



KBR PART ONE **PHYSICS SYLLABUS**  
**FLUOROSCOPY**



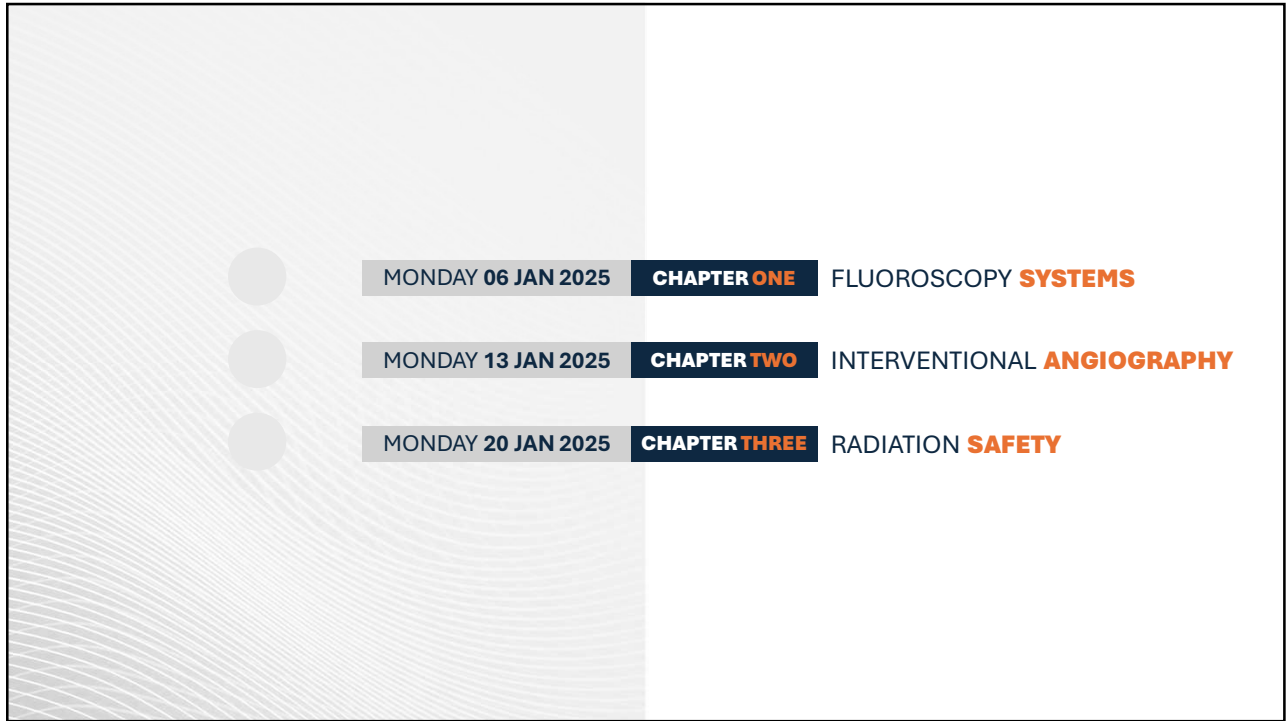
**HAMAD DARWISH**

2

**THREE**  
CHAPTERS

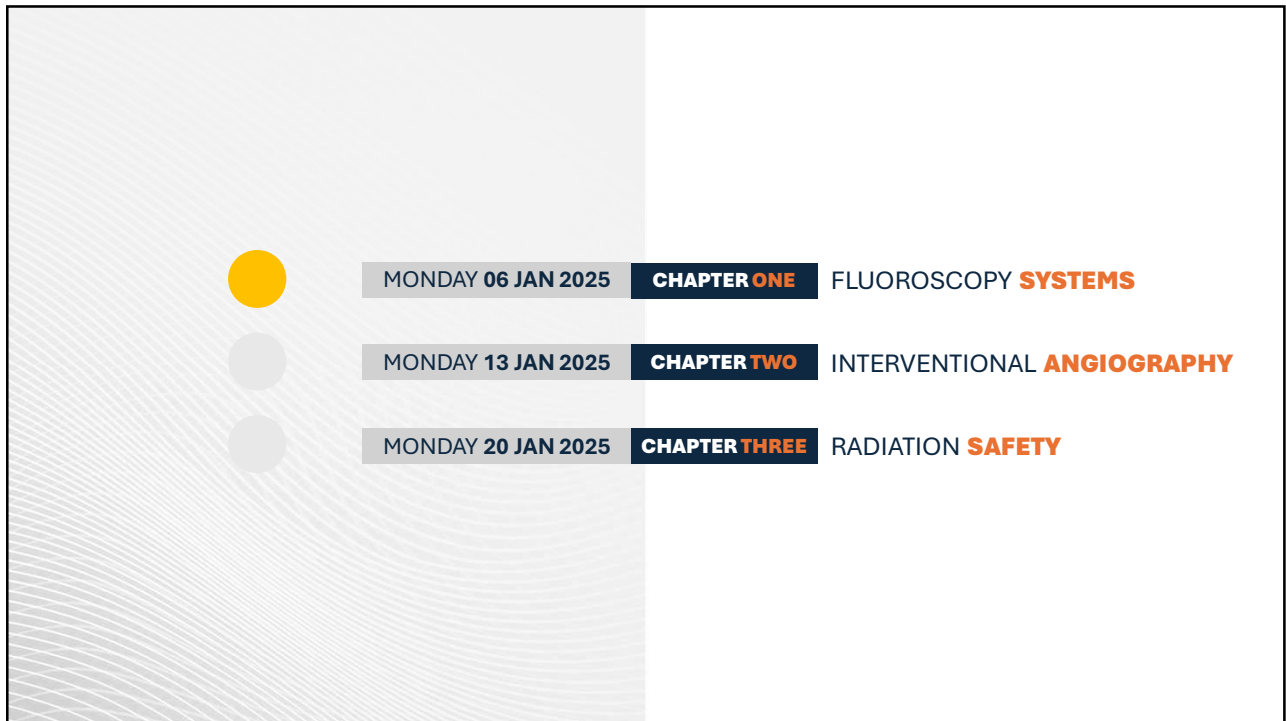
MONDAY 06 JAN 2025	<b>CHAPTER ONE</b>	FLUOROSCOPY <b>SYSTEMS</b>
MONDAY 13 JAN 2025	<b>CHAPTER TWO</b>	INTERVENTIONAL <b>ANGIOGRAPHY</b>
MONDAY 20 JAN 2025	<b>CHAPTER THREE</b>	RADIATION <b>SAFETY</b>

3



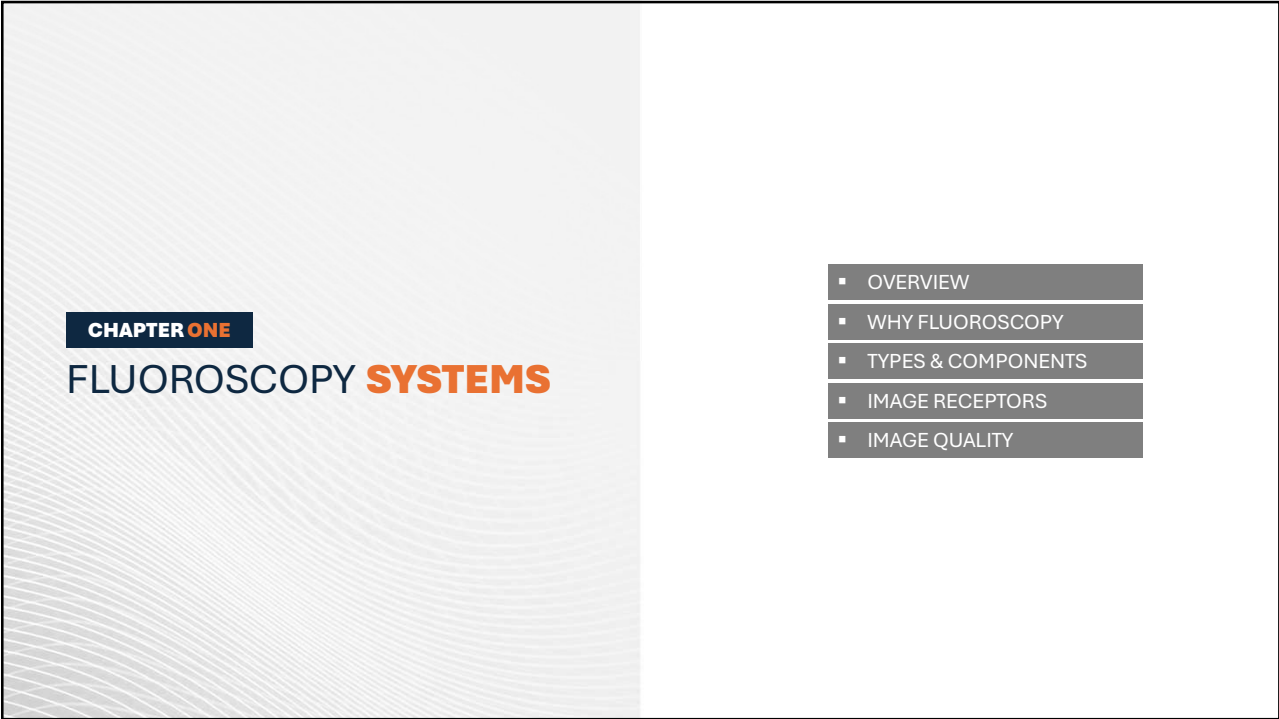
MONDAY 06 JAN 2025	<b>CHAPTER ONE</b>	FLUOROSCOPY <b>SYSTEMS</b>
MONDAY 13 JAN 2025	<b>CHAPTER TWO</b>	INTERVENTIONAL <b>ANGIOGRAPHY</b>
MONDAY 20 JAN 2025	<b>CHAPTER THREE</b>	RADIATION <b>SAFETY</b>

4



MONDAY 06 JAN 2025	<b>CHAPTER ONE</b>	FLUOROSCOPY <b>SYSTEMS</b>
MONDAY 13 JAN 2025	<b>CHAPTER TWO</b>	INTERVENTIONAL <b>ANGIOGRAPHY</b>
MONDAY 20 JAN 2025	<b>CHAPTER THREE</b>	RADIATION <b>SAFETY</b>

5

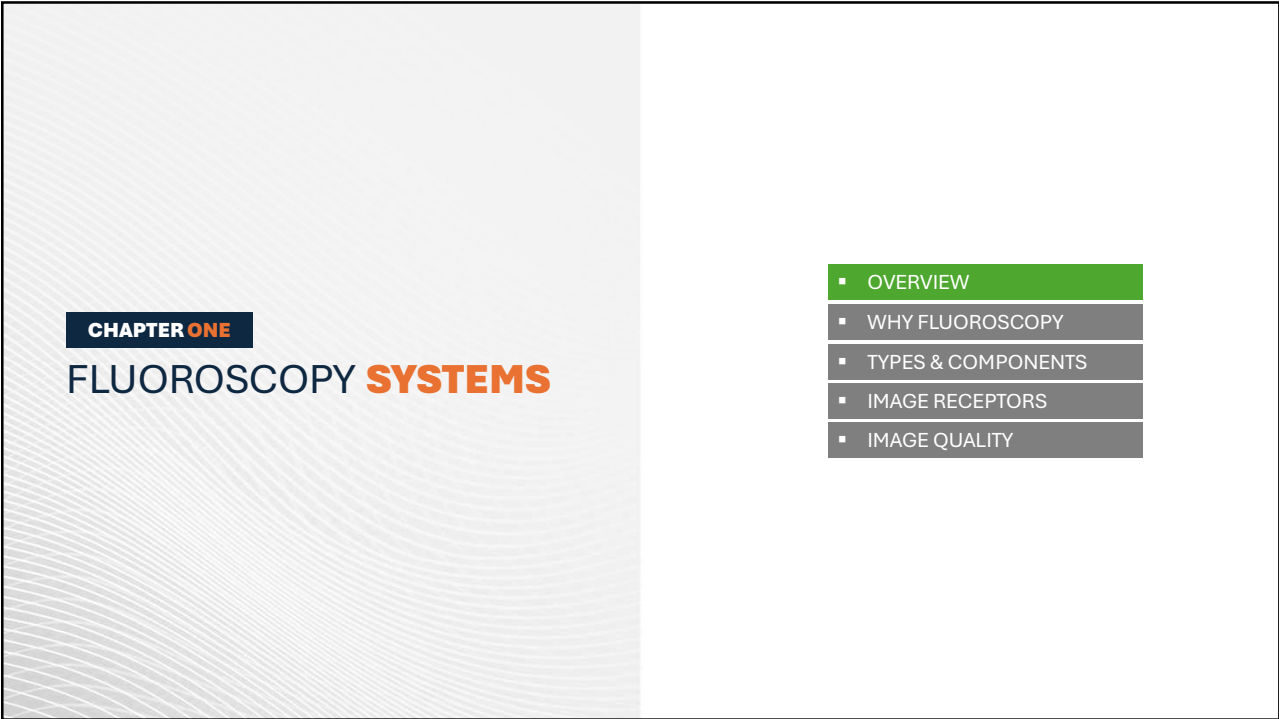


CHAPTER ONE  
FLUOROSCOPY **SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY

This slide features a light gray background with a subtle wavy pattern on the left side. The title 'CHAPTER ONE' is in a dark blue box, and 'FLUOROSCOPY SYSTEMS' is in large, bold letters. A vertical menu on the right lists five topics in gray boxes.

6



CHAPTER ONE  
FLUOROSCOPY **SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY


This slide is identical to slide 6, but the 'OVERVIEW' item in the menu is highlighted with a green background.

7

**CHAPTER ONE**

# FLUOROSCOPY

Fluoroscopy is an imaging technique that uses x-rays to create **moving images** of internal structures of the body in **real-time**.

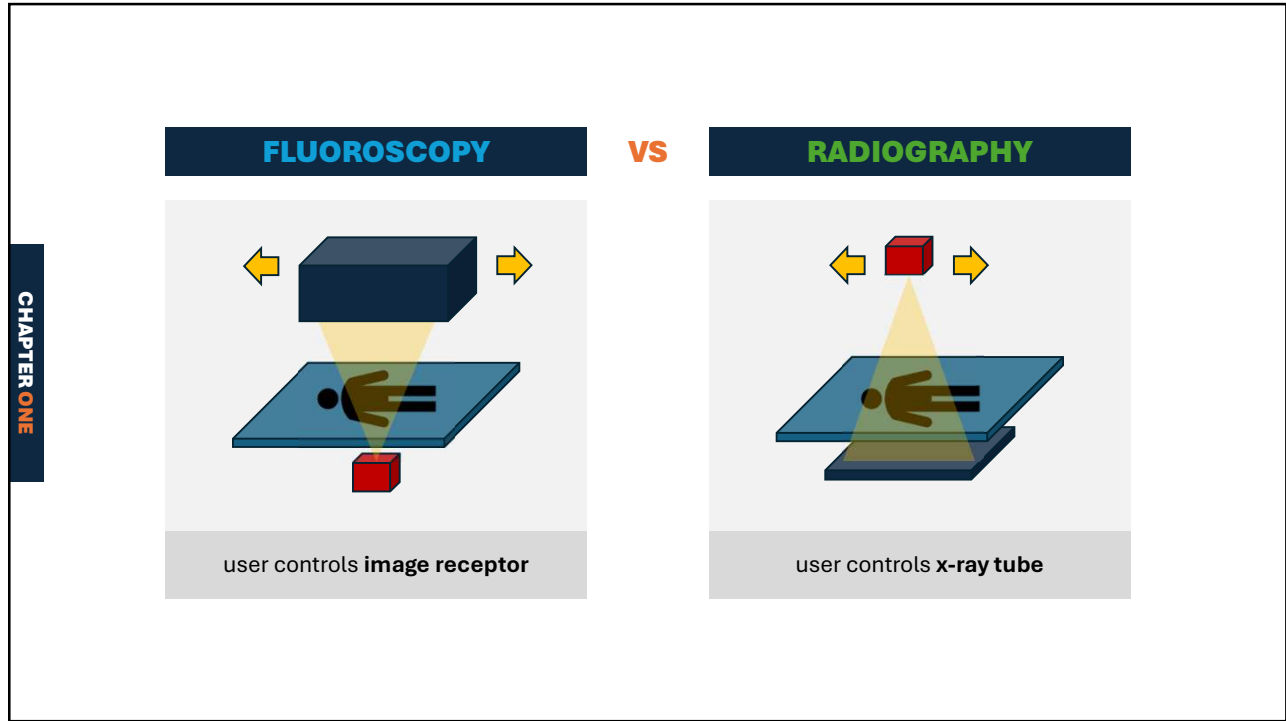


8

**CHAPTER ONE**

<b>FLUOROSCOPY</b>	<b>VS</b>	<b>RADIOGRAPHY</b>
Dynamic		Static
Continuous or Pulsed exposure		Short exposure
Lower mA		Higher mA
For diagnostic purposes and procedures		Mainly for diagnostic purposes

9



10

**CHAPTER ONE**  
**FLUOROSCOPY SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY

11

**CHAPTER ONE**

# FLUOROSCOPY **SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY

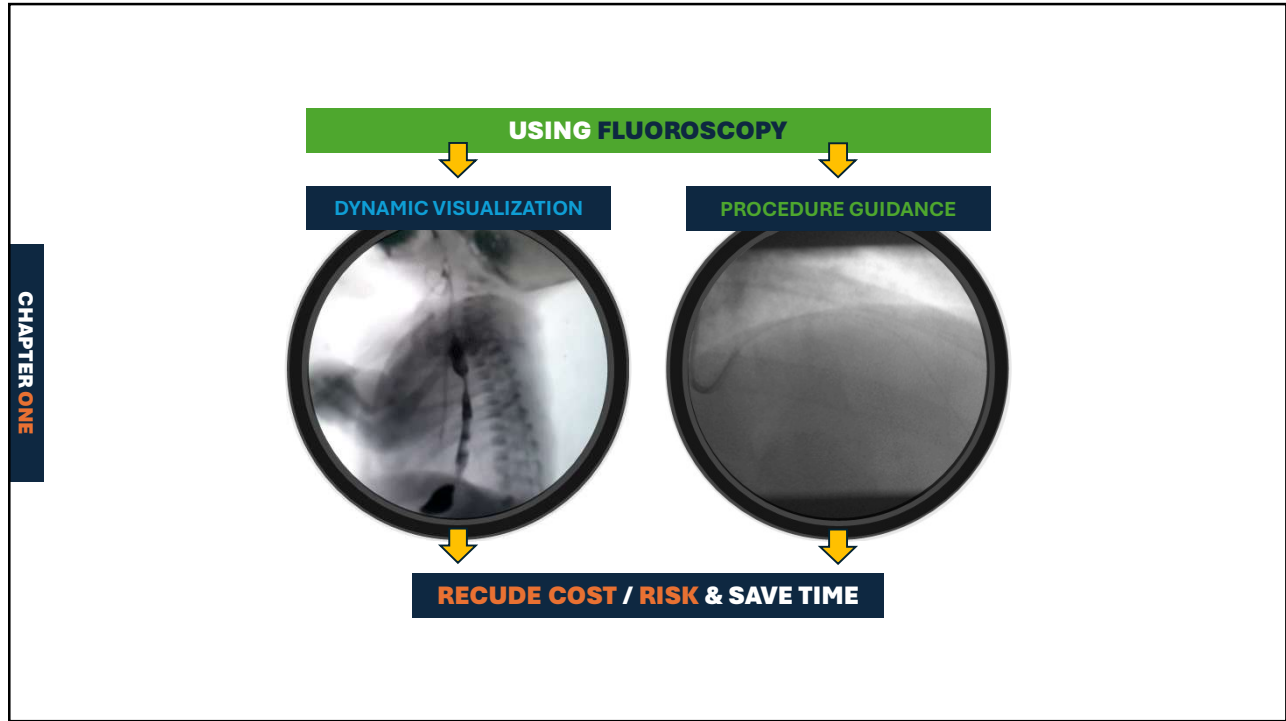
12

**CHAPTER ONE**

Fluoroscopy is a **powerful tool** that allows us to see moving images of the inside of the body in real-time.

<b>DYNAMIC VISUALIZATION</b>	<ul style="list-style-type: none"> <li>Observe movement of organs and systems &amp;</li> <li>Identify functional problems</li> </ul>
<b>PROCEDURE GUIDANCE</b>	<ul style="list-style-type: none"> <li>Precise instrument placement (stents / catheters)</li> <li>Real-time feedback (surgery)</li> </ul>
<b>REDUCE COST / RISK</b>	<ul style="list-style-type: none"> <li>Immediate assessment &amp; Instant feedback</li> <li>Potentially eliminating the need for further exams</li> </ul>

13

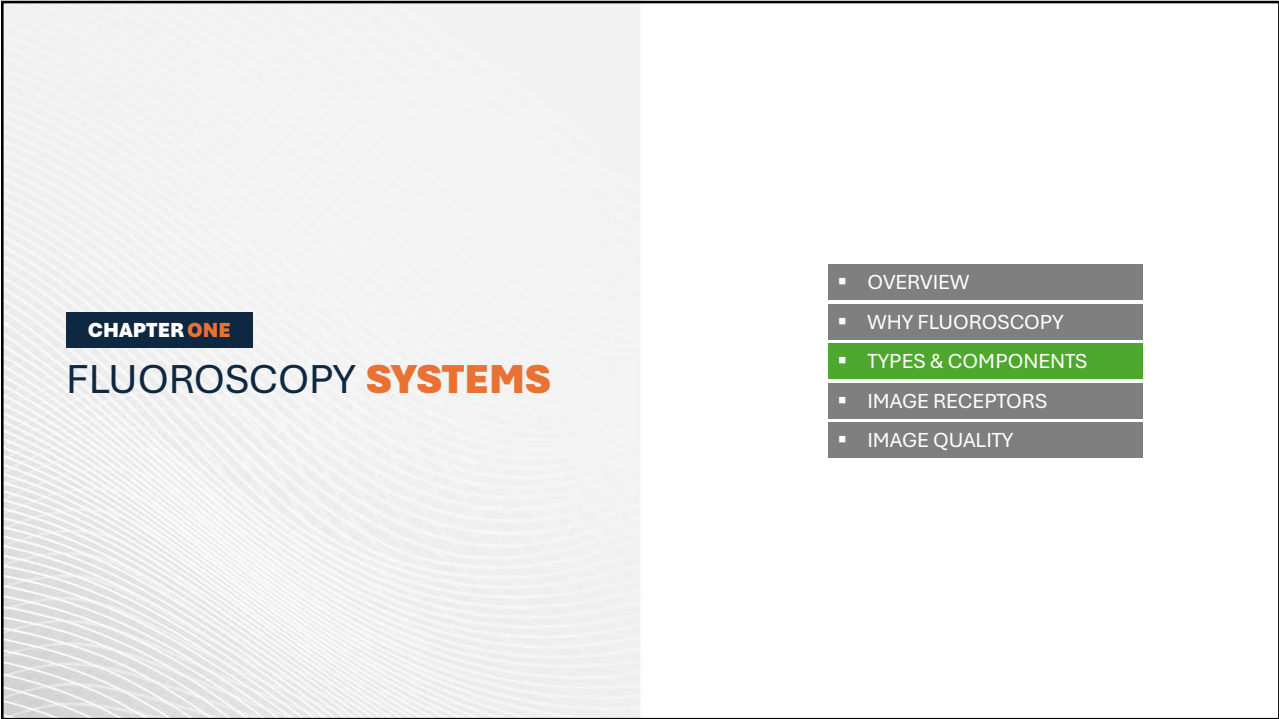


14

The slide features a light gray background with a subtle pattern of thin, curved lines. On the left side, a dark blue box contains the text "CHAPTER ONE" in white, followed by "FLUOROSCOPY SYSTEMS" in a larger, bold, orange font. On the right side, a vertical list of five items is presented, each in a dark gray box with a white square bullet point:

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY

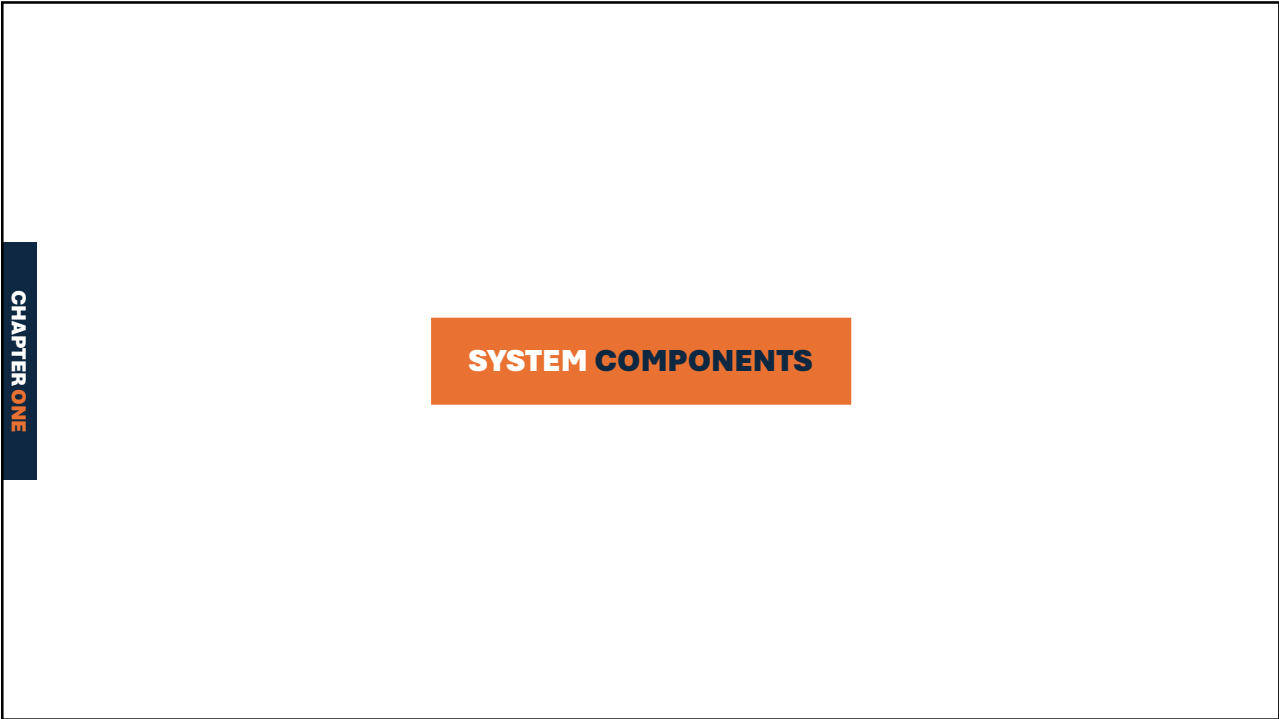
15



**CHAPTER ONE**  
**FLUOROSCOPY SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- **TYPES & COMPONENTS**
- IMAGE RECEPTORS
- IMAGE QUALITY

16



**CHAPTER ONE**

**SYSTEM COMPONENTS**

17

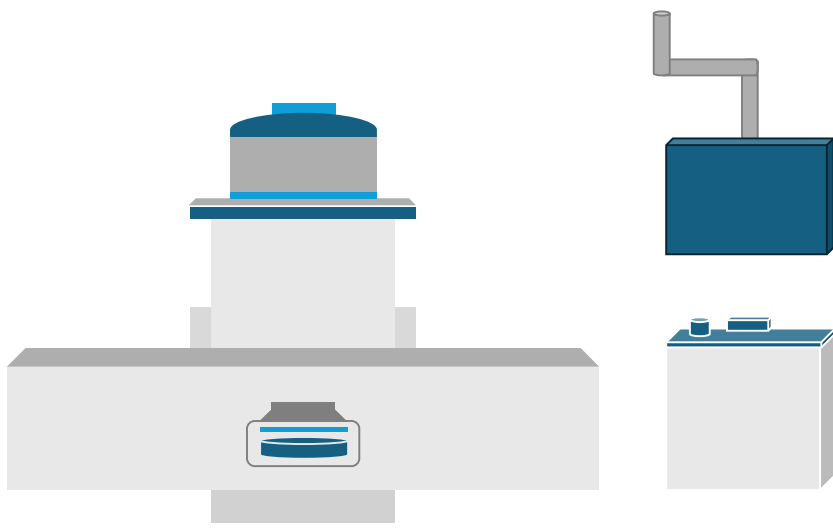


CHAPTER ONE

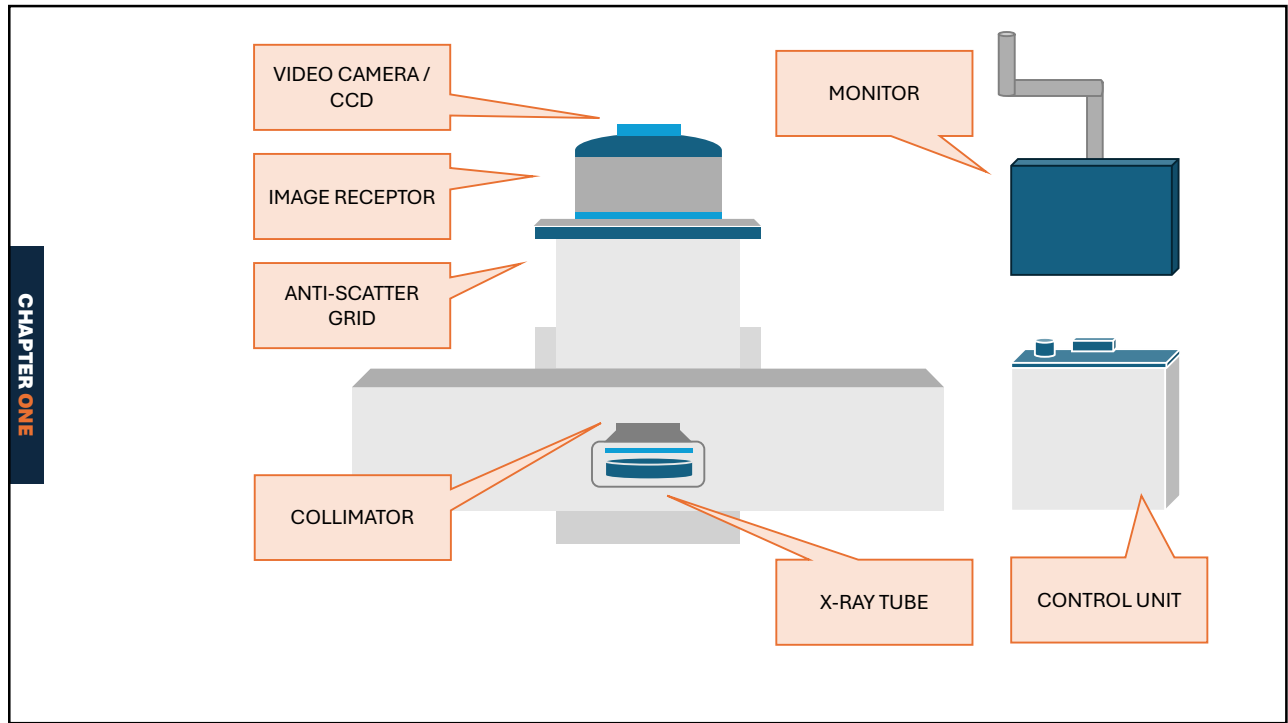
**EVERY FLUOROSCOPY SYSTEM INCLUDES A LIST OF ESSENTIAL COMPONENTS**

18

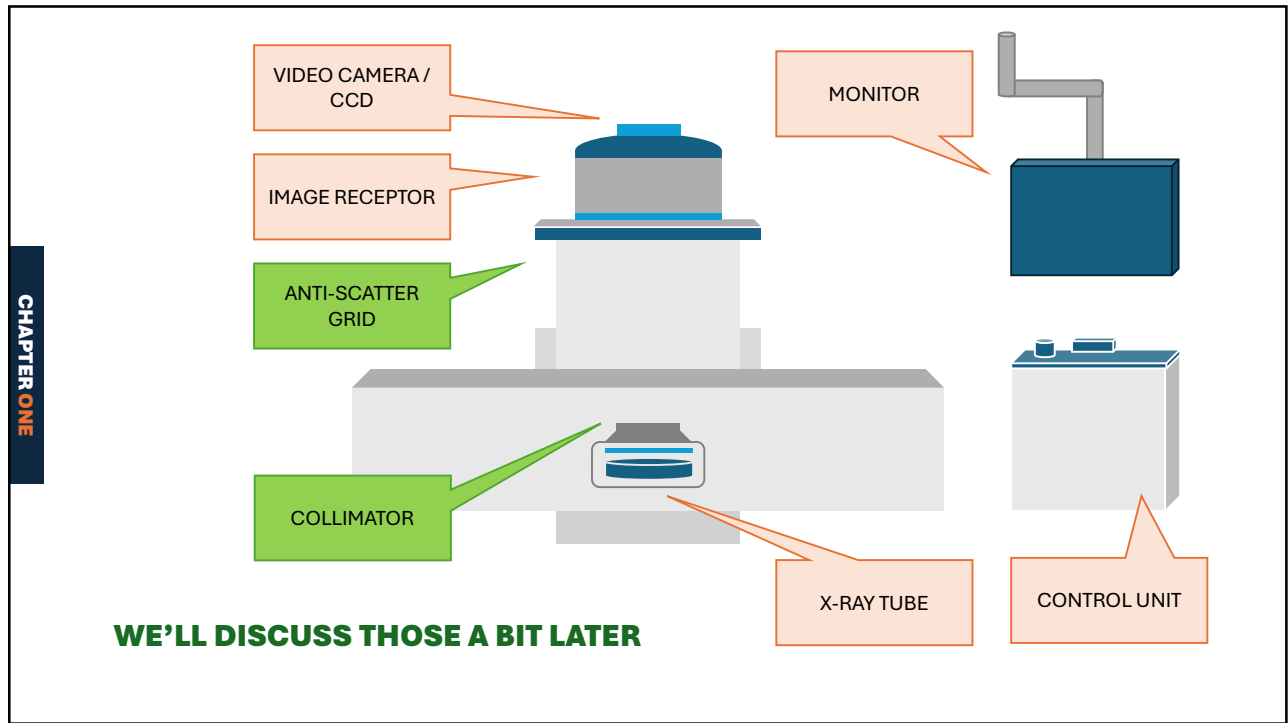
CHAPTER ONE



19

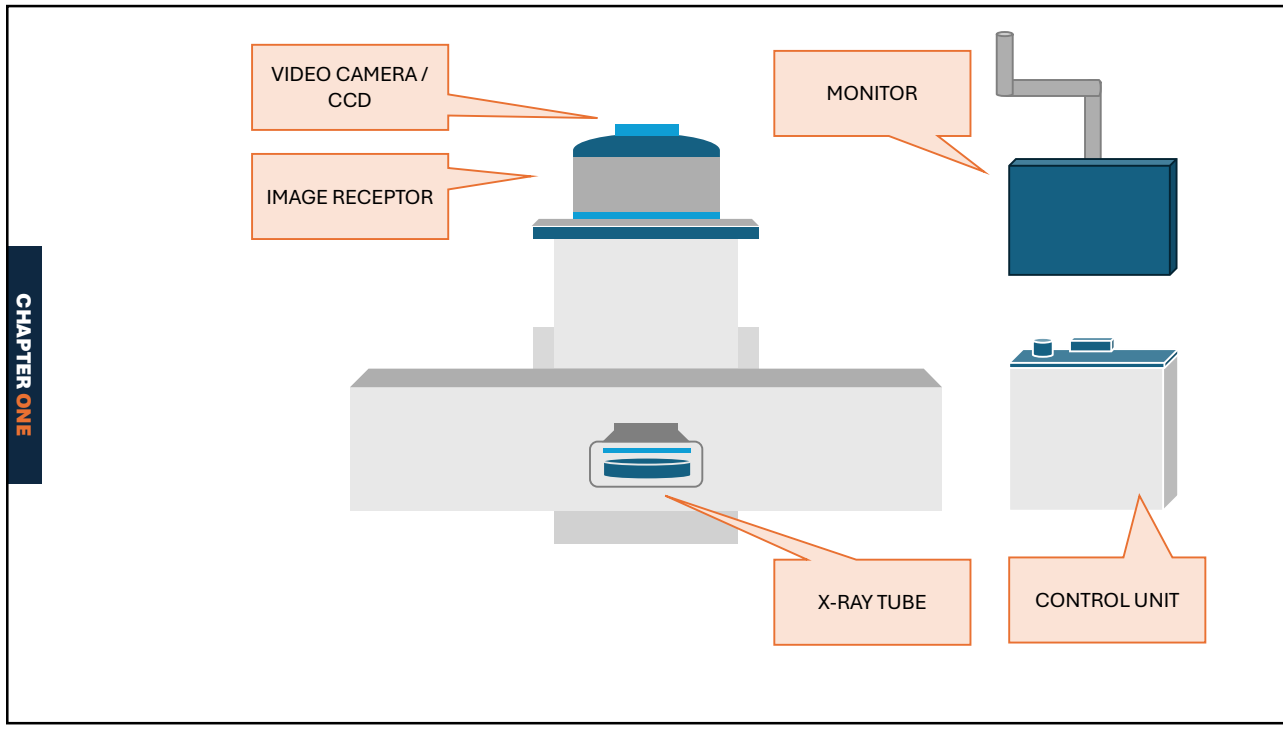


20



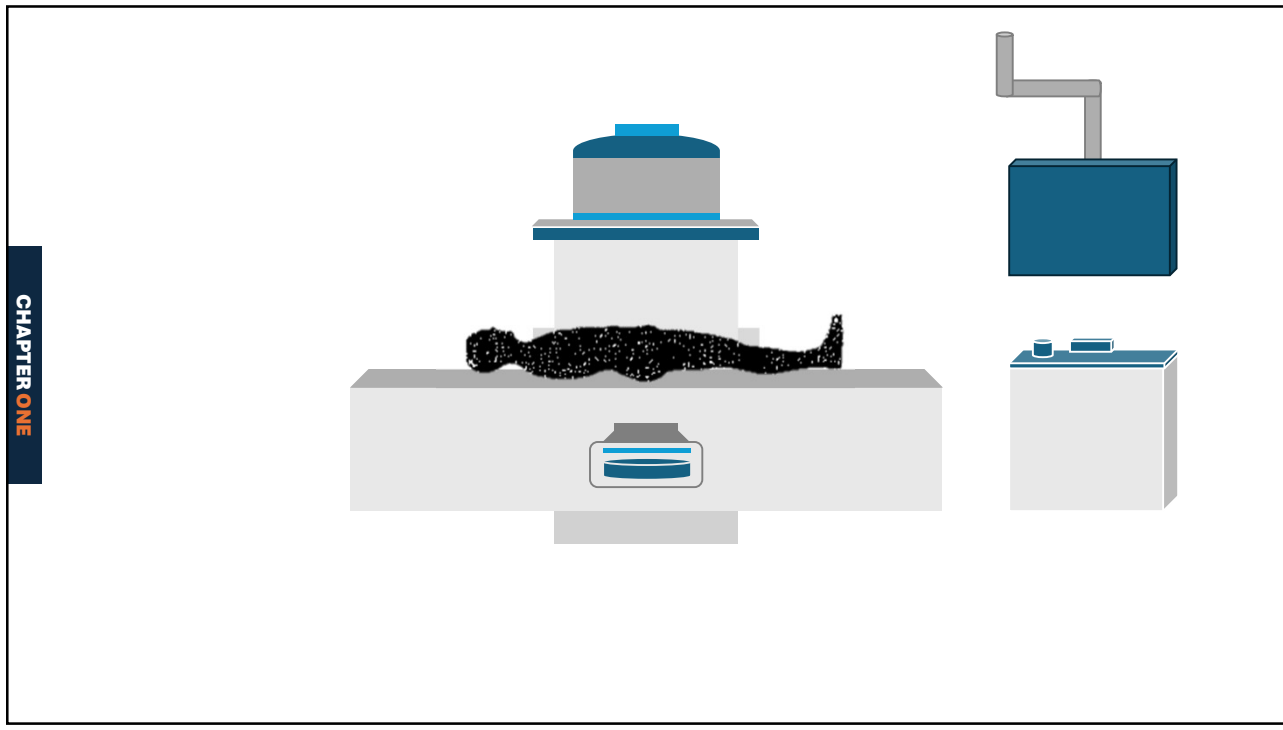
21

CHAPTER ONE



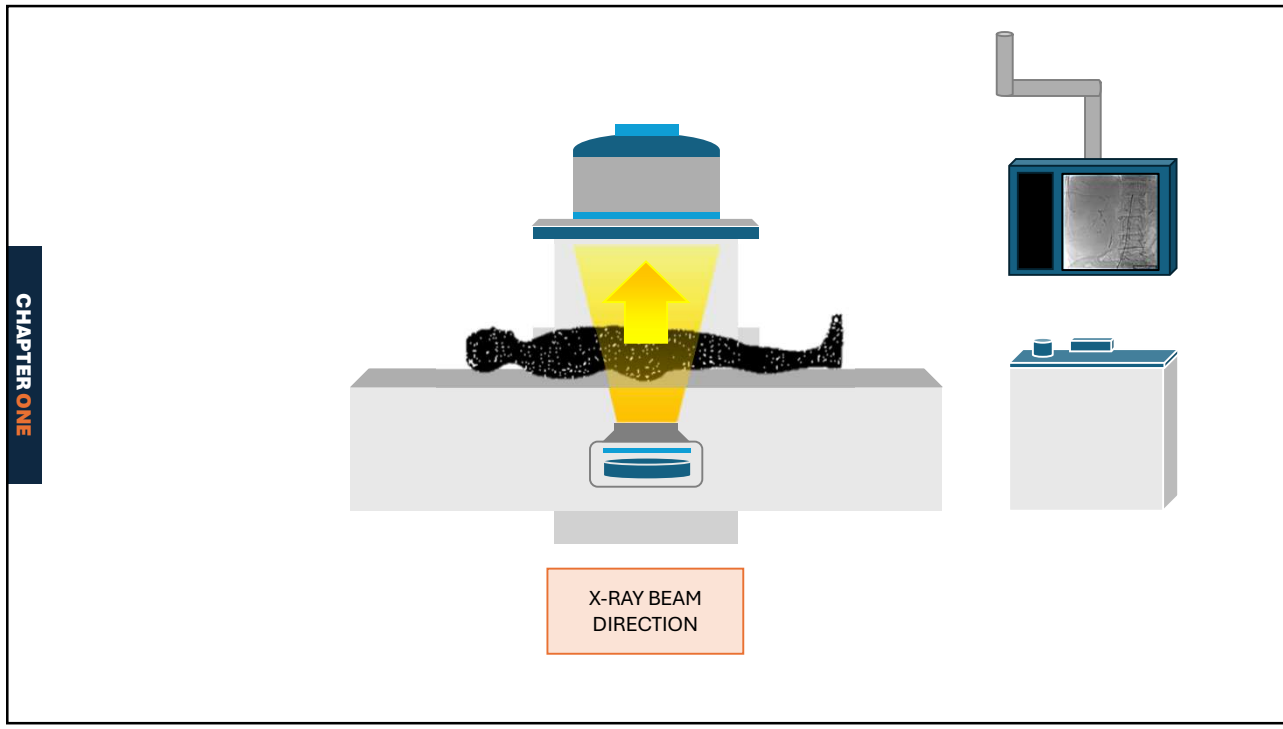
22

CHAPTER ONE



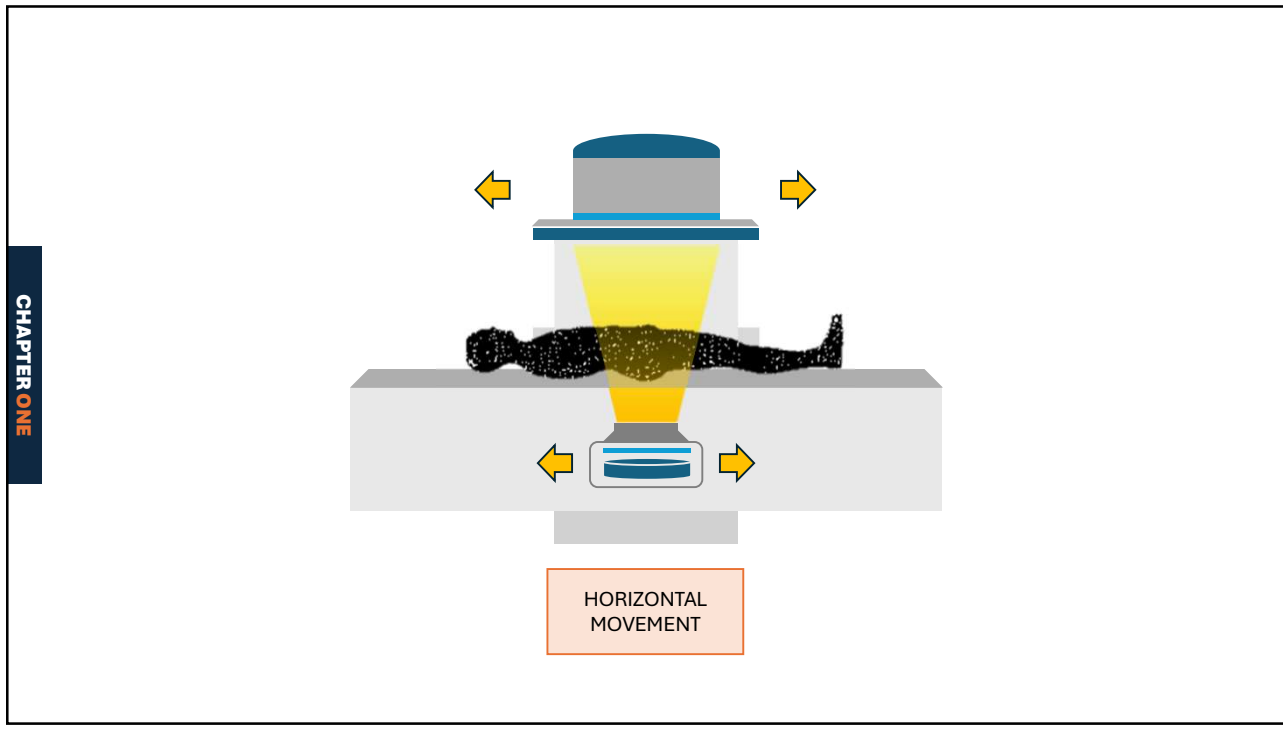
23

CHAPTER ONE



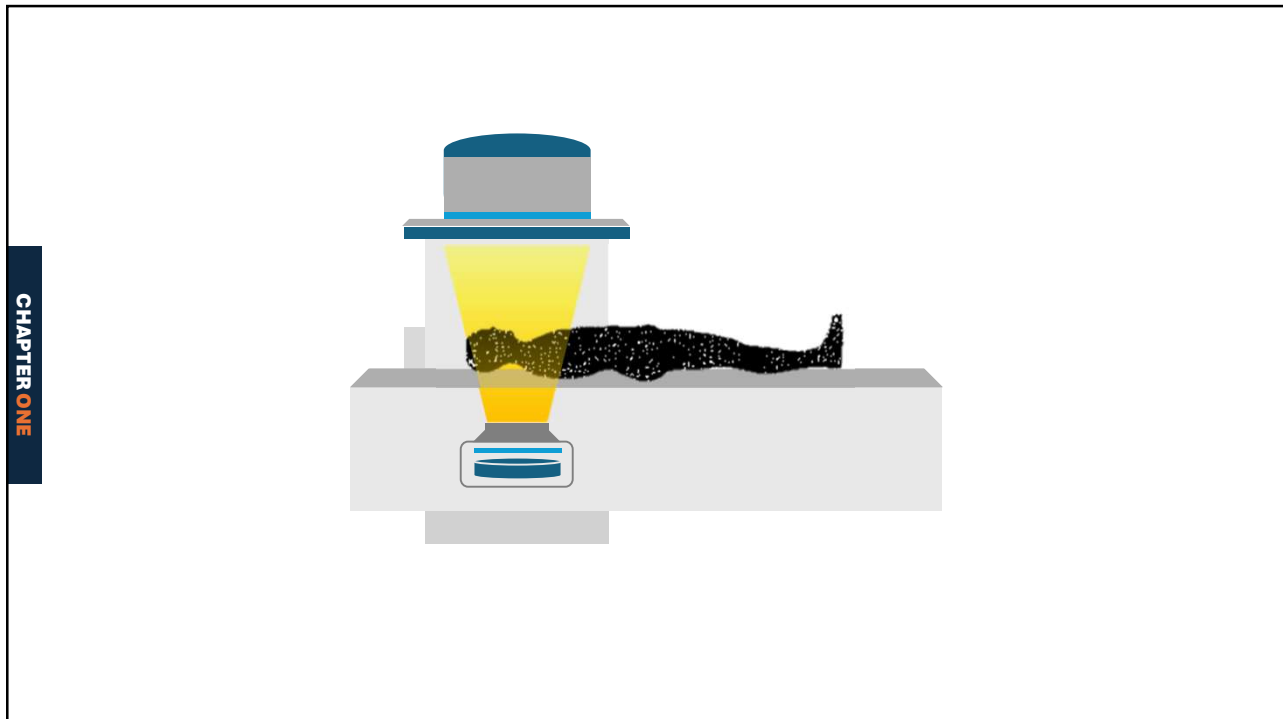
24

CHAPTER ONE



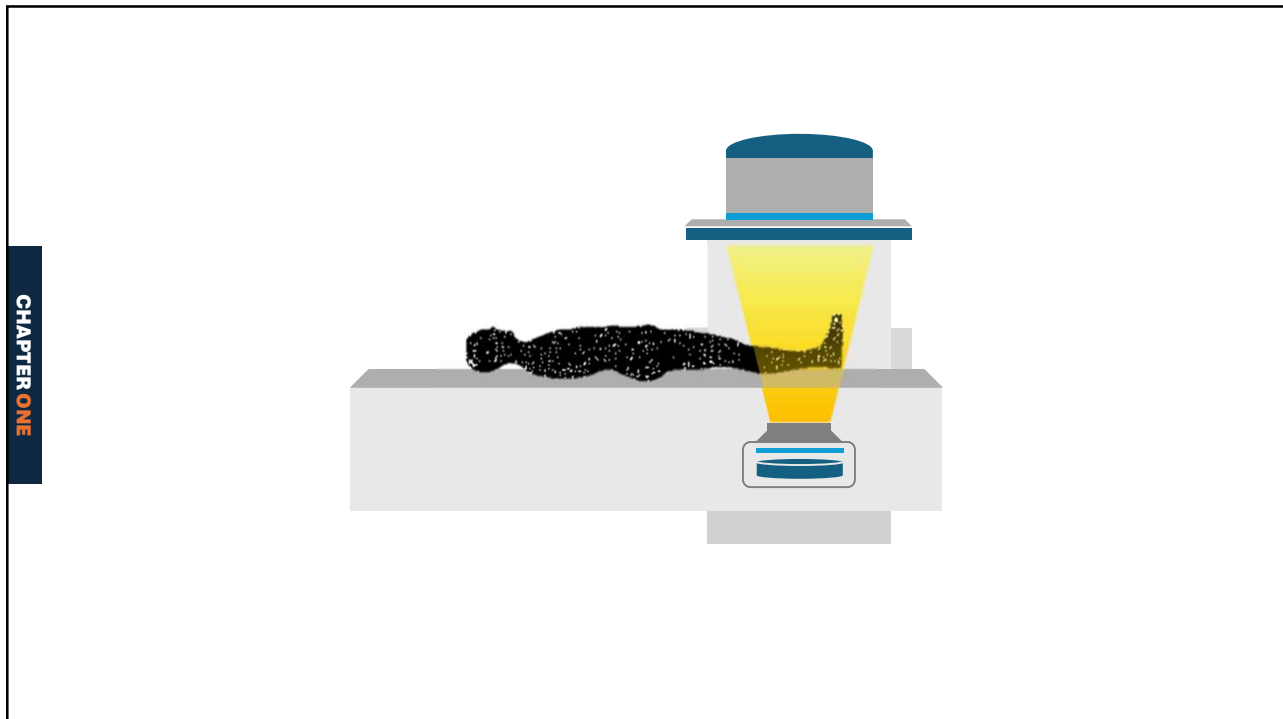
25

CHAPTER ONE



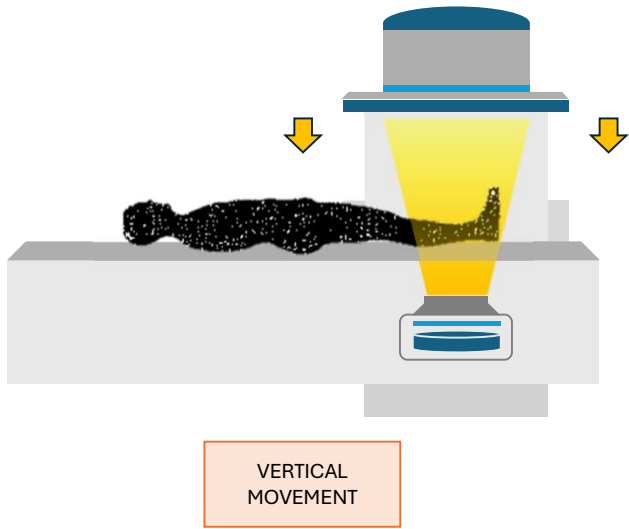
26

CHAPTER ONE



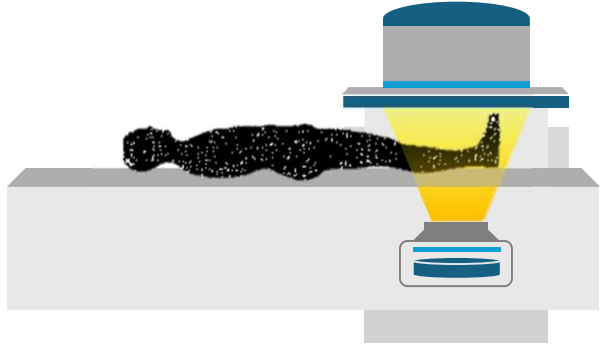
27

CHAPTER ONE



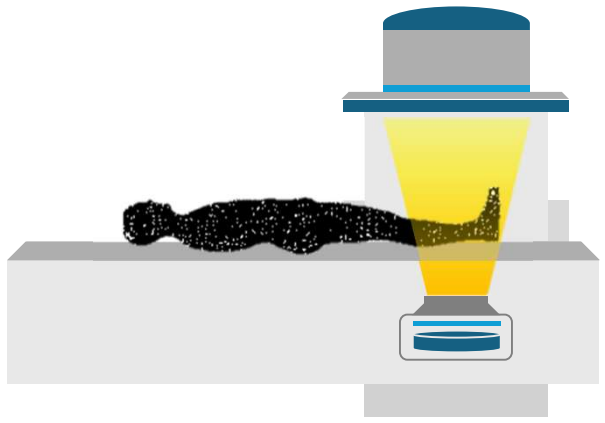
28

CHAPTER ONE



29

CHAPTER ONE



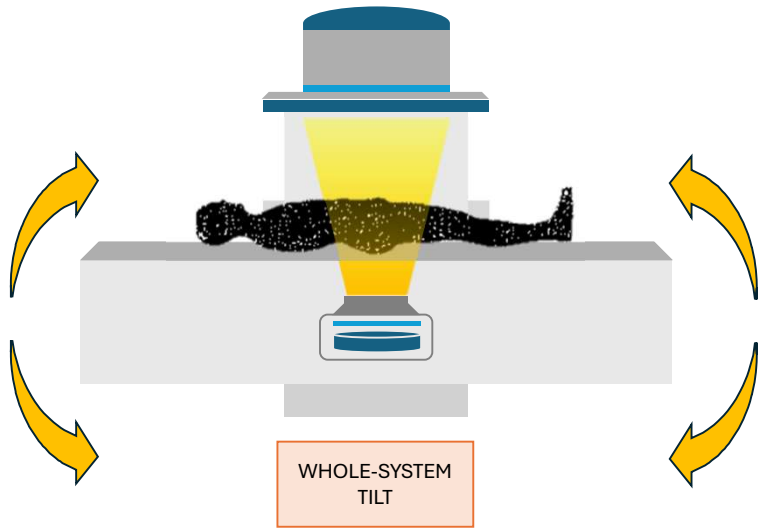
30

CHAPTER ONE



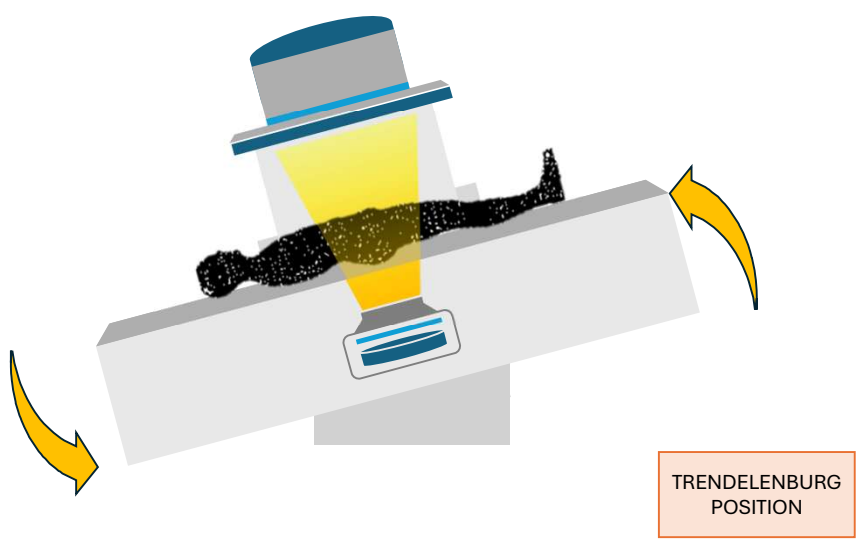
31

CHAPTER ONE



32

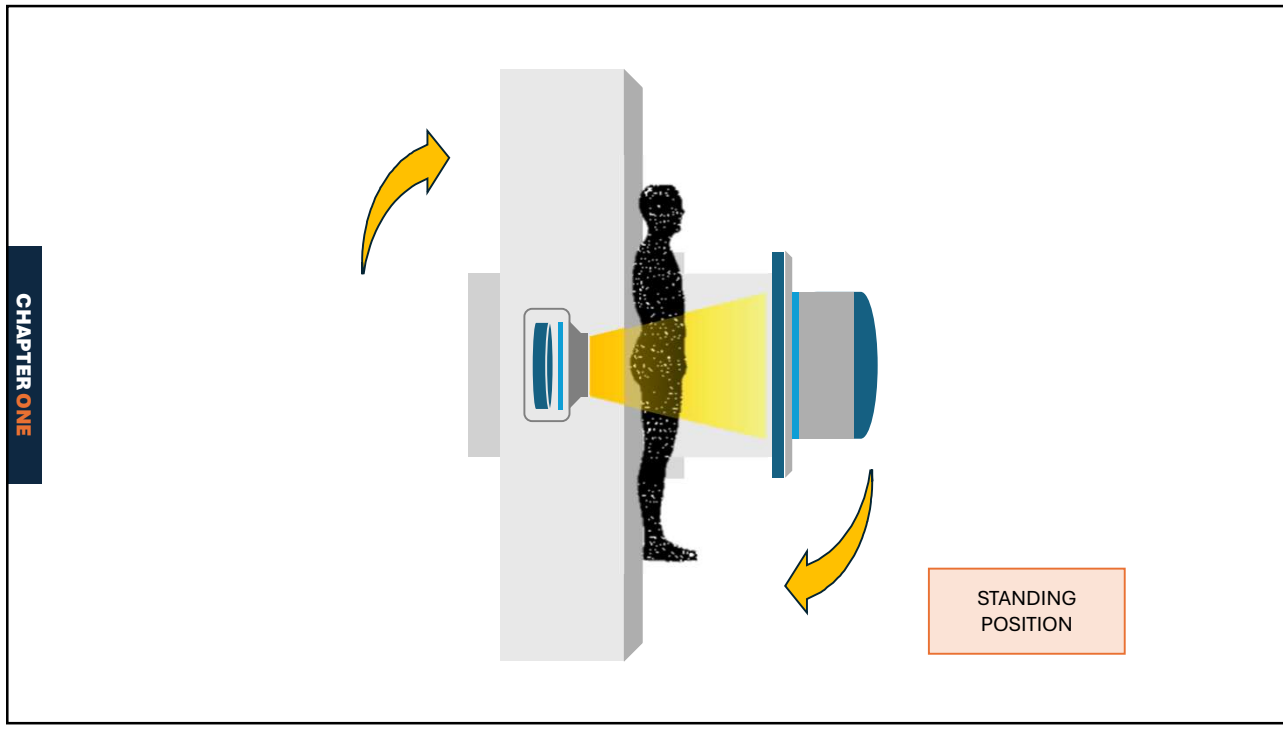
CHAPTER ONE



33

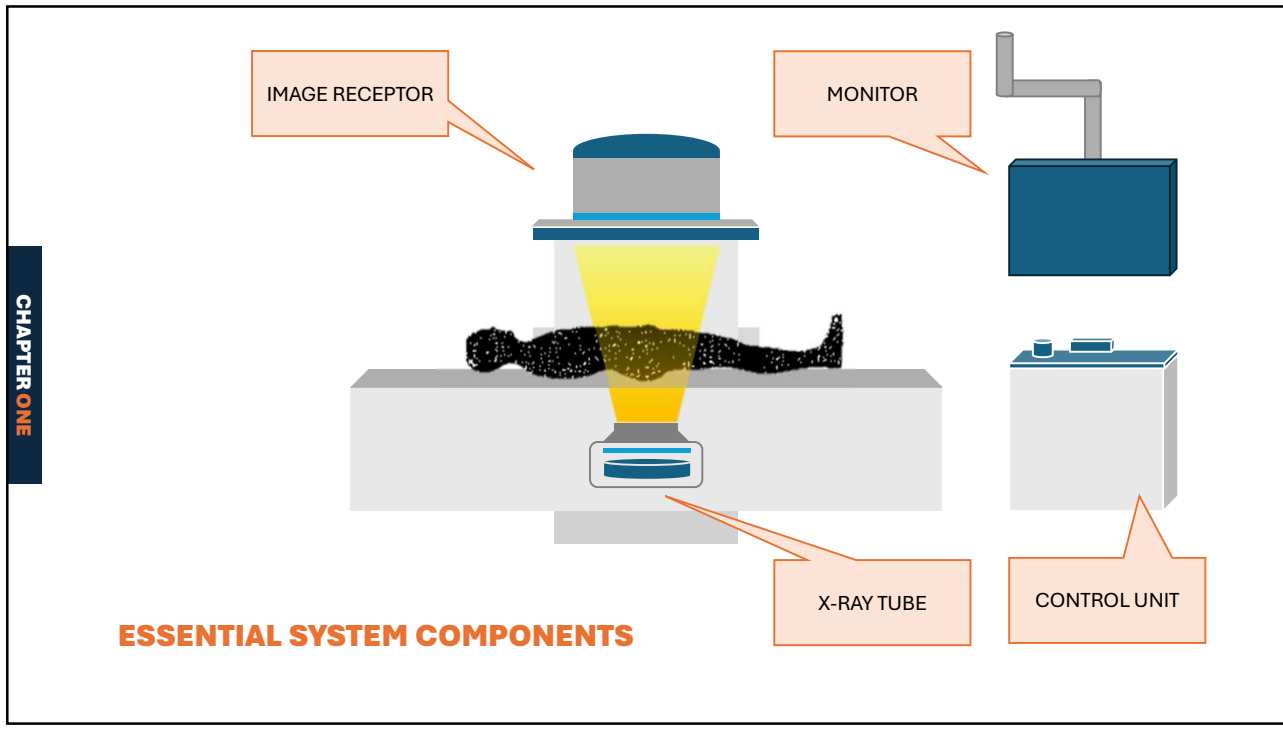


CHAPTER ONE

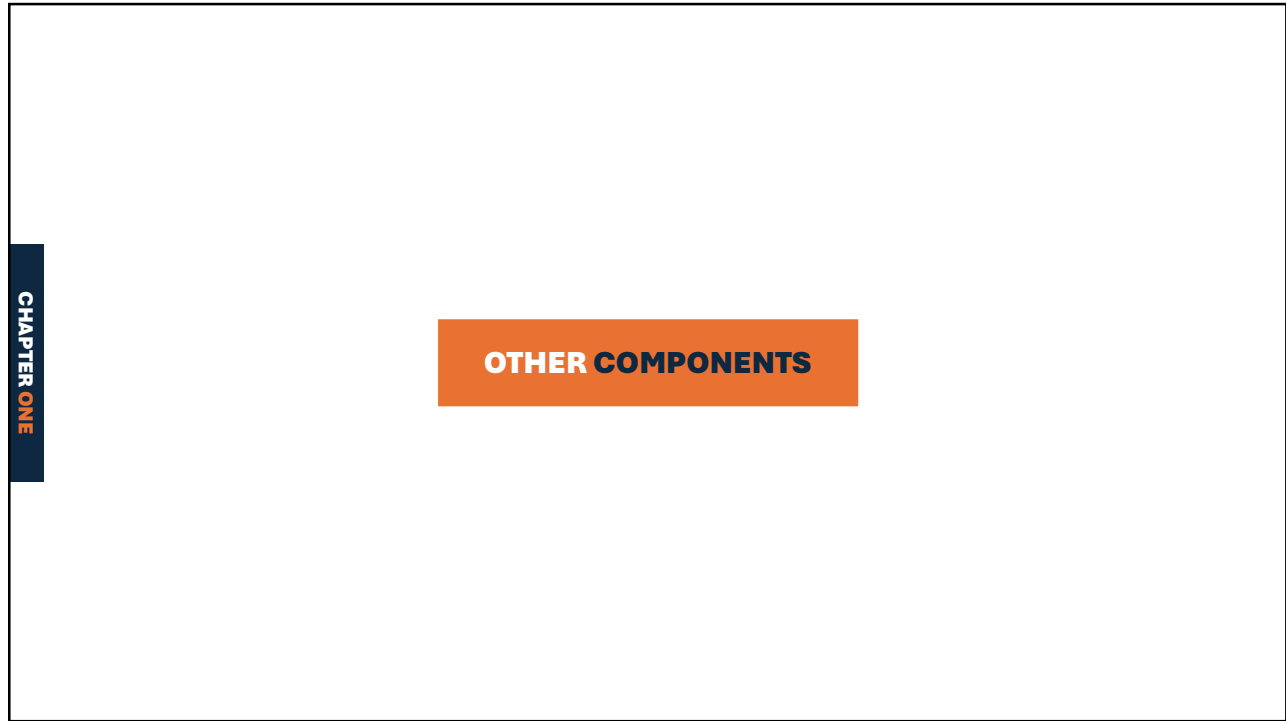


34

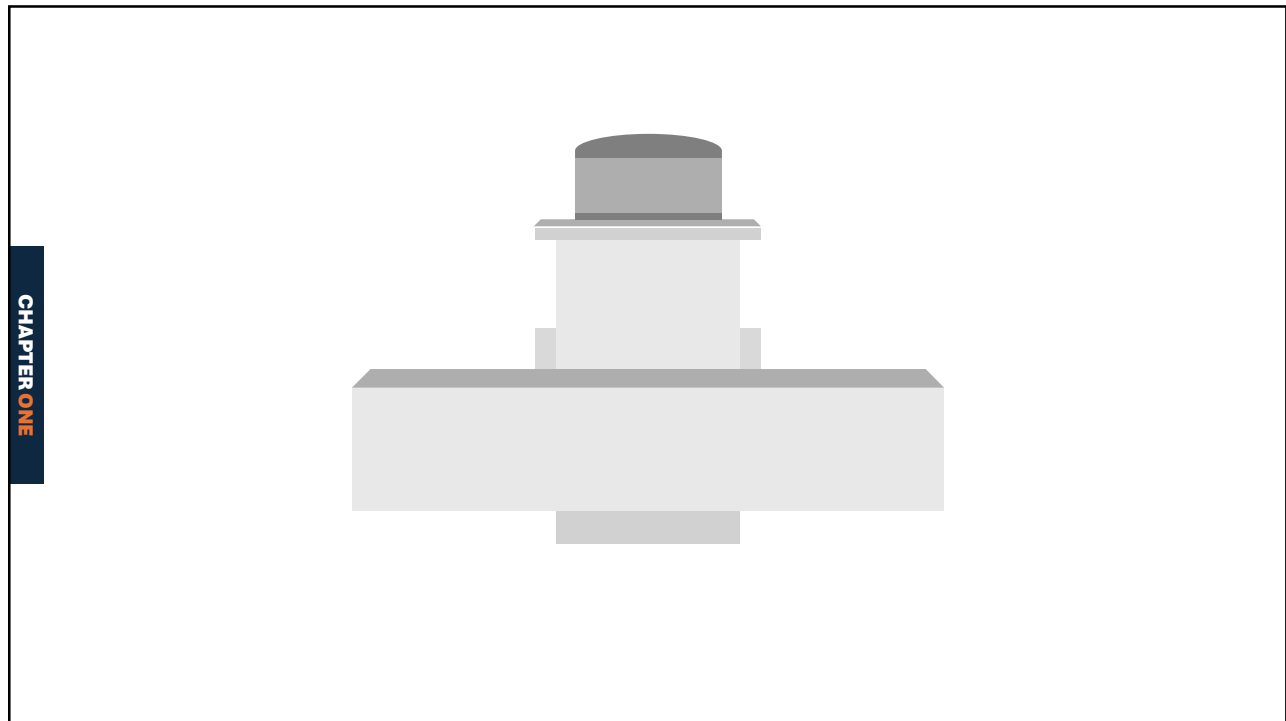
CHAPTER ONE



35

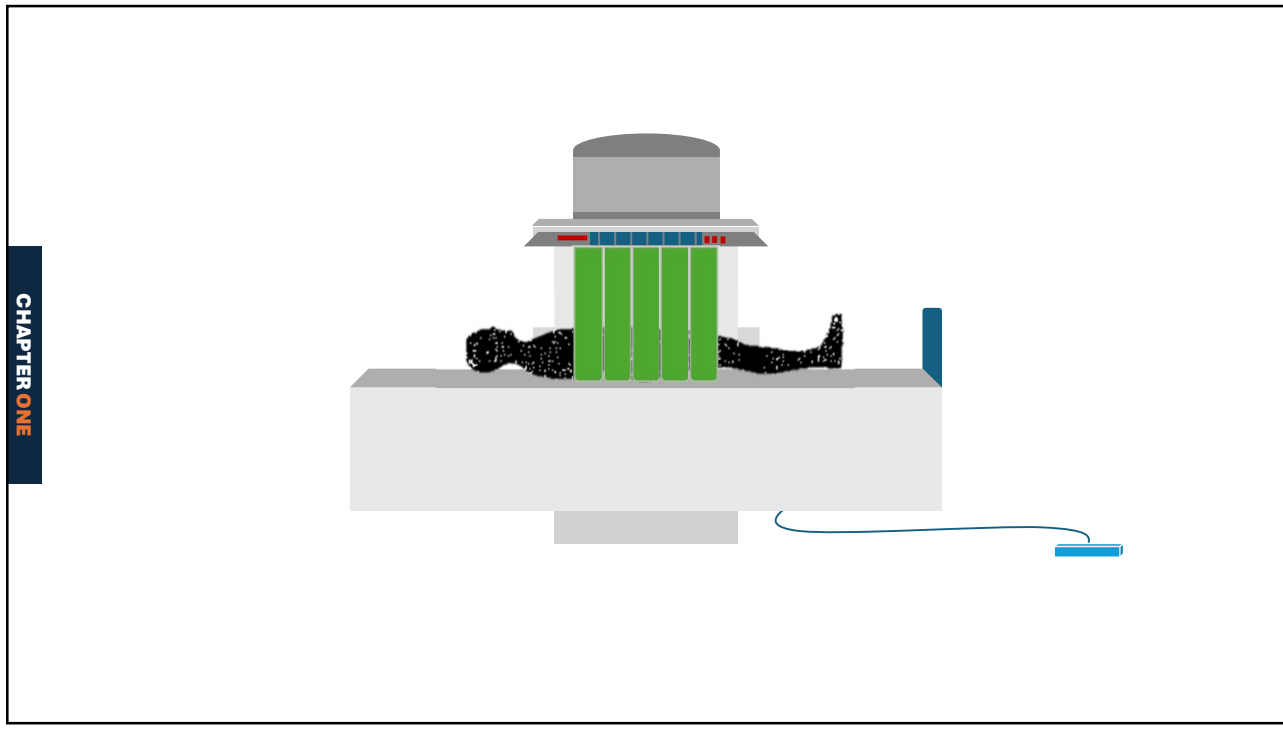


36



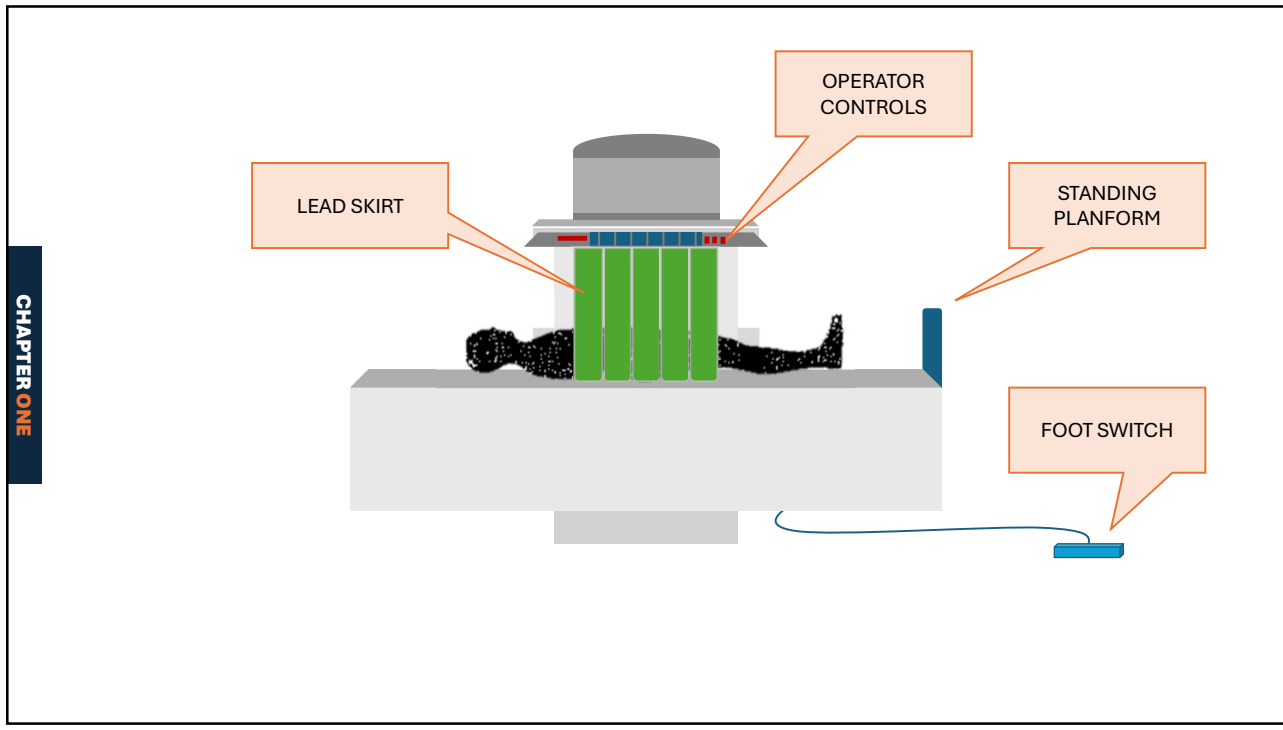
37

CHAPTER ONE

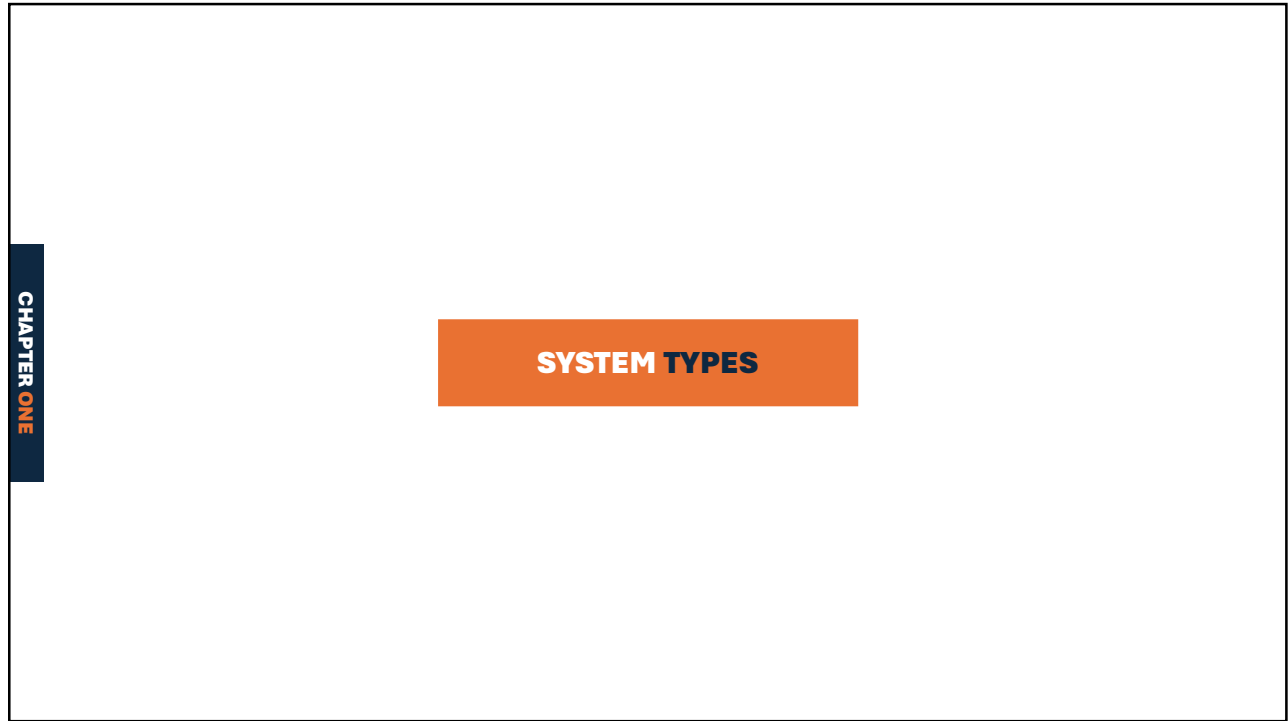


38

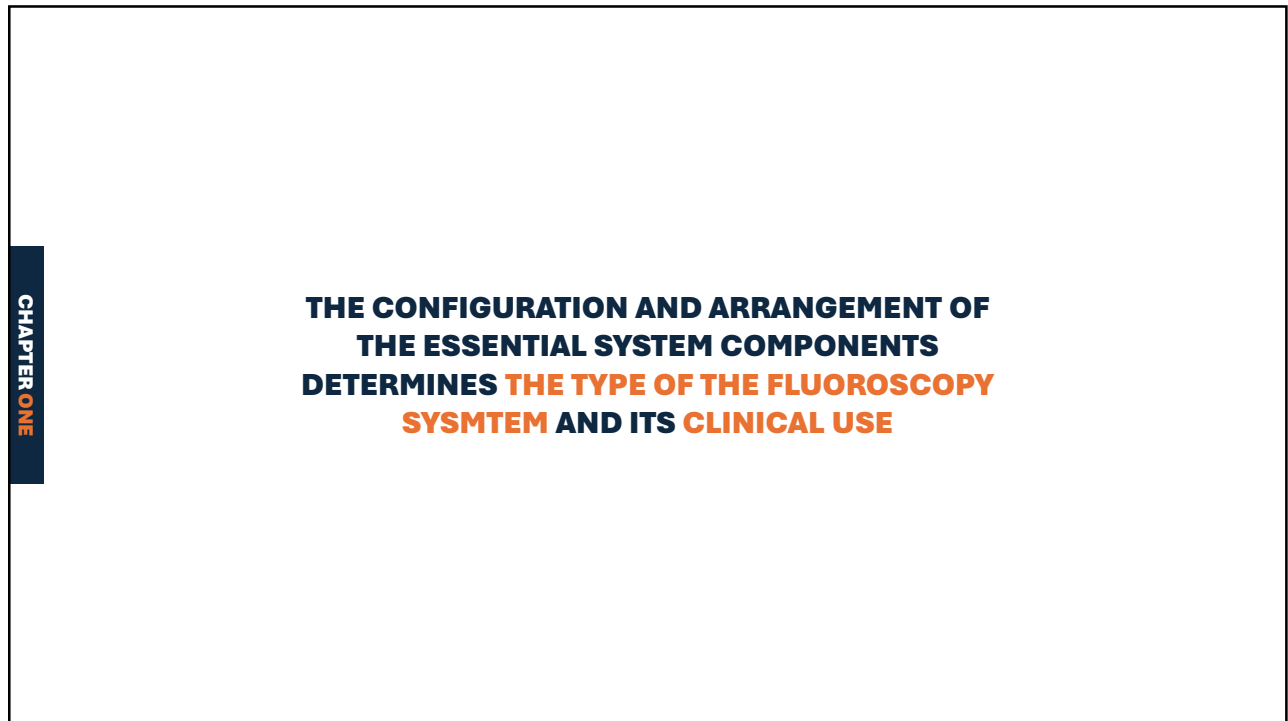
CHAPTER ONE



39

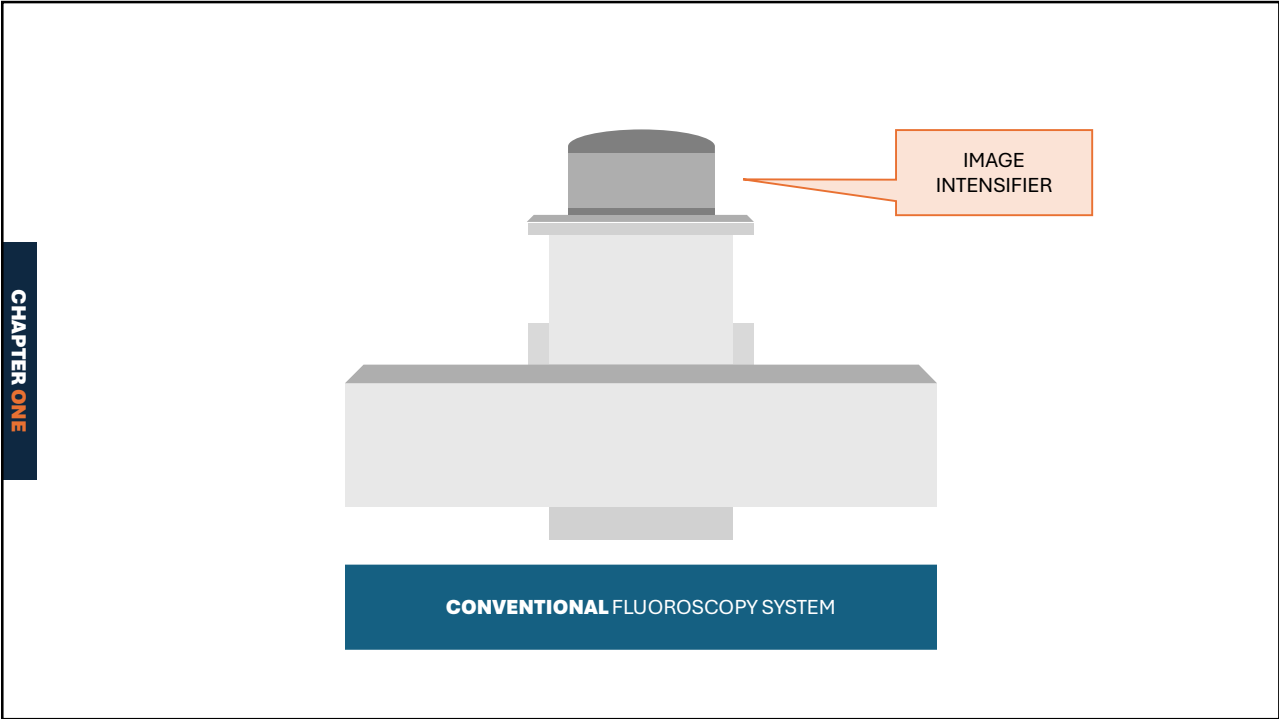


40



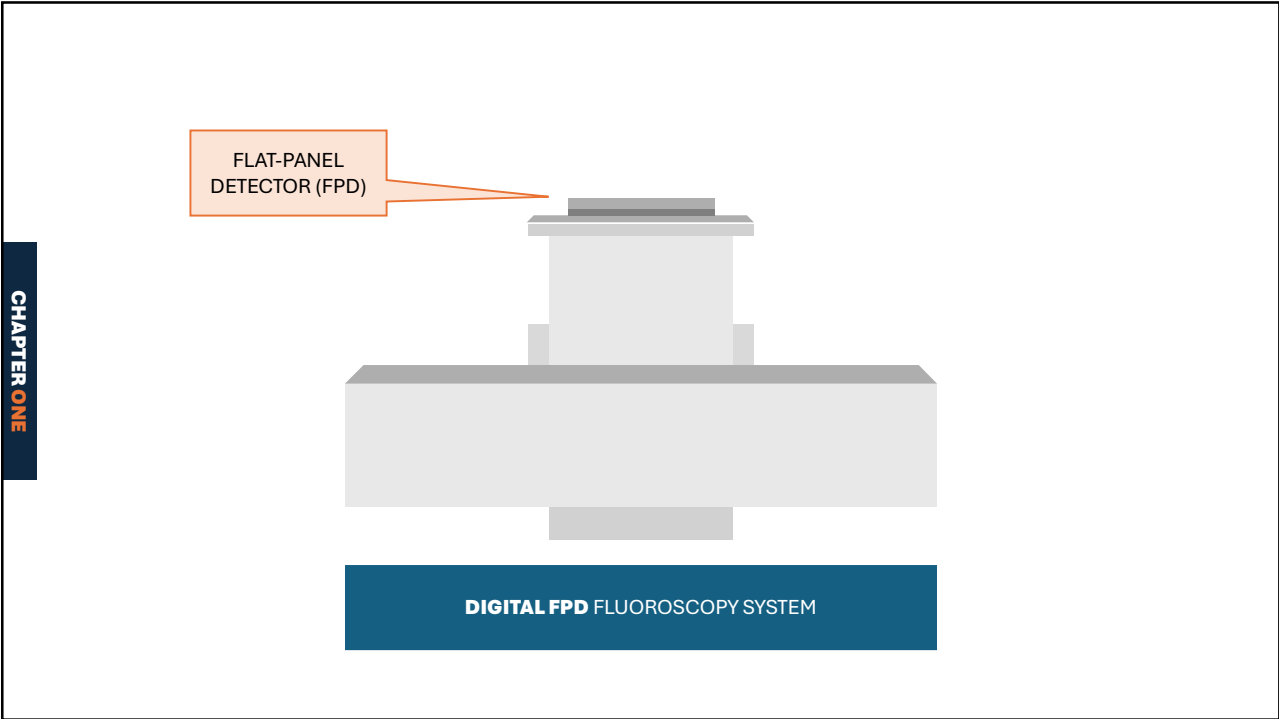
41

CHAPTER ONE



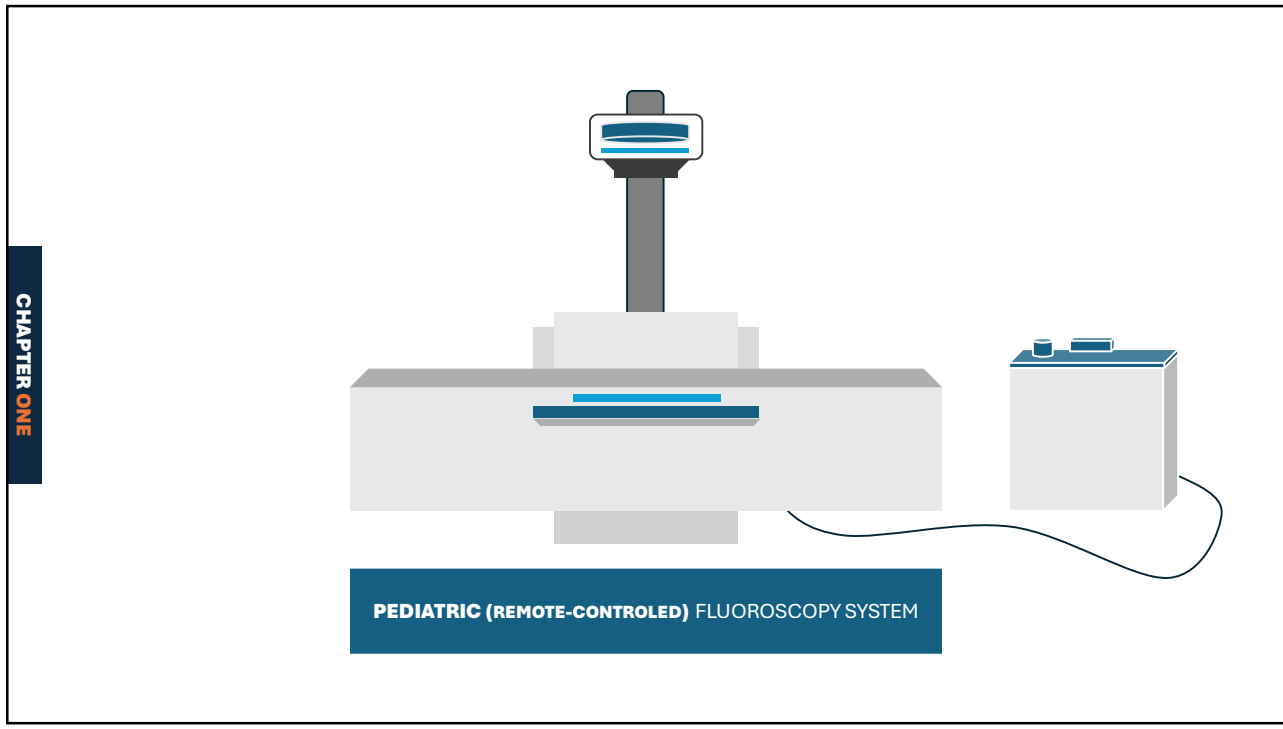
42

CHAPTER ONE



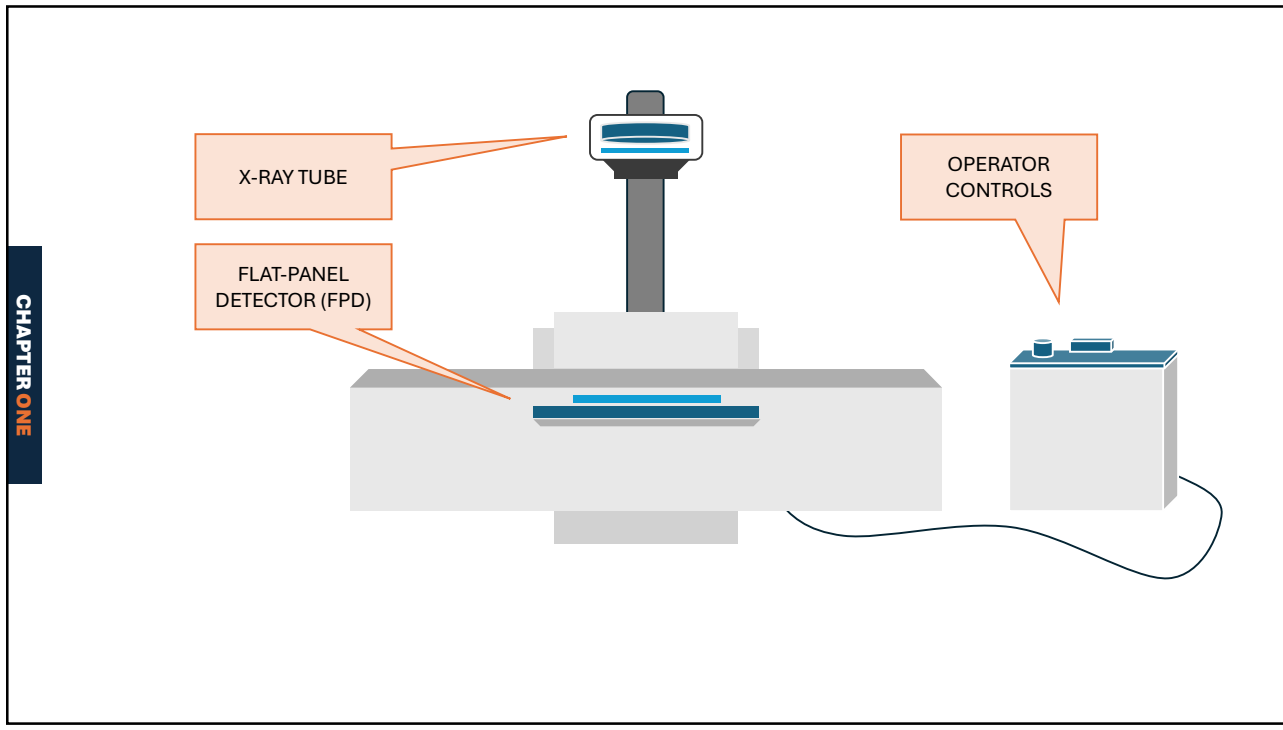
43

CHAPTER ONE



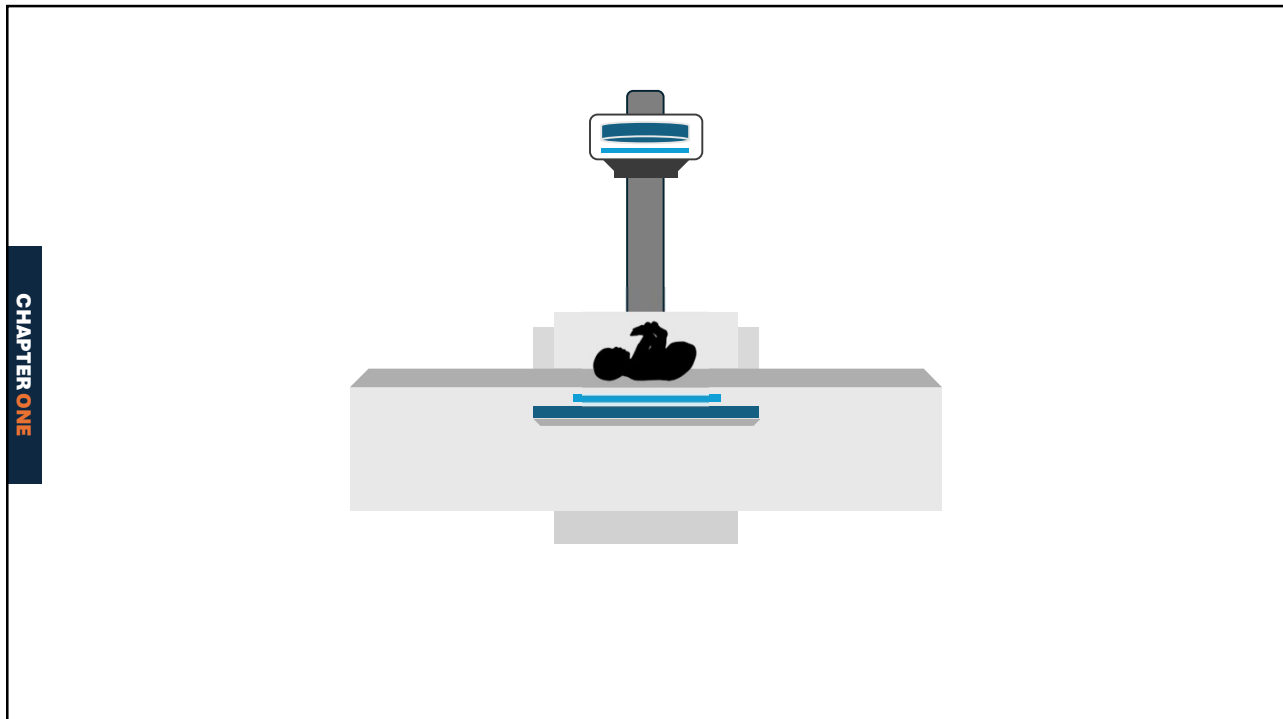
44

CHAPTER ONE



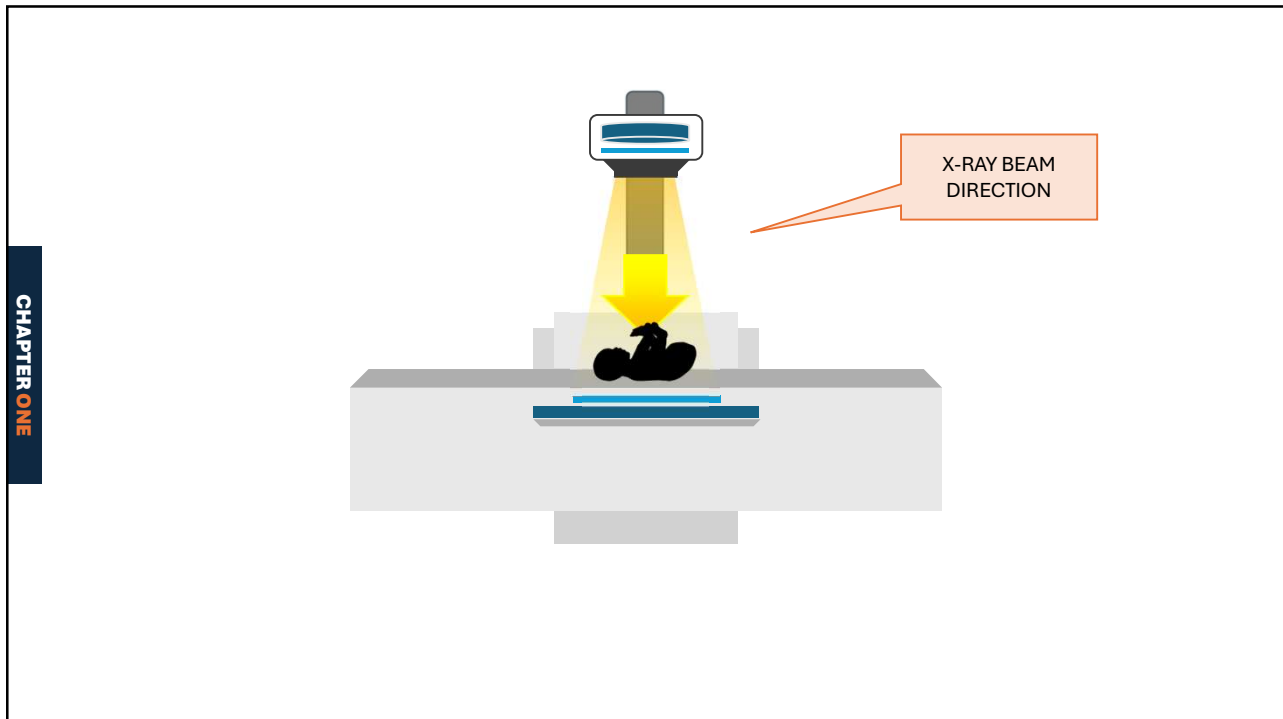
45

CHAPTER ONE



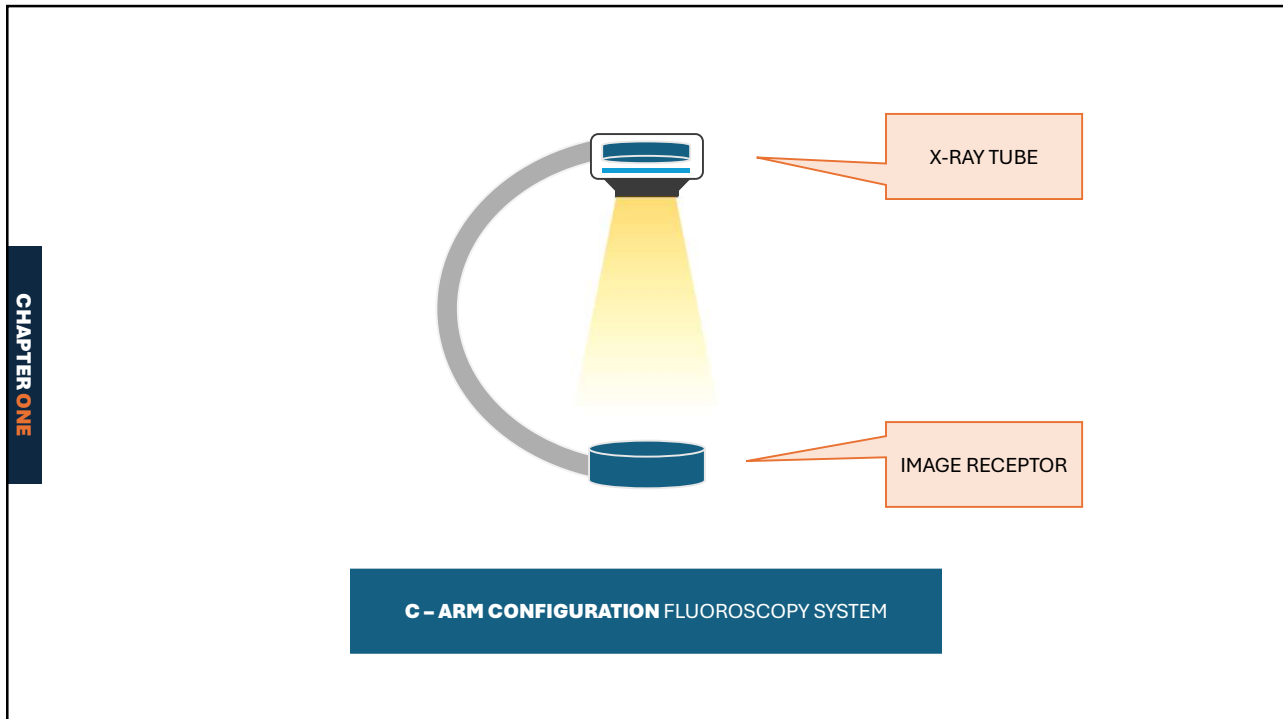
46

CHAPTER ONE



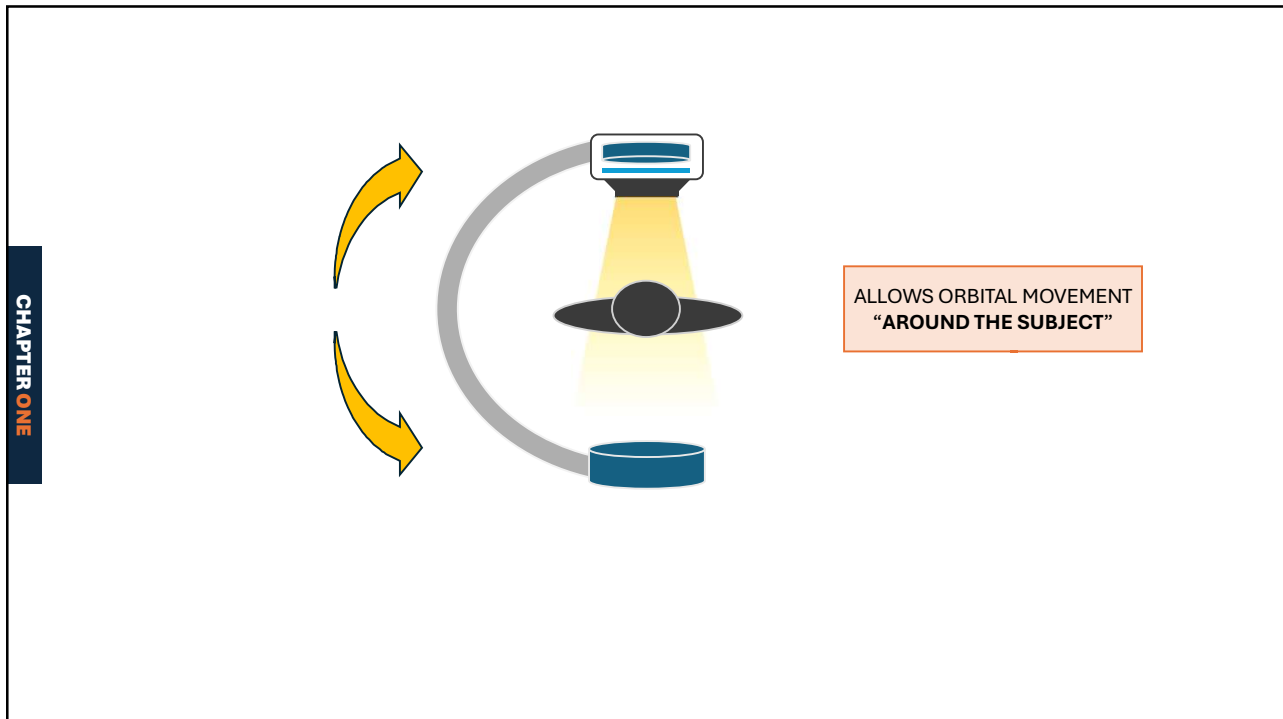
47

CHAPTER ONE



48

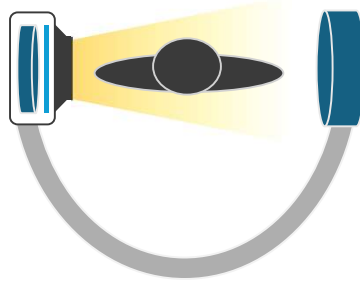
CHAPTER ONE



49



CHAPTER ONE

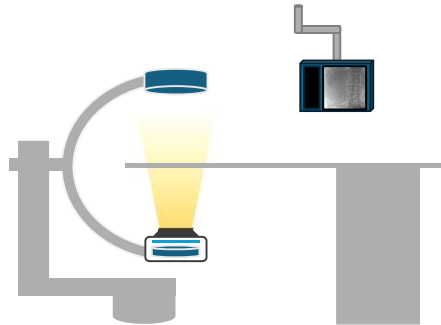


50

CHAPTER ONE

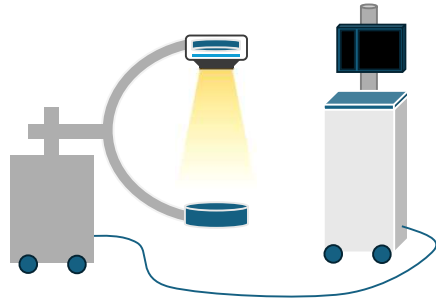
**C - ARM VARIATONS: INTERVENTIONAL SUITE**

C-ARM CAN BE EITHER  
CEILING OR FLOOR MOUNTED



51

**C - ARM VARIATIONS: MOBILE UNIT**



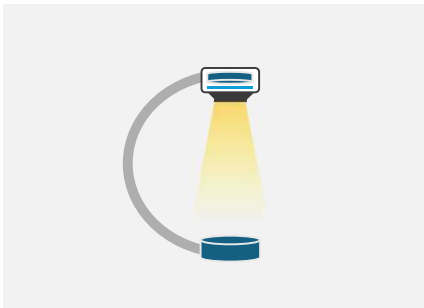
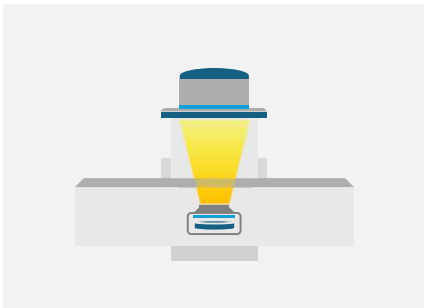
52

**TYPES OF FLUOROSCOPY SUMMARY**

**CONVENTIONAL**

VS

**INTERVENTIONAL**



- Generally used for **diagnostics**
- **Lower radiation** doses
- Found in Radiology Dept.

- Generally used for **procedures**
- **Higher radiation** doses
- Found in Radiology Dept. and other facilities like Cath Lab and OT.

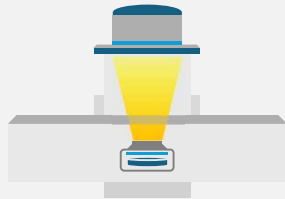
53

**TYPES OF FLUOROSCOPY SUMMARY**

**CONVENTIONAL**

**VS**

**INTERVENTIONAL**

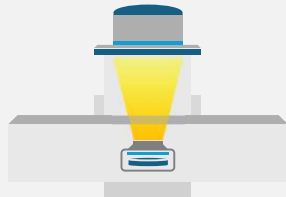


- Can have Image Intensifier (II) or Flat-Panel Detector (FPD)
- Tube can be under-couch (typical) or over-couch (remote-operated)



- Can have Image Intensifier (II) or Flat-Panel Detector (FPD)
- Can be fixed like an Interventional Suite (floor or ceiling mounted) or can be mobile for use in OT.

**COMPONENTS OF FLUOROSCOPY SUMMARY**



- X-Ray tube and Generator
- Collimator
- Anti-Scatter Grid
- Image Receptor (II or FPD)
- Video Camera / CCD
- Monitor
- Patient Couch
- Control Panel
- Computer

**CHAPTER ONE**  
**FLUOROSCOPY SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY

56

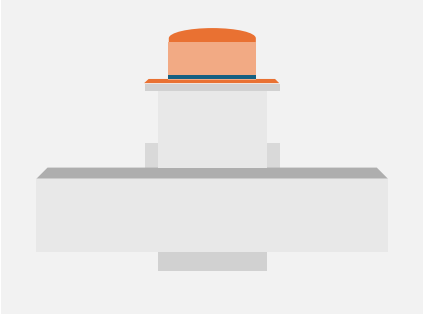
**CHAPTER ONE**  
**FLUOROSCOPY SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- **IMAGE RECEPTORS**
- IMAGE QUALITY

57

CHAPTER ONE

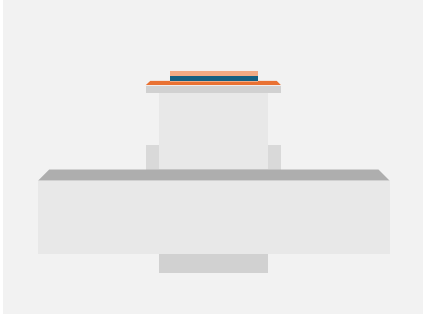
**IMAGE INTENSIFIER (II)**



Conventional **older technology**, but still in use today.

**VS**

**FLAT PANEL DETECTOR (FPD)**



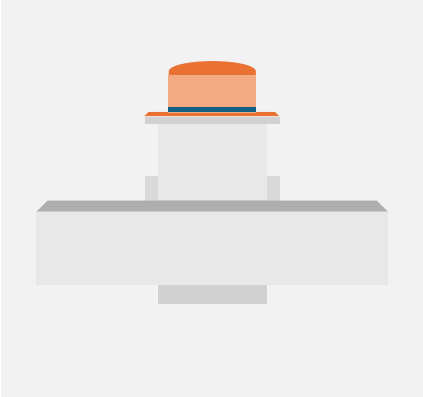
Largely replaced Image Intensifiers, in **most modern machines**

58

CHAPTER ONE

**KEY CHARACTERISTICS**

**IMAGE INTENSIFIER (II)**



**TECHNOLOGY**  
A vacuum tube containing a fluorescent input screen, photocathode, electron optics, and output screen.

**IMAGE FORMATION**  
X-rays are converted to light, then to electrons, amplified, and converted back to light.

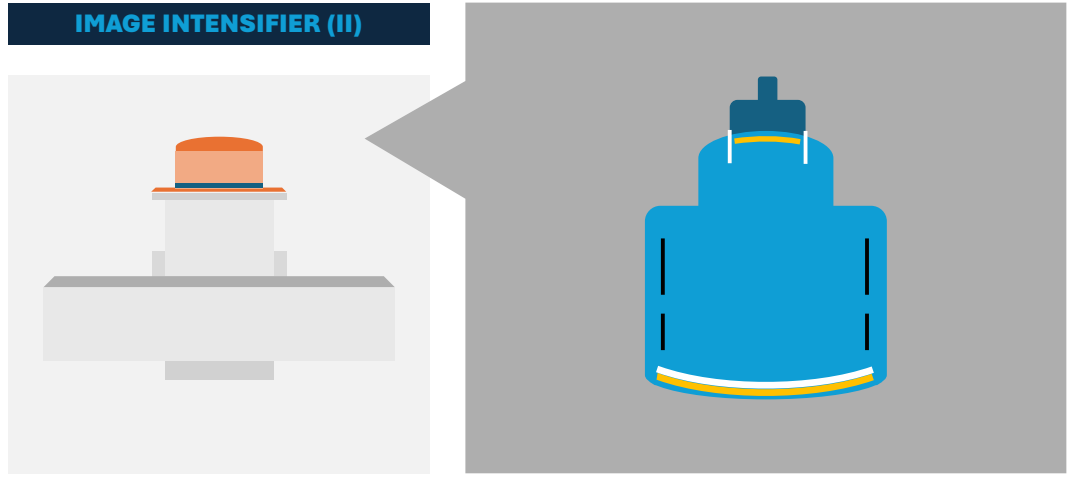
**ADVANTAGES**  
Mature technology with a long history and relatively lower cost compared to FPDs.

**DISADVANTAGES**

- Bulkier and heavier than FPDs.
- Image distortion, especially at the periphery.
- Lower detective quantum efficiency (DQE) leading to higher dose requirements.
- Limited dynamic range.

59

CHAPTER ONE



60

CHAPTER ONE

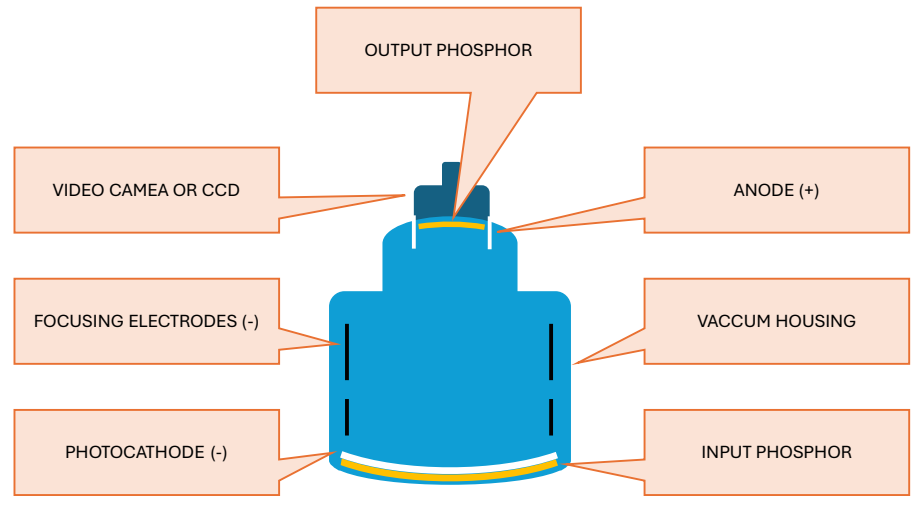
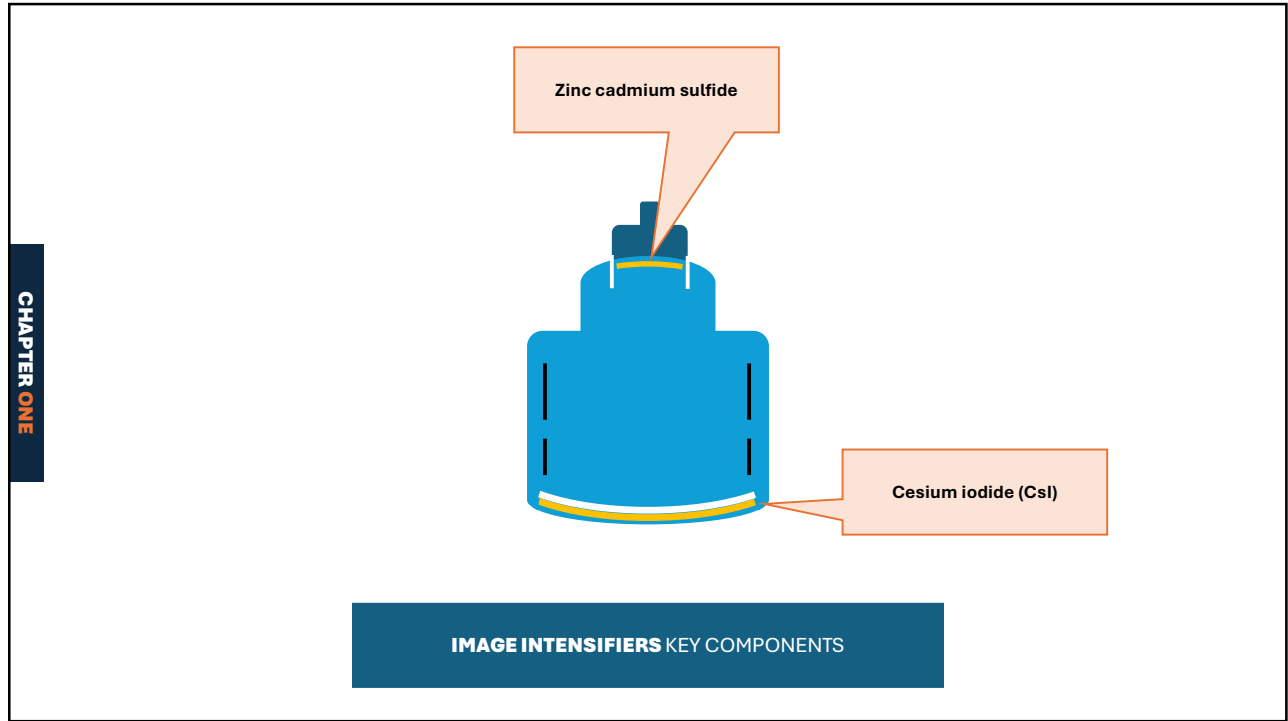
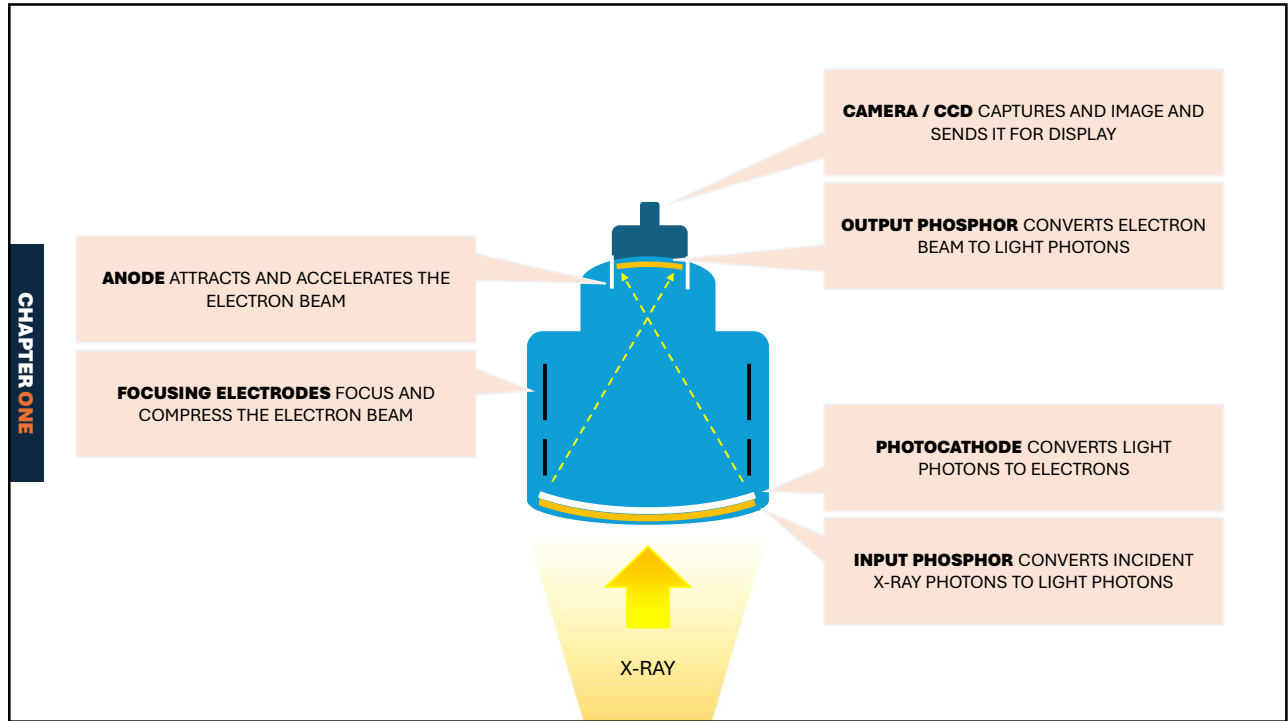


IMAGE INTENSIFIERS KEY COMPONENTS

61



62



63

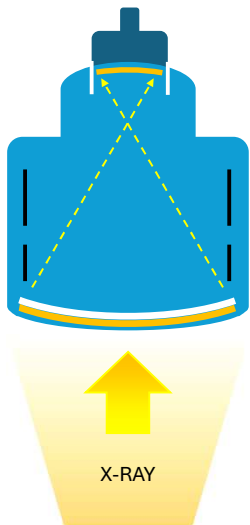


IMAGE INTENSIFIERS INCREASE **IMAGE BRIGHTNESS** DURING FLUOROSCOPY THROUGH TWO PROCESSES

**FLUX GAIN:**

The increase in the number of light photons at the output phosphor compared to the input phosphor due to acceleration of the electron beam.

$$\text{Number of photons at output phosphor} : \text{Number of photons at input phosphor}$$

**MINIFICATION GAIN:**

The increase in image brightness due to its concentration at the output phosphor compared to the input phosphor.

$$\text{Input phosphor diameter}^2 / \text{Output phosphor diameter}^2$$

$$\text{TOTAL BRIGHTNESS GAIN} = \text{FLUX GAIN} \times \text{MINIFICATION GAIN}$$

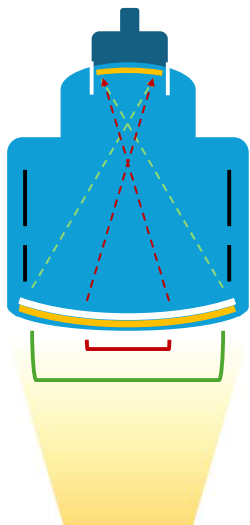
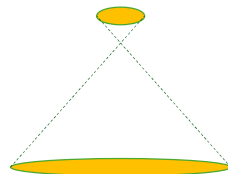


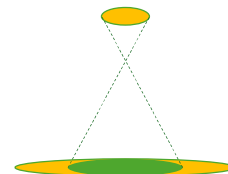
IMAGE INTENSIFIERS **FIELD-OF-VIEW** ADJUSTMENT (ZOOM)

Making the field of view smaller equals zooming-in or **magnifying** the subject; however, this is not digital zoom (**it is not free!**)



**LARGE FOV**

- High minification gain
- High image distortion (why?)
- Low radiation dose



**SMALL FOV**

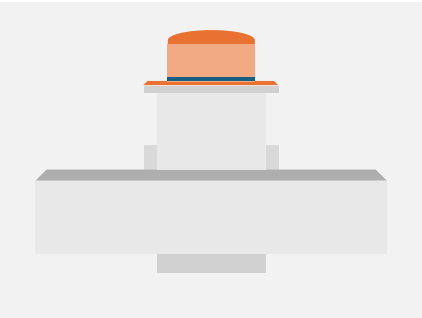
- low minification gain
- low image distortion (why?)
- high radiation dose

Magnification **affects radiation dose** because of the exposure compensation made by **Automatic Brightness Control (ABC)** system



CHAPTER ONE

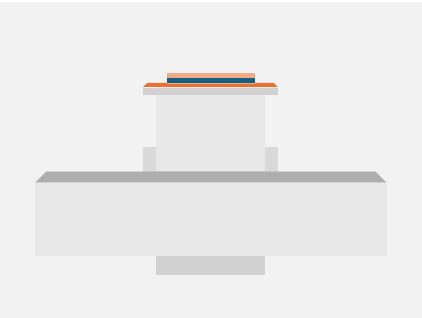
**IMAGE INTENSIFIER (II)**



Conventional **older technology**, but still in use today.

**VS**

**FLAT PANEL DETECTOR (FPD)**



Largely replaced Image Intensifiers, in **most modern machines**

66

CHAPTER ONE

**TECHNOLOGY**  
A solid-state device using an array of photodiodes to **directly** or **indirectly** convert X-rays into electrical charges.

**IMAGE FORMATION**  
X-rays are either directly converted to electrical charges or indirectly converted through a scintillator that emits light, which is then detected by photodiodes.

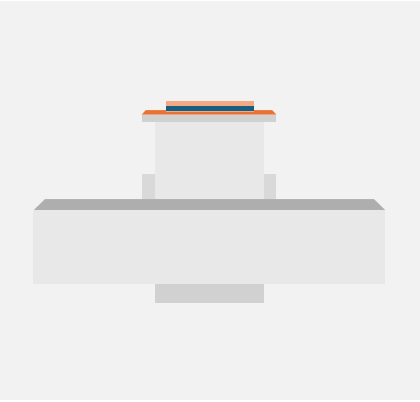
**ADVANTAGES**

- Compact, lightweight, and larger field of view (Square FOV)
- Higher DQE, resulting in lower dose requirements.
- Wider dynamic range, capturing more image detail.
- No image distortion.
- Superior image quality with higher spatial resolution.

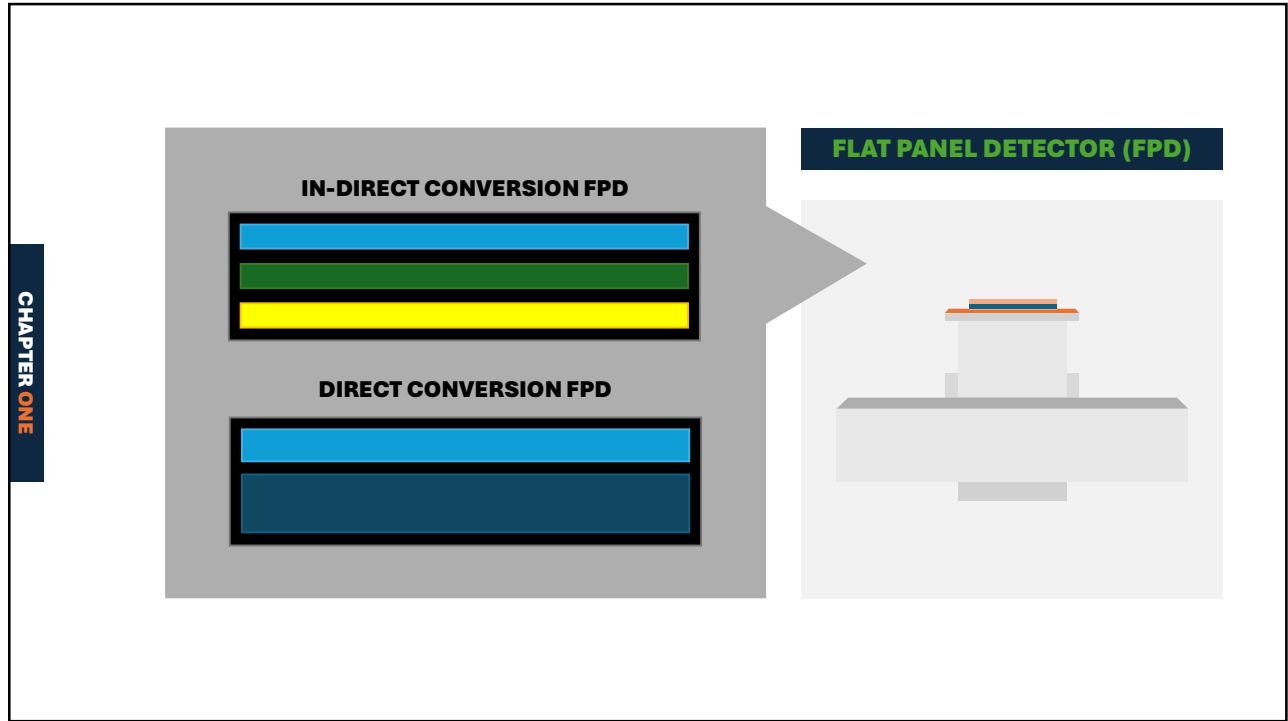
**DISADVANTAGES**  
Higher initial cost compared to image intensifiers and relatively more sensitive to damage from rough handling.

**KEY CHARACTERISTICS**

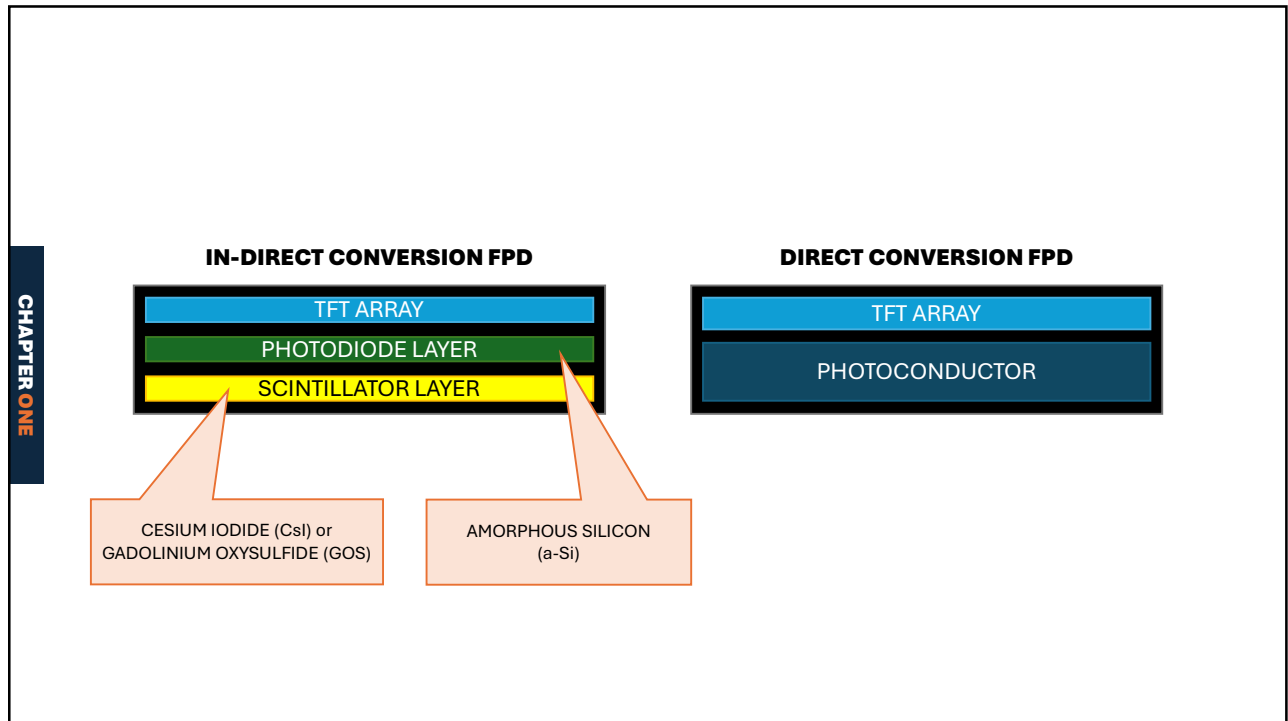
**FLAT PANEL DETECTOR (FPD)**



67



68



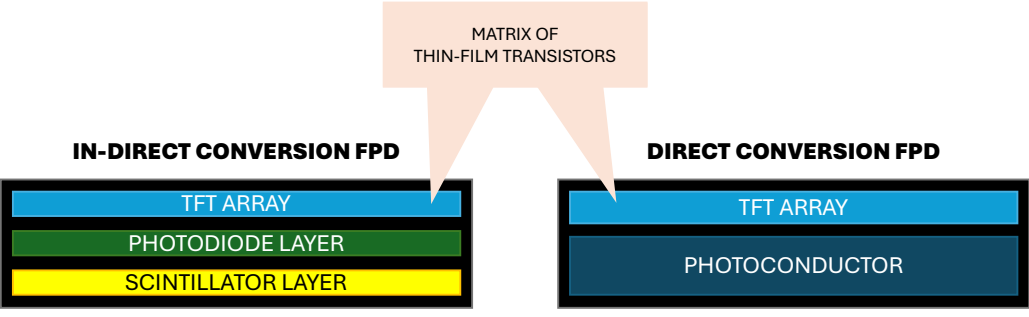
69

CHAPTER ONE

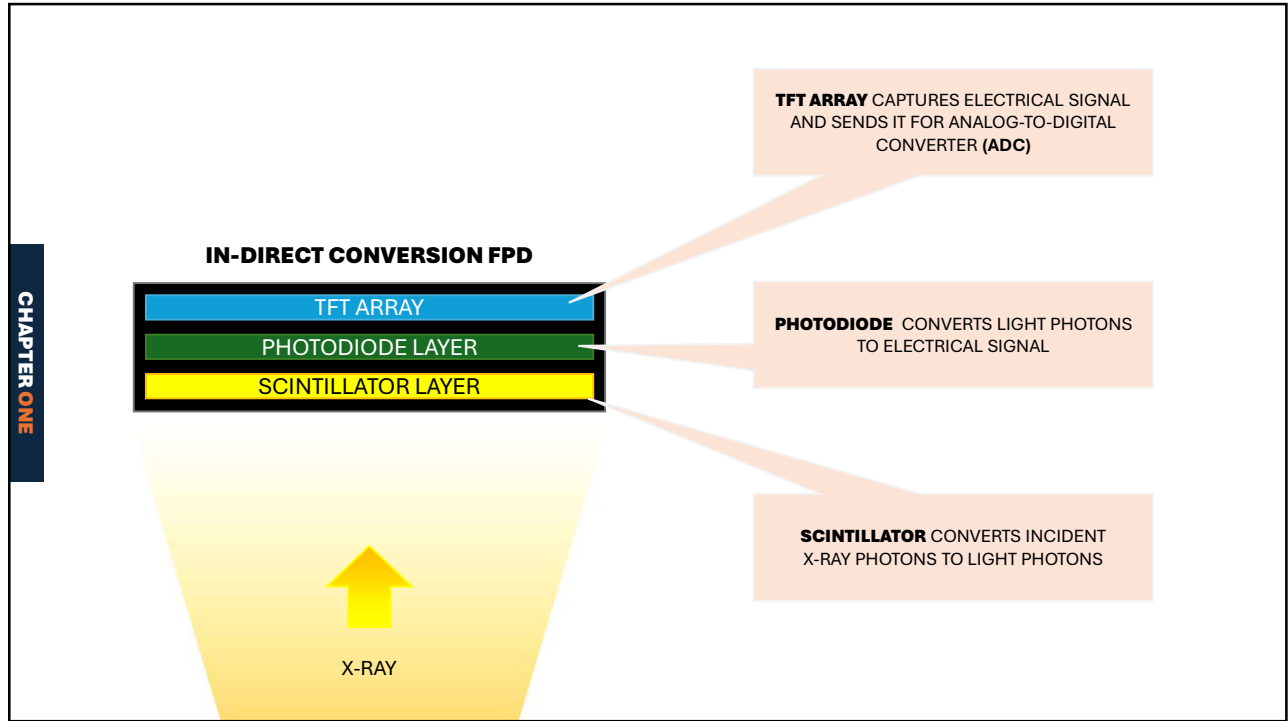


70

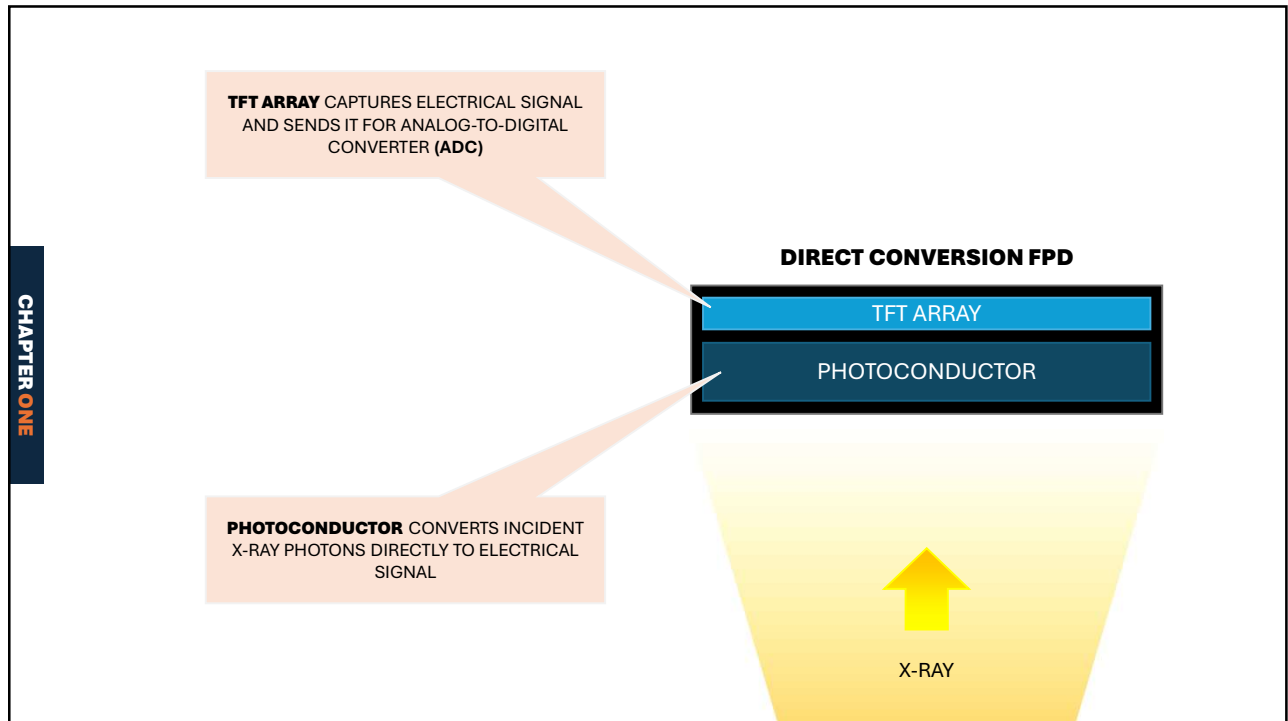
CHAPTER ONE



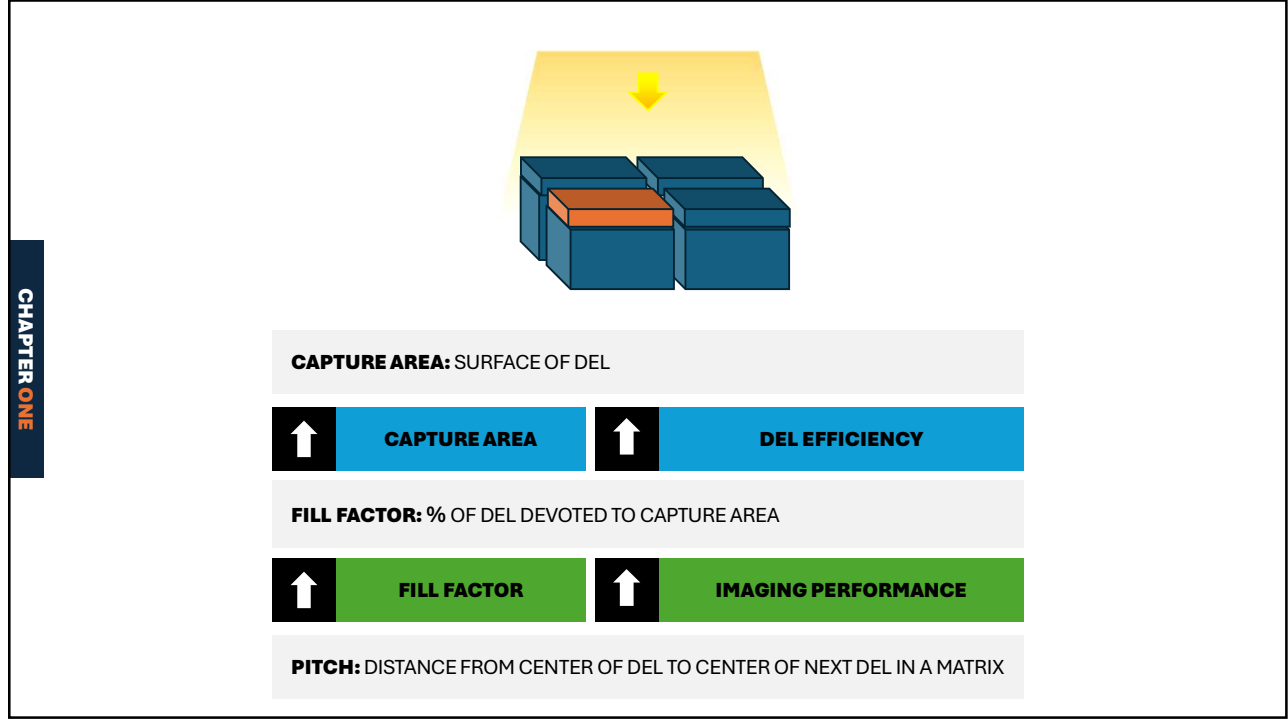
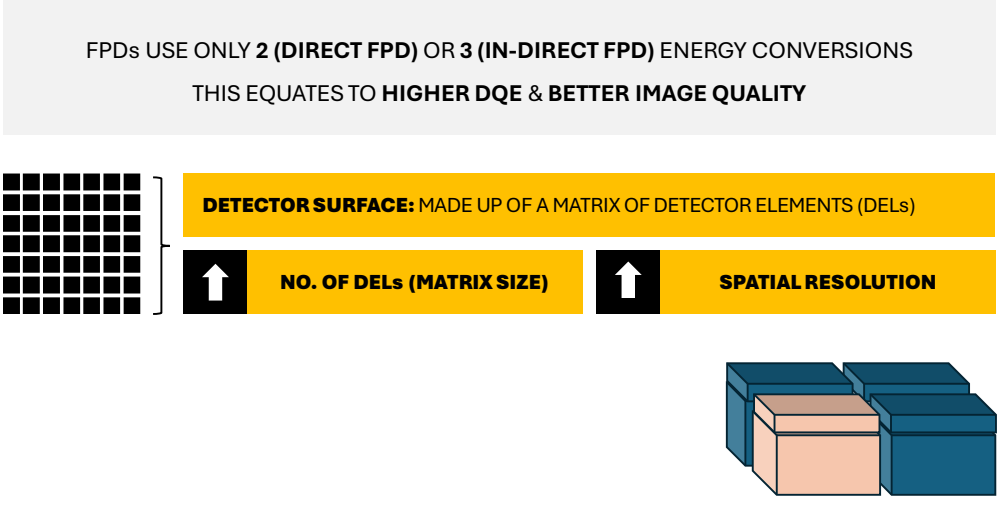
71





72



73



### TYPES OF IMAGE RECEPTORS SUMMARY

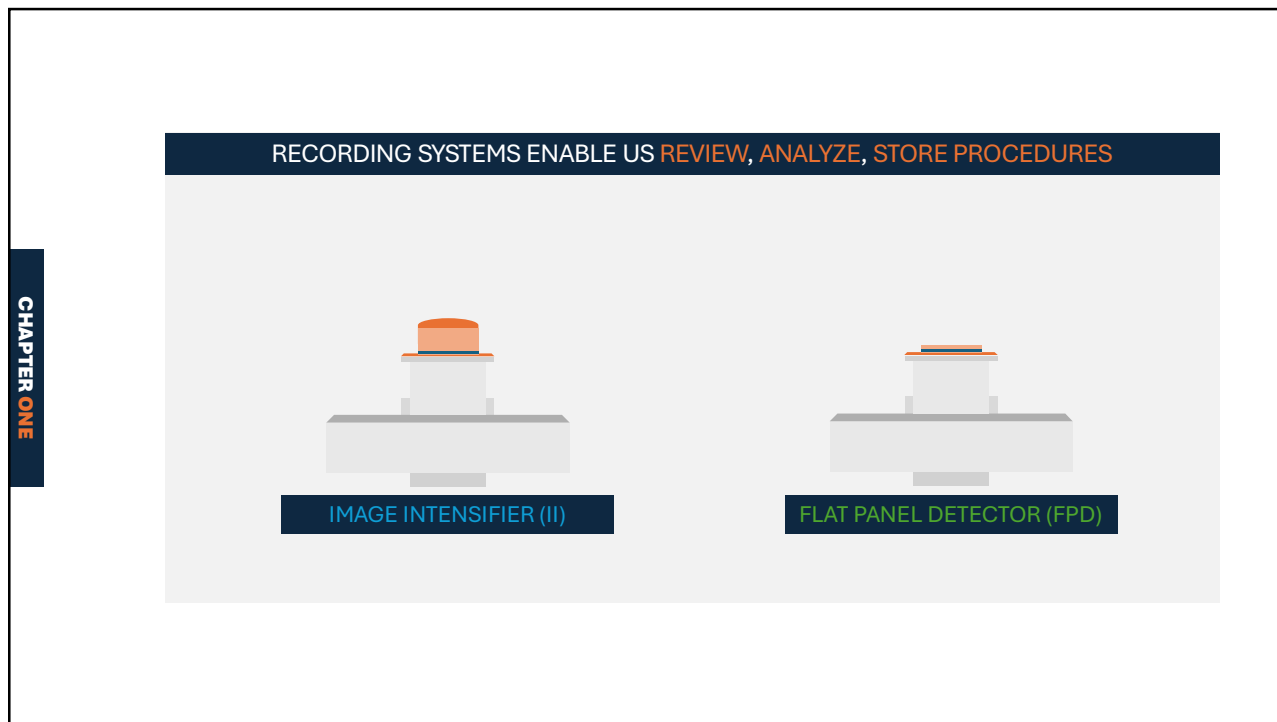
<b>IMAGE INTENSIFIER (II)</b>	VS	<b>FLAT PANEL DETECTOR (FPD)</b>
		
<p>Mature technology with a long history and relatively lower cost compared to FPDs.</p> <p><b>DISADVANTAGES</b></p> <ul style="list-style-type: none"> <li>Bulkier and heavier than FPDs.</li> <li>Image distortion, especially at the periphery.</li> <li>Lower detective quantum efficiency (DQE) leading to higher dose requirements.</li> <li>Limited dynamic range.</li> </ul>		<ul style="list-style-type: none"> <li>Compact, lightweight, and larger field of view (Square FOV)</li> <li>Higher DQE, resulting in lower dose requirements.</li> <li>Wider dynamic range, capturing more image detail.</li> <li>No image distortion.</li> <li>Superior image quality with higher spatial resolution.</li> </ul>

76

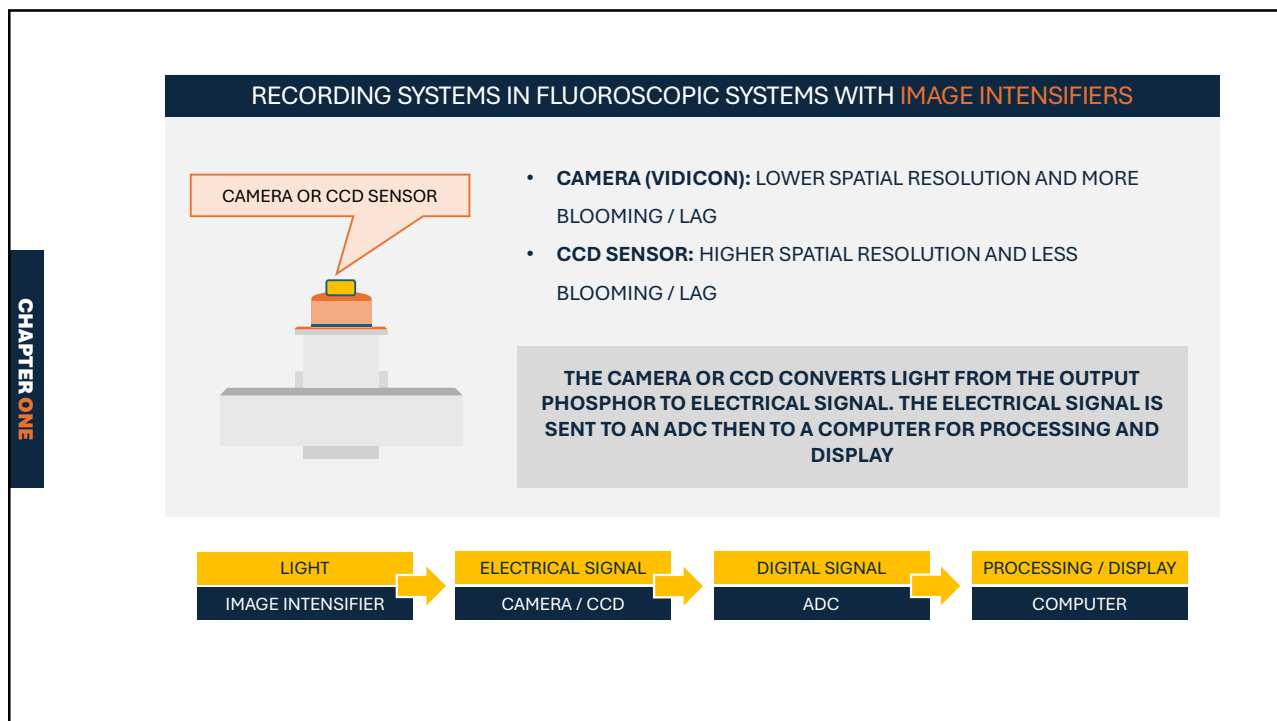
CHAPTER ONE

FLUOROSCOPY RECORDING SYSTEMS

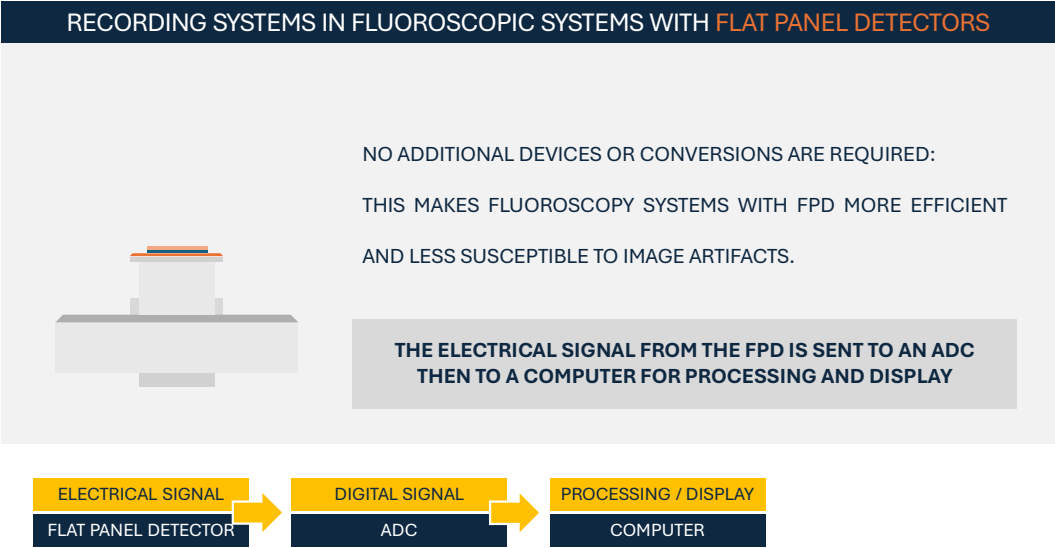
77



78



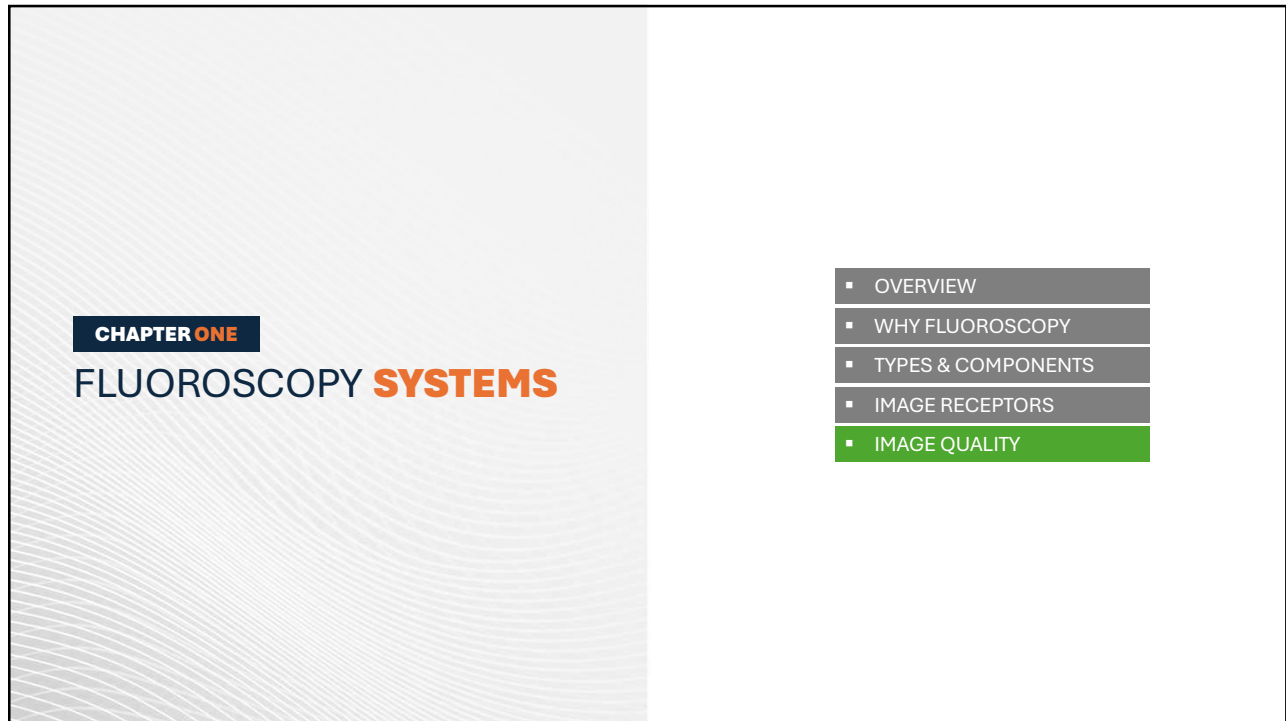
79



**CHAPTER ONE**  
**FLUOROSCOPY SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- IMAGE QUALITY

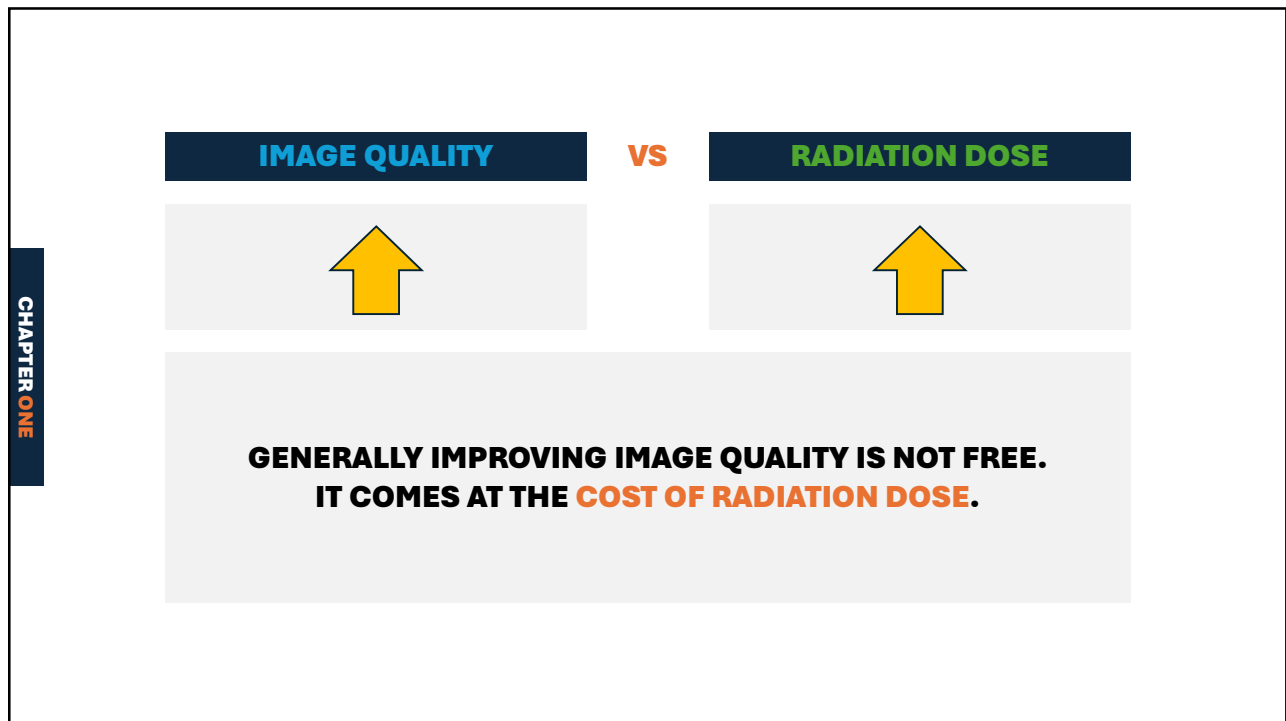




**CHAPTER ONE**  
**FLUOROSCOPY SYSTEMS**

- OVERVIEW
- WHY FLUOROSCOPY
- TYPES & COMPONENTS
- IMAGE RECEPTORS
- **IMAGE QUALITY**

82



**IMAGE QUALITY** VS **RADIATION DOSE**

**CHAPTER ONE**

**GENERALLY IMPROVING IMAGE QUALITY IS NOT FREE.  
IT COMES AT THE COST OF RADIATION DOSE.**

83

<b>CHAPTER ONE</b>	<b>SPATIAL RESOLUTION</b>	IMAGE DETAIL / STRUCTURAL SHARPNESS / SMALLEST VIEWABLE STRUCTURES
	<b>CONTRAST RESOLUTION</b>	VISIBLE DIFFERENCE IN BRIGHTNESS BETWEEN TWO ADJACENT STRUCTURES
	<b>IMAGE DENSITY</b>	GENERAL IMAGE DARKNESS OR BRIGHTNESS
	<b>IMAGE DISTORTION</b>	MISREPRESENTATION OF THE SIZE OR SHAPE OF OBJECTS
	<b>IMAGE ARTIFACTS</b>	UNWANTED FEATURES OF IMPERFECTIONS APPEARING IN THE IMAGE

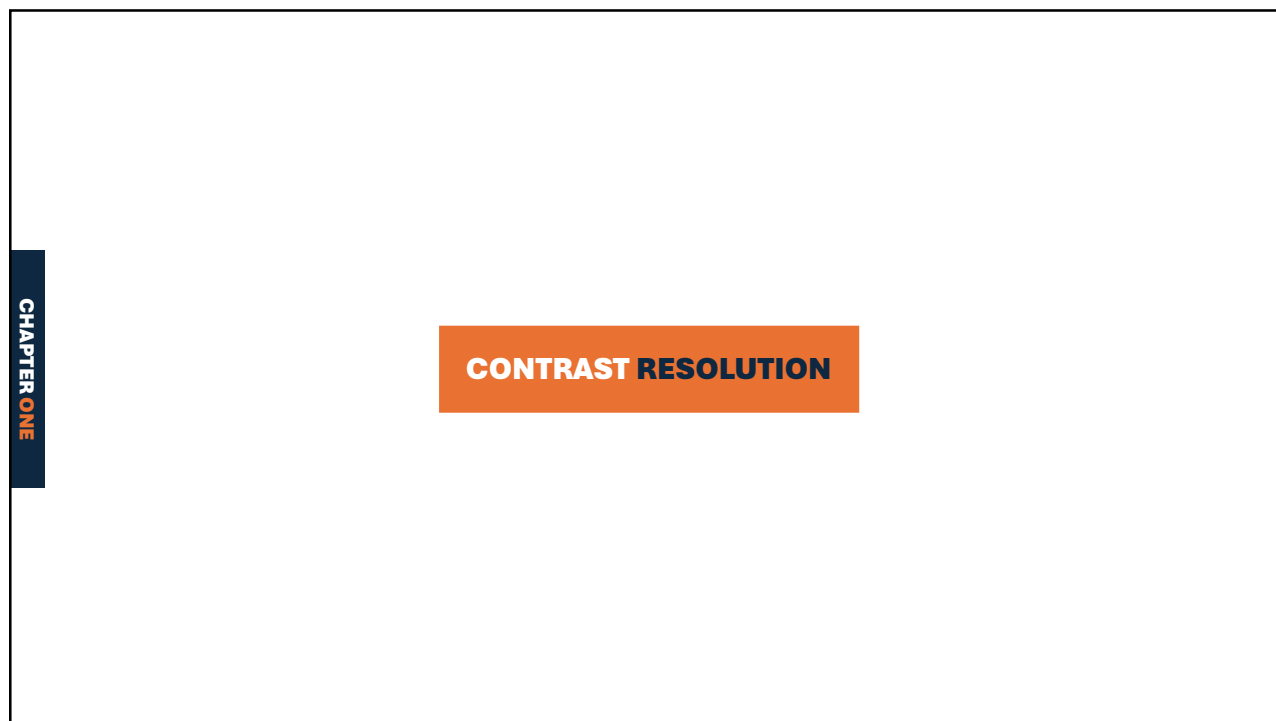
84



85

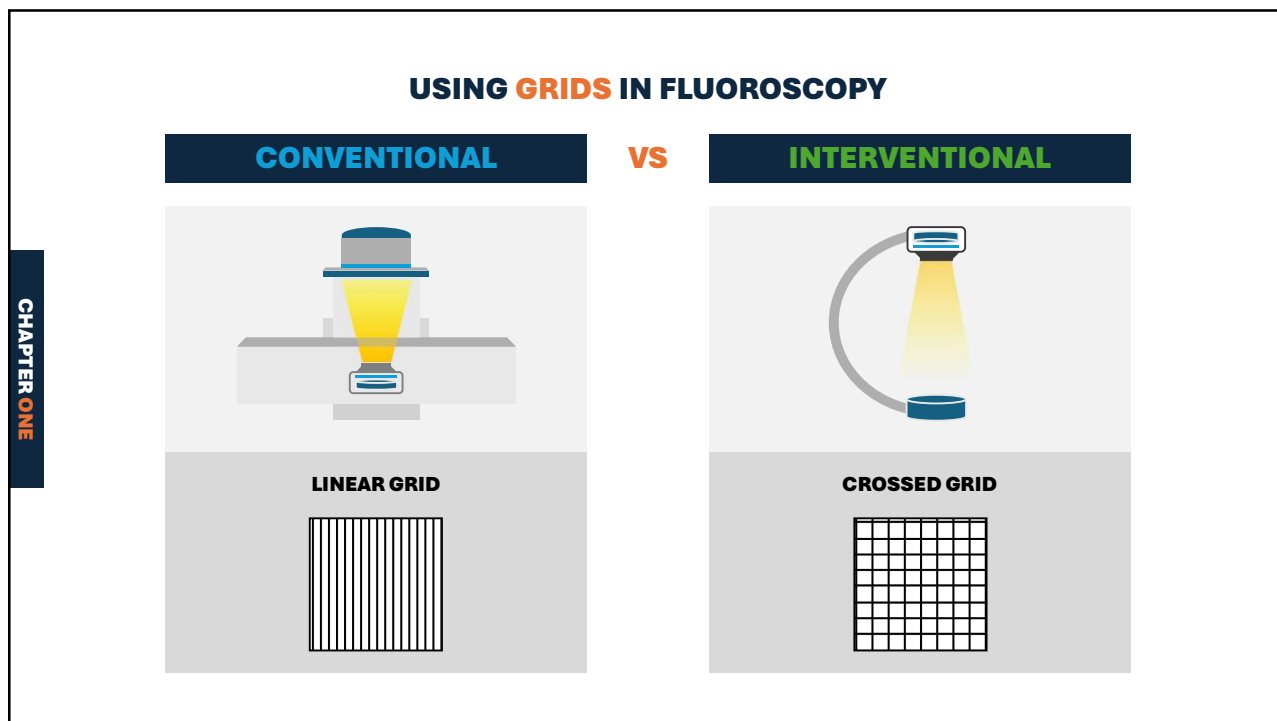
CHAPTER ONE	<b>Focal Spot Size</b>	A smaller focal spot on the X-ray tube reduces geometric blur – but at the cost of increased tube heat
	<b>Object-Image-Distance</b>	Decreasing the distance between the patient and the image receptor minimizes magnification and blur.
	<b>Source-Image-Distance</b>	Increasing the distance between the X-ray source and the image receptor can improve resolution - but often at the cost of increased dose.
	<b>Image Receptor</b>	Flat panel detectors with smaller pixel size offer better spatial resolution than image intensifiers.
	<b>Motion</b>	Patient or equipment motion blur can significantly degrade resolution.
	<b>Scatter Radiation</b>	Scatter radiation blurs the image, so using grids and collimation helps.

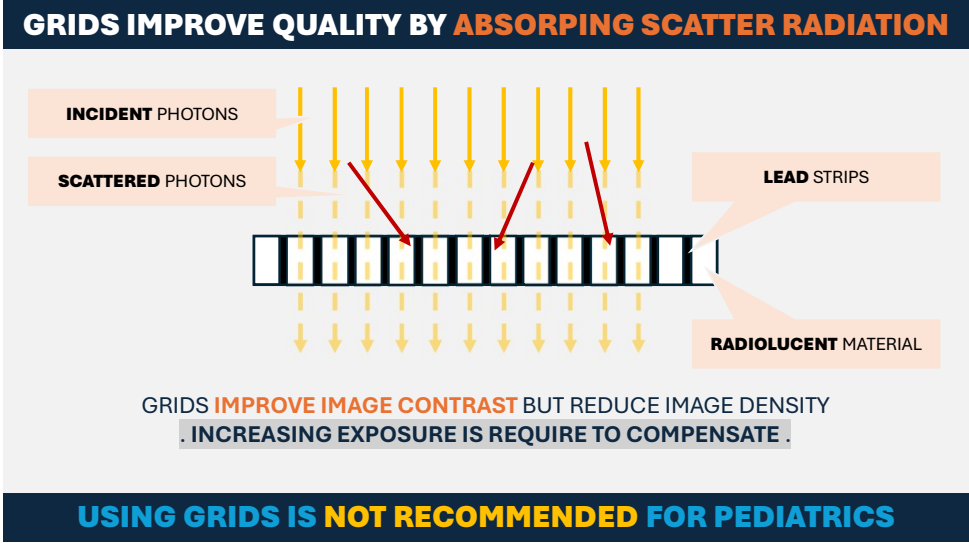
86



87

<b>kVp</b>	Using the appropriate kVp for the body part and exam ensures adequate penetration and differentiation of tissues.
<b>Scatter Radiation</b>	Scatter reduces contrast by adding a "fog" to the image. Grids, collimation, and air gaps help.
<b>Image Receptor</b>	FPDs generally offer better contrast resolution due to their wider dynamic range.
<b>Image Processing</b>	Digital image processing techniques can enhance contrast.
<b>Contrast Media</b>	Contrast media enhances subject contrast and improves image contrast as a result





**IMAGE DENSITY**

CHAPTER ONE	<b>kVp</b>	Higher kVp increases the energy of X-rays, making them more penetrating and resulting in higher image density – at the cost of lower contrast res.
	<b>mA</b>	mA controls the number of X-ray photons produced, and higher mA results in a higher image density. – at the cost of radiation dose
	<b>Exposure Time or Pulse Width</b>	Longer exposure time allows more X-rays to reach the detector, increasing image density – at the cost of radiation dose and potential motion blur
	<b>Contrast Media</b>	Adding contrast media increases incident photon absorption and reduces image density
	<b>Subject Size</b>	Larger or denser subjects increase incident photon and reduce image density

92



93

### ABC ADJUSTS EXPOSURE FACTORS TO COMPENSATE FOR:

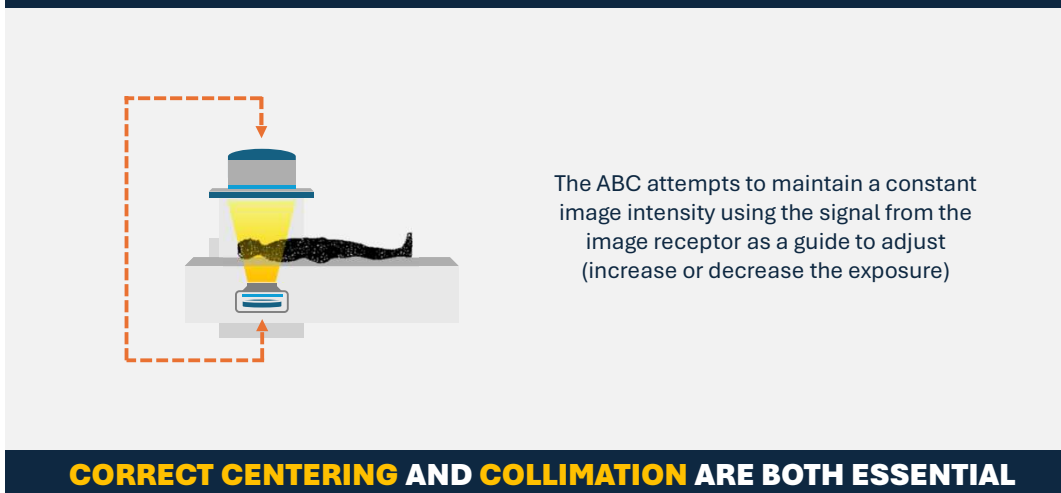
- VARIATIONS IN ATTENUATION DUE TO **THICKNESS / DENSITY OR CONTRAST MEDIA**
- VARIATIONS IN **DISTANCE**



The ABC adjusts the exposure (kVp & mA) to compensate for **changing the position of the image receptor** over the patient (or the patient position on the table) or for changing the Object-Image-Distance OID

94

### ABC USES A FEEDBACK LOOP TO ADJUST THE EXPOSURE IN REAL-TIME



The ABC attempts to maintain a constant image intensity using the signal from the image receptor as a guide to adjust (increase or decrease the exposure)

**CORRECT CENTERING AND COLLIMATION ARE BOTH ESSENTIAL**

95

## IMAGE QUALITY ISSUES WITH IMAGE INTENSIFIERS

96

### IMAGE INTENSIFIER (II) TECHNOLOGY HAS SOME INHERENT FLAWS



- **Vignetting:** decrease image brightness around the edges
- **Pincushioning:** image appears curved or bent inwards toward the center
- **S-shape distortion:** image appears curved or bent
- **Blooming:** image white-out (intense over-exposure)
- **Veiling glare:** a type of blooming that shows up as contrast-reducing haze

MANY CAUSED BY THE **CURVED DESIGN OF THE INPUT-PHOSPHOR AND PHOTO-CATHODE**

97



<b>VIGNETTING</b>	<b>PINCUSHION</b>	<b>S-SHAPE</b>
Reduced image quality near the edges	Image appear curved inwards	Image appear curved of bent
<b>BLOOMING</b>	<b>VEILING GLARE</b>	
Image white-out	Contrast reducing haze	

98

<b>VIGNETTING</b>	<b>PINCUSHION</b>	<b>S-SHAPE</b>
Reduced image quality near the edges	Image appear curved inwards	Image appear curved of bent
Caused by curved input-phosphor	Caused by curved input-phosphor and external magnetic fields	Caused by external magnetic fields or beam mis-angulation
Can be corrected with image processing or reducing OID	Can be corrected with image processing	Can be corrected with image processing
<b>BLOOMING</b>	<b>VEILING GLARE</b>	<b>Lag:</b> delay in response time of the II to changes in beam intensity
Image white-out	Contrast reducing haze	Can be corrected with frame averaging
High energy photons striking input-phosphor	Caused by scattering of x-ray, light, or electrons inside II	<b>Image Noise:</b> grainy image appearance
Can be corrected with better positioning / centering and collimation	Can be corrected with grids and collimation	Can be corrected with increasing exposure or reducing SID

99

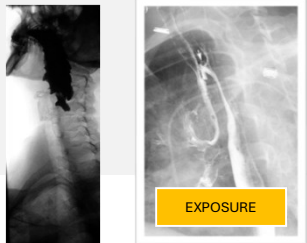
**SPOT IMAGING / LAST IMAGE HOLD**

100

**SPOT IMAGING**

A static fluorograph made during a fluoroscopic examination to record the subject

- AN ADDITIONAL SEPARATE EXPOSURE
- HIGHER IMAGE QUALITY
- HIGHER EXPOSURE (DOSE!)

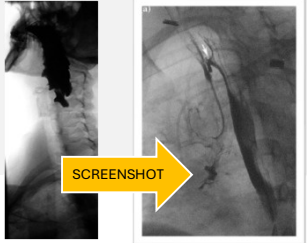


VS

**LAST IMAGE HOLD (LIH)**

A still image captured during a fluoroscopic examination without impacting patient dose

- A SCREEN-SHOT OF THE FLUORO IMAGE
- NO ADDITIONAL DOSE



101

A graphic divided into two vertical panels. The left panel has a light gray background with a wavy pattern and contains the text 'CHAPTER ONE' in a dark blue box and 'FLUOROSCOPY SYSTEMS' in blue and orange. The right panel is white and contains a green checkmark inside a light gray circle, with the text 'CHAPTER COMPLETED' below it.

**CHAPTER ONE**  
FLUOROSCOPY **SYSTEMS**

**CHAPTER**  
COMPLETED

102