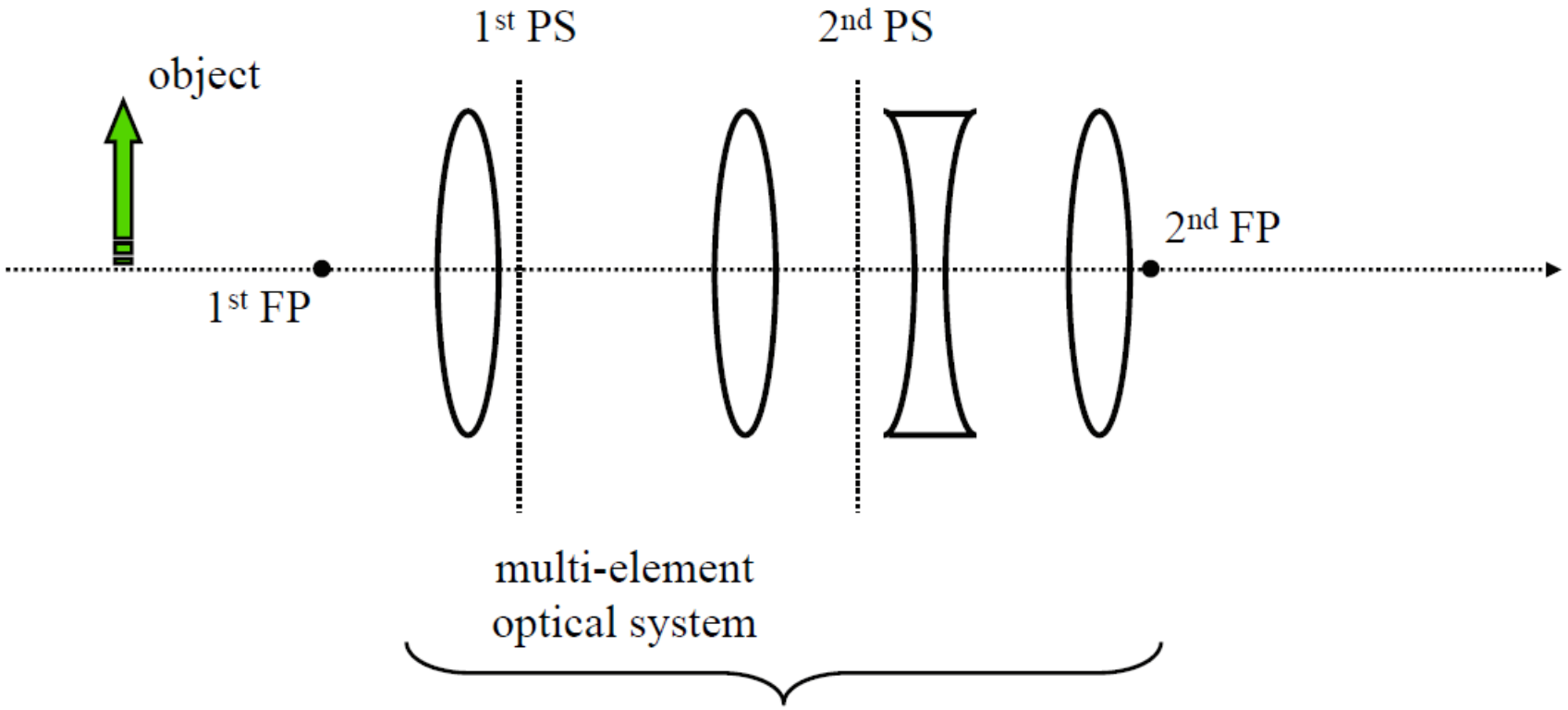
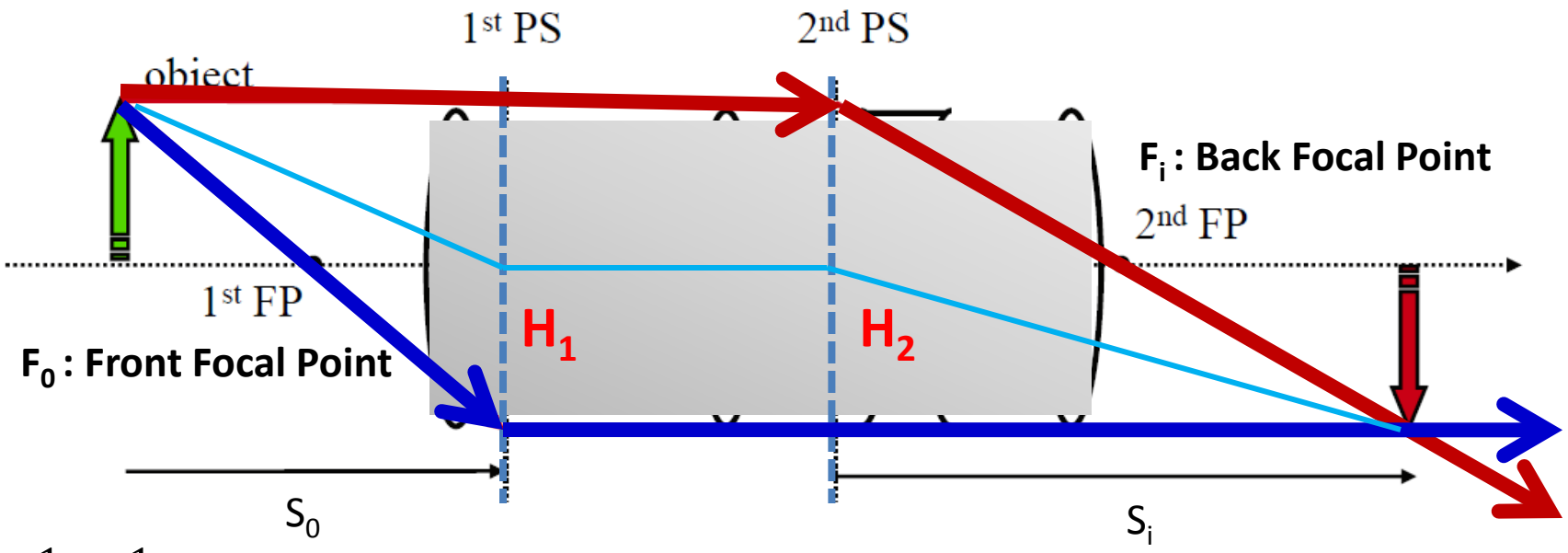
Multiple Elements



Principle Planes for Thick Lenses and Lens Systems

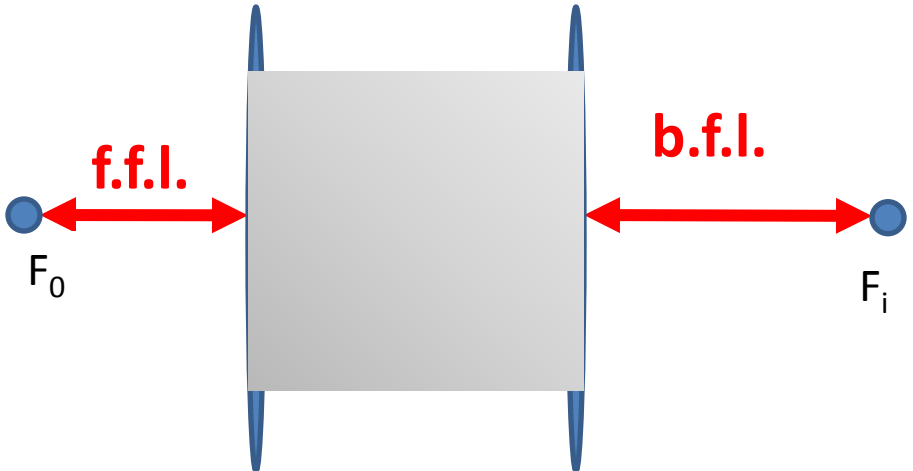


$$\frac{1}{f} = \frac{1}{s_0} + \frac{1}{s_i}$$

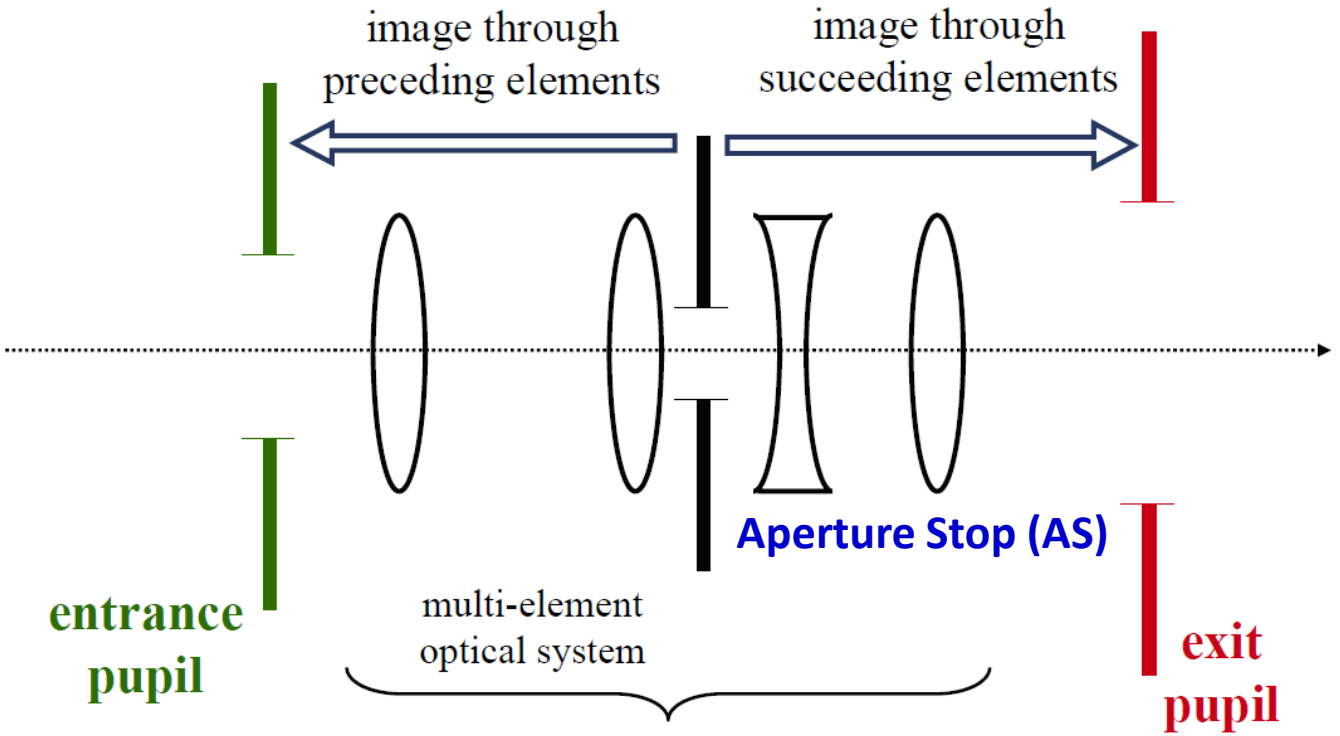
$$x_0 x_i = f^2$$

$$M_T \equiv \frac{y_i}{y_0} = -\frac{s_i}{s_o}$$

$$M_L \equiv \frac{dx_i}{dx_0} = -\frac{f^2}{x_0^2}$$



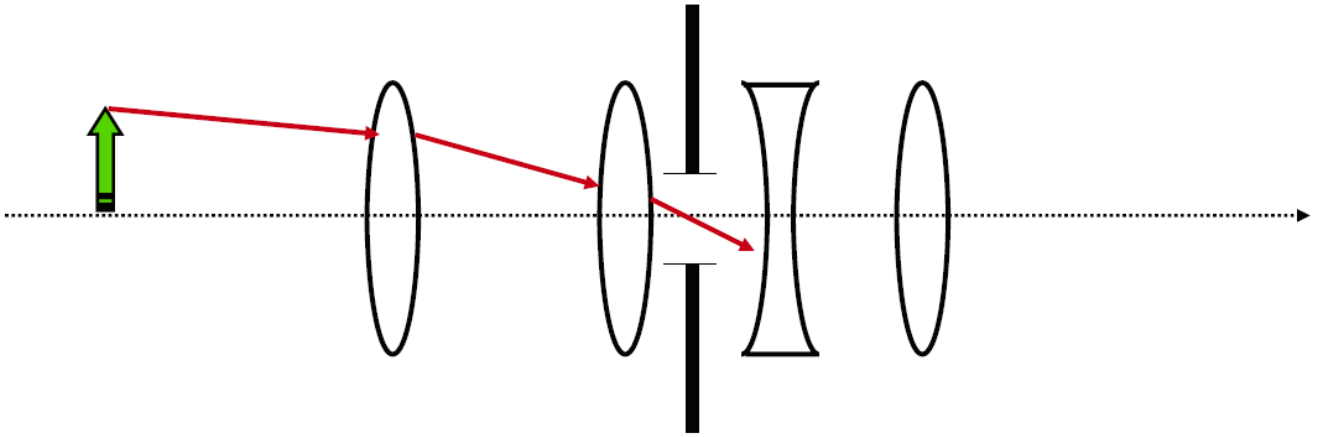
Aperture Stop and Entrance & Exit Pupil



The **aperture stop** (AS) is defined to be the stop or lens ring, which physically limits the solid angle of rays passing through the system from an **on-axis** object point. The aperture stop limits the brightness of an image.

The **entrance pupil** of a system is **the image of the aperture stop as seen from an axial point on the object through those elements preceding the stop**. (Hecht p. 171)
The **exit pupil** of a system is **the image of the aperture stop as seen from an axial point on the image plane through the interposed lenses, if there is any**. (Hecht p. 172)

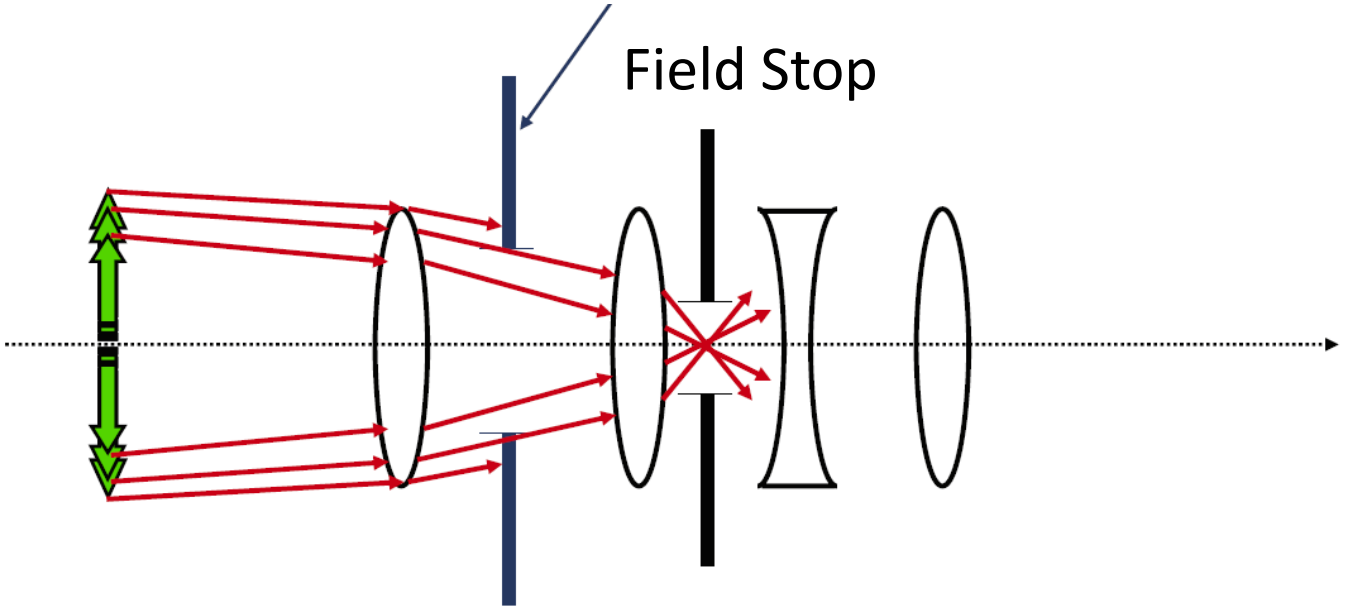
The Chief Ray



Starts from off-axis object,
Goes through the center of the Aperture

For an off-axis object, the chief ray (CR) is the ray that passes through the center of the aperture stop. Rays that pass through the edge of the aperture stop are marginal rays (MR).

The Field Stop and Aperture Stop

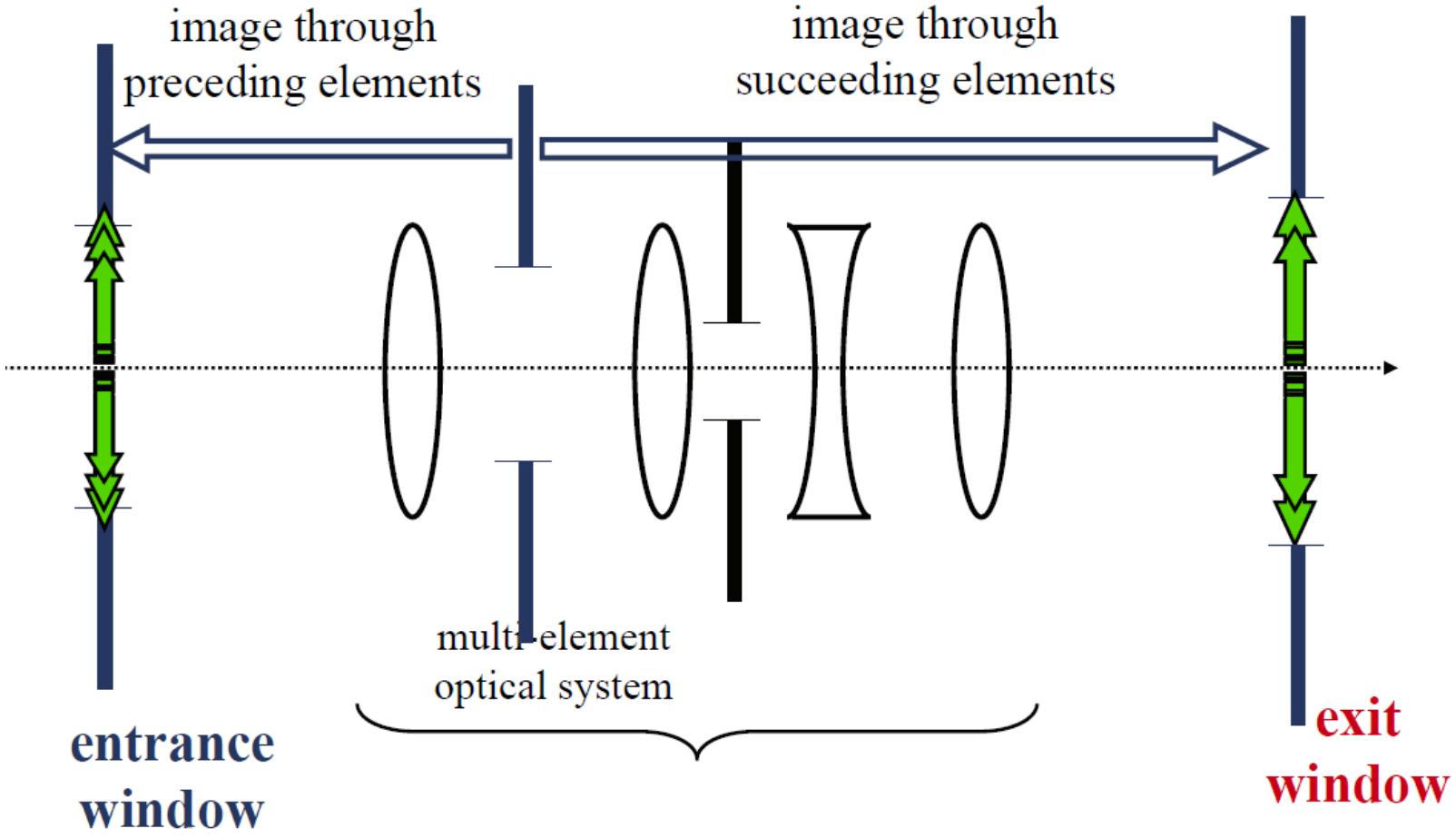


Limits the angular acceptance
of Chief Rays

The aperture stop determines the solid angle of the transmitted light cone for an on-axis object. It limits the brightness of an image. The **field stop** determines the solid angle formed by chief rays from **off-axis** objects. It limits the field of view of an optical instrument.

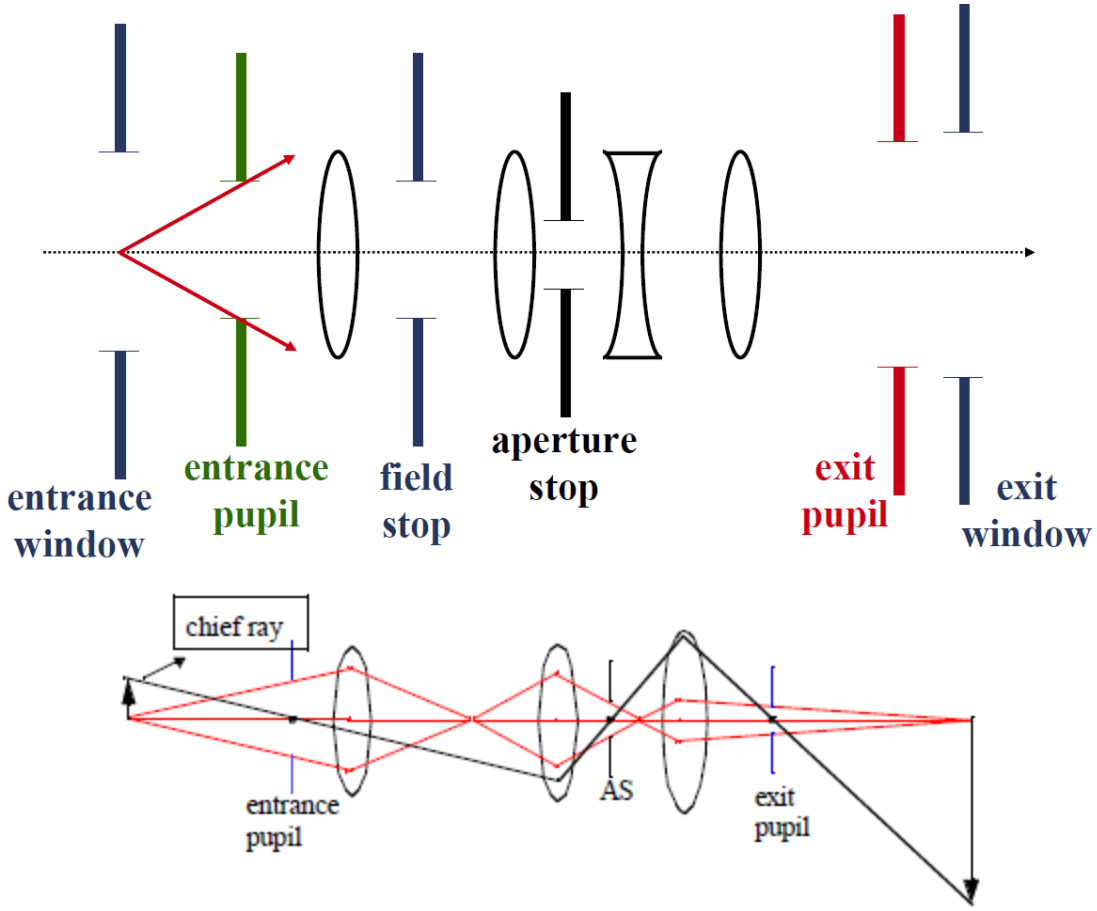
(source: http://electron9.phys.utk.edu/optics421/modules/m3/Stops.htm)

Entrance and Exit Window



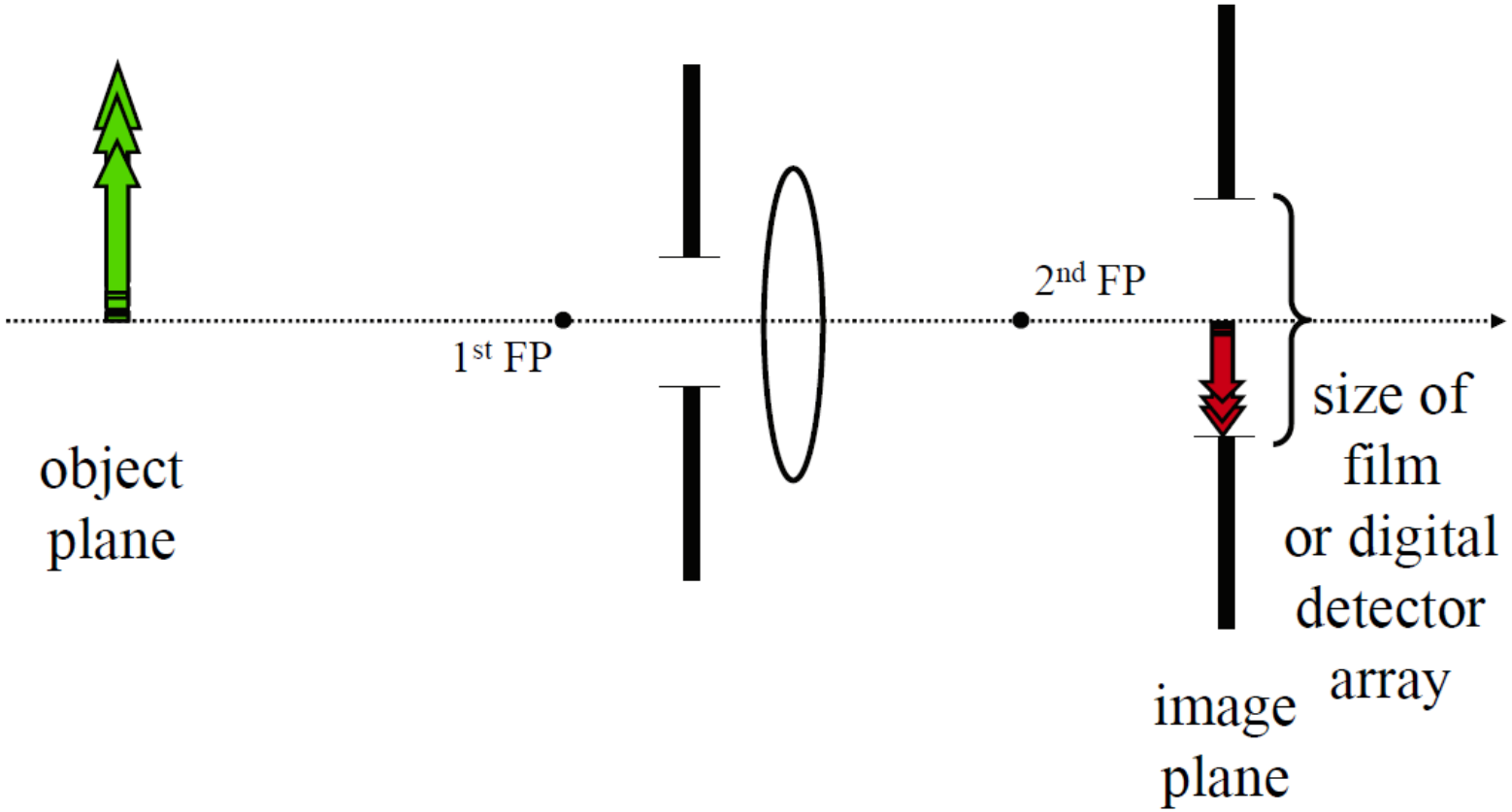
The image of the field stop as seen through all the optics before the field stop is called the **entrance window**. The image as seen through all the optics after the field stop is called the **exit window.**

All together

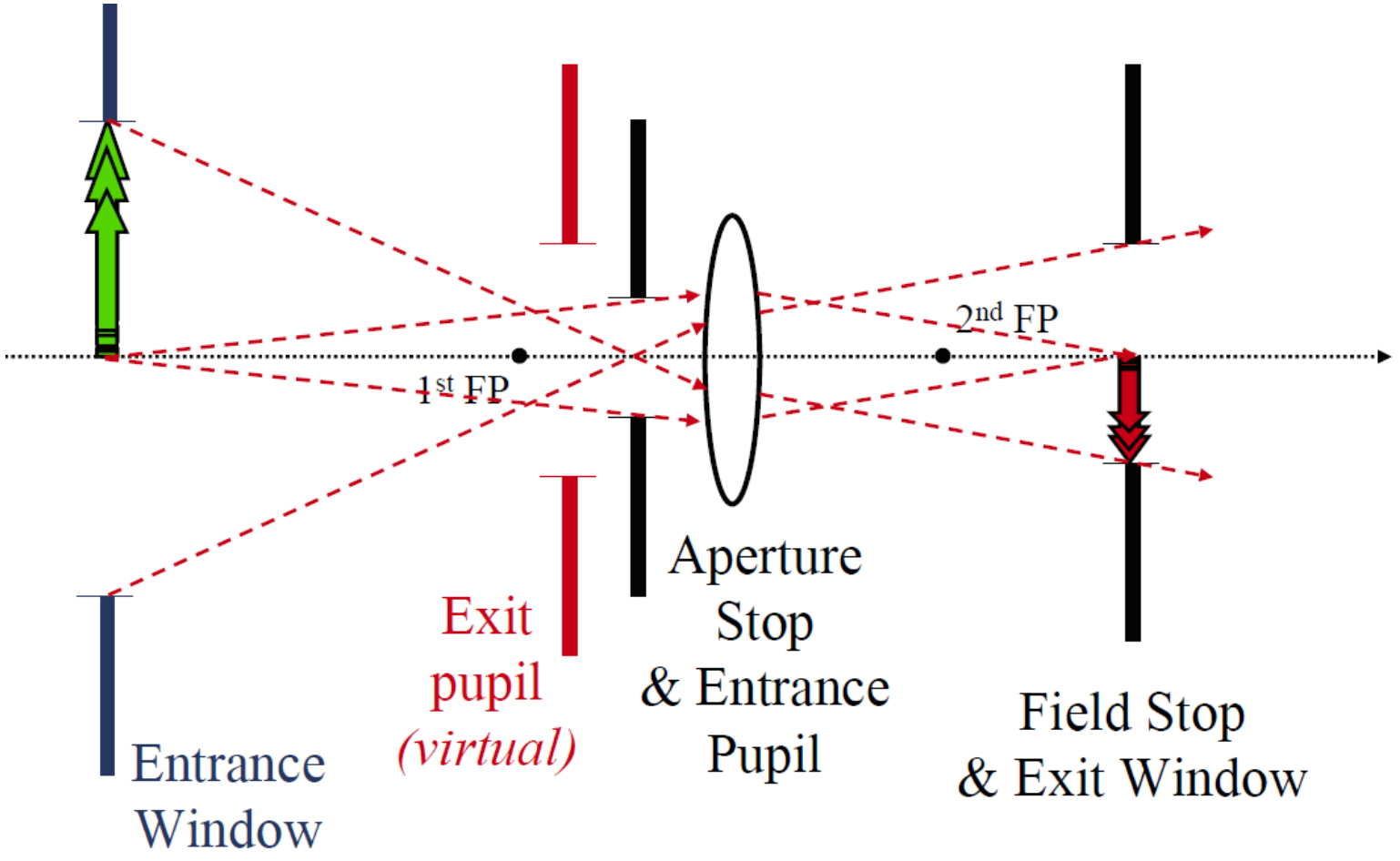


Two important aspects of any imaging system are the amount of radiation passed by the system and the extent of an object that is seen by the system. Stops and apertures limit the brightness of an image and the field of view of an optical system.

Example: Single Lens Camera



Example II: Aperture Stop + Field Stop



Vignetting