Imaging of Cancer:

A virtual tour of a Radiology Department

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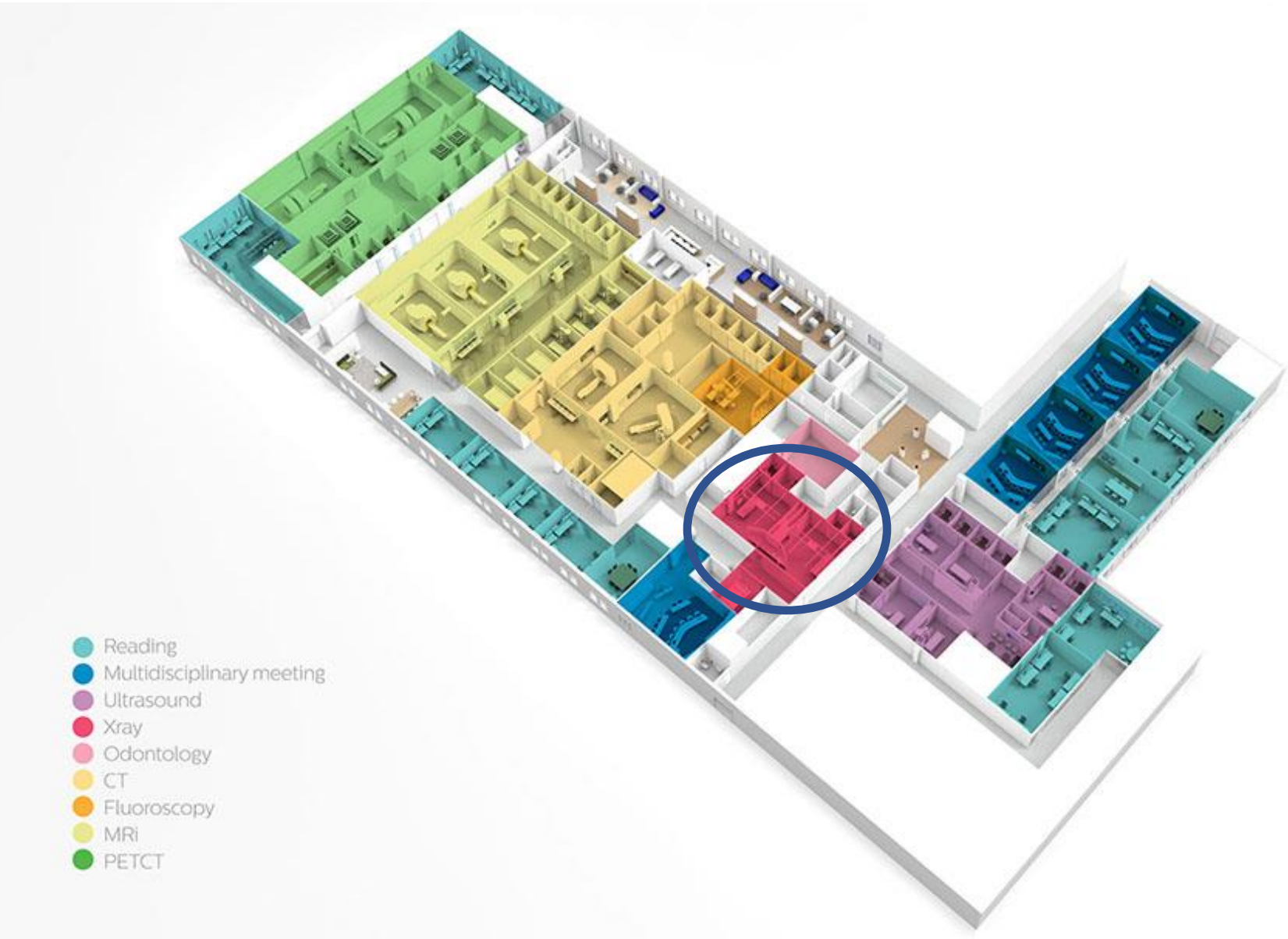
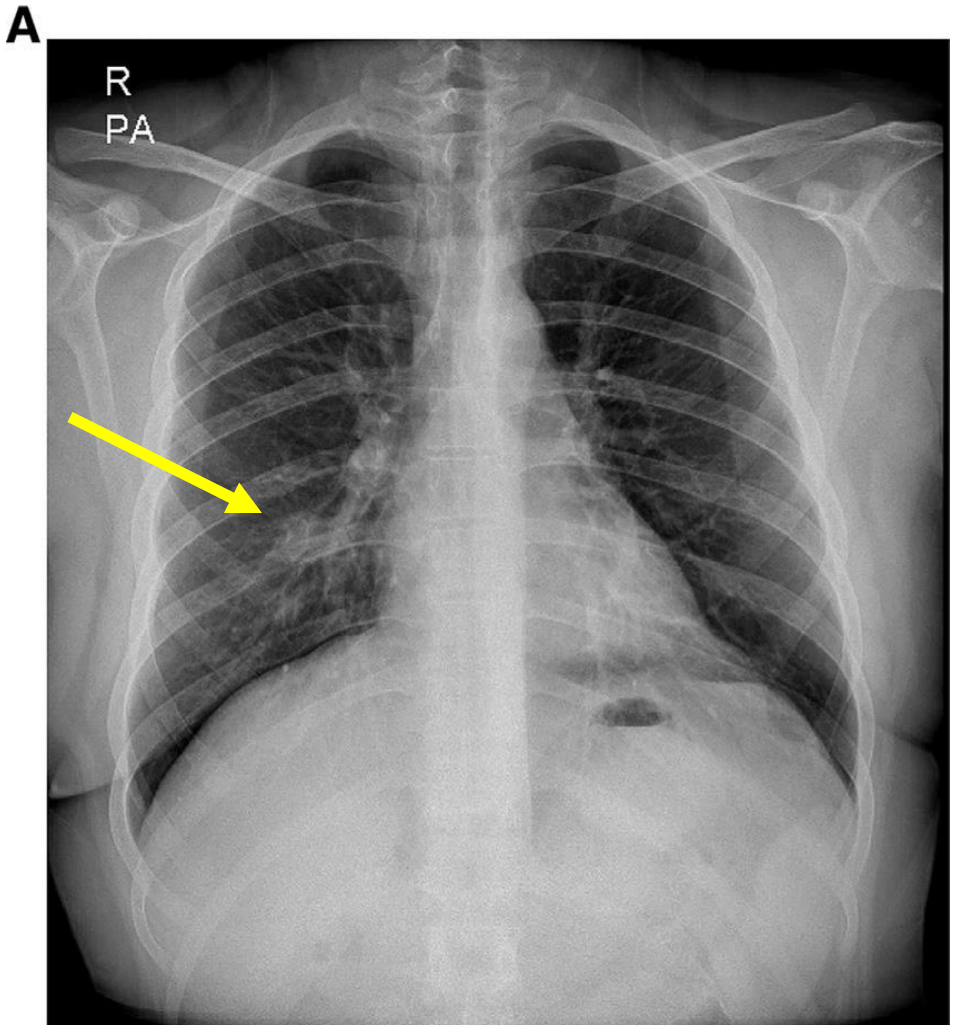
A Virtual Tour of the Radiology Department

- 67 year old with trauma to chest
- History of prostate cancer treated 10 years ago
- Chest X-ray (CXR) ordered.

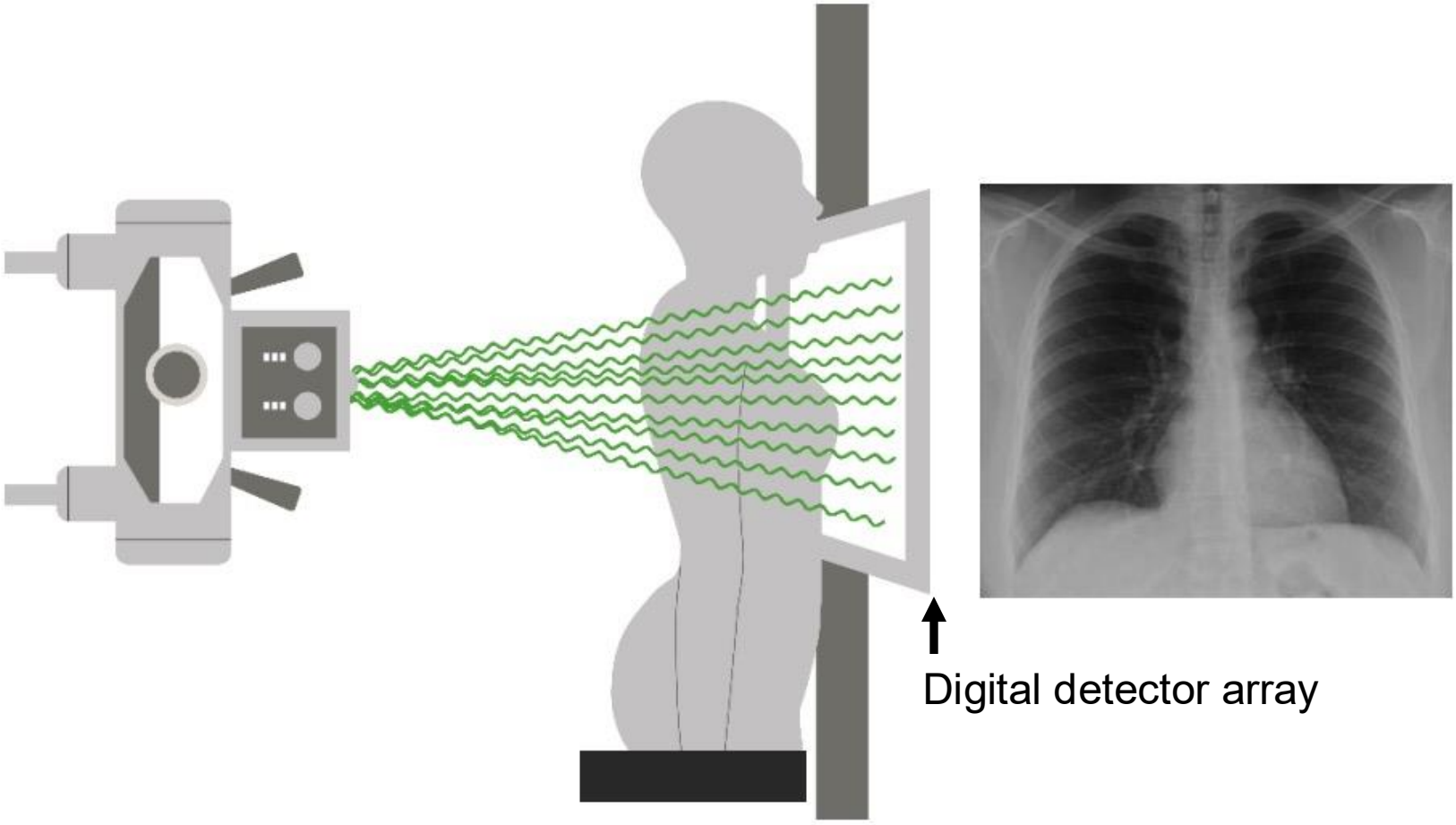

Reading
Multidisciplinary meeting
Ultrasound
Xray
Odontology
CT
Fluoroscopy
MRi
PETCT

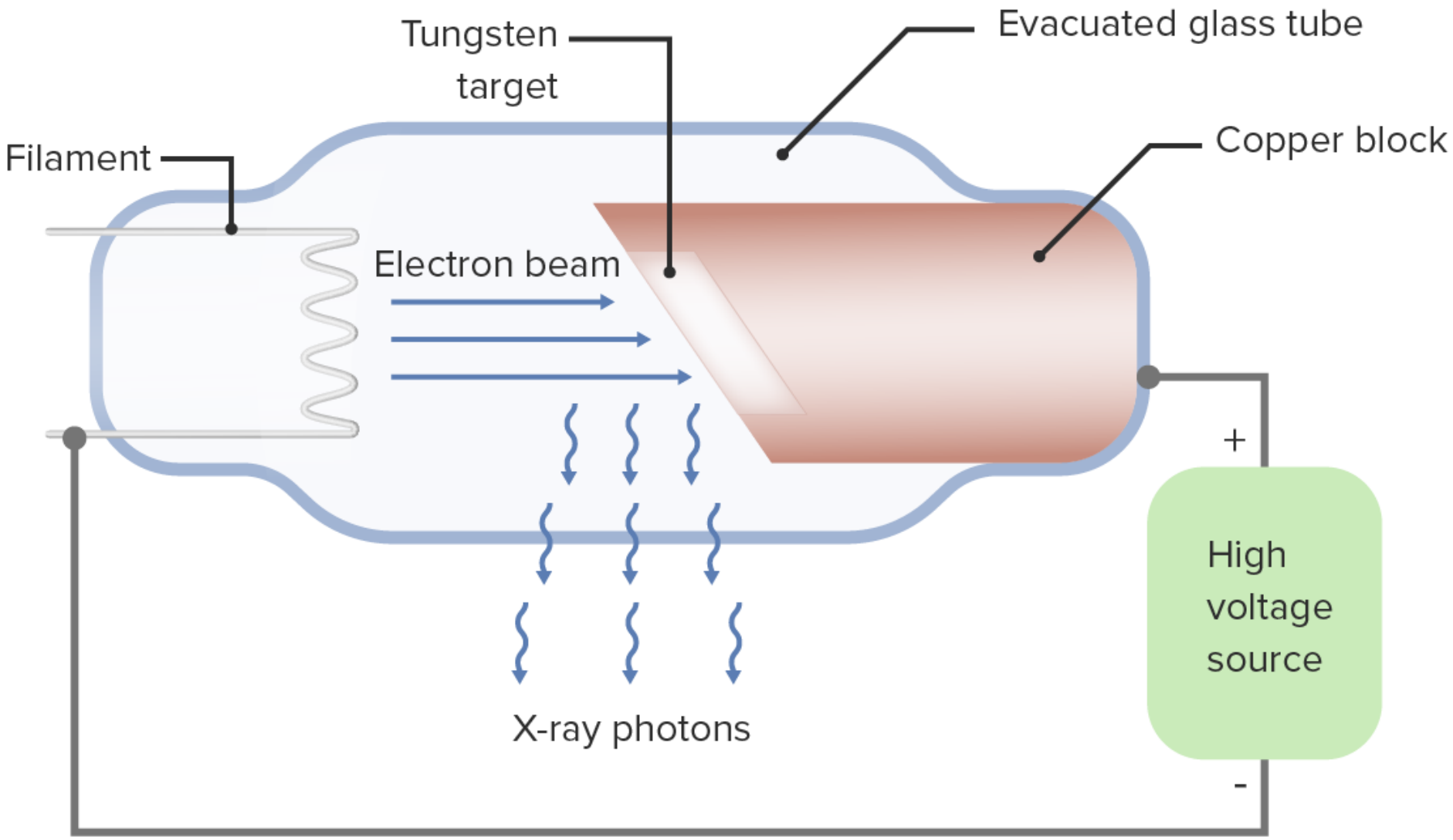


Faint pulmonary nodule is detected.

Is it real?
Is it cancer?

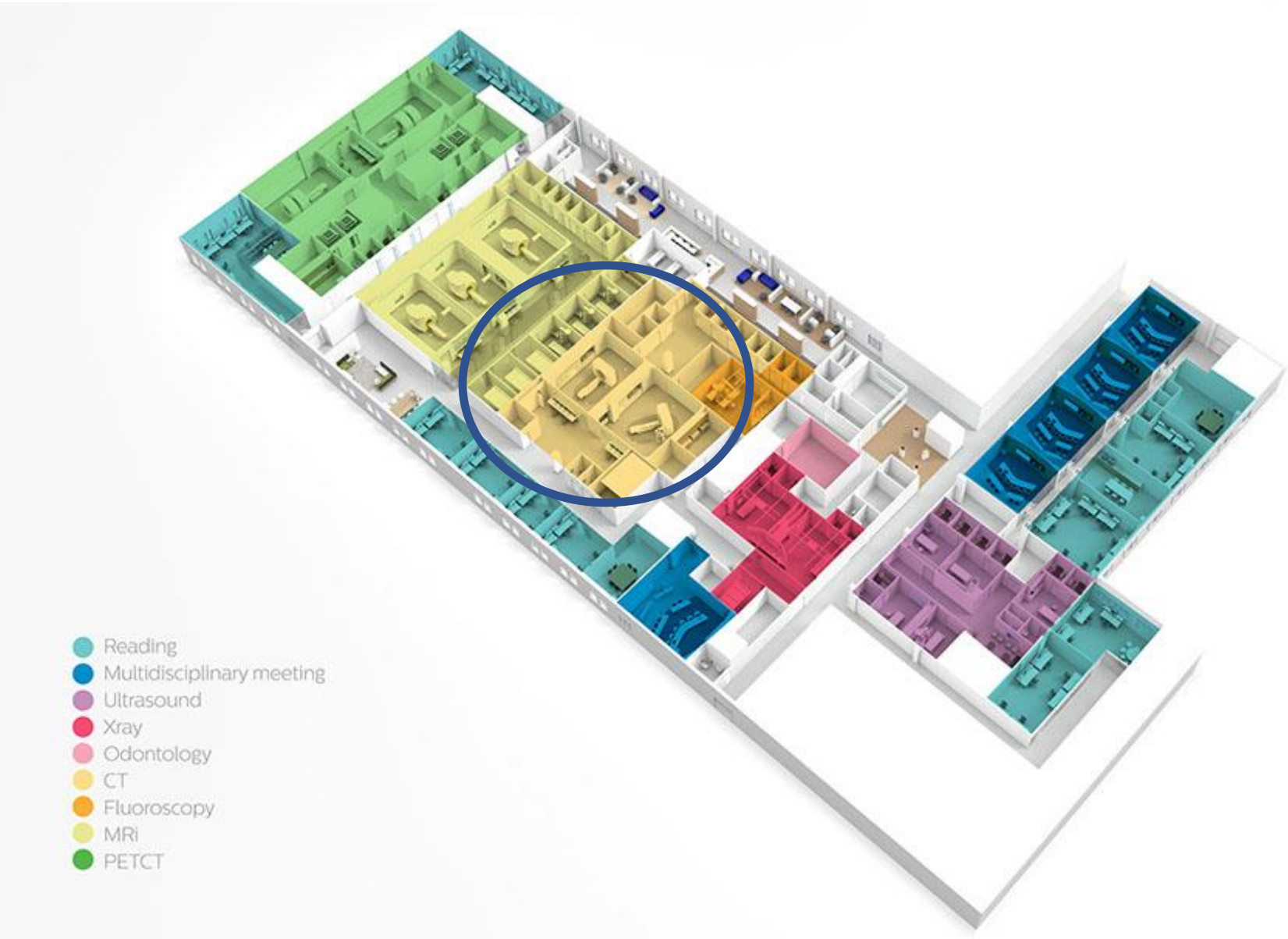
How is a CXR taken?




Tungsten target
Evacuated glass tube
Filament
Copper block
Electron beam
+
High voltage source
-
X-ray photons

A Virtual Tour of the Radiology Department

- 67 year old with trauma to chest
- History of prostate cancer treated 10 years ago
- CT scan ordered.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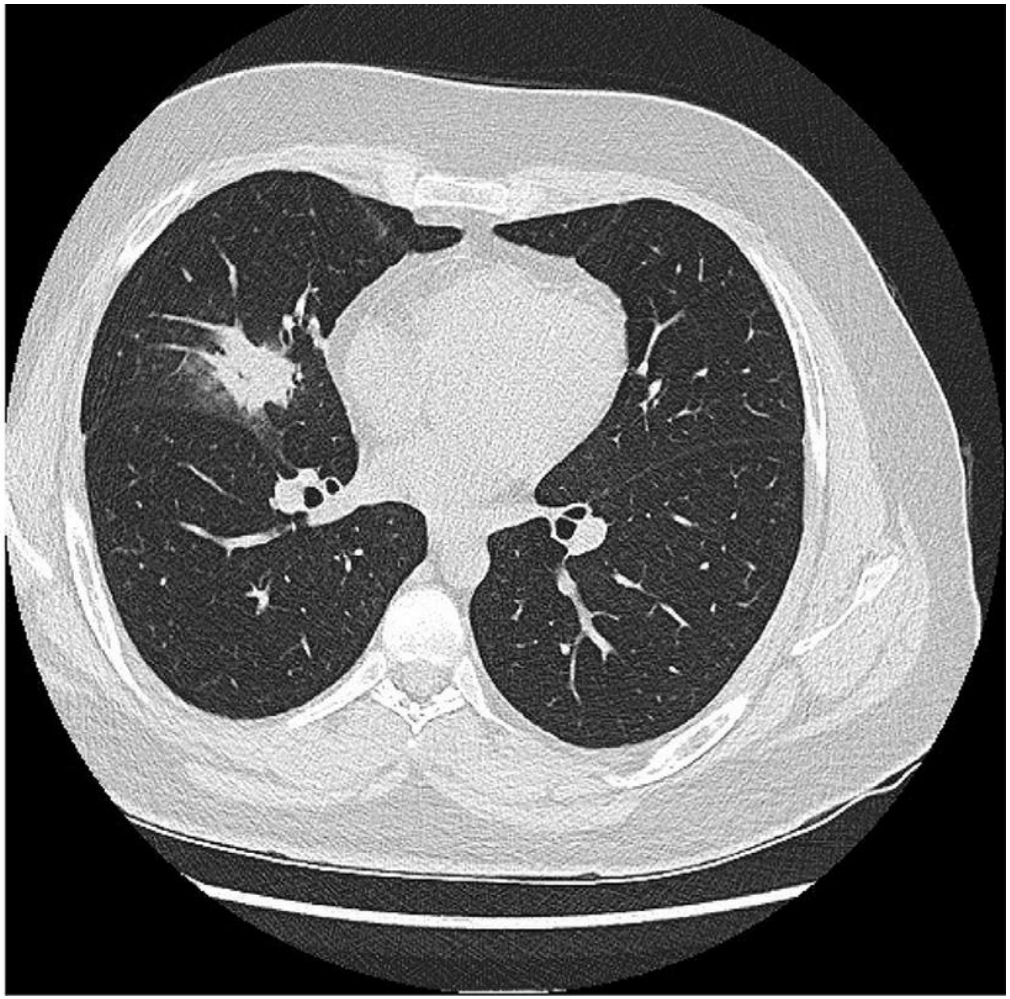
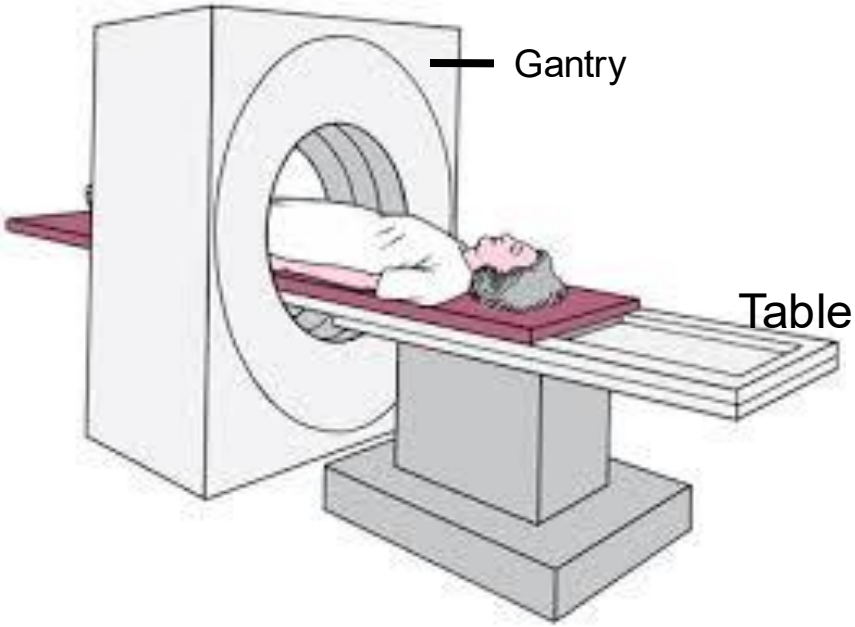
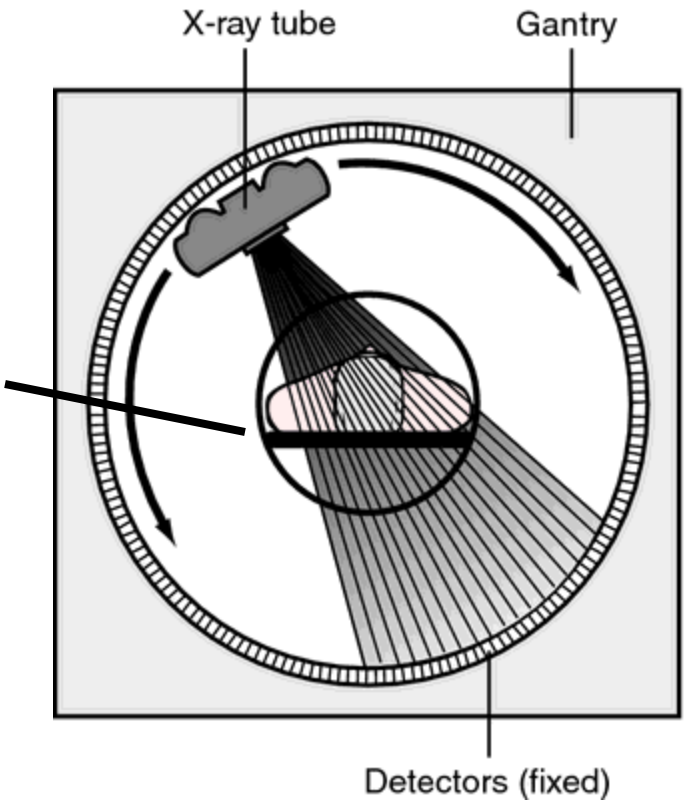
Computed Tomography

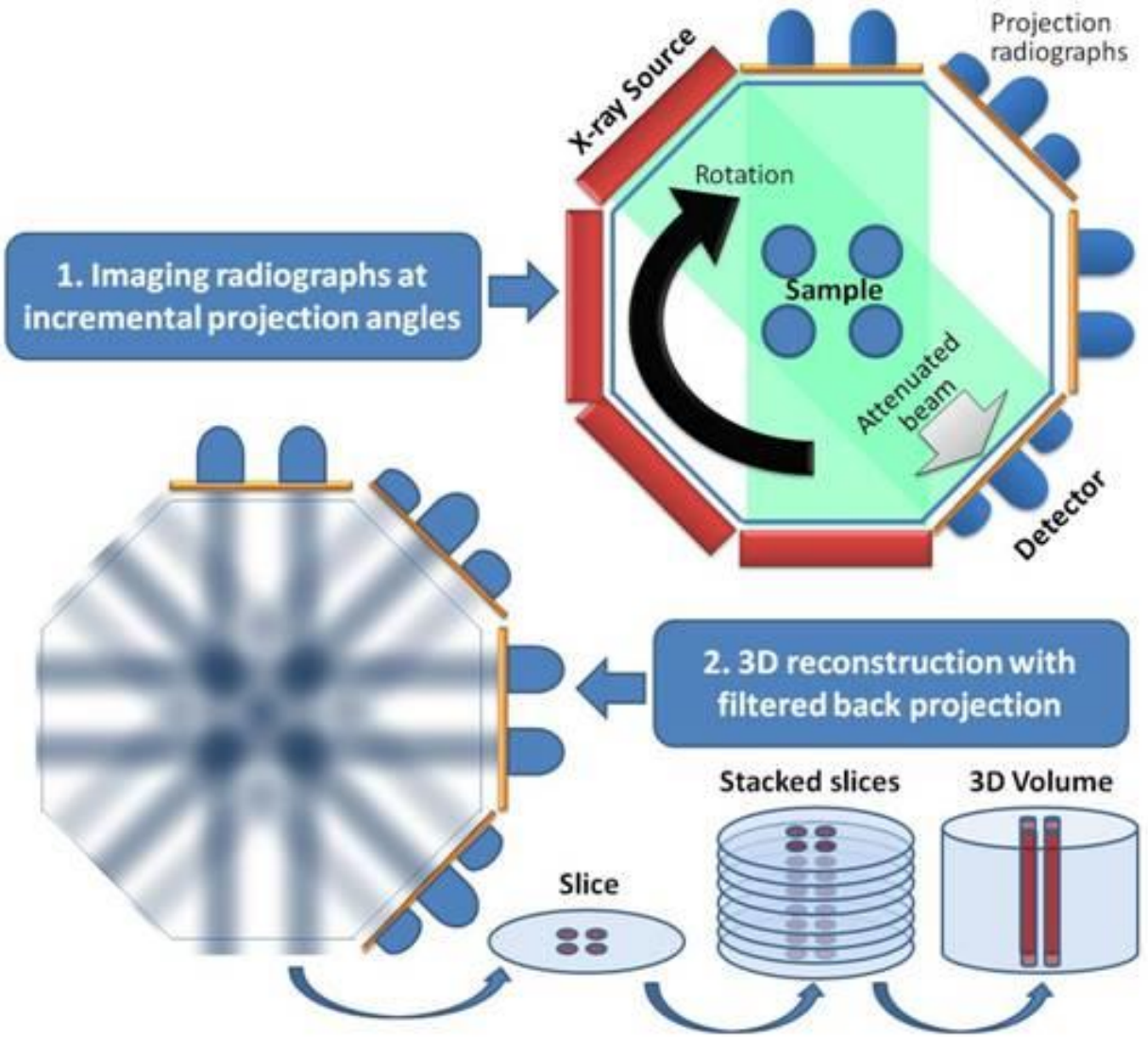


Basics of CT





Filtered Back Projection



“Volume” CT imaging

Advantages of CT

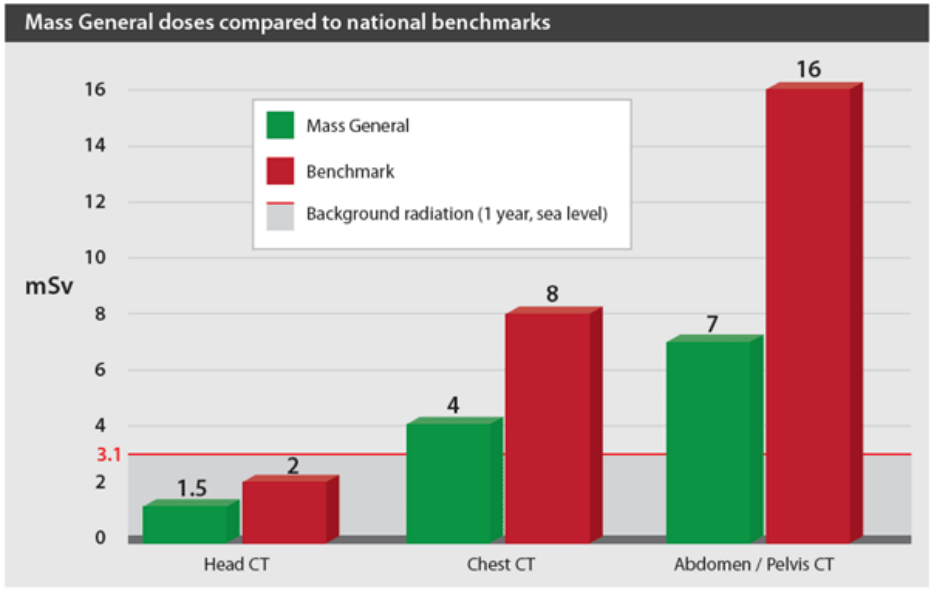
- Widely available
- Minimal prep (NPO, drink contrast or water)
- Very rapid (2-3 seconds neck to pelvis)
- High resolution
- Relatively inexpensive

Disadvantages

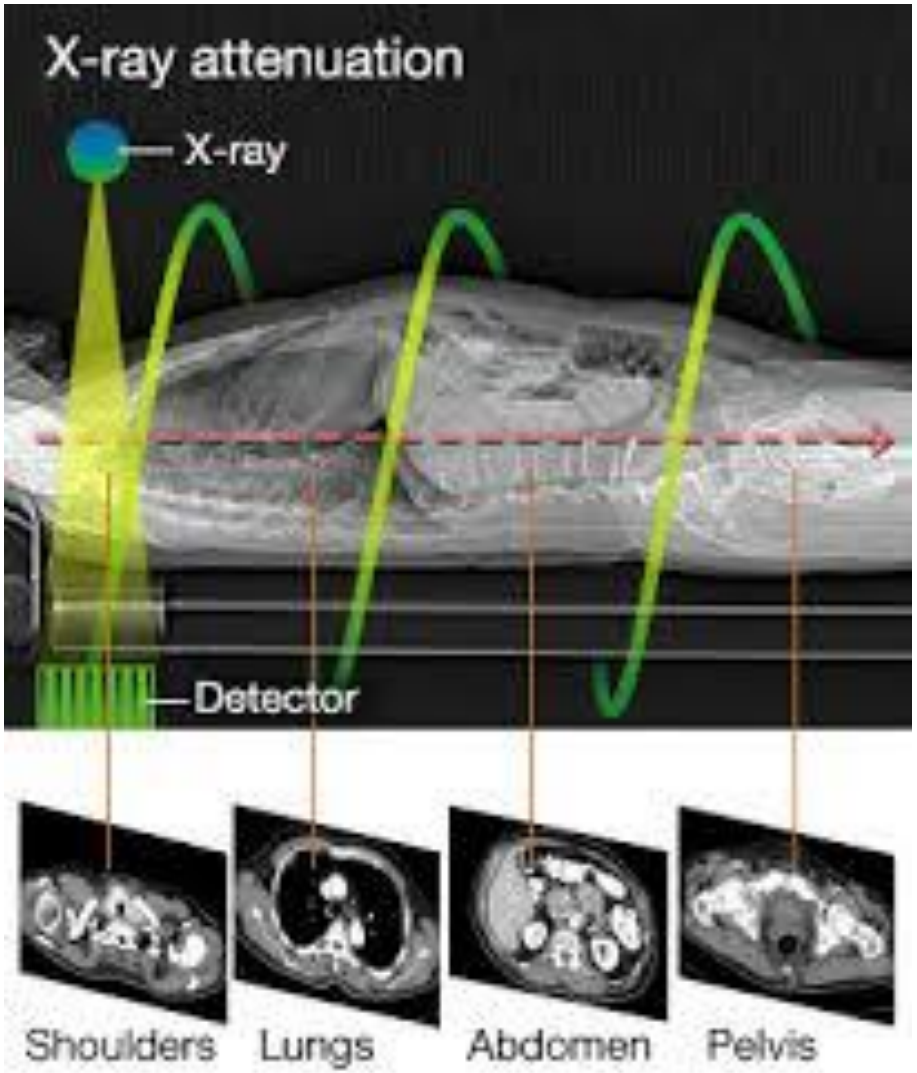
- **Radiation?**
- Often requires iv contrast media
  - Allergic reactions (minimal)
- Anatomic information only

Radiation Reduction on CT

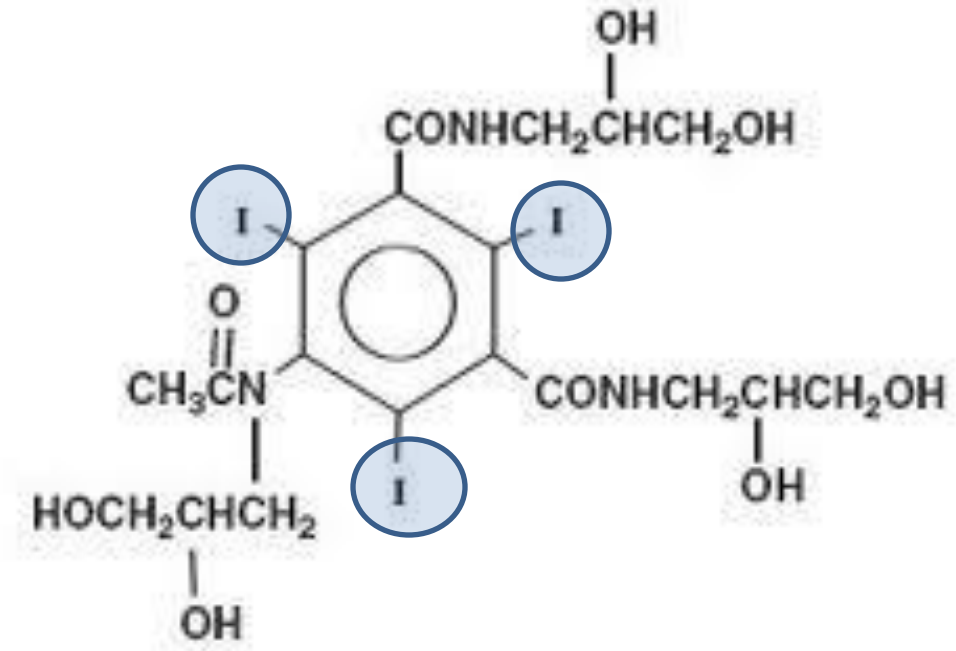
Lower kV (energy) x-rays
More sensitive detectors
Better reconstruction algorithms
“Synthetic” images



Attenuation differences thru the body mean less radiation for some regions

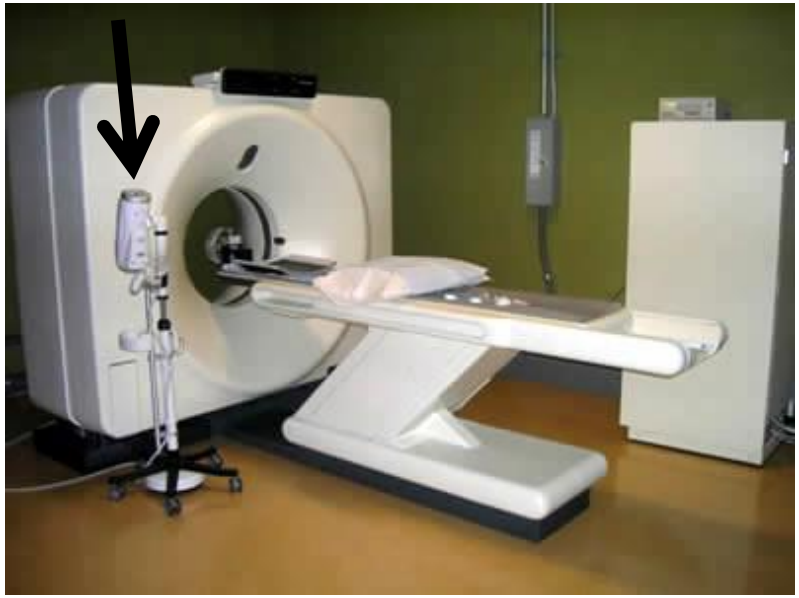


Non ionic Iodinated Contrast



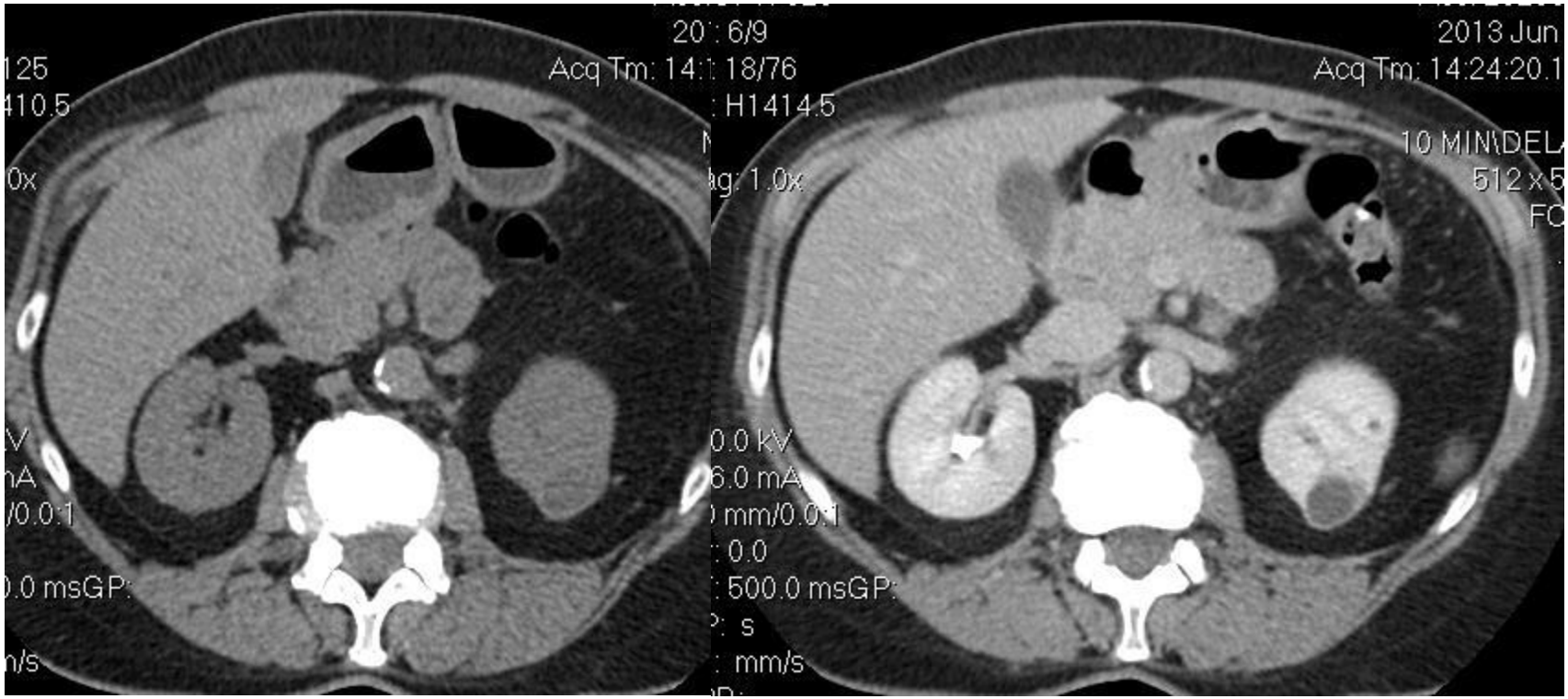
Typical dose 30-45 Grams of Iodine!!!

Iodinated Contrast



75-150cc of contrast injected.

Iodinated Contrast Media

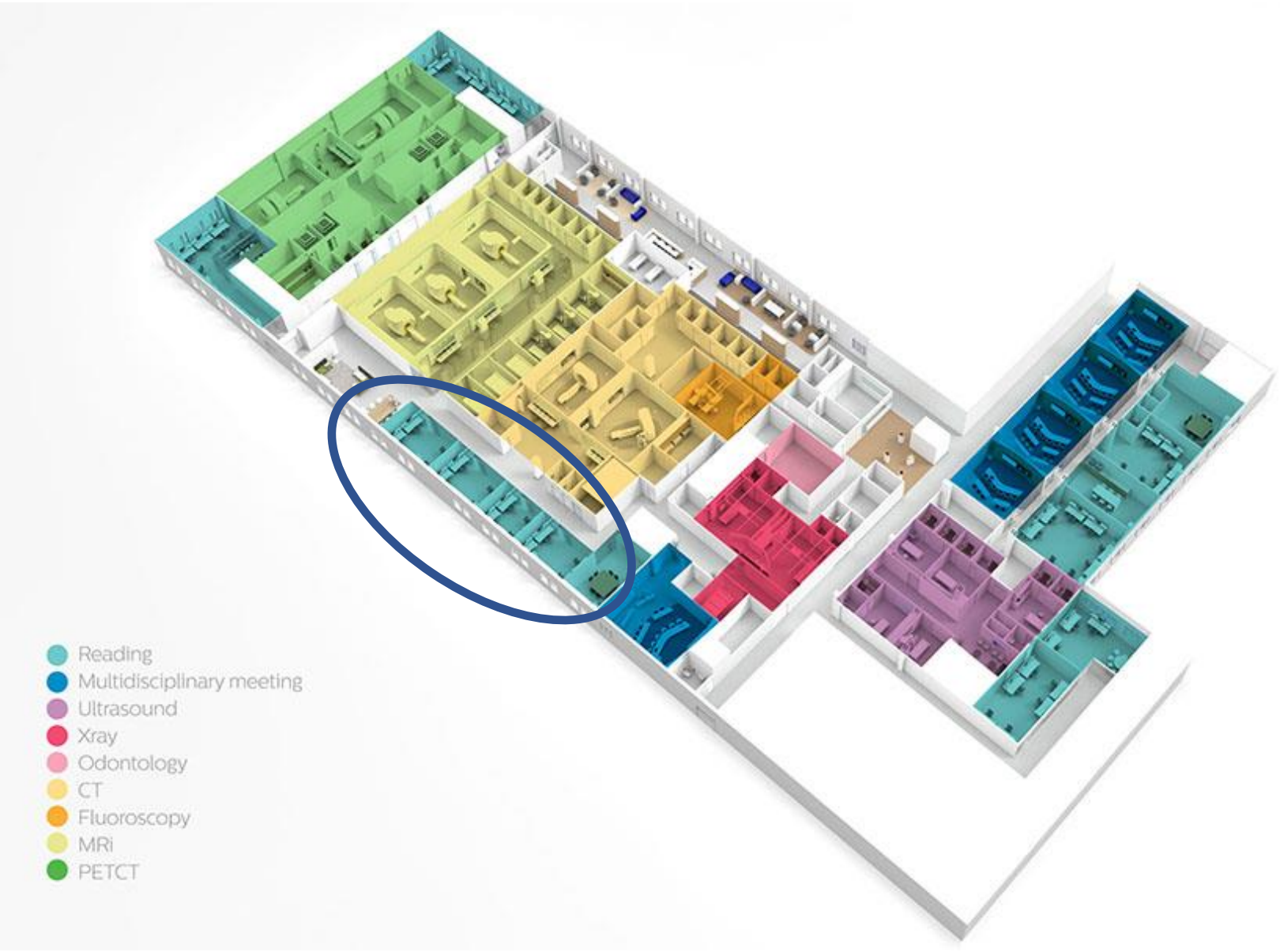


A new wrinkle: virtual non contrast CT

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

Update on our patient

- 67 year old with trauma to chest
- Pulmonary nodule confirmed
- Cystic lesion in the kidney on CT
- Next step: Ultrasound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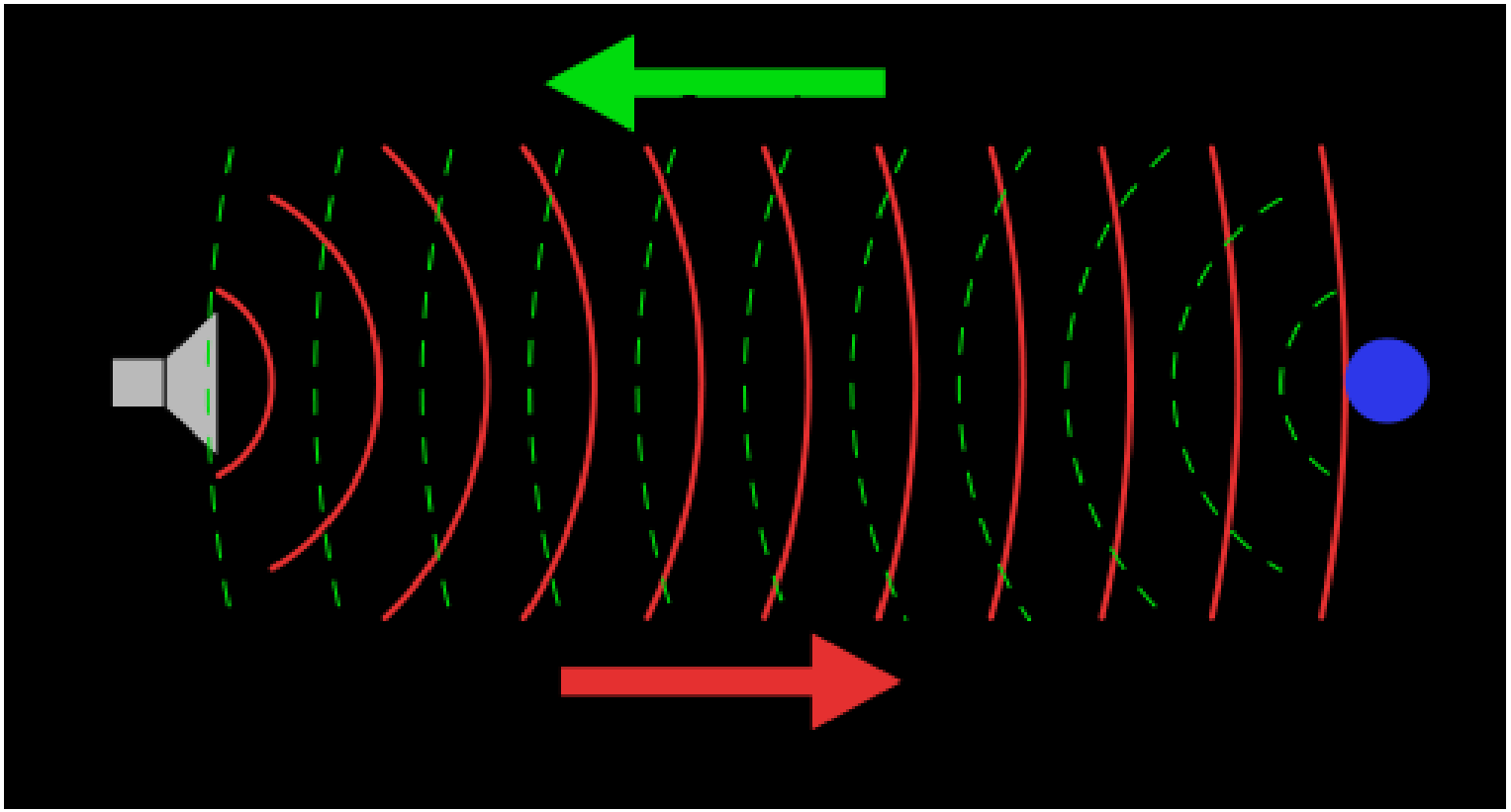
Ultrasound equipment: The new stethoscope?

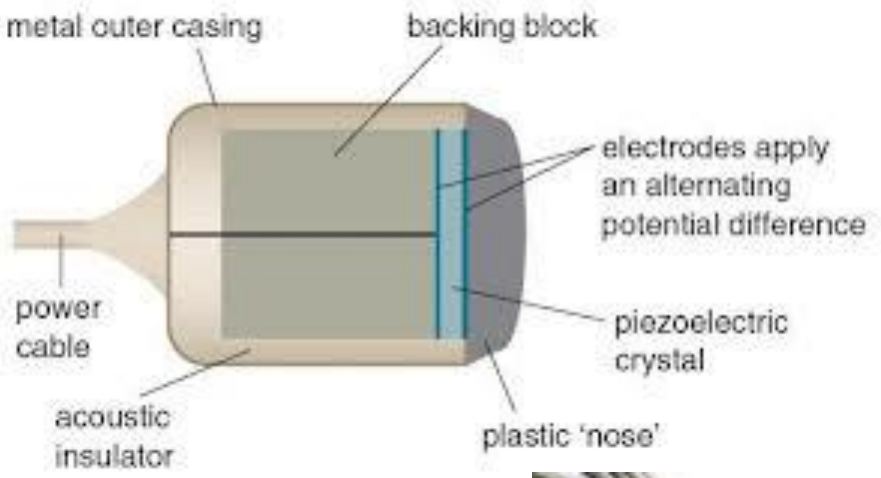
Ultrasound

US basics

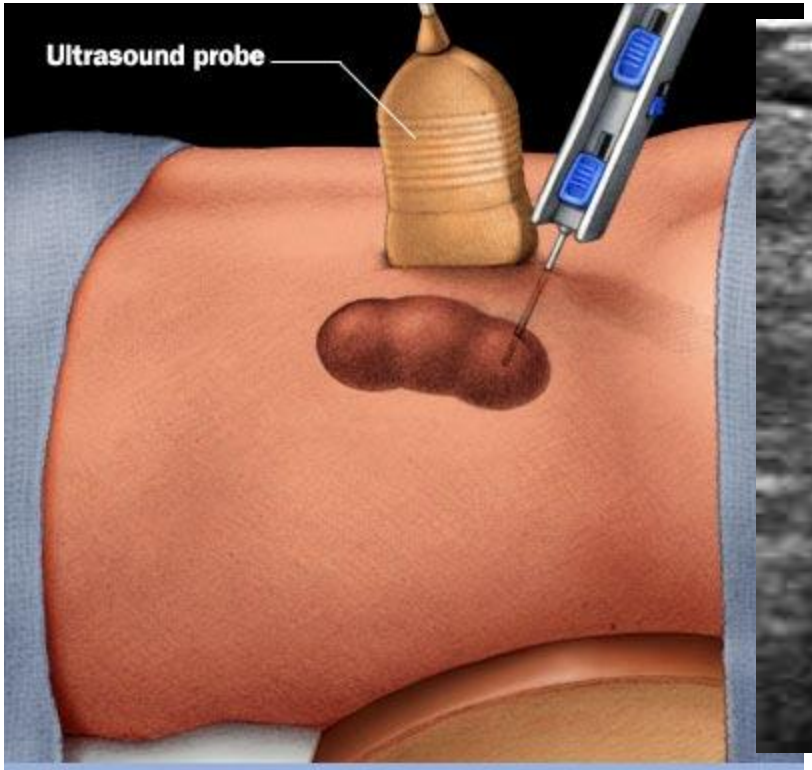


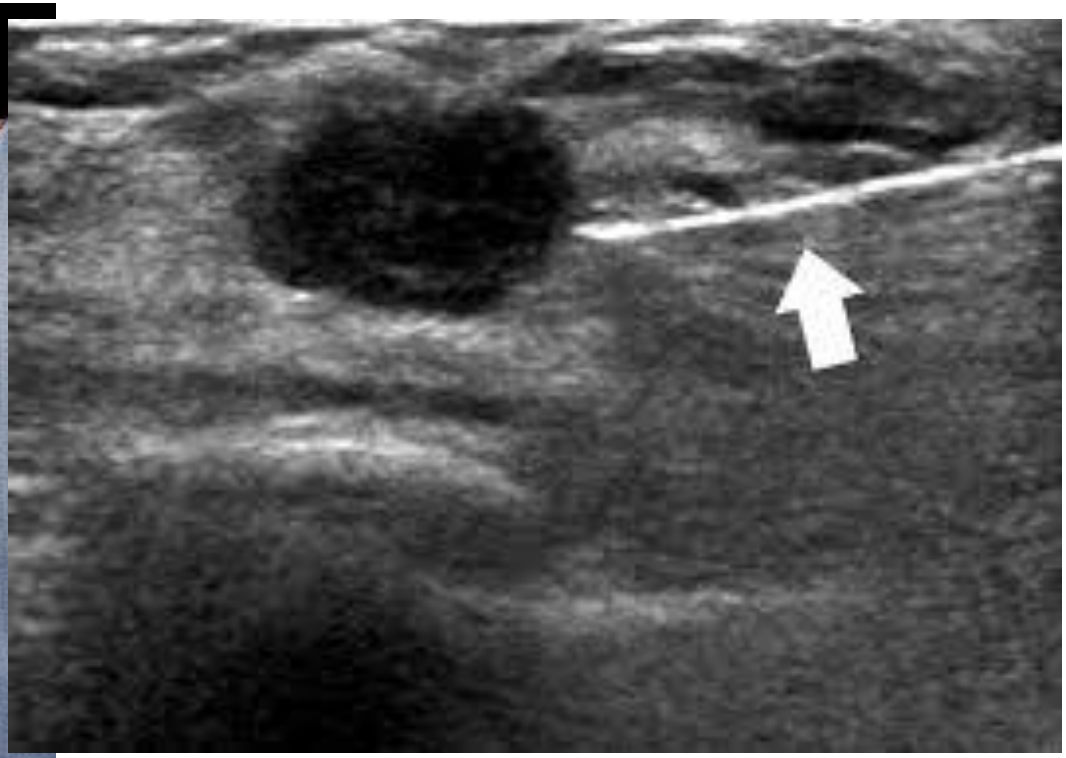
Imaging dependent on the speed of sound
In tissue

US Probes


metal outer casing
backing block
electrodes apply an alternating potential difference
power cable
piezoelectric crystal
acoustic insulator
plastic 'nose'

US guided biopsy in real time





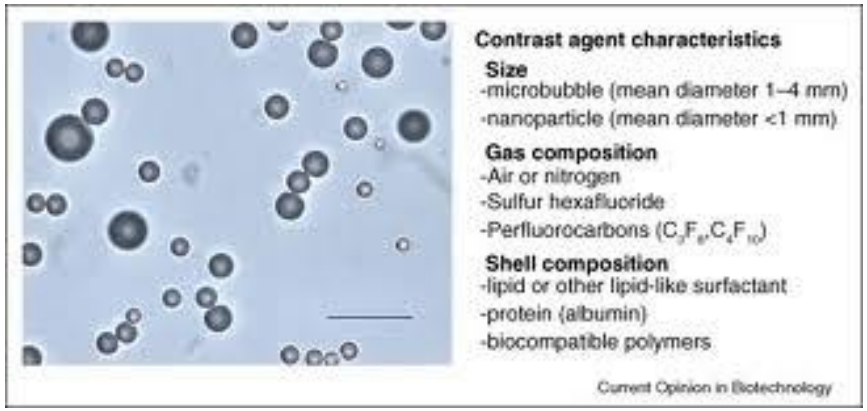
US advantages

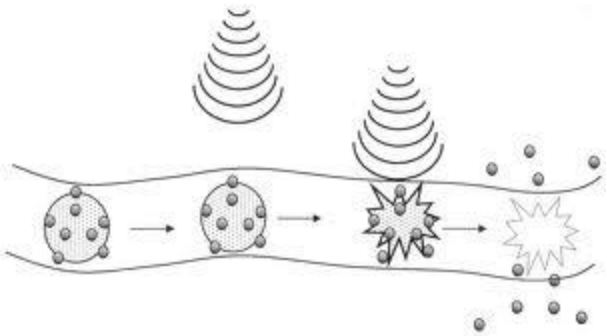
- No radiation
- Real time
- Inexpensive
- Quick, little prep
- No injection

US disadvantages

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

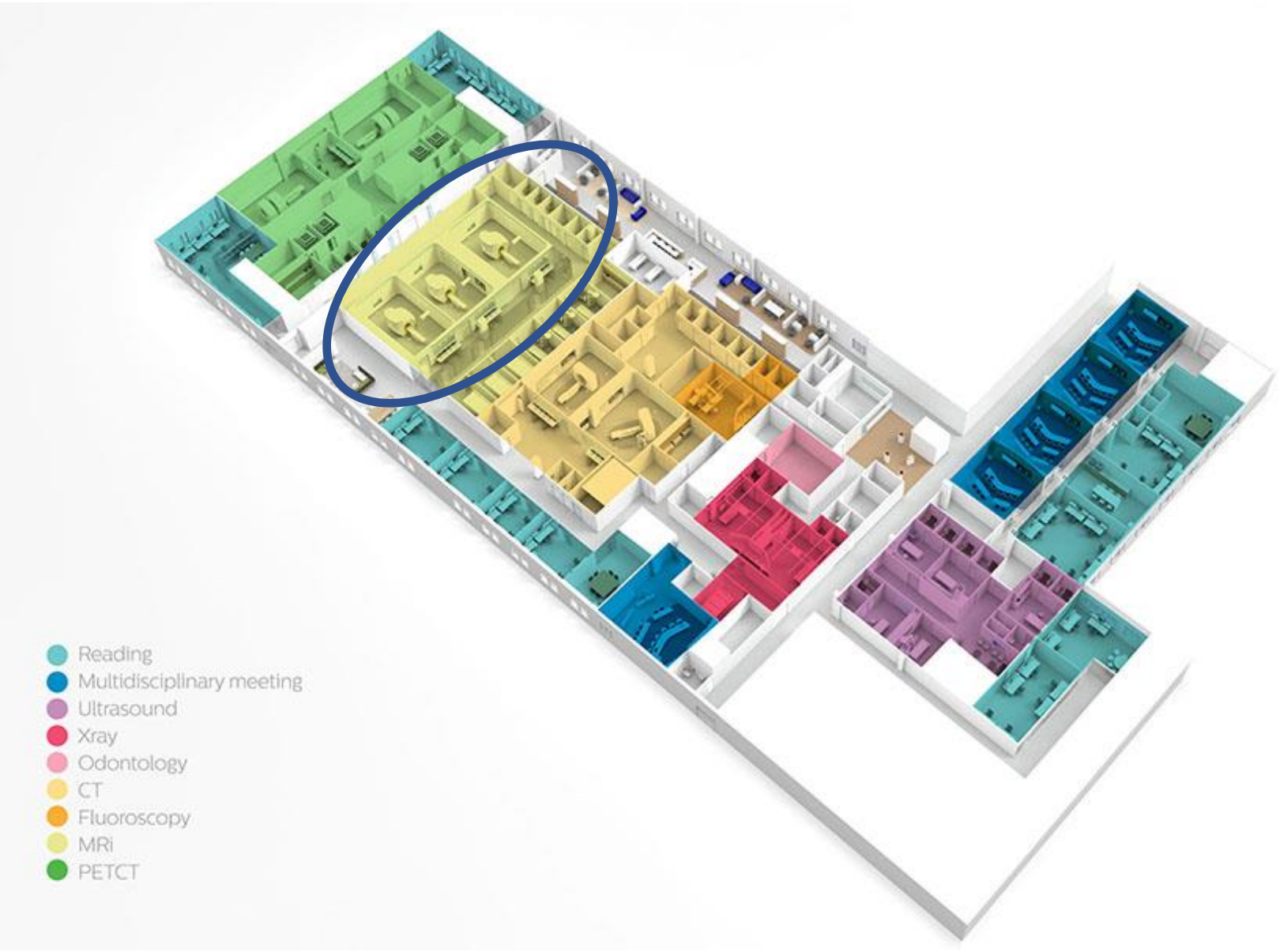
US Microbubble contrast





Update on our patient

- 67 year old with trauma to chest
- Pulmonary nodule confirmed
- Cystic lesion in the kidney
- Confirmed to be a cyst: no further workup required.
- However, an indeterminant liver lesion is seen.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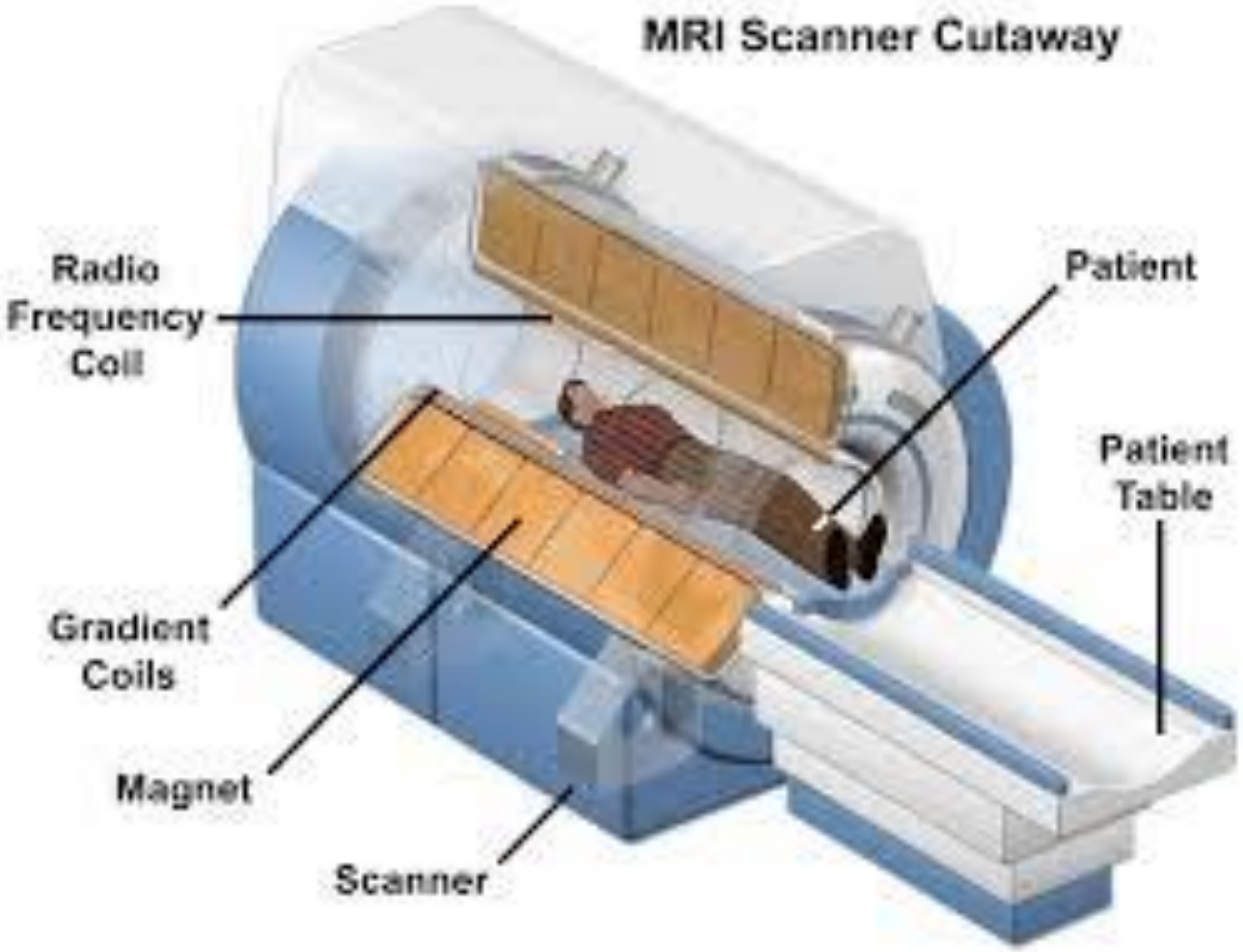
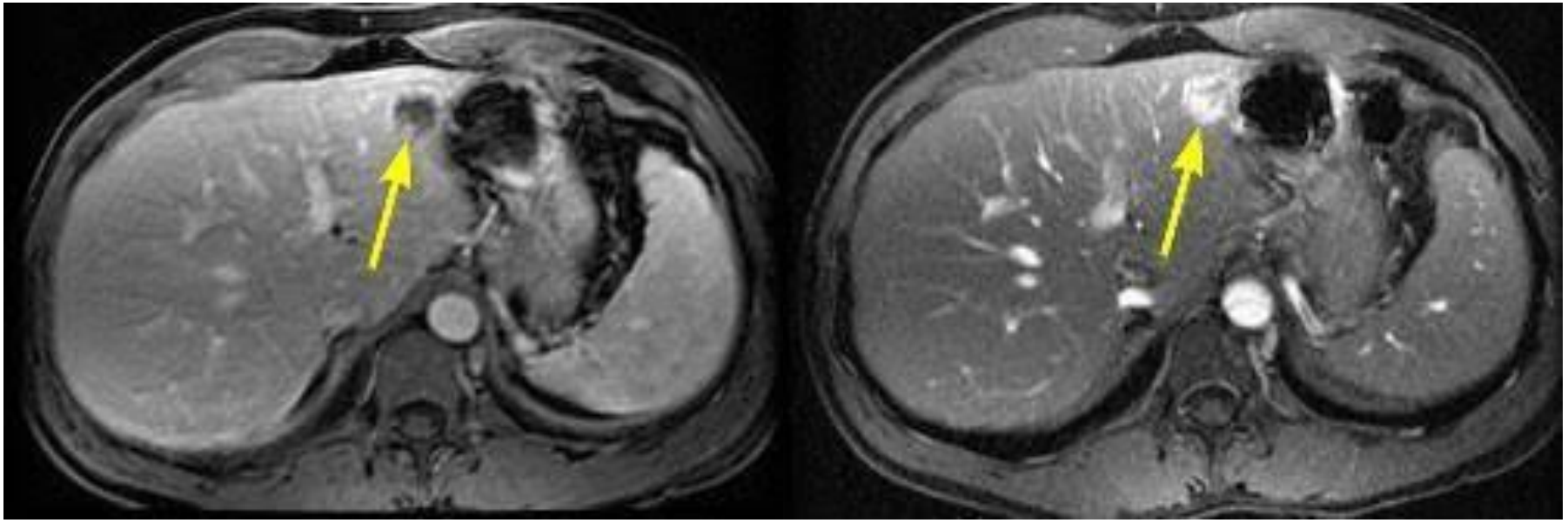
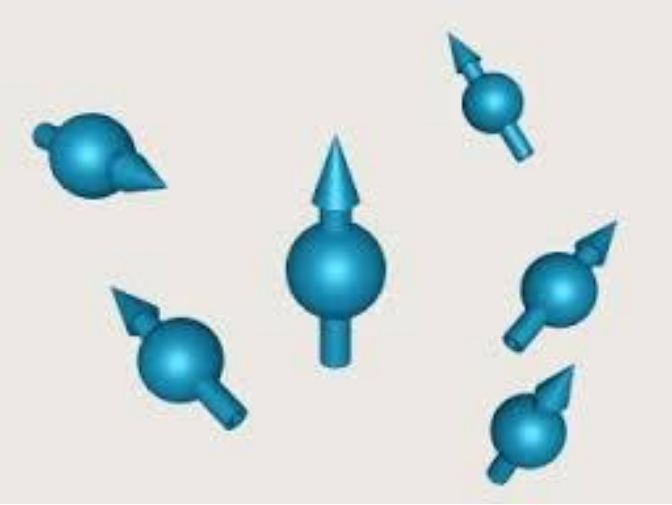
Magnetic Resonance Imaging Scanner



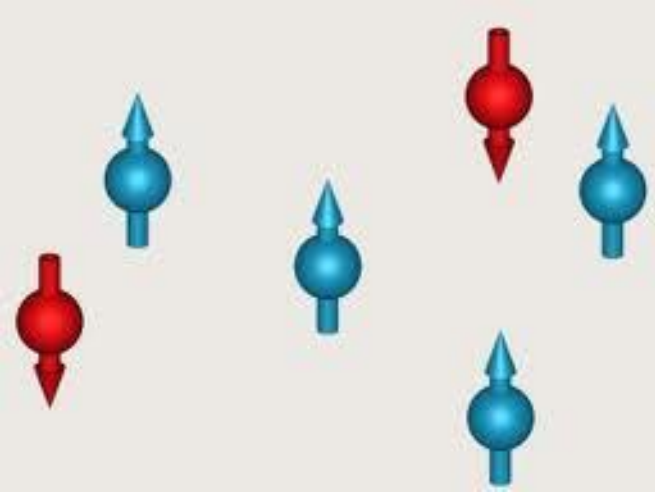
Magnetic Resonance Imaging



MRI Physics 101

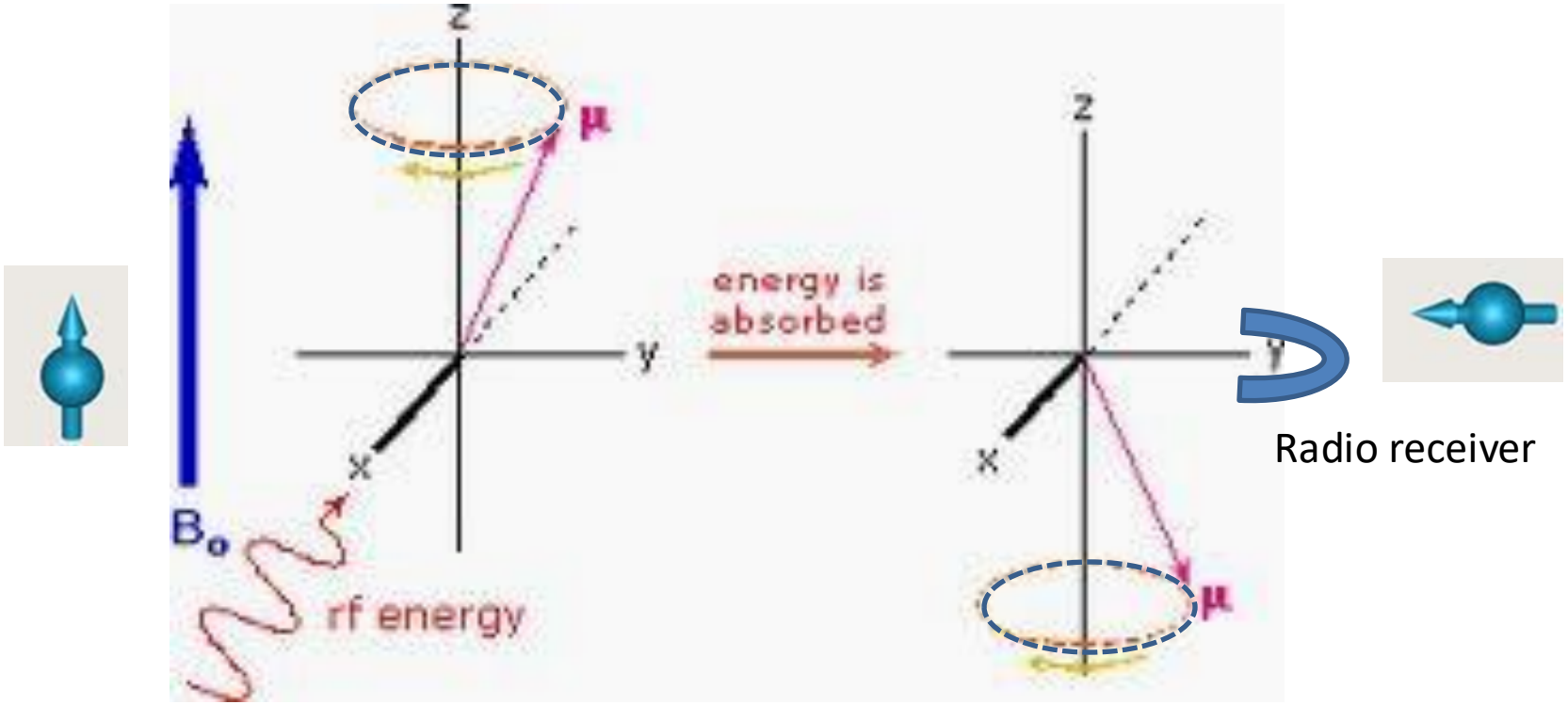


Protons in space: no field

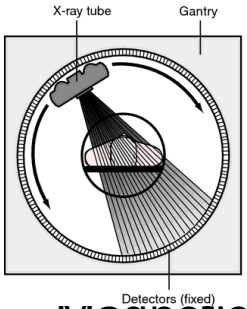


Protons in magnetic field

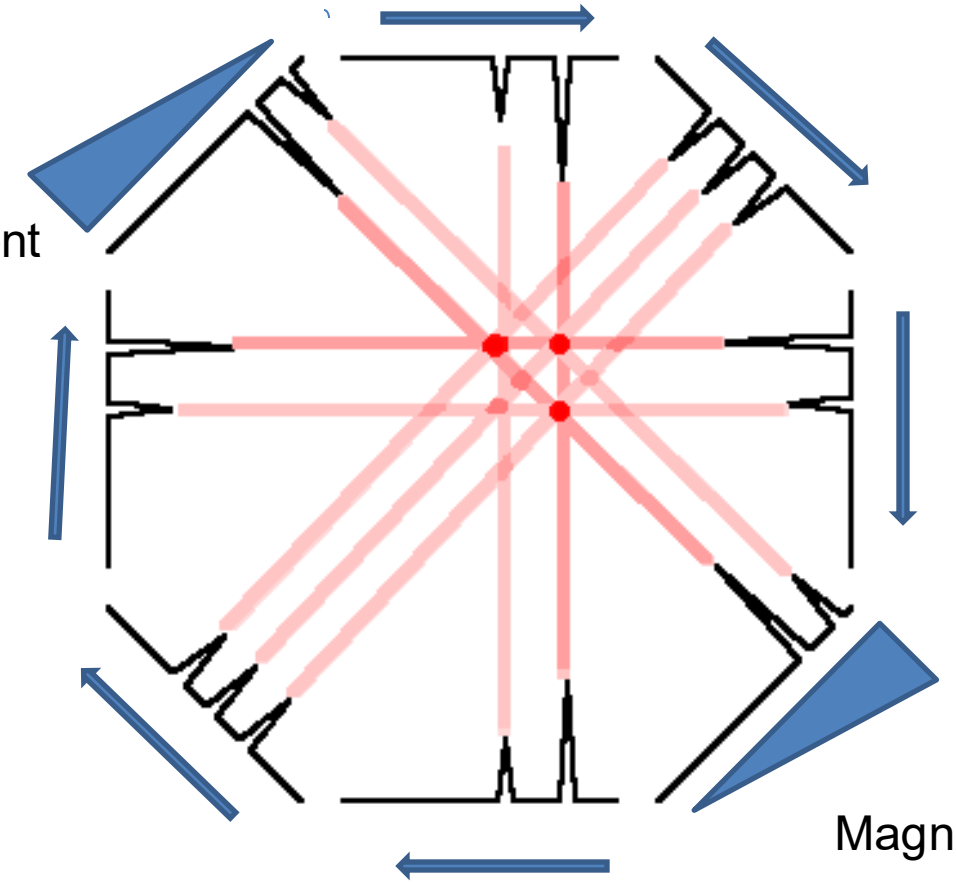
MR Physics



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

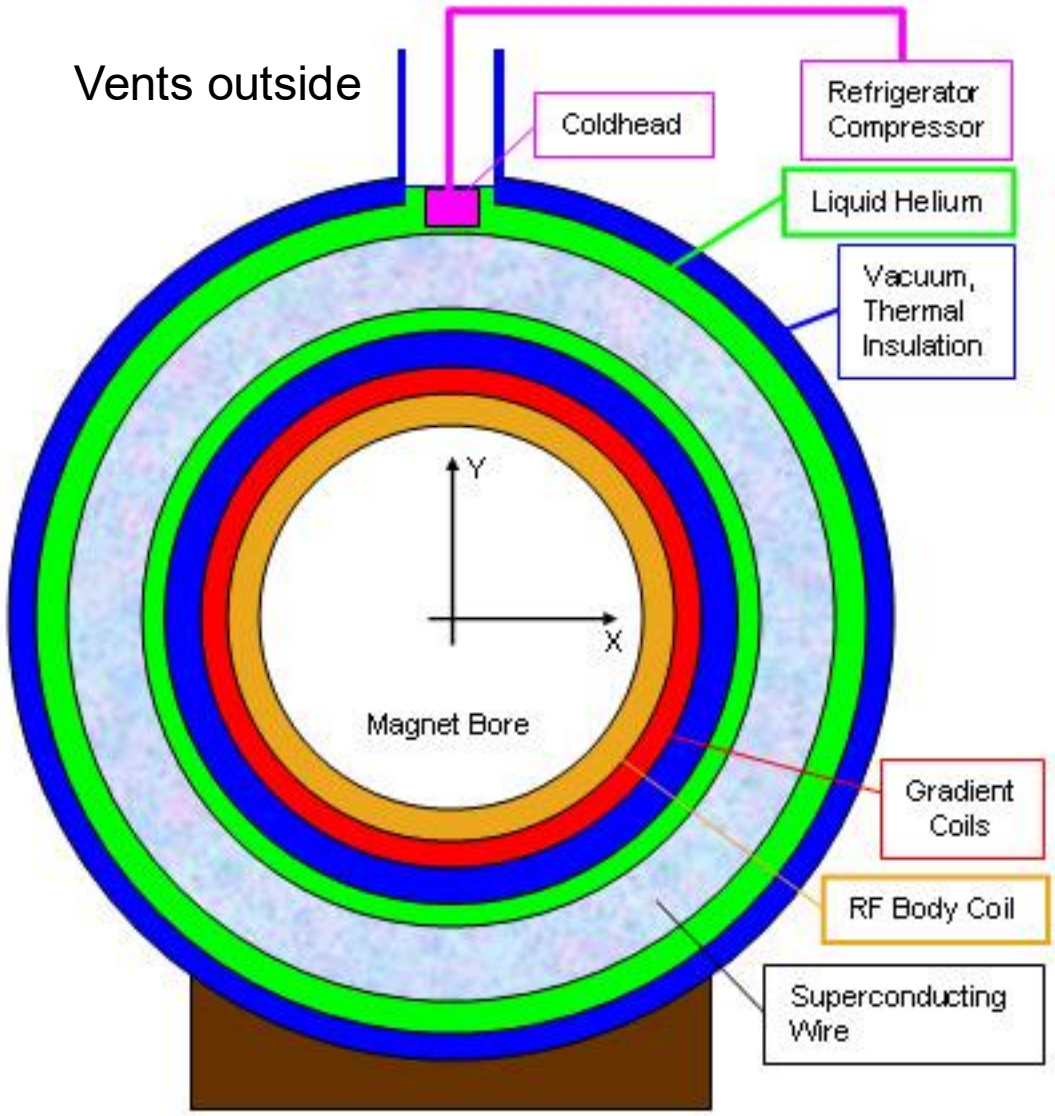


Magnetic Gradient



Magnetic Gradient

Anatomy of an MRI



MRI Advantages

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

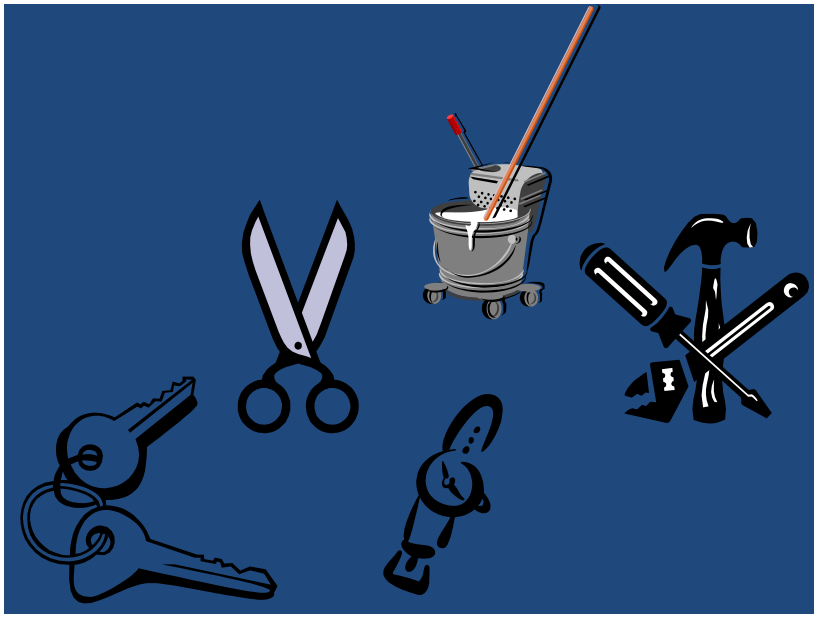
MR Disadvantages

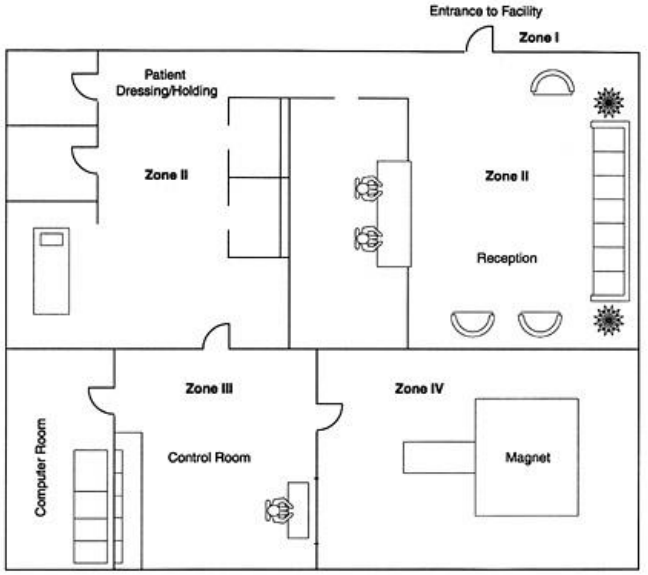
- Slower than CT
- More expensive
- Does not depict calcifications
- Safety issues
  - Metallic objects become projectiles
  - Incompatible with metallic implanted devices
    - Pacemakers
    - Cochlear implants
  - Quenching

Safety issues in MRI

MRI SAFETY

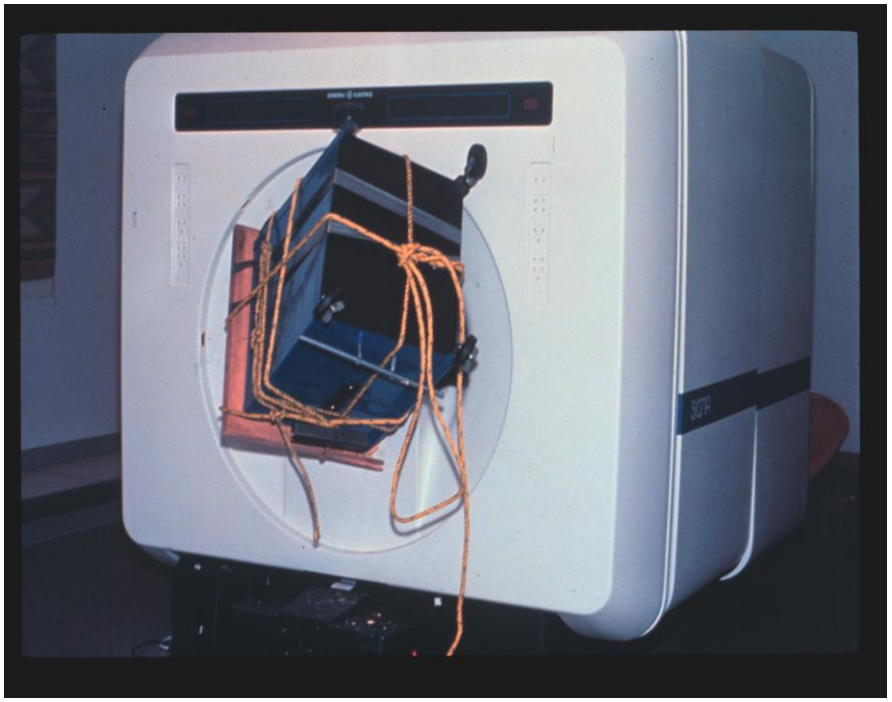
- MRI scanners are extremely powerful
- Objects that are attracted by the MRI magnetic field can reach 60 miles per hour.
- Metal objects used everyday (scissors, oxygen tanks, infusion pumps, etc) become projectiles
- MRI departments are divided into Zones for Safety





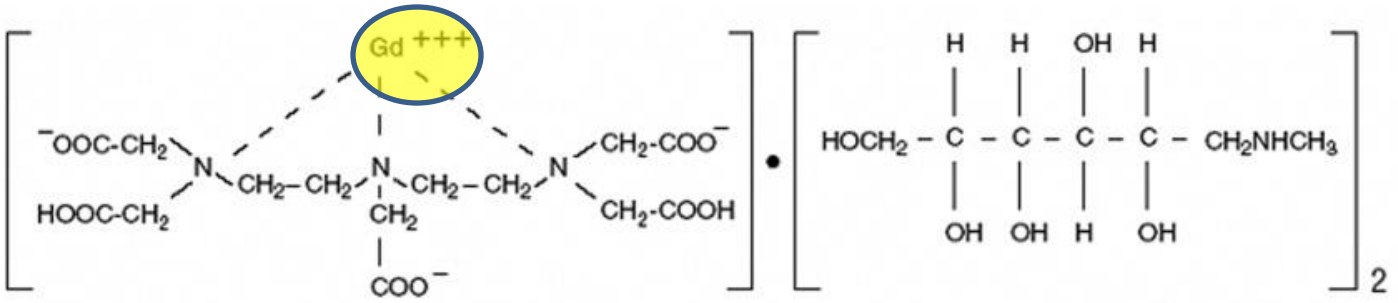
MRI SAFETY

-

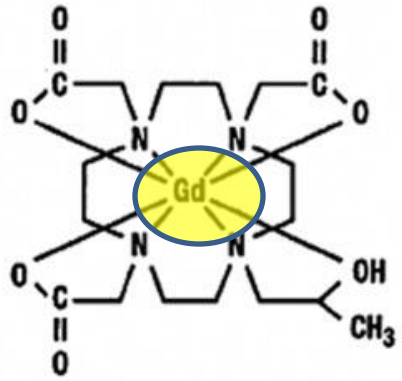


Value of Contrast Media

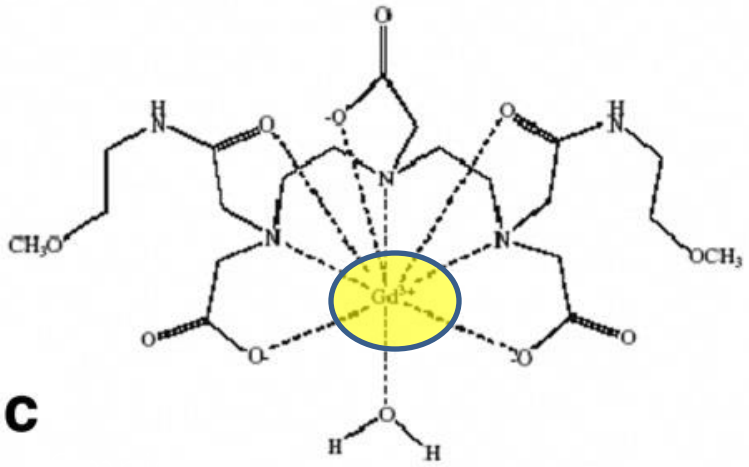
a


Gd +++
⁻OOC-CH₂
HOOC-CH₂
N
CH₂–CH₂
CH₂
CH₂-COO⁻
CH₂-COOH
COO⁻
HOCH₂
H
OH
C
CH₂NHCH₃
2

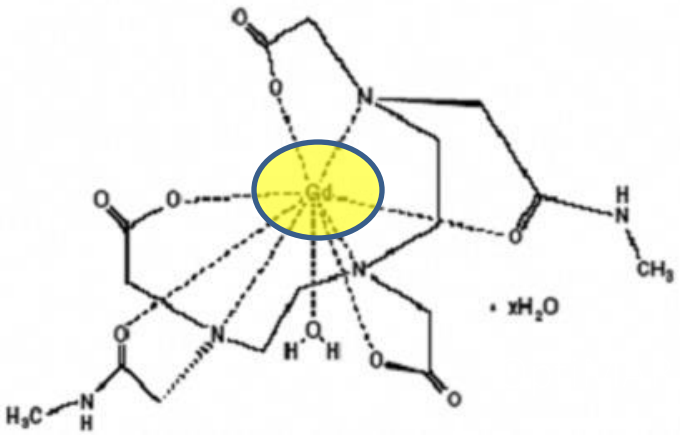
b


O
C
N
Gd
OH
CH₃

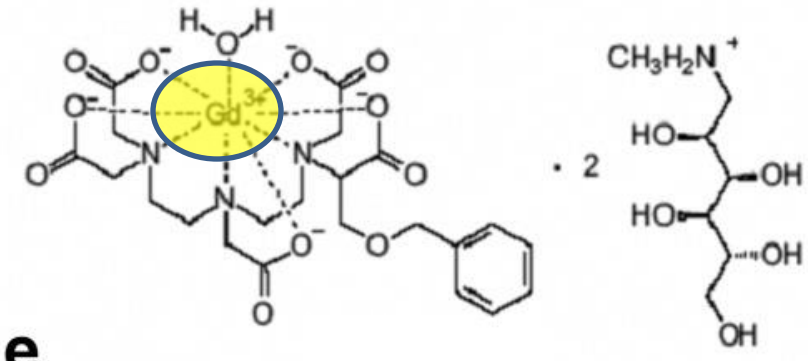
c


CH₃O
OCH₃
Gd³⁺
O
H

d


Gd
N
O
H
CH₃
H₃C
· xH₂O

e

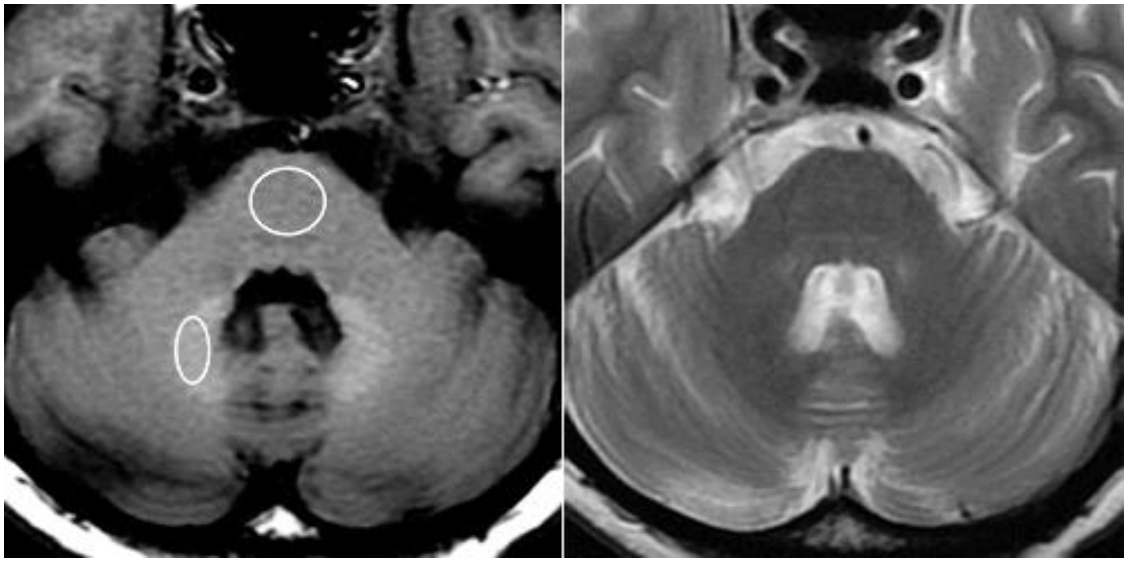

H
O
Gd³⁺
N
O
· 2
CH₃H₂N⁺
HO
OH

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!



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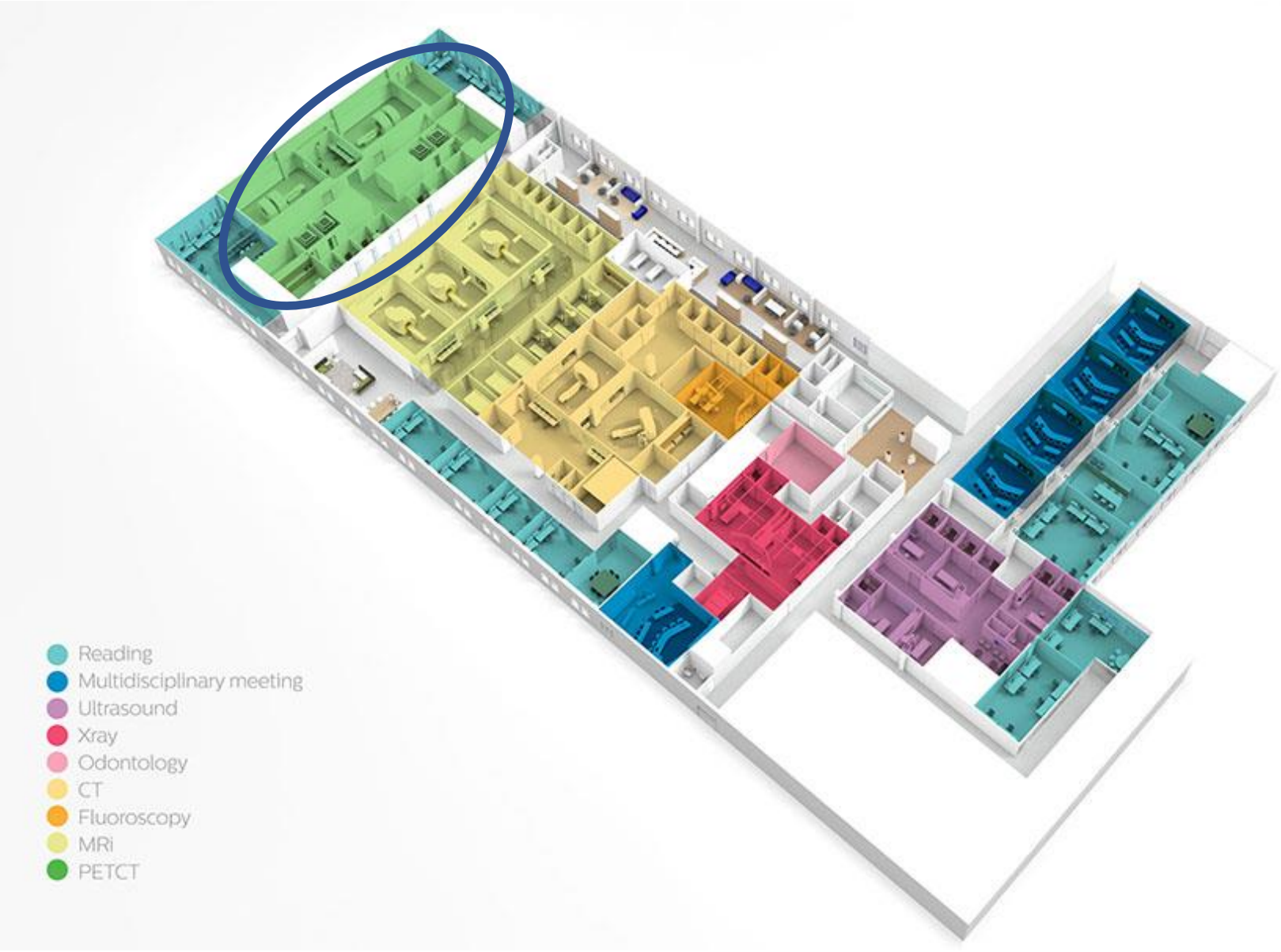
Update on our patient

- 67 year old with trauma to chest
- Pulmonary nodule confirmed
- Cystic lesion in the kidney
- Confirmed to be a cyst: no further workup required.
- Liver lesion is a benign hemangioma.
- What about that pulmonary nodule!!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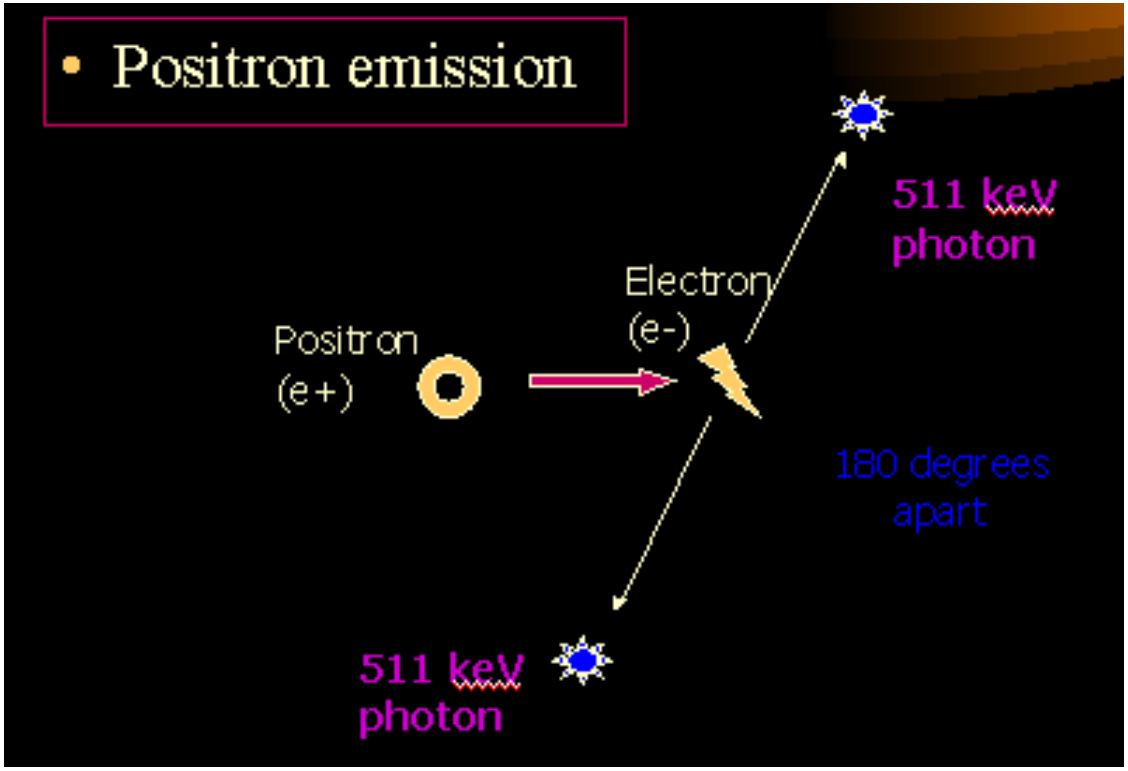
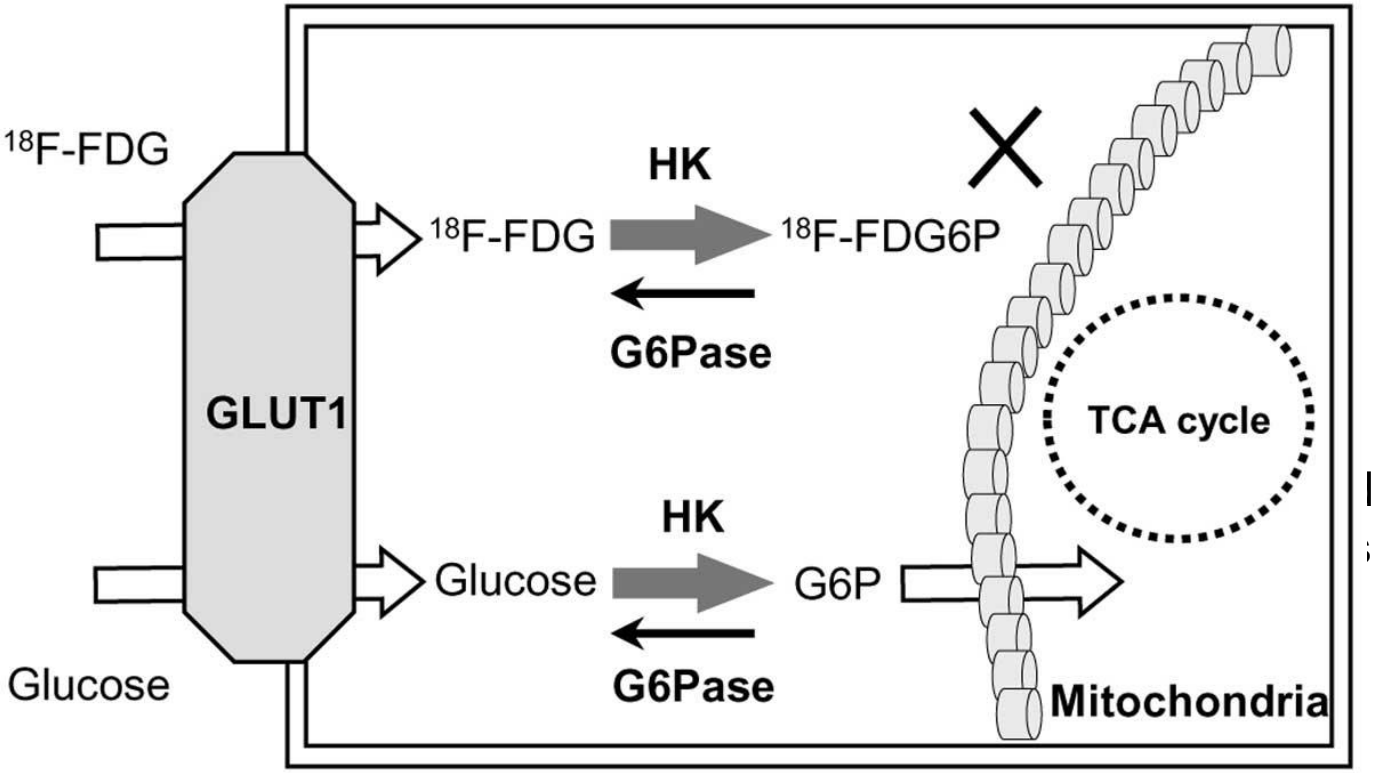
Positron Emission Tomography



F-18 Deoxyglucose

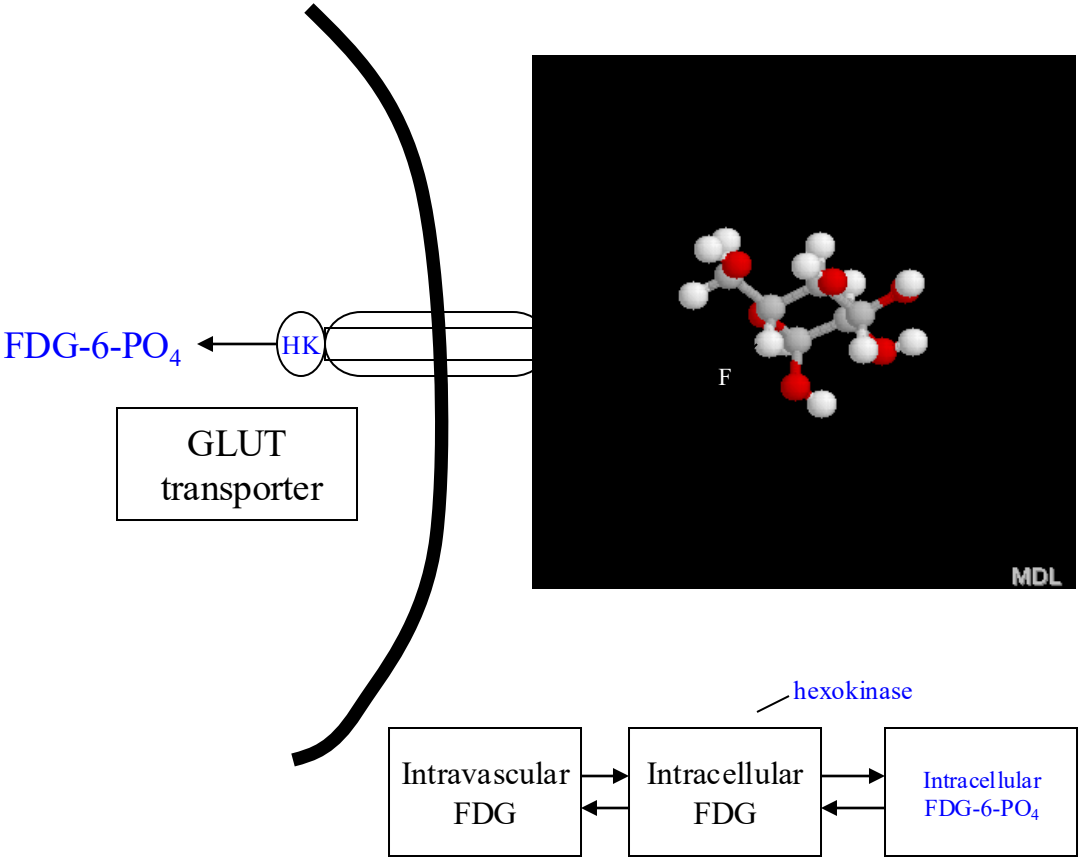
Otto Warburg

Lou Sokoloff

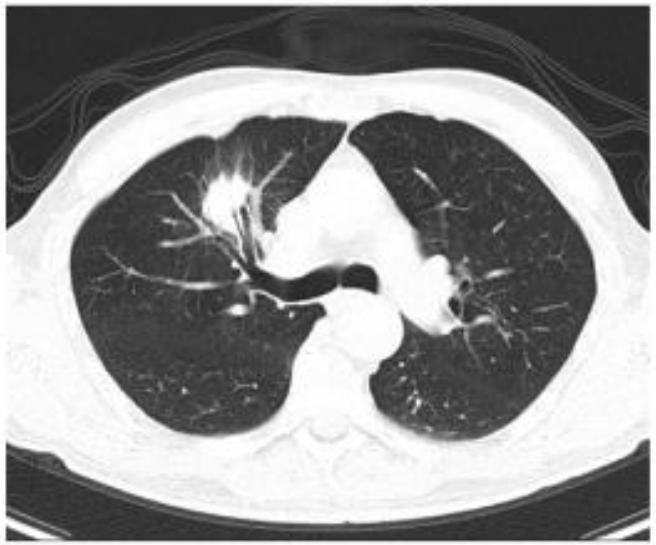


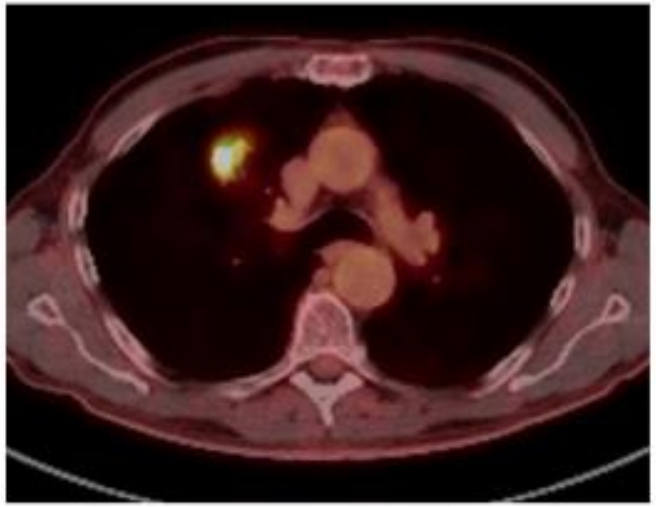
^{18}FDG PET Imaging

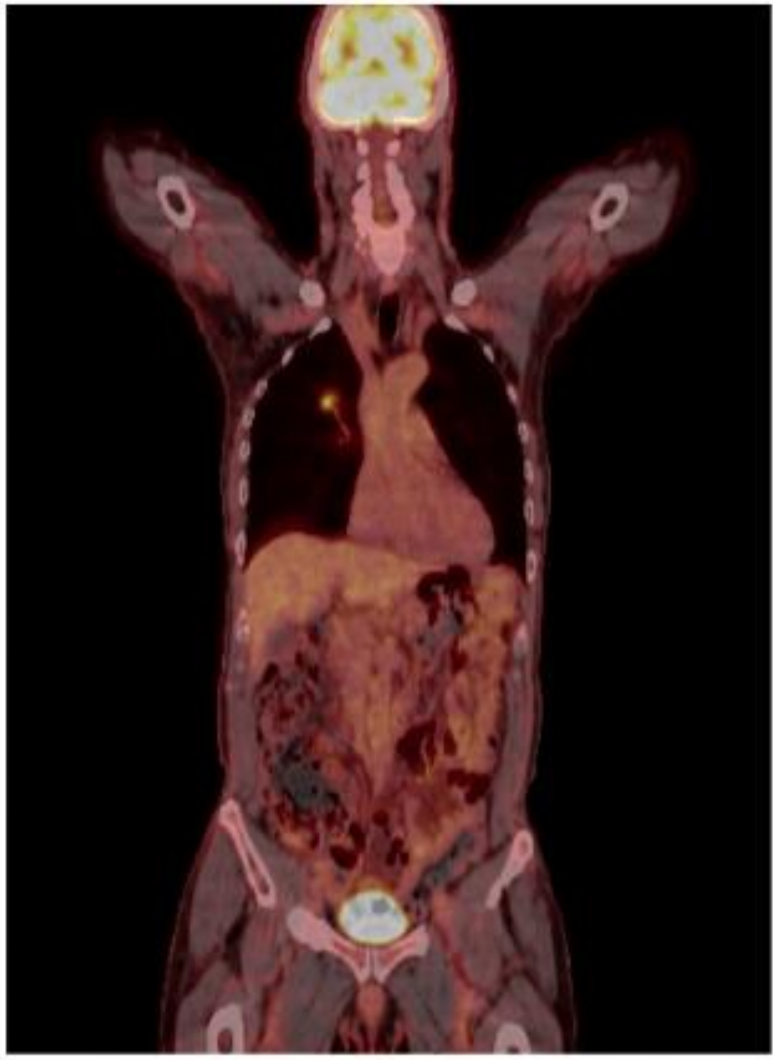
E PET MIP



Prostate Specific Membrane Antigen (PSMA) PET/CT







Notable other PET Agents

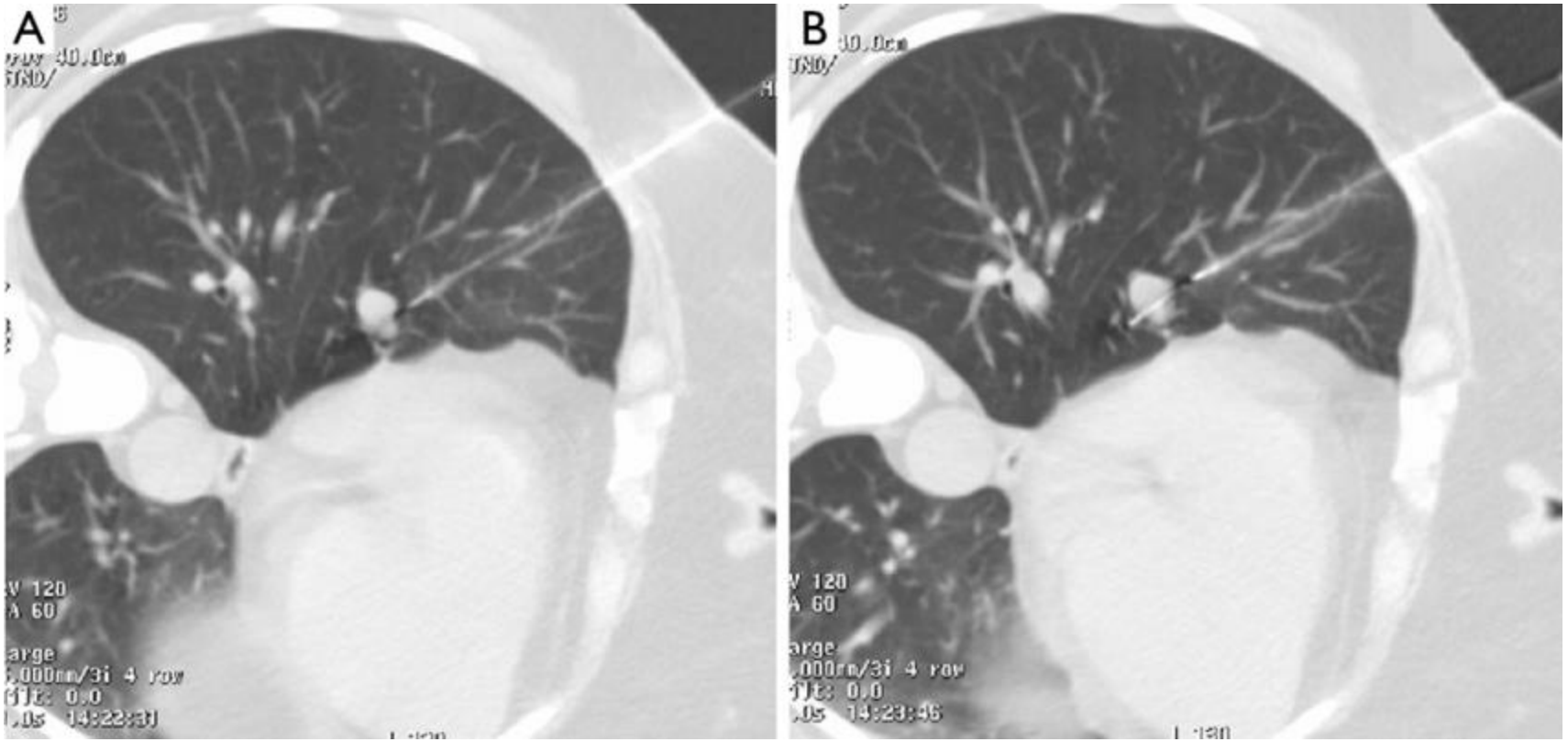
- Sodium Fluoride: Bone lesions
- Fluoroestadiol: Estrogen receptor
- Fluorocholine: Membrane Turnover
- Fluoromisonidozole: Hypoxia
- Florbetaben: Amyloid (Alzheimers)
- Zirconium Herceptin: labeled antibody
- Zirconium Oxine: Cell labeling

PET:Advantages and Disadvantages

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

Interventional Radiology (IR)

Percutaneous Biopsy (IR)



Update on our patient

- 67 year old with trauma to chest
- Pulmonary nodule confirmed
- PSMA positive on PET: likely metastatic prostate cancer but it’s the only lesion seen.
- Choices for patient:
  - Stereotactic Radiation
  - Surgical Resection
  - Lu-177 PSMA radionuclide therapy

Lessons from our virtual patient

- Modern imaging can address solve many issues
- By detecting incidental findings it can also generate 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 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:

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