STANDARD IMAGING®

QA **BEAMCHECKER**™ PLUS

REF 90501

U S E R M A N U A L

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General Precautions

Warnings and Cautions alert users to dangerous conditions that can occur if instructions in the manual are not obeyed. Warnings are conditions that can cause injury to the operator, while Cautions can cause damage to the equipment.

⚠ WARNING: Proper use of this device depends on careful reading of all instructions and labels.

⚠ WARNING: **Electrical shock hazard when connected to 300 V bias supply. Do not disassemble the QA BeamChecker Plus.**

⚠ WARNING: Where applicable, Standard Imaging products are designed to be used with the versions of common radiation delivery devices, treatment planning systems and other products or systems used in the delivery of ionizing radiation, available at the time the Standard Imaging product is released. Standard Imaging does not assume responsibility, liability and/or warrant against, problems with the use, reliability, safety or effectiveness that arise due to the evolution, updates or changes to these products or systems in the future. It is the responsibility of the customer or user to determine if the Standard Imaging product can be properly used with these products or systems.

⚠ CAUTION: This device should never be submerged in any liquid, scrubbed with an abrasive cleaner, or be stored or placed where liquids could be spilled or splashed onto it.

⚠ CAUTION: Do not drop, mishandle, or disassemble this device. Refer all servicing to qualified individuals.

⚠ CAUTION: Do not irradiate this device past the 20 x 20 cm field label edge.

⚠ CAUTION: Always use the QA BeamChecker Plus in the same orientation during Baseline Setup, Wire-Free, or Real-Time Operation Modes. Improper comparative measurements and/or out of tolerance fault messages will occur if used in a different orientation.

⚠ CAUTION: To help ensure measurement reproducibility over time and minimize possible backscatter effects from the treatment couch, especially for low energy photons, position the device in the same location on the treatment couch for every measurement.

⚠ CAUTION: When using the Bluetooth® Adapter Kit, be careful lifting the unit when it is lying flat to avoid damage to both the adapter and QA BeamChecker Plus. If necessary, remove the adapter before moving the unit.

⚠ CAUTION: The Bluetooth Adapter Kit will not communicate through the treatment vault wall, but because their signal is transmitted via RF, the cradle (with attached adapter) can be placed inside a cabinet or closet and still communicate effectively.

⚠ CAUTION: When using TomoTherapy® or Dynamic 5 Channel modes, only the photon side of the QA BeamChecker Plus should be used.

⚠ CAUTION: When performing Baseline or Real-Time Operation measurements, ensure the proper room is selected to avoid overwriting or adding new data to the wrong room.

⚠ CAUTION: In Physics Mode, no measurement data is stored within the database file. Data can only be saved by utilizing the Export .csv function.

⚠ CAUTION: It is recommended to avoid attaching the serial cable via the connector shell screws to the unit and instead relying on the inherent pressure fit of the connection. If the cable catches on an obstruction during gantry rotation, damage can occur if the connector cannot pull free.

⚠ CAUTION: Before upgrading to a new version of QA BeamChecker Plus software, download any Wire-Free data to the database.

⚠ CAUTION: Use provided power supply or equivalent as identified by Standard Imaging. Contact Standard Imaging for additional information.

⚠ CAUTION: To ensure long-term performance of the internal battery, it is recommended to recharge the QA BeamChecker Plus by always placing it on the Power/Data Cradle when not in use.

Table of Contents

1 Overview

NOTE: This manual refers to operation while using QA BeamChecker Plus Communication Software version 2.3.X. If using a previous version, contact Standard Imaging for the latest revision of the QA BeamChecker Plus Communication Software.

The QA BeamChecker Plus (QABC+) is a reliable and uncomplicated measurement instrument for daily quality assurance testing of linear accelerators, TomoTherapy Systems®, or other rotational delivery treatment delivery systems. It assists medical physicists in verifying that the constancy, symmetry, flatness, and other parameters of a beam are not changing over time.

The QA BeamChecker Plus consists of the standalone detector unit with 8 parallel plate ionization chambers, a Power/Data Cradle, and PC-based software for baselining the current machine parameters and viewing data in real-time. In the TomoTherapy mode, the additional Precision TomoTherapy Leveling Platform is required for proper testing of laser alignment.

The QA BeamChecker Plus is calibrated to a known source after manufacture. The outputs of the eight (8) internal parallel plate chambers are 'leveled' or adjusted via use of a multiplier for each chamber. This multiplier is based on a value of one (1.000) for a perfect, expected response. Each chamber multiplier is stored as an integer whole number (e.g., "1.000" is represented as "1000") in the device internal EEPROM memory for retention between release for sale and return for repair. If a QA BeamChecker Plus is returned to SI for an indicated repair (see pgs. 45-47), the device is 're-leveled' after repair and the new chamber 'leveling' values replace the previous values stored in the EEPROM memory.

In daily beam QA use, the QA BeamChecker Plus, as an internally comparative measurement tool, will indicate to the user if a given external radiotherapy beam has deviated from the original beam 'Baseline' parameters. The QA BeamChecker Plus does not require any third-party calibration throughout its lifetime and therefore has no associated calibration interval nor any required annual servicing.

1.1 Usage Overview

The physicist initially "baselines" each accelerator energy, using the included software. This stores a picture of the current beam constancy, flatness and symmetry, and generates a unique identifier for each energy. This energy identifier is the key for "Wire-Free" standalone operation of the QA BeamChecker Plus.

After initially creating baselines by connecting the QA BeamChecker Plus and using the accompanying software, no cables are required, and no software is needed for day to day operation of the instrument.

In daily use for linear accelerators, the QA BeamChecker Plus is simply placed back on the treatment couch using the baselined setup data parameters, a field size of 20 x 20 cm, and typically an SSD of 100 cm. Linear accelerator energies may be delivered in any order, and temperature and pressure corrections are automatically made by an on-board sensor. A unique flip feature is used to measure both photons and electrons. When the "photon side" is faced toward the beam, 3.5 cm of water-equivalent buildup is provided over the detectors,

while the “electron” side provides 1.5 cm. To switch sides, the unit is simply flipped over, and the MODE / PLAN button on the front of the unit is pushed to indicate the change and to invert the display. No additional buildup or trips into the treatment vault are typically required. In daily use for TomoTherapy or other rotational units, only the photon side is used. The following are evaluated for TomoTherapy mode: laser alignment (both fixed and moving), static output constancy, static energy constancy, lateral profile constancy, and dynamic output constancy.

Following an exposure, the QA BeamChecker Plus identifies the energy of the beam that was just used. It then applies this reading to look up the baseline parameters for that beam energy and compares them with the present readings. Daily measurements falling within the physicist-selected acceptance parameters (known as Action Levels) result in a green light displaying on the front panel of the device for about 10 seconds, followed by the unit re-arming itself for the next measurement. All data is stored on the QA BeamChecker Plus for later downloading. Measurements outside acceptance parameters cause a red light to flash, an audio alert to sound, and require the RESET button to be pushed on the front of the instrument to continue. Additional information is also presented on the large alphanumeric display on the front of the unit.

For rotational treatment machines or for dynamic beam delivery, such as enhanced dynamic wedge, the core functionality is very similar, however instead of selecting an energy to deliver, a plan is configured. This plan could be a particular energy, wedge angle, and jaw width (in the case of a TomoTherapy system) or any other unique identifier. In typical use for rotational delivery such as RapidArc™, first a CT image of the QA BeamChecker Plus must be acquired in order to contour its internal ion chambers. Using the image and its contours, a treatment plan is developed and delivered to the unit as a baseline measurement. Subsequent exposures compare the total composite dose delivered to each chamber to their baseline value, with any deviation signaling a problem with the beam delivery. Potential problems tested could include gantry rotation, dose rate, and/or delivery position.

About one month’s worth of data can be stored on the QA BeamChecker Plus before downloading is required, although downloading may be done at any time. The Power/Data Cradle provides the link to the computer’s RS-232 port, and the included software makes downloading and trending the data quick and easy. The simple four-tab interface guides the physicist through all the steps needed to evaluate data. Values for flatness, symmetry, and constancy are graphically displayed for analysis and review. Data can be viewed in graph or table form, and can easily be printed for archiving, if desired.

New memory management and diagnostic tools have been added in version 2.3 of the QA BeamChecker Plus, including:

- Improved clock function check on unit startup.
- Memory wear leveling: Measurement data better balanced across the entire memory footprint.
- CRC check and auto-correct from memory mirror on unit startup.
- Stand-alone diagnostic tool for improved Standard Imaging Support.

- Now accommodates the high dose rate (up to 2400 MU/min.) capability of modern linear accelerators. (NOTE: All new QA BeamChecker Plus devices (from SN Z142651 and higher) have high dose rate capability.")

2 Quick Start Guide

This section will give a basic overview for setting up and using the QA BeamChecker Plus. The steps listed here are covered in greater detail in following sections, and specific page numbers to these sections are included for additional reference.

- Getting Started
- Software Setup & Database Creation (Page 9 & 10)
- Room Setup (Page 10)
- Baseline Acquisition (Page 12)
- Performing Routine Measurements (Page 16)
- Data Download & Analysis (Page 24)

2.1 Getting Started

1. The following items are packaged with the QA BeamChecker Plus:

- (1) QA BeamChecker Plus
- (1) Power/Data Cradle
- (1) Universal Input Power Supply, 9 Volt DC
- (1) 25 ft. Serial Cable
- (1) 100 ft. Serial Cable
- (1) Serial to USB Adapter
- (1) QA BeamChecker Plus Communication Software CD-ROM
- This User Manual
- Any other optional accessories purchased

2. It is recommended to charge the QA BeamChecker Plus for 8 or more hours with the included Universal Input Power Supply (REF 76010) before use, which can be connected directly to the QA BeamChecker Plus or to the Power/Data Cradle.

3. To begin setup, bring the following items to the primary computer being used for this application: QA BeamChecker Plus, Universal Input Power Supply, Software CD, and one of the included serial cables.

4. Attach the power supply to live AC Mains Power and to the QA BeamChecker Plus (optional if battery has sufficient charge) and attach the serial cable from the QA BeamChecker Plus to an available computer serial port. If this local computer does not have a legacy serial port, please use the included Serial to USB Adapter. If you do not have this item, please contact Standard Imaging for Serial to USB Adapter (REF 70503) pricing and purchasing information.

Turning on the QA BeamChecker Plus for the First Time

Upon turning on the QA BeamChecker Plus, the firmware version is immediately displayed in two sets of 3-digit numbers. The first set displayed is the firmware version, e.g. 252, which

means version 2.5.2. The second set is the build number of this version, e.g. 002, which means build number 2. These numbers will display each time the QA BeamChecker Plus is turned on.

If no rooms or baselines are present on the unit, the display will show RM-. This means no rooms are available.

QA BeamChecker Plus Communication Software is now ready to be setup on a supported Microsoft® Windows® PC.

Windows® is a registered trademark of Microsoft Corporation.

2.2 Software Setup & Database Creation

1. Insert the Software CD into the PC and wait for the setup wizard to begin. If Autoplay is not enabled, browse the CD's contents and run the file Setup.exe. Follow the instructions to complete the setup. (See page 9 for more info)

2. Launch the QA Beam Checker Plus Communication Software. The device will turn on automatically. If it does not turn on automatically when the software is running, please check the serial communication path and (especially) the serial port setup (see Section 20, 'Features and Specifications').

3. A prompt will appear providing the opportunity to create a new database or browse for an existing database. Click Yes to create a new database (See page 10 for more info).

4. The Database Creator process will begin. If the QA BeamChecker Plus is properly connected, its serial number will be displayed. If not, refer to Section 16, 'Troubleshooting' for further information on diagnosing issues with the serial communication path. Continue the wizard by entering a database name and browsing for a location for the QA BeamChecker Plus database file to reside. It is advised to use a database naming convention that includes the device serial number for easy future identification.

NOTE: This one database file will contain measurement data taken for all treatment rooms assigned to this QA BeamChecker Plus. It is recommended to place the database in a location where it will be backed up, and if desired, accessible from other computers, such as a network location.

Complete the remaining steps, and the main Communication software interface will now be accessible.

5. The next step is to create a room to be used with the QA BeamChecker Plus. After completing the Database Creator process, a prompt will appear to allow creation of a room. Select the room type that matches the treatment machine desired and enter the remaining details to continue. Once completed, up to eight additional rooms may be added.

The QA BeamChecker Plus is now ready for acquisition of baselines.

2.3 Baseline Acquisition

A baseline is what the QA BeamChecker Plus uses to automatically determine which energy was delivered for static photon and electron measurements and serves as a comparative benchmark for subsequent exposures. A baseline must be acquired for each energy or plan delivered to the QA BeamChecker Plus.

NOTE: Additional preparations are necessary before taking this step for rotational methods such as TomoTherapy or IMAT/VMAT. See Appendix B for more information before proceeding.

NOTE: A baseline should be acquired roughly when the daily measurement will take place. For instance, if the daily measurement is regularly performed at 7:00 AM, the baseline should be taken at a similar time.

1. The QA BeamChecker Plus must be connected to the PC while baselines are acquired. Typically, the 100 ft serial cable is run from the computer (with USB adapter, if needed), into the treatment vault, and connected to the Power/Data Cradle (read more about the Power/Data Cradle on page 8). Using the pass-through port on the Power/Data Cradle, the 25 ft serial cable is used to connect the cradle to the QA BeamChecker Plus which is placed on the treatment couch. Ensure the QA BeamChecker Plus is flipped to the proper side based on initial energy to be delivered. Exact positioning varies by application; however 100 cm SSD and 20 x 20 cm field size is typical for static electron and photon exposure.

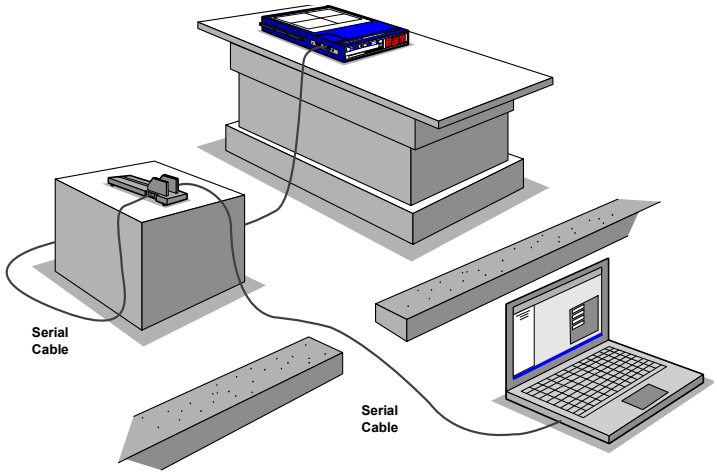


Figure 1: Typical QA BeamChecker Plus wired setup

2. Return to computer and launch the QA BeamChecker Plus software. At the top of the screen is a colored bar showing the hardware connection status. If the Baselines tab (bottom of screen) is selected, the status indicator at the top of the screen should show as yellow (Waiting). Click the Create New Baseline button.

3. Complete the form with the appropriate parameters and proceed to measurement. See page 12 for more information.

4. The status indicator should now show green (Ready). Review the entered parameters and expose the QA BeamChecker Plus with the desired energy or plan. The acquired

measurement values will show on screen. If satisfied with the measurement result, click Save Measurement. The main baseline screen is displayed, and results can be reviewed.

5. Repeat steps 2-4 for each desired energy or plan. The QA BeamChecker Plus will need to be flipped over if switching between photons and electrons. Baselines can be recreated at any time if necessary.

The QA BeamChecker Plus is now prepared for daily measurements.

2.4 Performing Routine Measurements

Routine measurements can be performed using either Wire-Free or Real-Time Operation modes, but this abbreviated guide will cover taking static linear accelerator measurements using the Wire-Free mode. The PC is not used for this method, therefore no cables or software are required.

Setup

1. Place the QA BeamChecker Plus on the treatment couch. For best results, match the approximate time of day and couch positioning used when the baselines were taken to minimize variance caused by accelerator warm-up and changes in scatter contribution. The unit will need to be flipped to the proper side for photon or electron measurement.

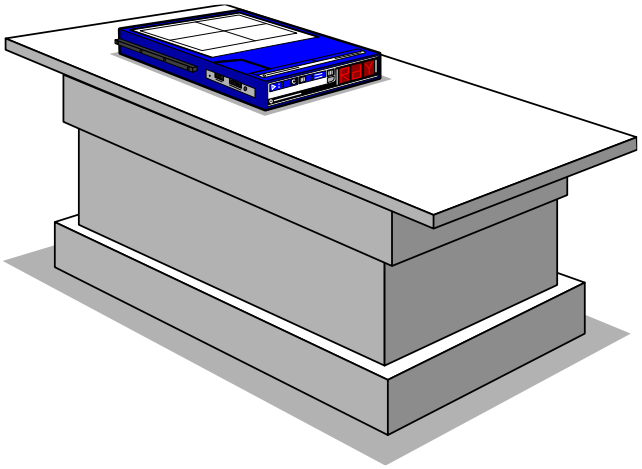


Figure 2: QA BeamChecker Plus Wire-Free setup

2. Turn the unit on. The firmware version will briefly display (e.g. 210), followed by RM (Room) alternating with SEL (Select), Room Select. Press the RESET/ROOM SELECT button to select the desired room (RM1, RM2, etc). After a brief pause the unit will display RdY (Ready).

3. Using the MODE / PLAN button (simply MODE on some models), select between Photon

4. Exit the vault and use the patient monitor and monitor to view the front of the QA BeamChecker Plus display.

Orientation may differ depending on room type or energy selected

Delivery

5. Expose the QA BeamChecker Plus with the desired energy. During the exposure, the QA BeamChecker Plus front display will show as spinning lines indicating a signal has been detected and measurement is in progress. After the exposure has ended, a single “beep” sound will occur, and an energy designation will show on the front display if it was successfully recognized. For example, 10X (10 MV photons). If the exposure falls within allowed action levels (tolerances) configured during the baseline – i.e. PASS, the QA BeamChecker Plus will automatically save the details for this measurement, reset and display RdY after about 10 seconds. It is now ready for the next energy exposure.

NOTE: If QA BeamChecker Plus has determined the energy falls outside of allowed action levels – i.e. FAIL, a repeated “beep” sound will occur and one or more of the following messages will appear on the front display: CST (Constancy), FLT (Flatness), ASM (Axial Symmetry), TSM (Transverse Symmetry). The speed and pattern of the beeping sound will differ depending on whether the measurement falls outside of action level 1 or 2. At this point, the treatment vault must be entered and the QA BeamChecker Plus manually reset by pressing the RESET/ROOM SELECT button. The details for this measurement will be saved for later investigation, and the QA BeamChecker Plus will display RdY. At this point, the failed energy can be attempted again, or a different energy can be tried.

6. Repeat the step 5 for all desired energies. If switching between photon and electron measurements, enter the vault to flip the device to the appropriate side and press the MODE / PLAN button. All measurements (pass or fail) will be saved for further review.

Measurement data is now ready to be downloaded by the PC for analysis and trending. Up to 512 unique measurements can be stored before download is required, but it is good practice to download data once every week to ensure the Wire-Free mode-acquired measurements are saved in the database..

2.5 Data Download & Analysis

1. To view the details for measurements taken in Wire-Free mode as explained in the previous section, the data must be transferred from the QA BeamChecker Plus to the database created

earlier with the PC software. If the Power/Data Cradle is attached via the serial cable to the PC with the QA BeamChecker Plus software installed, place the QA BeamChecker Plus in it. Alternatively, the cradle can be bypassed, and the serial cable from the PC can be attached directly to the QA BeamChecker Plus.

2. On the PC, launch the QA BeamChecker Plus Communication Software and select the Data View tab located towards the bottom of the screen.

3. In the upper left of the Data View tab is a Data Download area. If serial communication between the PC and the QA BeamChecker Plus is successful and data is available for download, the download button will show green and can be clicked at any time. Clicking this button will move all data from the QA BeamChecker Plus internal memory and will be visible in the Download Summary dialog. Click the Download Summary dialog 'Done' button to permit the data to be persisted in the database. At this point, the internal memory will be cleared for future measurements.

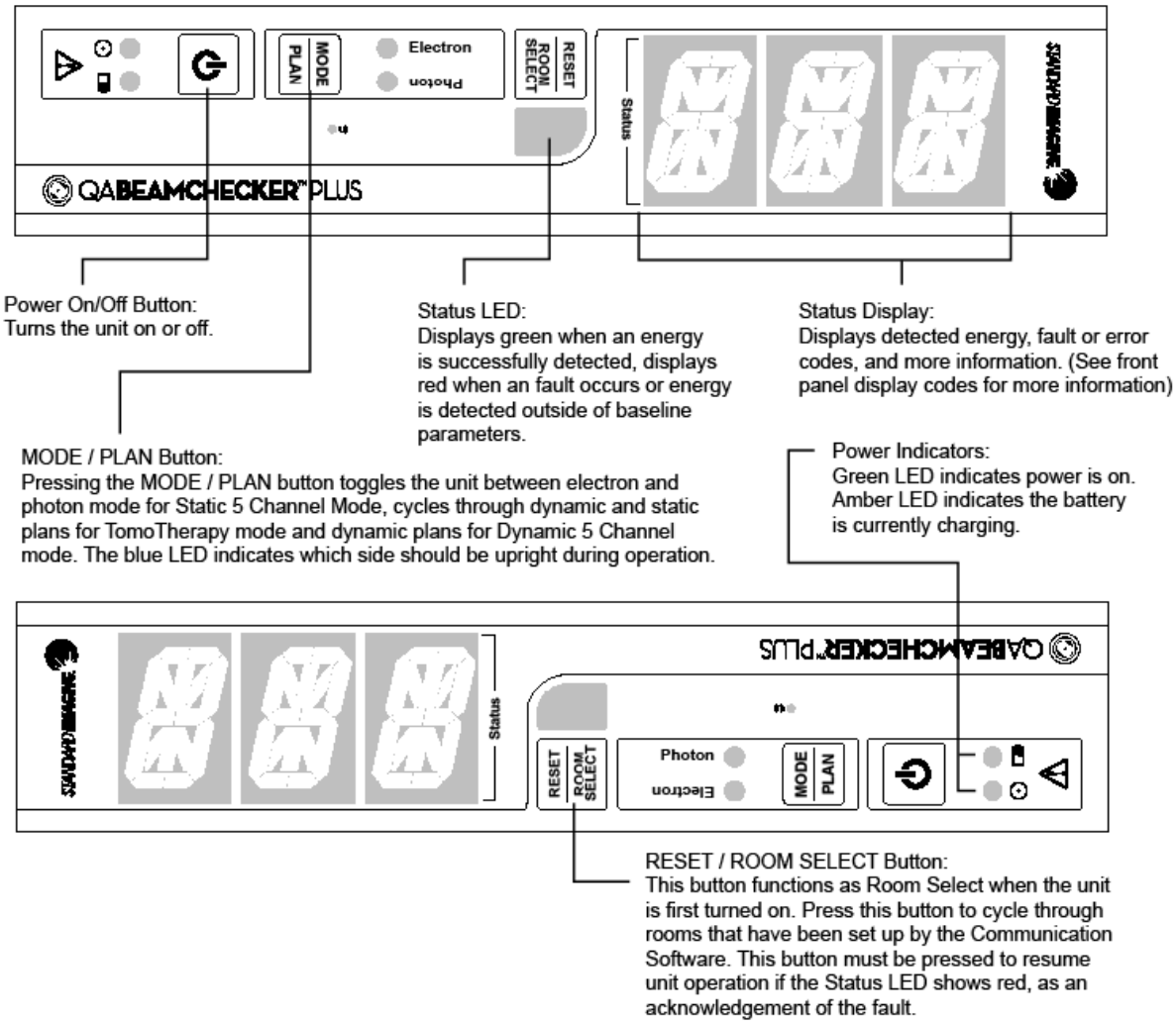
4. On this same screen, select an energy to view acquired measurement information.

5. Select a desired measurement date range and click the Update Chart button to see how measurements fall within the pre-configured action levels in chart view. Alternatively, the data can be viewed in tabular form by clicking the Table View button. In this view, measurements are shown as percentage difference compared to the baseline. Green values are passing, yellow values are outside of action level 1 and red values are outside of action level 2.

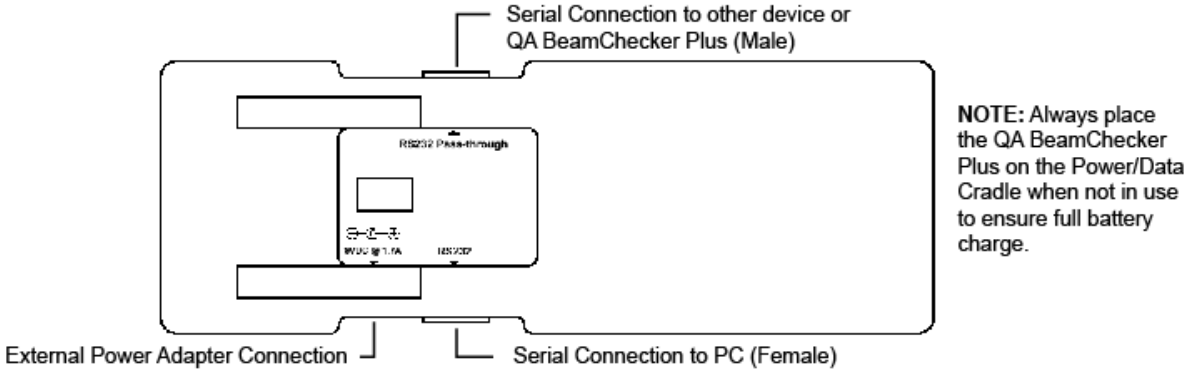
6. Data shown can be printed in report form or exported to .csv format for further analysis and calculation if desired by clicking the appropriate button.

3 Hardware Description

3.1 QA BeamChecker Plus Front Panel



3.2 Power/Data Cradle



4 Setting up the Communication Software

QA BeamChecker Plus Communication Software is designed to run under Microsoft Windows operating systems. See system requirements for more specific information. Before installing the software, it is recommended to close all other active programs.

NOTE: The account under which the QA BeamChecker Plus software is INSTALLED must have at least "Power User" access privileges within Windows. However, as of version 2.2.X, the software can be RUN as a basic "User". See the system administrator or operating system documentation for assistance and/or further details.

1. Insert the program CD-ROM into the computer's CD-ROM drive. If autorun is enabled, the InstallShield Wizard will begin automatically.

2. If autorun is disabled, browse to the CD-ROM root directory in Windows Explorer and double-click setup.exe to start the setup program.

3. Read through the software license agreement and click next to proceed with the setup. A QA BeamChecker Plus Communication Software program icon will be placed within the Start Menu under the Standard Imaging program group.

4. If prompted, restart the computer to complete setup and begin using the QA BeamChecker Plus Communication Software.

Upgrading an Existing Setup

The procedure for upgrading to a new version of the QA BeamChecker Plus Communication Software is roughly the same as setting up the software initially.

CAUTION: Before upgrading to a new version of QA BeamChecker Plus software, download any Wire-Free data to the database. If data is not downloaded prior to firmware upgrade, it may be lost.

NOTE: The account under which the QA BeamChecker Plus software is *setup* must have at least "Power User" access privileges within Windows. However, as of version 2.2.X, the software can be *run* as a basic "User". See the system administrator or operating system documentation for assistance and/or further details.

1. Insert the CD-ROM for the new version or run the executable downloaded from the Standard Imaging website.

2. If setup from a file downloaded from the Standard Imaging website, skip to step 3. Browse to the CD-ROM root directory or folder from the extracted .zip file in Windows Explorer and double-click setup.exe to start the setup program.

3. Proceed with the setup wizard. If an existing setup is detected, it will be upgraded to the new version and the new setup will be completed.

4. It is required that ALL computers using the QA BeamChecker Plus Communication Software are upgraded to the same version.

NOTE: Upon launching the software, the program should still "remember" where the last opened database resides and open it. However, with some software updates, the format of the database may change. In this case, the program will make a copy of the file in the same directory and convert the original to the new format. This process is transparent and happens automatically whenever a database with an older format is opened.

Firmware Upgrades

When a new version of the QA BeamChecker Plus Communication Software is installed, a firmware update may also be included. If a QA BeamChecker Plus unit is connected to the PC (either directly or via the Power/Data Cradle) and the software is opened, new firmware will automatically be uploaded to the unit.

NOTE: If installing a new software version at a facility with multiple QA BeamChecker Plus units, ensure that ALL units are upgraded with the latest firmware before performing daily measurements.

4.1 System Requirements

Software/Computer	
Operating System:	Windows 10 Professional, 64 bit recommended
Processor:	Dual Core, 1 GHz; Quad Core, 2 GHz Recommended
Memory:	32-bit OS: 2 GB, 4 GB Recommended 64-bit OS: 4 GB, 8 GB Recommended
Hard Drive:	32 GB or greater, 1 GB free space for initial software setup. 25% free space recommended
Screen Resolution:	1024 x 768 or greater
Optical Drive:	Compact Disc (CD) or Digital Versatile Disc (DVD)
Connectivity:	9 pin RS-232 serial port and IPv4 LAN, 100 Mbit/s or greater

5 Database and Room Setup and Management

5.1 Getting Started - Creating a Database

When starting the Communication Software for the first time, new database file will need to be created.

NOTE: An individual database file must be created for each QA BeamChecker Plus unit used.

Upon starting the software, connect the QA BeamChecker Plus to the PC and turn it on if necessary. A prompt will appear providing the opportunity to create a new database or browse for an existing database. Select Yes and use the Database Creator to create a new database file. Enter the appropriate information such as institution and database file name and location.

NOTE: The database file can be accessed from any computer running the QA BeamChecker Plus Communication Software, so a location on a network is an ideal selection. If this file is lost, measurement and baseline data cannot be recovered so periodic backup is highly recommended. This file can be moved to any location after the initial setup takes place.

If database already exists from a previous setup, select No and browse for its location.

Editing Database Properties

To edit the properties for the database such as institution information and view the full path of where the database is located, click the Room Properties icon on the toolbar or navigate to *File > Database > Properties*.

Moving or Renaming a Database

To move or rename a database file, close the QA BeamChecker Plus software, and browse for the file within Windows Explorer. Move the file to the desired location or rename the file. Reopen the QA BeamChecker Plus software and a message will appear notifying that the file cannot be found. Click Browse and open the file from the new location or select the renamed database file. From here, the software will recall this location until additional changes are made.

5.2 Next Step - Treatment Rooms

A single QA BeamChecker Plus unit has the ability to operate and store data from nine different treatment rooms. A room contains the baselines and measurement data for a specific machine. The total of nine rooms can be any combination of Static 5 Channel, TomoTherapy, or Dynamic 5 Channel rooms. Upon completing the Database Creator process, an opportunity to create a room will appear. However, at any other time, the following procedure describes how to add a treatment room.

Adding a Treatment Room

1. Connect the QA BeamChecker Plus and start the Communication Software.

NOTE: The QA BeamChecker Plus must be attached to the system in order to add treatment rooms.

2. If it is not already open, load the database file which matches the QA BeamChecker Plus attached to the system by clicking the open icon from the toolbar or navigating to File > Database > Open. Browse to and select the database file and click OK.

3. On the left side of the screen select the text "QABC Plus Zxxxxxx", where Zxxxxxx indicates the serial number of QA BeamChecker Plus associated with the database file.

4. Click the Add Room icon on the toolbar or navigate to *File > Room > Add Room*.

5. Enter the appropriate information for the new room including the Room Label/Number, Unit Type, and Machine Name. Three room types are available:

Static 5 Channel: For typical static beam delivery of linear accelerator beams. Parameters tested are beam constancy, flatness, axial (radial) symmetry, and transverse symmetry. Both the electron and photon sides of the QABC+ are used for this room type. For any beams tested with wedges, use the Dynamic 5 Channel room type (see below).

TomoTherapy Systems: For dynamic and static beams with TomoTherapy Systems (Hi·Art, H-Series or Radixact). This room type utilizes only the chambers along the X-axis within the QABC+ due to the jaw width configuration within the TomoTherapy treatment delivery system. Parameters tested in static mode are energy constancy, output constancy, and lateral profile constancy. In dynamic mode, output constancy for each chamber is tested. Only the photon side of the QABC+ is used for this room type.

Dynamic 5 Channel: For beam delivery using full field rotational machines such as RapidArc or VMAT. This mode can also be used for testing wedges, either physical or virtual. Each of the 5 primary chambers within the QABC+ (top, bottom, center, left, and right) are tested for output constancy. Only the photon side of the QABC+ is used for this mode.

Click the OK button to continue.

6. A new room will be added and can be accessed via the left side browser pane.

To add another room, repeat this process.

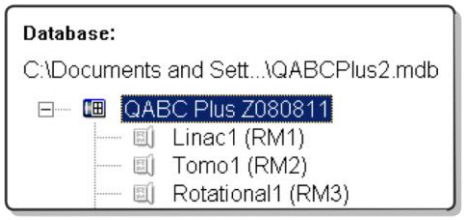
Deleting a Treatment Room

1. Connect the QA BeamChecker Plus and start the Communication Software.

NOTE: The QA BeamChecker Plus must be attached to the system in order to delete treatment rooms.

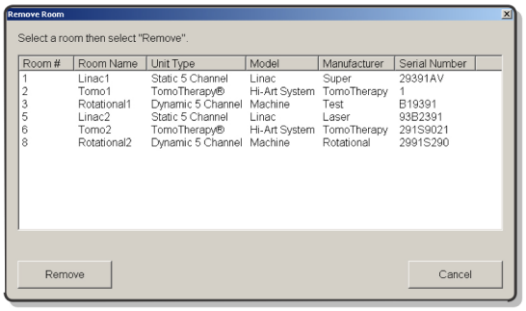
2. If it is not already open, load the database file which matches the QA BeamChecker Plus attached to the system by clicking the open icon from the toolbar or navigating to File > Database > Open. Browse to and select the database file and click OK.

3. On the left side of the screen select the text “QABC Plus Zxxxxxx”, where Zxxxxxx represents the serial number of QA BeamChecker Plus associated with the database file.



4. Navigate to *File > Room > Delete Room*.

5. A dialog box will appear and a room can be selected. Select the desired room and click the Remove button.



6. The software will ask for confirmation. Click OK to confirm or Cancel to abort.

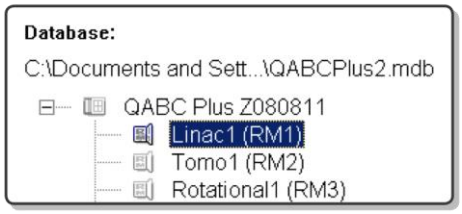
CAUTION: Once room is deleted, it CANNOT be recovered.

7. A .csv for each energy or plan within the room will be exported to the location selected. This file contains all baseline and measurement data. See Appendix C for format information.

To delete another room, repeat this process.

Editing a Treatment Room's Properties

1. Open the appropriate database file, and select a room by highlighting its name in the left side browser pane.



2. Click the Edit Room icon on the toolbar or navigate to *File > Room > Room Properties* and the properties edit window will appear. Here, the Name, Make, Model, Type, and Serial Number of the machine this room is assigned to can be changed. Additionally, the room label can be changed. Click OK to confirm changes or Cancel to abort.

6 Preparatory Measurements - Baselines

6.1 Introduction

Before getting started, ensure the software is properly installed and configured by reading the *Installing the Communication Software* and *Database Setup and Room Management* sections of this manual.

In order to begin taking routine measurements with the QA BeamChecker Plus, a Baseline must be created for each energy or plan to be tested. A baseline is a benchmark that is created to compare beam exposure to when using Wire-Free or Real-Time Operation modes. (See pages 16 and 19 respectively)

NOTE: A baseline should be acquired roughly when the daily measurement will take place. For instance, if the daily measurement is regularly performed at 7:00 AM, the baseline should be taken at a similar time.

This section of the manual details the procedure for creating a baseline for all three room types: Static 5 Channel, Dynamic 5 Channel, and TomoTherapy (Hi-Art, H-Series, or Radixact). While minimal pre-planning is required for routine photon and electron measurements (Static 5 Channel), Dynamic 5 Channel and TomoTherapy delivery require the creation of specifically prepared treatment plans. See Appendix B to learn about creating plans before proceeding.

The QA BeamChecker Plus must be connected to the PC while baselines are acquired. Typically, the 100 ft serial cable is run from the computer (with USB adapter, if needed), into the treatment vault, and connected to the Power/Data Cradle (read more about the Power/Data Cradle on page 8). Using the pass-through port on the Power/Data Cradle, the 25 ft serial cable is used to connect the cradle to the QA BeamChecker Plus which is placed on the treatment couch.

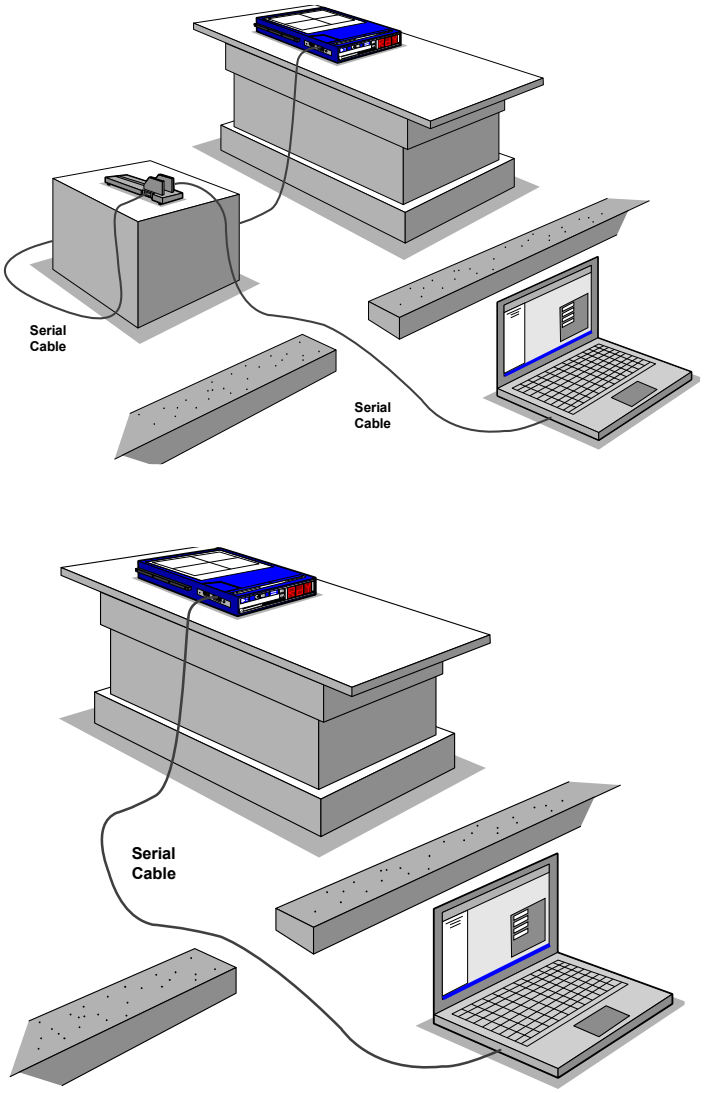


Figure 3: QA BeamChecker Plus connected to PC via serial cable shown using two methods: with and without cradle pass through

NOTE: A Bluetooth Adapter Kit (REF 70504) is an available option allowing wireless communication from the PC to the QA BeamChecker Plus in place of a wired serial connection. See page 53 for more details.

6.2 Step 1: Hardware Setup

Select the appropriate section below based on application: Static 5 Channel (traditional linear accelerator photon/electron measurements), Dynamic 5 Channel (IMAT, VMAT, or dynamic wedge measurements) or TomoTherapy System (static or dynamic exposure).

Static 5 Channel Room

1. Choose whether measuring photons or electrons. If electrons, ensure a 20 x 20 cm electron cone is attached to the accelerator.

2. Place the QA BeamChecker Plus on the treatment couch ensuring it is flipped to the proper side, Photon or Electron, as indicated by the large white field labels on both sides of the device.

3. Position the QA BeamChecker Plus at 100 cm SSD with a field size of 20 x 20 cm. Align the unit to the center of the field using the QA BeamChecker Plus fiducials and the room alignment lasers.

4. Connect the QA BeamChecker Plus to the PC as shown in Figure 3.

Dynamic 5 Channel Room

1. Place the QA BeamChecker Plus on the treatment couch ensuring it is flipped to the Photon side as indicated by the large white field labels on both sides of the device.

2. Position the QA BeamChecker Plus at 100 cm SSD with a field size of 20 x 20 cm. Align the unit to the center of the field using the QA BeamChecker Plus fiducials and the room alignment lasers.

3. Connect the QA BeamChecker Plus to the PC as shown in Figure 3.

TomoTherapy System Room

1. Place the Precision TomoTherapy Leveling Platform (or other leveling device) onto the treatment couch, and place the QA BeamChecker Plus onto it ensuring the Photon side is facing up as indicated by the large white field labels on both sides of the device.

2. Level the top of the QA BeamChecker Plus by placing the precision bubble level at the center of the top surface and adjusting the three leveling screws on the leveling platform as needed.

3. Adjust the vertical height using the treatment couch until the horizontal side lasers line up to the fiducial alignment mark on the top end of the QA BeamChecker Plus facing the bore of the TomoTherapy unit. After the couch height is correct, align the lasers to the crosshair on the top surface of the unit.

4. Now complete an MVCT of the QA BeamChecker Plus by following the directions for running a Patient Daily alignment procedure using Treatment Delivery Console and the appropriate TomoTherapy Treatment Planning software for your Treatment Delivery System. After completing the scan, register the MV image to the reference image (taken during the planning step - See *Appendix B*). Note registration adjustments.

5. Connect the QA BeamChecker Plus to the PC as shown in Figure 3.

6.3 Step 2: Prepare the Communication Software

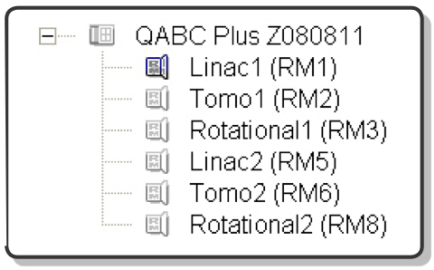
1. On the PC connected to the QA BeamChecker Plus, launch the QA BeamChecker Plus Communication Software.

NOTE: The QA BeamChecker Plus should automatically turn on when the communication software is launched.

2. If the database file associated with the QA BeamChecker Plus connected to the PC is not already open, open it by clicking the open icon on the toolbar or navigating to *File > Database > Open* and browse for the correct file.

3. Depending on the tab being viewed, the Connection Status shown at the top of the screen should read “Waiting for User” (yellow) or “Ready for Beam” (green). If the Connection Status shows as red, see the *Troubleshooting* section of this manual for more information.

4. If connection is verified, select the appropriate treatment room (RM1, RM2, etc) from the left side of the screen.



CAUTION: Ensure the proper room is selected to avoid overwriting or adding new data to the wrong room.

5. Select the Baselines tab at the bottom of the screen. At this point, the Connection Status shown at the top of the screen should be shown as “Connected, Waiting for User” (yellow).

6. Click the Create New Baseline button.

7. Enter parameters for the baseline. These parameters differ depending on the room type, Static 5 Channel, Dynamic 5 Channel or TomoTherapy, as follows:

Static 5 Channel Room

· **Energy Type:** Photons or Electrons
· **Energy:** Select from the pull down list (6X, 18E, etc)
· **Dose:** Configured dose value of the beam
· **Dose Rate:** Configured dose rate of the beam
· **Expected Output:** Expected beam out relative to existing calibration
· **SSD (Source to Surface Distance) in cm:** Default is 100
· **Gantry Angle in degrees:** Default is 0

· **Field Size (x,y) in cm:** Default is 20,20
· **Measured by:** Name or initials of the baseline creator
· **Action Levels:** represent the point at which a flatness, axial symmetry, transverse symmetry, or constancy 'out of tolerance' will occur during measurement in Real-Time Operation or Wire-Free Modes.

If a measured energy differs by or more than the percentage entered in 'Action Level 1' box, a level 1 'out of tolerance' will occur. Likewise, if a measured energy differs at or above the percentage entered in 'Action Level 2' box, a level 2 'out of tolerance' will occur, with Action Level 2 occurring at a greater percent difference. Default settings are Action Level 1 at 3% and Action Level 2 at 5%.

About Expected Output

If an output offset from previous beam calibration is known at time of baseline acquisition, this number can used to shift the measurement results. For example, if the baseline Expected Output is entered as 98%, an identical subsequent measurement in Wire-Free or Real-time modes will result in a -2% constancy result. This parameter can essentially be used to create asymmetric action levels. In this example using 98% for Expected Output, a 3% action level would produce a fault if the reading was 1% lower or 5% higher than the baseline.

Dynamic 5 Channel Room

· Label: D01 - D25. Up to 25 different plans can used per Dynamic 5 Channel room. Use this designation to identify which plan is being baselined.

· Dose: Configured dose value of the beam

· Dose Rate: Configured dose rate of the beam. Default is NA (not applicable)

· SSD (Source to Surface Distance) in cm: Default is 100

· Gantry Angle in degrees: Default is 0

· Field Size (x,y) in cm: Default is 20,20

· Measured by: Name or initials of the baseline creator

· Action Levels: represent the point at which a flatness, axial symmetry, transverse symmetry, or constancy 'out of tolerance' will occur during measurement in Real-Time Operation or Wire-Free Modes.

If a measured energy differs by or more than the percentage entered in 'Action Level 1' box, a level 1 'out of tolerance' will occur. Likewise, if a measured energy differs at or above the percentage entered in 'Action Level 2' box, a level 2 'out of tolerance' will occur, with Action Level 2 occurring at a greater percent difference. Default settings are Action Level 1 at 2% and Action Level 2 at 4%.

· Description: Use this field to help describe the plan. For example, "10X Rotational Plan B".

TomoTherapy System Room

· Delivery: Static or Dynamic (select based on plan type delivered, see Appendix B)

• Label: If Static Delivery selected, S01 - S25, if Dynamic Delivery Selected, D01 - D25. Up to 25 different plans for each Static and Dynamic can be used per TomoTherapy System room. Use this designation to identify which plan is being baselined.

• Dose: Configured dose value of the beam

• Dose Rate: Configured dose rate of the beam. Default is NA (not applicable)

• SAD (Source to Axis Distance) in cm: Default is 85

• Gantry Angle in degrees: Default is 0

• Field Size (x,y) in cm: Default is 5

• Measured by: Name or initials of the baseline creator

• Action Levels: represent the point at which a flatness, axial symmetry, transverse symmetry, or constancy 'out of tolerance' will occur during measurement in Real-Time Operation or Wire-Free Modes.

If a measured energy differs by or more than the percentage entered in 'Action Level 1' box, a level 1 'out of tolerance' will occur. Likewise, if a measured energy differs at or above the percentage entered in 'Action Level 2' box, a level 2 'out of tolerance' will occur, with Action Level 2 occurring at a greater percent difference. Default settings are Action Level 1 at 2% and Action Level 2 at 4%.

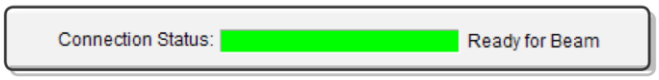
• Description: Use this field to help describe the plan. For example, "Jaw Width 2.5 cm Plan C".

8. Click Proceed to Measurement.

9. Review the entered parameters and ensure the QA BeamChecker Plus is properly aligned on the treatment couch. By clicking Modify, baseline parameters can be changed on the previous screen.

NOTE: Verify the QA BeamChecker Plus is flipped to the proper side. The side facing up should be labeled as Photon or Electron as desired. At this point the software is in control of the mode settings of the device so if the QA BeamChecker Plus display text orientation is incorrect, verify the proper room and delivery type in the baseline parameters.

10. The Connection Status should now read as "Ready for Beam" (green), indicating the QA BeamChecker Plus is ready for exposure. If satisfied with the selected parameters, irradiate the QA BeamChecker Plus.



11. Upon detecting signal, the QA BeamChecker Plus will begin measurement, and the Connection Status bar will alternate between green and yellow. Once exposure is completed, raw measured values will appear on the graphical representation of the QA BeamChecker

Plus' alignment field. Additionally, temperature, pressure and beam specific properties will appear and vary depending on the room type and delivery:

· Static 5 Channel: Flatness, Axial Symmetry, and Transverse Symmetry

· Dynamic 5 Channel: Left Reference, Top Reference, Center Reference, Bottom Reference, and Right Reference

· TomoTherapy System Static Delivery: Lateral Profile, Output Reference, and Energy Measurement

· TomoTherapy System Dynamic Delivery: Left Reference, Center Reference, and Right Reference

12. If satisfied with the baseline acquired, click Save Baseline. If for any reason the measurement was not satisfactory, click Clear Values and Re-Baseline to re-irradiate using the same parameters or modify the settings as explained in step 8.

6.4 Recreating Baselines

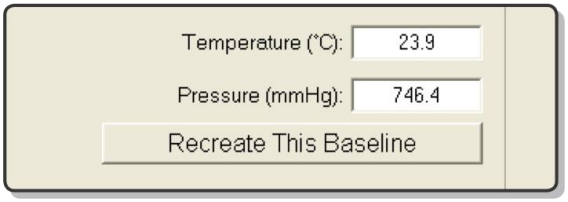
To recreate a baseline for a particular energy or plan, the procedure is nearly identical to creating a baseline.

1. Setup the QA BeamChecker Plus hardware as described in the section titled *Step 1: Hardware Setup* on page 12.

2. Continue with *Step 2: Prepare the Communication Software* steps 1-4.

3. On the Baselines tab, select the energy or plan to be recreated.

4. Click the Recreate This Baseline button.



5. Continue with steps 7-11 from *Step 2: Prepare the Communication Software*. The new baseline will be saved to the database.

NOTE: Once a new baseline is created, it is not possible to revert to an older version, however previous baselines are archived in the database for continued comparison to pre-existing measurements. After a baseline is recreated, subsequent measurements will be compared to the new baseline. See the *Data View - Download, Trending, and Analysis* section of this manual for more information.

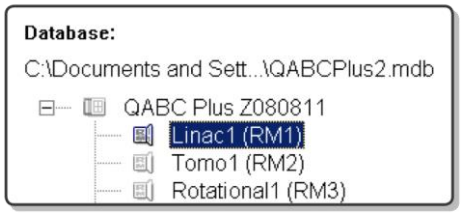
6.5 Deleting Baselines

If a plan or energy was created by mistake or is no longer needed, it can be deleted from the database using the following procedure.

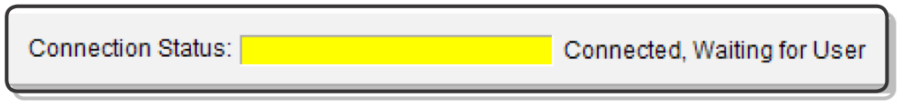
1. Connect the QA BeamChecker Plus to the PC.

2. Launch the Communication Software and ensure the correct database is loaded.

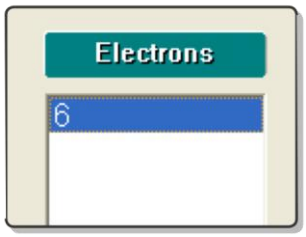
3. Select the desired room containing the plan or energy for deletion on the left side of the screen.



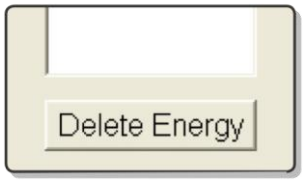
4. Select the Baselines tab and confirm the Connection Status reads “Connected, Waiting for User” (yellow).



5. Select the desired plan or energy for deletion.



6. Click the Delete Plan or Delete Energy button depending on the room type.



7. Confirm the operation.

CAUTION: Once an energy or plan is deleted, it CANNOT be recovered.

8. A .csv file will be exported which contains all baseline and measurement information for the selected plan or energy. Browse for a location to save this file and click OK to confirm.

7 Routine QA Measurements

7.1 Introduction

After baseline acquisition has been completed for the desired plans and energies by following the instructions in the *Preparatory Measurements - Baselines* section of this manual, the QA BeamChecker Plus is ready for routine measurements.

NOTE: It is recommended to perform routine measurements during the same part of the day that the baseline was acquired. While the on-board temperature and pressure sensor can compensate for some changes in environmental conditions, other factors such as the state of accelerator warm-up and repeatability of couch placement can produce false positives for faults in beam quality. Consistency is important to make an accurate relative comparison measurement.

The QA BeamChecker Plus offers two distinct modes for performing routine measurements: Wire-Free Mode and Real-Time Operation Mode. Both modes ultimately record identical, comprehensive measurement information, but differ in setup and the level of detail presented at time of measurement. Read on to learn about the benefits of each mode.

About Wire-Free Mode

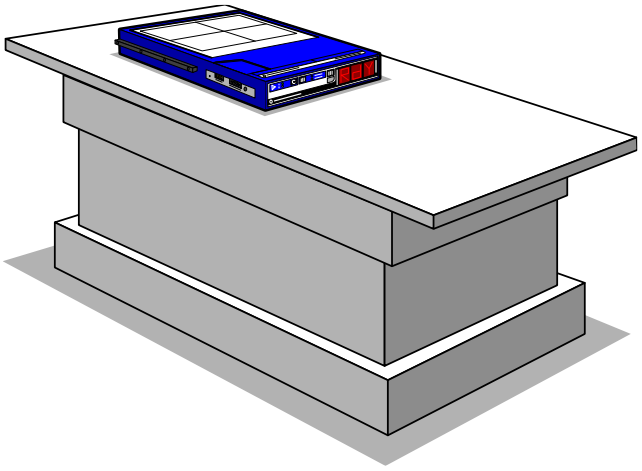


Figure 4: QA BeamChecker Plus Wire-Free setup

The Wire-Free Mode provides the fastest method for performing routine QA measurements for a linear accelerator by providing an easy, software-free solution for identifying if an energy or plan is out of tolerance. After creating baselines, the QA BeamChecker Plus is equipped with all the information necessary to perform automatic energy detection and relative comparison - all without being tethered to a computer. Set the QA BeamChecker Plus on the treatment couch, expose it to the beam with any baselined energy, and the front panel display

will identify the energy, give a pass/fail indication based on pre-configured action levels, save this measurement to internal memory, and automatically reset for the next exposure. All measurement data can be transferred to the PC for analysis and trending later.

Wire-Free mode is particularly useful in these situations:

· Performing routine QA when only a pass/fail indication is necessary at time of measurement

· Allowing radiation therapists to perform daily QA with minimal setup and configuration

About Real-Time Operation Mode

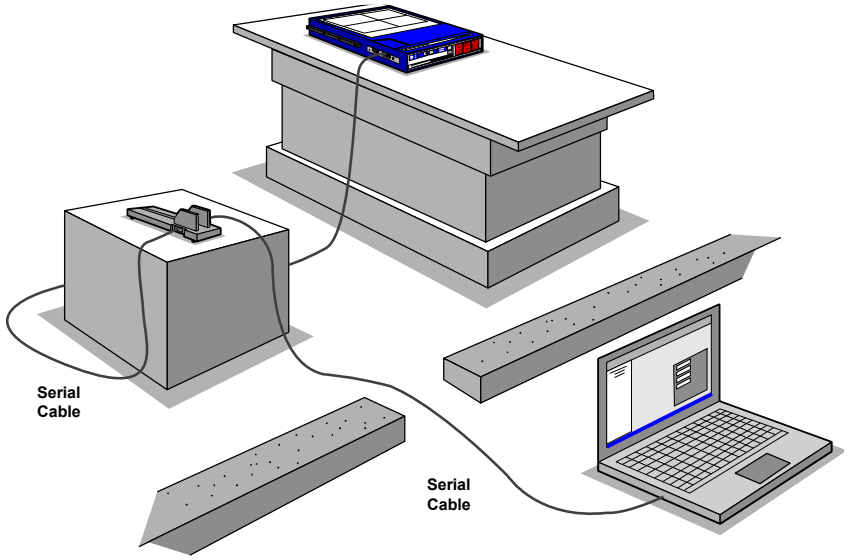


Figure 5: Typical QA BeamChecker Plus Real-Time Operation setup

The Real-Time Operation Mode provides routine QA measurements by displaying results through the Communication Software interface. With the QA BeamChecker Plus connected to the PC via RS-232 serial interface, the measured beam parameters, percentage difference from the baseline, and raw chamber values can be viewed in real-time. Upon measurement completion, the acquired data can be saved to the database or discarded. As in Wire-Free mode, linear accelerator photon and electron beams are automatically detected from baseline parameters.

Real-Time Operation mode is particularly useful in these situations:

· Performing routine QA when comprehensive beam information is necessary at time of measurement

· Experimentation or times when automatic saving to the database is not desired

· Dynamic 5 Channel and TomoTherapy room types where a plan must be manually selected to measure. Avoid trips in and out of the vault by selecting the desired plan via software control

7.2 Measurement with Wire-Free Mode

Select the appropriate section below based on application: Static 5 Channel (traditional linear accelerator photon/electron measurements), Dynamic 5 Channel (IMAT, VMAT, or dynamic wedge measurements) or TomoTherapy System (static or dynamic exposure).

NOTE: To ensure the QA BeamChecker Plus is always charged and ready to use, return the unit to its cradle after measurements are completed.

Static 5 Channel Room

1. Choose whether measuring photons or electrons. If using electrons, ensure a 20 x 20 cm electron cone is attached to the accelerator.

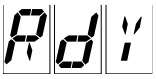
2. Place the QA BeamChecker Plus on the treatment couch ensuring it is flipped to the proper side, Photon or Electron, as indicated by the large white field labels on both sides of the device.

3. Position the QA BeamChecker Plus at 100 cm SSD with a field size of 20 x 20 cm. Align the unit to the center of the field using the QA BeamChecker Plus fiducials and the room alignment lasers.

4. Turn the QA BeamChecker Plus on using the power button on the front of the unit.

5. If only 1 room is configured, skip to step 6. After displaying the firmware version, the front panel will alternate between RM and SEL (Room Select). Press the RESET / ROOM SELECT button to cycle through the available rooms (displayed as RM1, RM2, etc). Once the desired room number is displayed, briefly wait and the selection will be set.

6. Select PHO (Photon) or ELE (Electron) mode using the MODE / PLAN button. If the QA BeamChecker Plus is flipped to the proper side, the front display should be properly oriented.



7. The front panel will now display Rdy (Ready).

8. Exit the vault and position the patient monitor to view the front panel of the QA BeamChecker Plus so its display is readable.

Orientation may differ depending on room type or energy selected

9. Deliver any energy to the QA BeamChecker Plus for which a baseline exists. Measurement will start automatically as indicated by spinning lines displayed on the front panel.

10. Check the patient monitor to verify the energy was detected successfully. For example, if 6 MV was administered, 06E will be displayed, and the measurement will be saved. If the beam parameters fall below action level 1 (set at time of baseline), the unit will reset in roughly ten seconds, re-arm, and display Rdy. If the unit beeps repeatedly and a fault is displayed or the energy is not detected, see the following section of the manual: *Wire-Free Measurement Fault*.

11. Repeat steps 9-10 for other energies if not switching between photons and electrons, otherwise enter the vault, flip the unit to the correct side, and continue from step 6.

12. Once completed, the acquired measurements can be transferred to the PC for analysis. For instructions, see the *Data View and Downloading Measurements* section of this manual.

Dynamic 5 Channel Room

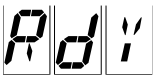
1. Place the QA BeamChecker Plus on the treatment couch ensuring it is flipped to the Photon side as indicated by the large white field labels on both sides of the device.

2. Position the QA BeamChecker Plus at 100 cm SSD with a field size of 20 x 20 cm. Align the unit to the center of the field using the QA BeamChecker Plus fiducials and the room alignment lasers.

3. Turn the QA BeamChecker Plus on using the power button on the front of the unit.

4. **If only 1 room is configured, skip to step 5.** After displaying the firmware version, the front panel will alternate between RM and SEL (Room Select). Press the RESET / ROOM SELECT button to cycle through the available rooms (displayed as RM1, RM2, etc). Once the desired room number is displayed, briefly wait and the selection will be set.

5. The QA BeamChecker Plus display will now alternate between PLN, SEL (Plan Select). Press the MODE / PLAN button to cycle through the available plans (displayed as D01, D02, etc). Once the desired plan number is displayed, briefly wait and the selection will be set.



6. The front panel will now display Rdy (Ready).

7. Exit the vault and position the patient monitor to view the front panel of the QA BeamChecker Plus so its display is readable.

Orientation may differ depending on room type or energy selected

8. Deliver the plan selected on the front panel of the unit. Measurement will start automatically as indicated by spinning lines displayed on the front panel.

9. Check the patient monitor to verify the plan was successfully delivered. For example, if D03 (label selected at time of baseline) was administered, d03 will be displayed, and the measurement will be saved. If the beam parameters fall below action level 1 (set at time of baseline), the unit will reset in roughly ten seconds, re-arm, and display Rdy. If the unit beeps repeatedly and a fault message is displayed, see the following section of the manual: *Wire-Free Measurement Fault*.

10. Repeat steps 8-9 to test the same plan again, otherwise enter the vault and use the MODE / PLAN button to select a new plan from the QA BeamChecker Plus front panel.

11. Once completed, the acquired measurements can be transferred to the PC for analysis. For instructions, see the *Data View and Downloading Measurements* section of this manual.

TomoTherapy System Room

1. Place the Precision TomoTherapy Leveling Platform (or other leveling device) onto the treatment couch, and place the QA BeamChecker Plus onto it ensuring the Photon side is facing up as indicated by the large white field labels on both sides of the device.

2. Level the top of the QA BeamChecker Plus by placing the precision bubble level at the center of the top surface, and adjusting the three leveling screws on the leveling platform as needed.

3. Adjust the vertical height using the treatment couch until the horizontal side lasers line up to the fiducial alignment mark on the top end of the QA BeamChecker Plus facing the bore of the TomoTherapy unit. After the couch height is correct, align the lasers to the crosshair on the top surface of the unit.

4. Exit the vault and position the patient monitor to view the front panel of the QA BeamChecker Plus so its display is readable.

Orientation may differ depending on room type or energy selected

5. Now complete an MVCT of the QA BeamChecker Plus by following the directions for running a procedure on the "What's Next?" box at the top of the screen in the TomoTherapy software. After completing the scan, go to the registration panel on the Operator's Station and register the MV image to the reference image (taken during the planning step - See *Appendix B*) using the manual adjustments. Note registration adjustments.

CAUTION: Do not irradiate past the 20 x 20 cm field label edge.

6. Turn the QA BeamChecker Plus on using the power button on the front of the unit.

RESET / ROOM SELECT

7. **(If only 1 room is configured, skip to step 5)** After displaying the firmware version, the front panel will alternate between RM and SEL (Room Select). Press the RESET / ROOM SELECT button to cycle through the available rooms (displayed as RM1, RM2, etc). Once the desired room number is displayed, briefly wait and the selection will be set.

MODE / PLAN

8. The QA BeamChecker Plus display will now alternate between PLN, SEL (Plan Select). Press the MODE / PLAN button to cycle through the available plans (displayed as D01, D02, S01, S02, etc). Once the desired plan number is displayed, briefly wait and the selection will be set.

9. The front panel will now display Rdy (Ready).

10. Deliver the plan selected on the front panel of the unit. Measurement will start automatically as indicated by spinning lines displayed on the front panel.

11. Check the patient monitor to verify the plan was successfully delivered. For example, if S02 (label selected at time of baseline) was administered, S02 will be displayed, and the measurement will be saved. If the beam parameters fall below action level 1 (set at time of baseline), the unit will reset in roughly ten seconds, re-arm, and display Rdy. If the unit beeps repeatedly and a fault message is displayed, see the following section of the manual: *Wire-Free Measurement Fault*.

MODE / PLAN

12. Repeat steps 10-11 to test the same plan again, otherwise enter the vault and use the MODE / PLAN button to select a new plan from the QA BeamChecker Plus front panel.

13. Once completed, the acquired measurements can be transferred to the PC for analysis. For instructions, see the *Data View and Downloading Measurements* section of this manual.

7.3 High-Dose Rate Measurements

The QABC+ is equipped (beginning with SN Z142651 and higher) to handle high dose rates up to 2400 MU/min and FFF beams.

NOTE: Existing QABC+ units can be upgraded to properly respond to high-dose rate beams with a simple hardware upgrade. Please contact your Standard Imaging representative for information on the upgrade.

The QABC+ should be set up in the same manner as used for standard daily linac QA measurements. In order to differentiate the beam qualities (e.g. 6 MV versus 6 MV FFF), it is suggested that two separate baselines are created during the initial setup of the device if a single room is set up in the software.

For example, a baseline using 100 MU can be created for the 6 MV FFF beam, and another can be created using 120 MU for the 6 MV beam in the same room. Alternatively, a separate room could be created within the software to manage the FFF beams independently.

7.4 Wire-Free Measurement Fault

If a measured energy falls out of range of the preset baseline, the QA BeamChecker Plus status indicator will show red and will respond differently based on action level:

Action Level	Blinking Rate	Beep Tone
1	Slow	On/Off Slow
2	Fast	Continuous

The front panel will also display a fault code. If more than one beam parameter is out of tolerance, multiple codes will display in sequence along with the detected energy.

In order to proceed to the next measurement, the fault must be acknowledged by entering the treatment room and pressing the RESET / ROOM RESET button on the front panel. These faults are recorded in the internal memory of the QA BeamChecker Plus for review after downloading (See page 24). If the unit is turned off before the RESET / ROOM SELECT button is pressed, this measurement point will not be saved.

The following is a list of possible fault codes by room type:

Static 5 Channel Room

ASM Axial Symmetry Out of Tolerance
TSM Transverse Symmetry Out of Tolerance
FLT Flatness Out of Tolerance
CST Constancy Out of Tolerance
XXX Energy could not be determined (See page 44)

Dynamic 5 Channel Room

OCC Output Constancy (Center) Out of Tolerance
OCT Output Constancy (Top) Out of Tolerance
OCb Output Constancy (Bottom) Out of Tolerance
OCL Output Constancy (Left) Out of Tolerance
OCR Output Constancy (Right) Out of Tolerance

TomoTherapy System Room - Static Mode

ENC Energy Constancy Out of Tolerance
LPC Lateral Profile Constancy Out of Tolerance
OCC Output Constancy (Center) Out of Tolerance

TomoTherapy System Room - Dynamic Mode

OCC Output Constancy (Center) Out of Tolerance
OCL Output Constancy (Left) Out of Tolerance
OCR Output Constancy (Right) Out of Tolerance

If one or more of these faults occur, follow the QA protocols defined by the facility to determine the next course of action.

7.5 Measurement with Real-Time Operation Mode

Select the appropriate section below based on application: Static 5 Channel (traditional linear accelerator photon/electron measurements), Dynamic 5 Channel (IMAT, VMAT, or dynamic wedge measurements) or TomoTherapy System (static or dynamic exposure).

NOTE: A Bluetooth Adapter Kit (REF 70504) is an available option allowing wireless communication from the PC to the QA BeamChecker Plus in place of a wired serial connection. See page 53 for more details.

Static 5 Channel Room

1. Choose whether measuring photons or electrons. If using electrons, ensure a 20 x 20 cm electron cone is attached to the accelerator.

2. Place the QA BeamChecker Plus on the treatment couch ensuring it is flipped to the proper side, Photon or Electron, as indicated by the large white field labels on both sides of the device.

3. Position the QA BeamChecker Plus at 100 cm SSD with a field size of 20 x 20 cm. Align the unit to the center of the field using the QA BeamChecker Plus fiducials and the room alignment lasers.

4. Connect the QA BeamChecker Plus to the PC as shown in Figure 5 and exit the vault.

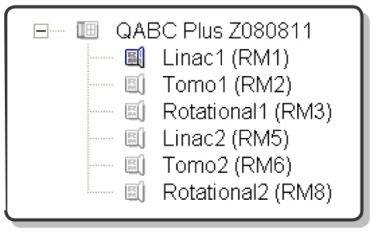
5. On the PC connected to the QA BeamChecker Plus, launch the QA BeamChecker Plus Communication Software.

NOTE: The QA BeamChecker Plus should automatically turn on when the communication software is launched.

6. If the database file associated with the QA BeamChecker Plus connected to the PC is not already open, open it by clicking the open icon on the toolbar or navigating to *File > Database > Open* and browse for the correct file.

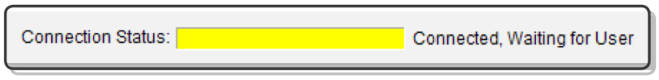
7. Depending on the tab being viewed, the Connection Status shown at the top of the screen should read “Connected, Waiting for User” (yellow) or “Ready for Beam” (green). If the Connection Status shows as red, see the *Troubleshooting* section of this manual for more information.

8. If connection is verified, select the appropriate treatment room (RM1, RM2, etc) from the left side of the screen.

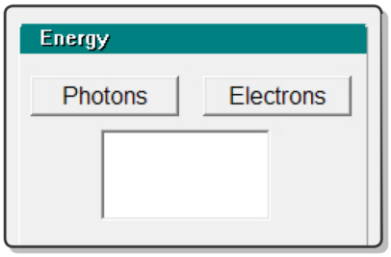


NOTE: Ensure the proper room is selected to avoid overwriting or adding new data to the wrong room.

9. Select the Real-Time Operation tab at the bottom of the screen. At this point, the Connection Status shown at the top of the screen should be shown as “Connected, Waiting for User” (yellow).



10. Select the energy type, photons or electrons, from the upper right of the screen. The Connection Status should now be shown as “Ready for Beam” (green).

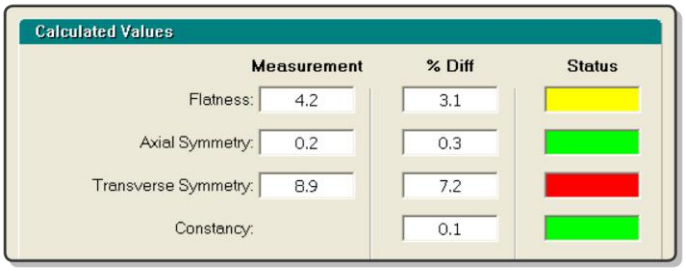


11. Deliver any energy to the QA BeamChecker Plus for which a baseline exists. Upon detecting signal, the QA BeamChecker Plus will begin measurement, and the Connection Status bar will alternate between green and yellow. Once exposure is completed, raw measured values will

appear on the graphical representation of the QA BeamChecker Plus' alignment field. Additionally, temperature, pressure and if the energy was detected successfully, baseline parameters.

Delivery specific measurements will be shown for the detected beam including flatness, axial and transverse symmetry. Percentage differences from the baseline will also be shown along with a status color code:

Green Within action level 1
Yellow At or outside of action level 1
Red At or outside of action level 2



Real-Time Operation results from Static 5 Channel mode

12. If desired, add a comment in the provided field. When the measurement is saved, this comment will be accessible in the Data View.

13. Click Save Results to save this measurement directly to the database or Reset to clear values and re-arm for the next measurement.

14. Repeat steps 11-12 for other energies if not switching between photons and electrons, otherwise enter the vault, flip the unit to the correct side, and continue from step 10.

15. Once completed, the acquired measurements can be viewed for analysis. For instructions, see the *Data View and Downloading Measurements* section of this manual.

Dynamic 5 Channel Room

1. Place the QA BeamChecker Plus on the treatment couch ensuring it is flipped to the Photon side as indicated by the large white field labels on both sides of the device.

2. Position the QA BeamChecker Plus at 100 cm SSD with a field size of 20 x 20 cm. Align the unit to the center of the field using the QA BeamChecker Plus fiducials and the room alignment lasers.

3. Connect the QA BeamChecker Plus to the PC as shown in Figure 5 and exit the vault.

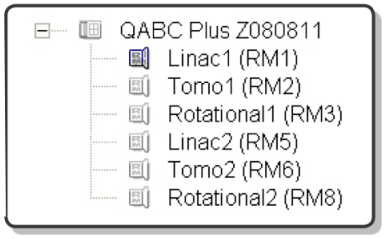
4. On the PC connected to the QA BeamChecker Plus, launch the QA BeamChecker Plus Communication Software.

NOTE: The QA BeamChecker Plus should automatically turn on when the communication software is launched.

5. If the database file associated with the QA BeamChecker Plus connected to the PC is not already open, open it by clicking the open icon on the toolbar or navigating to *File > Database > Open* and browse for the correct file.

6. Depending on the tab being viewed, the Connection Status shown at the top of the screen should read “Connected, Waiting for User” (yellow) or “Ready for Beam” (green). If the Connection Status shows as red, see the *Troubleshooting* section of this manual for more information.

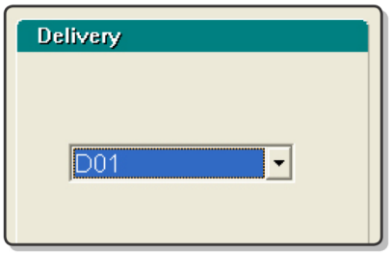
7. If connection is verified, select the appropriate treatment room (RM1, RM2, etc) from the left side of the screen.



NOTE: Ensure the proper room is selected to avoid overwriting or adding new data to the wrong room.

8. Select the Real-Time Operation tab at the bottom of the screen. At this point, the Connection Status shown at the top of the screen should be shown as “Connected, Waiting for User” (yellow).

9. Select the desired plan to test (D01-D25) from the Delivery area on the upper right of the screen. The Connection Status should now be shown as “Ready for Beam” (green).

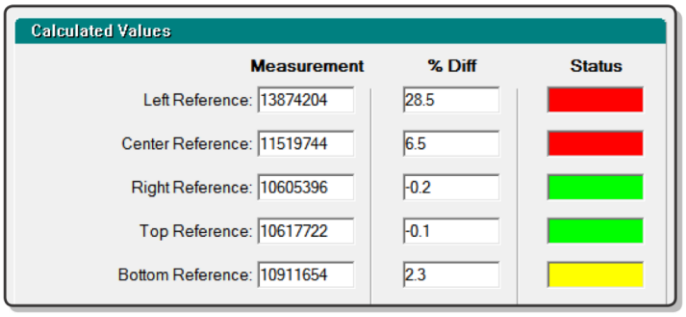


10. Deliver the selected plan to the QA BeamChecker Plus. Upon detecting signal, the QA BeamChecker Plus will begin measurement, and the Connection Status bar will alternate between green and yellow. Once exposure is completed, raw measured values will appear on

the graphical representation of the QA BeamChecker Plus' alignment field. Additionally, temperature, pressure, and baseline parameters.

Delivery specific measurements will be shown including temperature corrected measurements for the center, top, bottom, left, and right chambers. Percentage differences from the baseline will also be shown along with a status color code:

Green Within action level 1
Yellow At or outside of action level 1
Red At or outside of action level 2



Real-Time Operation results from Dynamic 5 Channel mode

11. If desired, add a comment in the provided field. When the measurement is saved, this comment will be accessible in the Data View.

12. Click Save Results to save this measurement directly to the database or Reset to clear values and re-arm for the next measurement.

13. Repeat steps 10-11 if not switching to a different plan, otherwise continue from step 9.

14. Once completed, the acquired measurements can be viewed for analysis. For instructions, see the *Data View and Downloading Measurements* section of this manual.

TomoTherapy System Room

1. Place the Precision TomoTherapy Leveling Platform (or other leveling device) onto the treatment couch and place the QA BeamChecker Plus onto it ensuring the Photon side is facing up as indicated by the large white field labels on both sides of the device.

2. Level the top of the QA BeamChecker Plus by placing the precision bubble level at the center of the top surface and adjusting the three leveling screws on the leveling platform as needed.

3. Adjust the vertical height using the treatment couch until the horizontal side lasers line up to the fiducial alignment mark on the top end of the QA BeamChecker Plus facing the bore of the TomoTherapy unit. After the couch height is correct, align the lasers to the crosshair on the top surface of the unit.

4. Connect the QA BeamChecker Plus to the PC as shown in Figure 5 and exit the vault.

5. Now complete an MVCT of the QA BeamChecker Plus by following the directions for running a procedure on the "What's Next?" box at the top of the screen in the TomoTherapy software. After completing the scan, go to the registration panel on the Operator's Station and register the MV image to the reference image (taken during the planning step - See *Appendix B*) using the manual adjustments. Note registration adjustments.

6. On the PC connected to the QA BeamChecker Plus, launch the QA BeamChecker Plus Communication Software.

NOTE: The QA BeamChecker Plus should automatically turn on when the communication software is launched.

7. If the database file associated with the QA BeamChecker Plus connected to the PC is not already open, open it by clicking the open icon on the toolbar or navigating to *File* > *Database* > *Open* and browse for the correct file.

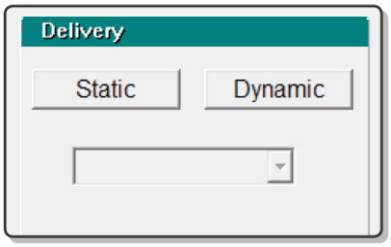
8. Depending on the tab being viewed, the Connection Status shown at the top of the screen should read "Connected, Waiting for User" (yellow) or "Ready for Beam" (green). If the Connection Status shows as red, see the *Troubleshooting* section of this manual for more information.

9. If connection is verified, select the appropriate treatment room (RM1, RM2, etc) from the left side of the screen.

NOTE: Ensure the proper room is selected to avoid overwriting or adding new data to the wrong room.

10. Select the Real-Time Operation tab at the bottom of the screen. At this point, the Connection Status shown at the top of the screen should be shown as "Connected, Waiting for User" (yellow).

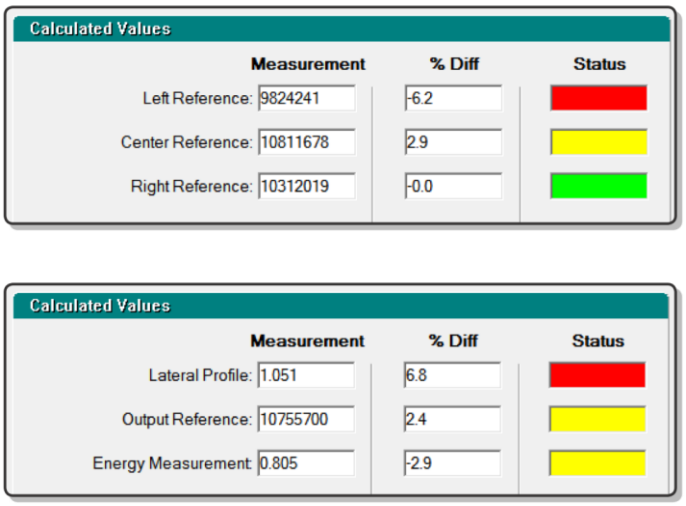
11. Select the intended delivery, static or dynamic, and then desired plan to test (D01-D25 or S01-S25) from the Delivery area on the upper right of the screen. The Connection Status should now be shown as "Ready for Beam" (green).



12. Deliver the selected plan to the QA BeamChecker Plus. Upon detecting signal, the QA BeamChecker Plus will begin measurement, and the Connection Status bar will alternate between green and yellow. Once the exposure is completed, raw measured values, temperature, pressure, and baseline parameters are shown.

Delivery specific measurements will be shown including lateral profile, output reference, and energy measurement for static plans, and temperature corrected measurements for the center, left, and right chambers for dynamic plans. Percentage differences from the baseline will also be shown along with a status color code:

Green Within action level 1
Yellow At or outside of action level 1
Red At or outside of action level 2



Real-Time Operation results from Dynamic and Static modes respectively

13. If desired, add a comment in the provided field. When the measurement is saved, this comment will be accessible in the Data View.

14. Click Save Results to save this measurement directly to the database or Reset to clear values and re-arm for the next measurement.

15. Repeat steps 12-13 if not switching to a different plan, otherwise continue from step 11.

16. Once completed, the acquired measurements can be viewed for analysis. For instructions, see the *Data View and Downloading Measurements* section of this manual.

8 Data View, Downloading Measurements and Reporting

When data has been acquired by the QA BeamChecker Plus in either Wire-Free or Real-Time Operation modes, selecting the Data View tab allows the data to be viewed in detail.

If data has been acquired in the Real-Time Operation mode, it is already part of the database and ready to view. However, if data was acquired using the Wire-Free mode, it will need to be downloaded from the QA BeamChecker Plus.

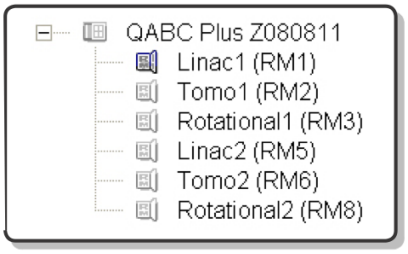
NOTE: Once data is part of the database, there is no differentiation between data acquired in Wire-Free or Real-Time Operation modes.

8.1 Downloading Measurements from Wire-Free Mode

To download data from the QA BeamChecker Plus unit after a Wire-Free data acquisition, follow these steps:

1. Place the QA BeamChecker Plus on the Power/Data Cradle while connected to the PC or connect the QA BeamChecker Plus to the PC directly.

2. Ensure the appropriate database is loaded within the Communication Software and select the desired treatment room from the left side browser pane.

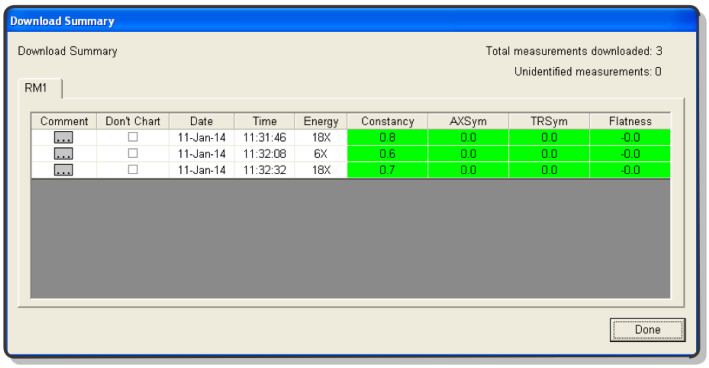


3. Click the Data View tab at the bottom of the screen.

4. The Connection Status indicator will show green and become enabled indicating that new data is available for download.

Click it to download data from the QA BeamChecker Plus to the database file.

5. Once completed, a download summary window appears showing all new measurement data organized by room. In the upper right corner of this window, a total of unidentified measurements is also displayed. This number corresponds to the number of measurements that prompted the XXX error (unidentified energy).

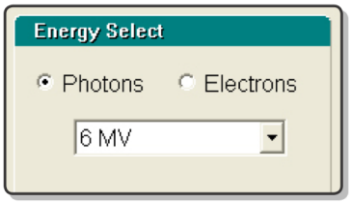


NOTE: When downloading data, all data from all rooms is transferred to the Communication Software database.

NOTE: It is not necessary to download acquired data from the QA BeamChecker Plus after every Wire-Free session. The QA BeamChecker Plus internal memory will hold up to 512 measurements before the data will need to be transferred to the software database.

8.2 Selectively Viewing Data

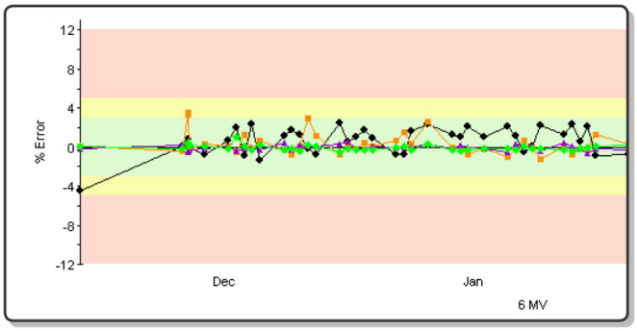
Data acquired in Wire-Free or Real-Time Operation modes can be viewed by energy when browsing data for a Static 5 Channel room, or by plan for a Dynamic 5 Channel or TomoTherapy room. From the Energy or View panel, use the pull down menu to select an acquired energy or test from the list. The energy and type will appear along with the parameters that were specified at the time of baseline creation.



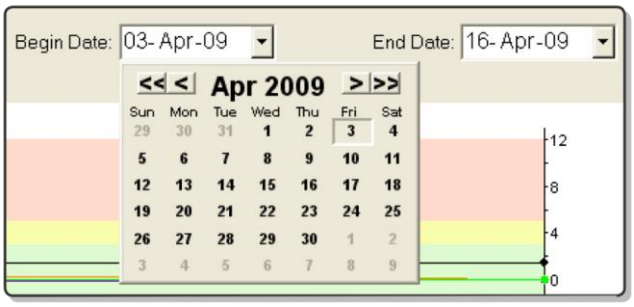
Using the Chart View

The Chart View shows measurements points on a graph, with the x-axis representing the date and the y-axis representing the deviation from the baseline. Points on graph appear in one of three regions:

Green Below action level 1
Yellow At or above action level 1, but below action level 2
Red At or above action level 2

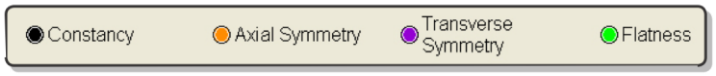


Select the Begin Date, End Date, and click the Update Chart button. The Chart View will update to reflect the specified range.

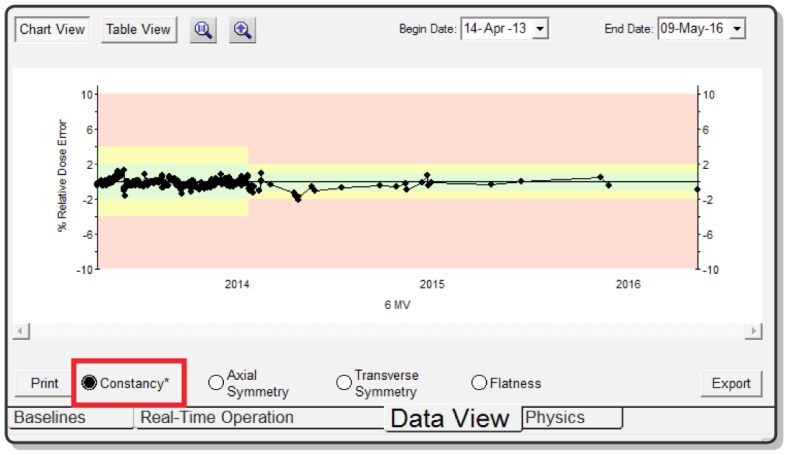


Click and drag horizontally within the Chart View, to zoom to a selection range. To return to the top-level zoom, click the 1:1 zoom button. If multiple sequential drag selections are made, they can be reverted one at a time by clicking the up arrow zoom button.

The components of the Chart View (constancy, axial symmetry, output measurement, etc) can be toggled on or off by clicking the component name shown below the Chart View.



The constancy results for the static mode can be viewed with the vertical axis label as a relative dose by de-selecting all of the other parameters on the graph.



Using the Table View

To view the data in tabular format, click the Table View button. Each row represents a unique measurement point and includes the date and time of measurement along with percentage differences from the baseline.

The colors shown on the table indicate how close the acquired values are to the baseline. Just like the status indicators found in the Real-Time Operation mode, the colors of the cells are defined as follows:

Green Below action level 1
Yellow At or above action level 1, but below action level 2
Red At or above action level 2

Comment	Don't Chart	Date	Time	Constancy	AXSym	TRSym	Flatness
	☐	29-Dec-11	16:05:03	0.7	-0.2	-0.1	0.1
	☐	30-Dec-11	07:13:27	0.4	6.0	-0.1	0.1
	☐	03-Jan-12	07:14:43	0.4	-0.2	-0.1	0.1
	☐	04-Jan-12	07:08:06	-0.1	-0.1	-0.2	0.1
	☐	05-Jan-12	07:10:26	6.0	-0.3	-0.1	0.1
	☐	06-Jan-12	06:58:02	0.4	-0.3	-0.3	0.1
	☐	09-Jan-12	06:55:16	0.3	-0.2	-0.1	0.0
	☐	10-Jan-12	06:50:24	0.3	-4.0	-0.2	0.1
	☐	11-Jan-12	06:51:39	0.5	-0.3	-0.2	0.1
	☐	12-Jan-12	06:56:06	1.1	-4.0	0.0	0.0
	☐	13-Jan-12	06:51:17	1.1	-0.2	0.1	-0.1
	☐	16-Jan-12	07:02:03	-0.3	-0.4	-0.1	0.1
	☐	17-Jan-12	06:55:51	0.7	-0.3	-0.1	0.1

Checking a box in the Don't Chart column will hide that data point in the Chart View. This is useful to hide a mistaken or erratic data point from the Chart View.

Clicking the [...] box in the Comment column will allow entry of a comment for the selected row. Measurements with comments are indicated by a red checkmark on the corresponding [...] button.

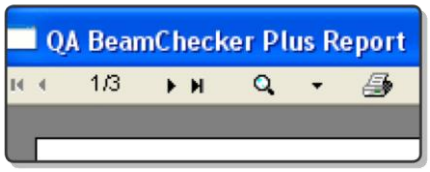
8.3 Printing and Exporting

Printing Reports

1. In Chart or Table View, click the Print button.

2. A dialog will appear, asking for the user to sign off on the report. The text entered in the Approve Report dialog will appear next to the time and date stamp on the report when printed. When ready, select OK.

3. A print preview will be displayed, containing the measurements currently being browsed. To print, click the printer icon at the top of the preview.



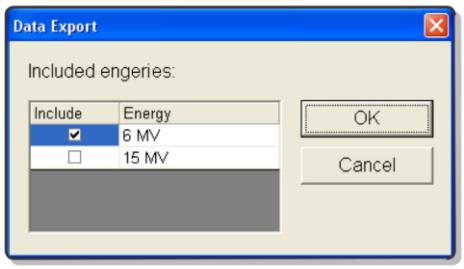
4. Select a printer and click OK to complete the print operation.

Exporting Measurement Data

1. Select any energy or plan within Data View.

2. Press the Export button and a checkbox list will appear containing all energies or plans available for the currently selected room.

3. Select the energies or plans for export. Each box checked will produce an individual .csv file. Click OK to confirm.



4. Select a directory to save the export files and click OK to complete the export operation.

NOTE: If a data point is checked as Don't Chart in Table view, it will remain in the exported .csv file.

9 Physics Mode

The Physics Mode allows use of the QA BeamChecker Plus as a 5 channel chamber and electrometer array for taking real-time measurements. Because data collected is not associated with baselines or saved to the database file, this mode is ideal for experimental or customized measurements. For this mode, the QA BeamChecker Plus must be connected to the PC.

NOTE: A Bluetooth Adapter Kit (REF 70504) is an available option allowing wireless communication from the PC to the QA BeamChecker Plus in place of a wired serial connection. See page 53 for more details.

9.1 Setup

1. Place the QA BeamChecker Plus on the treatment couch flipped to the desired side.

2. Connect the QA BeamChecker Plus to the PC and exit the vault.

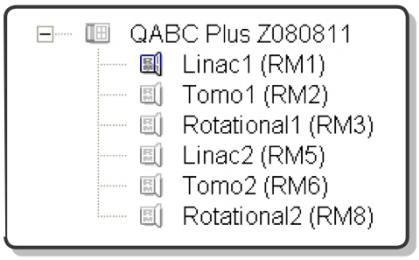
3. On the PC connected to the QA BeamChecker Plus, launch the QA BeamChecker Plus Communication Software.

NOTE: The QA BeamChecker Plus should automatically turn on when the communication software is launched.

4. If the database file associated with the QA BeamChecker Plus connected to the PC is not already open, open it by clicking the open icon on the toolbar or navigating to *File > Database > Open* and browse for the correct file.

5. Depending on the tab being viewed, the Connection Status shown at the top of the screen should read “Connected, Waiting for User” (yellow) or “Ready for Beam” (green). If the Connection Status shows as red, see the *Troubleshooting* section of this manual for more information.

6. If connection is verified, select the appropriate treatment room (RM1, RM2, etc) from the left side of the screen. While Physics mode measurements are not part of database, a room selection is required to define which measurement parameters are displayed. For instance, if a Static 5 Channel room is selected, Flatness, Axial Symmetry, and Transverse Symmetry are shown. However, if a TomoTherapy System room is selected, Lateral Profile, Output Reference, and Energy Measurements are shown.

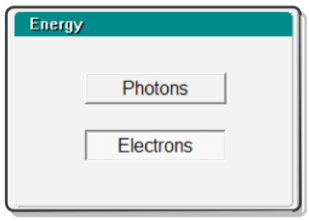


NOTE: If using a TomoTherapy System or Dynamic 5 Channel room, the QA BeamChecker Plus must be flipped to the Photon side to ensure correct labeling of the left and right chambers.

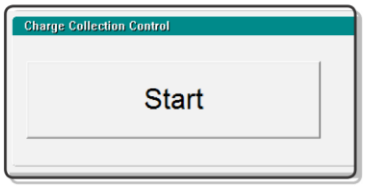
7. Select the Physics tab at the bottom of the screen to view the Physics mode interface.

9.2 Working with Physics Mode

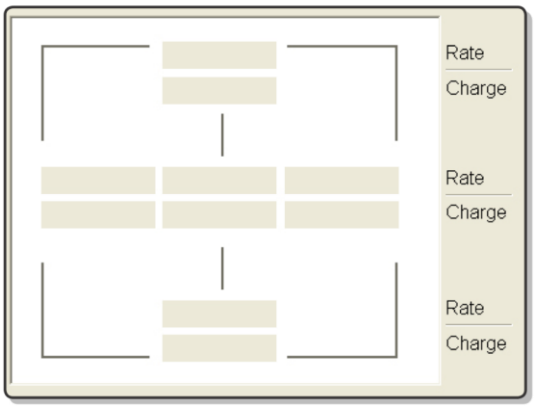
1. If a Static 5 Channel room is selected, first select Photons or Electrons depending on which side of the device is flipped up. If a TomoTherapy System room is chosen, select Static or Dynamic. If a Dynamic 5 Channel room is used, no selection is required.



2. Click the Start button to begin measurement.

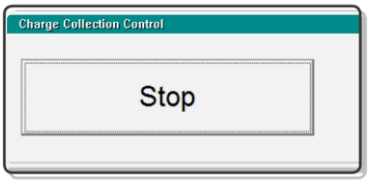


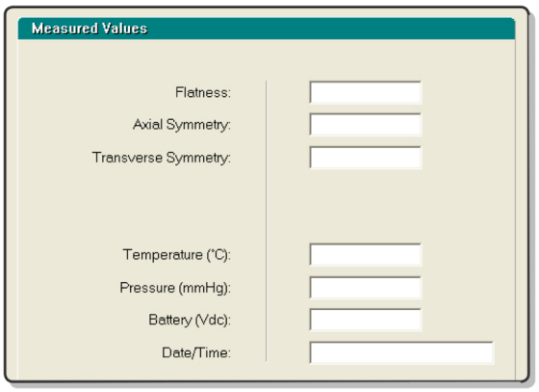
3. Elapsed Time is shown along with Rate and Charge measurements displayed on the graphical representation of the QA BeamChecker Plus chamber layout. The measurement will continue until the Stop button is clicked.



NOTE: The numbers seen in the Physics Mode are not amps or coulombs, nor are they calibrated. They are A to D converter counts from an amplifier displayed as digital read-out units.

4. Upon clicking the Stop button, measurement information will be displayed along with temperature, pressure, battery voltage, and the date and time when the measurement completed.

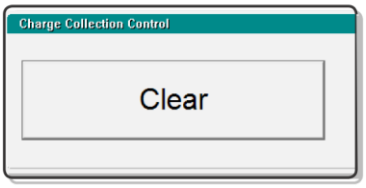




5. Data acquired can be exported to .csv file by clicking the Export .csv button and browsing for a location to save the file.

NOTE: No measurement data taken while in Physics Mode is stored within the database file. Data can only be saved by utilizing the Export .csv function.

6. Click the Clear button to clear the displayed data. After the data is cleared, the Start button will be available to begin another acquisition.



10 About Synchronization and Database Relationship

10.1 Introduction

When a link is established between a QA BeamChecker Plus and a database file, they are considered to be “synchronized”. The relationship between the two is defined as the database being the master and the QA BeamChecker Plus being the slave.

Because of this, the QA BeamChecker Plus must be connected to the computer when certain configuration changes are made such as adding and deleting rooms, energies, or plans. Changes made to the database are pushed to the unit as they occur. Additionally, the QA BeamChecker Plus must be connected to the computer when creating a new database to establish a connection between the two based on the unit’s serial number.

With this master/slave relationship, room configuration and baseline data can easily be re-pushed from the software to the hardware in the event of the pair becoming unsynchronized.

10.2 Usage and Troubleshooting

Why are the Database and QA BeamChecker Plus “Not Synchronized”?

Below is a list of causes for the database to become unsynchronized from a QA BeamChecker Plus:

· The time and date differ by more than 2 hours between the PC system time and the real-time clock within the QA BeamChecker Plus

· The QA BeamChecker Plus has been synchronized with a different database file since the last connection

What to do if Not Synchronized

If upon launching the software the unit is reported as Not Synchronized in the top status bar check the following things before re-synchronizing:

· Ensure the correct database file is opened

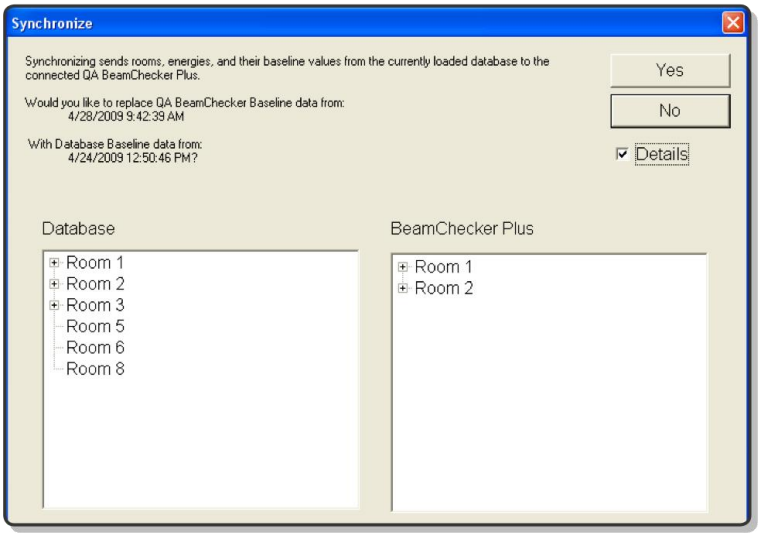
· Ensure the system time/date on the PC is correct

· Ensure the correct QA BeamChecker Plus is attached to the PC

Performing a Synchronize Operation

If the above factors are all correct, perform a synchronize operation either by clicking the Synchronize button to the right of the Connection Status indicator or by navigating to *File > Database > Synchronize*.

Upon starting this operation, the following window will appear:



The left column shows the room, energy, and plan information that exists within the database, and the right column shows which information is stored within the QA BeamChecker Plus internal memory. By clicking either Yes or Synchronize, the values will be pushed from left to right and the main QA BeamChecker Plus software interface will be displayed.

If the QA BeamChecker Plus was synchronized to the incorrect database, simply open the correct database file and re-perform the synchronize operation.

NOTE: If using QA BeamChecker Plus software version 2.2.2 and above, Wire-Free measurement data will not be deleted during the synchronization process. Upon the completion of the synchronization operation, go to the Data View tab to download any Wire-Free data to the currently opened database.

What to do if Synchronization is Not Allowed

In QA BeamChecker Plus software versions 2.2.1 and below, if Wire-Free mode measurement data is present within the QA BeamChecker Plus internal memory, a synchronization operation is not permitted. The data will first need to be downloaded to the correct database file before proceeding. If the correct database file cannot be located, the measurement data must be erased from the unit before proceeding. This can be accomplished by first creating a new database, then re-synchronizing to the desired database.

If version 2.2.2 and above is used, synchronization IS permitted even if measurement data remains on the unit. Once synchronization is performed, data will remain on the QA BeamChecker Plus and can be downloaded to the database once synchronization is completed.

CAUTION: Ensure you are using the correct database file before proceeding with the download process. If data is transferred to the incorrect database, it cannot be moved to another database without assistance from Standard Imaging.

Take Advantage of the Synchronize Function

A synchronization operation can be useful if using the QA BeamChecker Plus with more than one database. If using one QA BeamChecker Plus in any situation where more than the allowed 9 treatment rooms are required, multiple databases can be created, each with their own 9 treatment rooms. Additionally, one database could contain a test configuration, and another could contain "official" measurement data. Simply perform measurements with one database, download the data, and synchronize to another database to switch between multiple files.

11 Using Other Accessories

11.1 Bluetooth Adapter Kit

The Bluetooth Adapter Kit (REF 70504) allows QA BeamChecker Plus wireless communication for operations that typically require a cable connection to the PC such as baseline, Real-Time Operation and Physics mode measurements.

Each kit includes two adapters, one with a male interface and with a female interface. Each adapter must be supplied with a power source. The QA BeamChecker Plus internal battery provides power through the serial port to the male interface adapter, so no external power adapter is required. However, the female interface adapter connected to the PC or cradle requires power via an included external adapter. See image for an illustration of a typical configurations.

Using the Bluetooth Adapter Kit

1. If already using the QA BeamChecker Plus Data/Communication Cradle in the vault with a cable attached from the PC, skip this step. If not, run a 9-pin serial cable from the PC into the treatment vault.

2. If using the cradle as stated in step 1, connect the male Bluetooth interface adapter to the Serial Pass Through port on the cradle. If not using the cradle, connect the male Bluetooth interface adapter directly to a cable run from the PC.

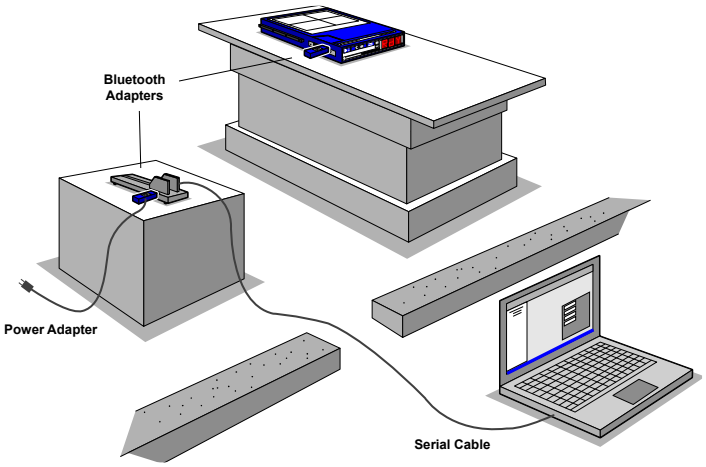
NOTE: The Bluetooth Adapter Kit will not communicate through the treatment vault wall, but because their signal is transmitted via RF, the cradle (with attached adapter) can be placed inside a cabinet or closet and still communicate effectively.

3. Connect the included power adapter from the male Bluetooth interface adapter to an available power outlet.

4. Connect the female interface adapter to the QA BeamChecker Plus where a serial cable is normally connected. No external power is required for most QA BeamChecker Plus units.

NOTE: The initial manufactured quantities of the QA BeamChecker Plus (serial number Z071551 and below from early 2007) do not provide power to the Bluetooth adapter through the serial port. However, the Bluetooth adapter will still function properly by using the external power adapter. A simple modification to these particular QA BeamChecker Plus units can be performed to enable this functionality. Contact Standard Imaging for information on obtaining this service procedure. See Tech Note 4050 available at www.standardimaging.com for additional information.

5. Once both adapters are attached and supplied with power, the green LED within each adapter should begin flashing. This indicates power is present and the adapter is searching for its counterpart. Once the adapters have successfully paired with one another, the green light will stop flashing and will remain constantly illuminated, indicating the connection between the adapters is being maintained. The connection should be maintained up to a separation of 100 feet.



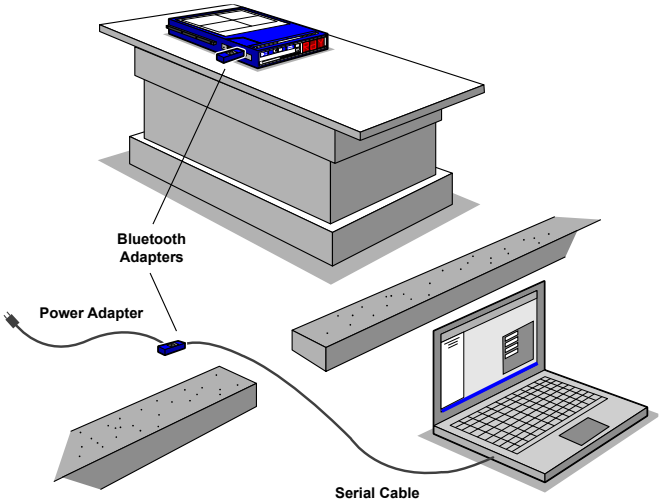


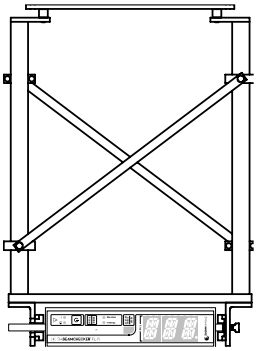
Figure 6: Diagram of typical connection methods

11.2 Gantry Mount Accessory

With the optional Gantry Mount Accessory (REF 70500), the QA BeamChecker Plus can attach to the gantry accessory tray on most linear accelerators to facilitate measurement at various gantry angles.

NOTE: The Gantry Mount Accessory must be custom made for a particular accelerator. Contact Standard Imaging for specific ordering information.

The Gantry Mount Accessory is comprised of three main sections:



Upper section: Interfaces with the accelerator gantry and is custom to a particular accelerator type

Middle section: Positions the QA BeamChecker Plus at the appropriate distance from the gantry

Lower Section: Holds the QA BeamChecker Plus securely in place

Using the Gantry Mount Accessory

1. Slide the Gantry Mount Accessory into the accessory tray of the linear accelerator. Depending on the accelerator type, this could be from the back or front of the gantry. If the tray requires entry of the mount from the back, it may be helpful to rotate the gantry 90° to facilitate easier insertion.

2. Slide the QA BeamChecker Plus into the Gantry Mount Accessory with the photon side up. The black rails on either side of the QA BeamChecker Plus will guide the instrument into place. Once fully inserted, the unit should “click” into place.

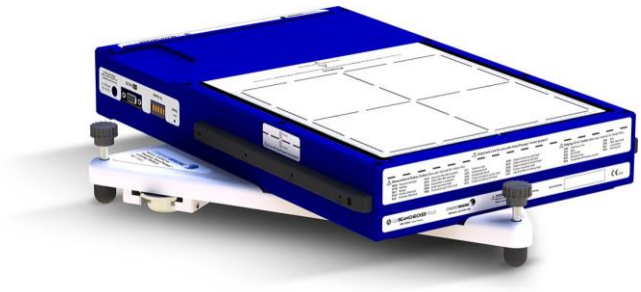
3. If required, connect the serial cable to the QA BeamChecker Plus to facilitate any Communication Software-based operations. Wire-Free mode measurements are recommended for gantry use to help avoid any incidents that could occur due to cable motion during gantry rotation.

NOTE: It is recommended to avoid attaching the serial cable via the connector shell screws to the unit and instead relying on the inherent pressure fit of the connection. If the cable catches on an obstruction during gantry rotation, damage can occur if the connector cannot pull free.

4. Perform any desired measurements.

5. Remove the QA BeamChecker Plus from the Gantry Mount Accessory by pulling the spring-loaded locking pin as shown in the image. While pulling on the locking pin, gently slide the QA BeamChecker Plus from the mount. The pin only needs to be held briefly to release the QA BeamChecker Plus from engagement.

11.3 Precision TomoTherapy Leveling Platform



Use of the Precision TomoTherapy Leveling Platform (REF 70505) is not necessary for all TomoTherapy system tests, however it is required for testing the laser positioning used with the Hi·Art, H-Series or Radixact Systems. The laser test facilitated by the QA BeamChecker Plus and accompanying leveling platform meets the requirements of D6 as recommended in the following paper:

J D Fenwick et al, "Quality assurance of a helical tomotherapy machine", Phys. Med Biol. 49 (2004)

D1: Output constancy quick check (+/- 2%)
D2: TPR 20/5 quick check (+/-2%)
D3: Lateral profile constancy quick check (+/-2%)
D4: Output ramp-up time (<10s)
D5: Combined dosimetric check (+/-2%)
D6: Lasers (+/-1 mm)

The laser test can be incorporated into the baseline and routine measurement procedures for more comprehensive TomoTherapy QA, but the basic steps are listed below.

1. Place the Precision TomoTherapy Leveling Platform onto the treatment couch and place the QA BeamChecker Plus onto it ensuring the Photon side is facing up as indicated by the large white field labels on both sides of the device.

2. Level the top of the QA BeamChecker Plus by placing the precision bubble level at the center of the top surface and adjusting the three leveling screws on the leveling platform as needed.

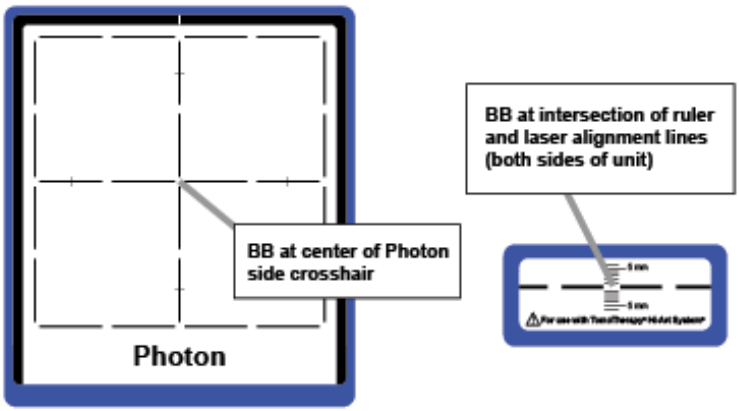
3. Adjust the vertical height using the treatment couch until the horizontal side lasers line up to the fiducial alignment mark on the top end of the QA BeamChecker Plus facing the bore of the TomoTherapy unit. After the couch height is correct, align the lasers to the crosshair on the top surface of the unit.

NOTE: If there is an offset between the green and the red lasers, note this offset by using the ruled marking on the top surface of the QA BeamChecker Plus. Red lasers should move to the same position relative to the setup position on a daily basis. Verify leveling is maintained.

4. Now complete an MVCT of the QA BeamChecker Plus by following the directions for running a procedure on the "What's Next?" box at the top of the screen in the TomoTherapy software. After completing the scan, go to the registration panel on the Operator's Station and register the MV image to the reference image (taken during the planning step - See *Appendix B*) using the manual adjustments. Note registration adjustments.

NOTE: Both the dynamic and static plan can be used to test the accuracy of the movable red lasers. Use the appropriate plan as described in the Getting Started - TomoTherapy section of this manual.

NOTE: There are 1.5 mm BBs located at the center of the crosshairs on the top "Photon" surface and side labels on the QA BeamChecker Plus. For the longitudinal adjustment, the Y axis positioning is correct if the BBs show up brightest on the center slice of the MVCT. If they do not, adjust longitudinal position accordingly until this is the case.



5. Continue with the typical QA procedure.

11.4 Serial to USB Adapter

Actual adapter appearance may vary

A USB to Serial Cable Adapter (REF 70503) is provided by Standard Imaging for situations where the computer used with the QA BeamChecker Plus does not have a 9-pin Serial Port. In order to use this adapter, the appropriate driver must first be setup. A CD ROM containing the necessary driver software and instructions for setup is included with the adapter.

It is recommended to always check the adapter manufacturer's website for the latest driver; the driver version to select will depend on the computer operating system used.

12 Appendix A: Definition of Algorithms

Legend of chamber locations. For TomoTherapy and Dynamic 5 Channel calculations, assume the Photon side is facing up

12.1 Applicable to All Modes

Temperature and Pressure Correction

For constancy measurements and comparison with values measured on subsequent times/days, a temperature and pressure correction is made to the reading of the following chambers:

Static 5 Channel: Center
TomoTherapy: Left, Center, Right
Dynamic 5 Channel: Top, Left, Center, Right, Bottom

$$M_{corr} = M_{raw} \times \left[\frac{273.15 + T(°C)}{295.15} \times \frac{760}{P(Torr)}\right]$$

where:

M_{corr} the corrected reading of appropriate chamber

M_{raw} the raw or uncorrected reading of appropriate chamber
T temperature in °C measured by on-board sensor
P pressure in Torr measured by on-board sensor

Output Constancy

Output Constancy is determined by using the following algorithm on the temperature and pressure corrected values from the following chambers over time (values are shown in percent):

Static 5 Channel: Center
TomoTherapy: Left, Center, Right
Dynamic 5 Channel: Top, Left, Center, Right, Bottom

$$\frac{\text{Center (at time t)} - \text{Center (at time } t_0)}{\text{Center (at time } t_0\text{)}}$$

where:

time t time at which new constancy measurement is being taken
time t_0 time at which initial benchmark value was taken

12.2 Applicable to Static 5 Channel Mode Only

The following values are determined by using the specified algorithm on the raw data values collected from the indicated ion chambers (values are shown in percent):

Flatness = (Max - Min) / (Max + Min)

where:

Max maximum value of Top, Center, Left, Right, Bottom
Min minimum value of Top, Center, Left, Right, Bottom

Axial Symmetry = (Top - Bottom) / Bottom

Transverse Symmetry = (Right - Left) / Left

12.3 Applicable to TomoTherapy Mode Only

The following values are determined by using the specified algorithm on the raw data values collected from the indicated ion chambers (values are shown in percent):

Energy Measurement = Pb-filtered / Center

NOTE: The center ion chamber has approximately 3.5 cm of water-equivalent buildup, while the Pb-filtered ion chamber has roughly 9.7 cm of water-equivalent buildup.

Lateral Profile = Left / Right

13 Appendix B: Developing TomoTherapy and Dynamic 5 Channel Plans

13.1 Introduction

To use the QA BeamChecker Plus for TomoTherapy and for tests of other rotational methods such as IMAT using the Dynamic 5 Channel mode, a plan must be created to deliver to the instrument. The initial exposure of the plan becomes the baseline for routine comparison. This guide is designed to give an overview of the procedure for creating QA BeamChecker Plus plans, but exact planning parameters will vary depending on site specific testing goals and requirements.

In general, the first step is creating a CT reference image of the QA BeamChecker Plus. Depending on planning capabilities, the instrument can be imaged with a either a conventional CT scanner or the treatment unit. This reference image is used for the planning process and also for comparison to the MVCT in routine TomoTherapy testing.

CAUTION: Do not irradiate past the 20 x 20 cm field label edge.

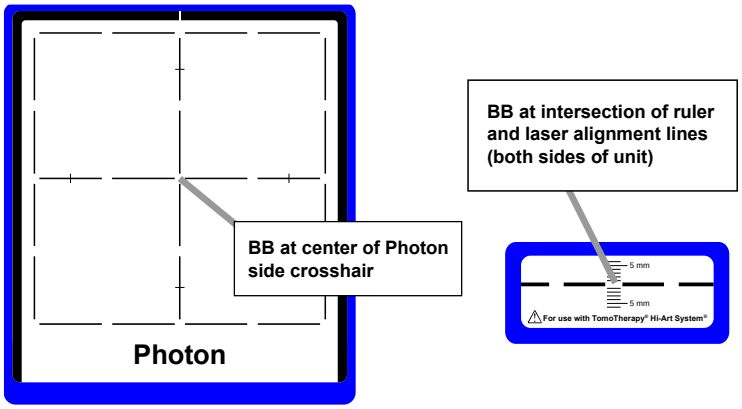
After the image is acquired, a treatment plan can be developed which targets the chambers within the QA BeamChecker Plus with a specific dose. Finally, this plan can be delivered to the QA BeamChecker Plus as a baseline and for routine measurement as explained in earlier sections of this user manual.

Multiple plans can be developed to test multiple energies for IMAT configurations or multiple jaw widths for TomoTherapy machines as desired. Since each QA BeamChecker Plus room can support up to 25 different plans, many tests can be performed to exercise the system(s) on a regular basis.

13.2 Acquiring a CT Reference Image

For a Dynamic 5 Channel or TomoTherapy Dynamic Mode tests, a CT planning image of the QA BeamChecker Plus must first be taken and transferred into a treatment planning system.

NOTE: There are 1.5 mm BBs located at the center of the crosshairs on the top "Photon" surface and side labels on the QA BeamChecker Plus.



For TomoTherapy, it is advantageous to CT the QA BeamChecker Plus so that the center of the image is aligned with the BBs and allow the device to eventually be setup by initially setting the green lasers to these BBs. In this way, setup can be kept constant for both static and dynamic procedures. Since the red laser positions can be set to any desired location as part of the treatment planning process, using the laser control on the ROI panel, the red lasers can be moved a known distance from the green lasers that can eventually be checked by using the ruled markings on the QA BeamChecker Plus.

The treatment plan is intended to deliver dose to the detectors in the QA BeamChecker Plus, thus requiring that contours are drawn to encompass the detectors. As a suggestion, five separate contours can be drawn around the left, center, right, top and bottom detectors with different doses prescribed to each of these contours. However, any size and number of contours that encompass the detector will work. Top and bottom chamber contours are not required for TomoTherapy planning as they are not used in either static or dynamic mode testing.

NOTE: Be careful when using auto contouring techniques as filters placed above and below the energy detection chambers within the QA BeamChecker Plus (See Appendix D: Chamber Location Diagram) can create heavy artifacts within a kV CT image. These artifacts can affect the volume perceived by the planning software and slightly affect the accuracy of the dose calculation. However, the QA BeamChecker Plus is used only as a constancy check. As long as the same plan is delivered, and in the same manner daily, the device will determine if the measurement is out of specification as compared to a baseline.

When performing TomoTherapy measurements, this reference image will be fused to the MVCT image taken after the initial positioning of the QA BeamChecker Plus. The exact steps will depend on the specific CT machine and treatment planning software used, and future developments within the TomoTherapy software.

After image acquisition and contouring, image(s) and contours can be sent to the treatment planning system for planning.

13.3 TomoTherapy System Planning

Static Mode

For the Static mode, a procedure can be created on the Operator's Station that irradiates the device with a static 1, 2.5 or 5 cm x 40 cm field, with only the MLCs modulating as the treatment couch moves past the treatment beam. Known as the TomoDirect™ mode, the gantry is held fixed at 0°. Refer to the appropriate Treatment Planning and Treatment Delivery System documentation from Accuray for specific information on developing treatment plans of this variety.

Dynamic Mode

For the Dynamic Mode, a plan or plans can be created using the TomoTherapy Treatment Planning Software. Multiple plans can be created and tested for each jaw width, but 2.5 cm is the most common. Ideally, the plan developed challenges the system in reproducibility, thereby potentially identifying any delivery issues in the QA routine. A different dose prescribed to the each of the chambers is one possible technique.

For efficiency, it is recommended that the dose is kept at a conventional fraction size to shorten delivery time.

NOTE: When planning delivery, limiting dose to the chambers when the gantry is at 90° and 270° (± 10-15°) is recommended. The parallel plate geometry of the chambers may produce inconsistent results when delivery is provided parallel to the chamber surface.

Refer to the appropriate Treatment Planning and Treatment Delivery System documentation from Accuray for specific information on developing treatment plans of this variety.

13.4 Dynamic 5 Channel Planning

A plan or plans can be created using the treatment planning software for the treatment system used. Ideally, the plan developed challenges the system in reproducibility, thereby potentially identifying any delivery issues in the QA routine. A different dose prescribed to the each of the chambers is a one possible technique.

For efficiency, it is recommended that the dose is kept at a conventional fraction size to shorten delivery time.

NOTE: When planning delivery, limiting dose to the chambers when the gantry is at 90° and 270° (± 10-15°) is recommended. The parallel plate geometry of the chambers may produce inconsistent results when delivery is provided parallel to the chamber surface.

Refer to the appropriate Treatment Planning and Treatment Delivery System documentation from your Linear accelerator vendor for specific information on developing treatment plans of this variety.

14 Appendix C: Explanation of Saved File Export

When exporting data or deleting a room from the QA BeamChecker Plus Communication Software database, a .csv file, (comma separated value) file is created that can be directly opened with any spreadsheet application. Each mode has a different exported format, and the resulting files will have data labels as described below.

14.1 Static 5 Channel Mode

When exporting from the Static 5 Channel Mode, an individual file is created for each energy. The format of each file is broken down into multiple sections using the following pattern: Baseline1; Measurements for Baseline1; Baseline2; Measurements for Baseline2; etc

Baseline Data

Data Label	Description
BASELINE_ID	A unique identifier for the baseline energy that incorporates date and time of measurement
FIELD_SIZE	Collimator size, as entered in the Baseline Setup screen
SSD	Source to Surface Distance, as entered in the Baseline Setup screen
DOSERATE	Linear accelerator dose rate, as entered in the Baseline Setup screen
DOSE	Linear accelerator dose, as entered in the Baseline Setup screen
GANTRYANGLE	Gantry angle, as entered in the Baseline Setup screen
TEMPERATURE	Internal temperature when baseline measurement was taken, in °C
PRESSURE	Pressure when baseline measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the baseline energy as determined by several ionization chambers and a proprietary algorithm
AXSYM	Axial symmetry of baseline energy, calculated from the ionization chamber readings
---	---
TRSYM	Transverse symmetry of baseline energy, calculated from the ionization chamber readings
---	---
FLATNESS	Flatness of baseline energy, calculated from the ionization chamber readings
---	---
CENTER_RAW	Data collected from the center ionization chamber during the baseline measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during the baseline measurement
TOP_RAW	Data collected from the top ionization chamber during the baseline measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during the baseline measurement

BOTTOM_RAW	Data collected from the bottom ionization chamber during the baseline measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during the baseline measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during the baseline measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during the baseline measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the baseline measurement
EXPECTED_OUTPUT	Expected Output, as entered in the Baseline Setup screen. This number is shown in up to four digits, e.g. 100.0% shows as 1000

Measurement data

Data Label	Description
BASELINE_ID	Identifies which baseline energy values were chosen for comparison to measurement data
DATE	Date when measurement was taken, in the format mmddyyyy
TIME	Time when measurement was taken, in the format hhmmss
---	---
---	---
CONSTANCY	Constancy of measured energy, calculated from the center ionization chamber compared to baseline center ionization chamber value
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the energy as determined by several ionization chambers and a proprietary algorithm. This is then compared to the set of ENERGYLEVEL values from baselines above
AXSYM	Axial symmetry of measured energy, calculated from ionization chamber readings
AXSYM_%DELTA	Axial symmetry percentage difference from baseline
TRSYM	Transverse symmetry of measured energy, calculated from ionization chamber readings
TRSYM_%DELTA	Transverse symmetry percentage difference from baseline
FLATNESS	Flatness of measured energy, calculated from ionization chamber readings
FLATNESS_%DELTA	Flatness percentage difference from baseline
CENTER_RAW	Data collected from the center ionization chamber during measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during measurement
TOP_RAW	Data collected from the top ionization chamber during measurement

RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the measurement
COMMENT	Measurement comment entered using the Data View interface

14.2 TomoTherapy Mode - Static Plans

When exporting from the TomoTherapy Mode, an individual file is created for each plan. The format of each file is broken down into multiple sections using the following pattern: Baseline1; Measurements for Baseline1; Baseline2; Measurements for Baseline2; etc

Baseline Data

Data Label	Description
BASELINE_ID	A unique identifier for the baseline energy that incorporates date and time of measurement
FIELD_SIZE	Collimator size, as entered in the Baseline Setup screen
SSD	Source to Surface Distance, as entered in the Baseline Setup screen
DOSERATE	Linear accelerator dose rate, as entered in the Baseline Setup screen
DOSE	Linear accelerator dose, as entered in the Baseline Setup screen
GANTRYANGLE	Gantry angle, as entered in the Baseline Setup screen
TEMPERATURE	Internal temperature when baseline measurement was taken, in °C
PRESSURE	Pressure when baseline measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the baseline energy as determined by several ionization chambers and a proprietary algorithm
LAT_PROFILE	Lateral profile of baseline, calculated from the ionization chamber readings
---	---
OUTPUT_MEASURE	Output measurement of baseline, calculated from the ionization chamber readings
---	---
ENERGY_MEASURE	Baseline energy measurement, calculated from the ionization chamber readings
---	---

CENTER_RAW	Data collected from the center ionization chamber during the baseline measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during the baseline measurement
TOP_RAW	Data collected from the top ionization chamber during the baseline measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during the baseline measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during the baseline measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during the baseline measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during the baseline measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during the baseline measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the baseline measurement

Measurement data

Data Label	Description
BASELINE_ID	Identifies which baseline energy values were chosen for comparison to measurement data
DATE	Date when measurement was taken, in the format mmddyyyy
TIME	Time when measurement was taken, in the format hhmmss
---	---
---	---
CONSTANCY	Constancy of measured energy, calculated from the center ionization chamber compared to baseline center ionization chamber value
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the energy as determined by several ionization chambers and a proprietary algorithm. This is then compared to the set of ENERGYLEVEL values from baselines above
LAT_PROFILE	Lateral profile of measurement, calculated from ionization chamber readings
LAT_PROFILE_%DELTA	Lateral profile percentage difference from baseline
OUTPUT_MEASURE	Output measurement, calculated from ionization chamber readings
OUTPUT_MEASURE_%DELTA	Output measurement percentage difference from baseline

ENERGY_MEASURE	Energy measurement, calculated from ionization chamber readings
ENERGY_MEASURE_%DELTA	Energy measurement percentage difference from baseline
CENTER_RAW	Data collected from the center ionization chamber during measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during measurement
TOP_RAW	Data collected from the top ionization chamber during measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the measurement
COMMENT	Measurement comment entered using the Data View interface

14.3 TomoTherapy Mode - Dynamic Plans

When exporting from the TomoTherapy Mode, an individual file is created for each plan. The format of each file is broken down into multiple sections using the following pattern: Baseline1; Measurements for Baseline1; Baseline2; Measurements for Baseline2; etc

Baseline Data

Data Label	Description
BASELINE_ID	A unique identifier for the baseline energy that incorporates date and time of measurement
FIELD_SIZE	Collimator size, as entered in the Baseline Setup screen
SSD	Source to Surface Distance, as entered in the Baseline Setup screen
DOSERATE	Linear accelerator dose rate, as entered in the Baseline Setup screen
DOSE	Linear accelerator dose, as entered in the Baseline Setup screen
GANTRYANGLE	Gantry angle, as entered in the Baseline Setup screen
TEMPERATURE	Internal temperature when baseline measurement was taken, in °C
PRESSURE	Pressure when baseline measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the baseline energy as determined by several ionization chambers and a proprietary algorithm
LEFT_OUTPUT	Baseline left channel output (temperature/pressure corrected)

---	---
CENTER_OUTPUT	Baseline center channel output (temperature/pressure corrected)
---	---
RIGHT_OUTPUT	Baseline right channel output (temperature/pressure corrected)
---	---
CENTER_RAW	Data collected from the center ionization chamber during the baseline measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during the baseline measurement
TOP_RAW	Data collected from the top ionization chamber during the baseline measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during the baseline measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during the baseline measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during the baseline measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during the baseline measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during the baseline measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the baseline measurement

Measurement data

Data Label	Description
BASELINE_ID	Identifies which baseline energy values were chosen for comparison to measurement data
DATE	Date when measurement was taken, in the format mmddyyyy
TIME	Time when measurement was taken, in the format hhmmss
---	---
---	---
CONSTANCY	Constancy of measured energy, calculated from the center ionization chamber compared to baseline center ionization chamber value
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the energy as determined by several ionization chambers and a proprietary algorithm. This is then compared to the set of ENERGYLEVEL values from baselines above
LEFT_OUTPUT	Left channel output (temperature/pressure corrected)

LEFT_OUTPUT_%DELTA	Left channel output difference from baseline
CENTER_OUTPUT	Center channel output (temperature/pressure corrected)
CENTER_OUTPUT_%DELTA	Center channel output percentage difference from baseline
RIGHT_OUTPUT	Right channel output (temperature/pressure corrected)
RIGHT_OUTPUT_%DELTA	Right channel output percentage difference from baseline
CENTER_RAW	Data collected from the center ionization chamber during measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during measurement
TOP_RAW	Data collected from the top ionization chamber during measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the measurement
COMMENT	Measurement comment entered using the Data View interface

14.4 Dynamic 5 Channel Mode

When exporting from the Dynamic 5 Channel Mode, an individual file is created for each plan. The format of each file is broken down into multiple sections using the following pattern: Baseline1; Measurements for Baseline1; Baseline2; Measurements for Baseline2; etc

Baseline Data

Data Label	Description
BASELINE_ID	A unique identifier for the baseline energy that incorporates date and time of measurement
FIELD_SIZE	Collimator size, as entered in the Baseline Setup screen
SSD	Source to Surface Distance, as entered in the Baseline Setup screen
DOSERATE	Linear accelerator dose rate, as entered in the Baseline Setup screen
DOSE	Linear accelerator dose, as entered in the Baseline Setup screen
GANTRYANGLE	Gantry angle, as entered in the Baseline Setup screen
TEMPERATURE	Internal temperature when baseline measurement was taken, in °C
PRESSURE	Pressure when baseline measurement was taken, in mmHg

ENERGYLEVEL	A unique identifier for the baseline energy as determined by several ionization chambers and a proprietary algorithm
LEFT_OUTPUT	Baseline left channel output (temperature/pressure corrected)
---	---
CENTER_OUTPUT	Baseline center channel output (temperature/pressure corrected)
---	---
RIGHT_OUTPUT	Baseline right channel output (temperature/pressure corrected)
---	---
TOP_OUTPUT	Baseline top channel output (temperature/pressure corrected)
---	---
BOTTOM_OUTPUT	Baseline bottom channel output (temperature/pressure corrected)
---	---
CENTER_RAW	Data collected from the center ionization chamber during the baseline measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during the baseline measurement
TOP_RAW	Data collected from the top ionization chamber during the baseline measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during the baseline measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during the baseline measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during the baseline measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during the baseline measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during the baseline measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the baseline measurement

Measurement data

Data Label	Description
BASELINE_ID	Identifies which baseline energy values were chosen for comparison to measurement data
DATE	Date when measurement was taken, in the format mmddyyyy
TIME	Time when measurement was taken, in the format hhmmss
---	---
---	---

CONSTANCY	Constancy of measured energy, calculated from the center ionization chamber compared to baseline center ionization chamber value
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
ENERGYLEVEL	A unique identifier for the energy as determined by several ionization chambers and a proprietary algorithm. This is then compared to the set of ENERGYLEVEL values from baselines above
LEFT_OUTPUT	Left channel output (temperature/pressure corrected)
LEFT_OUTPUT_%DELTA	Left channel output difference from baseline
CENTER_OUTPUT	Center channel output (temperature/pressure corrected)
CENTER_OUTPUT_%DELTA	Center channel output percentage difference from baseline
RIGHT_OUTPUT	Right channel output (temperature/pressure corrected)
RIGHT_OUTPUT_%DELTA	Right channel output percentage difference from baseline
TOP_OUTPUT	Top channel output (temperature/pressure corrected)
TOP_OUTPUT_%DELTA	Top channel output percentage difference from baseline
BOTTOM_OUTPUT	Bottom channel output (temperature/pressure corrected)
BOTTOM_OUTPUT_%DELTA	Bottom channel output percentage difference from baseline
CENTER_RAW	Data collected from the center ionization chamber during measurement
LTP_RTE_RAW	Data collected from the left (photon side) or right (electron side) ionization chamber during measurement
TOP_RAW	Data collected from the top ionization chamber during measurement
RTP_LTE_RAW	Data collected from the right (photon side) or left (electron side) ionization chamber during measurement
BOTTOM_RAW	Data collected from the bottom ionization chamber during measurement
ONE_MM_ALUM_RAW	Data collected from energy channel 1 during measurement, primarily used for electrons
SIX_MM_ALUM_RAW	Data collected from energy channel 2 during measurement, primarily used for electrons
SIX_MM_LEAD_RAW	Data collected from energy channel 3 during measurement, primarily used for photons
NUM_SAMPLES	Number of samples collected by the analog-to-digital converter during the measurement
COMMENT	Measurement comment entered using the Data View interface

14.5 Physics Mode

The exported file for the Physics mode is broken into 3 sections: Rate Data, Charge Data, and Mode Specific. The rate and charge sections are the same for all three room types, however, the information exported for Section 3 varies by mode as described below.

Section 1 - Rate Data (Same for All Modes)

Data Label	Description
TOP	Data collected from the top ionization chamber during measurement
LEFT	Data collected from the left ionization chamber during measurement
CENTER	Data collected from the center ionization chamber during measurement
RIGHT	Data collected from the right ionization chamber during measurement
BOTTOM	Data collected from the bottom ionization chamber during measurement

Section 2 - Charge Data (Same for All Modes)

Data Label	Description
TOP	Data collected from the top ionization chamber during measurement
LEFT	Data collected from the left ionization chamber during measurement
CENTER	Data collected from the center ionization chamber during measurement
RIGHT	Data collected from the right ionization chamber during measurement
BOTTOM	Data collected from the bottom ionization chamber during measurement

Section 3 - Mode Specific (Static 5 Channel)

Data Label	Description
FLATNESS	Flatness of baseline energy, calculated from the ionization chamber readings
TRANSVERSE SYMMETRY	Transverse symmetry of baseline energy, calculated from the ionization chamber readings
AXIAL SYMMETRY	Axial symmetry of baseline energy, calculated from the ionization chamber readings
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
BATTERY	Internal battery voltage at time of reception of 'Stop Measurement' command, in Volts DC
DATE	Date and time when measurement was taken, in the format mmddyyyy, hhmmss
ELAPSED	The elapsed time of measurement

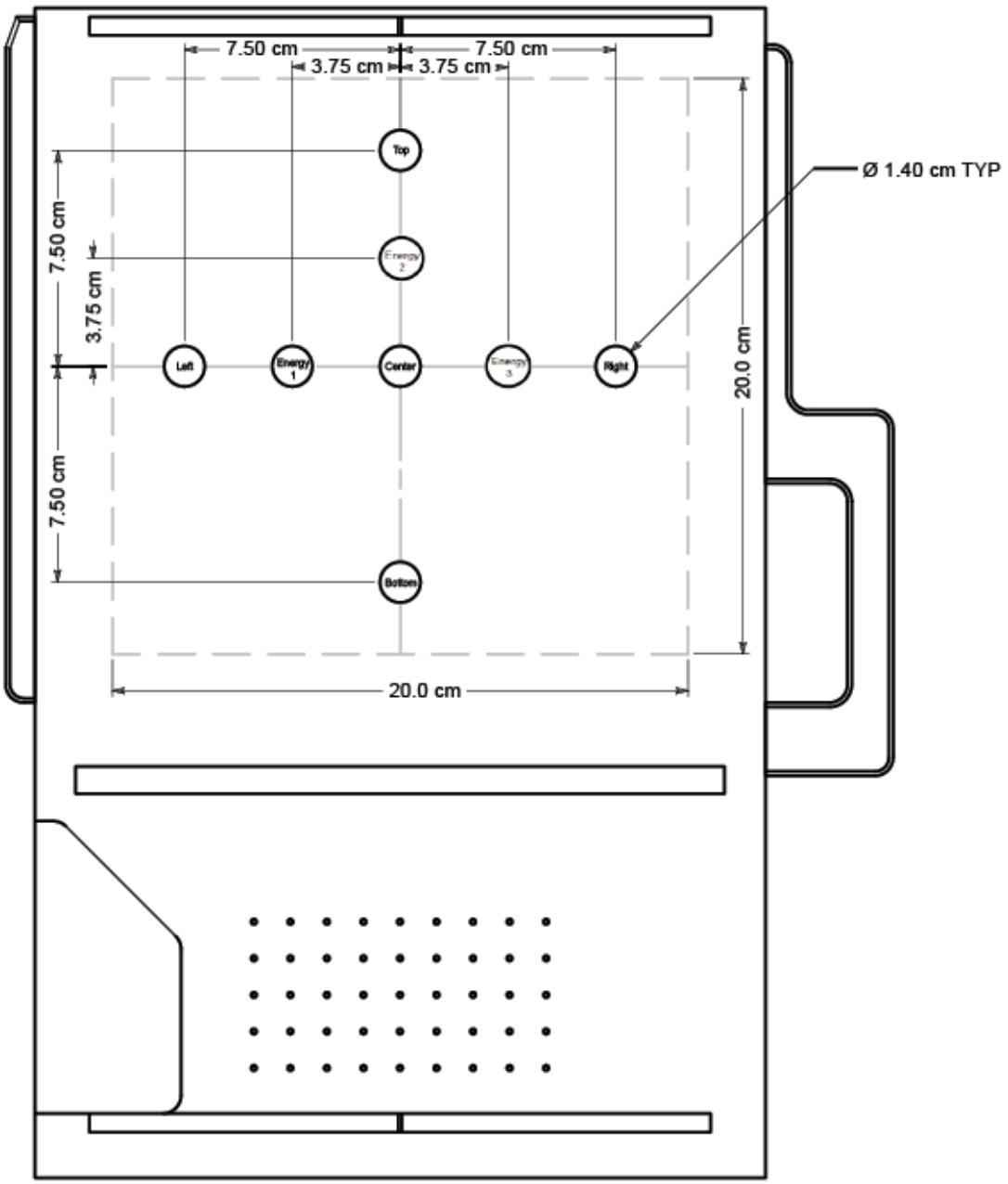
Section 3 - Mode Specific (TomoTherapy)

Data Label	Description
LEFT OUTPUT	Left channel output (temperature/pressure corrected)
CENTER OUTPUT	Center channel output (temperature/pressure corrected)
RIGHT OUTPUT	Right channel output (temperature/pressure corrected)
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
BATTERY	Internal battery voltage at time of reception of 'Stop Measurement' command, in Volts DC
DATE	Date and time when measurement was taken, in the format mmddyyyy, hhmmss
ELAPSED	The elapsed time of measurement

Section 3 - Mode Specific (Dynamic 5 Channel)

Data Label	Description
LEFT OUTPUT	Left channel output (temperature/pressure corrected)
CENTER OUTPUT	Center channel output (temperature/pressure corrected)
RIGHT OUTPUT	Right channel output (temperature/pressure corrected)
TOP OUTPUT	Top channel output (temperature/pressure corrected)
BOTTOM OUTPUT	Bottom channel output (temperature/pressure corrected)
TEMPERATURE	Internal temperature when measurement was taken, in °C
PRESSURE	Pressure when measurement was taken, in mmHg
BATTERY	Internal battery voltage at time of reception of 'Stop Measurement' command, in Volts DC
DATE	Date and time when measurement was taken, in the format mmddyyyy, hhmmss
ELAPSED	The elapsed time of measurement

15 Appendix D: Chamber Location Diagram



Drawing not to scale

16 Troubleshooting / Frequently Asked Questions

Refer to the following scenarios if experiencing problems with the QA BeamChecker Plus. Before contacting Standard Imaging, read this section to potentially resolve an issue without sending the device in for service.

16.1 Troubleshooting Scenarios

The QA BeamChecker Plus will not respond to commands made from its front panel or through Real-Time Operation Mode.

Possible Cause 1:

The QA BeamChecker Plus is not powered on. Press the power on/off button on the front panel of the device.

Possible Cause 2:

The internal battery is low or dead. Either place the device in the cradle or attach the Universal Input Power Supply, connected to live AC Mains power, directly to the QA BeamChecker Plus.

Possible Cause 3:

The interface does not respond. Press the pinhole reset switch on the BOTTOM of the unit. This will provide a 'hard' reset to the unit but will not erase any daily QA data (acquired in the Wire-Free Mode) in the internal memory.

The QA BeamChecker Plus Connection Status is shown as "Disconnected" by the Communication Software

Possible Cause 1:

The QA BeamChecker Plus is not properly resting on the cradle or cable is not attached to the PC. Make sure the unit has been firmly placed on the cradle and confirm all cables between the cradle and PC or the QA BeamChecker Plus and PC are properly inserted.

Possible Cause 2:

The COM port is not properly configured in Microsoft Windows. The COM port must be set within the range of ports 1 through 8. If using a Serial to USB adapter or PCI serial port add-on card, the COM port for these devices can be assigned in the Device Manager within the Control Panel. Refer to Section 20 'Features and Specifications' for further COM 'Port Settings' criteria, including correct data rate, or to the operating system/computer user manual or contact the computer manufacturer for more information.

Possible Cause 3:

The QA BeamChecker Plus is not turned on. The Communication Software will automatically detect any connected QA BeamChecker Plus and power it on. If all data connections and the serial port setup is verified as correct, ensure that the Universal Input Power supply, connected to live AC Mains power, is attached to the unit or to the Power/Data Cradle in the cradle in the event of a low battery.

Possible Cause 4:

If using the Serial to USB Adapter with a laptop computer, the laptop may need to be plugged into a wall outlet with a grounded power supply. If the laptop does not have a grounded power supply, please contact Standard Imaging for more information. See Tech Note 4050 available at www.standardimaging.com for additional information.

Possible Cause 5:

A Serial to USB Adapter is being used, but the drivers have not been setup. The Serial to USB Adapter will NOT work without the correct device driver installed on the PC. Check the adapter packaging for a CD or DVD ROM that contains the device driver installer. You may also check the manufacturer website and download the correct, latest device driver installer for the USB to Serial Adapter. Consult the instructions included with the adapter to ensure proper driver setup.

The QA BeamChecker Plus Connection Status is shown as "Not Synchronized" by the Communication Software
See the *About Synchronization and Database Relationship* section of this manual for more information.

There is no place to connect the QA BeamChecker Plus or Power/Data Cradle to the PC.
Possible Cause 1:

The computer does not have a serial port. Some notebook or small form factor computers no longer have the 'legacy' physical serial port. Several 3rd party companies manufacture adapters which allow connection of a serial device through a USB port. Standard Imaging highly recommends use of the provided Serial to USB Adapter (REF 70503) for best assurance of a reliable serial connection. Contact Standard Imaging for pricing and purchasing information if you no longer have one. If a USB connection is not available, an internal PCI serial port add-on card or USB hub may be used. Consult the computer manufacturer for more information.

When taking measurements in Wire-Free mode, fault code 'XXX' appears on the QA BeamChecker Plus front panel status display.
Possible Cause 1:

A baseline has not been acquired for the detected energy or the measured energy is outside of the automatic detection tolerance. Ensure a baseline measurement has been acquired for the attempted energy. Being out of tolerance is typically caused by a baseline being acquired at a much different time of day compared to the time of day that the daily QA data measurements are taken. Due to accelerator warm-up considerations, it is recommended to acquire baselines in similar conditions and time of day of daily measurements for best results. See page 12 for instructions on how to create or recreate baselines.

Possible Cause 2:

The QA BeamChecker Plus is not flipped to the proper side or the MODE / PLAN switch has not been pressed to indicate the correct orientation. Ensure that the proper side faces up on the QA BeamChecker Plus when placed on the treatment couch. The text on the field label

should match the desired energy. Also, the blue light on the front panel should match the desired type, either photon or electron, and the status display will be orientated in the correct direction.

Possible Cause 3:

The QA BeamChecker Plus is not rotated in the same direction on the couch that it was placed when baseline measurements were taken. Although the field shape on the surface of the QA BeamChecker Plus is symmetrical, the unit must be consistently used in the same orientation from baseline measurement to Wire-Free or Real-Time Operation Modes.

Error codes 'E00' to 'E09' or 'CRC' or 'MEM LOW' appear on the QA BeamChecker Plus front panel display.

Possible Cause 1:

An internal hardware failure may have occurred. Turn off the QA BeamChecker Plus, and turn it back on to attempt to clear the error. If the Error Code is reported again, please provide a system 'Reset' by pressing the pinhole reset switch on the BOTTOM of the unit. If upon power-up, the Error Code is reported again, check the following list for corrective action(s); if no user corrective actions are available, please contact Standard Imaging, Inc. Support. Please have the Error Code(s) ready when explaining the issue to our support personnel.

QA BeamChecker Plus Error/Information Codes

E00	Unknown Error
E01	Bias
E02	EEPROM
E03	Display Driver
E04	Barometer/Temperature Module
E05	Analog-to-Digital Converter IC
E06	Real-time Clock Communication
E07	Low Battery
E08	Internal Memory Full
E09	Real-time Clock Not Running
CRC	Memory fault detected
MEM LOW	Memory is available for less than 32 new measurements. Please download the daily QA data as soon as possible

About CRC Errors

As of version 2.3, all stored data, including baseline information and routine measurements, is duplicated across two internal memory chips within the QA BeamChecker Plus. When a CRC error occurs, this indicates a mismatch in one or more entries between the two memory chips.

Upon detection of a such an error, a repair operation is attempted. If upon rebooting the QA BeamChecker Plus, the CRC error is no longer displayed, the repair was likely successful. However, anytime this error is displayed, it is recommended to contact Standard Imaging for diagnostic review.

On some energies, QA BeamChecker Plus measurements show inconsistent variation day to day even though other measurement with other devices indicated linac should not be exhibiting this behavior.
Tip 1:

When taking measurements with the QA BeamChecker Plus, the instrument should be placed in the same position on the couch as when the baseline measurement was taken. Variations in placement can affect how scatter from elements in the couch contributes to the chamber signal readings, especially for low energy photons.

Tip 2

Performing measurements at roughly the same time each day (within a couple of hours) will increase the consistency of the reading. Additionally, the daily measurement should correspond to the time of day that the baseline was taken. Working from a baseline taken in the morning and performing daily measurements in the evening can contribute variation, as much as 2% depending on the consistency of temperature, pressure, but more significantly how "warmed up" the treatment machine is. An initial linac warm-up of 500-1000 monitor units is recommended before any QA measurements are taken.

When using the software, certain screen elements such as buttons or text are cut off or hidden

Possible Cause 1:

The screen resolution is set too low. Ensure the system screen resolution is set to at least 1024 x 768 pixels and the QA BeamChecker Plus software window is maximized.

Possible Cause 2:

The system font and screen elements setting is set to non-default. Setting above 96 DPI (Windows 2000 or XP) or 100% (Windows Vista or 7) can crop certain screen elements. This can also be solved without changing the global Windows setting by using the "Disable display scaling on high DPI settings" compatibility setting. This setting can be accessed by right-clicking the program shortcut, selecting Properties and navigating to the Compatibility tab.

16.2 Frequently Asked Questions

Can I install the QA BeamChecker Plus software on multiple PCs?
Yes. There is no limit (technically or legally) to how many PCs can run the QA BeamChecker Plus software application simultaneously. Since the database file can be stored to a network accessible location, it is common to have the Communications Software installed at the control console of each treatment room, as well as other computers that may be used to examine measurement data saved in the database in greater detail.

What are the differences between Wire-Free and Real-Time Operation modes?
See the Routine Measurements section of this manual for more information.

Can I measure Baselines and use Real-Time Operation and Physics modes wirelessly?
Yes. While a serial cable will still need to be run from the PC into the treatment vault, the optional Bluetooth Adapter Kit (REF 70504) can supply a wireless connection within the vault only, between this cable and the QA BeamChecker Plus. Contact Standard Imaging for pricing and purchasing information.

How much data can be stored on the QA BeamChecker Plus before I need to transfer to the PC?
The internal memory within the QA BeamChecker Plus can store up 512 measurement points before a transfer is necessary. The number of energies and rooms used will dictate how much time this equals. We recommend transferring this data once per week, or as often as is convenient, because once measurements are transferred to the PC, they can be easily backed up.

I know my linear accelerator is providing a bit "over" or "under" the intended dose. Can I assign offsets to my baseline to account for this difference in my daily measurements?
No. The QA BeamChecker Plus is designed to perform daily measurements relative to a raw measurement baseline. It is not designed for absolute dosimetry. If a known, consistent offset has developed, creating a new baseline to account for this difference is recommended. The QA BeamChecker Plus will only determine deviations from measured baselines, not a predefined zero point.

Does the QA BeamChecker Plus support 4 or 5 MeV electron beams?
No. Due to the low signal strength of 4 and 5 MeV, and the amount of buildup material above the chambers, these energies are not supported by the QA BeamChecker Plus.

17 Maintenance

Exterior cleaning of the device can be done with a soft brush and a cloth. Gently brush all surfaces to remove dirt and dust. Be especially careful that this is an external cleaning only and do not permit any liquid to seep into the QA BeamChecker Plus in any manner during cleaning.

There are no user serviceable parts on the QA BeamChecker Plus. The warranty will become void if the QA BeamChecker Plus is disassembled.

If assistance is desired in the proper disposal of this product (including accessories and components), after its useful life, please return to Standard Imaging.

18 Parts and Accessories

REF Description

90501 QA BeamChecker Plus
80117 User Manual
70500 Gantry Mount Accessory (varies by linac model)
50299 QA BeamChecker Plus Communication Software
70502 QA BeamChecker Plus Power/Data Cradle
70503 Serial to USB Adapter
70504 Bluetooth Adapter Kit
70505 Precision TomoTherapy Leveling Platform
20474 Universal Input Power Supply, 9 Volt DC, 2.0 A, 60601-1 compliant
20177 Power Cord, AC, USA
NOTE: The Universal Input Power Supply is used with a region-specific power cord. Please specify for regions outside of the USA.

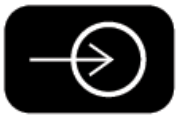
19 Description of Symbols

The following symbols are found on the QA BeamChecker Plus:

Power On/Off Switch

Dangerous Voltage
Present Inside Enclosure

Attention, Consult
Accompanying Documents



Signal Input

Battery Charge Indicator

Reset

Power On

Sound/Speaker

Ready for Beam Exposure*

Waiting for User Input*

*Other codes are displayed on the QA BeamChecker Plus front panel depending on scenario. See the *Routine QA Measurements* and *Troubleshooting* sections of this manual for detailed information.

20 Features and Specifications

Detectors Chamber Volume: Parallel Plate Separation: Collection Electrode:	8 vented, fully guarded, ionization chambers: · 1 center detector · 4 quadrant detectors, 7.5 cm from center · 3 energy identification chambers 0.6 cm^3 4.0 mm 1.39 cm diameter
Inherent Buildup: Photon Side: Electron Side:	 3.5 cm water-equivalent material 1.5 cm water-equivalent material
Light Field Alignment:	20 cm x 20 cm alignment grid
Radiation Measured: Photons: Electrons:	 ^{60}Co to 25 MV 6 MeV to 25 MeV
Real-time Clock:	On board, for data validation and storage, provides time and date stamp to all data
QABC Plus Memory Capacity:	Stores up to 512 data points before transfer required
Temperature/pressure measurement: Pressure Resolution: Temperature Resolution:	Precision sensor on board, automatic compensation 0.1 mmHg 0.1°C
Operating Parameters: Temperature: Relative Humidity: Pressure: High Dose Rate:	 15 to 35 °C 20 to 80% non-condensing 500 to 825 mmHg Up to 2400 MU/min (Requires updated hardware.)
Storage Parameters: Temperature: Relative Humidity: Pressure:	 -15 to 50 °C 10 to 95% non-condensing 600 to 800 mmHg
Audio:	On board speaker for audio feedback on start-up, button presses, operator alerts, etc.
Dimensions (QA BeamChecker Plus): Width: Height: Length:	 30.86 cm (12.15 in) 6.15 cm (2.42 in) 40.64 cm (16.00 in)
Dimensions (Power/Data Cradle): Width: Height: Length:	 10.16 cm (4.00 in) 7.16 cm (2.82 in) 29.21 cm (11.50 in)
Dimensions (Gantry Mount): Width: Height: Length:	 36 cm (14.17 in) 50 cm (19.69 in), typical varies by accelerator 29 cm (11.42 in)

Dimensions (Precision Leveling Platform): Triangle Side Length: Height:	 38 cm (14.96 in) 6.5 cm (2.56 in)
Weight: QA BeamChecker Plus: Power/Data Cradle: Gantry Mount: Precision Leveling Platform:	 5.0 kg (11 lbs) 1.8 kg (4 lbs) 5.3 kg (11.68 lbs) 1.25 kg (2.75 lbs)
Mode of Operation:	Continuous
Power Requirements: Battery: Battery Recharge Time: Charger Input:	 1.2 Ah SLA, 4 hours of continuous use. Approximately 8 hours from full discharge. 90 – 240 VAC, 50-60 Hz, EN/IEC 60601-1 approved power supply, GlobTek®, Inc. model GTM96180-1811-2.0-T3 The use of any other power supply and using alternates other than the UL/CSA recognized power cord can degrade minimum safety. The proper replacements from Standard Imaging, Inc. are required for compliance with the requirements of IEC 60601-1.
Product Standards:	IEC 60601-1_1, IEC 60601-1-2_1,
Patents:	US Patent Numbers 7,189,975 and 7,470,912
PC Hardware Requirement:	Available COM port within range of COM1 through COM8; RS-232 Default: Uni-directional 19,200 baud, 8 data bits, no parity, 1 stop bit
Software/Computer Requirements: Operating System: Processor: Memory: Hard Drive: Screen Resolution: Optical Drive: Connectivity:	 Windows 10 Professional, 64 bit recommended Dual Core, 1 GHz; Quad Core, 2 GHz Recommended 32-bit OS: 2 GB, 4 GB Recommended 64-bit OS: 4 GB, 8 GB Recommended 32 GB or greater, 1 GB free space for initial software setup. 25% free space recommended. 1024 x 768 or greater Compact Disc (CD) or Digital Versatile Disc (DVD) 9 pin RS-232 serial port and IPv4 LAN, 100 Mbit/s or greater

21 WARRANTY STATEMENT- 4424-18

Standard Imaging, Inc. sells this product under the warranty herein set forth. The warranty is extended only to the buyer purchasing the product directly from Standard Imaging, Inc. or as a new product from an authorized dealer or distributor of Standard Imaging, Inc.

For a period provided in the table below from the date of original delivery to the purchaser or a distributor, this Standard Imaging, Inc. product, provided in the table, is warranted against functional defects in design, materials and workmanship, provided it is properly operated under conditions of normal use, and that repairs and replacements are made in accordance herewith. The foregoing warranty shall not apply to normal wear and tear, or if the product has been altered, disassembled or repaired other than by Standard Imaging, Inc. or if the product has been subject to abuse, misuse, off-label use, negligence or accident.

Product	Warranty Period
Standard Imaging Ionization Chambers	5 years
Standard Imaging Detectors	1 year
Standard Imaging Well Chambers	2 years
Standard Imaging Electrometers	5 years
Standard Imaging BeamChecker Products	2 years
TomoScanner and TomoElectrometer	2 years
Standard Imaging Software Products	1 year
All Other Standard Imaging Products	1 year
Standard Imaging Custom Products	1 year
Standard Imaging Remanufactured Products	180 days
Standard Imaging Custom Select Products	90 days
Consumables	90 days
Serviced Product	90 days (for service performed)
Resale Products	As defined by the Original Equipment Manufacturer
ADCL Product Calibration (Standard Imaging uses the UW-ADCL for recalibrations required under warranty, unless otherwise requested)	0 - 90 days = 100% of ADCL Calibration Costs 91 - 182 days = 75% of ADCL Calibration Costs 183 – 365 days = 50% of ADCL Calibration Costs 366 – 639 days = 25% of ADCL Calibration Costs (days from date of shipment to customer)

Standard Imaging's sole and exclusive obligation and the purchaser's sole and exclusive remedy under the above warranties are, at Standard Imaging's option, limited to repairing, replacing free of charge or revising labeling and manual content on, a product: (1) which contains a defect covered by the above warranties; (2) which are reported to Standard Imaging, Inc. not later than seven (7) days after the expiration date of the warranty period in the table; (3) which are returned to Standard Imaging, Inc. promptly after discovery of the defect; and (4) which are found to be defective upon examination by Standard Imaging Inc. All transportation charges (including customs, tariffs, duties and brokerage fees) are the buyer's responsibility. This warranty extends to every part of the product excluding consumables (fuses, batteries, or glass breakage) or material reactions. Standard Imaging, Inc.

shall not be otherwise liable for any damages, including but not limited to, incidental damages, consequential damages, or special damages. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days.

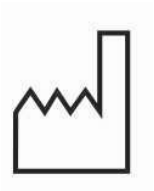
This warranty is in lieu of all other warranties, express or implied, whether statutory or otherwise, including any implied warranty of fitness for a particular purpose. In no event shall Standard Imaging, Inc. be liable for any incidental or consequential damages resulting from the use, misuse or abuse of the product or caused by any defect, failure, malfunction or material reactions of the product, whether a claim of such damages is based upon the warranty, contract, negligence, or otherwise.

This warranty represents the current standard warranty of Standard Imaging, Inc. Please refer to the labeling or instruction manual of your Standard Imaging, Inc. product or the Standard Imaging, Inc. web page for any warranty conditions unique to the product.

22 Serialization Information

Standard Imaging products that are serialized contain coded logic in the serial number which indicates the product, day and year of manufacture, and a sequential unit number for identification:

A YY DDD X
A Unique product ID
YY Last two digits of the year
(e.g. 1999 = 99, 2000 = 00)
DDD Day of the year (1≤ DDD ≤ 365)
X Unique unit ID number (0 ≤ X ≤ 9)



23 Customer Care Policy Statement

Standard Imaging, at its discretion, may extend customer support only to the buyer purchasing the product directly from Standard Imaging, Inc. or as a new product from an authorized dealer or distributor of Standard Imaging, Inc. This customer care statement is in lieu of all other customer support statements, express or implied, whether statutory or otherwise, including any implied statements of fitness for a particular purpose.

Standard Imaging:

- Technical support is preferentially biased to those customers with valid and applicable Standard Imaging Certificate of Maintenance agreements.
- Technical support may range from providing detailed solutions to upgrade recommendations to the latest version of software for discontinued products.
- Will, at a minimum, provide technical support during its normal hours of operation.
- May, at its discretion, limit support of ancillary systems beyond its direct control, such as information technology systems, database management and 3rd party programs.
- Will provide technical support for the product for a minimum of 7 years from the date of delivery or discontinuance.
- Will not provide technical support for obsolete products, those products which are 7 years past the date of discontinuance.
- Will provide technical support for any and all involving issues with significant product risk, regardless of product age.

This customer care statement represents the current standard customer care statement of Standard Imaging, Inc. Please refer to the labeling or instruction manual of your Standard Imaging, Inc. product or the Standard Imaging, Inc. web page for any customer care statement conditions unique to the product. Specifications subject to change without notice.

24 Customer Responsibility

This product and its components will perform properly and reliably only when operated and maintained in accordance with the instructions contained in this manual and accompanying labels. A defective device should not be used. Parts which may be broken or missing or are clearly worn, distorted or contaminated should be replaced immediately with genuine replacement parts manufactured by or made available from Standard Imaging Inc.

⚠ CAUTION: Federal law in the U.S.A. and Canadian law restrict the sale, distribution, or use of this product to, by, or on the order of a licensed medical practitioner. The use of this product should be restricted to the supervision of a qualified medical physicist.

⚠ CAUTION: As desired by IAEA, English is the default language for labeling and manuals. If translated versions are available, resolve any differences in favor of the English versions.

⚠ WARNING: Measurement of high activity radioactive sources is potentially hazardous and should be performed by qualified personnel.

⚠ WARNING: Proper use of this device depends on careful reading of all instructions and labels.

⚠ WARNING: Where applicable, Standard Imaging products are designed to be used with the versions of common radiation delivery devices, treatment planning systems and other products or systems used in the delivery of ionizing radiation, available at the time the Standard Imaging product is released. Standard Imaging does not assume responsibility, liability and/or warrant against, problems with the use, reliability, safety or effectiveness that arise due to the evolution, updates or changes to these products or systems in the future. It is the responsibility of the customer or user to determine if the Standard Imaging product can be properly used with these products or systems.

Should repair or replacement of this product become necessary after the warranty period, the customer should seek advice from Standard Imaging Inc. prior to such repair or replacement. If this product is in need of repair, it should not be used until all repairs have been made and the product is functioning properly and ready for use. After repair, the product may need to be calibrated. The owner of this product has sole responsibility for any malfunction resulting from abuse, improper use or maintenance, or repair by anyone other than Standard Imaging Inc.

Standard Imaging will make numerous and reasonable attempts to contact a customer following completed manufacture or service of a product. Should a customer product remain at Standard Imaging for more than 1 year following its completed manufacture or service, Standard Imaging reserves the right to resell, restock, donate, discard or destroy the product.

If, in relation to the use of this product, a death or a serious deterioration of health has occurred, this should be reported to Standard Imaging, Inc. and the National Competent Authority of the country in which the incident occurred. When in doubt, please consult with an advisor or reach out to Standard Imaging, Inc. for further assistance.

25 Service Policy

If service, including recalibration, is required, please contact Standard Imaging's Customer Service department by phone or email prior to shipping the product. Standard Imaging's Customer Service and Technical Service staff will attempt to address the product issue via phone or email. If unable to address the issue, a return material authorization (RMA) number will be issued. With the RMA number, the product can be returned to Standard Imaging. It is the responsibility of the customer to properly package, insure and ship the product, with the RMA number clearly identified on the outside of the package. The customer must immediately file a claim with their carrier for any shipping damage or lost shipments. Return shipping and insurance is to be pre-paid or billed to the customer, and the customer may request a specific shipper. Items found to be out of warranty are subject to a minimum service fee of 1 hour labor (excluding recalibrations) for diagnostic efforts and require a purchase order (PO) before service is performed. With concurrence from customer, the product may be replaced if it is unserviceable or if the required service is cost prohibitive. Products incurring service charges may be held for payment. Standard Imaging does not provide loaner products. See the Standard Imaging Warranty and Customer Responsibility for additional information.

26 Return Policy

No merchandise will be accepted for credit without prior approval of return. Please contact Standard Imaging's Customer Service Department to receive a return authorization number before returning any merchandise for exchange or credit. Products manufactured by Standard Imaging must be returned within thirty days of receipt of order in 'like new' condition. No credit will be given for products returned after thirty days from receipt of order. A minimum twenty percent restocking fee will be charged on all returned merchandise. All materials returned must be shipped pre-paid. Credit for returned goods will be issued to customer's account for use against future purchases of merchandise only. Special orders, custom products, re-sale (not manufactured by Standard Imaging) products, and ADCL calibrations will not be accepted for return credit or exchange.

All products may not be registered, cleared, licensed or approved for sale in all countries or territories. Please contact Standard Imaging Customer Care for details.

CE 2862

EC	REP	Hoff & Lowendahl AB Högåsvägen 125 SE-741 41 Knivsta, Sweden

Authorized representative for the EU is Hoff & Lowendahl AB Högåsvägen 125, SE-741 41, Knivsta, Sweden (SRN: SE-AR-000001888). Contact information: info@lowendahl.eu.

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