

Technical Description and Application Examples

FBS2 Top Hat Beam Shaper

1. FBS2 – Top-Hat Beam Shaper

Diffractive Beam Shaping Concept based on Fourier methods;

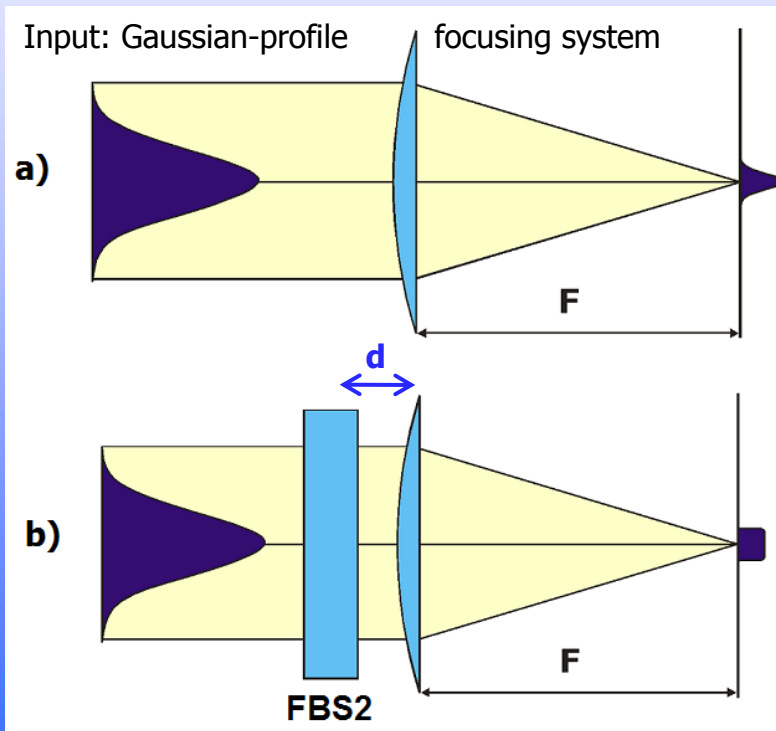
FBS2 -> **F**undamental **B**eam **M**ode **S**haper **2**nd generation

→ increased DOF and optimized square footprint

Transforming Gaussian TEM₀₀ beam into square or round homogeneous Top-Hat profile;

Top Hat size is near diffraction limit and is given by: $\sim \lambda / \text{NA}$;

Achievable Top Hat sizes: **1 μm – 200 μm**



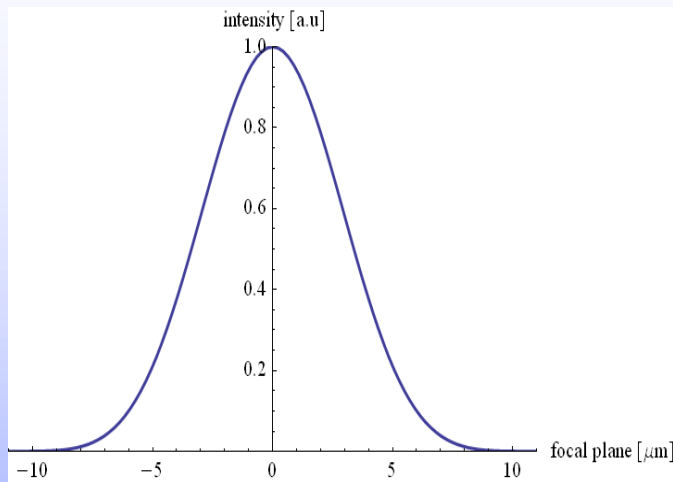
without FBS2 Beam Shaper: Gaussian-profile at focal plane

with FBS2 Beam Shaper: Top-Hat-profile at focal plane

- FBS2 works together with focusing system (FS)
- Top Hat size just depends on wavelength (λ) and numerical aperture (NA) of focused beam
- distance d between FBS2 and FS up to several meters

2. Intensity distribution at focal plane - without and with FBS2 Top Hat beam shaper -

- without FBS2 shaper \Rightarrow diffraction limited Gaussian profile



Main FBS2 advantages:

- smallest achievable Top-Hat size:
 \approx always 1,5x of diffraction limited Gaussian-spot @ $1/e^2$

- achievable Top Hat profiles:
square

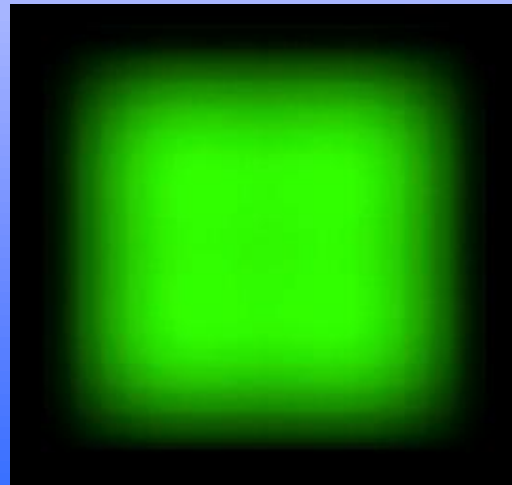
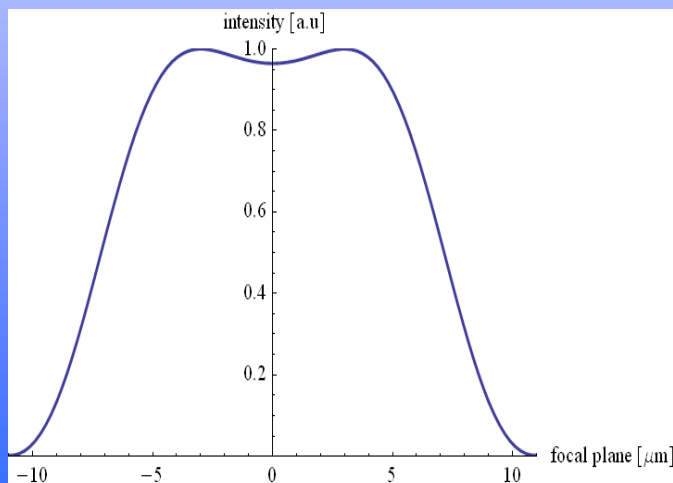
- diffraction efficiency:
> 95% of energy in Top Hat

- homogeneity:
modulation < (+/-) 2,5%

- depth of focus:
similar as for Gaussian beam

- insensitive to misalignment, ellipticity and input diameter variation:
(+/-) 5-10%

- with FBS2 shaper \Rightarrow near diffraction limit Top Hat profile



3. Optical setup for FBS2 Top-Hat beam shaper - setup overview -

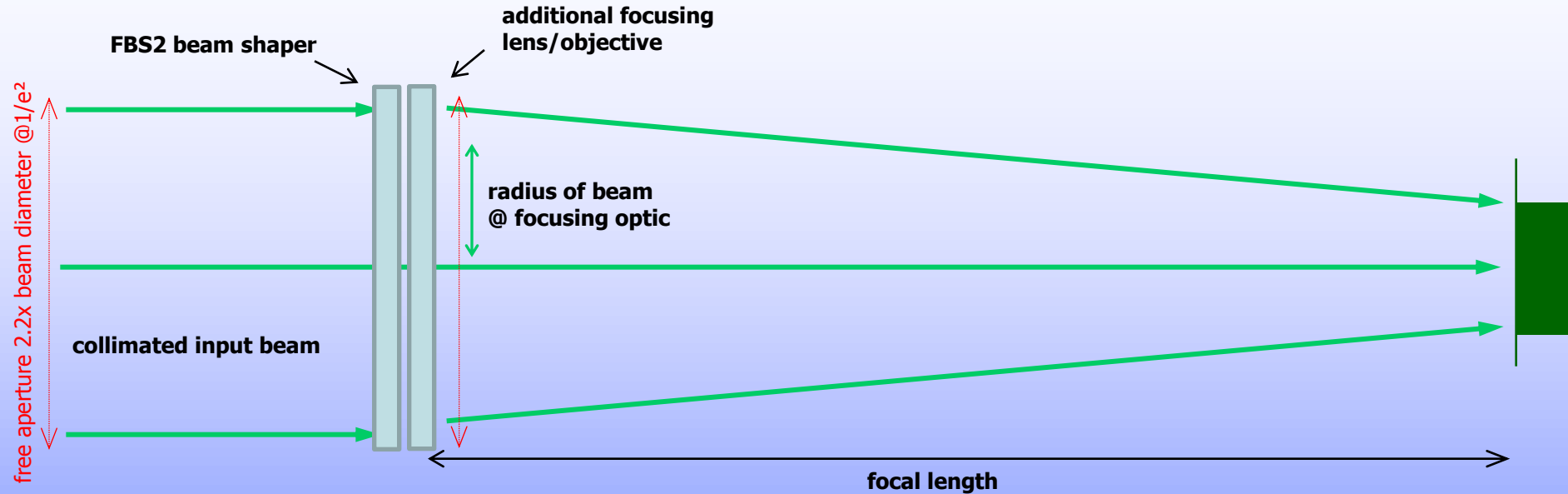
There are different possibilities to integrate the FBS2 beam shaper into an optical setup:

- a. Beam shaper directly in front of a focusing optic/objective
- b. Beam shaper in front of a beam expander
- c. Beam shaper within a beam expander

Independent of optical setup the user has to consider that:

- The free aperture along the total beam path have to be at least 2.2x (better 2.5x) bigger than the beam diameter @ $1/e^2$
- The Top Hat size is always given by: $\frac{\lambda}{NA}$
 λ is the used wavelength;
NA is the numerical aperture of focused beam and is given by: $\frac{\text{beam radius @ focusing optic}}{\text{focal length of focusing optic}}$

3a. Optical setup for FBS2 Top-Hat beam shaper - beam shaper in front of focusing optic -

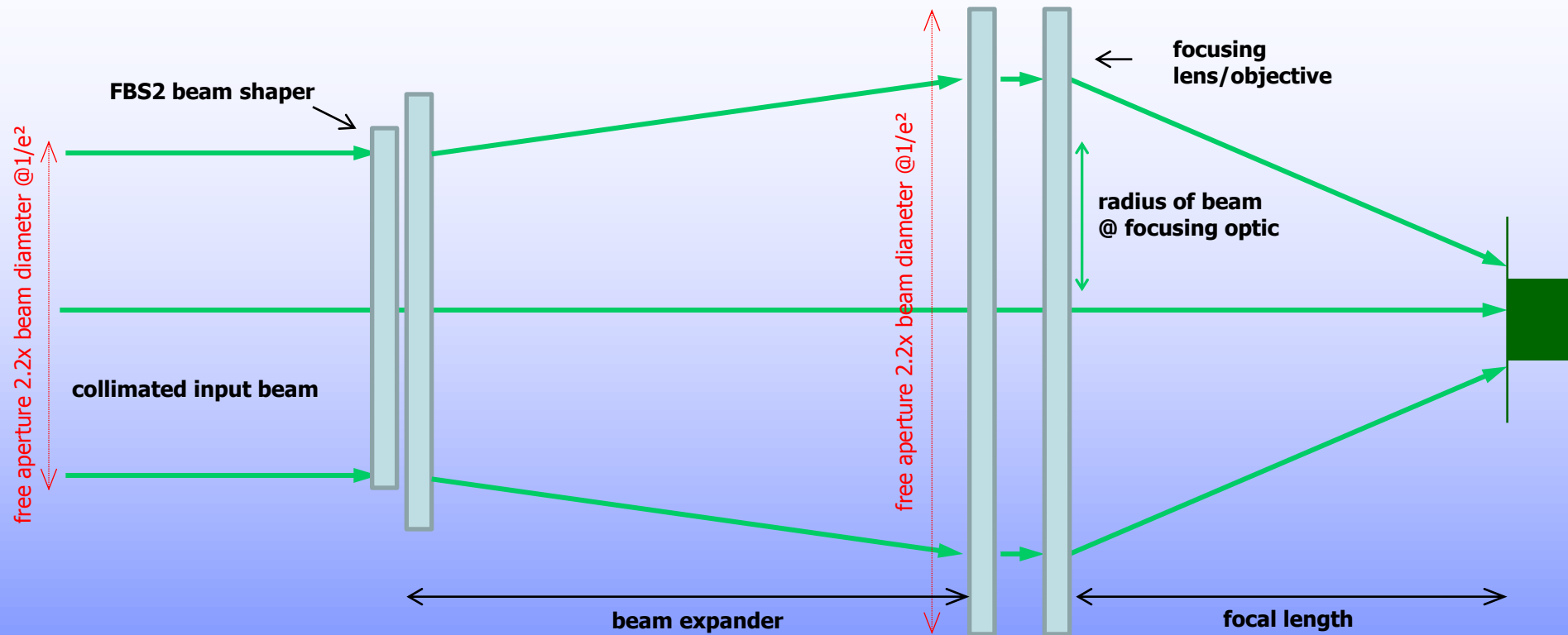


By introducing the FBS2 beam shaper into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a homogeneous Top-Hat profile.

When a Gaussian TEM₀₀ input beam with a diameter of 5mm@ $1/e^2$ is used the diameter of the free aperture along the total beam path have to be at least 11mm (better 13mm).

If for example a wavelength with 532nm, a Gaussian TEM₀₀ input beam with a diameter of 5mm@ $1/e^2$ and a focusing lens with $f=160\text{mm}$ is used, ones will get a homogeneous Top Hat profile with a diameter of 34 μm .

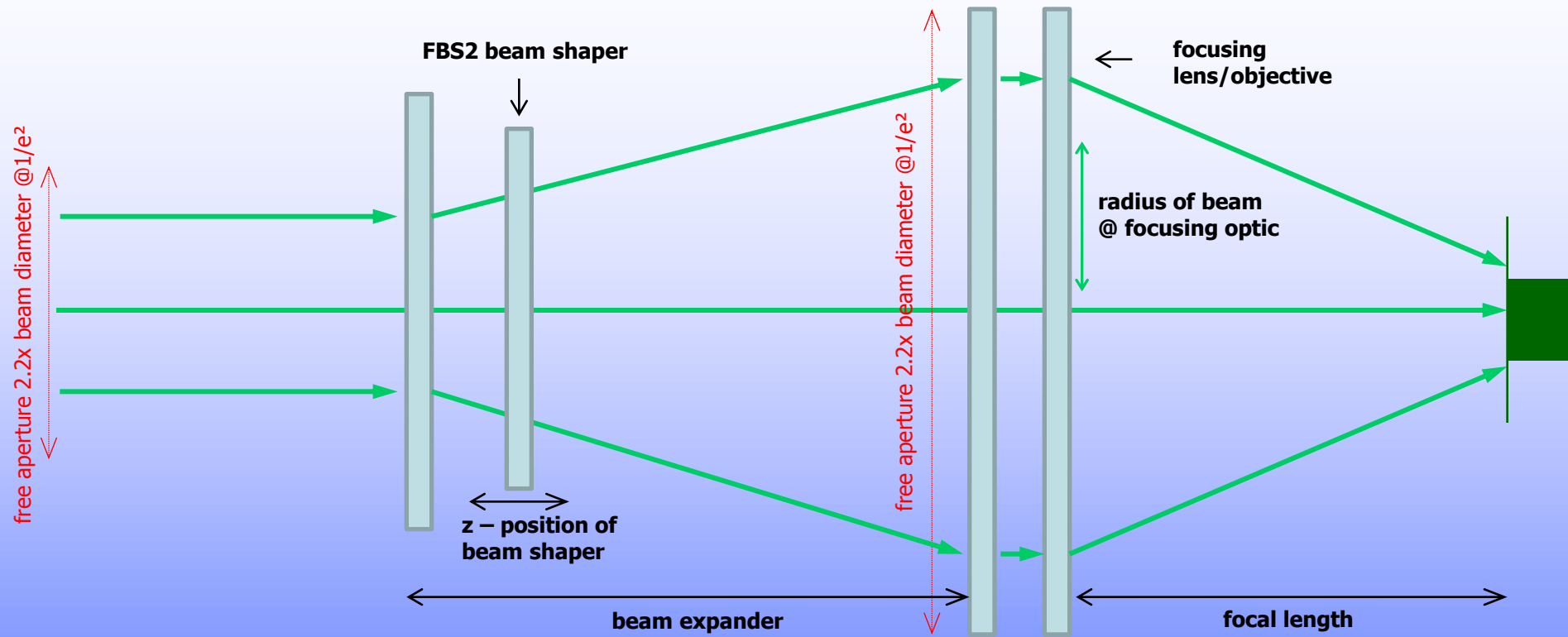
3b. Optical setup for FBS2 Top-Hat beam shaper - beam shaper in front of beam expander -



There is also the possibility to introduce the FBS2 beam shaper into the beam path in front of a beam expander. This leads to a higher numerical aperture of focused beam and to a smaller Top Hat profile.

Example: A Gaussian beam with a diameter of $5\text{mm}@1/e^2$ illuminates the FBS2 beam shaper and is afterwards increased by a beam expander to a beam diameter of 8mm . With an focusing optic with $f=50\text{mm}$ the user can generate a Top Hat with a diameter of $7\mu\text{m}$. The needed free aperture increases with the expanded beam. For a beam with a diameter of 8mm the free aperture have to be at least 18mm .

3c. Optical setup for FBS2 Top-Hat beam shaper - beam shaper within beam expander -



A further and even more flexible possibility is to introduce the FBS2 beam shaper 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 FBS2 beam shaper by shifting the shaper along z-axis.

Specifications of FBS2 Top Hat beam shaper

material:	fused silica	
diameter:	25.4 mm	tolerance +/- 0.1 mm
input beam:	TEM ₀₀ , different models for diameter@1/e ² : 2.0, 3.0 ... or 10 mm	tolerance +/- 5 %
necessary free aperture:	2.2x (or better 2.5x) beam diameter@1/e ²	along total beam path
Top Hat size:	1,5x diffraction limited Gaussian spot	square form (round optional)
homogeneity:	+/- 2.5%	rel. to average intensity within tophat
wavelength:	different models for: 1064nm, 532nm or 355nm	others on request
transmission:	> 99%	AR/AR coating
efficiency:	> 90 %	of input energy within tophat profile
damage threshold:	4 J/cm ² @ 532nm, 10 ns	
recommendation:	x/y-adjustment mount HSF02	free aperture: 23 mm
accessories:	beam expander	