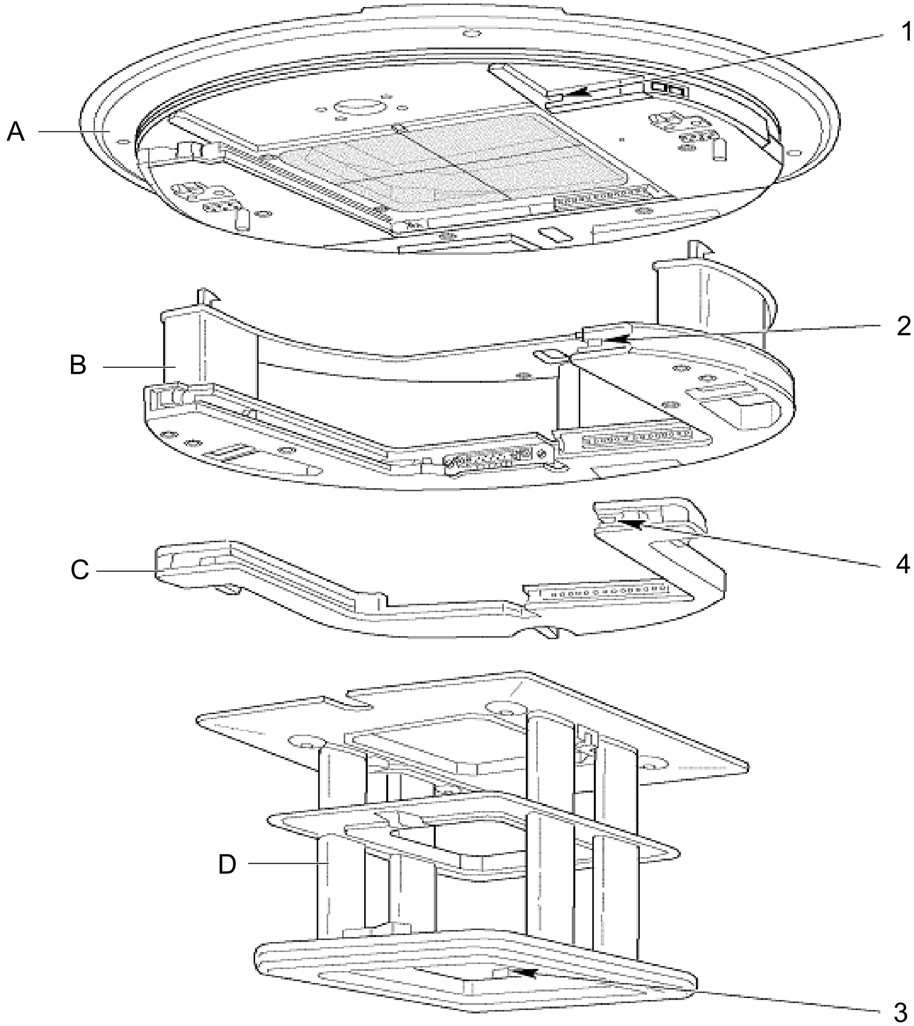
Performing MLC Diagnostic Tests

Using the Service application, you can perform various MLC diagnostic tests, including comparing MLC plan and actual leaf positions. You can also measure the speed of the carriage movement, and the force (pulse width) used to move the MLC and its leaves. In addition, you can check the LED indicators for the MLC.

See Appendix A “Service Screens,” for more information.

Accessories

Accessories are a set of static devices that can be mounted on the collimator head at the beam exit, and combined as needed to produce the desired radiation beam shape. See Figure 35 on page 132.



A Interface mount and slot 1. **B** Accessory mount and slot 2.
C Compensator mount and slot 4. **D** Electron mount and slot 3.

Figure 35 Accessories for Collimation

Standard accessories have specific dimensions and dose distributions, are verified by the system, and used repeatedly on a number of patients. Standard accessories include electron applicators, wedges, and blocks. Accessories may be combined as needed—for example, wedges and blocks used together—to produce the desired radiation beam shape.

Each standard accessory has a unique identifier code that is read optically during setup and treatment. In addition, the TrueBeam system can identify customized accessories using Varian-provided custom code labels. Standard and custom codes work identically; they differ only in that standard codes are specific to the machine, whereas custom codes are specific to the patient. These identifier codes are linked to machine parameters to ensure proper system setup and configuration. For example, if you install a custom compensator, the TrueBeam software allows only compatible X-ray modes.

For more information on using custom codes, see “Custom Coding” on page 134.

Ensuring Proper Installation

For the safety of the patient, as well as the operator, it is imperative that operators always verify manually and visually that accessories are correctly installed before beginning a treatment.

The TrueBeam includes various safeguards to detect improper installation.

Sensing switches—Detect the accessories and ensure that they are properly mounted. A touch guard collision sensor is mounted on each electron applicator, which in turn is mounted on the electron applicator mount (see Figure 35 on page 132).

Two latches at each slot—Indicate proper installation and seating of the accessory

An optical reader at each slot —Reports the accessory code to the collimator controller. If the code does not agree with the expected code, the COL node raises a fault and issues a warning to the operator. In addition to error messages at the workstation, immediate feedback is provided to the operator by an

Indicator lamp on the collimator head—Gives the operator immediate feedback and augments error messages at the workstation (see Figure 36 on page 134). It lights red if either an incorrect accessory is mounted or if it is incorrectly seated.

A collision sensor (touch guard)—Is mounted on the far end of slot 3 (towards the treatment location). If at any time during setup or treatment the collision sensor contacts a solid object, COL raises a collision interlock, BEL and MEL safety loops are opened, and the TrueBeam system asserts beam and motion interlocks.

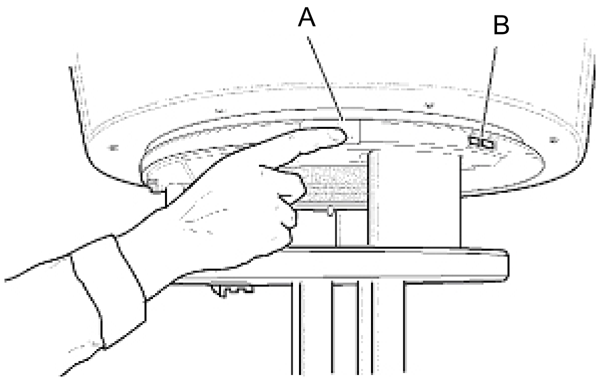


Figure 36 Reset Button (A) and Collision Indicator Lamp (B)

During setup, the operator can activate the Collision Override button on the collimator head to override the software and continue positioning the accessory. When collision override is active, it is possible for a moving part of the system to come into contact with an operator or a patient. During such an operation, the TrueBeam control system restricts and reduces the speed of the external motion axes.

Custom Coding

Custom coding allows operators to easily configure custom accessories for a patient by uniquely identifying the accessories with special adhesive labels.

Authorized users can add custom-coded accessories to morning checkout treatments, and authorized service personnel can test custom coding.

Using Custom Coding in Treatment

Custom coding blends into treatment delivery as follows:

1. Personnel in the mold room attach identifying custom coding labels to the field-shaping and blocking trays during assembly. They note the type of accessory and code numbers from the labels in the patient's chart, and the information is transferred to the plan using planning software such as Aria.

2. At treatment time, the operator installs the required standard and custom accessories in the correct accessory mounts.

   Custom-coded accessories are installed in the same manner as other accessories. For step-by-step instructions on installing accessories, refer to the *TrueBeam Instructions for Use.*

3. The accessory configuration and the codes of any installed custom accessories are sent to the TrueBeam plan.

4. The TrueBeam uses an optical reader to read the codes on the labels on the installed trays and compares them with the codes in the plan.

   If the accessories installed on the TrueBeam do not match those entered at the TrueBeam workstation console, an interlock prevents beam-on.

Custom Codes for Accessories

Four kinds of custom accessories can be labeled with custom code numbers. The TrueBeam Custom Coding option provides a set of uniquely shaped labels for each accessory type.

Table 8 shows the types of custom accessories you can label, where these accessories are installed, and the name and range of code numbers for each kind of label.

Table 8 Custom Accessories and Their Labels

Accessory	Position in Collimator	Label Name	Range of Available Codes	Quantity Per Set
Compensator	Interface mount Compensator mount	Slot 1 & 4 Comp	1–364 (364 codes)	26
Photon Block	Accessory mount	Slot 2 Photon Blocks	1–1664 (1664 codes)	208
6x6 Electron FFDA	Electron Aperture	Slot 3 6x6 E-Aperture	1–124 (124 codes)	42
Electron FFDA (10x10 and larger)	Electron Aperture	Slot 3 E-Aperture	3328–3707 (380 codes)	38

The custom coding label fits over the line of holes on the edge of the tray that plugs into the optical reader when the tray is installed (Figure 37 on page 137). The TrueBeam then reads the pattern and decodes it.

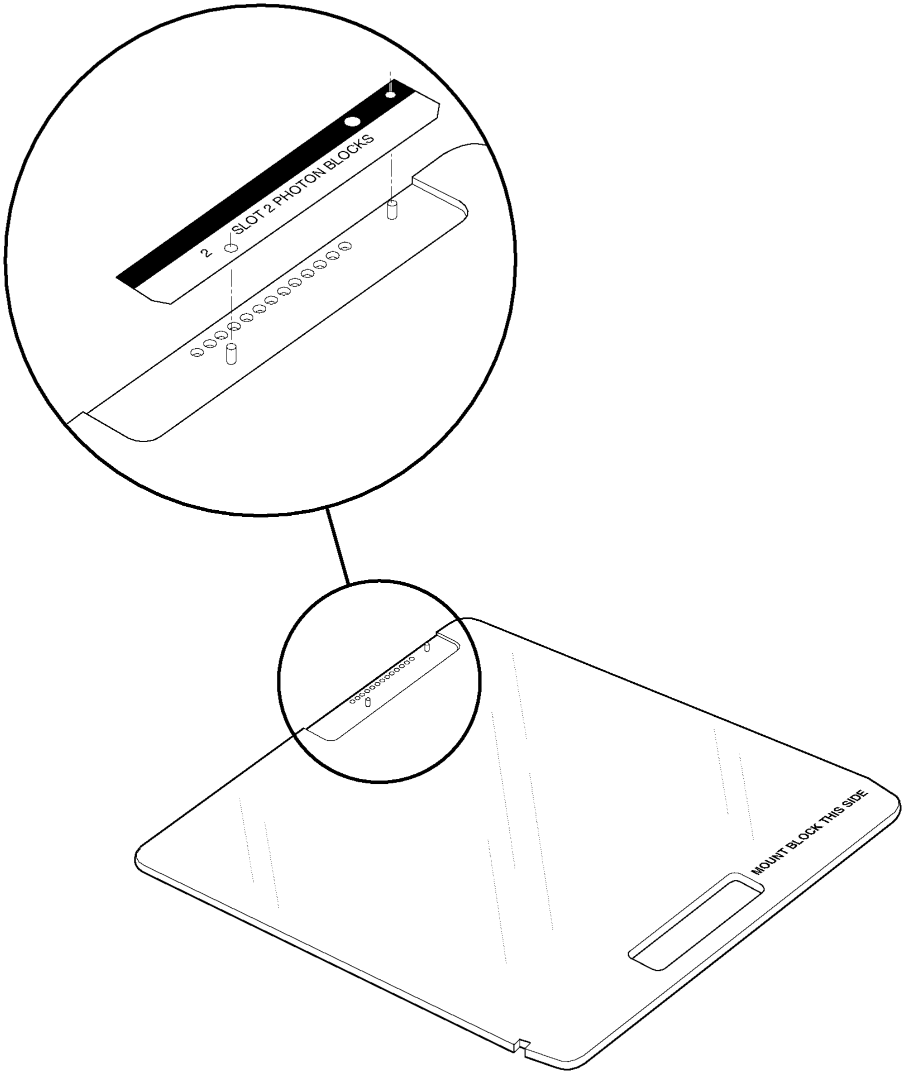


Figure 37 Placing a Label with Code Number 2 on a Block Tray

Applying Custom-Coded Labels to Trays

Each custom code label has a series of holes in a pattern that designates a specific number when seen by an optical reader (Figure 38 on page 138).

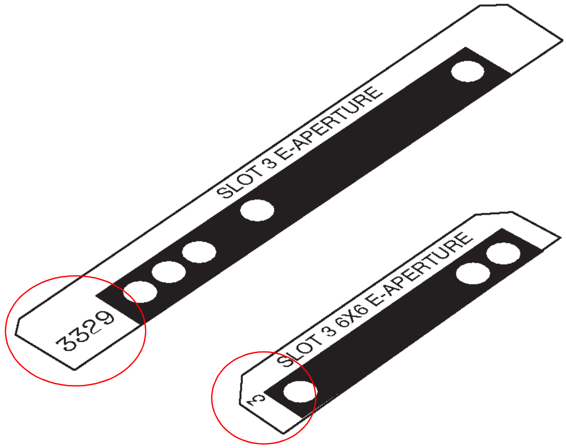
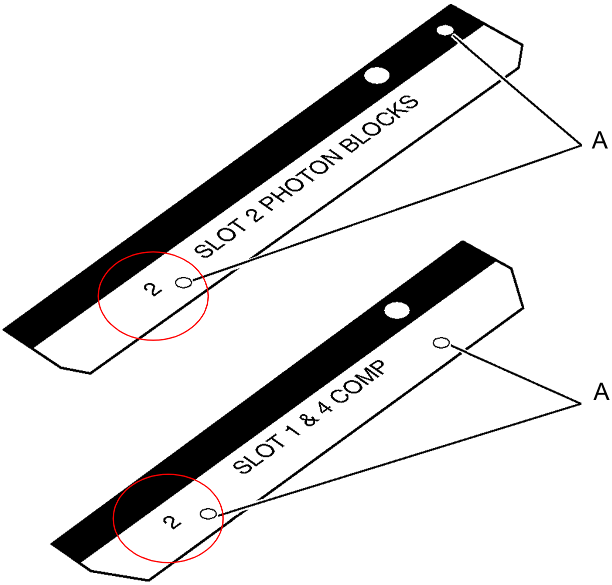


Figure 38 Custom Code Labels for E-Aperture Accessory

Several of the label types share overlapping ranges of code numbers. For example, Figure 39 shows code number 2 used for both a Slot 2 Photon Blocks label and a Slot 1&4 Comp label. The unique identification is created by the combination of the slot in which the accessory is installed and the code number on the label.



A Alignment holes; shared codes circled in red.

Figure 39 Custom Code Labels for Compensator and Photon Block Accessories

To apply a custom-coded label to a tray:

1. Choose the appropriate label type for the accessory.
2. Attach the label to the tray, orientating the label as follows:
   - For Slot 1 & 4 Comp, align small holes in the label over alignment pins or holes in tray.
   - For Slot 2 Photon Blocks, align small holes in the label over alignment pins or holes in tray (see Figure 39).
   - For Slot 3 E-Aperture and 6x6 E-Aperture, slip the label under alignment tabs.

   For an illustration of slot locations, see Figure 37 on page 137.
3. Note the type of accessory and the label number in the patient's chart.

Reusing Codes

You can re-assign code numbers to new patients. However, you must not use the same code numbers for more than one *active* patient.

WARNING: Do not use the same custom code numbers for more than one active patient.

To recycle a tray of an inactive patient, leave the label attached and reassign the code numbers to the new patient.

Varian recommends that you do not try to remove the labels and re-apply them to a new tray, because the adhesive of the labels will wear off.

If two treatment machines have the same codes entered and a patient for one treatment machine is moved to the other machine, two sets of accessories might be available for that one patient. To avoid this conflict, Varian recommends that you order enough custom code labels to ensure an adequate supply for your patients and to assign a unique code number to each accessory.

Troubleshooting

Collimation faults are typically motion faults, such as a collimator rotation fault, or a jaw moving too slowly. Accessory faults typically occur when an accessory is not properly seated, or the wrong accessory is installed for the treatment plan. Such issues are normally detected during initialization prior to treatment. An asserted fault prevents treatment until it is resolved.

MLC Faults

Upon detecting any of the following conditions, the COL reports a fault, BEL and MEL safety loops are opened, and the TrueBeam system asserts beam and motion interlocks.

- MLC optical link or communication is offline.
- MLC optical links are swapped (reversed).
- Orders received and the type of MLC configured (including no MLC configured) do not match.
- The type of MLC configured and the type of MLC connected do not match.
- The requested position of the moving MLC carriage deviates from primary carriage position readout by more than 1 mm at isocenter.
- Difference between primary and secondary carriage position readout exceeds 0.735 mm at isocenter.
- Difference between primary and secondary leaf position readout exceeds 2.5 mm at isocenter.
- Leaf motor current exceeds configured values (0.21 A for full leaf, 0.14 A for half leaf).
- The MLC cannot be held within 0.5 mm of the requested position at isocenter when in standstill.

Accessory Faults

The accessory faults include:

- Mismatch of the installed accessory and the accessory called for in the plan.
- Inactive accessory switch in the installed accessory.
- Invalid accessory called for in the plan.

Chapter 10 Power Distribution System

The TrueBeam Power Distribution System converts site power to various machine supply levels and transforms power input to the modulator and console; it then distributes these voltages throughout the TrueBeam machine. Functions included in this process are current limiting, and control and monitoring of Emergency Off and beam safety systems, and fans.

Notably, this power distribution system:

- Is tightly related to the Stand control system, which provides switching and monitoring of power.
- Interfaces to most of the electrical systems distributed throughout the TrueBeam system. These electronics have specific power needs in specific machine locations.
- Consists of many printed circuit boards (PCBs) at numerous locations, which must work together to complete the power distribution system.

This chapter covers how the TrueBeam Power Distribution System distributes power to the console, Stand, gantry, and modulator, with descriptions of the component printed circuit boards. Also included is information on TrueBeam power states and details of various emergency and uninterrupted operation features. The overview describes the system from a functional, physical, and logical view.

The information in this chapter is intended to help you perform basic monitoring, servicing, and troubleshooting of the TrueBeam power system.

Power Distribution System Functions

The TrueBeam Power Distribution System (PDS) has these functions:

- Terminates alternating current (AC) power input wiring.
- Transforms wide AC input range to standard values within the PDS Mains transformer and PFN (pulse-forming network), the high-voltage power supply transformer.
- Distributes, controls, and monitors the AC and direct current (DC) sources to loads throughout the TrueBeam.
- Provides load protection with circuit breakers (CBs), fuses, overload relays, overcurrent protection thermistors, and electronic overcurrent protection devices.
- Provides and distribute power for the TrueBeam Start function; see “Start” on page 164 for more information.
- Provides and distributes power for TrueBeam Emergency Stop and remote trip functions, through the Console Power Distribution (see “Console Power” on page 150).

  Emergency Stop buttons immediately disconnect energy sources and shut off power to the TrueBeam. In Service mode, Emergency Stop immediately shuts off power to most components in the TrueBeam machine (except the kV detector which is powered from the console). In Treatment mode, Emergency Stop immediately shuts off power to the TrueBeam machine, but leaves 24V control to all nodes and subnodes. In both cases console power remains available.
- Provides an Emergency Disconnect function. This switch, located on a console room wall with the console circuit breakers, removes power to the TrueBeam. See “Emergency Disconnect” on page 151 for more information.
- Provides an Auto Restart function; similar to the remote trip function, Auto Restart can be configured by the user. See “Emergency Disconnect” on page 151 for more information.
- Provides an interface to the treatment room and other customer options through the Relay Junction Box.

Power System Physical View

Two sources of AC power provided from the owner's facility supply the TrueBeam system and its five main components (Figure 40):

- A 5 kilovolt-amp (kVA) power source, single phase at 220 ±20 Vac, protected at 20 A, for the Console cabinets in the console area.
- A three-phase 45 kVA power source at 200 to 480 Vac, protected with the appropriate circuit breaker, with an Under Voltage Relay (UVR) option for remote trip.

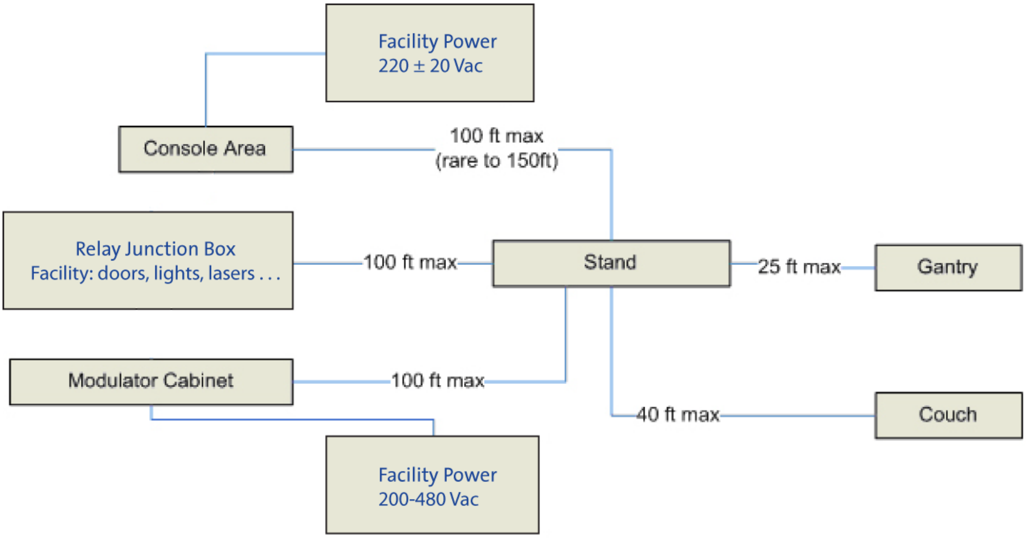


Figure 40 TrueBeam **Power System Overview**

This figure also shows the cable runs between the components.

Console Area—Is the site of the main control user interface, which includes the TrueBeam workstation computer and monitors, the control console, and an uninterrupted power supply.

Modulator cabinet—Houses the Mains transformer, which matches the hospital input power to the internal power needs of the TrueBeam. The modulator can be located in the treatment room, in a closet, or in a remote location from the console or Stand areas or elsewhere in a ventilated and cooled location.

Most of the larger power switching and protection devices are also located in the Modulator cabinet, as well as in the Pulse Forming Network (PFN) assembly.

Stand, Gantry, and Couch—Are all located in the treatment room. The Stand is attached to a baseframe mounted in the floor and supports the gantry with a bearing device that allows 370° of rotation. The Couch turntable is mounted to the same baseframe and supports the couch on a bearing that allows 200° degrees of rotation.

Power Distribution System Logical View

The TrueBeam Power Distribution System can be broken into five logical sections representing different physical locations for power functions, as shown in Figure 41.

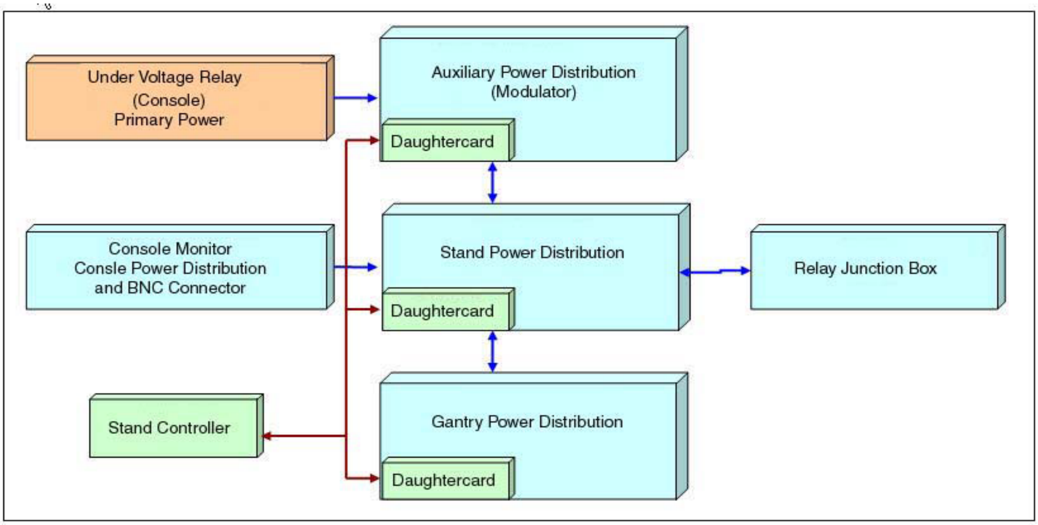


Figure 41 Power Distribution Logical View

The Under Voltage Relay component is shown here only as a reference for primary power into the machine; it is not included in the five main power distribution elements. The couch is not shown here; it is a load on the power system, but does not contain other power functionality.

Power Functions

Each of the five physical components shown in Figure 40 on page 143 contains power electronics, including discrete components (transformers, relays, breakers, and so on), and printed circuit boards. These five logical components correspond to the physical components.

Modulator—The Modulator includes the primary power electronics in the Modulator cabinet, consisting of the Mains and high-voltage power supply (HVPS) transformers, various system breakers and relays, and the APD circuit board. The primary purpose is controlling power into the machine, and switching power for the PFN (pulse-forming network).

SPD—The Stand Power Distribution board breaks out power from the modulator to electronics in the Stand. Its other functions include EMO routing, the Relay Junction Box interface, and power distribution to the remaining modules in the system.

GPD—The Gantry Power Distribution limits current, and controls, monitors, and distributes power to gantry power loads.

RJB—The Relay Junction Box houses interfaces to customer-provided power for treatment room lights, lasers, door switches, and peripherals, and indicators to the machine electrical system. This box is located outside of the machine to ensure when EMO is pressed all machine AC power is removed (room lights will remain on at the RJB).

Note: *Not shown here, the TrueBeam system also includes a customer interface (terminal) board that resides between the SPD and RJB, and allows terminal connections to the machine interface and includes protection circuits.*

ConMan—The Console Power Management routes and switches power from the UPS to the system 24 V power supply based on the site configuration and system operating mode.

The ConMan PCB also has Beam Tuning monitor jacks for monitoring system beam analog signals, for beam optimization and troubleshooting by Varian service personnel.

Communications

The APD, SPD, and GPD PCBs (or “motherboards”) each host a daughterboard to support serial communication. Each daughterboard is a CAN serial communication board that provides control and monitoring from the Stand controller PCB to the power distribution boards over a serial link. Monitoring includes tracking analog signals through an onboard analog-to-digital (A/D) converter. Expansion is available through a serial peripheral interface (SPI) interface

Three board-to-board connectors, with three ID pins, connect the daughterboard to the power distribution PCB. The ID pins allow coding to include location-specific functions (if desired), and enable unique CAN header identification for communications with the Stand PCB. The daughterboards are identical and can be exchanged for troubleshooting.

Components View

Figure 42 on page 147 shows power distribution for the major components and subcomponents in the TrueBeam power distribution system.

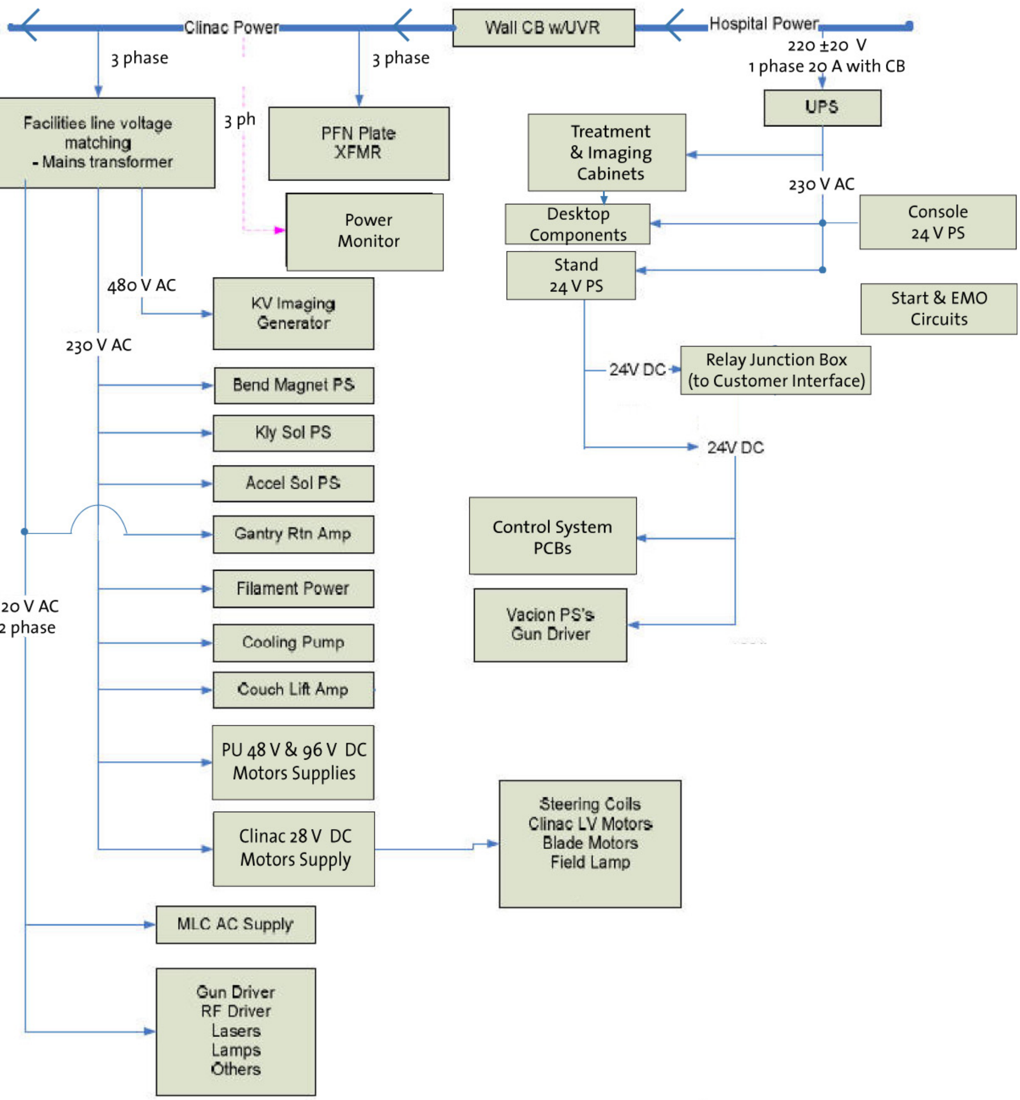


Figure 42 TrueBeam Power Distribution System

Power States

The TrueBeam has five power states. Figure 43 on page 149 shows the actions that trigger transitions between the functional states.

Power Off—TrueBeam is disconnected from the power supply.

Power Saver (Standby)—Power supply for the control system, (24 V DC, and Vacion pumps is enabled, as is the 28 V DC power supply to motion axes. All other power for motion and beam generation system is removed (all AC voltages). This mode does not maintain the TrueBeam in a stable, operating state (temperature is not controlled, and other subsystems such as the bending magnet are off).

On—All power supplies except the high voltage power supply in the modulator are enabled. Operator-controlled motions are possible.

Ready—Beam generation and motions are possible. Treatment can be started. Power is not yet applied to the PFN, but a treatment energy has been selected, and the pretreatment calibration checks (Cal Check) and parameter programming has been completed. The key on the control console is in the Unlocked position.

Treatment or Beam On—This state is the same as the Ready state, except that power is applied to the PFN; the beam is triggered on

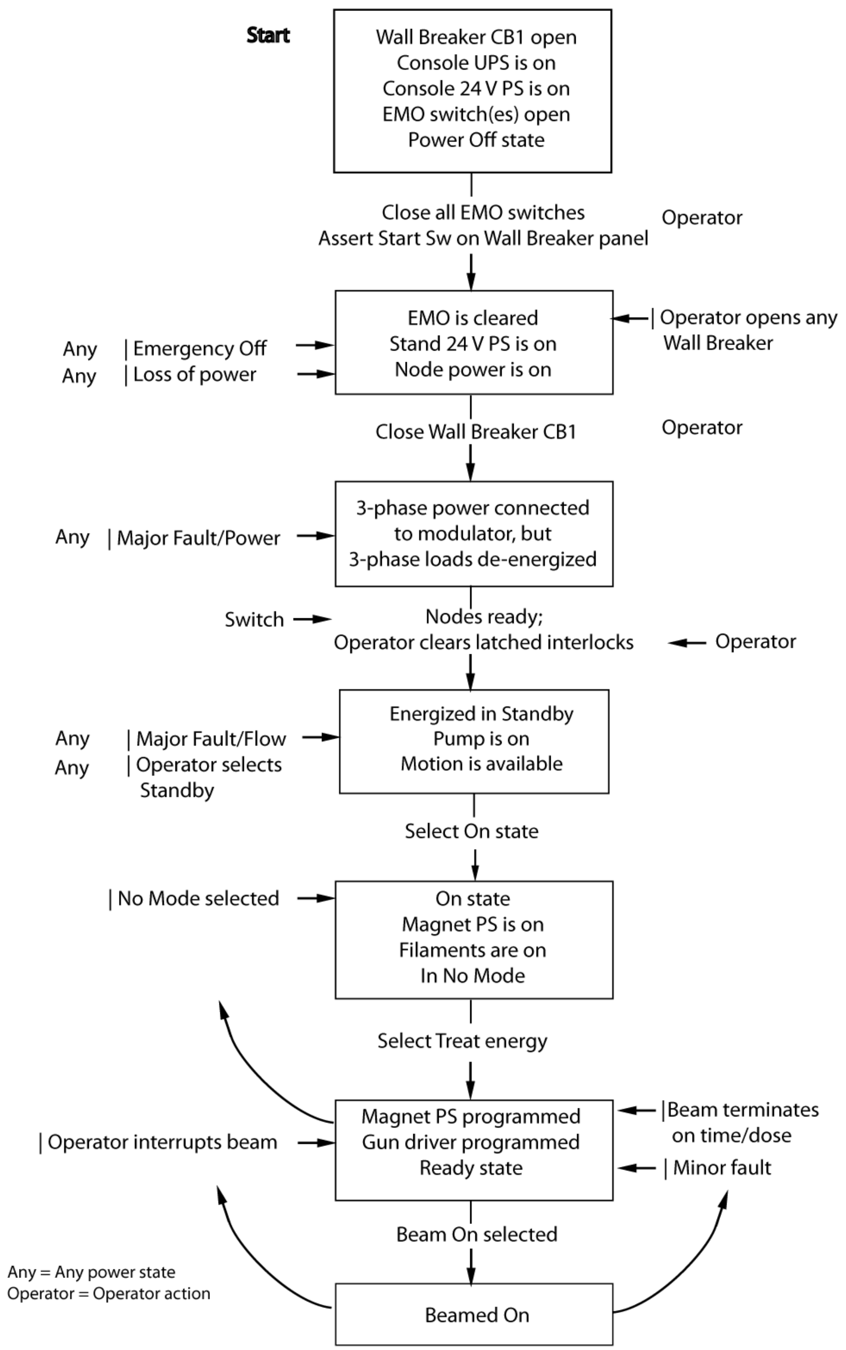


Figure 43 State Resulting from Emergency Off

Console Power

Console Power Distribution includes the Wall Breaker Panel, the console cabinets, the power outlet for the 220 V AC for the cabinets, and the monitor and interface assembly (ConMan).

Console cabinets include the treatment cabinet, which houses the Emergency Stop power supply and is described in this section; and the imaging cabinet.

Wall Breaker Panel

Primary power is provided through the Wall Breaker Panel with the Under Voltage Relay (UVR)—a device that implements the remote trip function. The Wall Breaker Panel power source, located near the control console, connects to the modulator, for power to be transformed and distributed throughout the TrueBeam system. This section describes its components.

CB1 and CB2 circuit breakers—These separate wall circuit breakers provide site power for console room lighting and outlets, treatment room lighting and outlets, and treatment room door actuators. See “Wall Breaker Circuit Breakers” on page 151 for more information.

Remote trip device—This device is either a contactor or an UVR on CB1, to open the three-phase power to the modulator. Asserting the Emergency Off function (by pressing an Emergency Stop button, for example) removes 24 V DC power and opens the source of three-phase power to the modulator.

Start switch—This switch clears an EMO trip. After an EMO trip, such as from a power loss, the Start switch must be asserted before power can be reapplied to the Modulator cabinet. Some sites may restrict the TrueBeam from automatically restarting after a power loss. In such cases, power for the UVR or the contactor coil is supplied from the power input, with a different arrangement of the Start switch and pilot relay (if used).

Emergency Disconnect function components—For dangerous situations not handled by the EMO function—such as a fire in the Console cabinets—the Emergency Disconnect function de-energizes all TrueBeam devices. See “Emergency Disconnect” on page 151 for more information.

Wall Breaker Circuit Breakers

To protect electrical circuits from damage caused by overload or short circuit, the TrueBeam system uses six different circuit breakers to detect a fault condition and immediately discontinue electrical flow. These include a three-phase circuit breaker, with three tripping mechanisms, to interrupt a branching circuit with more than one live conductor when any pole trips; a two-pole circuit breaker, which contains two tripping mechanisms; and four single-pole breakers that connect to console and treatment area power.

CB1—Is a three-phase type circuit breaker that handles 45 kVA power to the modulator cabinet with an under voltage relay.

CB2—This two-pole type circuit breaker carries all the TrueBeam-specific power outputs connected to the 220 V line at 30 A. The CB2 circuit breaker is directly connected to the console area uninterrupted power supply (UPS), which delivers power to all the treatment or imaging computers and XI computers, the Ethernet switch, the 24 volts power supply, the intercom, and other devices.

The console has these additional, single-pole circuit breakers.

CB4—.Is connected for console area lighting and power receptacle outlets in the console area. It has a proper current rating (typically 15 A).

CB5—Supplies power to treatment room lighting, lasers, and power receptacle outlets in the treatment room.

CB6—Supports the console area power outlets.

Emergency Disconnect

The Emergency Disconnect function is a means to de-energize all TrueBeam devices when a dangerous situation exists, such as a fire in the Console cabinets, which is not handled by the EMO function. In such a case, the operator flips the Emergency Disconnect switch, located on the Wall Breaker Panel, to open Wall Breaker CB1, remove input 220 V AC to the UPS, and shut down the output from the UPS.

CAUTION: The Emergency Disconnect switch (or button) shuts off all power to the TrueBeam. Use the switch only during an emergency. Otherwise, use the proper shutdown procedure to turn off power to the TrueBeam. DO NOT test the Emergency Disconnect switch when computers are on. Before testing the switch, shut off all computers to prevent data corruption and damage to the computer operating system.

In Service and Treatment modes, the Emergency Disconnect switch is the only way to shut off all power to the TrueBeam.

Console Cabinets

The console cabinets use one source of single phase, 50 Hz or 60 Hz, power: 200 V to 240 V AC for the input to the console uninterrupted power supply (UPS). This power supply provides power to devices that cannot be interrupted, to preserve treatment data. The UPS is rated for a maximum 3 kVA.

Console Treatment Cabinet

Functions of the treatment cabinet include housing and distributing UPS power, as well as the Emergency Stop power supply.

The treatment cabinet houses a 3 kVA UPS and supplementary battery, sourced by the 220 V AC input, and distributes the UPS output as follows:

- (230 V AC) to the console cabinets, and the Treatment workstation.
- To the Stand to source the Stand 24 V power supply for the nodes and the Stand Ethernet switch.

The treatment cabinet also houses the Emergency Stop (emergency off) 24 V power supply, and:

- Maintains the AC source from the UPS to the Stand 24 V power source when emergency machine off (EMO) circuits are opened and the machine is in Treatment mode. However, hazardous sources are deenergized.
- Disables the AC source from the UPS to the Stand 24 V power source when EMO is opened and the machine is not in Treatment mode.
- Has an input from the Stand Power PCB that can disable the UPS source to the Stand 24 V power source for the nodes.

Monitor and Interface Assembly

The Console Monitor and Interface PCB (ConMan) includes Beam Tuning monitor jacks (BNC) for monitoring system beam analog signals, for beam optimization and troubleshooting by Varian service personnel. The ConMan processes the EMO and other state control signals for power control, and has indicator LEDs to assist with power-up of the TrueBeam system. Status indicators include:

- EMO PS 24 V, which is EMO loop 24 V power supply input.
- 24VL3, which is +24 V from the Stand power supply.
- LIVE24V, which is the EMO 24 V source, protected by a 0.9 A polyfuse.
- EMO GOOD, which indicates a complete EMO system with the EMO relays.
- EMO switch outputs console, Stand, couch, and room closed.

Stand Power

Power distribution is controlled through the controller in the Stand, which houses:

- Stand motors power supply assembly. This includes power to the gantry motor driver, enabled or disabled via 24 V relay control from the Stand controller board.
- Stand power distribution (SPD) PCB.
- Power supplies for beam generation, motion control, and beam focusing.
- Kilovolt generator.
- Klystron and the klystron solenoid focusing coil.
- Motor amplifiers.
- Other nodes.

Stand Motors Power Supply Assembly

Four power supplies comprise the Stand motors power supply, which distributes power to these components:

- Imaging arms (two supplies).
- Low-voltage motors in the steering coils, lamp power, and other components.
- Node power.

Stand Power Distribution PCB

The Stand Power Distribution PCB (SPD PCB) distributes power for DC and AC power outputs in the Stand, gantry, couch, and the customer interface. The Stand power supply runs power directly to the 48 V and 96 V DC power outputs. Within 50 ms after disabling the output, 28 V outputs are reduced to less than 3 V.

The SPD PCB also implements a control and status interface for a CAN daughterboard, mounted on the SPD PCB. This daughterboard is the first node of the two-nodes-serial-link to the Stand. Through this link, the Stand controller PCB controls and monitors most of the power distributed through the SPD PCB.

Through its daughterboard, the SPD PCB controls these relays in the Relay Junction Box (RJB), at 24VDC (100 mA max load):

- Beam Off, Ready, and Beam On relays
- Room lights relay
- Positioning lasers relay
- Backpointer lasers relay.

Figure 44 on page 155 shows an overview of the SPD PCB and its inputs and outputs.

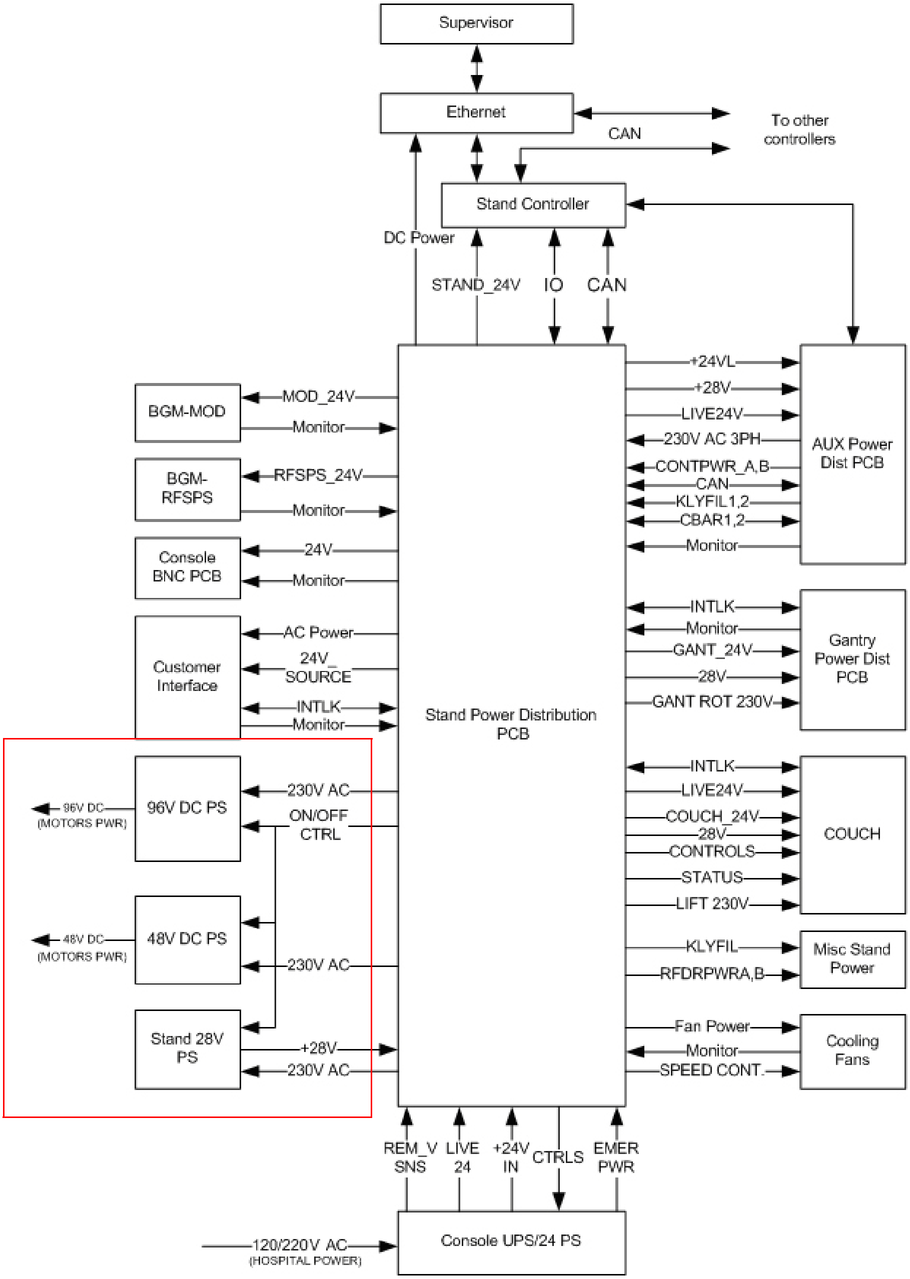


Figure 44 Stand Power Distribution PCB (Motors Power Supply Assembly in Red)

Power Supplies

The Stand power supply runs power directly to the 48 V and 96 V DC power outputs. Within 50 ms after disabling the output, 28 V outputs are reduced to less than 3 V.

There are three 48 V power supplies in the Stand motors power supply assembly (shown in Figure 44 on page 155). Two power supplies are connected in series to provide 96 V. The third power supply provides 48 V. The SPD PCB provides a voltage source (5 mA) to control these three DC power supplies. The optocouplers in the DC power supplies are connected in series so that they can be turned on or off at the same time.

A similar control output is available for the 28 V power supply in the same assembly.

24 V power is sourced and fused to the Stand controller. It includes an electrical fuse (e-fuse) with a mechanical reset switch on the SPD. An e-fuse is an electrical, controlled, high side switch with overcurrent protection.

The following 24 V input power is controlled and monitored for verification:

- Supervisor node; includes a mechanical reset switch on the SPD.
- Gantry rotation motor amplifier to source the control circuitry.
- Gantry rotation brake control.
- Couch lift motor amplifier to source the control circuitry.
- Room interface circuitry.

Stand Controller

The Stand controller monitors the 24 V and 28 V outputs, and the controller turns off the power supply input power if the monitored sources are out of the permissible range.

However, power supplies do not detect an open condition. If the control cable is unplugged, power supplies are turned off.

Gantry Power

The Gantry Power Distribution (GPD) PCB controls and monitors power for gantry subsystems and distributes power for AC and DC power outputs in the gantry.

The GPD is the collection point for analog monitor signals of video bandwidth. The collected signals are passed, through a single cable to the Stand, and then to the console. Maintenance technicians can monitor these signals on an oscilloscope to verify and tune beam parameters.

A daughterboard mounted on the GPD provides communications between the Stand controller and the GPD, controls power sources, monitors and facilitates control of power sources, and monitors performance.

Figure 45 on page 158 shows an overview of GPD and its functions.

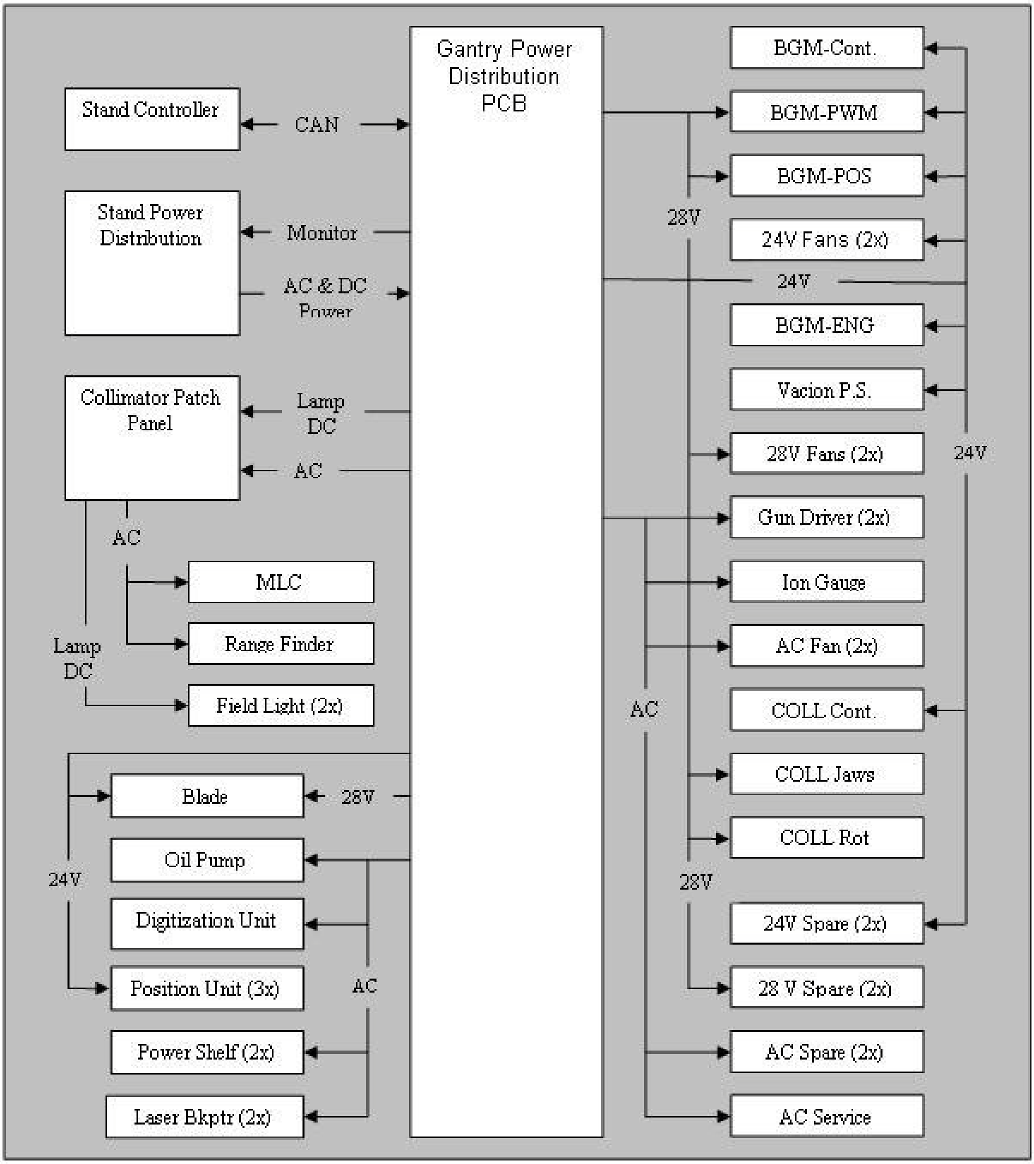


Figure 45 Overview of Gantry Power Distribution

Gantry Power Distribution

The Gantry Power Distribution PCB (GPD PCB) controls, monitors, and provides 120 V AC power, as well as 28 V, 48 V, and 96 V DC power, for gantry components. In addition to the power outputs and components described in the sections that follow, these components include:

- Motors in collimator and beam generation and monitoring-positioning (BGM-POS) axes.
- BGM-pulse width modulation (BGM-PWM) controller.

General AC Power Outputs

The GPD PCB carries out these functions for general AC power outputs:

- Controls and monitors the range finder lamp source (120 V AC) through the GPD PCB daughterboard with current limited to 1.5 A.
- Implements range finder lamp soft-start to prevent a power surge and extend bulb life.
- Sources power to the thermocouple gauge sensor; limited at 1.0 A.
- Controls, through the GPD PCB daughterboard, 120 V AC (1A limit each) power for two, gantry-mounted AC fans.
- Controls and monitors the laser back-pointer and indicator sources (120 V AC, 1.5A maximum current limit) through the GPD PCB daughterboard.

Electron Gun Driver

Gantry power distribution provides 120 V AC power (2A current limit) to the BGM-Electron Gun (EGN) AC input, to power the crowbar, hotdeck, and high-voltage power supply.

Other 120 V AC Power Outputs

Using the GPD PCB daughterboard, gantry power distribution controls and monitors 120 V AC power to the following components:

- AC power shelf connections (2 A each current limit).
- AC input to the MV image detector digitization unit (1.5 A current limit).
- AC input to the MLC head (5 A current limit).
- kV source oil pump (2 A current limit).
- Two spare AC power connections (2 A current limit).
- AC input to a machine service connector (3 A current limit). This power is available any time that 120 V AC power is available at the GPD system (and disabled when the Power Enable loop is open).

Field Lamps

Through the GPD PCB and daughterboard, the Stand controller controls, monitors, and selects the DC supply voltage to one of two field lamps.

The GPD field lamp circuits include lamp voltage and current monitoring, through the GPD PCB daughterboard.

GPD implements a DC/DC power source with soft-start to generate 5.65 V nominal (±2%) power, maximum current 4 A, for the field lamp. Full output is reached in 3 to 5 seconds.

Gantry Fans

The GPD supplies general gantry cooling fans with 120 V AC, and supplies fans that specifically cool the console cabinets with 24 V DC.

The GPD DC fan control includes a PWM output for speed control that is filtered providing a DC control voltage of 0 to 15 V.

Through the GPD daughterboard, the Stand controller monitors the status of both gantry cooling fans.

GPD Daughterboard

Gantry components described in this section are controlled and monitored by the GPD, through the GPD PCB daughterboard.

Collimators and BGM Controllers

Using the GPD PCB daughterboard, the gantry controls and monitors 28 V DC power (7 A minimum current limit) to the collimation rotation, collimator jaws, and to the BGM-POS and BGM-PWM controllers. By default, the power is off to these components.

Blade Motors and Driver Power Spares

The GPD PCB daughterboard controls and monitors 28 V DC power to the kV blade controller and to two 28 V DC spare outputs (all with 4 A minimum current limit). By default, power is off.

Printed Circuit Board Control Power

The GPD PCB daughterboard provides software-controlled 24 V DC power (4 A minimum limit) to all control boards in the gantry; by default, power is on. These control boards include:

- BGM controller
- Collimator controller
- BGM-POS controller
- BGM-PWM controller
- BGM-EGN controller
- PU1 (MV detector arm) controller
- PU2 (kilovoltage detector) controller
- PU3 (kilovoltage source) controller
- Blade control board
- Control power spares (2).

Control Cabinet Fans

Gantry power distribution provides 24 V DC power to the cooling fans in the gantry PCB enclosure. Total current is limited to 3 A.

Vacion Pump Power Supply

The GPD PCB daughterboard provides software-controlled 24 V DC power (4 A minimum current limit) to the vacion power supply (software default is on). The vacion pump can be run with the control system disabled.

Vacion power is removed when EMO is open (regardless of the state of control 24 V DC power). Software can actively disable the vacion during vacion overcurrent fault conditions.

Modulator Power

The modulator generates high-voltage power supply pulses for the klystron. Pulse power is routed to the klystron pulse transformer tank through a set of high-voltage coaxial cables. The output of the step-up pulse transformer is applied directly to the cathode of the klystron.

Primary Power Distribution

The primary power distribution assembly for the modulator (Figure 46 on page 163) is located in the Modulator cabinet. This assembly includes a soft-start circuit to limit in-rush current to the Mains transformer power. The assembly controls and monitors these components:

- Primary power distribution assembly, including related subassemblies; the Modulator Auxiliary Power Distribution (referred to as the APD) PCB, assemblies, and switching-related modulator power components.
- The PFN (pulse-forming network) assembly, which generates the high-power pulse for the klystron in the Stand.

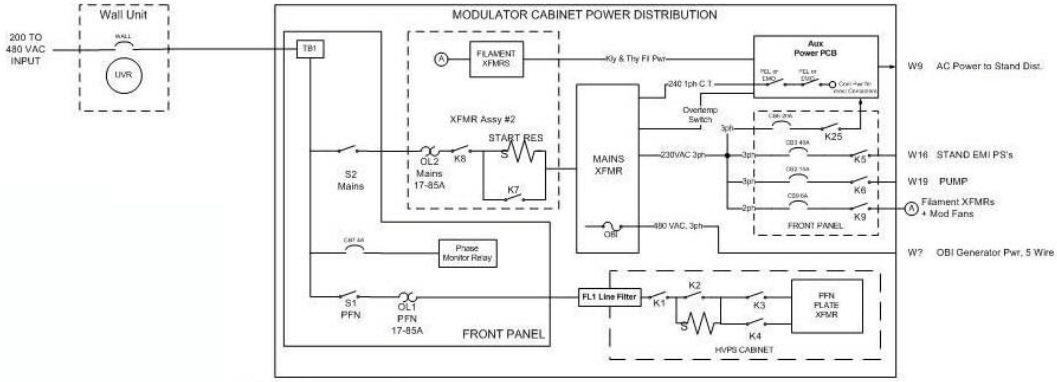


Figure 46 Primary Power Distribution

Modulator APD

The APD PCB (Figure 47) is the main interface between the Stand control system and the modulator. It controls, monitors, and provides power for the Modulator Auxiliary components described in this section.

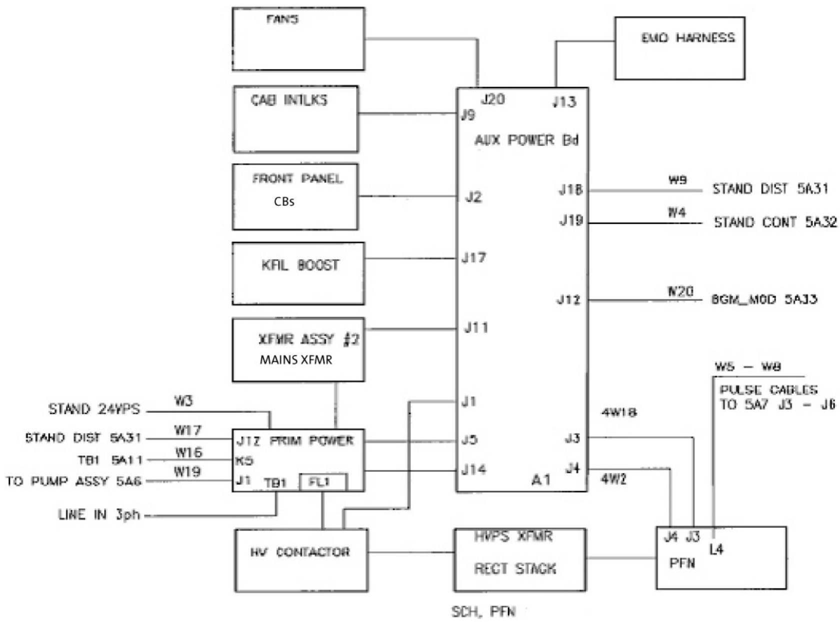


Figure 47 Modulator Auxiliary Power Distribution (APD) PCB

The APD PCB supplies the following power:

- 120 Vac power, 3 A (maximum, protected by a circuit breaker); source for contactor coil power outputs.
- 120/240 Vac power, 10 A (maximum, protected by a circuit breaker); control power source to the appropriate Stand and gantry power outputs.
- 120 Vac power, 2 A (maximum), for modulator-mounted AC cooling fans near the modulator Mains transformer.
- 24 V power to the daughterboard on APD PCB and for contactor position sensing.
- 28 V DC power, (5 A maximum) for DC fans for primary power cooling. The APD PCB monitors the status signal for the DC fans. Its power source is 24 V DC from the SPD system.

The APD PCB includes circuit breakers for the water pump, motors, Stand power supply outputs, klystron filaments, and line voltage monitor.

Emergency Off

The APD PCB contains primary components of the Emergency Machine Off (EMO) circuitry and provides circuitry for the Modulator cabinet EMO switch.

This PCB receives and responds to signals from the EMO loop and from the Beam Enable loop (BEL). The EMO safety loop disables both the UVR and first-level contactors when EMO is open. Latching EMO relays prevents the TrueBeam from being re-energized when the EMO switch is deactivated.

Start

APD processes the Start function, which turns on power to the TrueBeam.

There are two Start switches: one on the Modulator front panel assembly, the other on the main breaker panel. Manually pressing a Start switch powers up the TrueBeam system, and, if an Emergency Stop button has been pressed and then reset, clears the EMO fault interlock.

On manual startup, the UVR 24V DC circuit energizes the UVR (or external contactor).

AC Supply Voltages

Through its daughterboard, APD monitors the presence of two phases of control power that originate in the Mains transformer in the primary power distribution assembly.

The APD monitors the presence of key AC supply voltages, including motors power (three-phase, 230 V AC) to keep the Motion Enable loop (MEL) closed. When motors power is interrupted (one phase or more), the APD opens the MEL safety loop within 10 ms to initiate a fast ramp-down stop of all motions.

The APD PCB includes circuit breakers for the line voltage and motors.

Mains Transformer

The APD controls the Mains transformer and provides power for a disconnect switch. The APD performs these actions:

- When a line condition exists, de-energizes all AC power outputs.
- When either EMO or the Power Enable loop (PEL) is open, de-energizes the Mains transformer power.

  In-rush current to the mains transformer power is limited by a soft-start circuit in the primary power distribution assembly.
- Through a daughterboard output, disables the Mains transformer contactor control to prevent relay cycling during PEL control testing.

Beam On

Beam On control is activated from the BGM controller (BGM-CONT) through the modulator controller (BGM-MOD) to apply AC power to the pulse-forming network (PFN) in the modulator. To energize the PFN, the APD converts the low-level control signals from the BGM to higher levels to pull in contactors in the primary power distribution assembly. The APD also sends out monitor signals, through its daughterboard, to the Stand controller to verify that the control system is properly operating.

Stand Water Pump and Power Supplies

The APD PCB controls and monitors the Stand water pump and power supplies, and has circuit breakers for these components.

Through the APD daughterboard, the Stand controller controls and monitors the pump contactor in the primary power distribution assembly. When the PEL is open, the water pump 230 V AC is disabled.

Through the APD and its connection to a contactor in the primary power assembly, the Stand controller controls and monitors a separate connection to the Stand power supplies. The APD connects to three contactors:

- The Stand contactor controls the 230V AC source for the magnet power supplies in the Stand.
- The Filaments contactor uses two ferro-resonant regulating transformers to provide filament power to the main and D-Qing thyratrons in the PFN and to the klystron.
- The Motors contactor is a separate circuit on the APD that monitors actual contactor output (three-phase motors power) to open the MEL and initiate a controlled stop of moving axes on loss of motors power. This circuit also provides input to the APD daughterboard to indicate status.

Klystron Filaments and Overcurrent Protection

The APD PCB monitors the klystron and PFN thyratron filaments and performs these functions:

- To detect an open or shorted klystron filament, the APD system uses interlocks for the filament's secondary (output) voltage and current. The interlock circuit verifies that current is being drawn and that voltage above 200V AC is available.
- To provide overcurrent protection for the PFN thyratron filaments and to control power loads, the APD has directly mounted circuit breakers.

Interlocks

The power distribution system has hardware interlocks to prevent simultaneous application of power for the modulator Mode A and Mode B states. The APD system:

- Interlocks the KHV1 and KHV2 Beam On relays to detect welded contacts on contactor K1 in the primary power distribution assembly, which feeds the PFN plate transformer.
- Selects PFN modulator mode, high (B) or low (A), at the BGM-MOD controller, through interlocked control relays. These relays are named Mode B (high voltage at low pulse-repetition rate) and Mode A (low voltage at high repetition rate); the variance maintains the maximum average power at 5 kW and allows operating with a range of guide energy from very low to very high.
- Monitors the AC door interlock, through the daughterboard.

Pulse-Forming Network Assembly

The pulse-forming network assembly creates extremely high power pulses to drive the klystron, which is the RF source for the accelerator guide. It uses pulses of about 8 megawatts (MW) to generate 5 MW RF peak pulses from the klystron, to drive the accelerator guide.

The APD PCB provides power to a disconnect switch for the pulse-forming network (PFN).

Power to the high-voltage power supply transformer (HVPS) is disabled when:

- Either EMO or PEL is open.
- In hardware, any Modulator cabinet door interlocks are open.
- BEL is open.

Power can be enabled under software control from the BGM-MOD.

Servicing the Power System

Most servicing of the TrueBeam Power Distribution System will be performed by Varian Service personnel. However, the Service application allows monitoring power and performing basic maintenance, including periodically testing circuits.

To monitor power in the Service application:

1. Start the Service application. For instructions, see “Starting Service” on page 47.
2. On the Service screen, click the **Power** tab.
3. Click a subtab button to display its controls.

Control and Status indicators display whether node controls are activated and whether power is on at the nodes. That is, control indicators show that power is turned on (green) or off (gray) to the component or circuit. Status indicators show that the component is connected and receiving power (green) or not activated or not receiving power (gray). A flashing, red indicator means that a node is not installed or disconnected.

Gantry—Displays power distribution to the various GPD PCB components, including 24 V power to the beam generation and monitoring system and its components, and imaging system components. Power also is monitored for gantry fans, axis motion of jaws and collimator rotation, field lamps, motor voltages, spare DC and AC power, and other gantry power, including to the digitization unit, laser backpointer, MLC, range finder, oil pump, and accent lights.

Stand—Displays power distribution to the various SPD PCB components. This display enables you to monitor power to Stand PCB components, including nodes, axis motion, lift and gantry power, fans; relays for the MV and kV beam, lights, and the room laser as well as for door interlocks and customer-supplied devices; and emergency off switches and circuitry.

Mod Aux—Displays power distribution to the various APD PCB components and shows the status of the Mains Transformers and PFN interlock strings.

See Appendix A, “Service Screens,” for more information on these screens.

Chapter 11 Cooling System

The TrueBeam system is cooled by water, air, and oil. The cooling system performs these functions:

- Maintains the operation of RF components at a constant temperature.
- Keeps components operating at temperatures well below critical to prevent damage from overheating.
- Keeps heat-sensitive electronics operating in a safe and efficient manner well below critical temperatures.
- Monitors flow rates, temperatures, pressures, and water level to detect problems.
- Responds to problems with warnings and subsequent actions.
- Includes a water pump capable of supplying adequate flow rates regardless of site voltage and frequency.

The cooling system is composed of water-cooling and air-cooling systems. The cooling system control is located in the Stand, the stationary vertical post at the back of the TrueBeam machine. The Stand controller monitors and controls all components of the water-cooling system in the Stand. The Beam Generation and Monitoring (BGM) subsystem monitors and controls all water-cooling system components in the gantry.

Water Cooling

The TrueBeam plumbing system includes water-cooling components, to prevent damage in case of overheating in the system.

Water to cool these components flows from the facility source (such as a city water supply) into the TrueBeam machine—specifically, to the Stand, which uses a pump to move water through the system. The TrueBeam system extracts heat from power-dissipating components; the water then is pumped to a heat exchanger to cool the components to 40° C. Water is then stored in a reservoir where it is pressurized by a pump.

Added pressure from the water pump increases the flow-rate (in gallons per minute) of the water as it flows through components. The pump runs at constant speed to provide a fixed flow-rate and pressure and adequate flow to each component.

The includes sensors in the following locations:

- Three temperature and one flow sensor in the pump stand.
- Six flow sensors in the gantry.
- Two flow sensors in the Stand.

Sensors in the system measure water flow-rates, temperature, and pump speed for cooling components. The Stand controller monitors these sensors and processes their data to regulate the cooling system.

Cooling system water and facility water never mix. The facility plumbing system discharges heated facility water to a drain or recirculating system when the facility water valve is open; when a chiller is in use, the facility water valve is closed.

The cooling system is set to 40° C. The water cooling system requires distilled water mixed with a copper-corrosion inhibitor and a biocide, which are in an additive kit supplied with the TrueBeam.

Water Pump Subsystem

A key component of the water-cooling system is the water pump subsystem, housed in the Stand. The Stand controller sets the water pump speed and controls power to the water pump. Figure 48 on page 171 shows the Service > Cooling tab with an illustration of the pump components.

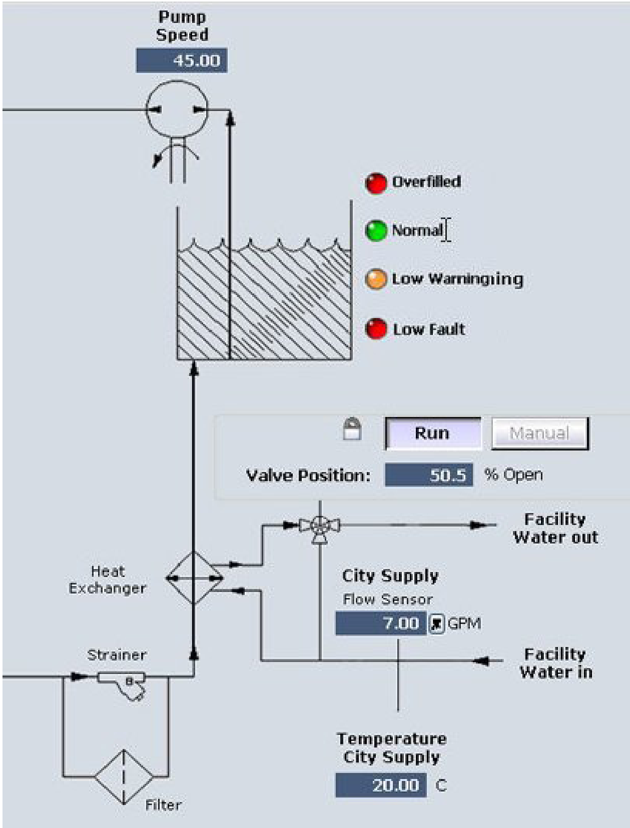


Figure 48 Cooling Screen—Pump Components

The water-pump subsystem consists of the following components:

Stand Controller—Checks sensors that monitor the rate of water flowing through the TrueBeam system, the temperature of the water as it circulates through the TrueBeam, and the water level in the reservoir. The controller processes sensor data and regulates the three-way, facility water valve; the water pump; and the power of fans in the Stand, gantry, and modulator.

Figure 49 illustrates the operation of the cooling system controller, which is located in the Stand controller printed circuit board.

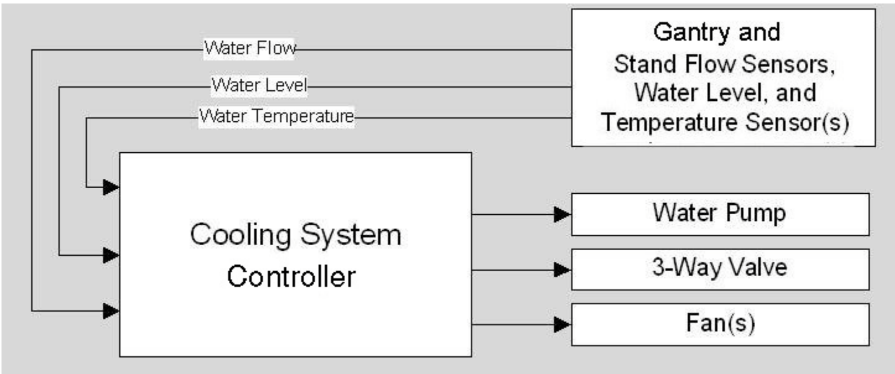


Figure 49 Cooling System Controller

Facility Water Control Valve—This oscillating valve controls the rate of facility water flowing through the TrueBeam.

Strainer—Removes large debris such as teflon tape, solder, goo from algae buildup, deteriorated rubber from inside of hoses, and pipe sealant.

Filter—Removes much smaller particles in the water.

Pump—Circulates water throughout various Stand and gantry components. An AC motor in the Stand drives the centrifugal pump, which is controlled by the Stand controller. Pump motor speeds are low (51.7 hertz, 2,973 revolutions per minute) and high (56.7 Hz, 3,260 RPM). The pump has three operational modes: on, off, and Power Saver, which is used to turn off the pump for long periods, such as for weekends and nights.

Heat Exchanger—Is a compact heat exchanger in the Stand that allows water from the TrueBeam and facility water, at different temperatures, to flow past each other and exchange heat. The heat exchanger expels the heat from the TrueBeam system and the heat from the X-ray tube; the heated water then flows to the water pump. Cooling system water and facility water never mix.

Reservoir—Contains water after it is cooled by the heat exchanger.

Monitoring the Water Cooling System

Sensors measure water flow-rates, water temperature, and water pump speed for cooling system components. Service mode software enables you to view measurements.

The water flow-rate in the TrueBeam is controlled by the pump speed. Stand water flow-rates are monitored by the Stand controller. The flow-rate of facility water to the heat exchanger is proportional to the water temperature in the TrueBeam.

The Stand controller monitors the TrueBeam for overflow, low, and critically low water levels in the TrueBeam water reservoir. Overflow in the reservoir typically is caused by overfilling, but also is possible if the pump is turned off with the gantry in the upright position, and very rarely, if facility water gets into the system water.

Devices that you can use to monitor the water cooling system include a sight-tube on the owner site that checks water level and an analog temperature gauge.

Pump Motor Drive

The AC-motor drive in the water pump is controlled by the TrueBeam Stand controller. There are three operational modes when the motor is energized: On, Stopped, and Power Saver. When the motor is deengergized, there is only Off mode.

Pump power is three-phase 230 V, 50 or 60 Hz or three-phase.

Expected Flow and Pressure

Expected water pump pressure is 44 to 48 psi. You can view the pressure on the pump stand gauge.

Table 9 shows the range of measured water flow rates at full speed, in gallons per minute. Readings outside the range of these low and high rates will trigger faults.

Table 9 Water Flow Rates

Component	Flow Rate Low – High
Klystron	4.5 – 9.0
Klystron solenoid / circulator / waterload	2.7 – 6.0
Guide	3.0 – 6.0
Energy switch/ Bend magnet	0.26 – 1.0
Guide solenoid - long	1.0 – 2.5
Guide solenoid - short	1.1 – 2.5
Electron collimator/ orbit chamber	1.25 – 2.2
Target	0.8 – 1.3

Air Cooling

The TrueBeam is cooled by fans that circulate air inside the gantry, Stand, modulator, medicine cabinet, and miscellaneous power supplies. The air cooling system extracts heat from the TrueBeam and expels the hot air into the treatment room.

The air cooling system cools heat-sensitive components within an acceptable temperature range under all operating conditions at altitudes up to 3000 meters (9850 feet).

Heat-sensitive components in the Stand include the:

- Water pump motor.
- Bend magnet power supply.
- Guide solenoid power supply.
- Klystron solenoid power supply.
- Various printed circuit boards.

Heat-sensitive components in the gantry include control cabinet boards and MLC assembly boards.

While the TrueBeam is in Power Saver mode, all fans operate at manufacturer-set high speed.

The Stand controls the power of mounted cooling fans in the Stand, gantry, and modulator.

Careful positioning of intakes and exhausts determine air flow paths. Heat-sensitive components are first exposed to incoming air. Then as the air inside the system heats, the air rises and is blown out through the top or the upper, back portion of the system.

At the Stand, an intake with filter is positioned on the backside, above the pulse tank, and two exhausts are at the top of the Stand. Fans at the exhausts blow air upwards.

At the gantry, intakes are positioned around the collimator and near TrueBeam control boards that reside near the gantry counterweight. Looking at the gantry when the counterweight is positioned down, the exhausts are located near the Stand and gantry interface on top of the gantry. Exhausts are placed in areas not visible from the couch.

Troubleshooting

Service mode diagnostic tools, such as fault interlocks and meter readouts, enable you to monitor the cooling system. You must investigate and resolve air flow problems because they can cause components to overheat and permanently damage the TrueBeam.

For example, a temperature sensor detects that the air temperature is low. The control system acknowledges and signals the problem. Alerted by the signal, you check and replace fans, as necessary. In this example, the problem could happen in all operational modes.

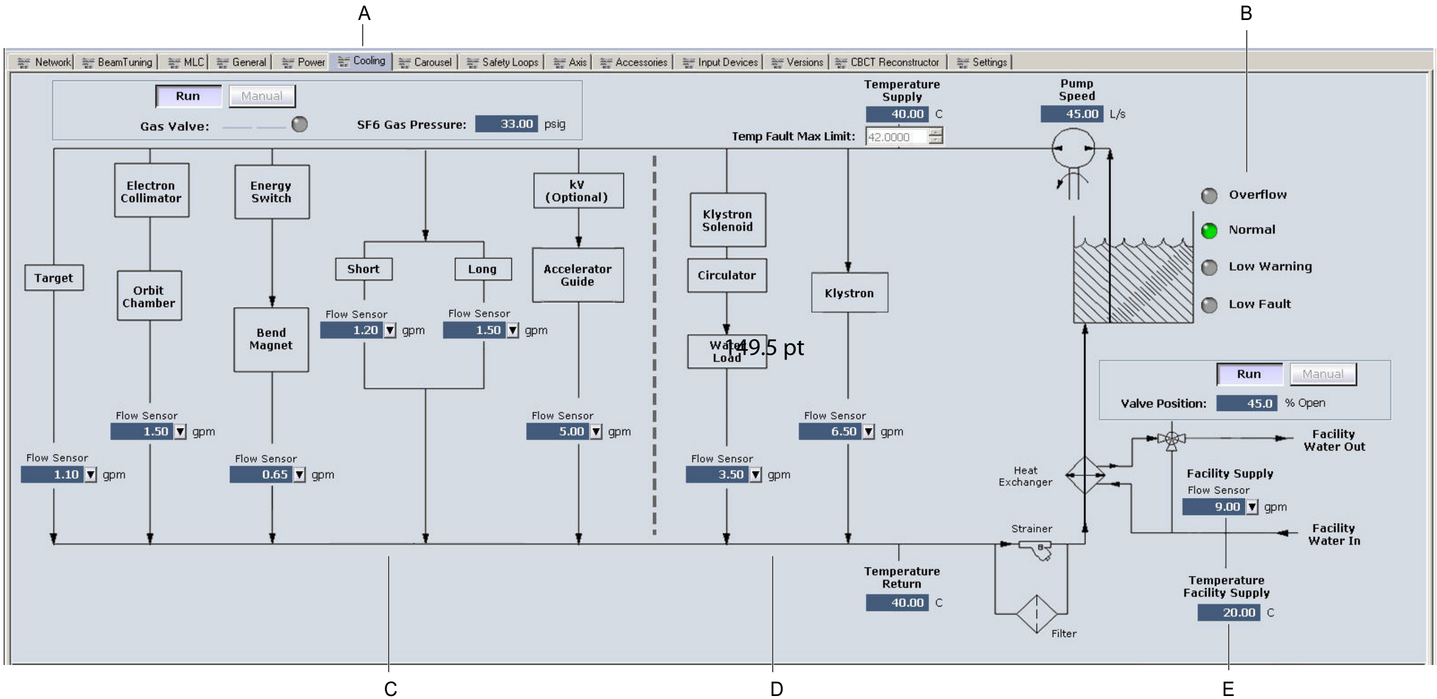
To access the monitoring tools for the cooling system:

1. Start the Service application. For instructions, see "Starting Service" on page 47.
2. Click the Cooling tab. The Service > Cooling screen appears with a schematic of the cooling system; the gantry system appears on the left and the Stand system on the right (Figure 50 on page 177).

Fault Interlocks

Warnings and fault interlocks are generated when the water temperature in the TrueBeam is not within working limits or when a flow-rate in the TrueBeam is too high or too low. Various conditions can make cooling system operations unsafe, including hardware failure, clogged flow sensors, or a water pump relay that is open when it should be closed.

At the top of the Service screen, indicator-buttons, when clicked, enable you to view fault interlocks in the TrueBeam. Clicking the COOL indicator-button opens the COOL Fault Interlock Details window. That window has a series of columns with information to help you diagnose problems in the cooling system.



A Service Cooling tab.
B Indicators (water level)
C Gantry cooling system
D Stand cooling system
E Meter readout (facility supply temperature)

Figure 50 Service Application–Cooling System

Cooling Tab

Clicking the Cooling tab in the bottom half of the Service screen displays a diagram of the cooling system. The diagram uses arrows to show the water flowing through the gantry and Stand, and displays water temperature, water pump speed, and the level of water in the reservoir.

Water Flow

Flow sensors show the rate of water, in gallons per minute, flowing through gantry and Stand components.

Cooling system water flows through these gantry components:

- Target.
- Electron collimator and orbit chamber, which directs a beam toward the collimator.
- Energy switch and bend magnet
- Short and long solenoid guides, which focus a beam as it accelerates.
- kV (Optional) and accelerator guide, which sends microwave energy to the accelerator.

Water flows through these Stand components:

- Klystron solenoid.
- Circulator.
- Water load, which absorbs energy that returns from the waveguide.
- Klystron.

Water Temperature

Three sensors in the Stand monitor water temperature, which are then displayed in the Cooling tab, in various meter readouts for water supply temperatures; all temperatures are in Celsius. If the water temperature reaches 45° for more than 5 minutes, a minor fault will prevent the machine from beaming on. If the water temperature overheats to 48°, a major fault cause power to be shut down and de-energize some heat-producing components such as the klystron and accelerator solenoids.

Temperature displays include:

- Temperature Supply. Cold water flowing from the reservoir into the TrueBeam, with the maximum limit for a temperature fault.
- Temperature Return. Returned (hot) system water flowing back into the reservoir.
- Temperature Facility Supply. Facility water circulating through the Facility Supply system.

Pump Speed

The Stand controller sets the water pump speed and controls power to the water pump. The Pump Speed reading shows a preprogrammed pump speed at the preset speeds of On, Off, and Power Saver.

Water Reservoir Indicators

Status indicators show the reservoir water level. For guidance on filling and draining the reservoir, contact Varian Service.

Overflow—Is a flashing, red light that indicates too much water in the reservoir. Water must be drained from the reservoir. City water may be leaking in machine water circuit through the Heat Exchanger.

Normal—Is a green light that indicates reservoir level is normal.

Low Warning—Is an orange light indicates the water level in the reservoir is low because of leaks or evaporation. The reservoir must be filled to the appropriate level, which is 10 gallons.

Low Fault—When lit, signals a critically low water level. The TrueBeam is set to Power Saver mode as a safety measure to prevent the pump from running dry.

Valve Position and Facility Water Controls

These controls in the lower right of the Cooling tab show facility water status.

Valve Position—Can be operated only by Varian Service personnel.

Facility Water Out—Indicates facility water flowing from the heat exchanger to the city.

Facility Water In—Indicates facility water flowing into the heat exchanger.

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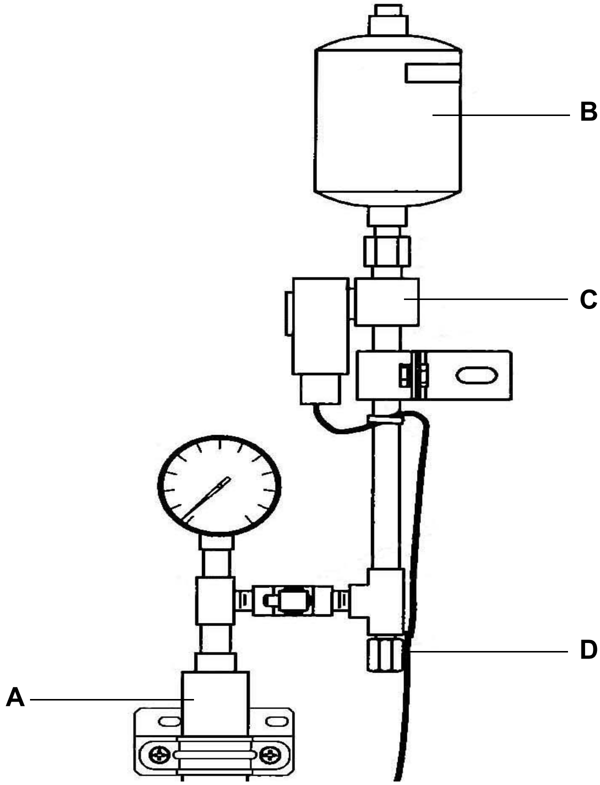
Chapter 12 SF_6 Gas System

The accelerator waveguide in the Stand is filled with pressurized, dielectric sulfur hexafluoride (SF_6) gas. SF_6 gas is an electrical insulator that is used to protect waveguide components when arcing occurs.

The SF6 gas system (Figure 51) consists of a filter, a pressure sensor, and relief and solenoid valves.



A Pressure sensor. **B** Filter. **C** Solenoid valve. **D** Pressure relief valve.

Figure 51 SF_6 Gas System

SF_6 Gas Control System

SF_6 gas pressure is controlled by the Stand controller (Figure 52), which can open and close the SF_6 gas valve as required to maintain SF_6 pressure.

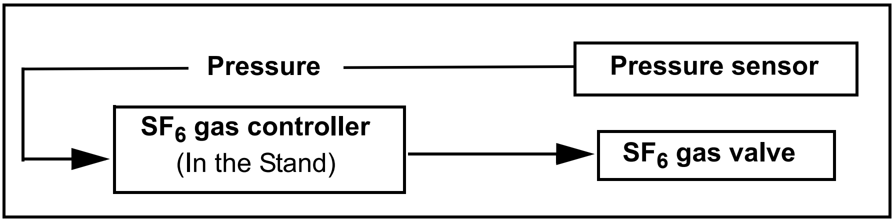


Figure 52 SF_6 Gas Controller

The Stand controller also monitors the SF_6 gas tank pressure to ensure that the tank has sufficient pressure to recharge the waveguide. If the system is not able to add pressure, the controller sends an onscreen alert, which is shown in the Service Cooling tab.

The Stand controller receives gas pressure data from the pressure sensor (0 to 5 V output, 0 to 60 psi), which indicates pressure in the SF_6 gas system. When gas pressure drops critically, the controller opens the SF_6 gas valve automatically to fill the system.

Auto-fill works when tank regulator and shutoff valves are open. The valves are sometimes left closed for safety reasons and, in case of a gas leak, to prevent SF_6 gas in the tank from being wasted.

During auto-fill, SF_6 gas pressure can rise above the upper limit of 33.5 pound-force per square inch gauge (psig). If pressure rises above 33.5 psig, the Stand controller closes the SF_6 gas valve to maintain pressure. If SF_6 pressure drops below 30.5 psig, the controller opens the valve to increase pressure.

The Stand controller controls the SF_6 gas valve when the TrueBeam is in the Power Saver and On modes, but does not control the valve during Beam On. In all modes, a warning is generated if the SF_6 gas pressure drops at a faster rate than 1.8 psig in 24 hours.

The Stand controller provides 24 volts DC power, protected from overload, to the SF_6 gas valve.

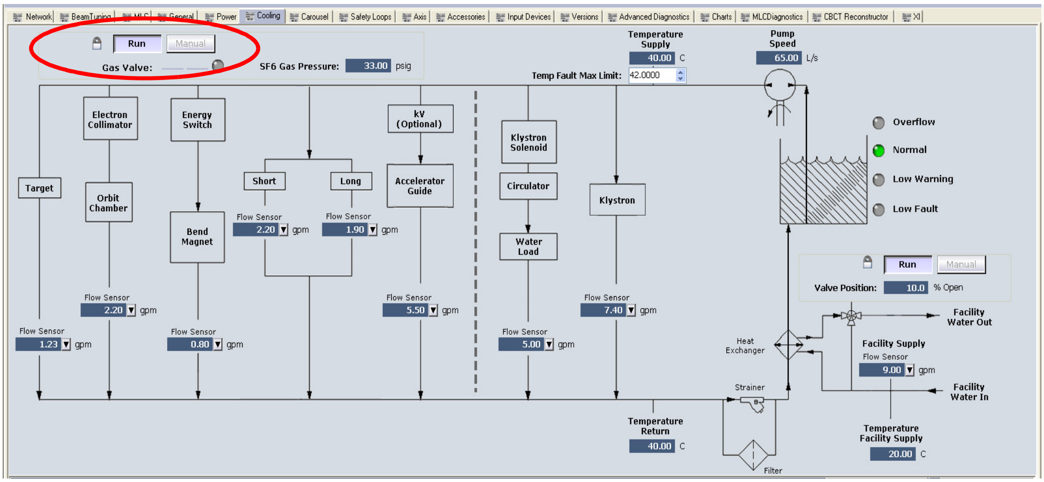
The solenoid valve opens for refilling the SF_6 gas system.

Servicing the SF_6 Gas System

The Cooling tab in the Service screen includes the SF_6 gas valve control. The valve and pressure regulators can be used and adjusted only by Varian Service personnel.

To access monitoring tools for the SF_6 gas system:

1. Start the Service application. For instructions, see "Starting Service" on page 47.
2. Click the **Cooling** tab. The Service > Cooling screen appears with a schematic of the cooling system.



3. Click the **Run** button. When this mode is selected, the TrueBeam controls the SF_6 gas valve.

To adjust the pressure:

1. Click the **Lock** button to unlock the valve. This button is a toggle.
2. Click **Manual** to open the SF_6 gas valve and allow adjusting the physical regulator on the tank.
3. Adjust the pressure as needed. Avoid overpressurizing.

   Valve testing must be within safe limits (34.0 to 28.0 psig when the TrueBeam is on, 35.0 to 28.0 psig, when the TrueBeam is in Power Saver mode).

Troubleshooting

Faults and warnings provide useful diagnostic information to help you troubleshoot problems in the SF_6 gas system.

CAUTION: Sulfur hexafluoride is stored in the Stand as a liquid under pressure. SF_6 gas can cause rapid suffocation as well as frostbite, dizziness, and drowsiness.

The Stand controller generates a warning or fault if pressure sensor readings vary in Power Saver and On modes from set threshold values. The Stand controller also periodically checks the pressure reading to measure the leak rate. The controller issues a warning if the SF_6 leak rate exceeds the threshold, and issues a fault if gas pressure cannot be recharged to the acceptable range within a defined time.

Faults

SF_6 gas pressure in the waveguide is measured at a rate of 1Hz, or faster, and is regulated to a manufacturing configurable limit of 35.0 and 28.0 psig (±1 psig). The Stand controller issues a low fault if SF_6 gas pressure in the waveguide is outside the specified threshold.

Warnings

The Stand controller generates warnings in these cases:

- SF_6 gas pressure is within the range of 28.0 to 31.0 psig when the TrueBeam is on or in Power Saver mode.
- The SF_6 gas system fails to repressurize within 30 seconds after the SF_6 gas valve has been opened.

The controller also generates warnings if SF_6 gas pressure drops more than 28.0 psig or faster than 1.8 psig, as follows:

- Faster than 1.8 psig in Power Saver mode after 6 hours, in a 24-hour period sampled every 2 hours.
- In Power Saver mode, from 35.0 psig to 28.0 psig faster than 1.8 psig during 24 hours.
- In all modes during a 24-hour period, if gas pressure drops to 1 psig from 3 psig, and to 1 psig from 3 psig faster than 1.8 psig.

Generated warning messages may state that the gas pressure:

- In the waveguide is lower than the specified threshold.
- Is dropping faster than expected.
- Could not be recharged to acceptable range within the defined time.

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Chapter 13 Vacuum System

The TrueBeam requires an ultra-high vacuum system to generate and transmit treatment beams, and to ensure proper, stable, and consistent beam operation. Three VacIon (vacion) pumps comprise the system.

Pumps

The TrueBeam vacuum system consists of vacion pumps in the Stand and gantry, as follows:

- Accelerator, pumping at 20 liters per second (20 L/s), in the gantry.
- Electron gun, pumping at 2 L/s, in the gantry.

  The electron gun pump is used only when TrueBeam systems are exposed to atmospheric pressure (“open to air”), such as when an electron gun is replaced.
- Klystron, pumping at 2 L/s, in the Stand.

Vacion pumps are enabled when the TrueBeam is in one of two modes, Power Saver or On mode, unless the main power supply has a voltage fault. Controllers enable or disable power to pumps.

Vacion Power Supplies

The power supply for the vacuum system is the vacion subsystem (BGM-VAC) in the BGM (see Figure 53):

- Power to the accelerator and electron gun is supplied by the BGM-VAC subnode, which is directly connected to the BGM-EGN subnode located in the gantry. BGM-EGN controls and monitors the vacion power supplies for the accelerator and electron gun. (See Figure 53):
- Power to the klystron vacion pump voltage is controlled and monitored by the BGM-MOD PCB located in the Stand. The PCB operates similarly to the BGM-VAC power supply in the gantry.

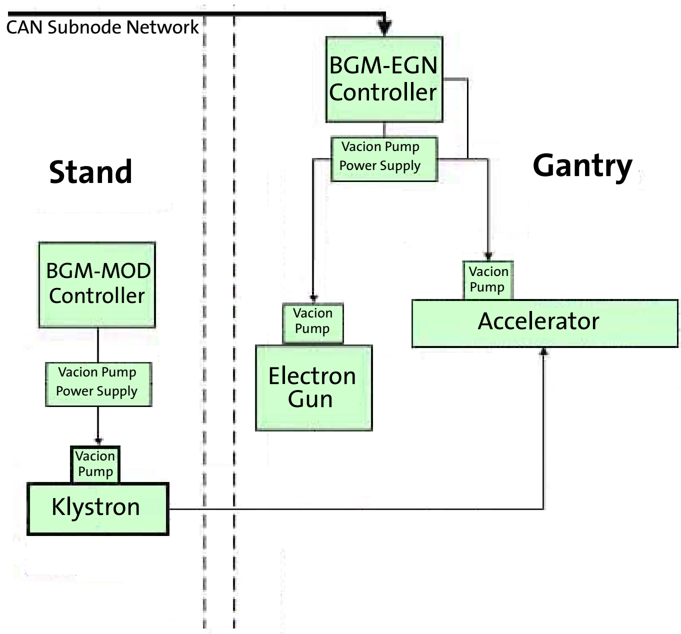

Figure 53 Vacuum System Pump and Power Supplies

The BGM-VAC power supply in the gantry:

- Generates -5 kilovolts (kV) power to the accelerator vacion pump and, if there is an electron gun vacion pump, 3.3 kV power to that pump.
- Protects the vacion pump -5V and 3.3 kV power supplies from overloading.
- Samples and buffers high-voltage currents and voltages.

The BGM-VAC power supply includes two printed circuit boards (PCB), and operates under two conditions:

- System, during which +24 volts (24V) system power is supplied. Control and monitoring are provided either by the BGM-VAC, or by the BGM-EGN and BGM-MOD subnodes (see Figure 53).
- Stand-alone, during which +24V power is supplied externally. Control and monitoring are provided by BGM-VAC.

  In the unlikely event that voltage is 20% higher than the nominal 3.3 kV or -5 kV voltage and cannot be fixed by disabling and re-enabling the power supply, the BGM-EGN or BGM-MOD turns off the vacion pump high voltage.

When the TrueBeam is powered on, the default setting for BGM-VAC power supplies is On.

The 24V power supplies for the accelerator and electron gun vacion pumps have overcurrent protection on the gantry power distribution board.

The klystron vacion 24V power supply has overcurrent protection on the Stand power distribution board.

Monitoring the Vacuum System

Software protects the vacuum system and maintains its stability with sensors that monitor vacuum levels and enable controllers to set alarms.

The primary vacuum sensor is the thermocouple gauge, which is located in the gantry and monitors the vacuum level. The thermocouple gauge provides rough vacuum monitoring when the system is at atmospheric pressure. This gauge has a 1 amp fuse power source, supplied with 125 V AC power from the gantry power distribution board.

Atmospheric pressure indicates a “waveguide-to-air” condition, in which the vacuum is lost and no beam can be generated. If the vacuum level is at atmospheric pressure, a BGM controller generates a fault interlock.

You can monitor the vacuum by checking the Vacuum meter readouts in the Service screen.

To monitor vacuum currents:

1. At the TrueBeam console workstation, start the Service application. For instructions, see “Starting Service” on page 47.
2. In the top half of the Service screen in the Vacuum area, view the Meter Readouts to see the actual currents for the accelerator, gun, and klystron vacion pumps (Figure 54).

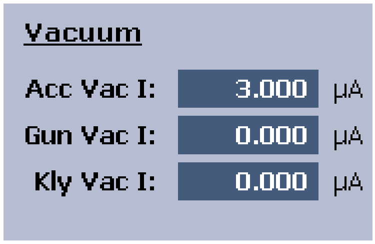

Figure 54 Service Mode–Vacion Pump Currents

Fault Interlocks

Unsafe electrical and pressure fluctuations in the vacuum system can cause faults in the system. A pump controller generates a protective fault interlock if the reading of a vacuum sensor is outside of a configured upper limit. For example, a power failure or power surge generates a fault interlock.

There are two groups of vacuum system fault interlocks: VAC1, which is major and causes the TrueBeam system to switch to Power Saver mode; and VAC2, which is minor.

You should try to clear fault interlocks. If you are unable to clear a fault interlock or if minor vacion fault interlocks regularly appear (which could indicate a more serious condition), contact Varian service.

If the vacion current in the accelerator or electron gun is higher than the specified limit or the vacion voltage is not within the specified range, the BGM-EGN controller reports the error.

If the current in the klystron vacion pump is higher than the specified limit or the vacion voltage is not within the specified range, the BGM-MOD controller reports the error.

VAC1 Fault Interlock

The TrueBeam system generates a vacuum-current related VAC1 fault interlock when an impurity, major leak, or transient release of gas occurs somewhere in an area controlled by the power supply circuits that monitor pump current. If the current remains high or increases, the pump could stall and possibly cause excessive damage to the accelerator, klystron, or bend magnet.

Possible causes of a VAC1 problem include a defective vacion pump or power supply, or the failure of the BGM-VAC power supply.

VAC2 Fault Interlock

Faults that generate a VAC2 fault interlock are similar to VAC1 faults, except that the consequences of VAC2 faults are less severe. For example, a minor leak generates a a vacuum current-related VAC2 fault interlock. VAC2 interlocks are usually automatically cleared after an impurity vanishes. A leak requires repair by trained personnel.

Possible causes of a a vacuum current-related VAC2 fault include:

- A defective vacion pump or pump power supply.
- A sudden or greater-than-normal heating of the accelerator waveguide that causes outgassing of the copper. This problem can happen when the TrueBeam has not been used for several days.

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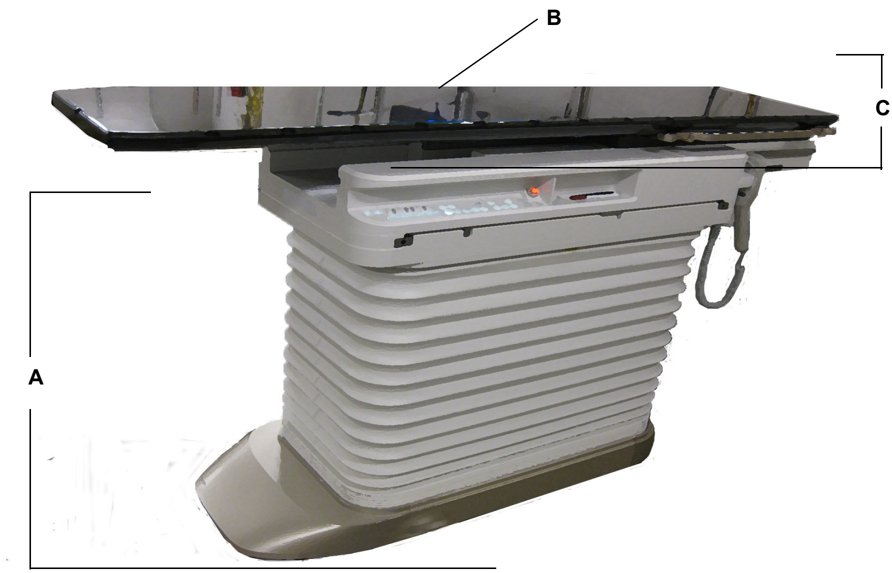
Chapter 14 Couch

The treatment couch is used by a radiotherapist to accurately and safely position a patient for radiation therapy treatment in the TrueBeam.

Figure 55 shows the couch, which consists of an upper couch (with couch top) and lower couch (or pedestal). The safe working load, with the couch top, is 228kg (500 lbs).



A Lower couch (pedestal). **B** Couch top. **C** Upper couch.

Figure 55 Treatment Couch

Various operation modes and control devices allow operators to maneuver the couch, the couch safety system, and a procedure for calibrating couch motion axes.

For instructions on operating the couch, including with the side panels and pendant, and couch emergency controls, see the *TrueBeam Instructions for Use*.

Couch Operation

There are two modes of couch operation:

- Treatment, when the couch is used during patient treatment.
- Service, when the TrueBeam system is undergoing maintenance or repair. In this mode, an operation such as calibrating couch motion axes is possible.

Two-way control devices enable operators to control couch movement. These devices include two side panels, located on either side of the couch, and two pendants. Power to pendants and side panels is disabled during treatment (Beam On).

Side panels are located on both sides of the couch.

Pendants attach to the end of the couch. If a pendant is not securely hung on a couch hook, a protective interlock prevents the treatment beam from generating. A light in the cubby hole alerts you to secure the pendant on a couch hook to prevent the pendant from being radiated during Beam On.

The couch can be moved along three major axes and can be rotated. Couch top lateral and longitudinal axes movements are directed by the controller in the upper couch. Pedestal rotation and lift axes movements are directed by the lower couch controller in the gantry Stand.

The couch top has these end limits, measured in Varian scale:

- Lateral end limits, between 75.5 cm and 124.5cm.
- Longitudinal end limits, between 15.5 cm and 160.5 cm.
- Lower Couch limits: rotation between 85° and 275°; vertical between 59.5 cm and 166.5 cm.

Couch Safety System and Emergency Controls

The safety system in the couch includes Emergency Stop buttons. Emergency operation controls include a couch Float mode and a hand crank that enable an operator to manually move the couch and safely remove a patient from the couch.

Emergency Stop Buttons

The couch safety system is activated by a site power failure or by pressing any Emergency Stop button (Figure 56).

Figure 56 Emergency Stop Button

When the TrueBeam is in Treatment mode, pressing an Emergency Stop button immediately shuts off couch motors and stops all power-driven motion and terminates a beam. A backup battery provides 24-volt power to enable an operator to safely evacuate a patient by moving and lowering the couch, retracting the longitudinal axis away from the gantry, and moving the lateral axis to the center of its motion range. Backup power is available for at least 10 minutes after a power loss.

When Emergency mode is active, the three emergency control buttons on side panels are lit. In the Stand, a light on the service control panel is lit.

Emergency Operation Controls

In addition to Emergency Stop buttons in the console area and treatment room, there are additional emergency controls for the couch:

- Four buttons on each side panel allow moving the couch in an emergency or during a power outage: emergency motion enable, emergency float, emergency stop, and emergency down.
- A control panel, in the back of the Stand, allows access to Varian Service personnel.
- A Clearance Override button on the control console can be used to avoid a collision with the couch.
- If the TrueBeam safety system has detected a collision, a Collision Override Reset button on the side panel allows moving axes away from the collision.

Float Mode

Float mode is a patient-setup aid that permits a radiotherapist to manually move the couch top, clear the couch top over the gantry or imagers, and then lower a patient. When the couch is in Float mode, all motorized movements stop and beam generation is not possible.

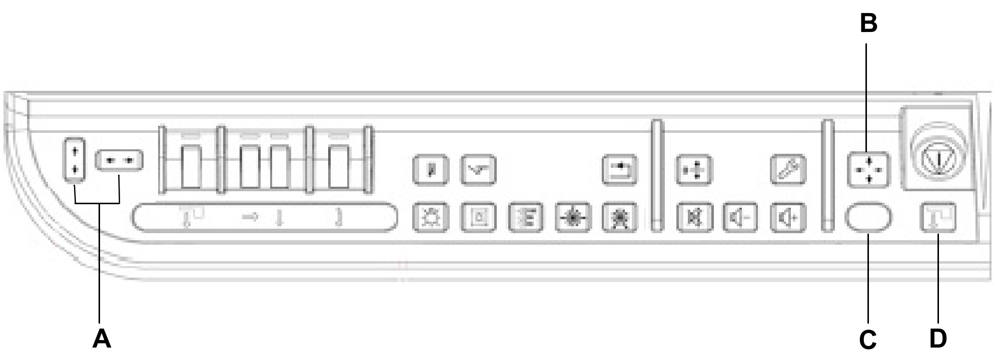
WARNING: Be careful when manually moving the couch top. To avoid damaging the couch, move the couch top in a slow, controlled manner.

WARNING: Be careful when moving the couch while imager arms are extended. To prevent a collision between the couch and imager arms, check that imager arms are retracted.

WARNING: During retraction, imager arms can move close to the gantry and couch, causing a pinch hazard. Always keep away from the gantry, couch, and imager arms when they are in motion.

Float mode controls on the couch side panel include two buttons (Figure 57, A):

- Up and Down Arrows button, which unlocks the lateral motion brake so that you can lift the couch top or move it sideways.
- Left and Right Arrows button, which unlocks the longitudinal brake so that you can move the couch top can forward and backward.



A Float mode. **B** Emergency float.**C** Emergency motion enable. **D** Emergency down.

Figure 57 Side Panel Float and Emergency Buttons.

Hand Crank

When electrical power is on but the couch controls have stopped working, you can manually lower the couch with the couch hand crank.

WARNING: Never use an externally powered driver instead of the hand crank when using the brake override button. An externally powered driver could cause electronic damage. The battery could also discharge during use and brakes could automatically engage, resulting in a dangerous situation.

To manually move the couch with the hand crank:

1. Press an **Emergency Stop** button.
2. Open the Stand and locate the Emergency Operations control panel.
3. To release the lift and rotation brakes, press the Lift-Rotation Brake Override button. The override LED illuminates.
4. Assemble the hand crank so that it consists of the 6-inch extension shaft, the 1/2-inch hex socket, and the crank.

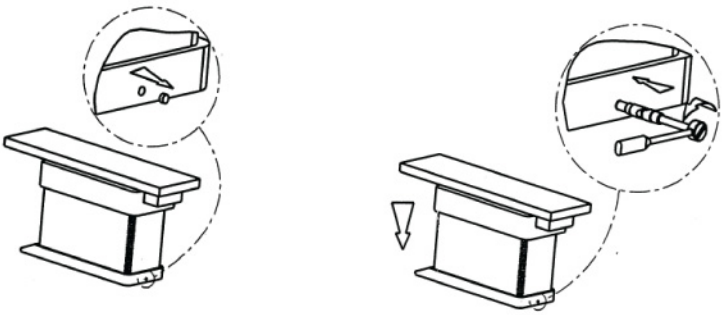


Figure 58 Couch Crank Area (Left) and Hand Crank (Right)

5. Remove the cap from the lower-rear-center portion of the lift base (Figure 58.).

6. Insert the hex end of the extension shaft through the opening at the lower rear of the couch and onto the end of the lift screw shaft.

Note: *It is difficult to see the lift screw shaft, but you can engage the hex drive by touch.*

7. To lower the couch, rotate the ratchet counterclockwise.
8. When you have finished the service tasks, press the Lift-Rotation Brake Override button again to engage the brakes.

Calibrating the Couch

You can use the Service couch calibration tool to calibrate the couch.

To calibrate the couch:

1. Start the Service application. For instructions, see “Starting Service” on page 47.
2. In the lower half of the Service screen, click the **Axis** tab, and then the **Couch** subtab to view couch vertical, longitudinal, lateral, and rotation positions.
3. Use the **Calibrate** option to capture couch positions and calibrate the couch. The Calibrated Status indicator turns green when a position has been captured.
4. After calibrating the couch, ensure that travel ranges can be achieved per specifications.

   Use an external measurement device to measure displacement and confirm that couch lateral positions at several capture points match the actual positions displayed on the in-room monitor.

   The measurement device can be a tape measure, laser, optical transducer, or some other type of device.

For more information on calibrating the couch, contact Varian Service.

Chapter 15 Pendant

The pendant is a hand-held device that is used to move TrueBeam axes in the treatment room. There are two pendants, which are attached to pendant hooks on the treatment couch.

For instructions on how to operate the pendant to move TrueBeam equipment, see the *TrueBeam Instructions for Use*.

Axis Control Hierarchy

The pendant is one of a trio of operator control devices, along with the couch side panels and control console, that control axis motion. Pendants and couch side panels are the main control devices inside the treatment room. They control the motions of the gantry, couch, multileaf collimator, and imager arms. Pendants also control the room lights, field light, optical distance indicator, lasers, and pendant flashlight.

A control hierarchy exists among the pendant and couch side panels and the control console, and pendant thumbwheels and automated targets. Pendants and couch side panels have higher priority for moving machine axes (such as imager arms and the gantry) than do the control console or Service application.

If a motion direction is made from a higher priority device and motion is in progress, the TrueBeam interrupts its current motion and executes the new motion directed by the higher priority device. If a motion direction is made from a device that has equal or lower priority, the TrueBeam ignores the new motion direction.

Control Console—When controlling motion axes, pendants have priority over the control console at all times. You cannot use the control console to move an axis until a Motion Enable bar on a pendant is released.

Side Panels—While an axis is being controlled by a couch side panel, the pendant cannot be used to move the axis. You must first release a Motion Enable button on a couch side panel before you can use a pendant to move an axis.

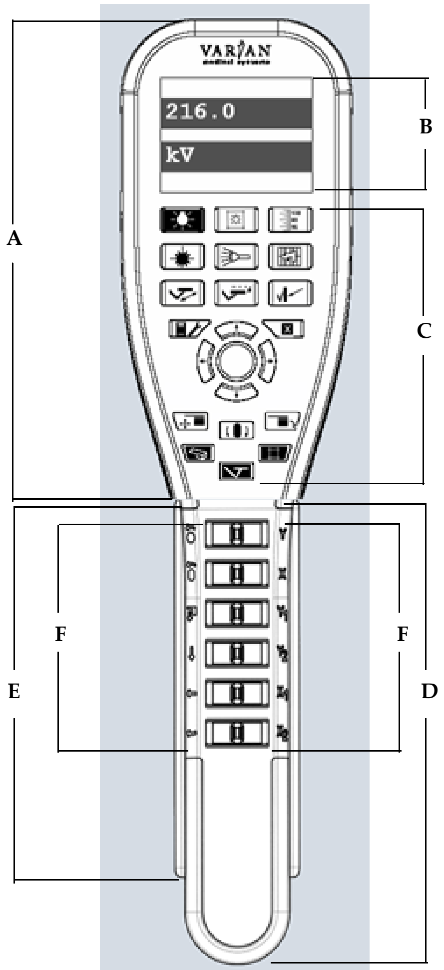
Target Control—For manually entered axis targets, thumbwheels have priority over automated targets on an in-room pendant.

Downloaded targets become inactive when you use pendant thumbwheels to control an axis. Pendant targets remain available for approximately one minute. Pressing auto-enter reactivates targets and starts axis motion toward the targets.

Couch Control—When the couch is in Float mode, an operator manually moving the couch has sole control over the lateral and longitudinal axes. Pendants and the couch side panels cannot be used while an operator is manually moving the couch.

Pendant Components

Figure 59 illustrates the components of the pendant, with the room light selected. For a complete description of the pendant and its controls, see the *TrueBeam Instructions for Use*.



A Paddle. **B** Display. **C** Control button.
D Handle. **E** Motion Enable bar. **F** Thumbwheels.

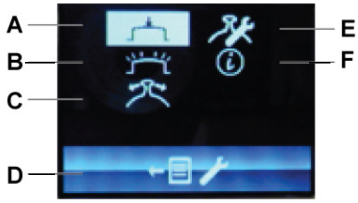
Figure 59 Pendant

Pendant Tests

Pendant tests include those you can run using the Service button on the pendant, and tests that run automatically when the couch applies power to the pendant.

Testing the Pendant

You can test operation of the pendant and its controls using various routines that become available on pressing the **Service** button on the pendant. You can also recalibrate the thumbwheels, if they lose their factory settings or calibration.



A Button test. **B** LED test. **C** Thumbwheel test.
D Test menu icon. **E** Thumbwheel calibration. **F** Information.

Figure 60 Pendant Test Menu

To start a pendant test:

1. Press the **Service** button on the pendant.

   The test main menu appears, showing four test options: button, LED, thumbwheel, and thumbwheel calibration. The menu also has a button for displaying pendant information, such as its software and firmware versions and serial number (Figure 60).

2. To navigate the pendant test menu:
   - Press a pendant **Navigation** button to advance to the desired test or option.
   - To return to normal operation, from the test main menu, press the **Service** button. This button toggles between Test mode and Normal mode.
   - To return to Normal mode if you are viewing a test or information screen, press the **Service** button twice.

To test pendant buttons:

1. Navigate to the Button test; then press **Enter** on the pendant to start the test.
2. Press each button on the pendant. When contact is made, the button lights up. When you remove your finger from the button, the light turns off.
3. If any buttons fail to light, contact Varian Service.

To test pendant LEDs:

1. Navigate to the LED test.

   All LEDs become lit. After 5 seconds, the test system lights each LED in sequence dimly, and then repeats the test to light each LED in sequence brightly.
2. If any LED fails to light, contact Varian Service.

To test thumbwheels:

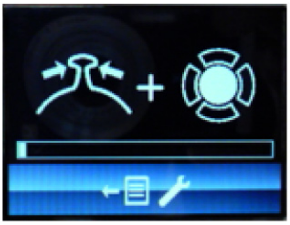
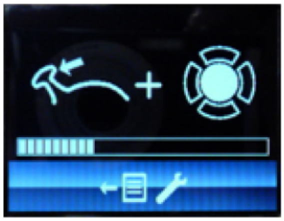
1. Navigate to the Thumbwheel test.

   All the thumbwheel LEDs and the Enter button light.
2. To begin the test, press the **Enter** button.
3. Follow the prompts from the lit thumbwheels, testing the thumbwheel that is lit and pressing **Enter** until you have tested all thumbwheels.

To recalibrate thumbwheels:

1. Navigate to the Thumbwheel Calibration option.
2. To begin the test, press the **Enter** button.

   The LEDs on the pendant handle illuminate to show you the thumbwheel that you are testing. The following illustrates the three thumbwheel position tests: center, right, and left.

The test begins with the center (off) position of the first (top) thumbwheel.

3. Follow the pendant prompts, and press the thumbwheel where indicated; then press the **Enter** button.
4. Repeat step 3 for the remaining center positions, as well as the left and right positions.

   A clock icon indicates wait time during thumbwheel calibration. A check icon briefly appears to indicate that calibration has been completed.
5. Repeat step 3 and step 4 to perform the test a second time to ensure accuracy.

To display pendant information:

1. Press the **Service** button on the pendant.
2. Press a pendant **Navigation** button to advance to the Information ("i") option; then press **Enter**.

Automatic Pendant Tests

When the couch applies power to a pendant, the pendant performs automatic self-tests. These include separate memory, LCD, CPLD, button, and thumbwheel tests.

If all self-tests pass, then the Varian logo is displayed for about 10 seconds; all button LEDs will stop flashing. The pendant is ready for normal operation.

If a test fails, the pendant will flash all of its button LED and become inoperable; the failure must be resolved so that the pendants LED no longer flash.

To troubleshoot a pendant failure, choose from the following options:

- Using the main Service screen, retrieve the faults or warnings reported by the pendant. Follow the suggestion on how to fix the pendant problem. See Chapter 4, “Introduction to Service,” for more information on starting the Service application and viewing faults.
- Start the pendant test, as described in “Testing the Pendant” on page 202.
- Cycle the pendant power by disconnecting and reconnecting the pendant cable. This can resolve some self-tests, such as the thumbwheel test, that failed because the thumbwheels were not at center position during power up.

Storing the Pendants

To safely store pendants when they are not in use, the couch has two pendant hooks, one each on the left and right rear end (Figure 61).

To store the pendants:

1. Hang the pendants so that their cables do not cross over one another.

   Each pendant hangs by a loop that is attached to the back of the pendant. Magnets in the pendants detect when they are on the hooks and pull the pendants into the proper hanging position.

2. Make sure that the light on the hook is off, indicating that the pendant is properly mounted.

   Each hook has a light to indicate whether a pendant is properly mounted on the hook. The light is on if the pendant is improperly mounted. If the pendants are not properly mounted on the hooks, a beam will not be generated.

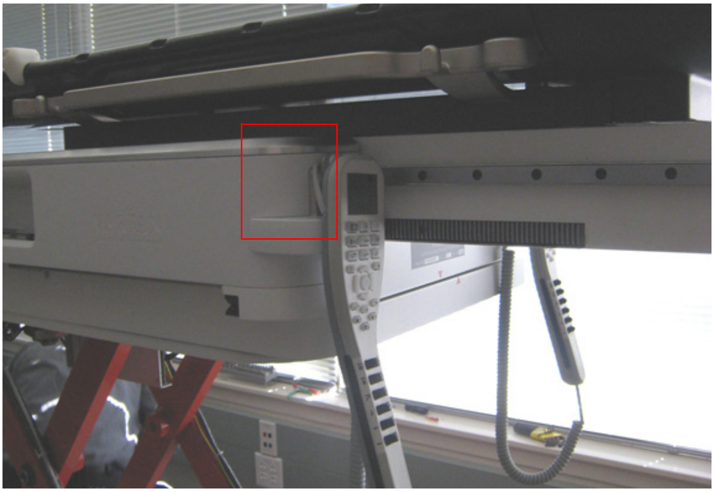


Figure 61 Pendant Hook (red inset)

When Pendants Fail

If a pendant fails, either replace the pendant with another pendant or remove the pendant and its cable.

To replace an inoperable pendant:

1. Remove the pendant by inserting a paper clip into the hole on the back side of the pendant (Figure 62) to release the locking clip on the cable connector.
2. Plug in the replacement-pendant.

   The Supervisor initializes the replacement and begins normal operation.
3. Perform a thumbwheel calibration following the instructions in “Testing the Pendant” on page 202.

Figure 62 Paper Clip Hole in Pendant

To remove a pendant and its cable:

- Insert a paper clip into the hole near where the cable plugs into the couch (Figure 63).

  The Supervisor configures the TrueBeam system to operate with one pendant and begin normal operation.

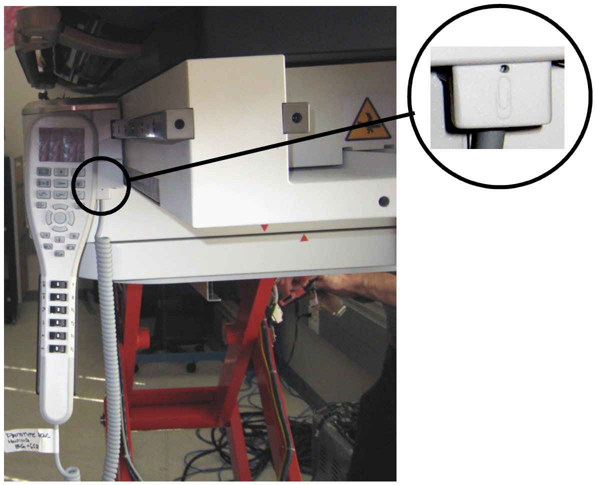


Figure 63 Paper Clip Hole at Cable Plugin to Couch

Pendant Operation During Service

Service technicians can use the pendant during maintenance of the TrueBeam.

For testing purposes, a pendant can be plugged into a service port on the Stand. The pendant then is in an independent, standalone state, and does not receive communications from the Supervisor in the TrueBeam.

Appendix A Service Screens

Many of Service application screens are intended for operations performed only by Varian Service or factory personnel. Users who have logged in without such rights will see read-only displays; some options will not be visible.

See Chapter 4, “Introduction to Service,” for information on starting and using the Service application.

Service Screen Layout

The top section of the Service screen contains fault interlocks and routine interlocks, represented by buttons that identify functional operation groups of TrueBeam parameters.

The middle section of the Service screen shows the status of the TrueBeam. Included in this section are controls for loading beam templates, generating event logs, monitoring power, and moving machine axes. Also included is a GoTo menu for cycling MLC and axes.

The bottom section of the Service screen contains tabs, described in this appendix, that show TrueBeam communications data for its subsystems.

Common to all Service screens are two buttons in the taskbar at the bottom of the screen. **Save Configuration** saves changes to the configuration file. **Close** exits the Service application. For information on other interface conventions and common features, see “About the Service Screen” on page 49.

Scales

The TrueBeam uses two scales, the Varian IEC 60601-2-1, displayed as **VAR_IEC**, and Varian IEC 61217, displayed as **IEC1217**. Figure 64 displays the scales and their differences.

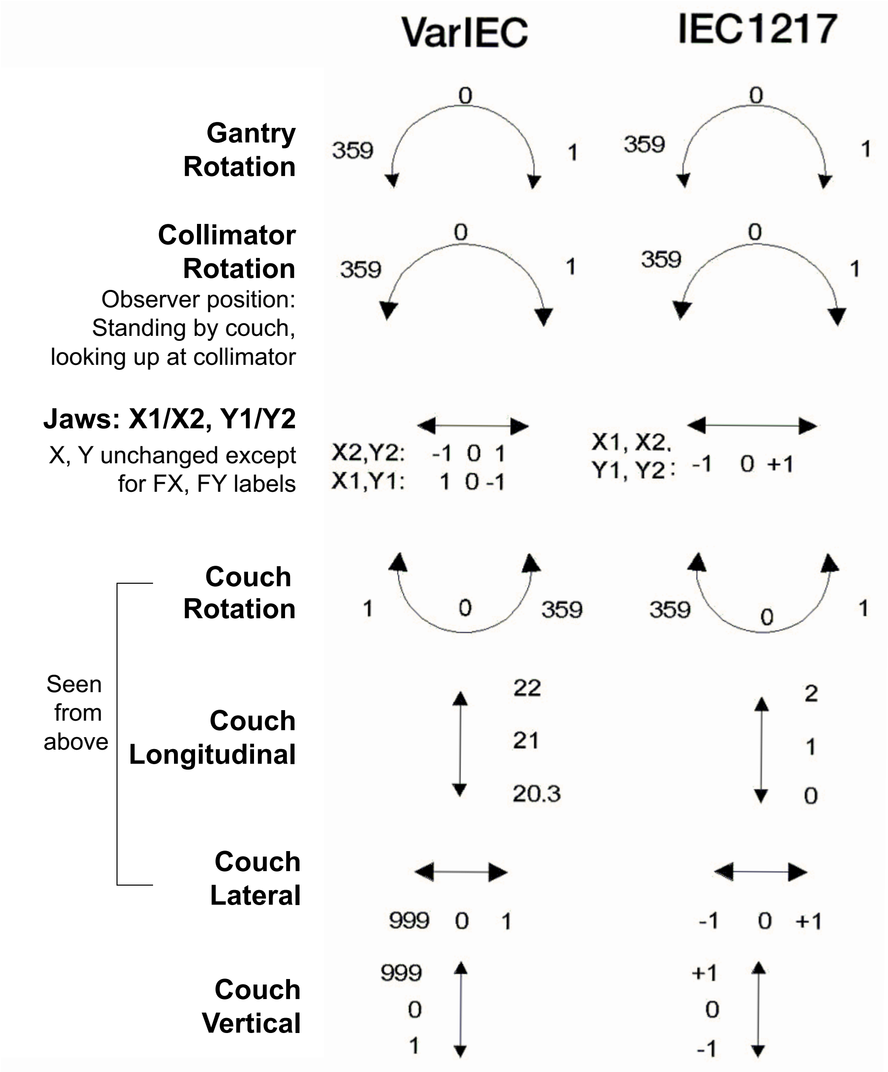


Figure 64 Position Values for Each Scale

Using GoTo Functions

At the lower right of the Machine Controls section, the GoTo menu allows selecting various axes and MLC functions, for diagnosis and troubleshooting purposes.

GoTo—Commands the system to move to the currently loaded set values for motion axes.

Axes Info—Displays a dialog box with editable parameters for the motion axes. Information includes the device ID, motion and target type, requested speed (%), motor current (A), motion status (power off, uninitialized, initialized, or unknown), position (at plan or at target), and whether the axis is enabled. Also indicated is whether controls on the pendant, side panel, or control console are connected to the axis, and whether the Motion Enable button is pressed.

Enable/Disable Motion Axes—Allows locking motion axes, with is useful in stereotactic surgery. Selecting GoTo > Enable/Disable Motion Axes displays a dialog box for enabling or disabling the motion axes (Stand gantry; collimator rotation; and the four couch axes, vertical, lateral, longitudinal, and rotational).

Cycle Axes—For reliability testing, allows moving to a given axis between two positions repeatedly for a specified number of times and plotting the data. You select a motion axis, and enter a start and stop target position, and repeat count. Clicking the **Start** button begins the selected cycle.

Cycle MLC—For reliability testing, allows moving MLC leaves according to a set of loaded MLC plans. You load the plans and then select the number of cycles to test. Sets of MLC files are grouped under playlist files. Click **Open** to display the dynamic MLC plan. Click **Select All** to select all control points; click **Clear All** to clear all control points. Click the **Start** button to begin the autocycle. The dialog box also displays the execution state of the cycling.

Dry Run—Displays a screen with instructions on performing a dry run on a dynamic MLC plan. Follow the instructions and click **Enable Dry Run** to perform the dry run; or click **Cancel** to stop the dry run.

Radiation Safe Mode—Allows testing inside the treatment room with measuring devices and beaming on, without delivering MUs. Selecting this mode displays a Safe Mode Status window in the Machine Controls area. The option closes the X1/Y1 jaws to 0.5 cm.

Encoder Display—Displays position readouts of the primary and secondary sensors (encoders) on the motion axes. Orange indicates the position is unknown. Motion axes include the four couch and four jaw axes; the gantry and collimator axes; and the various carousel axes—radial, transverse, ion chamber, target drive, and Energy Switch.

Network Tab

The Network tab contains four subtabs:

- Conn Status, which shows nodes and subnodes connection status.
- Comm Statistics, which shows communication statistics for nodes.
- Comp Simulation, which shows the component simulation status.
- Node Config, which shows node configuration files in extensible markup language (XML).

The **Detach Config Display** checkbox opens a Node Configuration window that displays node configuration files in extensible markup language (XML). Use this window to see configuration settings.

Conn Status Subtab

The Connection Status subtab contains controls for rebooting nodes and verifying connections to the Supervisor and X-ray imager. Indicators show the status of node and subnode connections.

Buttons

The Network/Conn Status tab has these button controls:

- **Reboot** to reboot a single node.
- **Reboot All** to reboot all nodes.
- **24V Recycle** reboots the node by recycling 24V power through it.
- **Ping** to test whether Supervisor and X-ray Imager nodes are operating and connected.
- **Sync Config** to synchronize the workstation copy of a node configuration file with the node.
- **Update Sim Status** to simulate operation of the selected nodes in software.

Nodes

The Nodes area provides controls and status indicators for the control system nodes:

- Supervisor (SPV)
- Stand (STN)
- Beam (BGM)
- Collimator (COL)
- Couch Upper (CCHU)
- Couch Lower (CCHL)
- X-ray Imager (XI)
- kV Source (KVS)
- kV Detector (KVD)
- MV Detector (MVD).

Conn Status—Shows connection status. A green indicator means the node is connected to the network; a red indicator means the node is disconnected.

Board Temperature—Displays actual temperature (in Celsius) of printed circuit board in a node.

CRC/Sync Status—Displays the status of a Cyclic Redundancy Check and synchronizing configuration files synchronization. This synchronizes the workstation copy of the node configuration file with the node. Select a checkbox to instruct the system to check the corresponding node.

Simulate—Selects a node for the system to simulate in software, after the corresponding hardware has been adjusted.

Simulation Status—Displays the status of the node being simulated. A green indicator means the node is being simulated; a gray indicator means the node is not selected.

BGM Subnodes

The BGM Subnodes area provides controls and status indicators for the beam generation and monitoring subnodes:

- Modulator (MOD)
- Electron Gun (EGN)
- Solenoid (RFSPS)
- Steering (PWM)
- Position (POS)

BGM Controller State—Displays the actual state of BGM controller.

Conn Status—Shows the connection status. A green indicator means the node is connected to the network; a red indicator means the node is disconnected.

State—Displays the actual state of BGM subnode

Error—A green indicator means an error occurred in the node; a gray indicator means the node is error-free.

Warning—A green indicator means that the node issued a warning; a gray indicator means the node is warning-free.

Interlock—A green indicator means the node asserted an interlock; a gray indicator means the node is interlock-free.

Board Temperature—Displays actual temperature (in Celsius) of printed circuit board in a subnode.

Stand Subnodes

The Stand Subnodes area provides status indicators for the Stand power distribution subnodes:

- Auxiliary Power Distribution (APD)
- Gantry Power Distribution (GPD)
- Stand Power Distribution (SPD).

Comm Statistics Subtab

The Comm Statistics subtab provides access to communication statistics for the following nodes, as selected from the **Node** menu:

- Beam Generation and Monitoring
- Upper and lower couches
- Collimator
- Kilovolt detector
- Kilovolt source
- Megavolt detector
- Supervisor
- Stand
- X-ray imager.

Get Comm Statistics—Instructs the system to retrieve and display the communication statistics for the selected node.

Clear—Clears the display window.

Export—Exports communication statistics to C:\VMSOS\AppData\TDS\Output\Service folder. Exported files are date-stamped and time-stamped.

Comp Simulation Subtab

The Comp Simulation subtab displays the component simulation status for each of the system nodes, on clicking the corresponding node button:

- BGM (Beam)
- STN (Stand)
- COL (Collimator)
- CCHU (Couch Upper)
- CCHL (Couch Lower)
- XI (X-ray imager)
- KVS (kV source)
- KVD (kV detector)
- MVD (MV detector)

Component Simulated—A green indicator means that node are being simulated in software; a gray indicator means the node components are not being simulated.

Component Simulation Status—Displays which components of the selected node are being simulated, indicated by the green light; a gray indicator means that no node component is being simulated.

NodeConfig Subtab

The Node Config subtab enables you to view the XML configuration file of the system nodes. The Network/NodeConfig tab has these controls:

- **Nodes** menu lets you select the node to access.
- **View Configuration** button retrieves and displays the configuration data for the selected node.
- **View Defaults.xml** button displays the configuration file (see Figure 65 on page 216). To edit the file, use the System Admin application.


```
-<NominalBeamData>
   <innerRadialPlateHighGain>false</innerRadialPlateHighGain>
   <innerTransversePlateHighGain>false</innerTransversePlateHighGain>
   <outerRadialPlateHighGain>false</outerRadialPlateHighGain>
   <outerTransversePlateHighGain>false</outerTransversePlateHighGain>
   <nominalIonChargeA min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeB min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeC min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeD min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeE min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeF min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeG min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeH min="0.00001"max="0.001">0.0001</nominalIonCharg
   <nominalIonChargeI min="0.00001"max="0.001">0.0001</nominalIonCharge
   <nominalIonChargeJ min="0.00001"max="0.001">0.0001</nominalIonCharge
   <nominalTargetCurrent min="0.00001"max="0.001">0.0001</nominalTarget
   <nominalRFforwardPower min="0"max="5">0</nominalRFforwardPower>
   <nominalTarget1Ratio min="-10.0"max="10.0">0.0</nominalTarget1Ratio>
   <nominalTarget2Ratio min="-10.0"max="10.0">0.0</nominalTarget2Ratio>
 </NominalBeamData>
```


Figure 65 Portion of BGM Configuration File

Beam Tuning Tab

The Beam Tuning tab enables you to view beam tuning signals from the TrueBeam. You can also adjust beam tuning parameters and turn beam tuning controls on and off.

The Beam Tuning tab includes 12 subtabs, described in sections that follow.

Beam Tuning Indicators

The indicators at the bottom of each of the beam tuning screens display the connection status of the BGM node and each of the BGM subnodes. A green indicator means the node is connected to the network; a red indicator means it is disconnected.

Beam Tuning Buttons

The buttons at the bottom of each of the beam tuning tabs are available for all of the subtabs.

CalCheck On—Enables automatic calibration checking.

Off—Disables automatic calibration checking. Turning off Cal Check is useful for faster initial tuning of the TrueBeam.

Indicator Between Off and Saturate—Is green if CalCheck is on, and gray if CalCheck is off.

Saturate—During beam steering, sets the bend magnet current to maximum value for at least 6 seconds, a technique used to remove hysterisis (resistance to a change in magnetization) in the bend magnet

Retrieve Ion Charge Capacity—runs the following tests, with test results displayed in a window:

- Checks the capacitance of ion chamber plates by capturing a specified charge on the plate. Ion charge capacity can be recalibrated as capacitance changes for future comparisons.
- Trips faults in case the charge is poor (the TrueBeam is not tuned).

To apply the results to the configuration file, click **Retrieve**.

Calculate Ion Charge Offset—Captures the charge offset (noise reduction value) and displays the test results in a window. To apply the results to the configuration file, choose OK.

Calculate Nominal Beam Data—Calculates nominal beam data when PFN and Dose servos are off and the output is peaked, and displays test results in a window. To apply the results to the configuration file, click **OK**.

Common Beam Tuning Controls

The controls and meter readouts described here are common to most of the Beam Tuning subtabs.

Servos

The Servos section has controls for the beam servo function and displays the servo's power status, as well as the status of Supervisor commands to the servo.

Servos include:

- Dose (normal dose)
- AFC (automatic frequency control).
- PFN (pulse forming network).
- Angle R (angle radial)
- Angle T (angle transverse)
- Pos R (radial position)
- Pos T (transverse position).

On or **Off** buttons turn the respective servo on or off, with green indicating power to the servo is on, and gray means it is off. (The exception are the Pos R and Pos T servos. These servos are not needed for electron mode. So even if the Pos R and Pos T servos are on, if electron energies are prepared, the indicators will appear gray; if X-ray energies are prepared, the indicators will appear green, as expected.)

The Order and Status columns show whether the Supervisor has issued a command to hold the beam or freeze it (as during imaging, to deliver the beam at a fixed rate for a period of time). These respective conditions appear as Held and Freeze in both columns.

Triggers

The Triggers section turns a trigger pulse on or off, and displays the state of the trigger. Internal defines a starting point to measure the trigger; Klystron measures the start point from where the klystron current begins rising. Triggers include:

- Gun
- RF (radio frequency)
- AFC (automatic frequency control)
- Mod (modulator)

Delay

Entering a value in the data box automatically adjusts the pulse delay to the enabled triggers:

- Gun (ext): the external electron gun trigger.
- RF: internal or external RF trigger.
- AFC (ext): external AFC trigger.
- Mod: modulator trigger.

Duration

This value sets the delay of the trigger pulse to the enabled trigger.

Beam Steering

These parameters display, and allow adjusting, the following beam-steering voltages (V) for enabled servos:

- RFDR V: RF driver voltage. (programmed and displayed are the same).
- RF Pwr Out: Actual RF power output voltage.
- RF Fwd: Actual forwarded RF voltage.
- RF Refl: Actual reflected RF voltage.
- AFC V: AFC voltage.
- AFC Balance voltage.
- PFN V: Pulse forming network voltage.
- Gun Grid V: Electron gun grid voltage.

These parameters display and allow adjusting these beam-steering currents (I) for enabled servos:

- ASol Prog I: Accelerator solenoid programming.
- Angle R: Radial angle.
- (Angle) T: Transverse angle current.
- Pos R: Radial position current.
- (Pos) T: Transverse position current.
- Buncher R: Radial buncher current.
- (Buncher) T: Transverse buncher current.
- Trim: Trim current.

Preset Subtab

The Preset subtab allows monitoring and programming electrical power, and adjusting trigger frequencies and pulse widths.

In addition to common beam tuning controls (see page 218), the Preset tab has controls for adjusting preset parameters for the electron gun, vacuums, and triggers. Meter readouts display actual power signals from the gun and vacuum. Parameters include current (I), resistance (R), and voltage (V).

Bend magnet parameters include:

- BMag Prog: programming current. When locked, this parameter cannot be adjusted. Click to unlock or lock.
- BMag Exp I: expected current.
- BMag I: actual current.
- BMag R: resistance.
- BMag V: voltage.

Accelerator solenoid parameters include:

- ASol Prog I: programming current.
- ASol Exp I: expected current.
- ASol I: current.
- ASol R: resistance.
- ASol V: voltage.

Klystron solenoid parameters include:

- KSol Prog I: programming current.
- KSol Exp I: expected current.
- KSol I: current.
- KSol R: resistance.
- KSol V: voltage.

Klystron parameters include:

- Klystron I: current.
- Klystron V: voltage.

Other parameters that can be adjusted include:

- Perveance. (Significance of the space charge effect on the motion of the low-energy electron beam.)
- VSWRL: Voltage standing wave ratio (ratio of the amplitude of a partial standing wave at the maximum, to the amplitude at an adjacent node (minimum)).

Gun

The Gun section has controls for the gun, filament, hotdeck, crowbar, and high voltage power supply. Parameters include current (I), resistance (R), and voltage (V).

- Gun Grid V: Gun grid voltage.
- Gun HVPS: Electron gun high voltage power supply.
- Gun Fil V: Gun filament voltage.
- Gun Fil Step V: Actual electron gun filament step voltage.
- Gun Fil I: Actual electron gun filament current.
- Bias V: Actual bias voltage.
- Hotdeck: Indicates whether power at the hotdeck is on (green) or off (gray). The hotdeck is where the bias voltage and grid pulse are produced and applied to the electron gun grid, and where heater power is applied to the filament.
- Crowbar: Shows whether power at the crowbar, a safety relay, is on (green) or off (gray).
- HVPS: Turns power to high voltage power supply on or off. Indicator shows whether power is on (green) or off (gray).
- HVPS Pwr: Shows whether power to high voltage power supply is on (green) or off (gray).

Vacion Voltage

This area shows actual voltage for these vacion components:

- Accelerator.
- Klystron: Klystron vacuum.
- Gun Vac V: Electron gun vacuum voltage.

When unlocked, these parameters can be adjusted:

- Kly Vac Pwr: Klystron vacuum power.
- Gun Vac Pwr: Electron gun vacuum power.

Click to unlock or lock.

Local Gun, Local RF, and Local Mod Triggers

This section of the Beam Tuning/Preset tab allows capturing values at the local subnode (EGN, RF, or MOD), rather than at the BGM node. Enter the frequency and pulse width for generating the local triggers for the electron gun, RF, and modulator. Click the **Start-Stop** buttons to turn the triggers on and off.

RF Process Subtab

In addition to common beam tuning controls (see page 218), the Beam Tuning/RF Process subtab has controls and meter readouts that enable you to process radio frequency to get peak RF output; configure the primary dose rate; and monitor and adjust AFC triangular wave generation power and frequencies. These techniques are done as part of initial beam-tuning when technicians first start up the TrueBeam. (

After adjusting the parameters, click the **Start-Stop** buttons to process the peak RF or generate the AFC triangular wave.

Peak RF

The peak RF procedure finds the RF driver programming voltage that yields the local maximum dose rate.

Adjust these values before starting the peak RF process:

- RFDR V:
- RF driver voltage.
- Acc Vac I: Accelerator vacuum current (display only).

Also adjust these Primary Dose Rate values:

- Min: Minimum
- Max: Maximum
- Increment
- Samples: the number of recordings, as determined by the Min, Max, and Increment values.
- Interval.

AFC Triangular Wave Generation

These parameters are used to generate an AFC triangular wave, a technique used to clean the guide on first starting the TrueBeam.

AFC V, or AFC voltage, is display only.

Adjust these values before starting the wave generation:

- Frequency (Hz)
- Amplitude (peak-to-peak; voltage).
- Offset (voltage).

AFC Subtab

In addition to common beam tuning controls (see page 218), the Beam Tuning/AFC subtab has controls and meter readouts to adjust AFC sweep parameters, view AFC voltage, and start AFC sweep. After adjusting the parameters, click the **Start-Stop** buttons to run the test.

This test verifies whether the TrueBeam can beam on and produce a stable dose output. Test results appear on an oscilloscope.

The AFC V parameter displays and allows adjusting the AFC voltage and actual voltage.

Adjust these parameters before starting the sweep:

- Min: Minimum sweep
- Max: Maximum sweep
- Increment
- Samples: the number of recordings, as determined by the Min, Max, and Increment values.
- Interval.

Energy Switch Subtab

The Energy Switch subtab allows adjusting the position of the Energy Switch and viewing the actual position.

Preliminary Subtab

In addition to common beam tuning controls (see page 218), the Beam Tuning/Preliminary subtab has controls and meter readouts for calibrating preliminary radial and transverse balances; viewing whether the axes are moving; and adjusting local triggers in the electron gun, RF, and modulator. You can adjust and view carousel radial and transverse axes and view their position and power information.

After adjusting radial and transverse balance parameters, click **Calibrate** to calibrate the beam parameters. After adjusting trigger parameters generated at the local (EGN, RF, and MOD) subnode, click the **Start-Stop** buttons to turn the triggers on and off.

Radial Balance

These parameters let you view gain values for radial angle and position symmetry, and adjust and calibrate their balance:

- Sym AR: Angle radial symmetry (read-only)
- Angle R Bal: Angle radial balance gain
- Sym PR: Position radial symmetry (read-only)
- Pos R Bal: Position radial balance gain.

Transverse Balance

These parameters let you view gain values for transverse angle and position symmetry, and adjust and calibrate their balance:

- Sym AT: Angle radial symmetry (read-only)
- Angle T Bal: Angle transverse balance gain
- Sym PT: Position transverse symmetry (read-only)
- Pos T Bal: Position transverse balance gain.

Carousel Radial

You can adjust only the carousel's radial axis position; other parameters are read-only:

- Radial Axis (or offset)
- Position (Base value plus the offset)
- Motor Current: Reported at the axis.
- Base (Polar) (Factory or startup position)
- View the base.
- Exp. Sec. Pos.1: Position of the secondary position readout sensor (SPRO).
- Moving: Indicates whether the axis is moving (green) or stationary (gray).

Carousel Transverse

You can adjust only the carousel's transverse axis position; other parameters are read-only:

- Transverse Axis (or offset).
- Position. Calculated as Base value plus the offset.
- Motor Current.
- Base (Polar). Factory or startup position.
- Exp. Sec. Pos.1: Position of the secondary position readout sensor (SPRO).
- Moving: Indicates whether the axis is moving (green) or stationary (gray).

Dose Cal Subtab

In addition to common beam tuning controls (see page 218), the Beam Tuning/Dose Calibration subtab has controls and meter readouts for viewing primary and secondary ion chamber power supplies and adjusting the gain and offsets to calibrate the primary and secondary doses. After calibration, total dose output readouts should match or closely approximate values reported by a standard measuring device.

Dosimetry Calibration

These ion power supply values are read-only:

- Ion Pwr 1: Voltage in the primary ion chamber power supply.
- Ion Pwr 2: Voltage in the secondary ion chamber power supply.

Adjust these values and then click **Calibrate** to determine the gain and offsets needed to calibrate the primary and secondary doses:

- MU 1 Gain: Primary dose gain.
- MU 2 Gain: Secondary dose gain.
- Standard: Readout entered from external dose measurement device.

Symmetry Cal Subtab

In addition to common beam tuning controls (see page 218), the Beam Tuning/Symmetry Cal subtab has controls and meter readouts that enable you to view power signals and calibrate beam symmetry. The Limits subtab (see page 230) displays additional, related information on the symmetry calibration.

Table 10 shows the types of Symmetry calibration and their parameters.

This calibration is a linear function that uses two points (Positive and Negative) to calculate the gain (hence the two Calibrate buttons for each calibration type). Click **Retrieve** to get BGM values. After adjusting radial and transverse balance parameters, click **Calibrate** to calibrate the balance gain. You use a third-party measurement device to measure the dose, and compare it against machine readings.

After performing the symmetry calibration procedures, beam symmetry readouts should be close to 0% in both the radial and transverse planes, with or without enabling the angle R, angle T, position R, and position T servos.

Table 10 Symmetry Calibrations

Calibration	Parameter	Description
Angle Radial	Sym AR Angle R	Angle radial symmetry (read-only). Angle radial current.

Table 10 Symmetry Calibrations

Calibration	Parameter	Description
Angle Transverse	Sym AT Angle AT	Angle transverse symmetry (read-only) Angle transverse current
Position Radial	Sym PR Angle R	Position radial symmetry (read-only) Position radial current
Position Transverse	Sym AT Angle T	Position transverse symmetry (read-only) Position transverse current
All symmetries	Balance	Balance gain.
	Gain	Overall gain of a particular symmetry calibration value.

Flat Cal Subtab

In addition to common beam tuning controls (see page 218), the Beam Tuning/Flat Cal subtab has controls and meter readouts that enable you to calibrate beam flatness.

Symmetry calibration should be completed before flatness calibration. This calibration should produce readings close to 0, whether or not the steering servos are enabled.

After entering the flatness values, click **Calibrate**. Radial and transverse flatness parameters include:

- R Gain: Radial flatness gain.
- R Balance: Radial flatness balance.
- R: Radial flatness (read-only).
- T Gain: Transverse flatness gain.
- T Balance: Transverse flatness balance.
- T: Radial transverse (read-only).

Cal Check Subtab

The Cal Check tab is used to perform a series of redundant tests that check the ion charge capacity and the nominal beam. Additional read-only test data appears on the Dose Diag tab.

For the ion charge capacity test, each plate is charged above and below its limit. As well, the various beam parameters are tested above and below their limits, using all energies configured on the TrueBeam.

A successful Cal Check passes all steps, including the ion charge capacity and nominal beam test.

Indicators give the status of the test, where green indicates the test passed; red indicates the test failed. For Below and Above Limit status, indicators show whether the test energy has been delivered (green) or not (gray).

Cal Check

The leftmost column shows the status of the individual tests:

- Ion Charge Capacity: Checks cable connections.
- Ion Chamber Interlock: Fault interlocks are asserted properly when system limits were exceeded.
- Accumulated Charge Limit Primary: The accumulated primary charge reached the test limit.
- Accumulated Charge Limit Secondary: The accumulated secondary charge reached the test limit.
- Normal Beam: Tests proper functioning of the dosimetry circuitry.
- Controlling Timer: The MUs and dose rate over time were delivered correctly.

These parameters indicate pulses injected into the plate, below and above the system limits for the charge:

- Prim Sec Difference: Difference between primary and secondary charges.
- Primary Charge/Pulse: Primary charge per pulse.
- Secondary Charge/ Pulse: Secondary charge per pulse.
- Primary Charge Rate; above limit only.
- Secondary Charge Rate; above limit only.
- Sym AR: Symmetry angle radial.
- Sym AT: Symmetry angle transverse.
- Sym PR: Symmetry position radial.
- Sym PT: Symmetry position transverse.
- Flat R: Radial flatness.
- Flat T: Transverse flatness.
- XRay Target Charge 1.
- XRay Target Charge 2.

Ion Charge Capacity

This section displays results of ion charge capacity test for all ion chamber plates, A through J.

Ion Chamber Leakage

This area displays leakage test results, which ideally, should be 0.

Dose Diag Subtab

The Dose Diagnostics subtab displays a snapshot of data when the beam is on, with test results of the ion charge capacity and offsets, as well as nominal beam data. Calculated nominal beam data can be saved for future Beam Ons.

Gun Diag Subtab

The Gun Diagnostics subtab displays information about the electron gun and its power supply. Controls and meter readouts enable you to view calibration check power status, ion charge capacity and offsets, and nominal beam data.

The top part of this information is described in “Gun” on page 221.

In addition, the tab displays read-only information about the gun current (I), temperature of its printed circuit board, and hot deck power supply information:

- Gun I: Gun current.
- Gun Vacion I: Gun vacion current
- Temperature: EGN PCB temperature.
- 5V Monitoring: Hotdeck power supply.
- 15V Monitoring: Hotdeck power supply.
- -15V Monitoring: Hotdeck power supply.

Limits Subtab

The Limits subtab contains controls and meter readouts for setting servo limits and calculating steering sensitivity. This information is related to that on the Symmetry Cal tab (see page 226).

Dose Servo and AFC Servo

These sections display pulses and maximum and minimum output.

PFN Servo

This section displays Fwd Pwr Tol (forward power tolerance).

RF Servo

This section displays the number of pulses.

Angle and Position Servos

These sections have options for calculating the steering sensitivity of the four angle and positions servos—Angle Radial, Angle Transverse, Position Radial, and Position Transverse servos. Internal values are compared to those captured by a third-party dose measurement device. Parameters are:

- Pulses: Number of beam pulses.
- Sensitivity: Steering sensitivity.
- Positive: Positive tolerance; click **Retrieve** to enter configured setting.
- Negative: Negative tolerance; click **Retrieve** to enter configured setting.
- Click **Calc Sens** to calculate the steering sensitivity.

MLC Tab

The MLC tab enables you to view multileaf collimator (MLC) positions, currents, pulse width modulation (PWM), and a graphical display of the MLC. You can also initialize the MLC and view MLC status.

The MLC tab includes status indicators, commands, and four subtabs: Positions, Currents, PWMs, and MLC Display.

Click the **Detached MLC Display** button to open a separate window containing the MLC Display.

In addition, all of the MLC tabs, with the exception of Diagnostics, allow you to perform MLC LED diagnostics and calibrate it. For instructions, see “Performing MLC Diagnostic Tests” on page 131.

MLC Buttons and Indicator

The buttons and the indicator at the bottom of each of the MLC tabs are available for all of the subtabs.

Collimator—Green means that the collimator is connected.

Close—Moves the MLC leaves to their closed position, nearest the center.

Retract—Moves the MLC leaves to their open position, farthest from the center.

Go to Plan—If an MLC plan is loaded, moves the MLC leaves, and each leaf on the MLC, to the location specified in the table and index of the current plan.

MLC Indicators on All Subtabs

These status indicators are common to all MLC subtabs:

Initialized—MLC is or is not initialized.

MLC General Status—Shows whether the MLC has any fault interlocks, such as for its leaves, carriages, FPGAs, and so on, but excluding power or communication faults.

MLC Power Status—Shows whether the MLC has any power fault interlocks.

MLC Communication Status—Shows whether the MLC has any communications fault interlocks.

LimSw—Refers to whether the carriage has contacted the limit switch that marks the end or home position.

Also displayed is the installed MLC model.

Brake—Displays the status of the brake.

MLC Commands

The following commands are common to all MLC subtabs. Display the commands by selecting the **Commands** checkbox on the right side of the tab.

Initialize—Click to initialize the MLC.

Calibrate—Click to calibrate the MLC; if necessary, click the **Lock** button to unlock the calibration command.

Initialization Details—Select this option to view details about the initialization states and substates of the MLC and carriage banks A and B. Possible states include (Initialized (Power Off), Settling at Position, Ready (Powered, Maintains Position), No Substate, Uninitialized.

Calibrating the LED

The LED calibration procedure optimizes light output. During calibration, the leaf edge blocks the path of the infrared LED light; the subsequent leaf position offset is used to calculate its calibration parameter. The transmitter and the detector of this light are vertically and horizontally aligned. Calibration options appear in the MLC tabs and subtabs (with the exception of the MLC Diagnostics subtab).

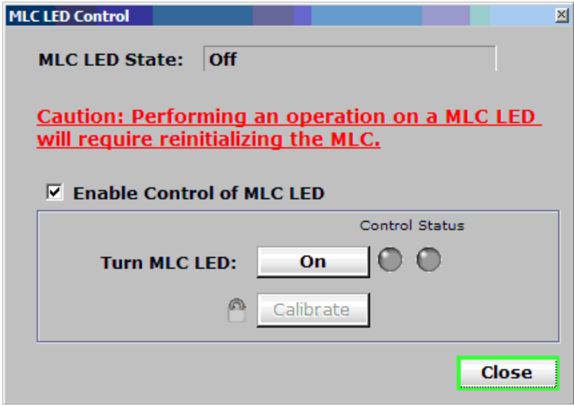


Figure 66 MLC LED Calibration

To calibrate the MLC LED:

1. In the MLC tab, click the **LED Diagnostics** button.
2. In the MLC LED Control dialog box, click the **Turn MLC LED: On** button to turn on the option.
3. Click the **Calibrate** button to calibrate the LED. Click the **Lock** button.
4. Using a digital oscilloscope, measure the voltage at transmitter and receiver side, measuring across the resister R1 on the LED Emitter board.

   Voltage should measure ECP or EUP depending on whether the LED is calibrated.

   If no voltage can be measured, check the emitter board and LED. Make sure that the circuit is receiving power.
5. Using the oscilloscope, measure the voltage across the Test Point 6 (TP6) and Ground (GND) on the LED Receiver board.

   It should measure RCP or RUP depending on whether the LED is calibrated.
6. Align the receiver aperture along the horizontal plane so that the receiver voltage measured is maximized to RCP or RUP.

   If no voltage can be measured, check the receiver board. Make sure that the circuit is receiving power.

7. Cover the front of the receiver aperture to block the path of infrared light between emitter and receiver.
8. Click the **Calibrate** button. The calibration will fail and the LED will turn off.
9. Click **Turn MLC LED: On** to turn on the LED again. Click **Cancel** to cancel the previous calibration.
10. Turn on the LED again. Click the **Lock** button next to the **Calibrate** button.

    The pulse across R1 on emitter board should now measure EUP.
11. Click the **Calibrate** button.

    The status changes to calibrating and then to Ready, and the LED turns off. The emitter side voltage is adjusted for receiver side pulse measuring 1V.

Positions Subtab

The Positions subtab shows actual and plan positions as well as hardware positions for the leaves and carriage banks A and B.

At the Positions button, you select either:

- Actual plan positions at the isoplane.
- Primary position readouts (PRO) and secondary position readouts (SPRO) of hardware positions at the leaf plane.

Plan, Actual Positions (Isoplane)

By default, the MLC > Positions tab shows the actual position in machine internal scale of the two carriage banks, their leaves, and the PRO (primary sensory readout) position of the selected leaf.

MLC Motion Status—Displays whether power is on or off, or whether the MLC is initialized or not.

Show Plan Positions—Displays the plan and actual positions for carriage banks A and B, as well as information on leaf control points—a location relative to the isoplane, set in the plan, and directed by the Supervisor. If you select this option, you can specify a value in **Plan Control Point** and click **Play** to display the sequence of movement for the selected control points in a plan. Select a value for **Repeat** to replay the sequence.

Hardware Positions

If you select Hardware Positions from the Positions drop-down menu, you can use these check boxes to display the position of leaves:

Show Hw PROs—Displays the PRO (primary sensor readout) and SPRO (secondary sensor readout) positions of carriage banks A and B.

Show Values at Leaf Plane—Displays the PRO and SPRO positions at the leaf plane, where the beam would contact the leaf.

Leaf Plans As Offset—Shows the leaf value at the leaf plane in relation to the isoplane, with offset for some curvature due to the physical design of the leaf and how it blocks the beam

Currents Subtab

The Currents subtab shows the currents for carriage banks A and B and for all leaves.

PWMs Subtab

The PWMs subtab shows the pulse width modulation for carriage banks A and B and all leaves.

Communication Subtab

The Communication subtab shows statistics for various data communications parameters, including received and transmitted packets, and CRC errors in received packets; violations and CRC errors received; and roundtrip data errors and successes.

MLC Display Subtab

The MLC Display subtab shows a graphical display of the MLC. Placing a cursor over parts of the MLC graphic reveals the positions of jaws and actual and plan positions of leaves. Data on control point, collimator, and display scale, initialization and power status is also shown.

MLC Diagnostics Subtab

This subtab allows performing MLC diagnostics to verify the working condition and performance of the carriages and leaves. You can perform these diagnostics:

- MLC Difference test shows the PRO (primary sensor readout) and the SPRO (secondary sensor readout) position values, and their difference for carriages and leaves.
- MLC Motor Driver tests consist of PWM and Velocity tests. The PWM test measures the average driving force (pulse width) that can drive a leaf with a speed of 1 mm per second. The Velocity test drives the MLC leaves with constant PWM and velocity computed from sampled positions over known intervals; velocity is expected to be constant.

  The degradation (increase) of the pulse width value or variation in velocity for any given leaf over time indicates increasing resistive force on the leaf due to bent parts, adjacent leaves that are touching, direct accumulation, and so on.
- LED Diagnostics test allows calibrating the MLC LED, in which the light source current is changed to maximize optical receiver output. Failure indicates the LED is not working, displacement of the receiver from its optimal position, or degradation of the LED or the receiver. The test does not mechanically adjust the position of receiver parts.

To perform the MLC Difference test:

1. On the Service screen, click the **MLC** tab.
2. Click the **Diagnostics** button beneath the tabs.
3. Choose **MLC Difference Test** from the Test menu.
4. Select what data to view: carriage Bank A or Bank B. If desired, select the **Show Raw Data** option to display all data columns.

   To clear the buffer that stores motion records, click the **Reset Records** button on the right side of the screen.

5. Click the **Capture** button; then choose the mode of data capture in the Capture MLC Data dialog box:
   - Select **Get Available Records** to capture MLC motion data currently available in the buffer if the MLC move has already been done. Then click the **Submit** button in the Capture MLC Data dialog box to begin the capture.
   - Select **Capture On Event**. In the table that appears, select the event—Beam On, Beam Off, or User to define the event.
6. Click **Start** to begin the capture and **Stop** to end it.
7. Click **Save** to name the XML file and save the data.

To generate the MLC motion data:

1. Click the **Load** button, and in the dialog box that appears, select the XML file for the MLC test.
2. Click the **Reset Records** button on the right side of the screen to clear the buffer that stores the motion records.
3. Run the plan by beaming, playing the MLC Plan, or performing a dry run.

   When the plan has completed executing, the Difference test displays data corresponding to the event captured.
4. Click **Save** to name the XML file and save the data.
5. Click **Load** to load the previously saved test data.

To perform MLC Motor Driver tests:

1. On the **MLC** tab, click the **Diagnostics** button and choose MLC Motor Driver Tests.
2. Select a test:
   - MLC PWM test moves the carriage to the retracted position and then samples the minimum driving force needed to move a leaf 1 mm/second; the higher the value, the more responsive the MLC.
   - MLC Velocity test moves the carriage to the retracted position and then samples the speed of the MLC leaf movement at a constant force (pulse width).
3. Click **Open** to display the test options.

4. Set the test parameters:
   - If you chose the MLC PWM test, specify the **Start** and **End** values (1 to 255) and Increment (2 to 255) of the move.
   - If you chose the MLC Velocity test, specify a PWM value from 1 to 255 and a distance from 1 mm to 150 mm to move the leaves.
   - To store test results temporarily, click **Save Temporary MLC Data**.
5. Click **Start** to begin the test.
6. Choose from these display options:
   - To display the results of a previous test, click **Results**; then select and open the file.
   - Click **Clear** to clear the buffer and onscreen display of previous tests.
7. Click **Close** to exit the test.

To perform LED diagnostics:

1. Click the **LED Diagnostics** button in the lower right of any MLC tab (with the exception of the MLC/Diagnostics tab).

   A dialog box appears warning you that performing an operation on an MLC LED will require reinitializing the MLC.
2. Select the checkbox **Enable Control of MLC LED**.
3. For the **Turn MLC LED:** parameter, click the button to turn the LED on or off.
4. Click the **Help** button to display a screen showing the emitter and path of the infrared light beam, the receiver, and the light intensity variation on the receiver's side in a direction perpendicular to the light beam direction.
5. When you have finished, click the **Close** button.
6. Calibrate the MLC.

General Tab

The General tab contains retrievable records for the TrueBeam nodes, and detailed motion, beam, cooling, and power data. For troubleshooting purposes, you can also display the status of Customer Interface DIP Switch settings to display whether safety loops are enabled, and FPGA internal registers.

Node Records Subtab

To retrieve records:

1. Go to the General tab and click **Node Records**.
2. In the Nodes list, select the node record you want, as described in the following sections.
3. Use the Count data box to specify the number of records to retrieve or export.
4. Click **Retrieve** to display the records.

   To export the data, click **Export** and specify the file to save. To clear the Records display, click **Clear**.

Motion Nodes

You can display records for these individual motion nodes:

- Collimator Rotation
- MLC
- Stand Gantry
- X1 and X2 jaws
- Y1 and Y2 jaws
- Couch: Upper Lateral and Longitudinal; Lower Rotation and Vertical
- KVD Hand, Wrist, Elbow, and Shoulder
- KVS Wrist, Elbow, and Shoulder
- KVS Blade X1 and X2; KVS Blade Y1 and Y2; KVS Filter Foil; KVS Filter Shape
- MVD Hand, Wrist, and Elbow

Beam Records

You can retrieve beam records for the BGM beam and Supervisor nodes (prefaced with BGM and SPV, respectively).

The BGM beam record contains ion chamber data, target current, primary and secondary dose per pulse, gun pulse width, steering current, dose data, FPGA dosimetry data, symmetry, and more information.

Supervisor beam record contains information regarding control point (or set point), order (the position expected for the axis of interest in the next 20 ms) and status (the current position for the axis of interest) for motion axes and beam delivery.

Cooling Records

The Stand (STN) cooling system record contains information about cooling water flow and temperature readings from temperature sensors mounted at different locations.

Power Records

Power records detail power distribution for modulator auxiliary, gantry, and Stand power (STN Power) distribution components (STN APD, GPD, and SPD, respectively). These records contain data about node power, axis motions, fans, lamps, emergency off switches, motors voltage, daughterboards, and more information.

Customer Interface Subtab

This read-only display shows the status of safety loops for various TrueBeam components, including the treatment door and neutron door, and FPGA internal registers. Varian Service personnel use this display for diagnosis. Neutron doors are protective doors inside the treatment door.

The NeuCare indicators show whether the beam energies are high enough to impact (“care [about]”) the BEL safety loop and require the neutron door be closed. NeuCare Set and NeuCare Get provide a two-way check (hardware and software) to report the door status and its impact on the safety loop.

Depending on the switch settings, the requirement to close the BEL loop and thus the neutron door can range from always; to energies above 4X, 6X, 9X, 10X, 12X, or 15X; or never. Each site can program the three DIP switches (A, B, and C) for the BEL safety loop, based on the desired behavior at that site.

FPGA Internal Registers compare two sets of DIP switch settings (Neutron AB, Neutron BB, and Neutron CB; then STN Neutron AB, STN Neutron BB, STN Neutron CB); then uses these comparisons to set the remaining parameters. Green indicates the DIP switch is set and gray that it is not.

Comparisons impact these registers:

NeuCare Set—FPGA sets this register (green) based on comparing 1 and 2. The FPGA determines whether the neutron door should be closed based on the DIP switches and energy, and sends this information to the CPLD, which echoes it to NeuCare Get.

NeuCare Get —CPLD firmware sets this register based on the NeuCare Set value.

NeuState—Shows the results of the neutron door BEL impact (green if BEL is open and power stopped).

Door State—Shows whether the door is open or closed and BEL impact (green if BEL is open and power stopped).

STN NeuCare Set SB—STN software sets this register based on comparing 1 and 2.

Power Tab

The Power tab enables you to view power distribution in gantry, Stand, and modulator auxiliary components, in three separate subtabs: Gantry, Stand, and Mod Aux (modulator auxiliary components).

All tabs have options for Varian Service personnel to Override Settings and use other than configured settings; or use the Default Settings from the configuration file. Hardware state is displayed as Power Connected, Indicators at the bottom of the Power tabs show the power states of the Stand and auxiliary, gantry, and Stand power distribution printed circuit boards.

Figure 67 Power Stand tab

Next to parameters, control indicators show whether power is being supplied to a component (green) or not (gray); and whether that component is connected and functioning (green) or not (gray). Where a Control indicator is missing for a parameter, control of that component is displayed in another Service tab. Where a Status indicator is missing, the component reports status on another Service tab.

Gantry Subtab

The Gantry subtab displays the status of power controls and power to gantry components. Meter readouts show hardware connections and power readings.

Power to Nodes

These indicators show whether the following nodes (or components) are supplied power, and where indicated, the status of power at the node (or component):

- BGM (beam generation and monitoring)
- EGN (electron gun)
- COL (collimator)
- POS (positioning units); also displays power status.
- PWM (pulse width modulation); also displays power status.
- Blade (kV collimator blade); also displays power status.
- MVD (MV image detector)
- KVD (MV image detector)
- KVS (kV source)
- Vacion Gun, Accel: Vacion gun and accelerator components.

Fans

Indicators show whether power is supplied to the primary and secondary 28 V (and their power status) and to the gantry fans.

Power Shelves

These indicators show 120 V AC power to primary and secondary power shelves, provided for future expansion of AC loads.

Axis Motion

These indicators show power supplied to the Jaws and Collimator Rotation axes, and whether those axes are powered.

Field Lamps

Indicators show whether power is supplied to the primary and secondary field lamp bulbs and the field lamp DC/DC power source with soft-start.

Meter readouts show lamp voltages and current.

Other Gantry Power

These indicators show power supplied to the digitization unit, laser backpointer, MLC, and range finder (Optical Distance Indicator), and whether those components are powered. You can also view whether:

- The oil pump reports that it is powered.
- Power is supplied to the primary and secondary accent lights.

Control Power

Indicators show the status of phases A and B of 120 V AC control power.

Motors Voltage

Meter readout data boxes show the actual voltage and actual current of 24 V and 28 V motors.

For spare outputs, indicators show whether power is supplied to 28 V DC primary and secondary spare outputs, and whether these outputs are powered. Also displayed is whether power is on to primary and secondary spare AC power connections.

Stand Subtab

The Stand subtab displays the status of power controls and supplies to Stand components. Meter readouts show hardware connections and power readings.

Power to Nodes

These indicators show power supplied to various nodes, including the Supervisor (SPV), and Stand components. Nodes include SPV, MOD (modulator), RFSPS (radio frequency (RF) source power supply, CCHU and CCHL (upper and lower couch), and MOD AUX (modulator auxiliary). Components include klystron vacion, laser guard, and RF driver. Control indicators also display the on-off status of console power, 48 V, 96 V , and 28 V power.

Status indicators display that power is on or off to the Supervisor and klystron vacion.

Mode Control

Mode Control indicators display whether emergency off power will be removed immediately or after a delay on pressing the Emergency Stop button or using an emergency off switch.

Axis Motion

Axis Motion indicators display 24 V AC power supplied to motors for the gantry and couch motor drivers (Gantry Soloist 24 V and Couch Soloist 24 V, respectively); and 28 V DC power supplied for couch lateral, longitudinal, and rotational movements. Status indicators show whether these motors report being powered.

Lift and Gantry Power Status

These indicators show the status of Gantry brake 24 V power, Gantry AC power, lift brake 28 V power, and lift AC power.

Fans

These indicators show whether the primary and secondary DC and AC fans are supplied power; you can view whether the DC fans report being powered.

RJB Relays

These indicators show components energized by relays that switch customer-provided AC power to light sources. The SPD supplies power through the customer terminal board (CTB) to the Relay Junction Box (RJB)

Indicators show whether these relays are supplied power, and whether the relays report being powered:

- Megavolt (MV) Ready
- Kilovolt (kV) generator
- kV Beam On
- Room lasers and lights, to allow control from a pendant
- Spare relay
- Beam Off light

RJB Doors/Supplies

Customer IF [interface] 24 V circuitry controls customer-supplied devices and spare switches, such as for monitoring equipment or secondary dosimetry systems. This indicator shows whether the customer circuits are powered, and the status they report.

The AC Out and AC Door Monitor indicators show the power status of treatment door interlocks: whether the door is closed (AC Out), and whether the closed door condition clears the interlock; if not, another error condition may be present (AC Door Monitor).

Stereotactic Disable

These indicators show whether power is supplied to controls at the gantry and couch that restrict selected axis motion during stereotactic treatments, when dose is applied at narrow angles. Status indicators show whether these controls are powered.

Emergency Off Switches

In case of a power loss, emergency power is available to move the couch and gantry rotation as necessary so that a patient can be removed from the treatment room.

Supplied with fused 24 V power from the SPD, the emergency off system has a 24 V backup battery that provides power for at least 10 minutes. The battery is charged from the 28 V DC source on the SPD.

Status indicators show whether the EMO Good circuitry that controls the emergency machine off (EMO) functions is on and connected to the Emergency Stop controls on control console (DKB), Stand, couch, and [treatment] room.

EMOPs

EMOPs indicators show the power status of emergency off circuitry.:

- EMOPs enabled
- Drive fault
- Couch (1) Gantry (0) EMOP select. Shows switch selected (1) on the EMOPs control panel in the Stand, to provide voltage to charge the batteries in the emergency power system. The default switch is the couch; Varian service personnel can switch the setting to the gantry for some gantry operations.

A meter readout shows the actual voltage of 24 V battery monitoring.

Stand Daughterboard

Meter readouts show the actual voltages supplied to the following components on the Stand daughterboard:

- 5 V Supervisor
- 24 V
- 28 V
- EMO loop current
- Primary and secondary field lamp bulbs.

Mod Aux Subtab

The Mod Aux subtab displays the status of power controls and power to auxiliary components. Meter readouts show hardware connections and power readings. Use this tab to monitor power to APD PCB components described in the following sections.

Aux Power

Indicators show the status of K5 Stand power and power to the K6 water pump. K5 and K6 are resistors that control the current when the transformer starts up and power surges.

Motors

Indicators show the status of 28 V DC power; three-phase, 230 V AC power; and ±120 V control power to the gantry, couch lift, imaging, and fan motors.

Filaments

Indicators show the status of control from the klystron filament transformer to the klystron in the Stand, and the status of power from the thyratron filament transformer to the thyratrons in the PFN.

Daughterboard

Meter readout data boxes show the actual voltage to the following components in the APD daughterboard:

- 12 V Beam On fail-safe circuit
- 24 V and 28 V input

Mains Transformers Interlock String

Indicators show the status of power to components of the interlock string for the mains transformers. When any of these contactors open, an interlock is tripped to shut off power:

- Room emergency off EMOFF6
- EMO Good
- Phase monitor
- Transformer overload Ok
- Mains switch S2
- Overtemp Switch OK
- PEL enable
- K8 main power (shuts off main power).
- K7 mains soft-start (limits in-rush current to the mains transformer power).

PFN Interlock String

Indicators show the status of power to components of the interlock string for the pulse forming network. When any of these contactors open, an interlock is tripped to shut off power to the PFN network:

- CBAR2 AC door.
- PFN overload OK
- PFN switch S1
- Beam loop 120V
- Mode A (K3); contactor for the PFN modulator mode A (low).
- Mode B (K4); contactor for the PFN modulator mode B (high).
- Mode selected
- Beam On kHV 2.
- kHV 1 ON (K1 coil)
- kHV+ (K1 closed)
- K2 PFN soft start

Cooling Tab

The Cooling tab shows readings for SF_6 gas pressure, water temperature, water flow, and water pump speed. An indicator shows the water level. Controls enable Varian Service personnel to turn the SF6 gas valve and water valve on and off.

See Chapter 11, “Cooling System,” for more information on these options and a schematic of the cooling system.

Carousel Tab

The Carousel tab contains controls, meter readouts, and indicators that show the status of foils and filters, initial axes, beam axes, and the field light. This tab has four subtabs: Foils/Filters, Init Axis, Beam Axis, and Field Light.

Commands

This option (which does not appear on the Foils/Filter tab) displays additional initialization and calibration commands.

In addition, Activate Record Retrieval allows retrieving raw axis information from captured files for diagnostic purposes, so that Varian Service personnel can see the behavior of the axis. This option is used with the Beam Axis tab, when tuning or calibrating the beam. For more information, see “General Tab” on page 240.

Indicators

Indicators at the bottom of all Carousel screens show the connection state of the six nodes:

- Beam Generation and Monitoring
- BGM POS, the BGM positioning subnode that controls the position of the Energy Switch, target, foils and filters, longitudinal (Y-stage) carousel, and ion chamber axes (position).
- RF Power Supply
- Modulator
- Electron Gun
- Pulse Width Modulation

Foils/Filters Subtab

The Foils/Filters subtab contains controls, meter readouts for X-ray filter and electron foil ports, and filter positions.

X-ray Filter Ports

Each numbered port displays the X-ray energy filter that is installed.

Mirror

Indicates the position of the mirror on the carousel that is used to project the field lights to simulate the beam position.

Electron Foil Ports

Each numbered port displays the electron energy foil that is installed.

Run Mode

Uses plan positions for foils and filters.

Manual Mode

Clicking the **Manual Mode** button allows manually adjusting positions for the carousel radial and transverse axes, as well as the ion chamber, target, and Energy Switch axes.

Click the **Drive To** button to move an axis to the programmed position. The Moving indicator shows whether an axis moving.

Open Port

This area displays the port assigned to have no foil or filter in it to affect the raw beam, for tuning electron energies and testing. This area is accessible to advanced and HASP users, and will otherwise appear empty.

Init Axis Subtab

The Init Axis subtab shows the current locations of the carousel in radial and transverse positions; the ion chamber target; and Energy Switch. Programmed and actual positions are shown for these parameters:

- Position shows the configured and reported axis location.
- Motor Current is the power supplied to the axis.
- Home Switch is the location of the axis limit start position.
- Opposite Switch is the location of the axis limit switch's other position.
- Travel Range is the range the axis can move between its home and opposite switch positions.
- Resolver Angle shows the value required to get to the Position value.
- Backlash (Raw) (not used for Energy Switch) is the count to overshoot a mechanical end stop before returning to an exact position.

Commands

If Commands is selected, additional buttons and indicators appear, to allow Varian Service personnel to edit and monitor settings.

Initialize—Initialize selected axes. For radial axes, the Initialize All allows initializing all axes. Initialization applies the calibration data to the axis position (a process called "homing"), to tell the node where the axis is.

Calibrate—When unlocked, calibrates axis. For radial axes, the Calibrate All allows calibrating all axes.

Acquire—Retrieves calibration data for the selected node.

Acquire All—Retrieves all calibration data for the nodes.

Moving, Home, Opposite, Initialized Indicators—In each area, shows whether the specific axis is currently moving, whether it has reached the home or opposite switch position, and whether it has been initialized.

You can also retrieve node records for diagnostics; see "General Tab" on page 240.

Beam Axis Subtab

The Beam Axis subtab contains controls for tuning and calibrating the beam. It includes controls and indicators for the carousel in radial and transverse positions, as well as for the ion chamber, target, and Energy Switch nodes. To display values, Varian Service personnel must first prepare the beam.

The port location of a filter is noted in Filter Port Number. Information includes axis initialization and calibration controls, meter readouts, and status indicators for programmed and actual positions.

For all axes, the Beam Axis tab displays these values; the radial and transverse axes include additional parameters.

Motor Current—Is the power supplied to the axis by the power distribution system.

Position—Is the axis base (factory or startup) position plus offset from the configured position. This can be adjusted for the ion chamber, target, and Energy Switch.

Expected Secondary Position—Shows the sensor's readout of the axis position. (There is no SPRO sensor readout value for the Energy Switch).

Moving and Initialized—Shows whether the axis is moving and initialized.

Base Polar (Carousel Radial and Transverse)—A constant value used to calculate the new position, when the axis offset is applied. The base position is set by the factory or on startup.

Acquire All Expected Sec Pos button —Allows acquiring and displaying position data for all axes from the SPRO sensor. This appears when Commands is selected.

Field Light Subtab

Use this screen to view the status of the Field Light bulbs. For information on the carousel radial and transverse, and ion chamber displays, which also appear on the Beam Axis tab, see "Beam Axis Subtab" on page 253.

Field Light —Clicking this button turns the field light on or off (bulb 1 by default), and moves the field light into position, where it can project upward onto the carousel mirror. Green indicates the bulb is on and in position; gray means the bulb is not turned on; red indicates the bulb is burned out. The SPV uses bulb 1 60% of the time, and bulb 2 40% of the time. However, if the carousel is already at position for a bulb, the carousel will use the positioned bulb.

To move bulb 2 into position, select Bulb 2 and then click **Field Light**.

Light Timer—Sets how long the field light will remain on, between 5 and 15 minutes; the default is 10 minutes.

Mimic Treatment Room Field Light—Clicking the checkbox enables the field light, in Service mode, to mimic the way it operates when the treatment room door is opened.

Safety Loops Tab

The Safety Loops tab contains indicators that show active safety loops in TrueBeam components, as well as schematics of the safety and emergency machine off (EMO) loops, and voltages at which loops are enabled.

The Safety Loop tab includes three subtabs:

- Safety Loops. Click to choose a safety loop schematic to view—Power (PEL), Motion (MEL), Beam (BEL), kV Beam (KVBEL), or Collimator Controller. These are described in the sections that follow.
- EMO Loops. Click to choose a schematic to view for an emergency machine off (EMO) loop—Main, Modulator, Couch, or Customer.
- Safety Loop Voltages displays readouts of voltages for the components within a safety loop.

Indicators show the on (green) or off (gray) state for signals (sent to and received by node or relay) and switches (which are green if closed, or gray if open).

A pair of indicators for a component shows that the safety loop affects that component. When both indicators are green, the safety loop is closed.

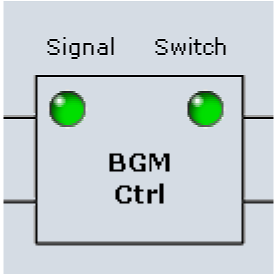


Figure 68 Active Signal and Switch Indicators

Power Enable Loop

The Power Enable loop section shows safety loops in the following TrueBeam components:

- Upper and lower couches
- Couch patch (relay connecting upper and lower couch)
- Stand controller
- BGM controller
- Collimator controller
- Kilovolt detector
- Kilovolt source
- X-ray imager
- Stand gantry, stand, and auxiliary power distribution systems
- Auxiliary power distribution daughterboard

Motion Enable Loop

The Motion Enable loop section shows safety loops in the same components listed in the previous section, “Power Enable Loop,” plus the MV detector. Not shown are the gantry power distribution system and stand daughterboard.

Beam Enable Loop

The Beam Enable loop section shows safety loops in the same components listed in the section "Power Enable Loop" on page 255, plus these beam generation and monitoring components:

- Pulse width modulation
- Positioning
- Modulator
- Radio frequency power supply
- Electron gun

The megavolt detector is also shown.

Collimator Controller

The Collimator Controller section shows the connections for the following BEL, MEL, and PEL switches:

- MicroBlaze processor (MB)
- Peripheral component interconnect (PCI)
- Field Programmable Gate Array (FPGA)
- Multileaf collimator (MLC) MB
- MLC PCI
- MLC FPGA

Connections for the following BEL, MEL, and PEL signals are shown:

- FPGA
- MLC FPGA

For more information on safety loops, see Appendix D, "Safety Loops," on page 283.

Axis Tab

The Axis tab contains readouts and indicators that show the actual positions and power and initialization states of axes in jaws, the gantry and collimator, couch, and couch PCBs. Additional Axis tab data includes temperatures, couch velocity, and switch and calibration status. Calibration and initialization controls are also provided.

The Axis tab includes four subtabs: Jaws, Gantry/Coll, Couch, and Couch PCBs.

Status and Taskbar

At the bottom of the screen for all subtabs, indicators show the connection status of the collimator, lower and upper couches, and the Stand (nodes). Indicators are green if the node—and all its related subsystems—is running and reporting status.

The taskbar includes **Save Configuration** and **Close** buttons to save changes to node configurations or close without saving.

Jaws Subtab

The Jaws subtab contains meter readouts and indicators that show axis positions and initialization states of the X and Y jaws. Controls enable you to initialize and calibrate the jaws.

Readouts

The Actual data boxes show the active values for each of the measured positions, currents, gains, and offsets.

Secondary Position—Is based on the isocenter and provided by sensors at the axis.

Motor Current—Is the value reported by the axis.

Primary ISO Gain—Is the primary isocenter gain.

Primary ISO Offset—Is the primary isocenter offset.

Primary Phys Pos—Is the physical position reported by the primary sensor.

Secondary Phys Pos—Is the physical position reported by the secondary sensor.

Indicators

These show the status of the axis and switches—whether the axis is at limits.

Axis State—Is initialized, uninitialized, ready, or moving.

Outer Limit Sw—Outer limit switch; green means the axis is at this limit, gray that it is not.

Inner Limit Sw—Inner limit switch; green means the axis is at this limit, gray that it is not.

Collision Limit Sw—Collision limit switch; green means the axis is at this limit, gray that it is not.

Initialized—Green means the axis is initialized, gray that it is not.

Calibrated—Green means the axis is calibrated, gray that it is not.

Buttons

Each pair of jaws can be initialized and calibrated, and each individual jaw can be calibrated based on the field light readout. Jaws are calibrated against two points (0 and 20 cm), to move equipment into position.

Initialize [X, Y] Jaws—Initializes selected jaw axis. Initialization applies the calibration data to the axis position (a process called "homing"), to tell the node where the axis is.

Calibrate [X, Y] Jaws—Uses an internal reference, set by external measuring devices, to determine how far the jaw can move in relation to the isocenter. Calibration is done at installation and periodically for quality assurance.

System Calibrate—Uses field light readout position to manually correct the Calibrate Jaws adjustment, by mechanically finding the limits of the component. This command ensures that the jaws are aligned to the isocenter and positioned accurately by applying position offsets.

Gantry/Coll Subtab

The Gantry/Coll subtab shows actual gantry and collimator rotation positions and axis initialization states. Indicators show the status of switches. Control buttons enable you to initialize axes and calibrate rotations.

Indicators

Collision Override—Green means the collision system has been overridden by the operator.

Touch Guard—Green means the sensor touch guard system is active.

Gantry Rotation

These values show single-point calibration, in relation to the isocenter.

Secondary Position—Is the angle reported by the secondary sensor.

Motor Current—Is the value reported by the axis.

Axis State—Is initialized, uninitialized, ready, or moving.

Calibrated—Green means the axis has been calibrated.

External Reference (Using Level) Calibrate—Provides calibration based on actual position, after the axis has been set using an external reference, a standard calibration level.

Gantry Image—Shows the angles of rotation for the gantry based on the scale selected for the system, Varian IEC or IEC 1217 (see Figure 64 on page 210).

Collimator Rotation

These values show single-point calibration, in relation to the isocenter.

Secondary Position—Is based on the isocenter and provided by sensors at the axis.

Motor Current—Is the value reported by the axis.

Primary ISO Gain—Is the primary isocenter gain.

Primary ISO Offset—Is the primary isocenter offset.

Initialize—Initializes the collimator rotation by applying the internal calibration data to the axis position, to tell the node where the axis is.

Calibrate—Uses an internal reference to determine how far the axis can move in relation to the isocenter. Calibration is done at installation and periodically for quality assurance.

Axis State—Is initialized, uninitialized, ready, or moving.

Home Limit Sw—Green means the axis is at the home limit switch.

Opposite Limit Sw—Green means the axis is at the opposite limit switch.

Initialized—Green means the axis has been initialized.

Calibrated—Green means the axis has been calibrated.

External Reference (Using Level) Calibrate—Provides calibration based on actual position, after the axis has been set using an external reference, a standard calibration level.

Collimator Image—Shows the angles of rotation for the collimator based on the scale selected for the system, Varian IEC or IEC 1217 (see Figure 64 on page 210).

Couch Subtab

The Couch subtab shows couch vertical, longitudinal, lateral, and rotational axes, motor data, and velocity. Indicators show the on or off status of switches. The couch images represent the axis, with the isocenter shown as a red cross. Buttons enable you to calibrate axes.

Readouts

Secondary Position—Is based on the isocenter and provided by sensors at the axis.

Tertiary Position—For the couch rotation axis only, is based on the isocenter and provided by sensors at the axis.

Motor Encoder—Is the sensor value at the axis.

Motor Current—Reports the current output at the axis.

Velocity—Shows the speed that the axis is moving.

Axis State—Is initialized, uninitialized, ready, or moving.

Indicators

Brake—For couch vertical and rotation axes, indicates whether the brake is set.

Switch A—Green means the axis is at the upper limit switch.

Switch B—Green means the axis is at the lower limit switch.

Calibrated—Green means the axis has been calibrated.

Buttons

The **Calibrate** button allows using an internal reference to determine how far the axis can move in relation to the isocenter. Calibration is done at installation and periodically for quality assurance.

Couch PCBs Subtab

The Couch PCBs subtab shows the actual power in upper couch and lower couch control boards, and the PCBs actual temperature. Table 11 shows the readout labels.

Table 11 Couch PCB Power Readings

<table>
<tr><th>Upper Couch PCB</th><th>Lower Couch PCB</th></tr>
<tr><td colspan="2">12 V
1.2 V
1.8 V
2.5 V
2.5 V Ref (reflected power)
–2.7 VA
+2.7 VA
3.0 V
3.3 V
5 V
–5 V
+5 VA
–5 V Ref
+5 V Ref
P 24 V
PD 5 V (power driver)
PD 28 V 1
PD 28 V 1
V Sensor</td></tr>
<tr><td>Lat Clutch I
(lateral clutch current)</td><td>Lift Motor Current</td></tr>
</table>

Table 11 Couch PCB Power Readings

Upper Couch PCB	Lower Couch PCB
Lng Clutch I (longitudinal clutch current)	Rtn Brake Current (rotation brake)
Lat Brake I (lateral brake current)	Lift Brake Current
Long Brake I (longitudinal brake current)	Lift Brake Current
Board Temperature	Board Temperature

Accessories Tab

The Accessories tab contains readouts and indicators that show details about these accessories: Interface (slot 1), Accessory (slot 2), Electron (slot 4), and Compensator (slot 3).

Illustrations show accessory slot locations.

Status—Shows whether power is on (green) or off (unlit) to the accessory.

Code—Displays the programmed and actual optical codes, used to match the accessory with the patient.

Name—Shows the actual accessory name.

State—Displays whether an accessory is installed.

Switches—Show the power on (green) or off (gray) status. Latch switch is green when the accessory is properly installed and latched in place. Other switches are gray if no accessory is installed. If an accessory is installed, a green Right or Left Post switch on the Interface mount or Latch Switch (on all other accessory mounts) indicate the accessory is installed and properly seated; a red light indicates the accessory is improperly mounted.

Input Devices Tab

The Input Devices tab includes six subtabs to diagnose the functionality of these input devices: pendant (left, right, and Stand, which is used only by Varian Service personnel), couch side panel (left and right), and control console.

Each subtab contains illustrations of input devices. Clicking the **Bypass** button enables you to verify that the simulated input devices and the workstation are communicating. For example, when you click the **MLC** button on the simulated pendant, the MLC button on the illustrated pendant in the Input Devices tab turns green, indicating that the MLC button is "pressed."

The **Run** button returns the device to normal operation.

A status bar at the bottom of the screen shows whether the input devices are being simulated and communicating with the workstation. (green) or not (gray). A red button indicates that the device is not connected (for example, when the CCH node is not present.)

Versions Tab

The Versions tab contains information about versions of installed components, including:

- Hardware: name, product code, serial number, and installation date.
- Software: application, version, and installation date.
- PCBs: name, serial number, and version.
- Firmware: name and version.

Control buttons enable you to refresh the Versions screen and export data to an XML file in C:\VMSOS\AppData\TDSService\Versions.

CBCT Reconstructor Tab

This tab is identical to the CBCT Reconstructor tab in the System Administration application. For more information, see "CBCT Reconstructor" on page 76.

Settings Tab

The Settings tab allow overriding the Treatment application and controlling motion when the treatment door is open or between multiple axes. This tab also allows deactivating Imaging system components while still permitting treatment.

Tabs include System Status, Limp Along, and Zone Rules.

System Status

Controls allow moving axes when the treatment door is open and overriding a reset of the Collision Override button. They can be set only by Varian Service personnel.

Enable DKB Motion of Targeted Axes When Door Open—When on, allows moving axes from the control console when the treatment door is open and the pendant is out of its cradle. This setting cannot be saved and will not carry over to Treatment mode.

Allow DKB Motion Continuation of External Axes When Door Open—

When on, allows continuing to move axes from the control console when the treatment door is open. This setting overrides the Treatment application, remains in effect in Treatment mode, and can be saved.

Sticky Collision Override—When on, this option takes precedence over the requirement to reset the Collision Override button if it is tripped. This setting cannot be saved and will not carry over to Treatment mode. Normally, the Collision Override button must be reset after a collision before motion can resume.

Imager Deactivation Subtab

This subtab allows isolating selected imaging system components while still allowing beam delivery. Hardware changes also are required, as noted in the instructions on how to deactivate the component safely.

Columns list the imaging system, whether it is operating normally and activated; deactivated; or status is unknown; actions necessary to deactivate the component; and instructions if components are to be deactivated or activated.

Six different modules within the X-ray Imaging system can be deactivated or activated.

MVD PU—Controls the MV detector positioning unit.

MV IDU, XI MV Module, DU—Controls the MV imaging detector unit, XI MV image acquisition module, and digitizing unit.

KVS and KVD—Control the kV source and detector units, respectively.

KV IDU, XI KV Module, XI Power Supply—Controls the kV imaging detector unit, XI kV image acquisition module, and X-ray Imaging system power supply.

NDI Camera, XI Power Supply—Controls the infrared camera used for respiratory gating and the power supply for the X-ray Imaging system.

XI Failure and XI I/O Module—Controls the input/output module for the X-ray Imaging system.A status bar at the bottom of the screen shows the connection status of the imaging node as connected (green) or disconnected (red).

Zone Rules Subtab

This subtab displays the possible positions of multiple axes, used by the Supervisor to avoid collisions, and specified in the configuration file. System restrictions allow the user to adjust positions by ± 5° (± 15° for the collimator) for angular axes and ± 1 cm for linear axes. Restrictions apply to Treatment mode only.

The Restore Defaults option allows resetting values to those in the configuration file.

Values are given for zone (for example, a defined rotational arc of the gantry), and start and end positions for both the reference (or check) axis and the restricted (or remote) axis. Values for linear axes positions appear in centimeters, and for angular axes in degrees.

Ten separate axes rules are shown; where a data box is empty, the valued used is the limit set in the configuration file.

1. Gantry Restricted by Couch Vertical High—Shows Couch Vertical positions that restrict the Gantry Rotation position in one zone.

2. Gantry Restricted by Couch Vertical Low—Shows Couch Vertical positions that restrict the Gantry Rotation positions in two zones.

3. Gantry Restricted by Couch Rotational
4. Gantry Restricted by Couch Rotational—Show Couch Rotation positions that restrict Gantry Rotation positions.

5. Gantry Restricted by Couch Lateral
6. Gantry Restricted by Couch Lateral—Show Couch Lateral positions that restrict Gantry Rotation positions.

7. Couch Vertical Restricted by Gantry—Shows Gantry Rotation positions that restrict Couch Vertical positions.

8. Couch Vertical Restricted by Gantry—Shows Gantry Rotation positions that restrict Couch Vertical positions in two zones.

9. Gantry Restricted by Couch Rotation and Couch Longitudinal —
10. Gantry Restricted by Couch Rotation and Couch Longitudinal—

Shows combination of Couch Rotation and Longitudinal that restrict Gantry Rotation positions.

XI Tab

The XI tab enables you to acquire images, perform tasks, and view readouts. The three XI subtabs each have additional tabs concerning MV imaging, kV imaging, imaging plans, generic tasks and readouts, and tasks. Tabs are displayed only when X-ray imagers are installed. For example, the kV tab is displayed when a kV imager is installed; the Tracking section with tracking data is displayed when a tracking source is installed.

Acquisition Subtab

The Acquisition subtab includes the tabs MV, kV, and Plans. MV and kV tabs have columns with listings for image mode, type, resolution, and acquisition mode; and corresponding notes for each item.

MV and kV Parameter Modification

Clicking a listing displays parameters that you can modify and options that you can select to configure image acquisition during Treatment mode only. A check button appears next to adjusted parameters that can be permanently adjusted (namely, number of frames and dose per frame for clinical modes); clicking the button approves the change. Most parameters can be changed only temporarily. (Figure 69). After parameters have been modified, imager arms must be recalibrated.

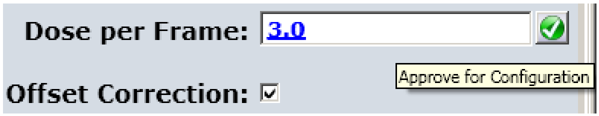


Figure 69 Approval Check Button

To save changes, click **Save Configuration**. Unapproved changes are automatically discarded when you select another image mode.

MV and kV Beam Preparation

MV Highres and MV Lowres modes require beam preparation before image acquisition.

kV Modes Not Requiring Beam Preparation—With the exception of the following modes, all kV modes require beam preparation:

- DualGain-AO
- DualGainHighKV-AO
- DualGainLowKV-AO
- DynamicGain-AO
- HighQuality-AO
- LowDose-AO
- DualGain-DF
- DualGainHighKV-DF
- DualGainLowKV-DF
- DynamicGain-DF
- HighQuality-DF
- LowDose-DF
- Test
- TestContinuous
- TestDualGain
- TestDynamicGain
- TestSingleGain

MV Modes Not Requiring Beam Preparation—Beam preparation before image acquisition is supported for all MV modes except:

- Highres
- Lowres
- Highres-DF
- Lowres-DF
- NoSync-DF
- NoSyncDRI-DF
- Sync-DF
- Test
- TestContinuous
- TestSingleGain

DF and Test Modes—Beam preparation before image acquisition is not supported for all dark field (DF) modes and all Test modes.

MV and kV Spontaneous Acquisition

Image modes that do not require beam preparation allow acquiring images spontaneously.

Clicking the **Acquire** button prepares and triggers image acquisition. The image is displayed in the currently selected view and a new entry is added to the gallery.

For continuous acquisition, click the **Acquire** button, which functions as an on-off toggle switch; click the button again to stop acquisition. The first image, last image, and one image per 10 elapsed seconds are saved.

Plans

The Plans tab lists imaging plans with predefined parameters that require beam preparation in two columns.

The first column lists the type of components involved. If a component is not installed, no plans involving it are listed. The second column lists the imaging plan name.

Tasks Subtab

The Tasks subtab enables you to perform various imager maintenance and calibration tasks.

MV—Includes tasks to upgrade the DU (digitizer unit) firmware, test the imaging chain, acquire a DU offset image, delete calibration files and upload calibration images.

kV—Include tasks to get generator diagnostics; update generator software, configure or calibrate the kV tube, test the imaging chain, delete calibration files, and upload calibration images.

Generic—Include tasks to get diagnostics, upload files, back up or restore calibrations, test the imaging network, and control the imaging power supply.

Completed—Shows the status of completed tasks.

Readouts Subtab

This subtab displays three different types of information, accessed by clicking the respective button, for different time scales.

MV—Shows the temperatures of the MV module and DU (digitizer unit); DU voltages and current.

kV—Shows information on the kV module temperatures, norm chamber, kV generator, and power supply.

Generic—Shows information on CPU, memory, and network usage; PC and input/output temperatures; PC fans; and power supply information for the Imaging system and NDI Camera.

PVA Calibration Tab

The Service/PVA Calibration tab is used to calibrate the MV and kV imagers and imaging modes. This process uses the Imager Calibration application to acquire an image and then use it to calibrate the imager or the imaging modes.

The workspace for the various imaging-related calibrations uses three main Imager Calibration screens: Summary, Details, and Calibrate, accessed by clicking the buttons in the PVA Calibration tab.

The Summary and Details screens color-code calibration data:

- Green indicates a mode was calibrated successfully, and the calibration is still valid.
- Red mean the mode has been calibrated, but the calibration data has expired.
- Gray means the calibration step has not been activated; it may require other steps to be calibrated first.

Users with advanced user rights can define the validity period of each calibration step for each imaging mode using the System Administration workspace. Users are responsible for setting and applying your own calibration intervals.

To start the Imager Calibration application:

1. Choose an option:
   - Start the Service application. For instructions, see “Starting Service” on page 47.
   - At the TrueBeam workstation, click **Imager Calibration** in the Select Major Mode menu. When prompted, enter your user name and password. The Service startup screen appears, showing the system status.
2. In the Imager Calibration Summary screen that appears, select an imaging mode to calibrate.

   To select multiple imaging modes to calibrate simultaneously, drag or **Ctrl-click** the cells with the calibration steps you want to use.

   For more information on an imaging mode to calibrate, click the **Details** button; or right-click an imaging mode in the Summary screen, and choose **Details** from the context menu.
3. Click the **Calibrate** button and follow the onscreen instructions.

For complete information on imaging calibration, see *TrueBeam Technical Reference Guide – Volume 2: Imaging*.

Summary Subtab

This subtab shows overview information on each imaging mode, including its name, energy, dose rate; and information on dark field and flood field calibration data, pixel correction, beam profile, and dose normalization calibrations. Also included are controls for acquiring test and test arc images.

This screen opens by default when you start the Imager Calibration application. It displays the MV, kV, and CBCT imaging modes and their calibrations in the preferred order of execution.

Details Subtab

This subtab displays information on the MV, kV, and CBCT imaging modes, including mode name, status of calibration (calibrated, not calibrated, or expired); date of calibration; and when calibration expires.

You display this screen either by clicking the **Details** button in the PVA Calibration tab, or clicking a calibration mode in the Summary screen.

Calibrate

Clicking this button displays the Image Acquisition workspace. This workspace uses a wizard to step you automatically to the next calibration task for the selected steps, prompt you to take any needed actions, and display the status of the calibration. When calibration is complete, you can accept or decline the calibration. You must save the calibration before exiting the Imager Calibration application; if not, all data from your current calibration mode will be lost.

Administration Subtab

Using the Administration workspace of the Imager Calibration application, you can configure all relevant settings for the acquisition of images and the calibration of the imaging system, to include:

- Communication parameters for the imaging system and the CBCT Reconstructor.
- Parameters for warming up the kV X-ray tube.
- Validity period for each type of calibration step.
- Logging levels per category and different data storage options.

In addition, you can:

- Edit kV templates, as well as add and delete them
- Acknowledge and override faults and interlocks in the system.

About Subtab

Displays information about three areas: Imaging, Automatic Workflow Management, and General.

Imaging Sources—Contains three subareas: X-Ray Imaging Sources, CBCT Reconstructor, and Unused Imager Position.

In X-ray Imaging System, click the check boxes to enable or disable the X-Ray Imaging System, the MV and kV imaging sources, and the Gating Camera.

In CBCT Reconstructor, click the check box to enable or disable the CBCT Reconstructor.

In Unused Imager Position, define the behavior of an unused imager arm. Controls in this area include a Send Targets check box and three option buttons: Mid, Retracted, and Based on Actuals. Deselecting Send Targets means that no target positions will be sent for an unused imager arm; the unused arm can remain at its current position. Selecting Send Targets allows choosing one of three behaviors for the imager arm:

- **Midrange** moves an unused imager arm to the mid-range position.
- **Retracted** retracts the imager arm.
- **Based on Actuals** moves the imager arm to the target position depending on its actual (current) position, which could be extended, mid-range, or retracted.

Automatic Workflow Management—Automatic workflow management guides an operator through the entire imaging process by automatically activating or deactivating the appropriate workspaces. Check boxes enable you to turn on or off the following workflows:

- Paired Acquisition: Automatically selects the next image to be acquired.
- Topogram Acquisition: After the topogram has been acquired, automatically activates the CBCT acquisition workspace.
- 3D-3D Match: After the CBCT has been acquired, automatically activates the 3D3D Match workspace.
- 2D-2D Match: After the two orthogonal images have been acquired, automatically activates the 2D2D Match workspace.
- 2D Match Plan Procedure: After the image of the plan procedure has been acquired, automatically activates the 2D Match workspace.
- 2D Match Beam Procedure: After the image of the beam procedure has been acquired, automatically activates the 2D Match workspace.
- Marker Match: After the two orthogonal images have been acquired, automatically activates the Marker Match workspace.

General—This area includes the Use Object Related Settings option, which stores volatile object-related settings. Storing settings can streamline processes, such as defining the window or level setting for images. It also allows using 6DoF for matching.

Configuration Subtab

This tab has four subtabs.

Installation—This subtab has two areas: Energies, where you view beam energies and dose rates, and MLC, where you can enter an ID for the multileaf collimator. The MLC ID is an alphanumeric field that matches the corresponding ID in the RadOnc Management system. To enter the ID, double-click the ID column and type.

General—This subtab includes two areas: Geometric Parameters and Couch Positions.

In Geometric Parameters, you can select AutoSetup and AutoGoTo motion permissions for moving blades, the gantry, collimator and collimator jaws, and the couch. (These features are not available for the imager arms.) AutoSetup and AutoGoTo motion permissions include:

- Instant: As soon as target positions are set, axes immediately move; an operator does not have to use pendants, side panels, or the control console.
- Remote: Axes can be moved (with pendants or side panels) inside the treatment room or (with the control console) from the console area.
- InRoom: Axes can be moved only with pendants or side panels.
- None: Moving axes requires using thumbwheels and Motion Enable buttons.

In Couch Positions, you can change the values for couch longitudinal settings by double-clicking the Value column.

Accessories—This subtab includes four areas where you can view information about wedges, applicators, other accessories (such as apertures and custom add-ons), and slots.

Energy Config—This parameter can be used only by Varian Service to display the factory configuration settings and copy the energy tuning parameters.

Synchronization Subtab

The Synchronization tab contains three subtabs: Backup, Export, and Restore. Clicking a subtab button displays controls for specifying the TrueBeam configuration files that you want copied (backed up), exported, and restored. File formats include WOX (Web Objects in XML) and XML (Extensible Markup Language). Using Export, you can export the current machine configuration file to the RadOnc Management system (ARIA software).

Common to all Synchronization subtabs is a **Browse (...)** button for opening a browser window to navigate to backup, export, and restore destinations for files. Each subtab also has a progress window for copy, export, and restore file operations.

Service Preferences Subtab

The Service Preferences tab contains two areas: Custom User Settings and AutoStartTime. Changing a parameter in this tab also affects both Service and Treatment applications.

In Custom User Settings, you can customize the date and time format and the size of records or you can select the default settings. In AutoStartTime, you can specify the time and days for the TrueBeam to automatically start; the machine will transition from Standby to On.

Tools Subtab

The Tools tab contains three subtabs.

The Flash Tools subtab has tools that can be used only by Varian service technicians.

The Services subtab allows start, stop, and restart of the Varian TrueBeam Model Service. Only Varian service technicians can stop and restart Axeda services.

Reboot IRM subtab has these sections:

- In **IRM**, clicking the button reboots the in-room computer, which runs the in-room monitors.
- **Duplicate Access in Treatment Room**, when enabled, launches the virtual network computing (VNC) viewer on the IRM computer and allows remote access to the workstation; the IRM computer can then perform all functions as if done at the console workstation.
- **Research Application** allows use of a research application with the TrueBeam.
- **Keyboard Shortcuts** allows using Windows shortcuts with the Service application.
- In the **IP Address** section, you can browse to and load the simple time server address, to automatically update the time display for the local time zone.
- The Progress window shows activity during rebooting; click **Clear** to clear the display.
- **Node Config** displays the configuration for the selected node and allows editing the node in the System Admin application. Select a node from the Nodes menu, and then click **View Configuration**.

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Appendix B Shortcuts

Use the shortcuts in this appendix to simplify performing keyboard commands and save time.

Ctrl + Key	Description
Ctrl+F	Show the Find All Files dialog box.
Ctrl+G	Open the Go To Folder dialog box.
Ctrl+N	Open the New dialog box.
Ctrl+O	Open the Open dialog box.
Ctrl+P	Open the Print dialog box.
Ctrl+S	Open the Save dialog box.
Ctrl+Esc	Show the Start menu.
Ctrl+Alt+Del	Log off, shut down, and open the Task Manager.
Alt + Key	
Alt+F4	Close the active item or quit the active program.
Alt+Tab	Switch between open items.
Alt+Esc	Cycle through items in the order in which they were opened.
Windows Key+ Key	
Windows key	Show or hide the Start menu.
Windows key +Pause-Break	Open the System Properties dialog box.
Windows key+D	Show the desktop.
Windows key+M	Minimize all windows.
Windows key+Shift+M	Restore minimized windows.
Windows key+E	Open My Computer.
Windows key+F	Search for a file or a folder.

Ctrl+Windows key+F	Search for computers.
Windows key+F1 function	Open Windows Help.
Windows key+L	Lock the keyboard.
Windows key+R	Open the Run dialog box.
Windows key+U	Open Utility Manager.

Appendix C Beam Data

This appendix includes information on beam performance for X-ray and electron energies, and transmission factors for each X-ray energy.

X-ray Mode Energies and Dose Rates

The maximum field size for X-ray modes is 40 cm by 40 cm.

Table 12 shows the maximum dose rates for each of the X-ray energies.

Table 12 Photon Energies (MV)

X-ray Energy	Maximum Dose Rate (Gy/min)
6x	6.0
8x	6.0
10x	6.0
15x	6.0
18x	6.0
20x	6.0
6xFFF	14.0
10xFFF	24.0

FFF = Flattening Filter Free. Maximum dose rate measured in water, 100 cm SSD, for 10 cm x 10 cm field, at depth of maximum dose.

Electron Mode Energies and Dose Rates

The maximum field size for electron modes is 25 cm by 25 cm, except for 6 HDTSe and 9 HDTSe, which have a maximum field size of 36 cm by 36 cm.

Table 13 shows maximum dose rates for each of the electron modes.

Table 13 Electron Energies (MeV)

Electron Energy	Maximum Dose Rate (Gy/min)
6e	10.0
9e	10.0
12e	10.0
15e	10.0
16e	10.0
18e	10.0
20e	10.0
22e	10.0
6 HDTSe	25.0
9 HDTSe	25.0

Maximum dose rate measured in water, 100 cm SSD, for 15 cm x 15 cm field, at depth of maximum dose (6 HDTSE and 9 HDTSe, 36 cm x 36 cm field).

Transmission Factors

This information applies to TrueBeam medical linear accelerators with a standard (5-mm leaf width) 120-leaf multileaf collimator (MLC).

Collimators

The distance from target to lower surface of the block tray is 65.4 cm for an TrueBeam; the primary collimator half-angle may be converted to radians using the relationship: 2r radians = 360°.
Varian 180° = IEC 0° for both collimator and gantry rotation.

Wedges

Wedges are optional. They include:

- 15° and 30° wedges made of low-carbon steel, with a density of 7.8 g/cm^3.
- 45° degree and 60° wedges made of lead alloy, with a density of 11.2 g/cm^3.

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Appendix D   Safety Loops

Safety enable loops in the TrueBeam system allow subsystem controller boards to inhibit power, beam generation, or motion if a subsystem, such as beam generation and monitoring, is not ready. Enable loops are routed through the subsystem and local networks. Each controller board in the safety loop can open one or more loops, and can monitor the state of each loop in case another controller board in the subsystem is opening a loop.

Enable loops are current-type loops. The Stand controller sources all loops with approximately 10 mA of current, with an output voltage of 20 to 24 V. Current flows out of the Stand controller and through the network to each controller board in a daisy chain. If a loop is closed, current returns to the Stand controller to complete the circuit.

Each controller board can open a safety loop to prevent current flow by opening an electronic switch (a transistor) in series with the loop. For any safety loop:

- If all boards in the loop path have their loop switches closed, then current flows and the loop is sensed by all the boards as closed. The closed loop allows the loop's respective function (power, beam, or motion) to proceed.
- If any board in the loop path has its loop switch open, then current is inhibited and the loop is sensed as open by all the boards. The open loop prevents the loop's respective function from proceeding.

Safety Loop Networks

Safety loops route through three networks in the TrueBeam: the subsystem, beam generation and monitoring (BGM) local, and power local networks.

Subsystem Network

The subsystem network routes through the main nodes in the TrueBeam system—the controllers in the Stand, couch, BGM, Imaging system, and the Collimator. The subsystem network has four safety loops:

- Beam Enable loop (BEL)
- Kilovolt Beam Enable loop (kVBEL)
- Motion Enable loop (MEL)
- Power Enable loop (PEL).

BGM Local Network

The BGM local network has one loop, BEL, and routes through the five BGM subnodes:

- BGM-Electron Gun (EGN)
- BGM-Modulator (MOD)
- BGM-Positioning (POS)
- BGM-Pulse Width Modulation (PWM)
- BGM-Radio Frequency Source Power Supply (RFSPS).

Power System Local Network

When a subsystem generates an interlock or a fault that impacts a safety loop, the subsystem opens the loop. The control system then opens the loop on all subsystems. Having the loop open all subsystems protects against one subsystem failing to open a loop.

The Stand opens the safety loops when an Emergency Stop button is pressed.

Types of Safety Loops

There are four types of safety loops:

- Beam Enable loop (BEL)
- Kilovolt Beam Enable loop (kVBEL)
- Motion Enable loop (MEL)
- Power Enable loop (PEL).

Beam Enable Loop

When the Beam Enable loop is open, the loop prevents a plan from being treated and a beam from being generated. The BEL is opened when you hold down the MV Beam On button while the treatment beam is being sent. Pressing the Beam Off button also opens the BEL and shuts off the beam.

If communications with the control console is lost, then the BEL is opened and the MV Beam On button on the console is inoperable.

The BGM Controller opens the BEL for various reasons, including if problems occur with dose symmetry and flatness.

KV BEL

When the Kilovolt Beam Enable loop is open, the kV BEL turns off the kV beam. Pressing the Beam Off button opens the kV BEL and shuts off the beam.

The kV Beam On button on the control console is a two-step (double action) button. When you hold down the button to the first stop position, the primary (kV ready) contacts are closed. Holding down the button all the way enables kV beam generation. When you release the button, the BEL is opened, and the kV beam shuts off.

If communications with the control console is lost, then the kVBEL is opened and the kV Beam On button on the console is inoperable.

Motion Enable Loop

The Motion Enable loop disables motion (in hardware) until the loop is explicitly enabled via an input device (pendant, side panel, or Console) Motion Enable operation.

When the Motion Enable loop is opened, the loop stops all machine motions. However, some internal motions can occur without the MEL closed.

The MEL is dependent on the Motion Enable buttons on the Console, and the Motion Enable bars on the Couch Side Panels and Pendants. If any pair of Motion Enable bar or button is pressed, then the MEL closes if all boards in the MEL loop are also closing their MEL switches. Boards open MEL switches if an error is detected that indicates it is not safe to move an external axis.

If, simultaneously, an operator at the console uses a console Motion Enable button and an operator in the treatment room uses a pendant Motion Enable bar, machine motions are prevented until the Motion Enable bar or button is released.

Operators in the treatment room can use multiple input devices (pendants and side panels) to move groups of machine axes. For example, if a pendant is controlling the couch, then a side panel cannot also control the couch, but it can control the gantry. In this case, releasing the Motion Enable bar or thumbwheel on the pendant stops only the couch from moving.

Motion Enable switches (pendant, console, couch side panels) and collision sensors are part of the MEL system. Operators can override collision sensors to move equipment away from a collision, or in special cases, such as to use an electron accessory during a treatment.

Power Enable Loop

For the PEL, power is removed via redundant relays upstream of all major system AC loads. The PEL is directly opened when any subsystem detects an error, and by Ethernet communications to specific control boards (such as in the Stand and RFSPS). All subsystem PELs are in a series. When the PEL is open, all subsystems monitor the state of the PEL and switch to a safe state.

An open Power Enable loop stops power:

- Required for beam generation and motion by shutting off relays in the modulator and on the Stand power distribution (SPD) and gantry power distribution (GPD) PCBs.
- To all system high current, power, and motion loads, and to radiation. Only 24 volts (24V) DC control power is retained when the PEL is open.

If the PEL is open, the Auxiliary Power Distribution Board daughterboard PEL status output is removed to deenergize AC power loads in the TrueBeam that circulated through the modulator but did not circulate through the Console AC power supply.

Restarting power requires pressing the modulator Start button, which latches EMO Good if the EMO loop is not open and brings the system to Power Saver state. All subsystem PELs must close their switches to close the loop. After PEL faults are cleared, the system can be switched to On state.

Safety Loop Tests

Safety loops are tested before all treatment. When the Ready button on the control console is pressed, all nodes are instructed to close safety loops, then one at a time open and close each safety loop to verify that each node has the capability of shutting off power, interrupting beam, or stopping axis motion if an error exists.

MEL Test

The MEL is tested to ensure that each node can open the loop and detect that the loop is open. The TrueBeam system performs a MEL test if the motion loop is closed to facilitate treatments involving dynamic external axes. If the loop test fails, the TrueBeam system generates a corresponding fault that prevents the loop from closing.

PEL Test

PEL is periodically tested by pressing an Emergency Stop button and checking whether hazardous motion subsystems and beam generation stop.

Opening Safety Loops

Various controllers, events and conditions can open a safety loop, including an assertion by the BGM-CONT system, press of a control console button, treatment plan interlock, or open treatment room door.

Beam Generation and Monitoring Controller

The controller for the Beam Generation and Monitoring system (BGM-CONT) is part of the chain of the BEL, MEL, and PEL safety loops (Figure 70 on page 288). All BGM subsystems (Electron Gun, Pulse Width Modulation, Positioning, Modulator, and Radio Frequency Subsystem Power Supply) can open the BEL to stop beam generation. When the BEL is open, the BGM-CONT disables the Electron Gun (EGN) trigger, and EGN will not route the Gun trigger through subsystems.

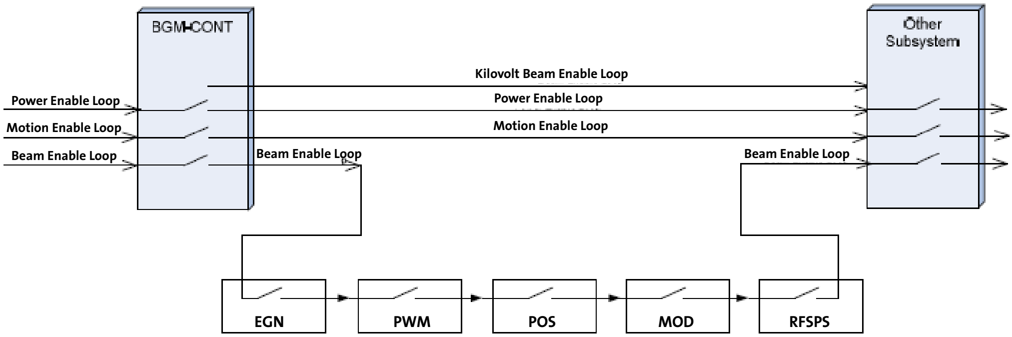

Figure 70 Safety Loops

Control Console

Buttons on the control console affect the BEL, KVBEL, and MEL. The BEL, MEL, and KVBEL loops are routed to the control console by the Stand controller.

Beam On—Pressing the Beam On button closes the BEL, MEL, and KVBEL are closed.

Motion Enable—Pressing these buttons on the control console affect only the MEL.

The two Motion Enable buttons on the control console enable remotely move machine parts such as the gantry and couch. You must hold down both buttons during remote motion (except during automated treatment). Holding down these buttons starts axes motions for parameters that need to be adjusted to plan or to target. Releasing a button stops machine motion.

The motion indicator to the left of the Motion Enable buttons lights green when the buttons are depressed.

Treatment Plan

If the safety loop needed for a treatment plan cannot be closed, the TrueBeam prevents a treatment plan from being run.

For instance, for a dynamic megavolt (MV) beam and kilovolt (kV) plan, an interlock can prevent beam generation by keeping the BEL open.

Treatment Door

The treatment room door state (closed or not closed) is monitored and the BEL cannot be closed unless the door is closed.

Safety Loop Circuits

The diagrams in this section illustrate the following circuits:

- Beam Enable loop
- Kilovolt Beam Enable loop
- Motion Enable loop
- Power Enable loop
- BEL, MEL, and PEL local signals
- Emergency Off loop.

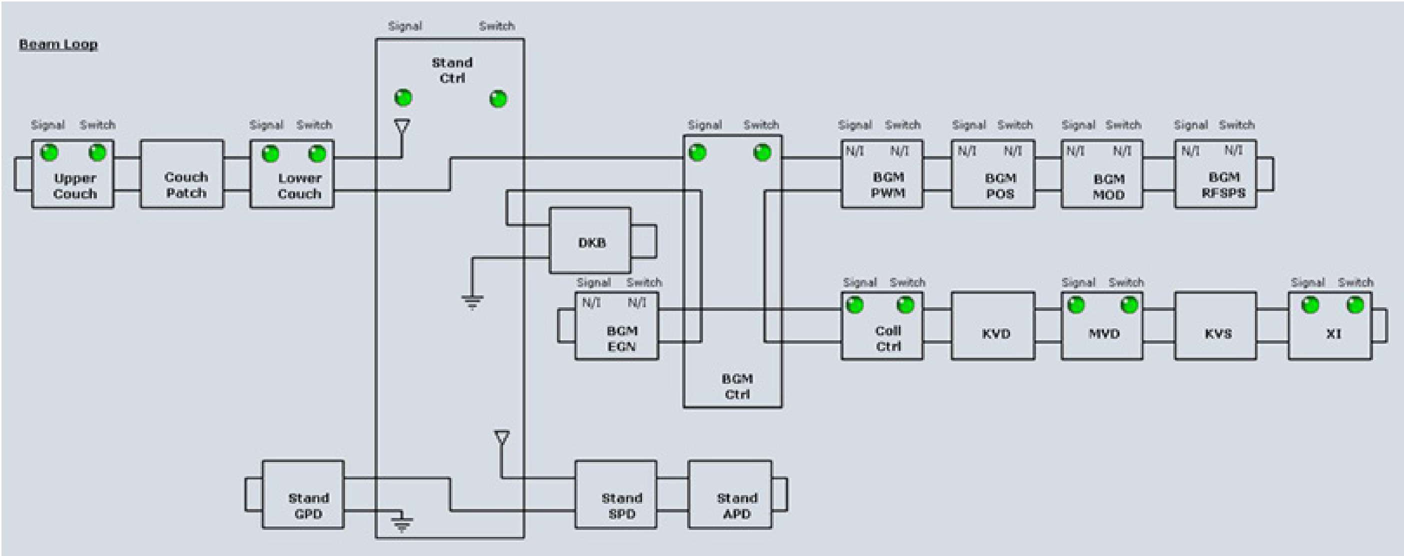

Figure 71 Beam Enable Loop with Signals

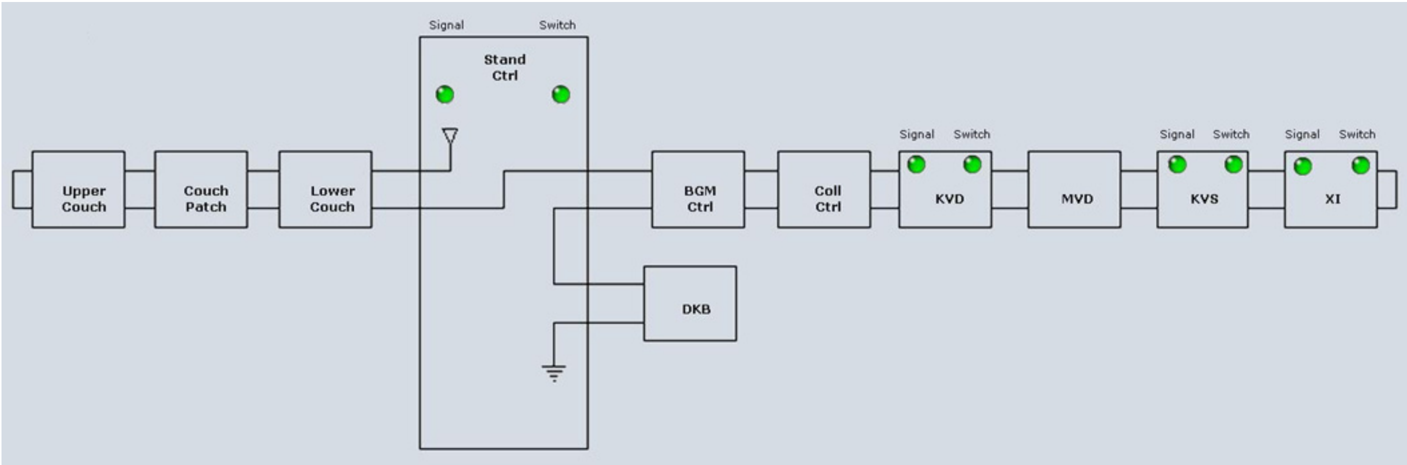

Figure 72 Kilovolt Beam Enable Loop with Signals

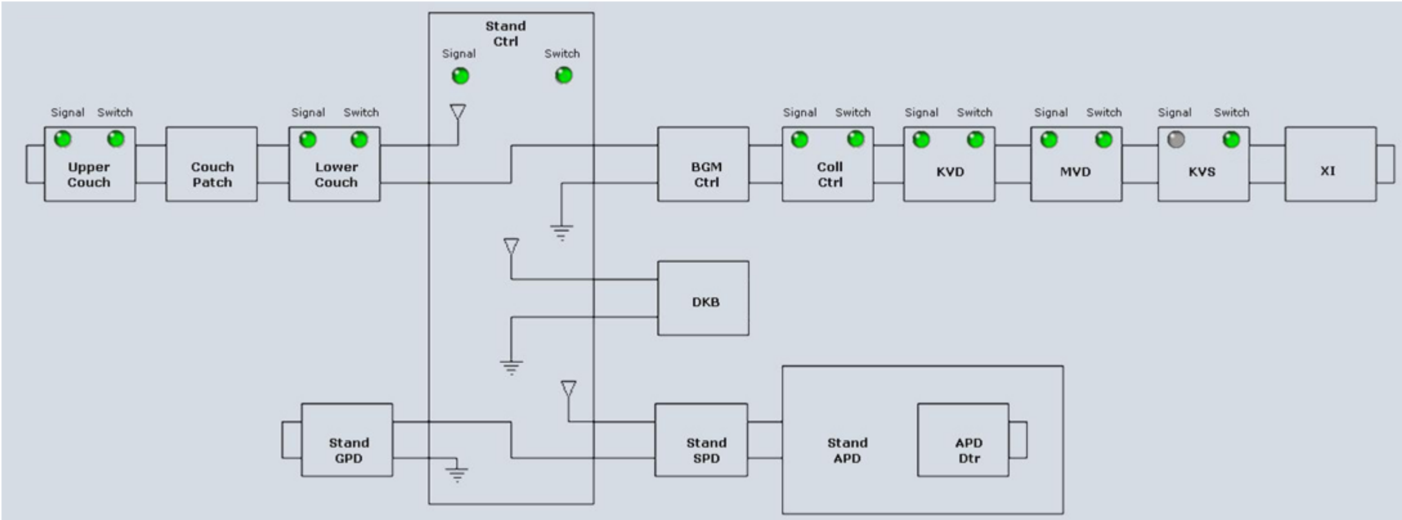

Figure 73 Motion Enable Loop with Signals

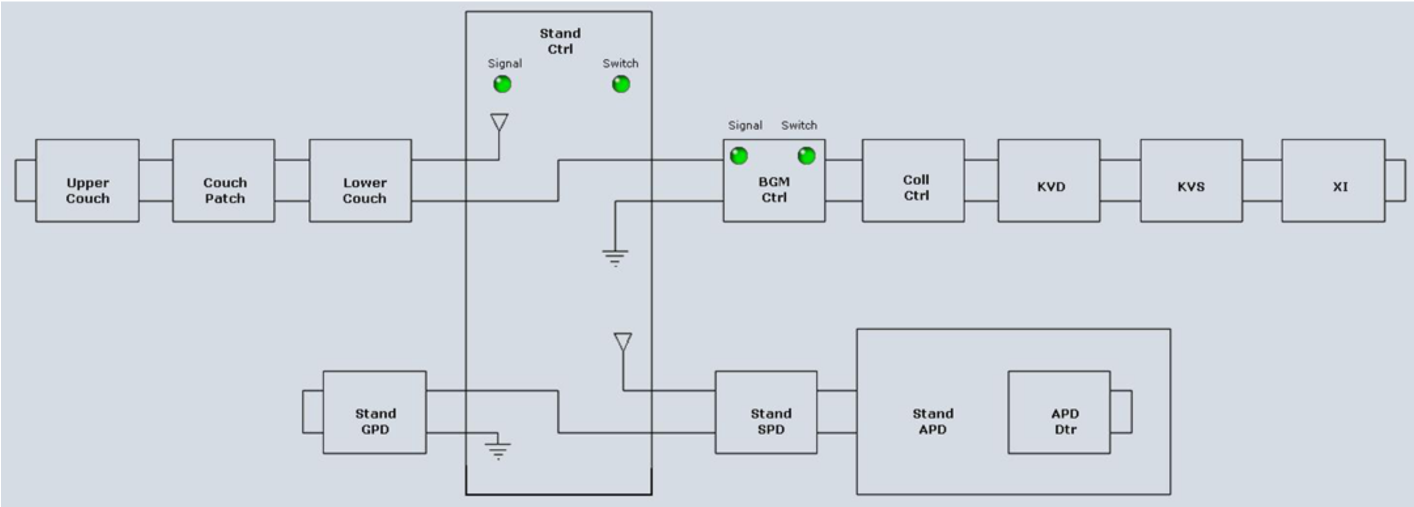

Figure 74 Power Enable Loop with Signals

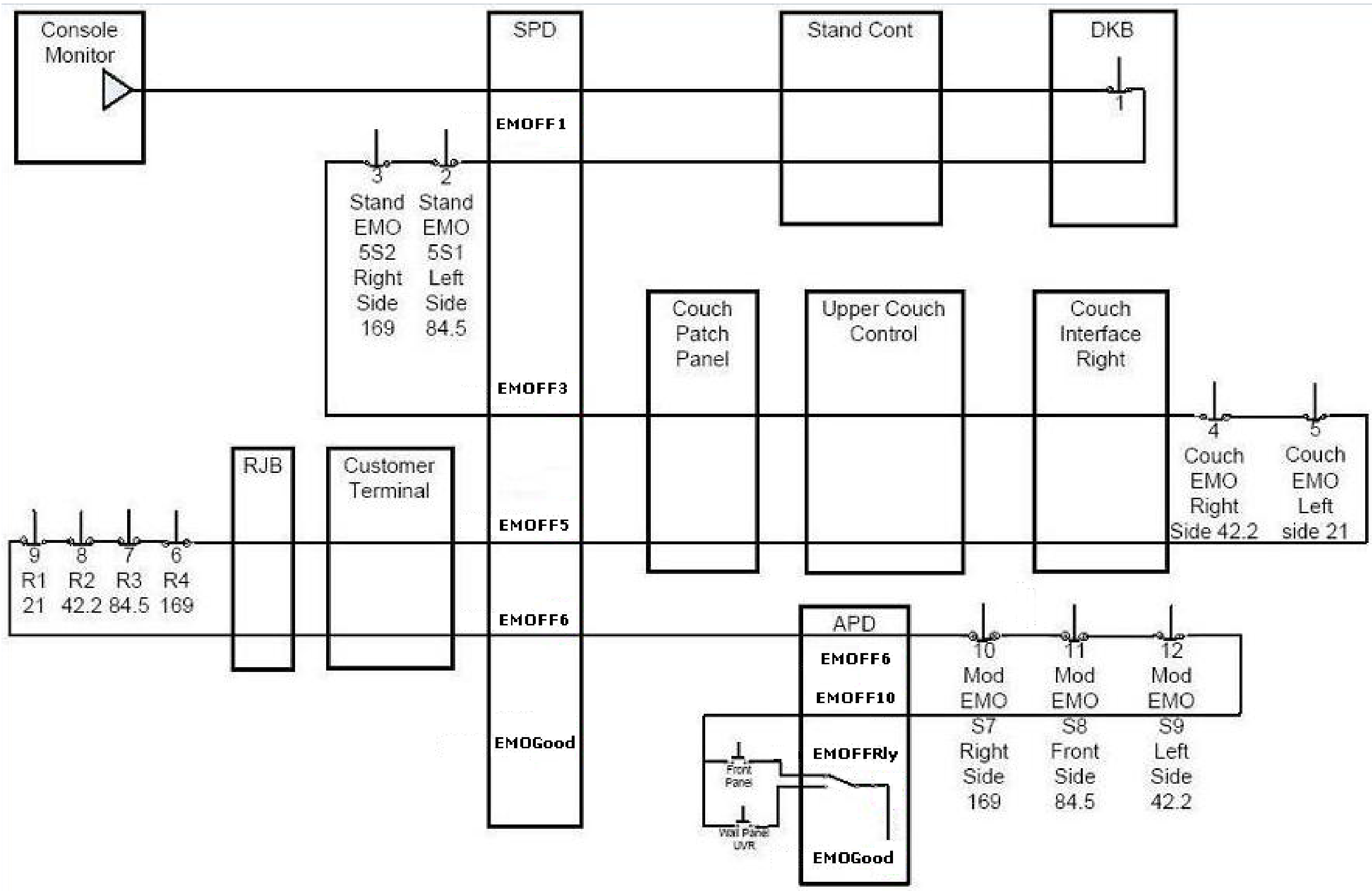

Figure 75 Emergency Off (EMO) Loop, Main

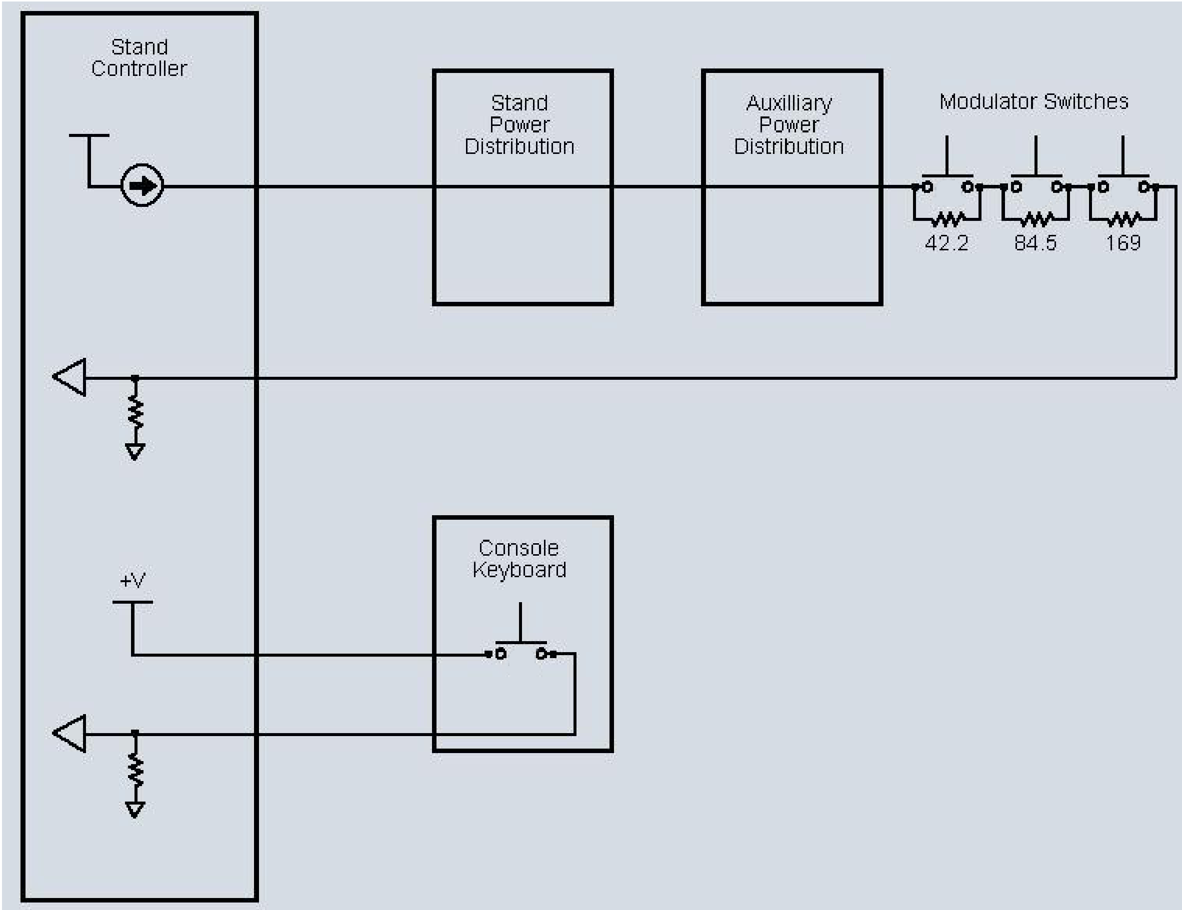

Figure 76 Emergency Off (EMO) Loop, Modulator

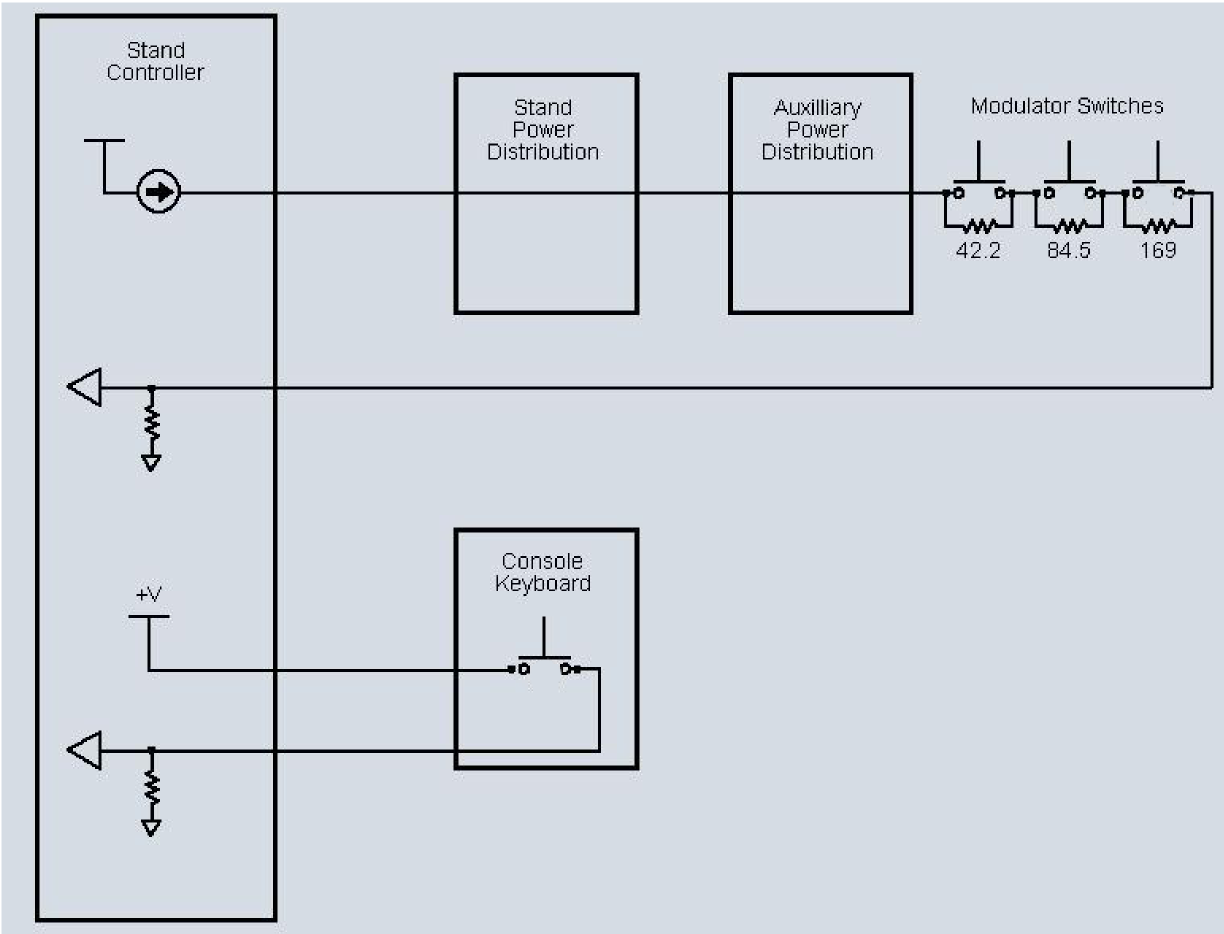

Figure 77 Emergency Off (EMO) Loop, Couch

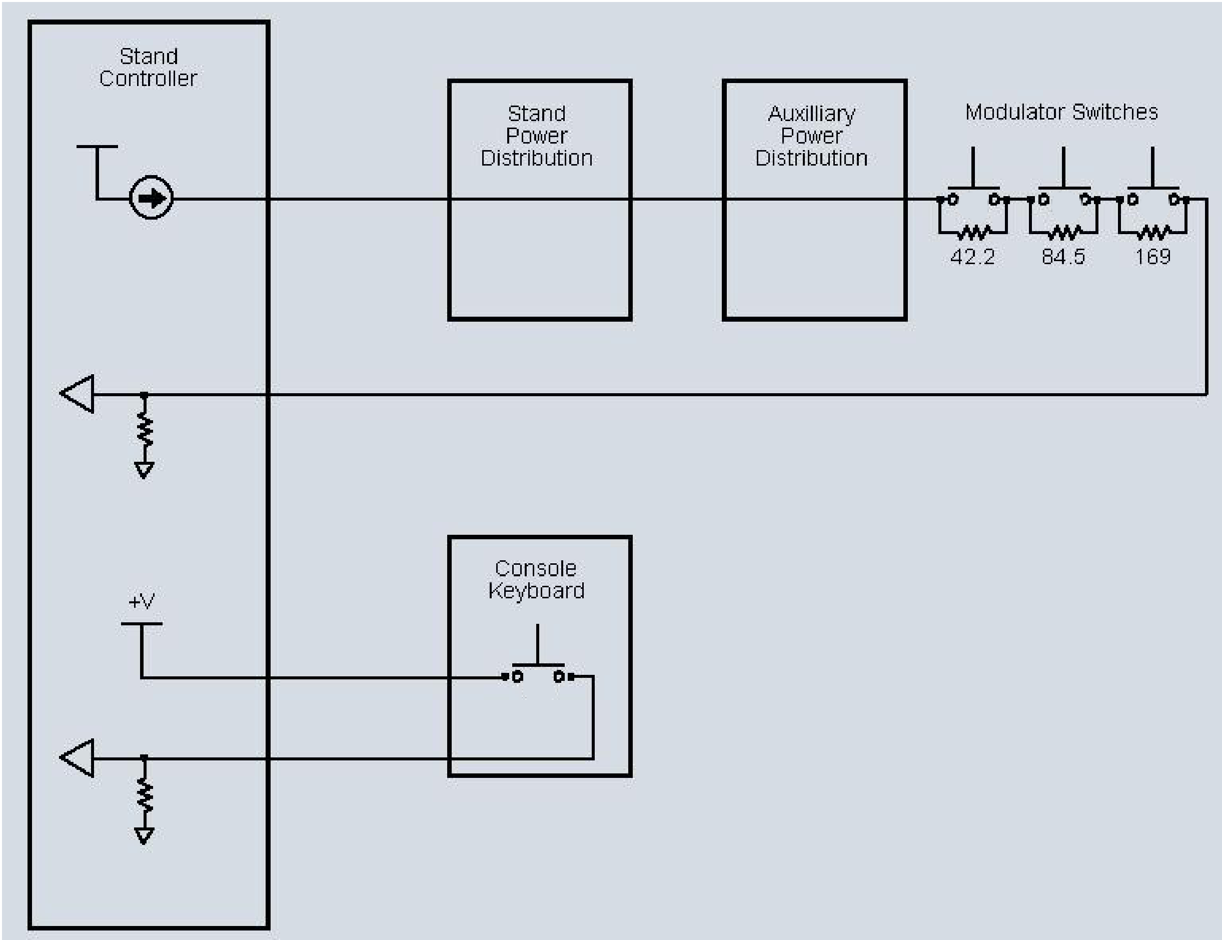

Figure 78 Emergency Off (EMO) Loop, Customer

Troubleshooting

You can use the Service/Safety Loops tabs to view the status of safety loops at specific nodes and subnodes

The Service application also allows controlling power relays for specific testing. Power relays are primarily controlled by the state of the TrueBeam.

Troubleshooting safety loops also can be done using e-fuses or test points on printed circuit boards. An e-fuse is an electrical, controlled, high-side switch with overcurrent protection and a mechanical reset switch (for example, on the Stand power distribution (SPD) PCB).

There are at least two types of test points on printed circuit boards:

- Low voltage, which can have a loop connection point on the top or bottom sides of the power distribution PCBs. Low-voltage test points can also be through-hole pads without a loop.
- Higher voltage (120V AC or higher), which are only though-hole pads without an installed loop.

For more information on troubleshooting safety loops, contact Varian Service.

Appendix E Auxiliary Device Interface

The TrueBeam system provides an auxiliary device interface (ADI) so that third-party auxiliary systems can be incorporated into the treatment delivery process. Such devices might include:

- A barcode reader for accessory devices.
- Positioning devices.
- Couch tops.
- Patient identification devices.

The TrueBeam ADI provides a standard software interface for such treatment devices, where the TrueBeam is the server and the auxiliary devices act as clients.

Overview

To maintain interface stability and interoperability, only a subset of the available TrueBeam data is exposed to the third-party device. Planned treatment data is exposed only when beam energy for a selected field is prepared.

The ADI provides the capability for the auxiliary device system to lock treatment until the auxiliary device system is ready. At the TrueBeam, this takes the form of a WKST interlock.

The Treatment application uses TCP/IP protocol for communication with ADI clients. All messages exchanged between the two systems are XML messages, encrypted using public key cryptography.

Multiple concurrent auxiliary devices can be connected to the treatment application. The devices are configured in Treatment preferences (Device ID, Device description).

Requirements

The third-party application must run on its own workstation, using Windows XP SP2 operating system.

If the auxiliary device needs more data (for example, an ultrasound system will have ultrasound images) it is the auxiliary application's responsibility to access the data and to stay synchronized with the patient under treatment.

For complete technical details, ask your Varian service representative for TrueBeam Treatment: Interface Specification (ADI).

Appendix F Preparing Legacy Plans

The TrueBeam system uses treatment plans developed with any radiation oncology planning system that exports standard DICOM RT plans. This appendix outlines specific requirements for Varian and third-party planning systems.

Varian Planning Systems

The TrueBeam system is designed to work seamlessly with the ARIA and VARiS Vision oncology treatment information systems.

New Plans

All plans developed using Eclipse can be used by the TrueBeam system. Follow your normal procedures for creating a plan, obtaining approvals, and scheduling the plan.

Existing Plans

TrueBeam series systems use plans that have been prepared for C-series Clinacs with ARIA or VARiS Vision without any change, with one exception: respiratory gating.

If the plan requires respiratory gating, you must update the plan in Eclipse, as follows:

1. Open the plan in Eclipse or RT Chart.
2. In the Plan Properties dialog box, select Use Gated.
3. Save the plan.

Third-Party Planning Systems

A plan developed with a third-party planning system must be imported into the information system. You export the plan from the planning system using a DICOM filter, and you import the resulting DICOM file into the ARIA or VARiS Vision information system.

- If you are using ARIA, there are no additional requirements.
- If you are using VARiS Vision, you must import the plan through an Eclipse SV workstation (Eclipse software with an SV license).

  The SV license permits you to reset the origin on the plan, so that the planning CT scan can be used for matching after a cone-beam CT image has been acquired in TrueBeam.

Eclipse formats the treatment planning data so that the structure sets (planning contours), planning CT images, and planning isocenter can be stored in the information system, and thereby successfully opened in TrueBeam.

Transferring MLC data in plans has these limitations:

- Plans developed for 120 MLC cannot be transferred directly for use with the HD 120 MLC, and vice-versa. The two MLCs have different leaf-end curvatures that affect dosimetric leaf gap, and different leaf height, material, and design that affect leakage.

  For guidelines on replanning, see the Varian technical bulletin CTB-TR-581.
- RT Chart cannot export or import text-format MLC plans. (DICOM files from Eclipse are not affected.)

Requirements

For the import process to be successful, the non-Varian treatment planning system must be able to export the following:

- CT images in DICOM format.
- Structure sets (planning contours) in a DICOM RT format.
- Plan information in a DICOM RT format. Plan information includes MUs and the dose prescription (reference point dose data).

CBCT

If a CBCT scan will be used to verify a patient's treatment, the planning CT must have contours on only the axial CT slices. The TrueBeam imaging system does not recognize contours on the sagittal or coronal slices.

DRRs

Some non-Varian treatment planning systems export digitally reconstructed radiographs (DRRs) as DICOM secondary capture images or bitmaps. Because these image types do not include any field geometry information, they must be scaled and aligned in ARIA RT Chart before they can be used as reference images.

Such images do not have any information about the reference coordinate system and reference conditions where they were acquired.

References images used for image matching must use the same coordinate system and reference conditions (frame of reference). If they do not, TrueBeam cannot save them to the information system. Without match results, no offline review is possible (acquired images can't be paired with references images).

If the third-party planning system does not provide setup field data, setup fields must be created, and the DRRs must be associated with the setup fields. The DRRs need to be scaled, aligned, attached, and set as the reference image using RT Chart.

Verification and Adjustment

All plan information imported from third-party planning systems must be verified once it is imported into ARIA.

- If the imported plan was created using multiple treatment prescription points, be aware that ARIA recognizes only the first treatment point.
- For photon fields, verify that all pertinent treatment data is transferred, including accessories, MLC configuration, MUs, and dose.
- If backup times and tolerance tables have not transferred, add them to the fields in RT Chart.

- If the images are not automatically connected to fields, or if essential information—such as scale, center, or 3D volume—is missing, this information must be added manually.
- Electron fields do not transfer from some third-party systems. You must first enter the cone size so that ARIA can associate the field size to the cone/energy combination.

  In cases where plan information does not transfer properly into ARIA, you can use RTP Exchange to adjust the plans. Note, however, that CBCT is not possible for these plans because RTP Exchange does not import sufficient information (such as planning CT, plan isocenter, and so forth) to support the CBCT process.

Confirming Plan Data for Treatment

All plans must be validated according to the protocol at your facility. If you are using ARIA, following is a typical sequence:

1. In the RT Chart Parameters workspace, do the following:
   - Confirm treatment information, including field sizes, gantry angles, collimator angles, wedges, and imager values.
   - If appropriate, add digital graticules to the treatment field DRRs.
2. In the RT Chart Reference Point workspace, confirm MU, dose per field, and total dose.
3. In the RT Chart Scheduling workspace, verify that all sessions are active, and schedule imaging sequence templates.
4. In the RT Chart Reference Point workspace, approve the plan for treatment.
5. In Time Planner, schedule the patient for treatment.

Appendix G External Interlocks

External interlocks supplied by the customer at the customer site include those located at the treatment room doors, and external inputs to the Neutron door and Emergency Stop switches. This section describes facilities for connecting these interlocks, and requirements for customer compliance.

Prior to installation of the radiotherapy unit at the customer sites, Varian supplies the customer with the following installation data package and associated customer connections drawing:

- *Varian Installation Data Package* (IDP; PN 100044034)
- Wiring Diagram, TrueBeam Customer Connections (PN 100025933).

The customer needs to refer to the “Safety Device Systems” section of the IDP and the customer connections drawing, for instructions and detailed requirements for preparing the connections for all external interlocks at the site. This documentation also includes advice for resetting these interlocks.

On installation, the installer wires the customer-supplied external inputs into the TrueBeam system at the Relay Junction box, as shown in Figure 79 on page 306. These connections are then internally fed to a customer terminal interface, which routes the signals to the Stand (STN) controller for monitoring.

If operation of the TrueBeam system activates any of these safety interlocks, the TrueBeam control system generates a fault condition to interrupt or prevent irradiation. To reset these interlocks, the customer fixes the condition that caused the interlock and acknowledges the interlock in the user interface (such as in Service or Treatment mode); in some cases, the customer may be required to enter a password to reset the system.

Examples of Neutron Door faults include:

- STN.SW.RoomCtrl.NeutronCareSetError
- STN.SW.RoomCtrl.NeutronDoorOpenDuringTreatment

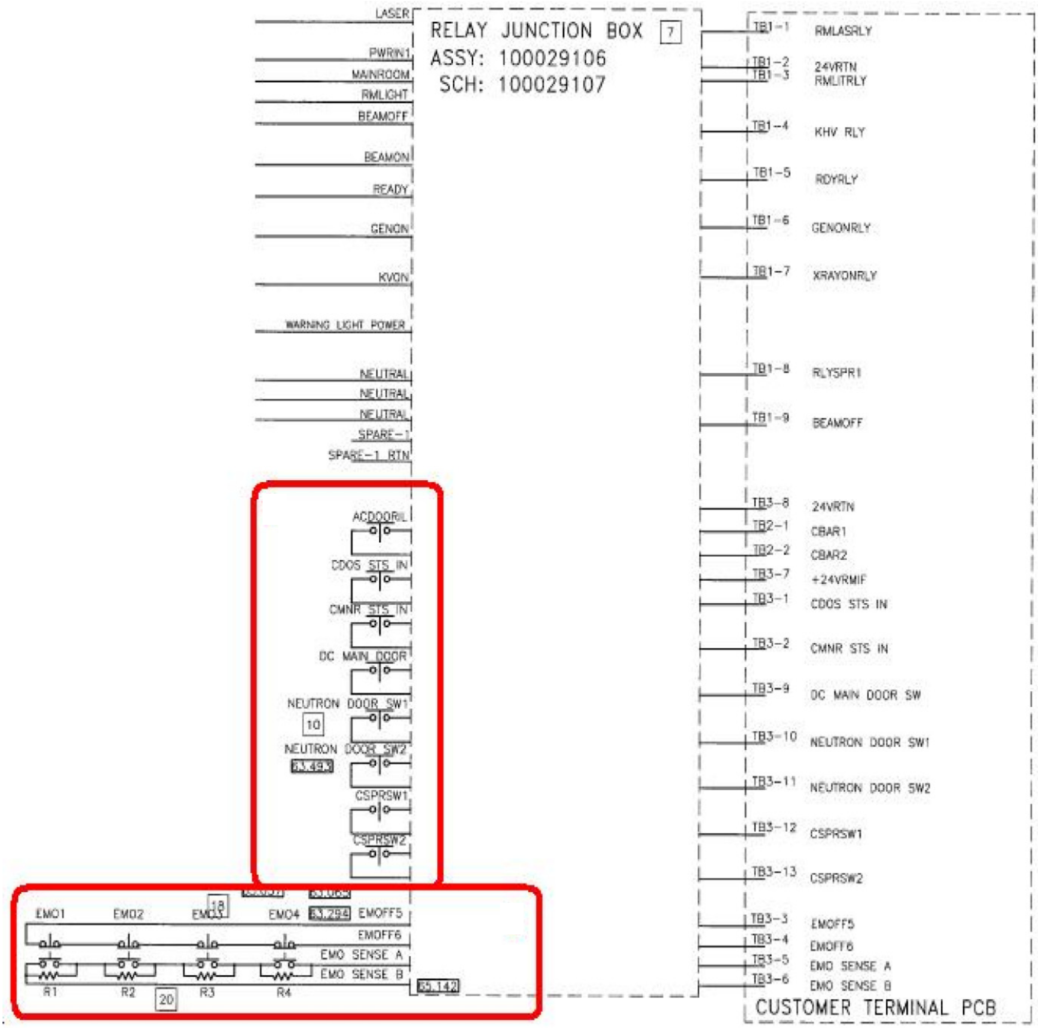

Figure 79 Relay Junction Box

Appendix H Recorded Treatment Parameters

After each treatment is concluded, the system saves treatment parameters to the radiation therapy patient information system. Table 14 lists the parameters, the units, and the precision with which they are recorded.

The default precision is 0.1° and 0.1 cm. You may configure the information system so that parameter values are recorded with a precision of 0.01° and 0.01 cm.

Table 14 Precision of Recorded Treatment Parameters

Parameter	Units	High Precision	Default Precision
Coll Rtn	degrees	0.01	0.1
Coll X/Field X	cm	0.01	0.1
Coll X1/X1	cm	0.01	0.1
Coll X2/X2	cm	0.01	0.1
Coll Y/Field Y	cm	0.01	0.1
Coll Y1/Y1	cm	0.01	0.1
Coll Y2/Y2	cm	0.01	0.1
Couch Lat	cm	0.01	0.1
Couch Lng	cm	0.01	0.1
Couch Rtn	degrees	0.01	0.1
Couch Vrt	cm	0.01	0.1
Dose Rate	MU/min	--	1
Energy	MV/MeV	--	1
kV Source Rtn	degrees	0.01	0.1
Gantry Rotation	degrees	0.01	0.1

Table 14 Precision of Recorded Treatment Parameters

Parameter	Units	High Precision	Default Precision
Image Lat	cm	0.01	0.1
Image Lng	cm	0.01	0.1
Image Vrt	cm	0.01	0.1
MU	MU	--	1
SSD	cm	0.01	0.1
Stop Angle	degrees	0.01	0.1
Time	min	0.01	0.01

Index

C

D

E

F

G

H

I

N

O

P

Q

R

S

T

U

V

W

X

Y

Z