Investigation of Focus Shift due to Thermal Lensing

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für Bildung
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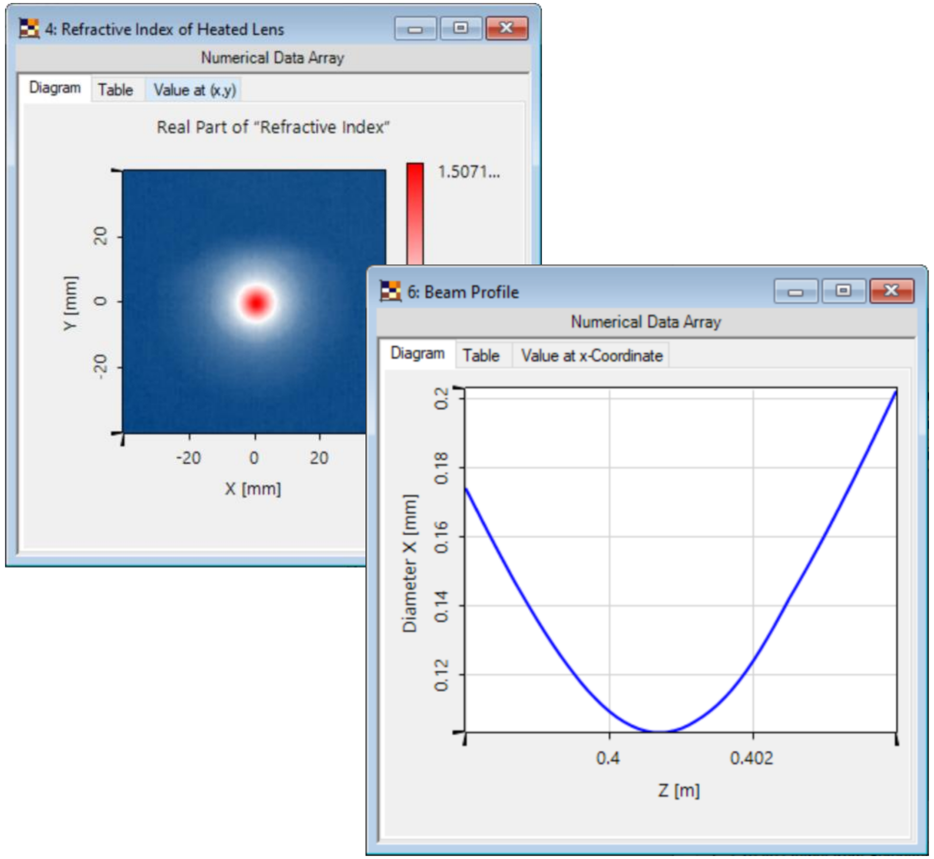
Abstract

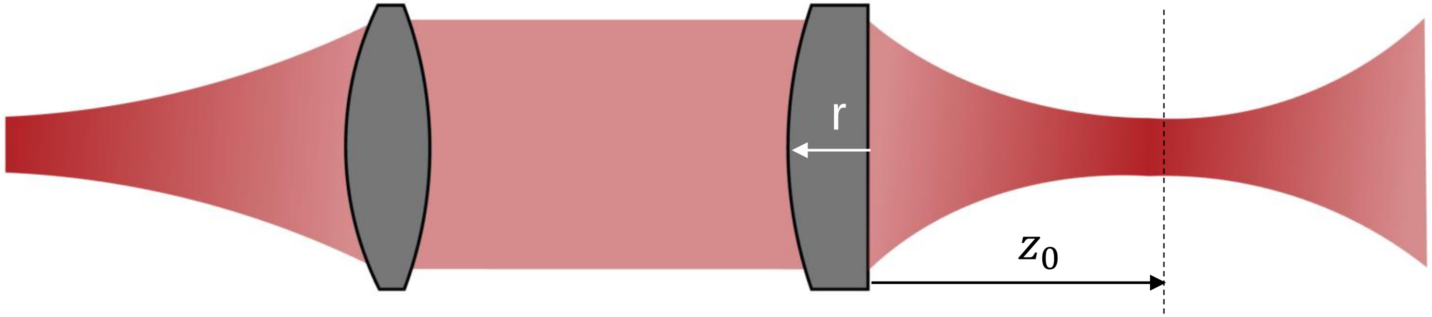


The advance of material processing technologies leads to more and more applications which utilize high-power laser sources. This generates a significant amount of heat in the individual components in the optical system which may introduce various optical effects such as the thermal lensing effect which will shift the focal length in a lens. In this use case, we demonstrate the focus shift generated by thermal lensing inside a focusing lens. The thermal lensing effect itself is defined by imported deformed surfaces and an inhomogeneous media which is calculated according to imported temperature data.

Modeling Task

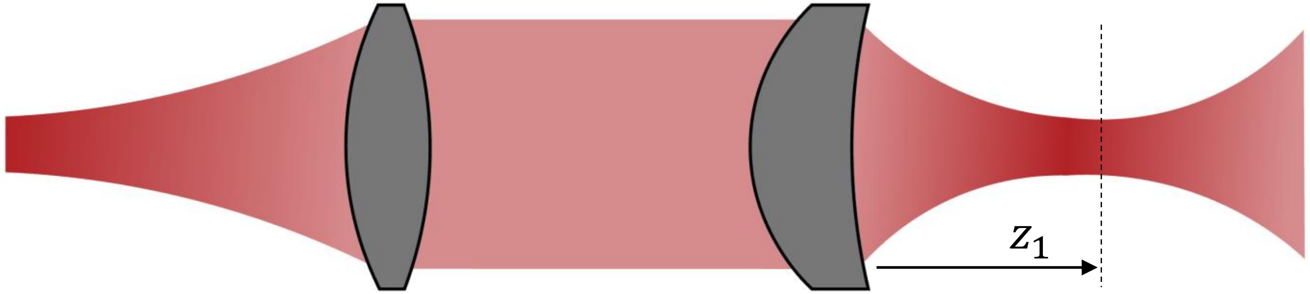
Lens
- Convex-plane
- r = 10 mm (without deformation)
- Material: bk7

a) Reference system



b) System with thermal effects

Gaussian wave
- 1070 nm wavelength
- 6° divergence
- 100 W power



Ideal collimation lens

Deformed lens

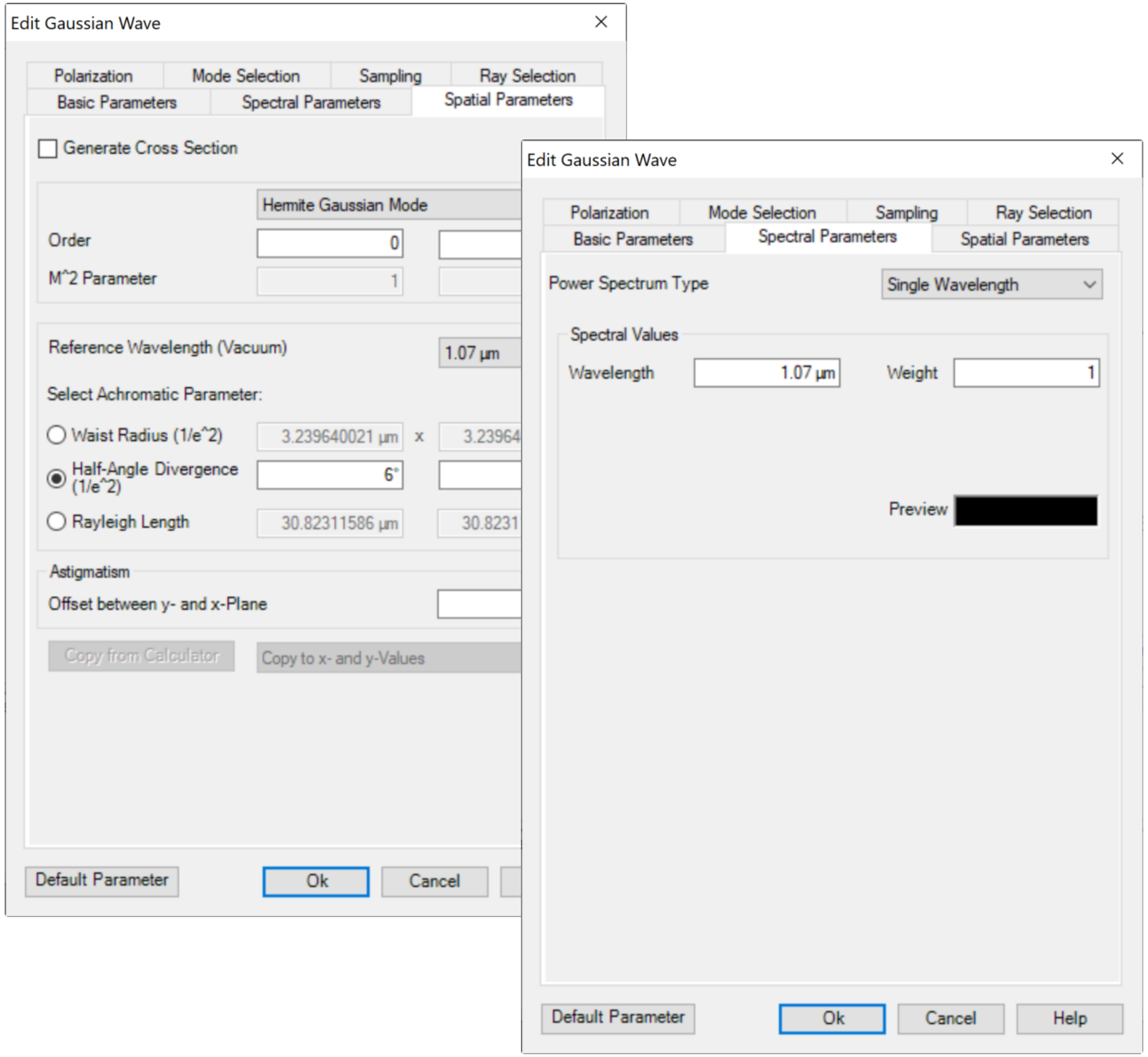
Simulation task:
Comparing the lens focus and focal spot of the heated lens with the unheated reference system

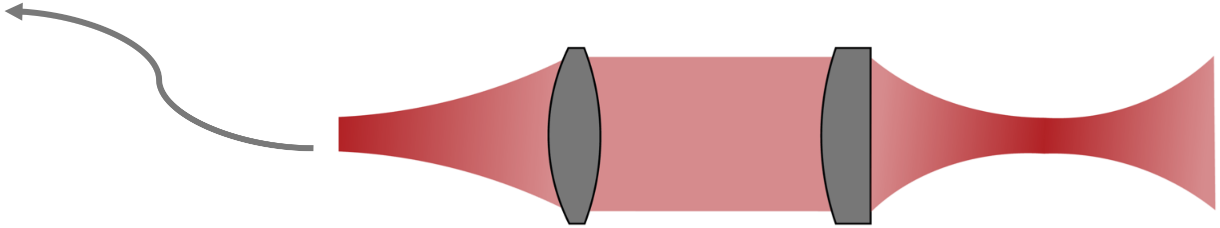
Temperature distribution and surface deformation have been calculated and exported via Ansys Mechanical(*).

(*) Ansys Inc, Ansys Mechanical (R1 2021) [Software]. 2021. https://www.ansys.com/

Building the System in VirtualLab Fusion

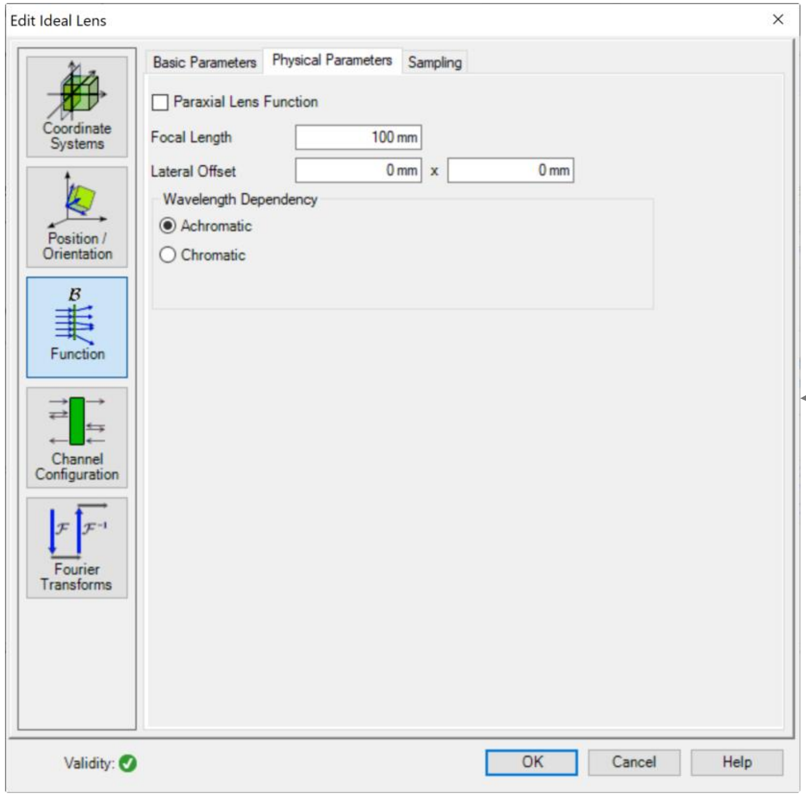
System Building Blocks - Source



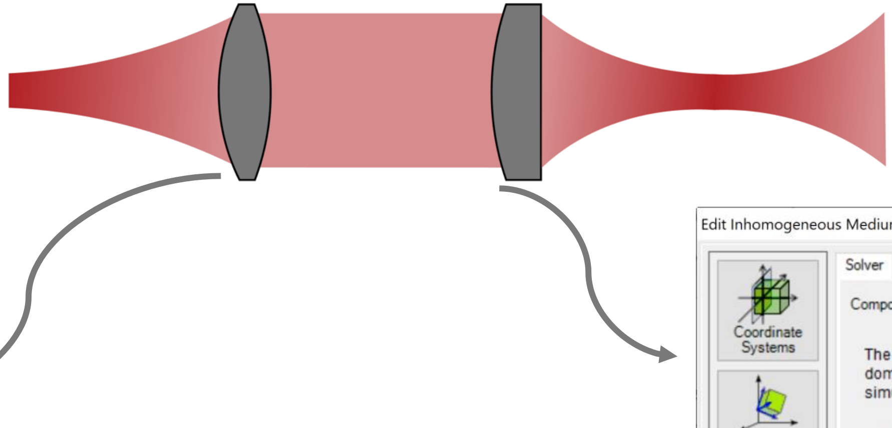


The Gaussian source model allow for a definition of a spatial Gaussian. The user can choose if the Gaussian shall be defined by its waist radius, divergence or Rayleigh length.

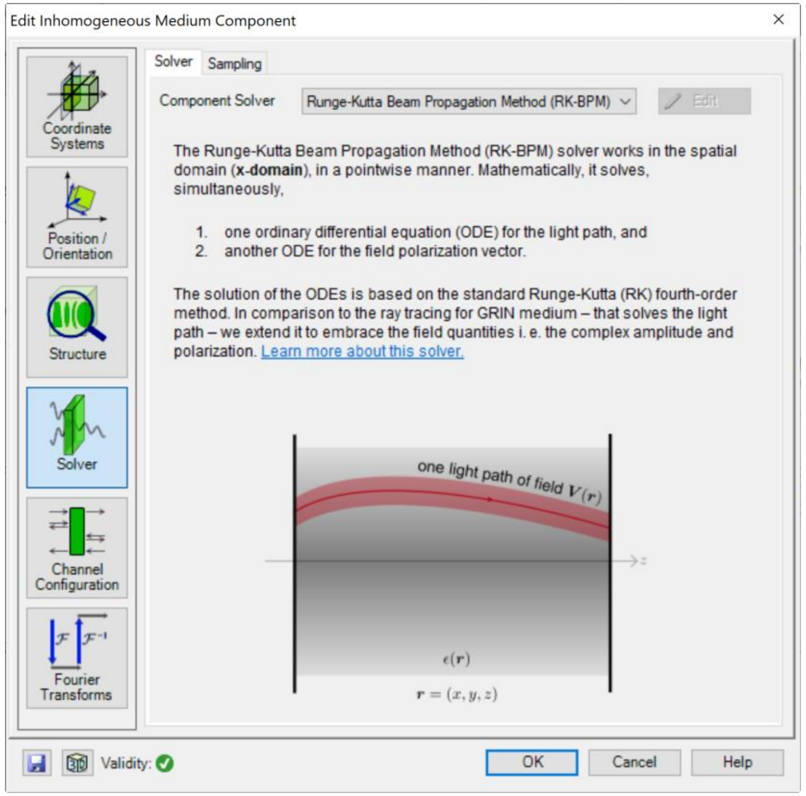
System Building Blocks - Components



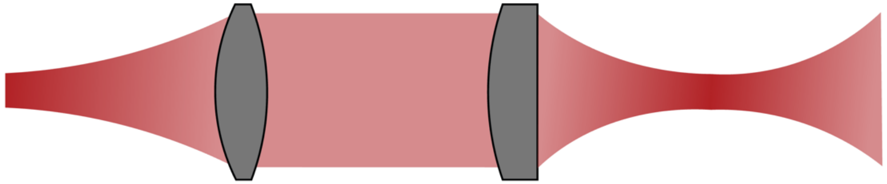
An ideal lens component is used to collimate the source. There are no thermal effects applied to the collimation lens.



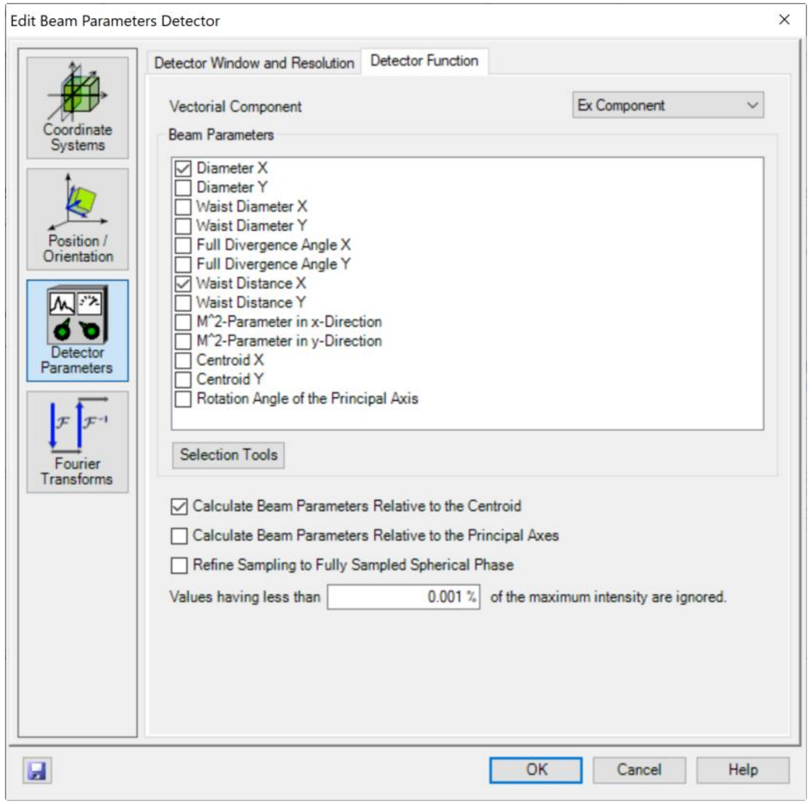
The heated lens is represented by an inhomogeneous media.
The temperature-dependent refractive index is calculated according to the imported temperature data.

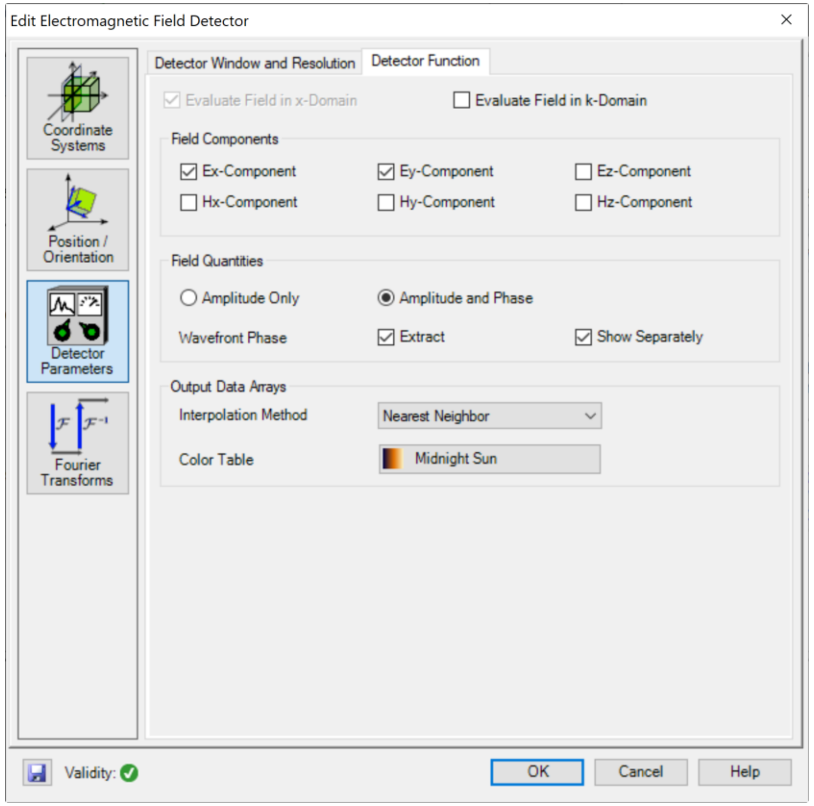


System Building Blocks - Detectors

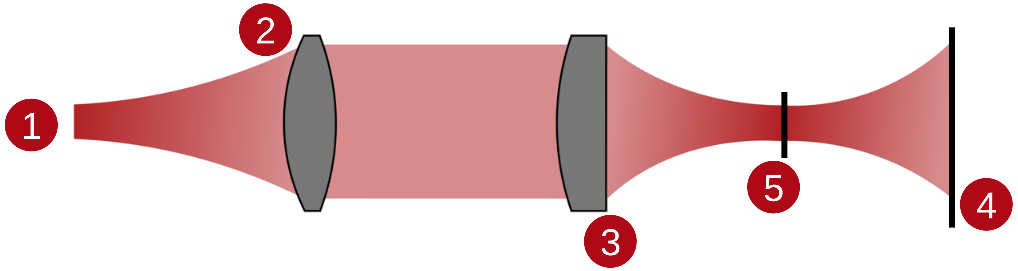


To determine the focal position, Beam Parameters Detectors applies the second moment theory, whereas the actual focal spot can be visualized by Electromagnetic Field Detector.



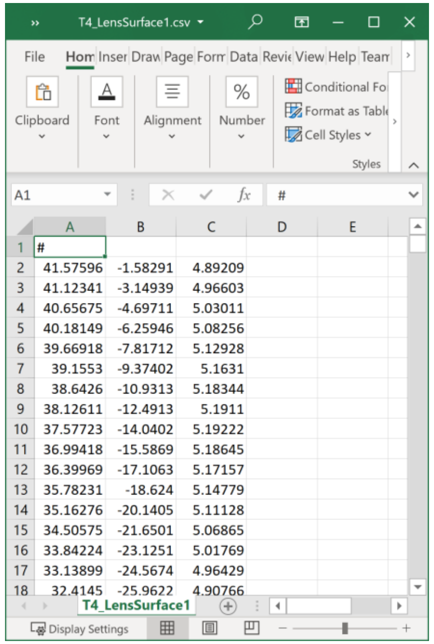


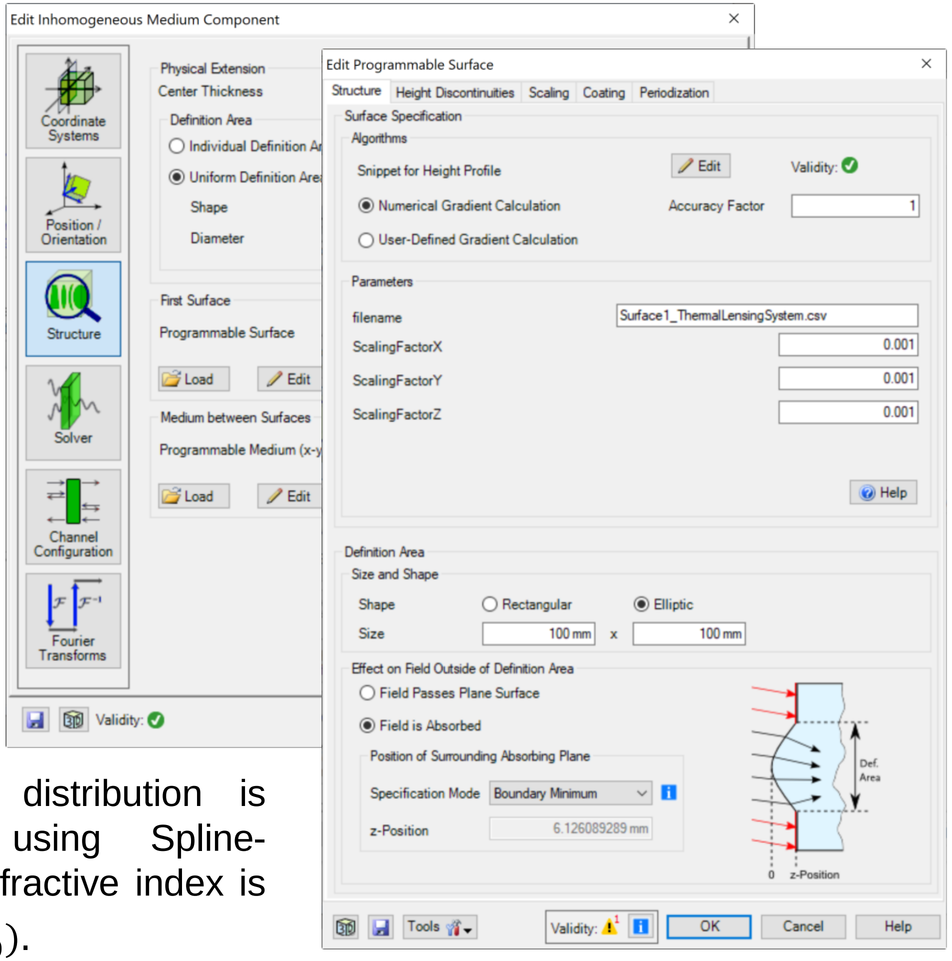
Summary – Components ...

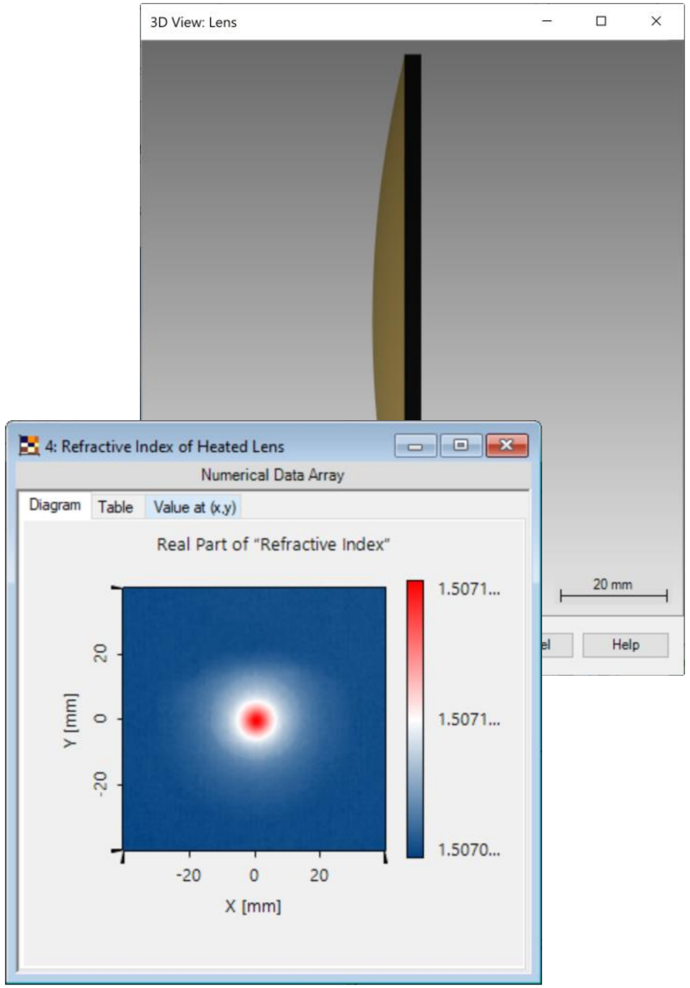


… of Optical System	… in VirtualLab Fusion	Source Model/Component Solver
1. Source	Gaussian Wave	Spatial Gaussian Function
2. Collimation Lens	Ideal Lens	Wavefront Response
3. Lens with Thermal Lensing	Inhomogeneous Component	RK-BPM & Local Plane Interface Approximation
4. Detector	Beam Parameter Detector	-
5. Detector	Camera Detector	-

Data Import





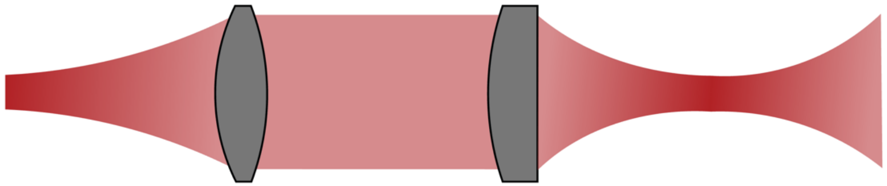


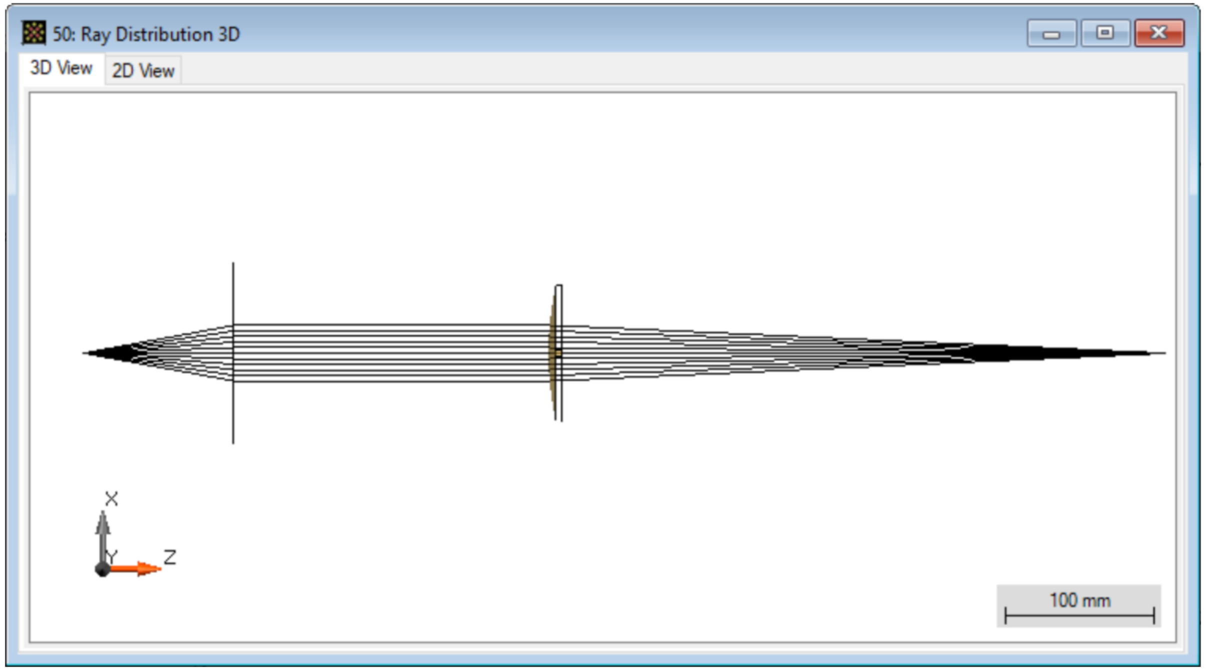
The surfaces and temperature distribution is imported from point clouds using Spline-Interpolation. The change in the refractive index is calculated by $n(T) = n_0 + \frac{dn}{dT}(T - T_0)$.

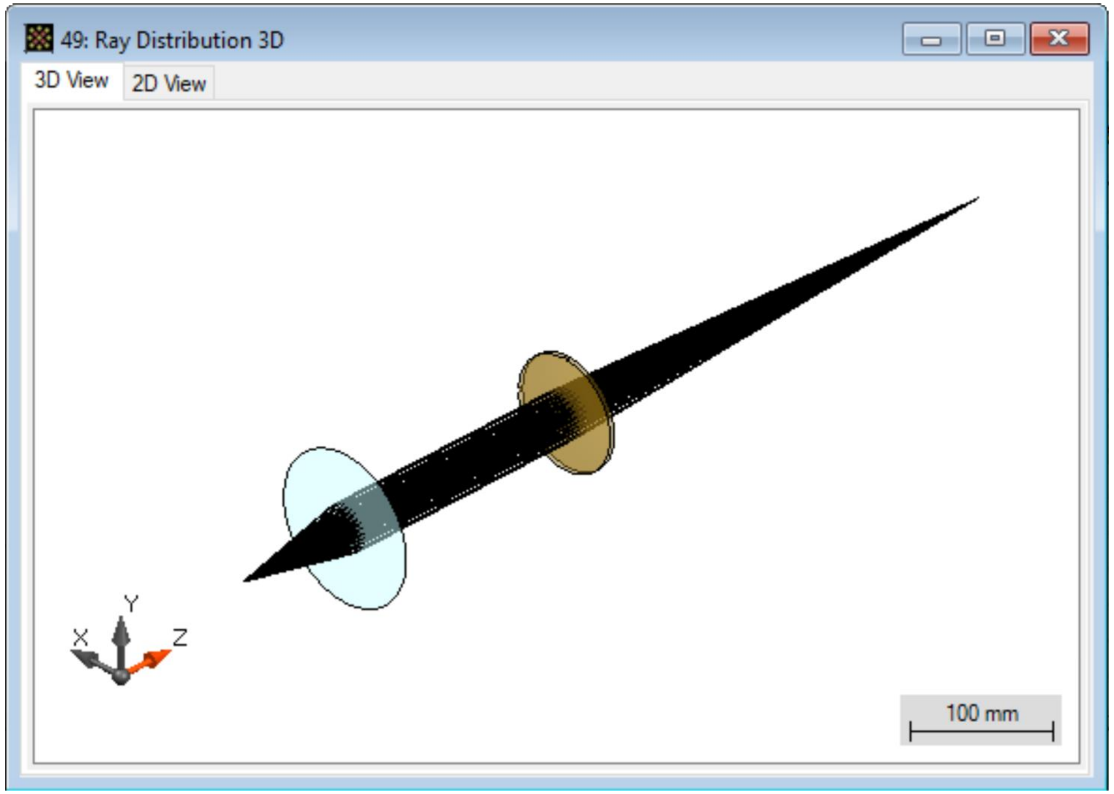
Please save the import files in the same directory as the os-files or adjust the „filename“ parameter.

Simulation Results

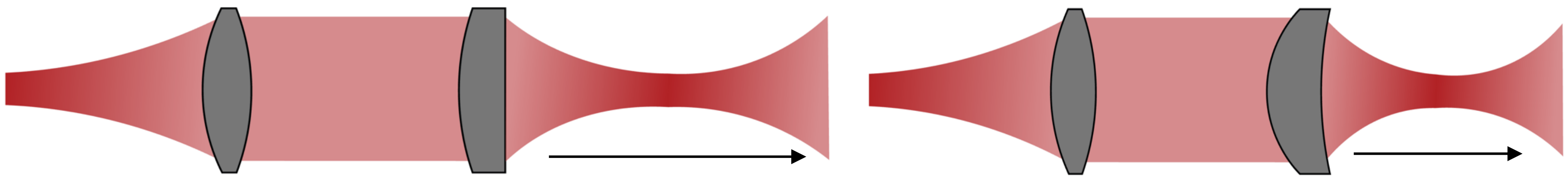
Ray Tracing Result

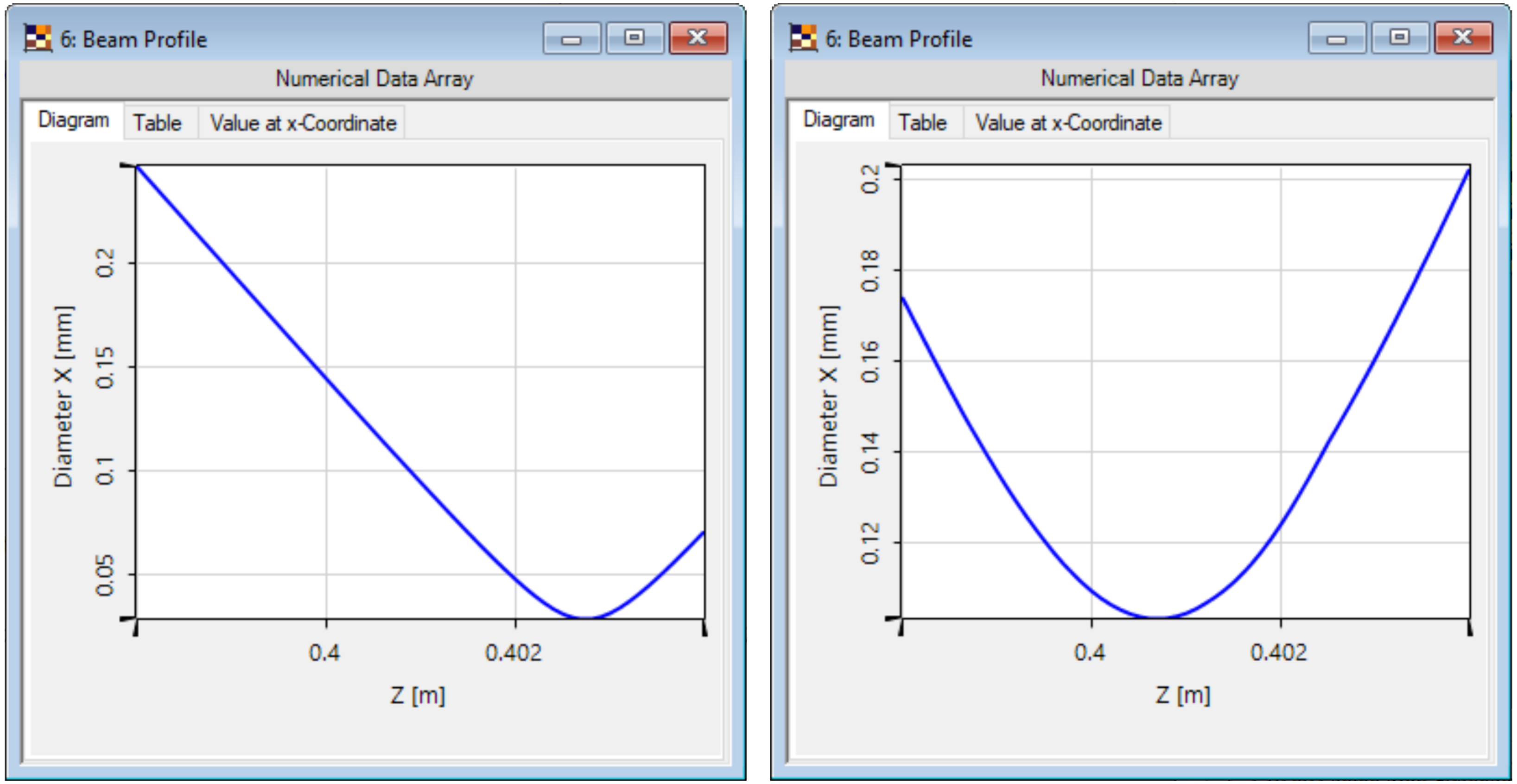






Field Tracing Result - Focus Shift

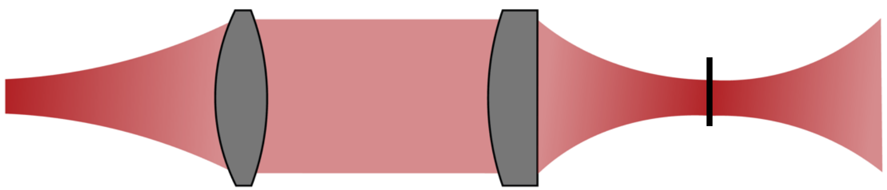




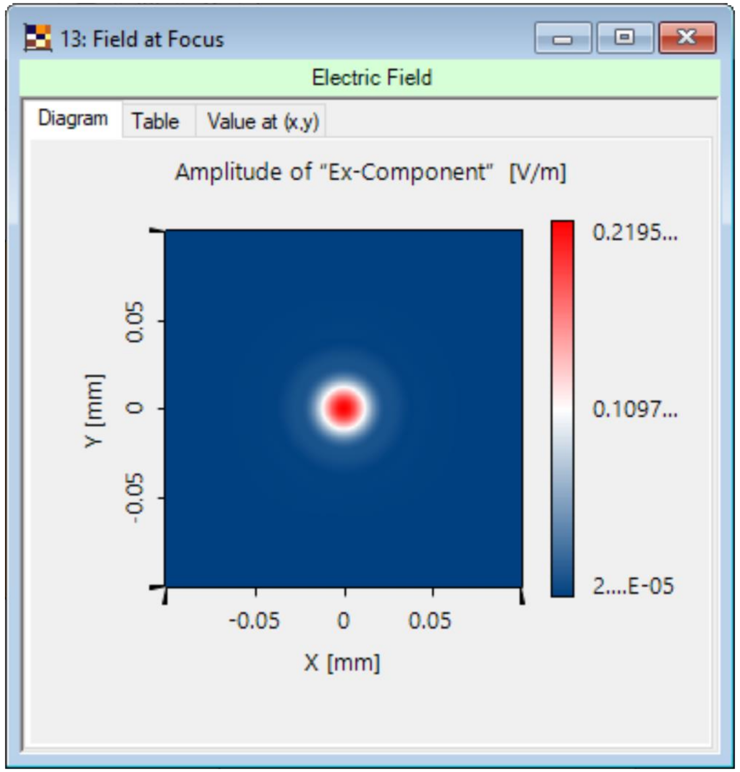
The deformation of the lens surface and the internal change of the refractive index result in a shorten effective focal length.

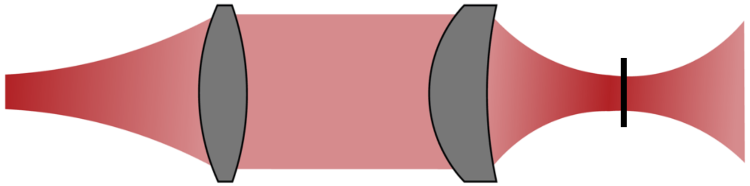
The beam caustic is visualized by using the second moment theory with a Parameter Run session in Virtual Lab.

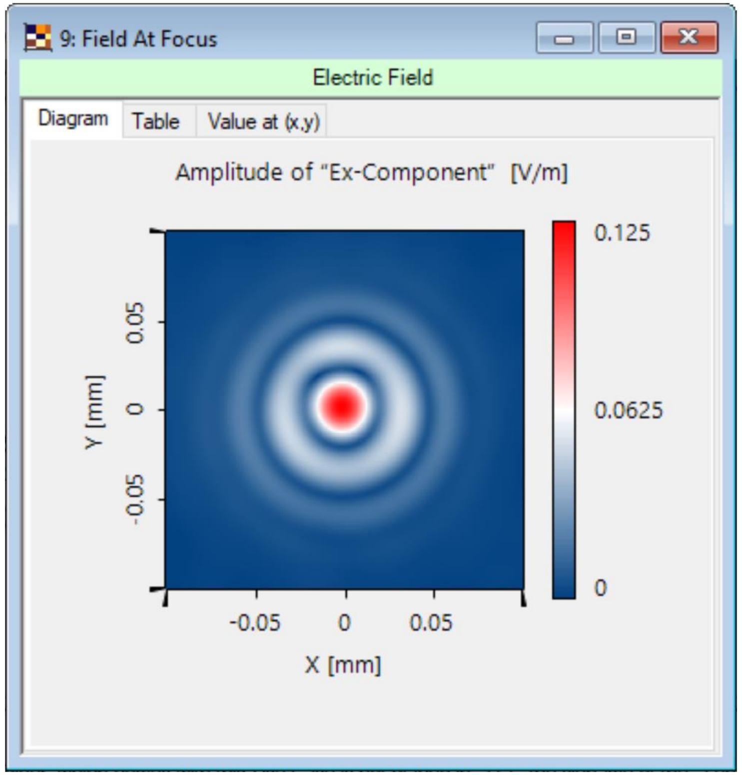
Field Tracing Result – Focal Spot



Reference system

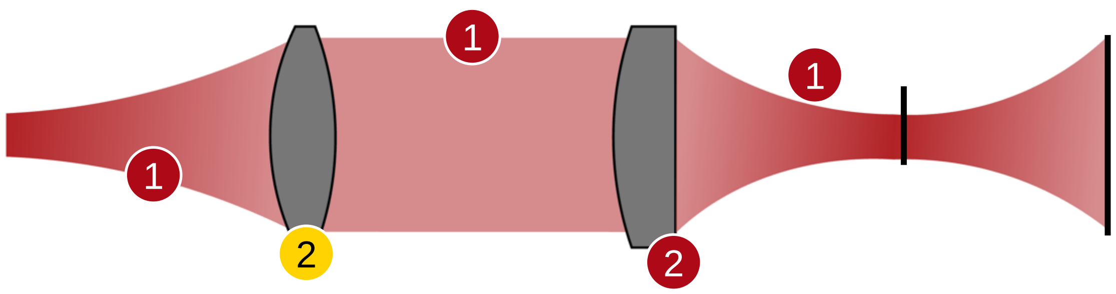


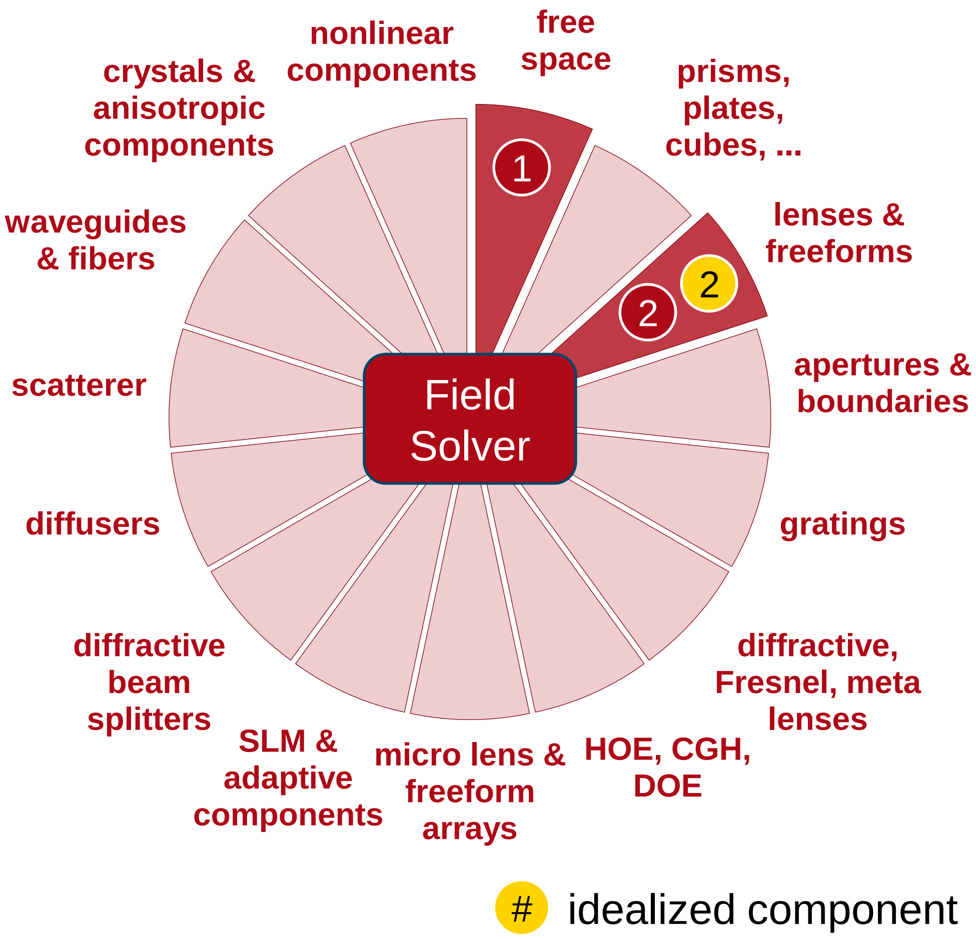




System with thermal lensing

VirtualLab Fusion Technologies





Document Information

title	Investigation of Focus Shift due to Thermal Lensing
document code	
version	1.0
edition	VirtualLab Fusion Basic
toolbox(es)	-
software version	2020.1 (Build 3.4)
category	Application Use Case
further reading	- Gaussian Beam Focused by a Thermal Lens - How to Work with the Programmable Medium and Example (Thermal Lens)

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