Introduction to Servicing Radiographic and R/F Systems

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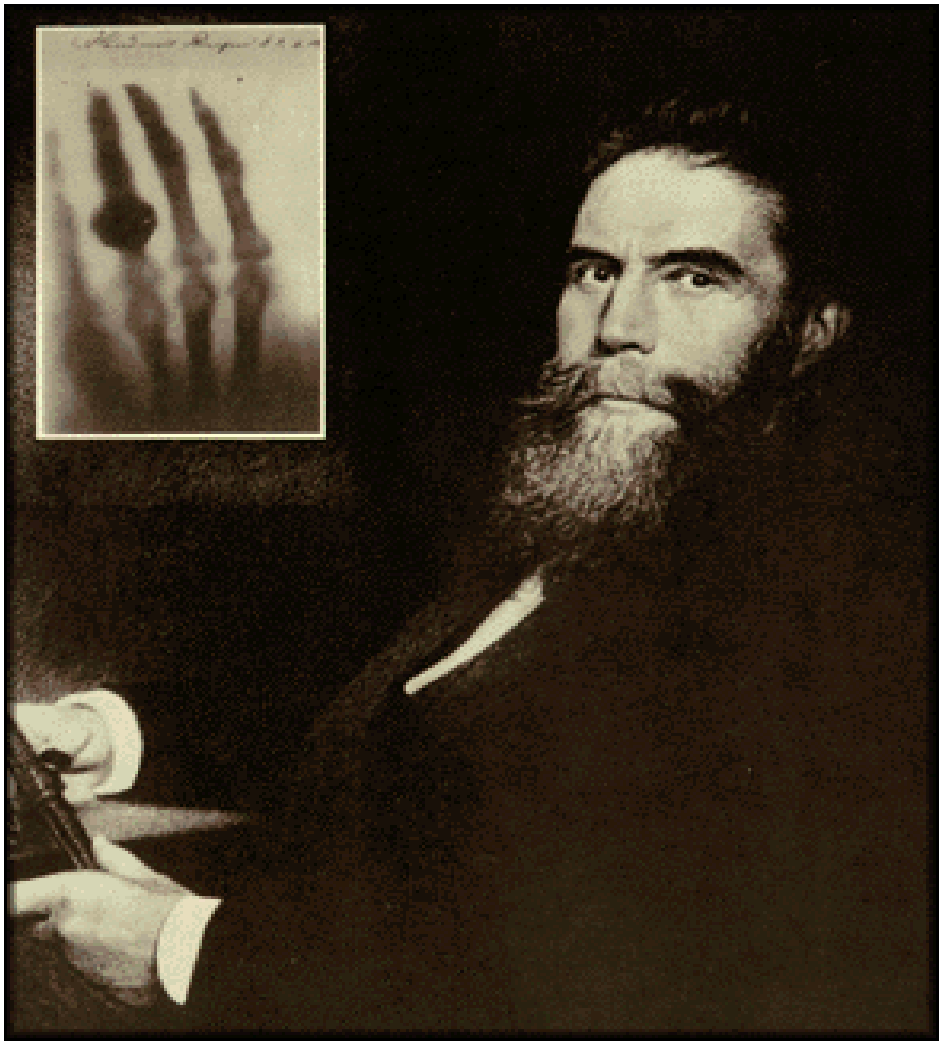
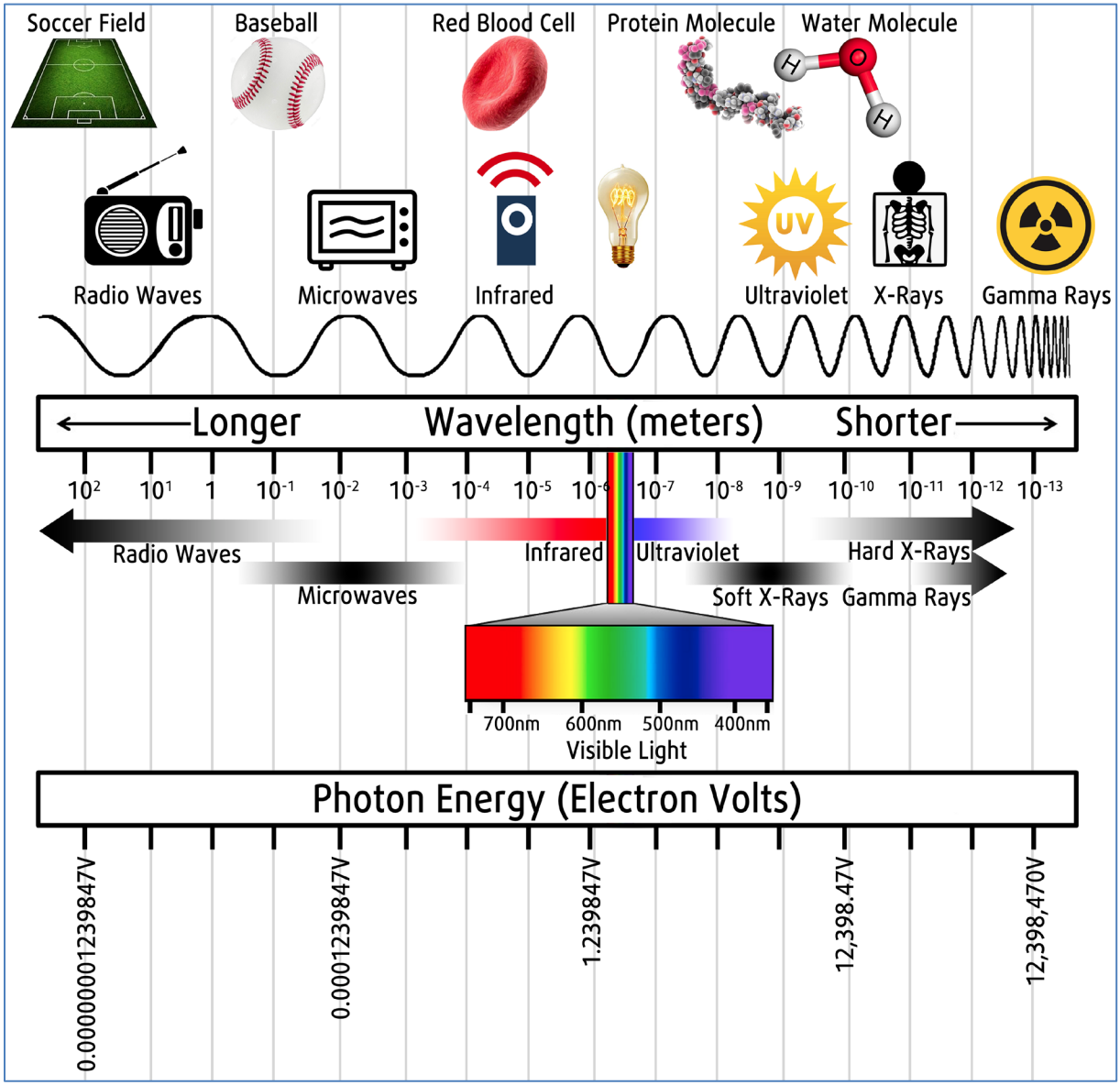
Wilhelm Roentgen Discovers X-Rays

- 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?

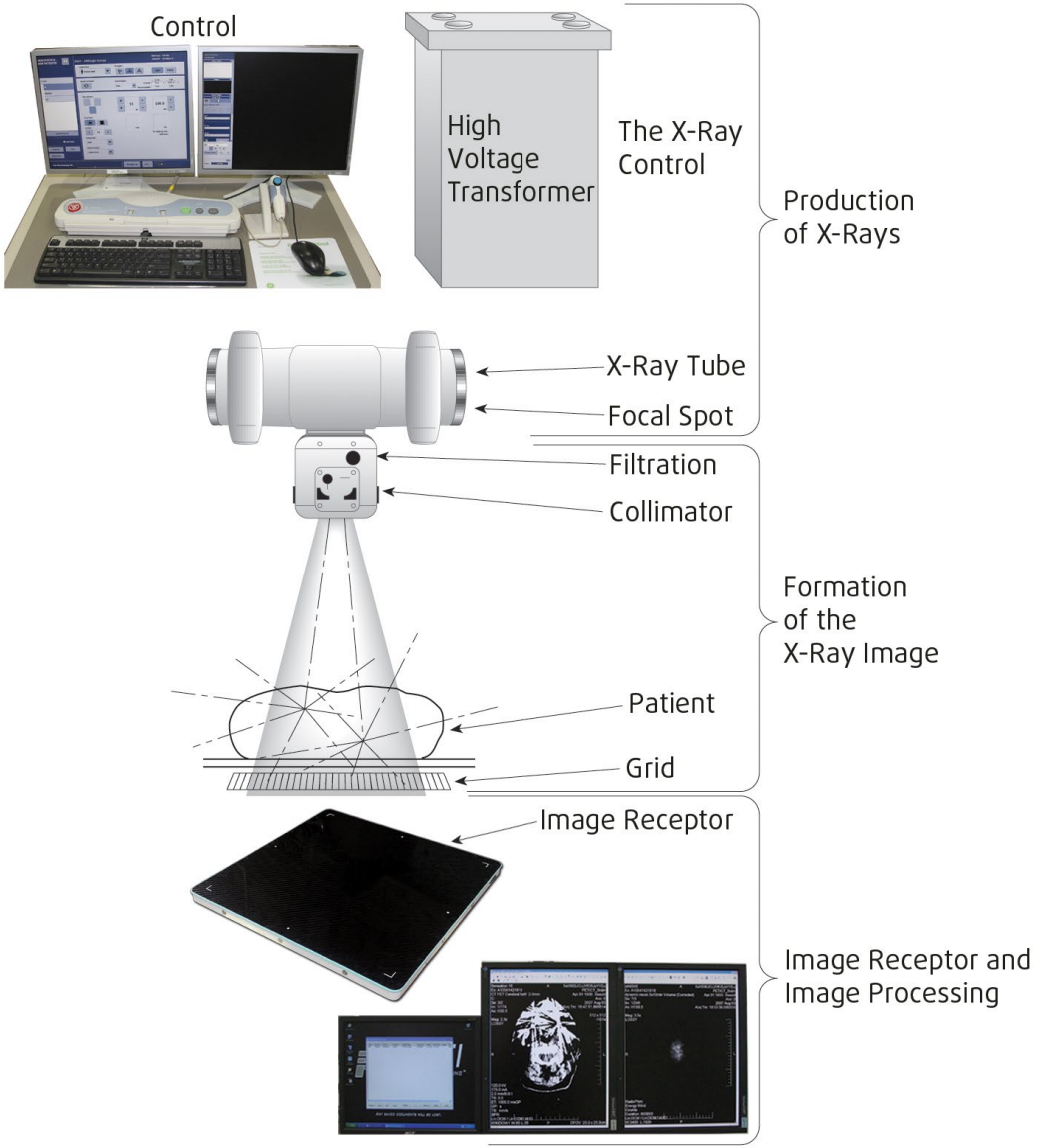
- Part of the electromagnetic spectrum
- High in frequency and low in wavelength
- Penetrating in nature



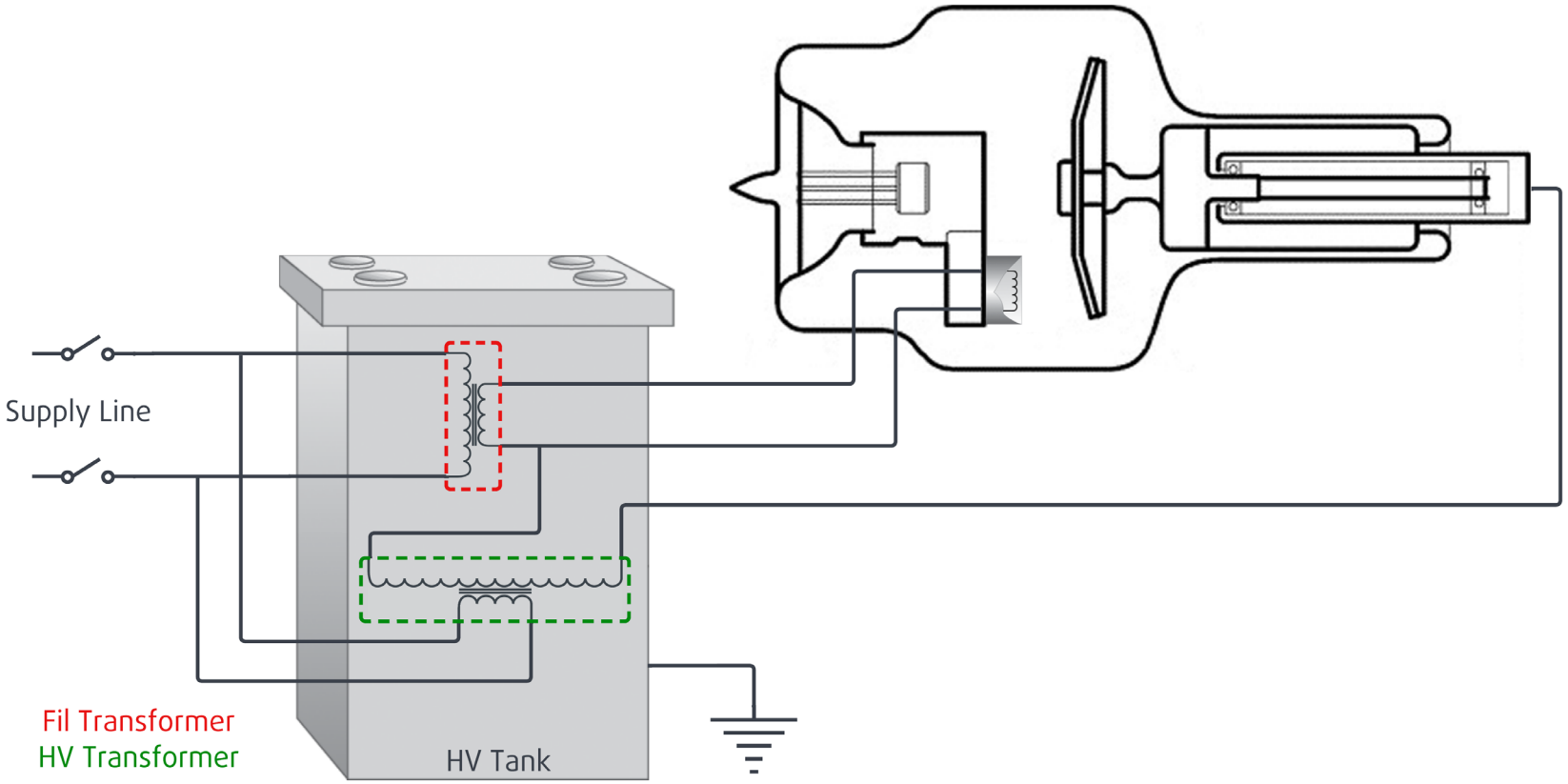
Basic Radiographic Imaging Room

Basic Radiographic Imaging Room

- Radiographic systems can be divided into three main areas



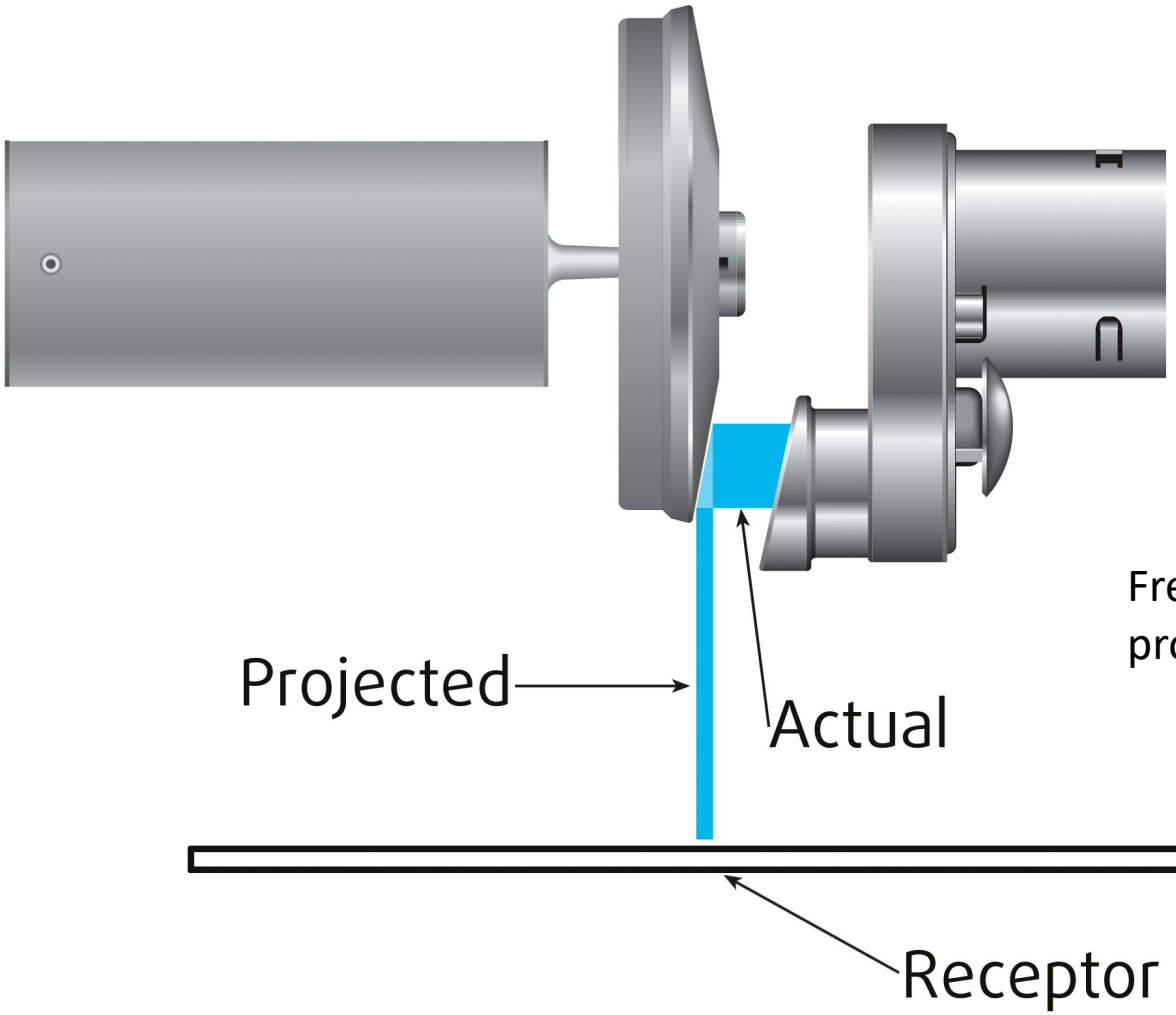
How are X-Rays Produced?



- ❑ Identify:
  - ❑ Anode
  - ❑ Cathode
  - ❑ kV-
  - ❑ kV+
  - ❑ kV Total
  - ❑ Filament Current
  - ❑ Tube Current (mA)
  - ❑ Photons

The X-Ray Tube (source of radiation)

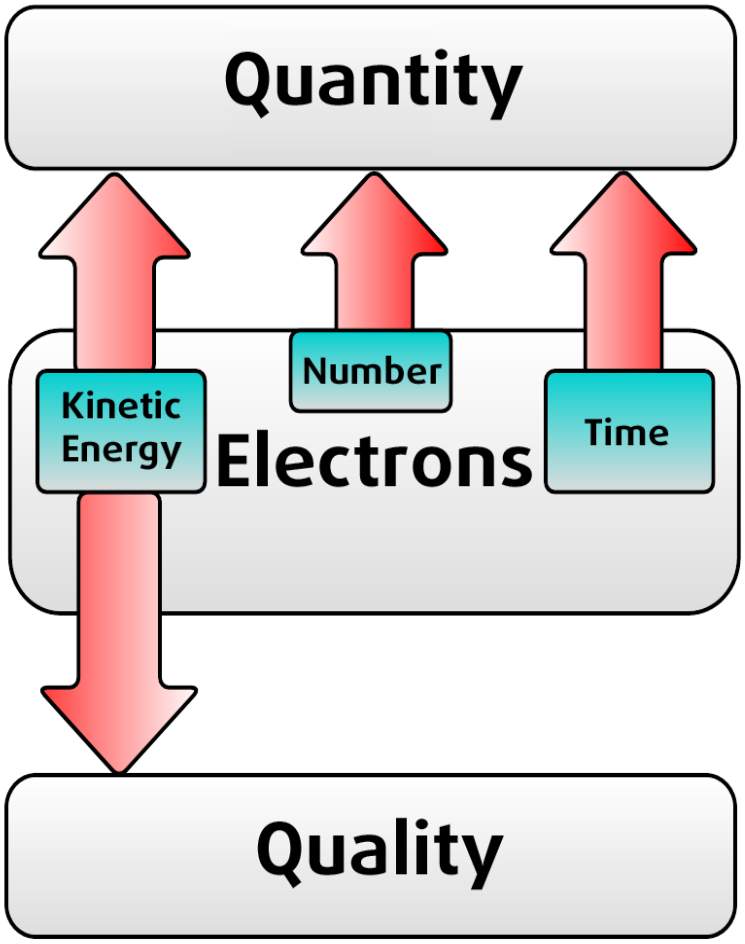
High potential (40-150 kVp) applied across the X-Ray tube



Free electrons are produced by the cathode

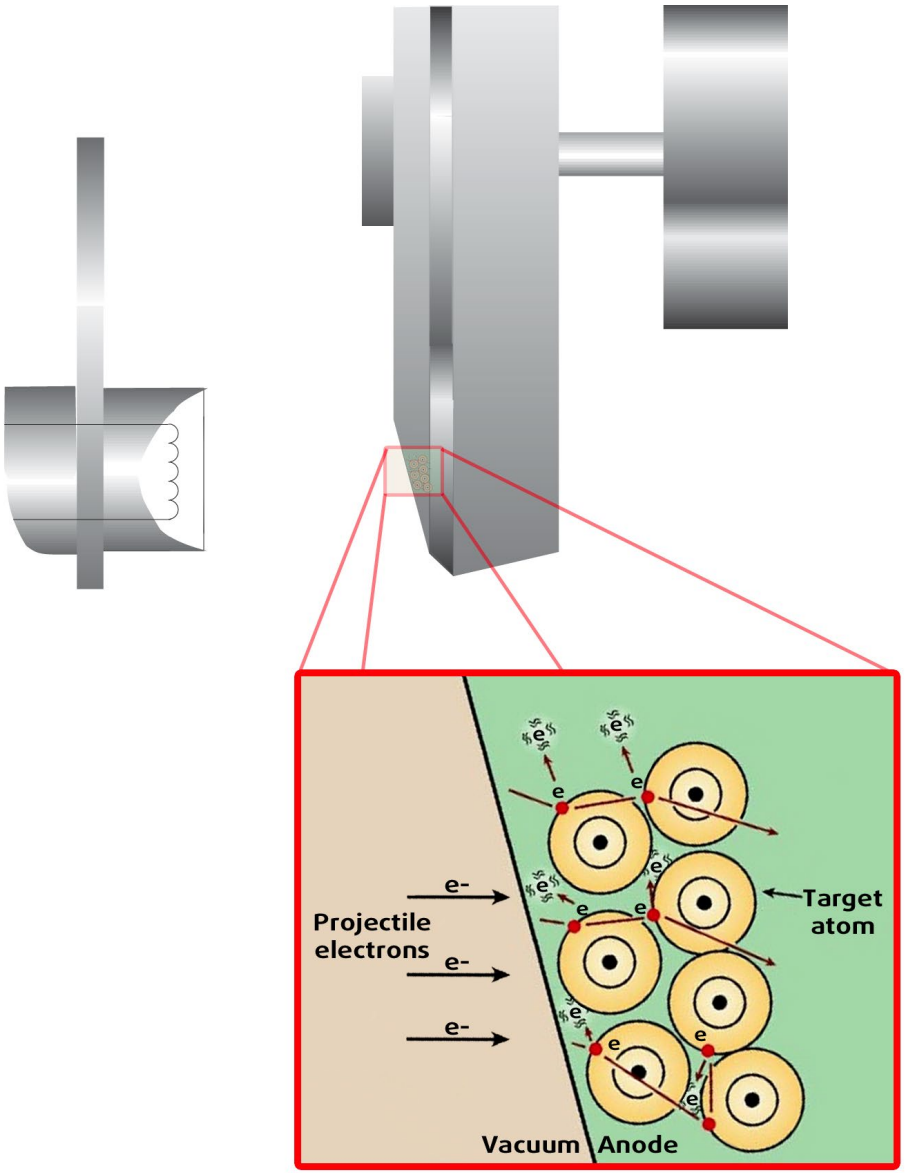
kV, mA, Time

- **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



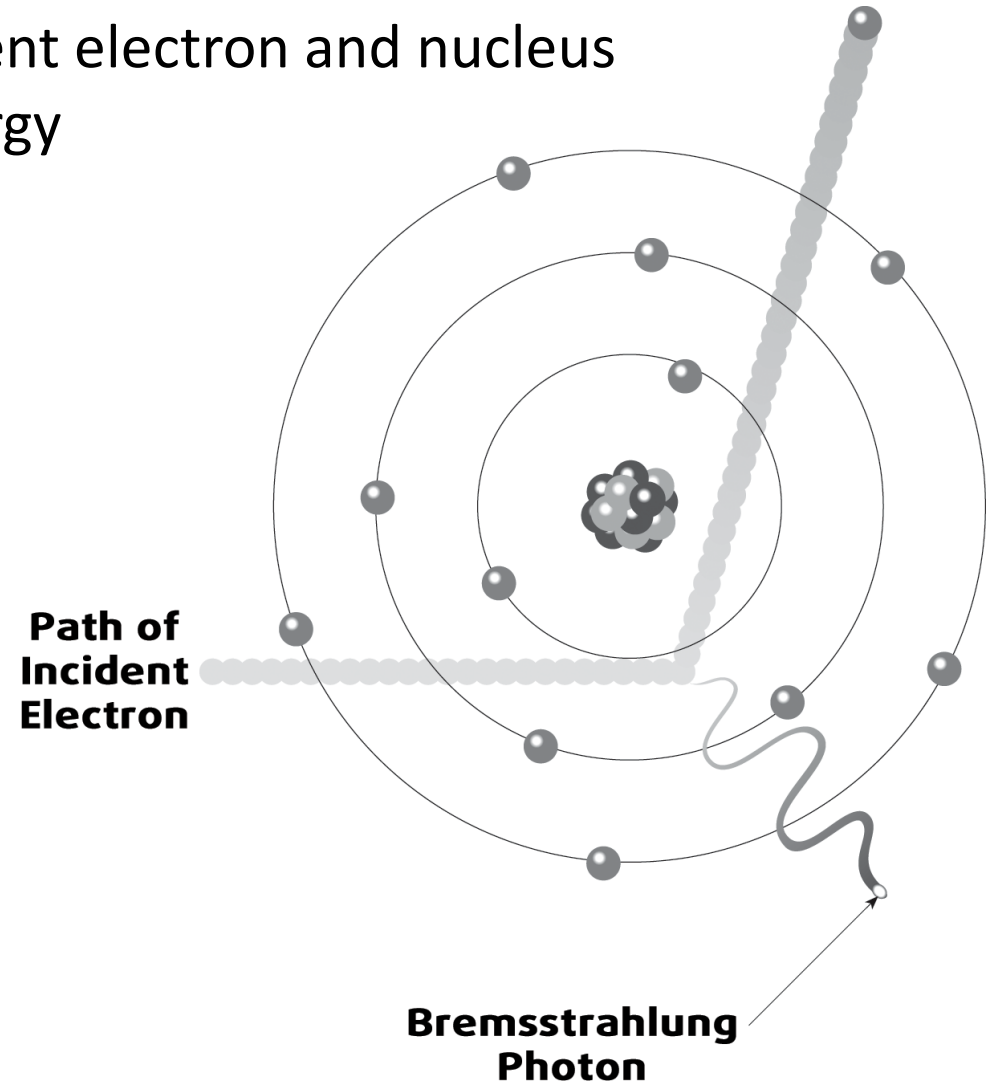
Creating X-Rays

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



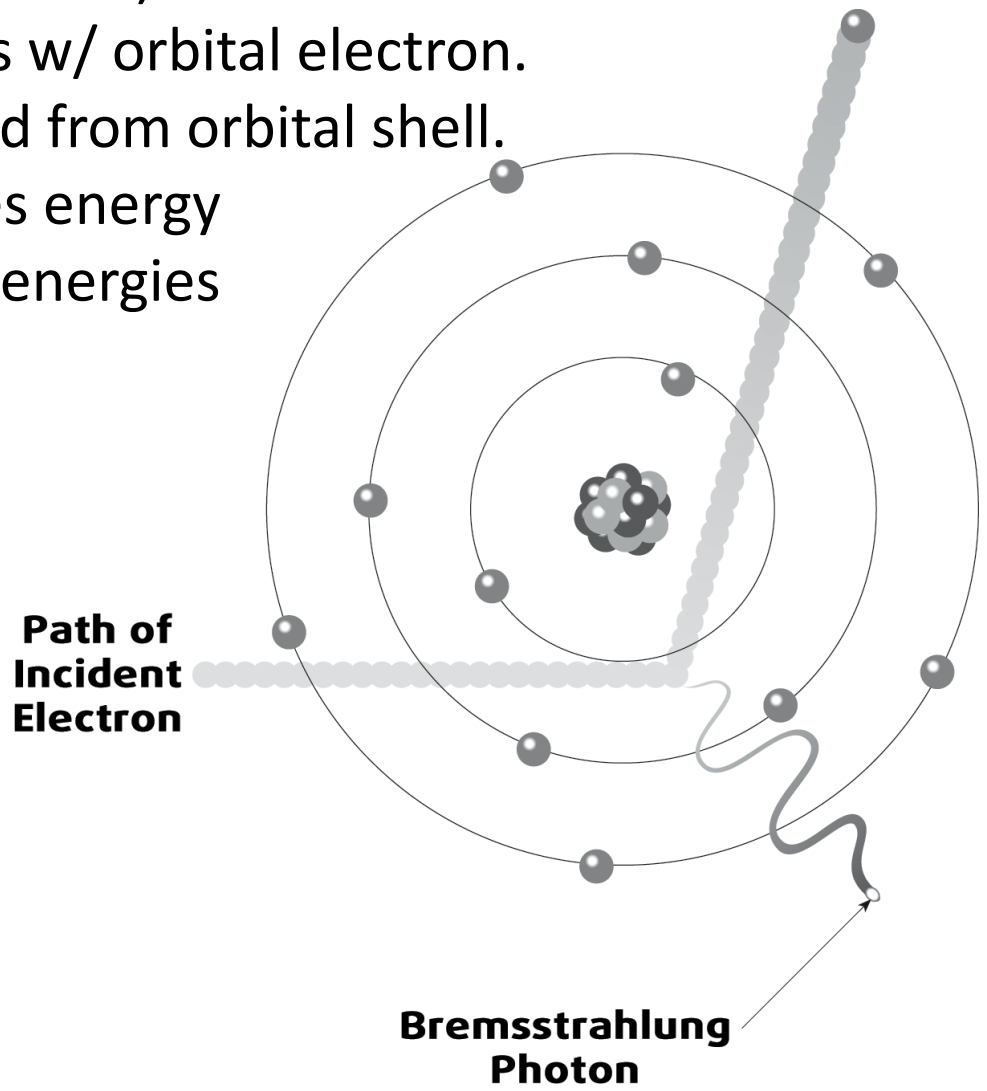
Creating X-Rays

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

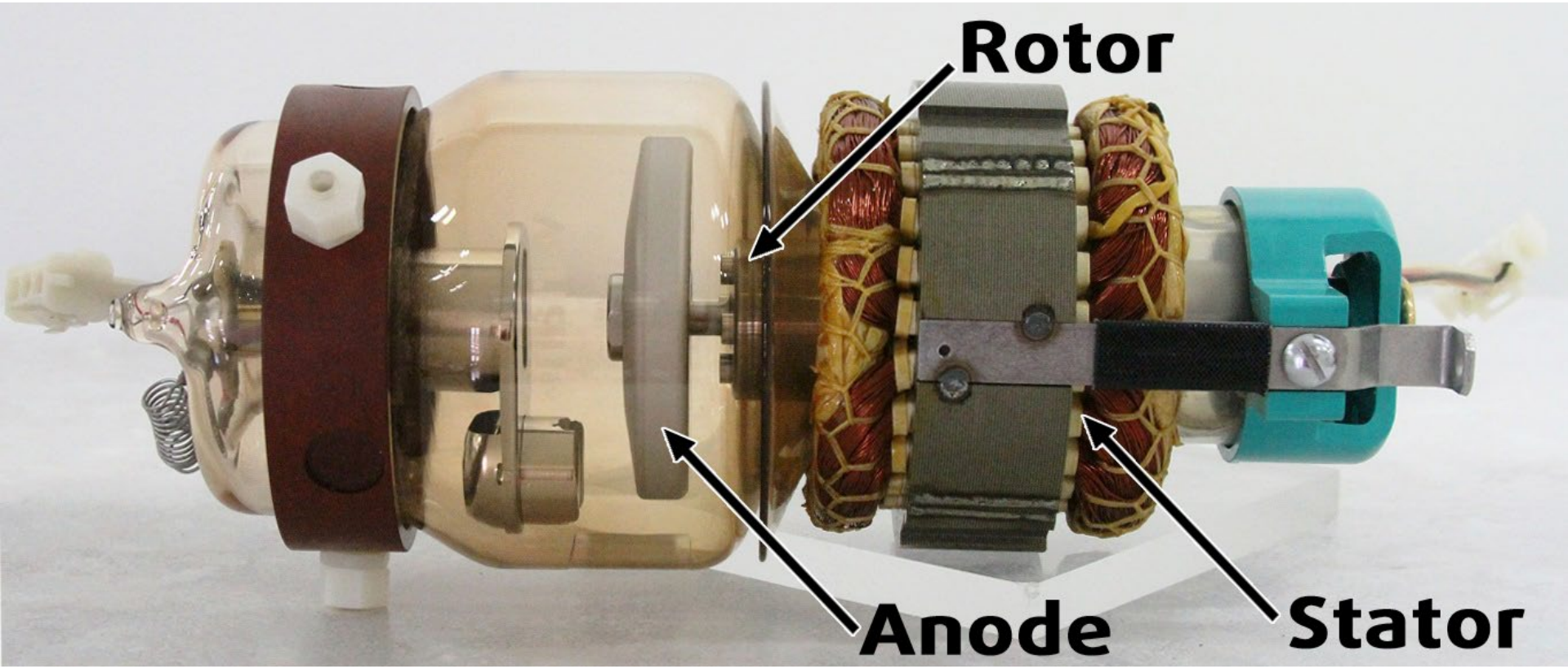


Creating X-Rays

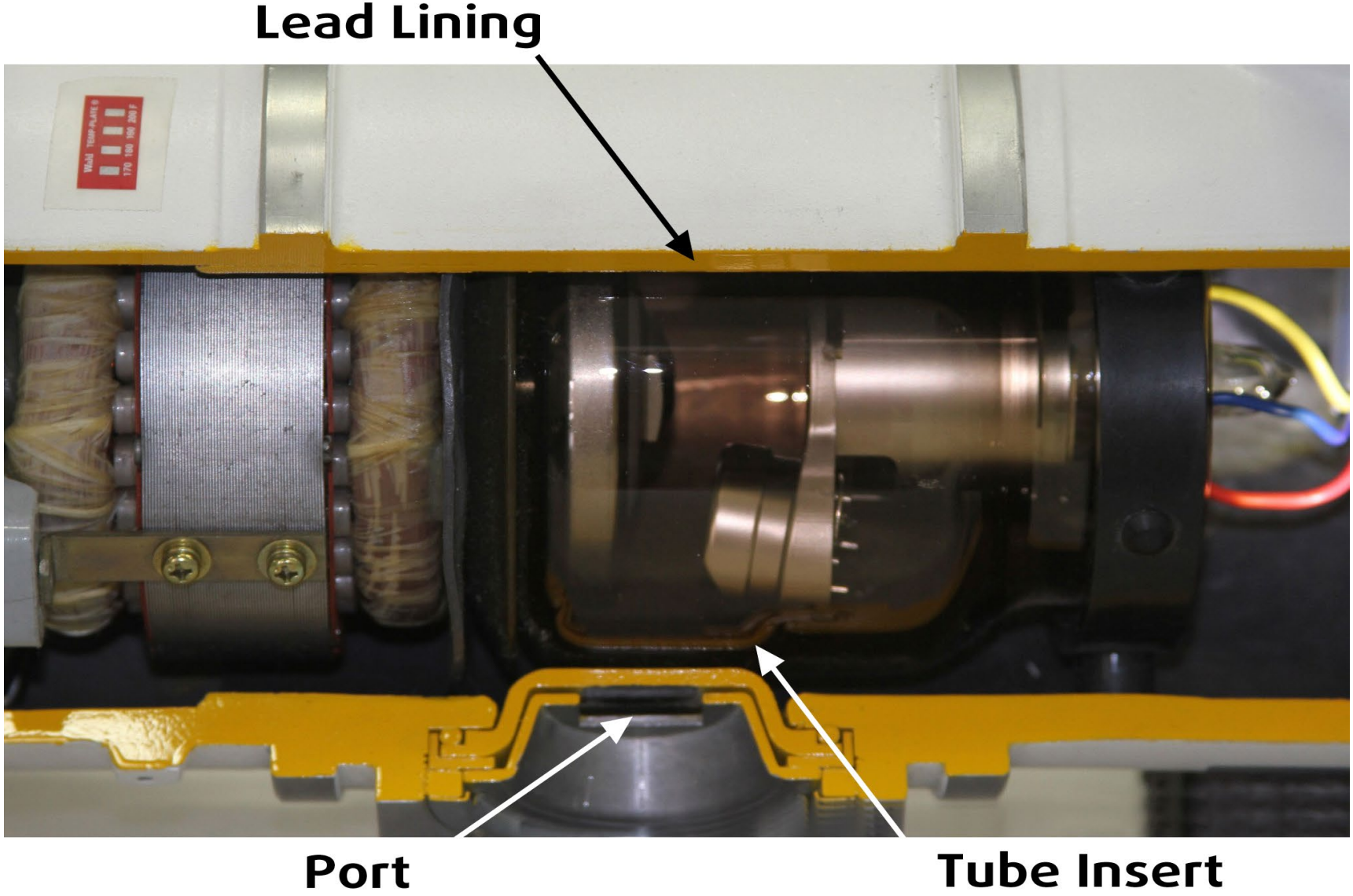
- Characteristic Radiation (Collision)
  - Incident electron collides w/ orbital electron.
  - Orbital electron is ejected from orbital shell.
  - Filling of vacancy releases energy characteristic of binding energies of target material.



X-Ray Tube Insert & Rotor

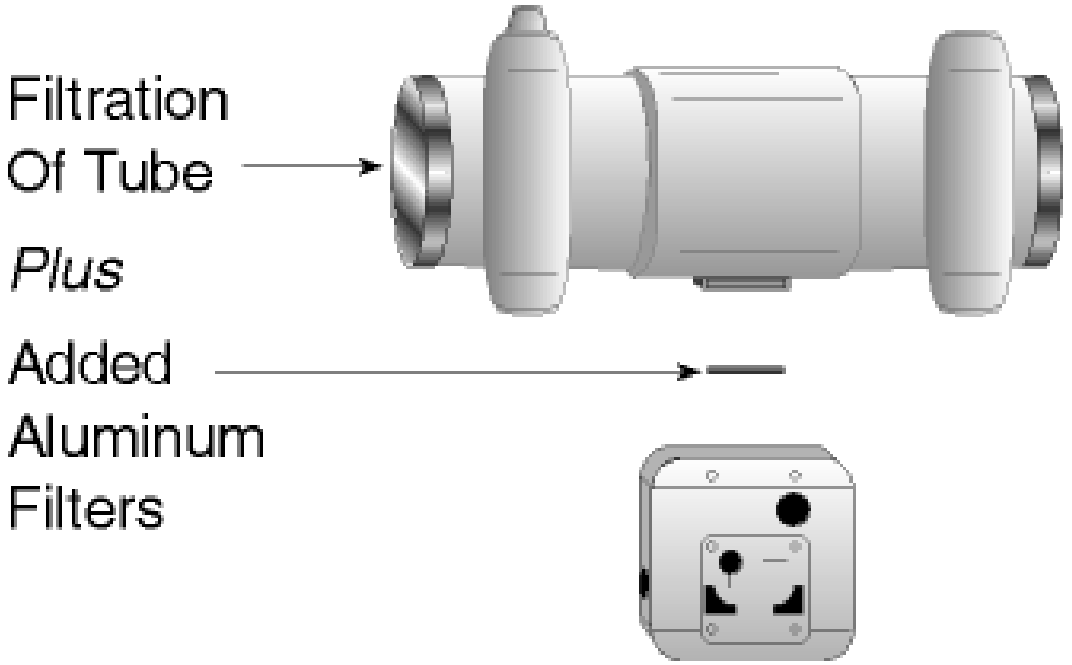


X-Ray Tube Housing & Insert



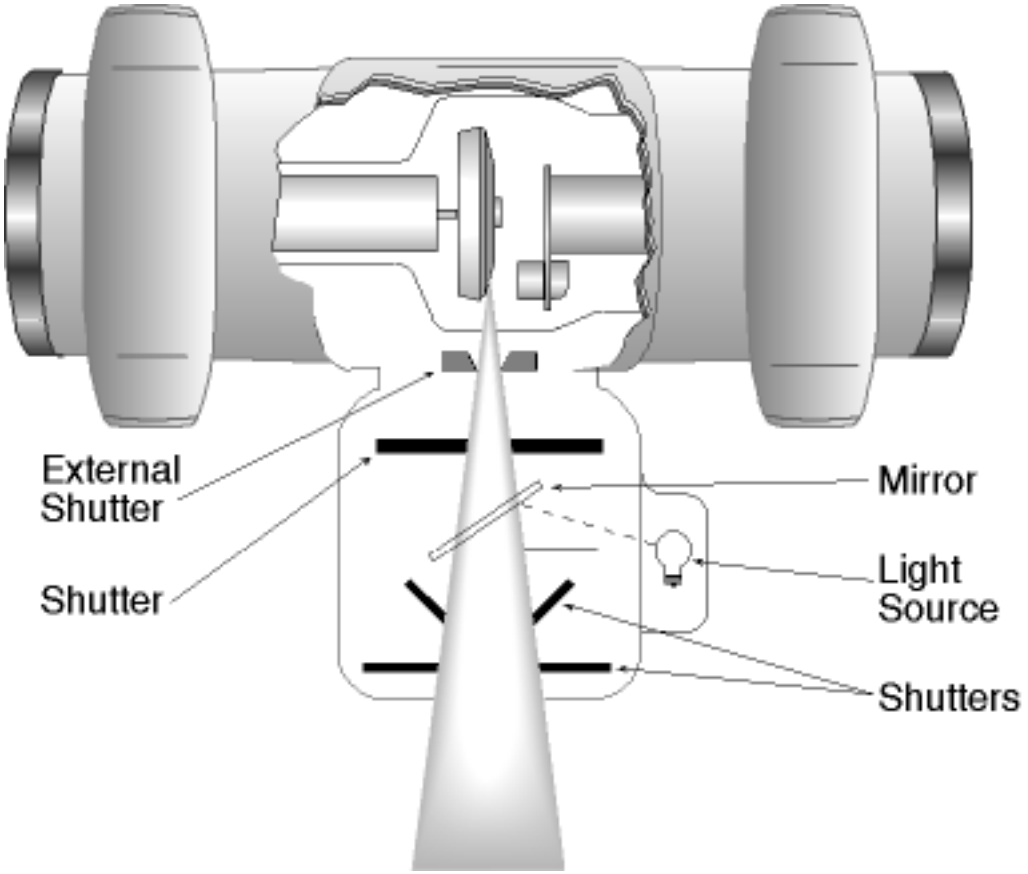
X-Ray Beam Must Be Filtered

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



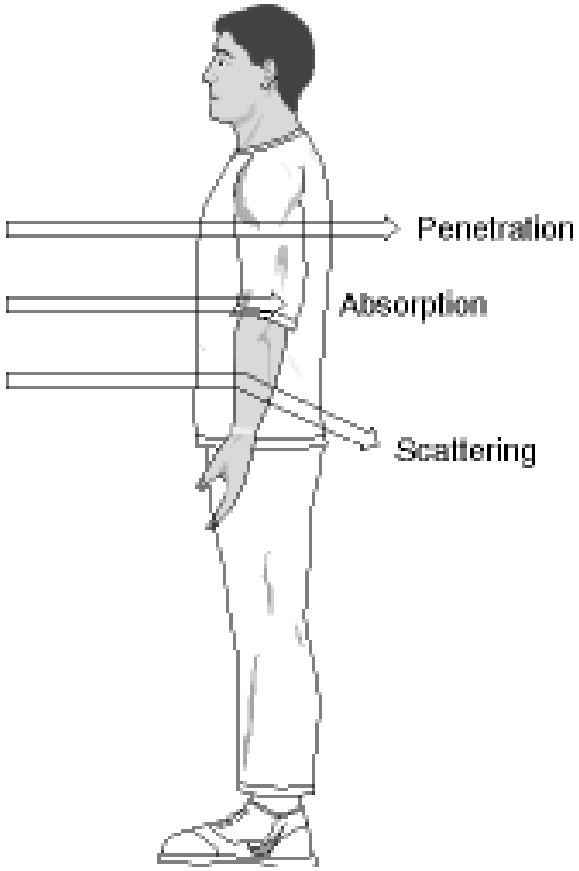
Collimating The X-Ray Beam

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



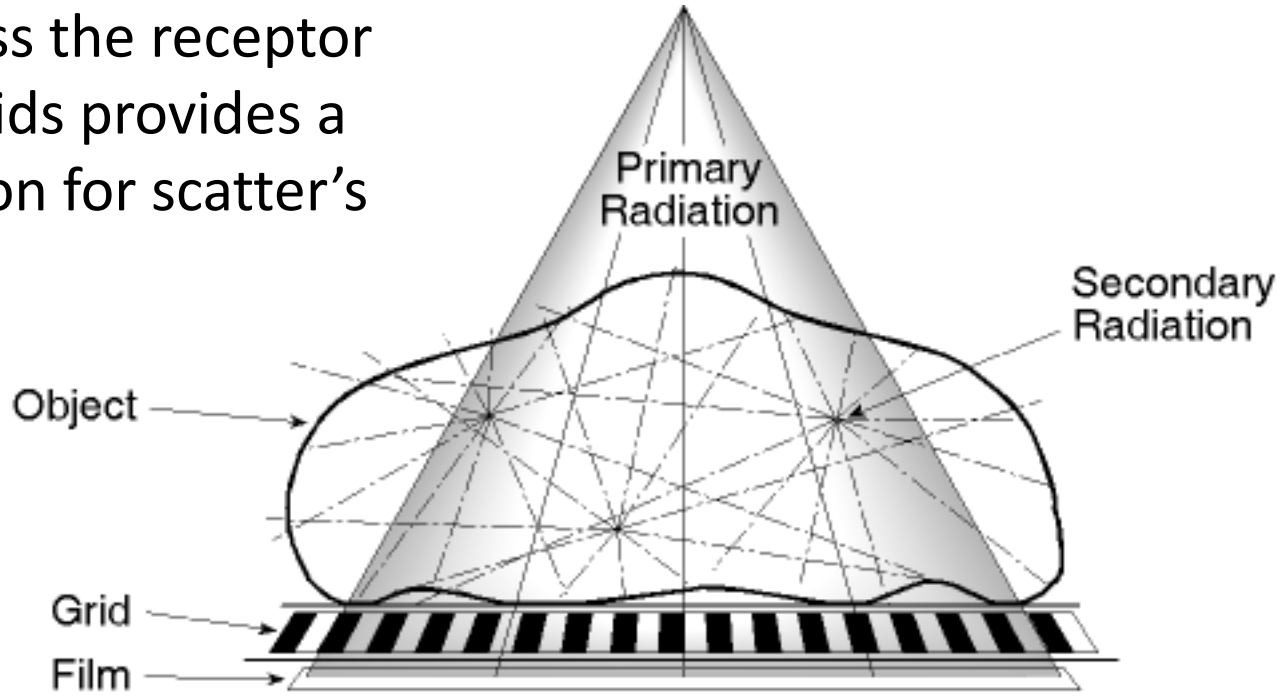
X-Ray Beam Interacting With Matter

- 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

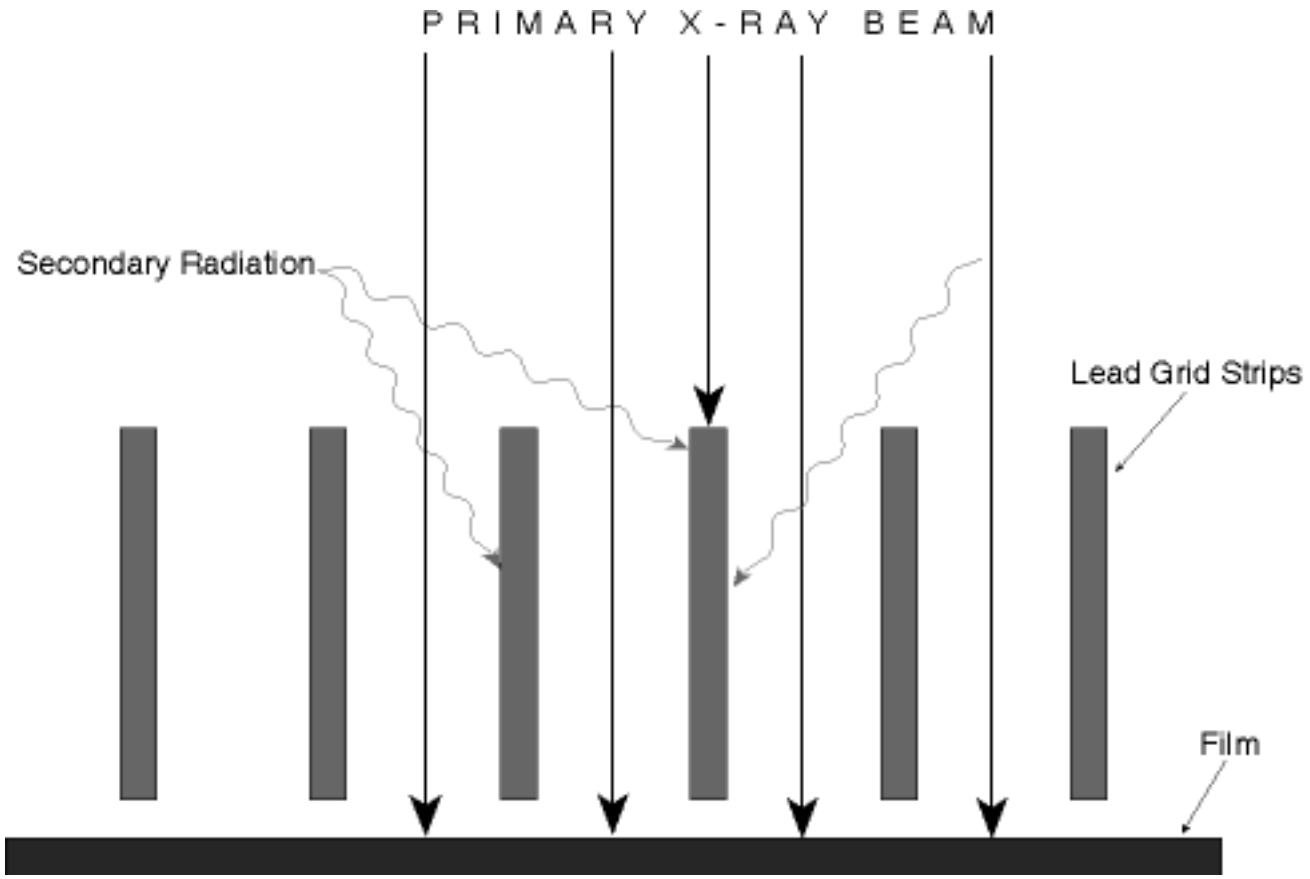


The Problem With Scatter

- 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

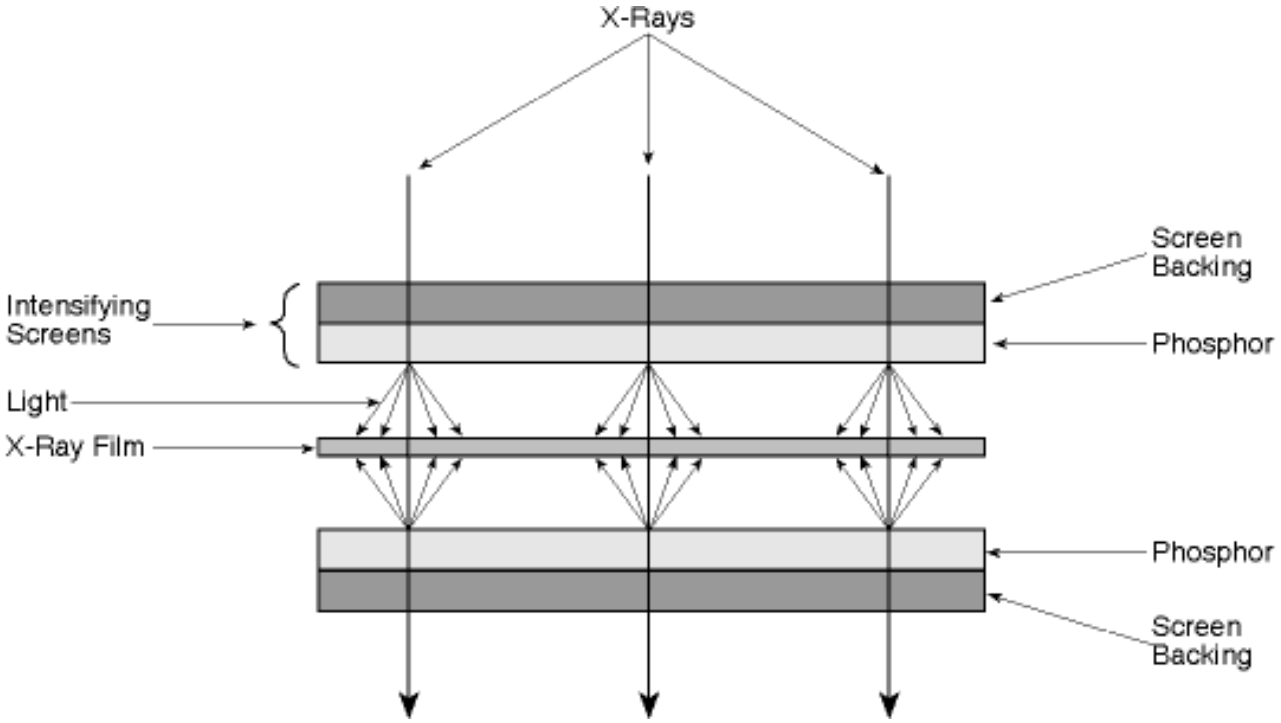


How X-Ray Grids Work



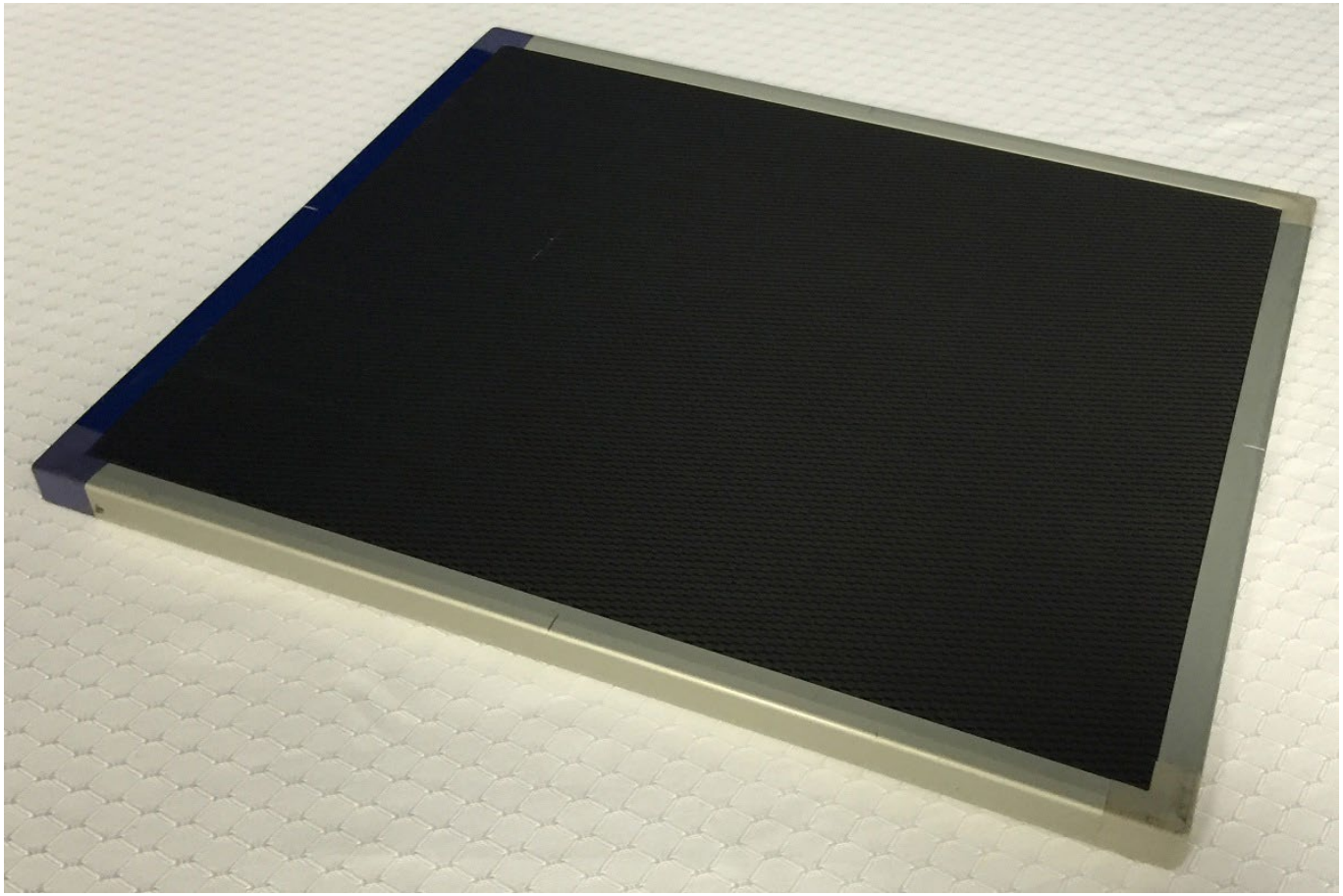
Film Screen Image Receptor

- 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



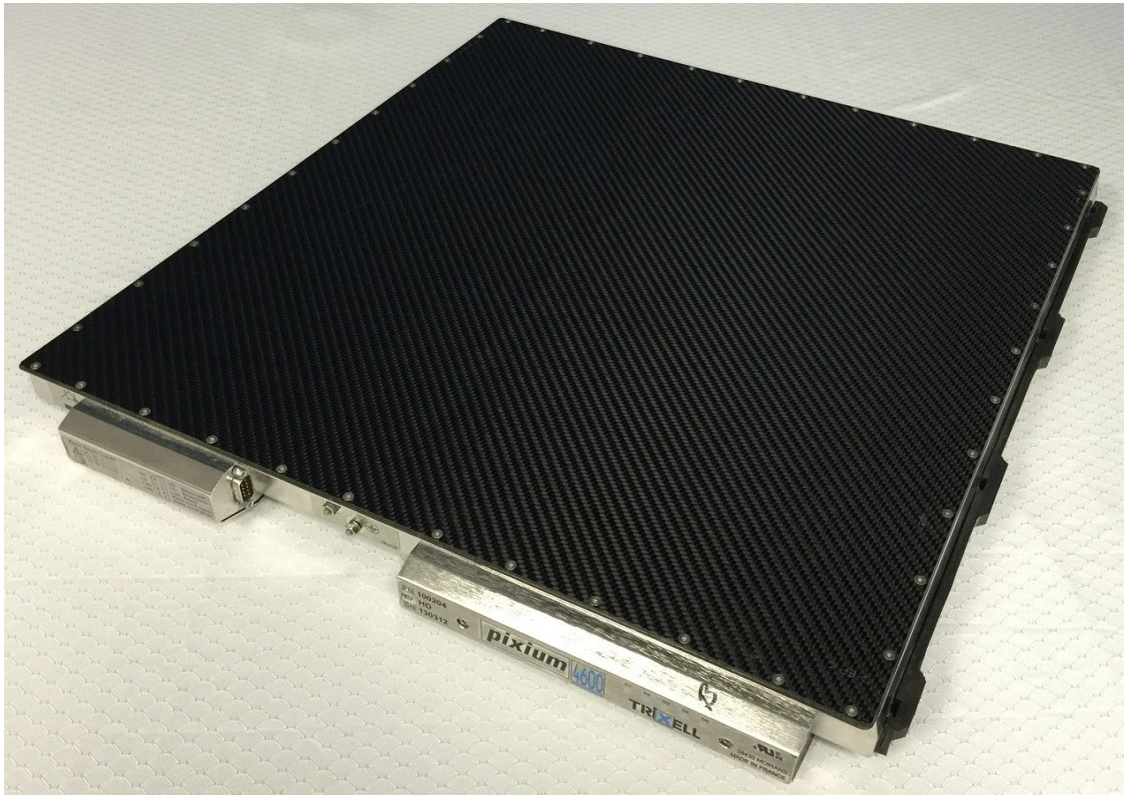
Cassette Style Radiographic Receptors

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

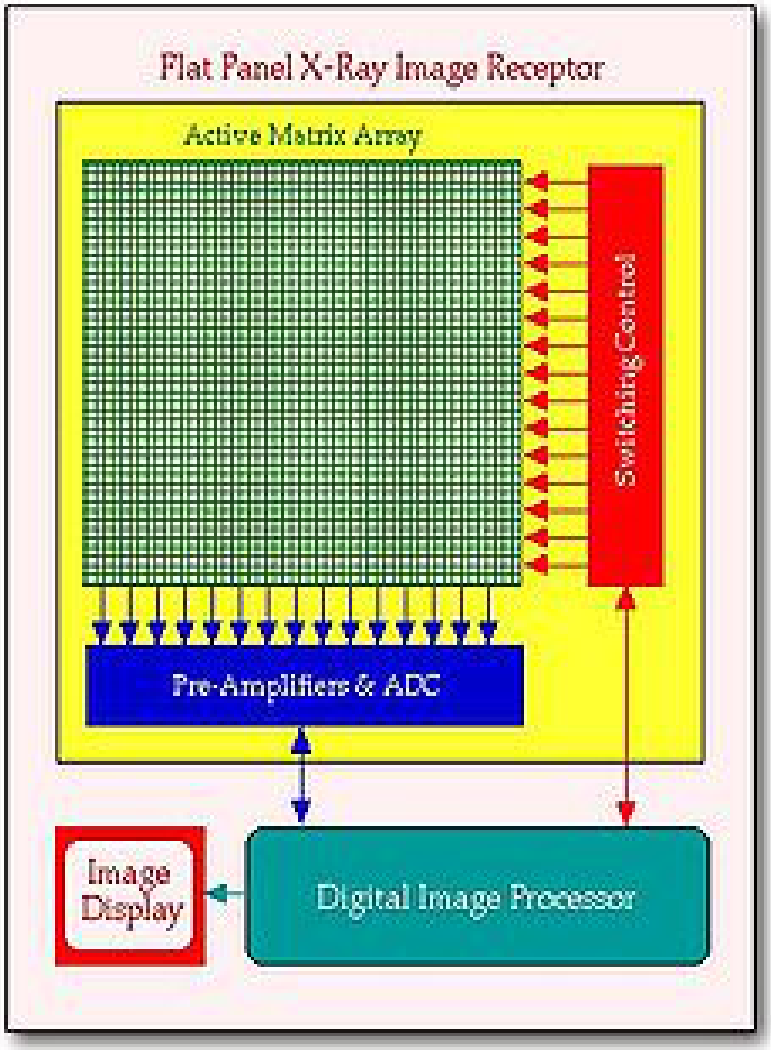


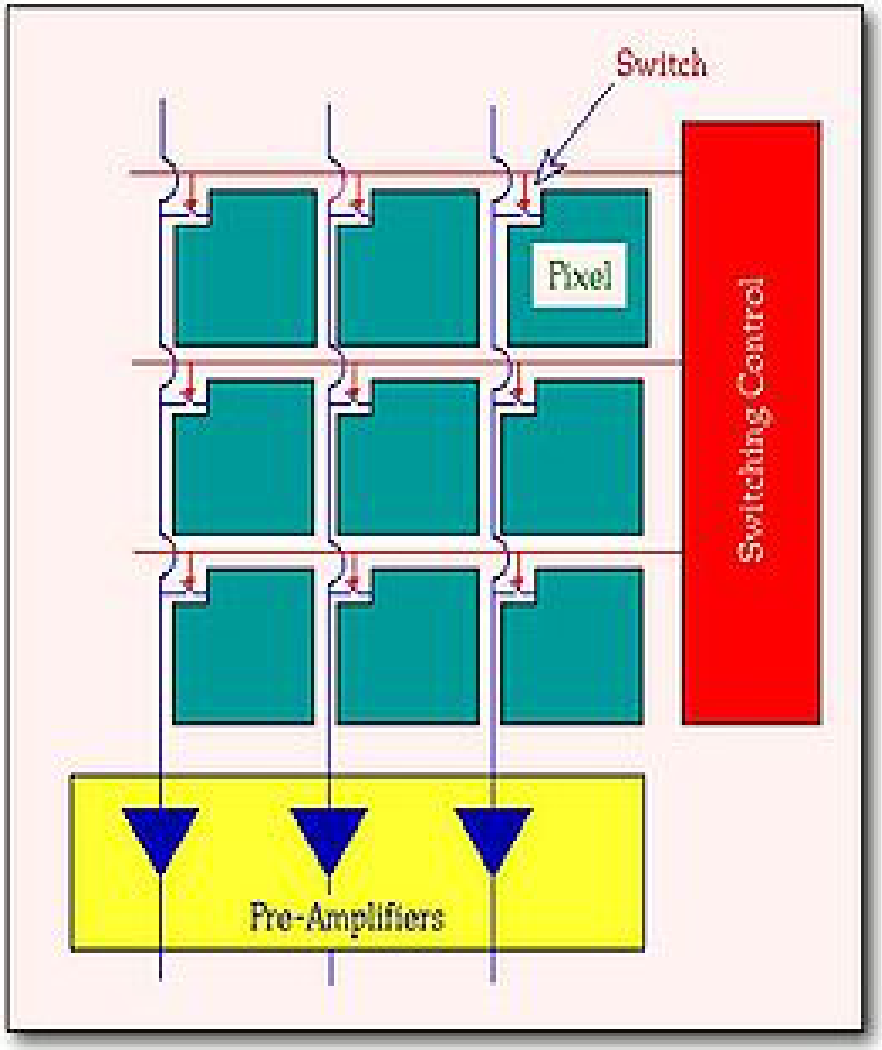
Fixed Installation Detector

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

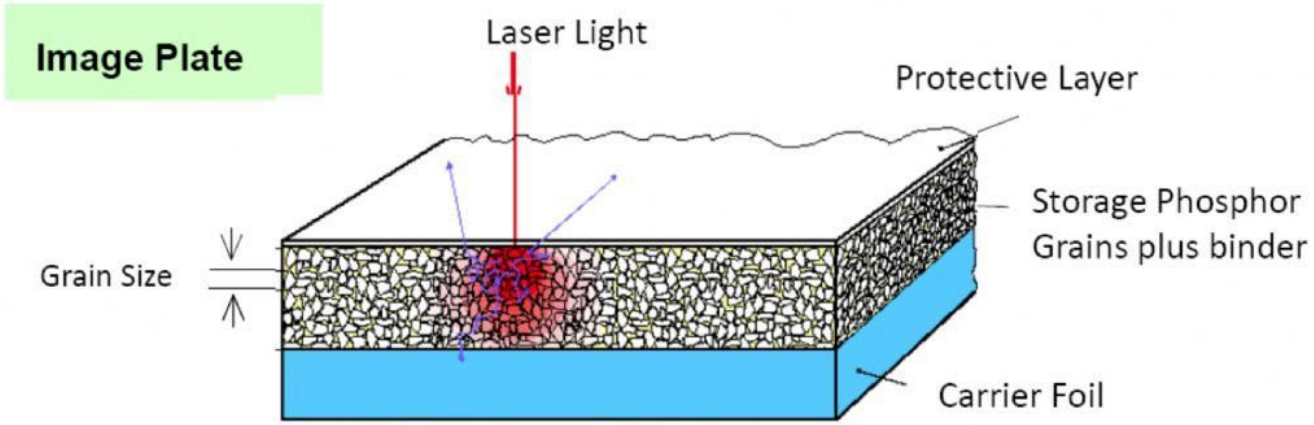


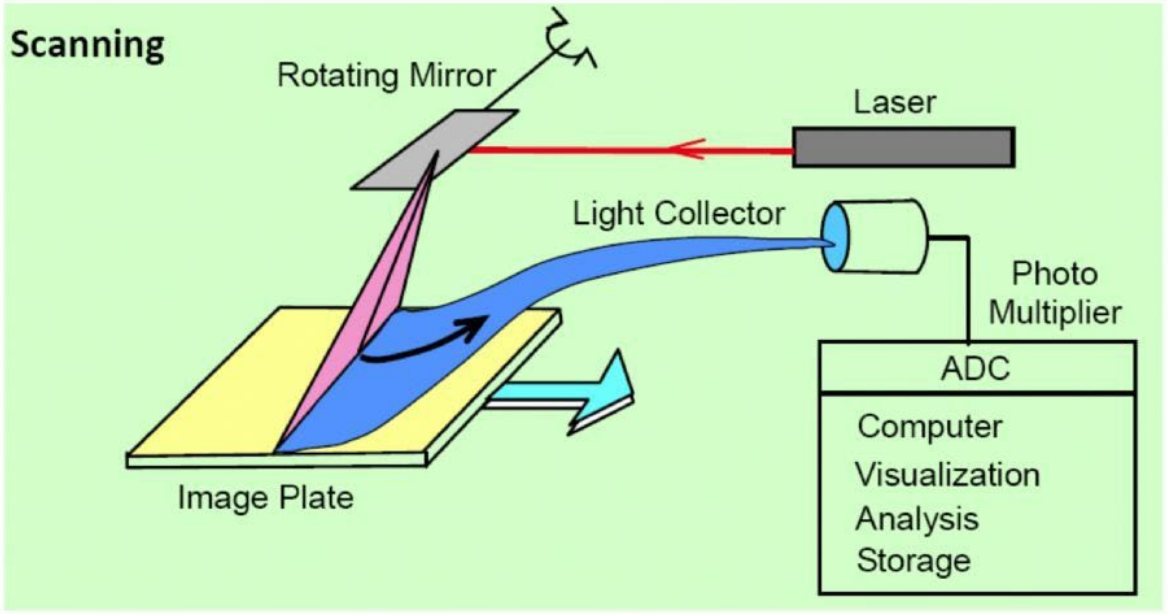
Digital Detector Sampling



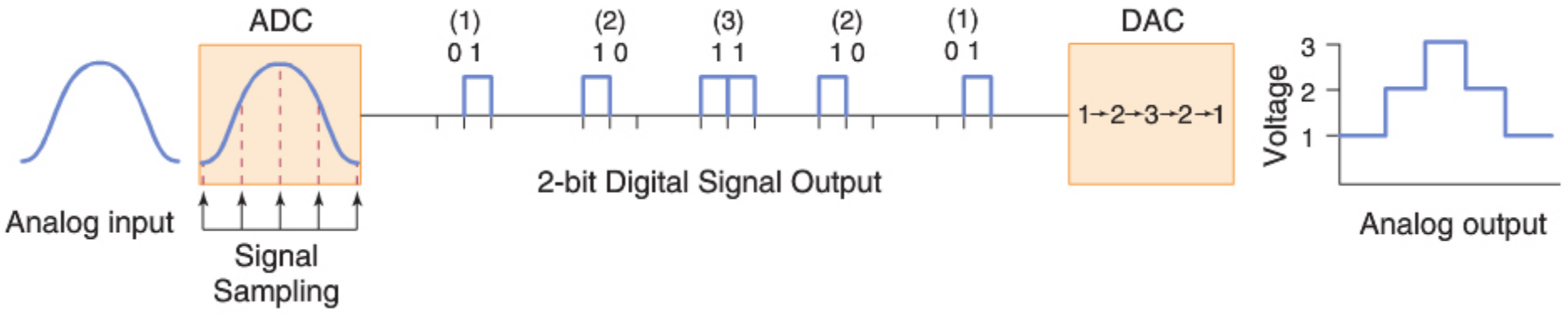


Computed Radiography(CR) Sampling





Digitizing Analog Signal



- ADC = Analog to Digital Converter
- DAC = Digital to Analog Converter

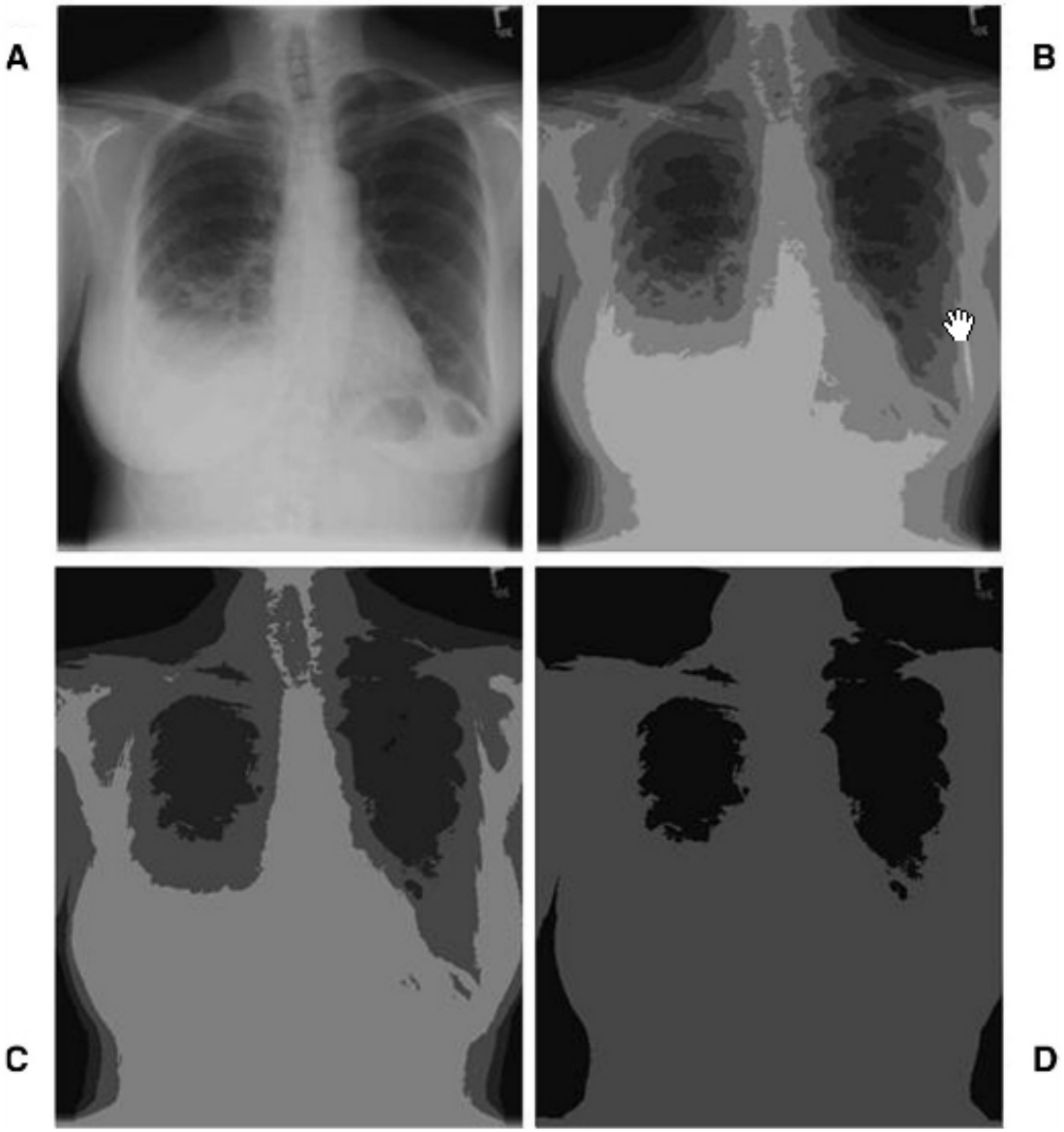
Quantization (ADC Bit Rate)

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)

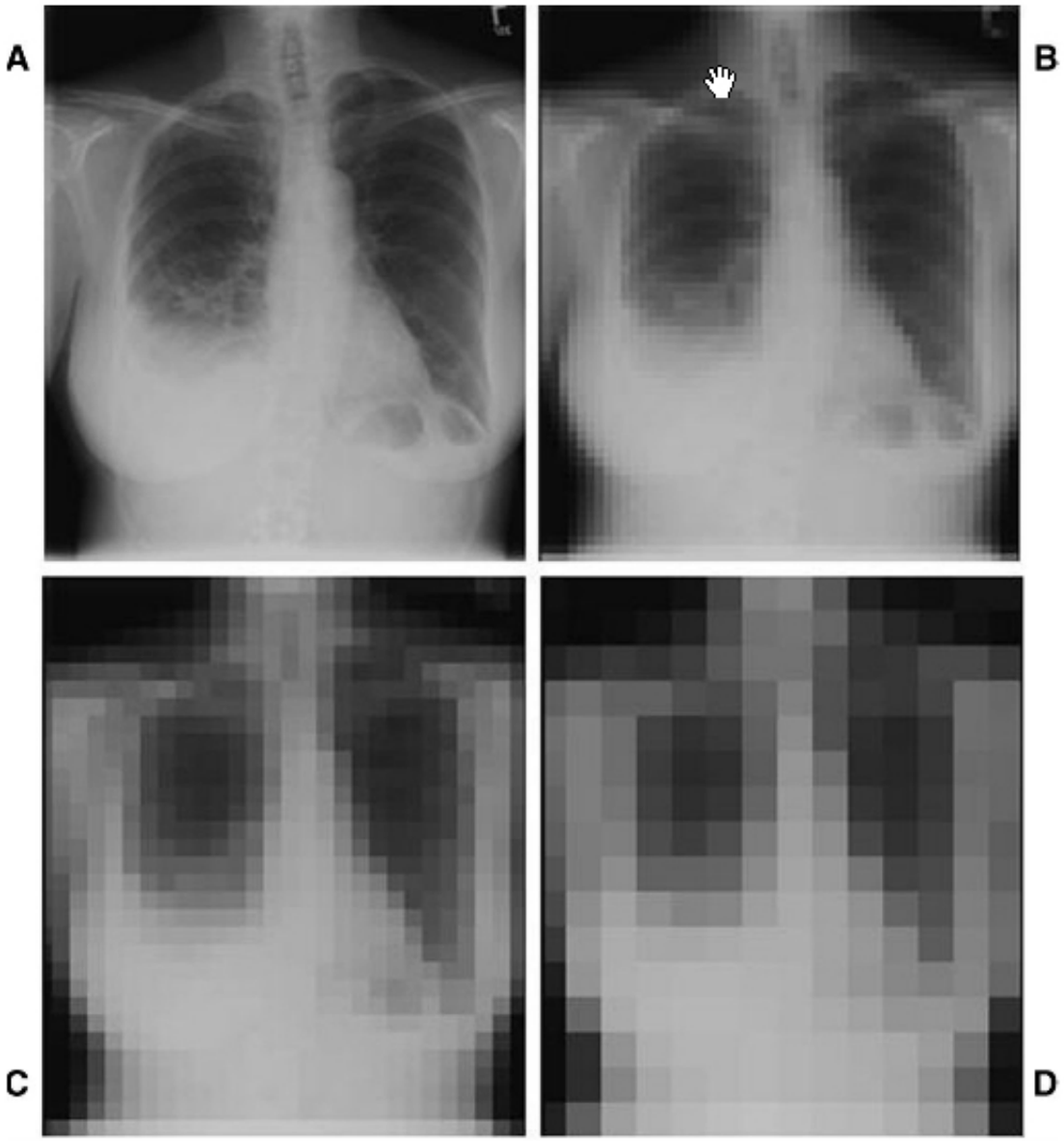
Effect Of ADC Bit Rate

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



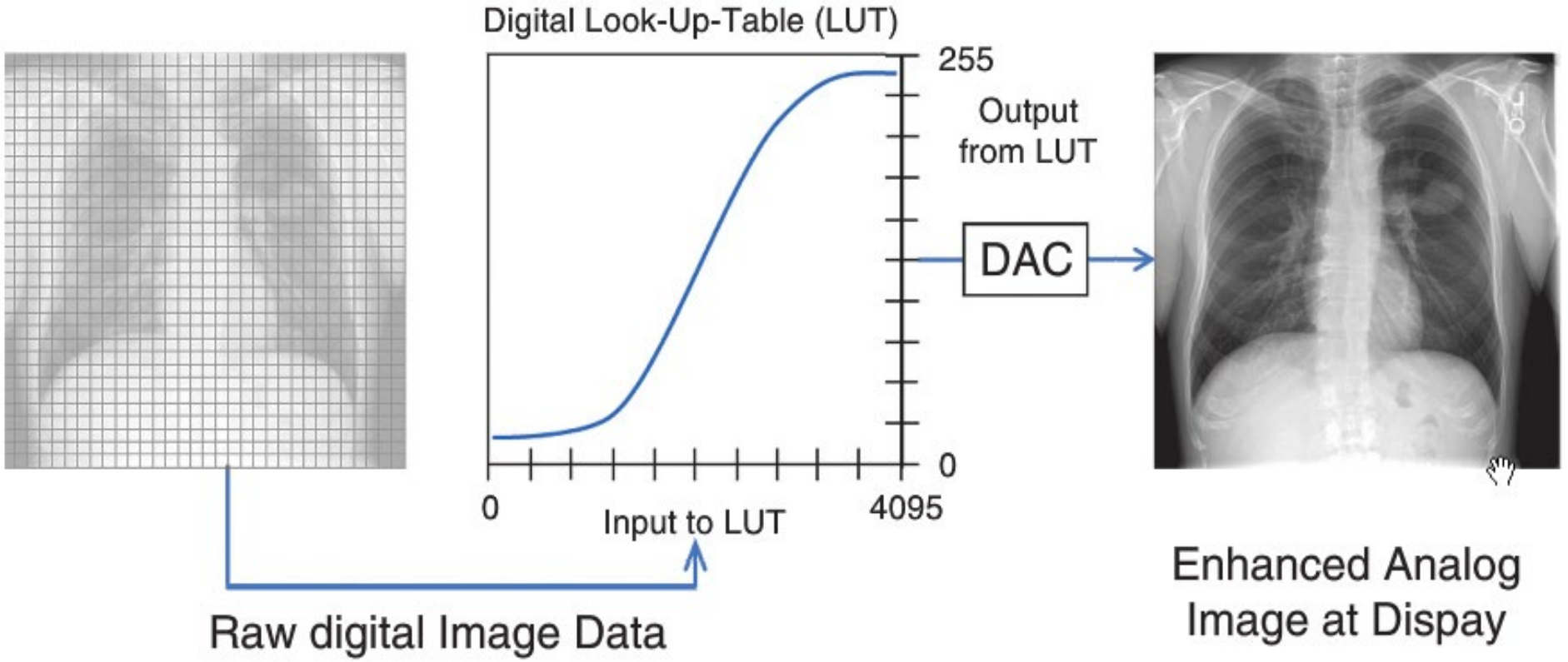
Effect Of Pixel Size Or Sample Rate

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



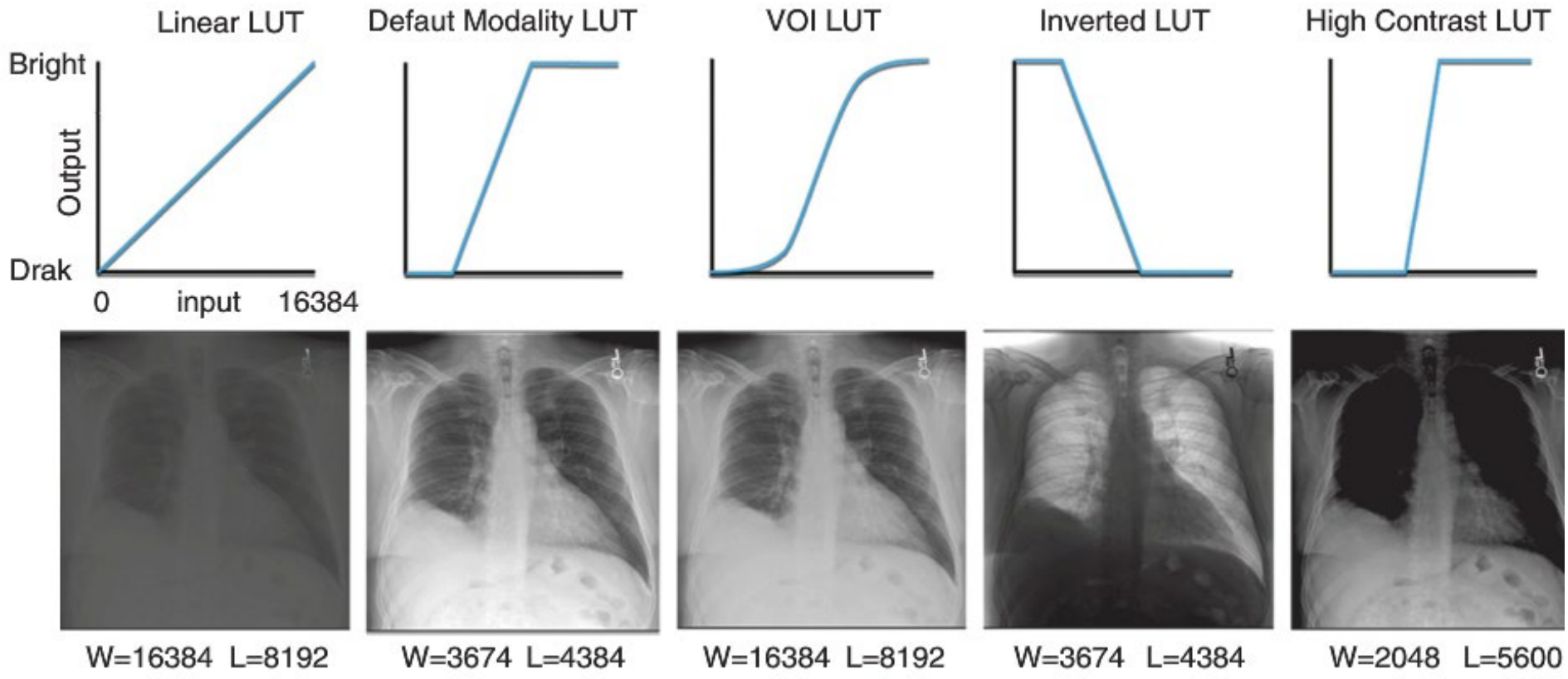
Viewing The Digital Image

- 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



Exposure Factors / Exposure Index

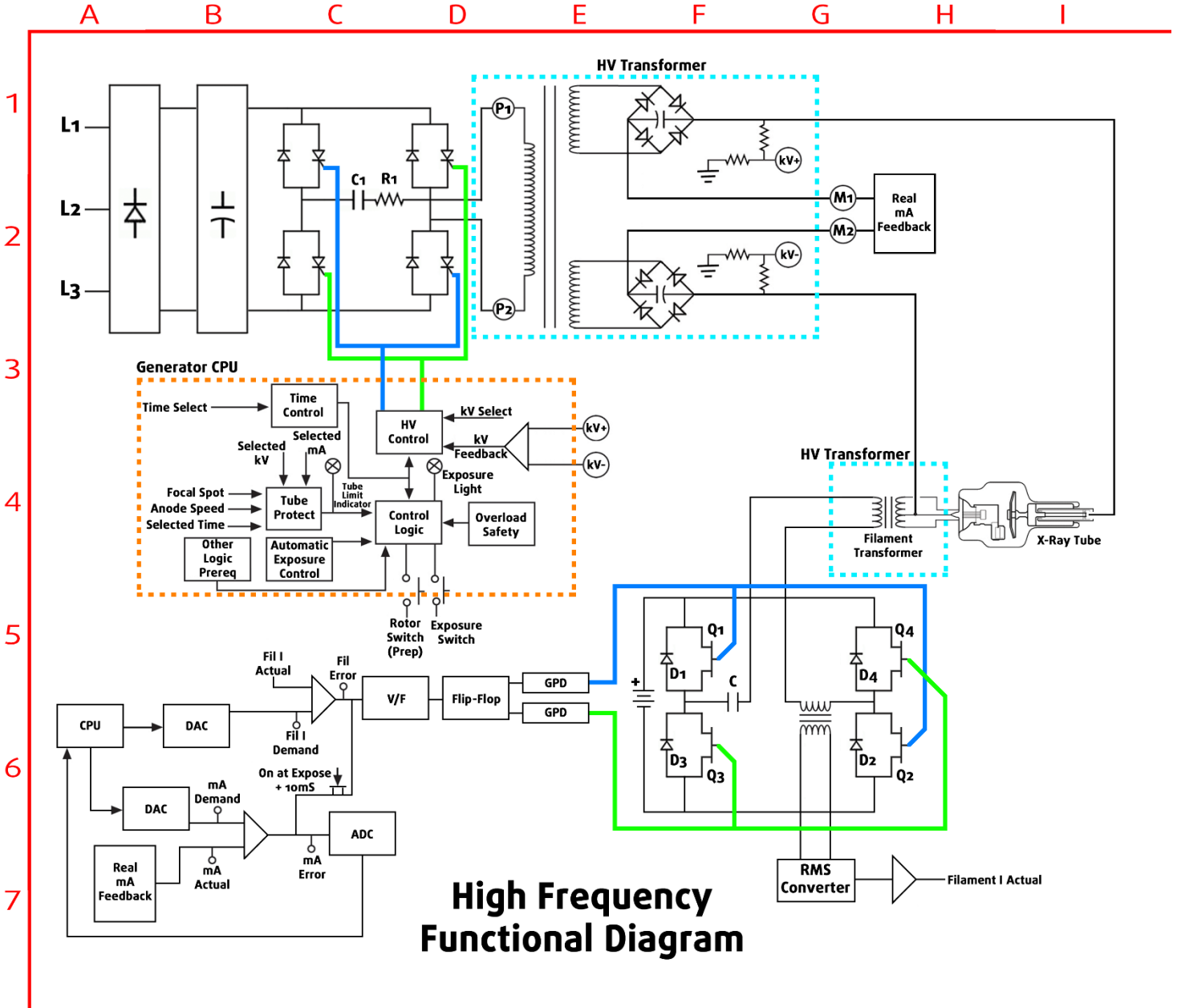
- Historic exposure factor understanding
  - High levels of exposure on film results in a very dark image, referred to as having **High Density**
  - Low levels of exposure result in **Low Density**
  - Comparing two areas of exposure would describe Contrast
    - A large difference in density would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

- 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)

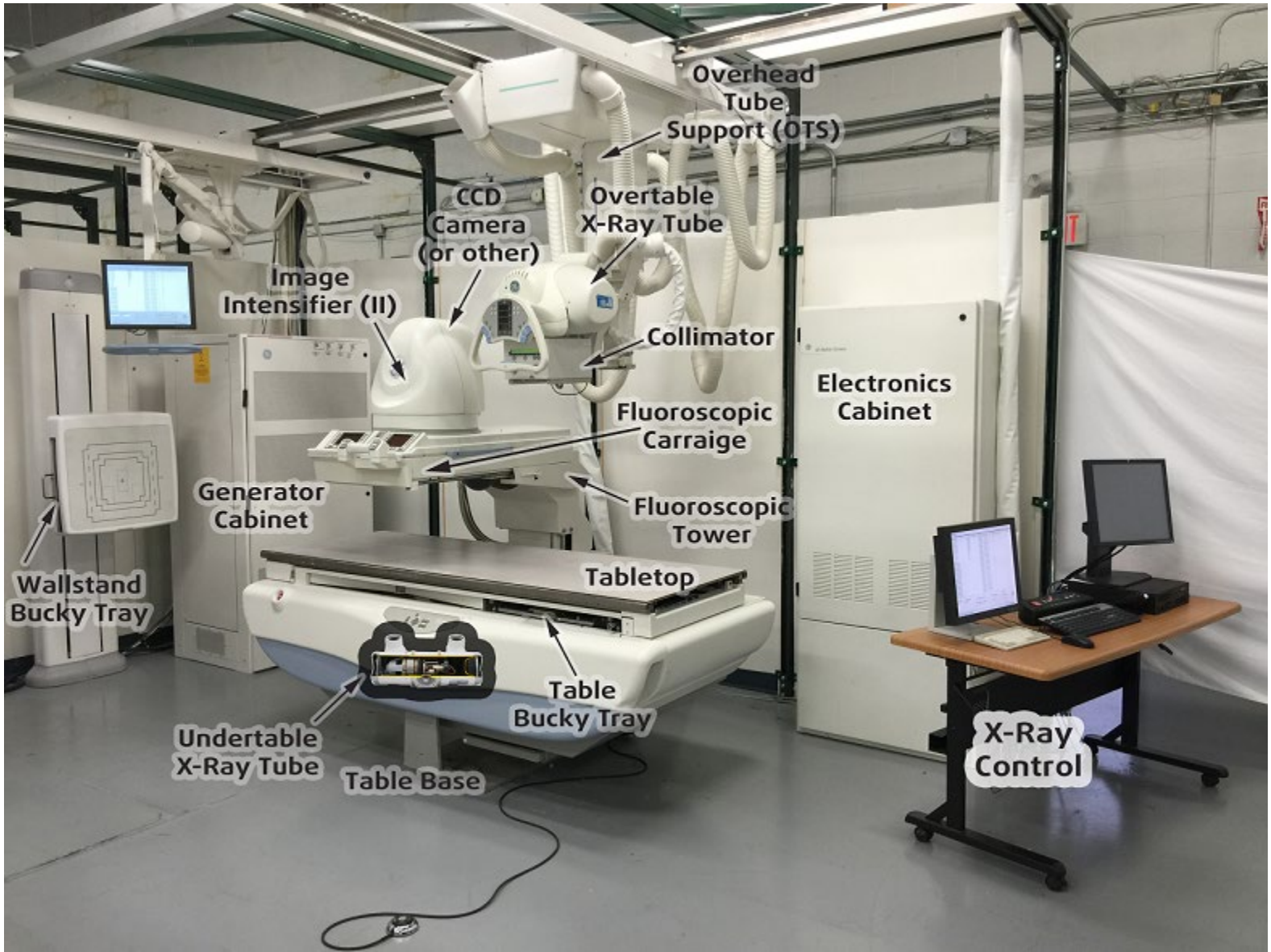


Image Chain With Image Intensifier

Image Intensifier Functional Diagram

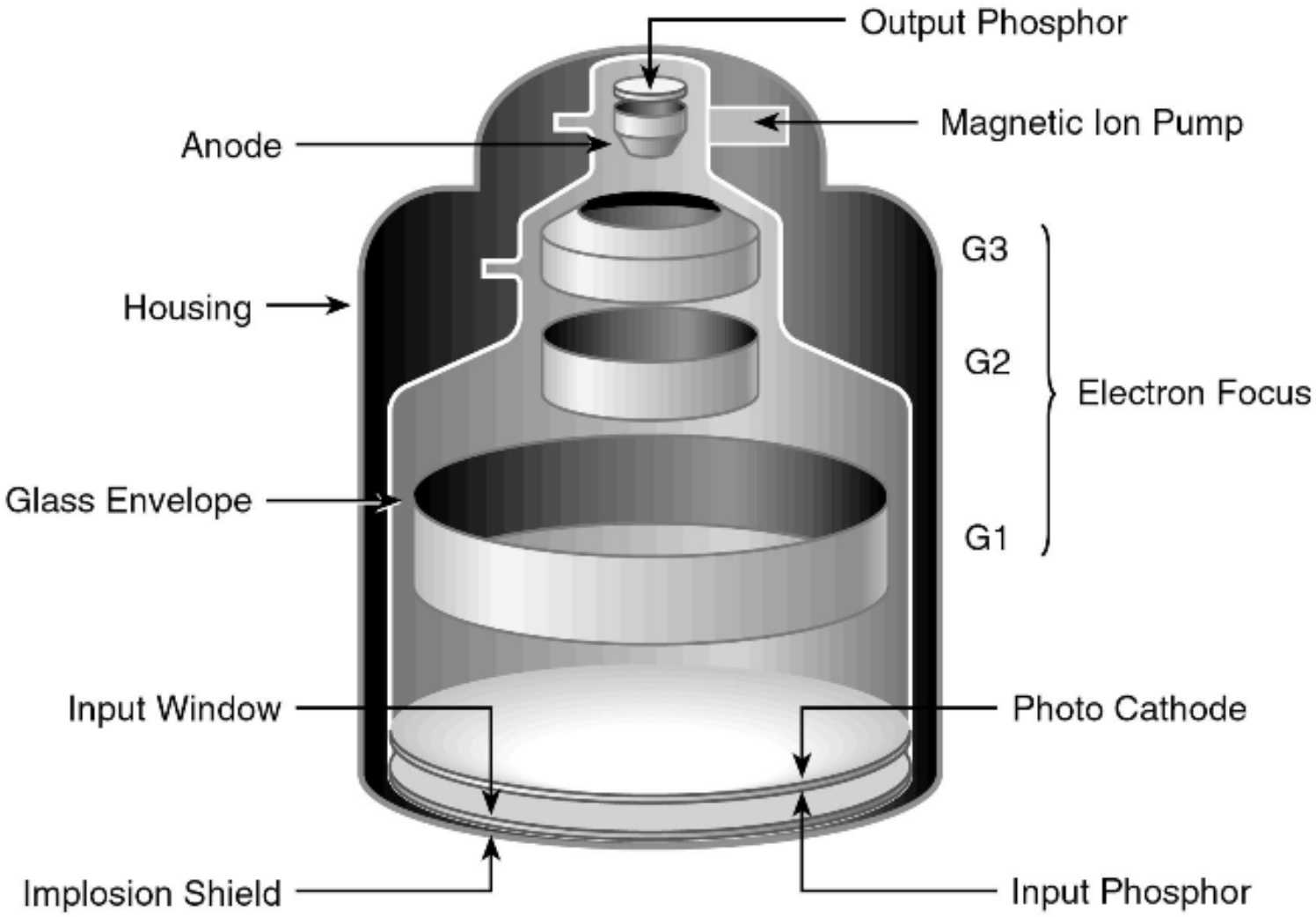


Image Chain (II/CCD Side Mount)

- Typical of full size RF Rooms

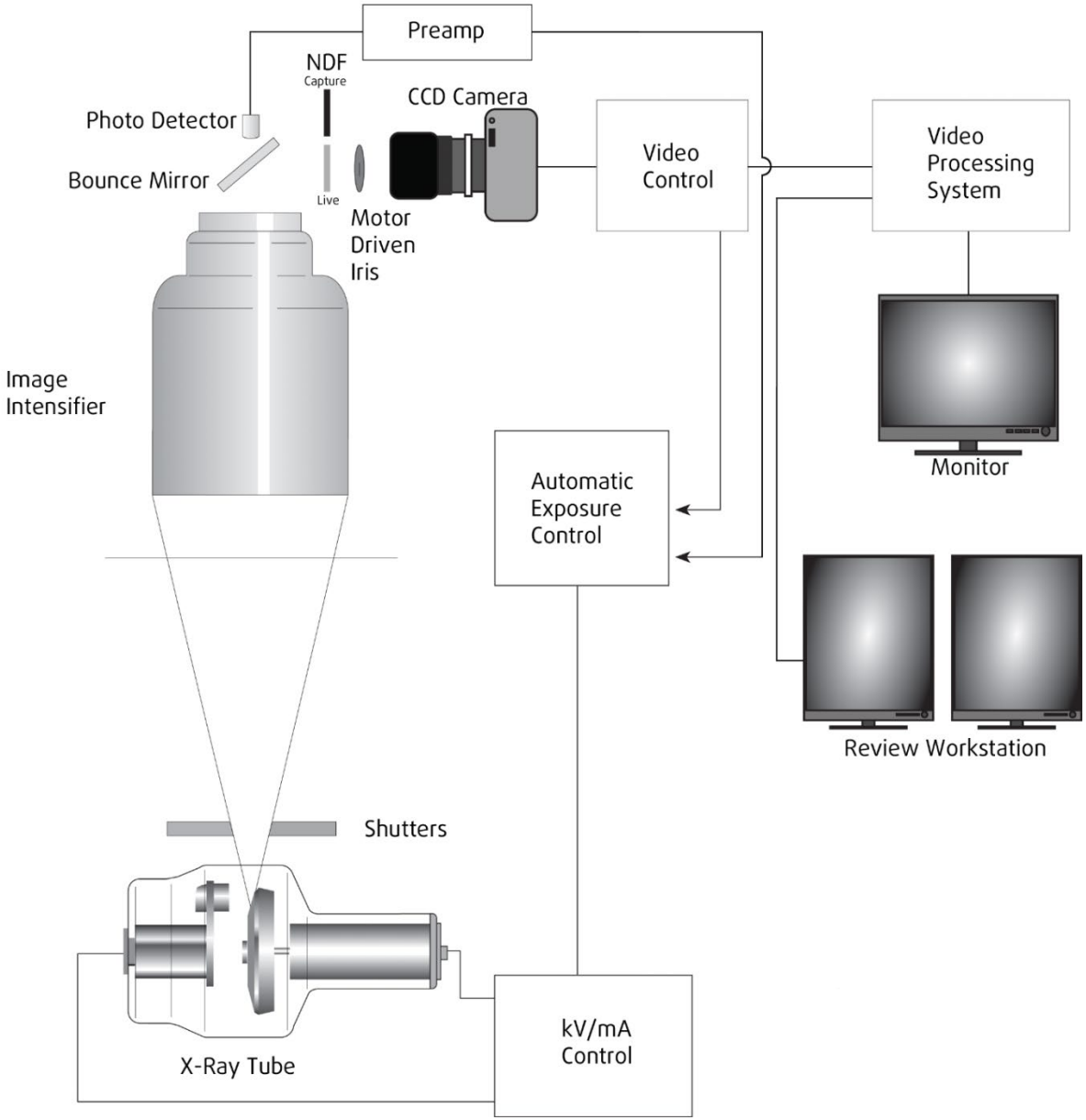
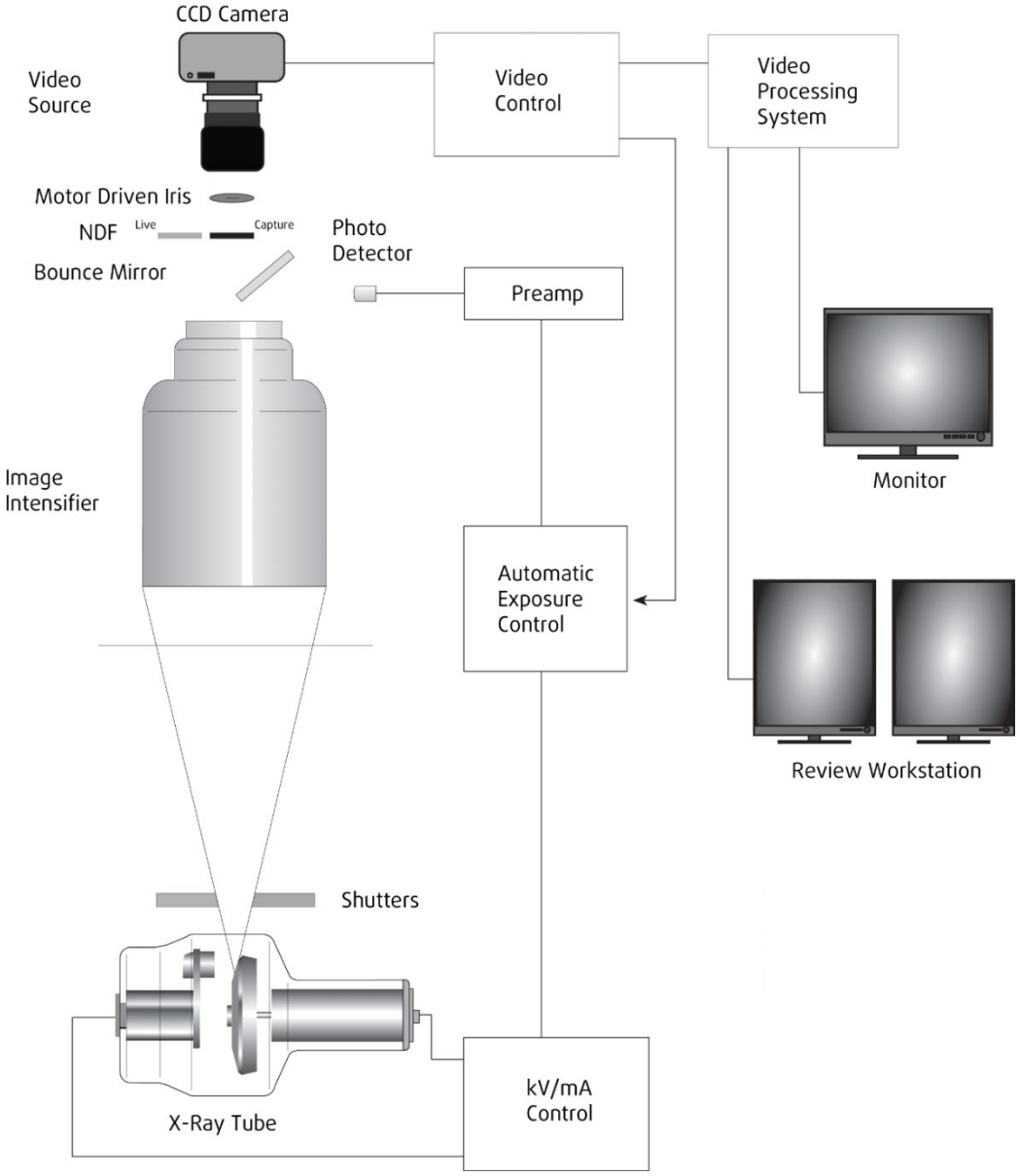


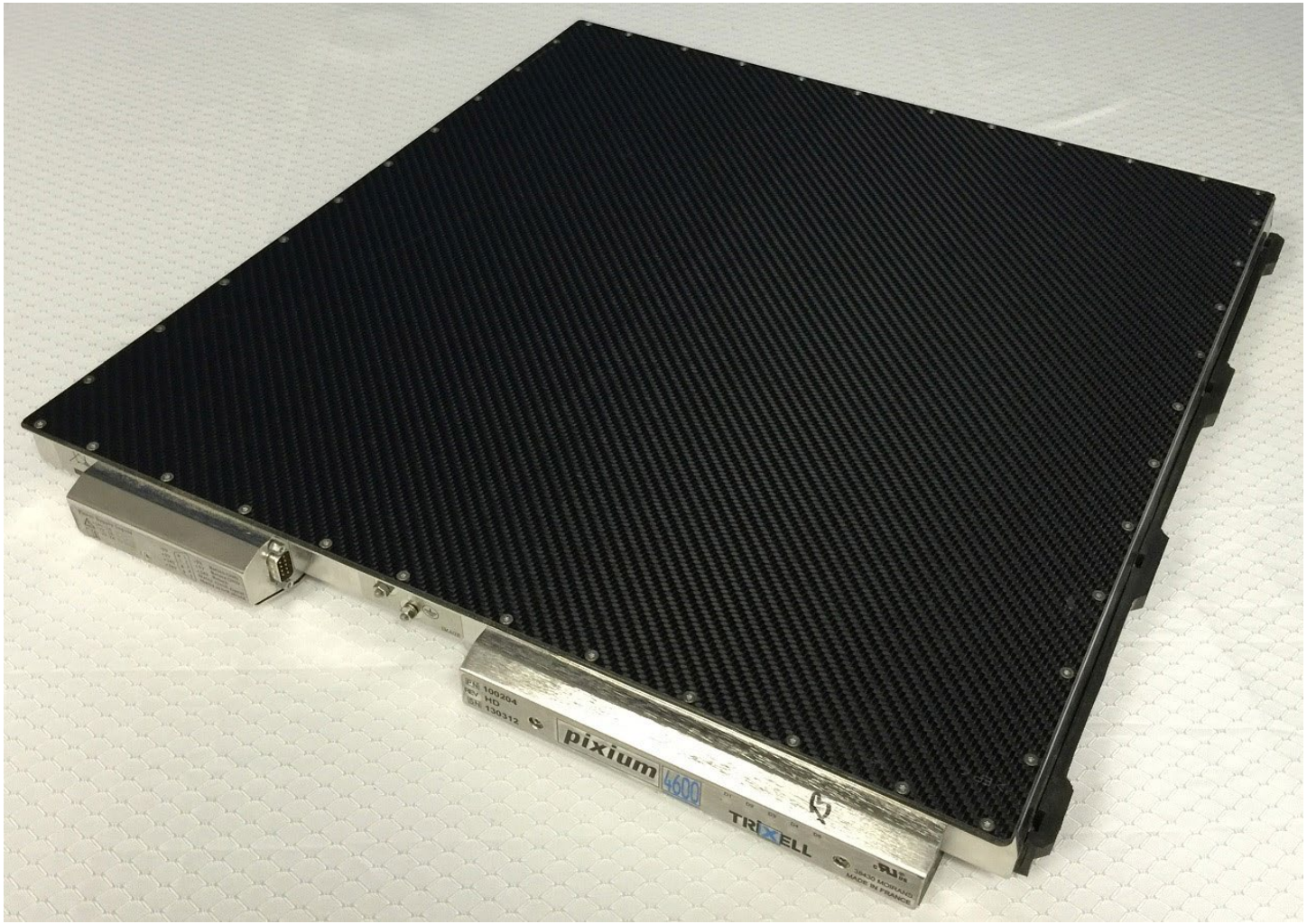
Image Chain (II/CCD Top Mount)

- 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

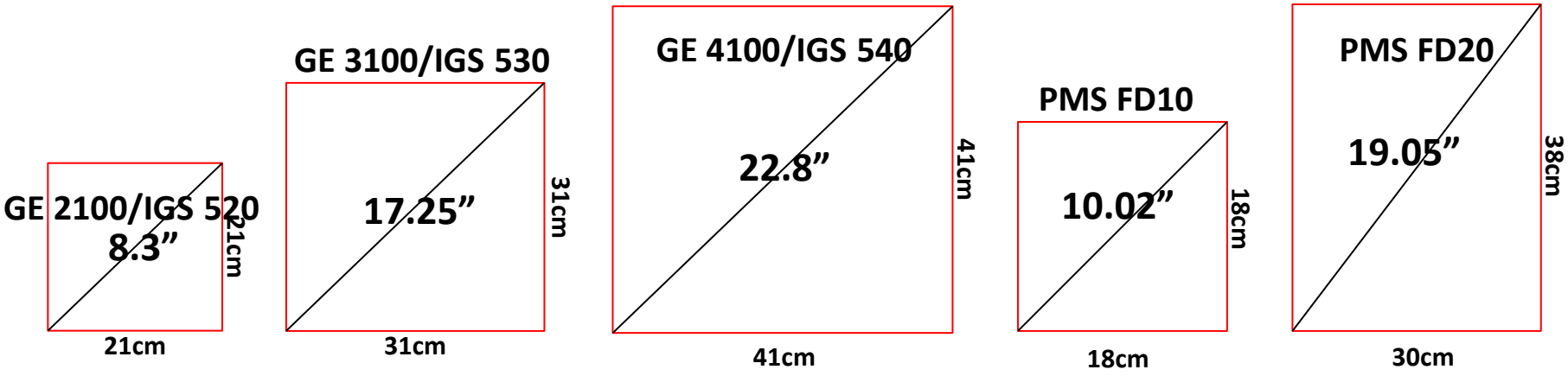
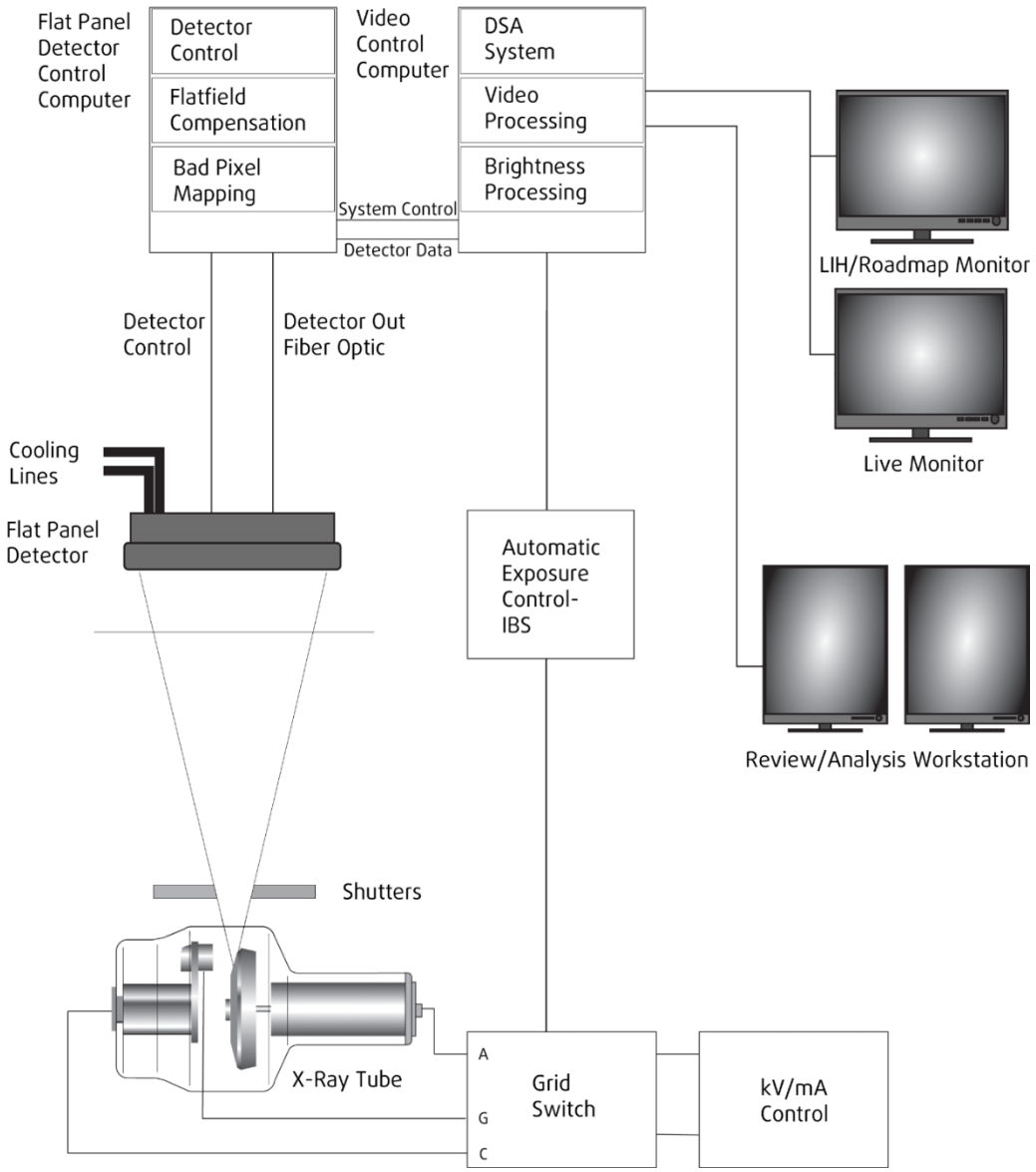
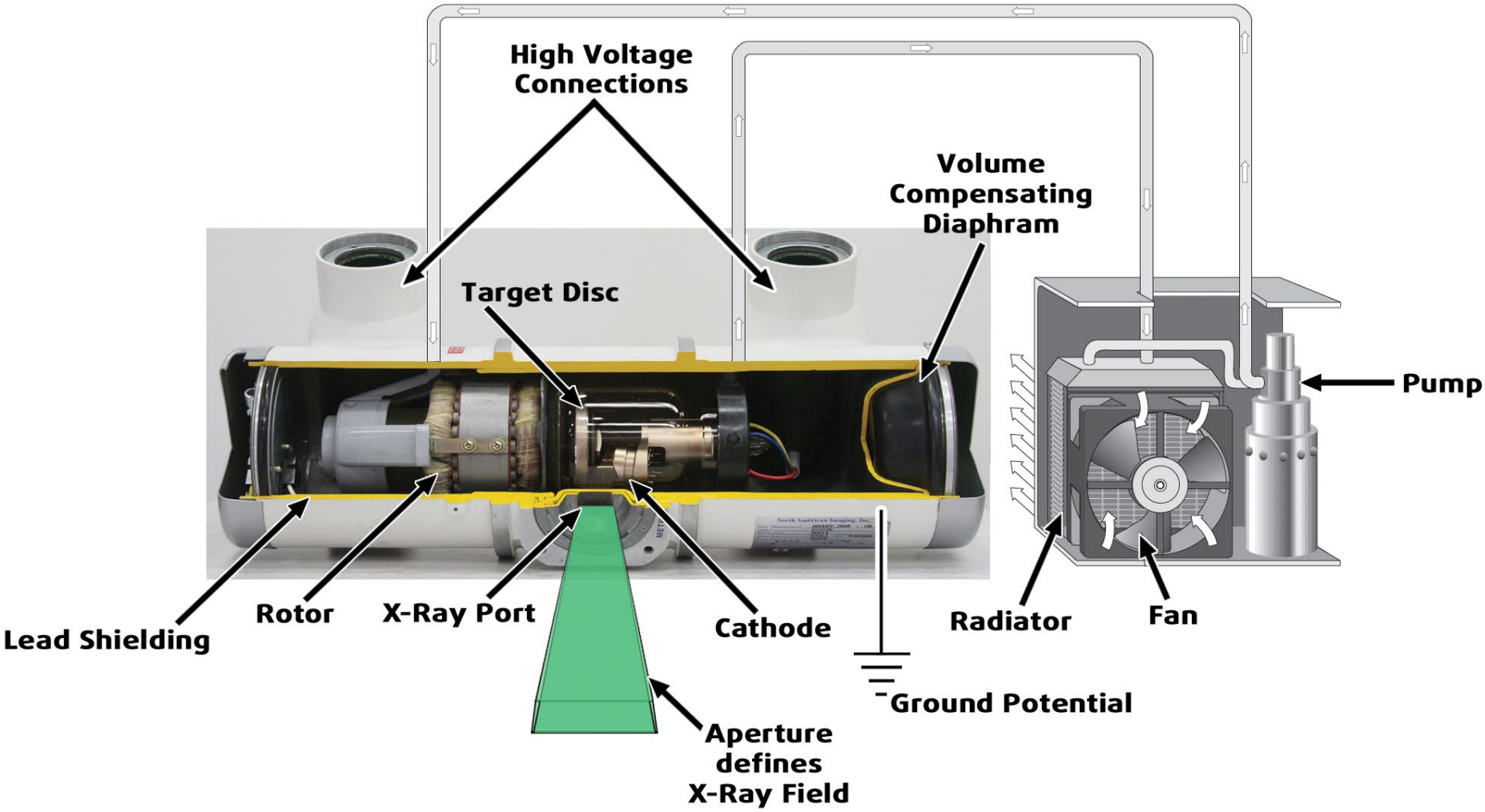


Image Chain (Flat Panel)



Fluoroscopy X-Ray Tubes

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

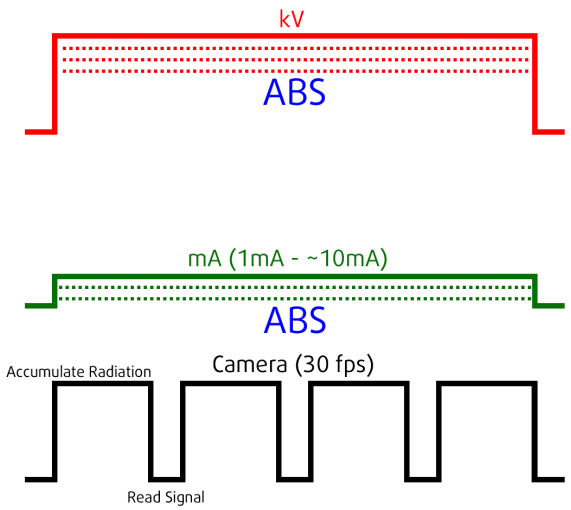


Fluoroscopic Modes Of Operation

- Fluoroscopy
  - Continuous Fluoro
  - Pulsed Fluoro
- Radiography
  - Digital Spot (Captures during live Fluoro run)
  - Sequential Capture (Cine and Vascular)

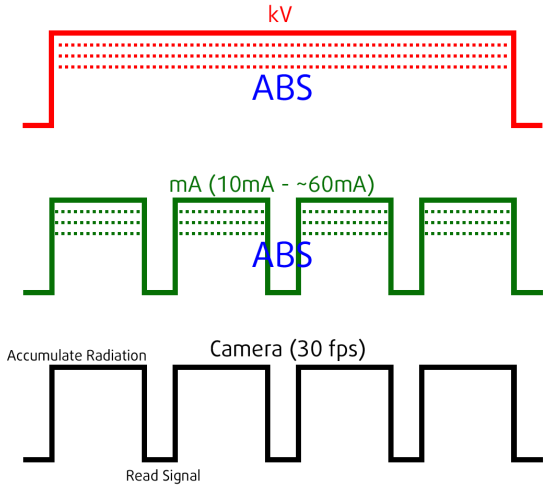
Fluoroscopic Modes Of Operation

- 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

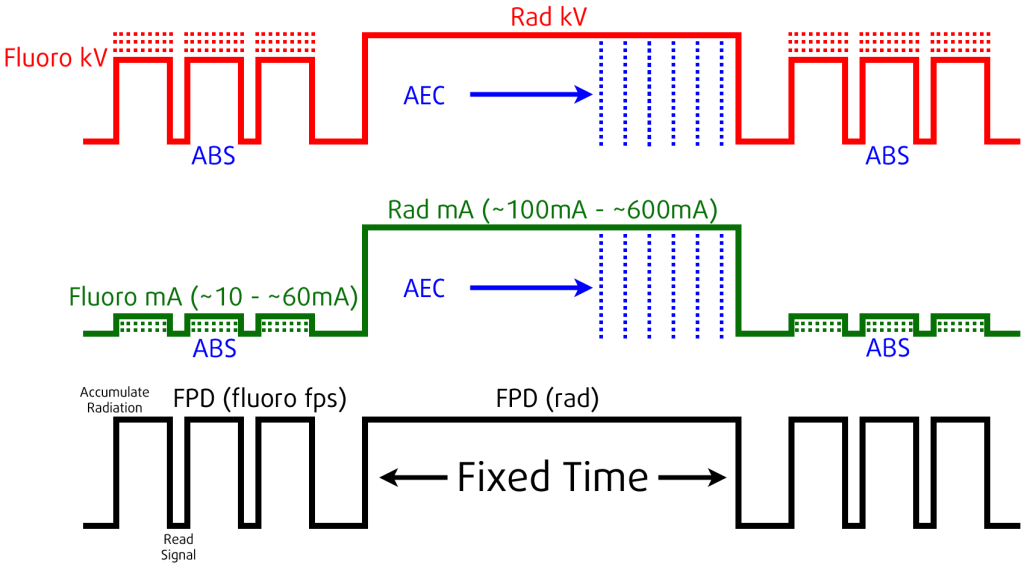


kV: Continuous
mA: Pulsed
FPD/Camera: 30 fps
Exp Control: ABS

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)

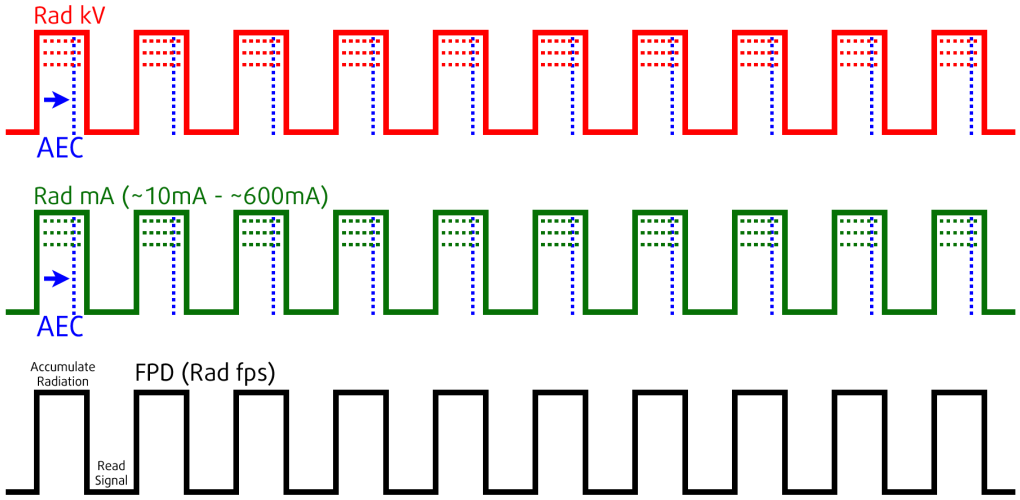


kV: Pulsed (Fluoro: X-Ray tube or inverter), continuous (Rad)
mA: Pulsed (fluoro), continuous (Rad)
FPD/Camera: 30 fps (fluoro), continuous (Rad)
Exp Control: ABS (fluoro), AEC(Rad)

On-Time Waveform Representations:
Digital Spot

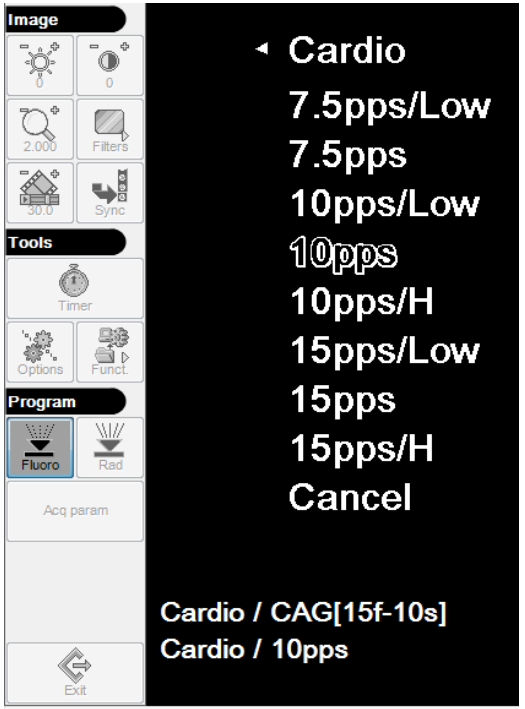
Fluoroscopic Modes Of Operation

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



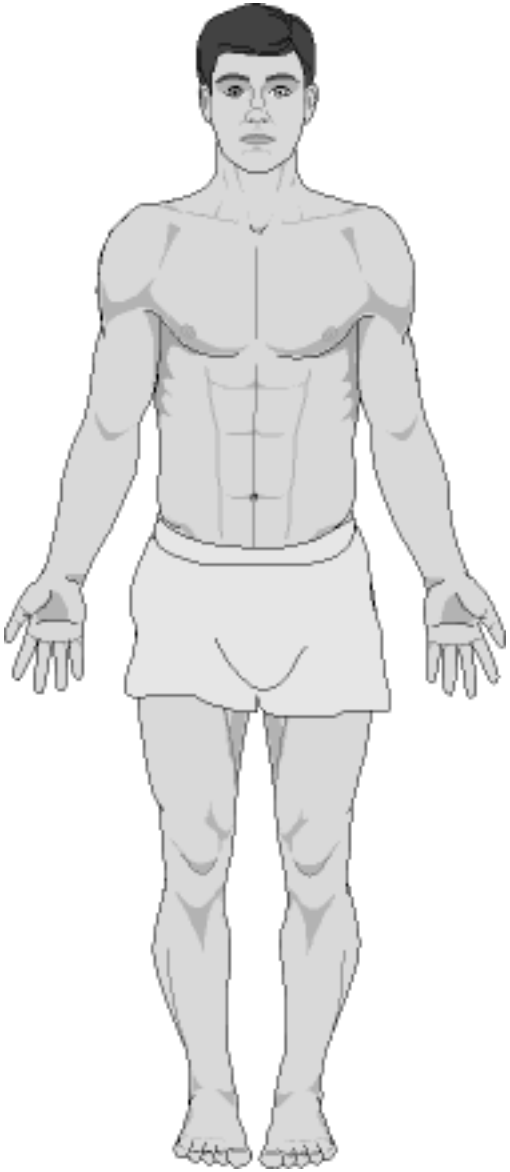
kV: Pulsed (X-Ray tube or inverter)
mA: Pulsed
Camera: 30-60 fps
Exp Control: AEC

On-Time Waveform Representations:
Cine



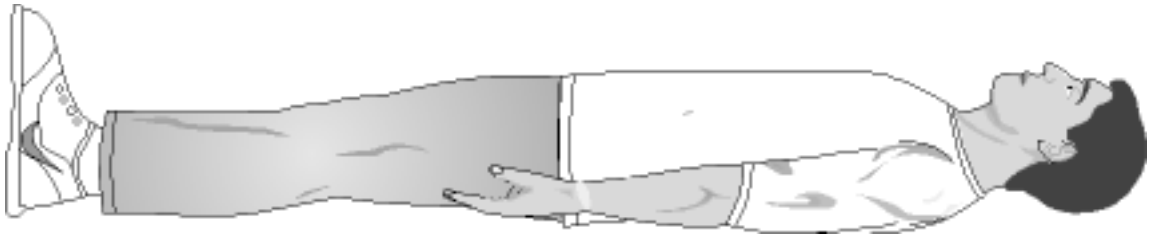
Patient Positioning and Viewing

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

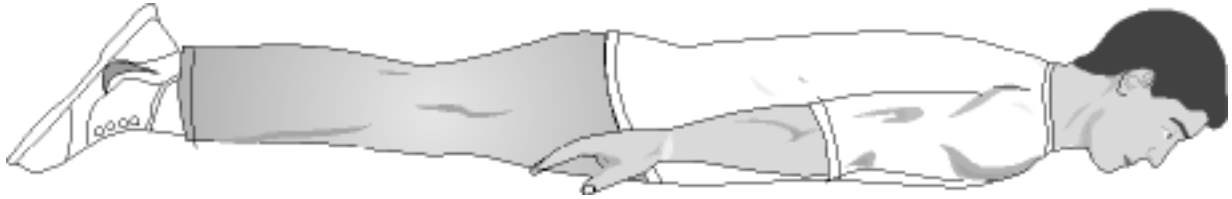


Patient Positioning and Viewing

Supine

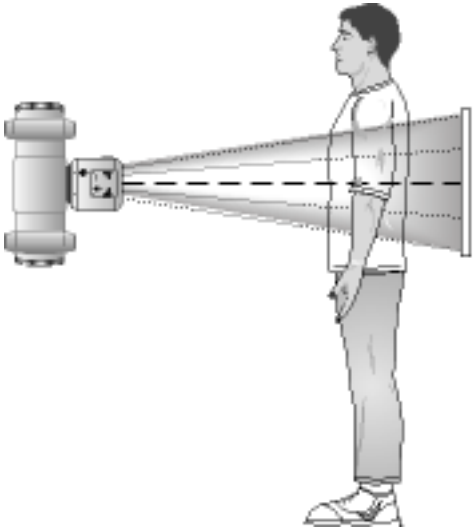


Prone

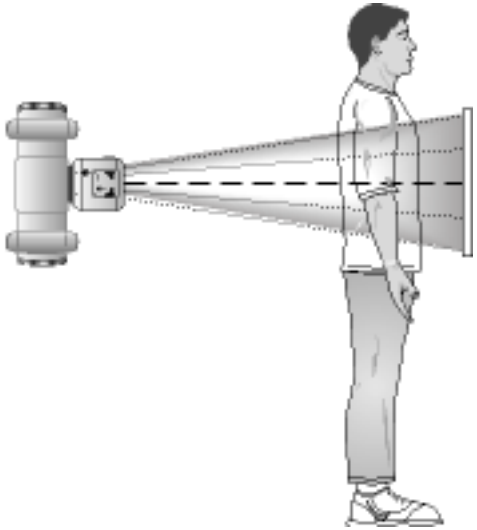


Patient Positioning and Viewing

- Projections
  - X-Ray tube to image receptor

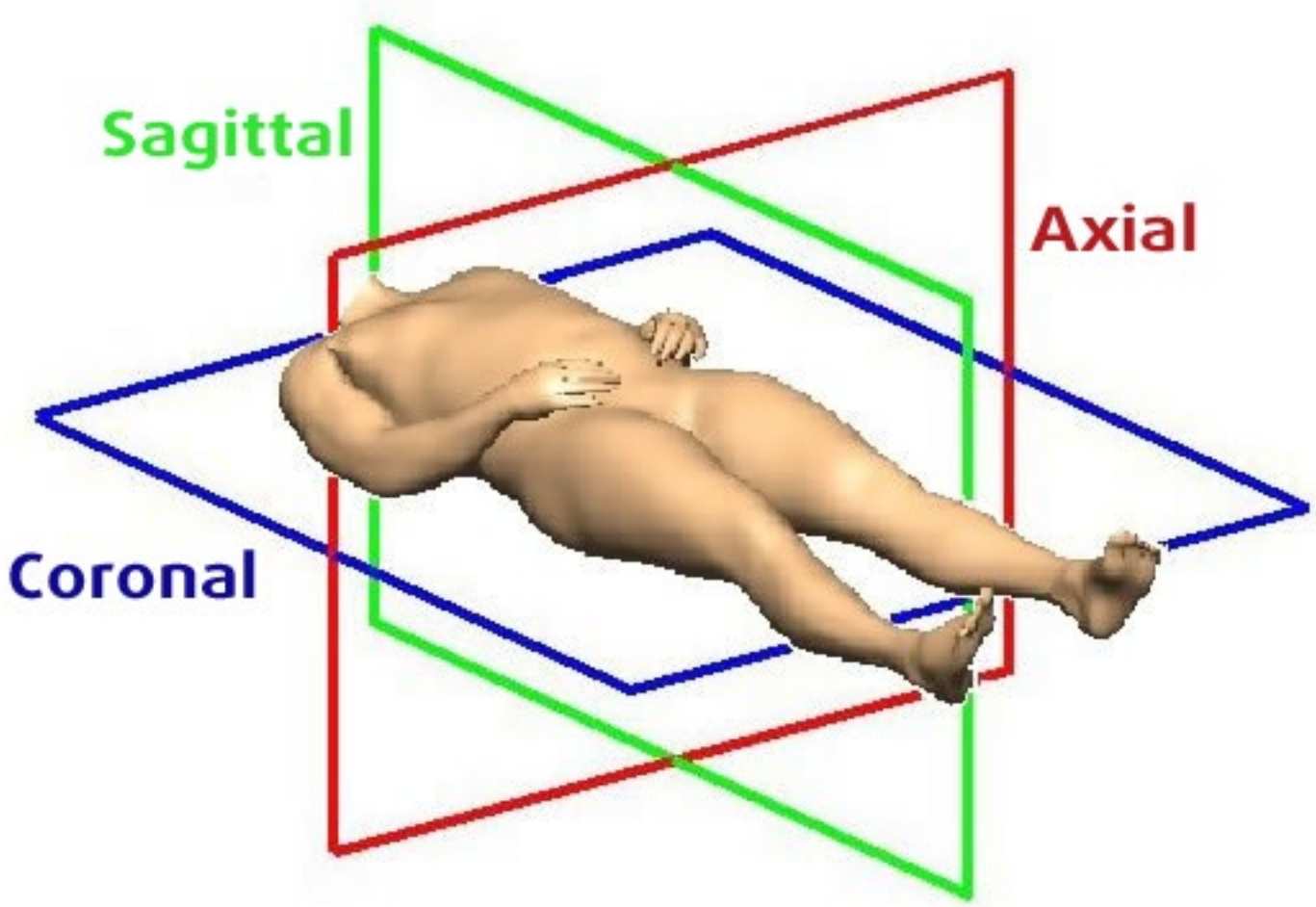


Anterior to Posterior(AP)



Posterior to Anterior(PA)

Patient Positioning and Viewing



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