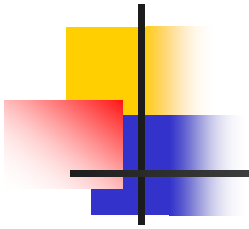
Image Guided Radiation Therapy – Edward Experience

John Fan, PhD
Edward Hospital
Naperville, Illinois

Outline

- PET/CT Simulation
- Manage Respiratory Motion – 4DCT Simulation
- On Board Imaging



Challenges in Radiation Therapy

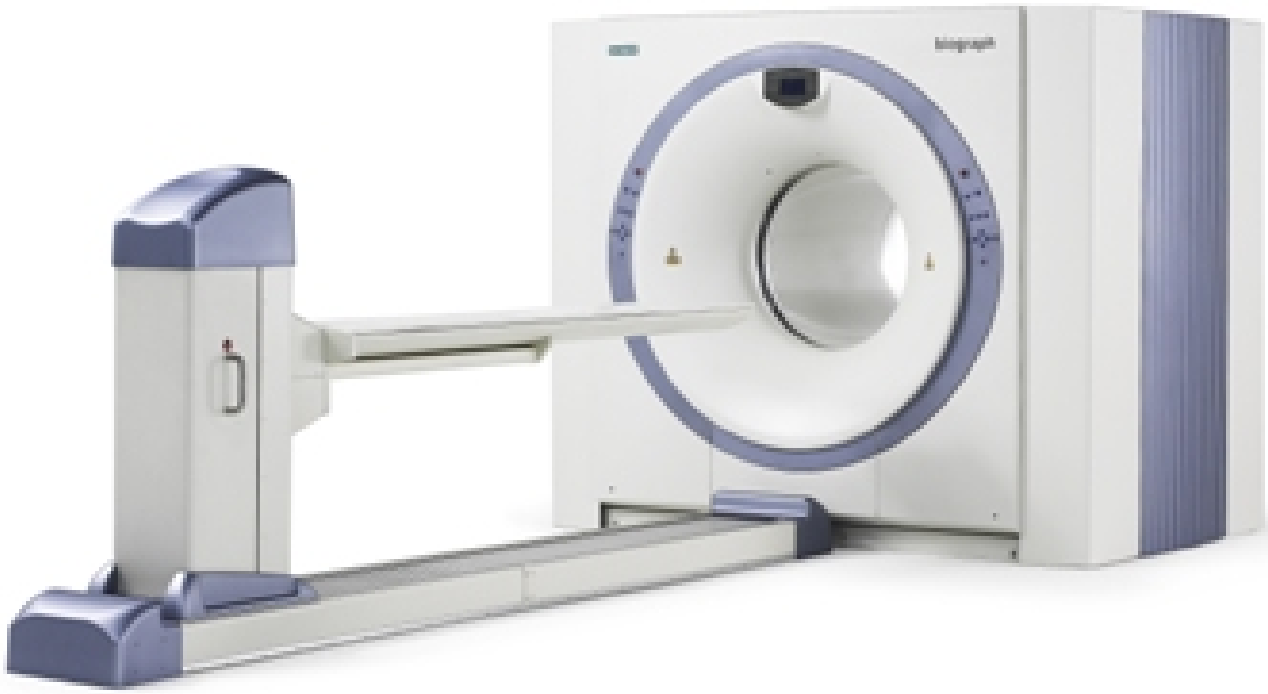
- Identifying the tumor
- Defining the tumor and target
- Hitting the target
- Knowing the tumor response to radiation

Imaging and image registration is the key for addressing these challenges

Imaging Techniques are Rarely Used “Solo”

- CT
- MR
- PET
- Ultrasound
- PET/CT Simulation
- 4DCT Simulation
- On Board Imaging

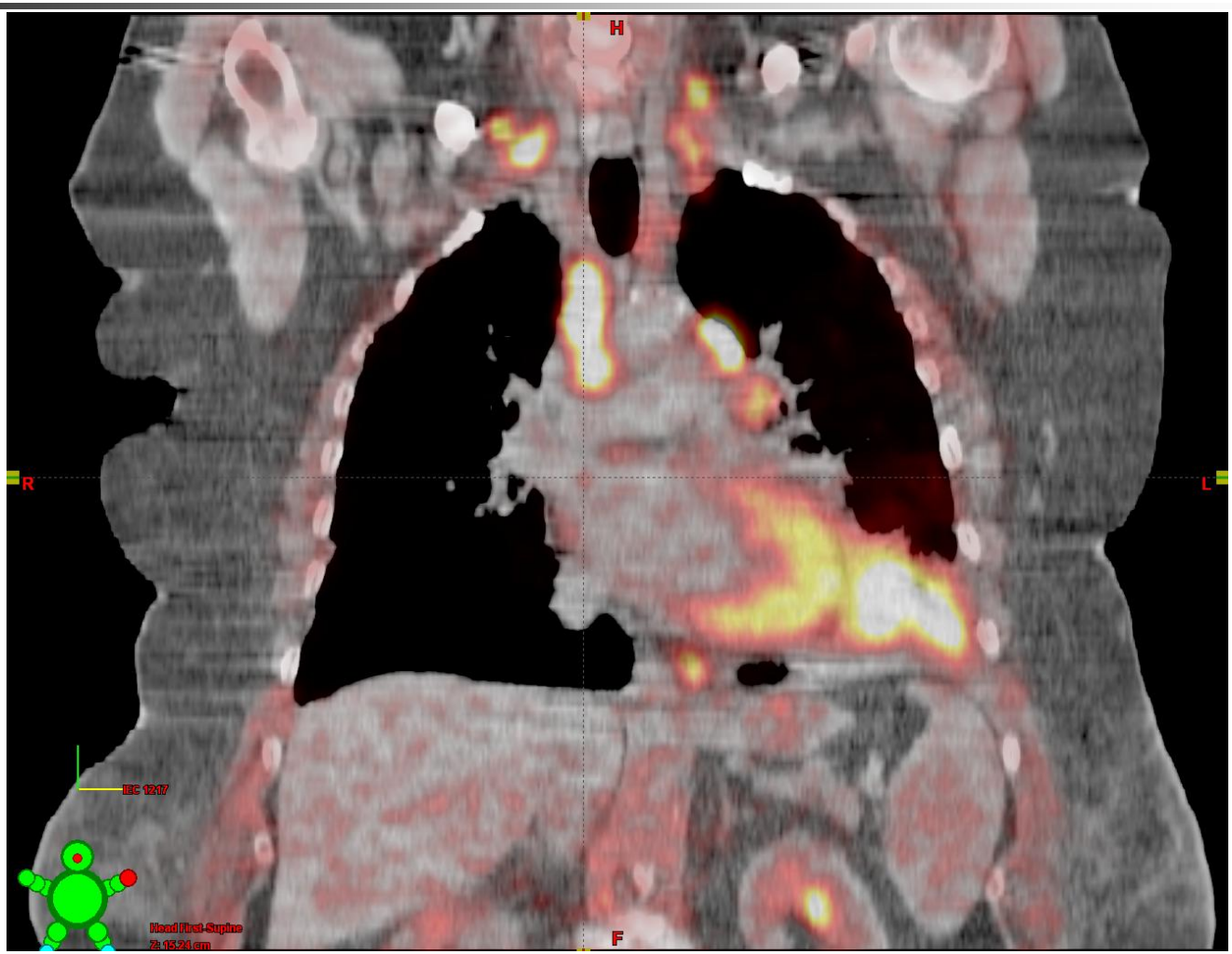
PET for Radiation Therapy Planning



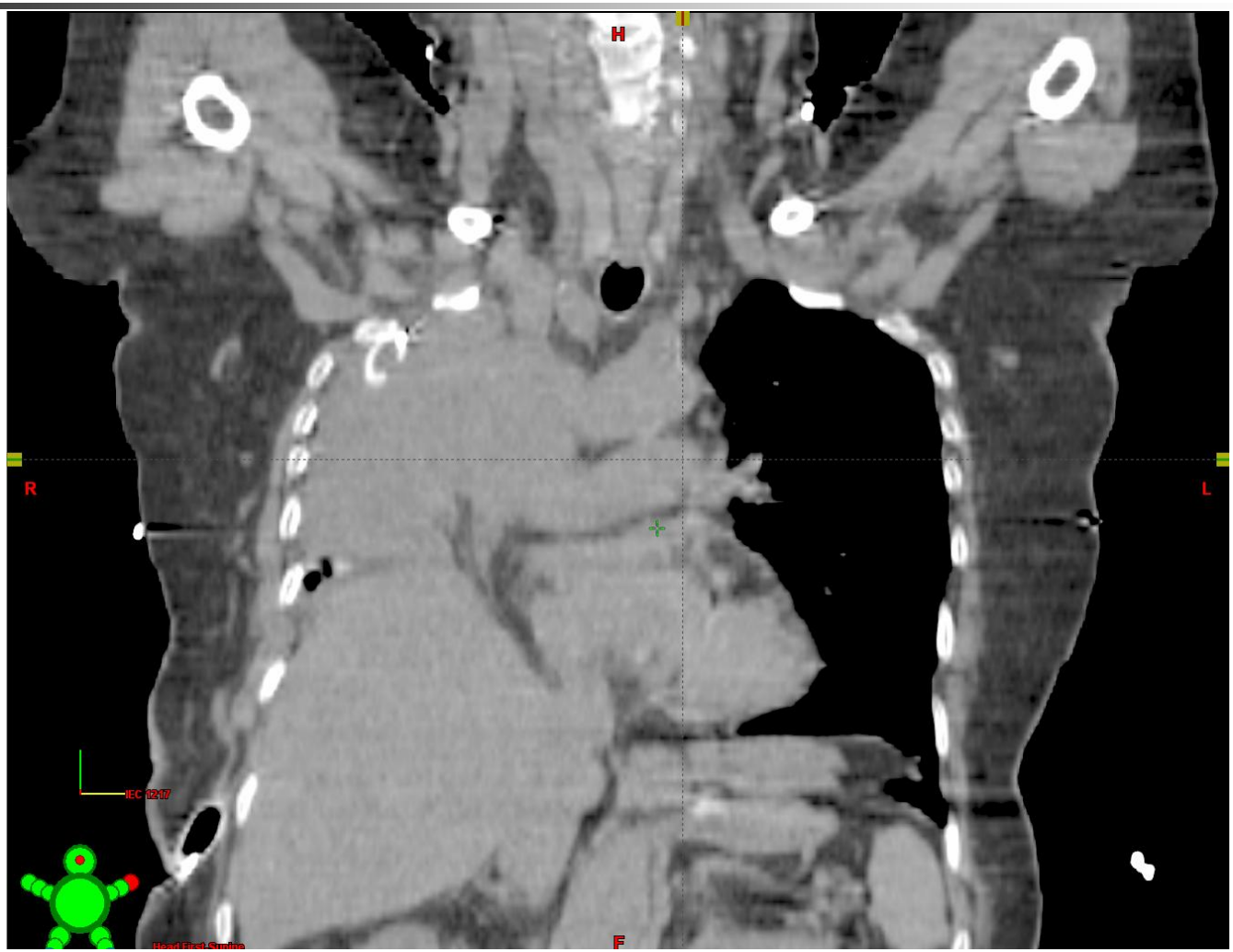
Why PET/CT Simulation?

- Distribution of activity is imaged
  - Physiology, function, biology
- Complementary to (~ anatomic) CT and MR
- Increased sensitivity compared to CT alone
- PET and CT in the same treatment position
- Accurate PET/CT fusion

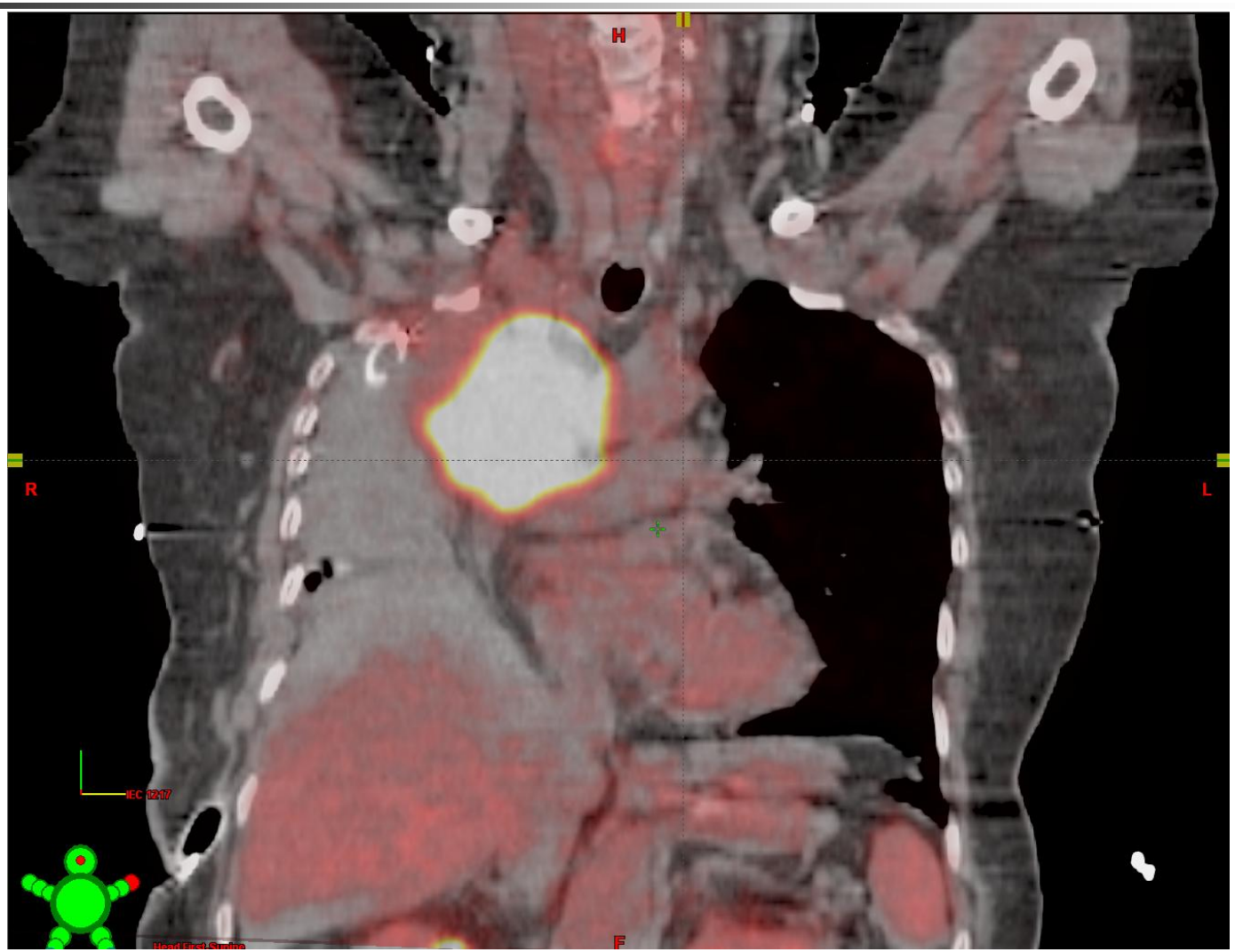
PET/CT Simulation



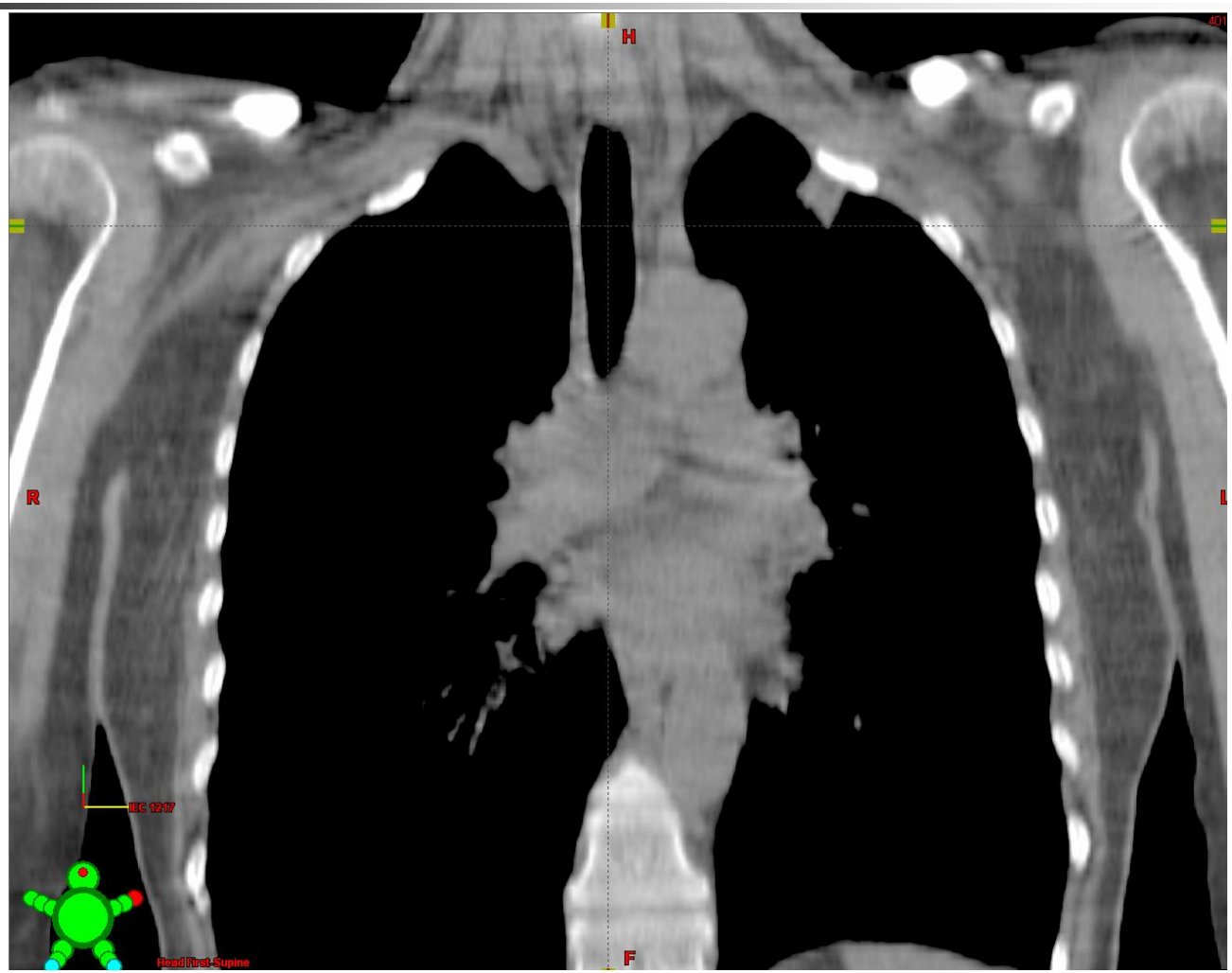
PET can Decrease Target Volume



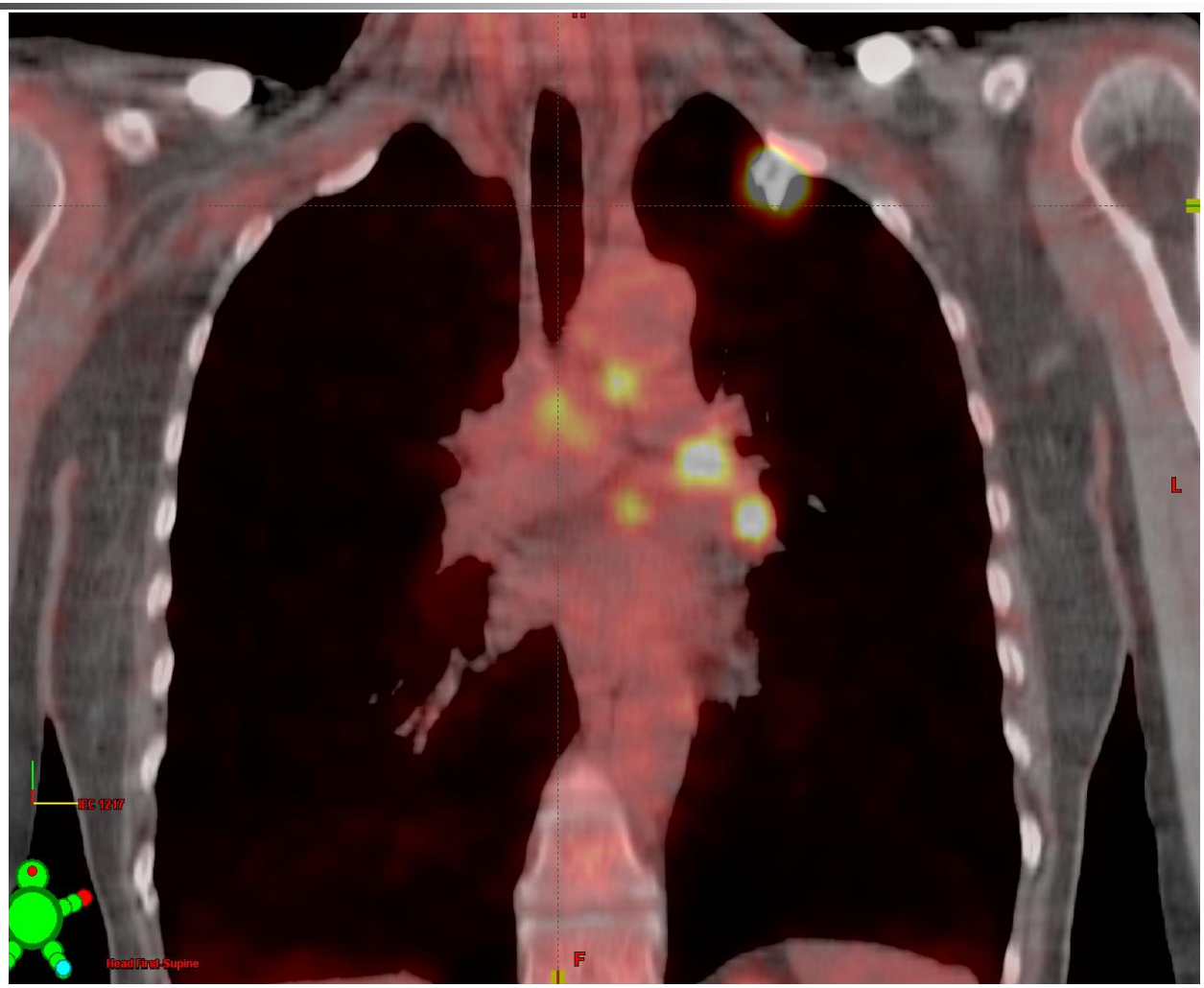
PET can Decrease Target Volume



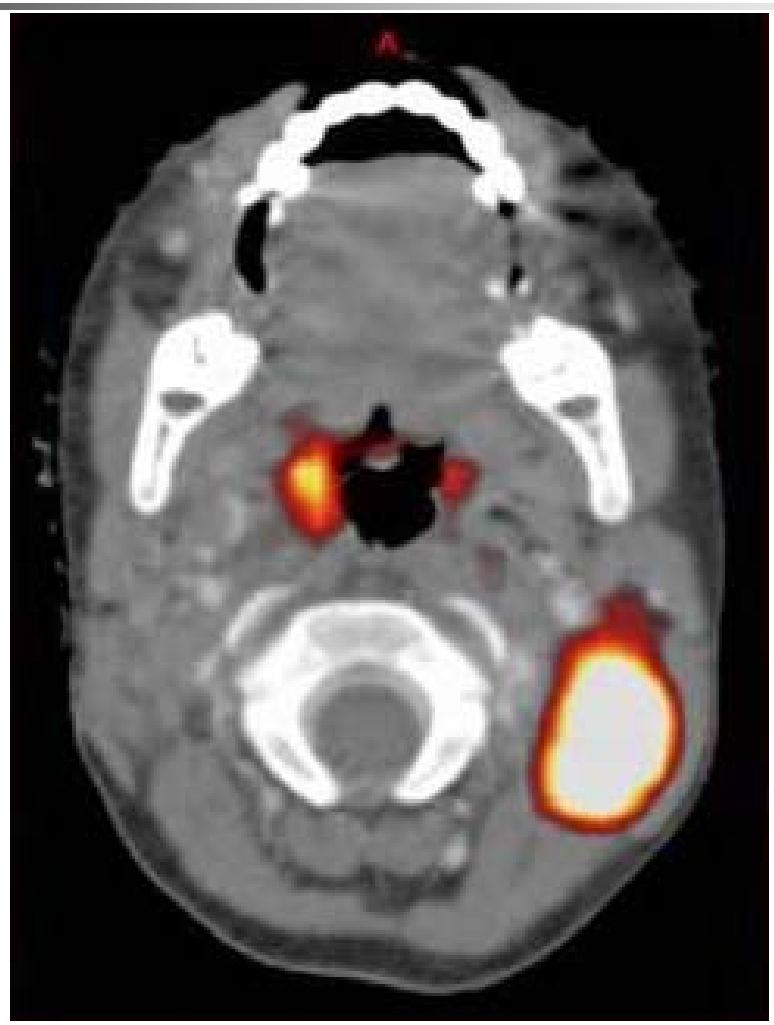
PET can Increase Target Volume



PET can Increase Target Volume



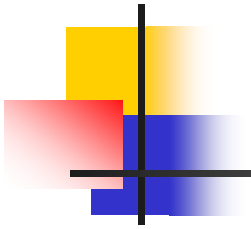
PET can Increase Target Volume



Are they Moving?

More Challenges in Radiation Therapy

- Identifying the tumor
- Defining the moving tumor and target
- Hitting the moving target
- Knowing the tumor response to radiation



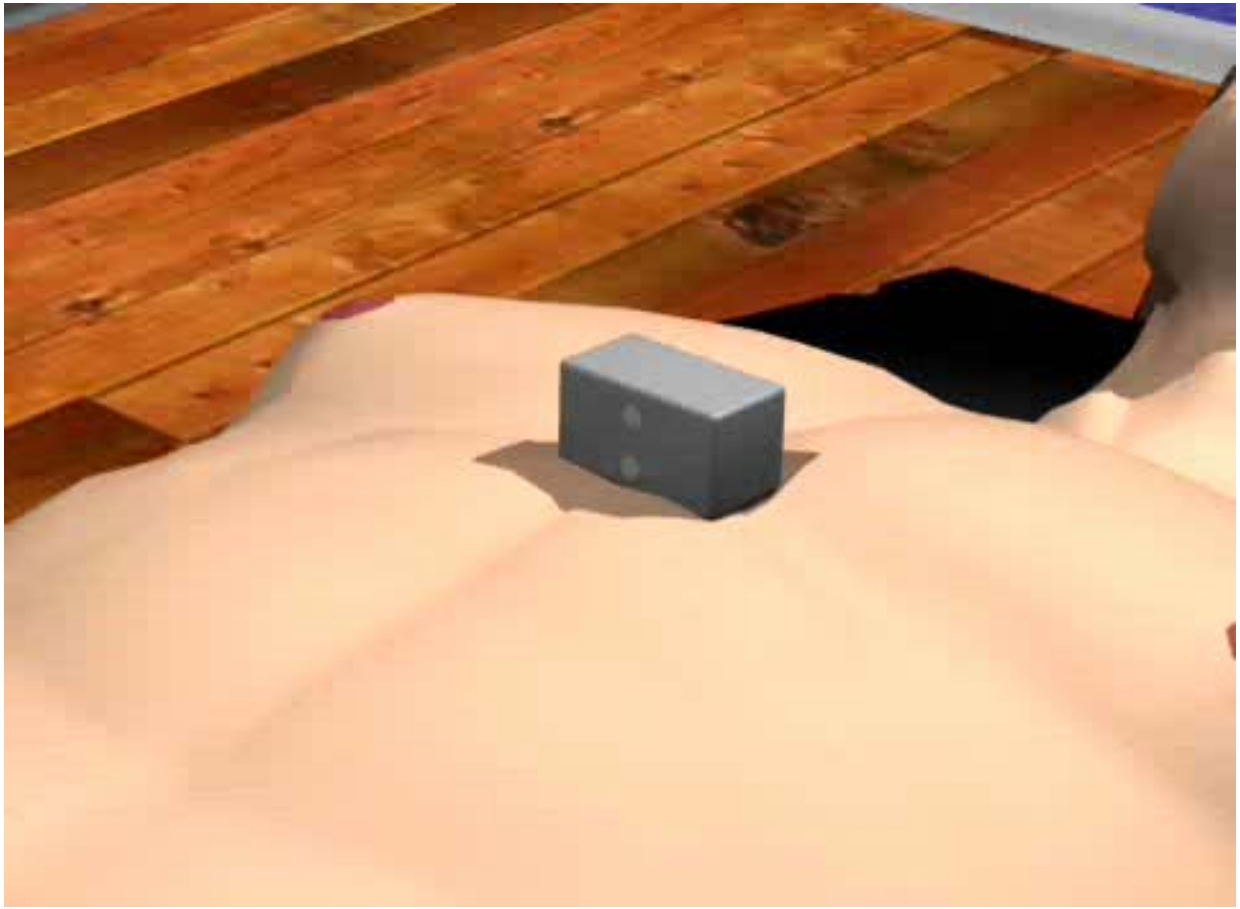
Types of Motion

- Intra-fraction
  - Within each fraction (example: lung)
- Inter-fraction
  - Between fractions (example: prostate)
- Combined with deformation
  - Example: pancreas

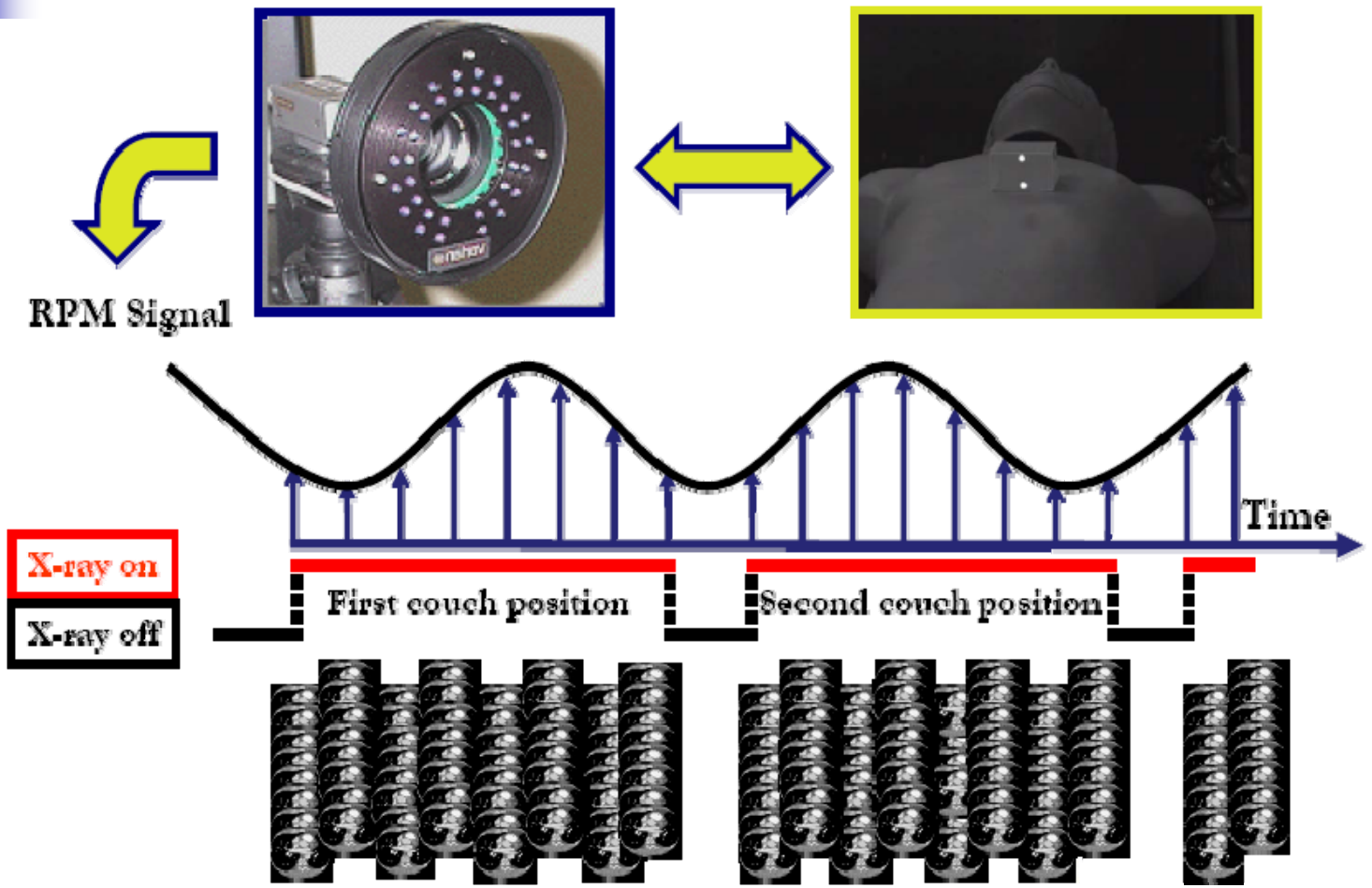
How to Monitor Breathing?

- Chest / abdomen height
  - Varian RPM System
- Belt based
  - Anzi Medical System (pressure based belt)
  - Philips (pneumatic belt)
- Metric spirometry

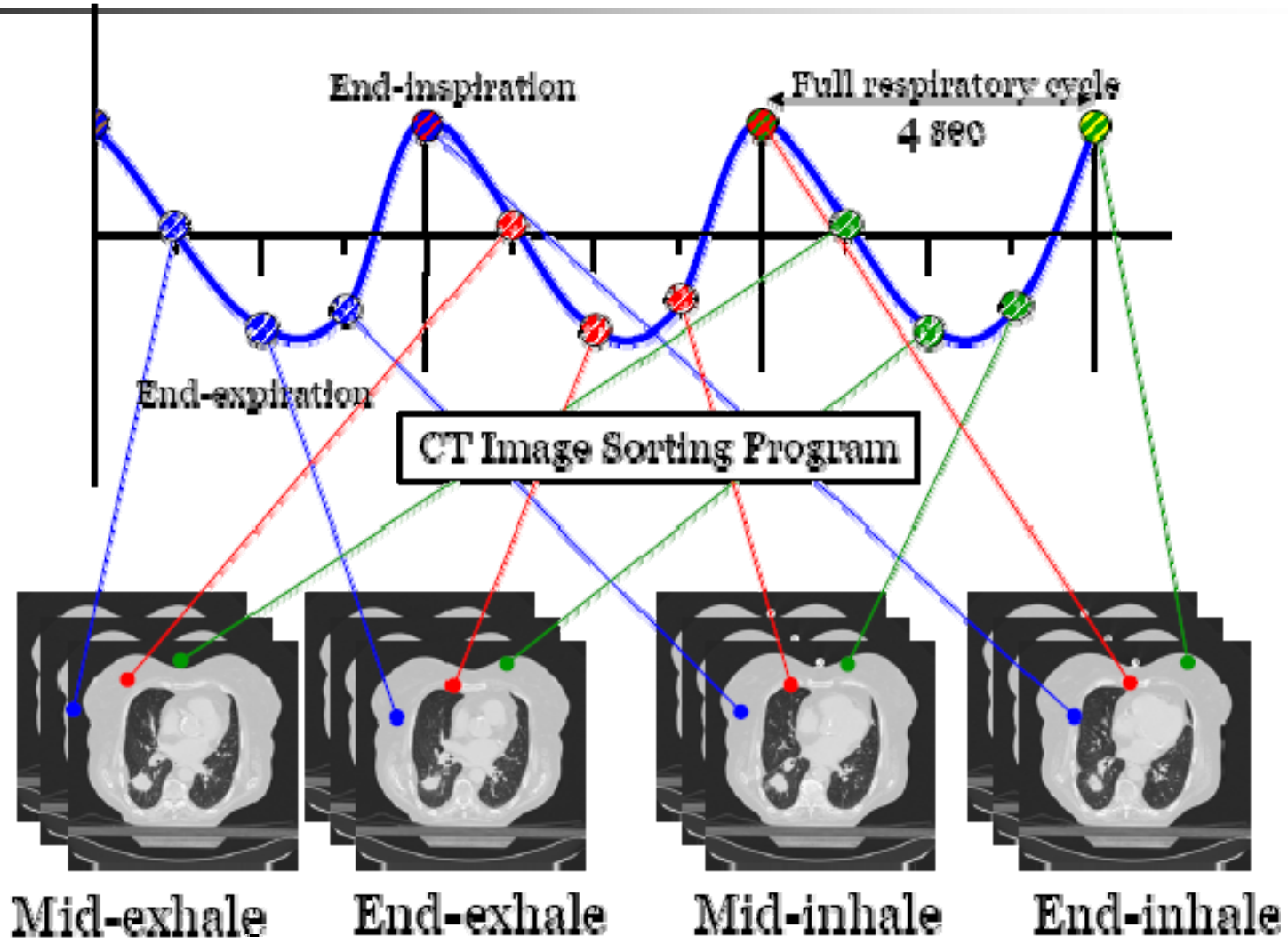
Varian RPM



4D CT Imaging

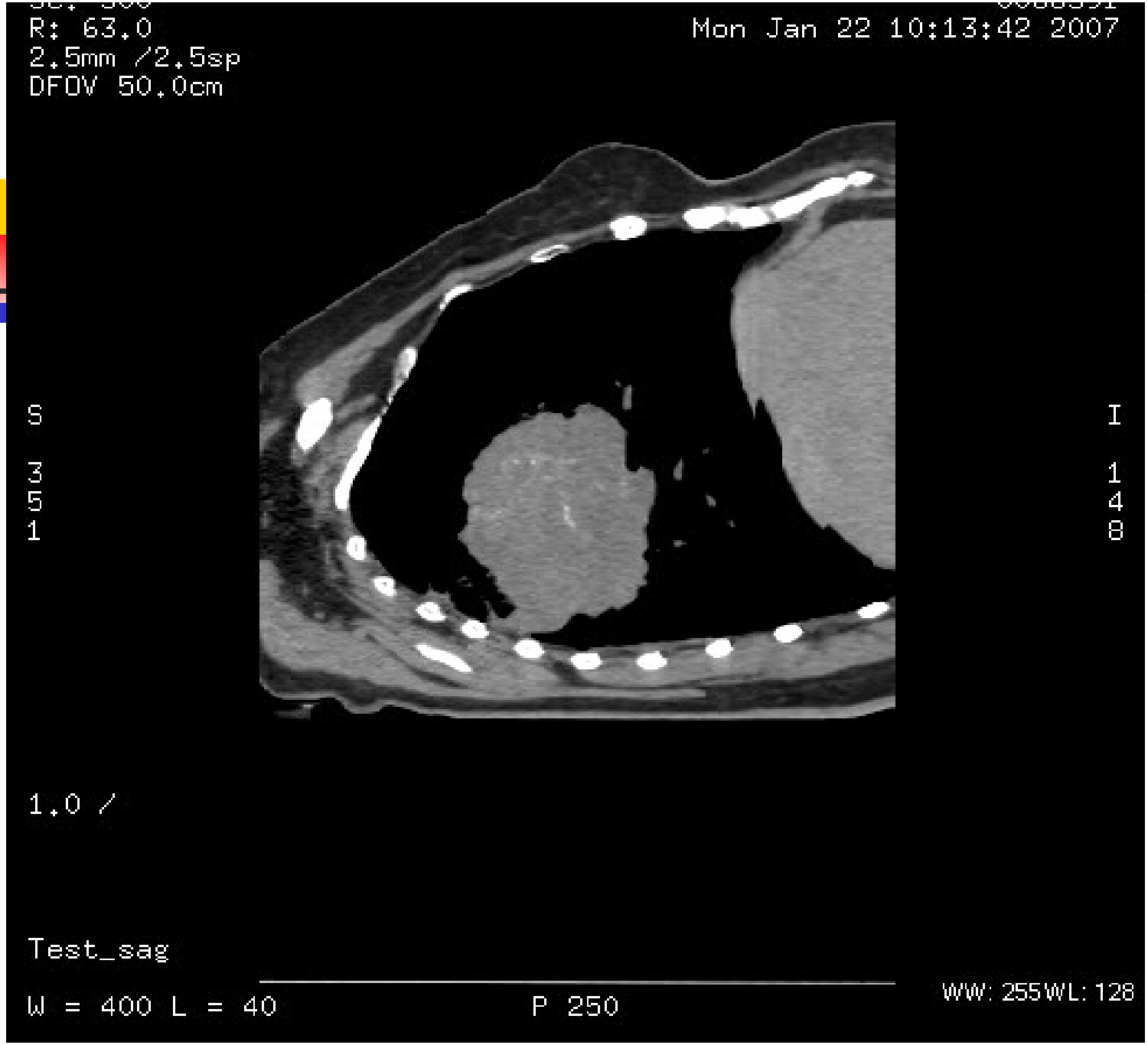


4DCT Image Sorting



4D


2.5mm /2.5sp
DFOV 50.0cm
R
250
L
250
1.0 /
Test
W = 350 L = 40
I 148
WW: 255WL: 128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2.5mm /2.5sp
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S
3
5
1
I
1
4
8
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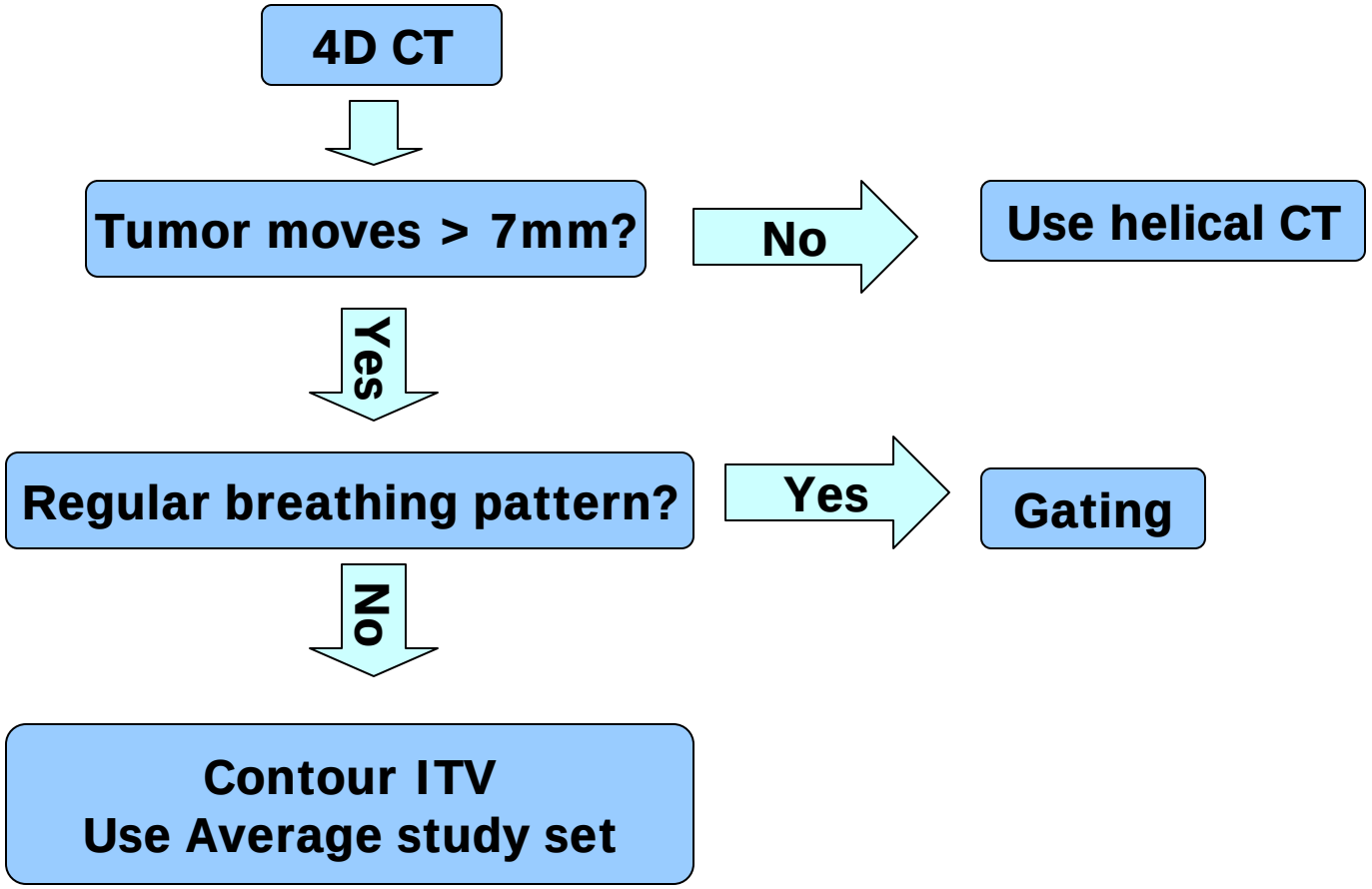
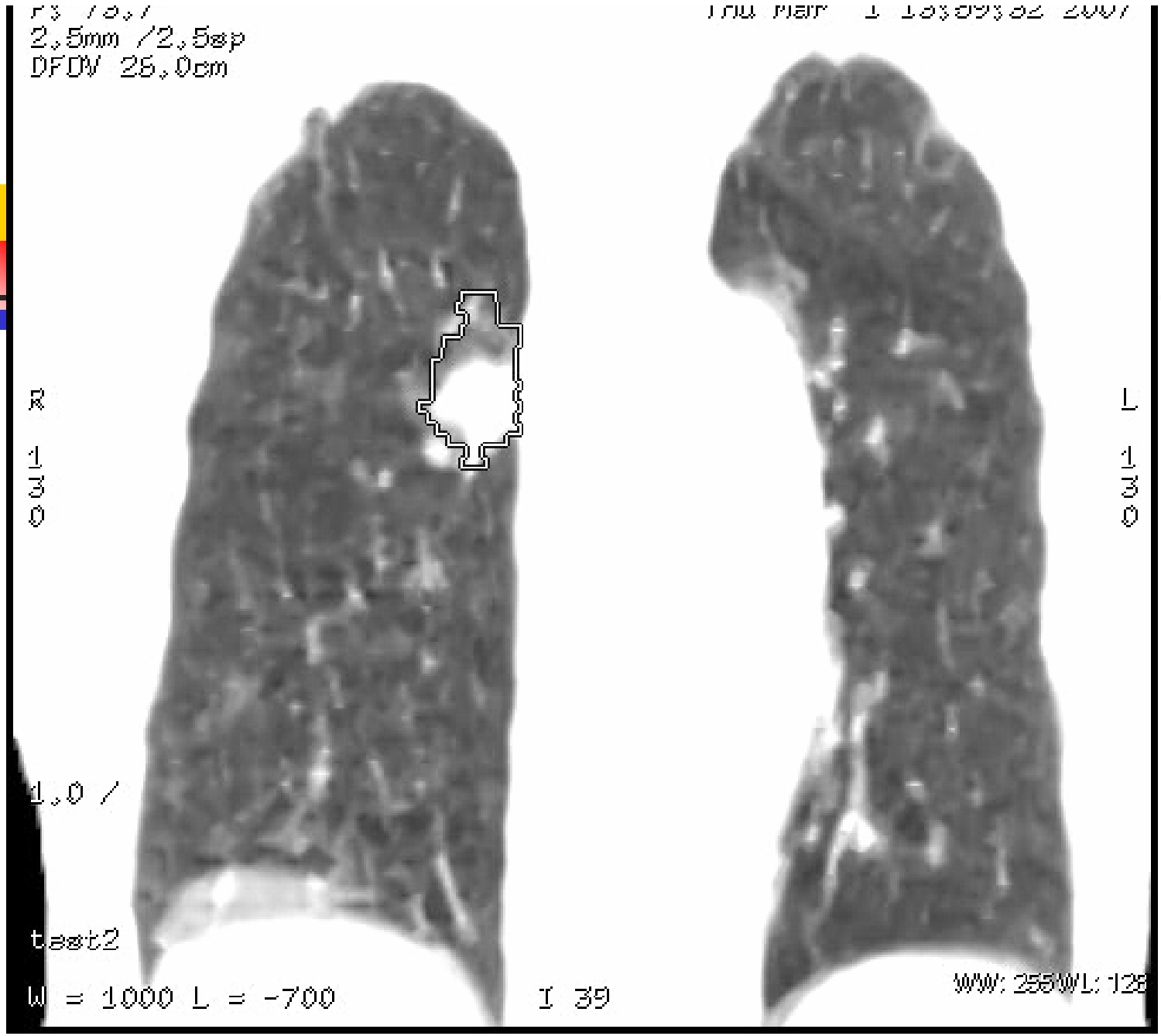
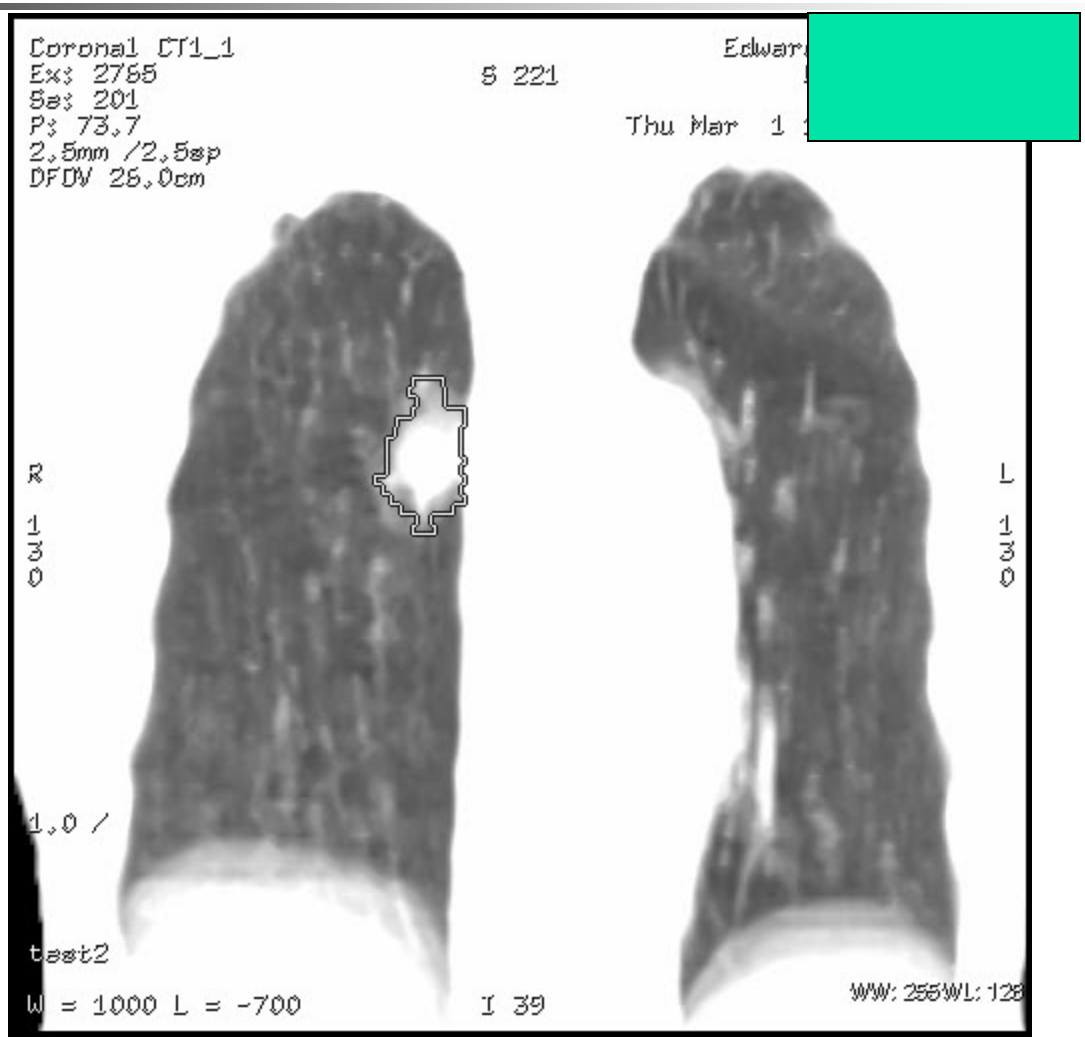
W = 400 L = 40
P 250
WW: 255WL: 128

Manage Respiratory Motion



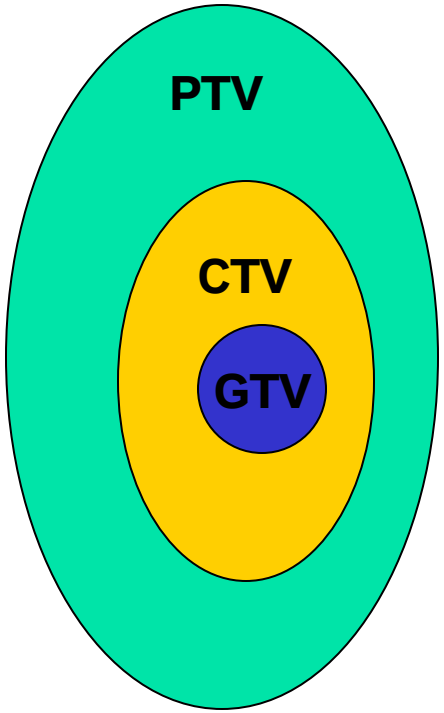

2,5mm /2,5sp
DFOV 25,0cm
R
130
L
130
1,0 /
test2
W = 1000 L = -700
I 39
WW: 255WL: 128

ITV on Ave Study Set for Planning



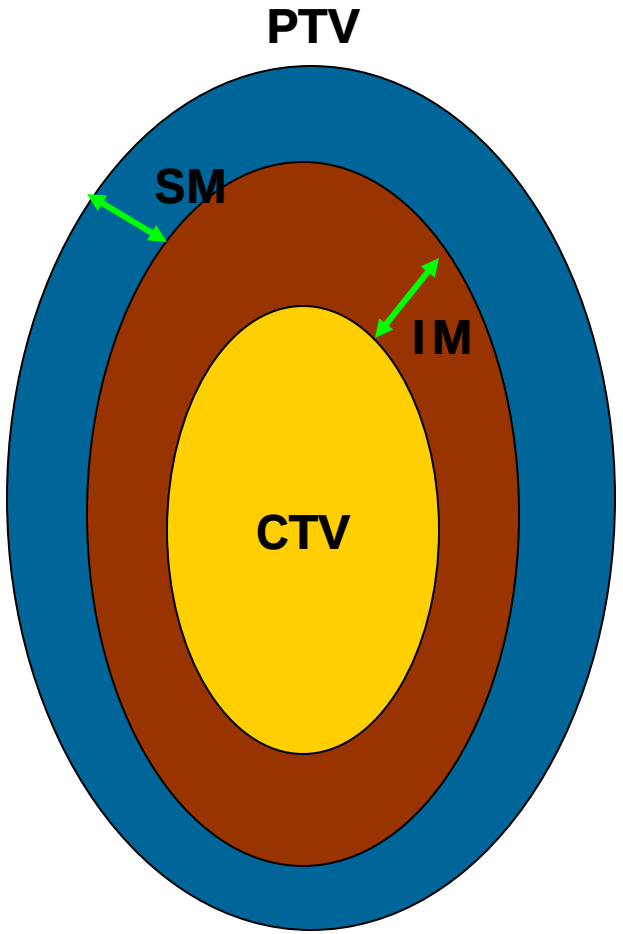
ICRU 62 Target Volume Delineation

- GTV – Gross Tumor Volume
- CTV – Clinical Target Volume
- PTV – Planning Target Volume



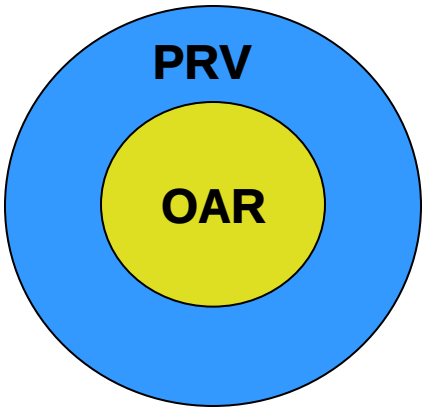
ICRU 62 Target Volume Delineation

- PTV = CTV + IM + SM
  - IM - Internal Margin, due to physiologic variations
  - SM - Setup Margin, due to technical factors

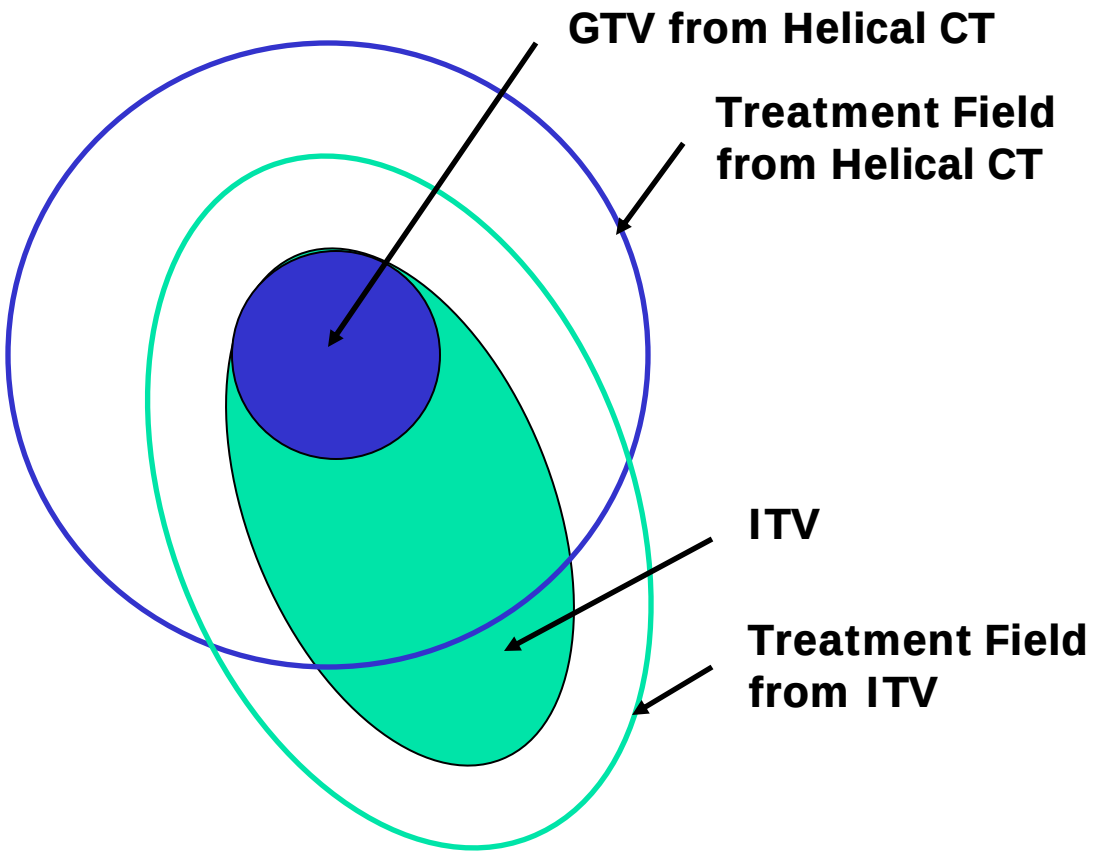


ICRU 62 Definition

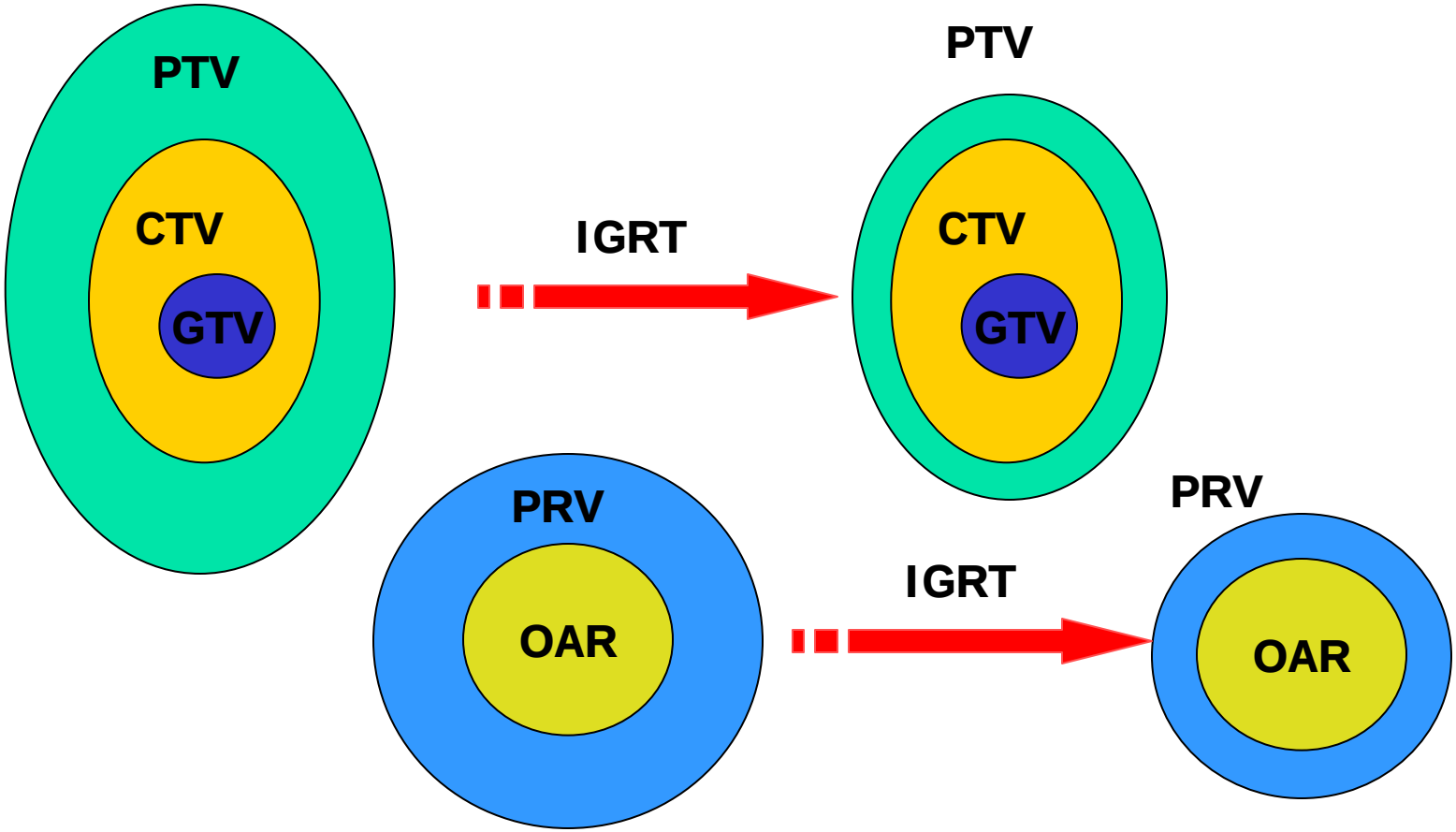
- OAR – Organ at Risk
- PRV – Planning Organ at Risk Volume
  - Margin added to OARs



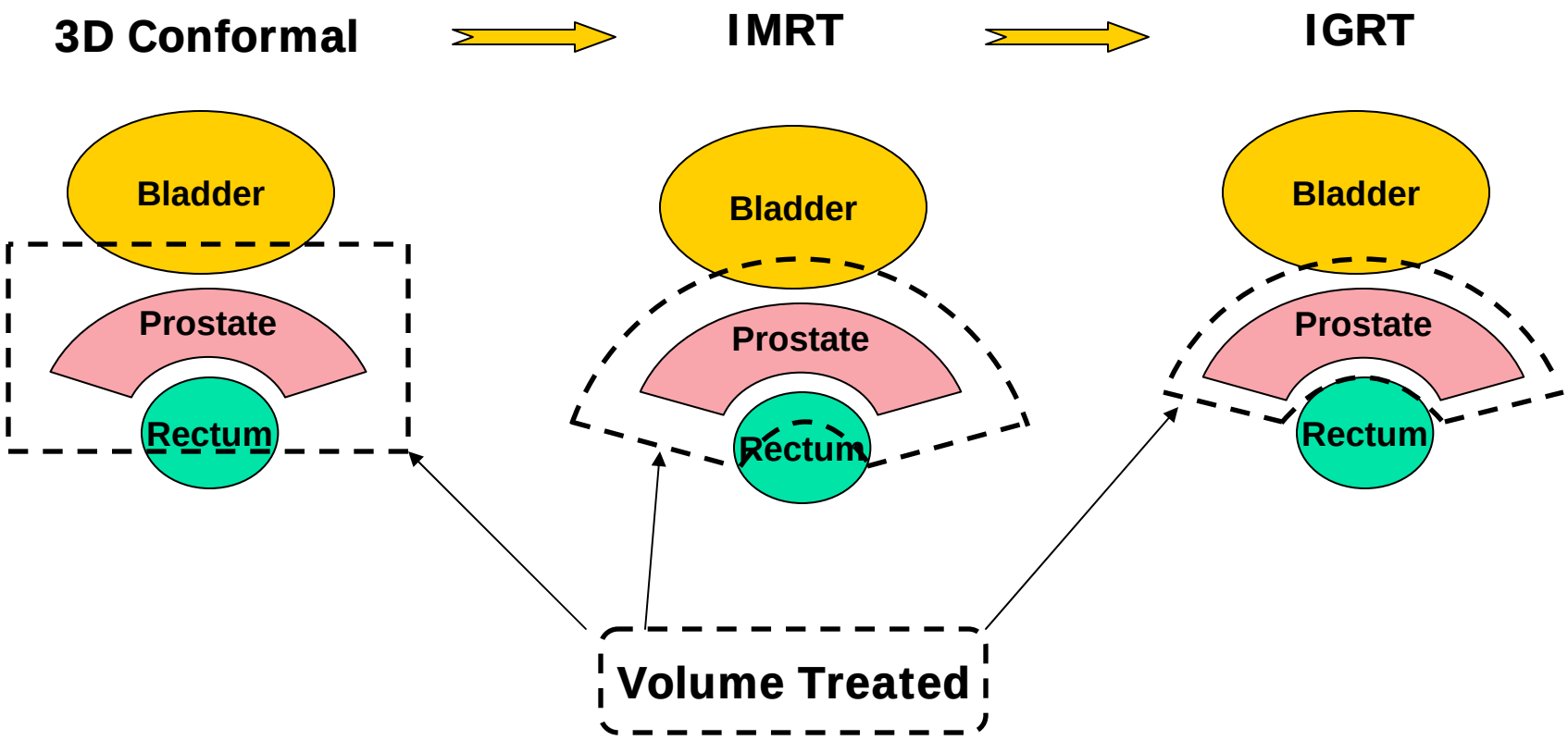
ITV → Customized Target Volume



IGRT can Reduce Internal Margin, Setup Margin, and Margin to OAR



Reduce Treatment Margin



On Board Imager – Varian Trilogy

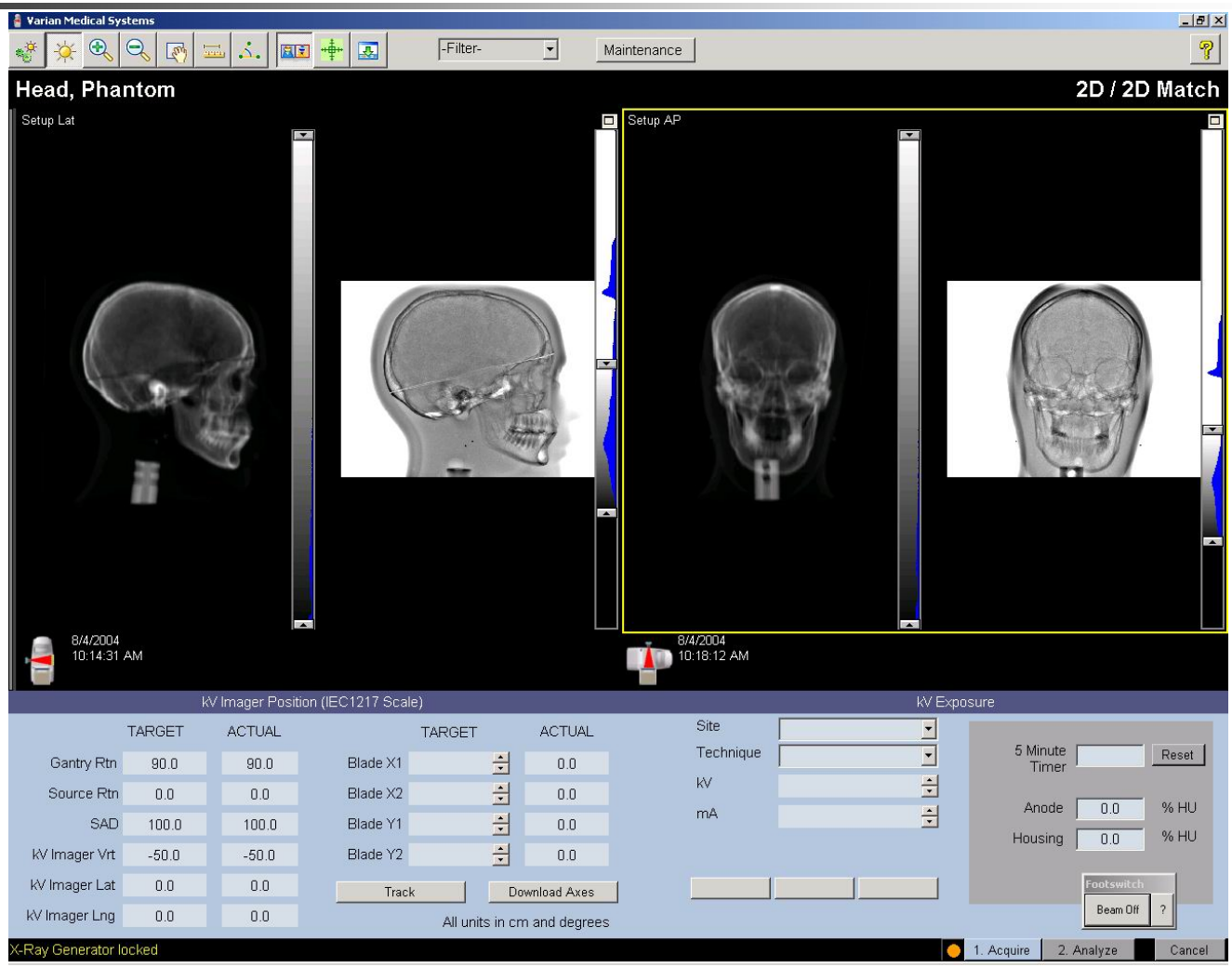
Image Matching

- 2D-2D matching of OBI images to DRRs
  - Anatomy matching
  - Implanted fiducials
- 3D-3D cone beam CT image match to treatment planning CT images
  - Anatomy matching
  - Structure set alignment of GTV, CTV, PTV, or contoured structures to acquired image

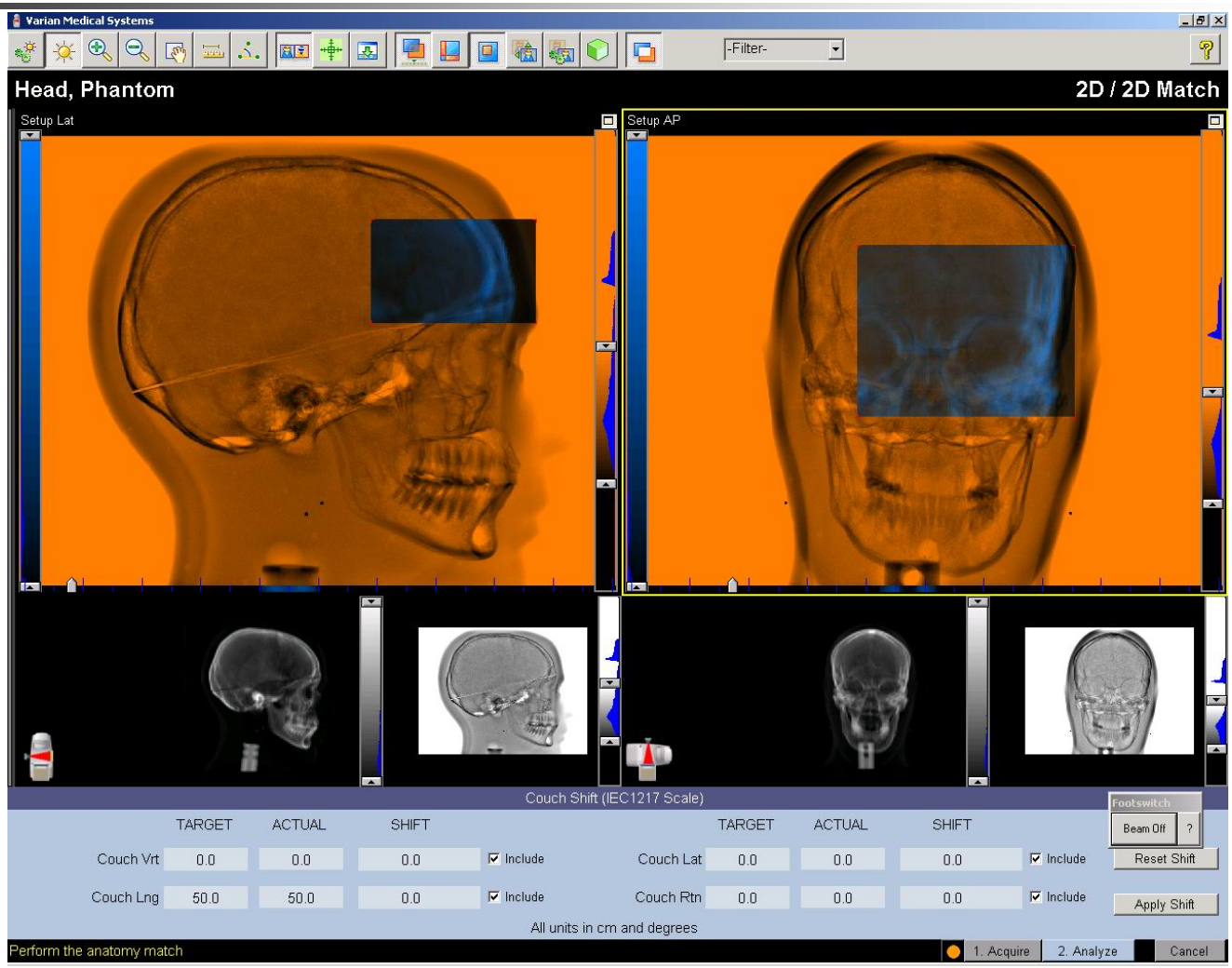
2D-2D Image Match

- Orthogonal pair of images
  - AP and Lateral – Brain, H&N
  - Orthogonal Oblique's - Pelvis

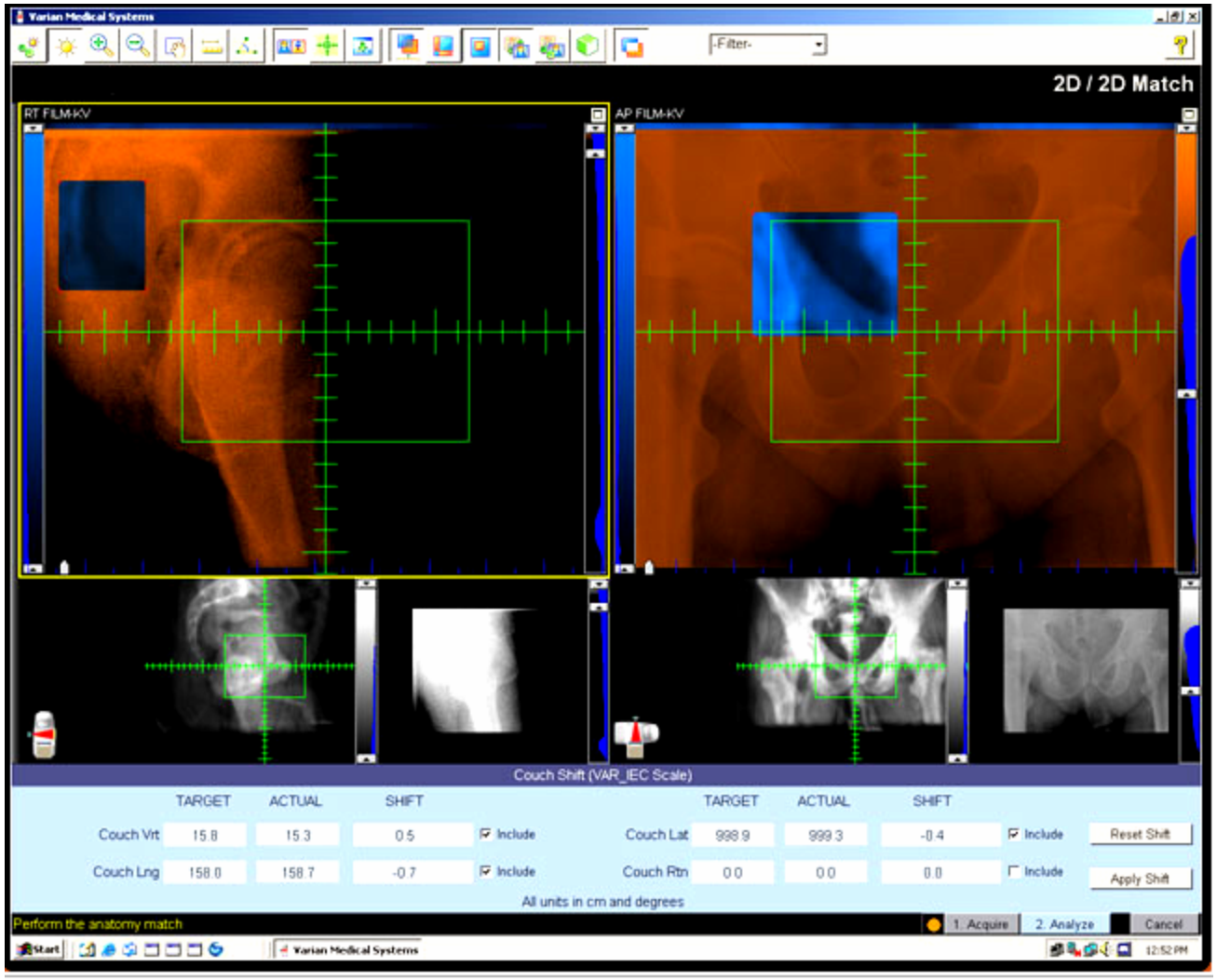
Brain: 2D-2D Anatomy Match



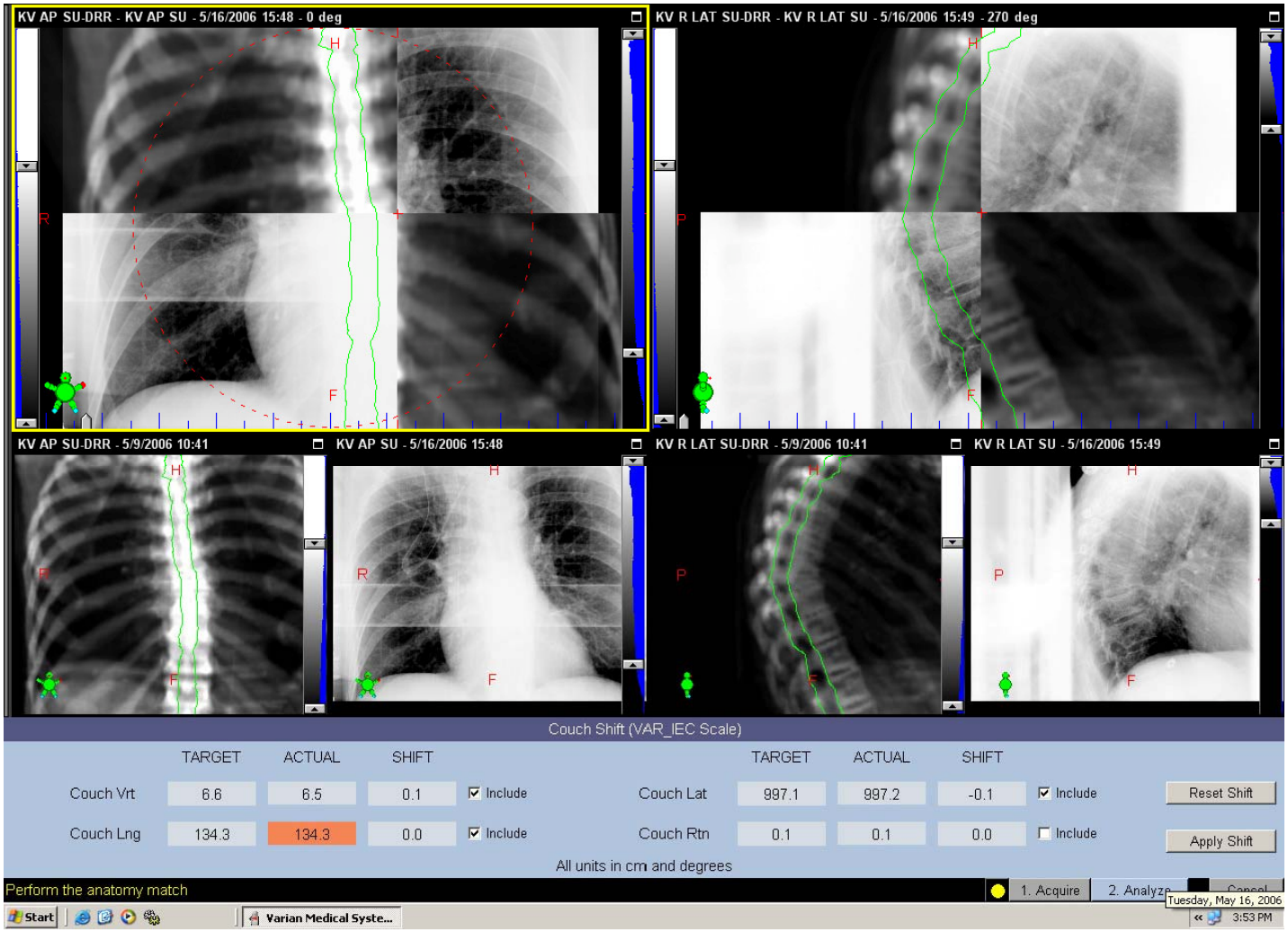
Brain: 2D-2D Anatomy Match



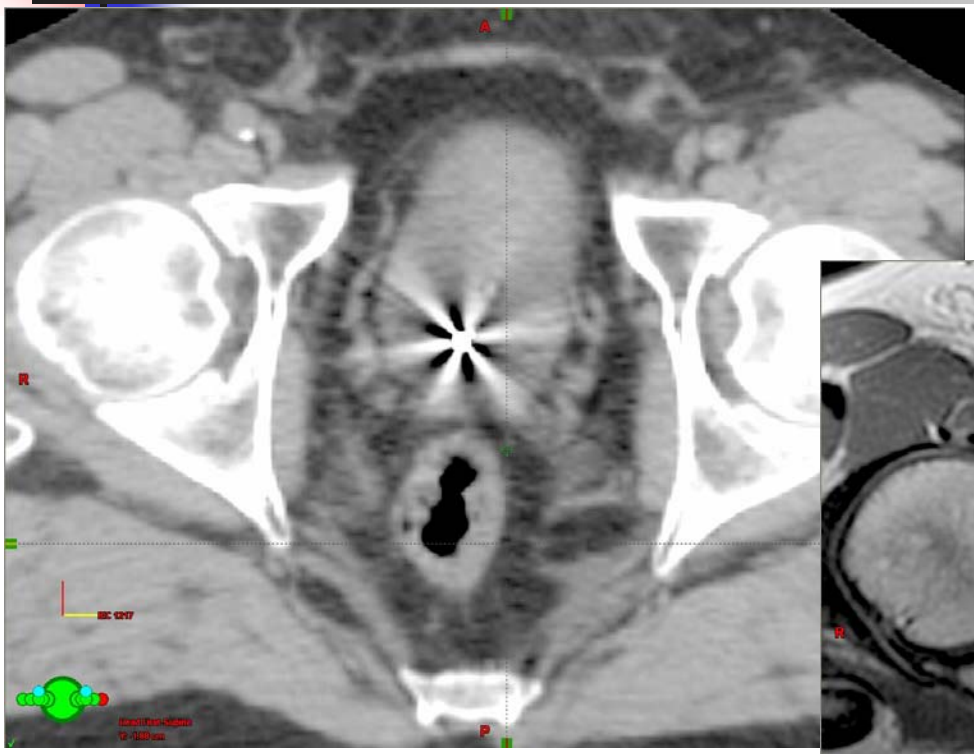
Pelvis: 2D-2D Anatomy Match



Spine: 2D-2D Anatomy Match



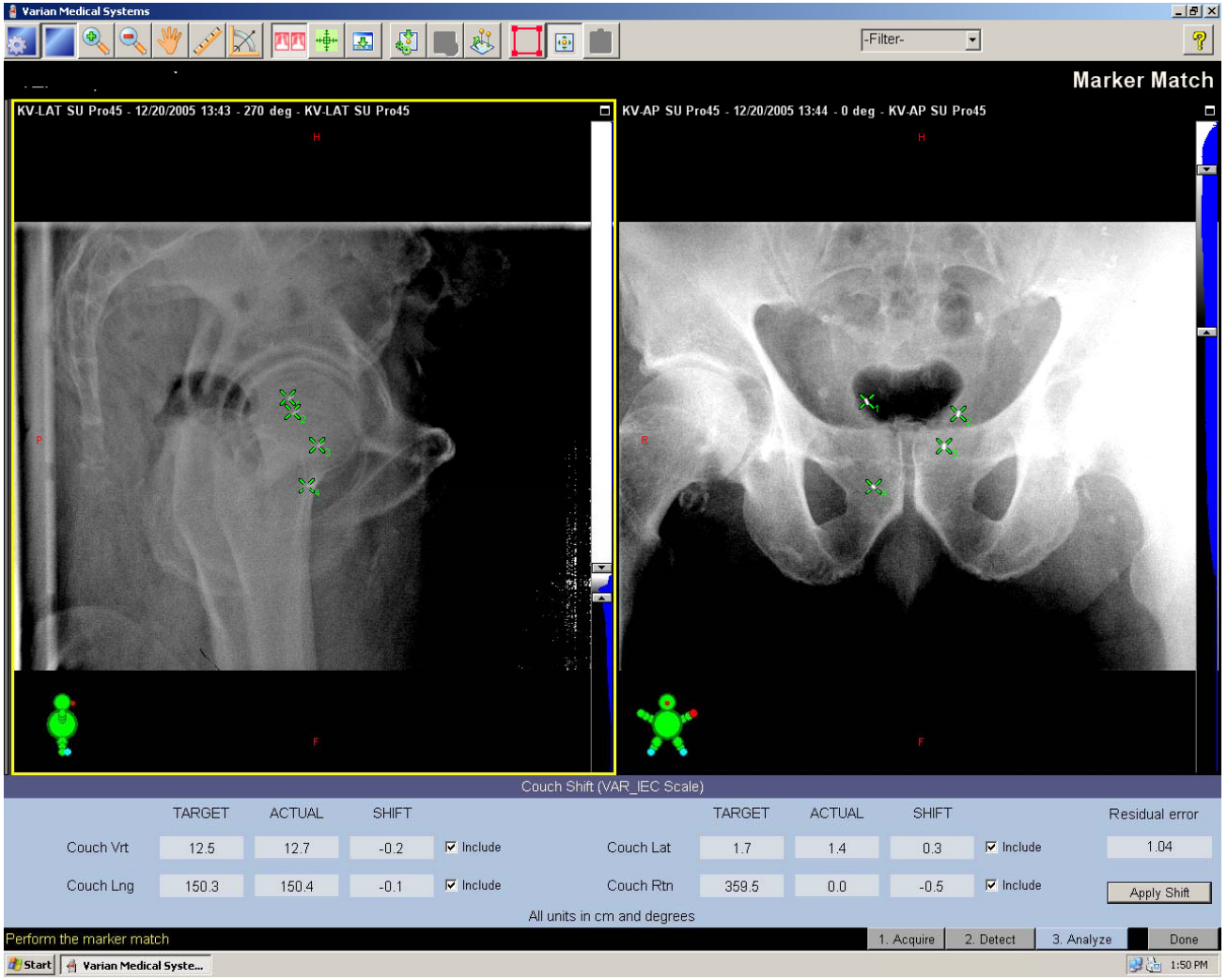
Prostate with Implanted Markers



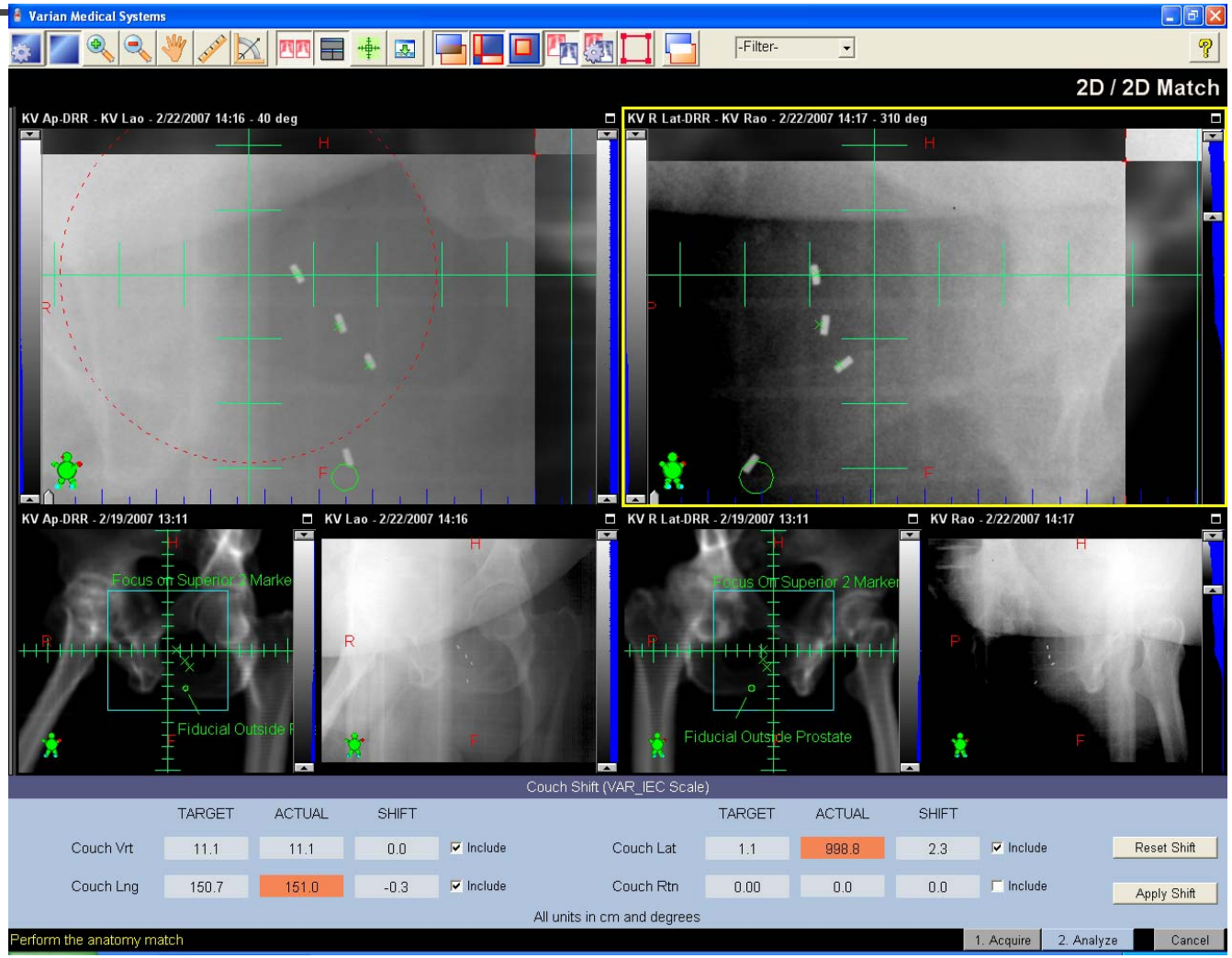
CT

MRI

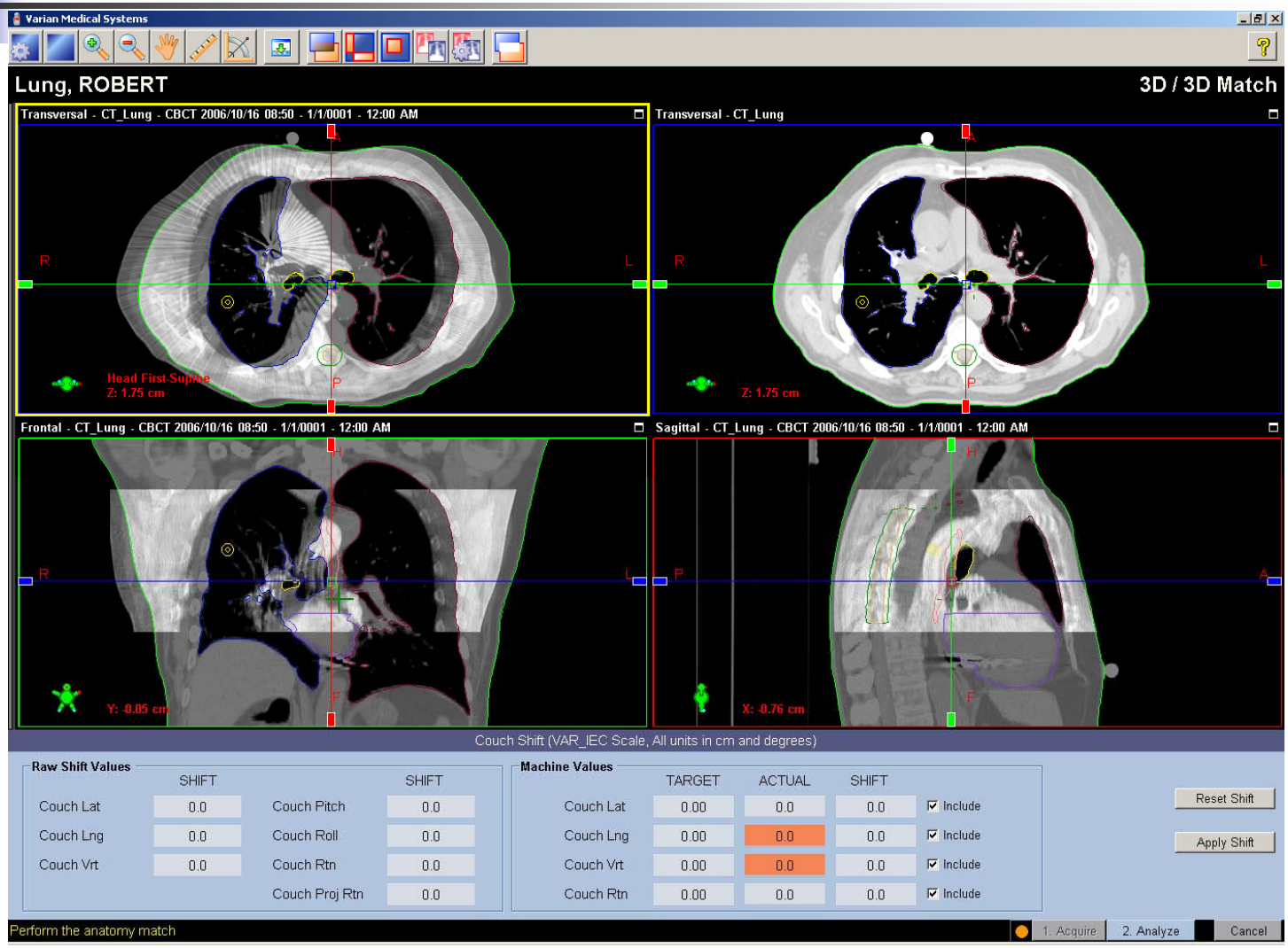
Prostate Implanted Marker Match



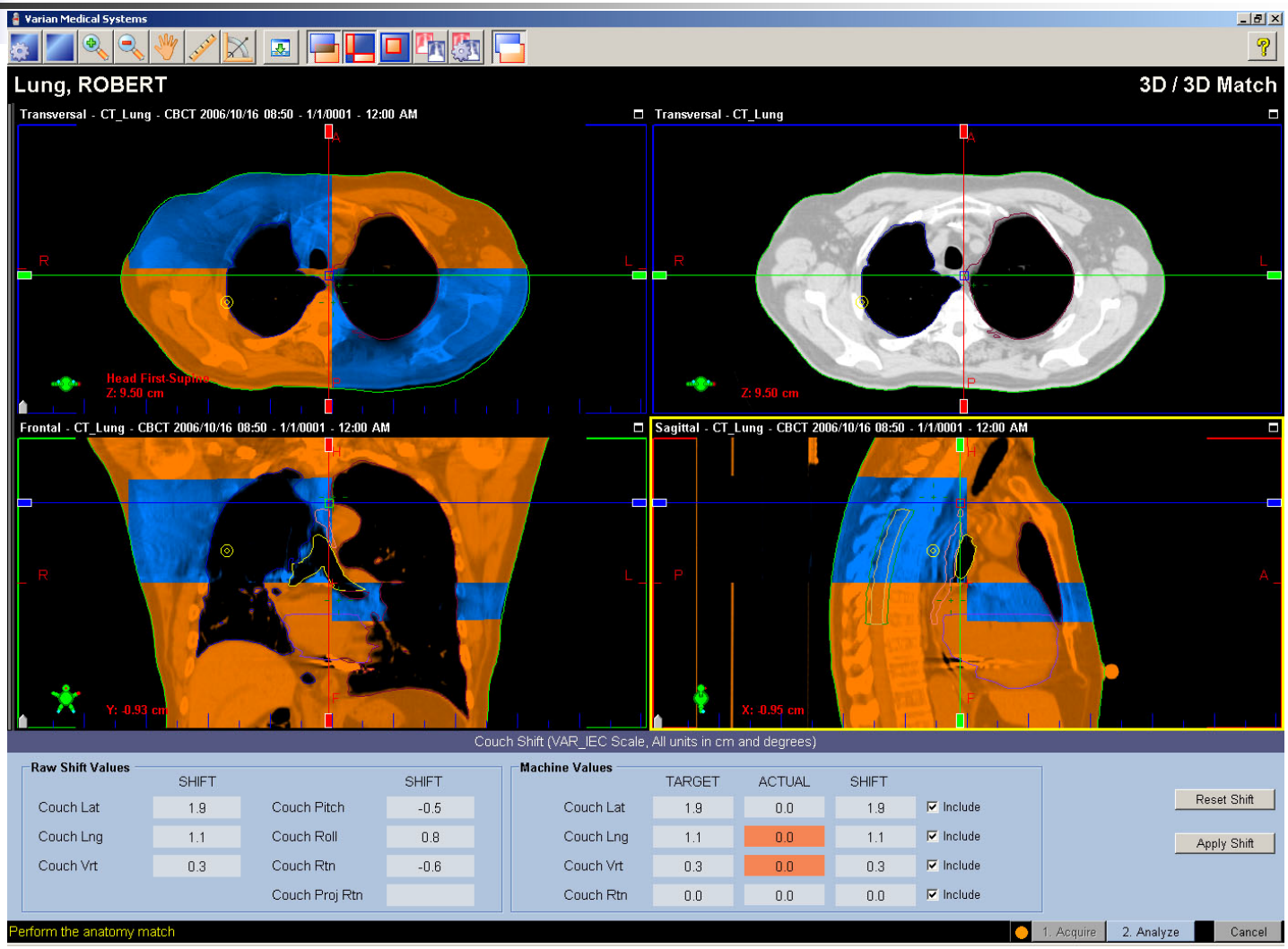
Prostate Implanted Marker Match



Lung CBCT – before matching



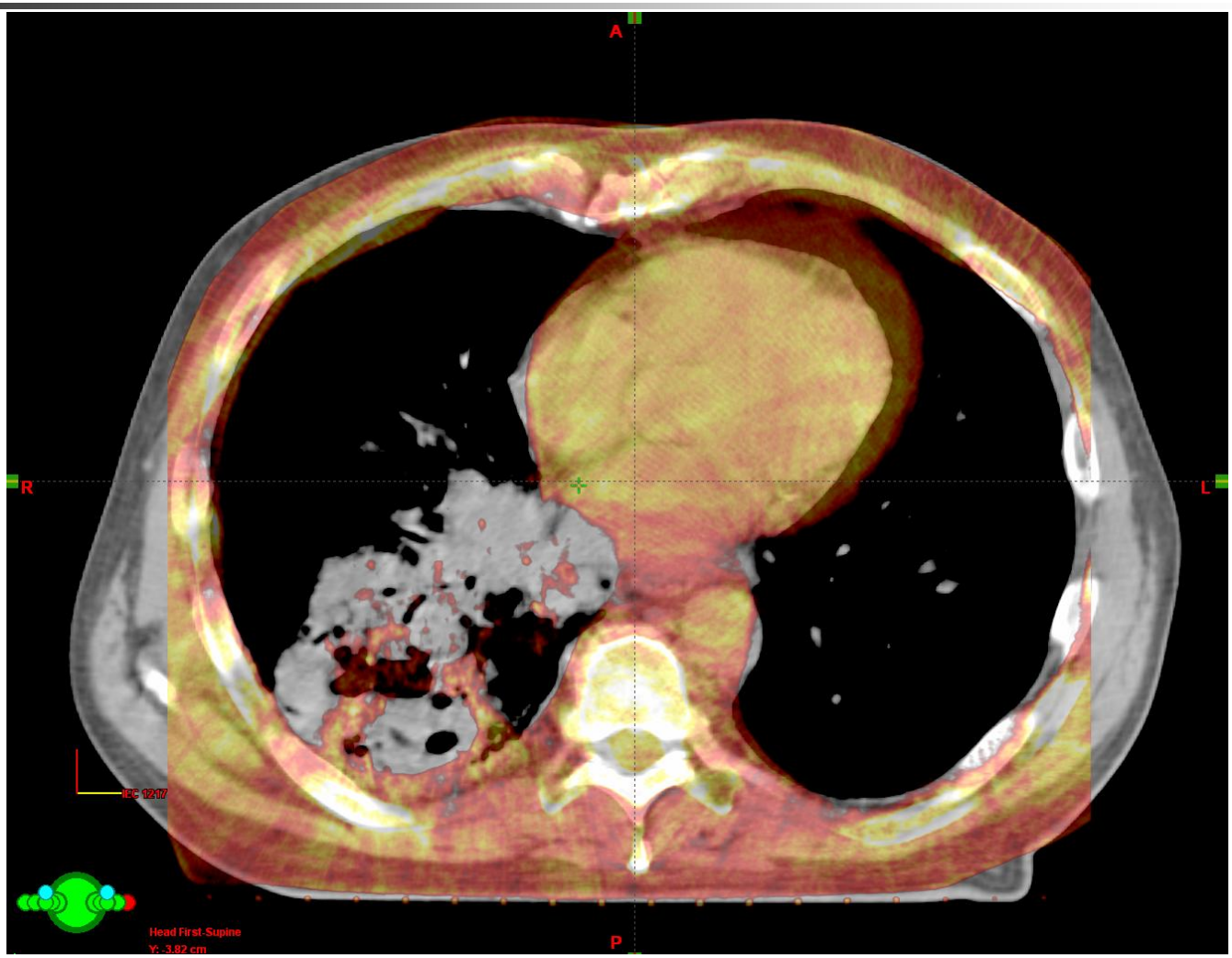
Lung CBCT – matched images



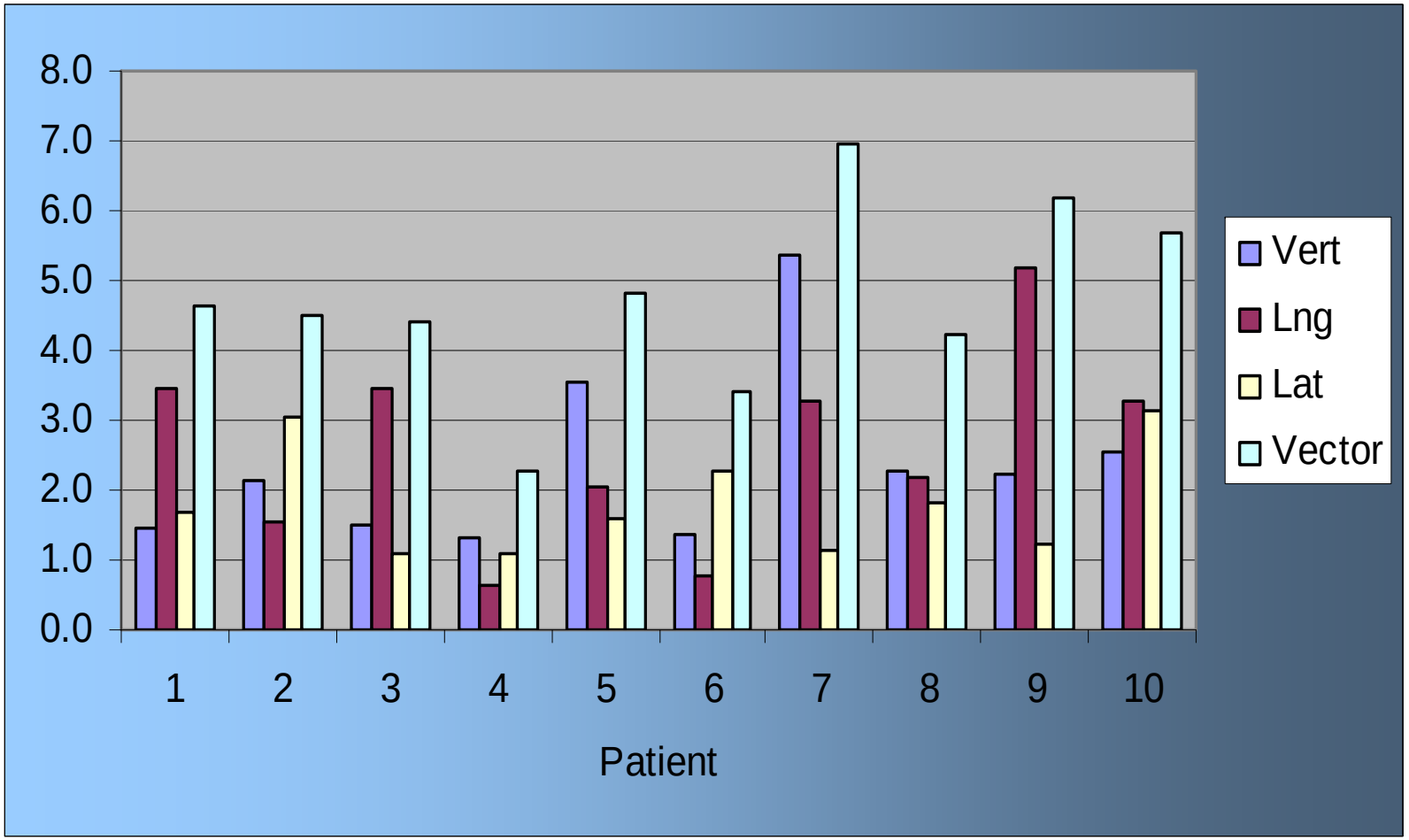
H&N CBCT 3D-3D Match

CBCT to Evaluate Tumor Response

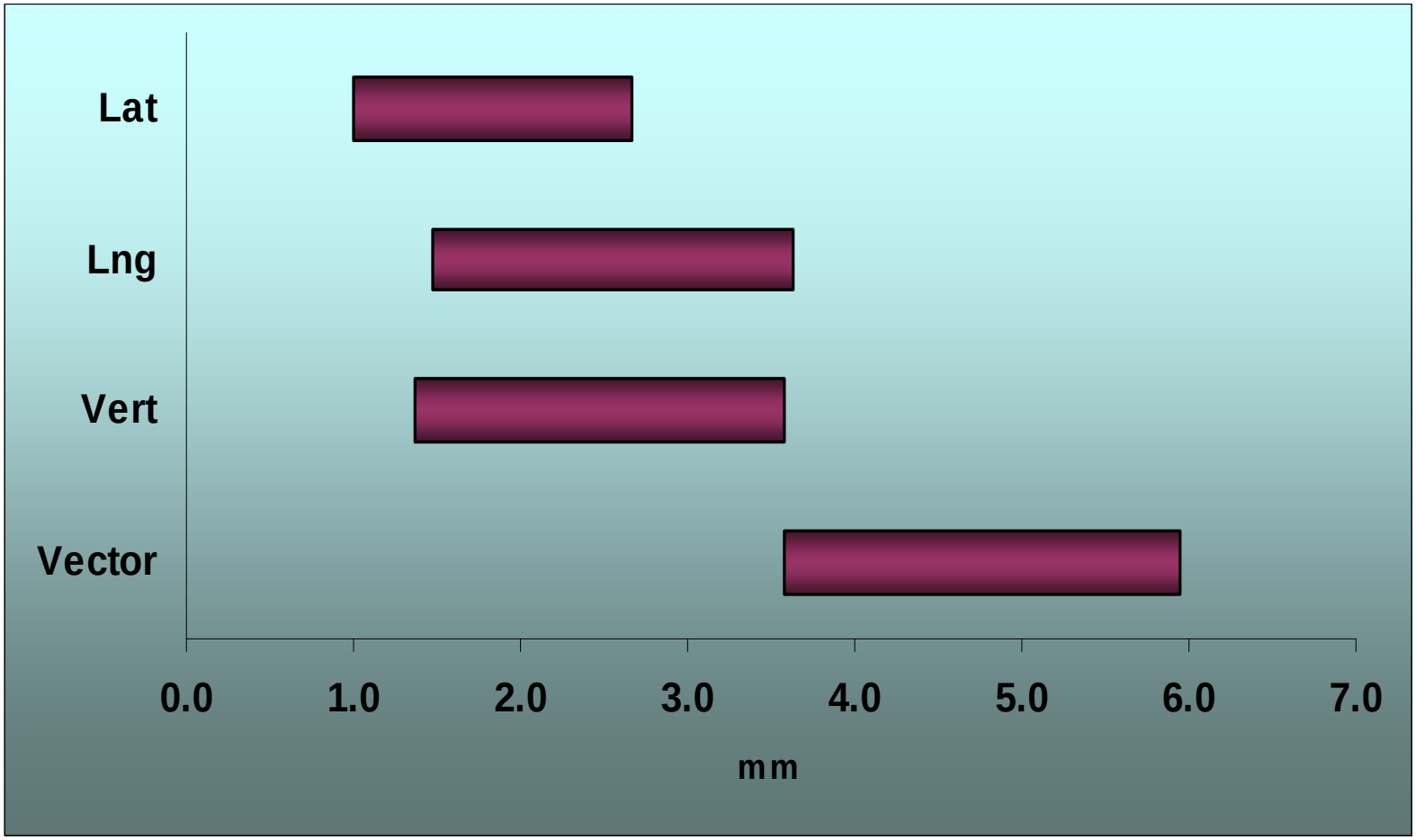
CBCT to Evaluate Tumor Response



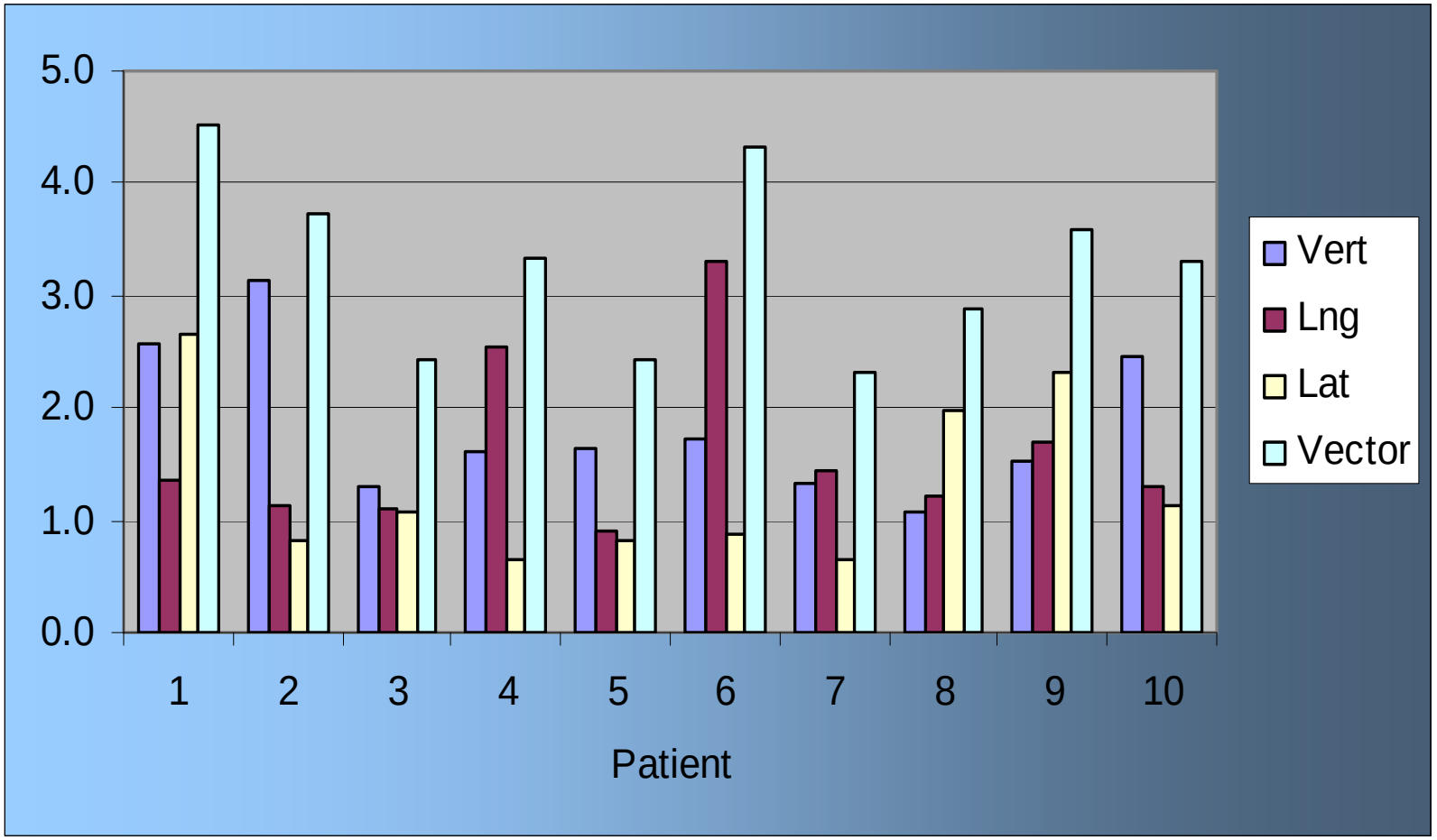
Average Shifts for Prostate



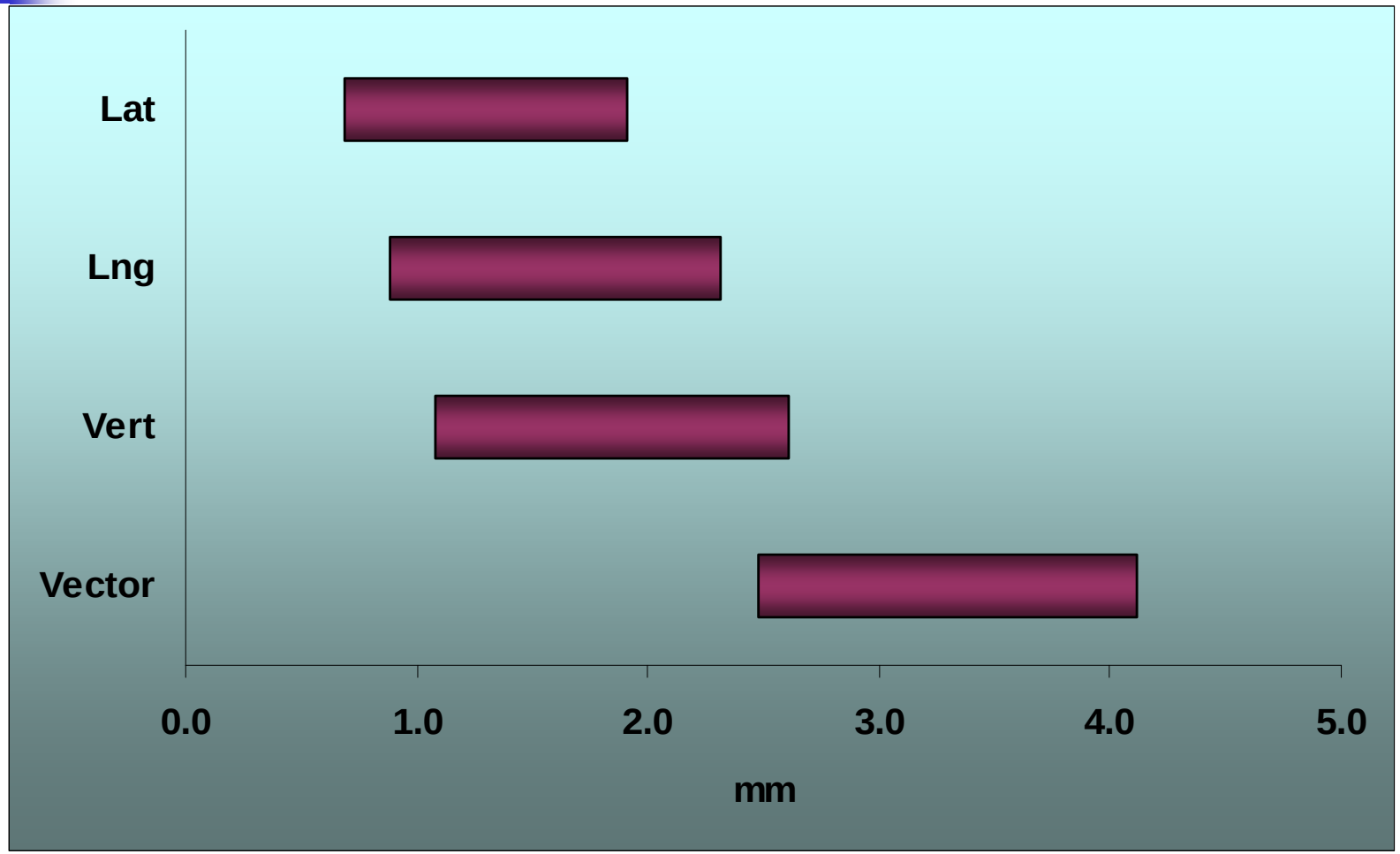
Average Shifts for All Prostate Patients



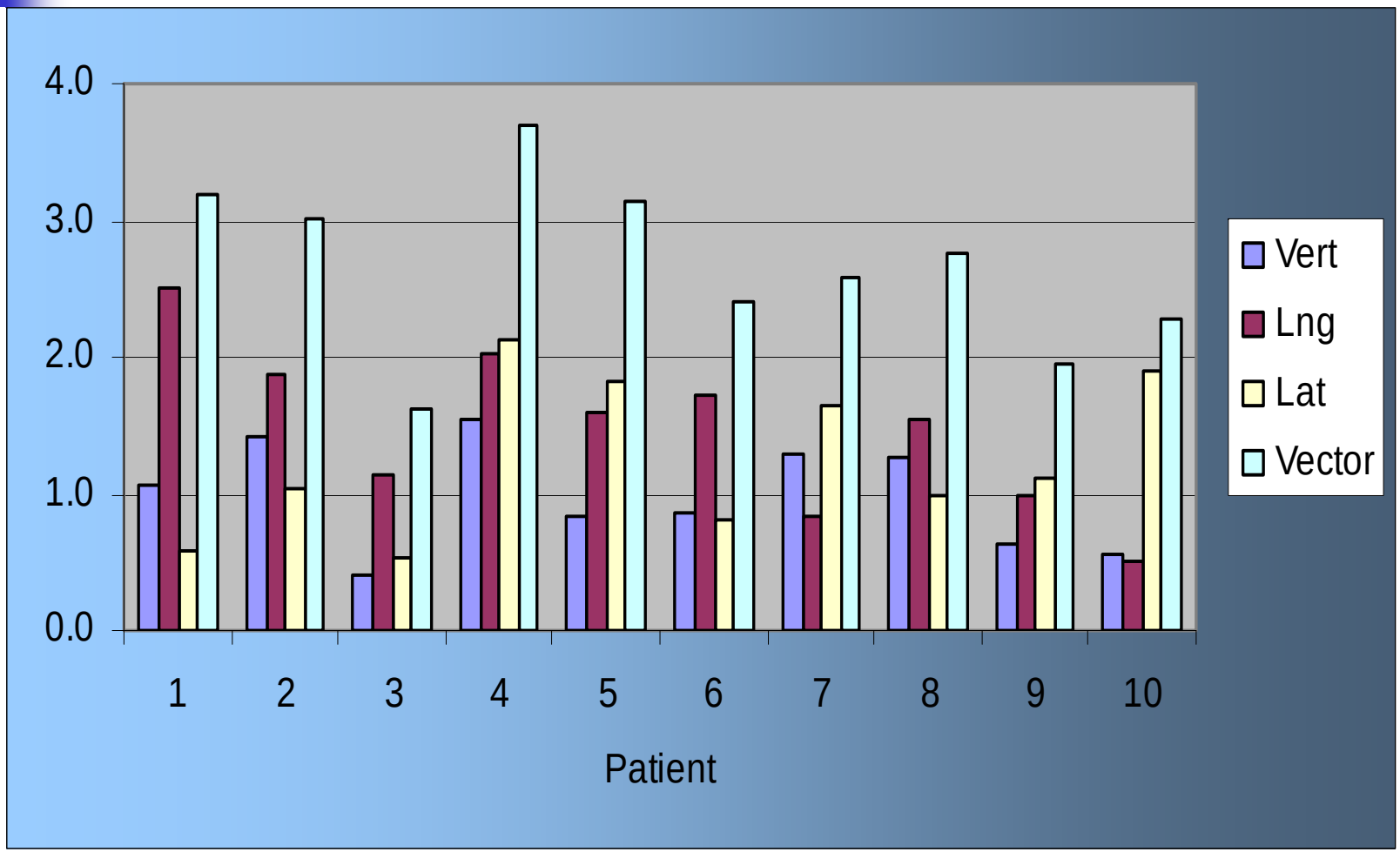
Average Shifts for GBM



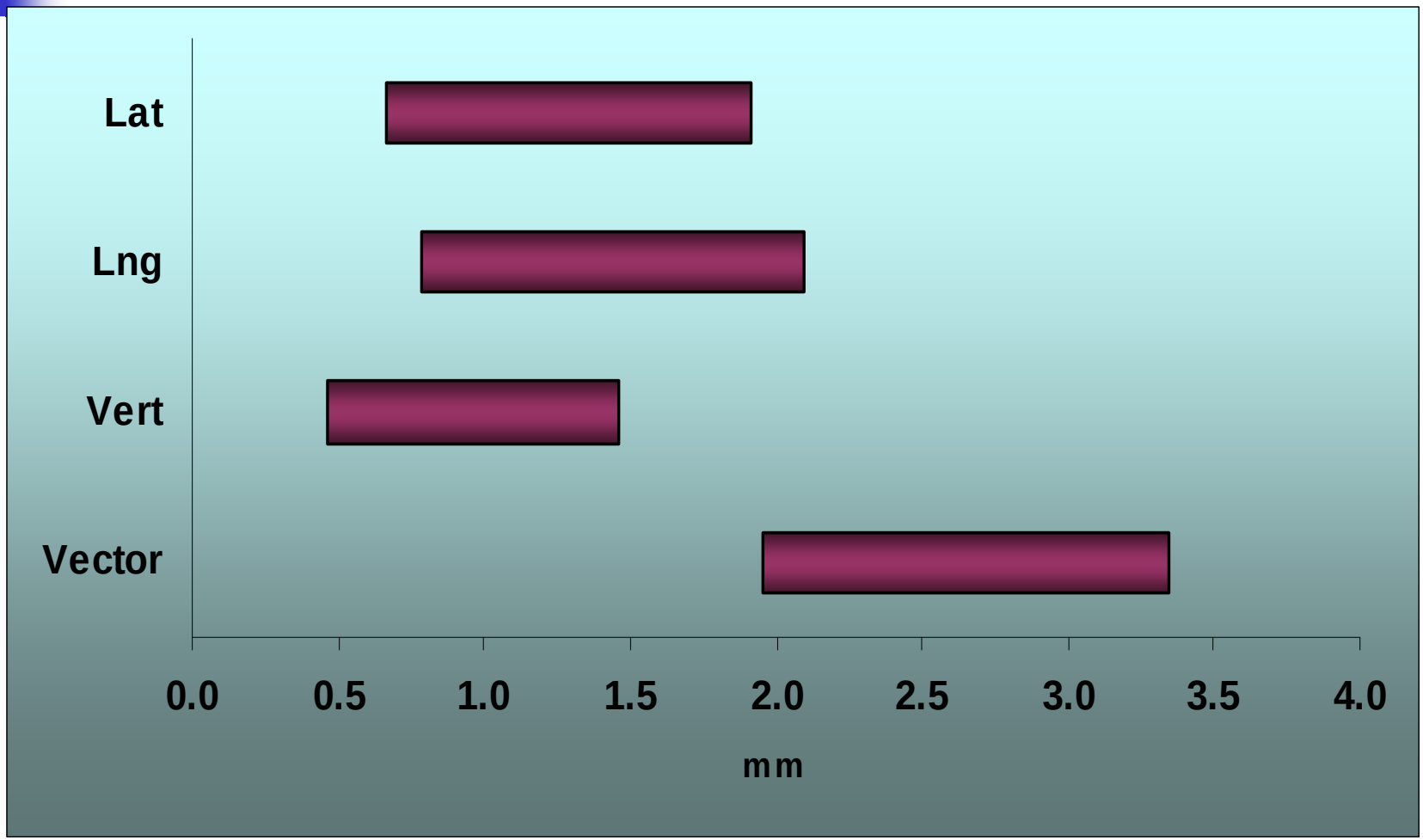
Average Shifts for All GBM Patients



Average Shifts for H&N



Average Shifts for All H&N Patients



Average Shifts + 2 X Standard Deviation

Site	Vert	Lng	Lat	Vector
Prostate	6.9	6.9	5.2	9.5
Prostate Bed	5.4	6.1	4.6	7.9
Brain (GBM)	4.9	4.5	3.7	6.6
H&N	3.0	4.1	3.8	5.4
Lung	5.8	10.1	6.1	11.3
Pancreas	8.6	10.5	6.9	13.3

IGRT Action Levels – Require Physician/Physics Review

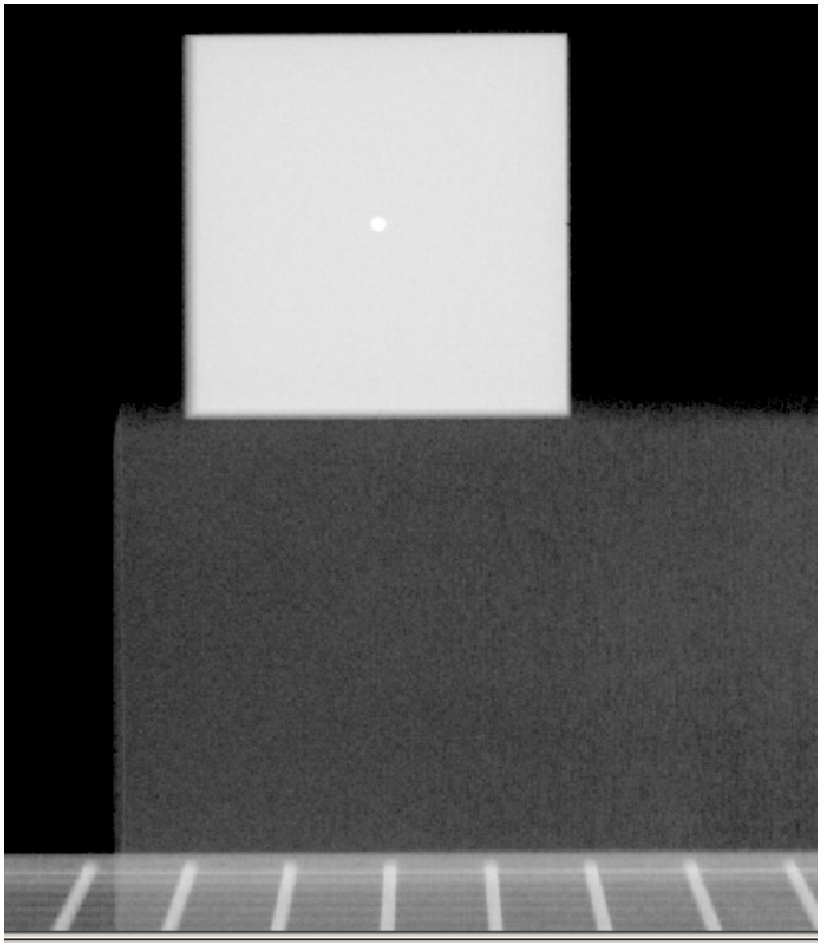
Prostate (Fiducials or Clips)	7 mm
GBM	5 mm
H&N	4 mm
Other (Lung, Pancreas, etc)	10 mm

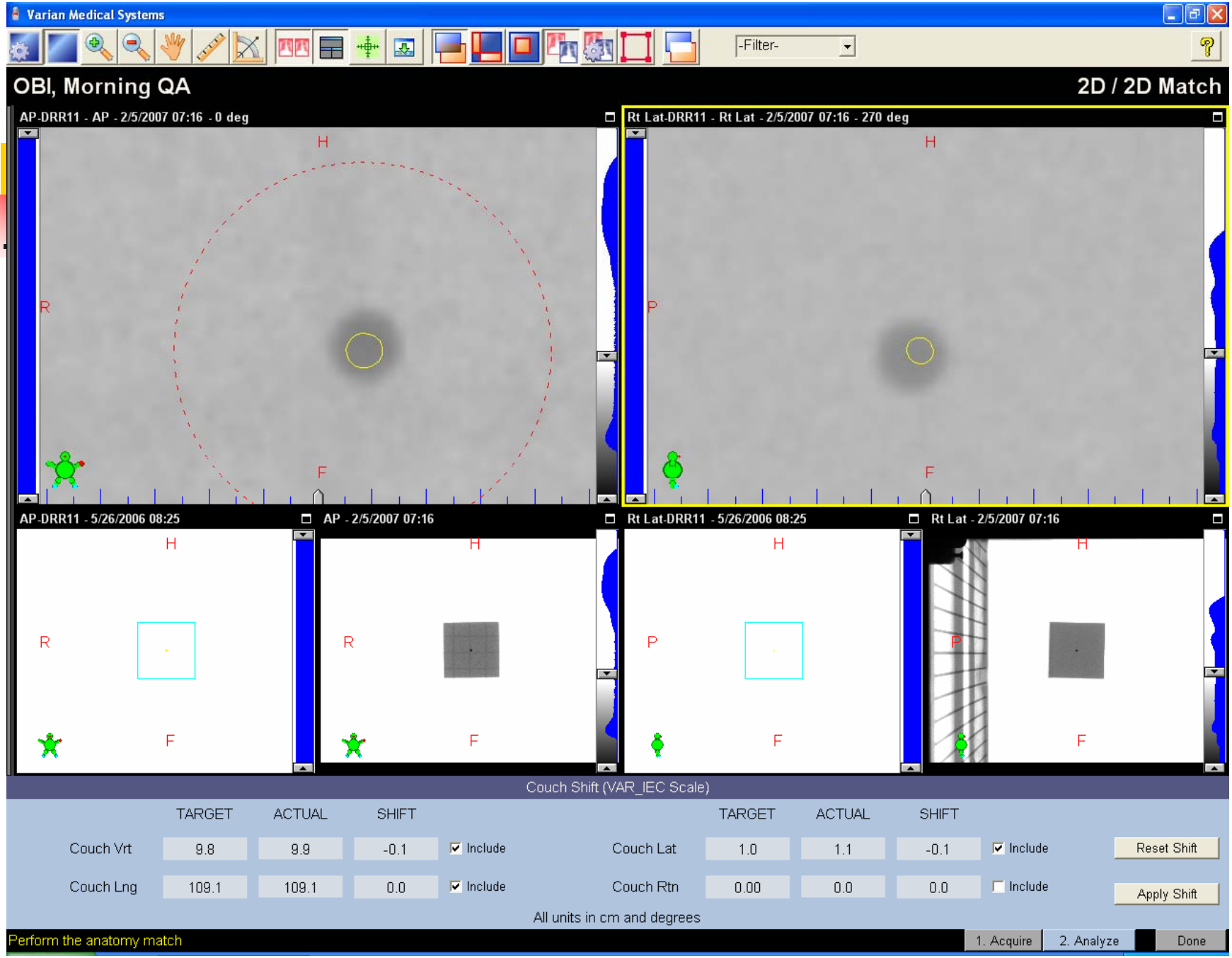
Quality Assurance

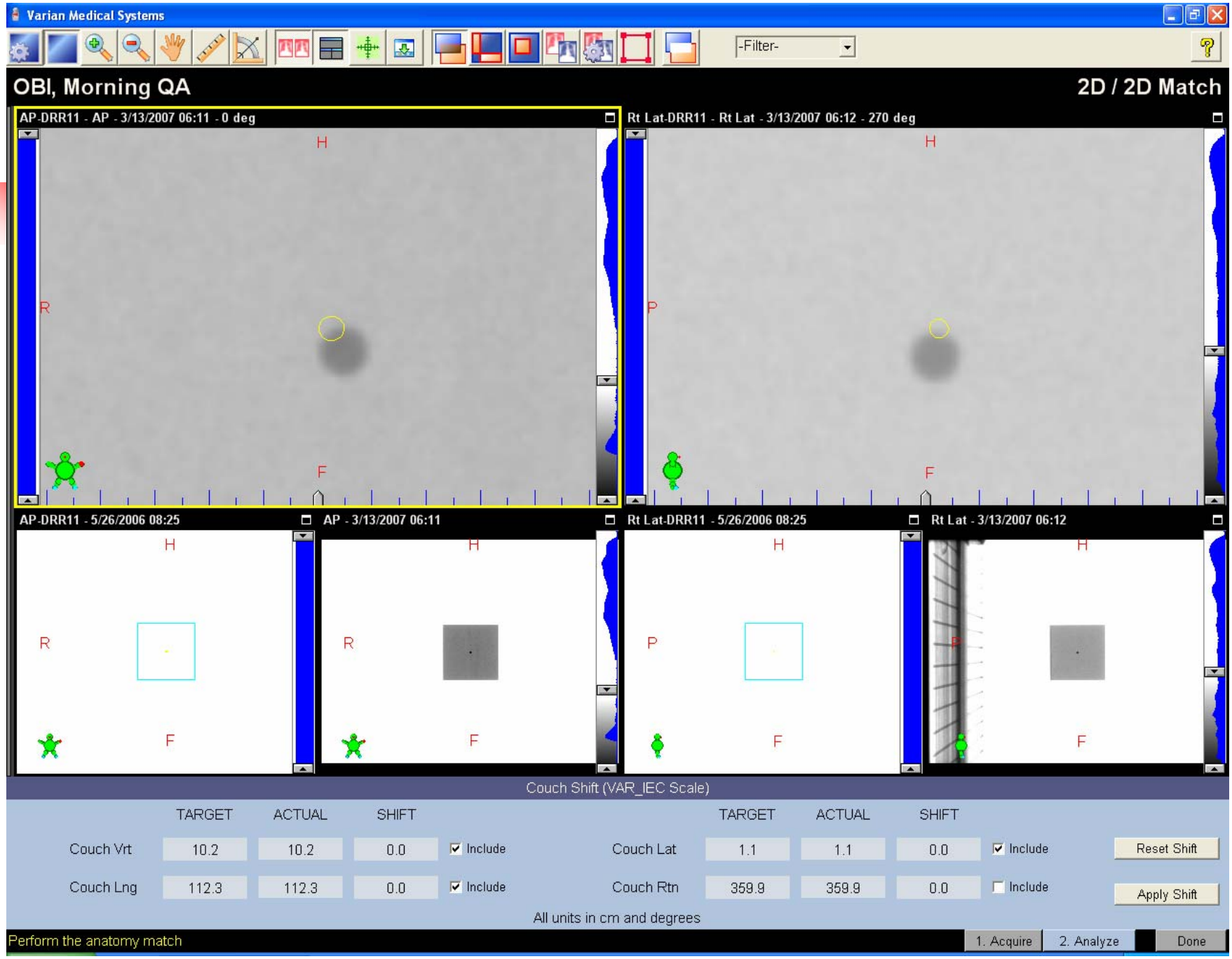
- Daily QA
  - Couch shifts with KV images
- Monthly QA
  - KV image – isocenter alignment
- Annual
  - CBCT – isocenter alignment

Daily QA

- Couch Shift Accuracy with KV Imaging

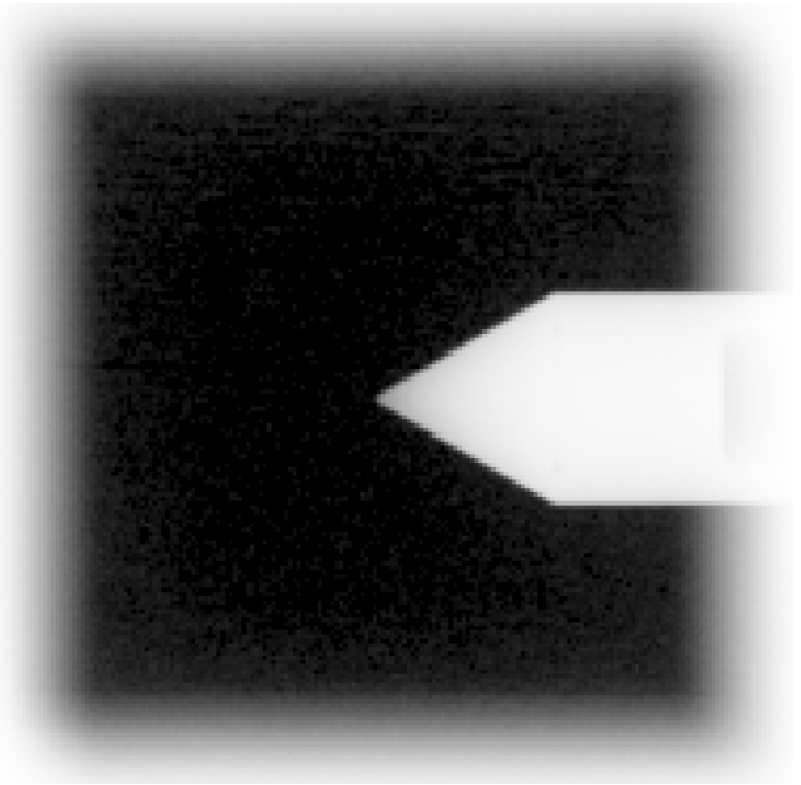



Varian Medical Systems
-Filter-
OBI, Morning QA
2D / 2D Match
AP-DRR11 - AP - 2/5/2007 07:16 - 0 deg
Rt Lat-DRR11 - Rt Lat - 2/5/2007 07:16 - 270 deg
AP-DRR11 - 5/26/2006 08:25
AP - 2/5/2007 07:16
Rt Lat-DRR11 - 5/26/2006 08:25
Rt Lat - 2/5/2007 07:16
H
R
P
F
Couch Shift (VAR_IEC Scale)
TARGET
ACTUAL
SHIFT
Couch Vrt
9.8
9.9
-0.1
Include
Couch Lng
109.1
109.1
0.0
Include
Couch Lat
1.0
1.1
-0.1
Include
Couch Rtn
0.00
0.0
0.0
Include
Reset Shift
Apply Shift
All units in cm and degrees
Perform the anatomy match
1. Acquire
2. Analyze
Done

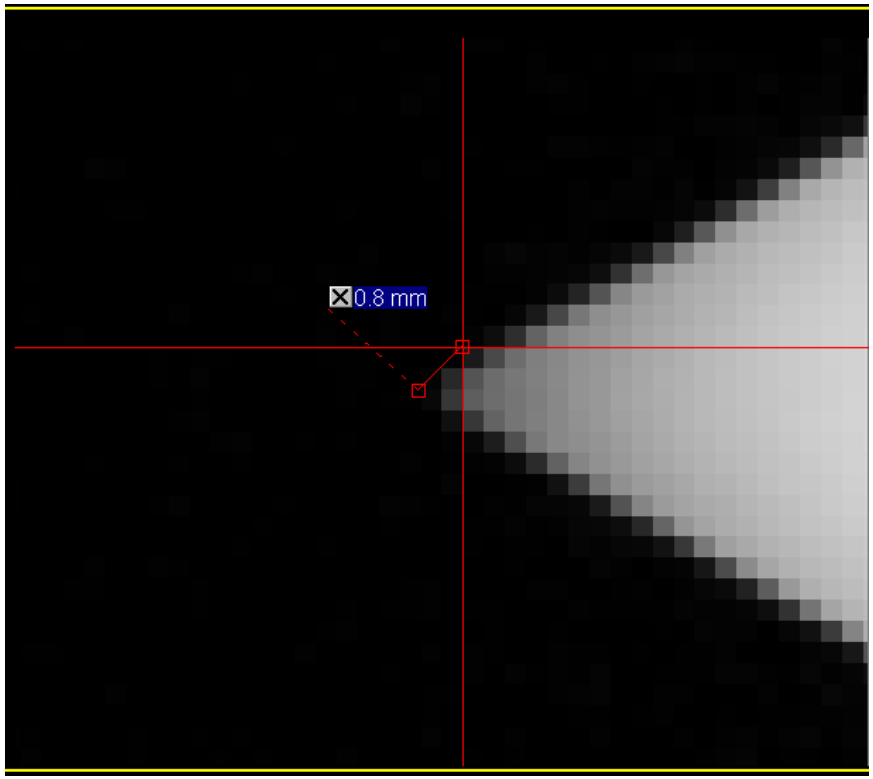

Varian Medical Systems
-Filter-
OBI, Morning QA
2D / 2D Match
AP-DRR11 - AP - 3/13/2007 06:11 - 0 deg
Rt Lat-DRR11 - Rt Lat - 3/13/2007 06:12 - 270 deg
AP-DRR11 - 5/26/2006 08:25
AP - 3/13/2007 06:11
Rt Lat-DRR11 - 5/26/2006 08:25
Rt Lat - 3/13/2007 06:12
Couch Shift (VAR_IEC Scale)
TARGET ACTUAL SHIFT
TARGET ACTUAL SHIFT
Couch Vrt 10.2 10.2 0.0 Include
Couch Lat 1.1 1.1 0.0 Include
Reset Shift
Couch Lng 112.3 112.3 0.0 Include
Couch Rtn 359.9 359.9 0.0 Include
Apply Shift
All units in cm and degrees
Perform the anatomy match
1. Acquire
2. Analyze
Done

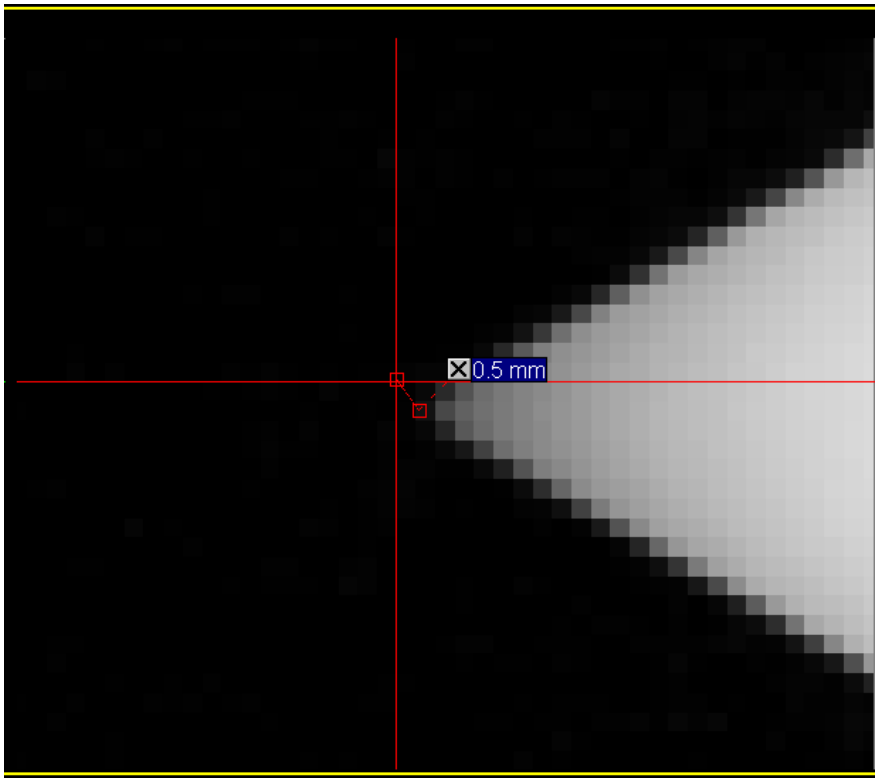
Monthly QA

- KV Image -
  Isocenter Alignment



KV Image – Isocenter Alignment





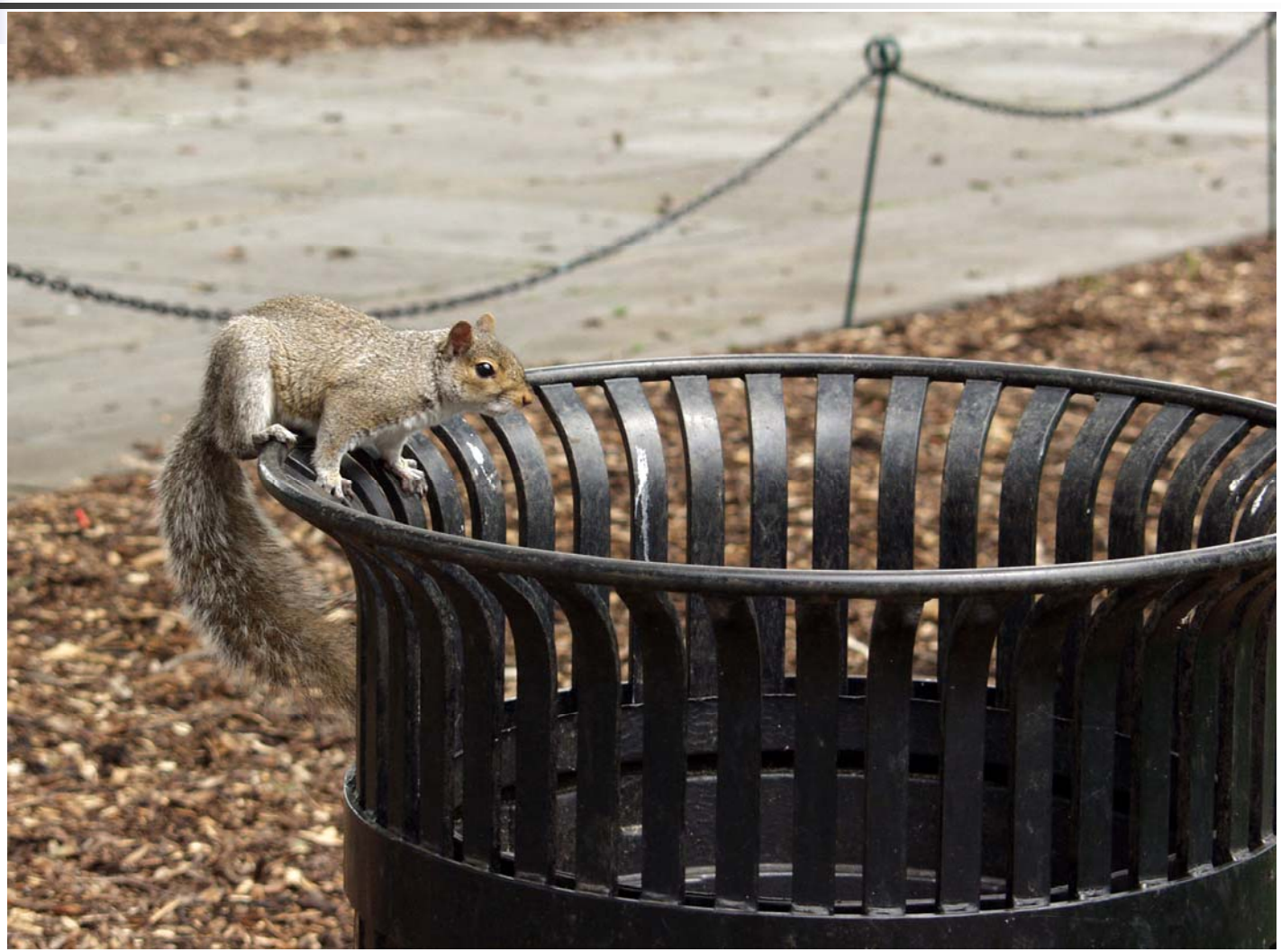
OBI - Some Limitations

- CT resolution and quality of DRR's are limiting factors
- Fiducial artifacts on CT images
- Artifacts on CBCT due to organ motion
- Treatment couch can not tilt and spin

Conclusion

- PET/CT and 4DCT Simulations help us to
  - Delineate target volume and critical structure more accurately
  - Customize, often decrease, internal margin
- On Board Imaging gives us valuable tool to
  - Reduce setup error
  - Track inter-fractional target / organ motion
  - Reduce internal & setup margins
  - Track tumor response – Adaptive Therapy

Adaptive Radiation Therapy, or a Black Hole?



Acknowledgement

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Julie Gruben (Dosimetrist)

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Robert Foster (Dosimetrist)

Joy Coldebella (Lead Therapist)

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