



# Using Atlas Information to Improve Cancer Treatment

## Edinburgh Cancer Centre

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*15 May 2012*

# Overview

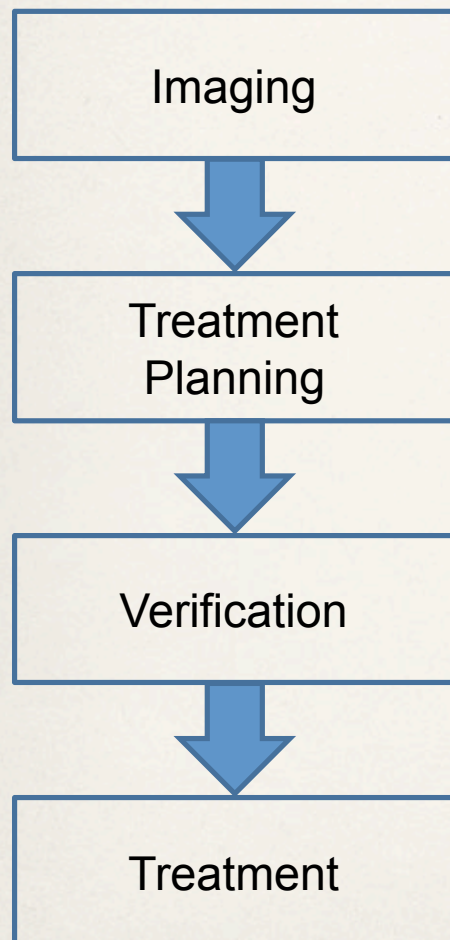
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- ❖ **Introduction to Radiotherapy**
  - ❖ The radiotherapy journey
  - ❖ Radiotherapy delivery
- ❖ **Identifying Organs and Planning**
  - ❖ CT scanning
  - ❖ Treatment planning
- ❖ **Using Atlas Information to Improve Treatment**
  - ❖ For automatic segmentation and contouring
  - ❖ Real-time, adaptive, radiotherapy planning
  - ❖ Outcome-driven radiotherapy



# The Radiotherapy Journey

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# CT Imaging

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Imaging

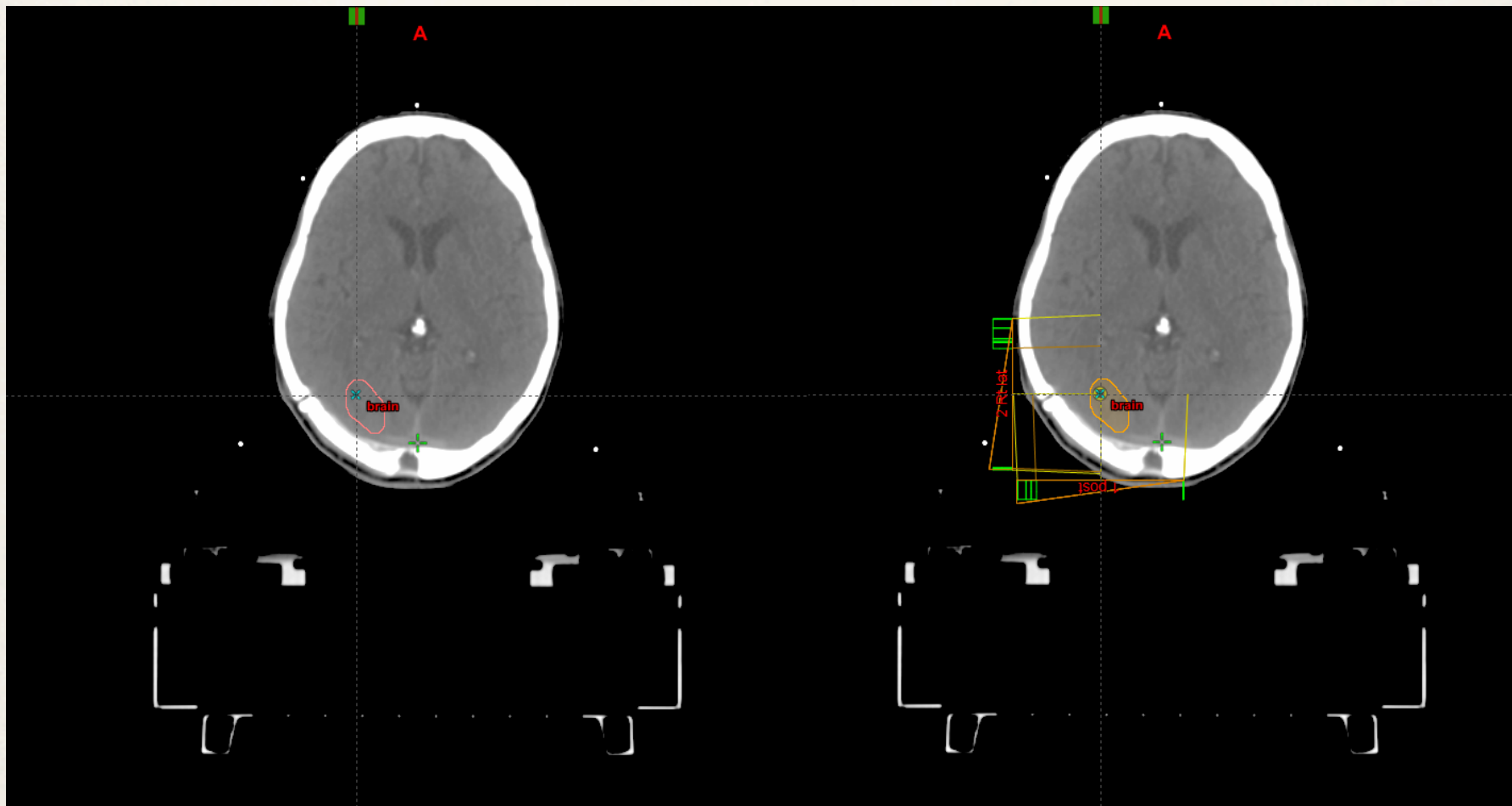
→ Planning

→ Verification

→ Treatment



# Treatment Planning



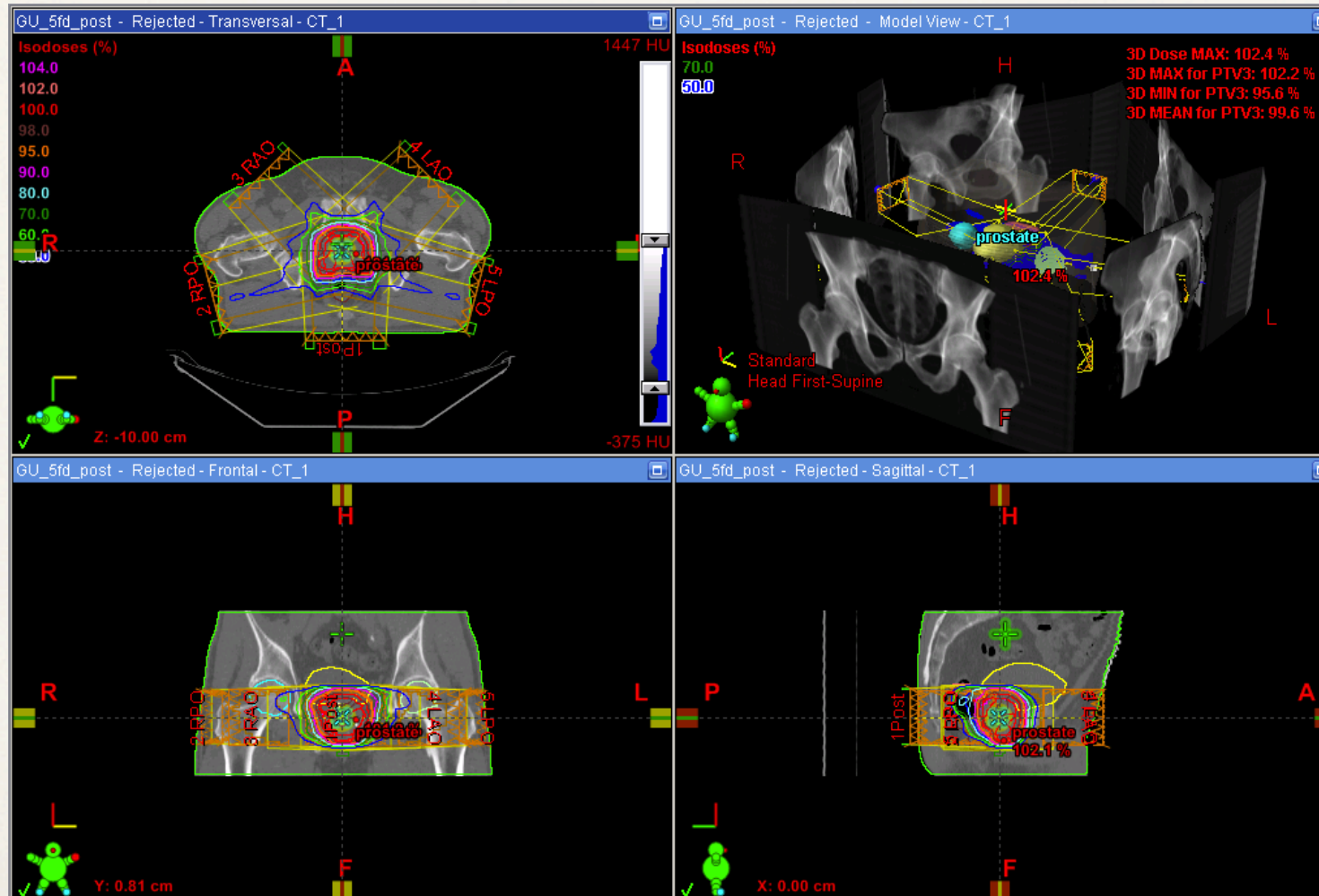
Imaging

Planning

Verification

Treatment

# Treatment Planning



Imaging

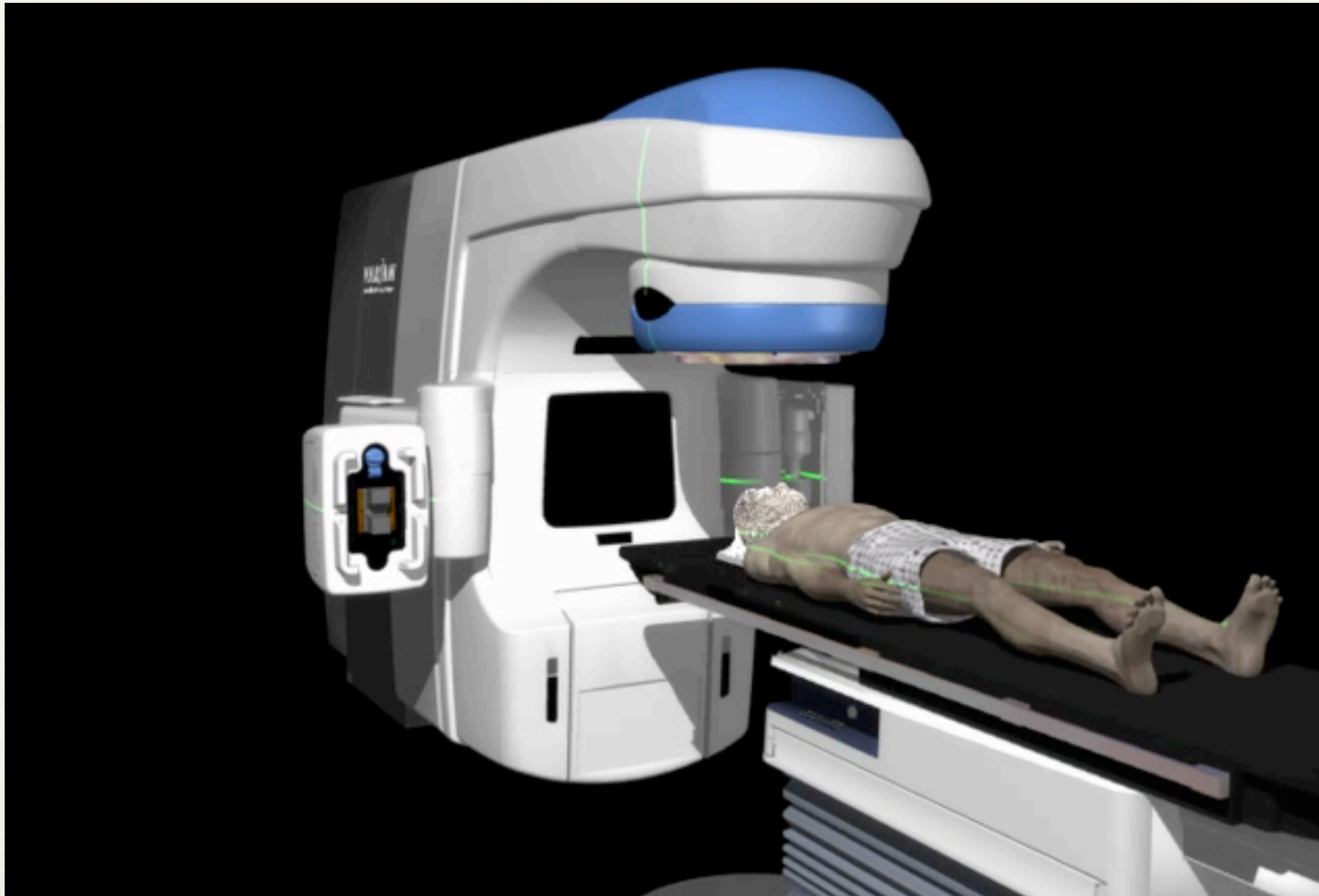
Planning

Verification

Treatment

# Image Verification

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Imaging

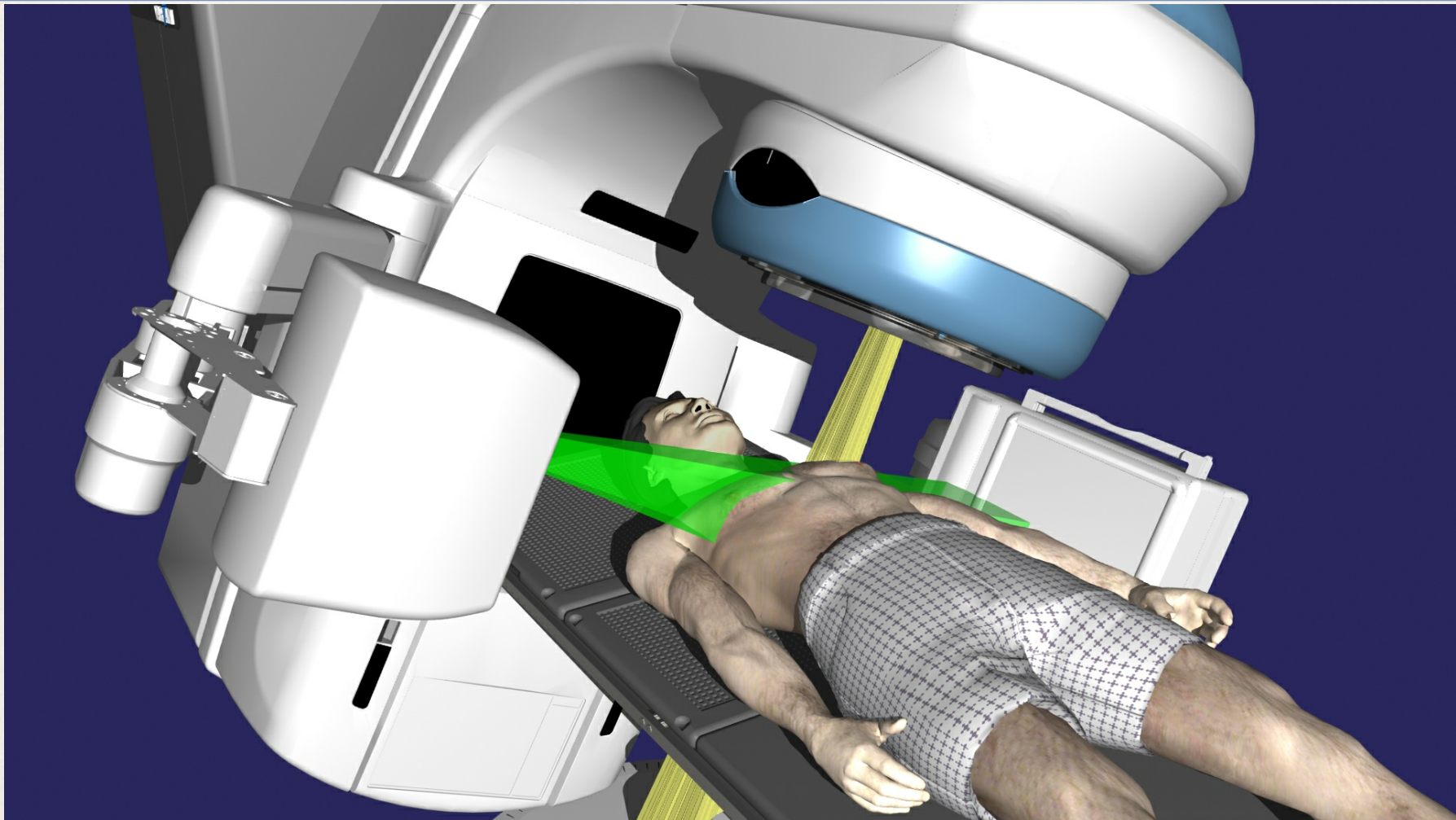
Planning

Verification

Treatment



# Image Verification and Treatment



Imaging

Planning

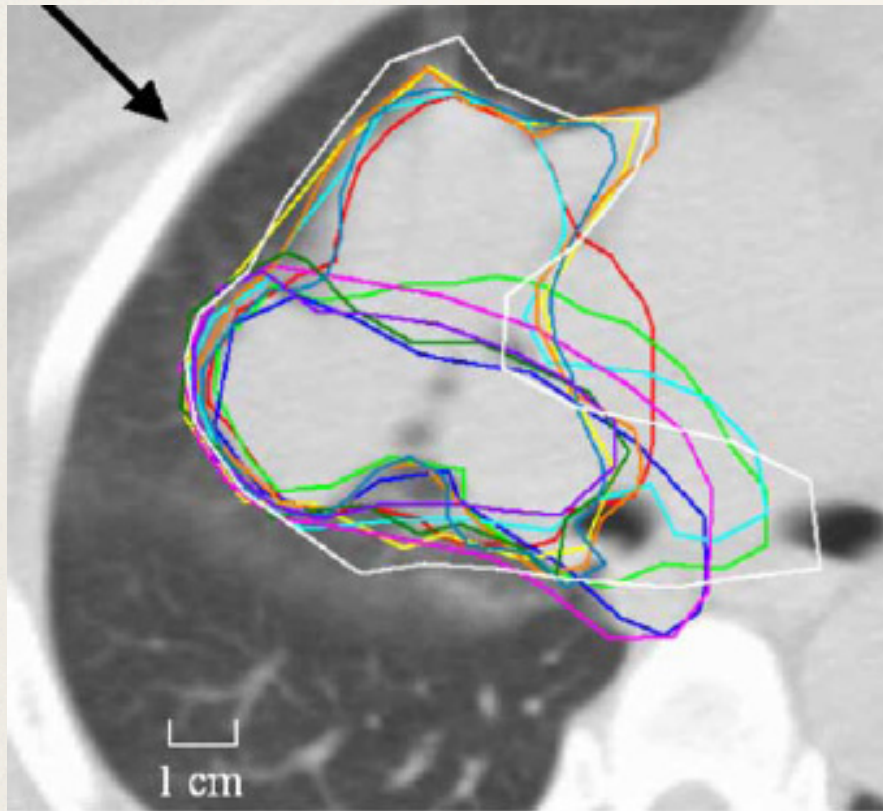
Verification

Treatment



# Using an Atlas for Segmentation

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- 11 radiation oncologists from 5 difference centres
- GTV on CT for 22 patients
- Large observer variation
- Considerable variation in style

Steenbakkens et al., Observer variation in target volume delineation of lung cancer related to radiation oncologist-computer interaction: A Big Brother Evaluation. *Radiother Oncol* 2005;77:182-190.

# Using an Atlas for Segmentation

Table 1

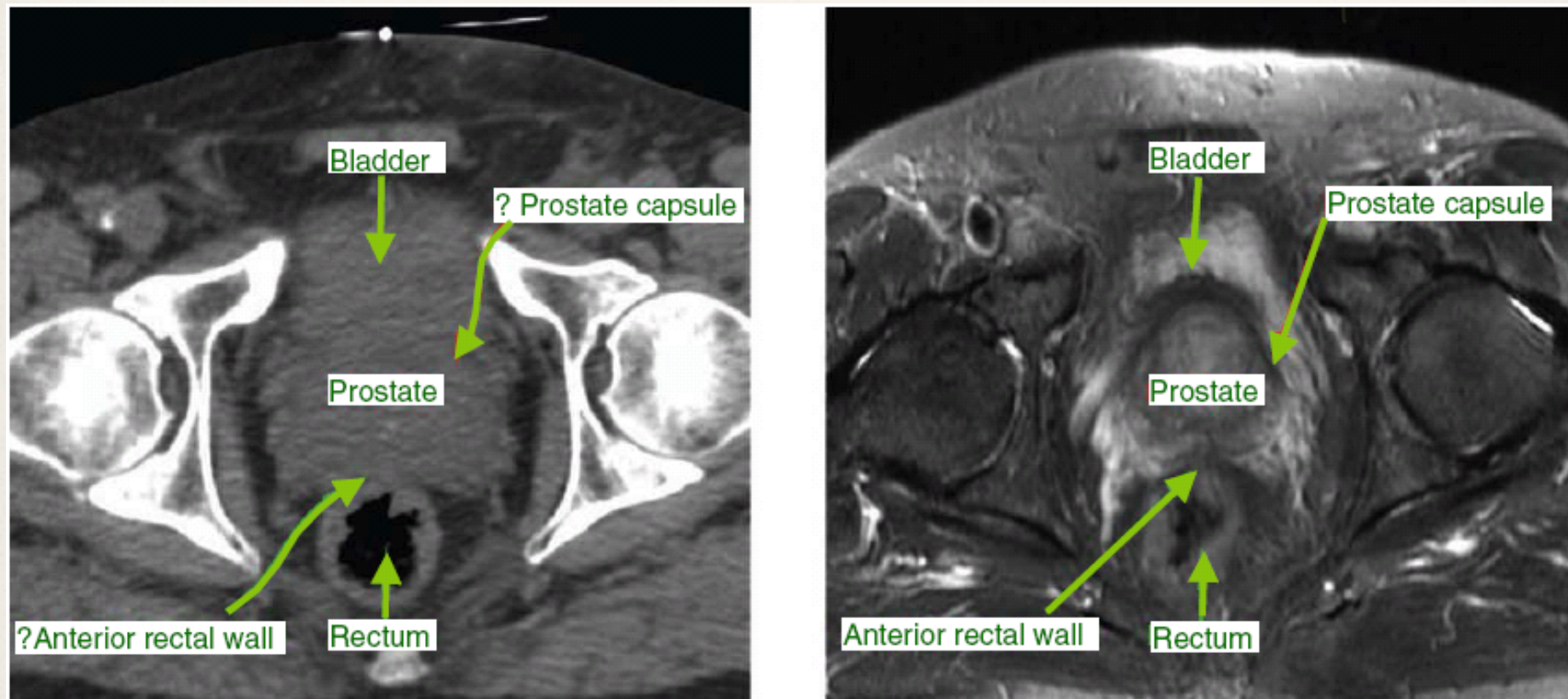
For all radiation oncologists, the mean GTV volume, the mean distance (measured from the median surface to each individual GTV), overall observer variation (overall SD), mean delineation time, mean number of slice changes, mean number of delineated points and mean number of corrections

Radiation oncologist	Mean volume (cm <sup>3</sup> )	Mean distance (cm)	Overall SD (cm)	Mean time (min)	Mean no. slice changes	Mean no. delineated points	Mean no. corrections
1	36	-0.64	1.51	14	288	183	29
2	48	-0.37	1.16	20	267	224	51
3	53	-0.43	1.39	8	121	143	16
4	55	-0.24	0.70	8	45	231	0
5	58	-0.33	1.27	25	163	182	56
6	67	-0.16	1.00	27	143	225	53
7	69	-0.12	0.62	15	121	239	49
8	72	-0.10	0.66	14	277	306	62
9	76	-0.02	0.74	9	277	314	18
10	93	0.09	0.57	18	126	187	41
11	129	0.40	0.61	14	207	238	53
All	69 (25)	-0.17	1.02	16	185	225	39

Radiation oncologists are ranked according to increasing mean delineated volume. SD, standard deviation. The number in the parenthesis is the standard deviation of the mean volumes of the observers.



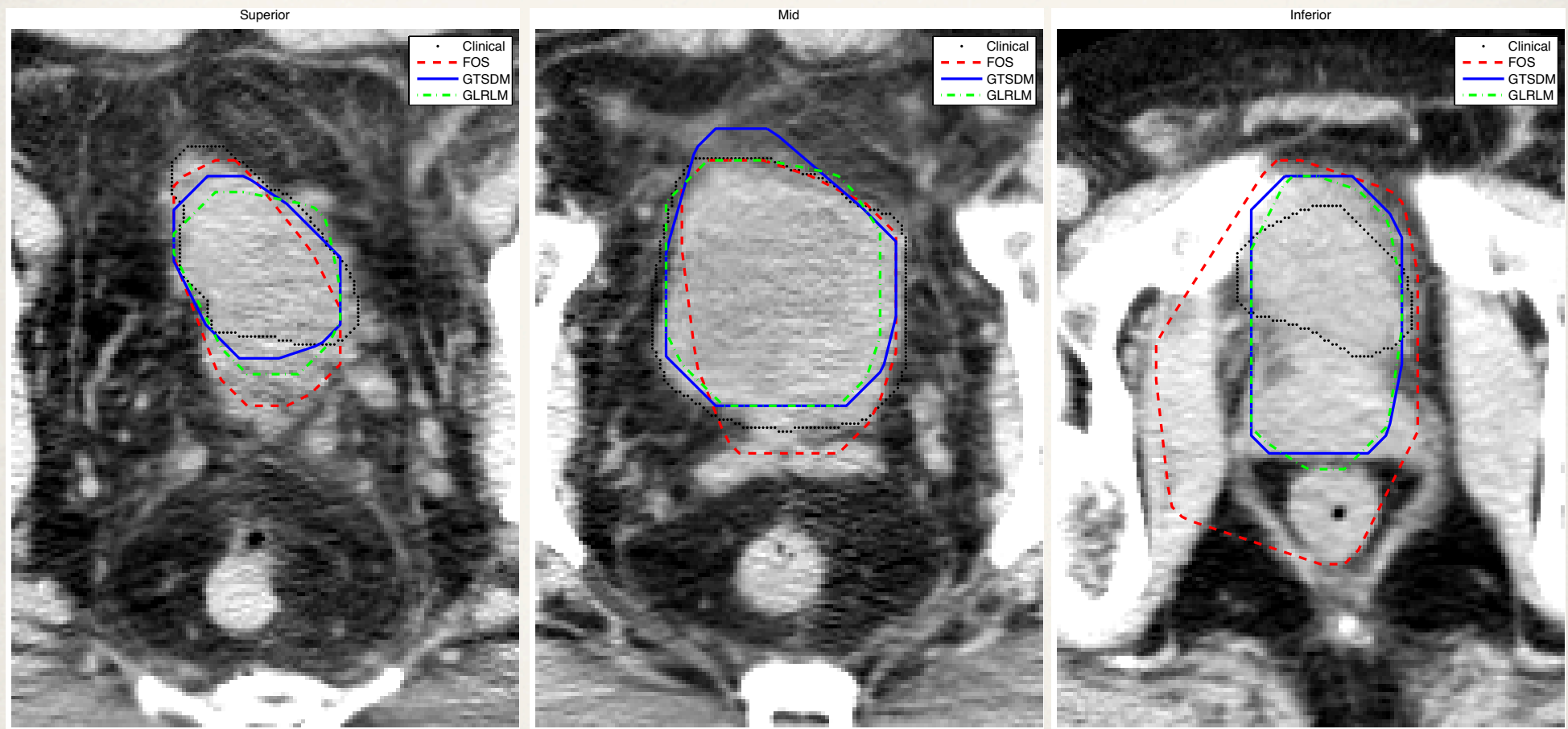
# Using an Atlas for Segmentation



Left, CT slice through a prostate and (right) the corresponding MR scan. Khoo and Joon 2006.

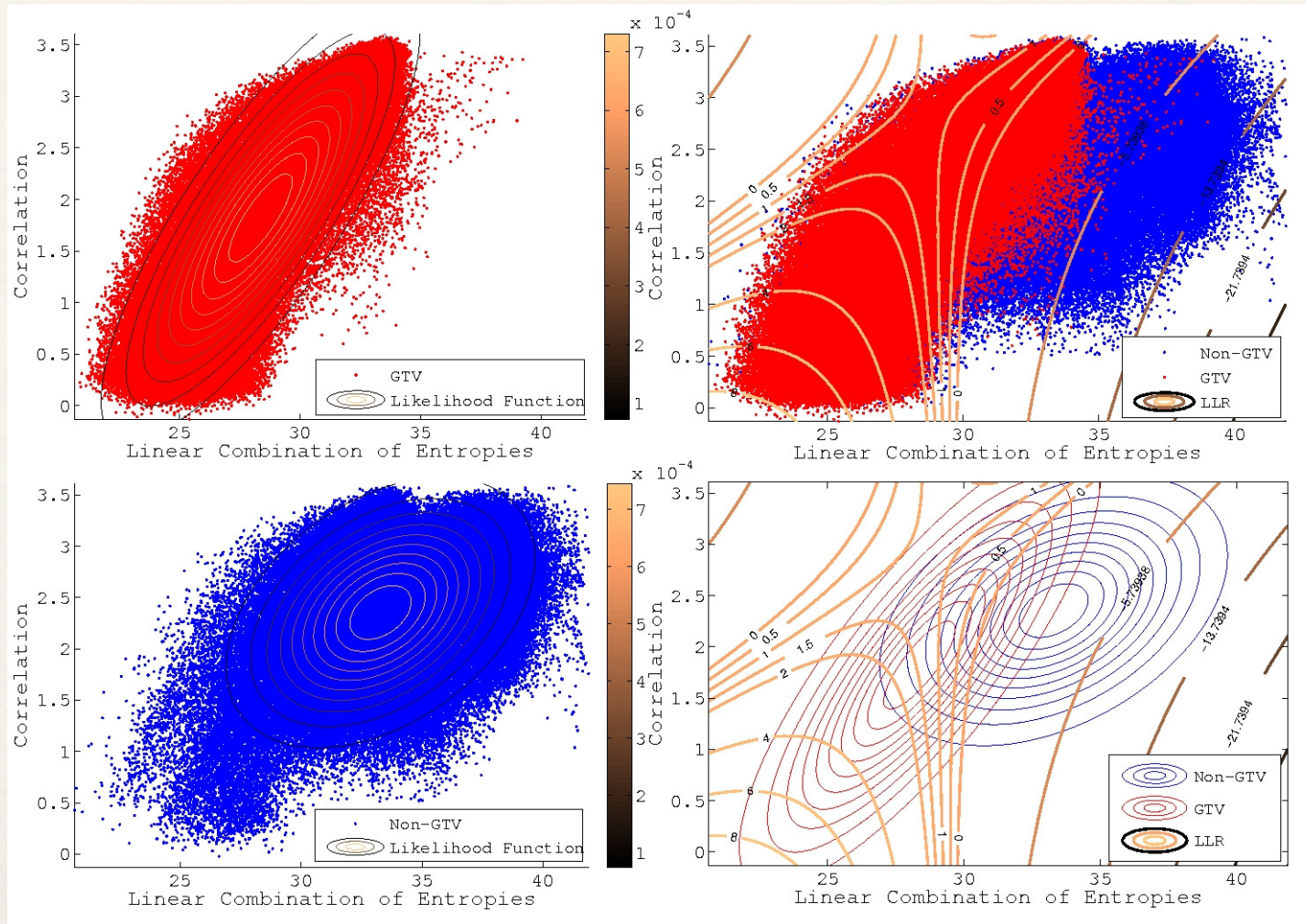
# Image Analysis for Segmentation

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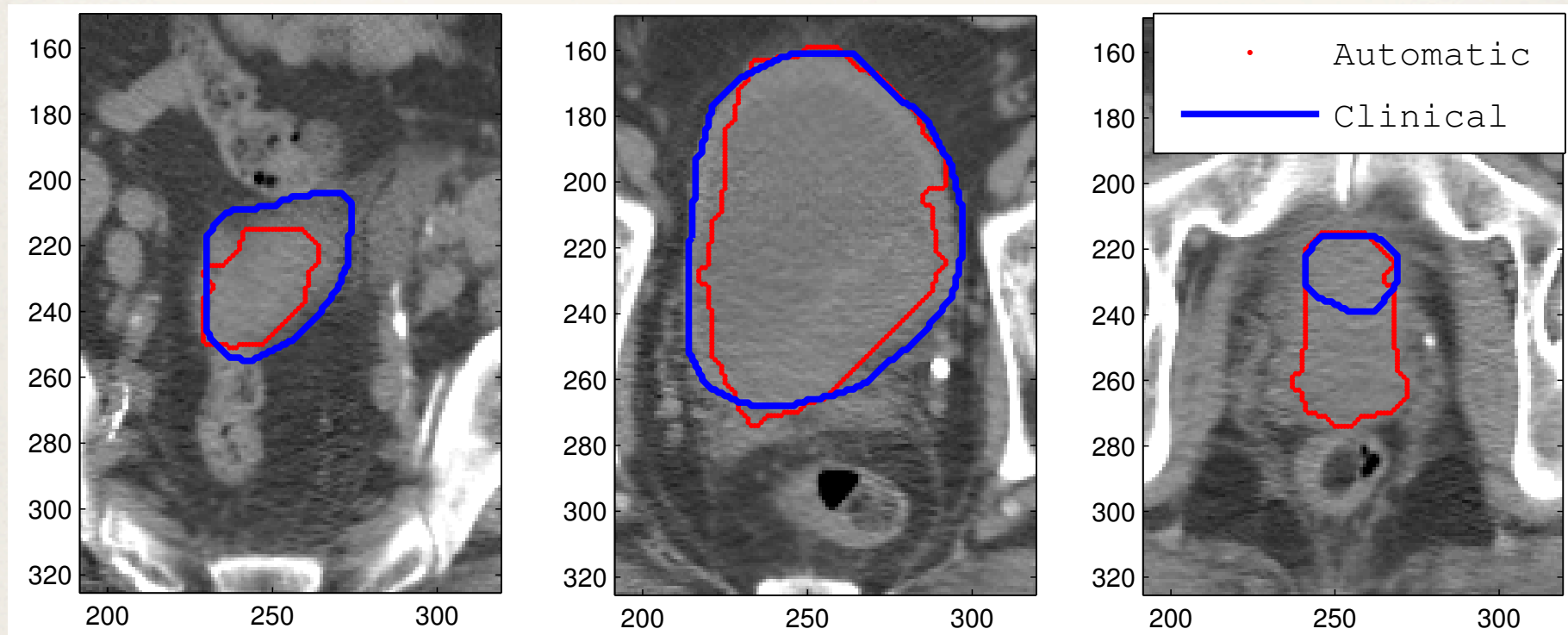




# Image Analysis for Segmentation



# Automatic Contouring

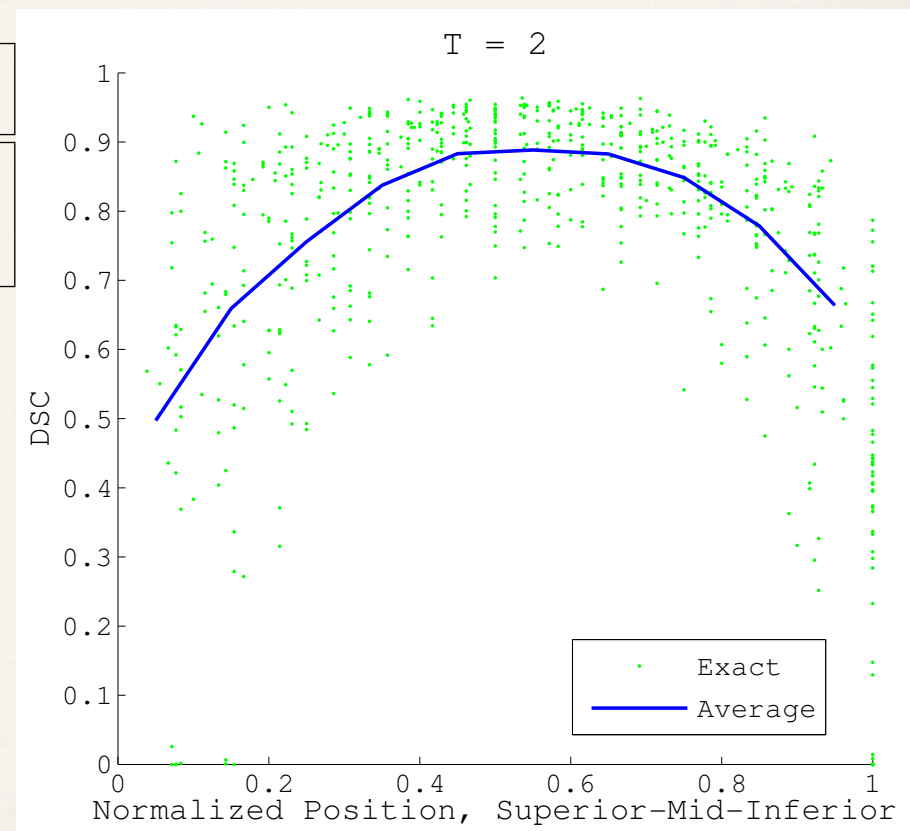
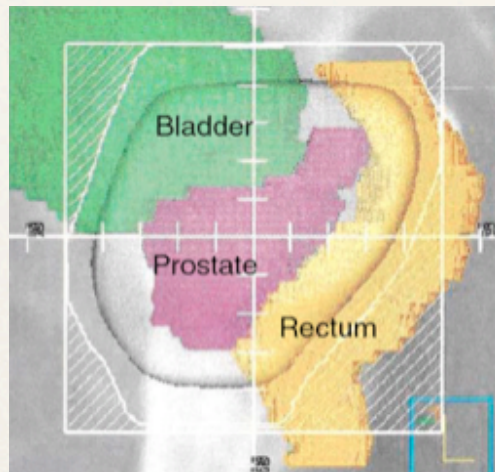


H. Laio, Steel R, W.H. Nailon, D.B. McLaren and S. McLaughlin. Entropy and wavelet denoising for enhancing the bladder prostate junction on radiotherapy planning CT images. Submitted to the 15th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), 2012.



# Automatic Contouring

Location	High Sensitivity Scheme		High Specificity Scheme	
	$\mu$	$\sigma$	$\mu$	$\sigma$
Superior	0.5763	0.2288	0.6464	0.2396
Mid	0.8160	0.0858	0.8643	0.0850
Inferior	0.6727	0.2145	0.6731	0.2228



H. Laio, Steel R, W.H. Nailon, D.B. McLaren and S. McLaughlin. Entropy and wavelet denoising for enhancing the bladder prostate junction on radiotherapy planning CT images. Submitted to the 15th International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI), 2012.

# Qualitative Evaluation

Excellent

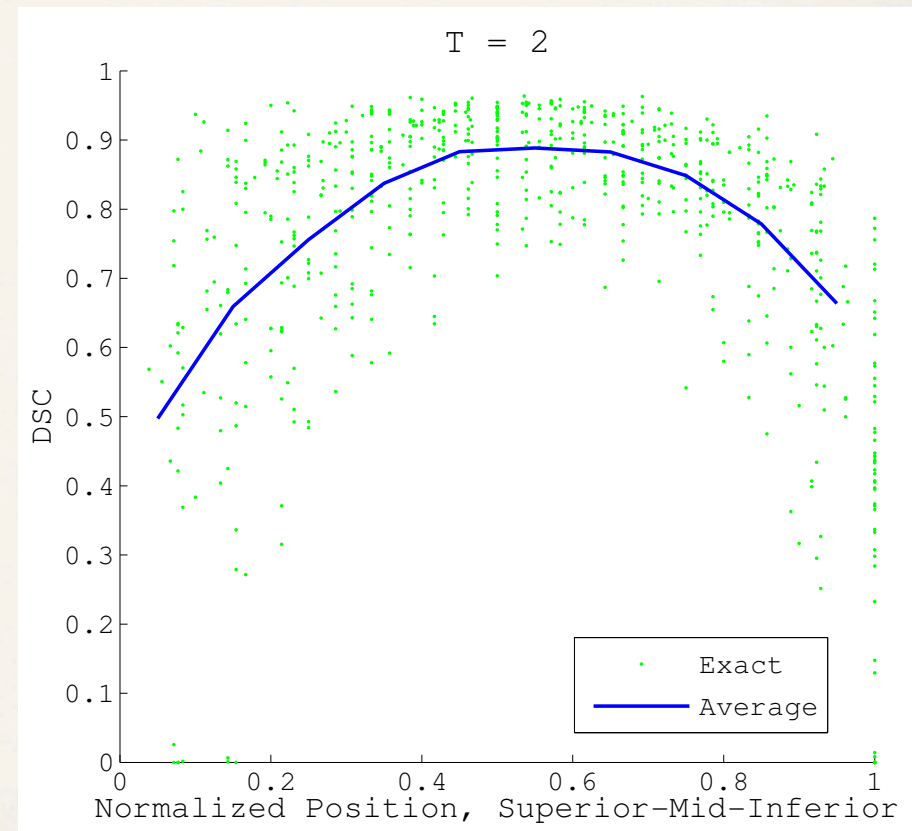
Good

Acceptable

Not Acceptable

**Random Case Selection**

**4 excellent, 3 good, 1 acceptable**

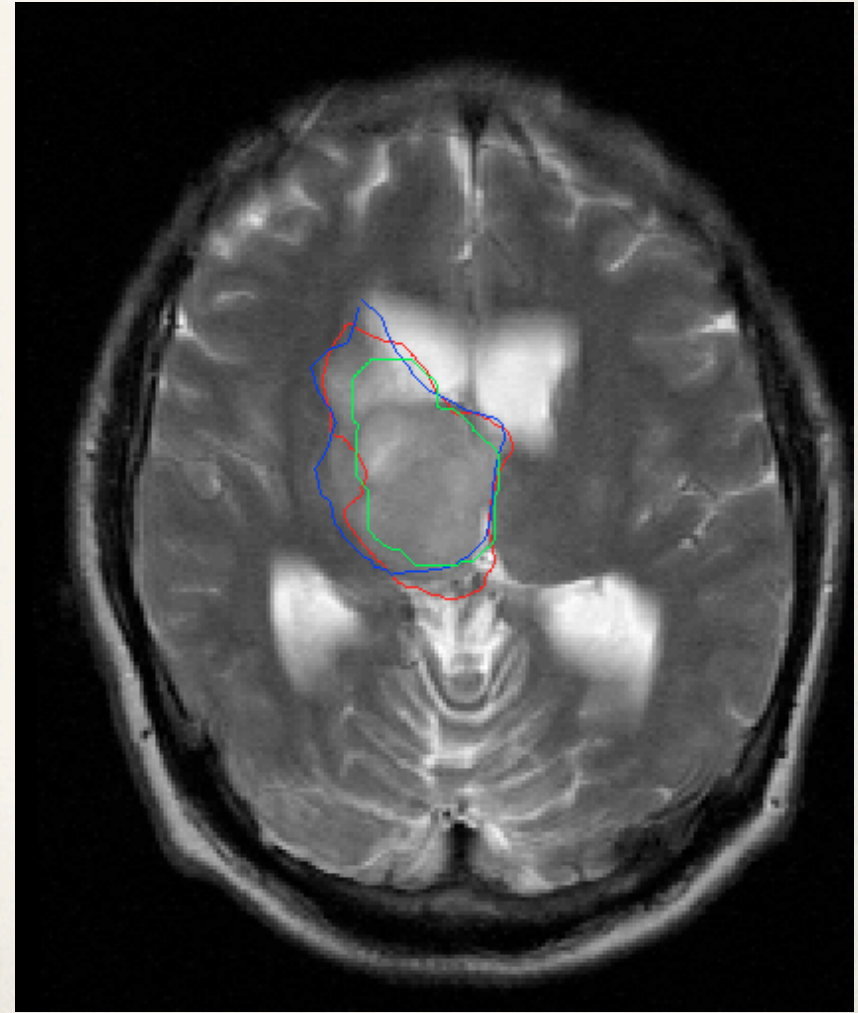
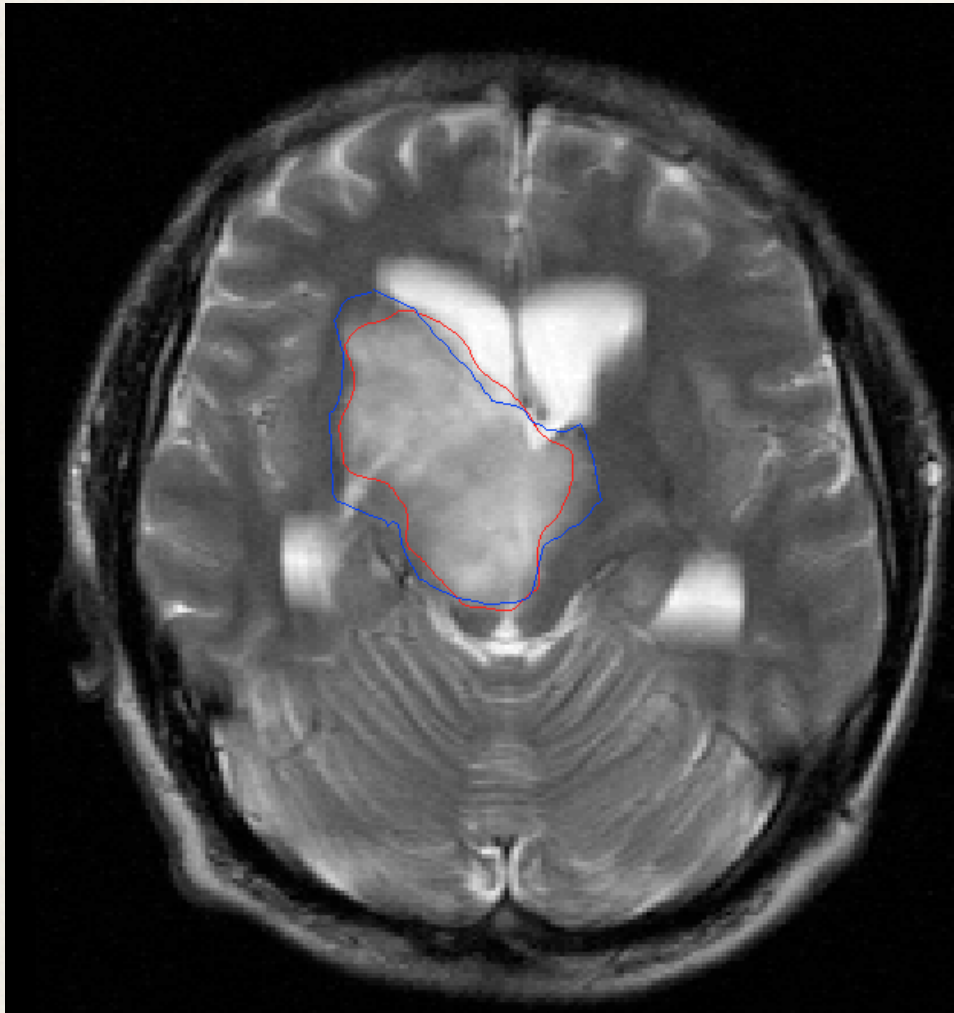


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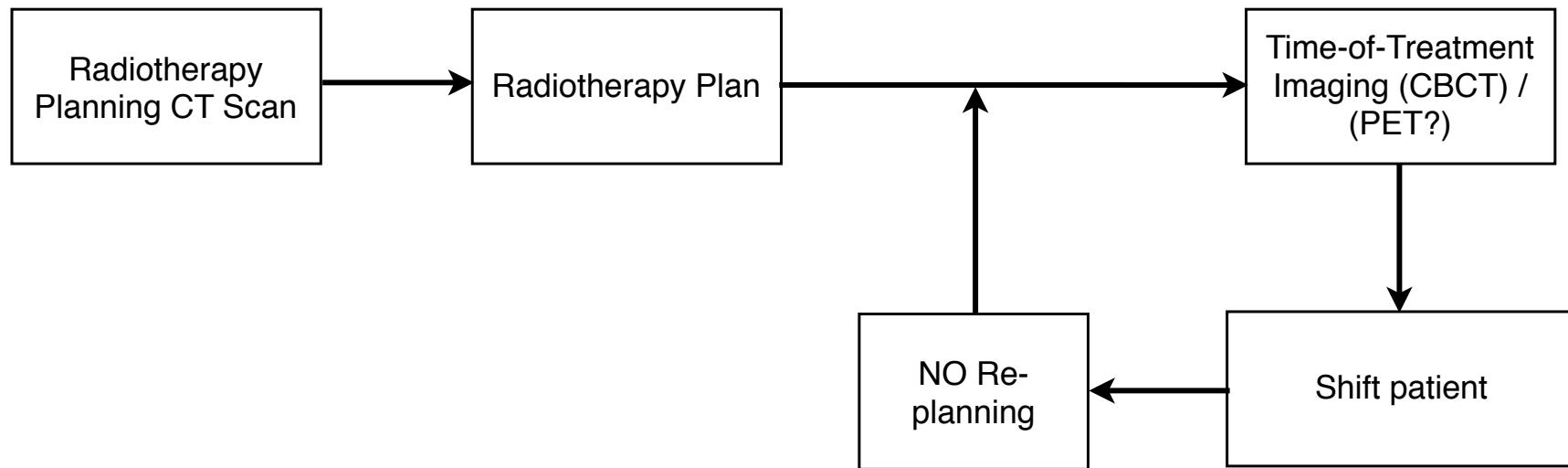
# Automatic Contouring - GBM

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# Using an Atlas for Adaptive RT

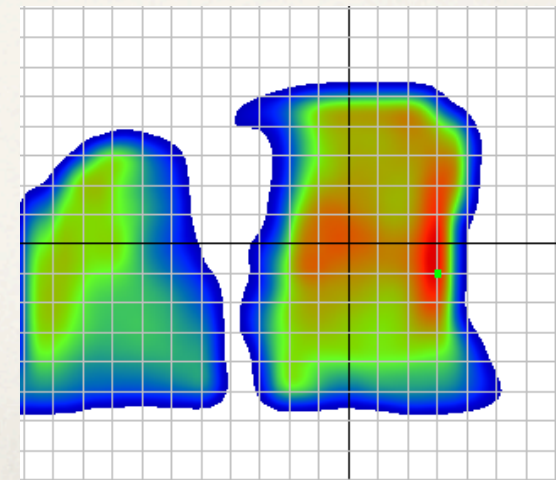
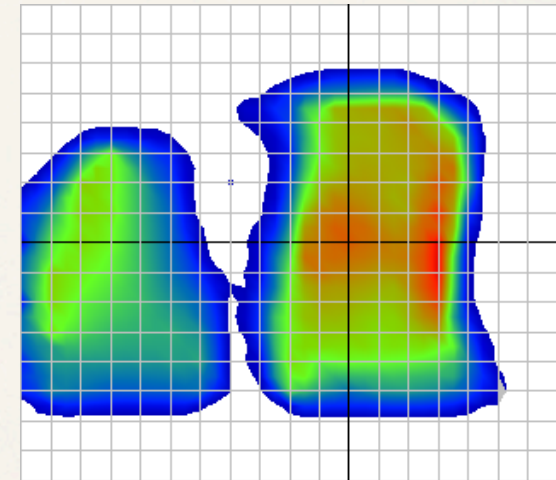
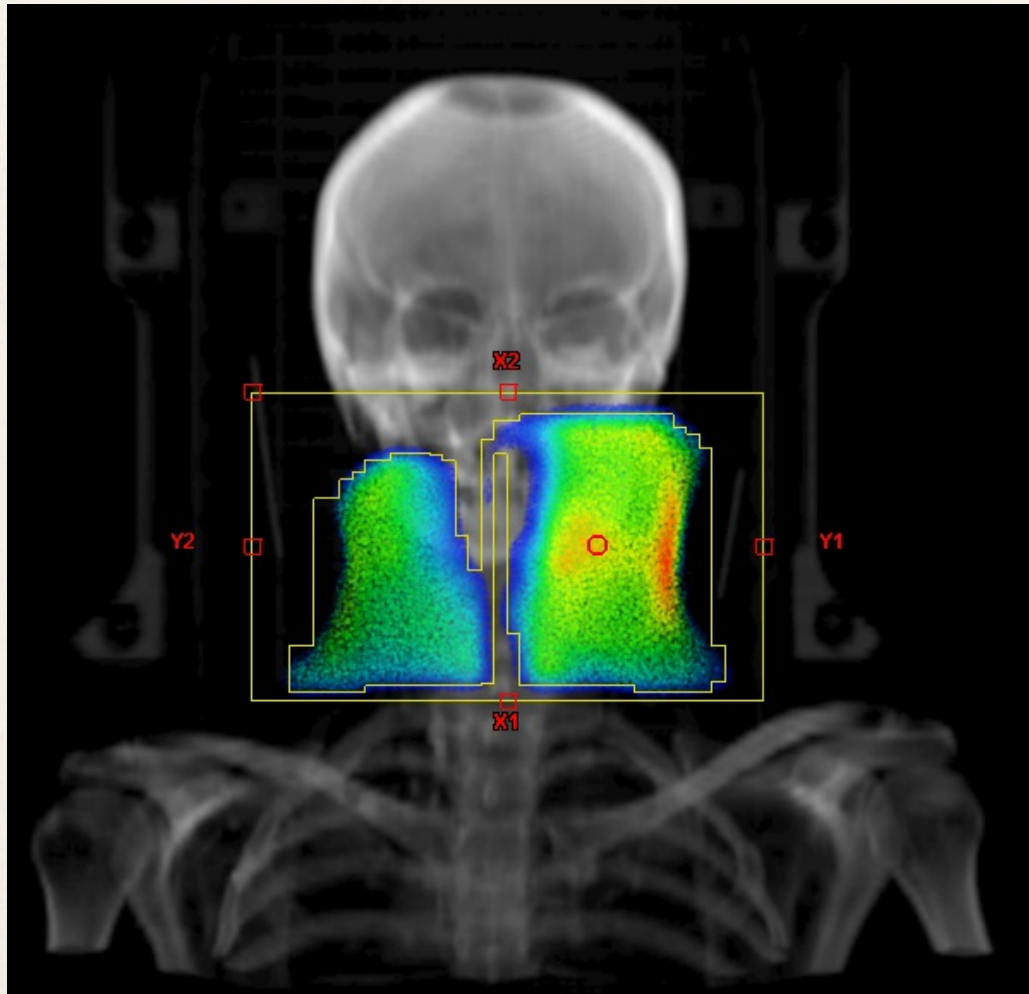
## Improving the Accuracy of Radiotherapy Using Information from an Atlas



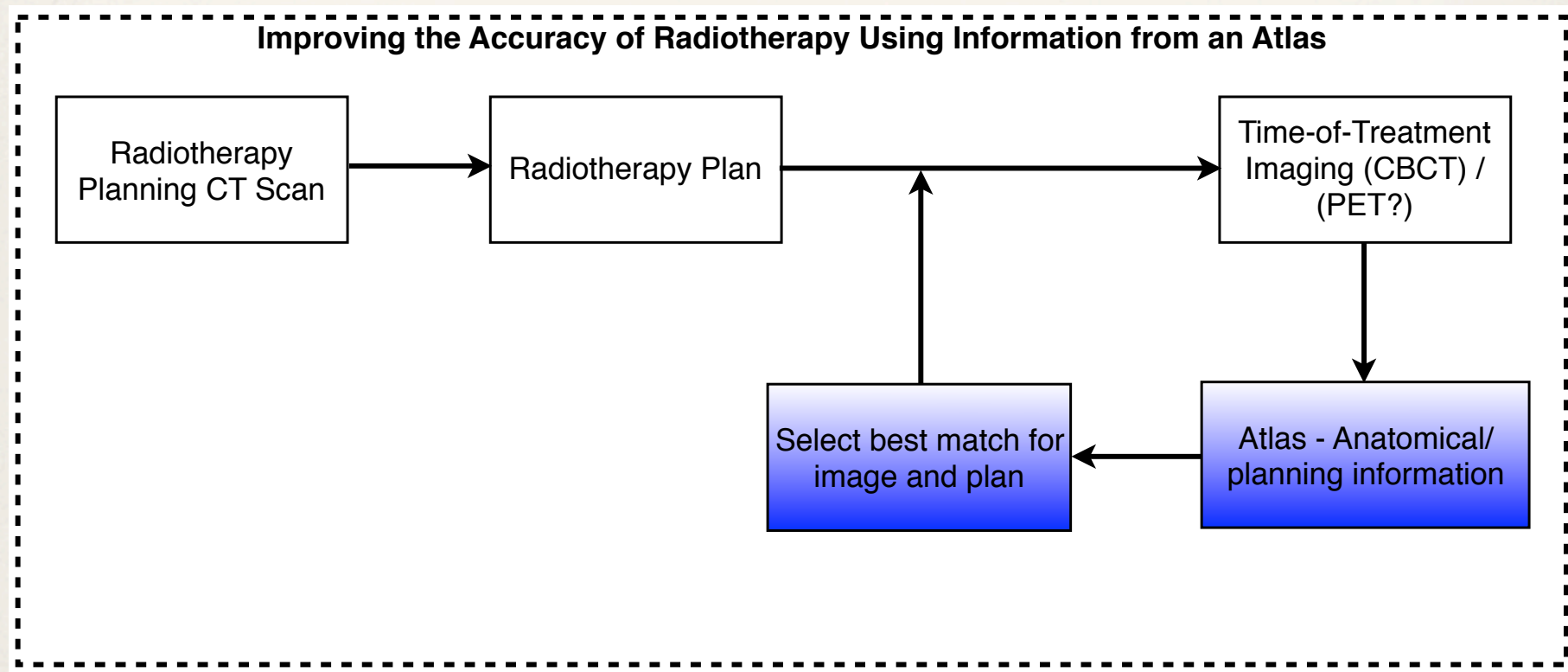


# Using an Atlas for Adaptive RT

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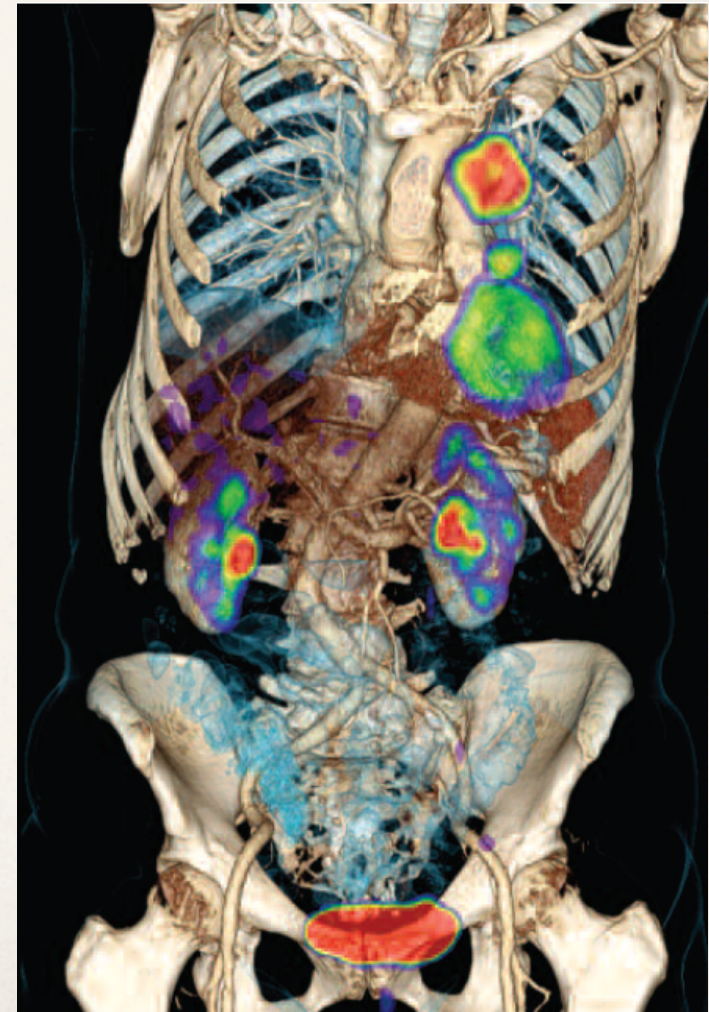
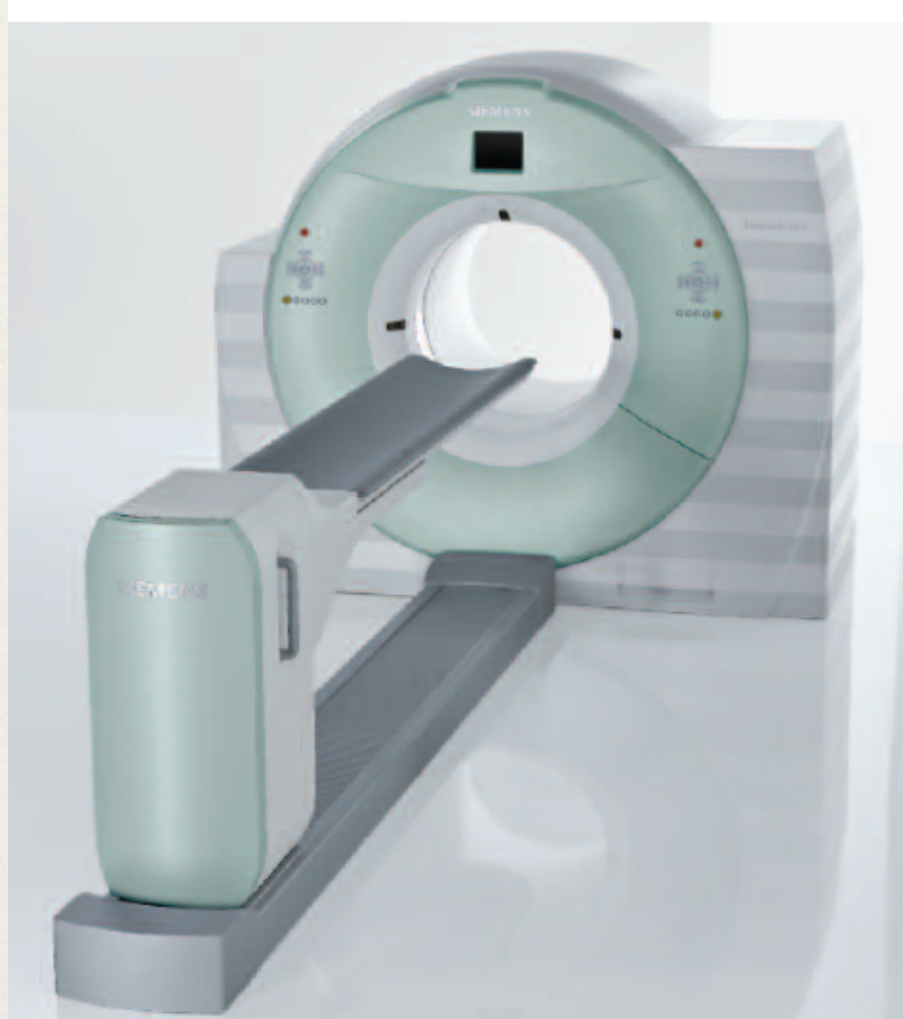
# Using an Atlas for Adaptive RT





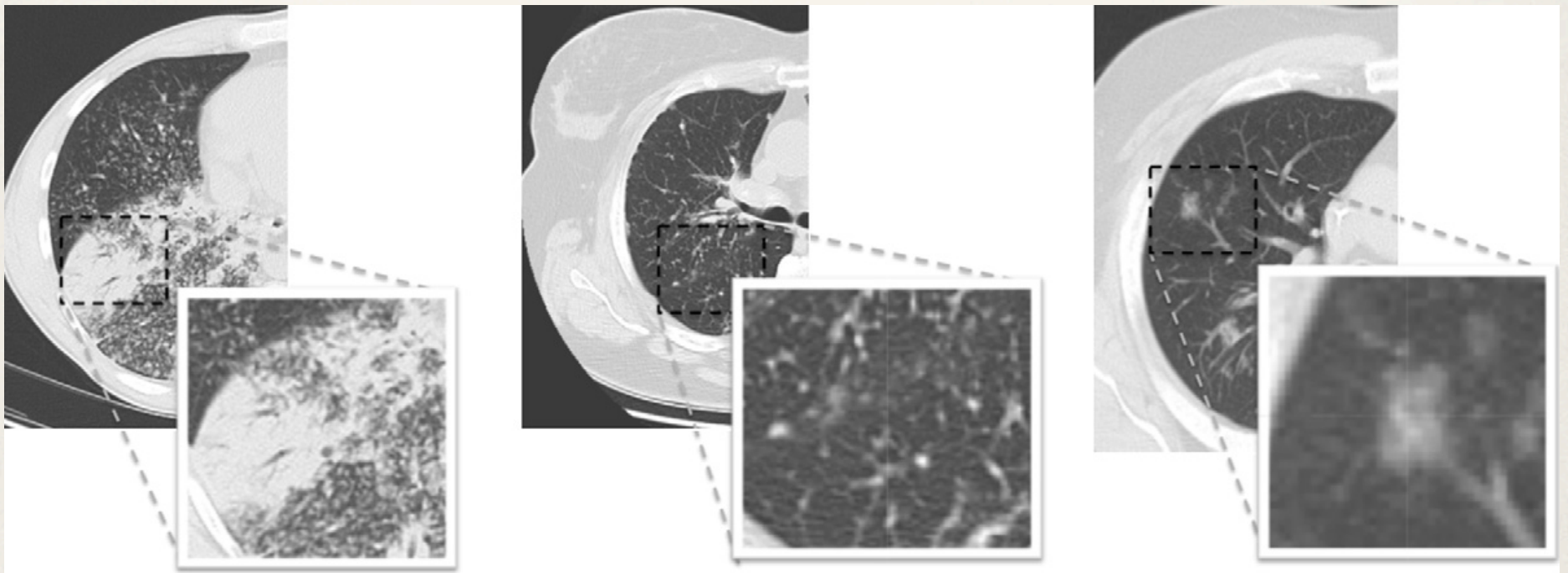
# An Atlas for Outcome-driven RT

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# An Atlas for Outcome-driven RT

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**Fig. 3.** (a) Consolidation, (b) nodules and nodular structures, (c) ground glass nodular opacities.



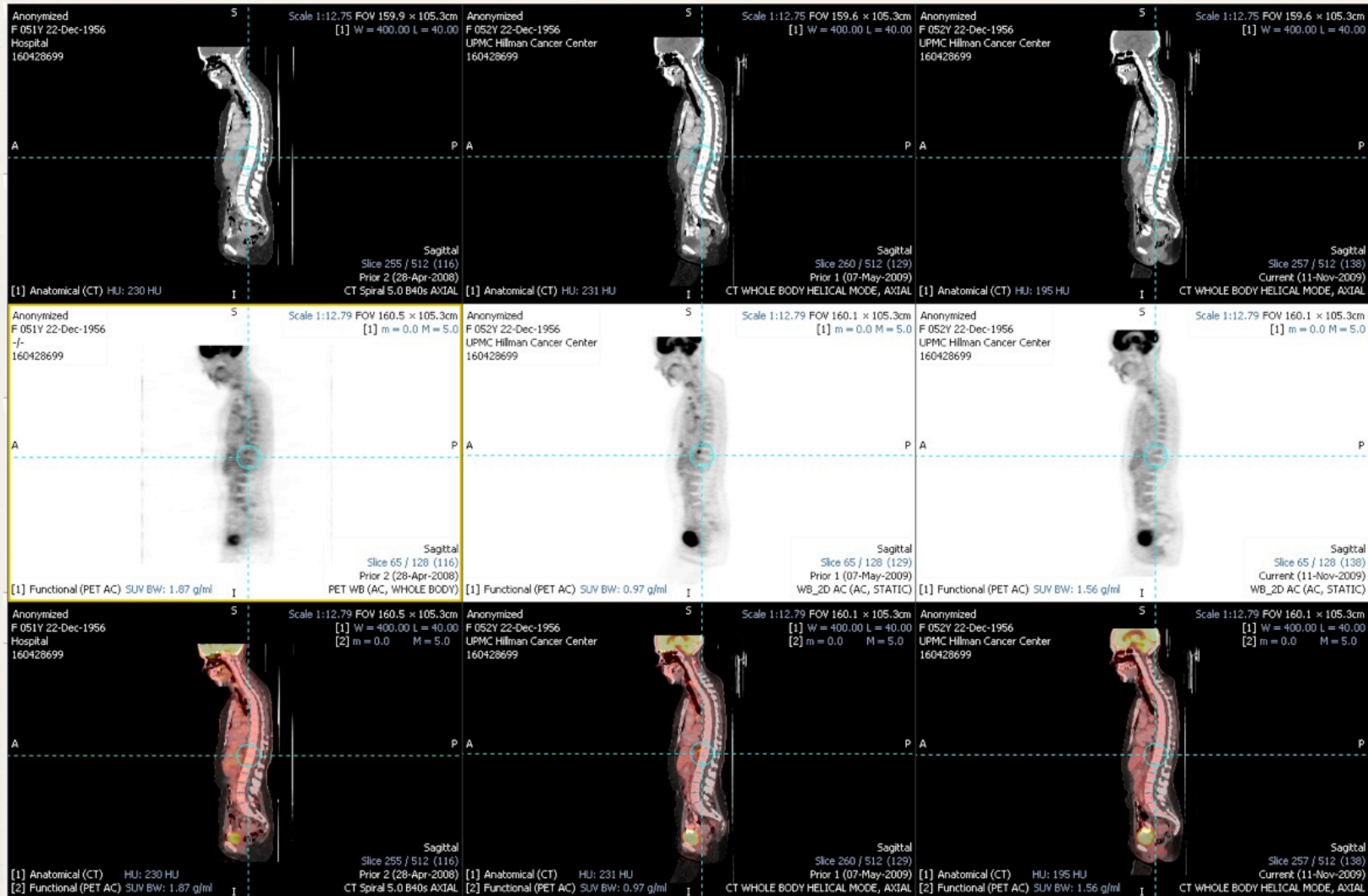
# An Atlas for Outcome-driven RT

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- ❖ **Pre and post-RT Patient Information**

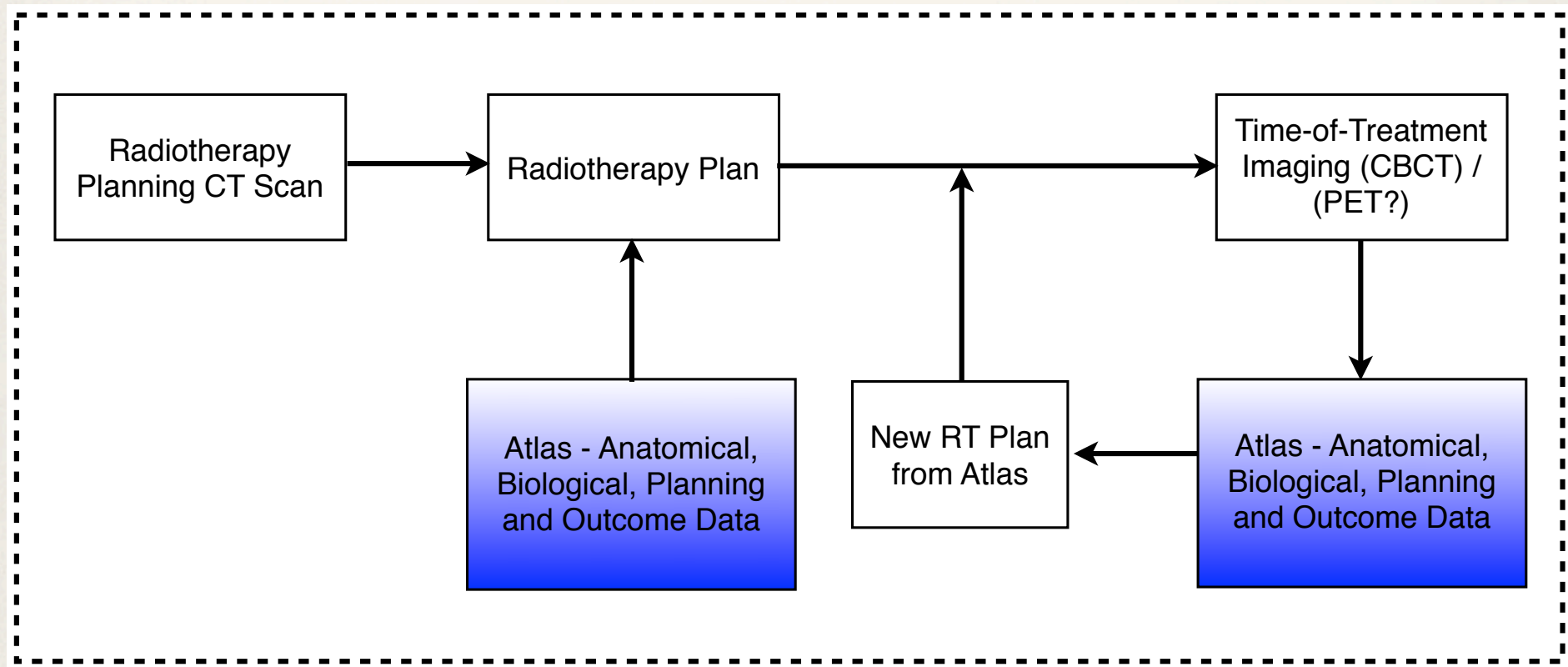
- ❖ Smoking status
- ❖ Co-morbidities
- ❖ Drugs
- ❖ Pathology
- ❖ Stage & Grade
- ❖ Exercise tolerance
- ❖ Pneumonitis grading (0, 1 mild, 2 moderate, 3 severe, 4 death)
- ❖ Planning target volume (volume irradiated)

# An Atlas for Outcome-driven RT





# An Atlas for Outcome-driven RT



# Acknowledgements

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- ❖ Dr Duncan McLaren
- ❖ Dr Robin Steel
- ❖ Prof Steve McLaughlin
- ❖ Hanqing Liao
- ❖ Yuan Tian
- ❖ Prof Ian Kunkler
- ❖ Prof David Cameron
- ❖ Dean Montgomery
- ❖ Yang Feng
- ❖ Kun Cheng
- ❖ Dr Sara Erridge
- ❖ Prof David Argyle