AbstractID: 13390 Title: A generalized dose-rate constant formalism for brachytherapy sources emitting anisotropic photon energy spectrum

Purpose: The aim of this work was to develop a generalized formalism for calculating the dose-rate constant, Λ, of radioactive sources emitting anisotropic photon energy spectra. **Method and Materials:** Although the Λ is defined on the transverse bisector of a brachytherapy source, its magnitude depends on both the primary photons emitted along the transverse bisector and the scattered photons arising from those primary photons emitted in other directions. For sources emitting nearly isotropic energy spectrum, the contribution of scattered photons can be taken into account easily by using Berger's energy-buildup factor. For sources with anisotropic photon emissions, a new dose-rate deposition kernel for unidirectional photon sources of unit intensity and energy E was introduced. The dose-rate produced by such a source at any location, $\vec{r}$, in water can then be determined by superposition of the angular photon energy spectrum with the dose-deposition kernel. **Results:** A generalized formalism for Λ was obtained:

$$\Lambda \equiv \frac{\dot{D}(\vec{r}_0)}{S_k} = \frac{\sum_i n(E_i;\theta_0,\varphi_0)\cdot E_i \cdot \left(\mu_{en}(E_i)/\rho\right)_{air}\cdot \overline{\Lambda}(E_i)}{\sum_i n(E_i;\theta_0,\varphi_0)\cdot E_i \cdot \left(\mu_{en}(E_i)/\rho\right)_{air}} \quad \text{with} \quad \overline{\Lambda}(E) = \int_\Omega \frac{n(E;\theta_s,\varphi_s)}{n(E;\theta_0,\varphi_0)} \frac{\dot{k}(\vec{r}_0;E,\theta_s,\varphi_s)}{E\cdot\left(\mu_{en}(E)/\rho\right)_{air}} d\Omega_s$$

where $\dot{k}(\vec{r};E,\theta_s,\varphi_s)$ is the dose-rate-deposition kernel with $\vec{r}$ denoting the dose-rate deposition site and (θ_s, φ_s) the orientation of an unidirectional source, $n(E;\theta_s,\varphi_s)$ is the number of photons emitted in the (θ_s, φ_s) direction, and $\left(\mu_{en}(E)/\rho\right)_{air}$ is the mass energy absorption coefficient of air. The subscript 0 denotes the reference point of Λ. This formalism exhibits two unique features essential for accurate Λ calculation: 1) it only requires relative photon energy spectra and 2) it does not depend on the methodology used in the determination of dose-deposition kernels or angular energy spectra. **Conclusion:** A generalized formalism, based on the dose deposition kernels of mono-energetic unidirectional photon sources, has been developed for calculating the Λ of low-energy brachytherapy sources. In addition, this formalism can also be used in the calculation of other dosimetry parameters for interstitial brachytherapy sources. Numerical testing of this formalism for some ^{125}I, ^{103}Pd, and ^{131}Cs sources will be presented.