Computed Tomography

Diagnostic Radiology

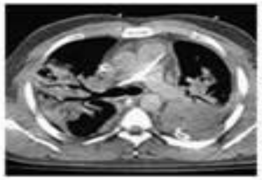
- Diagnostic radiology is the field of medicine that uses imaging exams and procedures to diagnose a patient. In any form of medical care, diagnostic radiology plays an integral part in the diagnosis of disease or injury.
- To diagnose the disease used by Ionizing radiation and Non-Ionizing Radiation .
- Depends on which part of the area to be Diagnosed.
- It may used as Therapeutic Radiology

Eg: Angiography treatment.

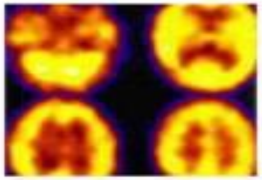
Types of Diagnostic Images

Types of Exams We Perform

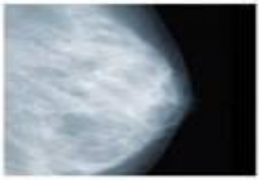
Modalities



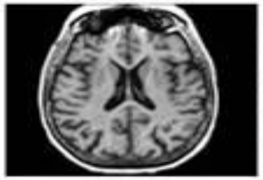
MRI – What: Produces high resolution cross-sectional images of soft tissue. Why: brain, spinal cord and interior ligaments.



Nuclear Medicine – What: Producers images of anatomical structures. Why: Assesses organ function in heart, kidney, thyroid and bones.



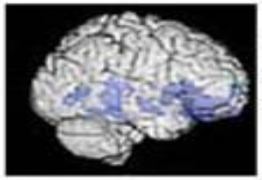
Mammography – What: Visualizes breast tissue. Why: primary screaming tool for breast cancer.



CT – What: Produces high resolution cross sectional images. Why: tumors, strokes, hemorrhages and infections.

X-ray – What: records images of organs and structures on film.

Fluoroscopy – What: video viewing of organs. Why: real time monitoring.



PET- What: Determines metabolic activity. Why: tumors, epilepsy and cardiac evaluation.

Ultrasound – What: produces visual images of internal organs. Why: viewing soft tissue.

PRIMEDEX HEALTH SYSTEMS, INC RADIOLOGIX

Pages from History.....

Designed by ***Godfrey N. Hounsfield*** to overcome the visual representation challenges in radiography and conventional tomography by collimating the X-ray beam and transmitting it only through small cross-sections of the body.

In 1979, **G.N. Hounsfield** shared the Nobel Prize in Physiology & Medicine with **Allan MacLeod Cormack**, Physics Professor who developed solutions to mathematical problems involved in CT.

Godfrey N. Hounsfield

Allan MacLeod Cormack

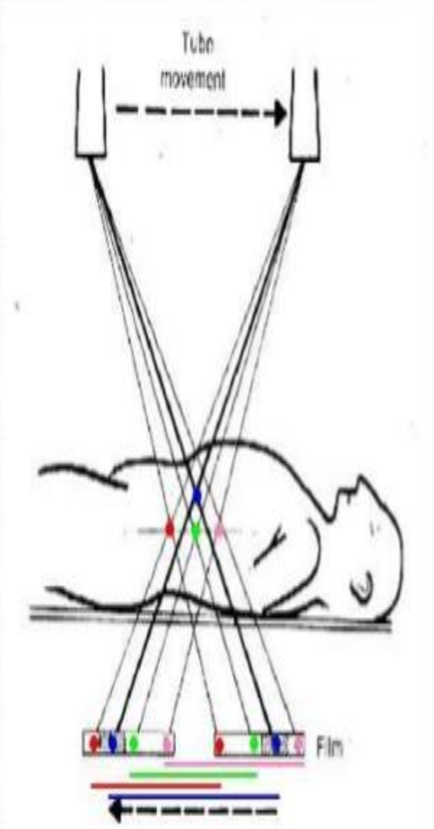
TOMOGRAPHY

- Imaging of Layer/Slice.

Principle

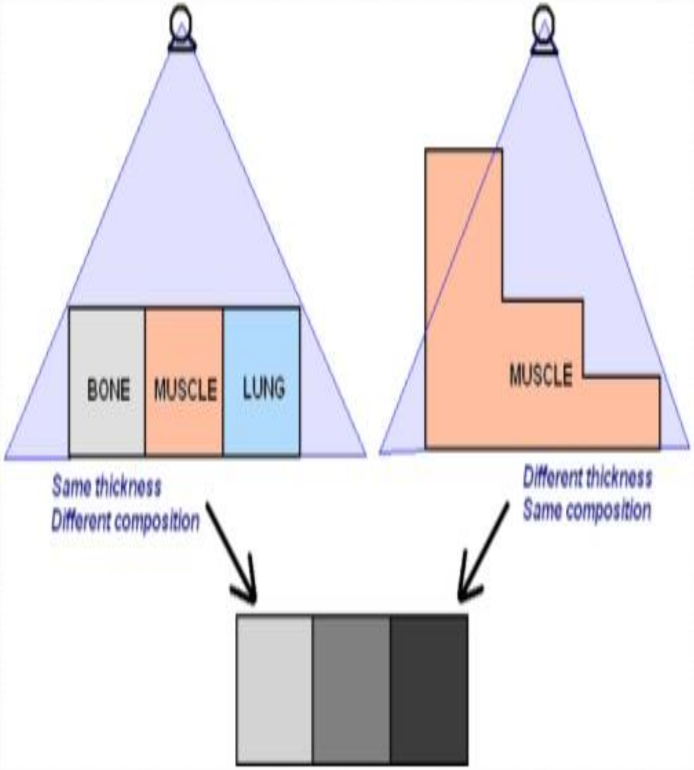
Images of structures lying above and below the plane are blurred out due to motion unsharpness while the structures lying in plane of interest appear sharp in in the image.

Tomography



Comparison of CT with Conventional Radiography

Radiographic procedure is qualitative and not quantitative

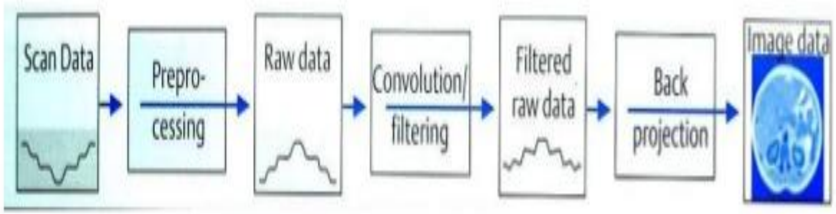


Basics Principle

The basic principle behind CT is that the internal structure of an object can be reconstructed from multiple projections of the object.

The ray projections are formed by scanning a thin cross section of the body with a narrow x-ray beam and measuring the transmitted radiation with a sensitive radiation detector.

CT scanning is a systematic collection and representation of projection data



Parts of Gantry

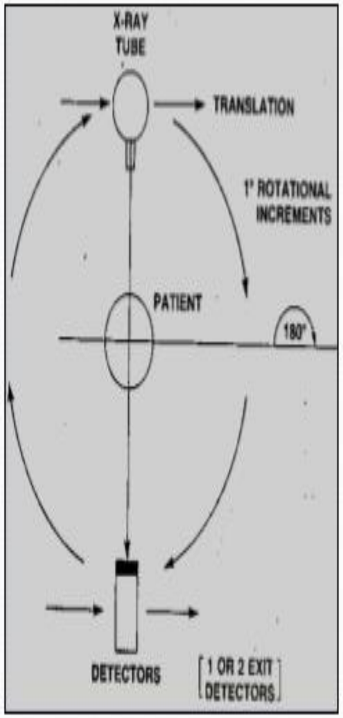
- **X-ray tube**: generates x-ray beams
- **Detector**: detects the x-rays passing through the patient's body.
- **Collimator**: narrows the beams of x-rays
- **Filters**: these are used to filter some rays from entering the patient's body that may be harmful.

....PTO

Generations of CT Scan

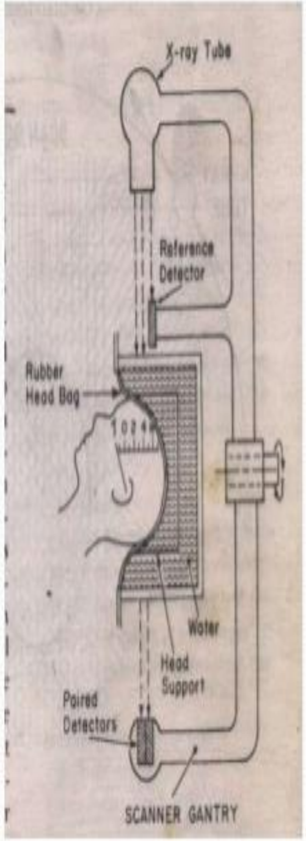
First Generation

- Narrow pencil beam
- Single detector
- Detector used is made up of NaI.
- Translate –Rotate movements of Tube- detector combination
- Scan time-5mins.
- Designed only for evaluation of brain.



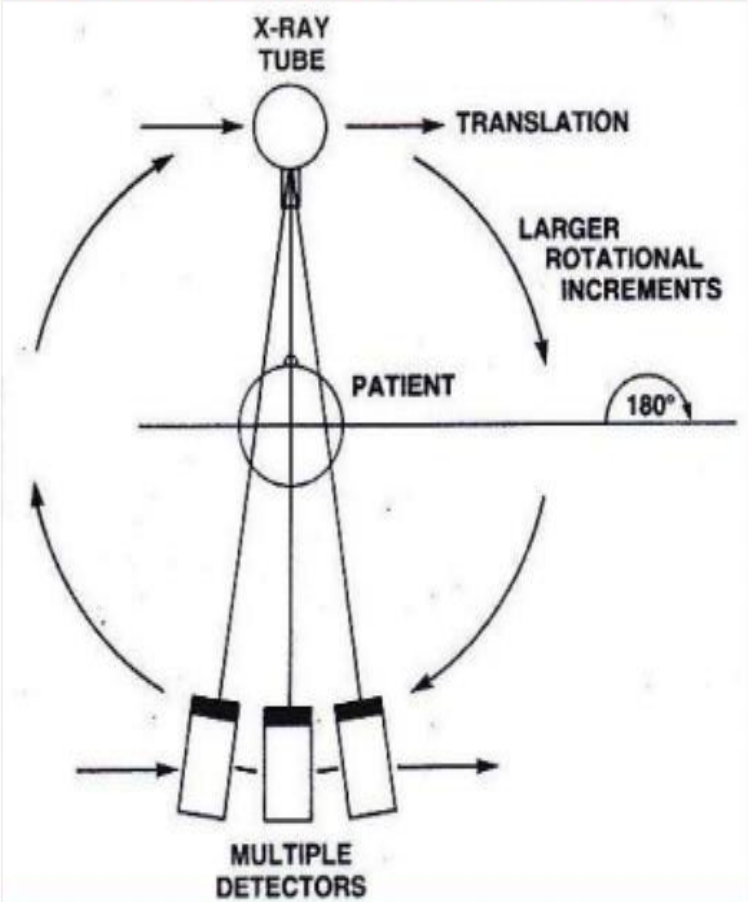
First generation CT Scanner

- Head kept enclosed in a water bath
- Paired detectors
- A reference detector



CT Generation

Second Generation CT Scanner

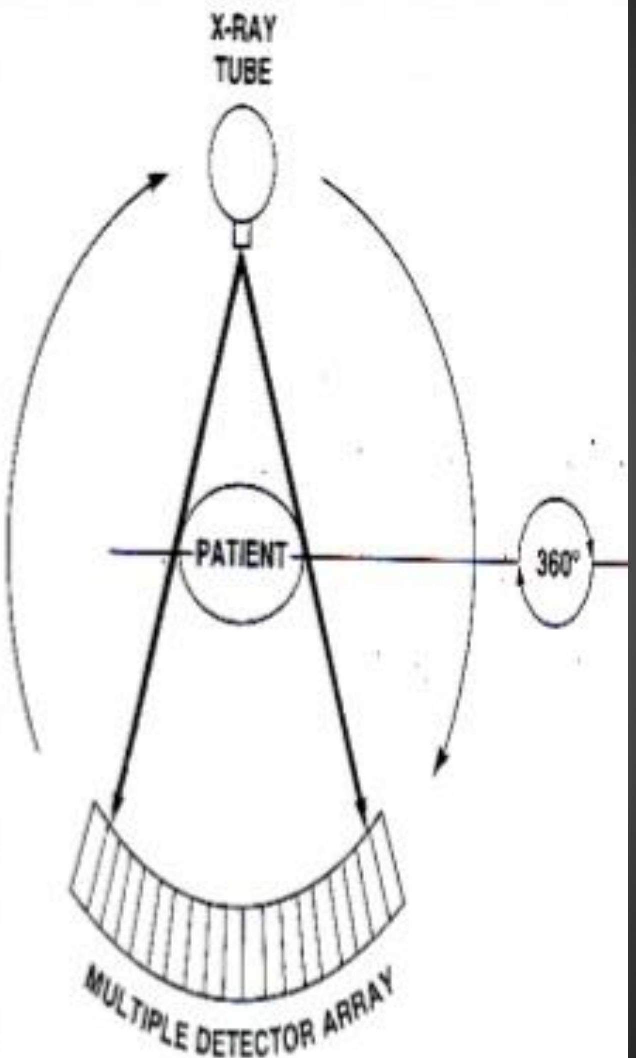


Second Generation

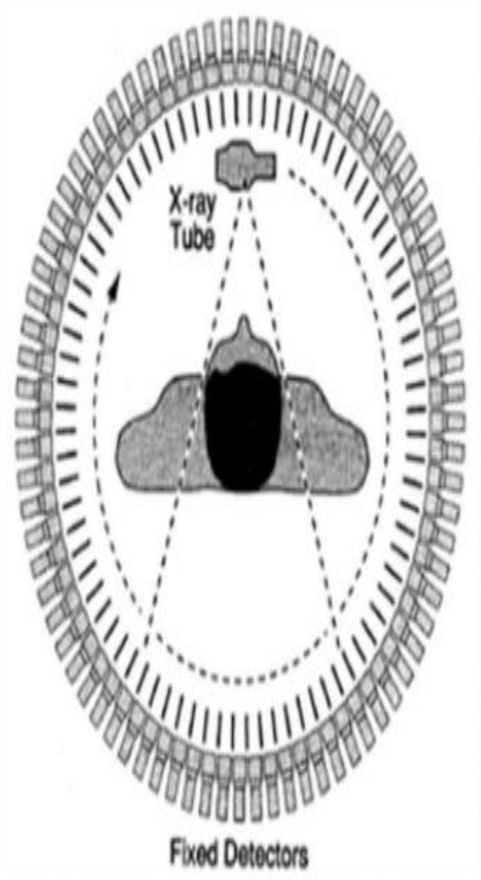
- Narrow fan beam
- Linear detector array(5 to30)
- Translate-Rotate movements of Tube-Detector combination
- Fewer linear movements are needed as there are more detectors to gather the data.
- Between linear movements, the gantry rotated 30^0
- Scan time~30secs(advantage over first generation)

Third Generation

- Rotate(tube)Rotate(detectors) Motion.
- Pulsed wide fan beam.
- Arc of detectors(600-900)
- Detectors are perfectly aligned with the X-Ray tube
- Both Xenon and scintillation crystal detectors can be used
- Scan time< 5secs
- Disadvantage: Ring Artifacts due to electronic drift between many detectors.



Fourth Generation

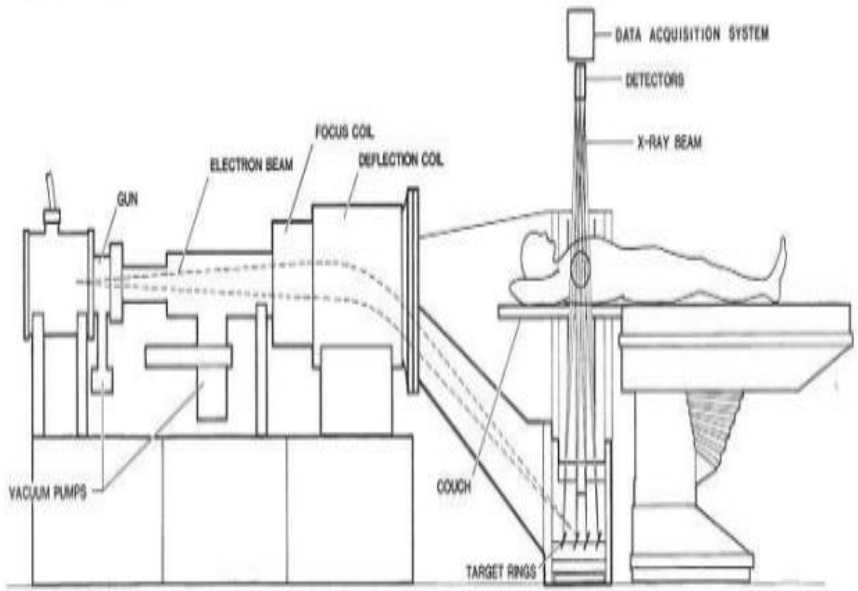


Fourth Generation

- Complete circular array of about 1200 to 4800 stationary detectors
- Single x-ray tube rotates with in the circular array of detectors
- Wide fan beam to cover the entire patient
- Scan time of newer scanners is about ½ s or, <2s.
- Designed to address ring artifacts by keeping detector assembly stationary.
- Disadvantage: High cost.

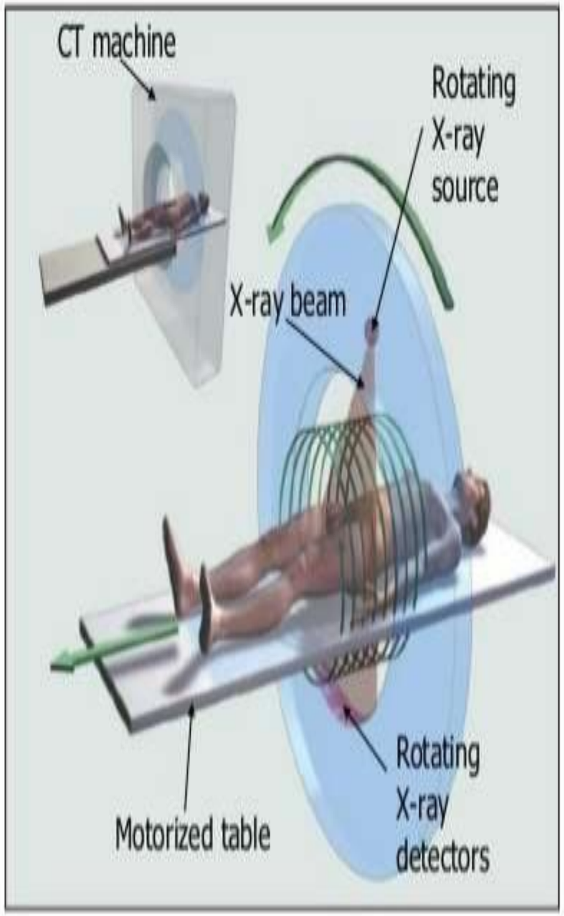
Fifth Generation

- stationary/stationary
- Developed specifically for cardiac tomographic imaging
- No conventional x-ray tube; large arc of tungsten encircles patient and lies directly opposite to the detector ring
- Electron beam steered around the patient to strike the annular tungsten target
- Capable of 50-msec scan times; can produce fast-frame-rate CT movies of the beating heart



- Electron gun
- Large Arcs of tungsten targets
- Detector ring
- 17 slices per second

Spiral CT



SPIRAL/HELICAL CT

- Spiral/Helical scanning uses third generation or fourth generation slip ring design.
- **Spiral computed tomography** (or helical computed tomography) is a computed tomography(CT) technology in which the source and detector travel along a helical path relative to the object. Typical implementations involve moving the patient couch through the bore of the scanner whilst the gantry rotates. Spiral CT can achieve improved image resolution for a given radiation dose, compared to individual slice acquisition. Most modern hospitals currently use spiral CT scanners.

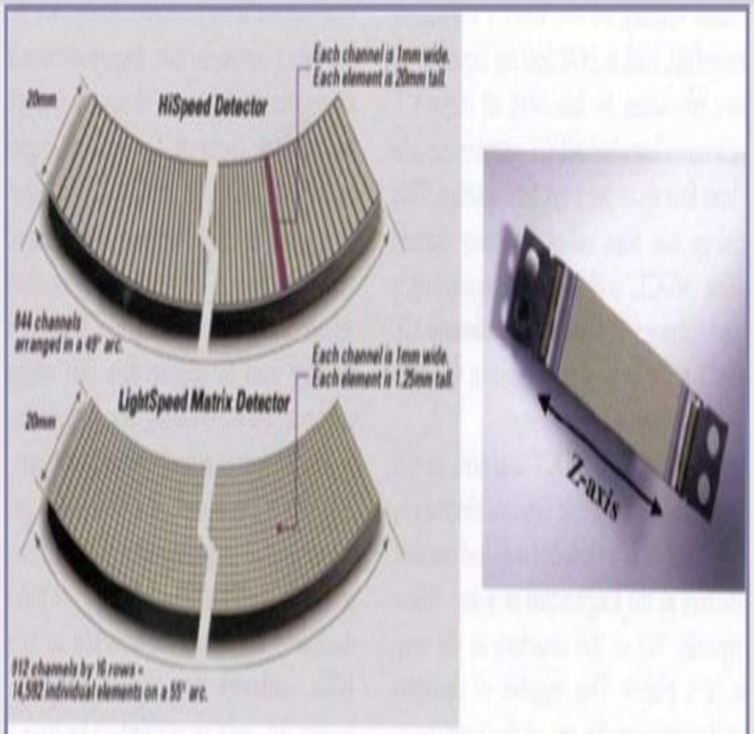
SLIP RING TECHNOLOGY

- In conventional CT scanning there was a paused between each gantry rotation. But in Helical CT, Slip Ring technology is used which allows continuous rotation of gantry without interruption.
- Slip Rings are electrical conducting brushes and component of gantry transferring the data or, electrical energy to and from the stationary part of gantry to rotating part of gantry for continuous rotation of gantry.

Contd....

- There are usually three slip rings made up of conduction materials(i.e. Sliver and Graphite.)
- First Slip Ring provides high voltage power to X-ray tube.
- Second provide low voltage to control system on rotating gantry and
- Third Slip Ring transfers digital data from rotating detectors arrays.

Multi-detector (MDCT) Computed Tomography



*GE LightSpeed, GE Medical Systems

*Aquillion 16, Toshiba Medical System

MDCT detectors

M. Mahesh, MDCT physics, the basic technology, image quality and radiation dose, Wolters Kluwer, 2009

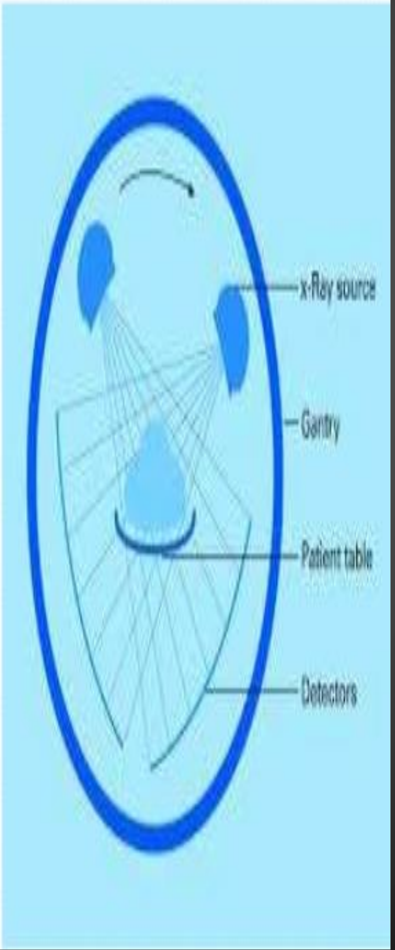
DUAL SOURCE CT

Dual Source CT (DSCT) is equipped with two X-ray tubes.

Two corresponding detectors are oriented in the gantry with an angular offset of 90 degrees.

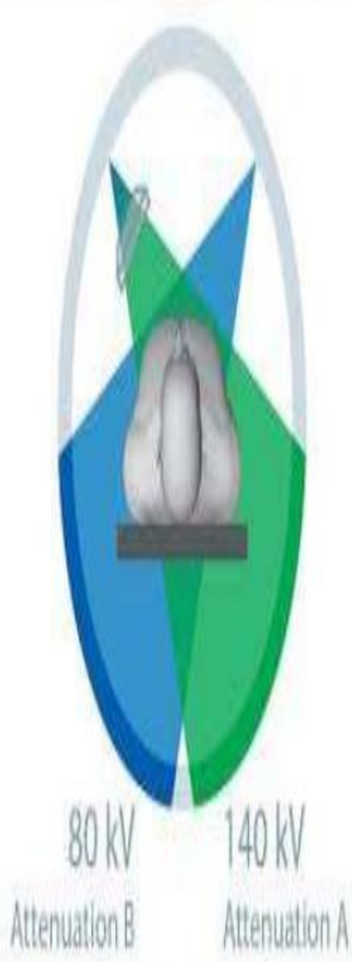
<u>ADVANTAGES</u>

1) **High temporal resolution(in response to time domain) for cardiac imaging without β blockers which means heart rate is independent upon temporal resolution.**
2) **Less radiation dose even for obese patient.**
3) **Faster acquisition time with shortest breathe hold.**



DUAL ENERGY CT

- Standard computed tomography (CT) scanners use normal X-rays to make cross-sectional 'slice-like' pictures or images of the body.
- A dual energy CT scanner is fairly new technology that uses both the normal X-ray and also a second less powerful X-ray to make the images.
- Two pictures are taken of the same slice at different energies.(i.e. **80/140KV ,100/140KV** Or,70/150KV)
- This gives dual energy CT additional advantages over standard CT for a wide range of tests and procedures.
- Most commonly used for **CT Angiography.**



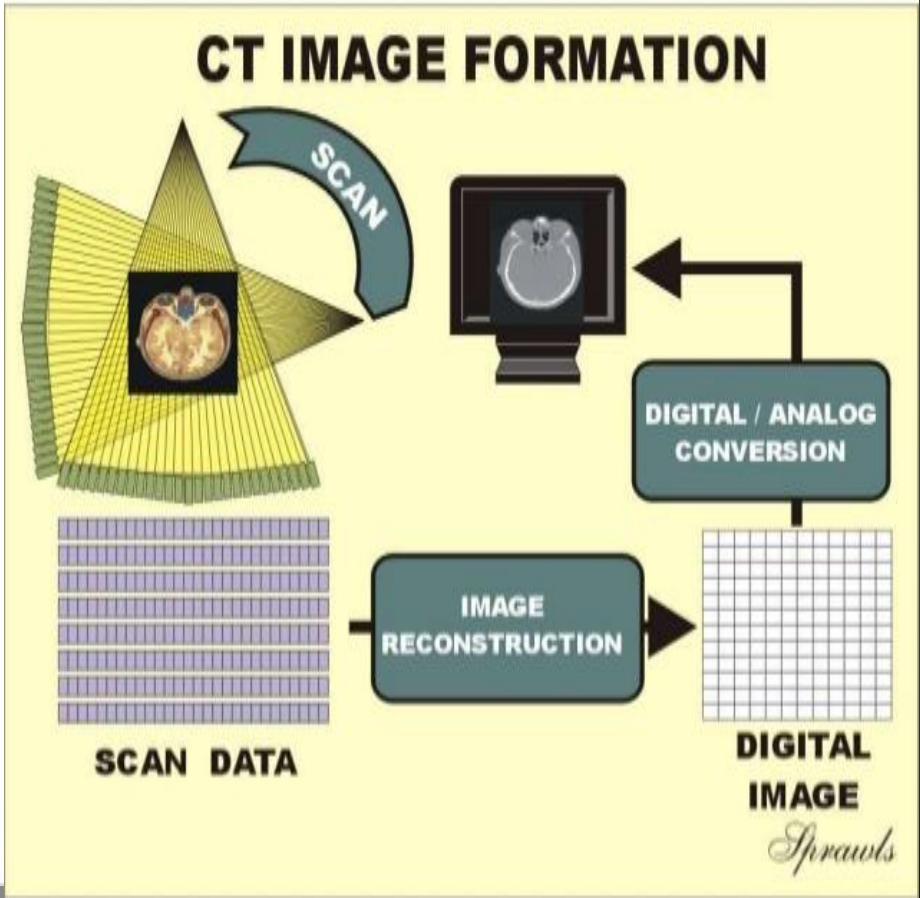
Generations

generation	configuration	detector	beam	Min scan time
first	Translate -rotate	1-2	Pencil thin	2.5min
second	Translate -rotate	3-52	Narrow fan	10sec
Third	Rotate- rotate	256-1000	Wide fan	0.5sec
fourth	Rotate- fixed	600-4800	Wide fan	1sec
fifth	Electron beam	1284	Wide fan electron beam	33ns

Three dimensional (3D) Image Reconstruction

- **The principle**
- Because contemporary CT scanners offer isotropic, or near isotropic resolution, display of images does not need to be restricted to the conventional axial images.
- Instead, it is possible for a software program to build a volume by 'stacking' the individual slices one on top of the other. The program may then display the volume in an alternative manner.

STEPS OF CT IMAGE FORMATION



Major components of Data Acquisition System(DAS)

a)X-ray Generators

Generators are located on rotating scan frames within the CT gantry to accommodate slip Ring.

Power: 50 to 80kw

Frequency: 5 to 50kHz

KVp: 80-120

mA:80-500

b) X-ray Tube

- Rotating anode x-ray tube with unique cooling.
- Small focal spot size (0.6mm) to improve spatial resolution.
- Anode heating capacity:1MHU to 7MHU
- Cooling rate:1MHU per minute.

c)X-ray Beam Filtration System

- CT employs monochromatic beam but radiation from

CT X-ray tube is polychromatic. so, X-ray beam is shaped by compensation filter.

a)Pre patient Collimators: Reduces the patient dose.

b)Post patient Collimators: Reduces the scattered radiation detectors.

Overall Functions of Collimators.

- To decrease scatter radiation
- To reduce patient dose
- To improve image quality
- Collimator width determines the slice thickness

d)Detectors

The detectors gather information by measuring the x-ray transmission through the patient.

- Two types:

Scintillation crystal detector

(Cadmium tungstate+ Si Photodiode)

Can be used in third and fourth generation scanners

Xenon gas ionisation chamber

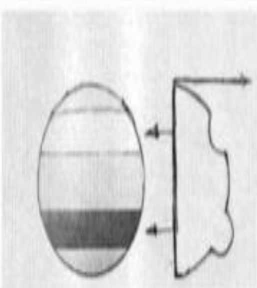
Can be used in third generation scanners only

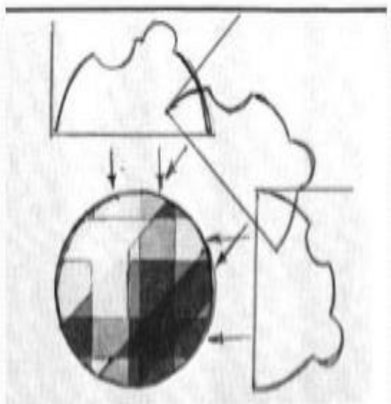
2)Reconstruction

- Reproduction of an image from raw data is called Reconstruction.

A)Simple back projection

The image is created by reflecting the attenuation profiles back in same direction they were obtained.





B)Iterative method

- It start with assumption that all point in matrix have same value and it was compared with measured value and make correction until Values come with in acceptable range.
- It contain three correction factor

1. SIMULTANEOUS RECONSTRUCTION
2. RAY BY RAY CORRECTION
3. POINT BY POINT CORRECTION

C)Analytical Method

Today commonly used .

Two popular method used in that method are:-

1. 2-*D FOURIER ANALYSIS*

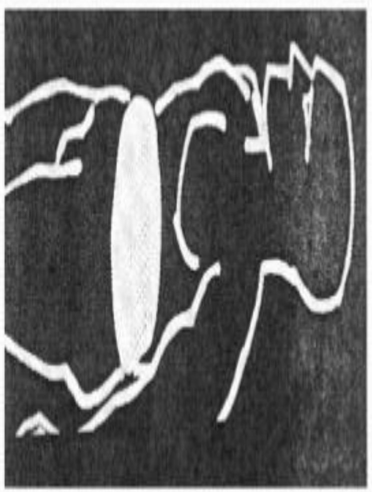
2.*FILTERED BACK PROJECTION*

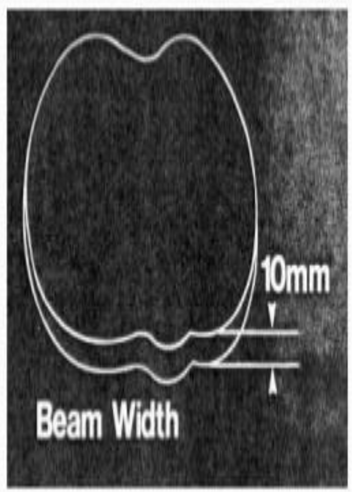
VARIOUS PARAMETERS OF CT

- SLICE
- MATRIX
- PIXEL
- VOXEL
- CT NUMBER
- WINDOWING
- WINDOW WIDTH
- WINDOW LEVEL
- PITCH

SLICE/CUT

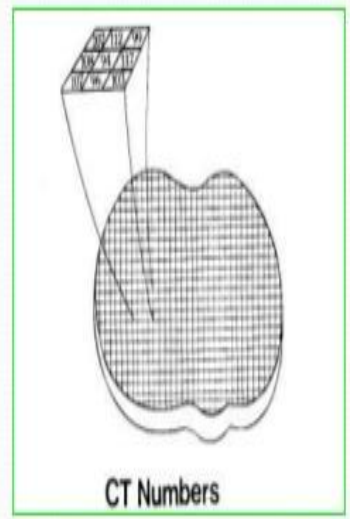
- The cross section portion of body which is scanned for production of CT image is called Slice.
- The slice has width and therefore volume.
- The width is determined by width of the x rays beam.





CT NUMBER

- The numbers in the image matrix is called CT NUMBER.
- Each pixel has a number which represents the x-ray attenuation in the corresponding voxel of the object.



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

WINDOWING is a system where the CT no. range of interest is spread cover the full grey scale available on the display system

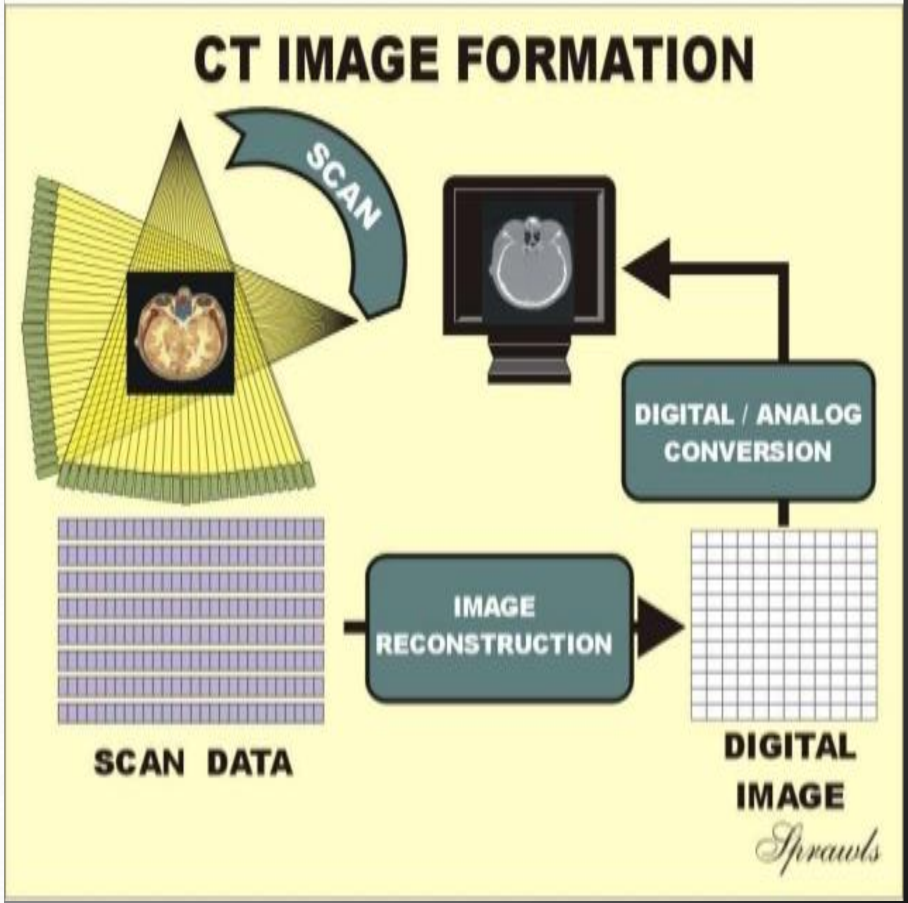
WINDOW WIDTH –Means total range of CT no. values selected for gray scale interpretation. It corresponds to contrast of the image.

WINDOW LEVEL– represents the CT no. selected for the centre of the range of the no. displayed on the image. It corresponds to brightness of image .

Pitch

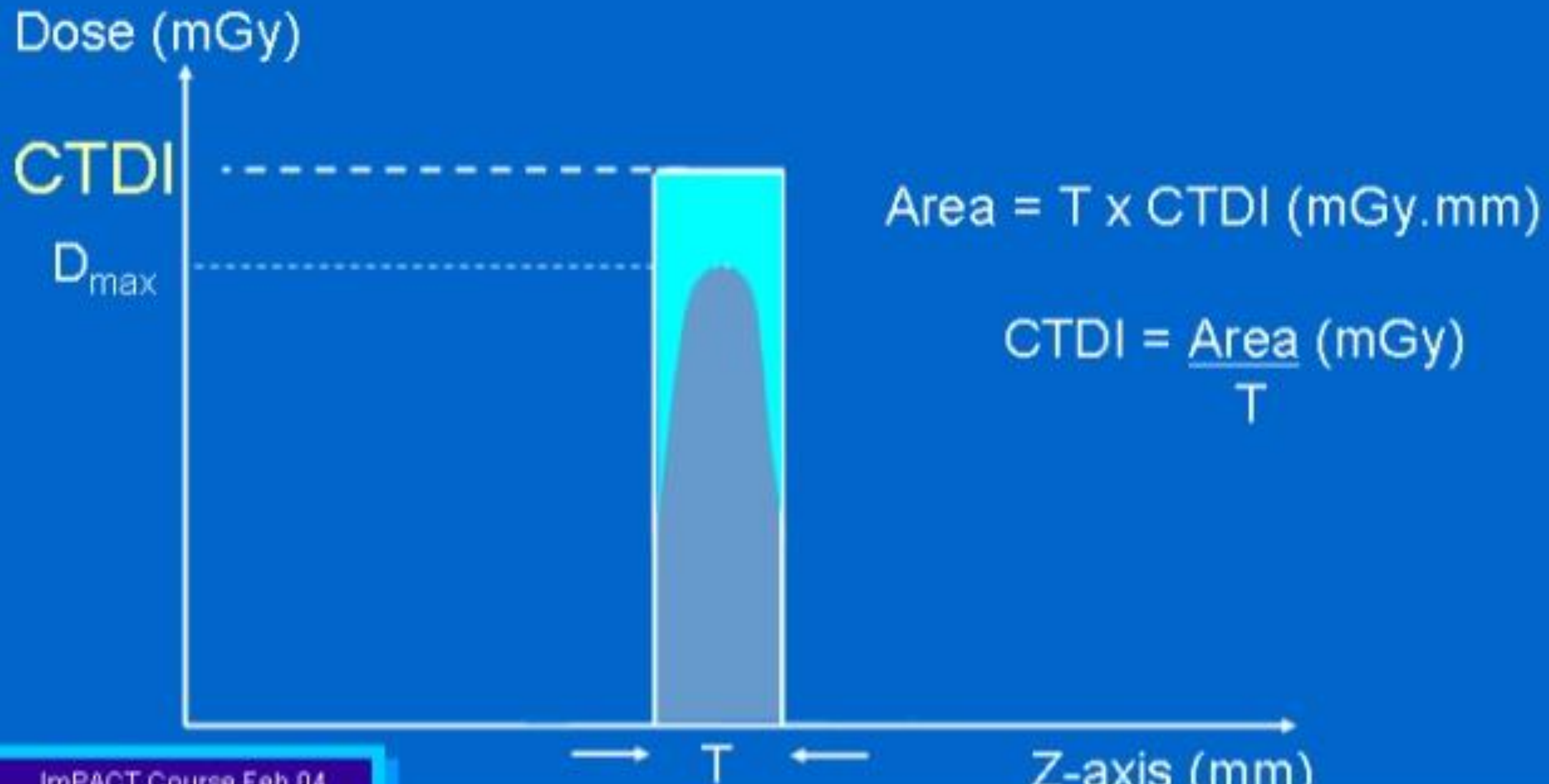
- The relationship between patient and tube motion is called Pitch.
- ***It is defined as table movement during each revolution of x-ray tube divided by collimation width.***
- For example: For a 5mm section, if patient moves 10mm during the time it takes for the x-ray tube to rotate through 360˚, the pitch is 2.
- Increasing pitch reduces the scan time and patient dose.

STEPS OF CT IMAGE FORMATION



Dose descriptors - CTDI

- CTDI is the total energy absorbed within a dose profile deposited within one nominal collimation



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FIGHT CANCER
THANK YOU!
THE END!