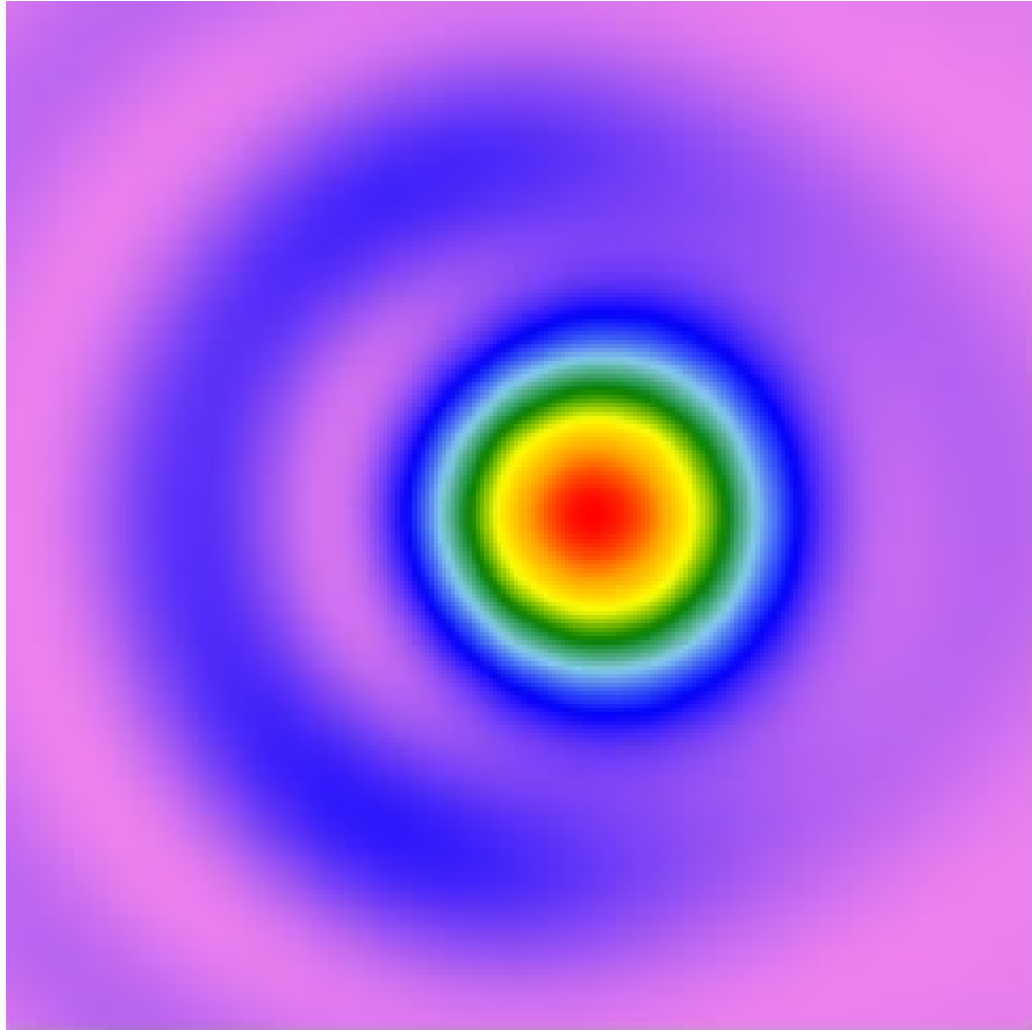


Analysis of Off-Axis Imaging by a High-NA Microscope

Abstract

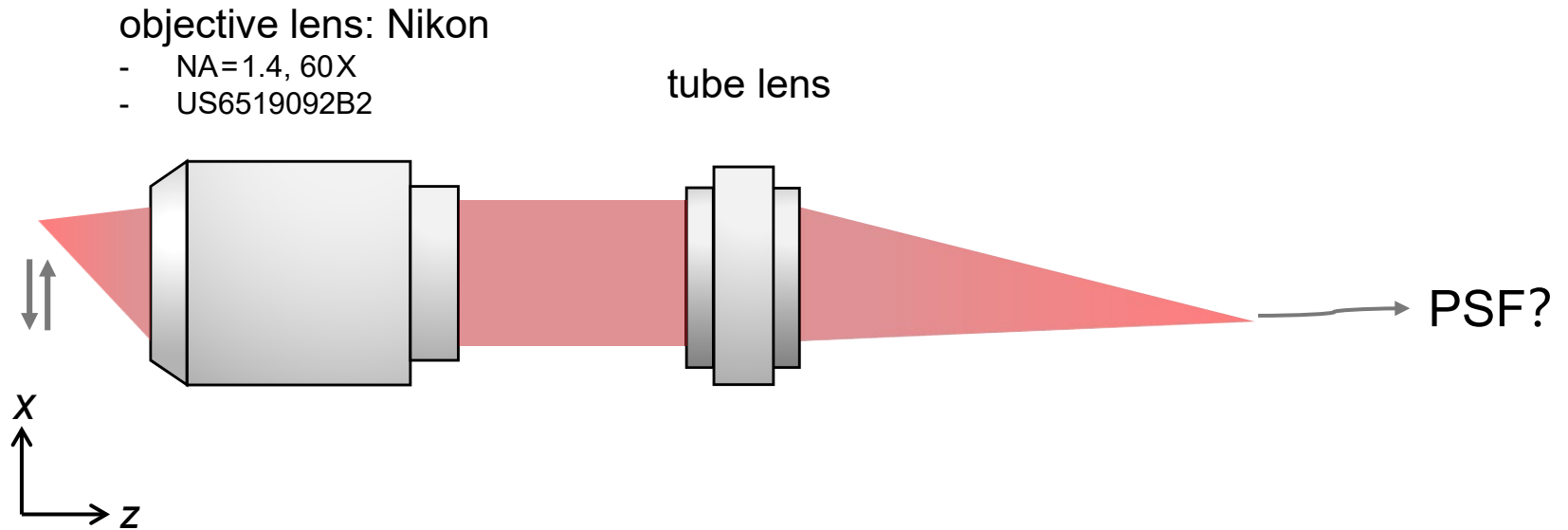


The off-axis PSF for imaging often suffers from the aberration of the microscopy system. It makes the microscopy system not perfectly shift-invariant as expected. VirtualLab Fusion provides a fast and convenient way to check the PSF for off-axis imaging with a high-NA microscope. This use case demonstrates the imaging of off-axis object points with different lateral shift distances, to check the influence of the aberrations.

Scenario

input spherical wave

- wavelength 587.5nm
- circularly polarized
- lateral shift in x-direction 20 μm , 40 μm , 60 μm , 80 μm , 100 μm



How is the PSF influenced by the aberrations in the case of off-axis imaging?

Building the System in VirtualLab Fusion

System Building Blocks

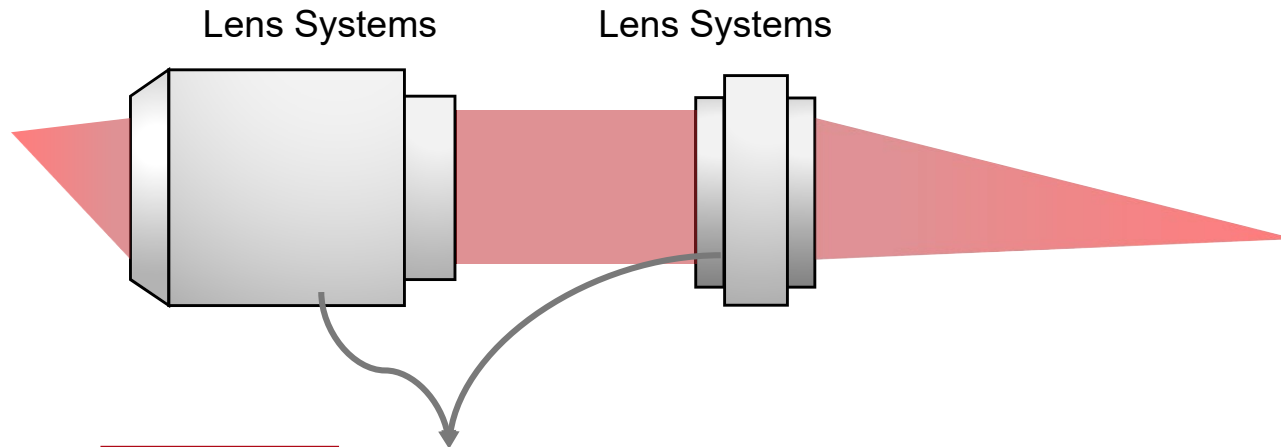
The diagram shows an optical system with three lenses and a detector. The system is represented by a red cone of light passing through three lenses. The software windows are:

- Generate Spherical Wave:** Shows parameters for the source field, including medium, distance to input plane (100 μm), and lateral offset (20 μm).
- Edit Lens System Component:** Shows a 3D view of the lens system and a table of components.
- Edit Camera Detector:** Shows detector window and resolution settings, including window size (50 μm x 50 μm) and number of sampling points (1024² (1:1)).

The **Edit Lens System Component** window displays the following table:

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Plane Interface	Non-Dispersive Material	Zemax Interf
2	150 μm	150 μm	Plane Interface	S-NSL3_OHARA in Hom	Zemax Interf
3	650 μm	800 μm	Conical Interface	LASF35_SCHOTT in Ho	Zemax Interf
4	3.6 mm	4.4 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
5	100 μm	4.5 mm	Conical Interface	GFK70_SUMITA in Hom	Zemax Interf
6	3.75 mm	8.25 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
7	100 μm	8.35 mm	Conical Interface	J-F5_HIKARI in Homog	Zemax Interf
8	1000 μm	9.35 mm	Conical Interface	GFK70_SUMITA in Hom	Zemax Interf
9	6.8 mm	16.15 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
10	150 μm	16.3 mm	Conical Interface	J-KZFH1_HIKARI in Hor	Zemax Interf
11	1000 μm	17.3 mm	Conical Interface	LITHOTEC-CAF2_SCHC	Zemax Interf
12	9.4 mm	26.7 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
13	150 μm	26.85 mm	Conical Interface	LK7E41_HIKARI in Hor	Zemax Interf

Solvers for Components



Edit Lens System Component

Solver Sampling

Component Solver: Local Plane Interface Approximation (LPIA) Edit

The LPIA solver works in the spatial domain (x domain), locally, in a pointwise manner. The solver follows that

1. the input field on the surface is treated as a composition of local plane waves (LPWs),
2. the part of the surface seen by each LPW is considered a plane interface (locally), and,
3. the interaction of the LPW with the local plane interface can be modeled by the Fresnel (or the layer) matrix.

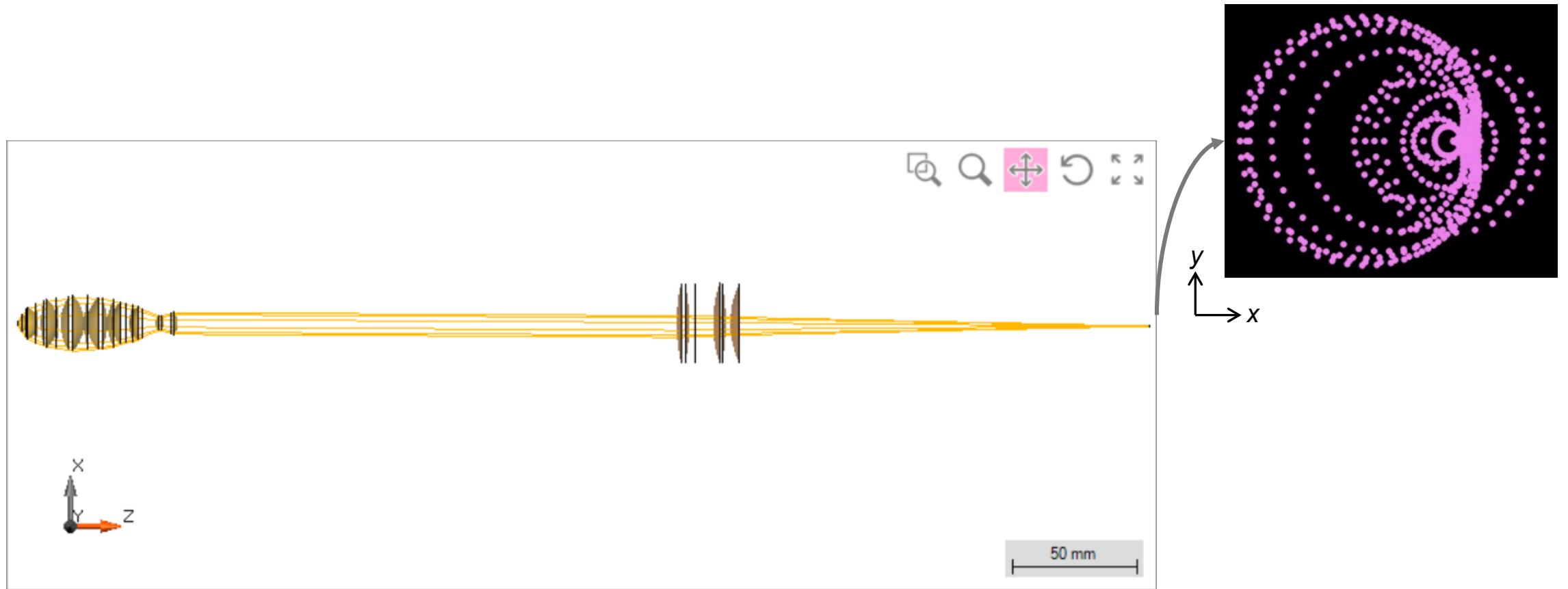
At an arbitrary location on the curved surface, an approximate local boundary condition is applied, which assumes the interaction of the LPW with the local plane interface. Thus, the Fresnel matrix (or layer matrix for coatings) can be used to connect input and output fields [Learn more about this solver.](#)

Components	Solvers
Lens Systems	Local Plane Interface Approximation (LPIA)

Geometric-Optics Simulations

by Ray Tracing

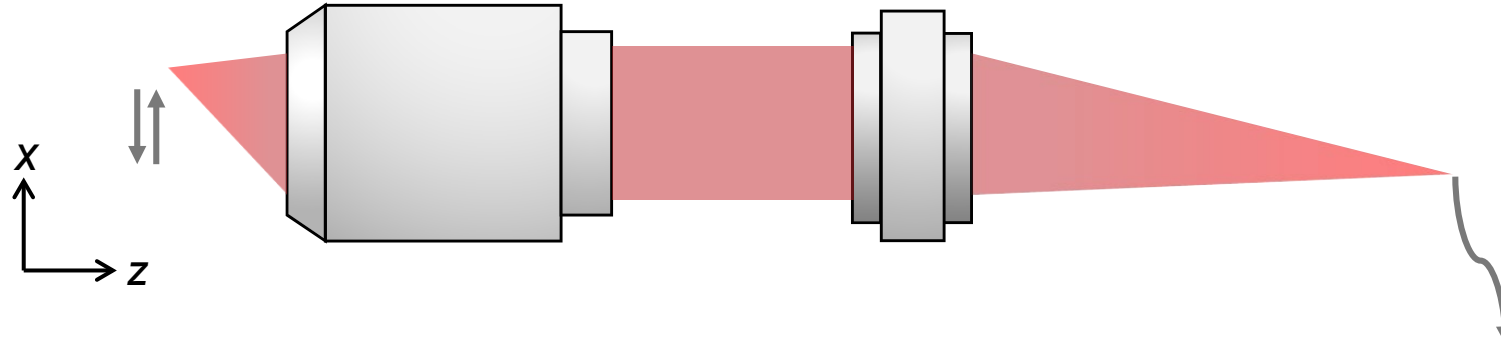
Results: Ray Tracing



Fast Physical-Optics Simulations

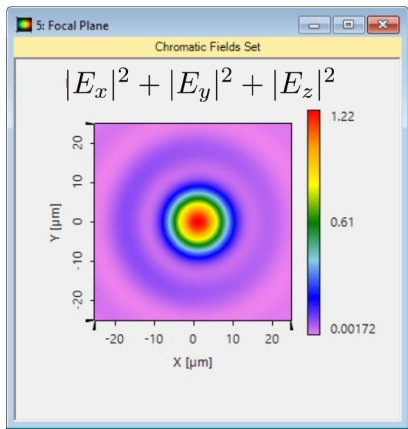
by Field Tracing

PSF at Focal Plane with Lateral Shifts

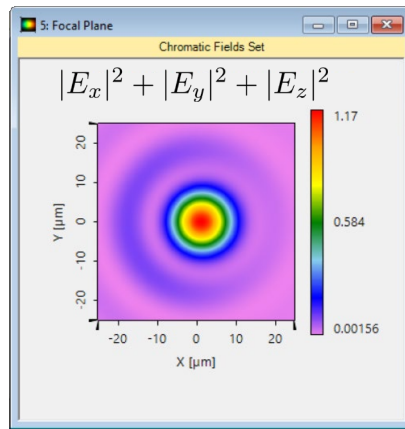


The distorted PSF is demonstrated when the lateral shift is $100\mu\text{m}$, i.e., the field of view is $\sim 200\mu\text{m}$.

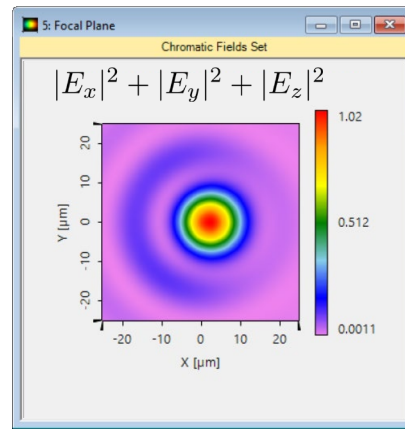
$x=20\mu\text{m}$



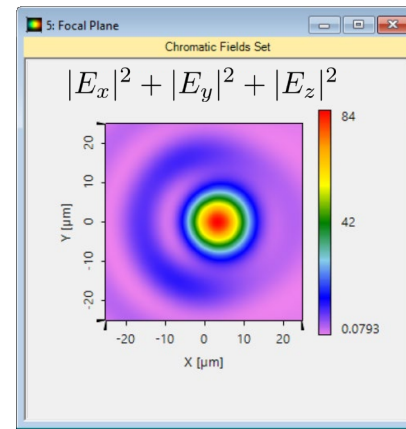
$x=40\mu\text{m}$



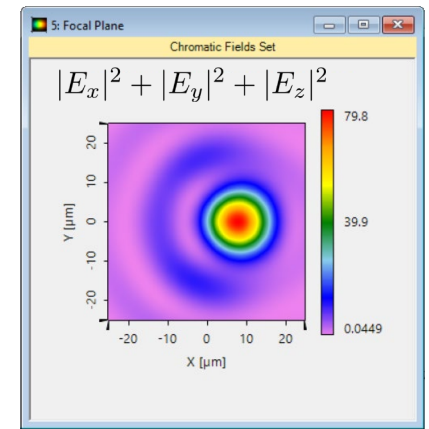
$x=60\mu\text{m}$



$x=80\mu\text{m}$



$x=100\mu\text{m}$



Document Information

title	Analysis of Off-Axis Imaging by a High-NA Microscope
document code	MIC.0016
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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>