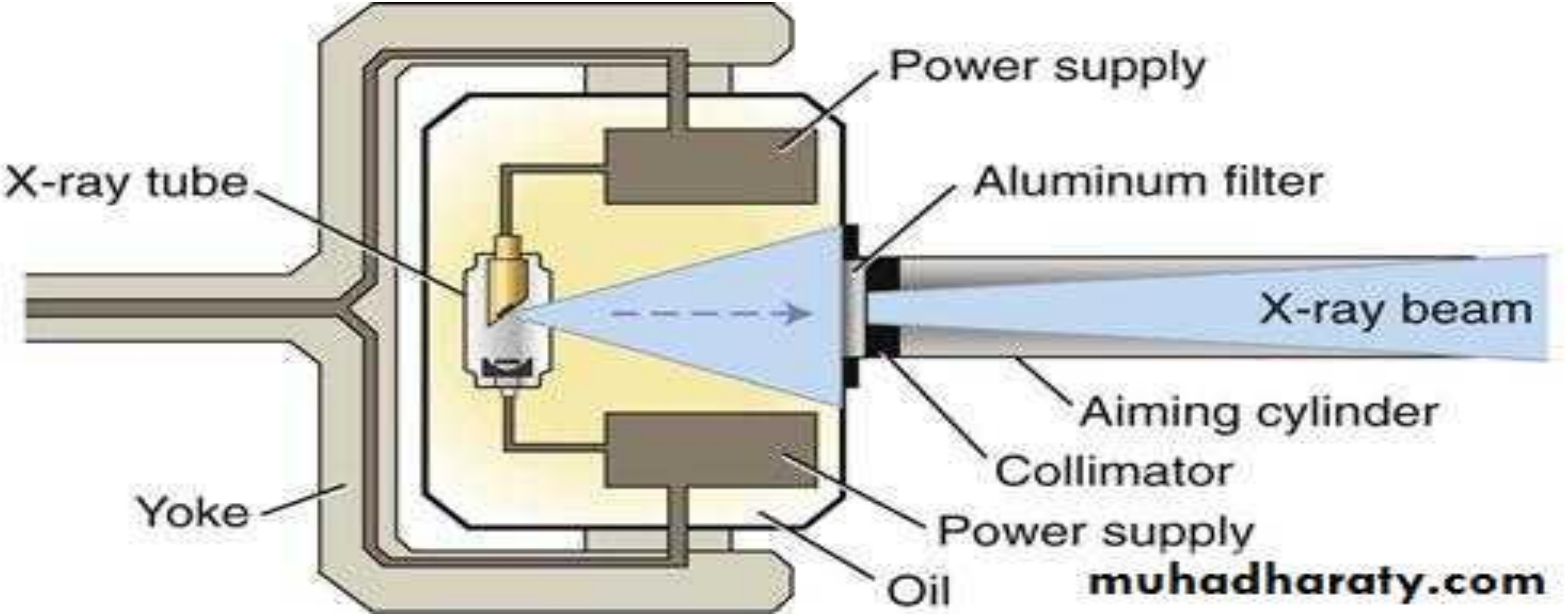
Factors controlling x-ray beam



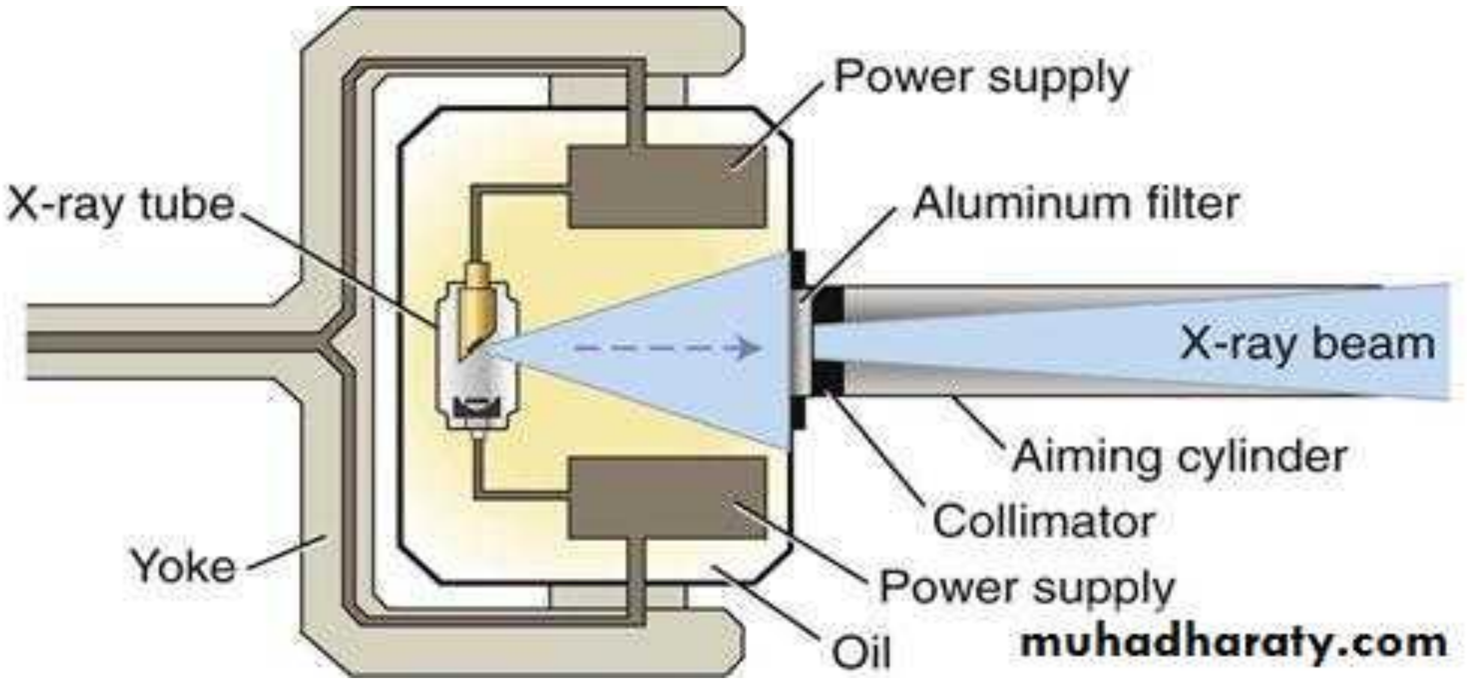
PROF.ABBAS AY TAHER

X - RAYS X-Rays are high energy ionizing electromagnetic radiation

X-rays are only produced when the 'beam is on' and are the result of the collision of accelerated electrons with a target material and thus X-rays are bremsstrahlung radiation. An important determinant of beam energy is the electrical potential through which a beam is accelerated.

FACTORS CONTROLLING THE X RAY BEAM :

1. EXPOSURE TIME (s)
2. TUBE CURRENT (mA)
3. TUBE VOLTAGE (kVp)
4. FILTRATION
5. COLLIMATION
6. SOURCE TO FILM DISTANCE
7. TARGET MATERIAL



XPOSURE TIME (s)

- Changing the time controls the duration of exposure & thus the number of photons generated.
- It determines the length of x- ray production
- The time of exposure is doubled, the number of photons generated is doubled, but the range of energies is unchanged.
- The effect of increasing or decreasing exposure time will control the quantity of x ray photons

TUBE CURRENT (mA)

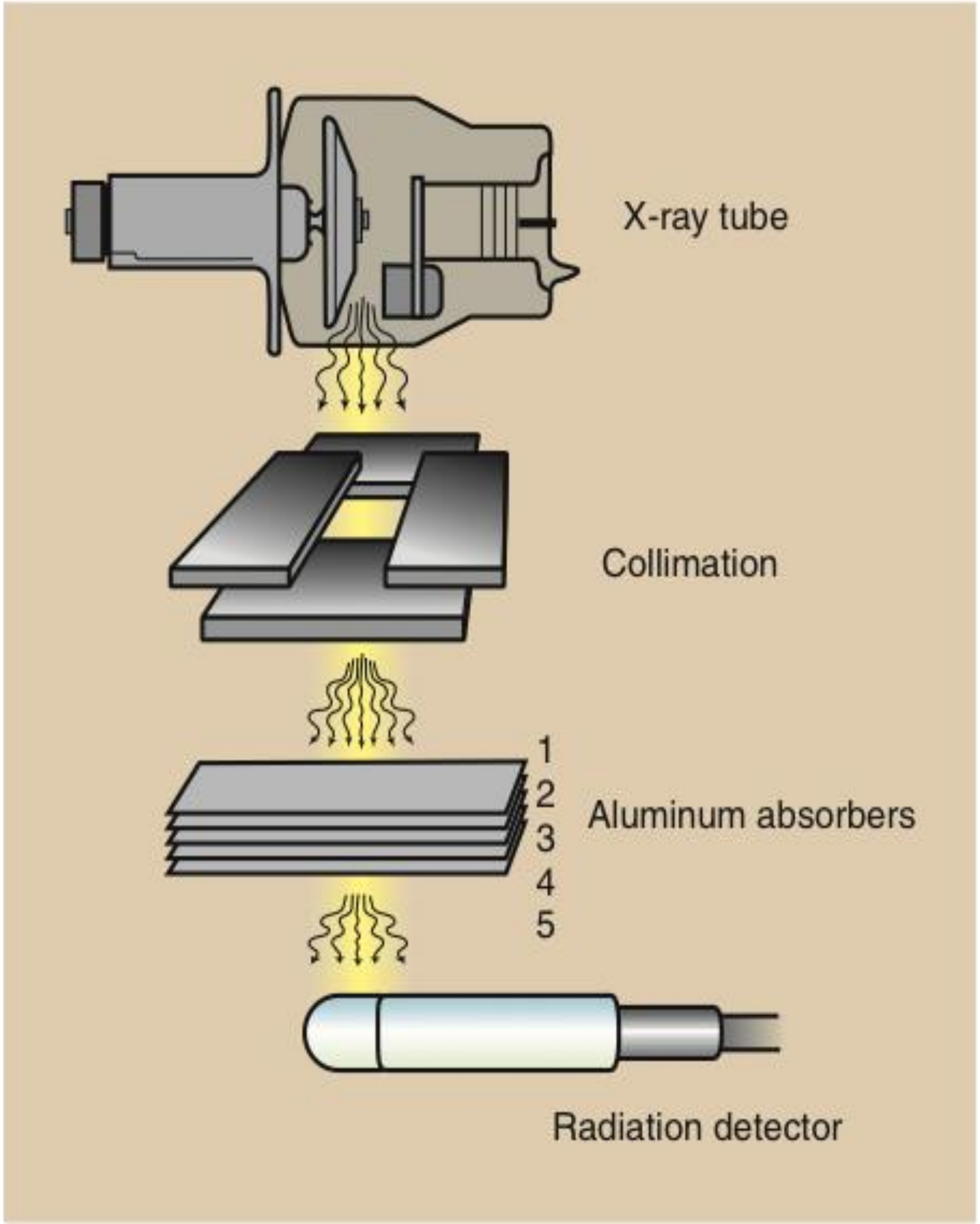
- Produced by flow of electrons from their point of origin(filament) to the anode (target) of x ray tube.
- The quantity of radiation produced by xray tube is directly related to tube current and the time, the tube is operated.
- There is a linear relationship between mA and tube output. Doubling the tube current should double the number of photons produced at each energy value.

TUBE VOLTAGE (kVp)

- Voltage is the measurement of force that refers to the potential difference between two electric charges.
- As the kV is increased, there is an increase in the energy of electrons when it strikes the target. It results in an increased efficiency of conversion of electron energy to x ray photons. This leads to - Increased number of photons - Increased mean energy of photons - Increased maximum energy of photons.

FILTRATION

Filtration is the removal of low energy, less penetrating photons from x-ray beam by placing filter in the path of x-ray beam. Filters are aluminium sheets placed at the end of the tube where x-rays exit.

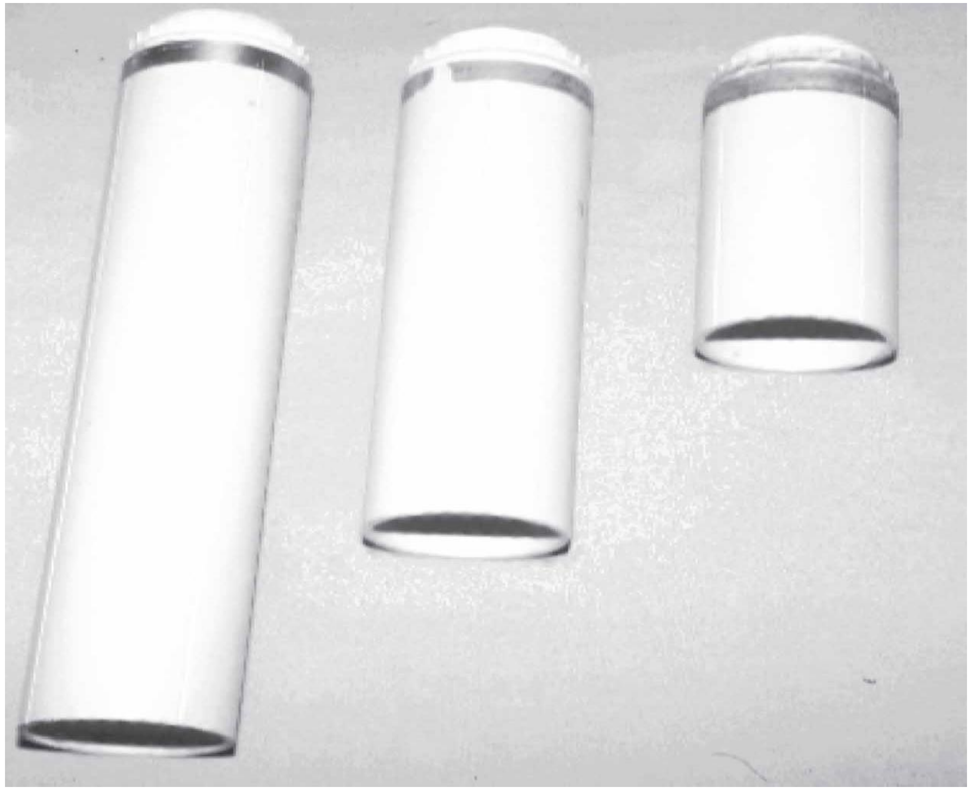


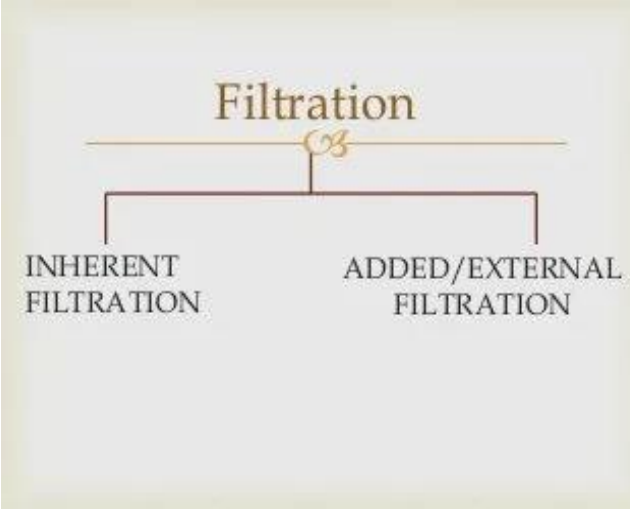
• **Inherent filtration :**
Consists of the materials that x-ray photons encounter as they travel from the focal spot on the target to form usable beam outside the tube enclosure.

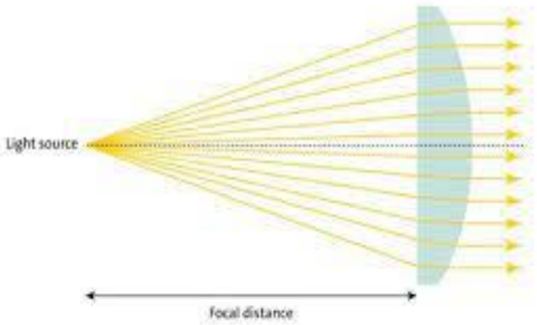
• **Added Filtration : It is the amount of filtration added externally to the x ray tube.**

• **Total filtration :** Sum of inherent filtration plus any added external filtration supplied in the form of aluminum disks placed over the prt in the head of the x-ray machine.

Round PIDs are available in 16, 12, and 8 inches (41, 30, and 20.5 cm).







Collimator:

A collimator is a device which narrows a beam of particles or waves. To narrow can mean either to cause the directions of motion to become more aligned in a specific direction (e.g., make collimated light or parallel rays), or to cause the spatial cross section of the beam to become smaller (beam limiting device).

In X-ray optics, gamma ray optics, and neutron optics**, a collimator is a device tha filters a stream of rays so that only those traveling parallel to a specified direction are allowed through**.

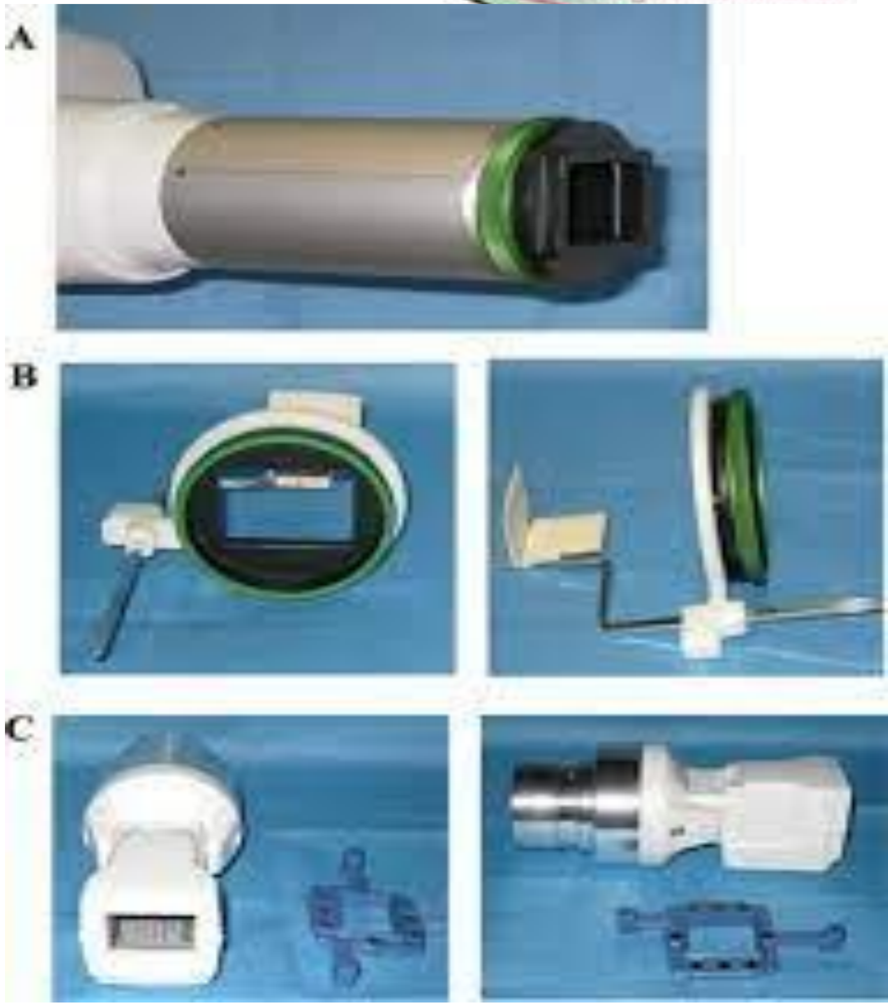
Collimators are used for X-ray, gamma-ray, and neutron imaging because it is not yet possible to focus these types of radiation into an image using lenses, as is routine with electromagnetic radiation at optical or near-optical wavelengths.

Collimators are also used in **radiation detectors in nuclear power stations** and nuclear medicine (scintigraphy- bone scan) to make directional sensitivity.

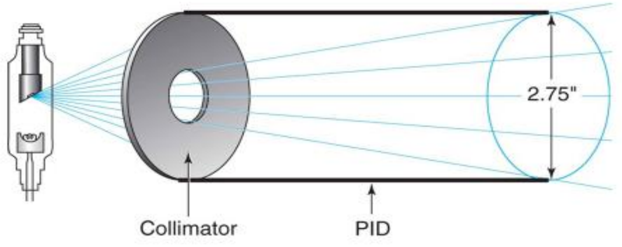
Collimators (beam limiting devices) are used in linear accelerators used for radiotherapy treatments. **They help to shape the beam of radiation emerging from the machine and can limit the maximum field size of a beam.**

The treatment head of a linear accelerator consists of both a primary and secondary collimator. The primary collimator is positioned after the electron beam has reached a vertical orientation.

When using photons, it is placed after the beam has passed through the X-ray target. The secondary collimator is positioned after either a flattening filter (for photon therapy) or a scattering foil (for electron therapy). The secondary collimator consists of two jaws which can be moved to either enlarge or minimize the size of the treatment field.



New systems involving multileaf collimators (MLCs) are used to further shape a beam to localize treatment fields in radiotherapy. MLCs consist of approximately 50–120 leaves of heavy, metal collimator plates which slide into place to form the desired field shape.



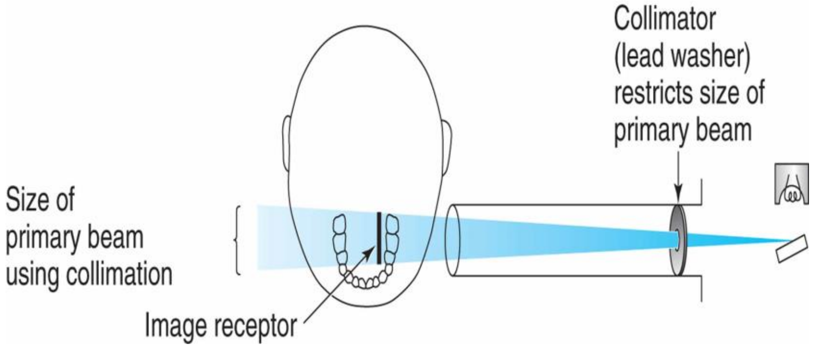
The collimator restricts the size of the primary beam to 2.75 in. (7 cm) at the end of the PID.

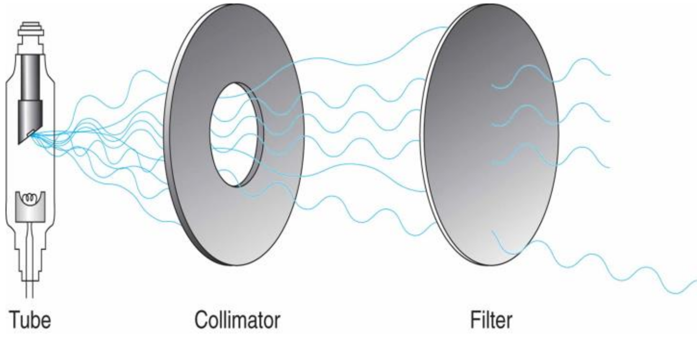
A collimator is a metallic barrier with an aperture in the middle used to reduce the size of the x-ray beam, thus the volume of irradiated tissue within patient is also reduced.

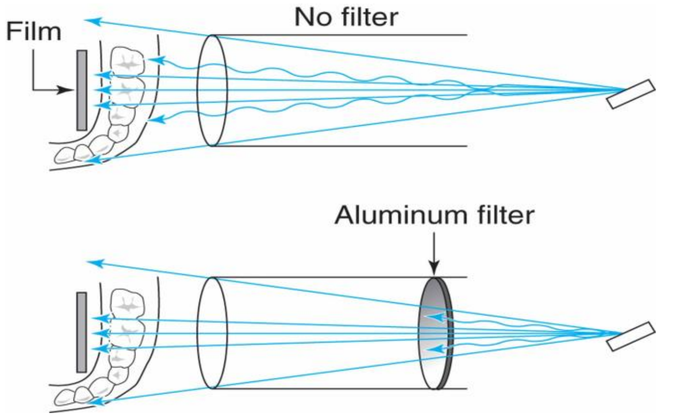
- Reduces patient exposure
- Reduces scatter radiation
- Increases film quality

With using of collimater:

Number of photons decreases.
Mean energy of photons is unchanged.
Maximum energy of the photons is unchanged







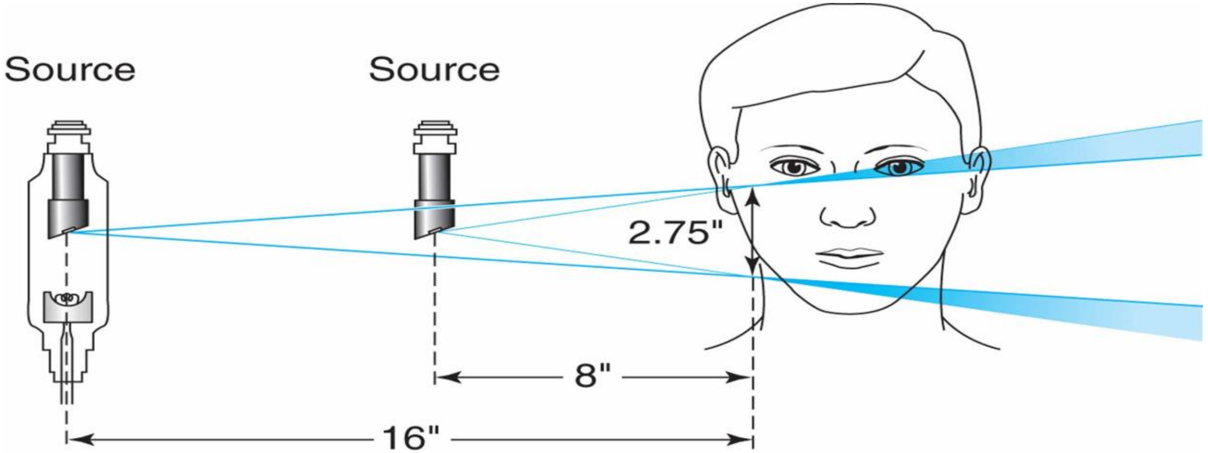
Types of collimator

- Diaphragm
- Tubular
- Rectangular
- Slit type

FILM DISTANCE

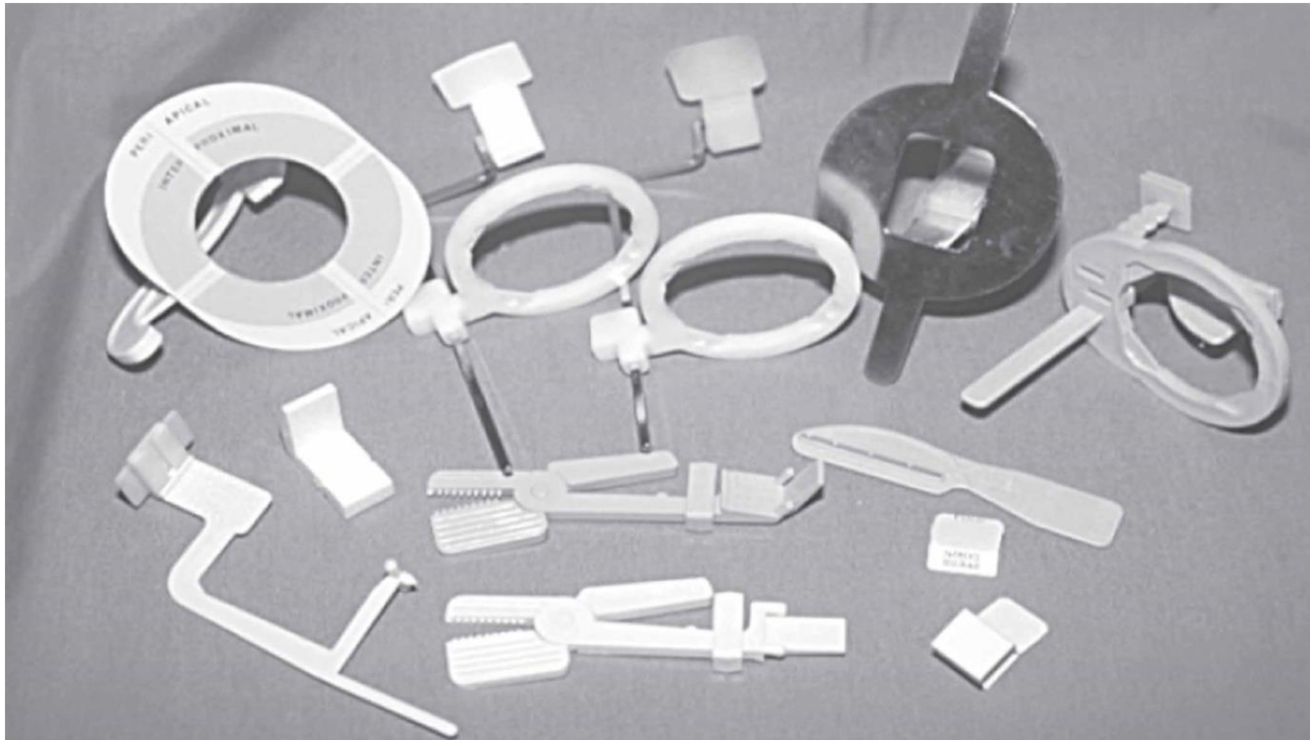
- The x-rays of primary beam emerge from the protective tube housing not as parallel rays but as divergent rays
- Intensity of the x-ray beam decreases as the distance from the source increases.

INVERSE SQUARE LAW : The intensity of the x-ray beam is inversely proportional to square of the source-film distance. I1/I2 = (D2)^2/(D1)^2



Target-surface distance. The longer the target-surface distance, the more parallel the x-rays and the less tissue exposed. Note that the beam size at the patient's skin entrance is 2.75 in. (7 cm) for both target-surface distances. It is the exit beam size that increases to expose a larger area when using the shorter target-surface distance

Many image receptor holding devices are available to fit most situations. The use of a holder prevents asking patients to put their fingers in the path of the primary beam.



• Doubling the Source-film distance, the exposure time will have to be increased by the factor of 4 to maintain the same density on the film.

TARGET MATERIAL

- Determines the efficiency of x-ray production.
- Higher the atomic number – greater will be the efficiency of the production of x-rays.
- Not important to consider for operator, as you cannot change the target material.

FACTORS AFFECTING QUALITY

- kVp
- Filtration FACTORS AFFECTING QUANTITY/ INTENSITY
- kVp
- mA
- Exposure time
- Filtration
- Collimation
- Distance

X-ray photon quantity refers to the number of photons produced during an exposure.

Factors influencing **x-ray quantity includes:**

•**peak voltage (kVp):** beam quantity is approximately proportional to the square of the tube potential

•**generator type**/voltage waveform: reducing ripple increases beam quantity

•**beam filtration:** increasing filtration reduces beam quantity

•**distance from the beam:** inverse square law

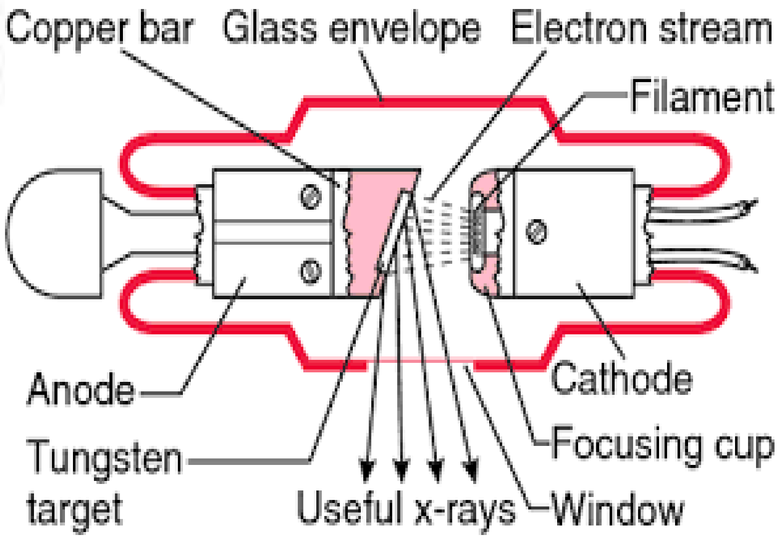
•**current (mA):** beam quantity is directly proportional to current

•**exposure time (seconds):** beam quantity is directly proportional to exposure time

•**anode material:** beam quantity is directly proportional to the atomic number (Z) of the anode material

X-ray photons quality relates to the x-ray spectrum changes and the effective photon ener

Factors relating to the production of radiograph 5

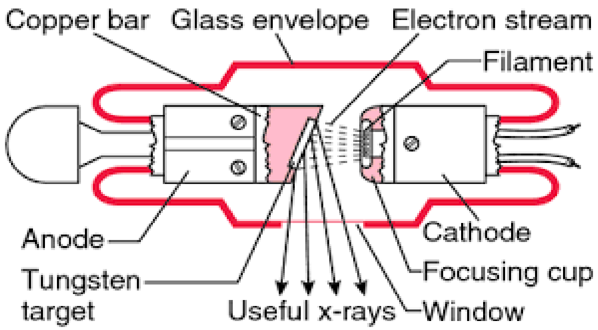


Professor Abbas AY Taher

X-ray photon quantity refers to the number of photons produced during an exposure.

Factors influencing x-ray quantity includes:

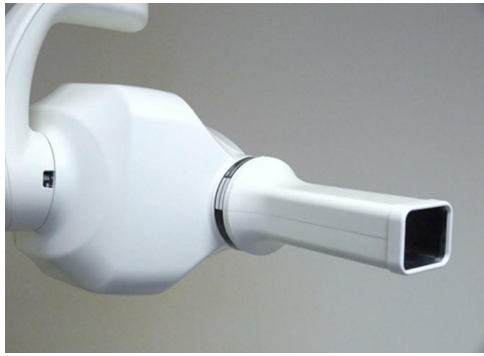
- peak voltage (kVp): beam quantity is approximately proportional to the square of the tube potential
- generator type/voltage waveform: reducing ripple increases beam quantity
- beam filtration: increasing filtration reduces beam quantity
- distance from the beam: inverse square law
- current (mA): beam quantity is directly proportional to current
- exposure time (seconds): beam quantity is directly proportional to exposure time
- anode material: beam quantity is directly proportional to the atomic number (Z) of the anode material



X-ray photons quality relates to the x-ray spectrum changes and the effective photon energy. The effective photon energy is approximately equal to between one third to one half of the maximum photon energy.

Factors influencing x-ray quality include:

- peak voltage (kVp)
- voltage waveform: reducing ripple increases quality
- beam filtration: increasing filtration increases quality through beam hardening
- anode material: photon energy depends on the binding energies of shells in the anode material

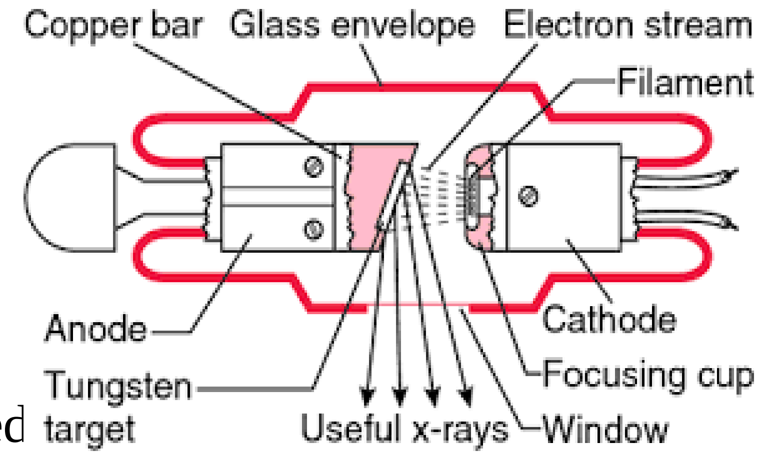


Factors relating to the production of radiograph:

A-Factors relating to the radiation beam.

B. Factors relating to the object factors

A. Factors relating to the X-ray film.

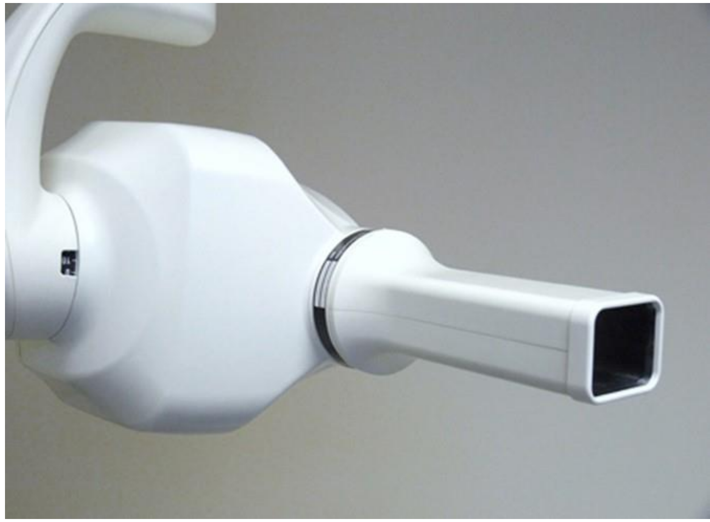


A. Factors relating to the radiation beam.

1.exposure time:-it's the interval during which X- rays are being produced exposure time is directly related to the total photon production thus increase exposure time cause increase in the quantity of X-radiation that's why exposure time has direct effect on film density.

2. Milliamperage:- its related to amount of electricity pass through the filament circuit. So it's directly control the rates of X- ray photon production thus it has direct effect on film density.

3. Kilovoltage:- kV it refers to the potential difference between cathode and anode in the X- ray tube the higher kVp the greater is the potential difference and the greaten is the energy of X- ray photons.



4. Tube–film distance:-this distance consist of (tube– object distance) and (object–film distance), now the tube –

A-film distance affect the intensity of radiation (according to inverse square law), while the tube

B-film distance affect the exposure time directly so the distance proportional directly with the exposure time but the distance proportion inversely with the intensity of radiation also the distance affect the dose of radiation because decrease the tube

C-film distance make the X- ray beam more diverge behind the skin area and more tissue is irradiated. While increase the distance make the beam less diverge and reduce the amount of tissue irradiated.

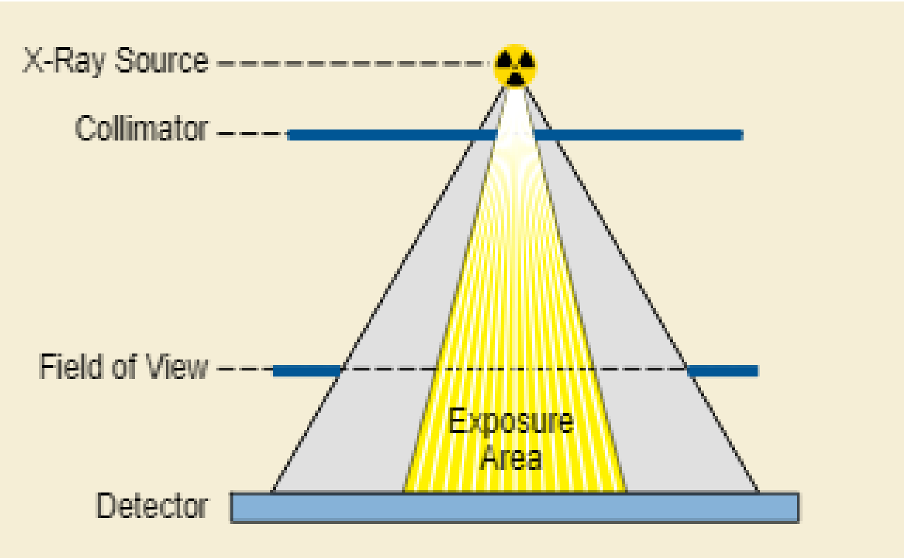
5. Focal spot size:- the focal spot or called the source of radiation must be as small as possible in size to get best image quality. So any movement in the head of X- ray machine affect this focal spot seize.

6. Collimation:- a basic rule of radiation stated that the diameter of circular X- ray beam should be no greaten than 2.75 inches while the rectangular beam dimension is 1½×2 inches collimator control the size and shape of the beam.

Effect of collimation:-

a. reduce the amount of tissue irradiated

b. Minimize the production of secondary radiation fog.



7. Filtration:- effect of filtration is the absorption of long wave length x- ray photons that have low penetrating power (can't penetrate the hard classified tissue). The result of filtration of X- ray beam is hardened beam (more short more length photon with high penetrated power) so increase the half – value layer also increase filtration affect the contrast and density but in different way the contrast is decreased (long scale) like the effect of increase kV. While the density is decreased because when filtration increase the result is the absorption of not only long wave length photons but even some of short wave length photons so the number of X-ray photons or the quantity or radiation is reduced so the density is reduced.

8. Equipment efficiency:- dental X- ray machine differ in construction and efficiency so the quality and quantity of X- ray beam vary from machine to another.

B – Factors relating to the object:-

The object is basically and x- ray absorbing medium so 2 points important about the object during exposure to x- ray:-

1. Thickness of the object.

2. Density of the object.

1.Thick object required more radiation to make a radiographic image so its often advisable to increase kV or mA and or exposure time in order to increase the amount of X- ray photons.

2.Dense object:- density refers to weight per unit volume of the object in dental radiography enamel of the tooth has highest density of all body tissues increase the density of the object increase its ability to absorb X-radiation. So hard tissue like enamel absorb great amount of radiation when compared with absorption of soft tissue like pulp because of object density.

C – Factors relating to the x- ray film:-

1. Reduction of secondary radiation:-

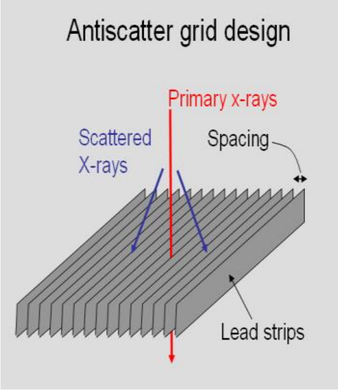
secondary radiation include scattered, stray leakage or any other radiation that not belong to primary X- ray secondary radiation is un desirable because it reaches all parts of the film and produces film fog minimizing this radiation done by:-

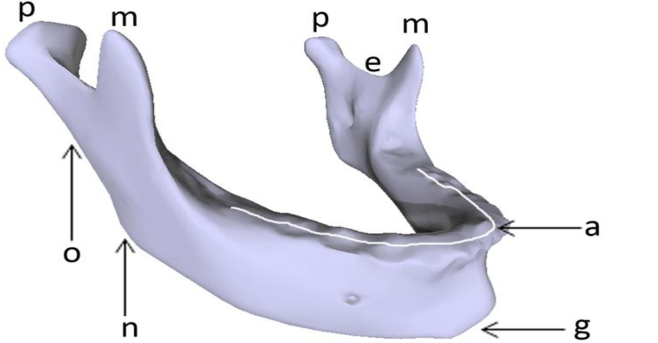
A. Using as small beam of radiation as possible.

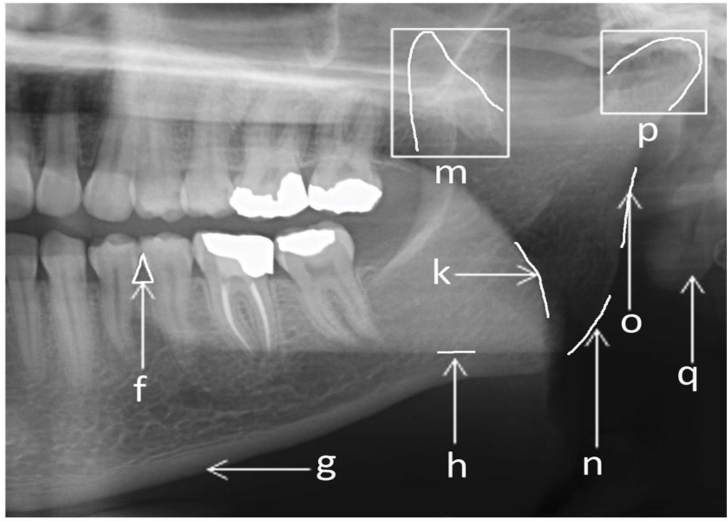
B. Proper collimation.

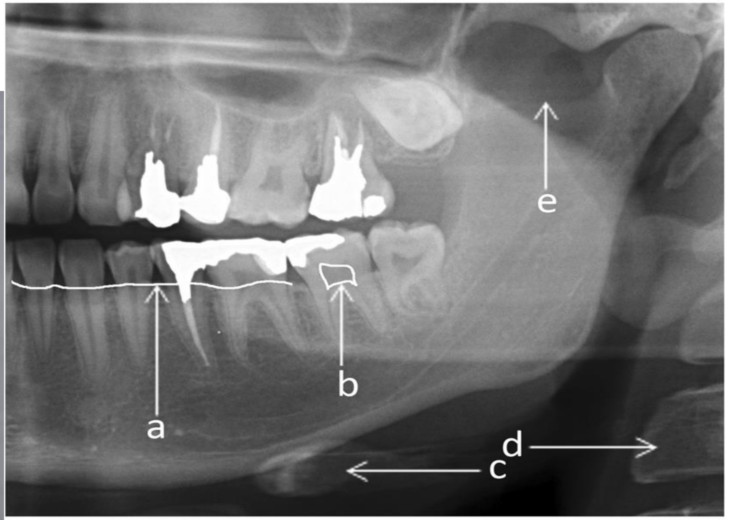
C. Using a sheet of lead foil behind the film in the film packeIn extra and intra

D. Oral film there is **grid** which is a sheet of absorbing material (lead) in strips shape this grid placed between the object and the film and it absorb this secondary radiation.







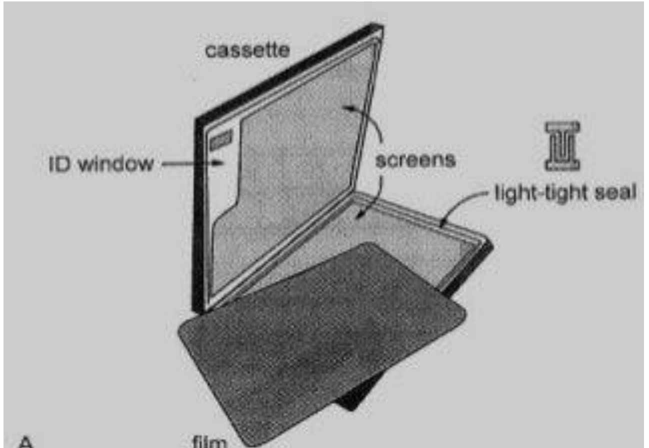


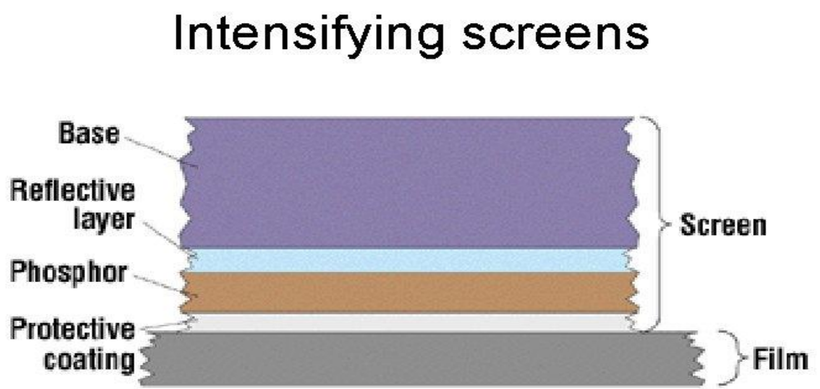
2. Film and film storage:-

X- ray film must stored in light tight containers because the **Ag Br Crystals in the emulsion** are sensitive to light as well as to X- ray. Also film must **not stored in place where we have excessive temperature or humidity or stray** radiation that's why it placed in a lead – **lined box and we should used it before the expiration**.

3. Intensifying screen

The term intensifying screen refers to the **screens used in X-ray cassettes in contact with the film**. Where the film has a single emulsion, a single intensifying screen is used facing and in contact with the emulsion side of the film. Paired intensifying screens are used with duplitized screen-type film. In all cases, the emission spectrum of the screens is matched to the spectral sensitivity of the film emulsion. Intensifying screens intensify the effect of the X-ray beam energy on the film by energy conversion. Some X-ray energy is absorbed by the screen and re-emitted as u. v. and visible light energy (Figure 5.1), to which the film has a greater sensitivity, thus producing a greater film response. The total quantity of X-ray energy converted depends on the ability of the screen to detect or absorb X-ray photons or quanta. Providing the film spectral sensitivity is matched to the screen emission spectrum then the screen with the highest quantum detection efficiency (QDE) produces the greatest film effect for a given radiation dose, phosphor layer thickness and packing densit





Proper film processing :

Causes:

•Inadequate Coverage/Missing Apices. A common receptor placement error is inadequate coverage of the area to be examined radiographically. Tilted Occlusal Plane. ...

•Backward Placement. ...

•Bending. ...

•Elongation. ...

•Horizontal Alignment Errors

•Beam Centering Errors

Fog:- is the unwanted film density (blackening) and thus reduce radiographic contrast.

SUMMARY :

Factors affecting intensity

Tube voltage (kVp)

Current (mA)

exposure time (s)

Filtration

Collimation

Source to film

- Distance

Factors affecting Quality

- kVp

Filtration

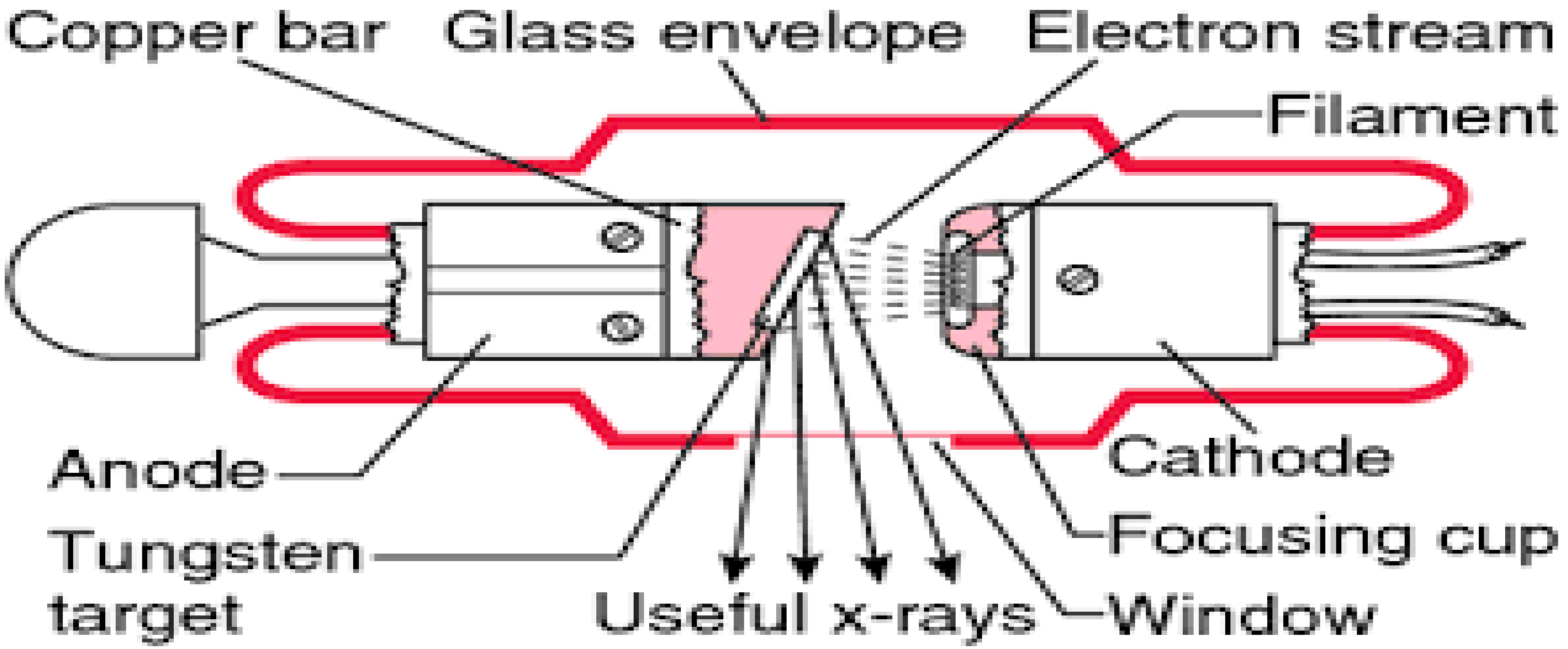
Factors affecting Quantity

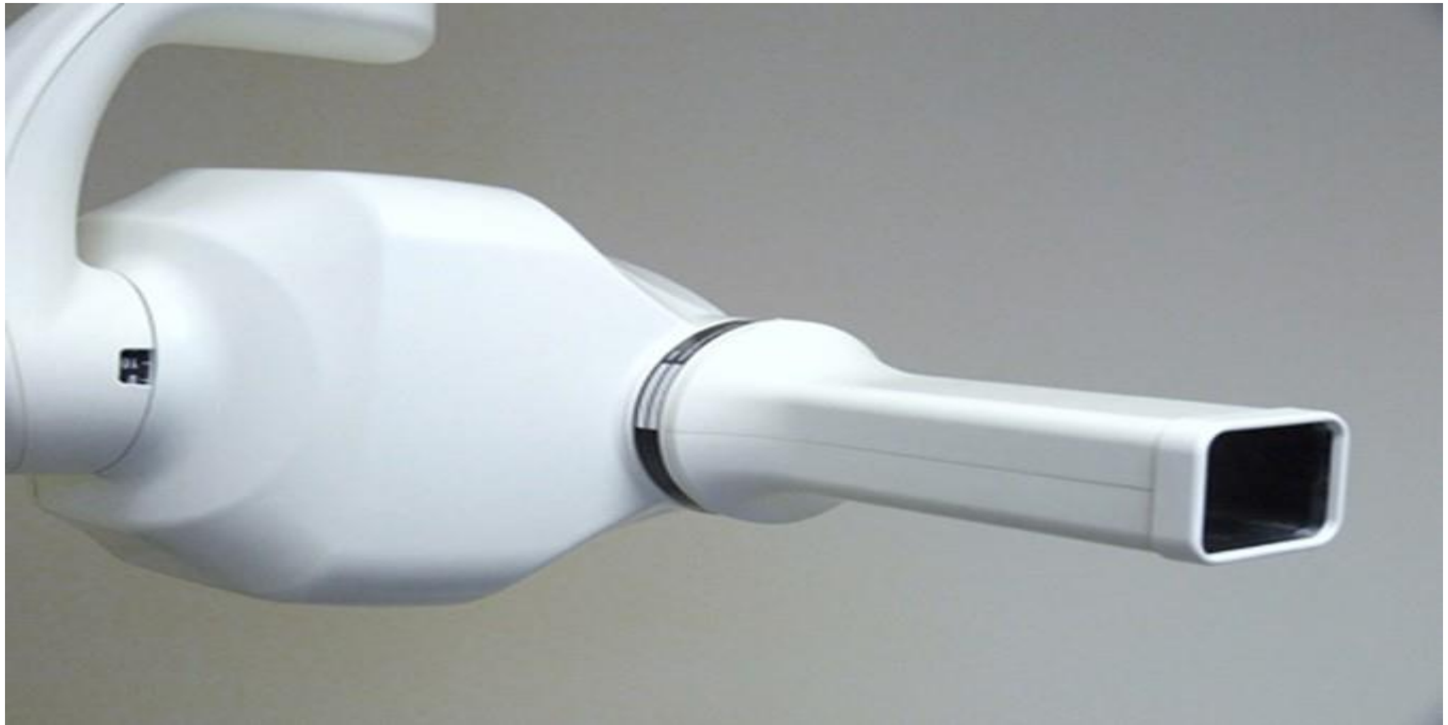
kVp

mA

Exposure time Filtration Collimation

Distance

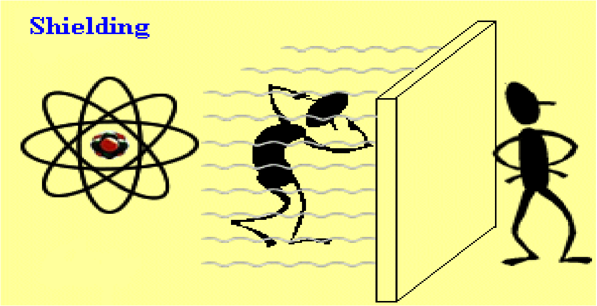




Reducing Dental Exposure

There are three guiding principles in radiation protection;

The first is the *principle of justification*, the dentist must do more good than harm.
In radiology this means the dentist should identify those situations where the benefit to a patient from the diagnostic exposure exceeds the low risk of harm. The second guiding rule is the *principle of optimization*.
This principle holds that dentists should use every means to reduce unnecessary exposure to their patient and themselves.
This philosophy of radiation protection is often referred to as the principle of **ALARA**
(*A*s *L*ow *A*s *R*easonably *A*chievable)



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This principle holds that dentists should use every means to reduce unnecessary exposure to their patient and themselves.
This philosophy of radiation protection is often referred to as the principle of ALARA
(*A*s *L*ow *A*s *R*easonably *A*chievable) ALARA holds that exposures to ionizing radiation should be kept as low as reasonably achievable, economic and social factors being taken into account.

The third principle is that of *dose limitation*.
Dose limits are used for occupational and public exposures to ensure that no individuals are exposed to **unacceptably high doses.**

Exposure time

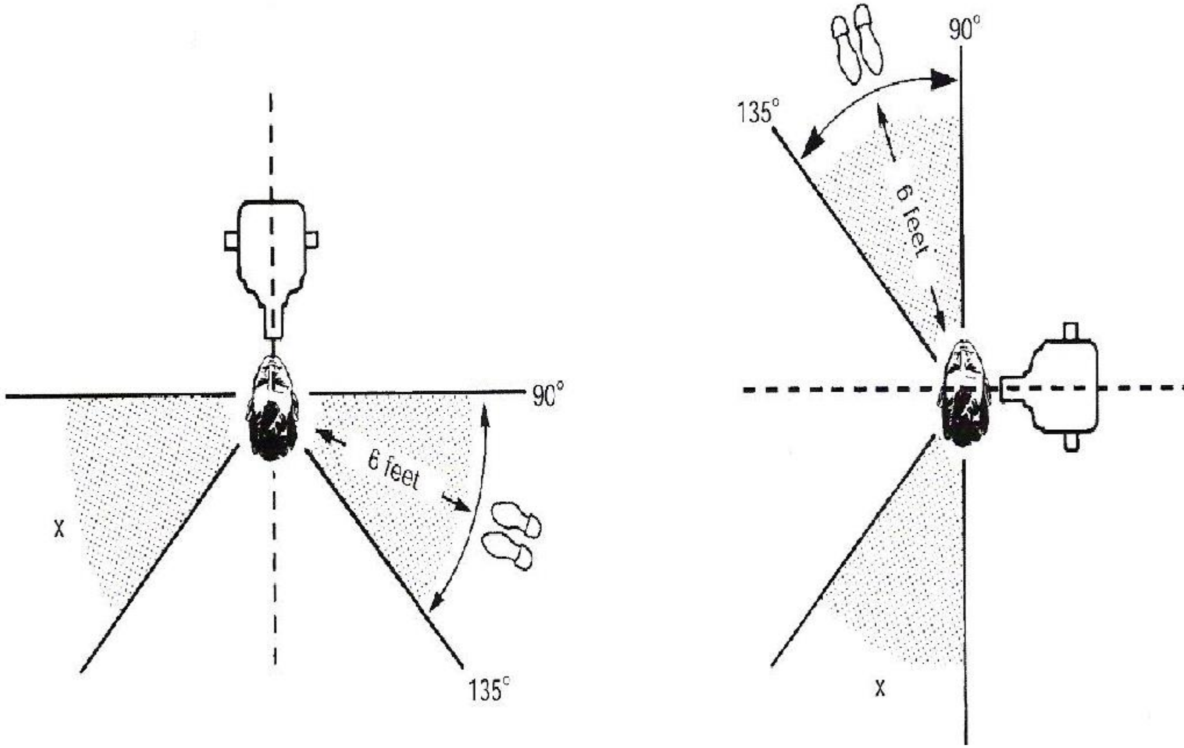
The less time you are exposed, the lower the dose of radiation you will receive

Distance

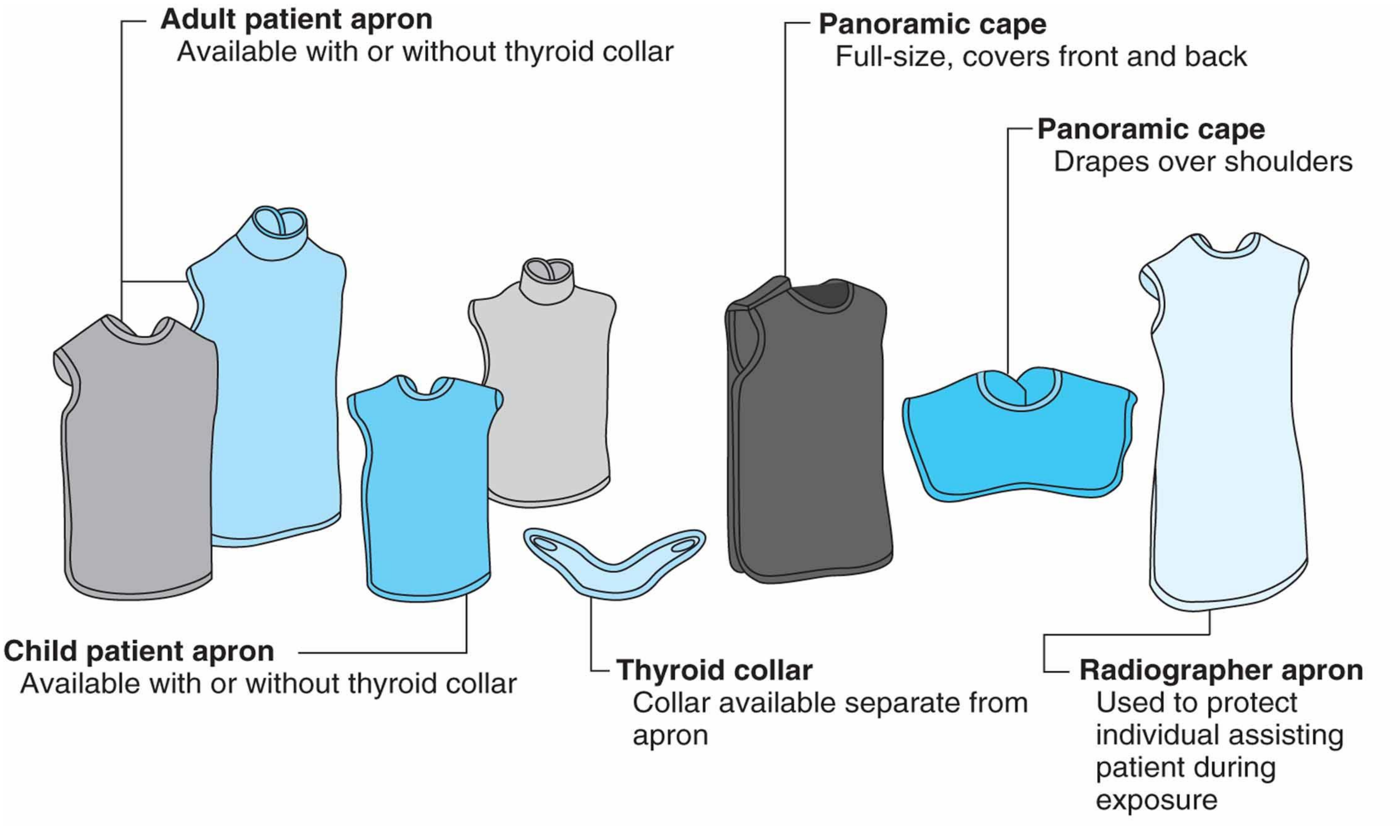
The further away you are from the source of the radiation, the less intense its effects will be

Shielding

Shield yourself behind a thick concrete wall or stay indoor. Protective covers made of thick concrete are very good at withstanding radiation penetration



Position-and-distance rule. If no barrier is available, the operator should stand at least 6 feet from the patient, at an angle of 90 to 135 degrees to the central ray of the x-ray beam when the exposure is made.

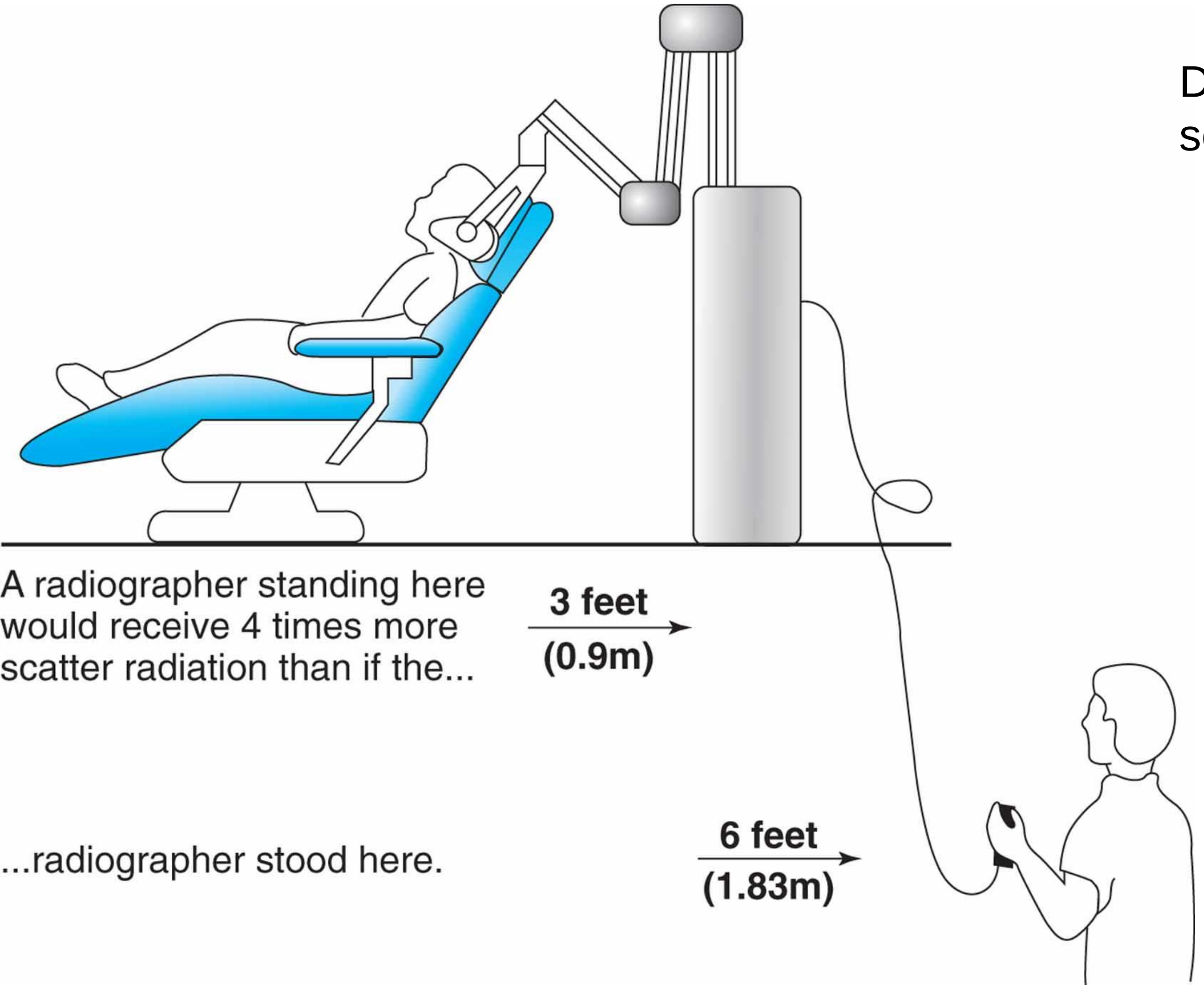


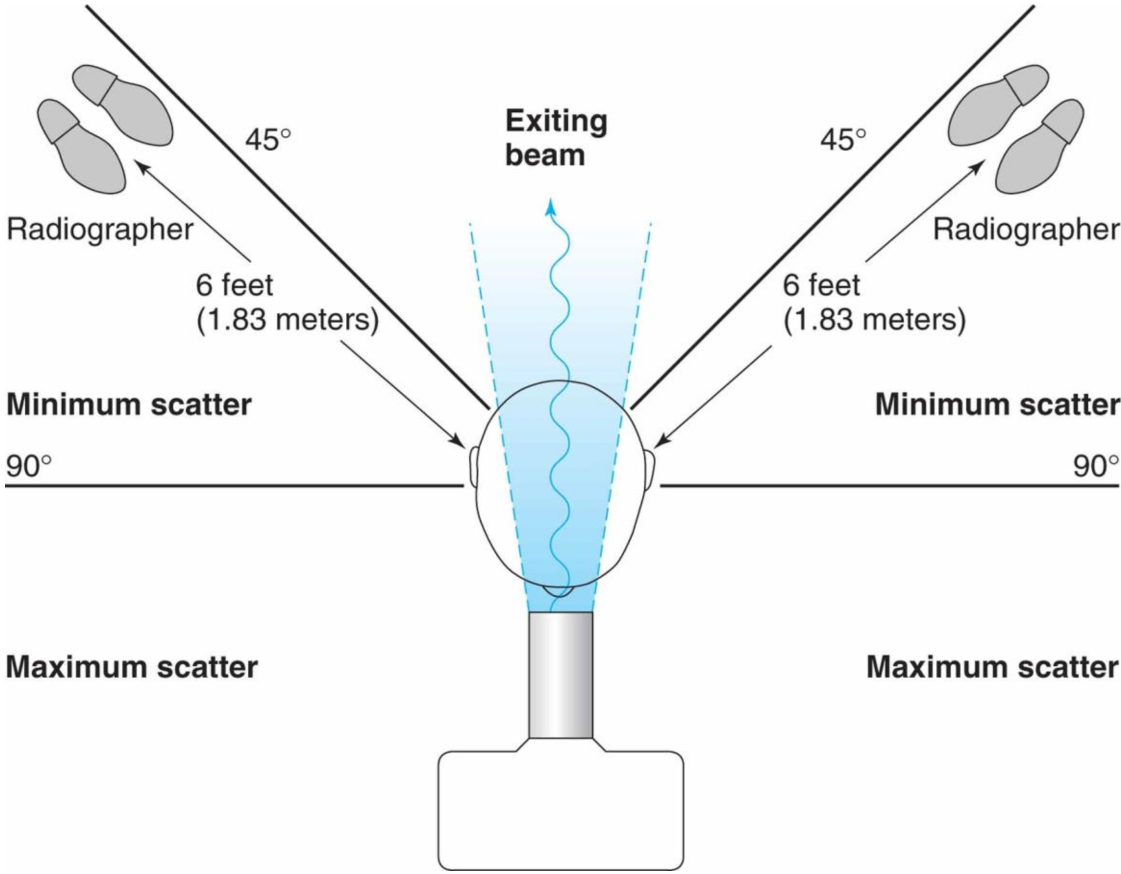
Lead aprons and thyroid collars are available in a wide range of sizes. Aprons are available with an attached thyroid collar, or the thyroid collar may be a separate part.

Summary of Methods to Protect the Radiographer

- Follow all patient protection measures.
- Do not contact the tubehead during exposure.
- Avoid retakes.
- Do not hold the image receptor for the patient.
- Use a protective barrier/shield.
- Use leaded protective clothing when necessary.
- Remain 6 ft (1.82 m) away and at a 45° angle from the exiting primary beam.
- Use radiation monitoring.

Distance is an effective means of reducing exposure from scatter radiation.





When structural shielding is not available, the radiographer should stand in a position at least 6 ft (1.83 m) from the head of the patient at an angle of 45º to the exiting primary beam.

THANK YOU