Computed Tomography (CT) Scan

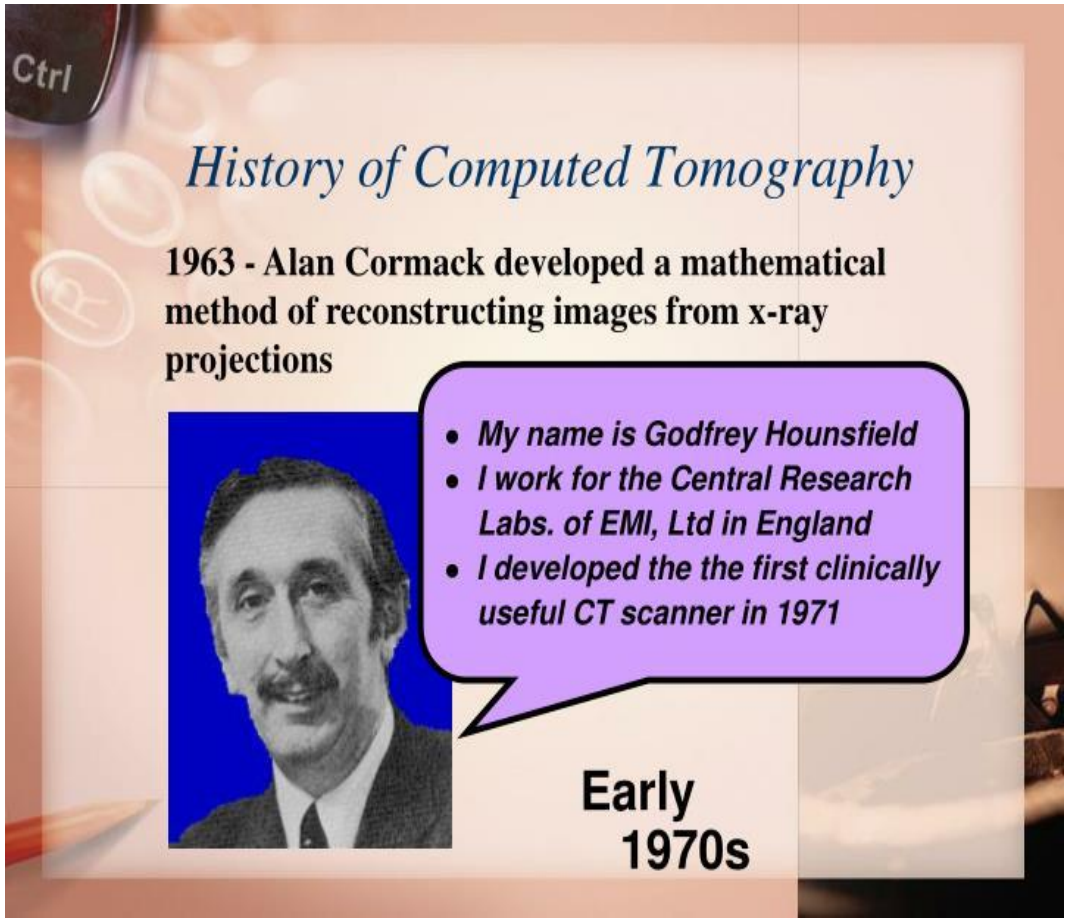
What is a computed tomography (CT) scan?

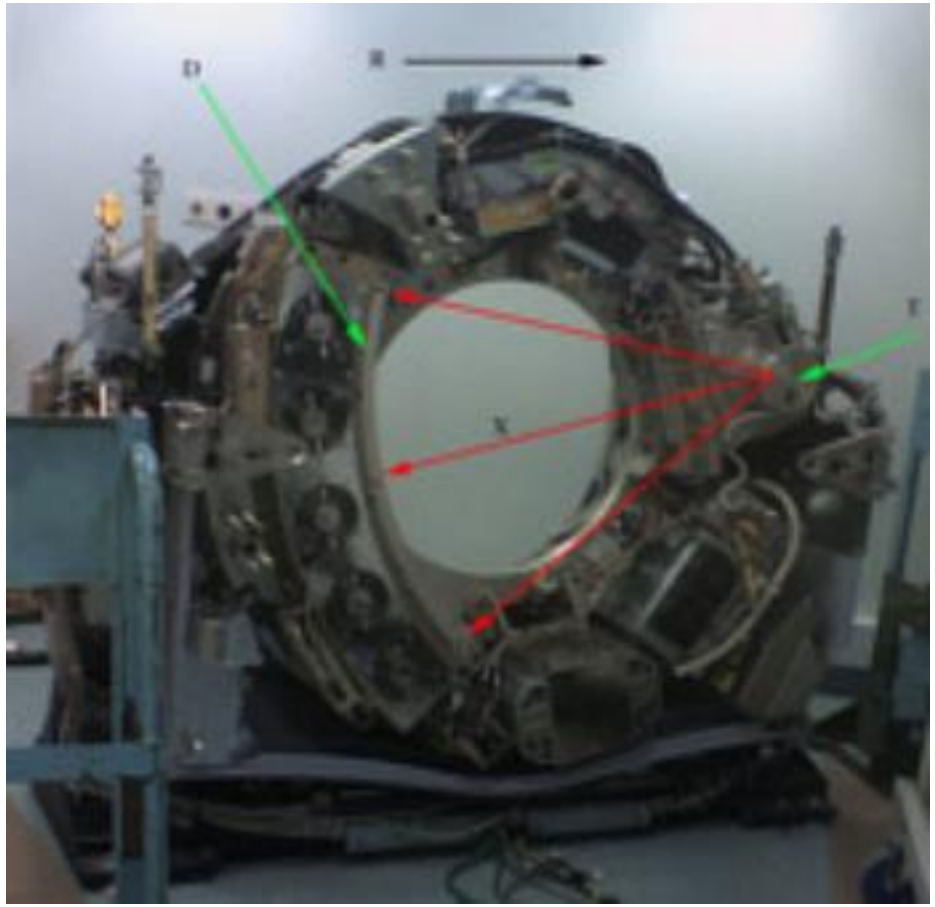
- It refers to a computerized x-ray imaging procedure in which a narrow beam of x-rays is aimed at a patient and quickly rotated around the body, producing signals that are processed by the computer to generate cross-sectional images, or “slices.”

- These slices are called tomographic images and can give a clinician more detailed information than conventional x-rays.

Computed Tomography (CT) Scan

- Once a number of successive slices are collected by the machine's computer, they can be digitally "stacked" together to form a three-dimensional (3D) image of the patient that allows for easier identification of basic structures as well as possible tumors or abnormalities.

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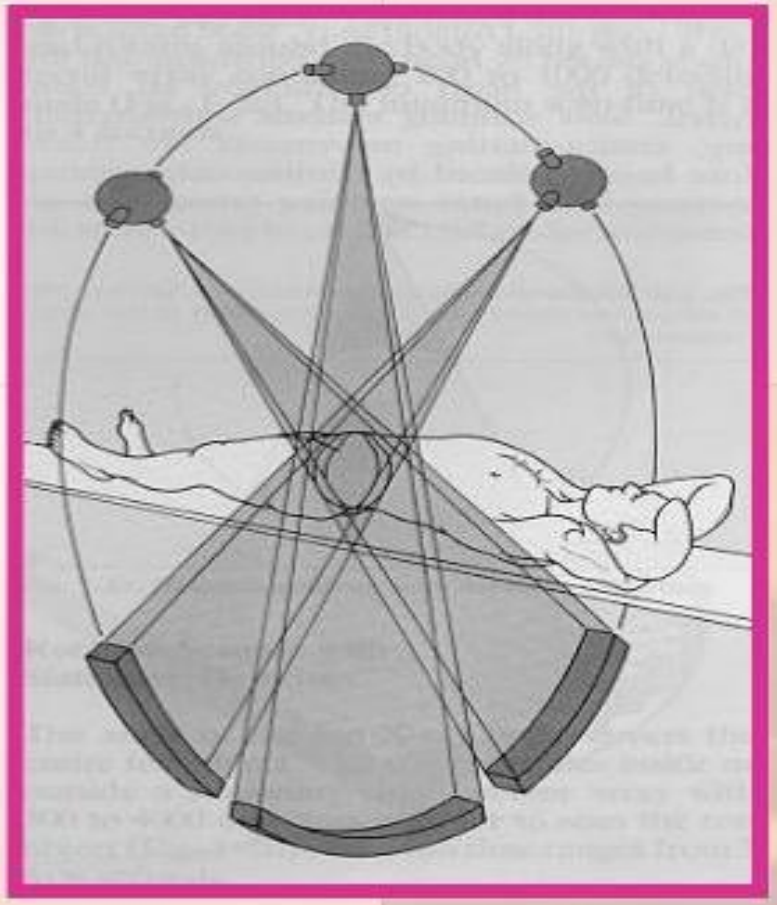
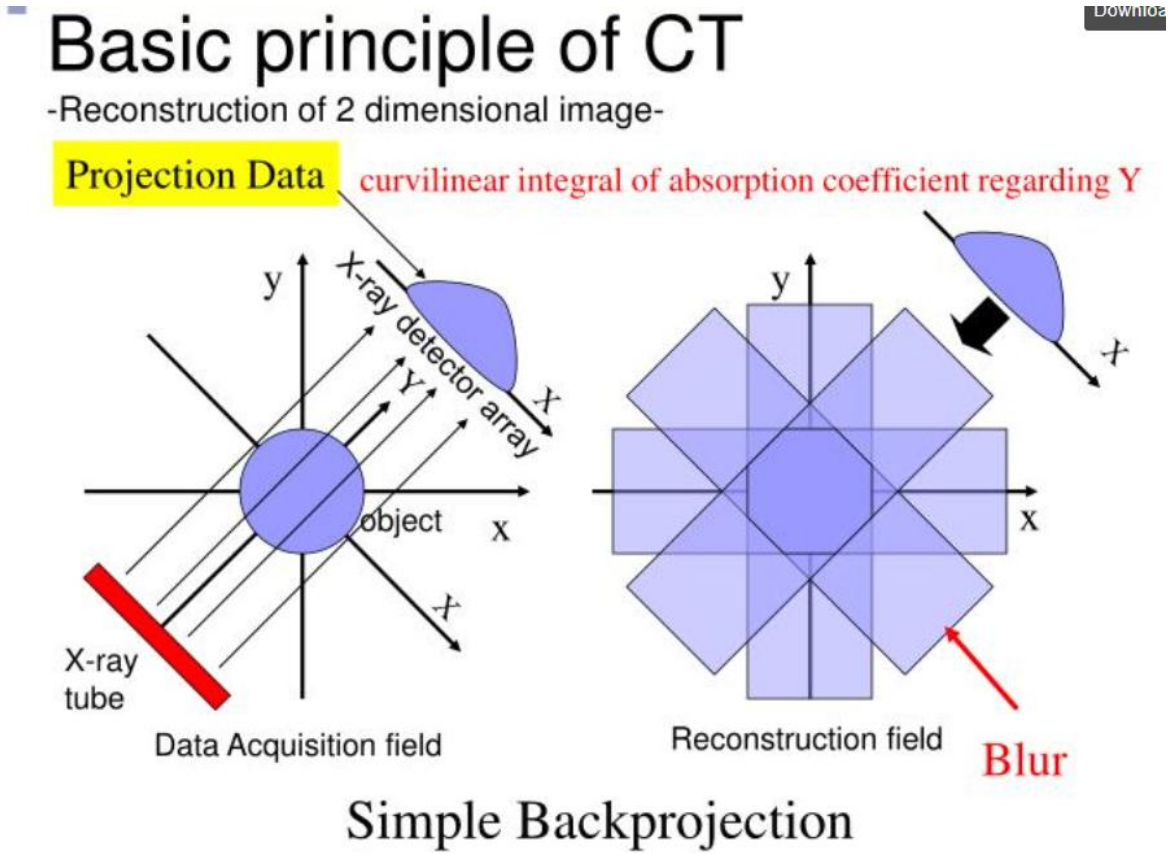
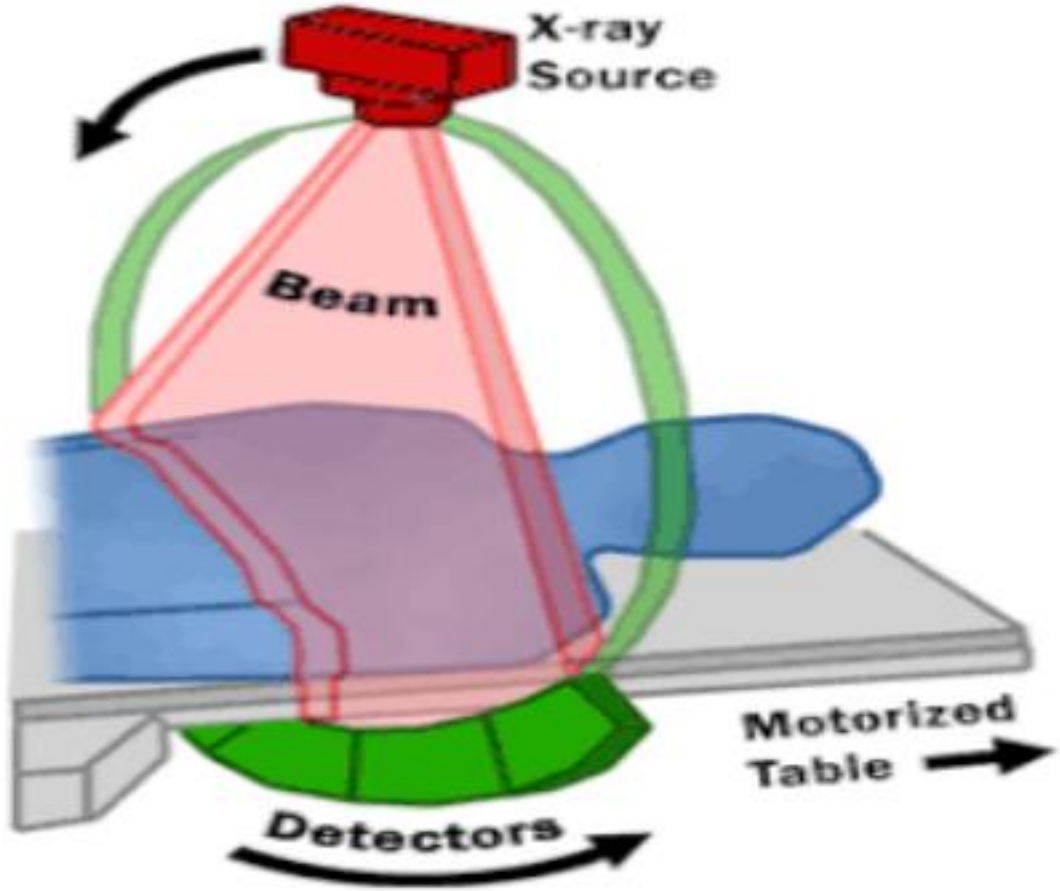
How does CT Work?

- Patient is placed in the center of the measurement field
- X-ray is passed through the patient's slice from many direction along a 360° path
- The transmitted beams are captured by the detectors which digitizes these signals
- These digitized signals called raw data are sent to a computer which create the CT image



Drawing of CT fan beam and patient in a CT imaging system





- Each time the x-ray source completes one full rotation, the CT computer uses sophisticated mathematical techniques to construct a 2-D image slice of the patient.

- The thickness of the tissue represented in each image slice can vary depending on the CT machine used, but usually ranges from 1-10 millimeters.

- When a full slice is completed, the image is stored and the motorized bed is moved forward incrementally into the gantry.

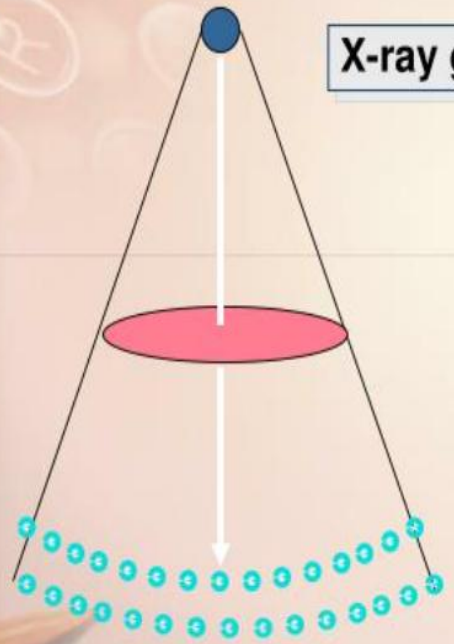
- The x-ray scanning process is continues until the desired number of slices is collected.

How does CT Work?

X-ray generation

Data acquisition

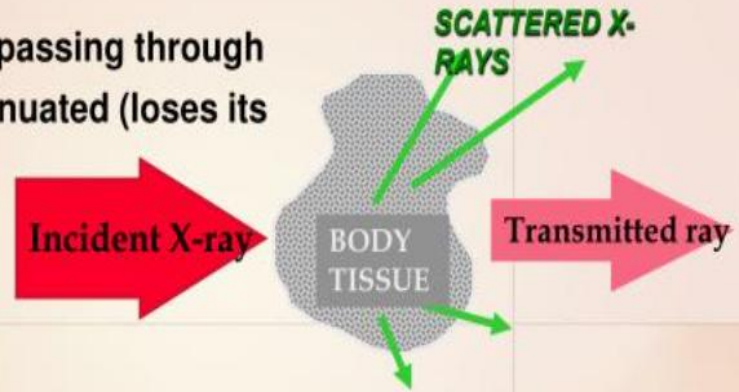
Recon. & postpro.



Concept of X-ray Attenuation

An X-ray beam passing through the body is attenuated (loses its energy) by :

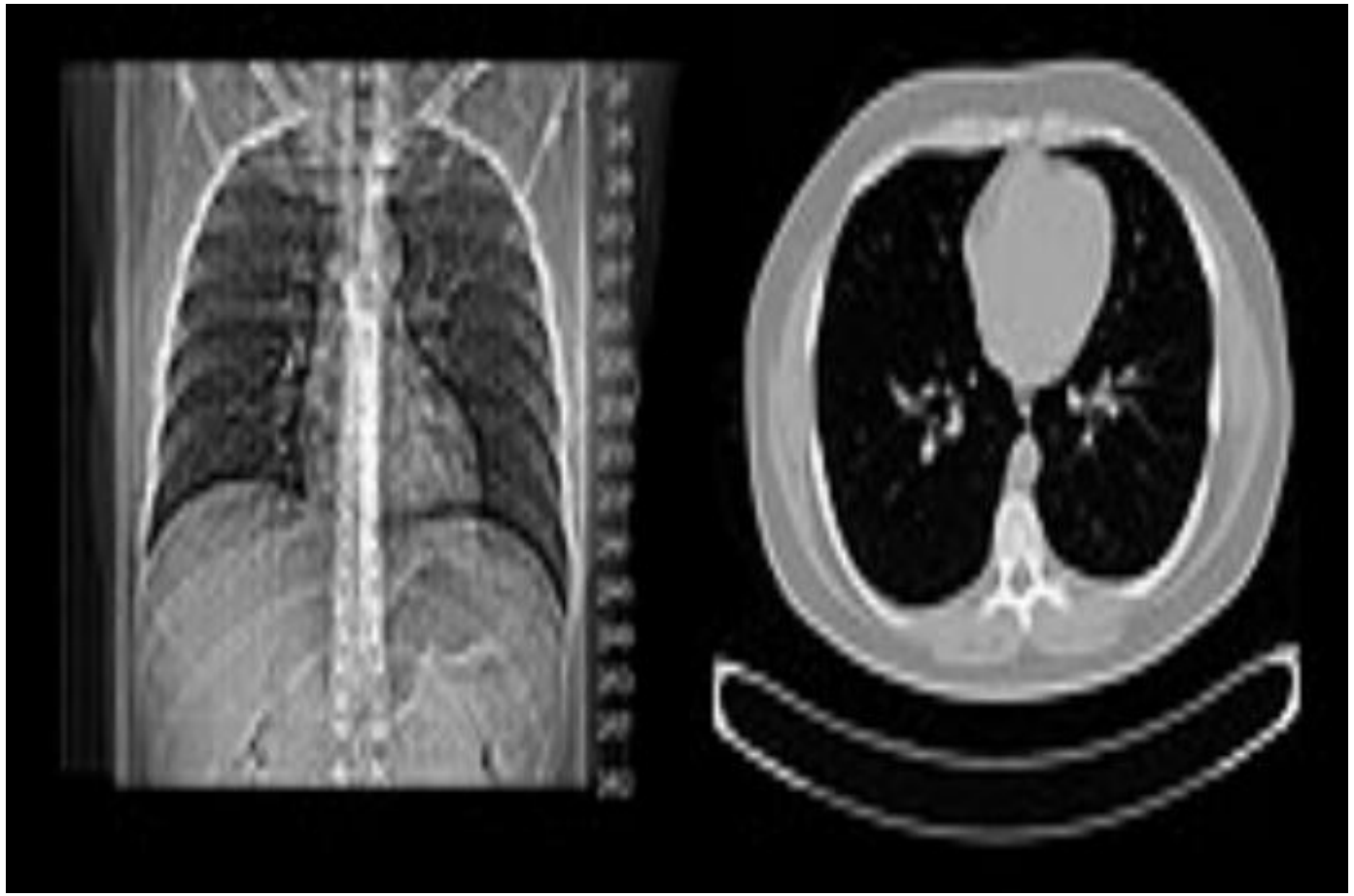
- Absorption
- Scattering



Absorption by the tissue is proportional to the density

MORE ATTENUATION

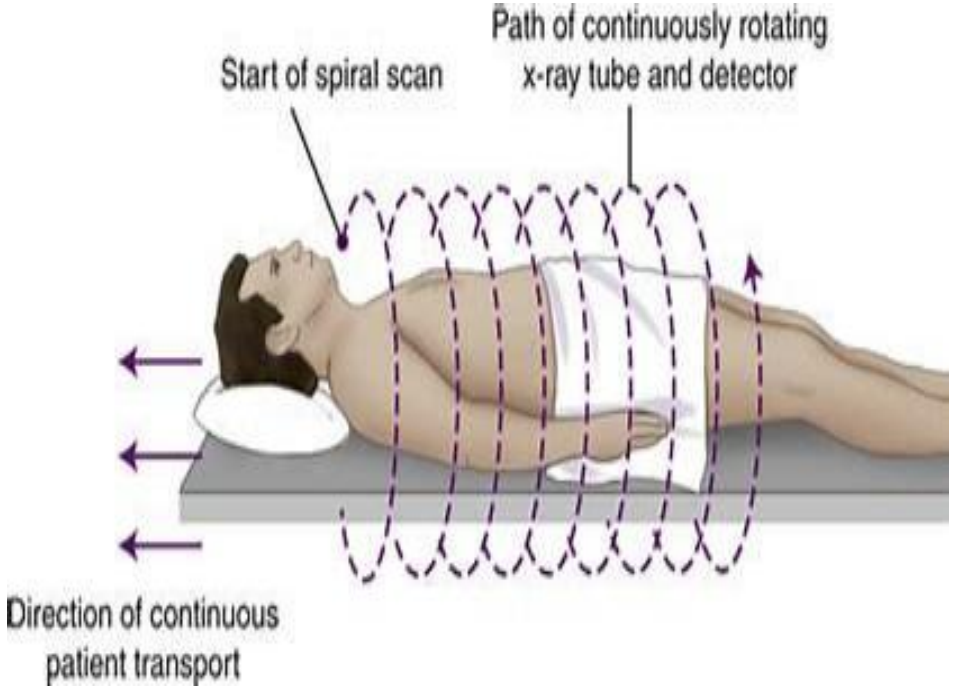
LESS ATTENUATION



CT scan of brain tumor

- CT scan of the thorax. The axial slice (right) is the image that corespondents to number 33 (left).

- Helical (Spiral) CT is a vast improvement over conventional CT scans. The patient lies on an exam table that passes through a doughnut-shaped scanner, while an X-ray tube rotates around the table.
- This movement results in a spiral shaped continuous data set without any gaps.



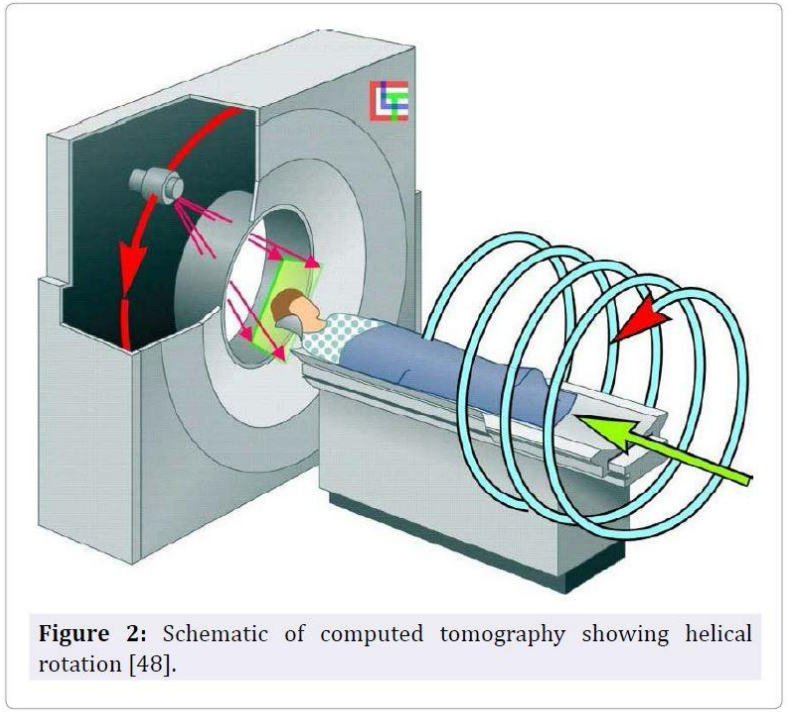
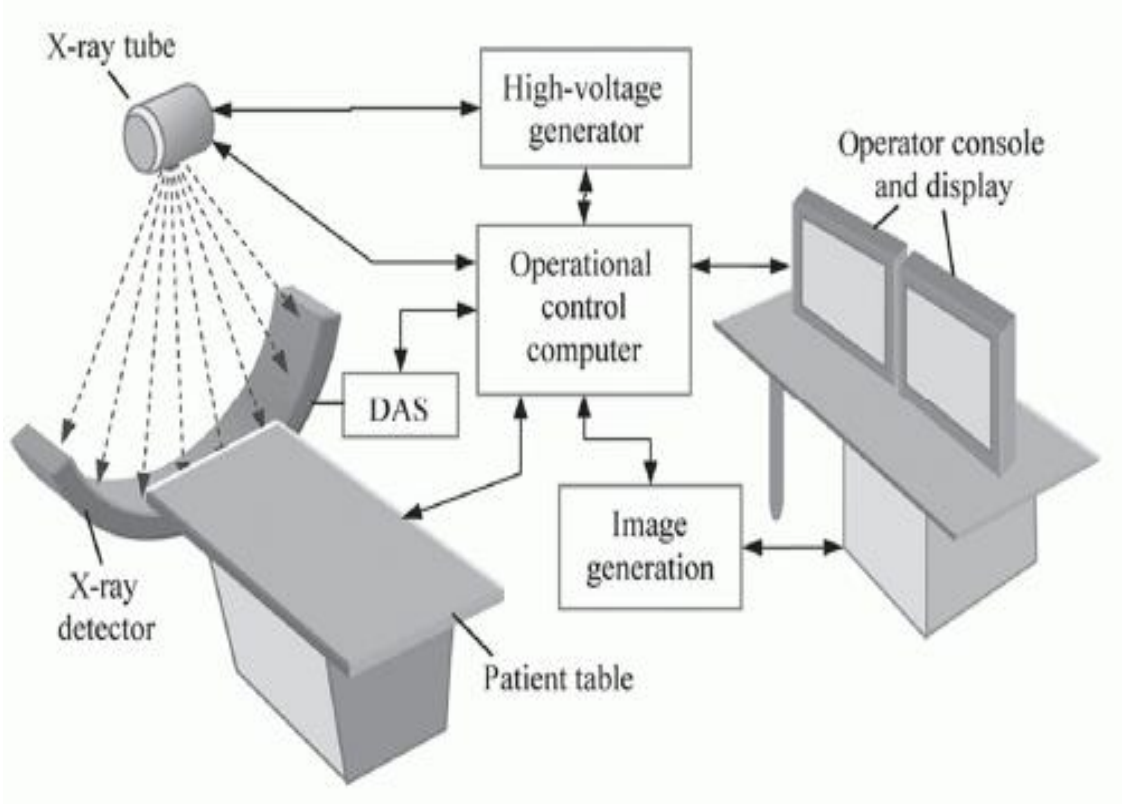
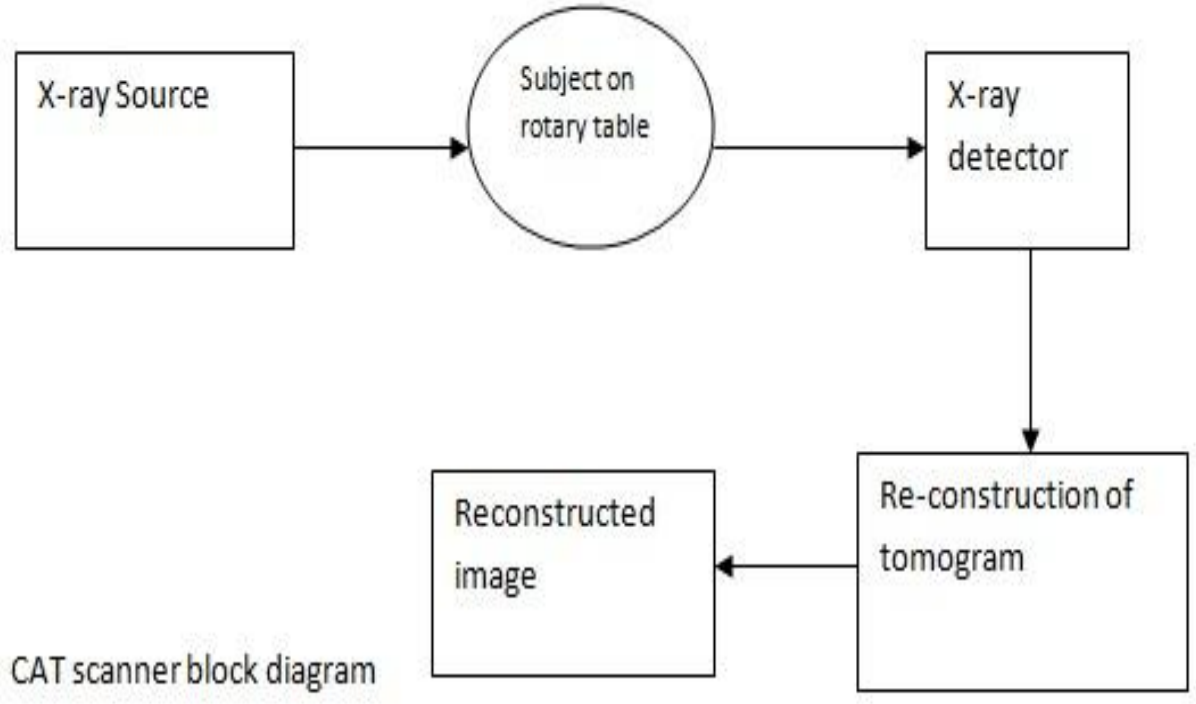


Figure 2: Schematic of computed tomography showing helical rotation [48].





Block diagram of CT scan

- Image slices can either be displayed individually or stacked together by the computer to generate a 3D image of the patient that shows the skeleton, organs, and tissues as well as any abnormalities the physician is trying to identify.

- Aadvantages: including the ability to rotate the 3D image in space or to view slices in succession, making it easier to find the exact place where a problem may be located.

When would I get a CT scan?

- CT scans can be used to identify disease or injury within various regions of the body.
- For example: Detecting possible tumors or lesions within the abdomen.

- A CT scan of the heart may be ordered when various types of heart disease

- A CT can also be used to image the head in order to locate injuries, tumors, clots leading to stroke, hemorrhage, and other conditions.

- It can image the lungs in order to reveal the presence of tumors, pulmonary embolisms (blood clots), excess fluid, and pneumonia.

- A CT scan is particularly useful when imaging complex bone fractures, severely eroded joints, or bone tumors since it usually produces more detail than would be possible with a conventional x-ray.

CT number scale

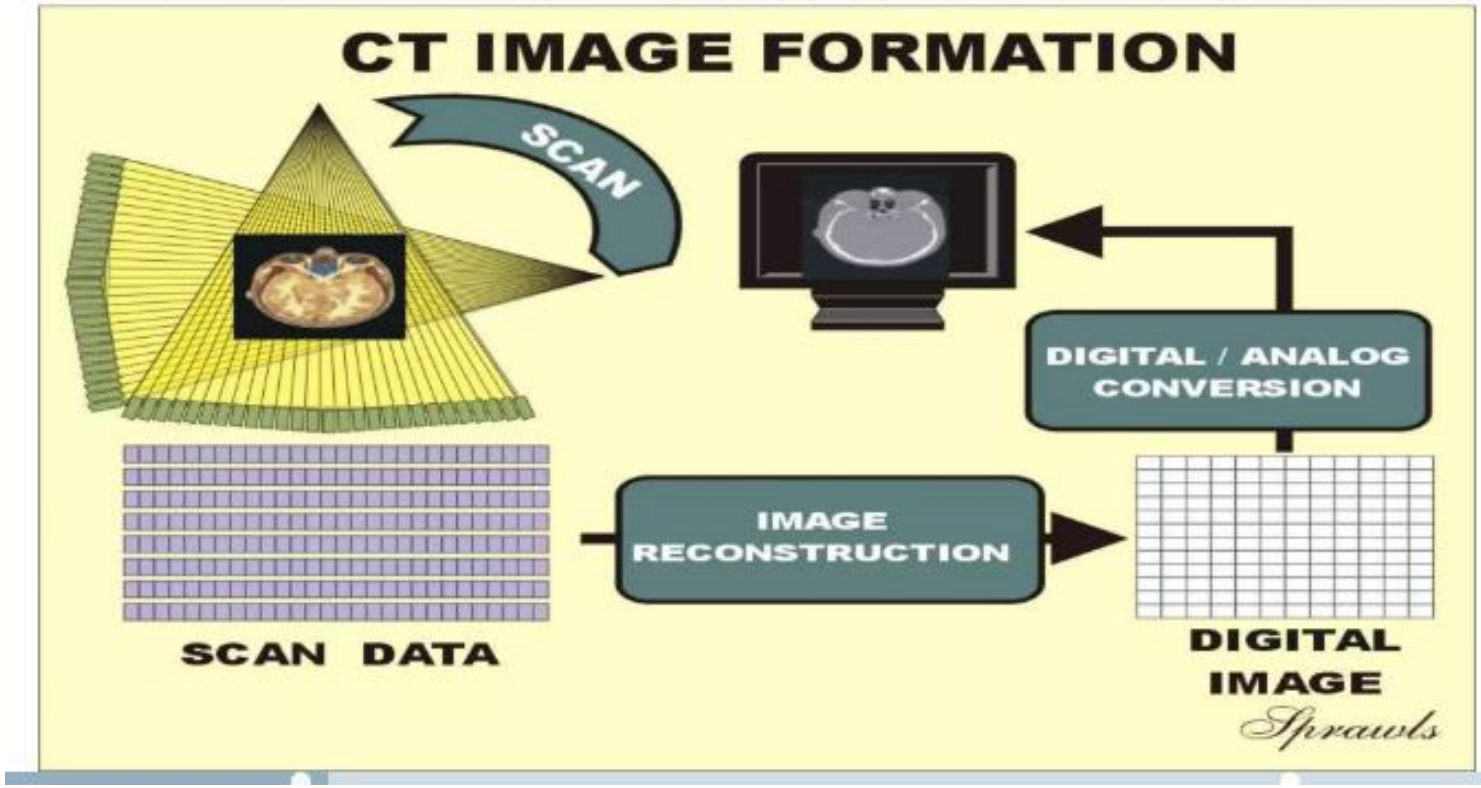
- Grey levels on CT image represent attenuation in each pixel
- Grey levels expressed in Hounsfield units (HU)
  - Water is 0 HU
  - Air is -1000 HU
  - Bone is 1000 - 3000 HU
- $HU = \frac{\mu_{object} - \mu_{water}}{\mu_{water}} \times 1000$

HU represents the linear attenuation of a material.

TISSUE AND CT NUMBER APPROXIMATE

Air	- 1000
Fat	-100
Pure water	**0**
CSF	**15**
White matter	45
Gray matter	**40**
Blood	**20**
Bone/calcification	+1000

STEPS OF CT IMAGE FORMATION



ADVANTAGE OF COMPUTED TOMOGRAPHY OVER CONVIENTIONAL RADIOGRAPHY.

- To overcome superimposition of structures.
- To improve contrast of the image.
- To measure small differences in tissue contrast.

What is a CT contrast agent?

- As with all x-rays, dense structures within the body—such as bone—are easily imaged, whereas soft tissues vary in their ability to stop x-rays and therefore may be faint or difficult to see.

- For this reason, contrast agents have been developed that are highly visible in an x-ray or CT scan and are safe to use in patients.

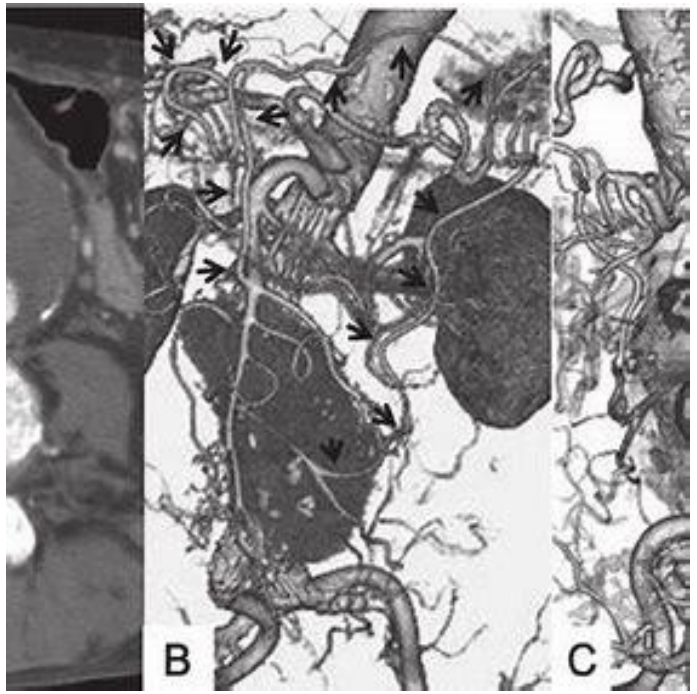
- Radiocontrast agents are typically iodine, barium-sulphate or gadolinium based compounds.

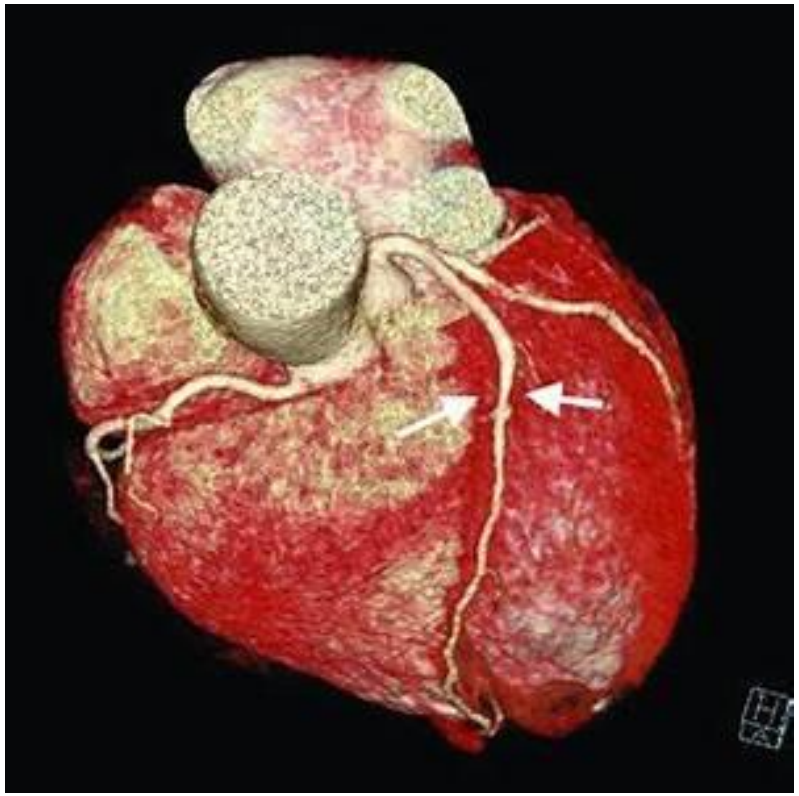
- Used to heighlight the structure like blood vessels

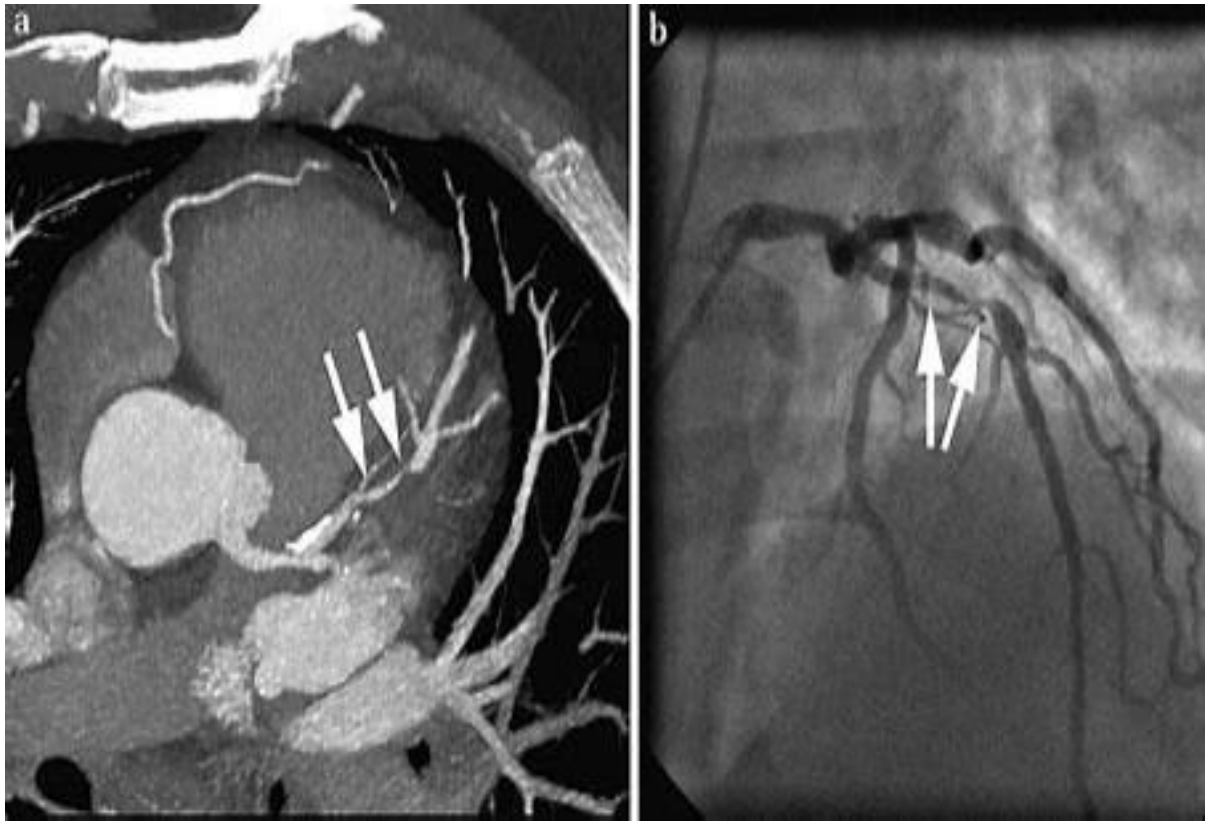
- It can also help to obtain functional information about tissues

What is a CT contrast agent?

- Example: Examination of the circulatory system, an intravenous (IV) contrast agent based on iodine is injected into the bloodstream to help illuminate blood vessels.
- This test is used to look for possible obstructions in blood vessels, including those in the heart.
- Oral contrast agents, such as barium-based compounds, are used for imaging the digestive system, including the esophagus, stomach, and gastrointestinal (GI) tract.







Coronary CT angiogram

Are there risks?

- CT scans can diagnose possibly life-threatening conditions such as hemorrhage, blood clots, or cancer.
- An early diagnosis of these conditions could potentially be lifesaving.
- However, CT scans use x-rays, and all x-rays produce ionizing radiation, it potential to cause biological effects in living tissue.
- This is a risk that increases with the number of exposures added up over the life of an individual.
- In general, if imaging of the abdomen and pelvis is needed, doctors prefer to use exams that do not use radiation, such as magnetic resonance imaging (MRI) or ultrasound.

THANK YOU