

# READING HOSPITAL SCHOOL OF HEALTH SCIENCES MEDICAL IMAGING PROGRAM

## BASICS OF CT--2021



### *System Operation and Instrumentation*

Mrs. Herb B.S., R.T. (R)(M)(ARRT)

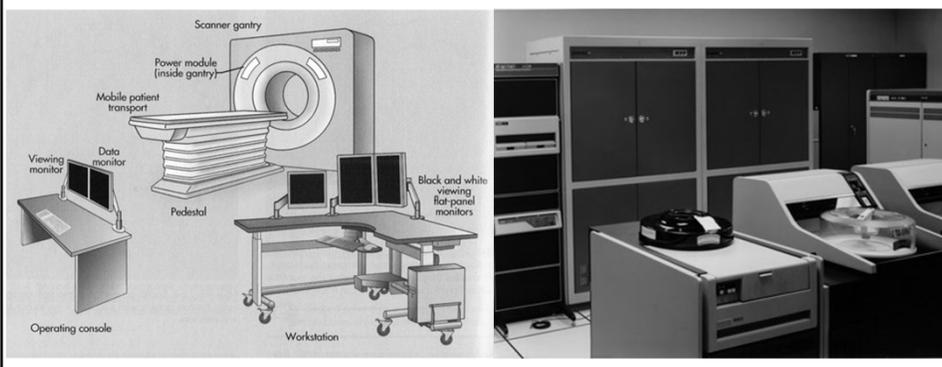
1

## Components of the CT System

Operating Console

Computer

Gantry



2

## Operating Console (*Display Console*)

Key point of interaction between technologist and imaging system (how the technologist and system communicate)

❖ **Graphical Monitors**: *Technologist Console, Work Stations for Reconstruction, Physicians Work Station*

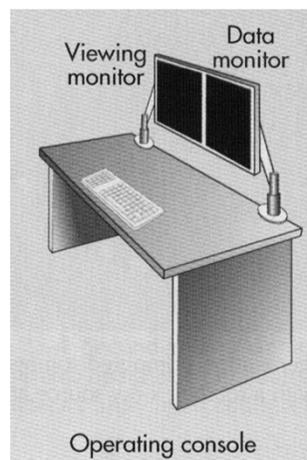
❖ **Keyboard**



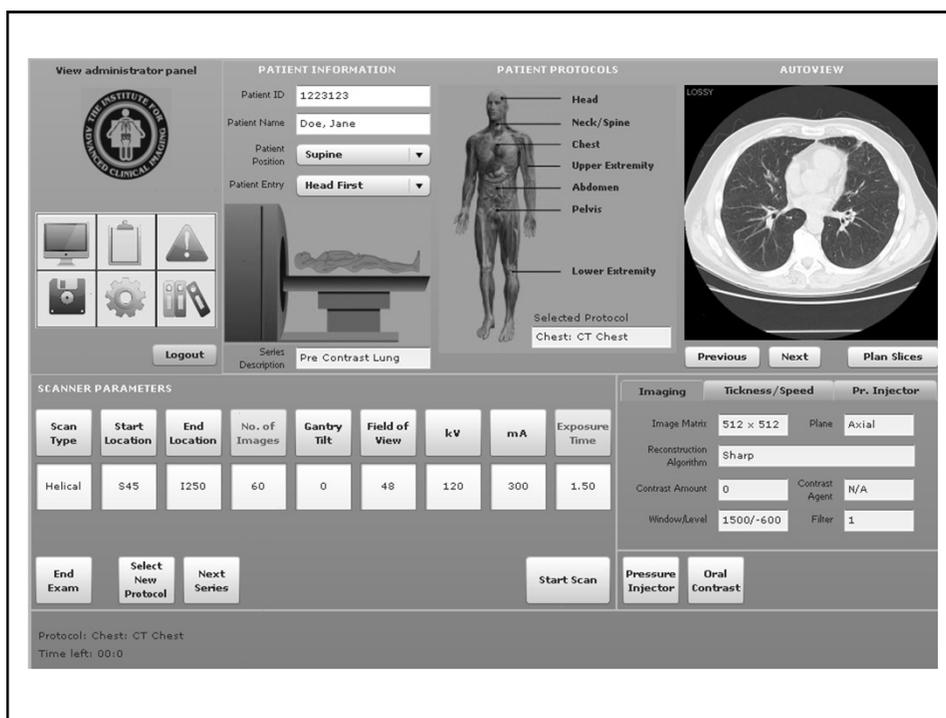
3

## Operating Console (*Display Console*)

1. Annotation of patient data
2. Identification for each image
3. Adjust various imaging parameters
4. Allows viewing of resulting image before transfer to hard copy or a PACS system for the Physician to view



4



5

## “Host” Computer

Primary link between technologist and imaging system (connection is made between the technologist and system)

- hard drives, archiving, and networking
- Mathematical equations solved
- Reconstruction time – The time between the end of imaging and the appearance of an image
  - Array Processor
- Retrieving capabilities
  - Can be networked



6

## “Host” Computer

### *Archiving*

- Optical disk/Optical tape
- Magnetic disk (floppy disk)/tape
- Film/CD/Digital videotape
- PACS



7

## “Host” Computer

### *Other capabilities:*

- Quality assurance checks
- Calibration checks
- Record system issues to the service engineer



8

# “Host” Computer

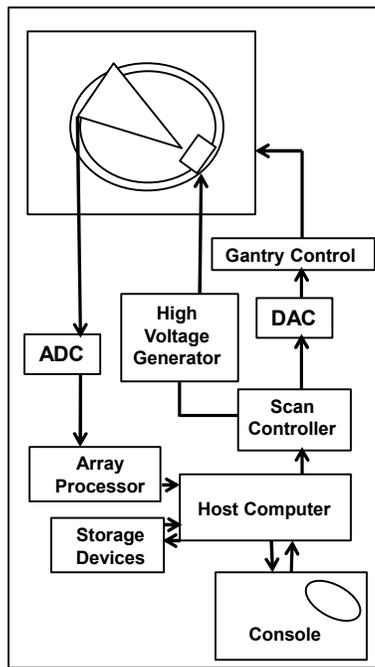
2 Types of Information:

## Analog

- Continuous wave pattern used by machinery
  - Gantry, table

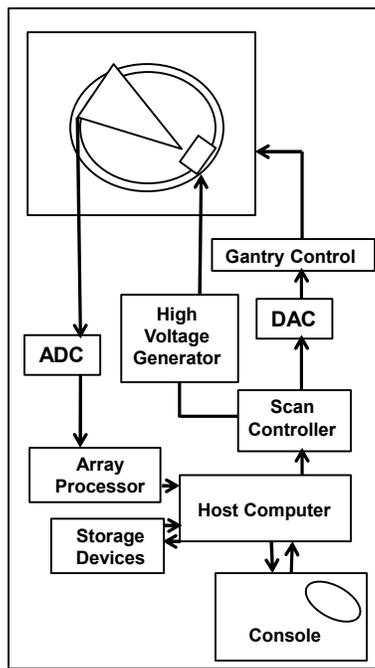
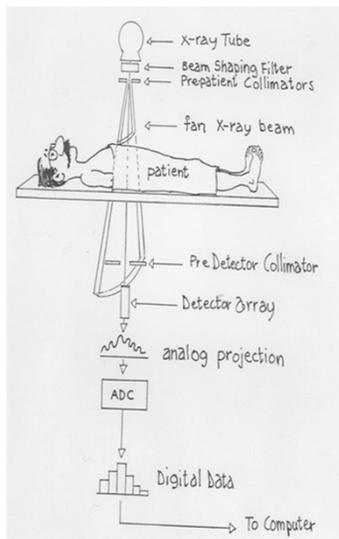
## Digital

- Discrete number used by computers



9

# “Host” Computer



10

## Gantry

### Key components:

- Slip rings and high voltage generator\*
  - Cooling system\*
- CT x-ray tube\*
- Detectors\*
- Collimators\*
- Table (slides through gantry)\*
- Data acquisition system
- Positioning lights
- Microphone



11

## Gantry

### *Slip rings, High voltage generator, Cooling system*

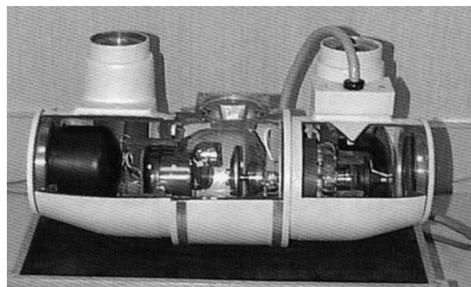
- SLIP RINGS: - brush like apparatus that allows for continuous scanning (1989)
- GENERATOR: High voltage transmitted to the x-ray tube
  - Kilowatts (kW) – determines the range of techniques
- COOLING SYSTEM: Blowers, Filters, Devices that perform oil-to-air heat exchange
  - Could produce 30 scans per exam, 10-20 exams per day = **10,000** exposures per month

12

## Gantry

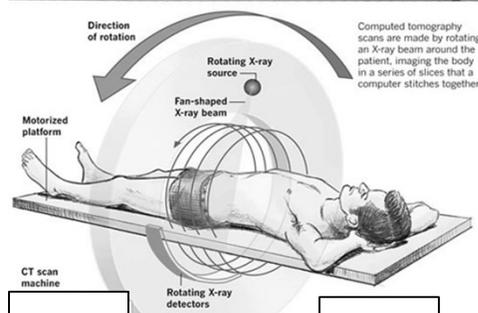
### *CT X-Ray Tube*

- Mounted on a rotating assembly
- Travels around the patient



### *Multislice Spiral CT*

- High thermal demand
  - Tube energized 60 seconds continuously



13

## Gantry

### *CT X-Ray Tube – BASICS*

- *Cathode* - Filament (thoriated tungsten wire) is heated and electrons are boiled off
  - The electrons are focused by a cup-shaped region in the cathode
  - Controlled by current in the wire (mA—milliamperere)
  - More than one wire used
    - *Larger* – Filament produces more electrons; Larger focal spot used
    - *Smaller* – Filament produces less electrons; Smaller focal spot used

14

## Gantry

### *CT X-Ray Tube*

- Focal Spot Size - ***Small***
  - Strikes a smaller region of the target (Small focal spot);  
Narrow electron beam
  - Good for thin slices and high ***spatial*** resolution imaging
    - *Spatial resolution* – ability of a system to define small objects distinctly
    - Extremities, high resolution chest, cardiac imaging
- Focal Spot Size – ***Large***
  - Used for larger scans – strikes larger portion of the anode
  - Chest, abdomen, thorax

15

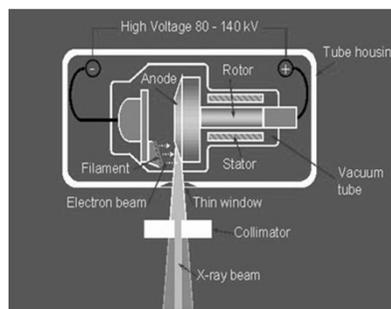
## Gantry

### *CT X-Ray Tube – BASICS (mA)*

The temperature of the filament determines how many electrons flow through the tube

- Controlled by the current in the wire (mA)
- 1 milliampere =1 mA

X-ray quantity is ***proportional*** to the number of electrons coming from the cathode



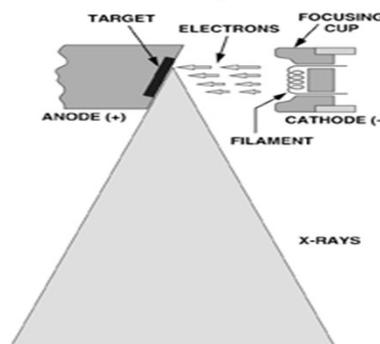
16

## Gantry

### *CT X-Ray Tube – BASICS (kVp)*

Energy level of the photons controlled by kV

- Quality of x-ray beam
- Determines the energy of the photons ability to penetrate the body
- Tube voltage (kV) controlled by the technologist



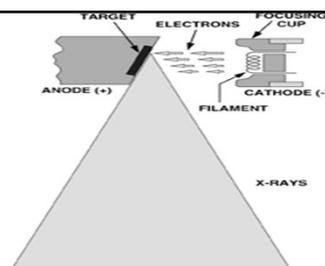
17

## Gantry

### *CT X-Ray Tube – BASICS*

#### Anode (Target)-

- High heat temperatures are generated here
- Made of tungsten alloy
- Anode rotates to minimize heat build-up on any one spot
  - Tube heating also related to the time between scans
  - Inter-scan delay occur briefly to allow cooling of the tube



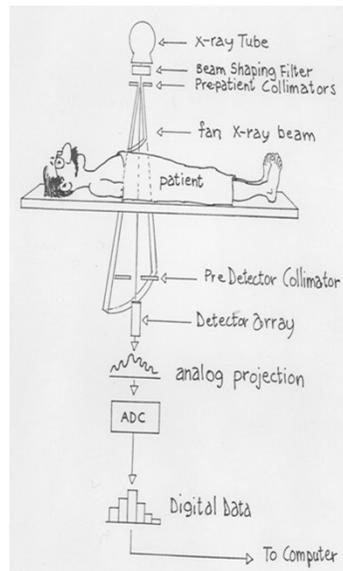
18

## Gantry

### ***Detectors***

X-ray beam passes through the patient and in CT we use detectors to collect the information.

- ***Detector Array*** –the entire collection of detectors included in the CT system
  - Situated in an arch or ring
- ***Detector*** –a single element or single type of detector used in the CT system



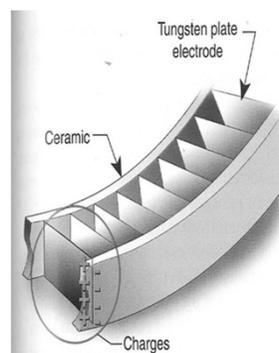
19

## Gantry

### ***Detector Types- Gas Ionizing Detector***

#### *Xenon Ionization Chambers- Gas Detectors*

- Contain xenon pressurized to 30 times normal atmospheric pressure
- Airtight chamber that is 1 millimeter wide



20

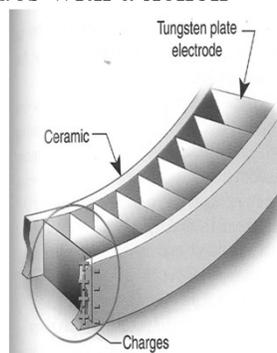
## Gantry

### *Detector Types*

#### *Xenon Ionization Chambers- Gas Detectors*

**\*\*How does this work?**

- Signal is produced when a photon collides with a xenon atom
- Impulse is amplified and sent to the data acquisition system
- Digitized by the analog to digital converter (ADC) and sent to the array processor to construct the image



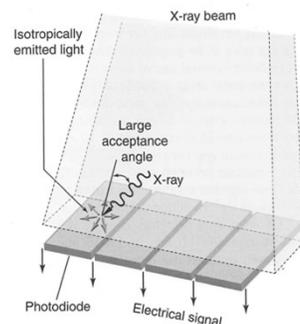
21

## Gantry

### *Detector Types*

#### *Solid State Crystal OR Scintillation Detector*

- Used in all helical and MSCT scanners
- Detector Material = solid crystalline
  - ***Cadmium Tungstate***
    - More dense than xenon gas
    - More sensitive to incoming x-rays at various angles



22

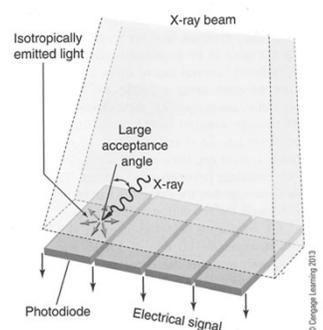
## Gantry

### *Detector Types*

#### Solid State Crystal OR Scintillation Detector

**\*\*How does it work?**

- An X-ray photon is detected by the solid state material
- Reaction between the photon and the crystal creates a flash of light
- Light is converted into usable electrical signal which is amplified and sent to the data acquisition system and digitized to be reconstructed into an image



23

## Gantry

### *Detector Types*

#### Solid State Crystal OR Scintillation Detector

Advantages:

- Smaller and cheaper
- Less positioning limitations
- More sensitive
  - 90% detection of x-rays to detector being absorbed

24

## Gantry

### ***Detector – Important Characteristics***

- Capture Efficiency – How well the detectors receive photons from the patient
- Absorption Efficiency – How well the detectors convert/absorb incoming x-ray photons
- Conversion Efficiency – Determined by how well the detector converts the absorbed photon information to a digital signal for the computer

25

## Gantry

### ***Detector – 4 conditions needed for detection***

- Photons needs to enter the detector
- Photon needs to collide with an atom
- Conversion (light or ion) is produced
- Amplification of the signal occurs

26

# Gantry

## ***Collimation***

### Function

- Restrict the x-ray beam to a specific area reducing scatter radiation.
  - Limits photons to area of interest
  - Improves contrast resolution; decreases patient dose
- Controls slice thickness

### 2 Types of Collimation:

- Pre-patient
- Post-Patient (pre-detector collimation)

27

# Gantry

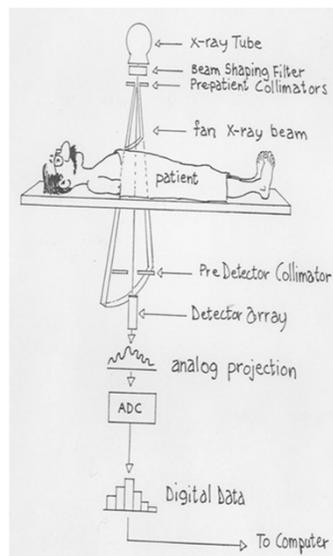
## ***Collimation***

### Pre-patient collimation

- Found between the tube and the patient
- Used to choose slice thickness by widening or narrowing the beam
- Reduces the patient's dose

### Post-patient collimation (pre-detector)

- Found between patient and detector
- Stops scatter radiation from entering the detector
- Works with pre-patient to better define slice thickness and reduce scatter from reaching the detector



28

## Patient Table

### *Characteristics*

- Referred to as a “couch”
- Flat or curved
- Made of carbon graphite fiber (decreases beam attenuation)
- Able to support entire weight while fed through the gantry



29

## Patient Table

### *Movement*

#### *Serial scan / Conventional*

- Table stops and image is taken
- Table moves for the next slice acquisition
- Table stops and image is taken

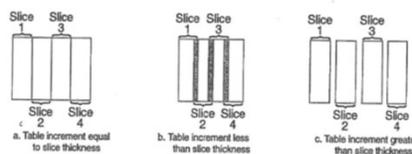


Fig. 3-9

a: To get contiguous slices, the table increment must be equal to the slice thickness.

b: If the table increment is less than the slice thickness, the slices will overlap.

c: If the table increment is greater than the slice thickness, there will be gaps between the slices.

#### *Helical and scout images*

- Continuous table movement

From ASRT CT Modules

30

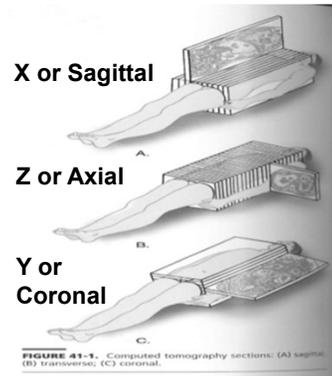
## Patient Table

### *Coordinates*

Patient is landmarked in X and Y Coordinates

- X = width (Left to right); Sagittal
- Y = height (Anterior to posterior); Coronal

**\*\*Z = Axis; Determines the thickness of the slice**



**FIGURE 41-1.** Computed tomography sections: (A) sagittal, (B) transverse, (C) coronal.

From Principles of Radiologic Imaging by Carlton

31

## Patient Table

*Scout Image/ Localizer scan*

AP or PA

- Tube in 0 degree position

Lateral

- Tube in 90 degree position



32

## Power Injector

Automatically delivers IV contrast to patient during CT scan

### Programmable Features

- Amount of contrast
- Rate of injection (cc/sec)
- Pressure
  - Can be decreased for smaller gauge needles
  - Can be increased for central lines



33

## Power Injector

### Single Power Injector

- Contrast only

### Dual Power Injector

- Combination of contrast and saline
- Can be delivered separately or simultaneously
  - Used to decrease the amount of contrast needed and also used to push it through quicker

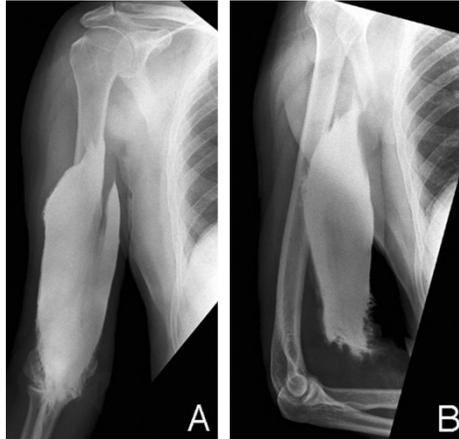


34

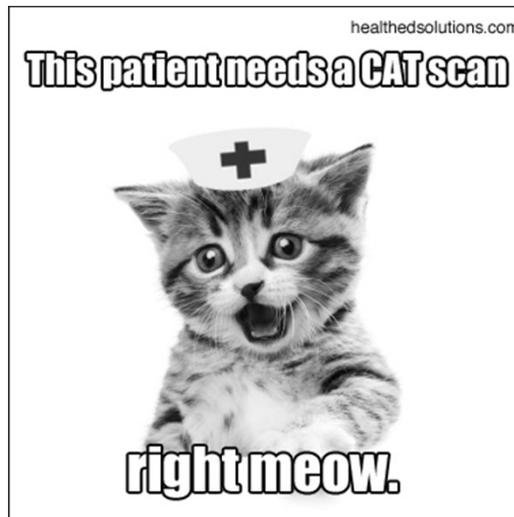
# Power Injector

## Safety issues

- Only used with compatible IV lines
- Incompatible lines can break off and travel through vessels
- Increased chance of extravasation:
  - *Accidental infusion of contrast into surrounding tissues*



35



36