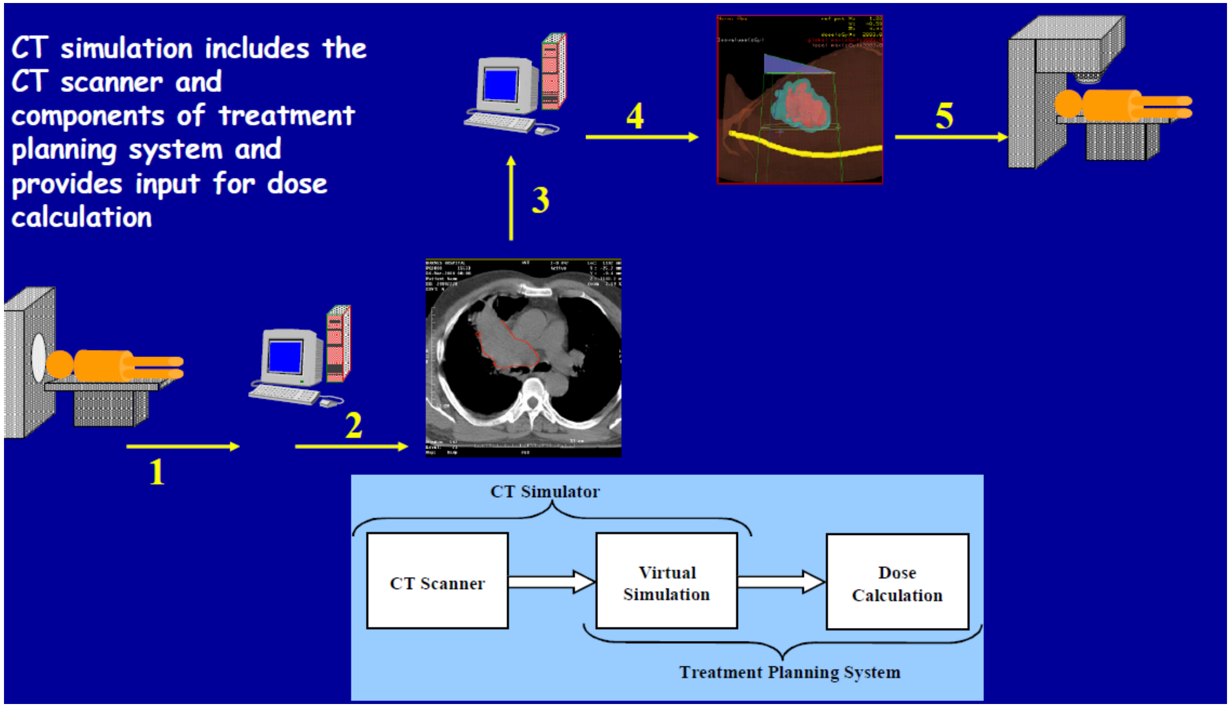
- What are the components of CT simulator




- CT scanner consists of a diagnostic quality CT scanner, laser patient positioning marking system, virtual simulation, 3D treatment planning software and different hardcopy output devices
- The CT scanner is used to acquire a volumetric CT scan of a patient which represents the virtual patient for planning

CT simulation process

## 1. CT-scan, patient positioning and immobilization

- Scanner acquires volumetric scan of a patient, which represents a virtual or digital patient
- Scan is acquired with
  - the patient immobilized in treatment position
  - treatment specific scan protocols
  - often increased scan limits
  - use of contrast
  - placement of localization marks on the patient skin

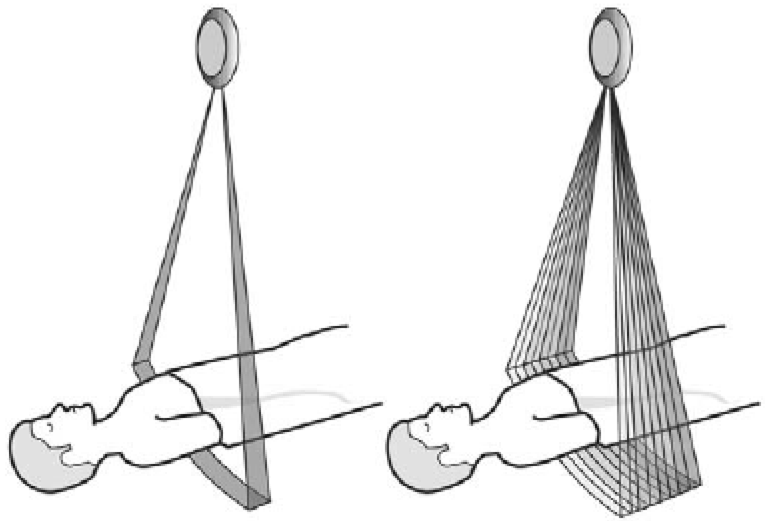
## 2. Treatment planning and CT-simulation

- Beam placement and treatment design is performed using virtual simulation software
  - Contouring of target and OAR using information obtained from different imaging modalities
  - Treatment isocenter placement
    - » can be a final isocenter marked (needs physician presence)
    - » a reference point marked (does not need physician's presence)
    - » localization marks are placed on the patient's skin
  - Placement of the beams, design of treatment portals and communication of information to TPS
  - Printing of DRRs and patient setup instruction

## 3. Treatment setup

- Patient is setup on the treatment machine according to instructions created from the CT-sim software
- Port films are acquired and compared with CT-sim DRRs

- Compare multi-slice scanner and single slice scanner



Single-Slice Multi-Slice

- Compare multi-slice scanner and single slice scanner

**Multislice scanners**

—Projection data from multiple slice is acquired simultaneously

—Uses multiple row of detectors in the z axis

—Enables acquisition of imaging studies faster than single slice scanners

Multi-slice CT

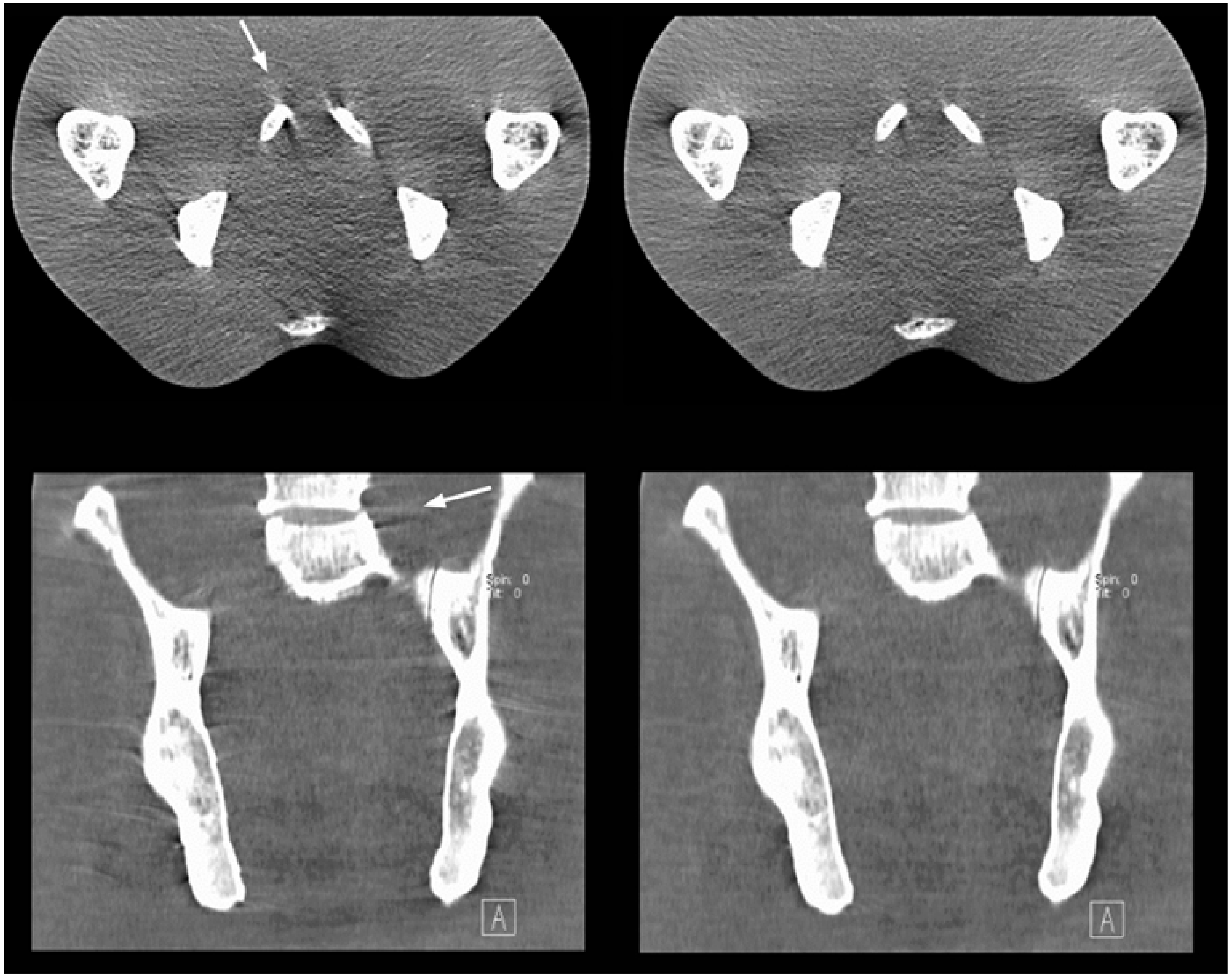
- Wider collimator width
- Post patient collimation
- Slice thickness – 0.75mm
- Rotation time – 0.5s

single-slice CT

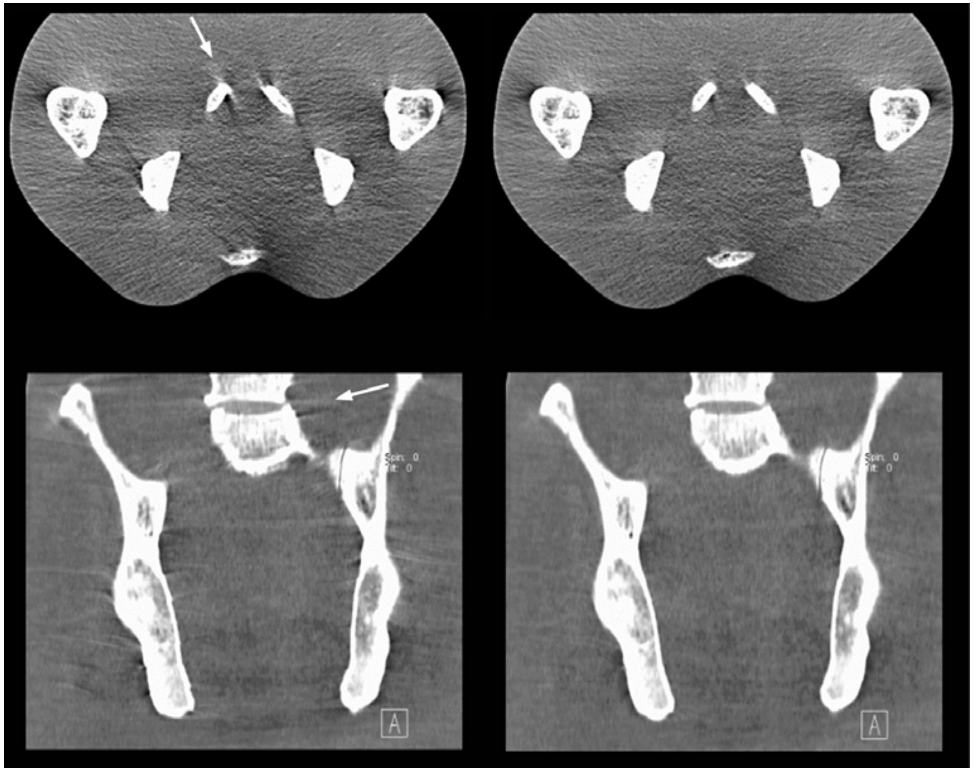
- Slice thickness – 3 mm
- Rotation time – 1s

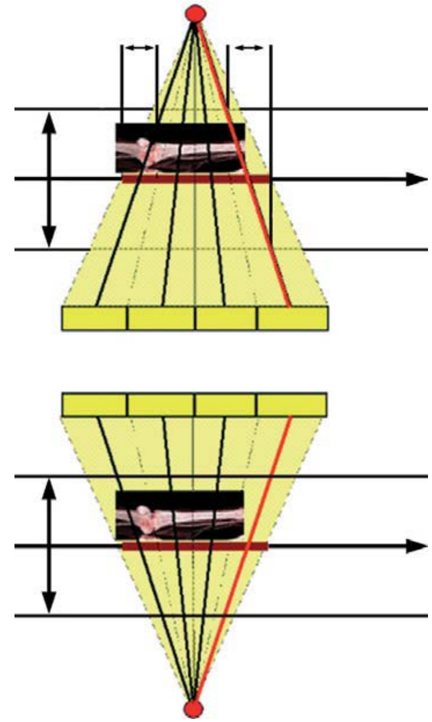
Goldman, Lee W. "Principles of CT: multislice CT." *Journal of nuclear medicine technology* 36.2 (2008): 57-68.

What is this artifact?

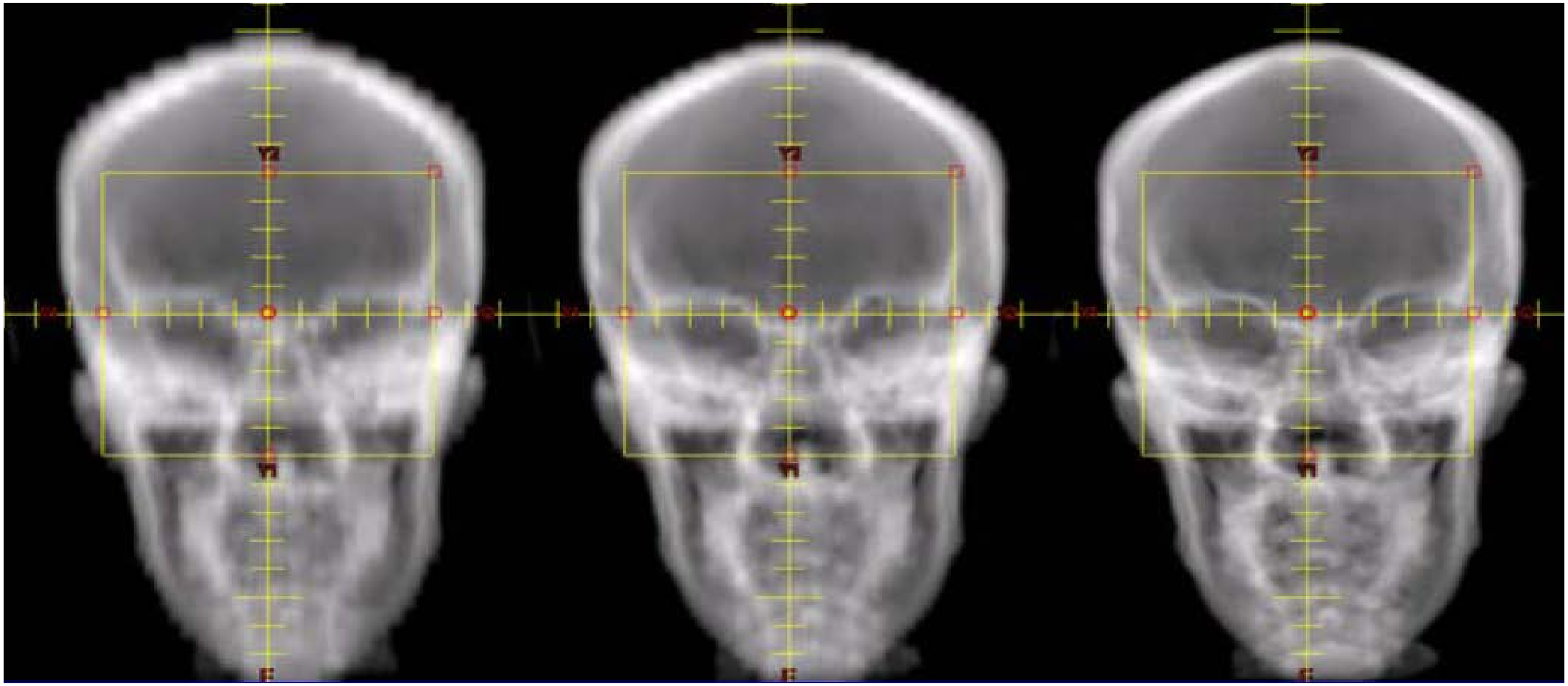


# The Cone-Angle Problem in Multi-slice CT

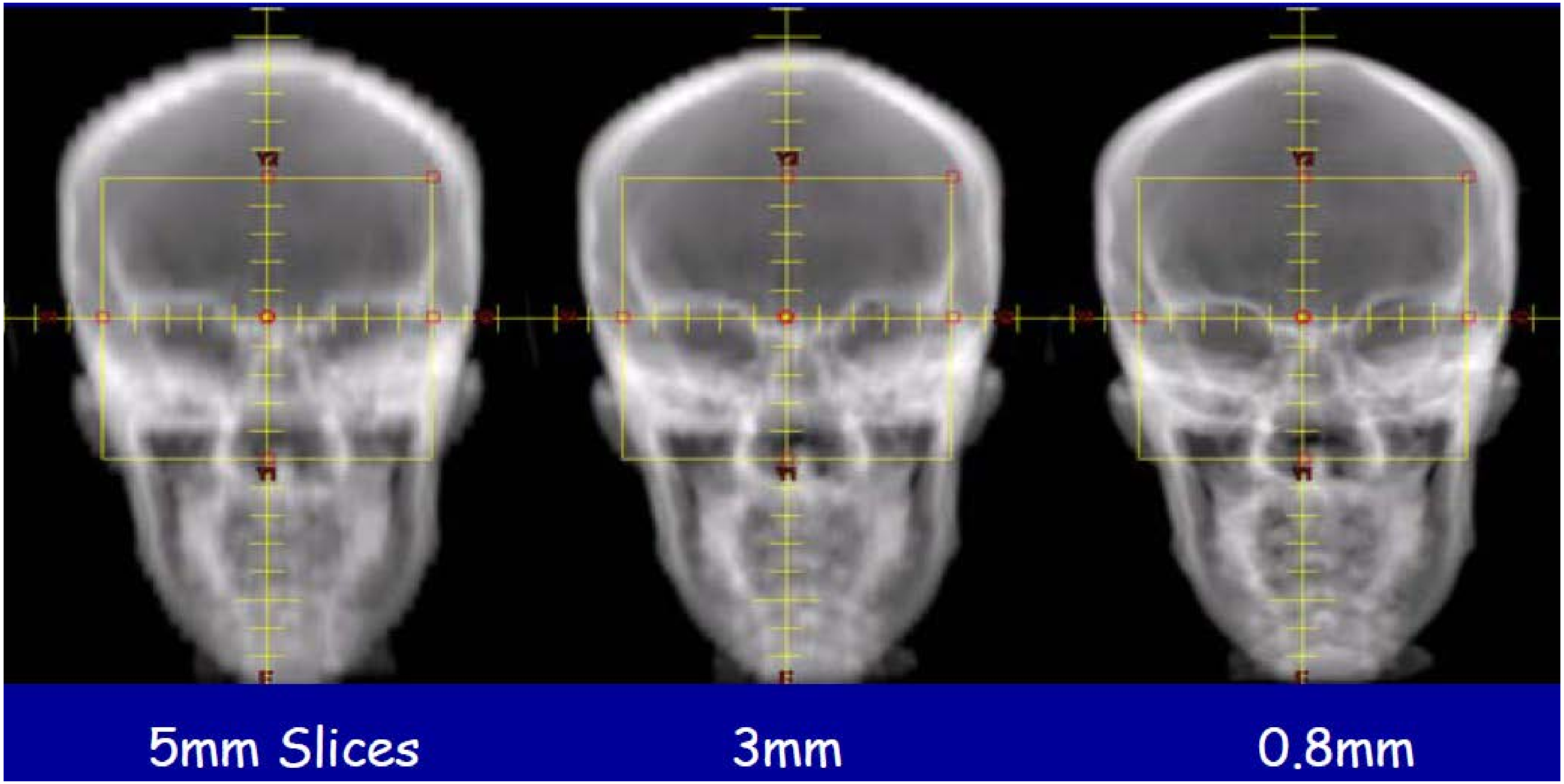




The measurement rays are tilted by the so called cone-angle with respect to the center plane. The cone-angle is largest for the slices at the outer edges of the detector and it increases with an increasing number of detector rows if their width is kept constant. As a first approximation, the cone-angle is neglected in multi-slice CT reconstruction approaches. Then, the measurement rays are treated as if they travel perpendicular to the z-axis, and modified two dimensional image-reconstruction algorithms are used. The data, however, are then inconsistent, and cone-beam artifacts will be produced



- What are these images?
- What is the difference between them


5mm Slices
3mm
0.8mm

# CT sim QA --- AAPM TG 66

(1)Radiation safety and patient safety test (including CT dosimetry)
(2) Electromechanical components
(3) Image quality

TABLE I. Test specifications for radiation and patient safety.

| Performance parameter | Test objective | Frequency | Tolerance limits |
|---|---|---|---|
| Shielding survey | To verify exposure levels around the CT-scanner room | Initially | NCRP recommendations or applicable regulatory limits |
| Patient dose from CT-scan, CTDI | To verify safe dose delivered from the scanner | Annually or after major CT-scanner component replacement | ±20% of manufacturer specifications |

TABLE III. Test specifications for image performance evaluation.[a]

| Performance parameter | Frequency | Tolerance limits |
|---|---|---|
| CT number accuracy | Daily—CT number for water<br>Monthly—4 to 5 different materials<br>Annually—Electron density phantom | For water, 0±5 HU |
| Image noise | Daily | Manufacturer specifications |
| In plane spatial integrity | Daily—$x$ or $y$ direction<br>Monthly—both directions | ±1 mm |
| Field uniformity | Monthly—most commonly used kVp<br>Annually—other used kVp settings | within ±5 HU |
| Electron density to CT number | Annually—or after scanner calibration | Consistent with commissioning results |

TABLE II. Test specifications for electromechanical components.[a]

| Performance parameter | Test objective | Frequency | Tolerance limits |
|---|---|---|---|
| Alignment of gantry lasers with the center of imaging plane | To verify proper identification of scan plane with gantry lasers | Daily | ±2 mm |
| Orientation of gantry lasers with respect to the imaging plane | To verify that the gantry lasers are parallel and orthogonal with the imaging plane over the full length of laser projection | Monthly and after laser adjustments | ±2 mm over the length of laser projection |
| Spacing of lateral wall lasers with respect to lateral gantry lasers and scan plane | To verify that lateral wall lasers are accurately spaced from the scan plane. This distance is used for patient localization marking | Monthly and after laser adjustments | ±2 mm |
| Orientation of wall lasers with respect to the imaging plane | To verify that the wall lasers are parallel and orthogonal with the imaging plane over the full length of laser projection | Monthly and after laser adjustments | ±2 mm over the length of laser projection |
| Orientation of the ceiling laser with respect to the imaging plane | To verify that the ceiling laser is orthogonal with the imaging plane | Monthly and after laser adjustments | ±2 mm over the length of laser projection |
| Orientation of the CT-scanner tabletop with respect to the imaging plane | To verify that the CT-scanner tabletop is level and orthogonal with the imaging plane | Monthly or when daily laser QA tests reveal rotational problems | ±2 mm over the length and width of the tabletop |
| Table vertical and longitudinal motion | To verify that the table longitudinal motion according to digital indicators is accurate and reproducible | Monthly | ±1 mm over the range of table motion |
| Table indexing and position | To verify table indexing and position accuracy under scanner | Annually | ±1 mm over the scan range |

# MRI simulator







- What are the advantages and disadvantages of MRI simulator

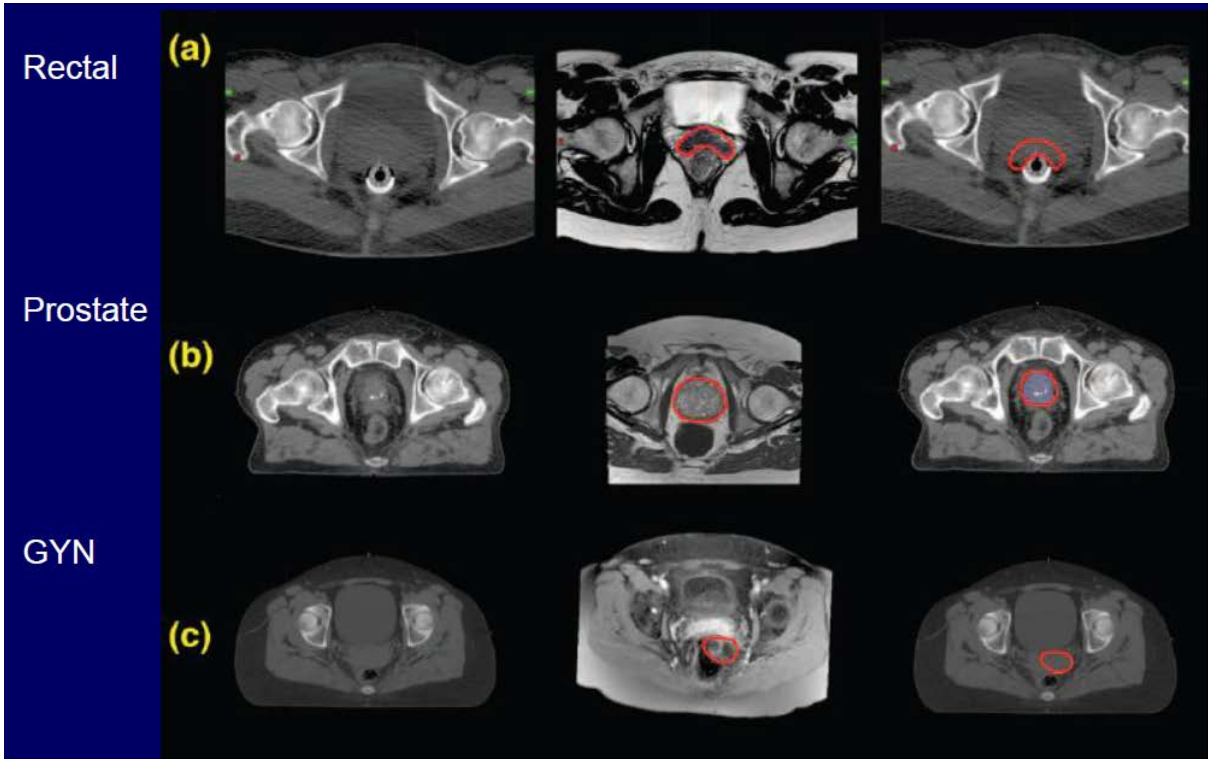
# MRI simulator

## Advantages

- Soft tissue contrast
- Multiple contrast (T1, T2,…)
- Functional imaging
- Any slice orientation

## disadvantages

- No electron density information
- Image distortion
- Bone not clear
- DRR



# MRI simulator

MRI simulator  VS. MRI scanner

# MRI simulator

- Wide bore MRI Scanner
- Flat table top, immobilization devices and compatible RF coils
- Movable lasers
- Simulation workstation
- RT-sim MRI protocols
- QA
- Integration in RT workflow

Cao 1