MIA – Medical Image Modalities

Master VIBOT – University of Girona

2011-2012

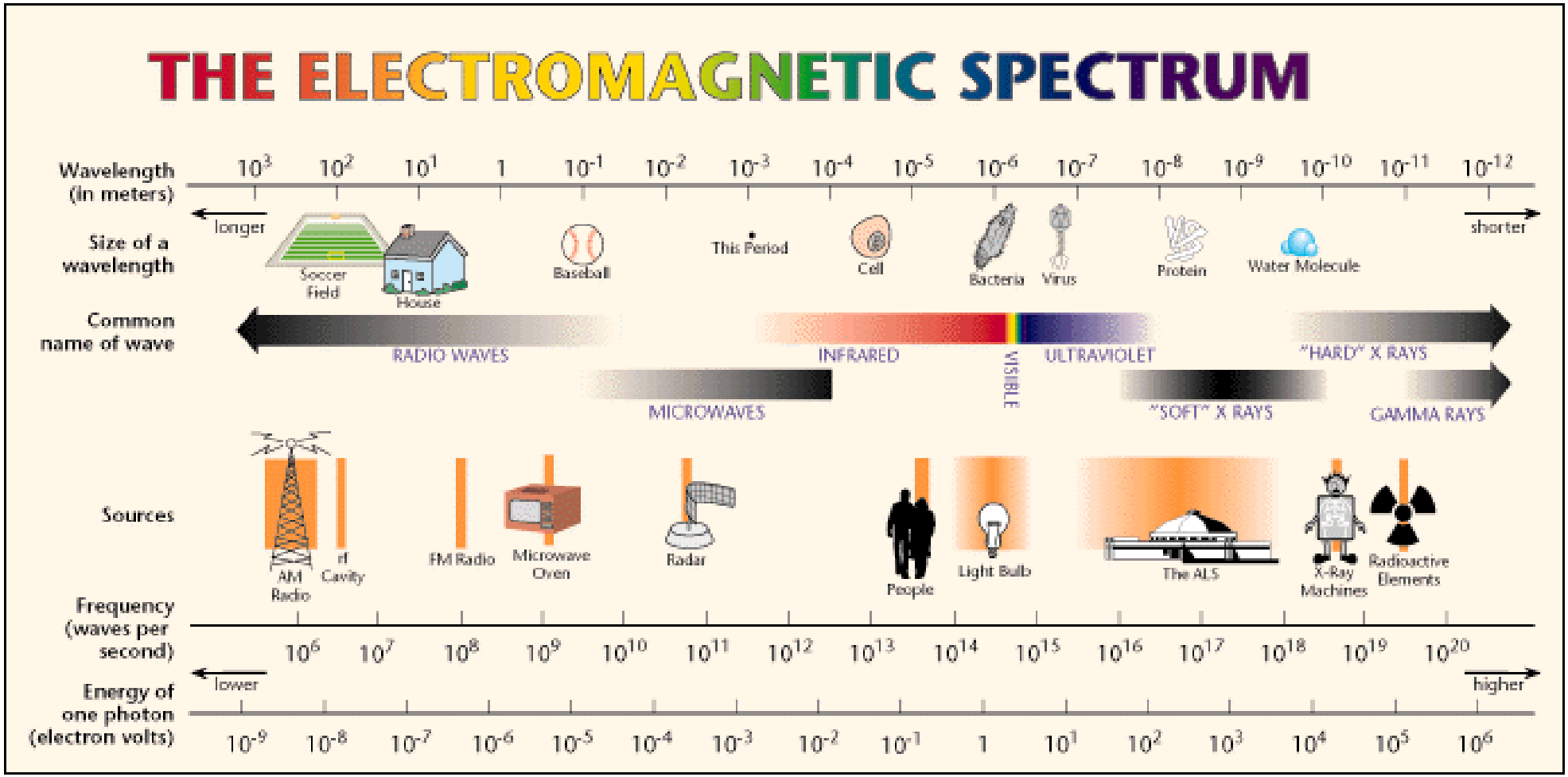
Medical Imaging

- Definition:
  - The technique and process used to **create images** of the **human body** (or parts and fuction thereof) for **clinical purposes**.

- As part of biological imaging, it incorporates:
  - Radiology
  - Nuclear medicine
  - Endoscopy
  - Thermography
  - Microscopy
  - Data as maps representation

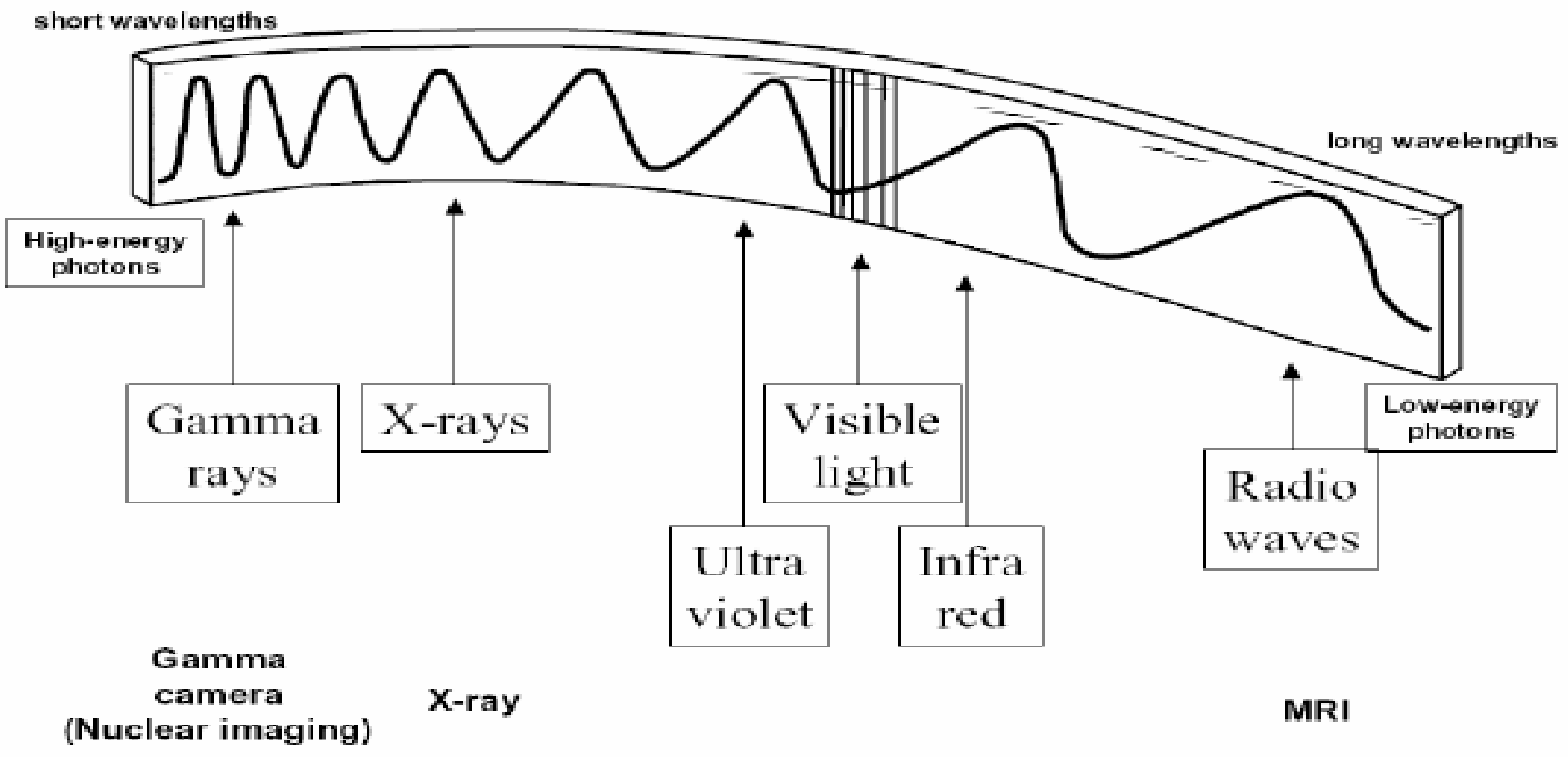
Medical Imaging: classification

- According to the energy of the radiation source



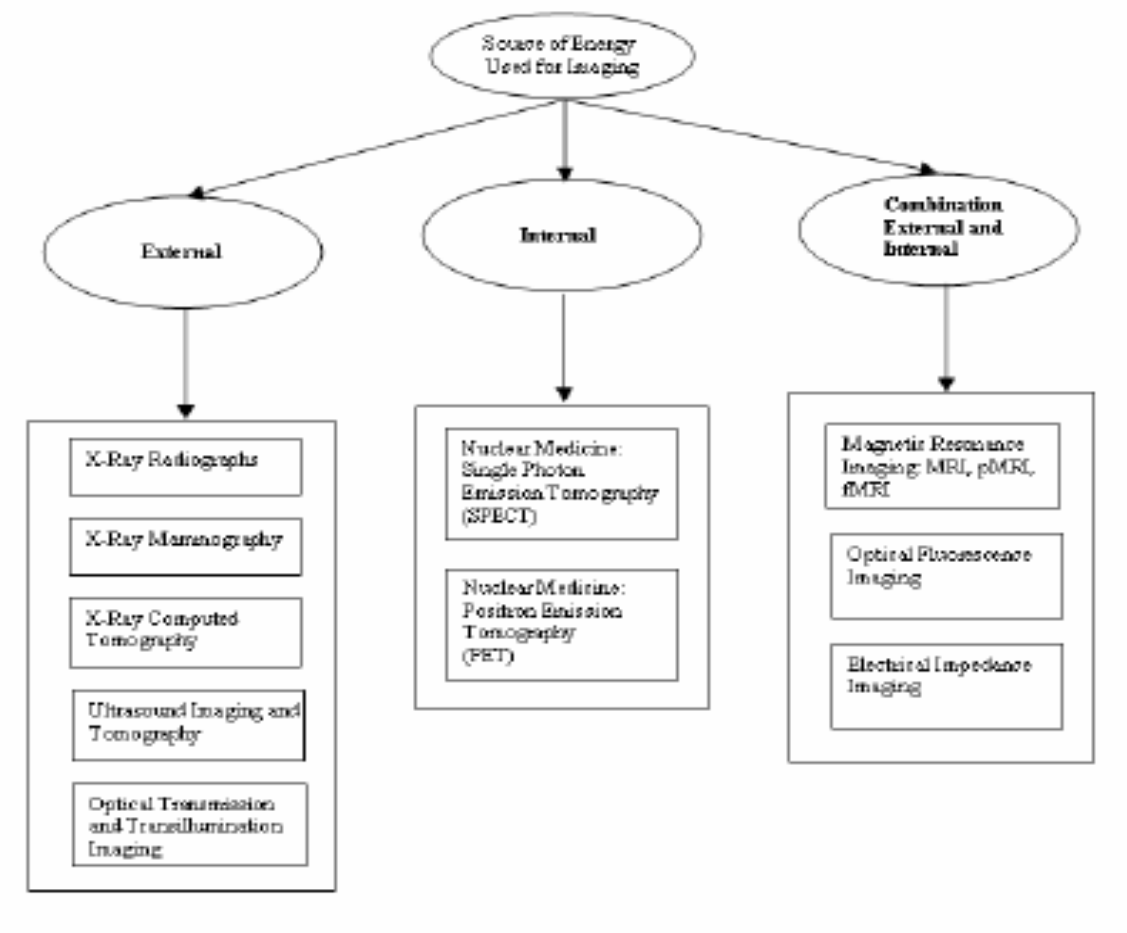
Medical Imaging: classification

- According to the energy of the radiation source



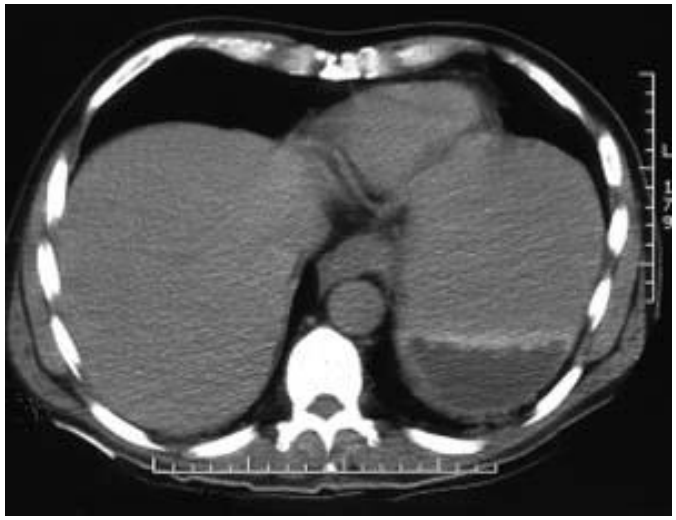
Medical Imaging: classification

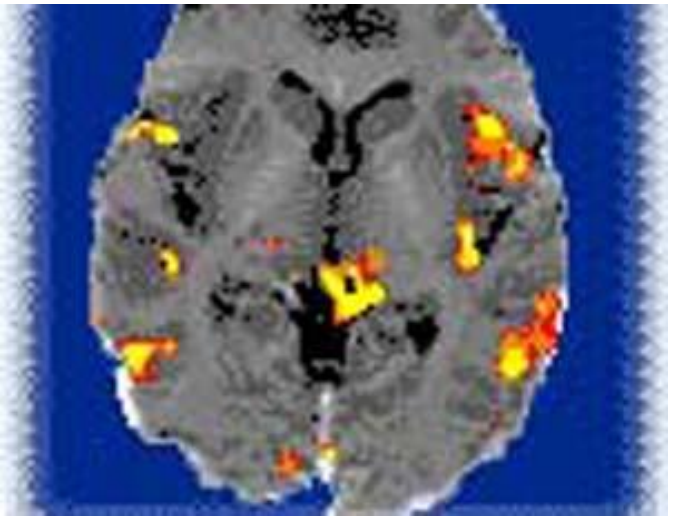
- According to the location of the radiation source

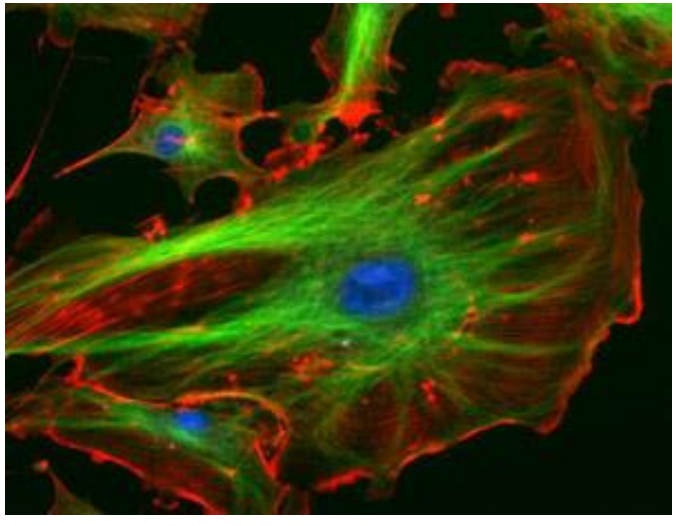


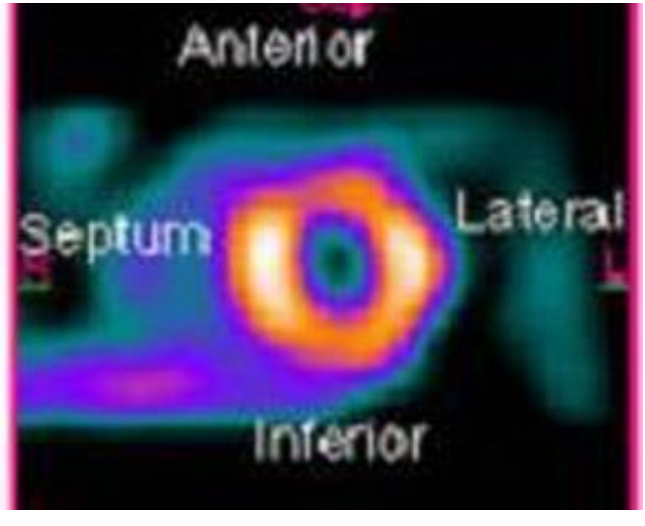
Medical Imaging: examples

- Examples of medical images









Medical Imaging: modalities

- Modalities:
  - X-Ray Imaging and Computed Tomography
  - Magnetic Resonance Imaging
  - Ultrasonic Imaging
  - Others (SPECT, …)

- General Image Characteristics:
  - Spatial Resolution
  - Signal-to-Noise Ratio
  - Contrast-to-Noise Ratio
  - Image Filtering
  - The Receiver Operating Curve

X-Ray Imaging

X-Ray Imaging

- Systems:
  - Chest X-rays, mammography
  - Dental X-rays
  - Fluoroscopy, angiography

- Properties:
  - High resolution
  - Low dose
  - Broad coverage
  - Short exposure time

X-Ray Imaging

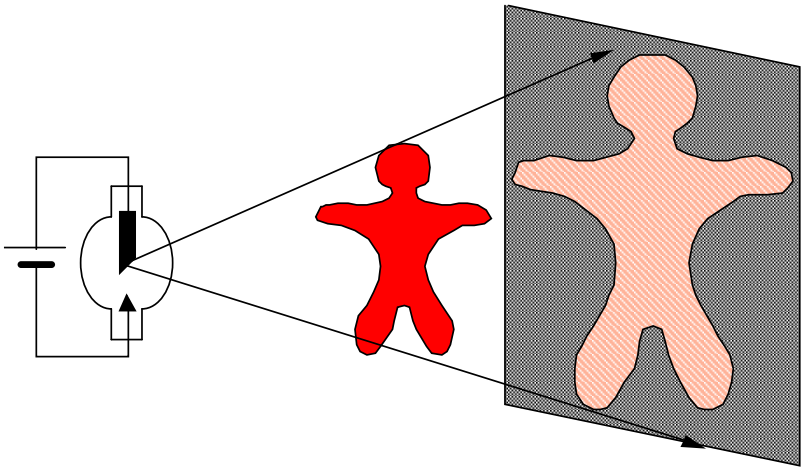
- How it works:
  - Projection imaging is the acquisition of a 2D image of patient's 3D anatomy
  - Is a transmission imaging procedure
  - The optical density at any location corresponds to the attenuation characteristics of the patient at that location

$$I(x,y) = I_0 e^{-d(x,y)\mu(x,y)}$$

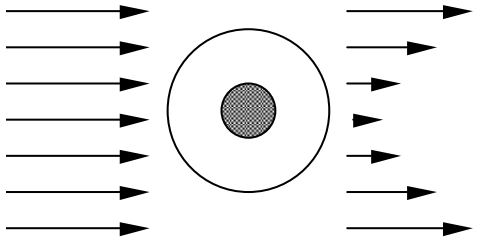
Air	Blood	Muscle	Bone
0	0.178	0.180	0.48

X-Ray Imaging

- How it works: projection imaging is the acquisition of a 2D image of patient's 3D anatomy



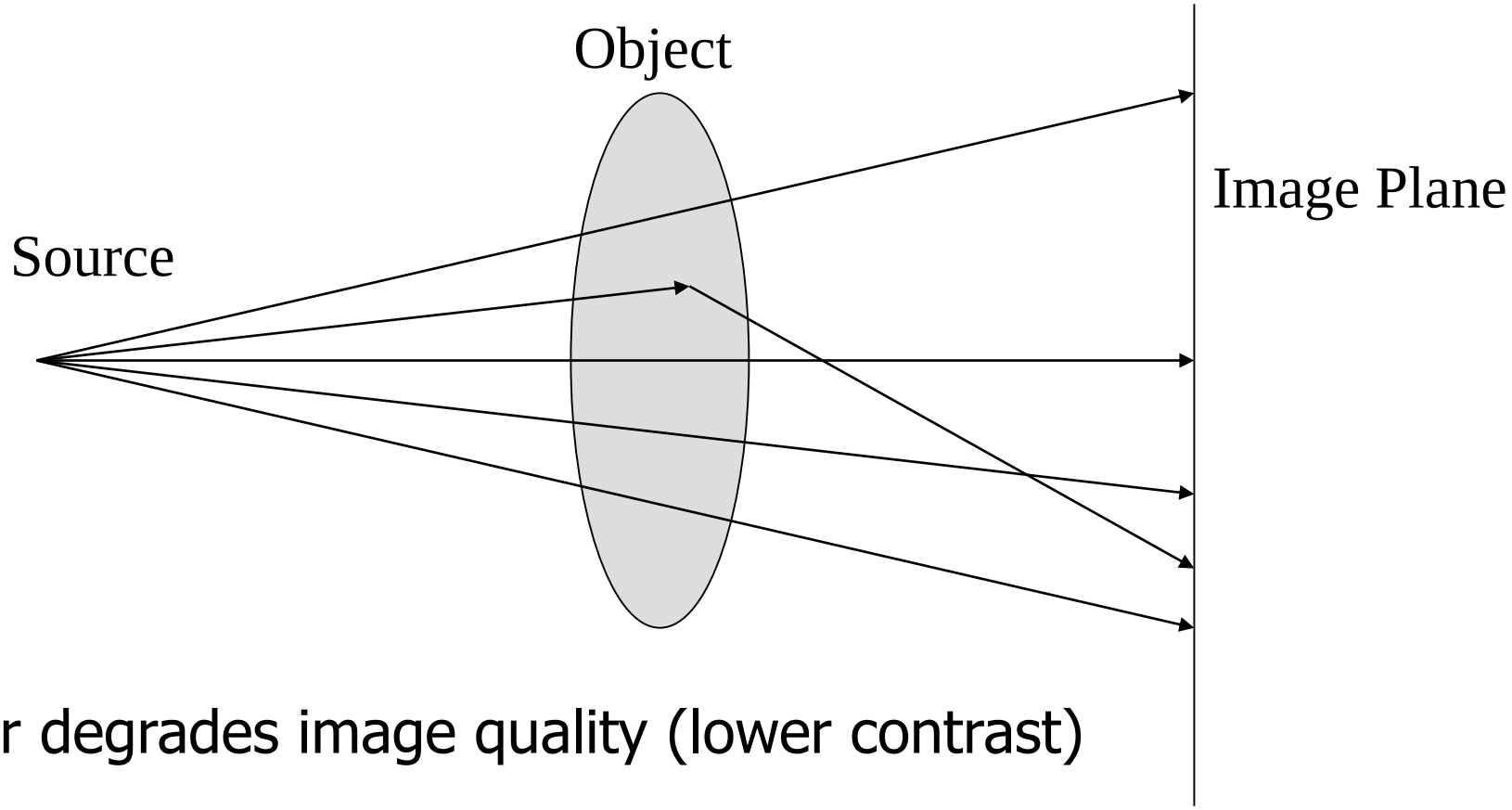
X-ray shadow cast by an object



Strength of shadow depends on composition and thickness

X-Ray Imaging

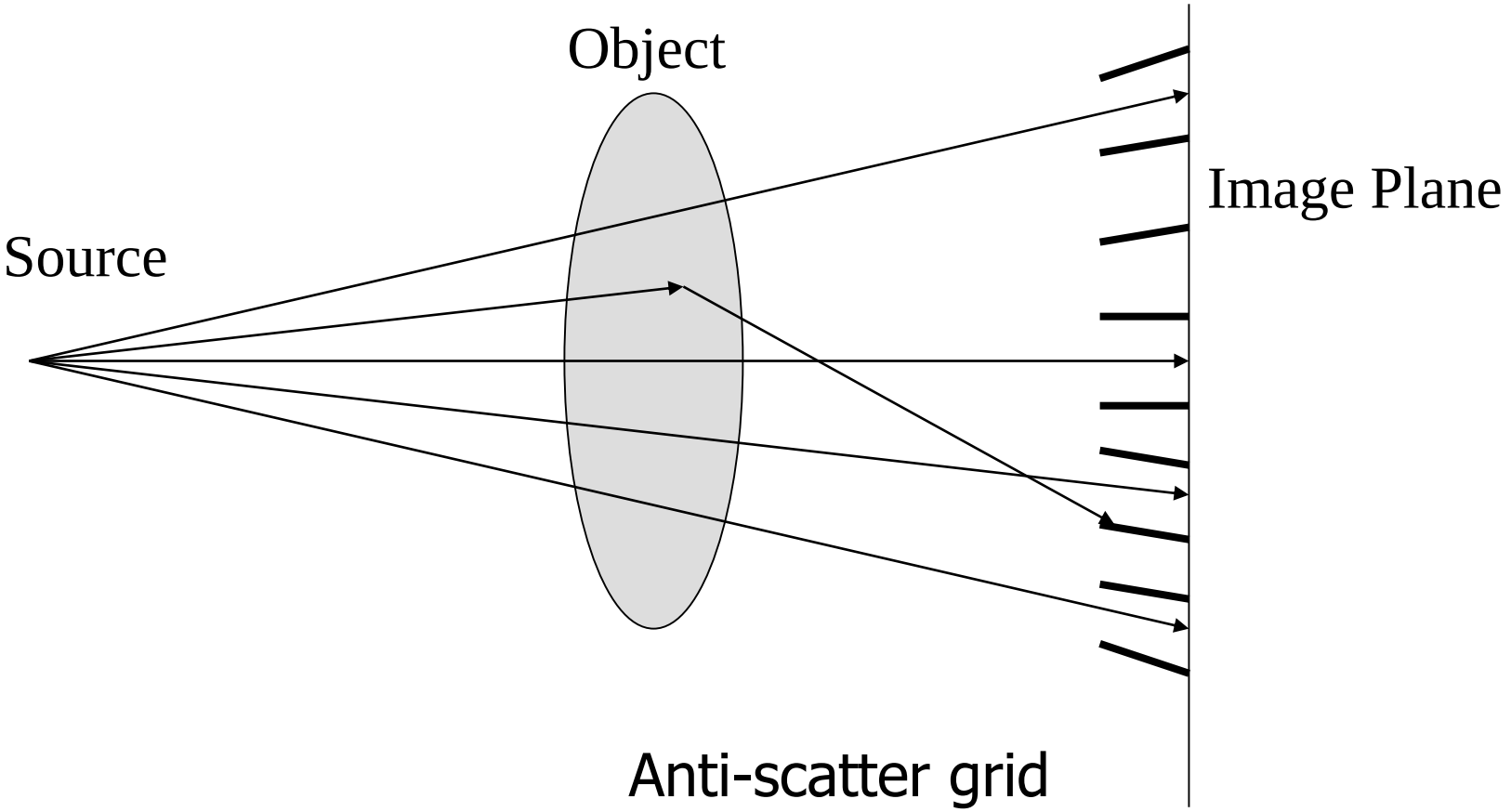
- Scattering



Scatter degrades image quality (lower contrast)

X-Ray Imaging

- Scattering



X-Ray Imaging

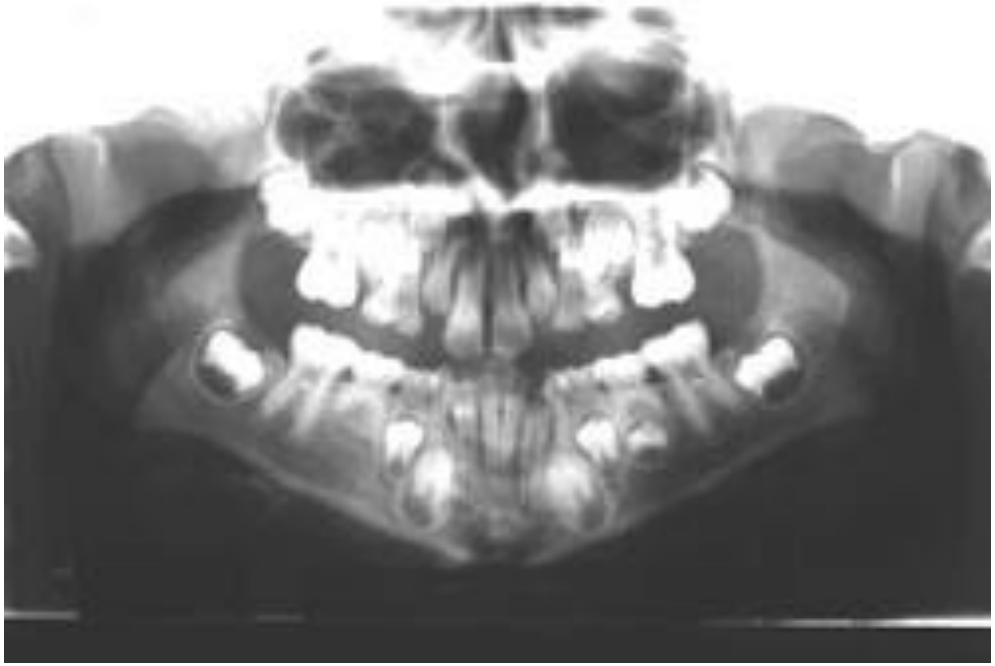
- Examples: full body

X-Ray Imaging

- Examples: torax

X-Ray Imaging

- Examples: dental

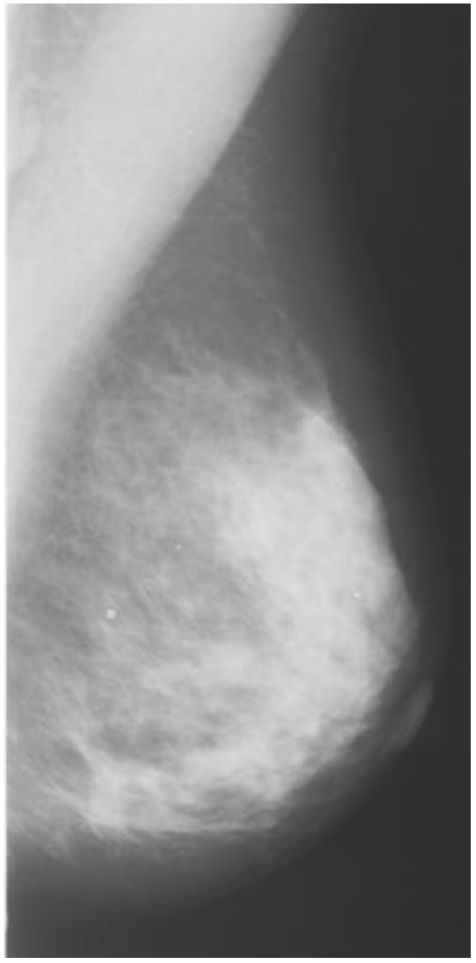


X-Ray Imaging

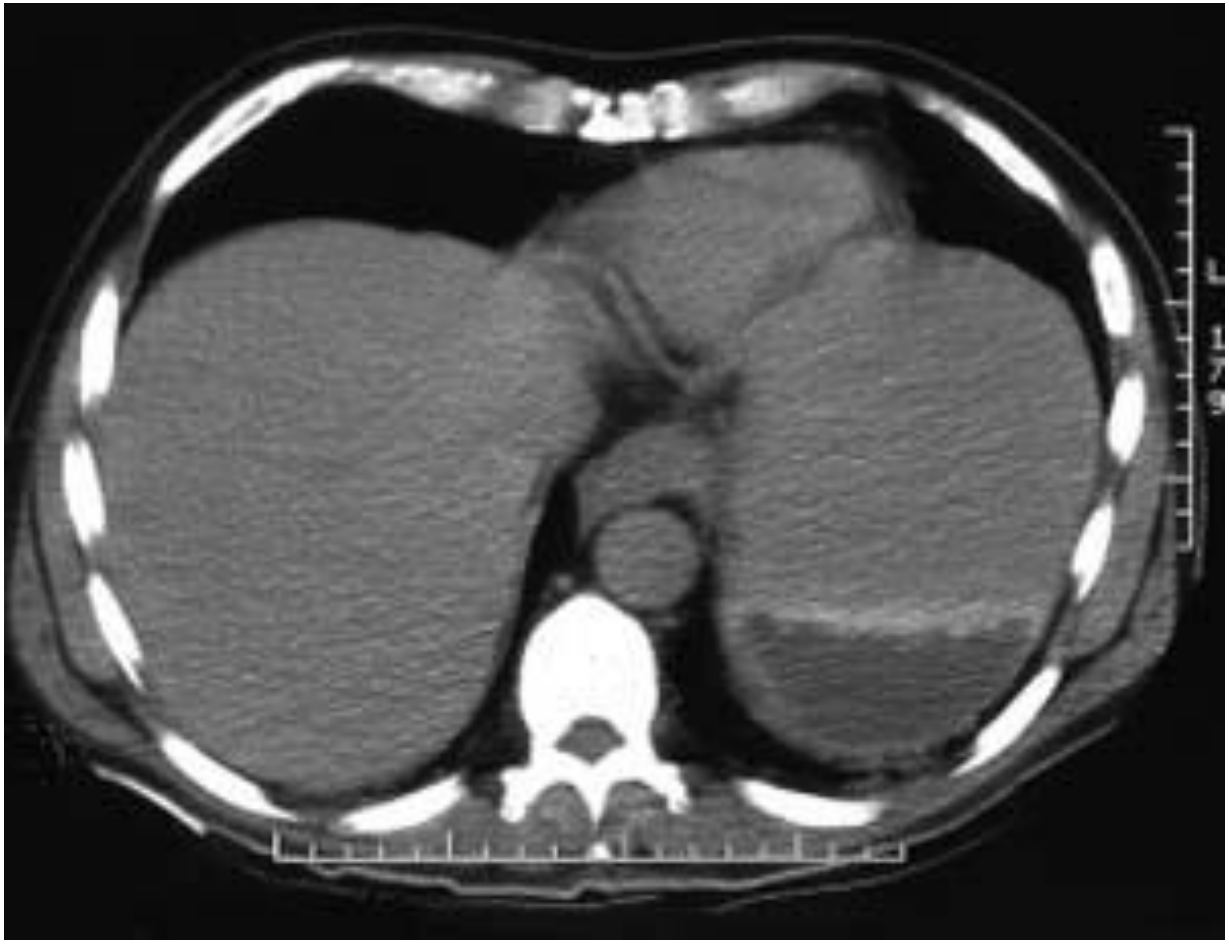
- Examples: bone information and injuries

X-Ray Imaging

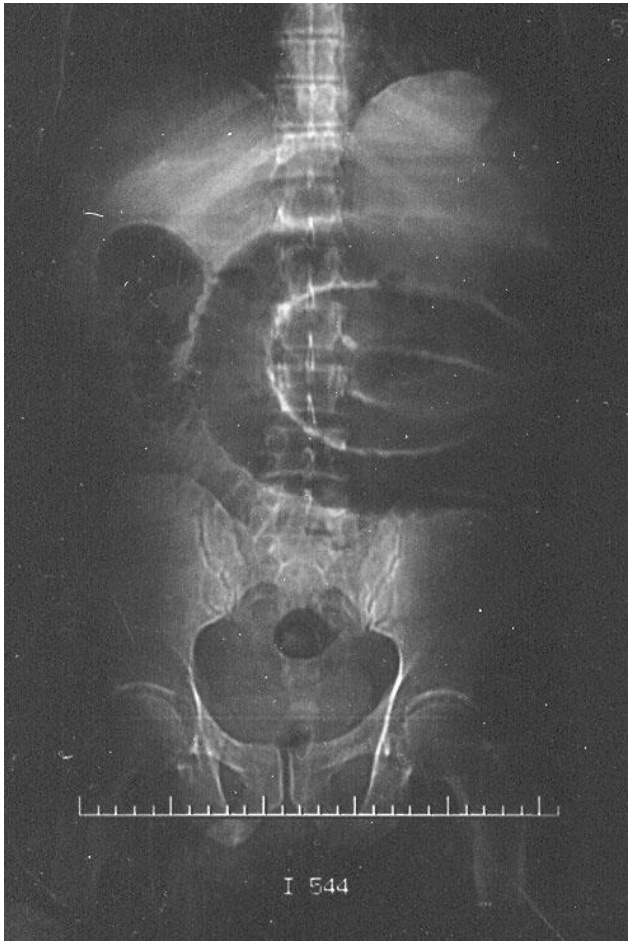
- Examples: mammography



Computed Tomography



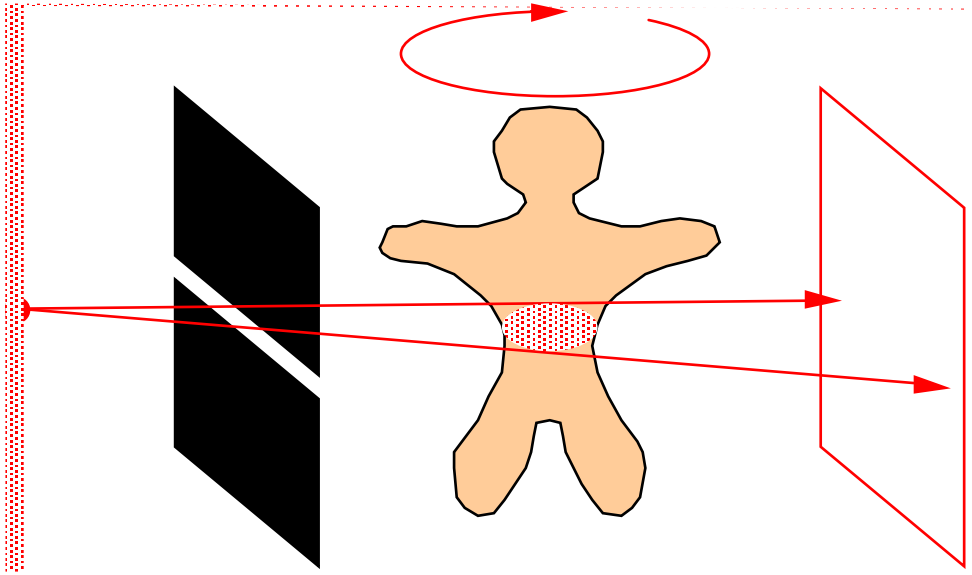
CT Image of plane through liver and stomach



Projection image from CT scans

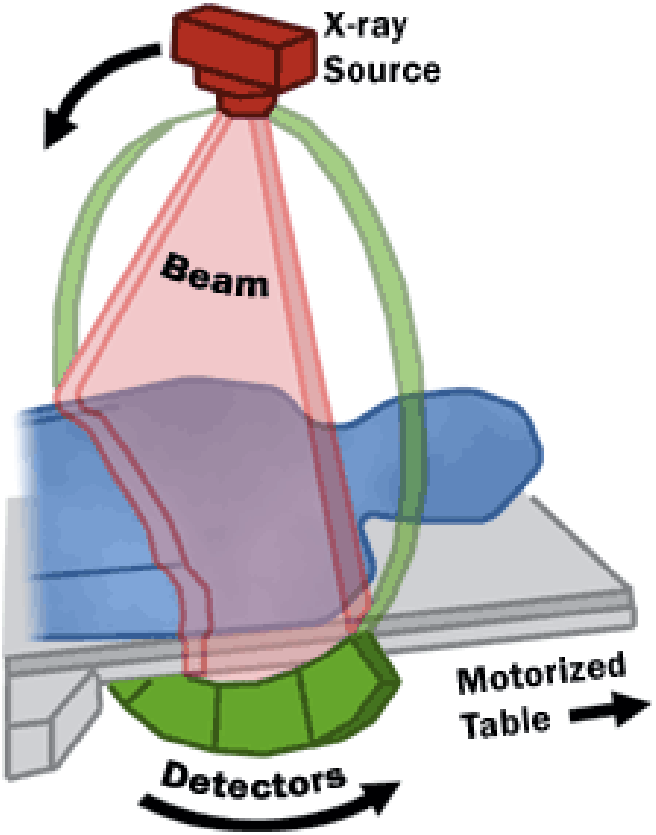
Computed Tomography

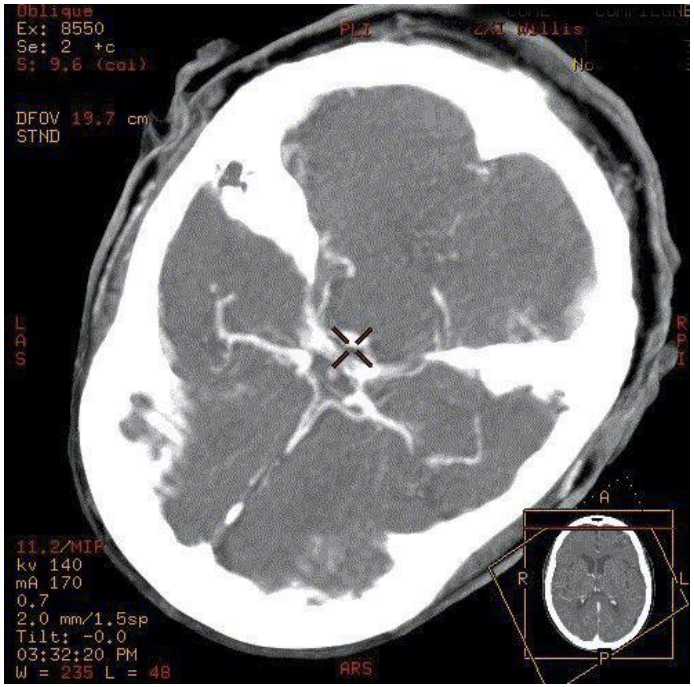
- How it works:
  - Only 1 plane is illuminated
  - Source-object motion provides added information
  - Currently most X-ray CT scanners have an X-ray source with a fan beam geometry and a 360° ring of X-ray detectors (~1000)



Computed Tomography

- How it works:



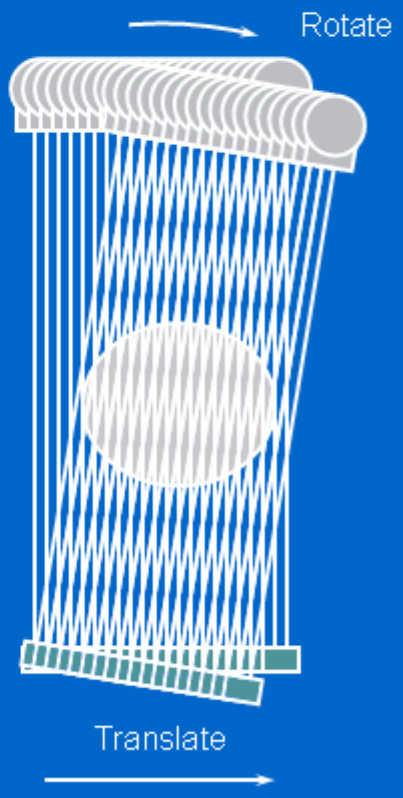


Computed Tomography

- How it works:

First generation CT scanner

- Single detector
- Translate - rotate acquisition
  - Translates across patient
  - Rotates around patient
- Very slow
  - minutes per slice

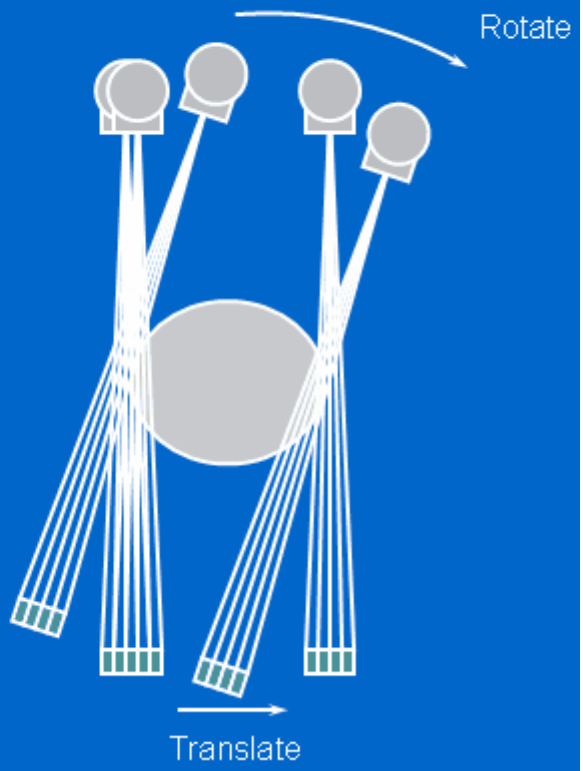


Computed Tomography

- How it works:

Second generation CT scanner

- Narrow fan beam (10°)
- Multiple detectors
- Multiple angle acquisition at each position
  - Larger angle rotate
  - Translate still required
- Slow
  - 20s per slice

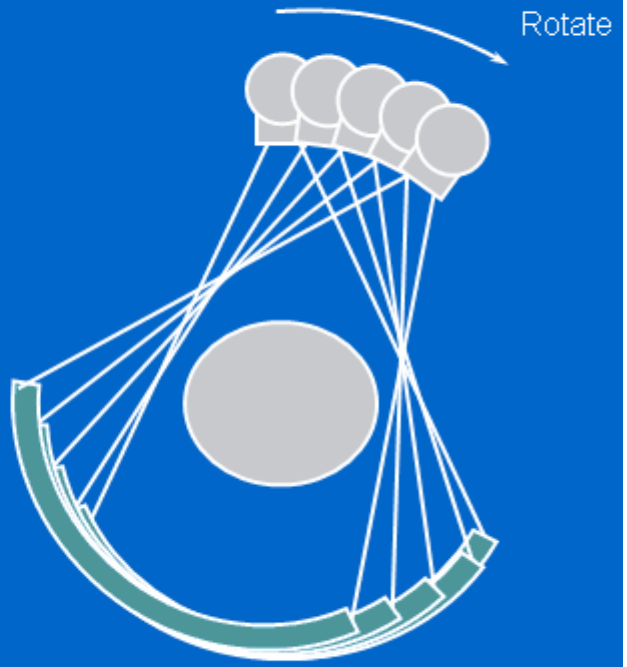


Computed Tomography

- How it works:

Third generation CT scanner

- Fan beam
- Multiple (500 - 1000) rotating detectors
- Rotation only
  - no translation required
- Much faster
  - as fast as 0.5 s per rotation
- Most common modern scanner design

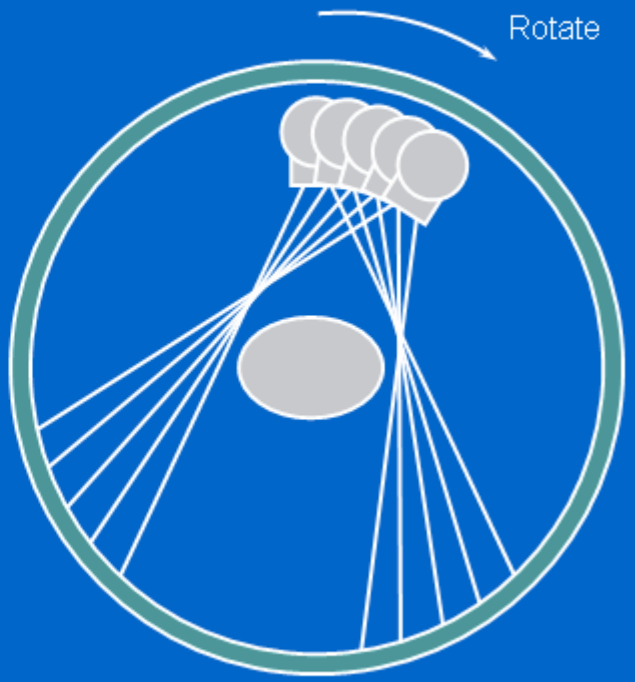


Computed Tomography

- How it works:

Fourth generation CT scanners

- Fan beam
- Static detectors all round gantry
- Only tube rotates
- Avoids ring artefact problems of 3rd generation scanners



Computed Tomography

- How it works: