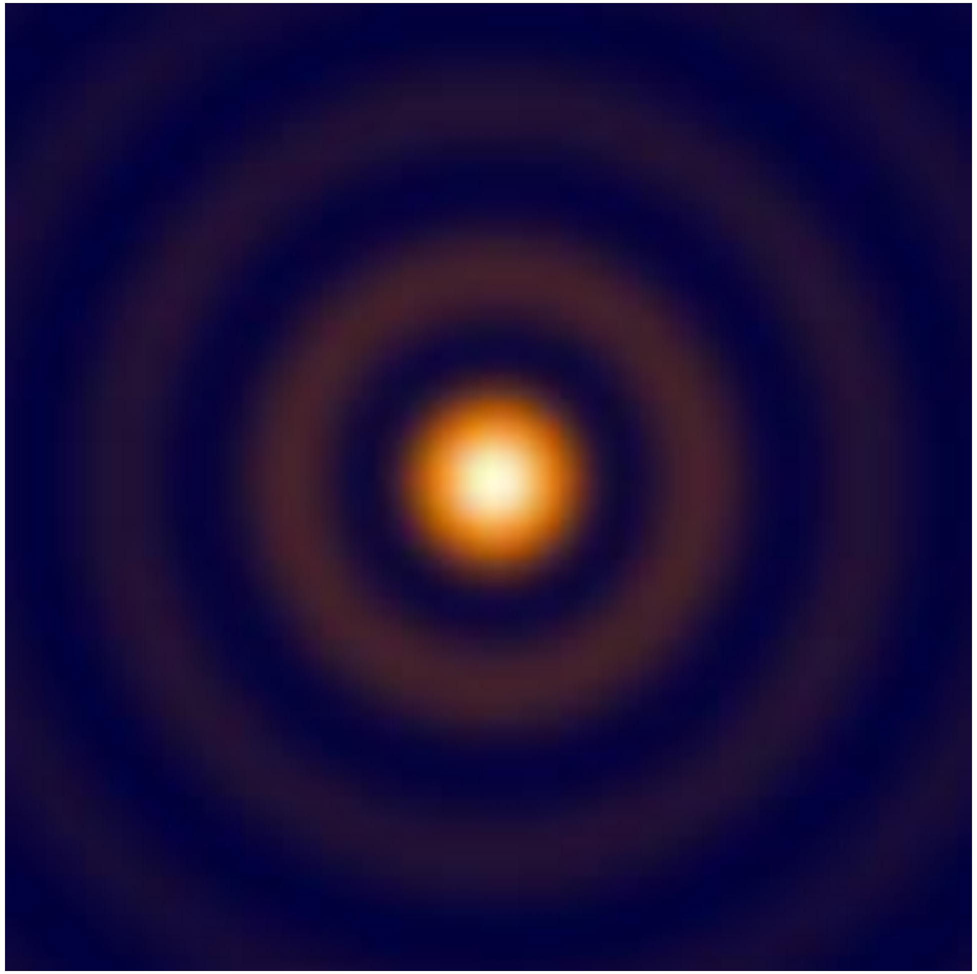
Tight Focusing of Variously Polarized Beams by an Idealized Aplanatic Lens

Abstract



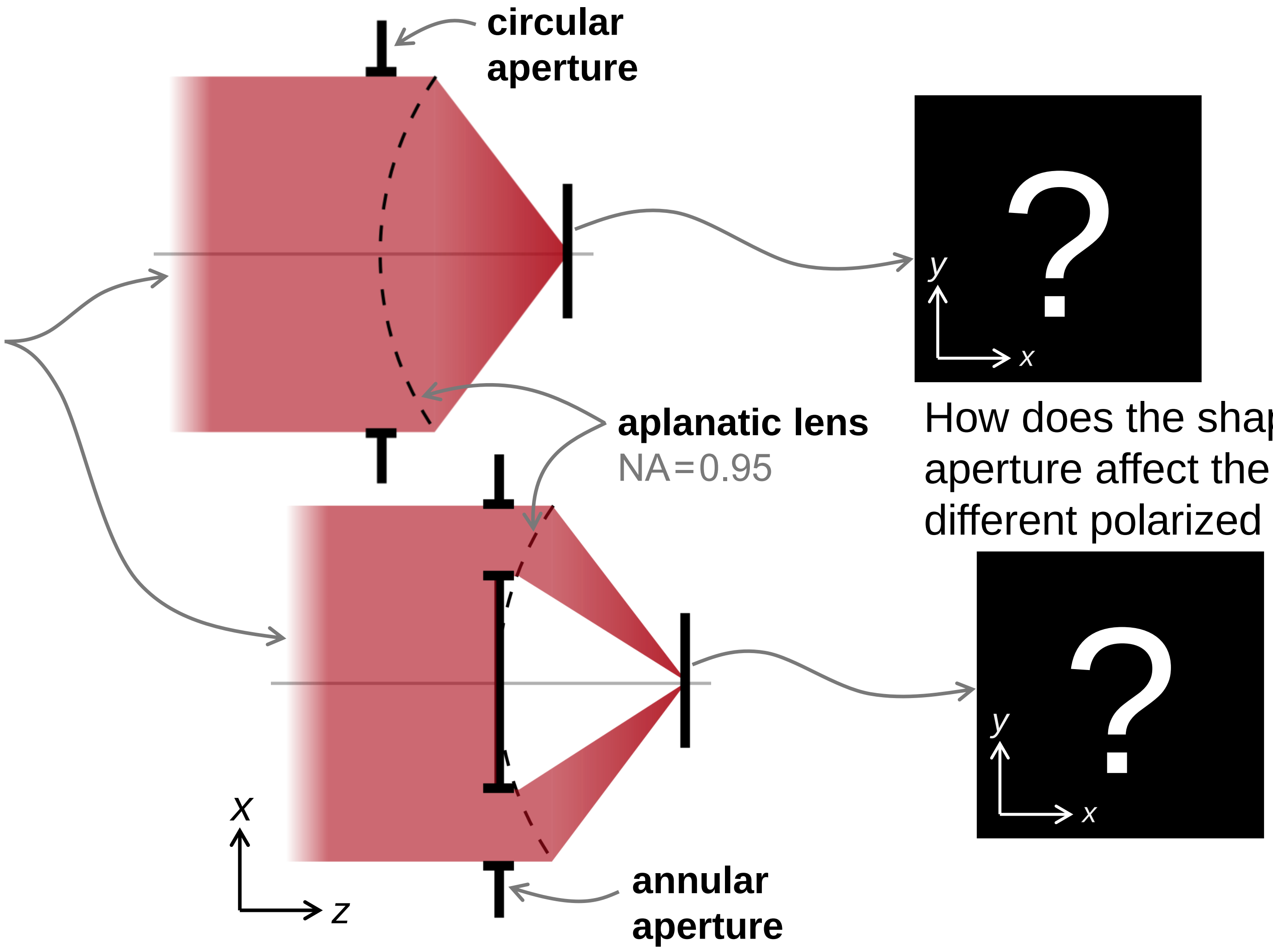
Knowing the vectorial electric field distribution near the focus of a high-NA objective lens is of great importance for applications e.g. microscopy, optical tweezer, laser machining, etc. The used high-NA objective lens is often assumed as an aplanatic lens (means spherical aberration and coma are neglected). We demonstrate the focusing of variously polarized beams, e.g. linearly, circularly and radially polarized beams, by an idealized aplanatic lens in VirtualLab Fusion. Further, the focal field with respect to different shapes of apertures, e.g. circular and annular, is investigated.

Modeling Task

input field

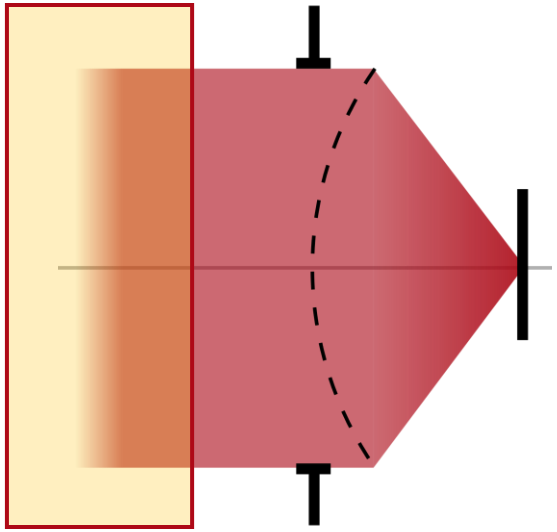
- wavelength: 632.8 nm
- Gaussian profile
- polarization states

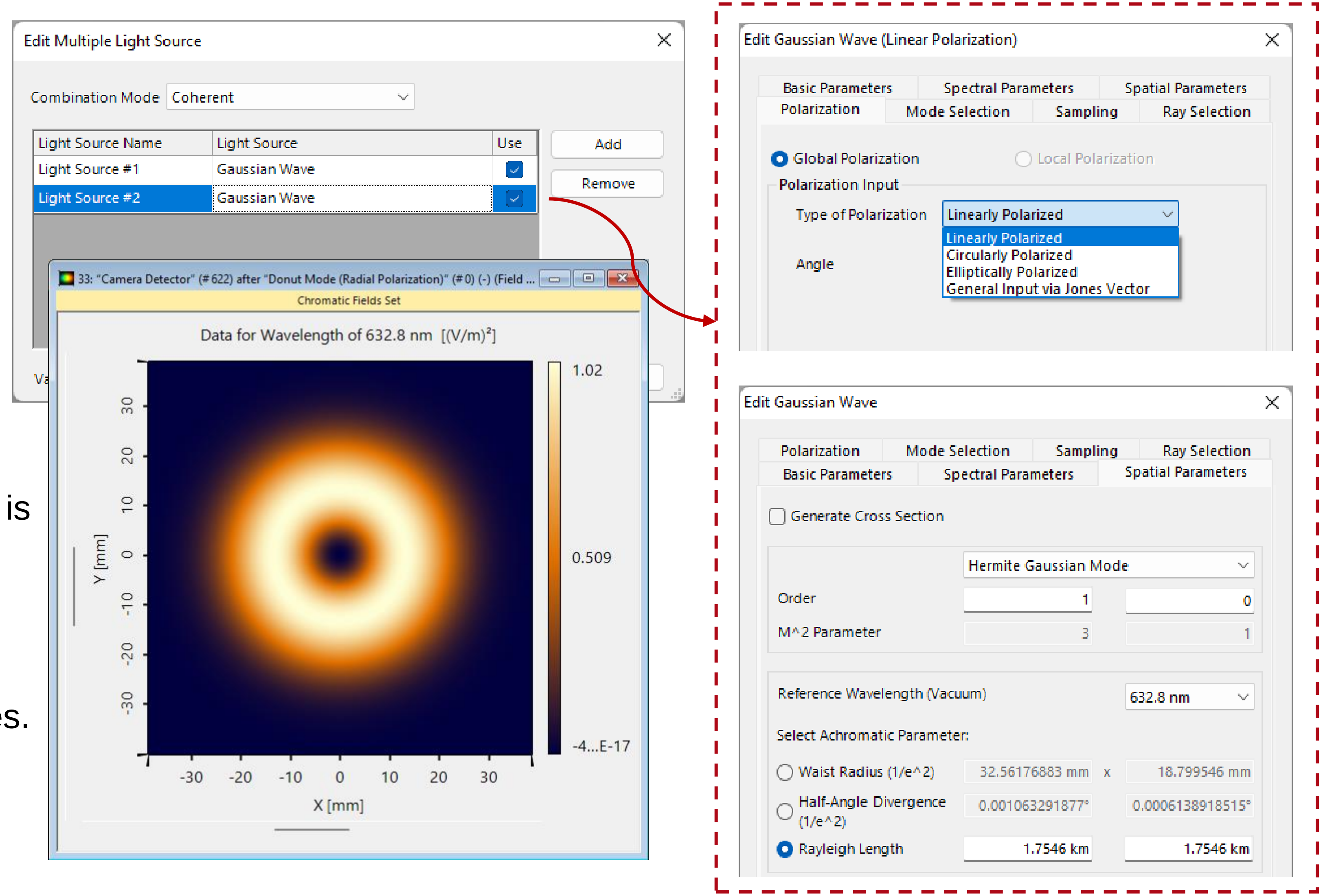
1) linearly polarized
2) circularly polarized
3) radially polarized



How does the shape of the aperture affect the focal spot for different polarized input fields?

Multiple Light Source – Radially Polarized Light

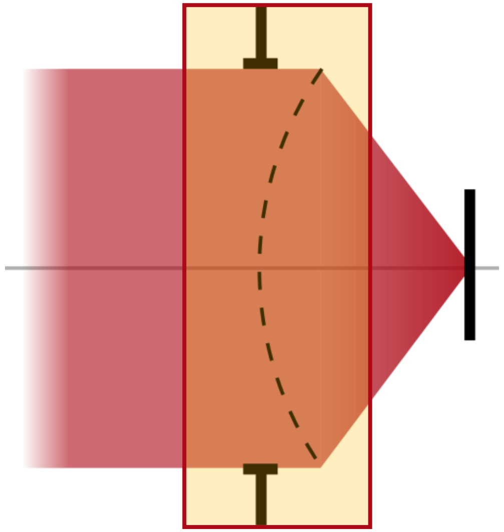


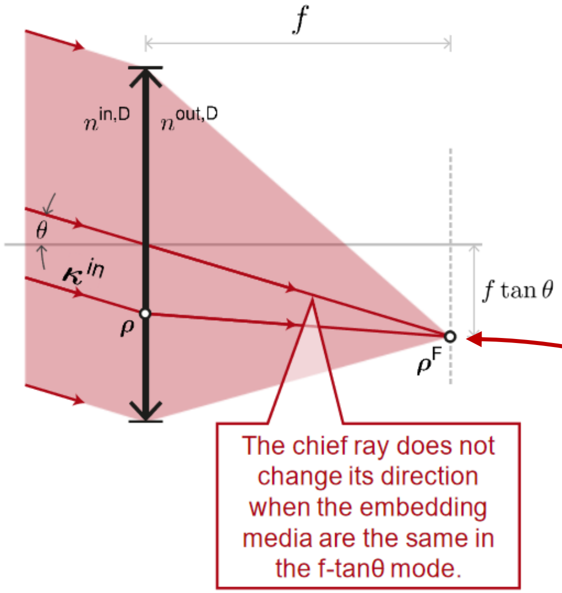


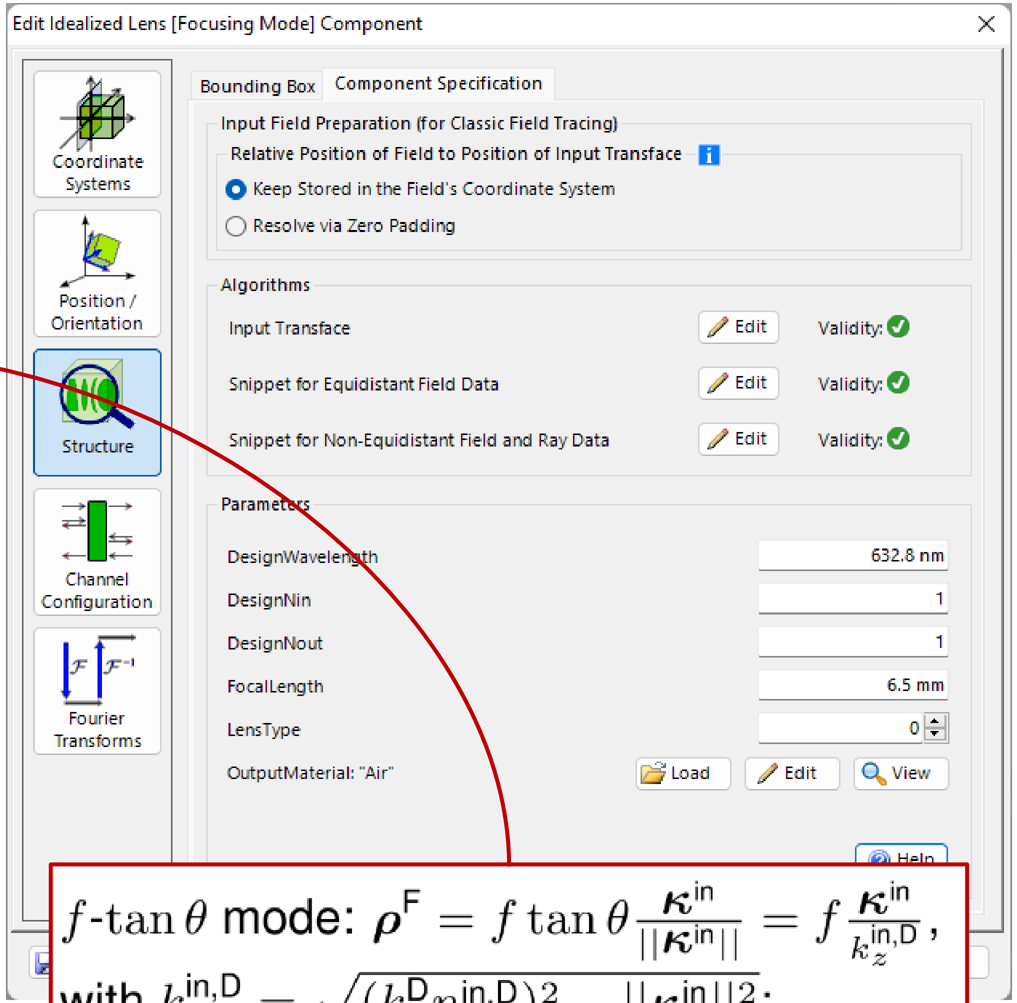
In order to model radially polarized light, it is required to combine two different source modes. This can be done by using the *Multiple Light Source*, which enables the combination of e.g. two Gaussian waves with different modes and polarization states. More information under:

Simulation of Multiple light Source with VirtualLab Fusion

Idealized Aplanatic Lens





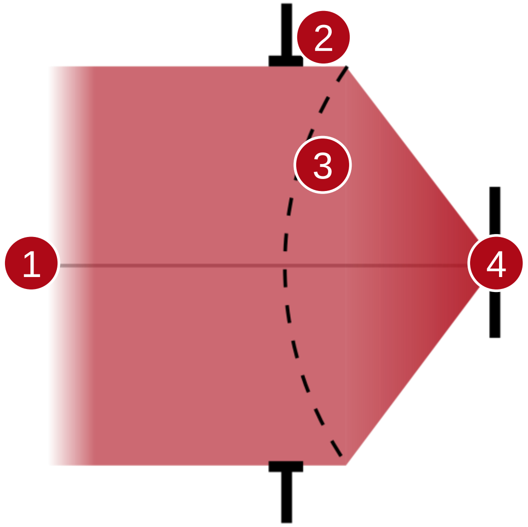


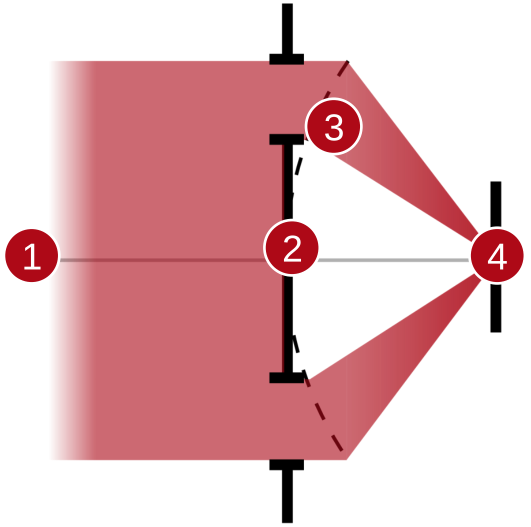
$$f\text{-}\tan\theta \text{ mode: } \boldsymbol{\rho}^{\mathsf{F}} = f\tan\theta\,\frac{\boldsymbol{\kappa}^{\mathsf{in}}}{||\boldsymbol{\kappa}^{\mathsf{in}}||} = f\,\frac{\boldsymbol{\kappa}^{\mathsf{in}}}{k_z^{\mathsf{in,D}}},$$

$$\text{with } k_z^{\mathsf{in,D}} = \sqrt{(k_0^{\mathsf{D}} n^{\mathsf{in,D}})^2 - ||\boldsymbol{\kappa}^{\mathsf{in}}||^2};$$

VirtualLab provides different types and definitions of idealized lens functions. In this Use Case we utilize an ideal focusing lens which provides an f-tantheta functionality. More information under:
Idealized Lens Functions

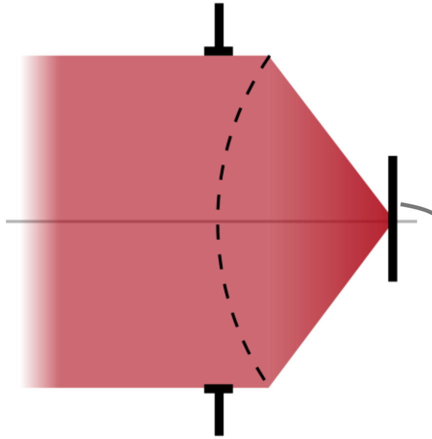
Summary – Components...





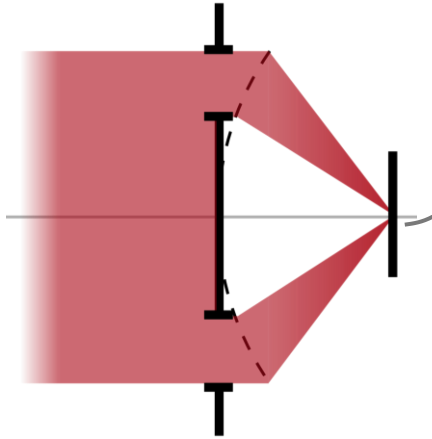
… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Magnitude
1. source	*Gaussian Wave / Multiple Source* with *Gaussian Waves*	Hermite Gaussian modes
2. aperture	*Aperture / Stop*	transmission function
3. idealized aplanatic lens	*Idealized Lens (Focusing Mode)*	transmission function
4. detector	• *Camera Detector* • *Electromagnetic Field Detector*	• energy density measurement • field component measurement

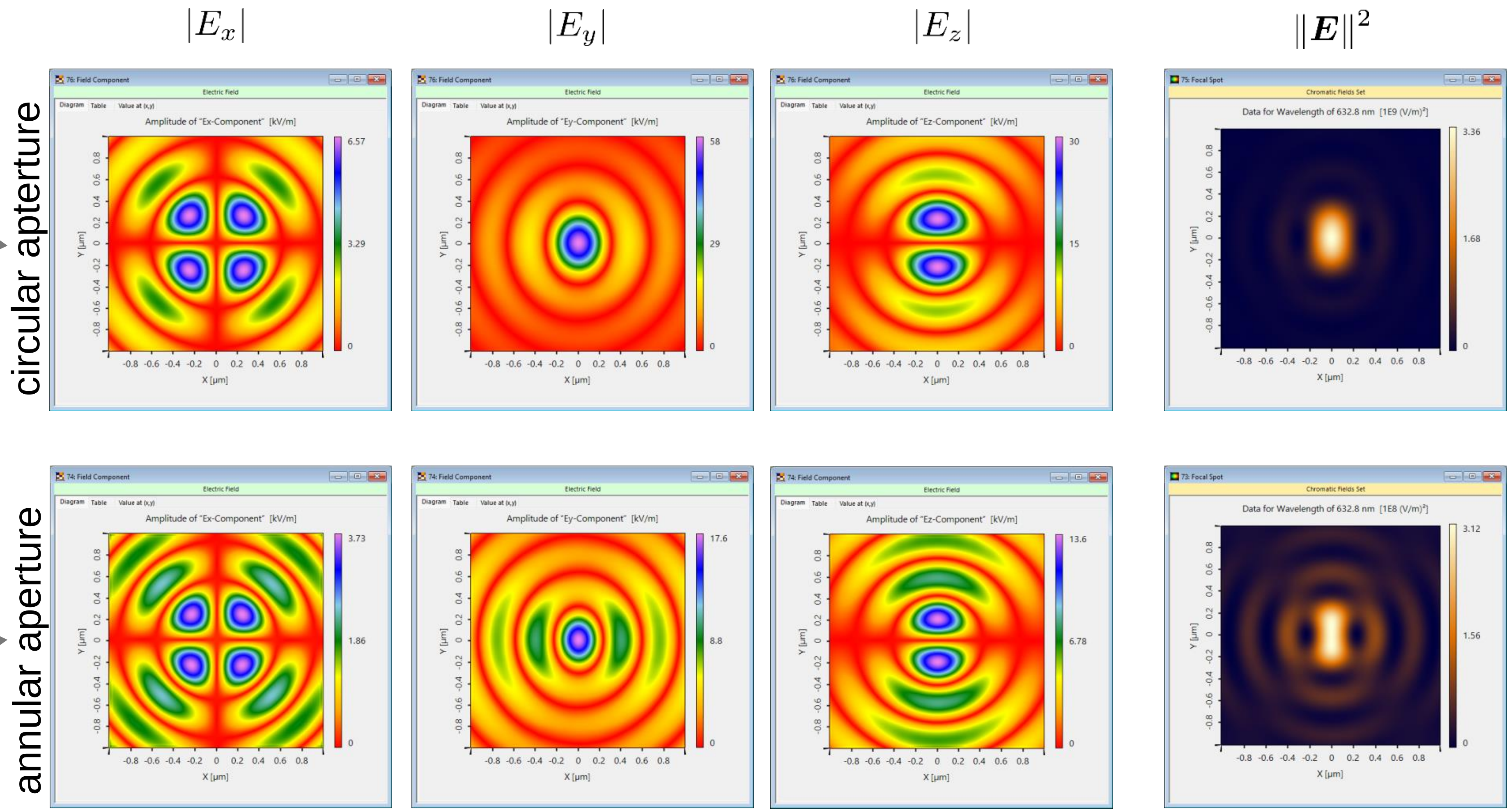
Circular vs. Annular Aperture: Linearly Polarized Input



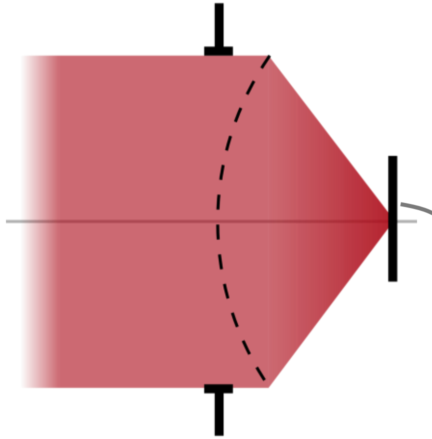
input wave

linear polarization in *y* direction

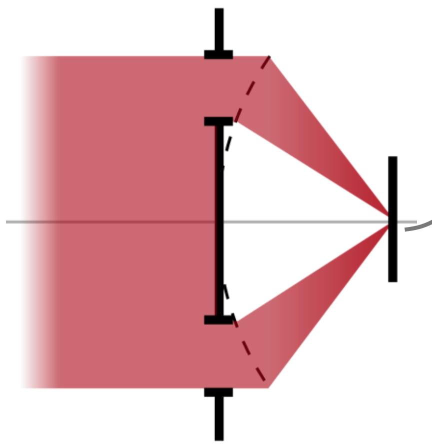


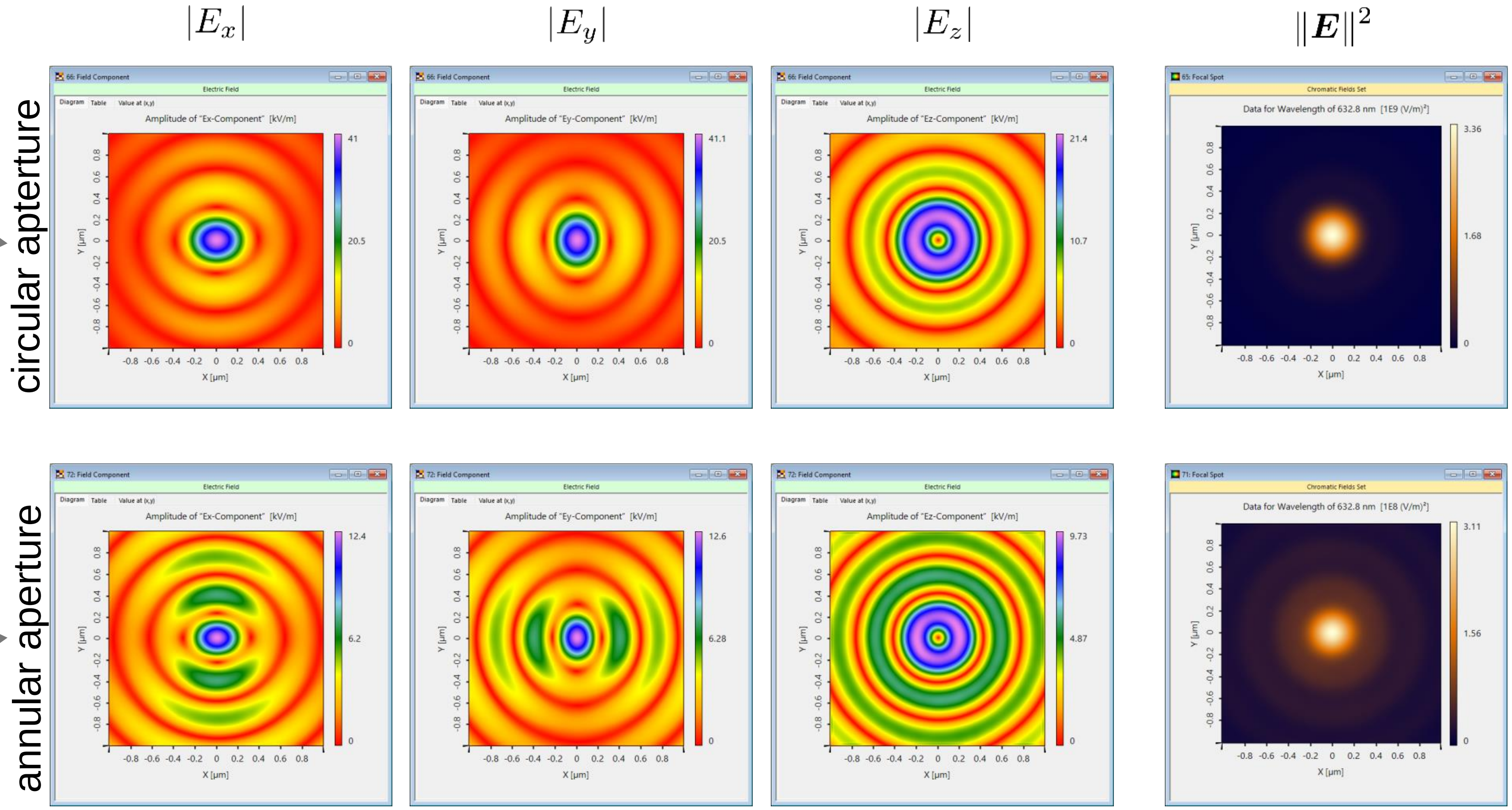


Circular vs. Annular Aperture: Circularly Polarized Input

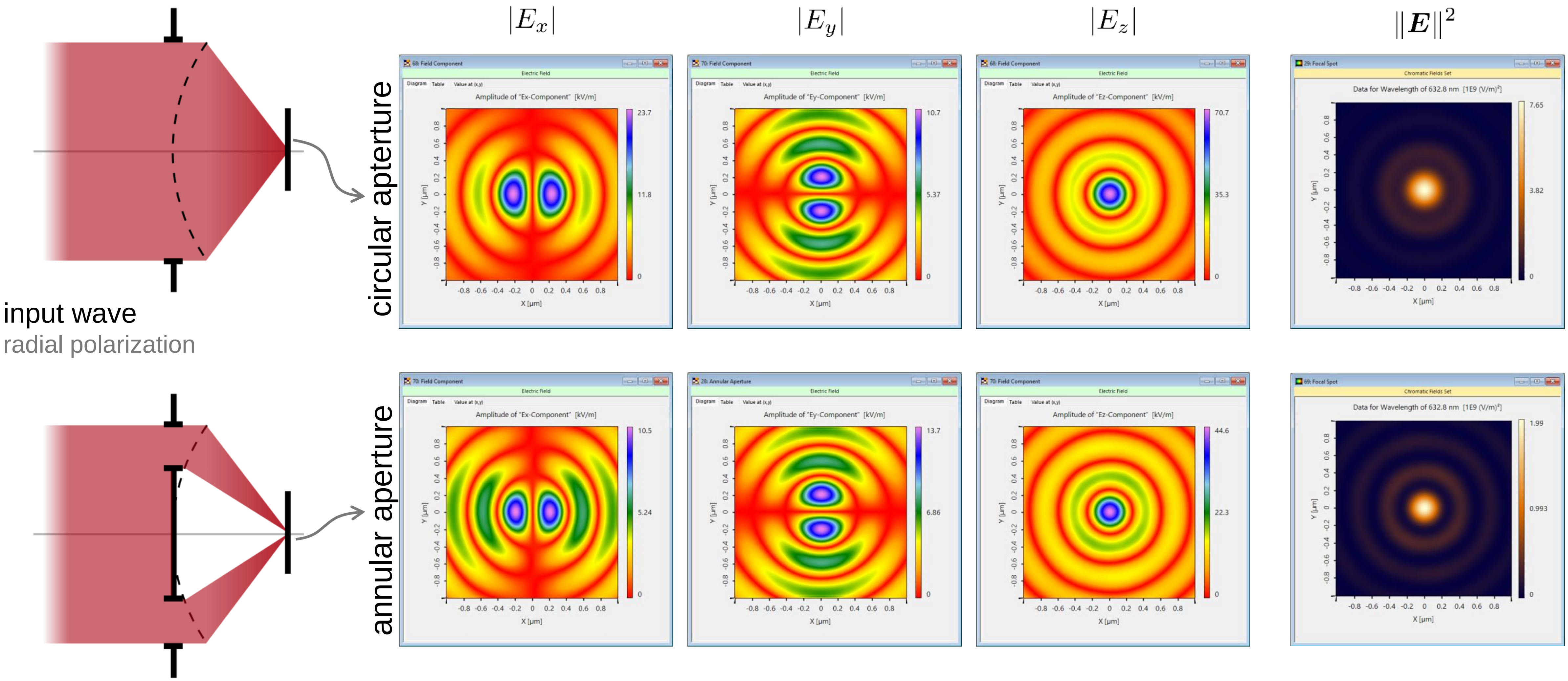


input wave
circular polarization
right-hand directly

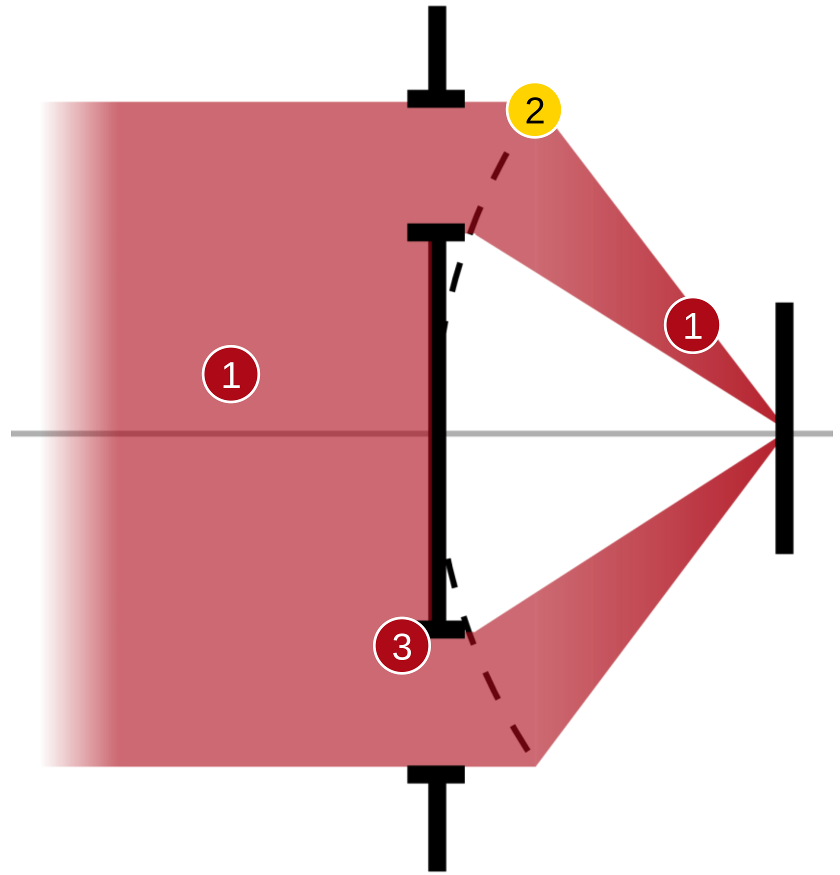


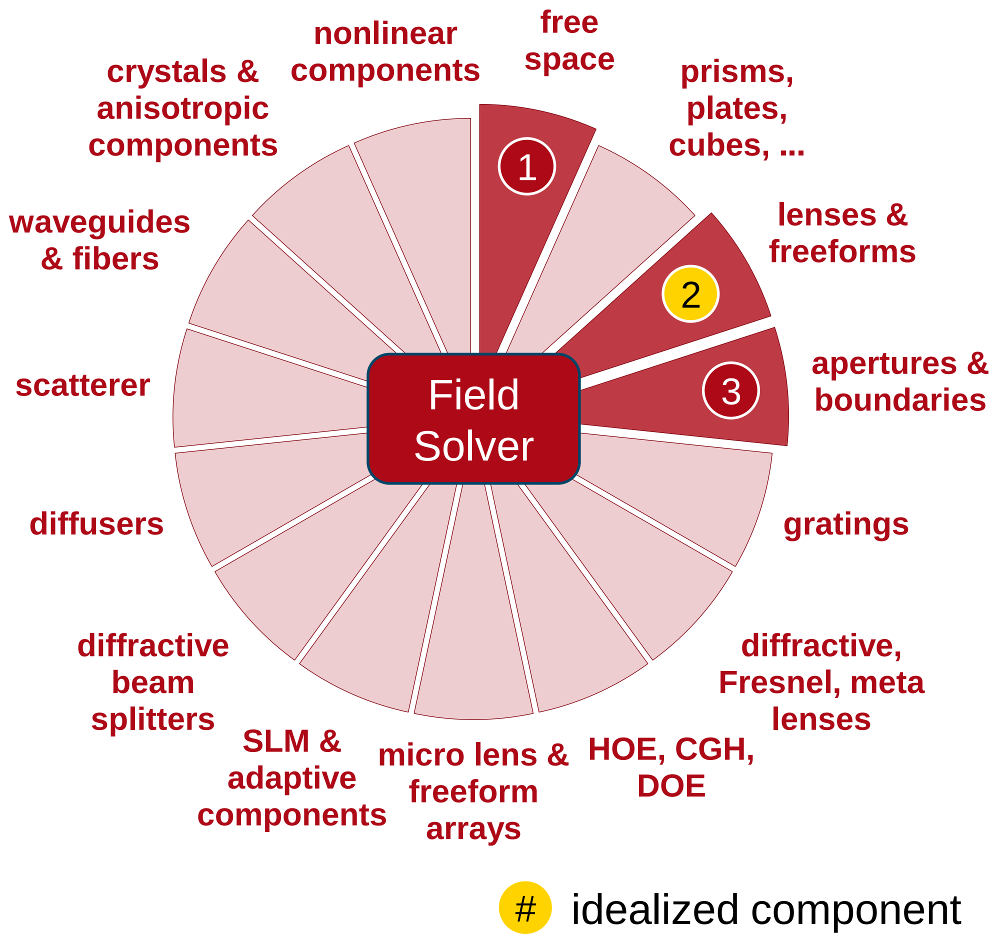


Circular vs. Annular Aperture: Radially Polarized Input



VirtualLab Fusion Technologies





Document Information

title	Tight Focusing of Variously Polarized Beams by an Idealized Aplanatic Lens
document code	MIC.0005
document version	1.1
software edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	• Analyzing High-NA Objective Lens Focusing • Investigation of Idealized Vectorial Focusing Situation Using Debye-Wolf Integral • Simulation of Multiple light Source with VirtualLab Fusion • Idealized Lens Functions