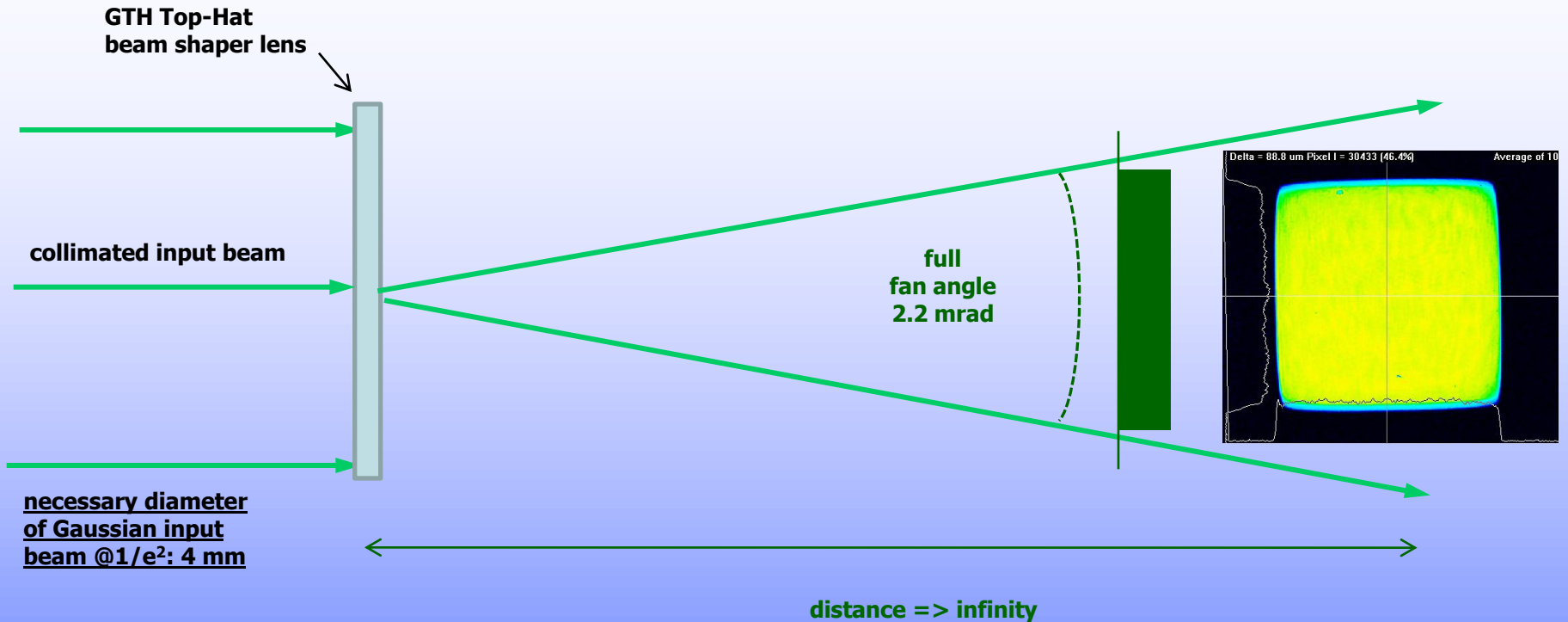


Product Technical Description

Gauss-to-Top-Hat Beam Shaper Lens

GTH-4-2.2

1. General function of Top-Hat beam shaper GTH-4-2.2



The Top-Hat beam shaper GTH-4-2.2 generating a square Top-Hat profile with a full fan angle of 2.2mrad. To get best results it is necessary to use a Gaussian TEM00 input beam with a **diameter of 4 mm@1/e²**.

For all setups using GTH beam shaper the user have to consider that the free aperture along the total beam path have to be at least 2.2 (better 2.5) times bigger than the beam diameter@1/e².

2. Optical setup for Top-Hat beam shaper GTH-4-2.2

- Setup overview -

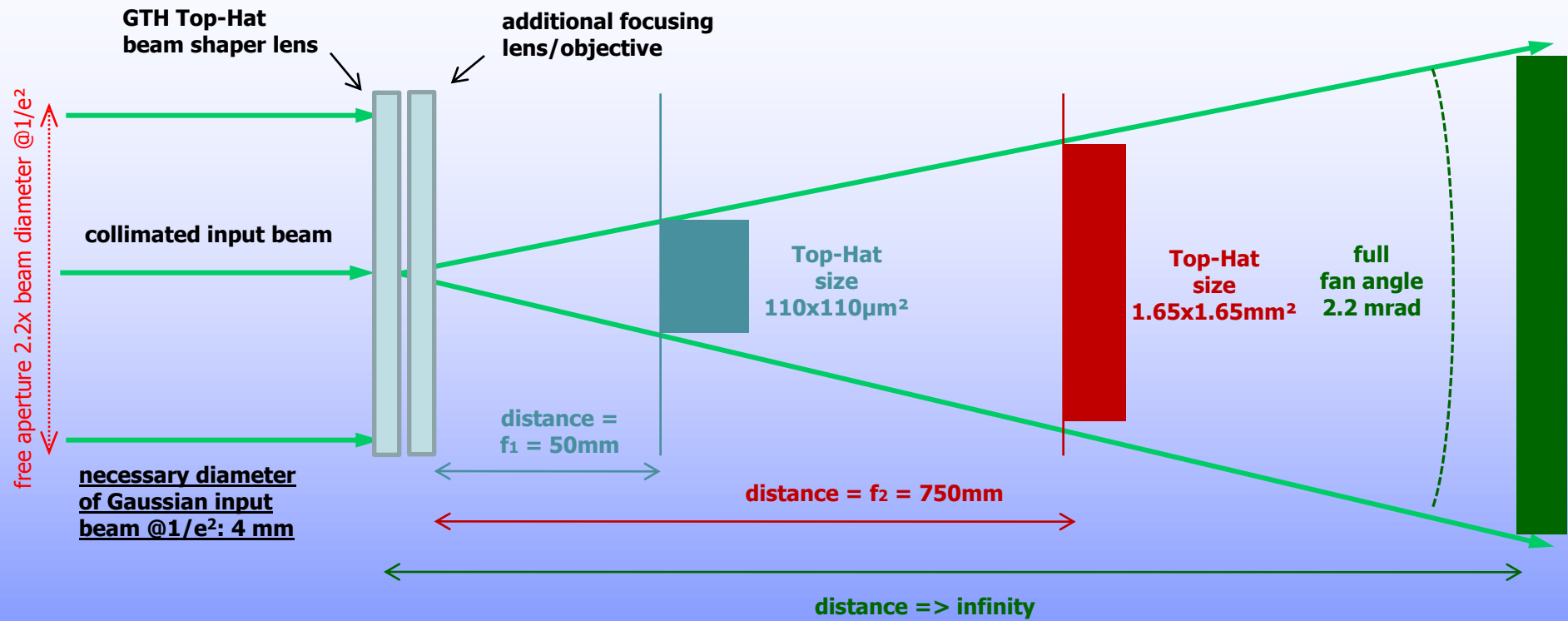
There are different possibilities to integrate the GTH-4-2.2 beam shaper into an optical setup:

- a. Beam shaper directly in front of focusing optic/objective (Top Hat size @1/e² >100μm):
 Top Hat size is determined by focal length (f) of focusing optic/objective and can be calculated as follows: $\frac{2.2}{1000} \cdot f$

- b. Beam shaper in front of beam expander (Top Hat size @1/e² <100μm):
 Top Hat size is determined by numerical aperture (NA) of focused beam and is given by:
- $$\approx \frac{4.4\mu\text{m}}{\text{NA}} \Rightarrow \approx 6.5x \text{ diffraction limited @1064nm (13x@532nm)}$$

- c. Beam shaper within beam expander (Top Hat size @1/e² <100μm):
 Top Hat size is determined by numerical aperture (NA) of focused beam and is given by:
- $$\approx \frac{4.4\mu\text{m}}{\text{NA}} \Rightarrow \approx 6.5x \text{ diffraction limited @1064nm (13x@532nm)}$$

2a. Optical setup for Top-Hat beam shaper GTH-4-2.2 - beam shaper in front of focusing optic -

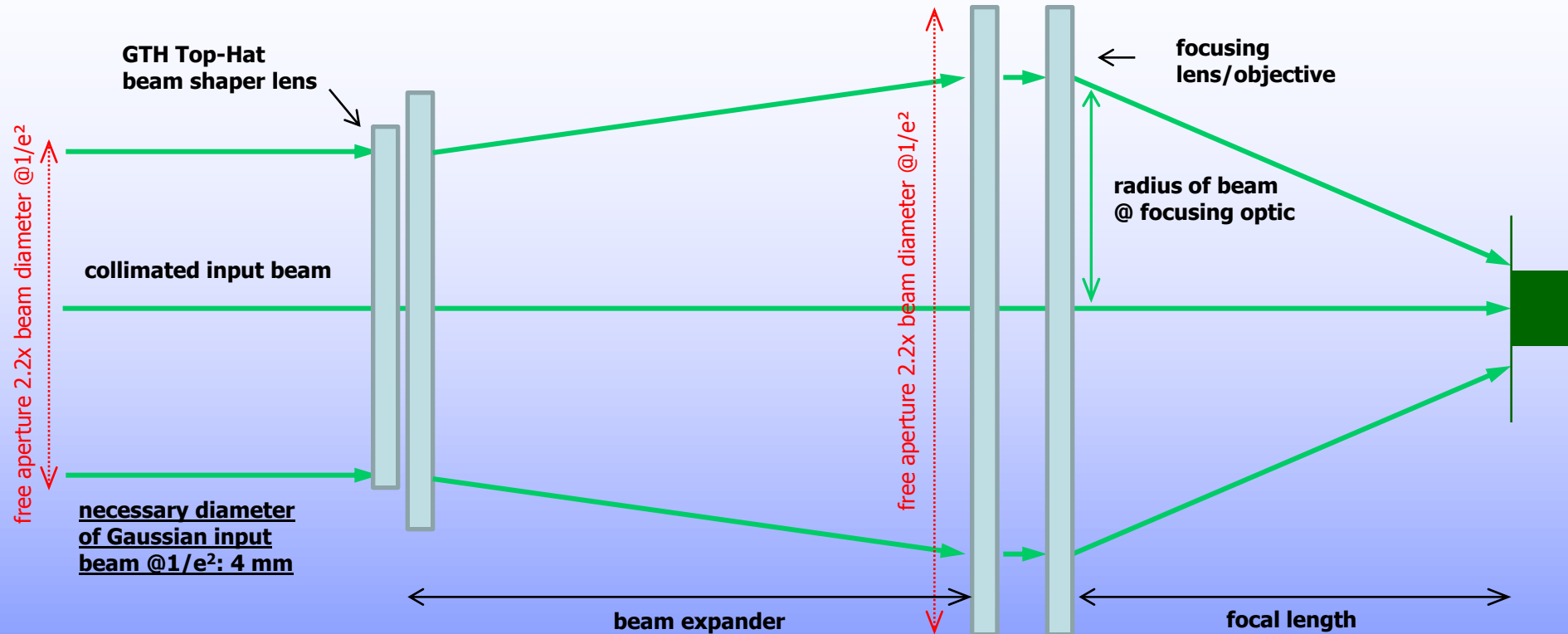


By introducing the GTH-4-2.2 into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a square homogeneous Top-Hat profile.

The necessary beam diameter at the position of GTH-4-2.2 is 4mm@1/e².

The resulting Top-Hat size is given by: $\left(\frac{2.2}{1000} \cdot \text{focal length} \right)$ for example with f= 50mm => 110µm

2b. Optical setup for Top-Hat beam shaper GTH-4-2.2 - beam shaper in front of beam expander -

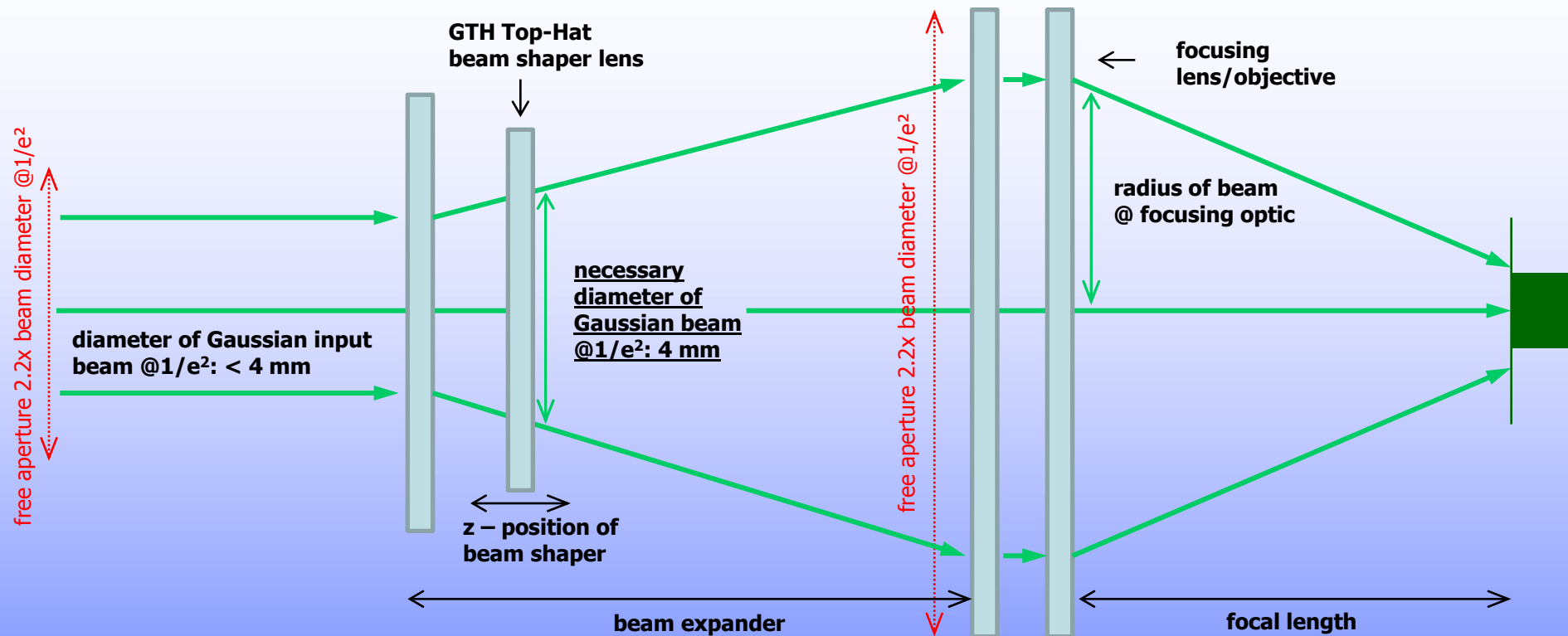


To realize Top Hat sizes smaller than 100 μm it's recommended to introduce the GTH-4-2.2 into the beam path in front of a beam expander. Initially the necessary input beam diameter of 4mm@1/e² is passing the GTH. Afterwards the beam is expanded and focused on working plane. The initial diffraction limited Gaussian spot at focal plane will be transformed into a square homogeneous Top-Hat profile.

The resulting Top-Hat size is given by: $\approx \frac{4.4\mu\text{m}}{\text{NA}} \Rightarrow \approx 6.5x \text{ diffraction limited @1064nm (13x@532nm)}$

NA represents the numerical aperture of focused beam and is given by: $\text{NA} = \frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$

2c. Optical setup for Top-Hat beam shaper GTH-4-2.2 - beam shaper within beam expander -

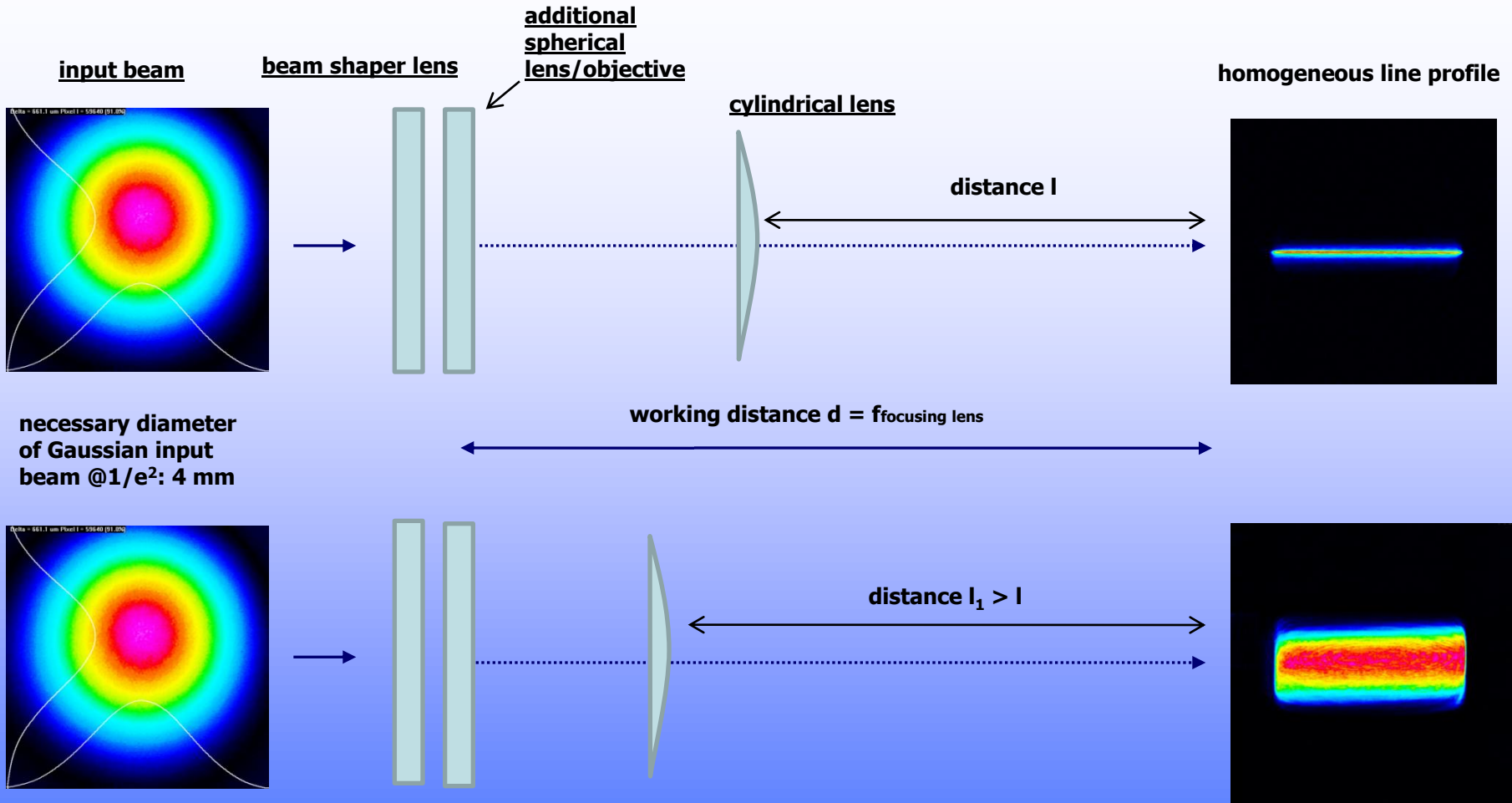


A further and even more flexible possibility is to introduce GTH-4-2.2 into the beam path within a beam expander. The user has the possibility for an easy "fine tuning" of beam diameter at the position of GTH-4-2.2 by shifting shaper along z-axis. It's just necessary to consider that the beam diameter at the position of GTH is $4 \text{ mm}@1/e^2$.

The resulting Top-Hat size is given by: $\approx \frac{4.4 \mu\text{m}}{\text{NA}} \Rightarrow \approx 6.5 \times \text{diffraction limited @} 1064 \text{ nm (} 13 \times @ 532 \text{ nm)}$

NA represents the numerical aperture of focused beam and is given by: $\text{NA} = \frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$

3. Homogeneous line generation with additional cylindrical lens



If an additional cylindrical lens is used, one can generate homogeneous line profiles. By varying the distance l the width of line profile (short axis) can be changed from near diffraction limited size to several millimeters. We recommend the use of a cylindrical lens or lens system with a focal length of $f=1.4\text{m}$.

4. Specification beam shaper lens GTH-4-2.2

input beam (at position of shaper)	TEM ₀₀ , diameter@1/e ² : 4 mm +/- 0.15 mm
necessary free aperture	always 2.2x beam diameter@1/e ² , along total beam path
full fan angle of Top-Hat generation	2.2mrad
achievable Top Hat size @ 1/e ²	6.5x diffraction limited@1064nm, 13x diffraction limited@532nm
efficiency	> 95% of input energy within Top Hat profile
homogeneity	+/- 5 % (rel. to average intensity within Top Hat)
damage threshold	3 J/cm ² @ 532nm, 10 ns
lens material	LF5 (Schott glass, n= 1.5659 @1060 nm, 1.5848 @546 nm, 1.6192 @365 nm)
recommended wavelength range	400...1550 nm
lens diameter	(12.0 -0.1) mm
lens thickness	(4.0 +/- 0.1) mm
clear aperture of lens	11.0 mm
AR/AR coating	@ (400-700)nm, (700-1300)nm, 1064nm, 532nm
beam shaper mounted in ring holder, diameter 1 inch	
accessories: adjustable x-y holder (990-0050), beam expander	