

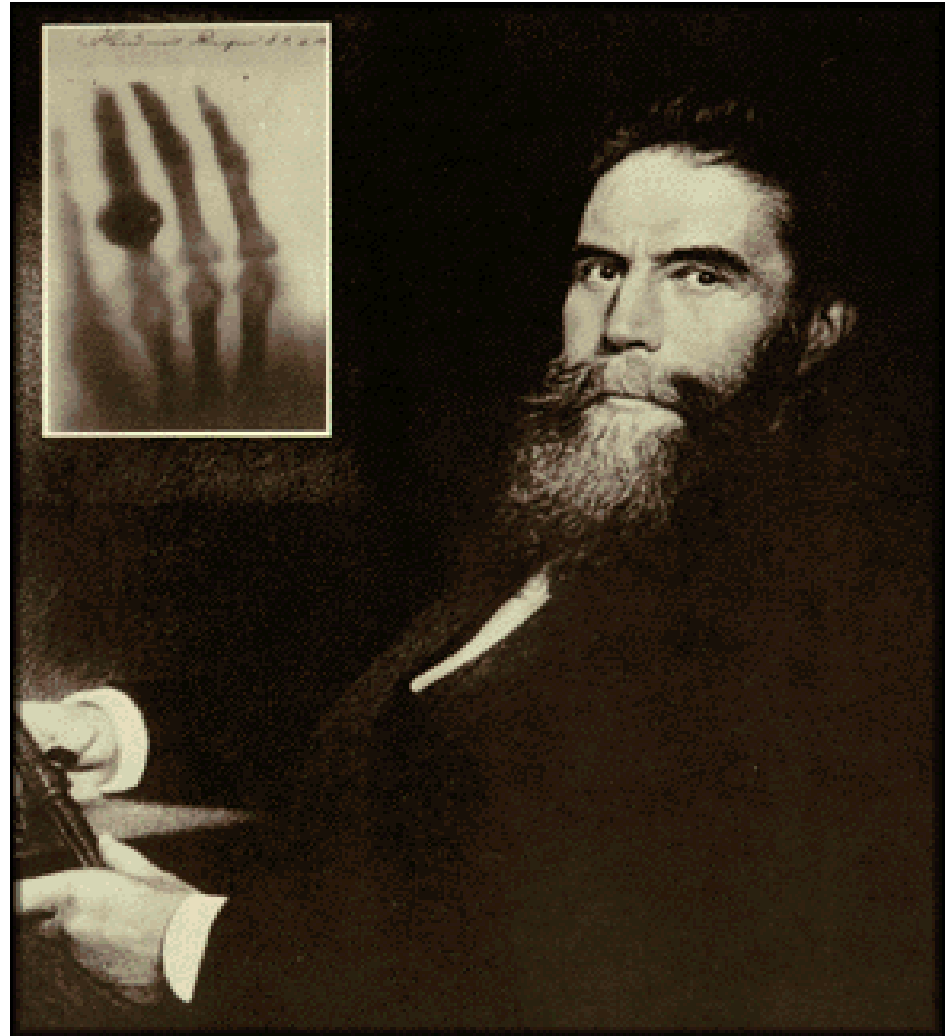


Introduction to Servicing Radiographic and R/F Systems

David Domanski
Lead Instructor, RSTI

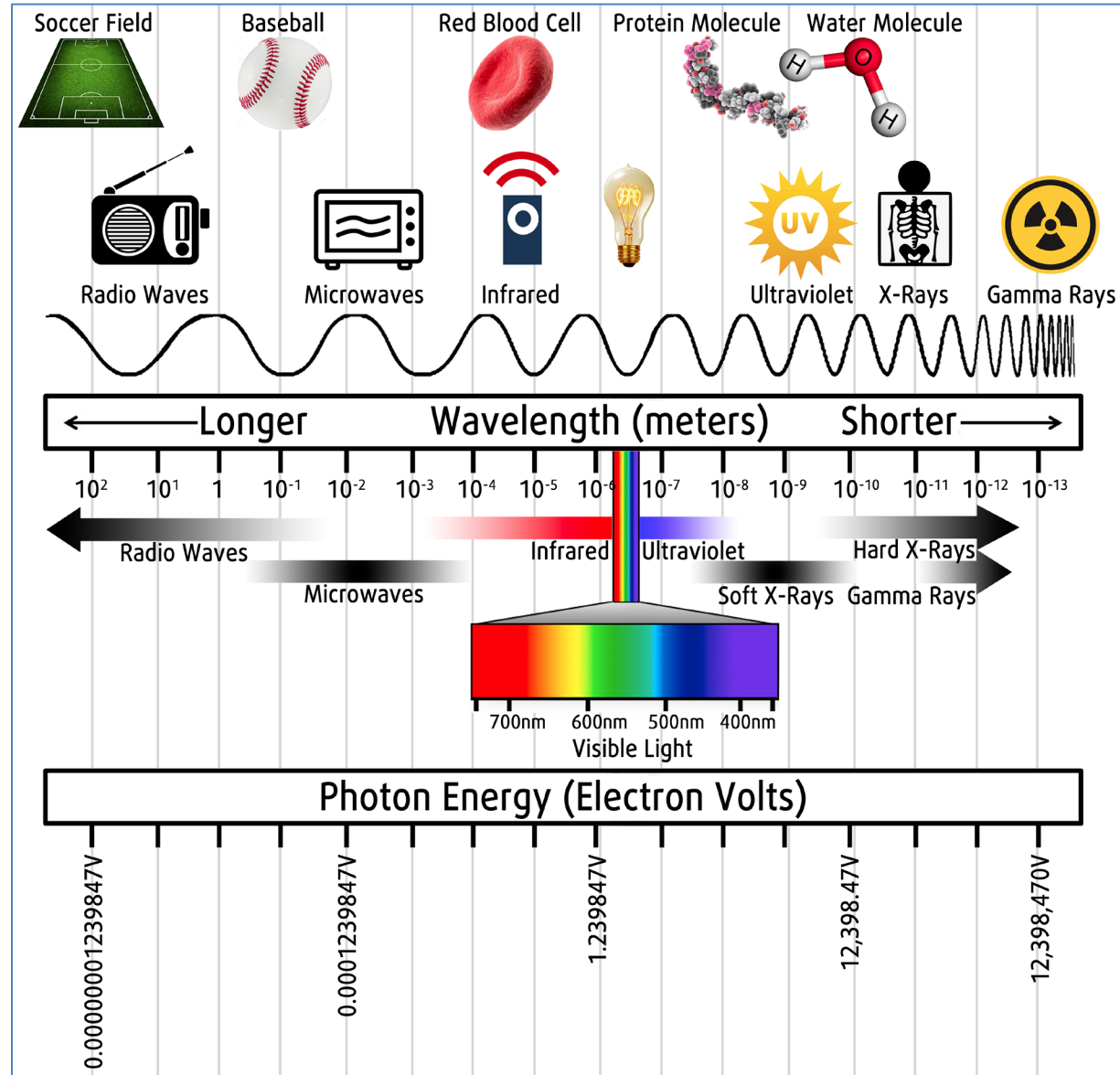
Wilhelm Roentgen Discovers X-Rays

- ❑ Nov 8, 1895 X-Rays were discovered by accident while experimenting with Crookes tubes
- ❑ They were called “X” rays because he didn’t know what kind of rays they were
- ❑ Many images of the human body were acquired with zero regard for safety
- ❑ This discovery earn him the first Nobel Prize in Physics in 1901



What are X-Rays?

- ☐ Part of the electromagnetic spectrum
- ☐ High in frequency and low in wavelength
- ☐ Penetrating in nature

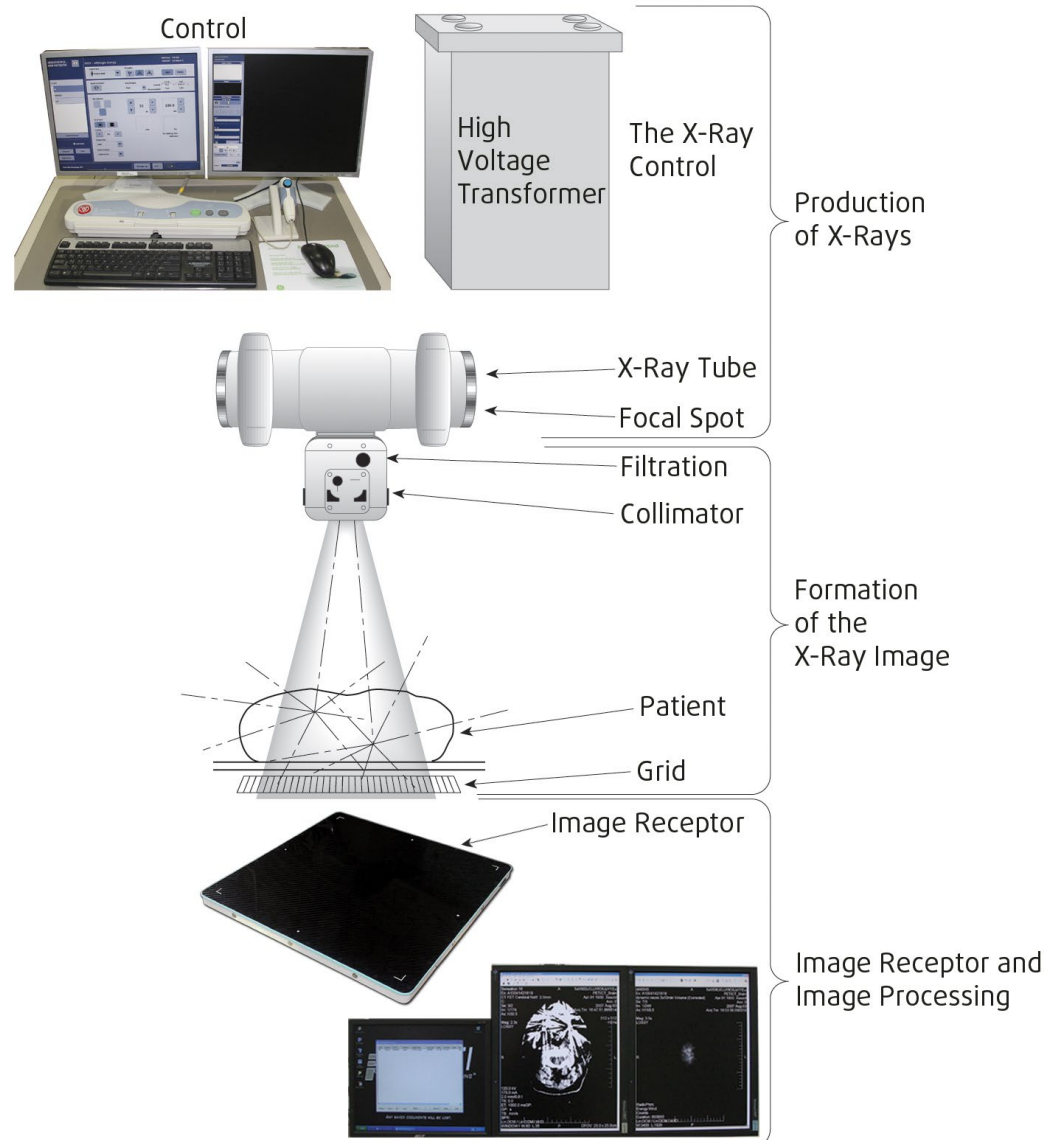


Basic Radiographic Imaging Room

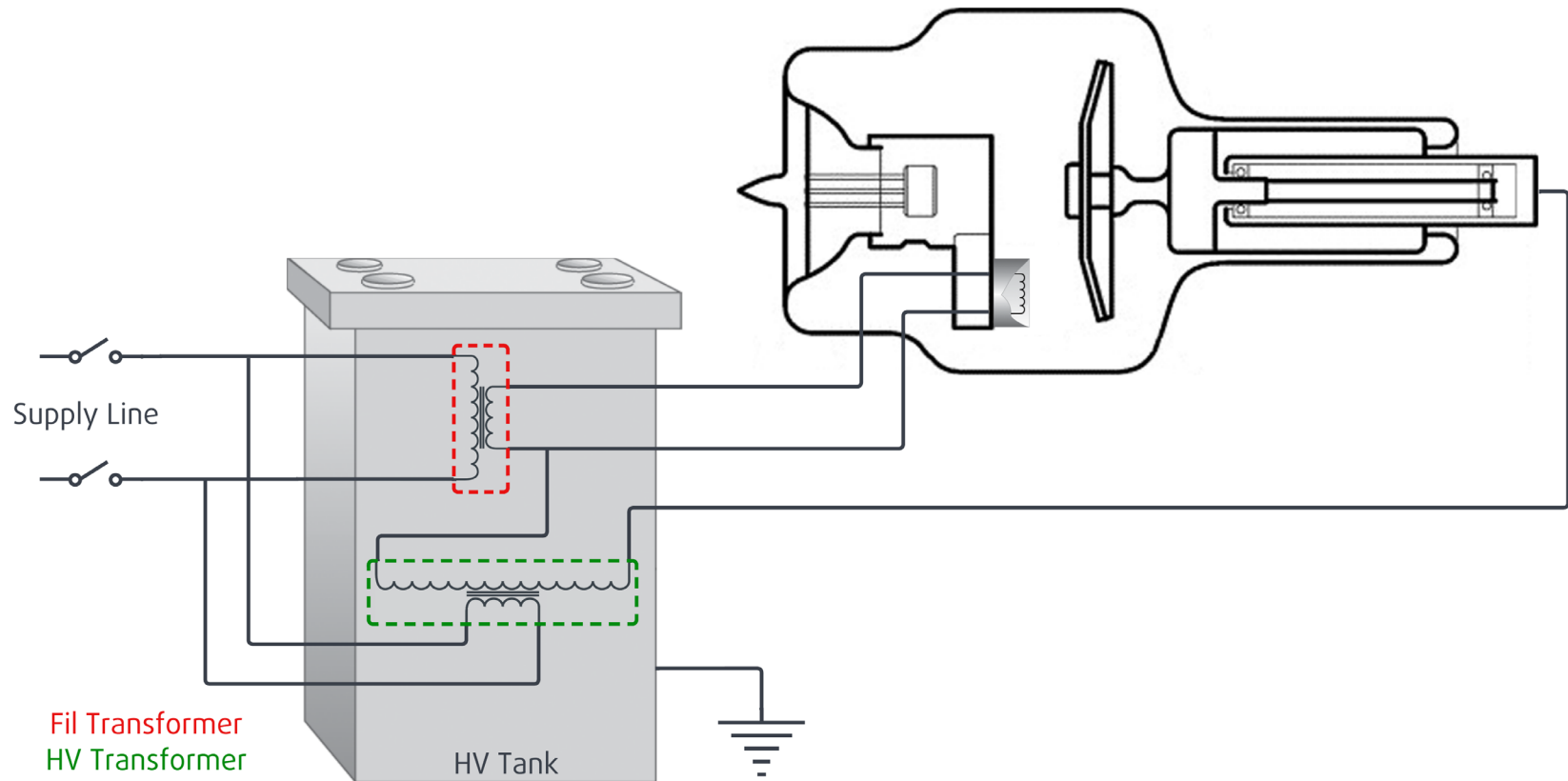


Basic Radiographic Imaging Room

- ❑ Radiographic systems can be divided into three main areas



How are X-Rays Produced?



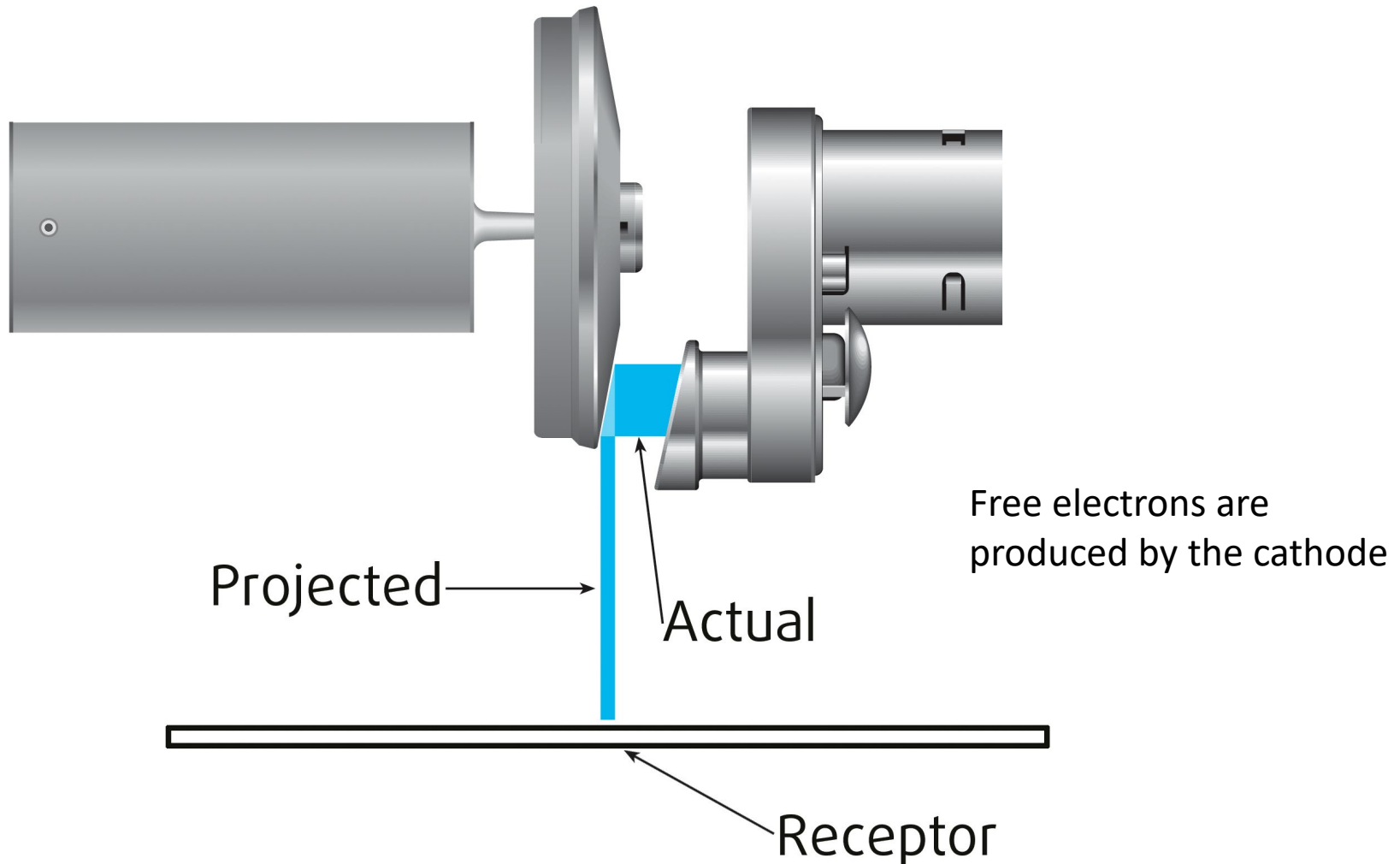
☐ Identify:

- ☐ Anode
- ☐ Cathode
- ☐ kV-
- ☐ kV+

- ☐ kV Total
- ☐ Filament Current
- ☐ Tube Current (mA)
- ☐ Photons

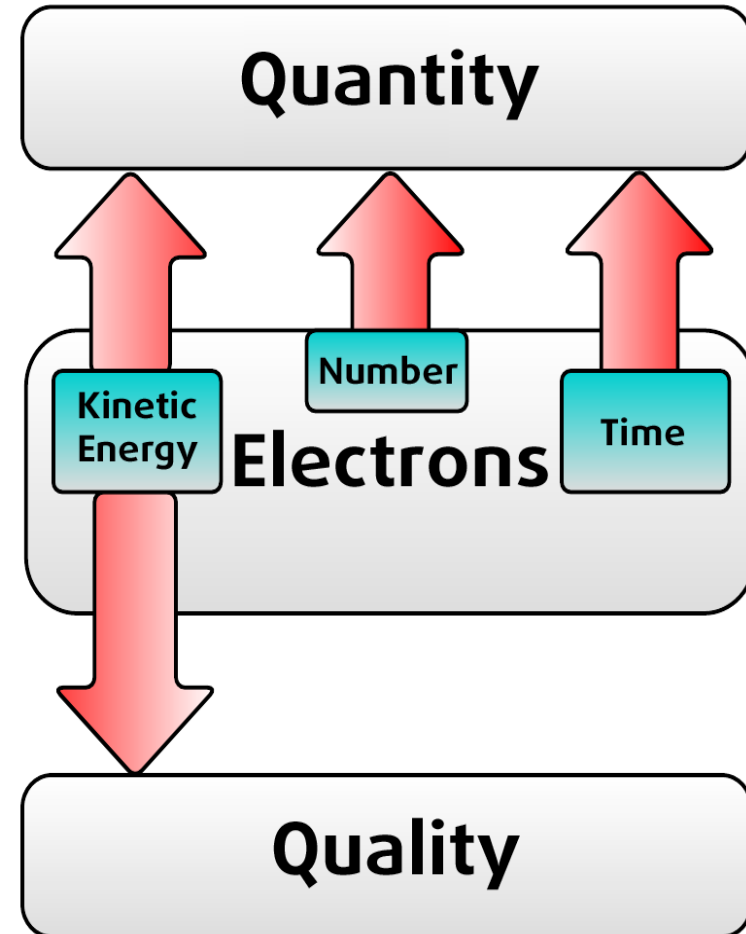
The X-Ray Tube (source of radiation)

High potential (40-150 kVp) applied across the X-Ray tube



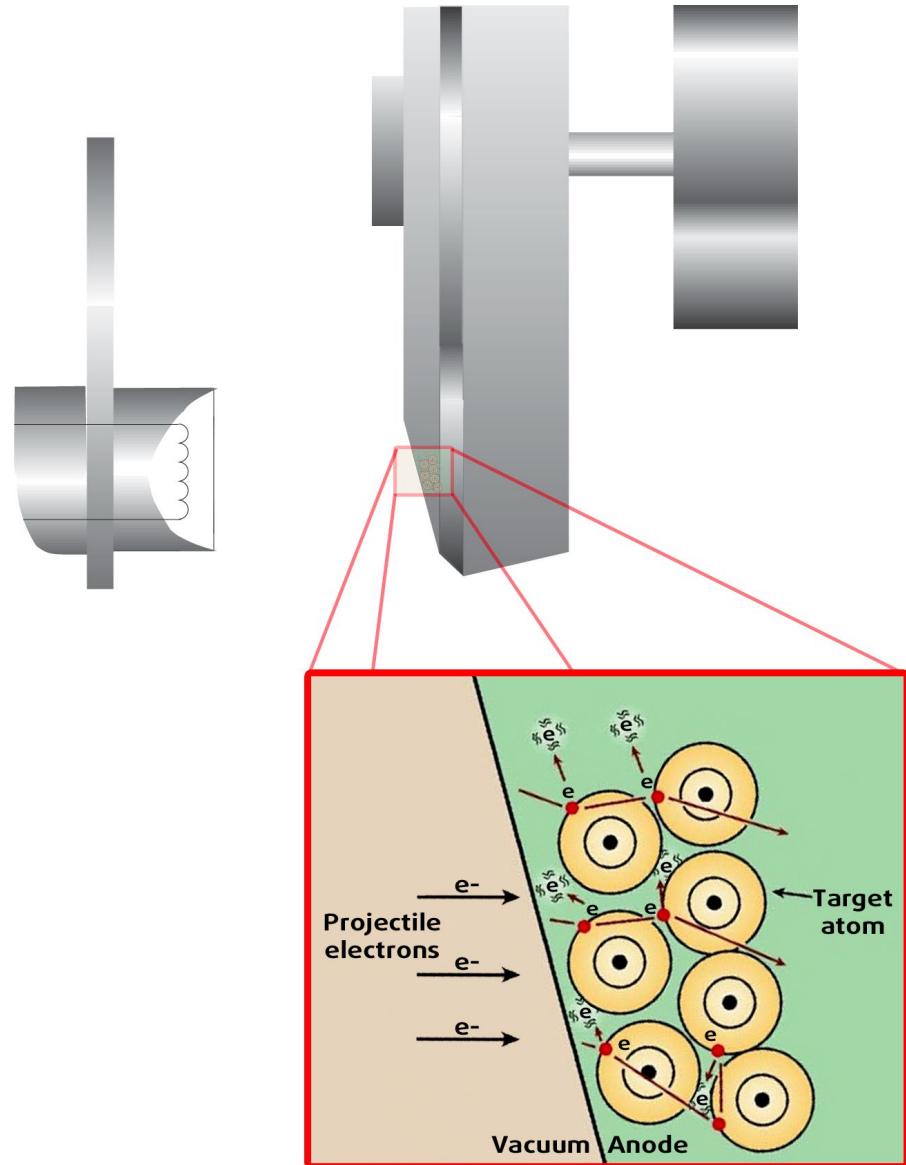
kV, mA, Time

- ❑ **Quantity** is a statement of the dose output
 - ❑ Measured as total dose or dose rate
- ❑ **Quality** is a statement of the energy distribution
 - ❑ Effects penetrating ability
 - ❑ Measured as kVp
- ❑ **Kinetic Energy** speaks to the voltage(kV) applied at the X-Ray tube
- ❑ **Number** is the number of electrons moved across the X-Ray tube(mA)
- ❑ **Time** is the duration of the exposure(integrates mA to mAS)
 - ❑ mAS = milliamp second



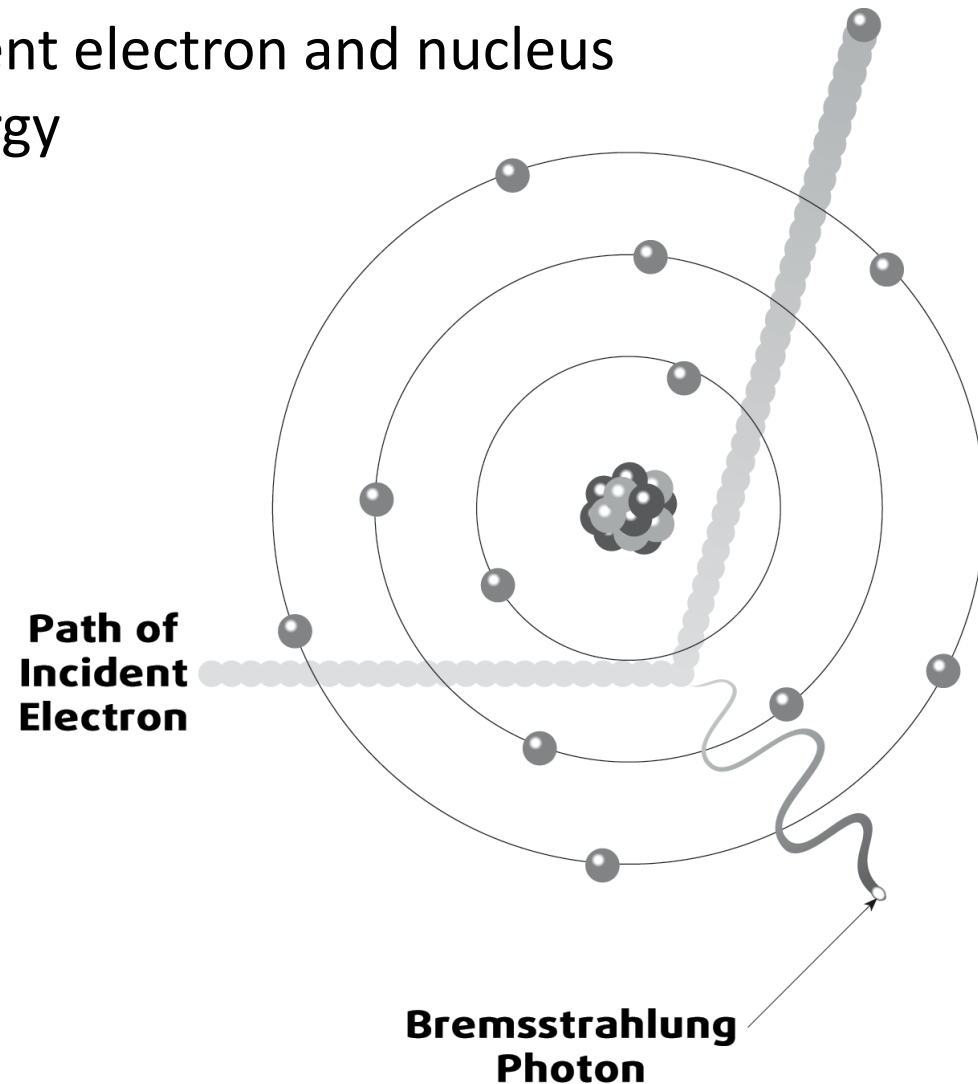
Creating X-Rays

- ❑ X-Rays are caused by the deceleration of electrons in the target (Anode)



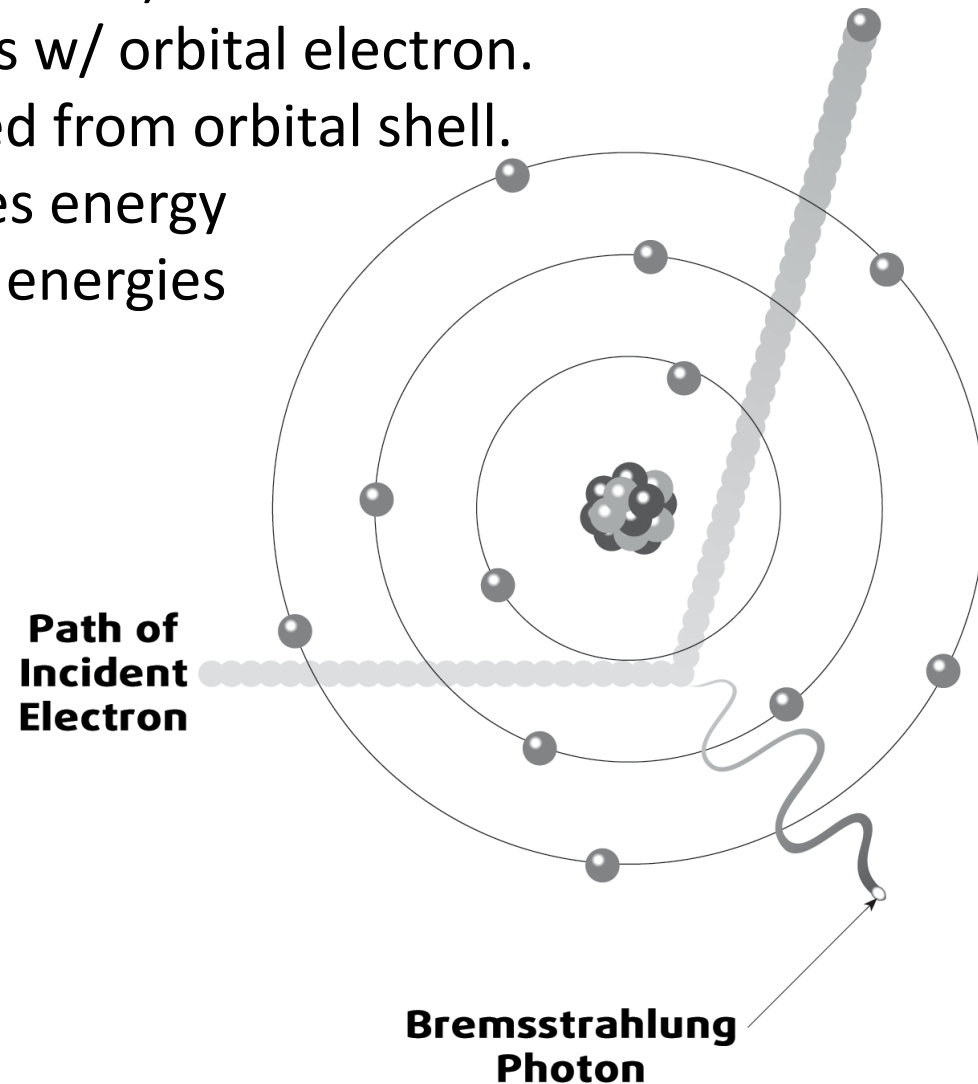
Creating X-Rays

- ❑ Bremsstrahlung (Braking)
 - ❑ Distance between incident electron and nucleus determines photon energy

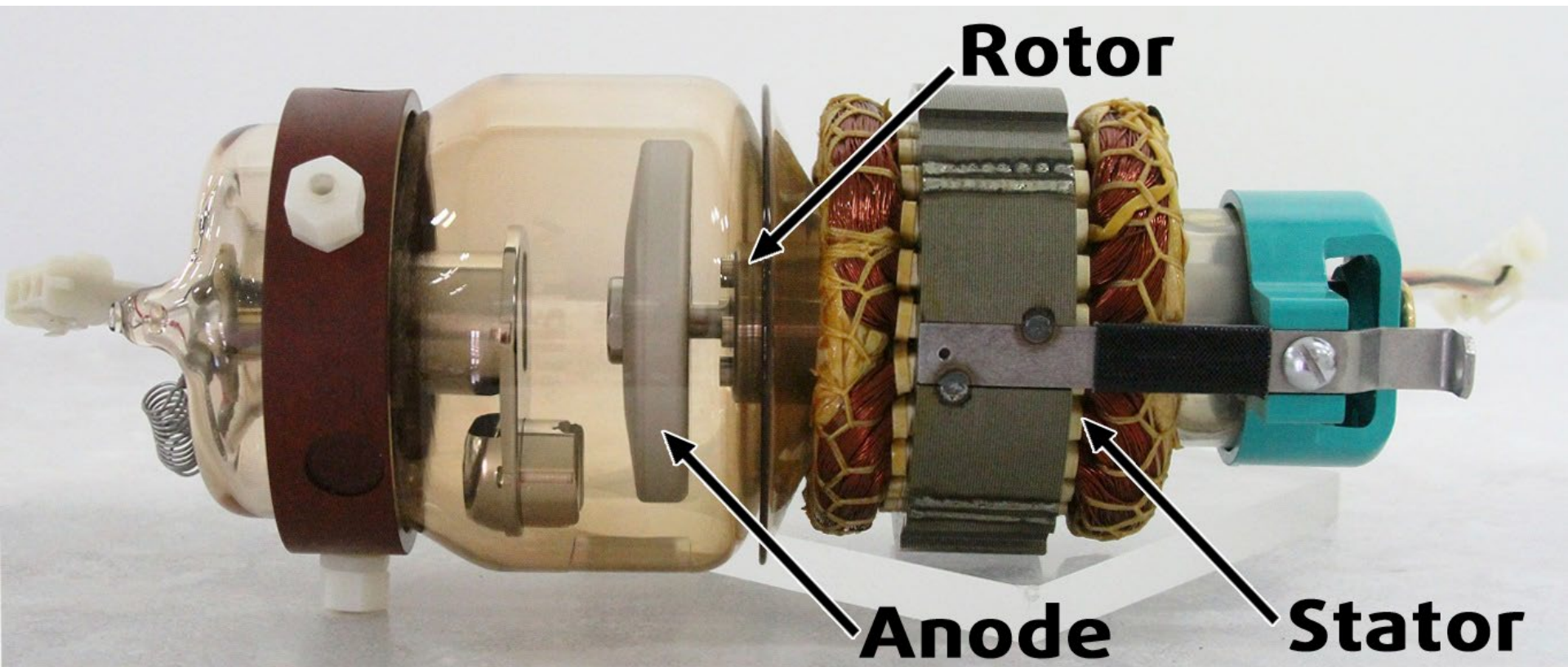


Creating X-Rays

- ❑ Characteristic Radiation (Collision)
 - ❑ Incident electron collides w/ orbital electron.
 - ❑ Orbital electron is ejected from orbital shell.
 - ❑ Filling of vacancy releases energy characteristic of binding energies of target material.

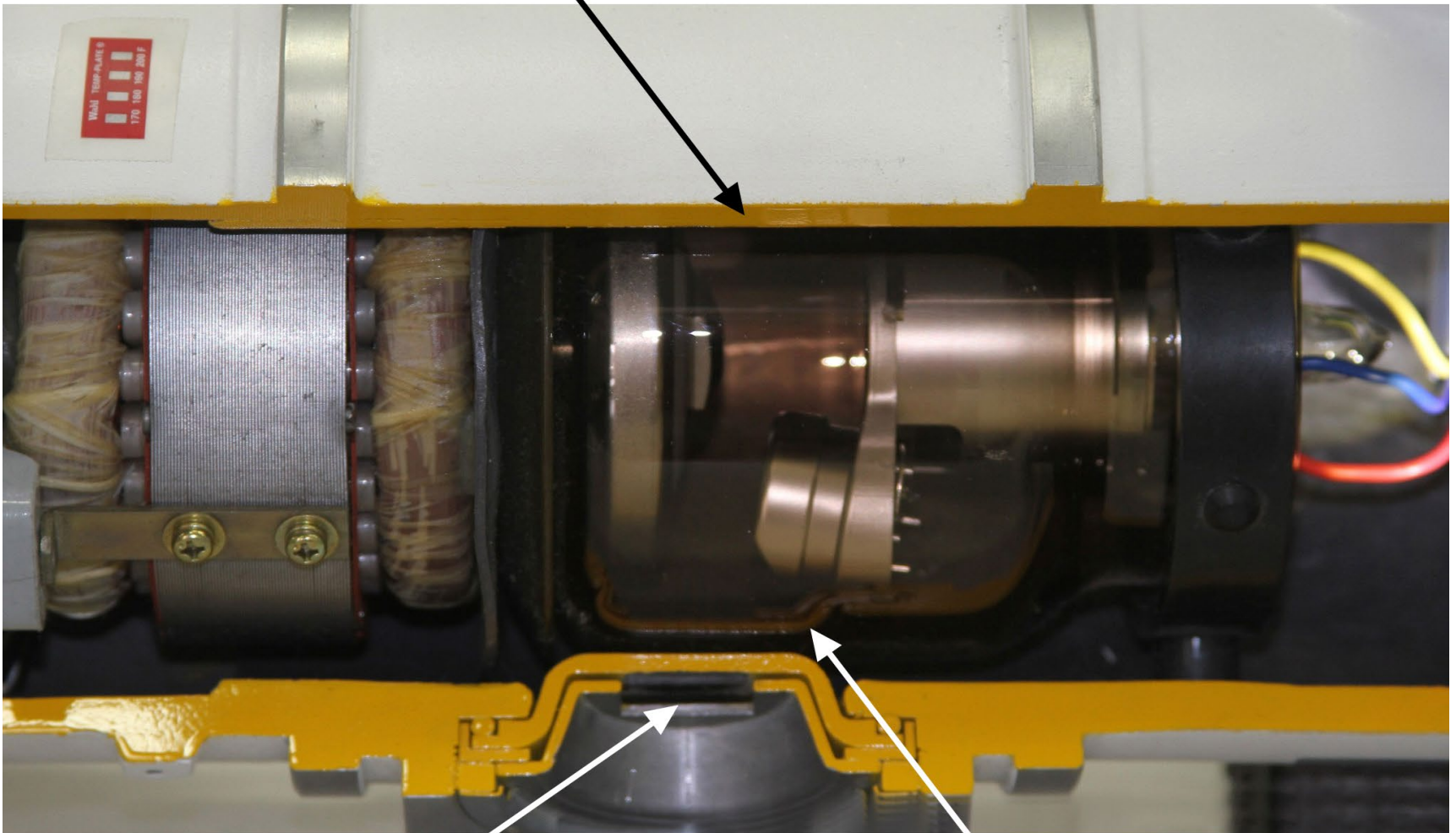


X-Ray Tube Insert & Rotor



X-Ray Tube Housing & Insert

Lead Lining

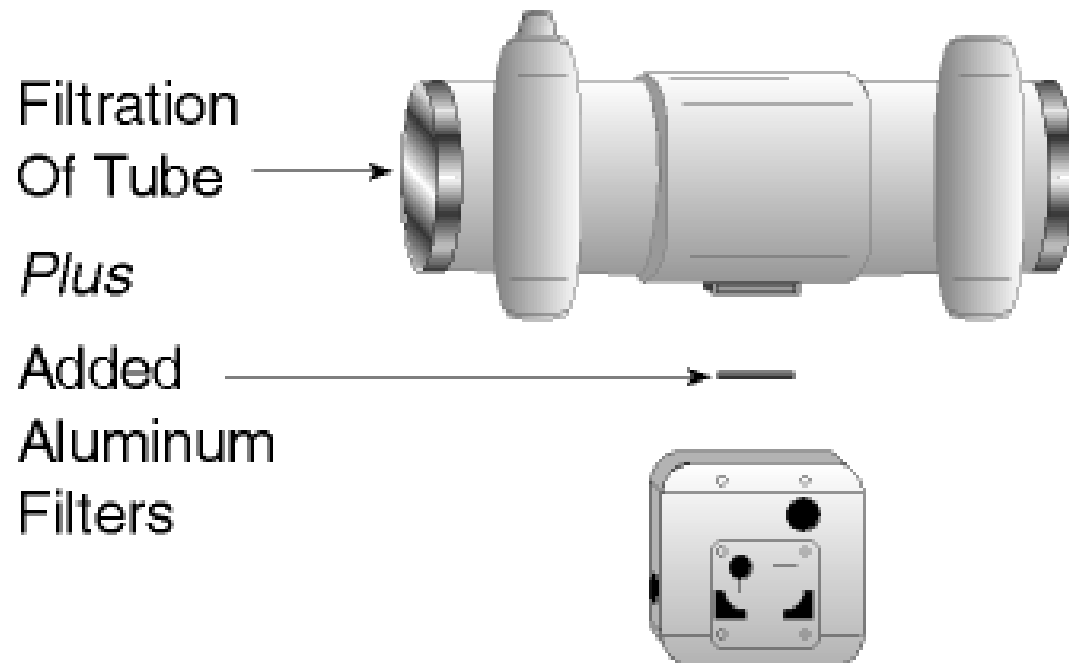


Port

Tube Insert

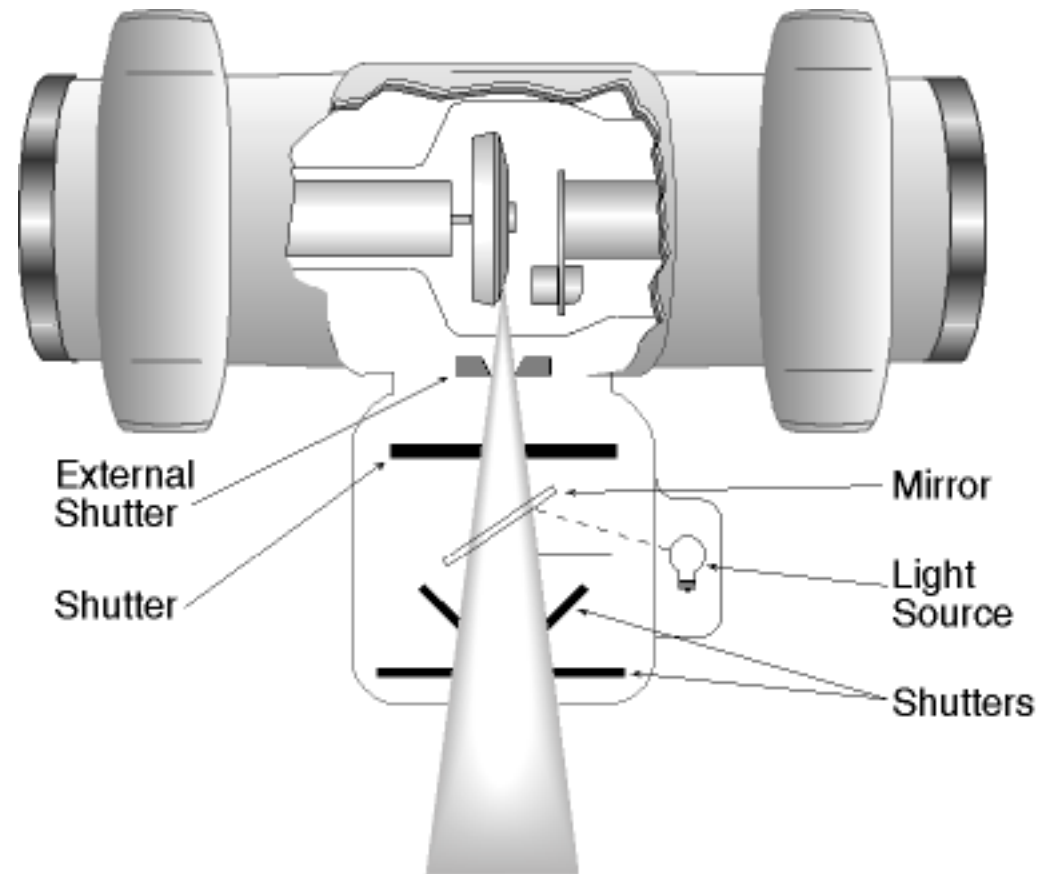
X-Ray Beam Must Be Filtered

- ☐ Filtration is required for:
 - ☐ Patient safety
 - ☐ FDA Compliance



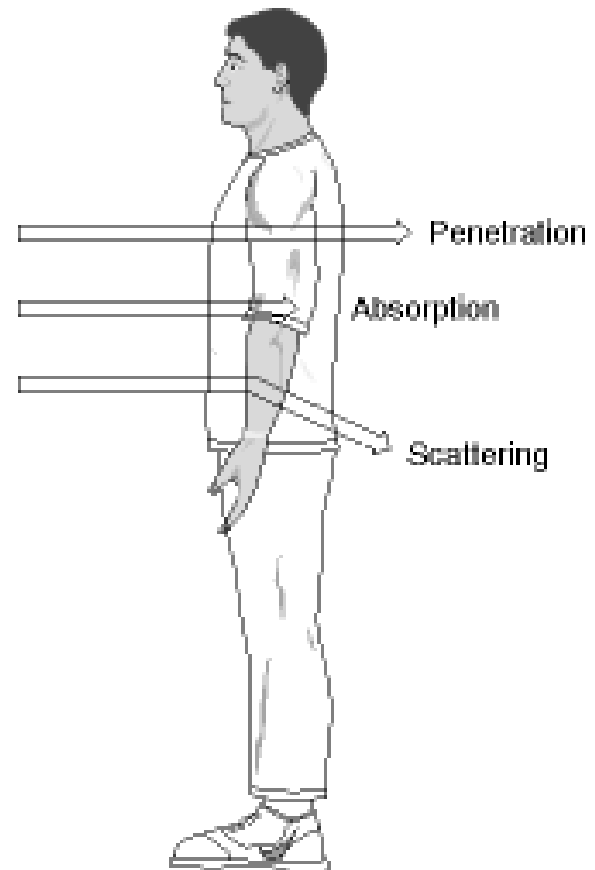
Collimating The X-Ray Beam

- ❑ Restricts the radiation to the area of interest
- ❑ Reduces scatter
- ❑ Provides a light field projection representing where the radiation exposure will fall



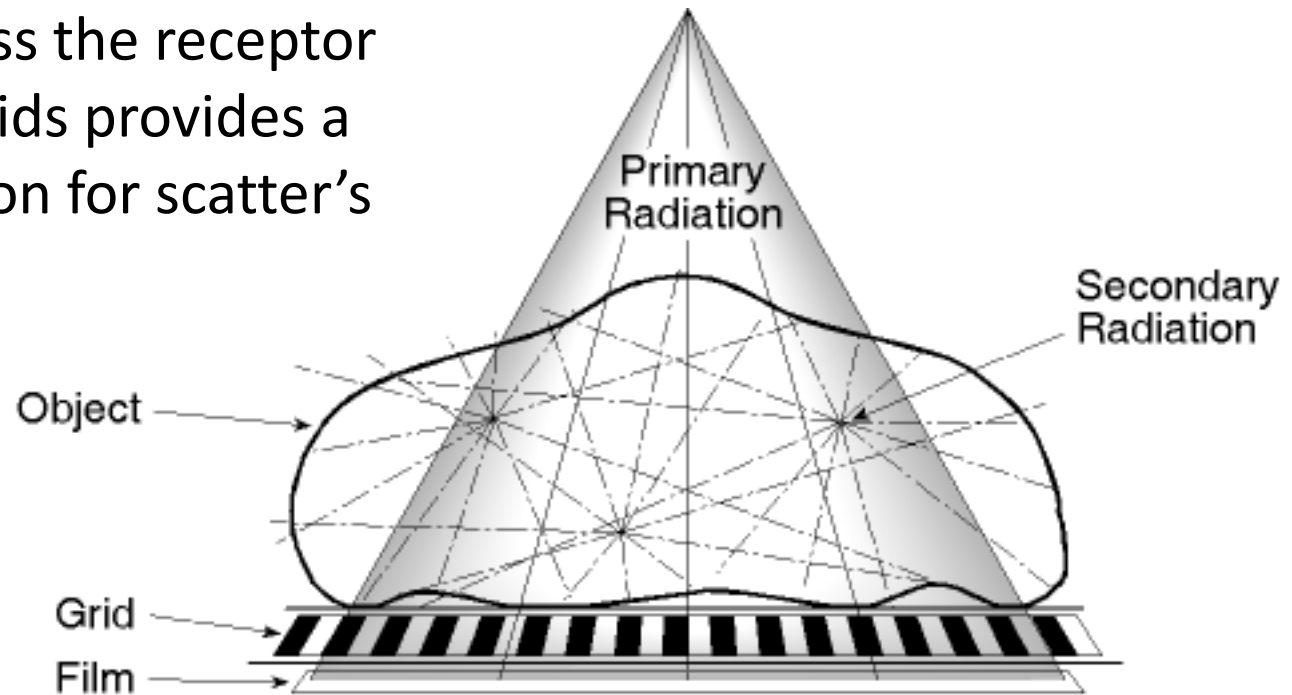
X-Ray Beam Interacting With Matter

- ❑ Three types of interaction with matter
 - ❑ Penetration – Un-impeded passage through matter. Technically no interaction
 - ❑ No contribution to patient dose
 - ❑ Absorption – Complete loss of X-Ray energy in matter
 - ❑ Primary source of patient dose
 - ❑ Scattering – Creation of new X-Ray photons that are off the original path from source to receptor
 - ❑ Some of these photons are absorbed locally (contribute to patient dose) and some make it to the image receptor

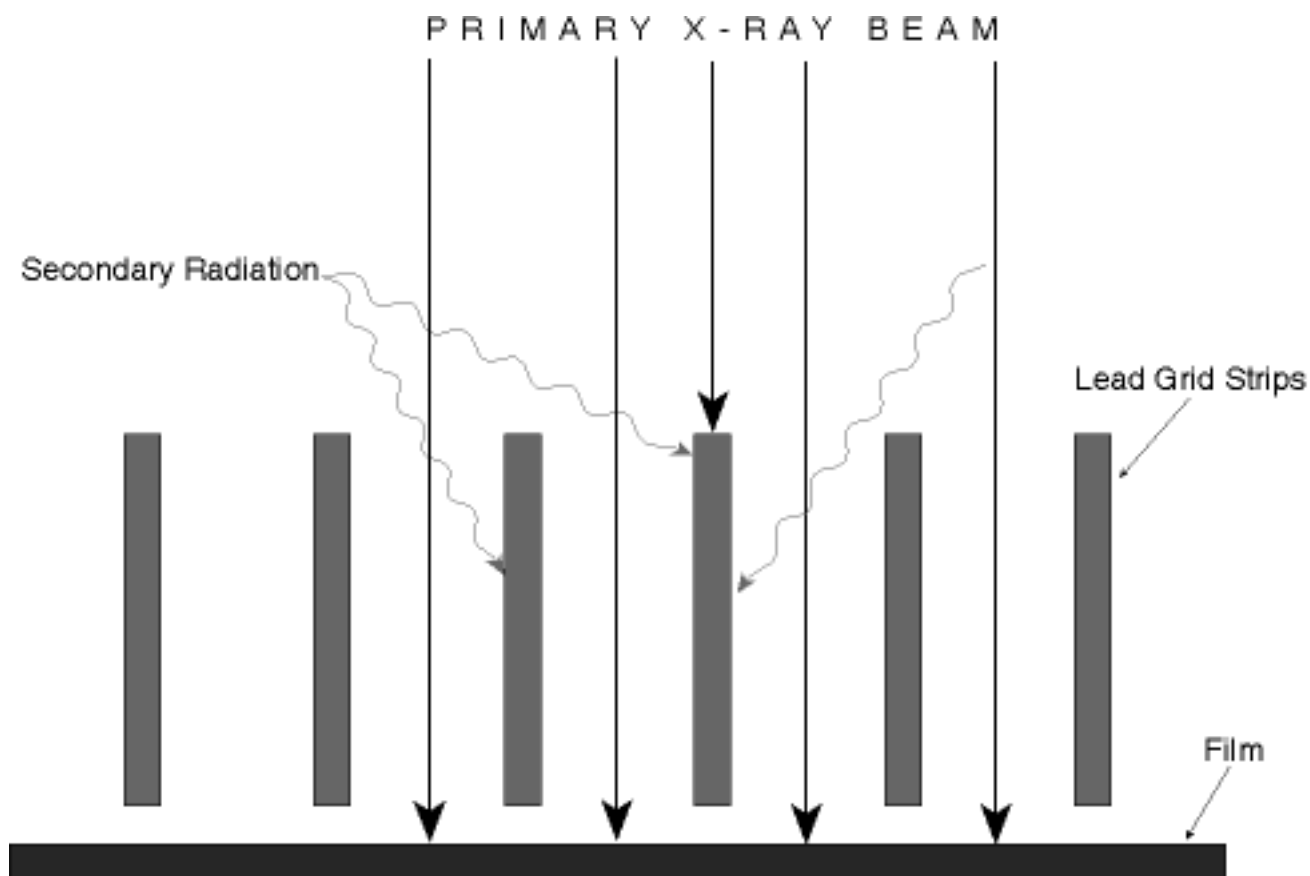


The Problem With Scatter

- ❑ Scatter – X-ray Photons not on the primary path from source to receptor tend to reduce contrast by casting fog or shadow across the receptor
- ❑ The use of grids provides a partial solution for scatter's effects

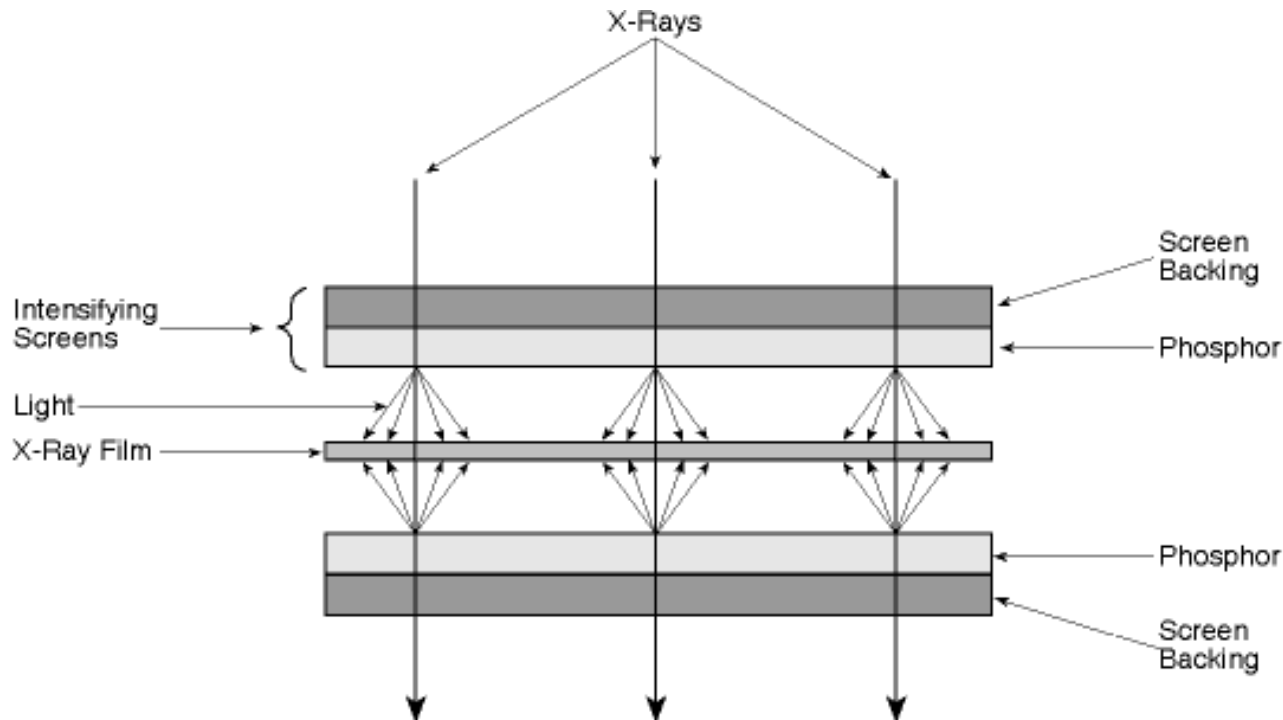


How X-Ray Grids Work



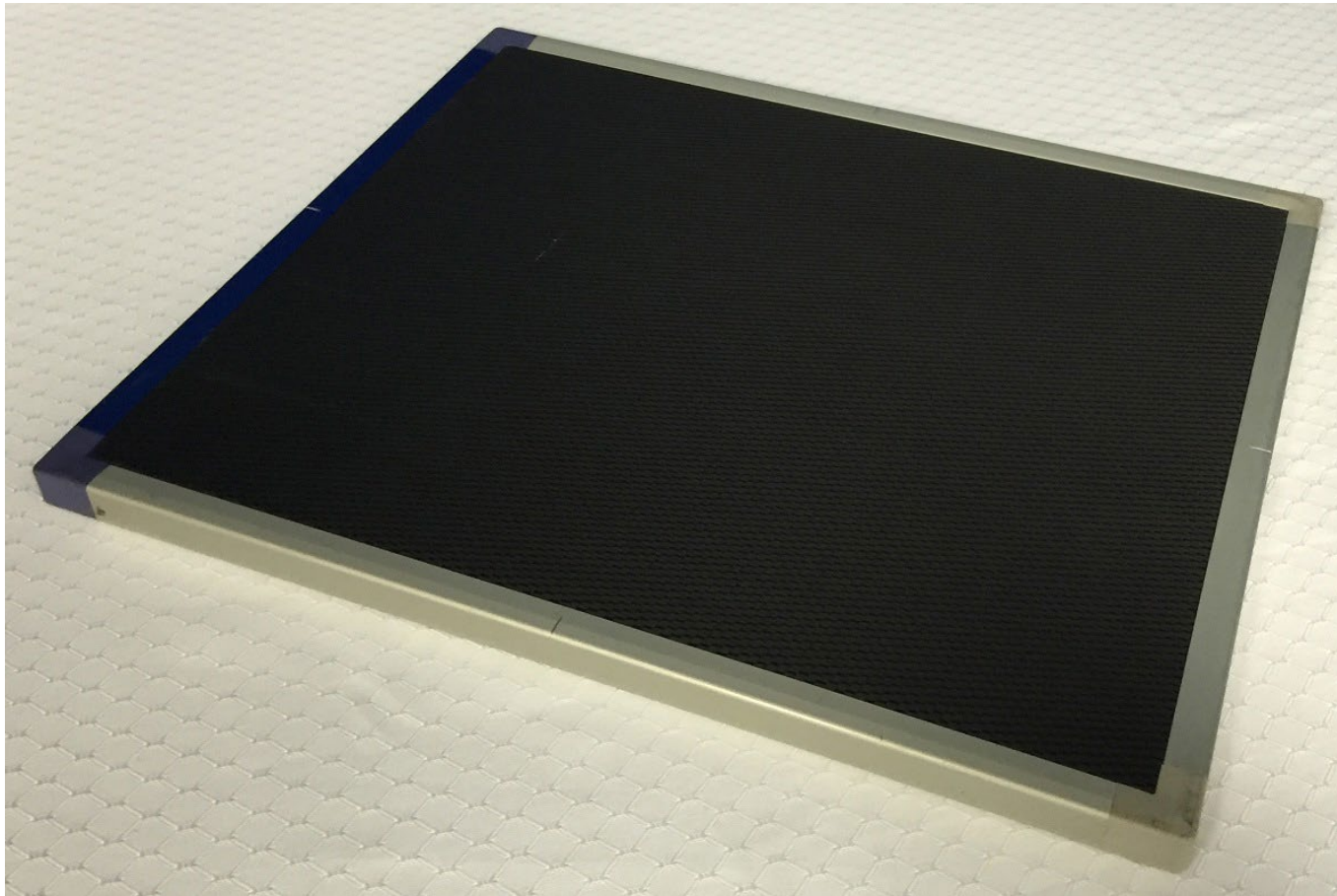
Film Screen Image Receptor

- ❑ Film Screen Cassettes are the original method for capturing X-Ray images
- ❑ They are the basis for current developments in digital radiographic imaging
 - ❑ The screens give off light just as the scintillation layers in digital do
 - ❑ The film “traps” the light signal similar to the way pixels accumulate electrical signals
 - ❑ The accumulated electrical signal is digitized and processed for display in gray scale terms mimicking X-Ray film



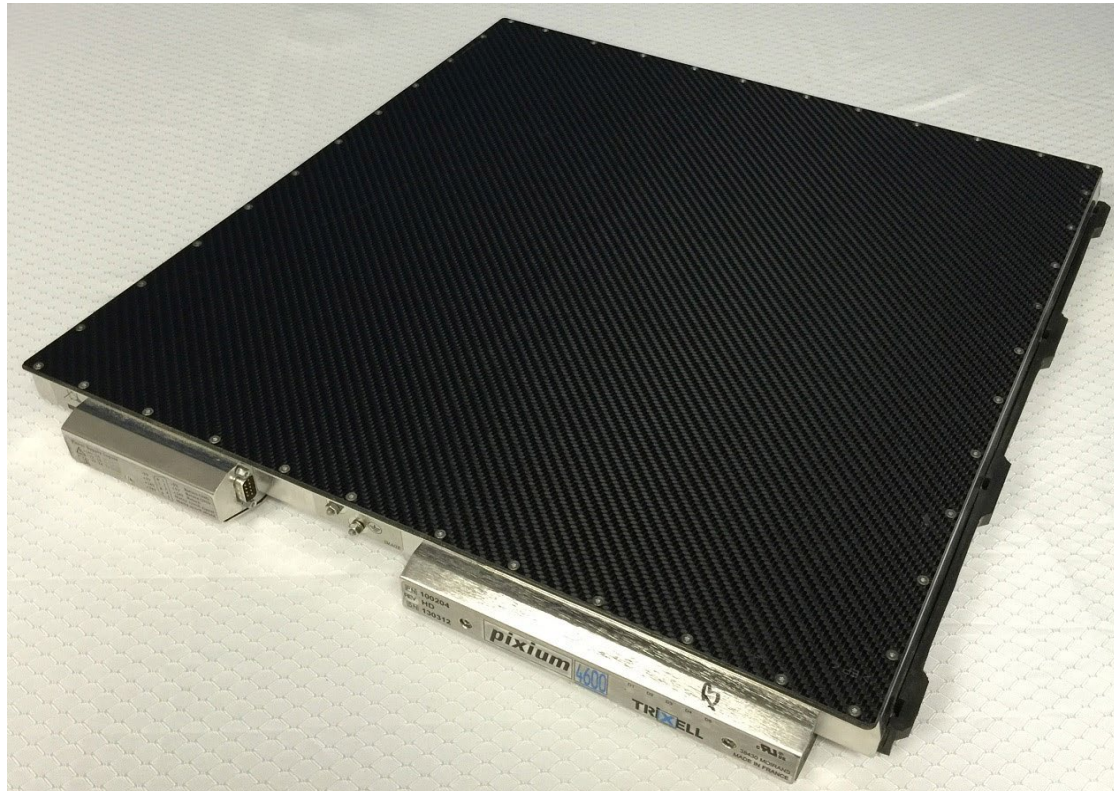
Cassette Style Radiographic Receptors

- ❑ Film Screen, CR and many Digital image receptors have the same form factor so they all can fit in a standard Bucky Tray

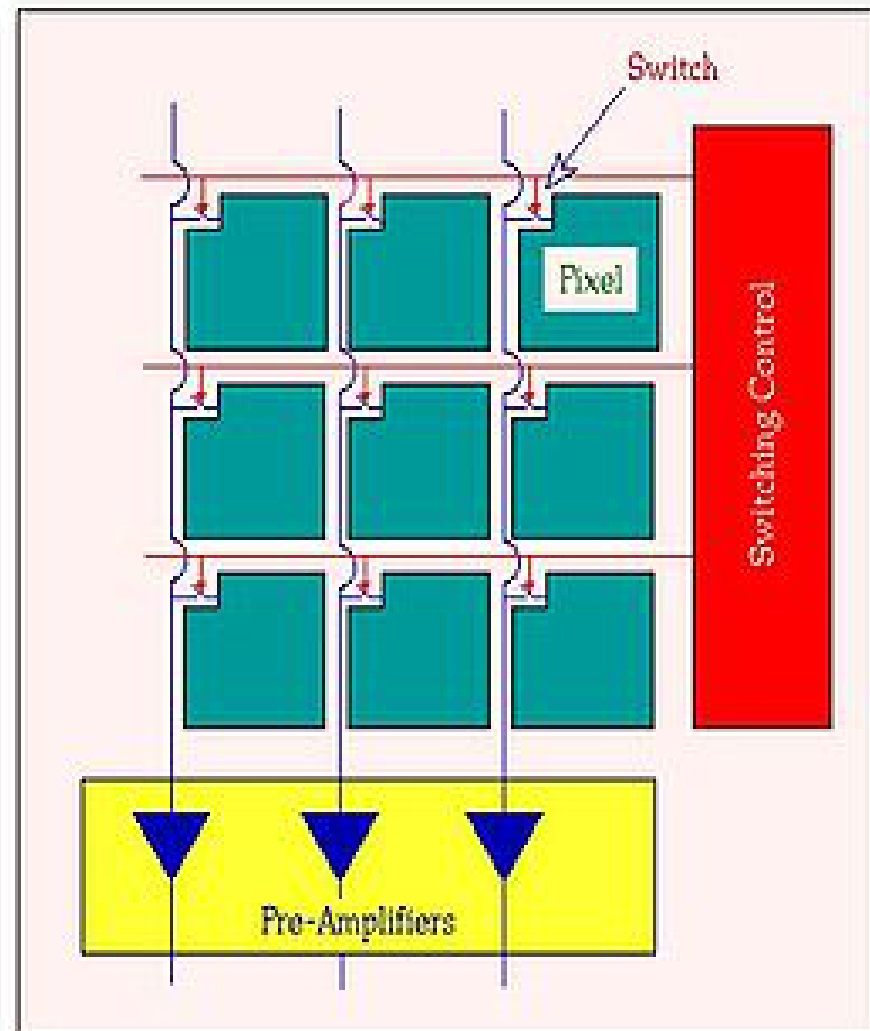
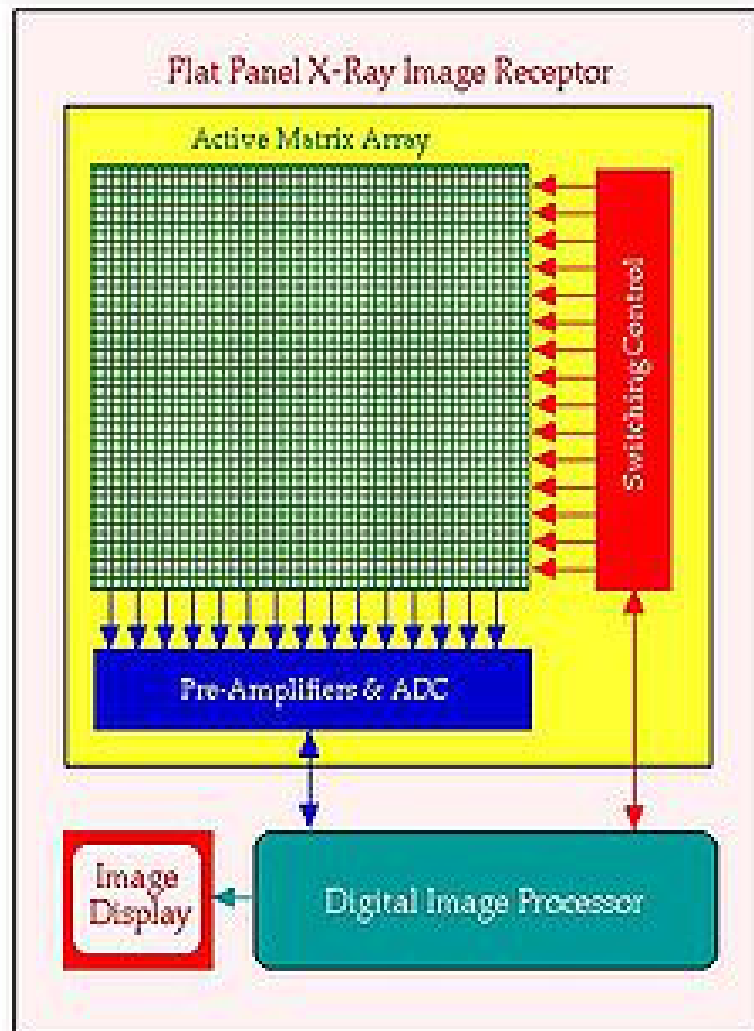


Fixed Installation Detector

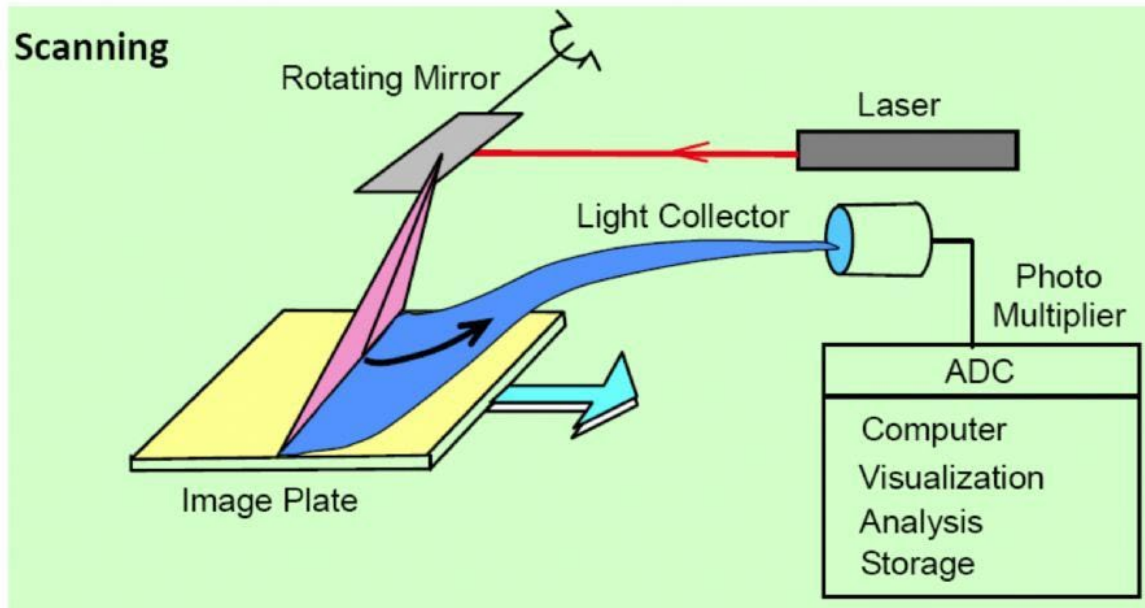
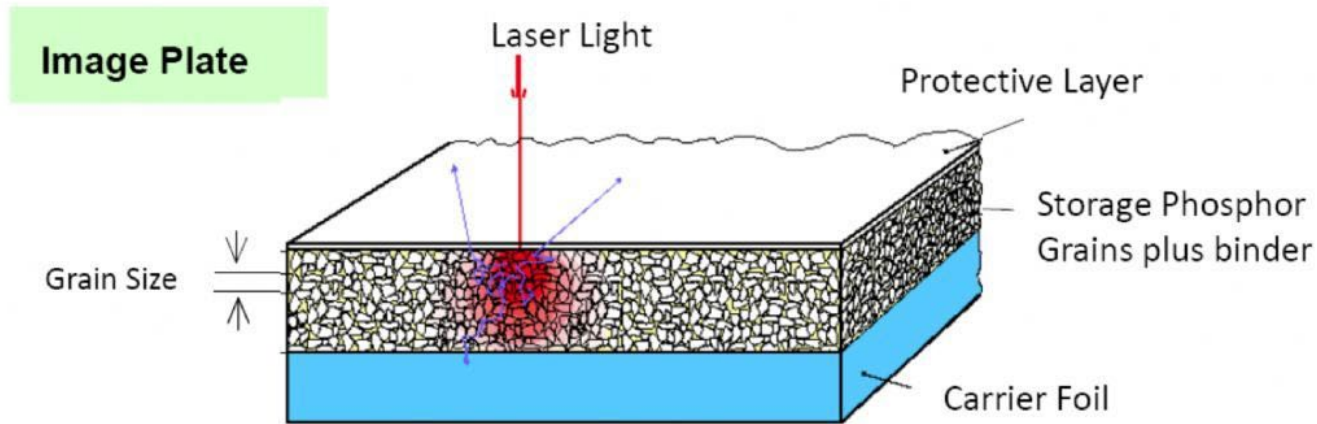
- ❑ Digital detectors in some cases are proprietary and intended for permanent installation



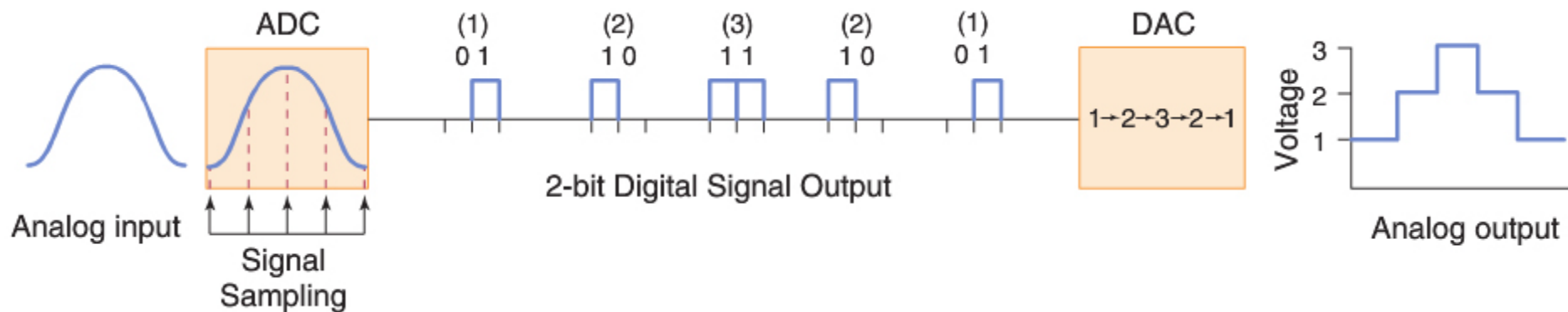
Digital Detector Sampling



Computed Radiography(CR) Sampling



Digitizing Analog Signal



❑ ADC = Analog to Digital Converter

❑ DAC = Digital to Analog Converter

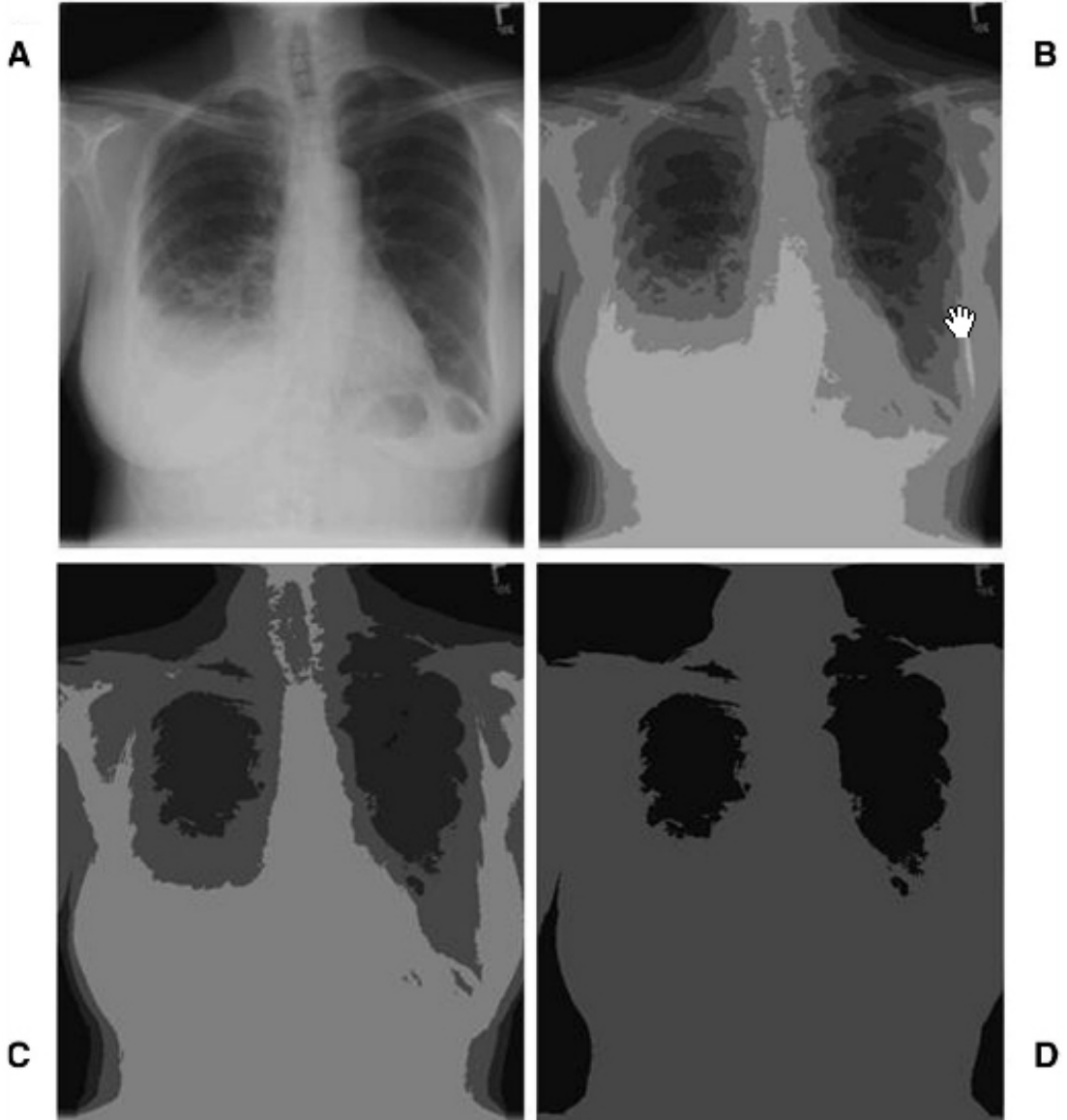
Quantization (ADC Bit Rate)

X	X	X	X	X	X	X	X
128	64	32	16	8	4	2	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

- ❑ Bit rate of the conversion directly relates to the accuracy of the digital number's representation of the original analog value
 - ❑ For example if the signal has a max value of 1VDC, @7Bit9(128 steps) each step would be 7.8mV and the accuracy would be half of that
- ❑ Lower bit rates reduce number of shades of gray available (See following images)

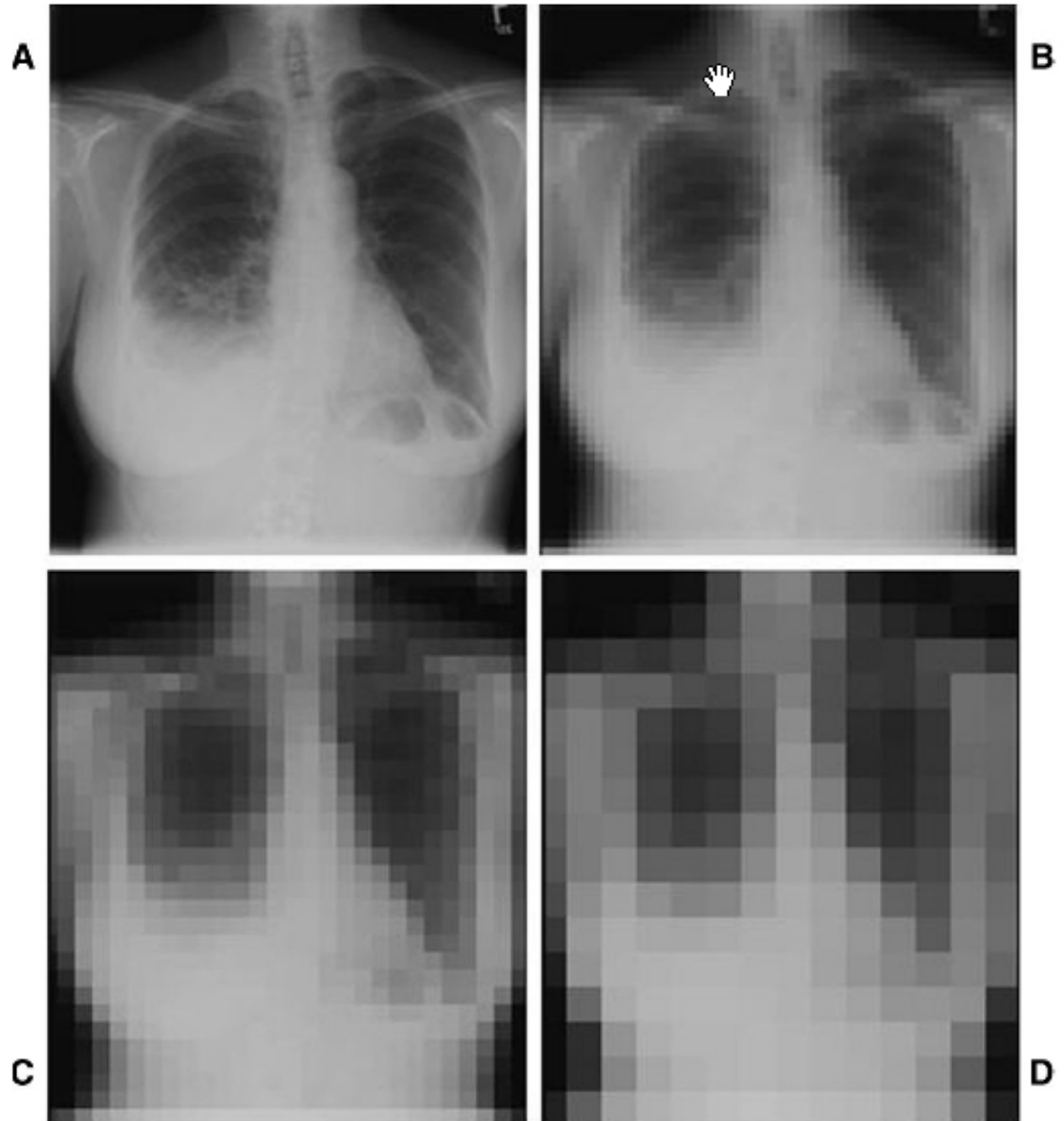
Effect Of ADC Bit Rate

- ☐ A = High Bit Rate Quantizer
- ☐ D = Very Low Bit Rate Quantizer



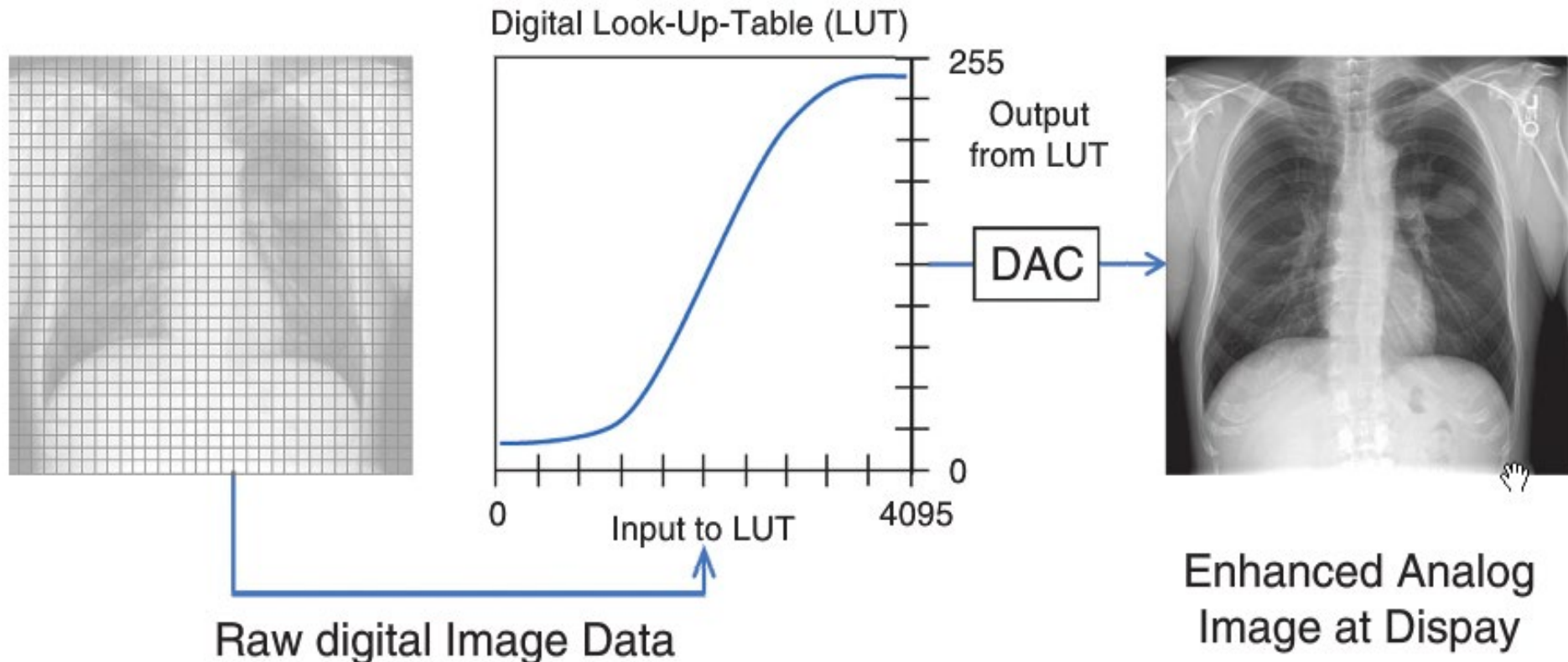
Effect Of Pixel Size Or Sample Rate

- ❑ More pixels per inch(FPD) or faster sample rates(CR) improve resolution



Viewing The Digital Image

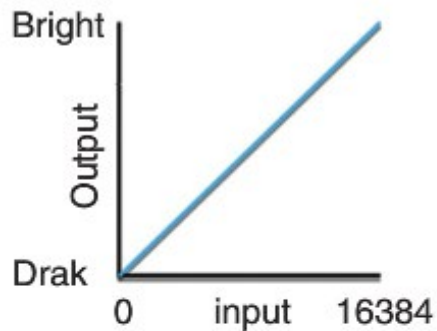
- ❑ Once the image is acquired and digitized, applying Look Up Tables(LUT) present the digital data in a format that provides a good image on the monitor



Viewing The Digital Image

- ❑ Modifying or applying special LUTs will change the presented image

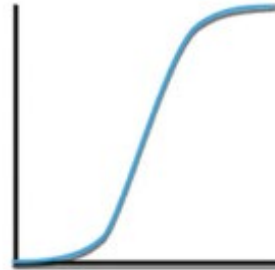
Linear LUT



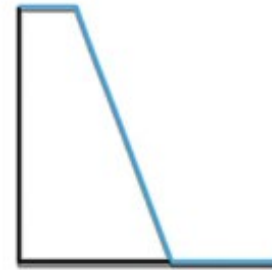
Default Modality LUT



VOI LUT



Inverted LUT



High Contrast LUT



W=16384 L=8192



W=3674 L=4384



W=16384 L=8192



W=3674 L=4384

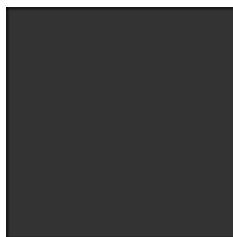


W=2048 L=5600

Exposure Factors / Exposure Index

☐ Historic exposure factor understanding

- ☐ High levels of exposure on film results in a very dark image, referred to as having **High Density**
- ☐ Low levels of exposure result in **Low Density**
- ☐ Comparing two areas of exposure would describe Contrast
 - ☐ A large difference in density would equal **High Contrast** and a small difference would be **Low Contrast**



High Density



Low Density



High Contrast



Low Contrast

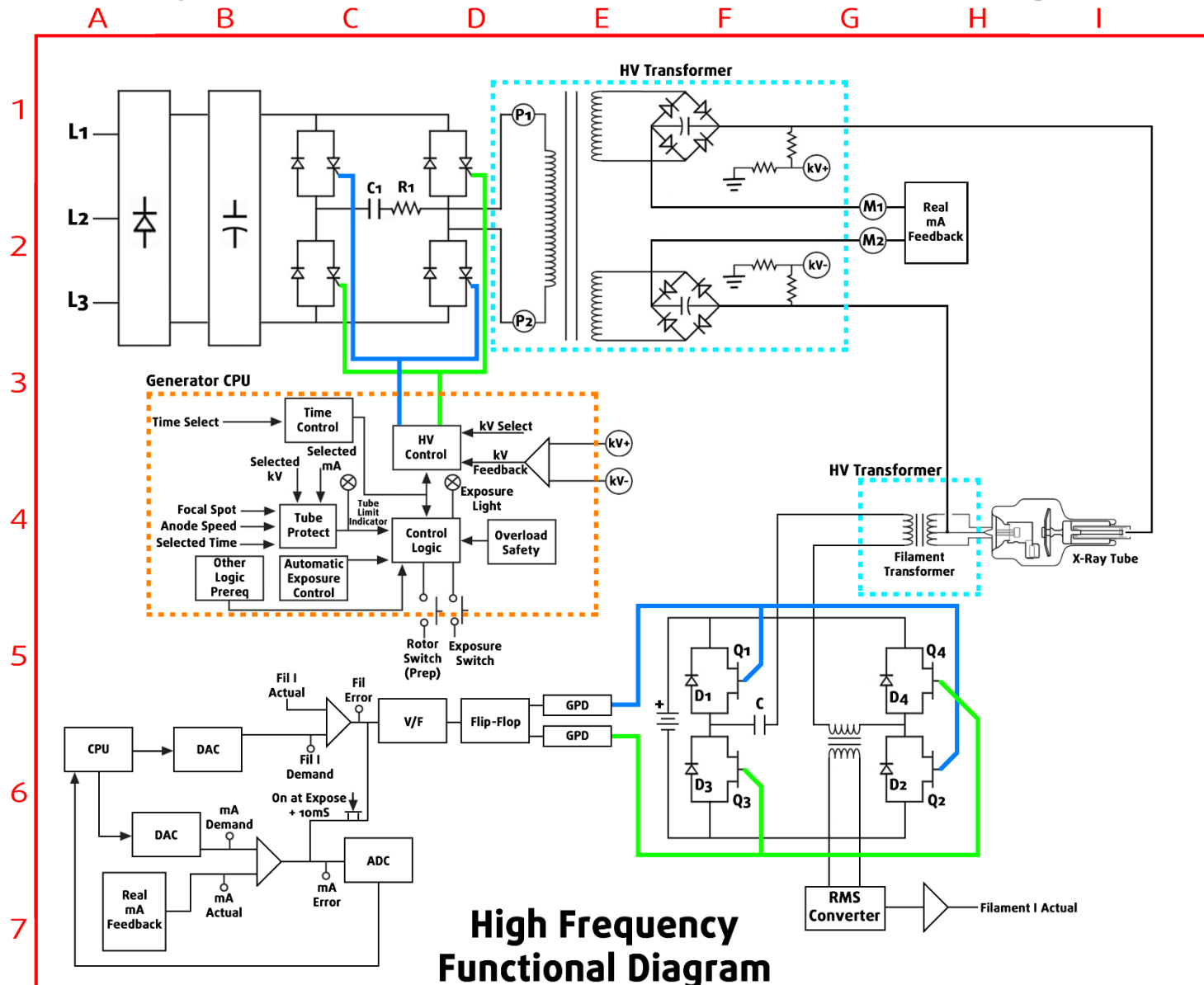
☐ Current exposure factor understanding

- ☐ Density is now analogous to Exposure Index(digital value relative to exposure level)
 - ☐ High EI number = High Density
 - ☐ Low EI number = Low Density
 - ☐ Contrast would be the difference between EI numbers

Factors Effecting Image Quality

Factor	Density	Contrast	Sharpness	Magnification	Distortion
Kilovoltage	✓	✓			
Milliamperage	✓				
Time (Phototiming)	✓				
Source to Image Distance (SID)	✓		✓	✓	✓
Object to Image Distance (OID)			✓	✓	✓
Misalignment					✓
Focal Spot Size			✓		
Grid	✓	✓	✓		
Cones & Collimators	✓	✓			
Filter	✓	✓			
Compression	✓				
Contrast Media	✓	✓			
Intensifying Screens	✓		✓		
Film & Processor	✓	✓	✓		
Image Post-Processing	✓	✓	✓	✓	✓
Motion			✓		
Subject (Patient)	✓	✓			
Heel Effect	✓				
Generator Efficiency	✓	✓			

X-Ray Generator Block Diagram



Radiographic/Fluoroscopic(RF) Room



RF Room Components(Image Intensifier)

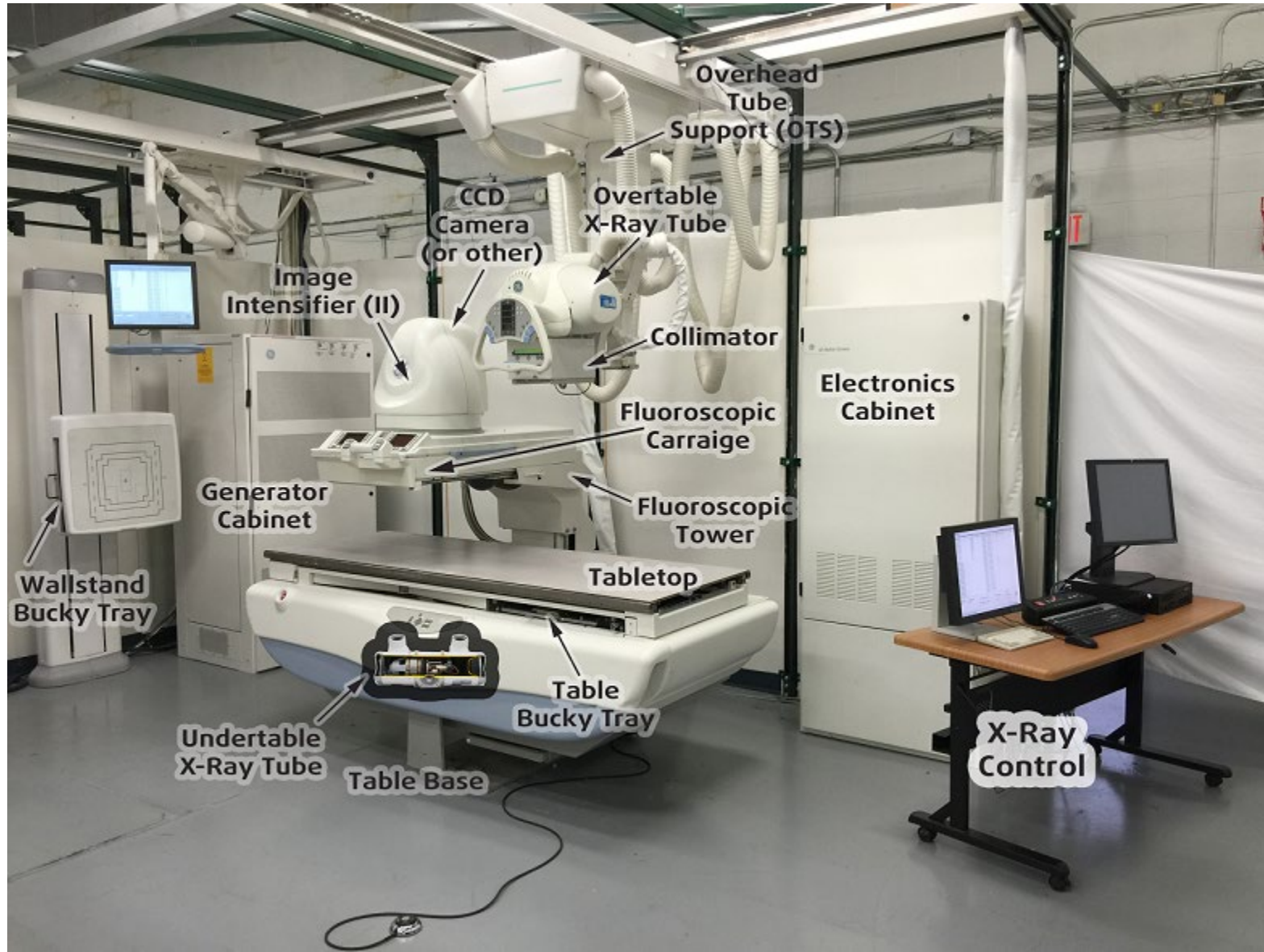


Image Chain With Image Intensifier



Image Intensifier Functional Diagram

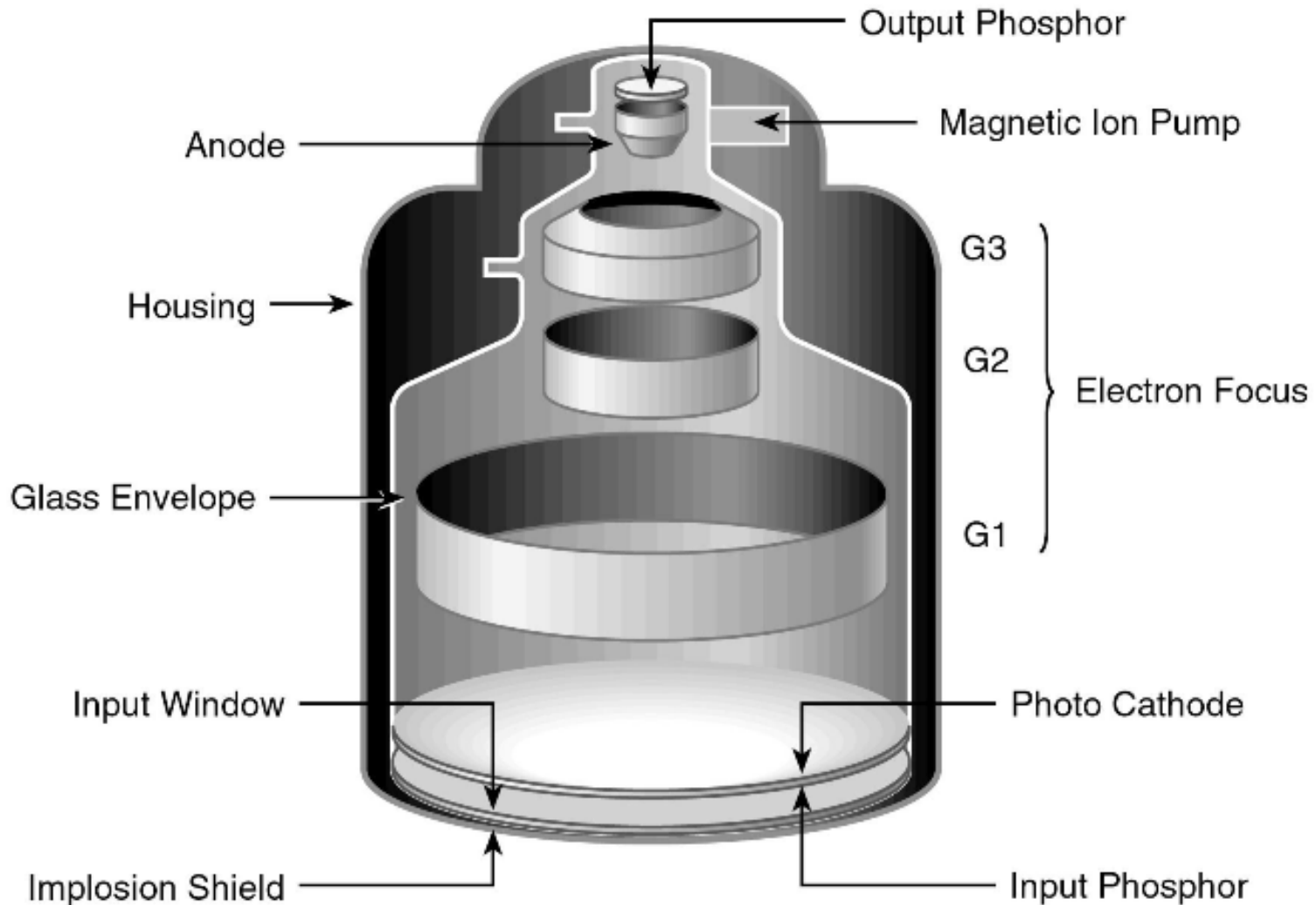


Image Chain (II/CCD Side Mount)

- ☐ Typical of full size RF Rooms

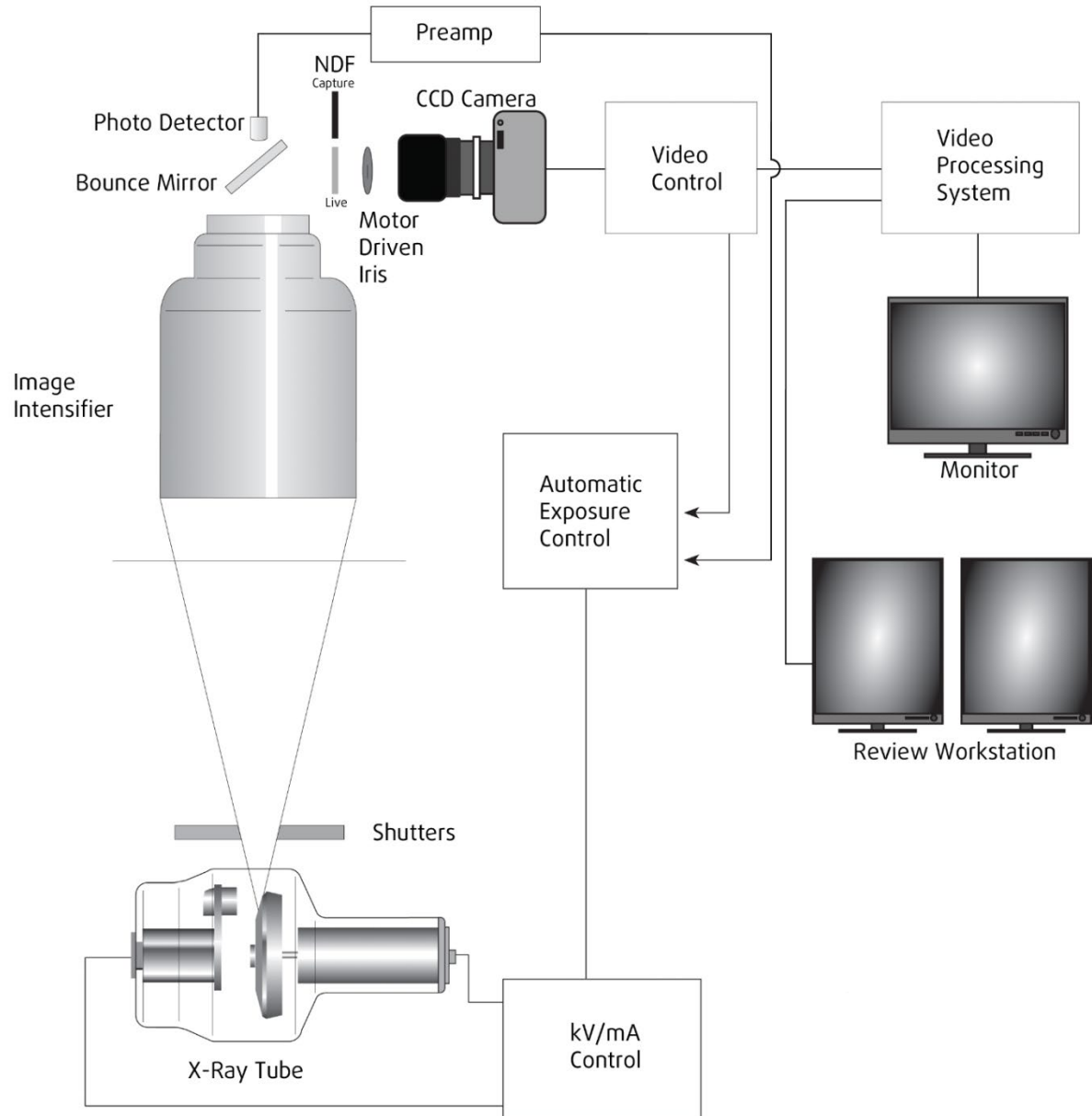
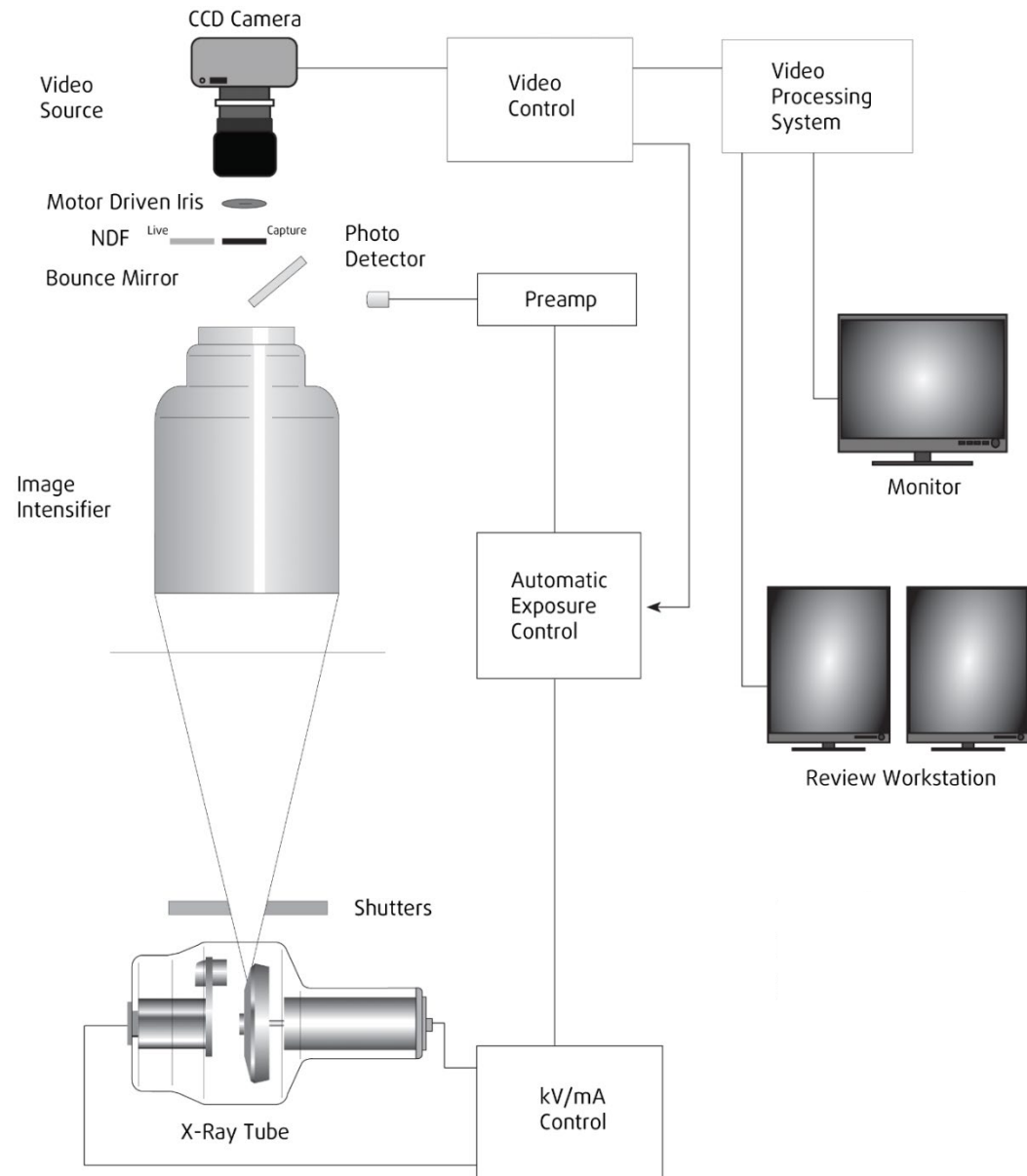


Image Chain (II/CCD Top Mount)

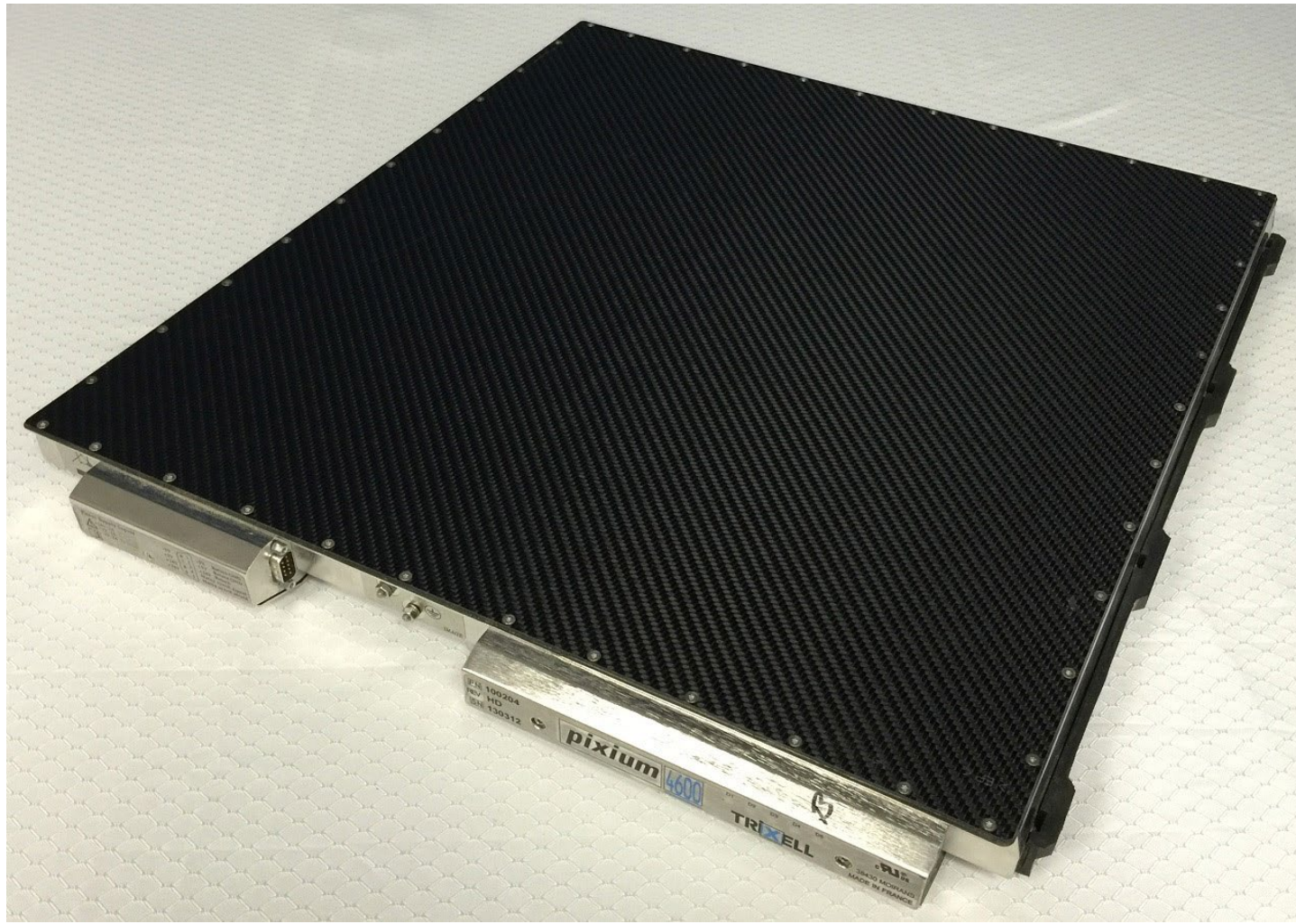
- Typical of portable Fluoroscopic Systems



RF Room (Flat Panel Detector)



Flat Panel Detector



FPD Sizes And Formats

- ❑ OEM's typically offer 2 or 3 FPD size models
 - ❑ General Fluoroscopy: Visualize large areas and anatomic systems
 - ❑ ~40cm X 40cm or rectangular
 - ❑ Cardiac: Visualize and measure functionality of the heart
 - ❑ ~20cm X 20cm
 - ❑ Angiography: Visualize vessels and organs of the body
 - ❑ ~40cm X 40cm or rectangular
 - ❑ "Hybrid" or "Swing"
 - ❑ Combination

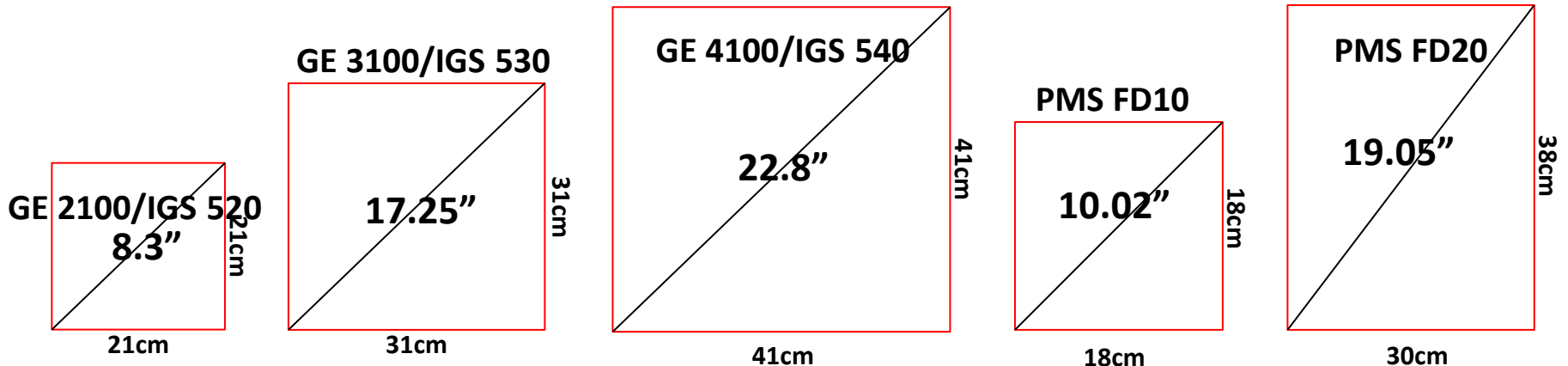
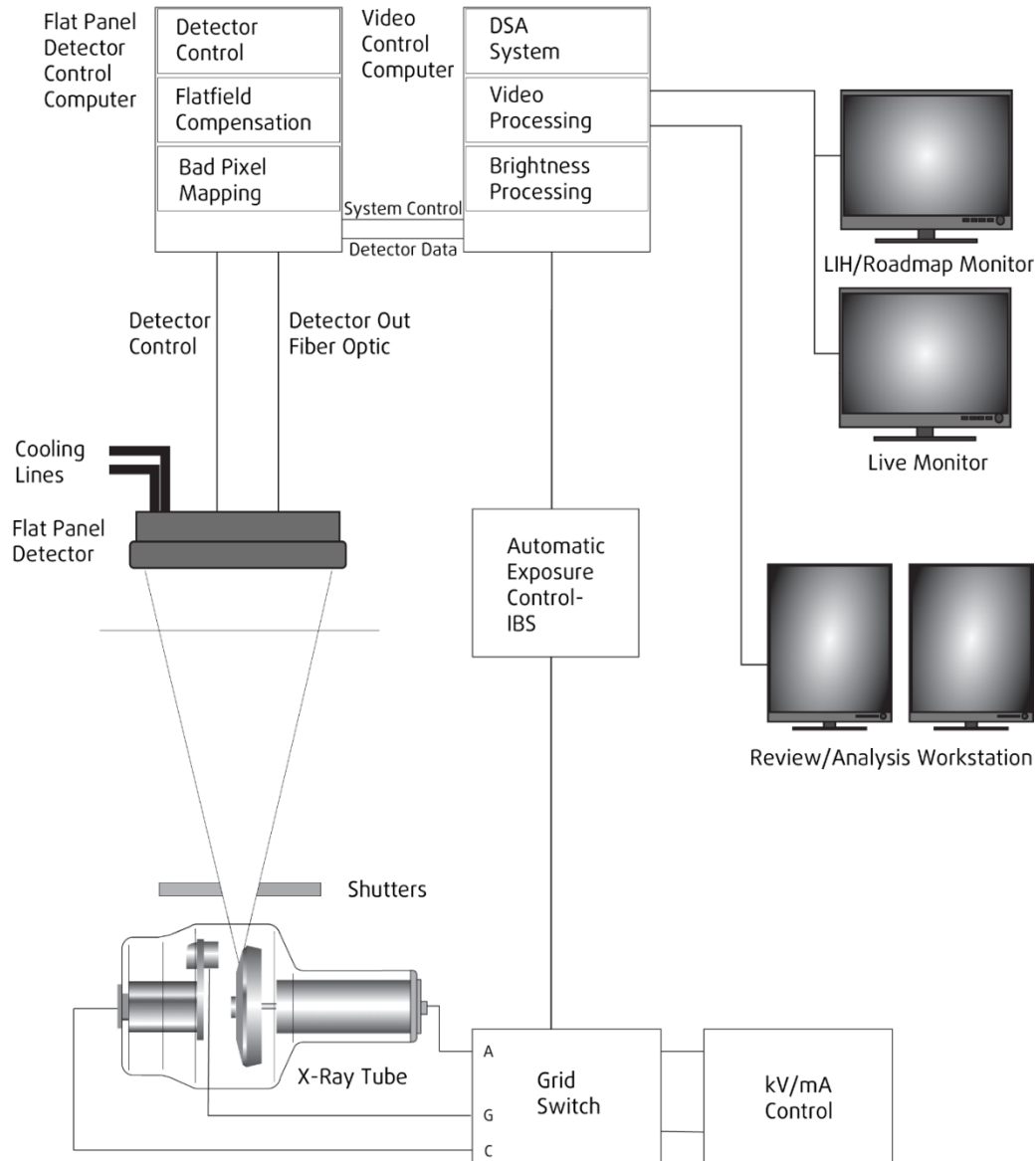
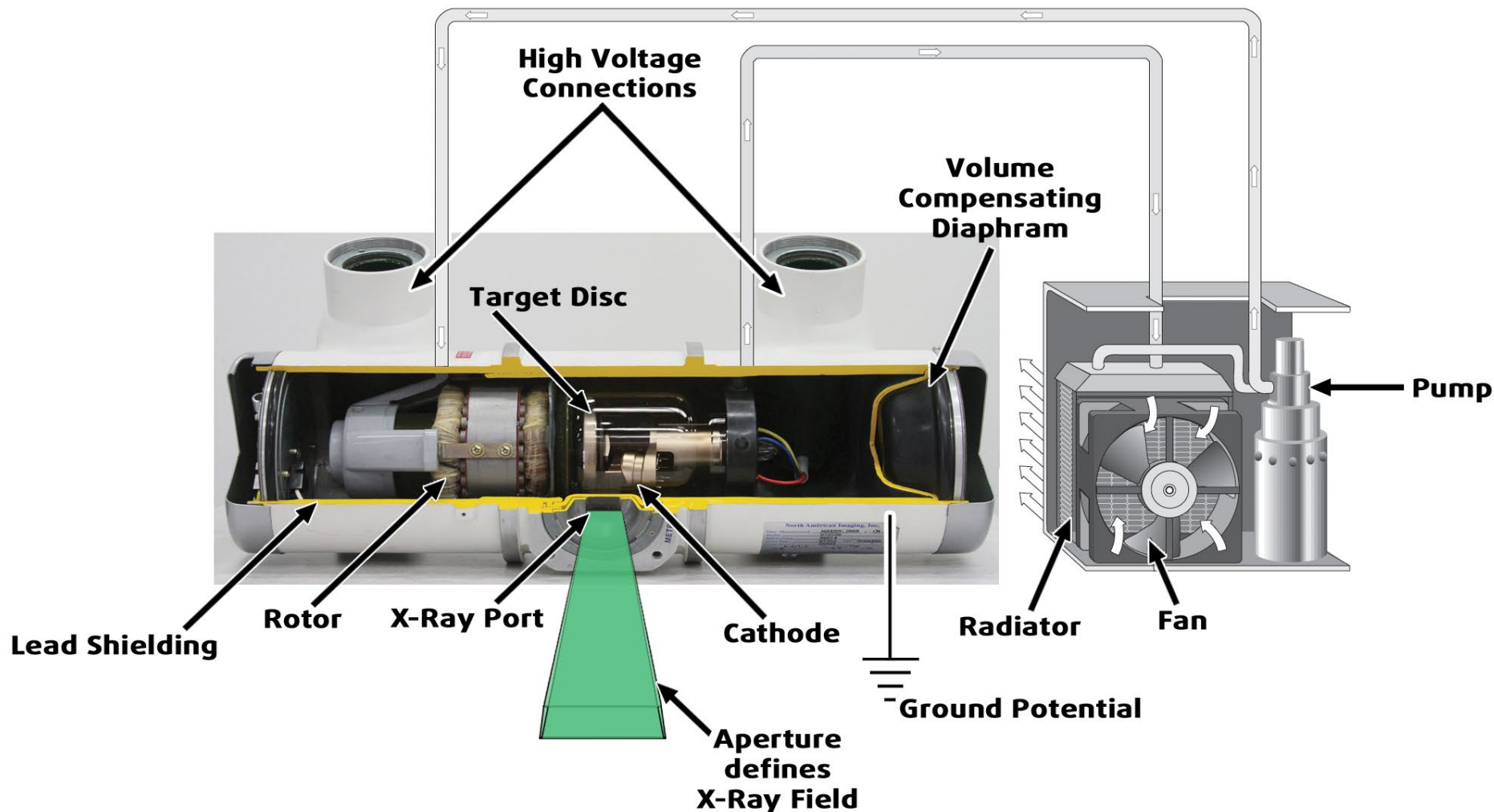


Image Chain (Flat Panel)



Fluoroscopy X-Ray Tubes

Due to long exposure times and high heat loads most fluoro tubes have augmented cooling



Fluoroscopic Modes Of Operation

☐ Fluoroscopy

- ☐ Continuous Fluoro

- ☐ Pulsed Fluoro

☐ Radiography

- ☐ Digital Spot (Captures during live Fluoro run)

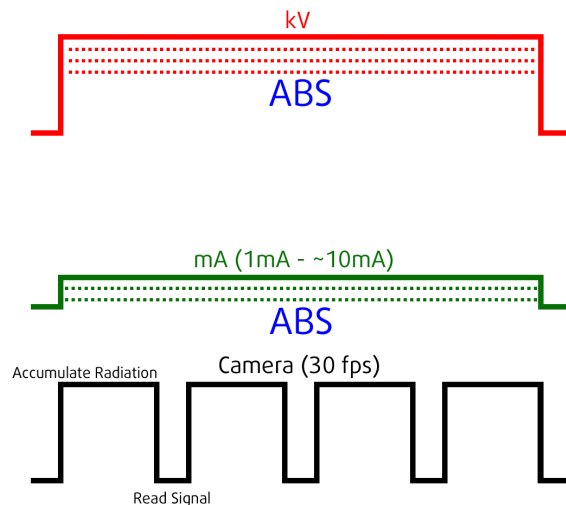
- ☐ Sequential Capture (Cine and Vascular)

Fluoroscopic Modes Of Operation

❑ Fluoroscopy:

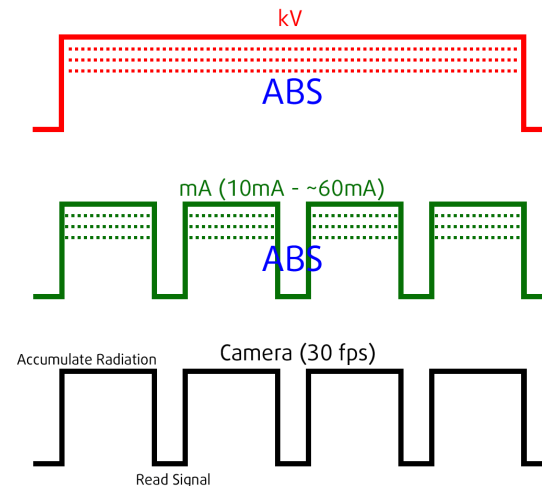
❑ Continuous (~10mA or less)

❑ Pulsed (Up to ~50mA)



kV: Continuous
mA: Continuous
Camera: 30 fps
Exp Control: ABS

On-Time Waveform Representations:
Fluoroscopy, Continuous



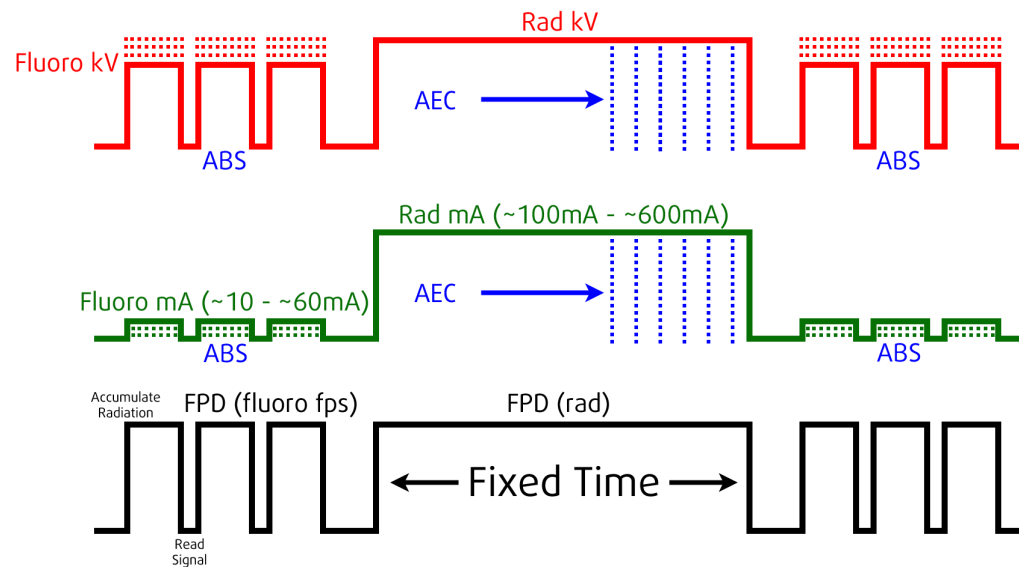
kV: Continuous
mA: Pulsed
FPD/Camera: 30 fps
Exp Control: ABS

On-Time Waveform Representations:
Fluoroscopy, Pulsed (mA)

Fluoroscopic Modes Of Operation

❑ Digital Spot:

- ❑ Acquired during Continuous or Pulsed Fluoro (~10mA to ~60mA)
- ❑ Spot Exposure – Radiographic level (~100mA to ~600mA)

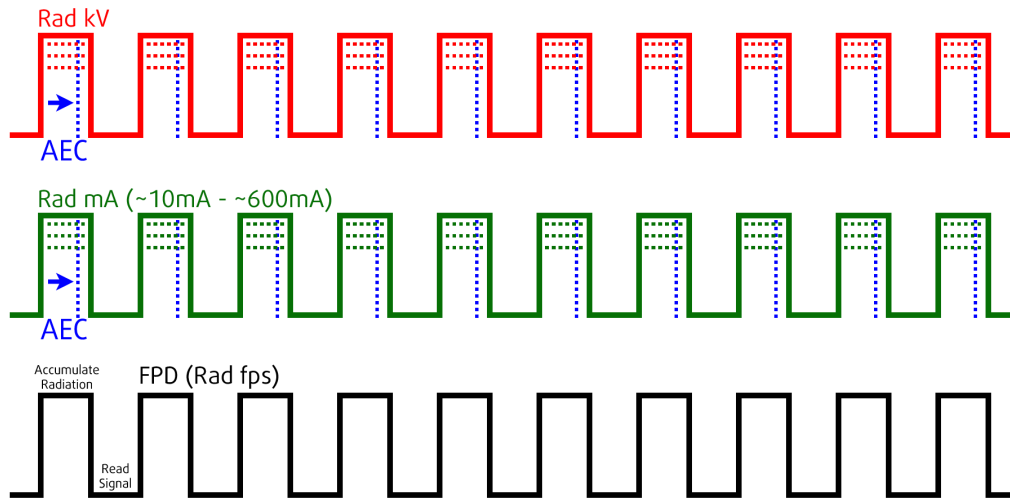


kV: Pulsed (Fluoro: X-Ray tube or inverter), continuous (Rad)
 mA: Pulsed (fluoro), continuous (Rad)
 FPD/Camera: 30 fps (fluoro), continuous (Rad)
 Exp Control: ABS (fluoro), AEC (Rad)

On-Time Waveform Representations:
Digital Spot

Fluoroscopic Modes Of Operation

- Radiography (“Cine”):
 - Capture radiographic level (up to >1,000mA) exposures in rapid succession at various frame rates
 - PPS = Fluoro, FPS = CINE/RAD



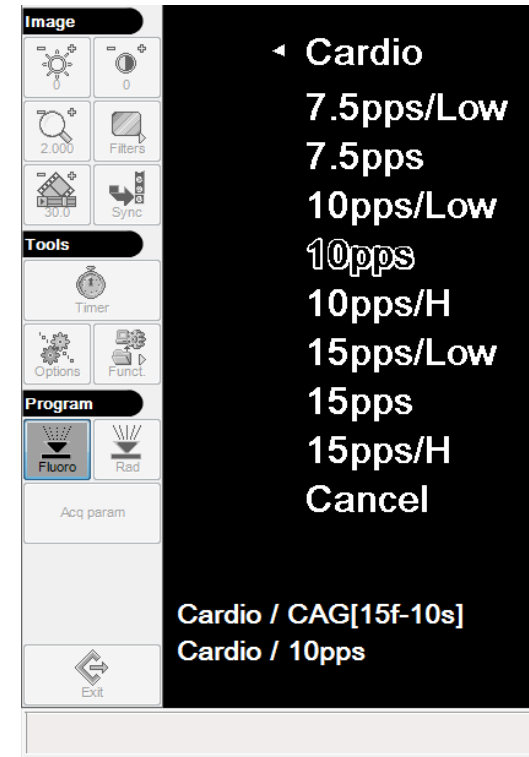
kV: Pulsed (X-Ray tube or inverter)

mA: Pulsed

Camera: 30-60 fps

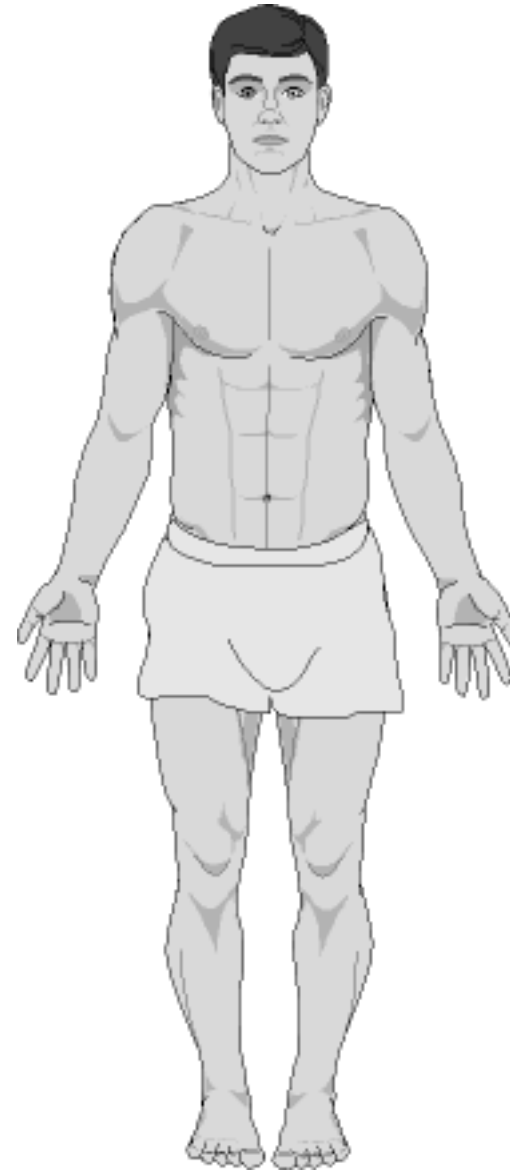
Exp Control: AEC

On-Time Waveform Representations:
Cine



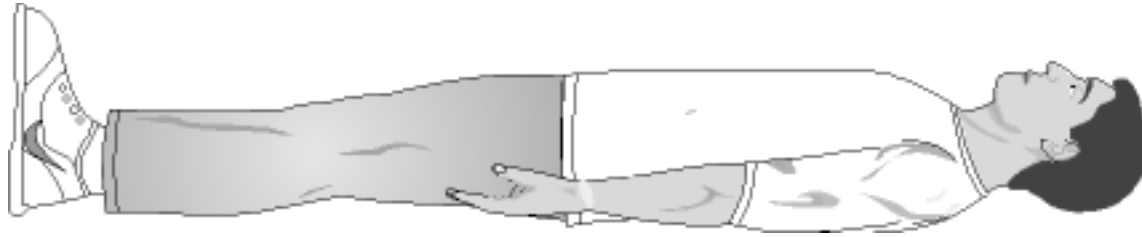
Patient Positioning and Viewing

- ☐ Anatomic Position
 - ☐ Proper orientation when the patient is viewed on the monitor regardless of how they oriented on the table

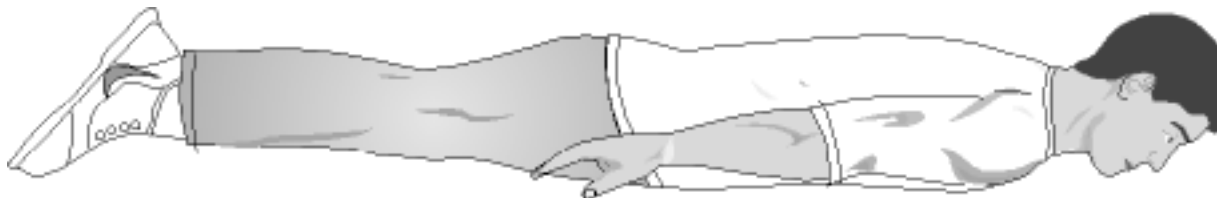


Patient Positioning and Viewing

Supine



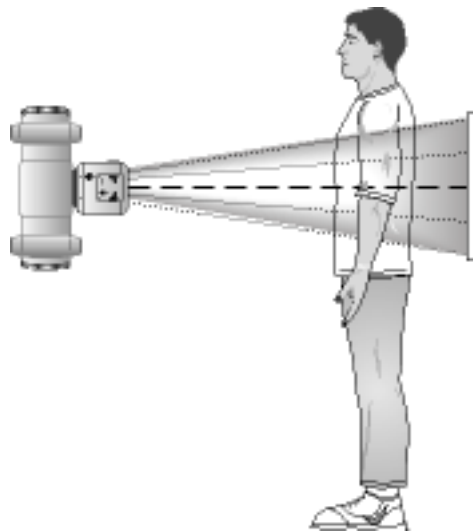
Prone



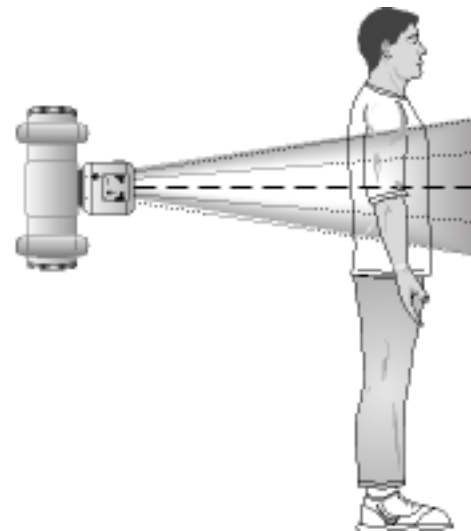
Patient Positioning and Viewing

☐ Projections

☐ X-Ray tube to image receptor

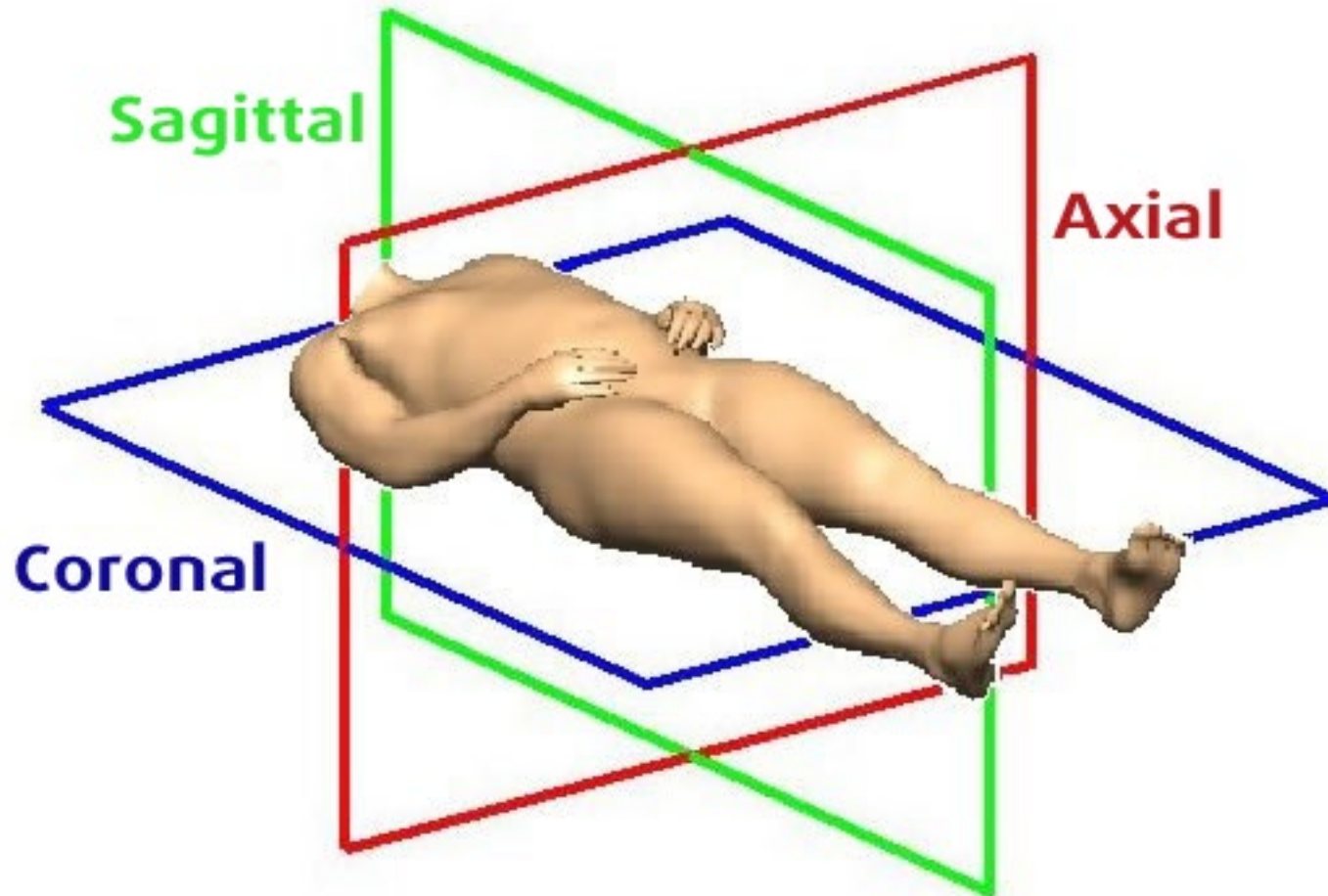


Anterior to Posterior(AP)



Posterior to Anterior(PA)

Patient Positioning and Viewing





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