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NHS Royal Surrey NHS Foundation Trust

The Implementation of SGRT for DIBH patients using SimRT and AlignRT InBore

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Royal Surrey NHS Foundation Trust

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The Royal Surrey Cancer Centre

NHS Royal Surrey NHS Foundation Trust

7 Linac department

2 sites – Guildford & Redhill

Installed SimRT and Replaced 2 c-arm linacs in Redhill with 2 ring gantry linacs with AlignRT

Continuing our linac replacement over the next few years → more SGRT installations

Why SimRT & AlignRT InBore?

Research

- Presentation from 3 vendors
- Comparison of specifications and research evidence available

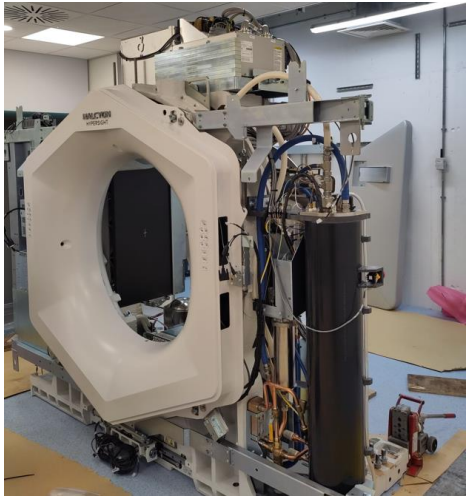
Considerations

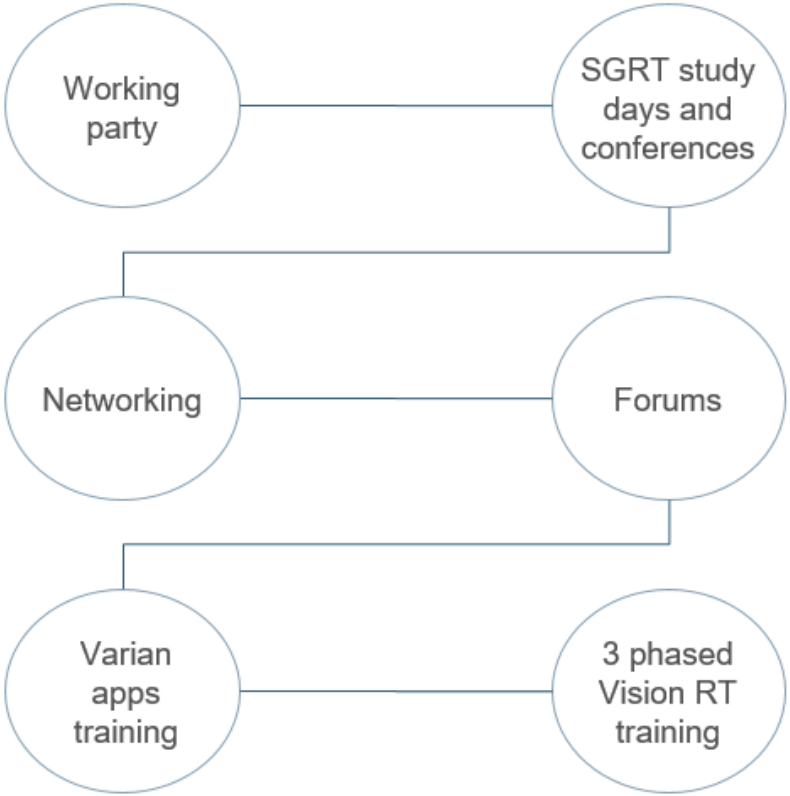
- Ease of use
- Communication with machine
- Quality of training
- Future proofing

Site specific

- Small bunkers
- VisionRT offers only clinically available in bore solution

Installation Project





Staff training

3 Phased training programme

1 WORKSHOP AND SITE VISIT

- Warsaw presentation and demonstrations
- ROI training
- Site visit to Oulu, Finland

2 ONLINE MODULES

- Presentations from Vision RT
- Online E-Learning for all staff
- Work instructions created

3 GO LIVE

- Vision RT on site for Day 1
- Phantom demonstrations
- Troubleshooting guidance
- Departmental competency pack

From SimRT to AlignRT

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SimRT
1 system

AlignRT
2 integrated systems

From SimRT to AlignRT

Royal Surrey Cancer Centre

SimRT
1 system

AlignRT
2 integrated systems

From SimRT to AlignRT

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SimRT

1 system

AlignRT

2 integrated systems

Out-of-bore

From SimRT to AlignRT

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Out-of-bore

In-bore

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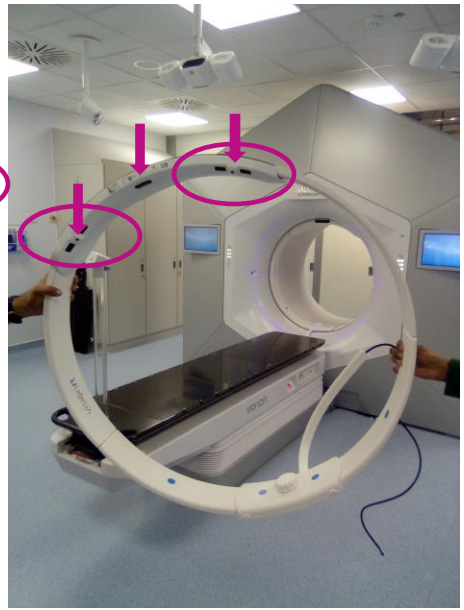
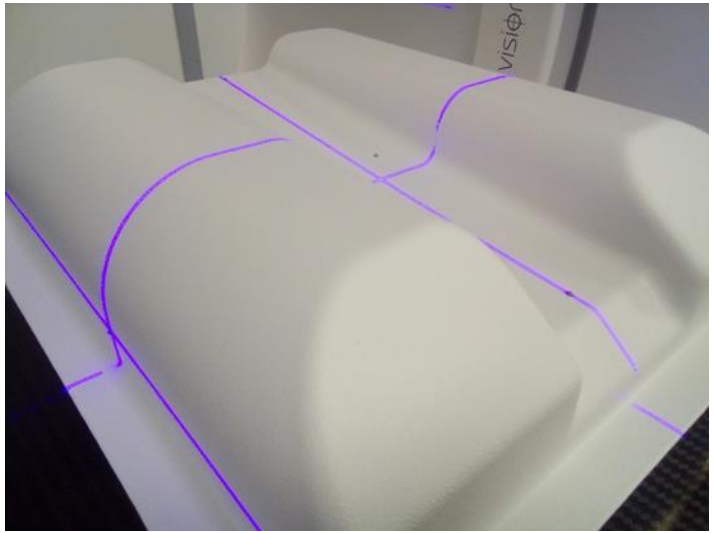


Commissioning from SimRT to AlignRT – VRT movement

Royal Surrey Cancer Centre

Preamble – affix ***5 ball-bearings*** (2mm Ø) to leg-phantom

- 1 ball-bearing to indicate location of isocentre in treatment-plan
- 4 ball-bearings to indicate laser/tattoo set-up



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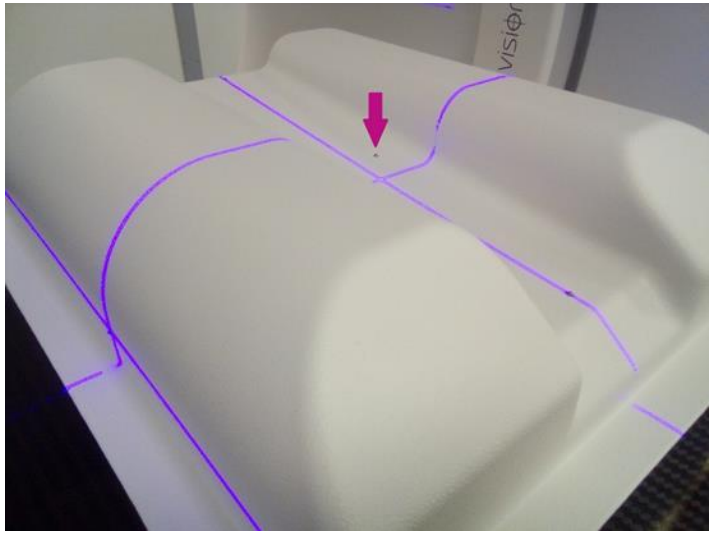

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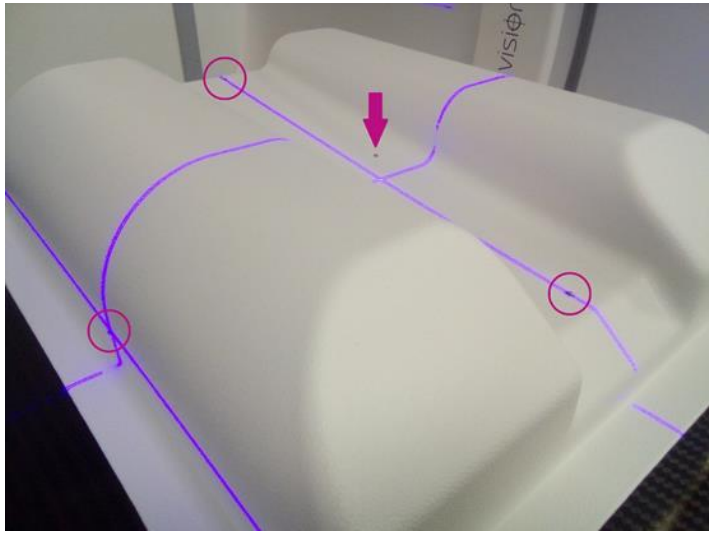

Commissioning from SimRT to AlignRT – VRT movement

Static accuracy of SimRT

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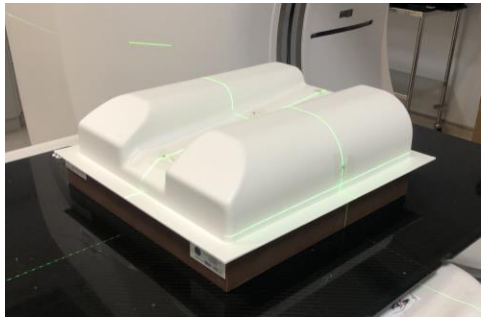
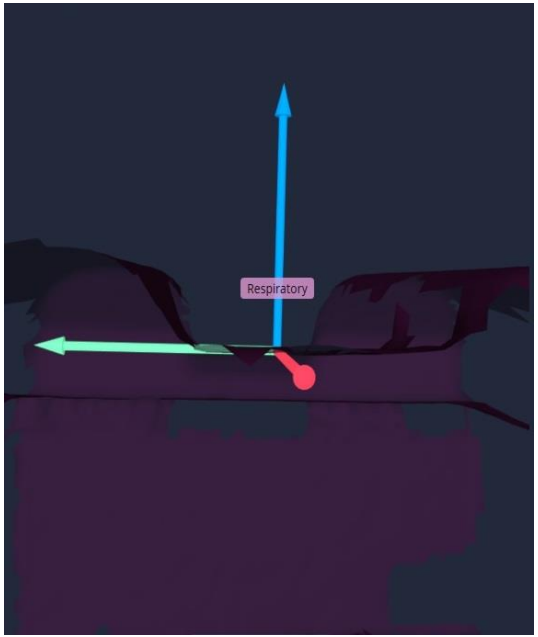
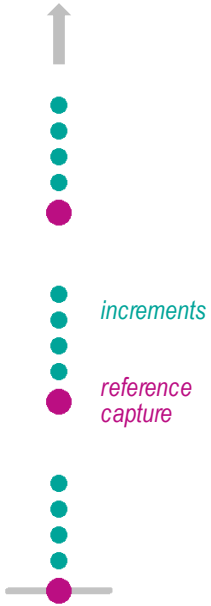
Method

- place leg-phantom on CT-couch, propped up on support
- align central ball-bearing to isocentre in SUP-INF and L-R directions
- take reference capture of phantom surface
- fine-tune alignment of ball-bearing to isocentre in ANT-POST direction
- select VRT starting position (between 0 and 14 cm above isocentre)
- take new reference capture of phantom surface
- start monitoring patch
- displace CT-couch in 5-mm increments

Tolerance ≤ 1 mm *(ESTRO/ACROP)*







Commissioning from SimRT to AlignRT – VRT movement

Static accuracy of SimRT

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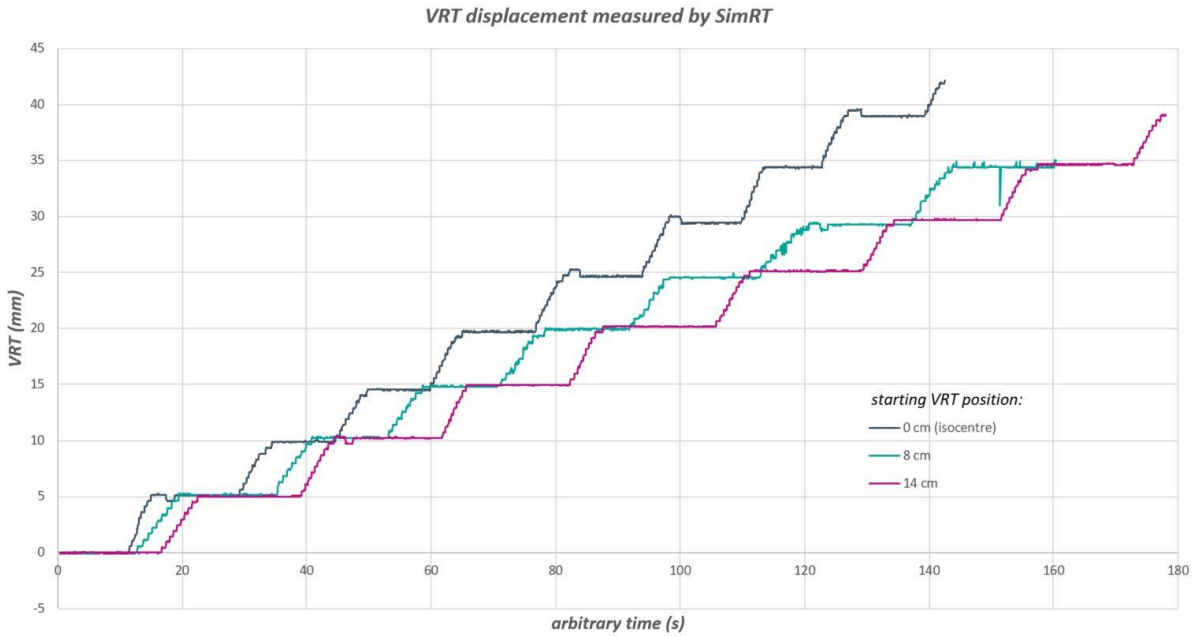

Results

- discrepancy within 0.5 mm for VRT displacements up to 2.5 cm

Commissioning from SimRT to AlignRT – VRT movement

Static accuracy of AlignRT (moving DICOM surface)

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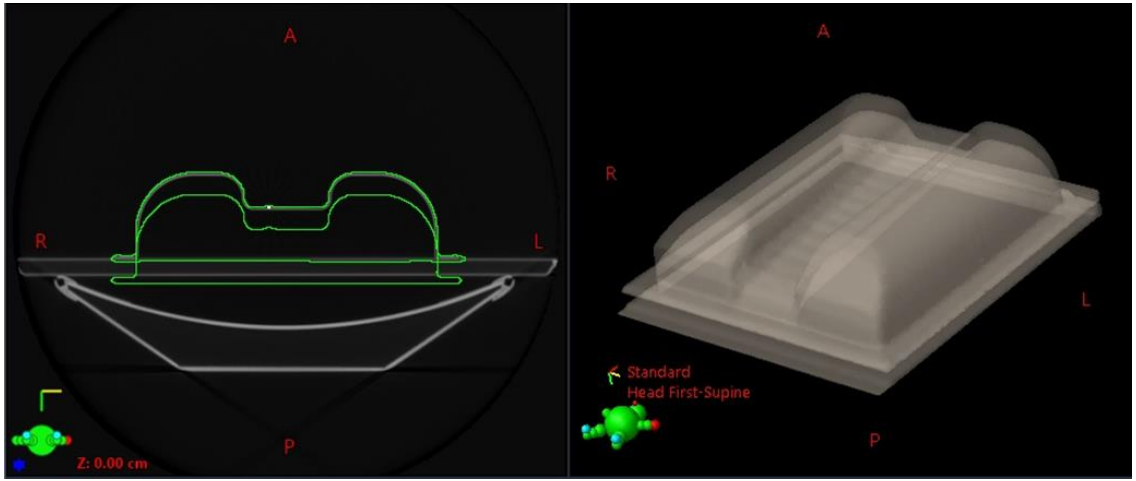
Method

- acquire a low-dose CT-scan of the leg-phantom
- acquire a planning CT-scan of the phantom
- in Eclipse,
  - on each CT-dataset, create a body-structure
  - on the low-dose CT-dataset, shift the body-structure by 2.00 cm posteriorly (to bypass uncertainty in couch displacement)



Commissioning from SimRT to AlignRT – VRT movement

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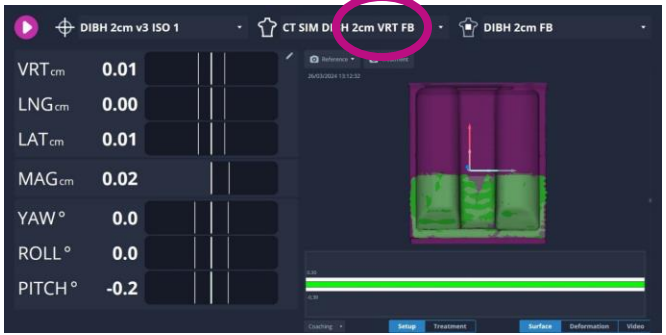
Static accuracy of AlignRT (moving DICOM surface)

Out-of-bore

1. *align using FB body-structure*



2. *monitor using BH body-structure*

Commissioning from SimRT to AlignRT – VRT movement

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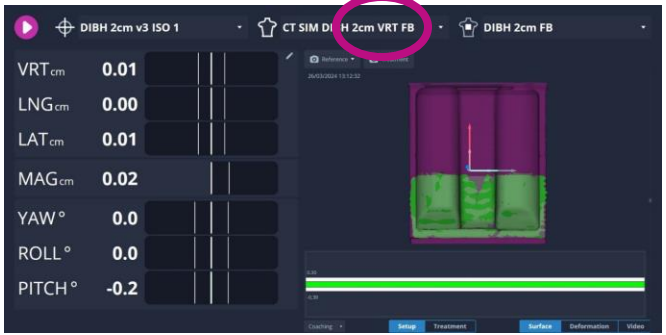
Static accuracy of AlignRT (moving DICOM surface)

Out-of-bore

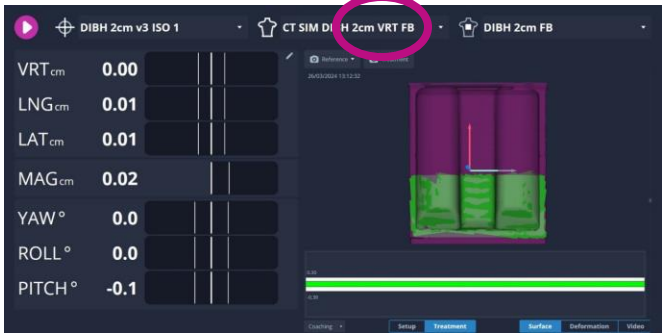
1. *align using FB body-structure*



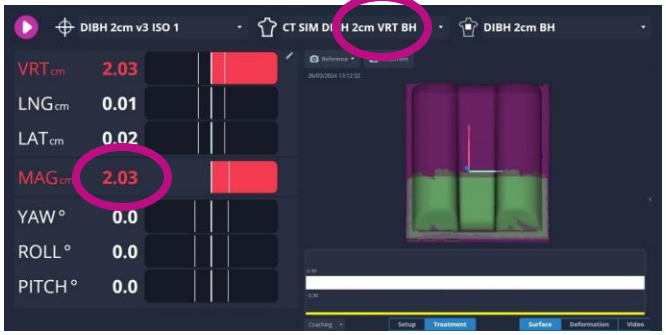
2. *monitor using BH body-structure*

In-bore

3. *translate phantom into bore, then monitor using FB body-structure*



4. *monitor using BH body*



Results

- breath-hold position measured within 0.5 mm of its nominal value by both camera systems
- identical accuracy achieved with isocentre shifted by 7.5 cm SUP (a test of the FoV)

Commissioning from SimRT to AlignRT – VRT movement

Dynamic accuracy of AlignRT (moving phantom)

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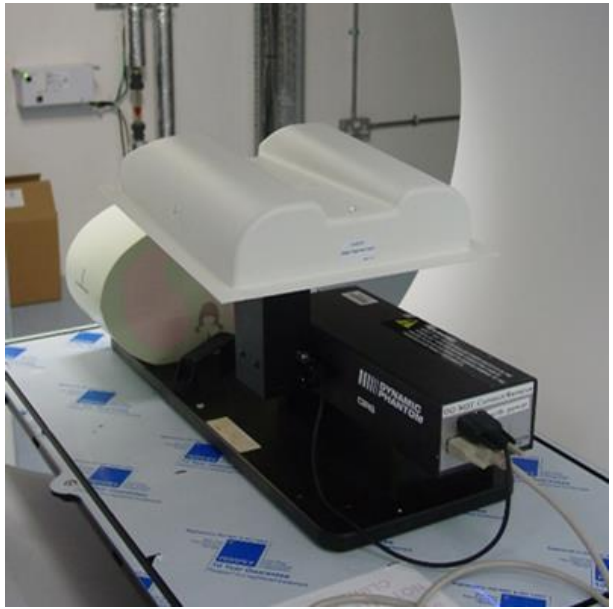
Method

- set up CIRS dynamic phantom
- place leg-phantom on top of surrogate platform
- take reference capture of leg-phantom with out-of-bore cameras
- start motion
- monitor motion using out-of-bore cameras
- translate phantom assembly into bore
- monitor motion using same reference capture and now using in-bore cameras



Commissioning from SimRT to AlignRT – VRT movement

Dynamic accuracy of AlignRT (moving phantom)

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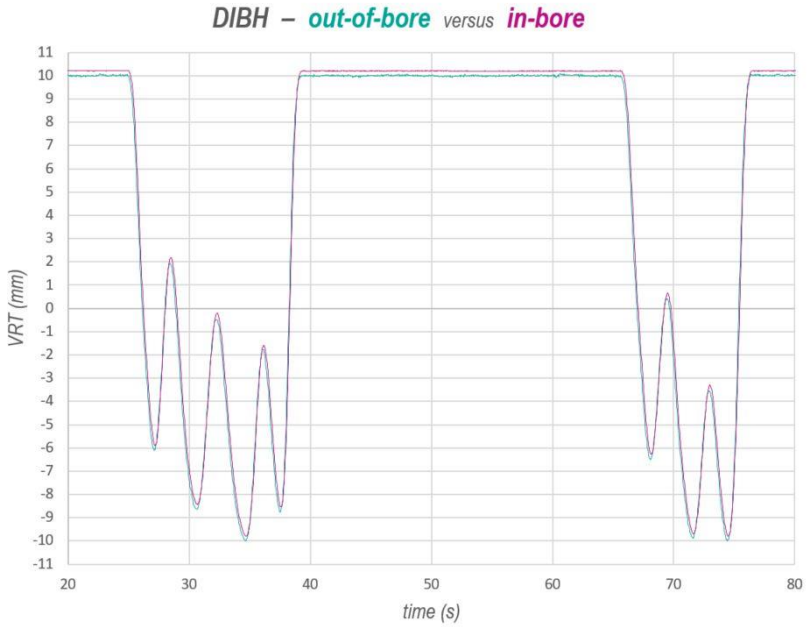

nominal range	20.0 mm
range measured by out-of-bore cameras	-10.0 ⟶ +10.0 mm
range measured by in-bore cameras	-9.8 ⟶ +10.2 mm

Results

- displacements measured within 0.2 mm of their nominal values by both camera systems

E2E QA from SimRT to AlignRT – 6DoF movement

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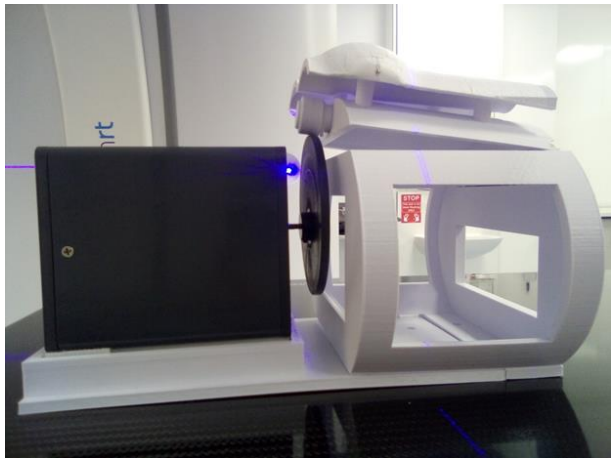
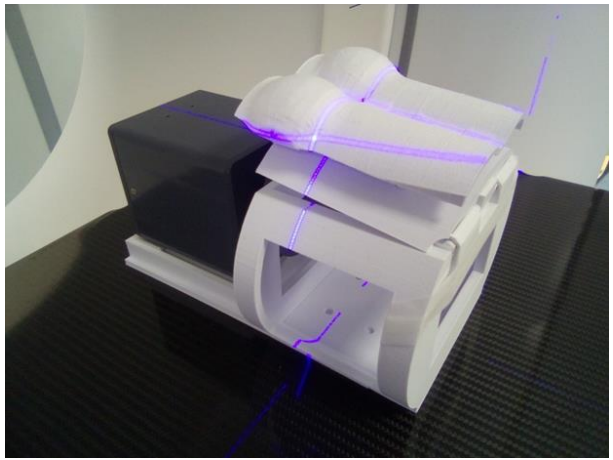
Preamble – *3d-printed phantom designed by Matt Jones (Head of Dosimetry and QA)*

[work-in-progress, intended for monthly-QA]





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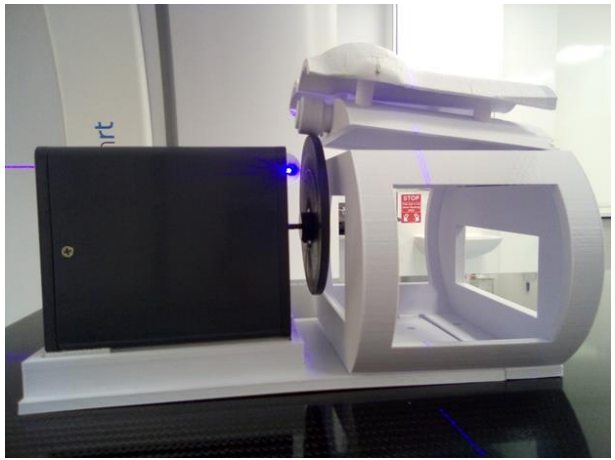

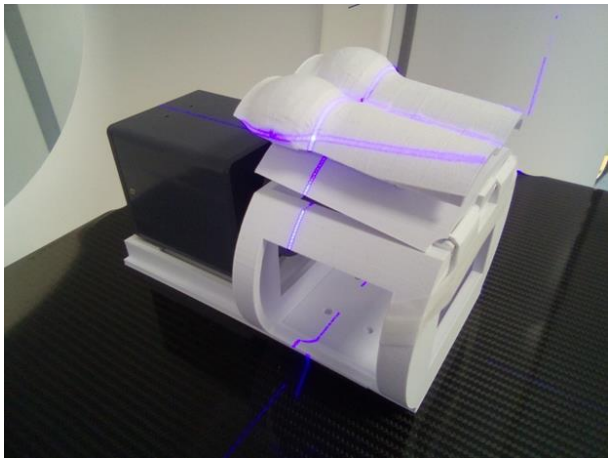

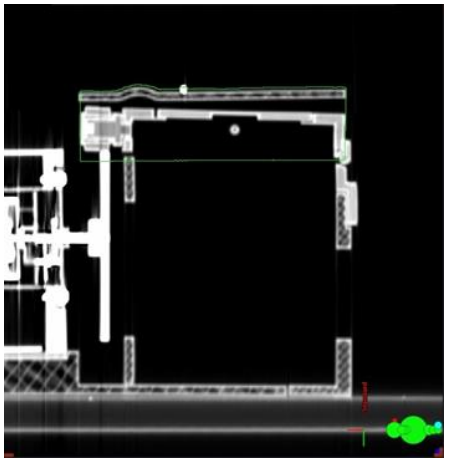

E2E QA from SimRT to AlignRT – 6DoF movement

VRT breathing trace in SimRT

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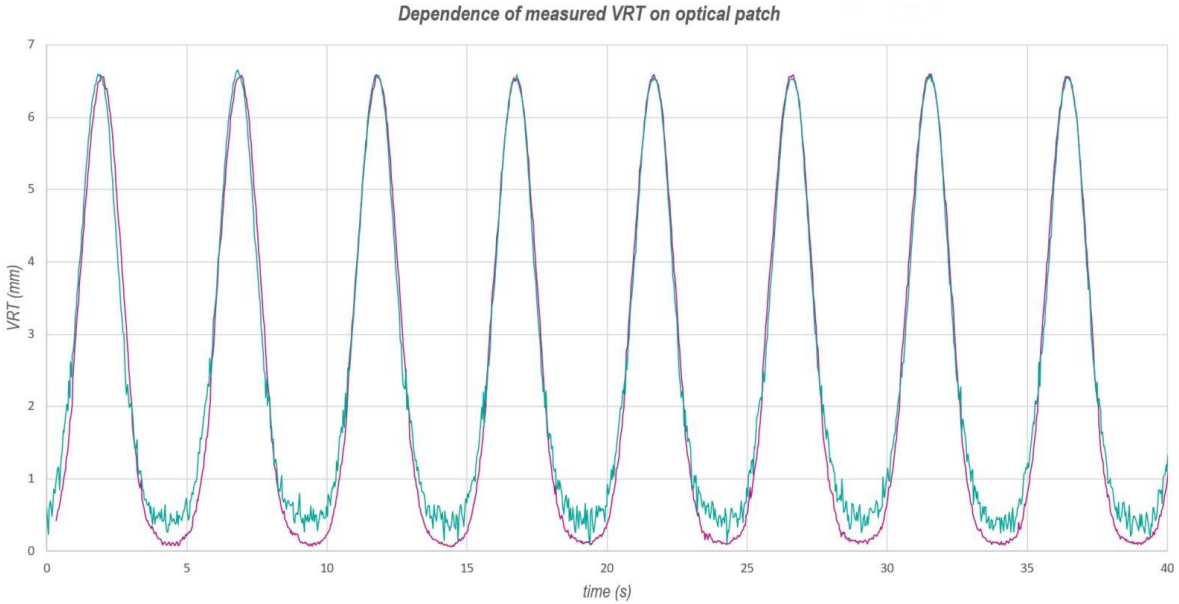

capture DOWN

capture UP

Result

- small dependence of measured VRT displacement on captured surface?

E2E QA from SimRT to AlignRT – 6DoF movement

6DoF breathing trace in AlignRT

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Method

- At the CT-scanner, scan the 3d-printed phantom in two positions:
  - a ***DOWN*** position mimicking a free-breathing surface
  - an ***UP*** position mimicking a breath-hold position
- In Eclipse, create a body-structure for each position

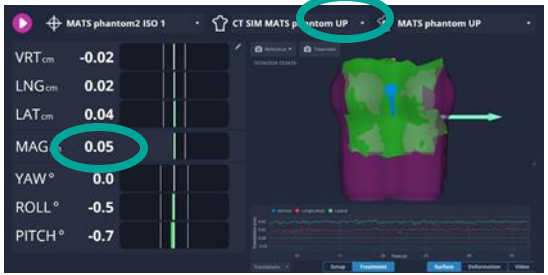
Preliminary results

- *position phantom down*
- *monitor DOWN surface*

- *position phantom up*
- *monitor UP surface*

Out-of-bore

In-bore



E2E QA from SimRT to AlignRT – 6DoF movement

6DoF breathing trace in AlignRT

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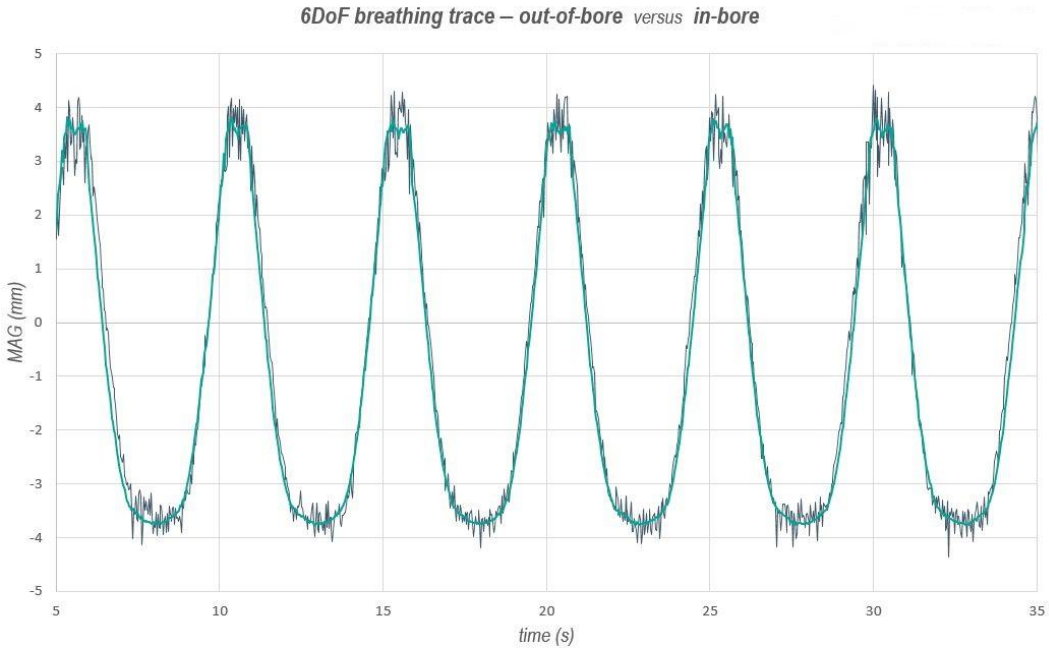
Preliminary results

- enable RPM motion
- *monitor UP surface*
- *compare out-of-bore versus in-bore*

DICOM surface out-of-bore

DICOM surface in-bore



E2E QA from SimRT to AlignRT – 6DoF movement

6DoF breathing trace in AlignRT

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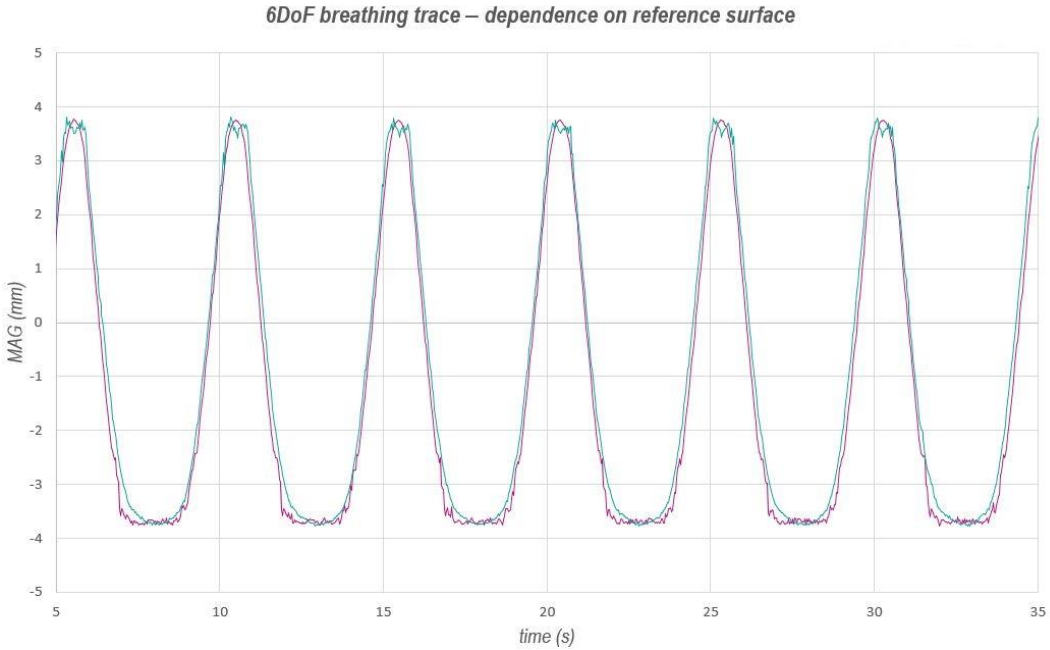
Preliminary results

- enable RPM motion
- *monitor in-bore*
- *compare UP versus DOWN surface*



DICOM surface in-bore

DICOM surface in-bore

- no dependence of measured MAG displacement on reference surface?

Future improvements?

- *glue 3d-printed components together*
- *mark UP and DOWN positions on RPM wheel*
- *3d-print larger surface*
- *change colour of surface to darker shade*

Data courtesy of Dina Roshd

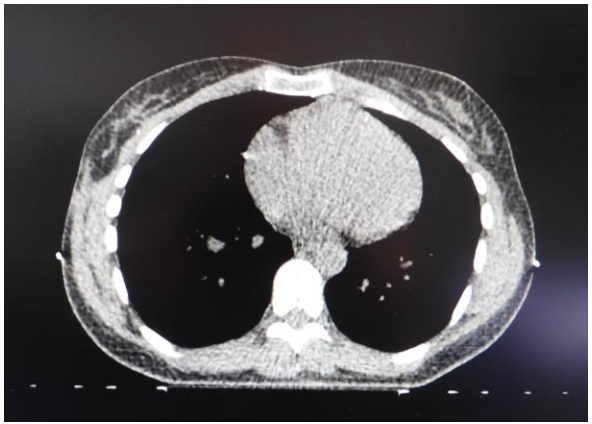
Clinical Introduction of SimRT

While our physics team were working hard on commissioning SimRT….

- Creation of Daily QA work instructions
- Creation of breast DIBH & 4DCT work instructions
- Complete VisionRT phase 2 online training
- Creation of training records
- Change to breast DIBH scanning protocol to include a low dose free breathing scan

Change in DIBH CT Scanning Protocol

AlignRT requires 2 CT scans hold → 1 free breathing & 1 breath

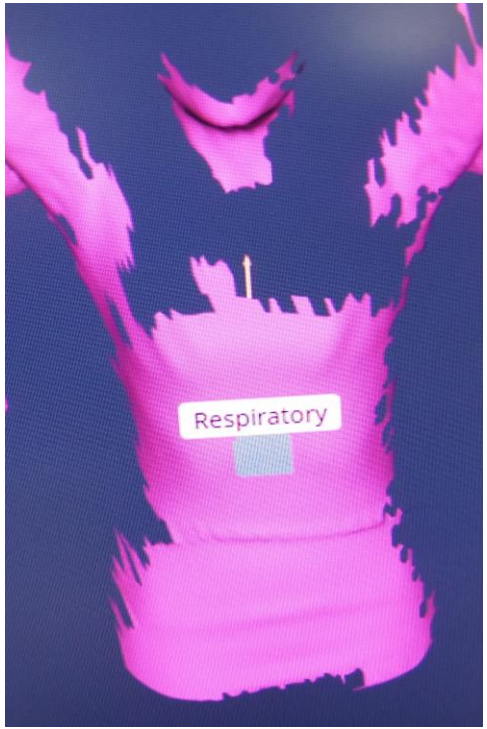


Low dose free breathing scan

Standard dose breath hold scan

Using SimRT to monitor breath hold

1. Set up patient using exterior lasers
2. Take surface capture of patient
3. Place tracking patch



Using SimRT to monitor breath hold

4. Turn on monitoring
5. Ask patient to breath hold
6. Ensure adequate depth and stability of breath hold
7. Repeat to check for consistency of breath hold
8. Move patient to bore isocentre and take surface capture
9. Move to most inferior scan level and take surface capture

Considerations for patch location

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Clinical Introduction of DIBH with AlignRT Inbore

- Previously used Varian RPM
- Introduced slowly into workflow
- Planning team needed time to adjust the planning for Halcyon
- Vision RT on site for demonstrations of workflow
- Cascaded training to rest of team
- Introduced 1-2 more DIBH breast patients a week to continue training and get planning team training complete too

DIBH Treatment Workflow using AlignRT

Free breathing set up	Set up in free breathing to free breathing CT body
DIBH set up	Switch to DIBH ref body and patient breathes in
Load	Load the patient in to the bore
InBore position	Check the patients FB and DIBH position against the RTD
Take CBCT in DIBH	Patient to be in DIBH for CBCT and when applying moves – take a ‘this session only’ capture
Treatment	Deliver treatment in DIBH with real time monitoring

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DIBH Workflow video

Set –Up Accuracy Audit

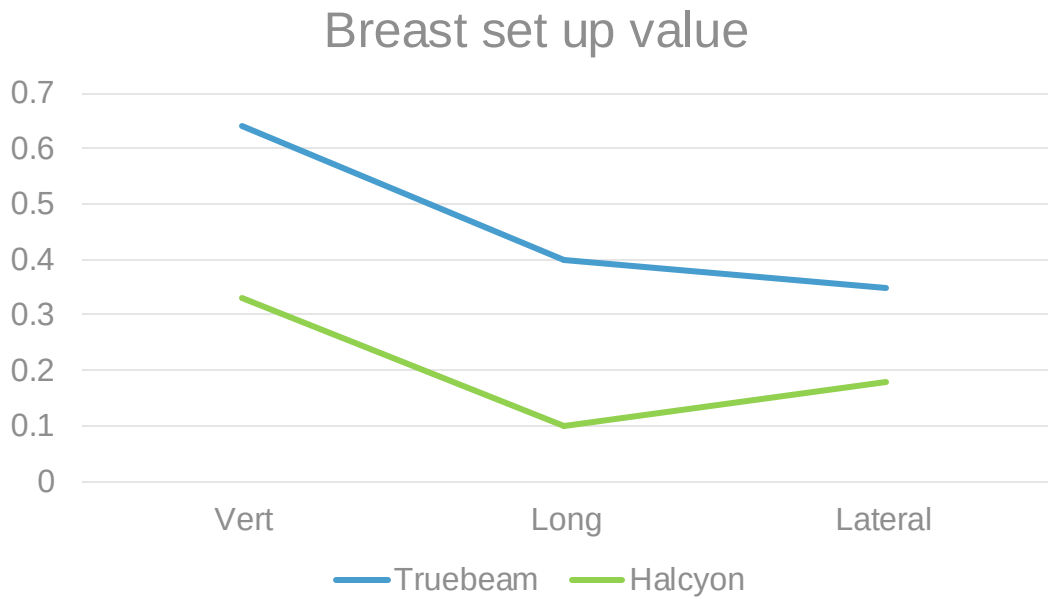
Breast patients

Tattoo set up on Truebeam VS SGRT on Halcyon

Patients set up to tattoo - Imaging isomoves ranged from 0.5-1.5cm

Patients were up to 2.5cm distance from their reference marks

Average imaging isomoves for all SGRT were under 0.4cm



Why Varian Halcyon & Ethos?

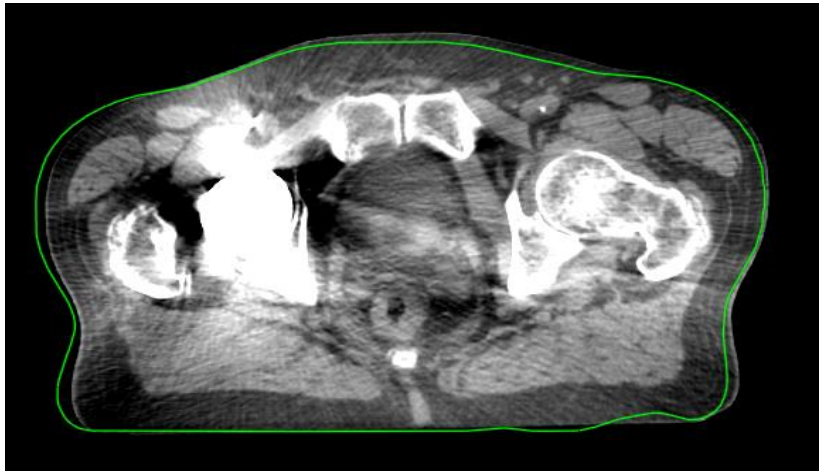
Ease of use

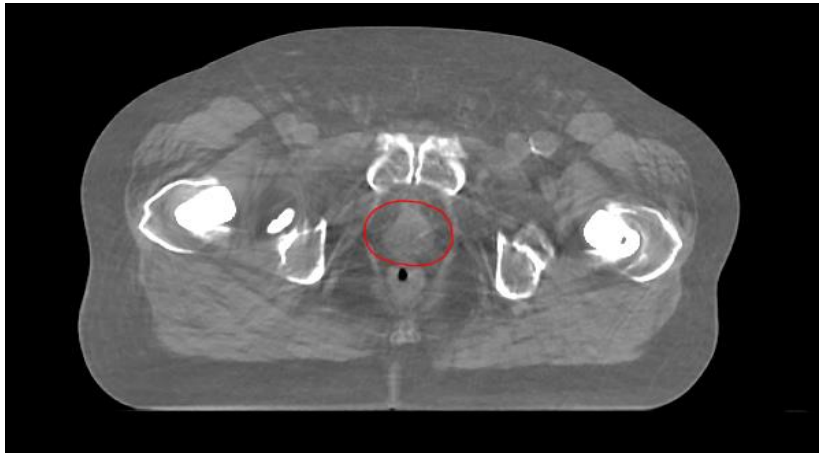
HyperSight Imaging

Delta-Couch Shift

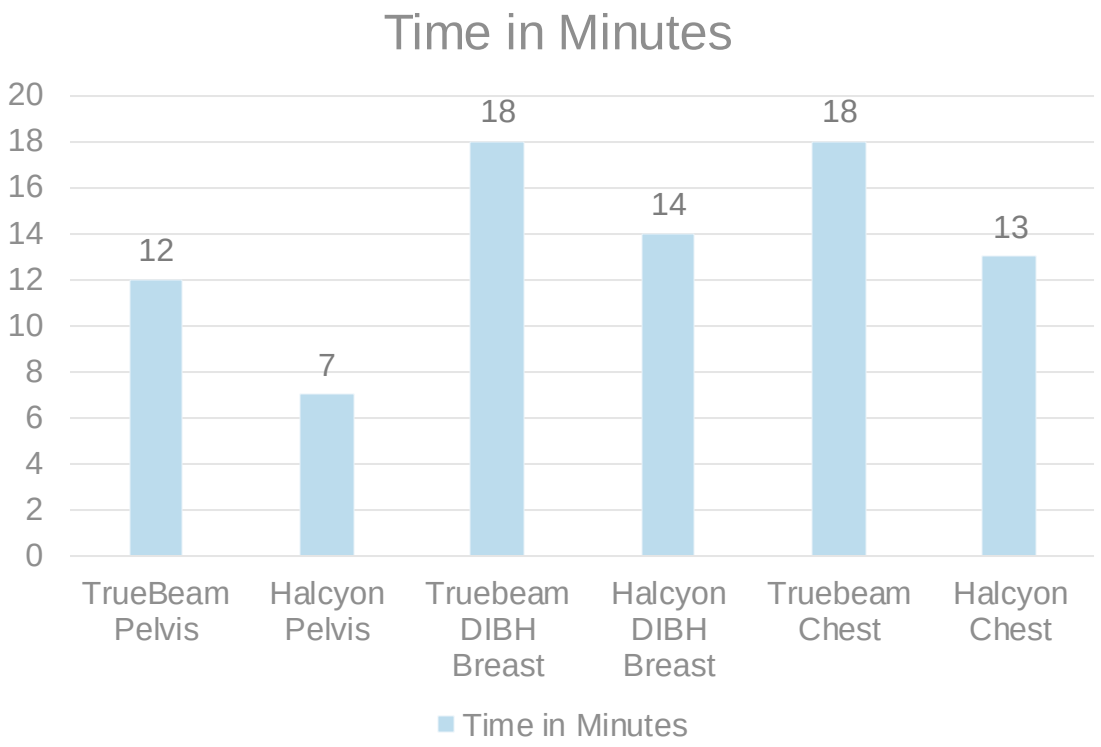
Increase capacity

Fewer delays





Time in motion audit



- Treatment type– IMRT vs RapidArc
- Pelvis – reduction of 4-5 mins
- DIBH Breast – reduction of 4 mins
- Chest – reduction of 5 mins

Our SGRT journey so far

Treated so far…

- All pelvis patients
- Chest
- Breast/SCF/DIBH +/- bolus (multi-isocenter)
- Palliative (all sites)
- Haematology H&N
- Abdomens
- PA nodes
- Radical brains
- Limbs

Future cases…

- Adaptive bladder treatment
- DIBH breast to include IMC
- Lung SABR
- Lower lung SABR using compression belt
- Tattooless radiotherapy

Thank you

- The VisionRT team
- The entire team at RSFT (Guildford & Redhill)
- Radiographers
- Physics (especially Dina Roshd for commissioning data & slides)
- Engineers

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Questions?