Commissioning AlignRT: A multi-clinic experience

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Disclosures

- No conflicts of interest to report

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Current SGRT applications

- Brainlab ExacTrac
- Varian RPM
- VisionRT AlignRT

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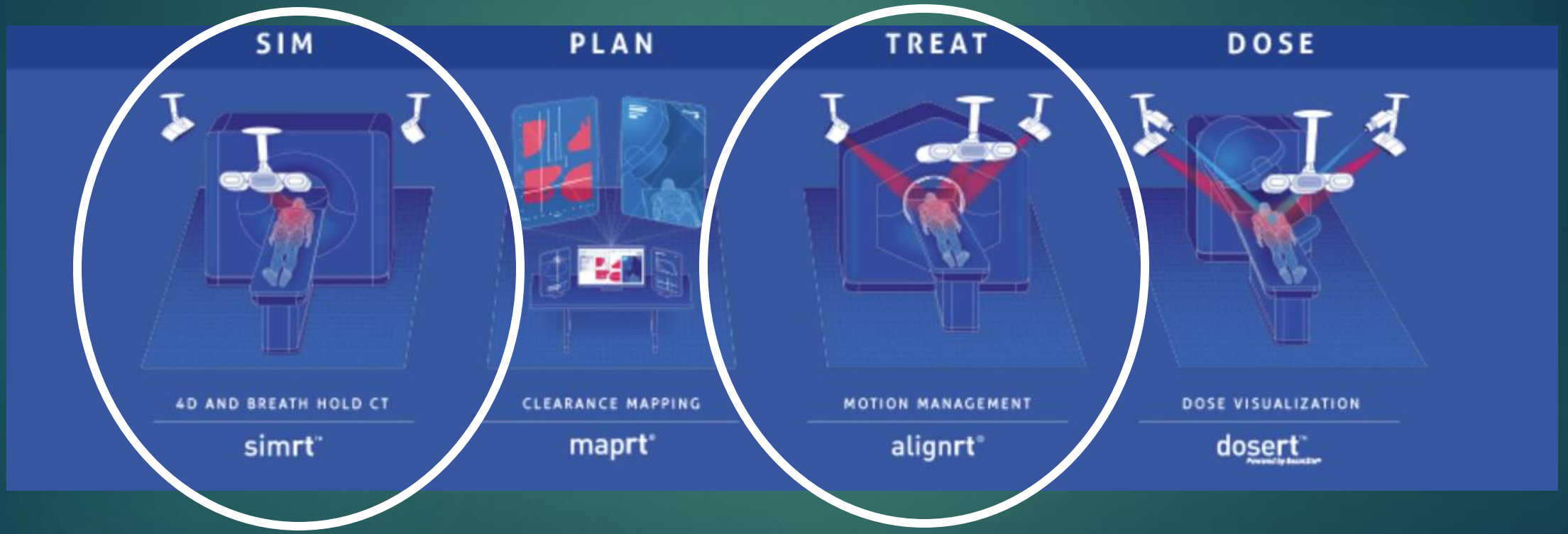
VisionRT's catalog



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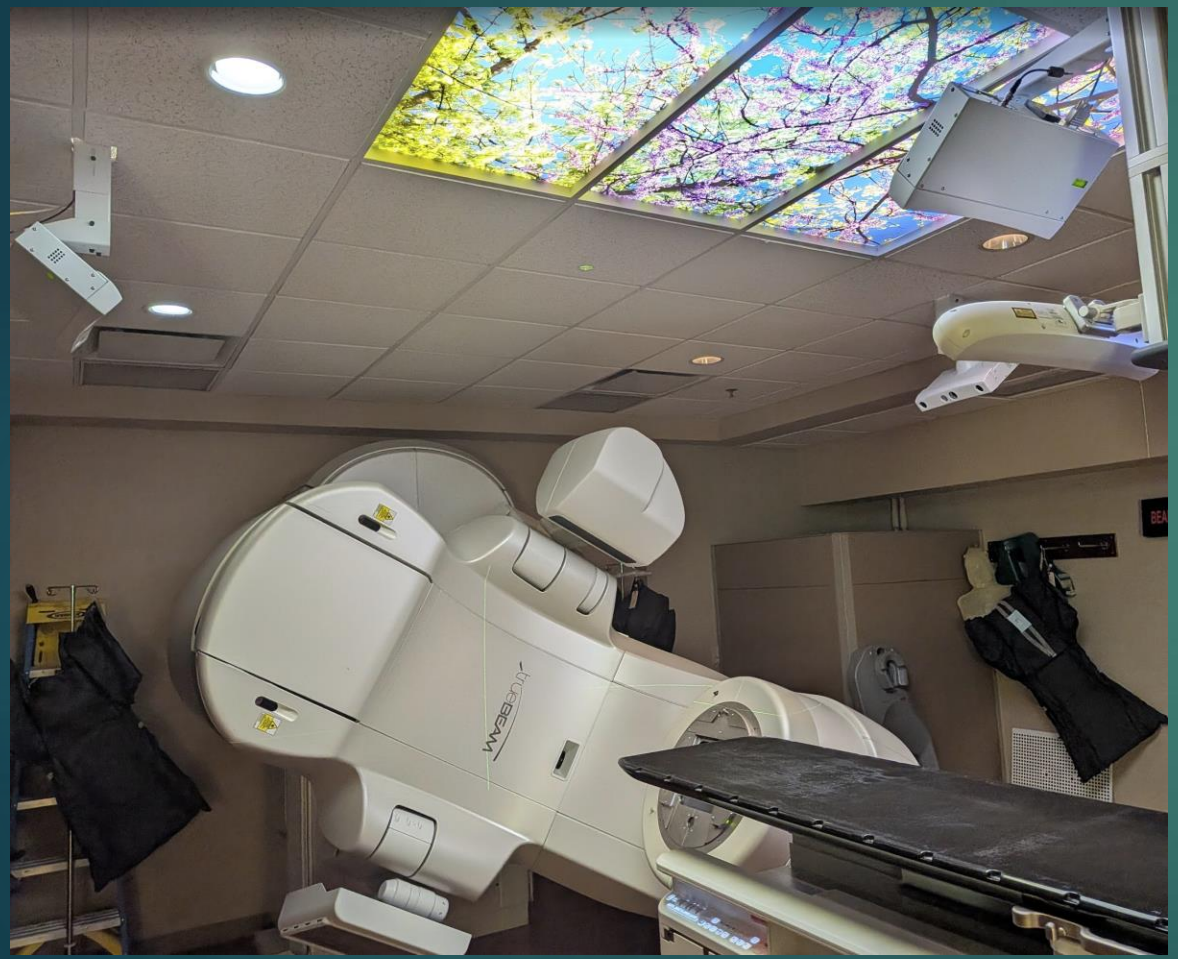
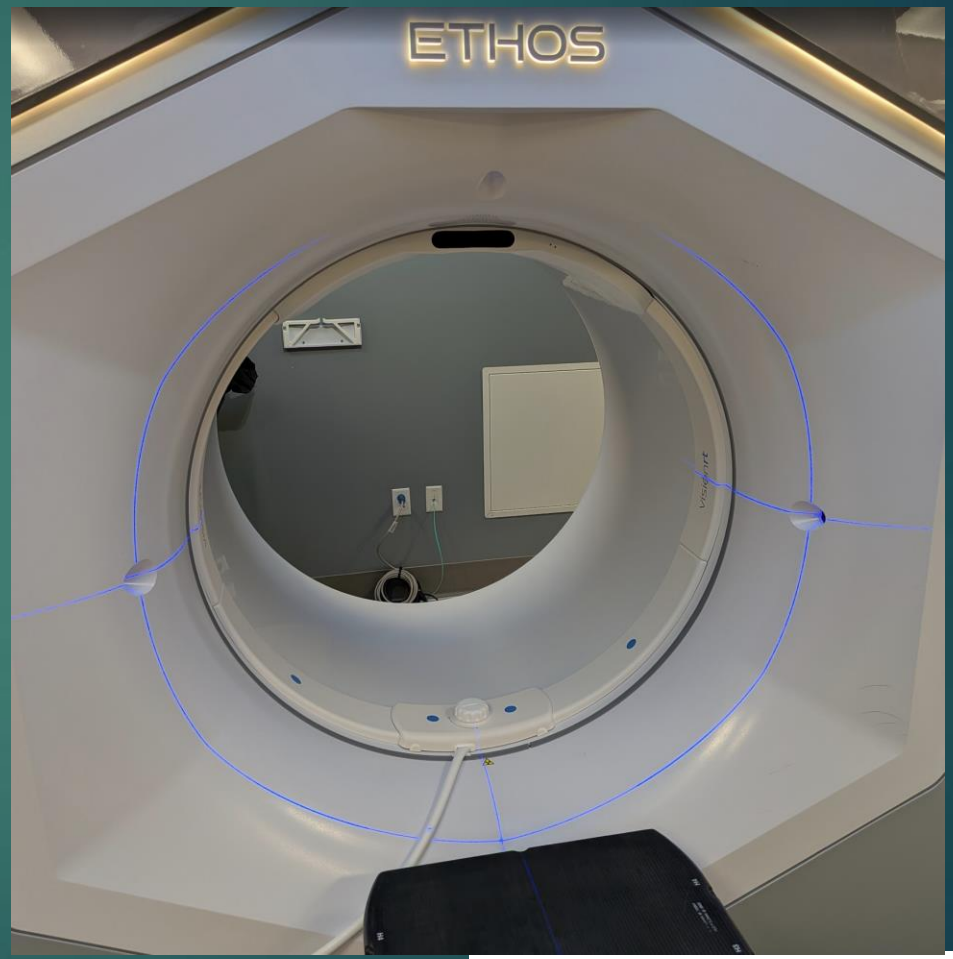
VisionRT's catalog





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What we'll be covering

1) Pre-acceptance and acceptance
2) Designing a commissioning checklist
3) Summarize our commissioning results for AlignRT and AlignRT inbore
4) Developing clinical workflows for clinicians
5) Designing routine quality assurance (QA)
6) Things that were unexpected (Expect the unexpected)

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Pre-acceptance

- Site survey:
  - Unobstructed camera pod placement
  - In vault computer location
  - In room lighting control
  - Camera pod power (switch)
  - UPS backup (?)
  - IT infrastructure
- Installing teams:
  - Expect many pre-installation visits
  - Look above your ceiling tiles

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Pre-acceptance

- Camera pod placement:
  - Cameras will not be vibrated or bumped
  - Cameras are very thermally sensitive and may require HVAC redirects

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Pre-acceptance

- In-vault user interface: This is a mirrored display of the console alignRT system and can be an instrumental tool in initial patient alignment
  - Ensure there is sufficient counter space
    - Your RTTs will NOT want this in the first place the installer suggests. Include them in the layout design
  - Ensure there is an unobstructed view of the patient from the computer
  - Consider therapist usability. If individual therapists are setting up a patient, a large wall mounted display maybe more ideal.

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Pre-acceptance

- Verify that your linac performance conforms to clinical standards at the most stringent technique that SGRT will be used:
  - Laser alignment
  - Relevant mechanical components (couch, gantry angle, etc.)
  - Optical distance indicators and front pointers
  - Radiation and imaging isocenter coincidence

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Pre-acceptance

- Communicate with your installer ahead of time. Test basic functionality and prepare test patients
  - Discuss preparation responsibilities and timelines
  - Verify network connectivity and read/write capability to any shared network drives
  - Note: Due to IT security, we had to cancel installation twice midway due to network communication failures

- If you've upgraded Truebeam v3.0 or later, your ADI may need to be upgraded. Reach out to Varian.

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Acceptance

- You'll be validating the system is working and performance to set standards that may not conform to your intended treatment protocols:
  - RMS < 1mm
  - Localization < 1mm and 1°
  - Beam hold functionality (Truebeam only)
  - Data transfer across network both ways

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Designing a commissioning checklist

- TG-147
- ESTRO-ACROP
- TG-302
  - Specific charge to provide patient positioning guidelines and requirements for commissioning and routine QA
  - Recommendations include and build on those provided in TG-147

AAPM task group report 302: Surface-guided radiotherapy

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Commissioning

- Establish objectives
  - Treatment technique (e.g. IMRT, SGRT, SRS)
  - Beam hold
  - Establish camera performance with and without occlusions
  - Interface with peripheral systems
  - Spatial drift and reproducibility
  - Static localization accuracy
  - Dynamic localization accuracy
  - End-to-end testing

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Interface with peripheral systems

- **Data transfer:** AlignRT has a local repository for DICOMs exported from Aria/Eclipse.
  - Verify this will accept any DICOMS sent through the export filter in your TPS
- **Data integrity:** Four image sets of the same AlignRT Cube phantom assigned with different patient orientations in Eclipse.
  - Verify each plan opens with surfaces correctly oriented
- **Integration with Truebeam:** When a patient is loaded in treatment mode on the Truebeam, AlignRT will automatically select this patient and plan from its database.
- **Interlocks:** "Authorization Pending" when AlignRT Motion Management is selected. Without it selected, "Auto-Authorize" allows regular linac use.
  - This is N/A for in-bore AlignRT

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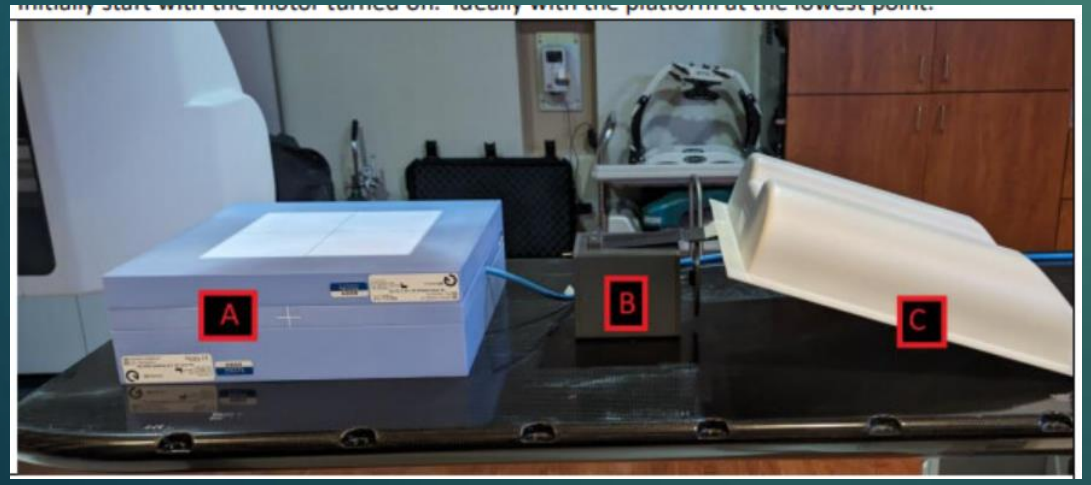
Dose delivery using beam hold

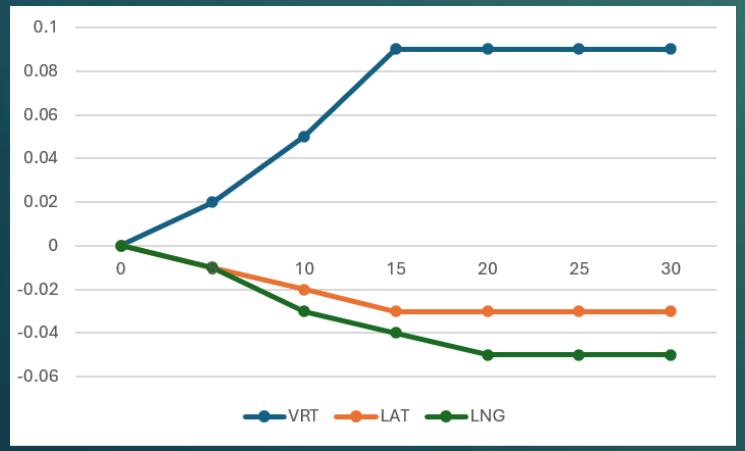
- Functionality of the ADI on Truebeam was validated. This feature is currently not being automated on Ethos systems
- The AlignRT leg phantom simulated respiratory motion using a sinusoidal motion motor. Beam Control in AlignRT was enabled, and a field was delivered to an ion chamber placed in solid water at isocenter. Another measurement was taken without beam control (i.e. continuous beam).

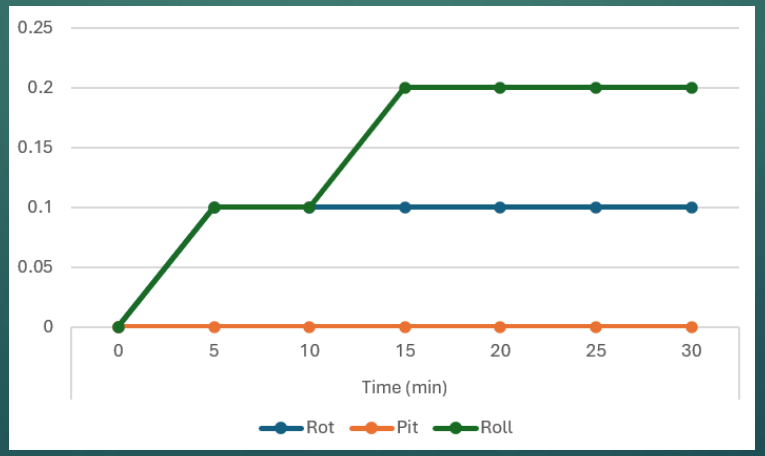


	nC
Beam hold	3.553
Continuous	3.559
Discrepancy	0.17%

Spatial Drift and Reproducibility

- **Spatial Drift:** Test of the measured drift of a stationary object as the cameras warm-up.
  - Procedure: The cameras were powered off for two hours. The AlignRT Cube phantom was aligned at isocenter using the room lasers. The cameras were powered on and a reference image of the cube was immediately taken. Deltas were recorded for all degrees of freedom (DoFs) periodically over 30 minutes
- **Reproducibility**: After warm-up, little to no changes observed after 20 minutes





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Static Localization

- Accuracy of the spatial motion using the AlignRT Cube phantom in 6 DoFs
  - Procedure: A reference image was taken with the cube at isocenter. Known shifts were applied. We tested this with all cameras unblocked then tested again with the patient left camera blocked to simulate gantry obstruction.

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Static localization

Setup:

a. No camera blocks,

		+1 cm shift			-1 cm shift		
	Baseline	Couch	AlignRT	Discrepancy	Couch	AlignRT	Discrepancy
VRT	-10.35	-9.35	1.01	-0.01	-11.35	-0.99	-0.01
LNG	120	121	0.99	0.01	119	-1.02	0.02
LAT	0	1	0.98	0.02	-1	-1.01	0.01

		+5cm shift			-5cm shift		
	Baseline	Couch	AlignRT	Discrepancy	Couch	AlignRT	Discrepancy
VRT	-10.35	-5.35	5.03	-0.03	-15.35	-4.96	-0.04
LNG	120	125	4.98	0.02	115	-5.05	0.05
LAT	0	5	4.97	0.03	-5	-5.06	0.06

g. Left camera blocked

		+1 cm shift			-1 cm shift		
	Baseline	Couch	AlignRT	Discrepancy	Couch	AlignRT	Discrepancy
VRT	-10.35	-9.35	1.03	-0.03	-11.35	-1.05	0.05
LNG	120	121	1	0	119	-1.03	0.03
LAT	0	1	1.02	-0.02	-1	-1.01	0.01

		+5cm shift			-5cm shift		
	Baseline	Couch	AlignRT	Discrepancy	Couch	AlignRT	Discrepancy
VRT	-10.35	-5.35	5.07	-0.07	-15.35	-4.92	-0.08
LNG	120	125	4.91	0.09	115	-5.09	0.09
LAT	0	5	4.97	0.03	-5	-5.03	0.03

inBore

	+1cm Shift			-1cm Shift		
	Actual	AlignRT	Error	Actual	AlignRT	Error
VRT	1.00	1.01	-0.01	-1.00	-1.01	0.01
LNG	1.00	1.01	-0.01	-1.00	-1.04	0.04
LAT	1.00	1.00	0.00	-1.00	-1.01	0.01

	+5cm Shift			-5cm Shift		
	Actual	AlignRT	Error	Actual	AlignRT	Error
VRT	5.00	5.02	-0.02	-5.00	-5.03	0.03
LNG	5.00	4.98	[illegible]	-5.00	-5.05	[illegible]
LAT	5.00	4.86	0.14	-5.00	-4.84	-0.16

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Dynamic Localization

- Because this system will not use breath gating, temporal accuracy was not a concern, so frame rate characterization and latency were not measured. Spatial accuracy, as it pertains to breath-hold, is validated by the static localization tests done previously.

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End-to-End Testing

- Overall system functionality and accuracy were evaluation by taking a test phantom from simulation.
  - A basic treatment field and setup fields were generated in Eclipse and aligned to an internal marker
  - The plan was imported into the AlignRT server and the delivery systems
  - Each phantom was aligned on the couch using AlignRT guidance
  - kV-CBCT and MV/kV planar imaging was performed to find the shift to the internal marker

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End-to-End Testing

Truebeam

dX	-0.4mm
dY	0.4mm
dZ	-0.6mm
Mag	0.8mm

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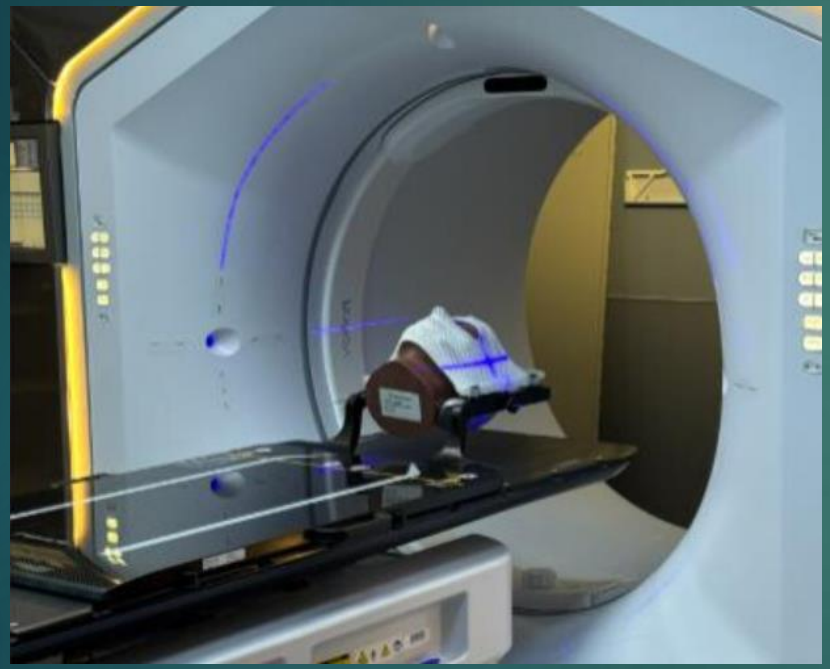
End-to-End Testing

Ethos



LAT	+1.3 mm
VRT	+3.0 mm
LNG	+0.4 mm
Mag.	+3.3 mm

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Develop workflows - Planning

- Dosimetry: transfer additional setup contours to planning CT
- Physicist: Export DICOMS to AlignRT server
- RTT: Import and setup patient in AlignRT

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Develop workflows – Simulation

- **RTT:** Coach patients through breath holds.
  - This should be the hardest day of their radiation treatment
- **Physicist:** Determine patient candidacy for DIBH
  - Reproducibility of breath hold
  - Sufficient vertical chest wall elevation (VCE)
  - Analyze the clinical benefit (i.e. chestwall and heart separation)
- **Team huddle:** RTT/physicist/oncologist should confer to determine if there is a clinical benefit from DIBH. Ideally before sending the patient home.

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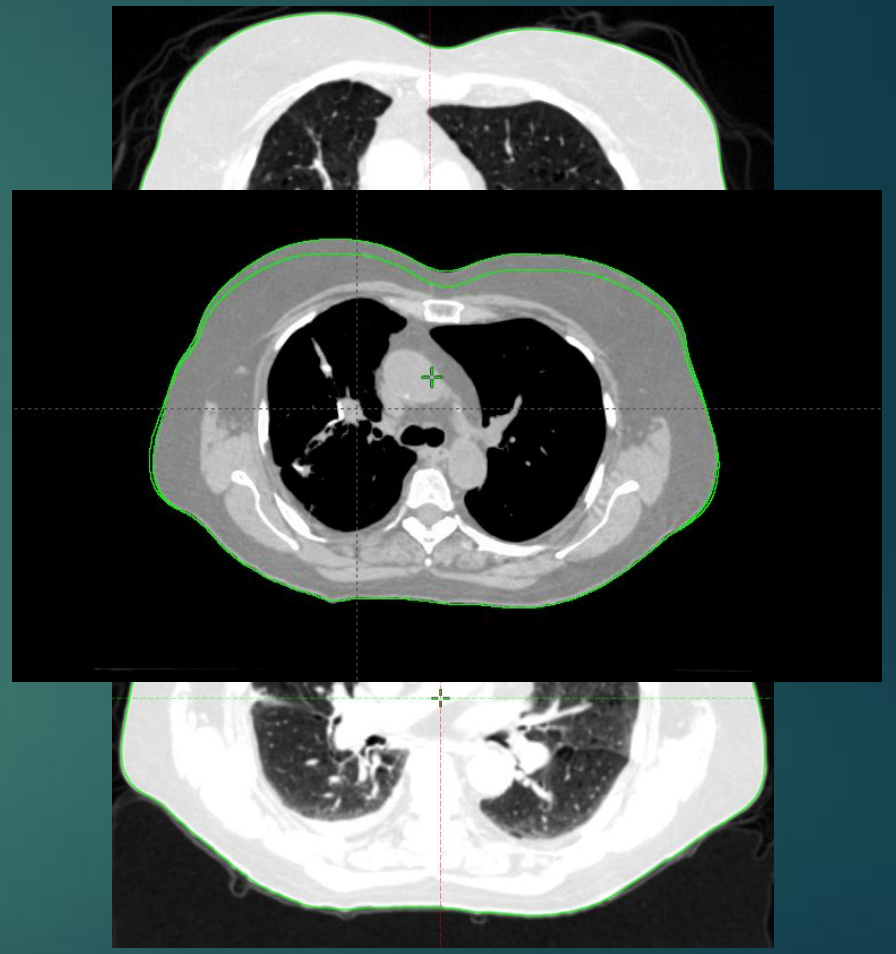
Treatment planning

1. **Import** both the DIBH and FB CT into the treatment planning system (TPS)
   - FOR registration for scans taken contiguously
2. **Reference surfaces**: auto-generate external structures
3. **Transfer** FB Body structure to DIBH planning CT



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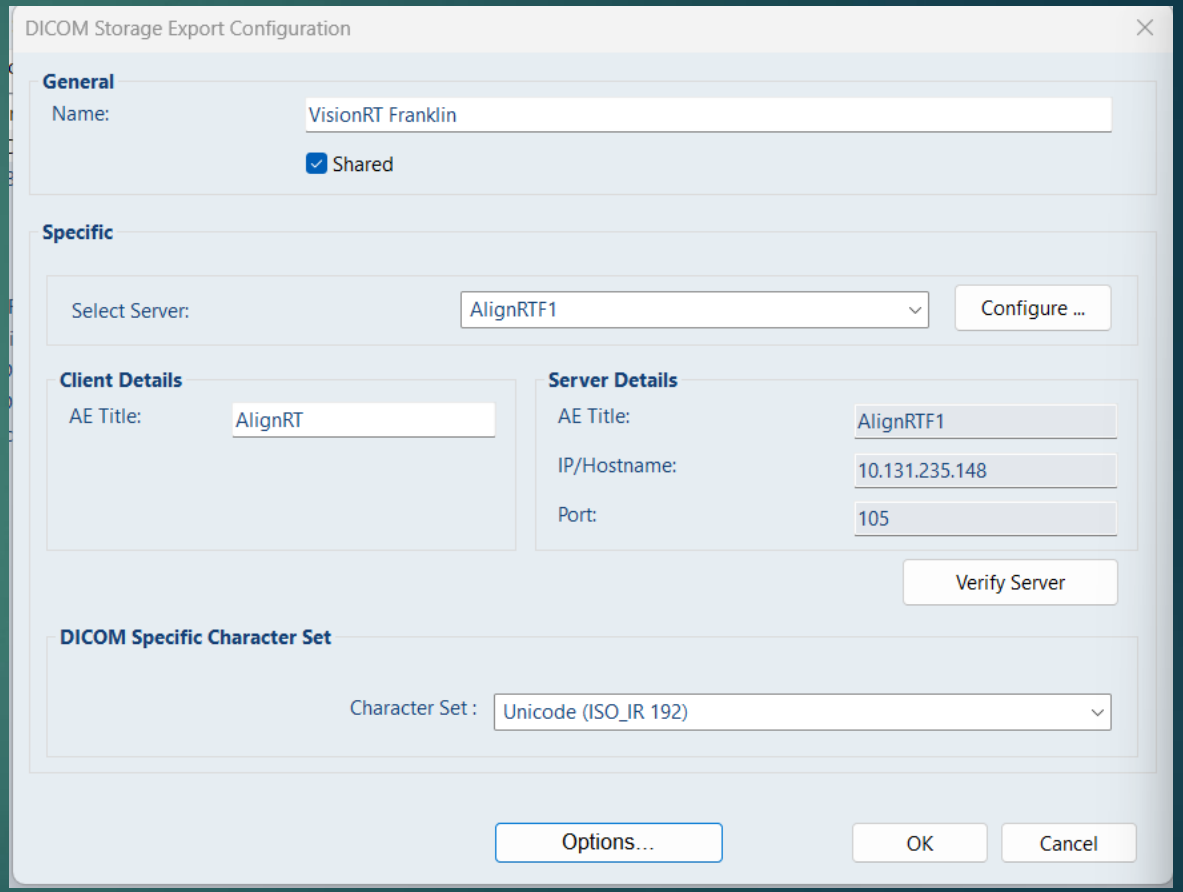
DICOM Export (to AlignRT)

- **DICOM Filters:** A semi-automated export filter from the TPS to the AlignRT server.
  - Unique and separate filters for each server
  - Export only the DICOM RTplan and Structure sets

Modality	Succeeded	Failed
Structure Set	1	0
Plan	1	0
Total	2	0



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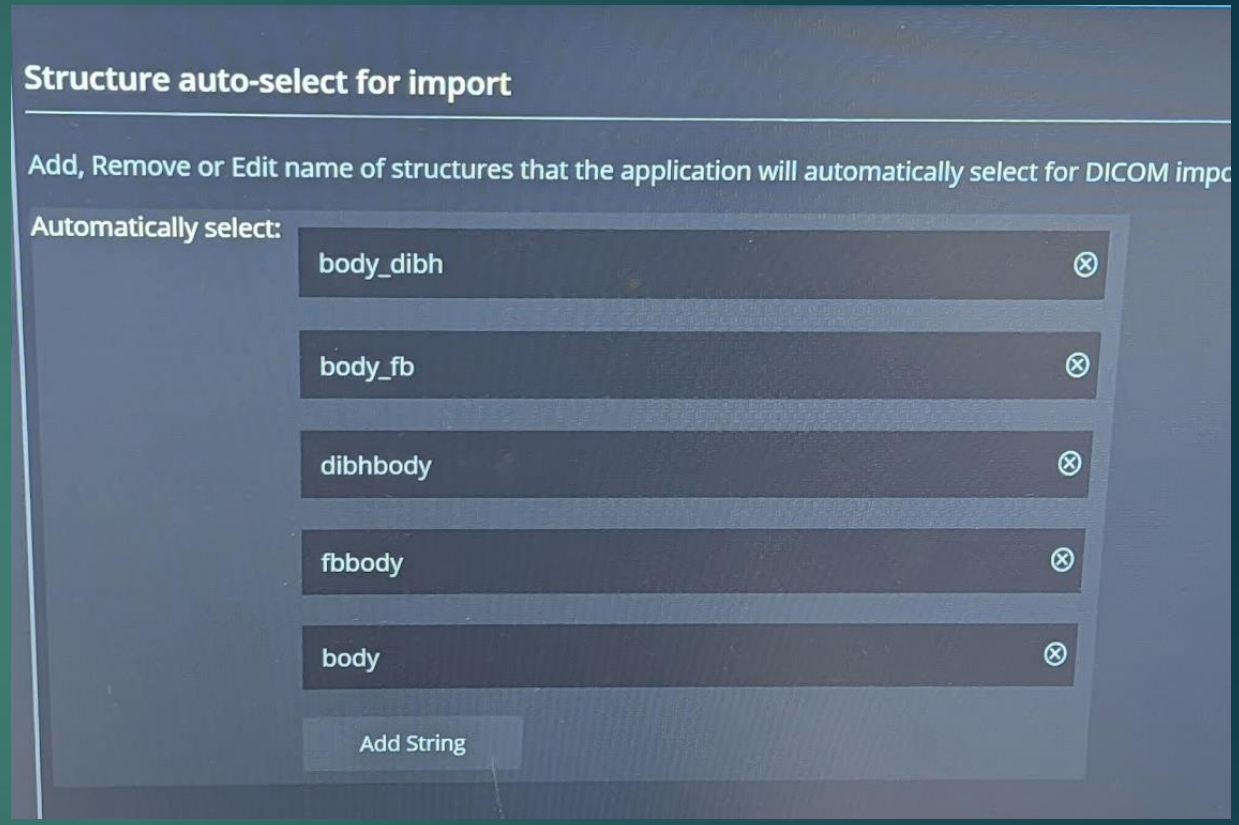
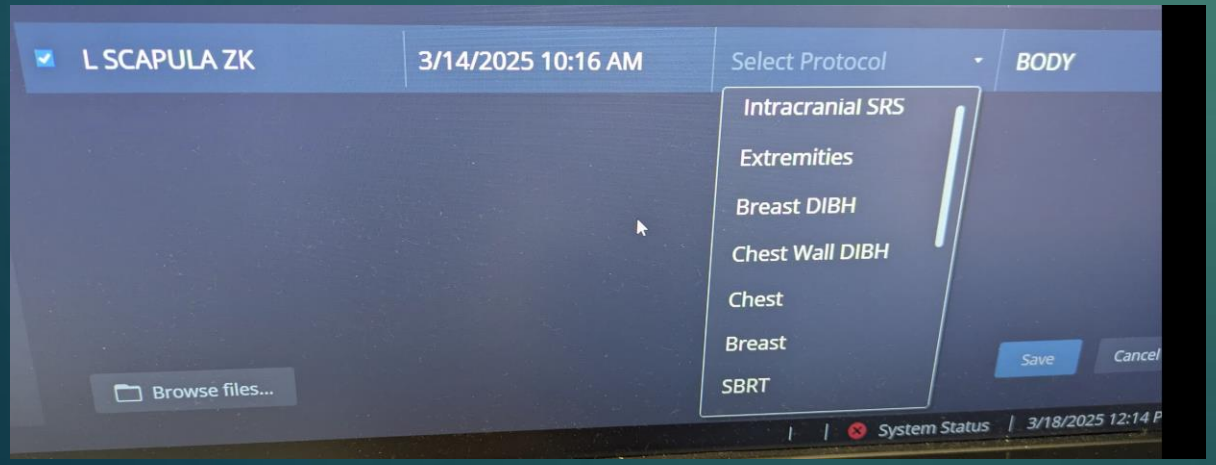
DICOM Import

- **Standardize:** Structure naming conventions
- **Automate:** Import filters can simplify patient preparation





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Daily QA

AlignRT O

1. Using the remote, turn off the VisionRT cameras, wait 20 seconds, then turn them back on.
2. On the VisionRT computer, open the AlignRT software and login.
3. On the AlignRT main screen click the Daily QA tile.
4. Follow the setup instructions:
    a. Set the vault dimmer switch to "nominal" levels. The appropriate lighting settings are marked.
    b. Remove items that block the cameras.
    c. Set the VisionRT Calibration Plate on the table with the correct orientation.
    d. Align the plate to isocenter (linac crosshairs and 100 SSD)
5. On the VisionRT computer in the vault, click 'Start Daily QA'
6. The result will be display in the upper right part of the screen. If the daily QA exceeds 1.0 mm, contact the physicist. The system will need to be recalibrated before using AlignRT for treatment.
7. Click 'Done' to finish.
8. Return the VisionRT Calibration Plate to its storage location.

RMS (mm)
mm

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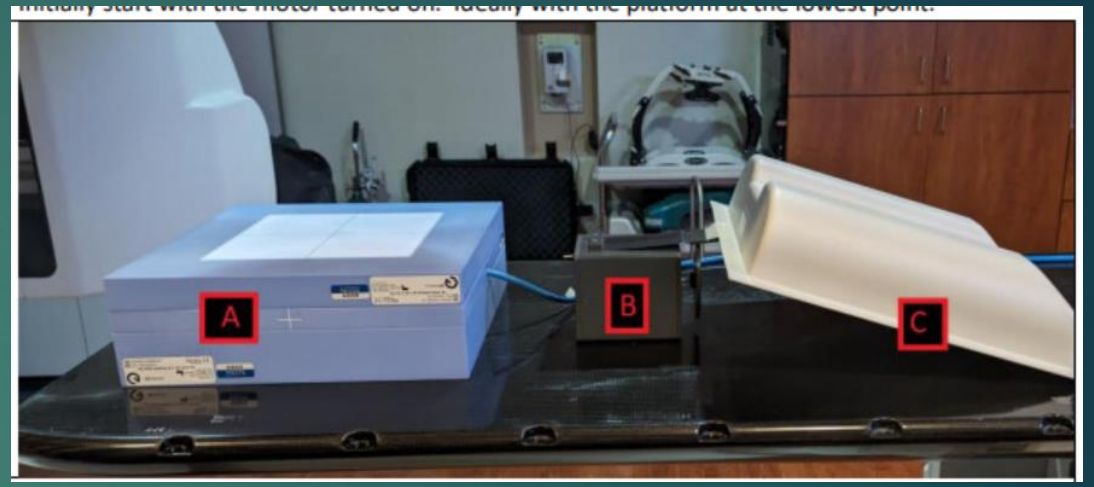
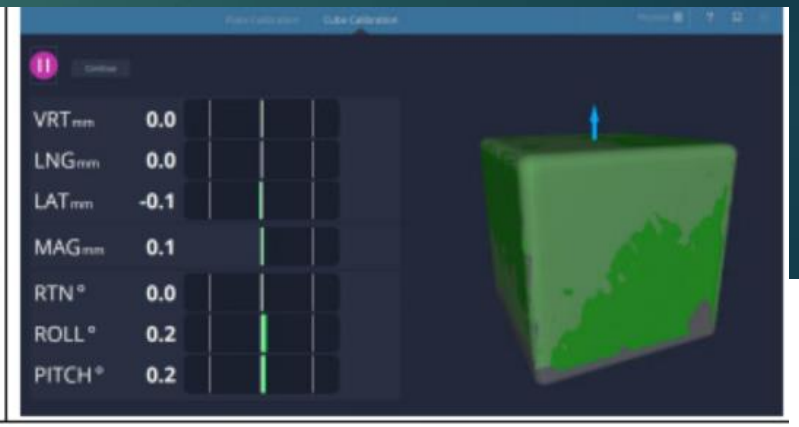
Physics QA

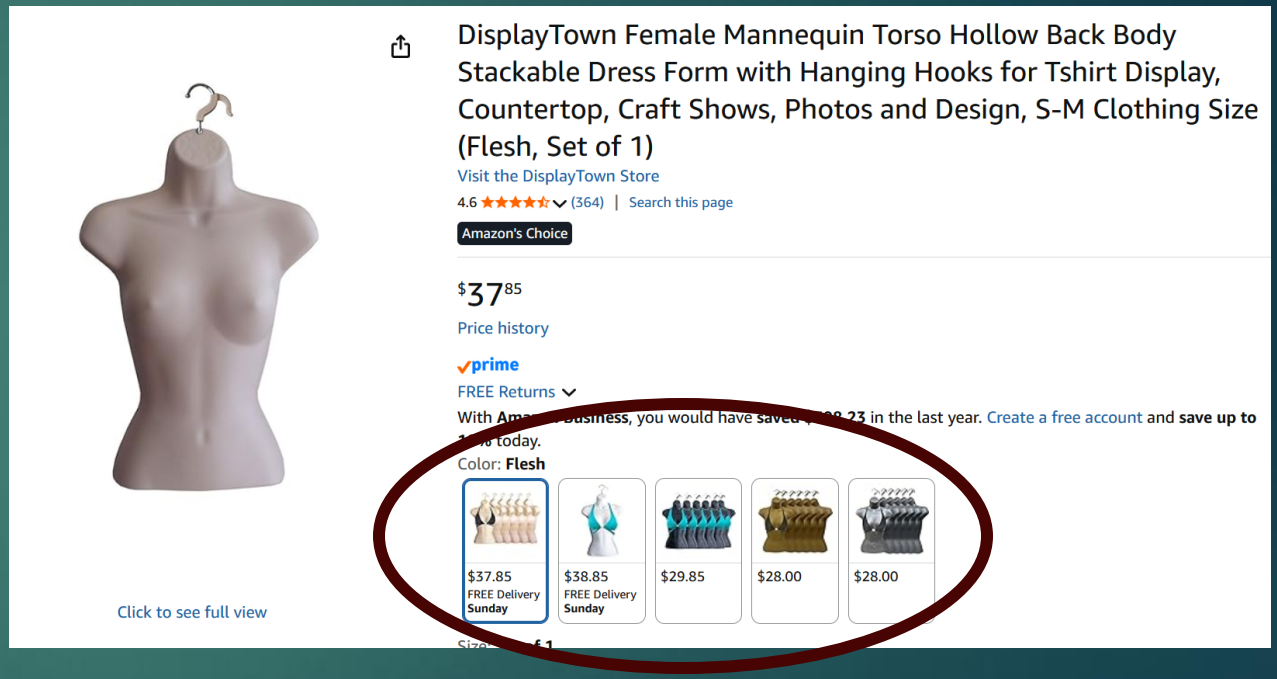
- **Monthly QA:**
  - Beam control and interlock functionality
  - Gated beam output constancy
  - Dynamic localization accuracy
  - Static localization accuracy
- **Annual QA:**
  - End-to-end localization
  - MV isocenter verification





The Unexpected

- Commissioning is only as stringent as your tools allow!
- **Phantom selection**:
  - Buy a torso phantom!
  - Skin tone matters!!
  - Consider how you will model respiratory motion
- **IT Infrastructure**:
  - Configure network storage and pass-through prior to acceptance
  - Have IT security ready and on speed dial during acceptance



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Closing remarks

- Your Task Group is your guide, but design commissioning checklists to your clinical needs
- Expect pre-acceptance to take several weeks and commissioning to take several nights
- Including your clinical team (RTTs, dosimetrists, and oncologists) in commissioning clinical workflows to build competency and trust in the system
- Build confidence one clinical protocol at a time
- Remember that skin surface is not your target. You must quantify the correlation between your surface ROI and the deep-seated anatomy for every patient

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Thanks

- I'd like to thank my clinical team at Vanderbilt Health

- Special thanks to those who shared their commissioning data:
  - Erin Chambers, MS
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  - Manuel Morales, PhD

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