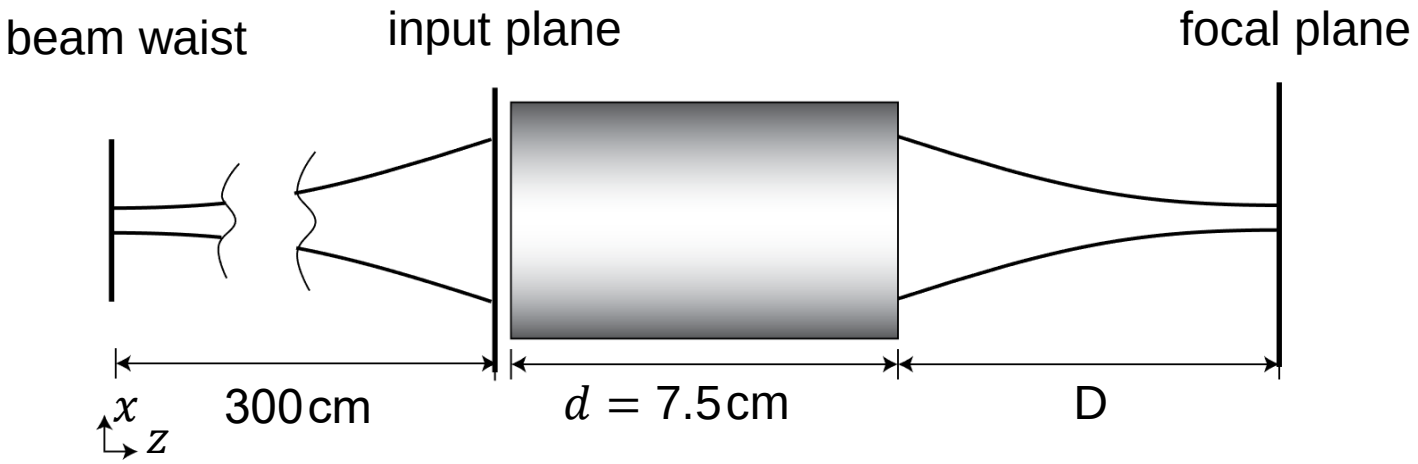
Laser Systems > Beam Delivery System

Gaussian Beam Focused by Thermal Lens

Task/System Illustration

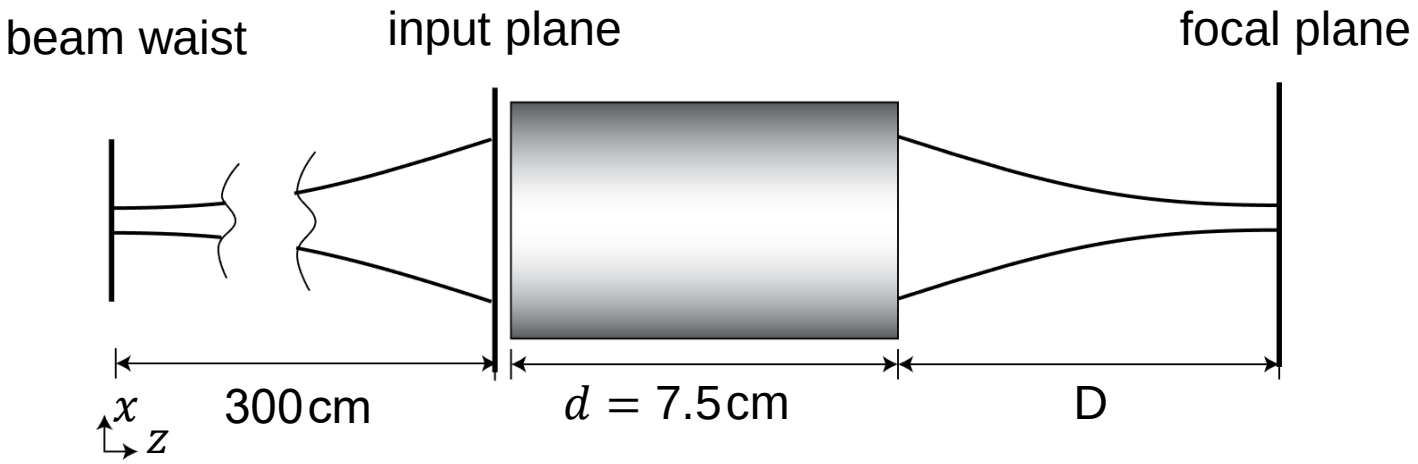


- simulation of a Gaussian beam focused by thermal lens effect induced by a high power laser.
- the refractive index $n(x, y)$ of the thermal lens changes with varying input power.

Highlights

- arbitrarily customizable refractive index profile
- using the Parameter Run document, users can simulate conveniently one system with varying parameters
- combination of different field tracing techniques

Specifications: Light Source



Parameter	Description / Value
coherence/mode	single Laguerre Gaussian (0,0) and (1,0) mode
wavelength	632.8 nm
polarization	linear in x-direction (0°)
beam waist radius	simulation 1: (0,0) mode: 760 µm
	simulation 2: (1,0) mode: 1 mm

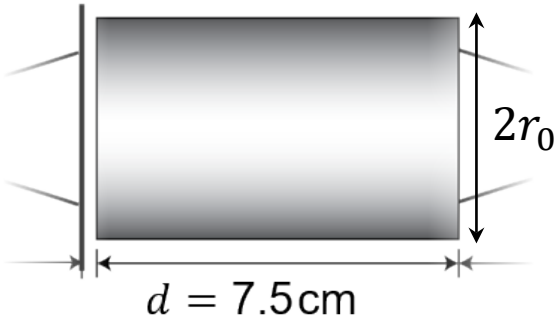
Specifications: Thermal Lens

- Refractive index is

$$n(x,y) = n_0 - \frac{\eta P_{\text{in}}}{4K\pi d} \cdot \frac{\delta n}{\delta T} \cdot \frac{r^2}{r_0^2}$$

with $r = \sqrt{x^2 + y^2}$, r_0 and d are shown in the figure, P_{in} is input power, K, η and $\frac{\delta n}{\delta T}$ are temperature-related parameters which can be found in [1]

- Here the values are
  - $r_0 = 0.31\,\text{cm}$, $d = 7.5\,\text{cm}$
  - $K = 11.1$ W/(cm°C), $\eta = 0.05$, $\frac{\delta n}{\delta T} = 7.3 \times 10^{-6}\,°\text{C}^{-1}$

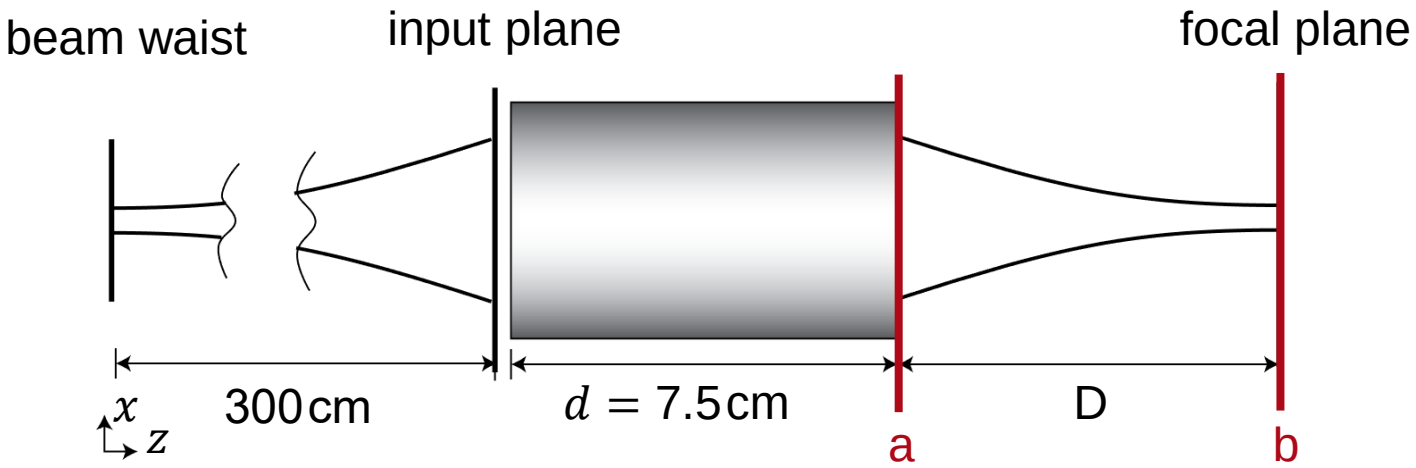


Highlight

arbitrarily customizable refractive index profile

[1] W. Koechner, “Thermal lensing in a nd:yag laser rod,” Appl. Opt. **9**, 2548–2553 (1970).

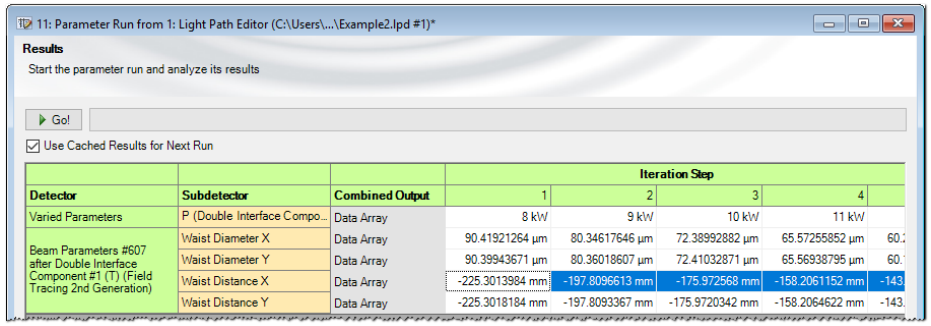
Specifications: Detector



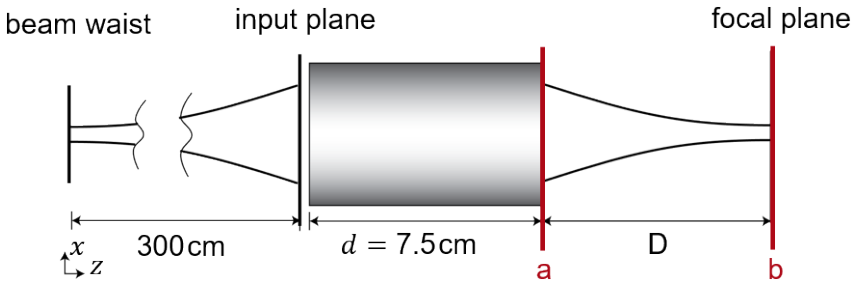
Position	Modeling Technique	Detector/Analyzer
a	field tracing	beam parameters for different input beams and input power values
b	field tracing	amplitude of E_x, E_y, E_z when input is (1,0) mode

Results: (0,0) Mode

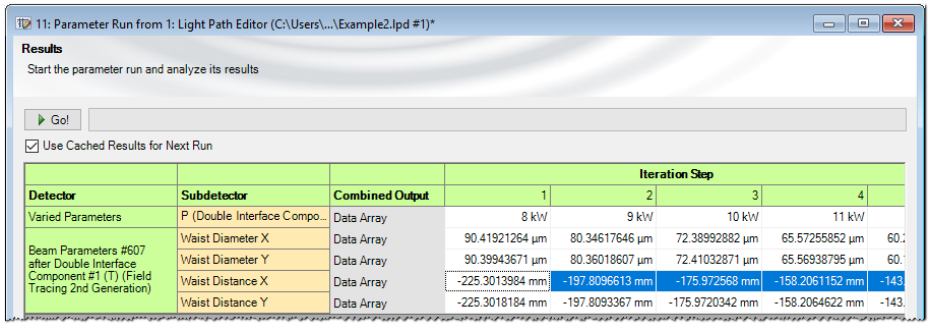
- Using the *Parameter Run* document, one can calculate the output beam parameters for input powers varying from 8 kW to 20 kW. The detector is at position *a.*
  - Absolute value of *Waist Distance* (distance *a* with respect to *b*) is distance *D.*
  - *Waist Diameter* is the waist diameter in focal plane (position *b*).



Detector	Subdetector	Combined Output	Iteration Step 1	2	3	4	
Varied Parameters	P (Double Interface Compo...	Data Array	8 kW	9 kW	10 kW	11 kW	
Beam Parameters #607 after Double Interface Component #1 (T) (Field Tracing 2nd Generation)	Waist Diameter X	Data Array	90.41921264 µm	80.34617646 µm	72.38992882 µm	65.57255852 µm	60.
	Waist Diameter Y	Data Array	90.39943671 µm	80.36018607 µm	72.41032871 µm	65.56938795 µm	60.
	Waist Distance X	Data Array	-225.3013984 mm	-197.8096613 mm	-175.972568 mm	-158.2061152 mm	-143
	Waist Distance Y	Data Array	-225.3018184 mm	-197.8093367 mm	-175.9720342 mm	-158.2064622 mm	-143.



Results: (0,0) Mode



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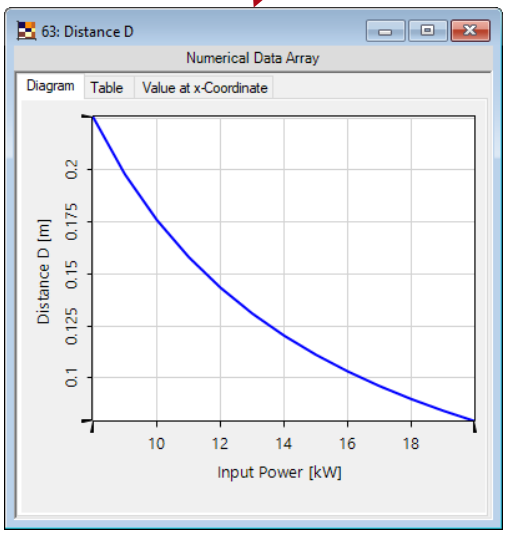
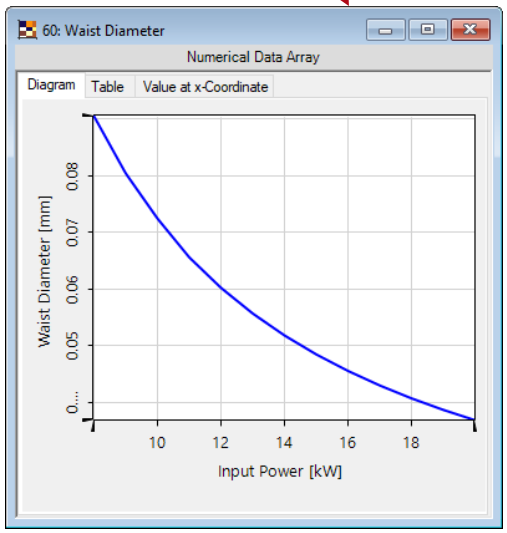
Highlight

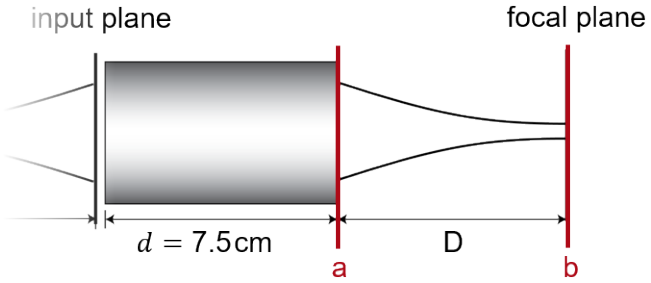
simulate conveniently one system with varying parameters



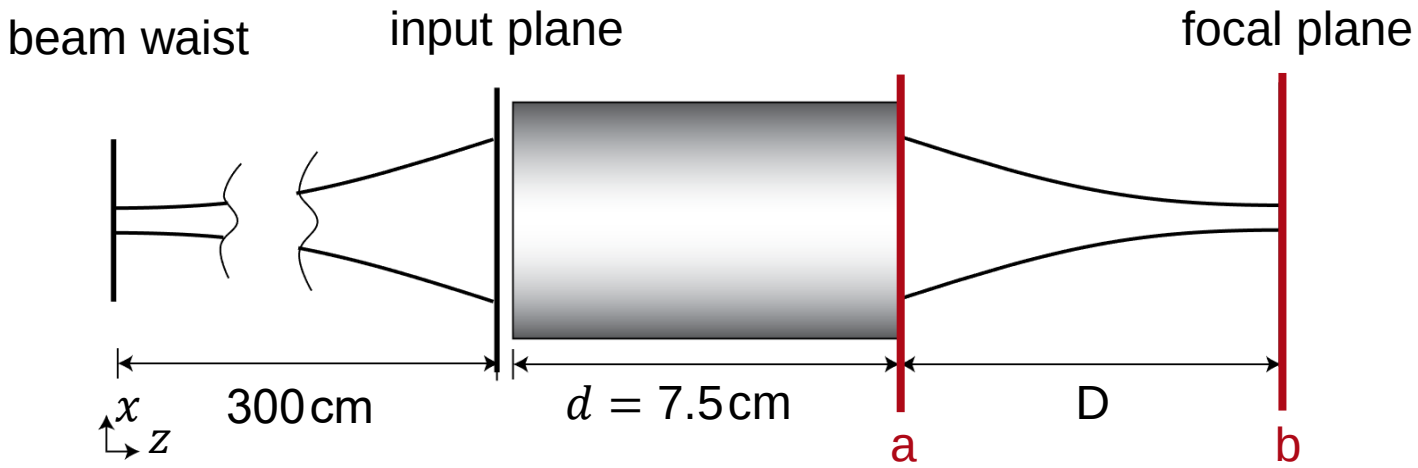
distance *D*



waist diameter at *b*



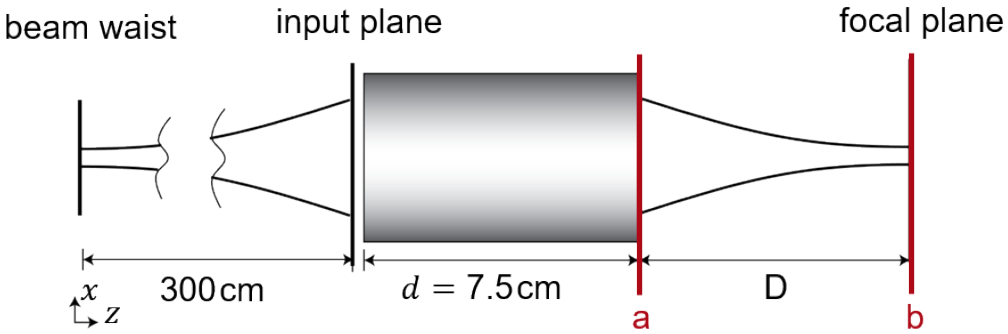
Results: (1,0) Mode



- For the thermal lens with applied 18 kW the simulated distance *D* is 91.0 mm.
- The technique to propagate fields through the thermal lens is described in [2].
- The technique to propagate fields from position *a* to *b* is diffractive propagation integral [3].

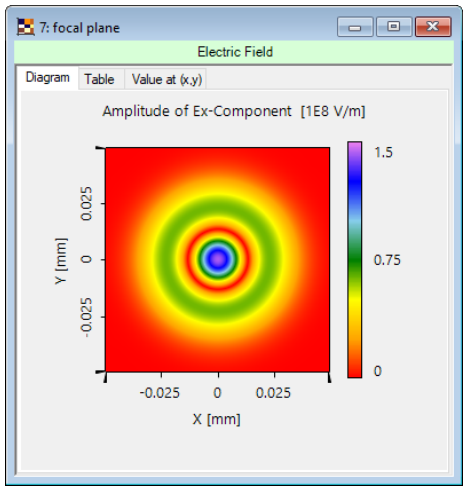
[2] H., Zhong, "Fast propagation of electromagnetic fields through Graded-Index Media," submitted in JOSA A
[3] F. Wyrowski, "Unification of the geometric and diffractive theories of electromagnetic fields," Proc. DGaO (2017).

Results: (1,0) Mode

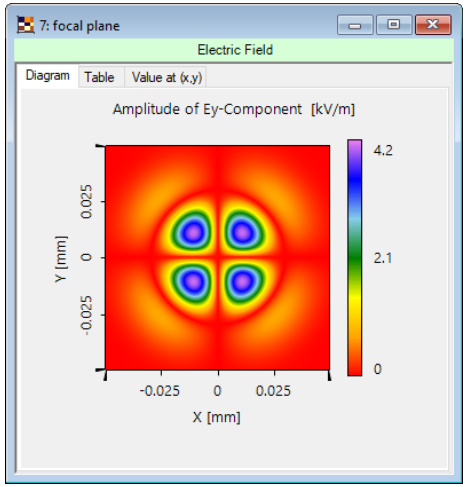


Highlight

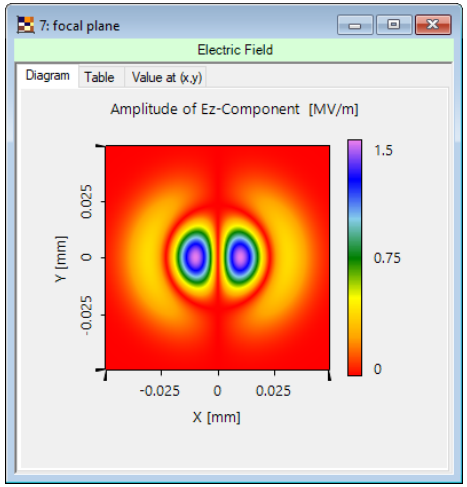
combination of different field tracing techniques



E_x



E_y



E_z

Document & Technical Info

code	BD.0008
version of document	1.0
title	Gaussian Beam Focused by Thermal Lens
category	Laser Systems > Beam Delivery Systems (BD)
author	Huiying Zhong (LightTrans)
used VL version	7.0.1.12

Specifications of PC Used for Simulation	
Processor	i7-5600U (2 CPU cores)
RAM	12 GB
Operating System	Windows 10