

Today: X-rays

Contrast media

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Contrast between different kinds of soft tissue is poor. In order to see structure of soft tissue when using X-rays a contrast medium can be used.

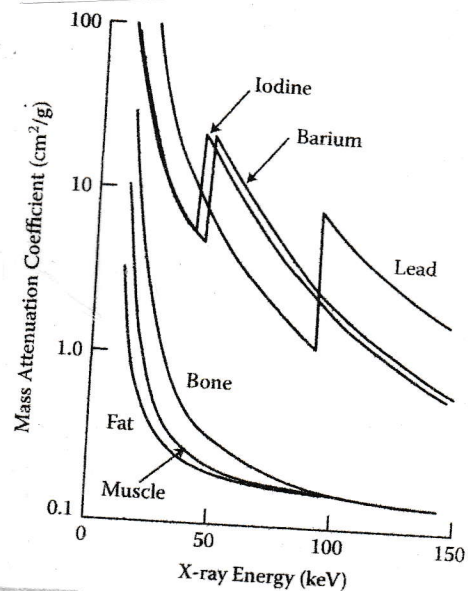
Contrast media are designed to be nontoxic compounds in liquid form that stay in body long enough for image formation, then excreted naturally.

Most common elements used

* Barium ($Z=56$)

* Iodine ($Z=53$)

The absorption edges are in the range of a typical diagnostic X-ray source \Rightarrow Enhances interaction even more 😊



For gastrointestinal tract, a drink or enema can be used as a delivery system

For urinary tract, iodine is commonly used & administered by injection. There are two types

- * Ionic \rightarrow Can be dangerous (1 in 40,000 chance of death)
- * Nonionic \rightarrow Safer but more expensive

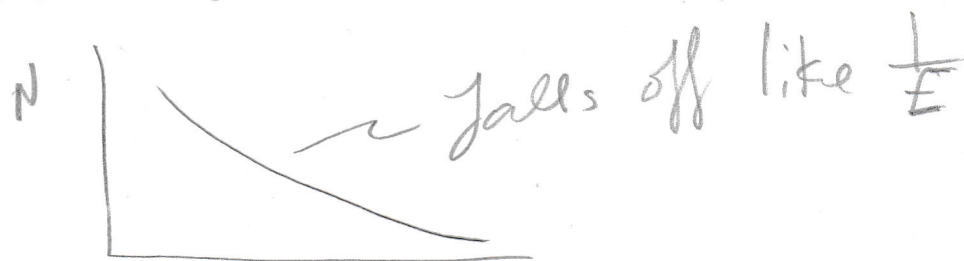
Generation of x-rays

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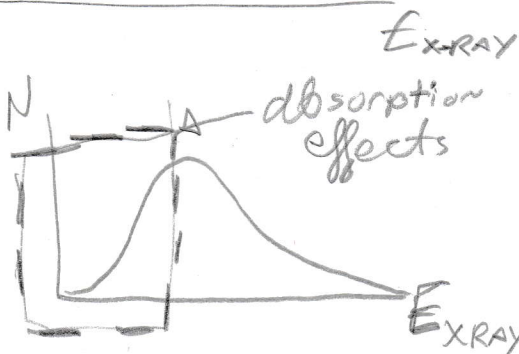
1st produce free electrons by "boiling" them off of a fine filament of tungsten by passing electric current through filament. ← cathode

An electric potential [voltage] applied to the liberated electrons & accelerates them between cathode & anode

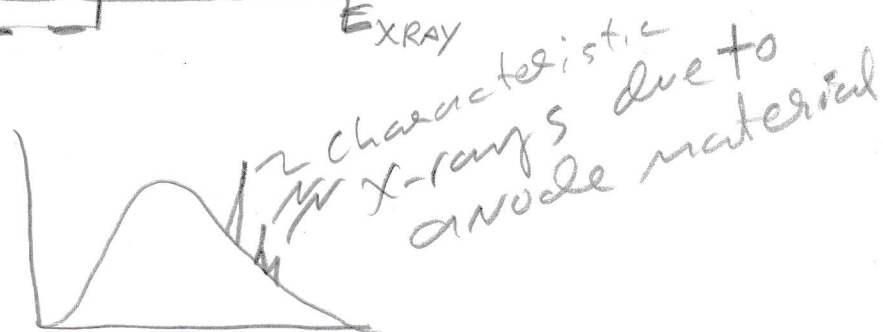
The electrons are slammed into anode & release energy through bremsstrahlung (braking radiation)

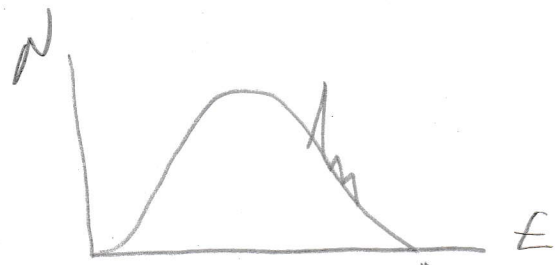


For lowest energies, photons are absorbed so



But Also characteristic x-rays





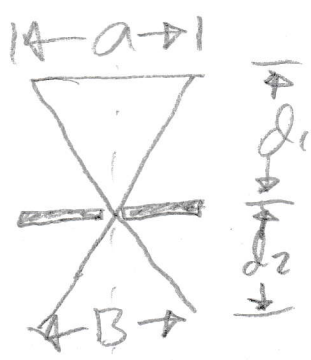
highest energy is determined by the accelerating potential

Characteristic X-rays:

- * Free electron collides with inner atomic electron & ejects that electron
- * Atomic electron from another orbital "jumps down" to fill hole left by ejected electron.

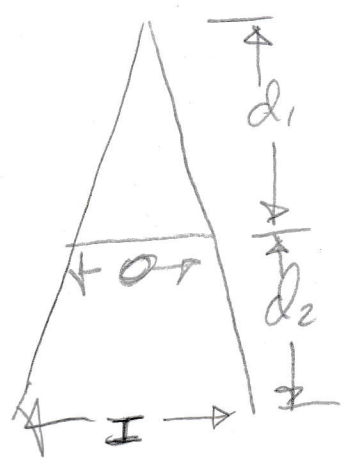
Blur

Focal spot a results in blurring of point-like features.



$$\frac{a}{d_1} = \frac{B}{d_2} \Rightarrow B = a \frac{d_2}{d_1}$$

Magnification



$$\frac{I}{d_1 + d_2} = \frac{I_0}{d_1}$$

≠ M ≡ magnification

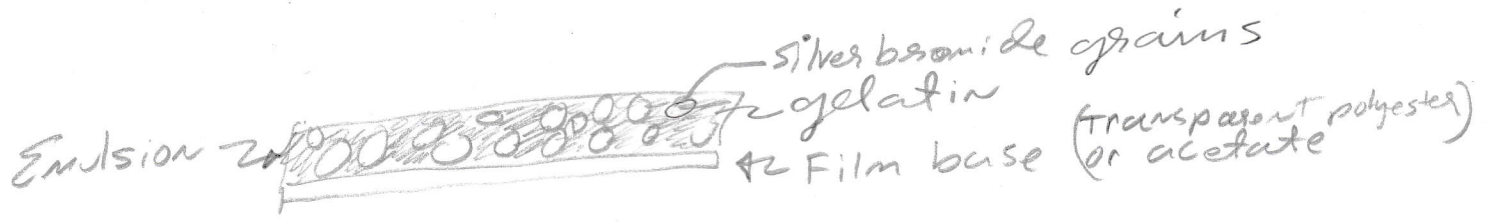
$$\neq M \equiv \frac{I}{I_0}$$

$$\Rightarrow M = \frac{d_1 + d_2}{d_1}$$

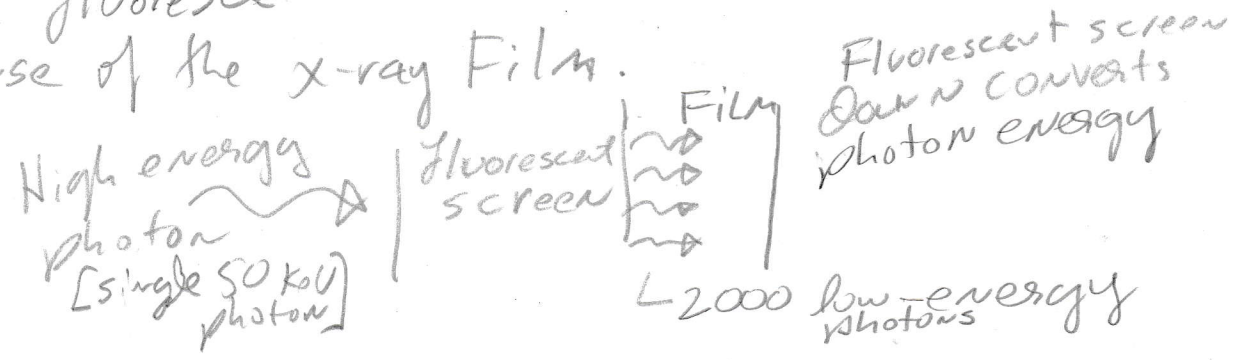
X-ray Detectors

Film: Imaging Chest & lungs, skeleton, gastrointestinal tract, & in dentistry

Good spatial resolution & sensitivity
 & low price & wide availability & permanency for record keeping



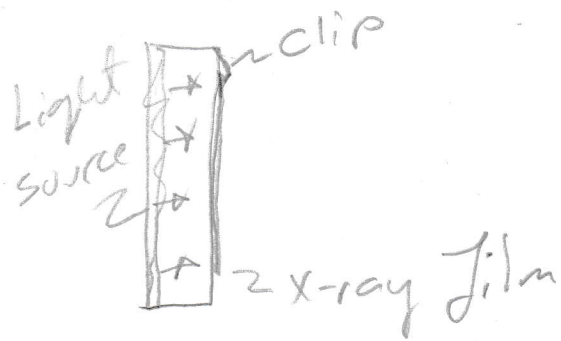
A fluorescent screen can enhance the response of the x-ray film.



Optical Density

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X-ray film are typically viewed through a light box



Perceived transparency & opaqueness made quantitative using

Optical Density \equiv OD

$$OD = \log \frac{I_0}{I} \quad \text{where}$$

$I_0 \equiv$ intensity before film

$I \equiv$ intensity after film

Digital Radiography

Radiography that uses electronic detectors instead of film \rightarrow Becoming more & more common

Computed Radiography \equiv CR require further processing & often use "storage phosphors" that can replace screen-film cassettes in existing X-ray systems

Electronic point detectors only measure X-ray transmission through a line. For image formation it is required that an array and/or scan be created

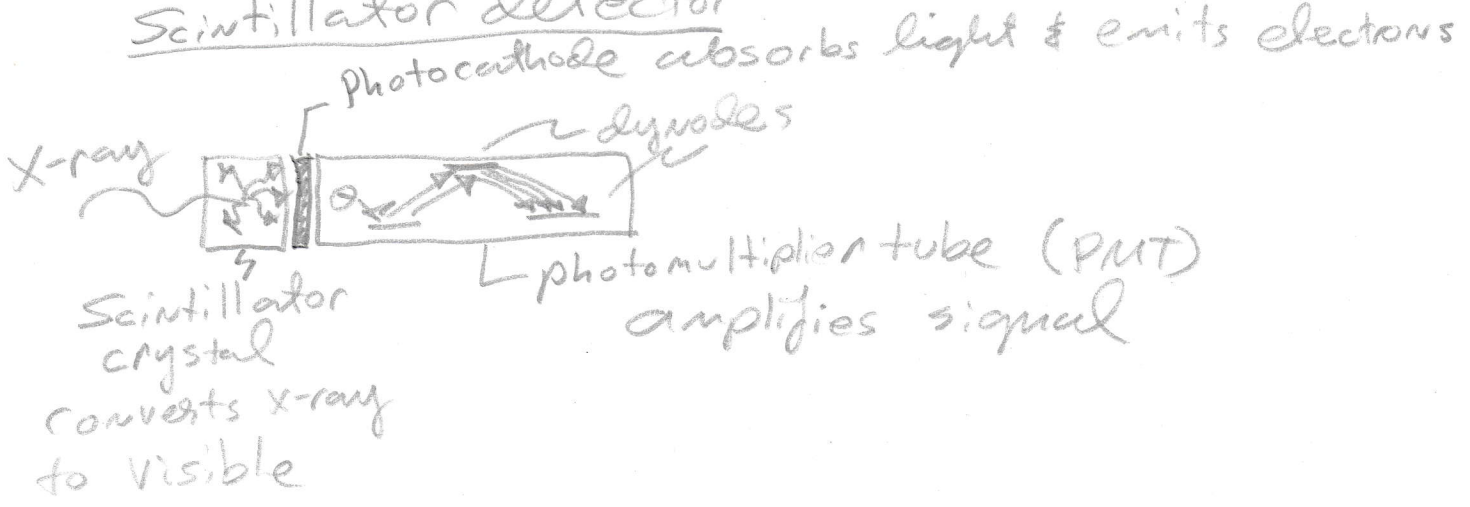
Electronic point detectors

Two popular choices:

- * Scintillators
 - * Gas ionization detectors
- } Electronic signal is proportional to x-ray intensity.

More complex than film BUT are better at distinguishing between low contrasting media

Scintillator detector



Gas ionization detector

