X-Ray (CT)

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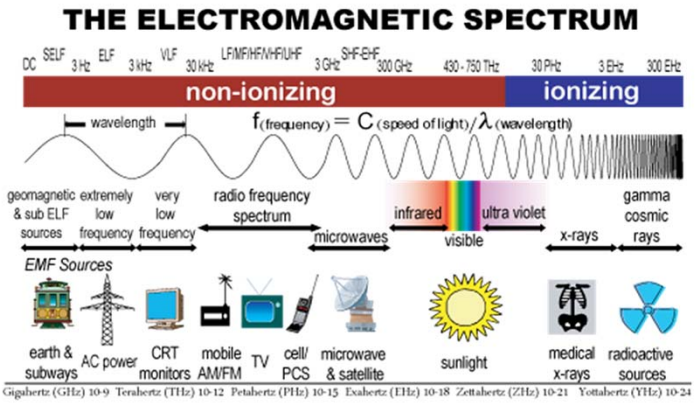
Software developed for EM 3D reconstruction is used by default in the XR-field. Therefore researcher

What are X-rays?

- X-ray are electromagnetic radiation similar to visible light. (Phone)

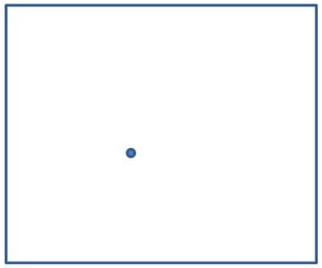


I've seem my death

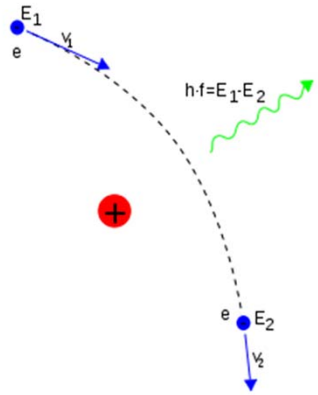
- In 1895 Röntgen discover this "light" that could pass through wood and tissues
- He called it X-Rays. X stands for unknown, NP 1901
- Died from carcinoma of the intestine

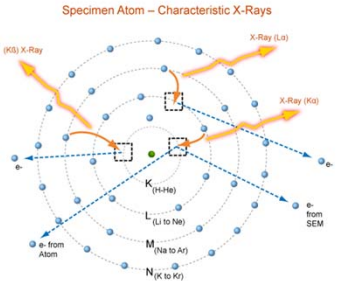
Physics: Produce X-rays

- Like visible light x-rays can be seems either as __ or as __
- Energy of a X-ray photon _____
- Produce X-rays: shoot electrons into matter
  - Bremsstrahlung (nucleus)
  - Characteristic X-ray (shell)

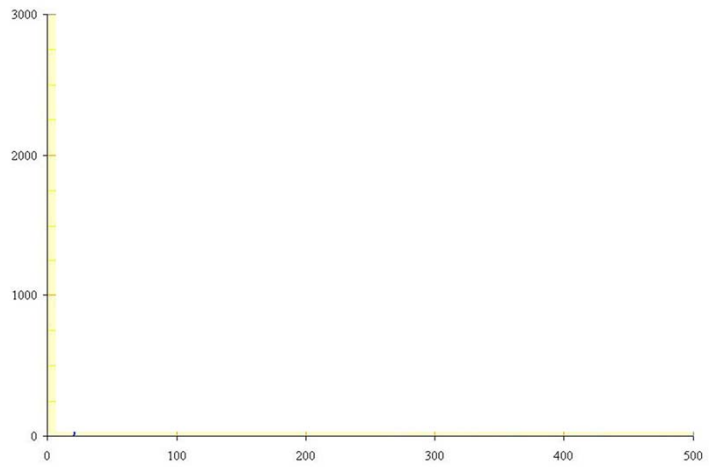


1) Particle or wave
2) E = h* v [h= planck's constant & v photon frecuency] = h * c /l [c speed of light, l wavele
3) Bremsstrahlung: an electron is decelerated by the charge of the nucleus (change direct
4) Characteristic: knocks an electron out of its shell causing a cascade of electrons droppi


E1
e
v1
h·f=E1-E2
e
E2
v2

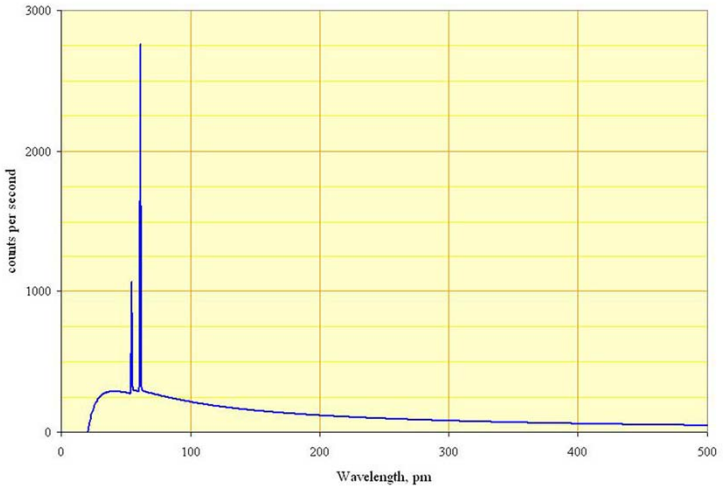

Specimen Atom – Characteristic X-Rays
(Kß) X-Ray
X-Ray (Lα)
X-Ray (Kα)
e-
e-
e- from SEM
e- from Atom
K (H-He)
L (Li to Ne)
M (Na to Ar)
N (K to Kr)

Resulting X-ray Spectrum



X = energy
Y = number of photons
Draw first Bremsstrahlung (label it) then draw Characteristic label it

Resulting X-ray Spectrum

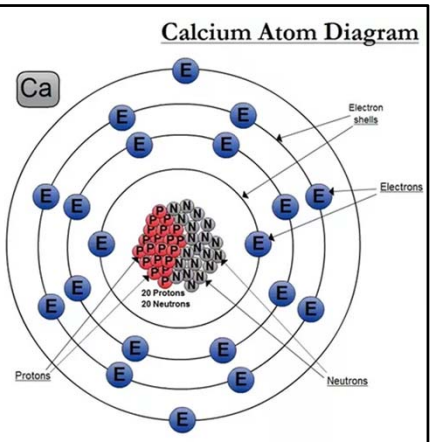


Y= energy

Physics: Interaction between X-rays and Matter (produce images)

- Three types:
  - Photoelectric absorption
  - Compton scattering
  - Rayleigh scattering

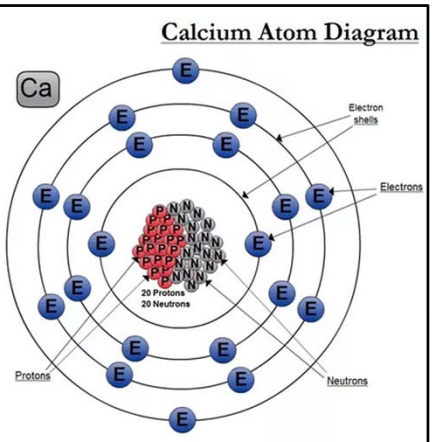
Photoelectric absorption



- An x-ray photon ____
- Probability of interaction___
- This effect is the principal effect that makes x-ray useful since different ----- have different ----.
- Therefore, x-rays images are -----

1) Einstein awarded Nobel price 1921
2) Draw: (a) x-ray knocks electron out of the shell [creates lower energy photon plus electı
3) Z^3 (atomic number) / E ^3
4) Tissues, atoms
5) X-ray attenuation maps.

Compton



- Interaction with outer shell, no _____
- Weak interaction, X-ray keeps most of ___

- But changes___
- Probability _____
- Tissues in the body have ___ variation in _____
- ___ useful

A) no shell cascade [output x-ray lower energy plus electron]
B) Most of its energy [vs previous case that Xray are at random]
C) A little direction
D) Proportional to e density
E) Small variation in electron density
F) Not____ It is noise

Rayleigh

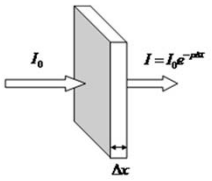
- No change of _____
- But Change on ____

- This interaction does ___ give us anatomical information

1) Energy
2) Direction

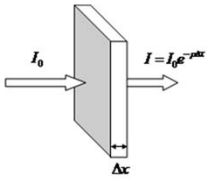
X-Ray attenuation
Beer Lambert Law

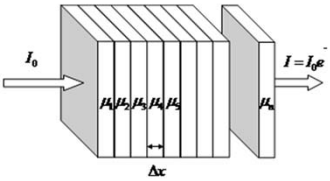
homogenous



- I=_____

- I= _____





- Integral form: ___
- Therefore I/Io is a _____

1) i=io e - (mu)d; Berr Lambert law
2) i1=io e - (mu1)d (intensity that comes out of slab 1)
3) I2 = i1 e - (mu2)d
4) I3 = i2 e - (mu3)d
5) All togheter io e - (mu1)d * e - (mu2)d * e - (mu3)d = Io e – (mu1 + mu2 +mu3)d =Io e
6) I = Io e Int– mu(x))dx (where mu(x) is the attenuation function)
7) Ln(I/Io)=Int(mu(x)dx

So I/io is this

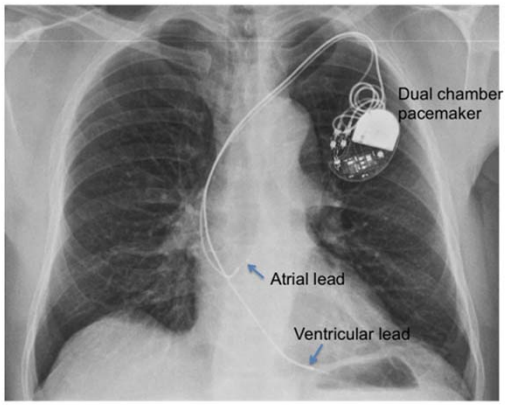
1

4

The beam intensity (number of x-ray photons) that transmit through the tissue and emerges at the other side of the specimen encodes attenuation information of the matter along its path

The problem with X-ray is that___

An X-ray is not



a) All structures are projected project on top of each other, they are superimposed
b) A slice though the body