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TOPICS
X-RAY TUBE
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IMAGE QUALITY
IMAGE EVALUATION
KBR PART ONE PHYSICS SYLLABUS
PROJECTION IMAGING

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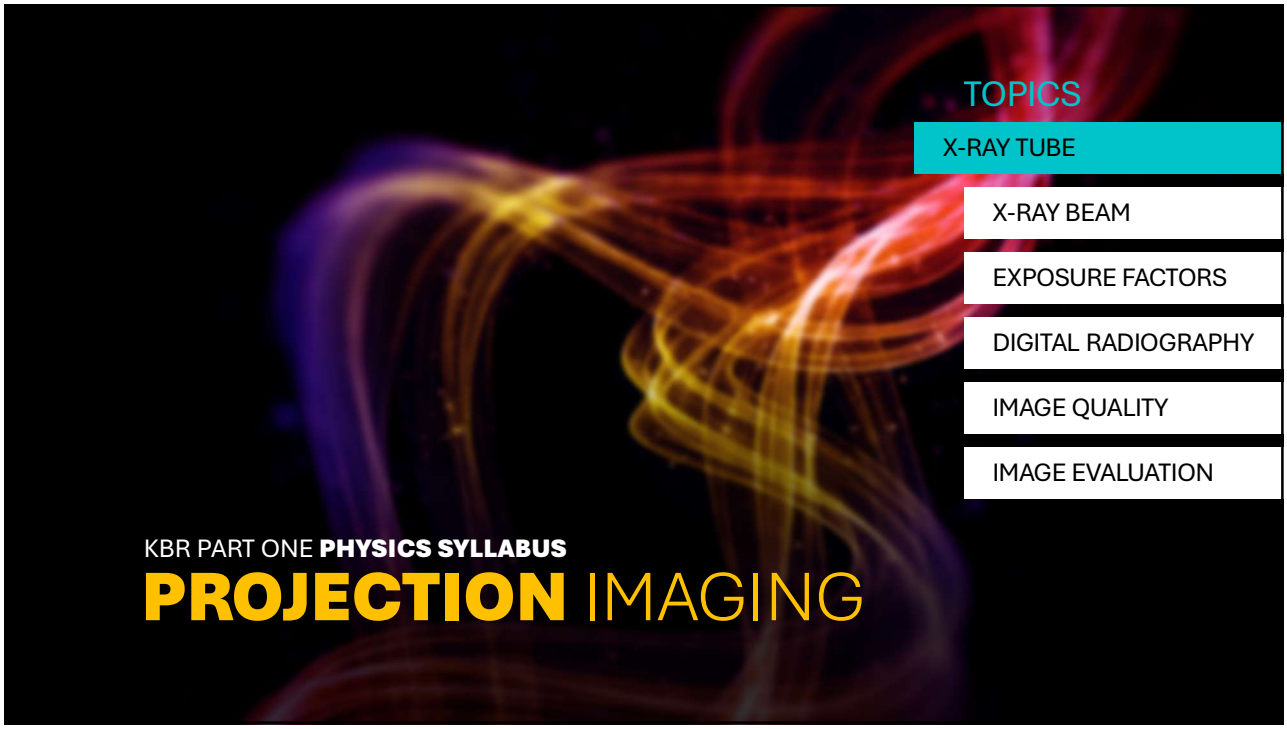
TOPICS
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PROJECTION IMAGING

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X-RAY TUBE COMPONENTS

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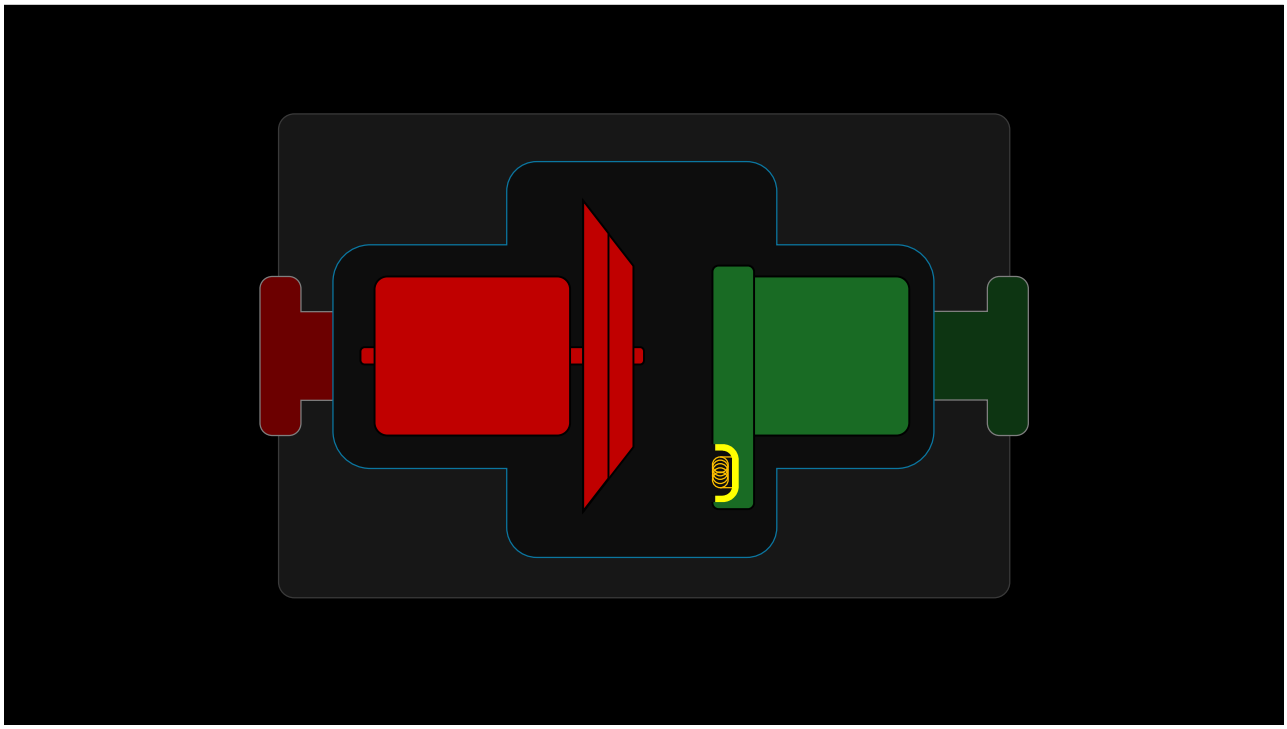

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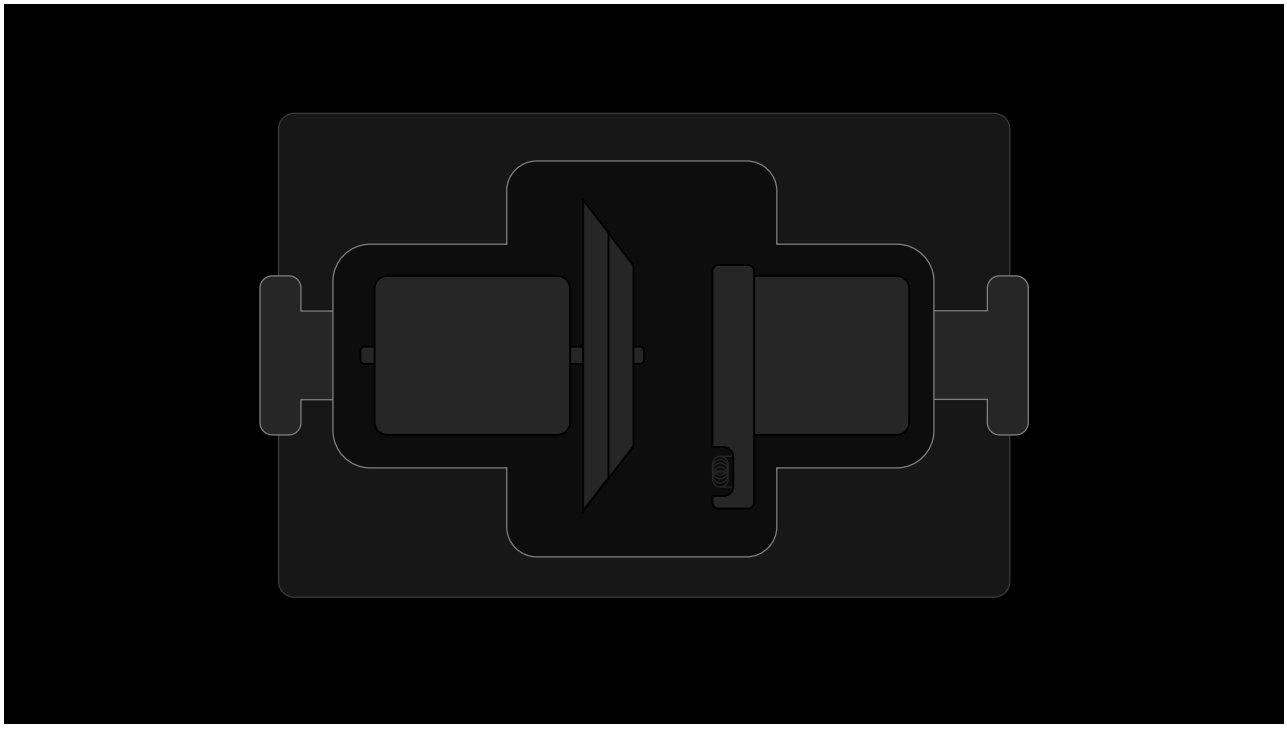

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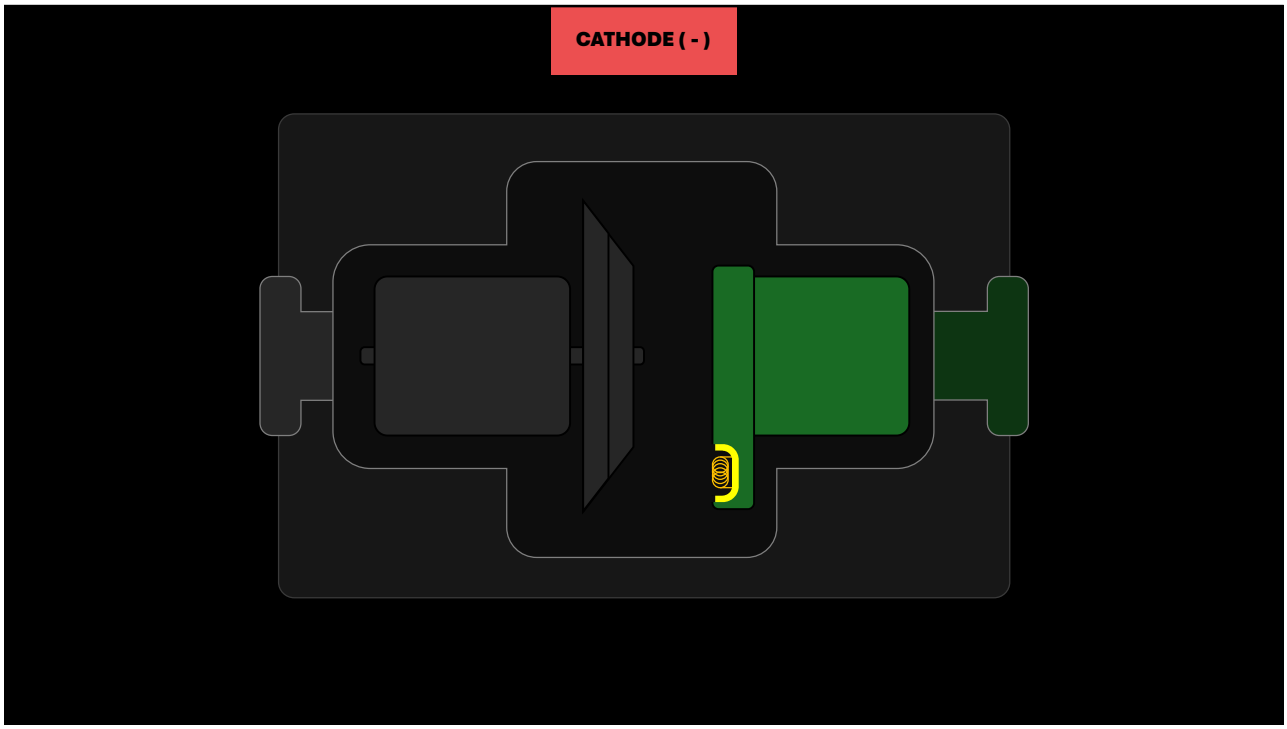
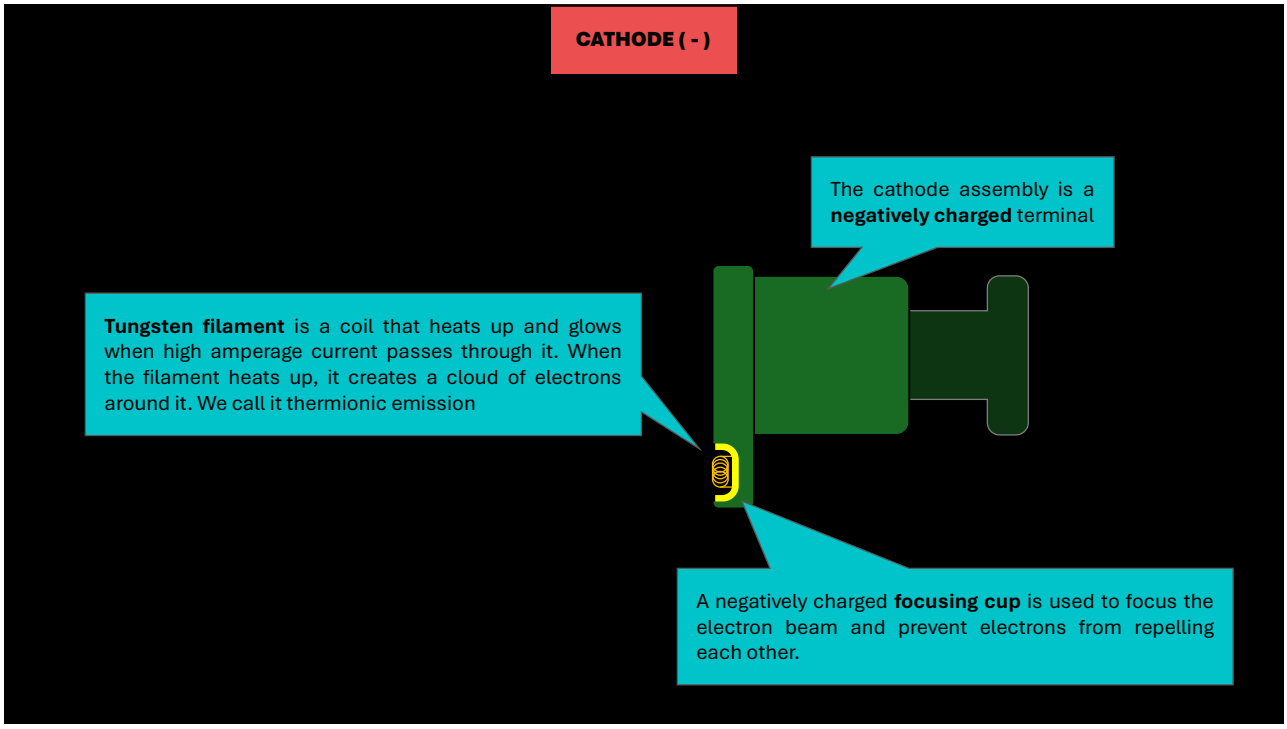
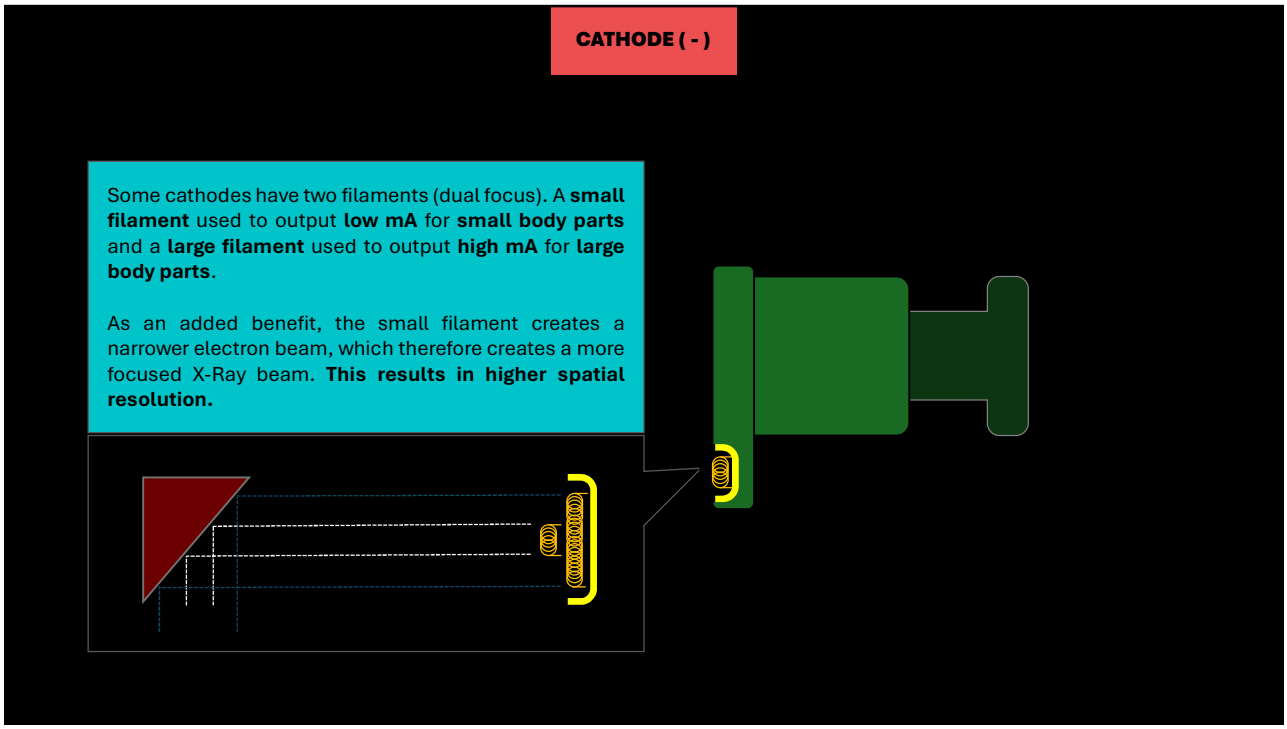

CATHODE (-)

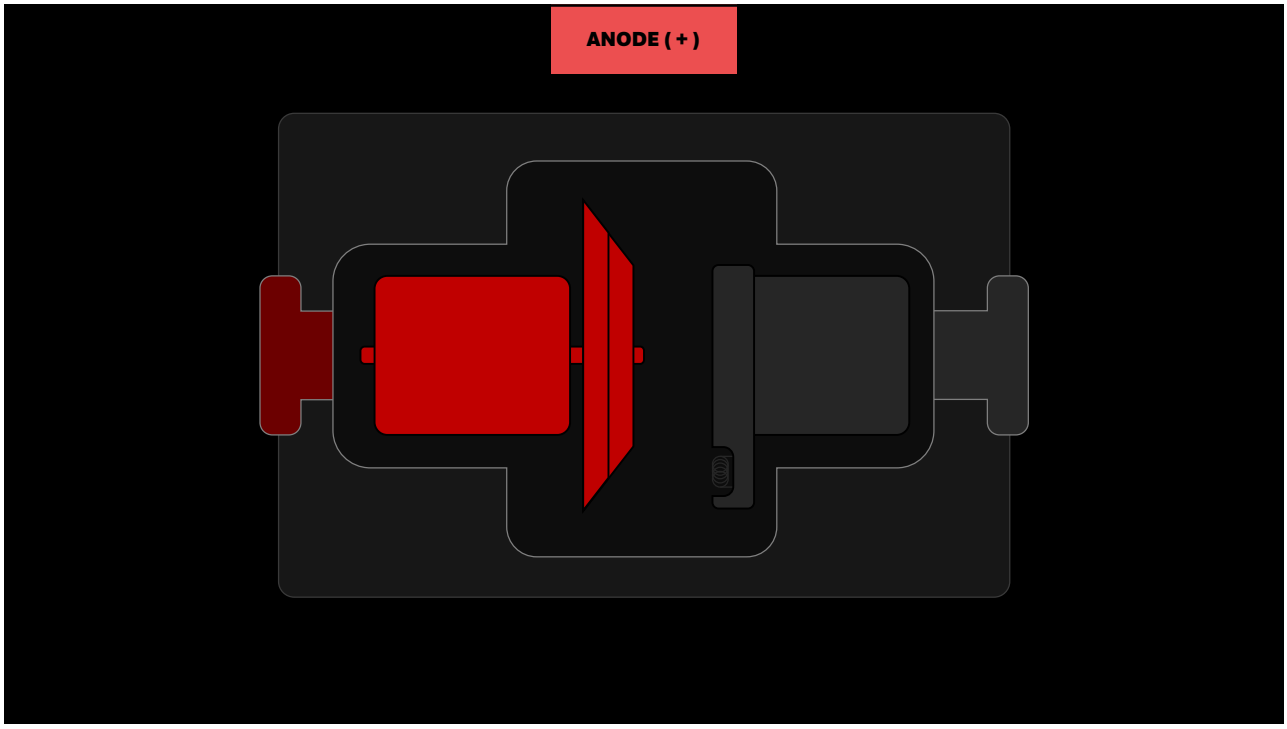
9


CATHODE (-)
The cathode assembly is a **negatively charged** terminal
Tungsten filament is a coil that heats up and glows when high amperage current passes through it. When the filament heats up, it creates a cloud of electrons around it. We call it thermionic emission
A negatively charged **focusing cup** is used to focus the electron beam and prevent electrons from repelling each other.

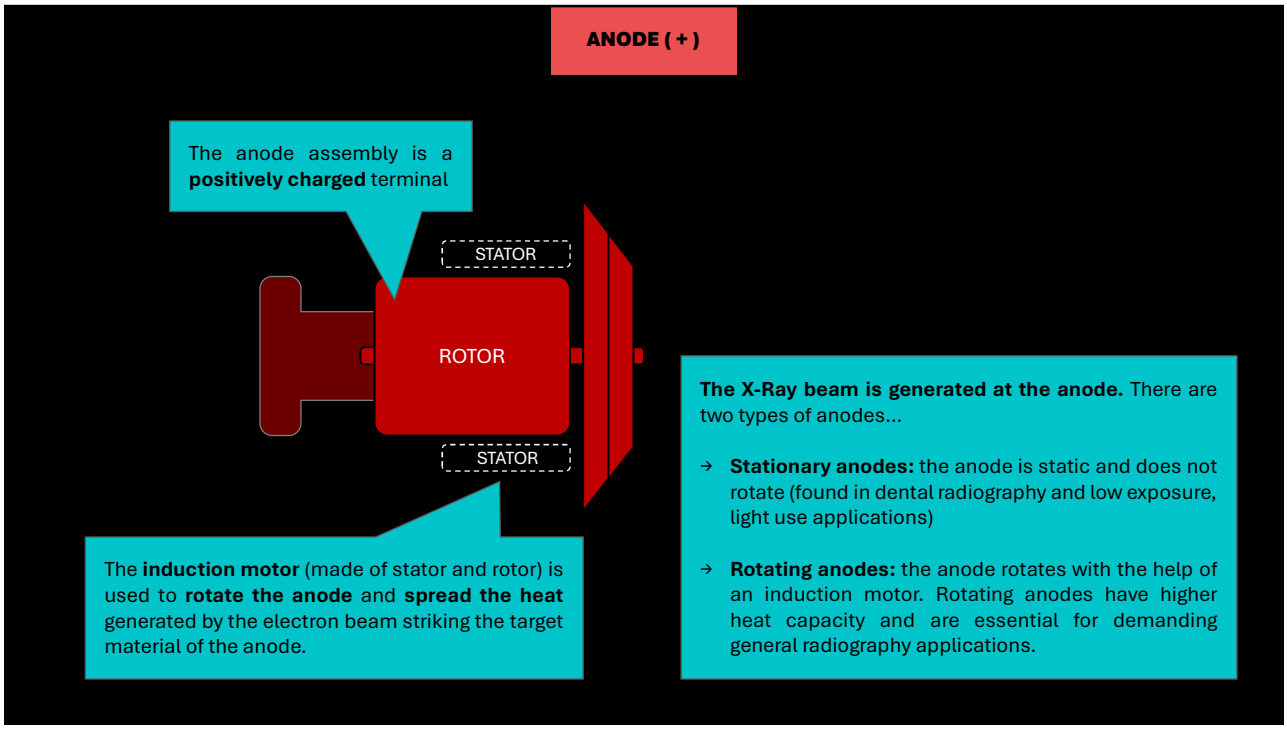
10


CATHODE (-)
Some cathodes have two filaments (dual focus). A **small filament** used to output **low mA** for **small body parts** and a **large filament** used to output **high mA** for **large body parts**.
As an added benefit, the small filament creates a narrower electron beam, which therefore creates a more focused X-Ray beam. **This results in higher spatial resolution.**

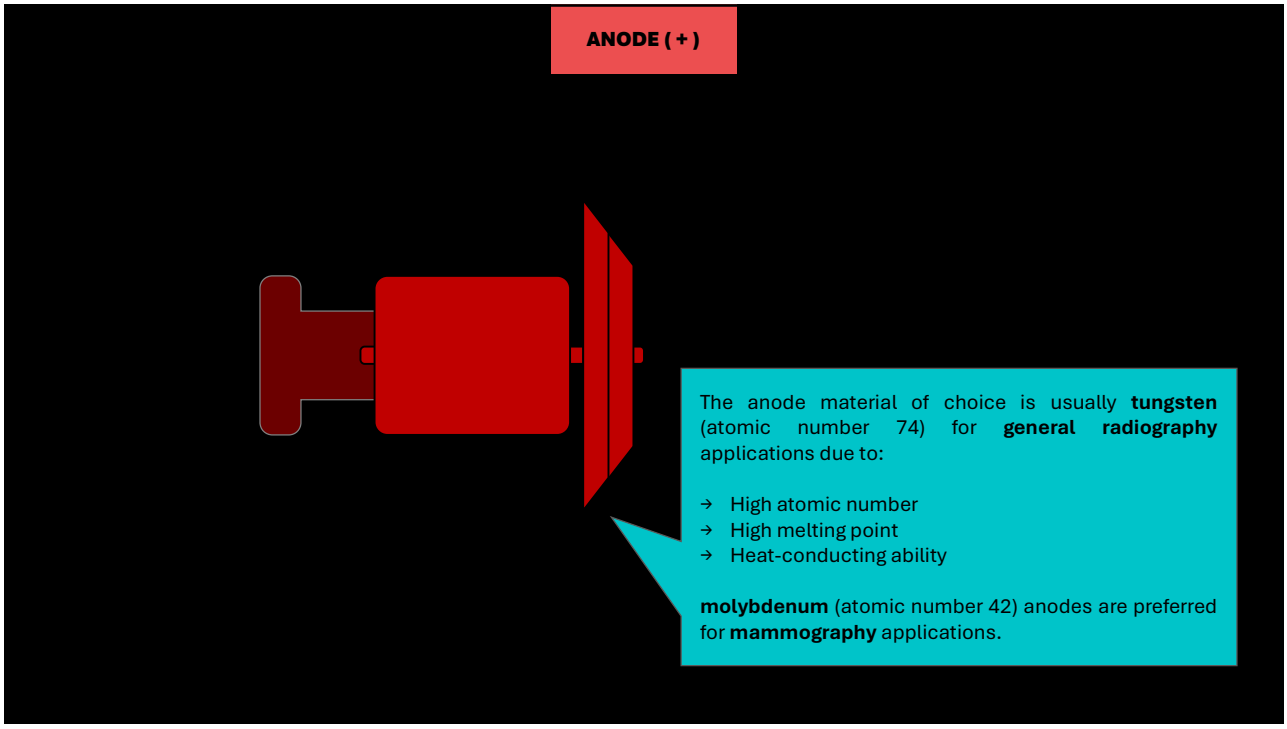
11


ANODE (+)

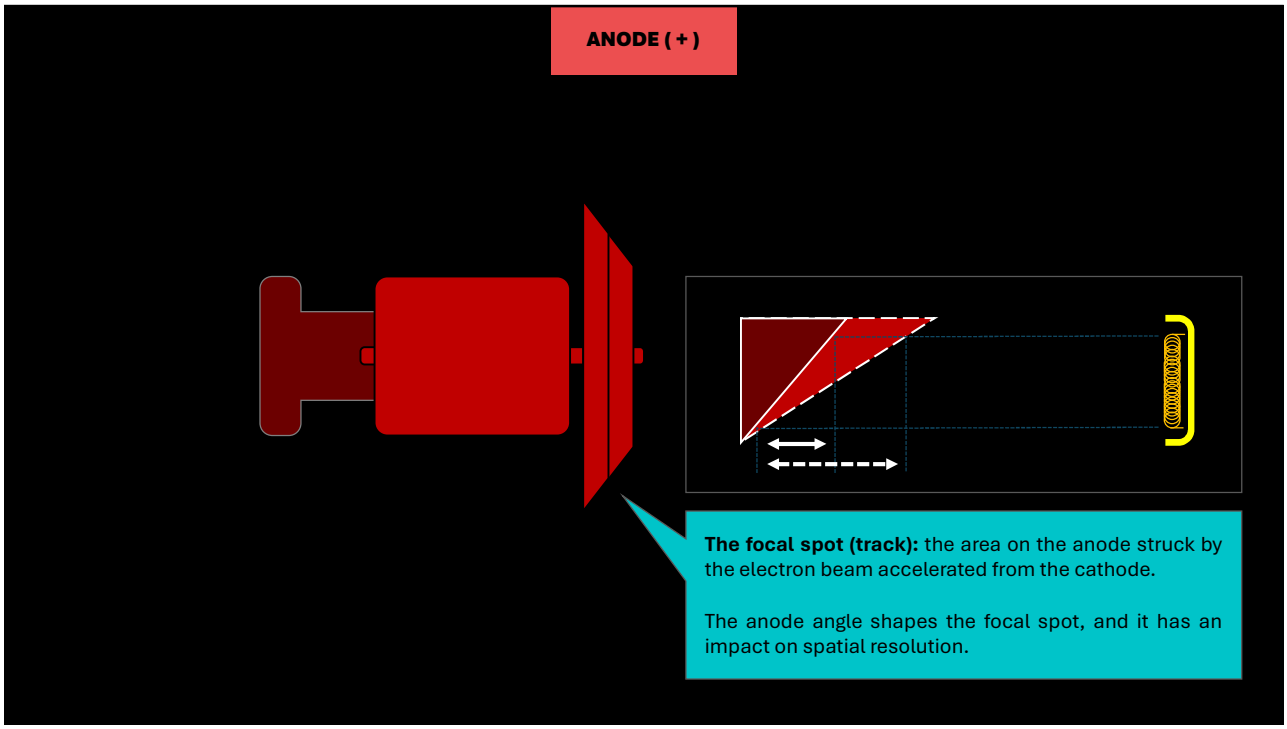
12


ANODE (+)
The anode assembly is a **positively charged** terminal
STATOR
ROTOR
STATOR
The **induction motor** (made of stator and rotor) is used to **rotate the anode** and **spread the heat** generated by the electron beam striking the target material of the anode.
The X-Ray beam is generated at the anode. There are two types of anodes...
→ **Stationary anodes:** the anode is static and does not rotate (found in dental radiography and low exposure, light use applications)
→ **Rotating anodes:** the anode rotates with the help of an induction motor. Rotating anodes have higher heat capacity and are essential for demanding general radiography applications.

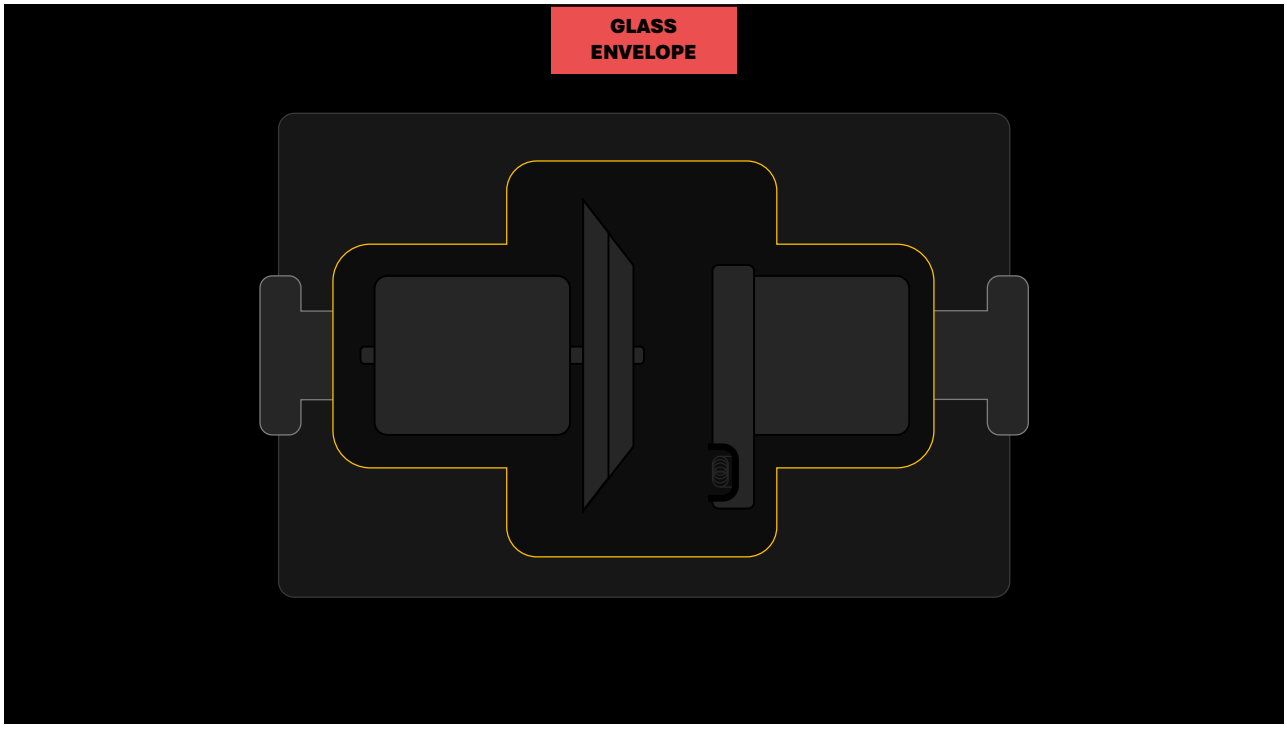
13


ANODE (+)
The anode material of choice is usually **tungsten** (atomic number 74) for **general radiography** applications due to:
→ High atomic number
→ High melting point
→ Heat-conducting ability
molybdenum (atomic number 42) anodes are preferred for **mammography** applications.

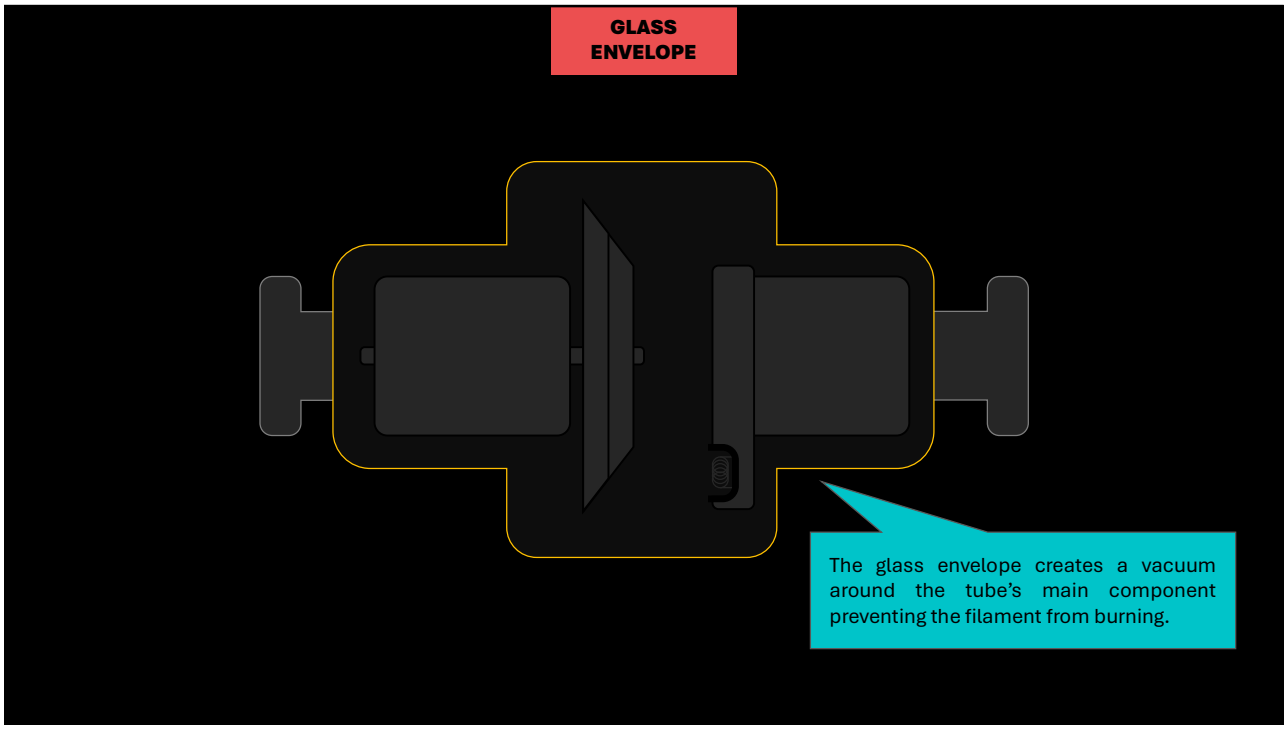
14


ANODE (+)
The focal spot (track): the area on the anode struck by the electron beam accelerated from the cathode.
The anode angle shapes the focal spot, and it has an impact on spatial resolution.

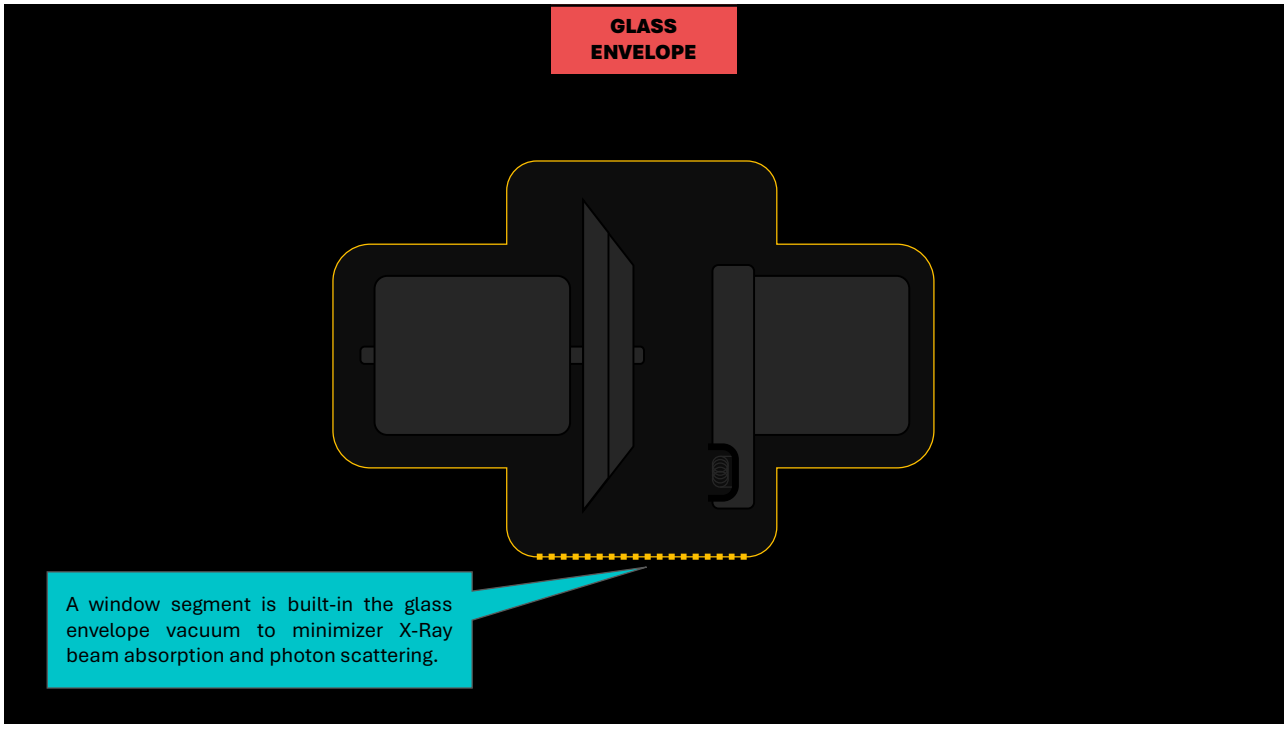
15


GLASS ENVELOPE

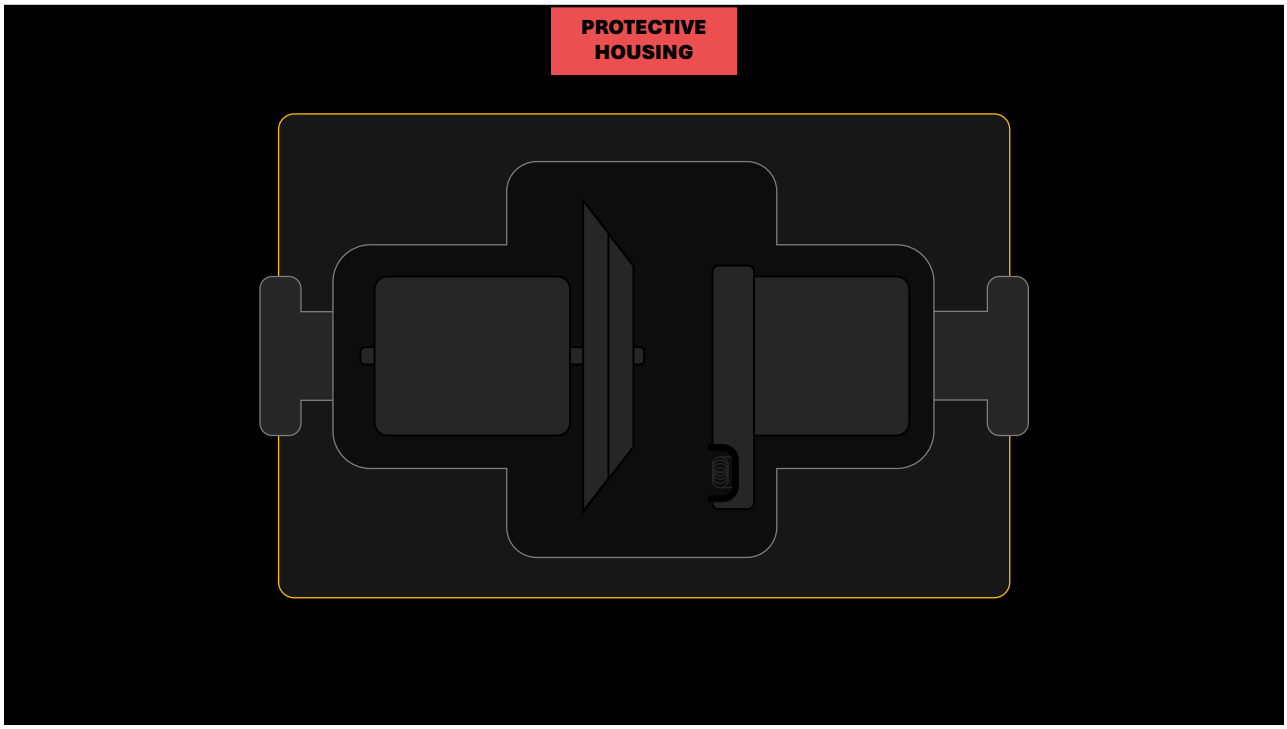
16


GLASS ENVELOPE
The glass envelope creates a vacuum around the tube's main component preventing the filament from burning.

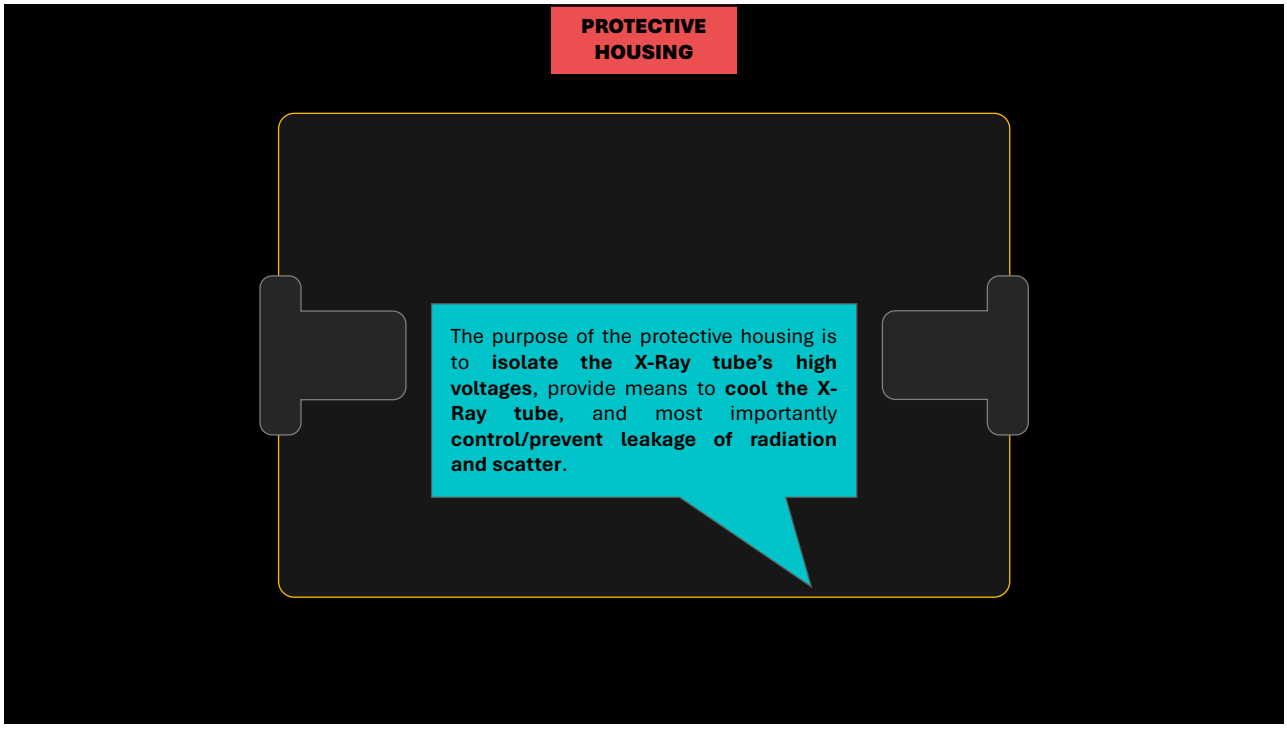
17


GLASS ENVELOPE
A window segment is built-in the glass envelope vacuum to minimizer X-Ray beam absorption and photon scattering.

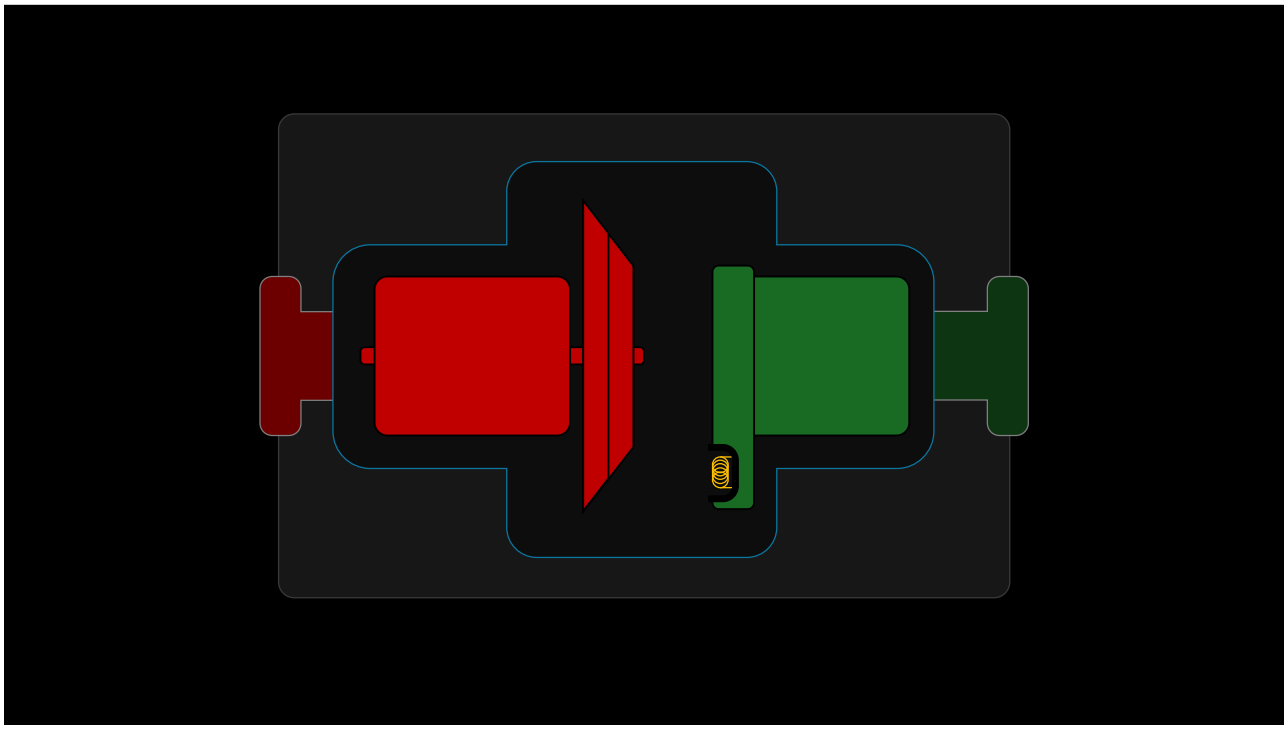
18


PROTECTIVE HOUSING

19


PROTECTIVE HOUSING
The purpose of the protective housing is to **isolate the X-Ray tube's high voltages**, provide means to **cool the X-Ray tube**, and most importantly **control/prevent leakage of radiation and scatter**.

20



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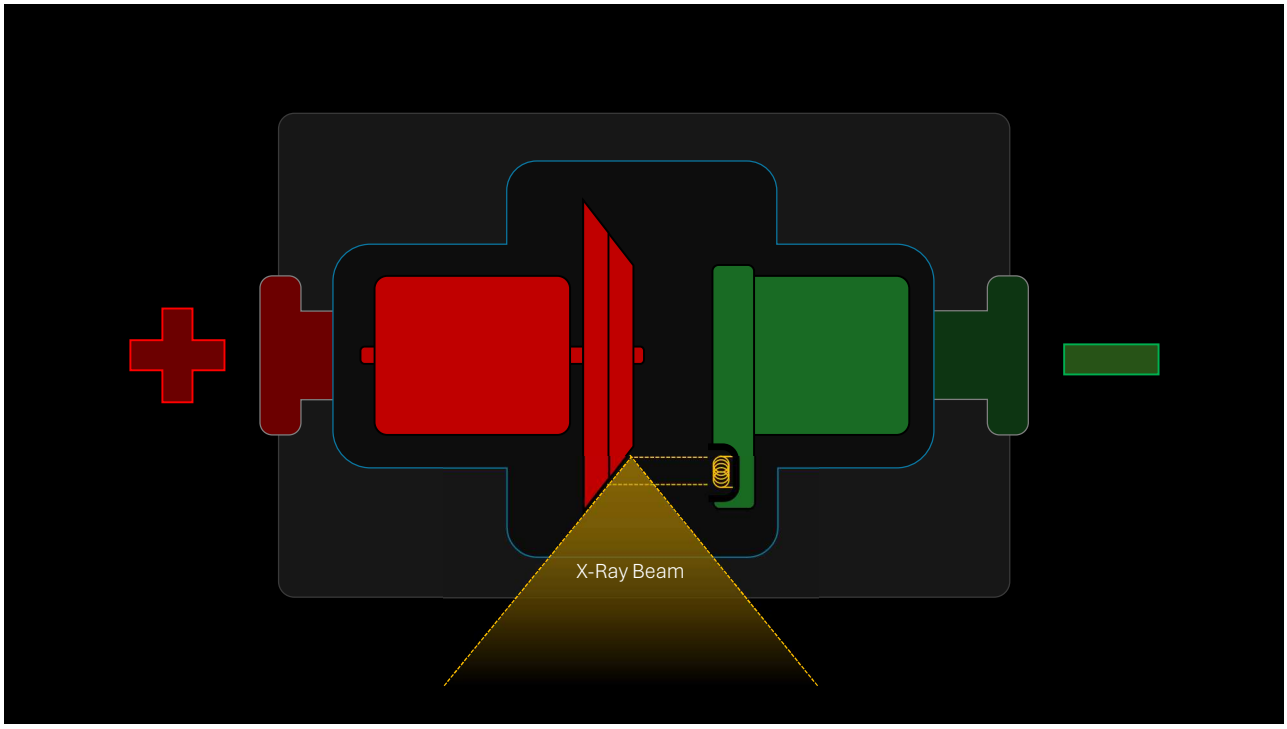

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ANODE HEAL EFFECT

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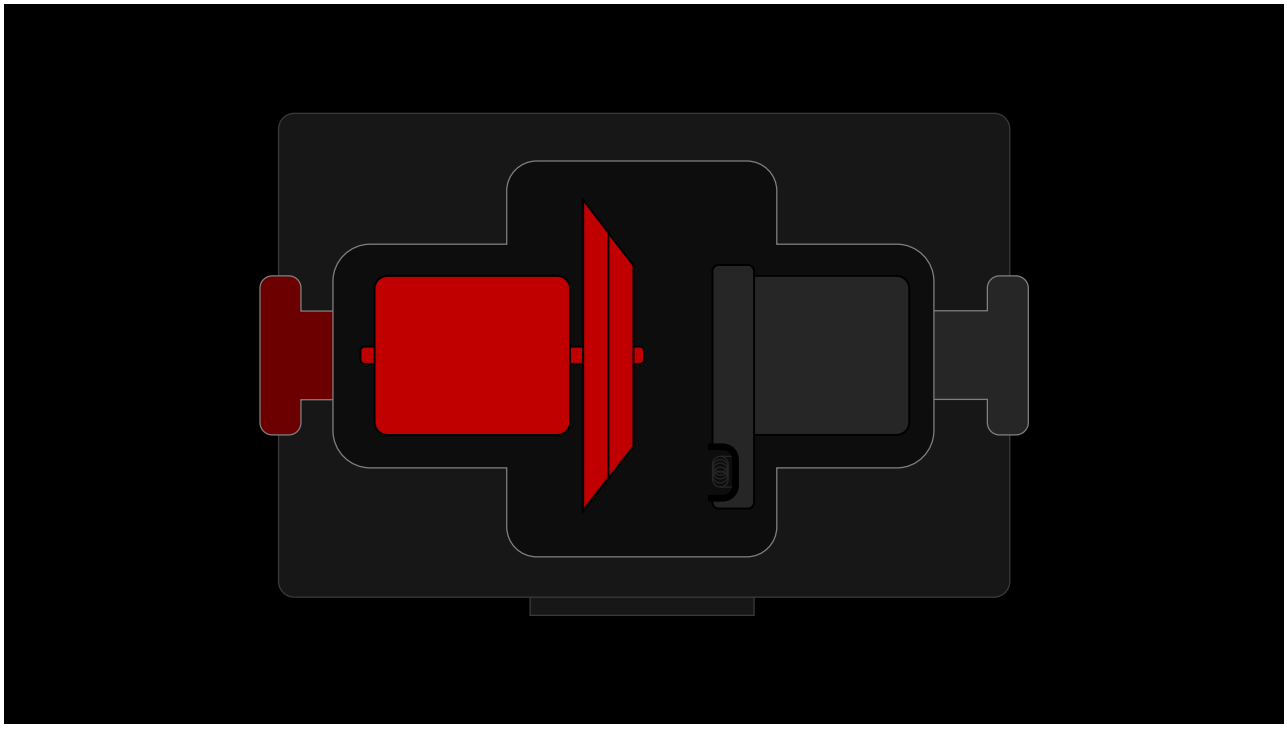

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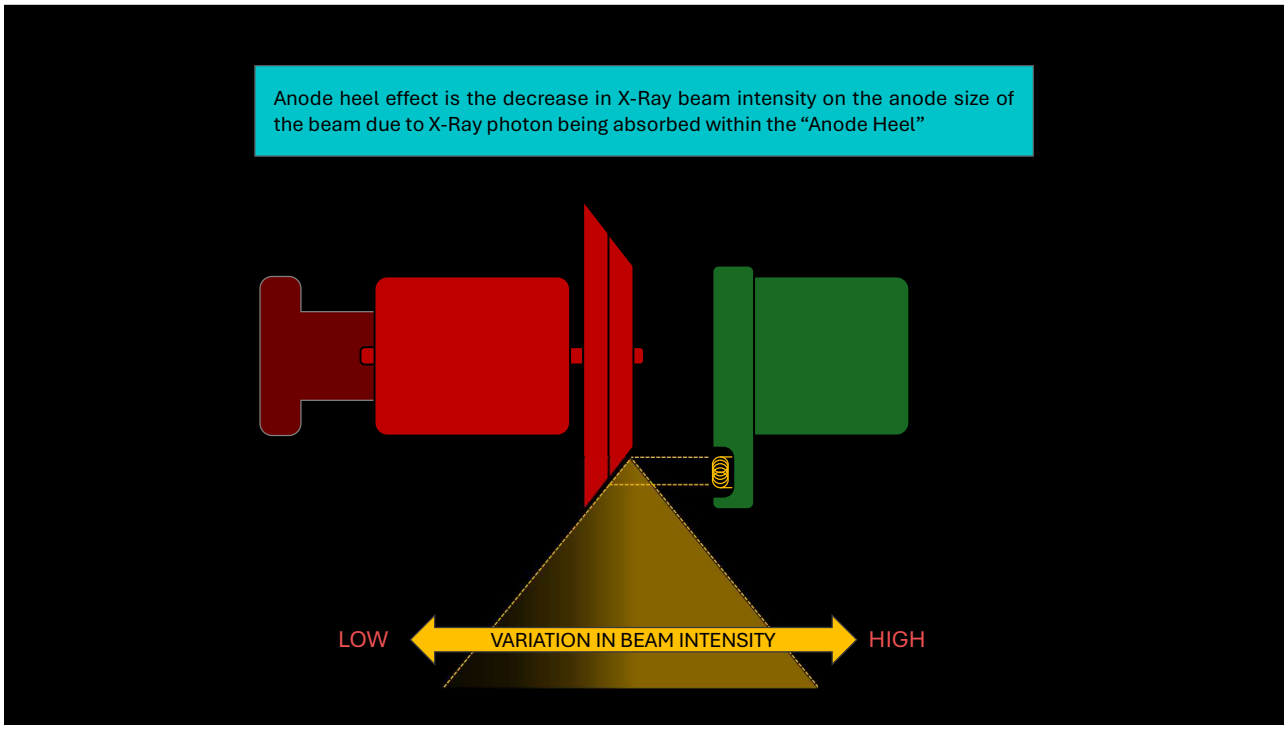
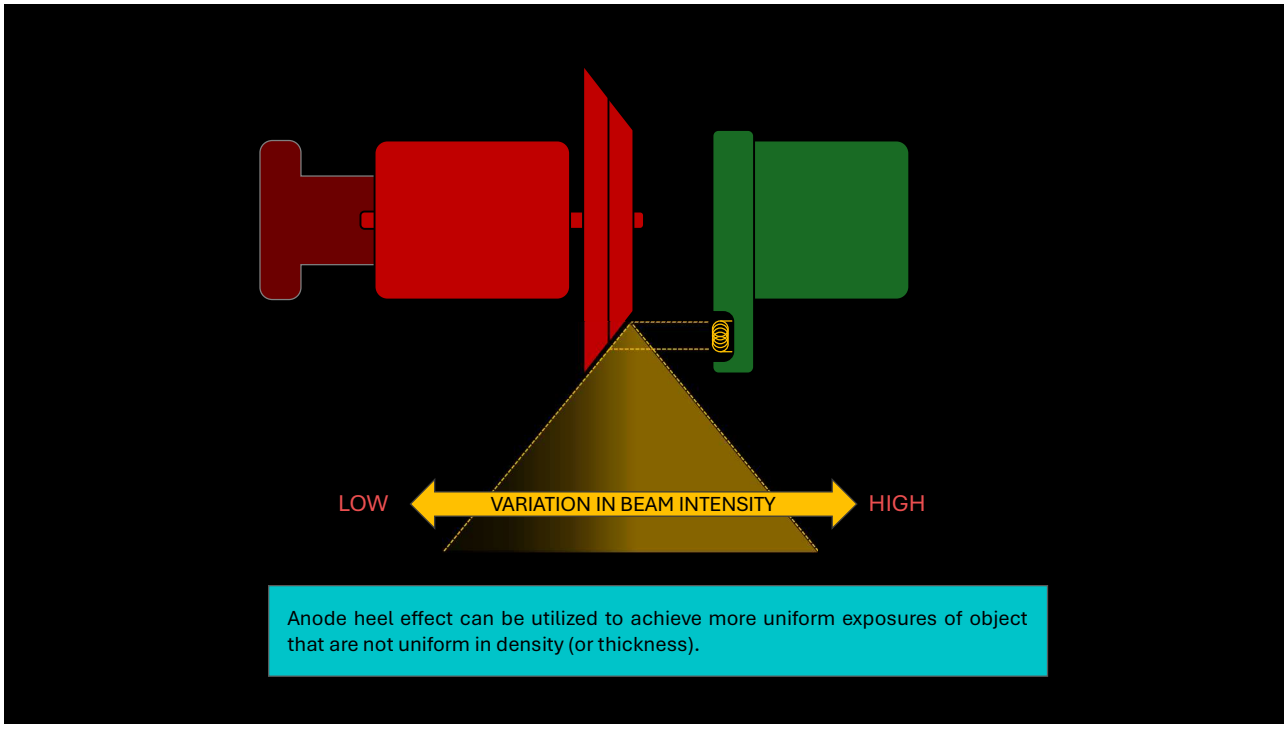
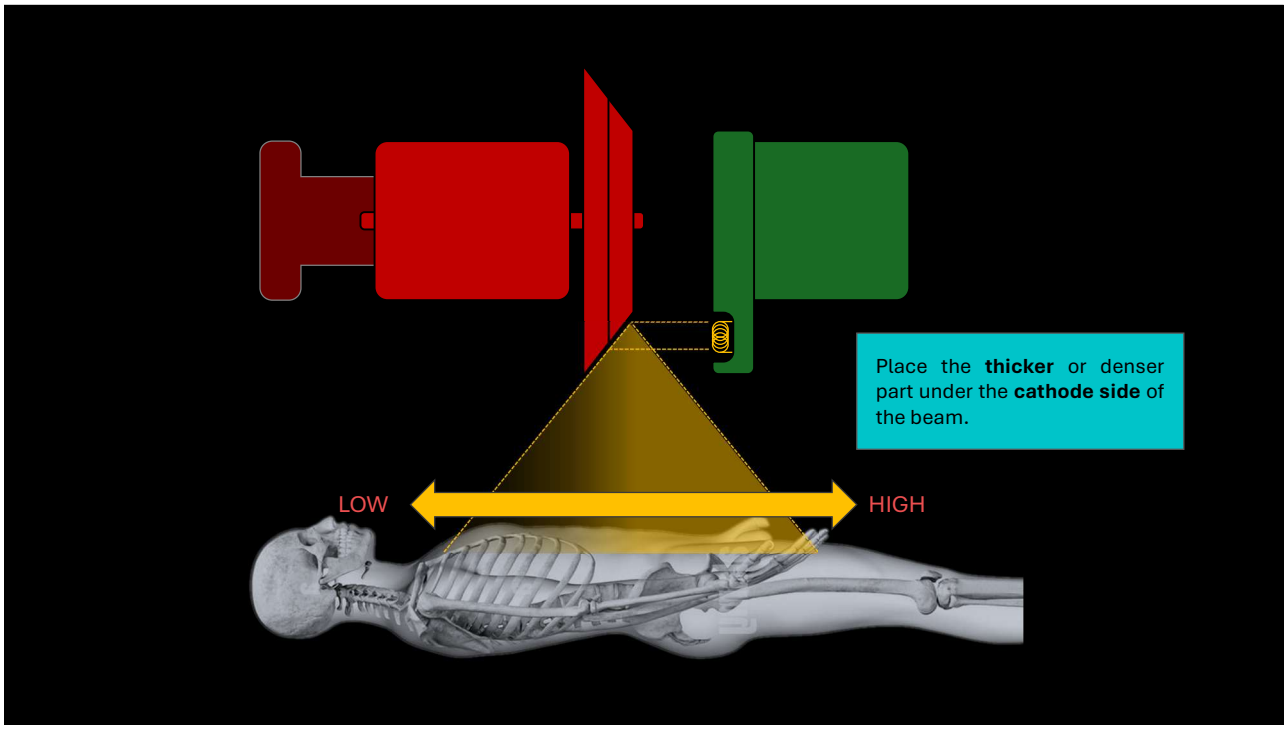

Anode heel effect is the decrease in X-Ray beam intensity on the anode size of the beam due to X-Ray photon being absorbed within the “Anode Heel”
LOW
VARIATION IN BEAM INTENSITY
HIGH

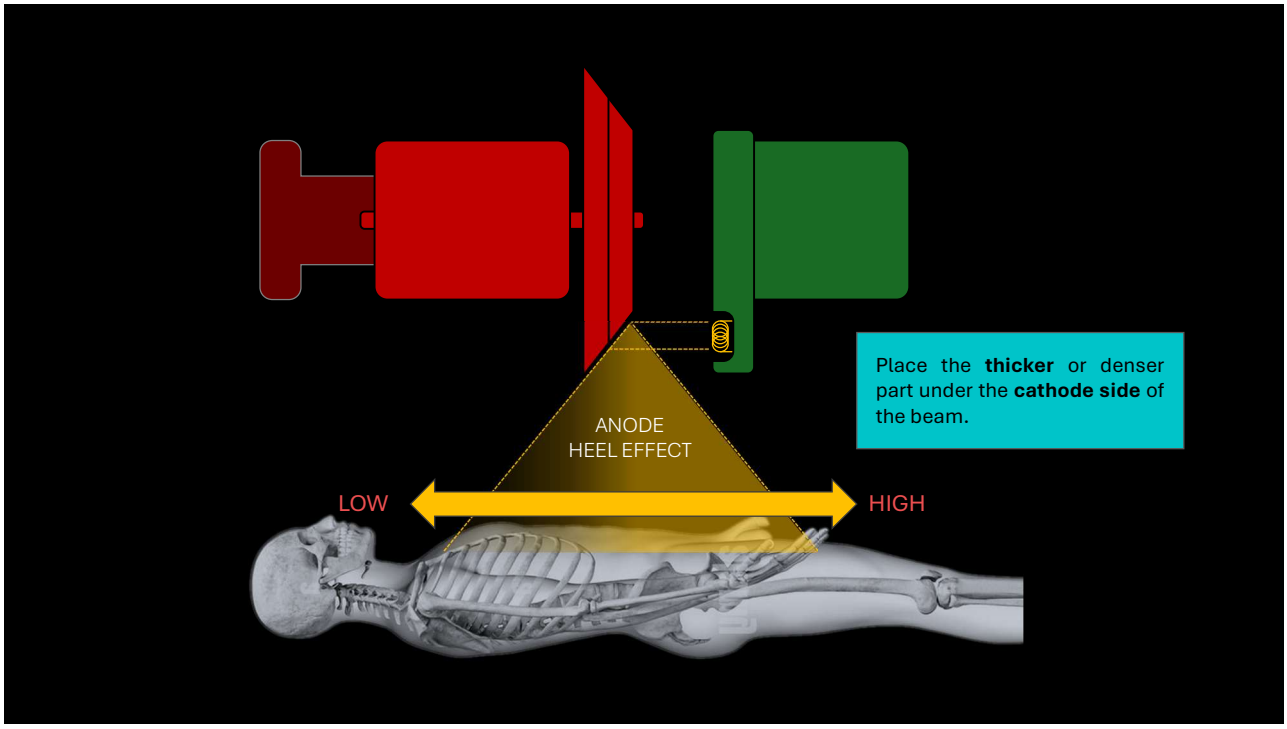
25


LOW
VARIATION IN BEAM INTENSITY
HIGH
Anode heel effect can be utilized to achieve more uniform exposures of object that are not uniform in density (or thickness).

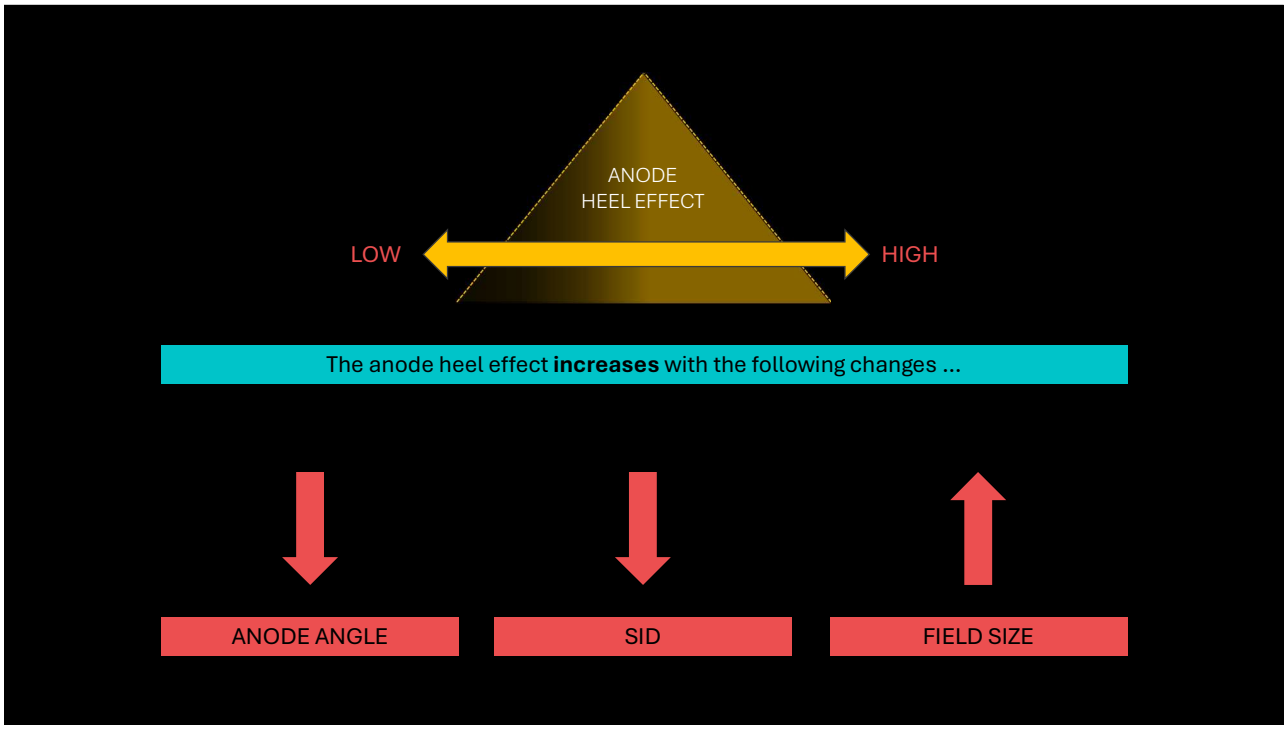
26


Place the **thicker** or denser part under the **cathode side** of the beam.
LOW
HIGH

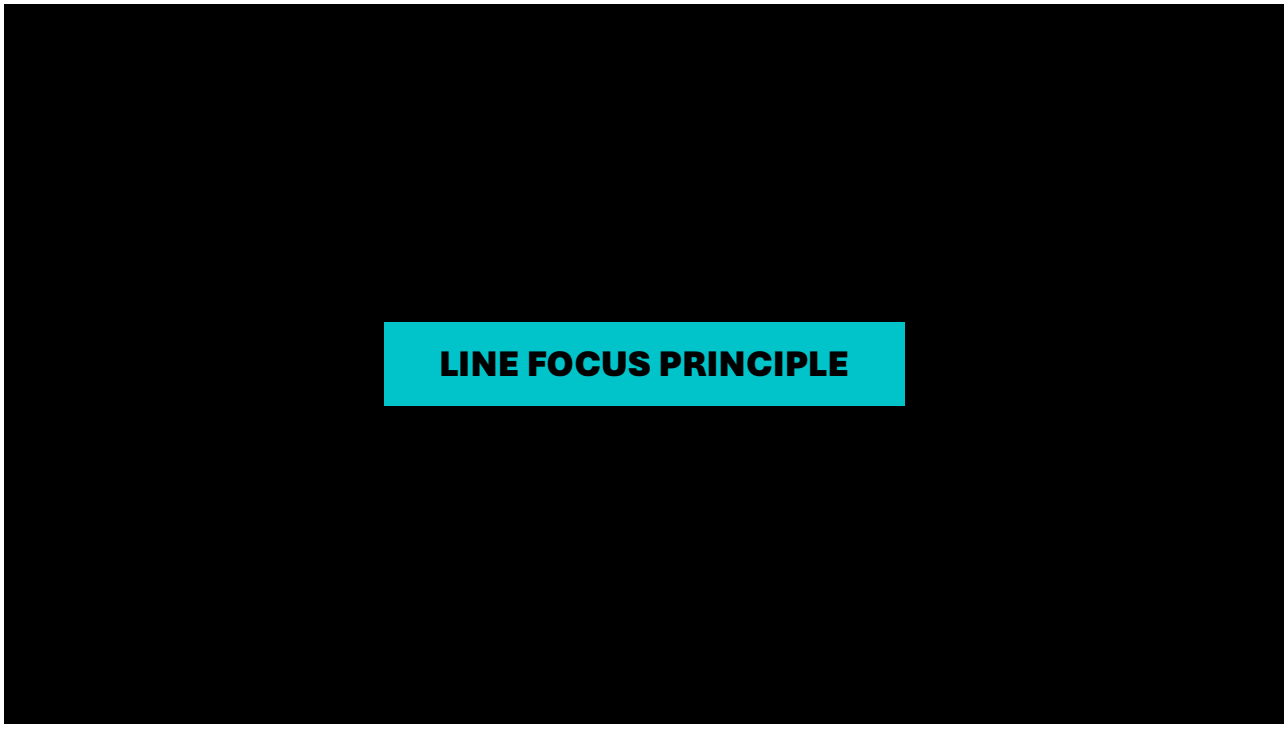
27


Place the **thicker** or denser part under the **cathode side** of the beam.
ANODE
HEEL EFFECT
LOW
HIGH

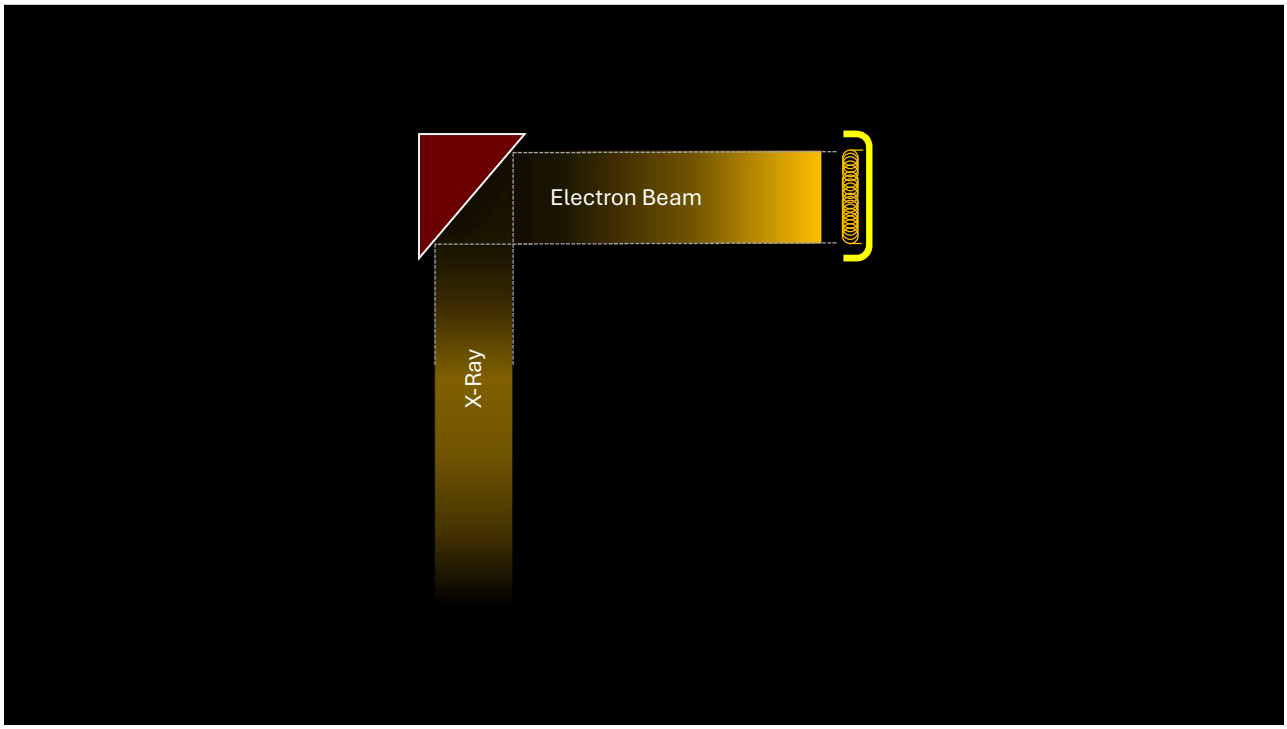
28


ANODE
HEEL EFFECT
LOW
HIGH
The anode heel effect **increases** with the following changes ...
ANODE ANGLE
SID
FIELD SIZE

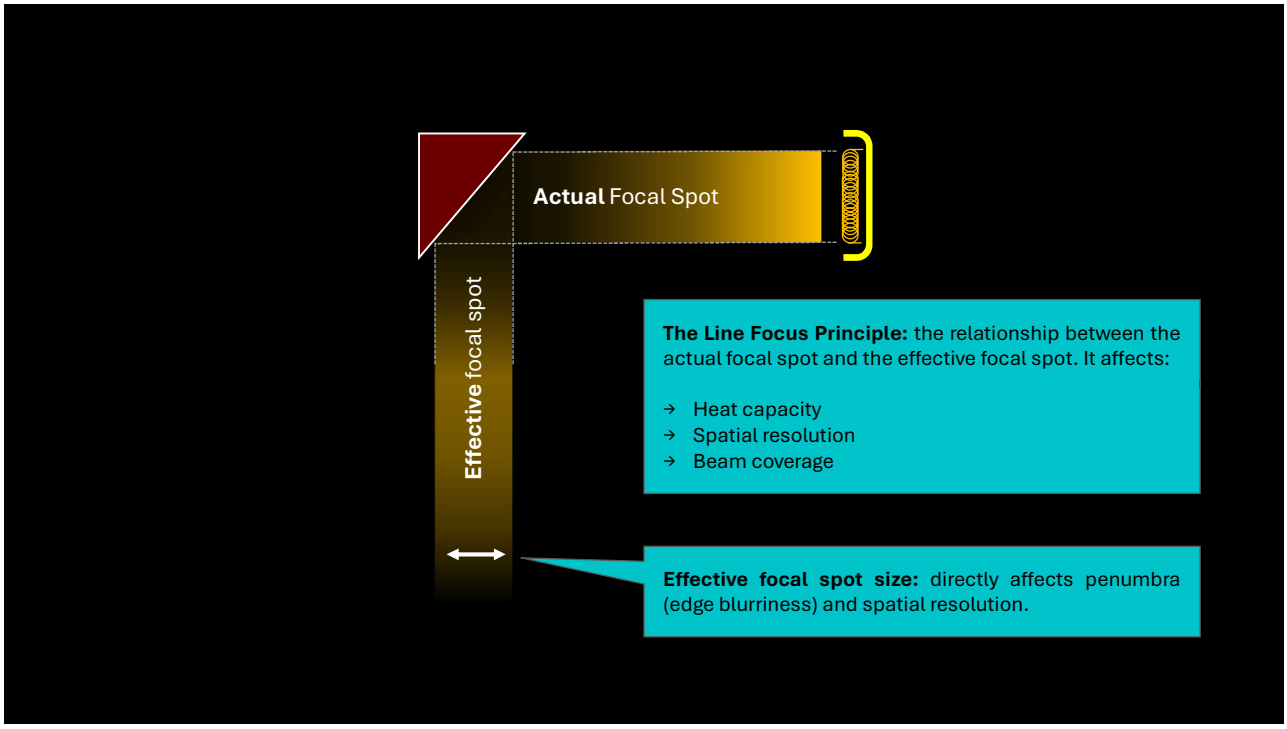
29


LINE FOCUS PRINCIPLE

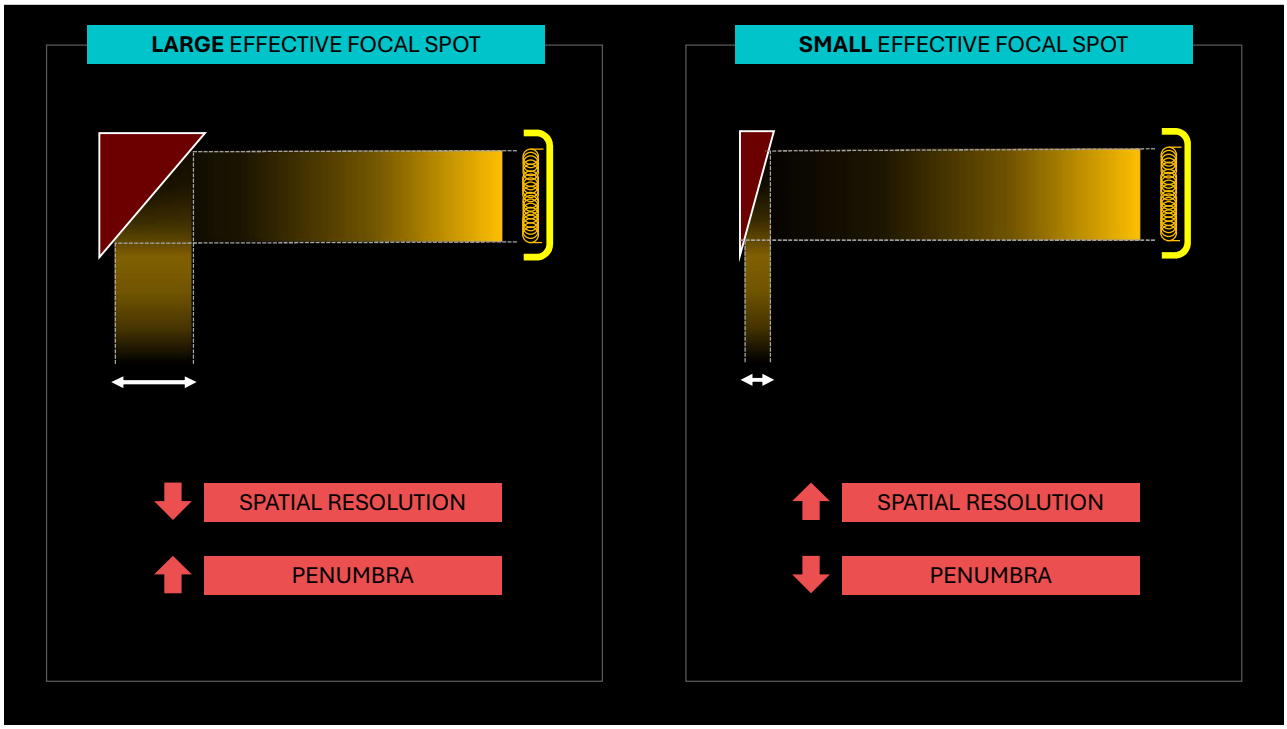
30


Electron Beam
X-Ray

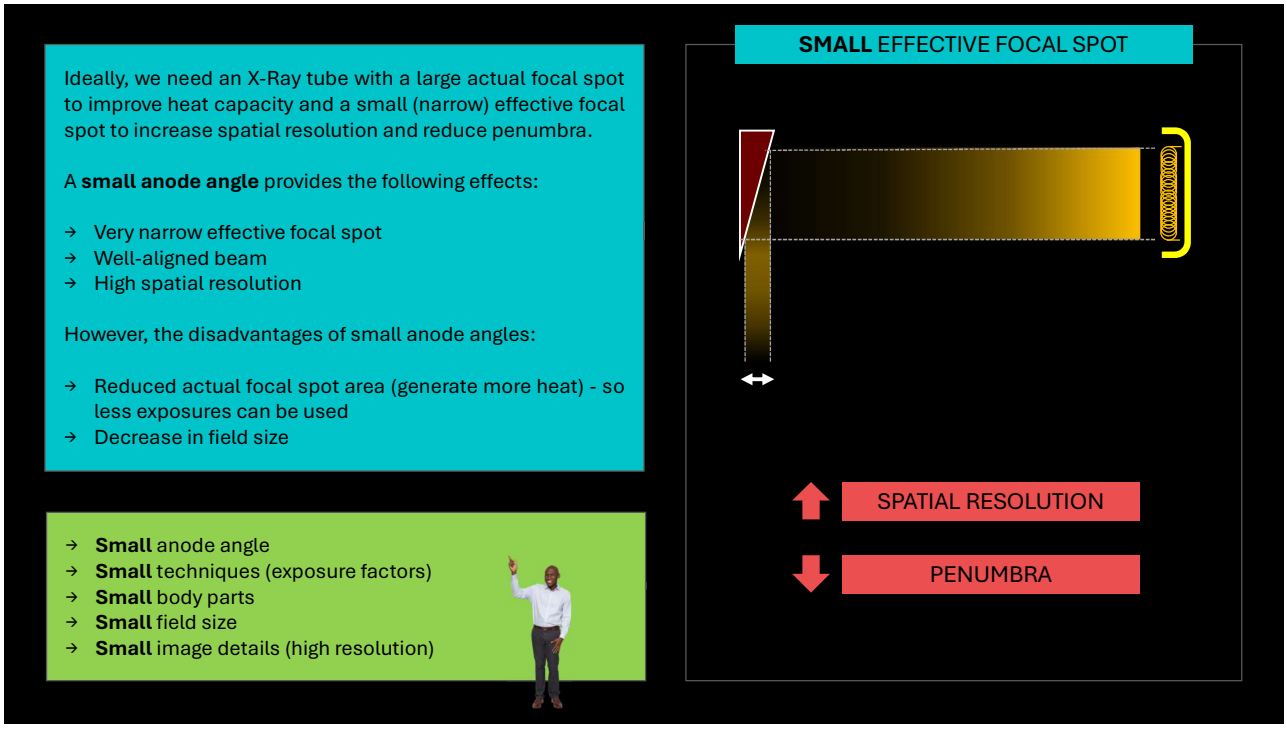
31


Actual Focal Spot
Effective focal spot
The Line Focus Principle: the relationship between the actual focal spot and the effective focal spot. It affects:
→ Heat capacity
→ Spatial resolution
→ Beam coverage
Effective focal spot size: directly affects penumbra (edge blurriness) and spatial resolution.

32


LARGE EFFECTIVE FOCAL SPOT
SPATIAL RESOLUTION
PENUMBRA
SMALL EFFECTIVE FOCAL SPOT
SPATIAL RESOLUTION
PENUMBRA

33


Ideally, we need an X-Ray tube with a large actual focal spot to improve heat capacity and a small (narrow) effective focal spot to increase spatial resolution and reduce penumbra.
A small anode angle provides the following effects:
→ Very narrow effective focal spot
→ Well-aligned beam
→ High spatial resolution
However, the disadvantages of small anode angles:
→ Reduced actual focal spot area (generate more heat) - so less exposures can be used
→ Decrease in field size
→ Small anode angle
→ Small techniques (exposure factors)
→ Small body parts
→ Small field size
→ Small image details (high resolution)
SMALL EFFECTIVE FOCAL SPOT
SPATIAL RESOLUTION
PENUMBRA

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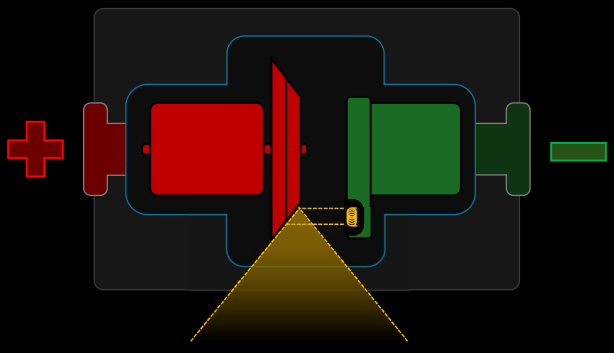
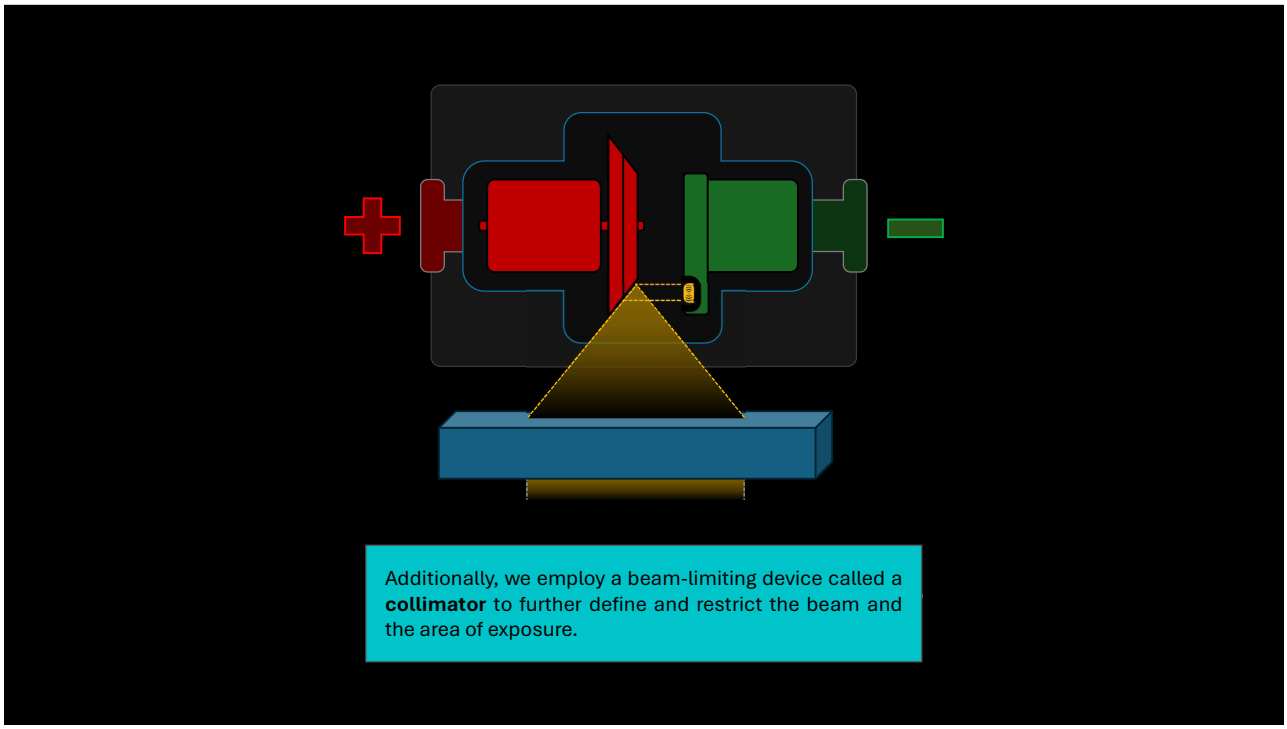
OFF-FOCUS RADIATION

35

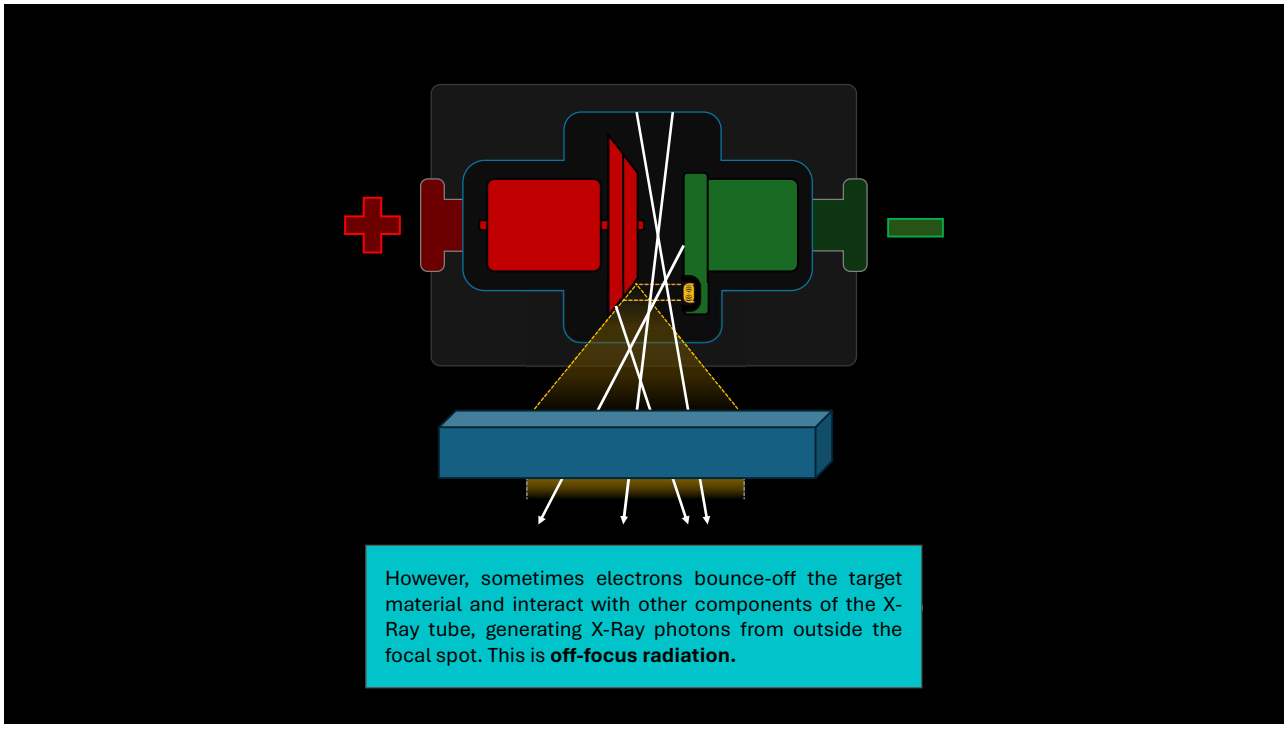


Most of the X-Ray beam is generated from the electron beam interacting with the anode's target material. This generates X-Ray photons that are aligned with each other.

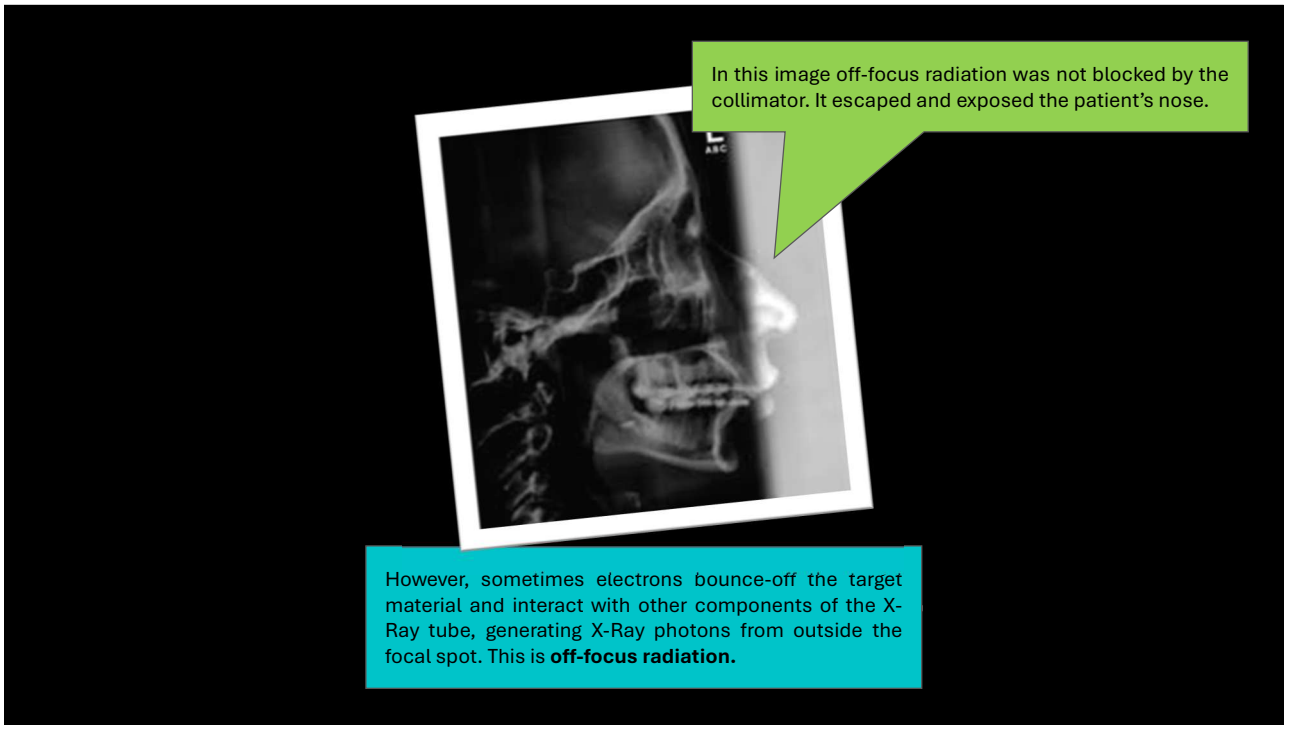
36


Additionally, we employ a beam-limiting device called a **collimator** to further define and restrict the beam and the area of exposure.

37


However, sometimes electrons bounce-off the target material and interact with other components of the X-Ray tube, generating X-Ray photons from outside the focal spot. This is **off-focus radiation.**

38


In this image off-focus radiation was not blocked by the collimator. It escaped and exposed the patient's nose.
However, sometimes electrons bounce-off the target material and interact with other components of the X-Ray tube, generating X-Ray photons from outside the focal spot. This is **off-focus radiation.**

39

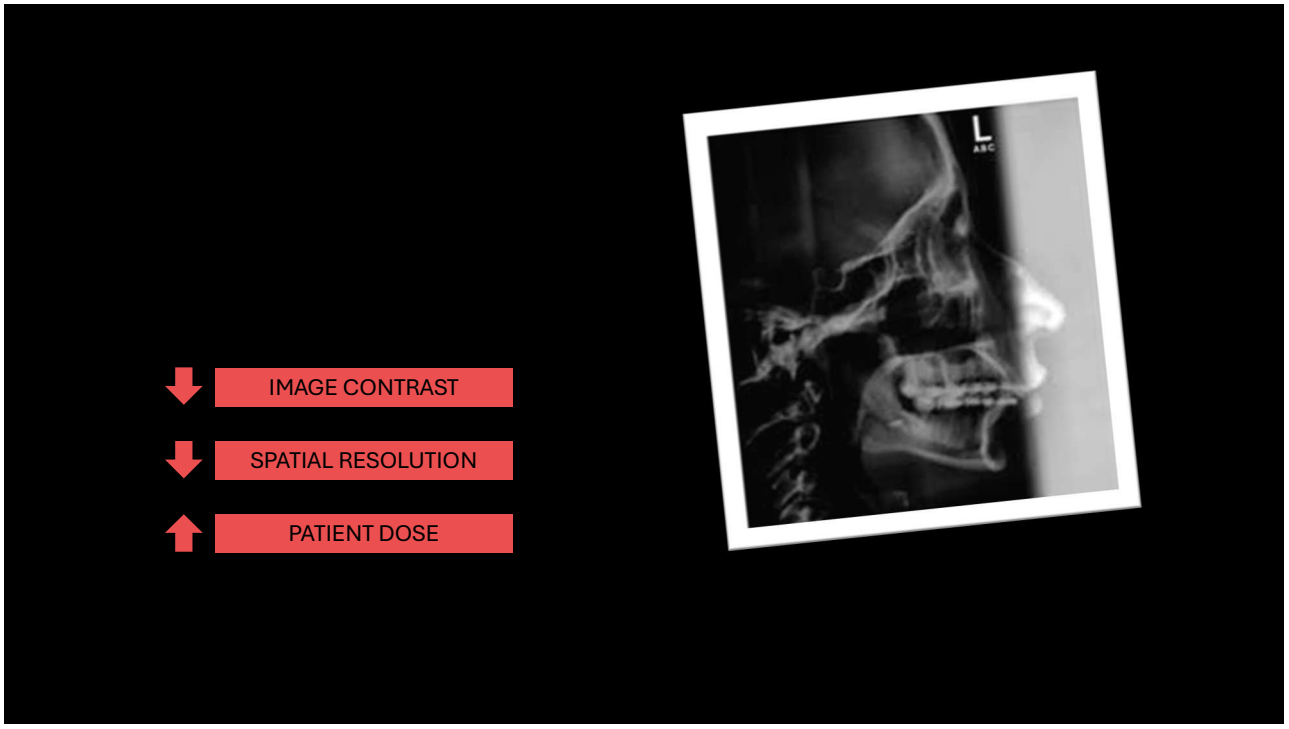
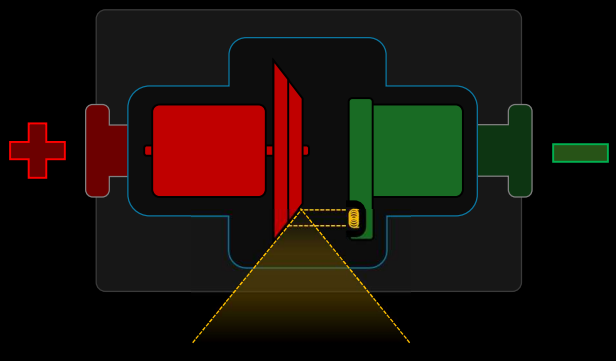


IMAGE CONTRAST
SPATIAL RESOLUTION
PATIENT DOSE

40

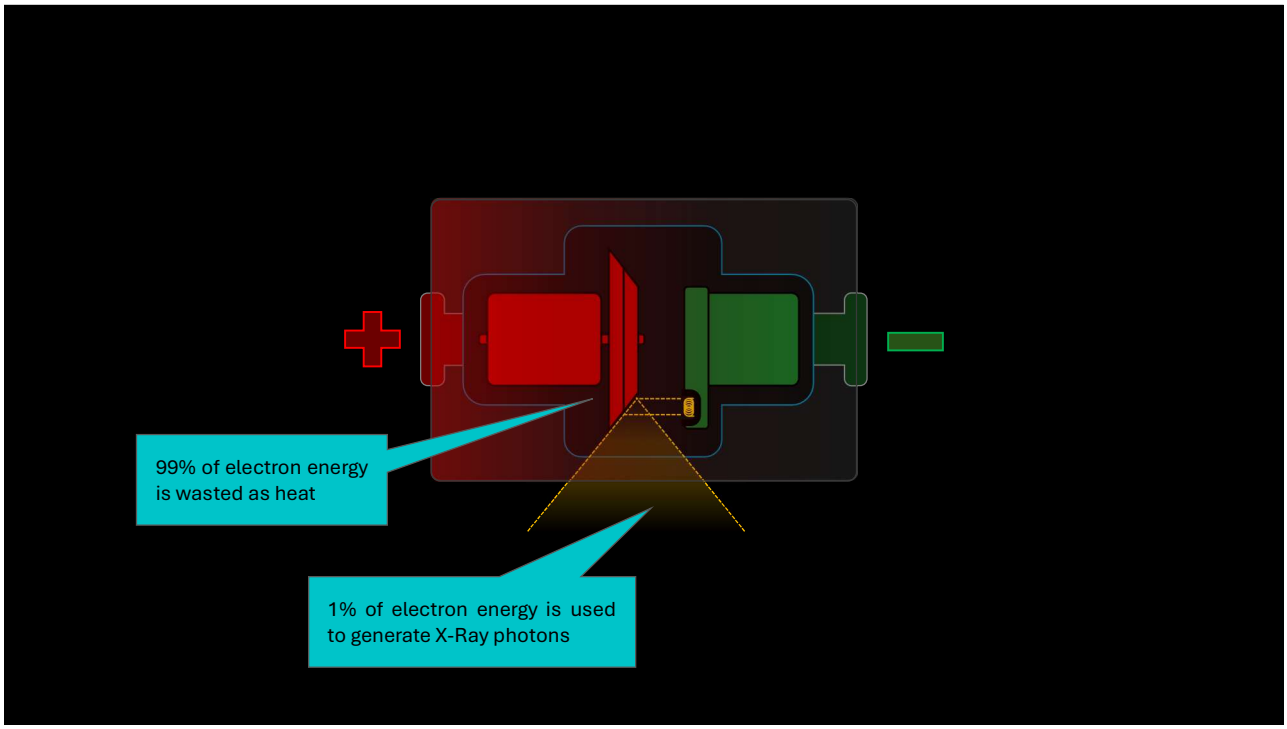
TUBE LOADING

41

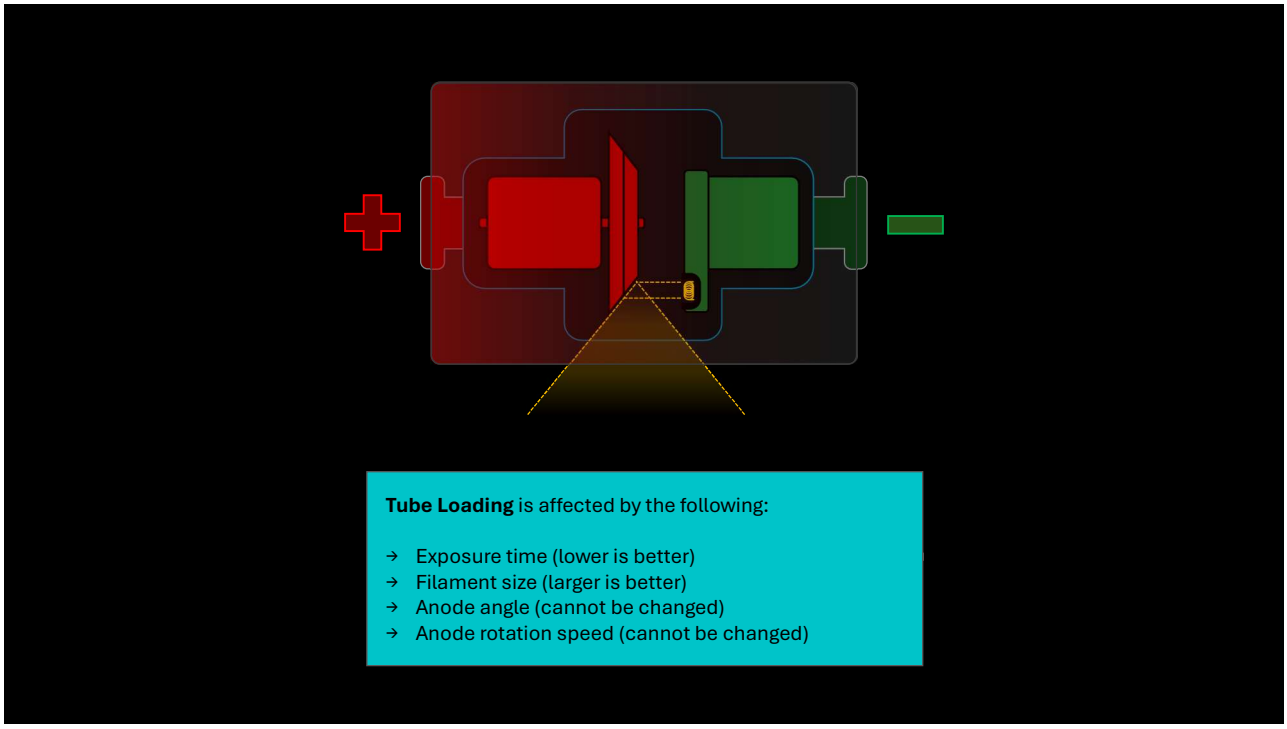


X-Ray generation is inefficient. It generates a large amount of heat. The heat created within the X-Ray tube during exposures is called **Tube Loading**.

42


99% of electron energy is wasted as heat
1% of electron energy is used to generate X-Ray photons

43


Tube Loading is affected by the following:
→ Exposure time (lower is better)
→ Filament size (larger is better)
→ Anode angle (cannot be changed)
→ Anode rotation speed (cannot be changed)

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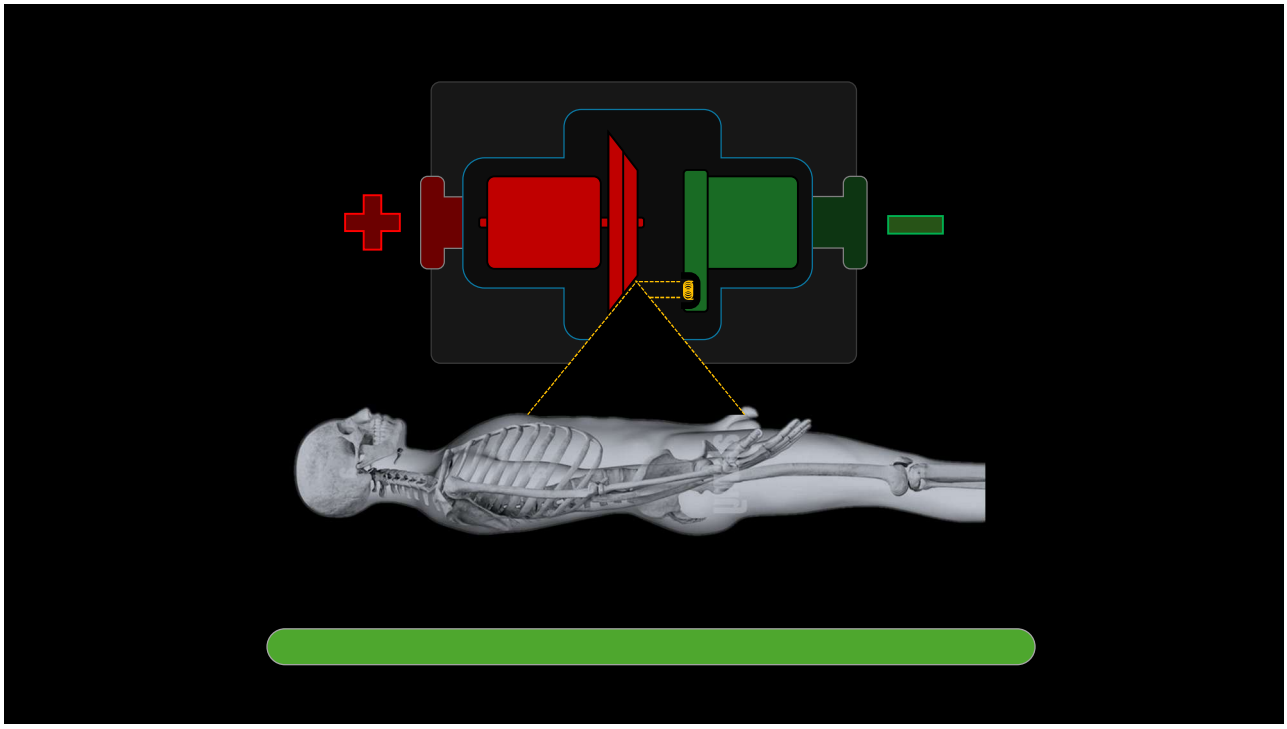
ANODE COOLING

45



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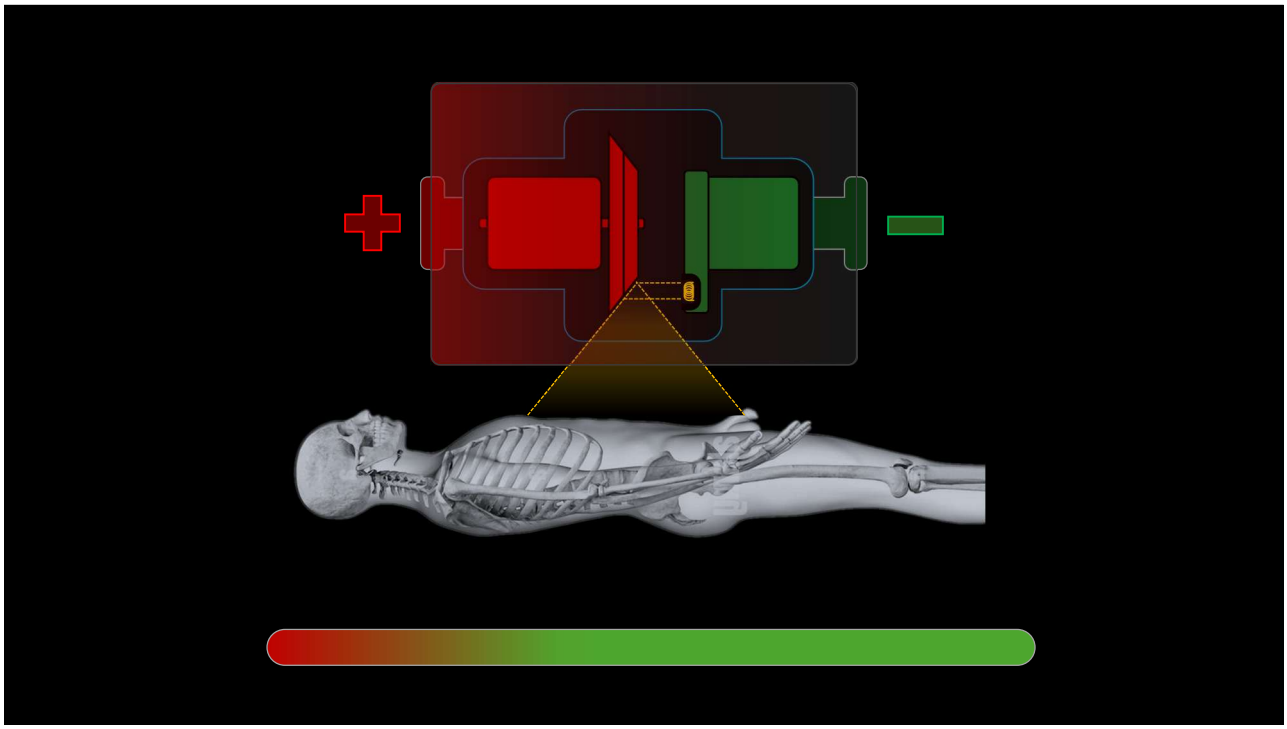

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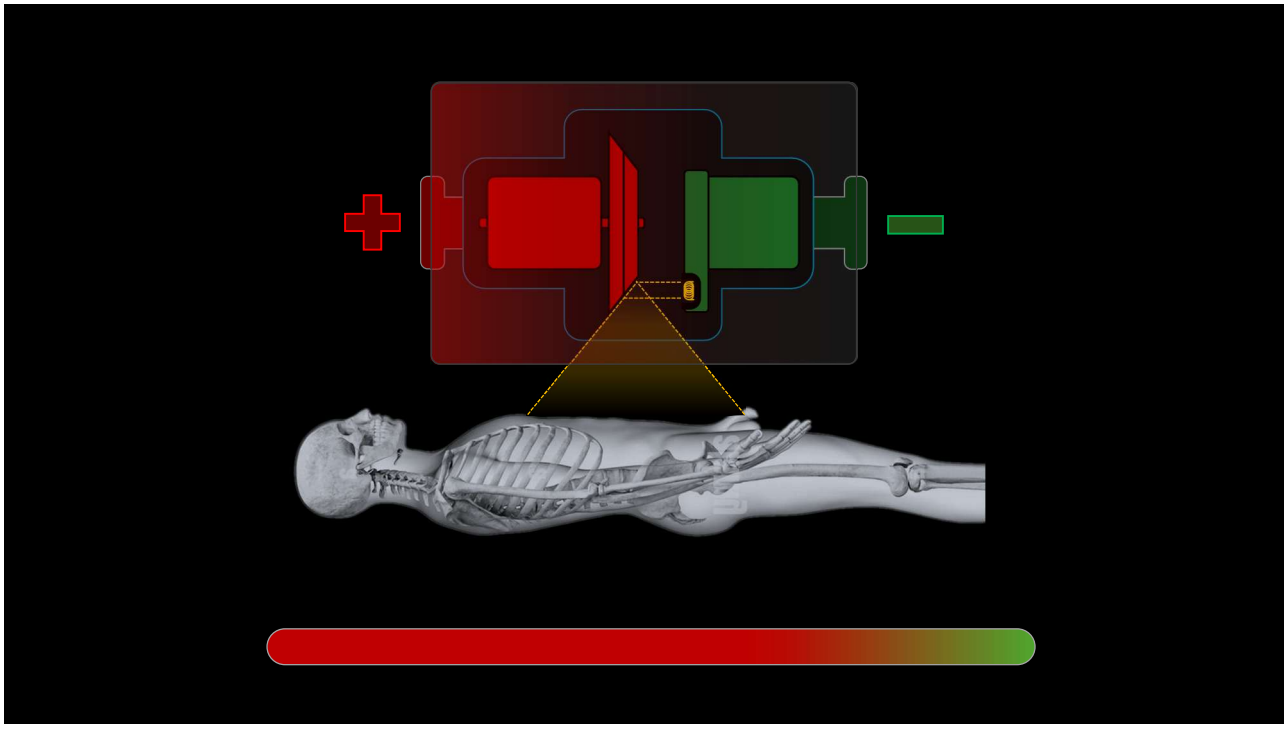

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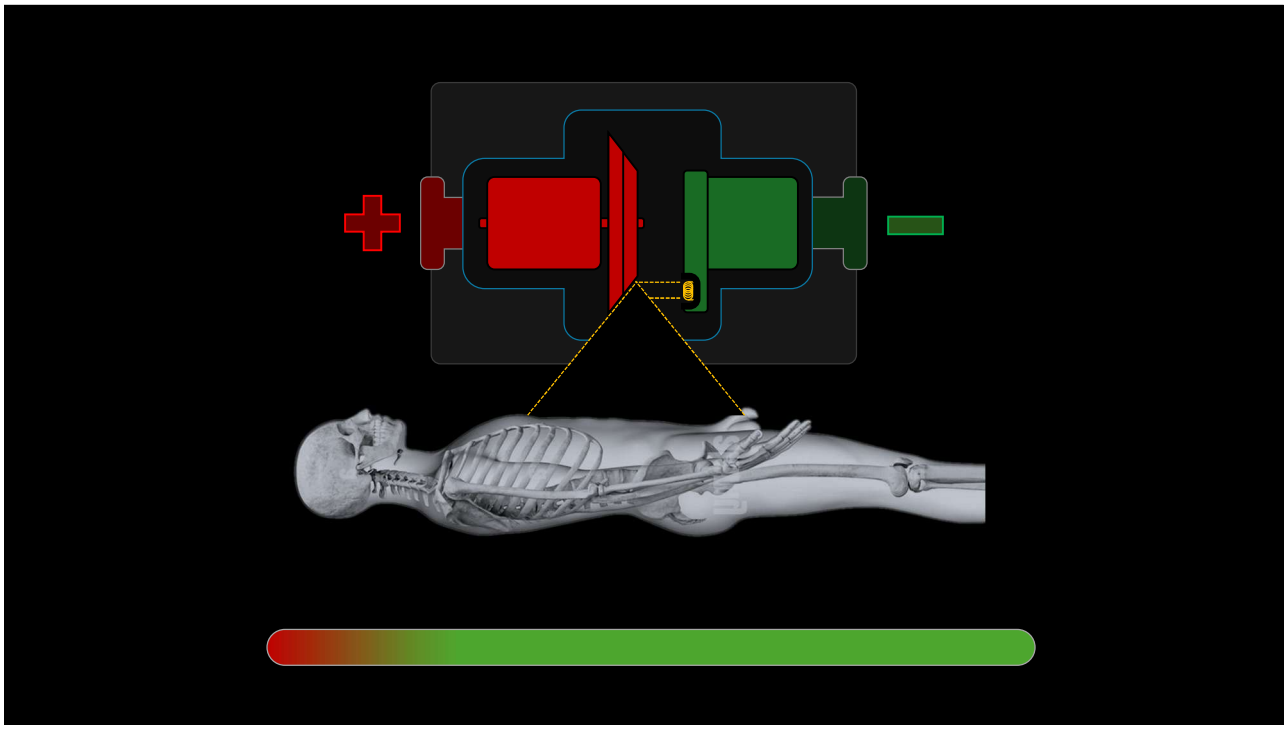

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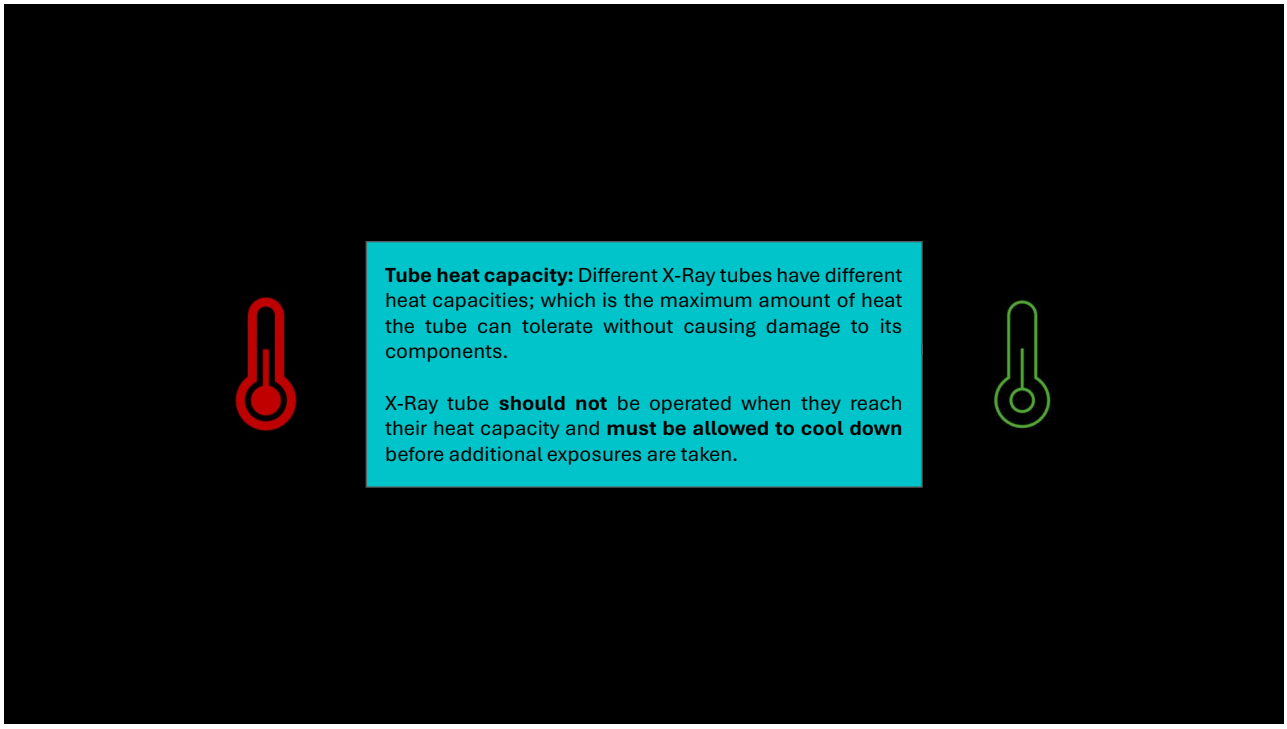
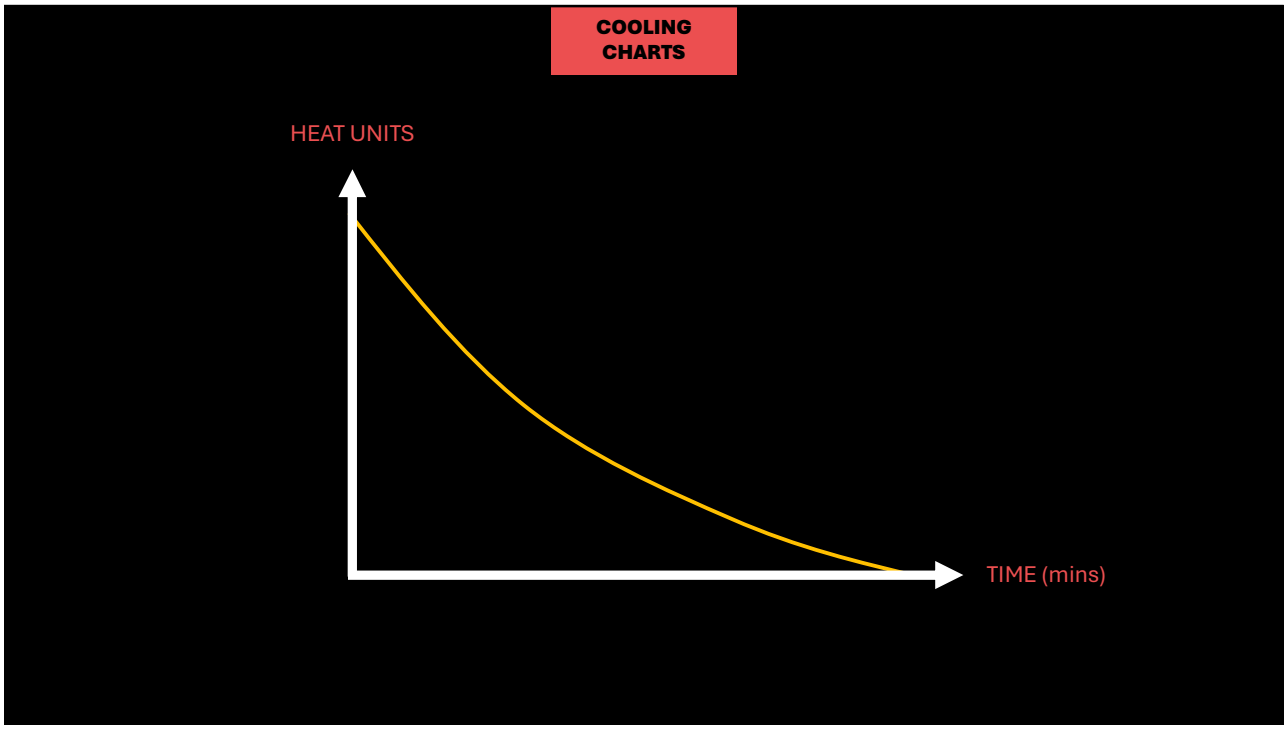

Tube heat capacity: Different X-Ray tubes have different heat capacities; which is the maximum amount of heat the tube can tolerate without causing damage to its components.
X-Ray tube **should not** be operated when they reach their heat capacity and **must be allowed to cool down** before additional exposures are taken.

50



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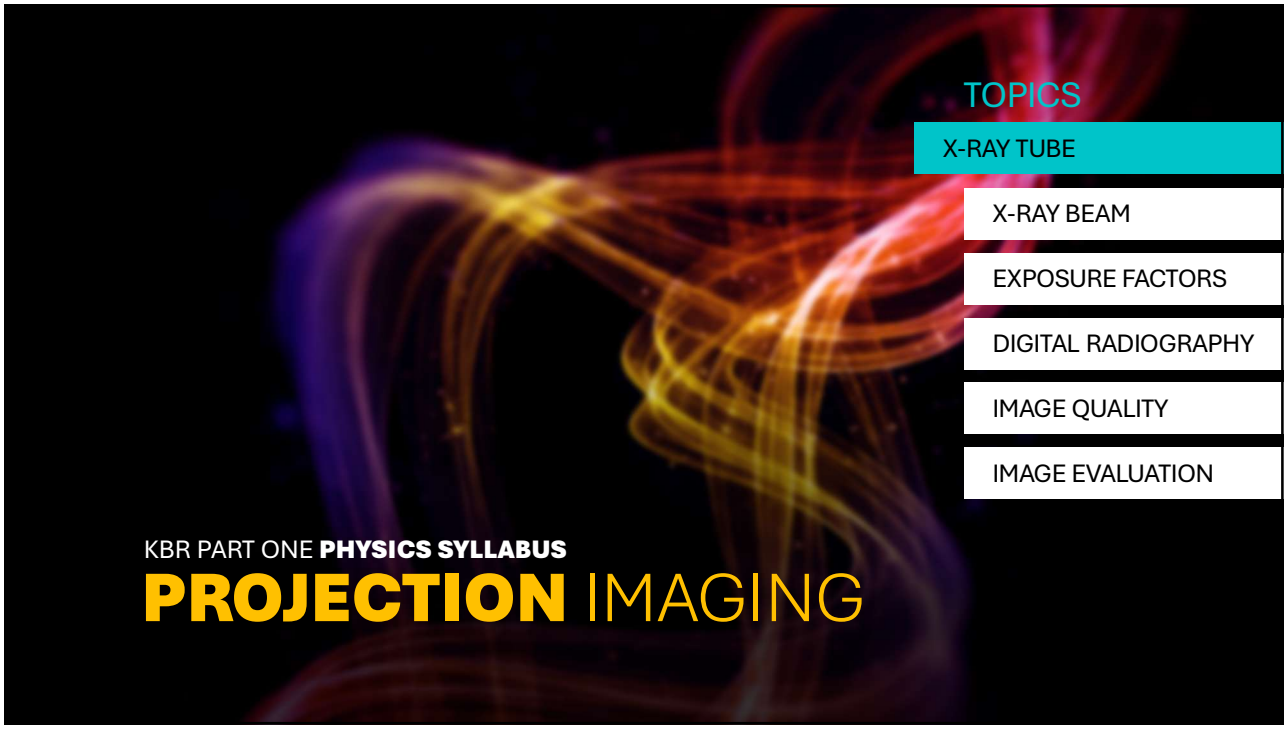
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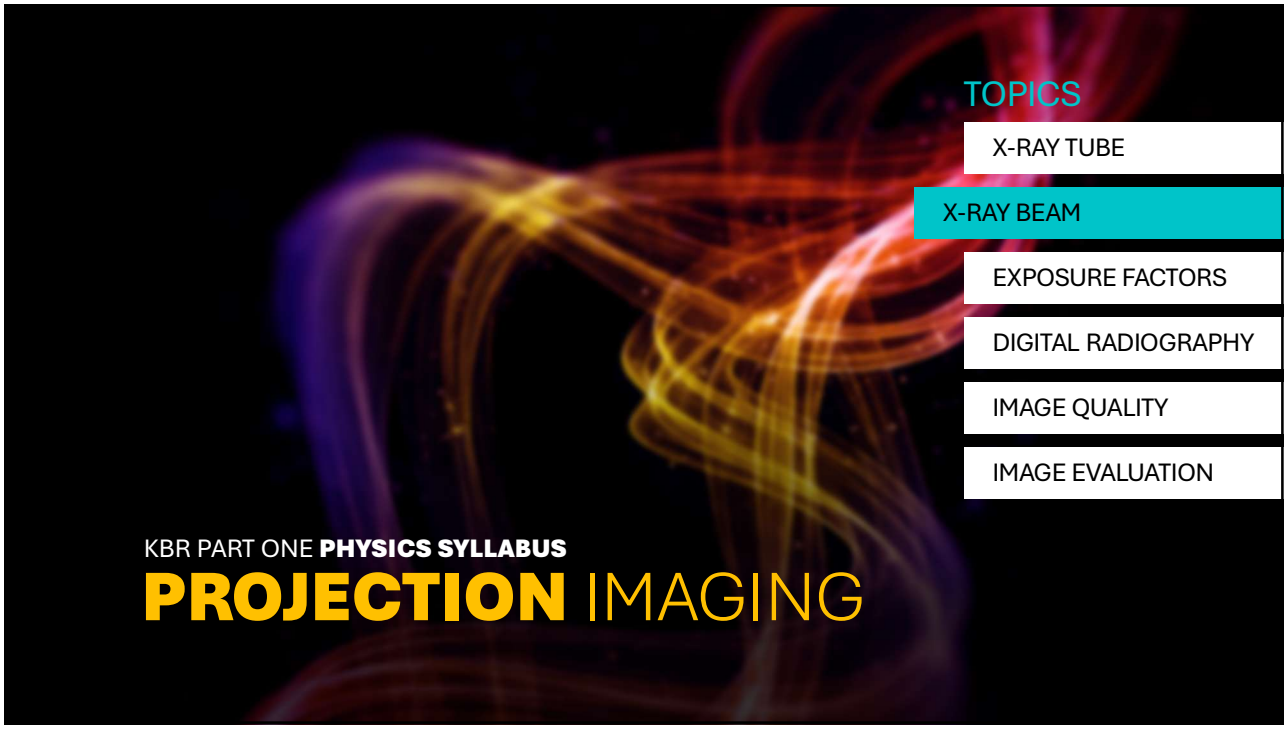
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X-RAY BEAM PROPERTIES

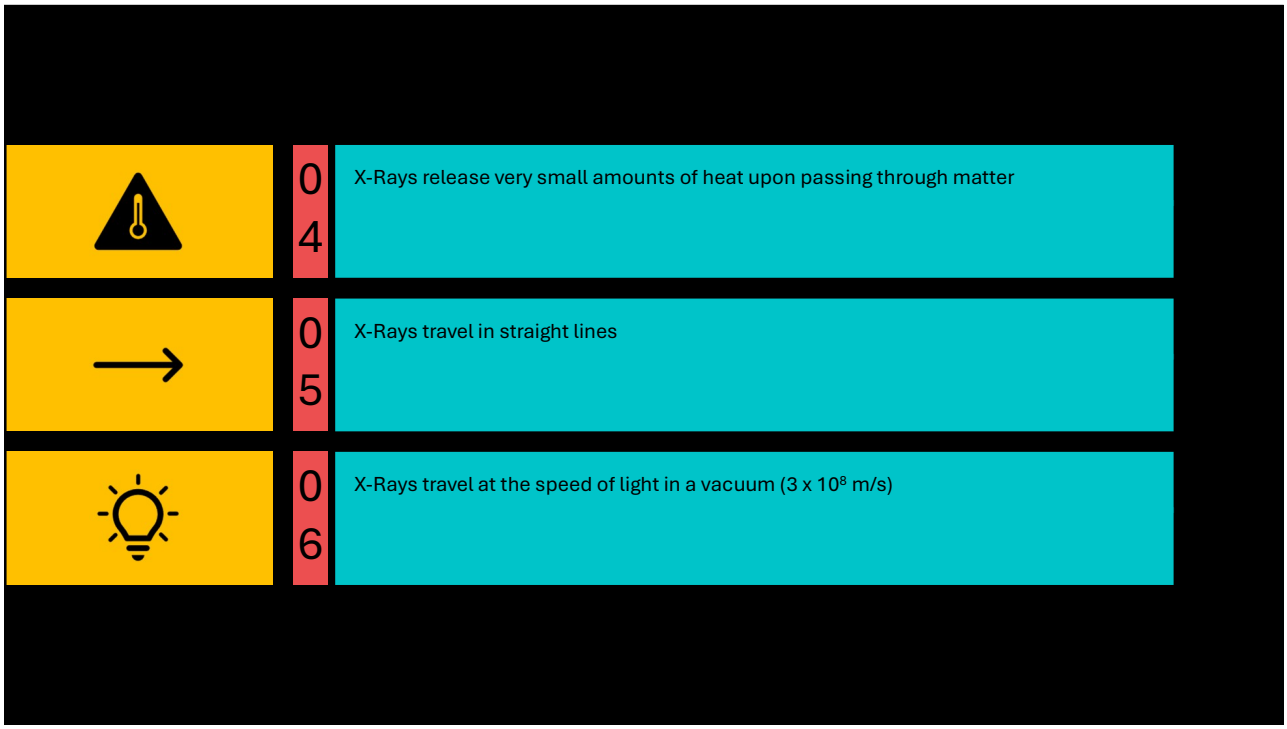
56

Since Rontgen's discovery of X-Rays in 1895, no scientist was able to add to the list of X-Ray properties Rontgen was able to identify in his thorough investigation. There are **12 X-Ray properties**.

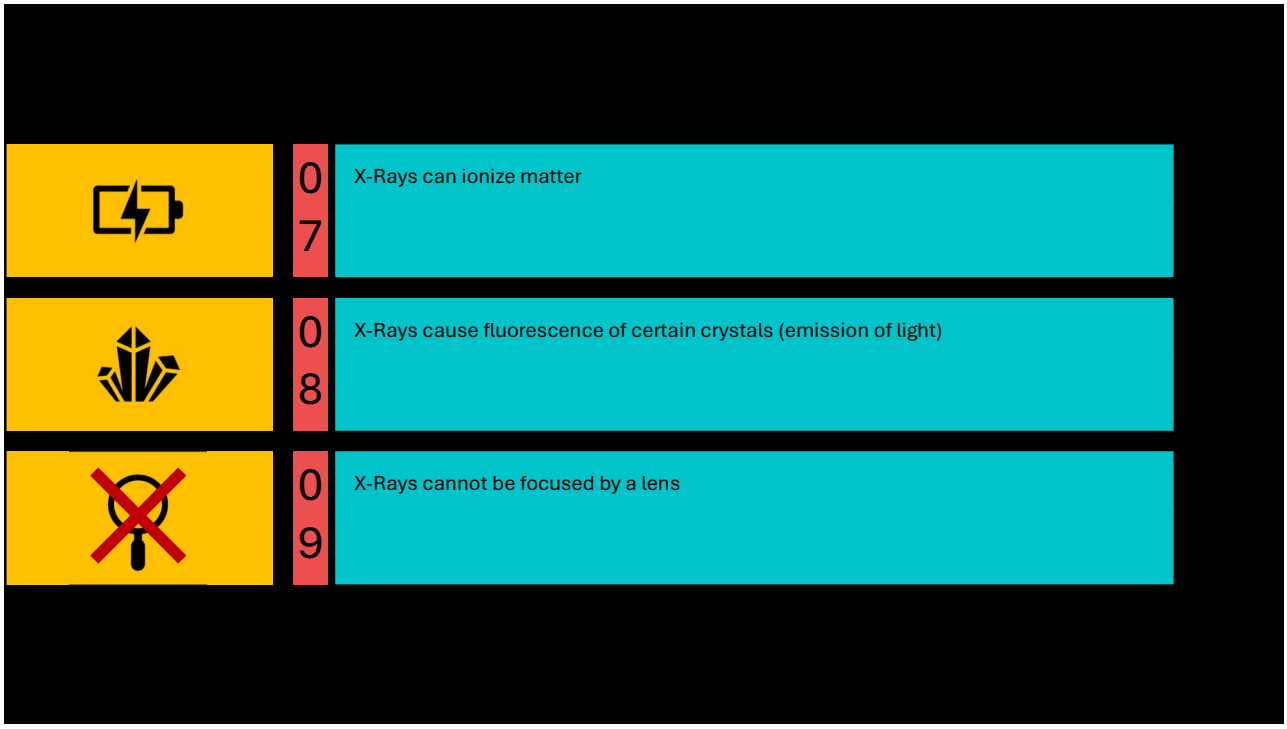
57

	01	X-Rays are a form of electromagnetic radiation. They are highly penetrating and invisible.
	02	X-Rays are electrically neutral and therefore not affected by either electric or magnetic fields.
	03	X-Rays can be produced over a wide variety of energies and wavelengths (Polyenergetic and heterogeneous)

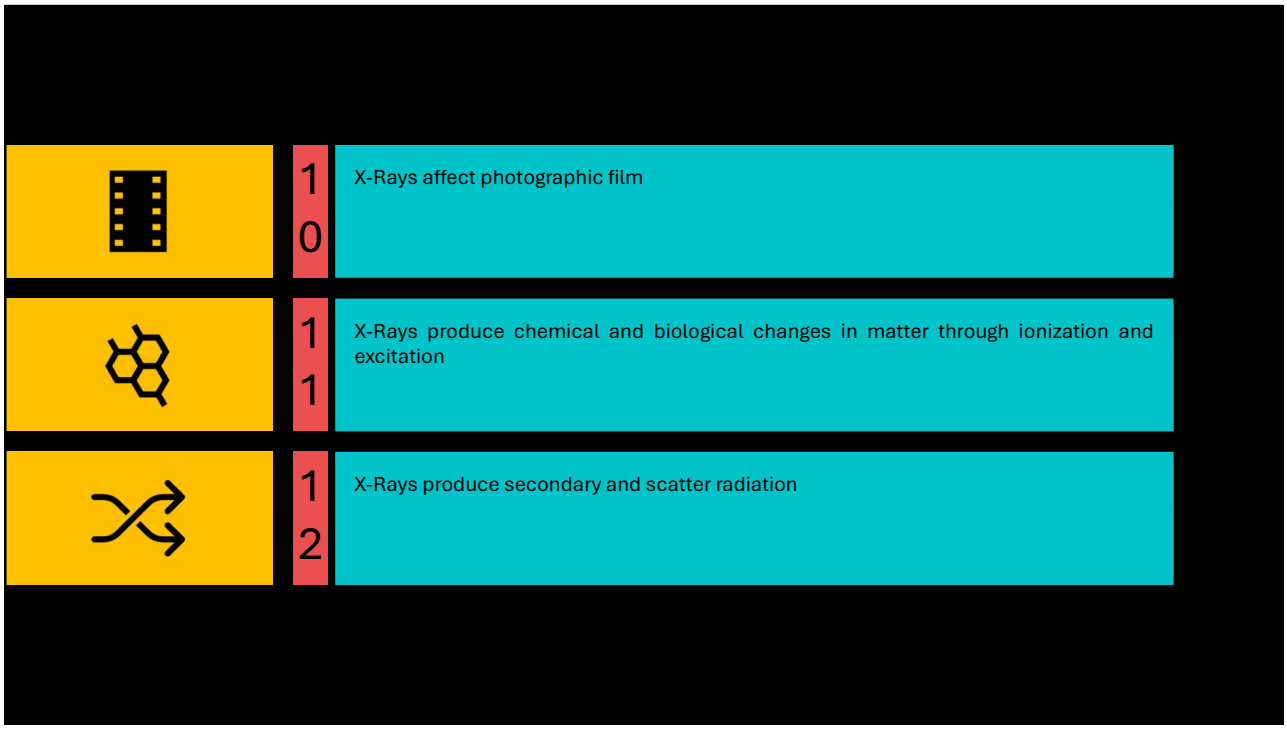
58


04
X-Rays release very small amounts of heat upon passing through matter
05
X-Rays travel in straight lines
06
X-Rays travel at the speed of light in a vacuum (3 x 10⁸ m/s)

59


07
X-Rays can ionize matter
08
X-Rays cause fluorescence of certain crystals (emission of light)
09
X-Rays cannot be focused by a lens

60


10
X-Rays affect photographic film
11
X-Rays produce chemical and biological changes in matter through ionization and excitation
12
X-Rays produce secondary and scatter radiation

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X-RAY BEAM QUANTITY

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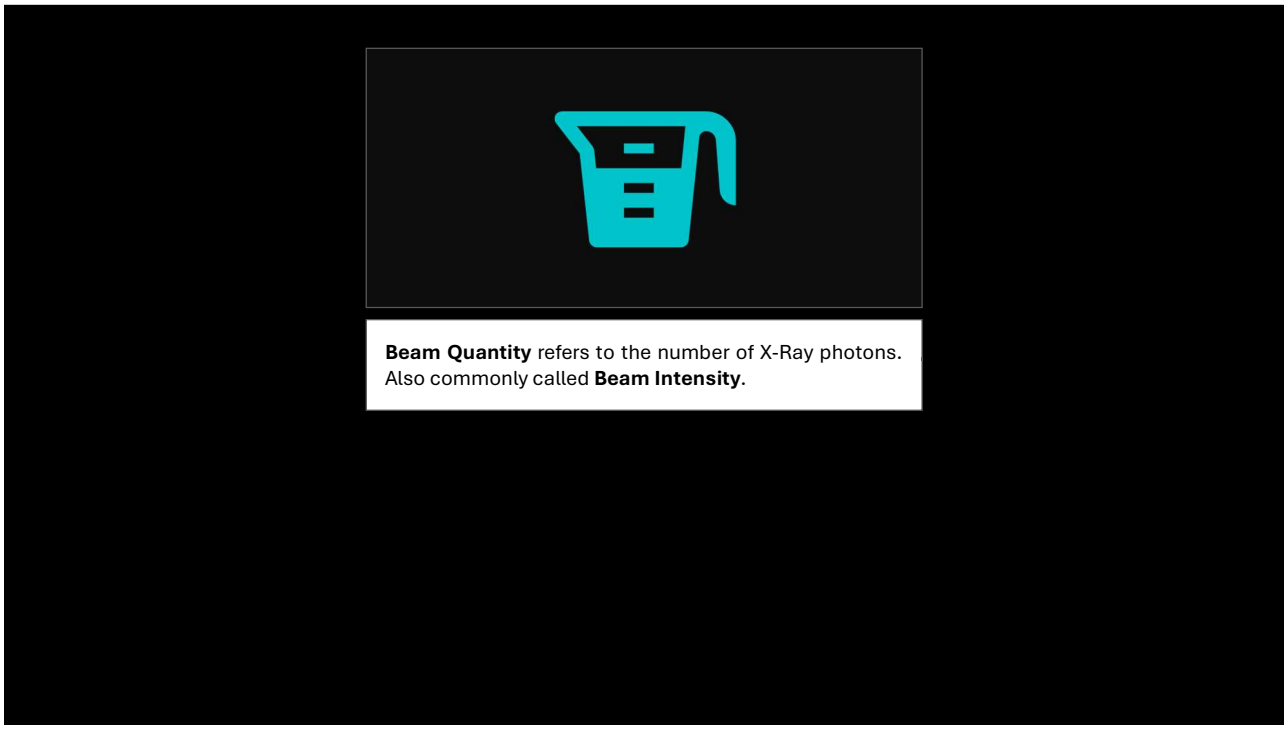
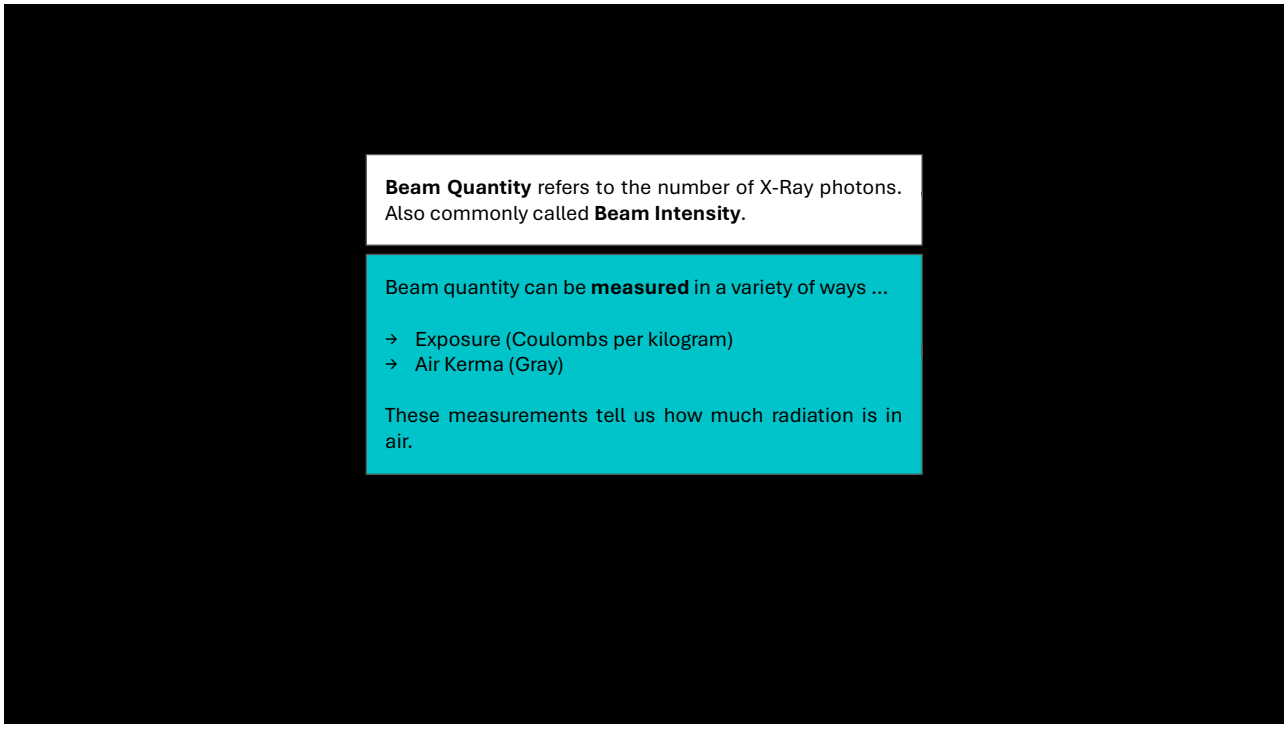


Beam Quantity refers to the number of X-Ray photons. Also commonly called **Beam Intensity**.

63



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Beam quantity can be **measured** in a variety of ways …

→ Exposure (Coulombs per kilogram)
→ Air Kerma (Gray)

These measurements tell us how much radiation is in air.

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Beam quantity is **influenced by** several factors …

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- Exposure Time (s)
- Kilovoltage peak (kVp)
- Distance
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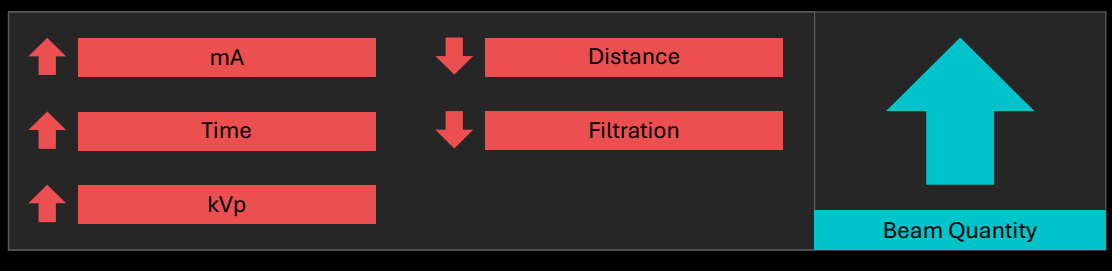

66

X-RAY BEAM QUALITY

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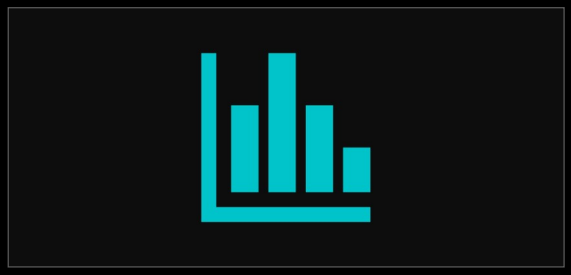

Beam Quality refers to the average energy of X-Ray photons. Also commonly called **Energy or Penetrability.**

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69

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Beam quality is **influenced only by** …

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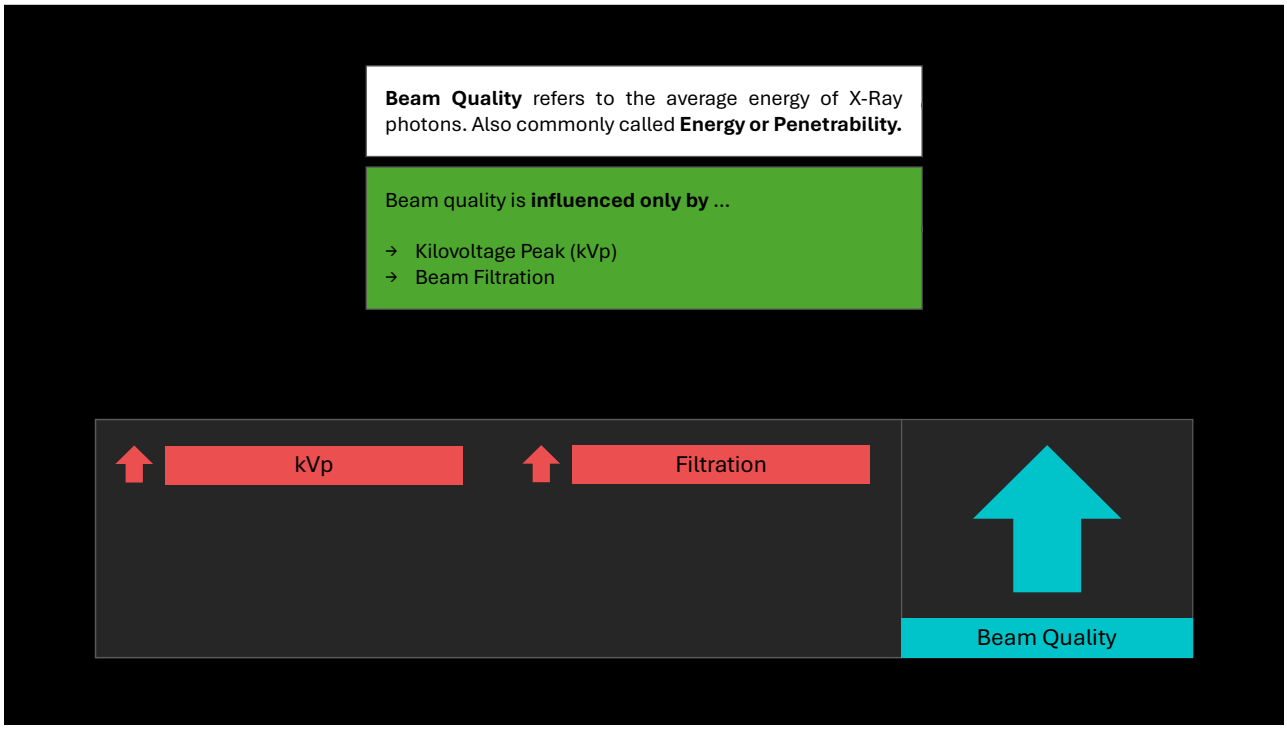
→ Beam Filtration

70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Beam quality is influenced only by ...
→ Kilovoltage Peak (kVp)
→ Beam Filtration
kVp
Filtration
Beam Quality

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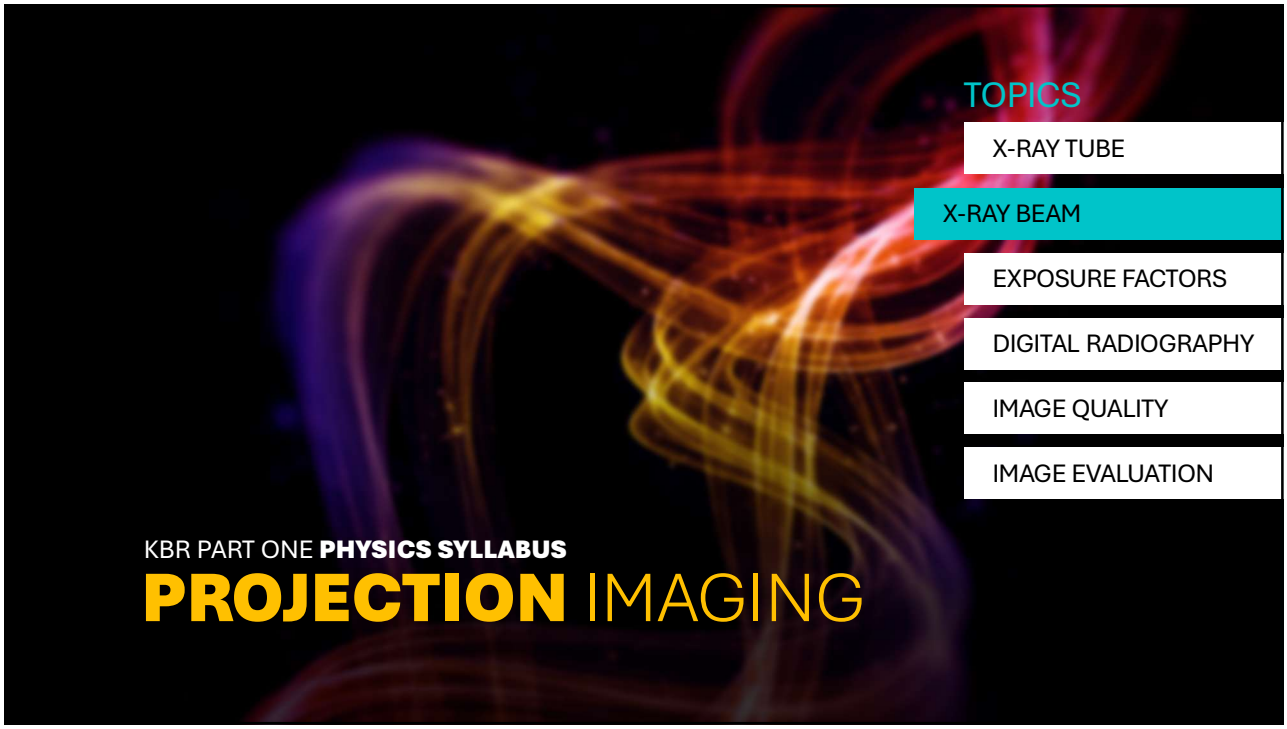
72


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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