Dan Wahl's Black Tube Calculation

LED at one end of the tube. The other end of the tube has an aperture. The tube contains neutral density attenuators somewhere along the light path.

The black tube dimensions: $inch := 0.0254 \cdot m$

$L := 5.68 \cdot inch$ (Length of the tube)

$D := 0.75 \cdot inch$ (Diameter of the aperture)

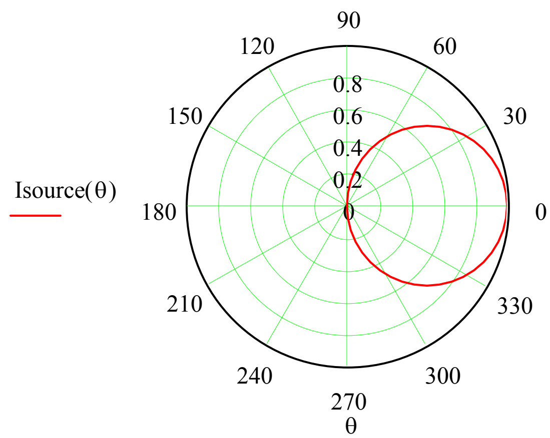
Source flux in the forward direction $Is := 1 \cdot \frac{1}{sec \cdot m^2}$

Source flux angular pattern: $f(\theta) := \cos(\theta)$ $Isource(\theta) := Is \cdot f(\theta)$ $\theta := -\frac{\pi}{2}, \left(-\frac{\pi}{2}\right) \cdot 0.95 .. \frac{\pi}{2}$

Fsource: Total # photons from source per unit time

$$Fsource := \int_0^{\frac{\pi}{2}} Is \cdot f(\theta) \cdot 2 \cdot \pi \cdot L^2 \cdot \sin(\theta)\, d\theta$$

$$Fsource = 0.065\,Hz$$



Faperture: Total # photons goting through the aperture per unit time

θ1: Angle defining the edge of the aperture $\theta1 := \frac{D}{2 \cdot L}$

$$Faperture := \int_0^{\theta1} Is \cdot f(\theta) \cdot 2 \cdot \pi \cdot L^2 \cdot \sin(\theta)\, d\theta \qquad Faperture = 2.846 \times 10^{-4}\,Hz$$

$$Fraction := \frac{\int_0^{\theta1} f(\theta) \cdot \sin(\theta)\, d\theta}{\int_0^{\frac{\pi}{2}} f(\theta) \cdot \sin(\theta)\, d\theta} \qquad Fraction = 4.352 \times 10^{-3}$$

Note: For the cos(θ) source pattern, Fraction = $\left(\frac{D}{2 \cdot L}\right)^2 = 4.359 \times 10^{-3}$