NED UNIVERSITY OF ENGINEERING AND TECHNOLOGY, PAKISTAN

SUBJECT: BIOMEDICAL ENGINEERING SYSTEM

NOTES TOPIC: CT-SCAN

Computed Tomography (CT scan)

The computed tomographic scanner is Revolutionary (changeable). It does not use an ordinary image receptor such as film or an image intensifier tube. Instead of well collimated x-ray beam is directed on to the patient and the attenuated image forming radiation is measured by a detector, whose response is transmitted to a computer. After analyzing the signal from the detector, the computer reconstructs the image and display it on a monitor. The image can be photograph for evaluation and filming. The computer reconstruction of the cross-sectional and anatomic structure is accomplished with mathematical equation (algorithms) adapted for computer processing.

- There are detectors present in the CT- scan
- Two types of detectors are present that is scintillation crystal detector and gas filled detector
- the phenomena of 2D or 3D is after the detector
- the cost of software is 60 to 65% of the total amount of the CT-scan
- Collimator limits the field size
- in CT (pre patient and post patient collimator) is present
- There is a well collimated synchronization of pre and post patient collimator has done
- Attenuate (Changing of the medium, the absorption which represents Photoelectric effect).

RECONSTRUCTS:

- Already constructed image again constructed by the detector
- first dotted image is formed on the detector
- then image Is reconstructed
- Filter layer gram or graph forms the dotted form of data.
- by applying Fourier transform image is reconstructed
- give slices cross-sectional view with the help of detector and specials software
- Fourier slice theorem is the algorithm used in CT scan

COMPONENTS OF CT-SCANNER

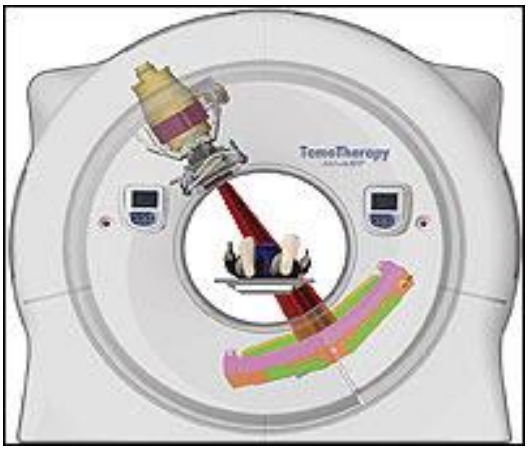
Major components are as under:

1. GANTRY

A slip-ring enables continuous rotation of the CT scanner gantry. Brushes on the rotating gantry, through contact with the stationary ring, allows power to be supplied to the gantry and the signal to be passed to the computer. Rotation times are between 0.25 - 3 seconds.

FUNCTION OF GANTRY:

- Gantry receive electronic command from operating console and transmit data to the processing system for image production and analysis
- To active large focal spot 400-1200mA current is required (variable focal size)
- To active small focal size 0-300mA current is required (variable focal size)
- 25-150KVp voltage is required.



2. THE PROCESSING SYSTEM

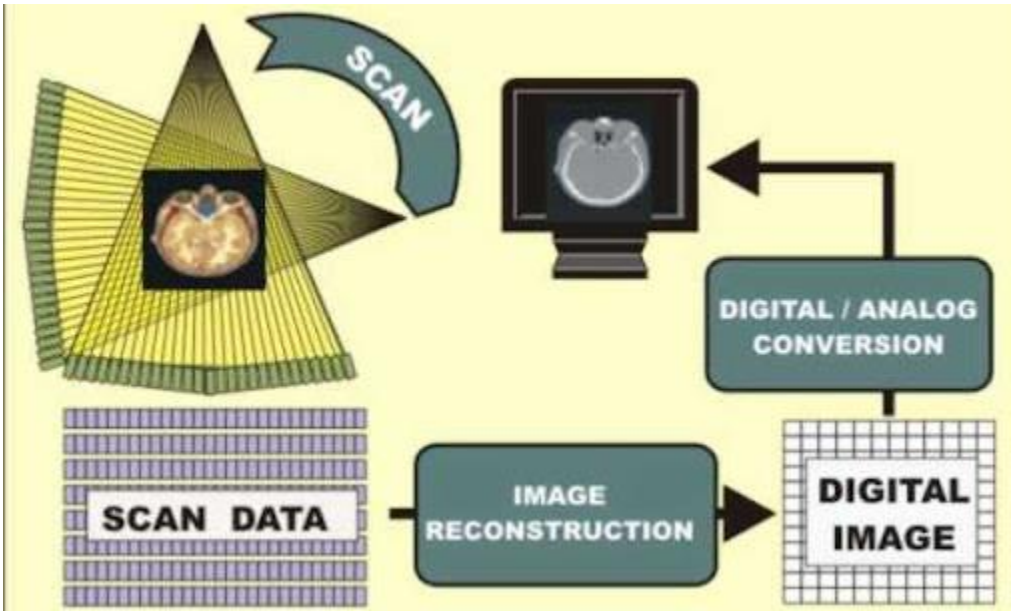
- Data acquisition system(DAS)
- Computer
- Operating Consoles(there 2 or more than 2 consoles present)
- First console (radiologist to set the basic parameters from)
- Second console (for the physician to examine the image)
- third console (to save the file or to transfer the file)
- fourth console (image storage system)

THE TECHNIQUE OF PRODUCING CT IMAGES:

The x-ray tube and the detector are rigidly couple to each other. The system executes translational and rotational movements and Trans Indicates the patient from main angular projection, with the aid of collimator pencil, thin beam x ray is produced. A detector converts the X-ray radiation into an electrical signal measuring electronics then amplifies the electrical signals and convert them into digital values. A computer then processes these

values and compute them into a matrix line density distribution pattern, which is reproduced on the video monitor as a pattern of grey shade

- Translation: straight, fall on axis
- Rotational: 360 degree
- Pencil beam: single radiation at a time more than one Beam is called fan Beam.
- Das stands for digitize the analogue signal
- Tomo: means slice or cross sectional view
- Line Matrix density it is the type of array which reads the dot per inch DPI, is the checker of the software which reads the dots per inch to plot the image.



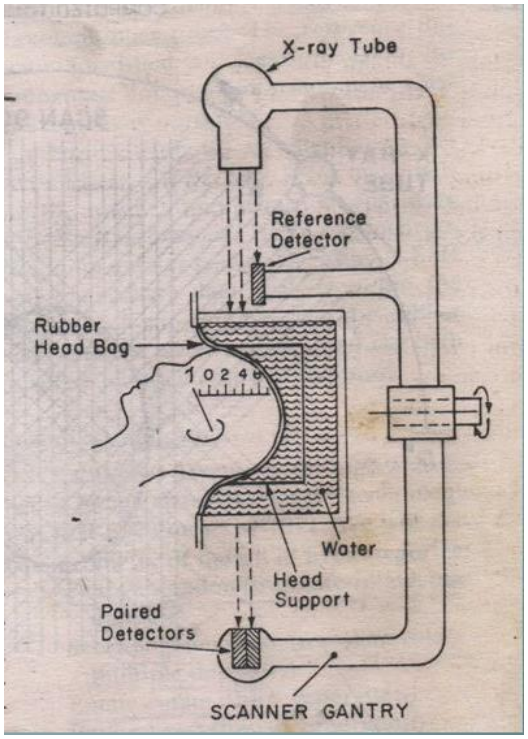
GENERATIONS OF CT-SCAN:

- Hounsfield discovered the CT scan
- time was the main focus for the production of CT
- due to number of detectors that time decreased in the CT

❖ FIRST GENERATION CT-SCAN

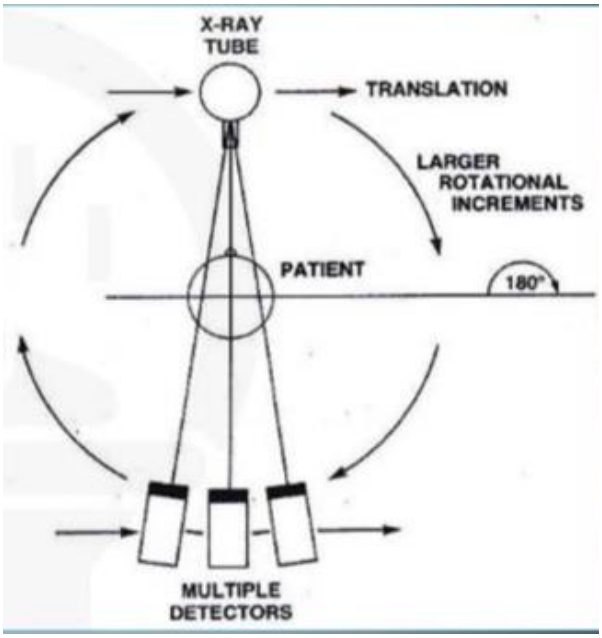
- Translate (x-ray tube), rotate (detectors) configuration.
- pencil shade beam was used
- single detector was used

- The scanning time was 5 minutes. Scanning time is the time required to reconstruct the image or the time required to expose the rays.
- the disadvantage of first generation CT Scan was its scanning time



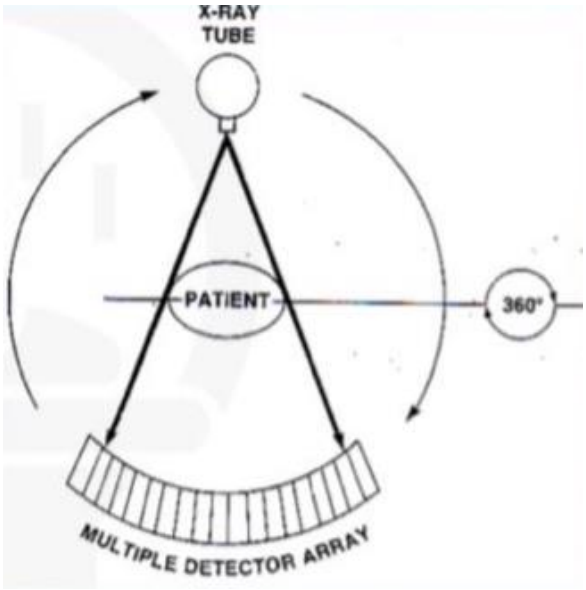
❖ SECOND GENERATION CT-SCAN:

- Translate rotate configuration
- Fan shaped Beam
- Detector array was present. consisting of 5-30 detectors in an array
- Scanning time was 30 seconds
- The disadvantage was because of fan shaped beam, there was a chance of scattering of radiation
- the place where detectors were present was linear



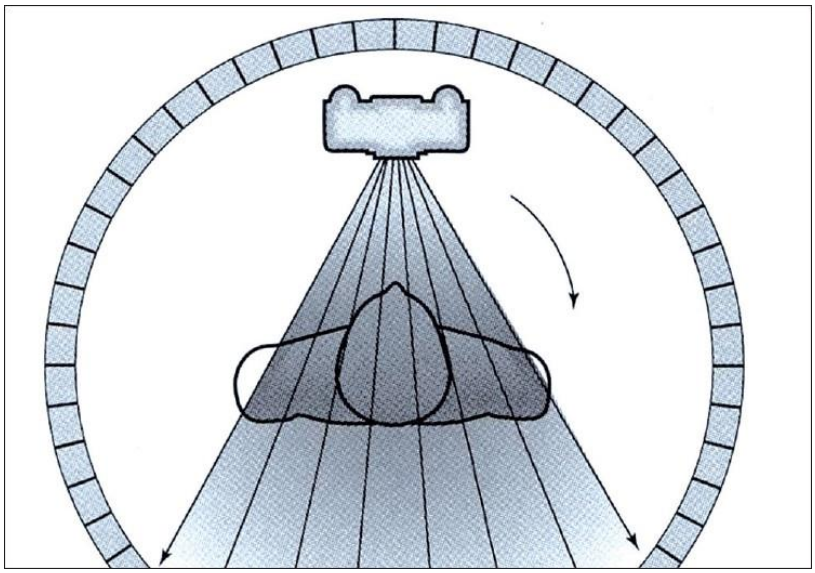
❖ THIRD GENERATON CT-SCAN:

- Rotational configuration
- the place where detectors were present is now circular as the radiations are in circular direction, it is called curvilinear
- Fan shaped beam was present
- detector array consisting of 60-500 detector was present
- Scanning time reduced to One Second
- disadvantage is if one detector malfunctions, complete array has to be changed



❖ FOURTH GENERATION CT-SCAN:

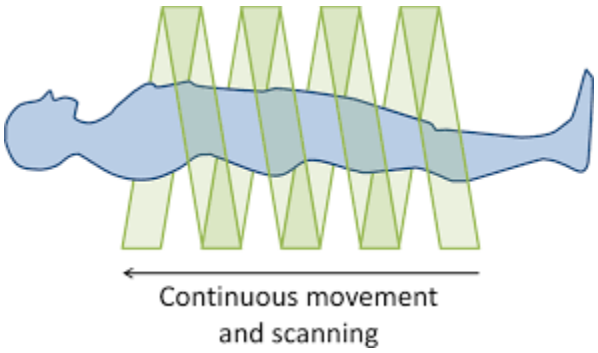
- Rotate stationary configuration
- detectors were at 360 degree angle
- fan shaped beam was used
- 8000 detectors were built
- Scanning time was 1 second
- ring artifact: fault minimized, if one detector malfunctions than other detector detects the image



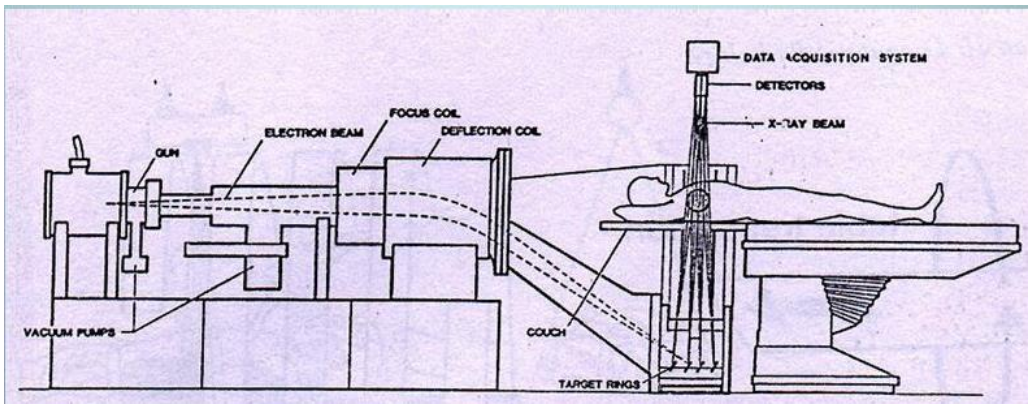
❖ FIFTH GENERATION CT-SCAN:

There are two types

- **Spiral CT**
  - Three slice at a time (X-ray tube rotates 3 times in 30 seconds)
  - Fan shaped beam
  - individual detector in 360 degree angle



- **Electron beam computed tomography(EBCT)**
  - A waveguide accelerates a focus electron beam onto a semicircular tungsten target actually there are four tungsten targets, so for tissue, slices are scanned at a same time
  - Nothing in a EBCT gantry moves except the electron beam

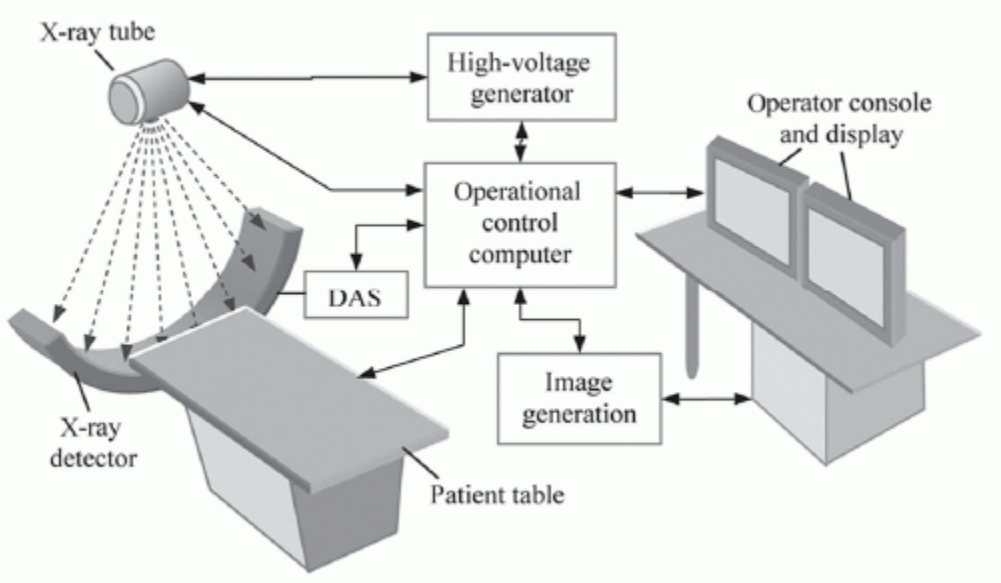


DATA ACQUISITION SYSTEM:

The process of acquiring the data starts after the detectors.

- Light is concerned with intensity

- intensity is concerned with current
- computer understands the voltage it get
- transducer convert current and voltage
- analogue integrated is used to remove Spikes or smoothening



Computer (Field Programmable Gate Array)

- it can equates 250000 equations and solve them simultaneously in the given period of scanning time

ANODE HEAT CAPACITY:

It must be around 8MHU (million Hounsfield unit)

DETECTOR ARRAY:

The original single-slice scanners had one row of detectors. Now all scanners are multi-slice and have 8-64 rows of detectors. There are generally 1000-2000 detectors in each row.

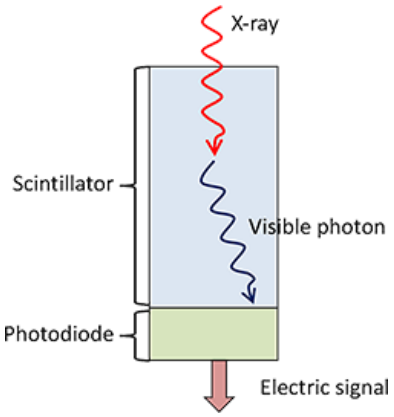
PROPERTIES OF DETECTOR ARRAY:

- High detection efficiency for x-rays in CT energy range

- High dynamic range
- Narrow gaps between active elements (good geometrical efficiency)
- Fast response
- Low cost
- Small physical size

TYPES OF DETECTORS:

1. SOLID STATE DETECTOR (SSD):



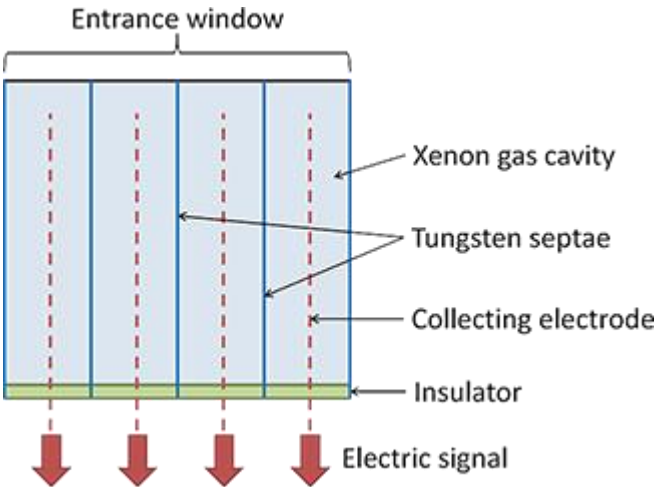
There is a solid scintillator layer that converts the x-rays into visible light photons. The photodiode then converts the photon input into an electrical signal.

Properties:

- High detection efficiency (~90%)
- High geometrical efficiency (~80%)
- Small physical size of detector elements

Most commonly used detector.

2. IONIZATION CHAMBER DETECTOR (no longer used):



The detector array is a single vessel filled with gases of a high atomic number (Krypton / Xenon) and subdivided into separate detectors by tungsten septate.

The x-rays ionize the gas and produce a signal at the collection electrodes.

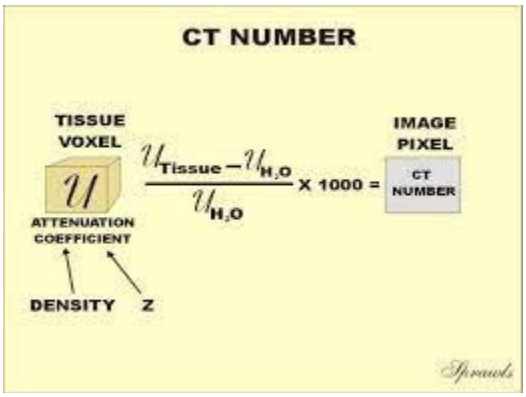
Properties:

- Lower detection efficiency (~50%)
- High stability
- Consistent sensitivity between detector elements

Ionization chambers have been superseded by solid-state detectors and are no longer used as they are unsuitable for multi slice scanners.

THE CT IMAGE FORMAT:

- The CT Image format consists of many cells, each assign a number and display as in optical density of brightness level onto the monitor
- the original City system format consisted of an 80*80=6400 cells For information
- the SI system provided 512*512 Matrix information which results in262144 number of cells
- City number set the value of attenuation example if the city number value has 1000 show all parameter will be set according to that it increases the chances of attenuation the city number vary from organ to organ



- Water is taken as reference point because its value is zero
- each cell of information is called pixel(picture element/ light element) and the numeric information contain in each pixel is called city number in when it grow according to the size then it is term as voxel
- FOD (Field of view)
- It is the diameter of the reconstructed image.