Exercise on light scattering

Exercise for week 8

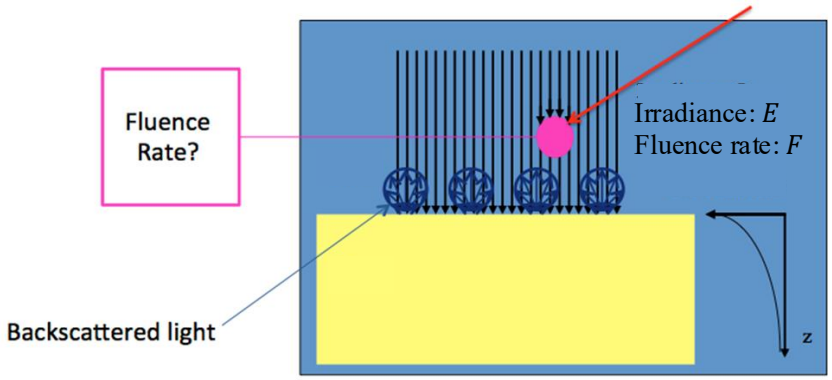
A thick (thickness >> μ_{eff}^{-1}) absorbing and scattering sample, indicated in yellow below, is illuminated at 660 nm by a collimated and 'broad' (spot diameter >> μ_{eff}^{-1}) light beam directed perpendicularly to the interface (let's consider a matching of the refractive indexes) with an unknown irradiance. A «small» and calibrated isotropic detector, which measures the fluence rate, is placed in the beam just above the solution (Neglect the shadow produced by the detector). A fraction of the light is backscattered and re-emitted by the tissue surface with a Lambertian profile.

The optical properties of the tissue at 660 nm are: $\mu_a = 0.001$ mm^{-1}, $\mu_s = 10$ mm^{-1}, $g = 0.9$, $k = 7.95$, $R = 93$ %.

Q1: Knowing the fluence rate (F) = 500 mW/cm^2 at a depth of 2,5 mm, what is the fluence rate measured by the detector outside the tissue in the light beam.

Q2: What is the depth inside the tissue at which the fluence rate F equals the irradiance E?

Q3: Discuss the evolution of the reflection coefficient R with changes of μ_a, μ_s' and n_2.



Collimated "broad" illumination perpendicular to the air-tissue interface

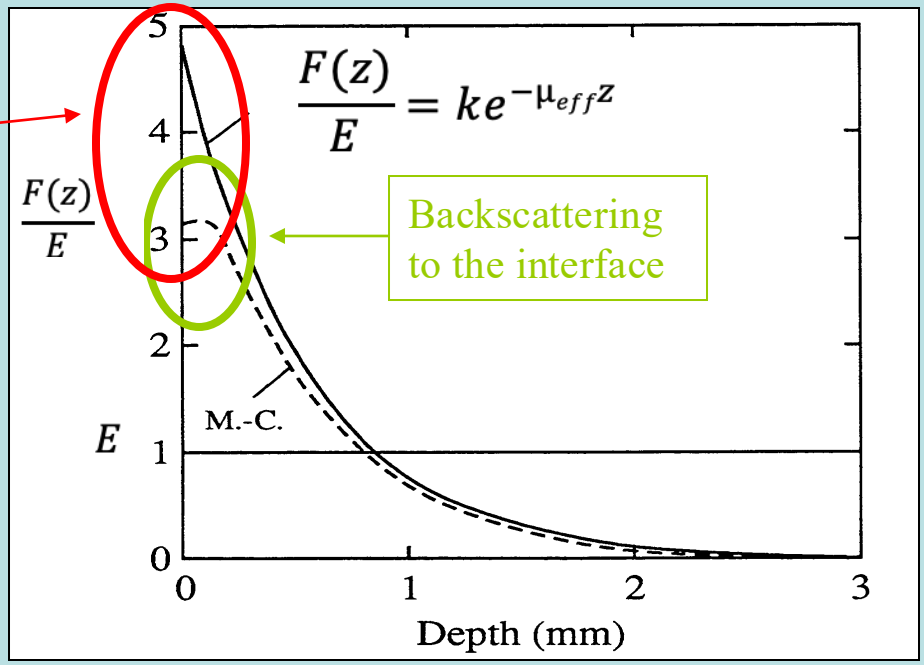
Semi-infinite volume of tissue (n=1.37)

Model and Monte-Carlo simulation (S.L Jacques)

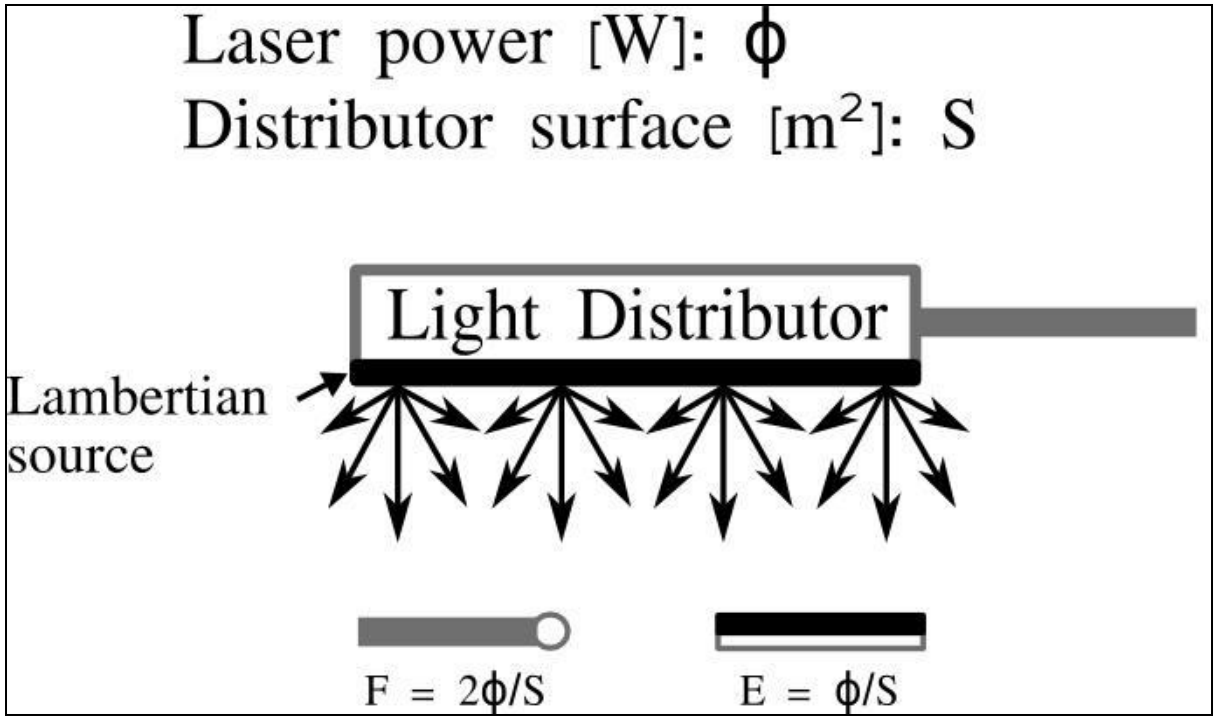
$\mu_a = 0.27\ mm^{-1}, \mu_s = 18.7\ mm^{-1}, \mu_{\text{eff}} = 1.76\ mm^{-1}$

$g = 0.81, k = 4.87$

Diffusion approximation is not valid anymore



Hint !


Laser power [W]: ϕ
Distributor surface [m²]: S
Light Distributor
Lambertian source
F = 2ϕ/S
E = ϕ/S