X-ray – CAT-scan

Principles of X-ray diagnostics,

Computer Assisted Tomography

Repetition, definitions

1. Define the X-ray radiation!
2. What processes lead to the attenuation of X-ray radiation?
3. What is the extent of the decay?

Decay I.

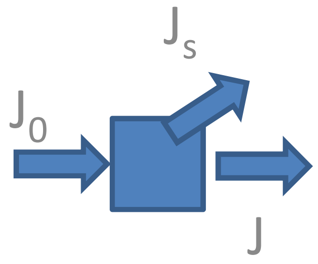
$$J = J_0 e^{-\mu \cdot x}$$

!!!Scattering:

J_s: scattered intensity

elastic scattering

Compton scattering



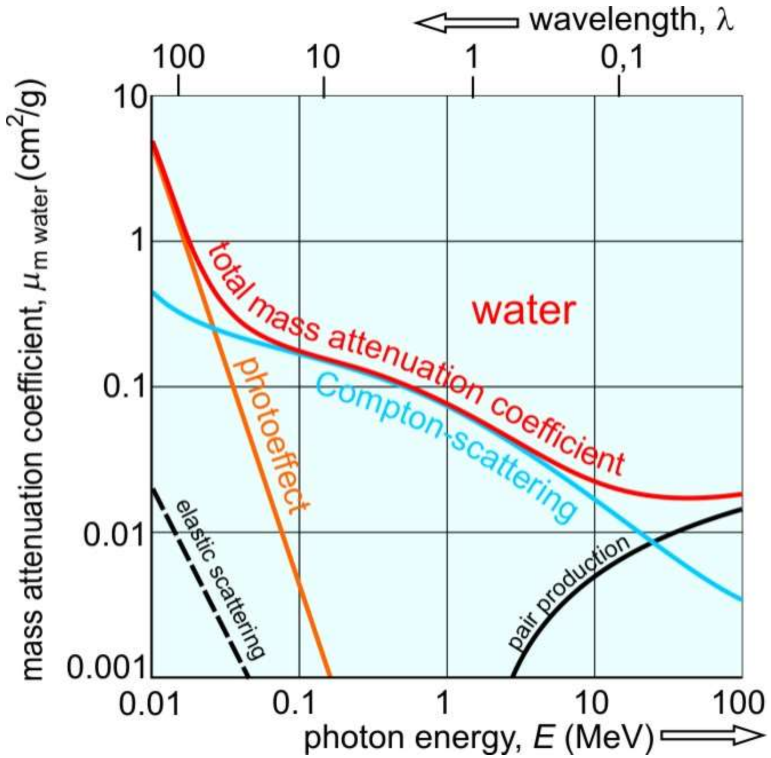
Decay II.

$$J = J_0 e^{-\mu \cdot x}$$

μ depends on:

- Atomic number (Z), density ($\mu = \mu_m \rho$)

  together: electron density: probability of absorption effects
- energy

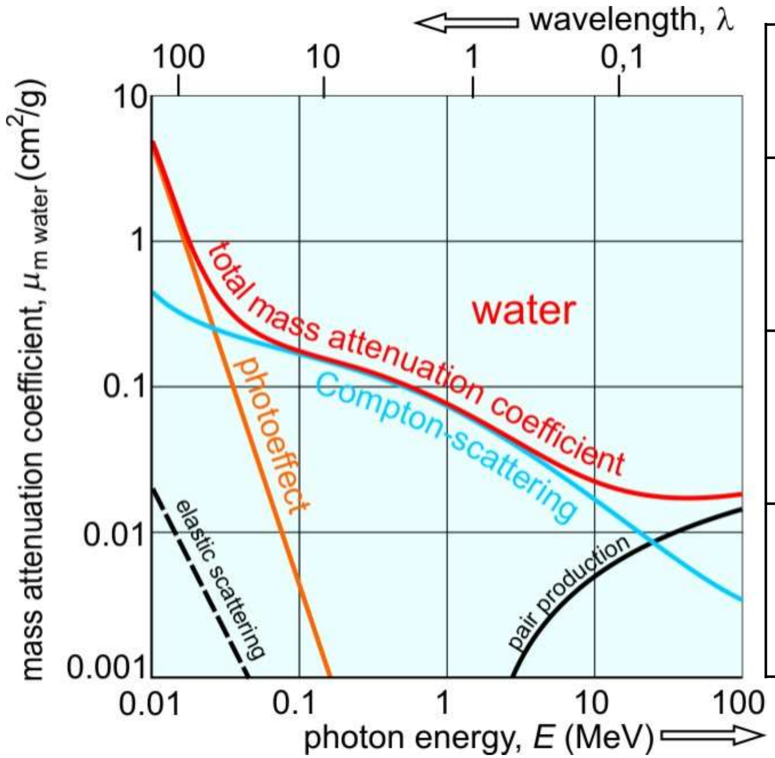


Decay III.

$$J = J_0 e^{-\mu \cdot x}$$

μ depends on:

- Atomic number (Z), density ($\mu = \mu_m \cdot \rho$)
  together: electron density: probability of absorption effects
- energy



!!!NOT independent:

Absorption process	μ_m depends on Z	μ_m depends on fotonenergy (E)
elastic scattering (more probable at lower E)	$\mu_m \sim Z^2$	$\mu_m \sim 1/E^2 \sim \lambda^2$
fotoeffect (more probable at lower E)	$\mu_m \sim Z^3$	$\mu_m \sim 1/E^3 \sim \lambda^3$
Compton scattering (more probable at higher E)	~ indep.	~λ

(+complication: continous E spectra)

Aim: Imaging

Basis:

Transmission (Absorbance) method:

the extent of absorption in a known “place” :

Gathered information:

usually morphological

rarely functional (DSA, lung movement)

Type of image:

usually static

rarely dynamic

1. X-ray image: 2D „summation” image
2. CT (CAT-scan) image: 3D

X-ray Image

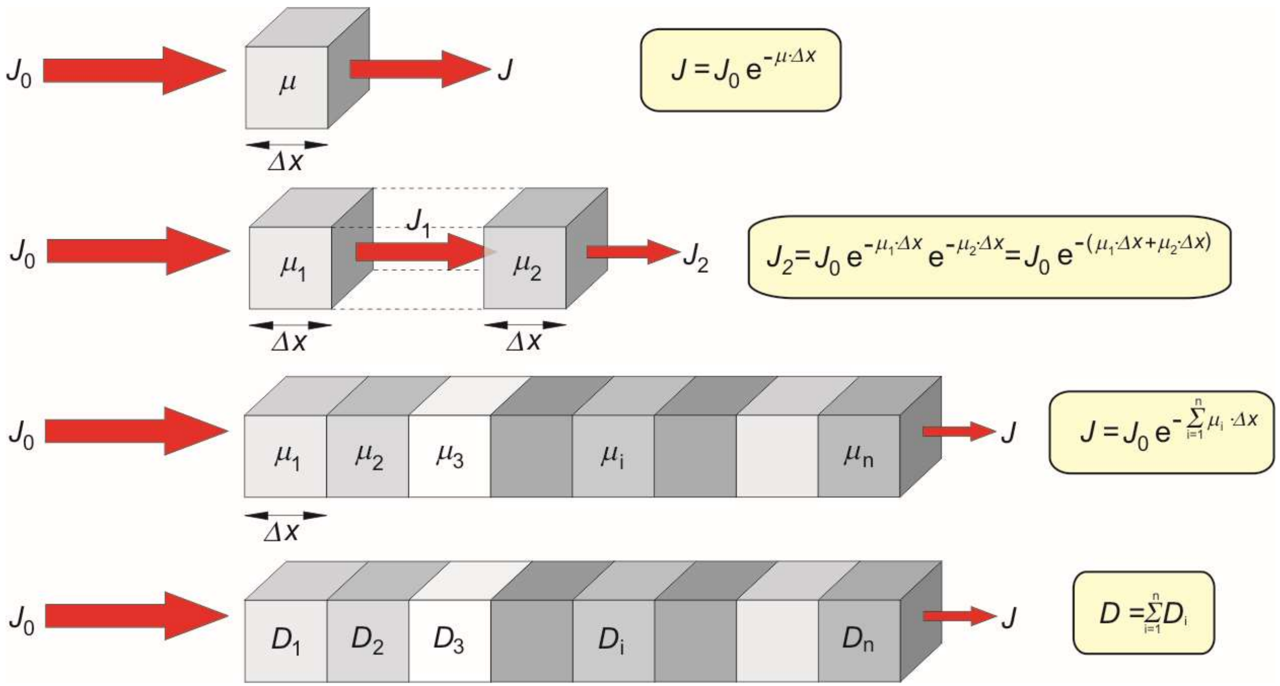
1. 2D – summation image:

$$J = J_0 e^{-(\mu_1 \Delta x + \mu_2 \Delta x + \ldots \mu_n \Delta x)} = J_0 e^{-\sum_{i=1}^{n} \mu_i \Delta x}$$

Let us introduce the concept of **elementary density**, $D_i = \mu_i \Delta x \cdot \lg e$. Then, the total density of the examined body part becomes:

$$D = \lg \frac{J_0}{J} = \sum_{i=1}^{n} D_i$$

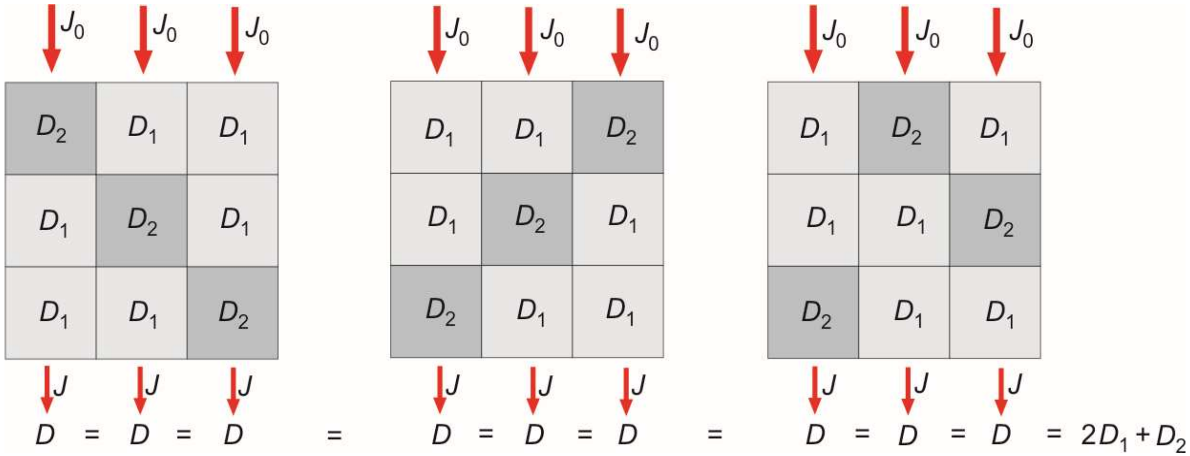
Concept and properties of one element (pixel) of the summation image

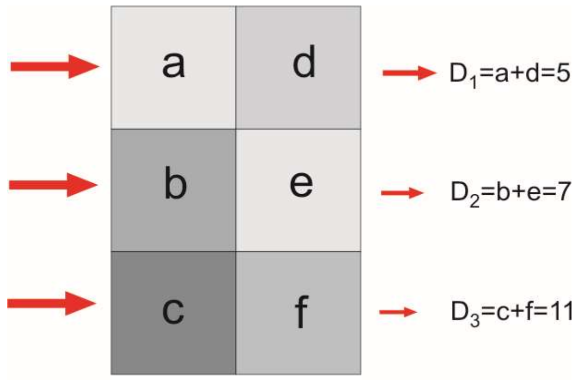


CT Image

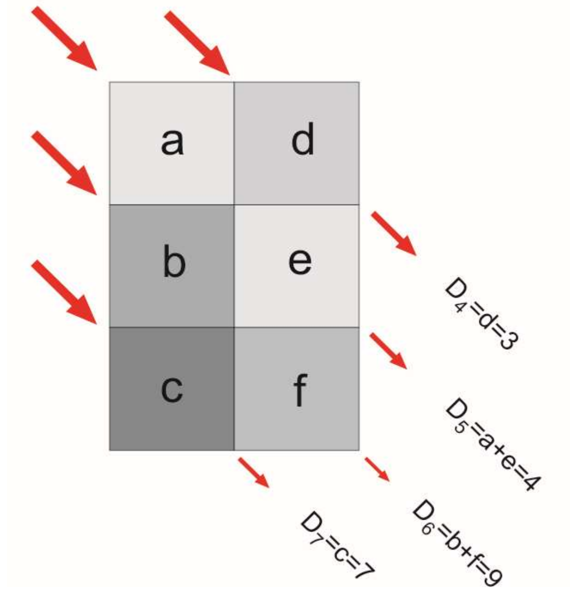
2. CT kép

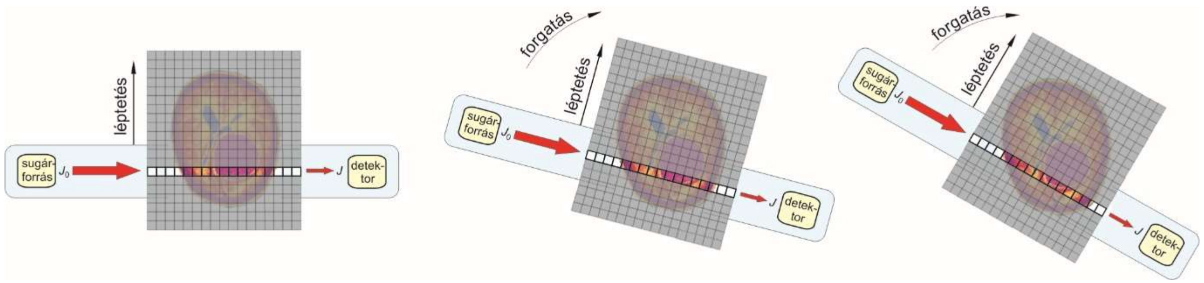
Elementary densities of the image projected on top of each other cannot be revealed by measurement from one direction only. In all the 3 cases the same summation image is obtained.





Elementary densities can be calculated from the summation data





Demonstration measurement

❖16_CAT-SCAN - Summation image and 3D reconstruction.mp4

Model measurement

- 17_CAT-SCAN - Measurement with a phantom.mp4

Lab report

- see excel file

The Image

What is needed to separate two points in an image?

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❖ 21_CAT-SCAN - demonstration of the DSA principle.mp4

The image

What is needed to separate two points in an image?

- contrast difference: X-ray density for X-ray and CT
- resolution

the quality of image depends on too:

- Signal/noise ratio

    noise: external noise+ internal noise

    + scattering! (elastic and Compton)