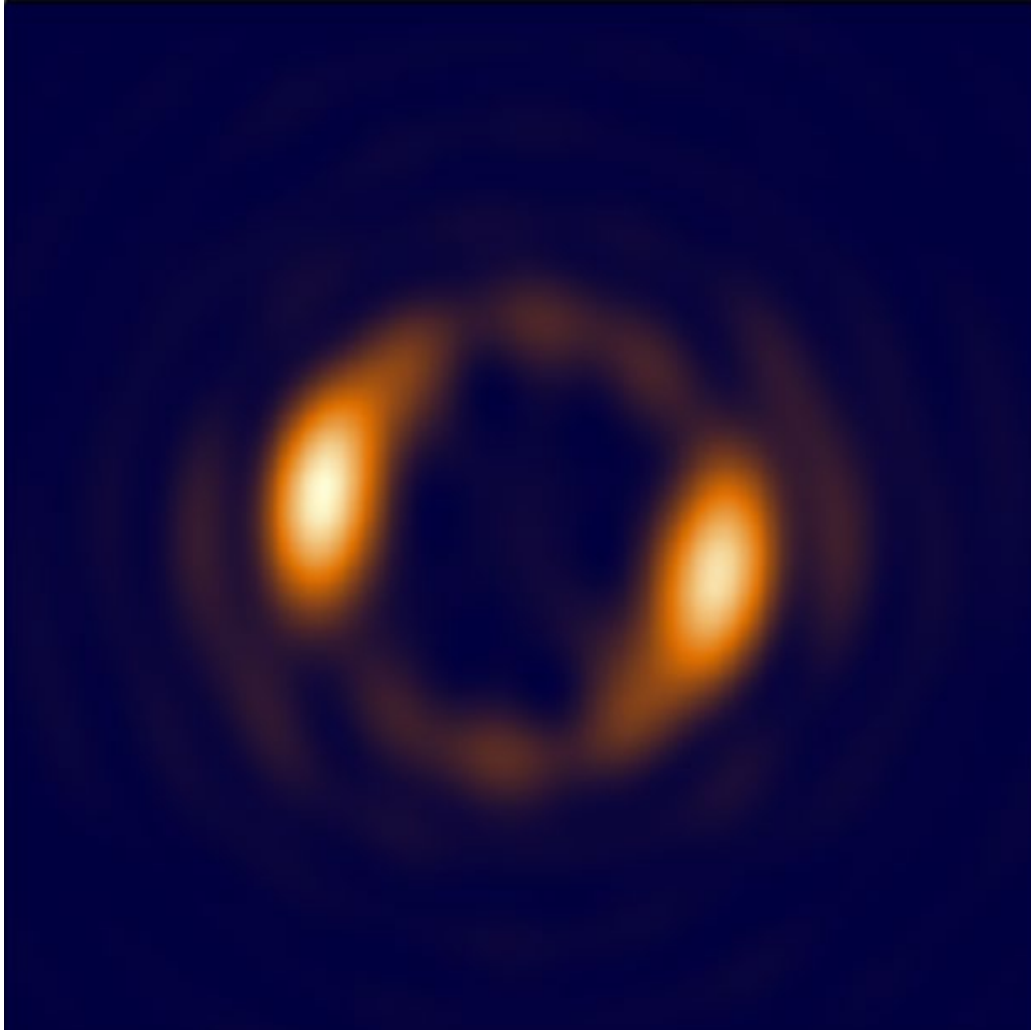


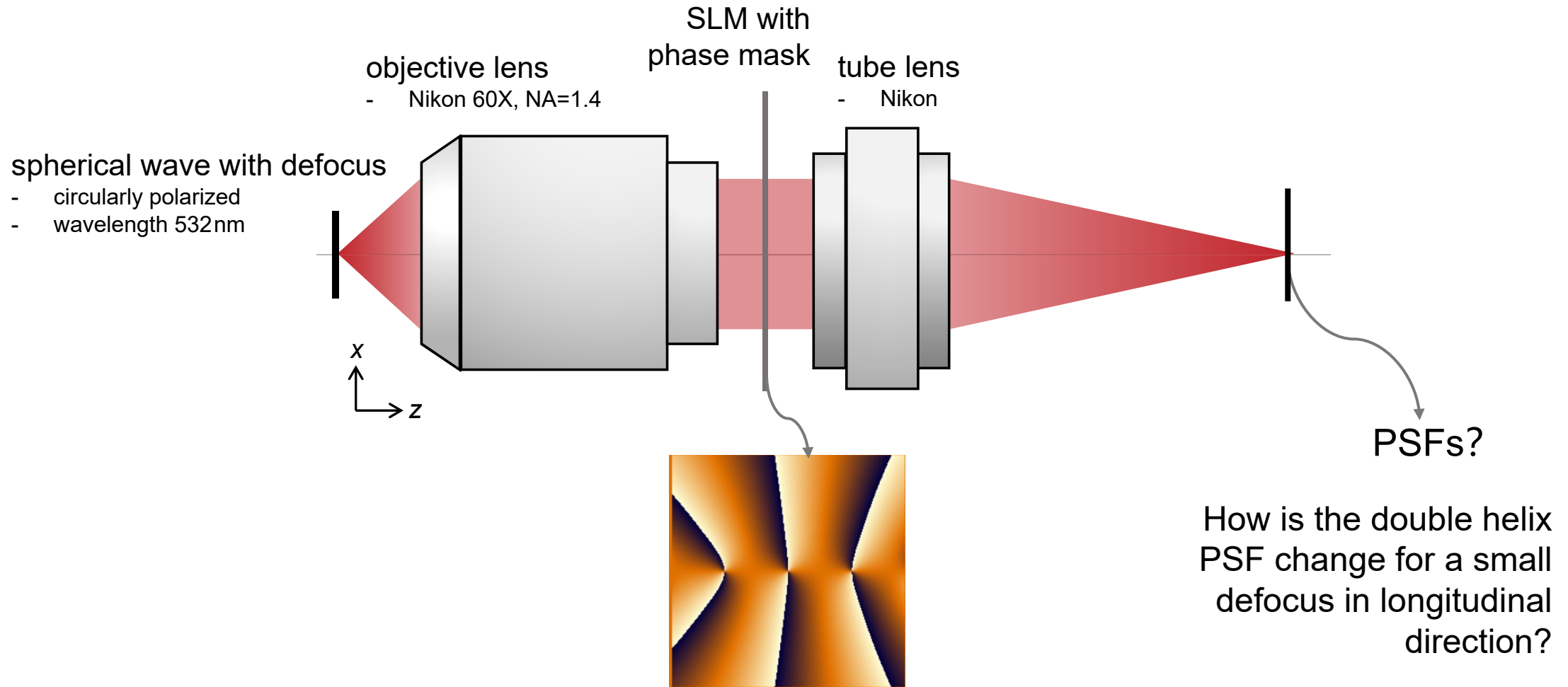
Double-Helix PSF for 3D Imaging Microscopy

Abstract



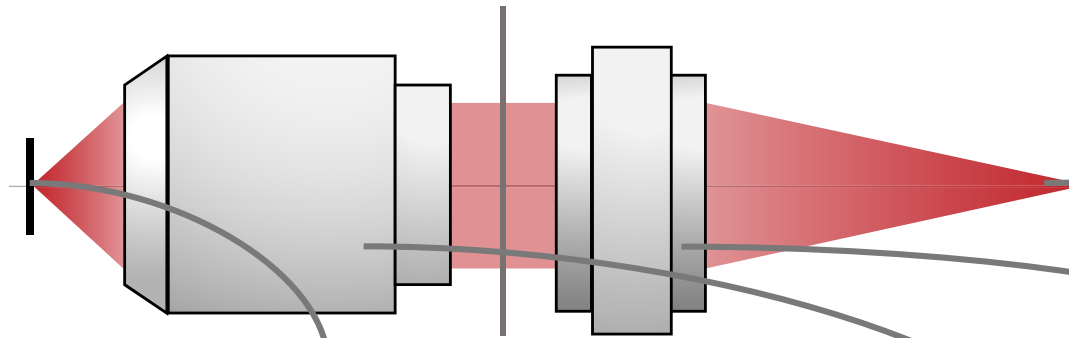
The Double-Helix (DH) PSF engineering provides a high resolution in the longitudinal direction for 3D imaging. It can be produced by adding a phase mask with vortices in the pupil plane [Ginni Grover et al., Opt. Exp. 2012]. VirtualLab Fusion provides a fast and convenient way to calculate the DH PSFs for small defoci of a high-NA microscopy system. This use case demonstrates the DH-PSFs have obvious changes with a defocus of ~ 130 nm.

Modeling Task



Building the System in VirtualLab Fusion

System Building Blocks



Edit Camera Detector

Coordinate Systems

Position / Orientation

Detector Window and Resolution | Detector Function

Detector Window

Scale Window Size by Factor

Set Window Size ×

Copy from ... Center Position ×

Generate Spherical Wave

Polarization | Mode Selection | Sampling | Ray Selection

Basic Parameters | Spectral Parameters | Spatial Parameters

Power Spectrum Type | Single Wavelength

Spectral Values

Wavelength Weight

Edit Programmable Function

Basic Parameters | Physical Parameters | Sampling

Coordinate Systems

Position / Orientation

Function

Construction Method | Single Function with Aperture

Aperture Size and Shape

Automatic Setting Manual Setting

Shape Rectangular Elliptic

Diameter ×

Relative Edge Width

Absolute Edge Width

Edit Lens System Component

Coordinate Systems

Position / Orientation

Structure

Solver

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Plane Interface	Abbe Number V_d Mater	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 Homoge	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	J-KZFH1_HIKARI in Hor	Zemax Interf

Edit Lens System Component

Coordinate Systems

Position / Orientation

Structure

Solver

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	E-SK10_HIKARI in Homc	Zemax Interface
2	5.1 mm	5.1 mm	Conical Interface	J-LAF7_HIKARI in Homc	Zemax Interface
3	2 mm	7.1 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interface
4	7.5 mm	14.6 mm	Conical Interface	BASF6_SCHOTT in Hon	Zemax Interface
5	5.1 mm	19.7 mm	Conical Interface	KZFH1_HIKARI in Homc	Zemax Interface
6	1.8 mm	21.5 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interface

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.](#)

Solver

input LPW output LPW

Edit Lens System Component

Solver: Sampling

Component Solver: Local Plane Interface Approximation (LPIA) [Edit]

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Solver

input LPW output LPW

Components

Solvers

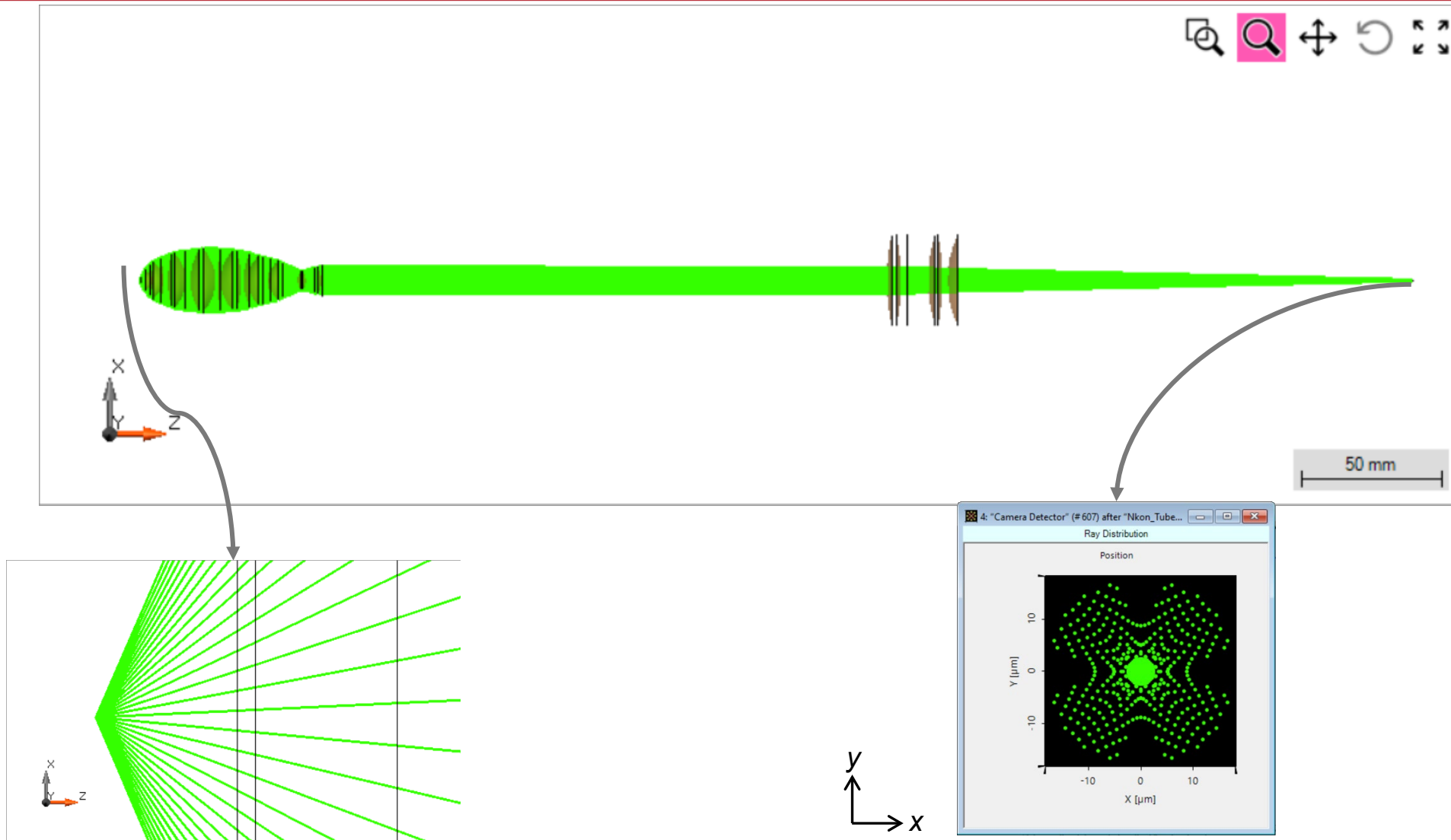
Lens Systems

Local Plane Interface Approximation (LPIA)

Geometric-Optics Simulations

by Ray Tracing

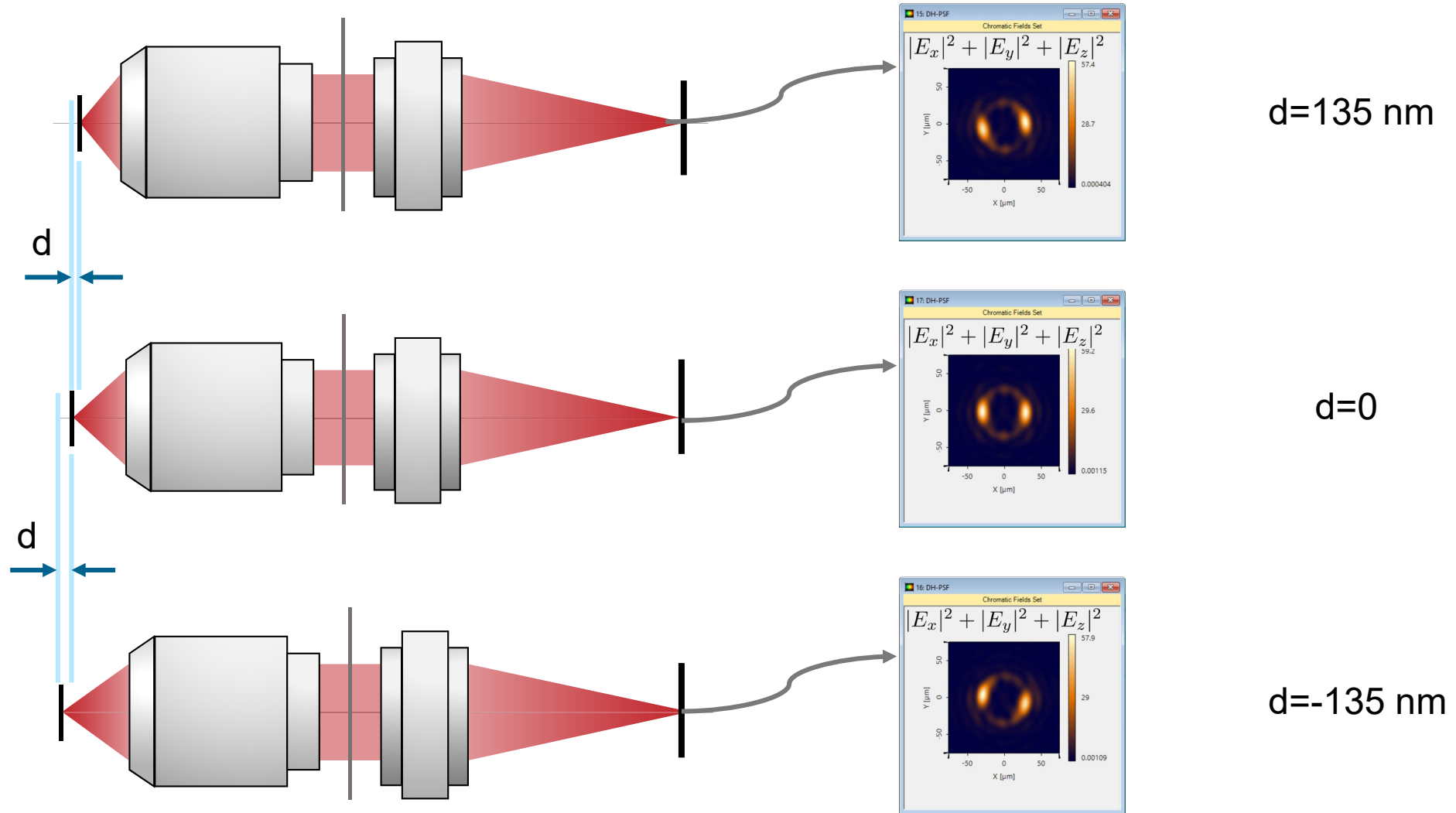
Results: Ray Tracing



Fast Physical-Optics Simulations

by Field Tracing

Double Helix PSFs at Image Plane for Different Defocuses



Document Information

title	Double-Helix PSF for 3D Imaging Microscopy
document code	MIC.0019
version	1.0
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>