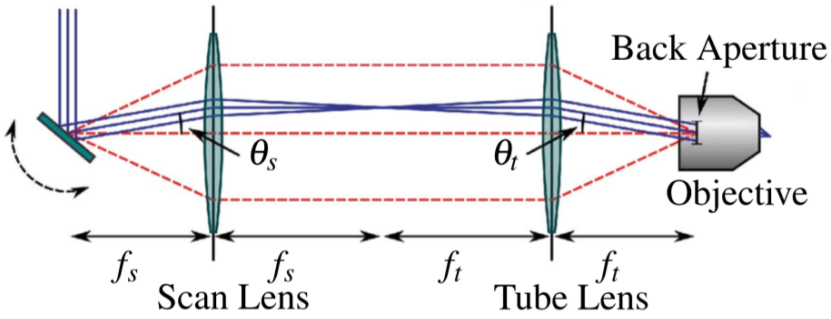
[1] Young 2015, ‘A pragmatic guide to multiphoton microscope design’, p305
[2] Specs from the website and the quote from Olympus




```
μm = 10^-6;
μs = 10^-6;
ns = 10^-9;
μrad = 10^-6;
mm = 10^-3;
nm = 10^-9;
Tera = 10^12;
kHz = 10^3;
Mega = 10^6;
Giga = 10^9;
λ = 800 nm;
```

Objective parameters [2]

```
fo = 7.2 mm;(*focal length of the objective. I asked Olympus*)
NA = 1.0 ;(*numerical aperture of the objective [2]*)
Dobj = 2 NA fo;(*objective back aperture*)
FOV = 18 mm / 25 / √2 ;(*estimated required FOV (arbitrary)*)
ft = 200 mm;(*focal length of the tube lens*)
fs = 45 mm;(*focal length of the scan lens*)
α = 8;(*number of beamlets*)
dot = 180 mm;(*distance between the objective and the tube lens. It is arbitrary*)
```

At the sample

$$\Delta Lo = \frac{FOV}{\alpha};$$ (*lateral travel at the sample for each beam*)

At the Objective

$$\theta maxo = \frac{FOV/2}{fo};$$ (*max scan angle at the objective back focal plane. Note that this is amplitude, not peak-to-peak*)

At the tube lens

$$\Delta Lt = \frac{ft}{fo}\,\Delta Lo\,;\,(*\text{lateral travel = interbeam distance at the tube lens}*)$$

$$Dtb = 2\,dot\,\theta maxo + Dobj;$$

(*minimun clear aperture of the tube lens: Dtb ≥ 2 ft θmaxo + Dobj. See eq.24 in [1]*)

$$dt = \frac{4\,\lambda}{\pi}\,\frac{ft}{Dobj};\,(*\text{single-beam diameter at the focus of the tube lens. Saleh eq 3.2-17}*)$$

$$DOFt = \frac{8\,\lambda}{\pi}\left(\frac{ft}{Dobj}\right)^2;$$

(*depth of focus at the focus of the tube lens. Saleh eq. 3.2-7 with z=0 and z0>>f*)

At the scanning mirror

$$dm = \frac{fs}{ft}\,Dobj;\,(*\text{single-beam diameter at the scanning mirror }\left(\text{telescopic equation}\right)*)$$

$$\theta maxm = \frac{ft}{fs}\,\theta maxo;\,(*\text{max scan angle at the scanning mirror }\left(\text{telescopic equation}\right).\text{ This is an amplitude, not the peak-to-peak angle}*)$$

$$\Delta dm = \frac{fs}{ft}\,\frac{ft}{fo}\,FOV\,/\,\alpha;\,(*\text{interbeam distance at the mirror}*)$$

At the scan lens

$$Dm = 2 * fs * \theta maxm + dm\,;\,(*\text{minimum diameter of the scan lens}*)$$

```
Grid[{{"", "Sample", "Objective BFP",
    "Tube lens", "Interm. image", "Scan lens", "Scanning mirror"},
   {"Focal length", "-", fo / mm "mm", ft / mm "mm", "-", fs / mm "mm", "-"},
   {"single-beam diameter", "-", Dobj / mm "mm",
    Dobj / mm "mm", dt / μm "μm", dm / mm "mm", dm / mm "mm"},
   {"Interbeamlet separation", 1. ΔLo / μm "μm", 0, ΔLt / mm "mm",
    ΔLt / mm "mm", ΔLt / mm "mm", 0},
   {"aperture", 1. FOV / μm "μm", Dobj / mm "mm", Dtb / mm "mm", "-", Dm / mm "mm", dm / mm "mm"},
   {"Max. angle", "-", θmaxo 180 / π "°", 0, 0, 0, θmaxm 180 / π "°"},
   {"Depth of focus", "-", "-", "-", DOFt / mm "mm", "-", "-"}}, Frame → All]
```

	Sample	Objective BFP	Tube lens	Interm. image	Scan lens	Scanning mirror
Focal length	–	7.2 mm	200 mm	–	45 mm	–
single-beam diameter	–	14.4 mm	14.4 mm	14.1471 μm	3.24 mm	3.24 mm
Interbeamlet separation	63.6396 μm	0	1.76777 mm	1.76777 mm	1.76777 mm	0
aperture	509.117 μm	14.4 mm	27.1279 mm	–	17.3821 mm	3.24 mm
Max. angle	–	2.02571 °	0	0	0	9.00316 °
Depth of focus	–	–	–	0.392975 mm	–	–

```
θresolution = ft/fs 300 nm/fo;(*angular reproducibility at the scanning mirror*)
θresolution / μrad
```

185.185