



catalyst

C-RAD's cutting-edge solutions ensure exceptionally high precision, safety and efficiency in advanced radiation therapy, helping to cure more cancer patients and improve their quality of life.

C-RAD Mission Statement



Why SIGRT for SRT?

- Demand for High Accuracy
- CBCT Only in Couch Setup Position
- Get Control of Motion During Couch Rotations



Keys for Stereotactic Delivery

- Fine Treatment Beam
→ Demand for High Accuracy
- Less Fractions
→ Less Tolerances for Error
- Longer Table Time
→ Motion Matters

**All in one Solution
for SRS and SBRT!**



SG-SRT Power by C-RAD

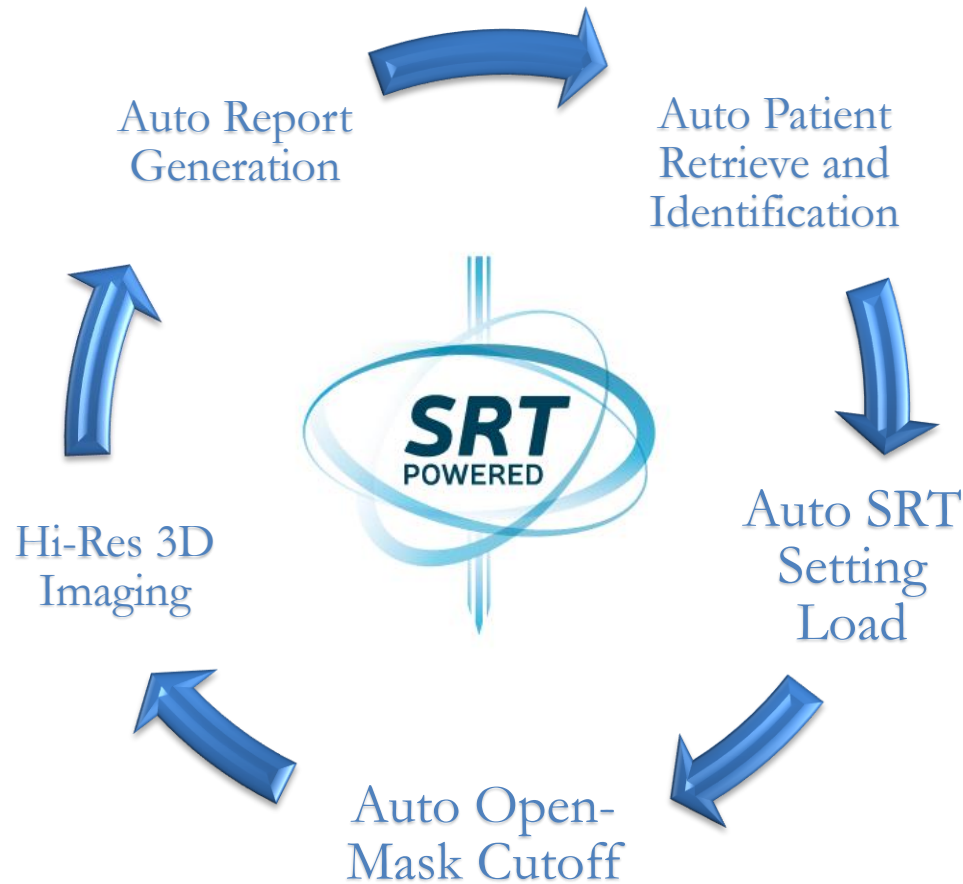


Workflow

Accuracy

QA

Intuitive SRT Workflow



Accuracy

Accuracy

Accuracy = Mean Value (abs) + Standard Deviation

Technical Specification:

Positioning SRS Accuracy with Catalyst HD	Within 0.5 mm and 1° (Mean Value + Standard Deviation) in All Directions for Rigid Body and Open Mask.
Motion Detection SRS Accuracy with Catalyst HD	Within 0.5 mm and 1° (Mean Value + Standard Deviation) in All Directions for Rigid Body and Open Mask for both Coplanar and Non-Coplanar Fields.

Accuracy

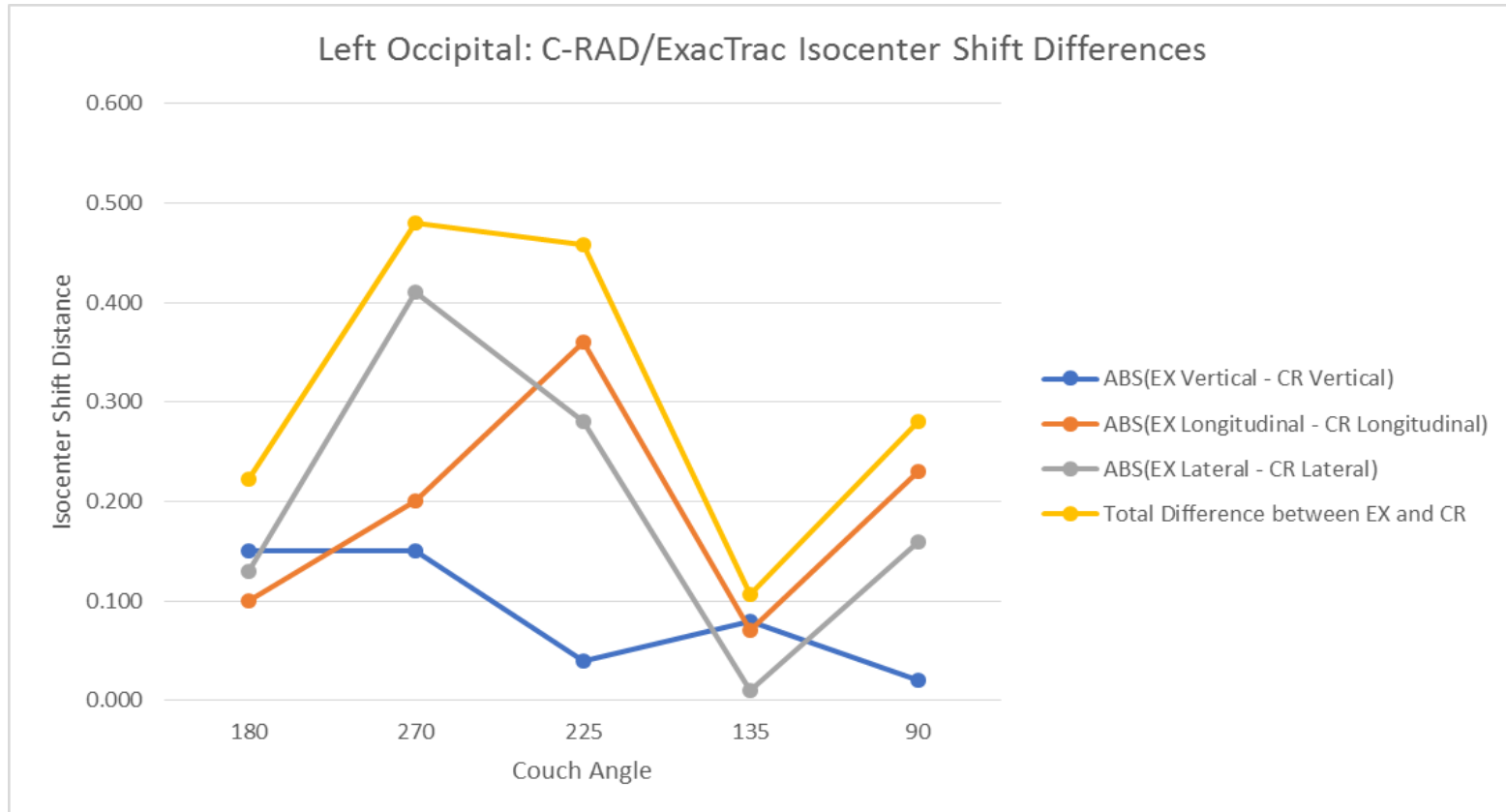
C-RAD SRS Validation Performed at Lund University, Sweden Accuracy Test Results (According to Varian Test Specification:

Isocenter Position	Max Deviation Registered in Any Direction
10 cm Between Isocenter and Surface (Middle to the Back of the Head)	Couch Rotations, All Angles, No Blocking: < 0.5 mm Couch Rotations, All Angles, With Blocking: < 0.5 mm Translations 10 mm X-Y: < 0.3 mm
15 cm Between Isocenter and Surface (Back of the head)	Couch Rotations: < 0.5 mm Couch Rotations and Blocked Side Systems: < 0.6 mm Translations 10 mm X-Y: < 0.3 mm

Accuracy

Accuracy Test Results Mays Cancer Center UT Health San Antonio MD Anderson Cancer Center

Conclusion: <1 mm Accuracy Catalyst HD vs. ExacTract



Accuracy

Michael Reiner, Klinikum der Universität München, Klinik und Poliklinik für Strahlentherapie und Radioonkologie

Conclusion on C-RAD SRS:

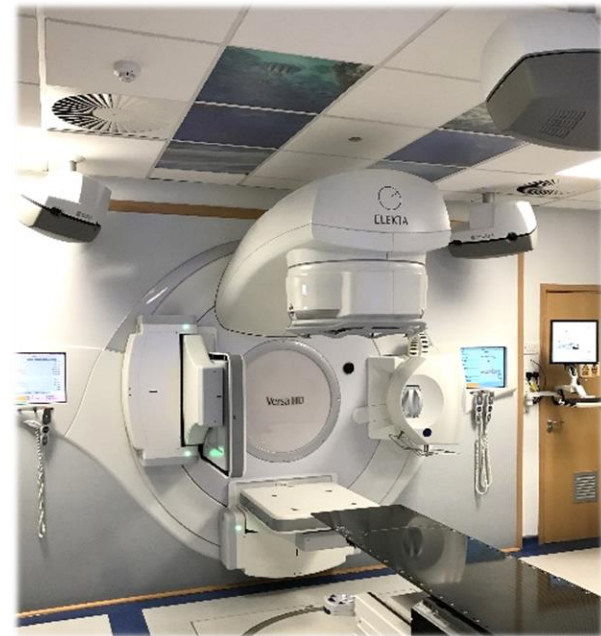
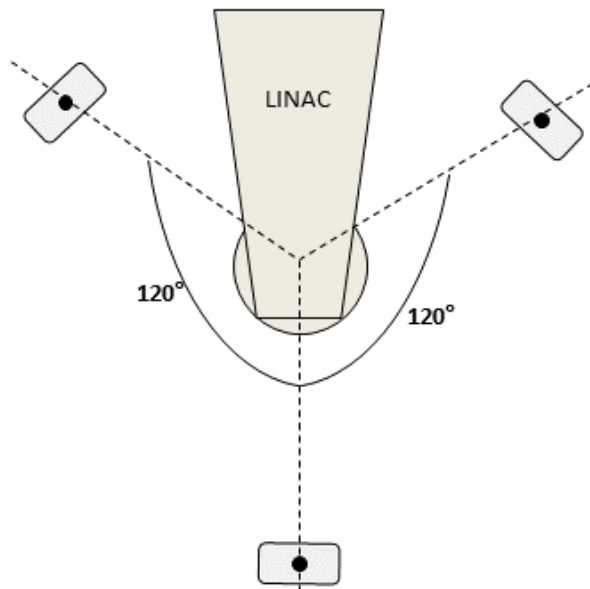
Accuracy for Isocentric Couch Rotations	≤ 1.0 mm
Reproducibility for Small Translations	better than 0.15 mm/0.05°
Reproducibility for Small Angular Deviations	better than 0.25 mm/0.10°

→ Same Range as Frame Based SRT with Bite Plate

First Clinical Experience with WBRT Patients Confirms the Results with Phantoms

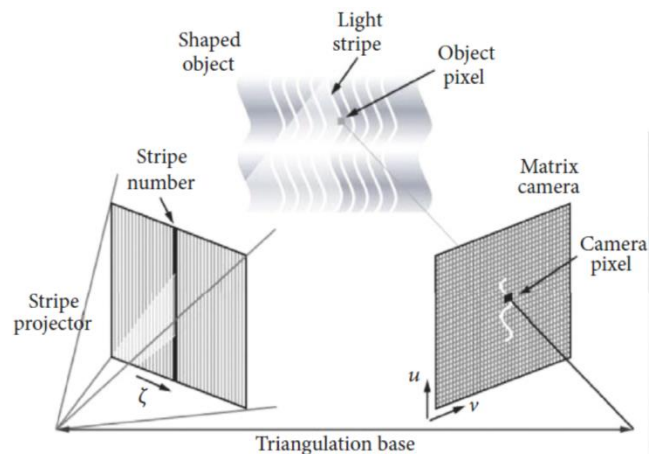
Treatment-Room Layout

- Optimal 360° Patient Coverage at any Couch Rotation
→ Maintained Precision for Non-Coplanar Field
- Fully Support Non-Coplanar SRS Treatment Delivery
- No Cameras in the Treatment Beam Line
→ Long System Life Time



Technology

- Structured Light Optical Triangulation Imaging for Capturing Patient Surface with High Resolution
- Blue Measurement Light
- Non-affected by Room Lighting Conditions (Optical Wavelength Filter)
 - No Dimming of the Room Light Required
 - No Ambient Light Dependent Impact of System Accuracy
- Red and Yellow Color Projections for Indication of Surface Discrepancy
- Cameras Equipped with Unique Shielding Against Scattered Radiation and Neutrons for Increased Life Time

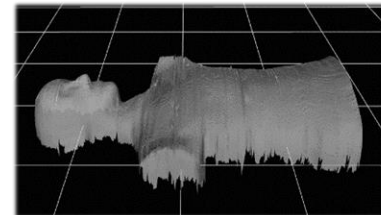


Algorithm

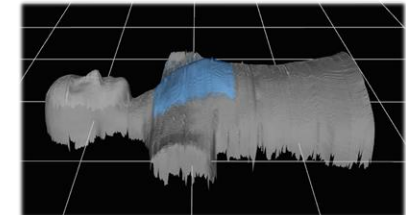
- Semi Non-Rigid Algorithm
Optimized for SRS

Illustrated Example:

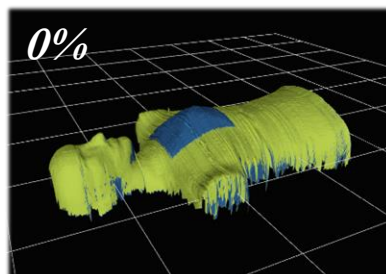
1. Live Image With Surface Discrepancy (Blue) and Whole Body Misalignment
2. Deformable Iterative Process for Surface Matching (0% -100%)



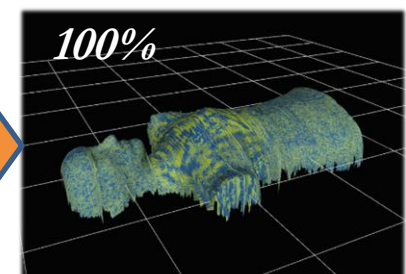
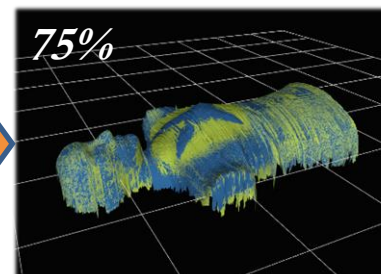
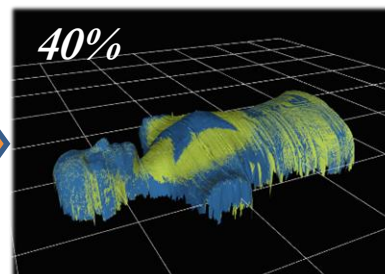
Reference Image



Live Image



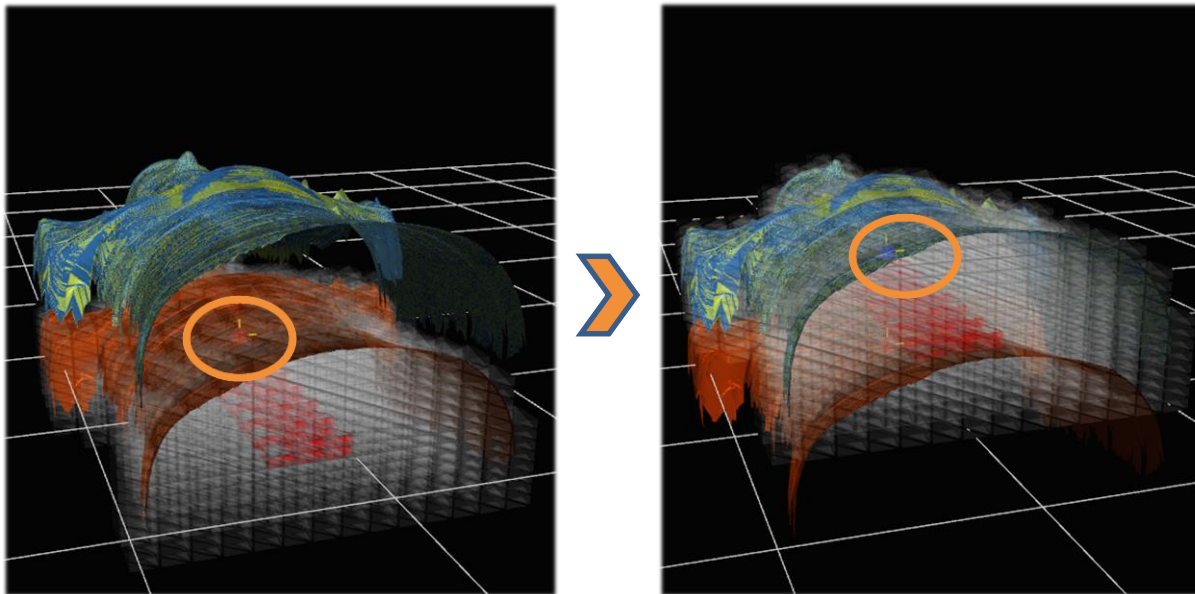
Start



Optimal Surface Match

Algorithm

3. True Volumetric Calculations for Isocenter Displacement and Correction



*Initial Reference Volume
(Isocenter Highlighted)*

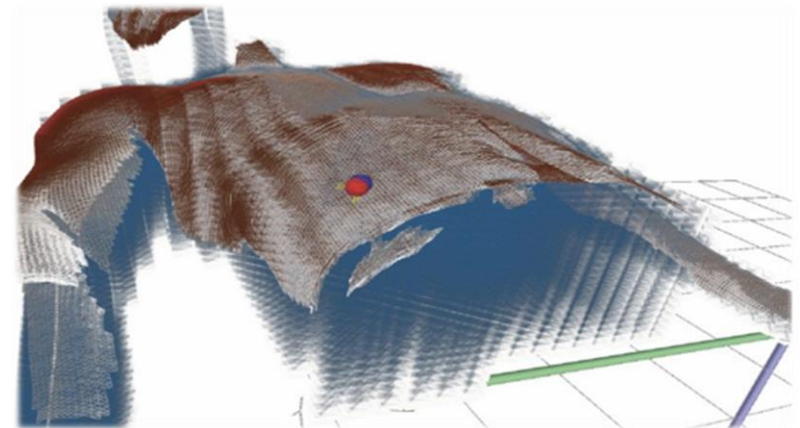
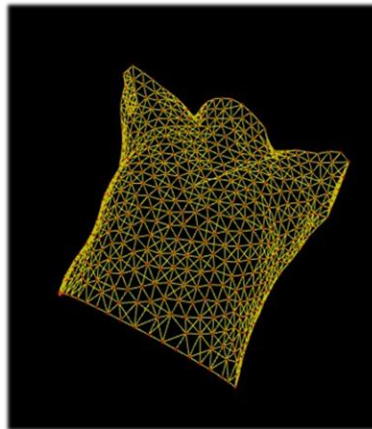
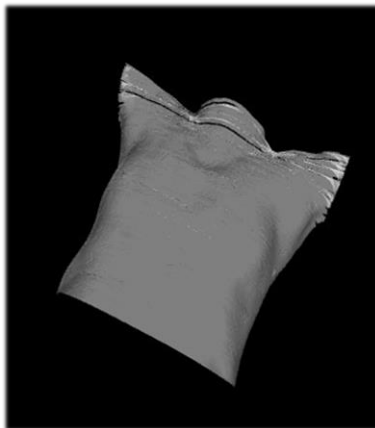
*Live Volume
(Isocenter Highlighted)*

4. Patient Positioning and Motion Management Data for Surface and 6 DOF Isocentric Alignment and Tracking

Algorithm

Benefits of Deformable Non-Rigid Algorithm

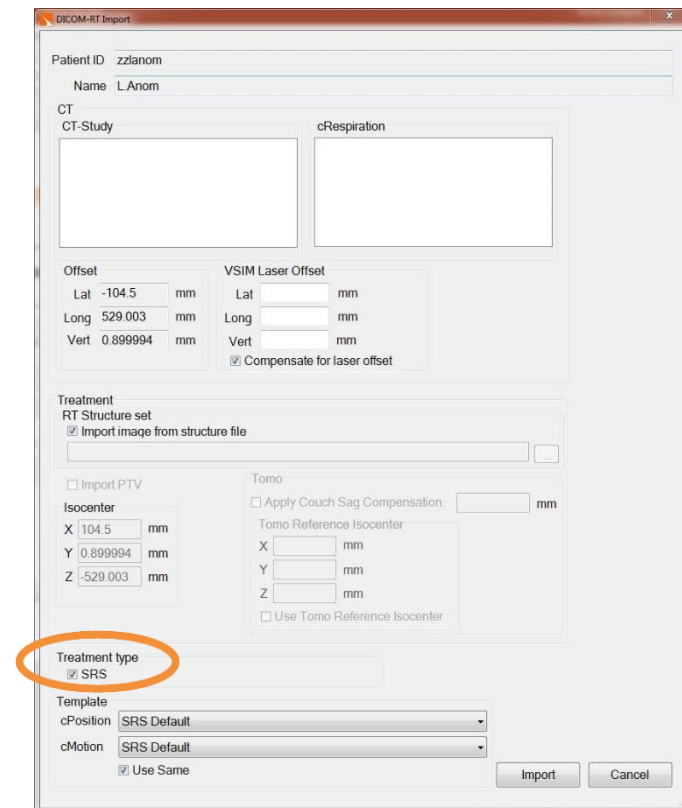
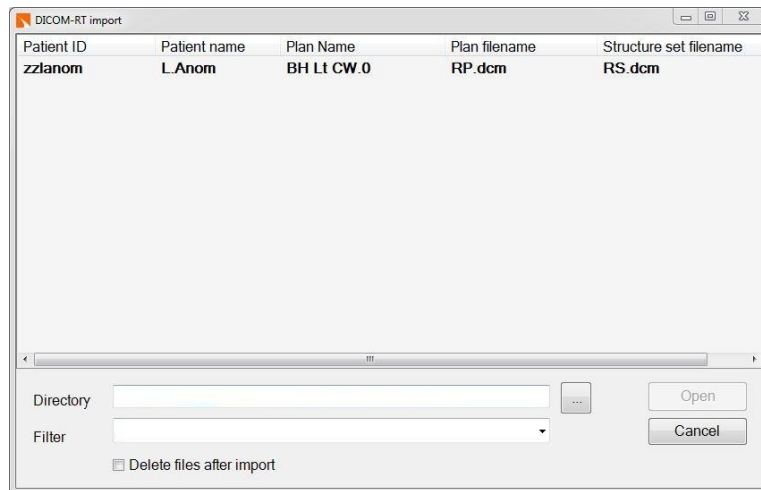
- Surface and 6 DOF Isocenter Calculations and Tolerances
- True Volume Tracking (Not Limited to ROI Calculations)
- Superior Accuracy on Isocenters Located Distal to Available Surface or Not Directly Underneath Surface by Connecting the Isocenter to Surface Through Volume Model
- Single Surface Image With no Need of Manual ROI Editing
- Deformable Algorithm Handles Eye Blinking and Patient Surface Change, No Need of Excluding Eyes or Lips



Workflow

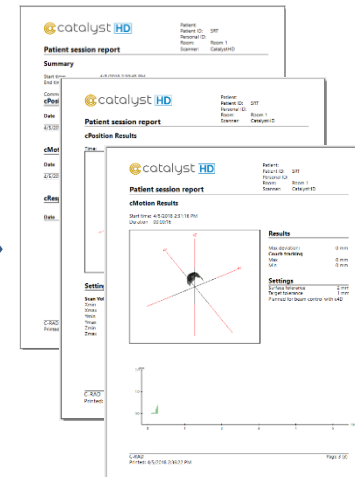
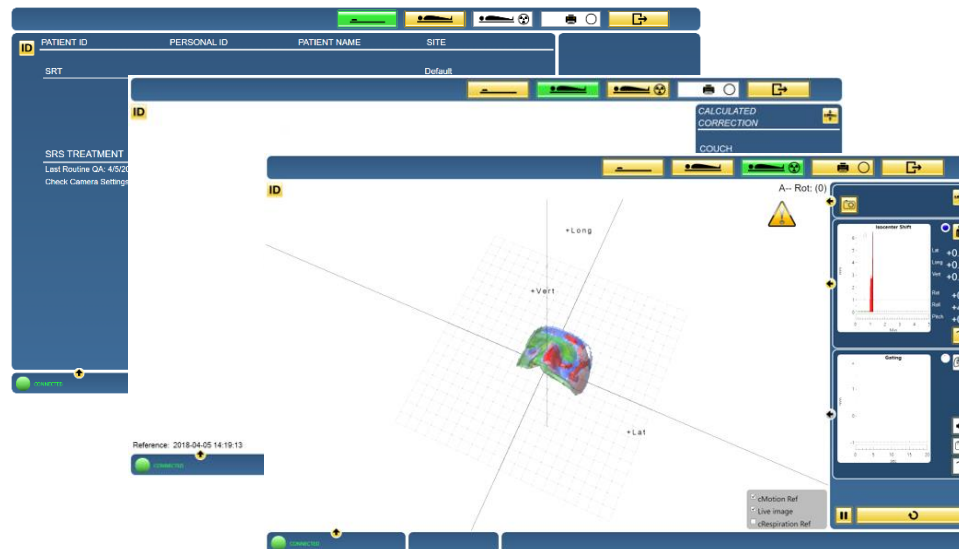
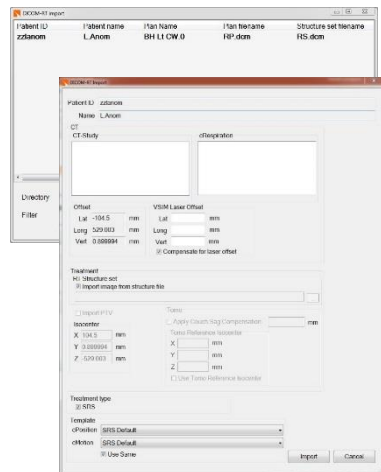
SRS Patient Import

- DICOM RT-Plan and Structure Set Import
- HighDoseTechniqueType DICOM Tag Used for Automatically Selecting the SRS Module



SRS Workflow

- Patient Import → DICOM RT-Plan and RT-Structure Set
- Pre-Setup → Auto Patient Selection and QA Check
- Patient Positioning → Surface Correction with Color Projections and Isocenter Alignment with Couch Corrections
- Treatment → Surface and Isocenter Motion Management Throughout all Treatment Field and Couch Rotations
- Session Summary → Summary of Fraction and Add Comment
- Generate Report → Fraction or Complete Treatment Reports



Varian Interoperability

Highest Level of Integration for Ease of Use and Safety Through Automation

- Vendor Interoperability Partners Since 2011
- Joint Validation on cSeries 2011 and TrueBeam 2015 for Catalyst and Catalyst HD
- Only SIGRT System Validated for Both FB and DIBH Respiratory Gating
- Validated for SRS
- Full ARIA and Mosaiq R&V Integration

Third-party Product Interoperability

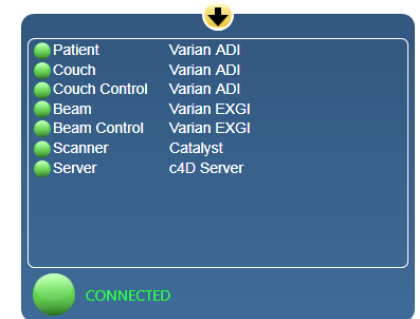


- Catalyst™ System and Catalyst HD™ System (TrueBeam and C-Series)

(Varian Homepage)

Varian Interoperability

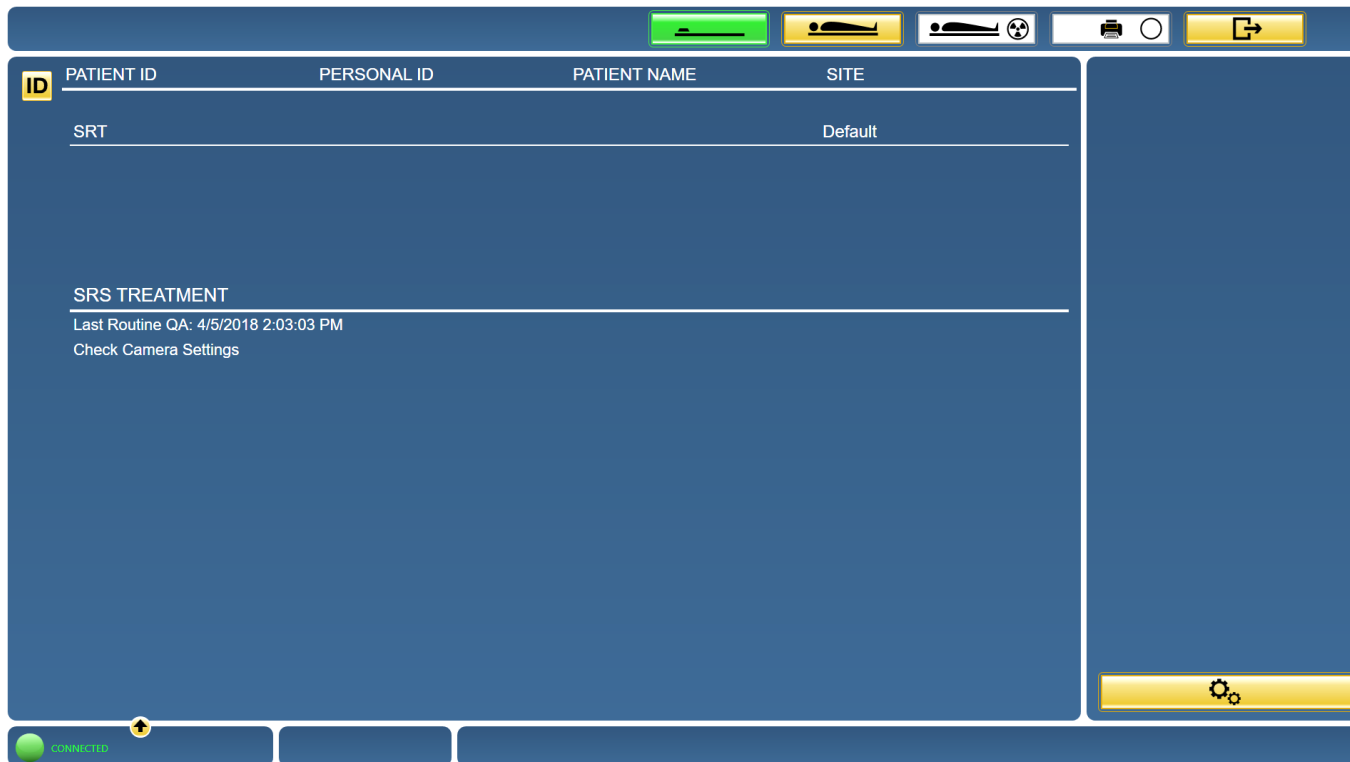
Highest Level of Integration for Ease of Use and Safety Through Automation



- Patient Synchronization – *ADI*
 - Automatically Load the Correct Patient
 - Verifies Patient ID, Plan ID, Field Name and Couch Rotation
- Couch Status – *ADI*
 - Receives Real-time Actual Couch Coordinates
- Couch Control – *ADI*
 - Capability of Sending Couch Corrections for a Time Efficient and Safe Patient Alignment
- Beam Status – *EXGI*
 - Receives Real-time Treatment Beam Status
- Beam Control – *EXGI*
 - Capability of Trigger Beam Hold for Motion Management and Respiratory Gating

Pre-Setup

- Linac Synchronization for Auto Patient Selection
- Auto QA Check
- Information Displayed Regarding SRS Treatment



The screenshot displays the C-RAD software interface. At the top, there is a navigation bar with several icons: a green bar with a white icon, a yellow bar with a black icon of a person lying down, a white bar with a black icon of a person lying down and a radiation symbol, a white bar with a printer icon and a circle, and a yellow bar with a white icon of a document with an arrow. Below this is a table with the following columns: ID, PATIENT ID, PERSONAL ID, PATIENT NAME, and SITE. The table contains one row with the value 'SRT' under PATIENT ID and 'Default' under SITE. Below the table, there is a section titled 'SRS TREATMENT' with the text 'Last Routine QA: 4/5/2018 2:03:03 PM' and 'Check Camera Settings'. At the bottom left, there is a green circle with the word 'CONNECTED' and a small yellow icon. At the bottom right, there is a yellow bar with a gear icon.

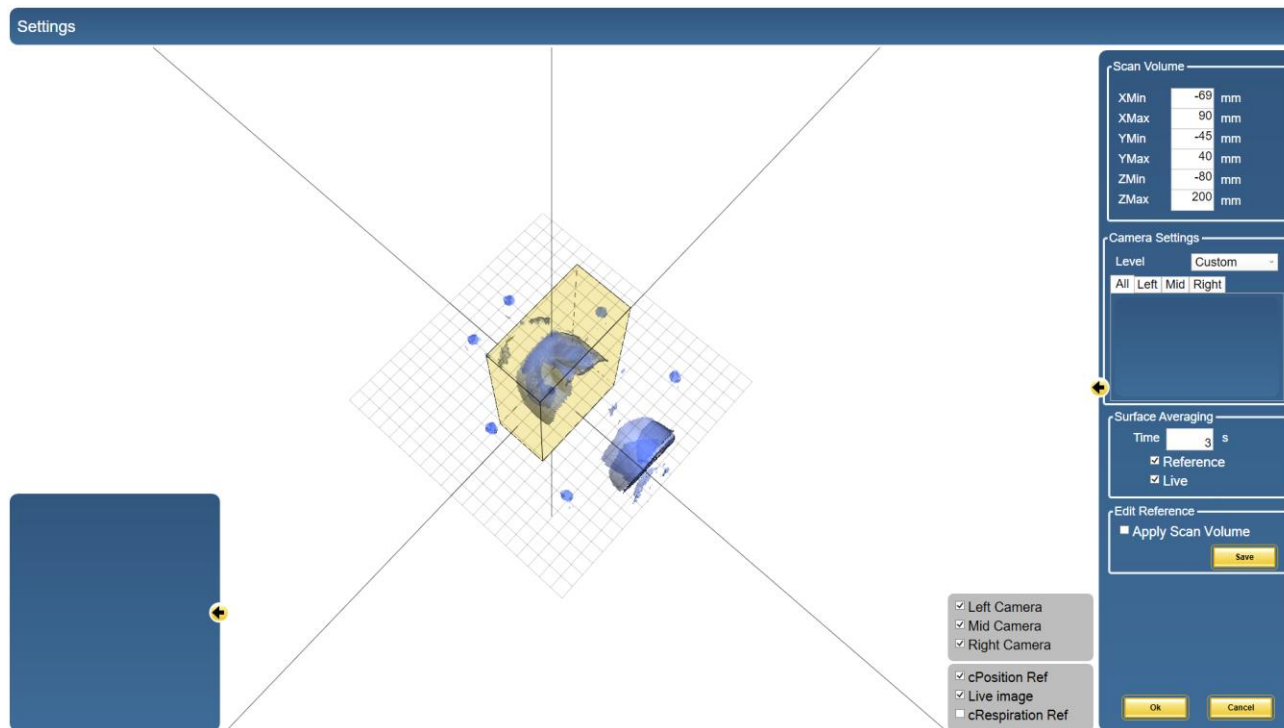
ID	PATIENT ID	PERSONAL ID	PATIENT NAME	SITE
	SRT			Default

SRS TREATMENT
Last Routine QA: 4/5/2018 2:03:03 PM
Check Camera Settings

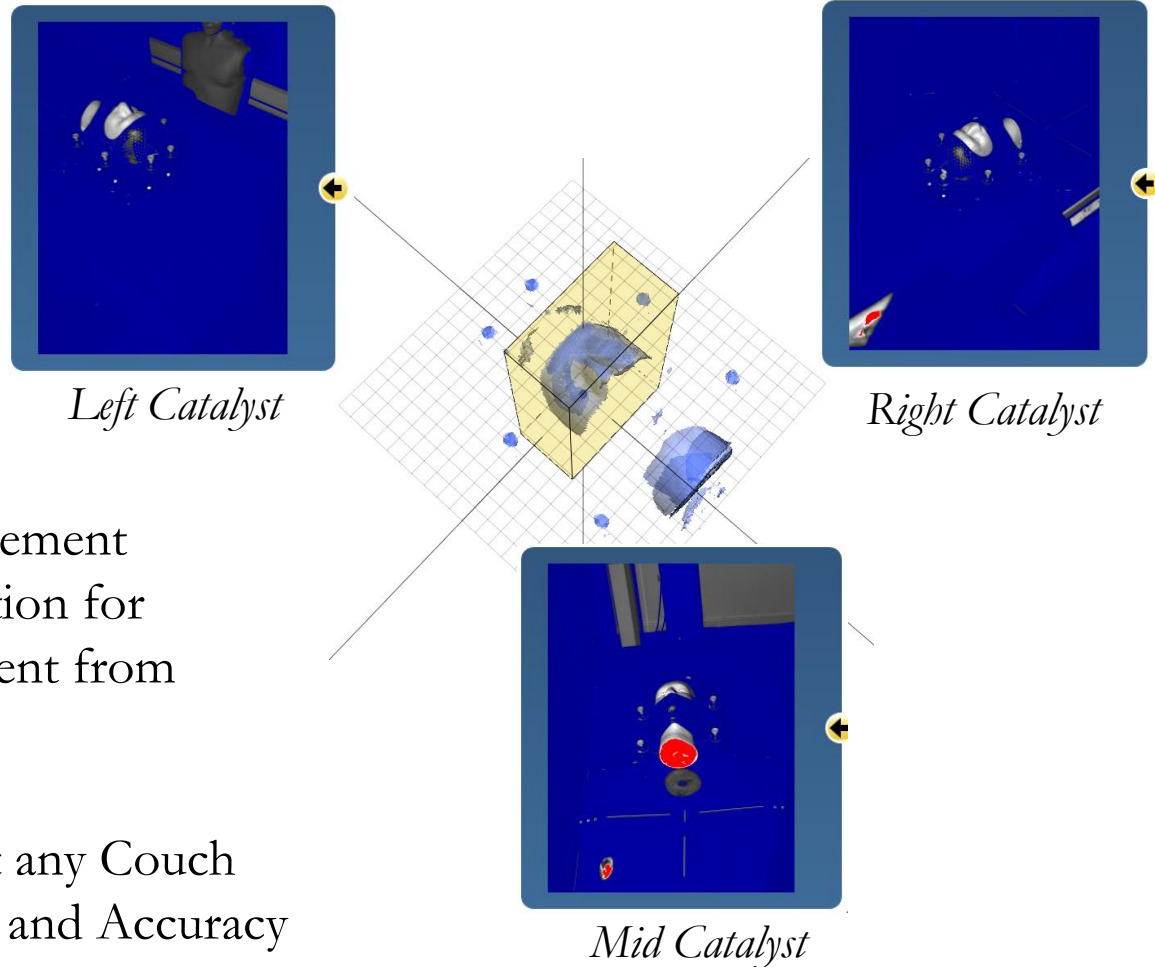
CONNECTED

Settings

- Define Scan Volume
- No Manual ROI Selection
- Auto Crop Functionality
- Detects the Skin, Not the Mask
- High Precision Camera Imaging (SRS Specific, x4 Higher Resolution)
- Registration HD Calculations Active for SRS



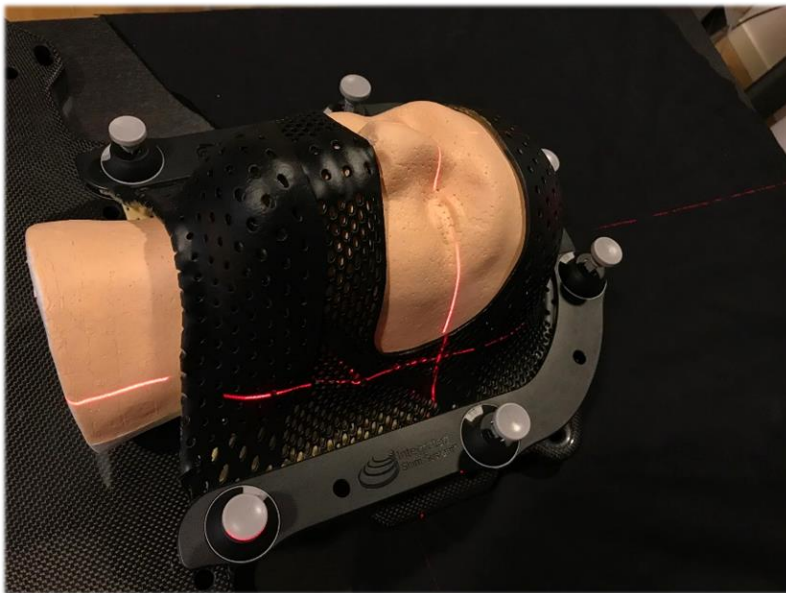
Optimal 360° Coverage



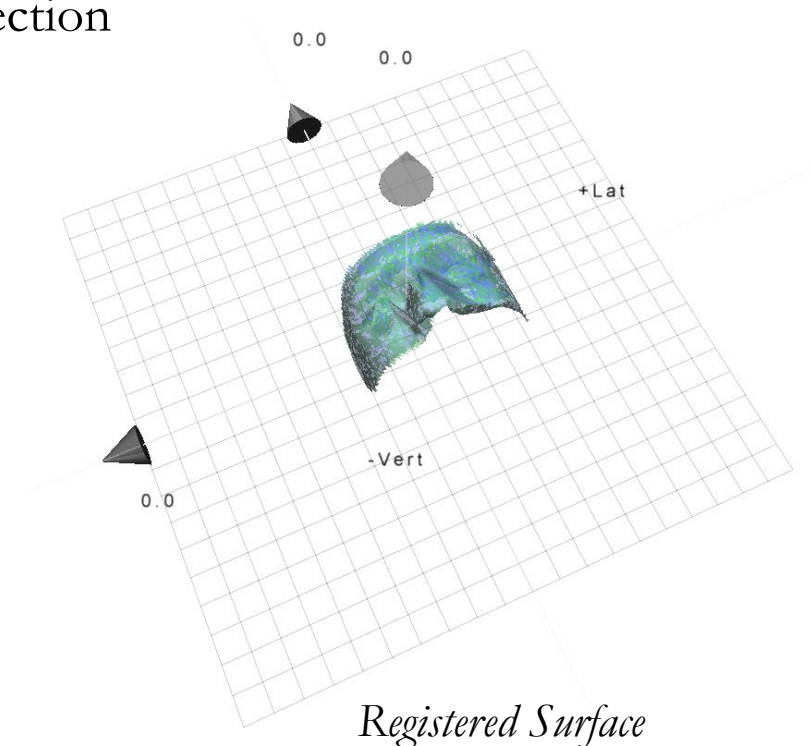
- The Unique C-RAD Arrangement Minimizes Camera Obstruction for Highest Accuracy Independent from Couch Angle
- Optimal Patient Coverage at any Couch Angle to Maintain Precision and Accuracy for all Non-Coplanar Fields

Open Mask – Auto Crop

- Auto Crop Functionality
 - No Need of Manual ROI Editing
 - Ease of Use and Time Efficiency
- Detects the Skin, Not the Mask
 - Increased Sensitivity in Motion Detection



Phantom Setup



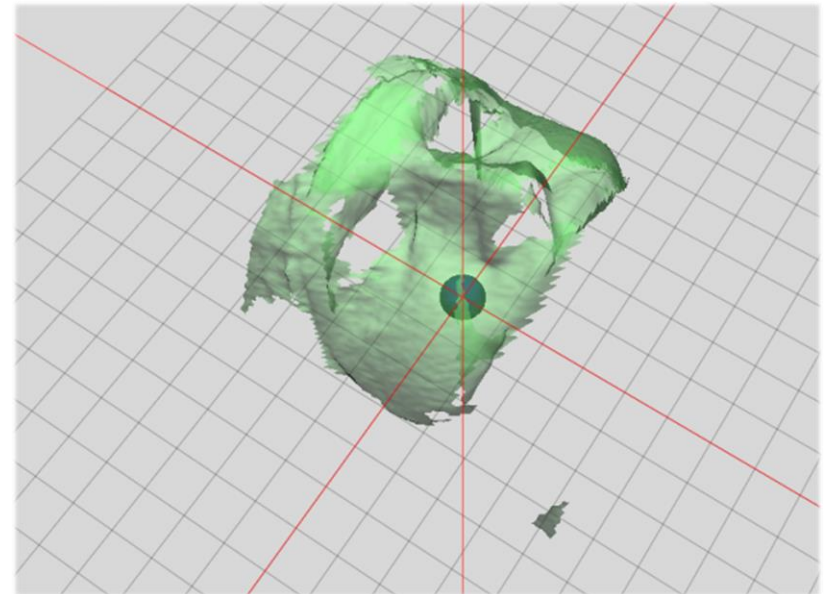
Registered Surface

Open Mask – Auto Crop

- Auto Crop Functionality
 - No Need of Manual ROI Editing
 - Ease of Use and Time Efficiency
- Detects the Skin, Not the Mask
 - Increased Sensitivity in Motion Detection



Patient

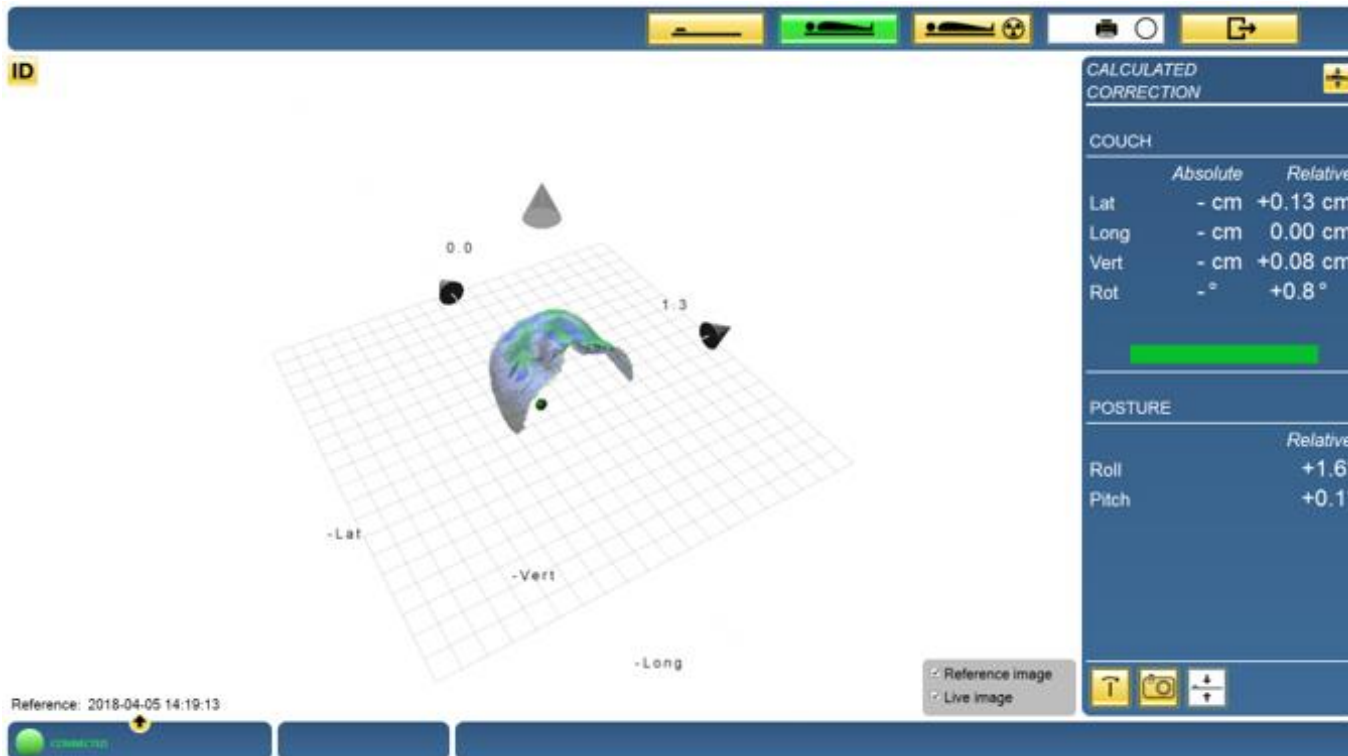


Registered Surface



PATIENT SETUP AND POSITIONING

- Surface Discrepancy Indicated by Dual Color Projection on Patients Skin
- 6 DOF Isocenter Calculations and Tolerances
- True Volume Calculations
- Couch Read and Control Interface



The screenshot displays the C-RAD software interface. At the top, there is a navigation bar with icons for different patient positions. Below this, the main workspace shows a 3D model of a patient's head and neck on a grid. The grid axes are labeled -Lat, -Vert, and -Long. A green bar indicates the surface discrepancy. On the right side, there is a control panel with the following data:

CALCULATED CORRECTION		
COUCH		
	Absolute	Relative
Lat	- cm	+0.13 cm
Long	- cm	0.00 cm
Vert	- cm	+0.08 cm
Rot	- °	+0.8 °

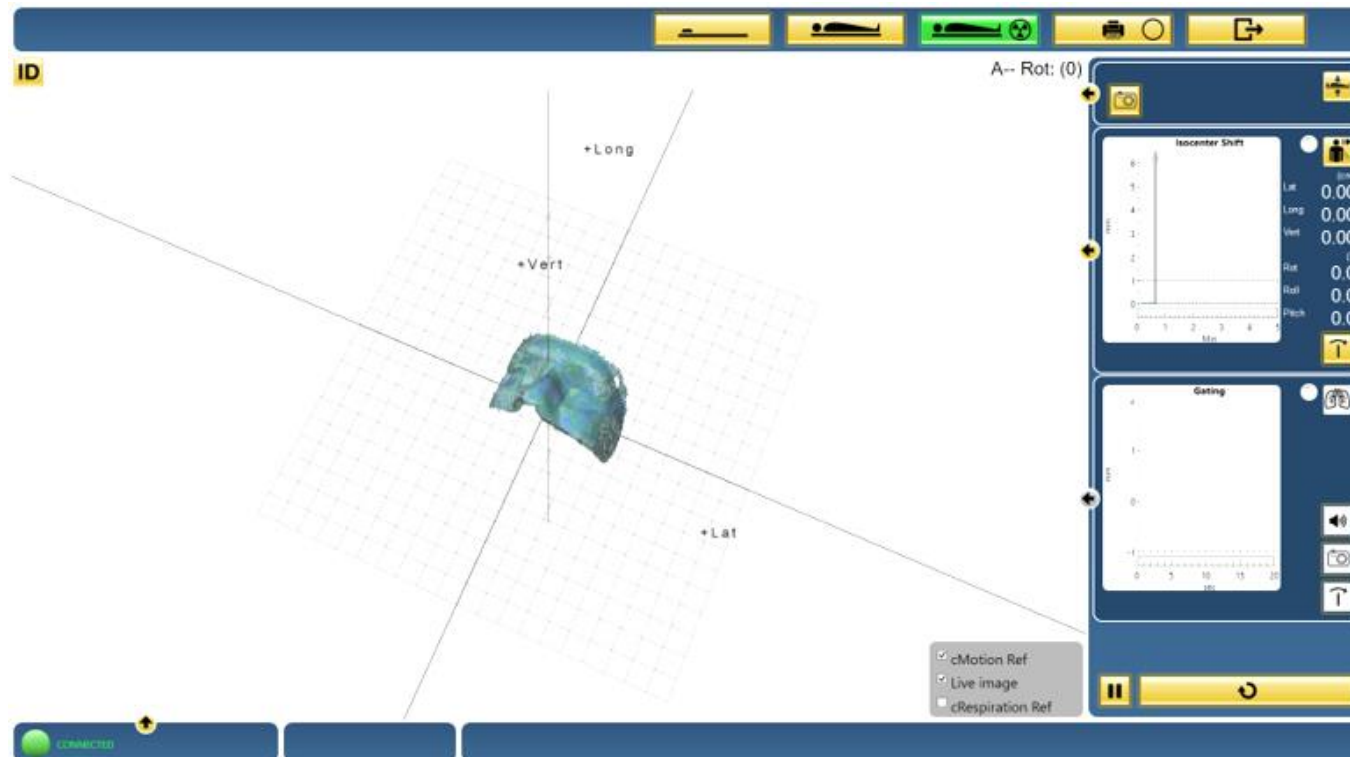
POSTURE	
	Relative
Roll	+1.6 °
Pitch	+0.1 °

At the bottom left, there is a reference timestamp: Reference: 2018-04-05 14:19:13. At the bottom right, there are icons for Reference image and Live image.



INTRA-FRACTION MOTION DETECTION

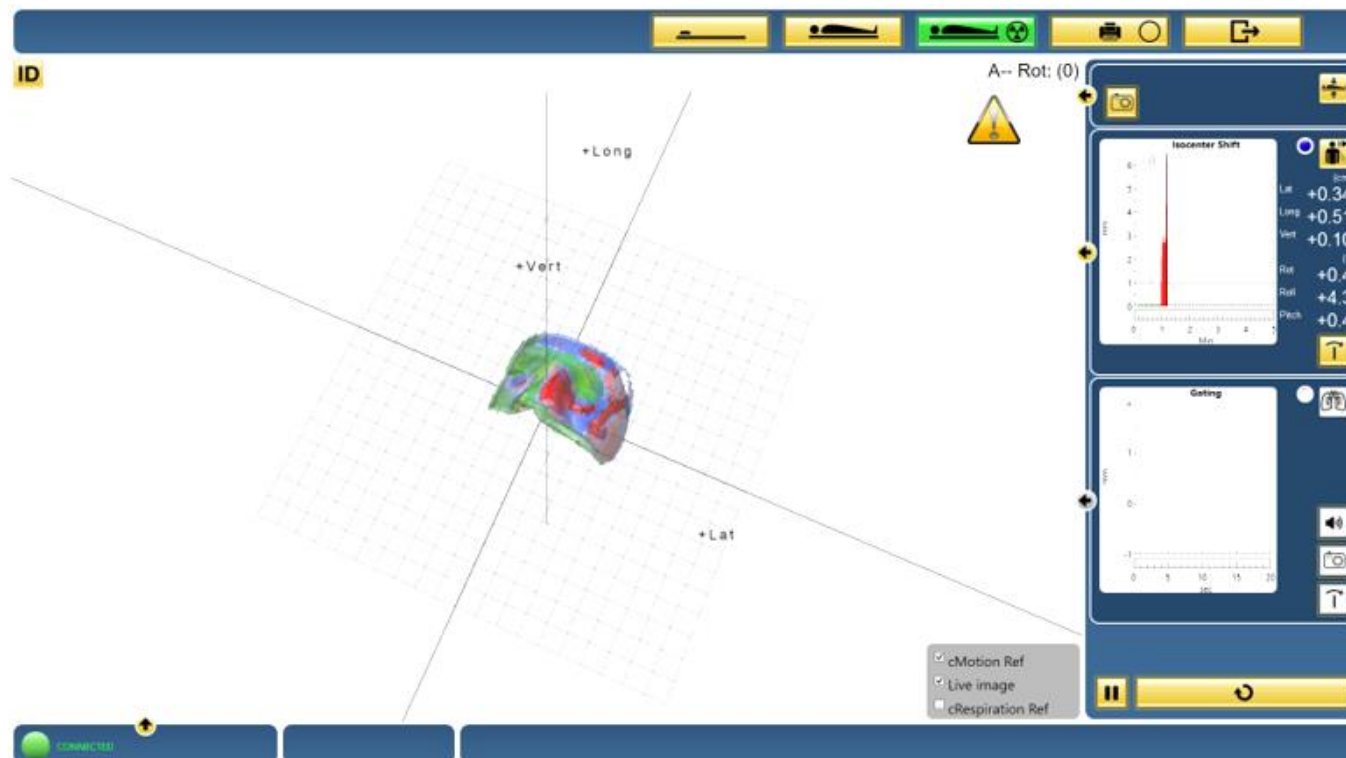
- Surface Discrepancy Indicated by Color Code on Surface Image
- 6 DOF Isocentric Displacement Calculations
- True Volumetric Tracking
- Beam Status and Control Interface





INTRA-FRACTION MOTION DETECTION

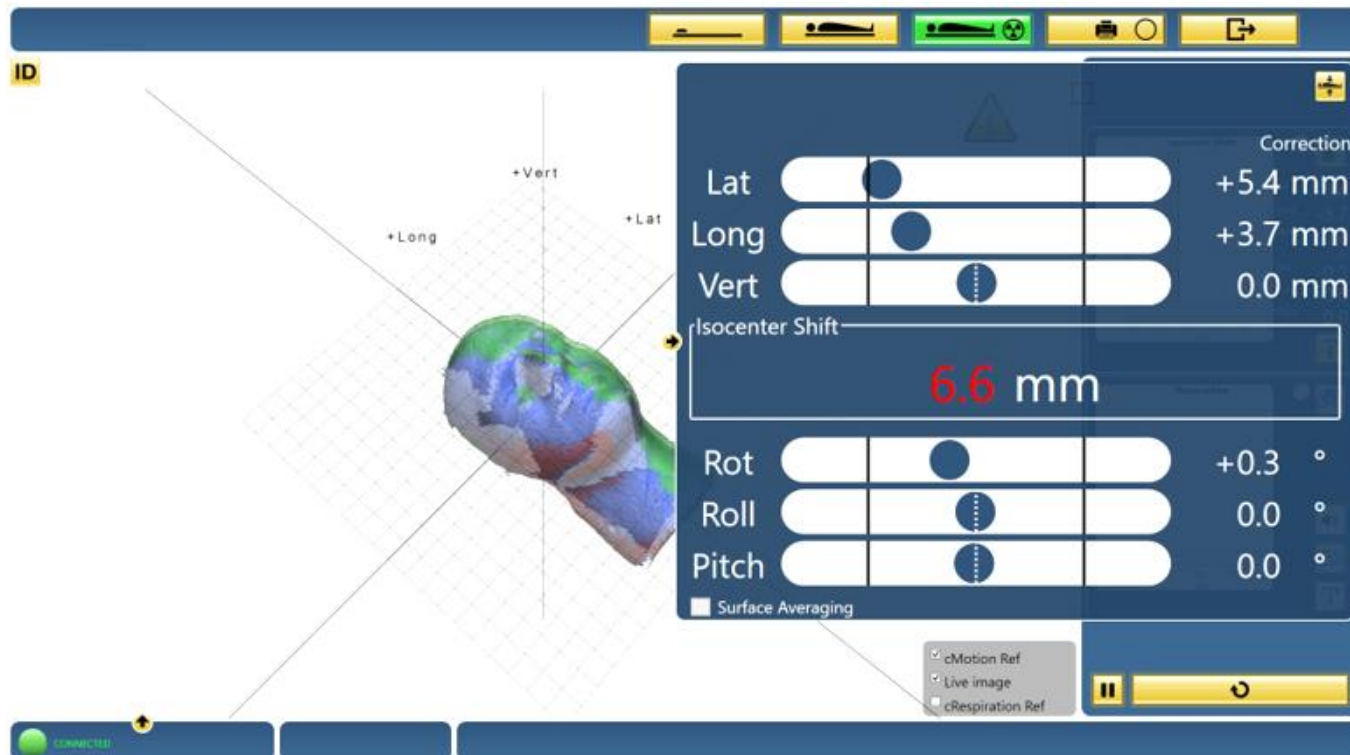
- Beam Hold Triggered by Surface and/or Isocenter Displacement
- Individual Tolerances for Isocenter and Surface
- Visual and Audio Alarm





INTRA-FRACTION MOTION DETECTION

- Expandable Isocenter Displacement and Correction Module Available at Treatment (SRS Specific)



The screenshot displays the C-RAD software interface for motion detection and correction. The main window shows a 3D model of a patient's head and neck, overlaid on a grid. The grid is labeled with axes: +Vert (vertical), +Long (longitudinal), and +Lat (lateral). A yellow arrow points to the model. On the right side, there is a control panel with the following settings:

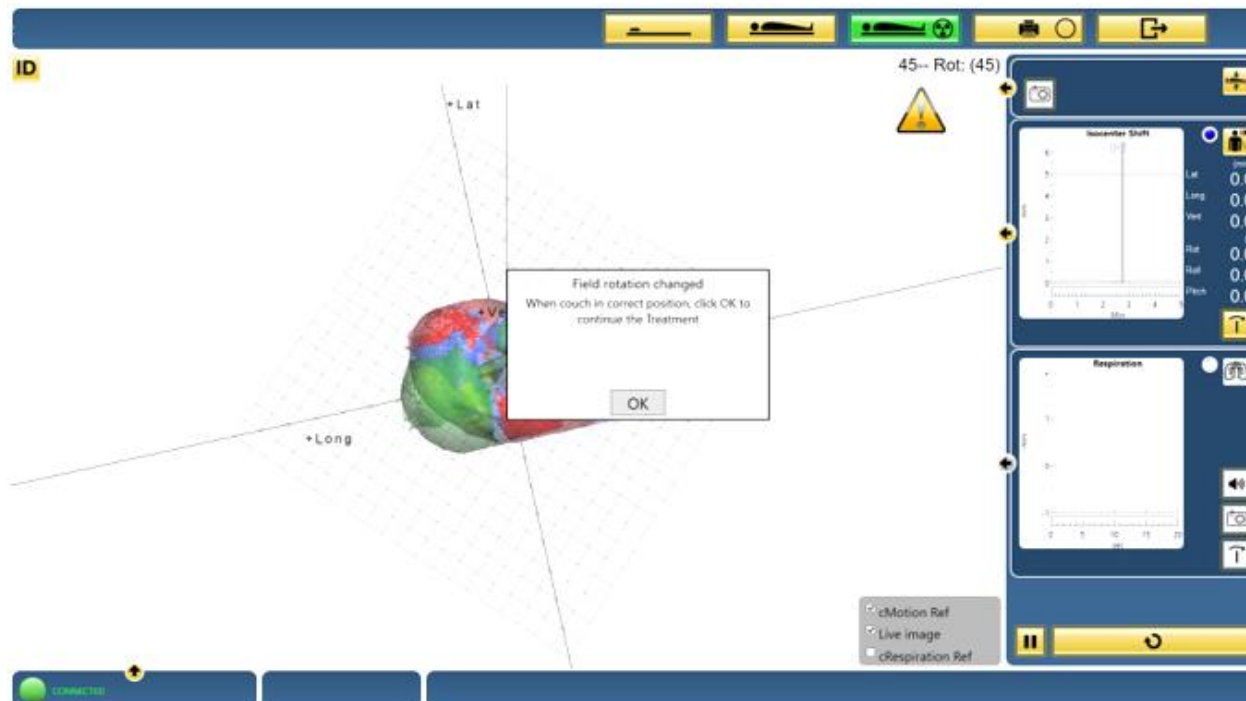
Parameter	Value	Unit
Lat	+5.4	mm
Long	+3.7	mm
Vert	0.0	mm
Isocenter Shift		
	6.6	mm
Rot	+0.3	°
Roll	0.0	°
Pitch	0.0	°

Below the correction panel, there is a checkbox for "Surface Averaging" which is currently unchecked. At the bottom right, there are three checkboxes: "cMotion Ref" (checked), "Live image" (checked), and "cRespiration Ref" (checked). A yellow button with a play icon and a yellow button with a refresh icon are also visible.



INTRA-FRACTION MOTION DETECTION

- Auto Treatment Field Synchronization and Couch Rotation Check
- Motion Reference Image Automatically Rotates According to Field Rotation for Non-Coplanar Treatments
- Field Rotation Changed Information to User
- Precision Non-Affected by Couch and/or Gantry Rotation



Reports

- Fraction or Full Treatment Reports
 - Positioning Results
 - Motion Monitoring Results
 - Respiratory Gating Results

catalyst HD Patient: SRT
 Patient ID: SRT
 Personal ID:
 Room: Room 1
 Scanner: CatalystHD

Patient session report

Summary
 Start time: 4/5/2018 2:30:45 PM
 End time: 4/5/2018 2:31:16 PM
 Comment:

cPosition Results

Date	Site	Reference	Lat (mm)	Long (mm)	Vert (mm)	Rot (°)	Roll (°)	Pitch (°)
4/5/2018 2:30:57 PM	Default	2018-04-05 14:29:43	+1.1	-0.5	+0.3	+1.0	+0.4	-0.1

cMotion Results

Date	Duration	Site	Max deviation (mm)	Tolerance (mm)
4/5/2018 2:31:16 PM	00:00:16	Default	0	1.0

cRespiration Results

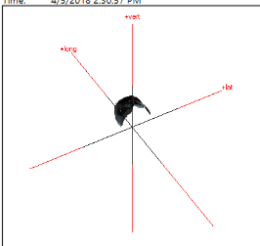
Date	Duration	Site	Reference
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C-RAD Printed: 4/5/2018 2:36:21 PM Page 1 (3)

catalyst HD Patient: SRT
 Patient ID: SRT
 Personal ID:
 Room: Room 1
 Scanner: CatalystHD

Patient session report

cPosition Results
 Time: 4/5/2018 2:30:57 PM



Couch

	Absolute	Relative
Lat	+1 mm	+1.1 mm
Long	-1 mm	-0.5 mm
Vert	0 mm	+0.3 mm
Rot	+1 °	+1.0 °

Posture

	Relative
Roll	+0.4 °
Pitch	-0.1 °

Settings

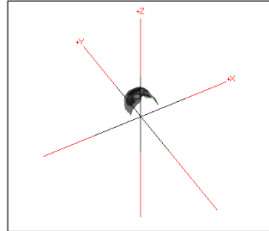
Scan Volume		Tolerance	
Xmin	-53 mm	Lat	6 mm
Xmax	90 mm	Long	6 mm
Ymin	-44 mm	Vert	6 mm
Ymax	90 mm	Rot	5 °
Zmin	-4 mm	Roll	5 °
Zmax	200 mm	Pitch	5 °
		Surface tolerance	12 mm

C-RAD Printed: 4/5/2018 2:36:22 PM Page 2 (3)

catalyst HD Patient: SRT
 Patient ID: SRT
 Personal ID:
 Room: Room 1
 Scanner: CatalystHD

Patient session report

cMotion Results
 Start time: 4/5/2018 2:31:16 PM
 Duration: 00:00:16

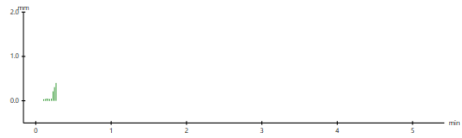


Results

Max deviation:	0 mm
Couch tracking	
Max	0 mm
Min	0 mm

Settings

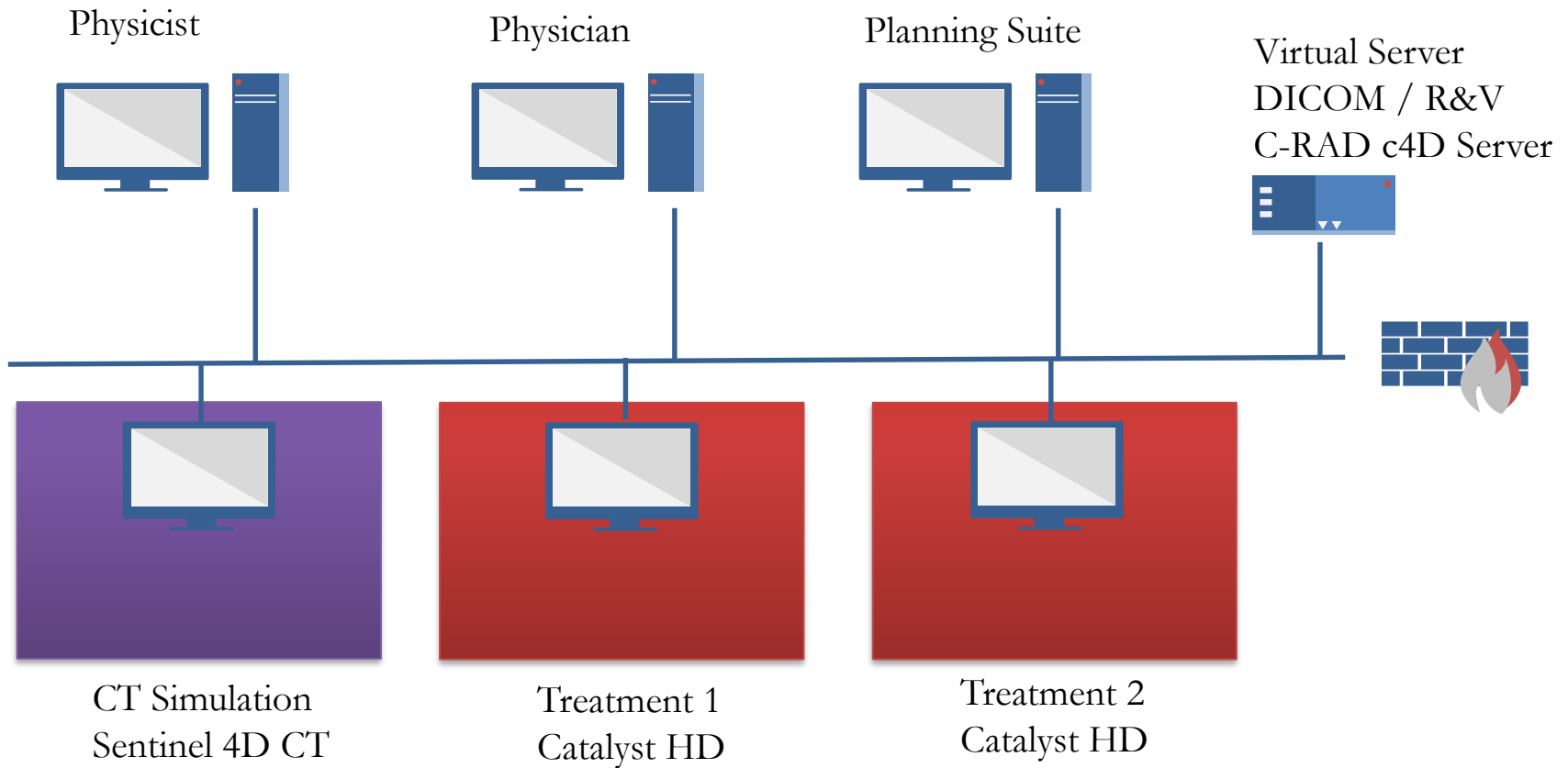
Surface tolerance	2 mm
Target tolerance	1 mm
Planned for beam control with c4D	



C-RAD Printed: 4/5/2018 2:36:22 PM Page 3 (3)

Multi-Room Support

Connection



Smart QA – Quality Assurance

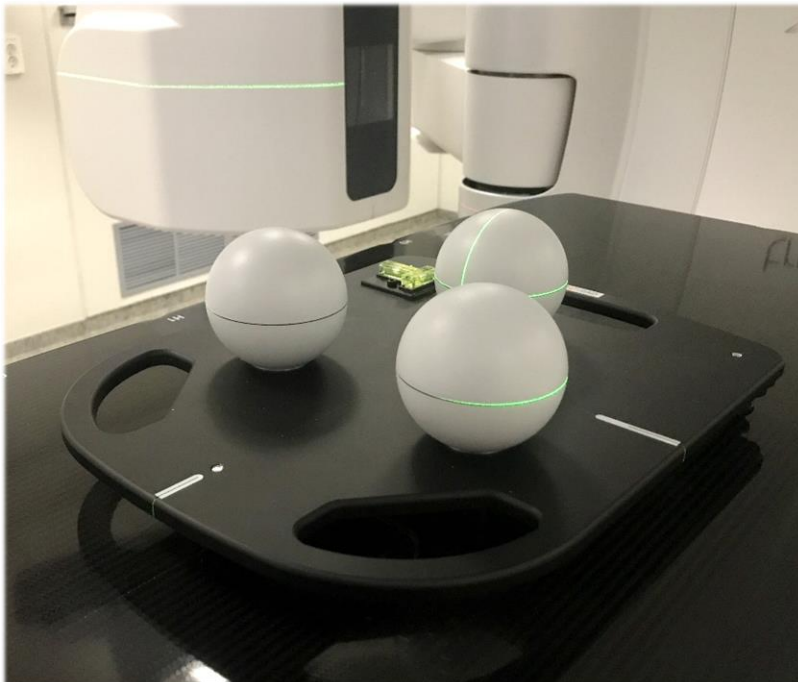
Smart QA

- QA Process and Phantom Designed for SRS and SBRT
→ Assuring System Performance and Treatment Accuracy
- Aligning the Catalyst Isocenter to the Radiation Isocenter
- Auto QA Validation for Every Patient Upon Patient Data Retrieval

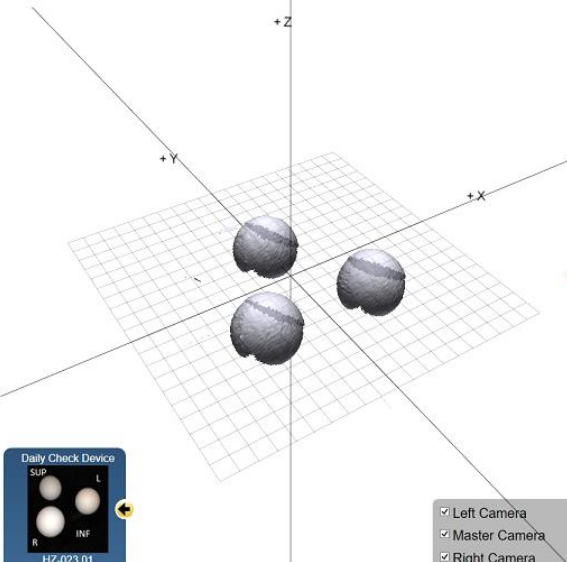


Smart QA

- Initial Isocenter Check Using Room Lasers
- Aligning the Three Catalysts to a Common System Isocenter



Routine QA - Alignment with room lasers



A 3D coordinate system diagram with axes labeled +X, +Y, and +Z. Three spheres are positioned on a grid plane. A yellow arrow points from the spheres towards the 'Check' button on the right.

Check			
Deviation			
Result	Left	Master	Right
Daily Check			
	Left: OK!		
		Mid: OK!	
			Right: OK!
Daily Check OK!			

Left Camera
 Master Camera
 Right Camera

Ready

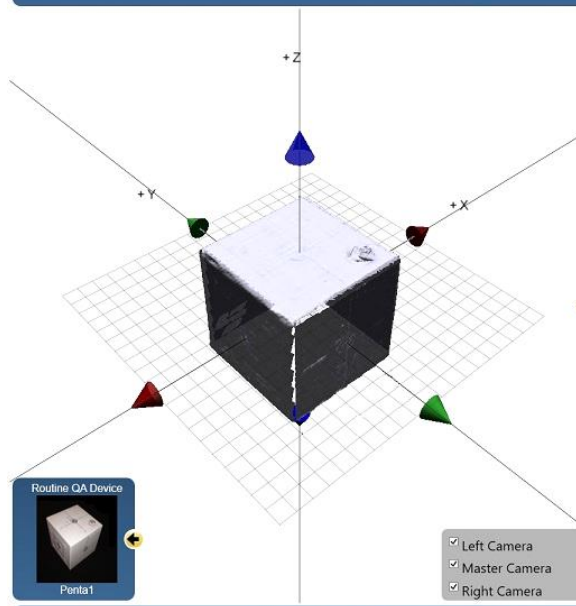
OK Cancel

Smart QA

- Adjustment of the Isocenter Using kV/MV Imaging
- Aligning System Isocenter to Radiation Isocenter
- Capability of Compensating for Couch Inaccuracy
- PentaGuide Phantom Iso4



Routine QA - Calibration of isocenter by verification imaging (MV/kV)



Check	
Deviation	
Calculated deviation	
X	-0.4 mm
Y	0.0 mm
Z	+0.3 mm
Add kV or MV couch correction	
kV or MV couch correction	
X	0.0 mm
Y	0.0 mm
Z	0.0 mm
Total Deviation	
Total deviation	
X	-0.4 mm
Y	0.0 mm
Z	+0.3 mm

Left Camera
 Master Camera
 Right Camera

Ready Last Routine QA: 10/10/2017 10:27:21 AM



catalyst

C-RAD's cutting-edge solutions ensure exceptionally high precision, safety and efficiency in advanced radiation therapy, helping to cure more cancer patients and improve their quality of life.

C-RAD Mission Statement

