

Q5537: How can we convert hard x rays into soft x rays?

ANSWER: Higher-energy (hard) x rays are converted to lower-energy (soft) x rays through Compton scattering interactions with electrons of the material through which the photons travel. If the intent is to produce lower-energy photons and not have them disappear, a lower atomic number material, such as water or many plastics, is desirable in order to avoid capture of photons in photoelectric events. Compton scatter occurs over all scattering angles, θ , from 0 to 180 degrees. The scattering angle is the angle taken by the scattered photon and is measured from the direction of travel of the original photon. The lower the energy of the original photons the more isotropic is the scatter. You may recall the relationship between the original photon energy, E_1 , the photon scattering angle, θ , and the energy of the scattered photon E_2 :

$$E_2 = \frac{E_1}{1 + \frac{E_1}{m_0 c^2} (1 - \cos \theta)} .$$

In this expression $m_0 c^2$ is the rest mass energy equivalence of the electron, 0.511 MeV. Photons that are high in initial energy lose a larger fraction of their energy in a given Compton event than do photons that are low in initial energy.

Since the angle of scatter determines the scattered photon energy one can specify the expected scattered photon energy at a particular scattering angle if the initial photon energy is known. With a monoenergetic primary photon source directed at a thin scatterer one can obtain photons of lower-known energies by sampling the scattered photons at specific scattering angles. The specification of a thin scatterer means that the scatterer thickness is much less than the mean free path of the incident photons so that multiple scattering is unlikely. If the original source is an x ray (bremsstrahlung) source it will emit a whole distribution of energies, so numerous photon energies would be expected at all individual scattering angles even when a thin scatterer is used.

I do not know what your intended application is, but if you are simply interested in degrading the initial photon energy a thick scatterer will encourage multiple scattering, which will reduce photon energy progressively with each scatter. As energy is reduced and the photoelectric interaction cross section increases relative to the Compton cross section, the photon may disappear in a photoelectric capture process.

If you require more information you can read more about Compton scatter in any of numerous texts dealing with radiation science and/or health physics—e.g., H. Cember, *Introduction to Health Physics*, McGraw-Hill, 1996.

I hope this is helpful.

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