Lecture 4.1c Unclear Points:

Just to clarify, when we define fluence through sum of path lengths divided by volume we don't necessarily have reached CPE. Is that right?

Correct

I understand in the Spencer Attix theory takes into account of knock on electrons, but what exactly are 'knock-on electrons'? Are these knock-on electrons really just secondary electrons?

Knock-on electrons are the secondary electrons produced by electron-electron interactions.

For a CPE condition you state, the medium has to be homogeneous in density and composition. However, when I look at the diagram on slide 5, I don't get this. How can we have two volumes homogeneous in density and composition? Wouldn't we need some distinguish, or else we would not be able to distinguish between volume "little v" and volume "big V"?

The division of the volume into V and v is somewhat arbitrary, as long as V is large enough that CPE exists,

When we are talking about energy transferred, net energy transferred, and energy imparted, do we need to know how to derive these equations or can we simply memorize the results.

You do not need to derive the equations, but you need to know what each energy means.

Why does the dose curve become parallel to the kerma curve at transient CPE?

Dose curve is parallel to collision kerma curve at TCPE by definition of TCPE. Dose is collision kerma at a point upstream. As long as dose does not decrease significantly it will be proportional to collision kerma. Look at Roesch relationship

\[
D(TCPE) = K_c e^{\mu'x}
\]

\(\mu'\) is effective attenuation coefficient and \(x\) is mean distance of electron transport. Over small distances this quantity is constant.

How are the unrestricted stopping power and the effects of knock-on electrons related?

In calculating unrestricted stopping power we integrate over fluence spectra for primary electrons only. Implicit in this integration is the inclusion of the secondary electrons resulting from collisional interactions.

How do you choose delta?

Delta is typically the energy of an electron that, if produced in the cavity, will not escape the cavity.
Sometimes the ratio of doses in two mediums is equal to the ratio of stopping powers (Bragg-Gray) or to the ratio of mass energy absorption coefficients. How are these cases different?

Use Bragg-Gray when we can assume there are no photons interacting inside the cavity, and all dose is delivered by the secondary electrons.

Ratio of mass-energy absorption coefficients used when we remove chamber and replace with tissue.

I don't see how the alternative definition of fluence is equivalent to our old definition of fluence. I can see how the units work out, but it is not clear to me how the sum of track lengths per unit volume is the same as the number of tracks per unit area.

This definition is in the Attix text.

III. DESCRIPTION OF IONIZING RADIATION FIELDS

D. An Alternative Definition of Fluence

Chilton (1978, 1979) has proven the validity of an alternative definition of fluence, namely:

The fluence at a point $P$ is numerically equal to the expectation value of the sum of the particle track lengths (assumed to be straight) that occur in an infinitesimal volume $dV$ at $P$, divided by $dV$.

This statement was shown to be true for nonisotropic as well as isotropic fields, irrespective of the shape of the volume. Thus one need not require a spherical volume to define fluence in this way. Moreover this definition lends itself to dosimetry calculations by the Monte Carlo method.

The references are to Chilton AB. A note on the fluence concept. Health Physics 34:715 (1979) and Chilton AB. Further comments on an alternate definition of fluence. Health Physics 36:637 (1979). I was not able to find the articles cited.

Question 2 on the pre test. The notes say that CPE talks about the number of particles entering and leaving a volume, but at a given energy. So do we define it as the number or energy leaving/entering the volume?

More specifically, it is the energy balance.

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Can you further explain the delta in Spencer-Attix theory?

Δ is a threshold energy. Secondary electrons with an energy less than Δ deposit their energy in the cavity, while electrons with an energy greater than Δ can carry energy out of the cavity. The restricted stopping power only includes energy losses to delta-rays whose energies are less than Δ, as these low-energy delta rays deposit their energies in the volume, while the high energy delta rays deposit their energies out side the volume.

I am still not clear on why CPE is not required to apply in Spencer-Attix Theory. Can you please elaborate on this?

In Spencer-Attix theory, energy deposition is considered to be local, so CPE not required. CPE is required when energy deposition is not local.