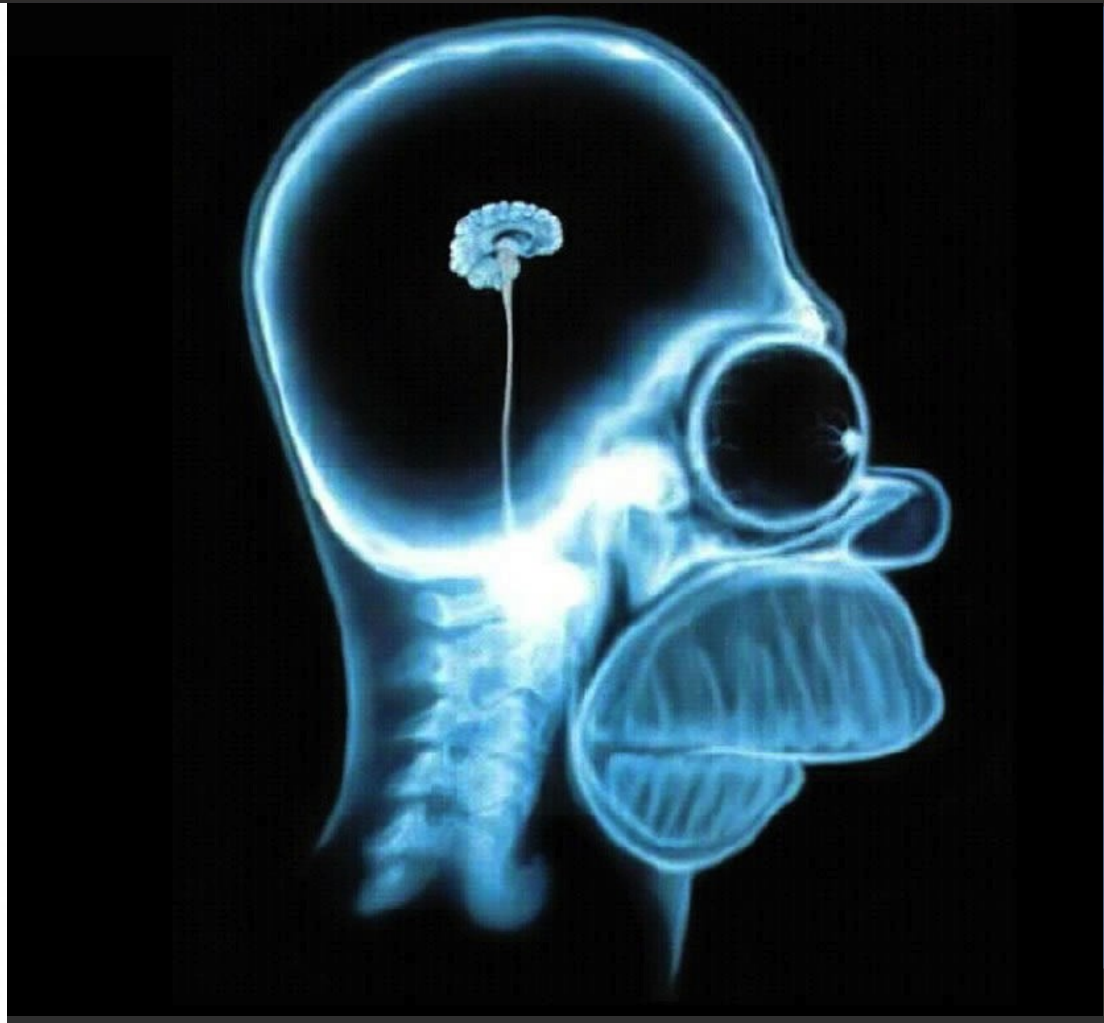


# **X-rays Images**

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UFPR  
Informatics Department

# X-rays Images



# X-rays Images

- Discovery:
  - German physicist Wilhelm Röntgen in 1895;
  - "X-rays" signify an unknown quantity;
  - X-rays were found emanating from Crookes tubes (grandpa X-rays tube);
  - Röntgen discovered its medical use when he made a picture of his wife's hand;
  - This picture was the first photograph of a human body part using X-rays.

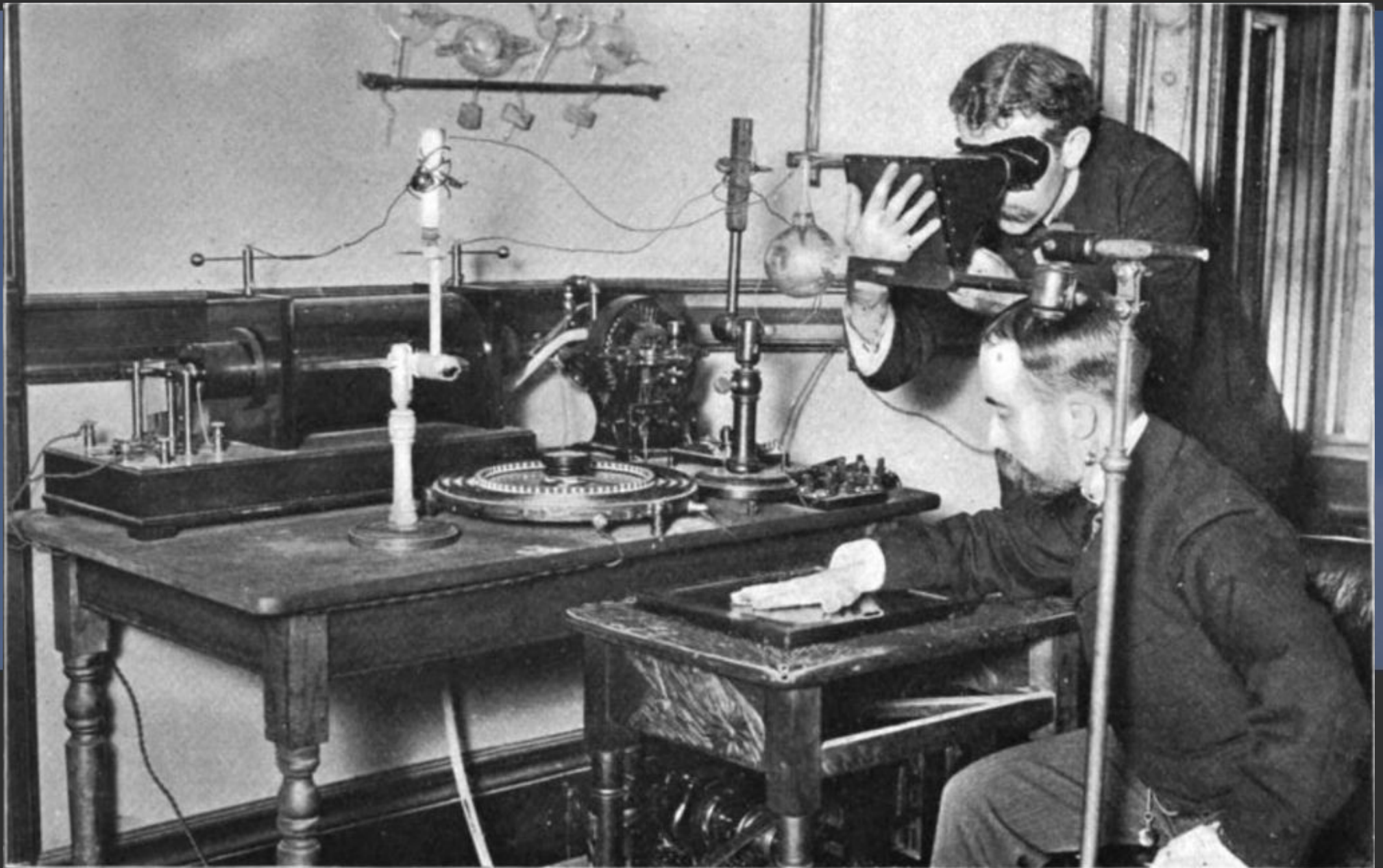
# X-rays Images

When saw the picture  
Bertha (Röntgen wives)  
said:

*"I have seen my death."*

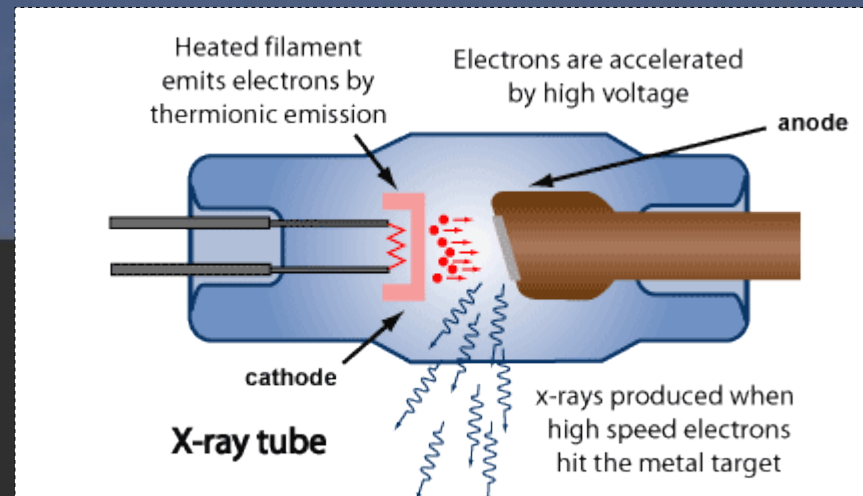


# X-rays Images



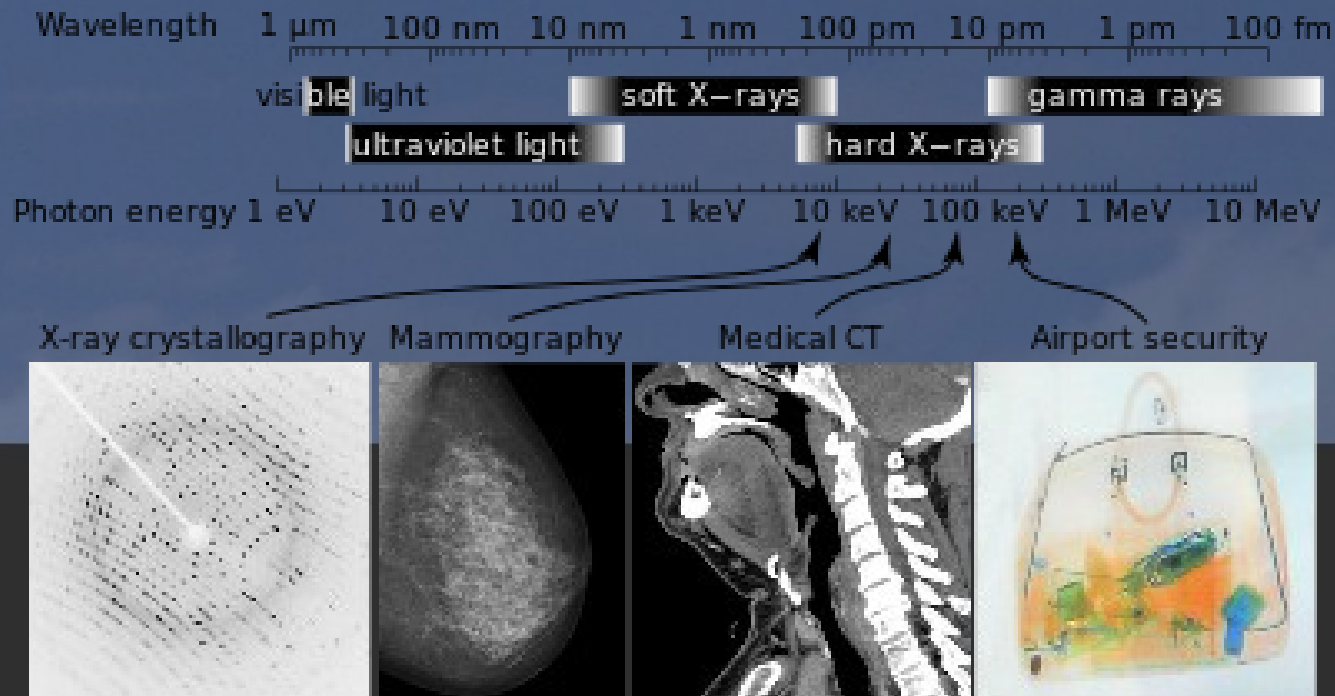
# X-rays Images

- Source:
  - X-rays are emitted by electrons;
  - Generated by an X-ray tube (vacuum tube);
    - High voltage to accelerate electrons;
    - High speed electrons released by cathode (+) to metal target called anode (-);
    - Target is usually tungsten or molybdenum;



# X-rays Images

- Energy:
  - X-rays have a wavelength in the range of 0.01 to 10 nanometers;
  - Frequencies in the range 30 petahertz to 30 exahertz ( $3 \times 10^{16}$  Hz to  $3 \times 10^{19}$  Hz)



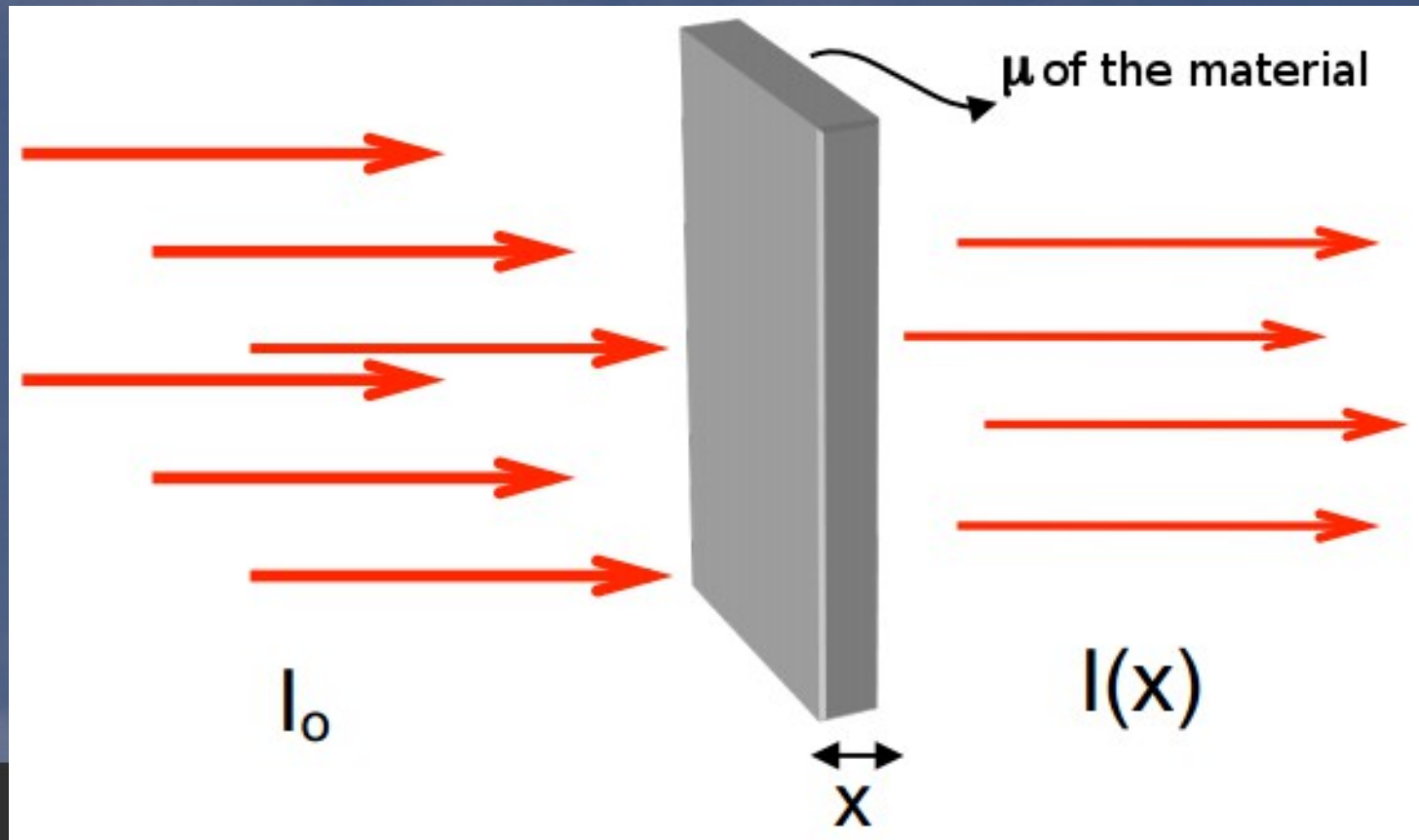
# X-rays Images

- X-ray Absorption or Attenuation:
  - Photoelectric absorption per unit mass;
  - The probability is proportional to  $I = I_0 \cdot e^{-\mu x}$ 
    - $I_0$  is the energy of the incident photon before pass through the materia;
    - $I$  is the energy of the incident photon after pass through the materia;
    - $\mu$  is linear attenuation coefficient;
    - $x$  is depth of material



# X-rays Images

$$I = I_0 \cdot e^{-\mu x}$$

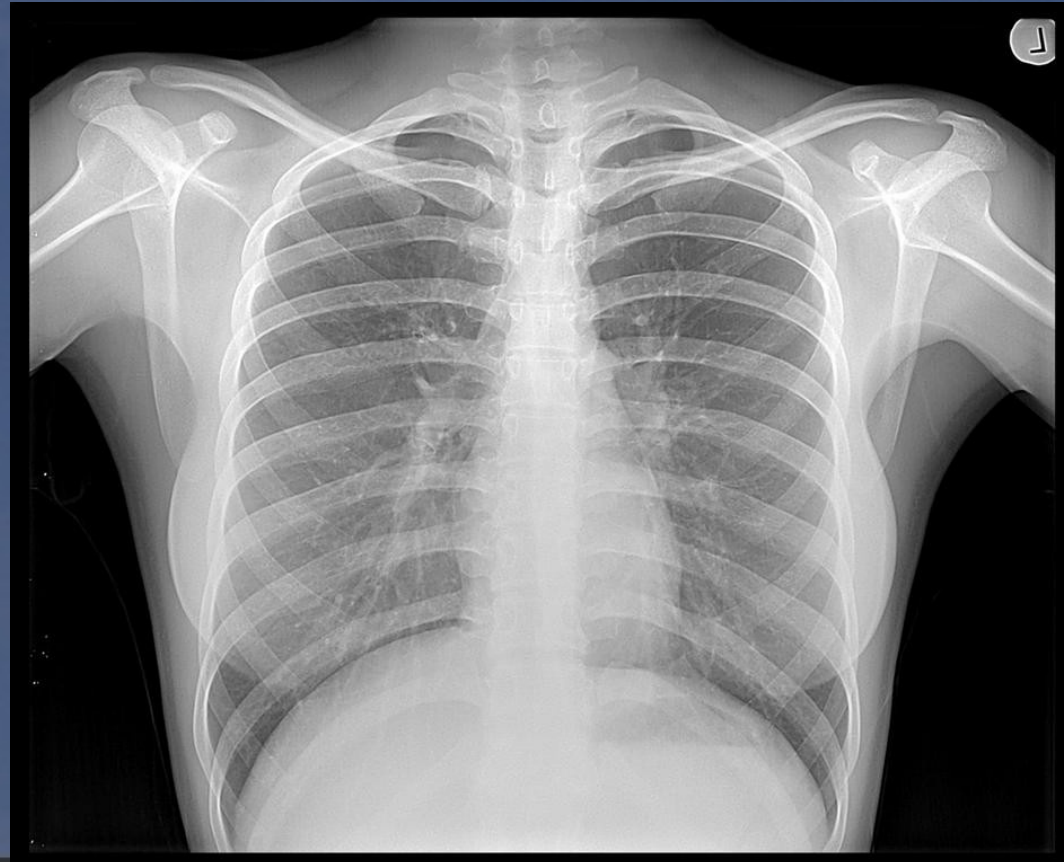


# X-rays Images

- X-ray Absorption:
  - Attenuation is the reduction in the number of photons as they pass through matter;
  - Occurs in different ways:
    - Some photons are absorbed by matter;
    - Others change course in matter (scatter).
  - High density bone attenuates (light areas);
  - Low density majority of the photons will reach the x-ray film.

# X-rays Images

<http://mrmackenzie.co.uk/2011/11/x-rays-in-medicine/>



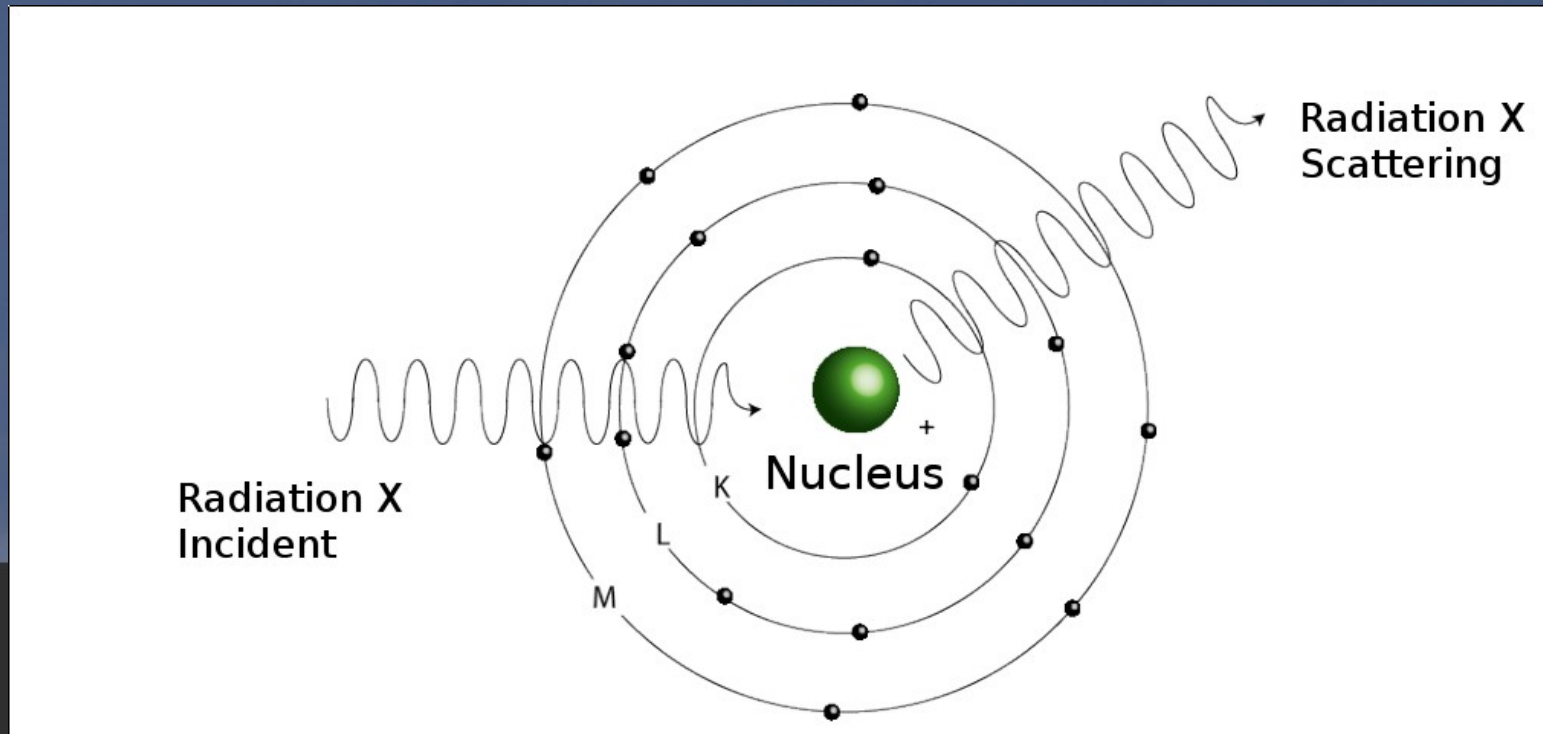
<http://www.prixray.com/>

# X-rays Images

- Interaction with matter:
  - Five types:
    - Coherent Scattering;
    - Pair Production;
    - Photodesintegration;
    - **Photoelectric Absorption;**
    - **Compton Scattering.**

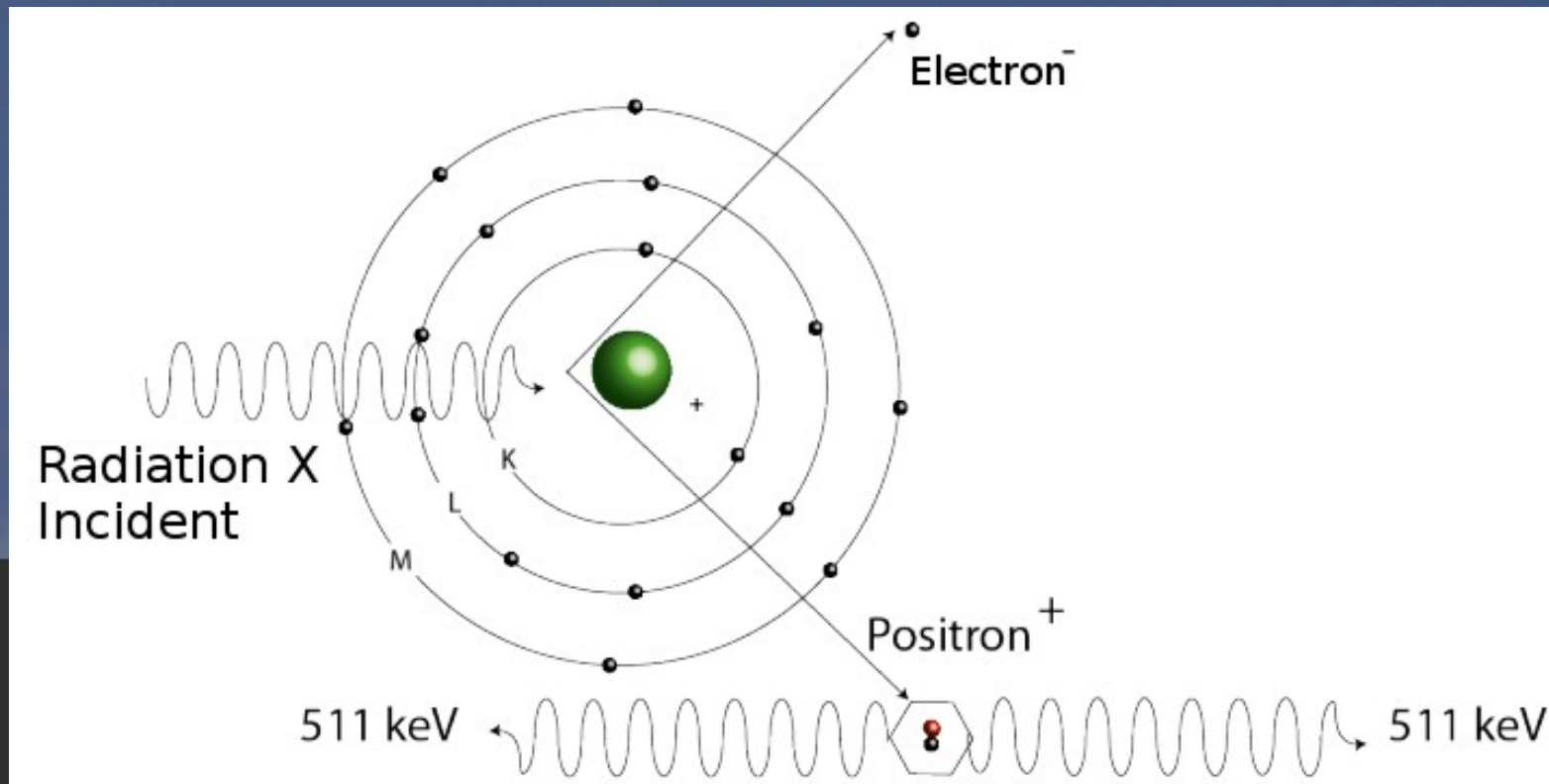
# X-rays Images

- Interaction with matter:
  - Coherent Scattering.
    - Energy bigger than 10keV.



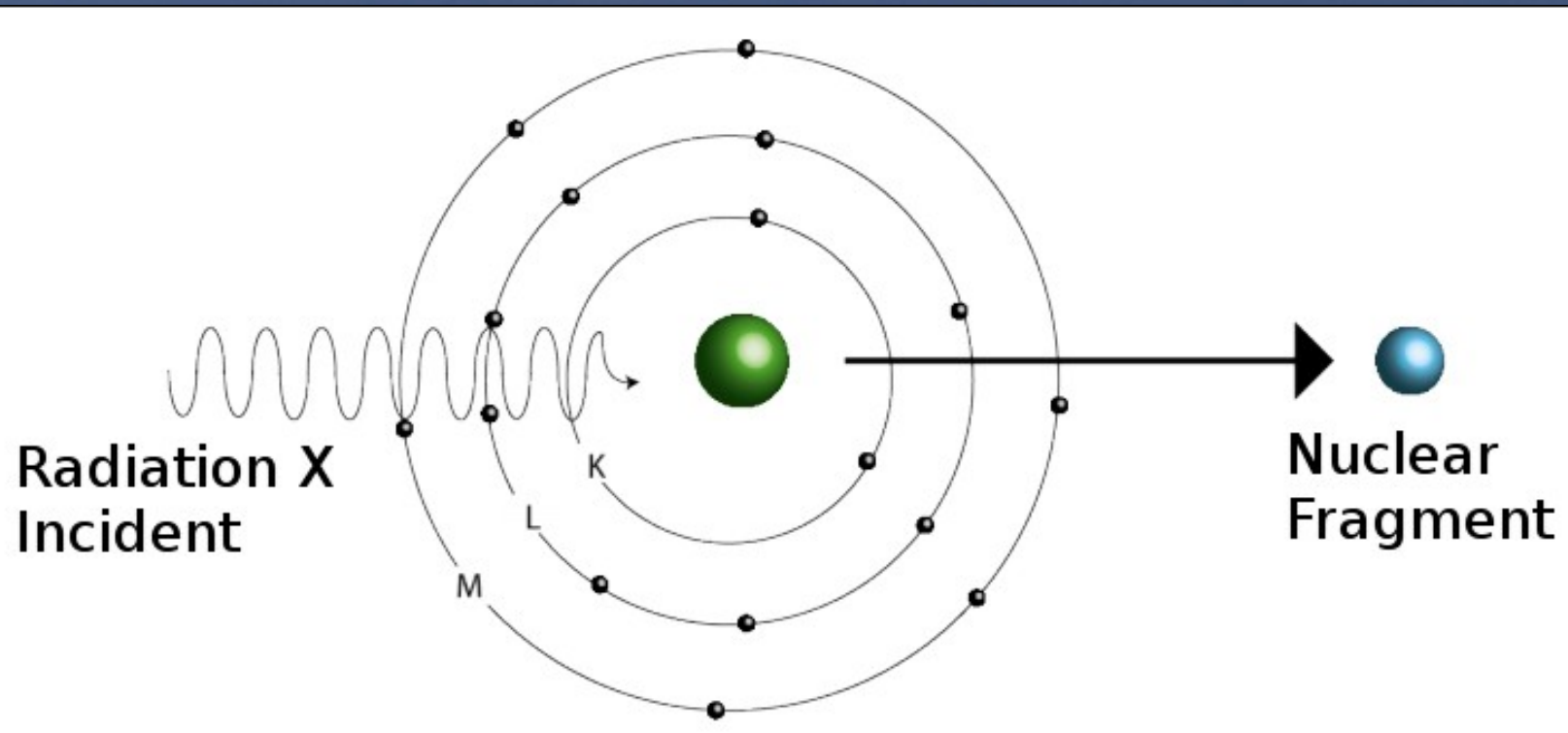
# X-rays Images

- Interaction with matter:
  - Pair Production.
    - Does not occur in diagnostic range.



# X-rays Images

- Interaction with matter:
  - Photodesintegration.
    - Photon is absorbed by the nucleus;



# X-rays Images

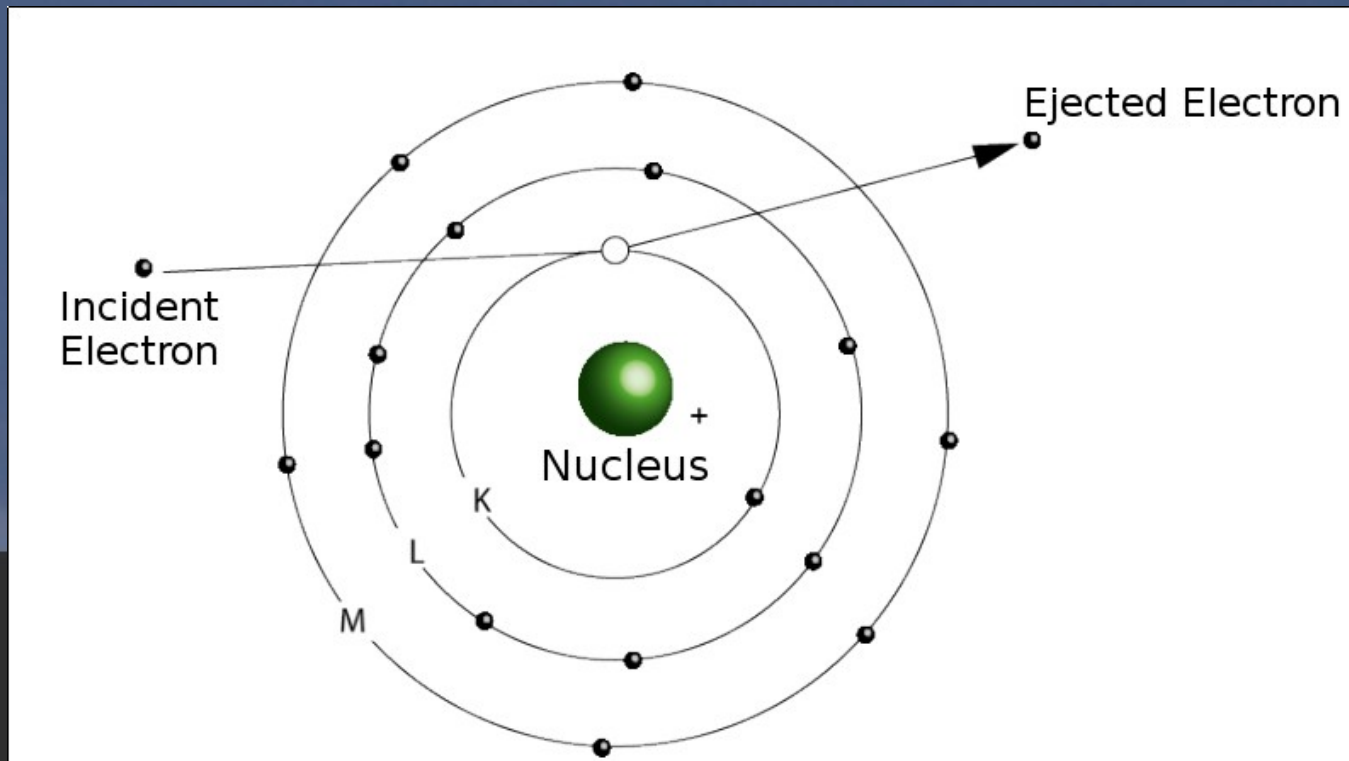
- Interaction with matter:
  - Photoelectric Absorption:
    - X-ray ejects a k-shell electron
    - “True absorption” - Photon is completely absorbed in process.
    - Also called “photo electric effect”
    - What gives clear areas of films.



# X-rays Images

- Interaction with matter:

- Photoelectric Absorption:

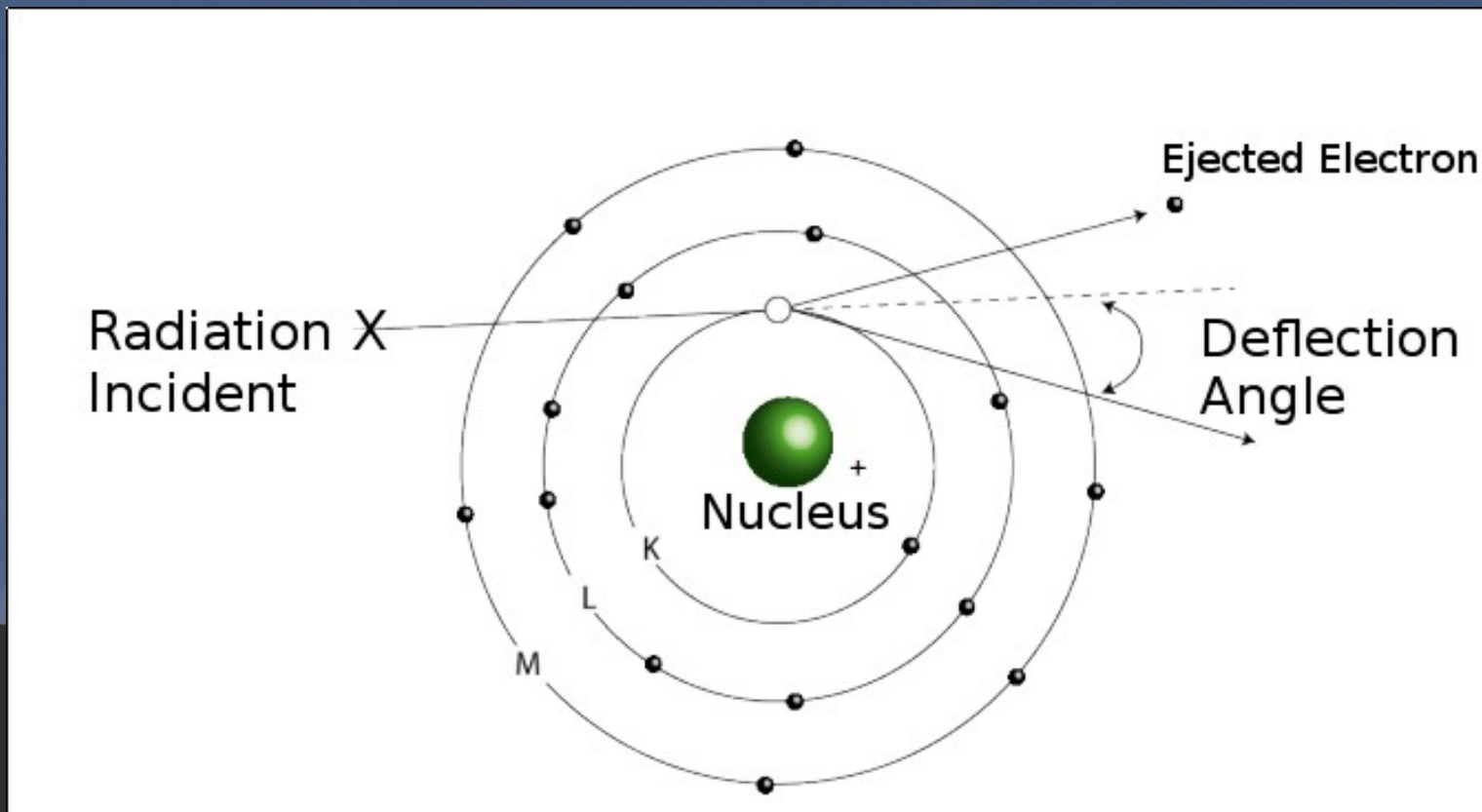


# X-rays Images

- Interaction with matter:
  - Compton Scattering:
    - Change direction of photon (any direction);
  - Reduction in photon energy;
  - Can occur with all x-rays;
  - Primary contributor to film fog;
  - Result radiation exposure (any direction).

# X-rays Images

- Interaction with matter:
  - Compton Scattering:



# X-rays Images

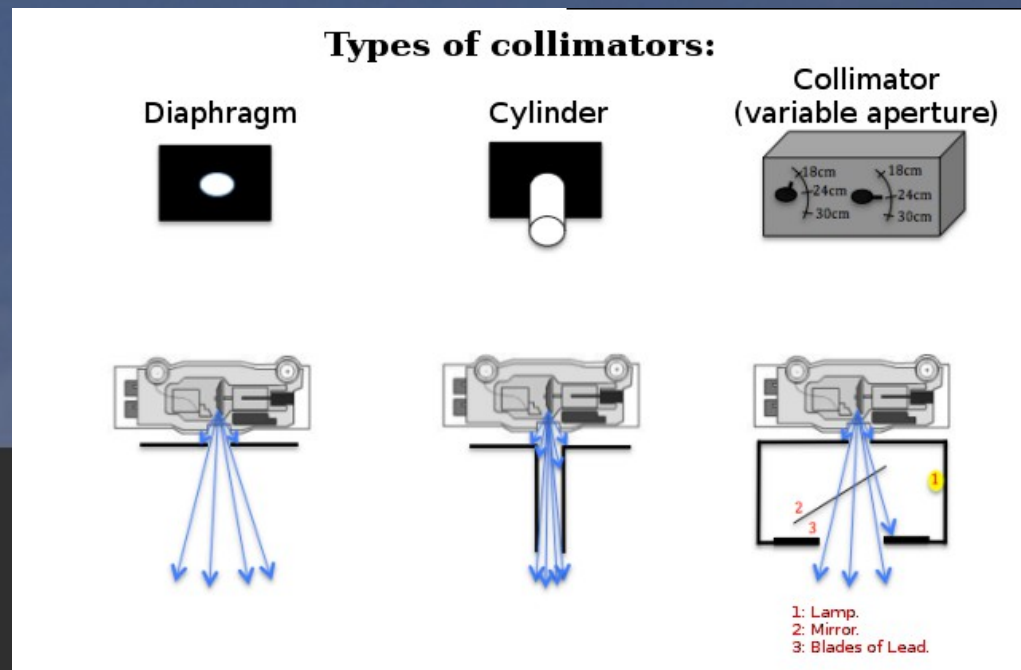
- X-ray Detectors:
  - X-ray Imaging:
    - Photographic film replaced by glass plates;
    - Digital imaging has been replacing photographic film;
    - The metal silver is a non-renewable resource (photographic and radiographic film).

# X-rays Images

- X-ray Detectors:
  - X-ray Imaging:
    - Photographic plates are sensitive to X-rays;
      - But they also required much X-ray exposure.
    - Intensifying screen are used to allow a lower dose to the patient.

# X-rays Images

- Collimators:
  - Device that narrows a beam of particles or waves;
  - Without collimator rays from all directions will be recorded.

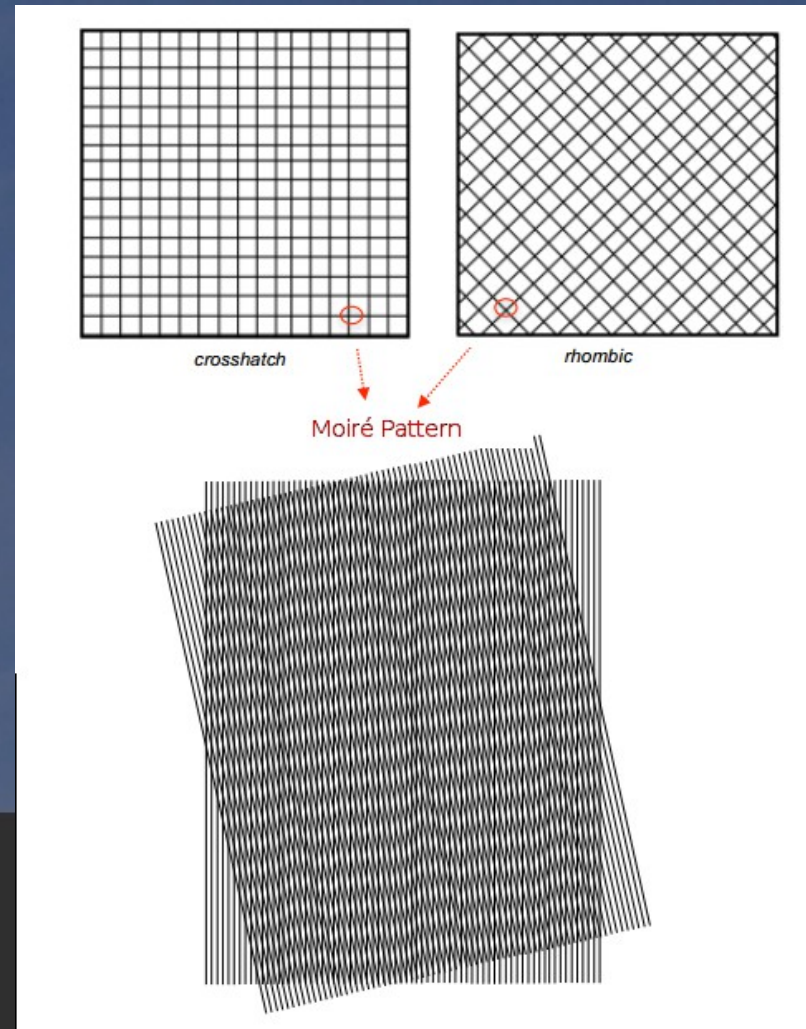
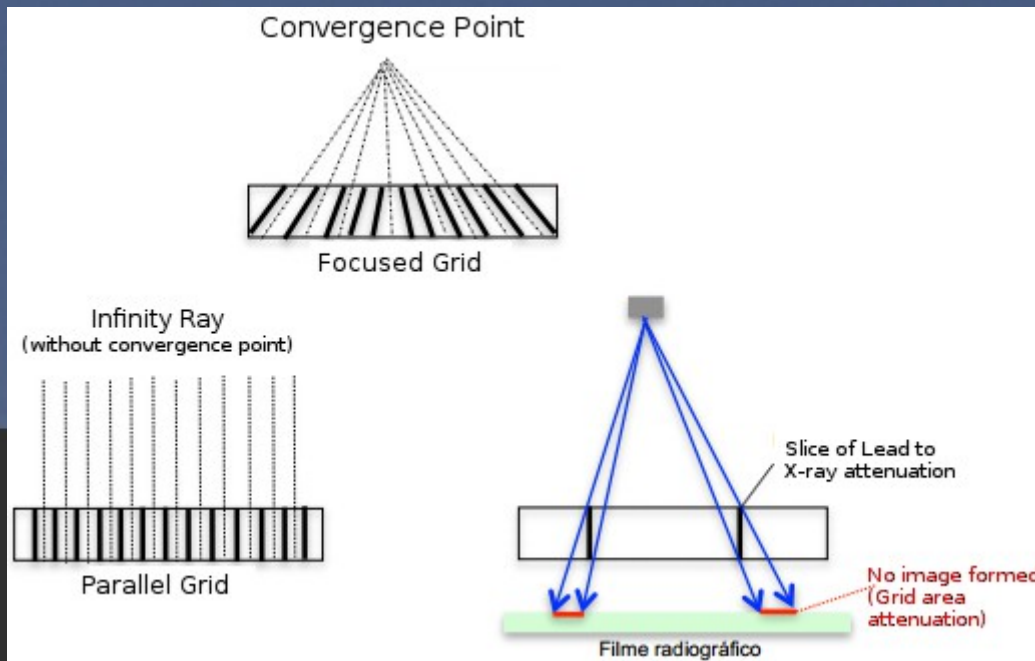


# X-rays Images

- Collimators:

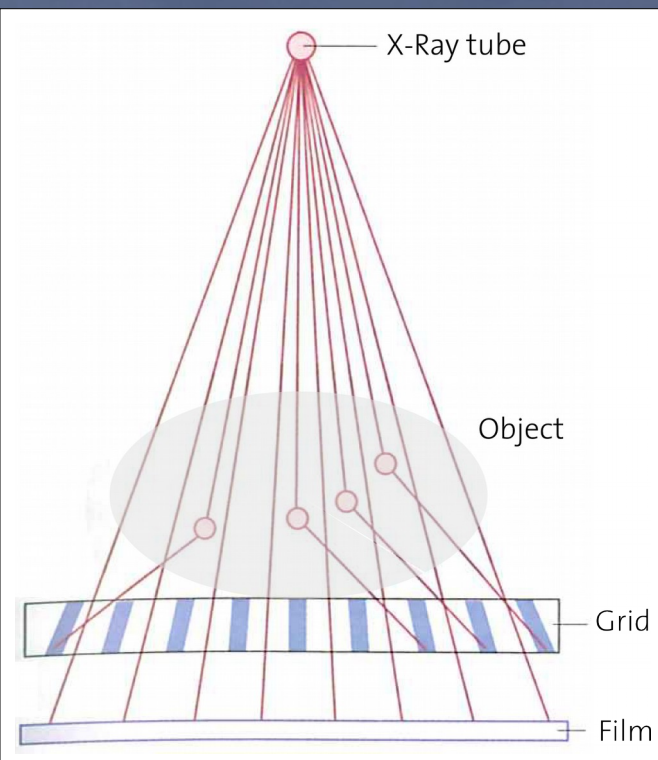
- Grids:

- Many kinds and shapes;
    - Combination of patterns.



# X-rays Images

- Collimators:



*Without grid*



*With grid and no increase in patient exposure*

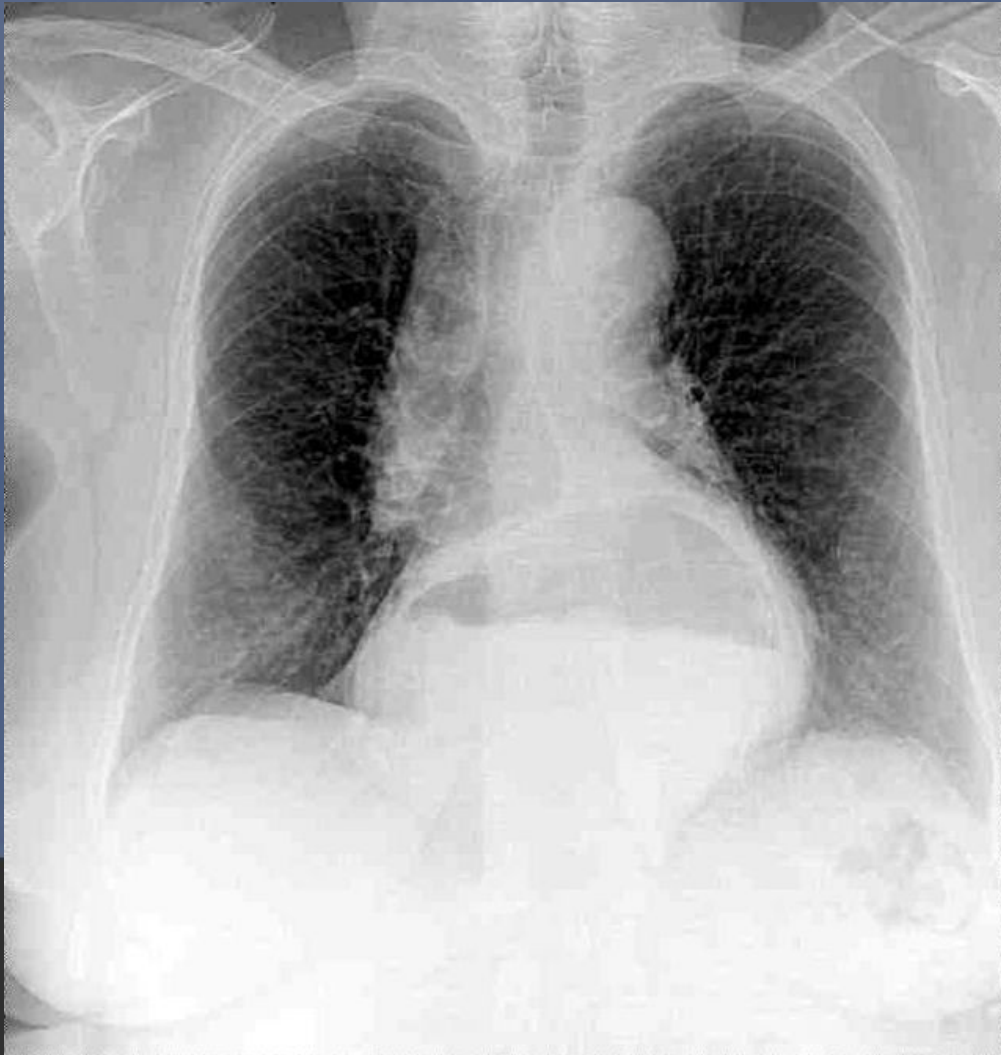


# X-rays Images

## Radiography

# X-rays Images

- Radiography:



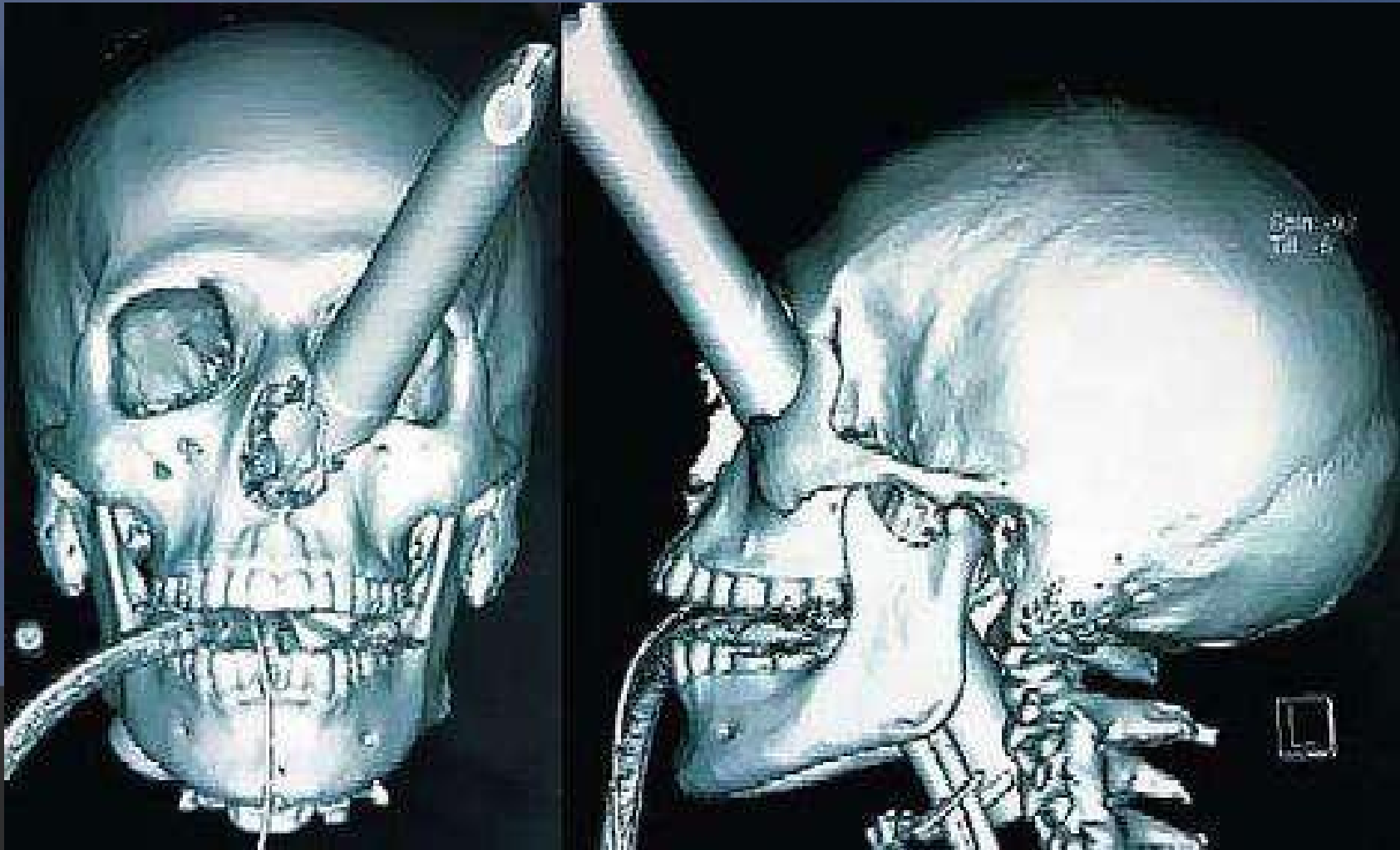
# X-rays Images

- Radiography:



# X-rays Images

- Radiography:



# X-rays Images

- Radiography:



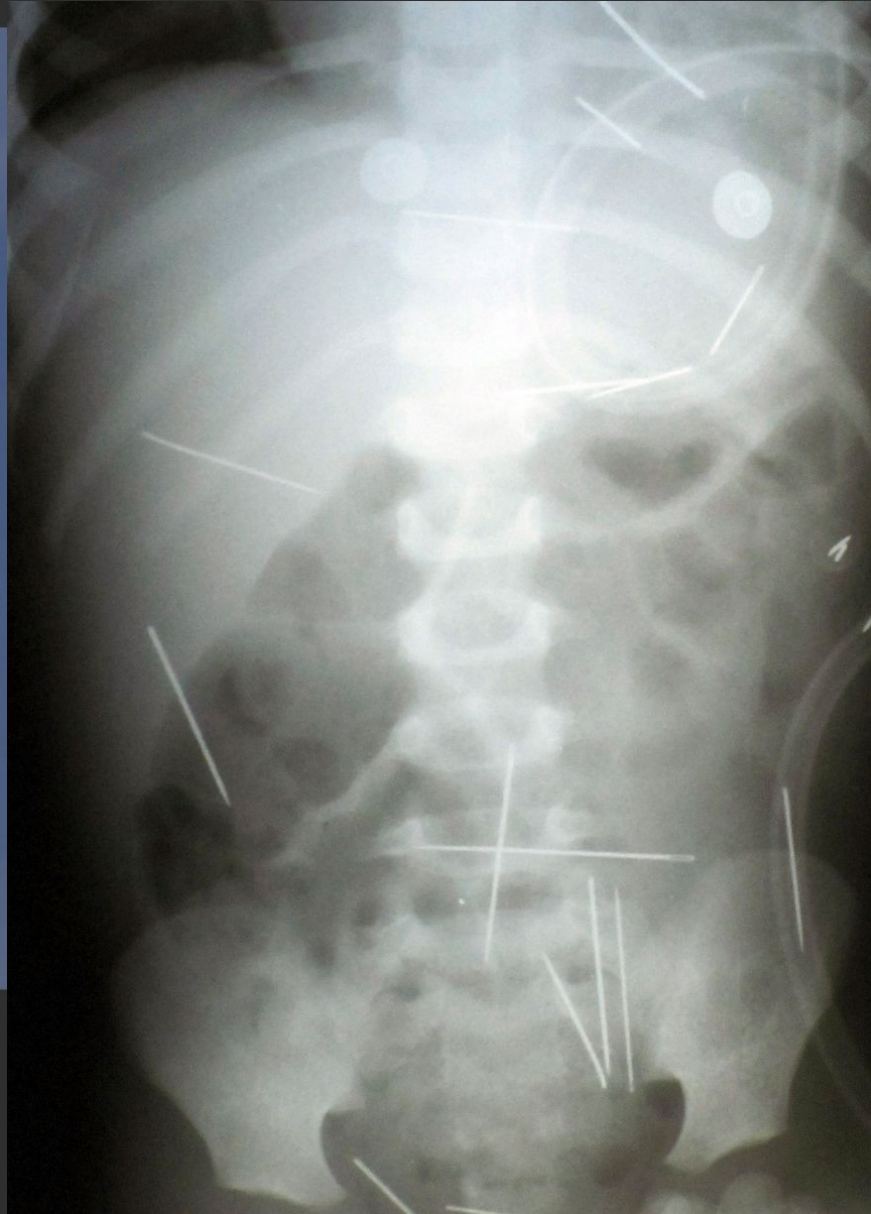
# X-rays Images

- Radiography:



# X-rays Images

- Radiography:



# X-rays Images

- Radiography:





# X-rays Images

- Radiography:



# X-rays Images

- Radiography:

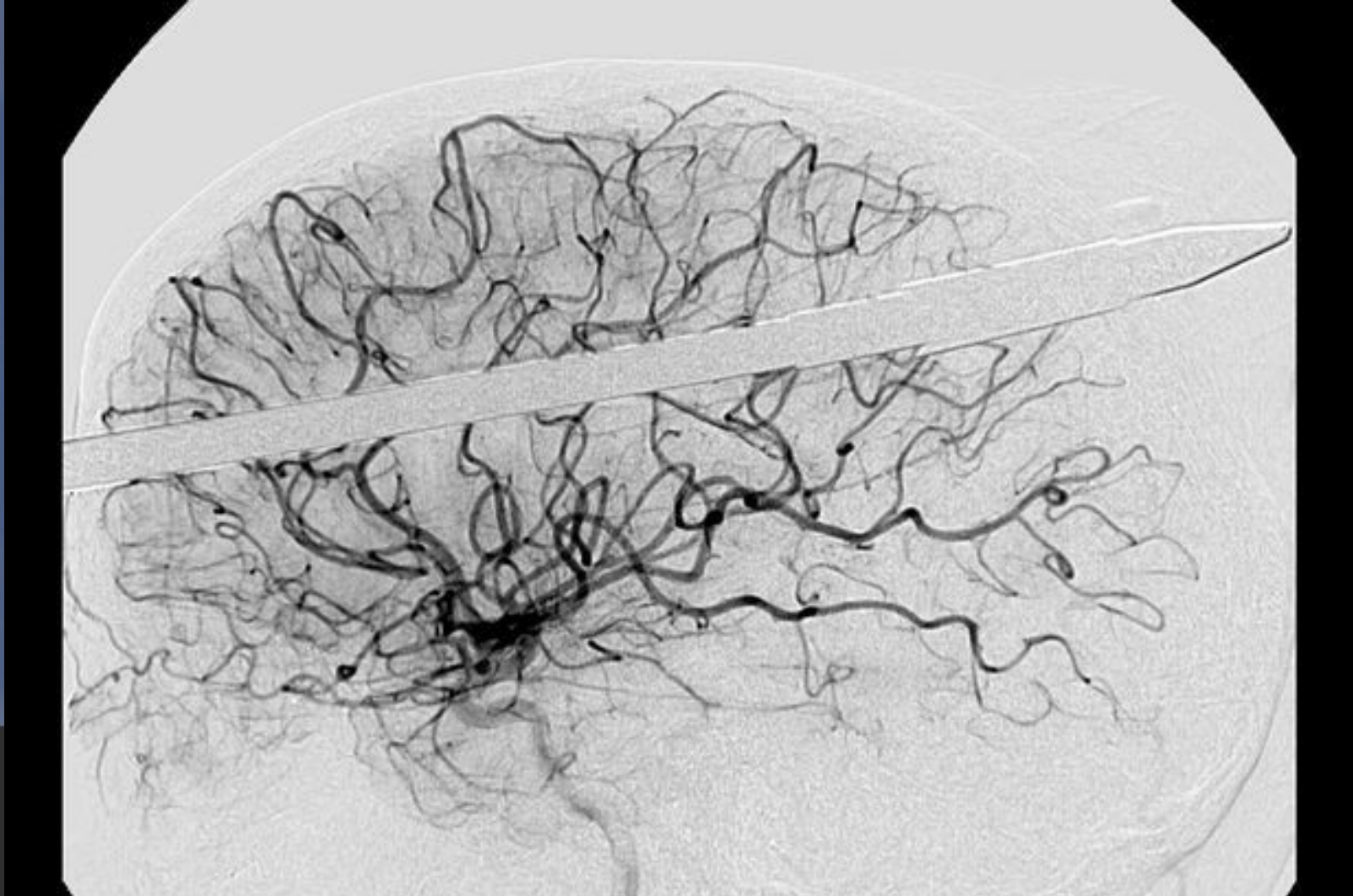


# X-rays Images

## Fluoroscopy

# X-rays Images

- Fluoroscopy:



# X-rays Images

- Fluoroscopy:



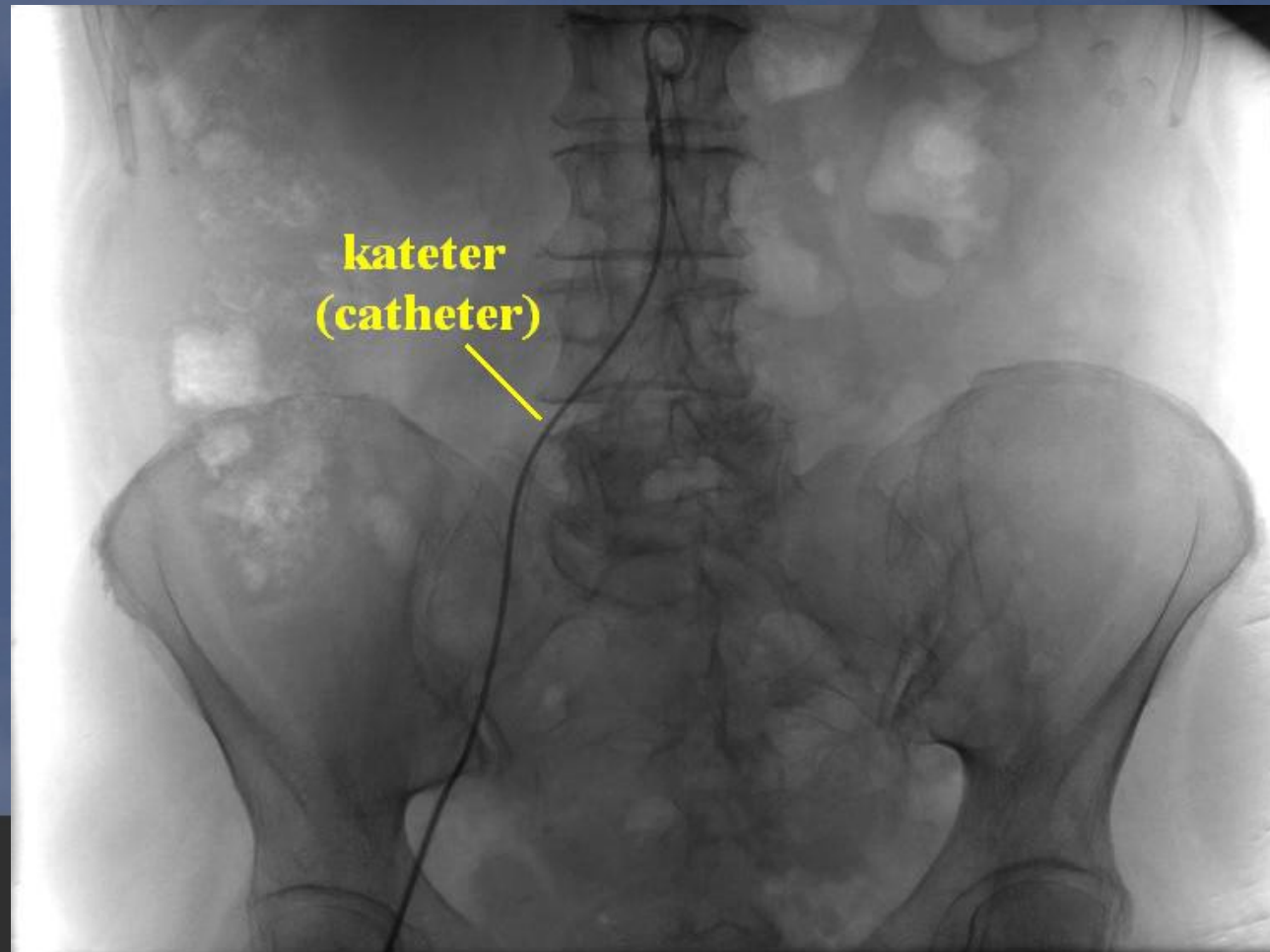
# X-rays Images

- Fluoroscopy:



# X-rays Images

- Catheterization:



# X-rays Images

- Angiography:

Finger Angioma

