

# SGRT throughout the Entire Radiation Workflow

Every patient... every fraction...

**Anton Eagle, MS,  
DABR**

Senior Medical Physicist

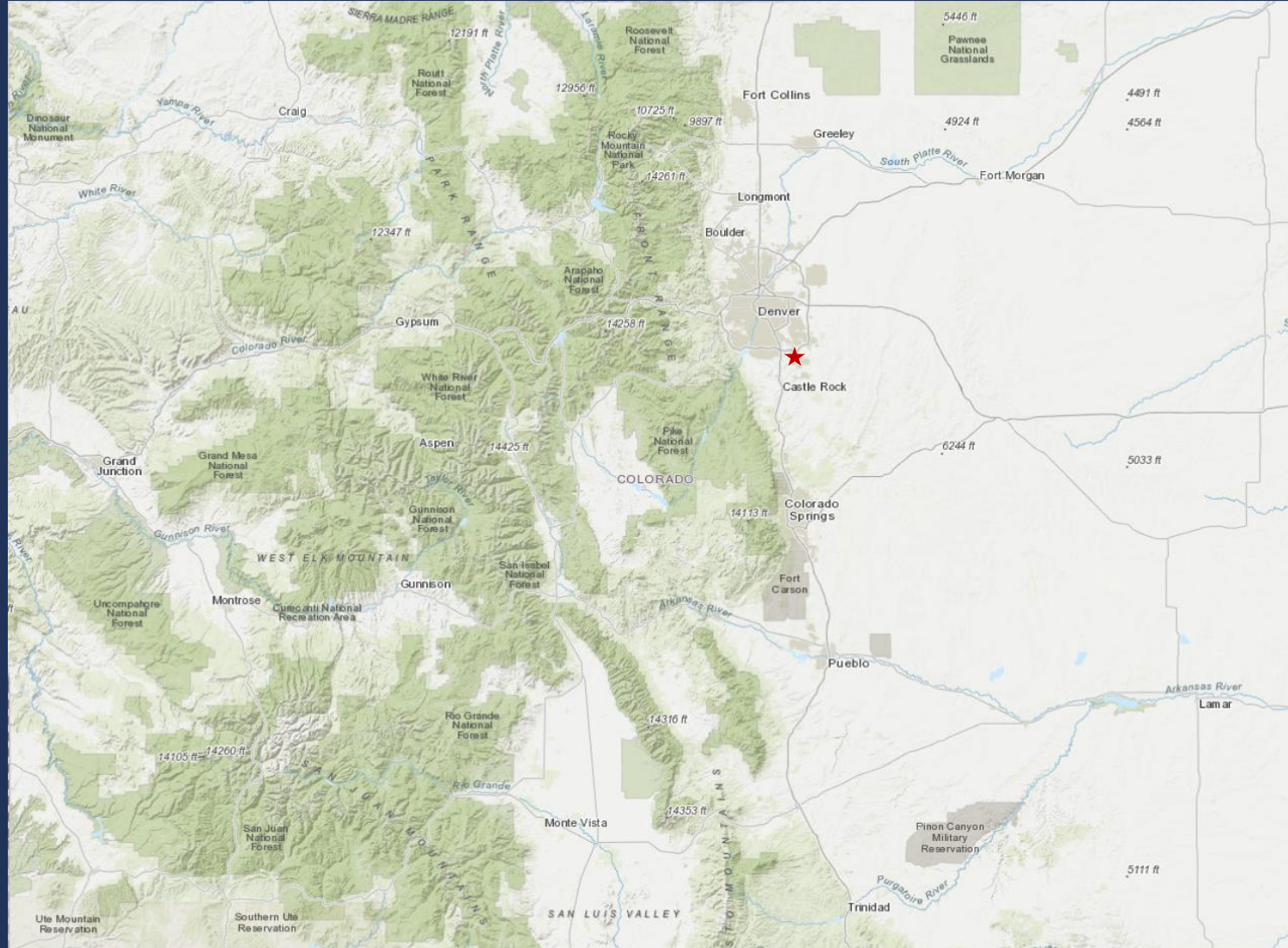
AdventHealth, Rocky Mountain Region

[Anton.Eagle@AdventHealth.com](mailto:Anton.Eagle@AdventHealth.com)

# Disclosures...

- I have no personal financial disclosures.
- AdventHealth - Parker has a PSAs with VisionRT and Varian Medical Systems.

# Who are we?





★ Parker, CO

Parker

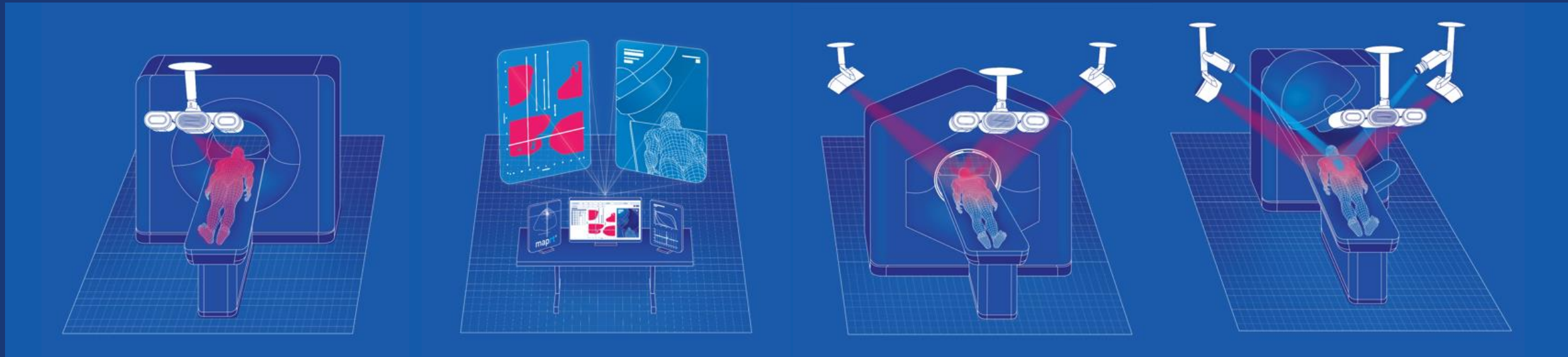
# AdventHealth, Parker

- Worldwide primary show site for VisionRT
- Mike Tallhamer – Chief Physicist
- Access to pre-production and beta versions
- Provide feedback for development

# SGRT...

... every patient... every fraction...

...every step.



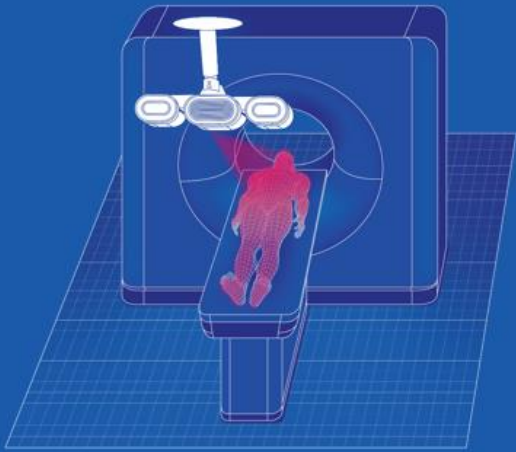
SIM

PLAN

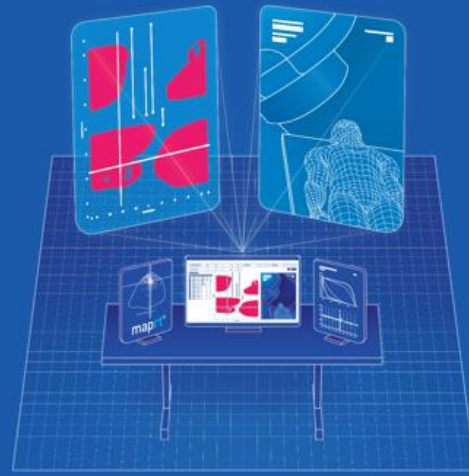
TREAT

DOSE

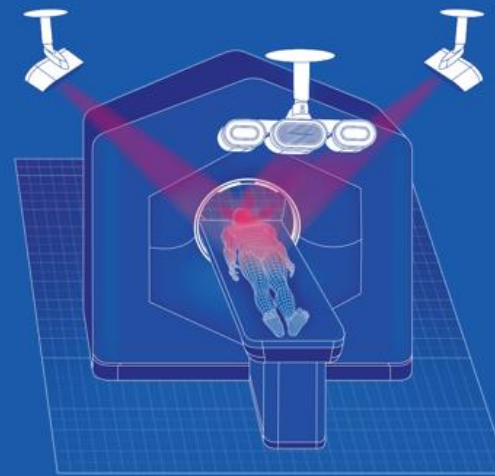
SGRT... throughout the entire Rad. Onc. workflow.



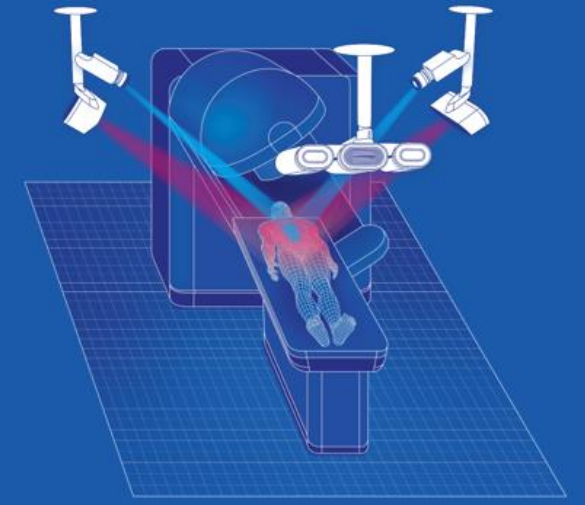
SIM



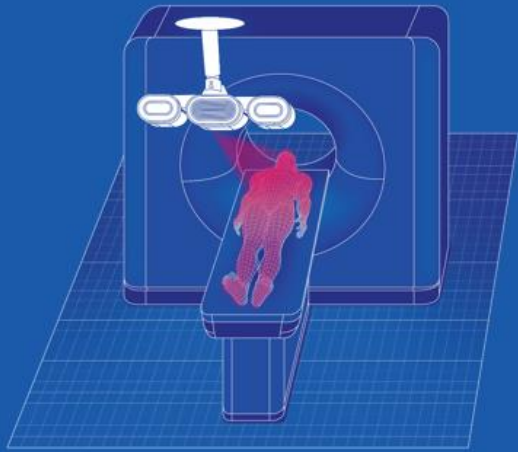
PLAN



TREAT

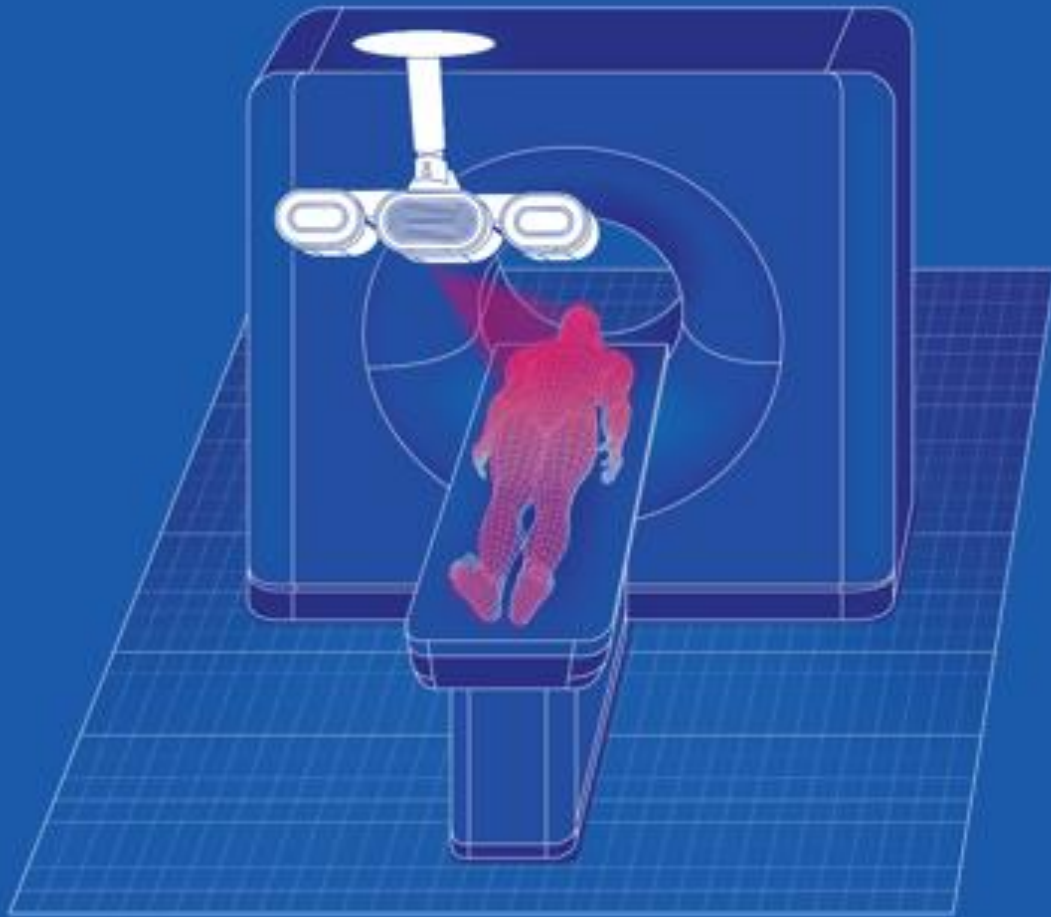


DOSE



# SIM<sup>RT</sup> Room

Used when...



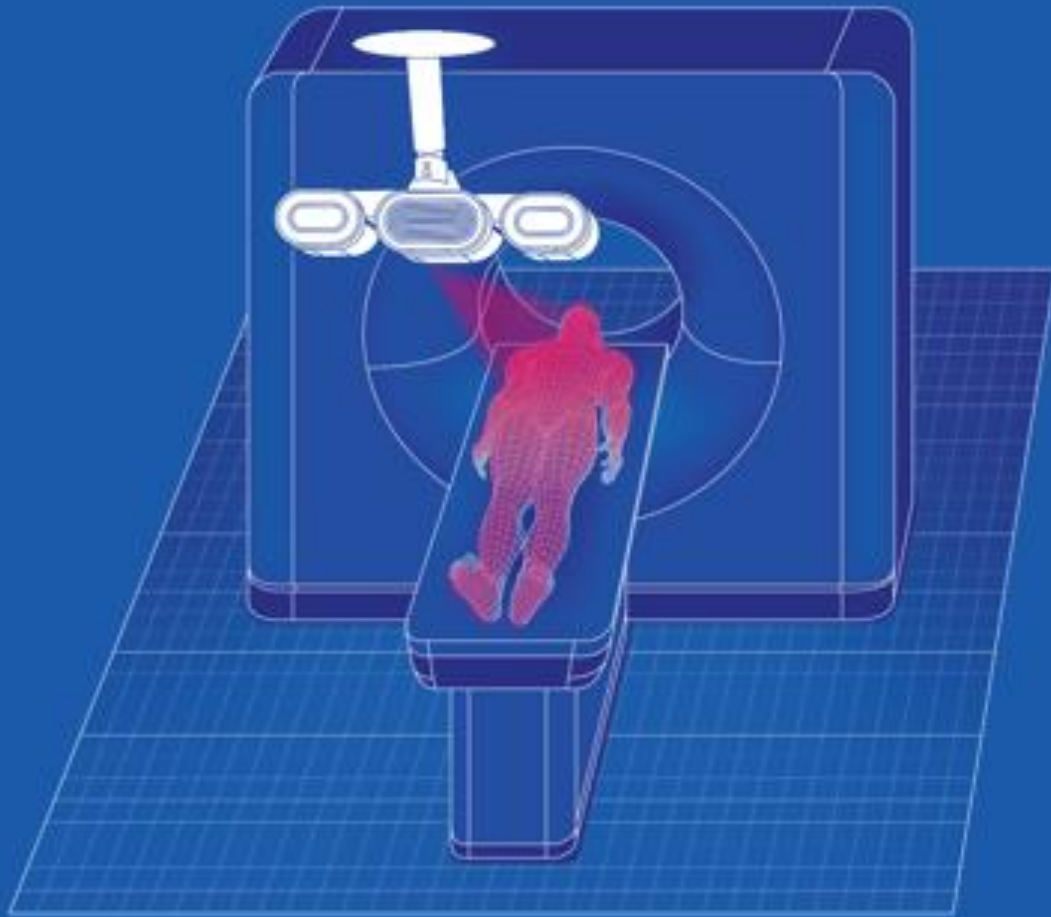
Need to monitor, control, or account for breath motion...

4D CT Workflows

Deep-Inspiration Breath Hold (DIBH)

- DIBH Breast
- Breath-Hold SBRT

## How does it work?



Use IR cameras to map surface

Select patch on surface to monitor

Can detect change in surface at patch during breath motion

What does this look like?

**Lung (4D Helical)** **SGCT1 Surface**

Capture Couch Velocity Edit Patch

6/1/2022 11:55:51 AM

Respiratory

Review Save Data... Edit Thresholds Monitoring

23.9 BPM

X-Ray ON

Amplitude (mm)

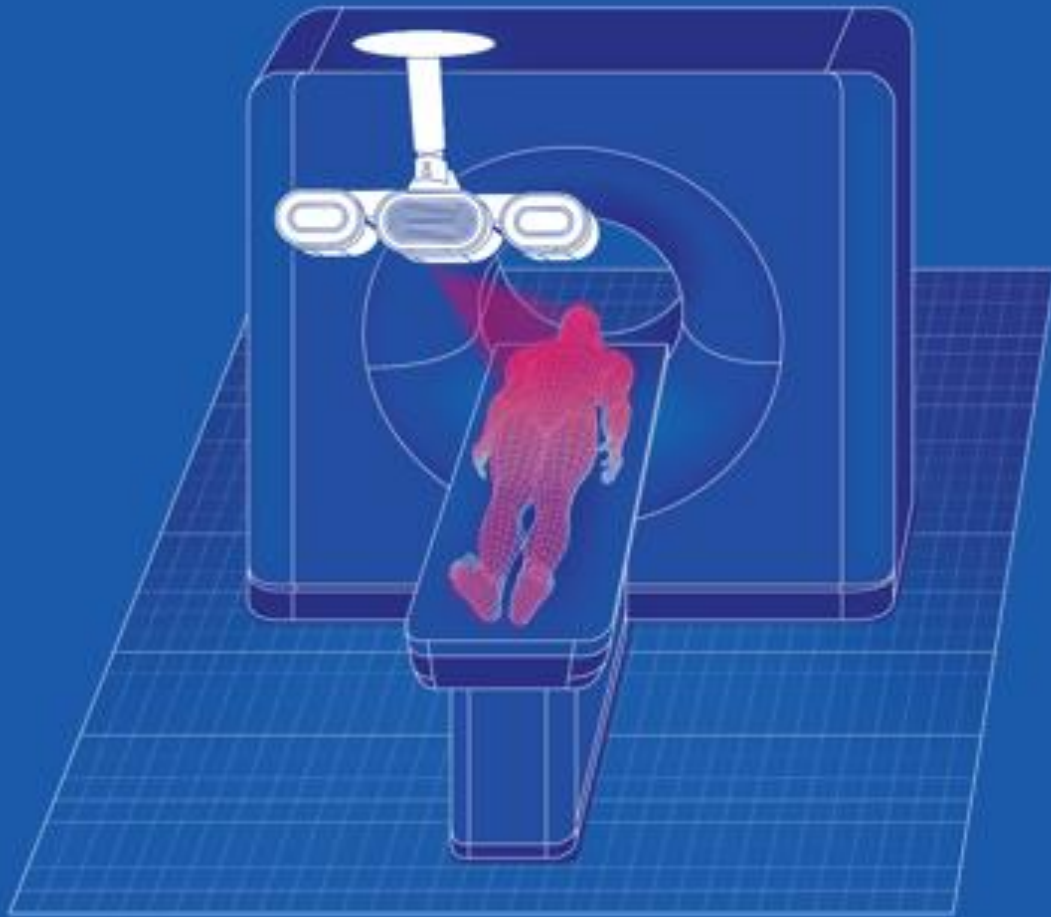
Time (s)

RTC

simrt<sup>™</sup> Database Storage softlock was unlocked | System Status | 6/1/2022 11:58 AM

What does this look like?

## Why do we use it?

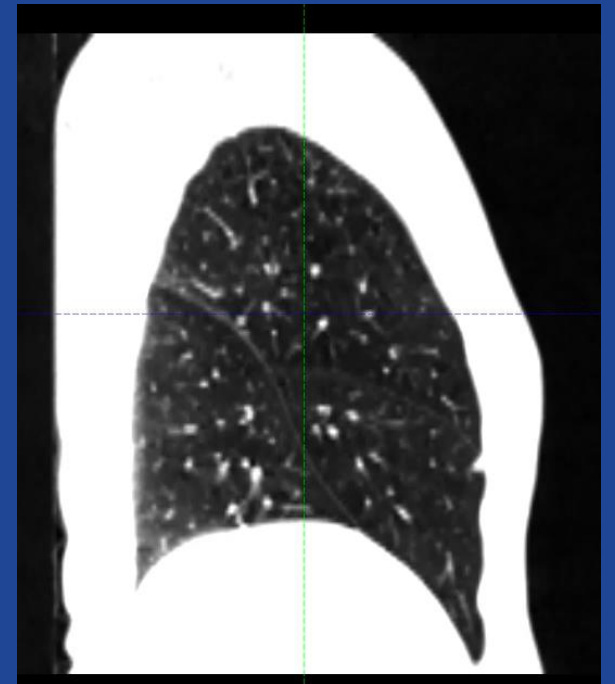


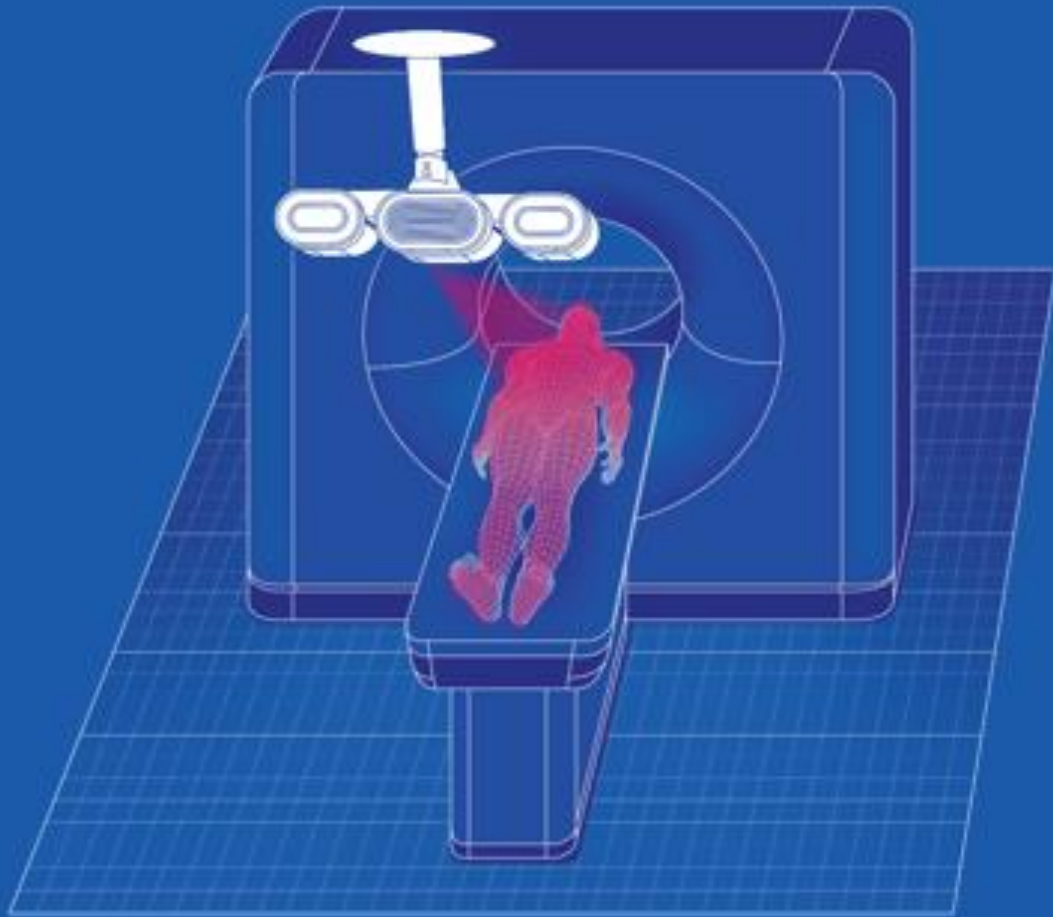
Being able to select the monitoring patch improves tracking

No cumbersome block to secure

Significantly faster workflow

Excellent 4D results

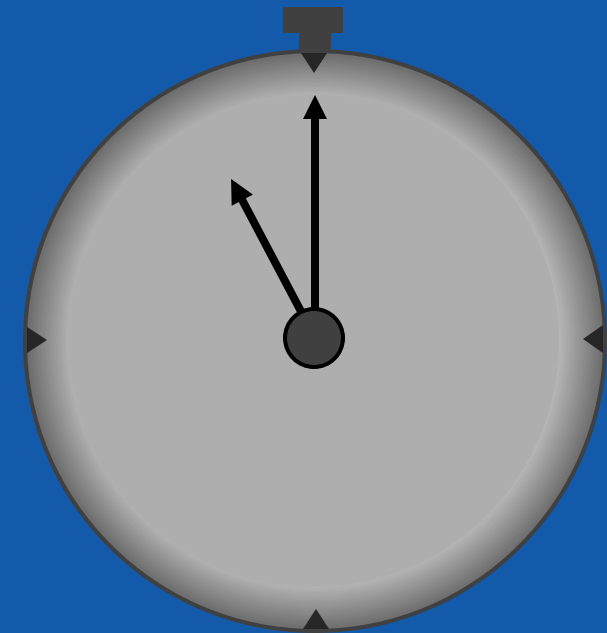
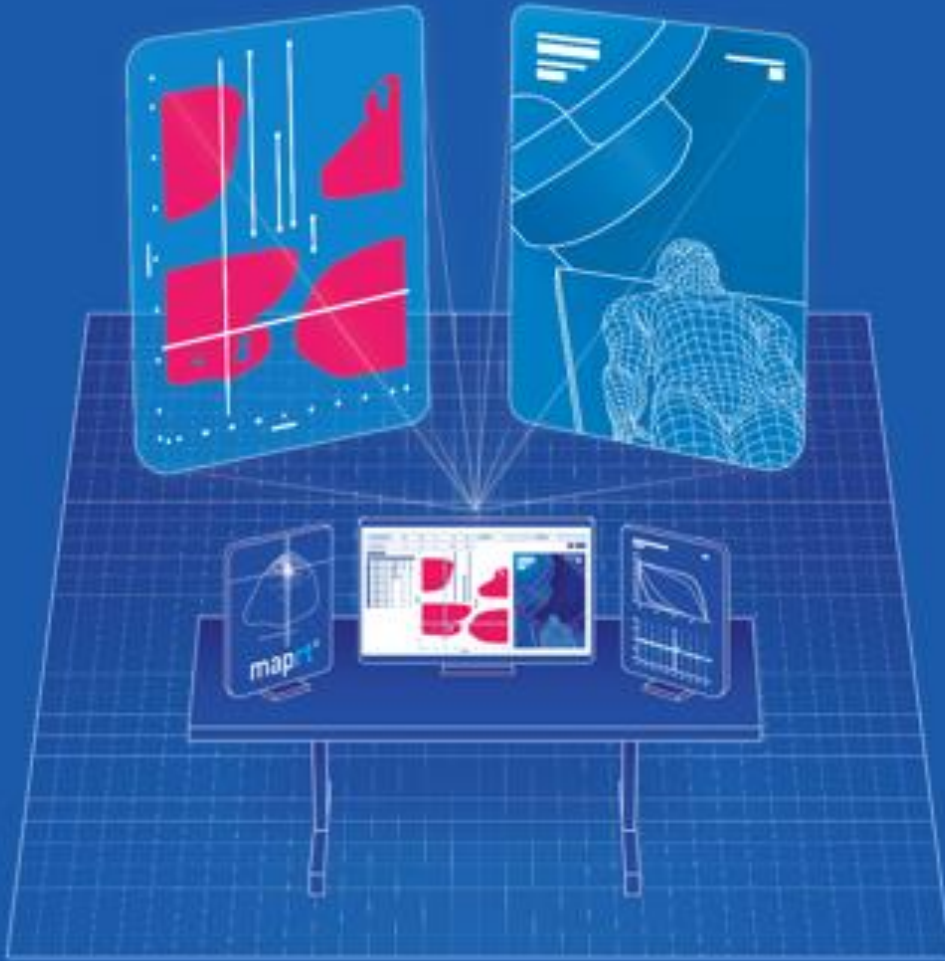




# Treatment Planning

Let's pause...

... and turn back the clock a few years



# Treatment Planning



**A few years ago...**

We have some unsolved problems

We have “Planning Gap” between  
sim and treatment

# Treatment Planning

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**Planning Gap**

# Treatment Planning

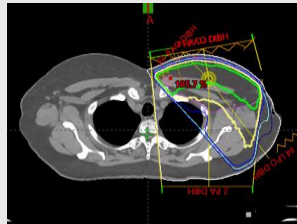
## Planning Gap

### 1 Limited collision modeling



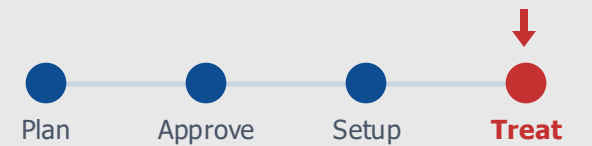
Only using Body contour... if at all.

### 2 Limited beam geometry



Coplanar, clearance uncertainty, better options not attempted

### 3 Late discovery



Issues surface at dry-run or first treatment

# Treatment Planning

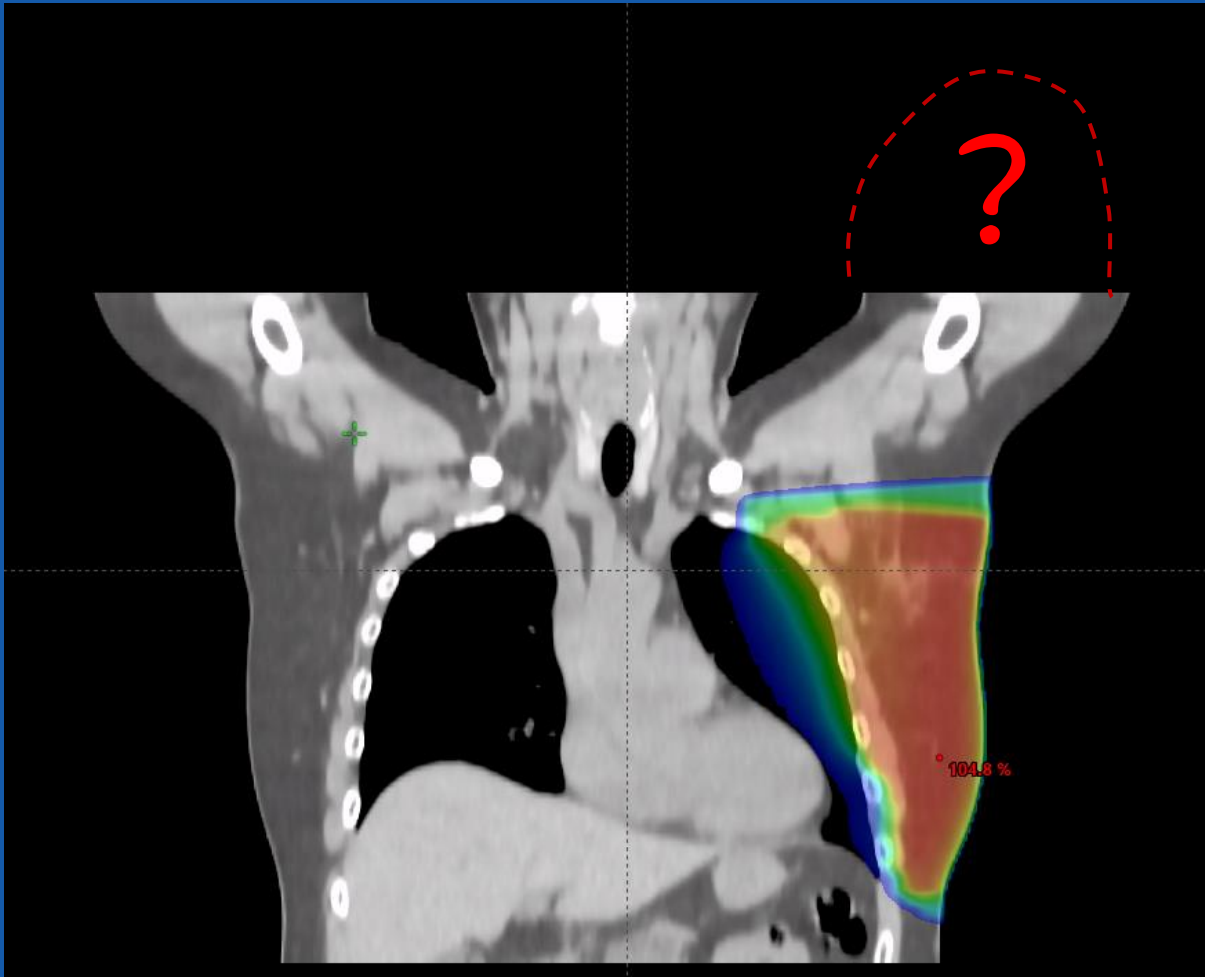
## Planning Gap

All issues have same cause

CTs only see a narrow band of the body

Often can't see collision risks

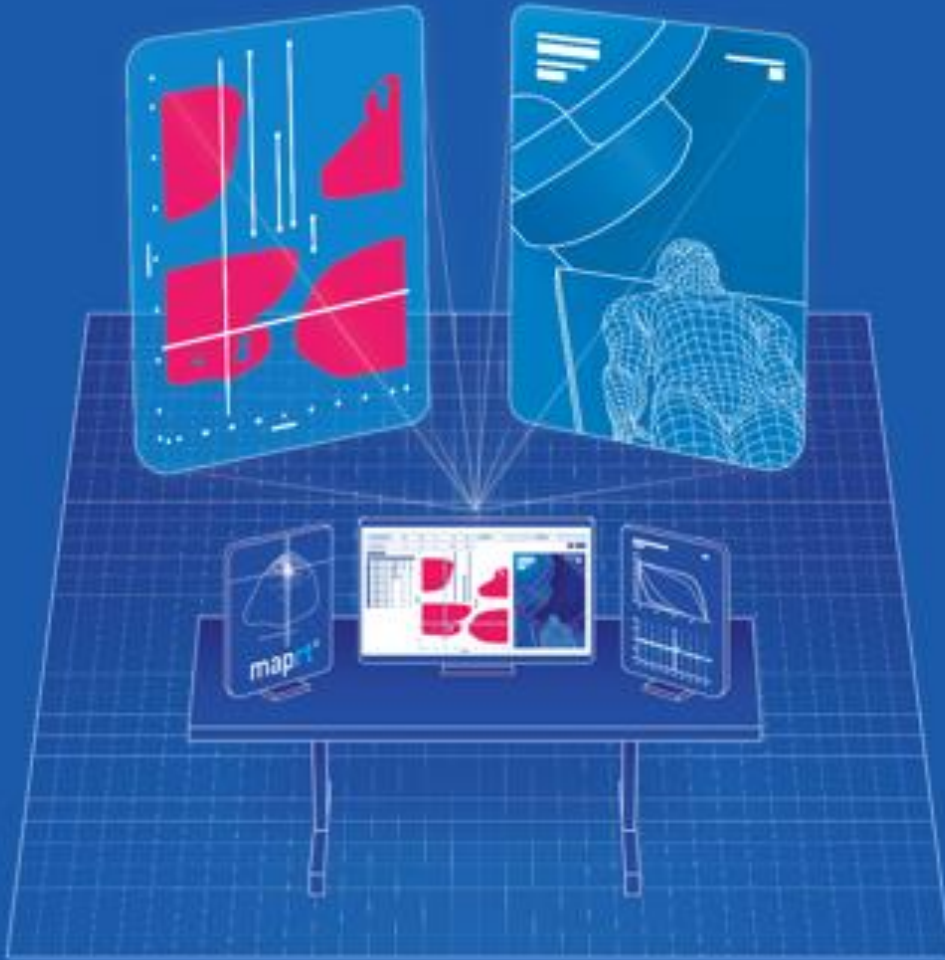
How do we solve this?



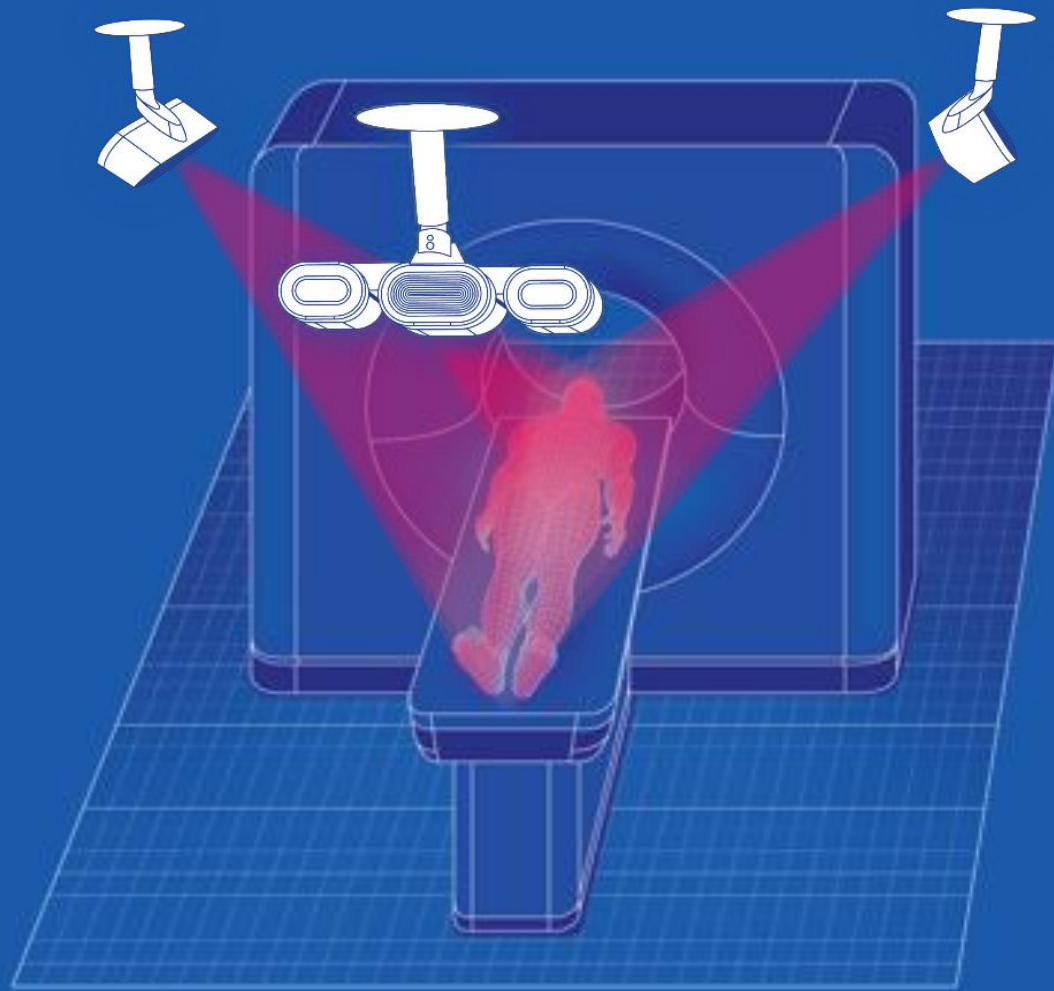
# Back to the CT-Sim room

How do we solve this?

Let's go back to the Sim room



# Back to the CT-Sim room



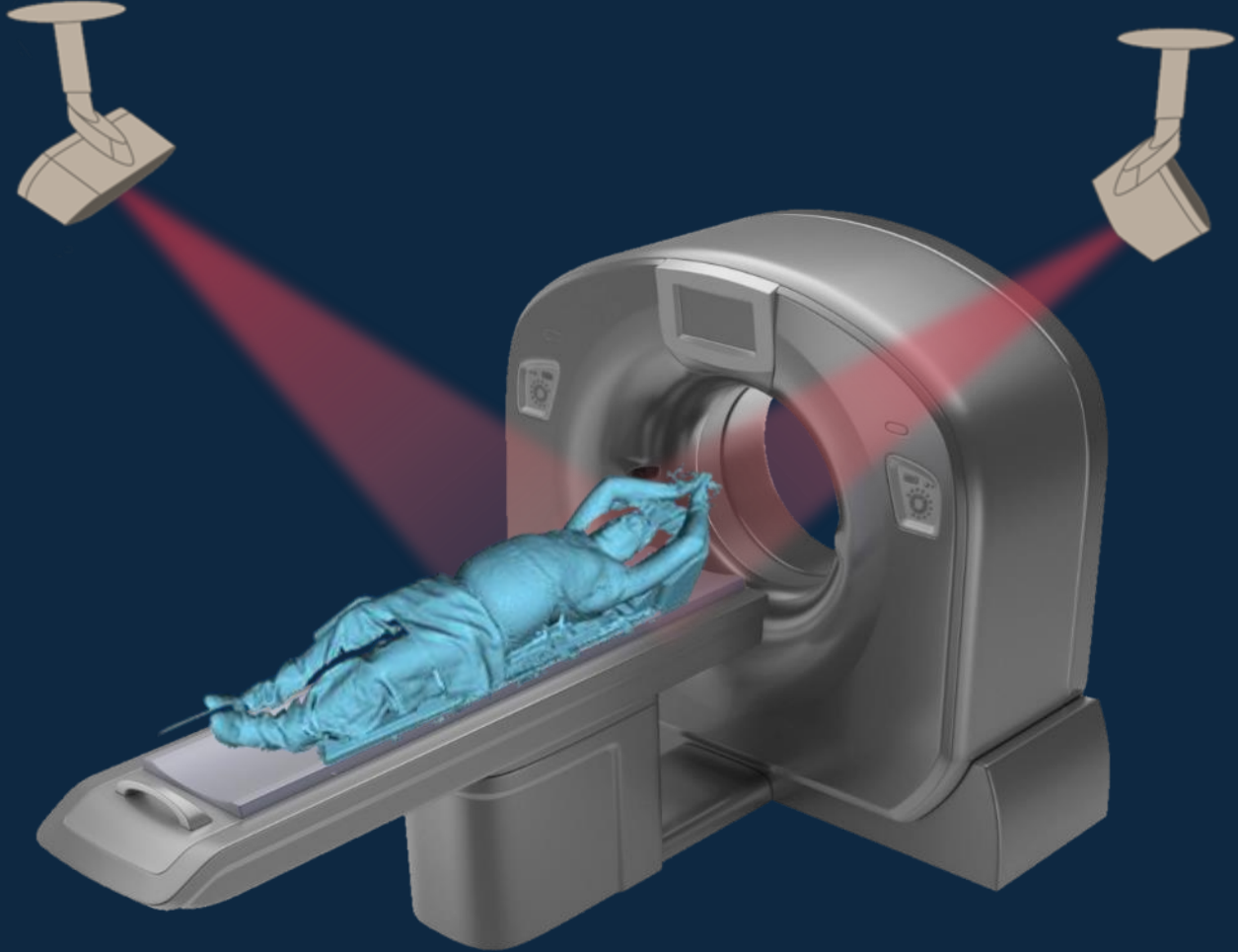
## Add VisonRT Cameras

Use IR cameras to map surface

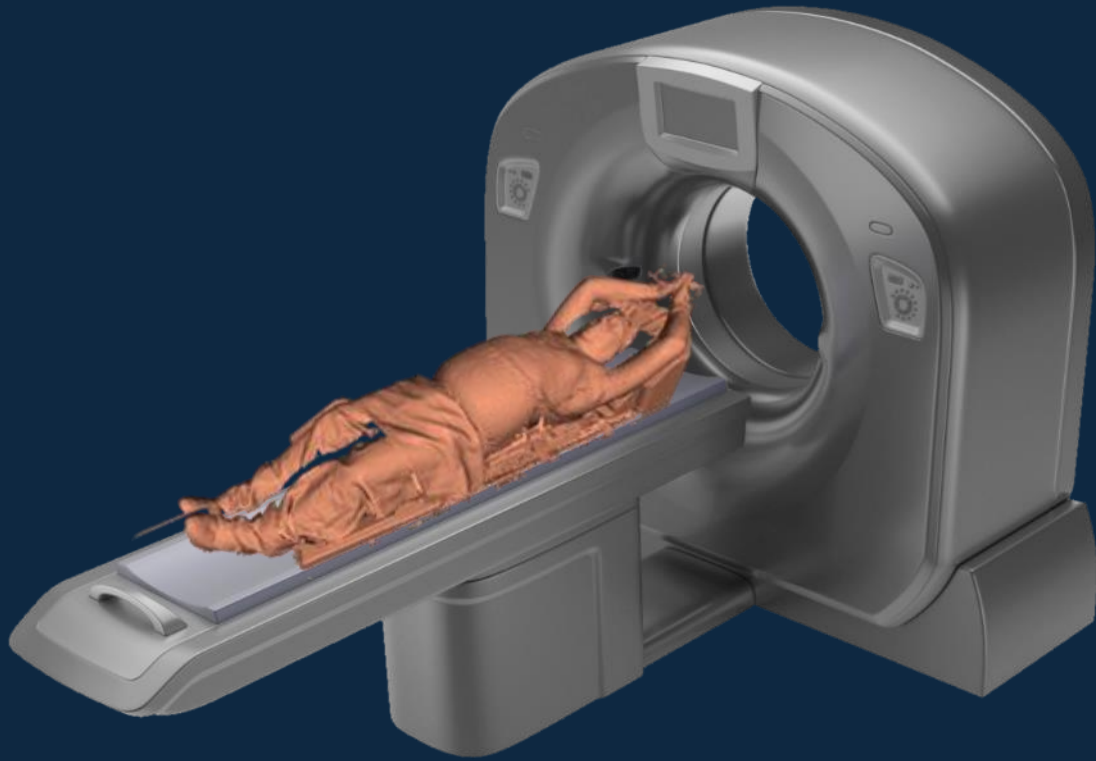
If we could map the whole surface... head to toe...

Then we could use this surface to check arc clearance

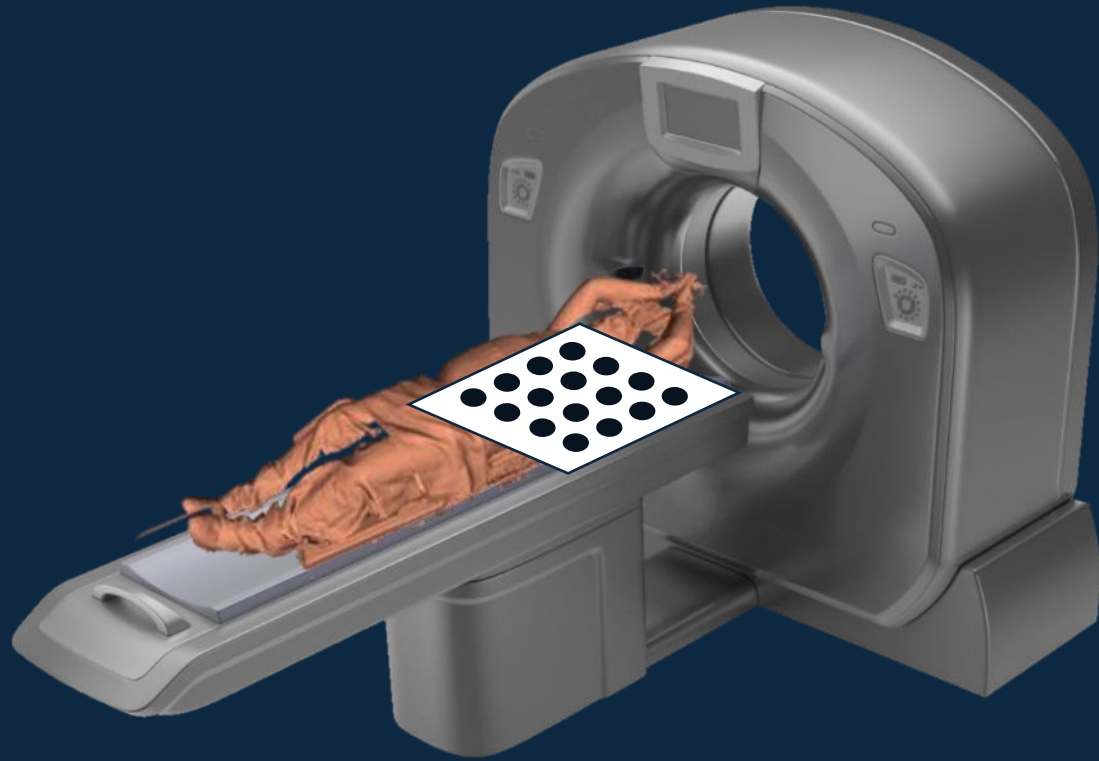
How do we make this work?

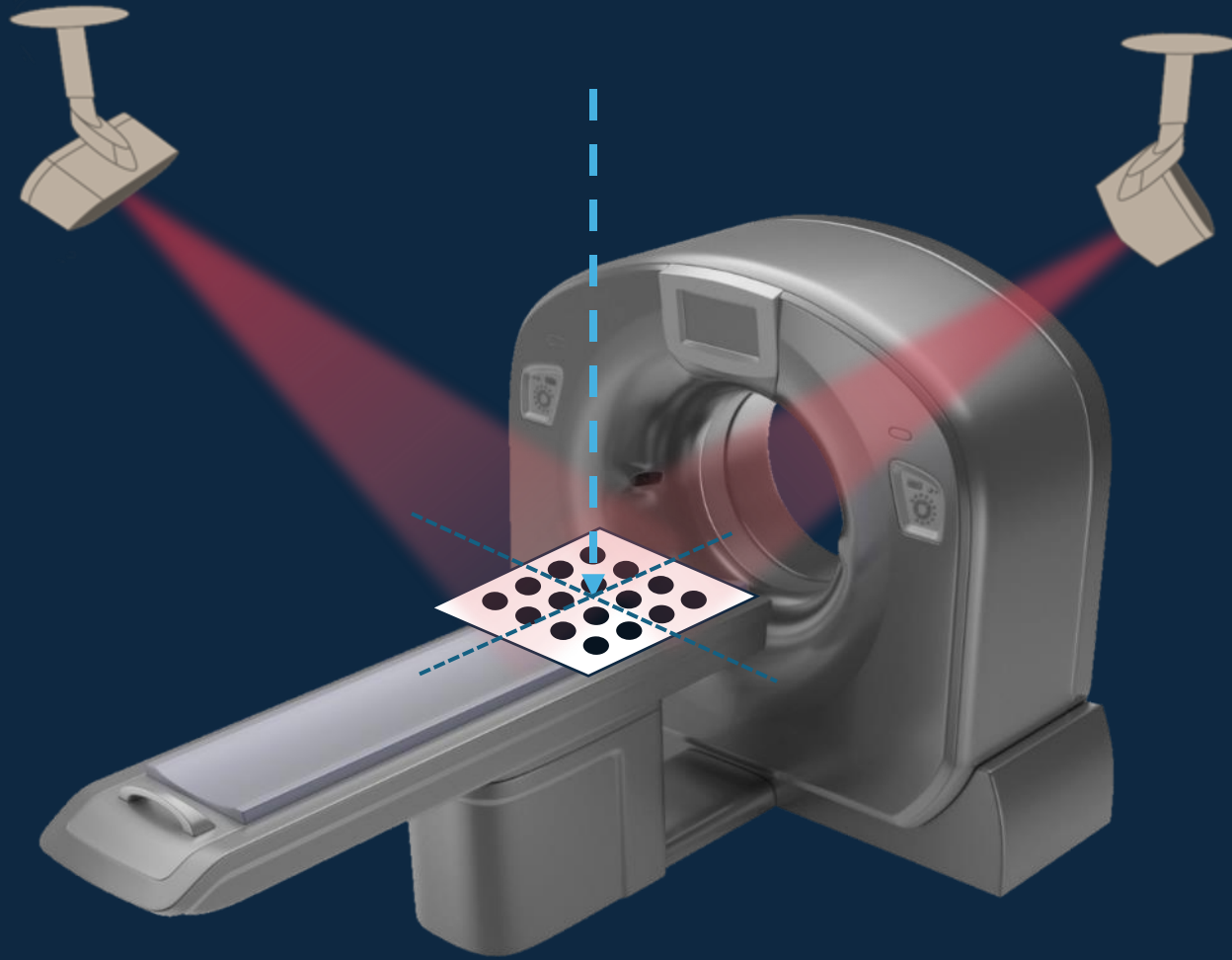


But we don't know where  
this is in CT space

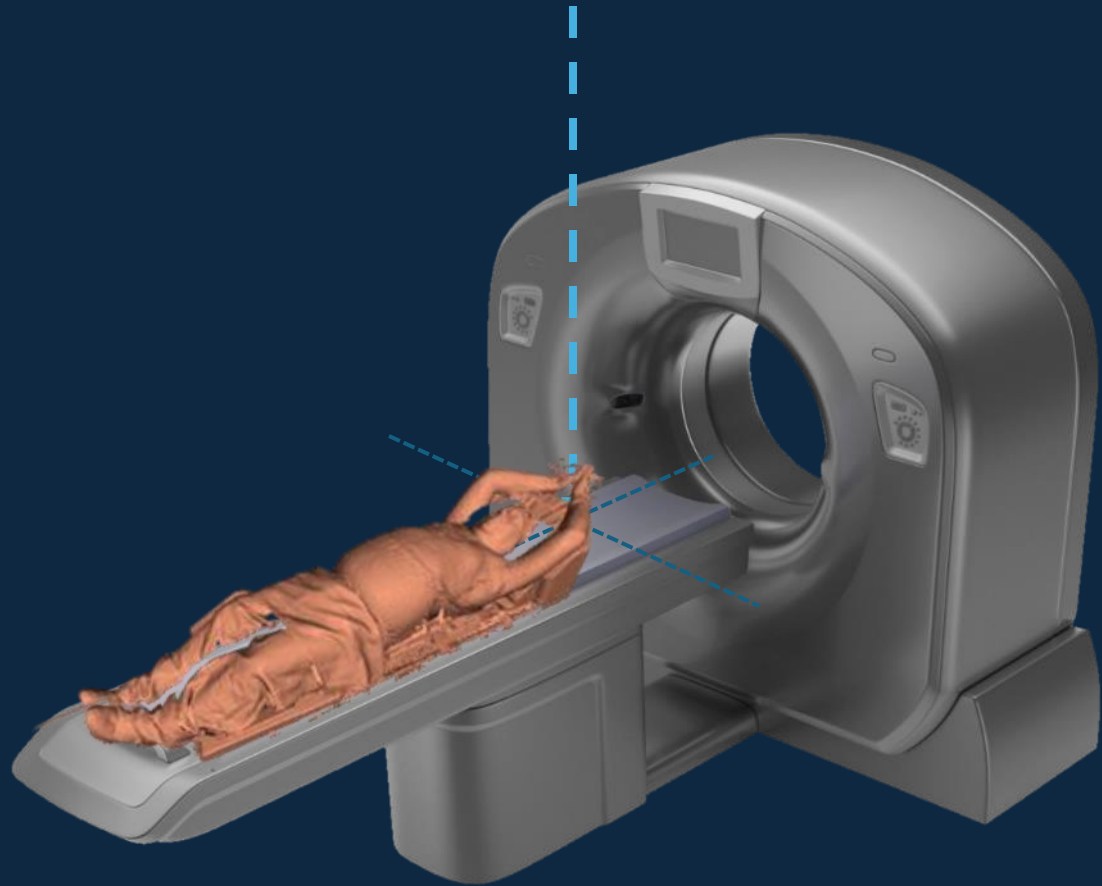


Use same method as  
AlignRT plate-calibration

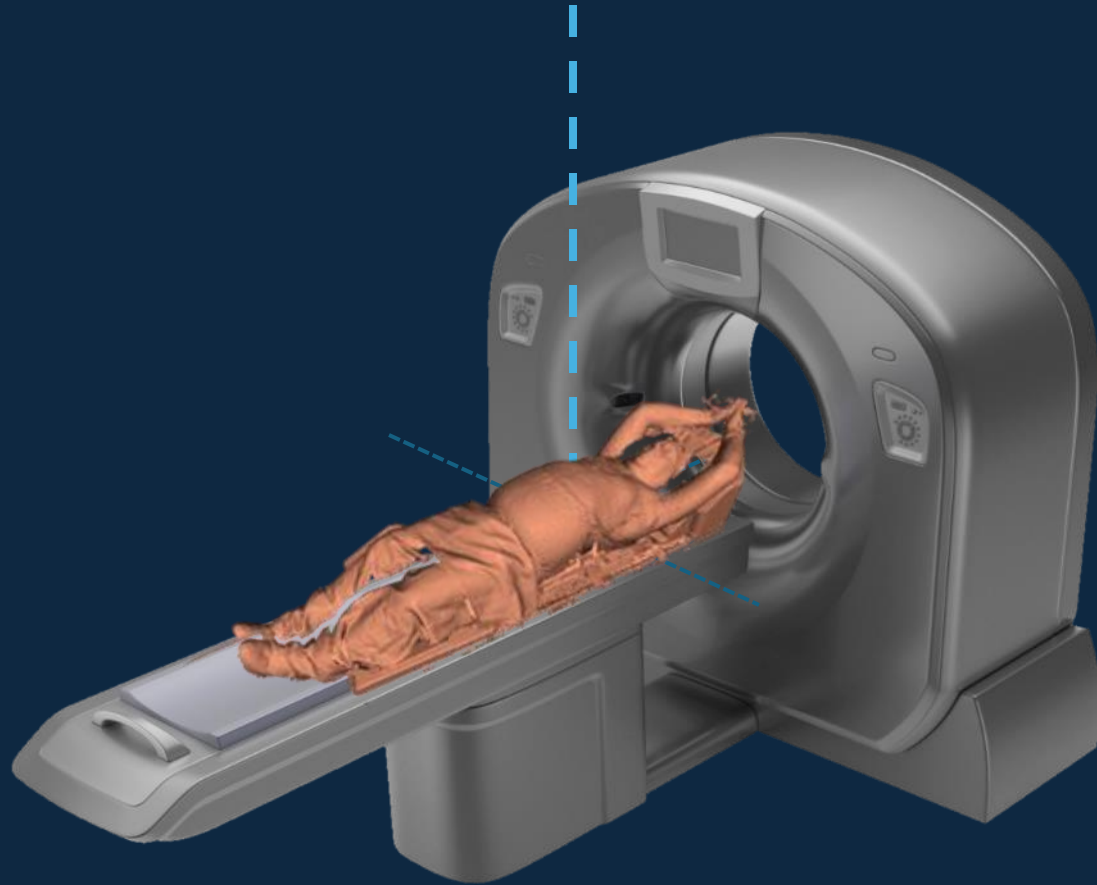




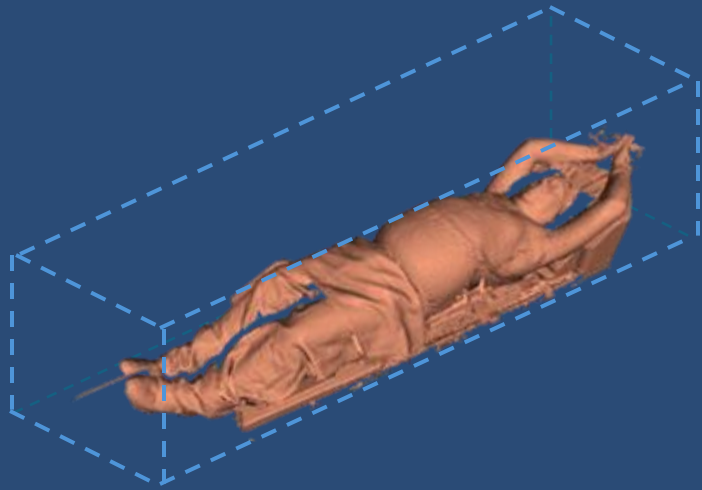
Now we have a point in  
3D space



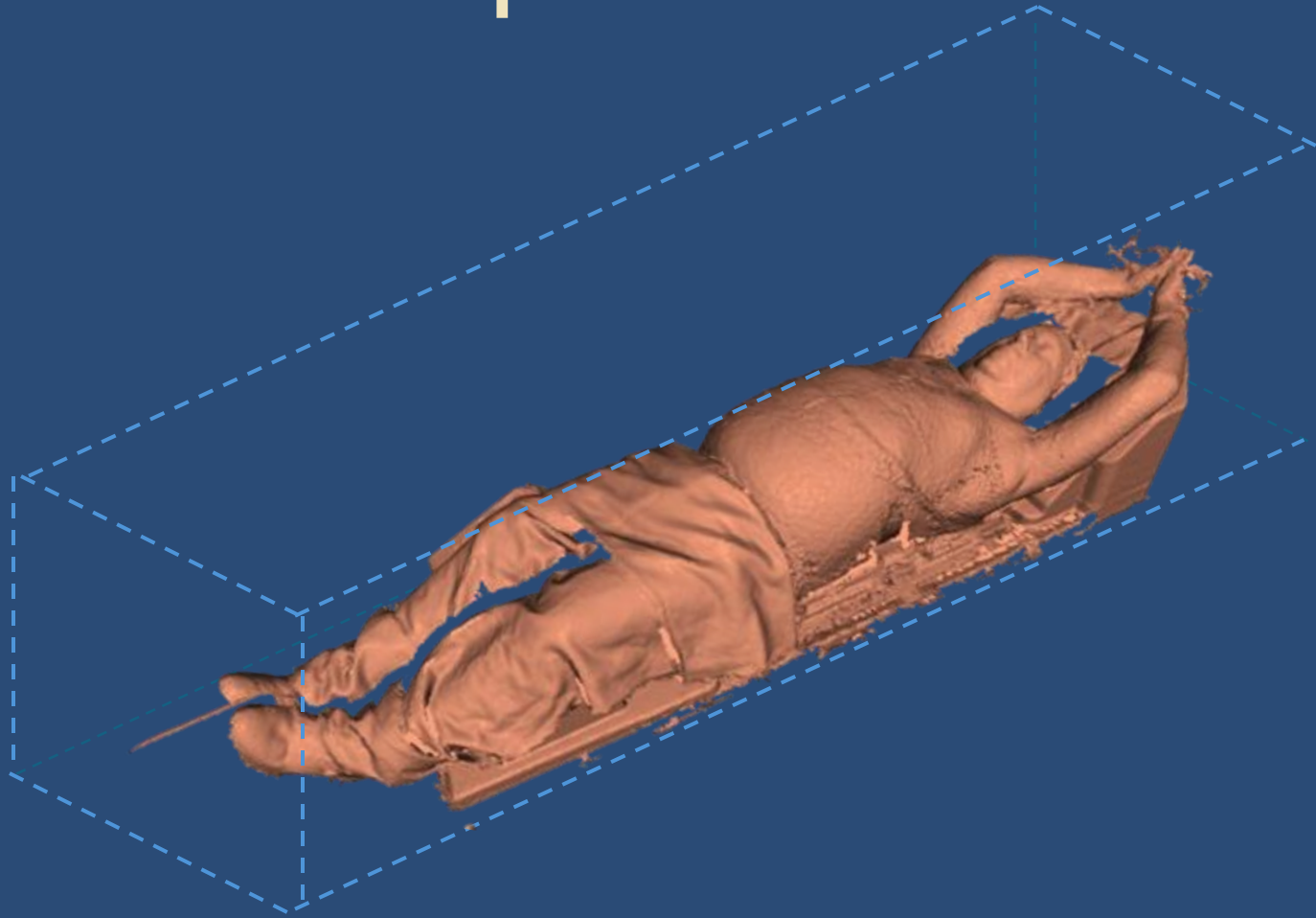
**Camera Space = CT Space**



# CT-Sim Space

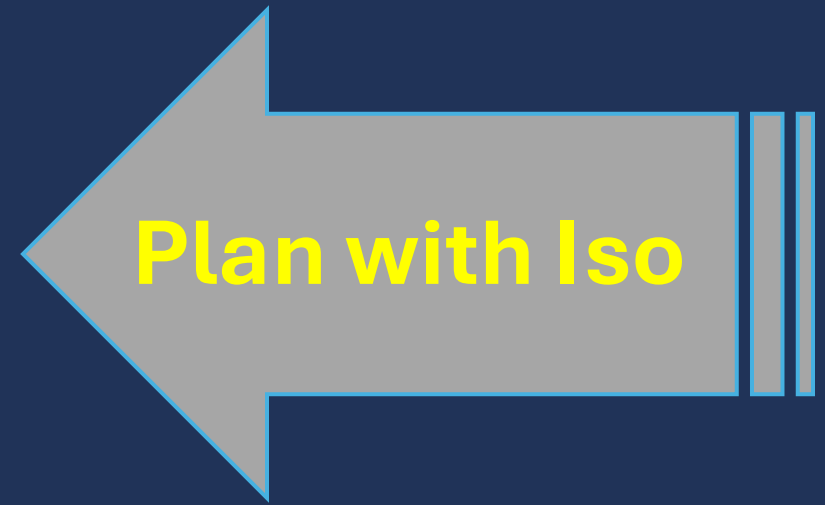
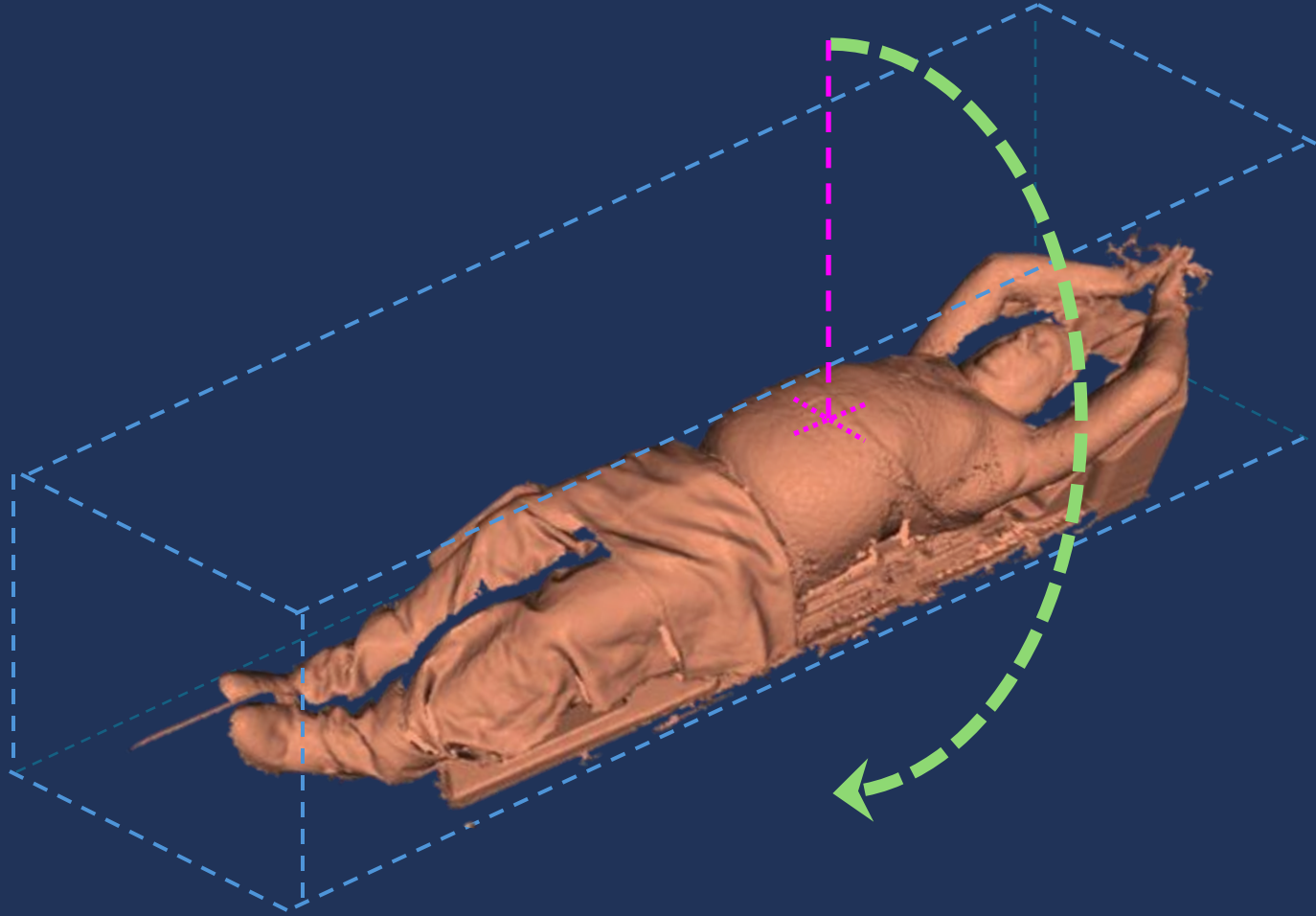


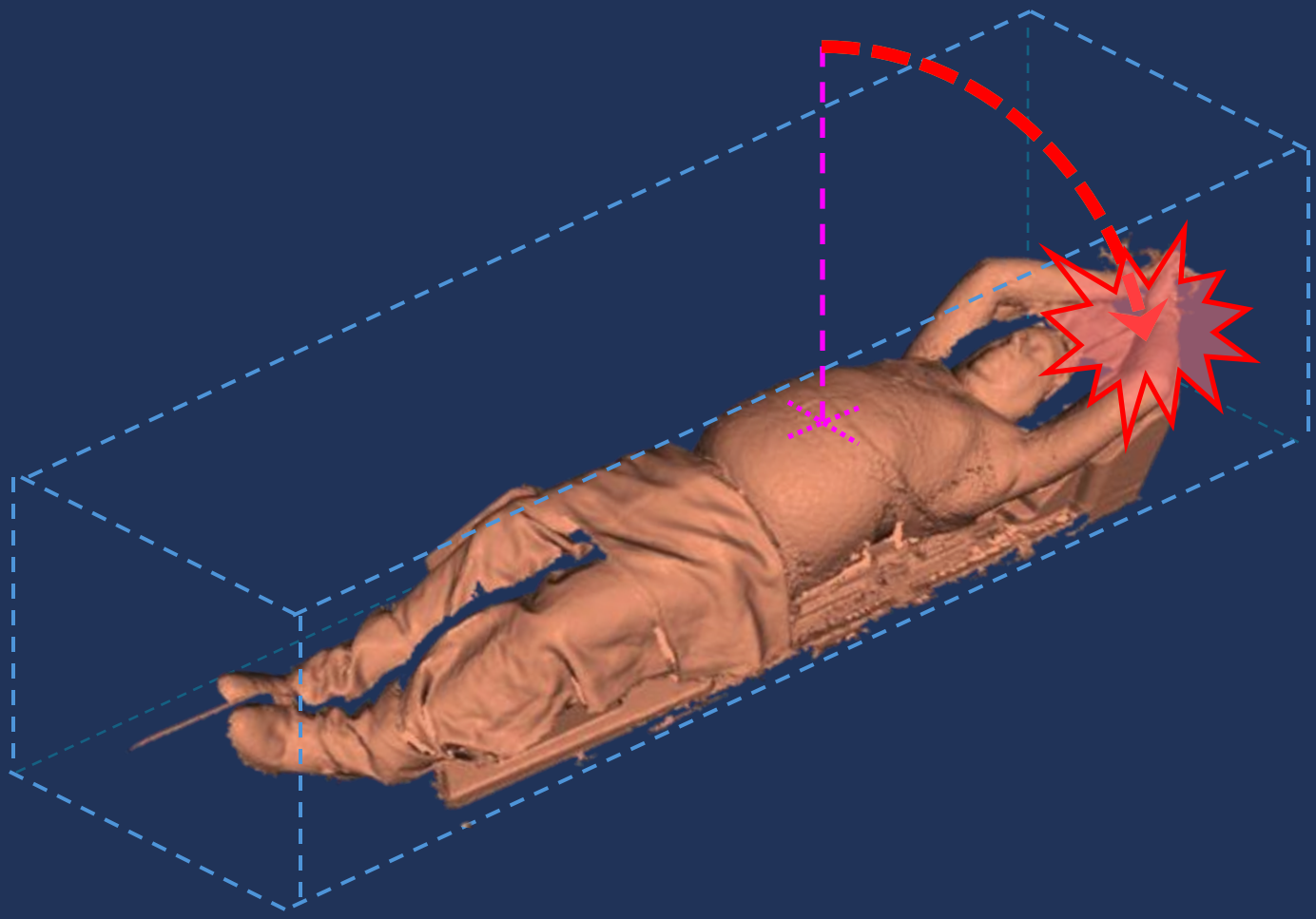
# CT-Sim Space



**To 3D map  
Software...**

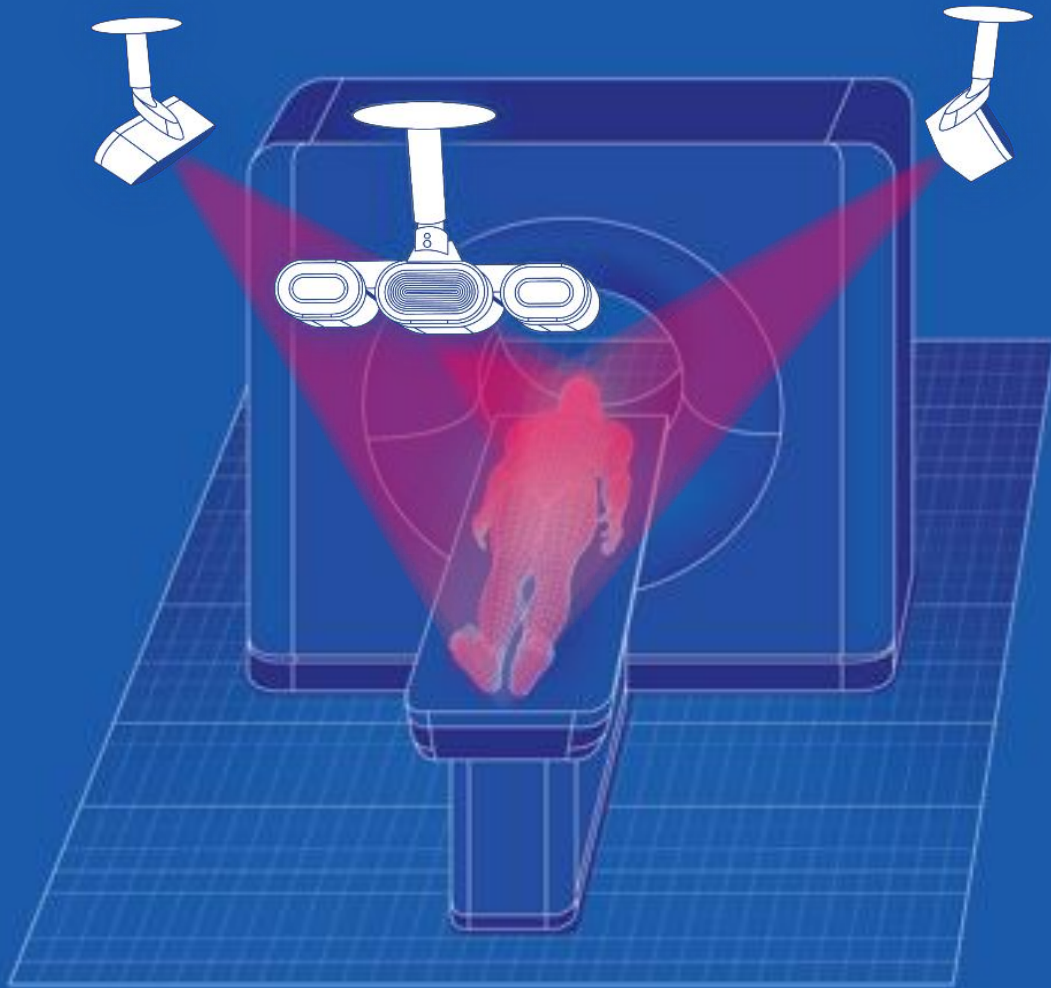
# 3D Mapping Software



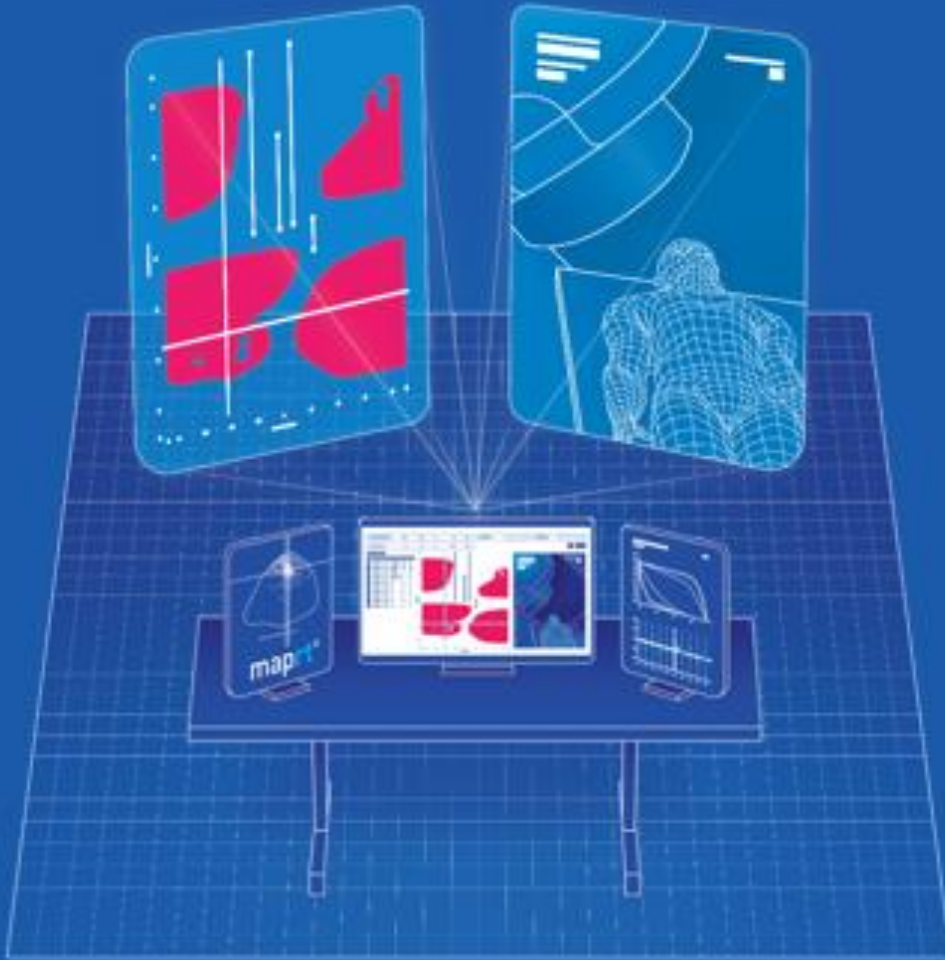


# MapRT<sup>®</sup>

Acquire surface during Sim



Now can use that surface during planning



Search Patients...   **Select Patient**   Review Setup   Clearance Map   NOT FOR CLINICAL USE

[Continue to Review Setup](#)

### Select Patient

Patient Name ↑	Patient ID	Modified Date	New Plan
XXXXXXXXXX	XXXXXXXXXX	04/12/2024 12:04:27	<input type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	02/12/2024 14:36:17	<input checked="" type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	05/12/2024 08:35:21	<input checked="" type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	17/12/2024 09:20:47	<input checked="" type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	12/11/2024 14:35:05	<input checked="" type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	12/11/2024 14:29:52	<input type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	26/11/2024 09:57:28	<input type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	16/01/2025 10:55:24	<input checked="" type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	11/02/2025 11:34:26	<input checked="" type="checkbox"/>
XXXXXXXXXX	XXXXXXXXXX	28/01/2025 09:50:58	<input checked="" type="checkbox"/>

### Select Plan For

Plan Name	Isocenter (mm)	Exported Date	New Plan ↑
preview	[0.0, 0.0, 0.0]	04/12/2024 12:04:27	<input type="checkbox"/>

[+ Load DICOM file](#)

**e**    [Select Patient](#)    [Review Setup](#)    [Clearance Map](#)    **NOT FOR CLINICAL USE**

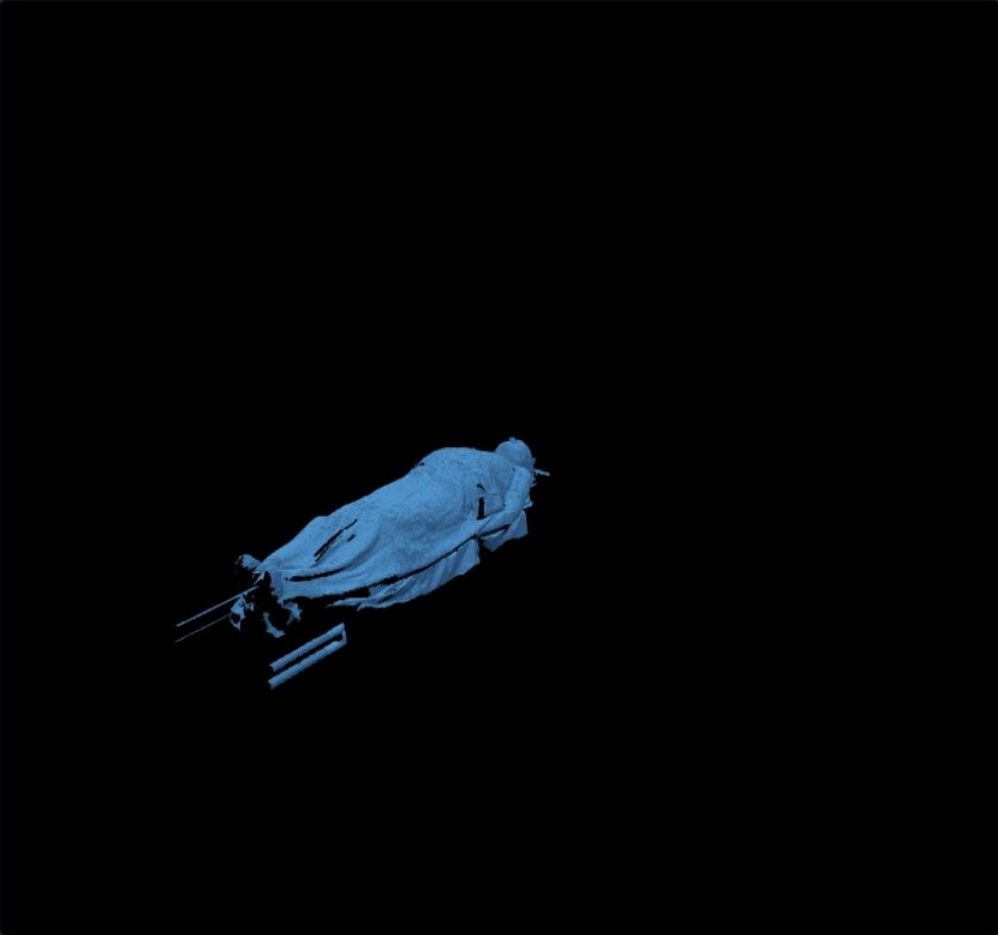
Plan Name: LtScvLN, ISO (mm) [36.8, 85.8, 108.3]    [Continue to Clearance Map](#)

Select Patient Surface

Surface Name	Captured
20250107 194251	07/01/2025 12:42:51
20250107 195856	07/01/2025 12:58:56

Select Treatment Room

Truebeam	<b>[Truebeam]</b> TrueBeam (img=Retracted)	IGRT Exact
Truebeam e10	<b>[Truebeam]</b> TrueBeam (e=10)	IGRT Exact
Truebeam e15	<b>[Truebeam]</b> TrueBeam (e=15)	IGRT Exact
Truebeam e20	<b>[Truebeam ]</b> TrueBeam (e=20)	IGRT Exact
Truebeam e25	<b>[Truebeam]</b> TrueBeam (e=25)	IGRT Exact
Truebeam e6	<b>[Truebeam]</b> TrueBeam (e=6)	IGRT Exact





Select Patient

Review Setup

Clearance Map

NOT FOR CLINICAL USE

Plan Name: LtScvLN, ISO (mm) [36.8, 85.8, 108.3]

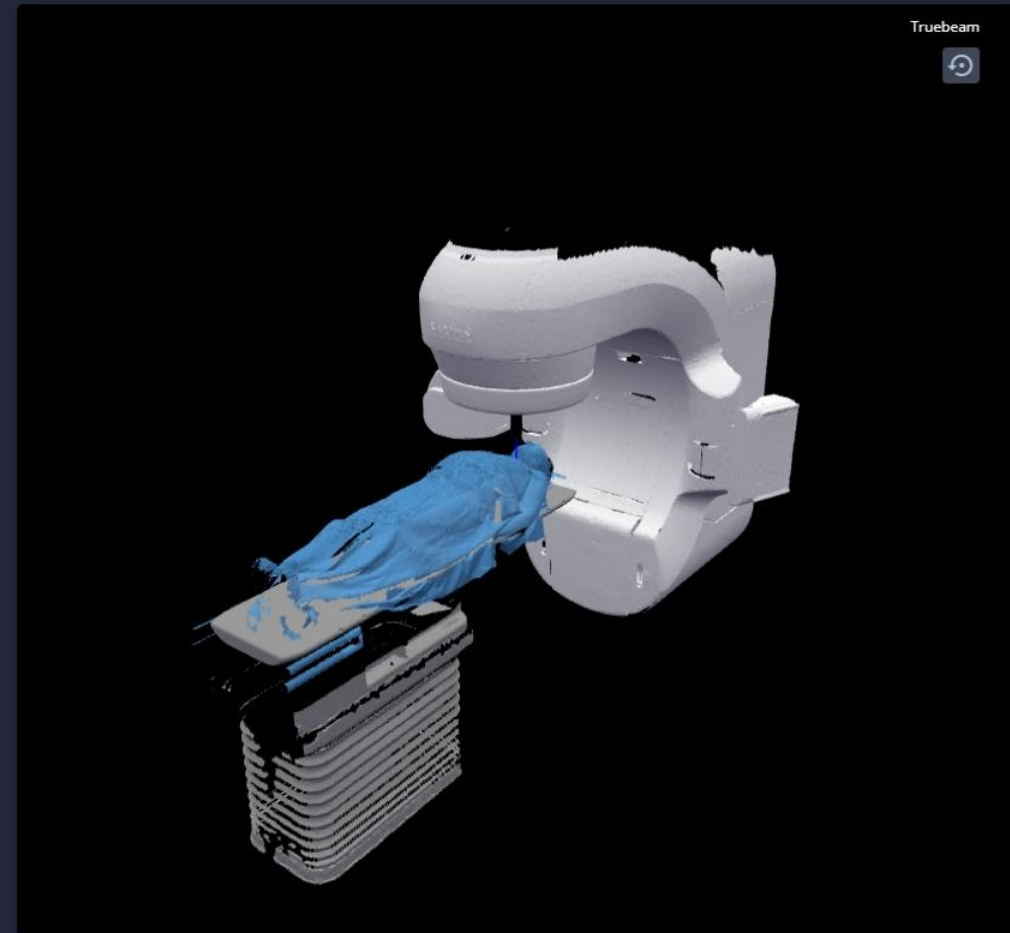
[Continue to Clearance Map](#)

### Select Patient Surface

Surface Name	Captured
20250107 194251	07/01/2025 12:42:51
20250107 195856	07/01/2025 12:58:56

### Select Treatment Room

Truebeam	<b>[Truebeam]</b> TrueBeam (img=Retracted)	IGRT Exact
Truebeam e10	<b>[Truebeam]</b> TrueBeam (e=10)	IGRT Exact
Truebeam e15	<b>[Truebeam]</b> TrueBeam (e=15)	IGRT Exact
Truebeam e20	<b>[Truebeam ]</b> TrueBeam (e=20)	IGRT Exact
Truebeam e25	<b>[Truebeam]</b> TrueBeam (e=25)	IGRT Exact
Truebeam e6	<b>[Truebeam]</b> TrueBeam (e=6)	IGRT Exact



**e**    [Select Patient](#)    [Review Setup](#)    [Clearance Map](#)    **NOT FOR CLINICAL USE**

Plan Name: LtScvLN, ISO (mm) [36.8, 85.8, 108.3]    [Continue to Clearance Map](#)

Select Patient Surface

Surface Name	Captured
20250107 194251	07/01/2025 12:42:51
20250107 195856	07/01/2025 12:58:56

Select Treatment Room

Truebeam e25	<b>[Truebeam]</b> TrueBeam (e=25)	IGRT Exact
Truebeam e6	<b>[Truebeam]</b> TrueBeam (e=6)	IGRT Exact
Truebeam Imager 50	<b>[Truebeam]</b> TrueBeam (img=50)	IGRT Exact
Truebeam Imager 60	<b>[Truebeam]</b> TrueBeam (img=60)	IGRT Exact
Truebeam Imager 70	<b>[Truebeam]</b> TrueBeam (img=70)	IGRT Exact

Truebeam Imager 60

A 3D perspective view of a Truebeam Imager 60 linear accelerator. The machine is white and grey, with a patient lying on the treatment table. The patient is covered with a blue blanket. The machine's gantry is positioned above the patient, and the treatment head is visible. The background is dark.

**e**      [Select Patient](#)    [Review Setup](#)    [Clearance Map](#)    **NOT FOR CLINICAL USE**

Plan Name: LtScvLN, ISO (mm) [36.8, 85.8, 108.3]      [Continue to Clearance Map](#)

Select Patient Surface

Surface Name	Captured
20250107 194251	07/01/2025 12:42:51
20250107 195856	07/01/2025 12:58:56

Select Treatment Room

<b>Truebeam</b>	<b>[Truebeam]</b> TrueBeam (img=Retracted)	IGRT Exact
Truebeam e10	[Truebeam] TrueBeam (e=10)	IGRT Exact
Truebeam e15	[Truebeam] TrueBeam (e=15)	IGRT Exact
Truebeam e20	[Truebeam ] TrueBeam (e=20)	IGRT Exact
Truebeam e25	[Truebeam] TrueBeam (e=25)	IGRT Exact
Truebeam e6	[Truebeam] TrueBeam (e=6)	IGRT Exact

ESAPI, TESTING  
PHY0019
Select Patient   Review Setup   Clearance Map   NOT FOR CLINICAL USE
rttrtt ▾

Isocenter (cm)

X (R-L) 14.13

Y (I-S) 67.03

Z (P-A) -7.49

Couch Buffer (cm) 2

Patient Buffer (cm) 2

Couch Shift (cm)

X 0

Y 0

Z 0

[Data](#)   [Report](#)

✖ MapRT has MLC

Status	#	ID	Type	Gantry	Couch	Direction	✓
✓	1	Good 1	Static	0°	0°	--	✓
✓	2	Good 2	Static	45°	0°	--	✓
✓	3	Good 3	Static	90°	0°	--	✓
✖	4	Bad Arc	Arc	0° to 170°	90°	CW	✓
✓	5	Good Arc	Arc	0° to 170°	0°	CW	✓
✖	6	Bad Field	Static	90°	90°	--	✓
✓	7	Good Field	Static	90°	0°	--	✓

C0° G:0°

Couch Angle(°)

0

Gantry Angle(°)

0

Truebeam

ESAPI, TESTING  
PHY0019
Select Patient
Review Setup
Clearance Map
NOT FOR CLINICAL USE
rttrtt ▾

Isocenter (cm) X (R-L) 14.13

Y (I-S) 67.03

Z (P-A) -7.49

Couch Buffer (cm) 2

Patient Buffer (cm) 2

Couch Shift (cm) X 0

Y 0

Z 0

Data

Report

✘ MapRT has MLC

Status	#	ID	Type	Gantry	Couch	Direction	✓
✓	1	Good 1	Static	0°	0°	--	✓
✓	2	Good 2	Static	45°	0°	--	✓
✓	3	Good 3	Static	90°	0°	--	✓
✘	4	Bad Arc	Arc	0° to 170°	90°	CW	✓
✓	5	Good Arc	Arc	0° to 170°	0°	CW	✓
✘	6	Bad Field	Static	90°	90°	--	✓
✓	7	Good Field	Static	90°	0°	--	✓

Gantry Angle (°) vs Couch Angle (°)

Couch Angle (°)

0

^

v

Gantry Angle (°)

0

^

v

Truebeam

ESAPI, TESTING  
PHY0019
Select Patient   Review Setup   **Clearance Map**   NOT FOR CLINICAL USE
rttrtt ▾

Isocenter (cm)

X (R-L) 14.13

Y (I-S) 67.03

Z (P-A) -7.49

Couch Buffer (cm)

2

Patient Buffer (cm)

2

Couch Shift (cm)

X 0

Y 0

Z 0

[Data](#)   [Report](#)

✖ MapRT has MLC

Status	#	ID	Type	Gantry	Couch	Direction	✓
✓	1	Good 1	Static	0°	0°	--	✓
✓	2	Good 2	Static	45°	0°	--	✓
✓	3	Good 3	Static	90°	0°	--	✓
✖	4	Bad Arc	Arc	0° to 170°	90°	CW	✓
✓	5	Good Arc	Arc	0° to 170°	0°	CW	✓
✖	6	Bad Field	Static	90°	90°	--	✓
✓	7	Good Field	Static	90°	0°	--	✓

C:342.5° G:261.8°

Couch Angle(°)

342.5

Gantry Angle(°)

261.8

Truebeam

ESAPI, TESTING  
PHY0019

Select Patient   Review Setup   Clearance Map   NOT FOR CLINICAL USE

rttrtt

Isocenter (cm)   X (R-L) 14.13   Y (I-S) 67.03   Z (P-A) -7.49   Couch Buffer (cm) 2   Patient Buffer (cm) 2

Couch Shift (cm)   X 0   Y 0   Z 0

Data   Report

MapRT has MLC

Status	#	ID	Type	Gantry	Couch	Direction	✓
✓	1	Good 1	Static	0°	0°	--	✓
✓	2	Good 2	Static	45°	0°	--	✓
✓	3	Good 3	Static	90°	0°	--	✓
✗	4	Bad Arc	Arc	0° to 170°	90°	CW	✓
✓	5	Good Arc	Arc	0° to 170°	0°	CW	✓
✗	6	Bad Field	Static	90°	90°	--	✓
✓	7	Good Field	Static	90°	0°	--	✓

Gantry Angle (°)

Couch Angle (°)

C:0° G:0°

4 5 6 7

Couch Angle (°) 0

Gantry Angle (°) 0

Truebeam

## Non-Coplanar planning...

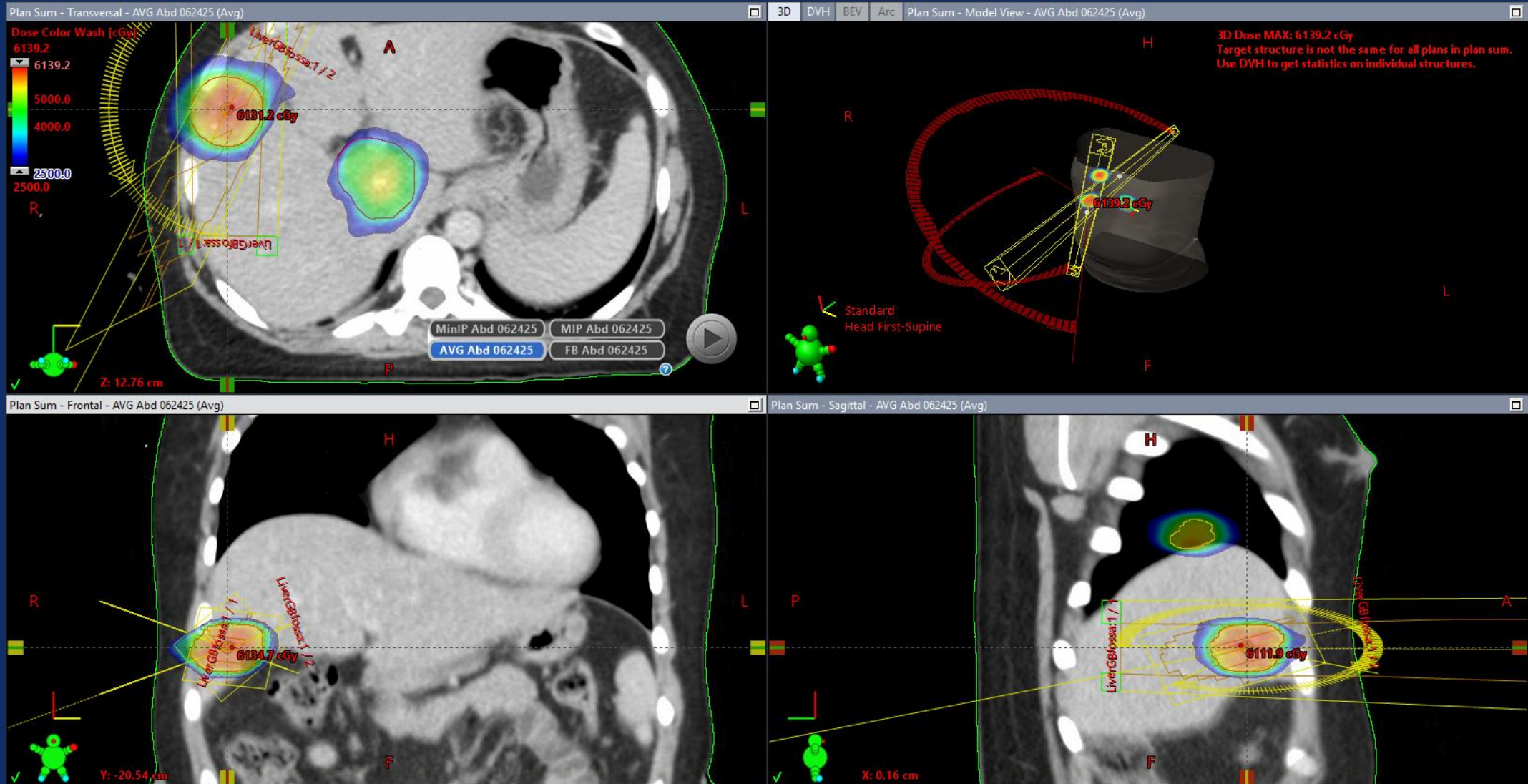
Reduces low-dose smear

Can improve conformity (depending on plan)

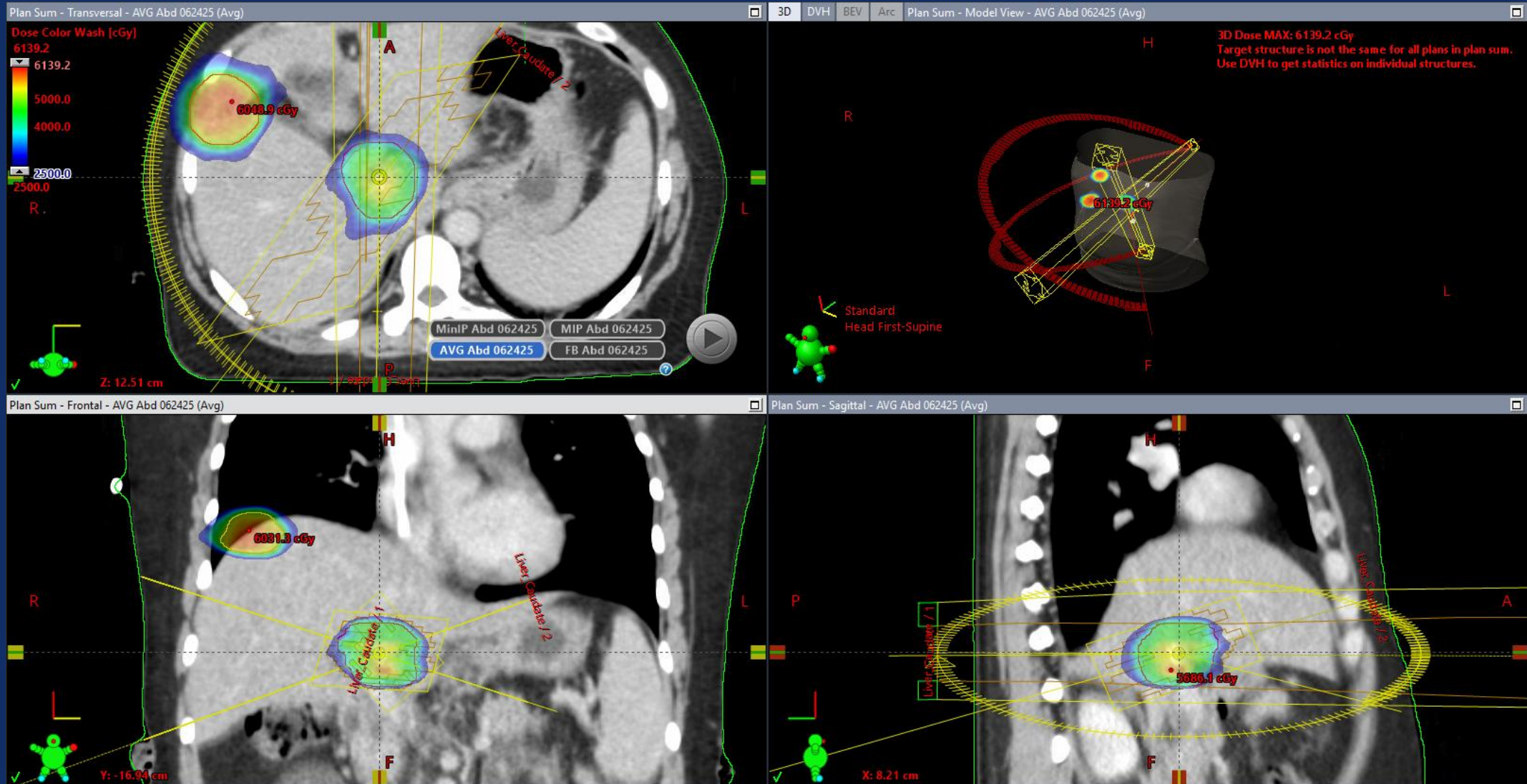
Some argue... doesn't make high-dose region any better

But, certainly doesn't make high-dose region worse.

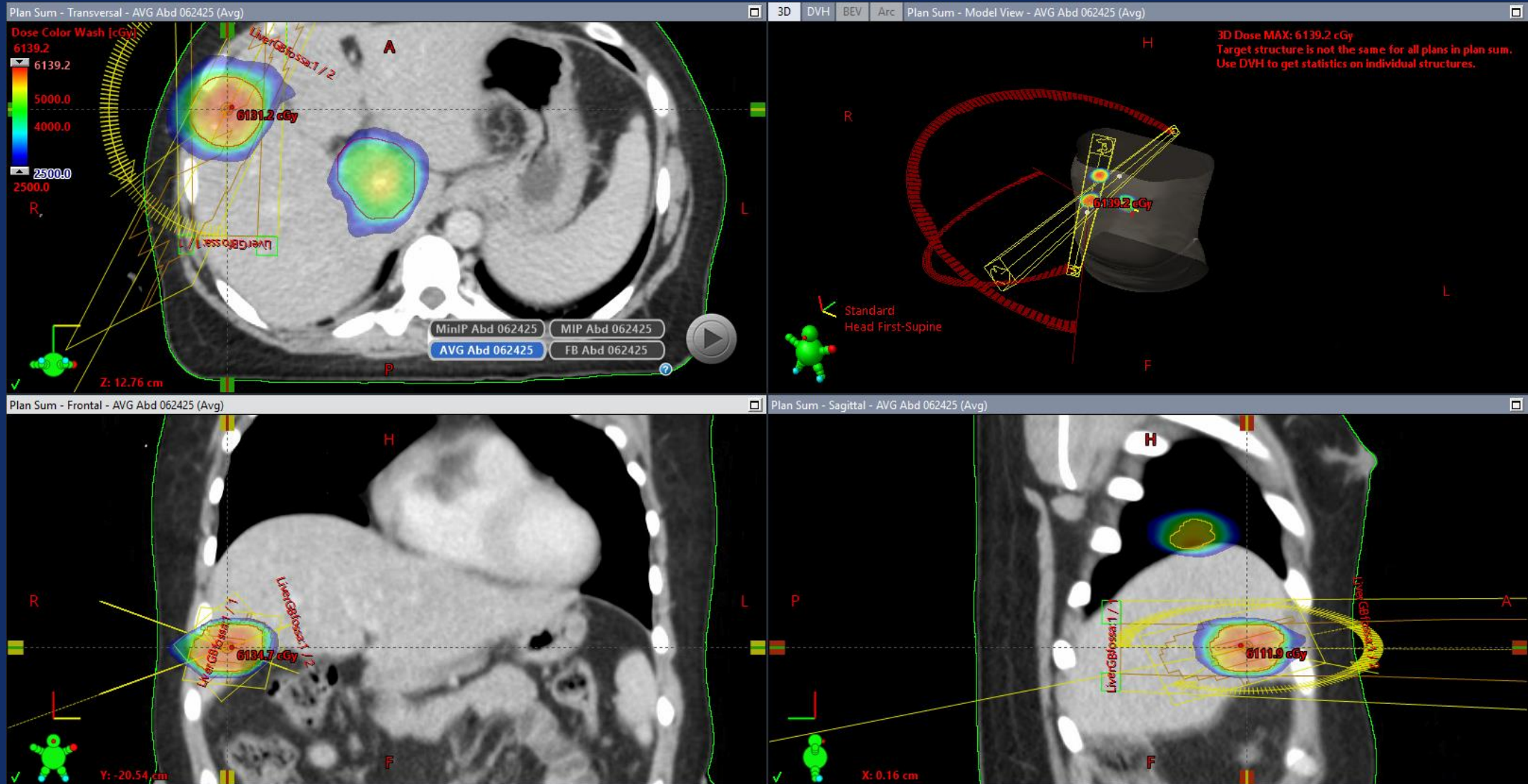
# MapRT<sup>®</sup>



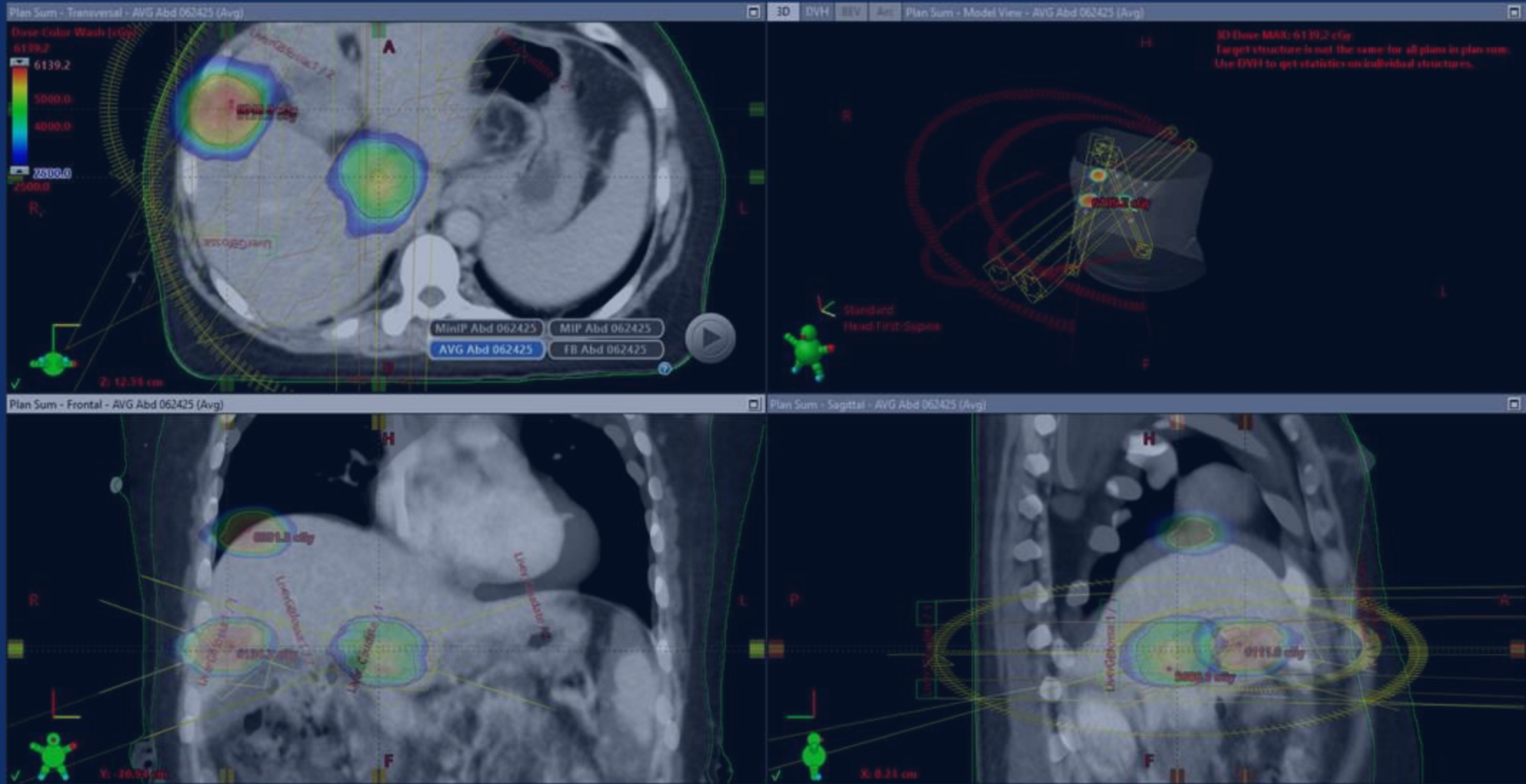
# MapRT<sup>®</sup>



# MapRT<sup>®</sup>



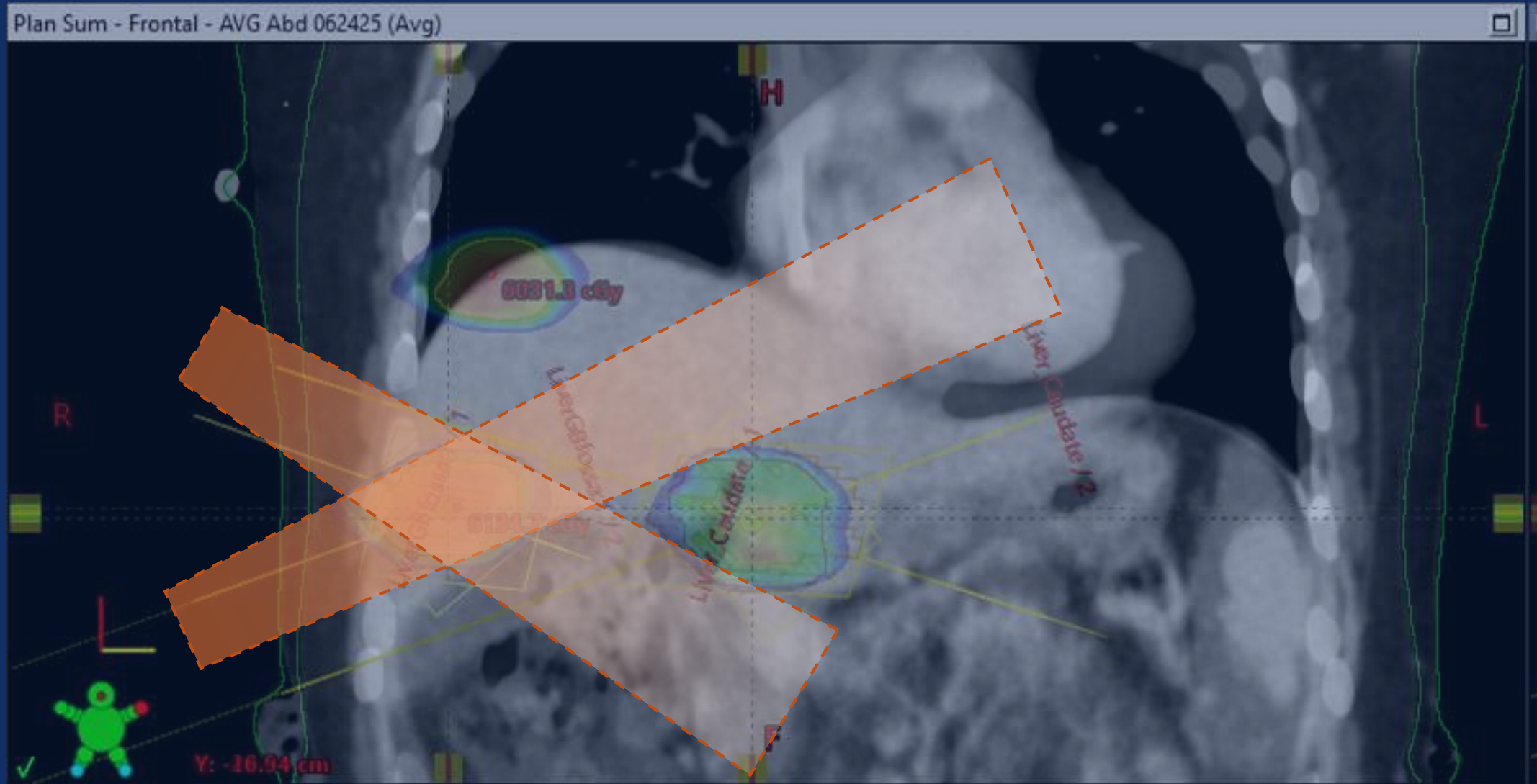
# MapRT®



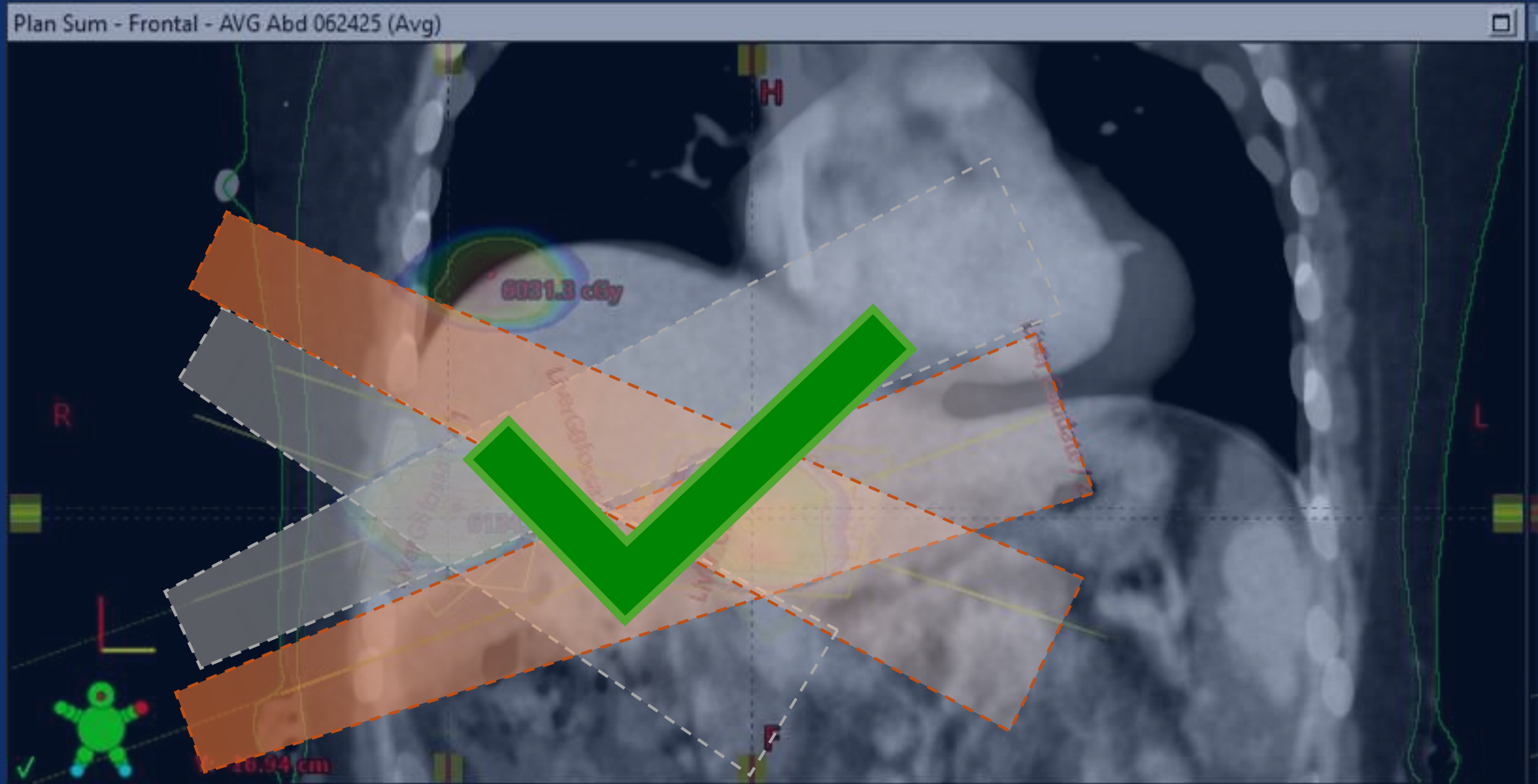
# MapRT<sup>®</sup>



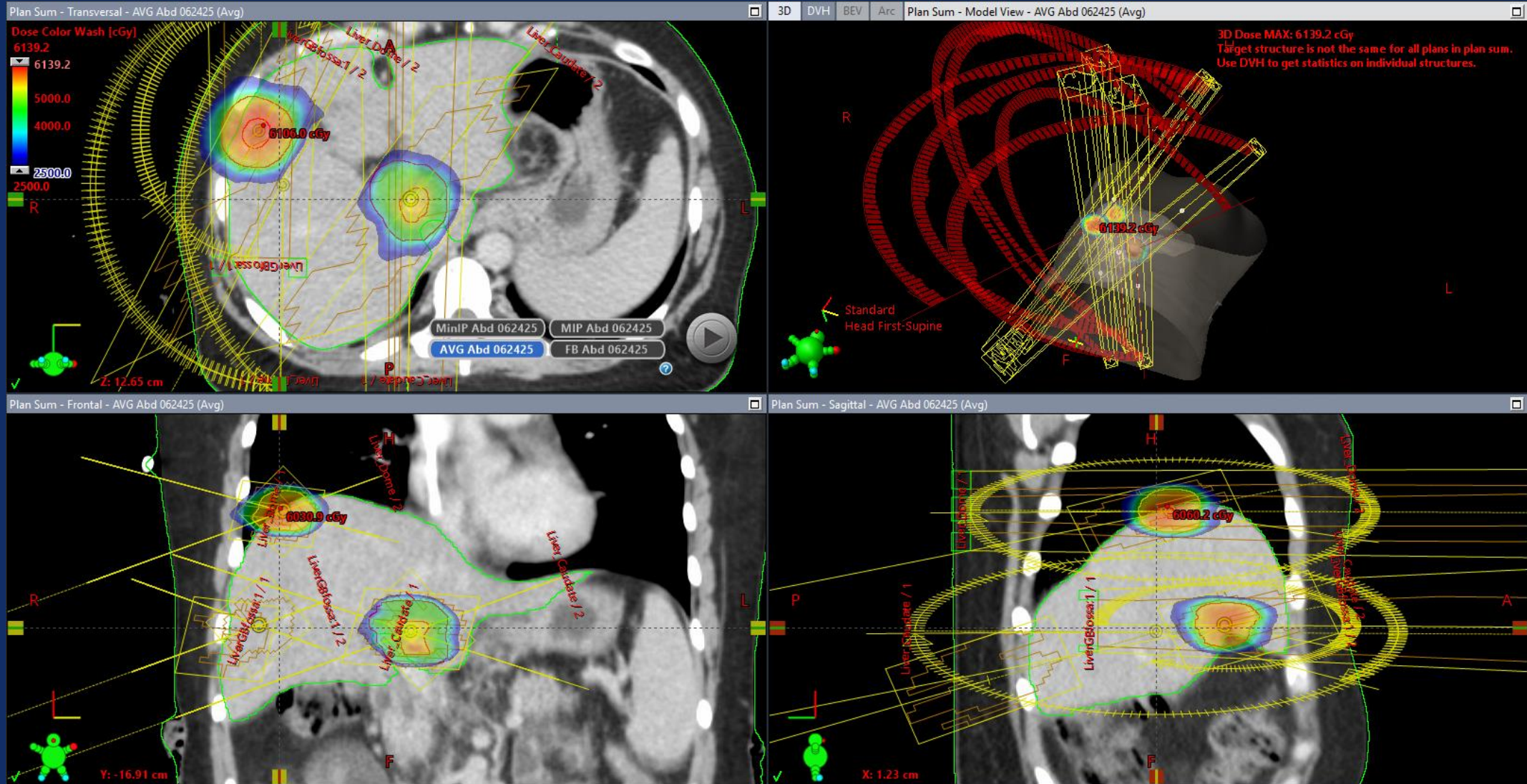
# MapRT<sup>®</sup>

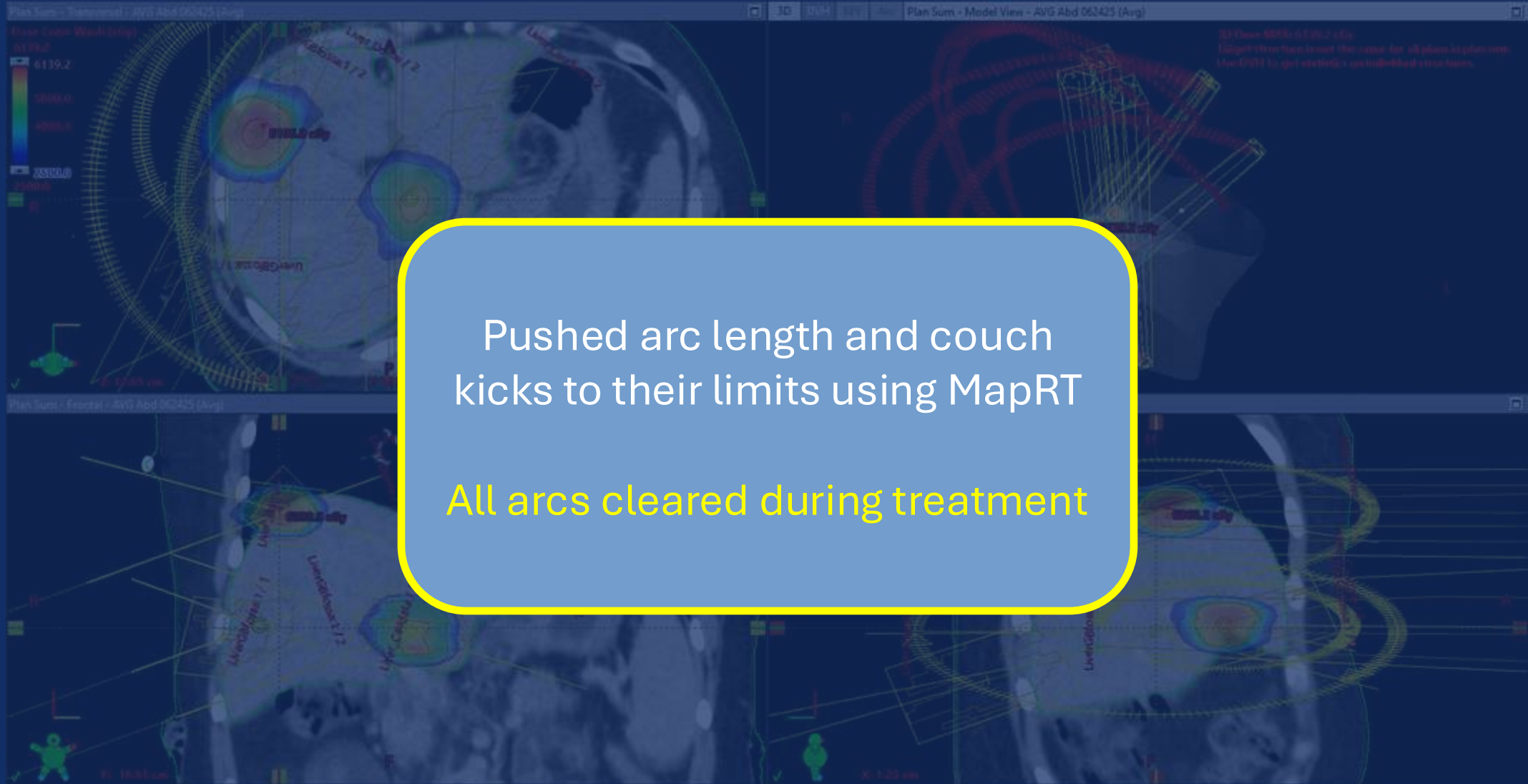


# MapRT®

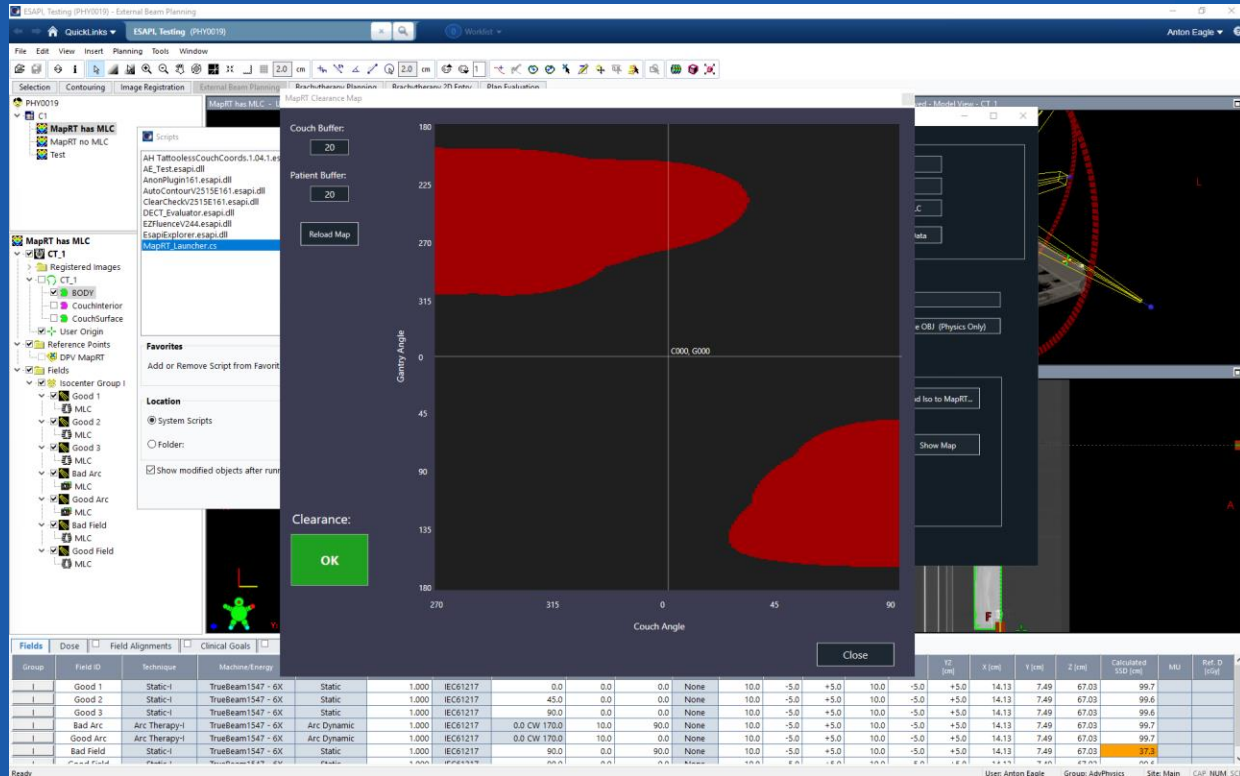


# MapRT<sup>®</sup>





# MapRT®



## Advanced MapRT

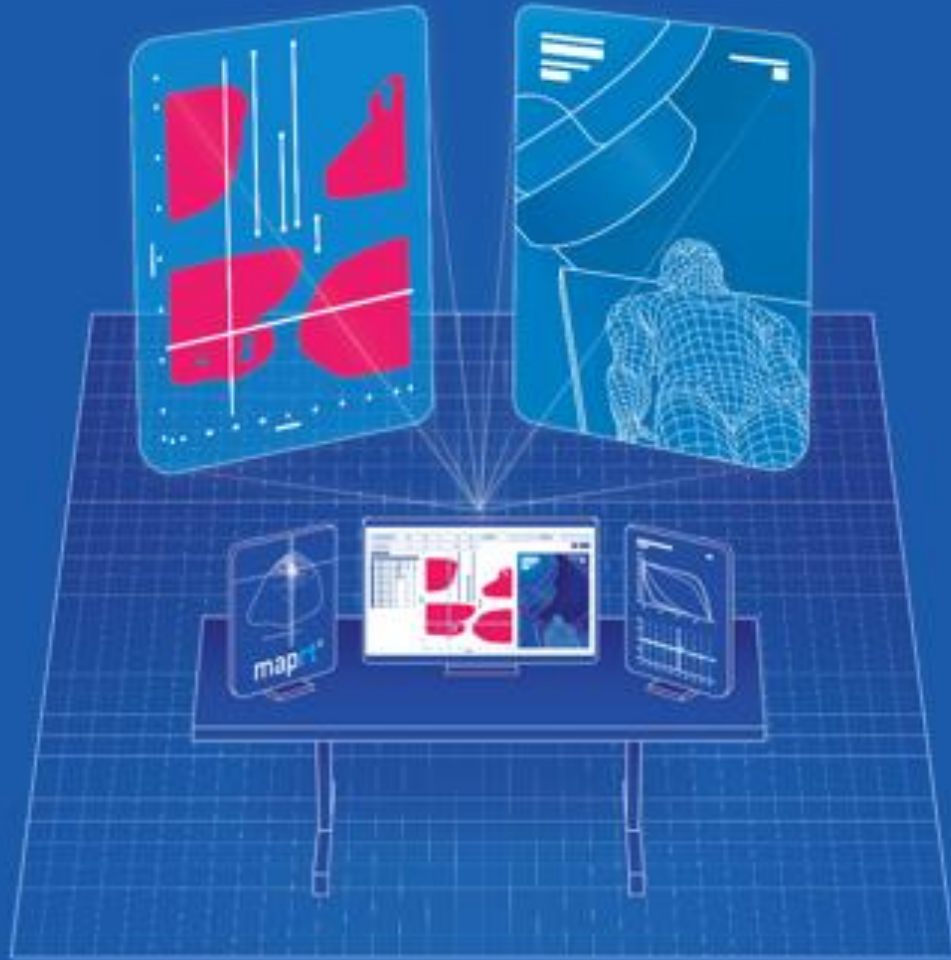
Comes with API

Can write ESAPI scripts to access 3D surface right in Eclipse

Can write Python apps, etc.

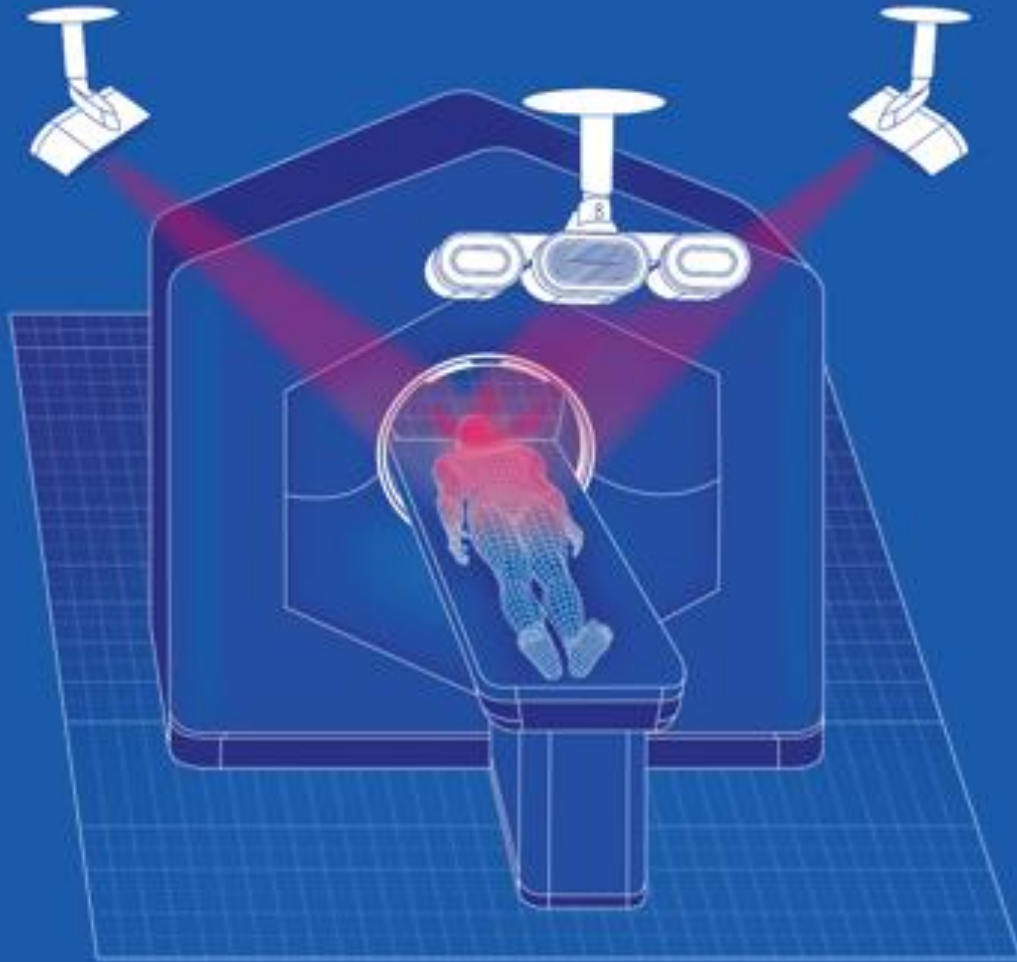
Can do anything you want with surfaces

# Treatment Planning

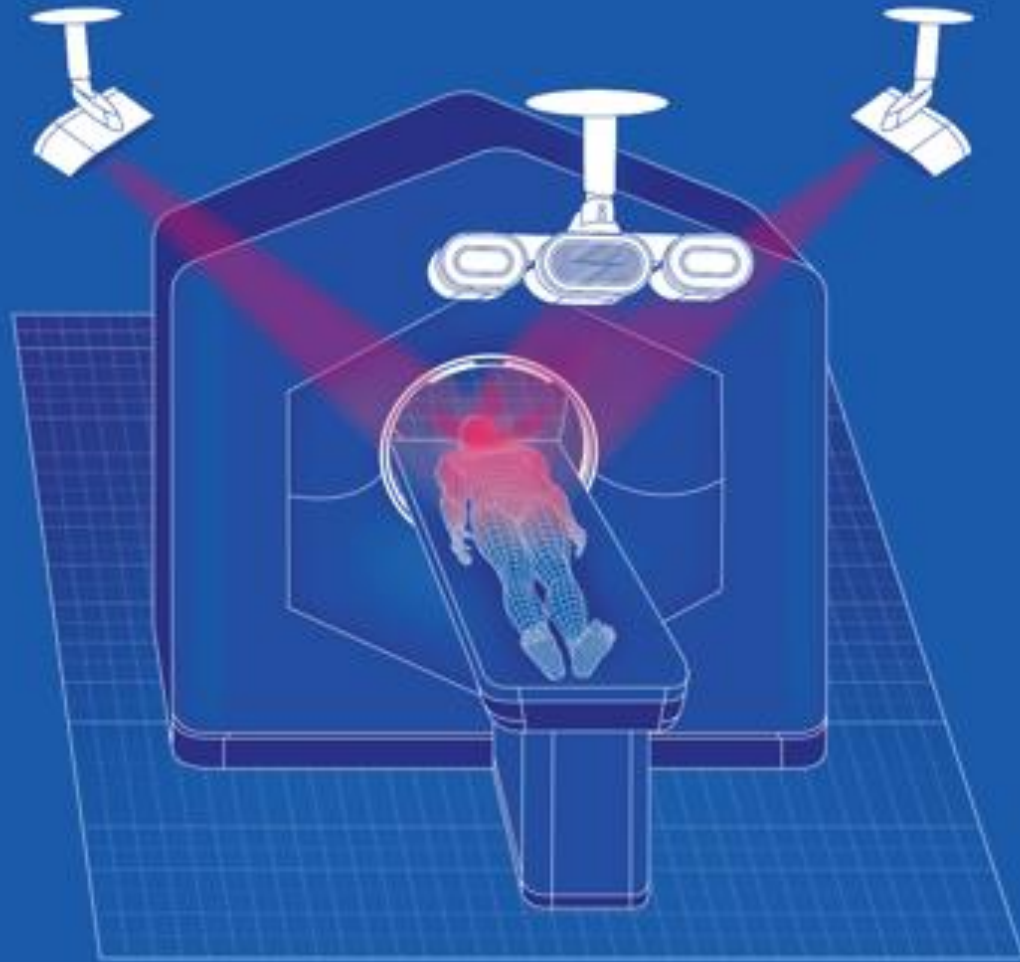


# Linac Vault

AlignRT<sup>®</sup>



## The Original SGRT Solution

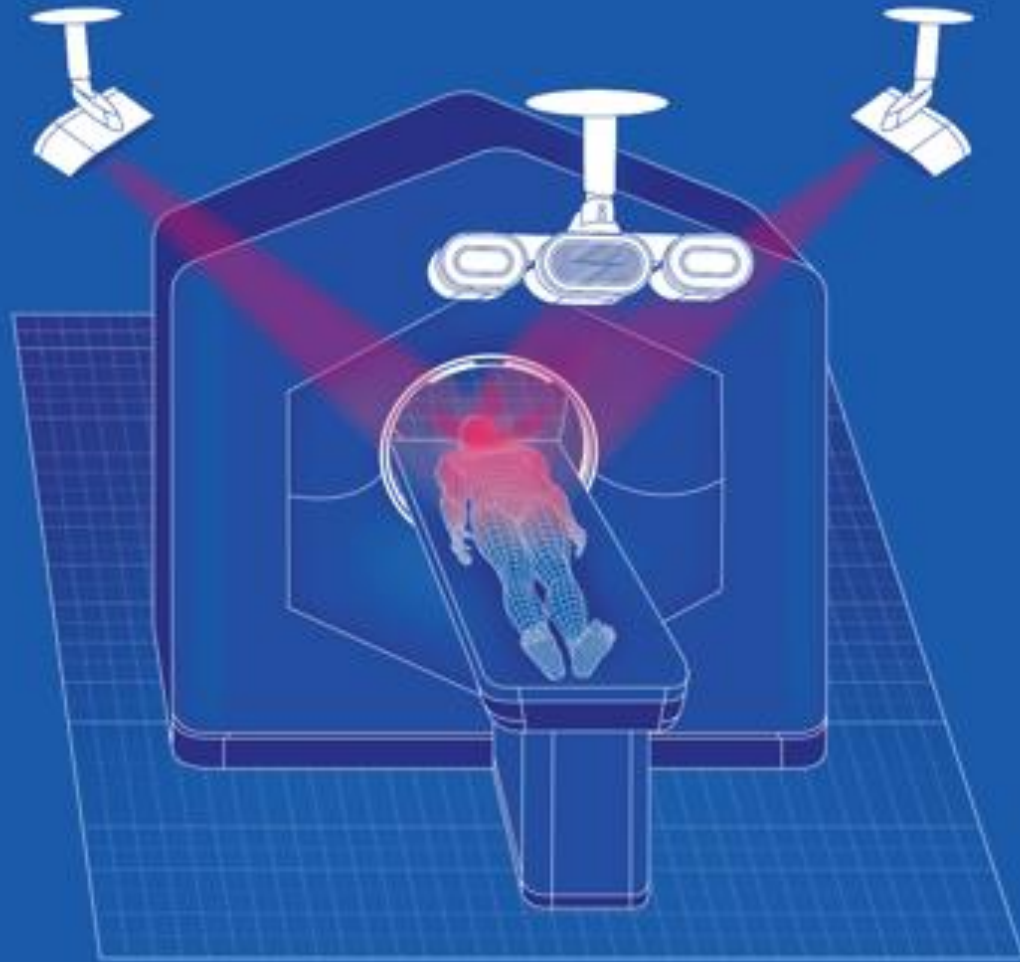


Tracks patient before and during Tx.

Assists with localization

Monitors immobilization

A suite of solutions...



Postural Video

Respiratory Module

OIS Module

AutoROI Module

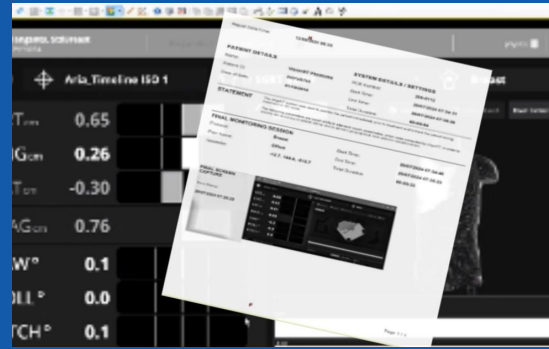
BeamGuide

# AlignRT<sup>®</sup>

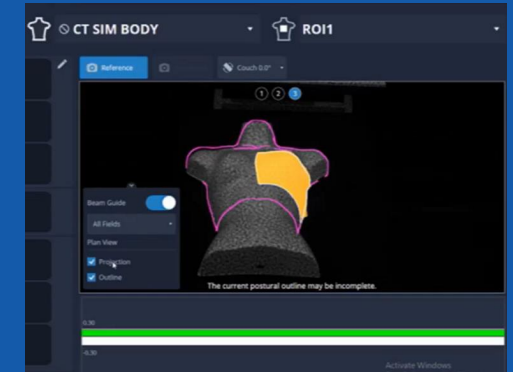
## Postural Video



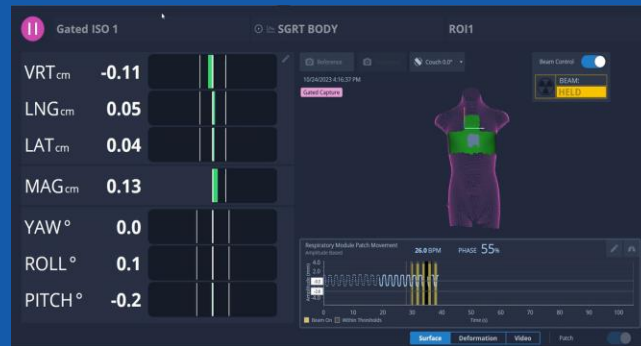
## OIS Module



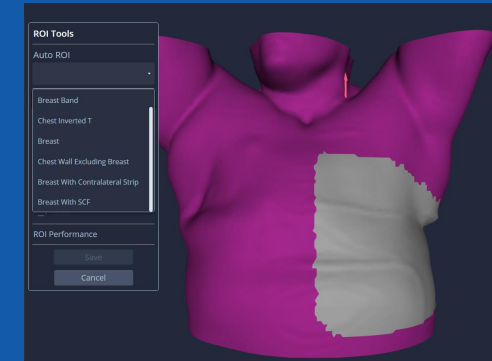
## BeamGuide



## Respiratory Module



## AutoROI Module



## Postural Video



Assists with patient setup

Shows outlines of all surface

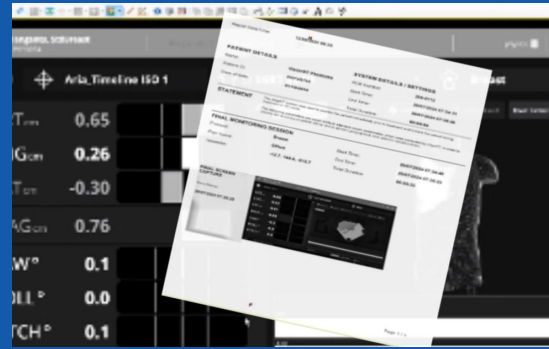
Can compare and adjust patient to outlines in real time

# AlignRT<sup>®</sup>

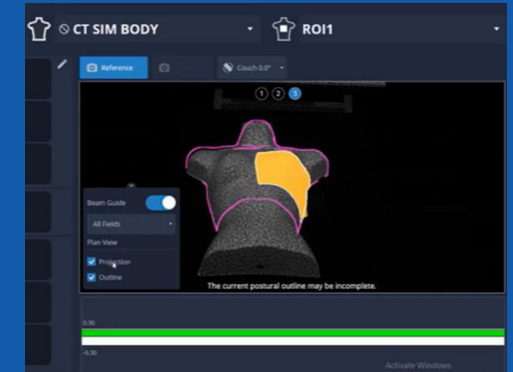
## Postural Video



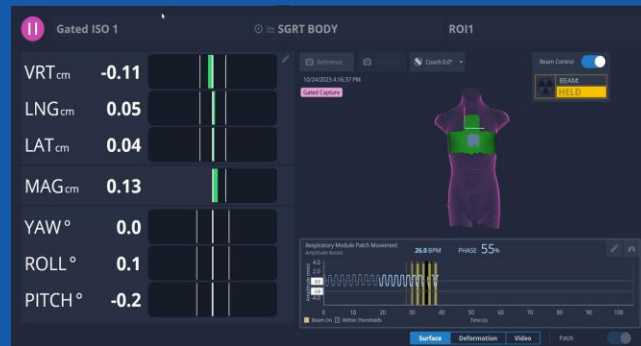
## OIS Module



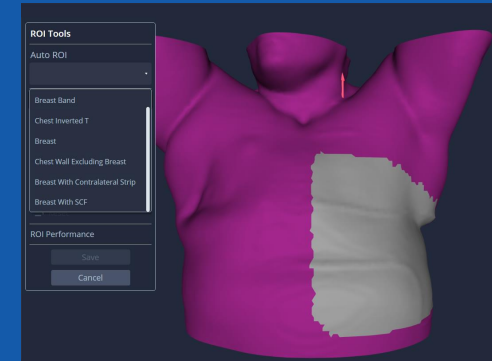
## BeamGuide



## Respiratory Module

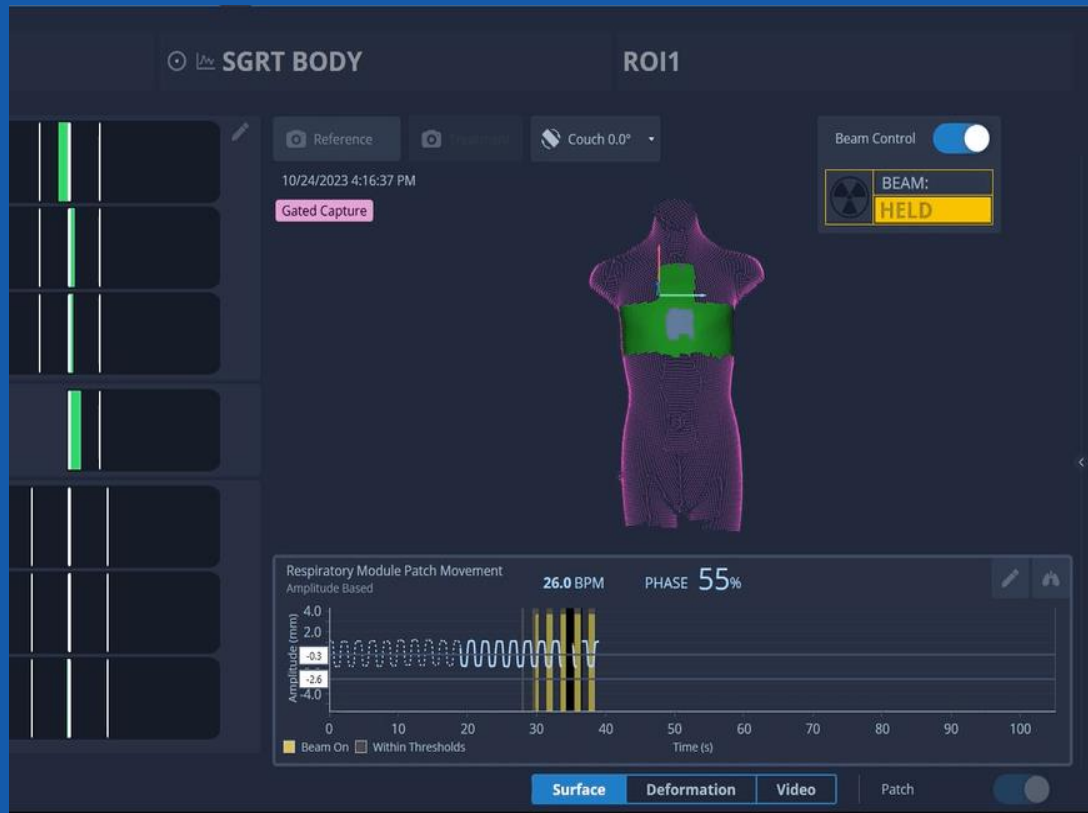


## AutoROI Module



# AlignRT<sup>®</sup>

## Respiratory Module



Phase and Amplitude Gating

Continuous monitoring in 6 DoF

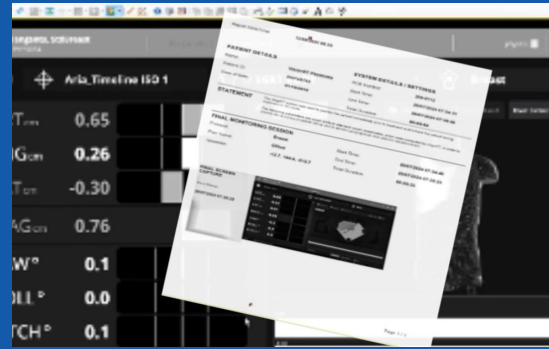
Deviceless Delivery

# AlignRT<sup>®</sup>

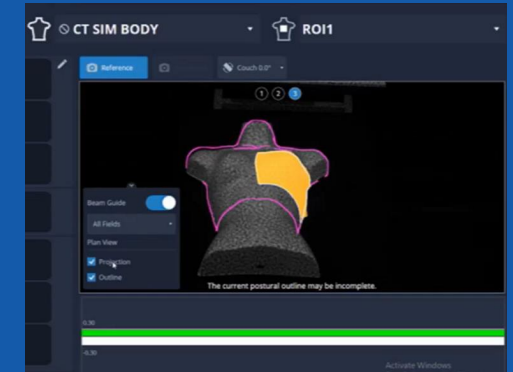
## Postural Video



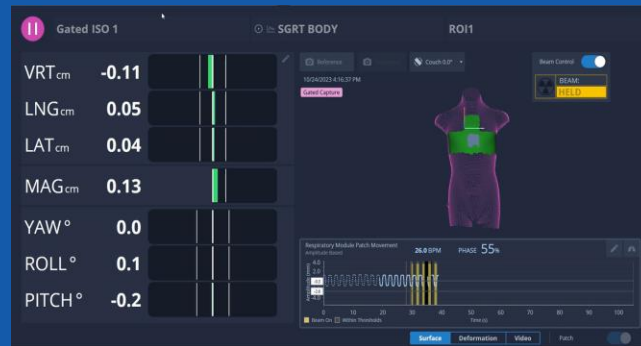
## OIS Module



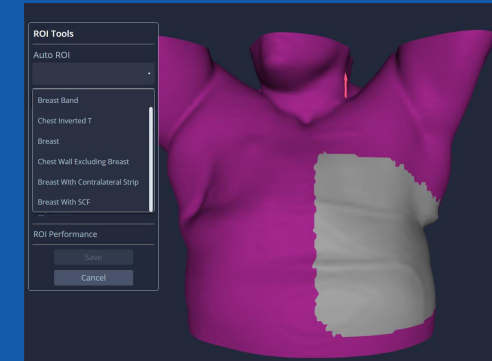
## BeamGuide



## Respiratory Module

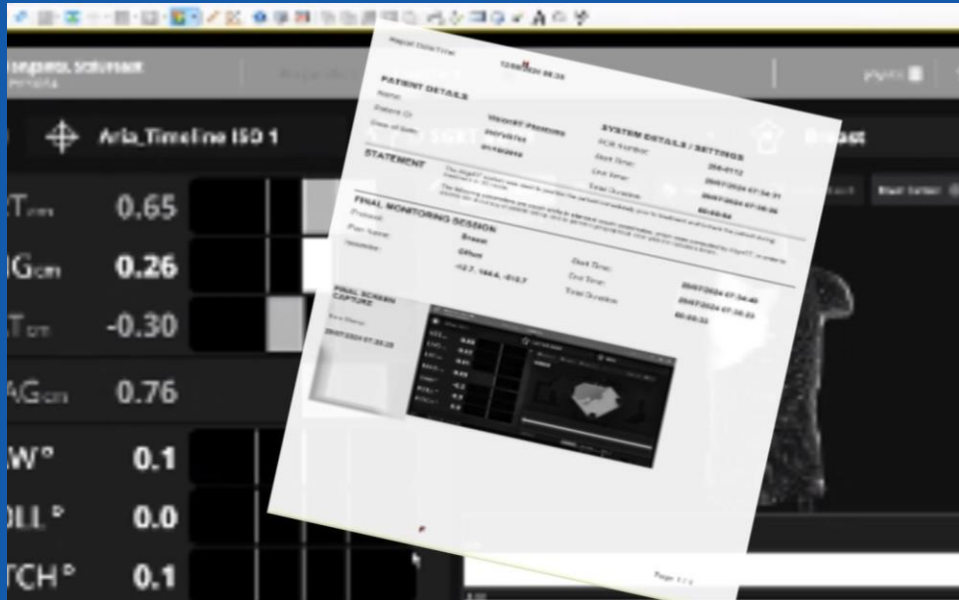


## AutoROI Module



# AlignRT®

## OIS Module



## AlignRT reports in ARIA

Show up in Offline Review Timeline

Reports show up in Doc's image list

Ready for approval

AlignRT Report - 4/20/2026 8:26 AM - ????

**alignRT<sup>®</sup> Treatment Report**

**AdventHealth**  
AdventHealth - Parker  
8395 Crown Crest Blvd  
Parker CO 80138

Report Date/Time: 4/20/2026 9:31 AM

**PATIENT DETAILS**  
Name: ██████████  
Patient ID: ██████████  
Date of Birth: ██████████

**SYSTEM DETAILS / SETTINGS**  
PCR Number: ██████████  
Start Time: 4/20/2026 8:09:26 AM  
End Time: 4/20/2026 8:26:14 AM  
Total Duration: 00:16:47

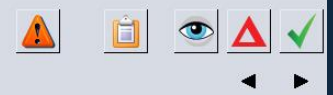
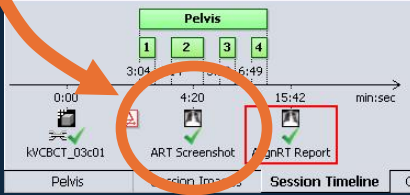
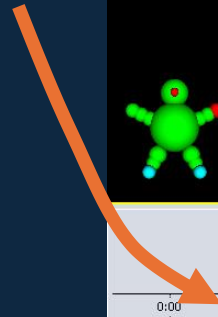
**STATEMENT**  
Surface guidance was employed during this treatment session to improve set-up accuracy, enable continuous intrafraction motion monitoring, and maintain geometric precision throughout treatment delivery.  
When active motion management is prohibited, automatic beam gating within the iGRT system was utilized to suspend radiation delivery using the patient's surface as a surrogate for internal target + OAR motion during the normal (Free Breathing) or augmented (PBRT) breathing cycle.

**SCREEN CAPTURE 1**  
Time Stamp: 4/20/2026 8:14:52 AM

WIL <sub>0</sub>	-0.04
TRG <sub>0</sub>	0.05
LAT <sub>0</sub>	0.01
MAG <sub>0</sub>	0.09
YAW <sub>0</sub>	-0.1
ROLL <sub>0</sub>	0.0
PITCH <sub>0</sub>	0.0

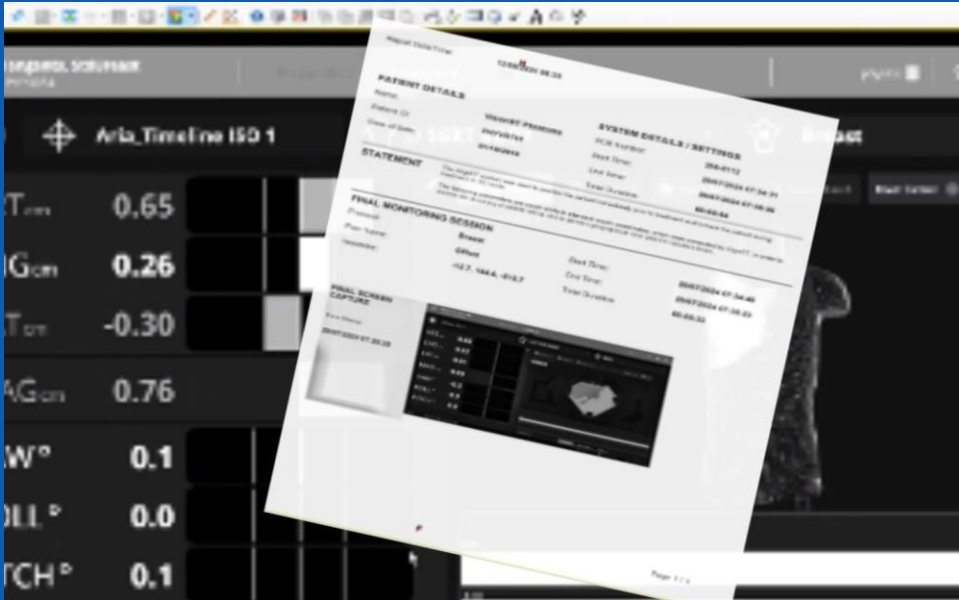
1.0 cm  
L

(Tanner MD, Andrew  
multihosplatacaa 4/20/2026 2:59 PM) ✓



# AlignRT<sup>®</sup>

## OIS Module



## AlignRT reports in ARIA

Show up in Offline Review Timeline

Reports show up in Doc's image list

Ready for approval

Satisfies CPT 77387 mod 26

CPT 77387 mod 26

## CPT 77387 mod 26

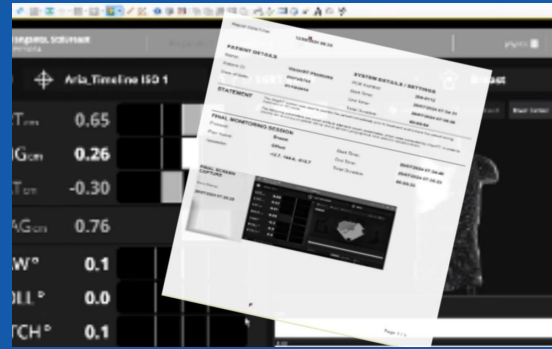
SGRT Element	CPT 77387-26 Billing Requirement	Explanation	Found Where?
Clinical Rationale	Validate medical necessity of SGRT use	Why SGRT was clinically indicated	Physician notes, Rx, or consult
Shift Verification	Supports guidance and tracking professional review	Record the magnitude of positional shifts	Offline Review (or similar)
SGRT Performance Summary	Shows that the service was performed	Document that SGRT was used	OIS reports <del>Was missing</del> Offline Review
Physician Review and Approval	Demonstrates professional interpretation & approval	Document that the Rad. Onc. approved data	Now app <del>Was missing</del> Offline Review

# AlignRT<sup>®</sup>

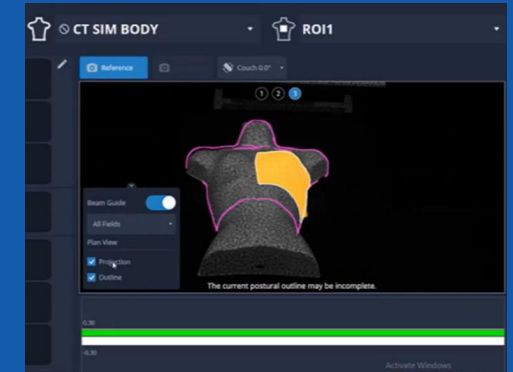
## Postural Video



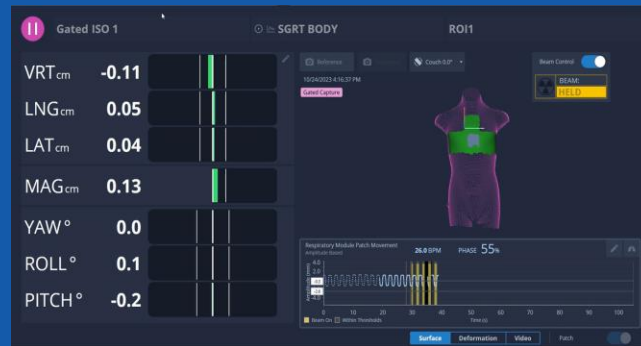
## OIS Module



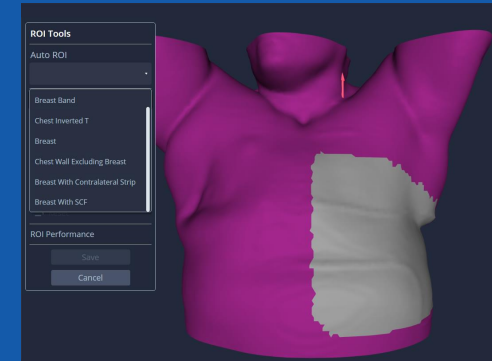
## BeamGuide



## Respiratory Module

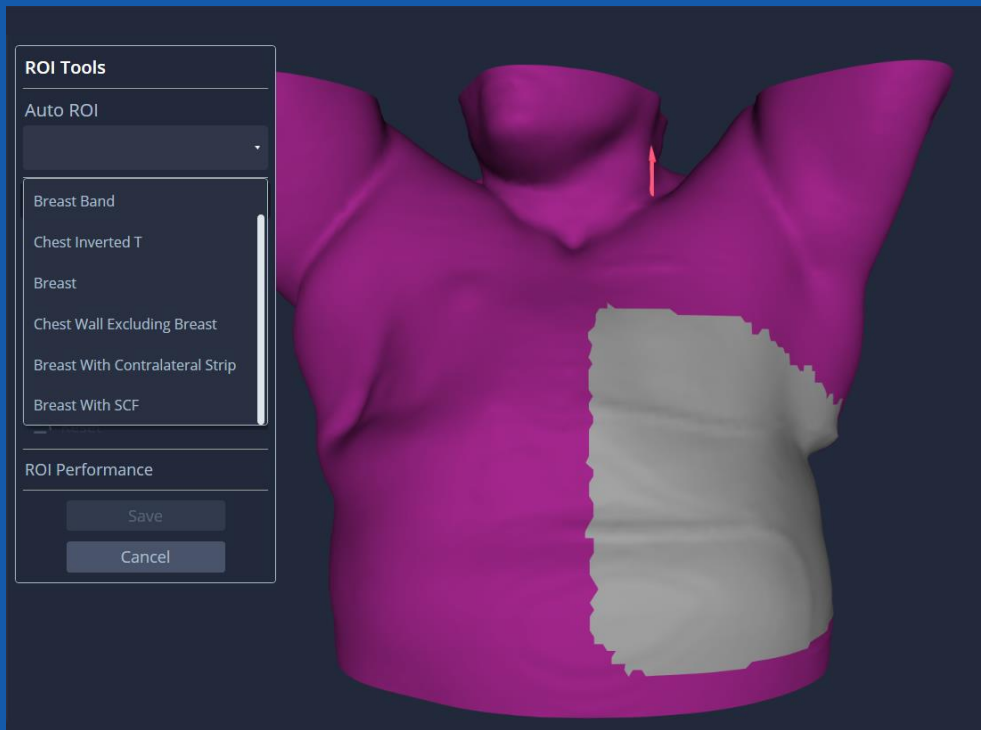


## AutoROI Module



# AlignRT<sup>®</sup>

## AutoROI Module



Protocol based automatic ROIs

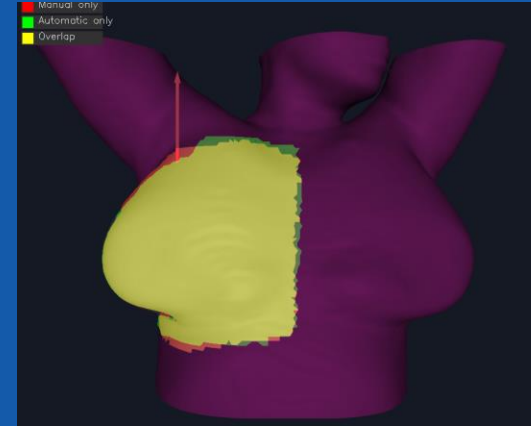
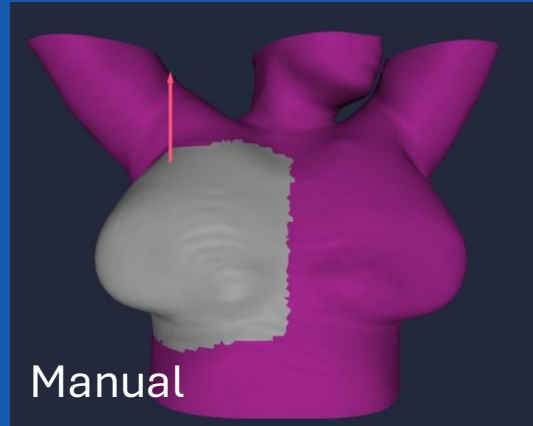
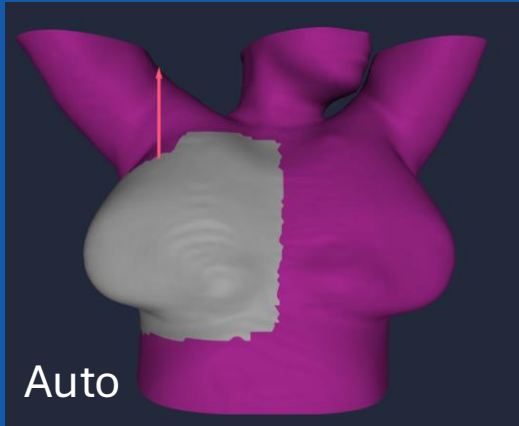
Provides 3-5 ROI options per protocol

Introduces ROI consistency among staff

ROI creation time: minutes → seconds

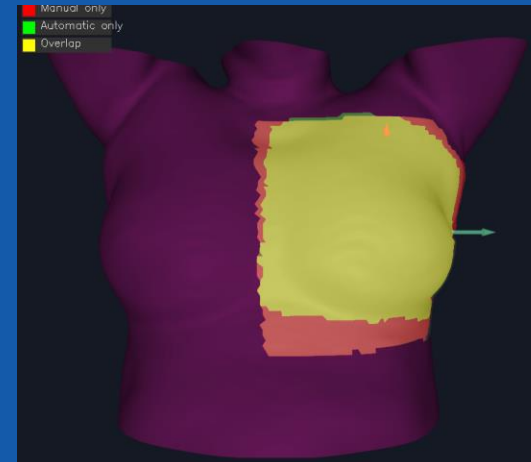
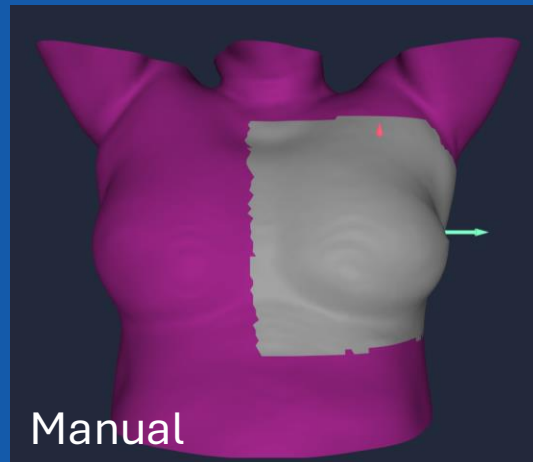
# AlignRT<sup>®</sup>

## AutoROI Module



### Right Breast

- Dice coefficient: 0.967
- RTDs: Clinically Equivalent
- Contour Time:
  - Auto: 8 seconds
  - Manual: 95 seconds



### Left Breast DIBH

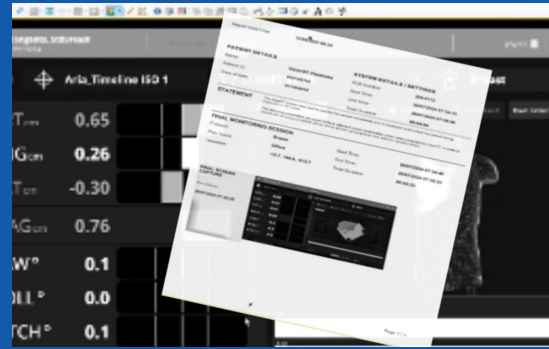
- Dice coefficient: 0.901
- RTDs: Clinically Equivalent
- Contour Time:
  - Auto: 10 seconds
  - Manual: 100 seconds

# AlignRT<sup>®</sup>

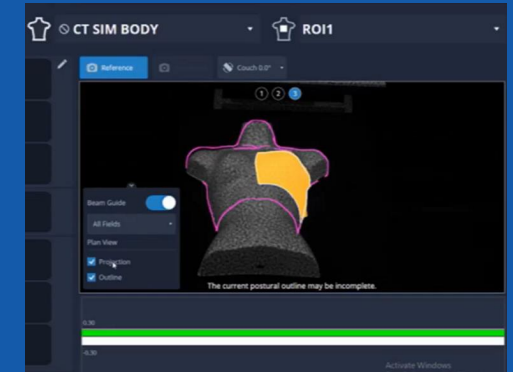
## Postural Video



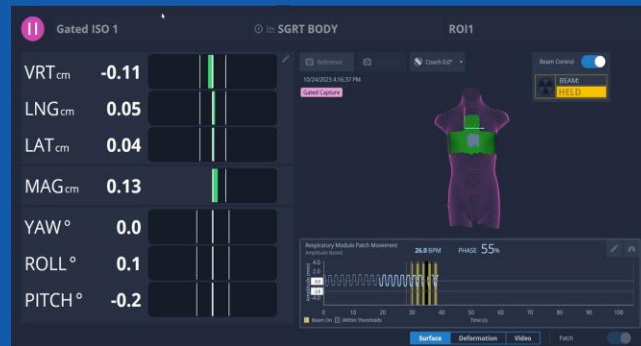
## OIS Module



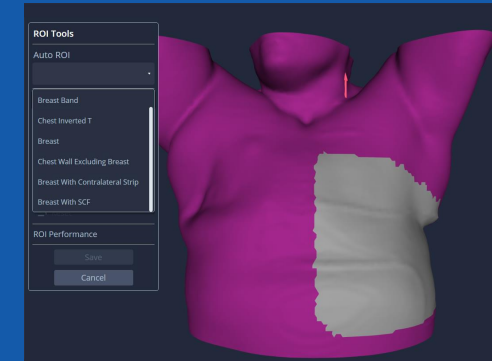
## BeamGuide



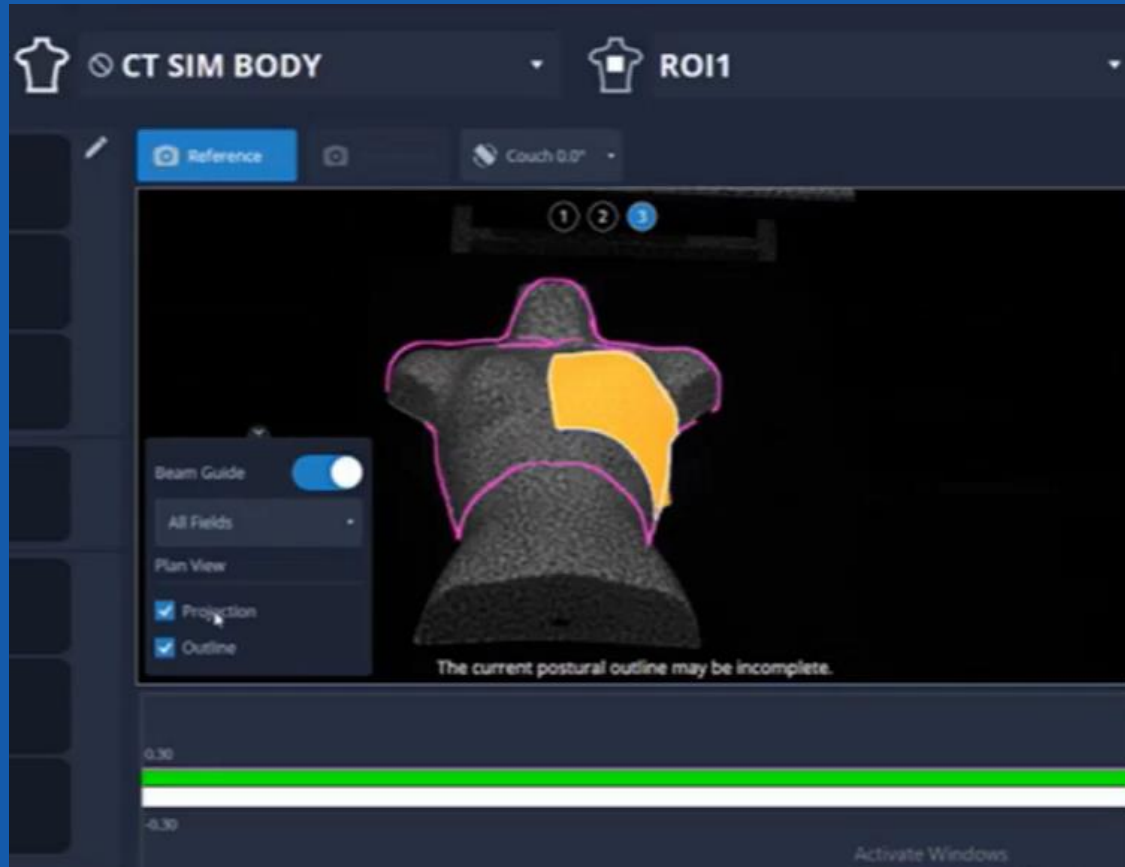
## Respiratory Module



## AutoROI Module



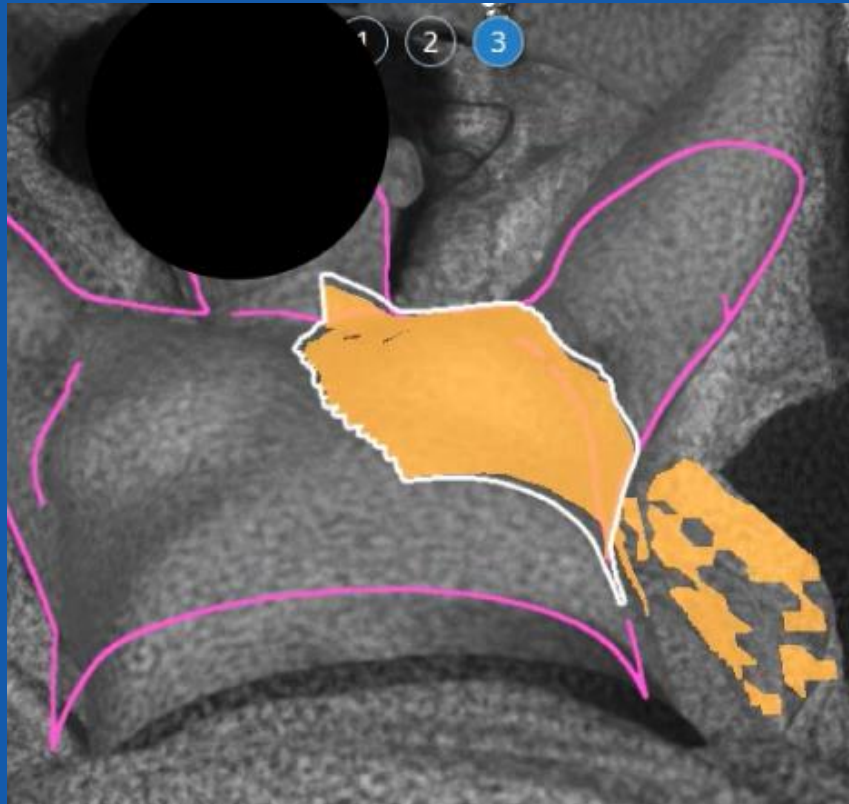
## BeamGuide



Overlays tx field onto real-time postural video

## BeamGuide

DIBH Lt Breast



Overlays tx field onto real-time postural video

White outline = intended (on DICOM surface)

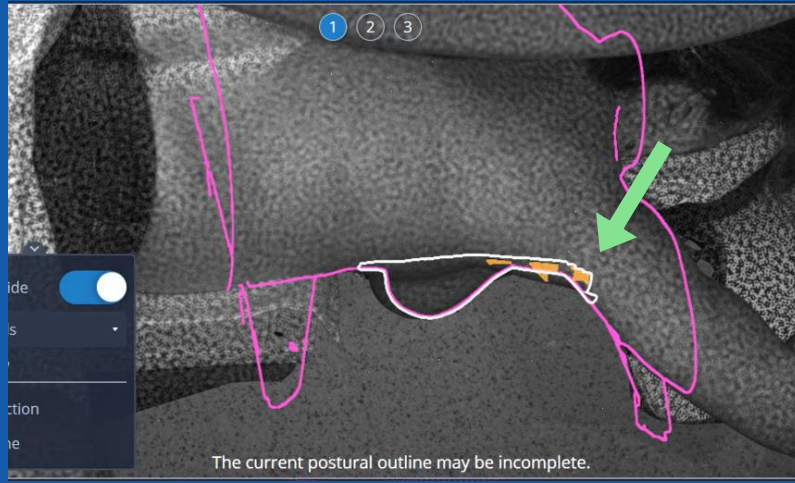
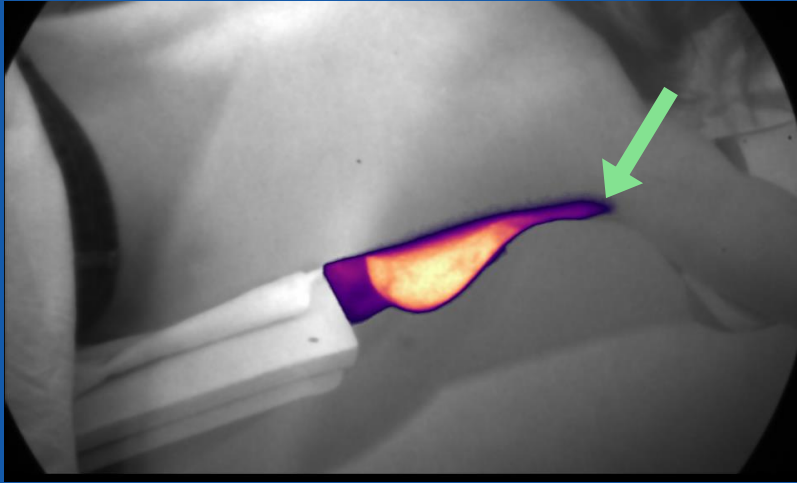
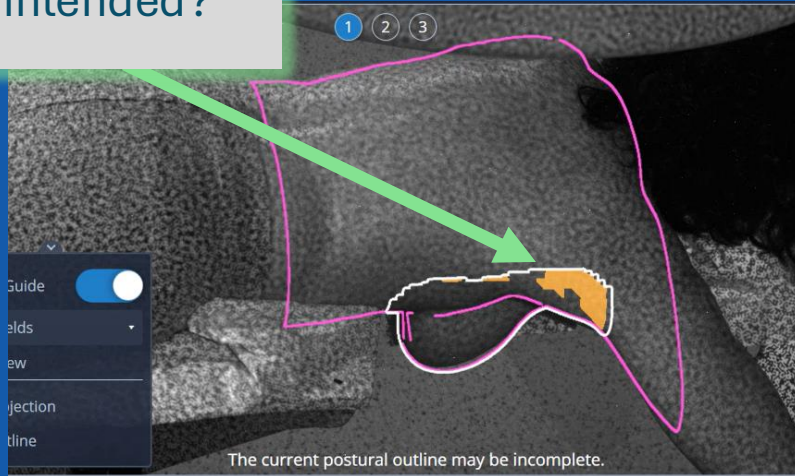
Orange is field projected onto current surface

Can assist in setup

# AlignRT<sup>®</sup>

## BeamGuide

Is this intended?



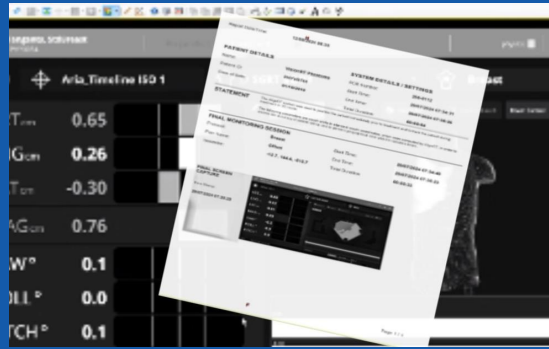
Can also be use  
spectively with DoseRT  
intended dose extents

# AlignRT<sup>®</sup>

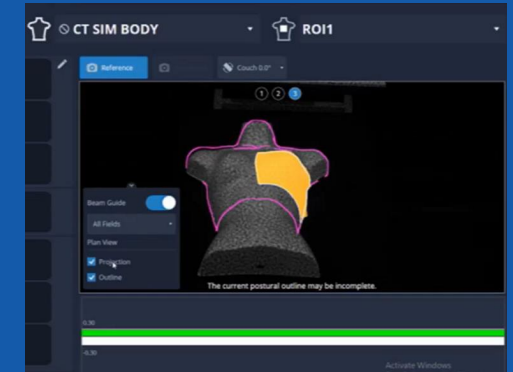
## Postural Video



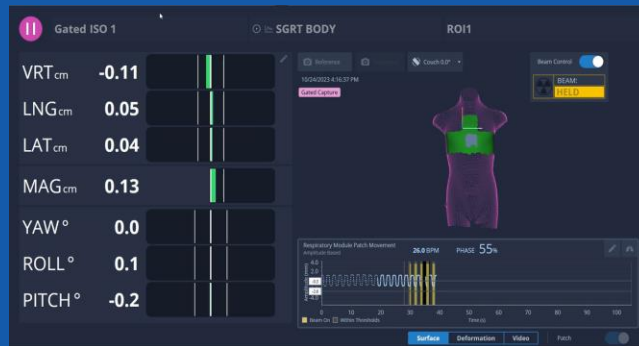
## OIS Module



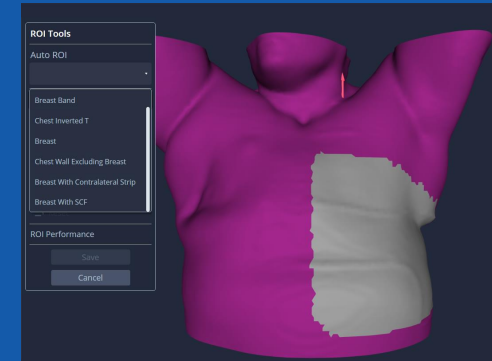
## BeamGuide



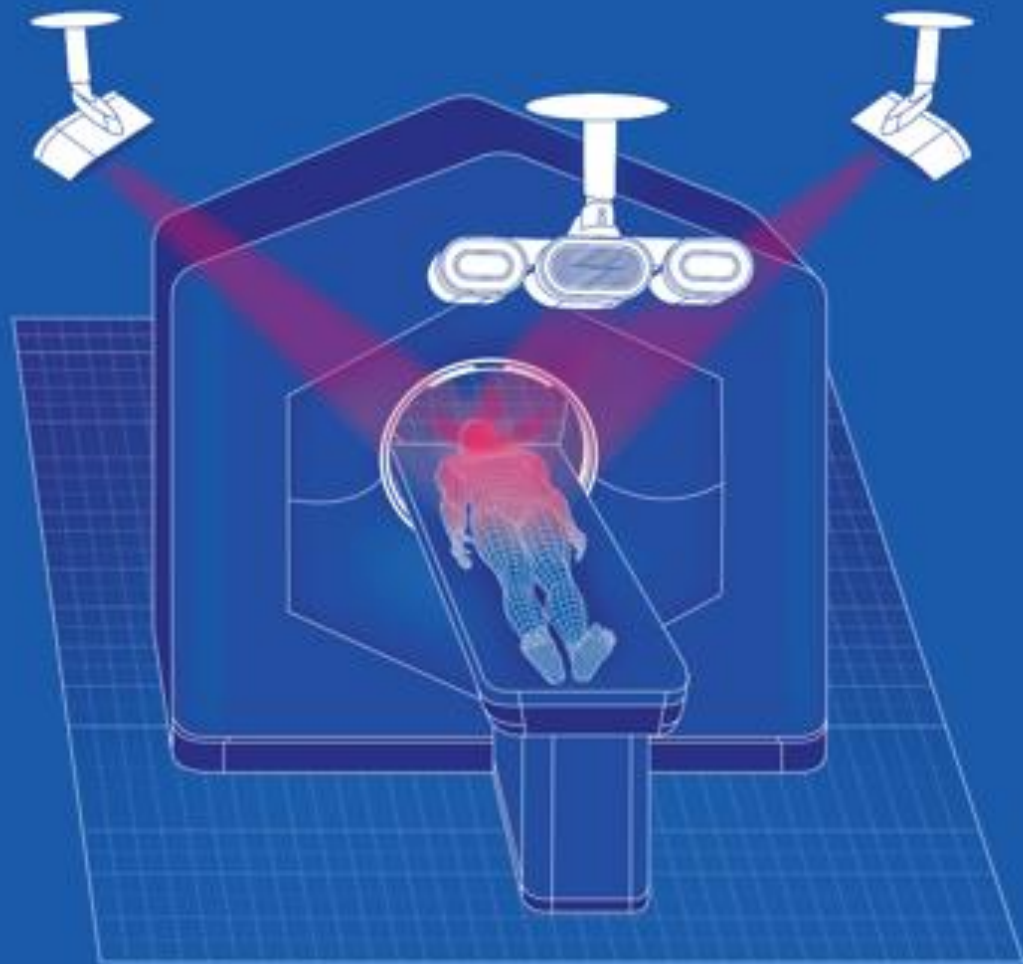
## Respiratory Module



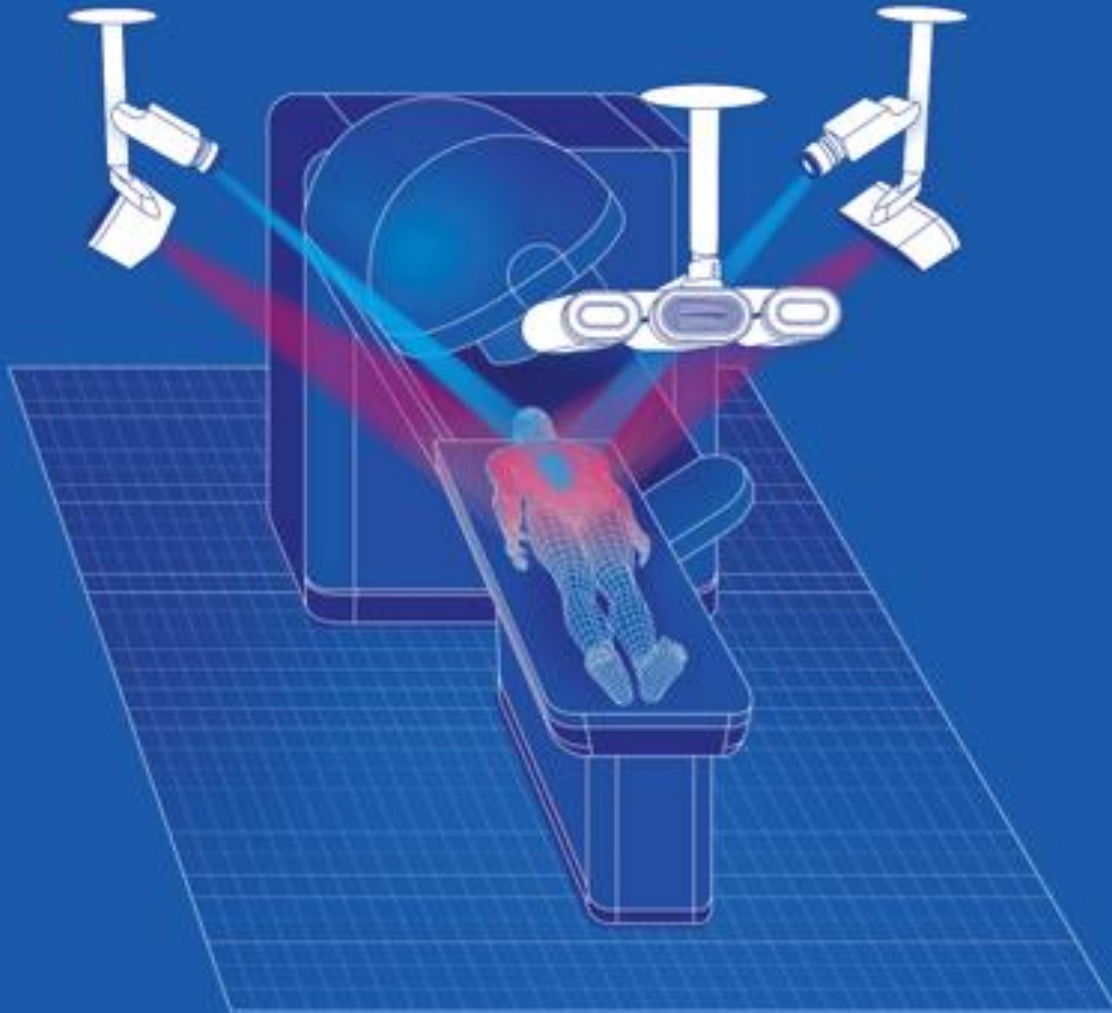
## AutoROI Module



# AlignRT<sup>®</sup>



# Dose Delivery



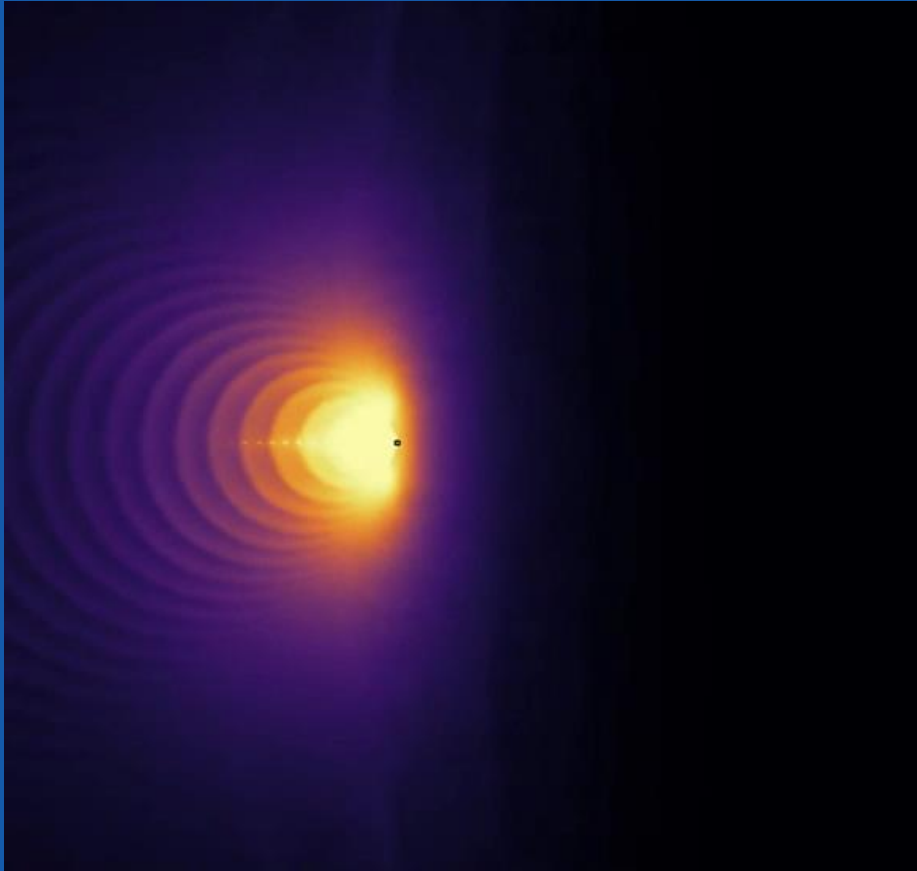
How to see dose on the surface?

Need to visualize Cherenkov emissions

What are Cherenkov emissions?

# Dose Delivery

## Cherenkov emissions

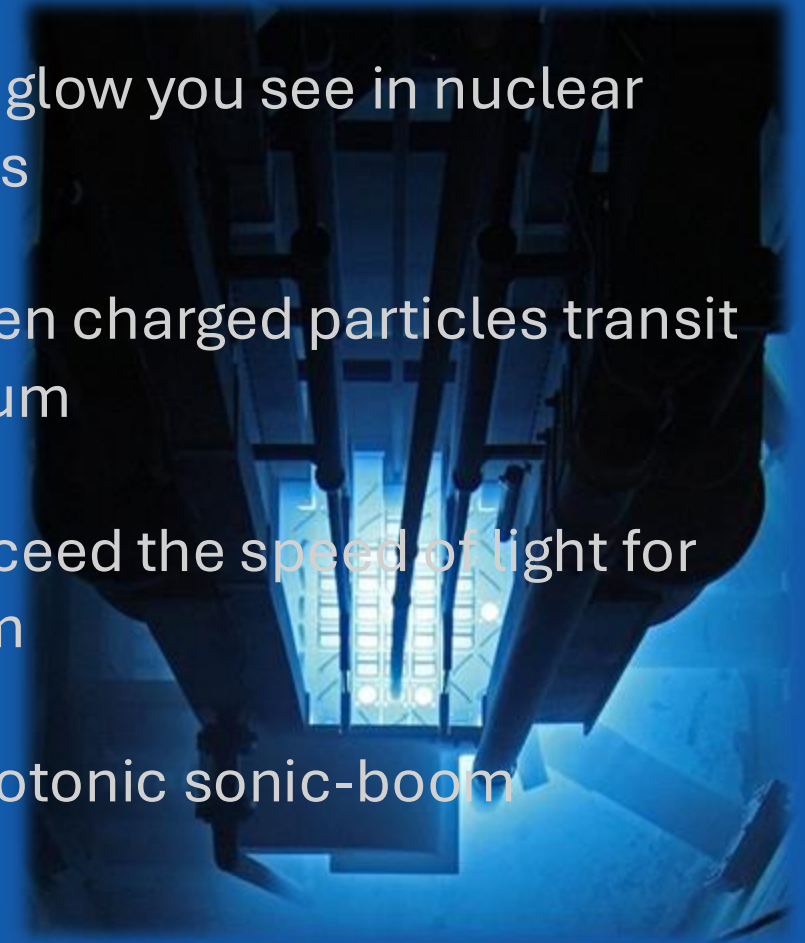


It's the blue glow you see in nuclear power plants

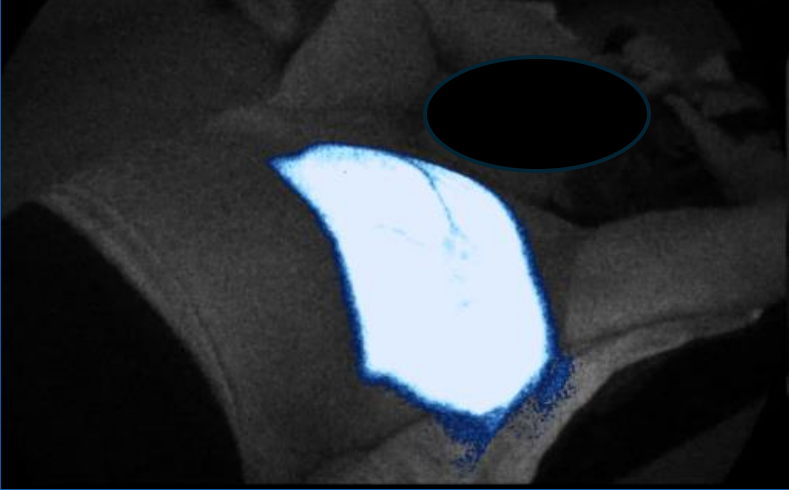
Created when charged particles transit some medium

Particles exceed the speed of light for that medium

It's like a photonic sonic-boom



# Dose Delivery



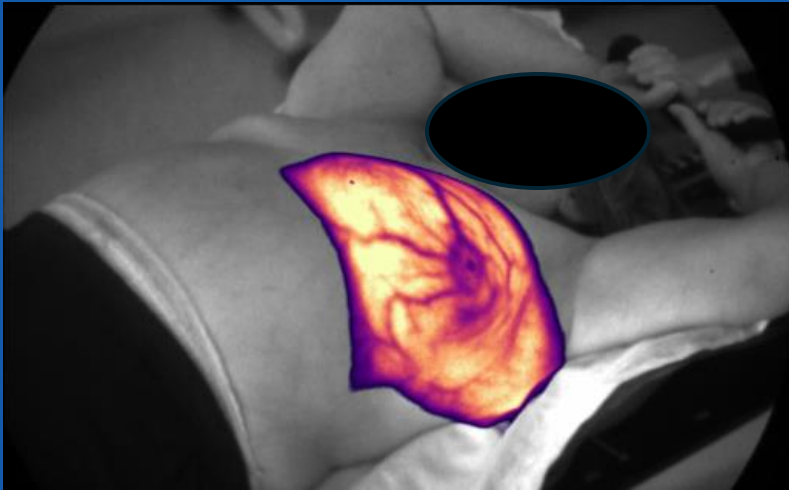
## Cherenkov emissions

Effect also happens in human tissue during radiation therapy

With sensitive camera, can capture image of these emissions

Can analyze emission to create a “dose” map

This is: DoseRT<sup>®</sup>



# DoseRT<sup>®</sup>

Why do we use this?

Detect setup / planning errors

Initial experience suggests ~10% of patients have...

- Compliance
- Setup
- Planning issues

Literature show similar

International Journal of  
Radiation Oncology • Biology • Physics





**Physics Contribution**

### Initial Clinical Experience of Cherenkov Imaging in External Beam Radiation Therapy Identifies Opportunities to Improve Treatment Delivery

Lesley A. Jarvis, MD, PhD,\* Rachael L. Hachadorian, MS,<sup>†</sup> Michael Jermyn, PhD,<sup>†</sup> Petr Bruza, PhD,<sup>†</sup> David A. Alexander, MD,<sup>†</sup> Irwin I. Tendler, PhD,<sup>†</sup> Benjamin B. David J. Gladstone, ScD,\*<sup>†</sup> Philip E. Bassem I. Zaki, MD,\* and Brian W. Pogue, PhD,<sup>‡</sup>†

\*Department of Medicine, Section of Radiation Oncology, Dartmouth Medical Center, Hanover, New Hampshire; and <sup>†</sup>Thayer School of Engineering, Hanover, New Hampshire; <sup>‡</sup>Department of Physics, Dartmouth College, Hanover, New Hampshire

Received Jun 5, 2020. Accepted for publication Nov 5, 2020.

**Purpose:** The value of Cherenkov imaging as an on-treatment quality assurance tool was evaluated in a 64-patient cohort during routine radiation treatment. **Methods and Materials:** Cherenkov cameras were used to monitor radiation therapy delivery for various sites, and patients were imaged, with some sites imaged multiple fractions with a mean distance to conformity of 1.5 mm. **Results:** In breast treatments, Cherenkov images identified lateral breast, the arm, or the chin and found nonideal lateral leg was monitored. For all 199 imaged breast treatments, the value of imaging dose through clear Cherenkov imaging also was able to assess field margins. Imaging of other anatomic sites confirmed the value of Cherenkov imaging as an on-treatment quality assurance tool.

Corresponding author: Lesley A. Jarvis, MD, PhD; E-mail: jarvis@hitchcock.org

This work has been funded by grant R01 EB023909 from the National Institutes of Health, with hardware support through R44 CA232 with the support of the Norris Cotton Cancer Center shared resource P30 CA023108.

Disclosures: L.A.J. and B.W.P. have a financial interest in Doi which manufactures cameras used in this study and is funded by grants; they also have a conflict of interest management plan at Dartmouth College and Dartmouth-Hitchcock Medical Center, which included independent review of the research integrity before publication. L.A.J. has a patent pending (application no. 62/874,124). R.L.H. has a patent pending (application no. 62/874,124). M.J. and P.B. are employees of Doi.

Int J Radiat Oncol Biol Phys, Vol. ■, No. ■, pp. 1–11, 2021. © 2021 Elsevier Inc. All rights reserved. <https://doi.org/10.1016/j.ijrobp.2020.11.013>

**Physics Contribution**

### Cherenkov Video Imaging Allows for the First Visualization of Radiation Therapy in Real Time

Lesley A. Jarvis, MD, PhD,\*<sup>†</sup> Rongxiao Zhang, BS,<sup>‡</sup> David J. Gladstone, ScD,\*<sup>†</sup> Shudong Jiang, PhD,<sup>§</sup> Whitney Hitchcock,<sup>||</sup> Oscar D. Friedman,<sup>§</sup> Adam K. Glaser, BE,<sup>§</sup> Michael Jermyn, PhD,<sup>§</sup> and Brian W. Pogue, PhD,<sup>||</sup>†

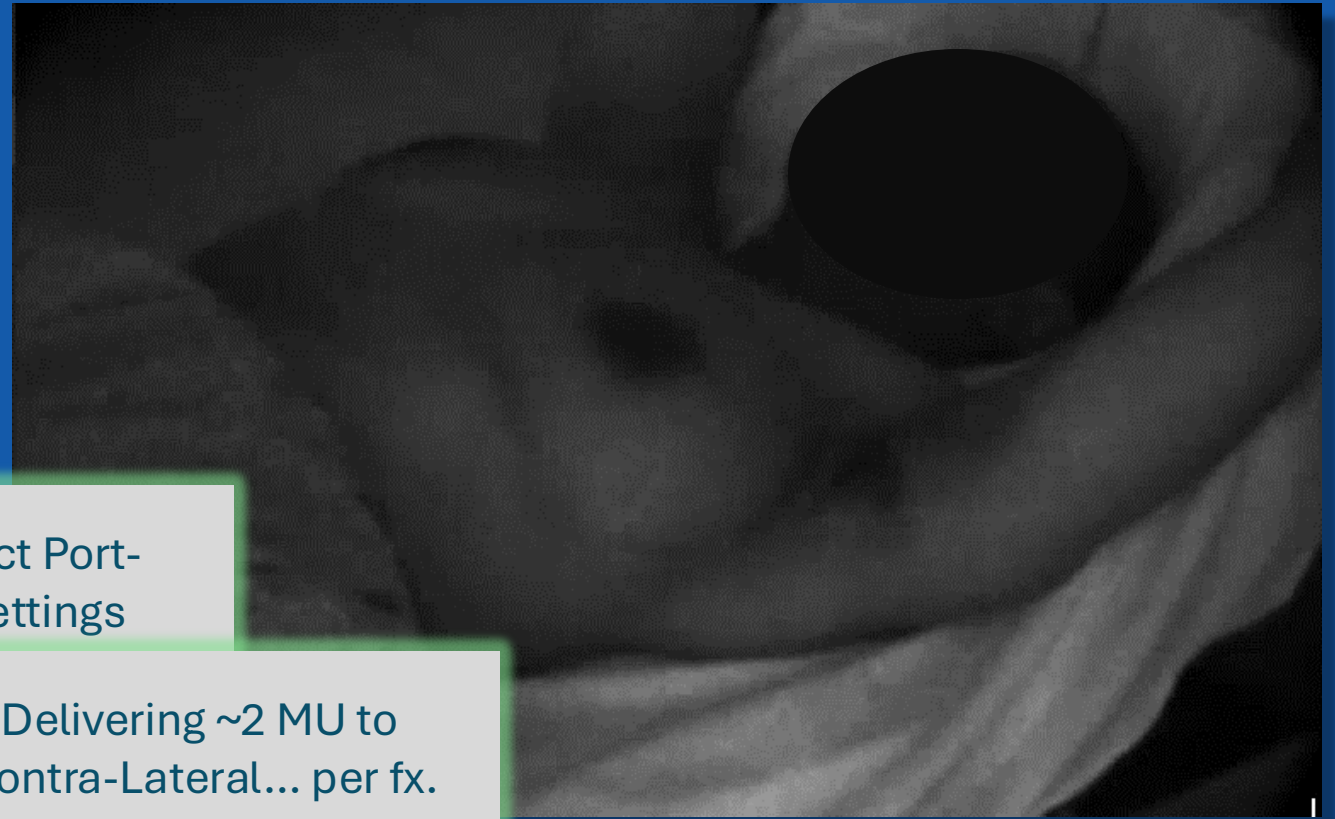
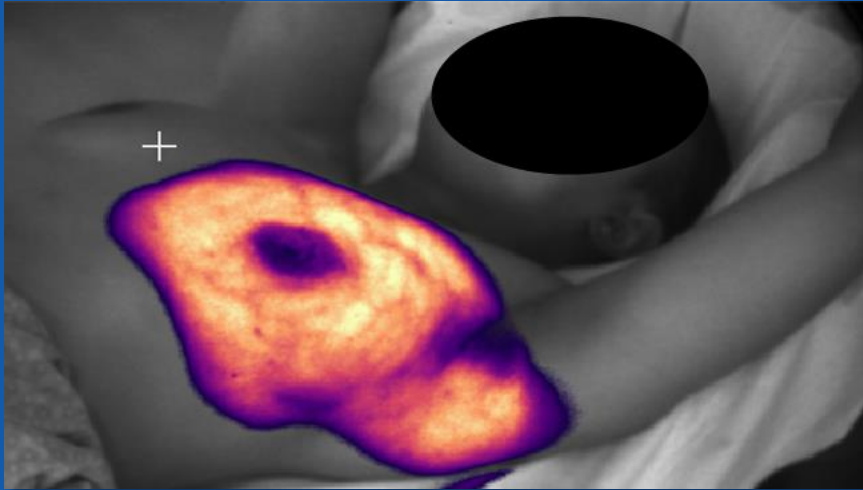
\*Department of Medicine, Geisel School of Medicine at Dartmouth College, Hanover, <sup>†</sup>Norris Cotton Cancer Center at the Dartmouth-Hitchcock Medical Center, Lebanon, <sup>‡</sup>Department of Physics and Astronomy and <sup>§</sup>Thayer School of Engineering, Dartmouth College, Hanover, and <sup>||</sup>Geisel School of Medicine at Dartmouth College, Hanover, New Hampshire

Received Oct 29, 2013, and in revised form Jan 1, 2014. Accepted for publication Jan 27, 2014.

**Purpose:** To determine whether Cherenkov light imaging can visualize radiation therapy in real time during breast radiation therapy. **Methods and Materials:** An intensified charge-coupled device (CCD) camera was synchronized to the 3.25-μs radiation pulses of the clinical linear accelerator with the intensifier set × 100. Cherenkov images were acquired continuously (2.8 frames/s) during fractionated whole breast irradiation with each frame an accumulation of 100 radiation pulses (approximately 5 monitor units). **Results:** The first patient images ever created are used to illustrate that Cherenkov emission can be visualized as a video during conditions typical for breast radiation therapy, even with complex treatment plans, mixed energies, and modulated treatment fields. Images were generated correlating to the superficial dose received by the patient and potentially the location of the resulting skin reactions. Major blood vessels are visible in the image, providing the potential to use these as biological landmarks for improved geometric accuracy. The potential for this system to detect radiation therapy misadministrations, which can result from hardware malfunction or patient positioning setup errors during individual fractions, is shown. **Conclusions:** Cherenkov imaging is a unique method for visualizing surface dose resulting in real-time quality control. We propose that this system could detect radiation therapy errors in everyday clinical practice at a time when these errors can be corrected to result in improved safety and quality of radiation therapy. © 2014 Elsevier Inc.

# DoseRT<sup>®</sup>

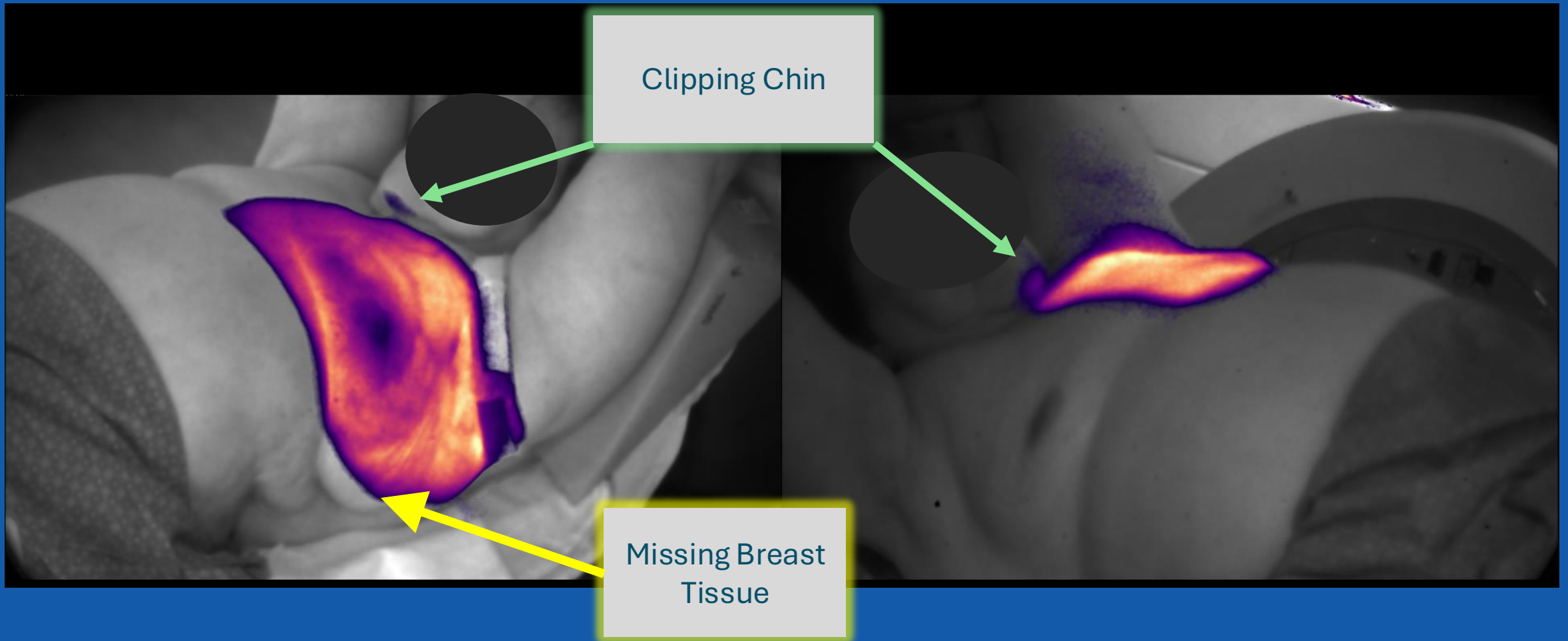
## Treatment issues...



Incorrect Port-Film Settings

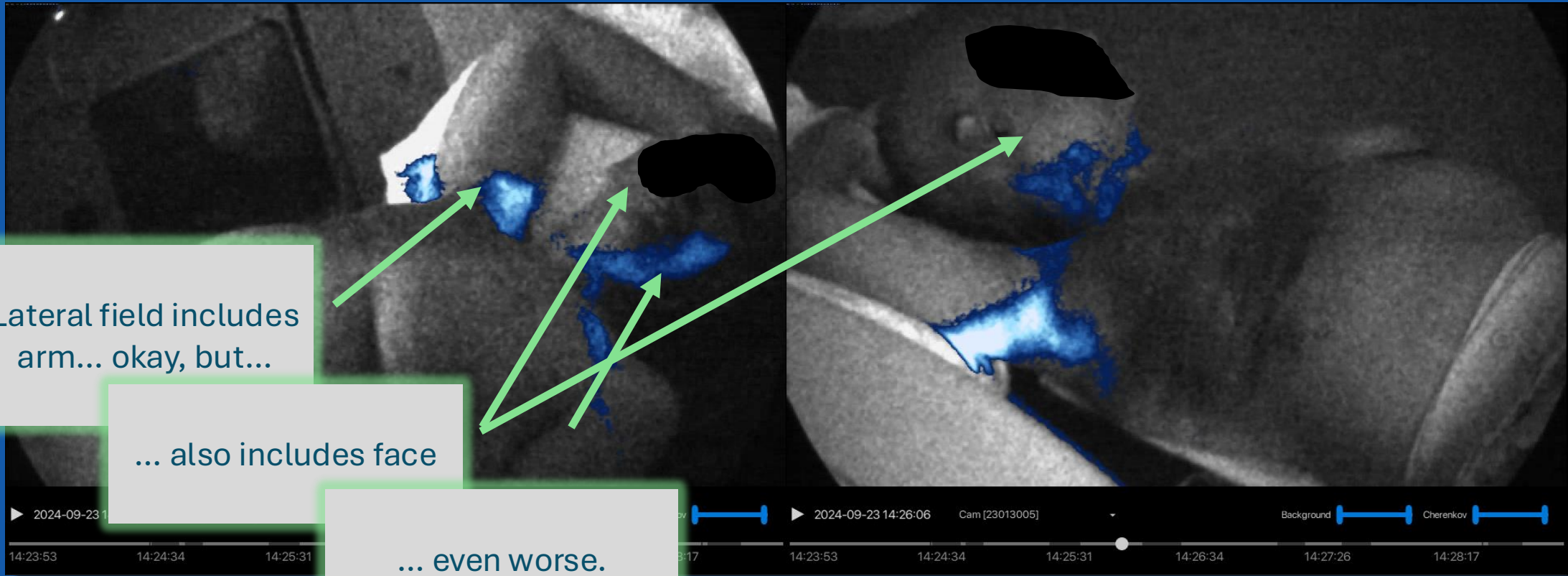
Delivering ~2 MU to Contra-Lateral... per fx.

## Treatment issues...



# DoseRT<sup>®</sup>

## Treatment issues...



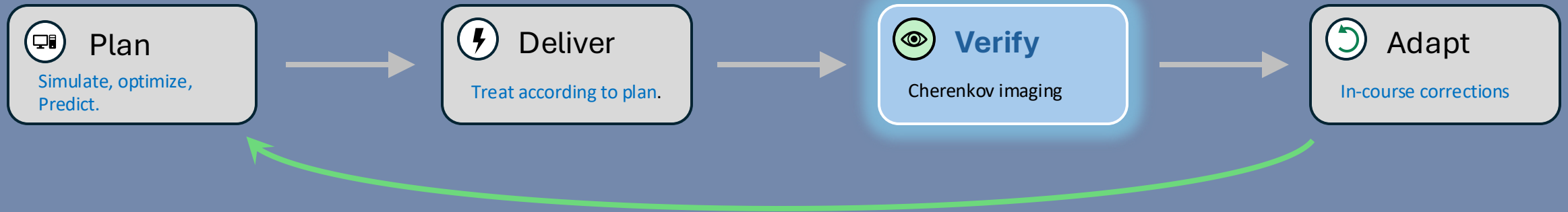
**BEFORE...**

Open-loop delivery...



**NOW...**

Closed-loop delivery...



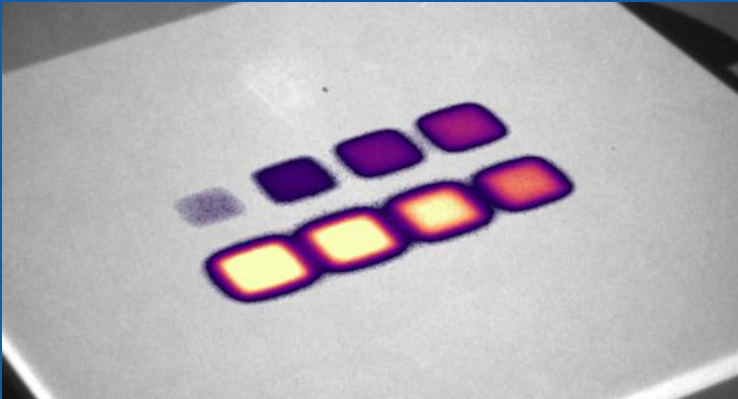
## Treatment issues...

Can we detect clinically relevant issues with this?

Yes... but requires scrutiny. Some kind of daily or weekly review.

# DoseRT<sup>®</sup>

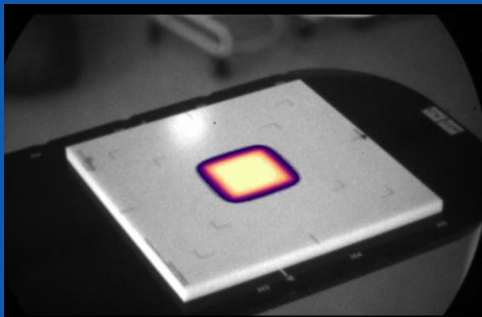
## Clinical Use



Like all systems... needs QA to use well

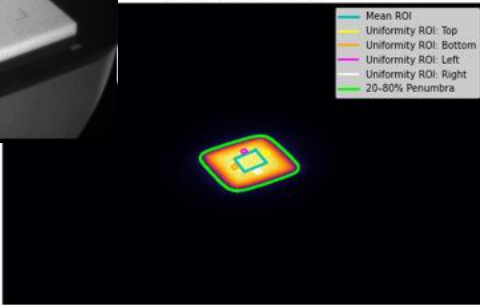
The more we ask it to do...

... the more rigorous QA will be needed

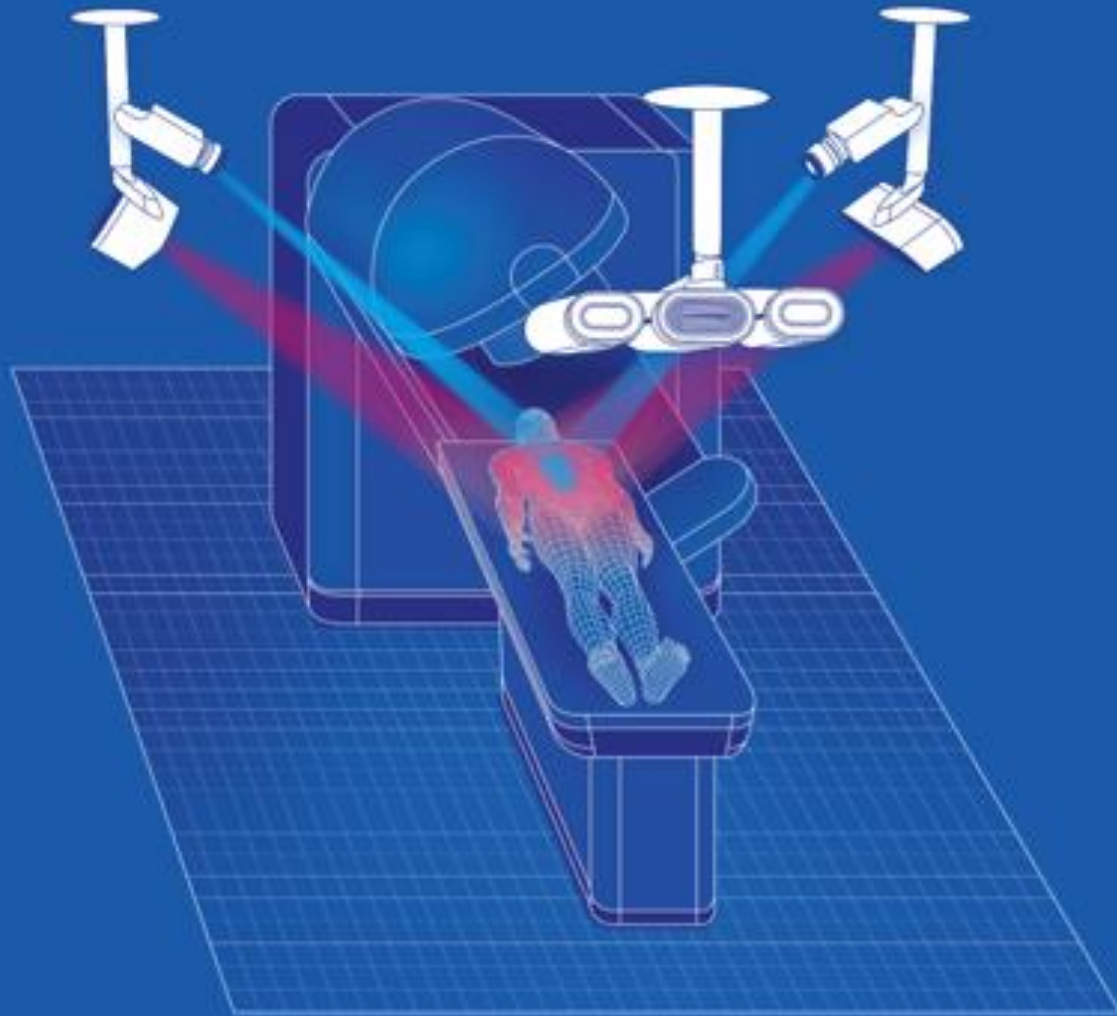


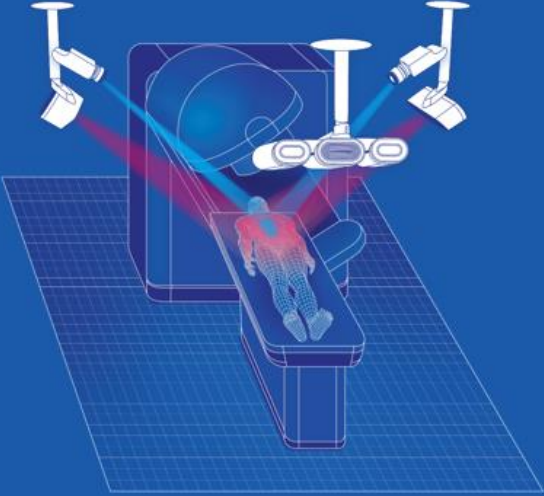
CAM0 Baseline (6X)

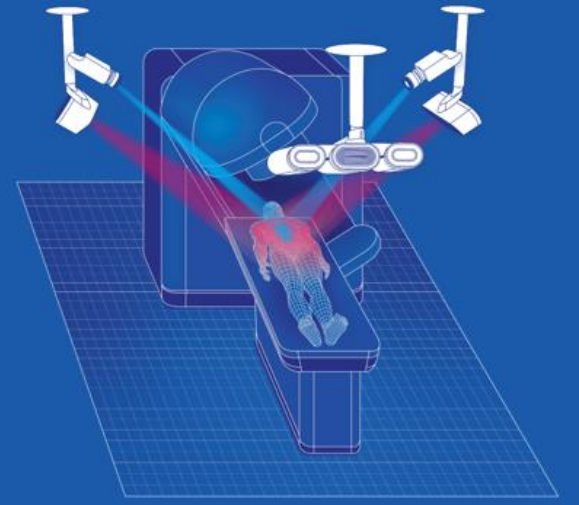
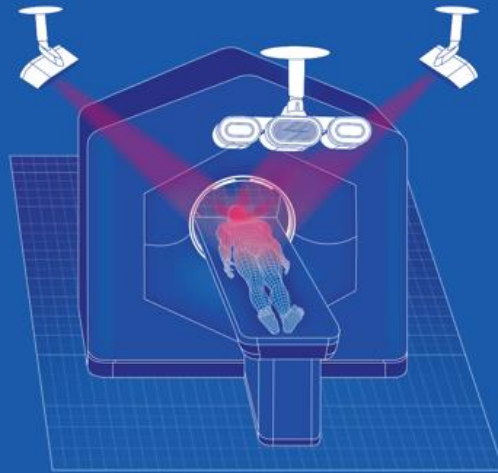
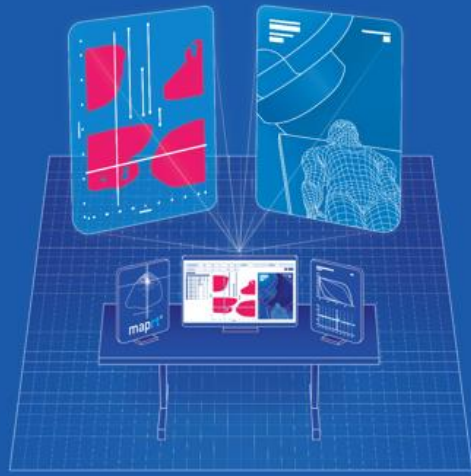
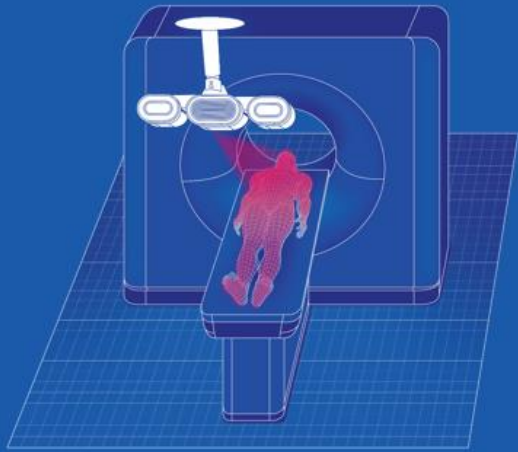
- Mean ROI
- Uniformity ROI: Top
- Uniformity ROI: Bottom
- Uniformity ROI: Left
- Uniformity ROI: Right
- 20-80% Penumbra



# DoseRT<sup>®</sup>



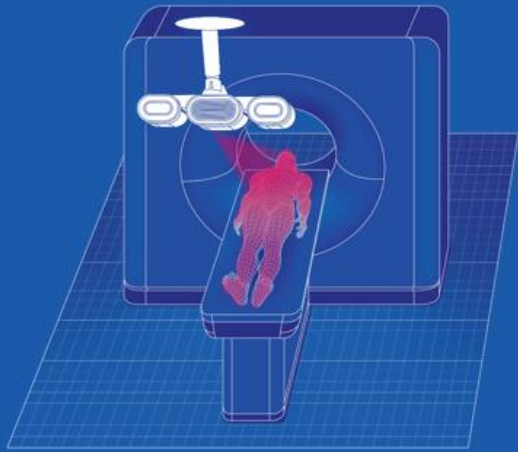




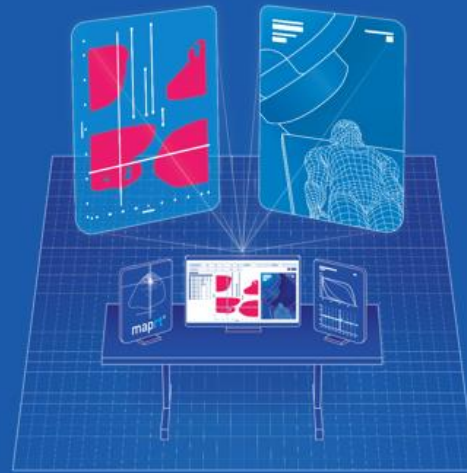
# SGRT...

... every patient... every fraction...

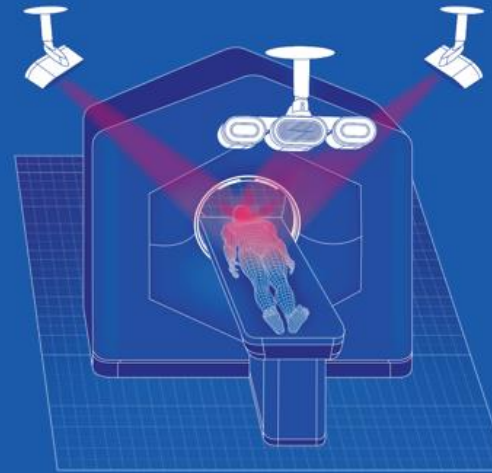
...every step.



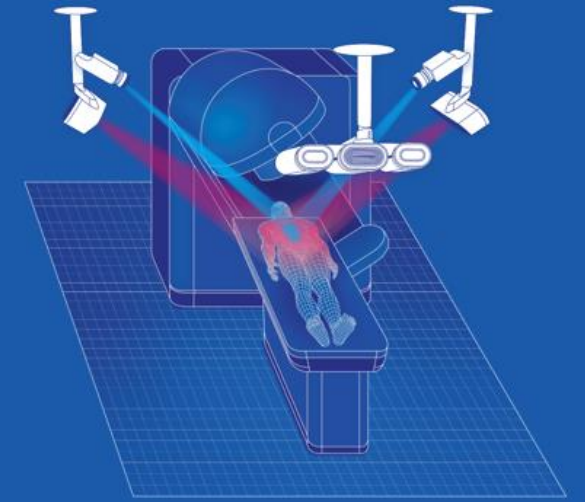
SIM



PLAN



TREAT



DOSE



# Thank you !

Special thanks to...

Mike Tallhamer



[michael.tallhamer@adventhealth.com](mailto:michael.tallhamer@adventhealth.com)

Adi Robinson



[adi.robinson@adventhealth.com](mailto:adi.robinson@adventhealth.com)