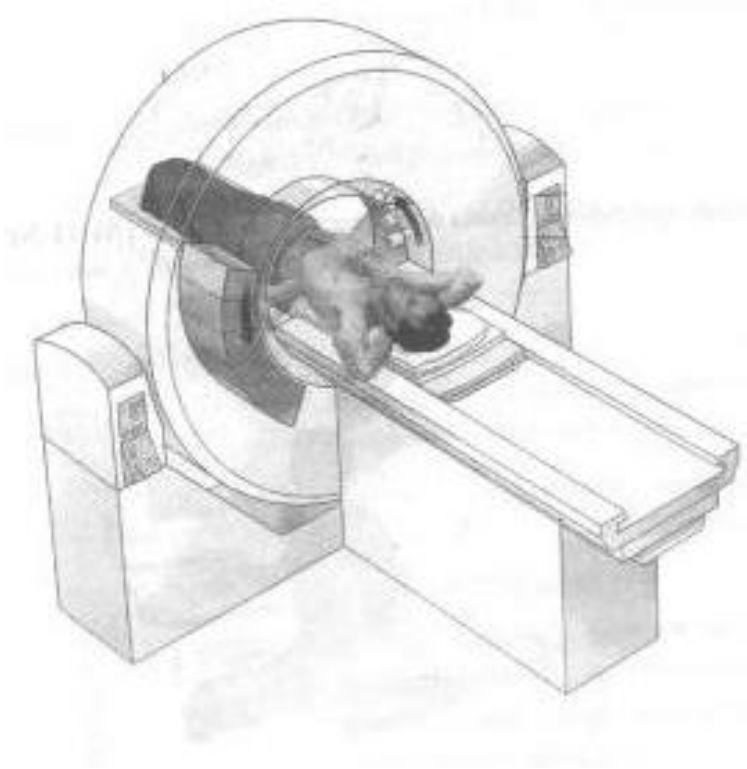
Module 11b:
3D Acquisition Systems

Computed Tomography (CT)

CT Images

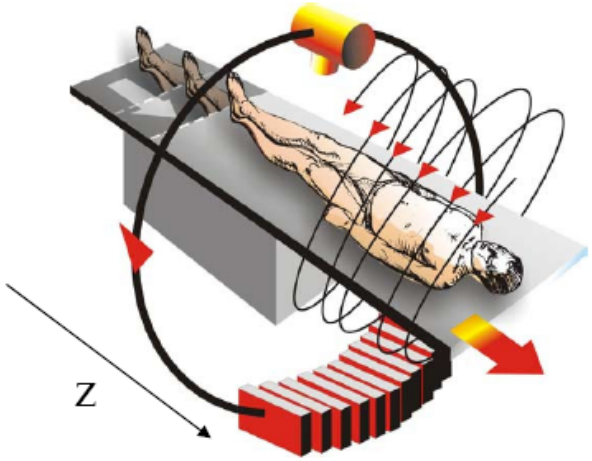
Computed Tomography

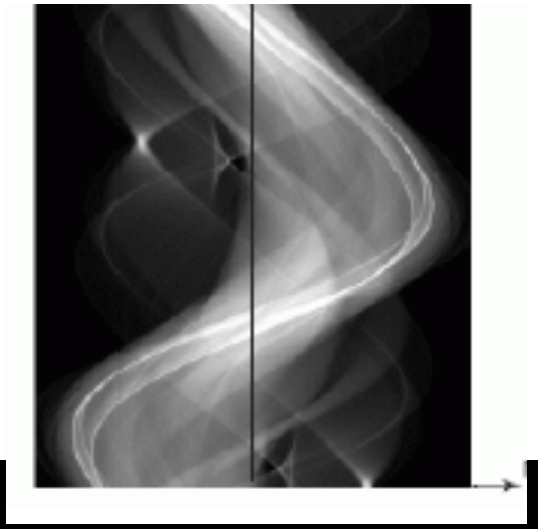
- Advance table with patient after each slice acquisition has been completed
- Rotate source detector pair around the patient



CT – How it works?

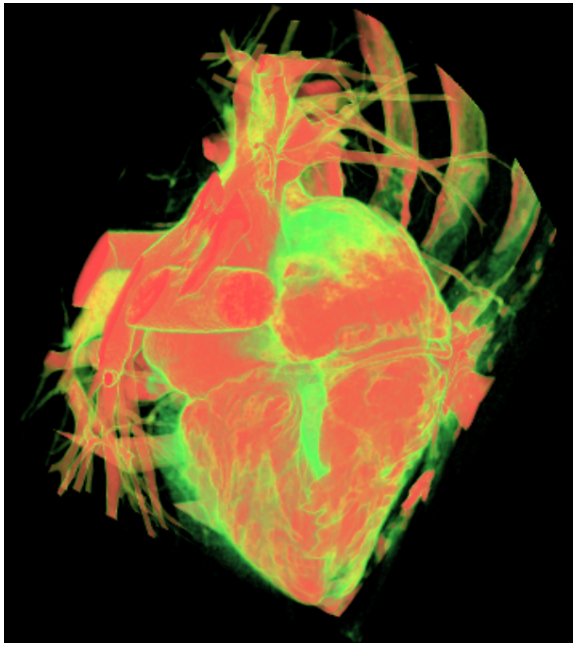
- Rotate source detector pair around the patient
- For each angle
  - Get a sinogram
  - Back-project data
  - Construct slice
- Math and physics more complicated than X-ray





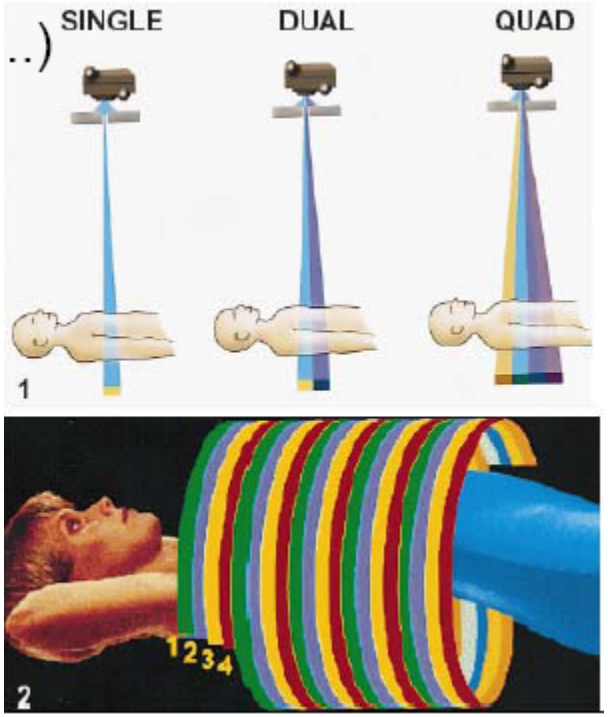
CT - Applications

- Applications of CT
  - head/neck (brain, maxillofacial, inner ear, soft tissues of the neck)
  - thorax (lungs, chest wall, heart and great vessels)
  - urogenital tract (kidneys, adrenals, bladder, prostate, female genitals)
  - abdomen(gastrointestinal tract, liver, pancreas, spleen)
  - musceloskeletal system

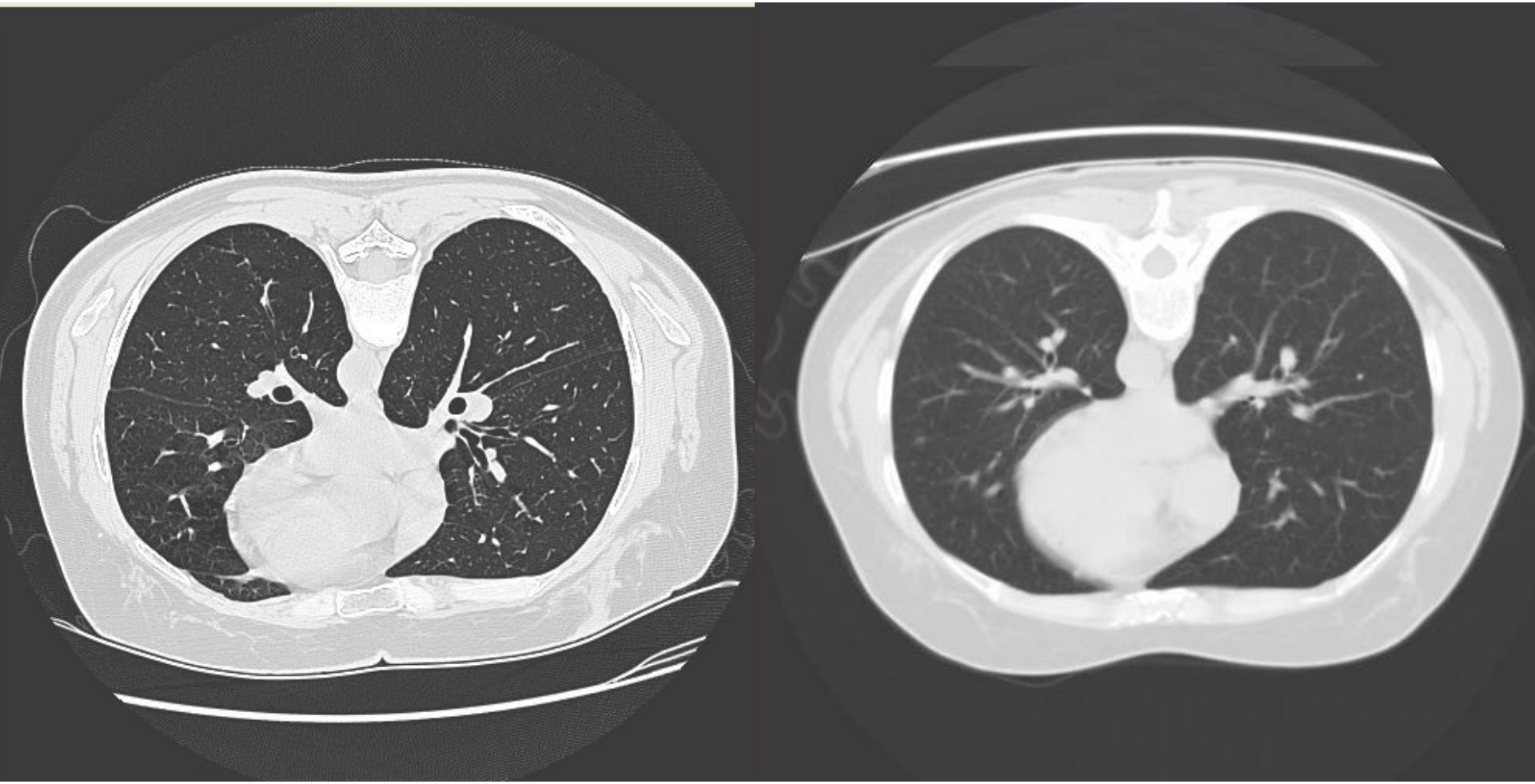


What's new?

- Nowadays (spiral) scanners are available that take up to 64 simultaneous slices
- Much More…
  - High-resolution CT
  - Low-dose CT



High-Resolution CT



High-Resolution CT

Regular CT

Summary of CT

- Images of sectional planes (tomography) are harder to interpret
- CT can visualize small density differences, e.g. grey matter, white matter, and CSF.
- CT can detect and diagnose disease that cannot be seen with X-ray.
- More expensive than X-ray.
- Ionizing radiation (can cause cancer).

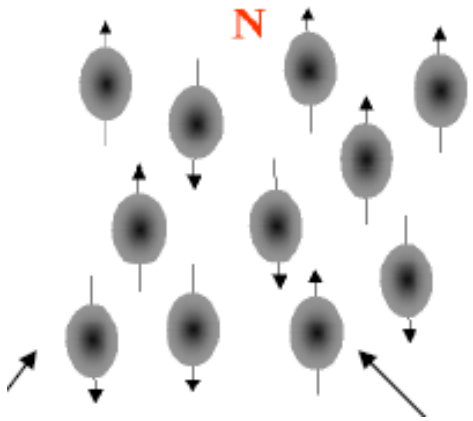
MRI

Magnetic Resonance Imaging/ Tomography

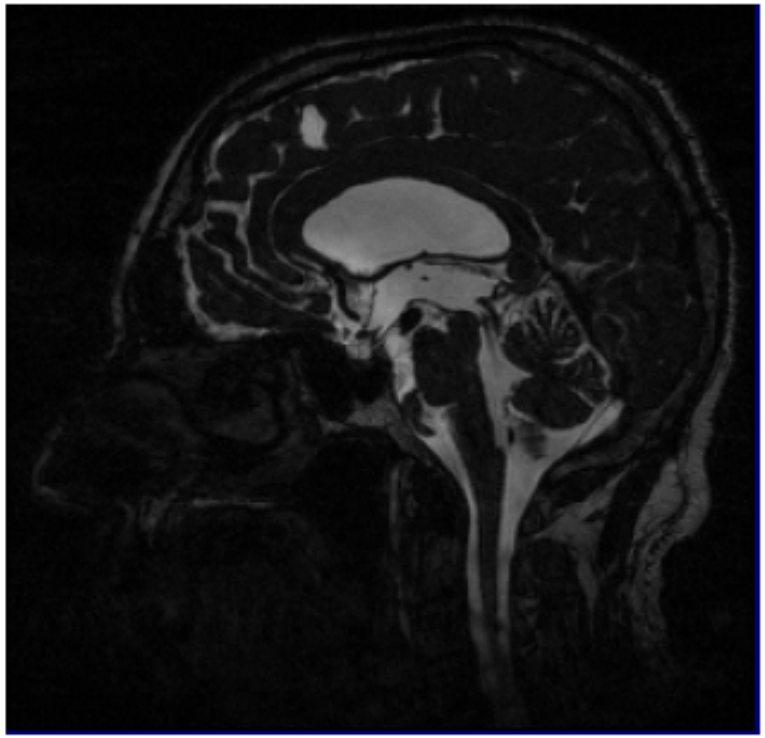
- MRI measures magnetic field
- 3D volume is reconstructed from measured proton
- Relatively slow image acquisition
- Noisy
- First human study published in 1977

MRI Image Formation

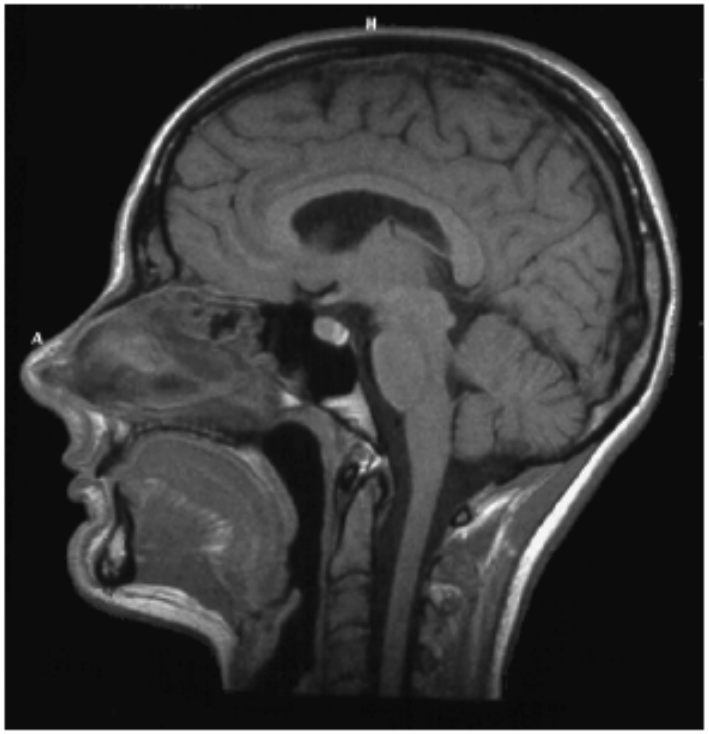
- The hydrogen atom has only one proton
- Protons are magnetic
- In a magnetic field, spin-up and spin-down protons have different energies
- Radio wave photons can flip the proton spins
- By controlling the energy differences between spin-up and spin-down and adjusting the radio waves, you can locate hydrogen in a person



Example – MRI Images



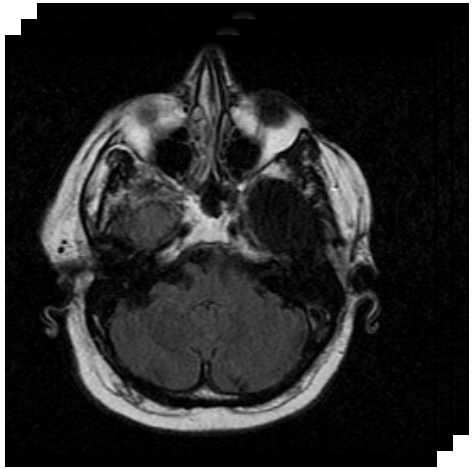
T2-weighted MRI-Image
(3D-CISS)



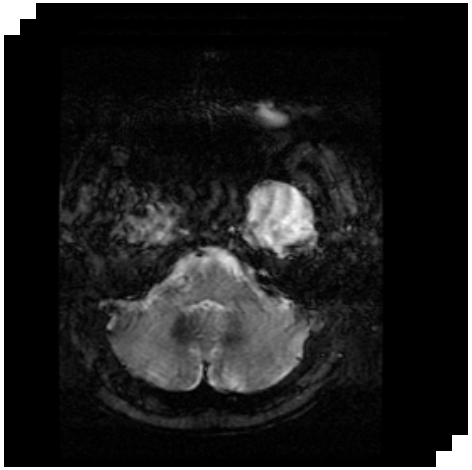
T1-weighted MRI-Image
(MR-Flash)

Sagittal Orientation

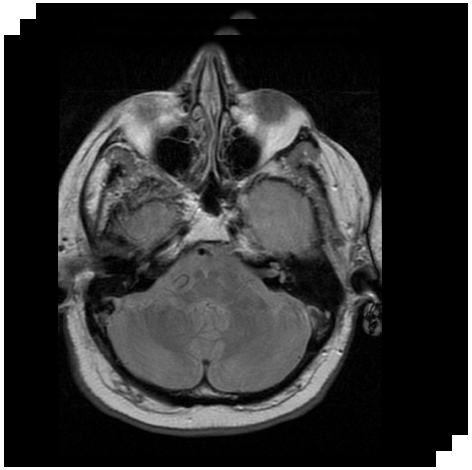
Multimodal Images



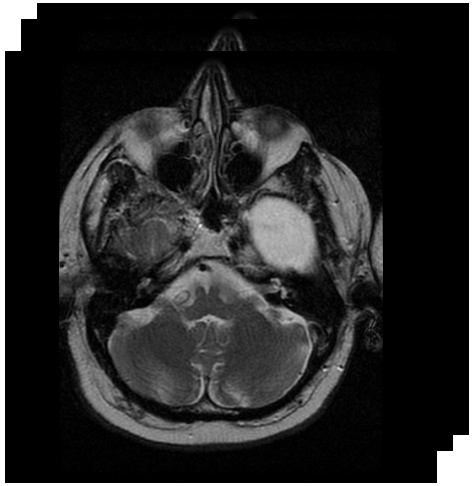
FLAIR



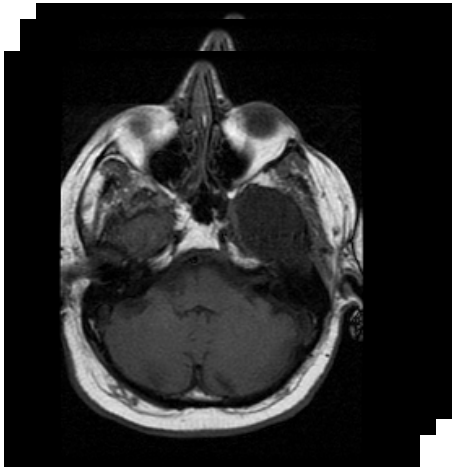
GRE



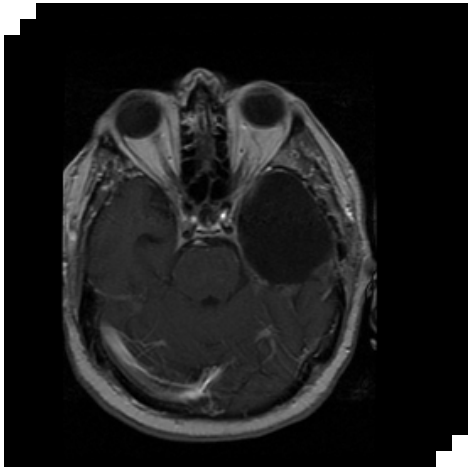
T2



T2 FSE



T1



T1C+

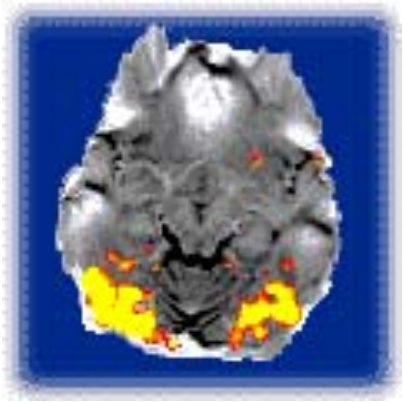
Features of MRI

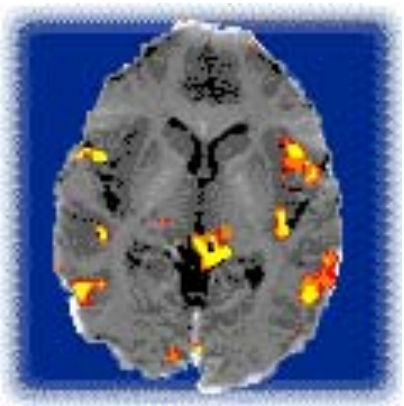
- No ionizing radiation – expected to not have any long-term or short-term harmful effects
- Many contrast mechanisms: contrast between tissues is determined by pulse sequences
- Can produce sectional as well as projection images.
- Slower and more expensive than X-ray
- Many imaging modes (water, T1, T2, flow, neural activity)
- Tomography at arbitrary angle

Others Imaging Techniques

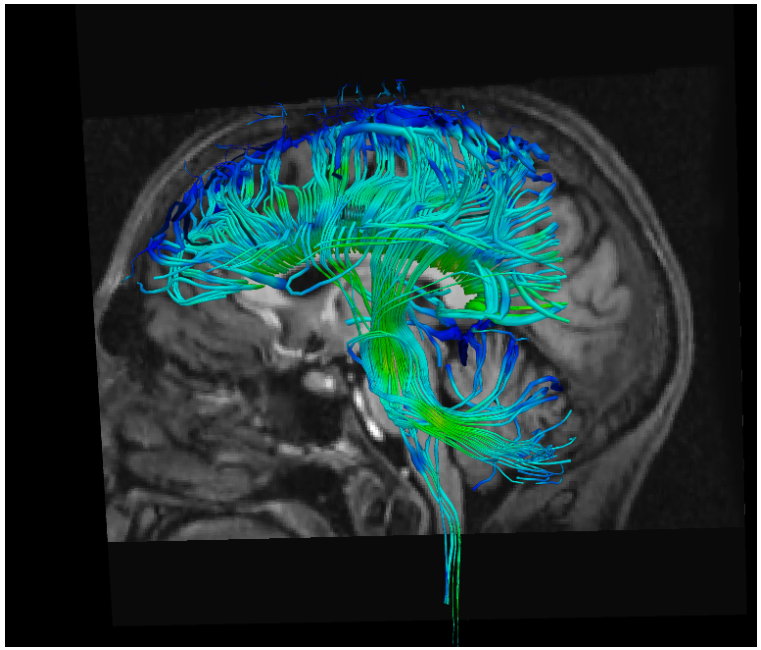
- fMRI: displays neural activity in the brain
- Dynamic MRI: good for mammography
- DT-MRI
- Multi-slice CT
- Low-dose CT
- Nuclear Imaging
- PET

Example of Other Imaging Techniques

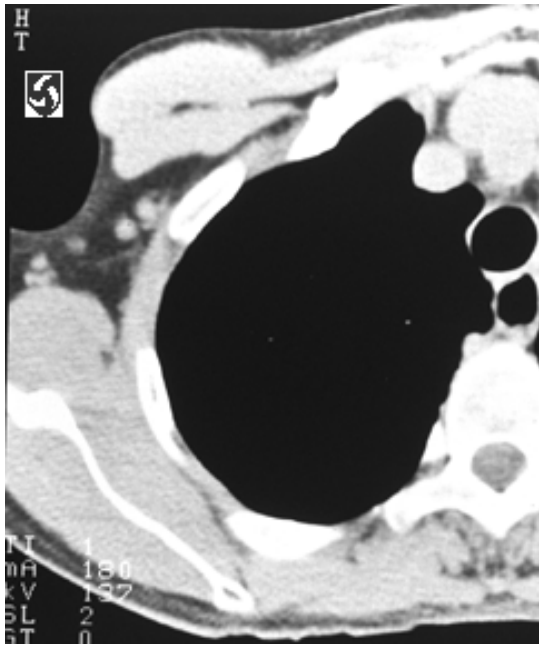




fMRI



DT-MRI



Low-dose CT

Conclusion: Medical Imaging

- Acquisition
  - CT
  - MRI
  - X-Ray
- Image/Volume formation