

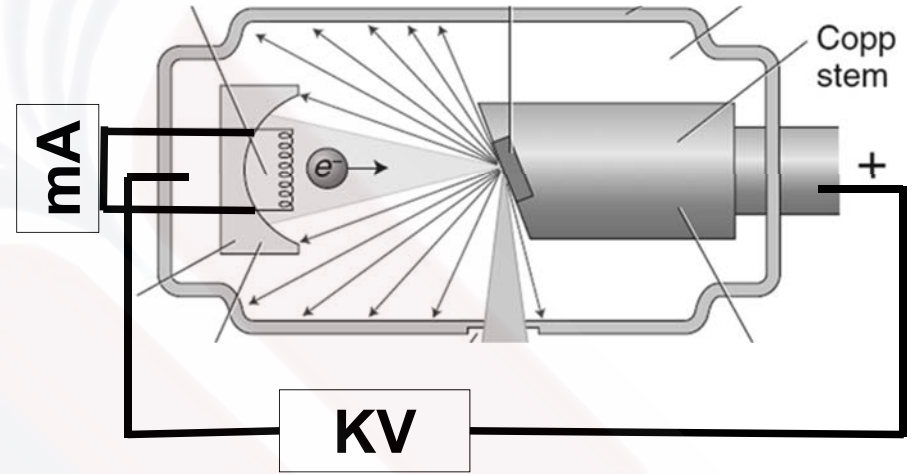
Radiation physics - 2

Lecture 2

Imad Brinjikji

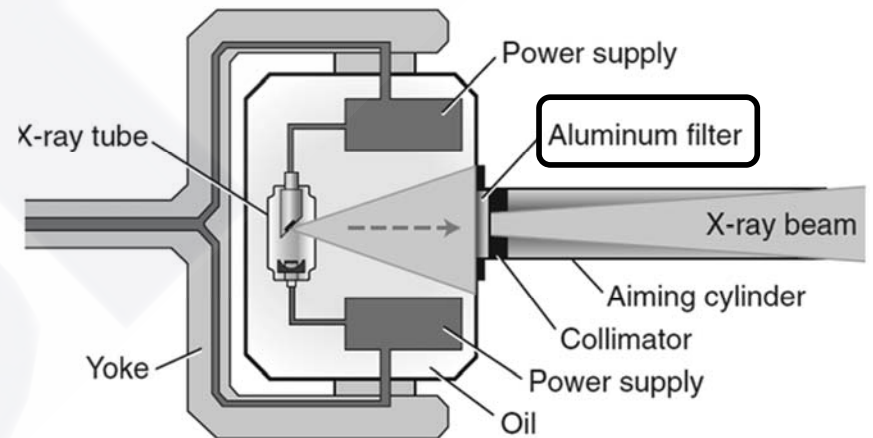
1

2



Filtration

The process of removing low-energy x-rays from the x-ray beam.



3

4

The maximum energy of photons (in eV)

=

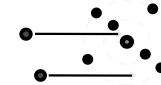
The numerical value of the applied KV

So it is called KVP

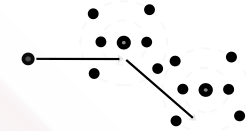
5

X-ray Spectrum results from (What about DC devices?)

Varying electron/nucleus distances



Multiple electron interactions



Varying voltage (for AC)



6

Filtration

Inherent

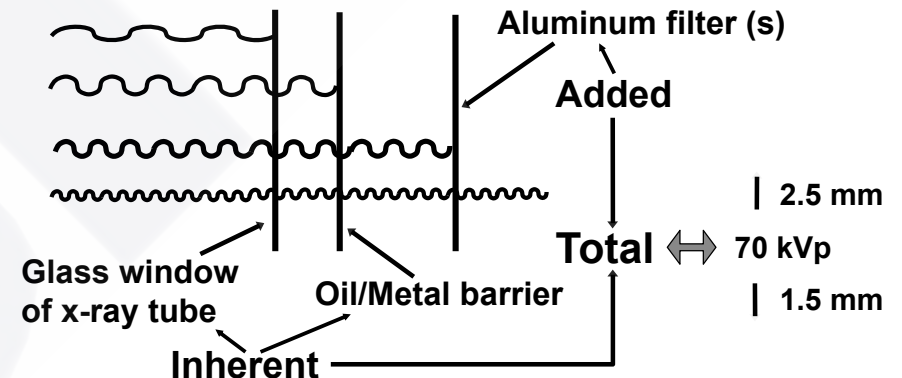
- The glass wall of the x-ray tube.
- The insulating oil.
- The barrier material that prevents the oil from escaping through the x-ray port.

Added

Aluminum

7

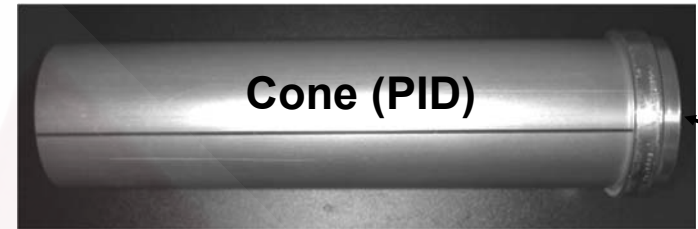
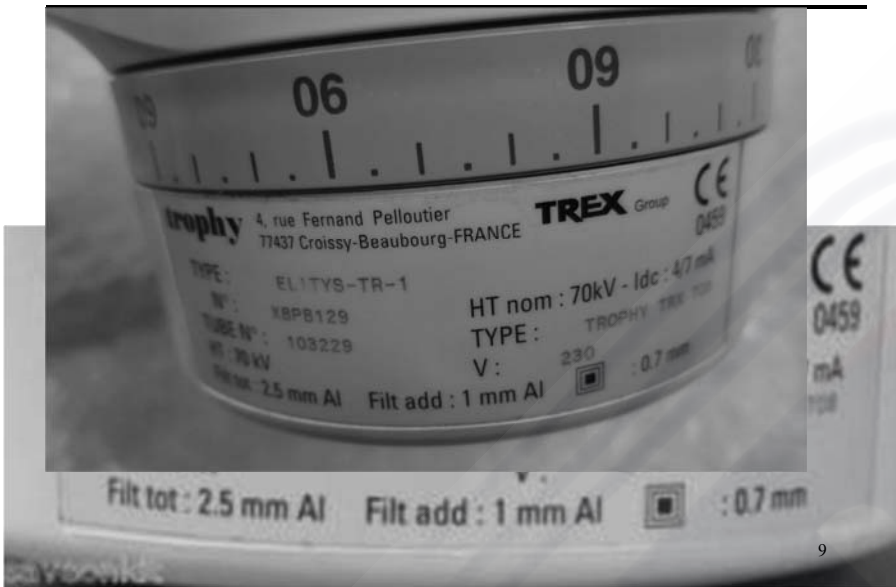
Total Filtration



Equivalent to 0.5 – 2 mm Al

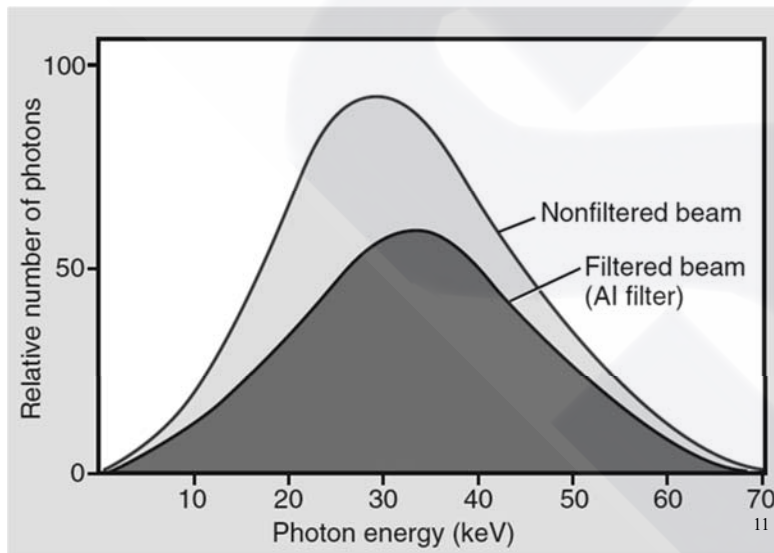
8

Filtration



The filter is usually located in the end of the PID which is attached to the tubehead.

Filtration



Collimation

Regulates the size and/or shape of the x-ray beam.

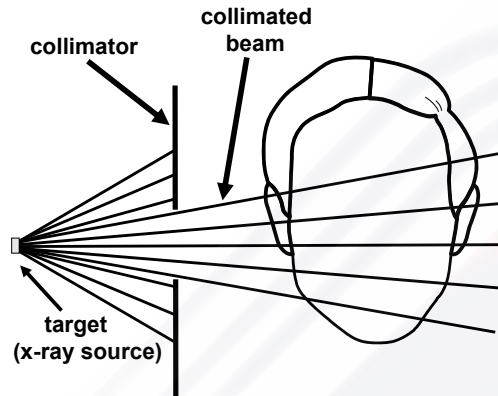
- ↓ Area covered (less patient exposure)
- ↓ Scatter radiation

Collimation

front views

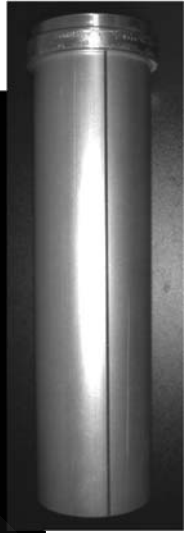
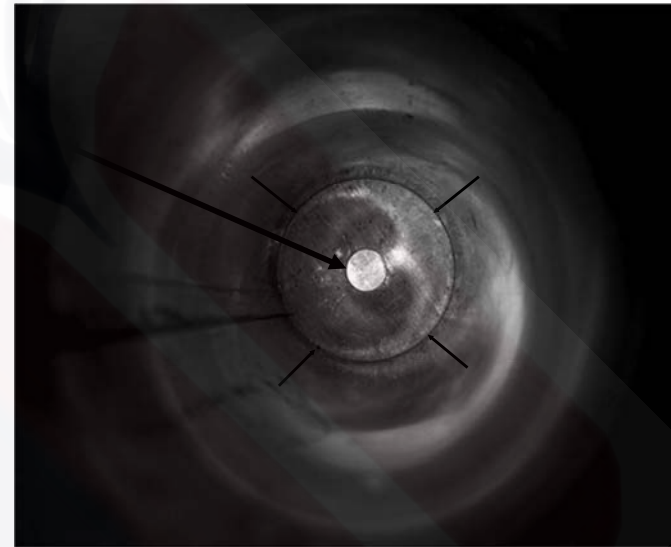


side view

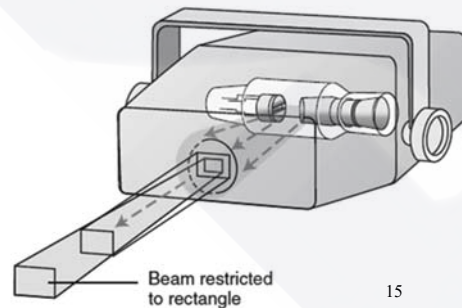
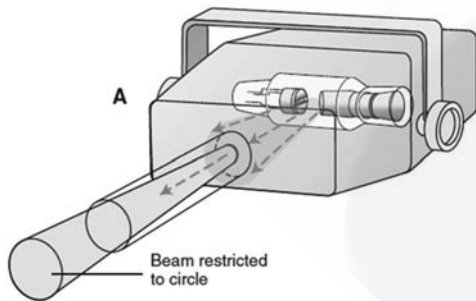


13

Collimator



14



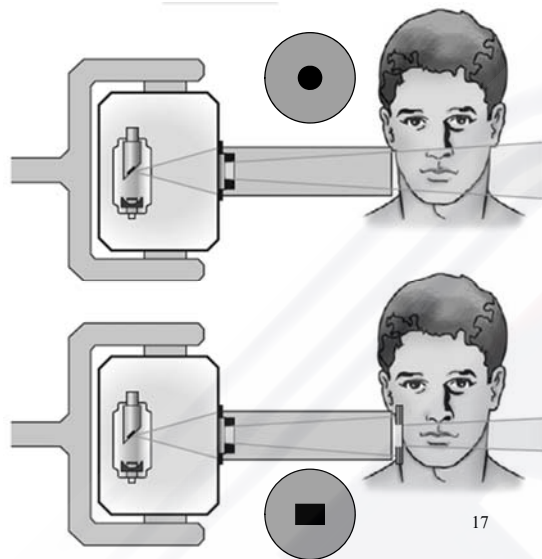
15

Comparison between rectangular and round (circular) collimators

Rectangular collimators decrease the radiation dose by up to 5-folds.

16

In rectangular collimators, the area of the patient's skin surface exposed is reduced by 60% over that of a round (7 cm) PID.



17

Collimators also improve image quality.

Less exposed tissues



Less interactions



Less scattering



Better image

18

Energy vs. Quantity

	Energy	vs.	Quantity
kVp	↑		↑
mA	No change		↑
Time	No change		↑
Filtration	↑		↓

19

Inverse Square Law

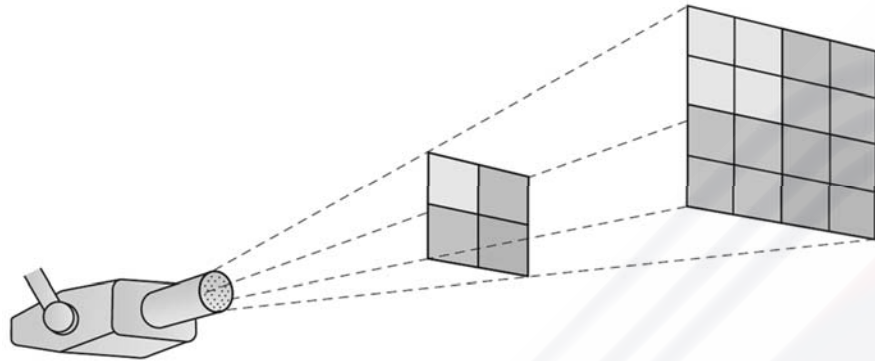
The intensity of radiation varies inversely as the square of the target*film distance

* target = source, focal spot, focus

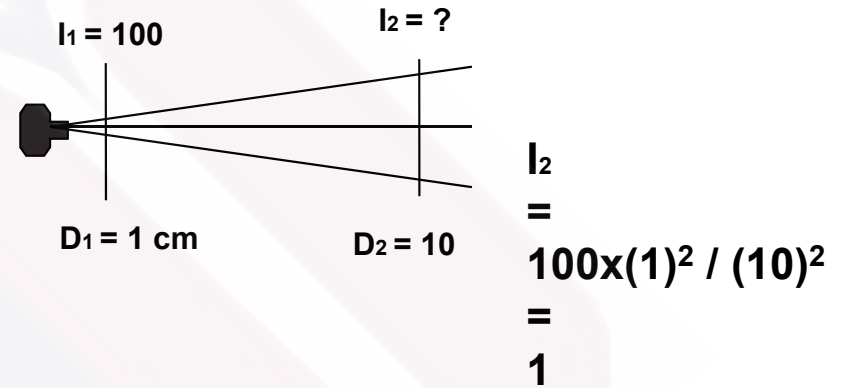
$$\frac{I_1}{I_2} = \frac{(D_2)^2}{(D_1)^2}$$

20

Inverse Square Law



21



22

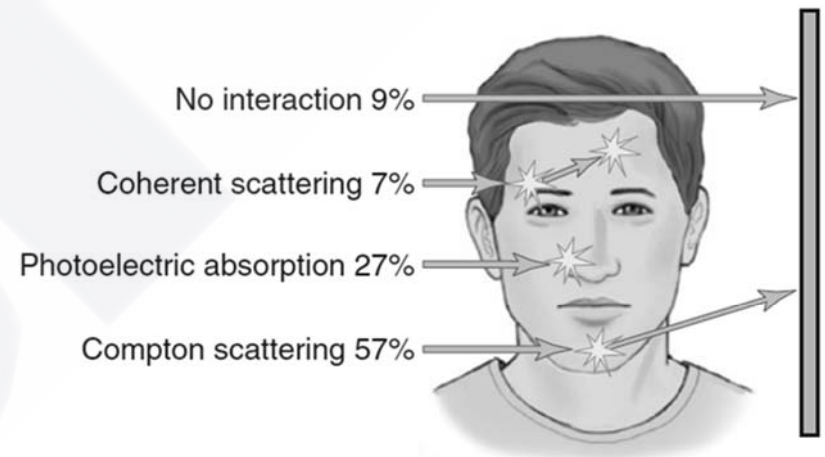
Interaction between X-ray photons and tissues

Scattering

Absorption

About 9% of the photons pass through the patient's head without interaction.

23



24

Absorption

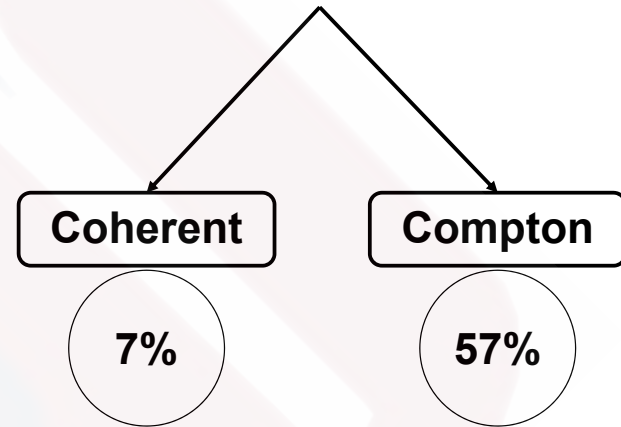
Photons ionize absorber atoms, convert their energy into kinetic energy of the ejected electron, and cease to exist.

27%

25

Scattering

Photons interact with absorber atoms, but then move off in another direction.



26

Coherent scattering

Low-energy incident photon (<10 keV).

+

A whole atom

↓

The atom momentarily is excited.

↓

The atom quickly returns to the ground state.

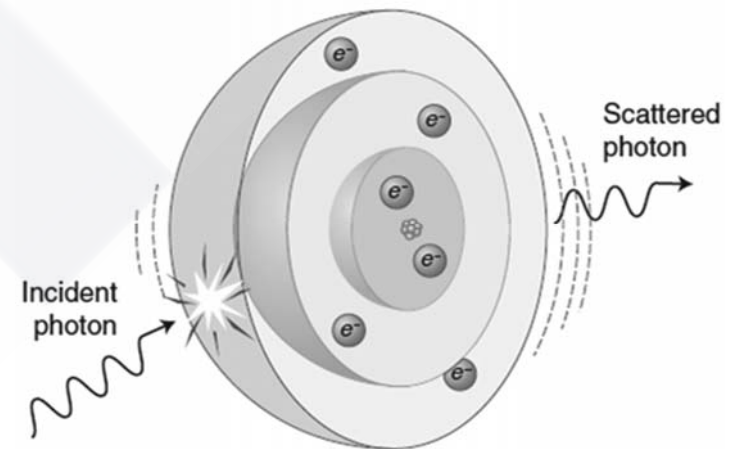
The photon ceases to exist

↓

A scattered photon is emitted (new) at a different angle from the path of the incident photon.

27

Coherent scattering



Contribute little to film fog.

28

Compton scattering

A photon

+

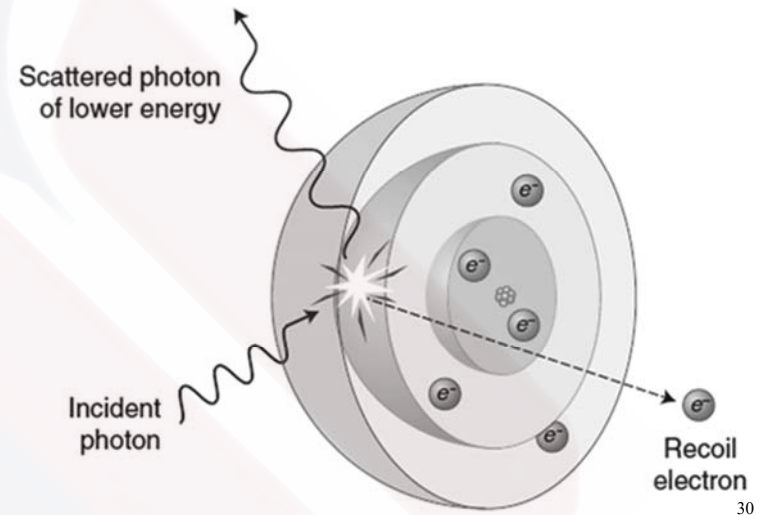
An outer orbital electron.



- The electron is ejected from the target atom (the atom is ionized and the e^- ionizes other atoms).
- The photon is scattered in another direction.

29

Compton scattering



30

Compton scattering

- **Compton scattering is greater in bone than in soft tissue.**

31

Absorption

A photon

+

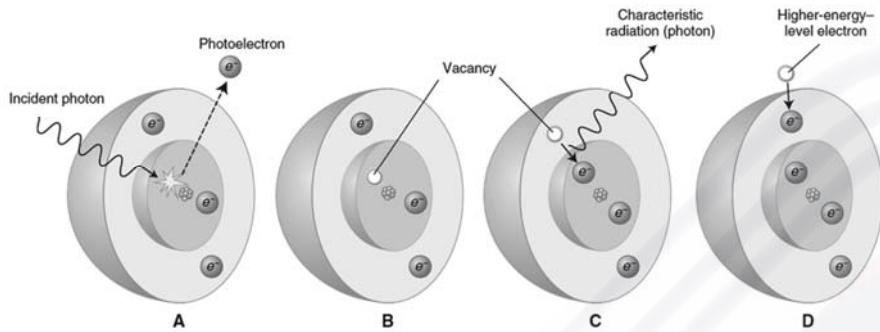
Inner e^-



- **The photon ceases to exist.**
- **An electron from an outer orbital fills the vacancy of the inner photon (the atom is ionized).**
- **A new photon is emitted.**

32

Absorption



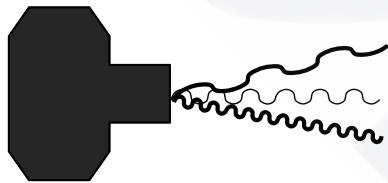
33

Absorption

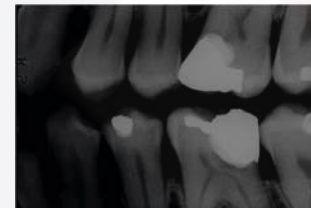
The probability that a photon will be absorbed in bone is approximately 6.5 times than in soft tissue.

34

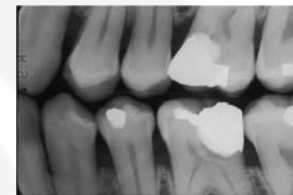
How changing KV, mA and exposure time affect the resultant radiograph?



35



Incorrect exposure factors
(too many x-rays or too much energy; film too dark)



Correct exposure factors



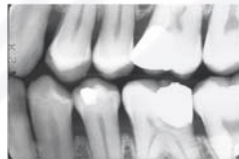
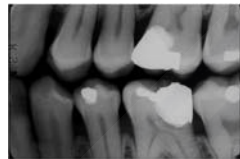
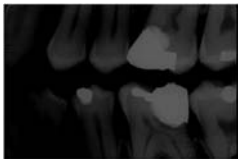
Incorrect exposure factors
(not enough x-rays or energy too low; film too light)

36

Constant patient size

- | | |
|--|----------|
| 1. Proper kVp, mA, exposure time (e.t.) | B |
| 2. Increase mA; no change in kVp, e.t. | A |
| 3. Decrease e.t.; no change in kVp, mA | C |
| 4. Increase kVp; no change in mA, e.t. | A |
| 5. Double mA, halve e.t.; no change in kVp | B |

**THE
END**



37