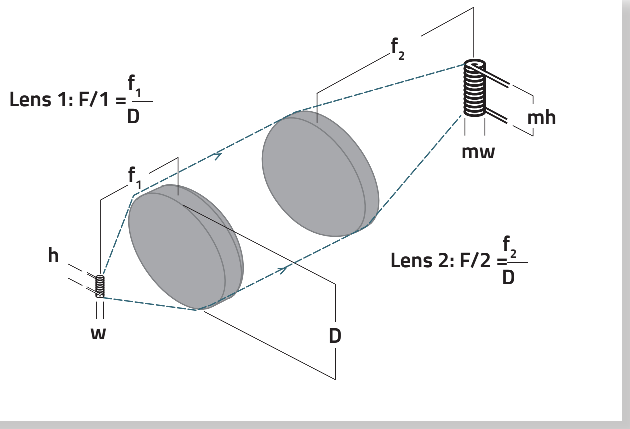
Choosing the right focusing lens



Typical optical system

The figure shows a typical optical system. The light of a filament is collected by the condensing optics (lens 1) and is focused by lens 2, resp.. The filament is imaged on the probe. The magnification of the filament on the probe is given by the ratio of the F/numbers.

m = (F/2) / (F/1), with F/number = f/Ø

With a good collimated beam, the diameter of the beam is constant and the magnification m is given by the ratio of the focal lengths.

m = f2/f1

Our light sources with condensing optics produce beams with 35 and 50 mm diameters. This means that the beam diameter of the condenser defines the diameter of the focusing lens.

If you have to irradiate relatively large probes (compared to the source) choose the focal length of the focusing lens in such a way that the image of the source is of the same size as the probe.

If there are limiting apertures, for example when the source is imaged on a fiber optic or a monochromator slit, the focal length of the focusing lens is defined by the maximum possible aperture angle (and the diameter of the beam).

The F/numbers have to be matched
The maximum possible aperture angle for the monochromator is given by its F/number and for the fiber optics by the numerical aperture (N.A.).

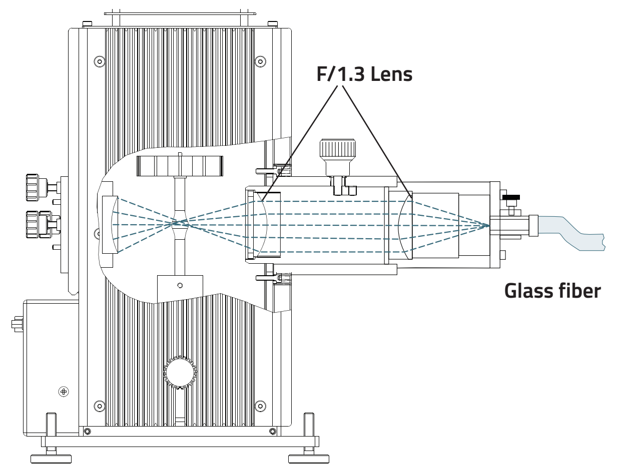
Example:
For a 35 mm diameter beam and a F/4 monochromator the focusing lens should also have at least a 35 mm diameter and a focal length of 35 x 4 = 140 mm (F/number = f/Ø).

Plano-convex lenses have low spherical aberration. In practice, a lens with 38 to 50 mm diameter and 150 mm focal length should be chosen. 142 mm would be custom-made. For practical application, a value close to 142 is sufficient.

The N.A. of quartz fibers is 0.22. With N.A. = 1/(2F/number) this corresponds to an F/number of 2.3. For a 35 mm beam the focal length of the focusing lens should be 35 x 2.3 = 80.5 mm.

This means for given condensing optics with F/1.0 to F/1.5, the source will always be magnified on a monochromator slit or a fiber optic. To understand this fundamental concept is very helpful for choosing the size of a source for the specific application. For example it is not very useful to use a 200 µm fiber for a 250 W halogen lamp with a filament of 7 x 3.5 mm^2. Even a 10 W lamp with 1.7 x 0.65 mm^2 does not give a better result.

A much better result can be achieved with arc lamps. Compared to halogen lamps they have a very small arc with approx. ten times higher radiance. The arc size of a 75 W Xe arc lamp for example is only 0.25 x 0.5 mm^2.



The NA of glass fibers is 0.56. This corresponds to an F/number of 0.9. Two F/1.3 optics are a good compromise.

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