

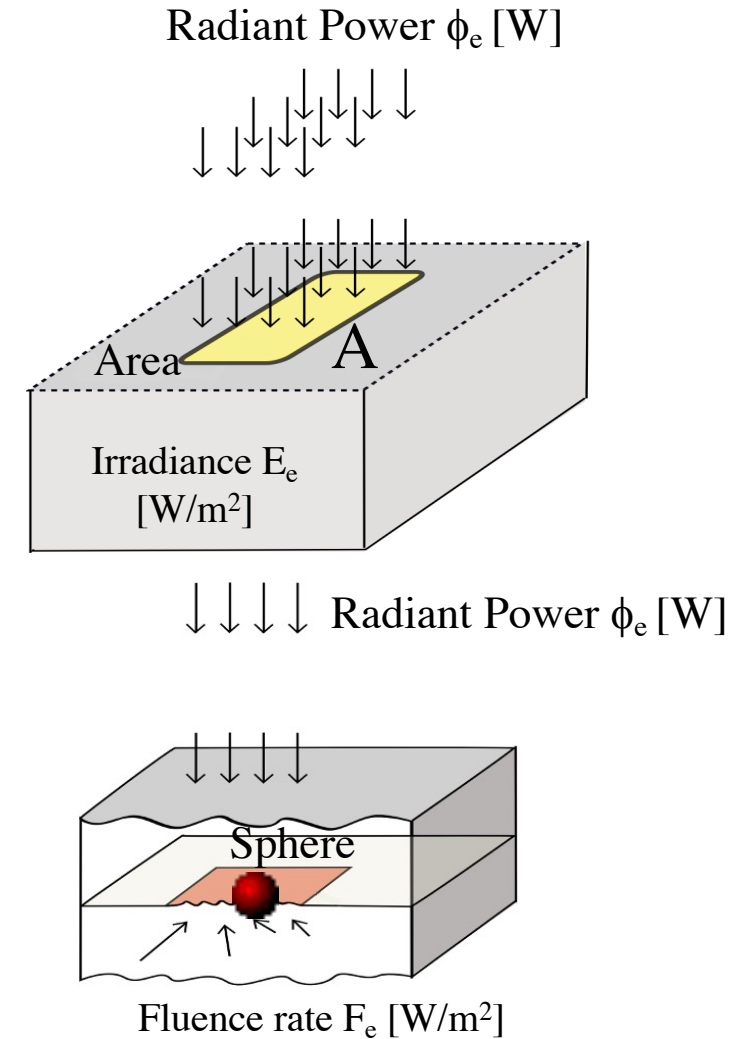
Exercise 2 **(In class)**

Difference between Fluence rate and Irradiance !

Radiometry (Definitions)

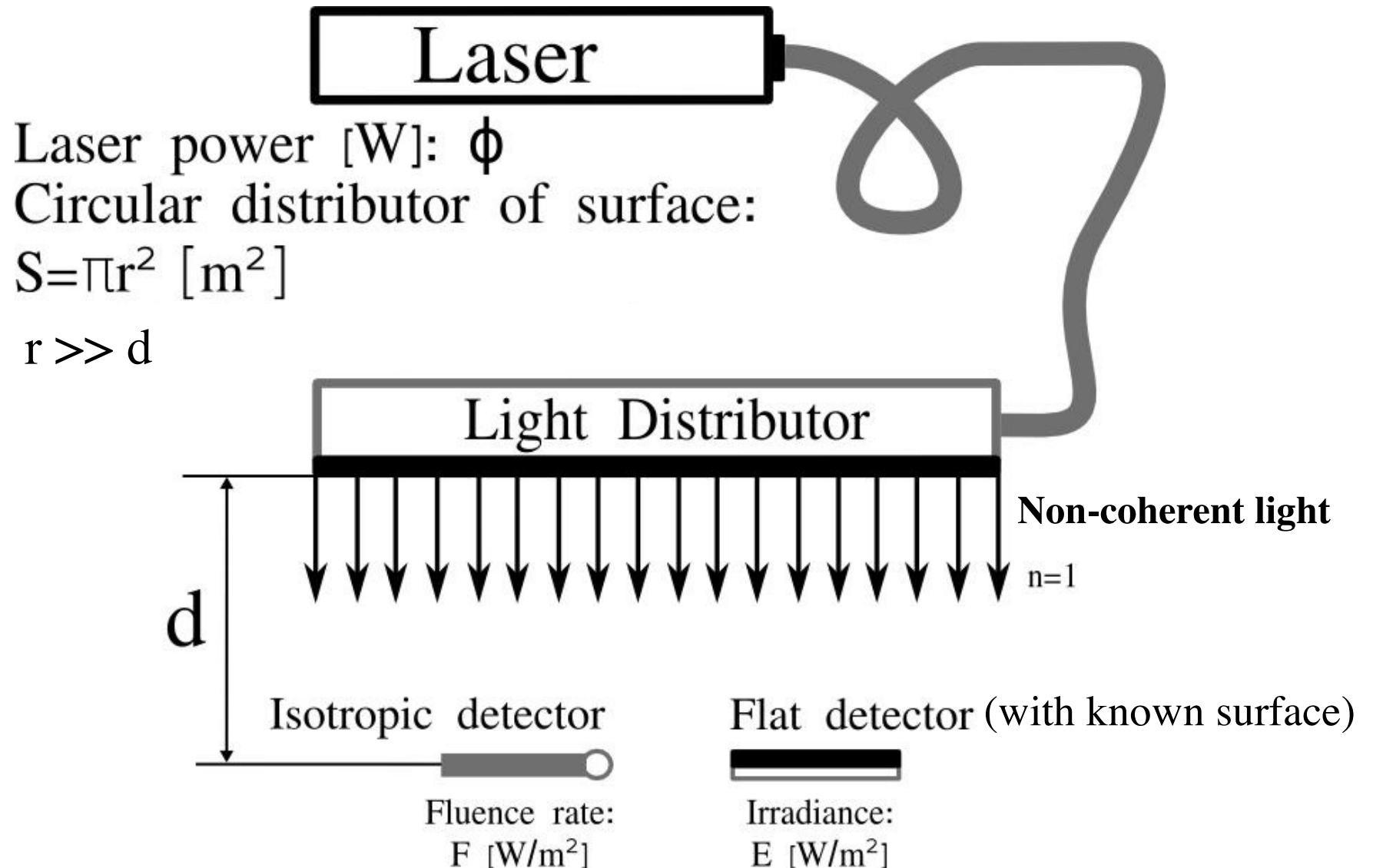
Irradiance vs. Fluence rate

- The irradiance is the radiant flux per unit area reaching the surface A .
- The fluence rate is the quantity measured with an isotropic power meter.
(Power entering a sphere presenting a unit cross-section)



Exercise 2

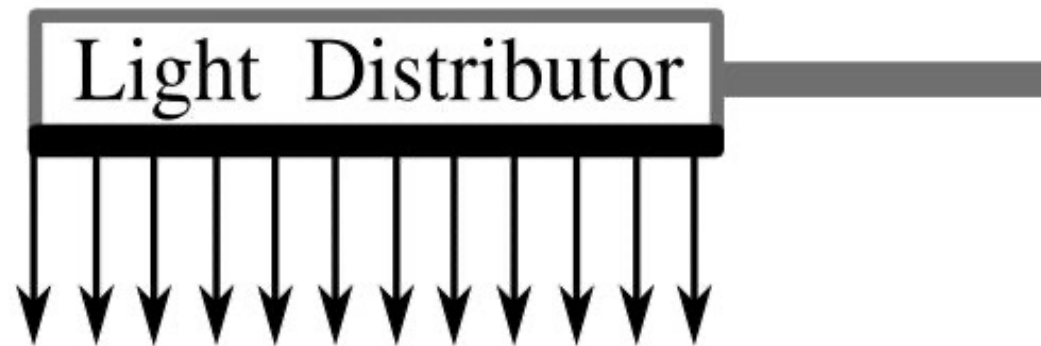
Fluence rate and Irradiance



Case 1

Laser power [W]: ϕ

Distributor surface [m²]: S



$F = ?$

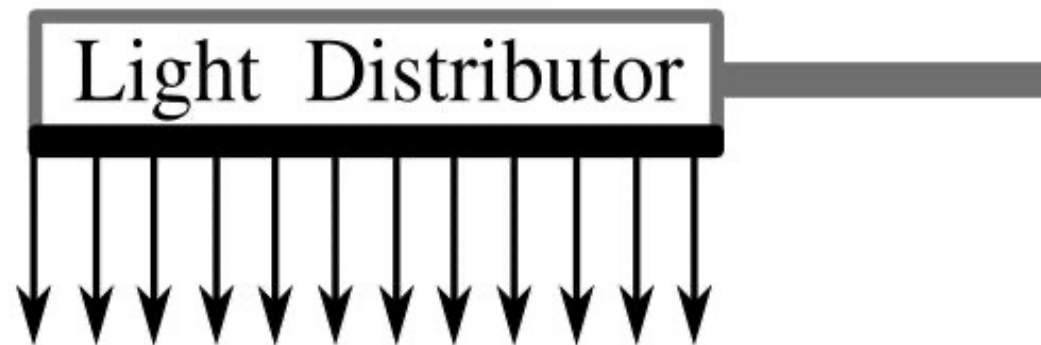


$E = ?$

Case 1 (solution)

Laser power [W]: ϕ

Distributor surface [m²]: S



$$F = \phi/S$$

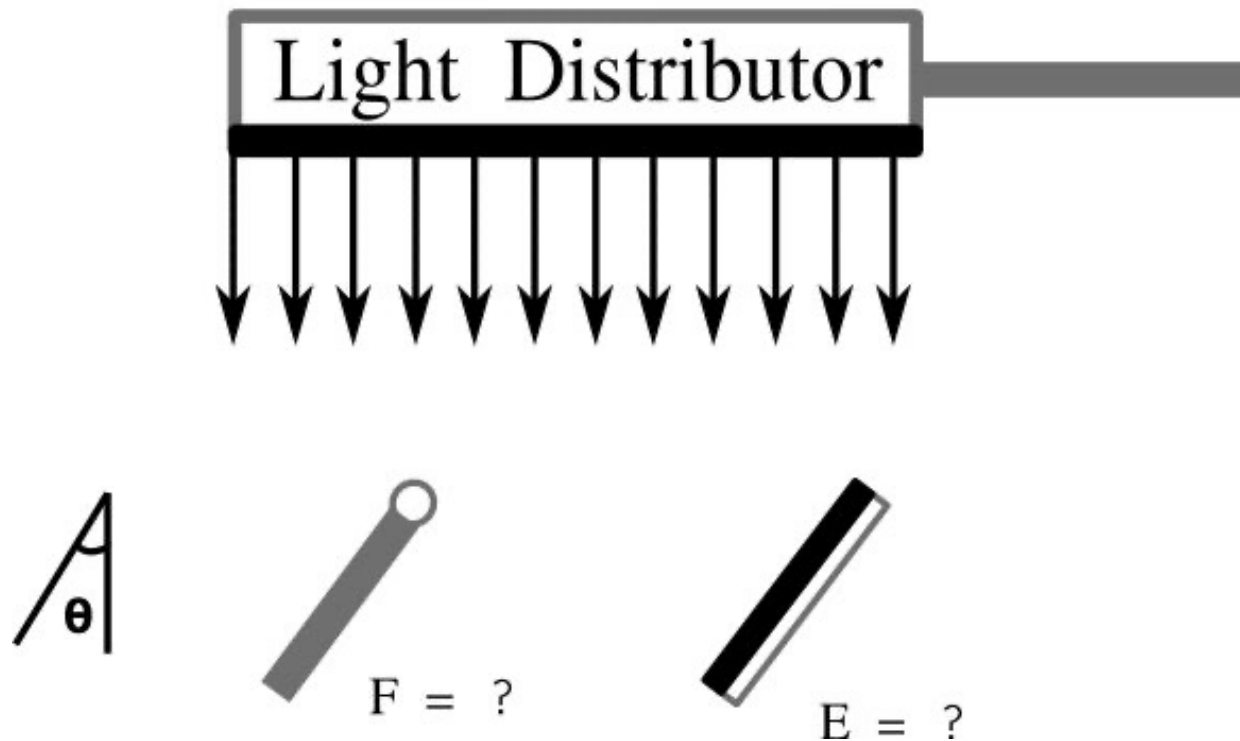


$$E = \phi/S$$

Case 2

Laser power [W]: ϕ

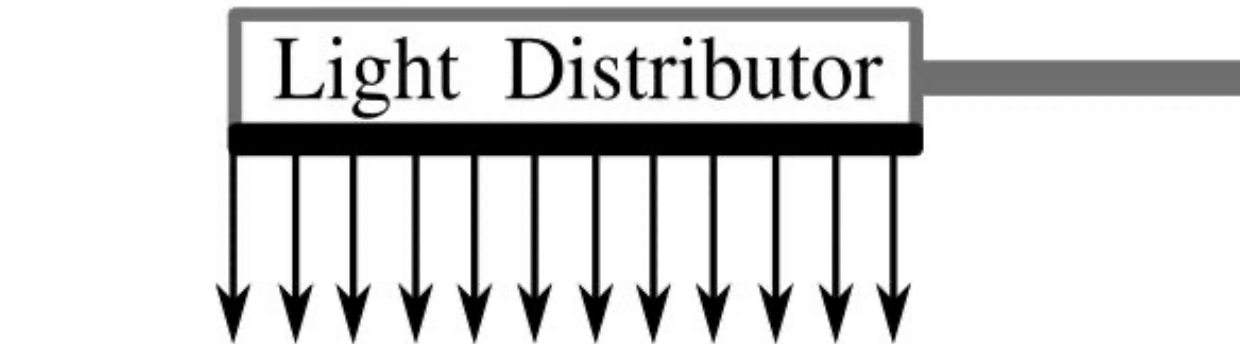
Distributor surface [m²]: S



Case 2 (solution)

Laser power [W]: ϕ

Distributor surface [m²]: S



$$F = \phi/S$$

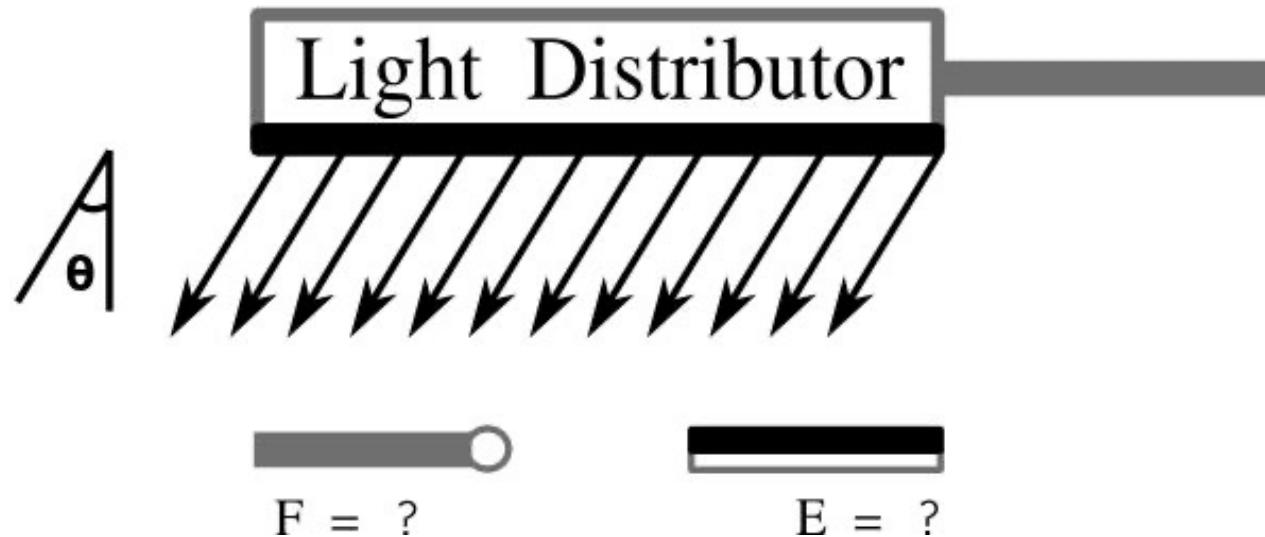


$$E = (\phi/S)\sin \theta$$

Case 3

Laser power [W]: ϕ

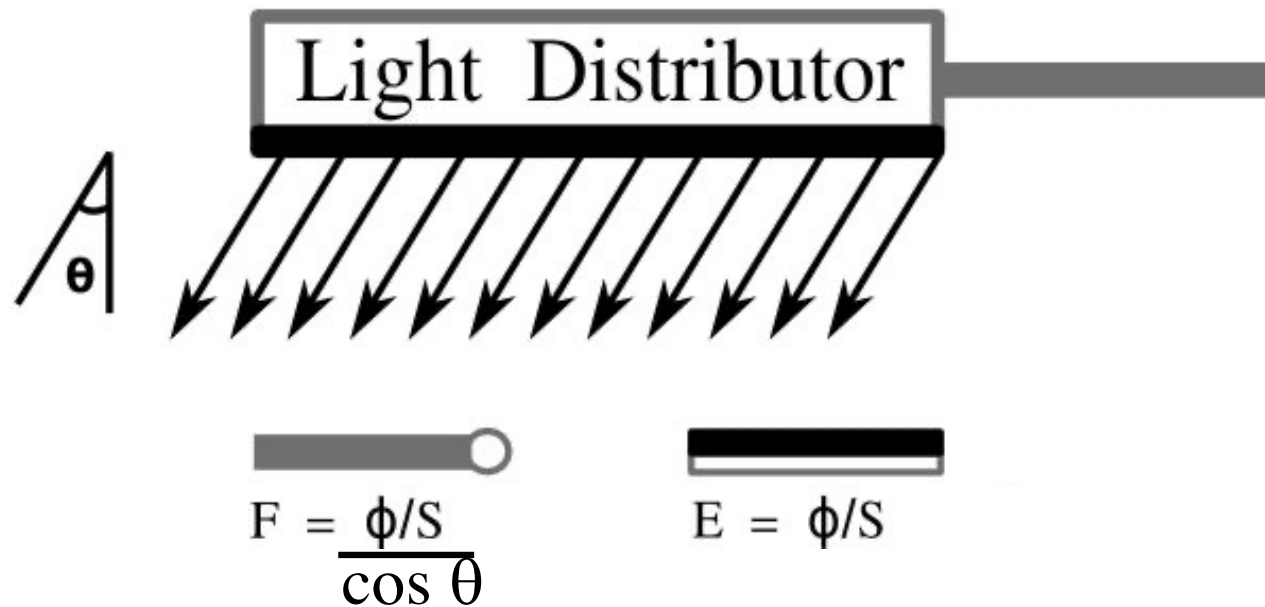
Distributor surface [m²]: S



Case 3 (solution)

Laser power [W]: ϕ

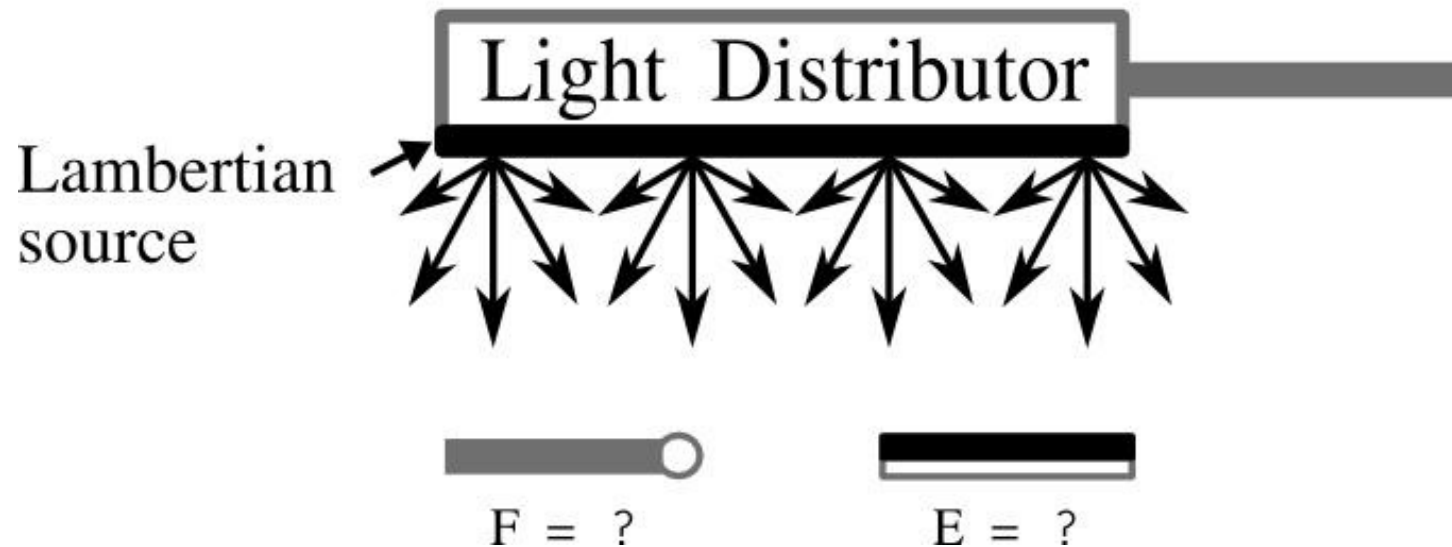
Distributor surface [m²]: S



Case 4

Laser power [W]: ϕ

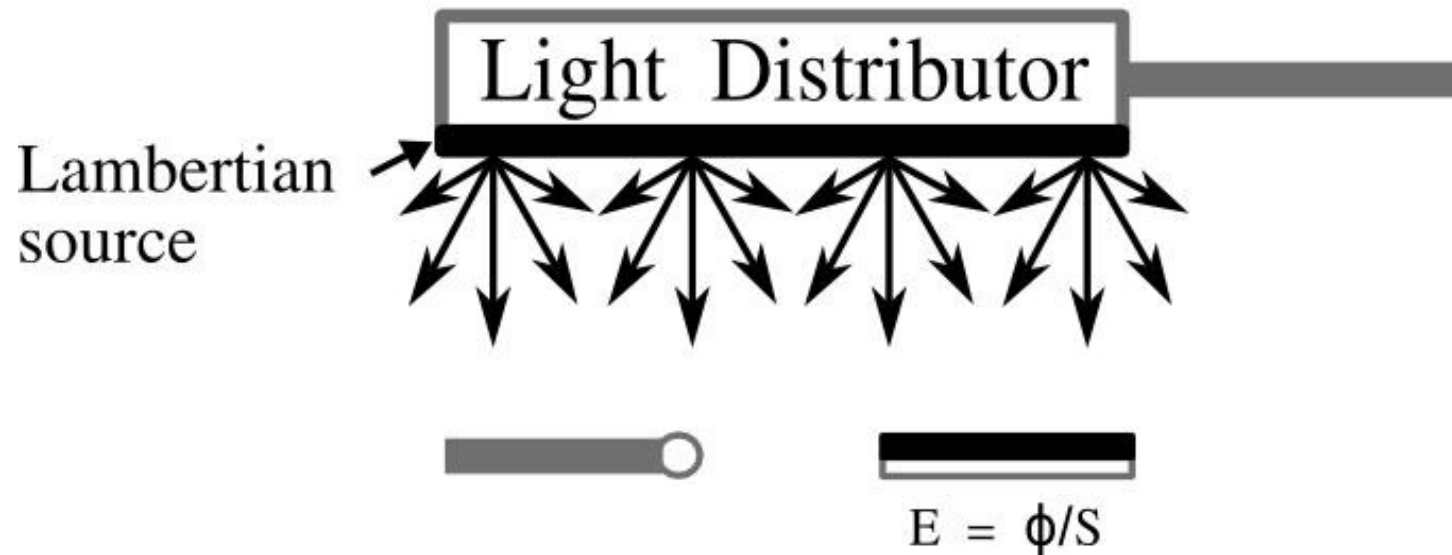
Distributor surface [m²]: S



Case 4 (solution)

Laser power [W]: ϕ

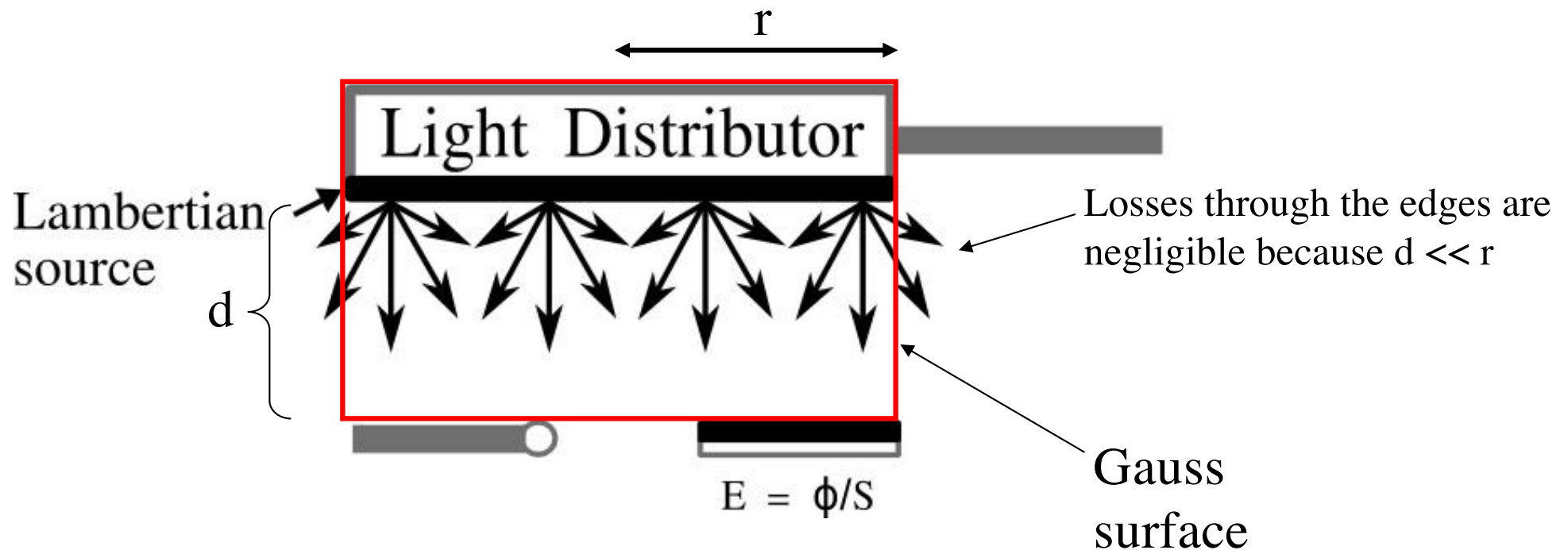
Distributor surface [m²]: S



Case 4 (solution)

Laser power [W]: ϕ

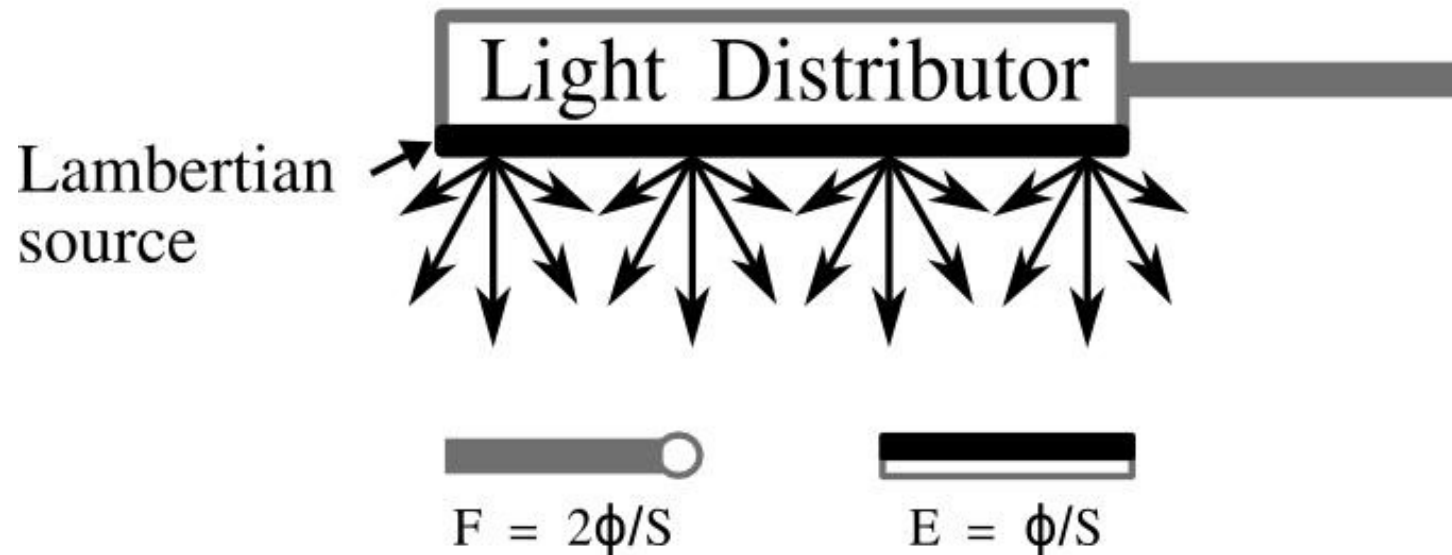
Distributor surface [m²]: S



Case 4 (solution)

Laser power [W]: ϕ

Distributor surface [m²]: S



Fluence Rate (definition)

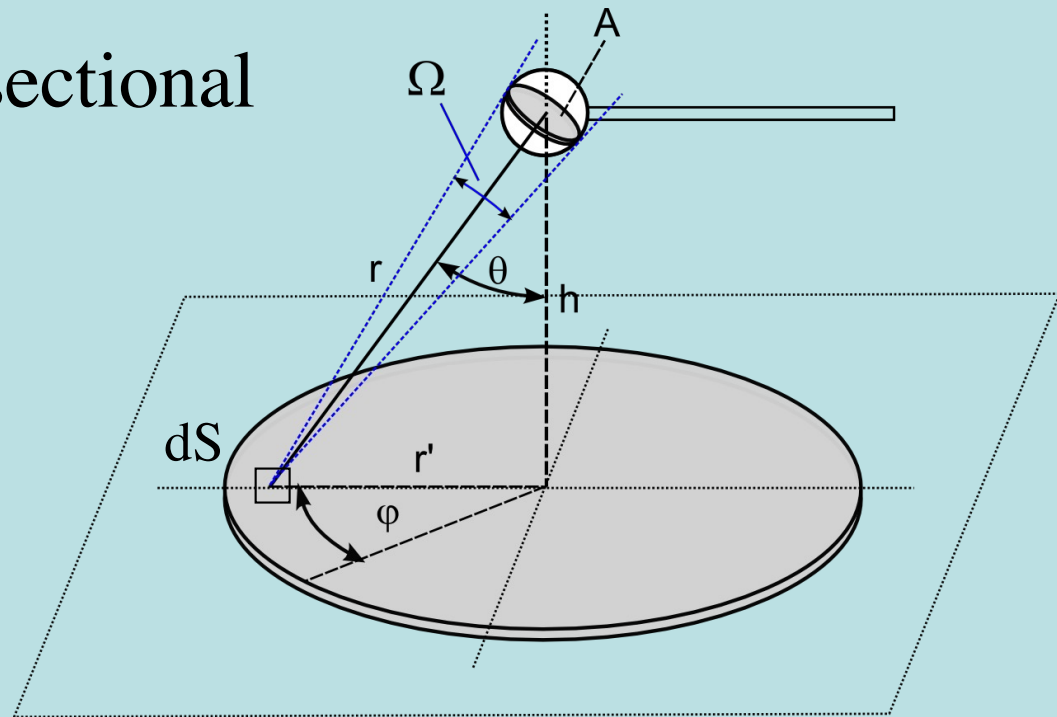
Definition:

The radiant fluence rate F at a given point in space is defined as the radiant flux Φ' incident on a small sphere, divided by the cross-sectional area A of that sphere

$$F = \frac{\Phi'}{A}$$

with

$$\Phi' = \int L \cdot dS \cdot \cos \theta \cdot \Omega$$



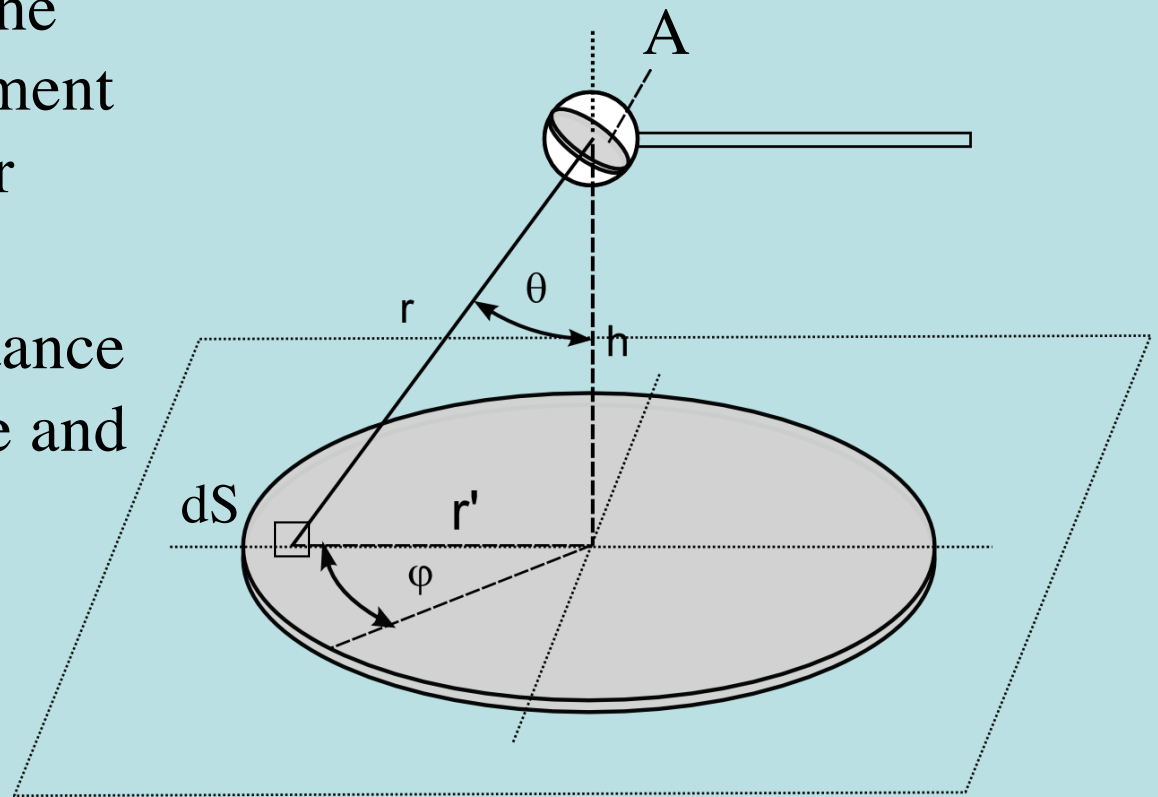
Case 4

$S =$ source surface

$A =$ detector surface (i.e. the cross section of the isotropic probe)

$r =$ distance between the source surface element dS and the detector surface A

$h =$ the orthogonal distance between the source and the detector
 $r = h / \cos \theta$
 $r' = h \tan \theta$



$$F = \frac{1}{A} \int_S L \cdot dS \cos \theta \Omega$$

Definition of the solid angle

$$\Omega = \frac{A}{r^2} = A \cdot \frac{\cos^2 \theta}{h^2}$$

$$= \frac{1}{A} \int_0^{2\pi} \int_0^{\frac{\pi}{2}} L \frac{h^2}{\cos^2 \theta} \tan \theta d\theta d\varphi \cdot \cos \theta \cdot A \frac{\cos^2 \theta}{h^2}$$

From the set-up geometry

$$dS = r' dr' d\varphi$$

$$r' = h \cdot \tan \theta$$

$$\text{and } \frac{dr'}{d\theta} = \frac{1}{\cos^2 \theta} \cdot h$$

$$dS = h \cdot \tan \theta \cdot \frac{h}{\cos^2 \theta} d\theta d\varphi$$

$$= \int_0^{2\pi} \int_0^{\frac{\pi}{2}} L \cdot \tan \theta \cdot \cos \theta d\theta d\varphi$$

$$= 2\pi \int_0^{\frac{\pi}{2}} L \cdot \cos \theta \cdot \tan \theta d\theta$$

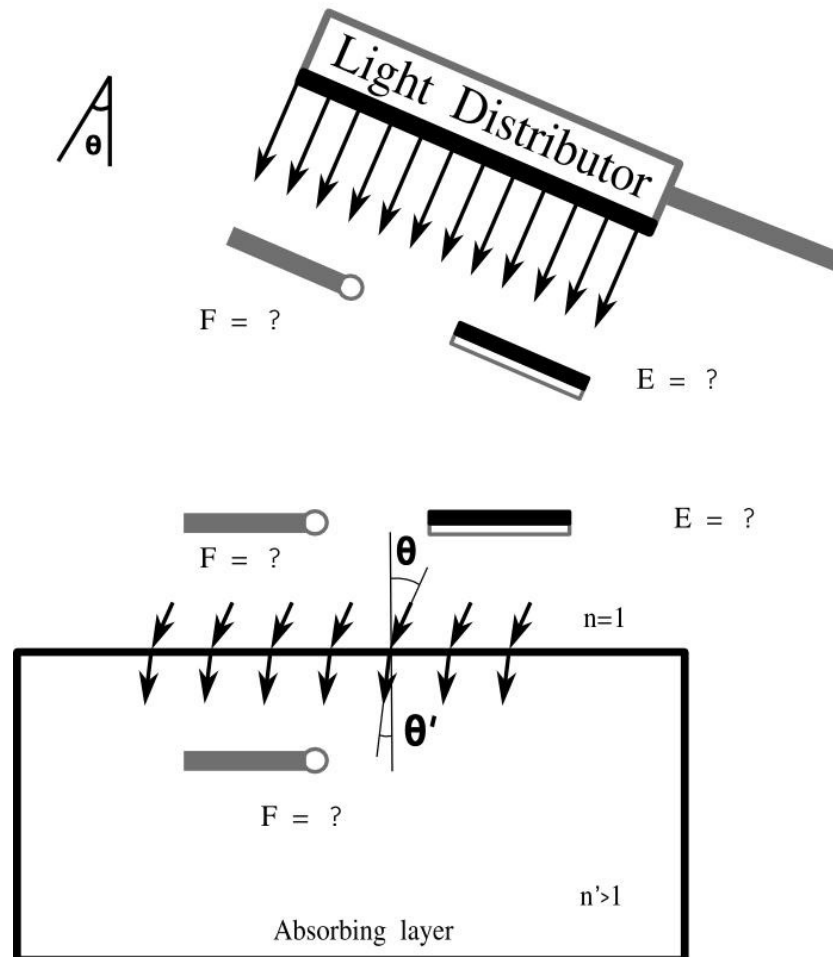
$$\int \cos \theta \cdot \tan \theta d\theta = -\cos \theta$$

$$= 2\pi \cdot L = 2M = 2 \frac{\Phi}{S}$$

Case 5

Laser power [W]: ϕ

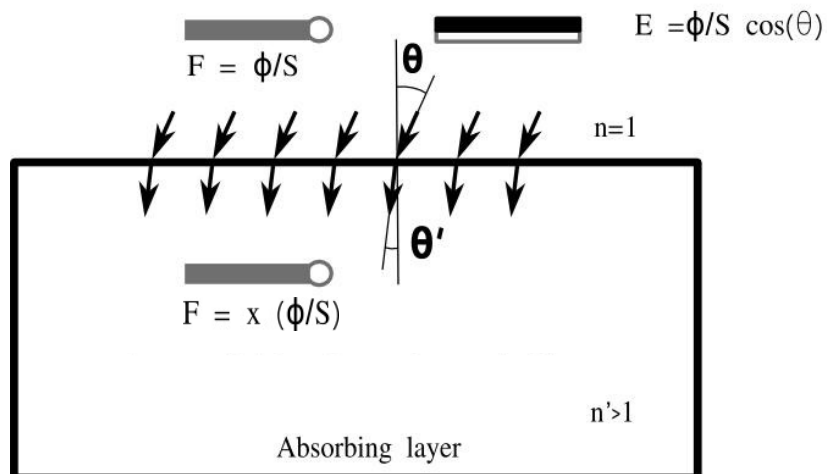
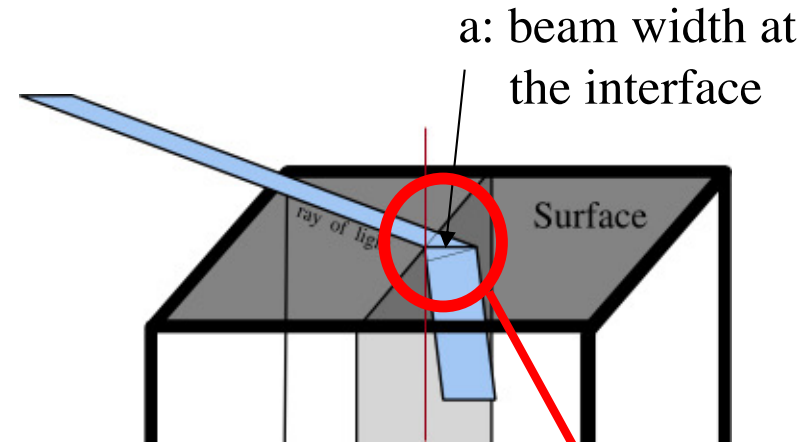
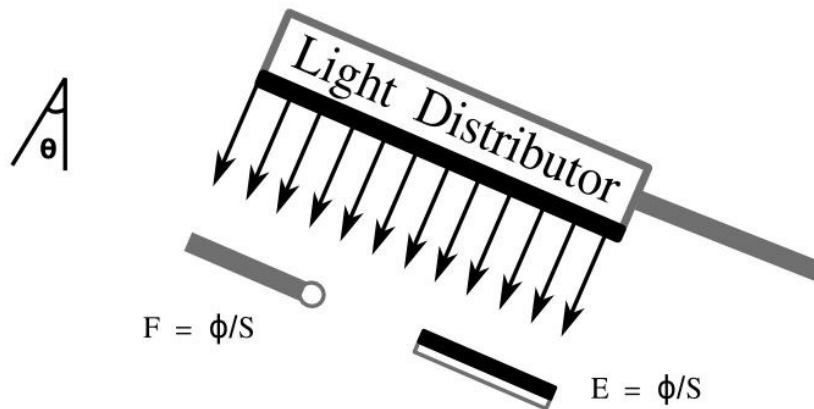
Distributor surface [m²]: S



Case 5 (solution)

Laser power [W]: ϕ

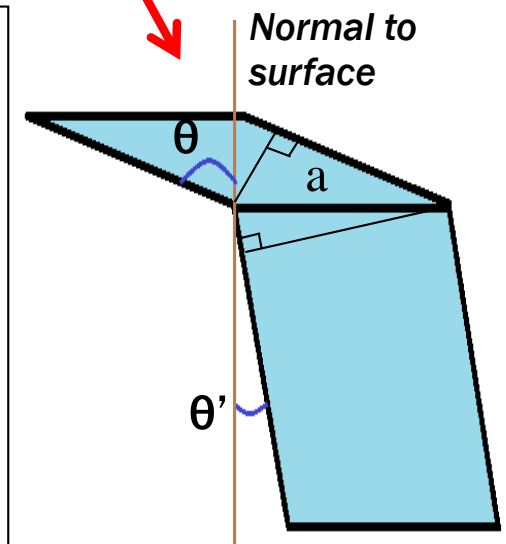
Distributor surface [m²]: S



$$\begin{cases} x = \frac{a \cos(\theta)}{a \cos(\theta')} \\ n \sin(\theta) = n' \sin(\theta') \end{cases}$$

$$F = \frac{\phi}{S} x$$

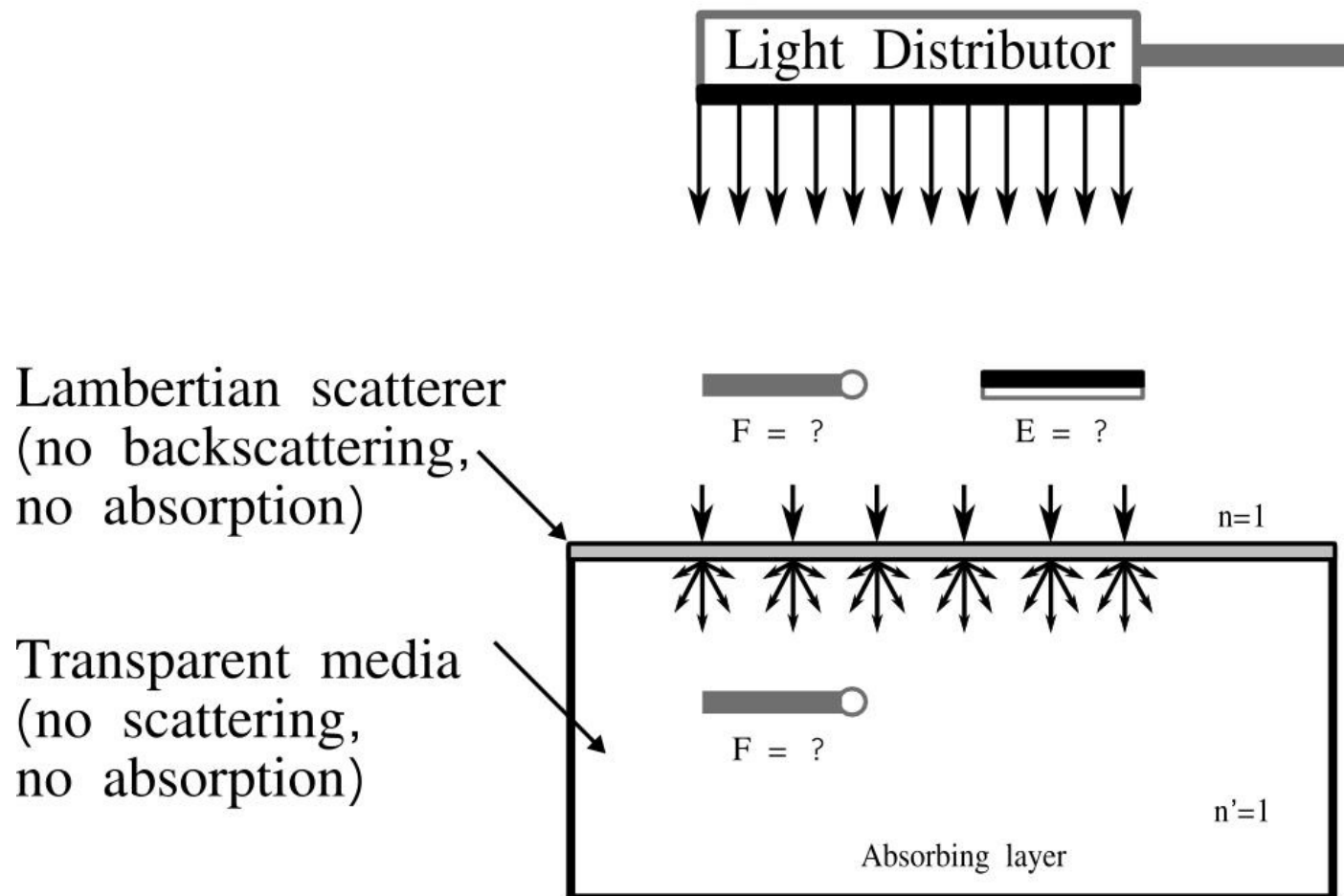
$$x = \frac{\cos(\theta)}{\cos(\arcsin[(\frac{n}{n'}) \sin(\theta)])}$$



Case 6

Laser power [W]: ϕ

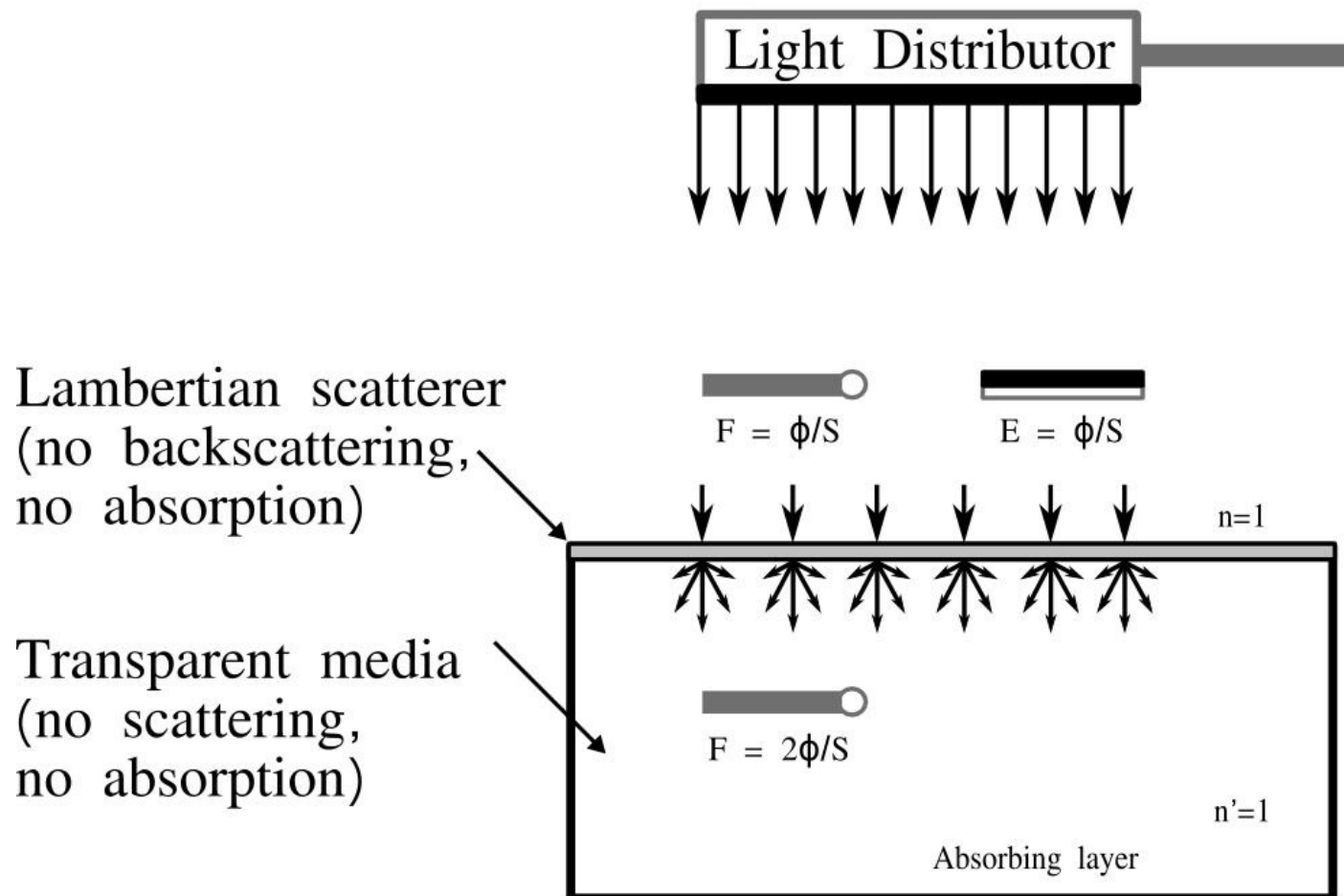
Distributor surface [m²]: S



Case 6 (solution)

Laser power [W]: ϕ

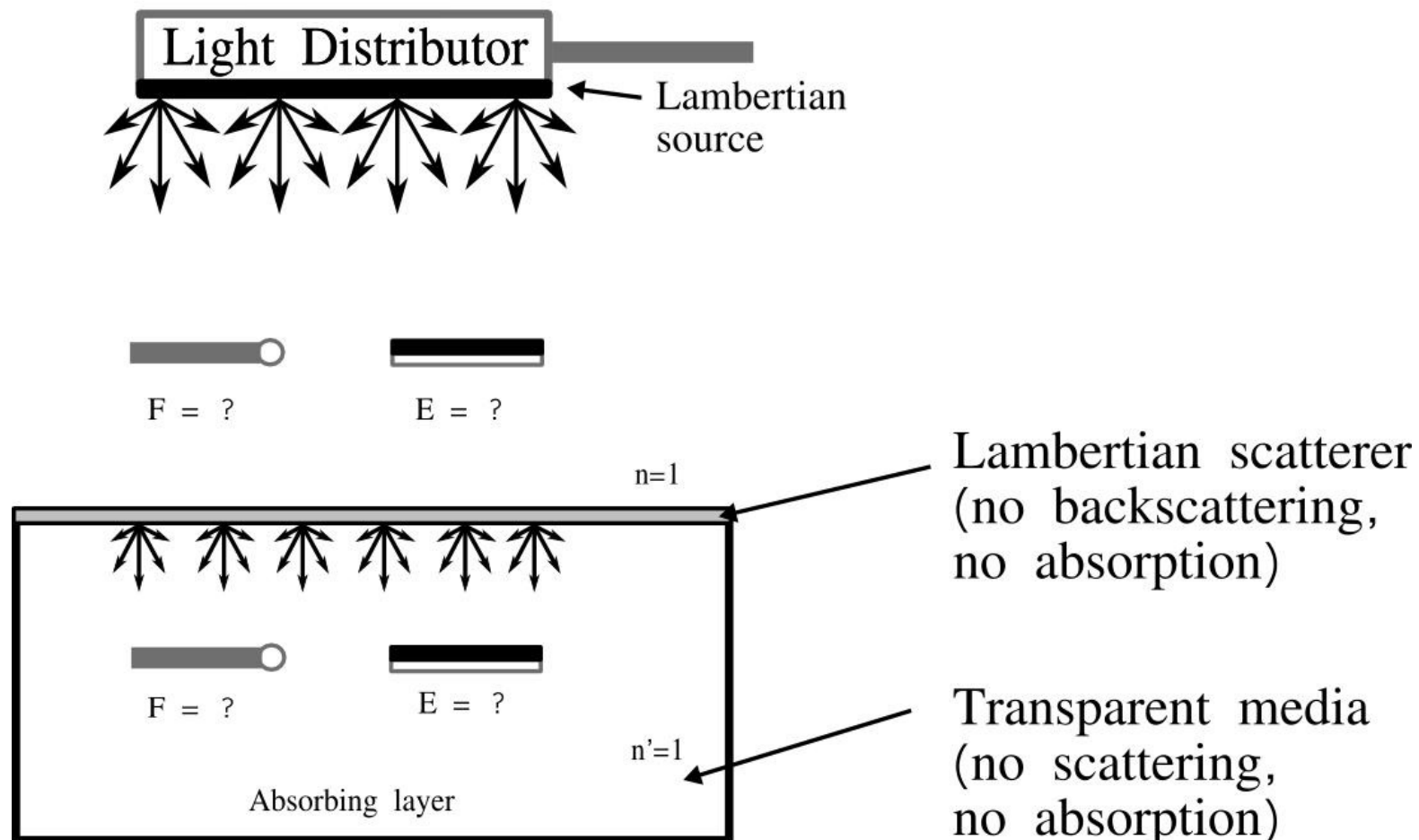
Distributor surface [m²]: S



Case 7

Laser power [W]: ϕ

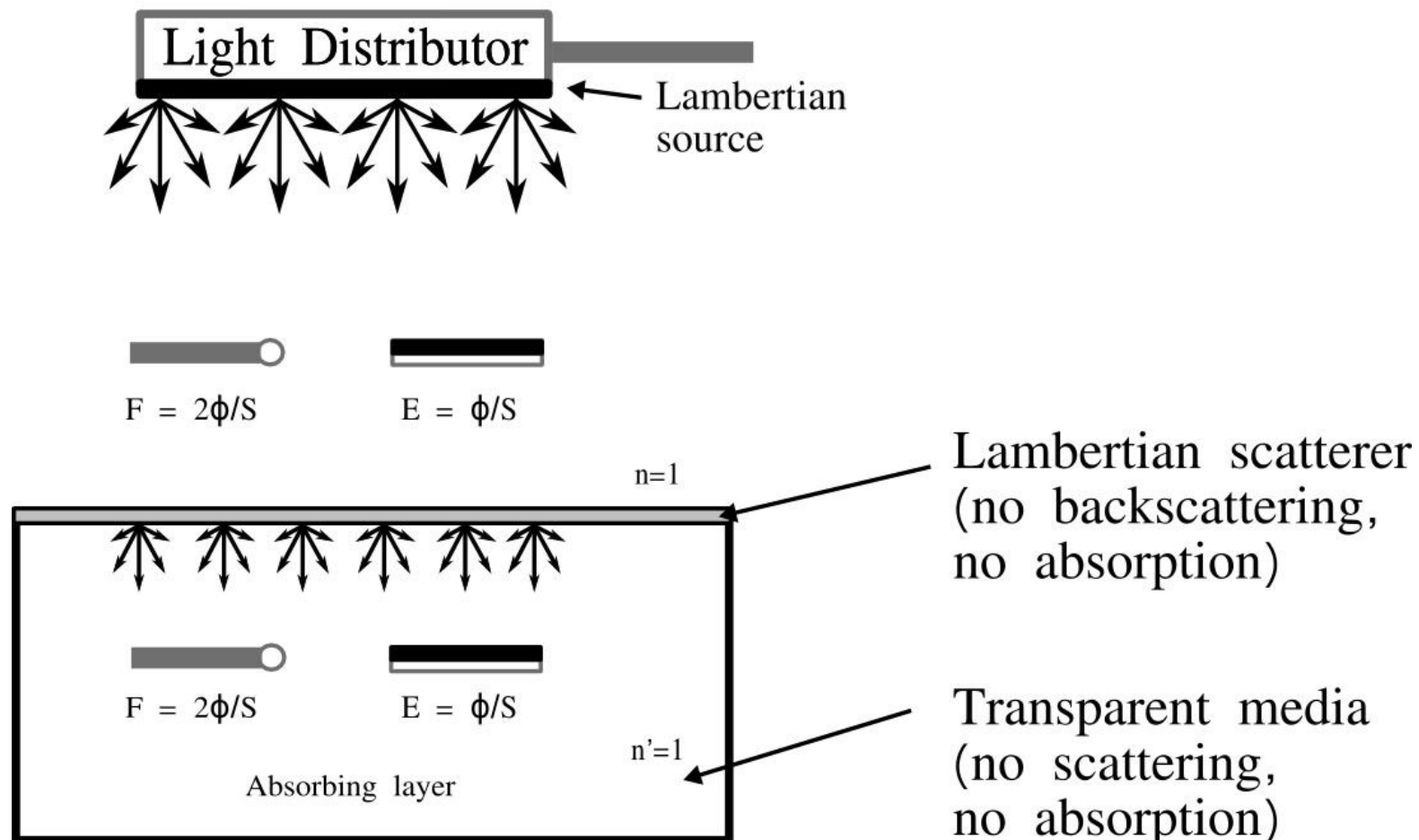
Distributor surface [m²]: S



Case 7 (solution)

Laser power [W]: ϕ

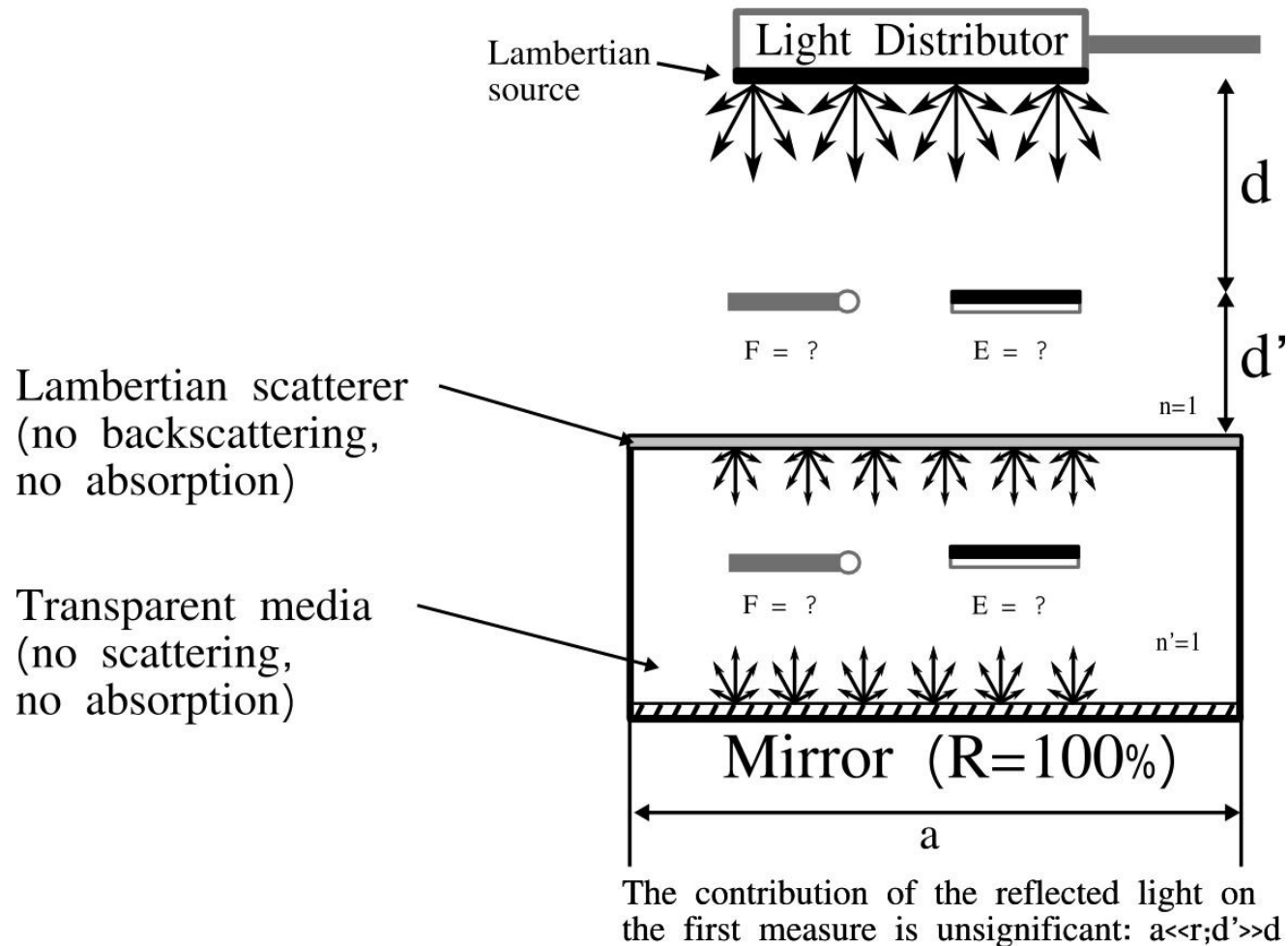
Distributor surface [m²]: S



Case 8

Laser power [W]: ϕ

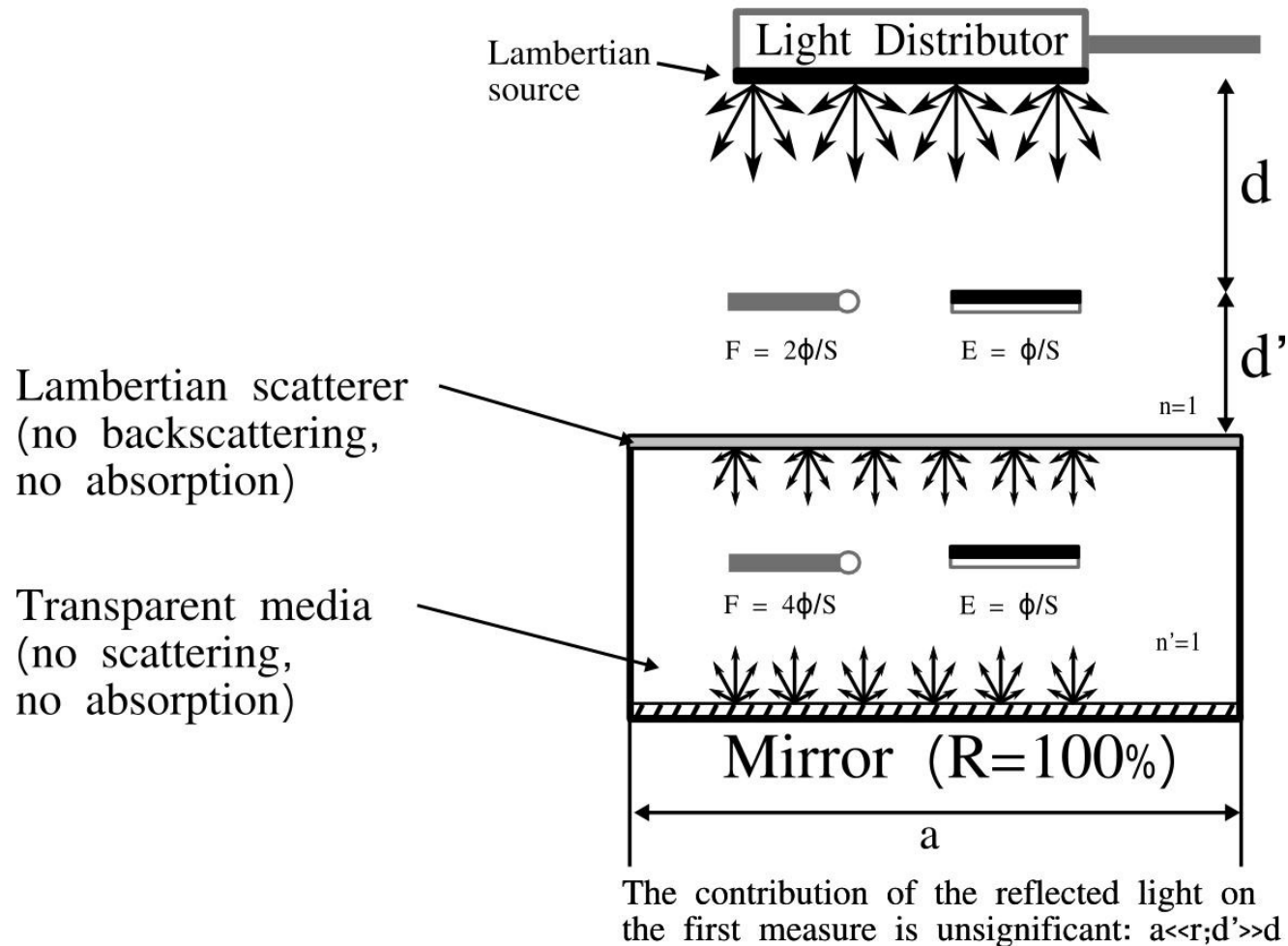
Distributor surface [m²]: S



Case 8 (solution)

Laser power [W]: ϕ

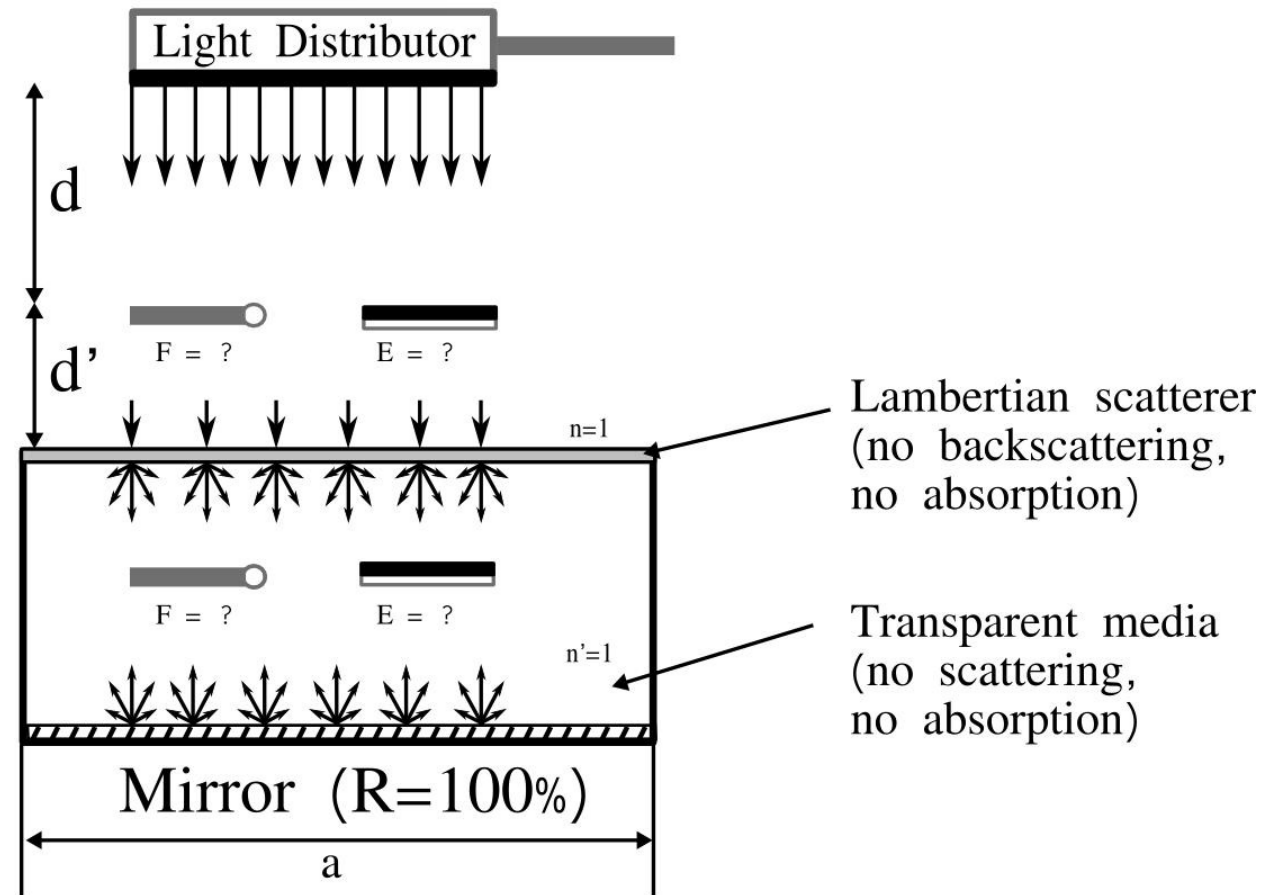
Distributor surface [m²]: S



Case 9

Laser power [W]: ϕ

Distributor surface [m²]: S

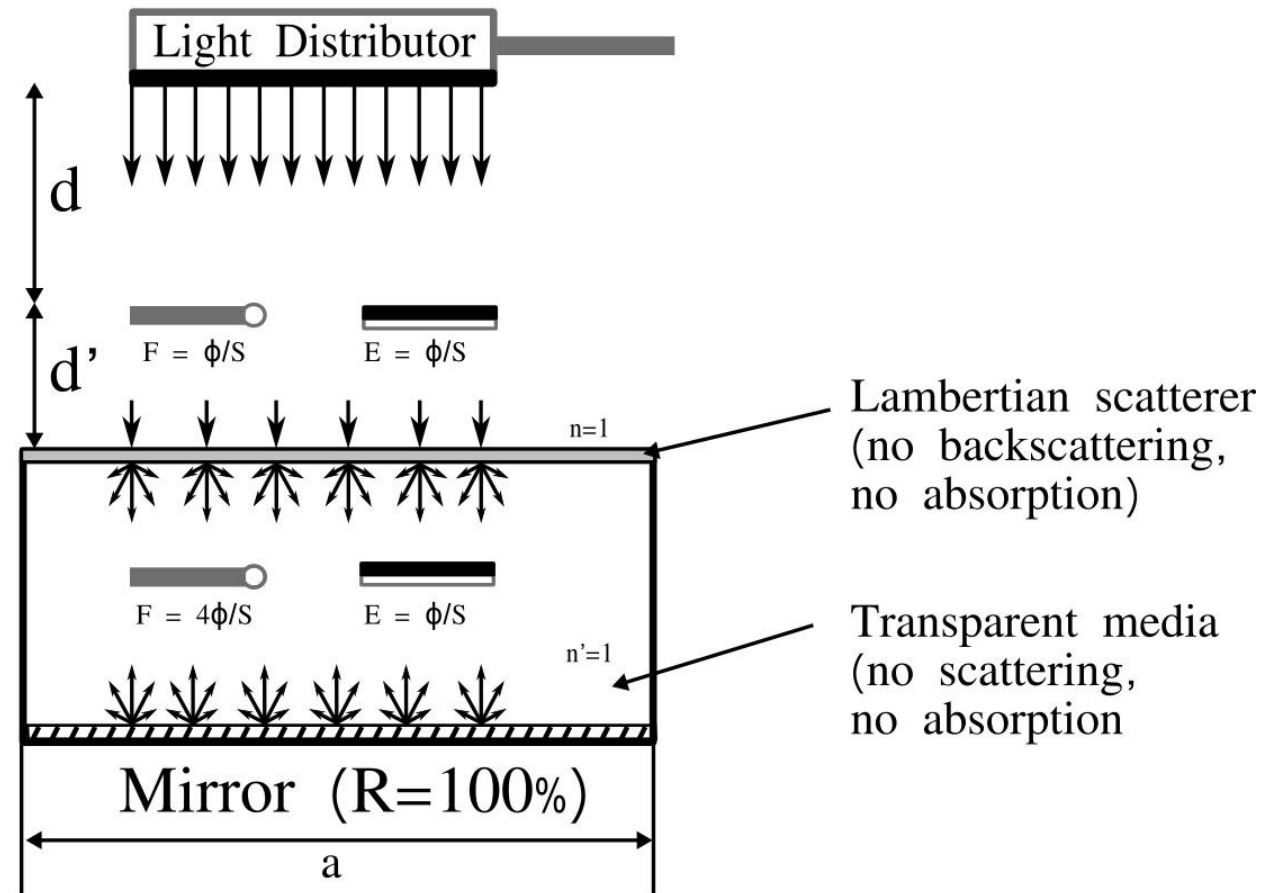


The contribution of the reflected light on the first measure is insignificant: $a \ll r; d' \gg d$

Case 9 (solution)

Laser power [W]: ϕ

Distributor surface [m²]: S



The contribution of the reflected light on the first measure is insignificant: $a \ll r; d' \gg d$