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Respiratory Motion Management and Image Guidance in Lung Cancer Radiotherapy

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Leeds Cancer Centre

IGRT and Motion Management in Lung Cancer: Why?

- Lung Cancers are challenging to outline!
- Lung Cancers and Patients Move!
- Lung Cancers and Patients Change Shape!

Talk Outline

- Improving the Basics
- Pre Treatment
- On Treatment
  - Motion Management
  - Image Guided RT

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Improving the Basics!

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Starting with the Basics

- Lung Q/A Meeting @ SJIO
  - Weekly MDT meeting of Consultant Clinical Oncologists, Consultant Radiologists, Dosimetrists, Physicists, Radiographers and SpRs.
  - Review all radical/SABR contours and any difficult cases
  - Review all planned lung RT cases
  - Review any on treatment problems eg CBCT
  - Discuss any unexpected toxicity

Starting with the Basics

- Better 3D CRT
  - Correct for tissue heterogeneity!- NOT UK
  - Use Type B Model if available
    - Models than in a approximate way consider changes in lateral electron transport
  - Dedicated Lung Dosimetrist/Physicists
  - Use published dose limits for lungs and be prepared to accept acute toxicity.

Don’t be Nihilistic!!!

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Pre-Treatment-
Need Better Target Definition

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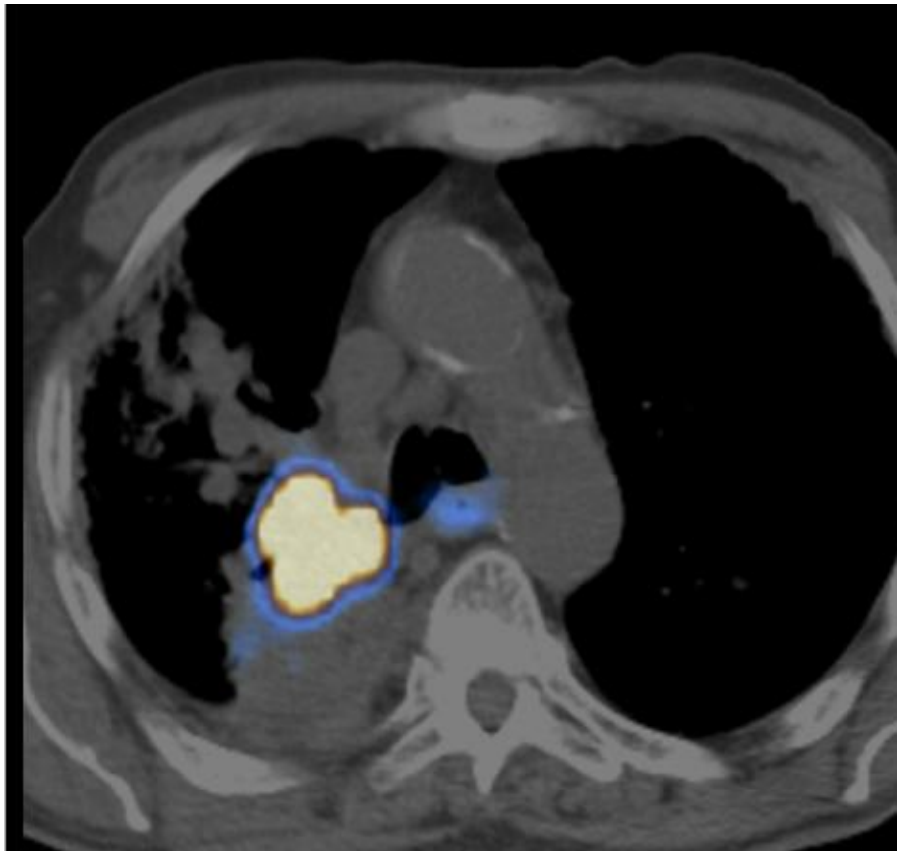
Identifying the GTV

- Many studies have shown considerable variation in GTV contouring between clinicians
- This can be improved by:
  - Training/Having a friendly radiologist!
  - Routine use of IV Contrast
  - PET/CT

Where's the tumour?

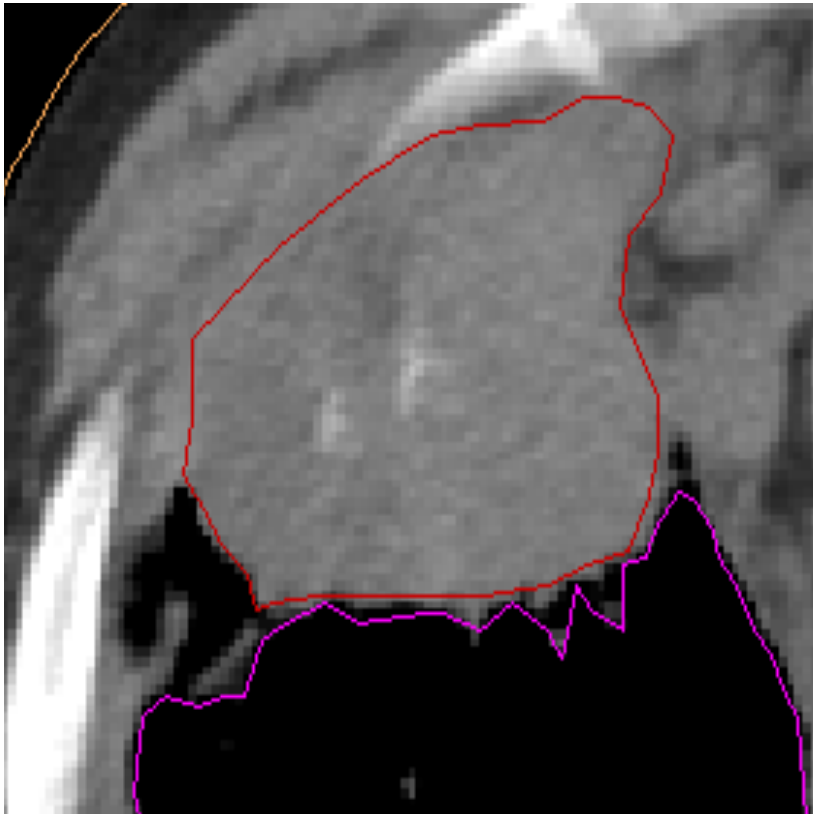
PET/CT Fusion

- Significant potential benefit by reducing RT volumes
- However:
  - False positive uptake in post-obstructive inflammation
  - Histological correlation of PET findings with pathology are lacking

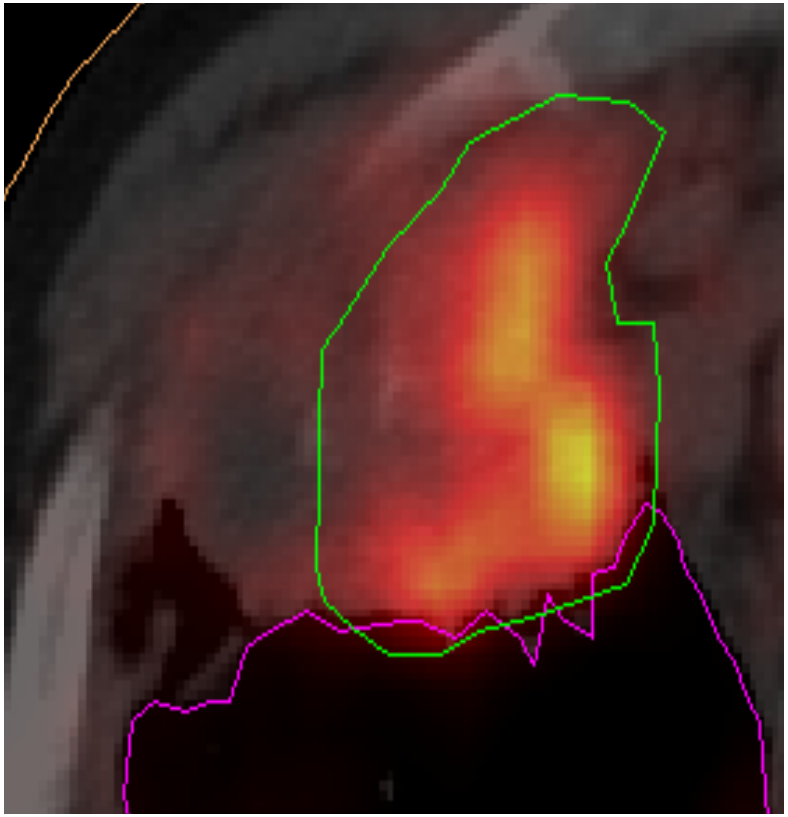


Nestle U, et al. Int J Radiat Oncol Biol Phys 1999;44:593-597

PET/CT Fusion



CT based GTV

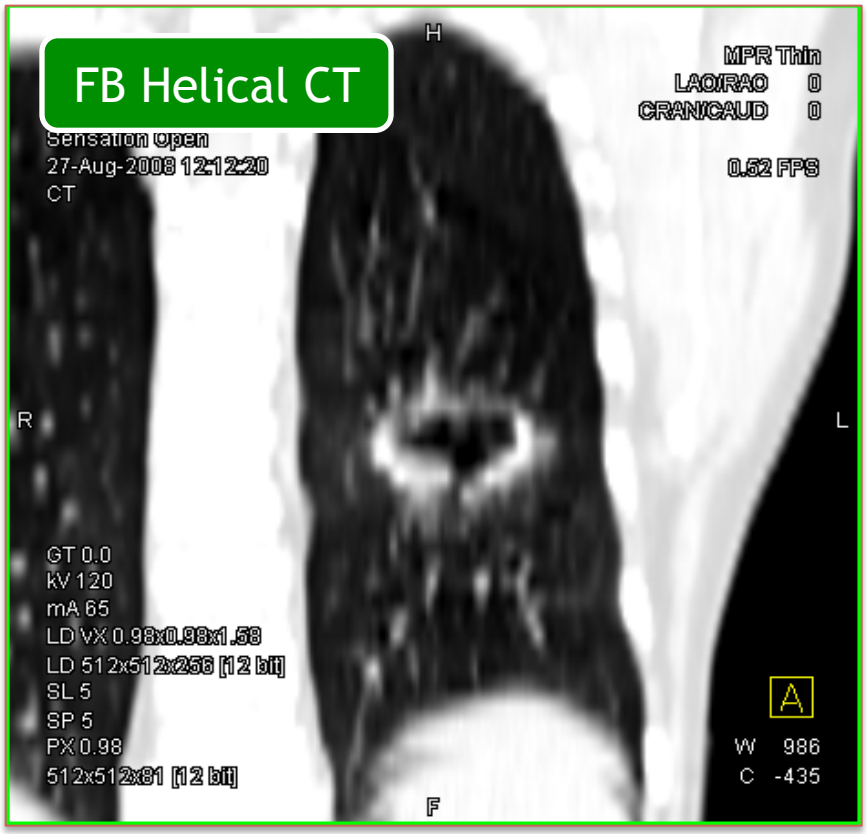


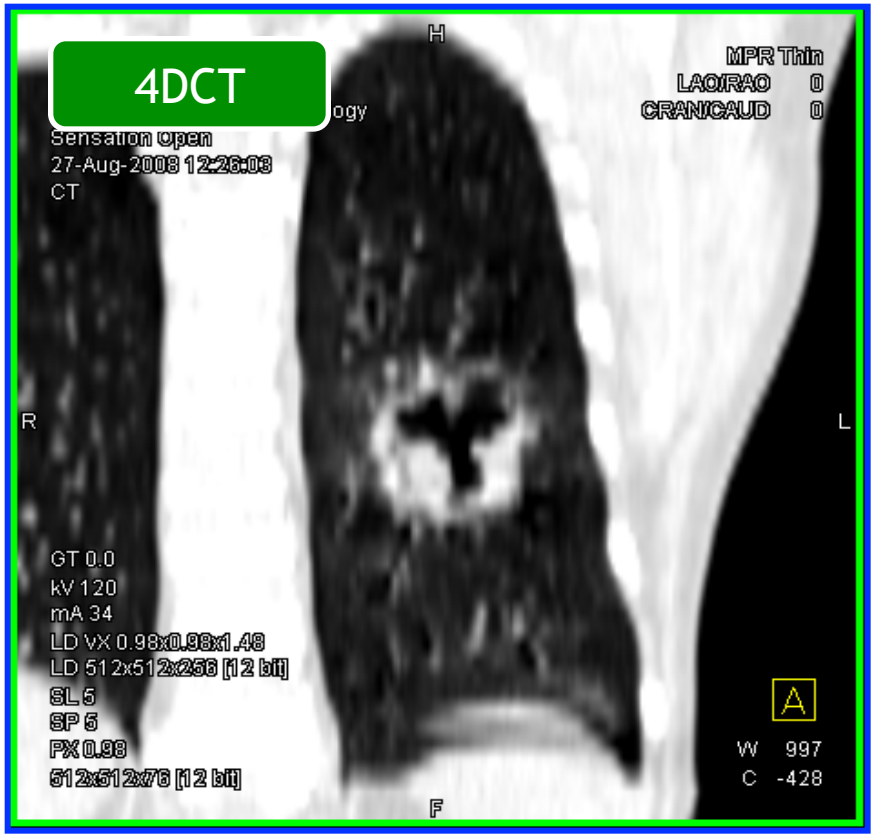
PET-CT based GTV

4D-CT Simulation

- 4DCT =4th dimension = time
- Basically uses an external surrogate of chest wall motion and links this to a long acquisition CT scan
- These images are then reconstructed into multiple CT datasets that represent the phases of breathing
- Why?
  - Standard free breathing helical scanning is inaccurate for moving targets
  - Allow quantification of tumour +/- OAR motion
    = PATIENT SPECIFIC MARGINS

Helical CT vs. 4DCT





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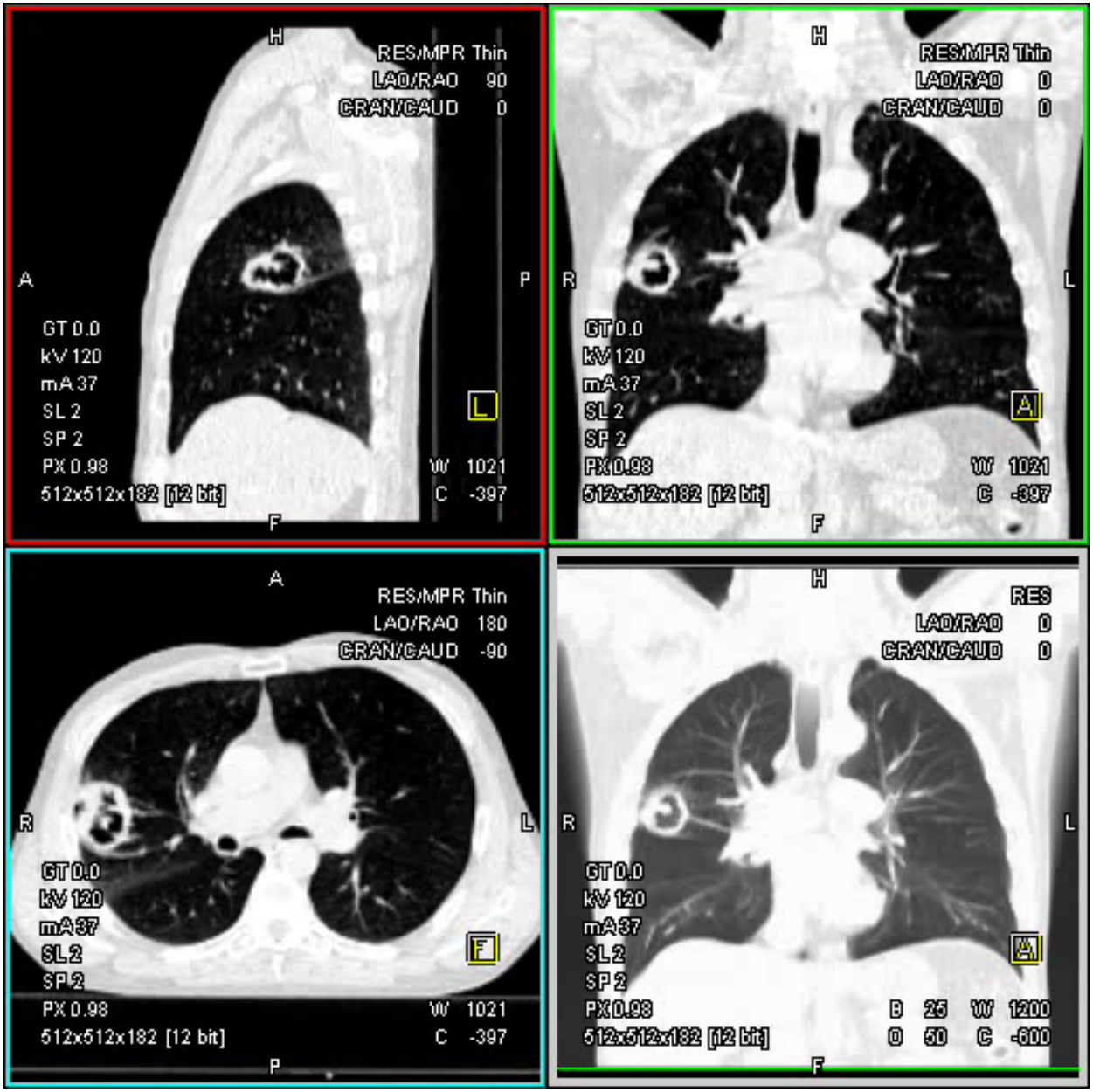
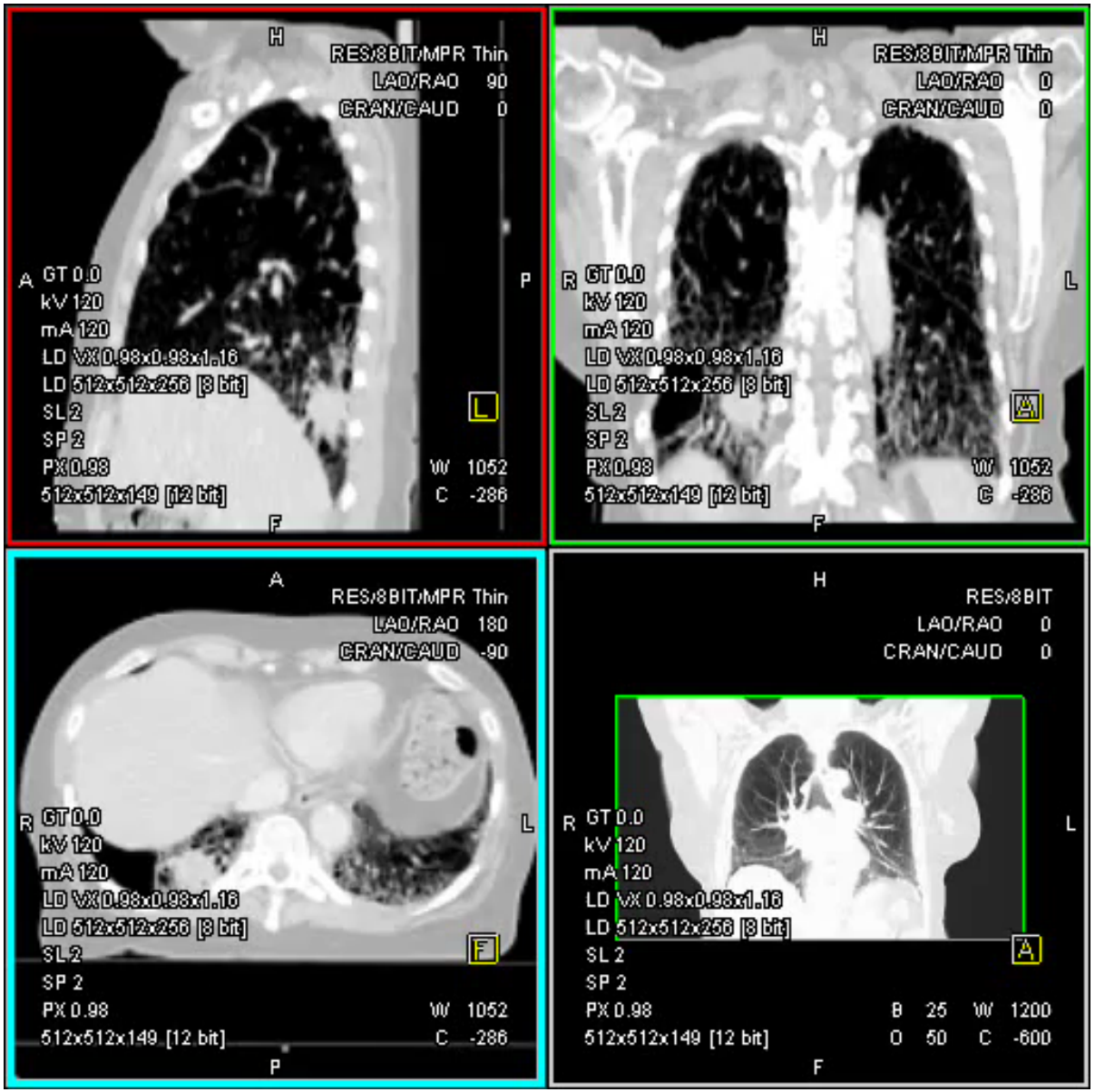
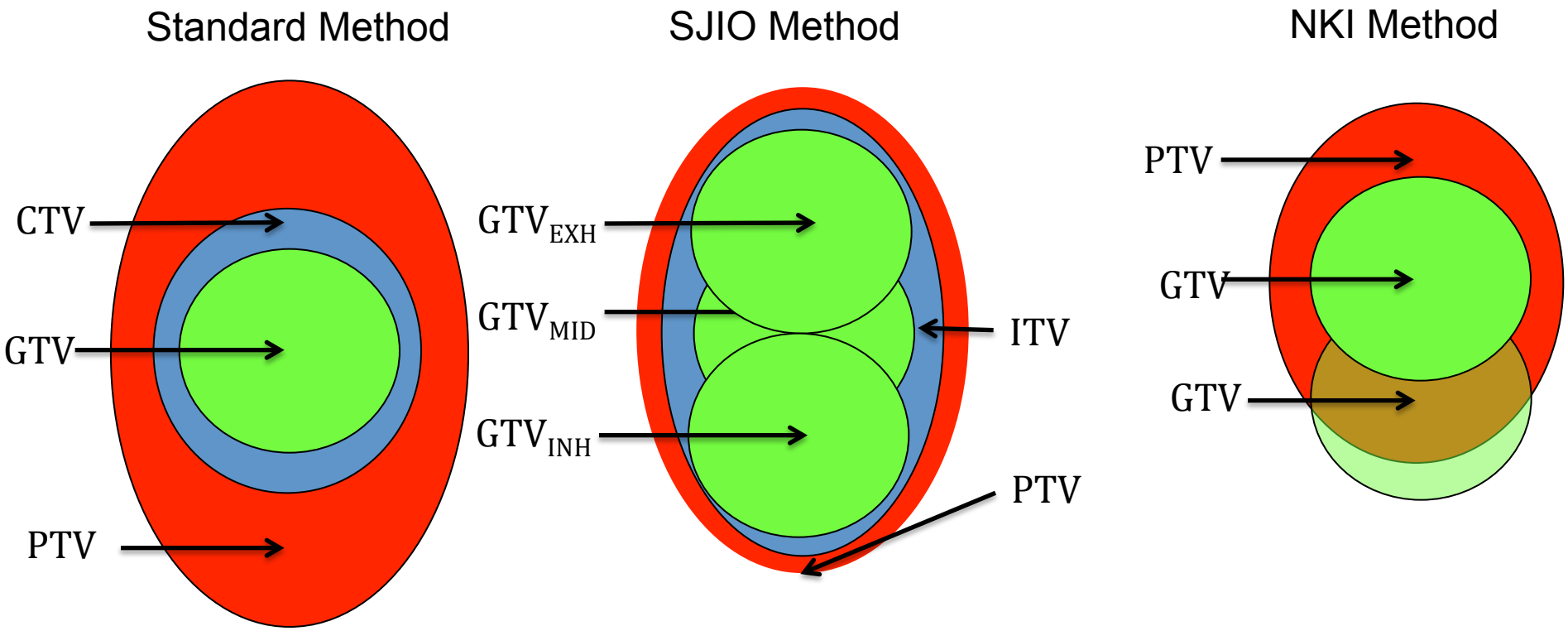


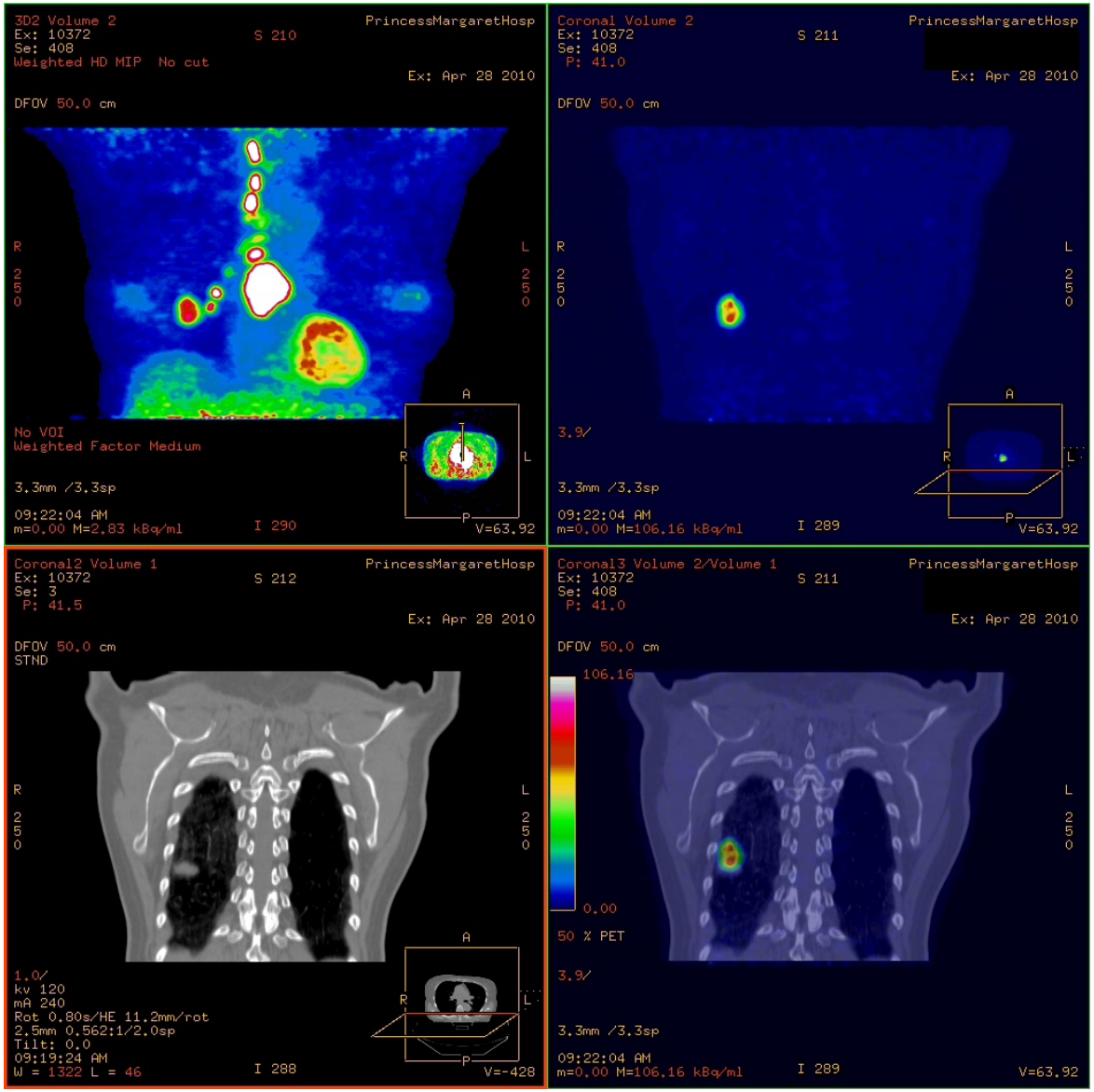
4DCT Patient Specific Margins



4DCT Patient Specific Margins

Generating your PTV using 4DCT





Movie courtesy of Dr Katy Clarke St James's Institute of Oncology

4D PET/CT

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On-Treatment-
Motion Management

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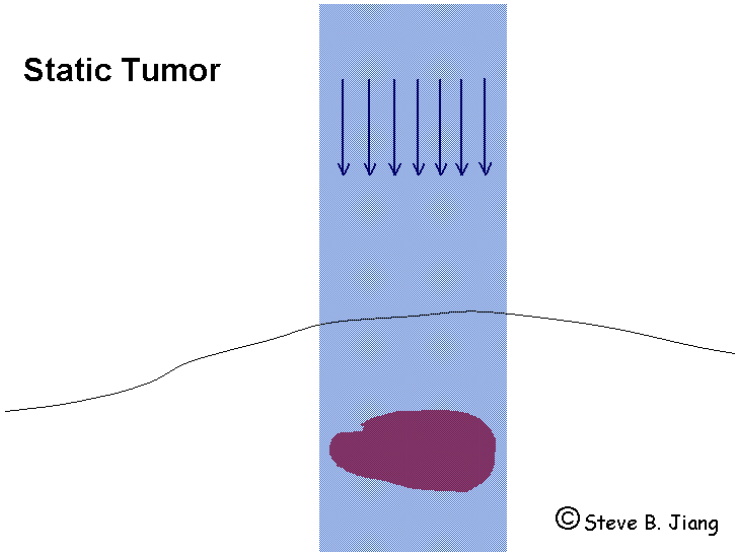
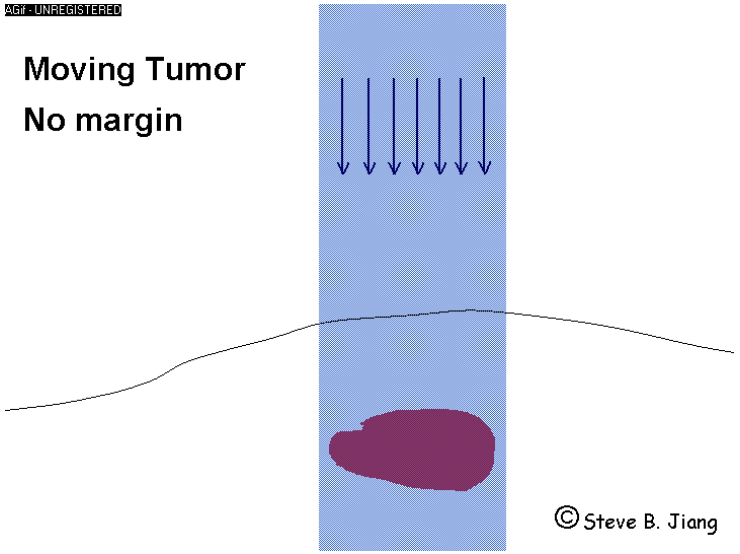
Motion Management

- Most Important is to quantify it first!
- If motion significant >0.5-1.0cm need to address it
- Lots of methods!

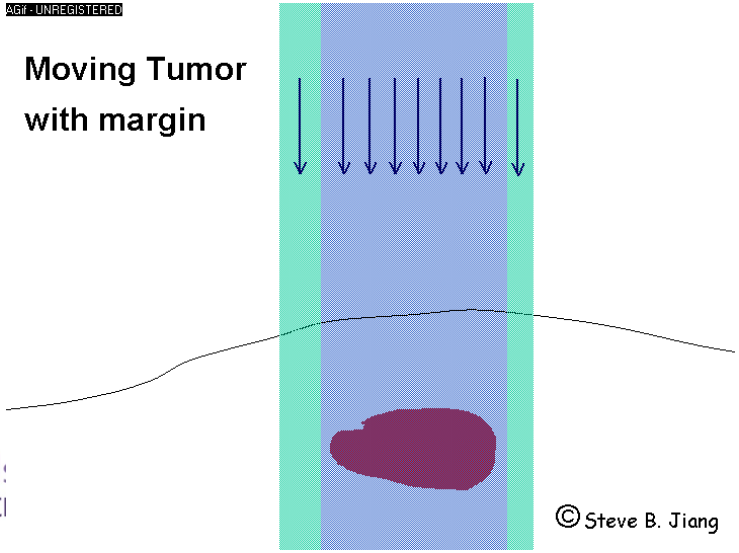
Static Tumor



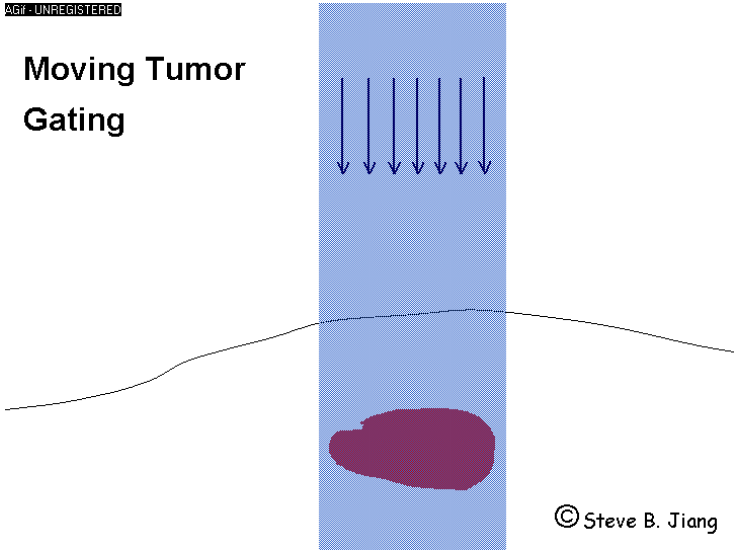
Moving Tumor
No margin

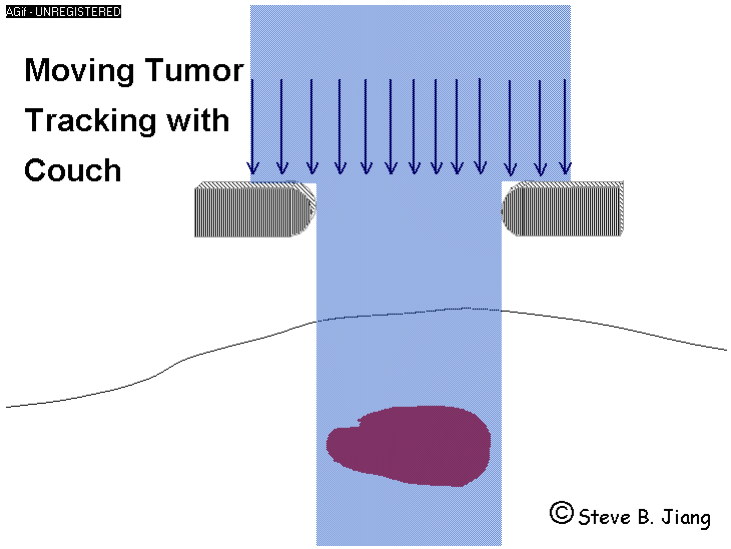


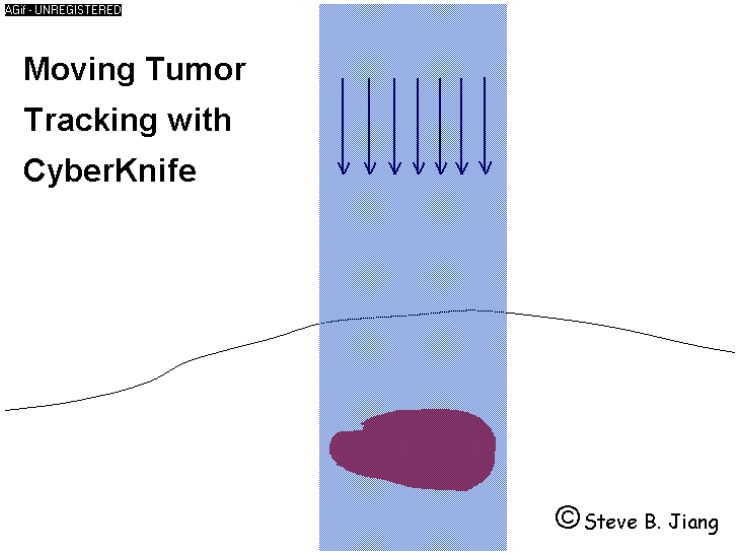
Moving Tumor
with margin



Moving Tumor
Gating




AGif - UNREGISTERED
Moving Tumor
Tracking with
Couch
© Steve B. Jiang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Moving Tumor
Tracking with
CyberKnife
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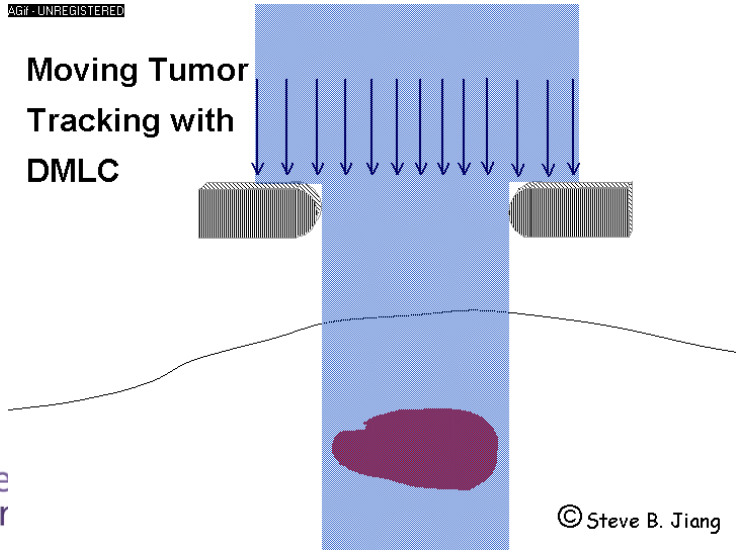
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Moving Tumor
Tracking with
DMLC
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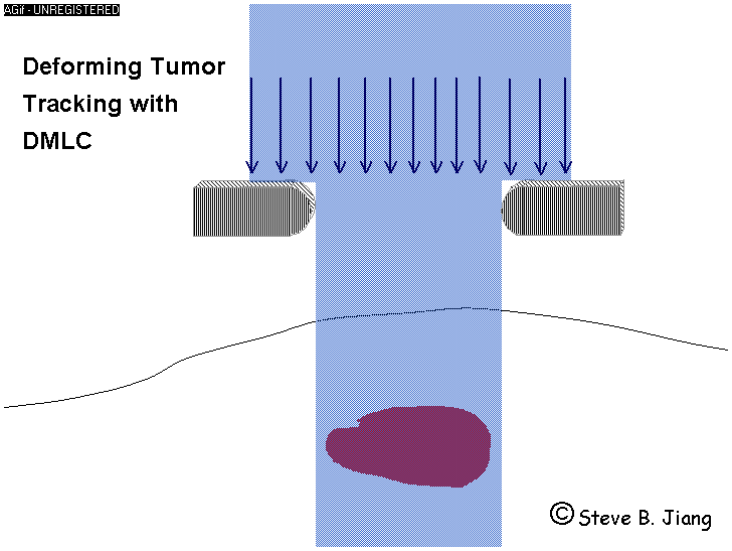
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Deforming Tumor
Tracking with
DMLC
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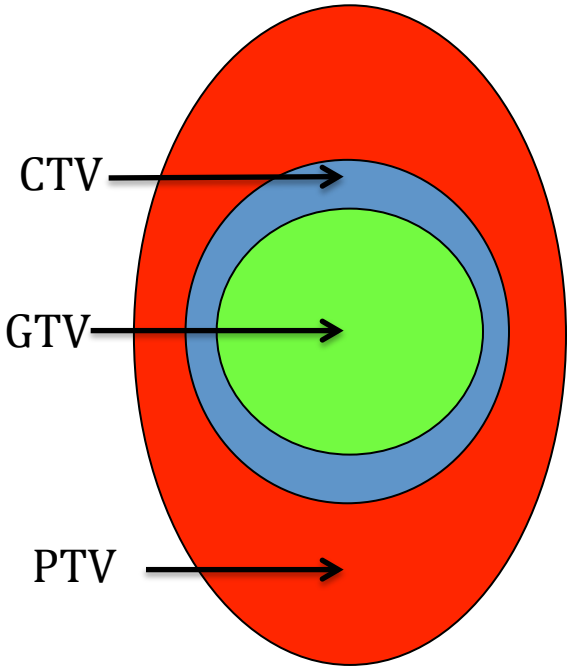
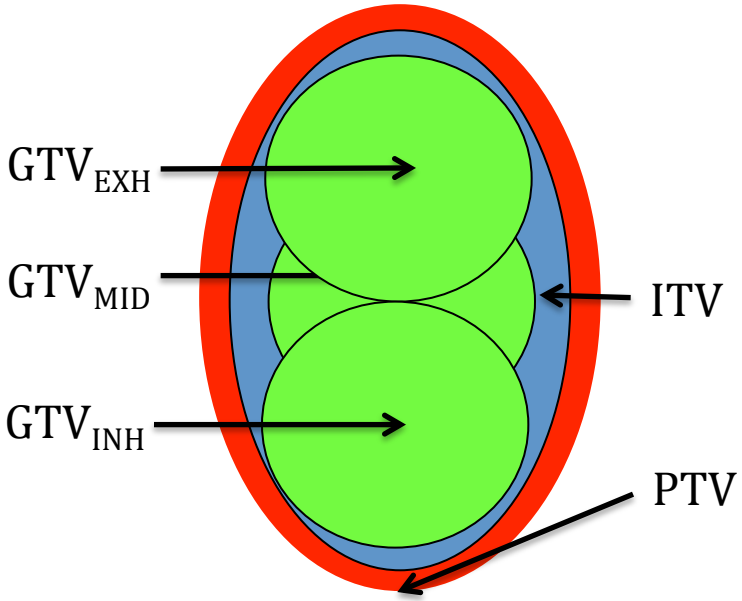
Motion Management

- Simple -Allow for it in you planning

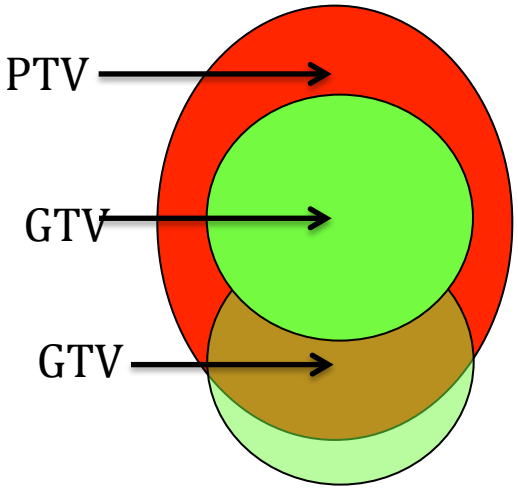
Standard Method



SJIO Method



NKI Method

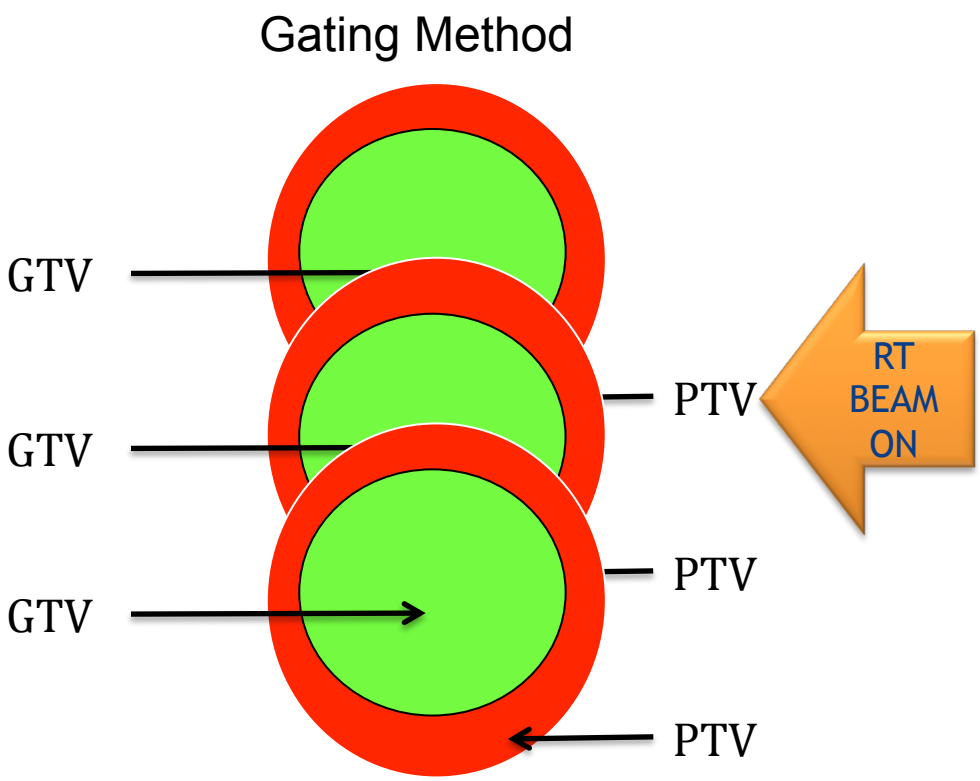


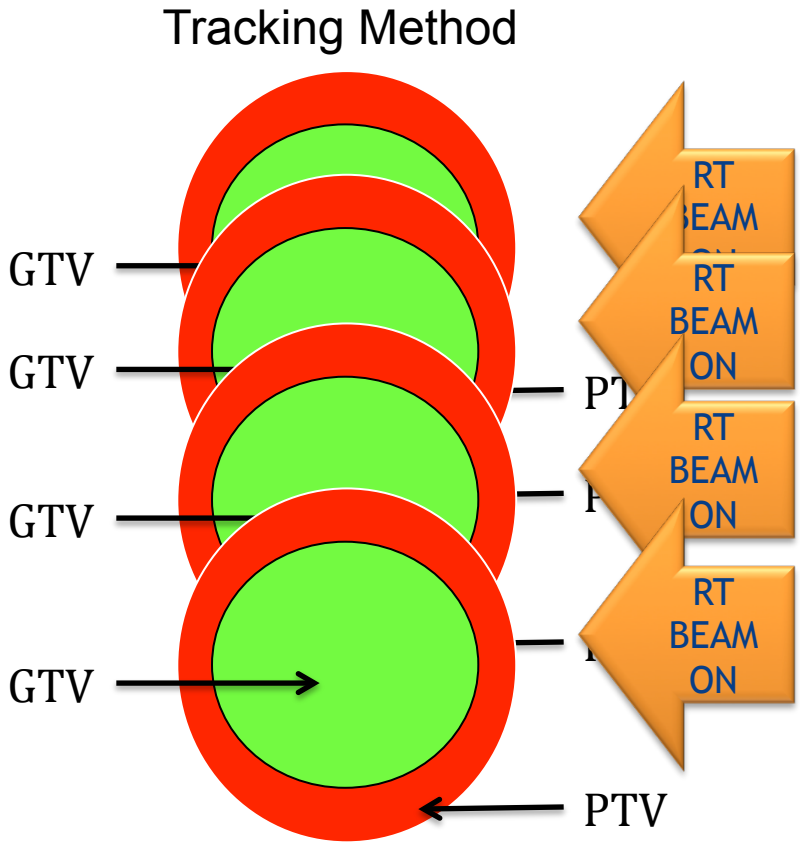
Motion Management

- Simple –Restrict it

Motion Management

- Gating and Tracking



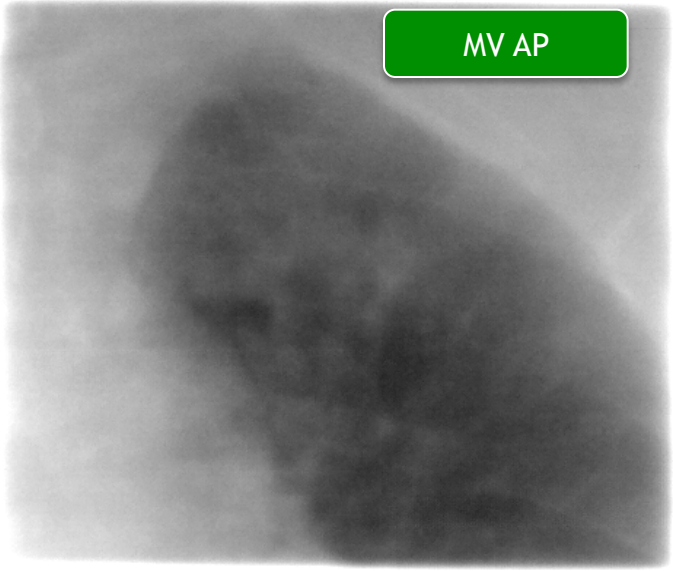


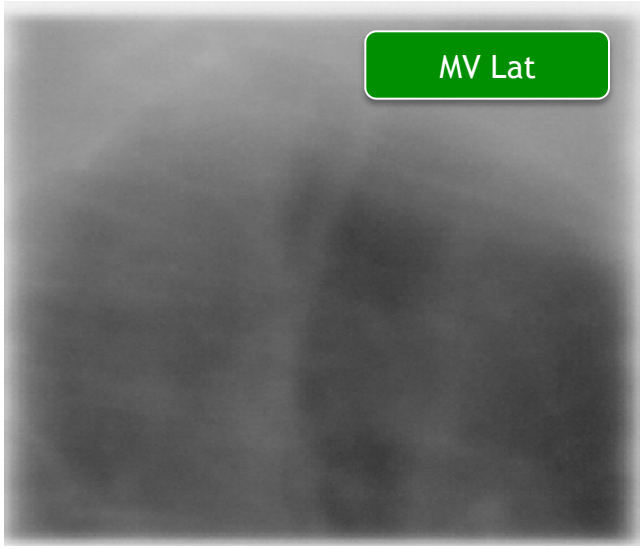
MV Orthogonal Imaging

- Traditionally orthogonal MV images were used to match to the "tumour"
- However, poor quality images.
  - Can't see tumour reliably
  - Often matching to a surrogate…… or at least trying to!
  - Can only detect gross changes in tumour volume/anatomy

MV Orthogonal Imaging

- MV Portal Imaging is POOR
- Likely we have missed tumours due to;
  - Collapse
  - Re-expansion
  - Changes in tumour motion
  - Response/Progression

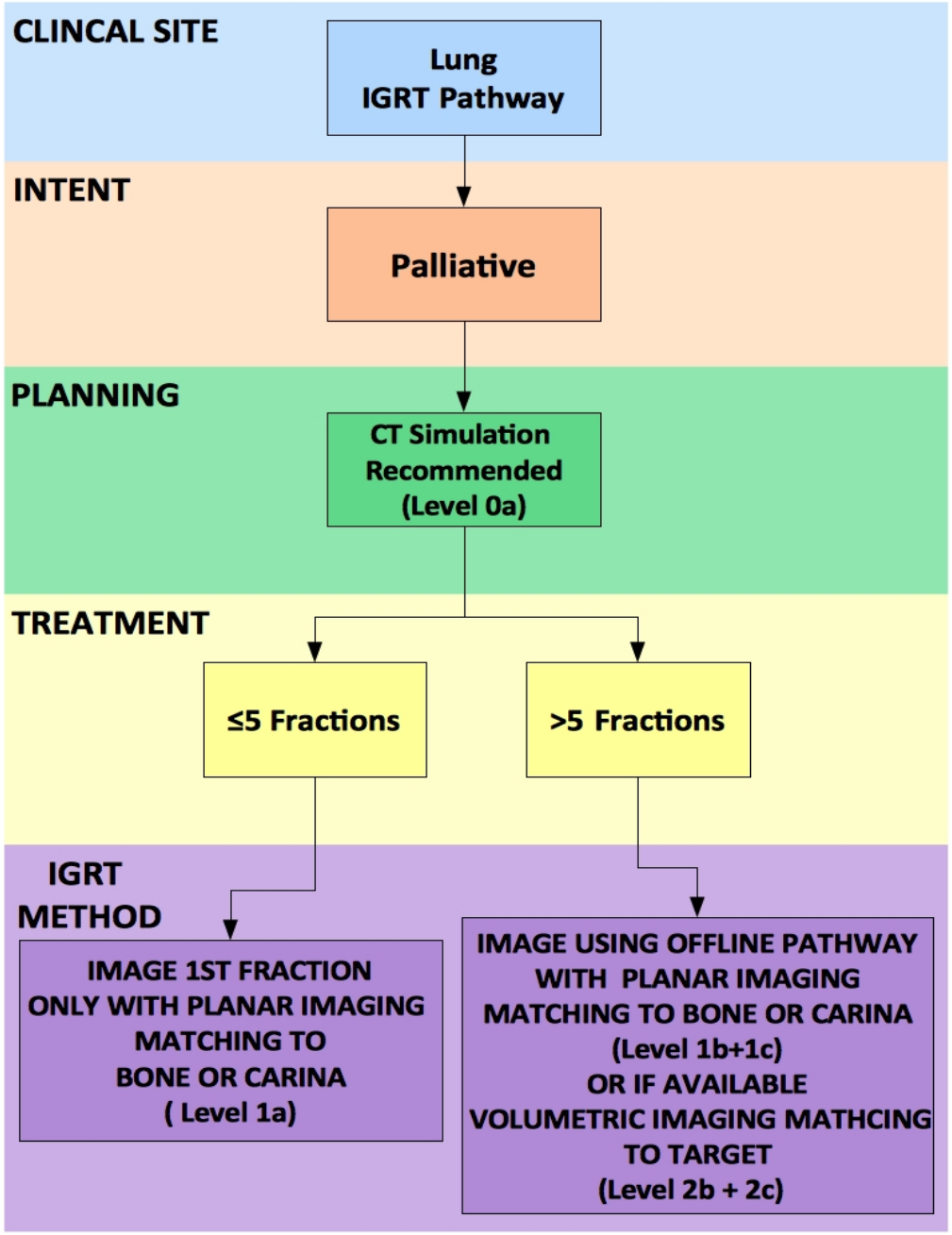




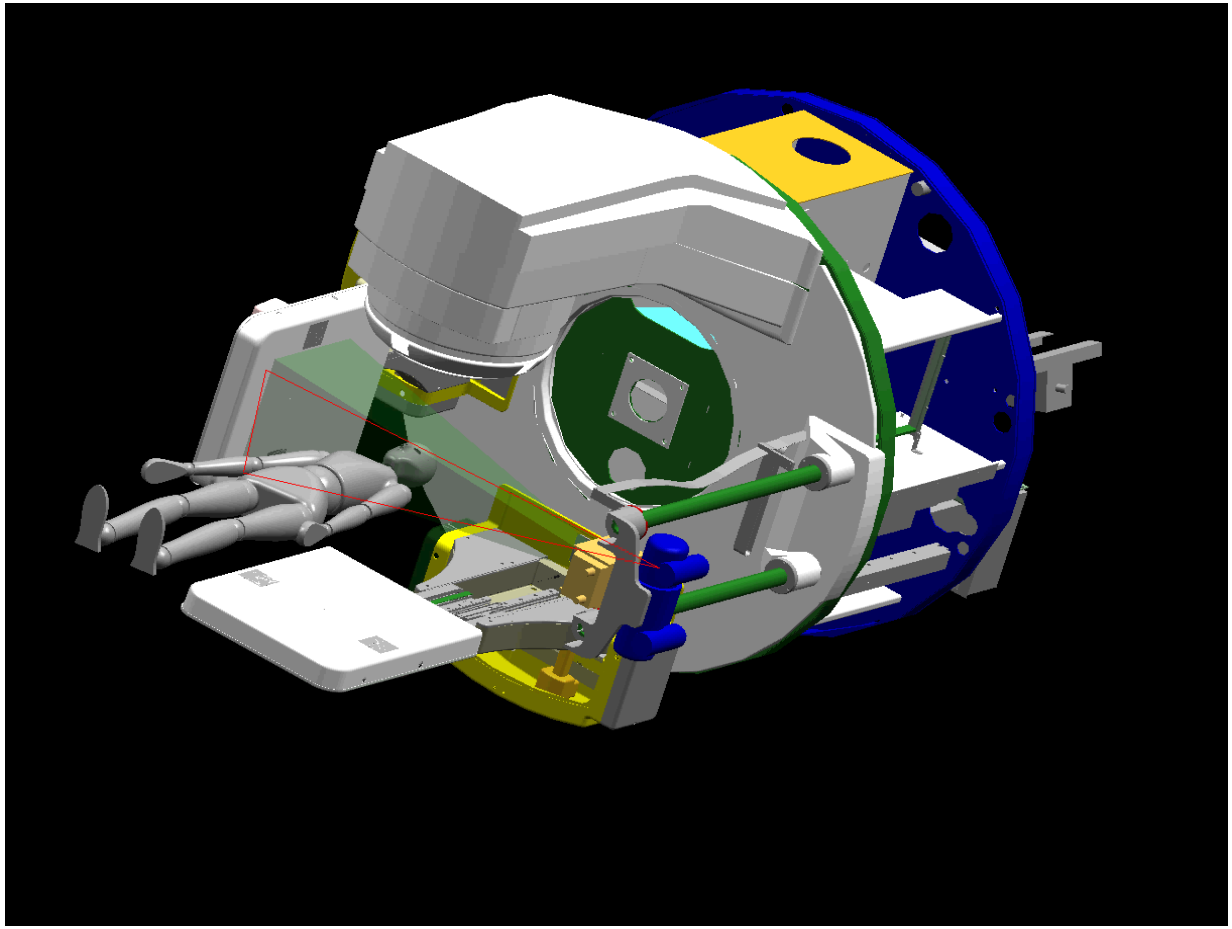
MV Orthogonal Images

- Only suitable for short course palliative RT where
  - Are looking to detect a gross systematic error
  - Larger margins are used to account for this uncertainty
  - Bony match is a reasonable surrogate
  - No close OARs that are close to tolerance

Palliative Lung RT Protocol



Volumetric Imaging- CBCT



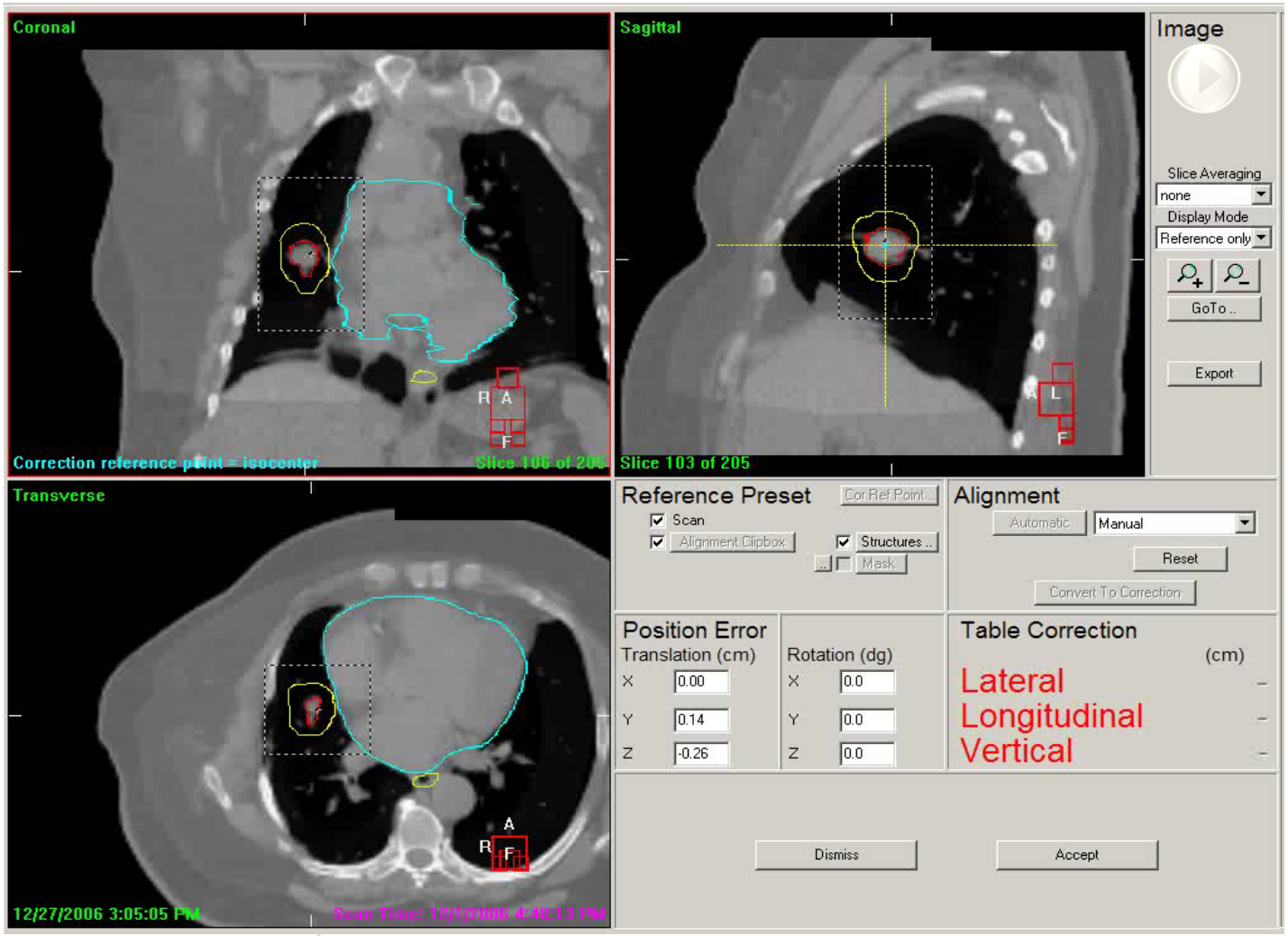
Volumetric Imaging with kV Cone Beam CT (CBCT)

- Provides CT "like" images whilst patient in on the treatment couch.
- Not diagnostic quality
- Similar to a Slow CT scan

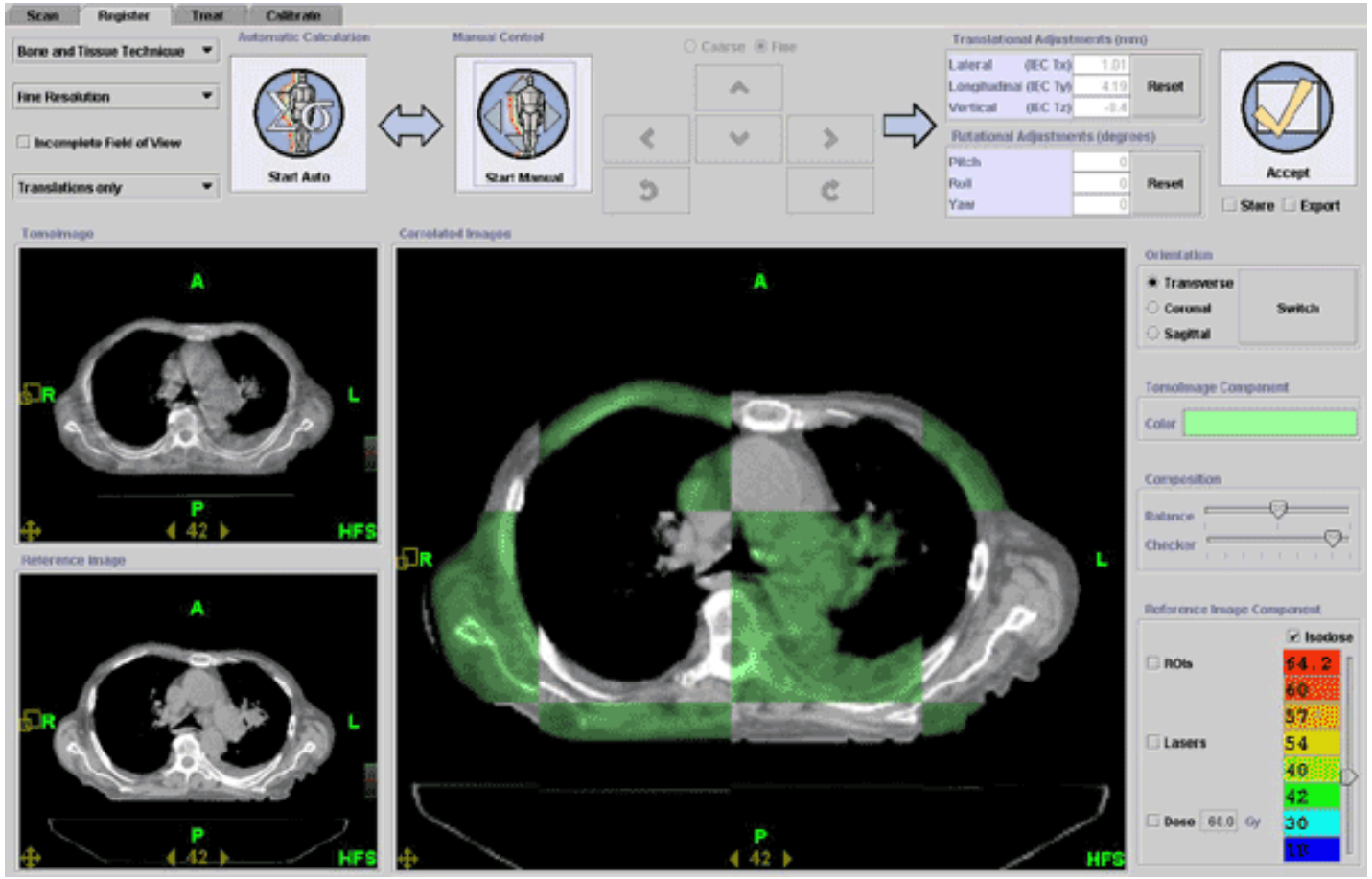
Volumetric Imaging with kV Cone Beam CT (CBCT)

- BUT…
  - For lung cancers CBCT is able to visualise parenchymal tumours easily
  - Slow CT equivalent and therefore can detect motion
  - Can detect collapse/re-expansion

Volumetric Imaging- CBCT



MV CT with Tomotherapy



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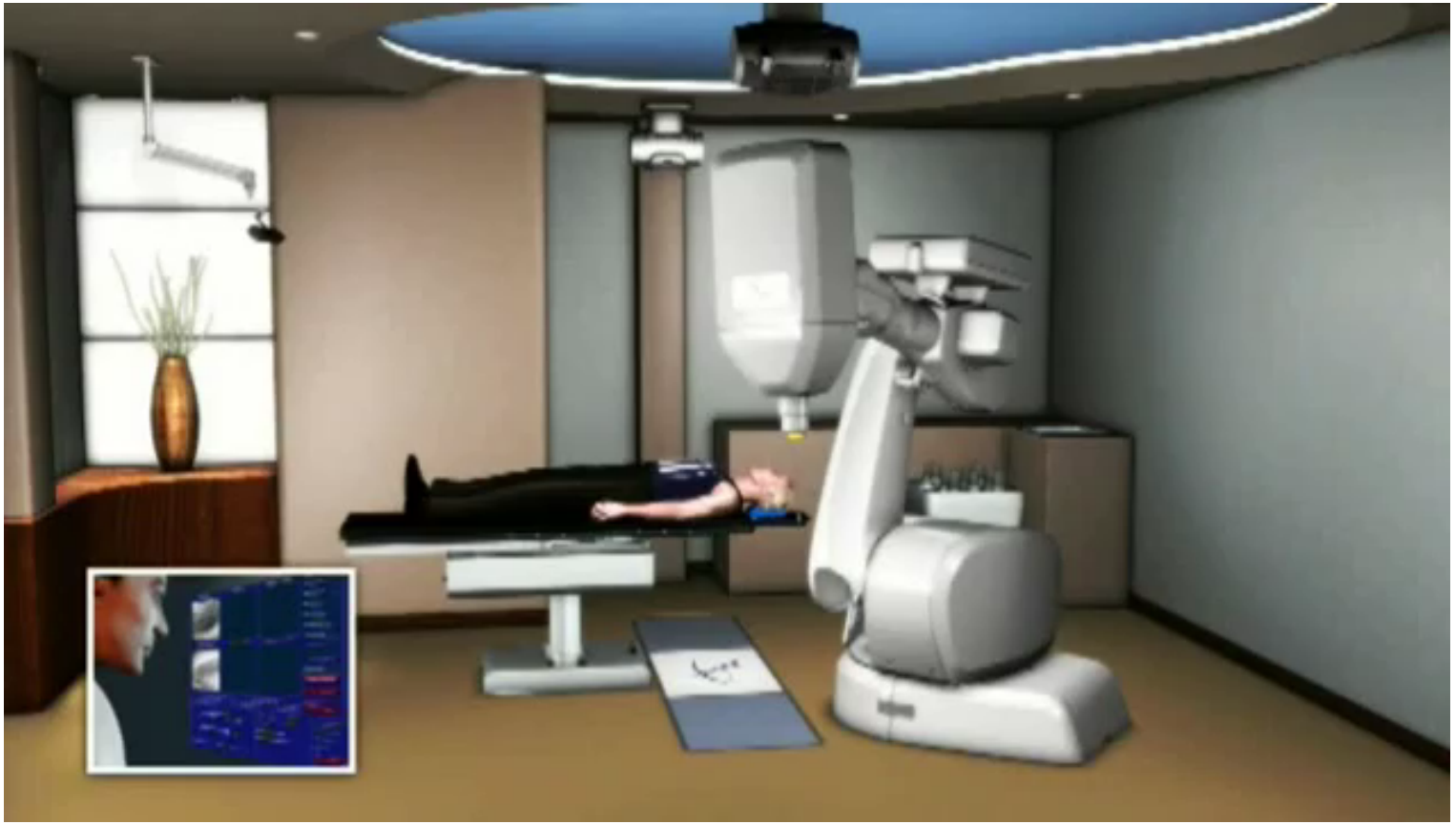
IGRT with implanted fiducials

- Metals fiducials can be placed near or in lung tumours
  - Percutaneously
  - Trans-bronchially
- Visualised with kV fluoroscopy/CBCT
- This allows accurate localisation
- Can allow tracking eg Cyberknife or gating (RTTS/BrainLab)

IGRT with Fiducials

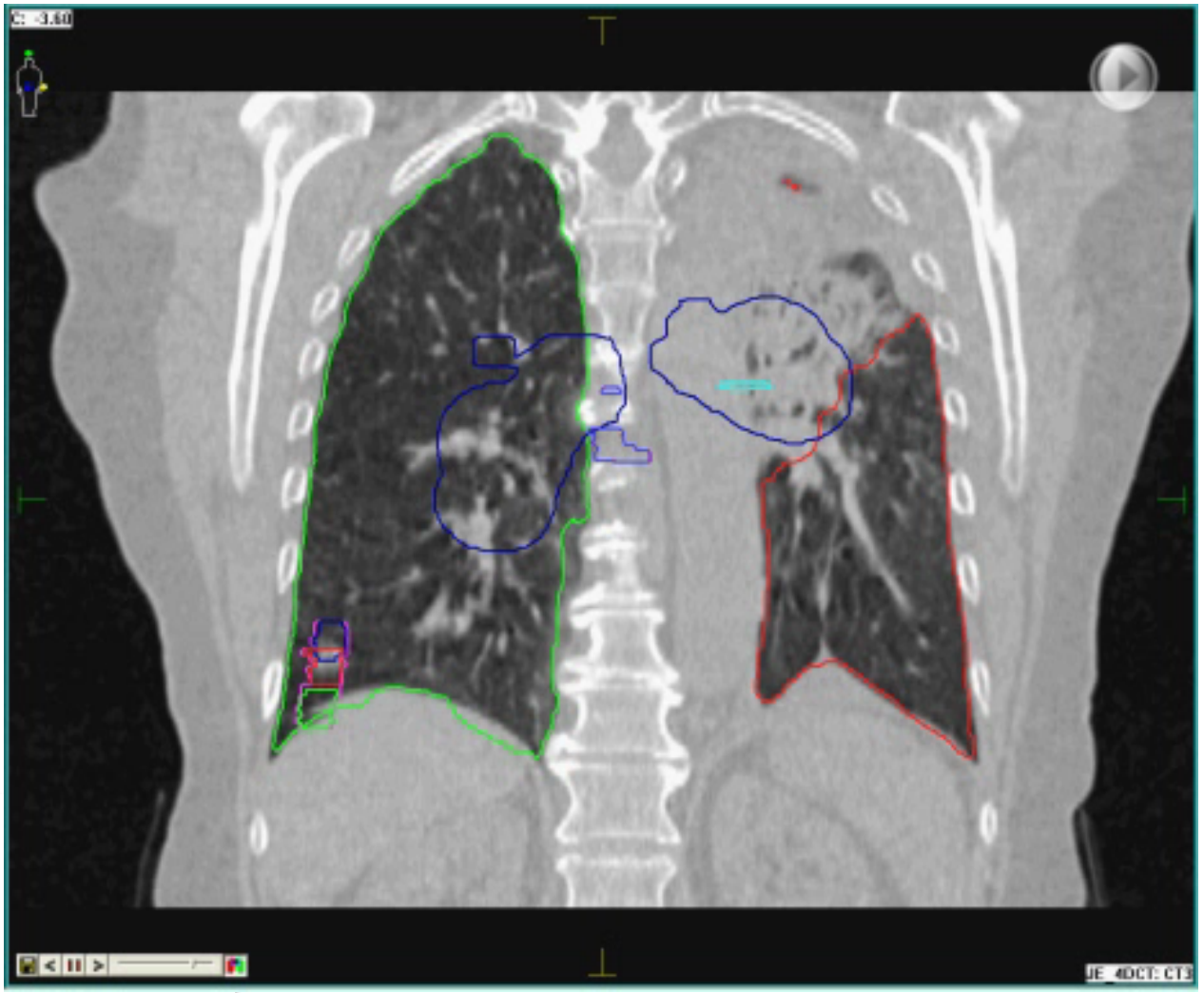
- Gating and Tracking



IGRT with implanted fiducials

- Advantages:
  - Real time tumour tracking ensures dose delivered to target as patient breathes
  - Can reduce Treatment Volumes
- Disadvantages:
  - Complications of fiducial placement
  - Can image tumour or OARs directly
  - Fiducials can move

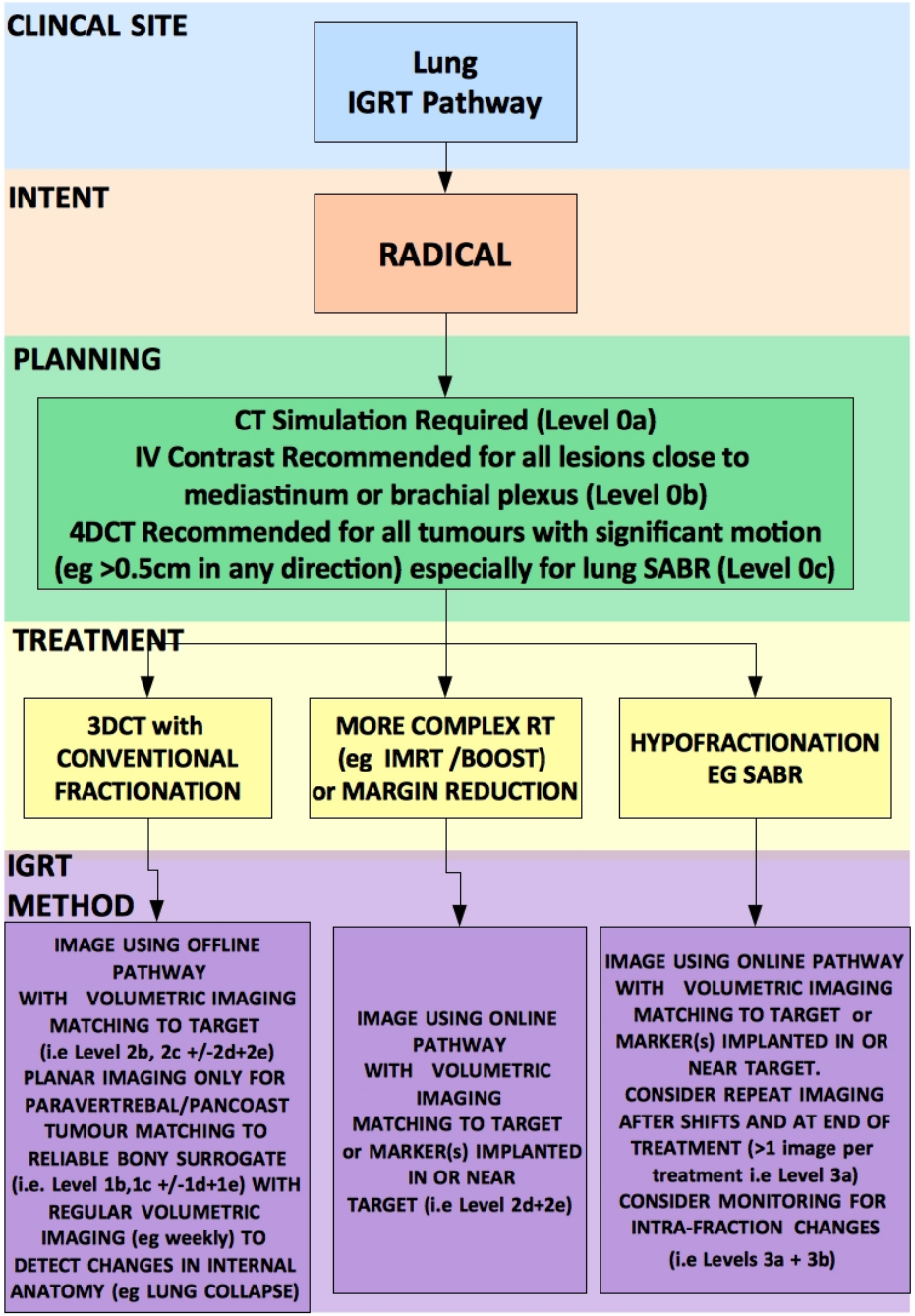
4D Cone Beam CT



Real Time Tracking with CBCT

- Currently in development
- Can acquire a CBCT during a VMAT delivery
- Can the real-time kV images be used to track anatomy or fiducials?

Radical Lung RT Protocol



Conclusion

- Lung RT is improving!!!
  - Better Target Definition
  - Patient Specific Margins
  - Manage Motion if required
  - Ensure Accurate Delivery

= BETTER OUTCOMES

Questions?

Acknowledgements

- Leeds Lung SABR Team
- UK SABR Consortium
- Department of Radiation Oncology, Princess Margaret Hospital, Toronto