Optical Methods in Diagnosis

Homework #6

We will determine photon absorption distribution for laser beams with finite diameters. Use the same parameters as Homework #5: $\mu_a = 6$ cm^{-1}, $\mu_s = 414$ cm^{-1}, g = 0.91, Henyey-Greenstein phase function, n_0(outside medium)=1, n_1(tissue)=1.37, $\Delta r = \Delta z = 0.1$ mm.

Plot the fluence rate (W/cm^2) distribution in the tissue (radius = 3 mm, thickness = 1.5 mm) for a collimated, normally incident beam that has (A) a uniform distribution with a radius of 0.5 mm and irradiance = 1
(flat - top)
W/cm^2, and (B) a Gaussian distribution with an e^{-2} radius of 0.5 mm and total power of 7.85 mW. Use variable-weight photons. Choose one of the following two approaches:

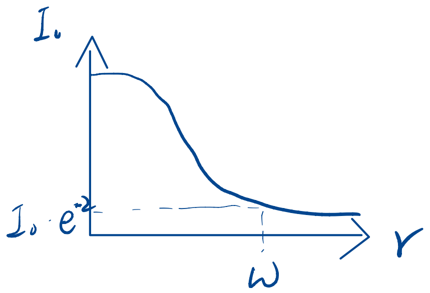
Method 1: Distribute input photons over area of the incident beam

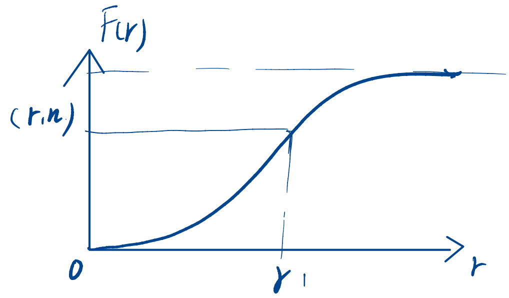
Modify your code "x = y = z = 0" to "z = 0, x = function (r.n.), y = function (r.n.)" for initial photon positions.

total power $= 1 \times \pi \times (0.05)^2 = 7.85$ mW

Method 2: Convolve the impulse response with the radial profile of the incident beam

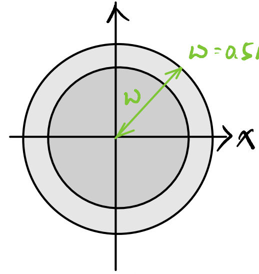
After the completion of Monte Carlo simulations for the impulse response (initial position x = y = z = 0), use a sub-program to compute the convolution of the impulse response and the source radial profile. Note that the first photon-tissue interaction needs to be handled separately.





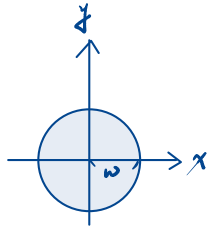
$$S(r) = \frac{2P}{\pi \omega^2} \cdot e^{-2r^2/\omega^2}$$

$$F(r) = 1 - e^{-\frac{2r_1^2}{\omega^2}}$$



shift-invariant system.
⇒ convolution integral to simplify calulation.

(A) uniform distribution



probability of a photon's initial position $r \le r_1$

$$(r.n) = F_1(r)\Big|_{r=r_1} = \frac{\pi r_1^2}{\pi \cdot w^2} = \frac{r_1^2}{w^2} \qquad r_1 = w\sqrt{(r.n)}$$

Fluence_rate_distribution, Incident beam power = 7.85e-3W, Source_type = Gaussian