UNIVERSITY of MARYLAND MEDICAL SYSTEM

Comparing the dosimetric accuracy of proton breast plans delivered with SGRT and CBCT setup

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Conflicts of Interest

None

Surface Guided Radiation Therapy (SGRT)

SGRT Systems: VisionRT, Catalyst, OSMS, Identify

Applications: Patient setup, position monitoring, respiratory motion management.

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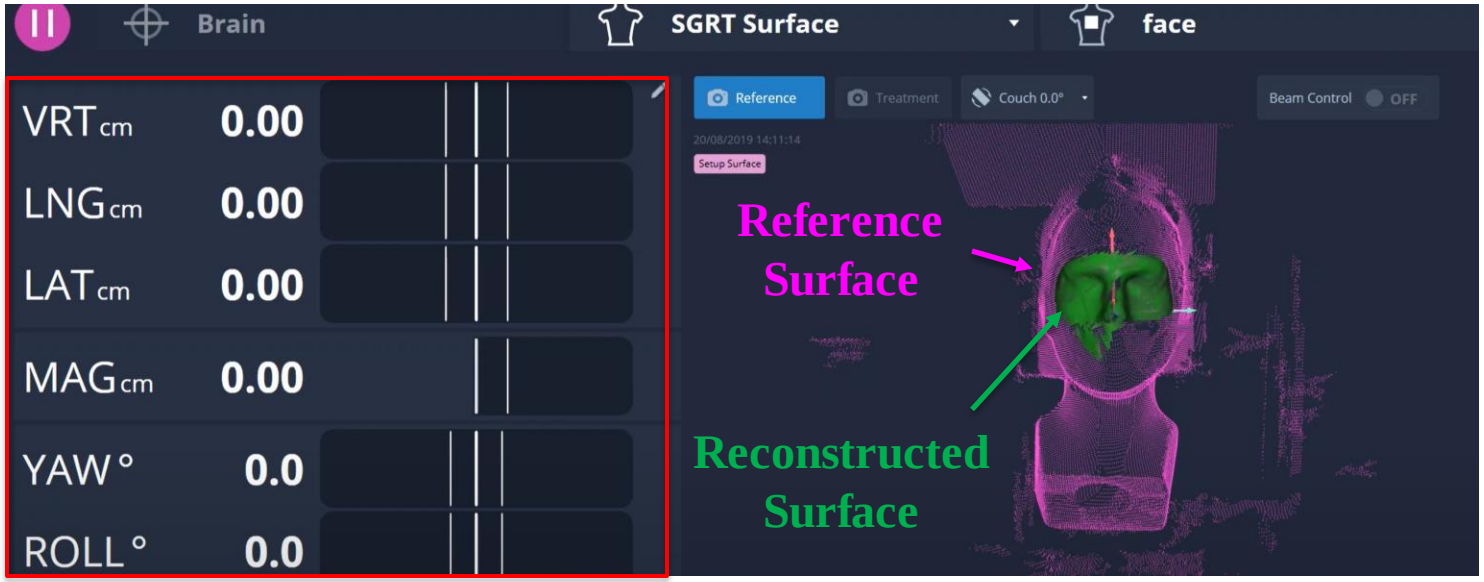
How these systems work:



Images from VisionRT

SGRT for Breast Cancer

There is good clinical evidence for the use of SGRT systems for breast radiotherapy

SGRT for Breast Cancer

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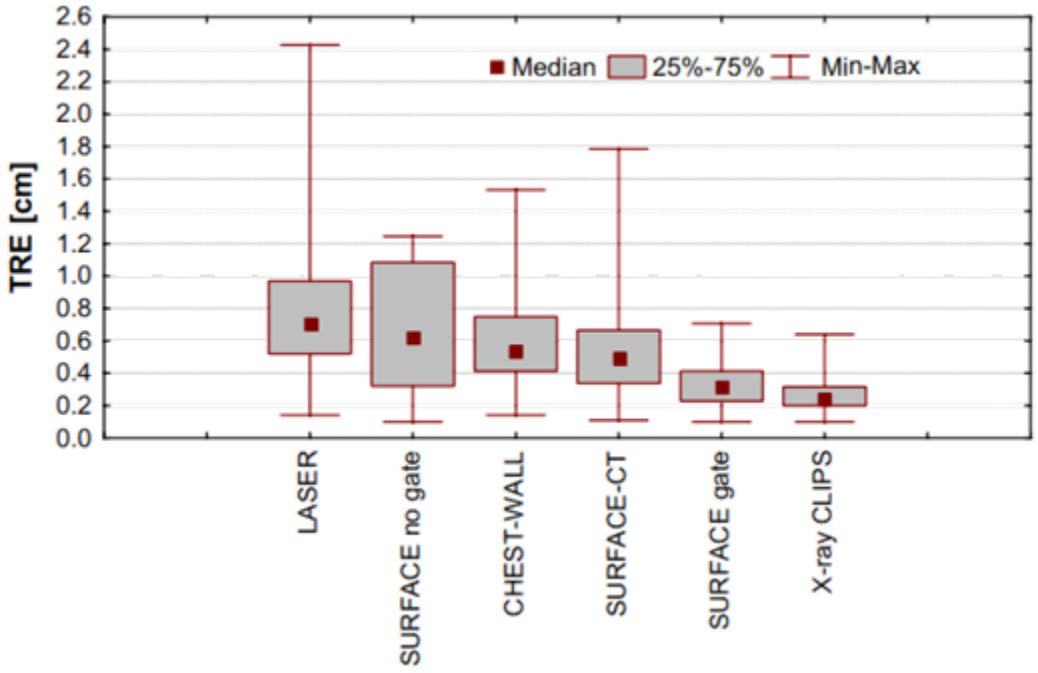
DP Gierga, et al. Int. J Rad Onc Biol Phys. (2008) 70(4): 1239-46.

- Evaluated target registration error (TRE) for laser-based, kV-pair to chestwall, kV to surgical clips, and SGRT setup on 12 APBI patients
- Finding: TRE of SGRT and clip-based setup were within 1mm (when using gated capture for SGRT)

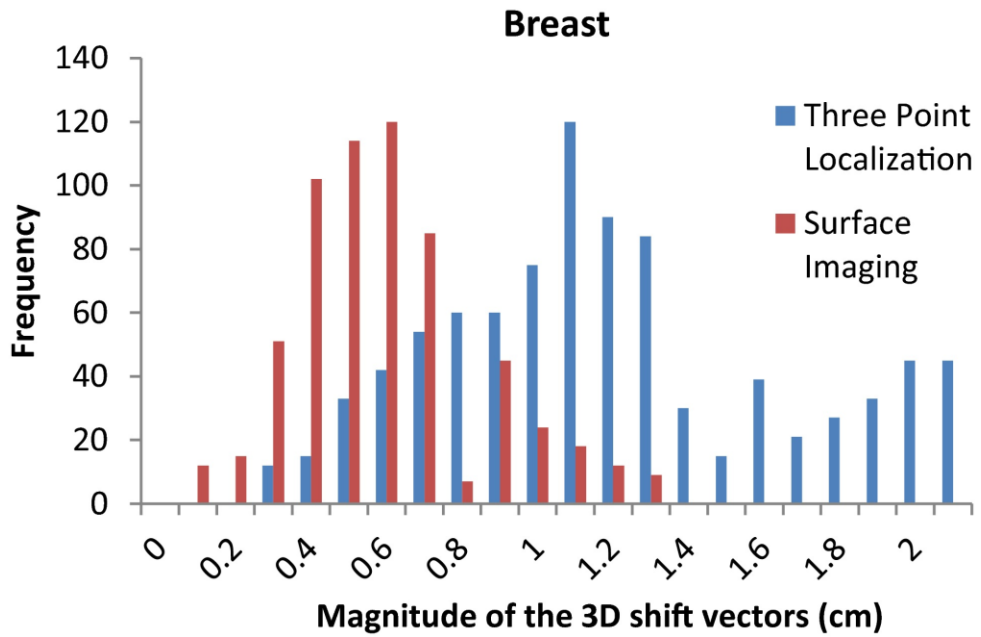


SGRT for Breast Cancer

There is good clinical evidence for the use of SGRT systems for breast radiotherapy

DN Stanley, et al. J. Appl Clin Med Phys. (2017) 18(6):58-61.

- Reviewed 600-900 individual breast RT fractions
- Compared 3D corrections from CBCT IGRT following initial setup using tattoos and SGRT
- Magnitude of shifts:
  - 1.4 ± 0.7 (SD) cm using tattoos
  - 0.6 ± 0.2 (SD) cm using SGRT



SGRT for Breast Cancer

There is good clinical evidence for the use of SGRT systems for breast radiotherapy

S Kost, et al. Pract Radiother. Oncol. (2019), 9(4): 239–47.

- Reviewed setup accuracy of anatomical landmarks (skin, chest wall , heart) on 915 MV port images after initial setup w/ and w/o SGRT
- Findings: setup error of all three landmarks were significantly smaller in the cohort initially setup with SGRT.

SGRT for Breast Cancer

A common thread in these and many other studies…

DP Gierga, et al. Int. J Rad Onc Biol Phys. (2008) 70(4): 1239-46.

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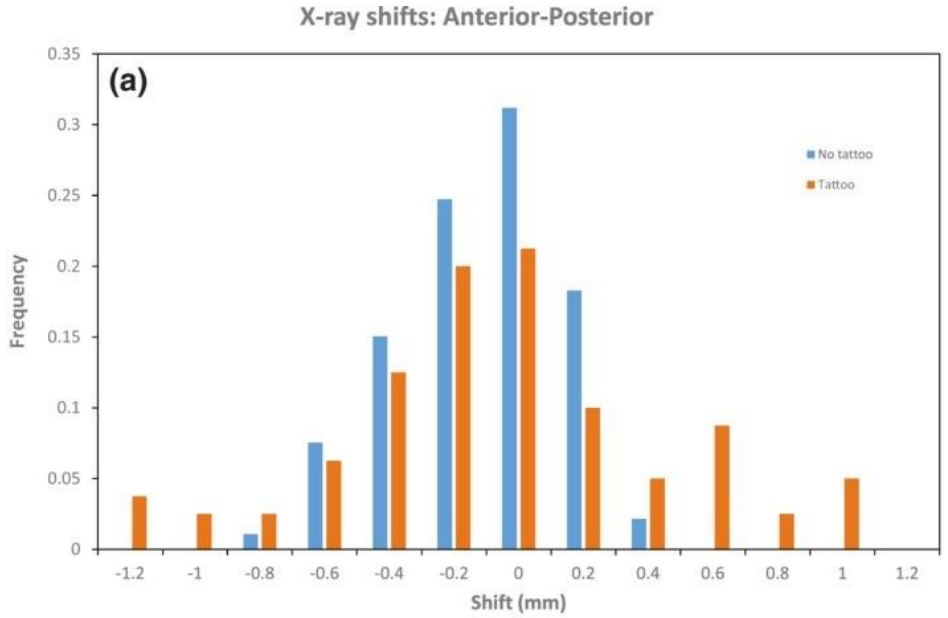
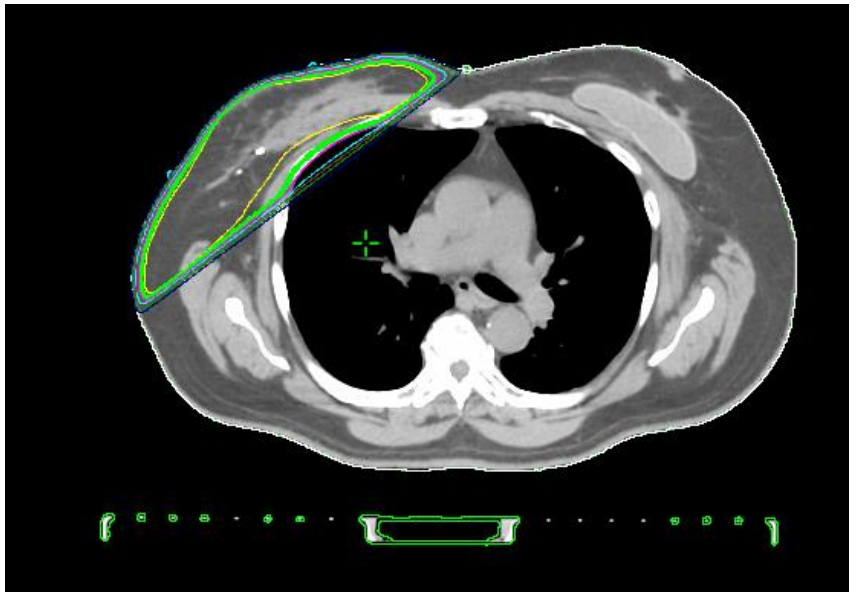
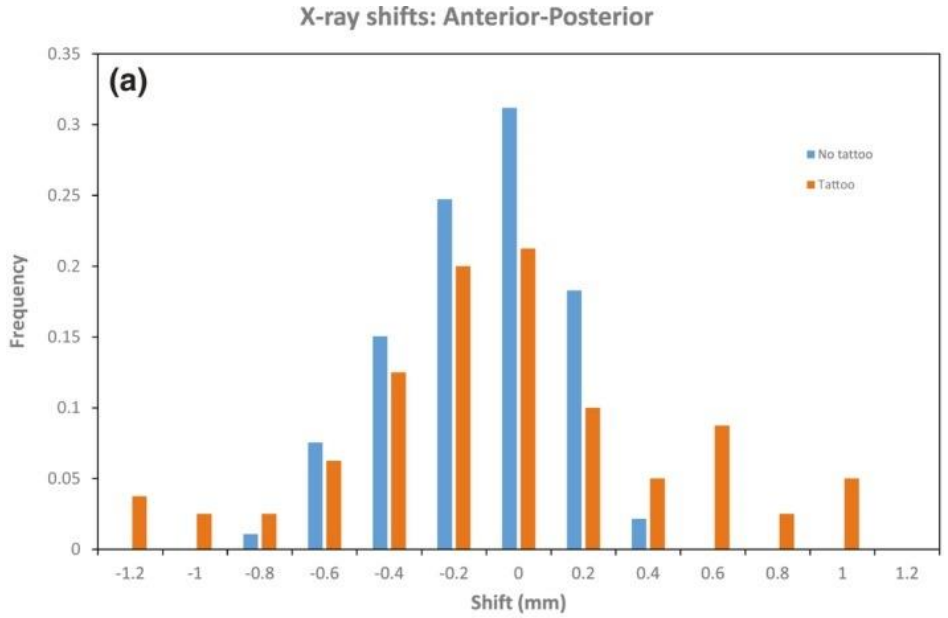


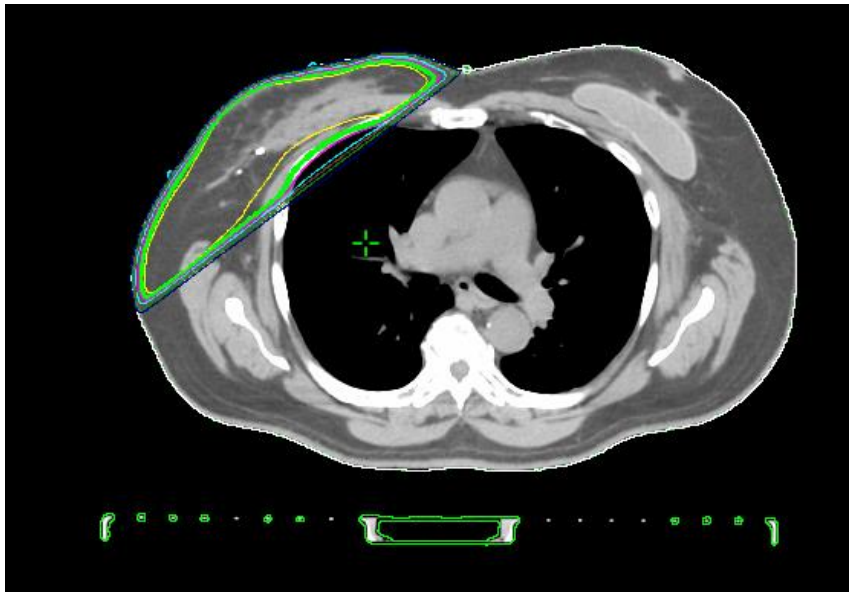


SGRT for Breast Cancer

This is reasonable for photon field-in-field and VMAT plans with sufficient flash

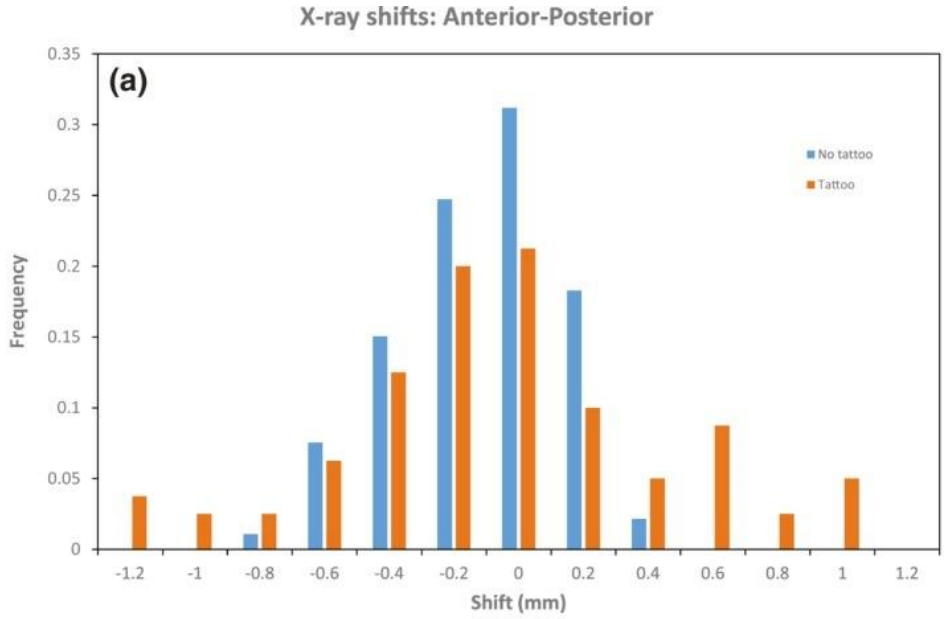
M Rossi, et al. J. Appl Clin Med Phys. (2018) 19(5):506-16.





SGRT for Breast Cancer

But is this true for proton therapy?



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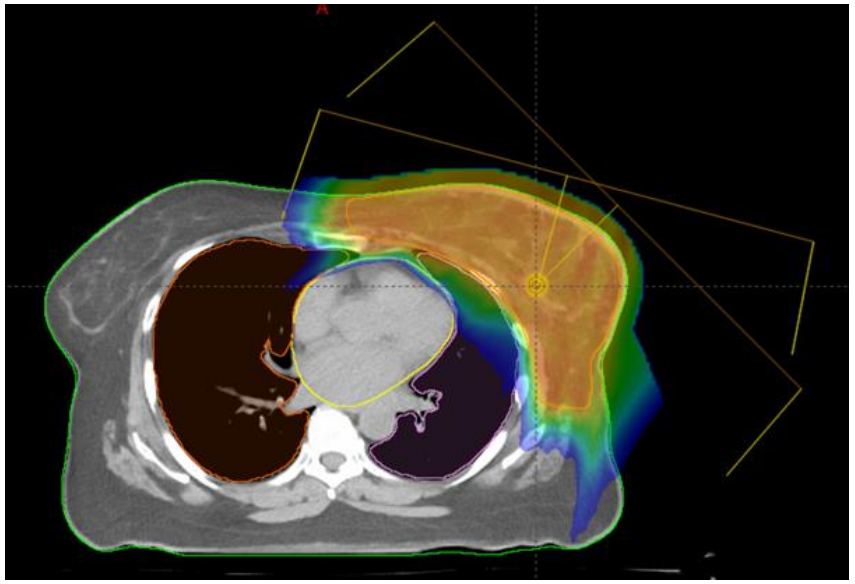


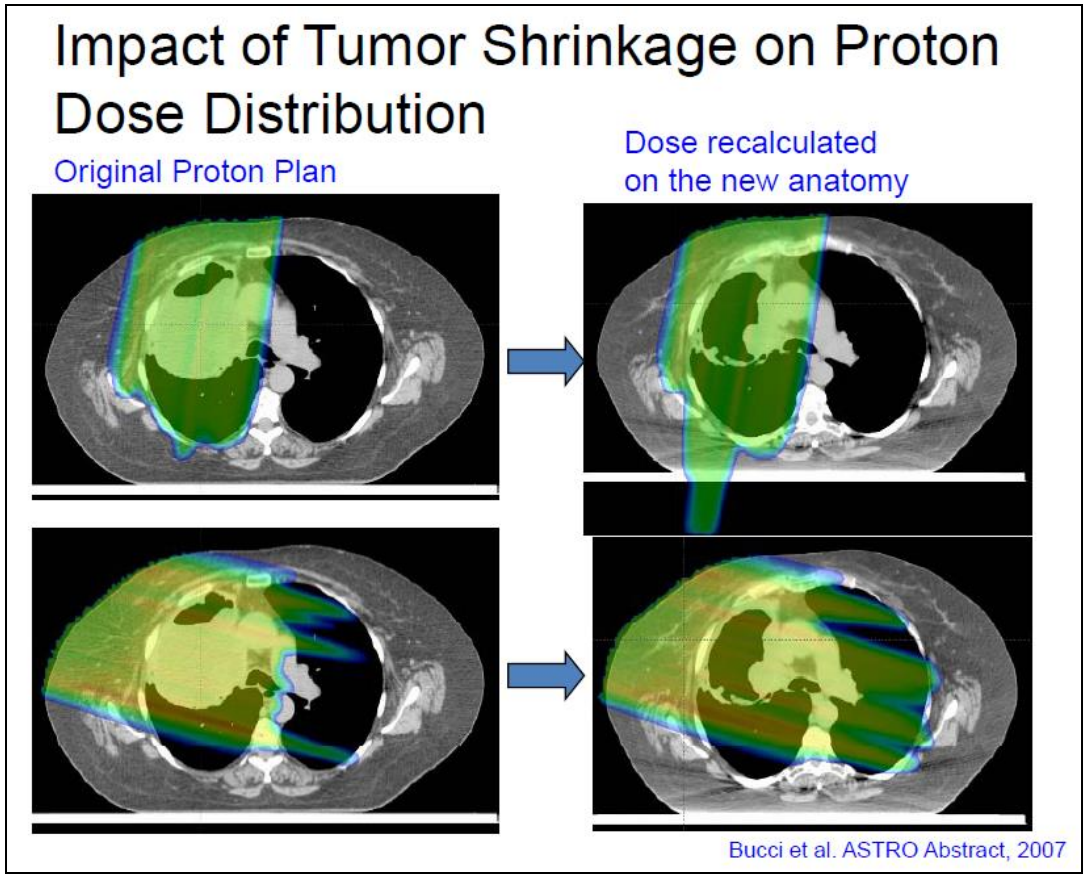
Challenges of Proton Therapy

Proton therapy is much more sensitive to anatomical changes and setup errors

Swelling, shrinking, and deformation of the breast is possible over the course of treatment.

↓

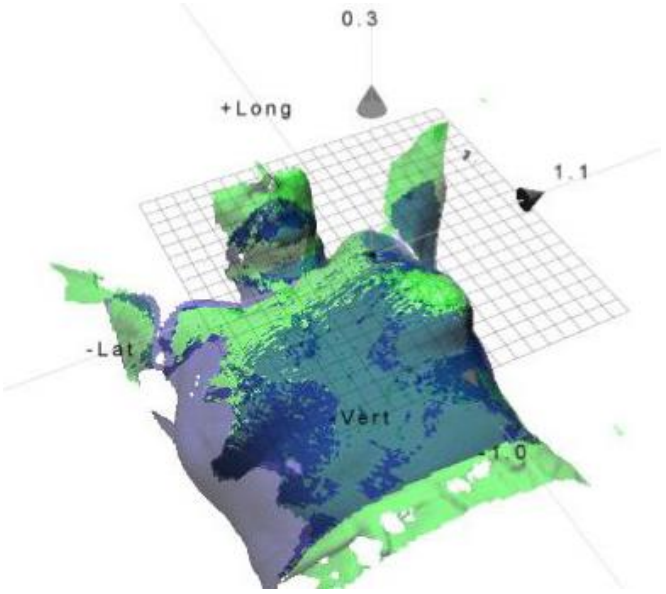
Potential to change delivered dose.



This studies objective

Objective: to investigate the dosimetric accuracy of SGRT setup in proton breast RT

A hurdle for conducting this investigation:



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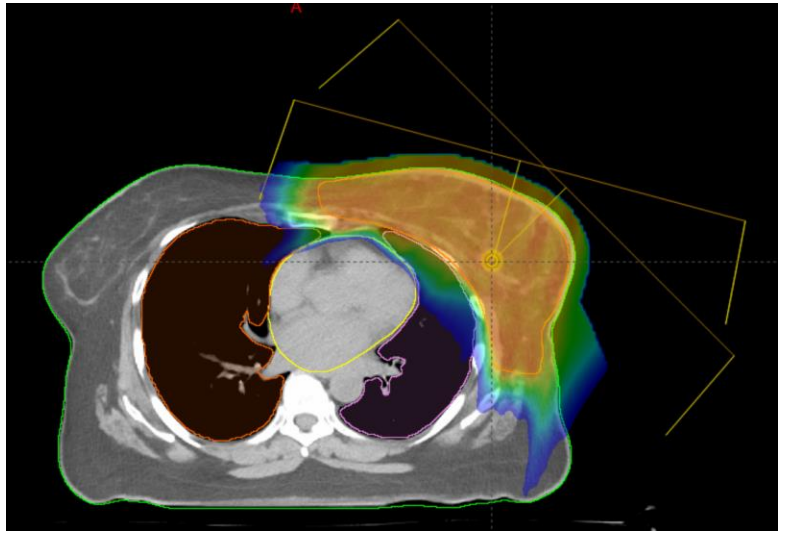


Goal of this research project

1. **Establish a method of simulating SGRT setups in a TPS**

2. **Evaluate the *dosimetric accuracy* of proton breast treatment plans delivered with SGRT vs. CBCT setup.**

Study Design: *Patient Cohort*

30 previously treated breast cancer patients (23/30 intact breast).

Received pencil beam scanning IMPT at Maryland Proton Treatment Center.

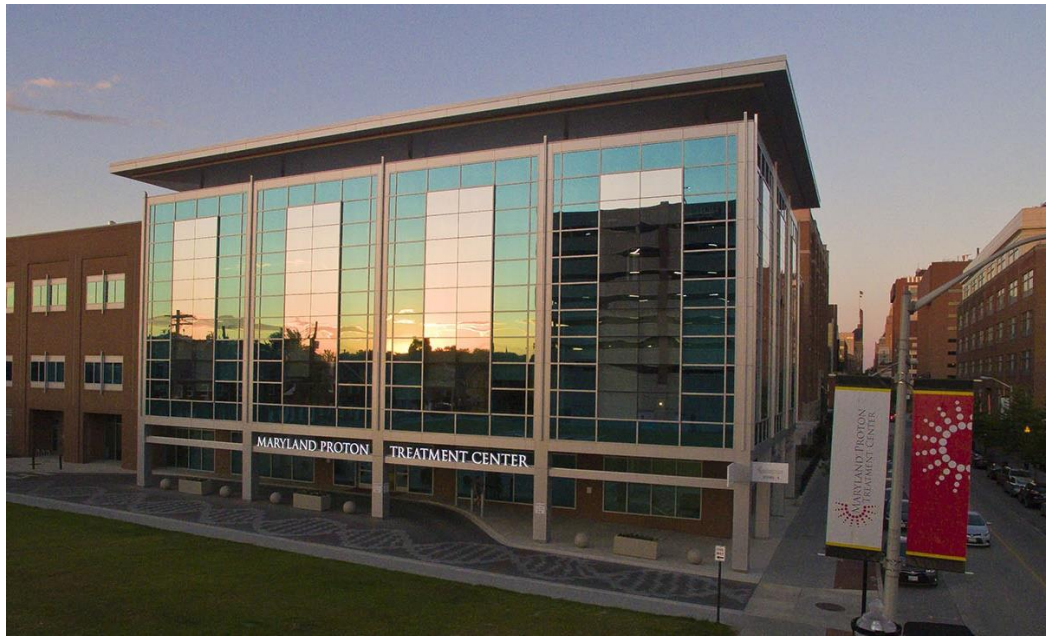
Clinical Treatment Setup:

First 3 Fractions:	*Afterwards:*
VisionRT + CBCT (Daily)	VisionRT (Daily) CBCT (Weekly)

Mid-Of Treatment:

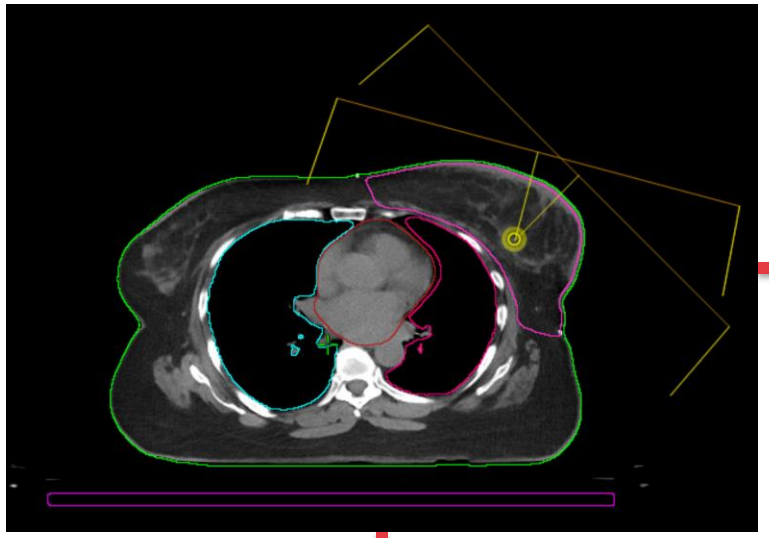
QA CT

(Used for dose calculation)



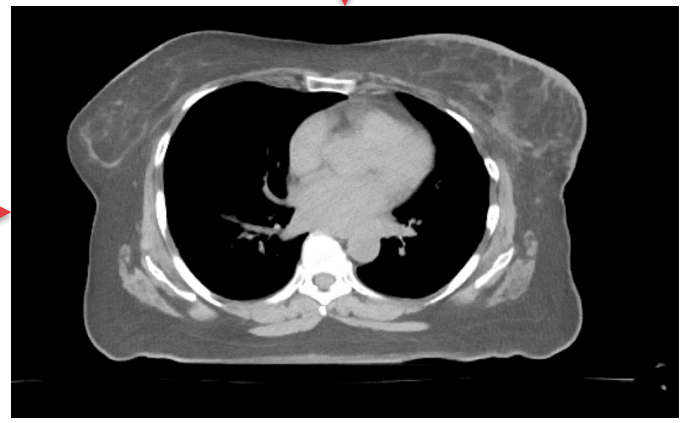
Study Design: Workflow

Planning CT



SGRT-like Registration

CBCT-like Registration

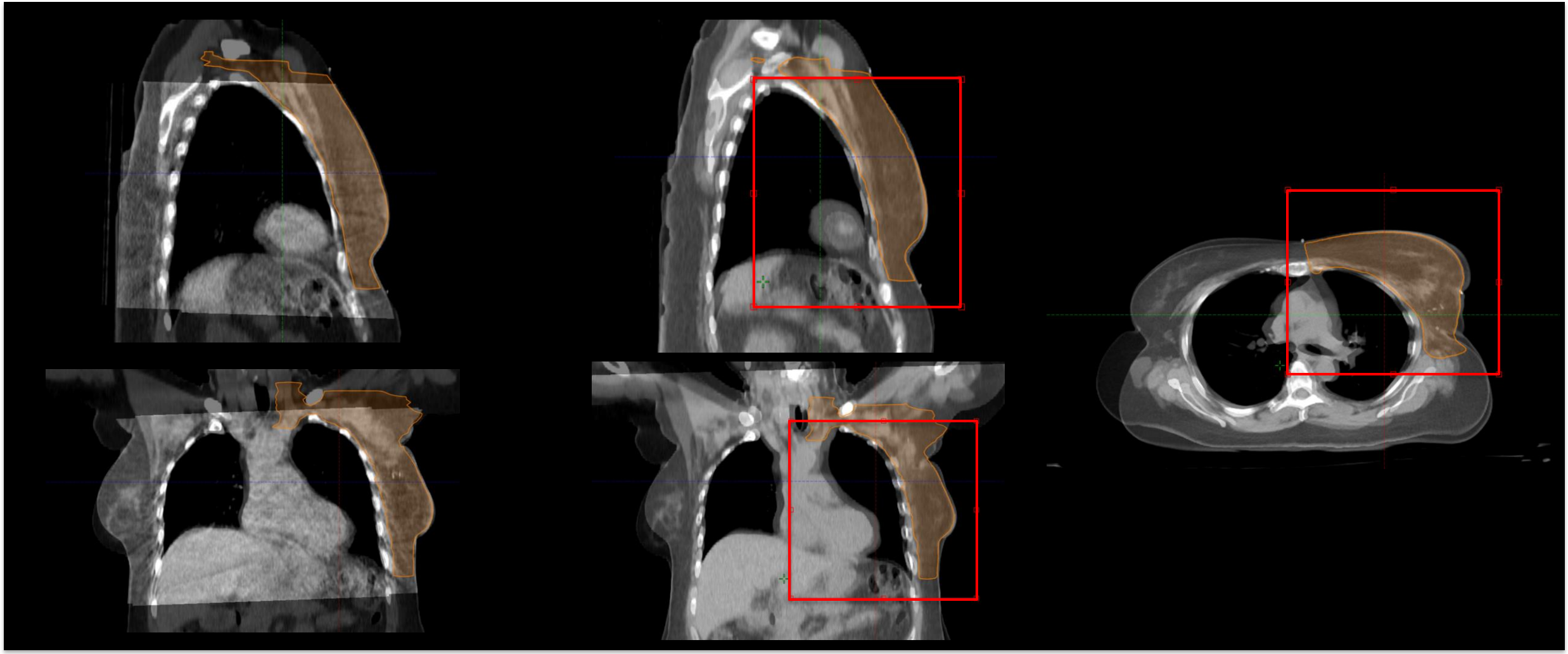


QA CT

Study Design: CBCT-like Registration

pCT – CBCT Registration

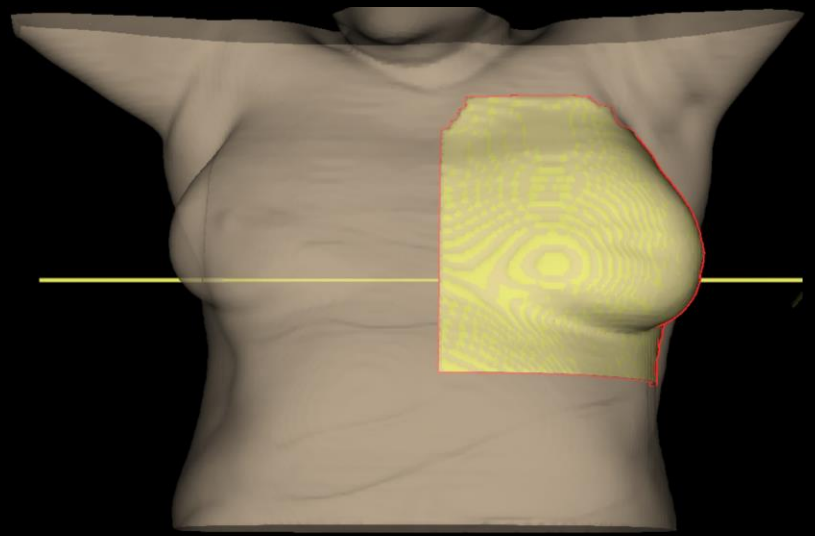
CBCT-like pCT – QA CT Registration

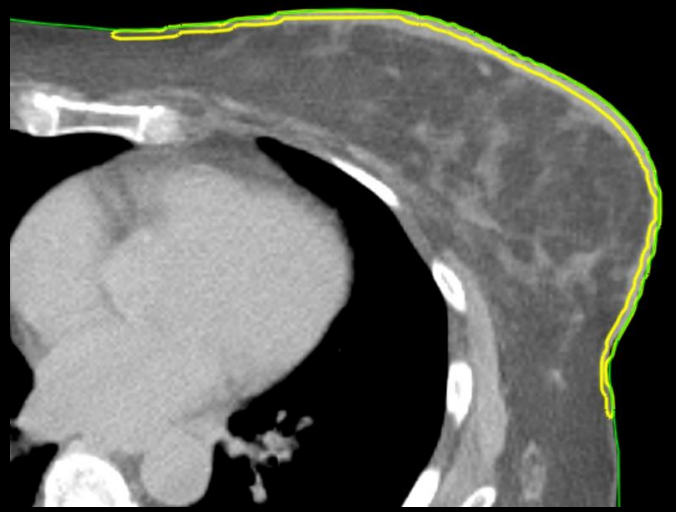


Study Design: *SGRT-like Registration*

Daily VisionRT Report

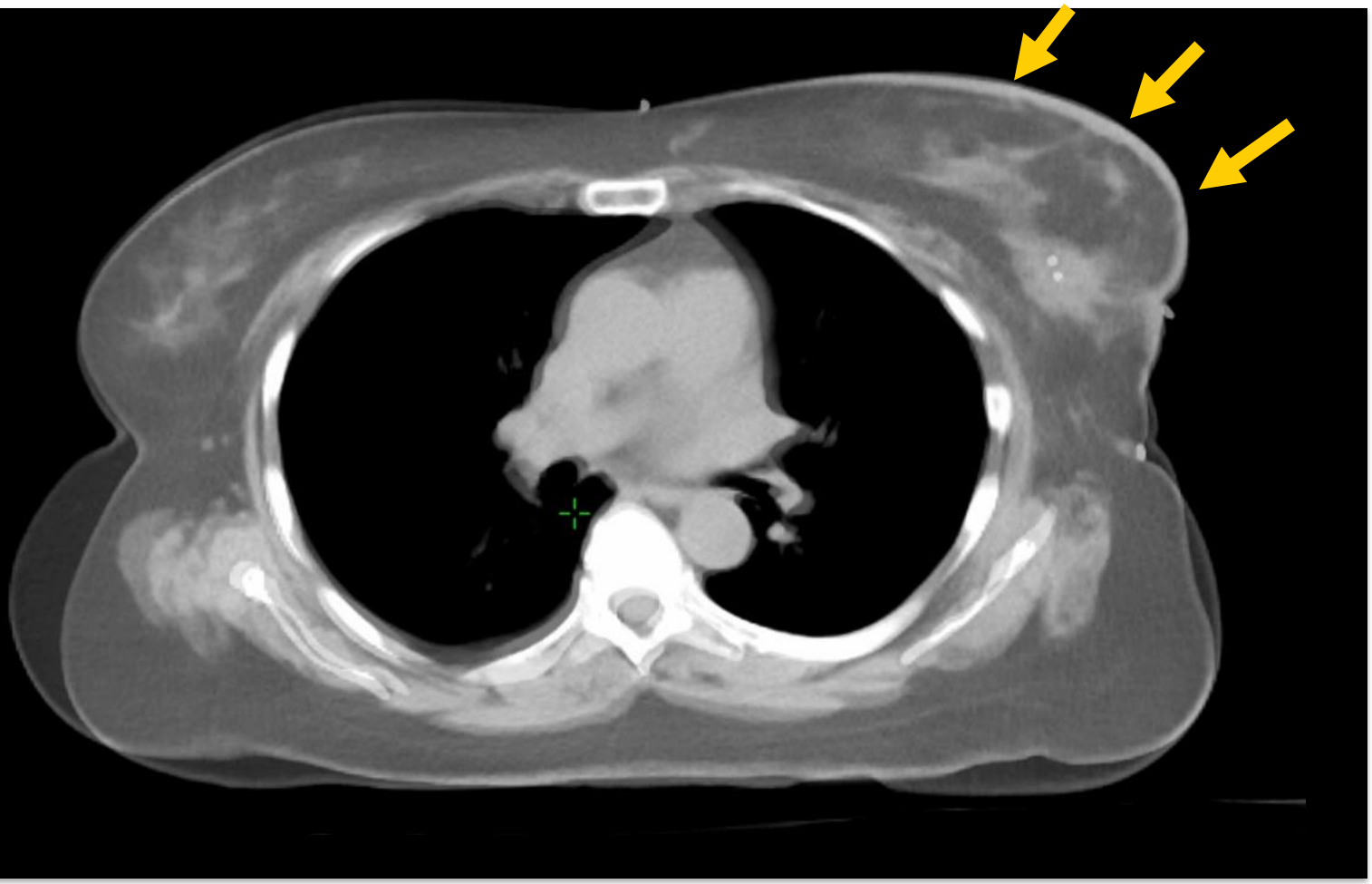
Surface contour on QA-CT





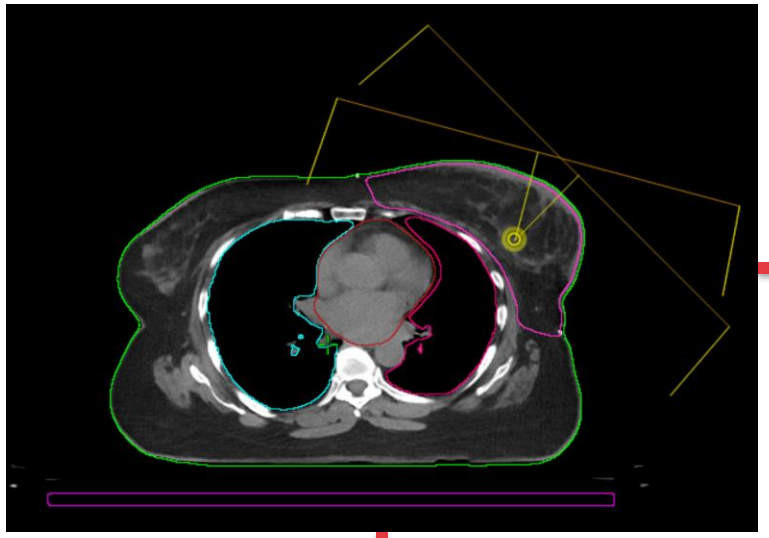
Study Design: *SGRT-like Registration*

Registration performed on surface contour only



Study Design: Dose Assessment

Planning CT



SGRT-like Registration

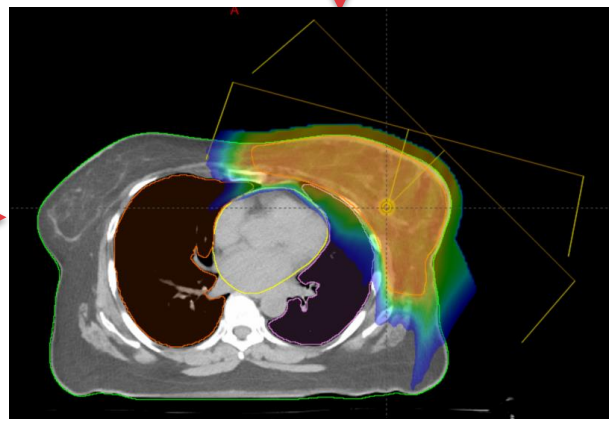
Dose Metrics

CTV: V95%,

Heart: V25Gy,V15Gy, Mean

Ipsilateral Lung: V20Gy, V10Gy, V5Gy

CBCT-like Registration



QA CT

Statistical analysis performed with α < 0.05

Results: *Statistical Analysis*

Volume	Metric	Average (Std. Dev.) Planning	CBCT	SGRT
CTV	V95% [%]	99.2 (0.6)	97.6 (1.7)	97.8 (1.7)
Heart	V25Gy [%]	0.6 (1.2)	0.5 (1.3)	0.6 (1.3)
	V15Gy [%]	1.3 (1.9)	1.1 (2.0)	1.3 (2.1)
	Mean [cGy]	67.1 (78.1)	59.6 (80.5)	63.8 (85.6)
Lung	V20Gy [%]	10.5 (5.9)	8.5 (5.7)	8.7 (5.9)
	V10Gy [%]	23.3 (10.9)	18.7 (10.3)	18.9 (10.9)
	V05Gy [%]	34.6 (13.6)	28.9 (13.4)	28.6 (14.4)

Four main findings:

1. Dose metrics were often lower on the QA-CT than on the planning CT, in both the CBCT and SGRT setup.

Results: *Statistical Analysis*

Volume	Metric	Average (Std. Dev.)			ANOVA	Paired t-test p-values	
		Planning	CBCT	SGRT	p-value	pCT - CBCT	pCT - SGRT
CTV	V95% [%]	99.2 (0.6)	97.6 (1.7)	97.8 (1.7)	< 0.001	< 0.001	< 0.001
Heart	V25Gy [%]	0.6 (1.2)	0.5 (1.3)	0.6 (1.3)	0.246	-	-
	V15Gy [%]	1.3 (1.9)	1.1 (2.0)	1.3 (2.1)	0.332	-	-
	Mean [cGy]	67.1 (78.1)	59.6 (80.5)	63.8 (85.6)	0.194	-	-
Lung	V20Gy [%]	10.5 (5.9)	8.5 (5.7)	8.7 (5.9)	0.010	0.005	0.022
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1. Dose metrics were often lower on the QA-CT than on the planning CT, in both the CBCT and SGRT setup.
2. The differences were only significant for the CTV and lung dose metrics.

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CTV	V95% [%]	99.2 (0.6)	97.6 (1.7)	97.8 (1.7)	< 0.001	< 0.001	< 0.001	0.150
Heart	V25Gy [%]	0.6 (1.2)	0.5 (1.3)	0.6 (1.3)	0.246	-	-	-
	V15Gy [%]	1.3 (1.9)	1.1 (2.0)	1.3 (2.1)	0.332	-	-	-
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Lung	V20Gy [%]	10.5 (5.9)	8.5 (5.7)	8.7 (5.9)	0.010	0.005	0.022	0.162
	V10Gy [%]	23.3 (10.9)	18.7 (10.3)	18.9 (10.9)	0.001	< 0.001	0.001	0.676
	V05Gy [%]	34.6 (13.6)	28.9 (13.4)	28.6 (14.4)	< 0.001	< 0.001	< 0.001	0.464

Four main findings:

1. Dose metrics were often lower on the QA-CT than on the planning CT, in both the CBCT and SGRT setup.
2. The differences were only significant for the CTV and lung dose metrics.
3. There was no significant difference between the lung and CTV dose metrics in the CBCT and SGRT setup.

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Four main findings:

1. Dose metrics were often lower on the QA-CT than on the planning CT, in both the CBCT and SGRT setup.
2. The differences were only significant for the CTV and lung dose metrics.
3. There was no significant difference between the lung and CTV dose metrics in the CBCT and SGRT setup.
4. Not shown: no detectable correlation between BMI or target state (intact or post-mastectomy) and accuracy.

Results: *Statistical Analysis*

Volume	Metric	Average (Std. Dev.)			ANOVA	Paired t-test p-values		
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1. Dose metrics were often lower on the QA-CT than on the planning CT, in both the CBCT and SGRT setup.
2. The differences were only significant for the CTV and lung dose metrics.
3. There was no significant difference between the lung and CTV dose metrics in the CBCT and SGRT setup.
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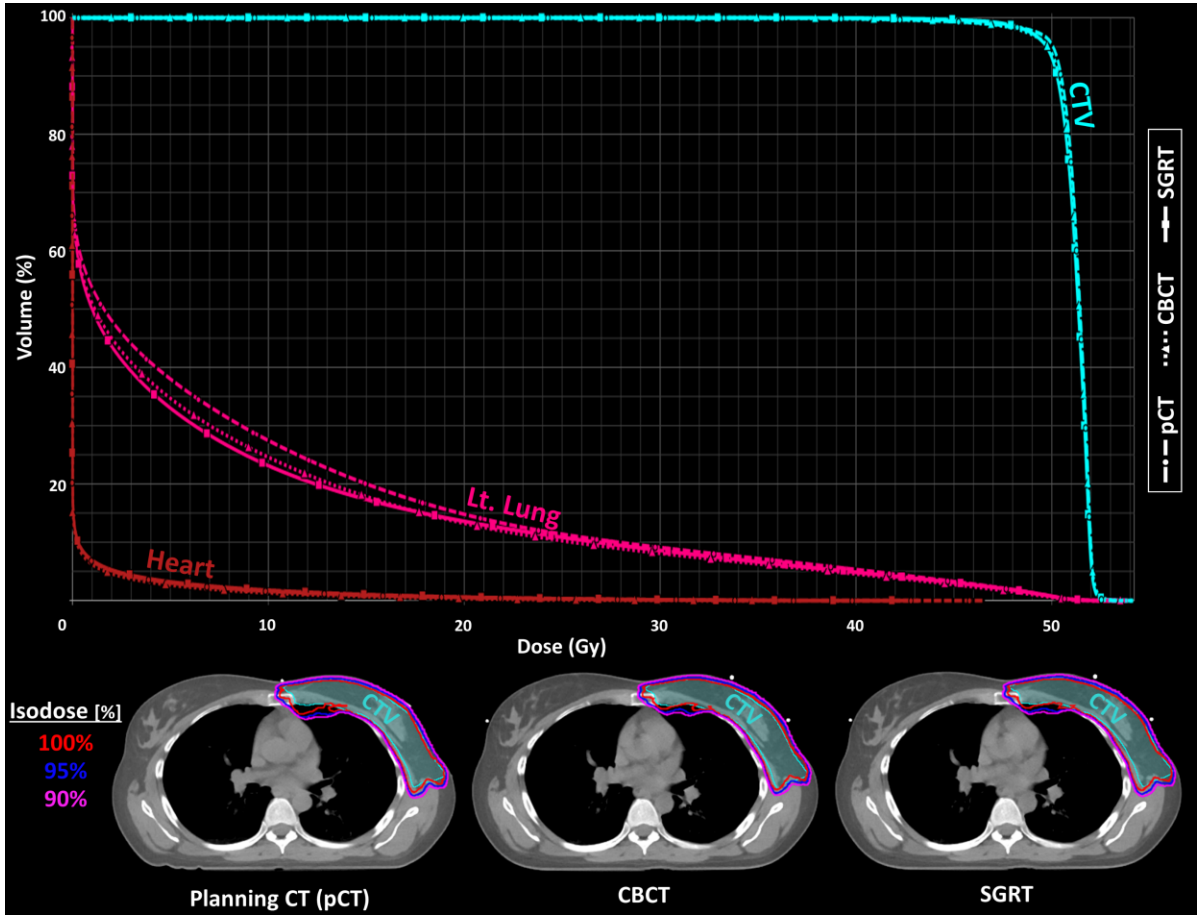
Take away: SGRT provides comparable dosimetric accuracy to that of image guidance with CBCT.

Discussion: *Limitations of study*

Heart dose analysis:

Heart was often far from treatment volume
→ little difference in dose metrics.

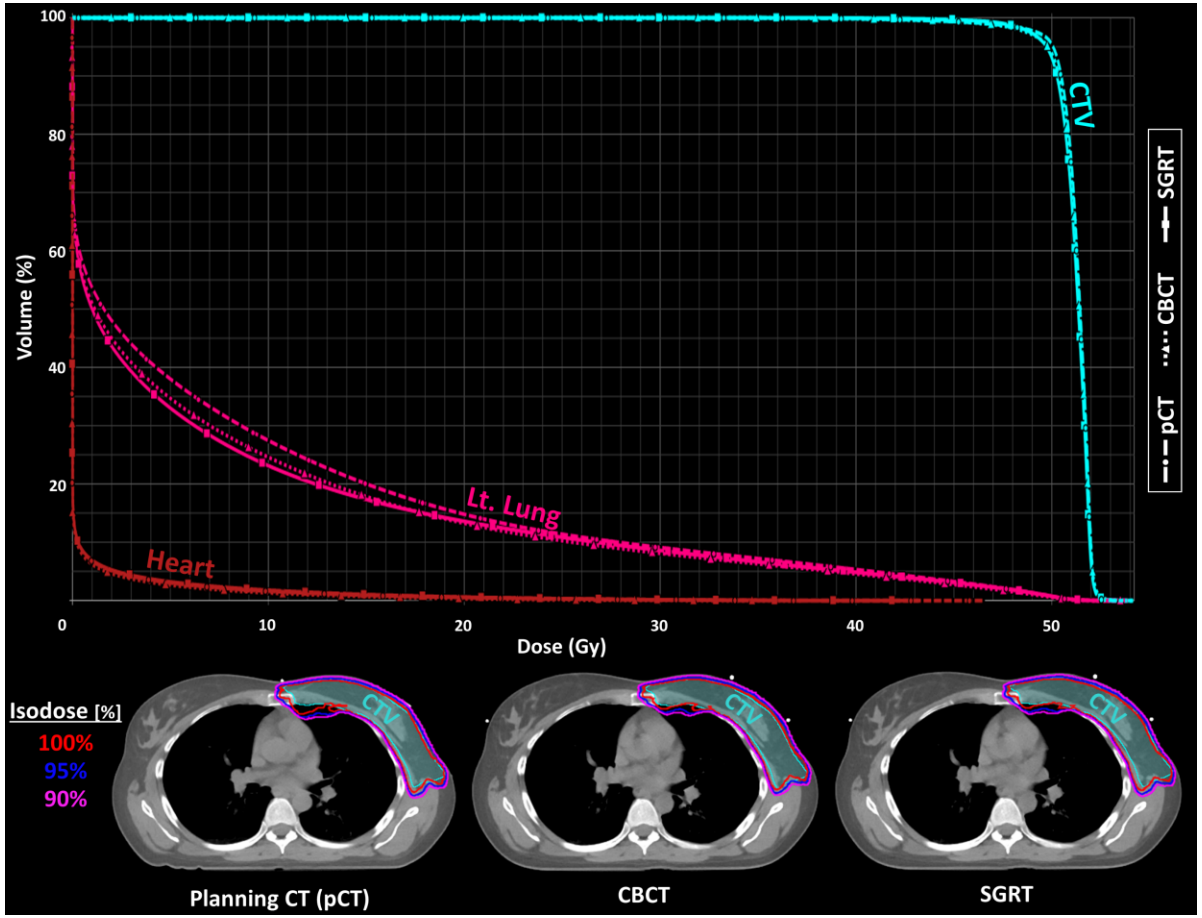
Artery and ventricle substructures (e.g. LAD) were not contoured / analyzed but may have larger differences.



Conclusion

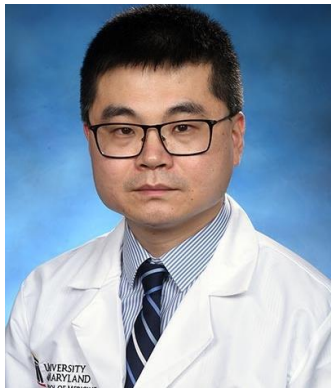
Final Conclusion:

Delivery accuracy of SGRT is comparable to CBCT-based IGRT for proton breast treatment plans.



Acknowledgements

Research Colleagues:



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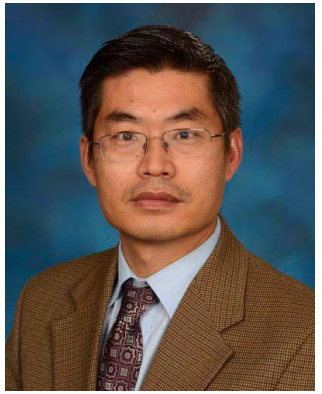

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Institutional Support:

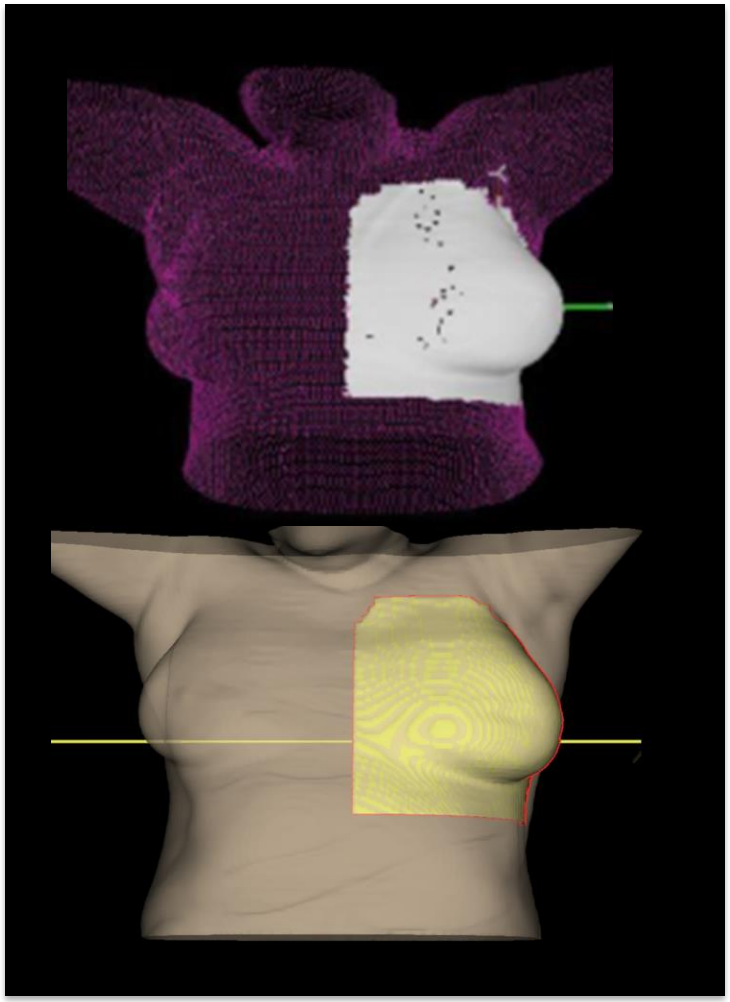
UNIVERSITY of MARYLAND MEDICAL CENTER

MARYLAND PROTON TREATMENT CENTER

Conference organizers:

SGRT COMMUNITY

Thank you!



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Conclusion: delivery accuracy of SGRT is comparable to CBCT-based IGRT for proton breast treatment plans.

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