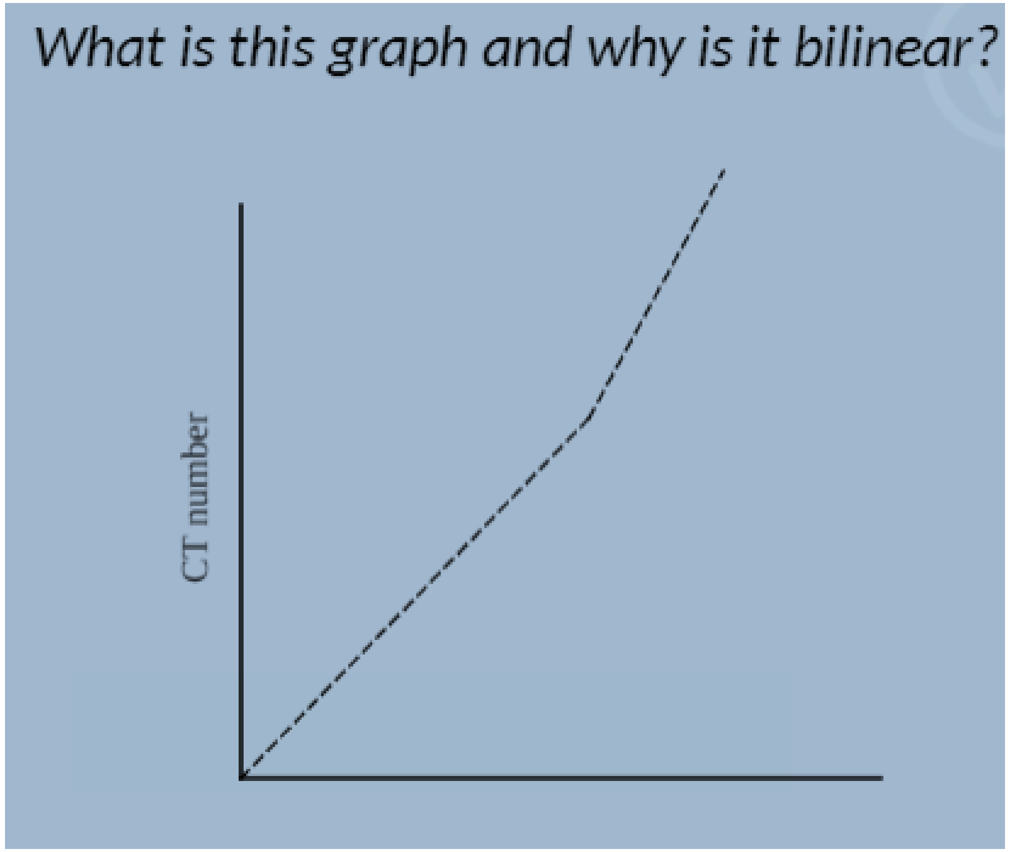
- **What is this phantom used for and why is it important for radiation therapy planning?**

- This is an electron density phantom which is used to establish a relationship between the electron density of various tissues and their corresponding CT number.
- Modern treatment planning systems typically employ corrections to account for heterogeneity of body tissues in dose computation.
- This phantom may be scanned on your CT and the actual electron densities in the cylinders may be related to the generated CT numbers
- This data may then be used to customize the CT number vs. electron density curve

- **What are some typical CT numbers for body tissues?**

Tissue	CT Number
Water	0
Air	-1000
Dense bone	1000
Fat	-20 to -100
Muscle	45 to 60
Lung	-300
Brain matter	25 to 45



- This graph depicts the relationship between CT number and electron density

- Compton-measured electron density CT number

- The non-linearity in the figure is a result of the change in atomic number of the tissues which affects the proportion of beam attenuation by Compton versus Photoelectric interactions.

- Break occurs slightly above electron density of water.

- **What is the definition of CT number?**
- **What is the difference between CT number and Hounsfield Unit (HU)?**

$$CT\ \# = 1000 \times \frac{(\mu_t - \mu_W)}{\mu_W}$$

Where:

u_t = linear attenuation coefficient for tissue in pixel

u_W = linear attenuation coefficient for water

- **CT number is the linear attenuation coefficient rescaled to water.**
- **Hounsfield unit is the CT number normalized to 1000.**
- **HU represents a 0.1% difference between the linear attenuation coefficient of sample vs. water.**
- **The attenuation coefficient of material depends upon X-ray beam energy. CT uses 120-140kVp X-rays (Compton region), therefore electron density may be inferred**

Describe the steps to perform a CT Sim end to end test.

Stereotactic Dose Verification Phantom from Standard Imaging, Inc.

1) Scan phantom with fiducial marker.
2) Transfer data to workstation and check orientation.
3) Outline external contour and calculate volume & area.
4) Align isocenter to fiducial marker, move CT couch to iso.
5) Mark phantom insuring lasers match fiducial marker
6) Set field, send to RTP system (check orientation & field)
7) Check CT numbers if phantom is heterogeneous
8) Send data to treatment machine
9) Print DRRs and setup documentation
10) Setup and verify phantom treatment

Your cancer center is planning to install PET/CT scanner to simulate radiation therapy patients and asks for your physics advice. What do you need to check and advise them?

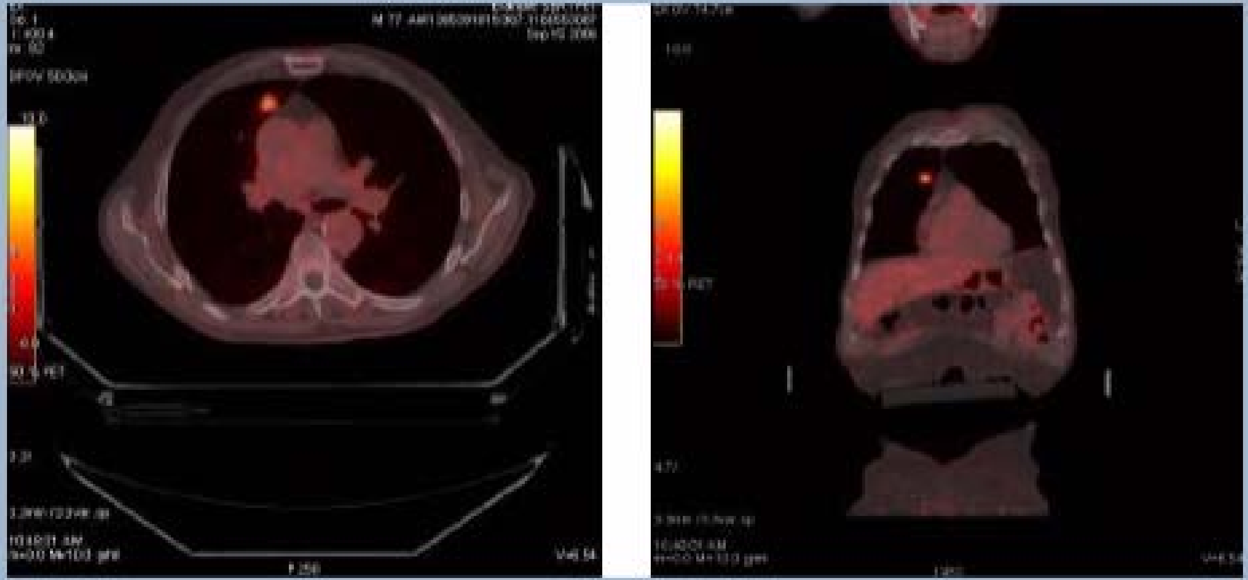


Image from Kearns et al, JACMP, 9, 141 (2008)

Your clinic just installed a new CT simulator. What commissioning tests would you do before approving it for clinical use?

- Safety and shielding (always the first!) This involves survey and testing CT-dose from various protocols.
- Accuracy of electro-mechanical components
- Image Quality: noise, resolution, spatial integrity
- Sofiware and data-transfer accuracy
- Process: Evaluate the overall simulation process

- The guiding document you can use is TG-66, QA for CT simulators (2003)

- This is the ACR CT accreditation phantom
- Consists of 4 slabs with different contents to measure various scanner parameters
- CT# in the uniform part must be 0±5 HU

1. CT# accuracy: Known materials must have the correct CT#
2. CT# uniformity: Uniform material → uniform CT# ± noise
3. Image noise: How much spread in CT# for uniform material
4. Low contrast resolution: Can you still distinguish adjacent objects with only a few CT# difference? How small an object?
5. High contrast (spatial) resolution: How many line pairs per cm (lp/cm) can you resolve?
6. Geometric accuracy: Is there any image distortion?