

# Technical Description and Application Examples

## FBSR Top Hat Beam Shaper

# 1. FBSR – Top-Hat Beam Shaper

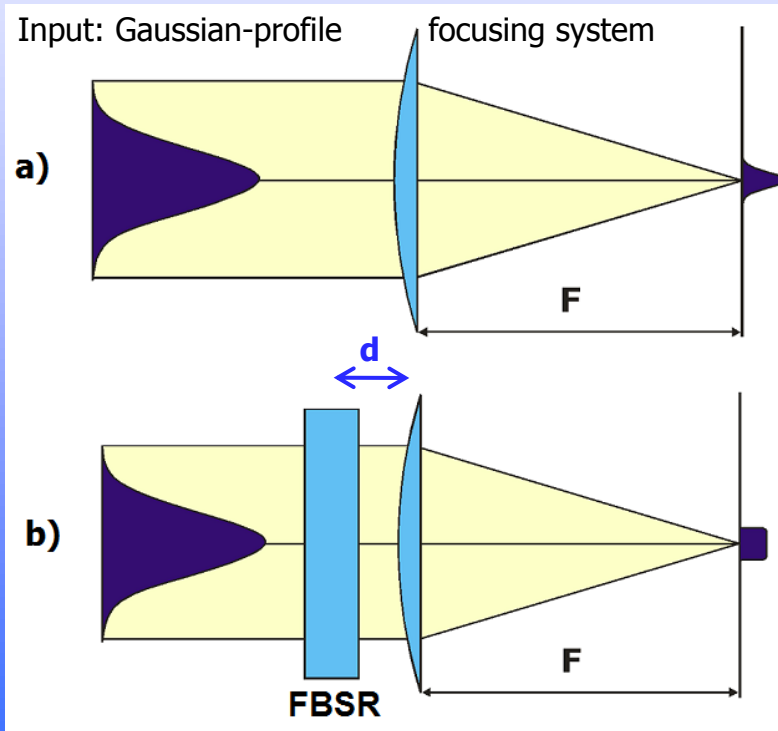
Diffraction Beam Shaping Concept based on Fourier methods;

**FBSR** -> **F**undamental **B**eam **M**ode **S**haper for **R**ound **T**op **H**at profiles

Transforming Gaussian TEM<sub>00</sub> 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 $\mu\text{m}$  – 200 $\mu\text{m}$**



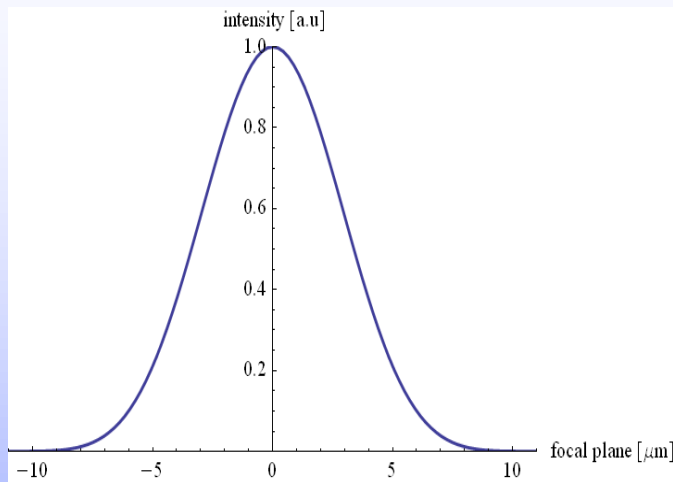
without FBSR Beam Shaper: Gaussian-profile at focal plane

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

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

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

- without FBSR shaper  $\Rightarrow$  diffraction limited Gaussian profile



### Main FBSR advantages:

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

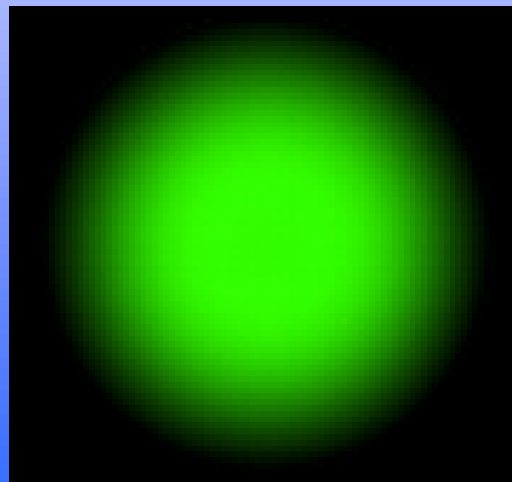
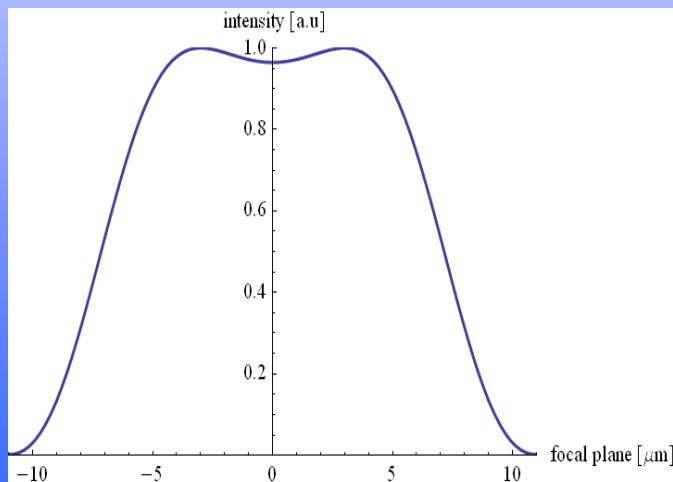
- achievable Top Hat profiles:  
round

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

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

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

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



### 3. Optical setup for FBSR Top-Hat beam shaper - setup overview -

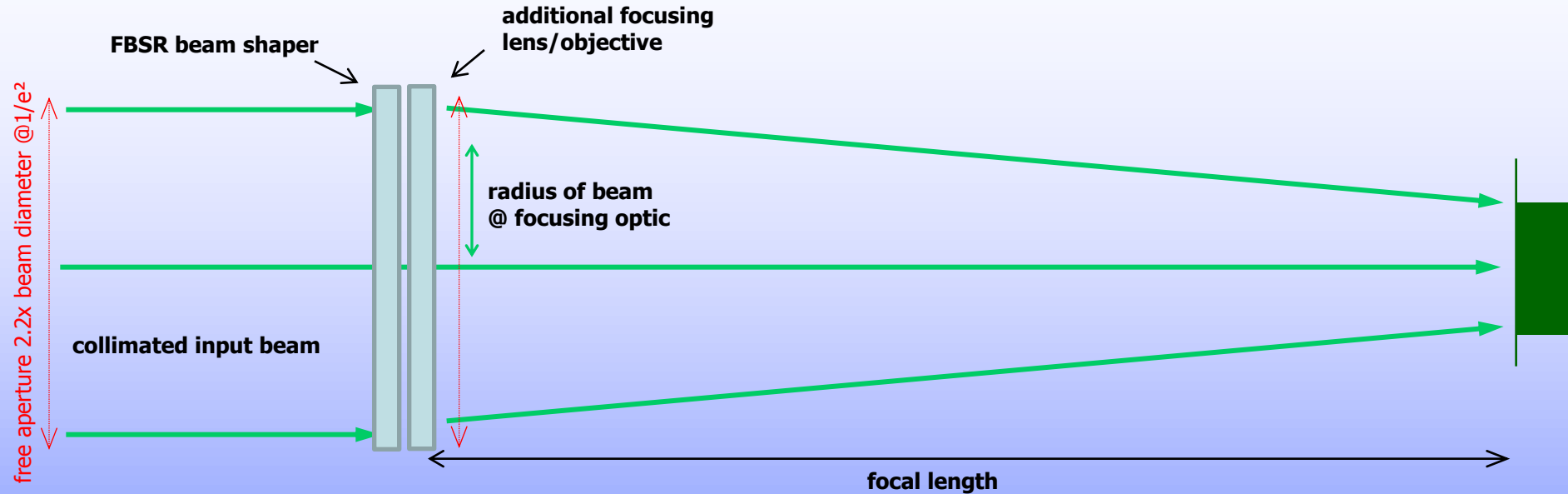
There are different possibilities to integrate the FBSR beam shaper into an optical setup:

- 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:  $\frac{\lambda}{NA}$   
 $\lambda$  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 FBSR Top-Hat beam shaper - beam shaper in front of focusing optic -

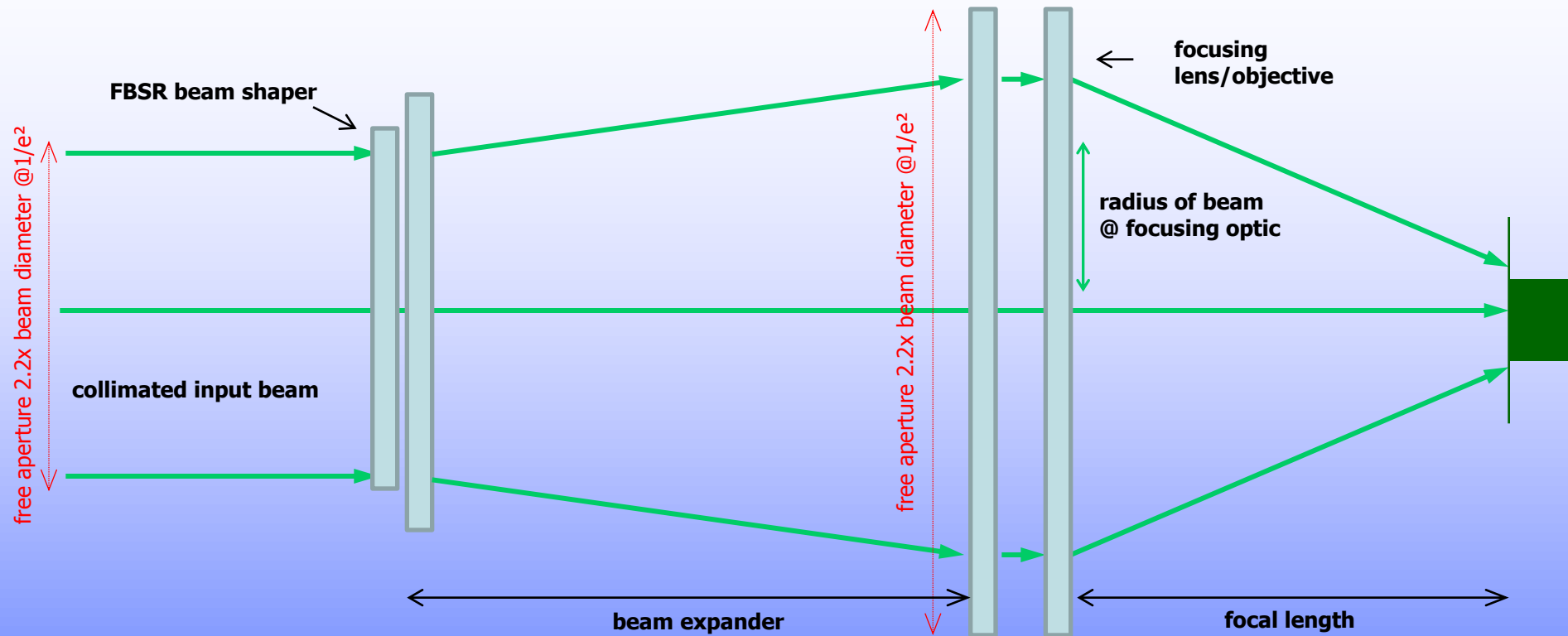


By introducing the FBSR beam shaper into the beam path in front of a lens/objective the initial diffraction limited Gaussian spot will be transformed into a homogeneous Top-Hat profile.

When a Gaussian TEM<sub>00</sub> 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 TEM<sub>00</sub> 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 $\mu\text{m}$ .

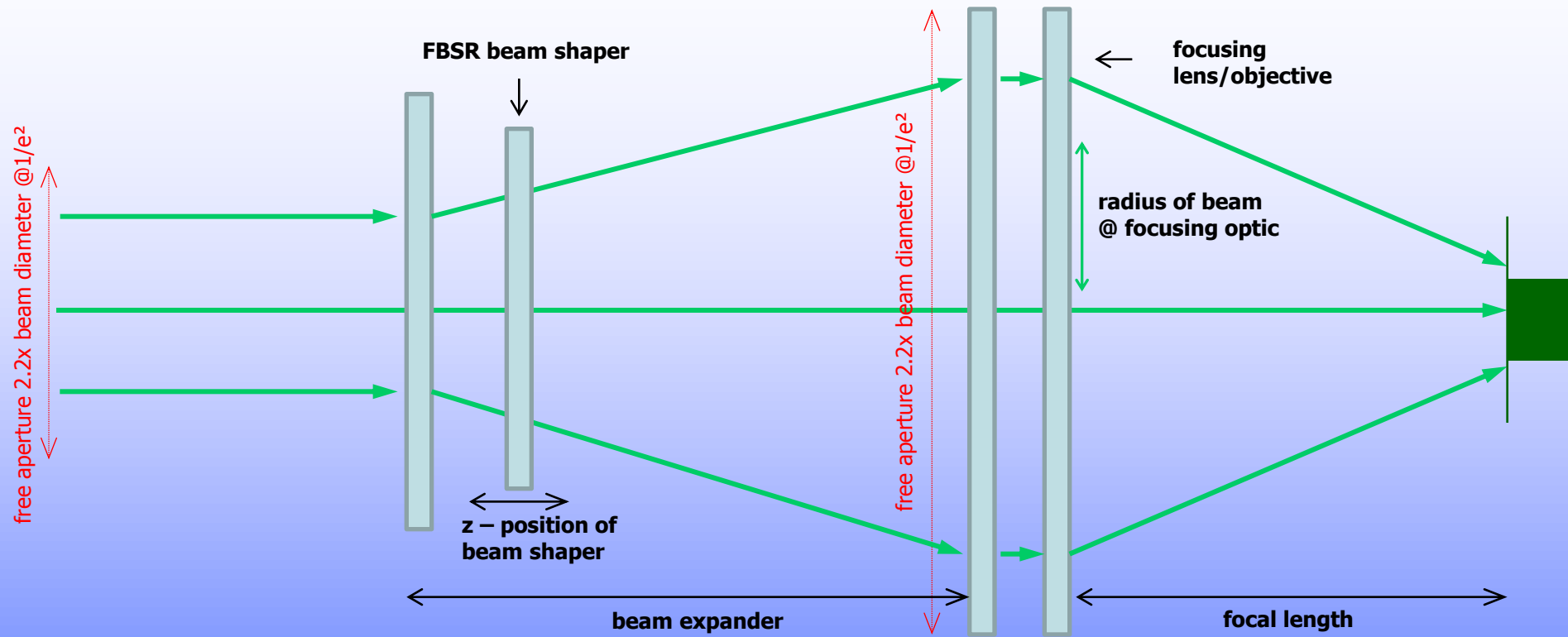
## 3b. Optical setup for FBSR Top-Hat beam shaper - beam shaper in front of beam expander -



There is also the possibility to introduce the FBSR 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 5mm@1/e<sup>2</sup> illuminates the FBSR beam shaper and is afterwards increased by a beam expander to a beam diameter of 8mm. With an focusing optic with f=50mm the user can generate a Top Hat with a diameter of 7µm. 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 FBSR Top-Hat beam shaper - beam shaper within beam expander -



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

## Specifications of FBSR Top Hat beam shaper

material:	fused silica	
diameter:	25.4 mm	tolerance +/- 0.1 mm
input beam:	TEM <sub>00</sub> , different models for diameter@1/e <sup>2</sup> : 2.0, 3.0 ... or 10 mm	tolerance +/- 5 %
necessary free aperture:	2.2x (or better 2.5x) beam diameter@1/e <sup>2</sup>	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:	> 95 %	of input energy within tophat profile
damage threshold:	4 J/cm <sup>2</sup> @ 532nm, 10 ns	
recommendation:	x/y-adjustment mount HSF01	free aperture: 23 mm
accessories:	beam expander	