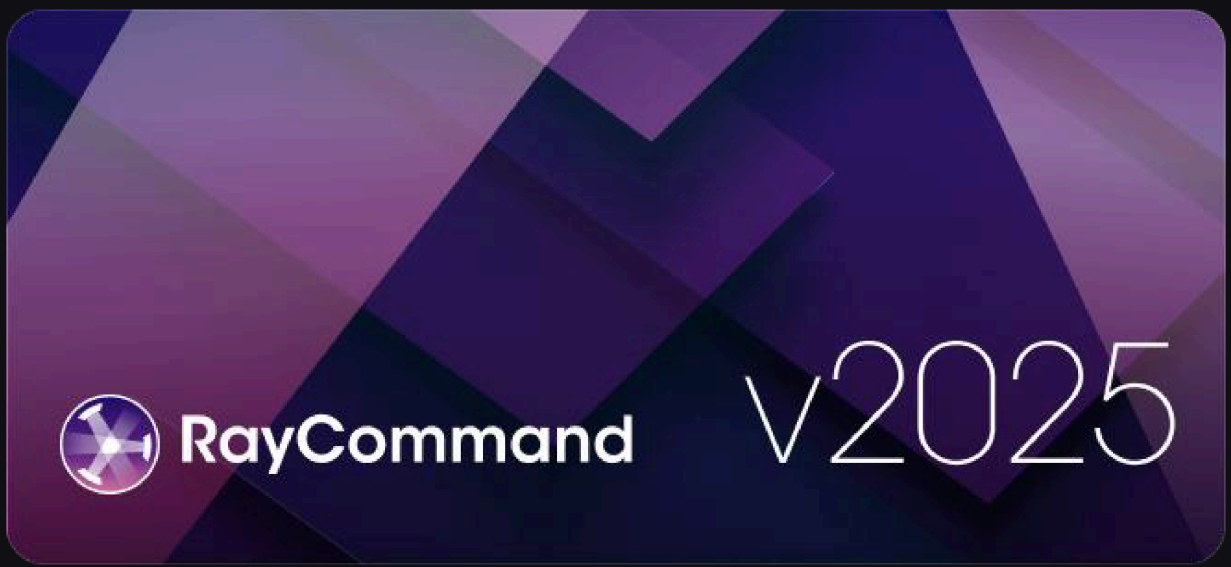
# RAYCOMMAND v2025

Instructions for Use



Traceback information:
Workspace Main version a1033
Checked in 2025-10-21
Skribenta version 5.6.020.1

## *Disclaimer*

For information on functionality not available for regulatory reasons, see the Regulatory Information in the RayStation Instructions for Use.

## *Declaration of conformity*

CE 2862

Complies with Medical Device Regulation (MDR) 2017/745. A copy of the corresponding Declaration of Conformity is available on request.

## *Safety notices*

Warning and caution notices in the user documentation inform about the safe use of the product and must be followed.

**WARNING!**

A warning notice informs about a risk for bodily harm or death. In most cases, the risk is related to mistreatment of the patient.

**CAUTION!**

A caution notice informs about a risk for damage to equipment, software or data.

***Note:*** *A note provides additional helpful information, tips or reminders.*

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## *Printed material*

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# TABLE OF CONTENTS

# 1 INTRODUCTION

## *About RayCommand*

The RayCommand application integrates with RayCare to allow the clinic to deliver plans created in RayStation as treatment sessions on treatment systems with a patient positioning system.

This manual describes the parts of the workflow that are directly related to the delivery of treatment plans and controlling the patient positioning system:

- Handling treatment appointments created in RayCare
- Preparation of the patient positioning system for imaging and delivery in RayCommand
- Performing treatment delivery in RayCommand
- Monitoring the treatment machine and patient positioning system using the RayCommand Machine monitor

## *About this manual*

This document is an addition to *RSL-D-RS-v2025-USM, RayStation v2025 User Manual* and summarizes some of the most important features of the RayCommand application.

The document includes appendices that are also parts of *RSL-D-RS-v2025-USM, RayStation v2025 User Manual* and *RSL-D-RS-v2025-RPHY, RayStation v2025 RayPhysics Manual*, relevant for RayCommand users.

Study this manual and the *RSL-D-RS-v2025-IFU, RayStation v2025 SP1 Instructions for Use* carefully before using the RayCommand application. Proper functioning of the device can only be guaranteed if the instructions in these documents are adhered to.

Study the Release Notes in this manual as well as the *RSL-D-RS-v2025-RN, RayStation v2025 SP1 Release Notes* carefully. These notes provide final instructions on how to use the RayCommand application.

The RayStation v2025 system is further described in the RayStation v2025 product documentation.

Refer to the RayCare v2025 product documentation for information about the RayCare v2025 system.

# 2 PRODUCT INFORMATION



This chapter describes the RayCommand product label. For product information regarding the RayStation v2025 system, refer to the *RSL-D-RS-v2025-IFU, RayStation v2025 SP1 Instructions for Use*.

The version number of an installed RayStation v2025 system can be found by choosing **Help: About RayStation** in the RayCommand menu.

The following information can be identified:

- Product name = RayStation
- 产品型号: RayStation (for the Chinese market only)
- Release version = **17.1**
- Marketing name = RayStation RayCommand v2025 SPC1
- Software build number = **17.1.0.451**
- Clinical build = Indicates that the software is designed for clinical use.

  Note: A clinical installation requires both a clinical build and a clinical license. Otherwise, 'Not for clinical use' will be displayed in the title bar.
- Product lifetime = The lifetime per market is one year after the next major release, but no less than three years

- Radiation treatment planning system software = The generic name of the product
- 产品名称: 放射治疗计划系统软件 (for the Chinese market only)
- MD = Indicates that the product is a medical device
- UDI = Unique Device Identification number
- CH REP = The Swiss authorized representative and importer
- CE 2862 = The CE mark and the notified body number
- = Production date
- = Consult instructions for use
- = The name and address of the manufacturer
- @ = The support e-mail address

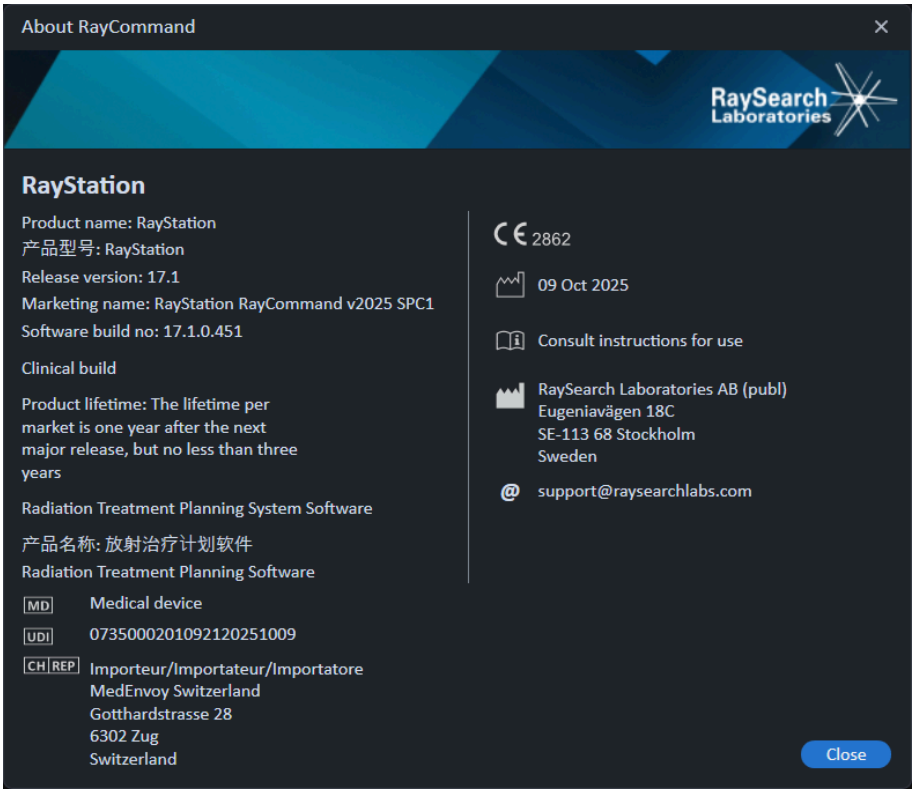



**Figure 1.** The **About RayCommand** dialog.

# 3 INFORMATION NEEDED FOR SAFE OPERATION

Adhere to the following warnings as well as the warnings described in *RSL-D-RS-v2025-IFU, RayStation v2025 SP1 Instructions for Use* for safe operation of the RayCommand application.

***Note:*** *RayCommand v2025 is compatible with RayCare v2025 and subsequently validated RayCare v2025 service packs. Check compatible versions with RaySearch Service.*

## 3.1 MANDATORY SITE TESTS

Before using RayCommand clinically after an upgrade of any relevant software or hardware, the test cases in the Acceptance Test Protocol shall be run, as a minimum, on an evaluation environment to verify the correctness of the clinical integration:

- *RSL-D-RCMD-v2025SPC1-ATP MA, RayCommand v2025 SPC1 Acceptance Test Protocol MedAustron*

In addition, the Installation Test Specification must be run on each clinical environment to verify the correctness of the clinical installation:

- *RSL-D-RCMD-v2025SPC1-ITS MA, RayCommand v2025 SPC1 Installation Test Specification MedAustron*

**WARNING!**

**Installation and reconfiguration testing.** To function correctly, RayCommand depends on configuration and external systems. Configuration changes in RayCommand, RayCare, RayStation or external systems require testing according to *RSL-D-RCMD-v2025SPC1-ITS MA, RayCommand v2025 SPC1 Installation Test Specification MedAustron*.

(334371)

## 3.2 SAFETY PRECAUTIONS

### 3.2.1 General

**WARNING!**

**Make sure that the intended plan is used.** All plans can be included in the treatment course, regardless of the prescription or the planned number of fractions. Exercise caution when assigning different plans to different fractions.

(1044096)

**WARNING!**

**Some state may not be persisted in services or drivers.** If the RayCommand room driver is restarted, the driver's cache of the state of external systems is lost. After a restart, the state will be unknown until the external system is reset.

(334439)

**WARNING!**

**Only results from completed treatment sessions are displayed in RayCare.** The results of the treatment sessions will not be displayed in RayCare until the session is completed. If it is not possible to complete the session, the result will not be displayed in RayCare.

(334370)

**WARNING!**

**Ensure sufficient training.** The user organization shall ensure that individuals authorized to perform treatment functions are appropriately trained for the functions they perform. Only individuals authorized to enter and accept machine setup or other patient treatment data should use this software. Carefully read all instructions prior to use. The user is responsible for proper clinical use and the prescribed radiation dose.

(334374)

**WARNING!**

**Installation and reconfiguration testing.** To function correctly, RayCommand depends on configuration and external systems. Configuration changes in RayCommand, RayCare or RayStation require testing according to *RSL-D-RCMD-v2025SPC1-ITS MA, RayCommand v2025 SPC1 Installation Test Specification MedAustron*.

(334371)

**WARNING!**

**Risks when using non-codified accessories.** If fixation devices or other non-codified accessories are used, it is the responsibility of the user to verify that the correct accessories are used and mounted correctly. The use of setup instructions and/or the beam set note is suggested for documenting the use of accessories. Fixation devices in RayCare and RayCommand support the use of IDs as an additional safety measure.

The correct usage of non-fixation device accessories and gating devices that are not codified is the responsibility of the delivery device and end user.

(931722)

**WARNING!**

**User must confirm patient identity.** The user is responsible for verifying the patient identity before clicking the *Confirm patient ID* button in the *Preparation* module.

(725703)

**WARNING!**

**Physics mode: Ensure that no patient is on table.** When in Physics mode, the user is responsible for verifying that there is no patient on the table before clicking the *Confirm no patient on table* button in the *Preparation* module.

(725702)

**WARNING!**

**Beam set note synchronization.** The beam set note is editable in RayStation, RayCare and RayCommand even if a session is open in RayCommand. Ensure that if the beam set note is significantly changed during a session to also inform the operator.

(1043064)

### 3.2.2 Configuration

**WARNING!**

**Machine models.** The user who configures which machine models are supported in which rooms shall have a very clear understanding of the clinic and its rooms and machine models. It is strongly discouraged to remove or rename any machine model in the configuration of a room. Instead, it is recommended to deprecate the machine in RayPhysics if a machine model is not to be used anymore. It is still possible to add new machine models to a room.

(1044097)

**WARNING!**

**Configuration of treatment room machine models.** Only compatible machine models must be listed in the machine models list when configuring the treatment room. Incorrect configuration can cause failure of service or incorrect treatment delivery.

(342666)

**WARNING!**

**Possible to approve/export plan with collision based on outdated imaging device transformation.** The RayStation collision check result is not invalidated if the imaging device transformation (IDT) vector for the treatment room is changed in Clinic Settings. It is the user's responsibility to ensure that the collision check is re-run for unapproved beam sets if the IDT is updated.

(409517)

**WARNING!**

**Ensure correct Imaging Device Transformation (IDT).** It is the responsibility of the clinic and user to ensure that the IDT vector for the treatment room is specified correctly in Clinic Settings.

(725706)

**WARNING!**

**Ensure configured margins for path planning are sufficient.** Path planning does not account for any uncertainties in the PPS position, e.g., due to couch sag. The configured margins for collision check must account for these uncertainties to avoid collisions during path execution. If the margins are larger than any potential uncertainties, this will also ensure there is no collision when entering or exiting a camera tracked position.

(825285)

**WARNING!**

**Final path validation.** The final path validation functionality ensures that paths are still valid after post-processing (e.g. uniform interpolation) has been applied. By applying the same validation checks as the path planners on post-processed paths, paths with invalid control points (e.g. colliding control points) are prevented from being executed.

The user is strongly advised to ensure that final path validation is enabled in the Motion configuration file. Otherwise, invalid post-processed paths may be sent for execution, which risks collisions, violations of allowed robot joint values, or larger than allowed inclinations for the patient couch.

(1202827)

**WARNING!**

**Interpolation distances.** Distances between control points in a planned path can be regulated through several parameters. Only control points returned by the path planner are validated to be free from collisions. Since the path planner does not know how the robot behaves between the planned control points, enlarging interpolation distances increases the risk of collisions that are not detected due to inadequate sampling of the path.

(1202828)

### 3.2.3 Registration

**WARNING!**

**Review automatic registration.** Always ensure that the automatic registration between the setup images and the planning CT is acceptable by manually reviewing the result.

(344618)

**WARNING!**

**Ensure that the correct imaging beam is used for imaging.** In RayCommand there is no connection between the setup beams of the plan and the treatment beams. For plans with multiple isocenters, the user must be aware of the risk of using the wrong imaging beam when acquiring the images. If setup images are acquired based on the wrong imaging position, the patient displacement for the resulting registration may be unsuitable for the treatment beam. Always give the setup beam in RayStation a unique and understandable name so that the correct corresponding imaging beam is selected for image acquisition and registration before beam delivery. The same goes for any new imaging beam saved in RayCommand for the beam set. The body site for the imaging beam can be used as a redundant indication of where the setup beam isocenter is positioned.

(410108)

### 3.2.4 Motion

**WARNING!**

**Safety when moving table top.** When using the motion service in RayCommand to move the patient positioning device, the user operating the Operator Deadman's Switch (ODS) must be attentive during the complete range of movement. The ODS must be released immediately when there is a risk of collision or patient injury.

Close attention is required because variation in the patient's daily position and changes in the room environment may not be adequately accounted for in the collision check for a path.

(334372)

**WARNING!**

**Ensure unobstructed view of patient.** Always ensure unobstructed view of the patient before and during irradiation or any other activity related to risk of patient safety.

(334373)

**WARNING!**

**Patient movement between imaging and completed treatment.** Patient movement between imaging and completed treatment is not automatically detected. Patient movement after imaging may cause incorrect patient setup.

(334434)

**WARNING!**

**Room view is an approximate representation of the treatment room and must not be used for determining patient setup or collisions.** Room view is not sufficiently accurate for determining patient setup or collisions.

(410298)

### 3.2.5 Eye treatment

**WARNING!**

**Machine for eye treatment requires aperture block support.** In RayPhysics, all snouts in the machine model which will be used for eye treatment must be configured to require the use of aperture blocks. Aperture blocks must not be supported in any other machine model.

(930954)

**WARNING!**

**Aperture block support in machine and room configuration.** The treatment machine configured to support aperture blocks shall only be configured to be used in treatment rooms that support eye treatment. Room configuration is performed in Clinic Settings.

(930951)

**WARNING!**

**Aperture block usage information not stored in RayCommand.** The treatment record from MAPTA will not contain information about any used aperture blocks. Therefore, no information is stored in RayCommand or RayCare about whether a plan has been delivered with an aperture block or not.

The clinic is advised to record whether an aperture block has been used, e.g., by using the final treatment note when signing a session.

(930952)

**WARNING!**

**Ensure using correct aperture block.** When a treatment plan requires the use of an aperture block, the user must ensure that the correct block is used and mounted correctly.

RayCommand does not store information about whether the aperture block is in place or is correctly positioned.

The clinic is advised to record the aperture block information during planning, either as a beam set note in RayStation or a setup instruction in RayCare.

(930953)

**WARNING!**

**Patient specific aperture block information not stored in RayCommand.**
RayCommand does not store or show any information about which aperture block should be mounted in the Passive Beam Modifier Pipe. The *Block name* assigned in RayStation is not propagated to or displayed in RayCommand. If any relevant information is entered in the *Block name*, the user must keep track of this separately.

The clinic is advised to record the aperture block information during planning, either as a beam set note in RayStation or a setup instruction in RayCare.

(930957)

# 4 RELEASE NOTES

This chapter contains important notes about the use of the RayCommand application. It contains information related to patient safety and lists new features, known issues and possible workarounds.

**Every user of the RayCommand application must be familiar with these known issues as well as the known issues described in** *RSL-D-RS-v2025-RN, RayStation v2025 SP1 Release Notes*. Contact the manufacturer for any questions about the content.

***Note:*** *Additional release notes may potentially be distributed shortly after installation.*

## *In this chapter*

This chapter contains the following sections:

## 4.1 NEWS AND IMPROVEMENTS IN RAYCOMMAND v2025 SPC1

This chapter describes the news and improvements in RayCommand v2025 SPC1 as compared to RayCommand 2024A SPC2.

### 4.1.1 Resolved Field Safety Notices (FSNs)

There are no resolved field safety notices (FSNs) in RayCommand v2025, as compared to RayStation 2024A SPC2.

### 4.1.2 Resolved issues related to patient safety

#### *User can sign a registration that they did not intend to sign*

It was possible for a user to sign an authentication dialog for a registration that they did not intend to sign. This could only occur if a second user, in second monitor, would do a registration and save it at the same time the first user was signing the previous registration. This has now been resolved.

(1472654)

### 4.1.3 New and significantly updated warnings

For the complete list of warnings, see *section 3.2 Safety precautions on page 16*.

#### *New warnings*

**WARNING!**

**Final path validation.** The final path validation functionality ensures that paths are still valid after post-processing (e.g. uniform interpolation) has been applied. By applying the same validation checks as the path planners on post-processed paths, paths with invalid control points (e.g. colliding control points) are prevented from being executed.

The user is strongly advised to ensure that final path validation is enabled in the Motion configuration file. Otherwise, invalid post-processed paths may be sent for execution, which risks collisions, violations of allowed robot joint values, or larger than allowed inclinations for the patient couch.

(1202827)

**WARNING!**

**Interpolation distances.** Distances between control points in a planned path can be regulated through several parameters. Only control points returned by the path planner are validated to be free from collisions. Since the path planner does not know how the robot behaves between the planned control points, enlarging interpolation distances increases the risk of collisions that are not detected due to inadequate sampling of the path.

(1202828)

*Significantly updated warnings*

**WARNING!**

**Ensure that the correct imaging beam is used for imaging.** In RayCommand there is no connection between the setup beams of the plan and the treatment beams. For plans with multiple isocenters, the user must be aware of the risk of using the wrong imaging beam when acquiring the images. If setup images are acquired based on the wrong imaging position, the patient displacement for the resulting registration may be unsuitable for the treatment beam. Always give the setup beam in RayStation a unique and understandable name so that the correct corresponding imaging beam is selected for image acquisition and registration before beam delivery. The same goes for any new imaging beam saved in RayCommand for the beam set. The body site for the imaging beam can be used as a redundant indication of where the setup beam isocenter is positioned.

(410108)



### 4.1.4 Registration

It is now possible to cancel an ongoing autoregistration.

### 4.1.5 Movement of components

It is now possible to move the PPS table and the nozzle elements at the same time.

### 4.1.6 Nozzle codes

Nozzle codes are read automatically from Exacure when connection is established.

### 4.1.7 Save imaging beam

It is now possible to save imaging parameters for the beam set, such that the imaging beam (different from the setup beams in the plan) can be used when acquiring images for future sessions with the beam set.

### 4.1.8 Save reordered beam

It is now possible to save a reordered beam delivery order for the beam set, such that the order (different from the one in the plan) is used for future sessions with the beam set.

### 4.1.9 Initiate beam line button

The **Initiate beam line** button is available in all modules apart from **Results** module, with the same functionality as for the one in **Delivery** module.

### 4.1.10 Edit setup margins

It is possible to edit the setup margins for a beam set, so that they are used for a registration instead of the ones specified in the plan in RayStation.

### 4.1.11 Room types

The ability to introduce multiple types of a room and swapping between them from the application menu has been introduced.

### 4.1.12 Save visualization preset

It is possible to save visualization presets for DRR, RT Image, CT and CBCT images for the beam set, such that the visualization presets (different from the generic ones specified in the configuration) can be used for registered images for future sessions with the beam set.

### 4.1.13 Session dialog handling

Some dialogs show information related to the current session.

If the session is closed from another monitor or user, these dialogs close automatically.

If information in the session changes while a dialog is open, the **OK** button becomes unavailable.

In that case, close the dialog and repeat the operation.

### 4.1.14 Protection of RayCommand files

RayCommand is now protected from unauthorized modifications of its files. The system will terminate if file integrity verification indicates any inconsistency or failure.

### 4.1.15 Helium modality plans

Helium plans can now be delivered via the RayCommand interface.

### 4.1.16 Improved path planning and motion work

Performance and stability improvement throughout the motion planning feature.

## 4.2 KNOWN ISSUES RELATED TO PATIENT SAFETY

### *Vulnerabilities when loading collision models for Motion service*

Several security vulnerabilities exist in the Assimp library which is used to load collision objects for the motion service in RayCommand and collision checking service in RayStation. These vulnerabilities can lead to an execution of an attacker's code, unauthorized update of collision models or unauthorized update of file specifying where collision models are located.

It is highly recommended to follow instructions located in the *RSL-D-RCMD-v2025SPC1-ITS MA, RayCommand v2025 SPC1 Installation Test Specification MedAustron* to limit access to folders containing collision objects and limit privileges for RayCommand service user.

(1473654)

## 4.3 OTHER KNOWN ISSUES

### 4.3.1 General

### *Room validation is passed even when the RayCommand room is improperly configured*

The room validation incorrectly passes when the RayCommand room is not properly configured, e.g. with the wrong machine model. However, it is not possible to start the session and therefore not possible to treat the patient with an erroneous room configuration.

(823886)

### *Closing session with unsaved beam set note*

If the beam set note in the Schedule module has been edited, but not saved, and the session is then closed, the edited note cannot be saved but the edited text will remain in the text box until a different session is selected in the Schedule panel.

(1043128)

### *Wrong target position representation can be shown in Room view when using two RayCommand clients*

If users in the internal and external rooms plan paths simultaneously, the target position representation will show the position of the latest selected position. This might be confusing if the user in one of the rooms is looking at the room view in *Delivery* module and the target position representation does not match the selected beam.

(825422)

### *Room view frozen after screen is unlocked*

If there is an active room view and the screen is locked, the room view may be frozen when the screen is unlocked. Switching to a different module and back will reload the room view, resolving the issue.

(1098773)

### *First continuation in continuation session not possible to remove*

If a continuation is created from the next spot or next layer for the first beam in a continuation session, the continuation cannot be removed. As a workaround, the user can either add a manual recording of one spot or directly complete the delivery without irradiating and then create a new continuation session.

(1098778)

# 5 RAYCOMMAND

*In this chapter*

This chapter contains the following sections:

## 5.1 SYSTEM OVERVIEW

The RayCommand v2025 system consists of two different applications: *RayCommand Main monitor* and *RayCommand Machine monitor*. The applications are intended to be run on one monitor each. Together they constitute a dual screen control system for the treatment control room.

Information displayed on the two monitors is meant to supplement each other. To get the best experience, the Machine monitor should be placed adjacent of the Main monitor in the control room.

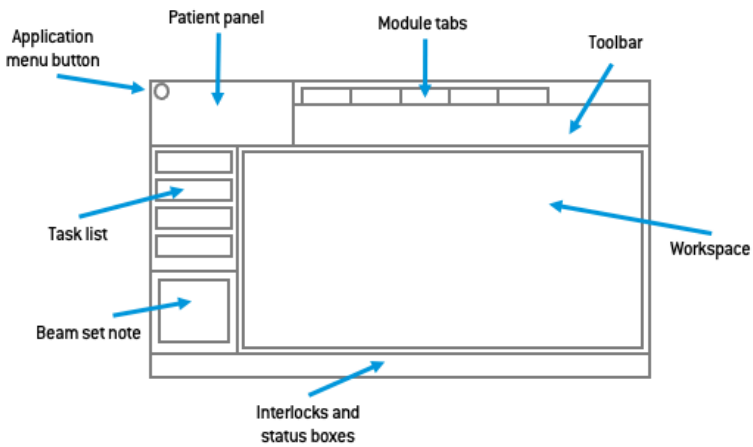
An additional RayCommand Main monitor application can also be run separately, for example inside the treatment room.

### 5.1.1 Main monitor

The Main monitor provides workflow support and provides the user with tools and information for managing and delivering a selected session.

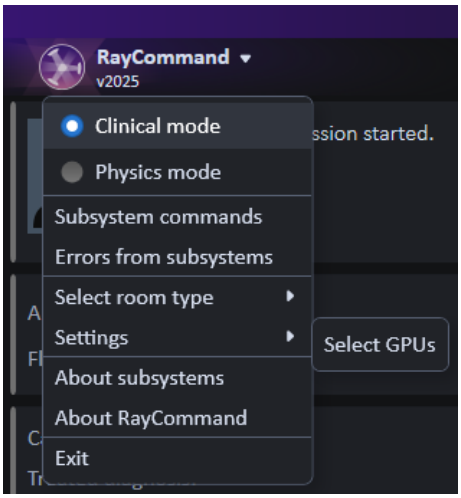
The list of tasks guides the user through the predefined activities to perform during the session. However, the user is always free to navigate to other parts of the interface.

The user interface in the Main monitor is divided into several areas:

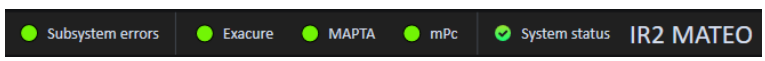



#### *Application menu*

The application menu button opens a menu with general application functionality. The application menu is opened by clicking the RayCommand icon in the upper left corner.




- **Clinical mode** – Normal treatment of patients.
- **Physics mode** – Non-clinical task, see *section 5.6 Physics mode on page 85*.
- **Machine QA tests** – Used to perform machine QA tests. Only available in Physics mode. See *section 5.6.1 Machine QA tests on page 87*.
- **Subsystem commands** – Commands that the user can trigger without having to be in a specific state.
- **Errors from subsystems** – Shows errors received from external subsystems, for example beam delivery system and patient positioning system.
- **Select room type** – For a treatment room where multiple types exist, click **Select room type** and then select room type from the drop-down menu. Each room type can have a specific collection of unique characteristics defined, such as specific in-room components or path planning characteristics.
  - For rooms where multiple types are specified, a red banner will appear the first time the application is started informing the user to select the current room type.
  - The name of the current room type will always appear at the bottom right of the application window.




- **Settings/Select GPUs**– Shows a dialog with an option to configure the graphics card used for GPU calculations.
- **Show Continue session summary dialog** (only visible for sessions restarted after a severe error) – Shows the continue session summary, where the user must confirm the state before continuing a session (see *Severe error on page 75*).

- **About subsystems** – Shows information collected from external subsystems (for example configuration version), and in some cases include the possibility to update the configuration version.
- **About RayCommand** – Shows version and regulatory information.

To update the subsystem configuration, the user must be part of the active directory group 'RayCommand-Administration'.

### *Patient panel*

The **Patient** panel shows information about the patient for the current session.

### *Module tabs*

The RayCommand application is divided into different parts called *modules*, which represent well-defined treatment activities. A module is accessed by clicking its module tab. The module tabs are placed sequentially from left to right, according to a typical treatment delivery workflow.

The treatment activities are:

- **Schedule**
- **Preparation**
- **Imaging**
- **Delivery**
- **Results**

### *Toolbar*

The toolbar contains tools and information related to the session and the selected module. Some content in the toolbar is available in several modules.

### *Delivery information*

During irradiation the progress of the beam delivery (current layer of total layers) is displayed.

### *Session information*

The session information shows information about the current session, the plan and beam set to be delivered, and the modality of the treatment.

### *Task list*

The task list guides the user through the tasks that have been assigned to the patient for the current session. Tasks are defined in RayCare as a part of the patient's care plan.

The task list panel is available in all modules apart from the Schedule module as soon as a session has been started.

Click on a task in the task list to open the **Task properties** dialog. Here the task can be set to completed.

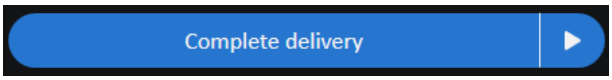
### *Beam set delivery note*

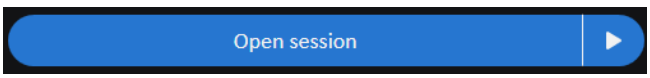
This note is assigned to the beam set in RayCare and the note is retrieved from RayCare.

### *Workflow button*

Click on the **Workflow** button to complete the main activity in the current module.

- Click on the button to complete the activity without moving to the next module.
- Click on the arrow to complete the activity and navigate to the next module.




### *Workspace area*

The workspace area displays information and functionality that is specific for the selected module.

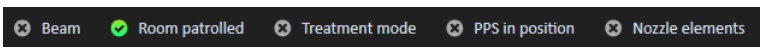
### *Interlock and system status*

Along the bottom of the Main monitor, interlock and system status is displayed. This information allows the user to get a quick overview of the current state. Tooltips about subsystems show detailed status.

Clicking on **System status** opens up a detailed view of individual service health status, and detailed error information if system health is degraded.

Clicking on **Subsystem errors** opens a view of any errors in subsystems. If there are active errors to monitor, the status color is red.

In the status bar, system information is also shown for actions that take several seconds to complete (such as autoregistration or reading nozzle codes).





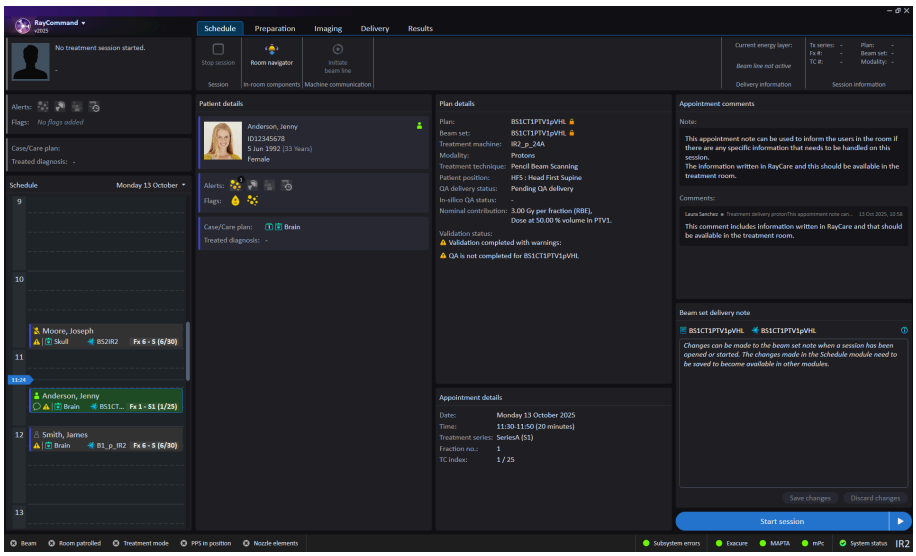
## 5.1.2 Machine monitor

The Machine monitor application complements the Main monitor with real time information from inside the treatment room and from the different devices included.

The main purpose of the Machine monitor application is to monitor the treatment devices. The interface is fixed, and all content is in the same place all the time. This provides users with current information and situational awareness.

## 5.2 MAIN MONITOR MODULES AND WORKFLOW

### 5.2.1 Schedule module

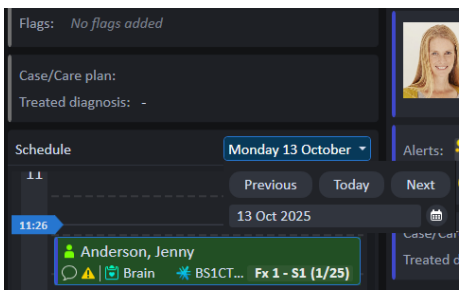



#### *Schedule panel*

The **Schedule** panel lists the appointments made for a treatment room on the selected date. Appointments are scheduled in RayCare.

An appointment is associated with a patient and a treatment session. By default, the panel shows today's appointments; however, it is possible to change the date to see sessions scheduled in the past or in the future.

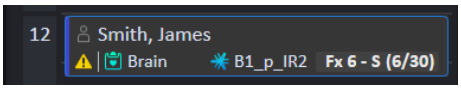
Select an appointment in the **Schedule** panel to get an overview of the patient and the associated treatment session in the **Patient details** panel.




***Note:*** *The patient information shown in the Patient details panel is not necessarily the patient information for the patient in the currently active treatment session. The current patient is always displayed in the Patient panel (to the upper left in the user interface).*

### *Appointments*

Treatment appointments are listed to the left in the **Schedule** workspace. Each appointment is summarized in a treatment appointment tile.




The treatment appointment tile contains the following information:

- Scheduled start time for the treatment appointment
- Estimated duration of the appointment
- Patient check-in status
- Session validation status
- Patient name
- Fraction number and the treatment course index out of total number of fractions. Indicated by a grey background.

The patient check-in status can have the following states:

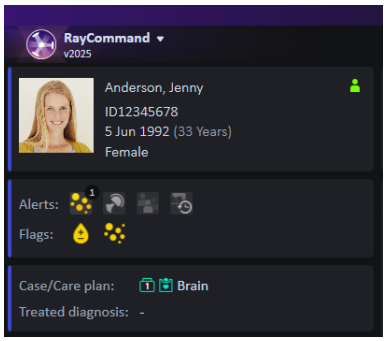
| Patient status | Description |
|---|---|
|  | Patient has not been checked in from RayCare |
|  | Patient has been checked in from RayCare |

The following session statuses exist:

| Session status | Description |
|---|---|
|   | Session has started and is in progress. |
|   | Session has been fully delivered. |
|   | Session is validated with a warning and needs an override before it can be started, or session has been partially delivered or over-delivered. |
|   | Session is validated with an error and cannot be started. |

The selected appointment is indicated with a blue frame. Information about the patient in the selected appointment is displayed in the **Patient details** panel.

The patient in the started session is displayed in the panel in the upper left corner.




***Note:*** *It is possible to deliver a plan in all rooms in which the appointed machine model is possible to use for delivering a plan.*

## *Patient details panel*

The **Patient details** panel displays information about the patient in the selected appointment.

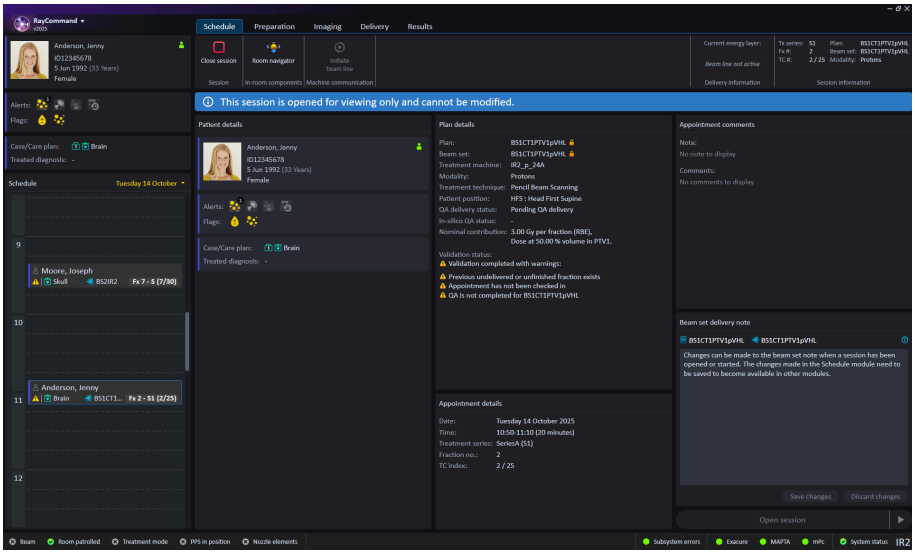
## *Beam set delivery note*

Changes can be made to the beam set note when a session has been opened or started. The changes made in the **Schedule** module need to be saved to become available in other modules.

## *The **Open session** button*

It is possible to open a session in Read Only mode if the session is scheduled for a different date than today, if the patient has not been checked in, or if the treatment has been delivered.

Click the **Open session** button to view the treatment session selected in the appointment schedule, without navigating to the next module.




## *The **Start session** button*

Click the **Start session** button to start the treatment session selected in the appointment schedule, without navigating to the next module.

Click on the arrow to start the selected treatment session and navigate to the next module (**Preparation**).

## *The **Continue session** button*

A session that has terminated due to a severe error can be started again to continue the ongoing session. The user must decide how to proceed and what steps must be taken regarding the imaging and registration, and if relevant also regarding delivered dose. For more information, see *Severe error on page 75*.

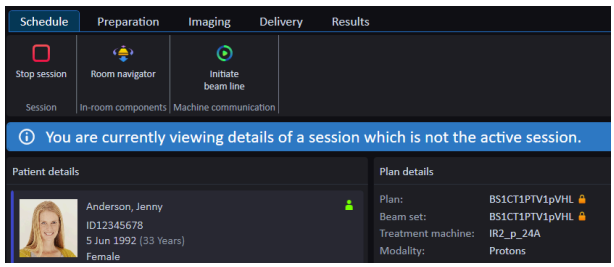
## *Workflow*

For a treatment session to start, the patient must be checked in from RayCare and there must be no beam set validation errors.

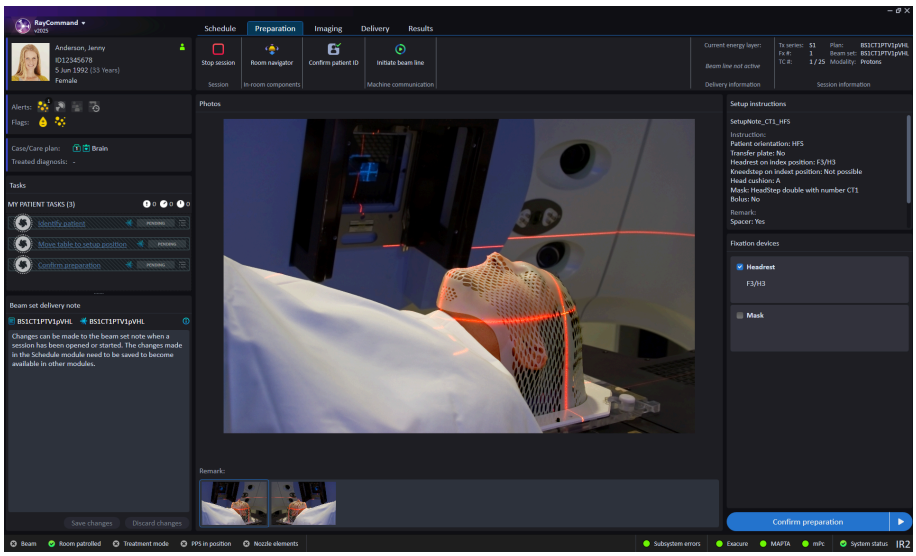
Validation errors and warnings are shown in the **Schedule** module. If the beam set has validation warnings, it is still possible to start the treatment session but the warnings must be overridden.

To start a session, select the appointment tile in the schedule and click the **Start session** button.

***Note:*** *A message will be displayed if another session than the active session is selected.*




## 5.2.2 Preparation module




### *Setup note panel*

The **Setup note** panel displays the setup notes created during setup in RayCare.

**WARNING!**

**Ensure using correct aperture block.** When a treatment plan requires the use of an aperture block, the user must ensure that the correct block is used and mounted correctly.

RayCommand does not store information about whether the aperture block is in place or is correctly positioned.

The clinic is advised to record the aperture block information during planning, either as a beam set note in RayStation or a setup instruction in RayCare.

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### *Fixation devices panel*

The **Fixation devices** panel displays a checklist of all devices to be used for patient positioning, defined during setup in RayCare. When a fixation device has been applied, the corresponding checkbox must be selected. If all checkboxes are not selected the user must save a statement of why all fixation devices are not used.

### *Photos panel*

The **Photos** panel displays the photos taken in RayCare during setup of the patient. If several photos are available, they are listed as thumbnails horizontally at the bottom. Select a thumbnail to display the photo in the panel.

### *Confirm preparation button*

Click the **Confirm preparation** button to confirm that the patient setup has been performed as instructed. If all listed fixation devices have not been checked, a reason for this must be provided and signed before preparation can be confirmed.

Clicking the button will confirm the setup without navigating to the next module. Clicking on the arrow will confirm the patient setup and navigate to the next module (**Imaging**).

### *Confirm patient ID*

Click the **Confirm patient ID** button after verifying that the identity of the patient in the room matches the patient for which the session is started. The patient ID must have been confirmed before setup images can be acquired.

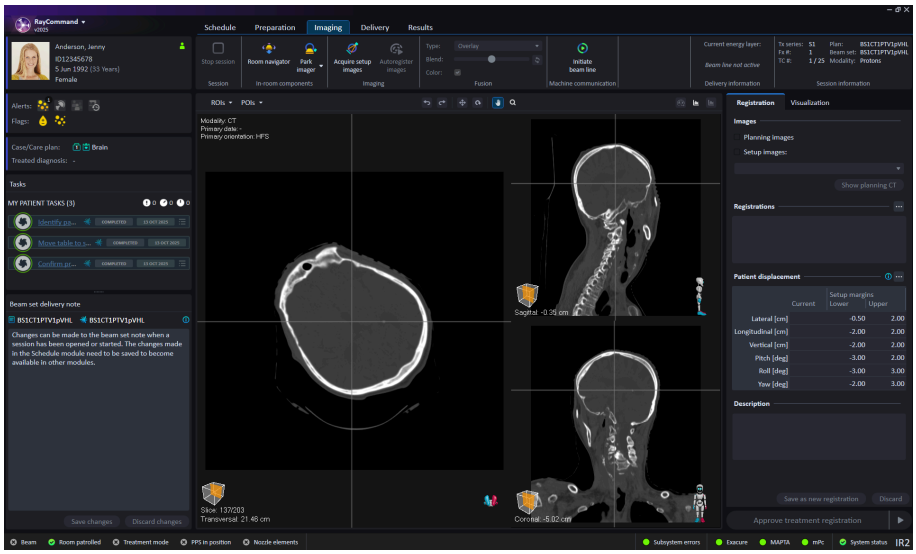
### *Workflow*

1. Verify the identity of the patient and then click the **Confirm patient ID** button.
2. Click the **Room navigator** button to open the **Room navigator** dialog.
3. Select the pre-defined target position for patient setup.
4. Click the buttons on the control console to execute the move of the patient positioner to the selected target position.
5. Apply the listed fixation devices. Verify the application of each device by selecting the corresponding checkbox.
6. Position the patient according to the photos and the setup instructions in the setup note.
7. Click the **Confirm preparation** button to confirm that the patient setup is correct.

### 5.2.3 Imaging module

In the **Imaging** module it is possible to acquire setup images for registration of the patient position.

It is possible to stop a session up until the setup images are acquired. Acquiring the images will deliver dose to the patient and each delivery should be stored in PACS.




#### *Algorithms for automatic image registration*

RayCommand offers a choice of two algorithms for automatic image registration. The choice of algorithm for the clinic will depend on the available imaging equipment, treatment intent and anatomical site.

- 2D/3D algorithm:
  - This algorithm is intended for registration of planar X-ray images with the planning CT image.

    The advantages of 2D imaging include delivering a lower dose compared with 3D and being faster to acquire. 2D images have less issues with metal artefacts and have smaller file sizes for storage and archiving.
- 3D/3D algorithm:
  - This algorithm is intended for registration of CBCT images with planning CT images.

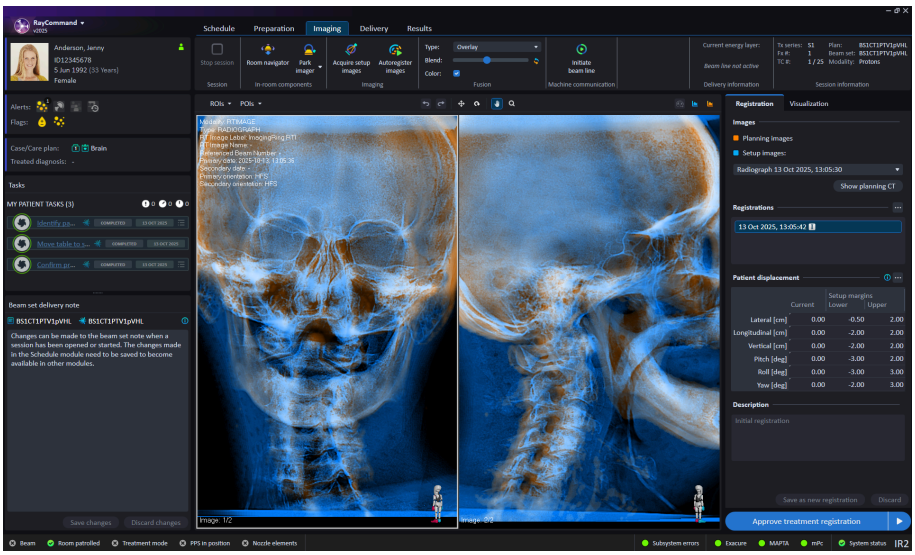
    The advantages of 3D imaging include superior visualization of soft tissues and access to volumetric information.

#### *Image area*

By default, the image area displays the planning CT image from the plan.

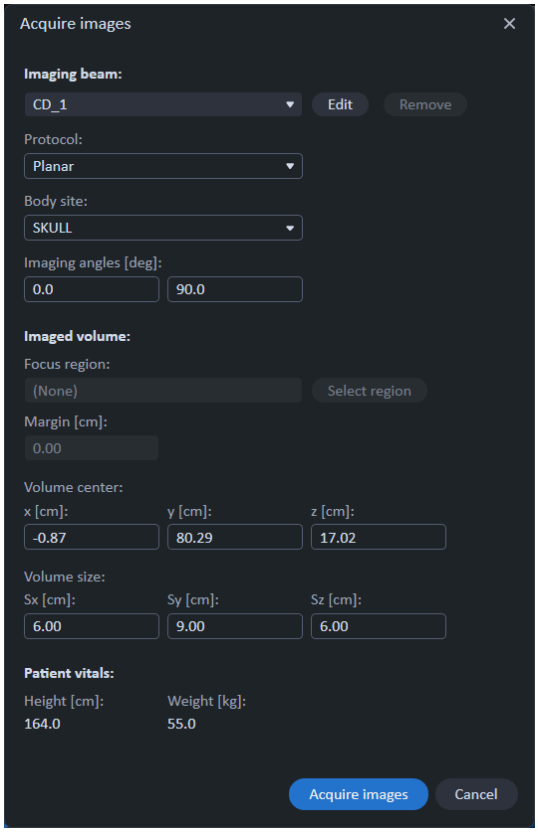
When setup images have been acquired, and the initial registration is performed, the fusion between the planning images and the setup images using the selected registration is displayed in the views. To switch between the views the N (next) and P (previous) keys can be used.

To display the planning CT images again, click the **Show planning CT** button in the **Registration** tab. To show a registration, select a registration in the **Registrations** list.




## *Acquire image workflow*

When clicking the **Acquire setup images** button, the **Acquire images** dialog is opened.



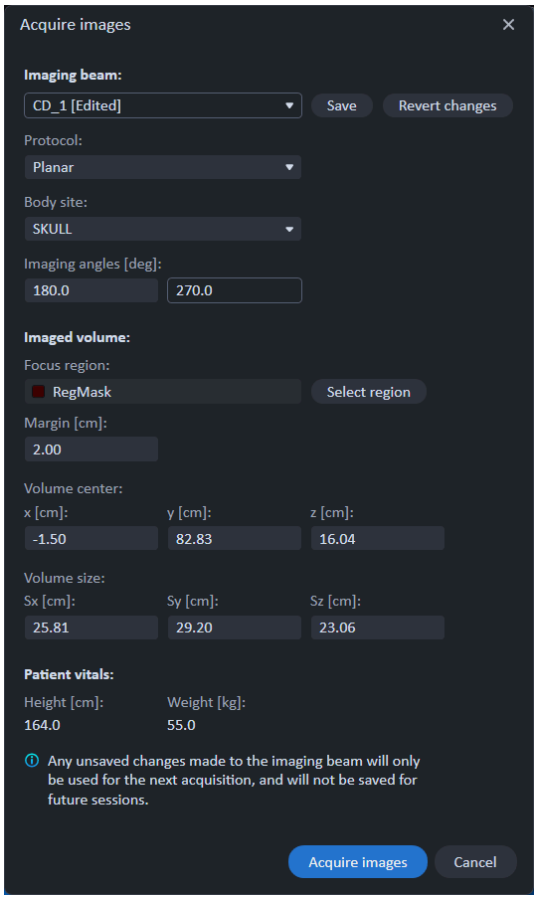

Under **Imaging beam**, the settings for the selected setup image are shown, including information about the imaging procotol (determining whether X-ray or CBCT image will be acquired), the field-of-view (imaged volume center and size) and the body site selected in RayStation for the setup image.

It is possible to modify the imaging angles, the field-of-view, the imaging protocol and the body site before acquiring images. The edited imaging parameters can be saved by clicking the **Save** button and entering a unique name for it, which will make it available for future sessions for the beam set. Note that unless saved, the edited changes will only affect the next image acquisition; the changes will not be propagated to subsequent sessions.

To edit the imaging parameters for an existing imaging beam:

1. In the **Imaging beam** drop-down list in the **Acquire images** dialog, select the imaging beam to edit.

2. Click **Edit**. The imaging parameters in the dialog can now be edited.




3. Edit the imaging parameters as desired.
4. (Optional) To calculate the imaged volume based on an ROI defined in the structure set, click **Select region** and select the **Focus region**. The imaged volume center is updated to the center of the selected ROI, and the imaged volume size is updated to the size of the bounding box surrounding the selected ROI. A uniform margin can be added to the calculated bounding box by entering a value in **Margin**.
5. (Optional) Click **Save**.
6. Enter a unique name of the new imaging beam for the saved imaging parameters. Click **Save**.

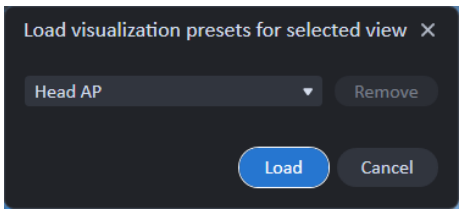
***Note:*** *RayCommand does not show a visual representation of the imaging parameters. Extra caution must be taken to ensure that the updated parameters will result in a suitable setup image.*

Under **Patient vitals** the patient height and weight to be sent to the imaging system are shown. These values are retrieved from the latest height and weight measurements available in RayCare. If the values do not exist, or if a connection to RayCare could not be established, the dialog will prompt the user for manual input.

***Note:*** *Height and weight are retrieved from RayCare when the Acquire image button is clicked. If modifications to height and/or weight are done in RayCare while the Acquire image dialog is still open, these changes will not be reflected. Hence, if any vitals need to be updated before acquiring the image, new measurements must be entered in RayCare and the Acquire image dialog closed and re-opened.*

## *Adjusting image quality*

To be able to compare the planning CT images and the daily setup images when performing the registration, the visualization settings may need to be adjusted. This is done from the Visualization tab to the right, where both the setup and planning image quality can be adjusted. For ease-of-use, it is possible to create generic presets for the images acquired at the clinic, as well as specific ones for a beam set, to be used in future sessions with the beam set. The visualization presets are saved in pairs, such that the presets for the primary and secondary images have the same name and are saved and applied together. Any saved visualization preset for a beam set can be removed. For the generic presets, it is recommended to create different presets for different body sites.




To improve the visibility of bone structures, a bone enhancement attenuation factor can be adjusted in the DRR settings to further highlight the higher density. It is also possible to improve the visibility of markers, by highlighting densities above a specific HU threshold. This is done by loading a preset where *UseMarker* is set to *true* and *MarkerThreshold* is set to a specific HU threshold value.

## *Flip fusion pattern*

To flip the fusion pattern, do one of the following:

- Click the **Flip pattern** button in the tool panel.
- Press the Space key when the image view is in focus.

For the fusion type **Overlay**, flipping the pattern will invert the fusion slider.

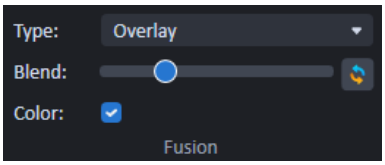



**Figure 2.** The **Flip pattern** button is found on the right side of the fusion slider.

## *Image settings*

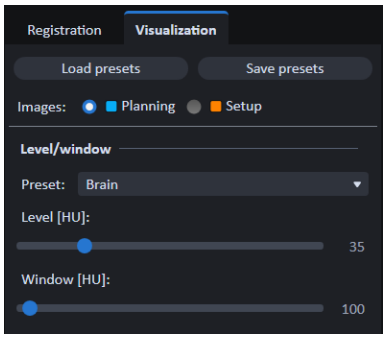
### Image settings CBCT

Available planning CT settings:

- Level/Window presets
- Level/Window

Available CBCT settings:

- Level/Window presets
- Level/Window

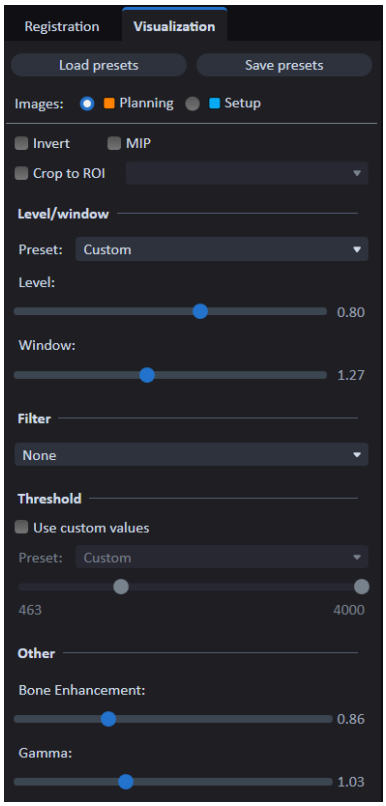



### Image settings X-ray

Available DRR settings:

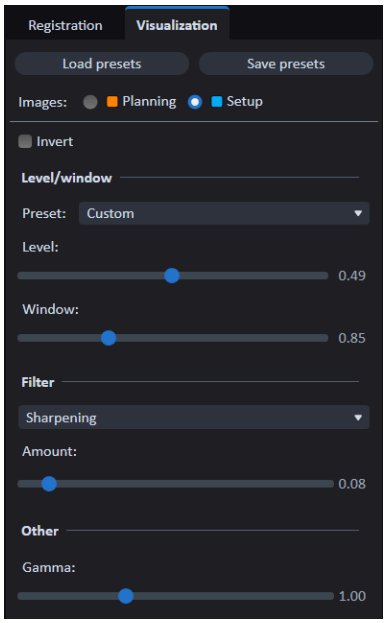
- Invert
- MIP
- Crop to ROI
- Level/Window preset
- Level
- Window
- Filter
  - Edge detection
  - Sharpening
- Use custom values
- Threshold presets
- Threshold
- Bone Enhancement

- Gamma




Available RT image settings:

- Invert
- Level/Window preset
- Level
- Window
- Filter
  - Edge detection
  - Sharpening
- Gamma


Registration
Visualization
Load presets
Save presets
Images:
Planning
Setup
Invert
Level/window
Preset:
Custom
Level:
0.49
Window:
0.85
Filter
Sharpening
Amount:
0.08
Other
Gamma:
1.00

### Invert

This setting inverts the DRR or RT image to display dark bones on a bright background, aligning it with the DRR settings in RayStation. This is the opposite of the **Invert** in previous versions of RayCommand.

This invert setting is disabled by default.

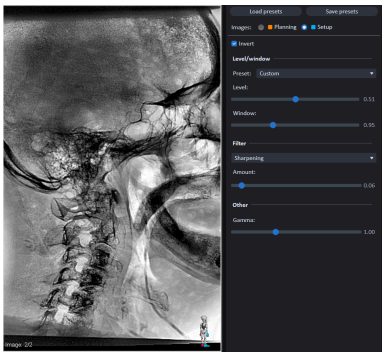



**Figure 3.** Inverted RT image: Dark bones on bright background.

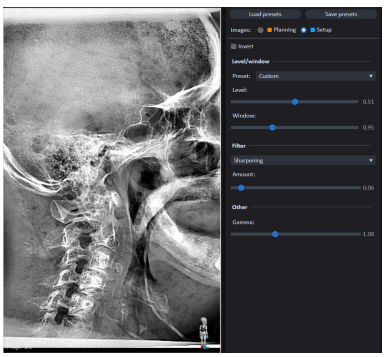
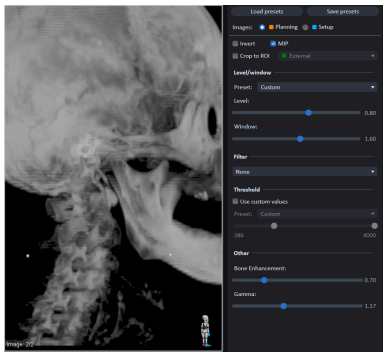



**Figure 4.** Non-inverted RT image: Bright bones on dark background.

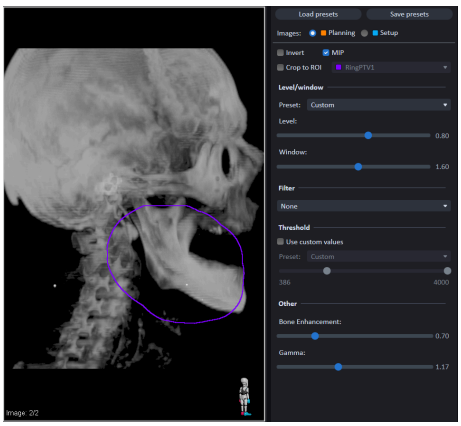
### MIP

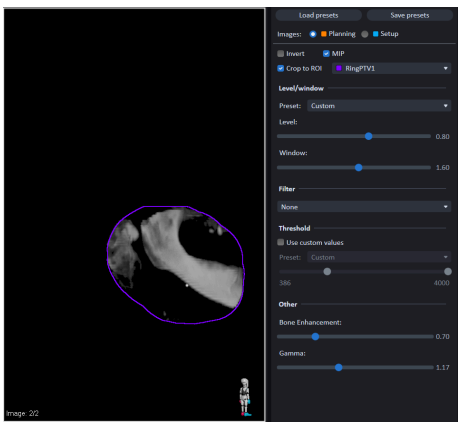
The MIP option can be enabled to display a maximum intensity projection of the CT image.



## Crop to ROI

It is possible to crop to the Region of Interest (ROI) that is selected from the drop-down list. This feature allows focusing on and enhancing specific areas of the image by cropping out unnecessary parts, thereby improving the clarity and relevance of the displayed region.



### Level/Window

The level/window functionality is used to adjust the contrast and brightness of the DRR or RT image, and operates on pixel values in the 0-1 range.

Preset level/window values are available in the drop-down menu, and the level/window can also be adjusted with a slider or with the level/window tool. Moving the level/window tool horizontally while pressing the left mouse button adjusts the contrast, whereas moving the tool vertically adjusts the brightness.

Level/window is applied after thresholding and bone enhancement.

### Edge detection

The edge detection filter calculates the pixel intensity gradients with central differences and displays the gradient magnitude as an image, where brighter regions correspond to stronger gradients (i.e., edges).

The brightness of the resulting image can be scaled with the amount slider to make edges more visible, where 0 is minimal brightness and 1 maximal brightness.

Edge detection is applied after the gamma filter.

**Figure 5.** A pelvic DRR image without edge detection.

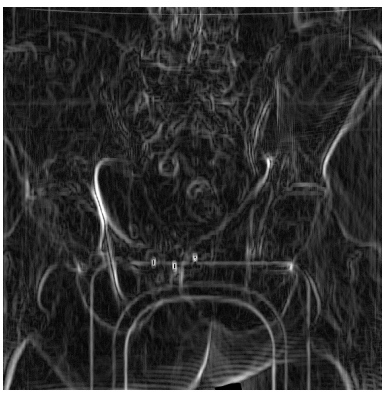


**Figure 6.** The same pelvic DRR as above, with edge detection enabled (amount set to 0.4).

### Sharpening

The sharpening filter uses the unsharp masking algorithm to sharpen edges in the image.

The strength of the filter can be adjusted with the amount slider, where 0 means that no sharpening is applied and 1 is maximal sharpening. Figure drr_sharpening_disabled.png shows a pelvic DRR without sharpening, whereas Figure drr_sharpening_enabled.png shows the same DRR image with sharpening enabled and sharpening amount set to 0.4.

Sharpening is applied after the gamma filter.

**Figure 7.** A pelvic DRR image without sharpening.

**Figure 8.** The same DRR image as above, with sharpening enabled (amount set to 0.4).

### Marker highlighting

It is possible to improve the visibility of markers by highlighting voxels above a specific HU value. This can be configured by loading a preset where *UseMarker* is set to *true* and *MarkerThreshold* is set to a specific HU threshold, typically >2000 HU. The voxels with a HU value above *MarkerThreshold* will be highlighted. See *Appendix D RT image and DRR settings* for instructions on creating and loading presets.

By default, marker highlighting is enabled and highlights voxels with HU values above 2750 HU.

Marker highlighting is available for DRR only.

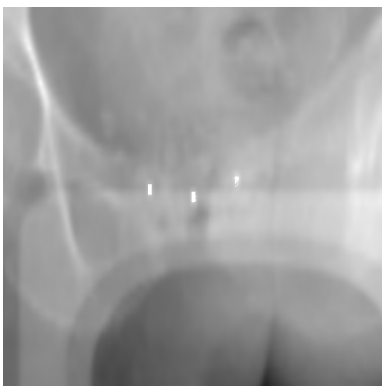


**Figure 9.** A DRR image with marker highlighting enabled.

**Figure 10.** The same DRR image as above, with marker highlighting disabled.

### Threshold

Thresholding can be applied on the DRR, to only display CT voxels within a specified Hounsfield unit (HU) range.

Preset threshold values are available in the drop-down menu for soft tissue, soft bone, and hard bone, and the upper and lower thresholds can also be adjusted with a slider. When using thresholding it is recommended to first set the level/window function to the **Default** preset; that is, the identity level/window 0.5/1.0.

Thresholding is available for DRR only.

**Figure 11.** Thresholding for soft tissue, soft bone and hard bone.

### Bone enhancement

It is possible to adjust the bone enhancement factor to increase or decrease the contrast between bone and other tissue types in a DRR image.

The bone enhancement factor has the range 0-3 and is used to scale the linear attenuation values that are derived from voxel HU values during DRR generation. This affects how much of the (simulated) incoming X-ray beam intensity that is absorbed by a particular tissue type. The default value of the bone enhancement factor is 1, which corresponds to applying no bone enhancement on the DRR.

The figures below demonstrate the impact of applying bone enhancement factor (BEF) to an anterior DRR image, where the contrast between bone and surrounding tissue is low due to occlusion by fat and soft tissue. By increasing the BEF from 1 to 3.0, the visibility of bone structures is significantly improved.

Bone enhancement is applied before level/window and is available for DRR only.

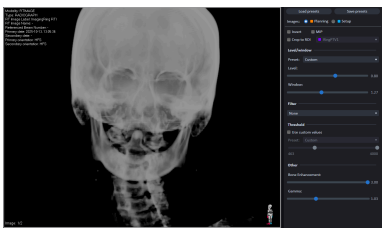


**Figure 12.** Anterior DRR image, with bone enhancement (BEF = 3.0).

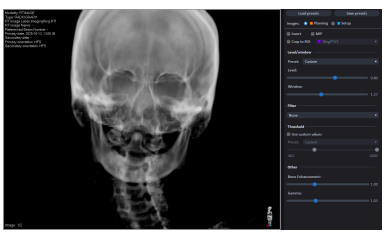


**Figure 13.** Anterior DRR image, without bone enhancement (BEF = 1.0).

### Gamma

The gamma filter is a non-linear contrast enhancement filter that applies a power-law (gamma) transformation $I'(x, y) = I(x, y)^{\gamma}$ on the pixel intensity values $I(x, y)$. The gamma parameter $\gamma$ can be adjusted with a slider and has the range 0-3, where 1 is the default value and corresponds to applying no contrast enhancement. Typically, $\gamma$ should be set to a value between 0.5 and 1 to increase the contrast of bone.

The gamma filter is applied after Level/Window.

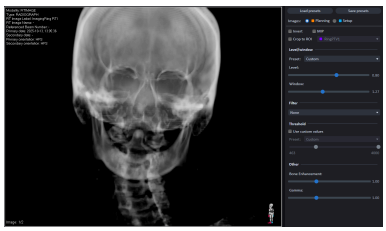


**Figure 14.** An anterior DRR image, without gamma correction $(\gamma = 1)$.

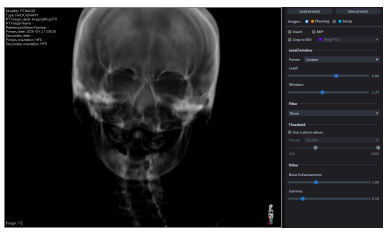


**Figure 15.** The same DRR image as above, with $\gamma$ set to 0.5.

### Enhance local contrast (CLAHE)

It is possible to improve the visibility of the RT images by applying a CLAHE filter. The CLAHE filter will enhance the local contrast in the image to visualize detailed information/structures within the RT images, improving the data used for verifying that the registration is correct.

The CLAHE filter can be disabled/enabled in the Main monitor configuration file (see *section D.1 Disable/enable CLAHE filter on page 121*).

**Figure 16.** A pelvic RT image before CLAHE filter is applied.

**Figure 17.** The same RT image as above, with CLAHE filter applied.

### *Registration panel*

The **Registration** panel manages images and registrations for the current session.

If the daily setup image is an X-ray image, the X-ray series will be the primary series (displayed in blue) when performing registration, and the planning CT (such as DRR) will be the secondary (displayed in orange). When the daily setup image is a CBCT image, the CBCT series will be the secondary series (orange) and the planning CT will be primary (blue).

It is possible to select to show the ROIs and POIs for the plan, to make it easier to register the DRR against the daily setup image.

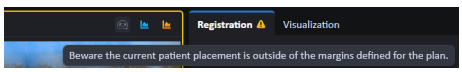
The correction vector will be shown in the section **Patient displacement**, together with the setup margins. The setup margins are initially specified for a beam set in RayStation. By accessing the context menu in the patient displacement region, the setup margins can be edited and saved for the beam set and used for future sessions instead of the ones from RayStation. The same saved setup margins will also be shown for any delivered session opened in read-only mode. The correction vector is defined relative to the specified rotation point, which is by default taken as the center-of-mass of the primary prescription ROI.

The registration can be modified by first clicking the rotation or translation tool icon in the top right corner, and then clicking and dragging using the left mouse button in the registration view.

It is also possible to move and rotate the registration with a fixed step size, one direction at a time, using the arrow keys with the corresponding tool. The same operation can be done using a smaller step size, by holding down the Shift key while using the arrow keys (see also the table below).

It is possible to lock the translation and rotation to a fixed axis: Lateral, longitudinal and vertical axis. These axes are defined both relative to the treatment room and to the patient (see Figure 18 and Figure 19). The keyboard shortcuts for each axis are shown in the table below.

If the patient displacement exceeds the configured tolerance, a yellow border will appear around the images and a warning icon will be shown in the **Registration** tab header, with associated tooltip.



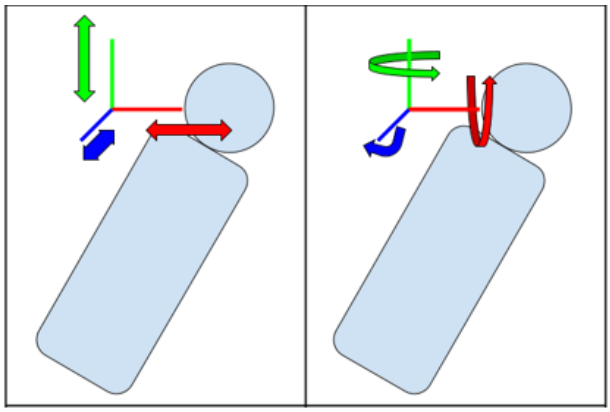


**Figure 18.** Translation and rotation axes as defined by the treatment room. Axes are longitudinal (green), lateral (red) and vertical (blue).

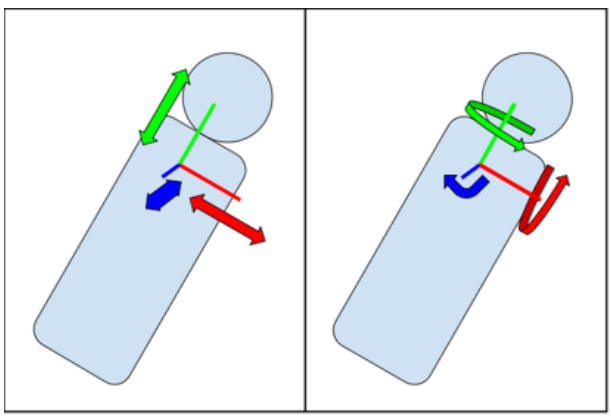


**Figure 19.** Translation and rotation axes as defined by the patient. Axes are longitudinal (green), lateral (red) and vertical (blue).

**Registration keyboard shortcuts:**

| Description | Keyboard shortcut key |
|---|---|
| Lock translation/rotation to lateral axis (relative to treatment room) | Q |
| Lock translation/rotation to longitudinal axis (relative to treatment room) | W |
| Lock translation/rotation to vertical axis (relative to treatment room) | E |
| Lock translation/rotation to lateral axis (relative to patient) | A |

| Description | Keyboard shortcut key |
|---|---|
| Lock translation/rotation to longitudinal axis (relative to patient) | S |
| Lock translation/rotation to vertical axis (relative to patient) | D |
| Rotation registration tool | R |
| Translation registration tool | T |
| Transform image with fixed step size | Arrow keys |
| Transform image with smaller fixed step size | Shift + Arrow keys |
| Undo last transformation | Ctrl+Z |
| Redo last transformation | Ctrl+Y |
| Zoom tool | Ctrl |
| Pan tool | Shift |
| Move fusion pattern tool | Alt |
| Flip fusion pattern | Space |
| Next image | N |
| Previous image | P |

### *Undo and redo registration transformations*

To undo transformations to the registration, do one of the following:

- Click the **Undo** button in the tool panel.
- Press Ctrl+Z.

To redo registration transformations that were undone, do one of the following:

- Click the **Redo** button in the tool panel.
- Press Ctrl+Y.

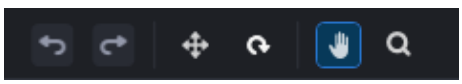


**Figure 20.** The **Undo** and **Redo** buttons are found to the left of the tool panel.

**WARNING!**

**Review automatic registration.** Always ensure that the automatic registration between the setup images and the planning CT is acceptable by manually reviewing the result.

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## *Acquire new images*

It is possible to acquire several images and save several different registrations.

It is only possible to approve one registration at a time. Before a new registration can be approved, the previously approved registration must be unapproved. However, it is possible to acquire a new image and save a registration.

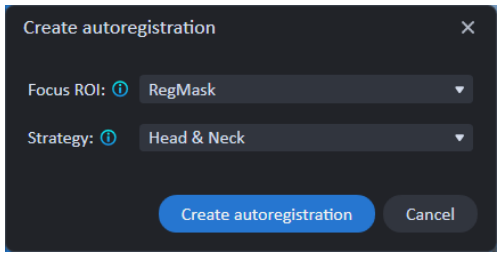
All saved registrations can be seen when opening an already delivered session.

## *Workflow (MedAustron)*

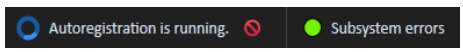
1. Click the **Room navigator** button to open the **Room navigator** dialog.
2. Select a pre-defined target position for imaging.
3. Use the control console to execute the move of the patient positioner to the selected target position.
4. Click the **Acquire setup image** button to request an image acquisition from the MedPhoton Controls system. If imaging beams are available with an imaging device selected and an imaged volume defined, a protocol for the image acquisition can be selected from the list of imaging beams. The angle offsets defined in the protocol are applied to the gantry angle of the imaging beam to calculate the imaging angles, and the imaging volume corresponds to the volume of interest in the MedPhoton Controls system.
5. Perform imaging acquisition in the MedPhoton application. The registration is performed automatically.
6. (Optional) Select ROIs or POIs to be shown, to facilitate the registration.
7. If needed, manually adjust the registration by using the registration tools available in the image area.
8. Add a description for the registration and confirm saving.
9. Save the modified registration by clicking the **Save as new registration** button.
10. (Optional) Click the **Autoregister images** button. The **Create autoregistration** dialog is opened where the user can select the **Focus ROI** (determining the focus region for the registration).

When performing registration with X-ray images, the registration **Strategy** (**Head & Neck** or **Pelvis/Thorax**) can be selected. The strategy determines which algorithm should be used, and is set to **Pelvis/Thorax** for pelvis/thorax cases and to **Head & Neck** for head/neck cases.

For CBCT registration, only the **Focus ROI** option is available.

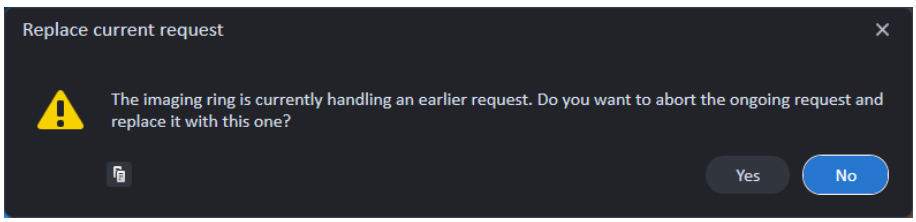



11. Click **Create autoregistration**. The status bar in the Main monitor shows that an autoregistration is being performed. From here it is also possible to cancel the ongoing autoregistration, if it was started in error or it takes too long to complete.

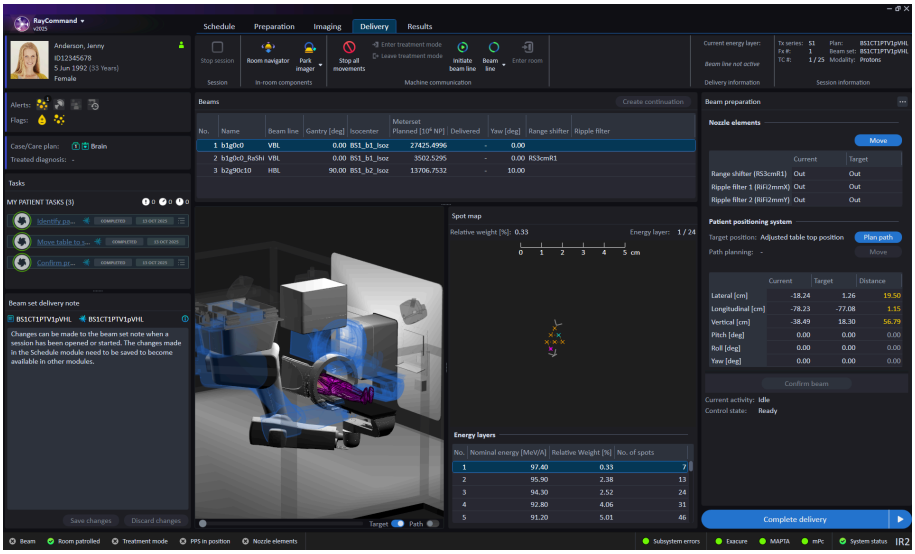



12. Move imager to a parking position that is not colliding with the treatment position ('Park Imager').
13. Click the **Approve treatment registration** button to approve the registration for treatment.

***Note:*** *If the user requests to acquire an image, to move the imager or to register an image during an already ongoing request, a dialog will inform the user about the ongoing request. It is recommended to wait for the request to finalize or to cancel the request in the medPhoton console.*



## 5.2.4 Delivery module




### *Beams panel*

The **Beams** panel displays a list of beams for the plan.

The fields represent the planned values of the beam, with the exception of **Delivered Meterset (%)** and **Status**. When a beam has been successfully delivered, it is marked with a green checkmark in the beam list. When a beam has been partially or overdelivered, it is marked with a warning symbol in the beam list.

The spot map shows the positions of the specified spots in the energy layer selected in the **Energy layers** table.

***Note:*** *In RayStation, the Beam meterset value displayed in the beam list and in the Plan report originates from the optimization or is set manually by the user.*

*In RayCommand, the displayed value for Meterset planned in the beam list is taken from the Specified Primary Meterset (3008,0032) of the beam record, which is the sum of all specified metersets for the control points in the beam. The specified meterset for each control point is calculated by summing all Scan Spot Meterset Weights (300A,0396), for all control points (energy layers) in the beam.*

*As a result, a minor discrepancy may be noted between the meterset displayed in RayStation compared to the meterset displayed in RayCommand.*

### *Beam preparation panel*

The **Beam preparation** panel displays the status for the beam currently selected in the **Beams** panel, and the devices that have been prepared for delivery of this beam.

The **Gantry** and **Snout** boxes are only shown in a room that has a gantry and a movable snout.

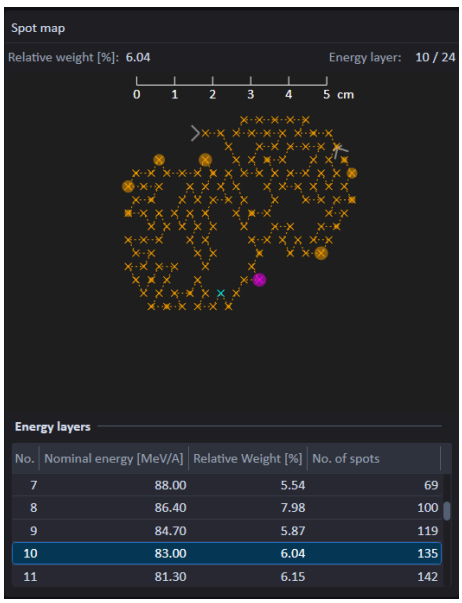
## *Room view panel*

The **Room view** panel displays the in-room components and their positions in the room. When a session is started, the room view also shows the ROIs that are defined as collision structures, i.e., structures accounted for in the collision check.

The blue target position representation shows the next beam's position. If the target position is not shown, click on the **Target** radio button below the room view or double-click on a beam to show the position.

## *Spot map panel*

The **Spot map** panel displays spot positions for the selected energy layer. The current layer is marked with a blue box. The heaviest and lightest spots per layer are colored with purple and blue. The direction of the spot delivery order is indicated with entrance and exit spot.




## *Complete delivery button*

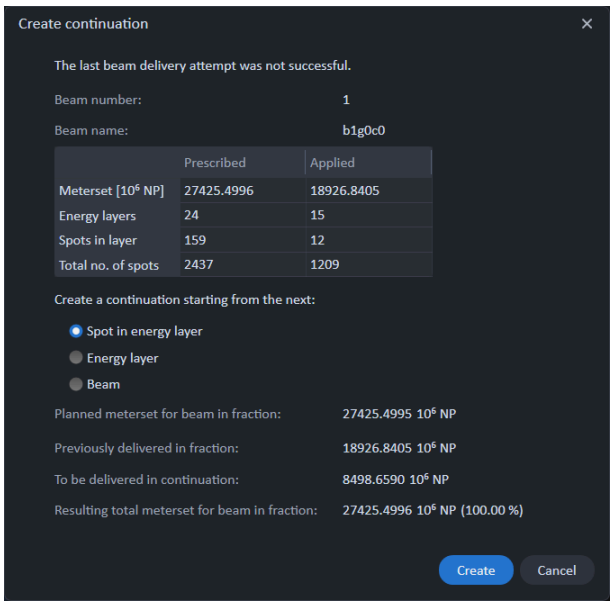
Click the **Complete delivery** button to complete the delivery and set the status for the treatment session to **Delivered** or **Partially delivered** without navigating to the next module. Click on the arrow to complete delivery and navigate to the next module (**Results**). It is possible to undo the **Complete delivery** action by accessing the context menu in the header of the **Beam preparation** panel.

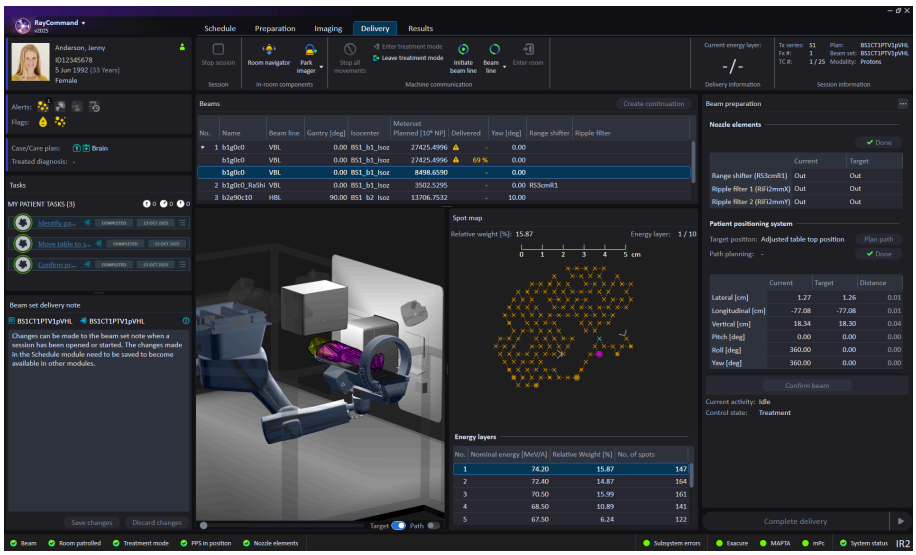
## *Continuation sessions*

If a beam has been interrupted it is possible to continue the delivery, either in the current session or as a new session.

The continuation session can be planned to continue either from the next spot, from the next energy layer or from the next beam in the plan.

If the delivery can be continued within the current session, a continuation session is created by clicking on the **Create continuation** button above the beam list. The beamline then needs to be re-initiated, and the continuation can be started.



If the continuation of the delivery will be done in a new session, the user must first leave treatment mode and complete the delivery, then sign the session in the **Results** module. The checkmark indicates that the rest of the beam must be planned in a new session.

When the session has been scheduled in RayCare and later starts in RayCommand again, the user must select how to create the continuation session by clicking on the **Create continuation** button above the beam list. The **Create continuation** dialog contains information about how much dose that should be delivered, has been delivered and is left to deliver.

The spot map for the partially delivered beam is not shown until the continuation has been created.

### Remove continuation

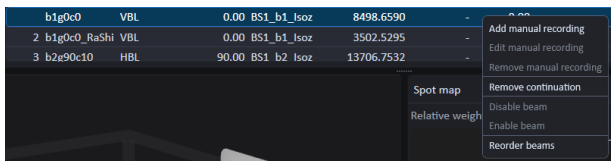
A created continuation that has not been delivered can be removed.

To remove the continuation, right-click on the beam and select **Remove continuation**.

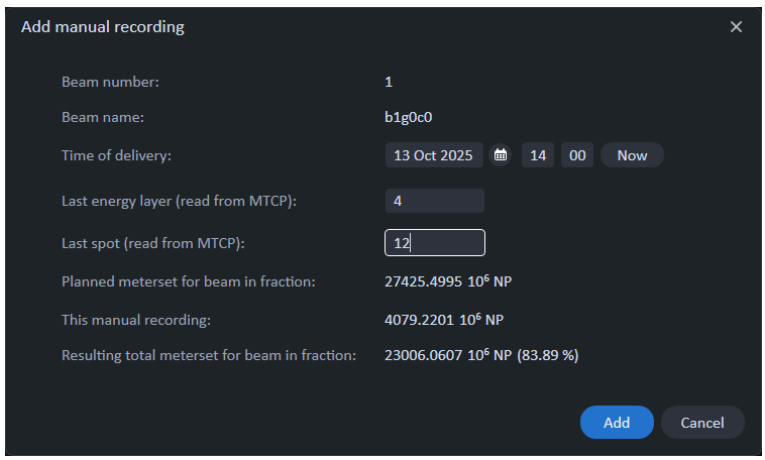
## *Manual recording*

In case the treatment record is not delivered from the beam delivery system, it is possible to manually record the delivered dose in RayCommand.

1. Right-click on the beam that has been delivered.




2. Enter the last delivered energy layer and spot, i.e., how much of the beam was delivered, and the time of delivery. RayCommand will record the dose as delivered according to the plan, up to the specified layer and spot, and when the delivery was made.



If no treatment record is received after a delivery, RayCommand will be in **Degraded** mode until the treatment has been manually recorded.

A manual recording can be edited or removed. If a continuation has been created, a warning text informs the user that only the recorded dose is affected. If the continuation has not been delivered yet, it is strongly recommended to remove it before editing or removing the manual recording.

### Disabling or enabling a beam

A beam with status **Not delivered** can be disabled from delivery. Disabled beams will not be included when initiating the beamline. Disabled beams have status **Disabled**. A disabled beam can be enabled.

Disabling and enabling of beams can only be done when beam delivery system is in an idle state.

To disable or enable a beam, right-click on the beam and select **Disable beam** or **Enable beam**.

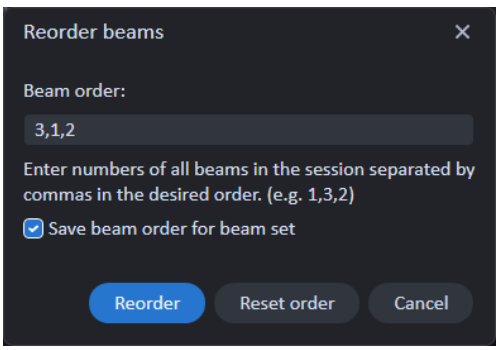
### Reordering beams

The delivery order of the beams in a plan can be changed. For example, the beams can be reordered to deliver all beams from the same angle or patient position at once.

The new beam order is entered as a comma-separated list of beam numbers. All beams planned for the session must be listed.

There is an option to save the beam delivery order for the beam set to be used in future sessions. If the checkbox is not selected, the beam order will only be used for the ongoing session and will have to be re-entered every time a session is started. If selected, the beam order will be used for the beam set in future sessions. The beam order cannot be saved for future sessions in a continuation session.

It is possible to reset the beam order to the default by selecting **Reset order**.



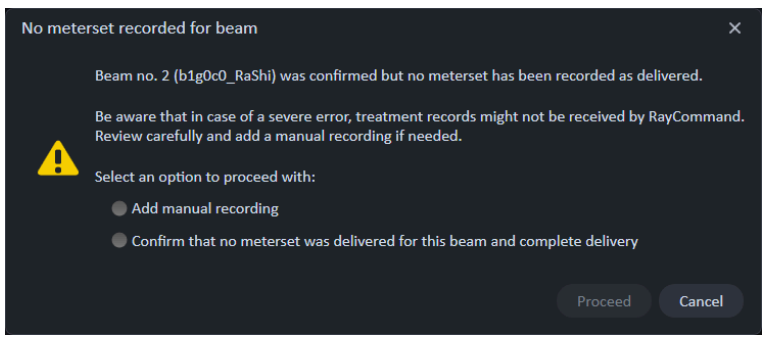

## *Workflow - MedAustron*

1. Click the **Room navigator** button to open the **Room navigator** dialog.
2. Select the target position for the beam.

The motion planning bar shows the progress status.

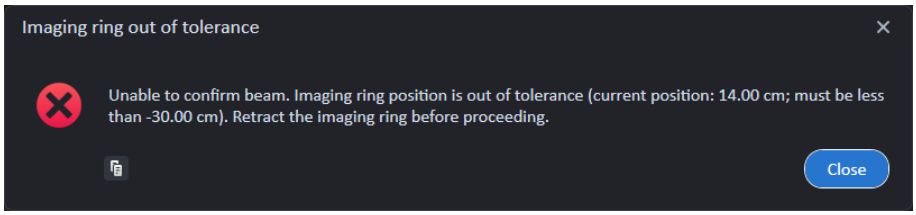
3. Use the control console to move the patient positioner to the selected target position.
4. Click the **Move** button in the Nozzle elements section to set the position of the nozzle elements to the planned position.
5. Click the **Plan path** button in the **Gantry/Snout** section to rotate the gantry to the target position (if applicable).
6. Move the PPS:
   a. Click **Plan path** to perform the path planning.
   b. Review the planned path.
   c. Click **Move** to move the PPS to treatment position.
7. Click the **Move snout** button to prepare the snout and move it to the target position (if applicable).
8. Click the **Enter treatment mode** button in the toolbar to lock all devices and set them in treatment mode.
9. Click the **Confirm beam** button to prepare the beam for delivery. Use the treatment control console to deliver the beam. If machine parameter verification fails, a dialog will be shown with the status of all invalid parameters or required overrides. If any previous beams have been overdelivered, a dialog will be shown stating which beams have been overdelivered.

   If no treatment records are received, a dialog will be shown prompting the user to perform a manual recording if necessary. For information about manual recording, see *Manual recording on page 70*.

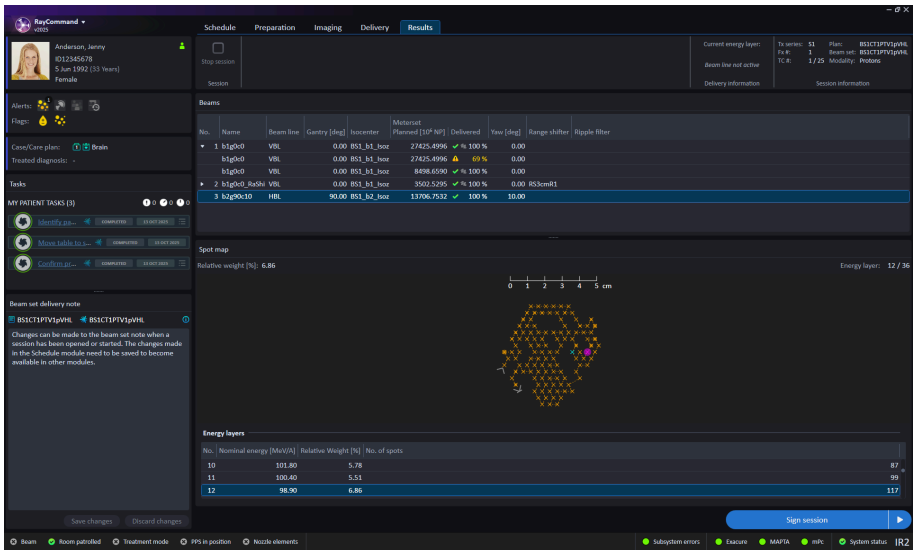



10. When all beams are delivered, click the **Complete delivery** button to set the status for the treatment session to delivered. If any previous beams have been overdelivered, a dialog will be shown stating which beams have been overdelivered.

***Note:*** *It is not possible to confirm the beam if the imaging ring is not parked at the end of the couch, unless the room is configured for an eye treatment.*



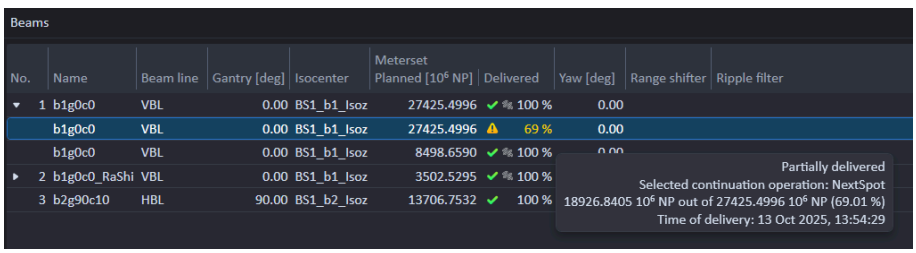

## 5.2.5 Results module




### *Beams panel*

The **Beams** panel displays the list of beams that are to be delivered. Beams that have already been delivered are indicated by a green checkmark.

When hovering over the percent sign (%) for a delivered beam in the **Delivery** column, the number of delivered NP and the time of the delivery are shown.




### *Spot map panel*

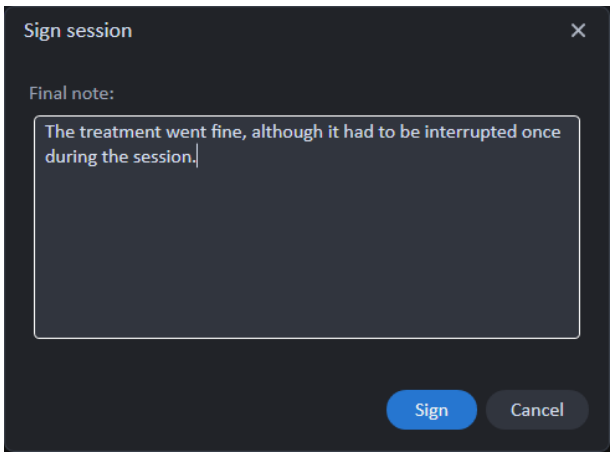
The **Spot map** panel displays delivered spots per energy layers.

### *Sign session button*

Click the **Sign session** button to complete the treatment session without navigating to the next module. Click on the arrow to complete the treatment session and navigate back to the first module (**Schedule**).

It is possible to enter a final note for the session. This note will also be shown in RayCare.

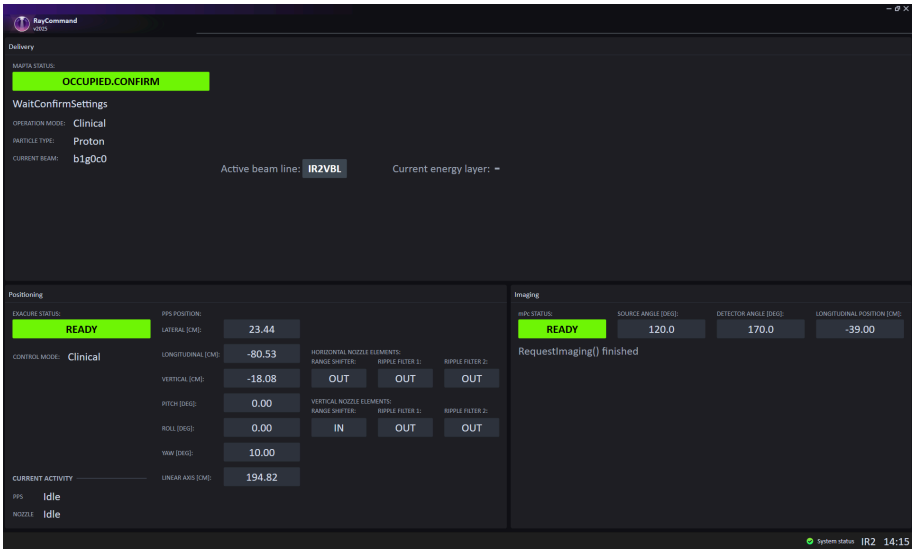
It is also possible to select if a continuation session should be created if the session was not fully delivered. The session needs to be scheduled in RayCare.




## 5.3 MACHINE MONITOR

The content on the Machine monitor complements the information on the Main monitor, with real time information from inside the treatment room.

The Machine monitor requires no interaction from the user but is used for viewing information only.




### 5.3.1 Delivery system

The **Delivery** panel shows the current status of the irradiation system and which beamline that occupies the synchrotron.

During the irradiation the 'Radiation on' icon is active, and the progress of the beam (delivery of the energy layer information) is shown.

### 5.3.2 Patient positioning system

The coordinates for the patient positioner show the current position of the patient positioner.

The following information is displayed in **Positioning**:

- PPS position
- Nozzle element positions
- Gantry angle (if applicable in the room)
- Snout position (if applicable in the room)

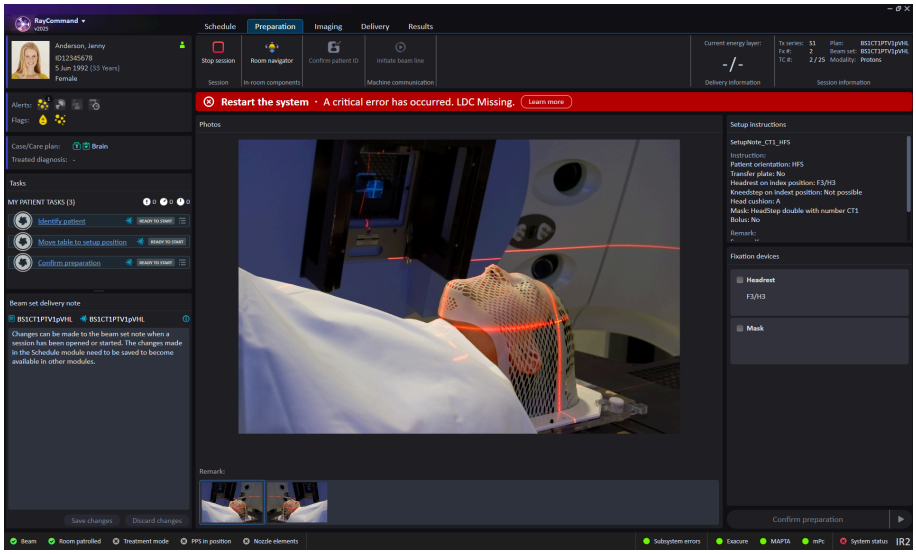
### 5.3.3 Imaging system

The current status of the imaging system is shown (including the current angle of the imager source and detector, and the current longitudinal position of the imaging ring).

## 5.4 SYSTEM HEALTH

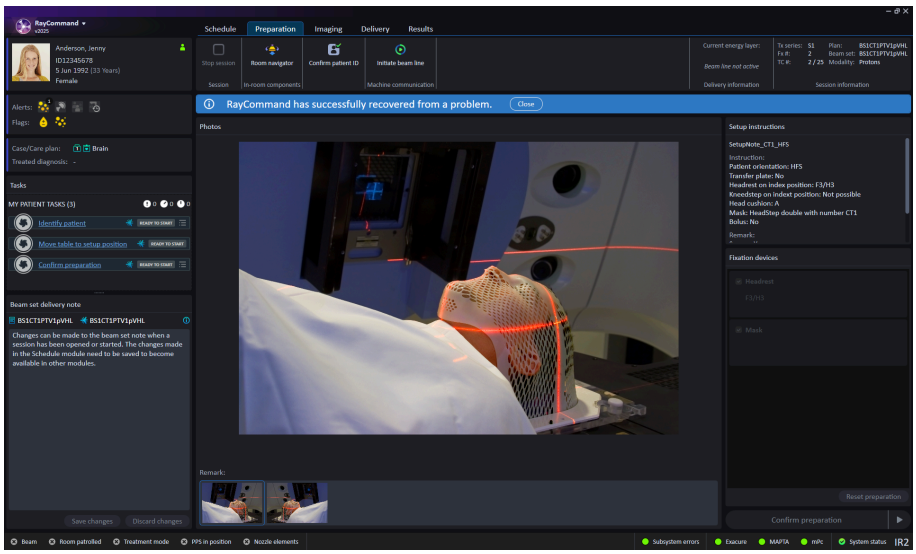
*Severe error*

If part of RayCommand has encountered a severe error, RayCommand will enter Error mode. A banner will be displayed at the top of the monitors.



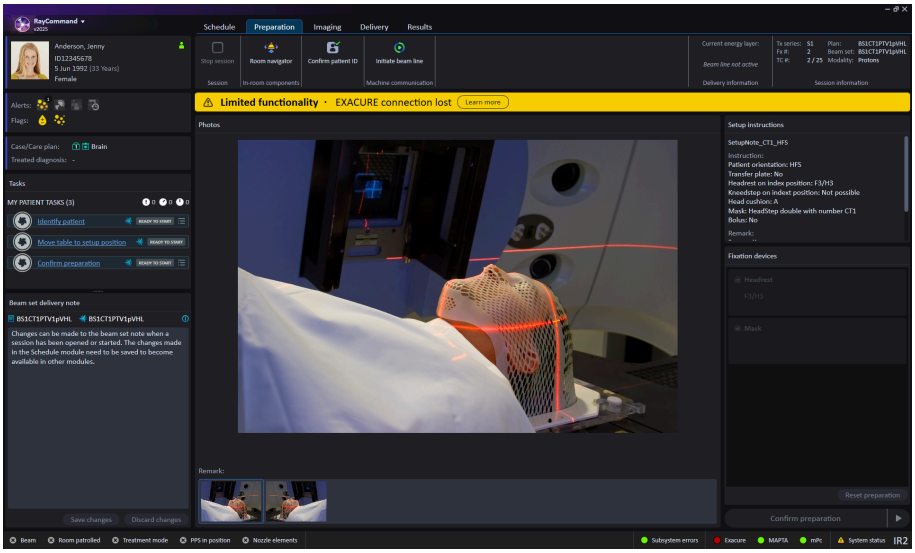

Interaction with a currently open session in the Main monitor will be limited, and the session state will be set to failed. An additional banner will be shown until the session has been stopped or completed.

To resolve the issue the services need to be restarted. After restart, the Main monitor will again allow full interaction and the banner with the error message can be closed.




## Degraded mode

If an external system encounters an error, RayCommand will enter **Degraded** mode. A banner with a message is displayed:




Interaction in **Degraded** mode is as normal, but interaction with external systems in faulty state will not be possible.

### Continue session after severe error

When the system has been restarted after a severe error, and thereby recovered from error mode, the interrupted session can be continued by clicking on the **Continue session** button.

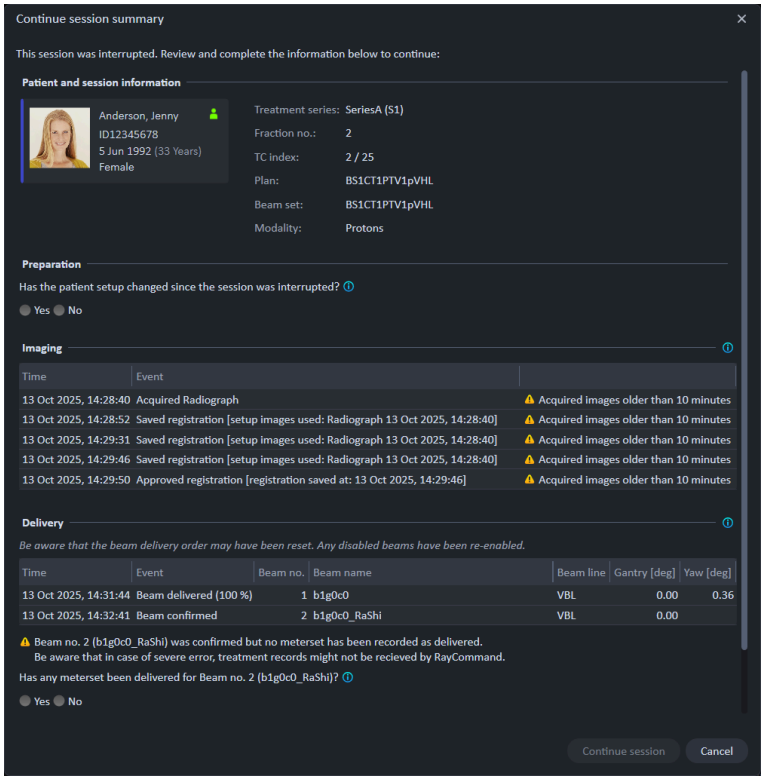
The user must confirm that the session is in the correct state by reviewing the **Continue session** dialog and responding as appropriate.

The position of the patient must be evaluated to determine whether it is still appropriate to use images and registrations acquired before the session interruption.

If the beam was confirmed, but no treatment record was received, the user must either confirm that no dose was delivered or manually record the delivered dose.

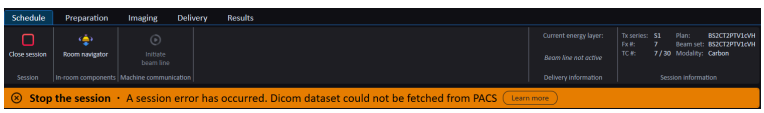
It is possible to close the dialog and open another module to review the current session details. After completing the review, reopen the **Continue Session** summary dialog from the application menu.

A QA session cannot be restarted after a severe error.




## *Session error*

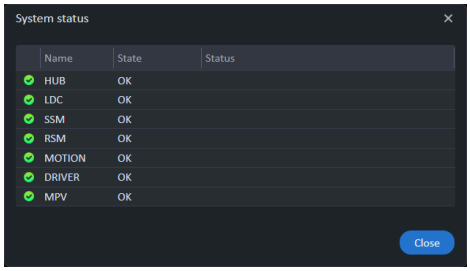
On rare occasions, a started session may be unable to continue because of an error, e.g., a session is opened and the RT plan cannot be fetched from PACS. If this happens, an orange banner is shown to indicate that the session needs to be restarted.

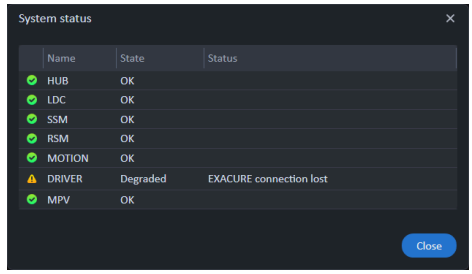


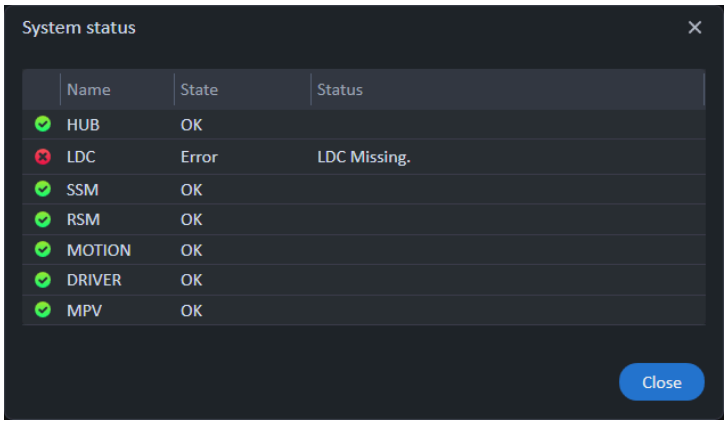

## *System status*

Along the bottom of the Main monitor, interlock and system status is displayed. This information allows the user to get a quick overview of the current state. Tooltips about subsystems show detailed status.

To see the status of each subsystem, the user can access the **Subsystems** dialog from the status bar. A list of any current errors per subsystem can also be viewed here.




## 5.5 PATIENT POSITIONING

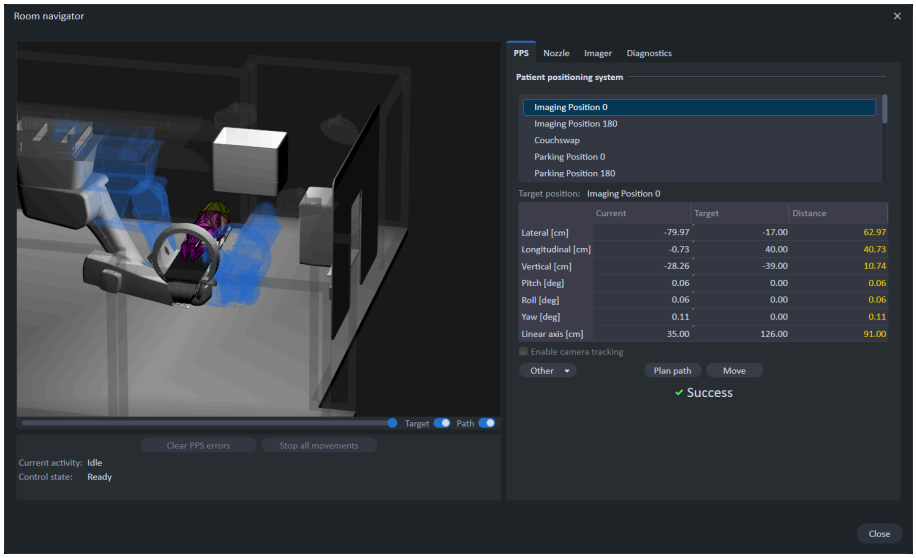
The patient positioning tools are located to the right of the toolbar and are available from all modules. Use these tools to control the position of the patient positioner.

### 5.5.1 Room navigator - MedAustron

Click the **Room navigator** button in the toolbar to open the **Room navigator** dialog.

#### *Room view panel*

The **Room view** panel is always displayed when the **Room navigator** is opened. The **Room view** panel displays the in-room components and their positions in the room. When a session is started, the room view also shows the ROIs that are defined as collision structures, i.e., structures accounted for in the collision check. The structures are shown with the same colors as specified in RayStation.




The information in the **Room view** is controlled via the mouse and keyboard as summarized in the table below.

### Keys

| Key | Function | Description |
|---|---|---|
| Left mouse button | Rotate camera | Rotates the camera to view the room from different angles. |
| Mouse wheel | Zoom in/out | Zooms in/out to get a closer or a more distant view of the room. |
| Space | Camera reset | Sets the camera to its default position. |
| G | Show grid | Grid of isocentric planes. |
| Ctrl+2 | Show collision models | Shows the convex hull geometries that are used in the Collision check. |

## *PPS tab*

Available positions for the Patient Position System are either predefined at system setup or created based on the beams in the current plan. It is also possible to enter an ad hoc position in the target column for moving the PPS.

To move the Patient Positioning System (PPS) to a new position:

1. Select a position in the list of target positions, or enter an ad hoc position in the target column. The selected target position is visualized as a blue transparent target couch, called the target position representation.

2. Press **Plan path**. The motion planning bar shows the progress of the path planning.
3. When a path has been calculated, the movement of the center of the couch can be seen as a green ribbon. It is possible to preview the calculated trajectory by dragging the slider displayed below the room view.
4. Press **Move** and use the control console to execute the move.

***Note:*** *The visualization of the path ribbon and the target position representation can be toggled by using the switch buttons below the room navigator.*

***Note:*** *The path planner will automatically use the deterministic path planner if the start and goal positions are in the allowed area. To force the path planner to use the non-deterministic path planner, select Initiate path using non-deterministic planner in the Other menu.*

To move the PPS without performing a collision check:

1. Select a position in the list of target positions, or enter an ad hoc position in the target column.
2. Click **Other** and select **Execute movement without collision check** from the menu.
3. Use the console to execute the move.

Coordinates for the patient positioner are shown in a table: current position, target position and the estimated distance between them. The same table is also displayed on the Machine monitor.

***Note:*** *Extra caution must be taken since the trajectory has not been verified to be possible to execute without a collision.*

***Note:*** *It is only possible to move the PPS without performing a collision check if the distance is within a specified tolerance. This type of movement is locked to certain users and password protected.*

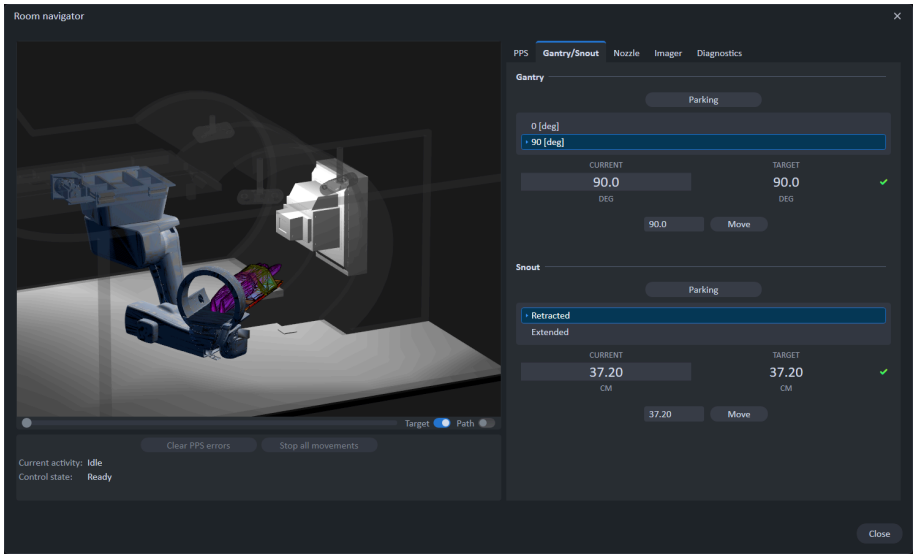
***Note:*** *The displayed distance from the start to target may increase and decrease several times before finally converging to the target. This is because the calculated trajectory may not be a straight line in the room.*

***Note:*** *The planned path will not be possible to execute if another in-room component has been moved since the path was planned.*

### *Gantry/Snout*

Positions for the gantry and snout are available for irradiation rooms with a gantry and movable snout. There are predefined parking positions and a possibility to enter ad hoc positions for the gantry angle and snout extension.

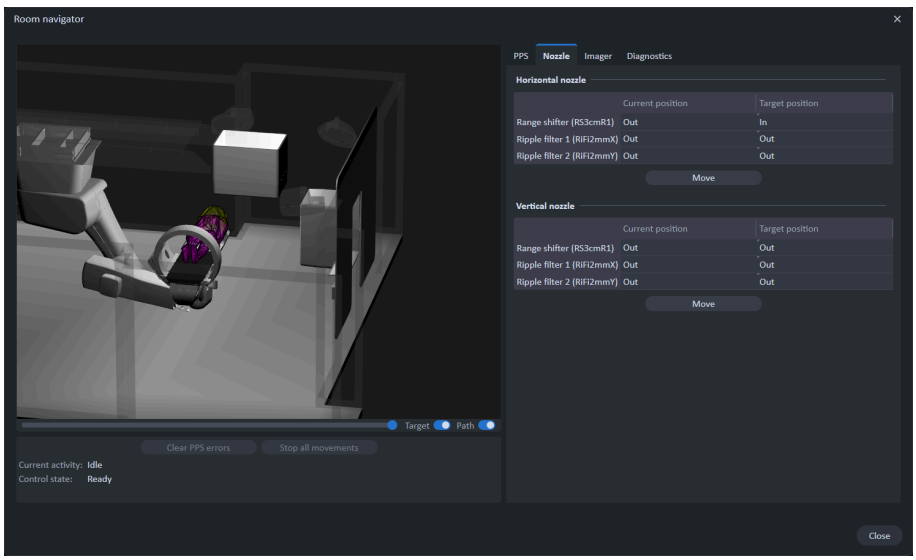
The gantry/snout will move to the initiated position when the control console is used for executing the move.




## *Nozzle*

Available positions for the nozzle filters (In or Out) can be set, and the positions initiated ad hoc.

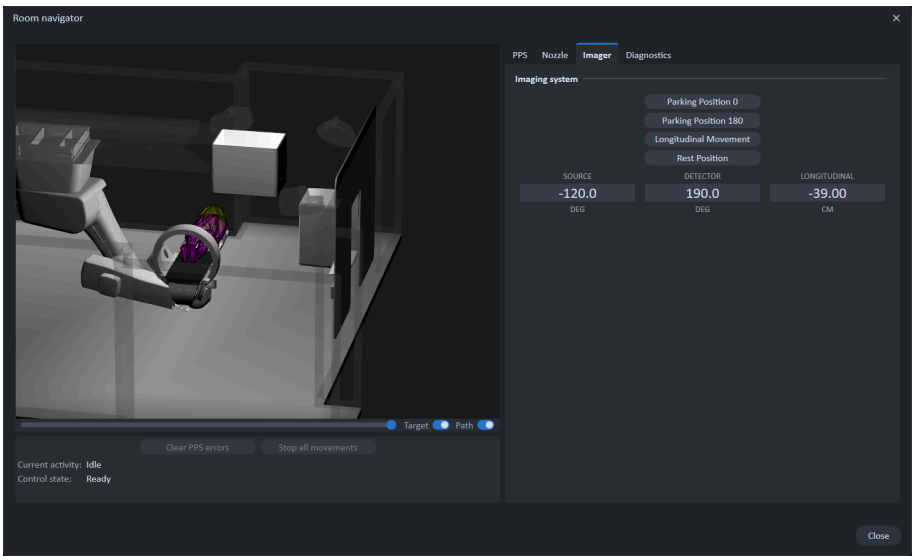
Initially in the grid, all positions are blank. Ad-hoc movements requires all positions to be set.




## *Imager*

Available positions for the imager are predefined at system setup. The position is sent directly to the imager system when a parking position is selected.

The imager will move to the selected position when the control console is used for executing the move.




## *Diagnostics*

The **Diagnostics** tab contains information nodes from external systems, to provide values for troubleshooting in RayCommand without the need of other tools.

## *Collision check (only available in Physics mode)*

The **Collision check** tab contains functionality for verifying the setup margins for a planned table top position.

1. Enter the rotation point position (in the table top coordinate system).
2. Enter the table top position corresponding to the nominal isocenter position to be verified (in the table top coordinate system).
3. Click **Plan path** to plan a path from the current position to the nominal table top position.
4. When a path has been successfully calculated, click **Move** and use the console to execute the move.
5. When the table top has been moved to the nominal table top position, enter the shift to verify in the **Shift from isocenter** table.
6. Try to move the table top to the shifted target position, either by planning a path and executing this plan when successfully calculated, or by selecting to move the table top without performing a collision check. Take extra caution and stop before a collision occurs.
7. Read the current value of the shift from the **Current** column in the **Shift from isocenter** table.

### 5.5.2 Automatic motion planning

MedAustron installations of RayCommand provide support for *automatic motion planning*.

Without automatic motion planning, the PPS would take a direct path from start to target positions. When executed without supervision, the direct movement can result in physical contact between components such as in the following examples:

- Patient and nozzle
- Table Top with the nozzle
- Imager with the nozzle
- Imager C-arm with the robot arm

With the automatic motion planning feature enabled, when a target position is selected in the **Room navigator**, RayCommand automatically computes a collision-free PPS movement from the start position to the target position.

In both cases, the user must maintain visual contact of the PPS and anticipate collisions while executing the movement with the control console. See *Chapter 3 Information needed for safe operation* for relevant safety precautions.

#### *Considerations for automatic motion planning*

There are some important considerations for automatic motion planning.

RayCommand provides two motion planners:

- **Deterministic planner**

  A rule-based planner runs if the PPS will yaw by more than 30 degrees (configurable) and is in a configurable volume around room isocenter.

  The rules of this planner specify that the PPS first translates to the field shift arc, where it yaws around the room isocenter, keeping the HFS patient head still, and finally translates to the goal. This planner is deterministic; it produces the same movement every time, given the same start and goal positions. The path planning is quick, but the path cannot be adjusted to avoid collision. If RayCommand detects that the path would collide, an error message is displayed. In that case, the user must move the imager, gantry or snout to make the move possible, or select **Initiate path using non-deterministic planner** in the **Other** menu in the **Room navigator**.

- **Non-deterministic planner**

  A sampling-based planner runs if the PPS will yaw by less than 30 degrees (configurable) or is not in the configurable volume around room isocenter.

  This motion planner samples for valid positions at random until enough positions have been found to move around obstacles. Because of the random sampling, this planner does not produce a deterministic solution. This means that if RayCommand plans a motion from

position A to position B and later plans another motion from A to B, the second motion can be different than the first.

**Timeouts**

The planner is not guaranteed to produce a solution. RayCommand imposes a configurable timeout on the planning time, typically 10 seconds. The more constrained the physical space, the more likely this timeout will be reached. If this occurs, it is recommended to try again. If multiple timeouts occur, try changing the start or target position or opening up the physical space, such as by retracting the nozzle or parking the imager.

**Contact margins**

Motion planning performance is sensitive to the preconfigured contact margins, which specify how close objects can get and in what context. For example, when the PPS is moving, in a suggested configuration, the table top may only approach to 10 cm from the nozzle, but when the nozzle is moving, the nozzle could approach to 0.5 cm from the table top. The contact margins may differ by mode (Service, Physics, Clinical). For Clinical mode, they are locked after customer acceptance. Contact RaySearch if you wish to customize the contact margins for Clinical mode.

**Handedness**

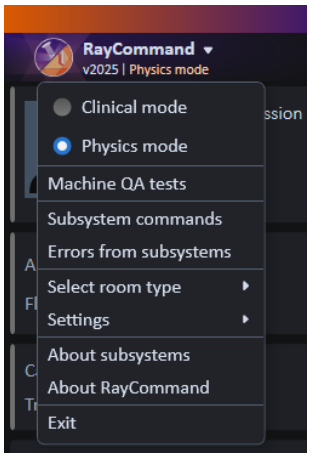
In some positions, the PPS robot arm can take a 'left' or 'right' handed configuration. Due to technical limitations, RayCommand cannot control which handedness the robot takes. As a rule of thumb, the system attempts to preserve the current handedness unless it is not physically feasible.

## 5.6 PHYSICS MODE

In Physics mode the user can perform the same activities as in Clinical mode, but the rules in Clinical mode do not apply in Physics mode (e.g., the user can perform activities in any order).

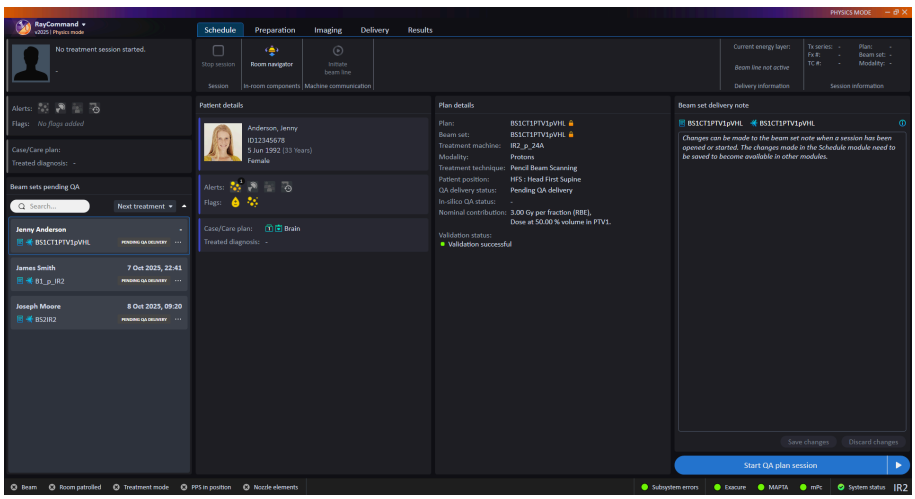
To perform quality assurance on scheduled plans:

1. Select **Physics mode** from the application menu.




RayCommand will now enter Physics mode, indicated in the title bar.

The schedule will be replaced with a list of scheduled plans for which quality assurance has not yet been performed. The QA list will include the plans with QA status **Pending QA delivery**, **Pending analysis** or **Failed measurements**. **Failed plans** and **Failed other** can be selected in RayCare but these plans will not be shown in the RayCommand QA list, nor will plans with QA status **Pass**.




2. Select a plan and click **Start session**. A QA session is created and started.

Treatment **Imaging** and **Delivery** can now proceed as normal, with the exception that the user needs to confirm that no patient is present on the table before delivering a beam. In Physics mode, it is possible to apply a correction vector to create an adjusted delivery position without

acquiring setup images for the session by accessing the context menu in the header of the **Registration** panel.

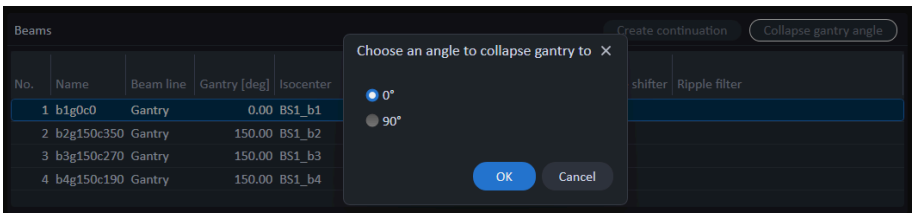
In Physics mode, the beams delivered will not contribute to nominal dose, and unapproved treatment courses can be delivered.

To be able to exit Physics mode, the session must first be stopped or completed.

### *Collapse gantry angle*

When making a delivery in Physics mode and the room has a gantry, the user can choose to collapse the gantry angles to 0 and 90 degrees for QA deliveries. All beams can then be delivered from the same gantry angle for the QA delivery.

The reason to why the gantry can be collapsed is that the phantom used only supports 0 or 90 degree angles. If the planned gantry angle of a beam is not 0 or 90 degrees, and the gantry is not collapsed, a warning is shown when confirming the beam.




To collapse gantry angle:

1. Click the **Collapse gantry angle** button.
2. Select which angle to collapse the gantry to.
3. Click **OK**.

### *Reset beam delivery*

It is possible to reset the delivery of a beam and deliver it again. Right click on the beam and select **Reset beam delivery**. This is only possible when beam delivery system is idle.

## 5.6.1 Machine QA tests

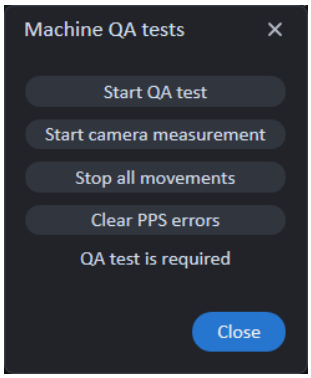
The following options are available for machine QA tests:

- **Start QA test** – Starts a QA test of the Exacure system.
- **Start camera measurement** – Starts camera tracking.
- **Stop all movements** – Stops any ongoing Exacure request.
- **Clear PPS errors** – Clears any PPS errors.

One of these texts will be shown, depending on current Exacure status:

- **QA test is required**

- **QA test is NOT required**




## 5.7 MACHINE PARAMETER VERIFICATION

The machine parameter verification compares planned and current values, and checks interlock status.

Interlocks are considered only unlocked or unlocked, and cannot be overridden. Values such as positions and angles have a hard tolerance that cannot be overridden. Hard tolerances always have precedence over user-defined tolerances.

The table below shows a complete list of verified machine parameters.

| Machine parameter | Hard tolerance | Soft tolerance | Description |
|---|---|---|---|
| Interlocks | — | — | All relevant interlocks. |
| Machine name | — | — | Verifies the machine model name. |
| Range shifters | — | — | Verifies inserted accessories. |
| Range modulators | — | — | |
| Total Meterset exceeded | — | User-defined | Verifies that the resulting total meterset from the following delivery is not greater than the planned meterset. |
| Planned Meterset subceeded | — | User-defined | Verifies that the resulting planned meterset from the following delivery is not less than the planned meterset. |
| Gantry angle | 0.5 degrees | User-defined | Verifies current gantry angle. |

| Machine parameter | Hard tolerance | Soft tolerance | Description |
|---|---|---|---|
| Snout position | 1 mm | User-defined | Verifies current snout position. |
| Table top vertical position | 1 mm | User-defined | Verifies current table top position. |
| Table top longitudinal position | 1 mm | User-defined | |
| Table top lateral position | 1 mm | User-defined | |
| Table top pitch angle | 0.5 degrees | User-defined | |
| Table top roll angle | 0.5 degrees | User-defined | |
| Table top yaw angle | 0.5 degrees | User-defined | |

## 5.8 INTERLOCKS

The interlocks used by RayCommand are software interlocks. There are two main types of interlocks:

- Relay interlocks are based on external signals.
- In-position interlocks are based on combinations of external signals and internal information. In-position interlocks use the tolerance table to evaluate if a target position has been reached.

***Note:*** *Using large tolerance values will enable the confirm beam command also in cases when hard tolerances prevent beam delivery.*

| Interlock | Type | Description |
|---|---|---|
| Treatment mode | Relay | Patient positioning system is in treatment mode. In-room components cannot be moved. |
| Beam | Relay | Beam is occupied by current room. |
| Room patrolled | Relay | Room is patrolled. This includes technical area and storage area interlocks, if applicable. |
| PPS | In-position | Table top is at the target position of the current beam. |
| Nozzle elements | In-position | Nozzle elements are at the target position of the current beam. |

| Interlock | Type | Description |
|---|---|---|
| Gantry | In-position | Gantry is at the target position of the current beam. |
| Snout | In-position | Snout is at the target position of the current beam. |

***Note:*** *The PPS interlock evaluates the table top position with regard to the planned position of the current beam. This is also referred to as the nominal position. Approving a registration of the daily image provides the adjusted position. The adjusted position has precedence for evaluating the table top position.*

## 5.9 LOGGING

All monitors and services write log events to file in CLEF format (Compact Log Event Format). An optional sink can be configured in the installer to stream log events to a Seq server (https://datalust.co/seq) which enables viewing log events in real time.

# 6 TREATMENT MANAGEMENT AND RESULTS

For information about treatment management and treatment results, see:

- *RSL-D-RC-v2025-USM, RayCare v2025 User Manual*
- Section *Dose tracking with RayCare treatment course* in *RSL-D-RS-v2025-USM, RayStation v2025 User Manual*.

# A CLINIC SETTINGS CONFIGURATION FOR RAYCOMMAND

In order to use RayCommand, configuration of the treatment settings in the Clinic settings application is needed. Most of the settings are configured at installation and are therefore described in the RayCommand installation documents. This section describes some important points of which the user should be aware.

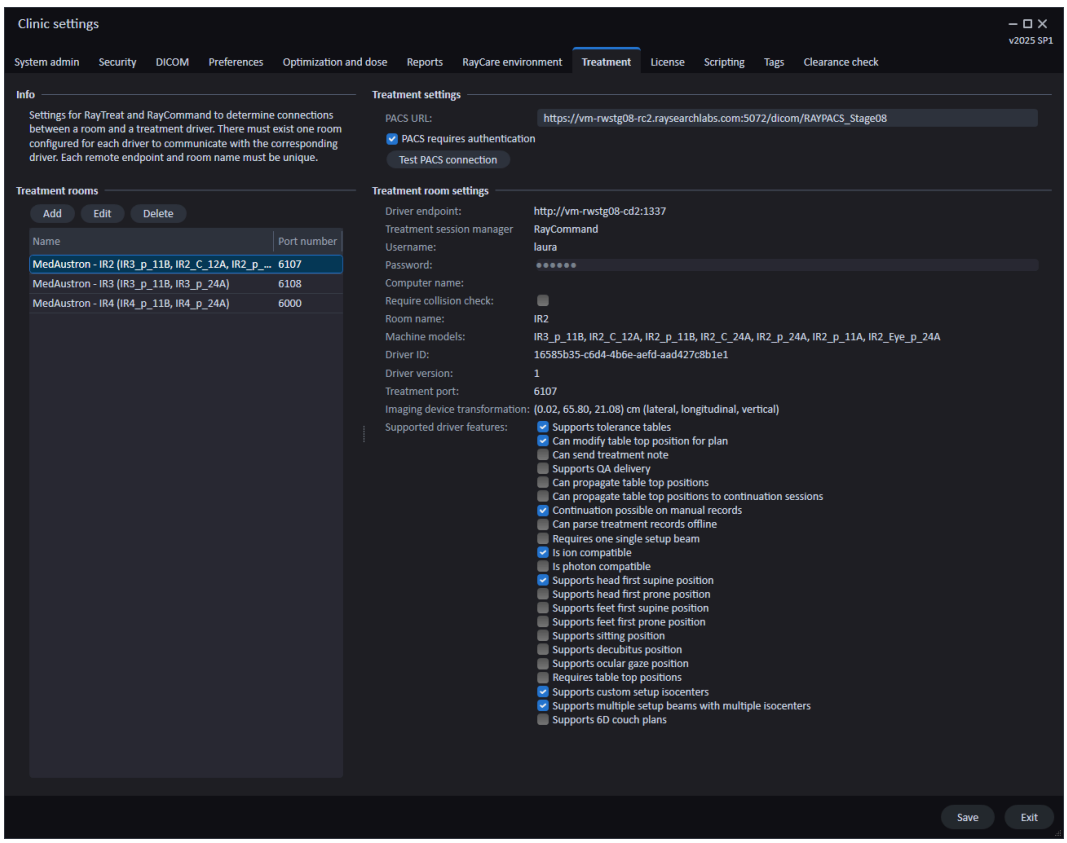



**Figure 21.** The **Treatment** tab in **Clinic settings**.

The configuration has a list of rooms. These reflect the rooms for which the user can schedule an appointment in RayCare. Each room also has a list of machine models. These reflect the models of the machine setup in RayPhysics and are used when creating a beam set in RayStation. The same machine model can be referenced in multiple rooms. It is also possible to let a single room support multiple machine models. RayCommand supports machine models with modality Protons, Helium ions or Carbon ions.

**WARNING!**

**Machine models.** The user who configures which machine models are supported in which rooms shall have a very clear understanding of the clinic and its rooms and machine models. It is strongly discouraged to remove or rename any machine model in the configuration of a room. Instead, it is recommended to deprecate the machine in RayPhysics if a machine model is not to be used anymore. It is still possible to add new machine models to a room.

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To edit treatment room settings, click the **Edit** button. This opens the **Edit treatment room settings** dialog.

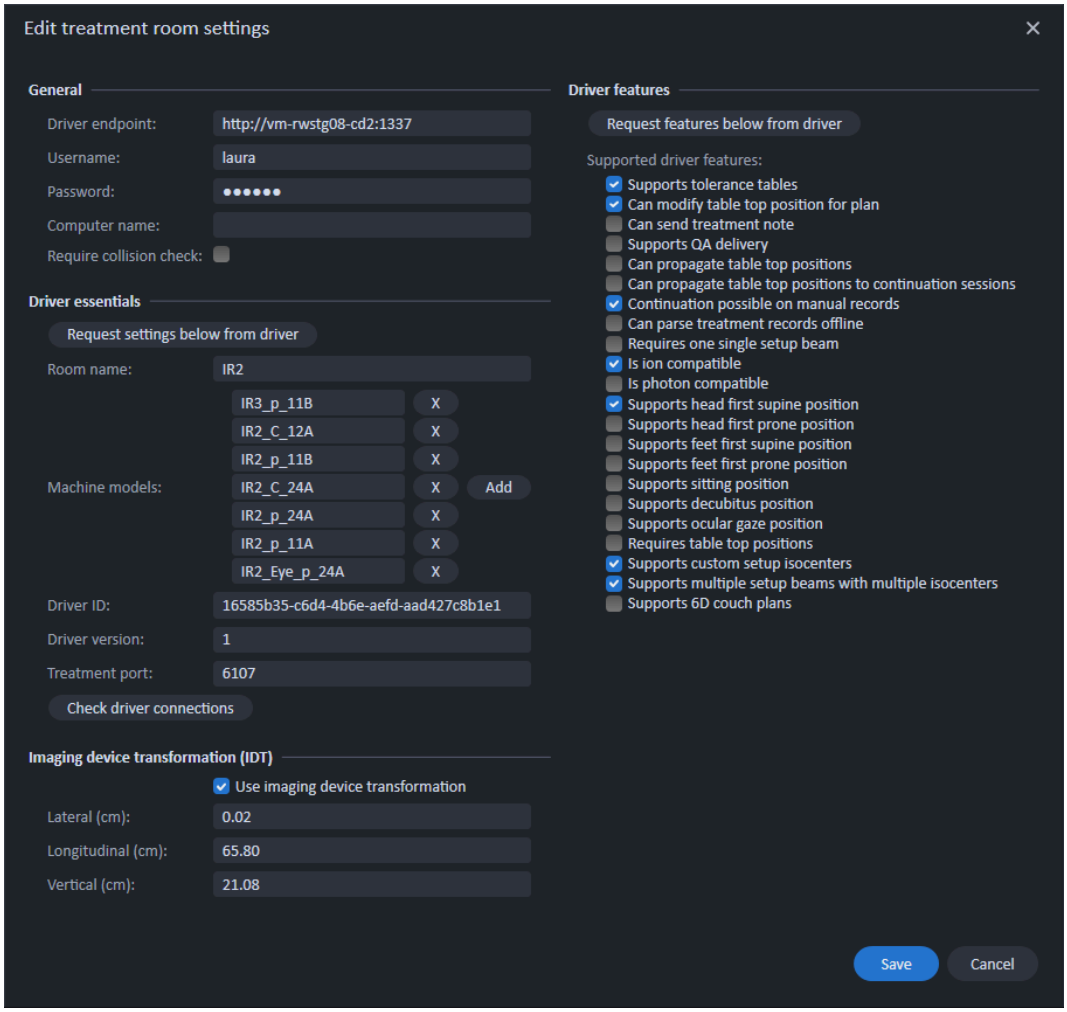



**Figure 22.** The **Edit treatment room settings** dialog.

In **Imaging device system** it is possible to enter an imaging device transformation in case the patient coordinate system and the imaging device do not match. If IDT is set to 0,0,0 the coordinate system for the patient and the imaging system is coinciding.

# B DEFINING SETUP IMAGING PARAMETERS IN RAYSTATION

This section describes the workflow in RayStation for configuring setup beams and imaging parameters for the medPhoton specific patient setup and imaging procedures performed by RayCommand.

## *In this chapter*

This chapter contains the following sections:



## B.1 COMMISSION AN ION TREATMENT MACHINE TO SUPPORT WORKFLOWS FOR MEDPHOTON IMAGING PROCEDURES

To support the patient setup and imaging procedures required for medPhoton delivery, the Ion treatment machine needs to be configured with the appropriate type of motion synchronization support.

How to configure motion synchronization.

1. Open the Add synchronization technique dialog in the **Motion synchronization** tab, see *Motion synchronization* in the *RSL-D-RS-v2025-RPHY, RayStation v2025 RayPhysics Manual*.

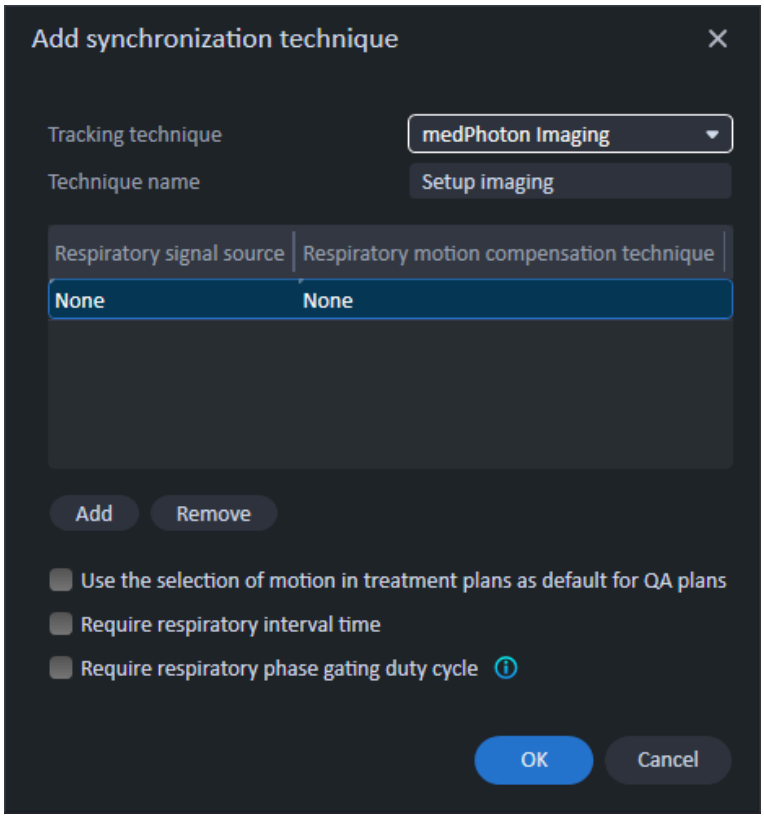
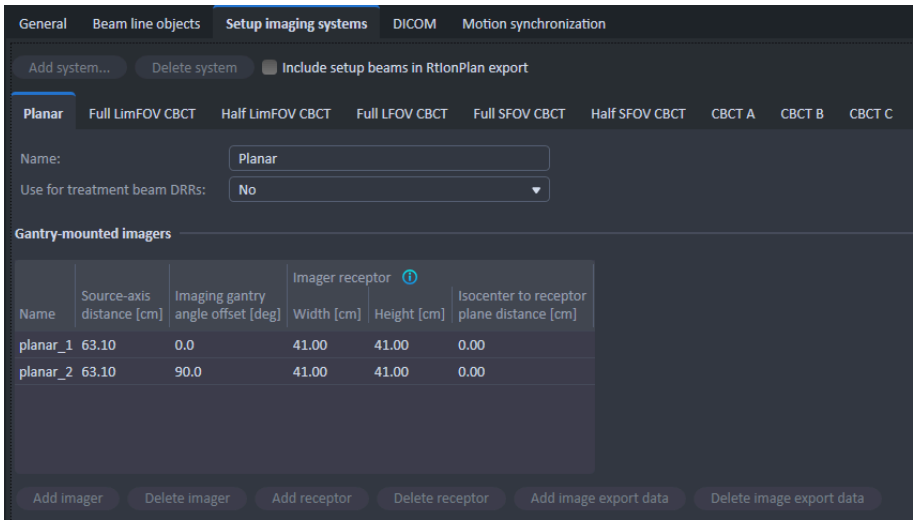



**Figure 23.** Add synchronization technique with support for medPhoton imaging procedures.

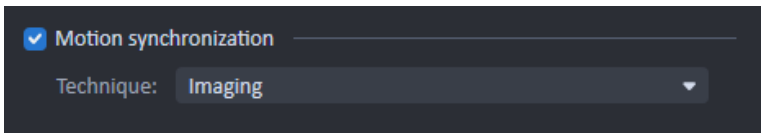
2. Add a motion synchronization technique with the Tracking technique selected as 'medPhoton Imaging'.
3. Add a name for the Tracking technique.

The other available properties in the **Motion synchronization** tab will not affect the standardized medPhoton patient setup and imaging flow.




## B.2 CREATE A BEAM SET INCLUDING IMAGING PARAMETERS

In the Add/Edit beam set dialog, select a motion synchronization technique with Tracking technique 'medPhoton' to enable the medPhoton flow for imaging and patient setup. For more information on how to define the technique, see *Commission an Ion Treatment Machine to support workflows for medPhoton imaging procedures on how such a technique is defined.*




When a motion synchronization technique of type 'medPhoton imaging' is selected, it will have the following consequences for that beam set.

- Setup beams with custom imaging isocenter will automatically be used.
  - Note that as a consequence the section for setup beam creation and setup beam isocenter selection will be hidden.
  - Setup beams will be created according to standard RayStation rules for gantry mounted and fixed imagers.
- Additional custom imaging isocenters for the setup beams are allowed to be created.
- A selected Tracked ROI is required per imaging isocenter.
- A selected Body site is required per imaging isocenter.
- An Imaged volume representation will be created, which can be edited.

## B.3 EDIT SETUP BEAM PROPERTIES IN THE SETUP BEAM LIST

The setup beams and imaging parameters are configured from the **Setup beams** tab. For further information, see *Setup beams* in the *RSL-D-RS-v2025-USM, RayStation v2025 User Manual*.

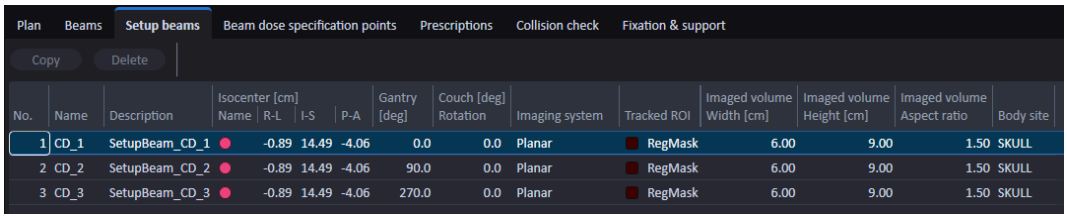
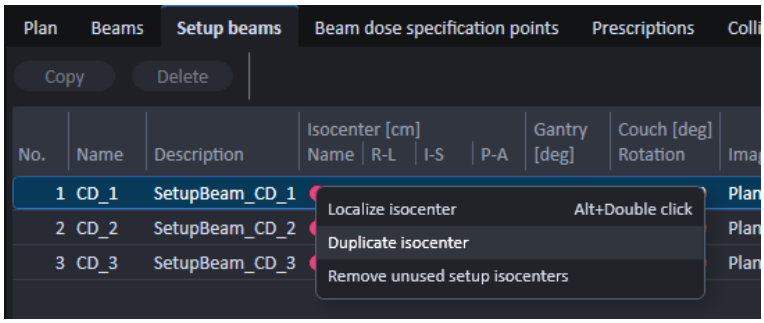



**Figure 24.** The setup beam list when using medPhoton imaging.

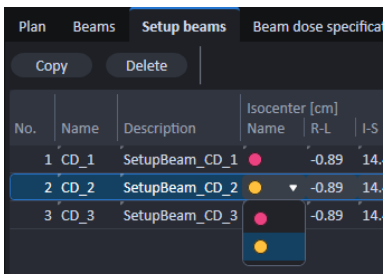
### *Assign a separate isocenter for a setup beam*

Define a new separate isocenter for the beam by right-clicking on an existing isocenter in the setup beam list and select **Duplicate isocenter**.




### *Select another isocenter for a setup beam*

Select another existing isocenter for a setup beam by right-clicking on the isocenter in the setup beam list and select another isocenter from the drop-down list.




### *Remove unused isocenters*

If undesired and unused isocenters exist in the beam sets, select **Clear unused isocenters**. All isocenters in the beam set that are not used by a beam will be deleted.

Note that the imaging isocenters do not have a name. Setup beam isocenters are marked in the patient views as 'Setup iso'.

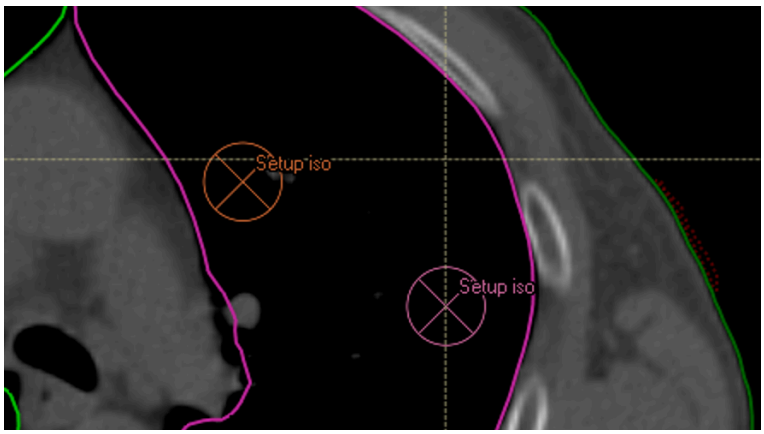
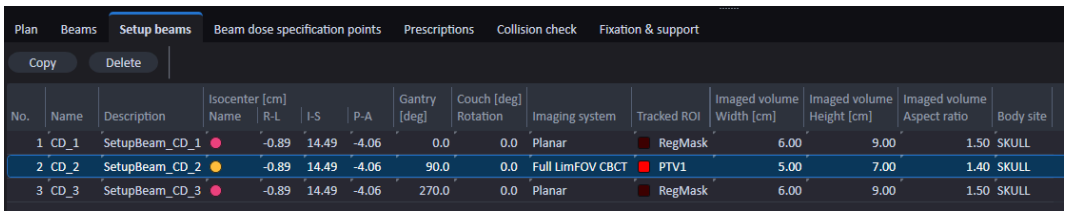



**Figure 25.** Setup isocenters in the patient view.

## B.4 SELECT PARAMETERS FOR IMAGING

For standard editing of setup beam parameters, see *Setup beams for proton plans and light ion plans* in the *RSL-D-RS-v2025-USM, RayStation v2025 User Manual*.



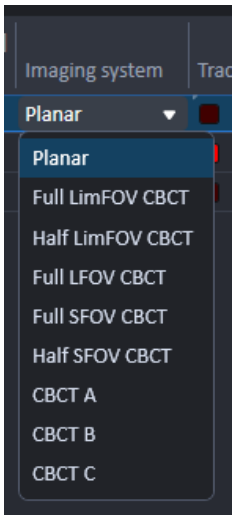

| No. | Name | Description | Isocenter [cm] Name | R-L | I-S | P-A | Gantry [deg] | Couch [deg] Rotation | Imaging system | Tracked ROI | Imaged volume Width [cm] | Imaged volume Height [cm] | Imaged volume Aspect ratio | Body site |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | CD_1 | SetupBeam_CD_1 | | -0.89 | 14.49 | -4.06 | 0.0 | 0.0 | Planar | RegMask | 6.00 | 9.00 | 1.50 | SKULL |
| 2 | CD_2 | SetupBeam_CD_2 | | -0.89 | 14.49 | -4.06 | 90.0 | 0.0 | Full LimFOV CBCT | PTV1 | 5.00 | 7.00 | 1.40 | SKULL |
| 3 | CD_3 | SetupBeam_CD_3 | | -0.89 | 14.49 | -4.06 | 270.0 | 0.0 | Planar | RegMask | 6.00 | 9.00 | 1.50 | SKULL |

**Figure 26.** The setup beam list for medPhoton imaging

The setup beam list will, in addition to present information for each setup beam, also display information that is defined per imaging isocenter. When editing properties related to the imaging isocenter, the information will be updated in all rows containing setup beams sharing that same imaging isocenter.

### *Imaging system*

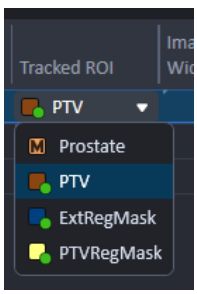
The user can select which imaging protocol to use per setup beam. The protocol includes the definition of the angles to use for setup imaging performed by that setup beam. If selecting an imaging system with multiple imagers with different offsets, setup imaging with RayCommand will be performed from all angles defined as the setup beam angle + the imager offset.




### *Tracked ROI*

A **Tracked ROI** is required to select per imaging isocenter. Select the appropriate ROI from the drop-down list that is populated with all ROIs which are not of **Organ at risk** type.

The selected ROI will be used in RayCommand as the default focus ROI for registrations of images acquired at that setup beam isocenter.



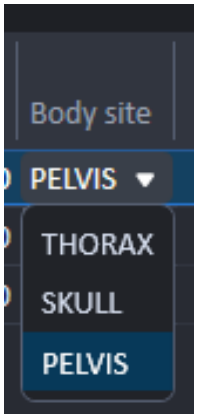

### *Width, height and aspect ratio of Imaged volume*

The width, height and aspect ratio of the volume to be imaged can be edited in the setup beam list as well as interactively changed from the DRR views. The relation ship (height = aspect ration * width) is always preserved when editing.

### *Body site*

A **Body site** is required to select per imaging isocenter. The **Body site** will be forwarded from RayCommand to the imaging system to define imaging parameters, to give optimal image quality of the body site imaged at this imaging isocenter.

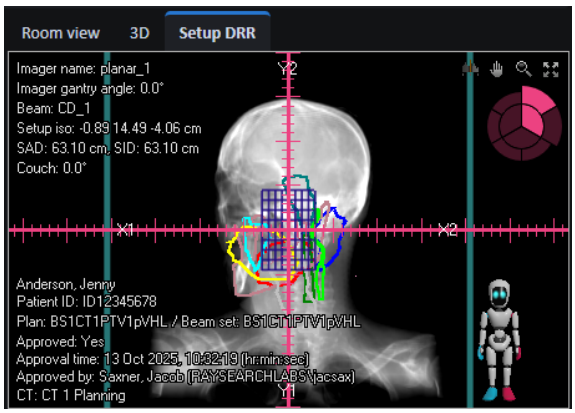
The available body sites to select from is defined in Clinic Settings, see *Preferences* in the *RSL-D-RS-v2025-USM, RayStation v2025 User Manual*.




### *DRR view*

For more information regarding what is displayed in the DRR views, see *DRR views and Settings* and *Setup beams* in the *RSL-D-RS-v2025-USM, RayStation v2025 User Manual*.

When looking at the setup DRR for a setup beam, DRRs for the different imaging angles will be possible to select in the different sections in the pie diagram in the upper right corner of the workspace. Change the selected imaging angle by clicking in the pie diagram or use arrow right/ arrow left keys.

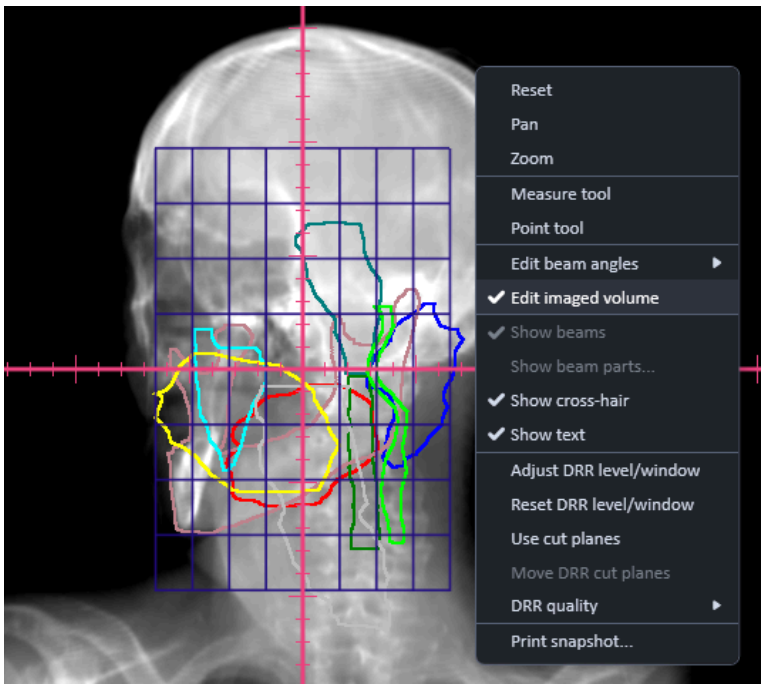



In the DRR, the imaged area is visualized as a grid, centered at the setup beam isocenter.

By right-clicking in the **Setup DRR** view and selecting the **Edit imaged volume** tool, it is possible to move and resize the imaged volume.

By using the **Edit imaged volume** tool, the isocenter of the setup beam can be moved in the DRR view by clicking and dragging in the central part of the grid. The isocenter is moved with the grid following.

To change the size of the imaged volume, for the isocenter of the selected setup beam, click and drag on the border of the grid. Interactive resizing is possible only with a fixed aspect ratio.



# C COLLISION CHECK IN RAYSTATION

## C.1 INTRODUCTION

The Collision check functionality in RayStation consists of tools designed for predicting collisions in the treatment room already in the planning phase, to avoid the discovery that a plan is non-deliverable when the patient is positioned on the treatment table and is ready for treatment.

In addition to the geometries of the treatment room, delivery system and robotic couch, the Collision check also enables the insert of a patient avatar whose shape is specified by the user in RayStation, and that is automatically positioned in the patient image stack. The Collision check also includes the modeling of fixation devices whose ID and position on the table top are defined in RayCare prior to planning.

The Collision check can be performed with the table top in its nominal position, as well as for a multitude of table top correction scenarios which are sampled by user-defined setup margins in all 6 degrees of freedom of the robotic couch. At plan approval, the user is not allowed to proceed if the Collision check has not been executed and a warning is shown if a collision has been detected.

The setup margins are exported to RayCommand along with the plan and structures representing the fixation devices and patient avatar. The setup margins and collision status are also included in the plan report.

## C.2 ADD FIXATION DEVICES

The fixation devices are created in RayStation as regular ROIs. These ROIs may be used in the collision check of the robotic motion tracking algorithm in RayCommand (see *section C.4 ROIs used in collision check on page 108*).

The fixation device IDs and table top positions (indices) used for the planning image data set are defined in RayCare and are retrieved by RayStation via scripting. The geometry of each available fixation device is stored in a structure template in RayStation. The devices used for the current plan are positioned in the image stack according to the table top position (index). The position and shapes of the fixation devices may be adjusted manually after being placed in the patient, for example to compensate for potential couch sag. The creation of the fixation ROIs in the patient is triggered from a script in RayStation.

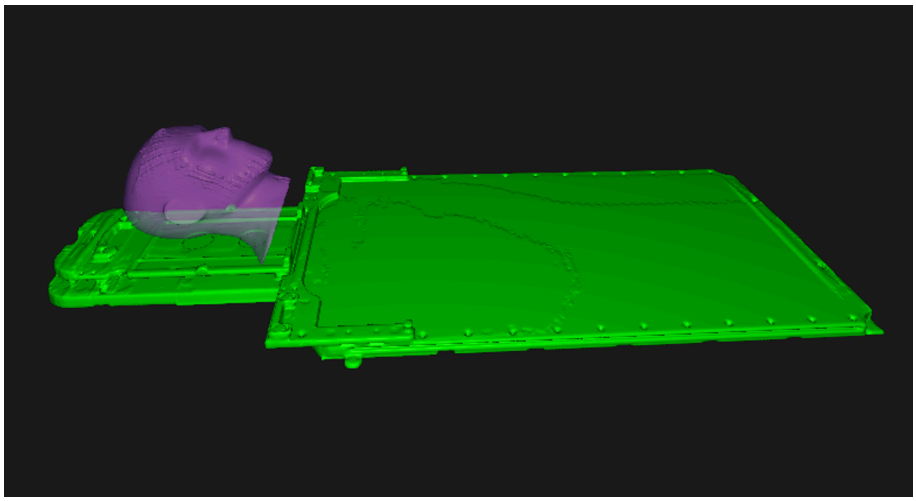
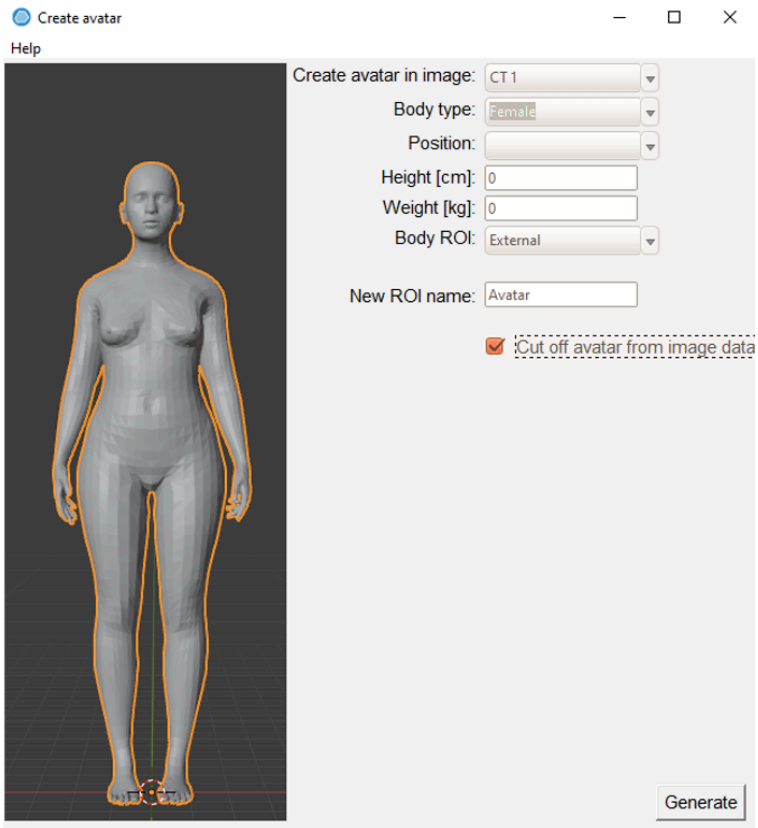


**Figure 27.** Example where the fixation device 'HeadStep' has been added to the patient.

## C.3 ADD A PATIENT AVATAR

The patient avatar is composed of regular RayStation ROIs of type **Avatar**. The avatar is constructed by a series of ROIs (torso, two arms, two legs and head & neck) so that individual body components may be manually adjusted if needed. The external ROI is always considered by the collision check.



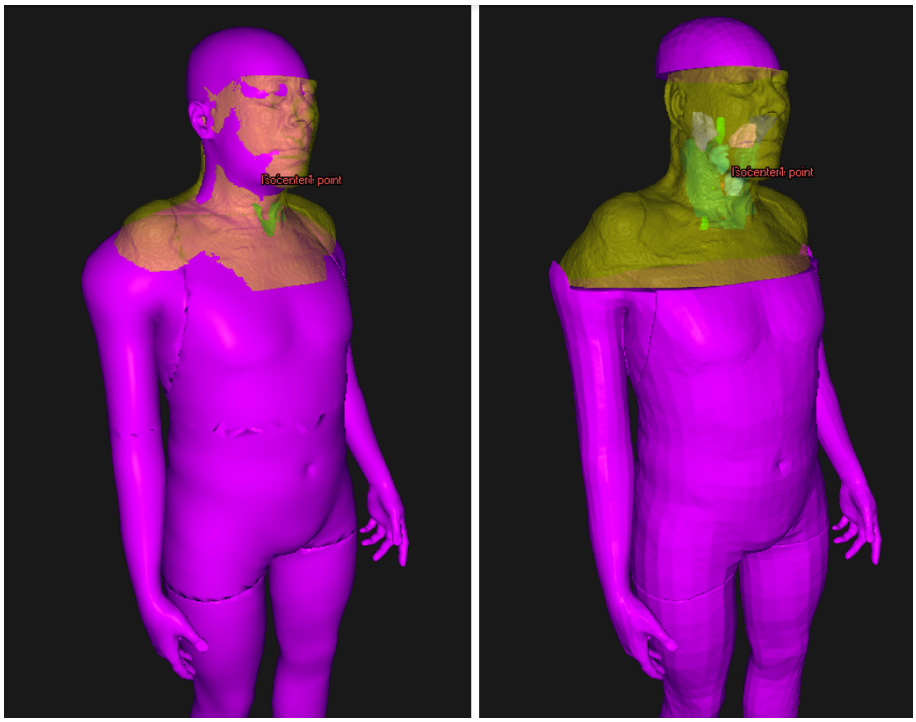

The creation of the avatar is handled by a RayStation script (script UI is shown above). If more than one CT is available, the CT image to be used is selected first in the script. The shape of the avatar is then defined by the following:

- Length
- Weight
- Body type (woman/man/child)
- Body position (arms down, arms up etc.).

The length and weight are populated automatically by data from RayCare. The body type is determined from the patient's sex and age according to the following:

- Man >= 13 years -> Man body type
- Man < 13 year -> Child body type
- Woman >= 11 year -> Woman body type
- Woman < 11 year -> Child body type

This data may be overridden in the avatar user interface. The avatar ROIs are automatically positioned in the patient coordinate system by a rigid registration to the external ROI, but the positions may be subsequently manually adjusted. Since the External ROI is included in the Collision check and often is the best representation of the true patient outline, the volume covered by the image data stack can optionally be subtracted from the avatar ROI (via the **Cut off Avatar by image data** checkbox). The effect of this function is exemplified below, where the **Cut off Avatar by image data** checkbox was selected for the avatar to the right.




## C.4 ROIS USED IN COLLISION CHECK

ROIs of type **Avatar** and **External** will always be included in the collision check. It is also possible to add other ROIs to be used in the collision check, for example fixation devices.

To include an ROI in the collision check, select the checkbox for the ROI in the **ROI properties** dialog or in the **ROI/POI details** dialog.

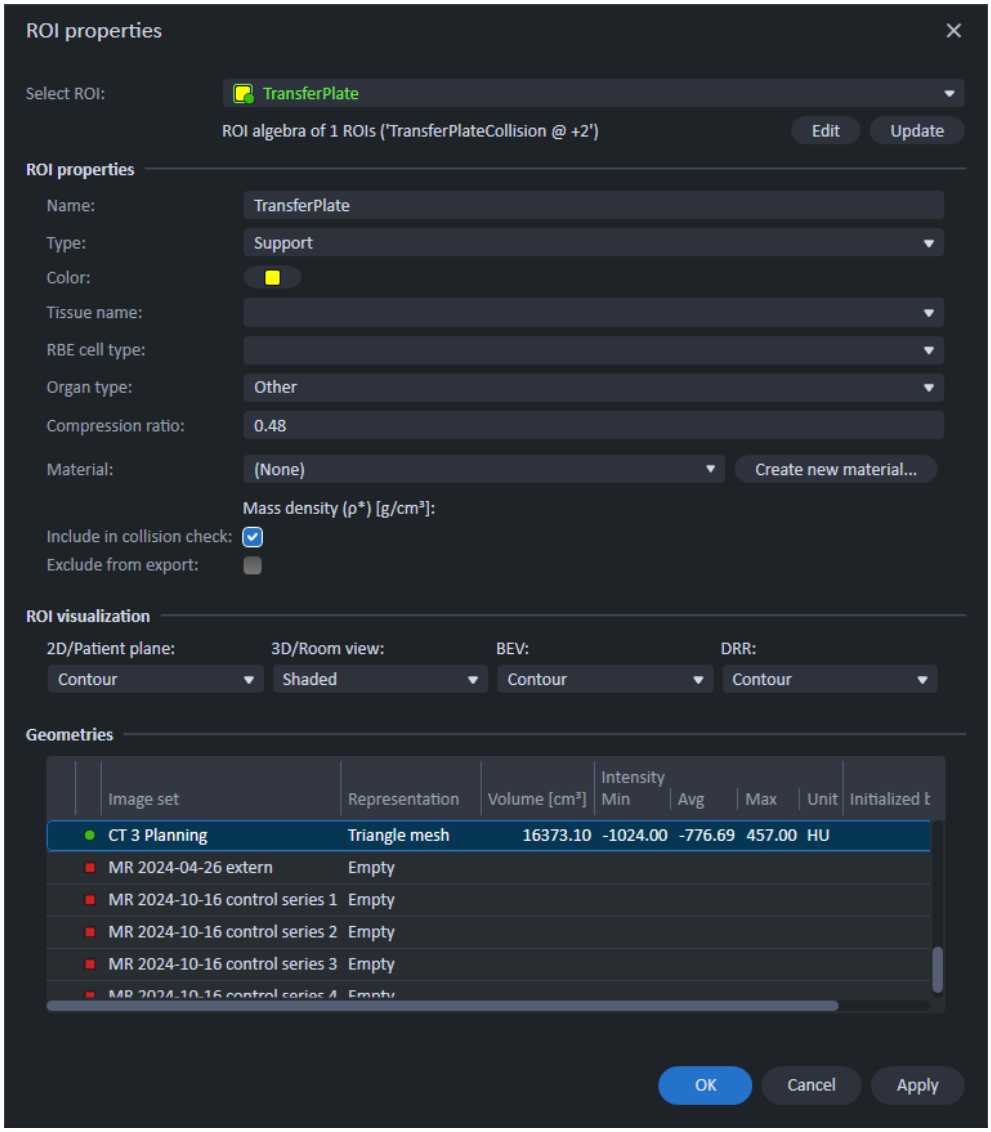



**Figure 28.** The **ROI properties** dialog.

***Note:*** *Beam set specific ROIs explicitly excluded in the beam set will not be used in the collision check.*

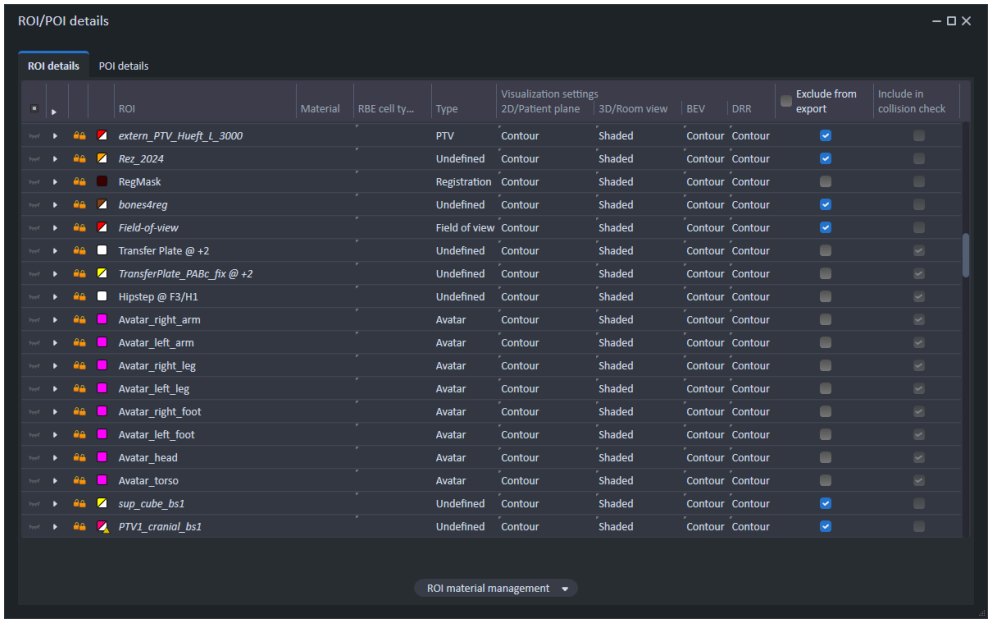
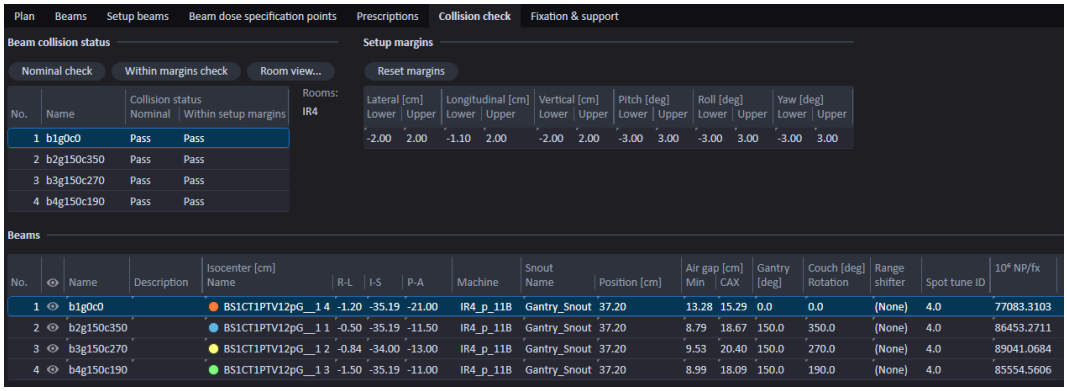



**Figure 29.** The **ROI/POI details** dialog.

## C.5 COLLISION CHECK TAB

The **Collision check** tab is the main workspace for the Collision check in RayStation, and is included in the **Plan design** and **Plan optimization** modules. The **Collision check** tab includes:

- Collision check execution buttons
- Collision status table
- Setup margins table
- List of rooms that the Collision check is performed for
- Room view execution button
- Planning parameters beams list




## C.6 COLLISION CHECK FUNCTIONS

The collision check can be performed with the patient in its nominal position (**Nominal check**), and for collisions considering the 6D movement of the table within the given setup margins (**Within margins check**). The **Nominal check** is also implicitly performed as part of the **Within margins check**. The result of these two tests is presented in the **Beam collision status** table. The status is one of the following:

- **Unknown** (if no check has been executed for the given setup)
- **Pass**
- **Fail**

**Within margins check** is performed for all possible scenarios combining the setup margin limits plus the nominal scenario (=65 scenarios). The setup margins are shown in the **Setup margins** table, with separate values for positive and negative margins. The setup margins are editable in the table, with default values of 2 cm for spatial margins and 3 degrees for angular margins. The default values are brought back by clicking the **Reset margins** button. The rotational center of the table top correction is by default taken as the center-of-mass of the primary prescription ROI.

The values of the setup margins do not refer to margins relative to the table top, but rather to the displacement of the body that leads to a counter movement of the table. For example, the scenario including a Lateral margin of +2 cm will investigate the scenario where the table is positioned at a Lateral position of −2 cm (see *section C.8 Room view on page 112*).

The treatment room which is used for the Collision check is identified by the beam model of the beam set and the treatment room settings as given in Clinic Settings. If the beam model of the current beam set serves more than one room, the Collision check is performed for all the rooms. This means that the so-called imaging device transformation (IDT) vector, which is needed for positioning the fixation devices and avatar correctly on the treatment table top and is stored per treatment room in Clinic settings, is required to be equal for the rooms that are included in a Collision check. This is verified by the Collision check algorithm. The names of the treatment rooms used in the Collision check are displayed in the **Collison check** tab.

A collision is noted if the convex hulls of the geometries of the model are within a specified contact margin. In RayStation v2025, these margins are by default set to 3 cm for collisions with snout or nozzle and is otherwise 1 cm. To change these values, contact RaySearch support.

## C.7 COLLISION STATUS INVALIDATION

The collision status is invalidated upon any change to:

- Patient plan
- Patient avatar ROIs
- Fixation ROIs
- External ROI
- Setup margin values (only Margin Collision check status)
- Plan prescription (only Margin Collision check status)

Note that the collision status is not invalidated in the following scenarios:

- The setup instructions (fixation devices and positions) have been updated in RayCare.
- The IDT vector for a room is changed after a Collision check has been executed.
- The beam set is already approved and a new ROI with **Include in collision check** selected is created.

## C.8 ROOM VIEW

**Room view** is a dialog that is opened from the **Collision check** tab.

The dialog shows a 3D rendition of the treatment room, displaying all the geometries included in the collision check for the selected beam (**Beam** drop-down list) of the current beam set. For beam sets with a beam model that is supported by more than one room, the room to be visualized is selected in the **Room** drop-down list. The motion of the robotic couch can be configured per treatment room in the corresponding configuration file.

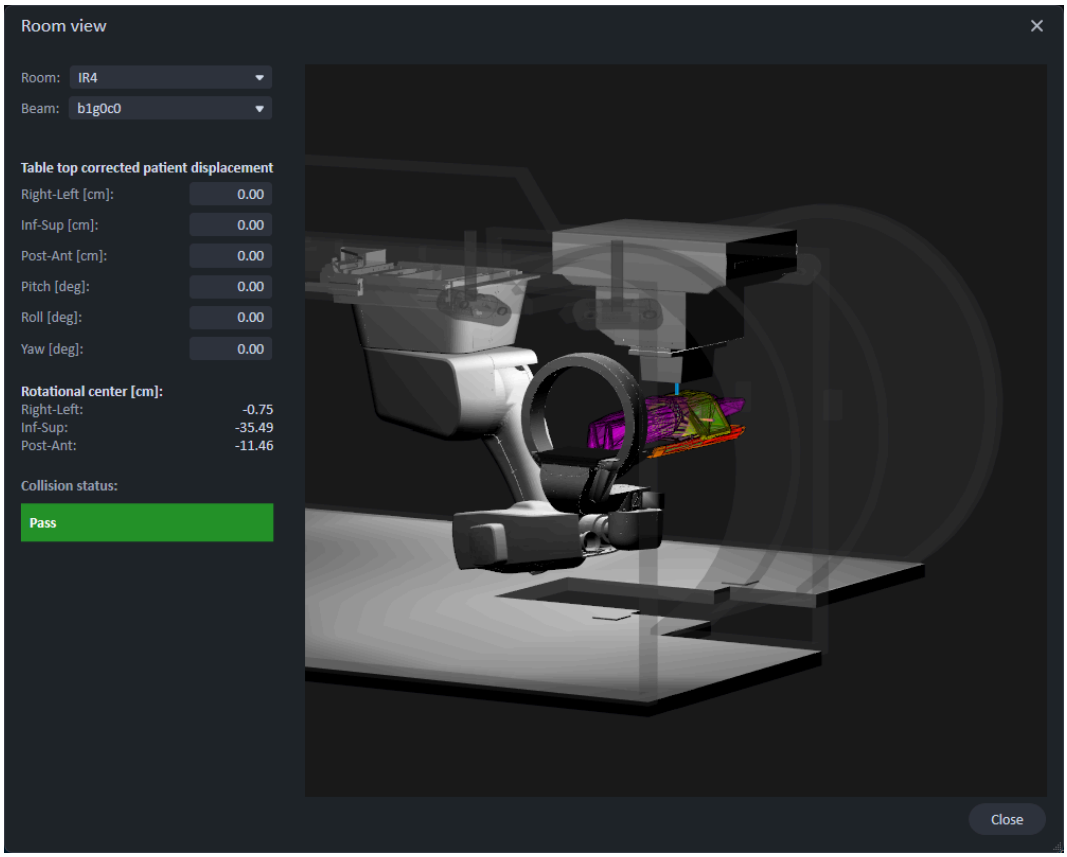
Besides investigating the nominal patient position, the **Room view** dialog also supports the possibility to study the effect of a 6D couch correction. It should be noted that the setup correction values entered in the user interface refer to the displacement of the patient and only implicitly the correction of the table since the patient displacement will generate a counter motion of the table top. However, the patient avatar will remain in its nominal position on the table top. The relation of the table top motion to the input patient displacement parameters is further explained in the table below.

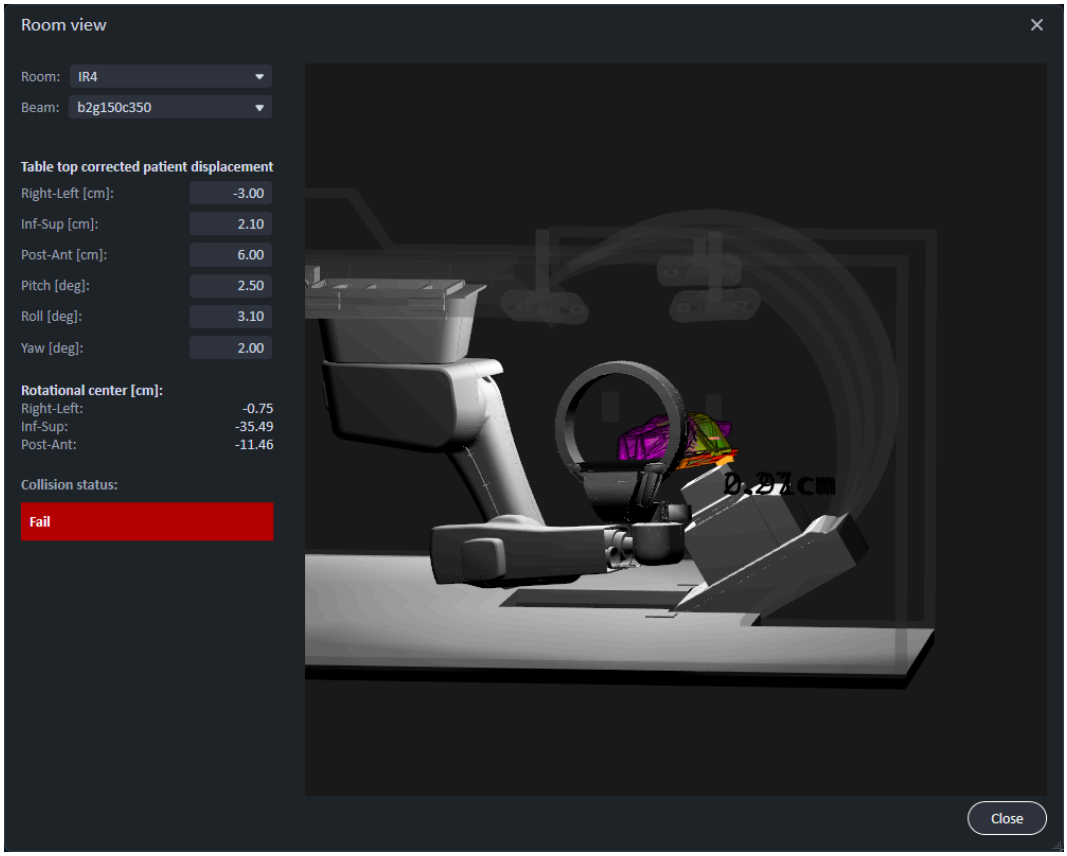
| | |
|---|---|
| Right-Left | HFS reference: Positive (negative) values indicate couch movement in patient's right (left) direction. |
| Inf-Sup | HFS reference: Positive (negative) values indicate couch movement in patient's inferior (superior) direction. |

| | |
|---|---|
| Post-Ant | HFS reference: Positive (negative) values indicate couch movement in patient's posterior (anterior) direction. |
| Pitch | HFS reference: Positive (negative) values indicate counterclockwise (clockwise) rotation as seen from patient's right side. Patient's head lowers (elevates). |
| Roll | HFS reference: Positive (negative) values indicate clockwise (counterclockwise) couch rotation as seen from patient's head. Patient's right hand lowers (elevates). |
| Yaw | HFS reference: Positive (negative) values indicate clockwise (counterclockwise) couch rotation as seen from above. Head moves to patient's left (right). |

The **Room view** dialog further indicates the collision status for the current room/beam/patient displacement. The possible states are:

- **Pass** (green)
- **Fail** (red)
- **Unreachable position** (red). Indicates that the couch robot cannot bring the table to the desired position.


Room view
Room: IR4
Beam: b1g0c0
Table top corrected patient displacement
Right-Left [cm]: 0.00
Inf-Sup [cm]: 0.00
Post-Ant [cm]: 0.00
Pitch [deg]: 0.00
Roll [deg]: 0.00
Yaw [deg]: 0.00
Rotational center [cm]:
Right-Left: -0.75
Inf-Sup: -35.49
Post-Ant: -11.46
Collision status:
Pass
Close




The information in the **Room view** is controlled via the mouse and keyboard as summarized in the table below.

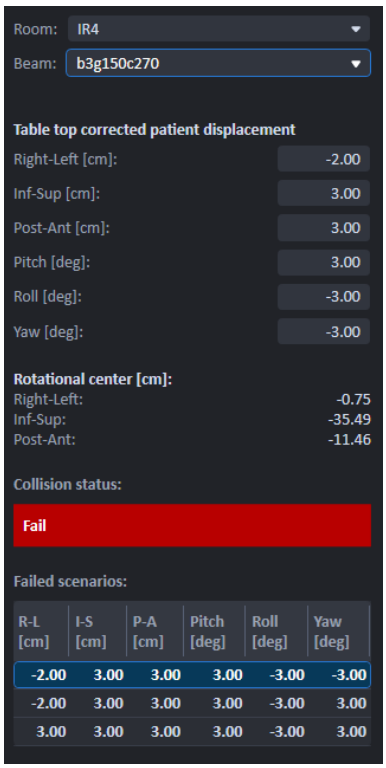
## *Keys*

| Key | Function | Description |
|---|---|---|
| Left mouse button | Rotate camera | Rotates the camera to view the room from different angles. |
| Mouse wheel | Zoom in/out | Zooms in/out to get a closer or a more distant view of the room. |
| Space | Camera reset | Sets the camera to its default position. |
| C | Show lines | Closest points of collision between objects. |

| Key | Function | Description |
|---|---|---|
| F | Show frames | Frame-of-reference of various components and their origin and rotational direction relative the reference coordinate system. |
| G | Show grid | Grid of isocentric planes. |
| Ctrl+2 | Show collision models | Shows the convex hull geometries that are used in the Collision check. |

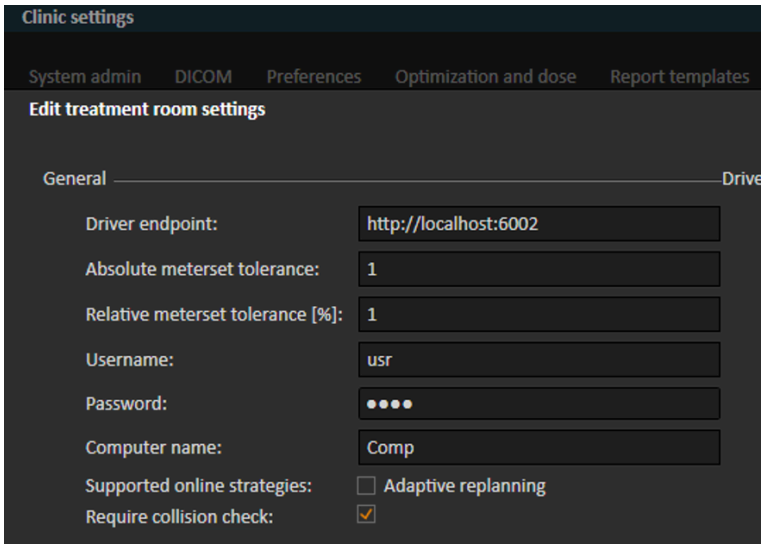
### *Investigating failed scenarios*

If the **Within margins check** fails, a list of failed scenarios for the selected beam and room is displayed in the **Room view**. A failed scenario can be shown by selecting it in the list. The **Room view** will be updated accordingly.




## C.9 PLAN APPROVAL

The user may select whether a Collision check (**Nominal** and **Within margins check**) must have been executed to allow plan approval. This is defined per treatment room and is controlled by the **Require collision check** checkbox in Clinic Settings.




At plan approval, the user will get a warning if any collision has been detected, but plan approval is not prohibited.

## C.10 PLAN REPORT

The setup margins and collision status tables are included in the plan report (see example below). If the **Require collision check** checkbox is selected in Clinic Settings (see *section C.9 Plan approval on page 116*), a Collison check must have been executed to allow plan report generation.

| Lateral [cm] | | Longitudinal [cm] | | Vertical [cm] | | Yaw [deg] | | Pitch [deg] | | Roll [deg] | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper | Lower | Upper |
| -2.0 | 1.0 | -2.0 | 2.0 | -1.00 | 2.0 | -3.0 | 3.0 | -3.0 | 3.0 | -1.00 | 3.0 |

### *Beam collision status*

| Beam # | Beam name | Collision status | |
|---|---|---|---|
| | | Nominal | Within setup margins |
| 1 | HBL | Pass | Pass |
| 2 | B2 | Pass | Fail |

## C.11 SCRIPTABLE FUNCTIONS

The following are the Collision check related actions available via scripting:

| | |
|---|---|
| NominalCollisionCheck() | Same as the **Nominal check** in the **Collison check** tab. |
| WithinMarginsCollisionCheck() | Same as the **Within margins check** in the **Collison check** tab. |
| ReadOnlyNominalCollisionCheckForBeam(..) | Performs the **Nominal check** for a given beam without affecting the collision status. |
| ReadOnlyWithinMarginsCollisionCheckForBeam(..) | Performs the **Within margins check** for a given beam without affecting the collision status. |

## C.12 SCRIPTABLE PROPERTIES

The following are the Collision check related properties available via scripting:

```
PatientSetup.CollisionProperties
   BeamCollisionStatus -> ScriptCollection
   SetupMargins -> ScriptObject
BeamCollisionStatus
   Nominal (get)
   WithinSetupMargins (get)
   FailedScenarios -> ScriptCollection
SetupMargins
   LateralLowerMargin (get/set)
   LateralUpperMargin (get/set)
   LongitudinalLowerMargin (get/set)
   LongitudinalUpperMargin (get/set)
   PitchLowerMargin (get/set)
   PitchUpperMargin (get/set)
   RollLowerMargin (get/set)
   RollUpperMargin (get/set)
   VerticalLowerMargin (get/set)
   VerticalUpperMargin (get/set)
   YawLowerMargin (get/set)
   YawUpperMargin (get/set)
   CollisionCheckScenario
   LateralShift (get)
   LongitudinalShift (get)
   PitchShift (get)
   RollShift (get)
   RoomName (get)
```

```
VerticalShift (get)
YawShift (get)
```

# D RT IMAGE AND DRR SETTINGS

## D.1 DISABLE/ENABLE CLAHE FILTER

The CLAHE filter can be disabled/enabled in the Main monitor configuration file. The filter is enabled by default.

### *Disable CLAHE filter*

1. Set the following key to `false`:

   `MainMonitor.VtkView.ApplyClaheFilter`

2. Restart the Main monitor.

### *Enable CLAHE filter*

1. Set the following key to `true`:

   `MainMonitor.VtkView.ApplyClaheFilter`

2. Restart the Main monitor.

## D.2 ADDING GENERIC PRESETS

It is possible to add generic RT image and DRR presets available for all patients, by modifying the values of the following keys:

- *MainMonitor.VtkView.VtkViewDrrRtImageVisualizationPresets.RtImageSettingsPreset*
- *MainMonitor.VtkView.VtkViewDrrRtImageVisualizationPresets.DrrImageSettingsPreset*

Both keys are found in the file *RayCommand.MainMonitor.exe.config*.

Each key value expects a list of presets that are specified in JSON format.

### *Example*

To add two DRR presets, modify the value of the key *MainMonitor.VtkView.VtkViewDrrRtImageVisualizationPresets.DrrImageSettingsPreset* to:

```
{'GroupName':'Head AP',
   'RtImageSettingsPreset': {'Invert':false,'Level':0.49,'Window':0.85,
   'Gamma':1.0,'FilterType':1, 'SharpeningAmount':0.08},
   'DrrImageSettingsPreset': {'Mip':false,'Invert':false,
   'ThresholdMin':463.0,'ThresholdMax':4000.0,'Level':0.80,'Window':1.27,
   'UseMarker':false,'MarkerThreshold':2750.0,'BoneEnhancement':0.86,
   'Gamma':1.03,'FilterType':0}

}
```

### *Available properties for RT image presets*

| Name | Required |
|---|---|
| Name | Yes |
| Invert | Yes |
| LevelWindowMin | Yes |
| LevelWindowMax | Yes |
| Gamma | Yes |
| FilterType | Yes |
| SharpeningAmount | No |
| EdgeDetectionAmount | No |

### *Available properties for DRR presets*

| Name | Required |
|---|---|
| Name | Yes |
| Mip | Yes |
| Invert | Yes |
| ThresholdMin | Yes |
| ThresholdMax | Yes |
| LevelWindowMin | Yes |
| LevelWindowMax | Yes |
| UseMarker | Yes |
| MarkerThreshold | Yes |
| BoneEnhancement | Yes |
| Gamma | Yes |
| FilterType | Yes |
| SharpeningAmount | No |
| EdgeDetectionAmount | No |

### *Filter type*

The filter type is specified using a number.

Available filter types and their corresponding numbers:

| Filter type | Number |
|---|---|
| None | 0 |
| Sharpening | 1 |
| Edge detection | 2 |

# E MOTION PLANNING

## E.1 MOTION PLANNING OVERVIEW

Motion planning can be divided into the following three steps:

1. **Planning waypoints** - Waypoints (orange circles) are inserted in between start and goal positions (blue circles). In this way, planning problems are simplified by dividing them into smaller chunks. Furthermore, certain moves can be enforced (e.g., moving around the snout in a controlled way).

**Figure 30.** Waypoints are created in between a start and goal to make a planning task more likely to succeed and to enforce certain types of moves.

2. **Planning paths between waypoints** - Next, plans (green circles) are created between each two consecutive waypoints using one of the available planning algorithms. Selection of the planning algorithm is performed based on the waypoints between which the planning is done.

**Figure 31.** A plan is created in between each two consecutive waypoints. Multiple planning algorithms are supported.

3. **Post processing** - In this step, users can regulate the interpolation density of a planned path. After the interpolation, validity checks are performed on the interpolated path.

**Figure 32.** Post processing consists of uniform interpolation and validation.

Below, each of the above mentioned steps are described in more detail. Additionally, some of the tuning parameters that the user can change to customize the planning behavior are described.

## E.2 WAYPOINTS PLANNING

The planning waypoints are generated by applying a series of policies. Which policies that are applied depends on the planning problem that needs to be solved. In the following sections, available policies are outlined.

### *Short path policy*

This waypoint policy checks if start and goal are close to each other. If they are, no other policies will be applied. This is done to avoid unnecessary movements, something that can be a consequence of applying other policies.

### *Highway path policy*

The highway path policy generates controlled moves around the snout area. Particularly, if the start waypoint and/or the goal waypoint is close to the snout, this policy will create waypoints *HighwayPathStart* and *HighwayPathGoal*, which will enforce arc shaped move around the snout. If both the start waypoint and the goal waypoint are classified as being close to the snout, this is the last policy that is applied. In that case, the resulting path looks as shown in Figure 33.

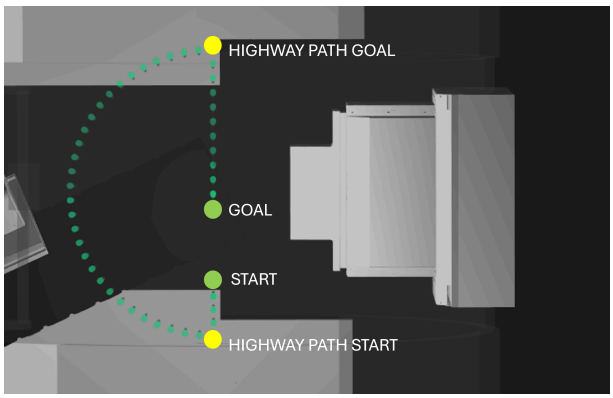



**Figure 33.** Illustration of a highway path when the start waypoint and the goal waypoint are close to the snout.

### *Auto level path policy*

When the start (resp. the goal) waypoint has a pitch or roll angle that exceeds the default limit (currently set to 1 degree), the auto level path policy creates a *StartLevel* (resp. *GoalLevel*) waypoint. The *StartLevel* (resp. *GoalLevel*) waypoint has pitch and roll angles set to zero, and other positions are the same position as the start (resp. goal) waypoint. The idea is to first make sure that the patient couch is moved to the horizontal position and after that do the main part of the planning with the default pitch and roll limits. An example is shown in Figure 34.

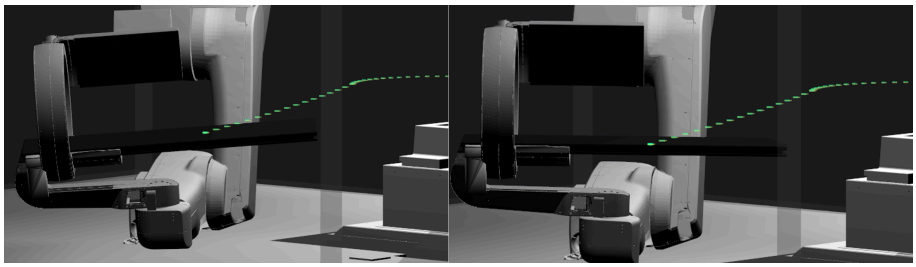


**Figure 34.** The couch starts from a position where the pitch and the roll angles exceed the default limits (left). This triggers the auto level path policy, which enforces making the couch horizontal at the beginning of the plan (right).

### *Clear snout policy*

This policy is only applied when the highway path policy does not get applied, and when the start and/or the goal waypoint is close to the snout. For instance, if the start waypoint is close to the snout, an additional waypoint *MoveAwayFromSnout* is created, which forces the planner to move from the snout before continuing to plan the rest of the movement (Figure 35).

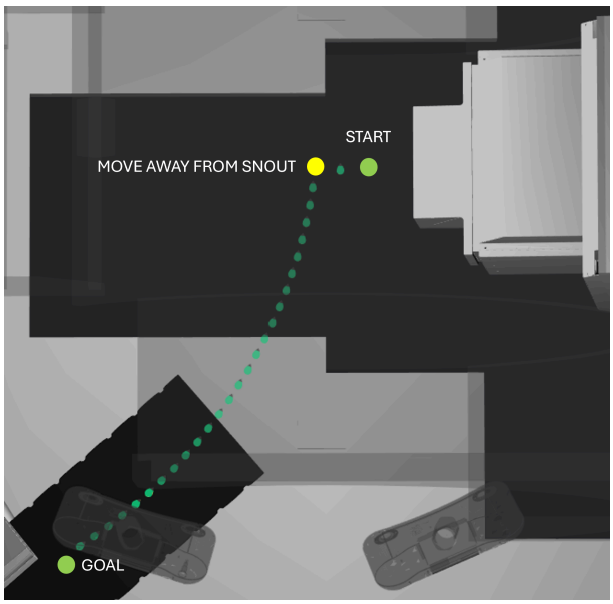



**Figure 35.** The clear snout path policy enforces moving the couch from the snout before continuing the rest of the movement.

### *Waypoint path policy*

The intention with this policy is to speed up non-deterministic planning (see *section E.3 Planning paths between waypoints on page 128*) when the yaw angle of the start waypoint is sufficiently larger than the yaw angle of the goal waypoint. It is activated only when the highway path policy

was not activated before. As shown in Figure 36, additional waypoints are inserted to split the planning problem into smaller chunks.

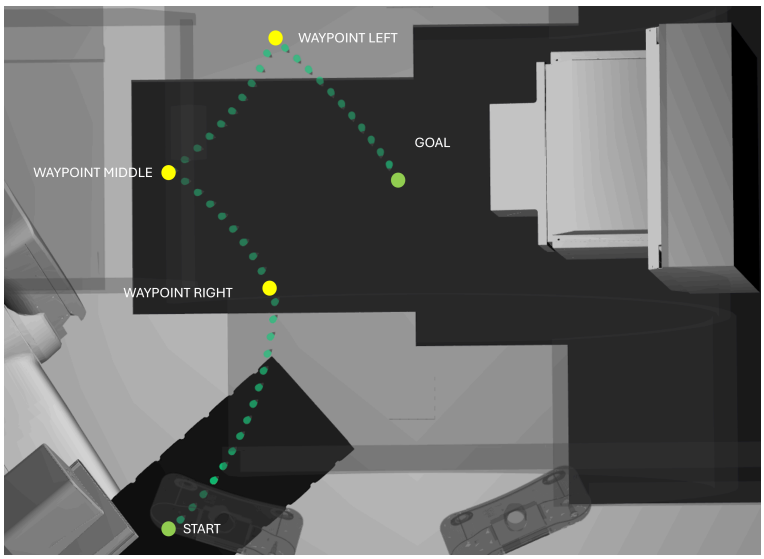



**Figure 36.** The waypoint path policy inserts additional waypoints to speed up planning in scenarios where the yaw angle difference between the start waypoint and the goal waypoint is large.

## E.3 PLANNING PATHS BETWEEN WAYPOINTS

A plan between two consecutive waypoints can be created using either a deterministic or a non-deterministic planner.

- **Deterministic planner** - Uses linear interpolation to connect two waypoints. It is fast and always produces the same path for a given start and goal positions. However, deterministic planning is sensitive to path planning involving obstacle avoidance. Thus, for this planning approach to succeed, the waypoints must be carefully selected. At this point, the deterministic planner is combined with highway path policy to plan simple and safe movements around the snout (Figure 37).

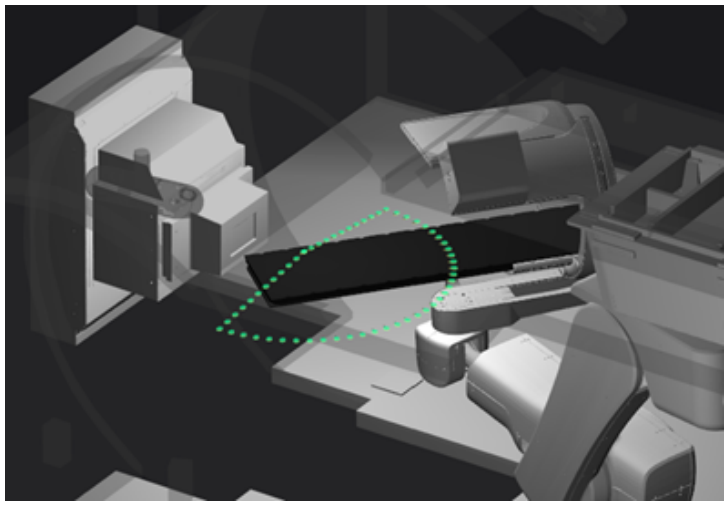


**Figure 37.** An example of a highway path, consisting of two highway path ramps (linear movements) and highway path arc (circular movement). The plan is created using highway path policy and deterministic algorithm.

- **Non-deterministic planner** - Relies on probabilistic sampling to create a path in between the waypoints. This algorithm is more flexible than the deterministic planner and can plan more difficult maneuvers. However, due to its probabilistic nature, a fixed set of inputs can result in different outputs (Figure 38). Additionally, there is less control over plans created by this planner, and the planning process may take longer than for deterministic planner.

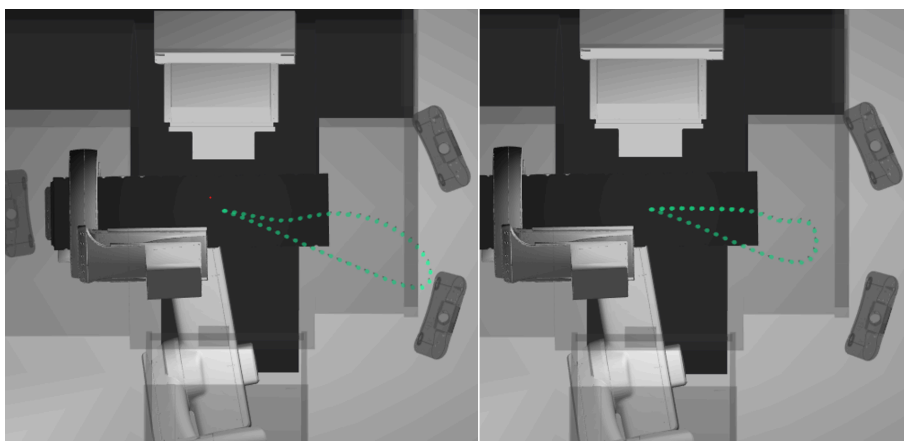


**Figure 38.** Given a fixed start and goal, non-deterministic planner can output different solution paths.

For certain types of plans, the deterministic and the non-deterministic planners can be combined (Figure 39). In this hybrid approach, the non-deterministic planner is used to move the patient

couch close to the snout and then plan the rest of the movement using the deterministic planner. This approach allows the best of both worlds:

- Flexibility of non-deterministic planner to perform obstacle avoidance and bring the patient positioning system close to the snout.
- Predictability of deterministic planner to perform controlled movements around the snout.

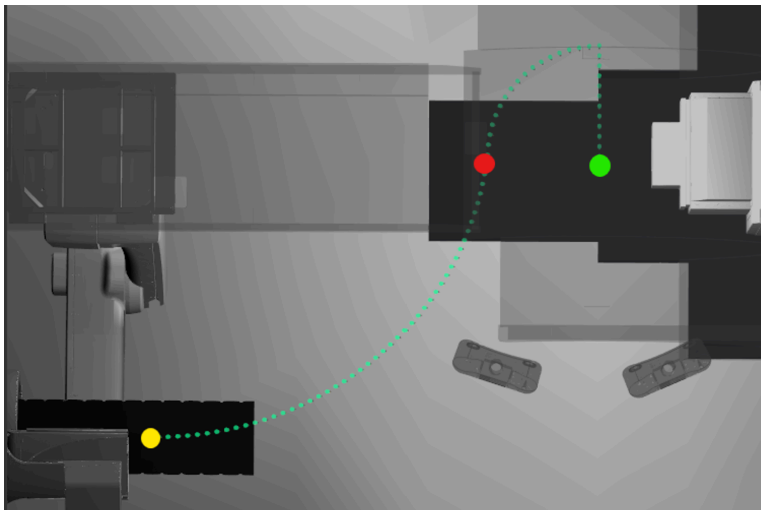


**Figure 39.** The hybrid planning: The non-deterministic planner is used to bring the robot close to the snout (the path between yellow and red). The deterministic planner is used to plan movements around the snout (the path between red and green).

Finally, both deterministic and non-deterministic planner run the following validity checks for every state of the path:

- Joint limit validity check: Verifies that the planned values of robot joints do not violate limits.
- Frame validity check: Verifies that the patient couch has allowed pitch and roll angles.
- Collision validity check: Verifies that every state is collision free.

## E.4 POST-PROCESSING

Path post-processing consists of uniform interpolation and path validation. The uniform interpolation makes sure that the distance between consecutive couch positions is roughly the same. The main reason for having this post-processing step is that some robots, when executing a path, slow down upon reaching path control points. Therefore, using large interpolation distance will reduce the number of slowdowns, thus reducing the overall execution time.

The default interpolation distance is configurable. Furthermore, custom interpolation distances can be set for certain path segments. At this point, the user can have a non-default interpolation distance for highway path ramp and highway path arc path segments. This is illustrated in Figure 40.

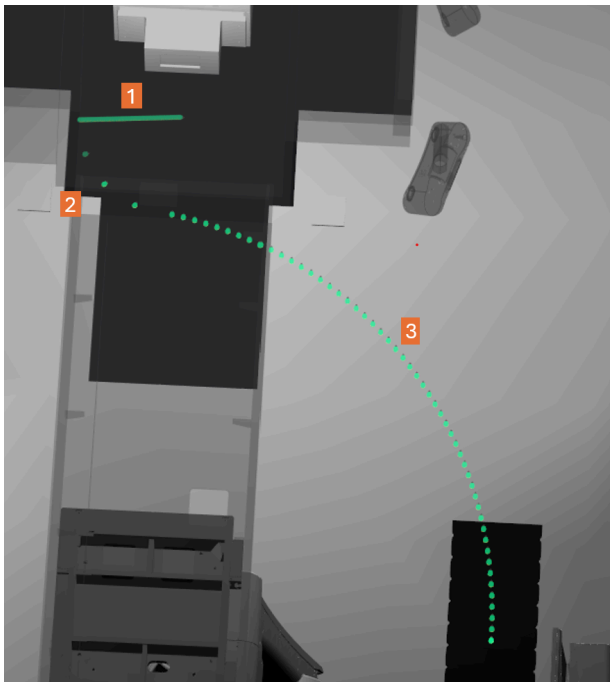



**Figure 40.** Users can set non-default interpolation distances for the highway path ramp (1) and the highway path arc (2). In this figure, the highway path ramp uses the sampling density of 1 cm, and the highway path ramp (2) uses sampling density of 20 cm. The path segment (3) uses the default value of 7 cm.

The second step of post-processing is path validation. Here, the same validity checks as in the planning step are run: joint limit, frame, and collision validity checks. This step is recommended for two reasons. First, the uniform interpolation changes the planned path, and the change positions were not validated during the planning stage. Second, it represents an extra layer of protection. This step is mandatory for the deterministic planners, since the deterministic plans get considerably changed during this stage. For the non-deterministic plans, this step can be turned off to achieve shorter planning times (not recommended).

# F ACCESS RIGHTS FOR RAYCOMMAND

The following actions in RayCommand requires authorization by a user with specific access rights.

| Action to authorize | Security operation name | AD group membership |
|---|---|---|
| Setting the MAPTA version | AdministrationRayCommand | RayCommand-Administration |
| Configuring GPU usage in RayCommand | AdministrationRayCommand | RayCommand-Administration |
| Changing the room type | AdministrationRayCommand | RayCommand-Administration |
| Editing the setup margins for the beam set | AdministrationRayCommand | RayCommand-Administration |
| Set QA plan status (in widget) | SignTreatmentSession | RayTreatment-TreatmentDeliver |
| Signing overrides when starting session | SignTreatmentSession | RayTreatment-TreatmentDeliver |
| Signing session | SignTreatmentSession | RayTreatment-TreatmentDeliver |
| Singing overrides when confirming preparation | SignTreatmentSession | RayTreatment-TreatmentDeliver |
| Approve registration | SignTreatmentSession | RayTreatment-TreatmentDeliver |
| Confirm session continuation after restart | SignTreatmentSession | RayTreatment-TreatmentDeliver |
| Enable or disable delivery of specific beam | DisableBeam | RayTreatment-TreatmentDeliver |
| Confirm non-collision checked movement | ExecuteMovementWithoutCollisionCheck | RayCommand-Users |

| Action to authorize | Security operation name | AD group membership |
|---|---|---|
| Confirm beam | ConfirmBeam | RayTreatment-TreatmentAd-min |

# G DEFINITIONS

| Term | Meaning |
|---|---|
| GPU | Graphics Processing Unit |
| BEV | Beam's Eye View |
| Control point | Position of the PPS in the treatment room according to IEC 61217:<br><br>Yaw (IEC theta, Rz),<br>X (table top lateral),<br>Y (table top longitude),<br>Z (vertical),<br>Pitch (IEC psi, Rx),<br>Roll (IEC phi, Ry) |
| DVH | Dose Volume Histogram |
| deg | Degrees |
| DRR | Digitally Reconstructed Radiograph |
| External ROI | The ROI used to define the outline of the patient in the dose computation. |
| GUI | Graphical User Interface |
| MU | Monitor Units |
| ROI | Region of Interest |
| Path | A sequence of control points. |
| Patient positioner | Collective name for the device used to place the patient on. This can typically be a treatment couch, or a chair mounted on a positioning device. |
| Trajectory | PPS speeds and accelerations through a path, calculated for the comfort of the patient, stability of the ROI, and protection of the PPS, with respect to mechanical limits and IEC standards. |

| Term | Meaning |
|---|---|
| Control console | The physical control panel provided by the manufacturer of the patient positioning system or the treatment machine. |
| PPS | Patient Positioning System |

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