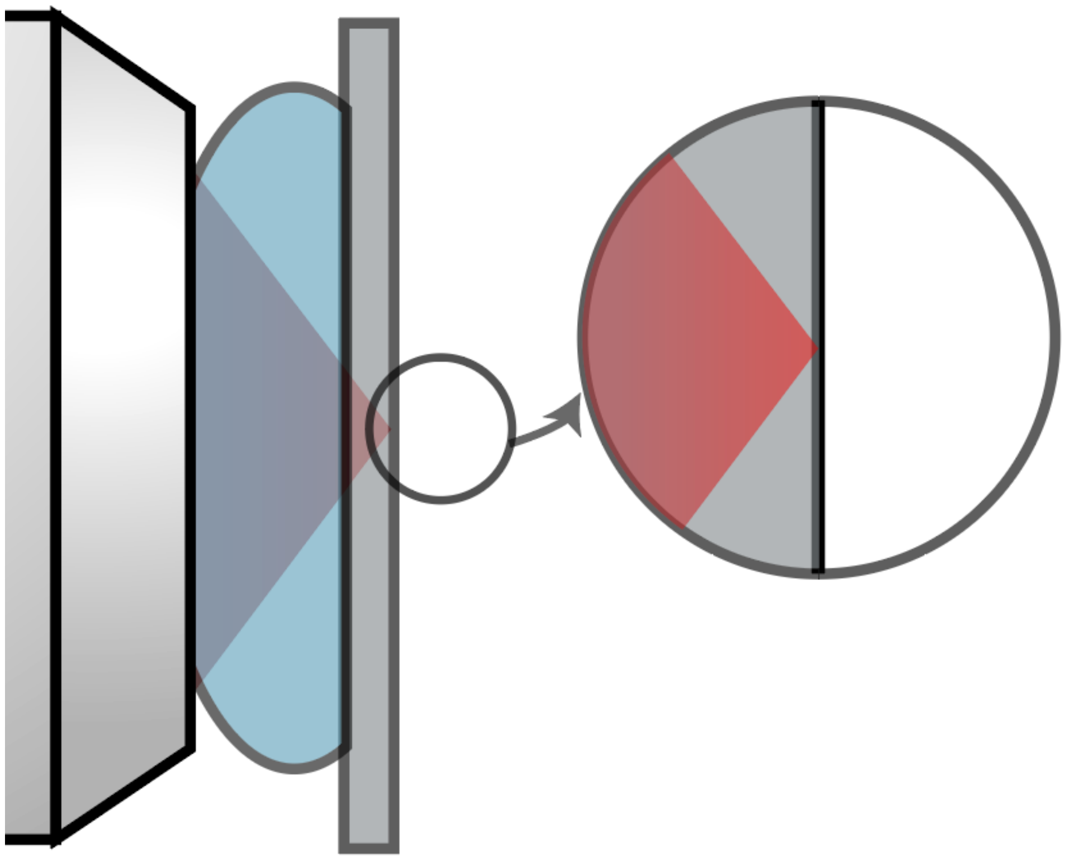
Tight Focusing by a High-NA Immersion Microscope

Abstract

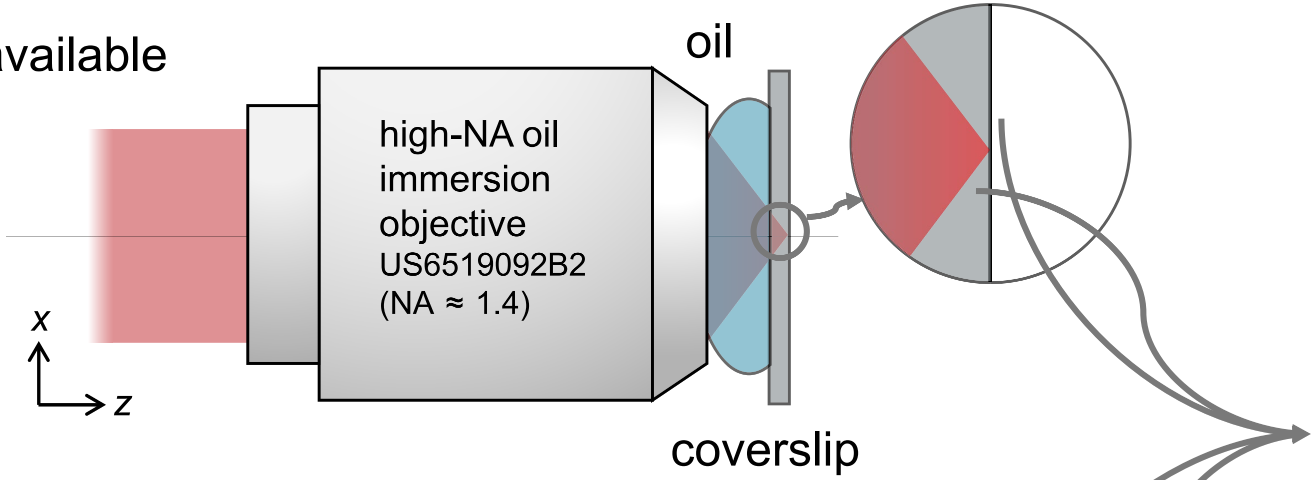


In an immersion microscope, there is often a coverslip which separates the immersion liquid and the specimen. Therefore, the PSF could be distorted by the interface of the coverslip at the focal plane, which is not very often considered well in the design procedure. In VirtualLab Fusion, the influence of the PSF by the interface of the coverslip can be analyzed straightforwardly. The distortion of the focal spot behind the coverslip is demonstrated and analyzed in a fully vectorial manner.

Scenario

1. real lens data available

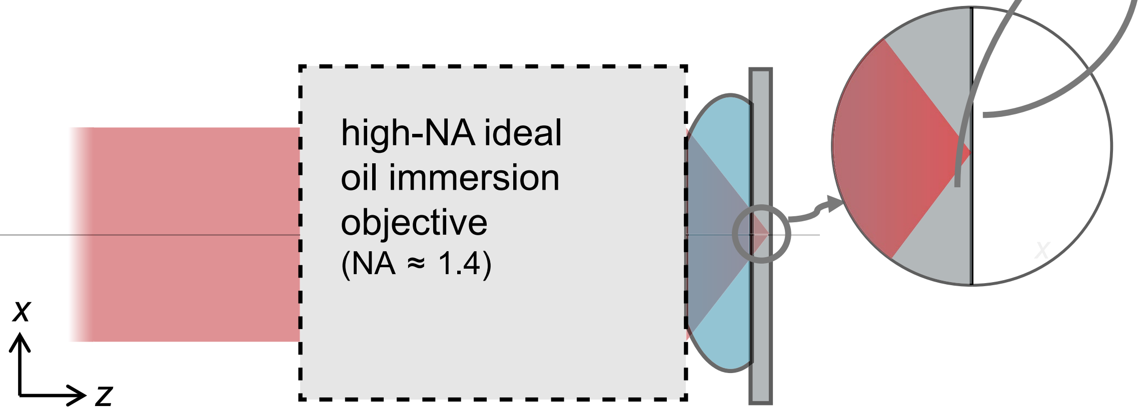
plane wave
- wavelength 532 nm
- linearly polarized in *x* direction



PSF & electric field?

2. no real lens data available

plane wave
- wavelength 532 nm
- linearly polarized in *x* direction

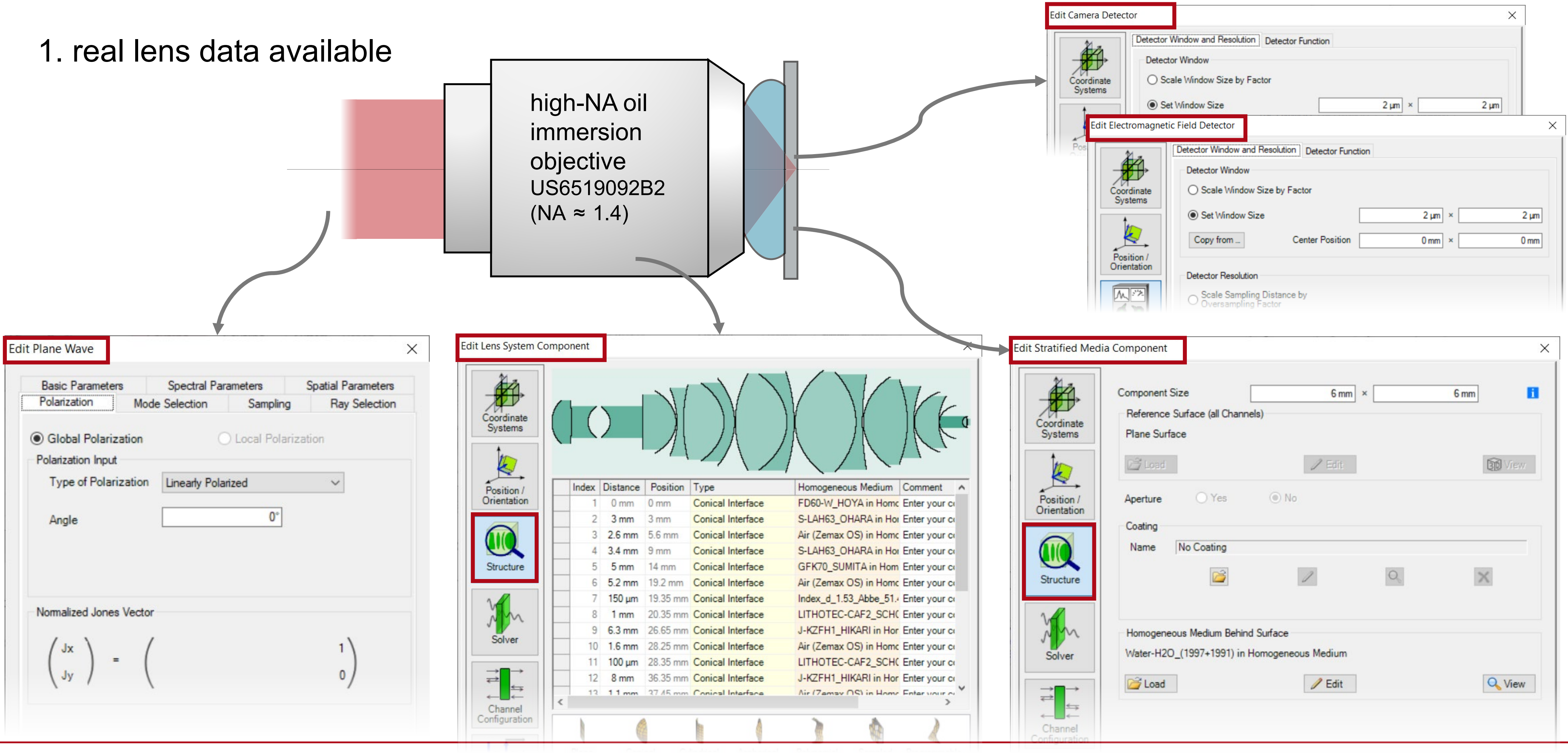


Comparison of the PSF and electric field before and behind the last surface of the coverslip to investigate how the PSF and the electric field are influenced?

Building the System in VirtualLab Fusion

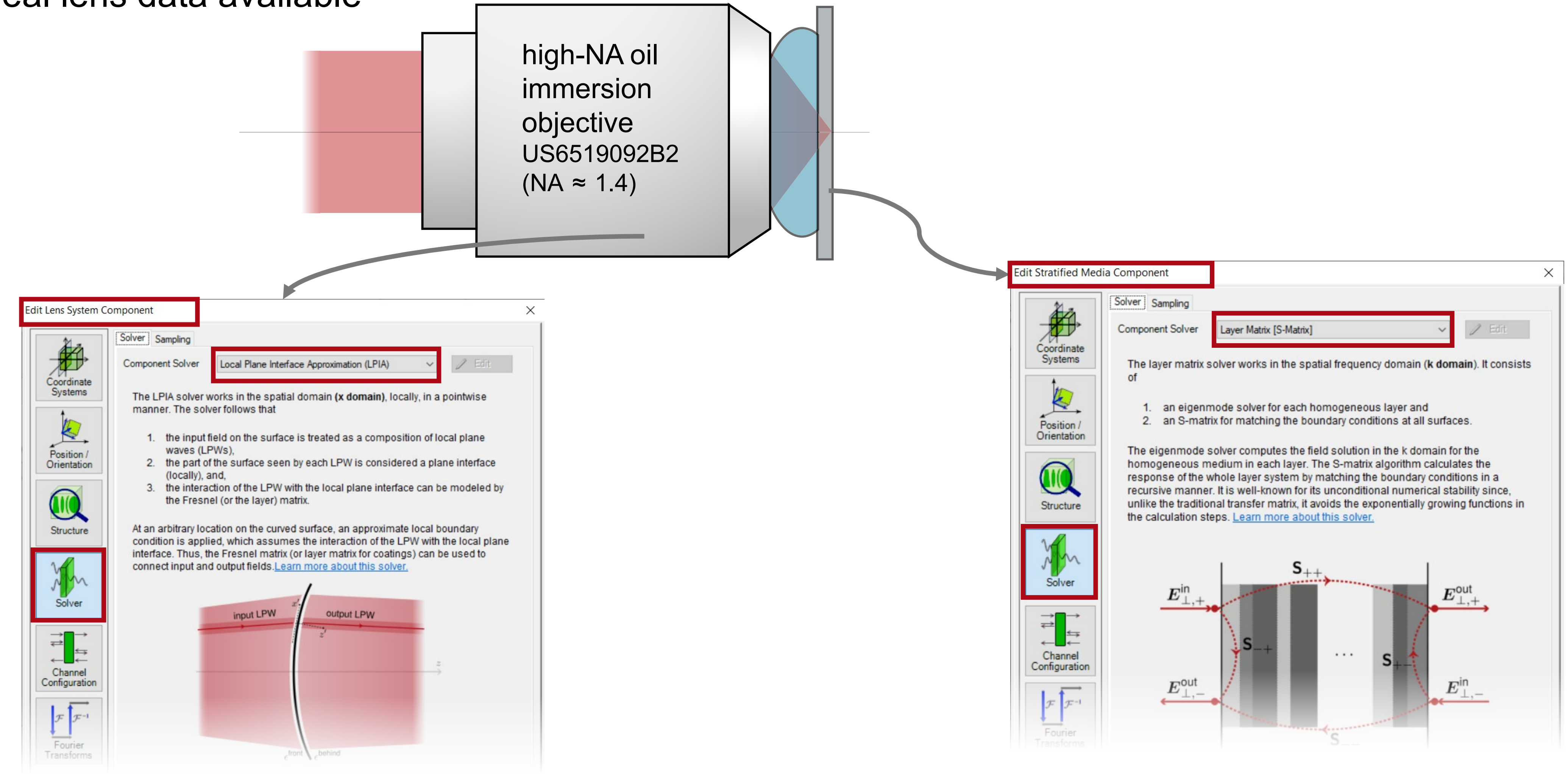
System Building Blocks

1. real lens data available



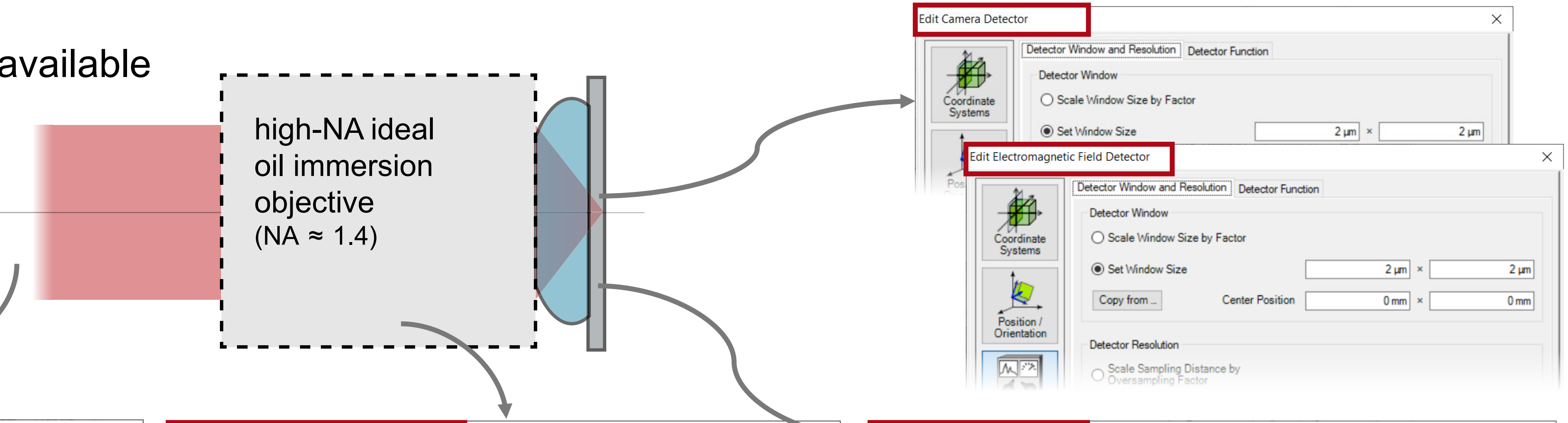
Solvers for Components

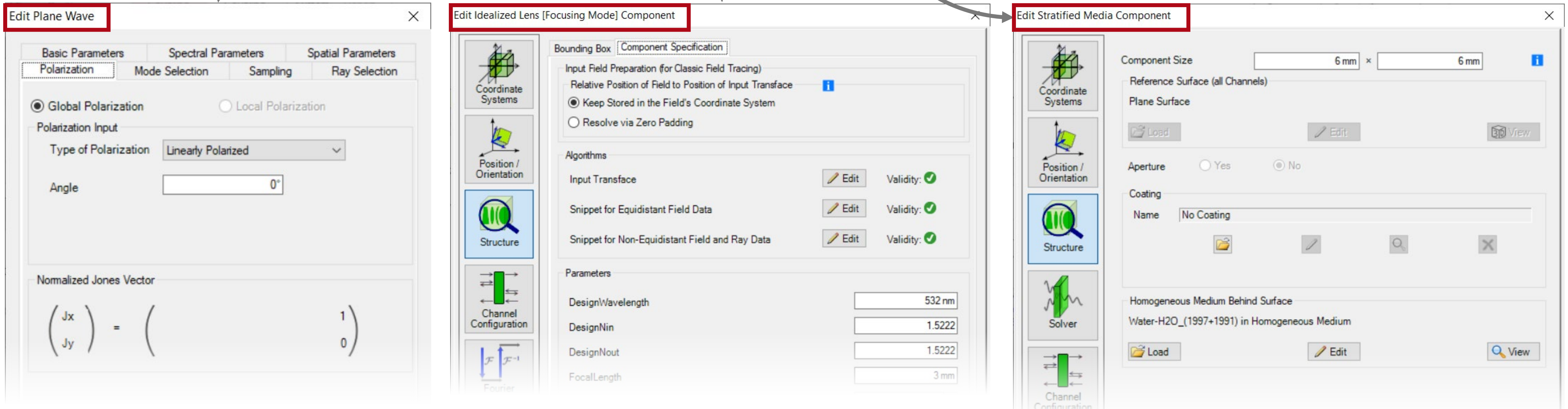
1. real lens data available



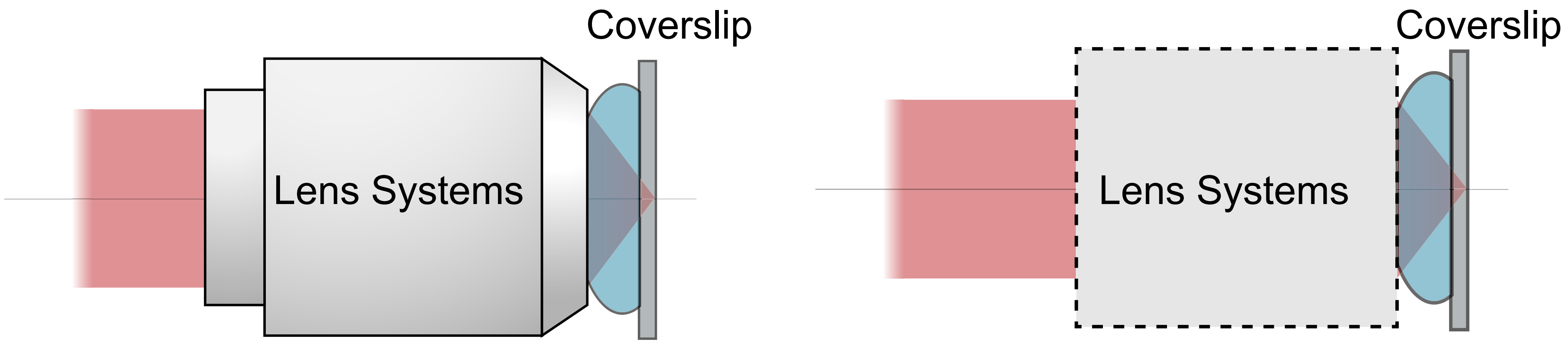
System Building Blocks

2. no real lens data available





Summary



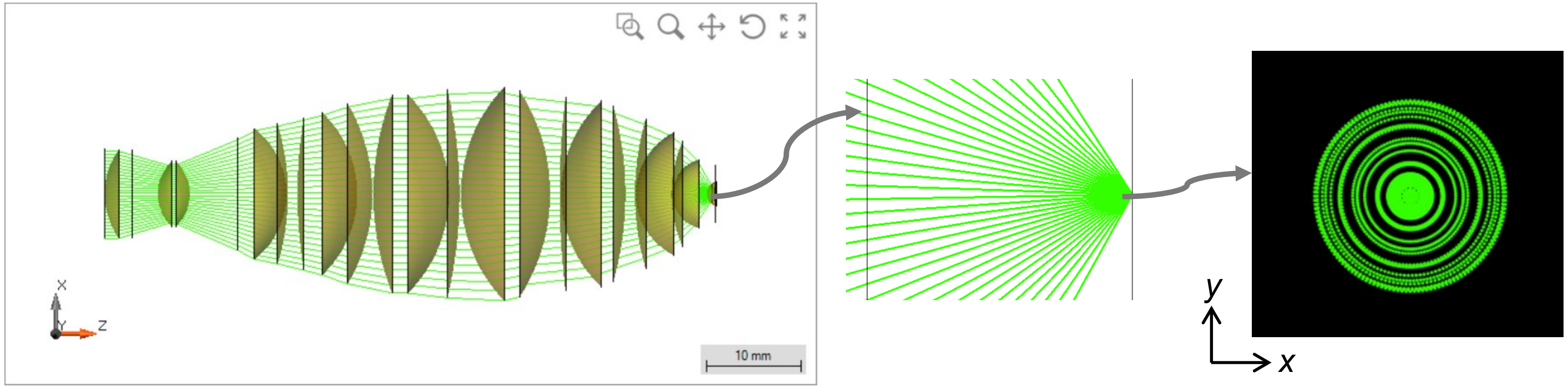
Components	Solvers
Lens Systems	Local Plane Interface Approximation (LPIA)
Coverslip	S-matrix for stratified medium

Geometric-Optics Simulations

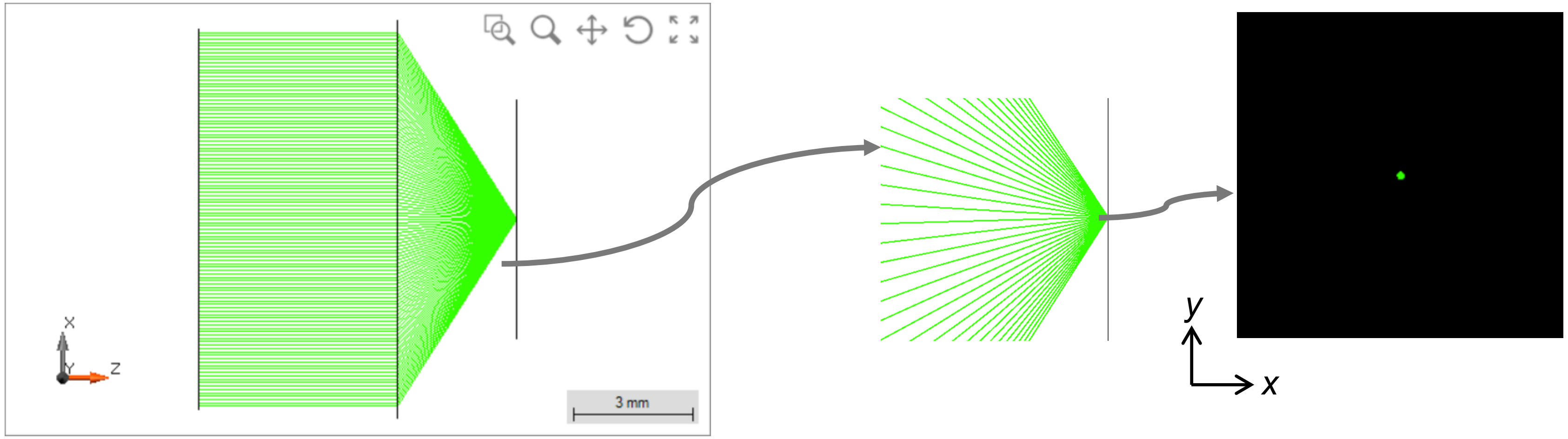
by Ray Tracing

Results: Ray Tracing

1. real lens data available



2. no real lens data available

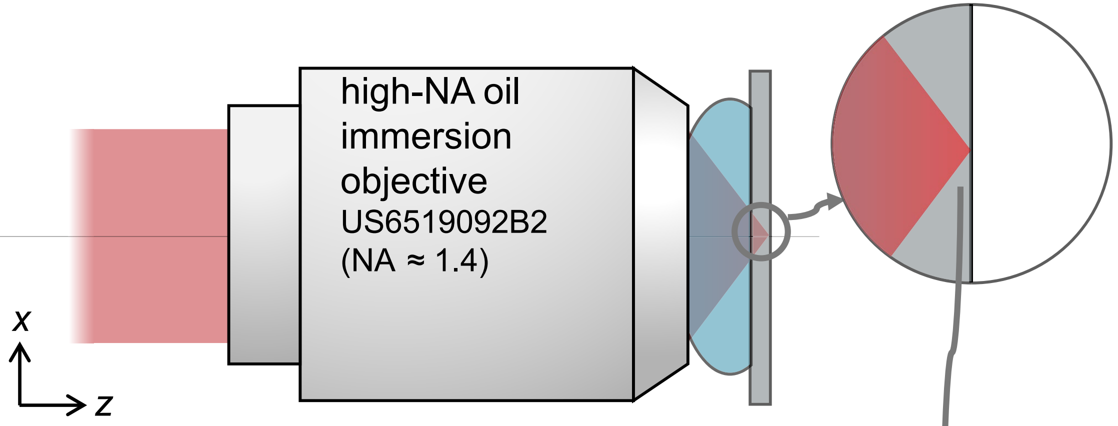


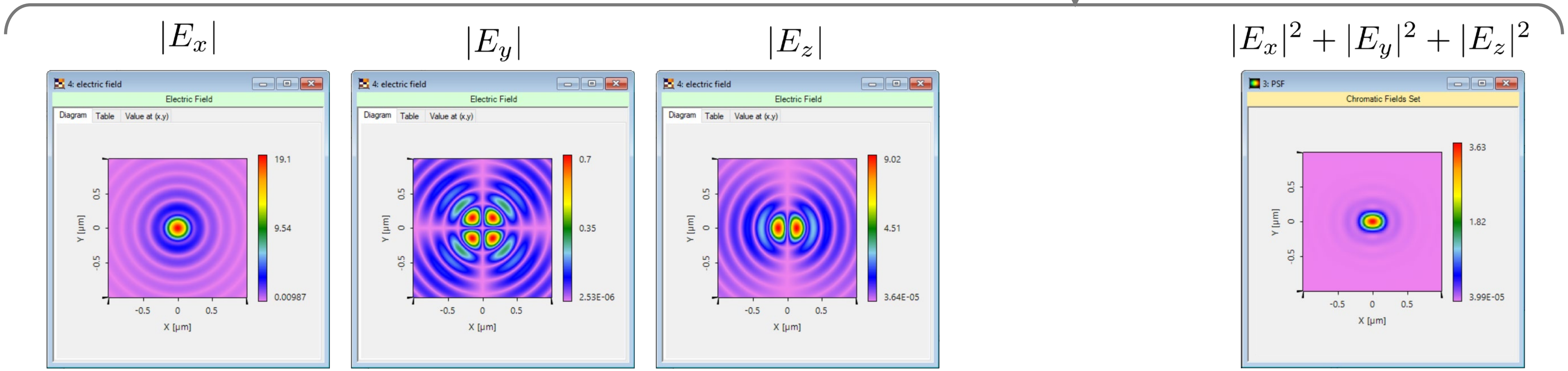
Fast Physical-Optics Simulations

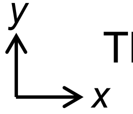
by Field Tracing

Focusing Before Last Interface of Coverslip

plane wave
- wavelength 532 nm
- linearly polarized in *x* direction





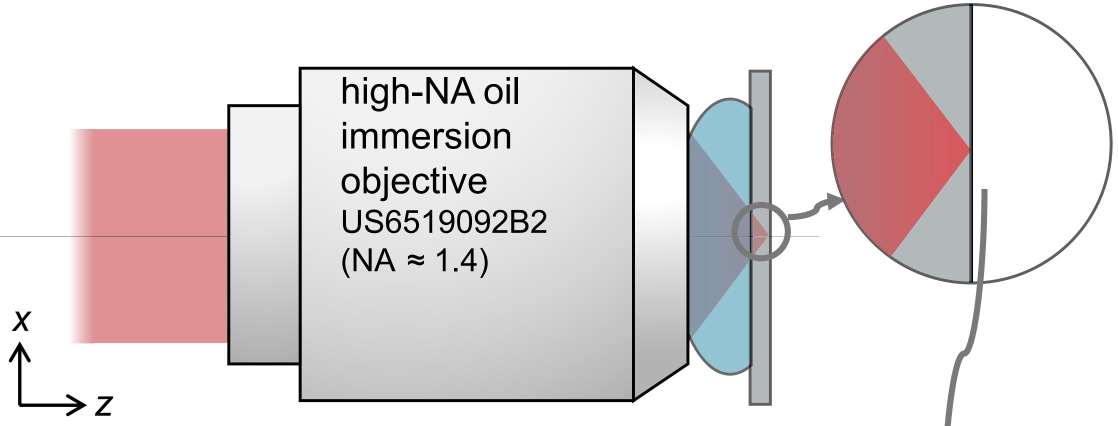


The cross-talk of different components of electric field is demonstrated.

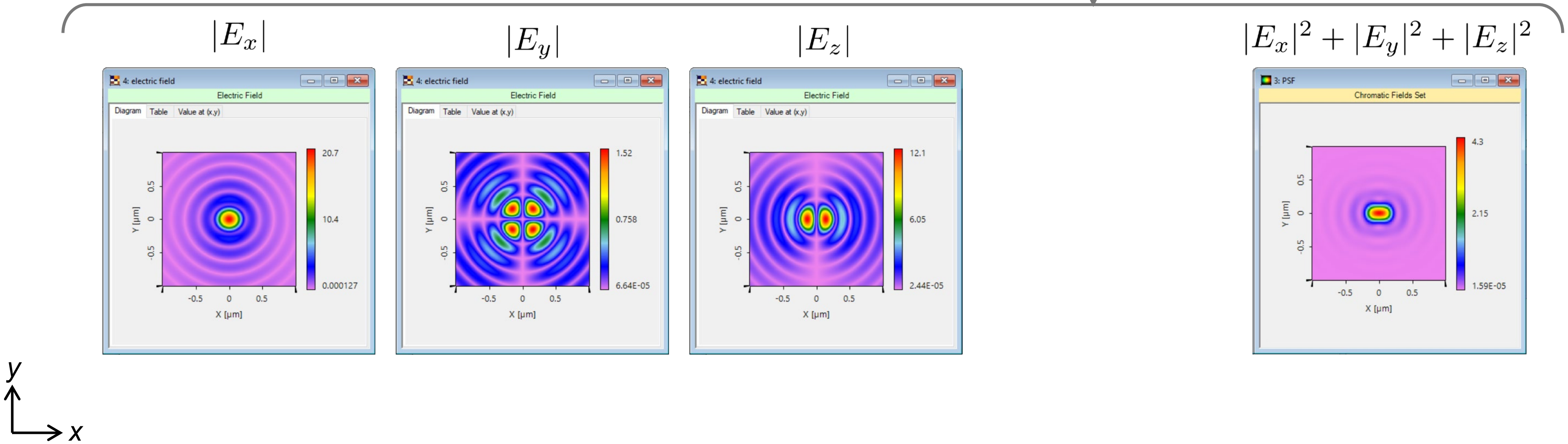
The asymmetry of the PSF is observed.

Focusing Behind Last Interface of Coverslip in Water

plane wave
- wavelength 532 nm
- linearly polarized in *x* direction



The PSF is elongated in x direction propagating through the interface.



Focusing Before Last Interface of Coverslip

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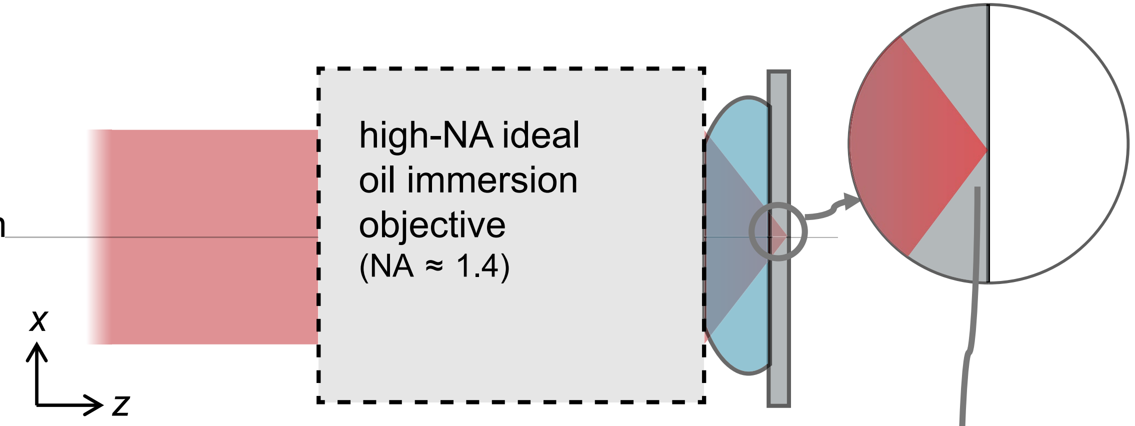

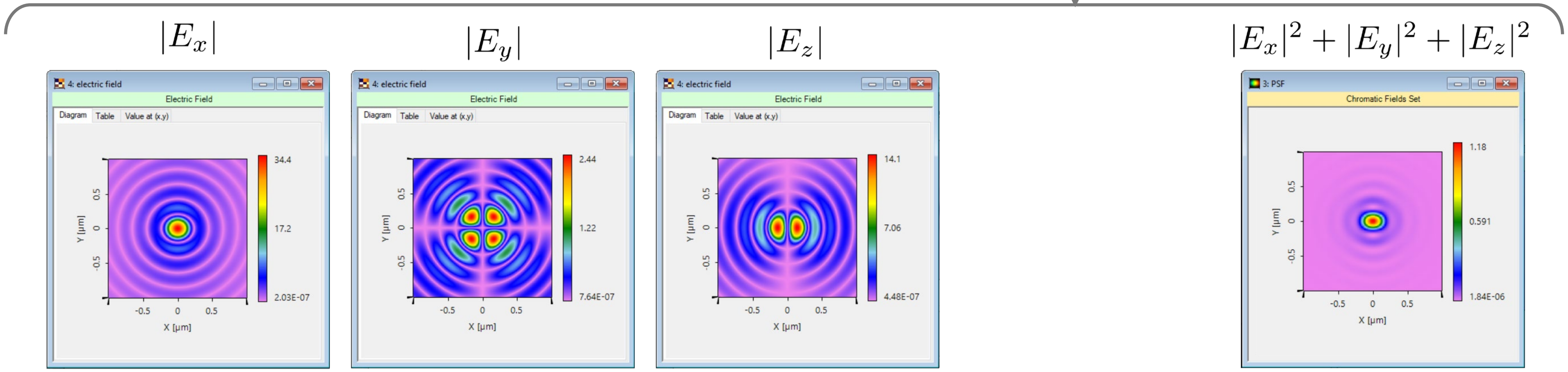

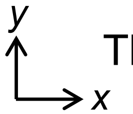

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Focusing Behind Last Interface of Coverslip in Water

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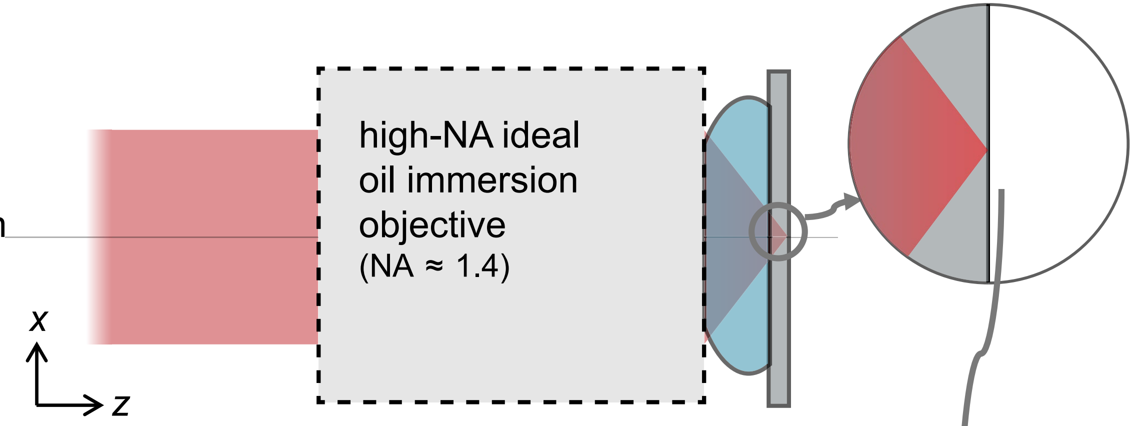

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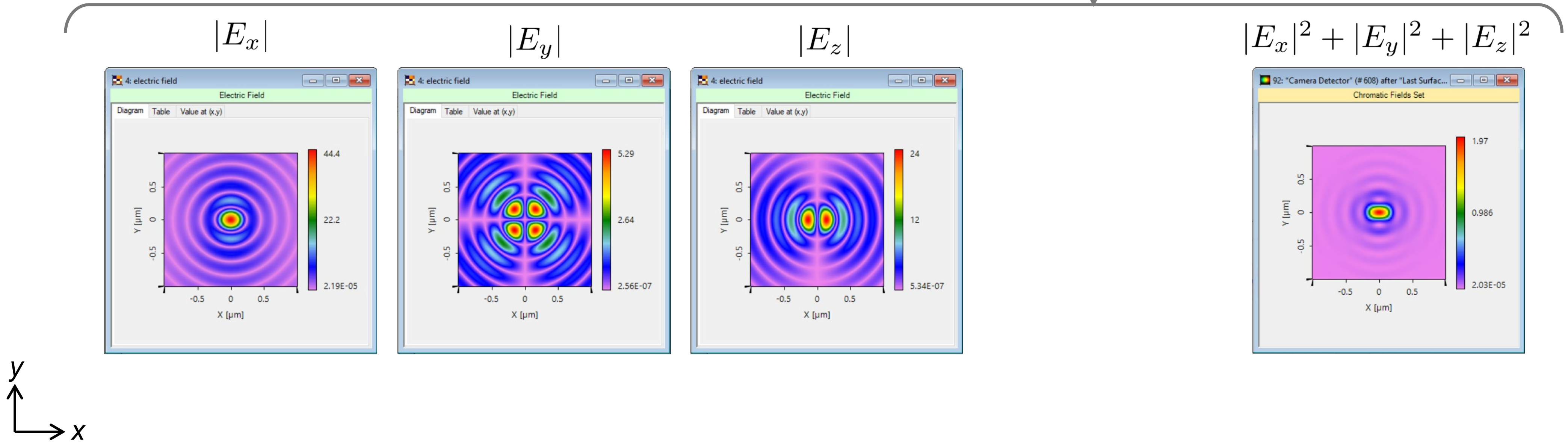
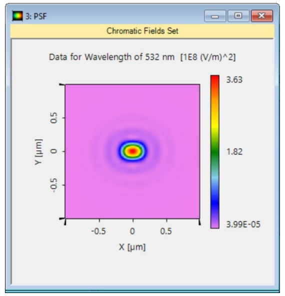
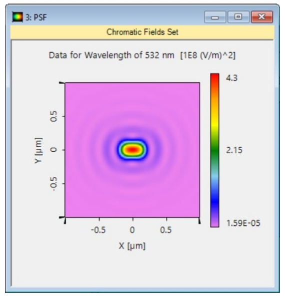
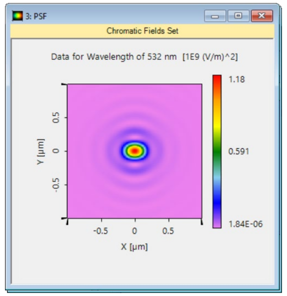
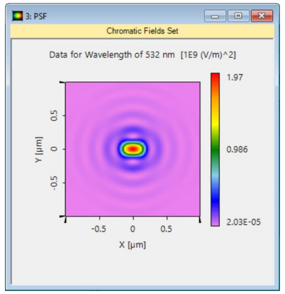


Summary

	before the last interface	behind the last interface
1. real lens data available	$\|E_x\|^2 + \|E_y\|^2 + \|E_z\|^2$  The asymmetry of the PSF is observed.	$\|E_x\|^2 + \|E_y\|^2 + \|E_z\|^2$  The PSF is elongated in x direction.
2. no real lens data available	$\|E_x\|^2 + \|E_y\|^2 + \|E_z\|^2$  The asymmetry of the PSF is observed.	$\|E_x\|^2 + \|E_y\|^2 + \|E_z\|^2$  The PSF is elongated in x direction.

Document Information

title	Tight Focusing by a High-NA Immersion Microscope
document code	MIC.0011
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further reading	- Debye-Wolf Integral Calculator - Analyzing High-NA Objective Lens - Resolution Investigation for Microscope Objective Lenses by Rayleigh Criterion