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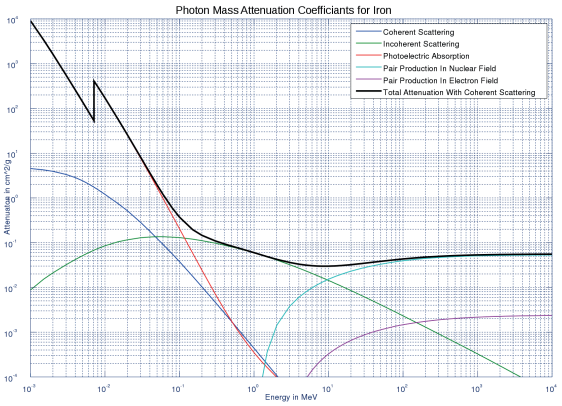
γ-Absoption Experiment

Abstract

Photons interact with matter by processes such as the photo-electric effect, Compton scattering, and pair formation. Due to this interaction the intensity of radiation passing matter decreases exponentially with penetration depth. This exponential decay is characterized by the so called absorption coefficient.
This coefficient depends on material properties and the photon energy. The goal of this experiment is to understand the interaction of photons with matter, to verify the exponential absorption law and to determine the absorption coefficients for a given material at various photon energies. In addition, these measurements imply the familiarization with basics of detectors and electronics.

Physics

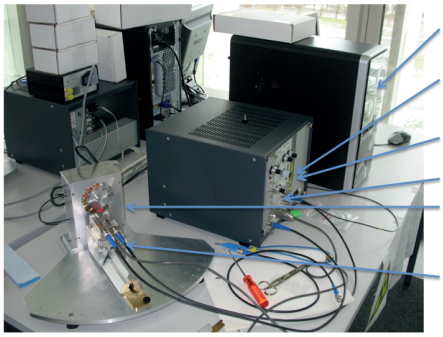


The relative importance of the photo-electric effect, Compton scattering and pair formation depends not only on the energy of the photon, but also on the absorbing material. As a very rough rule, the cross section for photoelectric absorption and pair production are strongly dependent on the atomic number Z (going roughly as Z^5 and Z^2, respectively), while the Compton process only varies linearly with Z.
In the energy region of interest for the present experiment (~100 keV), both the photoelectric and the Compton effects will play an important role.
Due to this interaction the intensity of radiation passing matter decreases exponentially with penetration depth. The exponential decay of the intensity as a function of the path length in the material is described by the so called absorption coefficient μ:

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

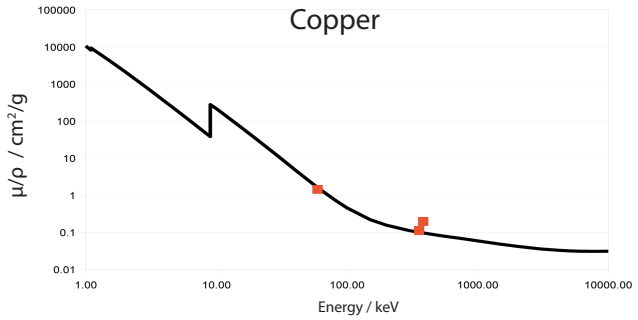
I(x): Photon intensity after crossing a thin material of thickness x
I_0: Initial photon intensity

Experimental Setup

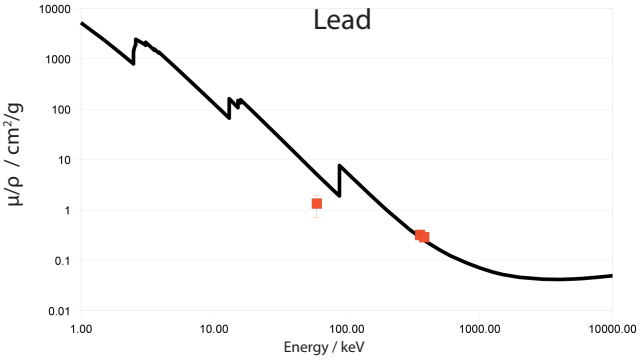


Various sample materials (Cu, Pb and Brass) with different thicknesses are irradiated from behind by an ^{241}Am (37 kBq) and ^{133}Ba (370 kBq) γ-source. The selection of the source and sample material is fully computer controllable.
The measurement of the photon intensity and energy is performed by a CdTe detector connected to a PCI multichannel analyzer including a 8k ADC for pulse-height analysis.

Results



Measured mass attenuation coefficients (red rectangles) in copper compared with literature values.



Measured mass attenuation coefficients (red rectangles) in lead compared with literature values. The measurement at 59 keV afflicted with a large error due to low statistics.

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