Slides for Statistics, Precision, and Solid Angle

22.01 – Intro to Radiation

October 14, 2015

Solid Angles, Dose vs. Distance

- Dose decreases with the inverse square of distance from the source:

$$Dose \propto \frac{1}{r^2}$$

- This is due to the decrease in *solid angle* subtended by the detector, shielding, person, etc. absorbing the radiation

Solid Angles, Dose vs. Distance

- The solid angle is defined in *steradians*, and given the symbol Ω.
- For a rectangle with width w and length l, at a distance r from a point source:

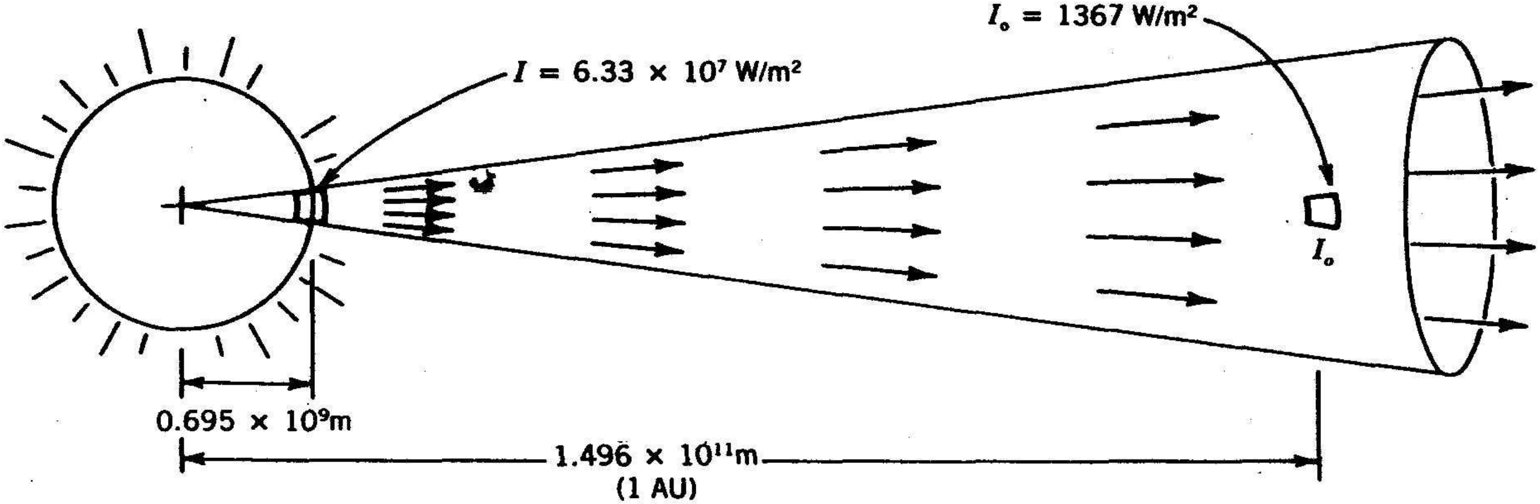
$$\Omega = 4arctan\left[\frac{wl}{2r\sqrt{4r^2 + w^2 + l^2}}\right]$$

- A full sphere has 4π steradians (Sr)

Solid Angles, Dose vs. Distance

http://www.powerfromthesun.net/Book/chapter02/chapter02.html

- Total *luminance (activity)* of a source is constant, but the *flux* through a surface decreases with distance



Exponential Gamma Attenuation

- Gamma sources are *attenuated* exponentially according to this formula:

Initial intensity

Mass attenuation coefficient

$$\boldsymbol{I = I_0 e^{-\left(\frac{\mu}{\rho}\right)\rho x}}$$

Distance through material

Transmitted intensity

Material density

- *Attenuation* means removal from a narrowly collimated beam *by any means*

Exponential Gamma Attenuation

Look up values in NIST x-ray attenuation tables:
http://www.nist.gov/pml/data/xraycoef/

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Mass attenuation coefficient

Distance through material

$$I = I_0 e^{-\left(\frac{\mu}{\rho}\right)\rho x}$$

Transmitted intensity

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Exponential Gamma Attenuation

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Mass attenuation coefficient

Initial intensity

$$I = I_0 e^{-\left(\frac{\mu}{\rho}\right)\rho x}$$

Distance through material

Transmitted intensity

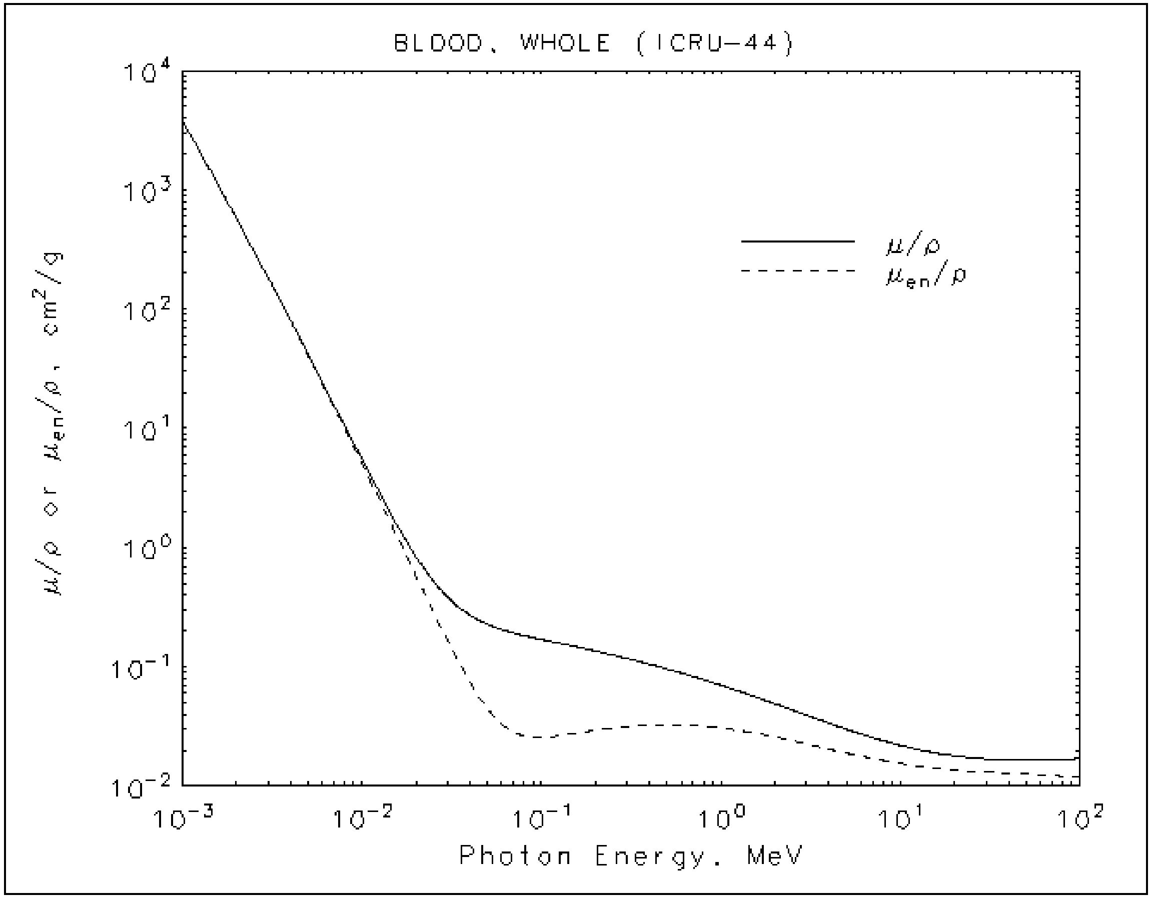
Material density

For compound materials, just add their total attenuation coefficients:

$$\mu_{total} = \left(\frac{\mu}{\rho}\right)_1 \rho_1 + \left(\frac{\mu}{\rho}\right)_2 \rho_2 + \cdots$$

Mass Attenuation Coefficients

http://physics.nist.gov/PhysRefData/XrayMassCoef/ComTab/blood.html



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Statistics, Counting, Uncertainty

Confidence increases with *counting time* and *counting rate*:

$$\sigma = \sqrt{\frac{count\ rate}{counting\ time}}$$

Count rates are expressed in counts per time plus or minus standard deviations:

$$counts\ per\ minute = CPM \pm \sigma$$

Statistics, Counting, Uncertainty

Remember to measure a *background count rate* with its own uncertainty:

$$\sigma_b = \sqrt{\frac{CPM_b}{t_b}}$$

Express total uncertainties in *quadrature*:

$$CPM_{net} = CPM_{total} - CPM_b \qquad \sigma_{net} = \sqrt{\frac{CPM_{total}}{t_{total}} + \frac{CPM_b}{t_b}}$$