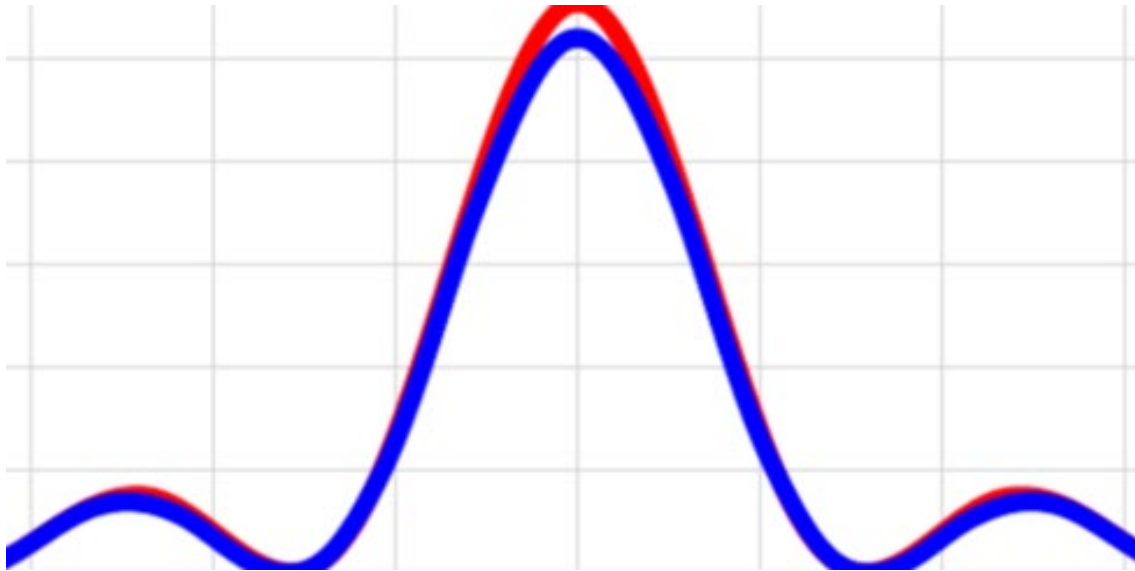


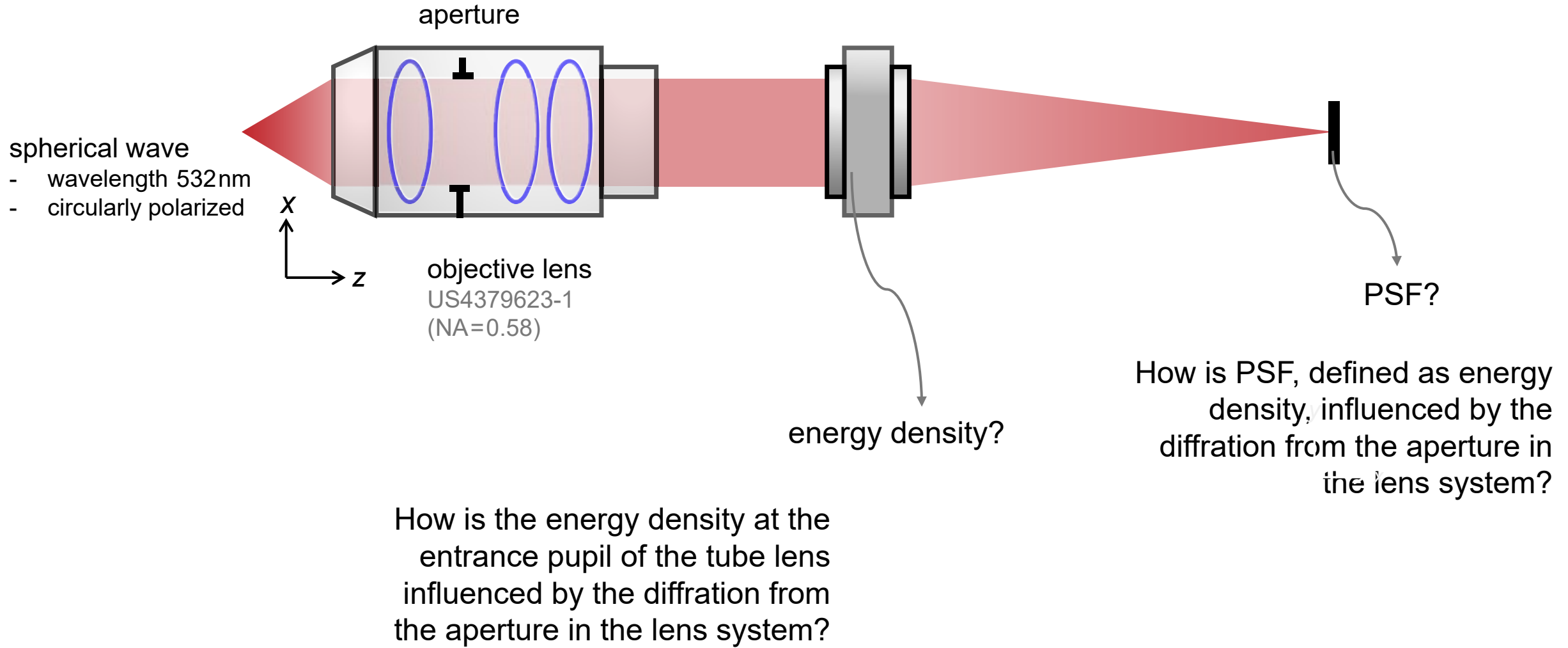
Diffraction from the Aperture in a Microscopy System

Abstract



In microscopy systems, the influence of the diffraction from the aperture in the system may have an effect on the PSF. However, it is rarely considered in the design as well as the usage. VirtualLab Fusion provides a straightforward way to include the diffraction effect in the microscopy lens system. This use case investigates the influences on the energy density at the entrance pupil of the tube lens as well as at the image plane.

Scenario



Building the System in VirtualLab Fusion

System Building Blocks

The diagram illustrates an optical system consisting of three lenses (blue ovals) and a detector (black bar). A red beam of light enters from the left, passes through the lenses, and is focused onto the detector. Three arrows point from the system to three software windows:

- Generate Spherical Wave:** A window for defining the input wave. It includes tabs for Polarization, Mode Selection, and Sampling. The Spectral Parameters tab is active, showing a Power Spectrum Type of Single Wavelength and a Wavelength of 532 nm.
- Edit Lens System Component:** A window for defining the lens system. It includes a Structure tab (active) showing a table of lens surfaces and a list of surface types (Plane, Conical, Cylindrical, Aspherical, Polynomial, Sampled, Programmable).
- Edit Camera Detector:** A window for defining the detector. It includes a Detector Window and Resolution section with a Set Window Size of 2 μm x 2 μm and a Center Position of 0 mm x 0 mm.

Generate Spherical Wave - Spectral Parameters

Power Spectrum Type: Single Wavelength

Spectral Values: Wavelength: 532 nm, Weight: 1

Edit Lens System Component - Structure

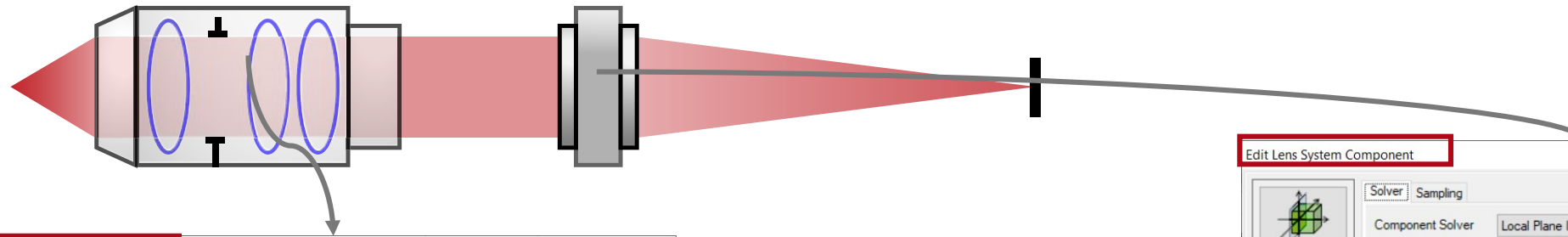
Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	LAC15_HOYA in Homog	Lens file surface
2	3.5 mm	3.5 mm	Conical Interface	Air (Zemax OS) in Homog	Lens file surface
3	214.03 μm	3.7141 mm	Conical Interface	SF11_SCHOTT in Homog	Lens file surface
4	1.5 mm	5.2141 mm	Conical Interface	LAC15_HOYA in Homog	Lens file surface
5	3 mm	8.2141 mm	Conical Interface	Air (Zemax OS) in Homog	Lens file surface
6	5.5693 mm	13.783 mm	Conical Interface	H-LAF7_NHG in Homog	Lens file surface
7	400.3 μm	14.184 mm	Plane Surface	H-LAF7_NHG in Homog	Enter your comr

Edit Camera Detector - Detector Window and Resolution

Detector Window: Scale Window Size by Factor, Set Window Size: 2 μm x 2 μm

Center Position: 0 mm x 0 mm

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.](#)

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.](#)

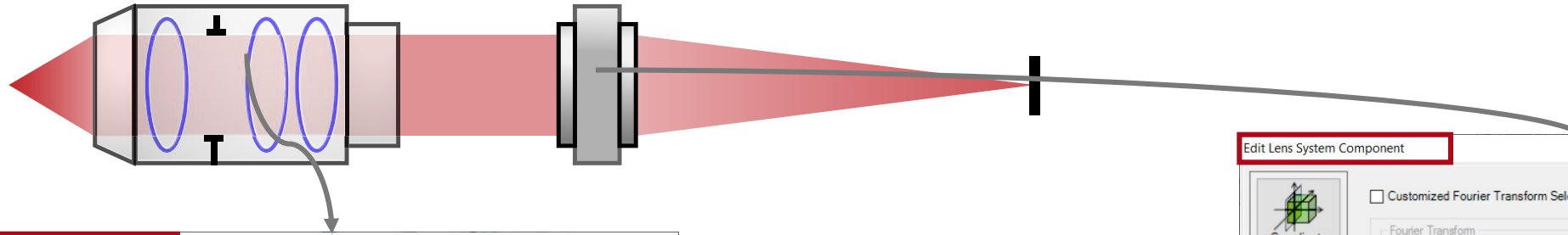
Components

Solvers

Lens Systems

Local Plane Interface Approximation (LPIA)

Fourier Transforms Before and After Components



Edit Lens System Component

Customized Fourier Transform Selection: Component

Fourier Transform	Inverse Fourier Transform
<input type="checkbox"/> Fast Fourier Transform	<input type="checkbox"/> Fast Fourier Transform
<input type="checkbox"/> Semi-Analytical Fourier Transform	<input type="checkbox"/> Semi-Analytical Fourier Transform
<input checked="" type="checkbox"/> Pointwise Fourier Transform	<input checked="" type="checkbox"/> Pointwise Fourier Transform
<input type="checkbox"/> Use Spherical Phase Only	<input type="checkbox"/> Use Spherical Phase Only

Enforce Pointwise Fourier Transform if Numerical Effort is Too High ⓘ
[Learn more about Fourier transforms.](#)

Customized Fourier Transform Selection: Source Modes

Fourier Transform	Inverse Fourier Transform
<input type="checkbox"/> Fast Fourier Transform	<input type="checkbox"/> Fast Fourier Transform
<input type="checkbox"/> Semi-Analytical Fourier Transform	<input type="checkbox"/> Semi-Analytical Fourier Transform
<input checked="" type="checkbox"/> Pointwise Fourier Transform	<input checked="" type="checkbox"/> Pointwise Fourier Transform
<input type="checkbox"/> Use Spherical Phase Only	<input type="checkbox"/> Use Spherical Phase Only

Enforce Pointwise Fourier Transform if Numerical Effort is Too High ⓘ
[Learn more about Fourier transforms.](#)

Coordinate Systems
Position / Orientation
Structure
Solver
Channel Configuration
Fourier Transforms

Validity: OK Cancel Help

Edit Lens System Component

Customized Fourier Transform Selection: Component

Fourier Transform	Inverse Fourier Transform
<input checked="" type="checkbox"/> Fast Fourier Transform	<input checked="" type="checkbox"/> Fast Fourier Transform
<input checked="" type="checkbox"/> Semi-Analytical Fourier Transform	<input checked="" type="checkbox"/> Semi-Analytical Fourier Transform
<input checked="" type="checkbox"/> Pointwise Fourier Transform	<input checked="" type="checkbox"/> Pointwise Fourier Transform
<input type="checkbox"/> Use Spherical Phase Only	<input type="checkbox"/> Use Spherical Phase Only

Enforce Pointwise Fourier Transform if Numerical Effort is Too High ⓘ
[Learn more about Fourier transforms.](#)

Customized Fourier Transform Selection: Source Modes

Fourier Transform	Inverse Fourier Transform
<input type="checkbox"/> Fast Fourier Transform	<input type="checkbox"/> Fast Fourier Transform
<input type="checkbox"/> Semi-Analytical Fourier Transform	<input type="checkbox"/> Semi-Analytical Fourier Transform
<input checked="" type="checkbox"/> Pointwise Fourier Transform	<input checked="" type="checkbox"/> Pointwise Fourier Transform
<input type="checkbox"/> Use Spherical Phase Only	<input type="checkbox"/> Use Spherical Phase Only

Enforce Pointwise Fourier Transform if Numerical Effort is Too High ⓘ
[Learn more about Fourier transforms.](#)

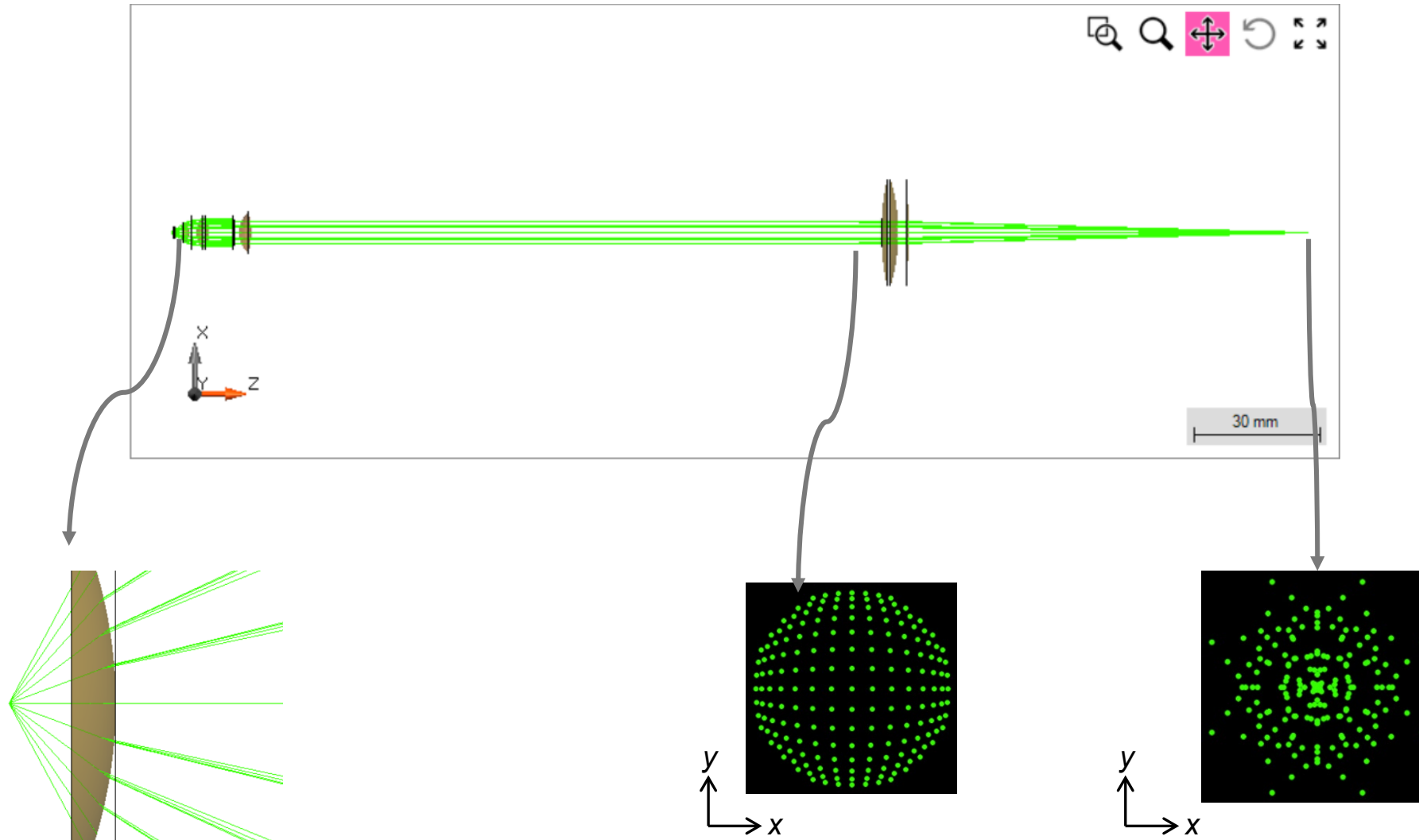
Coordinate Systems
Position / Orientation
Structure
Solver
Channel Configuration
Fourier Transforms

Validity: OK Cancel Help

Geometric-Optics Simulations

by Ray Tracing

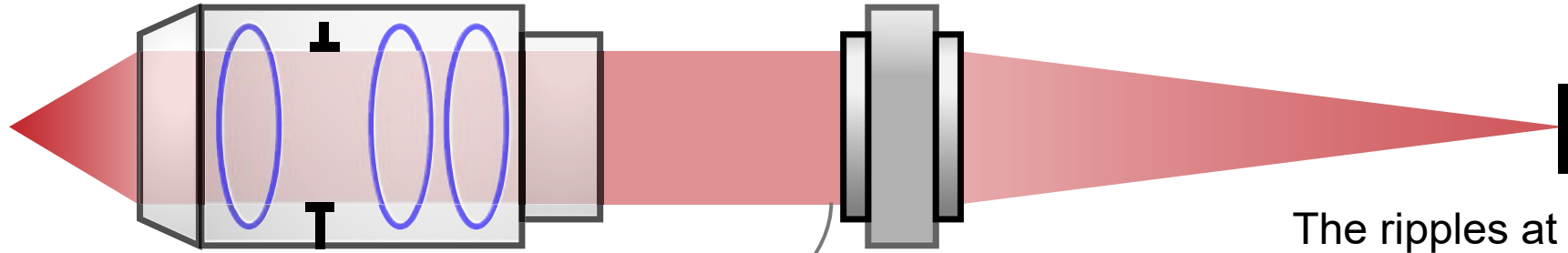
Results: Ray Tracing



Fast Physical-Optics Simulations

by Field Tracing

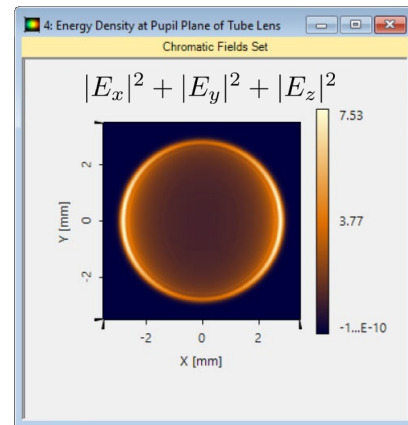
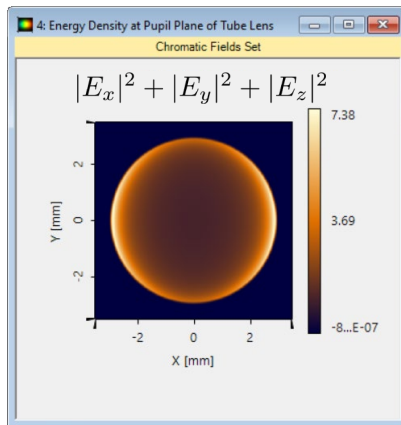
Energy Density at the Tube Lens



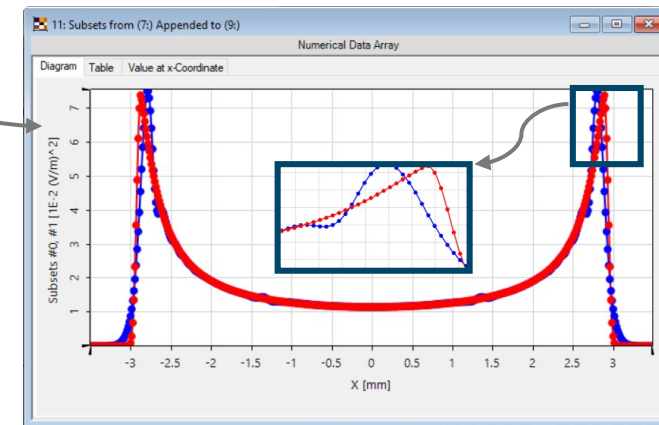
The ripples at the border are caused by the diffraction effect.

without diffraction effect

with diffraction effect

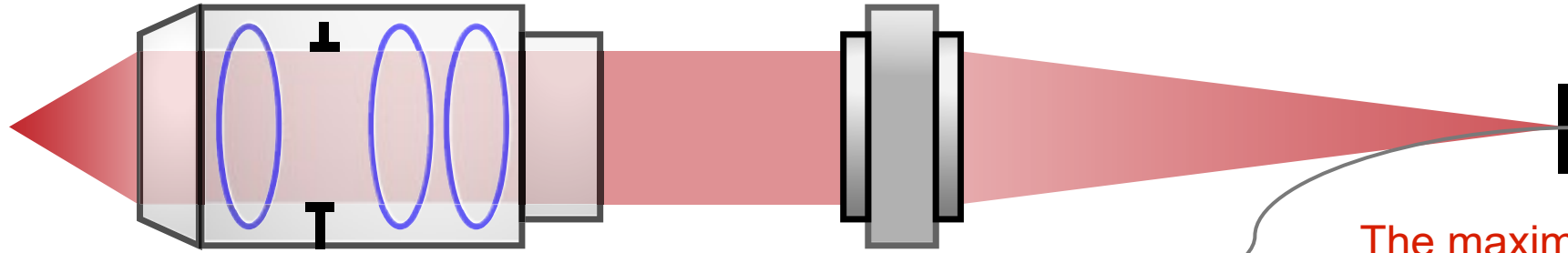


profiles along x direction



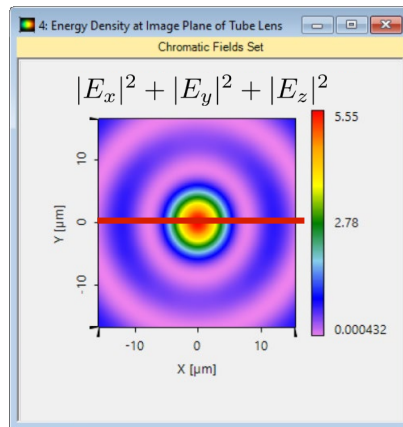
- with diffraction effect
- without diffraction effect

PSF at Image Plane

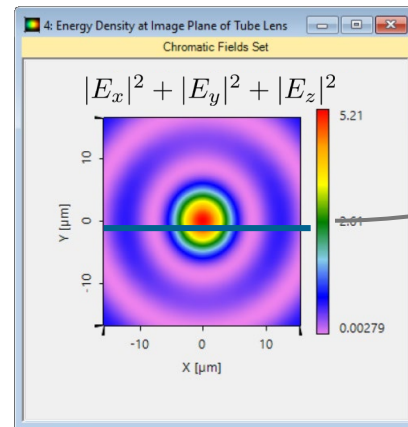


The maximum energy density is decreased due to the diffraction from the aperture.

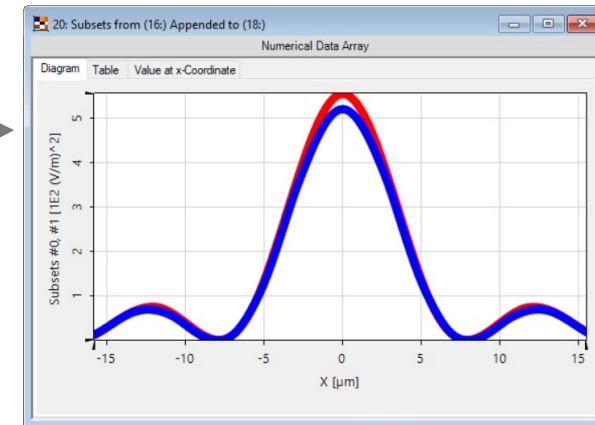
without diffraction from aperture in lens system



with diffraction from aperture in lens system



profiles along x directions



- with diffraction effect
- without diffraction effect

Document Information

title	Diffraction from the Aperture in a Microscopy System
document code	MIC.0017
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">- Debye-Wolf Integral Calculator- Analyzing High-NA Objective Lens- Resolution Investigation for Microscope Objective Lenses by Rayleigh Criterion