Motion Management In Lung Cancer

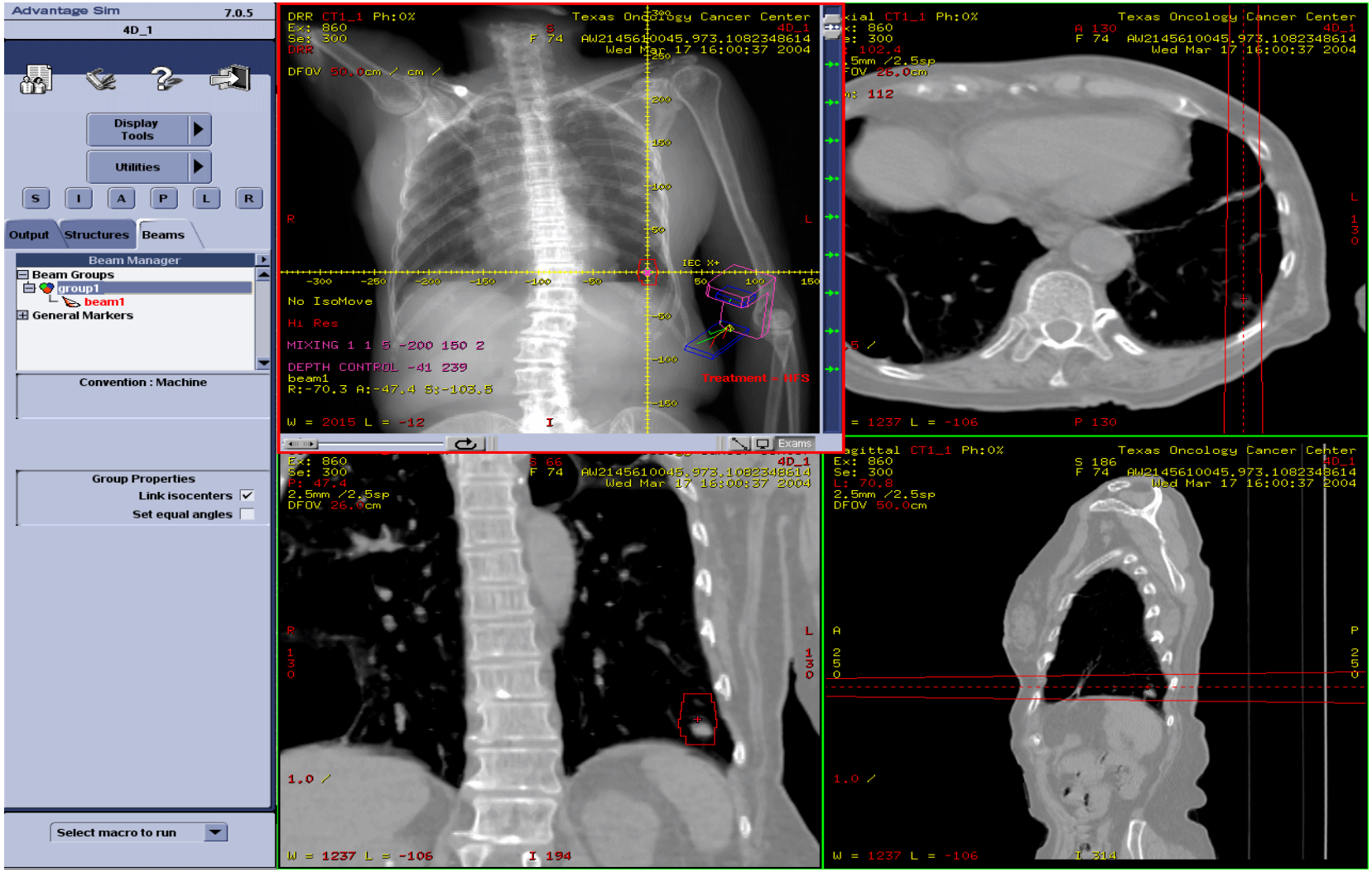
Dr. Sambit Swarup Nanda
Assistant Professor
Radiation Oncology
HBCH & MPMMCC , Varanasi

Aim & Accuracy

Learning Objectives

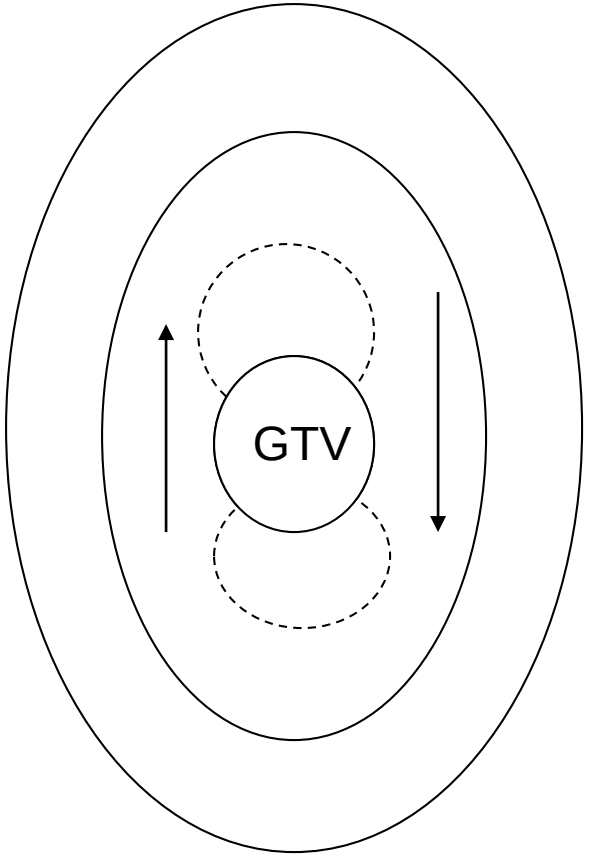
- Understand the techniques available for motion management, and the relationship between respiration and tumor motion.
- Outline the information available in 4DCT images, and the motion management decision making process.
- Discuss treatment planning for motion management cases.

Are Lung Tumours Static ?????



Treatment planning limitation with Motion

- Large Margin (Blindly)
- Greater Irradiation area
- Limitation in delivering dose
- More dose to normal structure



What is the Extent of Motion in a lung tumor ??

› Int J Radiat Oncol Biol Phys. 2002 Jul 15;53(4):822-34. doi: 10.1016/s0360-3016(02)02803-1.

Precise and real-time measurement of 3D tumor motion in lung due to breathing and heartbeat, measured during radiotherapy

Yvette Seppenwoolde [1], Hiroki Shirato, Kei Kitamura, Shinichi Shimizu, Marcel van Herk,

- Inserted gold markers- 20 patients
- Fluoroscopic real-time tumour tracking system

Seppenwoolde Y et al *IJROBP* 2002;53:822-34.

Results

- Amplitude of tumour motion greatest in cranial-caudal direction
  - Tumours in the lower lobe vs upper lobe
  - Not attached to rigid structures (such as chest wall and vertebrae) vs attached
  - 12±6 mm vs 2±2 mm .
- Lateral movement: 1.2±0.9 mm
- AP movement : 2.2±1.9 mm

Seppenwoolde Y et al *Int J Radiat Oncol Biol Phys* 2002;53:822-34.

Does LN motion same as lung Primary

> Int J Radiat Oncol Biol Phys. 2009 Jul 15;74(4):1092-9. doi: 10.1016/j.ijrobp.2008.09.031. Epub 2008 Dec 25.

Motion analysis of 100 mediastinal lymph nodes: potential pitfalls in treatment planning and adaptive strategies

Jason R Pantarotto [1], Anna H M Piet, Andrew Vincent, John R van Sörnsen de Koste, Suresh Senan

- 100 LN ⟶ 41 pts ⟶ 4D-CT scans
- Changes in nodal center of mass position.
- Average 3D nodal motion during quiet breathing- 0.68 cm (0.17-1.64 cm)
- Cranial-caudal direction maximum motion. 77% > 0.5 cm, 10% > 1.0 cm
- Strongly associated with nodal station (with lower mediastinal nodes showing the highest motion)
- Node >2cm vs > 2cm : no diff

Pantarotto JR et al. *Int J Radiat Oncol Biol Phys* 2009;74:1092-9.

Need for Motion Management … When !!!

- AAPM Task Group 76

- Magnitude of the motion is very small (<5 mm), the extra effort of using a respiratory management technique is "*unwarranted, unless significant normal tissue sparing can be gained with the respiratory-management technique*".

- 5-mm threshold - Significant motion artifacts or systematic errors.

Motion Management Techniques

Popular Management Strategies

- Free breathing (design target to compensate for full range of motion)
- Abdominal compression (use a device to limit diaphragm expansion)
- Gating (treat during select portions of the respiratory cycle)
- Active breathing control (patient controls breathing with assistance)
- Dynamic tumor tracking (radiation beam follows target as it moves)

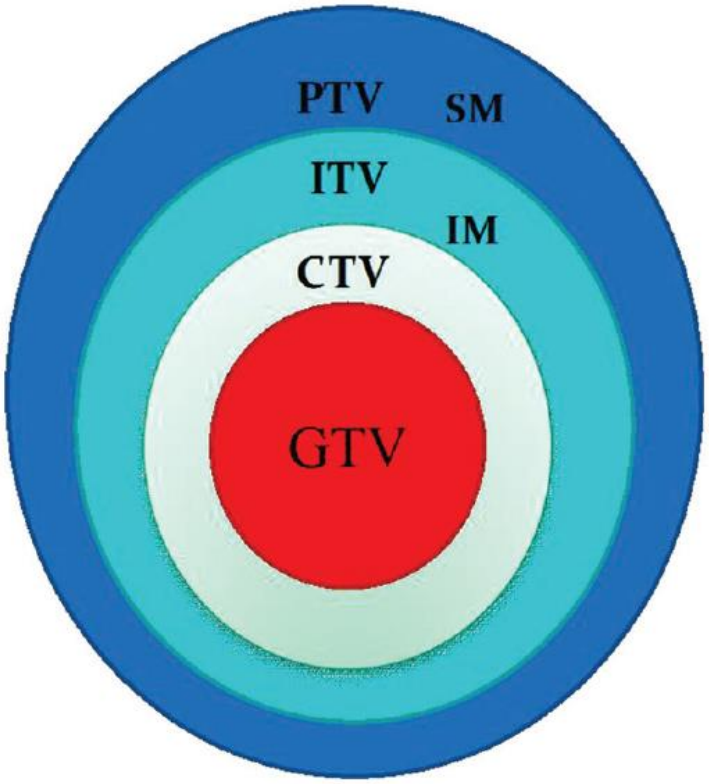
AAPM Task Group 76

1. Free breathing Technique (Motion Encompassing)

1. Take CT Images in extremes of tumor motion.

2. Deep inspiratory and deep expiratory Images

3. Create ITV from both sequences.



Abdominal Compression

- Forced Shallow breathing by limiting diaphragmatic motion.
- Abdominal compression plate in conjunction with SBRT frame
- Difficult reproducibility, need more imaging
- Difficult for obese and pt with poor respiratory function

Abdominal compression plate

Pneumatic pressure belt system

Motion Management Objectives

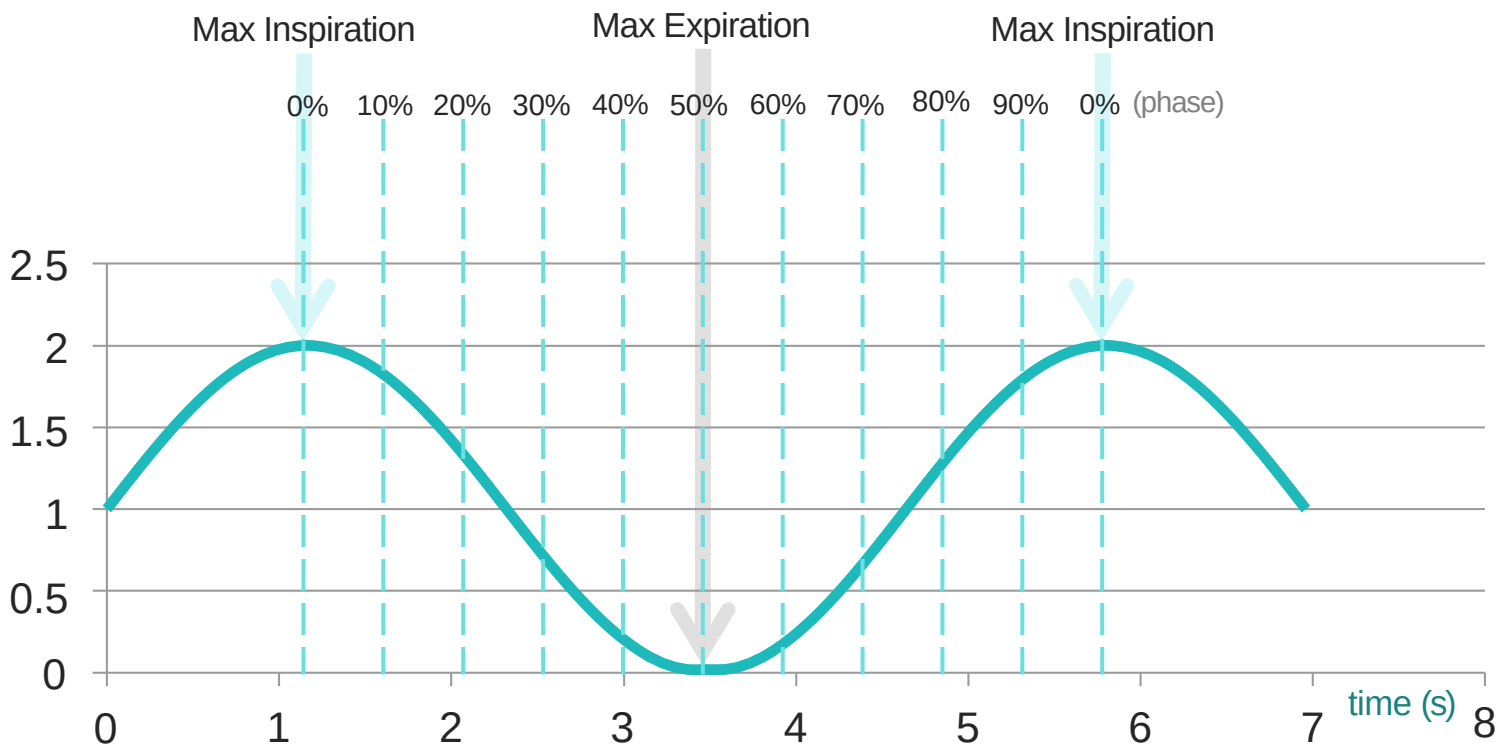
Compensate for tumor motion (monitor respiration and correlate with tumor motion)

Create smaller target volumes (utilize the most stable parts of respiratory cycle to reduce margins)

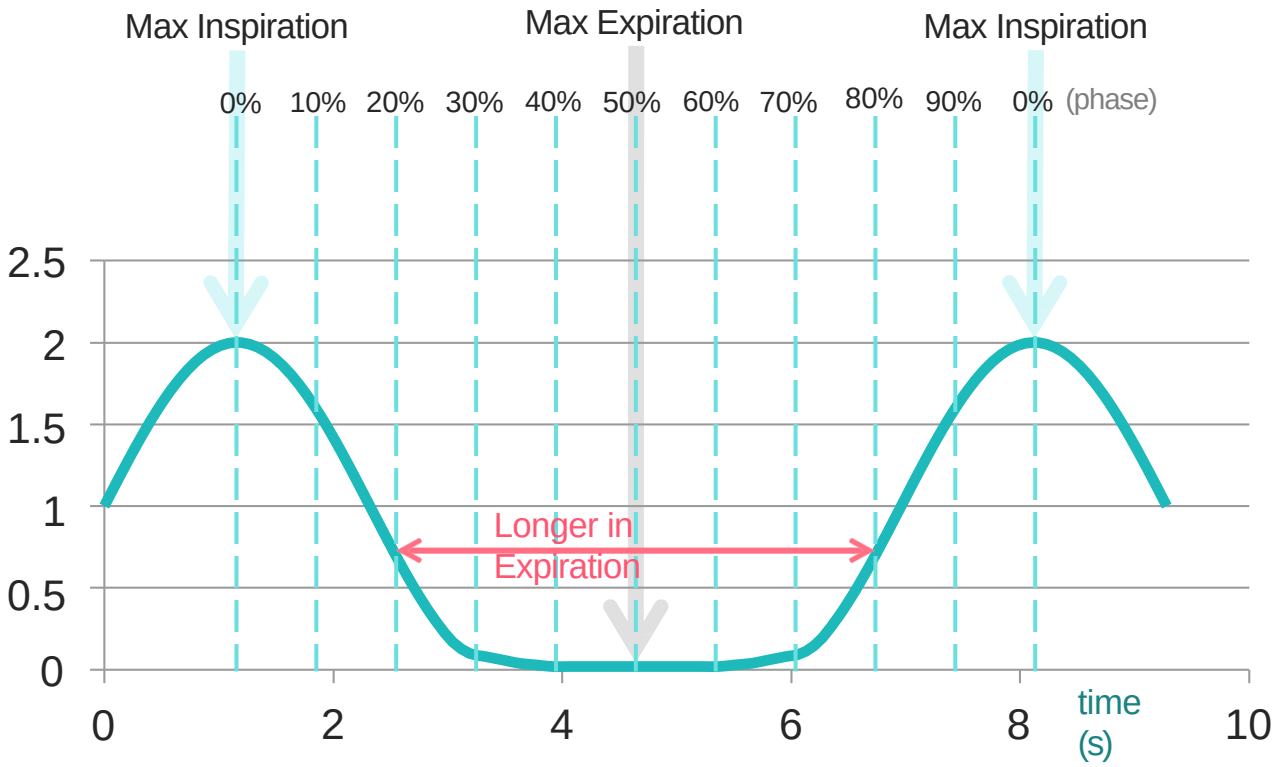
Decrease radiation to normal tissues (design more precise treatment plans and improve patient outcomes)

Gating

Respiration



Respiration



Gating Techniques

No Gating - “NO GATE”

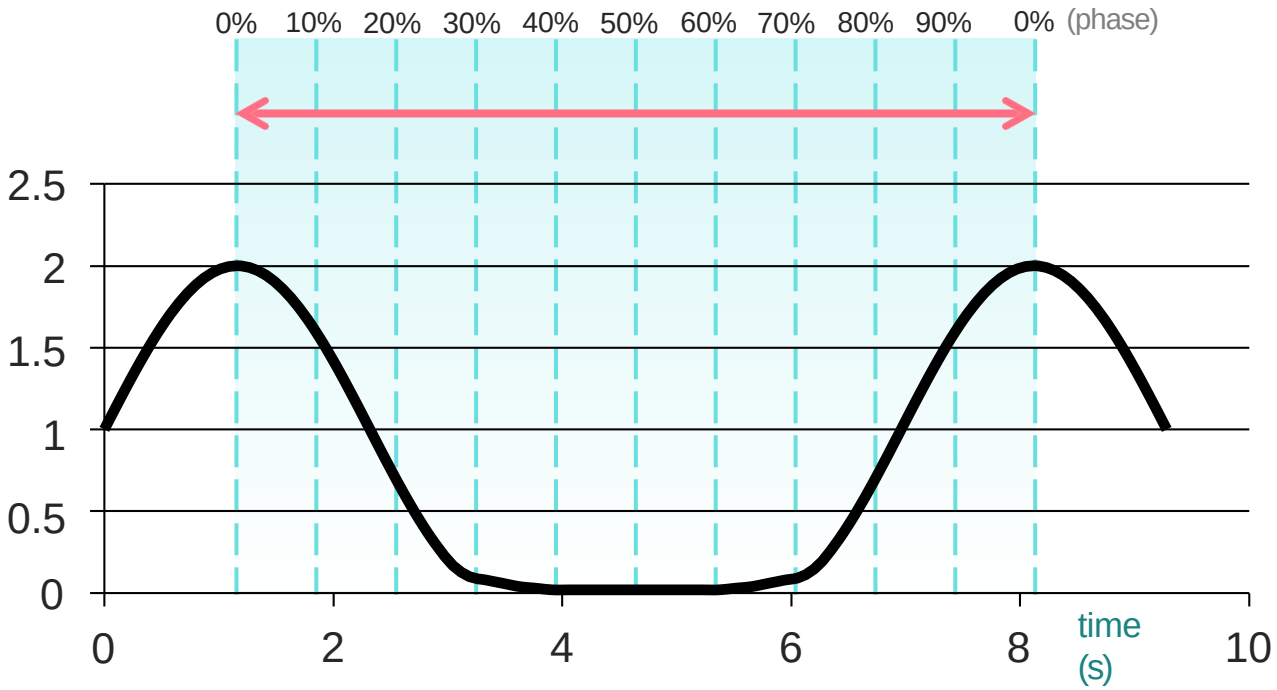
- Treatment is independent of respiratory cycle
- No target motion due to respiration (or compensated for by target margin)

Gating 0%-90% - “GATE 100”

- Treatment throughout “normal” respiratory cycle
- Target motion from normal inspiration/expiration cycle accounted for in ITV

GATE 0%-90%

“GATE100”

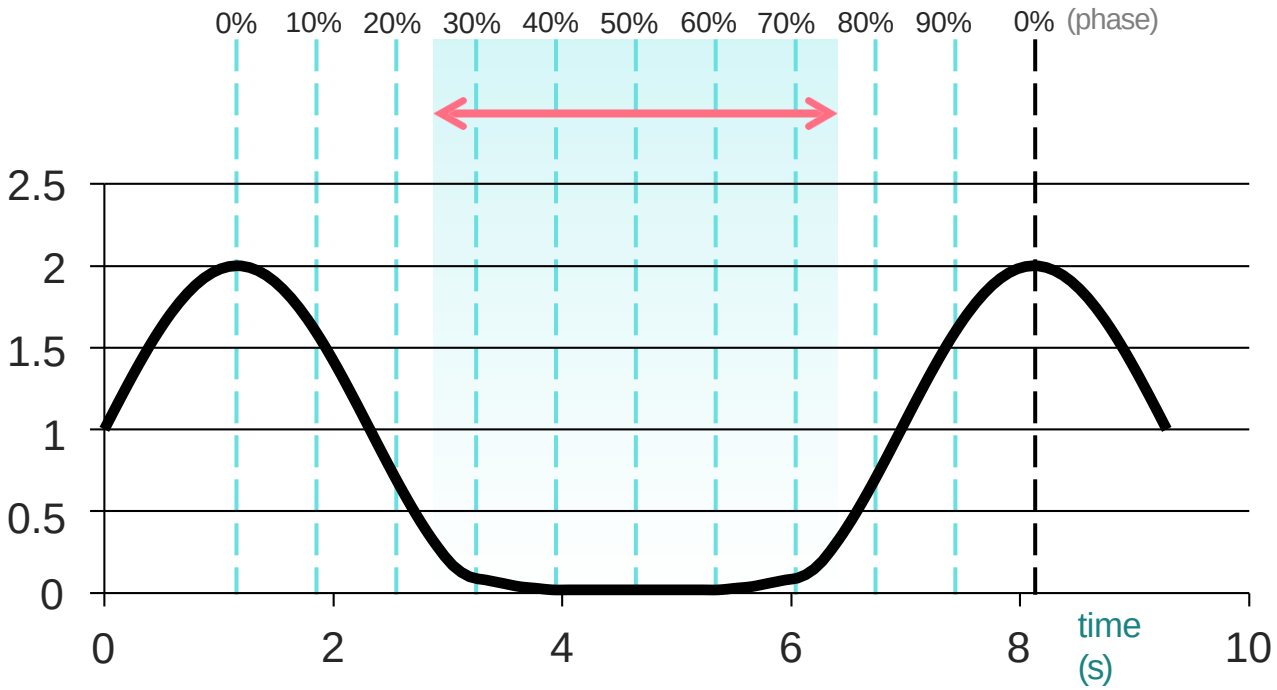


Gating Techniques

- Gating 30%-70% - “GATE30-70”
  - Treatment during expiration phases (30% to 70%) only
  - Target ITV is created from most stable portion of respiratory cycle

GATE 30%-70%

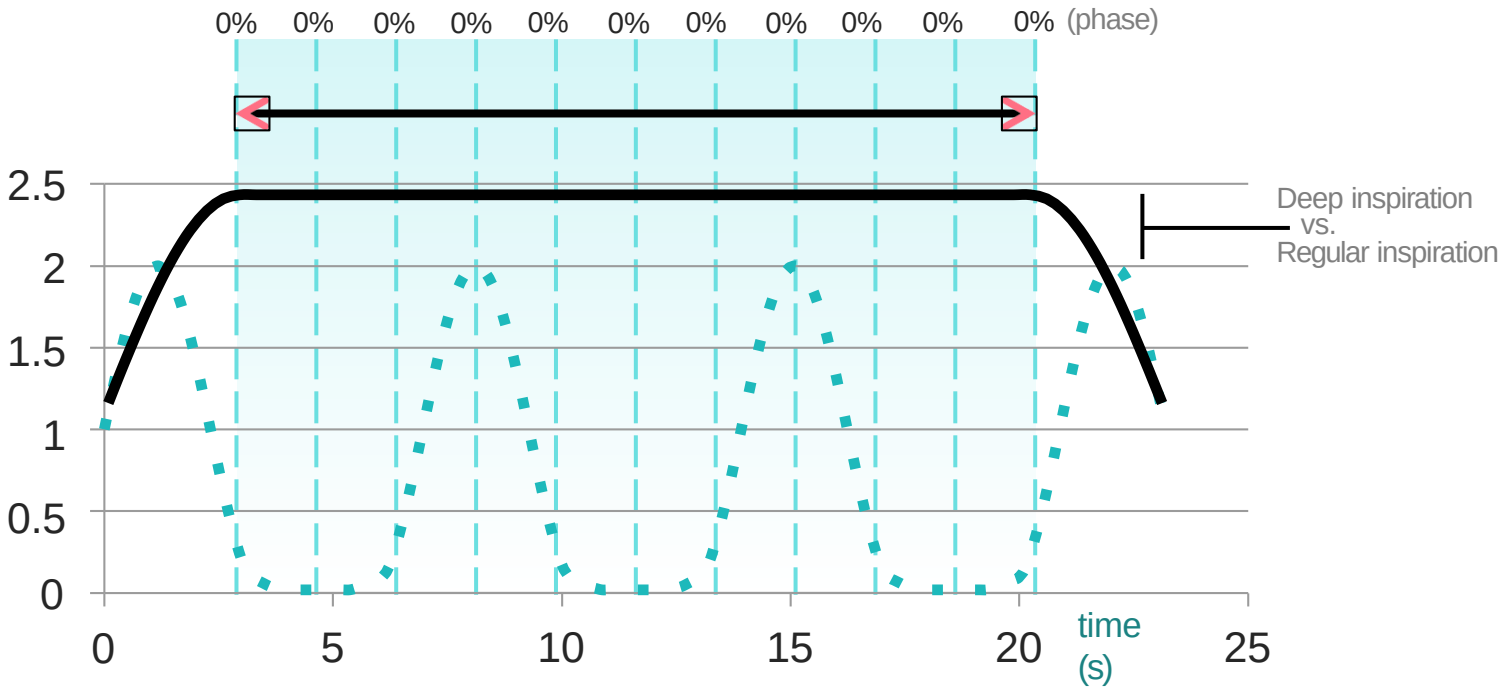
“GATE30-70”



Gating Techniques

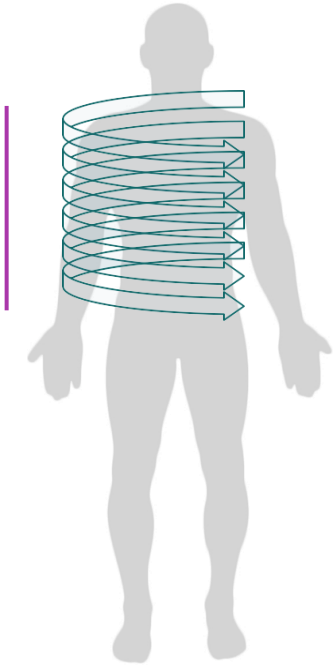
- Deep Inspiration Breath Hold - “DIBH”
  - Treatment during the max inspiration phase only (inspiration breath hold)
  - Target ITV is created from a single respiratory phase

Deep Inspiration Breath Hold "DIBH"

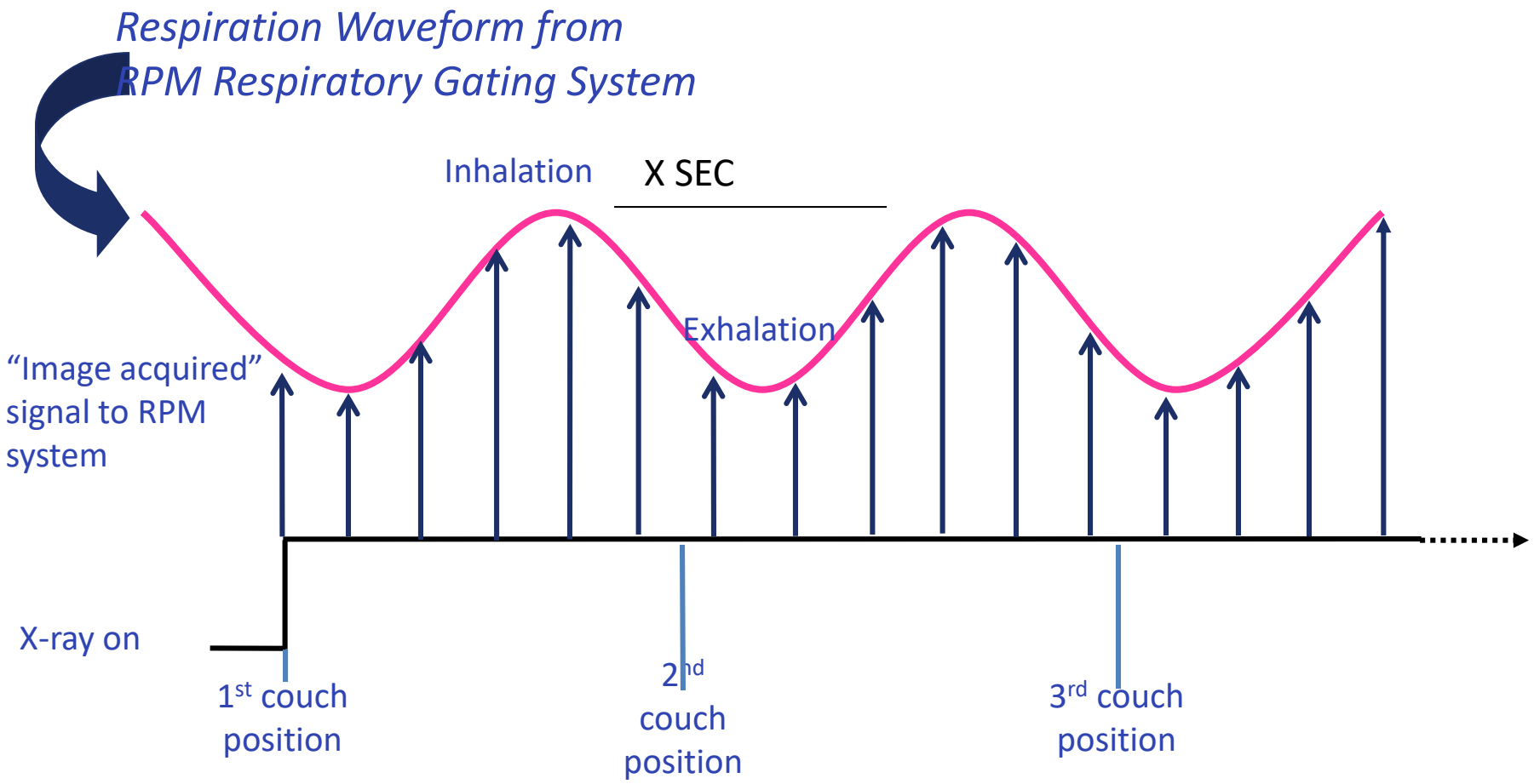


4DCT Concepts

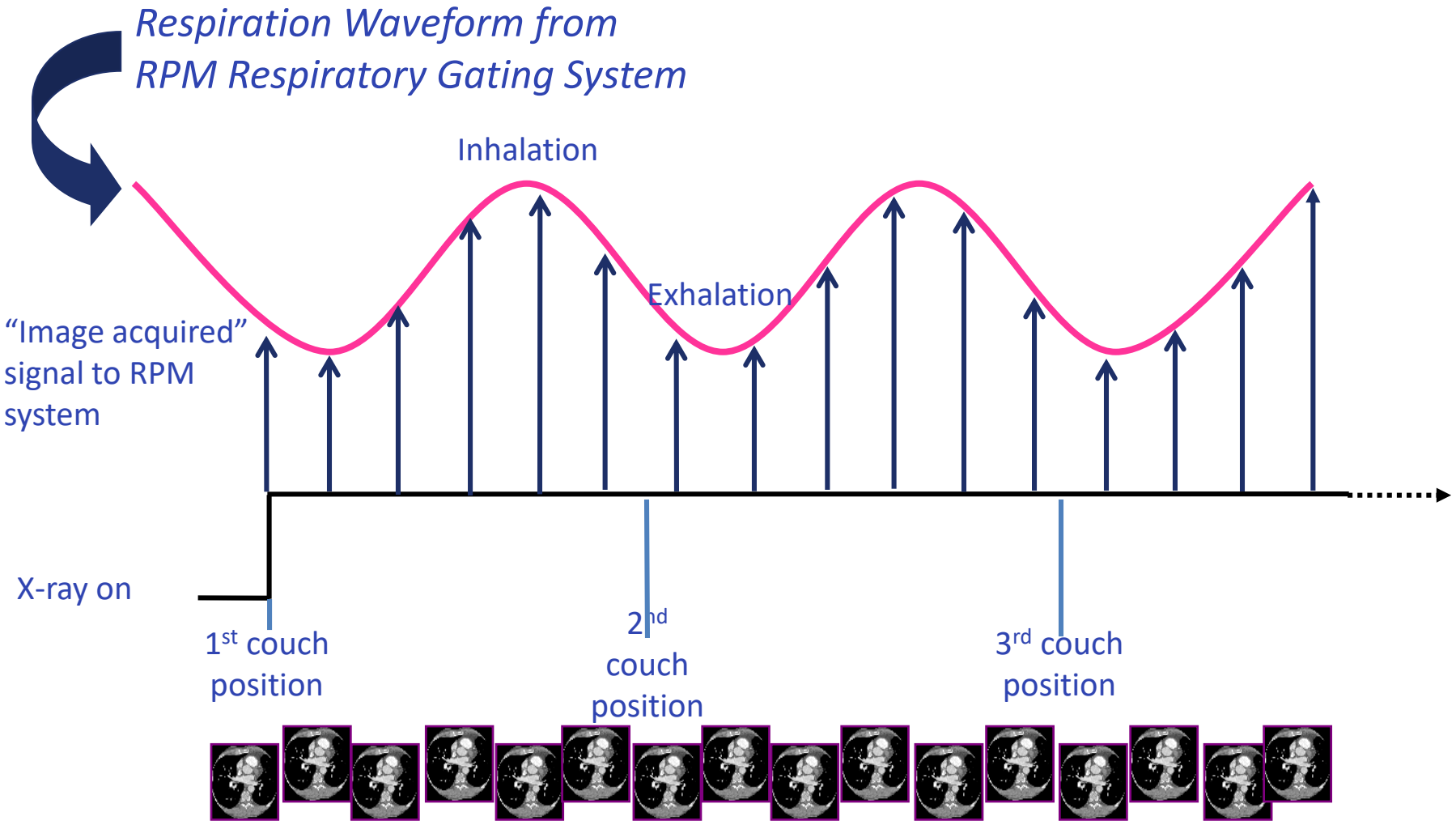
Acquire redundant CT data (helically or axially) to generate images throughout the breathing cycle for each slice



Retrospective 4D CT Image Acquisition



Retrospective 4D CT Image Acquisition



4DCT Images Binning

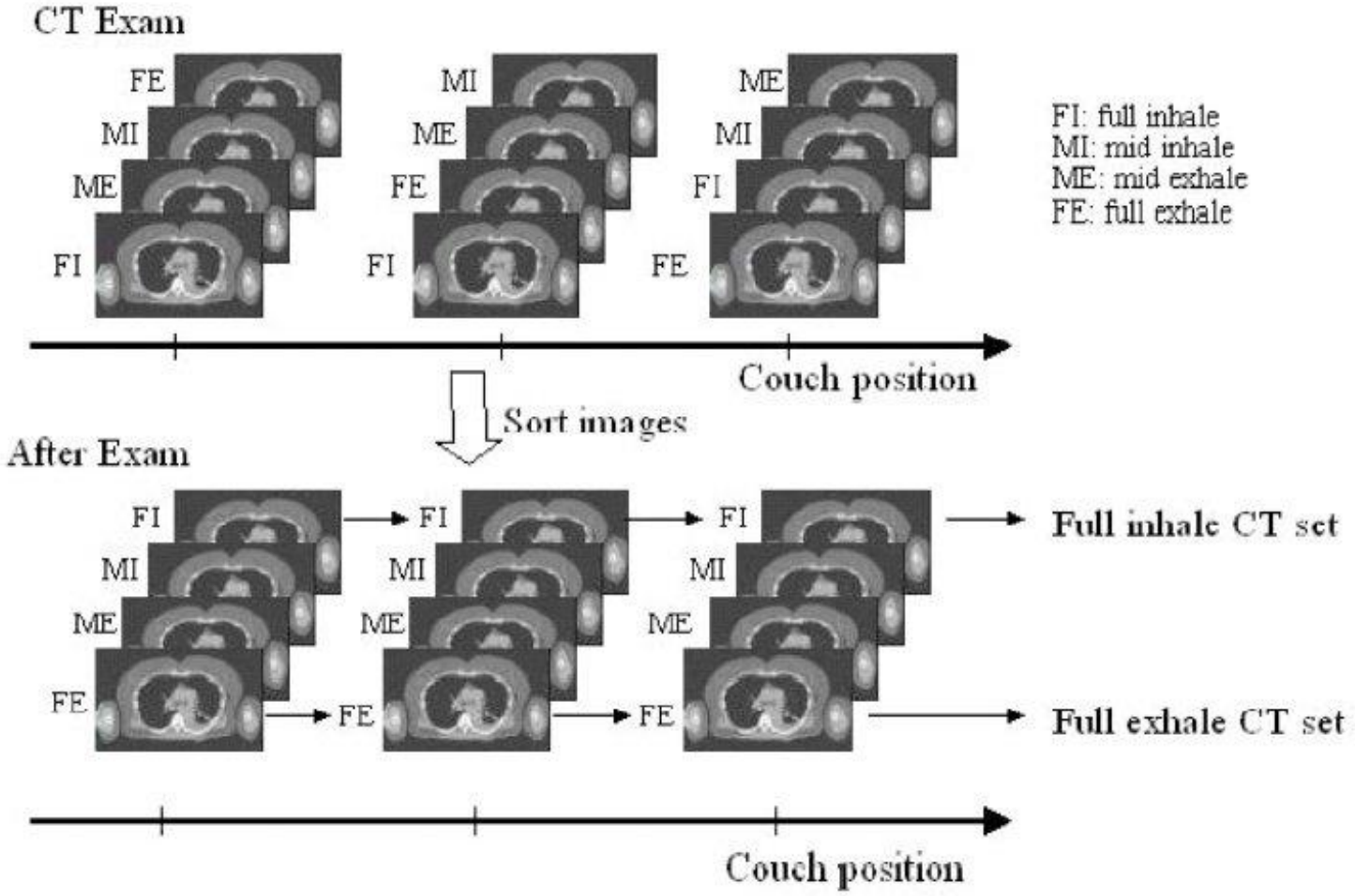
Individual phase images

- Typically 10 images, representing 10 phases
- Specific snapshots of the anatomy at various points in respiration

Composite images

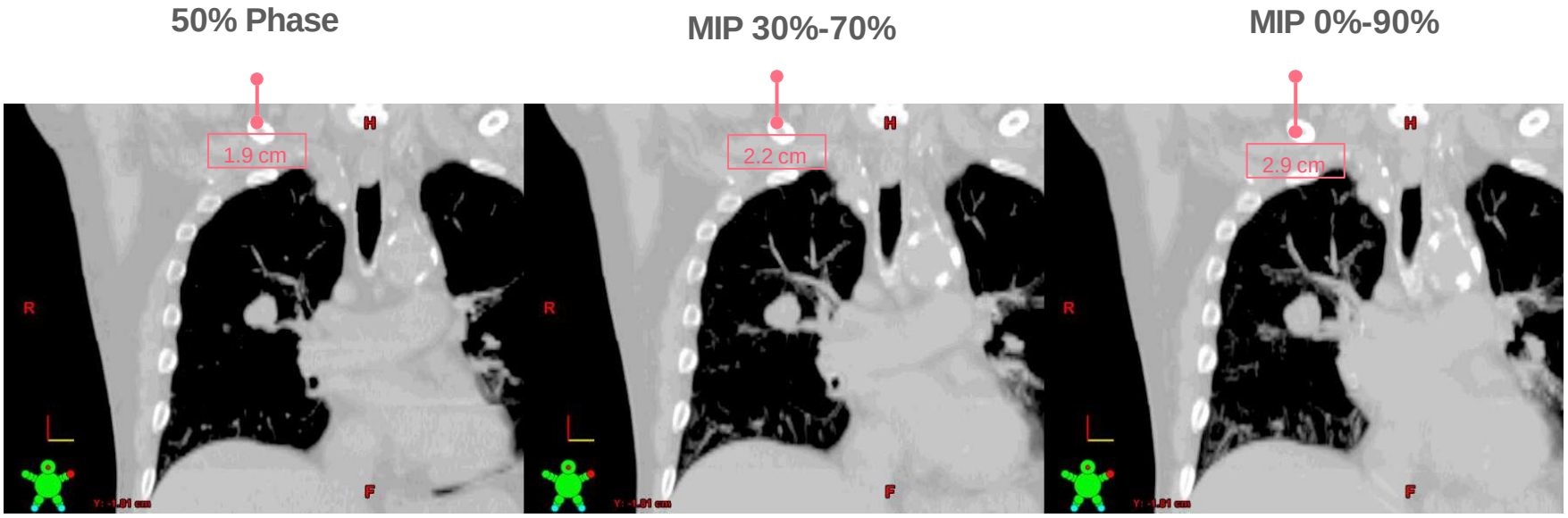
- Single 3D images generated from the individual phase images
- Used to depict portions of the respiratory cycle (multiple phases)
- Helpful for contouring and treatment planning
- Maximum intensity projection (MIP) images
- Average (AVG) images

Image Binning process



Maximum Intensity Projection Image (MIP)

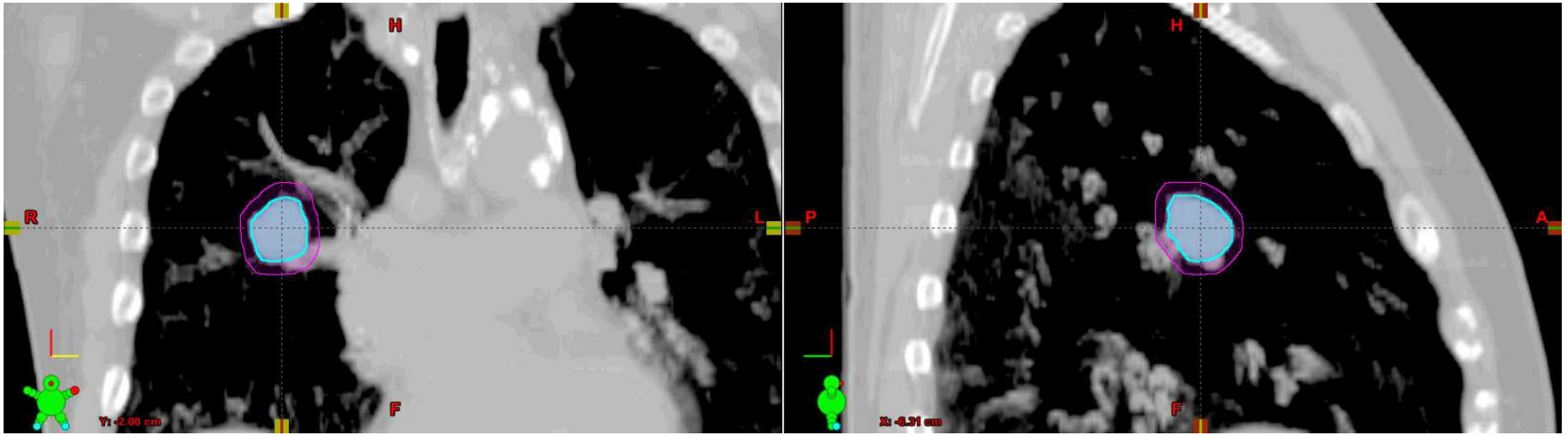
- 3D scan consisting of the greatest voxel intensities throughout the 4DCT scan
- Illustrates the range of tumor motion on a single image
- Tumor position visible in MIP for all of the included phases
- Not accurate for treatment planning (*i.e.* dose calculation)



Maximum Intensity Projection Image (MIP)

- Useful for contouring ITV
- Doesn't require 4D visualization capabilities in treatment planning system
- Extremely useful for lung tumors because of the differences in tissue density
- Can be deceptive or uninformative (no significant changes in density)

MIP 30%-70% vs. MIP 0%-90%



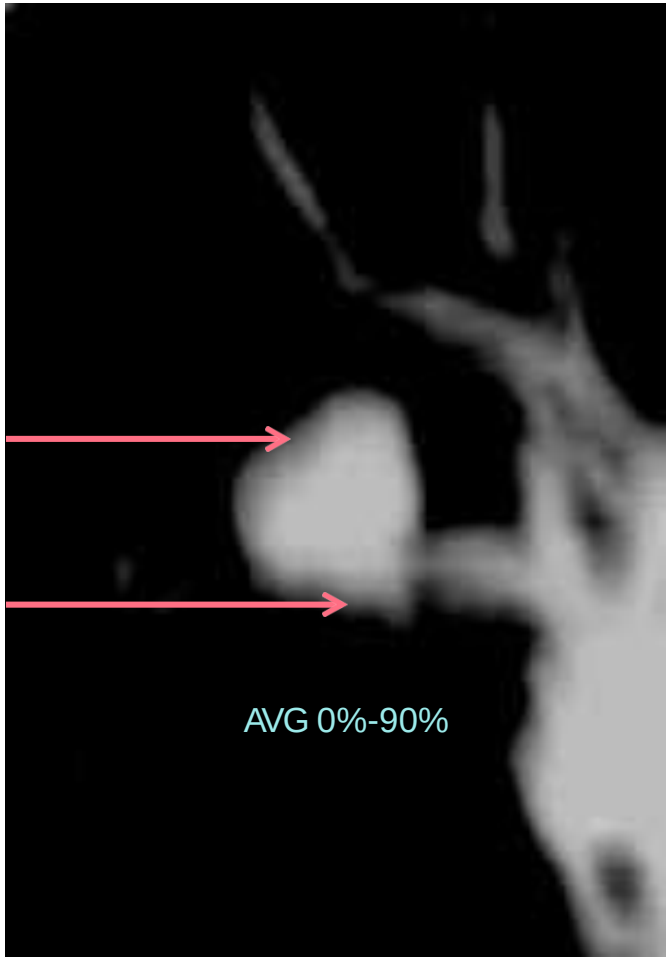
Average Image (AVG)

General

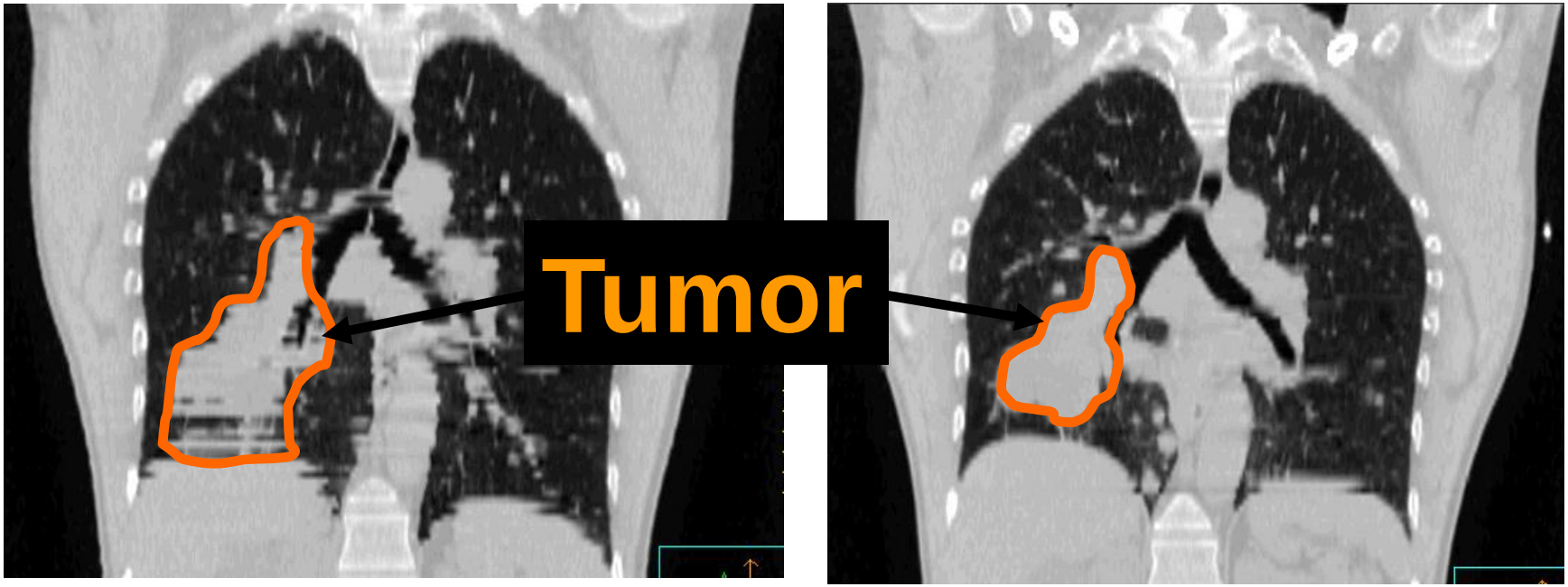
- Voxels equal to the arithmetic mean of the 4DCT
- Illustrates average pixel intensity during respiration
- Phases are equally weighted in image
- "Blurring" resulting from tumor motion

Treatment Planning

- Less useful for delineation (*i.e.* contouring ITV)
- More useful for dose calculation
- Not a perfect representation of tumor



Distorted images, incorrect anatomical positions, volumes or shapes



Conventional

With gated imaging

Pros and Cons of 4D CT

- ✓ Motion artifacts are reduced
- ✓ Tumor and organ spatial & temporal information available

- ❖ Time consuming
- ❖ CT tube heating
- ❖ Data management
- ❖ Artifacts created by irregular breathing

Active Breath Control

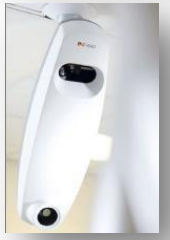
Patient controls breathing with assistance

To perform any type of respiratory gating, it is obvious a *device to monitor breathing* is required

Philips bellows

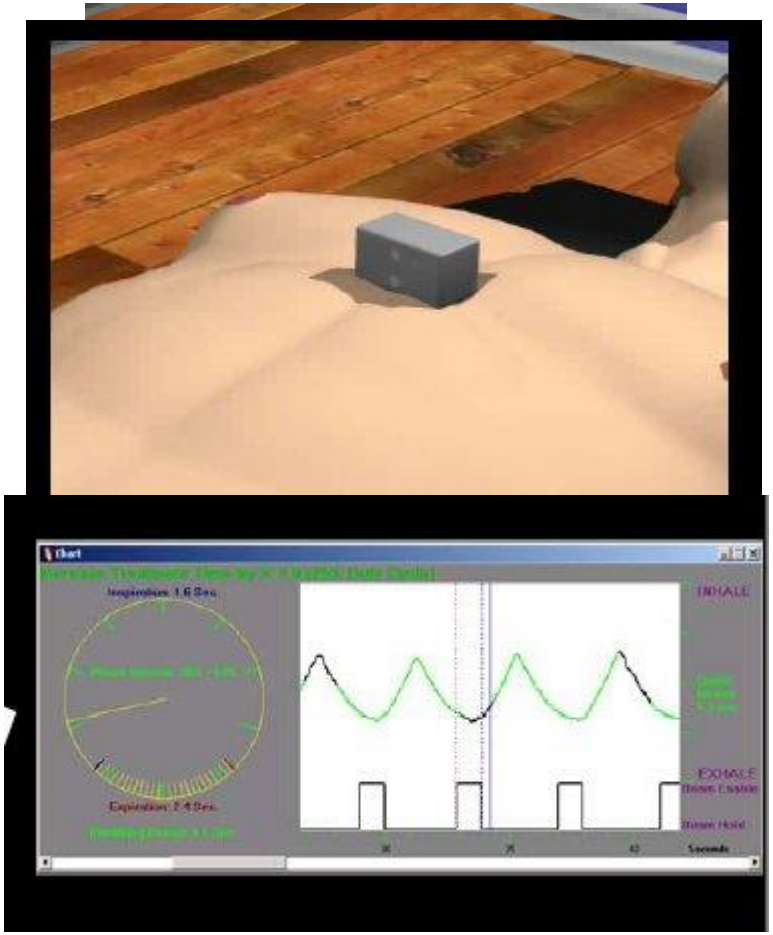
Varian RPM.™

Sentinel



Vision RT

4DCT SCAN



4D CT SCAN

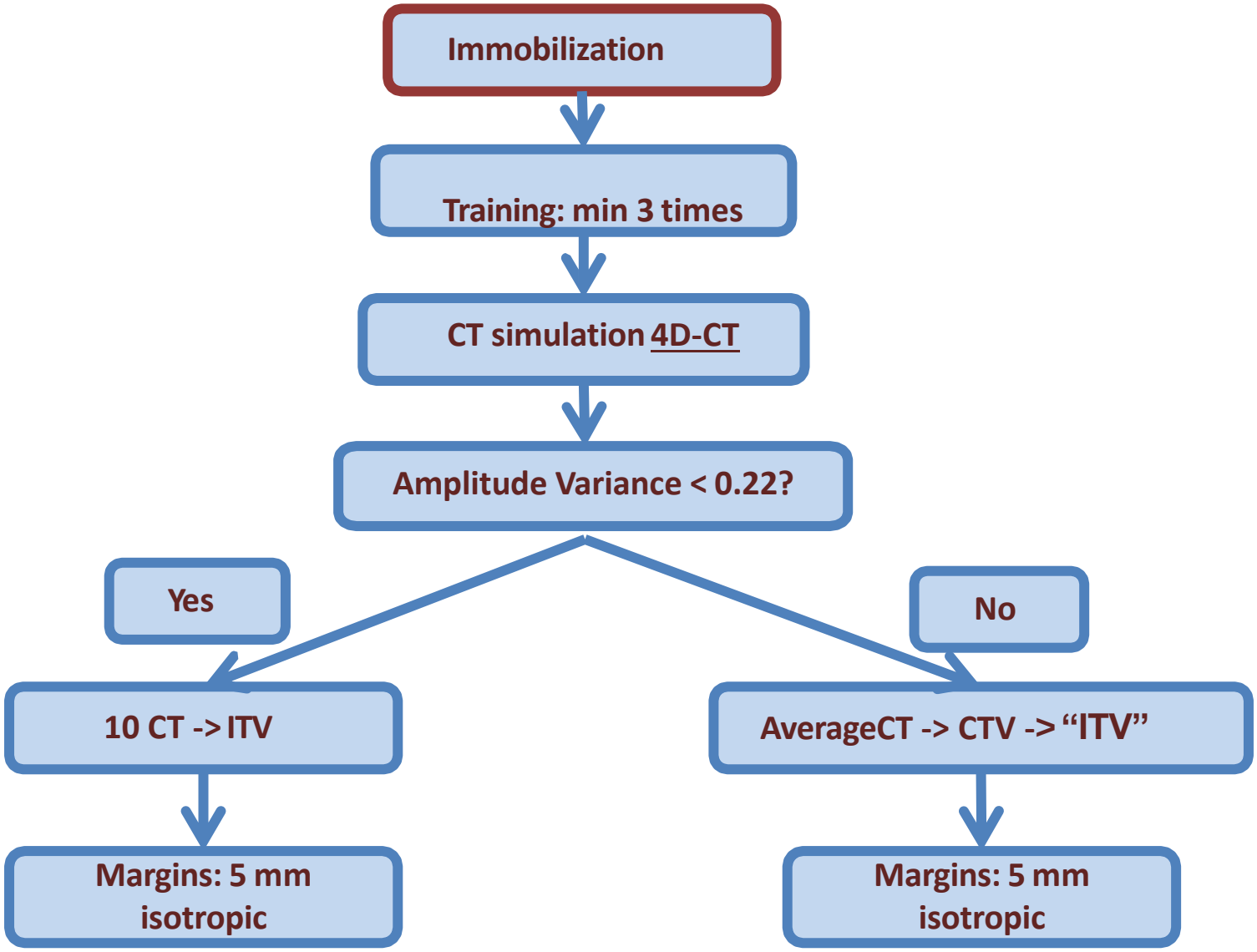
Real-time Position Management (RPM)

Infra red plastic box

In room camera

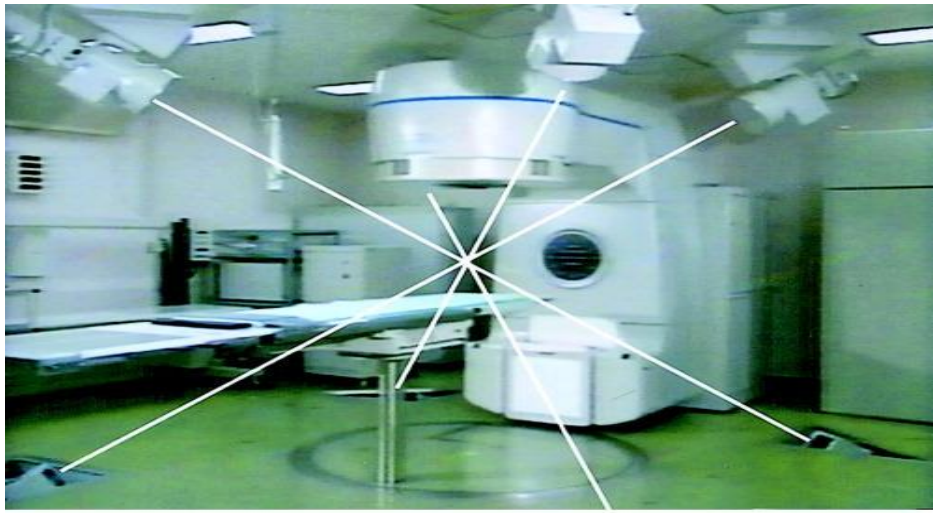
Associated software

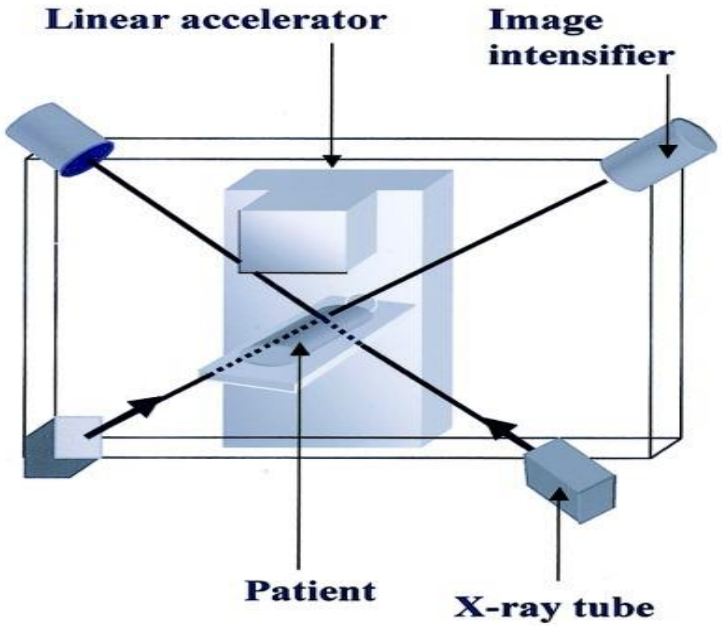
Contouring Work flow in our institute



Tumor Tracking

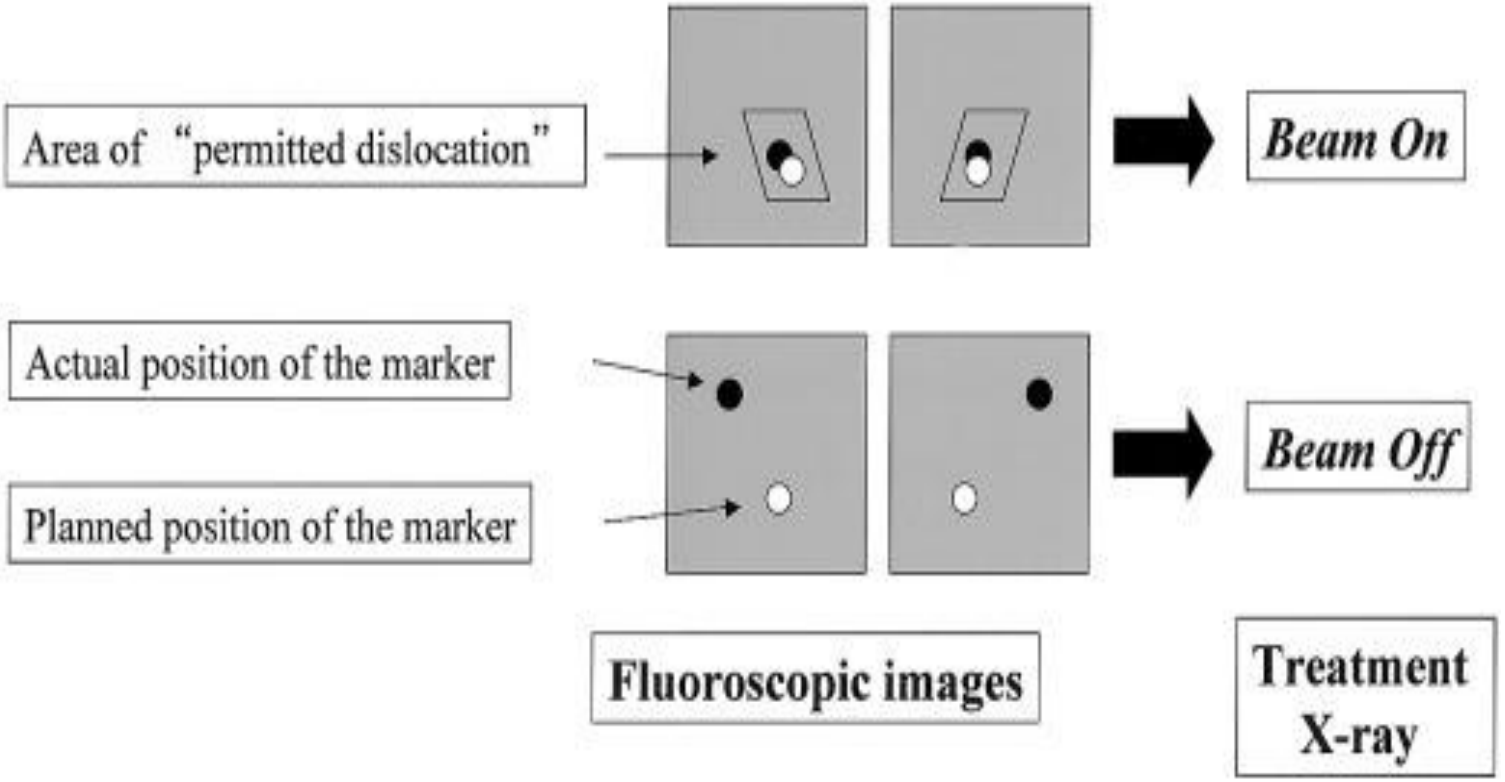
Real-time tumor-tracking radiation therapy for lung carcinoma by the aid of insertion of a gold marker using bronchofiberscopy





Harada T et al .Cancer. 2002 Oct 15;95(8):1720

Real-time tumor-tracking radiation therapy for lung carcinoma by the aid of insertion of a gold marker using bronchofiberscopy



Harada T et al .Cancer. 2002 Oct 15;95(8):1720

Thank You


महामना पंडित
मदन मोहन
मालवीय कैंसर
केन्द्र
MAHAMANA
PANDIT
MADAN MOHAN
MALAVIYA CANCER
CENTRE