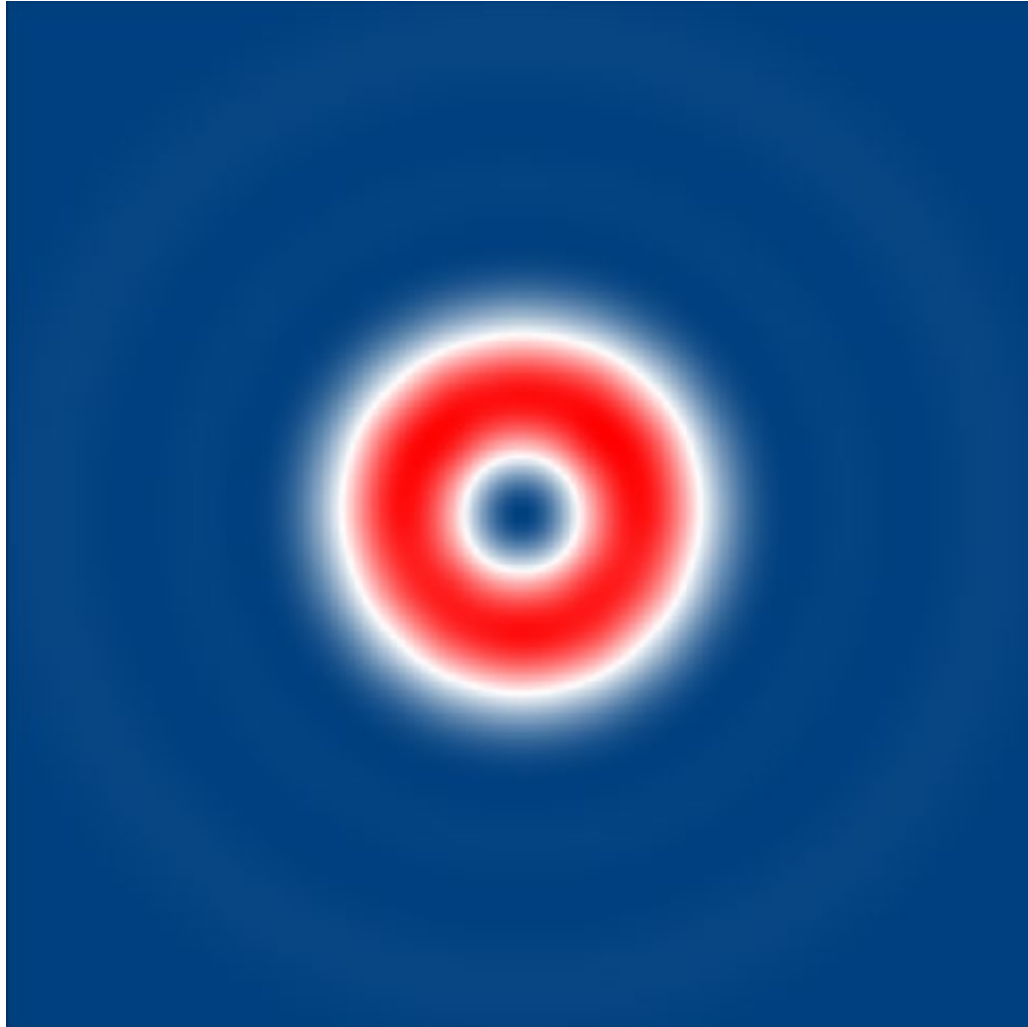


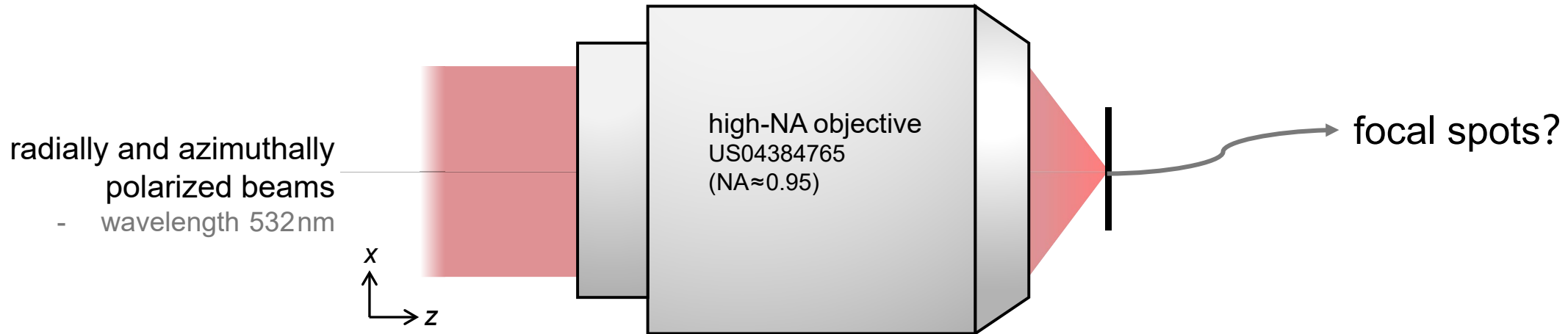
Focusing of Cylindrical Vector Beams by a High-NA Objective Lens

Abstract



The cylindrical vector beams are studied intensively in recent years. The small focal spot can be obtained by radially polarized beam for high-resolution applications. A donut-shaped focal spot can be obtained by azimuthally polarized beam, which has the potential for advanced imaging and lithography. In VirtualLab Fusion, the focusing of such cylindrical vector beams can be modeled and analyzed straightforwardly. The focal spot is demonstrated and analyzed in a fully vectorial manner.

Scenario



How are the focal spots influenced by the vectorial components of the electric field at the focal plane of focusing radially and azimuthally polarized beams?

Building the System in VirtualLab Fusion

System Building Blocks

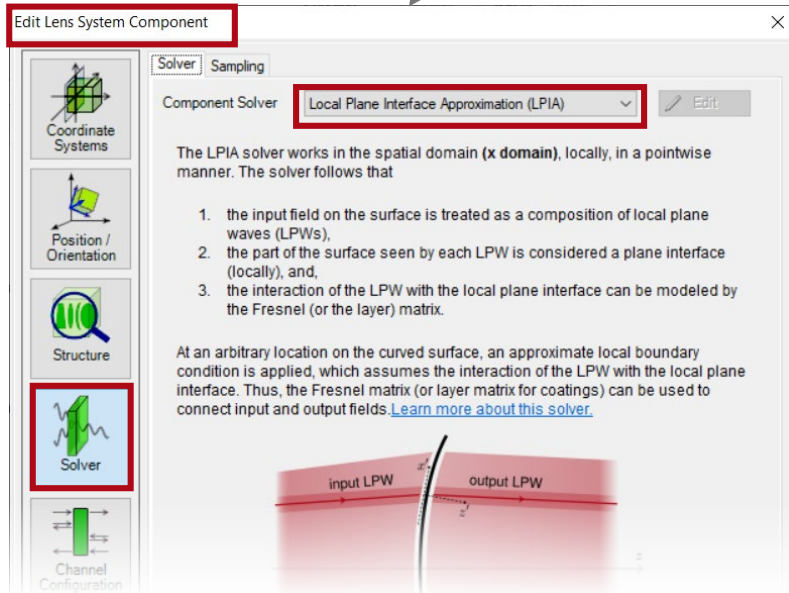
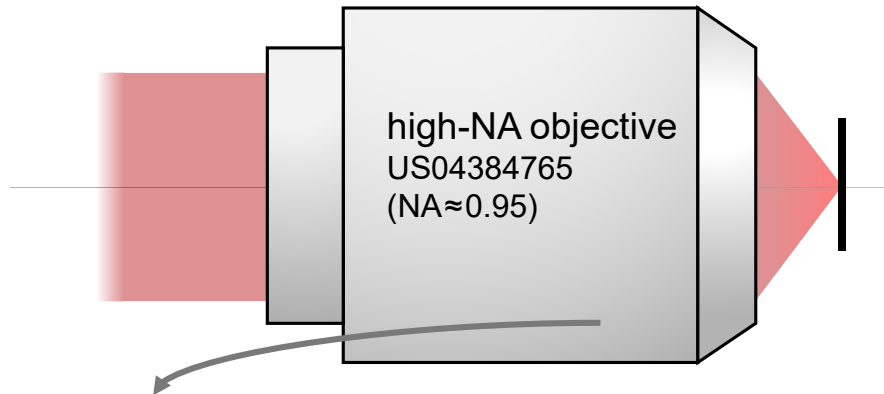
The diagram illustrates the system building blocks for a high-NA objective lens system. A central 3D model of a lens is labeled "high-NA objective US04384765 (NA≈0.95)". A red light source is shown on the left, and a detector is on the right. Three software interface windows are shown below the lens model, each with a red box highlighting a specific feature:

- Edit Combined Light Source:** Shows the "Combination Mode" set to "Coherent". It includes two "Programmable Light Source" sections, each with "Load", "Edit", and "View" buttons. The "Validity" status is shown as a green checkmark.
- Edit Lens System Component:** Displays a 2D schematic of the lens system and a table of component parameters. The "Structure" icon in the left sidebar is highlighted with a red box.
- Edit Camera Detector:** Shows the "Detector Function" tab. The "Components to Integrate" section has "Ex-Component" and "Ey-Component" checked, and "Ez-Component" unchecked. The "View Settings of Result" section has "False Color" selected and "Tricolor" as an option.

The "Edit Lens System Component" table contains the following data:

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	BAF52_SCHOTT in Hon	Zemax Interf
2	4 mm	4 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
3	8 mm	12 mm	Plane Interface	N-SK11_SCHOTT in Ho	Zemax Interf
4	11.3 mm	23.3 mm	Conical Interface	E-FD1_HOYA in Homog	Zemax Interf
5	3.5 mm	26.8 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
6	200 μm	27 mm	Conical Interface	CAF2_MISC in Homogen	Zemax Interf
7	4 mm	31 mm	Conical Interface	N-SF56_SCHOTT in Ho	Zemax Interf
8	1.3 mm	32.3 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
9	524.45 μm	32.824 mm	Plane Interface	Air (Zemax) in Homogen	Zemax Interf
10	24.448 μm	32.8 mm	Conical Interface	CAF2_MISC in Homogen	Zemax Interf
11	4.7 mm	37.5 mm	Conical Interface	LASFN16_SUMITA in Hc	Zemax Interf
12	1.45 mm	38.95 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
13	300 μm	38.25 mm	Conical Interface	LAK31_SCHOTT in Hon	Zemax Interf

Solvers for Components

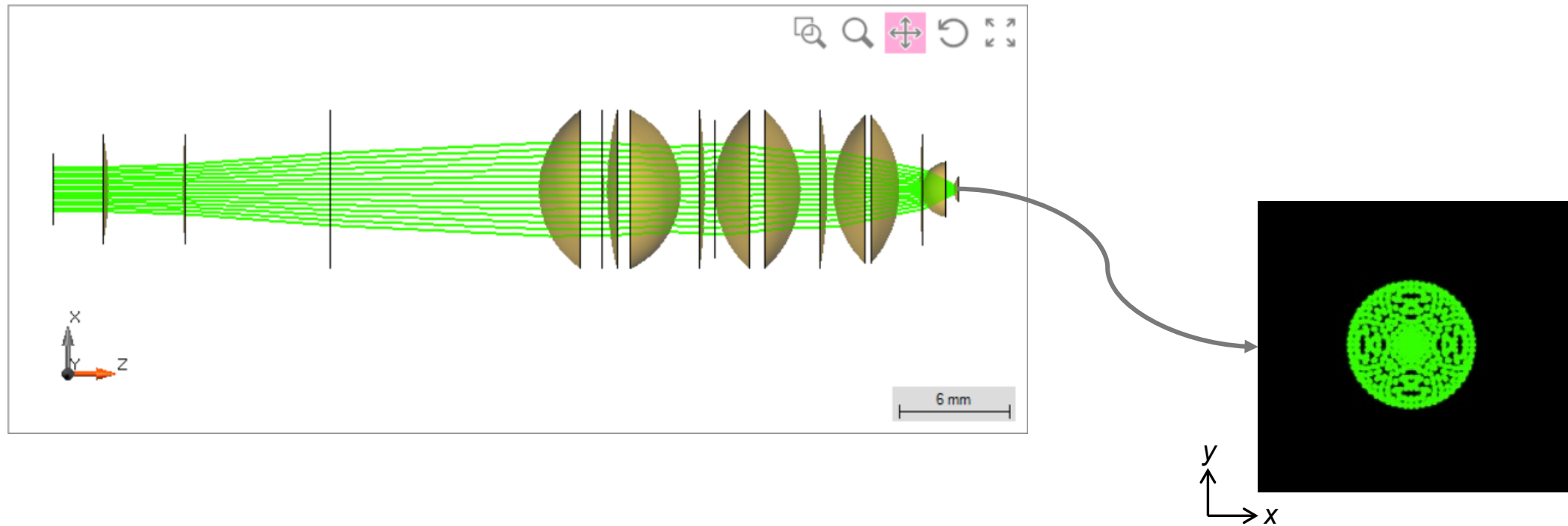


Components	Solvers
Lens Systems	Local Plane Interface Approximation (LPIA)

Geometric-Optics Simulations

by Ray Tracing

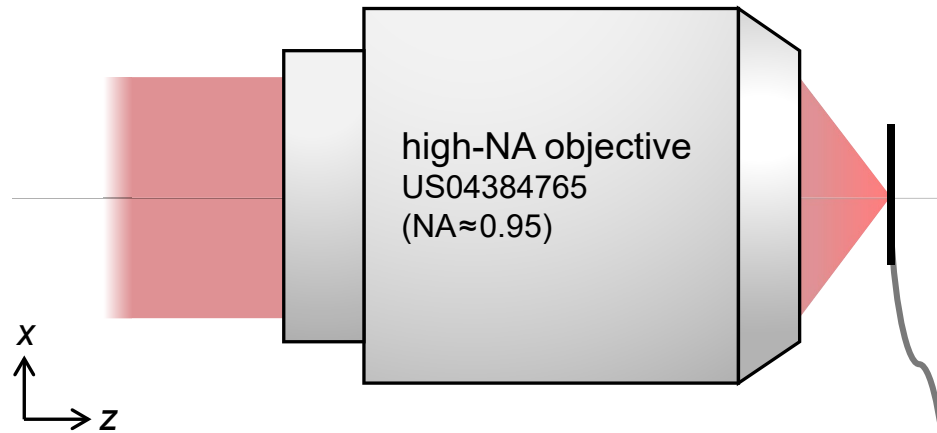
Results: Ray Tracing



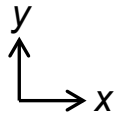
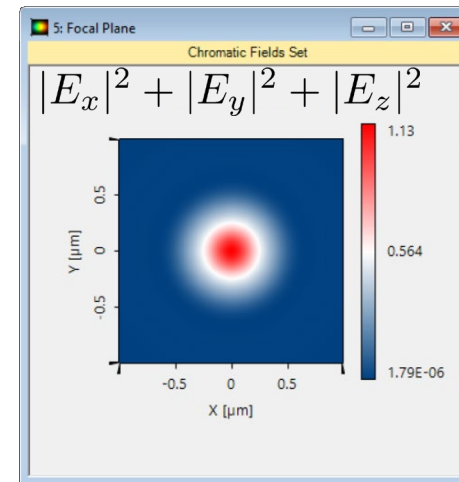
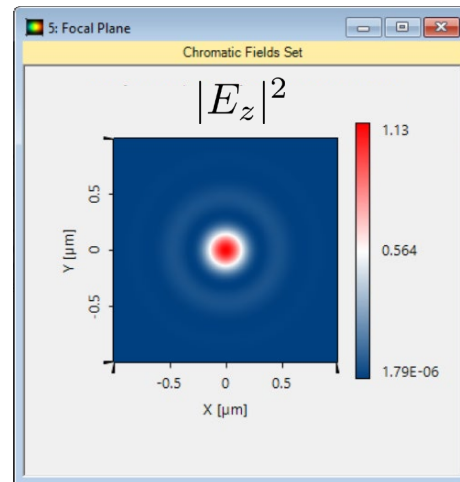
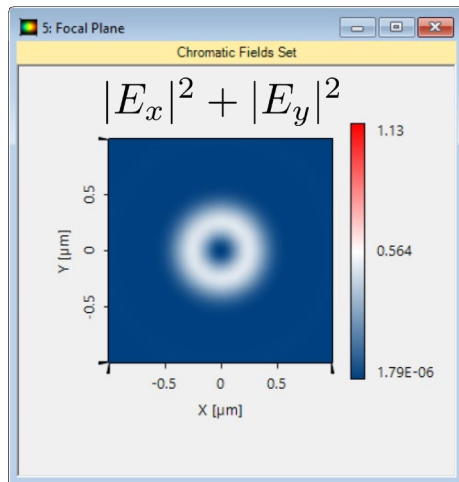
Fast Physical-Optics Simulations

by Field Tracing

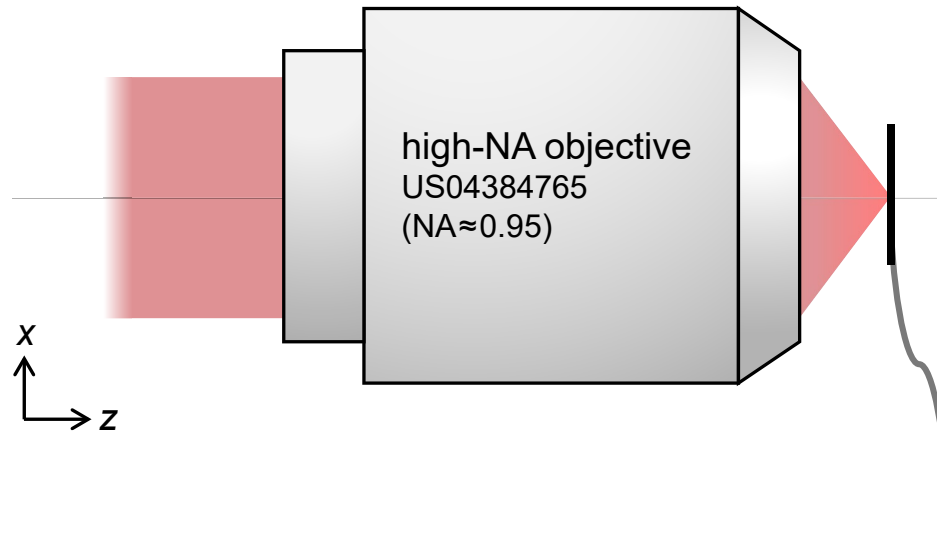
Tight Focusing of Radially Polarized Beam



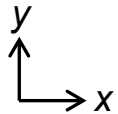
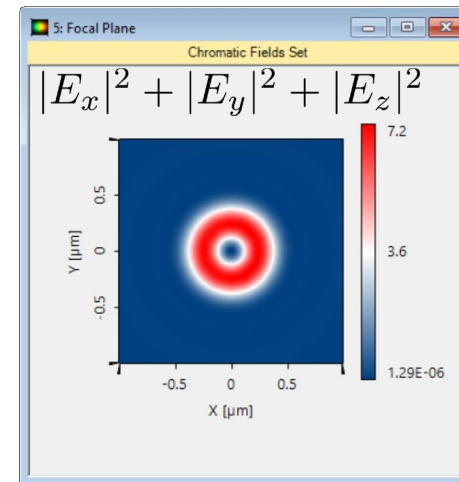
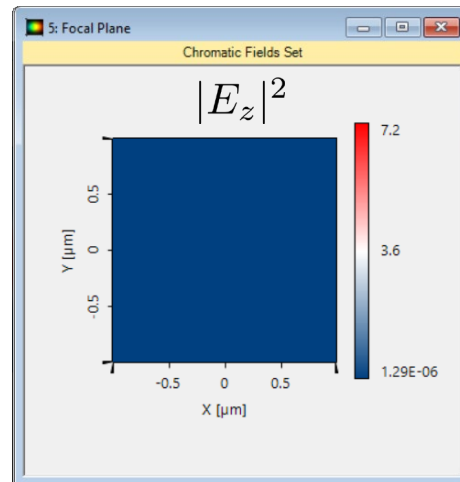
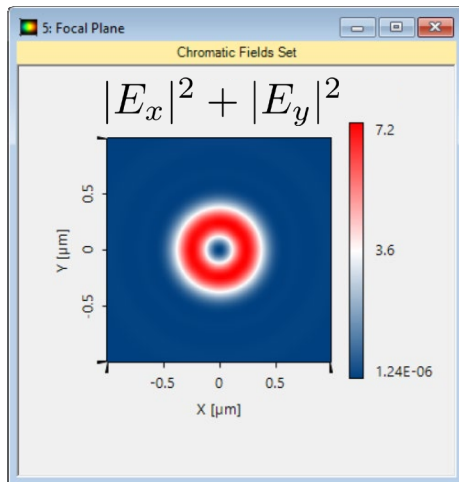
Strong axial component of the electric field, E_z , is demonstrated clearly.



Tight Focusing of Azimuthally Polarized Beam



The donut-shaped focal spot is demonstrated clearly.



Document Information

title	Focusing of Cylindrical Vector Beams by a High-NA Objective Lens
document code	MIC.0013
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edition	VirtualLab Fusion Basic
software version	2020.2 (Build 1.116)
category	Application Use Case
further reading	<ul style="list-style-type: none">- <u>Debye-Wolf Integral Calculator</u>- <u>Analyzing High-NA Objective Lens</u>- <u>Resolution Investigation for Microscope Objective Lenses by Rayleigh Criterion</u>