Practical geometric optics

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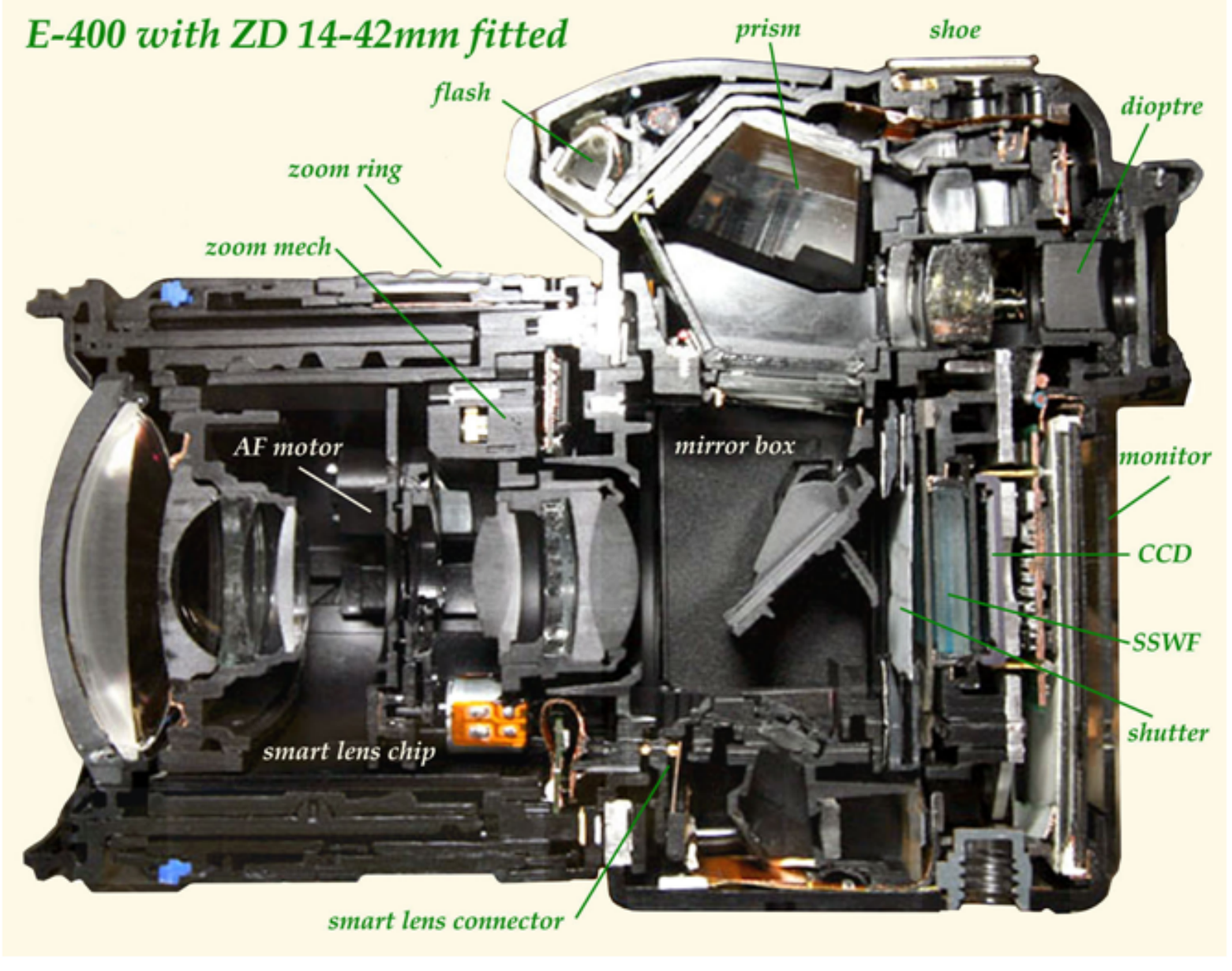
Outline of the talk:

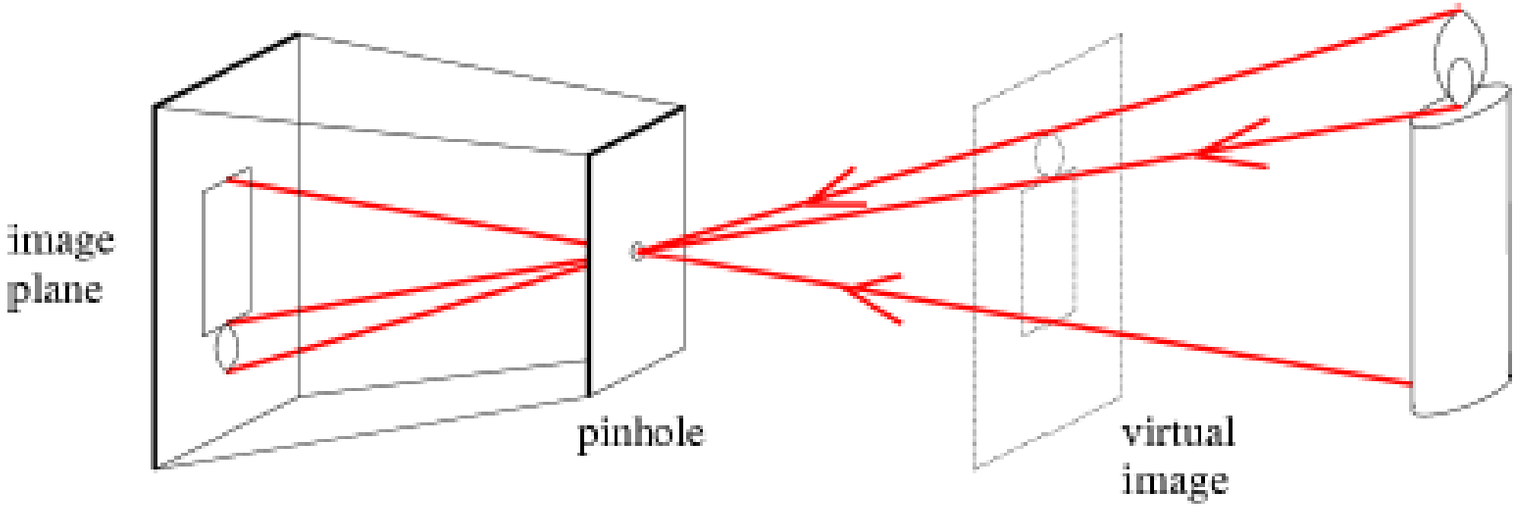
- Motivation, camera lens.
- Why lenses?
- Geometrical optics.
- Depth of field.

An SLR


E-400 with ZD 14-42mm fitted
prism
shoe
flash
dioptre
zoom ring
zoom mech
AF motor
mirror box
monitor
CCD
SSWF
shutter
smart lens chip
smart lens connector

A pinhole

- 15th centuty, Florence architect Filippo Brunelleschi (1377-1446) uses pinhole as a tool for perspective drawing
- 16th century, spreads in use, camera obscura (lat.)
- 1822 Frenchman J.-N. Niepce adds a photographic plate $\Rightarrow$ first photograph.



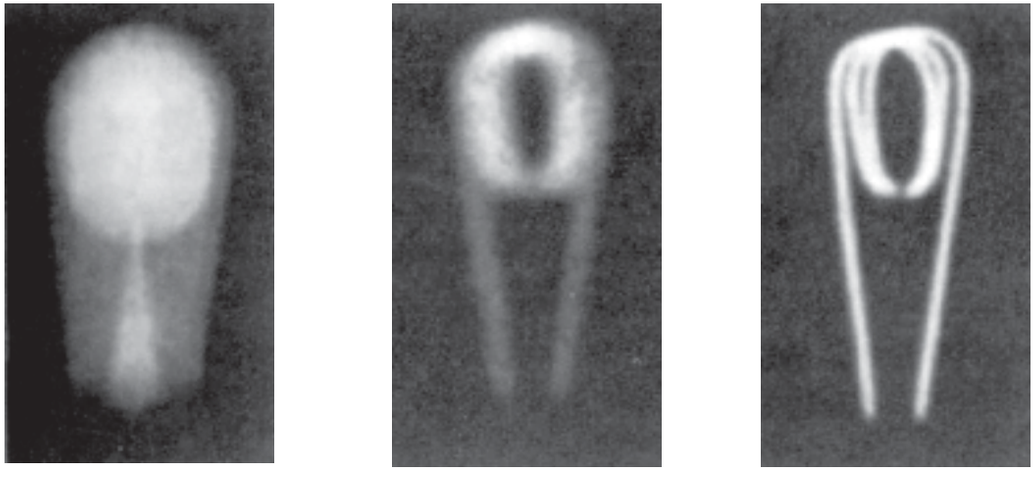
Size of hole in the pinhole

A trade-off:

a. A bigger hole takes in a bigger amount of light, but leads to more blur.

b. When the hole approaches the wavelength of light, diffration becomes an issue. This also leads to blurring.

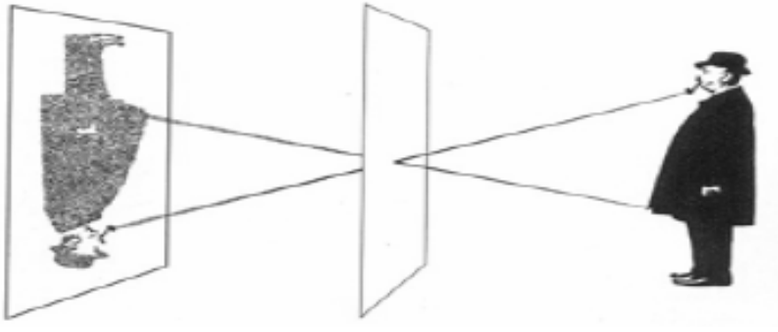
c. It is possible to derive an optimum for the image resolution. E.g. for f=100 [mm] and λ=500 [nm], the optimal hole size is dírky 0,32 [mm].



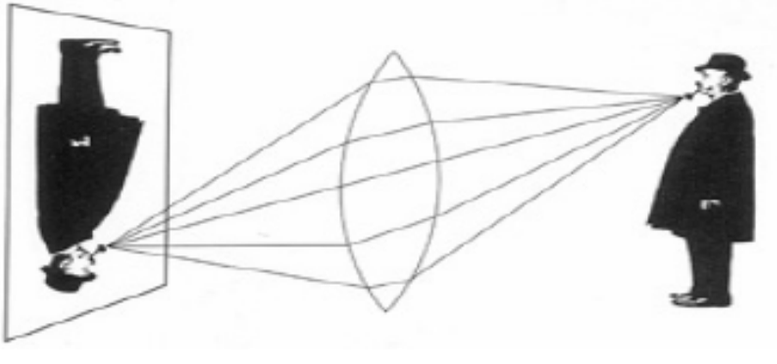
a b c

Why lenses?

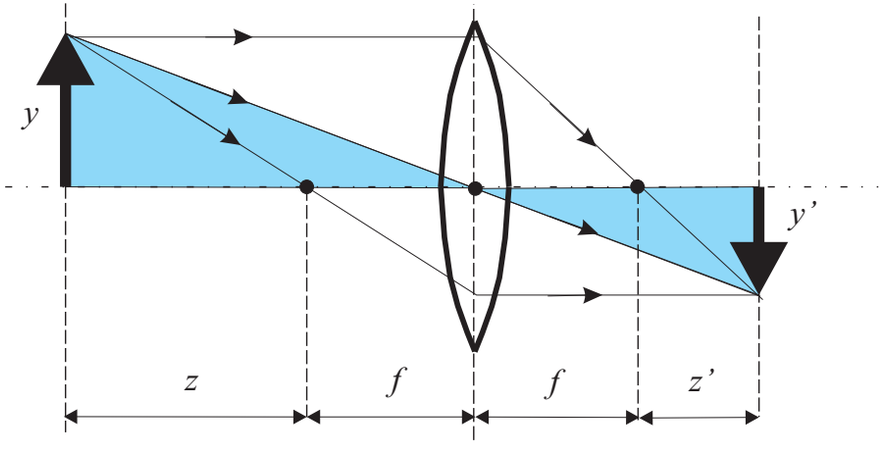
- Collects low number of photons
- Bumps into the diffration limit

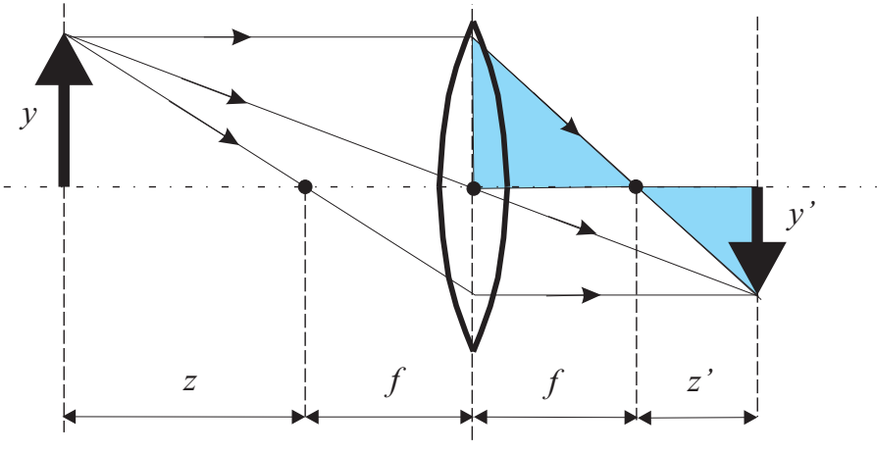


- Collects more photons
- Can be focused



Thin lens equation, similar △





$$\frac{y'}{y} = \frac{z' + f}{z + f}$$

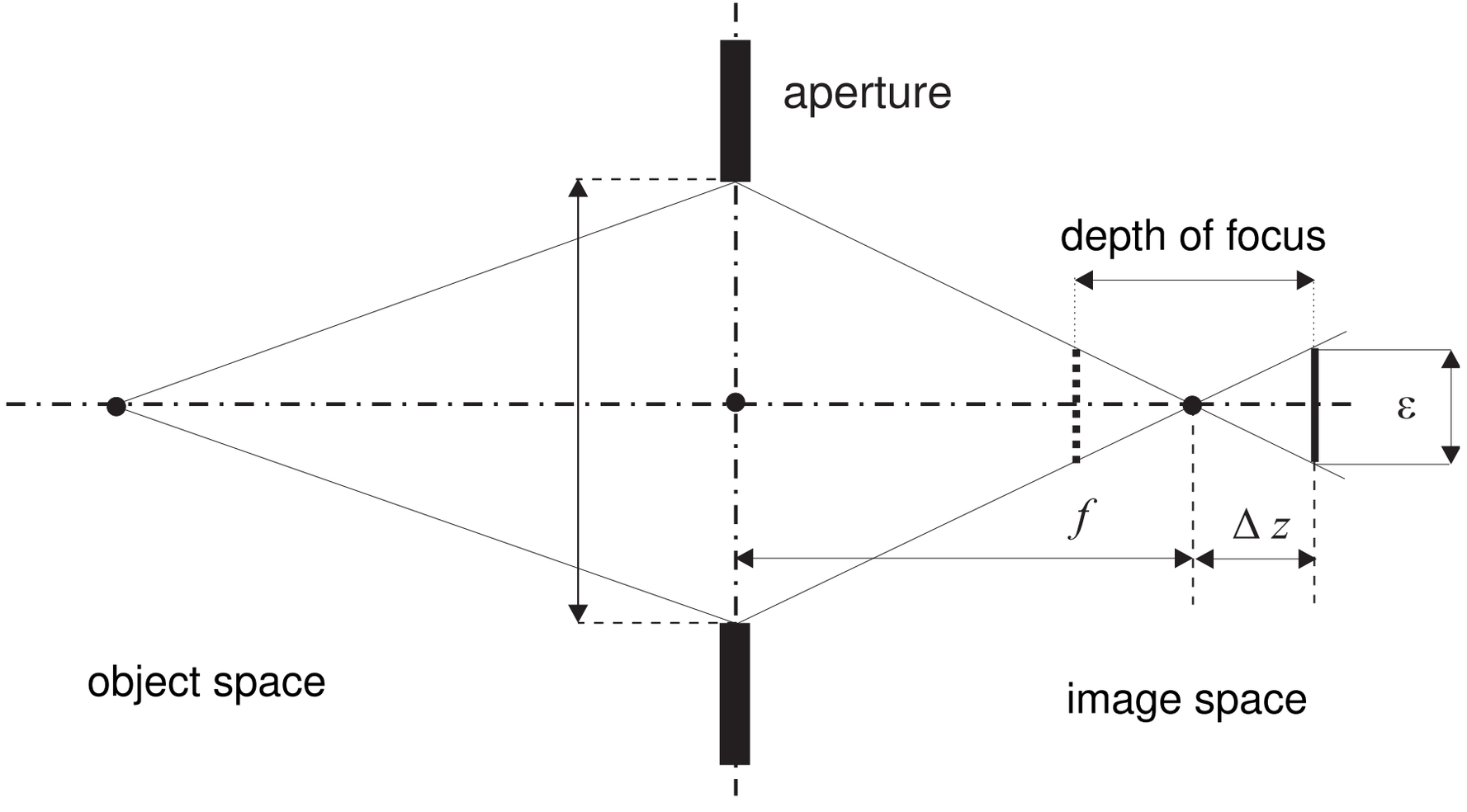
$$\frac{y'}{y} = \frac{z'}{f}$$

This gives:

$$\begin{aligned} \frac{z' + f}{z + f} &= \frac{z'}{f} \\ f(z' + f) &= z'(z + f) \\ fz' + f^2 &= zz' + fz' \\ f^2 &= z\,z' \end{aligned}$$

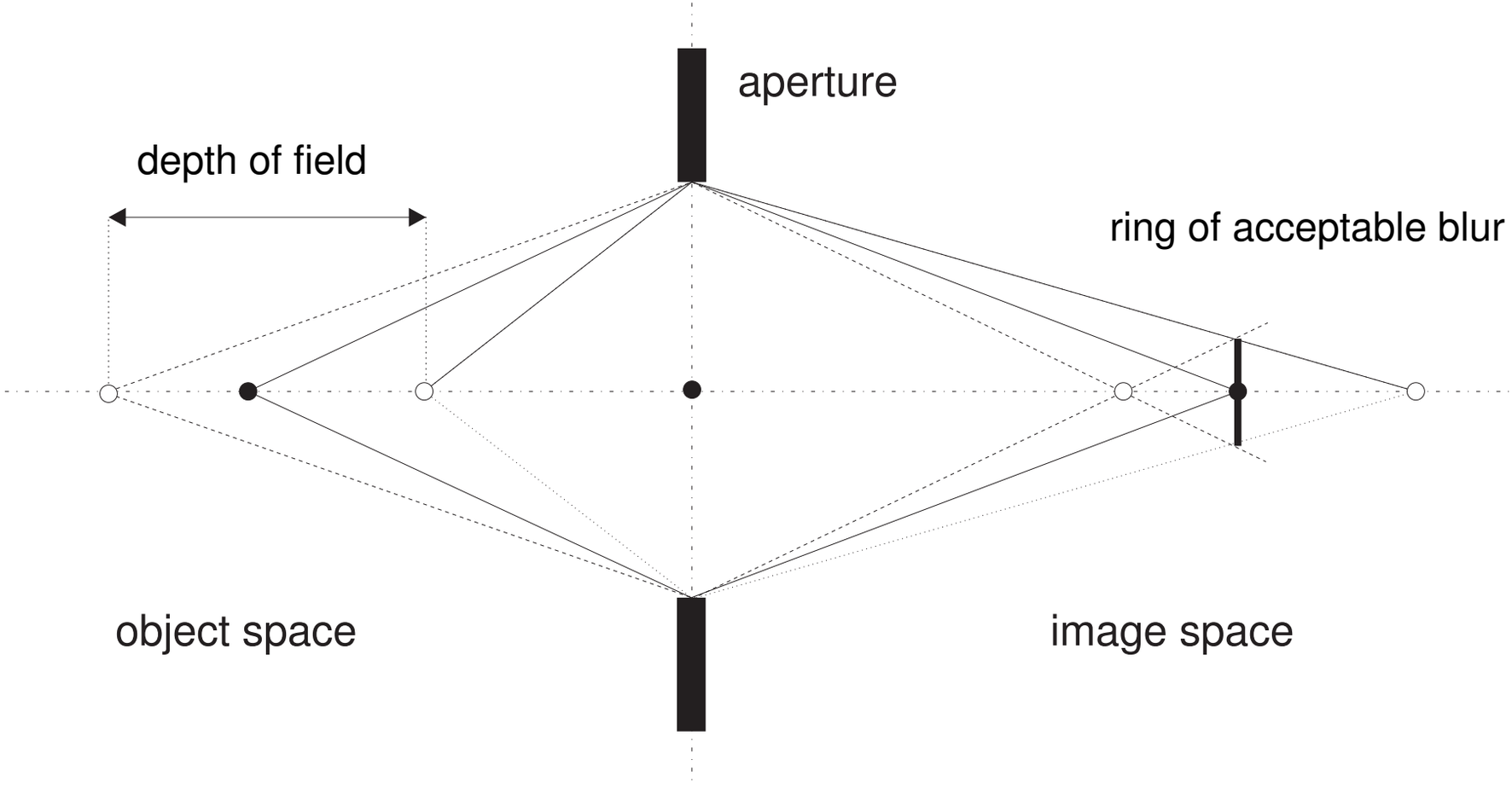
Depth of focus

It is possible to shift an image plane a little bit and still have a good sharpness. This is because pixel size is finite, size is ϵ.



Depth of field

Depth of field (DOF) specifies the range of distances in the object space for which the points are images sharpely on the image plane. This is of practical interest in photography and industrial imaging.



DOF, example

http://www.cambridgeincolour.com/tutorials/depth-of-field.htm

Dependence of DOF on aperture size

big aperture, low DOF

small aperture, big DOF

Dependence of DOF on focal length