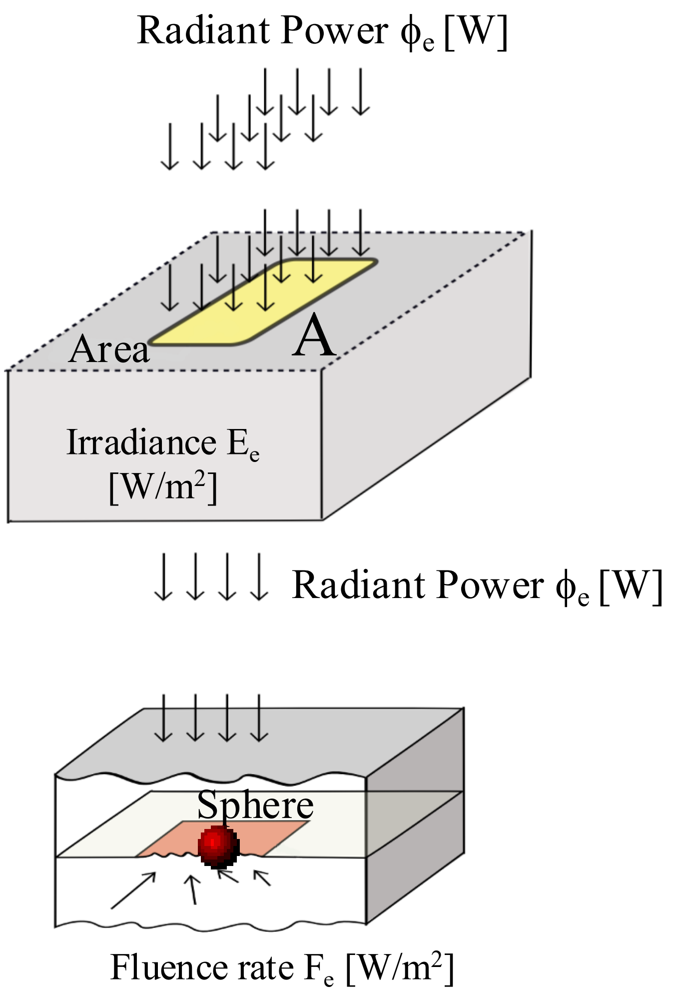
Exercise 2
(In class)

Difference between
Fluence rate and Irradiance !

Radiometry (Definitions)

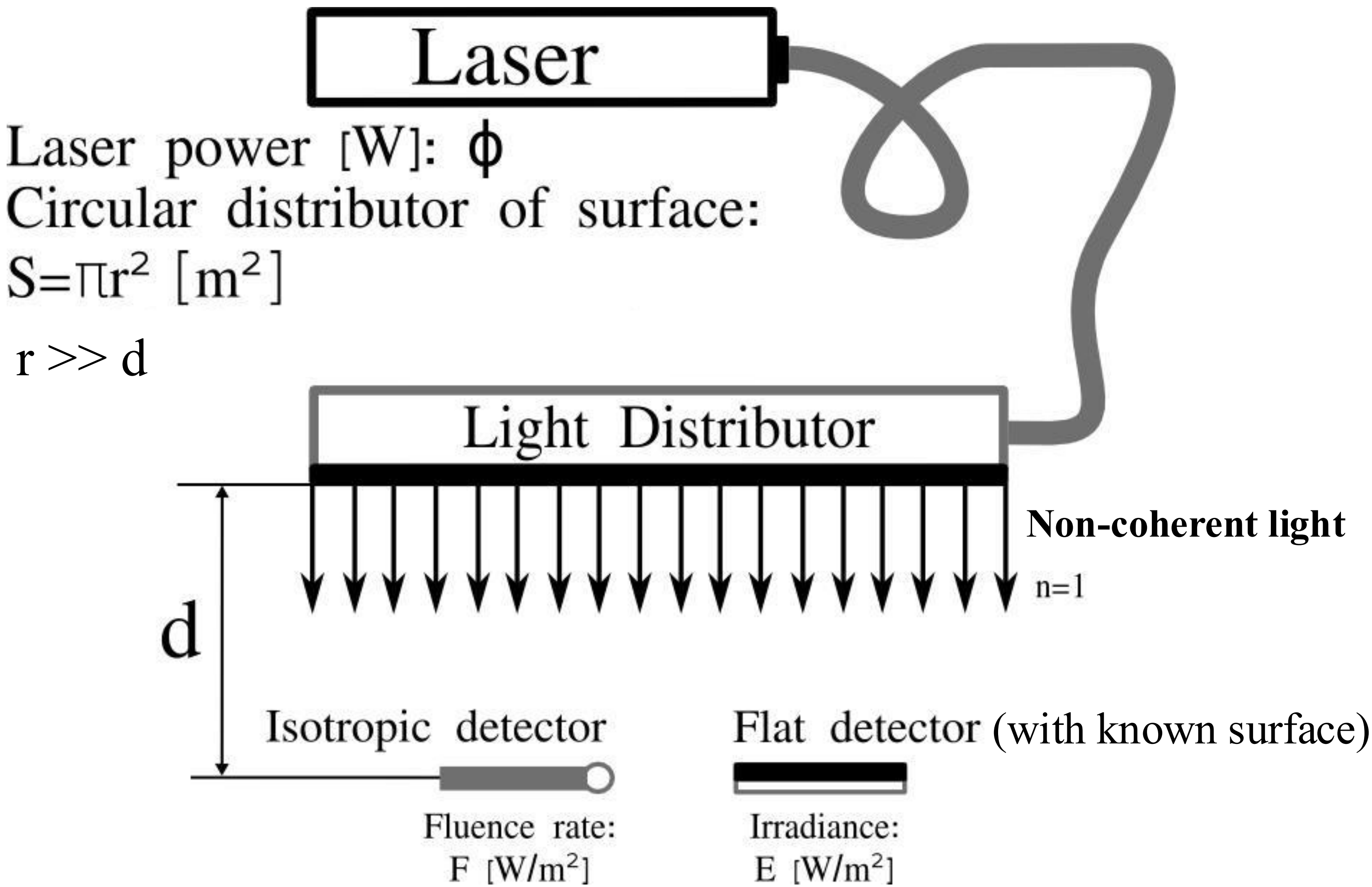
Irradiance vs. Fluence rate

- 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

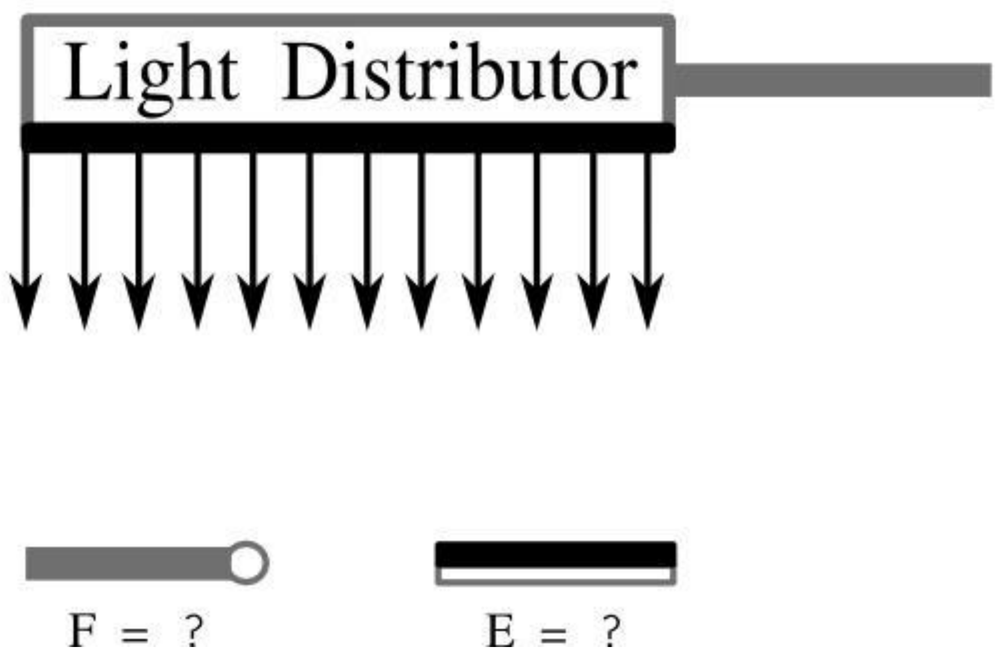
Fluence rate and Irradiance



Case 1

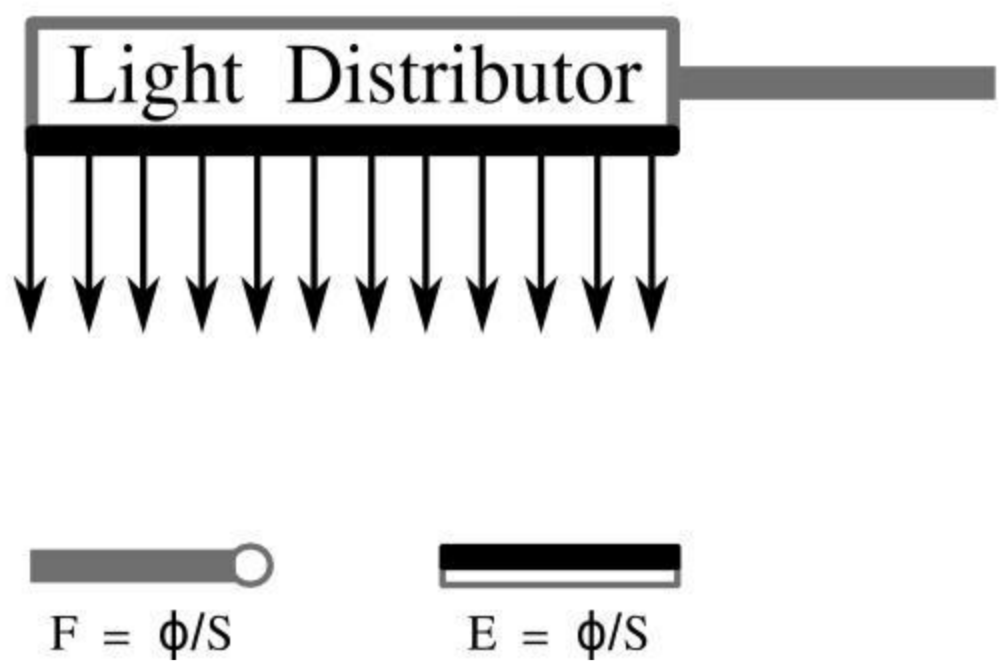
Laser power [W]: ϕ

Distributor surface [m^2]: S



Case 1 (solution)

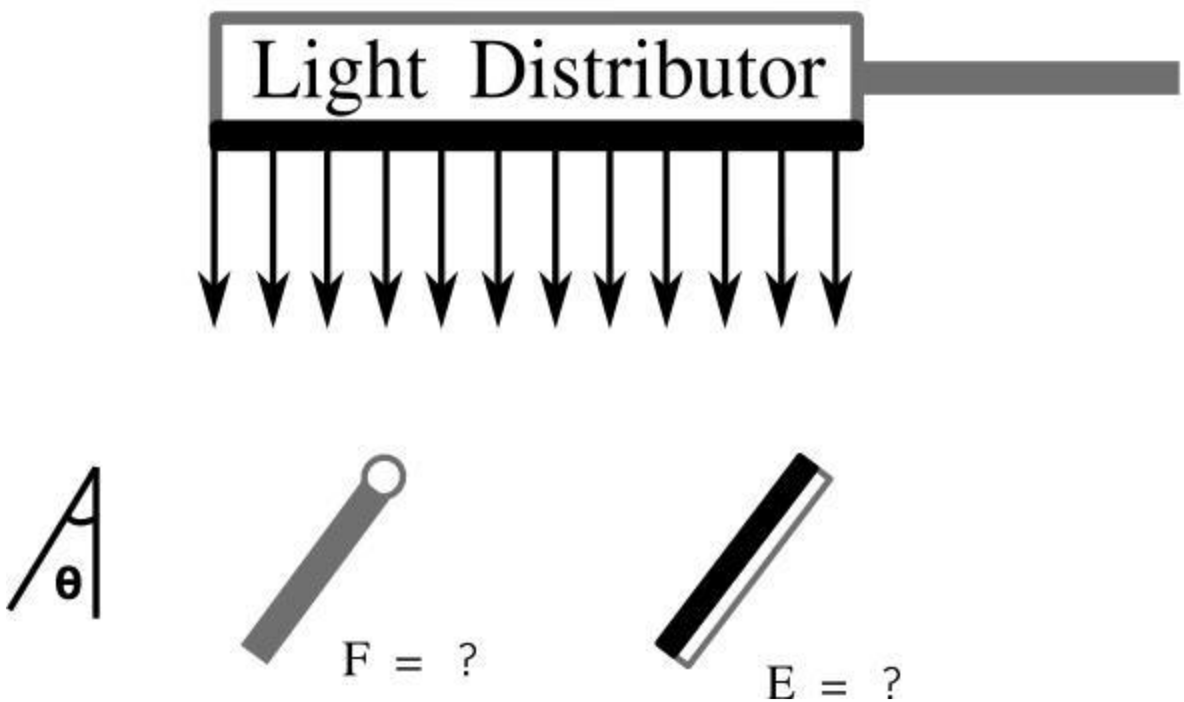
Laser power [W]: ϕ
Distributor surface [m^2]: S



Case 2

Laser power [W]: ϕ

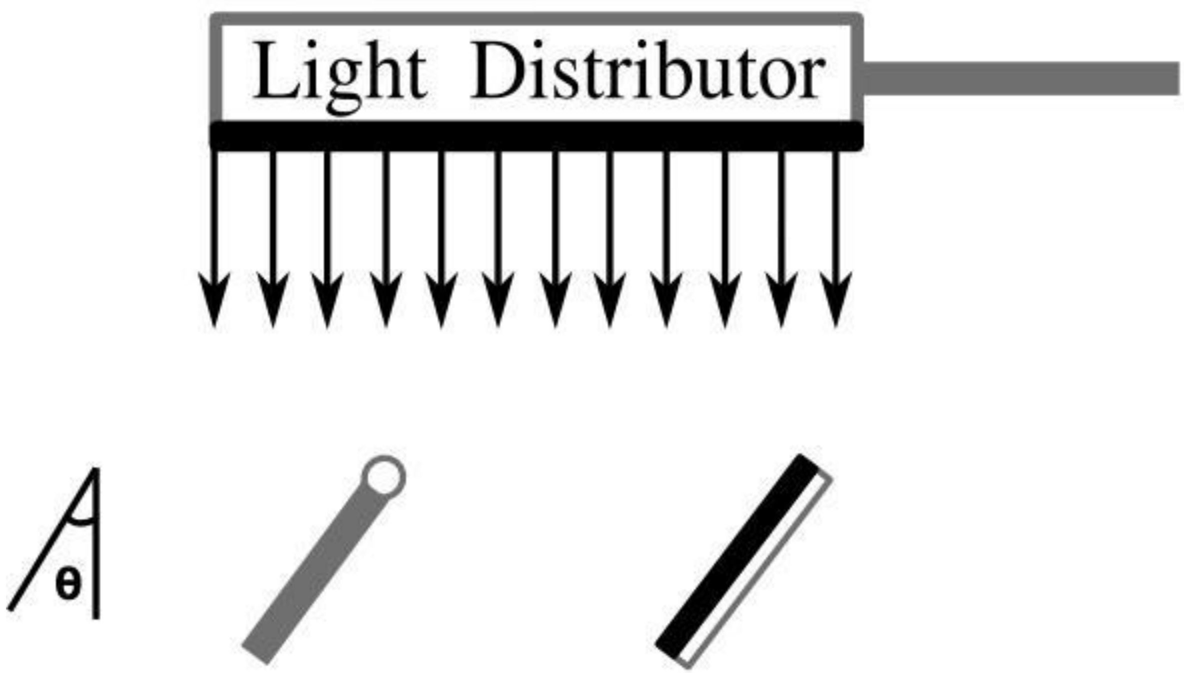
Distributor surface [m^2]: S



Case 2 (solution)

Laser power [W]: ϕ

Distributor surface [m^2]: S

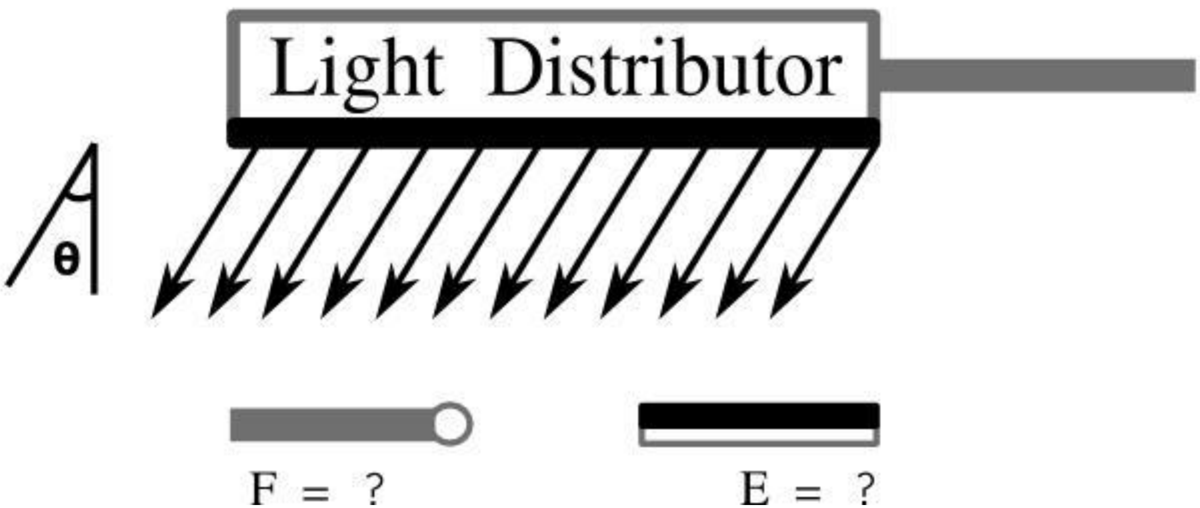


$F = \phi/S$ $E = (\phi/S)\sin\theta$

Case 3

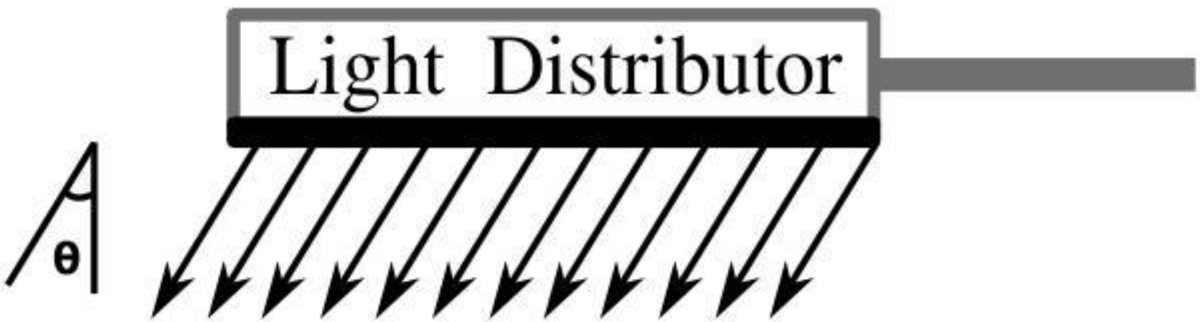
Laser power [W]: ϕ

Distributor surface [m^2]: S



Case 3 (solution)

Laser power [W]: ϕ
Distributor surface [m^2]: S

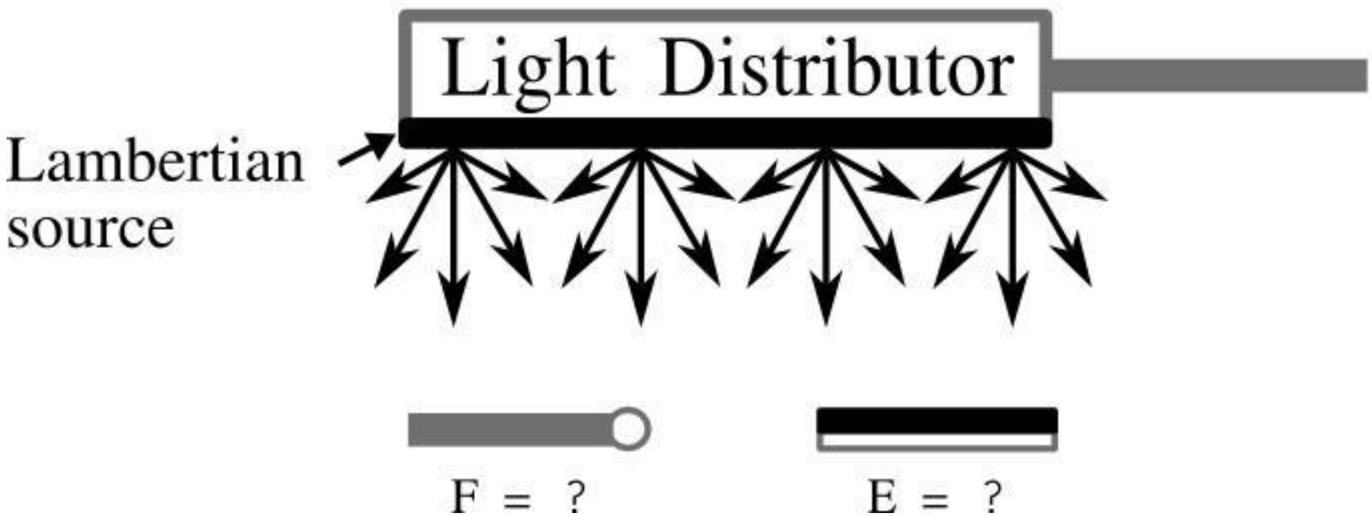


$$F = \frac{\phi/S}{\cos\theta} \qquad E = \phi/S$$

Case 4

Laser power [W]: ϕ

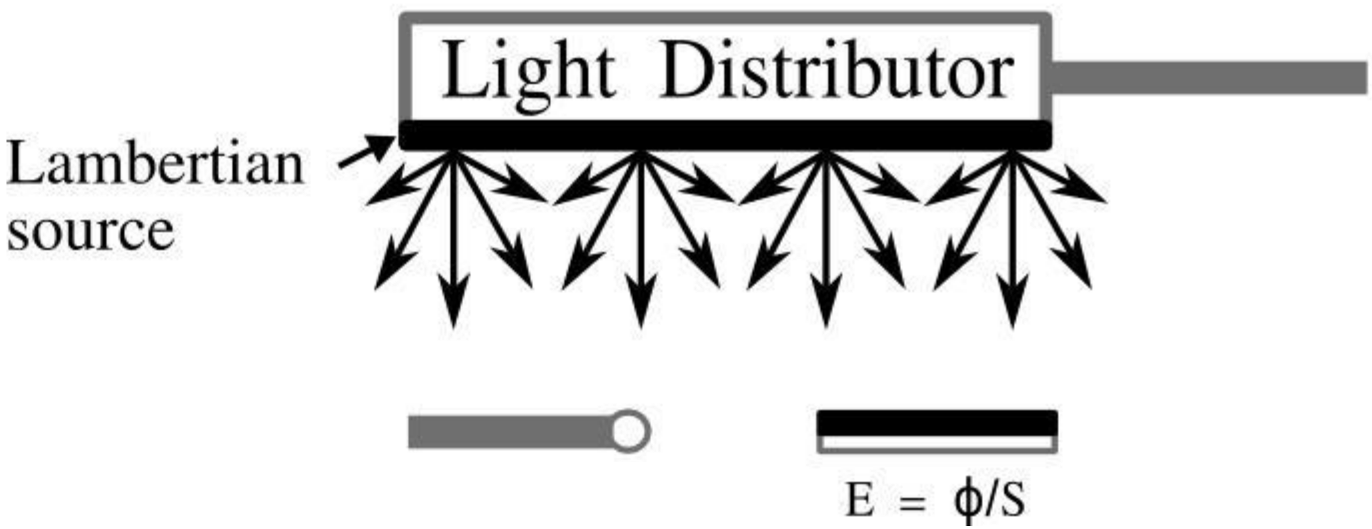
Distributor surface [m^2]: S



Case 4 (solution)

Laser power [W]: ϕ

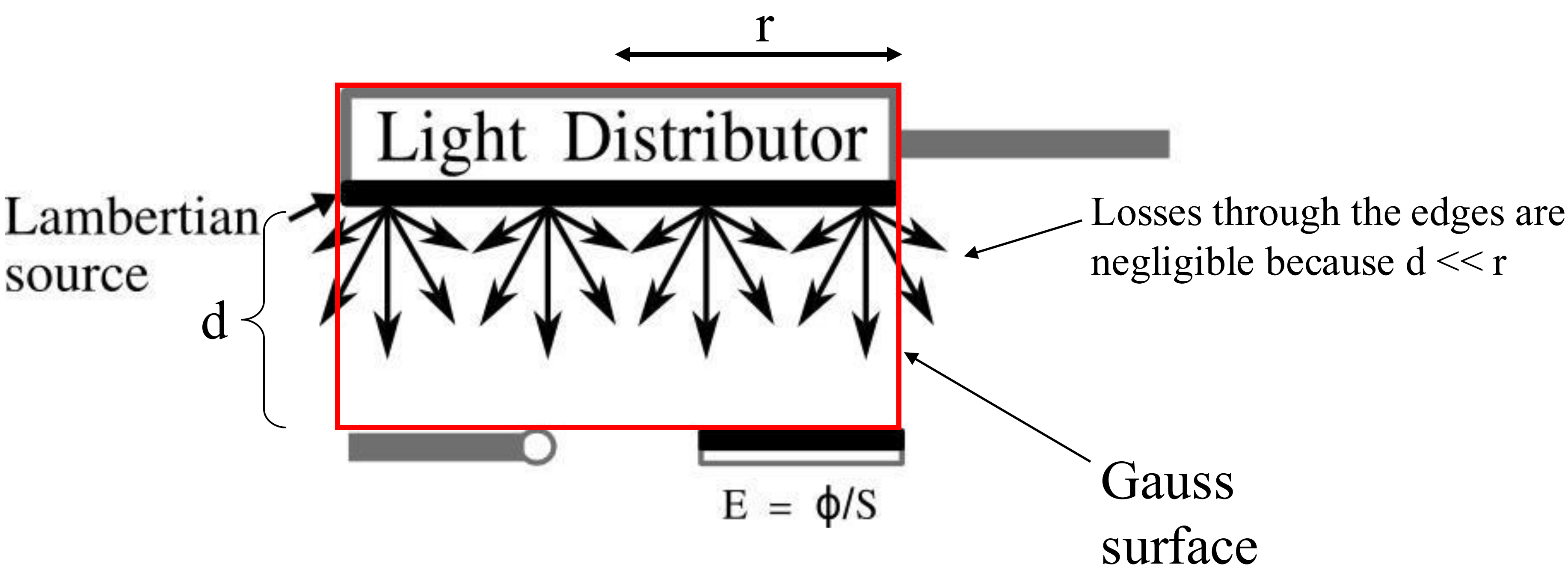
Distributor surface [m^2]: S



Case 4 (solution)

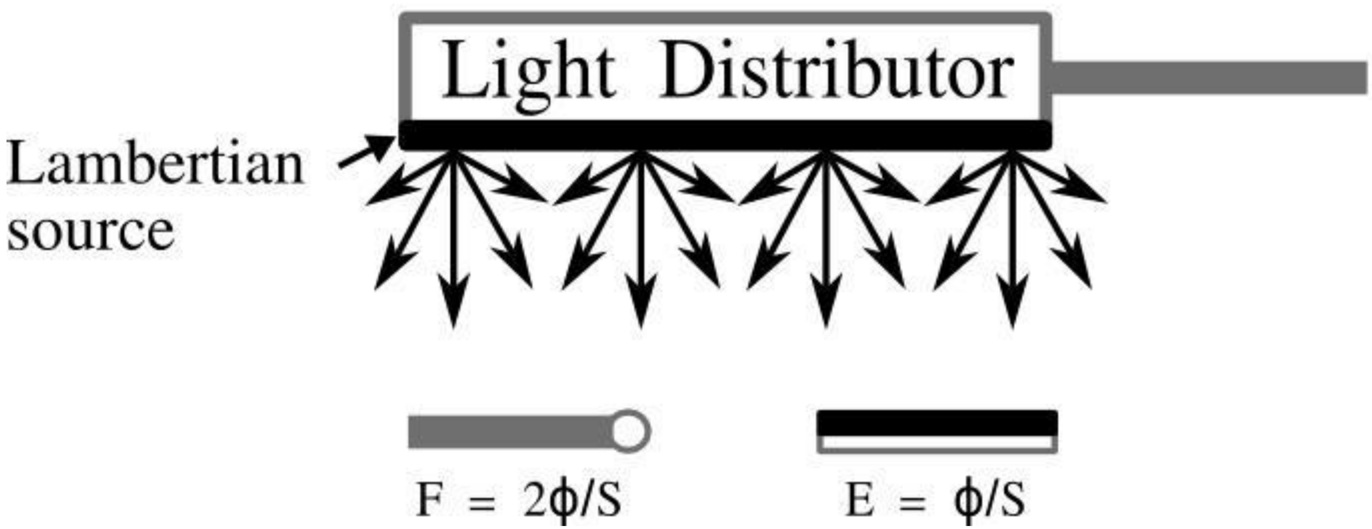
Laser power [W]: ϕ

Distributor surface [m^2]: S



Case 4 (solution)

Laser power [W]: ϕ
Distributor surface [m^2]: S

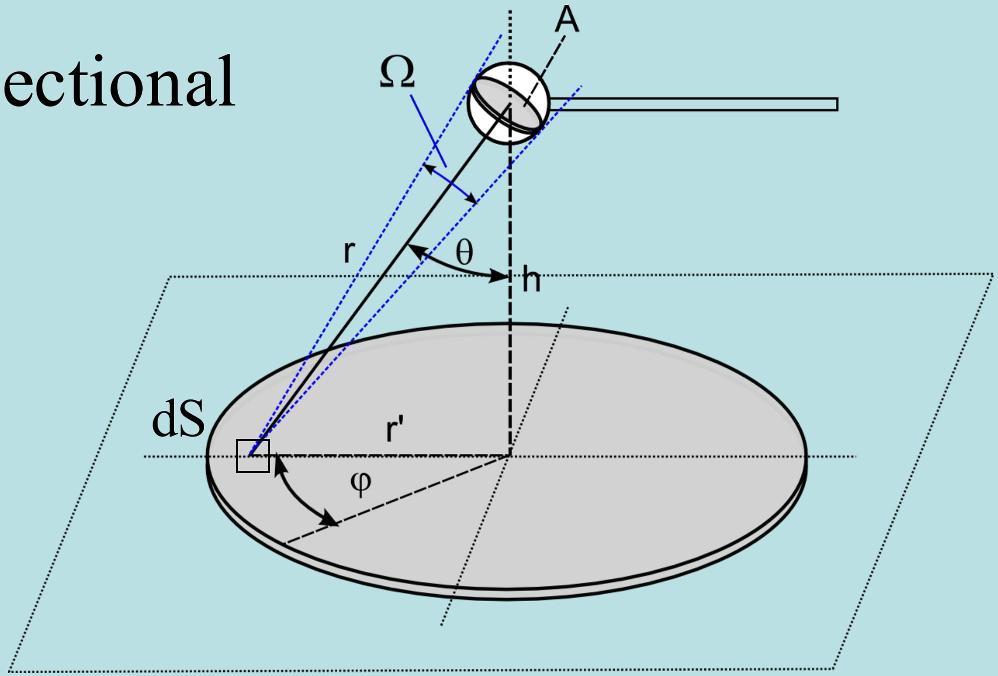


Case 4

Fluence Rate (definition)

Definition:

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



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

with

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

Case 4

S = source surface

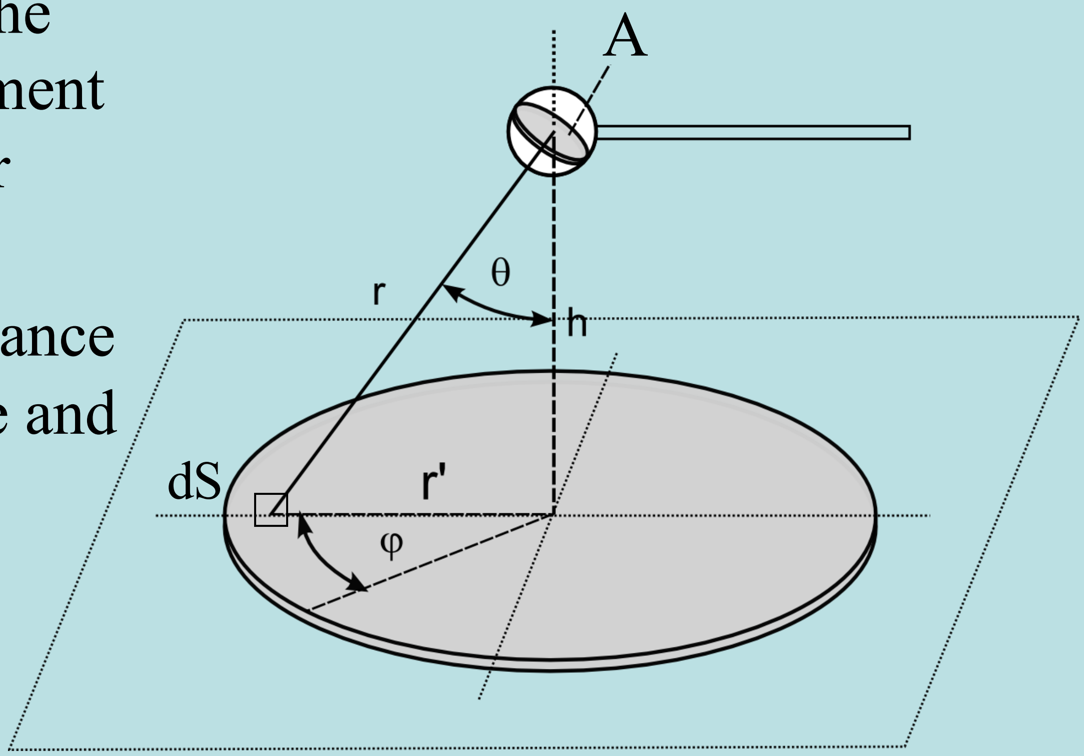
A = detector surface (i.e. the cross section of the isotropic probe)

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

h = the orthogonal distance between the source and the detector

$r = h/\cos\theta$

$r' = h\tan\theta$



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

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

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

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

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

Definition of the solid angle

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

From the set-up geometry

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

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

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

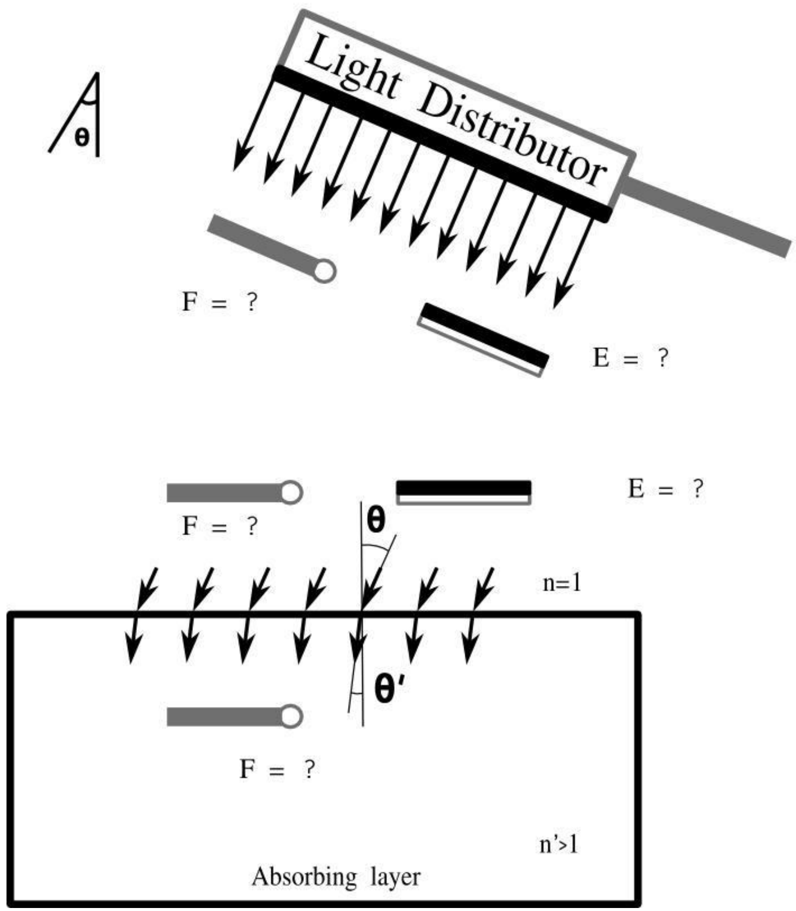
$$dS = h \square \tan\theta \square \frac{h}{\cos^2\theta} d\theta\, d\varphi$$

$$\square \cos\theta \square \tan\theta\, d\theta = -\cos\theta$$

Case 5

Laser power [W]: ϕ

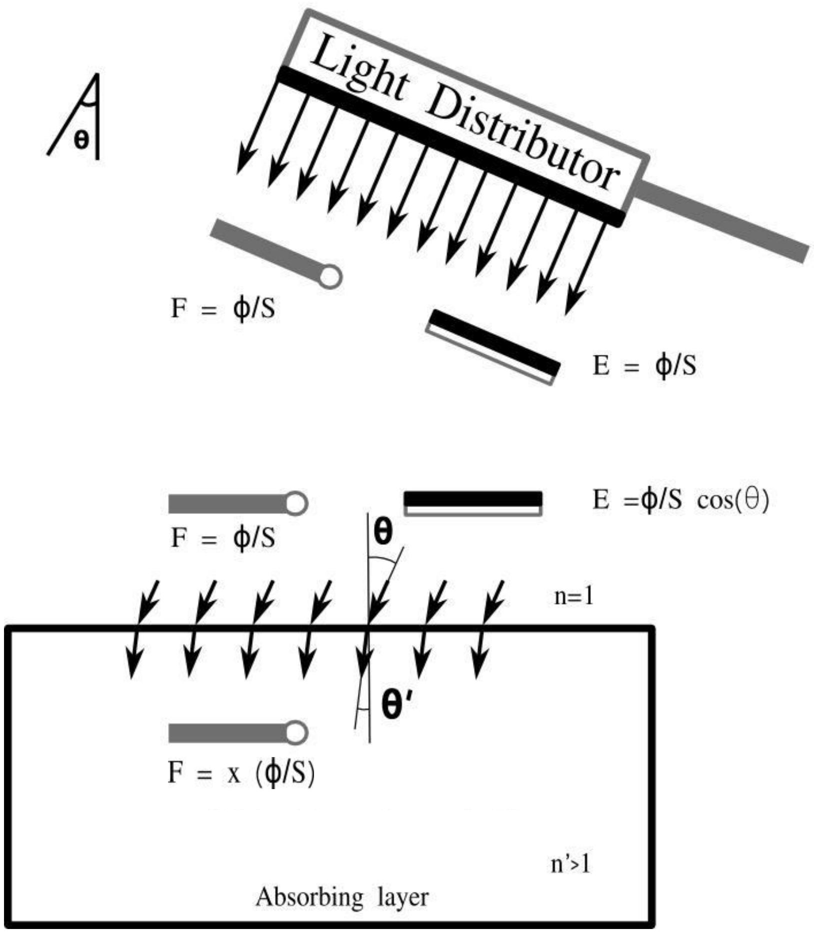
Distributor surface [m^2]: S

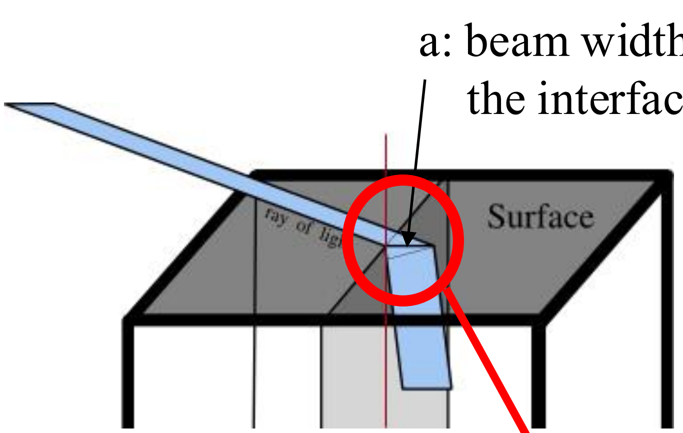


Case 5 (solution)

Laser power [W]: ϕ

Distributor surface [m²]: S

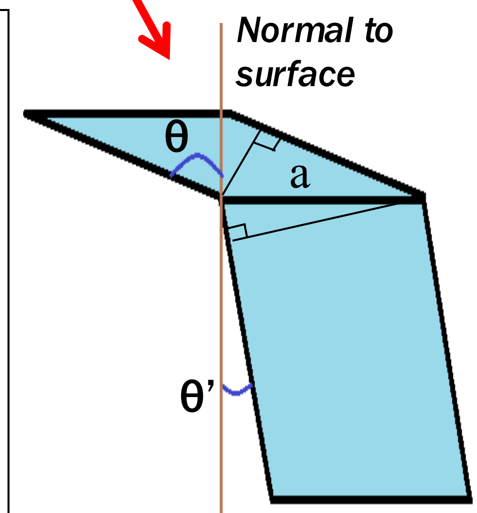




$$\begin{cases} x = \dfrac{a\cos(\theta)}{a\cos(\theta')} \\ n\sin(\theta) = n'\sin(\theta') \end{cases}$$

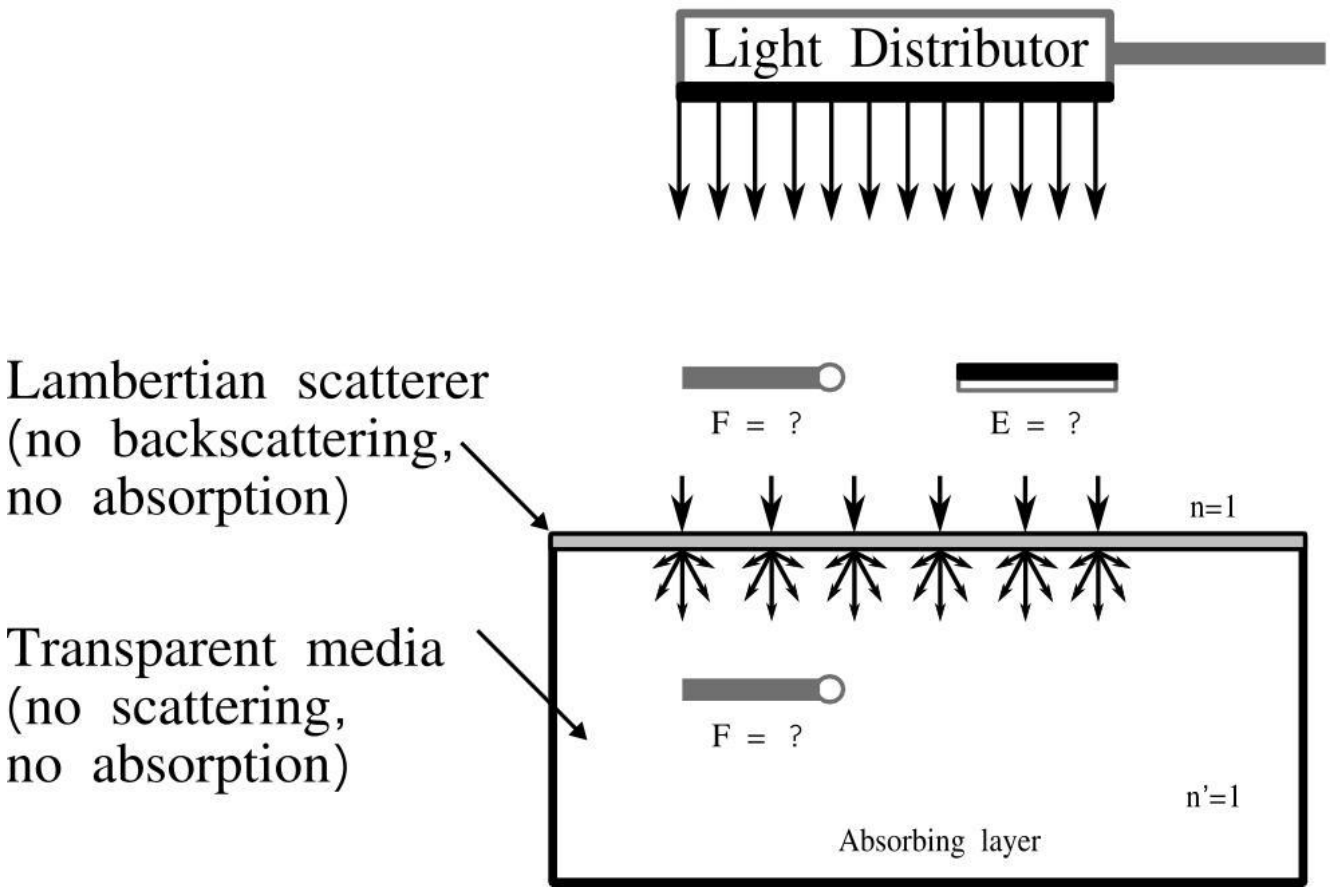
$$F = \frac{\phi}{S}x$$

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



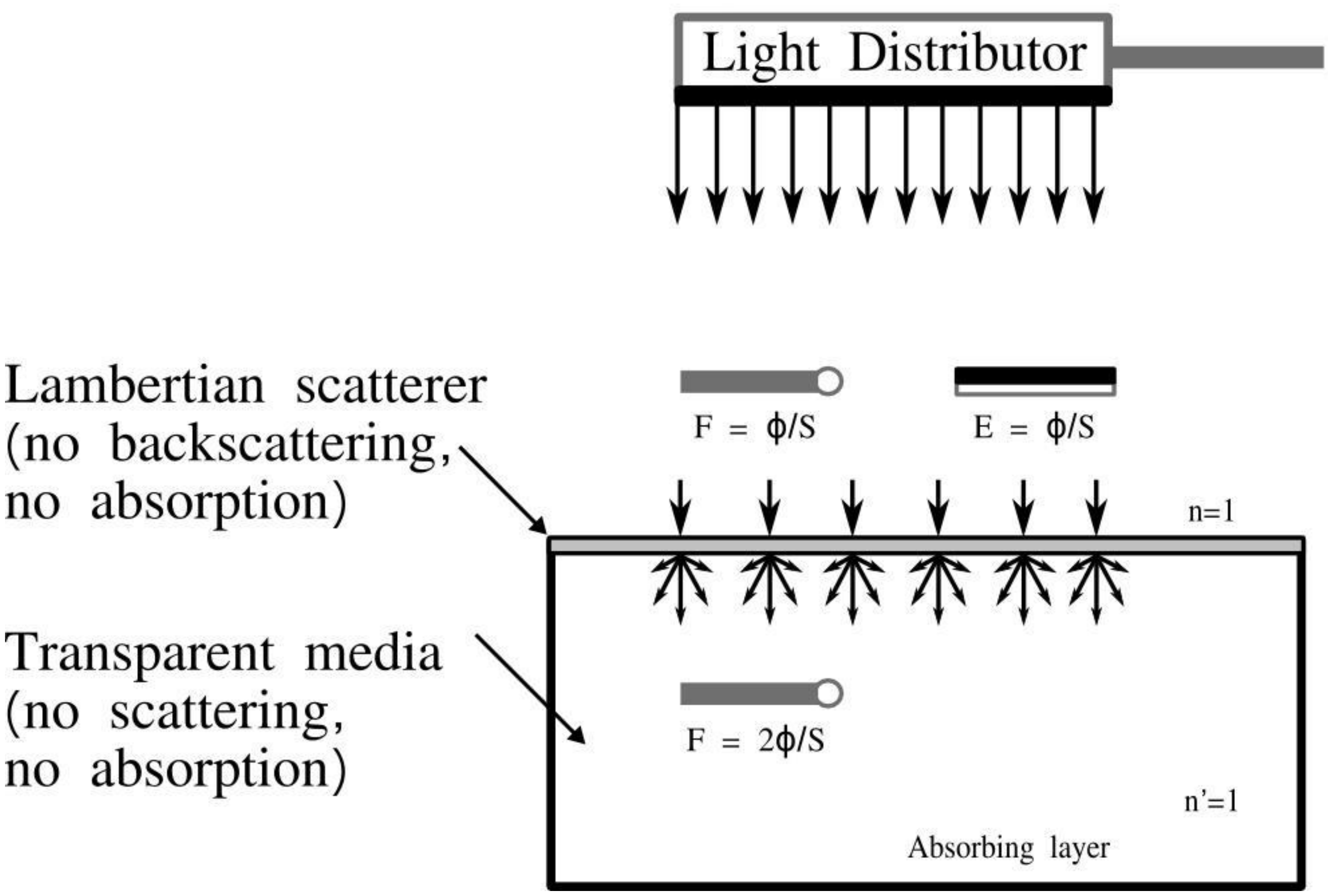
Case 6

Laser power [W]: ϕ
Distributor surface [m^2]: S



Case 6 (solution)

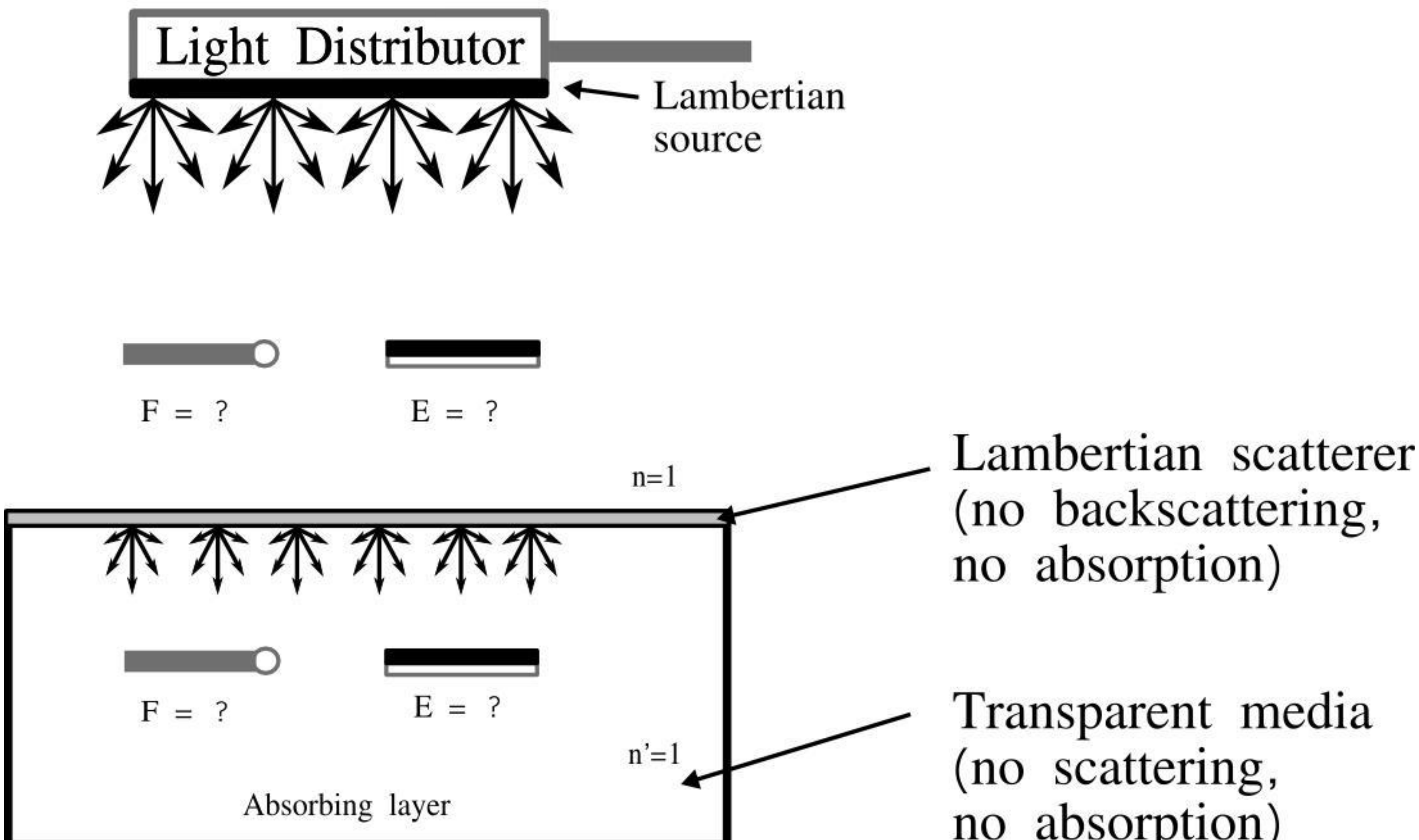
Laser power [W]: ϕ
Distributor surface [m^2]: S



Case 7

Laser power [W]: ϕ

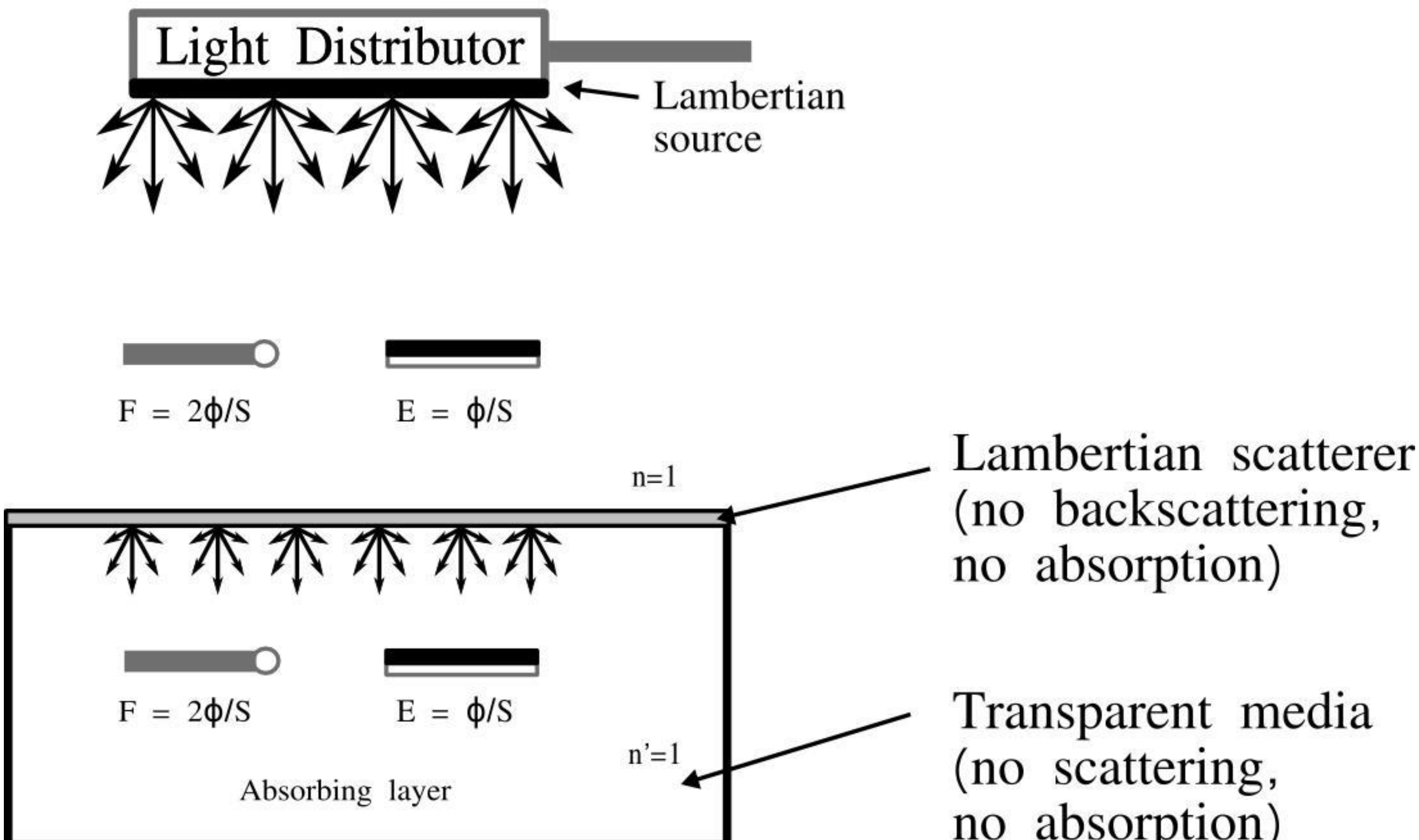
Distributor surface [m^2]: S



Case 7 (solution)

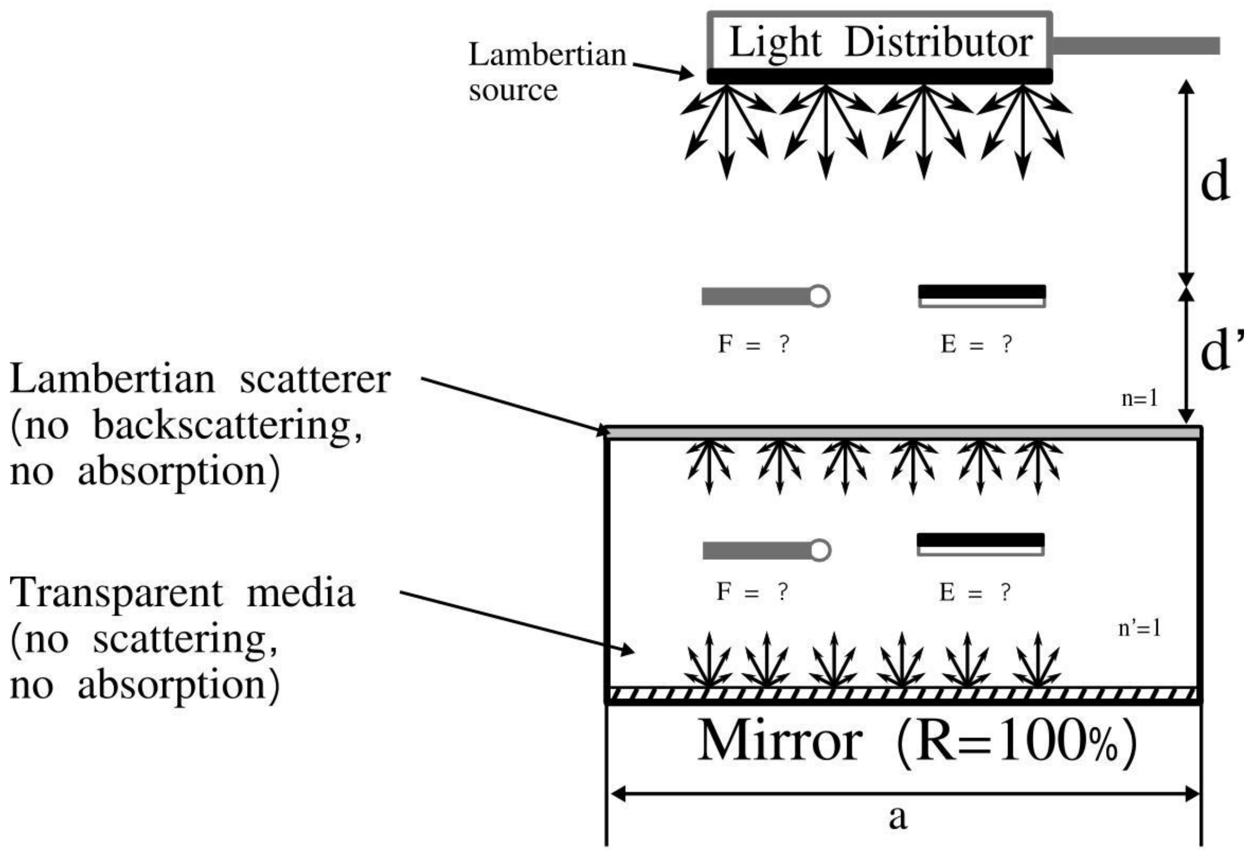
Laser power [W]: ϕ

Distributor surface [m^2]: S



Case 8

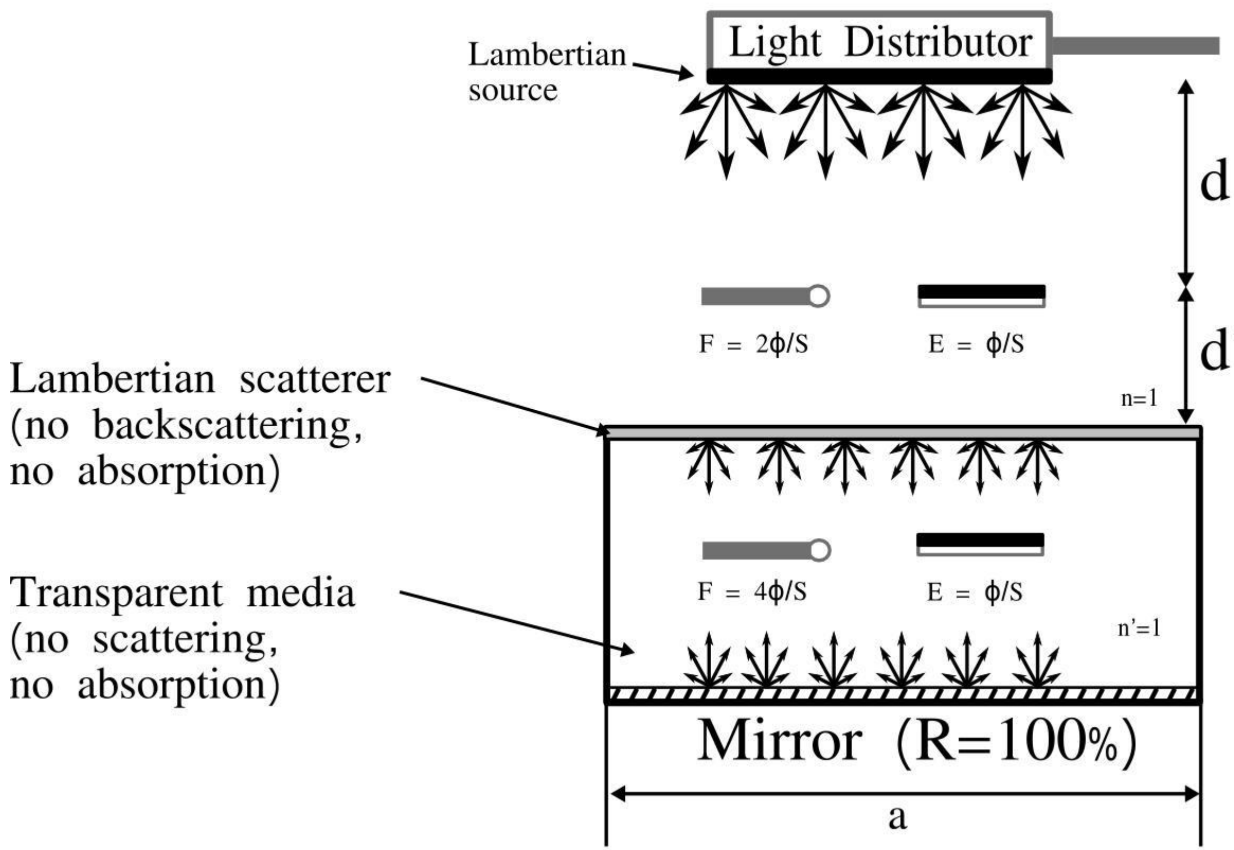
Laser power [W]: ϕ
Distributor surface [m^2]: S



The contribution of the reflected light on the first measure is unsignificant: a<<r;d'>>d

Case 8 (solution)

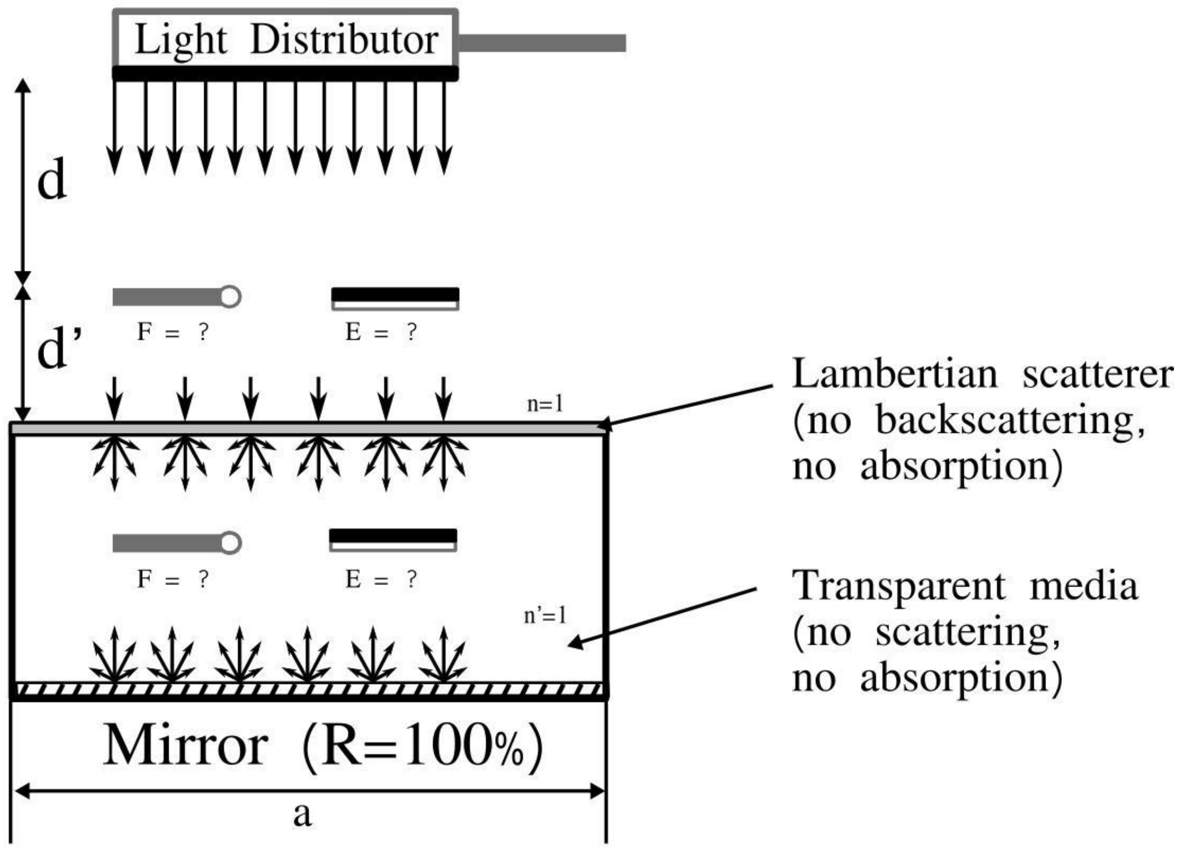
Laser power [W]: ϕ
Distributor surface [m^2]: S



The contribution of the reflected light on the first measure is unsignificant: a<<r;d'>>d

Case 9

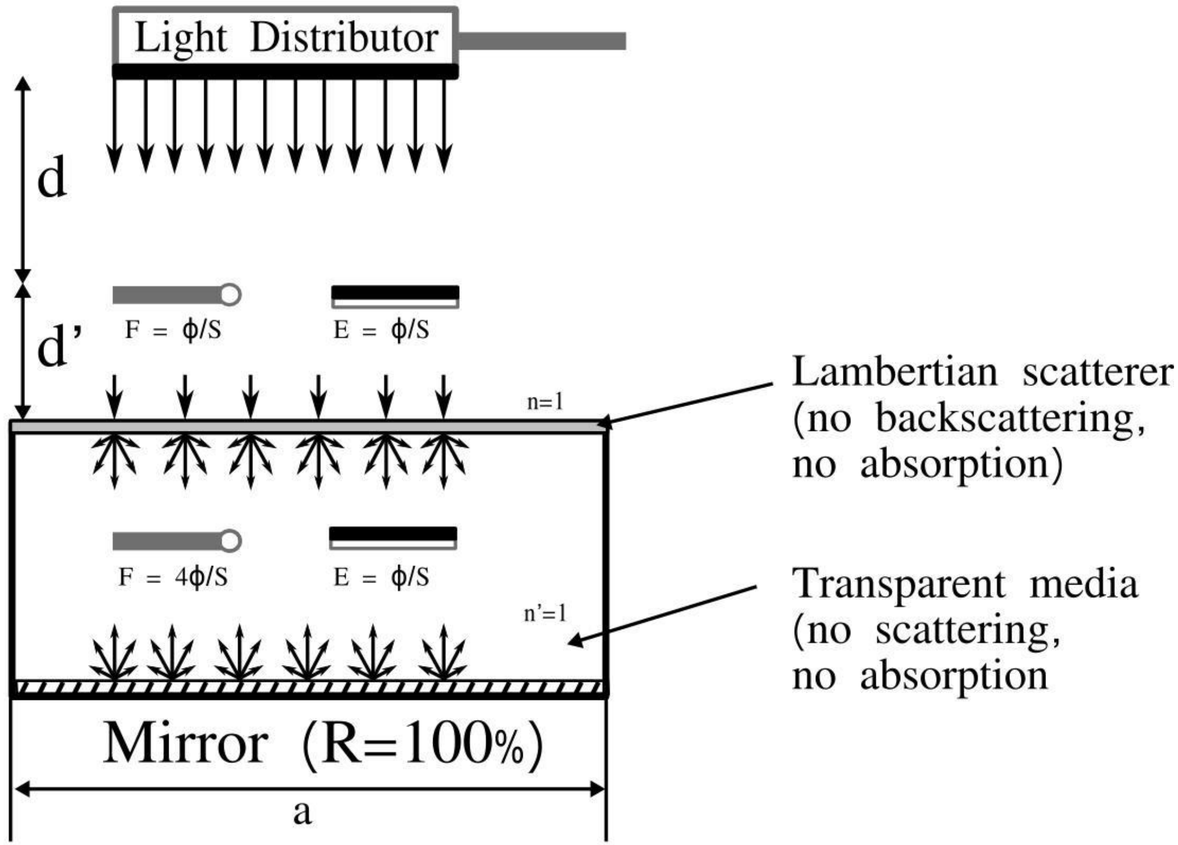
Laser power [W]: ϕ
Distributor surface [m^2]: S



The contribution of the reflected light on the first measure is unsignificant: a<<r;d'>>d

Case 9 (solution)

Laser power [W]: ϕ
Distributor surface [m^2]: S



The contribution of the reflected light on the first measure is unsignificant: a<<r;d'>>d