College of Health and Medical Technologies
Department of Radiology Technologies

# Review about CT machines
# Internal and external structures
# Types of CT machines

## 4 th stage

LECTUER 1

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MSc Radiographic Imaging

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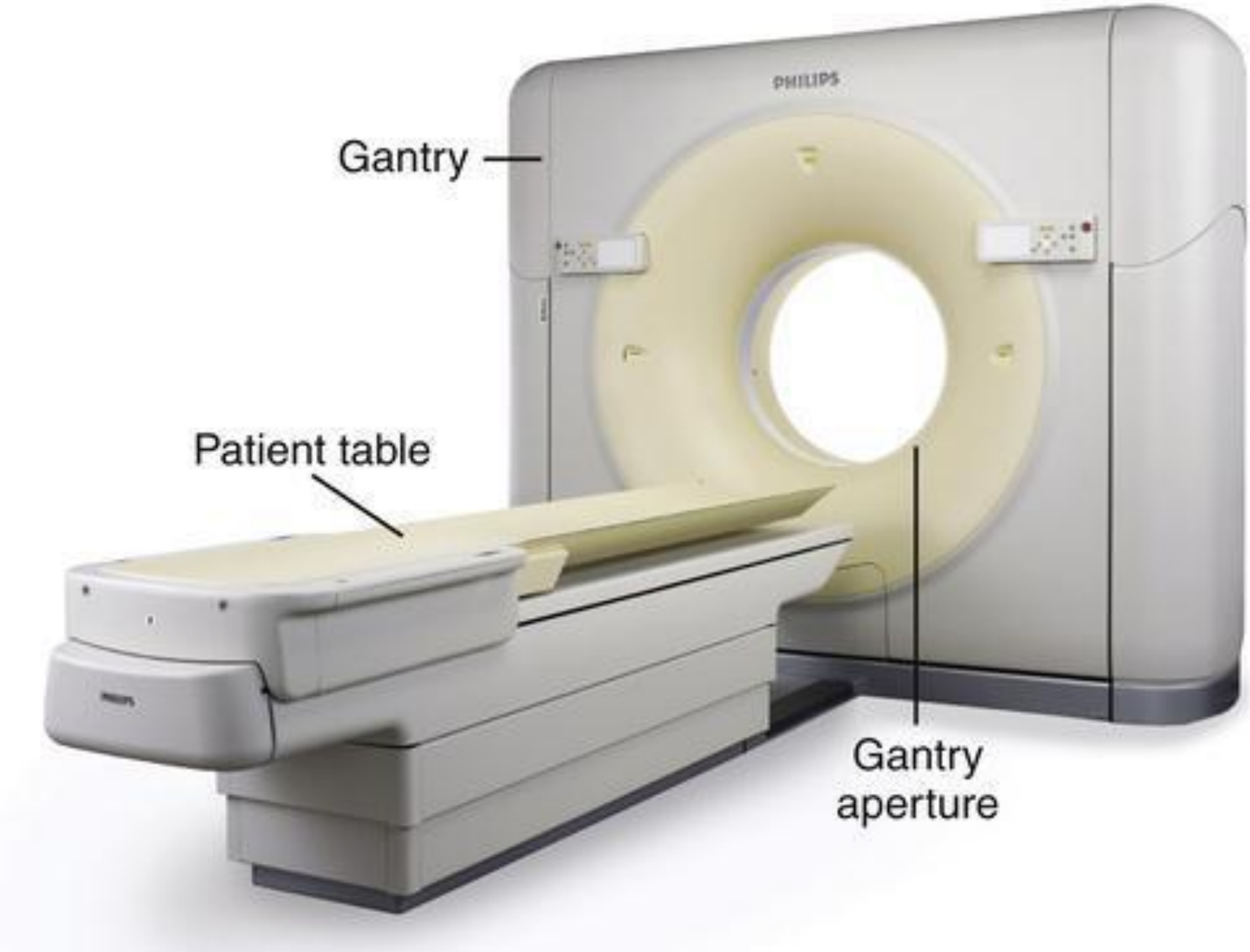

PHILIPS
Gantry
Patient table
Gantry aperture

**Computed tomography** is a special type of x-ray procedure that involves the indirect measurement of the weakening, or attenuationof x-rays at numerous positions located around the patient being investigated. (tomos—meaning section, graphy—picture in Greek) .

## COMMON NAMES

a. Computerized axial transverse scanning (Hounsfield, 1972)

b. Computerized axial tomography (CAT)

c. X-ray computed tomography (X-ray CT)

d. Computed/computerized tomography (CT)

Computed tomography (CT) is currently the preferred name.

## HISTORY LEADING TO CT SCAN

- 1917—Radon developed the basic mathematical equations.
- 1940—Frank and Takahashi published the basic principles of axial CT.
- 1956—Cormack developed theory of image reconstruction.
- 1967—Hounsfield developed the clinically useful CT scanner.
- 1973—First clinical brain scanner in Mayo Clinic.

FIGURE 1-2 First-generation model of a CT head scan-ner. (Courtesy Thorn EMI, London, United Kingdom.)

# Comparison of Conventional CT with Spiral CT

**Conventional** In conventional CT, a series of equally images is acquired

- Tube rotates around stationary patient (Table is incremented between acquisitions)
- All views in a slice are at same table position
- Power to X-ray tube via cord
- Scan CW and CCW to wind/unwind cord
- Interscan delays: 3.5 seconds between slices

**Helical (Spiral) Scan**

- Continuous tube rotation
- No interscan delays
- Power to X-ray tube via slip ring
- Continuous table motion as tube rotates
- Each view is at a different table position

Form images by synthesizing projection data via interpolation

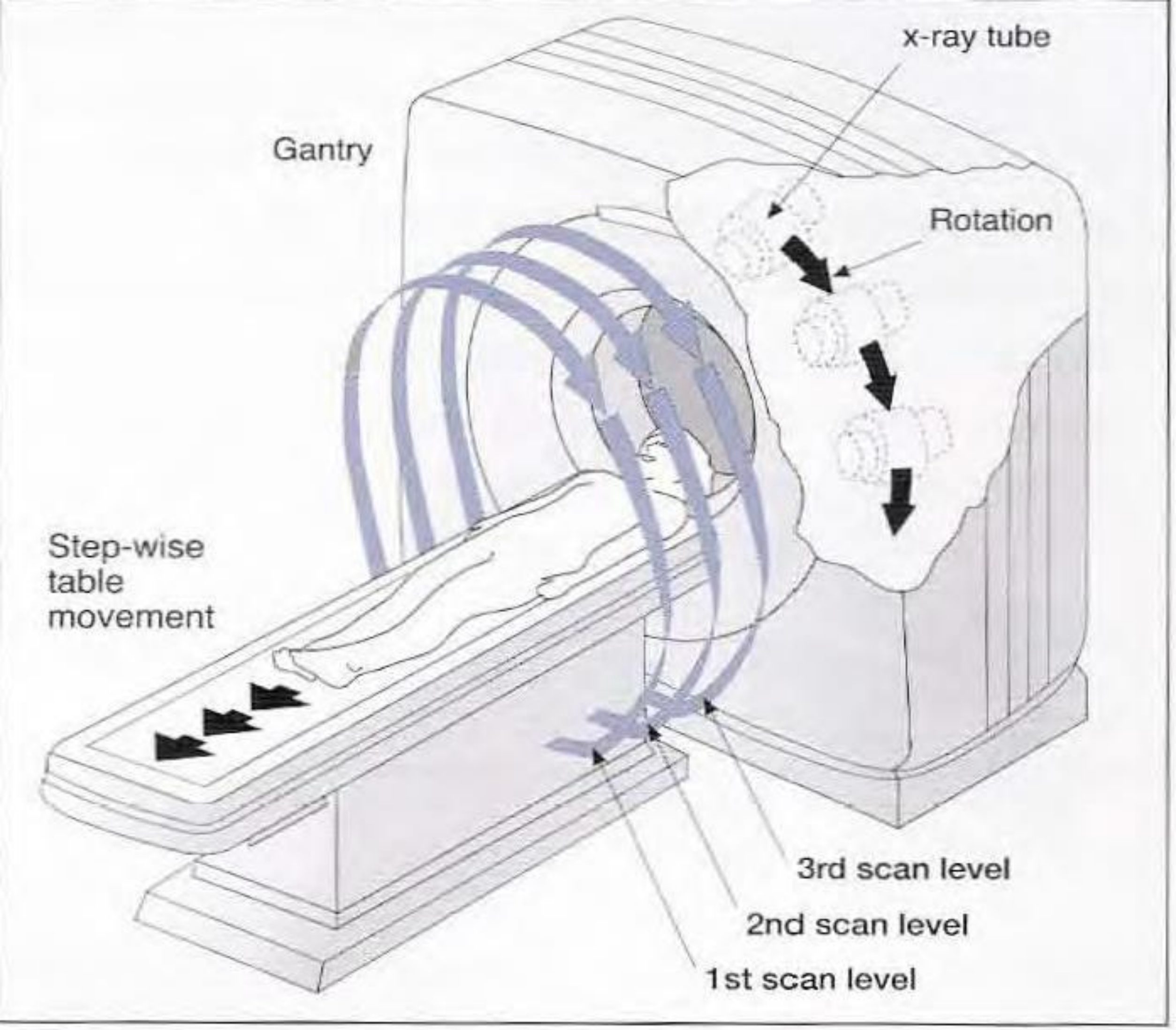


Fig. 7.1

**Conventional CT**

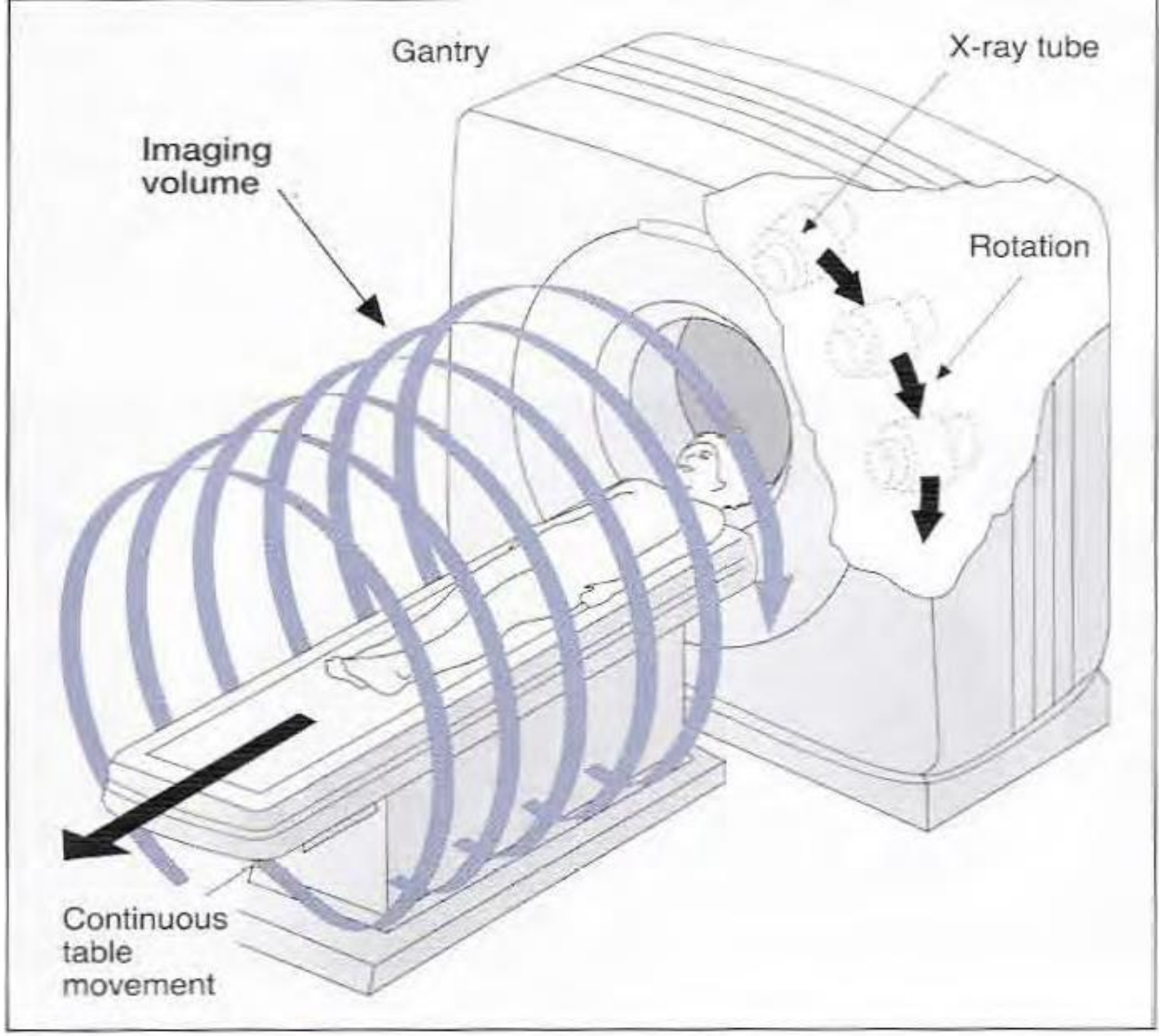


Fig. 7.2

**Helical(Spiral) CT**

# CT Components

## *gantry*

-The gantry is the ring-shaped part of the CT scanner. It houses many of the components necessary to produce and detect x-rays .

Components are mounted on a rotating scan frame. Gantries vary in total size as well as in the diameter of the opening, or aperture.

-The range of aperture size is typically 70 to 90 cm.

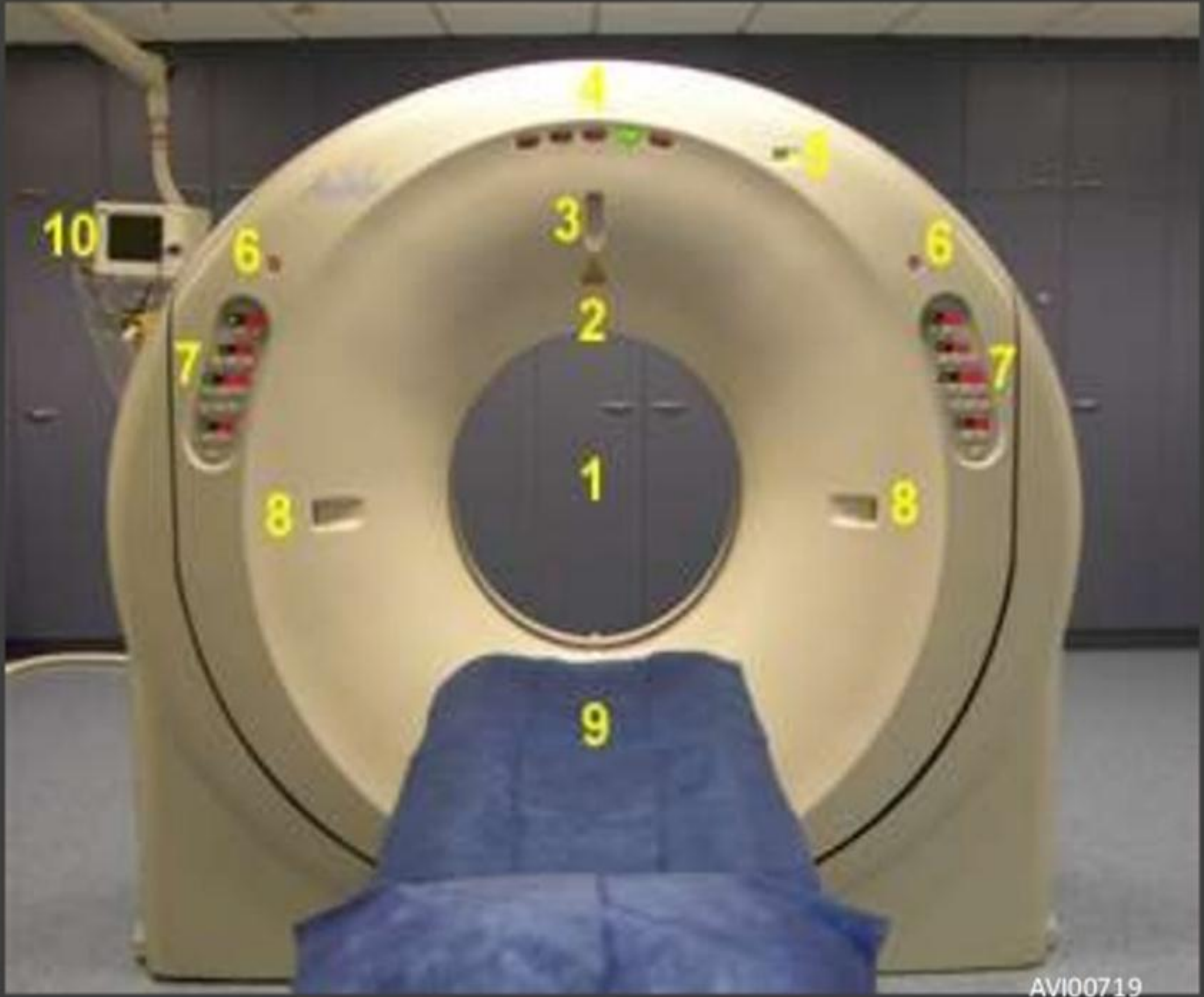
-The CT gantry can be tilted either forward or backward as needed to accommodate a variety of patients and examination protocols. The degree of tilt varies among systems, but ±15° to ±30° is usual.

The gantry also includes a laser light that is used to position the patient within the scanner.

-Control panels located on either side of the gantry opening allow the technologist to control the alignment lights, gantry tilt, and table movement. In most scanners, these functions may also be controlled via the operator's console.

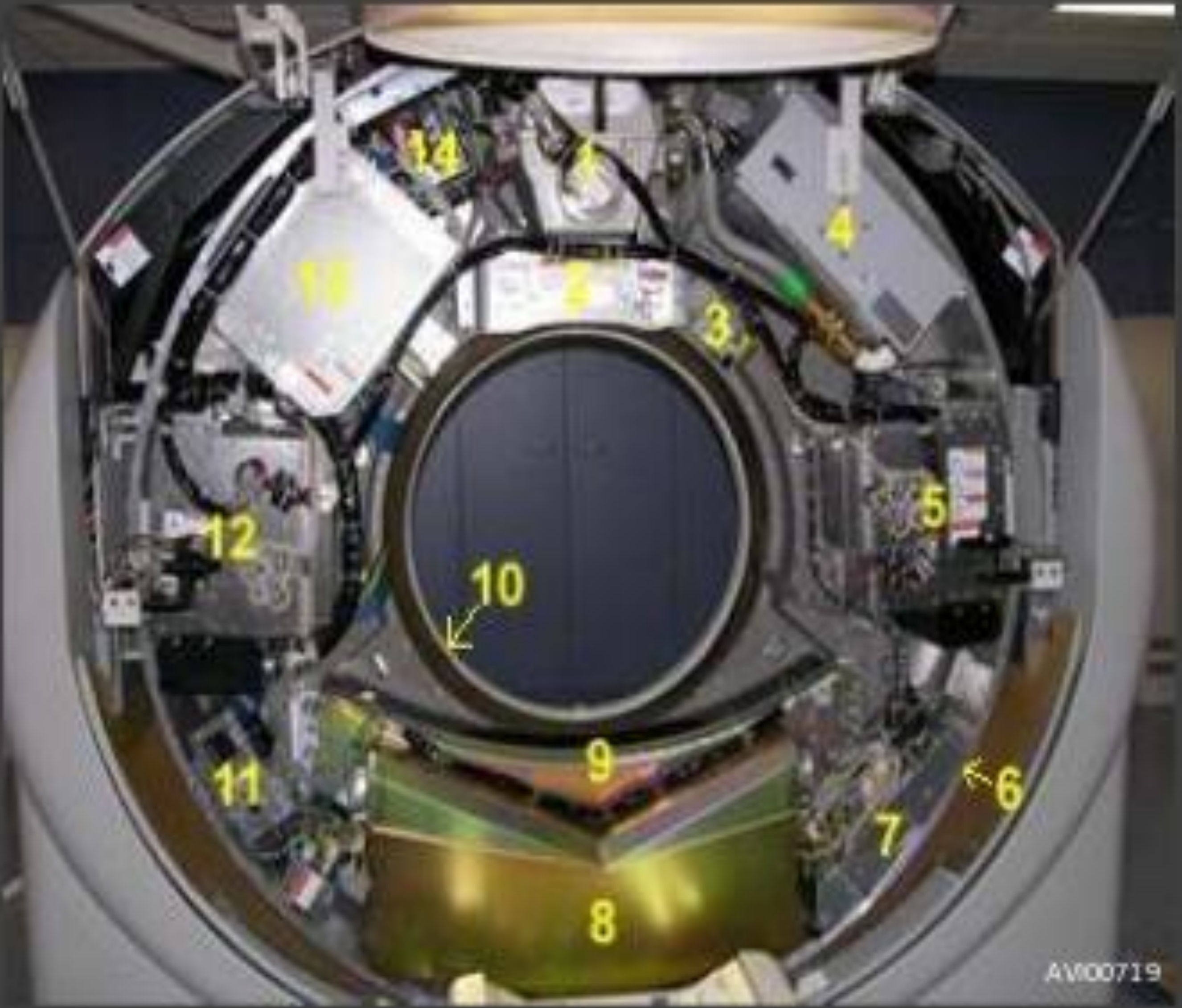
-A microphone is embedded in the gantry to allow communication between the patient and the technologist throughout the scan procedure.

# EXTERNAL APPEARANCE OF GANTRY




1.GANTRY APPERTURE
2.MICROPHONE
3.SAGITTAL LASER LIGHT ALIGNMENT
4.PATIENT GUIDE TABLE
5.X-RAY EXPOSURE INDICATOR LIGHT
6.EMERGENCY STOP BUTTOM
7.GANTRY CONTROL PANNEL
8.EXTERNAL LASER ALIGNMENT LIGHT
9.PATIENT COUCH
10.ECG GATING MONITOR

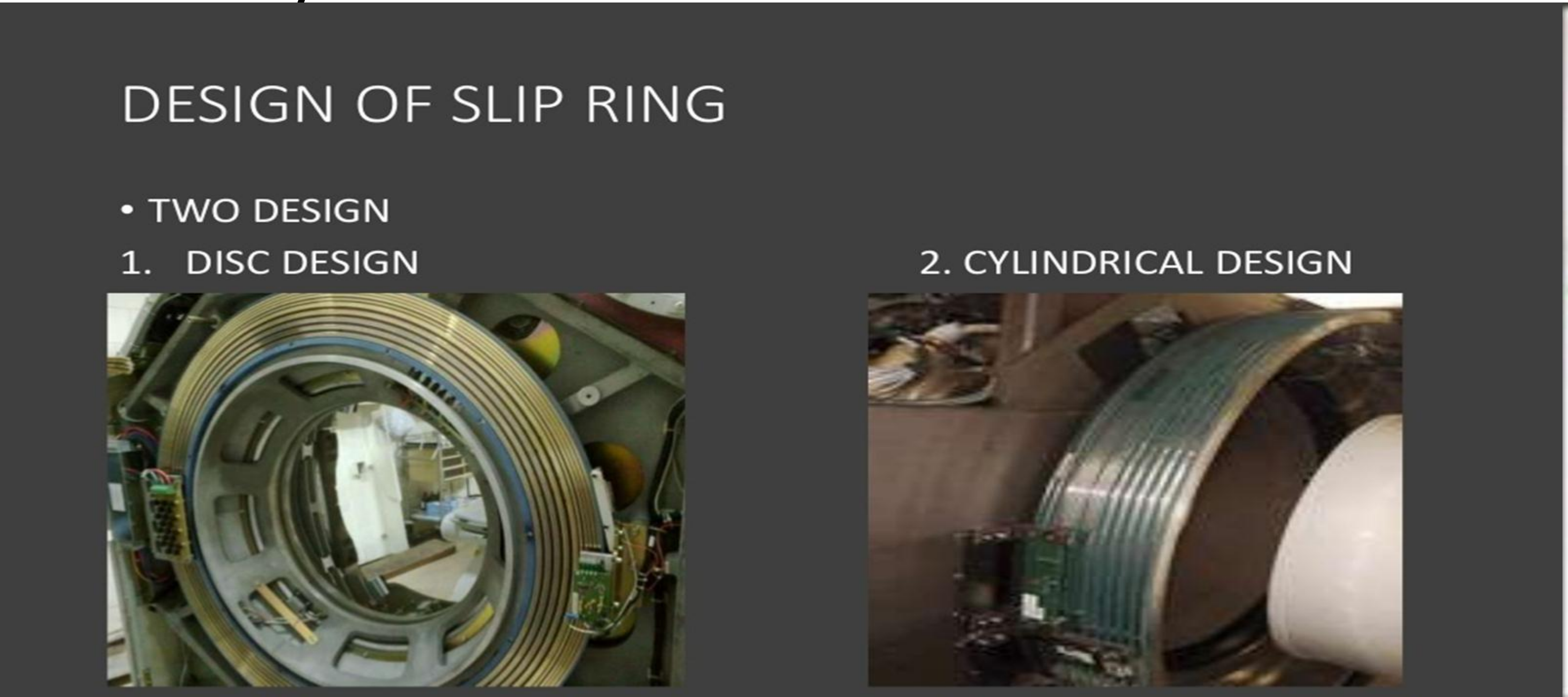
# INTERNAL APPEARANCE OF GANTRY

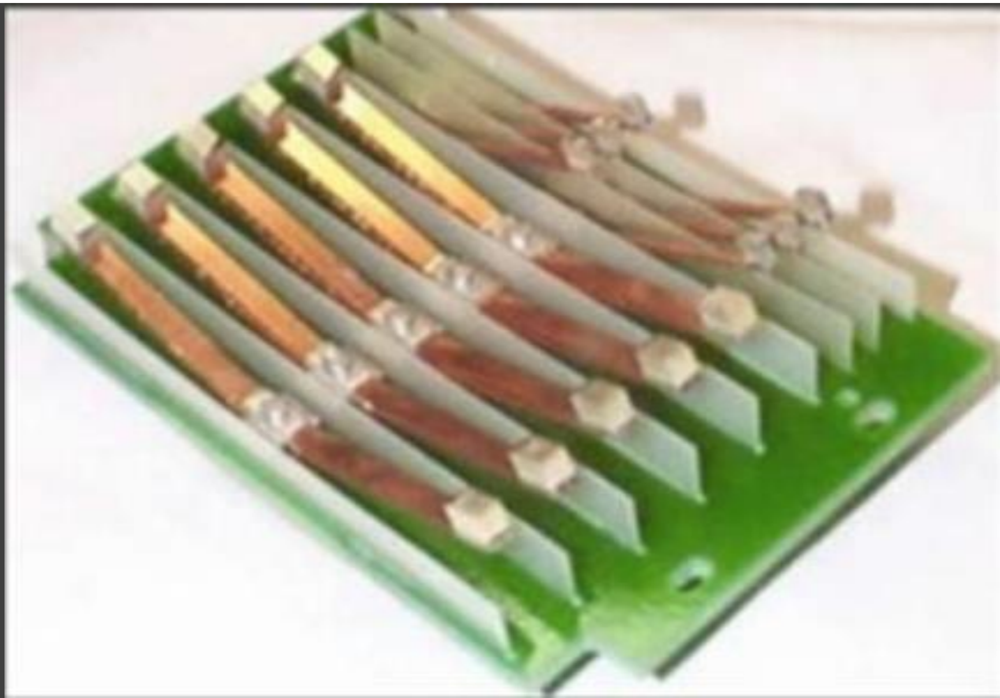



1. X-RAY TUBE
2. FILTER,COLLIMATOR,
3. INTERNAL PROJECTOR
4. OIL COOLER
5. HIGH VOLTAGE GENERATOR(0-75kv)
6DIRECT DRIVE GANTRY MOTOR
7. ROTATION CONTROL UNIT
8. DAS
9. DETECTOR
10. SLIP RING
11. DETECTOR COTROL UNIT
12. HVG (75-150 KV)
13. POWER UNIT
14. LINE NOISE FILTER

# Slip Rings

Early CT scanners used recoiling system cables to rotate the gantry frame. This design limited the scan method to the step-and-shoot mode and considerably limited the gantry rotation times. Current systems use electromechanical devices called slip rings. Slip rings use a brush like apparatus to provide continuous electrical power and electronic communication across a rotating surface. They permit the gantry frame to rotate continuously, eliminating the need to straighten twisted system cables.



# Generator

High-frequency generators are currently used in CT. They are small enough so that they can be located within the gantry. Highly stable three-phase generators have also been used, but because these are stand-alone units located near the gantry and require cables, they have become obsolete.

Generators produce high voltage and transmit it to the x-ray tube. The power capacity of the generator is listed in kilowatts (kW).

The power capacity of the generator determines the range of exposure techniques (i.e., kV and mA settings) available on a particular system.

CT generators produce high kV (generally 120–140 kV) to increase the intensity of the beam, which will increase the penetrating ability of the x-ray beam and thereby reduce patient dose. In addition, a higher kV setting will help to reduce the heat load on the x-ray tube by allowing a lower mA setting. Reducing the heat load on the x-ray tube will extend the life of the tube.

## ***Cooling Systems***

Cooling mechanisms are included in the gantry.

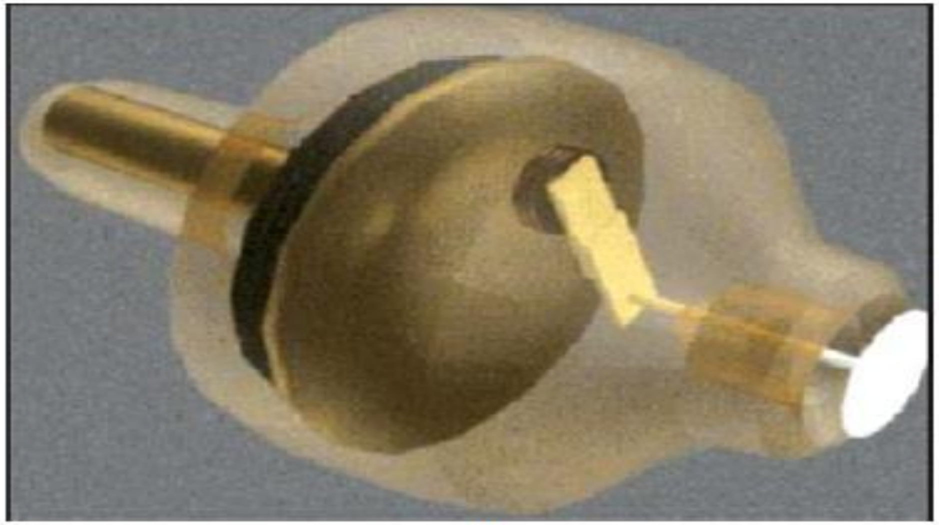
They can take different forms, such as blowers, filters, or devices that perform oil-to-air heat exchange.

Cooling mechanisms are important because many imaging components can be affected by temperature fl uctuation.

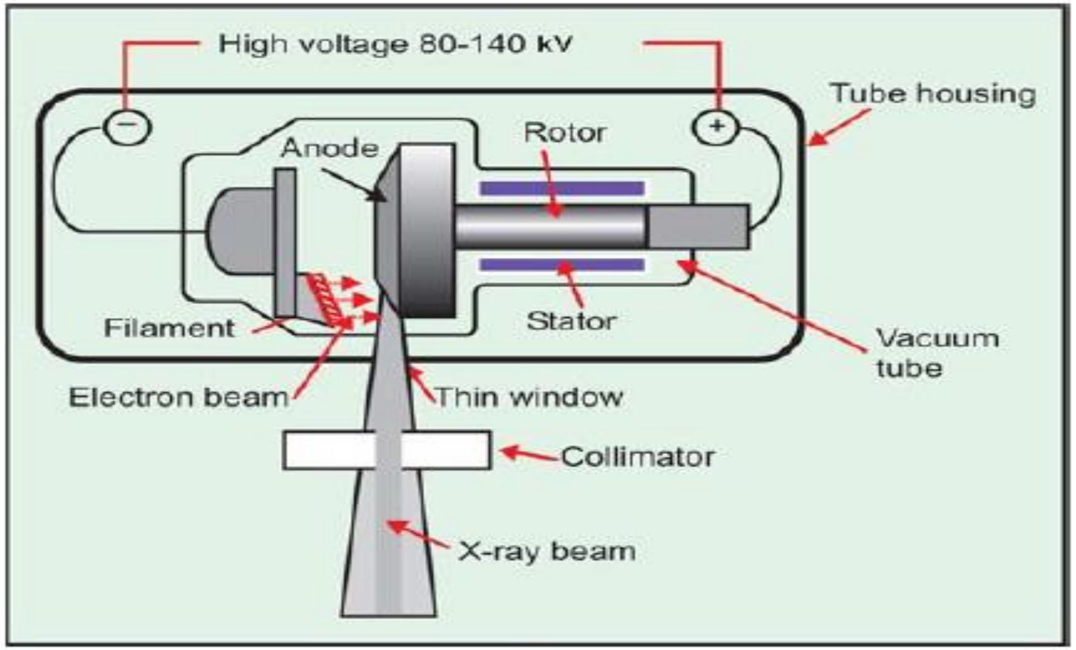
# X-ray Source

X-ray is produced by an X-ray tube. The three main parts of any X-ray tube are the anode, cathode and the filament. When the filament is heated, electrons are ejected from its surface. A large voltage between the cathode and the anode force electrons to accelerate towards the anode. The electrons hitting the anode (tungsten) produce Bremstrahlung radiation at an efficiency of only 1 percent. The other 99 percent of the electrons energy is converted into heat. Most modern system use tubes with two focal spots small spot is used for high resolution examination. And large spot is used for larger anatomic coverage.

*Stationary anode*—Used in eary scanners, oil cooled, large focal spot giving rise to higher potential radiation.
*Rotating anode*—Aircooled, small focal spot requires large heat capacity and fast cooling rates.
*Mechanical stresses due to tube rotation*—Up to 13 G for 0.5 second rotation.



A




B

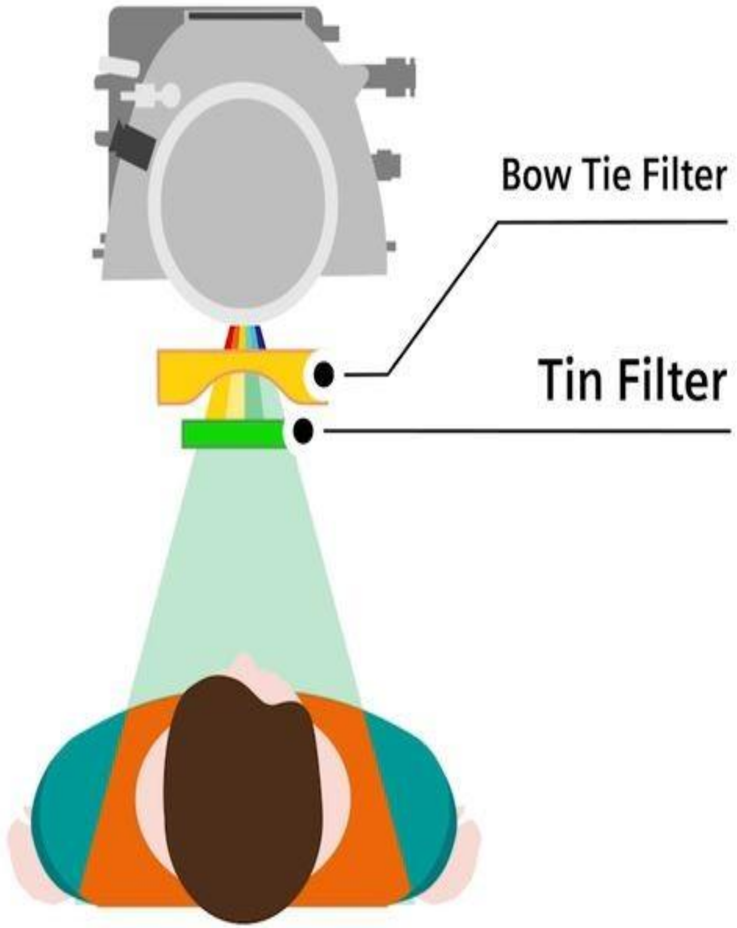
**Figs 1.8A and B:** (A) Rotating anode; (B) Conventional tube

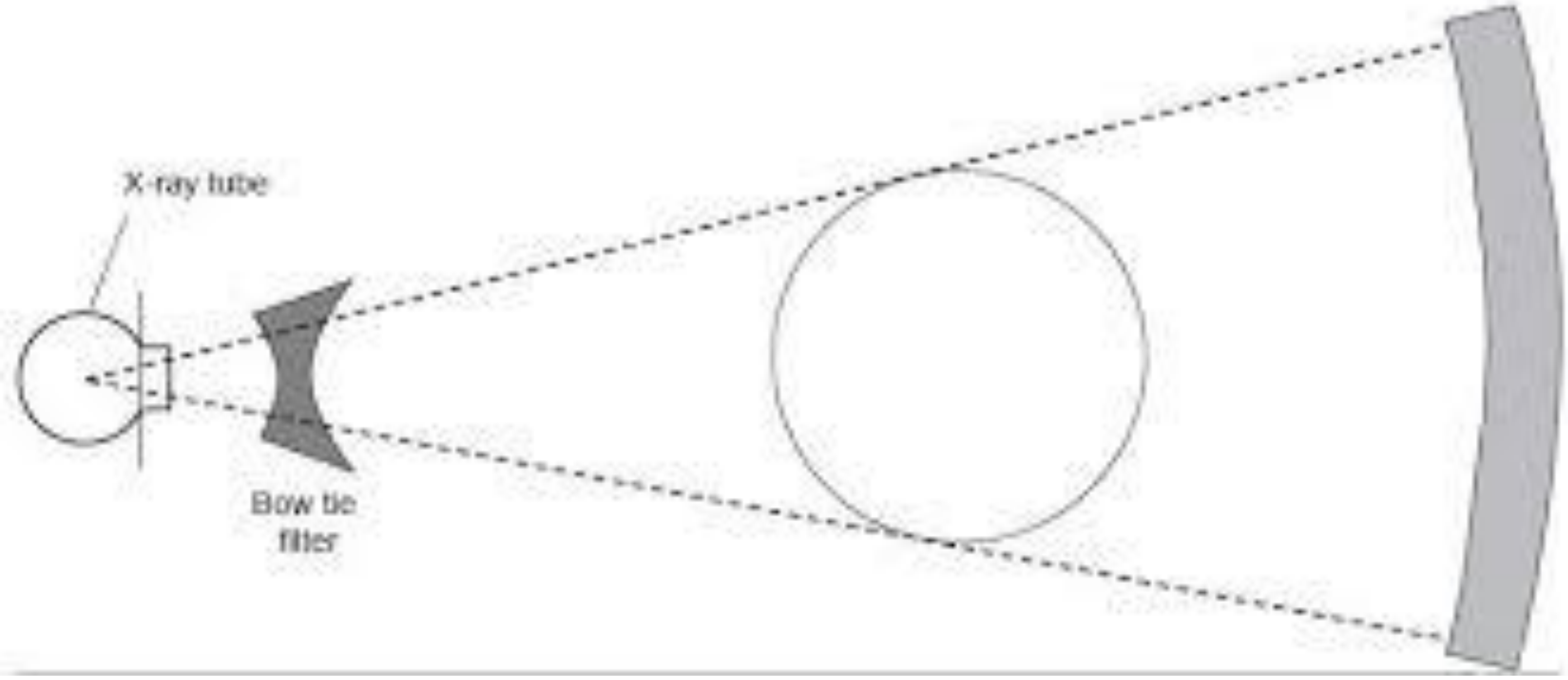
# Filtration

There are two types of filtration utilized in CT.

**Mathematical filters** such as bone or soft tissue algorithms are included into the CT reconstruction process to enhance resolution of a particular anatomical region of interest.

**Inherent tube filtration and filters made of aluminium or Teflon** are utilized in CT to shape the beam intensity by filtering out low energy photons that contribute to the production of scatter. Special filters called "bow-tie" filters absorb low energy photons before reaching the patient. X-ray beams are polychromatic in nature which means an Xray beam contains photons of many different energies. Ideally, the X-ray beam should be monochromatic or composed of photons having the same energy. Heavy filtration of the X-ray beam results in a more uniform beam. The more uniform the beam, the more accurate the attenuation values or CT numbers are for the scanned anatomical region. Provides for a equal photon distribution across the X-ray beam. Allows equal beam hardening were the X-ray passes through the filter and object. Lessens overall patient dose by removing softer radiation. Made of aluminium, grafite can be curved, wedge or flat in shape.


Bow Tie Filter
Tin Filter


X-ray tube
Bow tie
filter

# Collimation

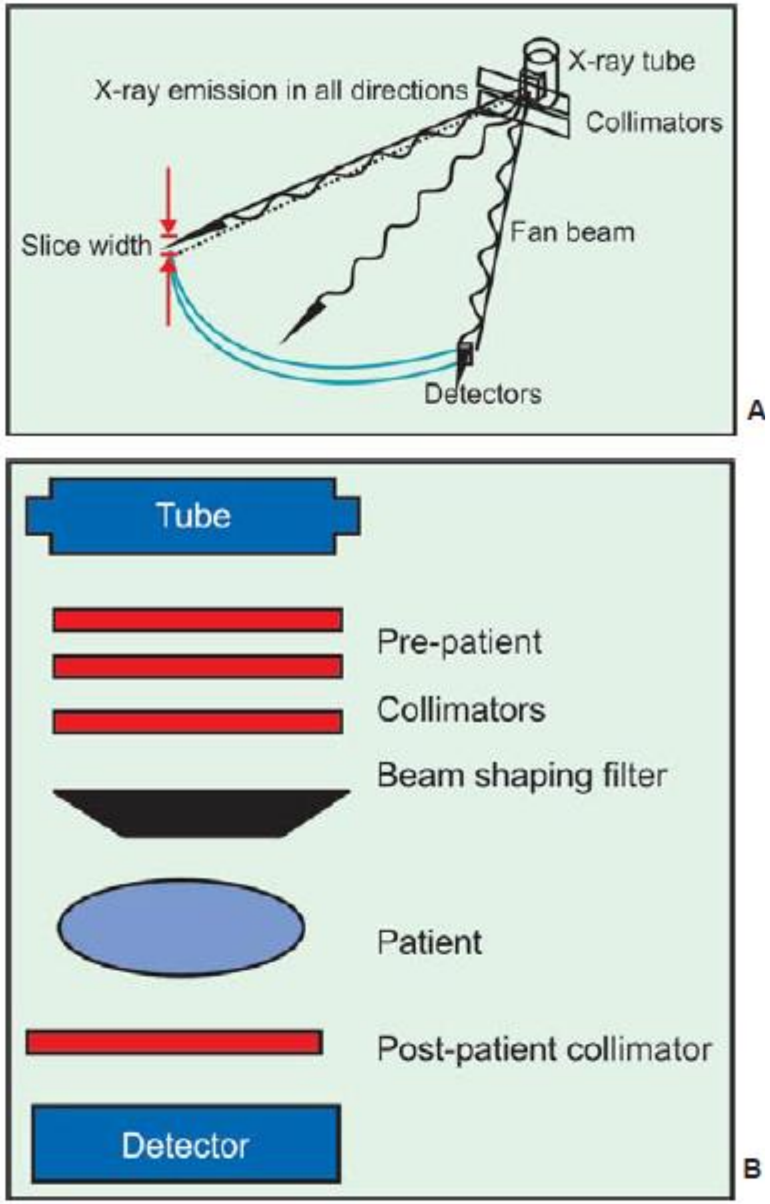
***Pre-patient collimation***

- Depends on the focal spot size
- Mounted on the tube housing
- Creates more parallel beam
- Reduces patient dose

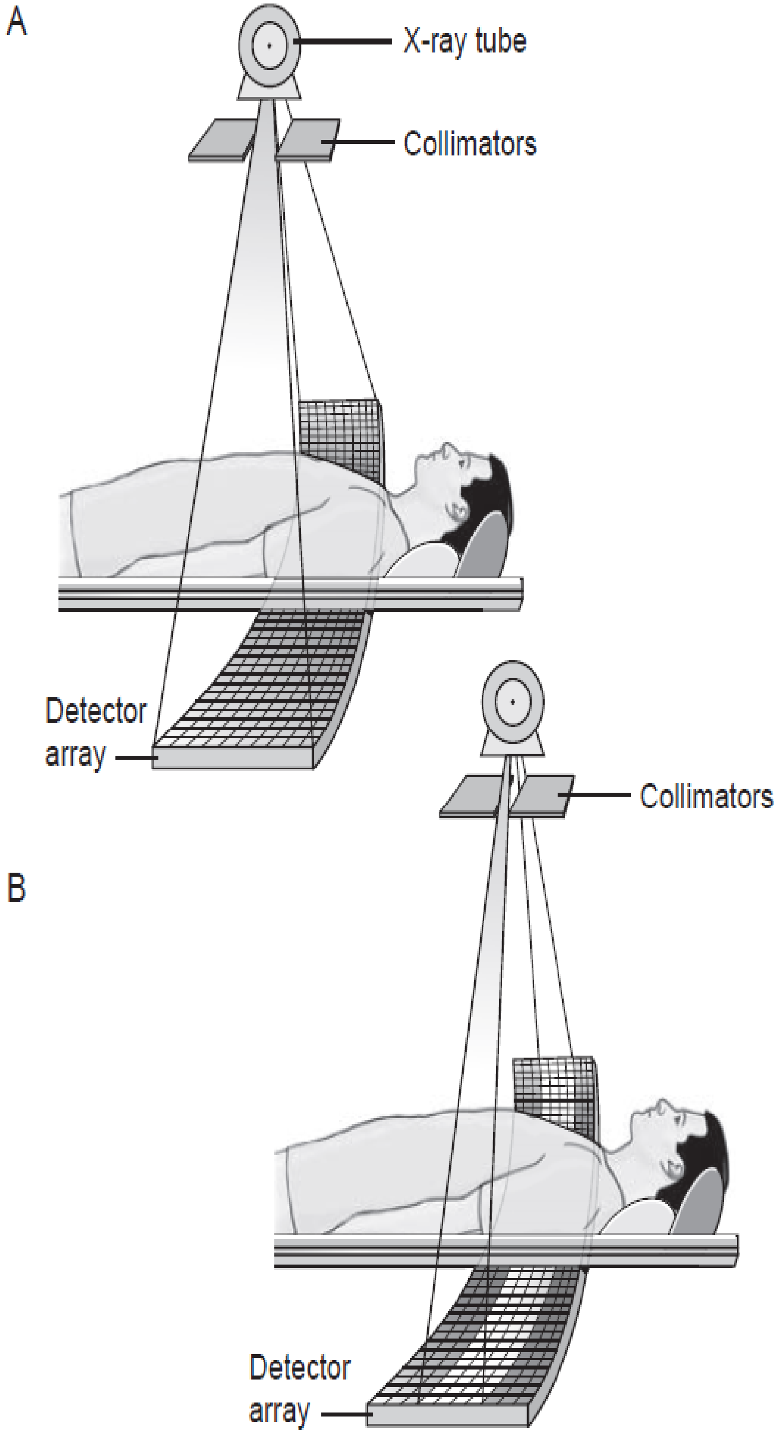
***Pre-detector collimation***

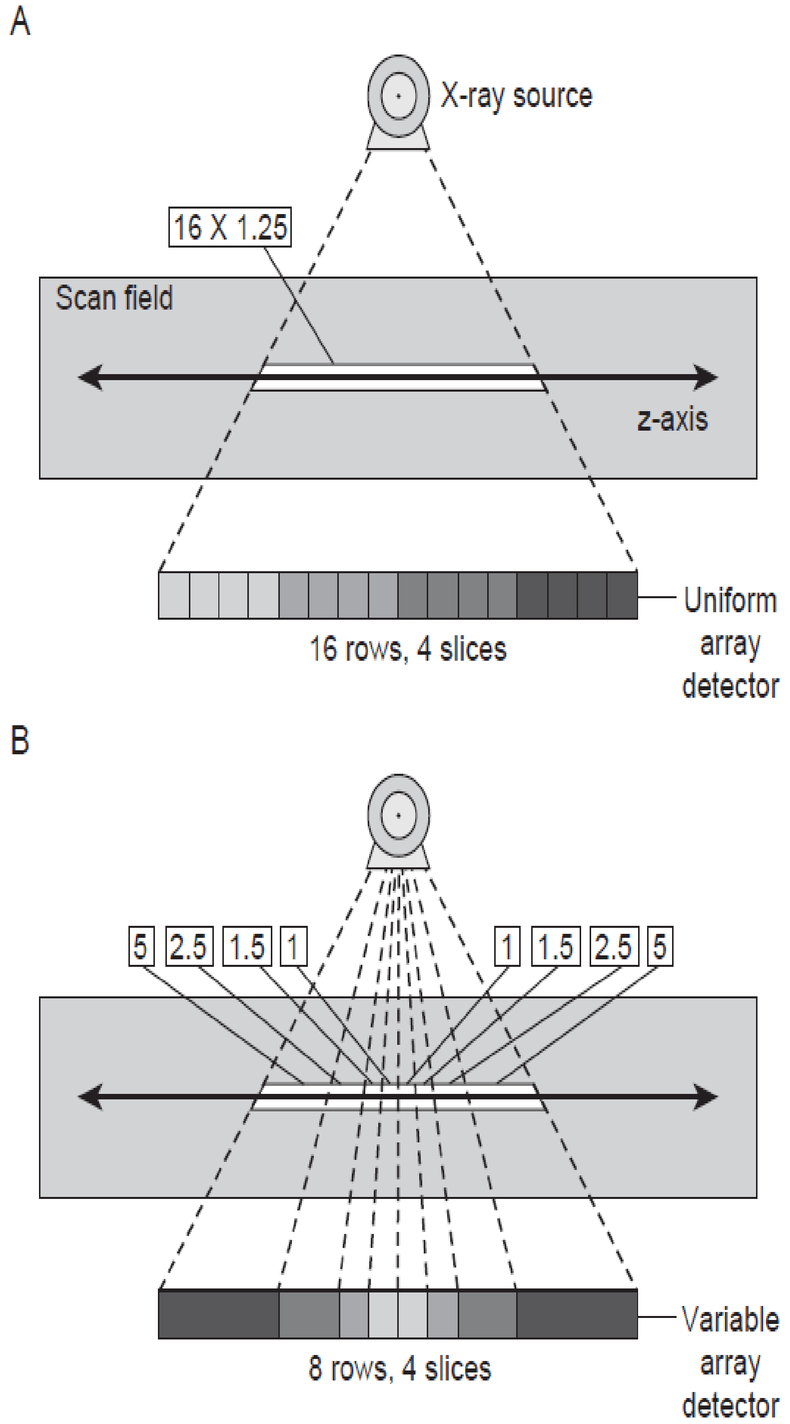
- Restricts the field of view of detectors
- Reduces the scatter radiation on the detector
- Aperture width helps determine the slice thickness

The X-ray field is filtered to reduce the low energy X-rays which are not useful for imaging but that increase the radiation dose received by the patient.
This process is called collimation.
The beam undergoes two-levels of collimation:
(1) source collimation, and (2) detector collimation.
The source collimator controls the thickness of the
tomographic slice (most common thickness are 1, 2,5 or 10 mm).




**Figs 1.9A and B:** Schematic diagram showing the relationship between detectors and collimators



# Detectors

Detectors gather information by measuring the X-ray attenuation through objects.
The most important properties of X-ray detectors
used in CT are:
a. Efficiency
b. Response time (after glow)
c. Linearity
Efficiency is related to the number of X-rays reaching the detector that are detected.
Response time is related to how fast the detected X-ray is converted into an electrical pulse or current.
Linearity is related to the proportionality between the output of the detector and the number of incident X-rays.
.

# The two types of detector that have been used for CT are:

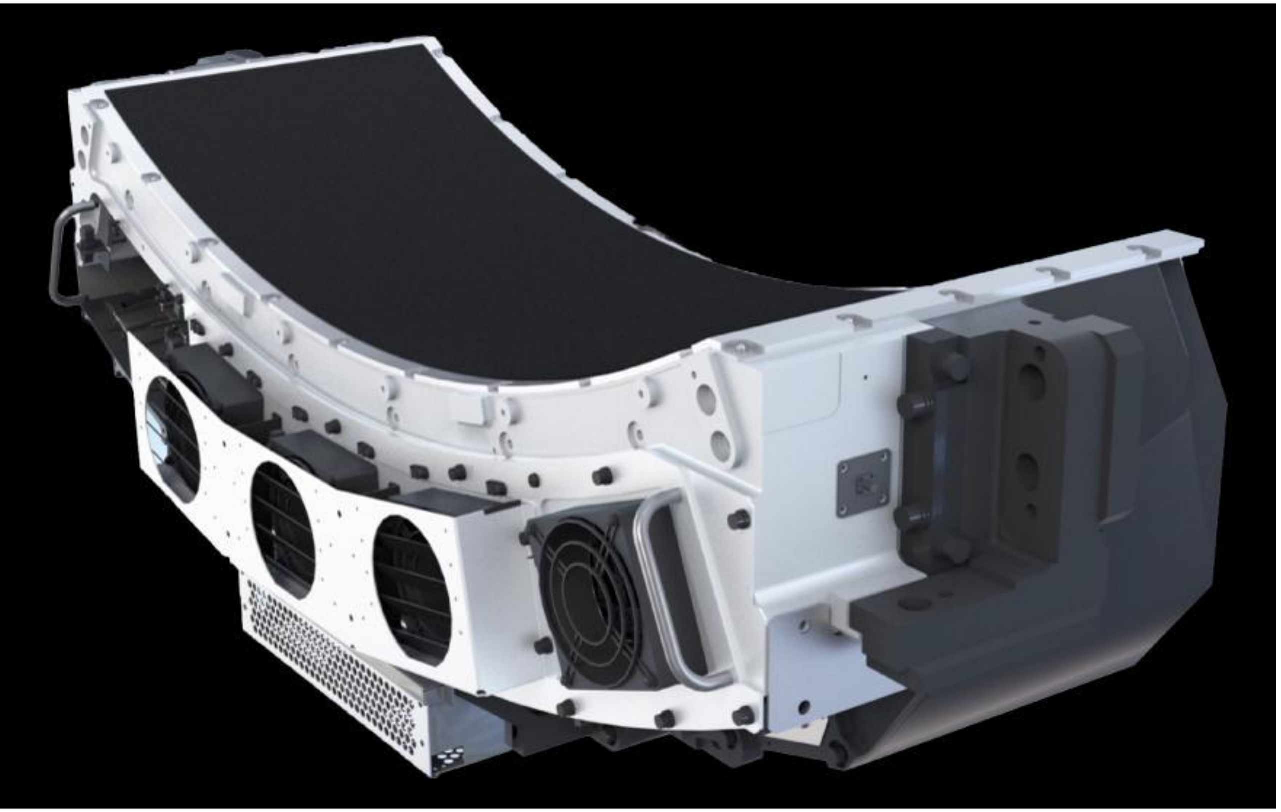
- ***Solid-State Crystal Detector***

Solid-state detectors are also called scintillation detectors because they use a crystal that fluoresces when struck by an x-ray photon. A photodiode is attached to the crystal and transforms the light energy into electrical (analog) energy. The individual detector elements are affi xed to a circuit board (Fig. 2-5). Solid-state crystal detectors have been made from a variety of materials, including cadmium tungstate, bismuth germinate, cesium iodide, and ceramic rare earth compounds such as gadolinium or yttrium. Because these solids have high atomic numbers and high

- ***Xenon Gas Detectors***

Pressurized xenon gas fills hollow chambers to produce detectors that absorb approximately 60% to 87% of the photons that reach them. Xenon gas is used because of its ability to remain stable under pressure. Compared with the solid-state variety, xenon gas detectors are significantly less expensive to produce, somewhat easier to calibrate, and are highly stable.

A xenon detector channel consists of three tungsten plates. When a photon enters the channel, it ionizes the xenon gas. These ions are accelerated and amplified by the electric fi eld between the plates. The collected charge produces an electric current. This current is then processed as raw data. A disadvantage of xenon gas is that it must be kept under pressure in an aluminum casing. This casing filters the x-ray beam to a certain extent. Loss of x-ray photons in the casing window and the space taken up by the plates are the major factors hampering detector efficiency.



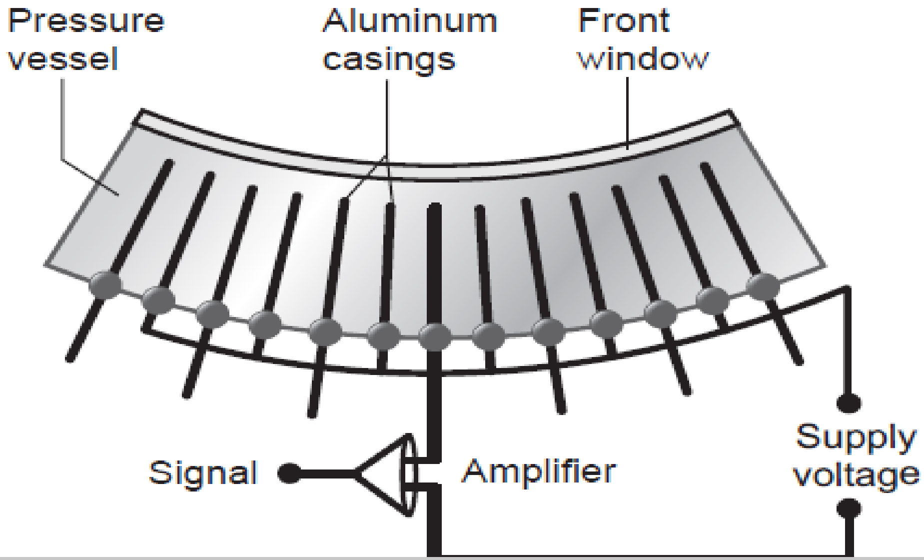



**FIGURE 2-4** Structure of a xenon gas detector array.

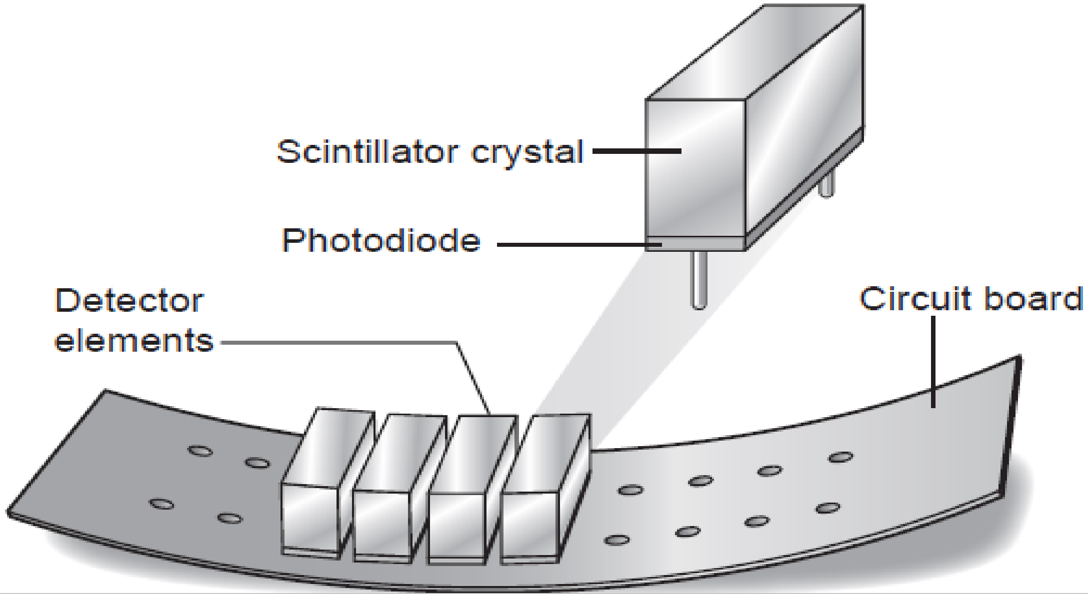
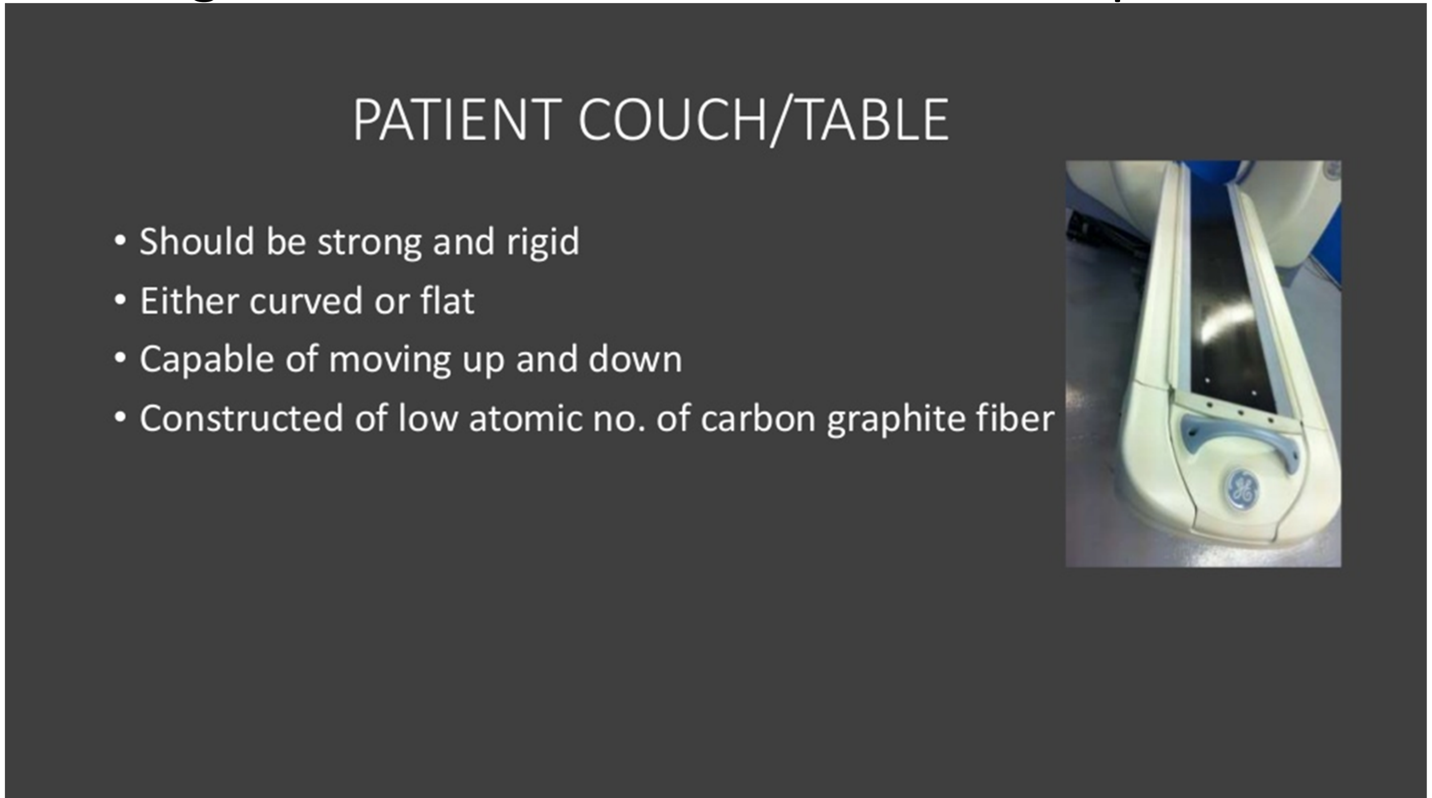



**FIGURE 2-5** Structure of a solid-state detector array.

# Table

The patient lies on the table (or couch, as it is referred to by some manufacturers) and is moved within the gantry for scanning. The process of moving the table by a specified measure is most commonly called incrementation, but is also referred to as feed, step, or index.

Helical CT table incrementation is quantified in millimeters per second because the table continues to move throughout the scan. The degree to which a table can move horizontally is called the scannable range, and will determine the extent a patient can be scanned without repositioning.



# Operator Console (OC)

## Function

The operator console (OC) is mainly used for the operator to set up the scan procedures and process the resultant image data.

### Scan Console

- Technical factors, slice thickness, no of scans, angle of gantry.
- Initiates scan, record patient data, sets FOV.

### Display Console

- Used to manipulate post scan data,
- Post processing work—measurements, MIPS, 3D formations.
- Window level and width.
- Scan/display monitor: The 17 inch monitor (21 inch optional) on the OC can be mainly used for two purposes, scanning patients and displaying images.
- Keyboard/Mouse:
- Main switch:
- CD-ROM drive: This drive is dedicated to service of application software installation.
- MOD (Magnetic Optical Disk) drive (optional): Image data can be stored in 5 inch MOD

# OPERATOR CONSOLE

- Permits control of all scan parameter
- Commands computer to reconstruct and transfer of image data for storage in data file
- pre-programed with kvp & mA
- Has three console