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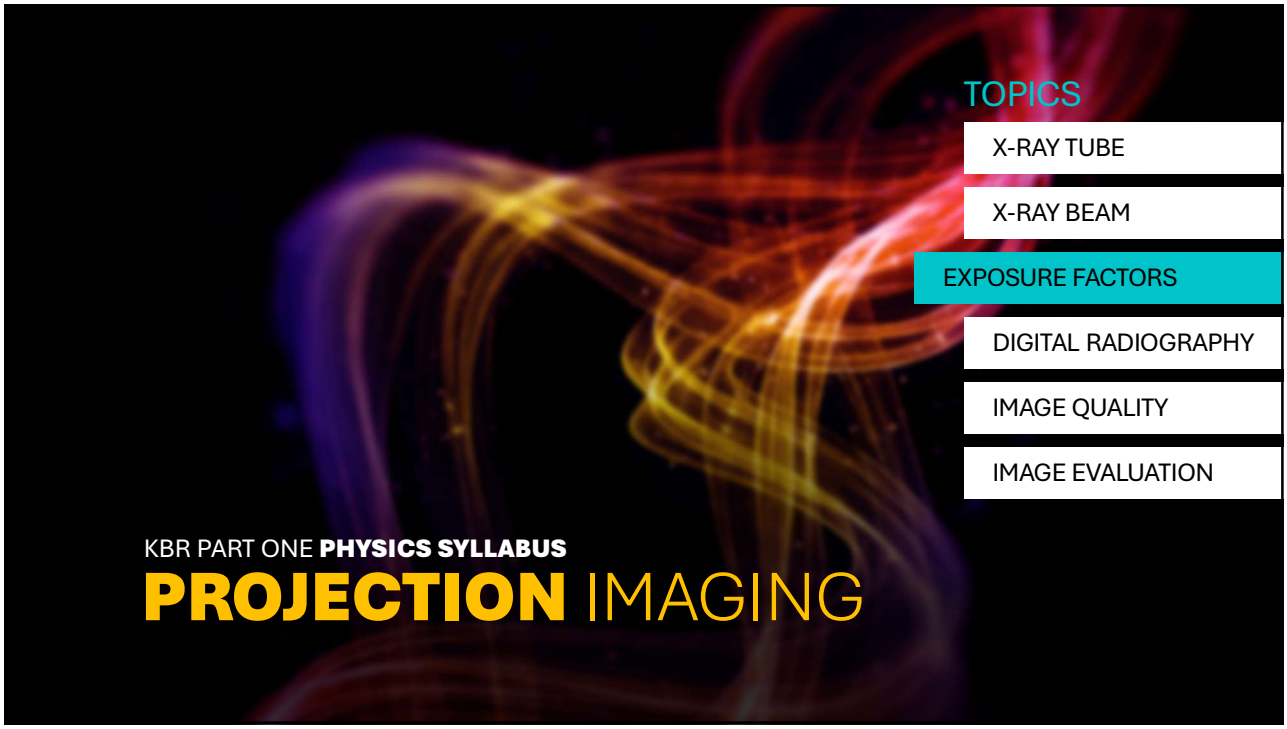
HAMAD DARWISH
KBR PART ONE PHYSICS SYLLABUS
PROJECTION IMAGING

75


TOPICS
X-RAY TUBE
X-RAY BEAM
EXPOSURE FACTORS
DIGITAL RADIOGRAPHY
IMAGE QUALITY
IMAGE EVALUATION
KBR PART ONE PHYSICS SYLLABUS
PROJECTION IMAGING

76


TOPICS
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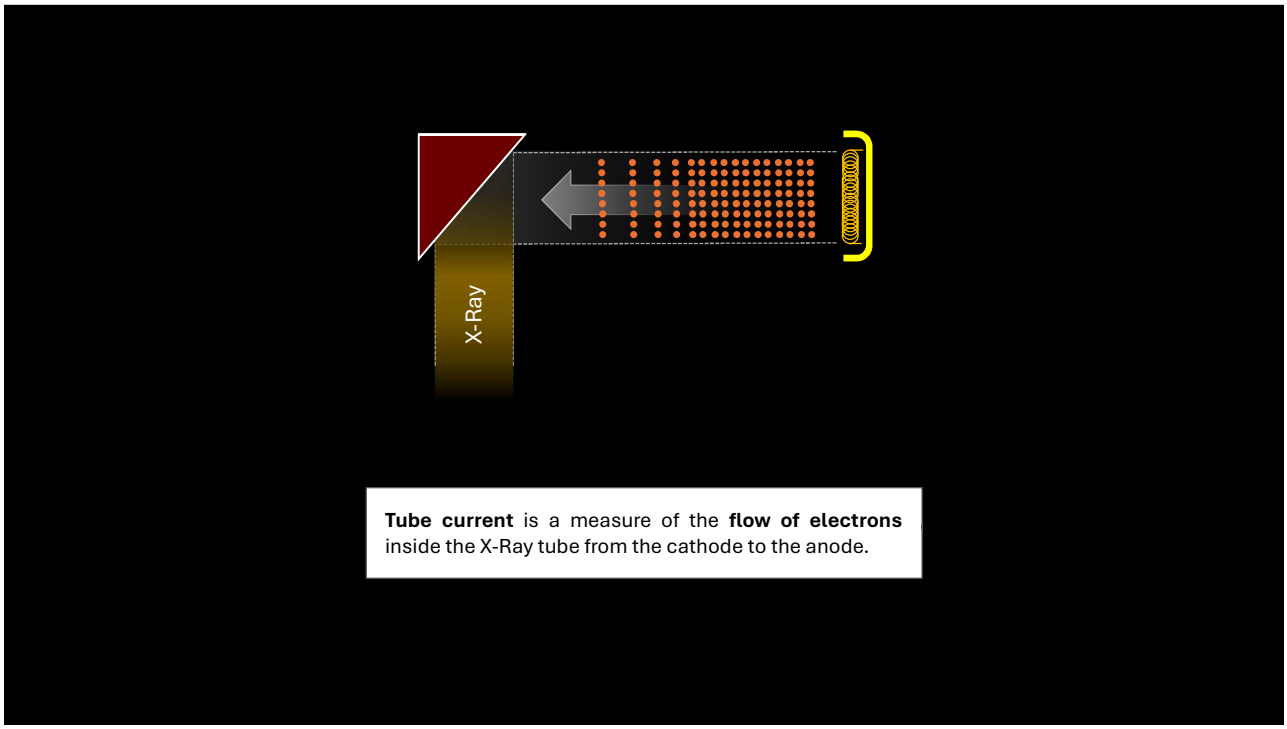
77

78

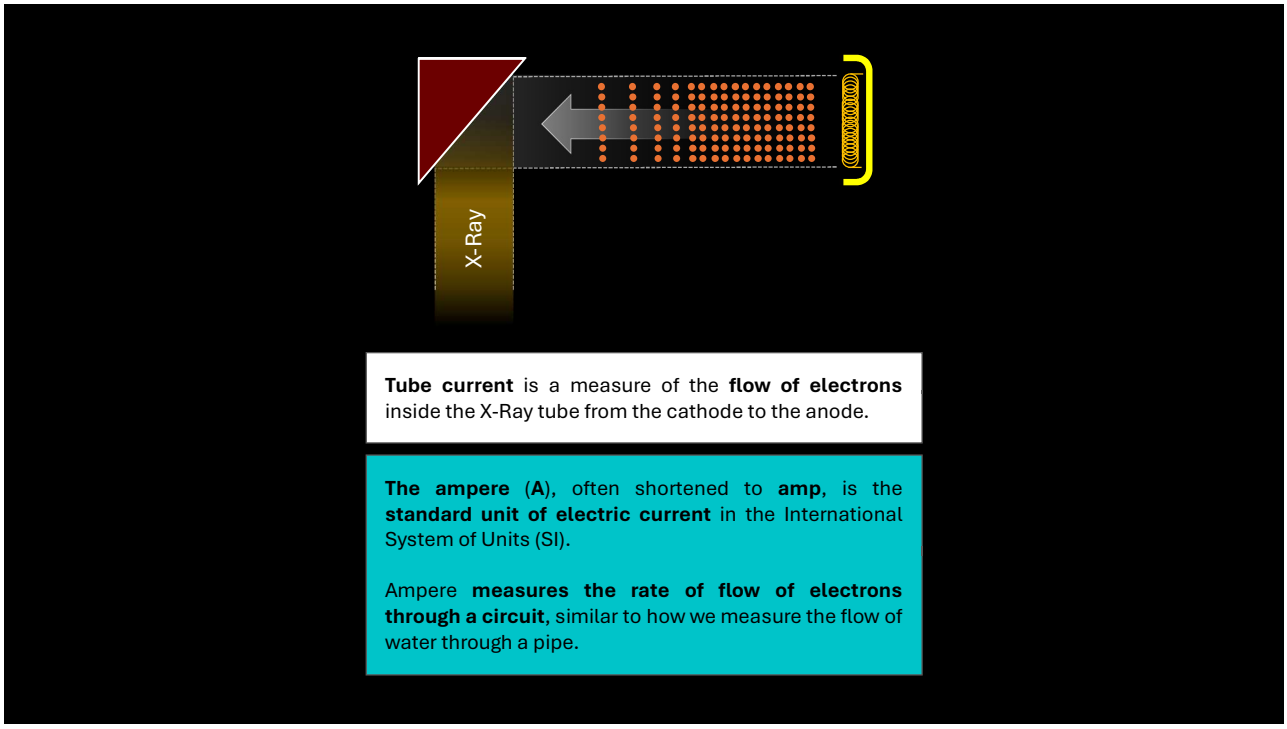
MILLIAMPERAGE

m A

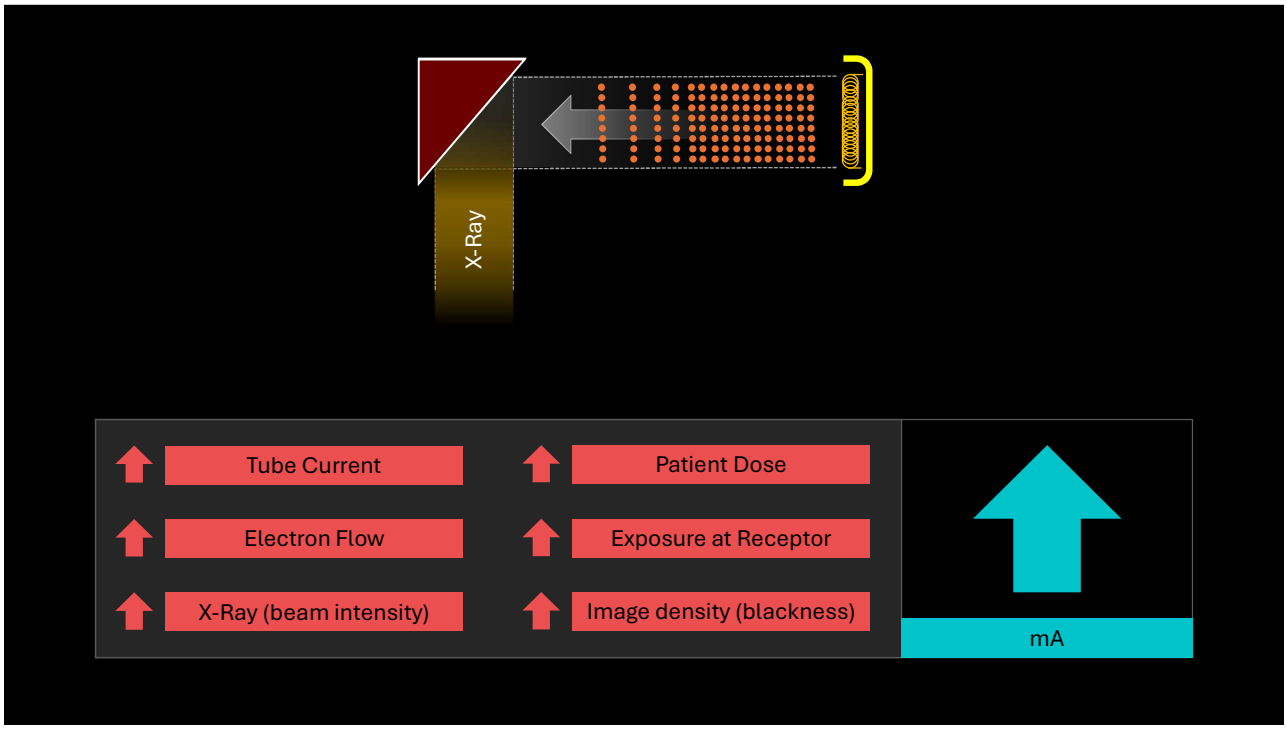
79


X-Ray
Tube current is a measure of the **flow of electrons** inside the X-Ray tube from the cathode to the anode.

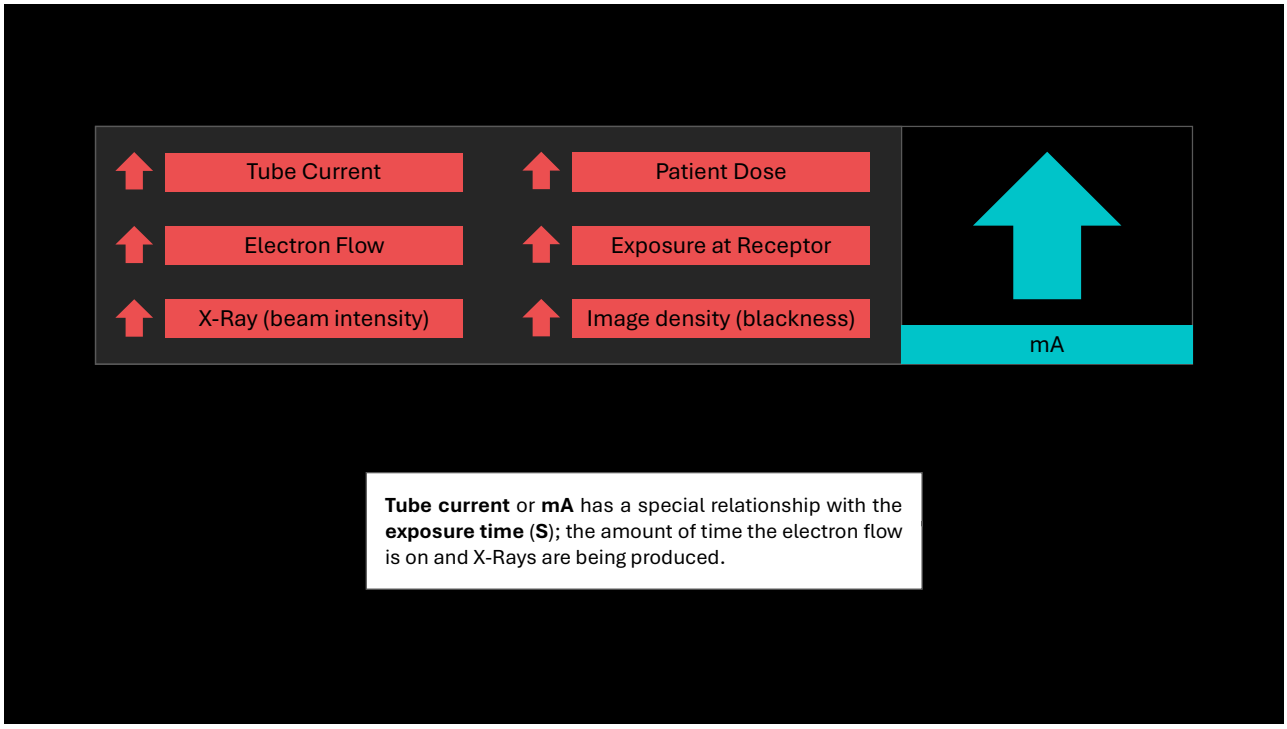
80


X-Ray
Tube current is a measure of the **flow of electrons** inside the X-Ray tube from the cathode to the anode.
The ampere (**A**), often shortened to **amp**, is the **standard unit of electric current** in the International System of Units (SI).
Ampere **measures the rate of flow of electrons through a circuit**, similar to how we measure the flow of water through a pipe.

81


X-Ray
Tube Current
Electron Flow
X-Ray (beam intensity)
Patient Dose
Exposure at Receptor
Image density (blackness)
mA

82

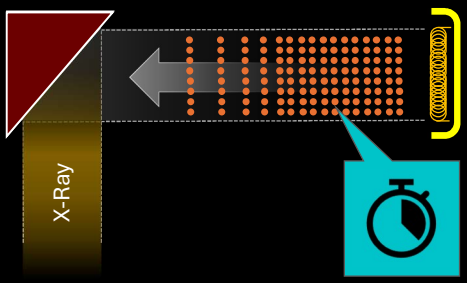

Tube Current
Electron Flow
X-Ray (beam intensity)
Patient Dose
Exposure at Receptor
Image density (blackness)
mA
Tube current or **mA** has a special relationship with the **exposure time** (**S**); the amount of time the electron flow is on and X-Rays are being produced.

83

EXPOSURE TIME

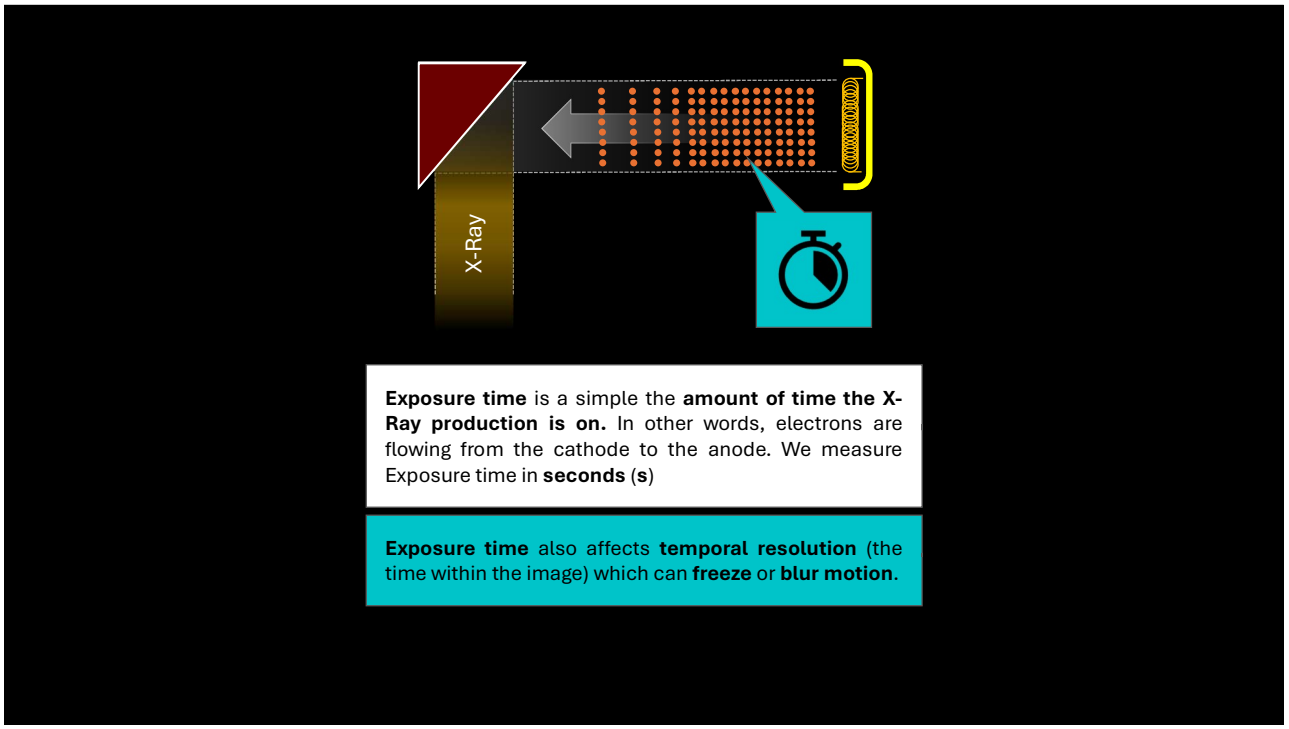
s

84

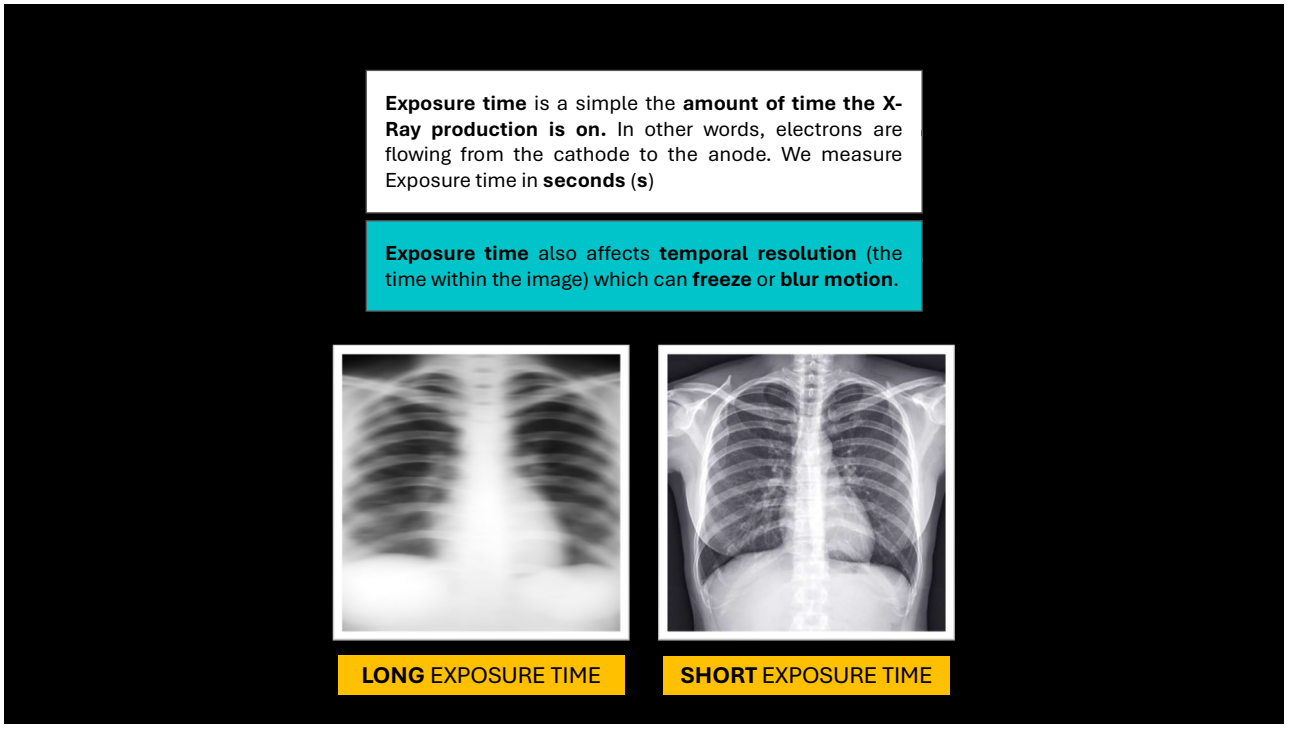


Exposure time is a simple the **amount of time the X-Ray production is on.** In other words, electrons are flowing from the cathode to the anode. We measure Exposure time in **seconds** (**s**)

85


X-Ray
Exposure time is a simple the **amount of time the X-Ray production is on.** In other words, electrons are flowing from the cathode to the anode. We measure Exposure time in **seconds** (**s**)
Exposure time also affects **temporal resolution** (the time within the image) which can **freeze** or **blur motion**.

86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LONG EXPOSURE TIME
SHORT EXPOSURE TIME

87

Exposure Time

is the only exposure factor that can affect temporal resolution.

Exposure time is a simple the **amount of time the X-Ray production is on.** In other words, electrons are flowing from the cathode to the anode. We measure Exposure time in **seconds** (**s**)

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88

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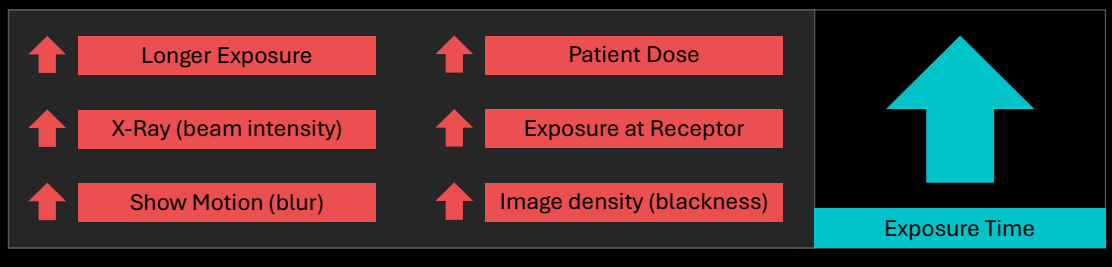
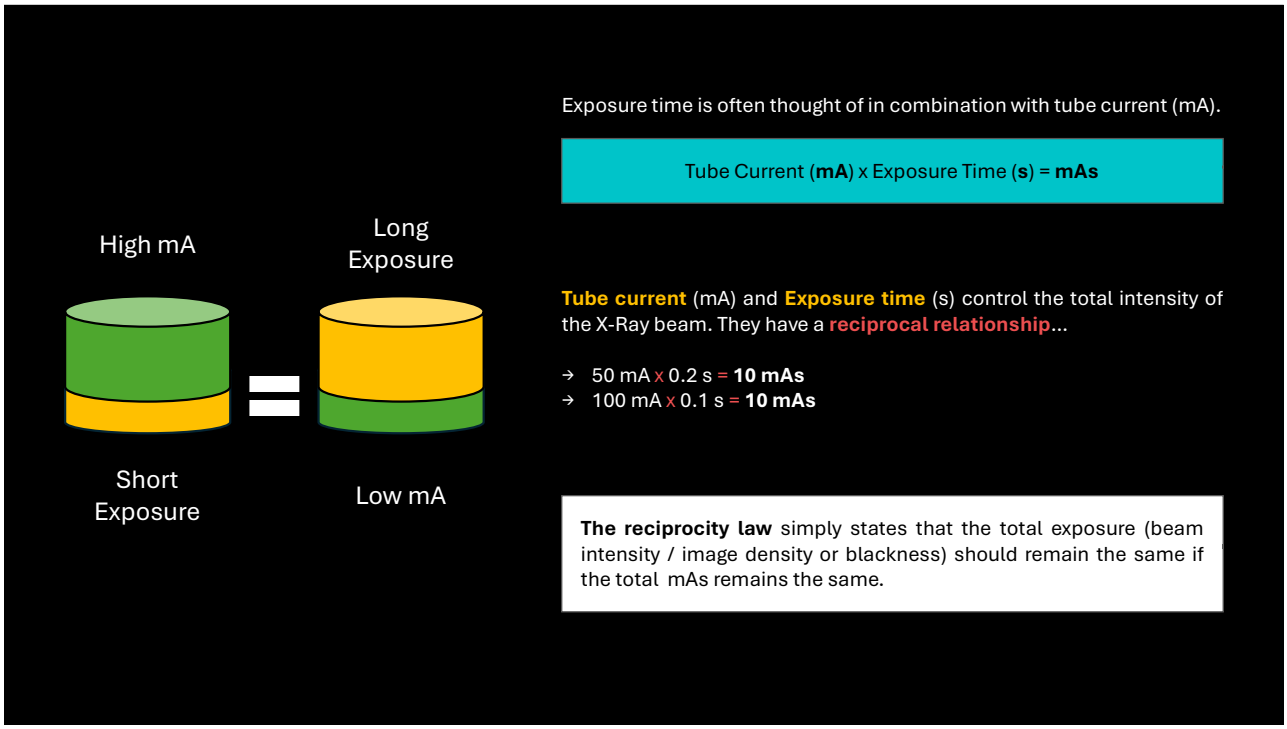
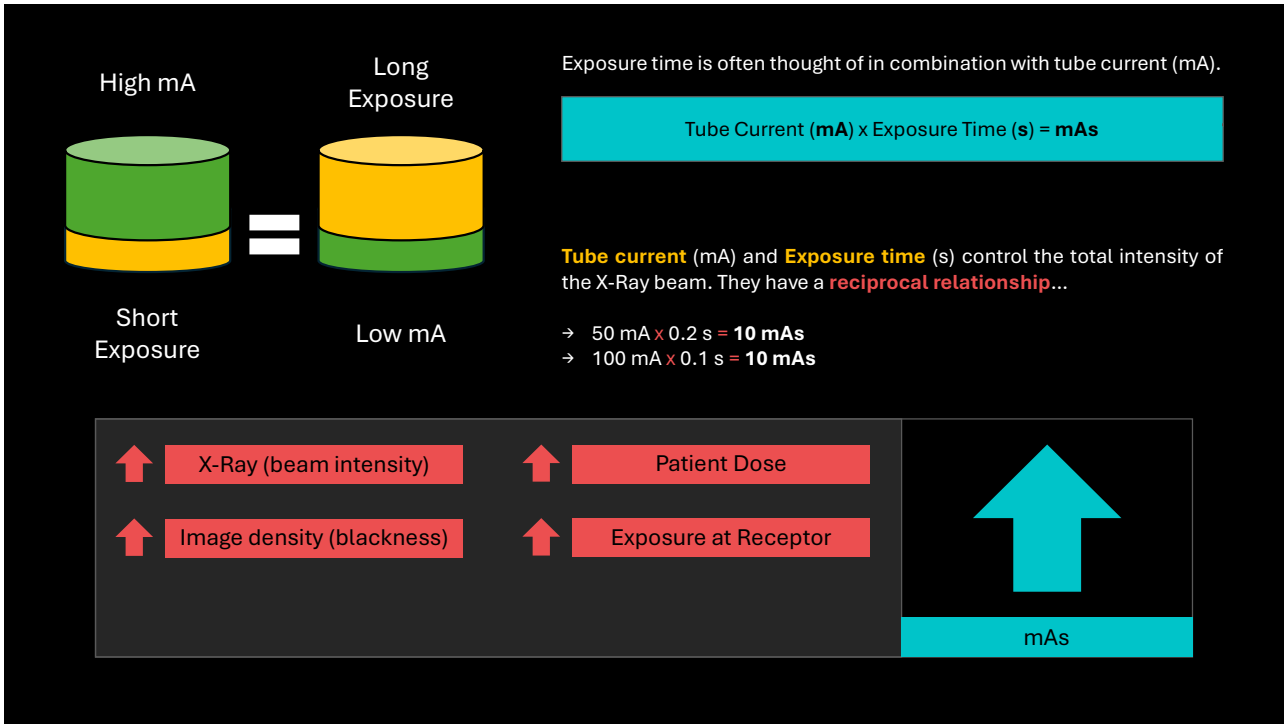


89


High mA
Long Exposure
Short Exposure
Low mA
Exposure time is often thought of in combination with tube current (mA).
Tube Current (mA) x Exposure Time (s) = mAs
Tube current (mA) and Exposure time (s) control the total intensity of the X-Ray beam. They have a reciprocal relationship...
→ 50 mA x 0.2 s = 10 mAs
→ 100 mA x 0.1 s = 10 mAs
The reciprocity law simply states that the total exposure (beam intensity / image density or blackness) should remain the same if the total mAs remains the same.

90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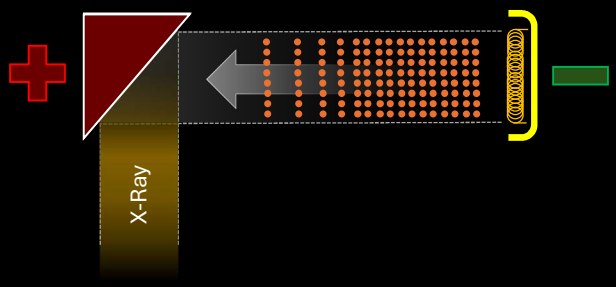
X-Ray (beam intensity)
Patient Dose
Image density (blackness)
Exposure at Receptor
mAs

91

KILOVOLTAGE PEAK

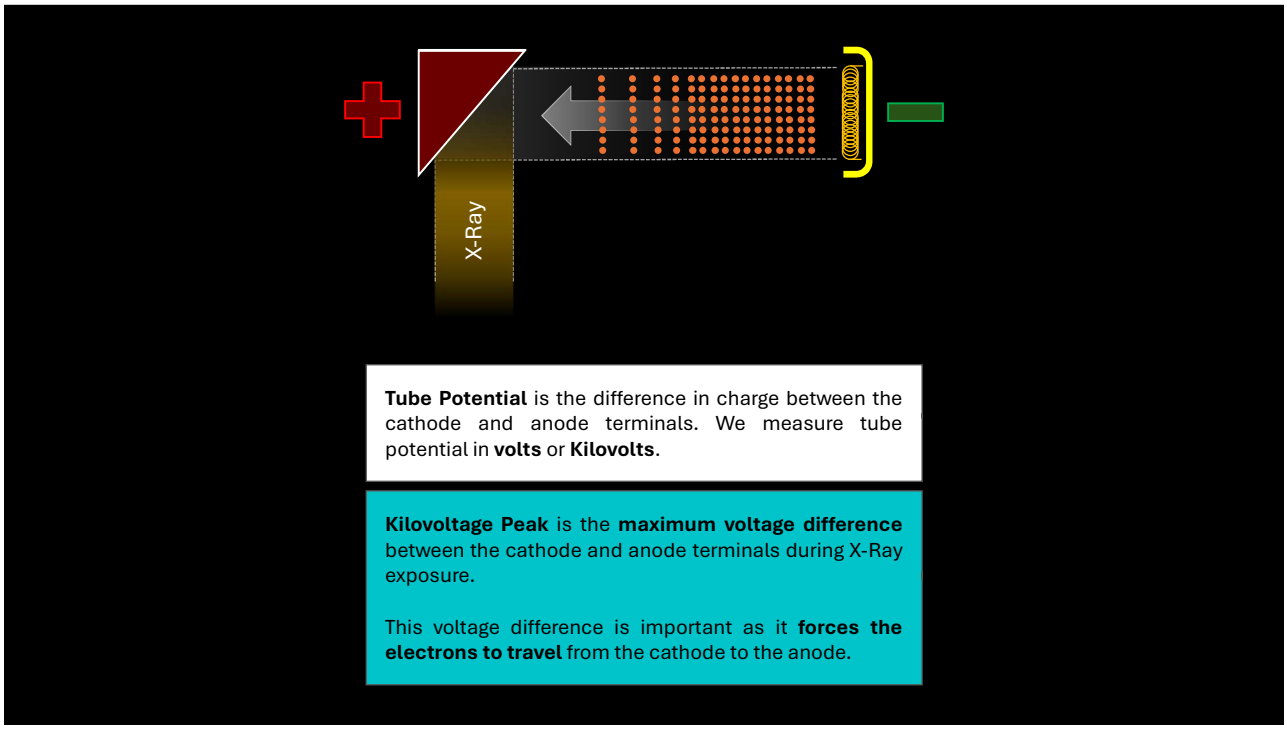
k V p

92



Tube Potential is the difference in charge between the cathode and anode terminals. We measure tube potential in **volts** or **Kilovolts**.

93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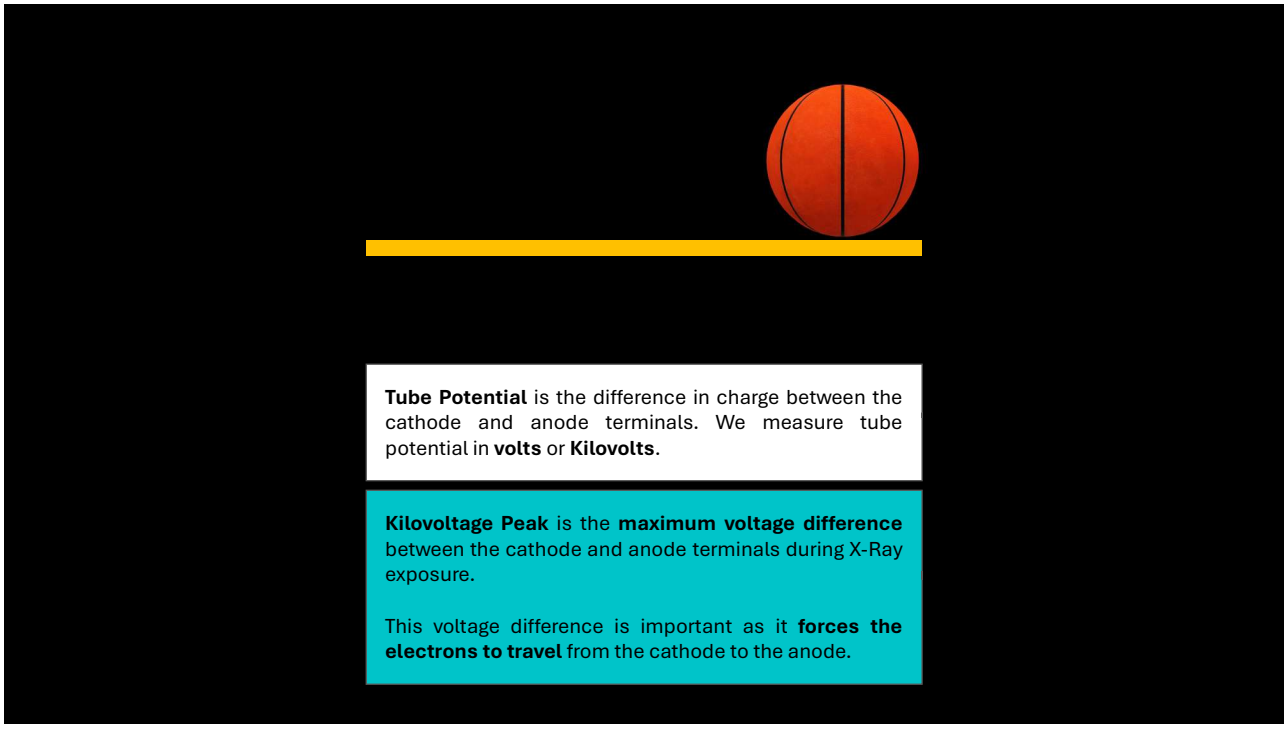
This voltage difference is important as it **forces the electrons to travel** from the cathode to the anode.

94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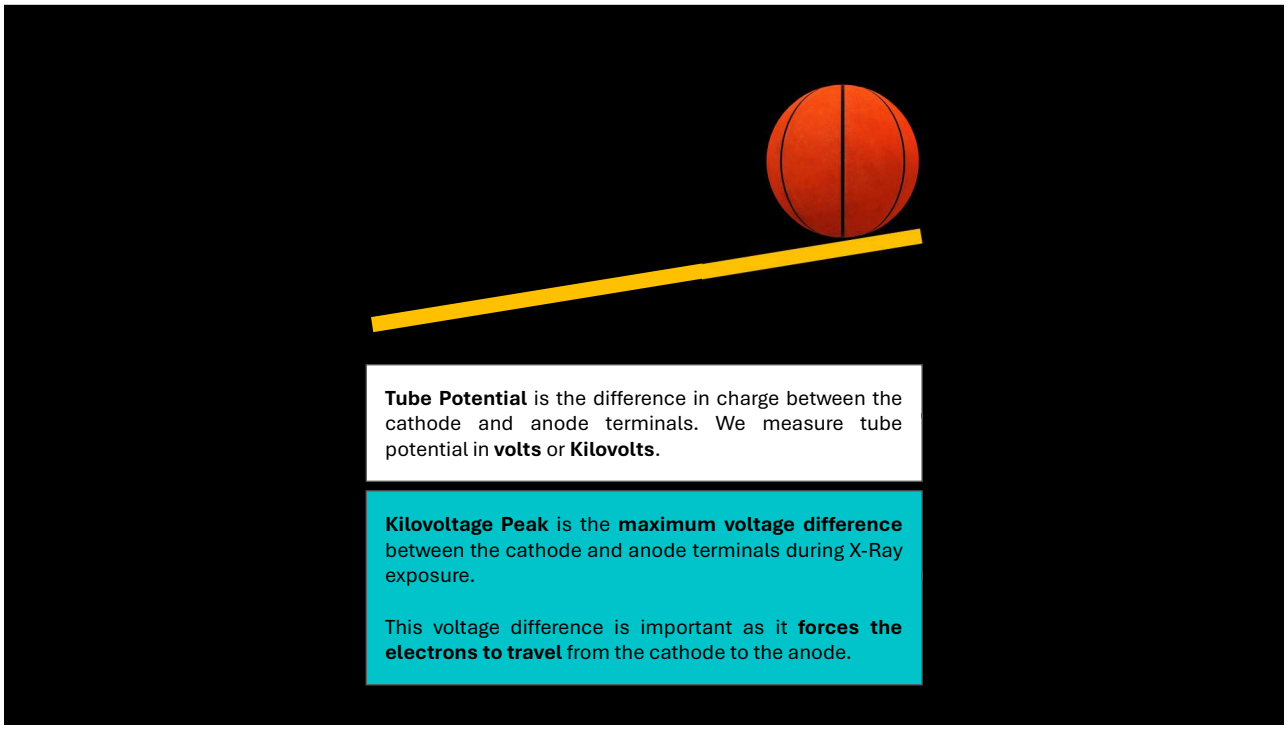
95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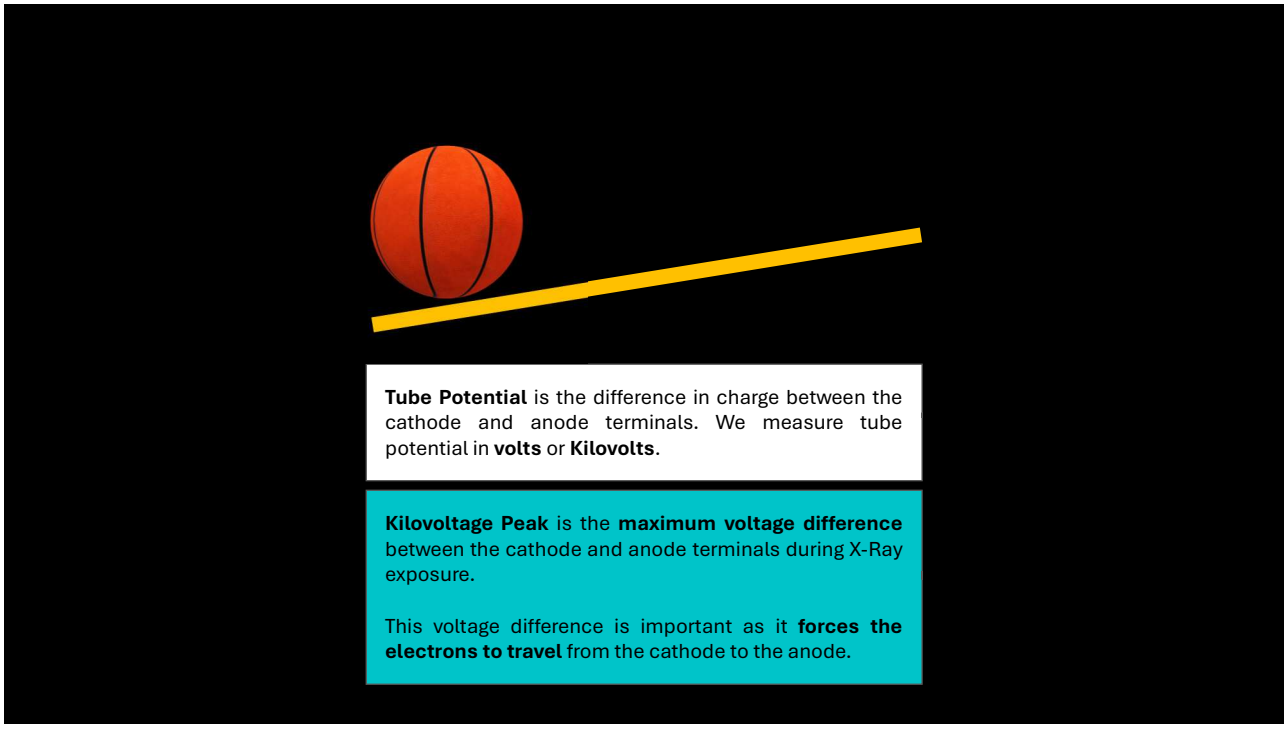
96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97

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Tube potential affects the **energy of the electrons** traveling from the cathode striking the anode target. Therefore; it affects also the **energy of the X-Ray beam** produced (**Beam Quality**) increasing the **penetration ability of the X-Ray beam**.

But it also affects **beam intensity** (**Beam Quantity**) as higher energy electrons will produce a **higher percentage of X-Ray photons** when striking the anode target.

98

kVp

is the only exposure factor that can change the energy of the X-Ray beam (Beam Quality)

kVp can affect both **beam quality** and **beam quantity**. its effect on the exposure is described in the 15% rule. **The 15 percent rule** simply states that in increase in kVp by 15% will double the total exposure (similar to doubling the mAs)

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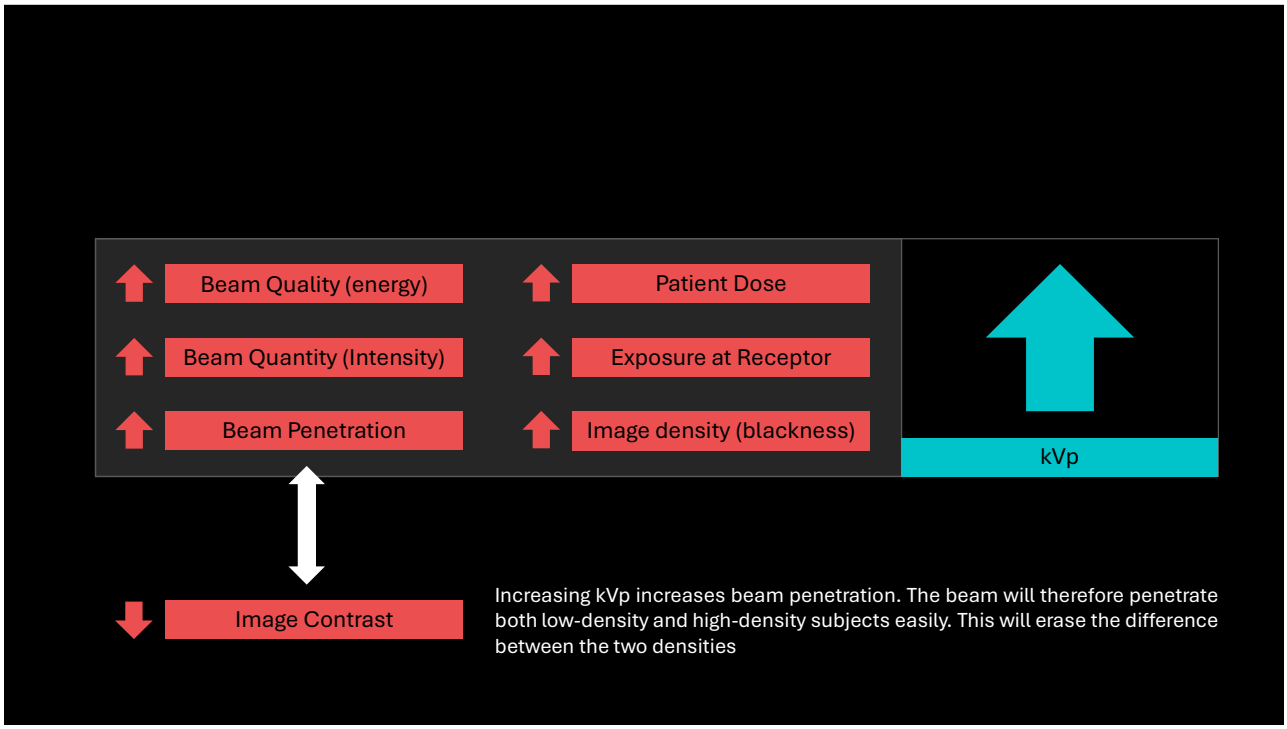
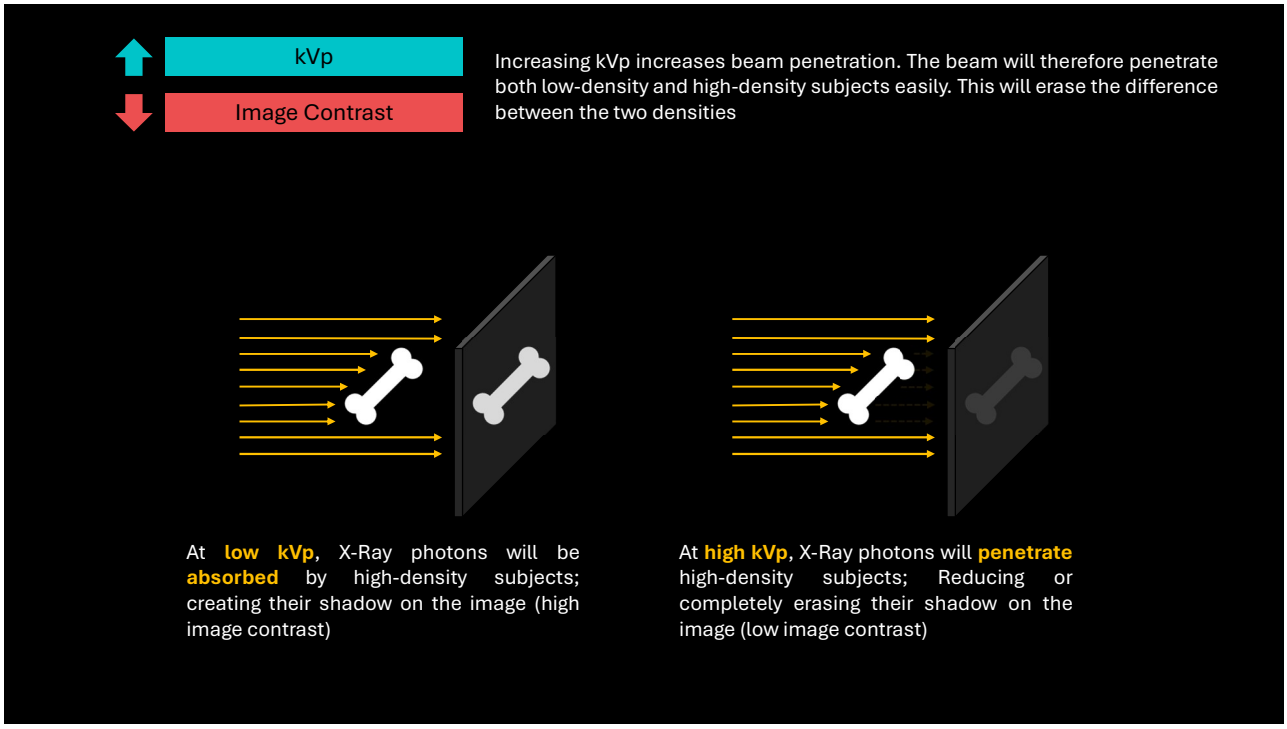
99


Beam Quality (energy)
Beam Quantity (Intensity)
Beam Penetration
Patient Dose
Exposure at Receptor
Image density (blackness)
kVp
Image Contrast
Increasing kVp increases beam penetration. The beam will therefore penetrate both low-density and high-density subjects easily. This will erase the difference between the two densities

100

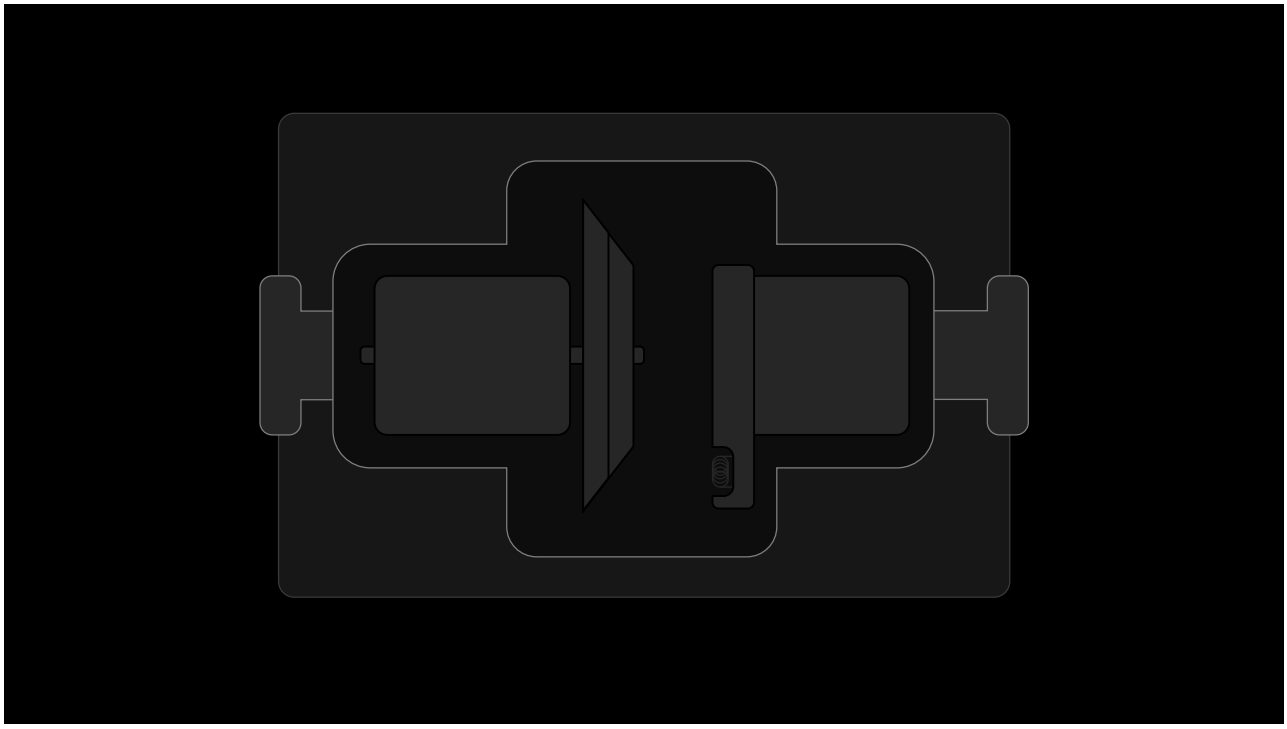

kVp
Image Contrast
Increasing kVp increases beam penetration. The beam will therefore penetrate both low-density and high-density subjects easily. This will erase the difference between the two densities
At low kVp, X-Ray photons will be absorbed by high-density subjects; creating their shadow on the image (high image contrast)
At high kVp, X-Ray photons will penetrate high-density subjects; Reducing or completely erasing their shadow on the image (low image contrast)

101

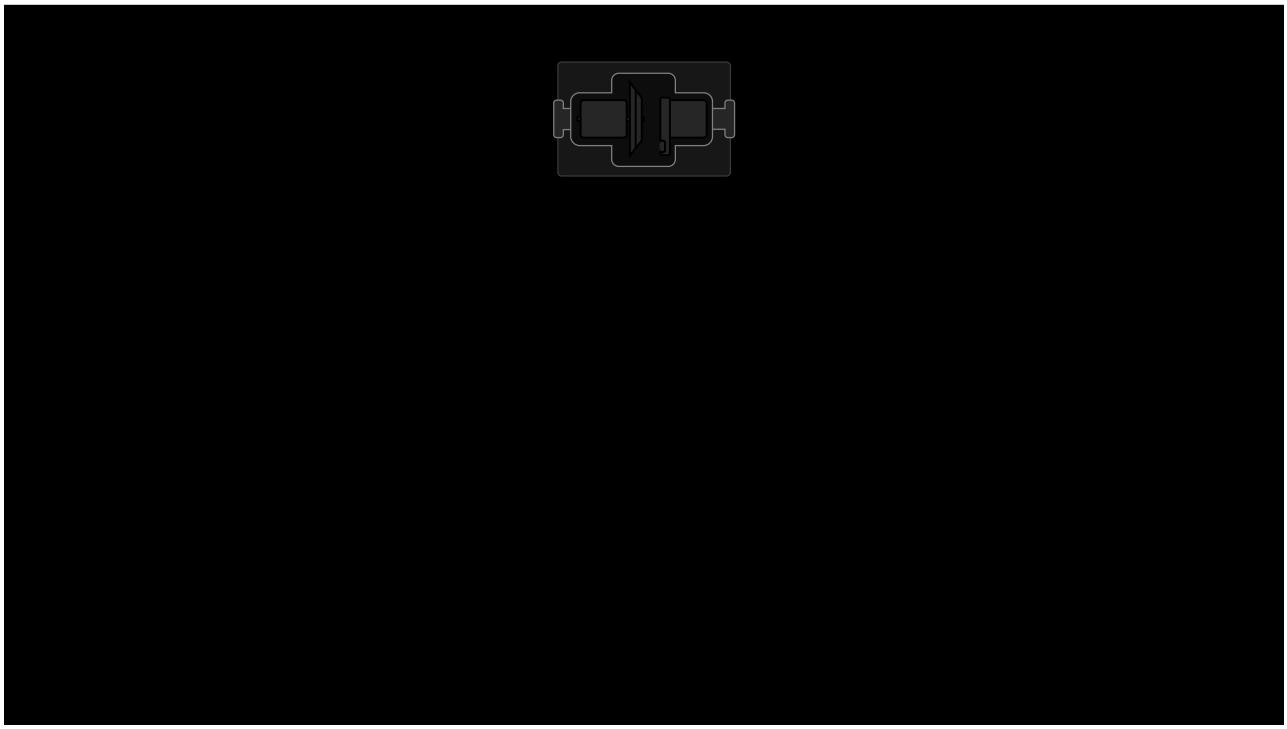
SOURCE-IMAGE-DISTANCE

S I D

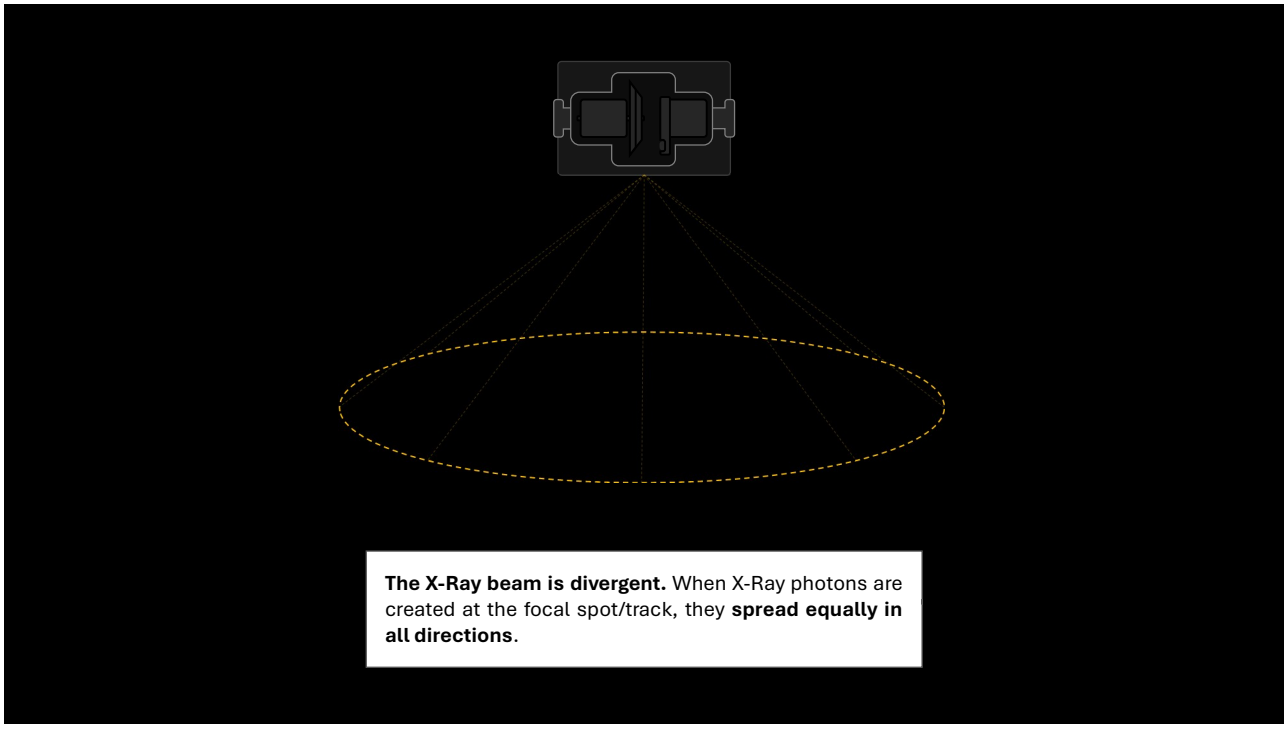
102



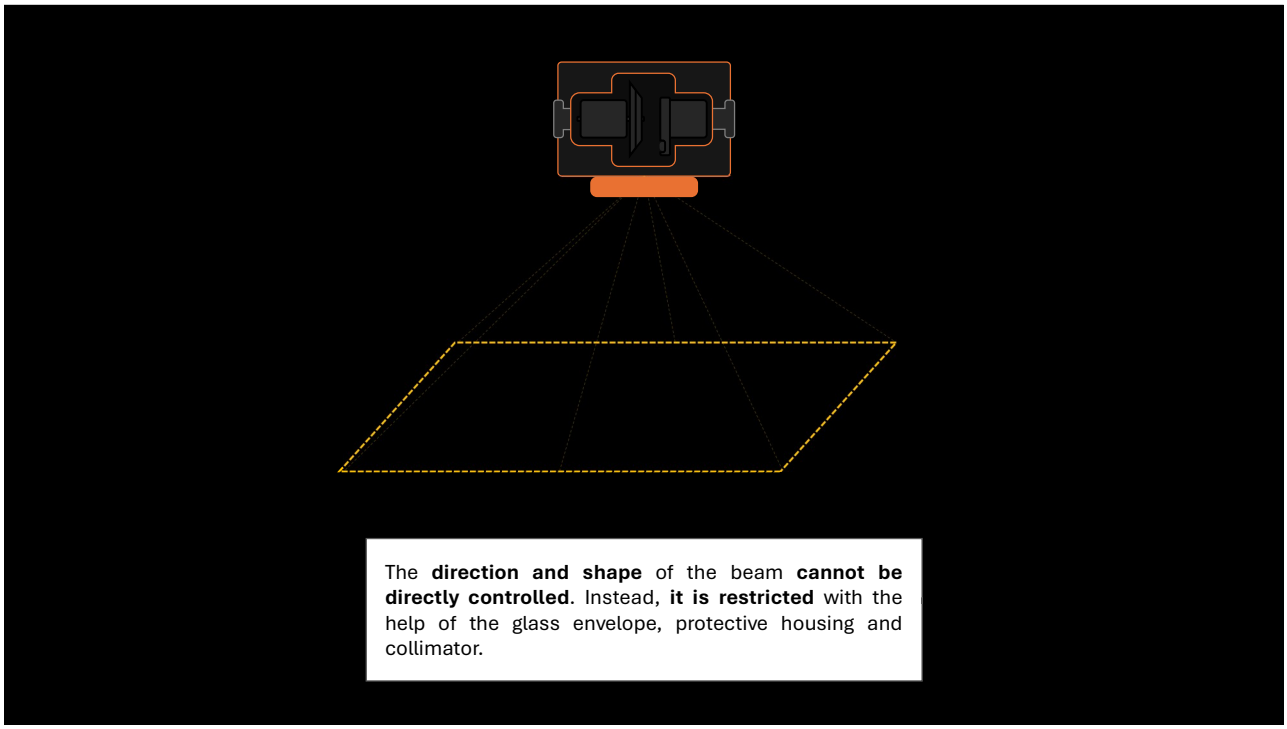
103



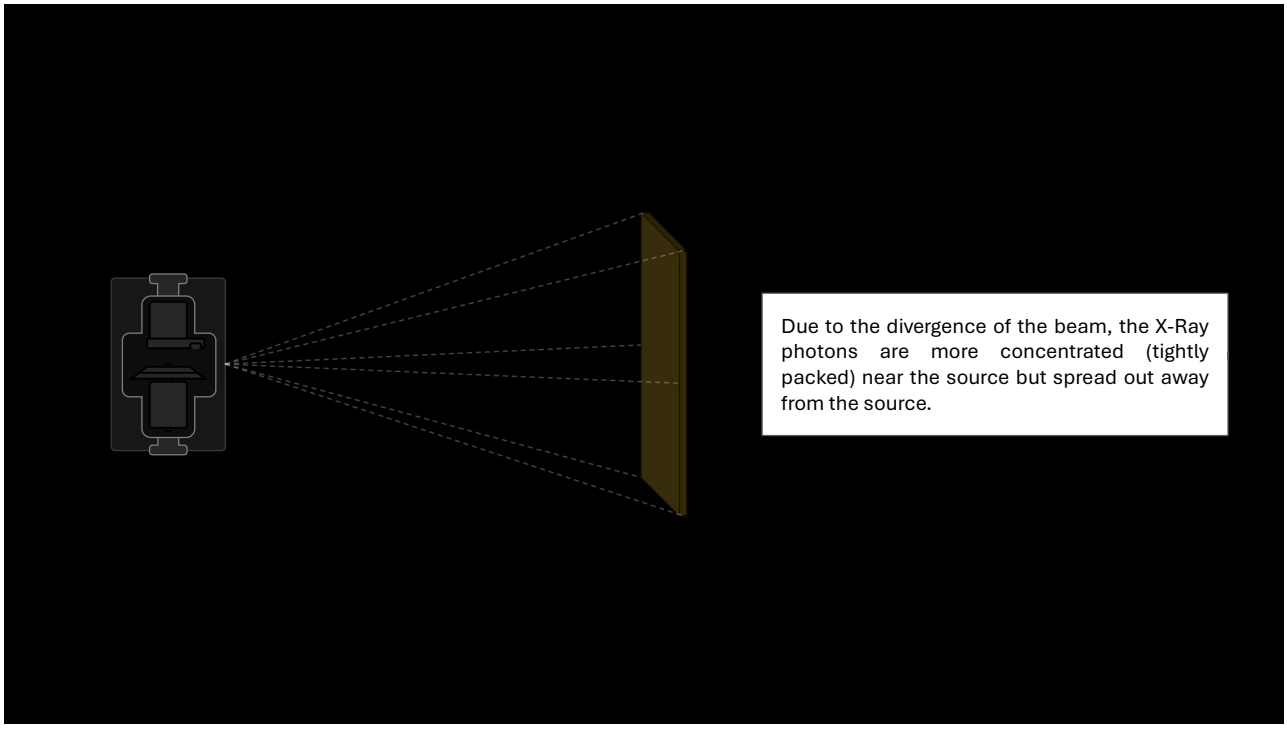
104


The X-Ray beam is divergent. When X-Ray photons are created at the focal spot/track, they **spread equally in all directions**.

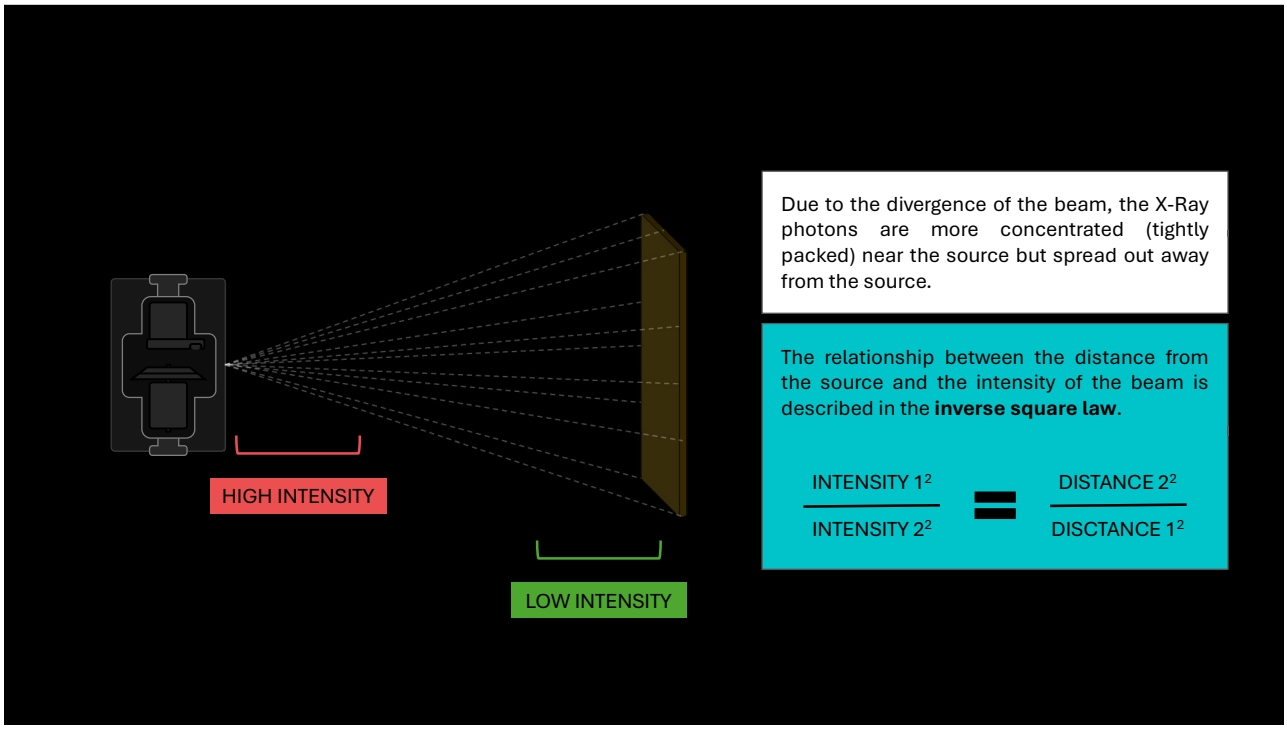
105


The **direction and shape** of the beam **cannot be directly controlled**. Instead, **it is restricted** with the help of the glass envelope, protective housing and collimator.

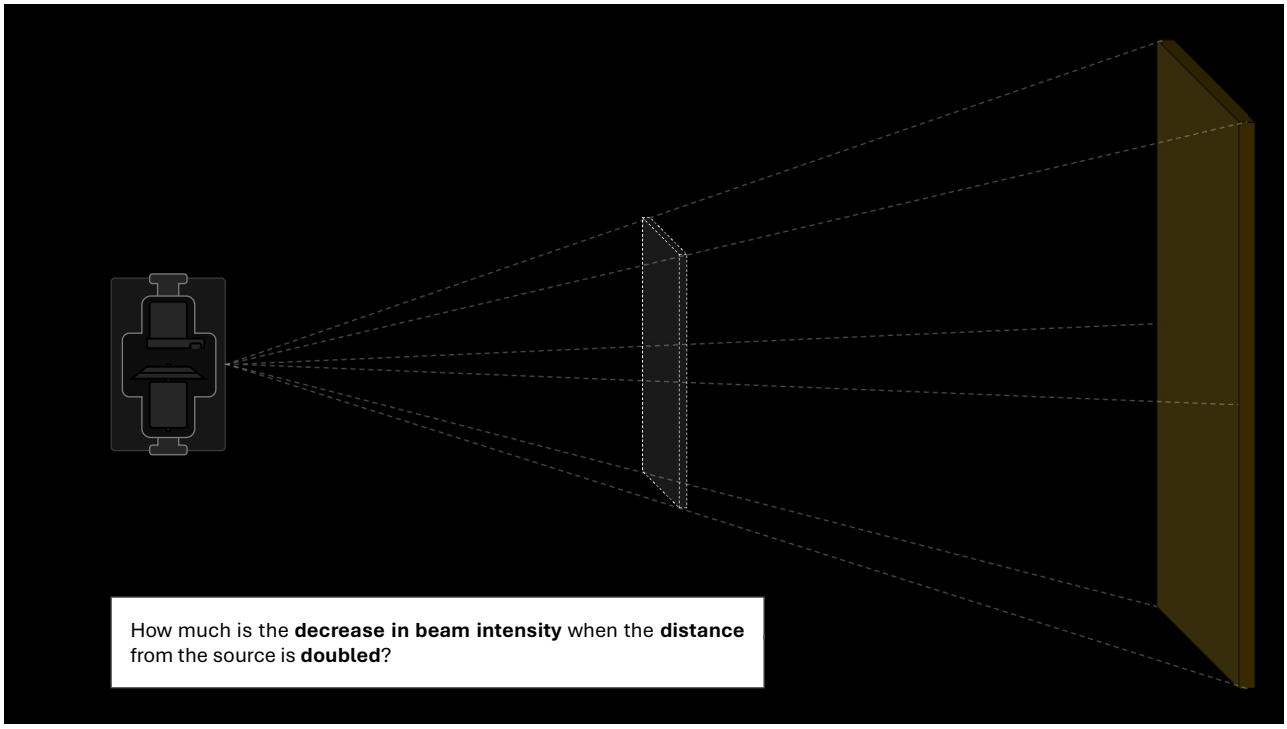
106


Due to the divergence of the beam, the X-Ray photons are more concentrated (tightly packed) near the source but spread out away from the source.

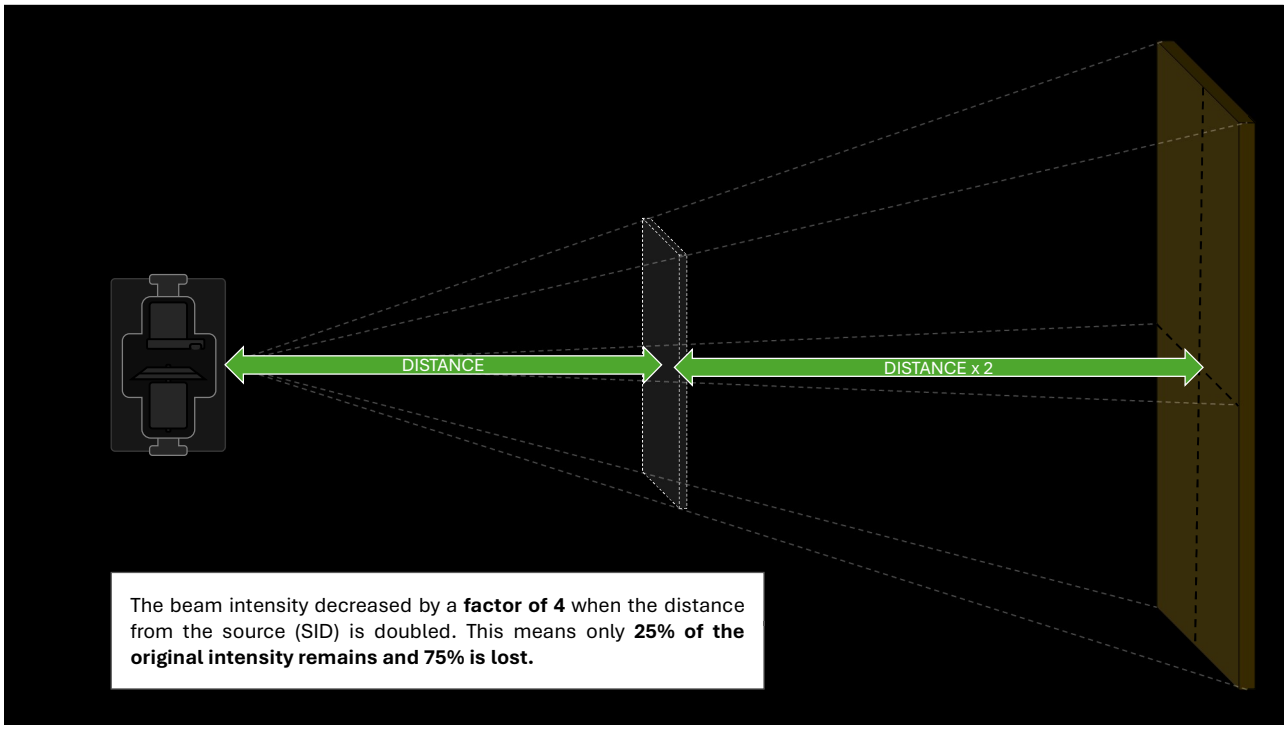
107


HIGH INTENSITY
LOW INTENSITY
Due to the divergence of the beam, the X-Ray photons are more concentrated (tightly packed) near the source but spread out away from the source.
The relationship between the distance from the source and the intensity of the beam is described in the **inverse square law**.
INTENSITY 1²
INTENSITY 2²
=
DISTANCE 2²
DISCTANCE 1²

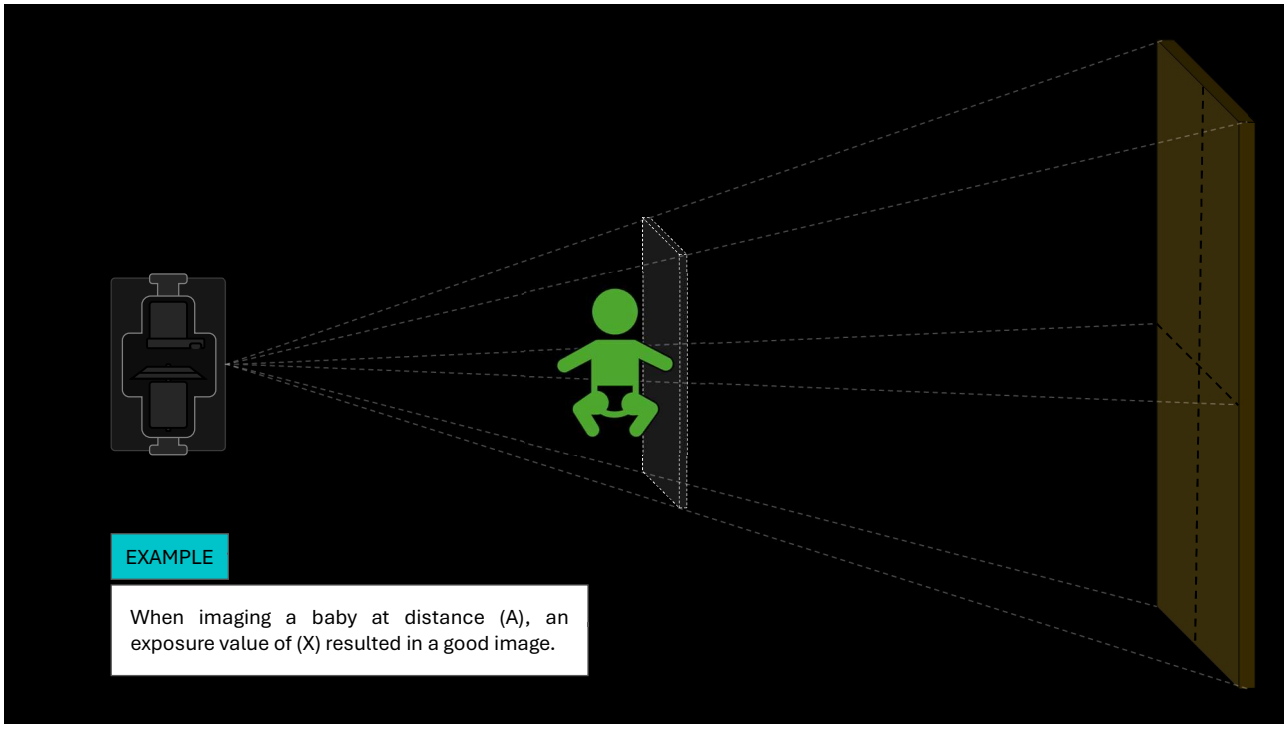
108


How much is the **decrease in beam intensity** when the **distance** from the source is **doubled**?

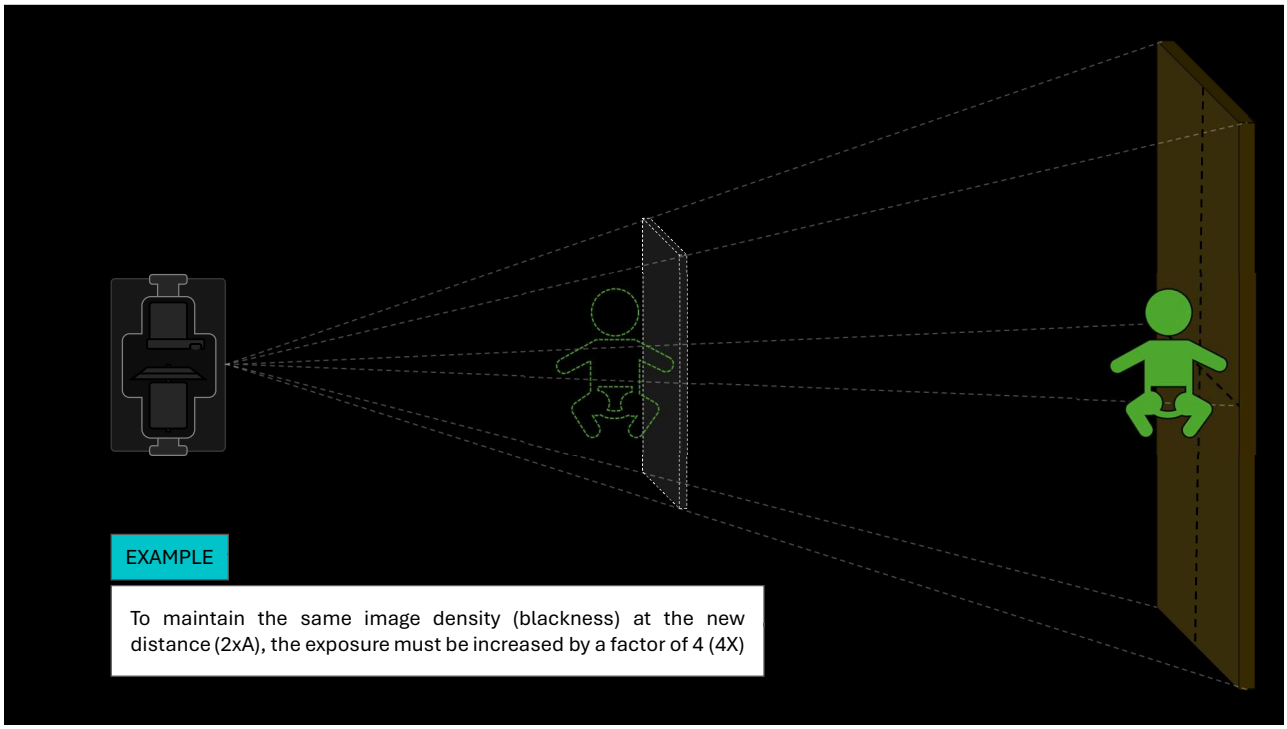
109


DISTANCE
DISTANCE x 2
The beam intensity decreased by a **factor of 4** when the distance from the source (SID) is doubled. This means only **25% of the original intensity remains and 75% is lost.**

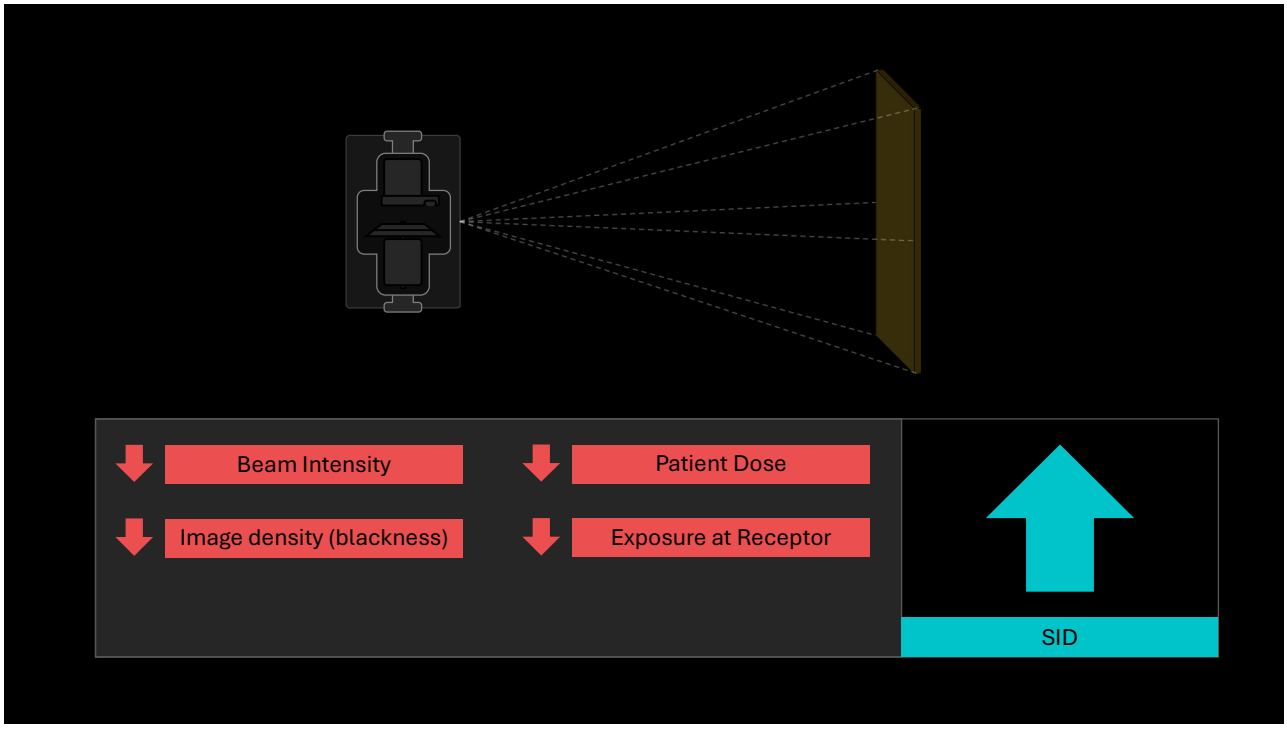
110


EXAMPLE
When imaging a baby at distance (A), an exposure value of (X) resulted in a good image.

111


EXAMPLE
To maintain the same image density (blackness) at the new distance (2xA), the exposure must be increased by a factor of 4 (4X)

112


Beam Intensity
Patient Dose
Image density (blackness)
Exposure at Receptor
SID

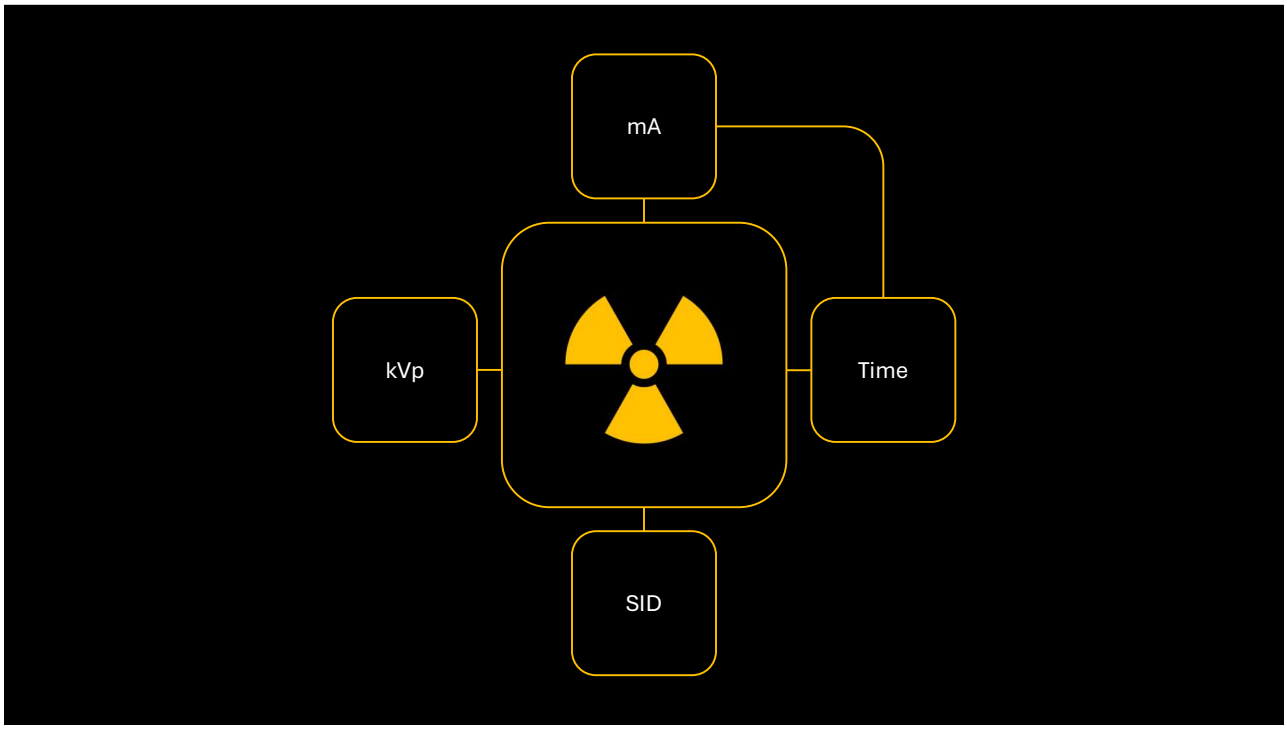
113

THE PRIME FACTORS

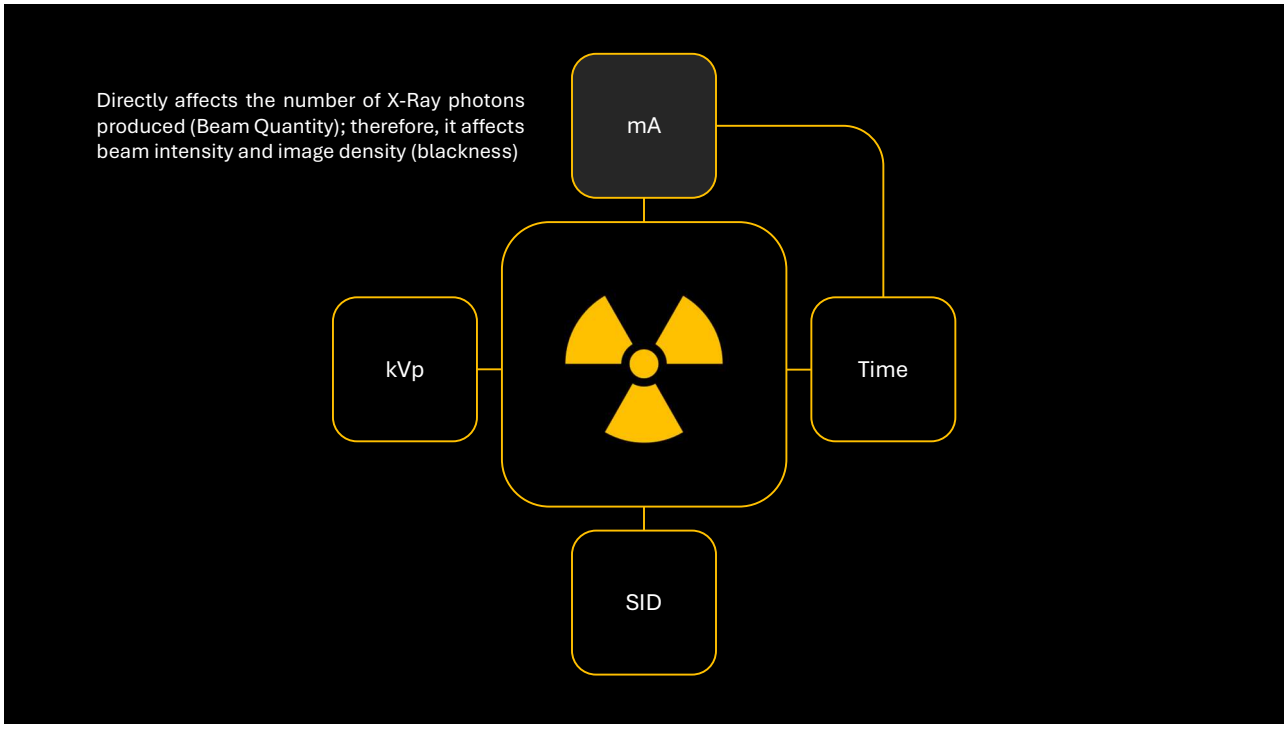
114

Every **radiographic exposure** consists four prime exposure factors

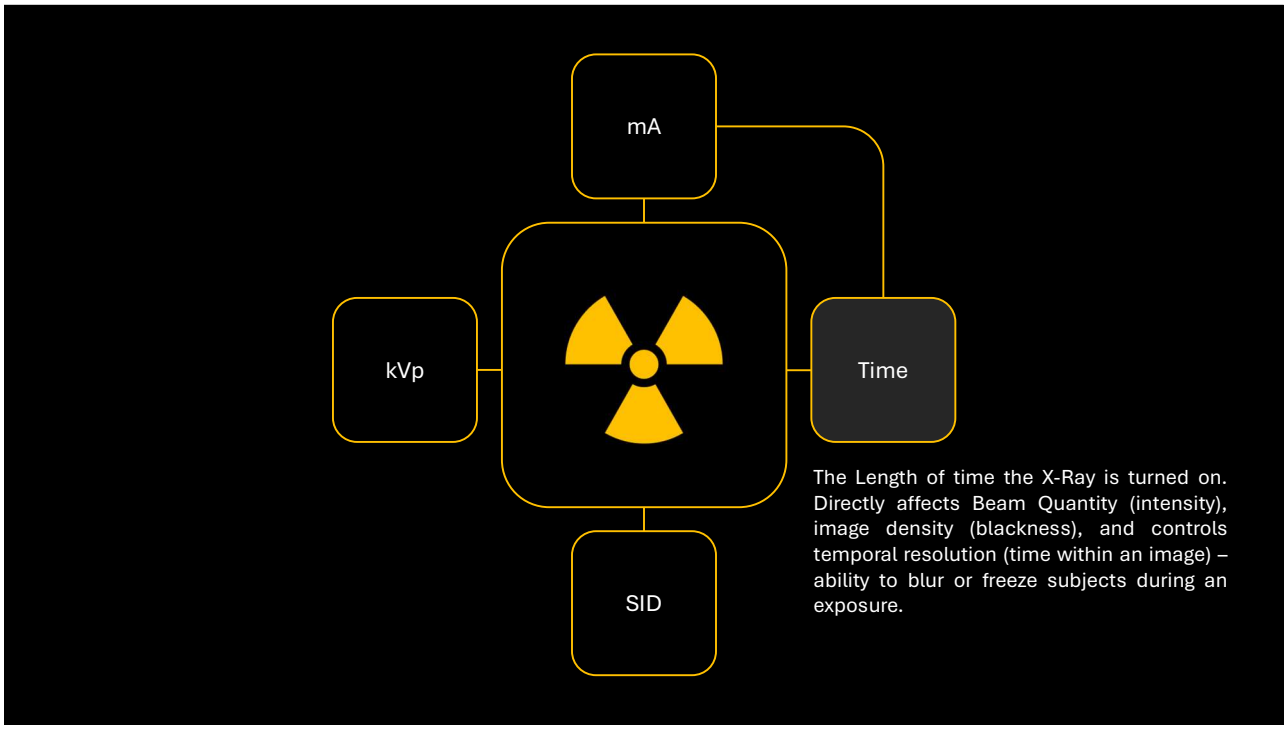
115


mA
kVp
Time
SID

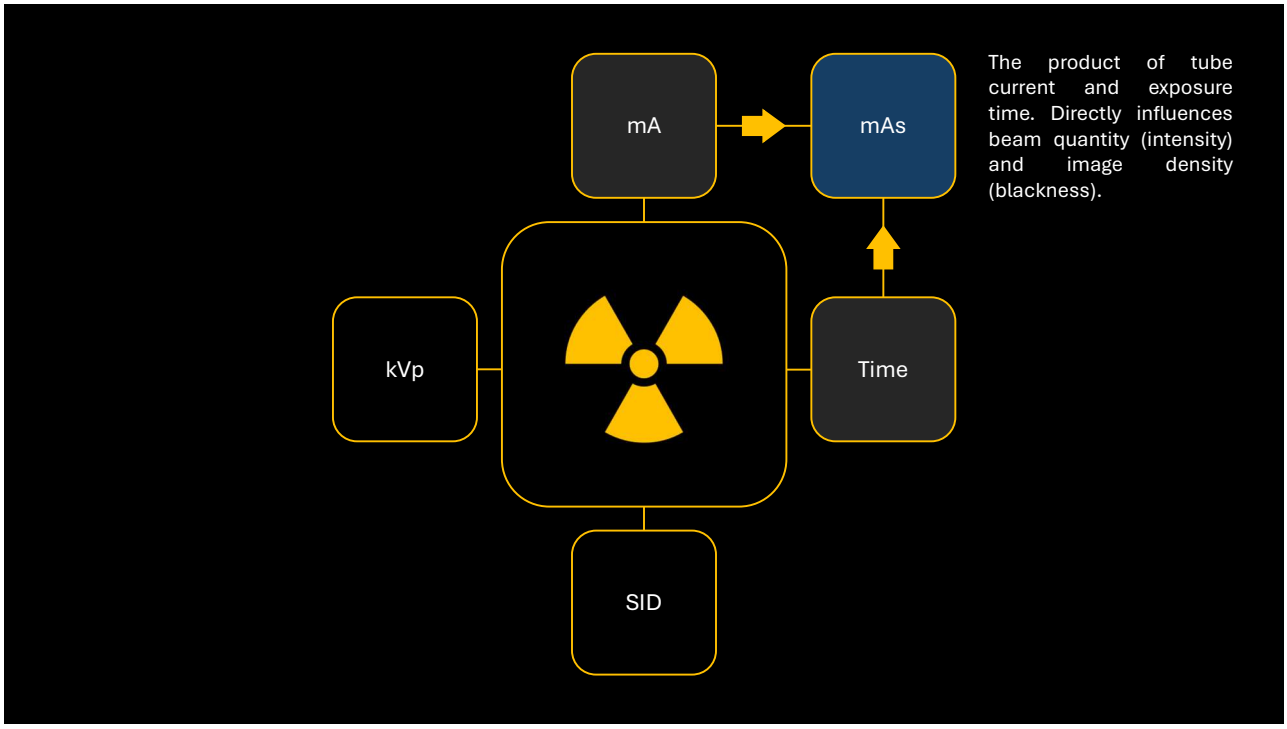
116


Directly affects the number of X-Ray photons produced (Beam Quantity); therefore, it affects beam intensity and image density (blackness)
mA
kVp
Time
SID

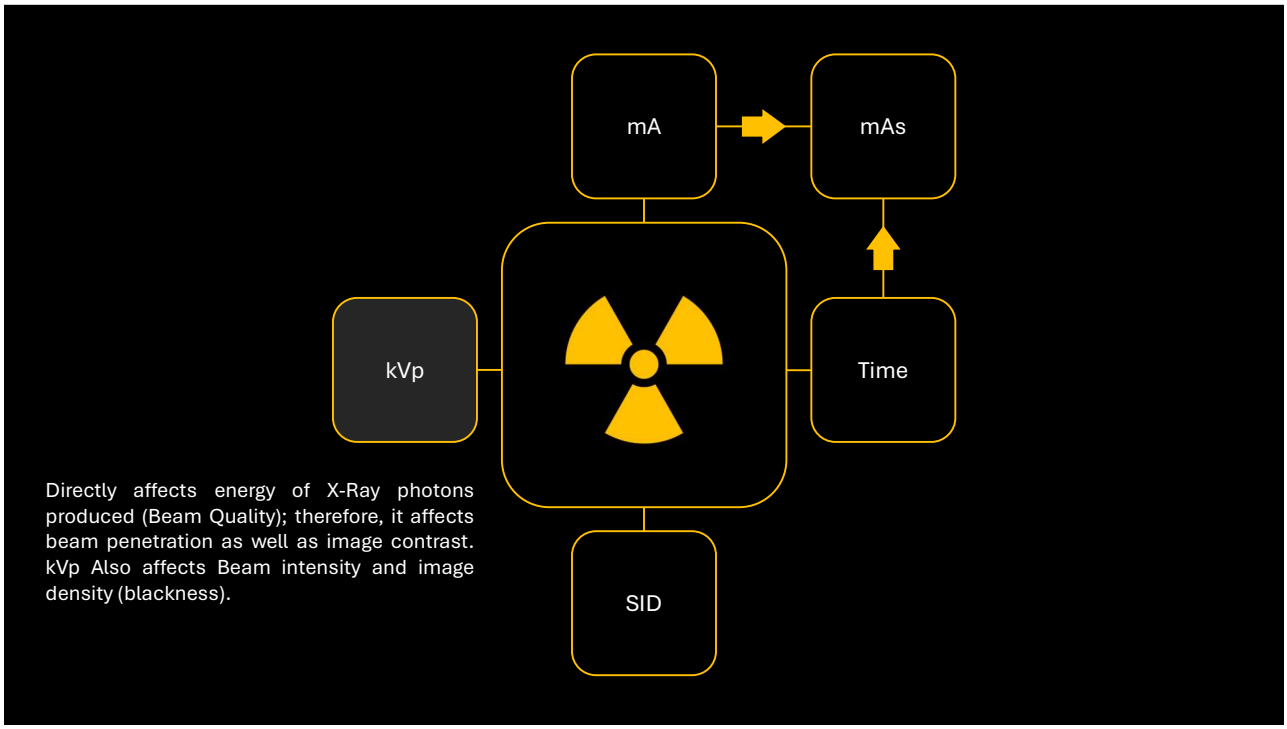
117


mA
kVp
Time
SID
The Length of time the X-Ray is turned on. Directly affects Beam Quantity (intensity), image density (blackness), and controls temporal resolution (time within an image) – ability to blur or freeze subjects during an exposure.

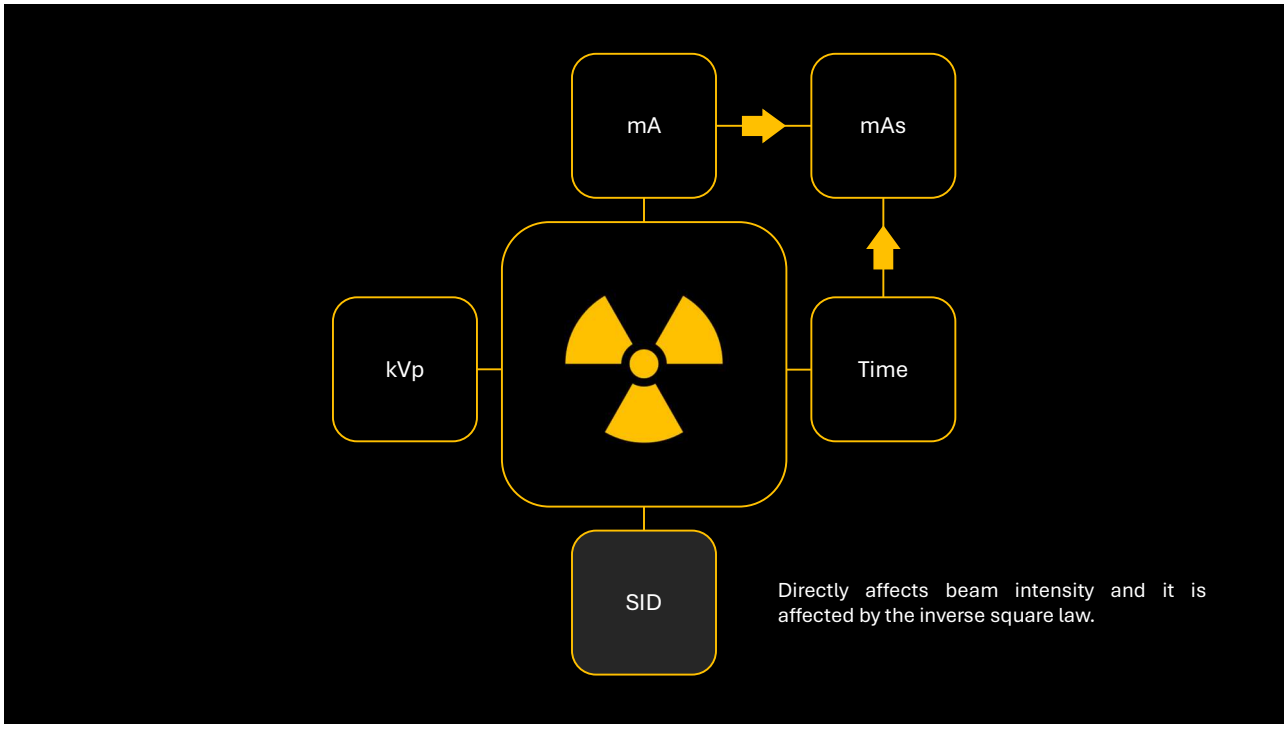
118


mA
mAs
The product of tube current and exposure time. Directly influences beam quantity (intensity) and image density (blackness).
kVp
Time
SID

119


mA
mAs
kVp
Time
SID
Directly affects energy of X-Ray photons produced (Beam Quality); therefore, it affects beam penetration as well as image contrast. kVp Also affects Beam intensity and image density (blackness).

120

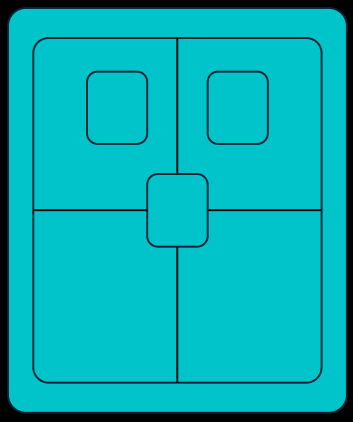

mA
mAs
kVp
Time
SID
Directly affects beam intensity and it is affected by the inverse square law.

121

AUTOMATIC EXPOSURE CONTROL

A E C

122

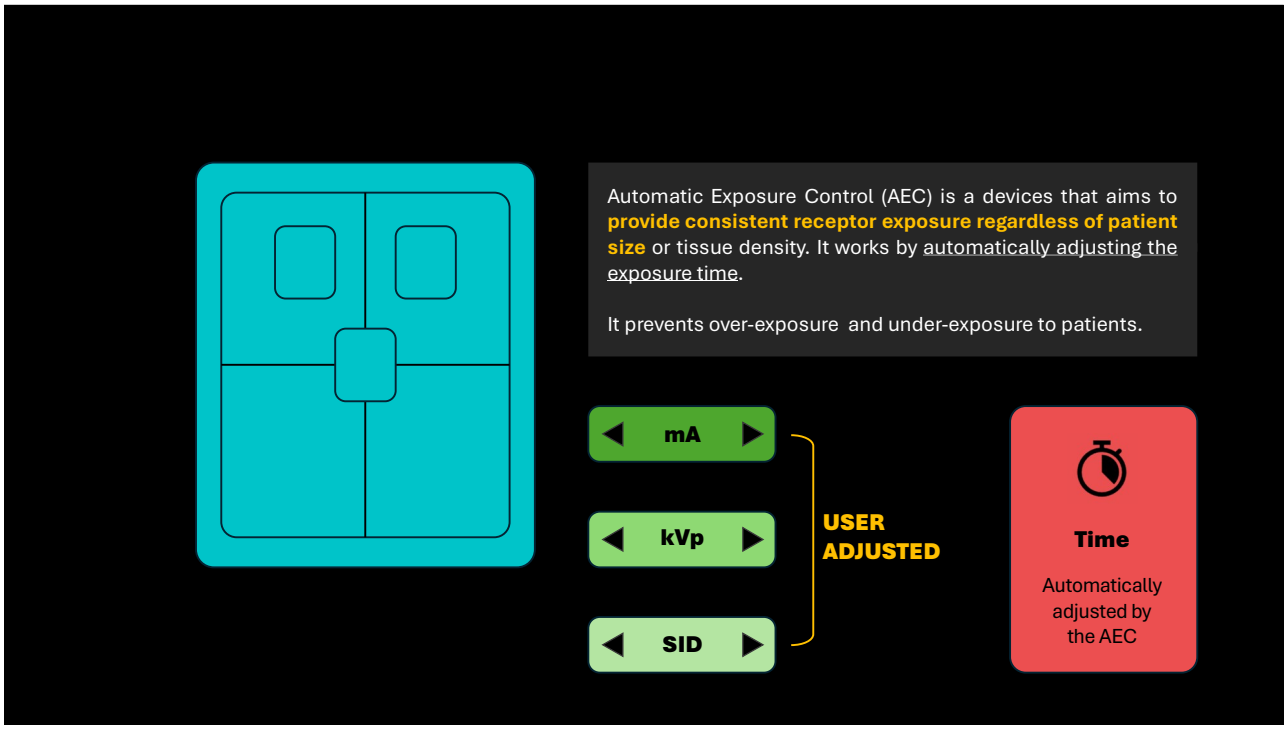


Radiographic exposure depend on many variables...
- → Patient size
- → Anatomy being exposed
- → SID (source-image-distance)
- → ...

Automatic Exposure Control (AEC) is a devices that aims to **provide consistent receptor exposure regardless of patient size** or tissue density. It works by automatically adjusting the exposure time.

It prevents over-exposure and under-exposure to patients.

123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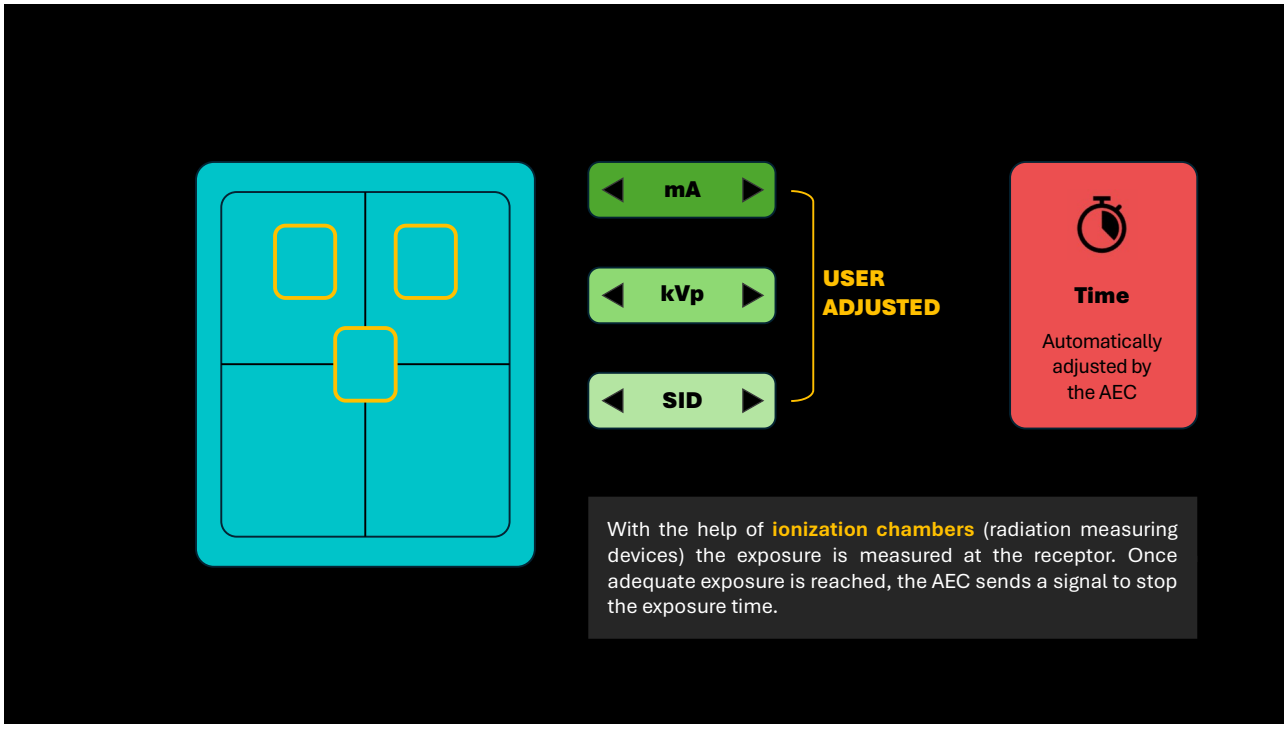
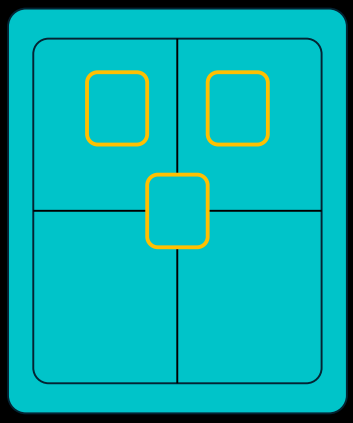
It prevents over-exposure and under-exposure to patients.
mA
kVp
SID
USER ADJUSTED
Time
Automatically adjusted by the AEC

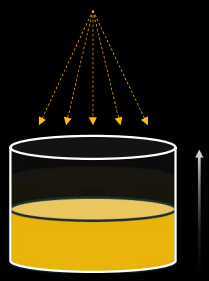
124


mA
kVp
SID
USER ADJUSTED
Time
Automatically adjusted by the AEC
With the help of ionization chambers (radiation measuring devices) the exposure is measured at the receptor. Once adequate exposure is reached, the AEC sends a signal to stop the exposure time.

125

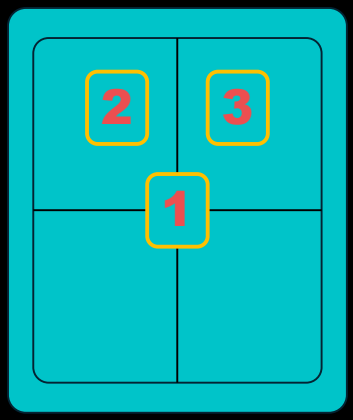


With the help of **ionization chambers** (radiation measuring devices) the exposure is measured at the receptor. Once adequate exposure is reached, the AEC sends a signal to stop the exposure time.



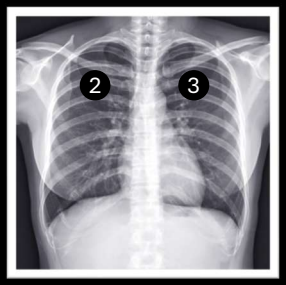
ionization chambers act like buckets; **They fill-up with radiation exiting the patient during an exposure**. Once the cup is full, adequate exposure is reached, and the exposure is switched-off

126



User must **select the most appropriate chamber** for the desired body part.

EXAMPLE:
- Chest X-Ray (chamber **2** and **3**)
- Spine X-Ray (chamber **1**)

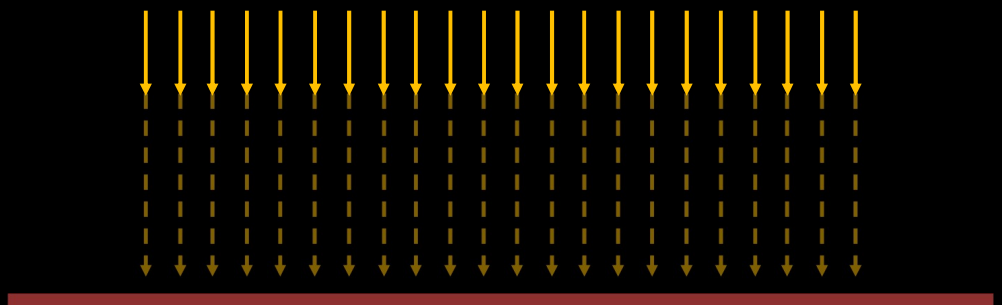


127

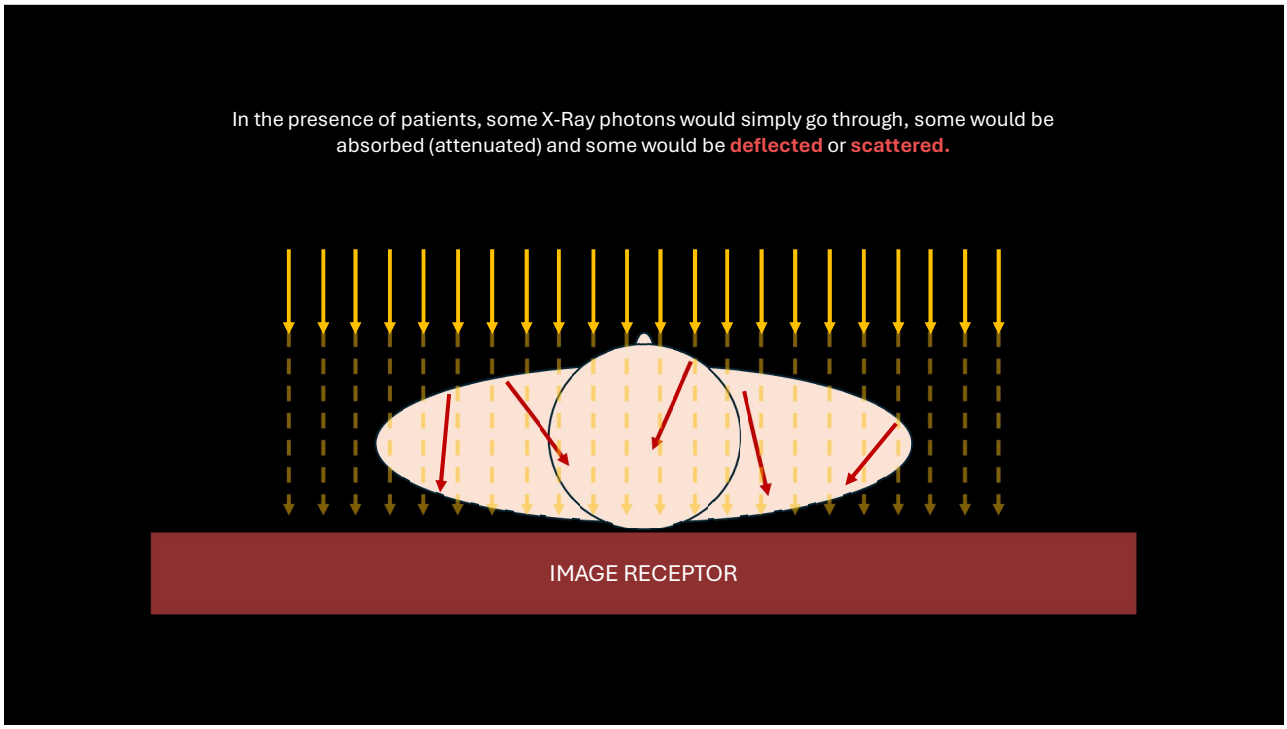
GRIDS

128

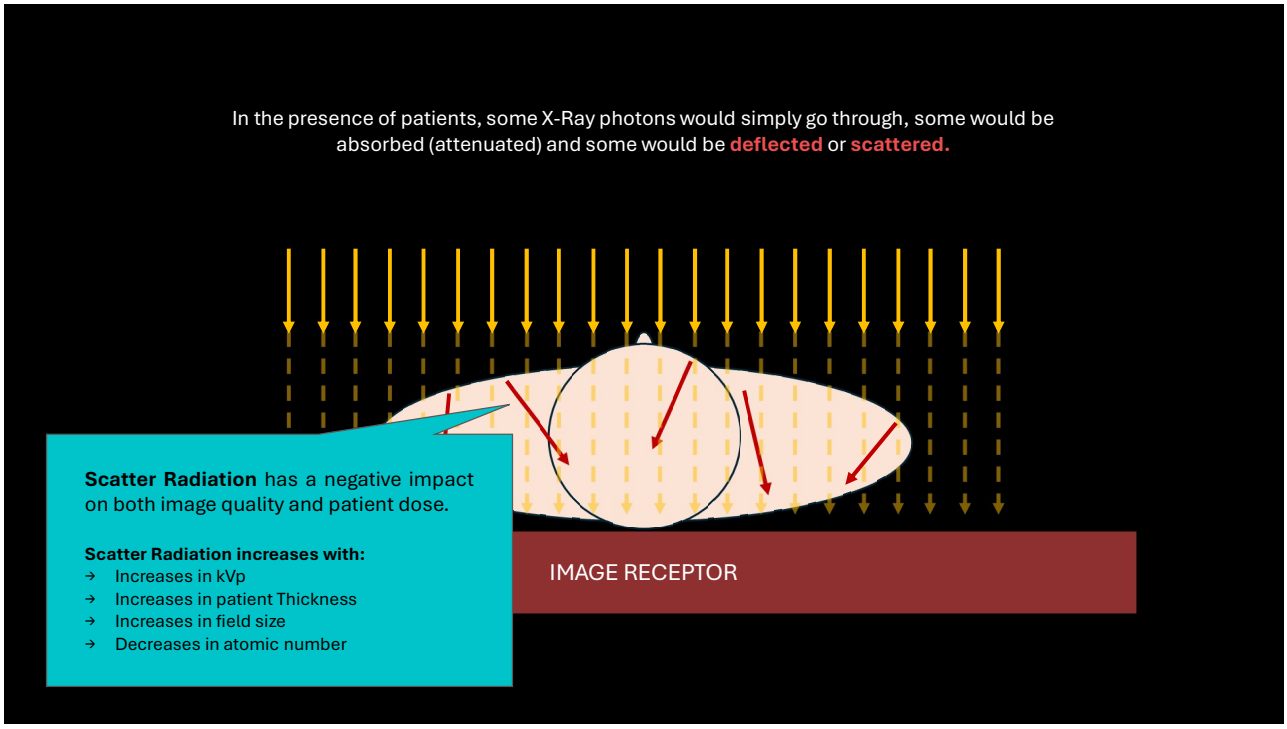
Uninterrupted, X-Ray photon **travel in straight lines** from the source to the image receptor.



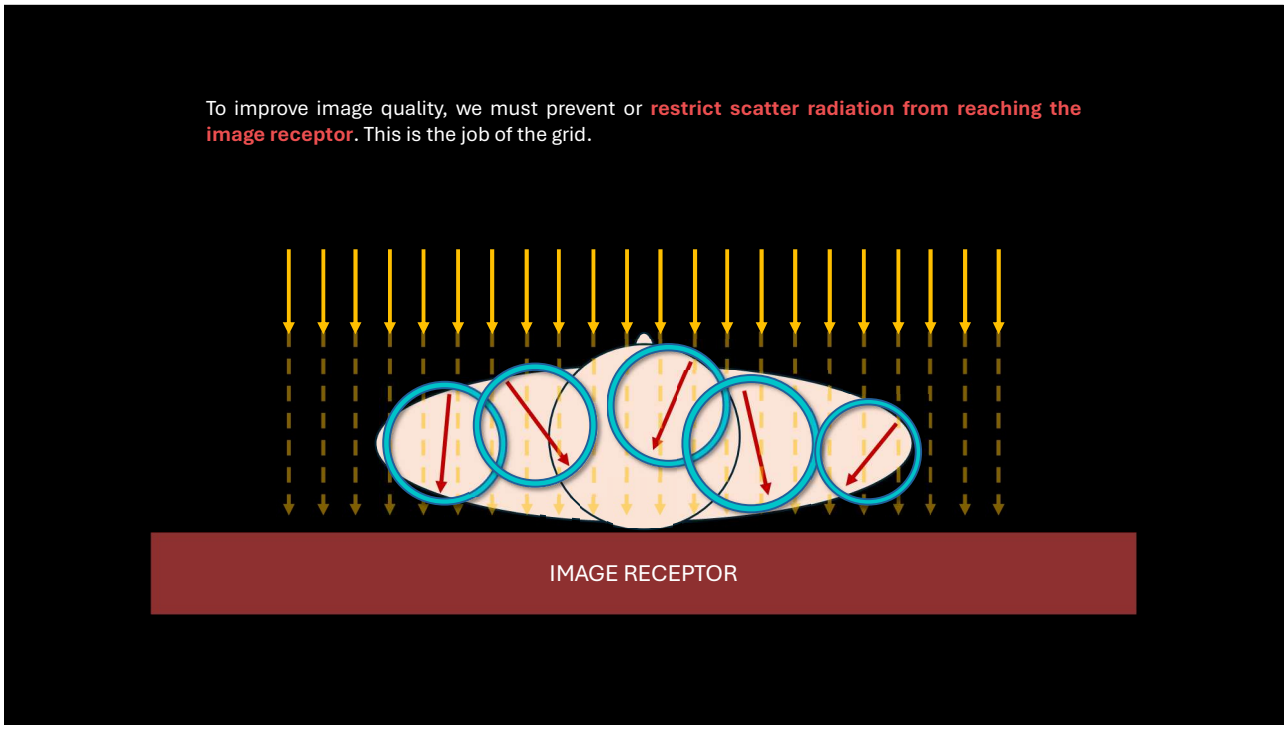
129


In the presence of patients, some X-Ray photons would simply go through, some would be absorbed (attenuated) and some would be deflected or scattered.
IMAGE RECEPTOR

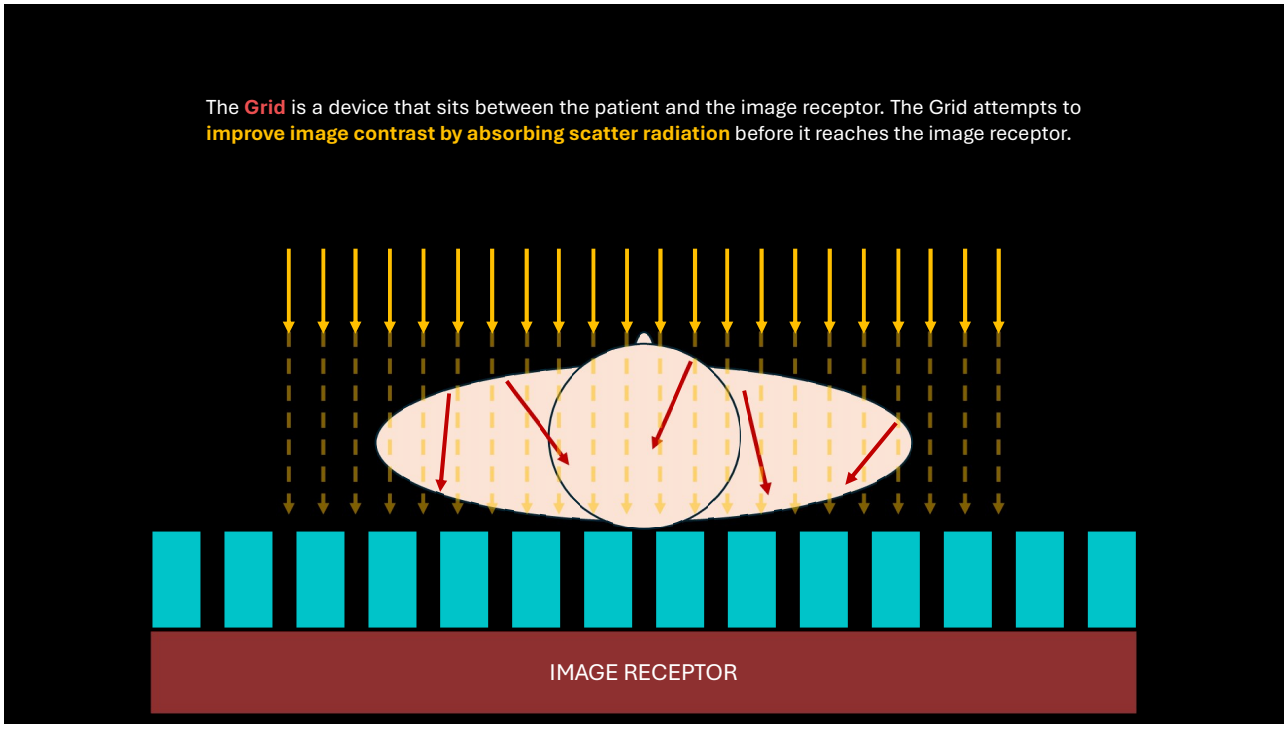
130


In the presence of patients, some X-Ray photons would simply go through, some would be absorbed (attenuated) and some would be deflected or scattered.
Scatter Radiation has a negative impact on both image quality and patient dose.
Scatter Radiation increases with:
→ Increases in kVp
→ Increases in patient Thickness
→ Increases in field size
→ Decreases in atomic number
IMAGE RECEPTOR

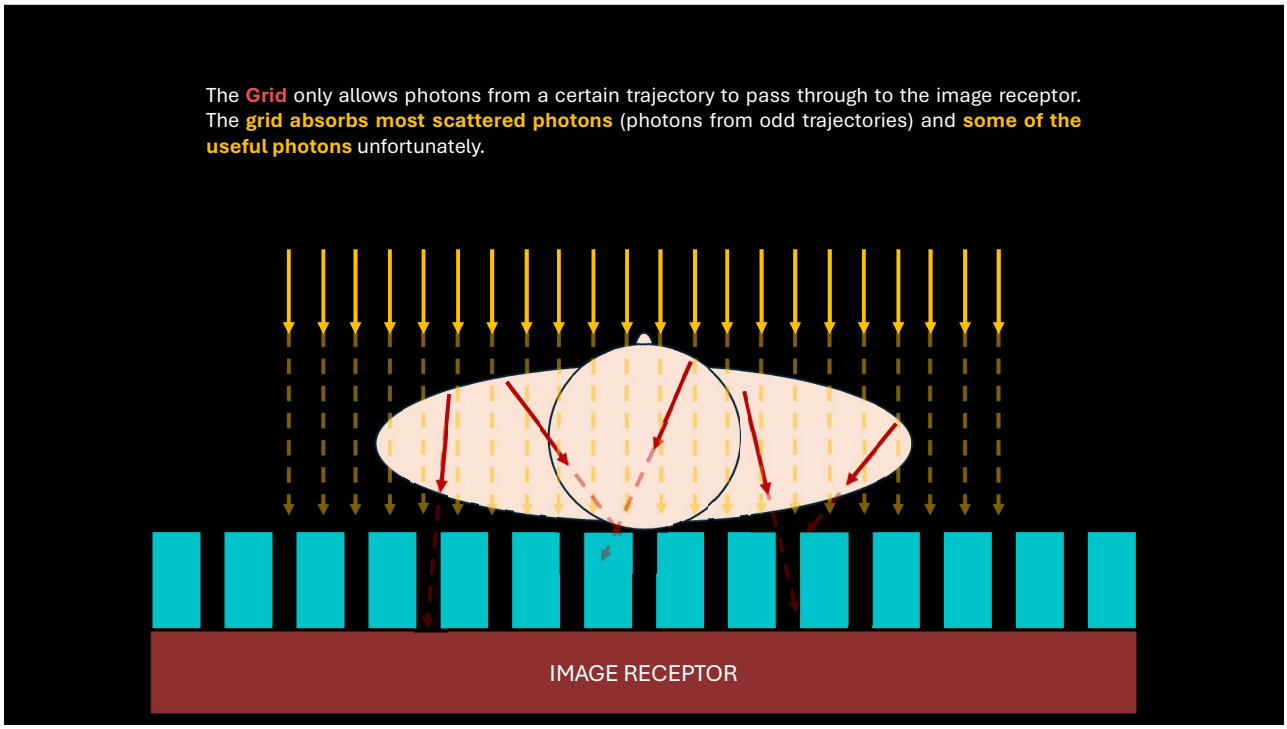
131


To improve image quality, we must prevent or restrict scatter radiation from reaching the image receptor. This is the job of the grid.
IMAGE RECEPTOR

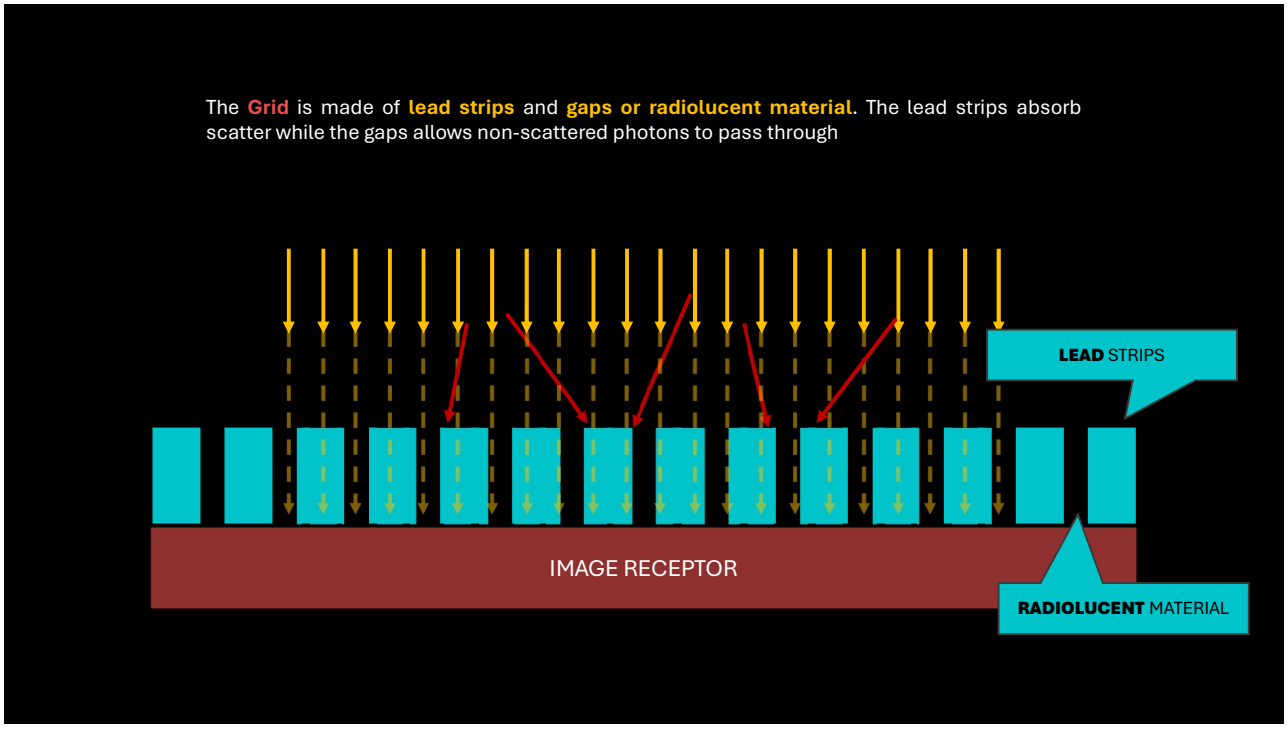
132


The Grid is a device that sits between the patient and the image receptor. The Grid attempts to improve image contrast by absorbing scatter radiation before it reaches the image receptor.
IMAGE RECEPTOR

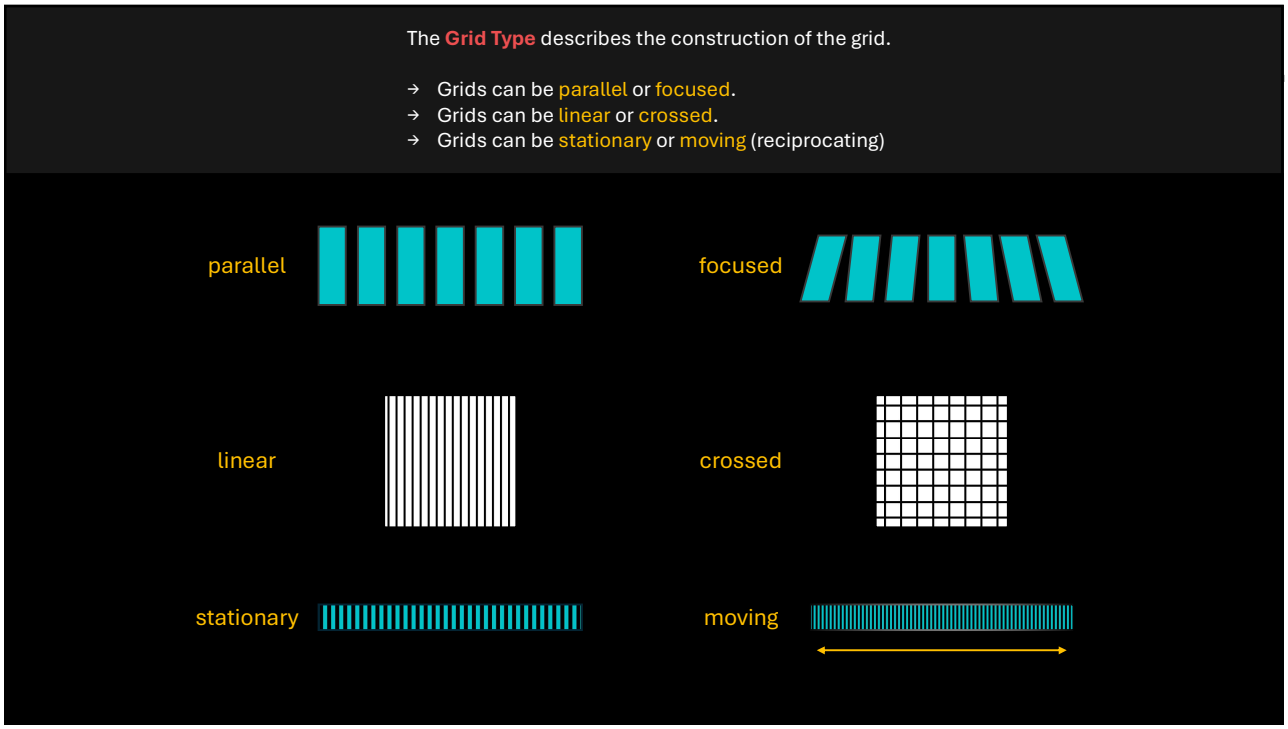
133


The Grid only allows photons from a certain trajectory to pass through to the image receptor.
The grid absorbs most scattered photons (photons from odd trajectories) and some of the useful photons unfortunately.
IMAGE RECEPTOR

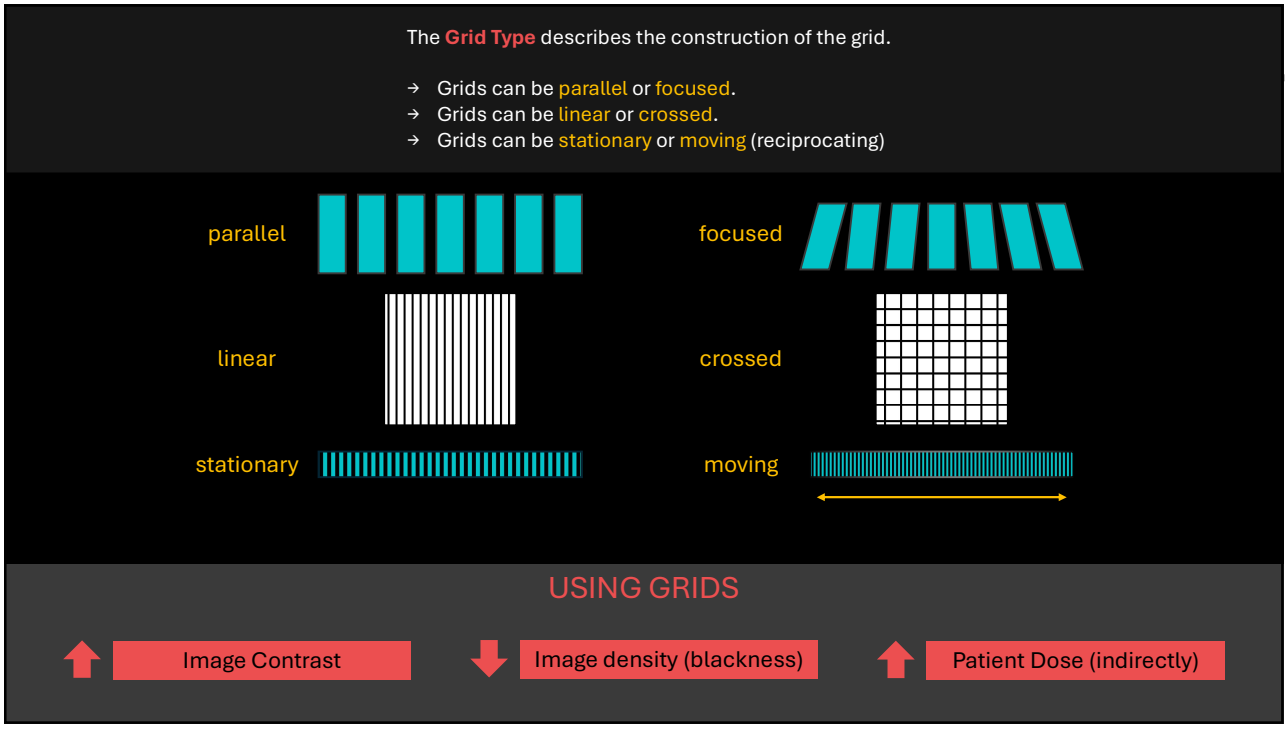
134


The Grid is made of lead strips and gaps or radiolucent material. The lead strips absorb scatter while the gaps allows non-scattered photons to pass through
LEAD STRIPS
IMAGE RECEPTOR
RADIOLUCENT MATERIAL

135


The Grid Type describes the construction of the grid.
→ Grids can be parallel or focused.
→ Grids can be linear or crossed.
→ Grids can be stationary or moving (reciprocating)
parallel
focused
linear
crossed
stationary
moving

136


The Grid Type describes the construction of the grid.
→ Grids can be parallel or focused.
→ Grids can be linear or crossed.
→ Grids can be stationary or moving (reciprocating)
parallel
focused
linear
crossed
stationary
moving
USING GRIDS
Image Contrast
Image density (blackness)
Patient Dose (indirectly)

137

The **Grid Ratio** is the relationship between **the height of the lead strips** and **the distance between them**. The higher the grid ratio, the more efficient is the grid at absorbing scatter radiation but a **higher exposure is required to compensate** for the significant decrease in photons reaching the image receptor.

HIGH **Grid Ratio**

16 : 1

LOW **Grid Ratio**

5 : 1

INCREASING GRID RATIO

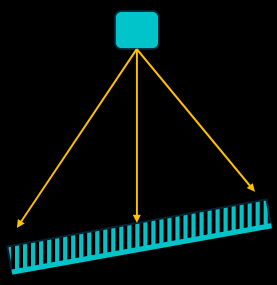
↑ Image Contrast

↓ Image density (blackness)

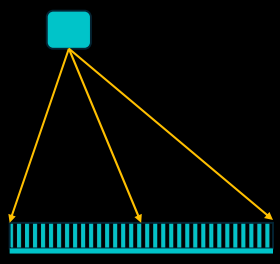
↑ Patient Dose (indirectly)

138

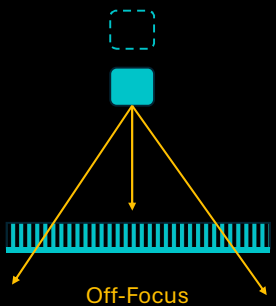
The **Grid Errors** describes the misuse of the grid.



Off-level



Off-Center



Off-Focus

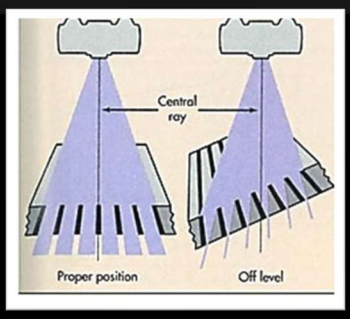
Upside-down

The **Grid Errors create image artifacts** and may create completely unusable images.

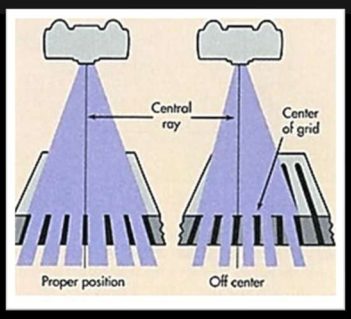
139

The **Grid Errors** describes the misuse of the grid.

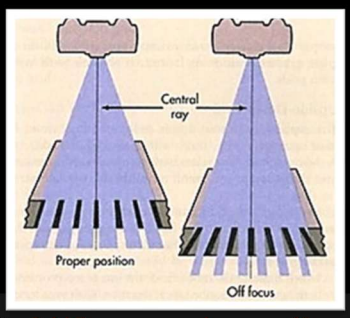
Off-level



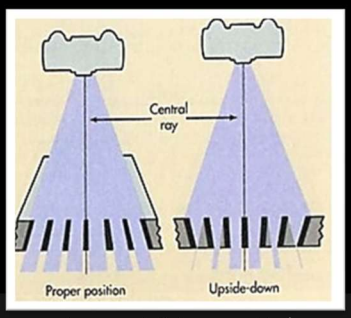
Off-Center



Off-Focus



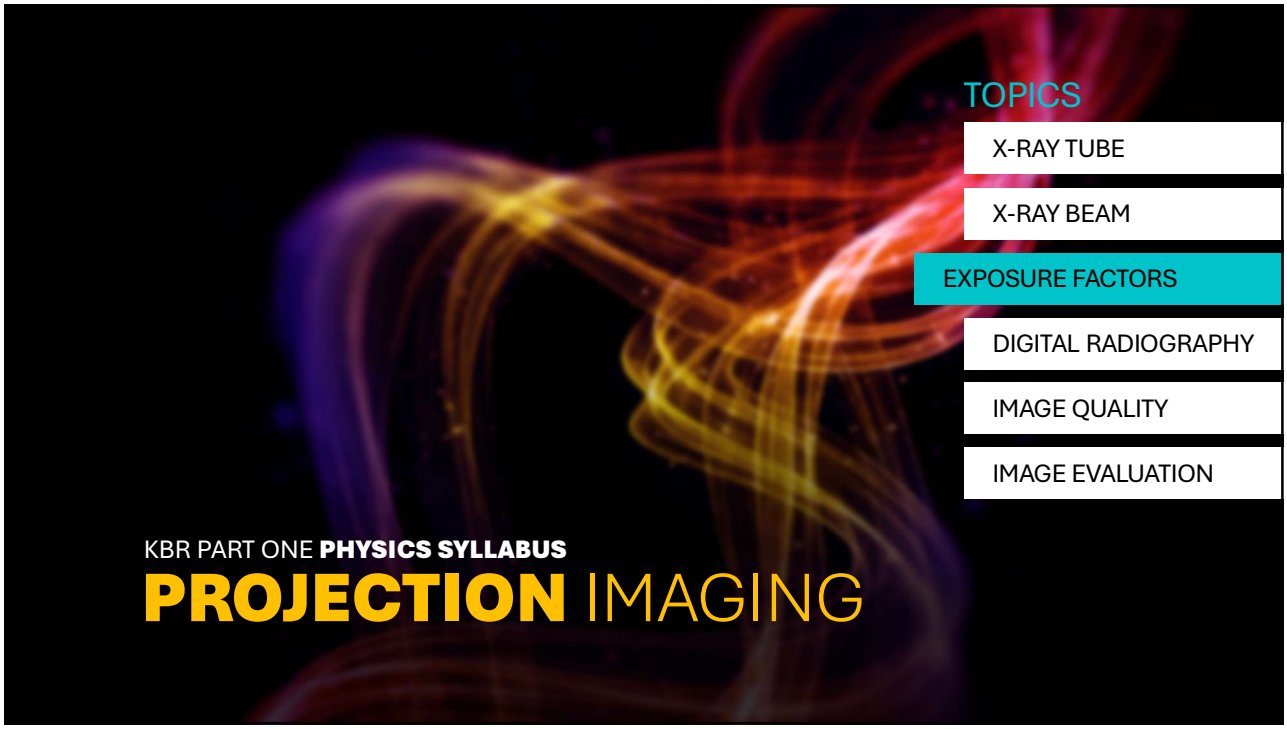
Upside-down



The **Grid Errors create image artifacts** and may create completely unusable images.

140

141


TOPICS
X-RAY TUBE
X-RAY BEAM
EXPOSURE FACTORS
DIGITAL RADIOGRAPHY
IMAGE QUALITY
IMAGE EVALUATION
KBR PART ONE PHYSICS SYLLABUS
PROJECTION IMAGING

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