# Introduction & optical principle

Imaging cameras are designed to picture objects using a lens that focuses the image on a photography film, and in most conditions the object, the lens and the film all lie on parallel planes (Fig. 1). In this case adjusting the focus simply requires moving the film or the lens along the axis of the lens to obtain a well focused image. (***Merklinger and Harold, 1996)***

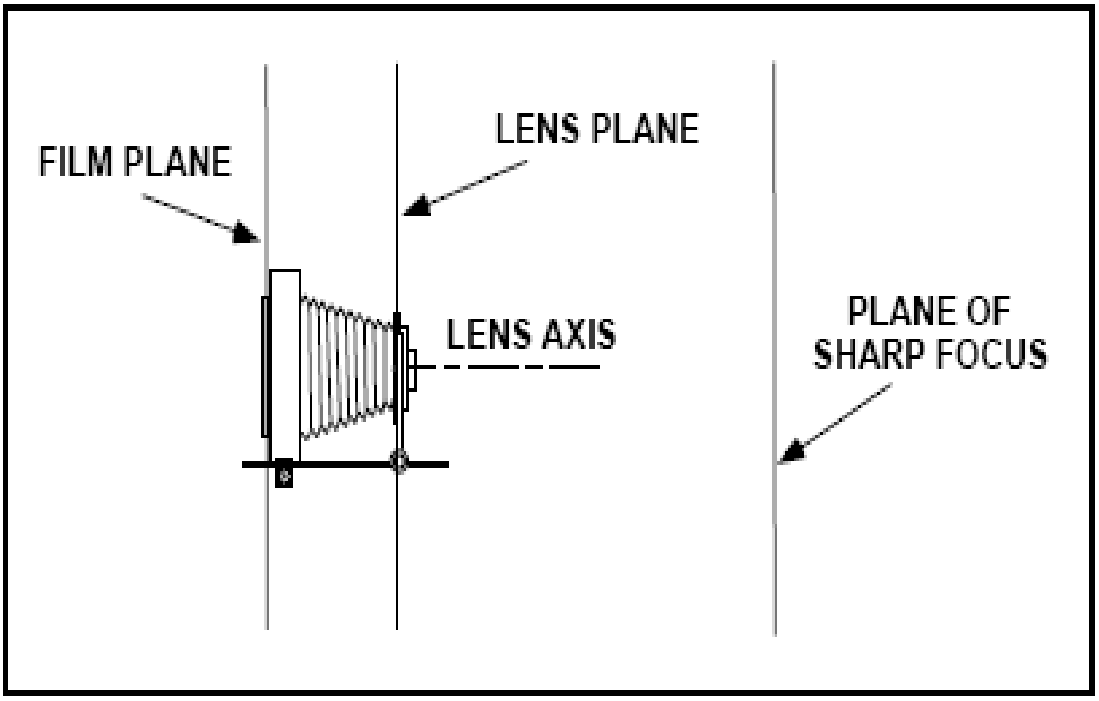


***Fig. 1:*** *For a 'normal' camera, the film plane, lens plane and plane of sharp focus are parallel to one another.* ***(Merklinger and Harold, 1996)***

But if we desire to picture an oblique object (Fig. 2), it will not be possible to bring it all in focus if we use the above technique, and here we will have to apply the Scheimpflug principle. ***(Merklinger and Harold, 2002)***

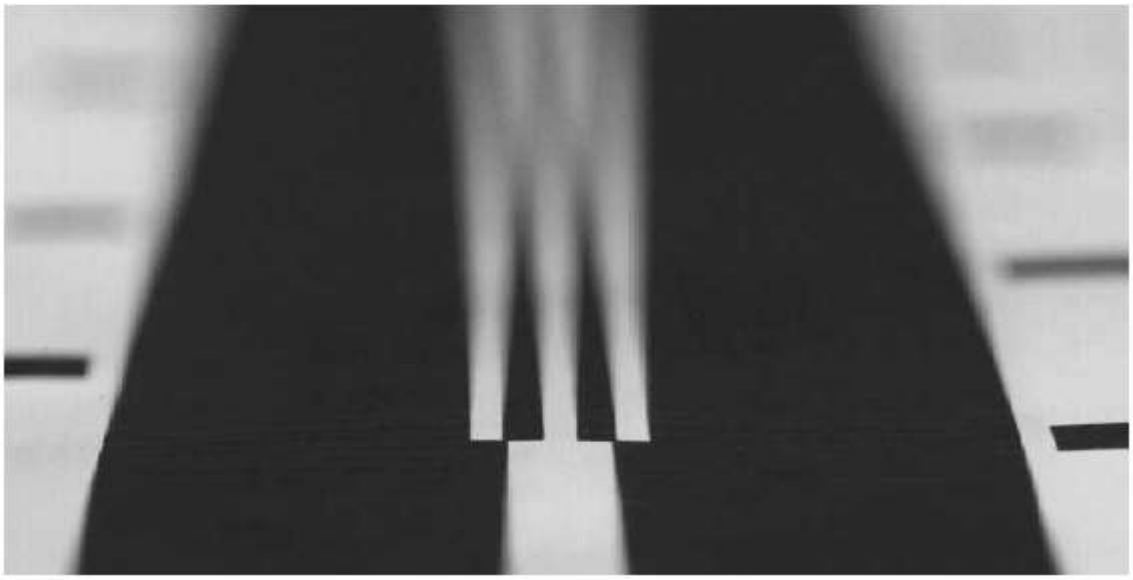

***Fig. 2:*** *image of an oblique object.* ***(Merklinger and Harold, 2002)***

The Scheimpflug rule is an optical technique that was initially discovered by a French camera maker, ***Jules Carpenter*** in the year ***1901***.

***Theodor Scheimpflug (1904)*** is an Austrian naval officer and photographic inventor who presented the technique in a more detailed and simple manner and hence the title ‘Scheimpflug Principle'. The Scheimpflug Principle which is a geometric rule governing camera movements that describes a technique to orient the plane of focus (the film) of an optical system (the camera) when the lens plane is not parallel

to the image plane and this technique was invented by him in 1904 (Apparatus for the Systematic Alteration or Distortion of Plane Pictures and Images) and his work was continued after his death by the Scheimpflug Institute in Vienna.

This principle is of major importance in professional photography and is used originally in picturing oblique objects without distortions as in architectural photography and in land surveying from the air.

Nowadays, the Scheimpflug principle is applied in Ophthalmic imaging machines to obtain optical sections of the entire anterior segment of the eye from the anterior surface of the cornea to the posterior surface of the lens allowing assessment of anterior and posterior corneal topography, anterior chamber depth, as well as anterior and posterior topography of the lens thus helping for better diagnosis and management of their disorders.

One of the advantages of Scheimpflug images over corneal topography is the it can picture and measure directly the central part of the cornea, while in the latter mostly the camera is placed in the center so that the central 1-2 mm area is not measured but only calculated. ***(Kitagawa et al, 1996)***

## Explaining the Scheimpflug principle:

When the lens and image planes are not parallel, adjusting focus rotates the plane of focus (PoF) rather than displacing it along the lens axis. The axis of rotation (hinge line) is the intersection between the lens' plane, the plane of sharp focus and a plane passing through the center of the lens parallel to the film plane, as shown in (Fig. 3). If the image plane is moved, the plane of focus rotates about this hinge line.

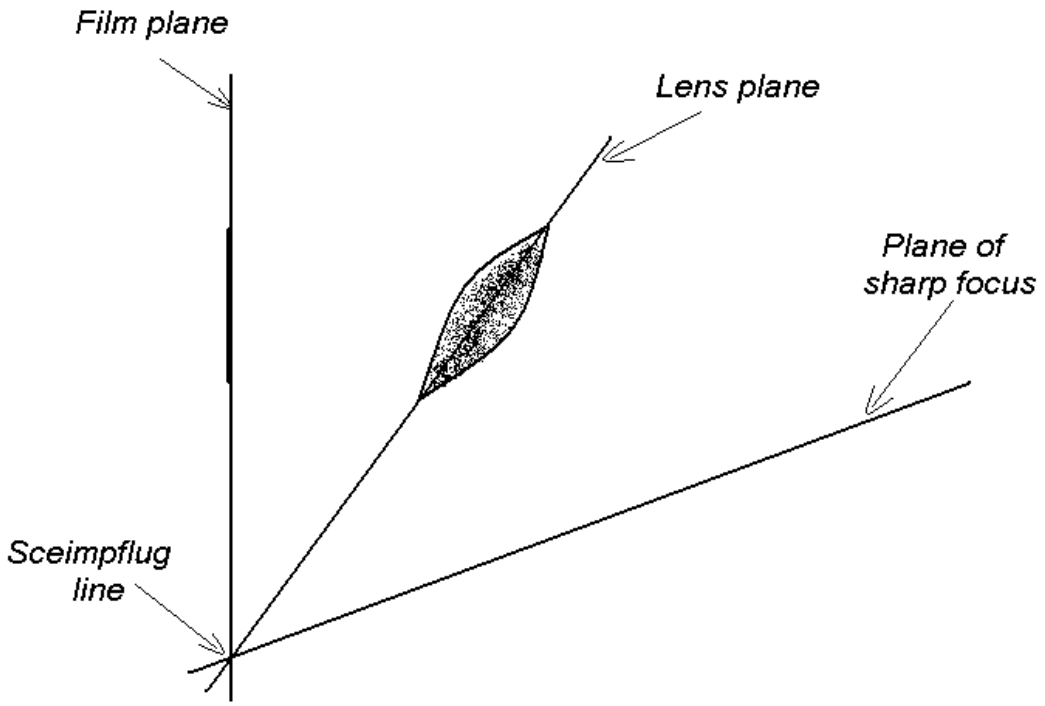


***Fig. 3:*** *Demonstrating the Sceimpflug line.* ***(Merklinger and Harold, 1996)***

When the lens and image planes are parallel, the depth of field (DoF) extends between parallel planes on either side of the plane of focus. When the Scheimpflug principle is employed, the DoF becomes wedge shaped, with the apex of the wedge at the rotation axis (Fig.4). The DoF is zero at the apex, remains shallow at the edge

of the lens's field of view, and increases with distance from the camera (where L is the depth of field measured in a direction perpendicular to the plane of sharp focus). The shallow DoF near the camera requires the PoF to be positioned carefully if near objects are to be rendered sharply.

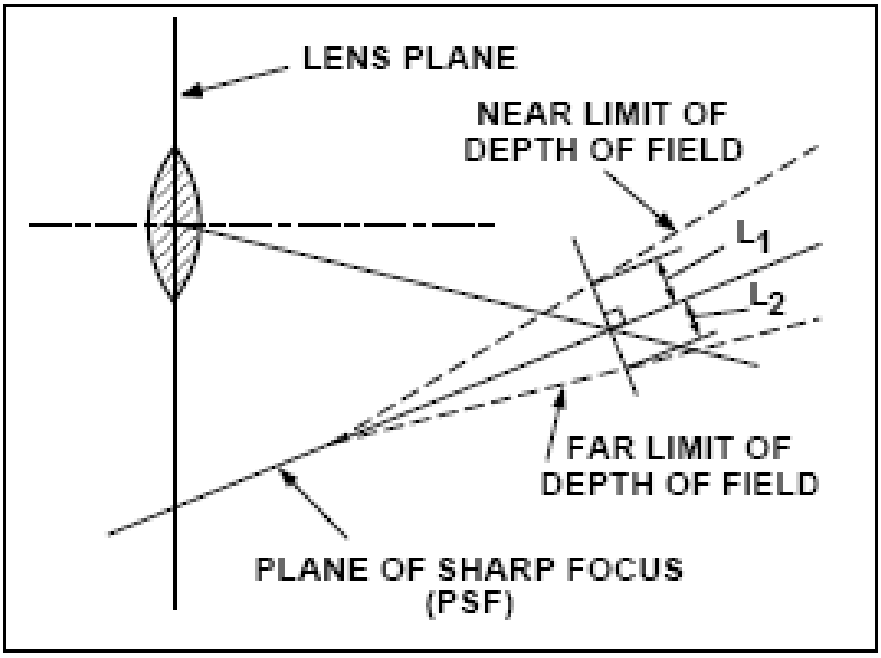


***Fig. 4:*** *Depth of field.* ***(Merklinger and Harold, 1996)***

Rotation of the plane of focus can be accomplished by rotating either the lens plane or the image plane. Rotating the lens maintains perspective in a vertical subject, such as a building, but requires a lens with a large image circle. Rotating the image plane (as by adjusting the back or rear standard on a view camera) alters perspective in a vertical subject, but works with a lens that has a smaller image circle. Rotation of the lens or back about a horizontal axis is commonly called tilt, and rotation about a vertical axis is commonly called swing. ***(Merklinger and Harold, 1996)***