

# Treatment Planning & IGRT Credentialing for NRG SBRT Trials

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## Learning Objectives

- Explain rationale behind credentialing requirements for NRG SBRT trials
- Describe credentialing for NRG SBRT trials
  - Phantom Irradiation
  - Benchmark planning
  - IGRT
- Provide hints to expedite process at your institution




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**NRG-BR001:**  
**A Phase I Study of SBRT for the Treatment of Multiple Metastases**

**PI: Steven Chmura, M.D., Ph.D.**  
**Medical Physics Co-Chairs:**  
**Hania Al-Hallaq, Ph.D.**  
**Martha Matuszak, Ph.D.**

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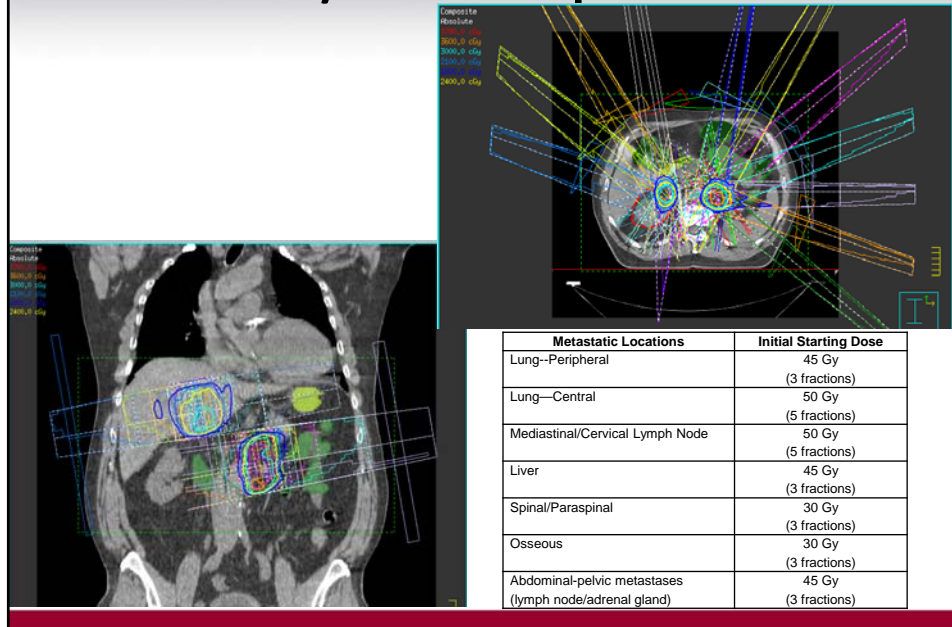


**NRG-BR002:**  
**A Phase II/III Trial of SBRT and/or Surgical Ablation for Newly Oligometastatic Breast Cancer**

**PI: Steven Chmura, M.D., Ph.D.**  
**Medical Physics Co-Chairs:**  
**Hania Al-Hallaq, Ph.D.**  
**Martha Matuszak, Ph.D.**

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## NRG BR001/002: Multiple Metastases



### Planning Challenges for Multiple Targets

- Multiple PTVs in proximity and overlapping with organs-at-risk (OARs):
  - Planning priorities
  - Dose conformity
  - 3D vs. IMRT/VMAT
  - Single vs. multiple isocenters
- Positioning & organ reproducibility
  - Motion management including PTV margins
  - Appropriate IGRT modality
  - Single vs. multiple isocenters

## NRG BR001 & BR002: Rationale for Credentialing Requirements

- How to be lenient enough to credential for 7 anatomical sites without the burden of repeating credentialing for each site?
- Credentialing tied to task being tested:
  - Single versus multiple isocenter
  - With or without motion management
  - IGRT for lesions in soft-tissue versus bony anatomy

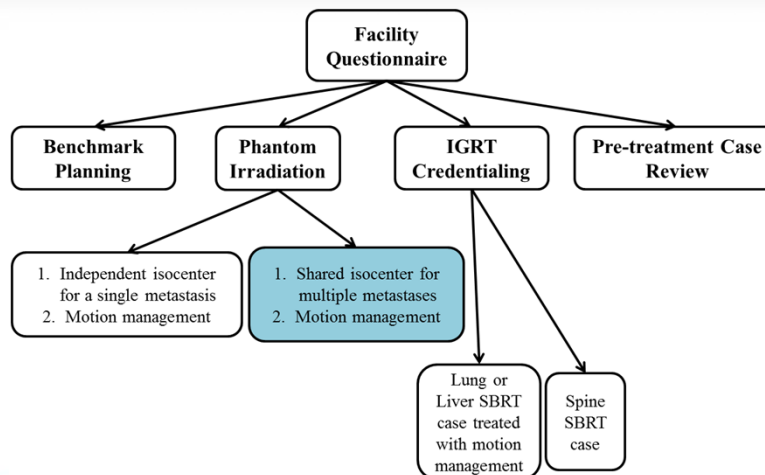
Special Article

Rationale of technical requirements for  
NRG-BR001: The first NCI-sponsored trial of SBRT  
for the treatment of multiple metastases

Al-Hallaq et al, *PRO*, Dec 2016.



## Credentialing Requirements



Al-Hallaq et al, *PRO*, Dec 2016.

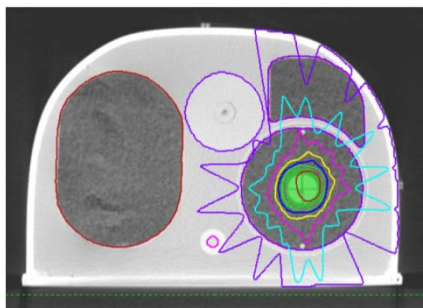


# 1. Phantom Irradiation

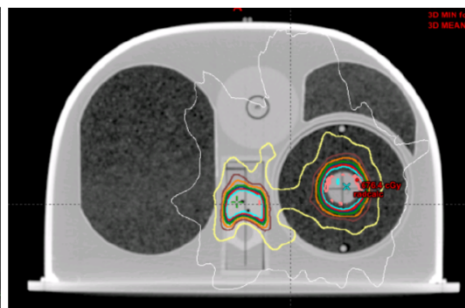


## NRG BR001/002: IROC SBRT Phantoms

Lung



Lung & Spine Irradiation



## Phantom Irradiation

- To minimize credentialing burden:
  - Either liver or lung phantom
  - Irradiate only with most complex modality (3D → IMRT → VMAT)
  - Techniques can be combined (e.g., FFF beam + motion management)
- *Caveat*: To treat multiple lesions with a single isocenter, must irradiate a 2 target phantom

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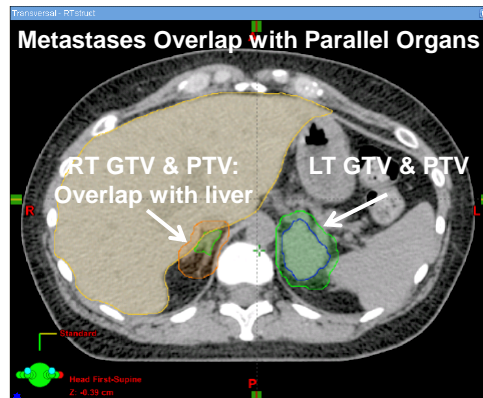
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## 2. Benchmark Planning

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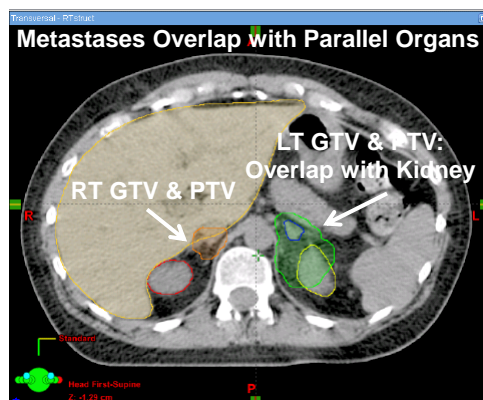
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## BR001 Benchmark Case: Bilateral Adrenal Metastases



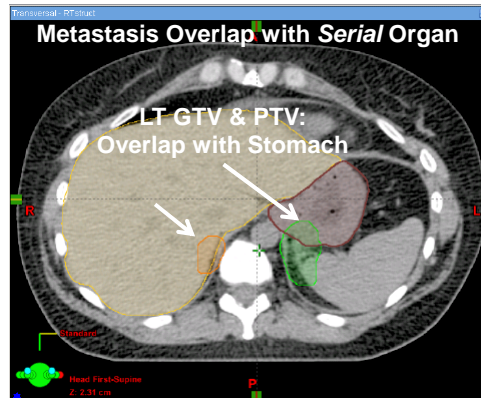
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## BR001 Benchmark Case: Bilateral Adrenal Metastases



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## BR001 Benchmark Case: Bilateral Adrenal Metastases

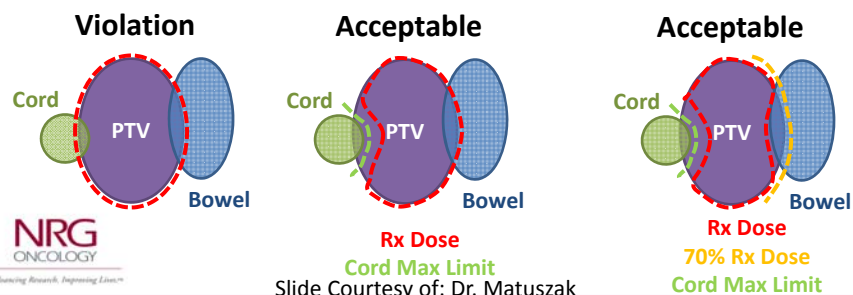


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## Planning Priorities when OARs overlap PTVs

1. Meet critical serial OAR (cord, cauda, sacral/brachial plexus) objectives
  - Avoid dose >105% Rx in any overlapping organs\*\* and outside of the PTV
2. Meet target coverage & conformity objectives
  - Allow target coverage to drop to variation acceptable in overlap regions with sensitive OARs (bowel, esophagus, stomach)
  - 70% Rx min dose required in PTV
3. Meet remaining OAR objectives



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Slide Courtesy of: Dr. Matuszak



## NRG BR001: Dose Conformity for *Single* Target per RTOG 0813

Table 6-4

PTV Volume (cc)	Ratio of 50% Prescription Isodose Volume to PTV Volume, R50%	Maximum Dose at 2cm (D2cm) from PTV in any direction as % of Prescribed Dose
1.8	< 7.5	<57.0
3.8	< 6.5	<57.0
7.4	< 6.0	<58.0
13.2	< 5.8	<59.0
22.0	< 5.5	<63.0
34.0	< 5.3	<68.0
50.0	< 5.0	<77.0
70.0	< 4.8	<86.0
95.0	< 4.4	<89.0
126.0	< 4.0	<91.0
163.0	< 3.7	<94.0

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## Summary of Benchmark Planning

Physics Contribution

**Benchmark Credentialing Results for  
NRG-BR001: The First National Cancer  
Institute-Sponsored Trial of Stereotactic Body  
Radiation Therapy for Multiple Metastases**

Al-Hallaq et al, *IJROBP*, Jan 2017.

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## Benchmark Passing Rates

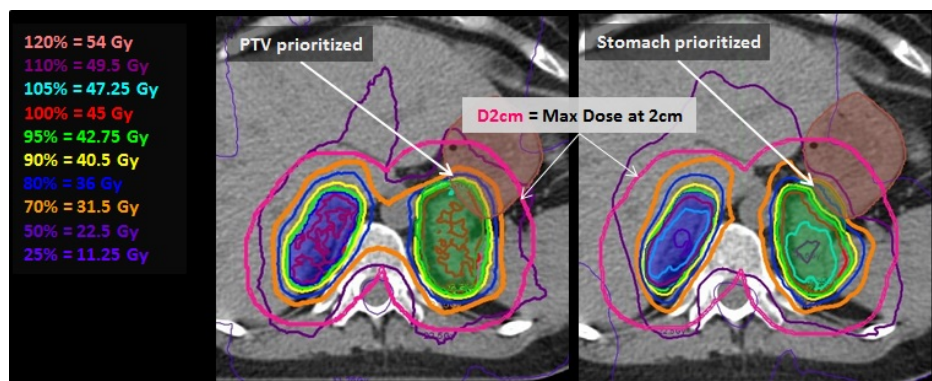
	No.	Percentage
<b>Number of attempts at passing benchmark (n = 63)</b>		
1	32	51% <sup>+</sup>
2	24	38%
3	3	5%
No further attempts	4	6%
<b>Reasons for not passing benchmark at first attempt (n = 31)</b>		
Separate plans did not meet OAR criteria	7	23%
PTV coverage unacceptably high or low	7	23%
Stomach dose constraints exceeded	3	10%
Spinal dose constraints* exceeded	7	23%
Conformity does not meet SBRT guideline	5	16%
Other	2	6%

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<sup>+</sup> Passing rate at first attempt of 37.5% (6/16) in first 4 months.

\* Spinal cord constraint is a hard limit. *Al-Hallaq et al, IJROBP, Jan 2017.*

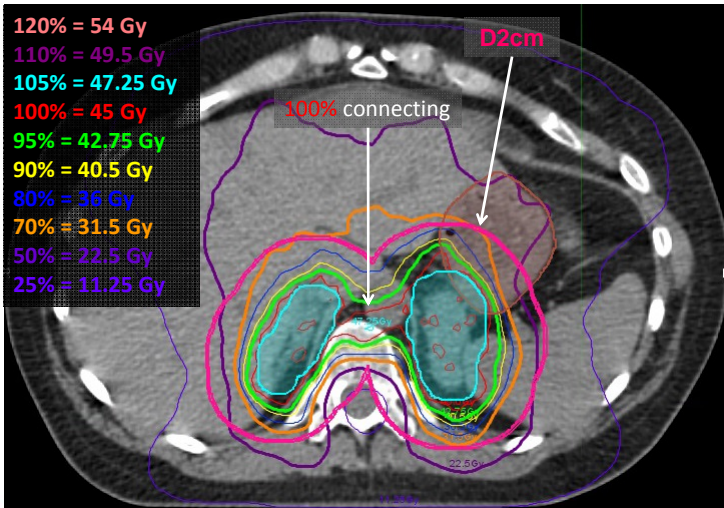
## Can Cover PTV or Spare Stomach



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*Al-Hallaq et al, IJROBP, Jan 2017.*

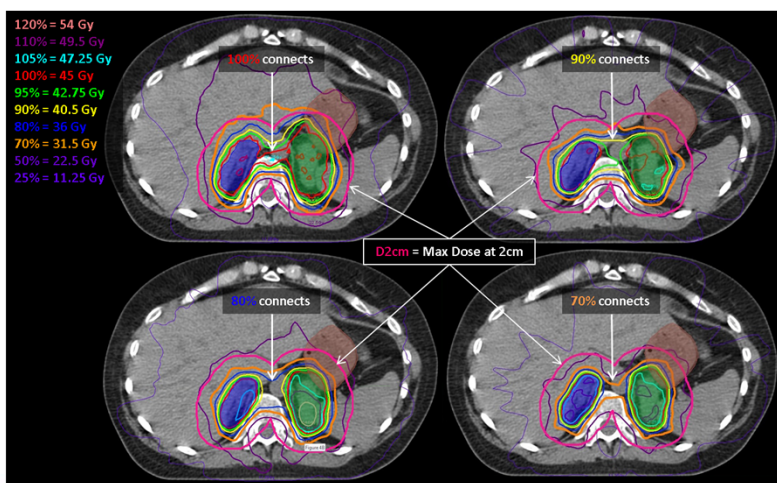
## VMAT Plan Conformity Does Not Meet SBRT Criteria



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Meets DVH but not conformity metrics.

## Variable Conformity Among VMAT Plans



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## Distribution of Planning Techniques

	No.	Percentage
<b>Planning technique (n = 59)</b>		
VMAT	46	78%
IMRT	8	14%
3DCRT	1	2%
CyberKnife	4	7%
<b>Number of plans / isocenters (n = 59)</b>		
1 plan / 1 isocenter	39*	66%
1 plan / 2 isocenters	14	24%
2 plans / 2 isocenters	2	3%
CyberKnife	4	7%
<b>Structures prioritized (n = 59)</b>		
PTV	44	75%
Stomach	14	24%



\* Only 8/46 institutions credentialed to treat multiple targets with a single isocenter.

Al-Hallaq et al, *IJROBP*, Jan 2017.

## Benchmark Planning Summary

- Challenging for institutions to pass!
  - Separate plans for each target
  - Conformity varied widely and was one of the biggest sources of difficulty



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### 3. IGRT Credentialing

#### Consensus on Minimum IGRT requirements for SBRT (*First protocol to provide consensus guidelines*)

Metastatic Location	Minimum IGRT Requirement	
	No Fiducials	With Fiducials**
Lung--Peripheral*	Volumetric (3D)	Orthogonal kV (2D)
Lung—Central*	Volumetric (3D)	Orthogonal kV (2D)
Mediastinal/Cervical LN	Volumetric (3D)	N/A
Liver*	Volumetric (3D)	Orthogonal kV (2D)
Spinal	Orthogonal kV (2D)	Orthogonal kV (2D)
Osseous*	Orthogonal kV (2D)	N/A
Abdominal-pelvic*	Volumetric (3D)	Orthogonal kV (2D)

\***NOTE:** When osseous/rib metastases are classified into another metastatic location, follow the IGRT guidelines for that site.

\*\***NOTE:** When a metastasis contains an implanted fiducial that is clearly visible on kV orthogonal or volumetric imaging, either method can be used

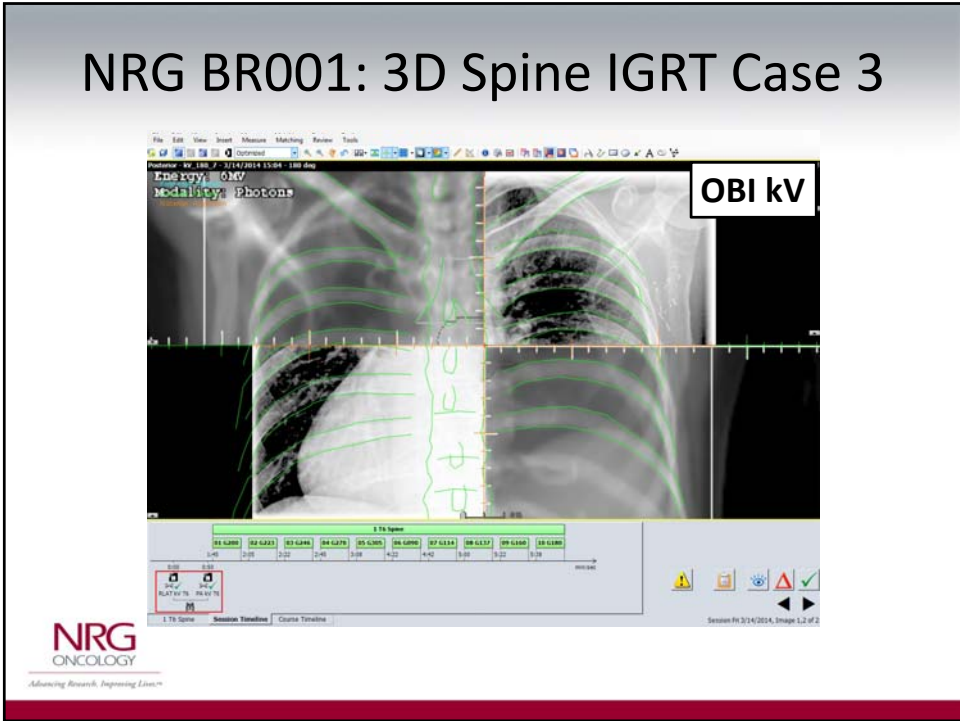
\***NOTE:** Registration using a soft tissue surrogate for the tumor is recommended for lung, liver, and abdominal-pelvic metastases for both 3D and 2D IGRT datasets.

## NRG BR001: IGRT Credentialing

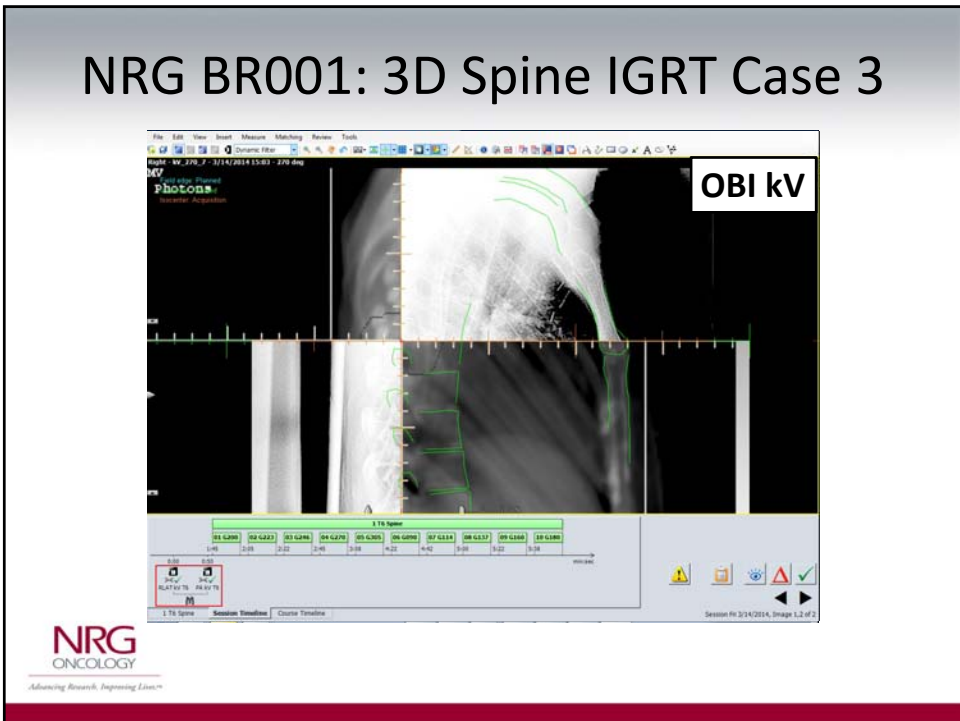
- Purpose:
  - To assess whether positioning with image-guidance will ensure accurate PTV coverage
- How is this accomplished?
  - Assess description of IGRT workflow including threshold for correction of translations & rotations
  - Assess image quality (technique, FOV)
  - Assess final treatment position relative to PTV margin required for protocol

## IGRT Credentialing Examples

# NRG BR001: 3D Spine IGRT Case 3



# NRG BR001: 3D Spine IGRT Case 3



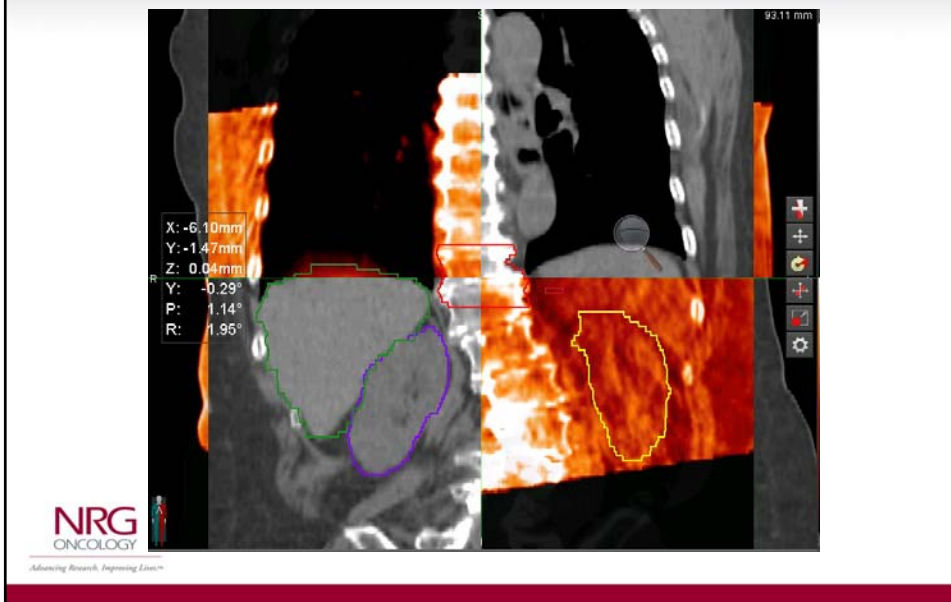




## NRG BR001: 3D Spine IGRT Case 9



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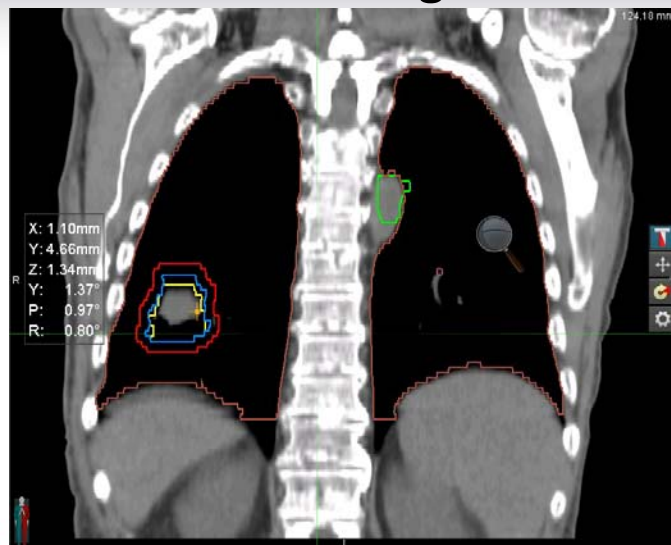
Axis	X (mm)	Y (mm)	Z (mm)
Institution's Shifts	-8.0	1.0	2.0
Reviewer's Shifts	-5.6	1.5	1.0
Difference	-2.4	0.5	1.0

Rotational Differences < 2 degrees

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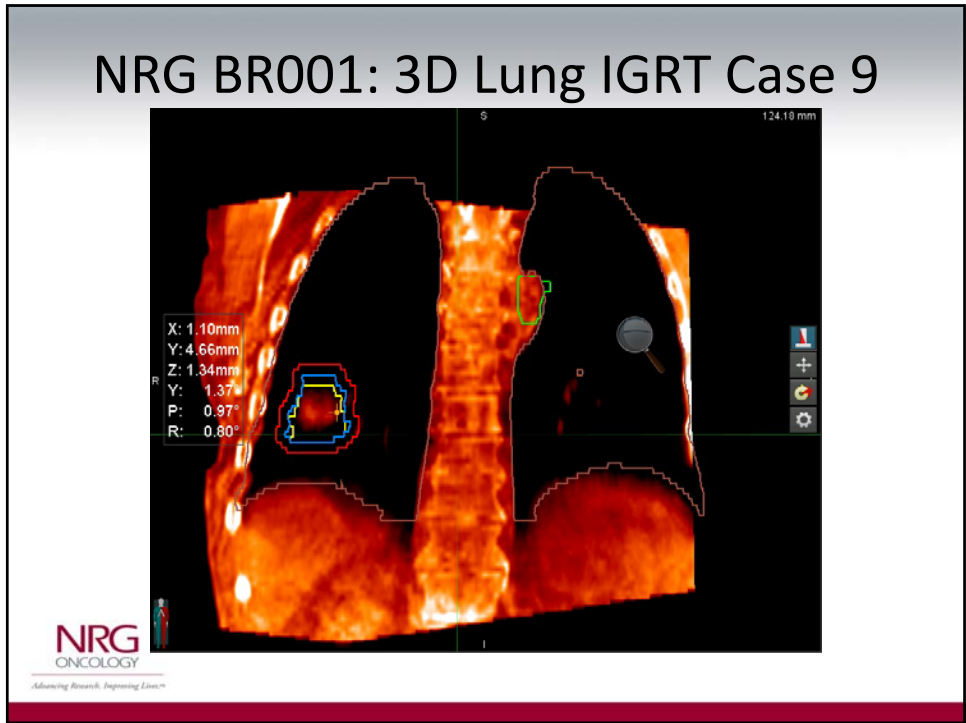
## NRG BR001: 3D Lung IGRT Case 9



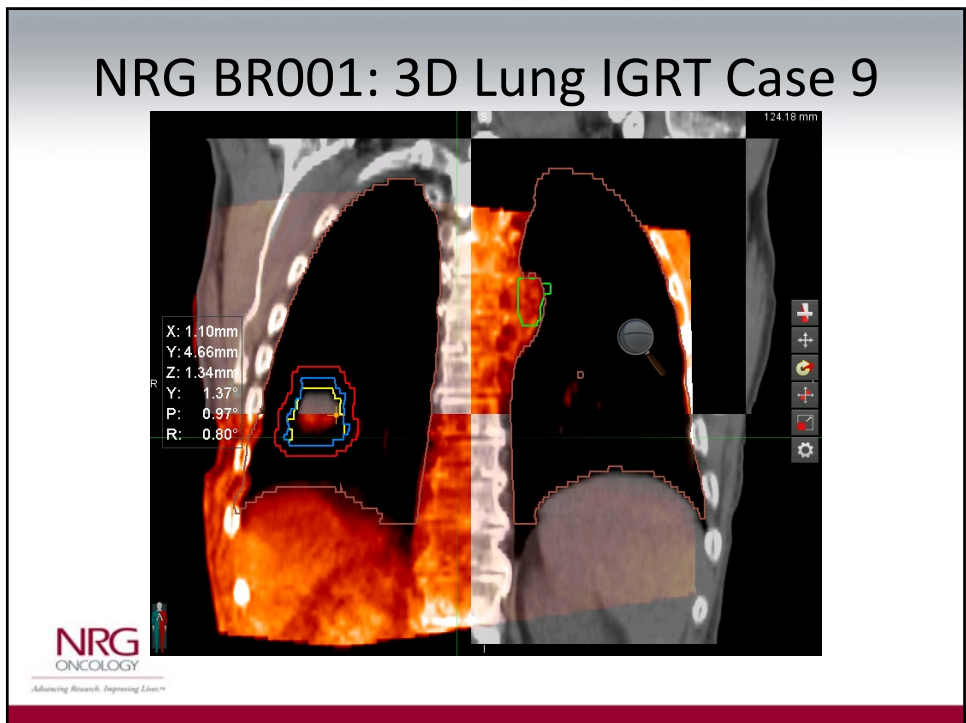
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## NRG BR001: 3D Lung IGRT Case 9



## NRG BR001: 3D Lung IGRT Case 9



## NRG BR001: 3D Lung IGRT Case 9

Axis	X (mm)	Y (mm)	Z (mm)
Institution's Shifts	2.3	-4.6	6.5
Reviewer's Shifts	1.6	0.1	-5.2
Difference	0.7	-4.7	-1.3

Rotational Differences < 2 degrees

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## Summary

- Treatment of multiple targets is challenging
  - Single vs multiple isocenters
  - Dose conformity
  - OAR avoidance
  - Motion management
  - Reproducibility of patient positioning
  - Accuracy of IGRT
- Credentialing is likewise challenging

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## How to expedite credentialing?

- FAQ (<http://irochouston.mdanderson.org> under “Credentialing”)
- Download DVH forms and use them during planning
- Send best examples of IGRT including all DICOM files
- Email physics PIs or NRG with any questions