Lecture 3.1a(2) Unclear Points:

We defined Kerma as the initial kinetic energy transfer from photons to charged particles at a certain point, that is, locally. When we are talking about collision kerma is that also just considered locally and do we therefore, calculate collision kerma for every occurring interaction?

Yes

Are we going to talk about K edge at some point in the lecture as there wasn't anything mentioned in the lecture notes or the text thus far? If not, could you please say a few words about it?

Discuss K edge

It looks like all coefficients we are dealing with originate from the linear attenuation coefficient mu that we can actually determine through measurements. Is that correct?

Yes

I don't understand this question, " With increasing incident photon energies, the ratio of the mass energy absorption coefficient to the mass energy transfer coefficient ______ due to _______ Bremsstrahlung production:" Could you please explain.

As the photon energy increases, the fraction of Bremsstrahlung increases, increasing the fraction of energy re-radiated, thus decreasing the ratio of the mass energy absorption coefficient to mass energy transfer coefficient

I don't understand the question about barium and why it is used in diagnostic imaging. Apparently I missed that in the lecture.

K edge of barium lies just below energy used in imaging, so enhanced absorption of radiation above K edge.

If water equivalent materials are only water equivalent at certain energies, why is solid water employed so often in the clinic?

We can make materials water-equivalent at particular energies, just not over all energies. “Water-equivalent” materials used in the clinic are typically water-equivalent at therapy energies, where material dependence is not as crucial.

If I understand the energy transfer coefficient correctly, we are essentially disregarding what happens to the electrons after their interaction with the photon, and are simply tracking the loss of photon energy as a function of path length through the material. Is it then fair to say that the average kinetic energy imparted by a photon to an electron in a single ionization event is the energy transfer coefficient times the mean free path of the photon in the material? In this way, for a given photon energy, we could
calculate from the average secondary electron energy the average range of a secondary electron in the material, and get some sense of how far the dose is deposited from the photon track. It seemed to me that this might be of interest when thinking about radiation effects on the sub-cellular scale.

Typically, energy is deposited over a track that is greater than the dimension of a cell. Consequently, single DNA strand breaks are the norm for photon irradiation. For more densely ionizing radiations, double strand breaks are more likely, hence the greater LET.

How does barium improve contrast in diagnostic imaging?

Can you go over number 6 of the pre-test in class?

Increase in attenuation for energies just above K-edge.

I’m still trying to understand the difference between the mass energy transfer coefficient and the mass energy absorption coefficient.

Mass-energy transfer coefficient – related to kerma; mass-energy absorption coefficient – neglect energy re-radiated and not locally deposited

How are the effective atomic numbers determined? And when would we choose m=3 for photoelectric instead of m=4?

For photoelectric effect, attenuation coefficient goes as $Z^3$ for high atomic number materials, $Z^4$ for lower atomic number materials. (Actually $Z^{3.8}$ for lower atomic number materials.) The $Z$-dependence comes out of approximate solution of Dirac equation. Just an approximation, so our numbers typically are empirical.

What do you mean when you say: some energy in case of photon interactions, is getting transferred to linear polarization?

Nothing, really.

What does it mean for energy to be “absorbed”? Through what processes does this occur? It seems that if the nuclei/atoms of the body “absorb” X energy, it puts them in an excited state, and they will decay back down with the radiation of X energy. Does “absorption” indicate losses to tissue heating, and some kind of damage, perhaps broken molecular bonds?

Yes.

In Question 6 above: I understand that the incident photon energy (the diagnostic) should be above the binding energy of the electrons (k edge of barium) to cause absorption of attenuation and subsequent contrast enhancement. Hope my answer is correct. Either way, I would like to hear a much clear explanation regarding the use of barium as a contrast agent in diagnostic imaging.
Binding energy of barium lies just below typical diagnostic x-ray energies, hence there is enhanced absorption of radiation from barium.