REACHING NEW HEIGHTS WITH SGRT

SURFACE GUIDED RADIATION THERAPY
SGRT COMMUNITY

The Role of SGRT for Online Adaptive SBRT Treatments Using AlignRT InBore on Ethos Linacs

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Surface-guided Radiotherapy (SGRT) for Online Adaptive SBRT Treatments Using AlignRT InBore on Ethos Linac

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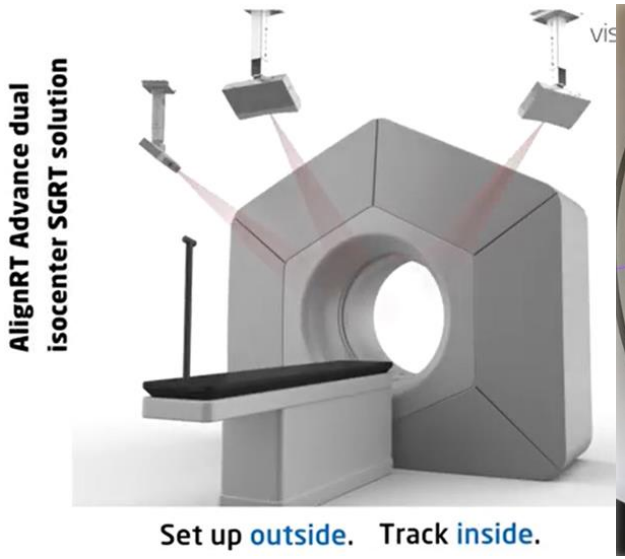
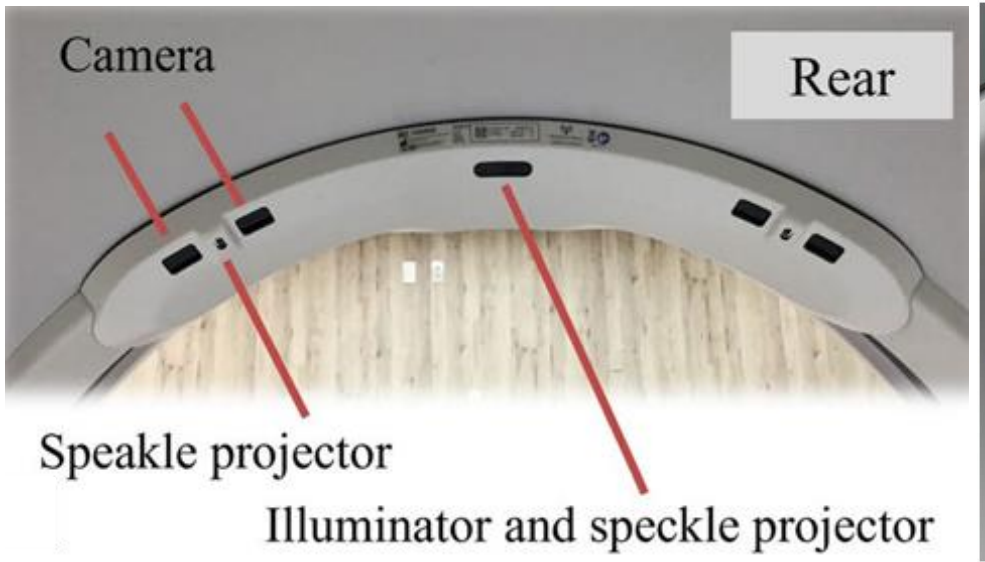
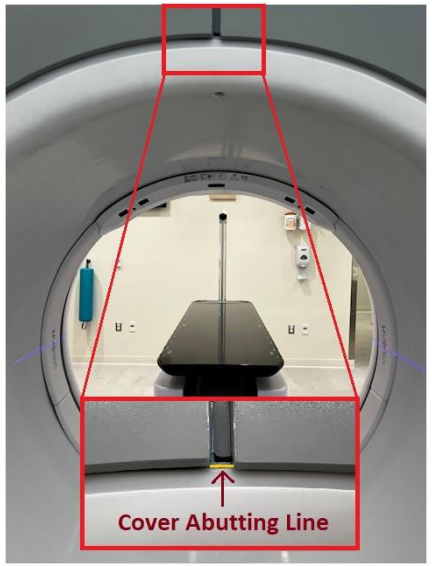
Background of AlignRT inBore System

- The external camera system to the simulation isocenter (simISO)
  - Three camera pods to provide 6DOF shifts, similar to the AlignRT Advance system
- The internal camera system to the treatment isocenter (txtISO)
  - Two camera pods on the ring inside the bore, having a smaller field of view (FOV)
  - Useful for monitoring body motion during online planning using RTD (Real-Time Delta)
    - A gentle daily collision check is required to pass inBore daily QA.







MSK Online Adaptive SBRT with SGRT

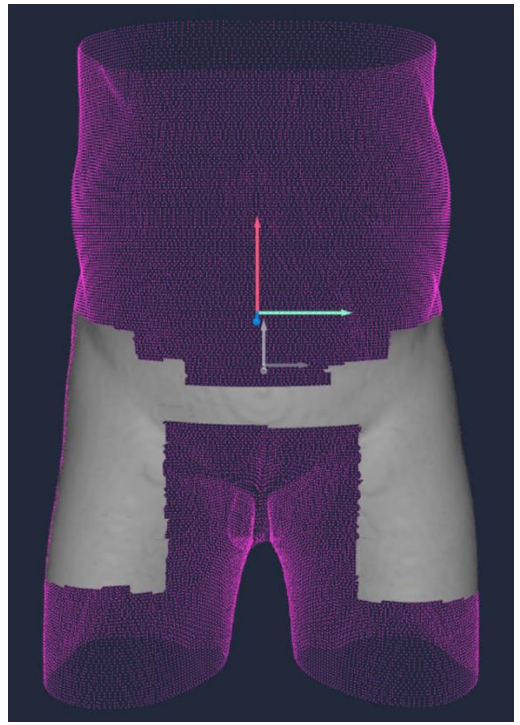
- Online adaptive SBRT for advanced prostate patients (with nodes)
  - SBRT Rx for EBRT-only treatments: 500/800cGy x5
  - SBRT Rx for post-brachy treatments: 500cGy x5
- Online adaptive re-planning on Ethos TPS system
  - Apply SGRT using DICOM reference to reproduce simCT external position
  - Using extended iCBCT-acuros for online planning and treatment
  - Patient motion monitoring during online planning using RTD (Real-Time Delta)
- SBRT setup with ±3mm PTV safety margin
  - Customized body mold without anterior mask fixation
  - Different daily bladder filling, rectum gas, and bowel positions
- SGRT motion monitoring with 3 intra-fractional CBCTs during SBRT
  - Intra-fractional body motion monitoring using RTD
  - Increasing bladder filling (full bladder) during ART-SBRT treatment using 3 CBCTs

Workflow for Prostate SGRT-ART-SBRT

- Initial Adaptive SBRT planning and plan checking
  - Planning (PTV margin: ±3mm) based on the simulation CT image using Ethos TPS
- SBRT setup using simulation CT DICOM external reference
  - Using 6DOF to reproduce the simulation position on the Ethos 3DOF couch
- Online Adaptive Re-planning on Ethos System
  - Using extended iCBCT-acuros for online adaptive planning
  - Adapt to daily prostate volume, bladder filling, rectum gas, and bowel positions
  - Patient motion monitoring during online planning using RTD (Real-Time Delta)
- On-treatment internal-external motion monitoring
  - Intra-fractional body motion monitoring using RTD and possible manual action
  - Intra-fractional CBCT (x3) monitoring internal organ motions
- Post-treatment patient-specific QA (PSQA)
  - PSQA for every fraction is conducted for any new clinical procedure

SGRT ROI for Setup and Monitoring

- ROI (region of interest) definition for pelvis patients
  - Cover the anterior and lateral thighs, avoid the private area, which will be covered by a towel and the belly area, which moves with respiration
  - Use the simulation CT body contour as the reference surface for SGRT setup
  - Minimize ROI deformation by adjusting the patient using Deformation View as a real-time guidance

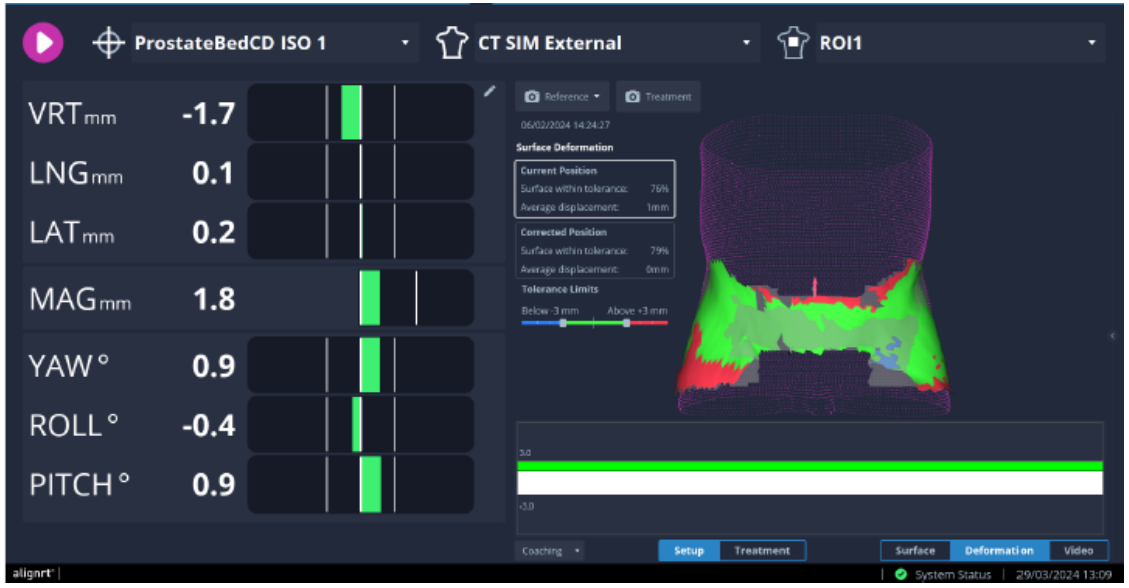


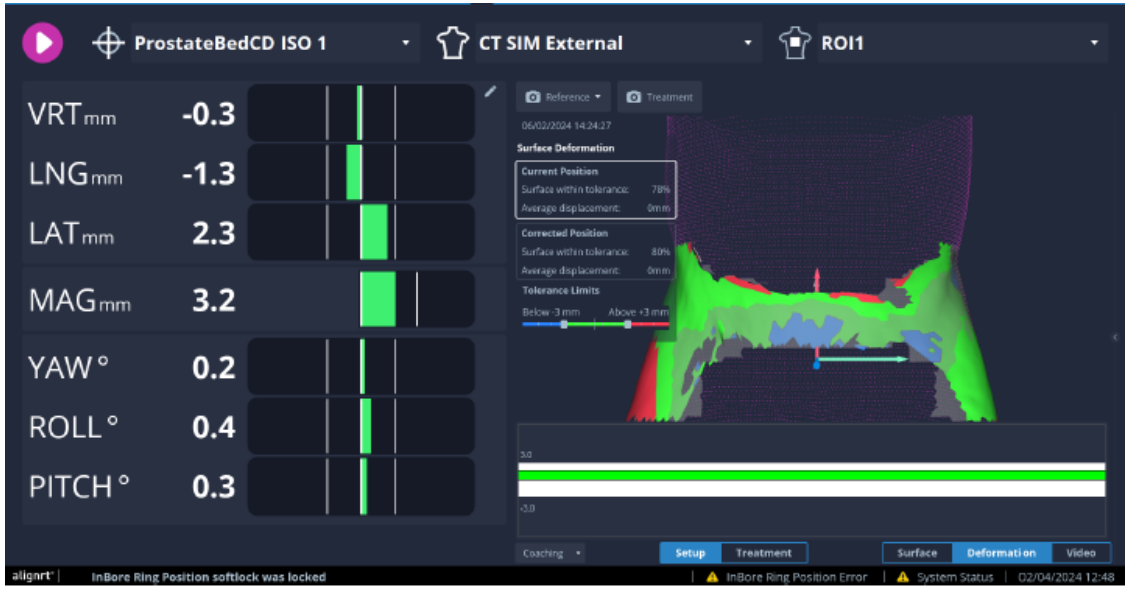
- 6DOF SGRT setup on the 3DOF Ethos couch
  - Adjust the patient's body to correct rotations (±1.5˚) first, then apply couch shifts (near zero)
  - On treatment, manual action will be taken if the patient moves out of the tolerance (±3mm).

SGRT Patient Setup in 6DOF

- SGRT guidance for adaptive patient setup using simCT DICOM reference
  - Using DICOM external body surface as the reference to reproduce the simCT body position
    - First, use the Postural Video to guide the initial SGRT setup
    - Second, correct body rotation shift first, and then apply couch shifts
    - Third, use the Deformation View to correct local deformation within the ROI

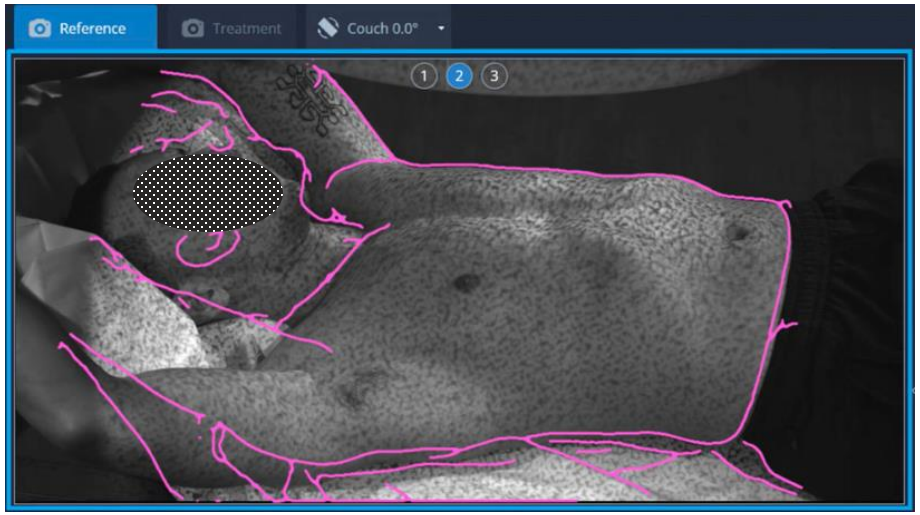
Green (±3mm), Red (>3mm), and Blue (<3mm)

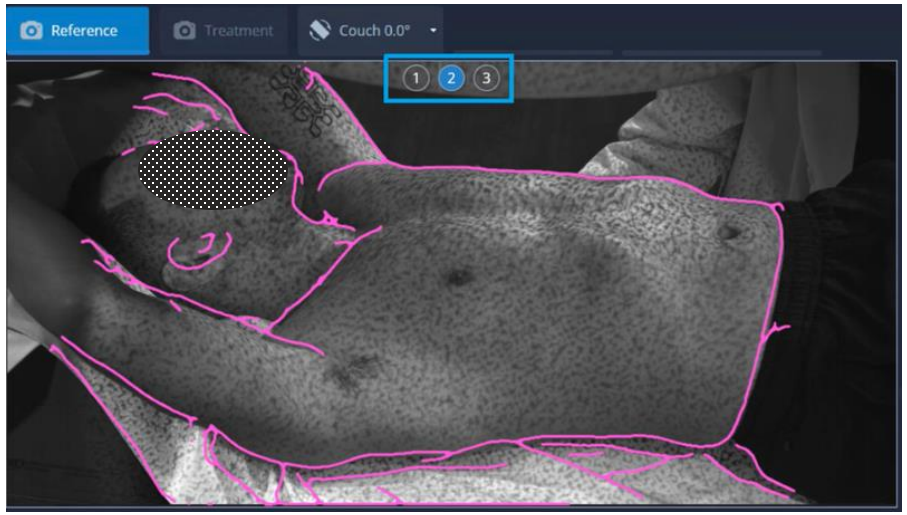




SGRT Workflow to Handle Deformation 1

- (1) Apply RTD in Postural Video mode at the beginning
  - Using body outlines (3 camera views) to adjust the patient and move the couch to the simISO.
  - Adjust torso alignment first, as it is heavier to move, then the extremities (correct deformation)

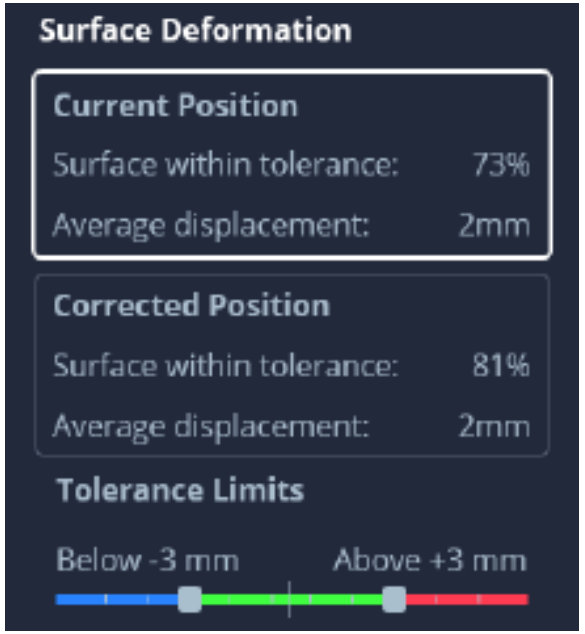




- (2) Minimize the 6DOF shifts, achieving near-zero-shift setup
  - Do not stop at the action thresholds (±3mm and ±1.5˚)
  - The key is to minimize the shifts (near-zero) before further correcting ROI deformation

SGRT Workflow to Handle Deformation 2

- (3) Change to Deformation View (Red >3mm, Green ±3mm, Blue <3mm)
  - Once near-zero 6DOF shifts are achieved, most ROI should be green.
  - Look for systematic color bias within the ROI.

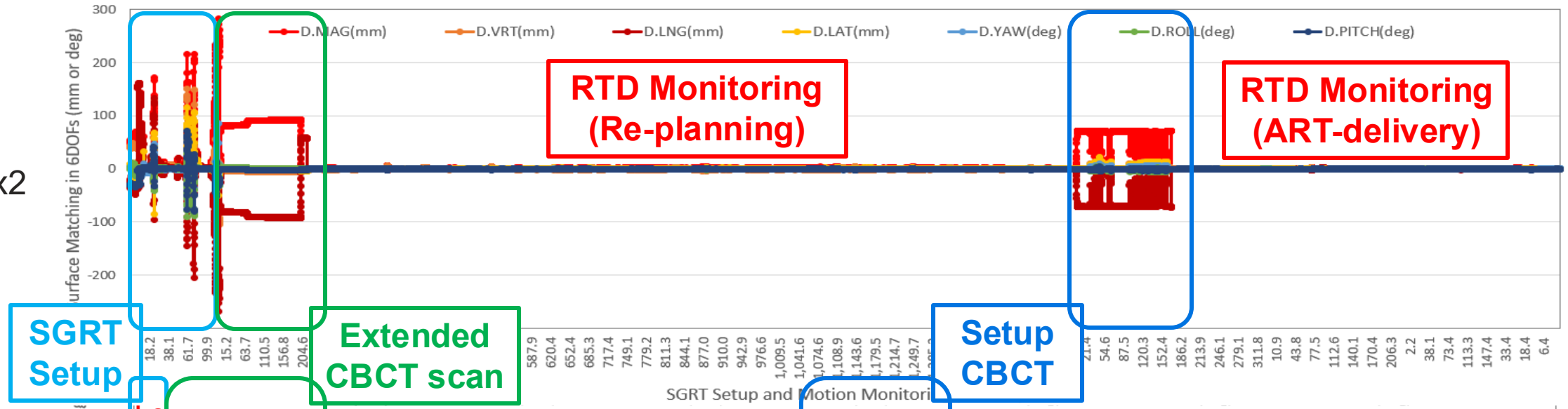


- Current Position (¾ ROI in Green)
- After couch shifts (>¾ ROI in Green)

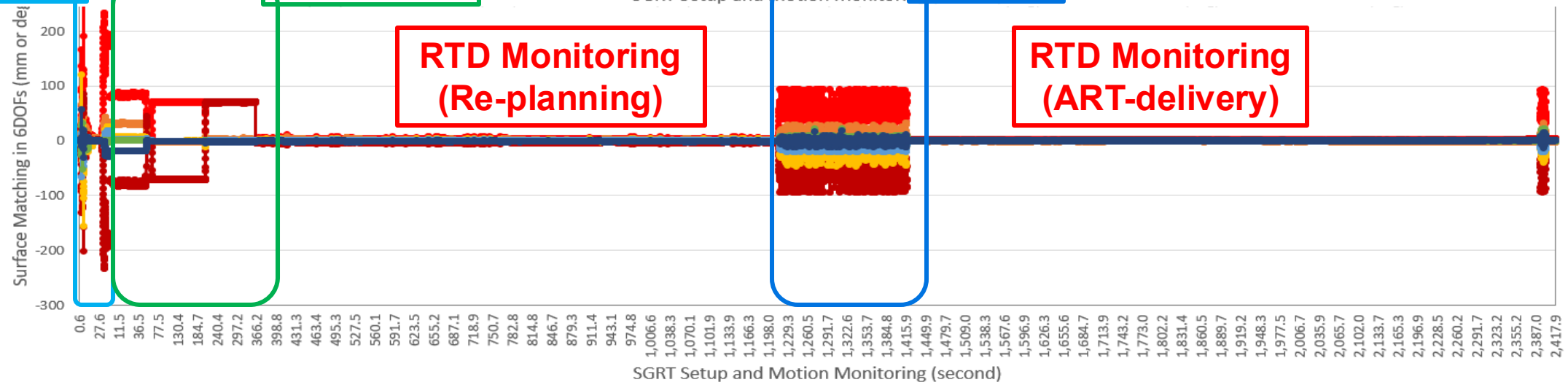
- (4) Load the patient into the bore, and perform CBCT @txtISO for final setup

SGRT Monitoring during Re-planning

Pt01_fx2

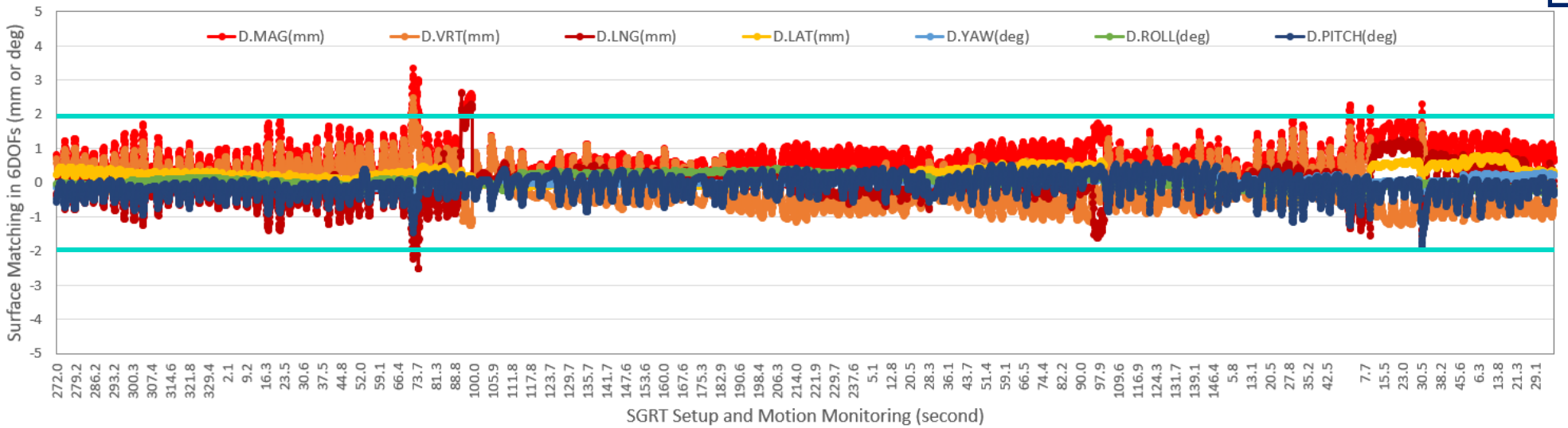


Pt05_fx4



Body Surface Motion during Treatment

Pt01_fx2



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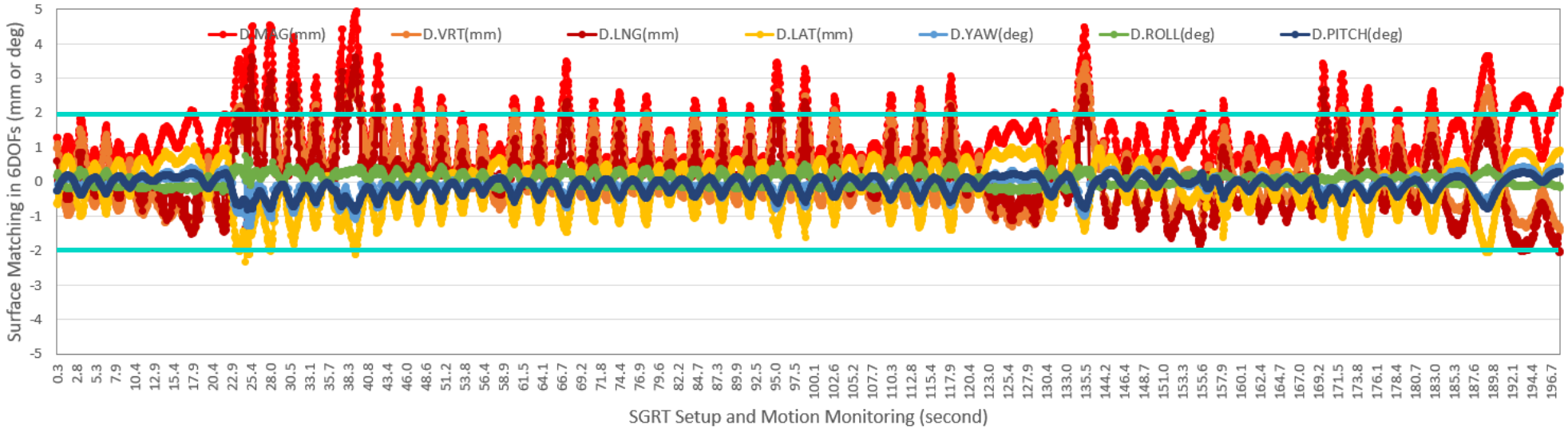
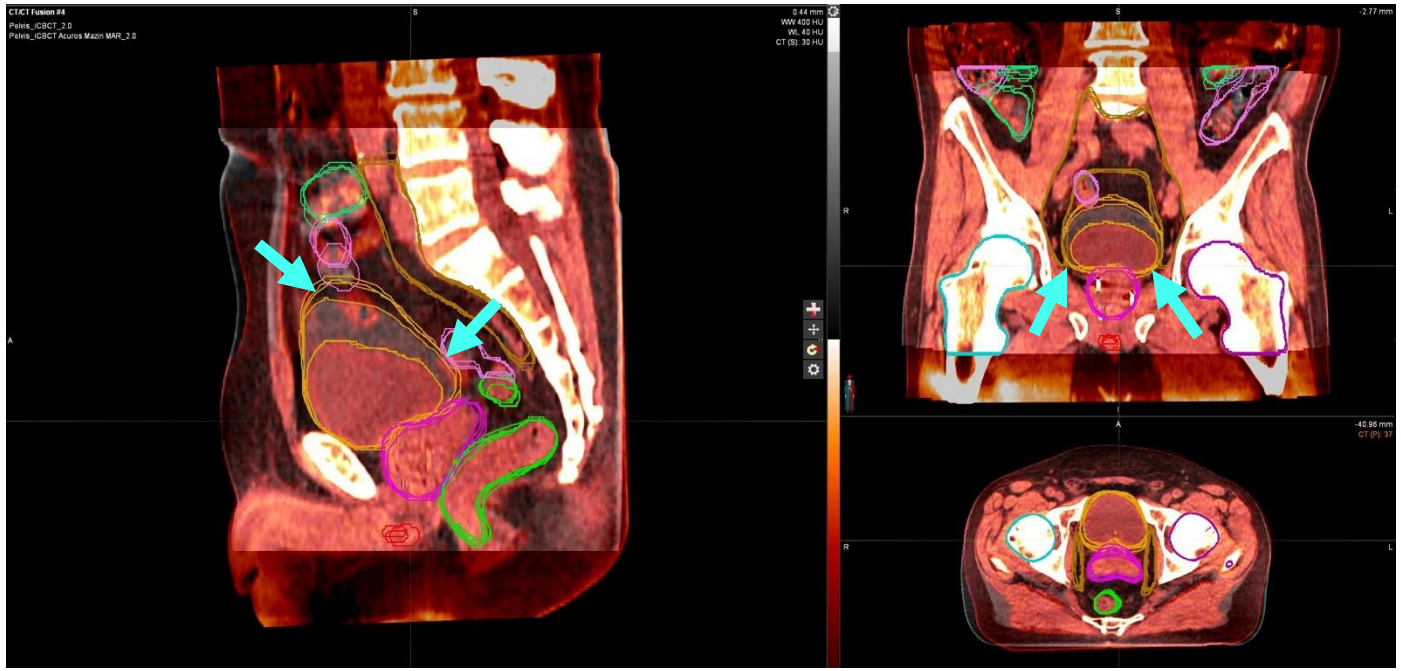
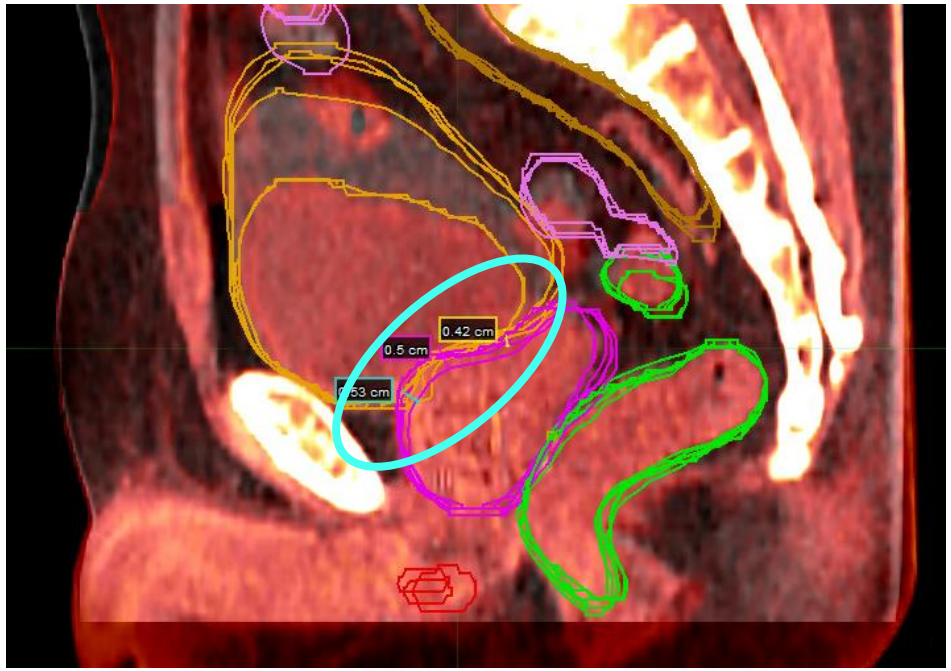


Organ Motion by Intra-Fractional CBCTs

- Bladder filling during treatment (2 cups of water before treatment)
  - The fullness of the bladder was checked with ultrasound before SGRT setup
  - During treatment, the bladder keeps enlarging toward the superior, anterior, and lateral directions.
  - The interface with the prostate remains within ~5mm uncertainty, as shown below.





Movements of Prostate and Nodes

- AI-based automatic segmentation of the prostate and nodes (CTVs)
  - MIM was used to perform the contouring and its statistical analysis among 4 CBCTs.
  - Only 3 out of 12 adaptive patients have been analyzed: more data will be collected and processed.
- Mean-Distance-to-Agreement (MDA) of CTVs among 4 intra-fx CBCTs
  - The prostate and nodes move about 1.9±0.5mm and 1.0±0.2mm, respectively.
- DICE similarity index of CTVs among 4 intra-fx CBCTs
  - Both the prostate (Dice=0.83) and nodes (Dice=0.91) maintain their shapes during treatment.

Patient	MDA				DICE			
	CTV_Prostate		CTV_Nodes		CTV_Prostate		CTV_Nodes	
	AVG	STD	AVG	STD	AVG	STD	AVG	STD
1	1.65	0.41	1.07	0.09	0.86	0.03	0.91	0.01
2	1.58	0.20	1.07	0.41	0.85	0.01	0.91	0.03
3	2.51	0.95	0.99	0.23	0.76	0.08	0.90	0.02
AVG	1.91	0.52	1.04	0.24	0.83	0.04	0.91	0.02

Conclusion

- SGRT is necessary for online adaptive SBRT of prostate cancer
  - Ensure PTV safety margin (±3mm) is secured under RTD surveillance
  - Bladder filling has minimal impact on prostate and nodal positions
- SGRT workflow is useful for reproducible setup and secured position
  - Correct body rotations using 6DOF SGRT on a 3DOF couch
  - Patient motion monitoring is necessary during online planning and treatment
- Further investigation is ongoing using clinical patient data
  - Only three out of 12 SGRT-ART-SBRT patients are analyzed
  - Intra-fractional CBCT will stop after the study conclusion is reached

Any Questions?

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Thank You!

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