Focused Beam Diameter with Focusing Lens

A beam of finite diameter is focused by a lens to obtain a smaller beam spot, as shown in Figure 1. If the diameter of the focused spot, d_0, is defined as the diameter which contains 86% of the focused energy, the focus spot size is determined by

$$d_0 = \frac{2f\lambda}{D}$$

where, *f* is the focal length of the focus lens, *D* is the entrance beam diameter, and is the wavelength.

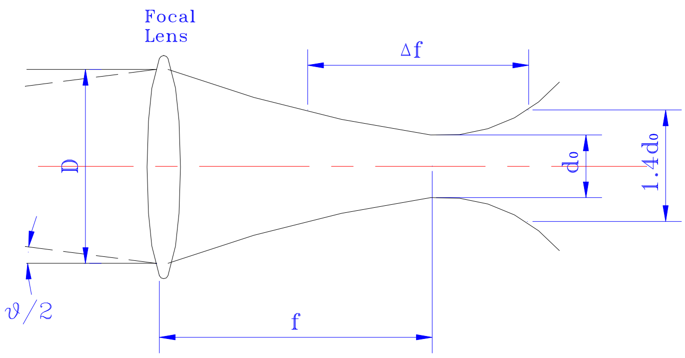

Figure 1: Focusing of a Gaussian beam

If the total beam divergence angle θ is known, the diameter of the focus spot size is given by

$$d_0 = f \bullet \vartheta$$

It is obvious that the focus spot size is smaller if the beam divergence angle is smaller. In order to get a smaller focus spot size, a beam expander is used to reduce the beam divergence angle in most applications.

As the Gaussian beam focuses from a lens down to a waist and then expands, there is a need to define a depth of focus. Normally, it is defined as the distance between the $\sqrt{2}d_0$ spot size points or 2 times Rayleigh range. It can be written as

$$\Delta f = 2Z_R \approx 2\pi\lambda F^2$$

or

$$\Delta f = \frac{2f^2\theta}{D}$$

where F is the f-number of a focusing lens, which is defined as

$$F = \frac{f}{D}$$

It is concluded from above Eqs. that a lens with a longer focal length gives a greater depth of focus and a larger focus spot size than a lens with a shorter focal length. Thus the focal length of the focus lens should be selected properly according to the application requirements.