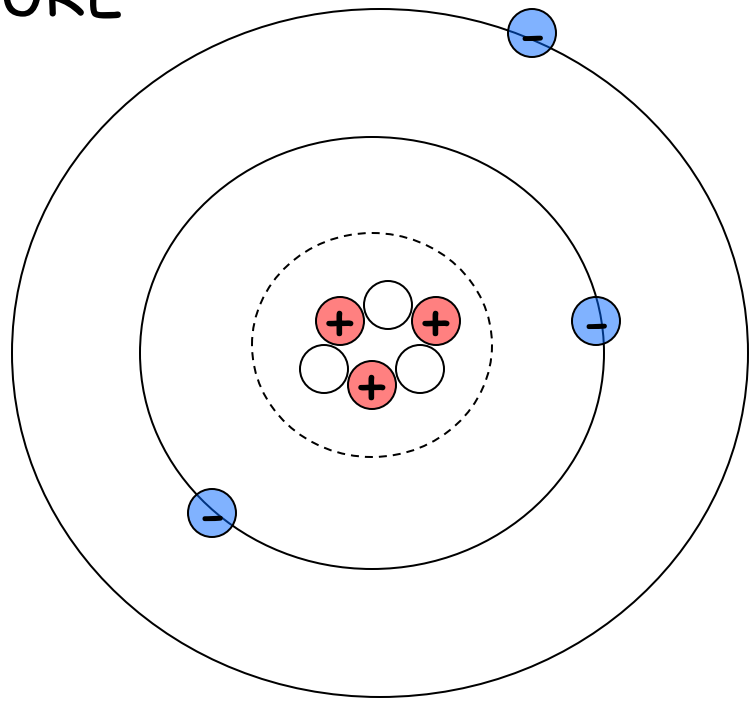

RADIATION PHYSICS
©Darrell Gulin/Corbis


atom
MATTER
atom
atom

ATOMIC STRUCTURE

Atom — Nucleus

Orbiting electrons



Nucleus
- Protons
- neutrons

Electrons
- Shells or orbits
- Binding energy

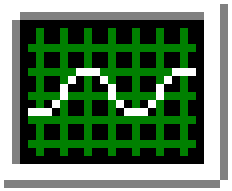
Atom v/s Molecule

Ionization

- Neutral atom
- Ion
- Ion pair

Radiation

- In form of waves or particles



Radioactivity

- Unstable atoms/elements
- Spontaneous disintegration

Ionizing radiation

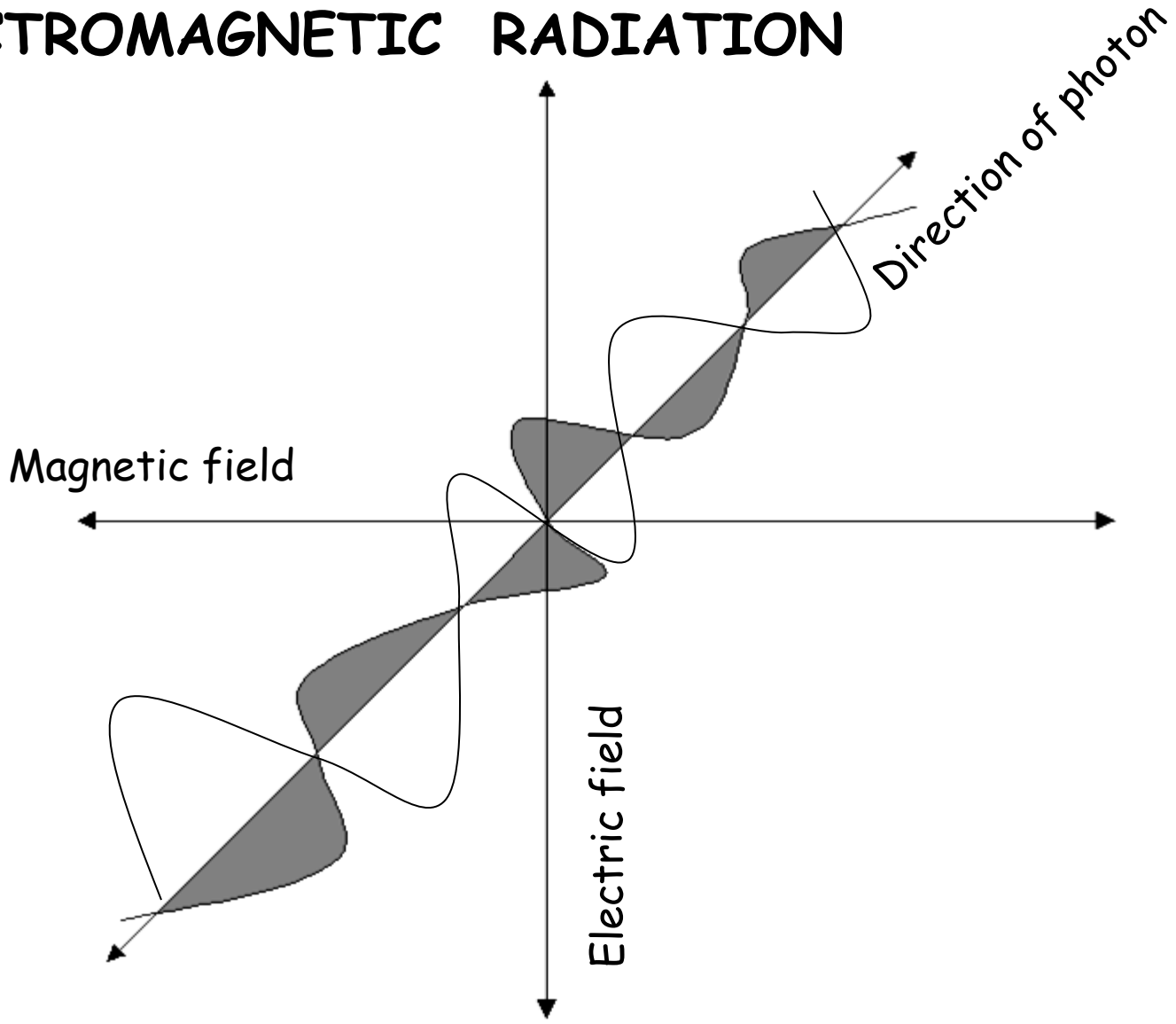
- Radiation producing ions
- 1. Particulate 2. Electromagnetic

Particulate radiations

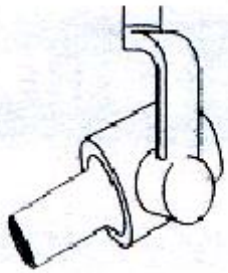
Tiny particles of matter that possess mass and travel in straight lines at high speeds

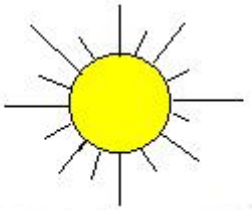
- Electrons
  1. Beta rays
  2. Cathode rays
- Alpha particles
- Protons
- Neutrons

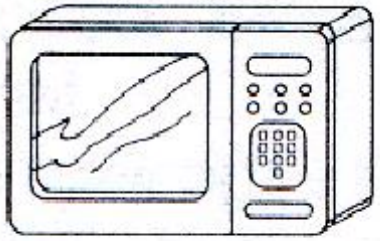
ELECTROMAGNETIC RADIATION

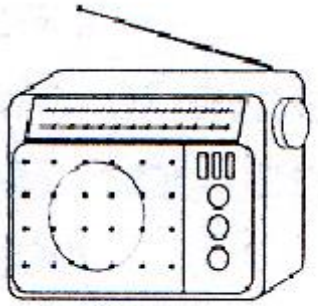


ENERGY TYPES	WAVELENGTHS	USES
	$\frac{1}{100,000}$	Radiotherapy
X-rays and gamma rays	$\frac{1}{10,000}$	
	$\frac{1}{1,000}$	
	$\frac{1}{100}$	
	$\frac{1}{10}$	Dental Radiography
	1	
Ultraviolet rays	10	Sun
	100	
Visible light	1,000	Photography
Infrared rays	10,000	
Measured in nanometers	100,000	Microwave
Measured in meters	$\frac{1}{1,000}$	
	$\frac{1}{100}$	Radar
	$\frac{1}{10}$	
	1	Television
	10	
Radio waves	100	
	1,000	Radio
	10,000	
	100,000	









ELECTROMAGNETIC RADIATION

- Have no mass or weight
- Have no electrical charge
- Travel at speed of light 3×10^8 m/s; 186000miles/s
- Travel as both a particle and a wave
- Propagate an electric field at rt. angles to path of travel
- Propagate a magnetic field at right angles to electric field
- Have different measurable energies(frequency & w.length)

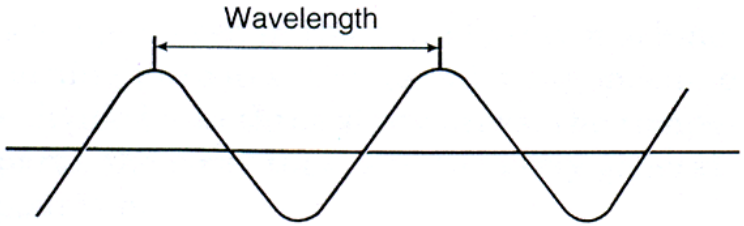
Particle concept

- Discrete bundles of energy called photons or quanta

Wave concept

- Travel in form of waves

1. Velocity
2. Wavelength- shorter w.l higher the energy



3. Frequency- if frequency high, w.l short

Long wavelength
Low frequency

Short wavelength
High frequency

X – RADIATION

X-rays are weightless bundles of energy without an electrical charge that travel in waves with a specific frequency at the speed of light.

Properties

- Are invisible, not detected by any of the senses
- No mass or weight, no electrical charge
- Travel at the speed of light
- Travel in straight lines, can be deflected & scattered
- Cannot be focused to a point and always diverge

X – RADIATION

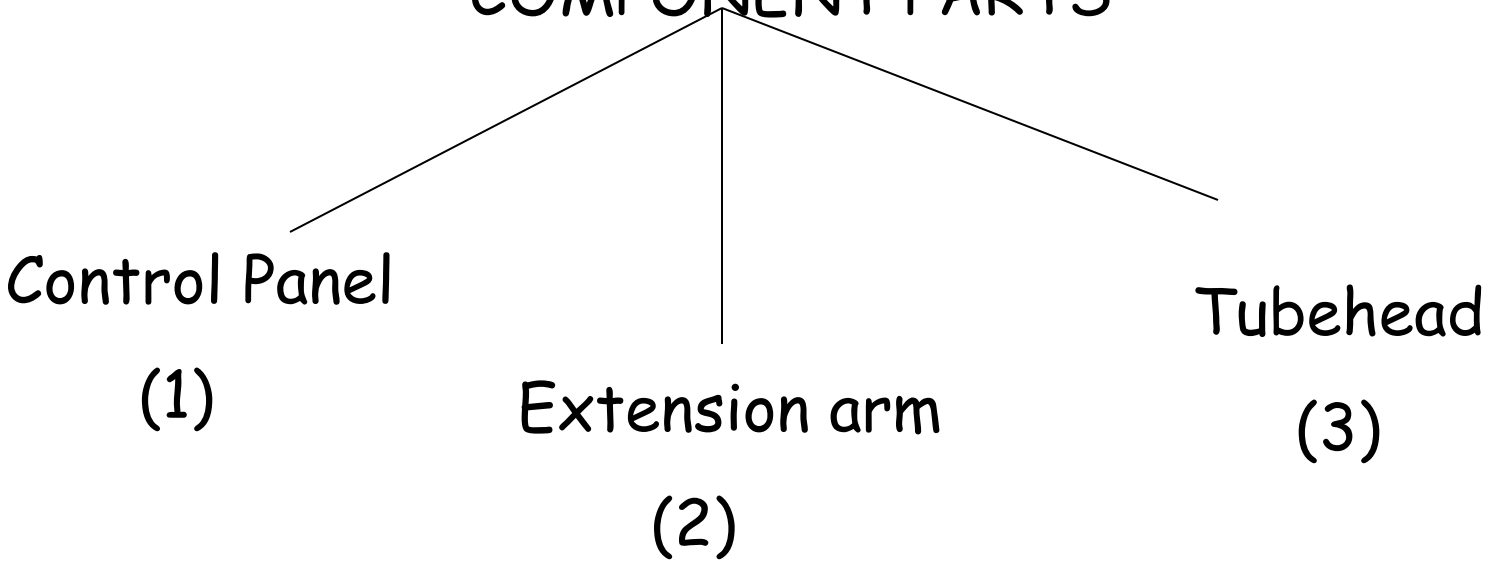
X-rays are weightless bundles of energy without an electrical charge that travel in waves with a specific frequency at the speed of light.

Properties

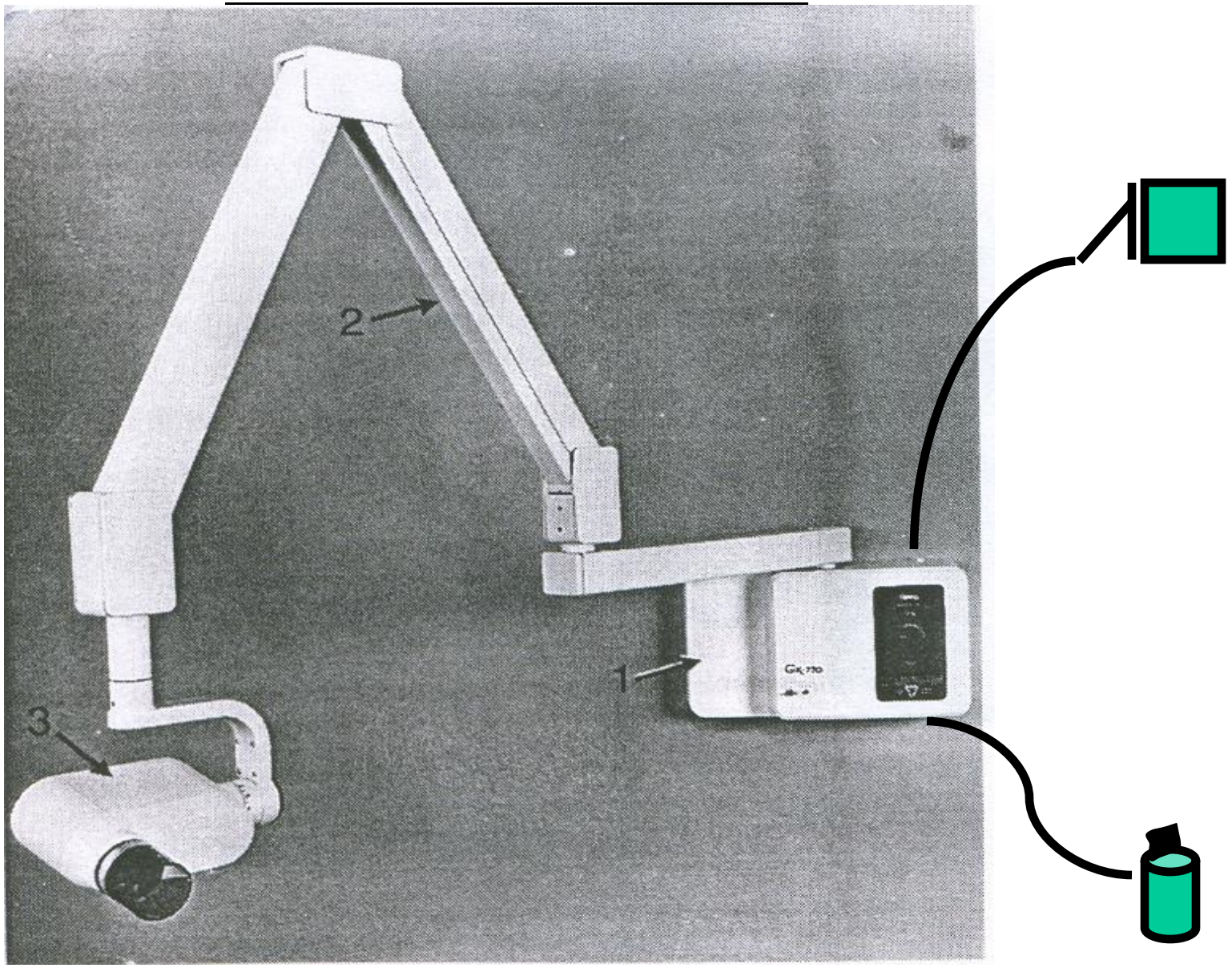
- Can penetrate solids, liquids, gases
- Are absorbed by matter
- Cause ionization of matter
- Can cause certain substances to fluoresce
- Can affect photographic film
- Can cause biologic changes in living cells

THE X – RAY MACHINE

COMPONENT PARTS



THE X - RAY MACHINE

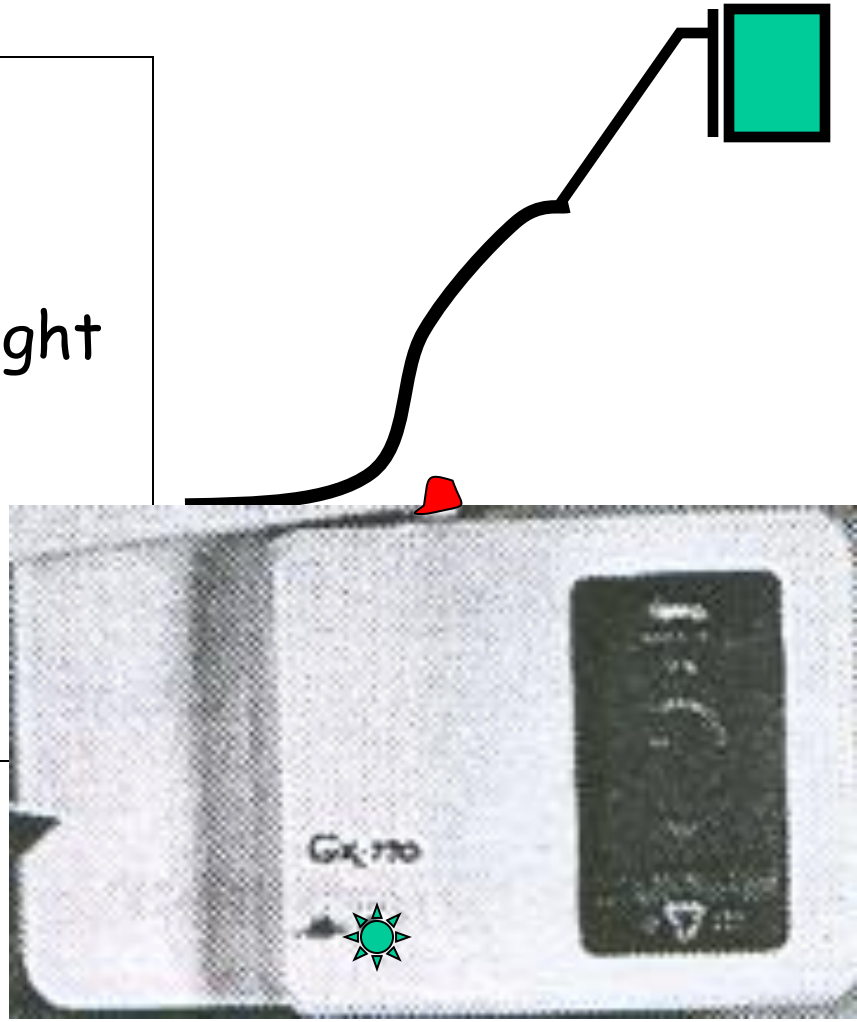


THE X – RAY MACHINE

CONTROL PANEL

- On – Off switch
- Indicator light
- Exposure button and indicator light
- Control devices

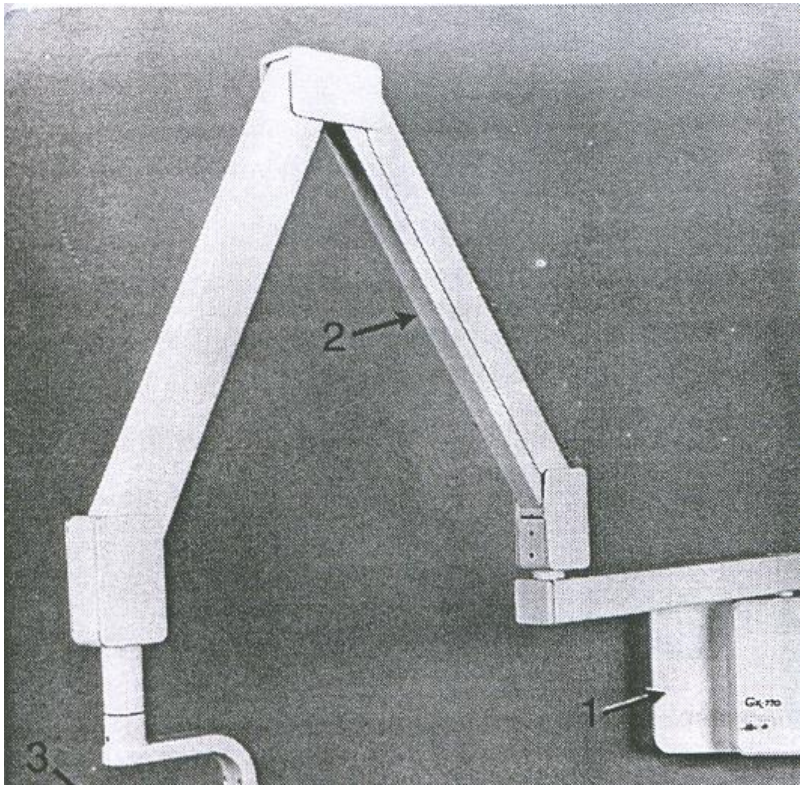
-Time selector
-Kilovoltage selector
-Milliamperage selector



THE X-RAY MACHINE

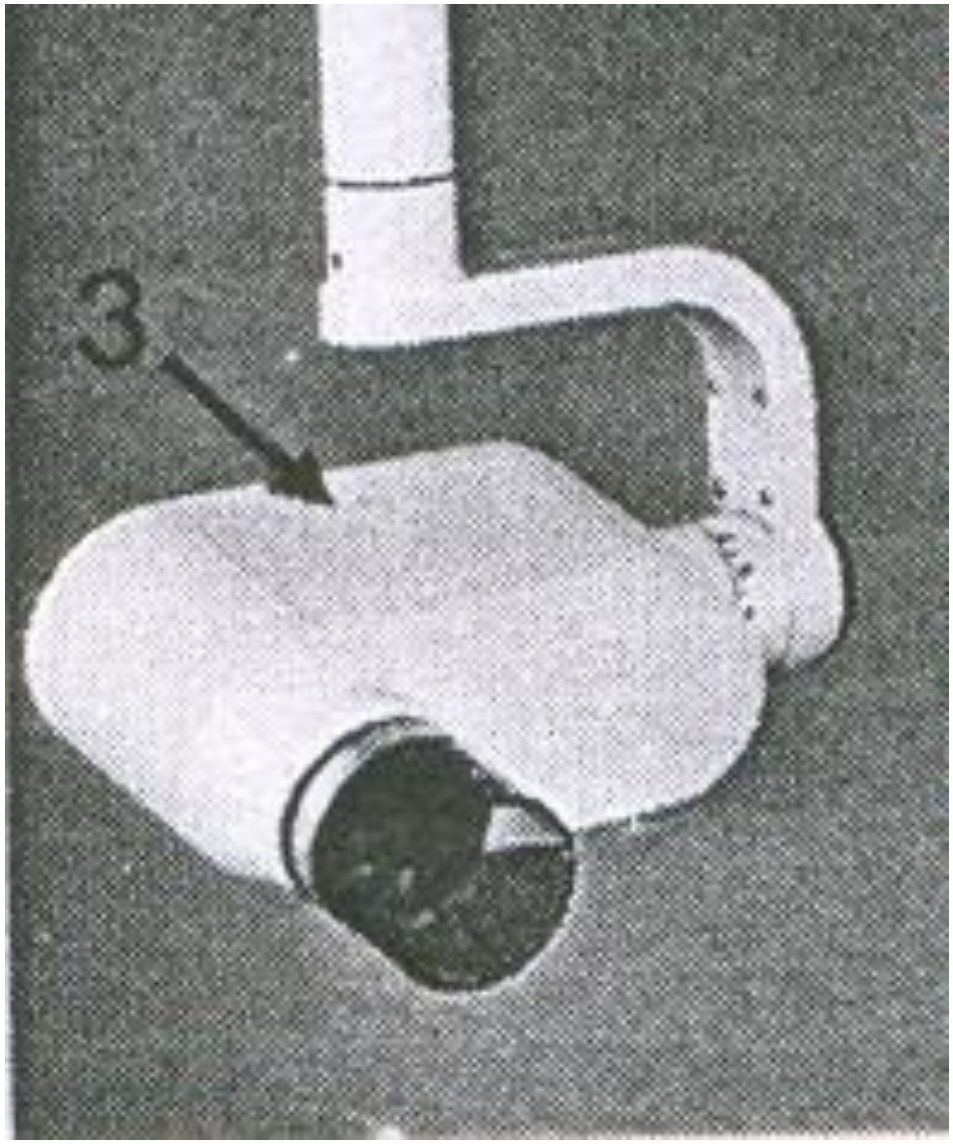
EXTENSION ARM

- Suspends x-ray tubehead
- Houses the electrical wires that extend from c.panel to tubehead



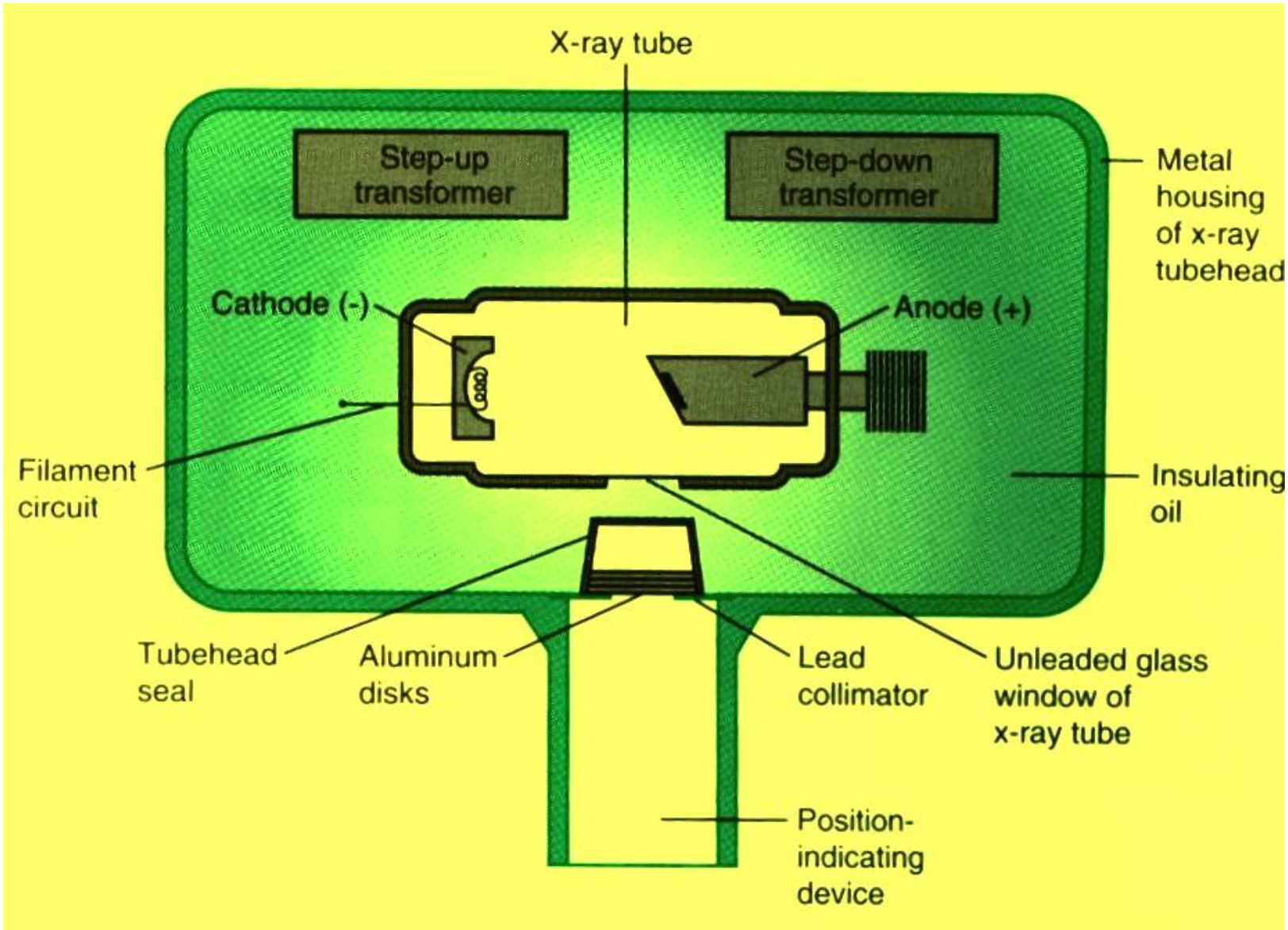
THE X-RAY MACHINE

X-RAY TUBEHEAD



THE X-RAY MACHINE

X-RAY TUBEHEAD



THE X-RAY MACHINE

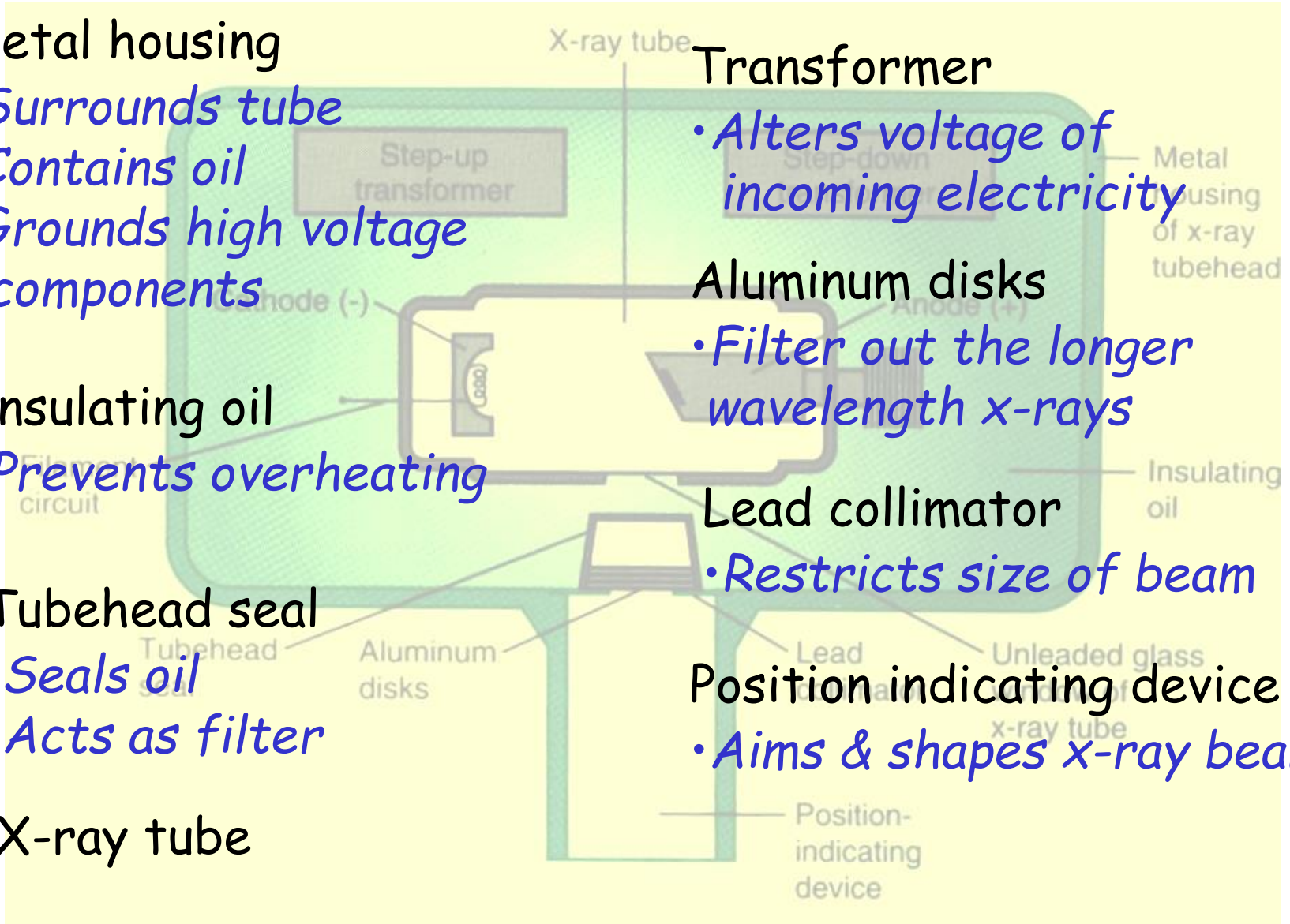
X-RAY TUBEHEAD

Metal housing
- *Surrounds tube*
- *Contains oil*
- *Grounds high voltage components*

Insulating oil
- *Prevents overheating*

Tubehead seal
- *Seals oil*
- *Acts as filter*

X-ray tube



Transformer
- *Alters voltage of incoming electricity*

Aluminum disks
- *Filter out the longer wavelength x-rays*

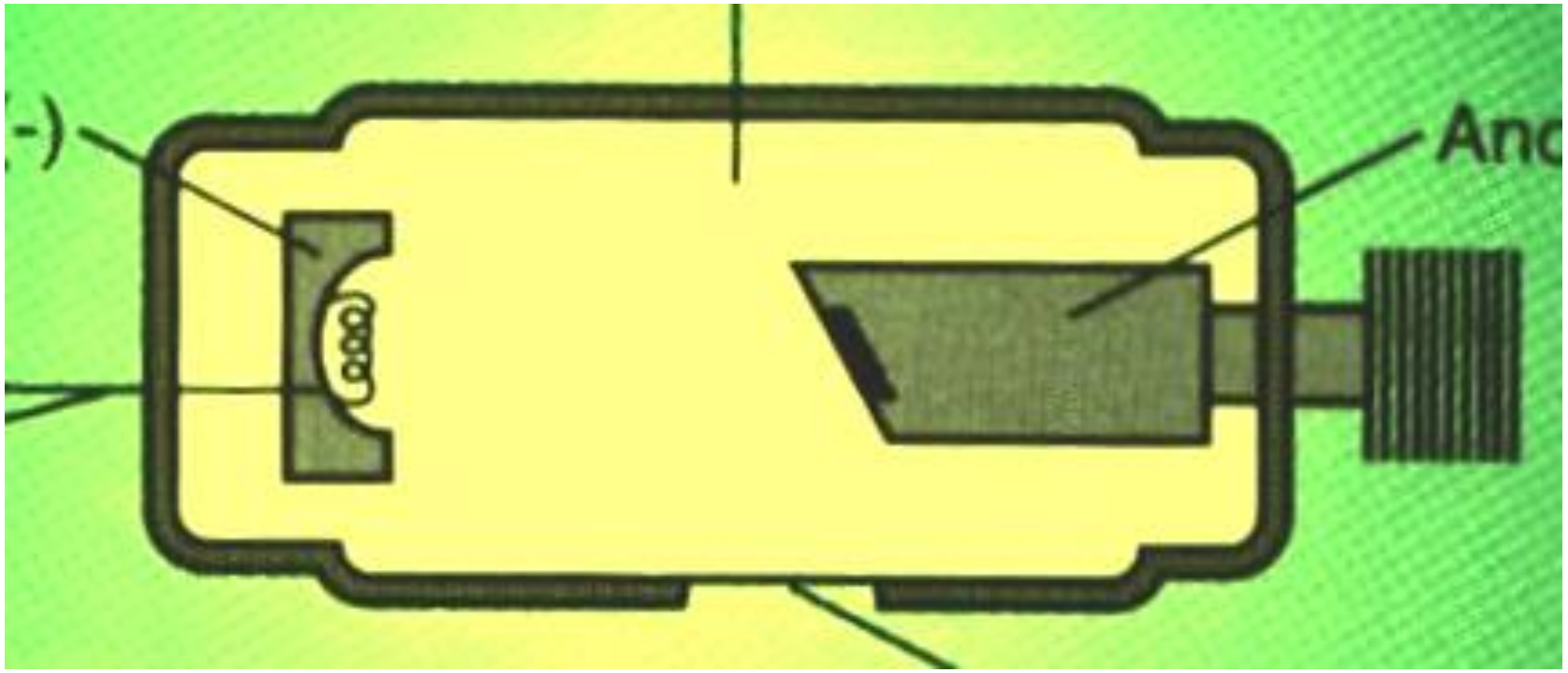
Lead collimator
- *Restricts size of beam*

Position indicating device
- *Aims & shapes x-ray beam*

X-ray tube

Heart of the x-ray generating system

- Lead glass housing
- Negative cathode
- Positive anode

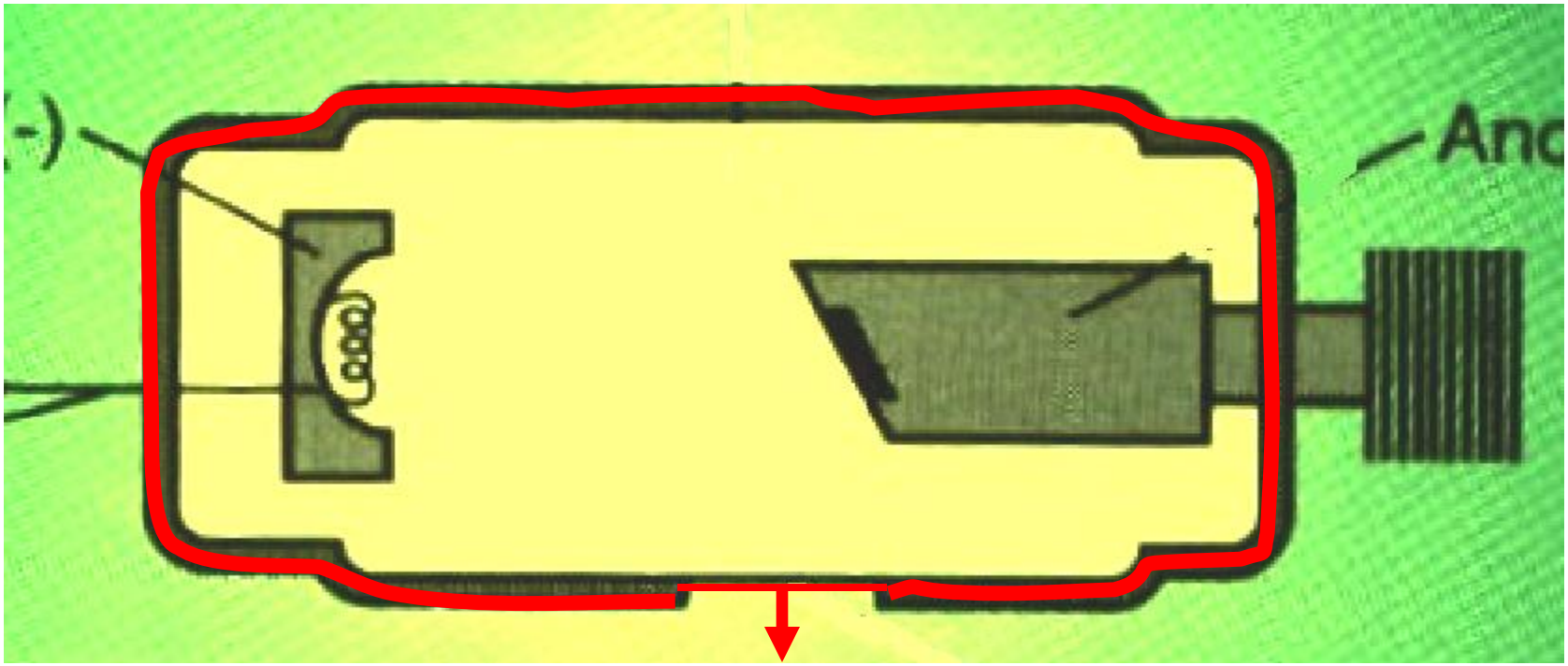


X-ray tube

Heart of the x-ray generating system

Lead glass housing

- Lead glass vacum tube
- Prevents x-rays escaping in all directions
- 'Window' to permit useful beam to exit

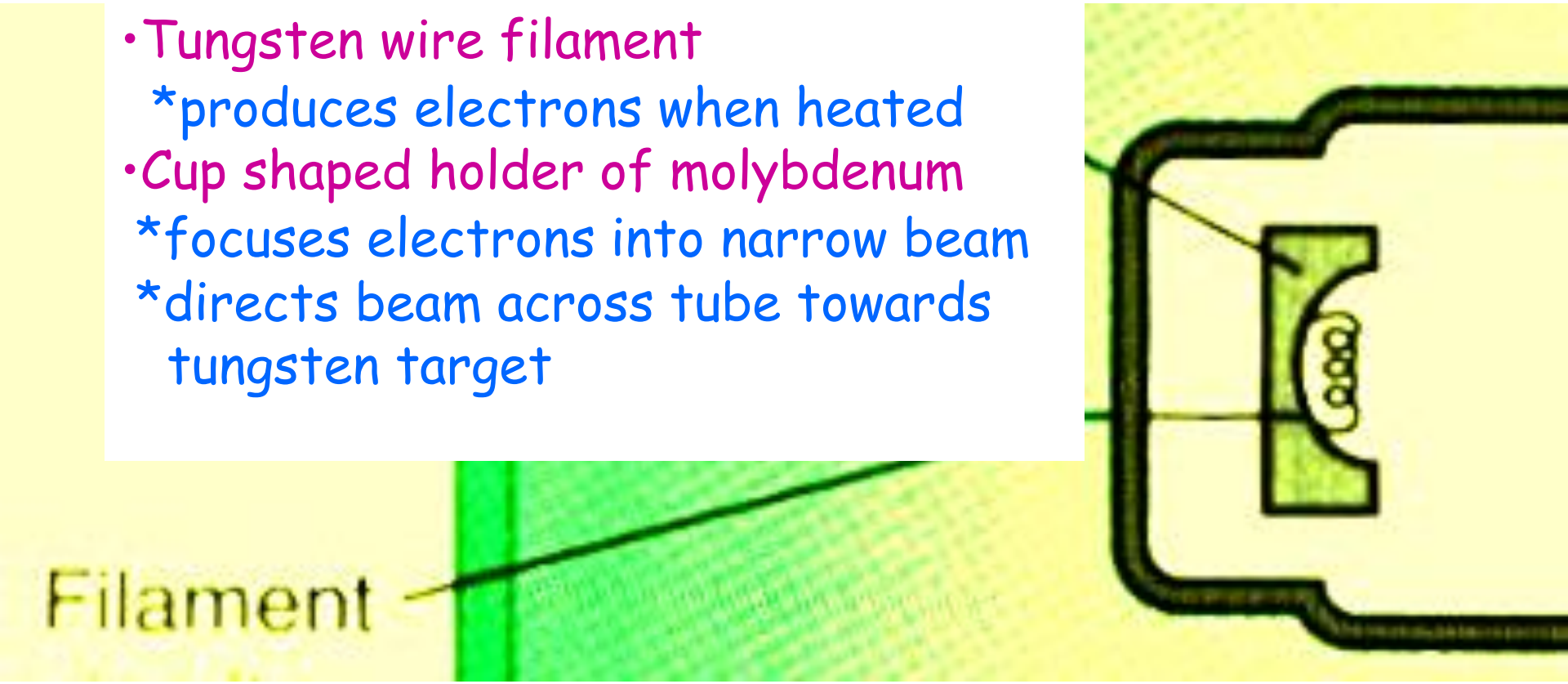


X-ray tube

Heart of the x-ray generating system

Cathode- 1.tungsten wire filament 2. Cup shaped holder

- Negative electrode
- Purpose -supply electrons necessary for x-ray generation
- Tungsten wire filament
  *produces electrons when heated
- Cup shaped holder of molybdenum
  *focuses electrons into narrow beam
  *directs beam across tube towards tungsten target



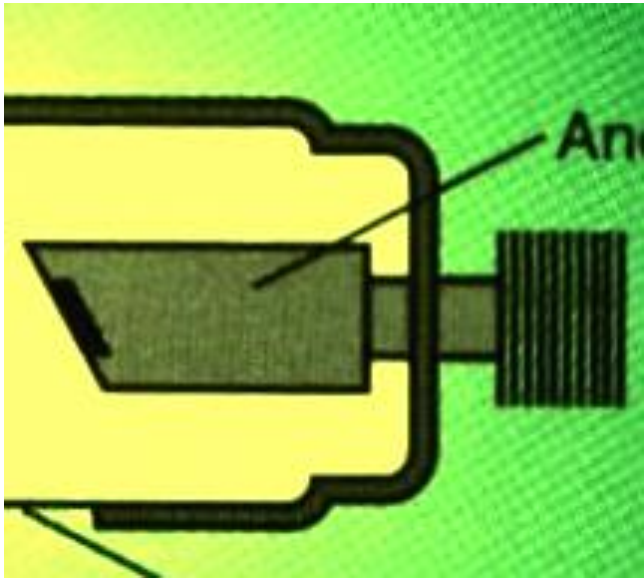
X-ray tube

Heart of the x-ray generating system

Anode- 1.tungsten target 2. Copper stem

- Positive electrode
- Purpose –convert electrons into x-ray photons

- Tungsten target
  - *serves as focal spot
  - *converts bombarding electrons into x-ray photons
- Copper stem
  - *dissipates heat away from target



Generation of x-rays

Concepts

- Electricity or electric current : Flow of electrons through conductor
- Amperage : measurement of number of electrons moving through a conductor(Amperes or milliamperes)
- Voltage : measurement of electrical force that causes electricity to move from neg. pole to pos. pole(V or Kv)

In x-ray production

- No. of electrons passing through the cathode filament can be ↑ or ↓ by milliamperage adjustment on C.PANEL

- Voltage of x-ray tube current- Kvp on CONTROL PANEL

Generation of x-rays

Concepts

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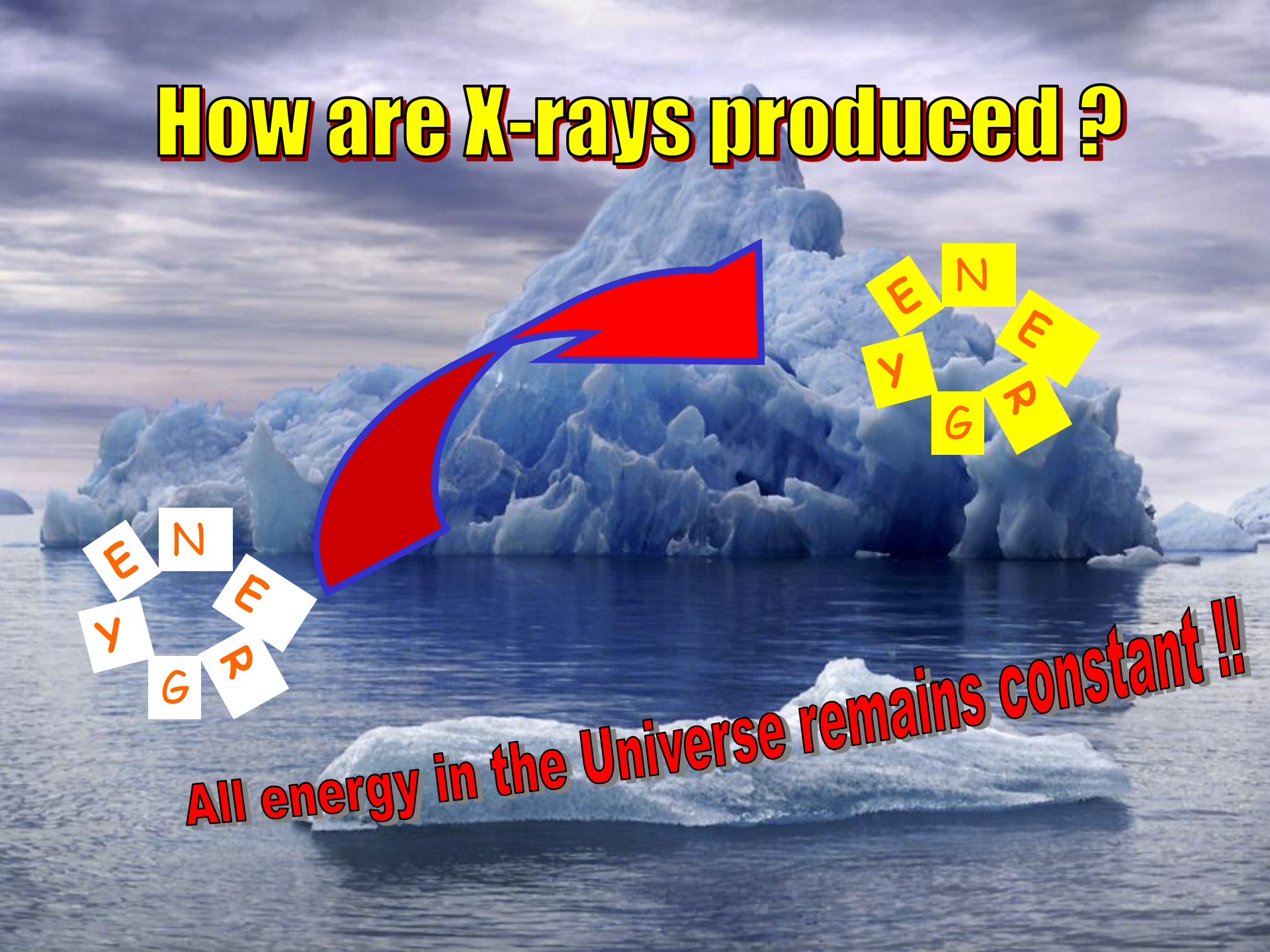
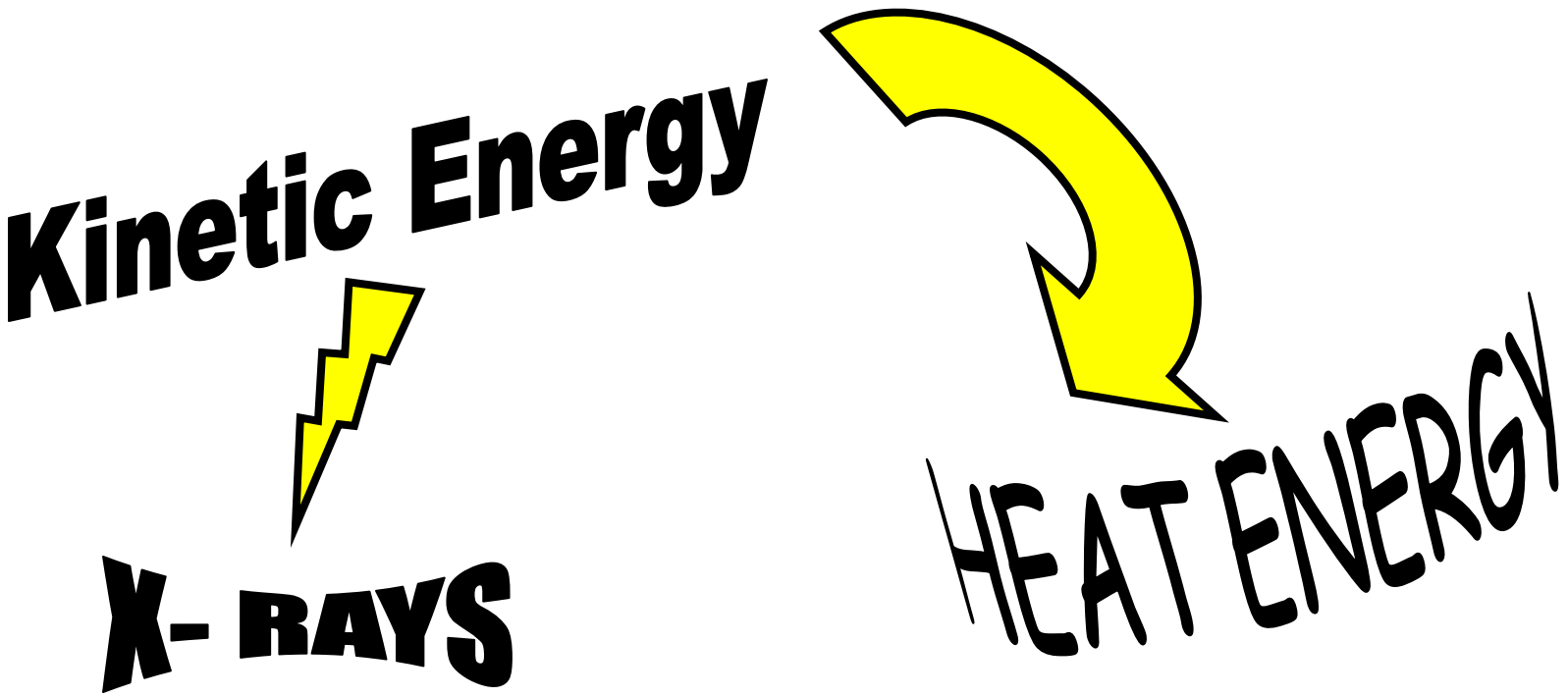
Rate of current flow = number of electrons moving past a point in a second

How are X-rays produced ?



All energy in the Universe remains constant !!


Kinetic Energy
X- RAYS
HEAT ENERGY

CIRCUITS

Path of electrical current

- Filament circuit- uses 5 to 10 volts

  Regulates the flow of electrical current to the filament, controlled by MA setting

- High voltage circuit- uses 65,000 to 100,000 volts

  Provides the high voltage required to accelerate electrons and to generate x- rays in the x-ray tube

TRANSFORMERS

A device that is used to either increase or decrease the voltage of the incoming electrical current and then route the electrical energy to the x-ray tube

INCOMING

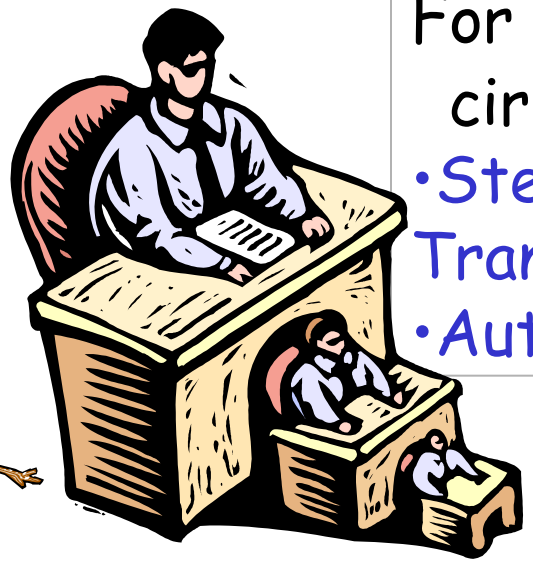
230 VOLTS

For filament circuit

Step down transformer

For high voltage circuit

- Step up Transformer
- Autotransformer



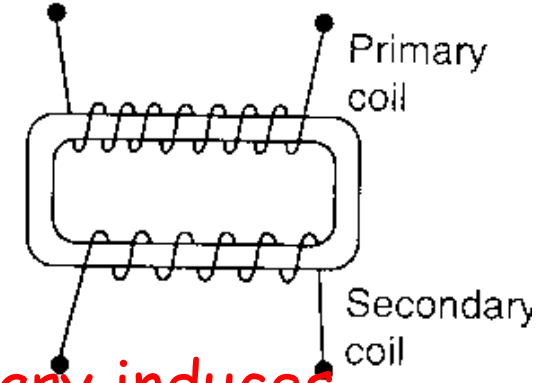
Step down transformer:For filament circuit

Decreases incoming 230 to 5 or 10 volts required

Primary has more wire coils than secondary

Primary –input

Secondary-output

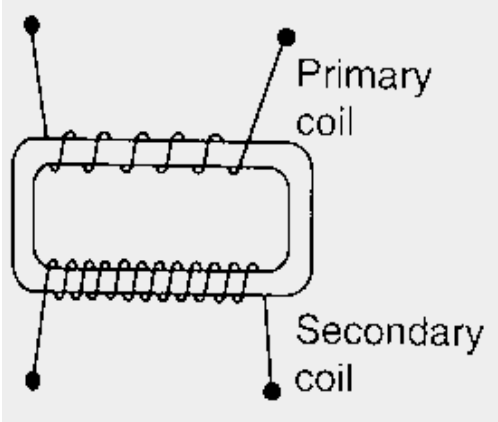


Electrical current which energises primary induces current in the secondary

Step up transformer: For high voltage circuit

Increases incoming 230 to 65,000 to 100,000 volts

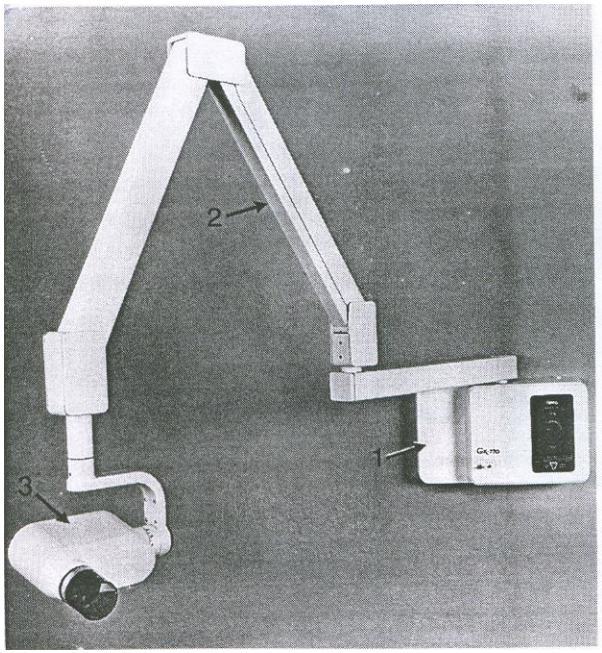
Secondary has more wire coils than primary



Autotransformer:Serves as voltage Compensator for minor fluctuations in current

PRODUCTION OF X-RAYS

I. Electricity from wall Outlet supplies power. When machine turned on electric current enters control panel and to tubehead via wires in the extension arm



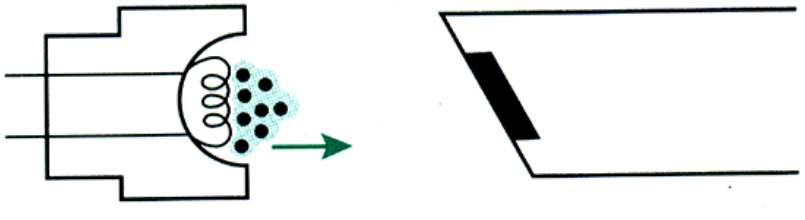
II. Autotransformer supplies the required voltage of 230 v to the tube circuitry

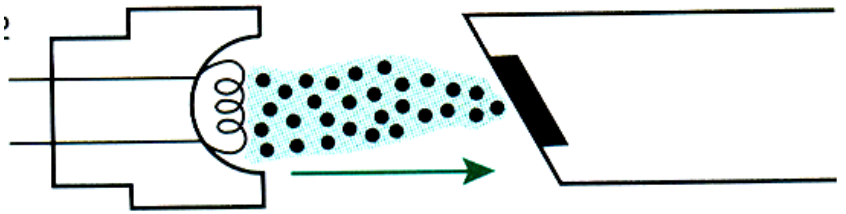
III Step down Transformer,which reduces incoming 230volts to 5 to 7 volts and supplies it to the filament thro' low tension circuit

PRODUCTION OF X-RAYS

IV. Filament circuit uses 3 to 5 volts to heat the filament. Thermionic emission occurs. Electron cloud forms around filament. Electrons stay in an electron cloud until high voltage circuit is activated

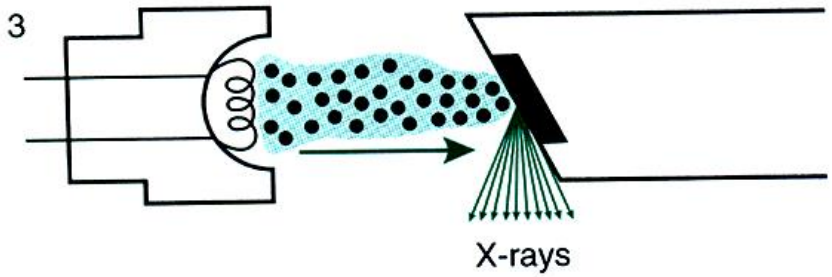
V. When exposure button is pushed, high voltage circuit activated. Electrons produced at cathode are accelerated across tube to the anode. Molybdenum focusing cup directs electrons to target

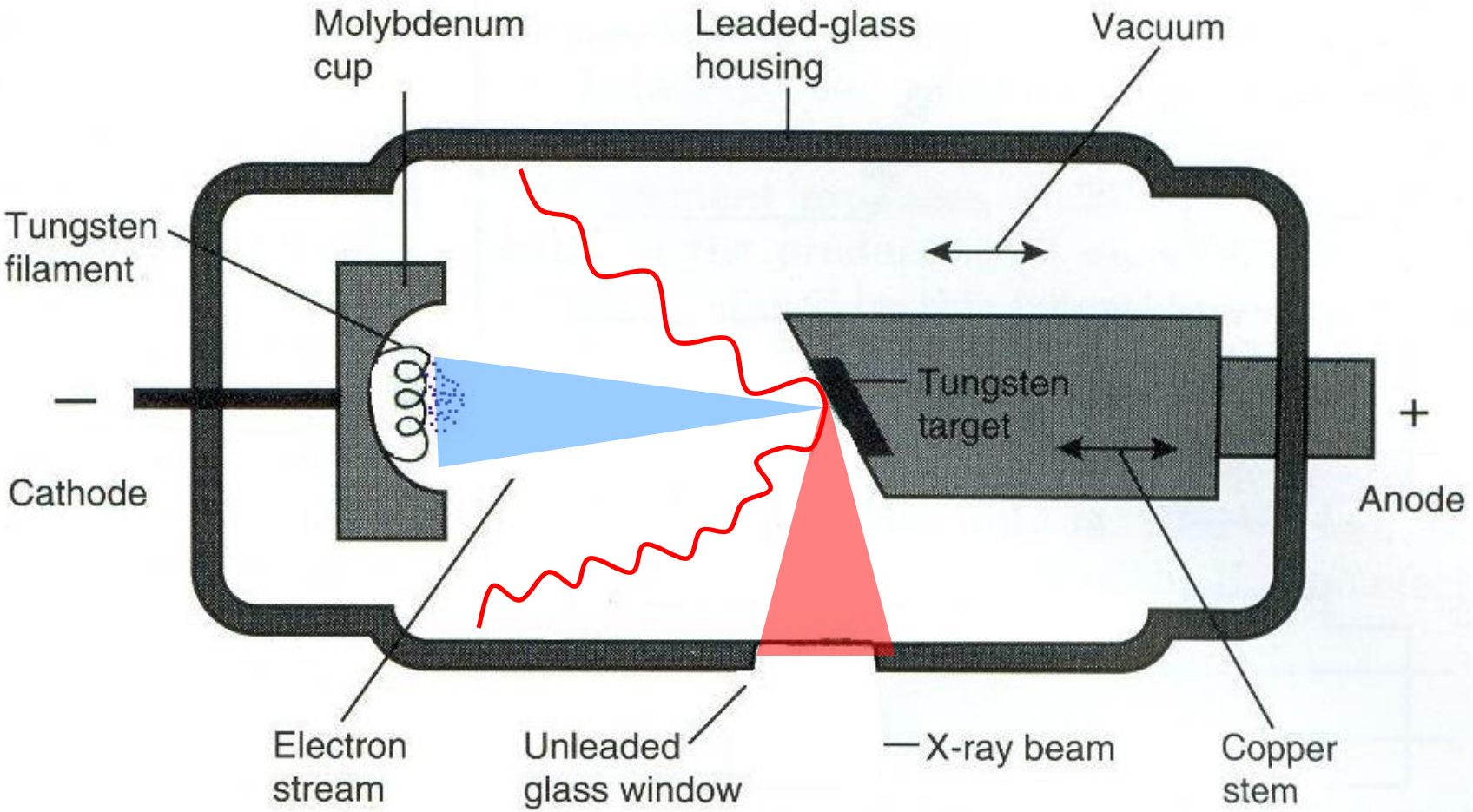




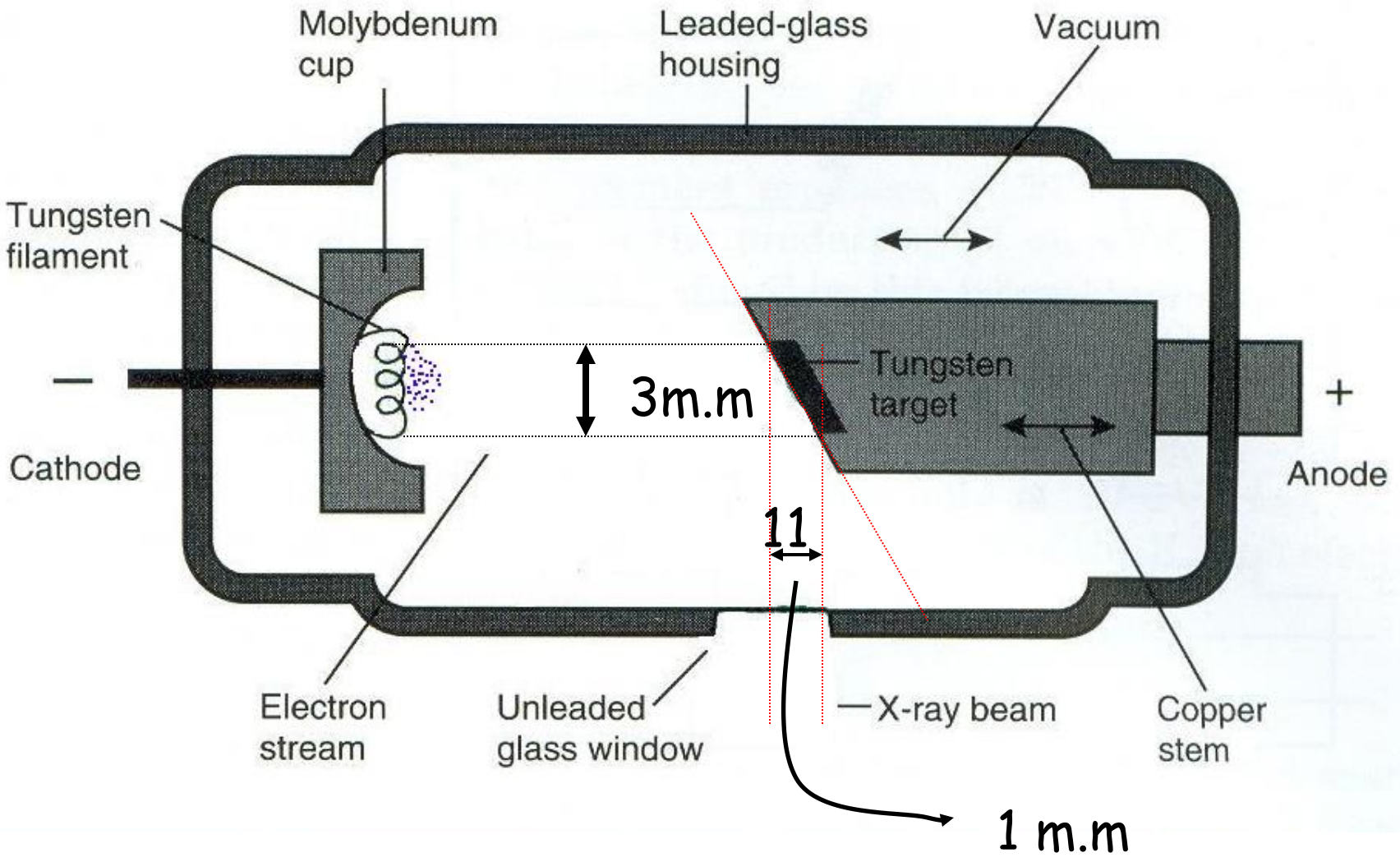
PRODUCTION OF X-RAYS

V. When electrons strike the tungsten target, their energy of motion(kinetic energy) is converted to x-ray energy (1%) and heat(99%)



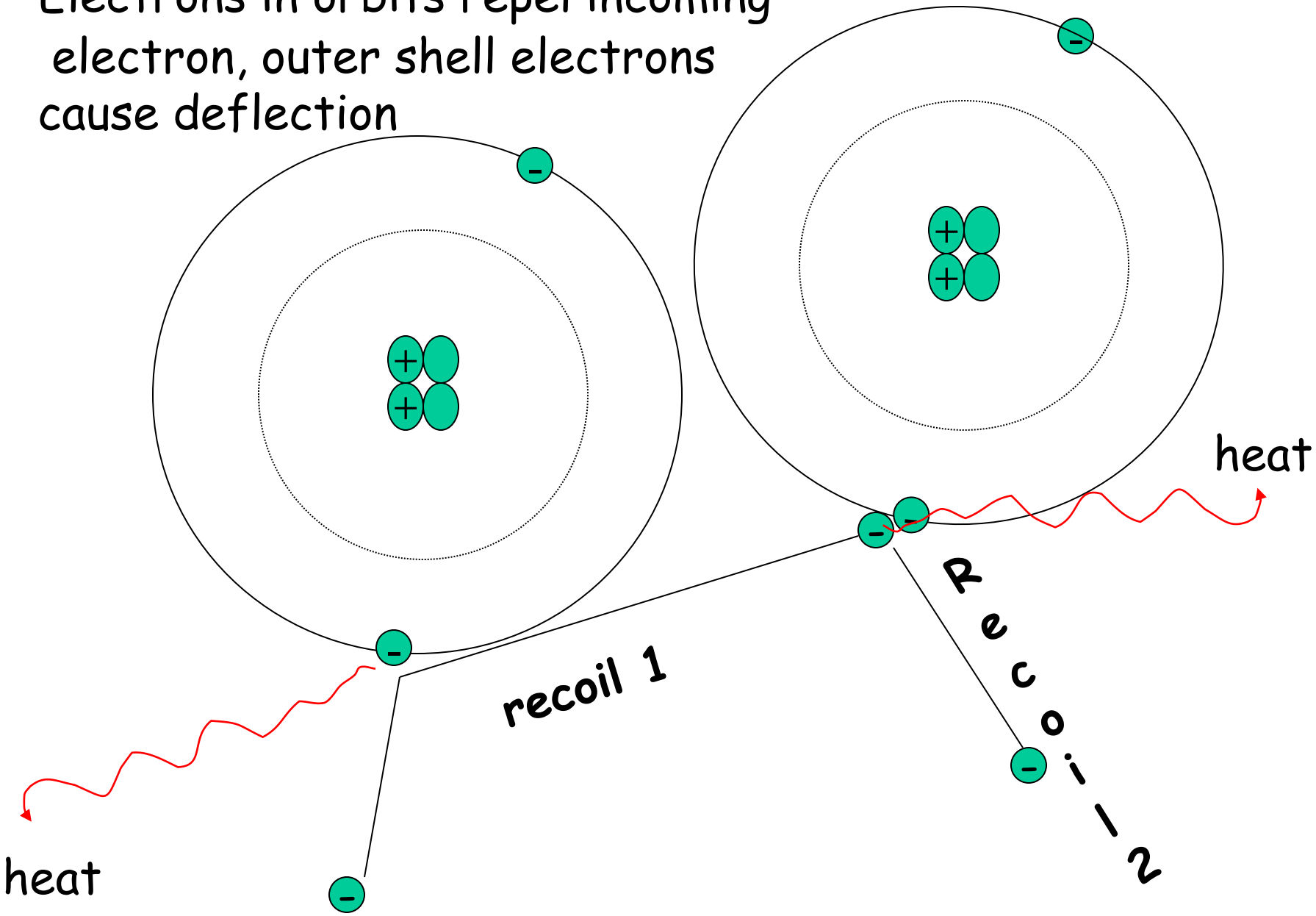

Molybdenum cup
Leaded-glass housing
Vacuum
Tungsten filament
Tungsten target
—
Cathode
+
Anode
Electron stream
Unleaded glass window
X-ray beam
Copper stem

LINE FOCUS PRINCIPLE

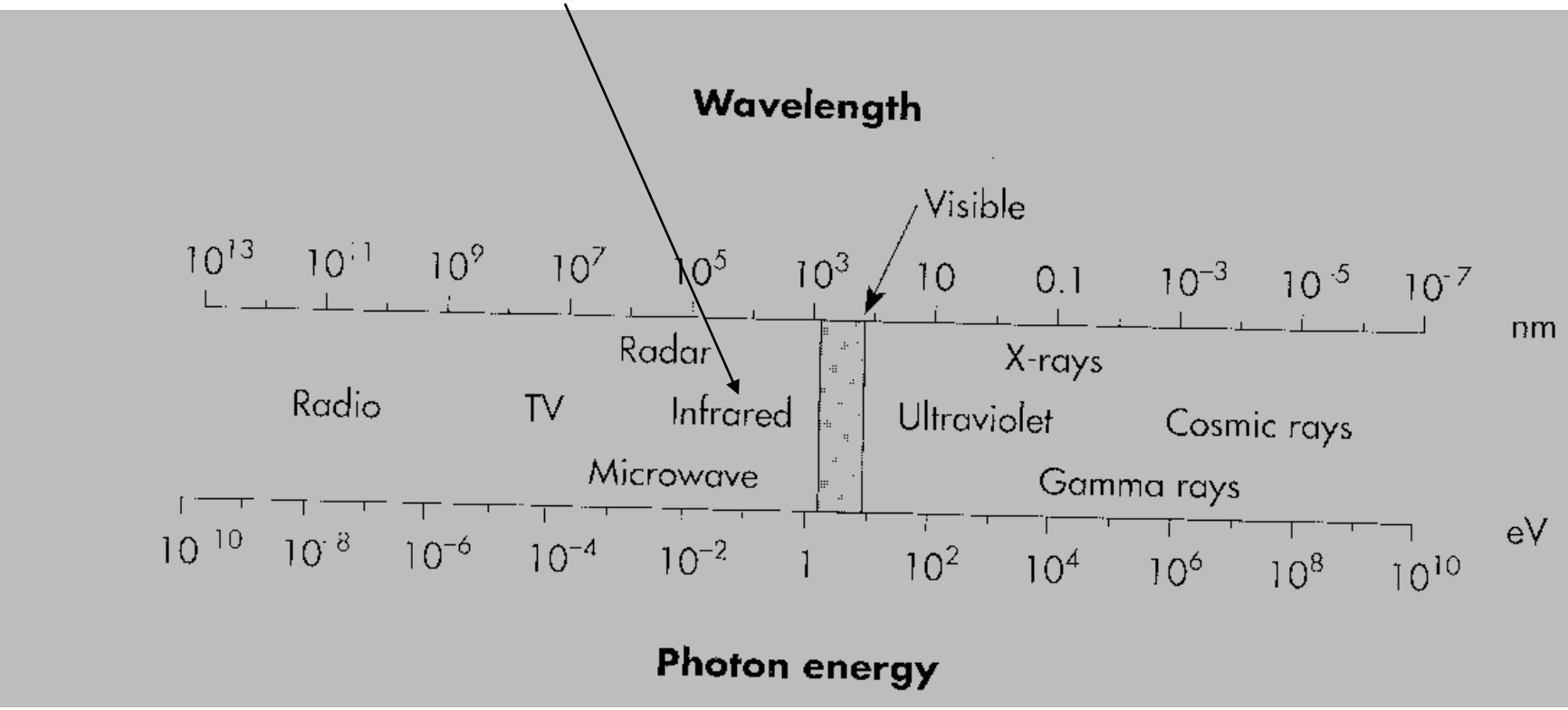


*Better heat dissipation *Sharper beam

Electrons in orbits repel incoming electron, outer shell electrons cause deflection



Heat

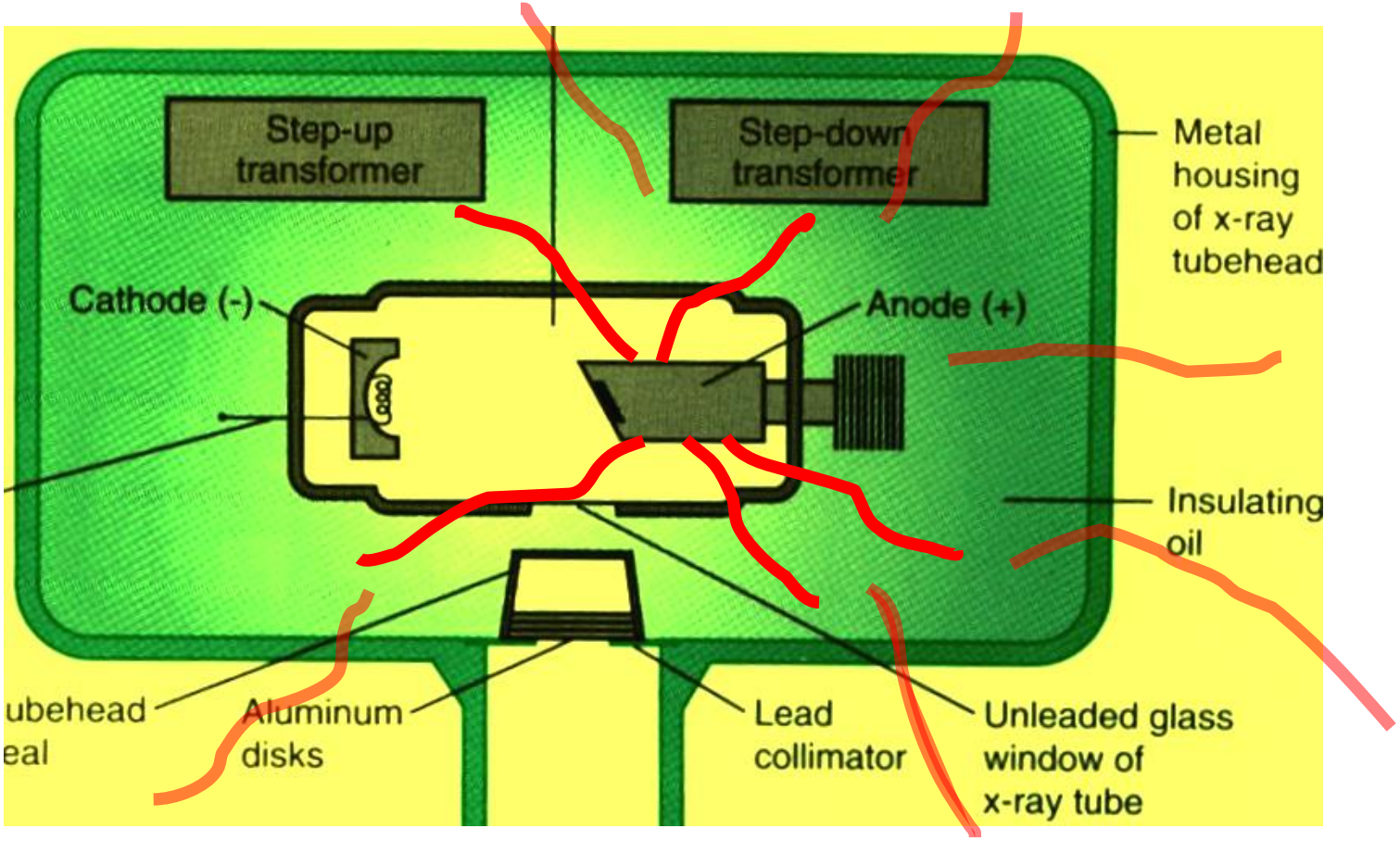


Photon energy= K.V x electron charge(e)

KeV

PRODUCTION OF X-RAYS

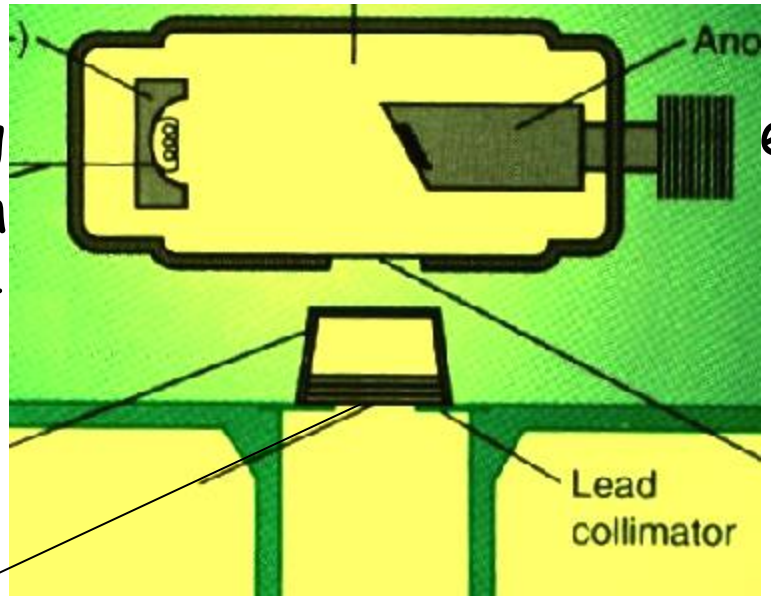
VI. Heat produced is carried away from the target through copper stem to insulating oil to the external atmosphere by conduction,convection & radiation



PRODUCTION OF X-RAYS

VII. X-rays produced are emitted from target in all directions; only a small portion is able to escape from the 'Window' as 'useful beam' of x-rays

VIII. The x-rays travel throug eal and aluminum disks/ filters. Th or filter the longer wavelength x-



Aluminum disks

PRODUCTION O

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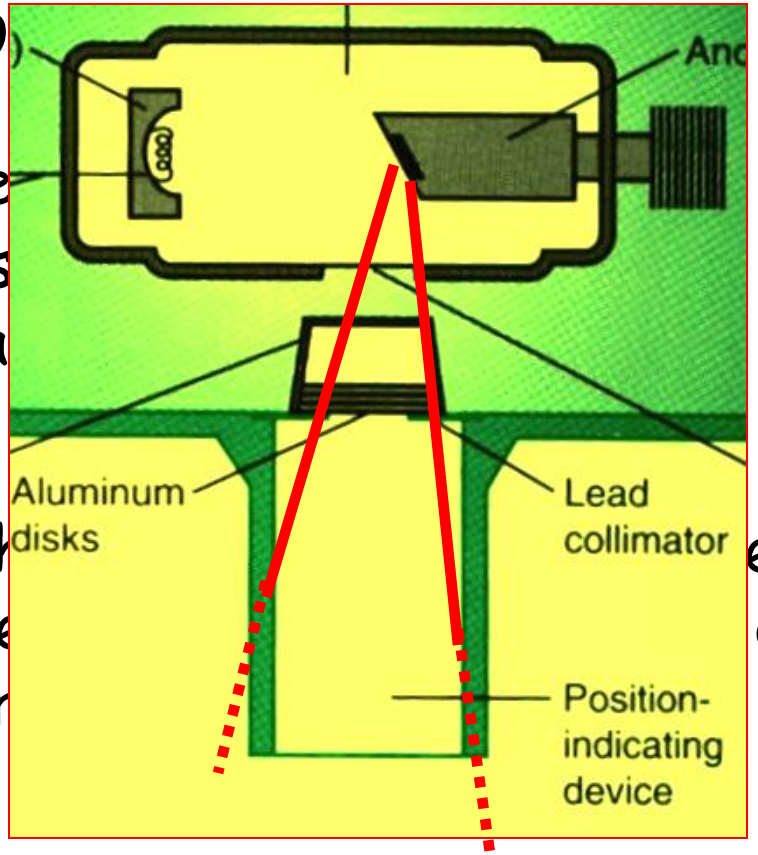


VIII. The x-rays travel through
and aluminum disks/ filters. The
filter the longer wavelength x-r

eal
or

IX. The size of the x-ray beam is restricted by the lead Collimator. The x-ray beam travels down the lead lined PID and exits the tubehead at the opening of the PID.

PRODUCTION OF X-RAYS

Types of x-rays produced

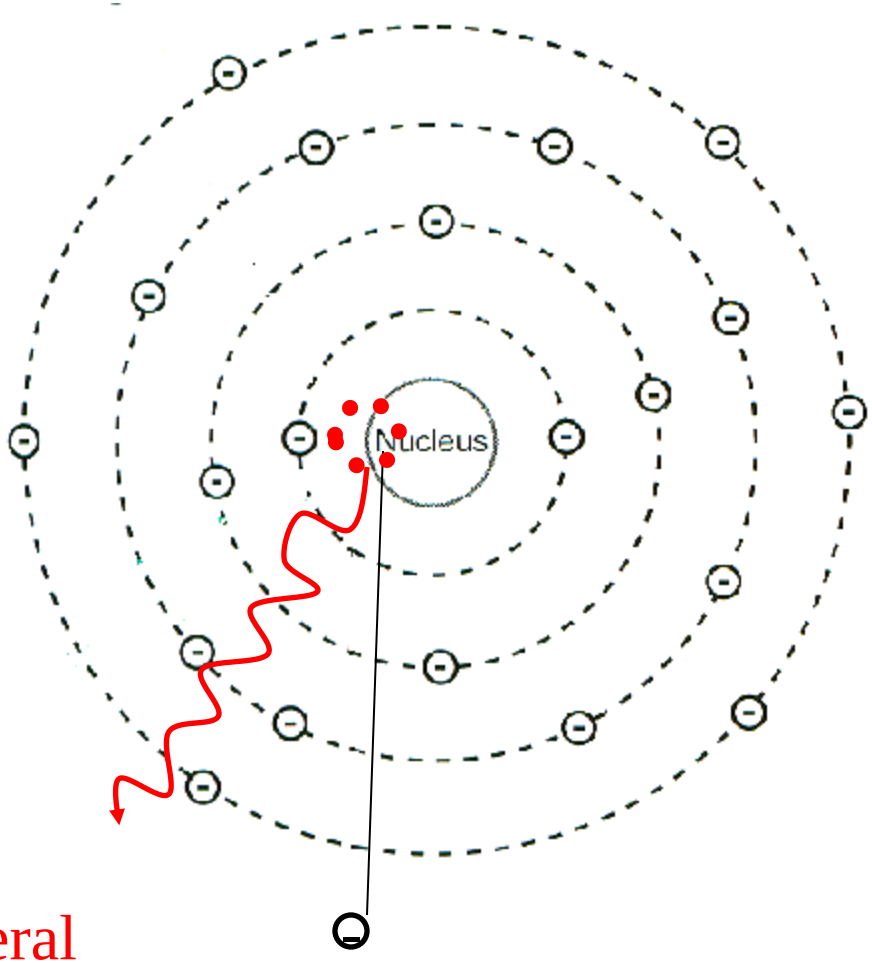
X-rays differ in

- Wavelength
- energy

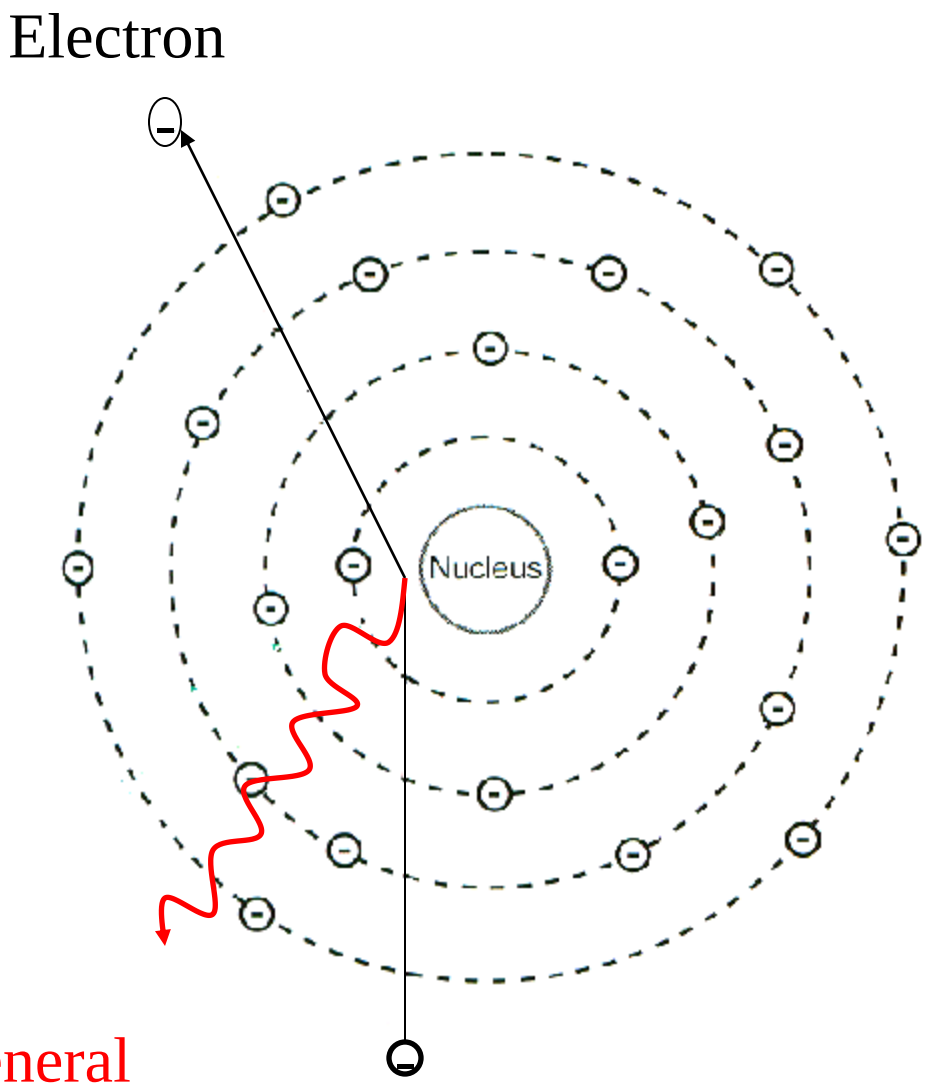
Kinetic energy of electrons converted to x-ray photons via one of two mechanisms

- **General or Bremsstrahlung radiation**
- Characteristic radiation

PRODUCTION OF X-RAYS

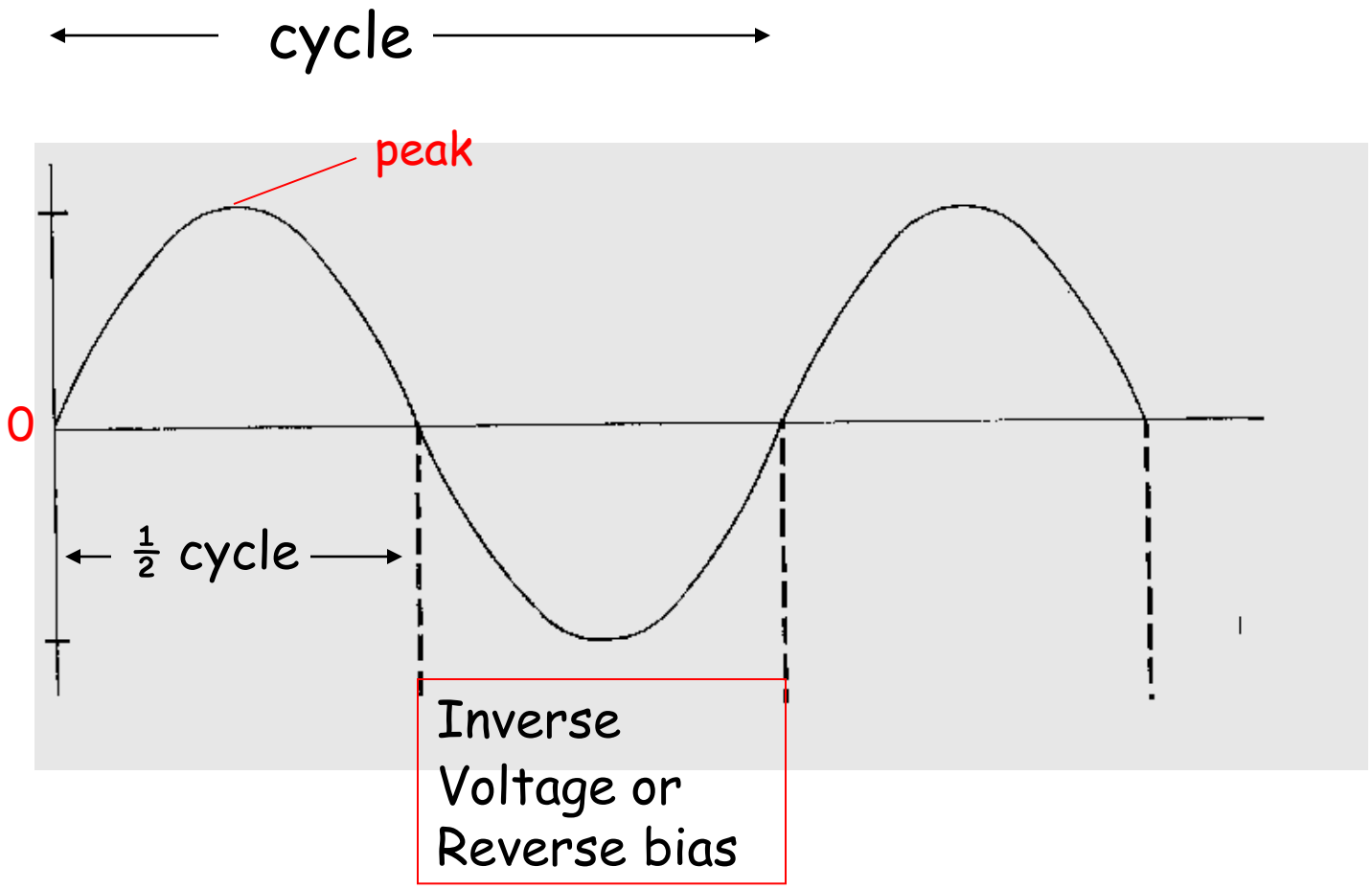


PRODUCTION OF X-RAYS



PRODUCTION OF X-RAYS

A.C current (60 cycles per second) variable



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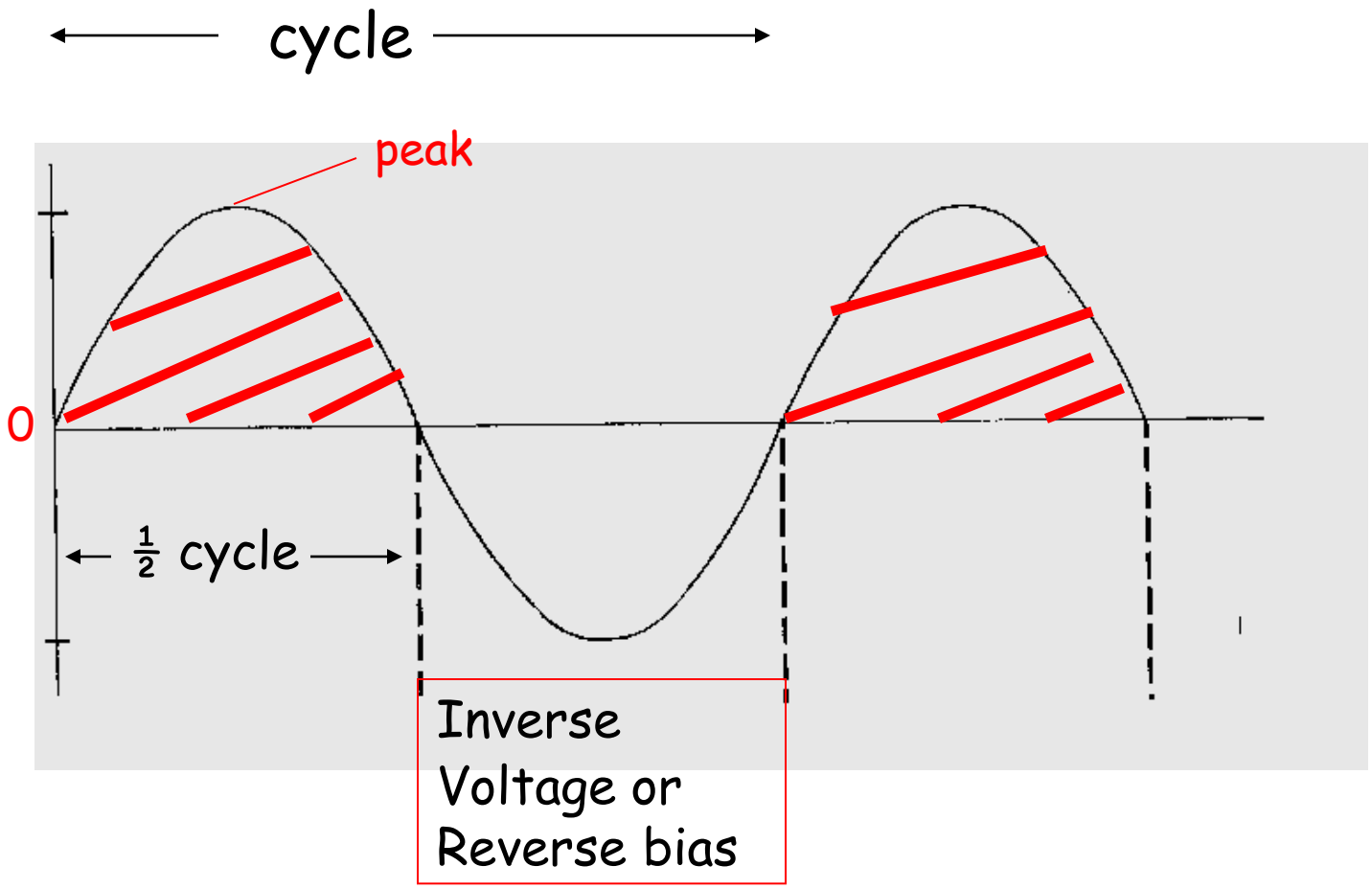

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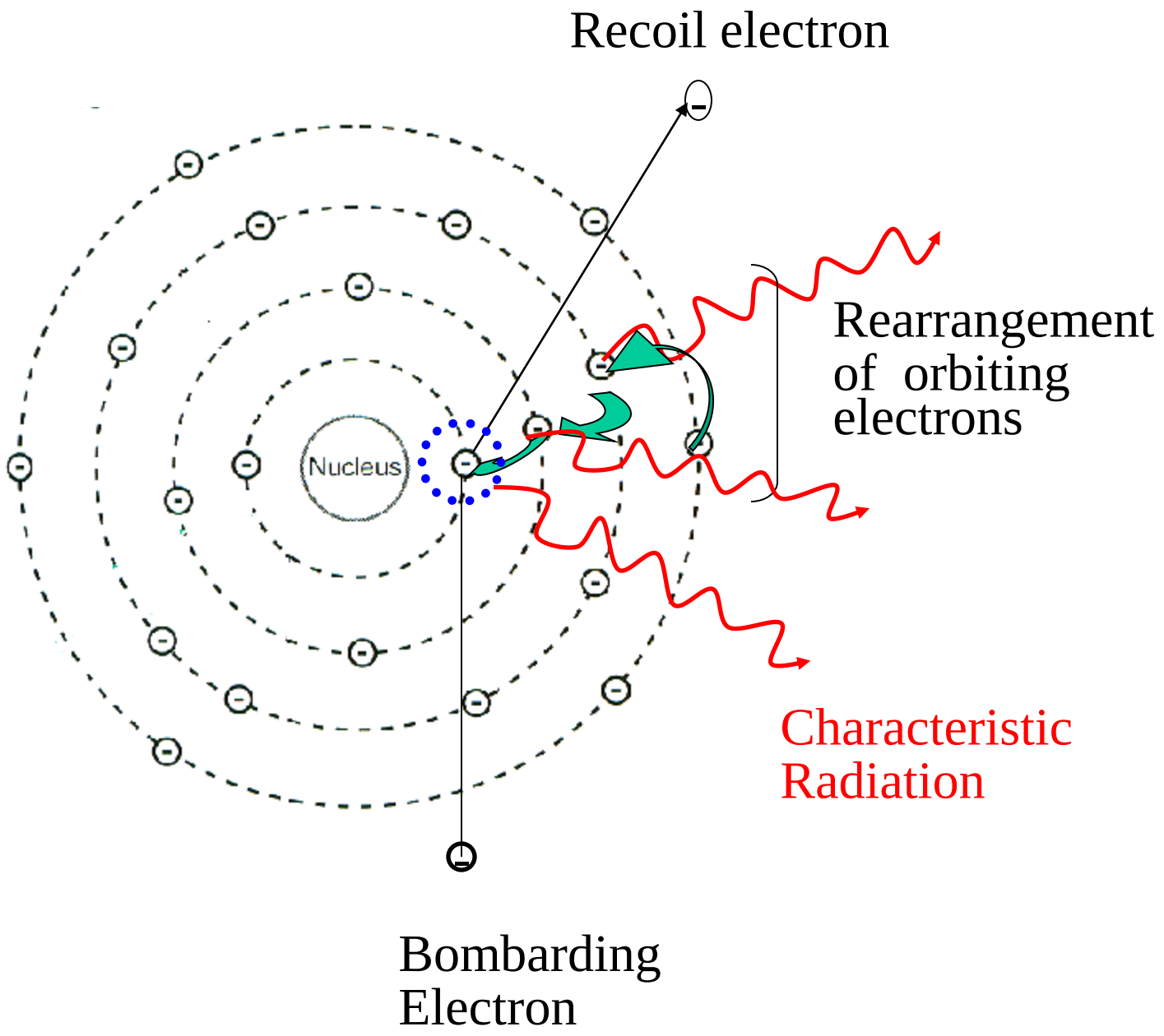


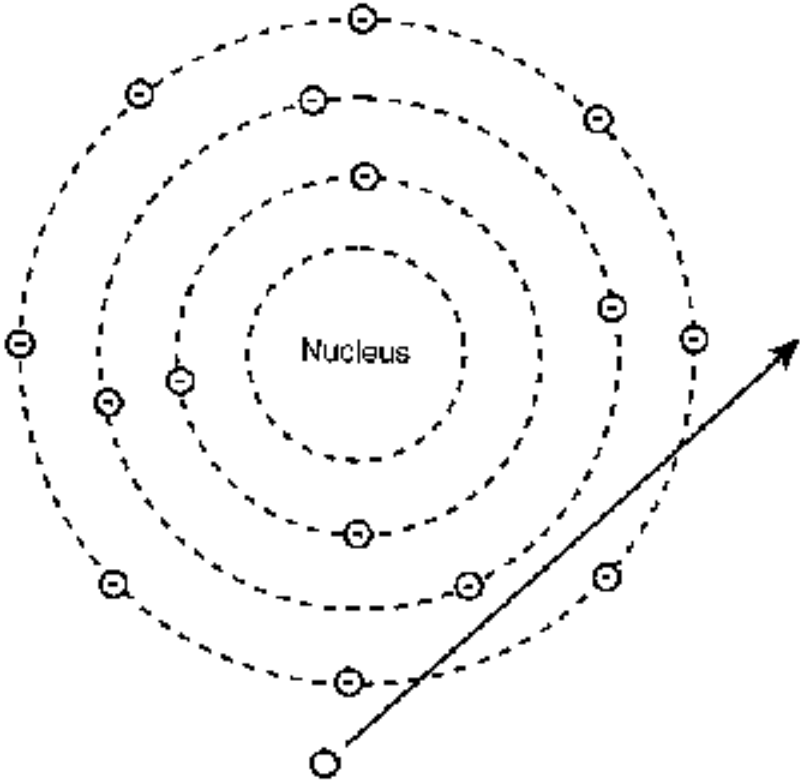
INTERACTIONS OF X-RADIATION

What happens after an x-ray exits the tubehead ?

- X-rays can pass through the patient without any interaction
- X-ray photons can be completely absorbed by patient
- X-ray photons can be scattered

INTERACTIONS OF X-RADIATION

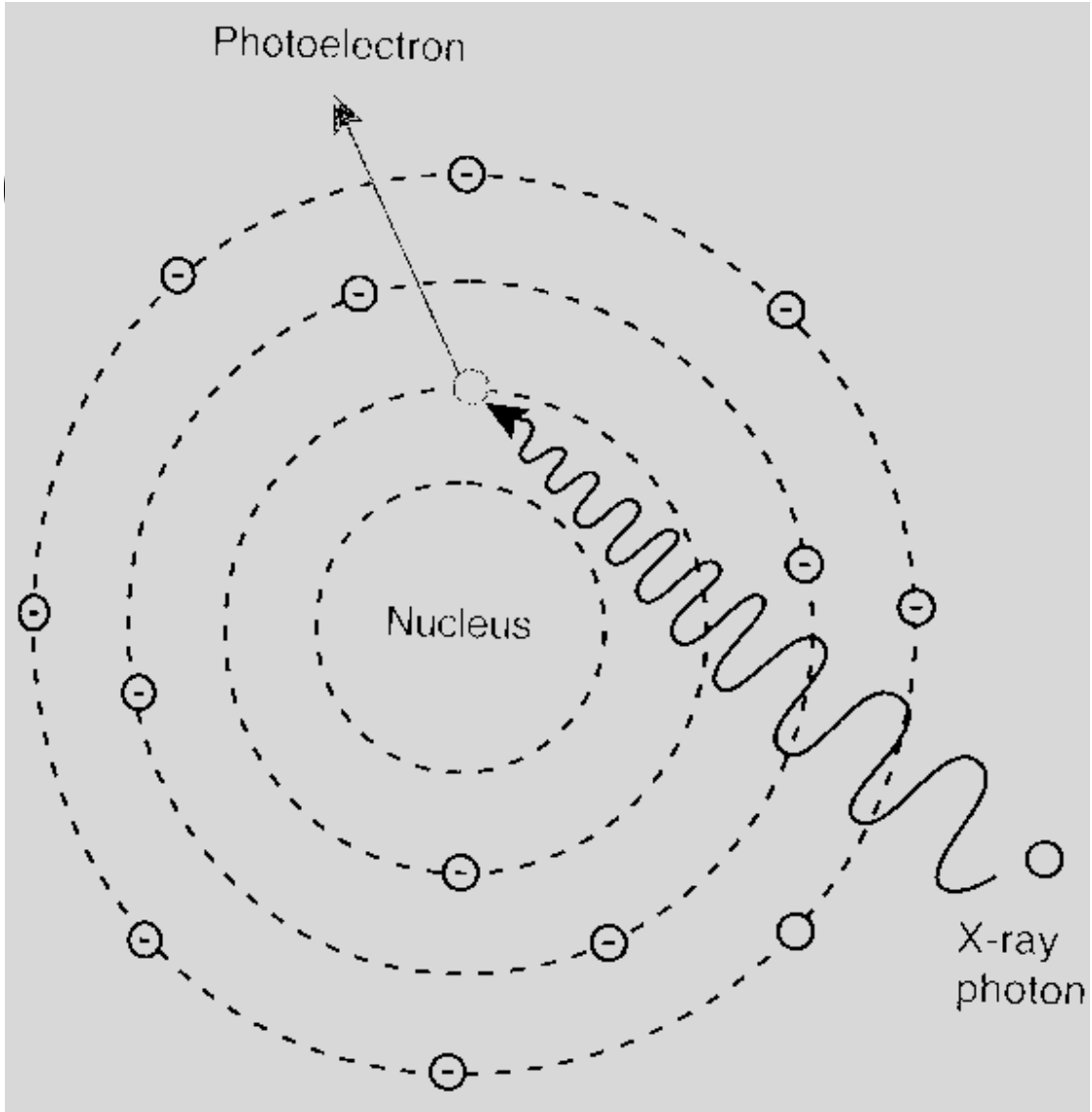
No interaction



- Responsible for producing densities on the film
- Makes dental radiography possible

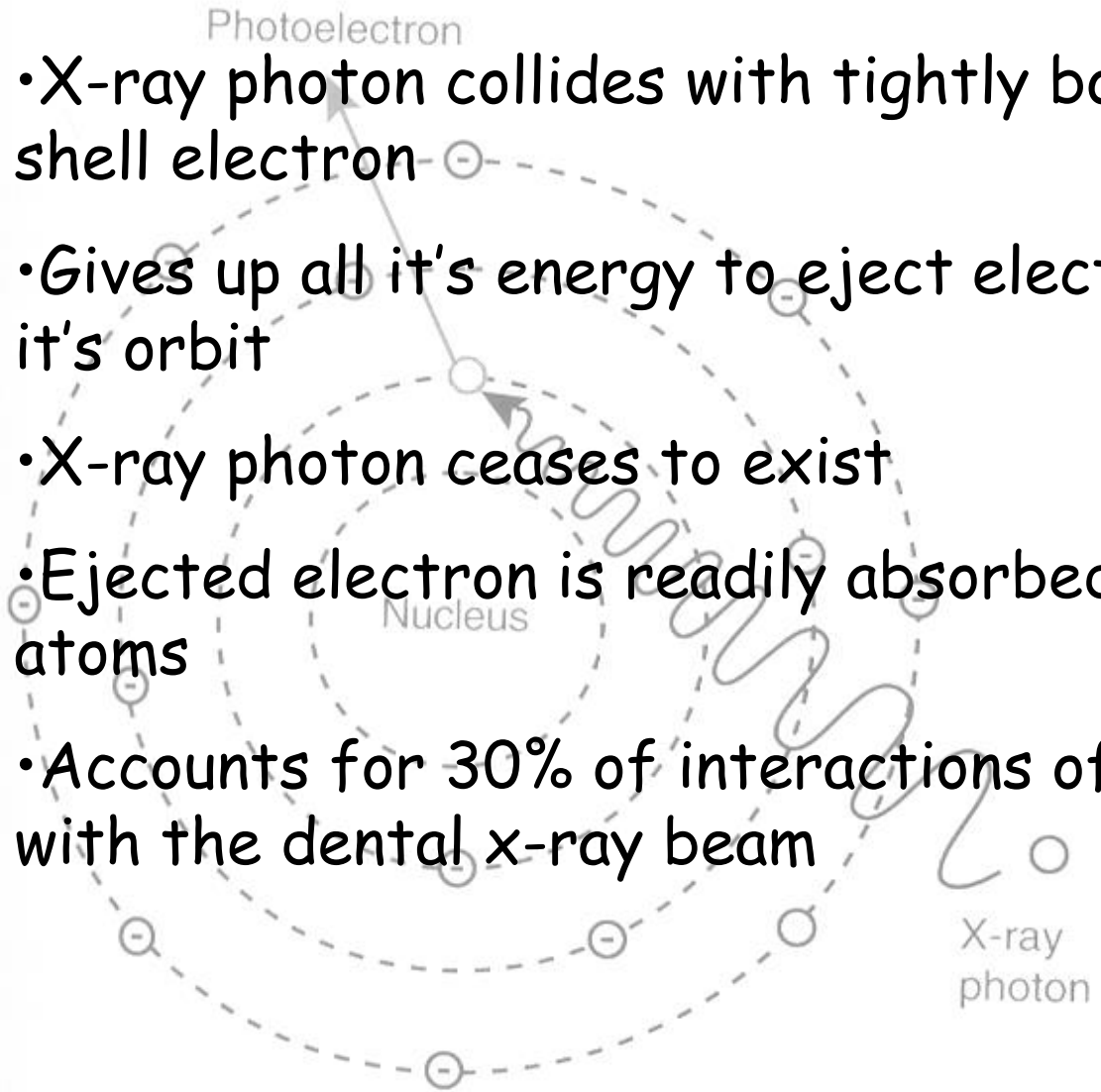
INTERACTIONS OF X-RADIATION

Absorption of Energy and Photoelectric Effect



INTERACTIONS OF X-RADIATION

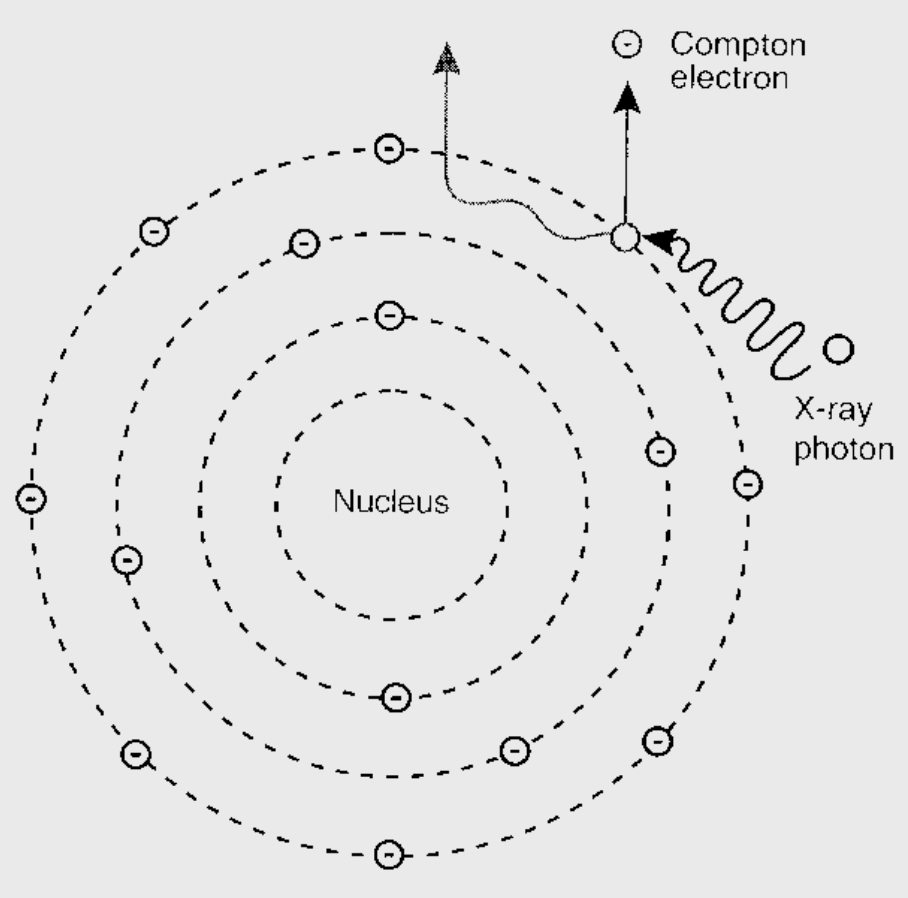
Absorption of Energy and Photoelectric Effect



- X-ray photon collides with tightly bound, inner shell electron
- Gives up all it's energy to eject electron from it's orbit
- X-ray photon ceases to exist
- Ejected electron is readily absorbed by other atoms
- Accounts for 30% of interactions of matter with the dental x-ray beam

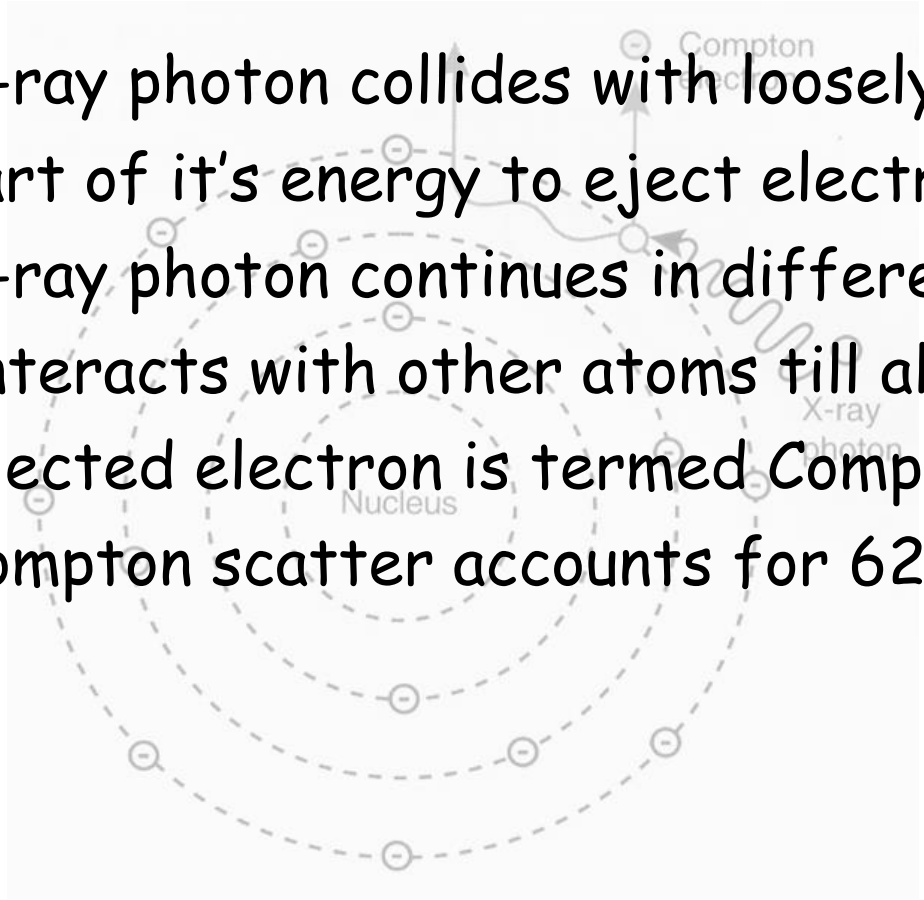
INTERACTIONS OF X-RADIATION

Compton Scatter



INTERACTIONS OF X-RADIATION

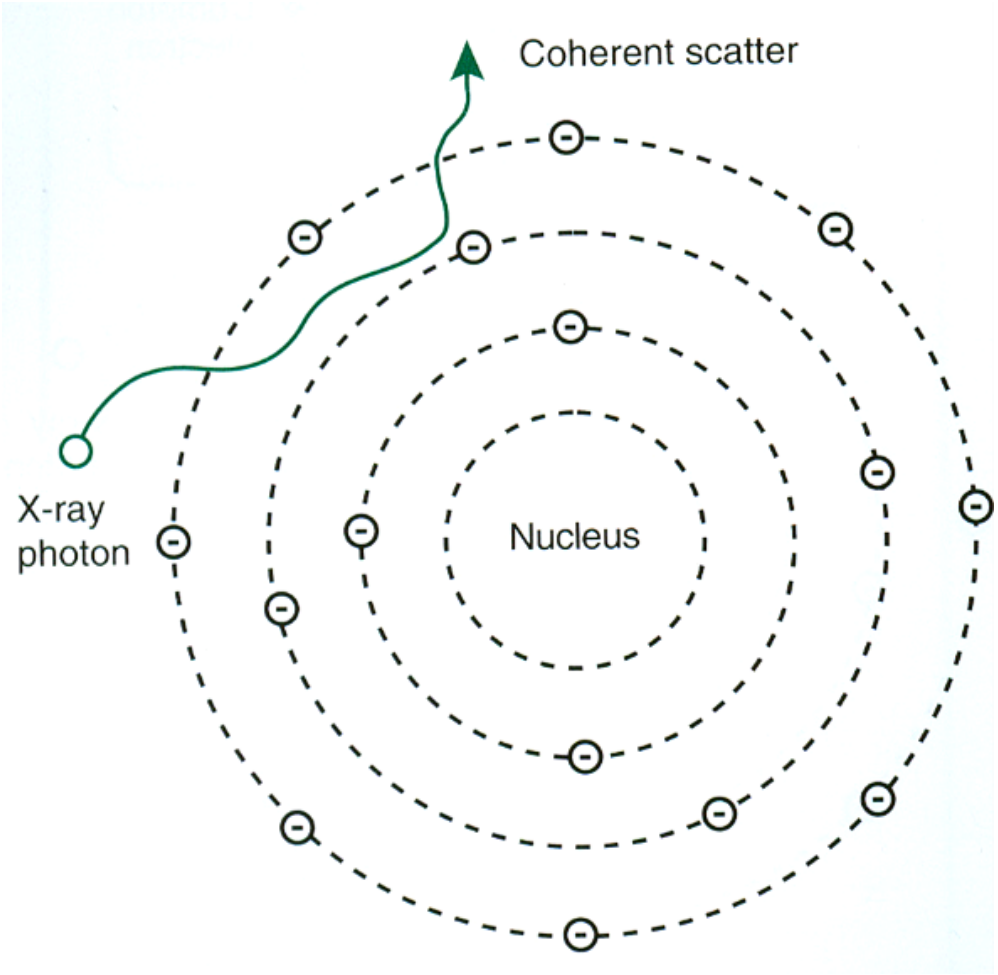
Compton Scatter



- X-ray photon collides with loosely bound outer electron
- Part of it's energy to eject electron from it's orbit
- X-ray photon continues in different direction with < energy
- Interacts with other atoms till all it's energy is gone
- Ejected electron is termed Compton electron
- Compton scatter accounts for 62% of interaction

INTERACTIONS OF X-RADIATION

Coherent Scatter



INTERACTIONS OF X-RADIATION

Coherent Scatter

- Also called unmodified scatter
- Low energy x-ray photon interacts with outer shell electron
- No change in atom
- X-ray photon scattered in different direction than incident photon
- No loss of energy & no ionization
- 8% of interactions of x-ray beam with matter