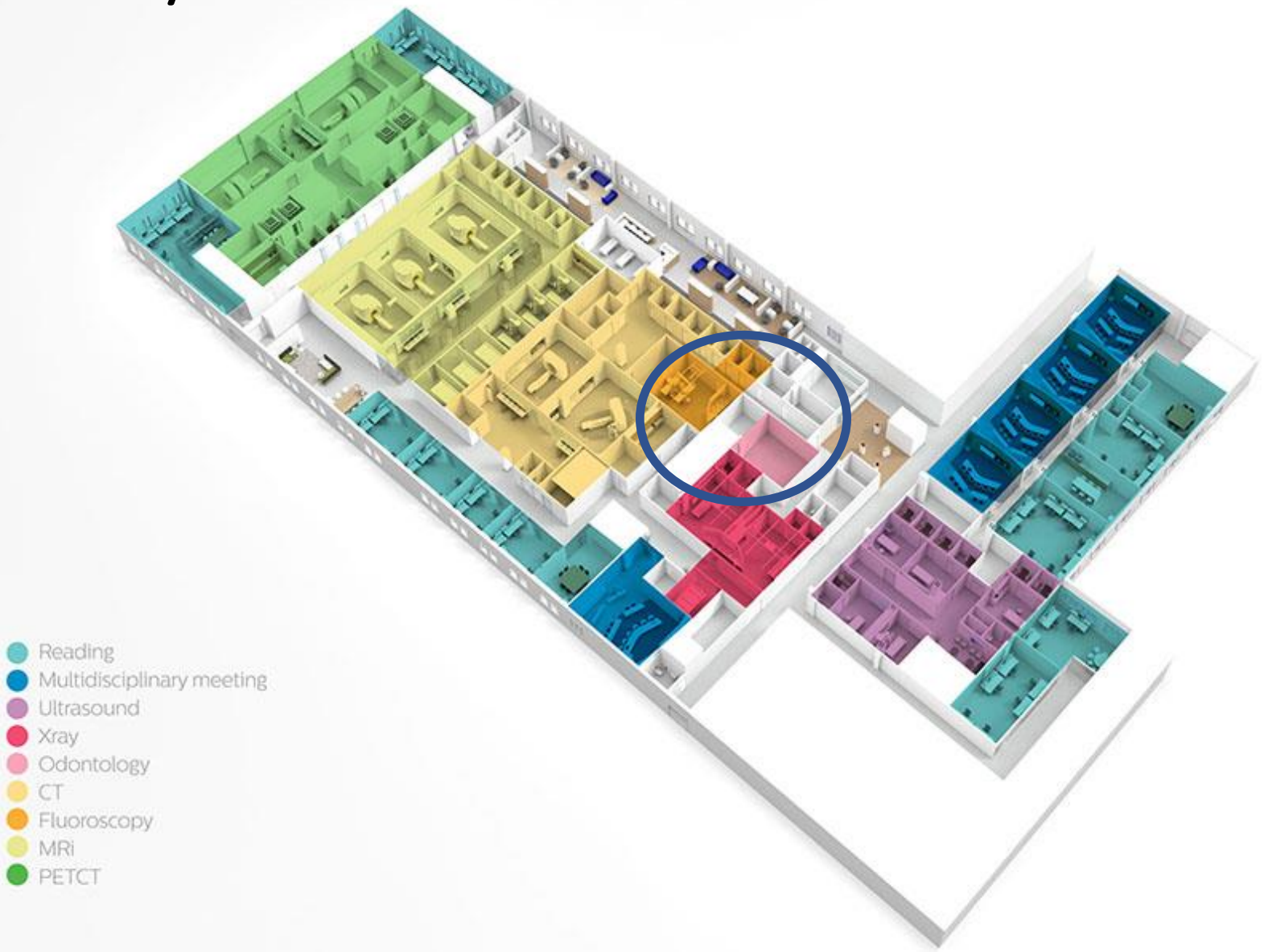
Imaging of cancer



Imaging of Cancer:

http://mip.nci.nih.gov
pchoyke@nih.gov

X ray


Reading
Multidisciplinary meeting
Ultrasound
Xray
Odontology
CT
Fluoroscopy
MRi
PETCT

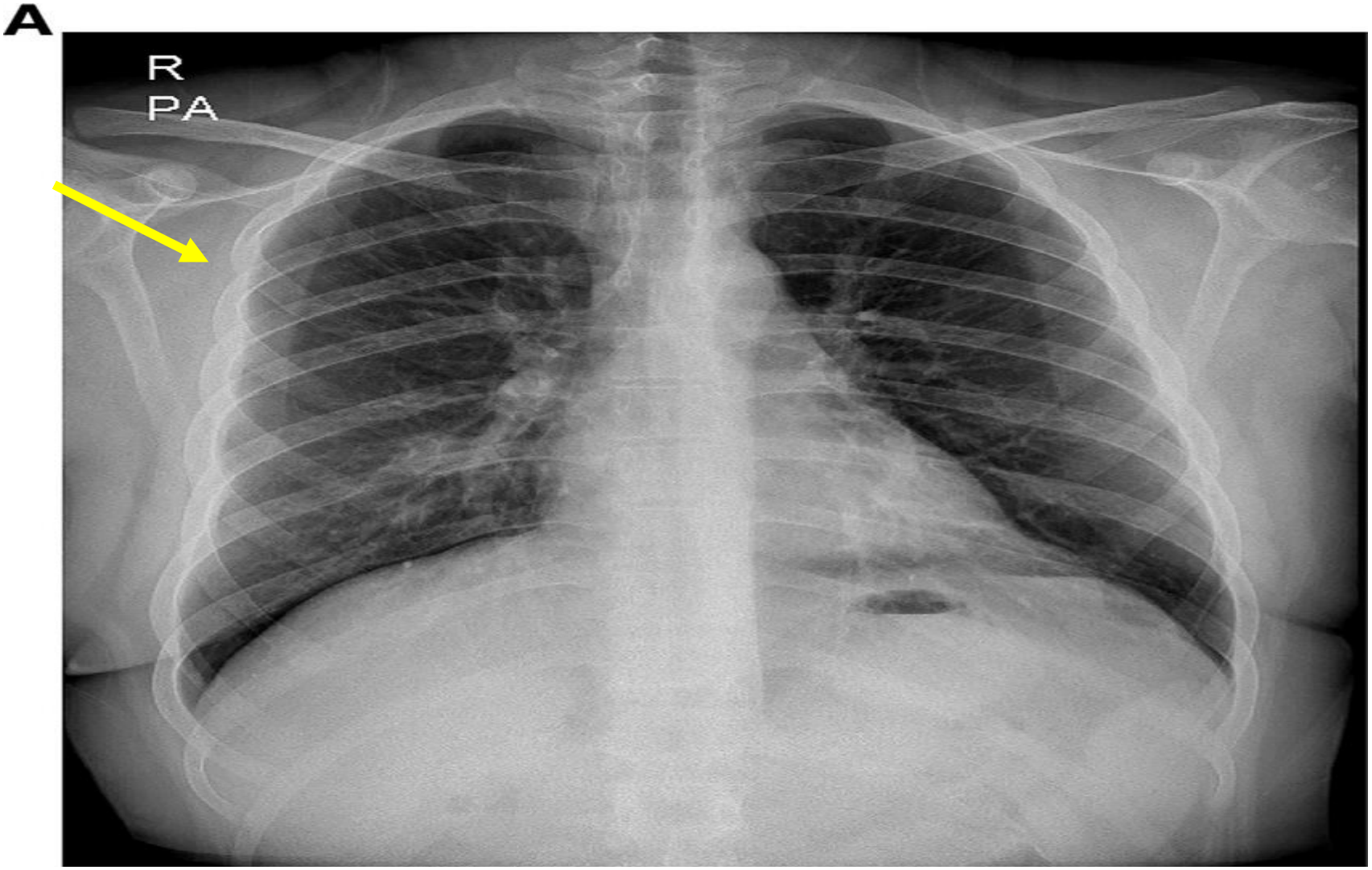
Digital radiography

All Radiography is digital now



Reduced storage costs
No more dark rooms, chemicals
Reduced waste production
Image available at multiple places at the same time

Pulmonary nodule

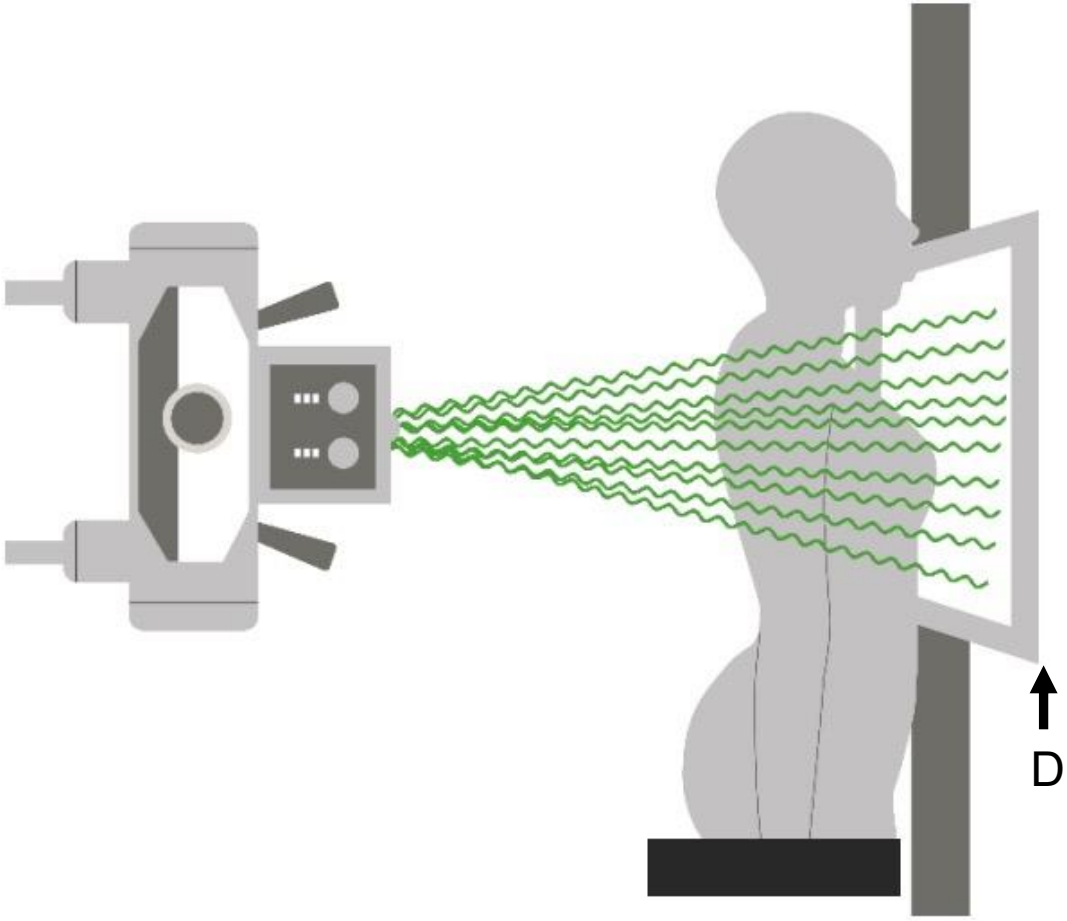


Digital CXR

Digital CXR is amenable to AI “interpretation”



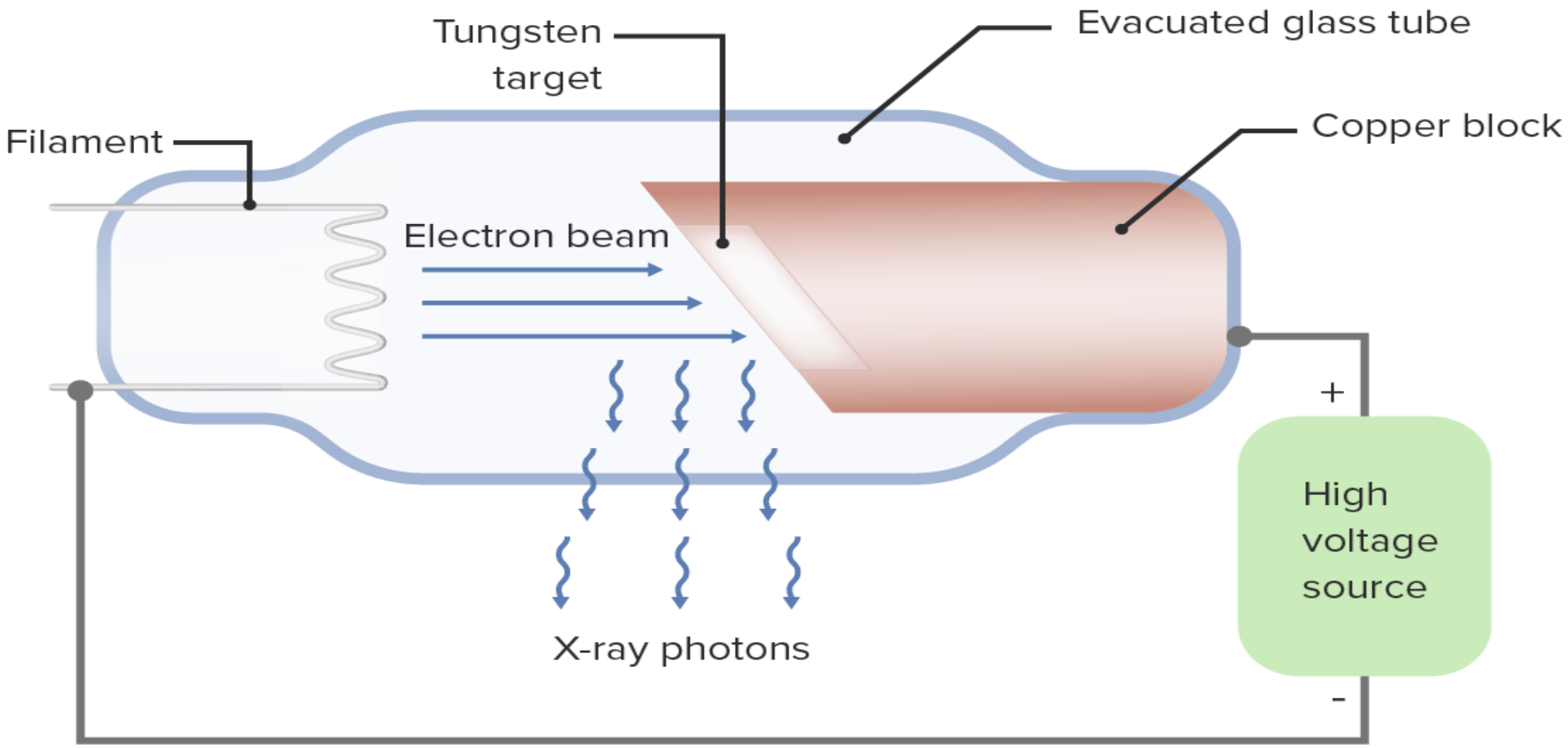
How is a CXR taken?





Digital detector array

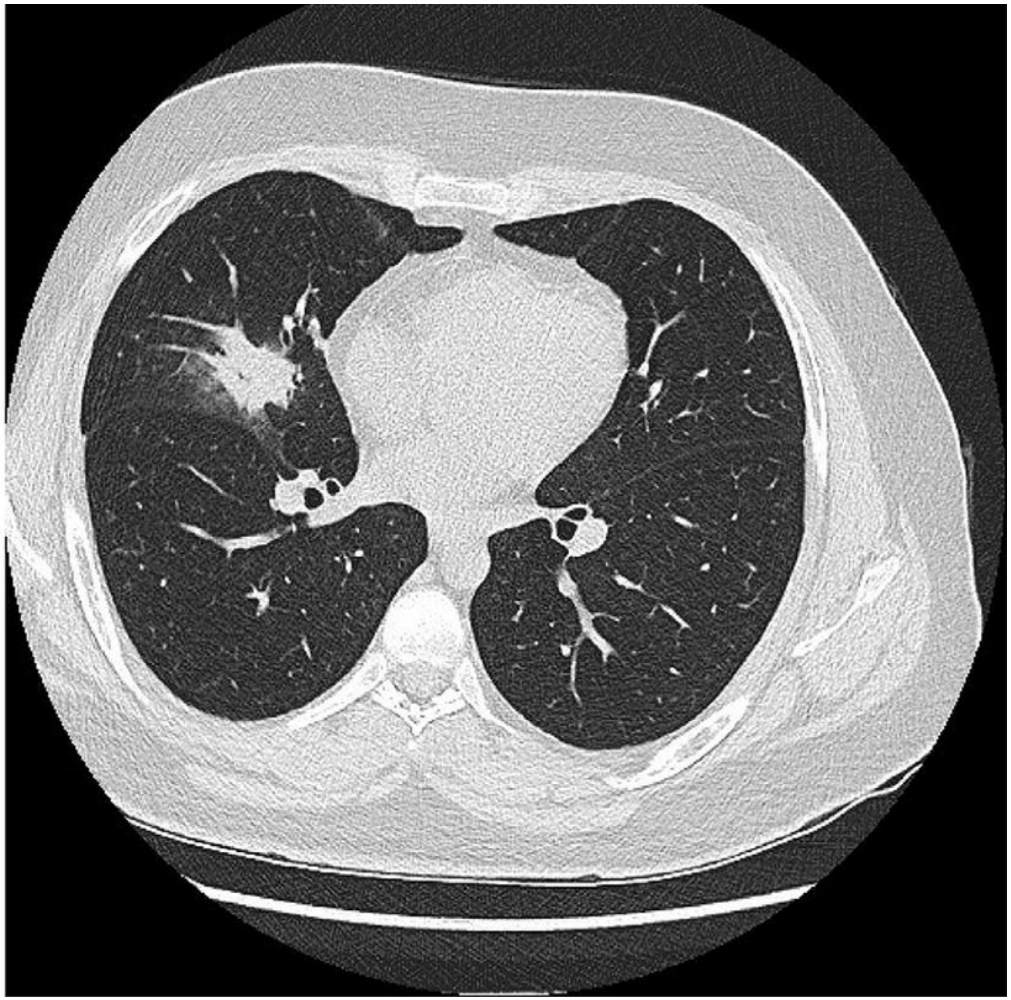
Electron beam



CT

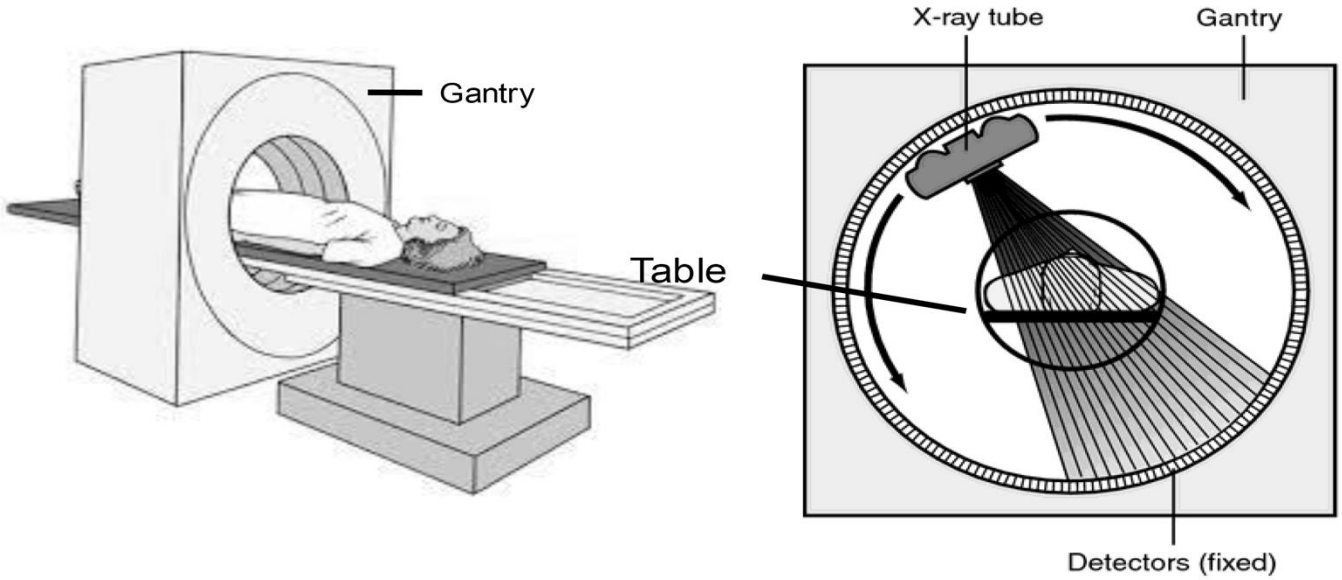

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Computed Tomography

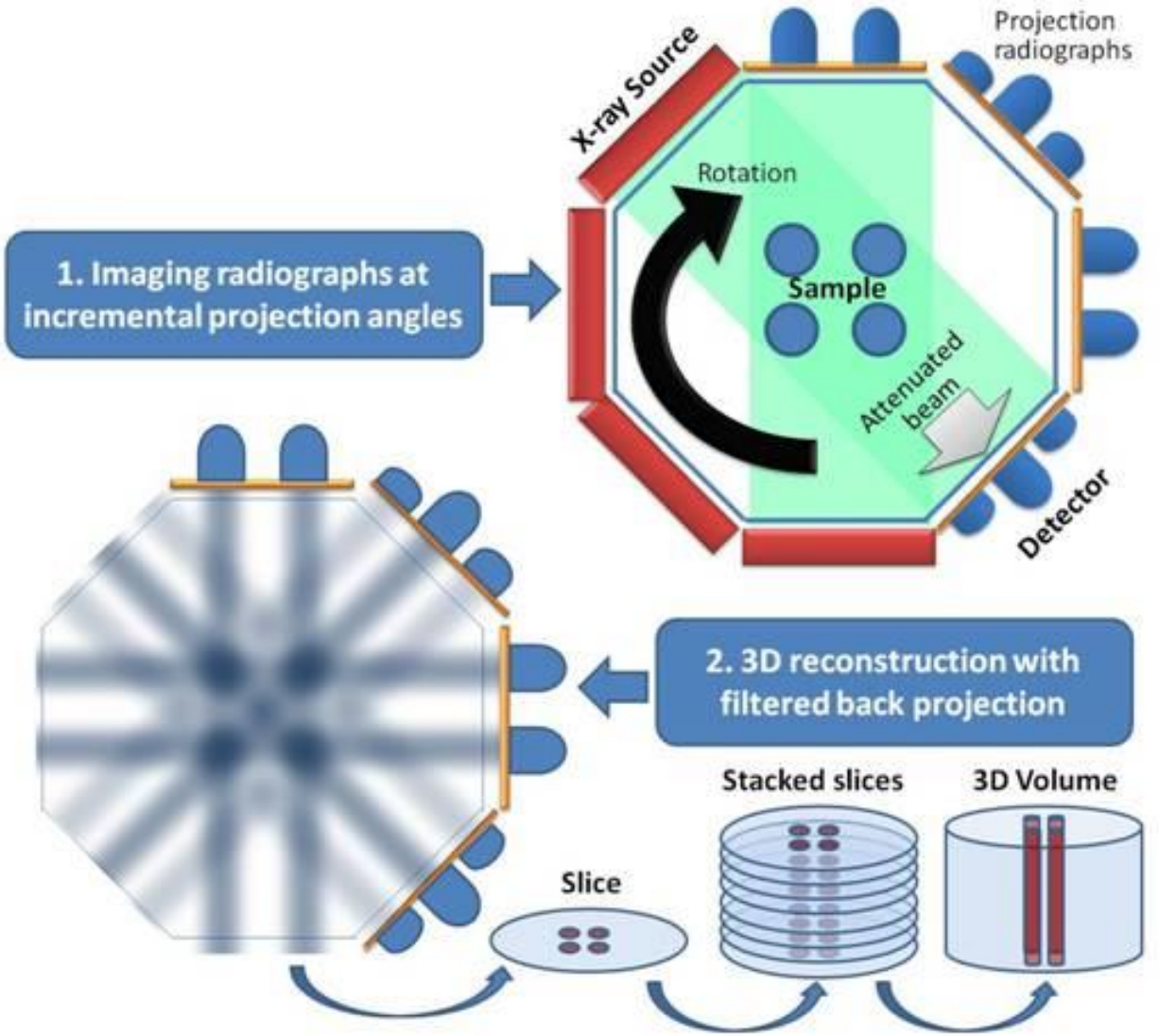


Basics of CT

Basics of CT



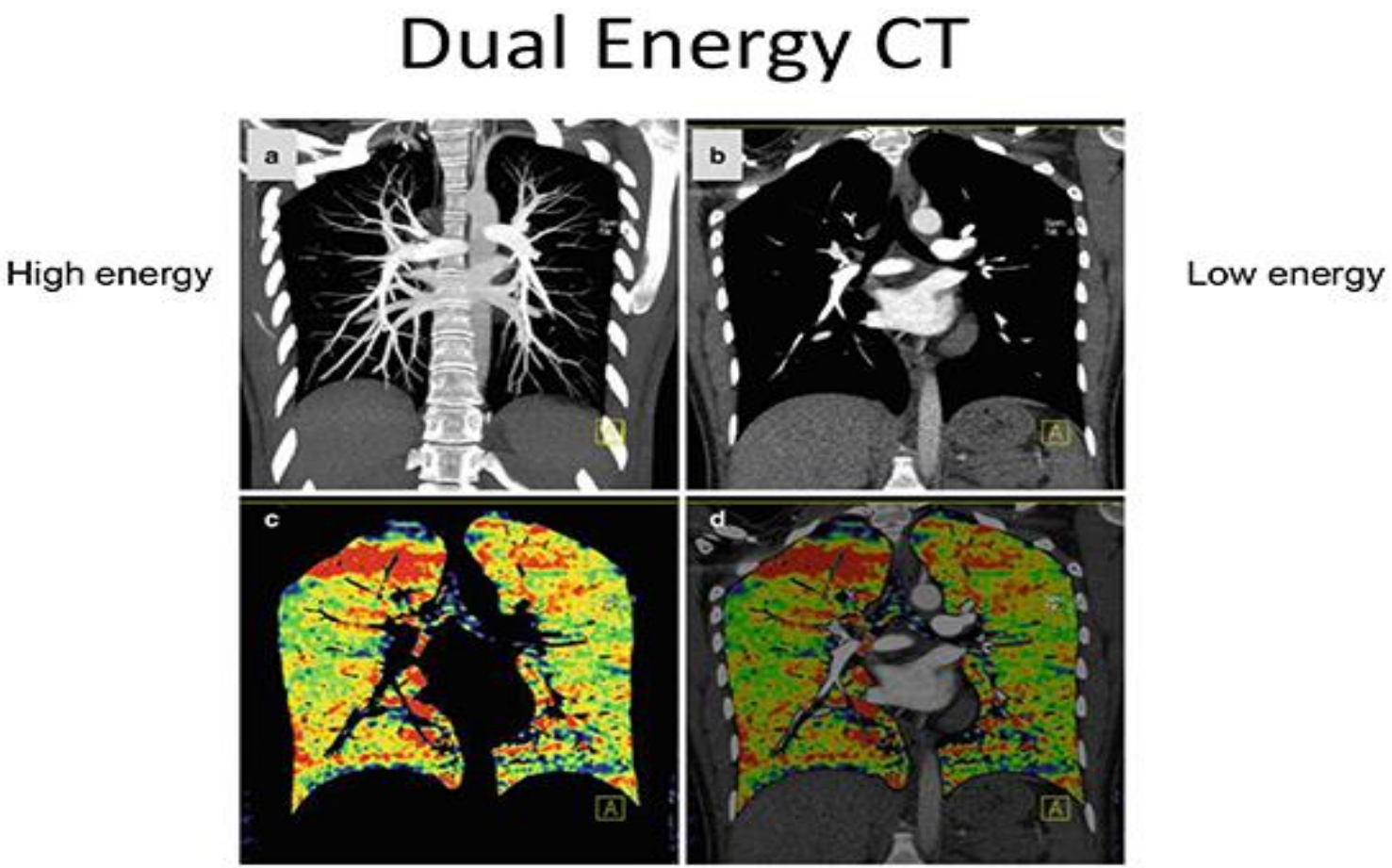
Filtered Back Projection



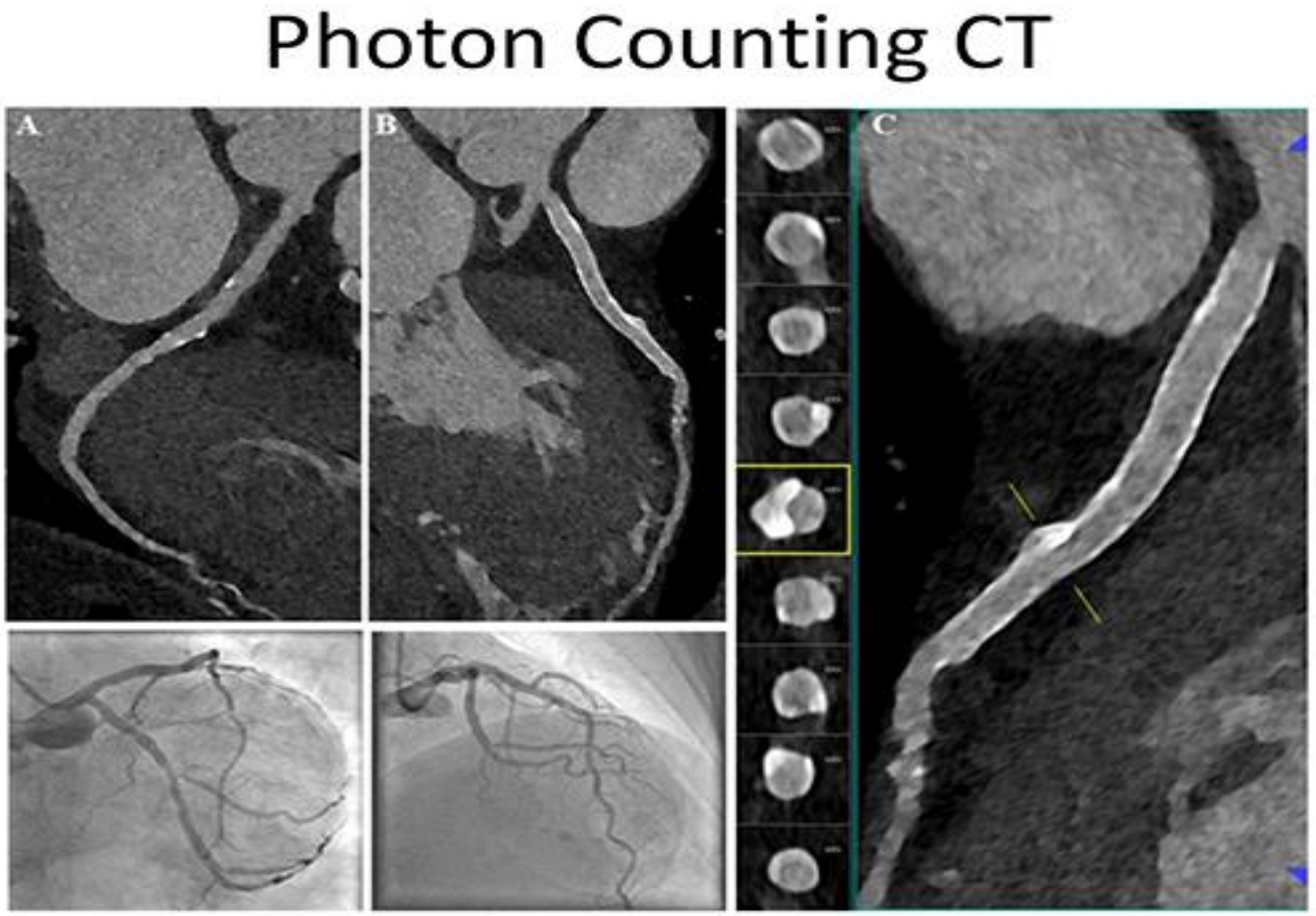
“Volume” CT imaging



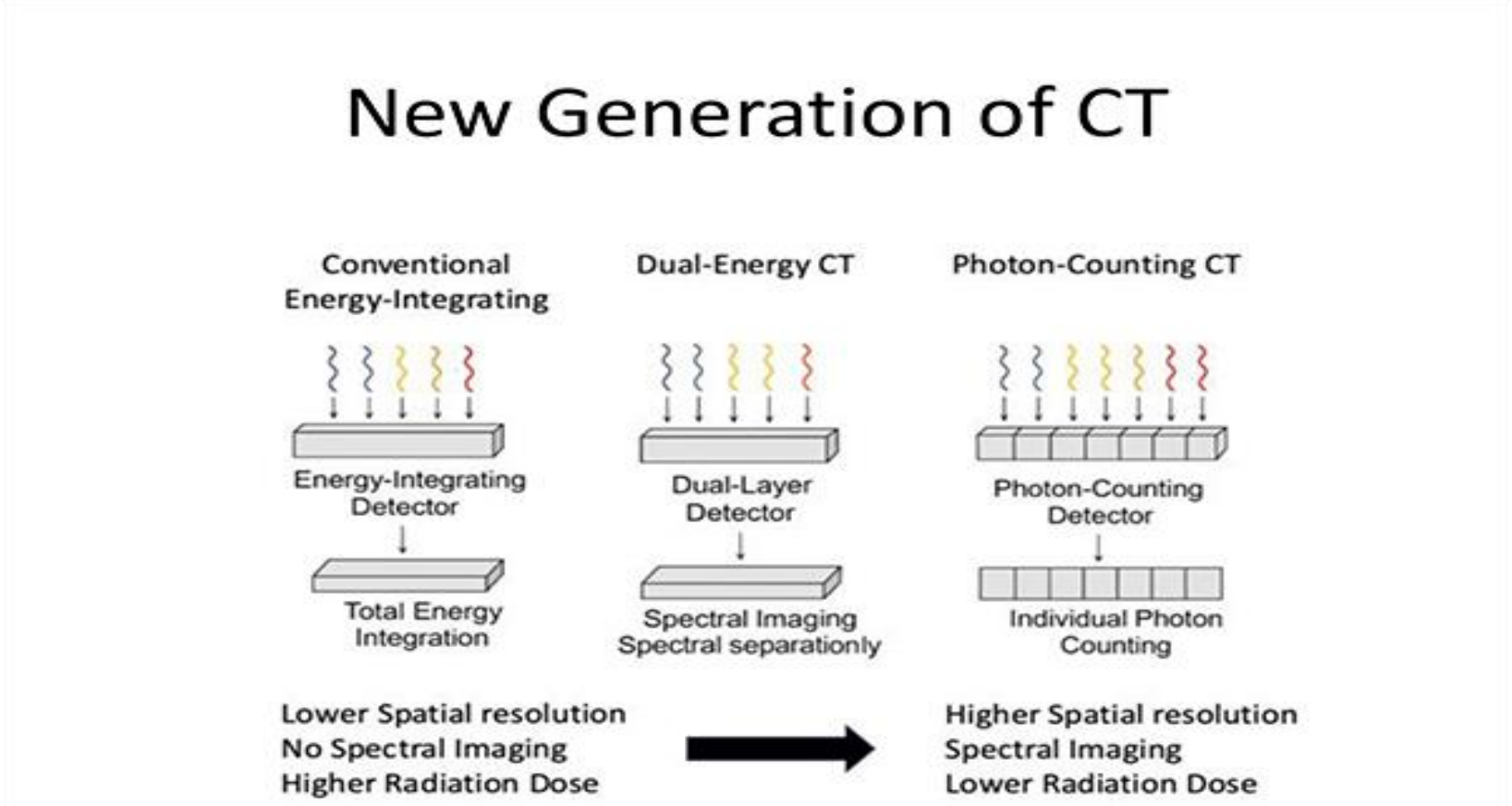
Dual energy CT



Photon Counting CT



New generation of CT



Advantages of CT

- Widely available
- Minimal prep (NPO, drink contrast or water)
- Very rapid (2-3 seconds neck to pelvis)
- High resolution
- Relatively inexpensive

Disadvantages

- **Radiation?**
- Often requires iv contrast media
  - Allergic reactions (minimal)
- Anatomic information only

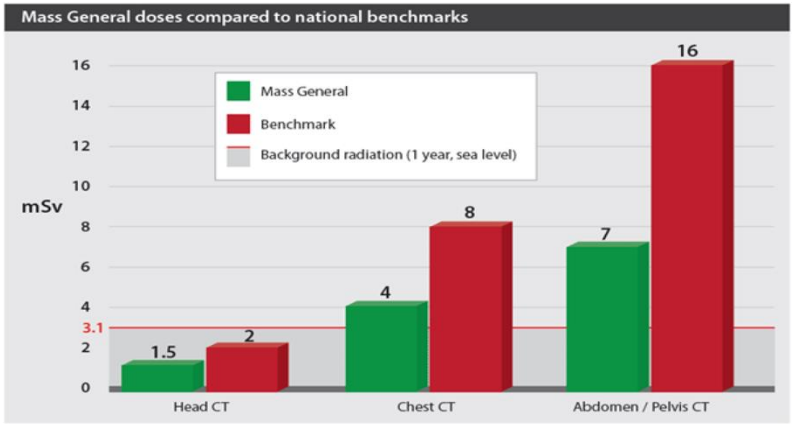
Radiation reduction

Radiation Reduction on CT



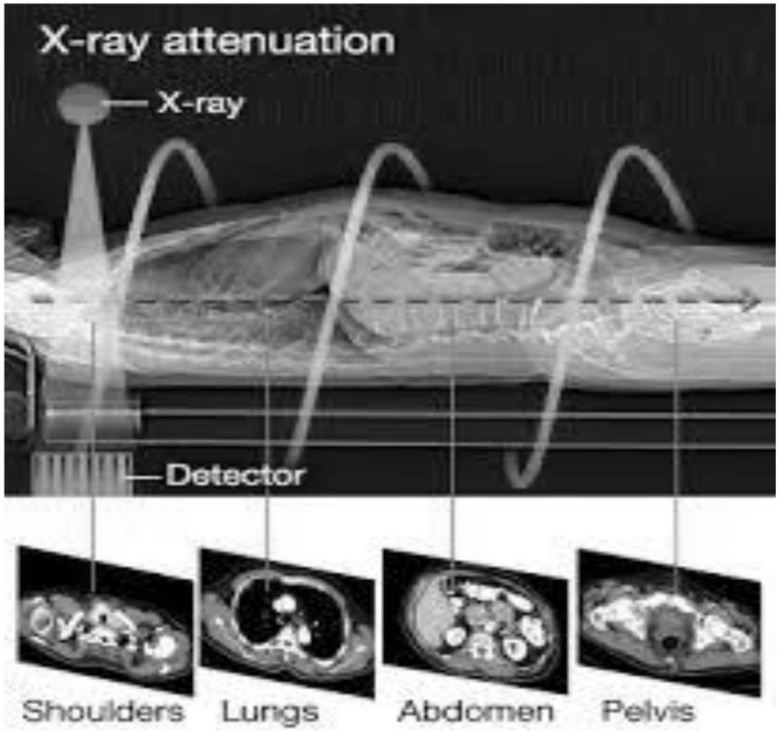


Lower kV (energy) x-rays
More sensitive detectors
Better reconstruction algorithms
“Synthetic” images

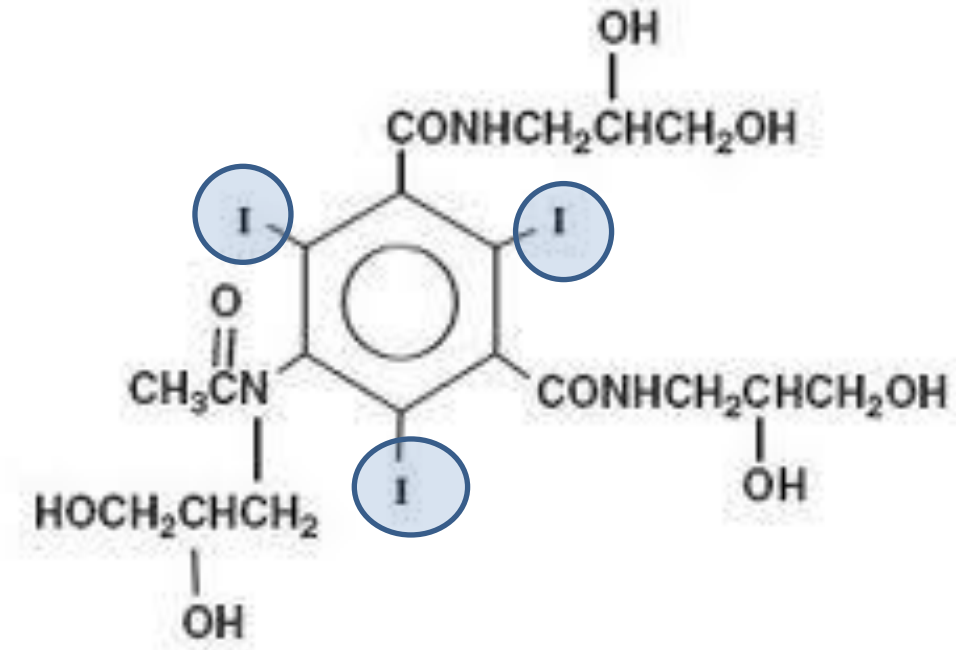


Attenuation differences

Attenuation differences thru the body mean less radiation for some regions



Non ionic Iodinated Contrast



Typical dose 30-45 Grams of Iodine!!!

Iodinated contrast

Iodinated Contrast

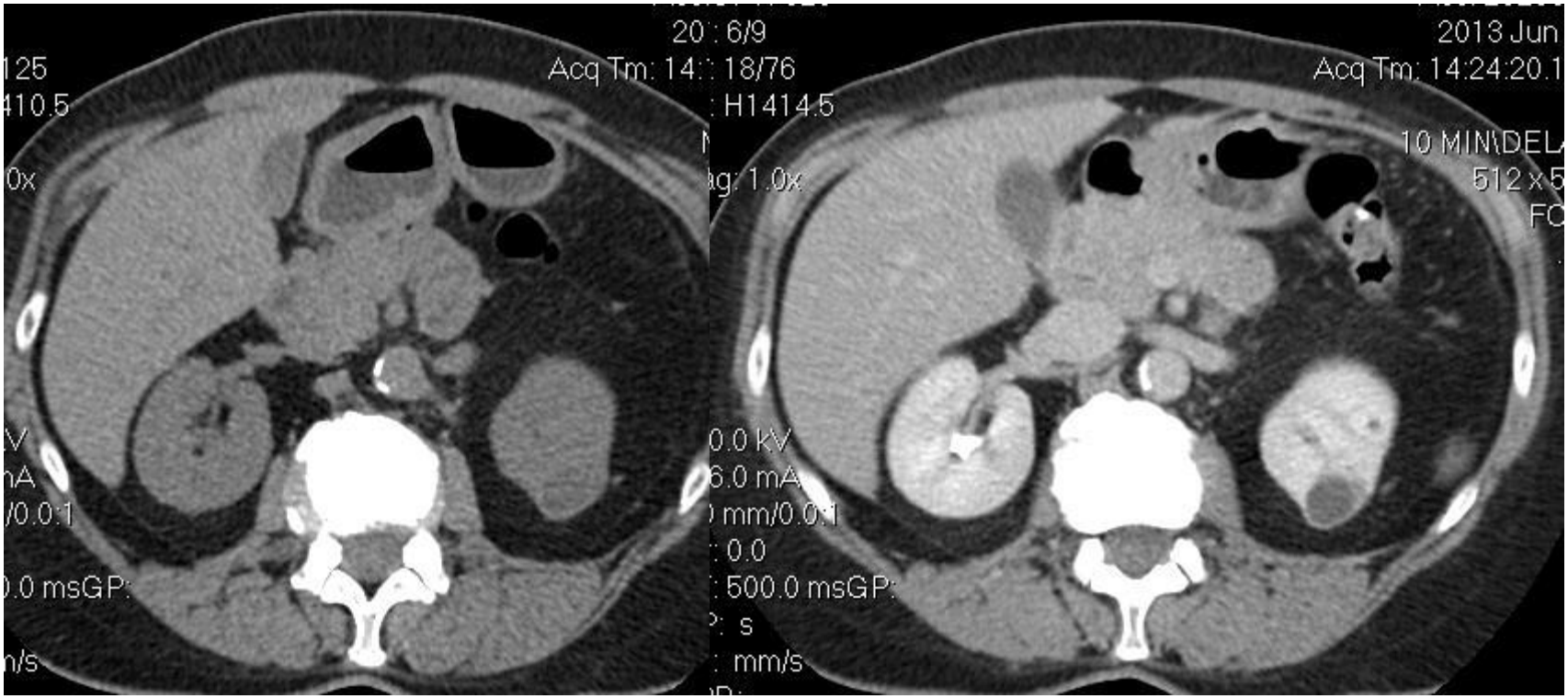




75-150cc of contrast injected.



Iodinated Contrast Media



A new wrinkle: virtual non contrast CT



- Can calculate the non contrast image from the contrast image.
- How does it work? Iodine in contrast has a characteristic absorption of x-rays.

Ultrasound


Reading
Multidisciplinary meeting
Ultrasound
Xray
Odontology
CT
Fluoroscopy
MRi
PETCT

Ultrasound equipment

Ultrasound equipment: The new stethoscope?

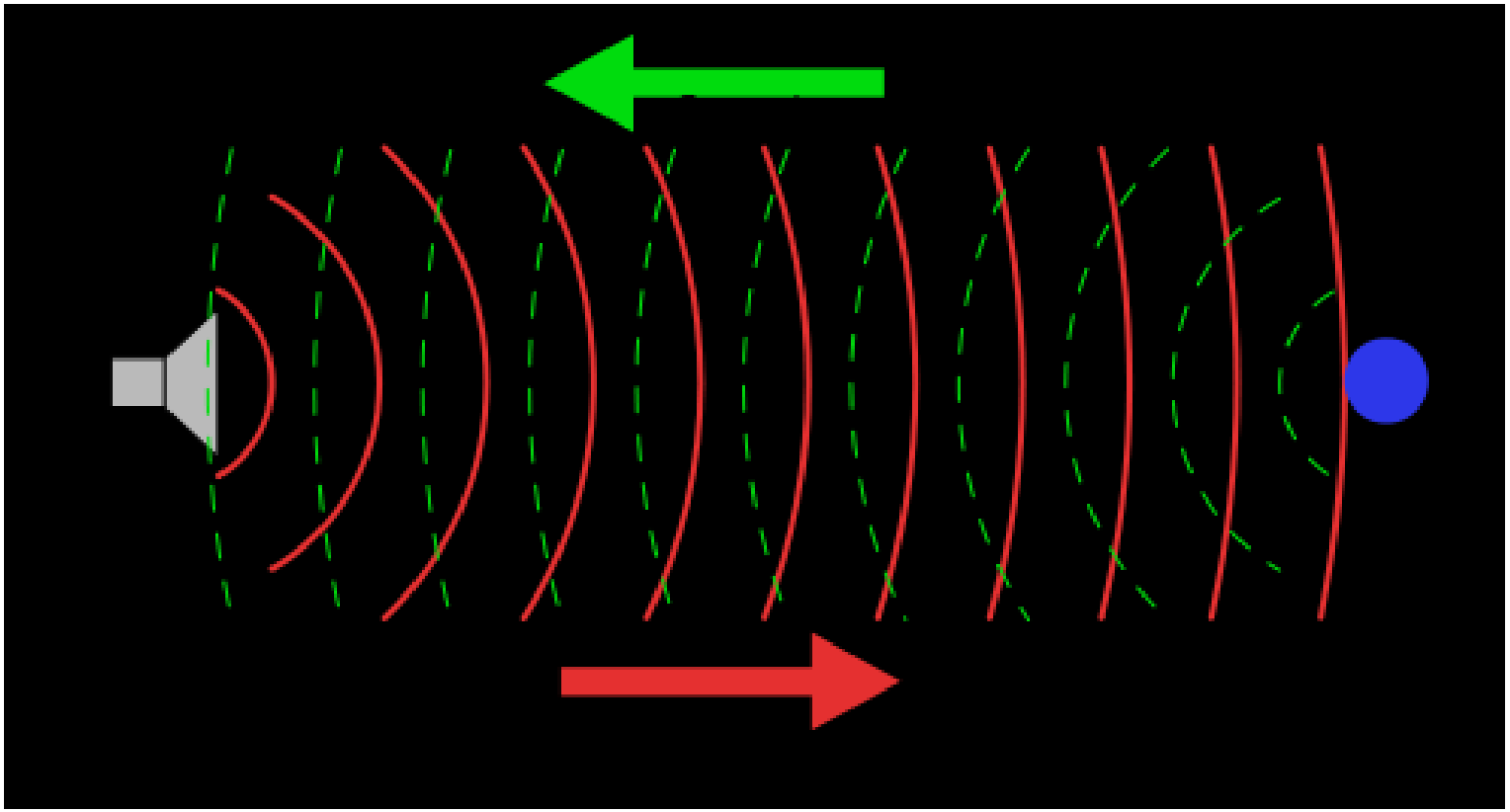




Ultrasound



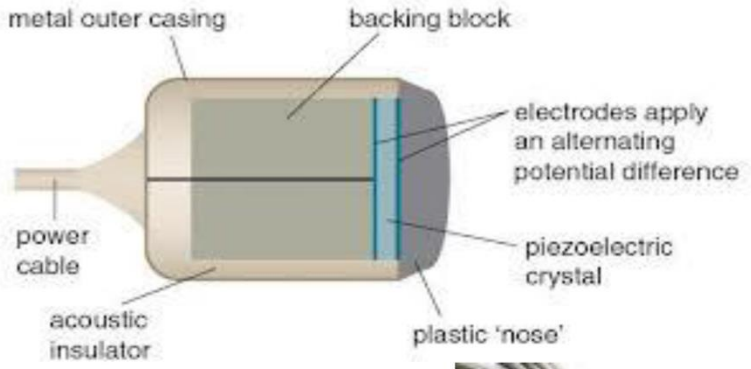
US basics



Imaging dependent on the speed of sound
In tissue

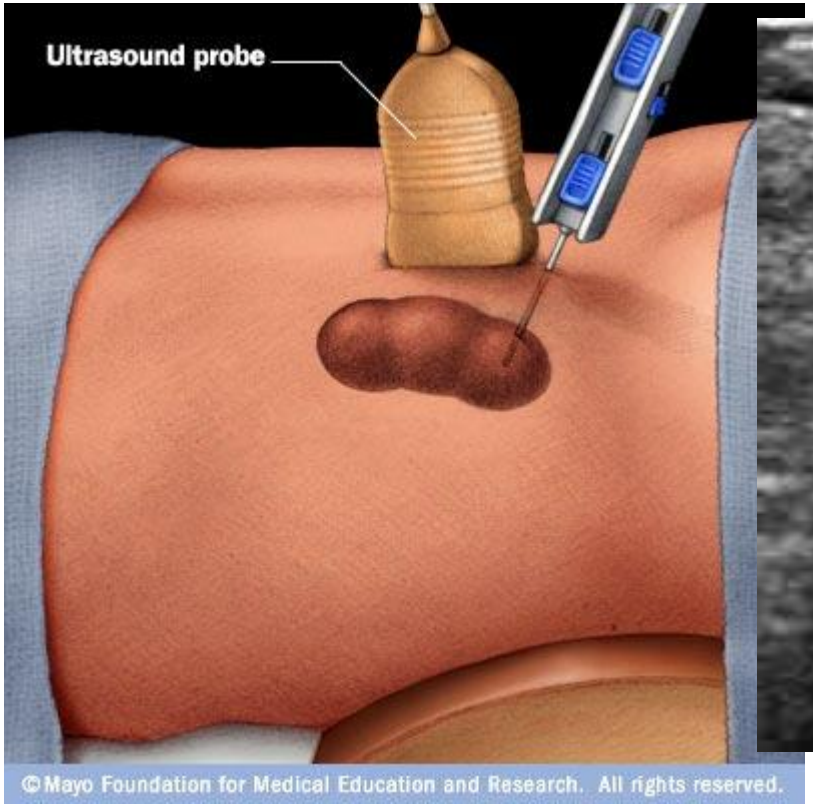
Ultrasound probes

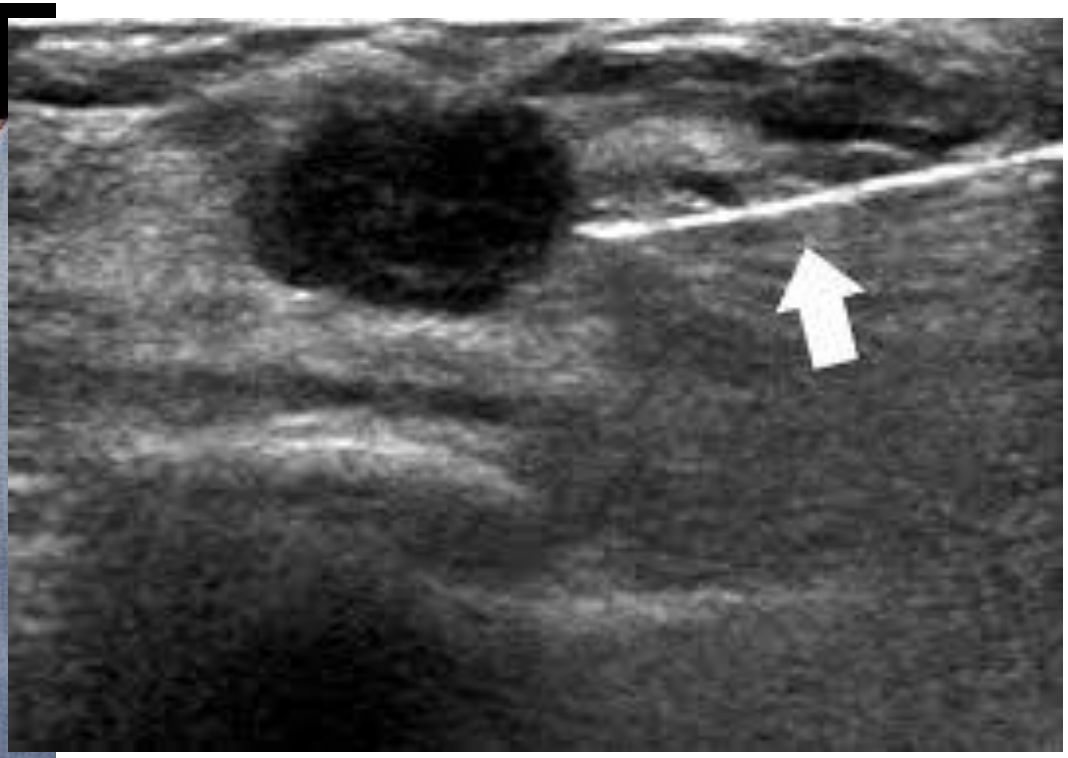
US Probes





US guided biopsy in real time





US advantages

- No radiation
- Real time
- Inexpensive
- Quick, little prep
- No injection

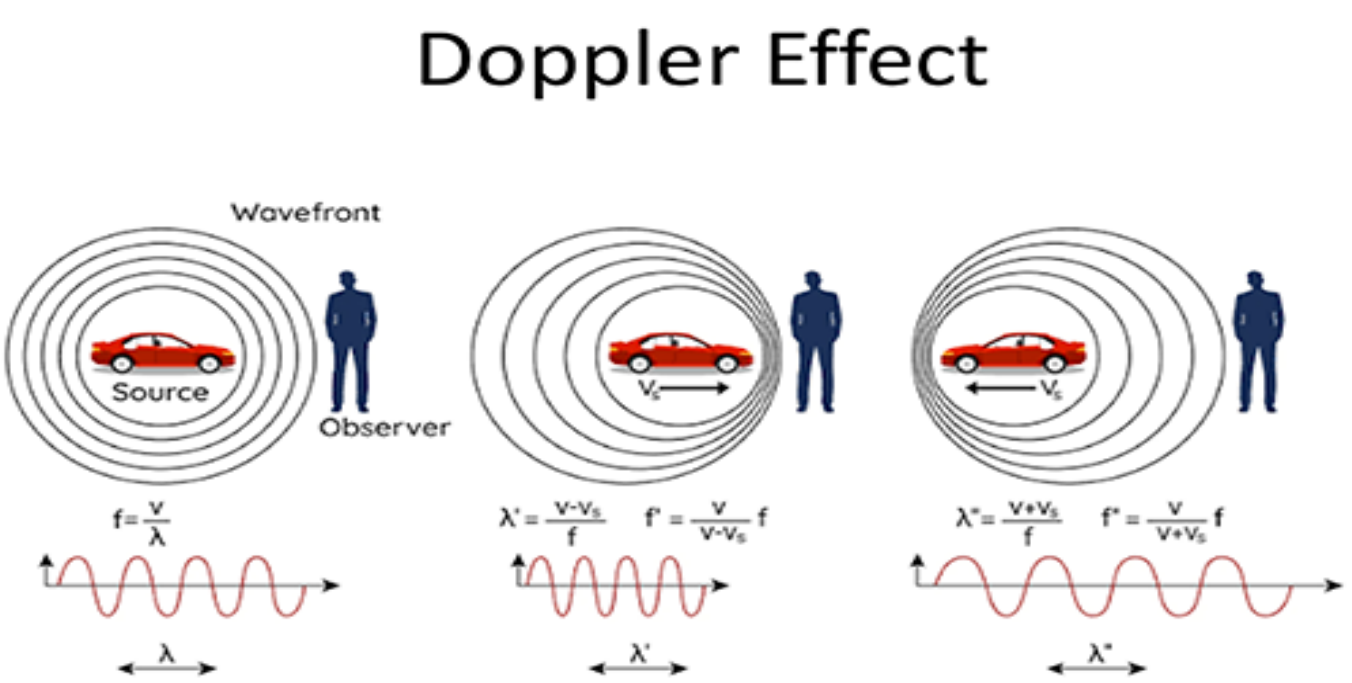
US disadvantages

- Operator dependent
- You only see what you look for
- Difficult to quantify
- Limited access (lungs, brain, bone etc.)

Doppler Ultrasound

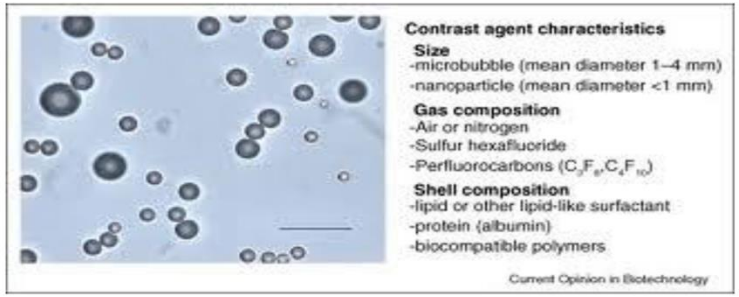


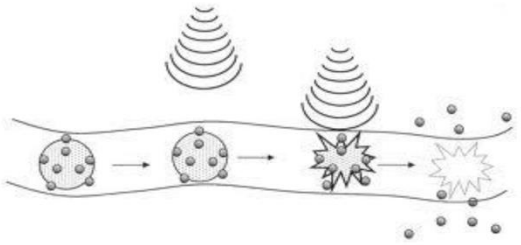
Doppler Effect

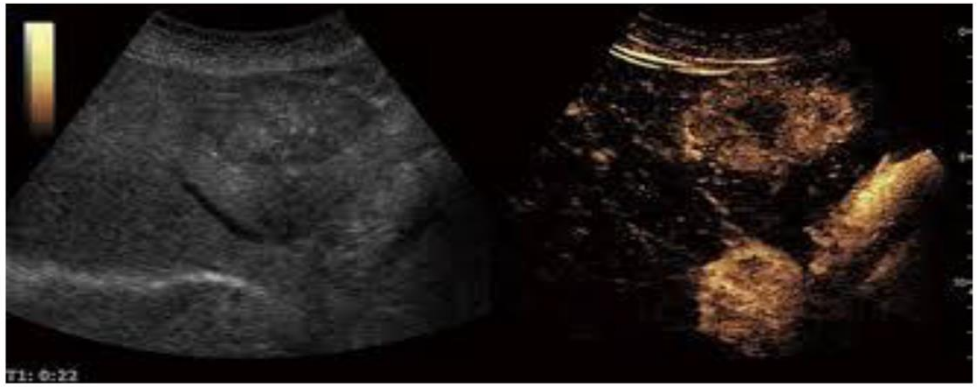


Microbubble contrast

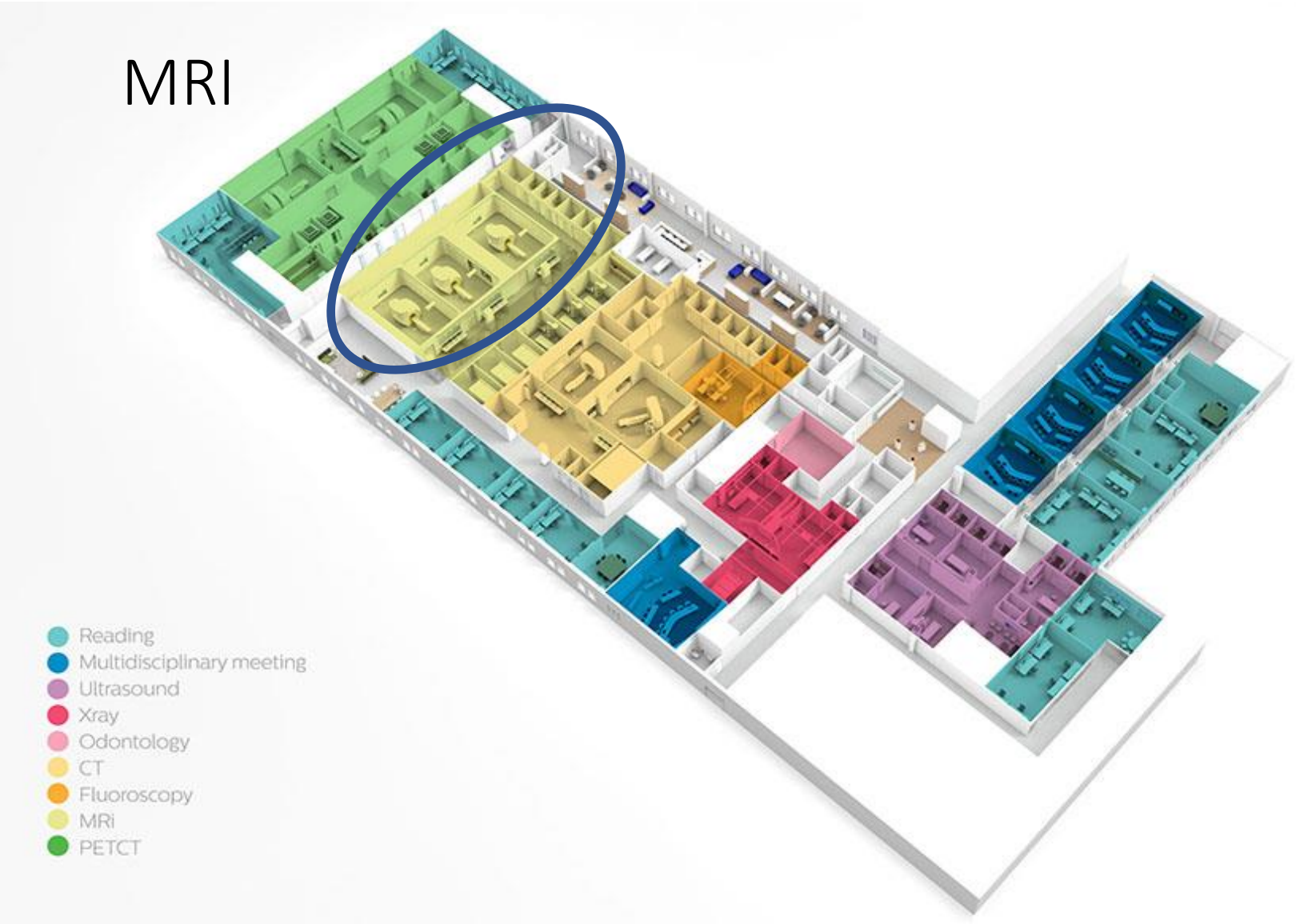
US Microbubble contrast





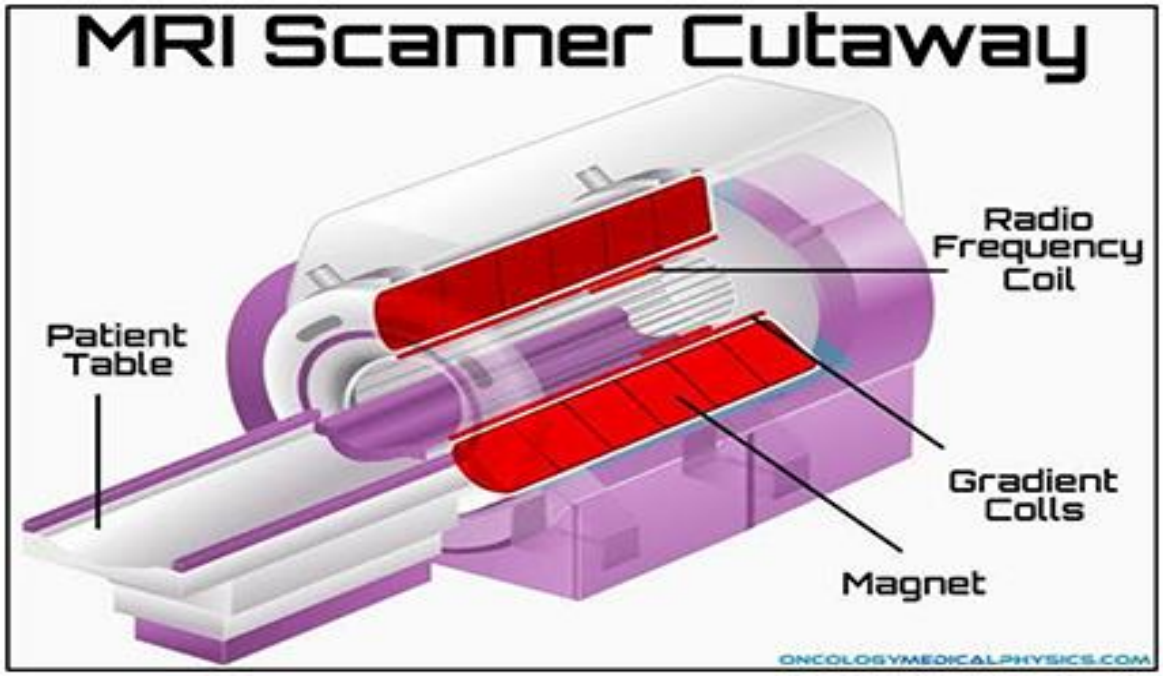


MRI

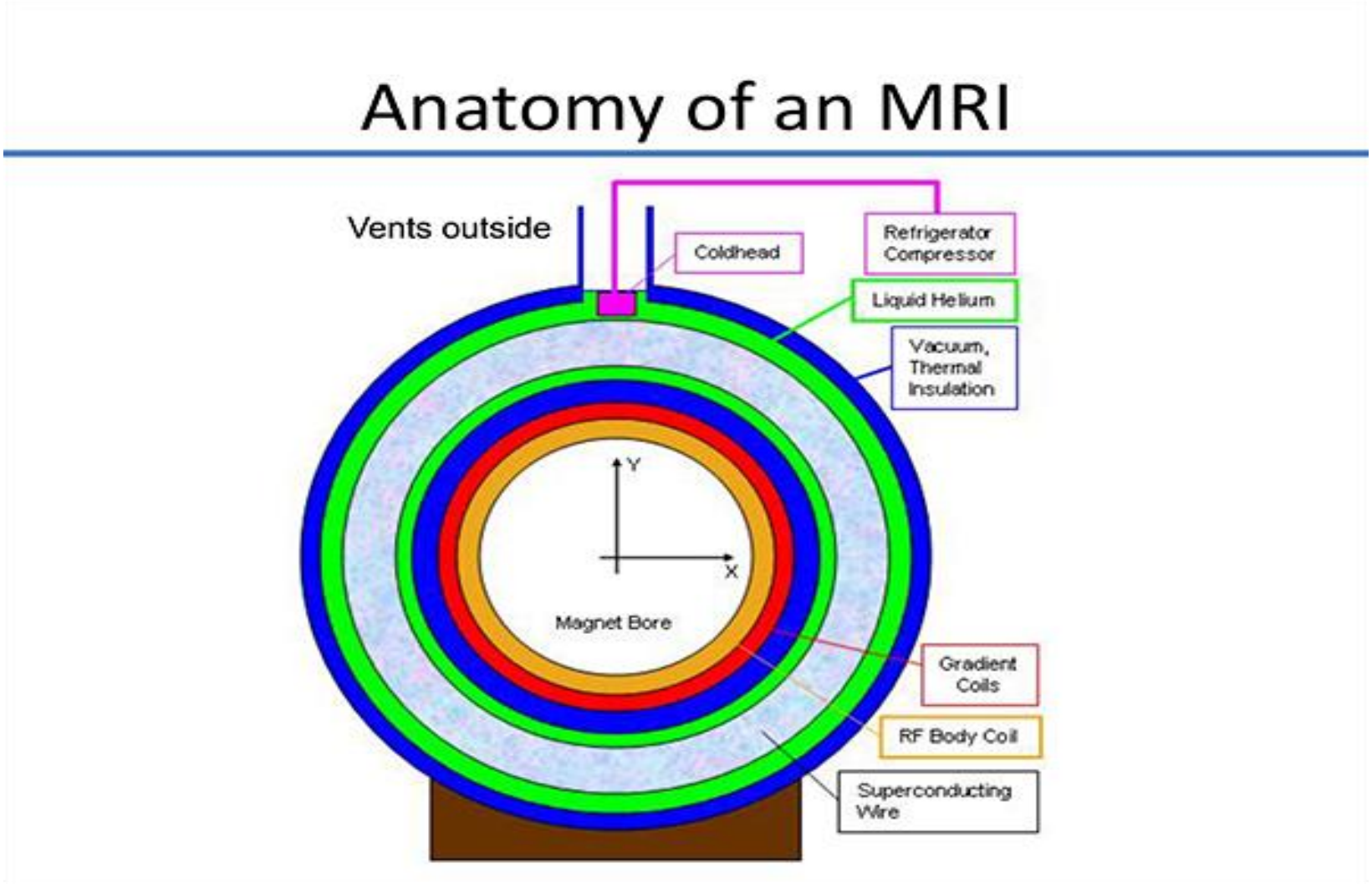

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MRI scanner cutaway

Magnetic Resonance Imaging Scanner

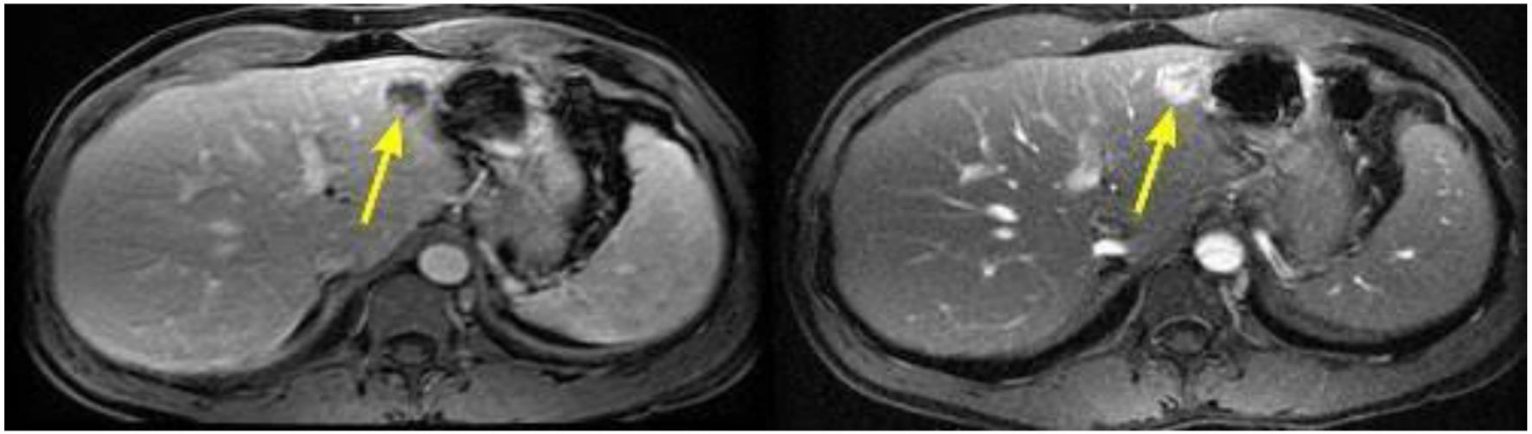


MRI anatomy


Anatomy of an MRI
Vents outside
Coldhead
Refrigerator Compressor
Liquid Helium
Vacuum, Thermal Insulation
Y
X
Magnet Bore
Gradient Coils
RF Body Coil
Superconducting Wire

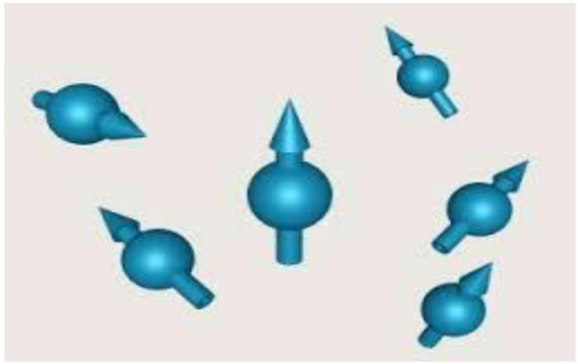
MRI

Magnetic Resonance Imaging

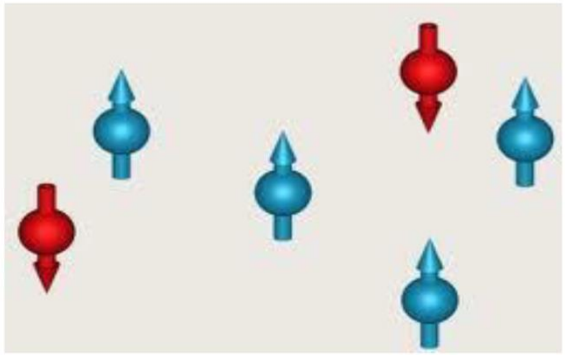


MRI physics

MRI Physics 101



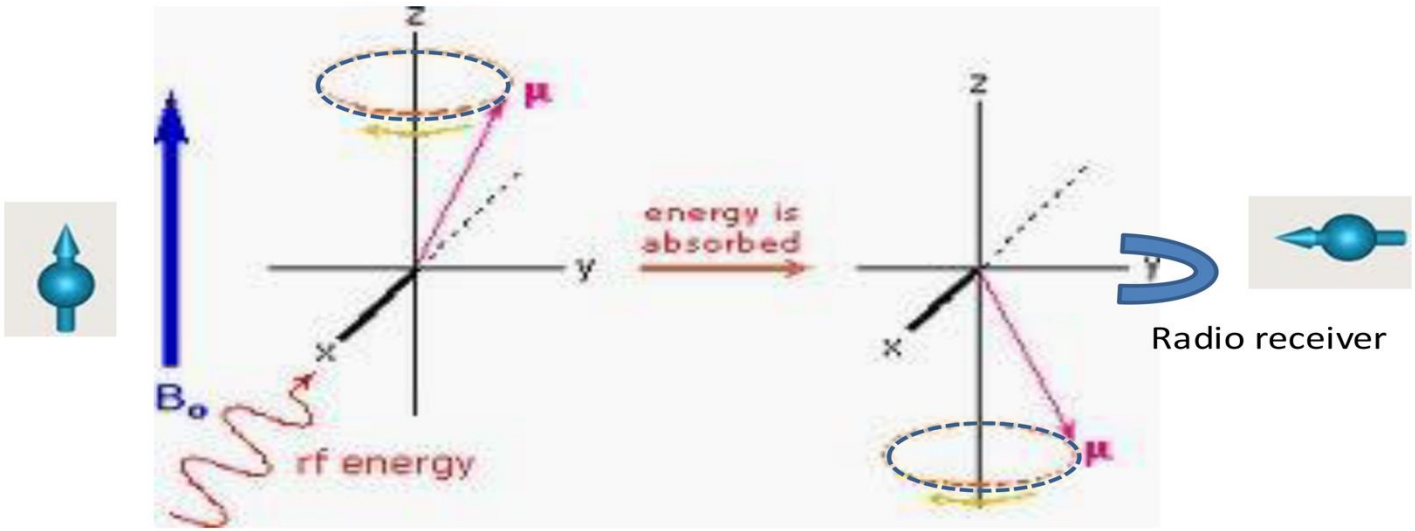
Protons in space: no field



Protons in magnetic field

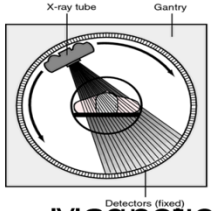
MRI

MR Physics

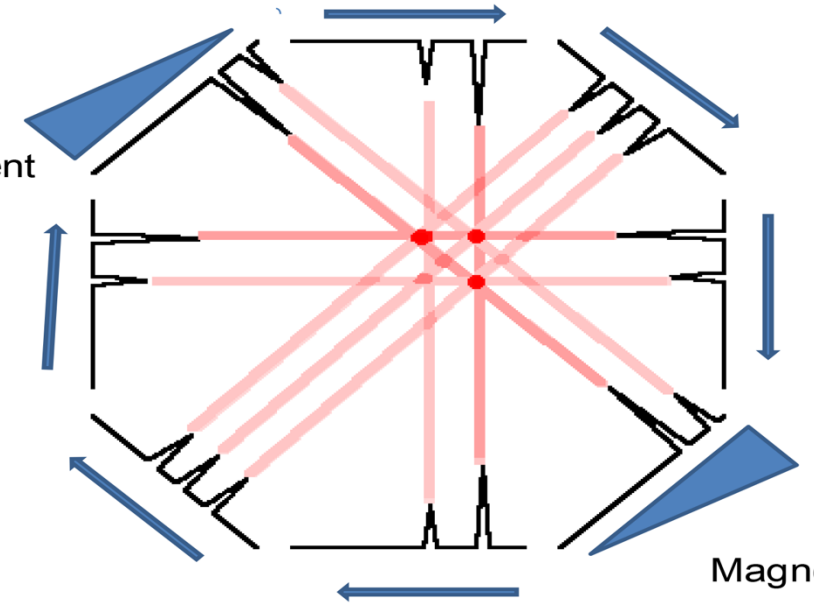


MRI image

Creating an MR Image:
No detectors! Just antennas (coils)



Magnetic Gradient



Magnetic Gradient

MRI Advantages

- No radiation
- Multiplanar
- Multiple contrast types:
  - T1 weighting, T2 weighting
  - Diffusion weighting
  - Contrast enhanced MRI
  - Spectroscopy

MR Disadvantages

- Slower than CT
- More expensive
- Does not depict calcifications
- Safety issues
  - Metallic objects become projectiles
  - Incompatible with metallic implanted devices
    - Pacemakers
    - Cochlear implants
  - Quenching

Safety issues in MRI

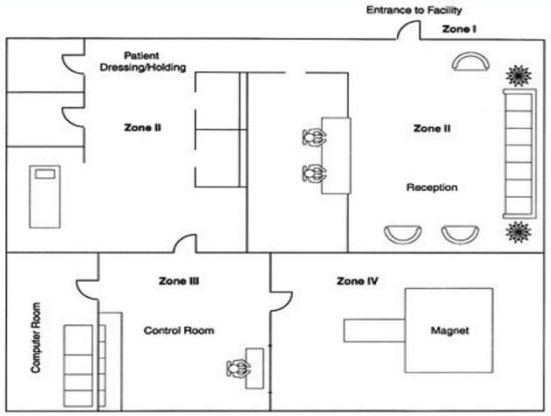


MRI safety

MRI SAFETY

- MRI scanners are extremely powerful
- Objects that are attracted by the MRI magnetic field can reach 60 miles per hour.
- Metal objects used everyday (scissors, oxygen tanks, infusion pumps, etc) become projectiles
- MRI departments are divided into Zones for Safety

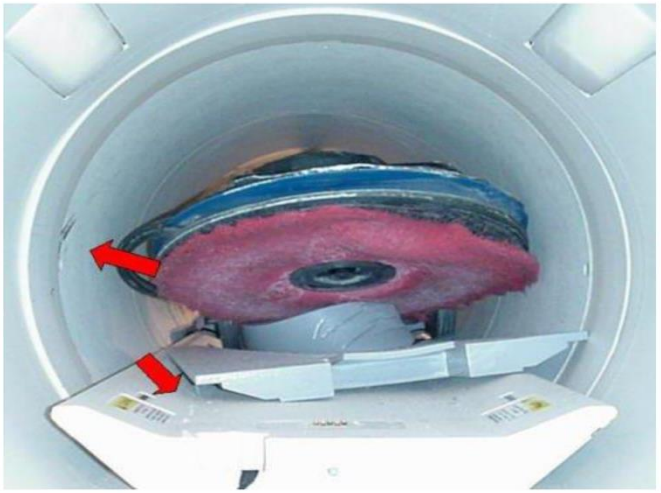


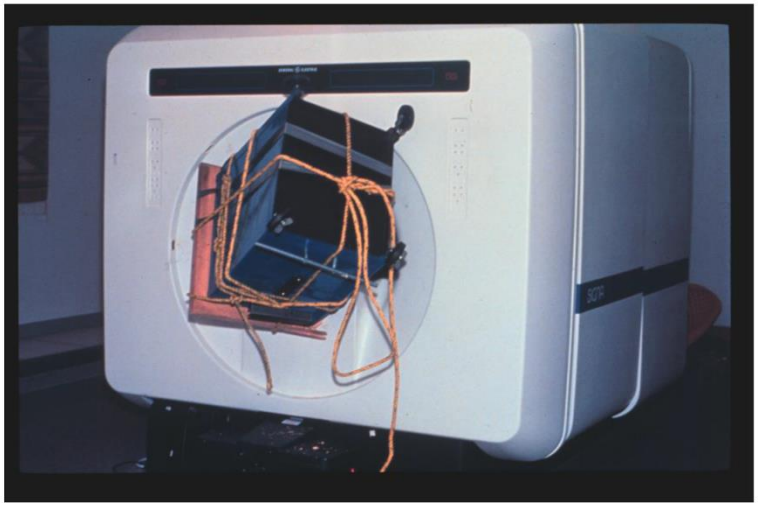


MRI Safety

MRI SAFETY

-



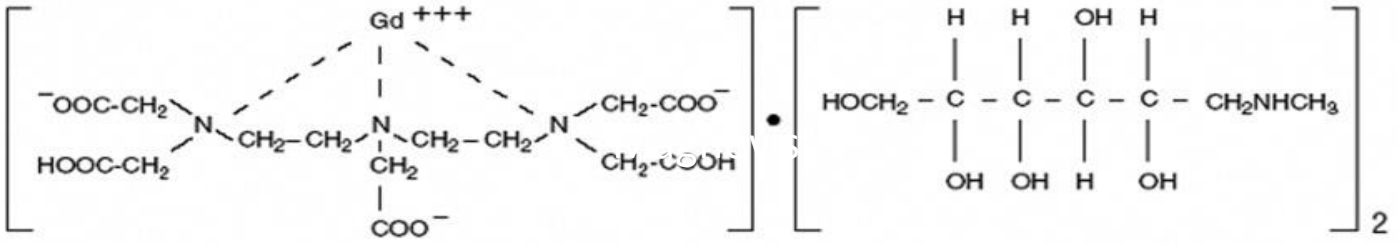


Value of Contrast Media

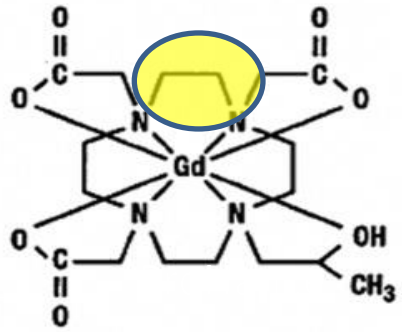


Contrast Chemicals

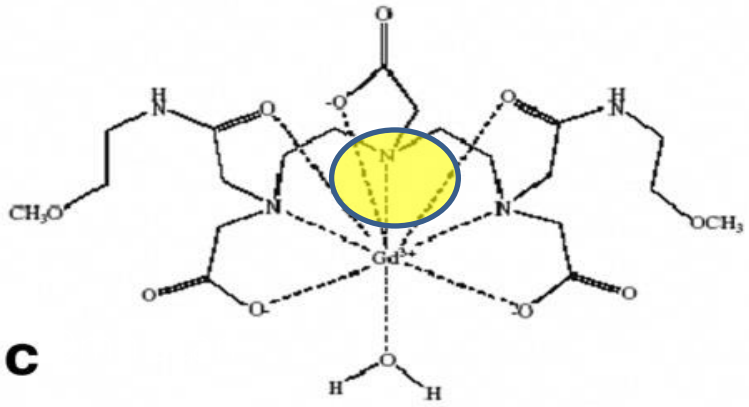
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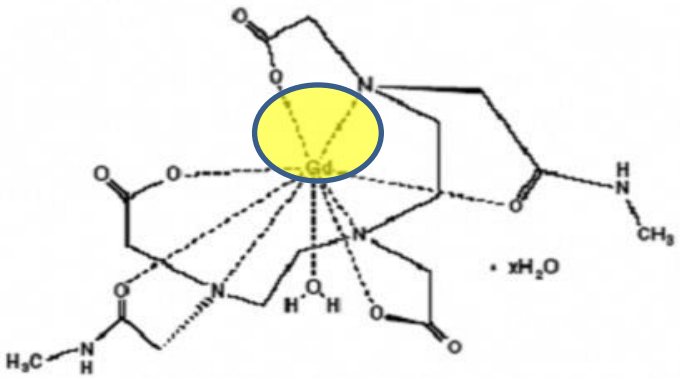
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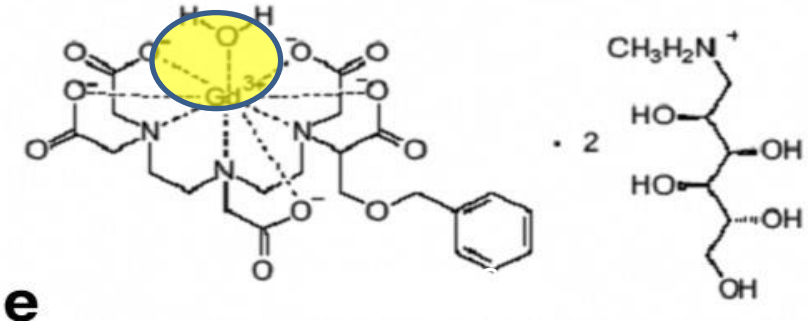
c



d



e



Contrast table

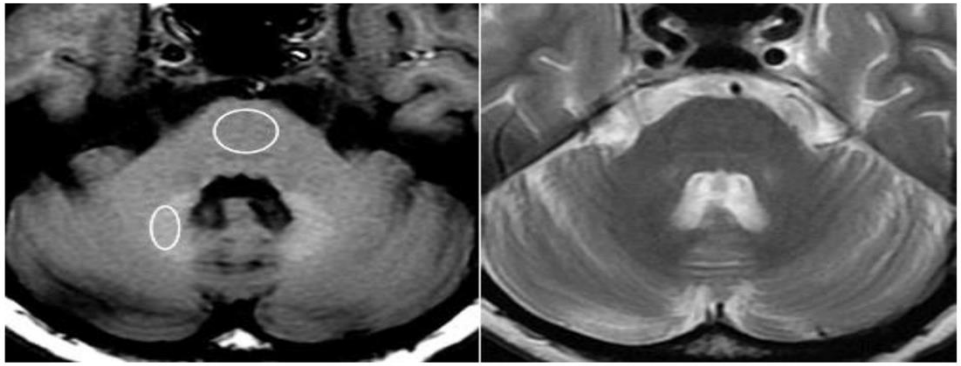
Extracellular Gd-CM	Type	Thermodynamic stability constant	Conditional Stability	Amount of excess chelate (mg ml^{-1})	Kinetic stability (dissociation half-life at pH 1.0)
Gadoversetamide, Gd-DTPA-BMEA (OptiMark, Tyco, St. Louis, MO)	Non-ionic linear	16.6	15	28.4	Not available
Gadodiamide, Gd-DTPA-BMA (Omniscan, GE, Waukesha, WI)	Non-ionic linear	16.9	14.9	12	35 s
Gadobutrol, Gd-BT-DO3A (Gadovist, Schering, Berlin, Germany)	Non-ionic cyclic	21.8	Not available	Not available	5 min
Gadoteridol, Gd-HP-DO3A (Prohance, Bracco, Italy)	Non-ionic cyclic	23.8	17.1	0.23	3 h
Gadopentetate Gd-DTPA (Magnavist, Schering, Berlin, Germany)	Ionic linear	22.1	18.1	0.4	10 min
Gadobenate, Gd-BOPTA, (Multihance, Bracco, Italy)	Ionic linear	22.6	18.4	None	Not available
Gadoterate, Gd-DOTA (Dotarem, Guerbet, France)	Ionic cyclic	25.8	18.8	None	>1 month

Gadolinium retention

- Gadolinium is highly toxic
- Patients with normal renal function excrete Gd-chelates within 24-48h
- Patients with abnormal renal function may take weeks to excrete the agent
- Dissociation of Gd from the chelate could deposit in soft tissues (documented)
  - Hugh et al. Tissue Gd conc .14-24 ng/mL
- With new agents the risk of free Gd deposition is minimal. Still, don't give Gd to a patient with very poor renal function

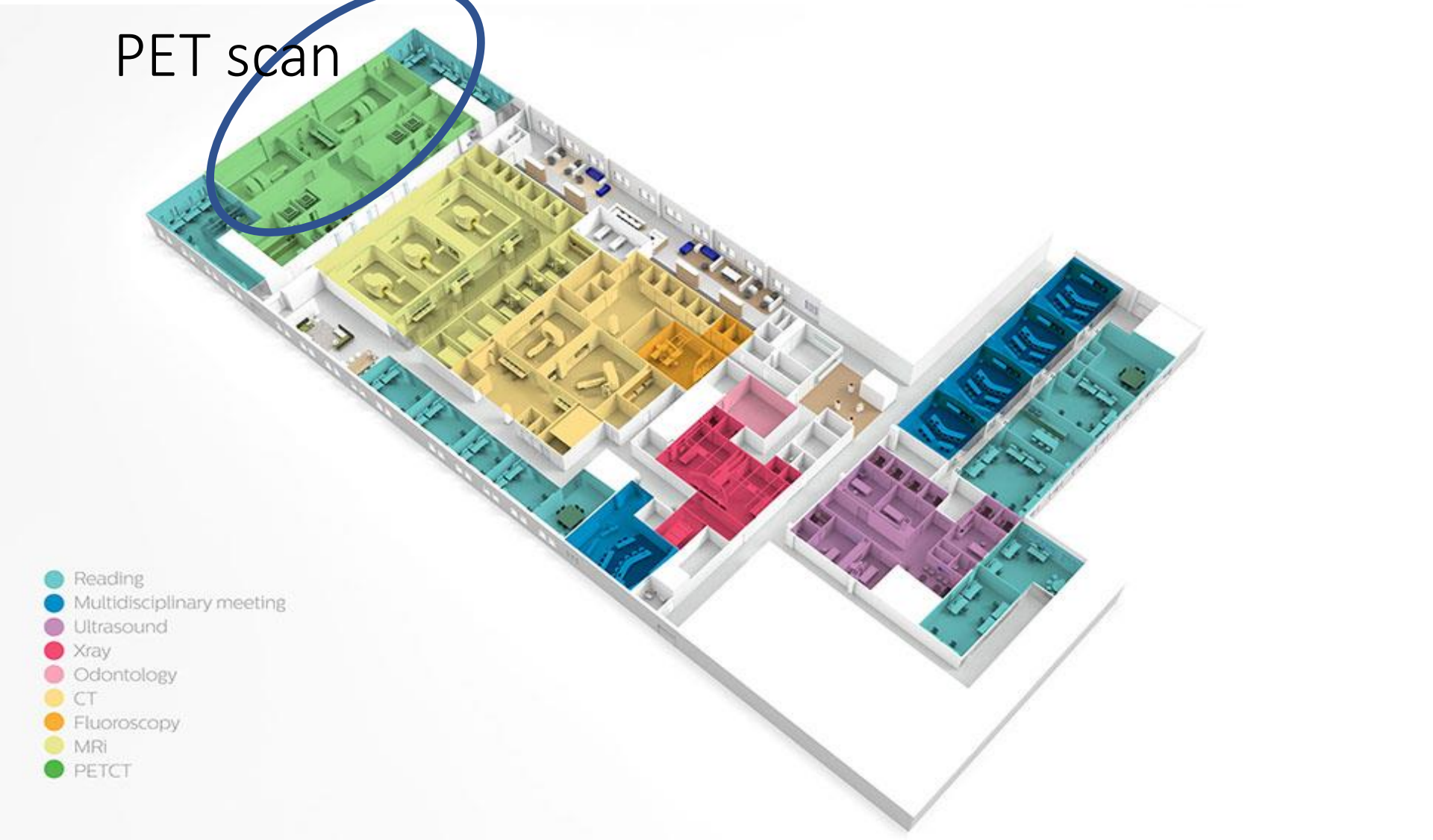
Residual gadolinium

Residual Gadolinium!

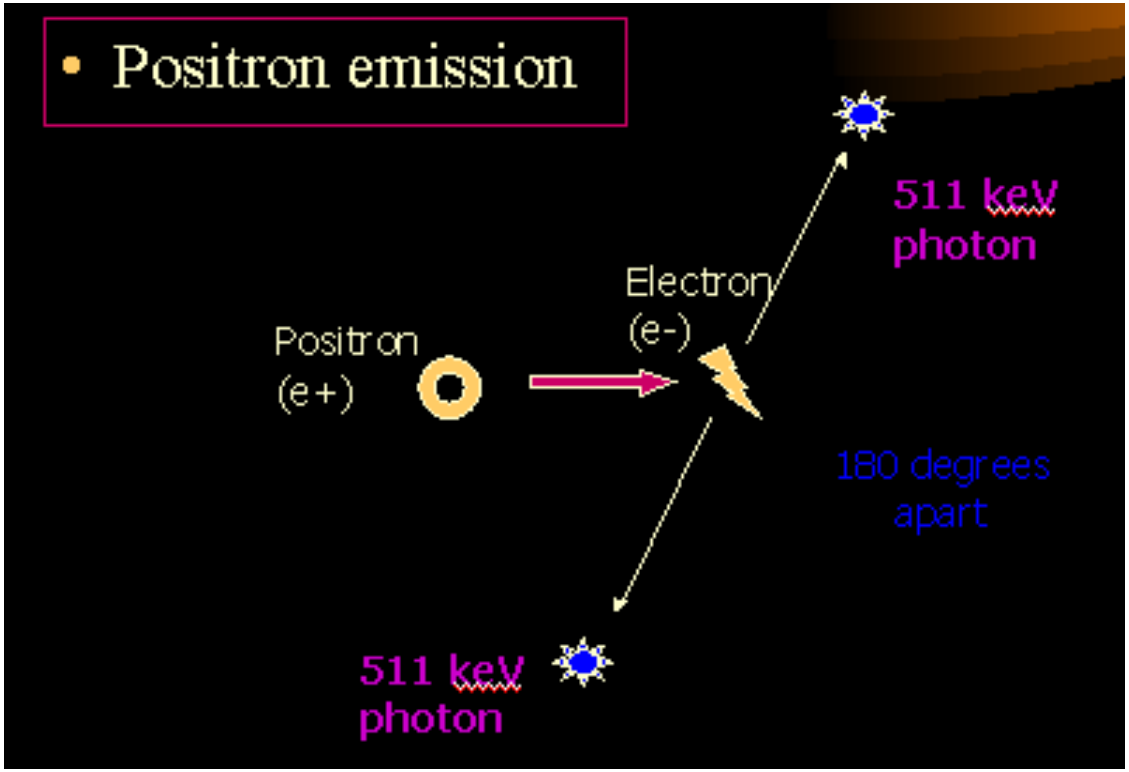


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Gadopentetate Gd-DTPA (Magnavist, Schering, Berlin, Germany)	Ionic linear	22.1	18.1	0.4	10 min
Gadobenate, Gd-BOPTA, (Multihance, Bracco, Italy)	Ionic linear	22.6	18.4	None	Not available
Gadoterate, Gd-DOTA (Dotarem, Guerbet, France)	Ionic cyclic	25.8	18.8	None	>1 month

PET scan


Reading
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Positron Emission Tomography



F-18 deoxyglucose

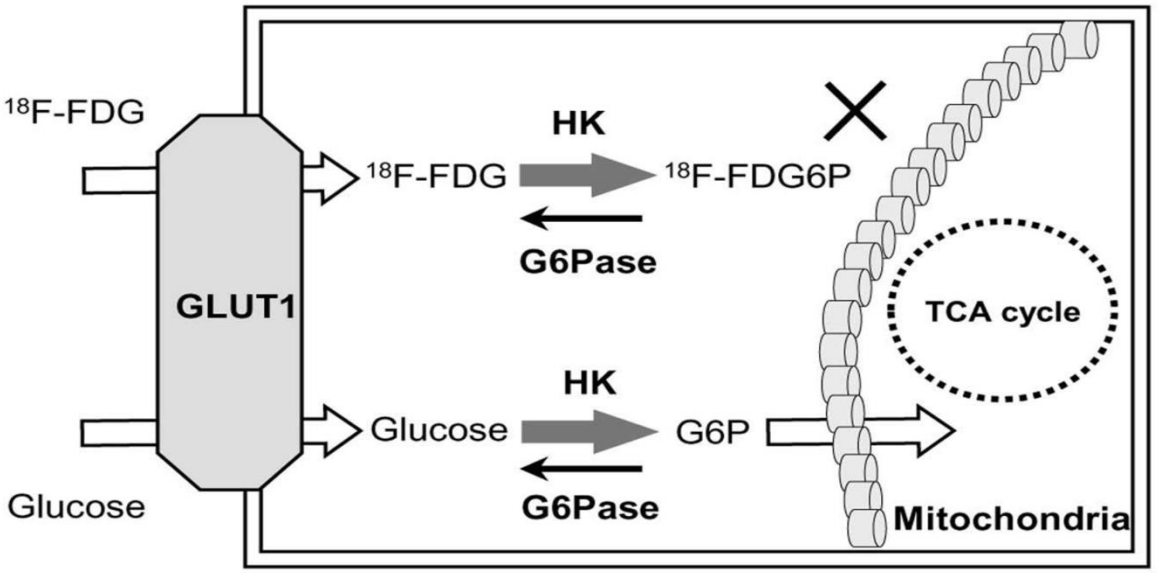
F-18 Deoxyglucose



Otto Warburg

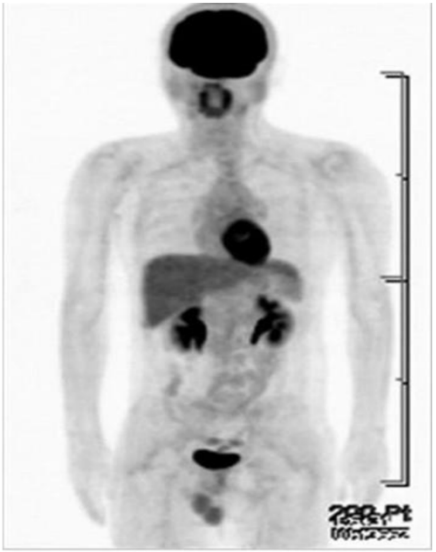


Lou Sokoloff

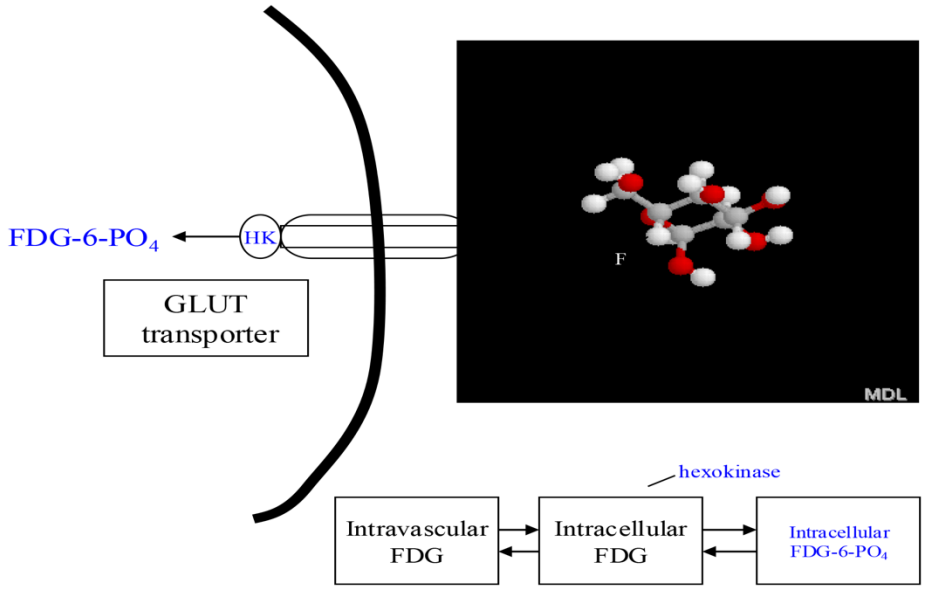


18FDG imaging

^{18}FDG PET Imaging

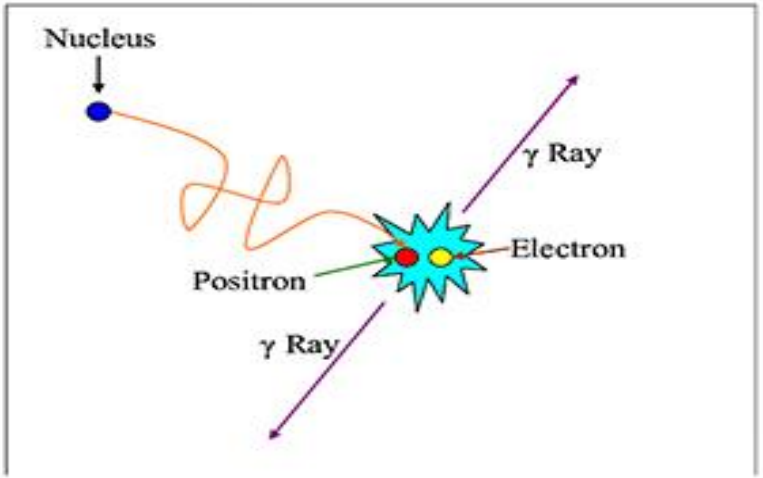


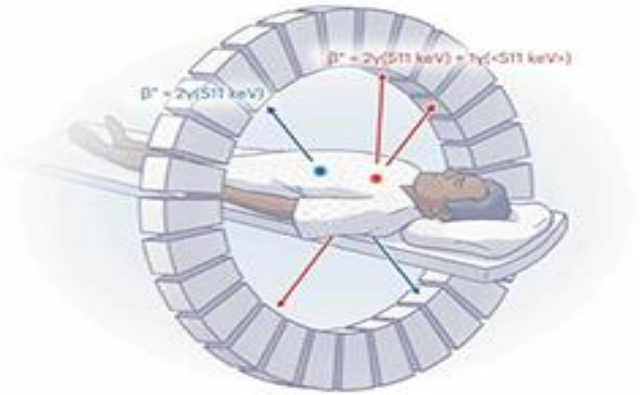
E PET MIP



PET

Positron Emission Tomography

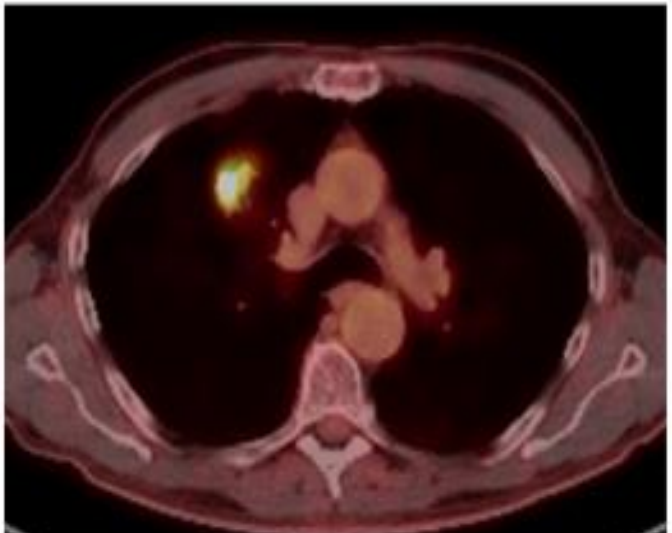


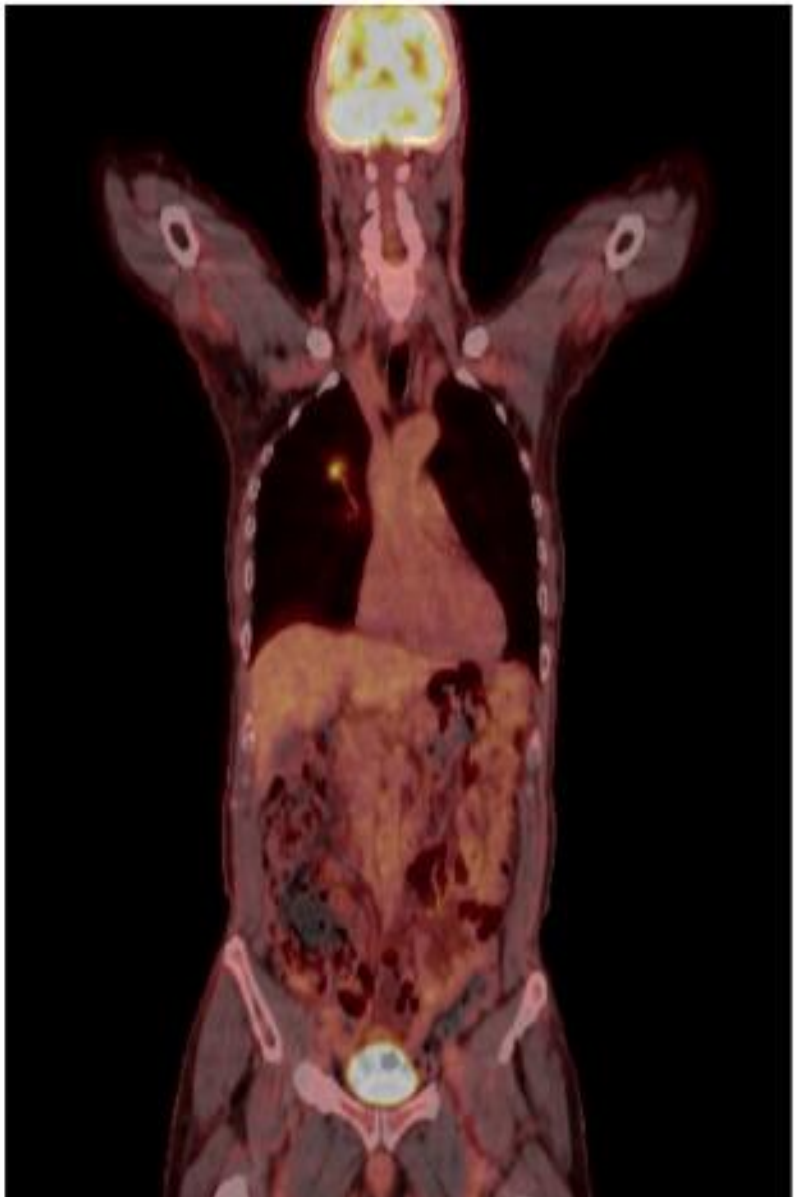


PSMA

Prostate Specific Membrane Antigen (PSMA) PET/CT







Notable other PET Agents

- Sodium Fluoride: Bone lesions
- Fluoroestadiol: Estrogen receptor
- Fluorocholine: Membrane Turnover
- Fluoromisonidozole: Hypoxia
- Florbetaben: Amyloid (Alzheimers)
- Zirconium Herceptin: labeled antibody
- Zirconium Oxine: Cell labeling

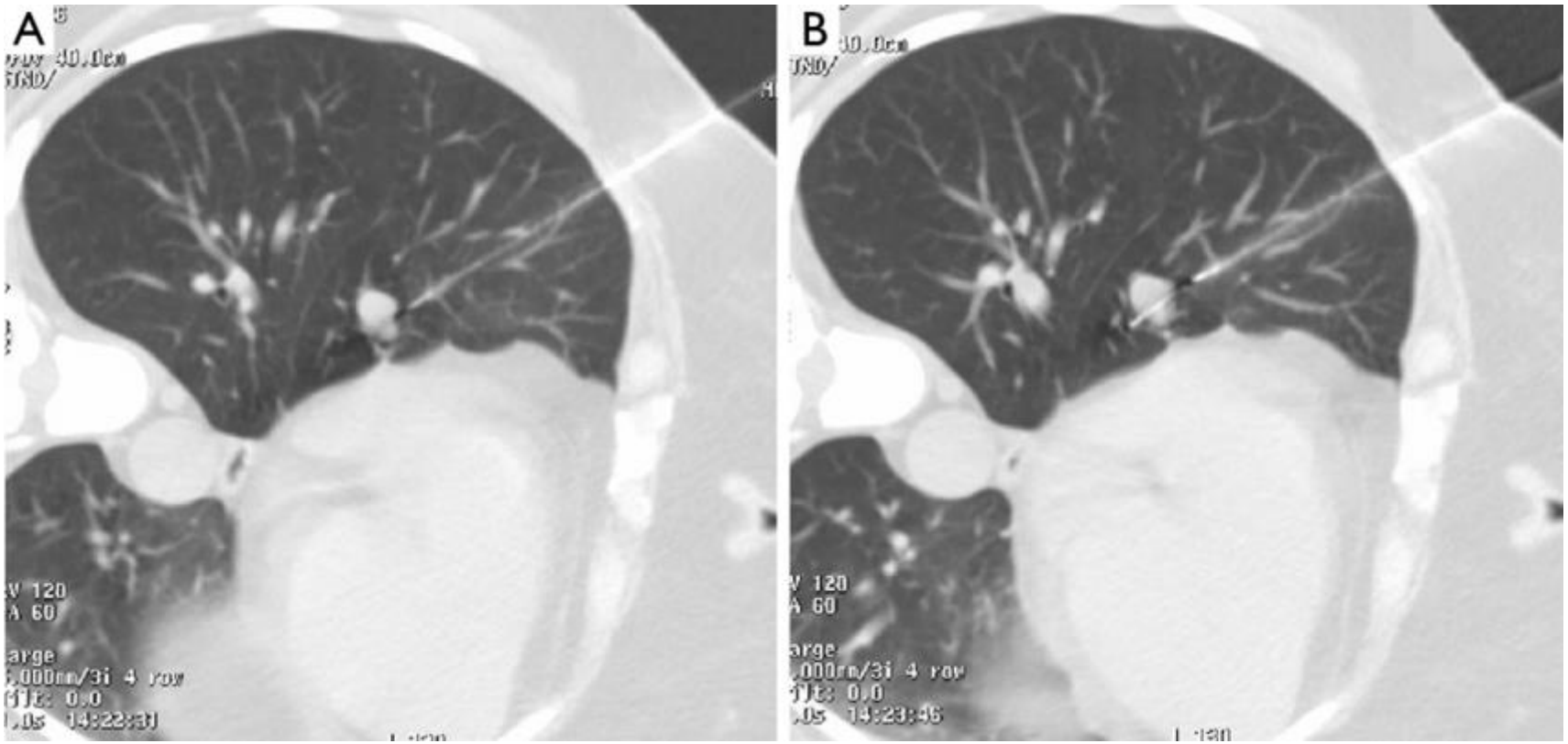
PET:Advantages and Disadvantages

- Highly sensitive
- Metabolic-Molecular information
- Combined with CT
- _____
- Expense
- Radiation
- Short half life

Interventional Radiology (IR)



Percutaneous Biopsy (IR)



Artificial Intelligence

Artificial Intelligence

- **Will it replace radiologists?**
  - No, it will make the life better by removing drudgery
  - It will improve delivery of care to patients
  - Will greatly help in triage

State of the art imaging

General Pointers about State of the Art Imaging

- Modern imaging can address solve many issues
- Anatomic imaging (CXR, CT, US) can answer questions about whether a lesion is solid or cystic or enhances and these can lead to differential diagnoses that determine the likelihood of malignancy.
- Molecular imaging (PET) offers more tissue specific diagnosis without the need for biopsy.
- Image guided biopsy may be a better approach when a PET agent is not available for a specific cancer and actual tissue specimen is needed.

Imaging of cancer



Imaging of Cancer:

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