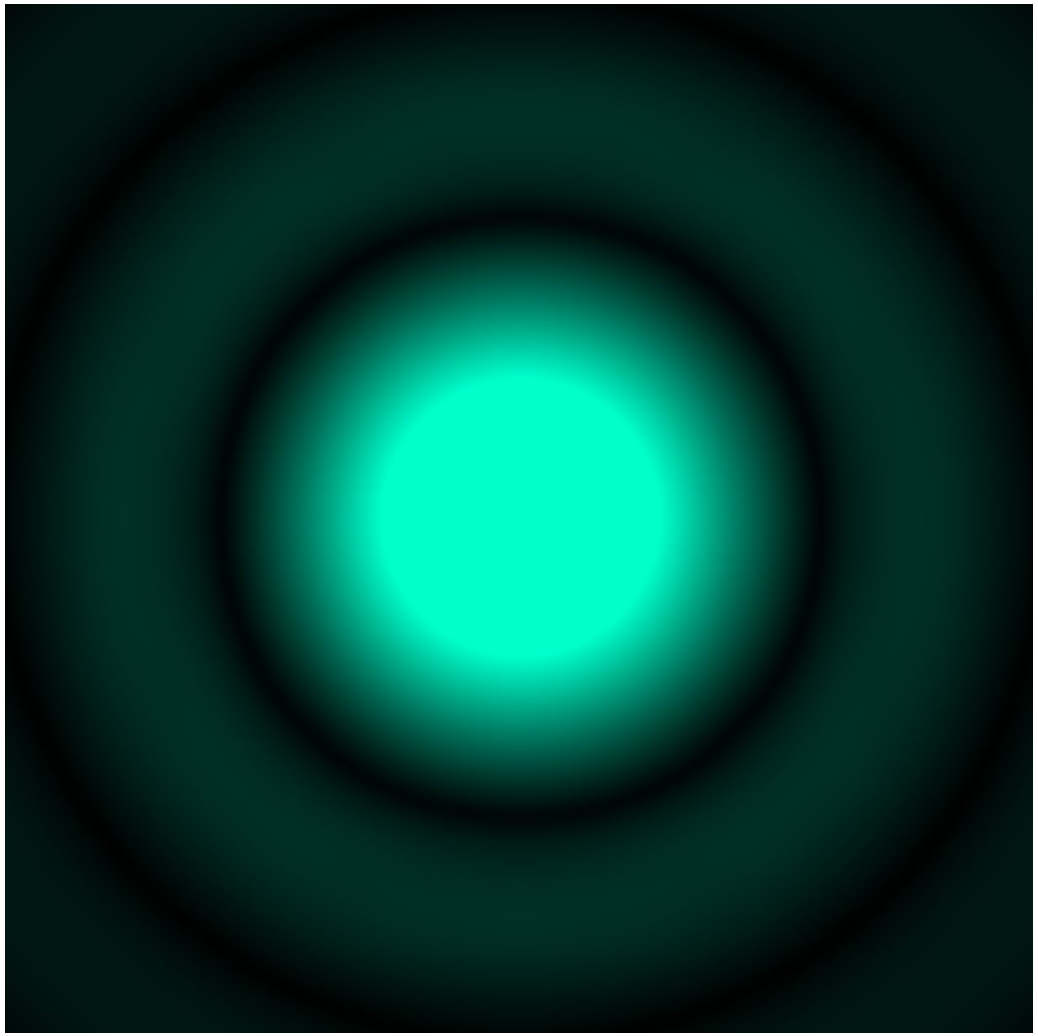
Pinhole Modeling in a Low-Fresnel-Number System

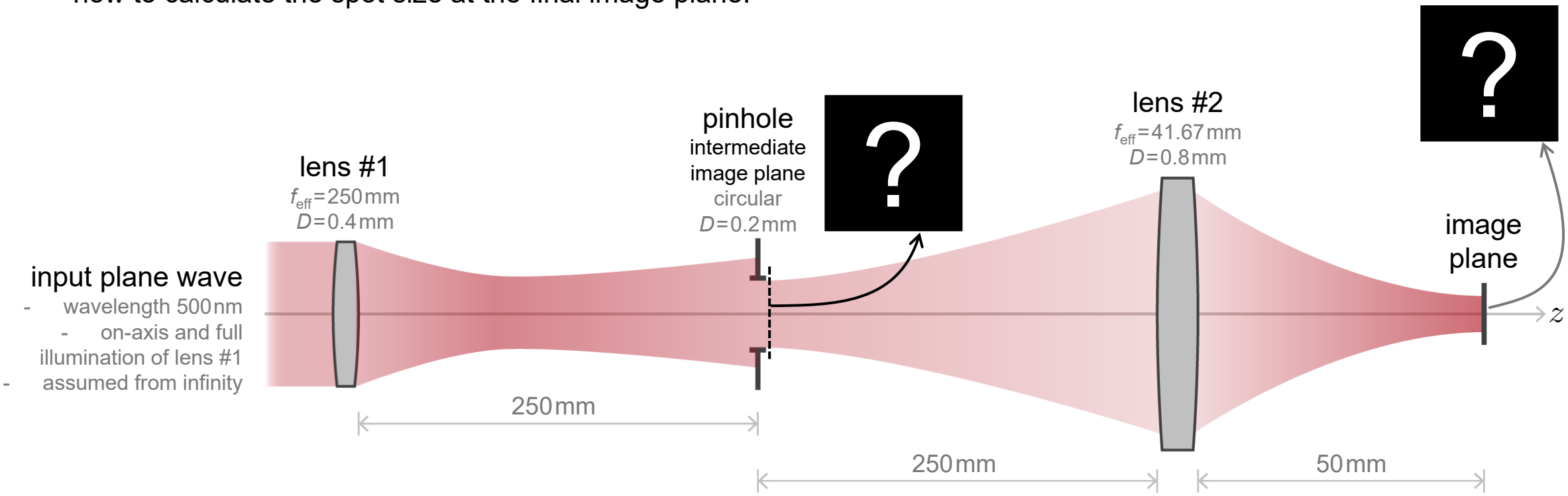
Abstract



Modeling of imaging systems with low Fresnel numbers is known to be challenging. In such systems, the light propagation is greatly determined by diffraction, and, to correctly model the complete system, possible diffractions at multiple surfaces and apertures must be considered. With the Fourier transform settings in VirtualLab Fusion, the inclusion of such diffraction effects can be adjusted flexibly. In this example, we show effect of the diffraction due to lens apertures and pinhole inside a low-Fresnel-number system.

Modeling Task

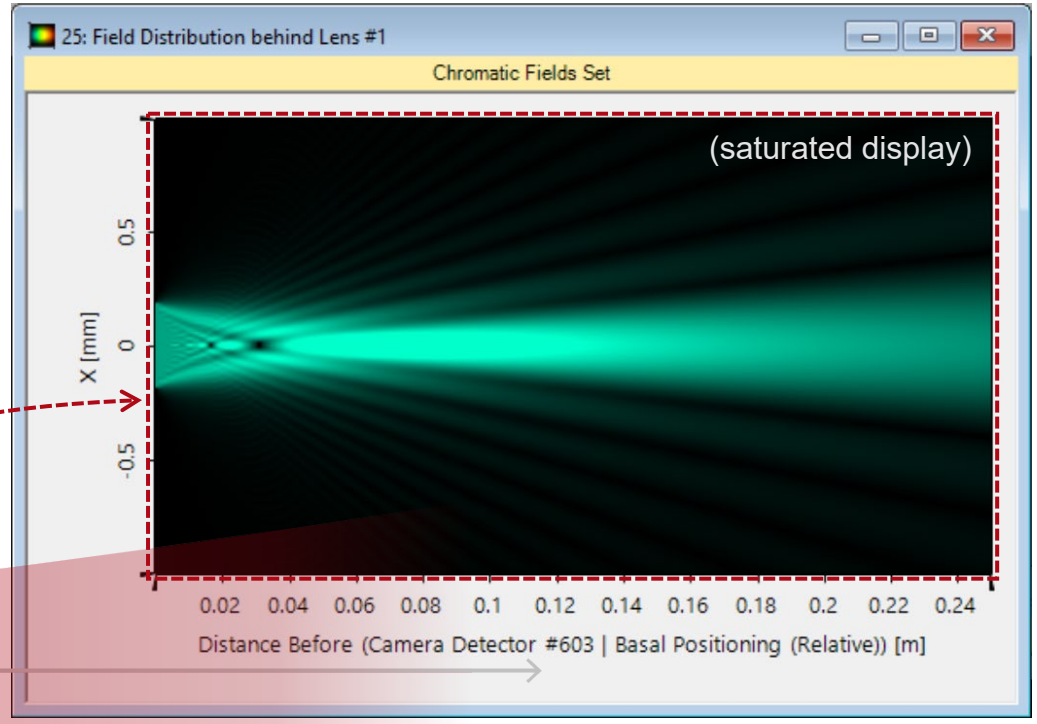
In the low Fresnel-number system, we show
- how does the pinhole truncate the light at the intermediate image plane, and
- how to calculate the spot size at the final image plane.



system parameters adapted from Fig. 9, M. Mout, *et al.*, Appl. Opt. 55, 3847-3853 (2016)

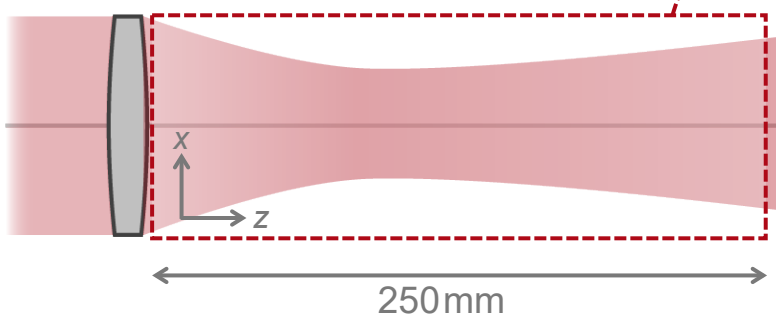
Field Propagation behind Lens #1

Propagation of the field behind lens #1 is dominated by the diffraction effect.



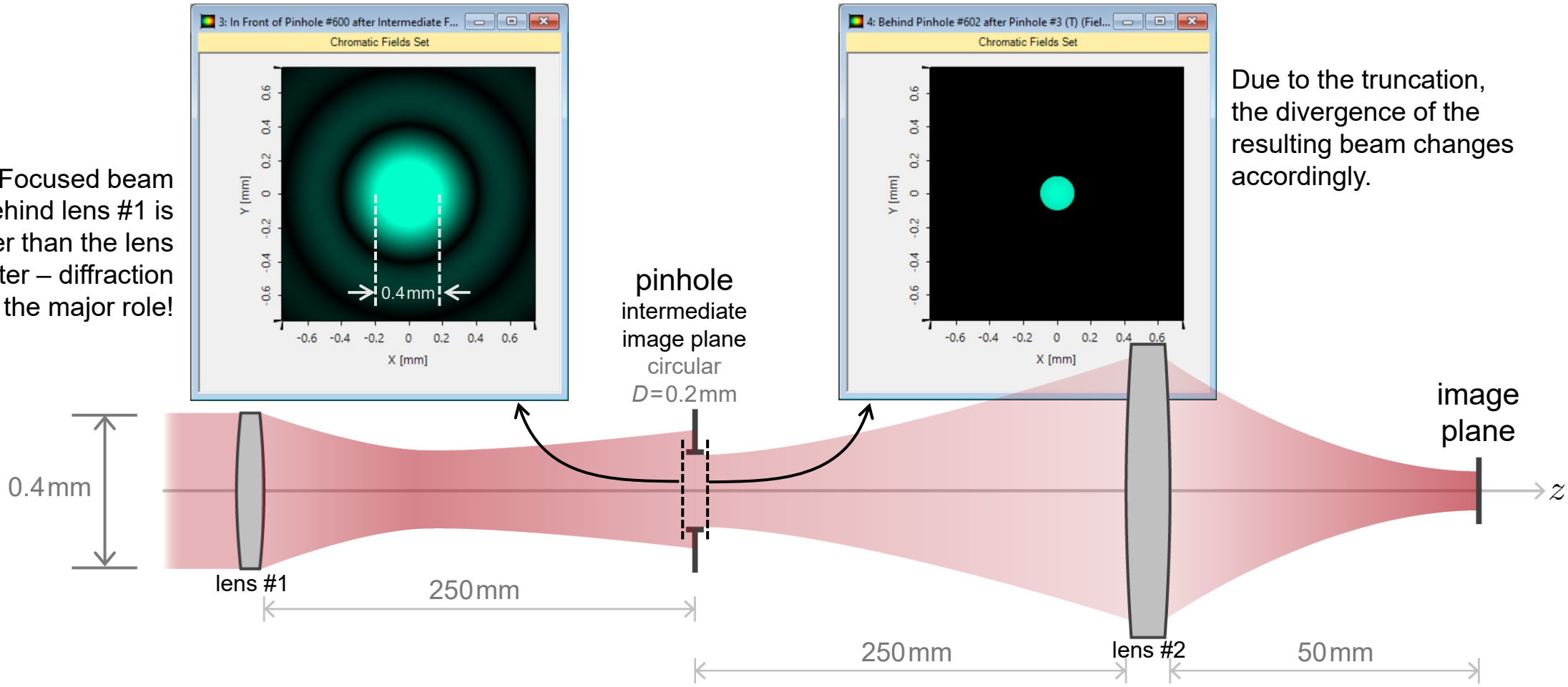
lens #1
f_{eff}=250mm
D=0.4mm

input plane wave
- wavelength 500nm
- on-axis and full illumination of lens #1
- assumed from infinity



In Front of and Behind the Pinhole

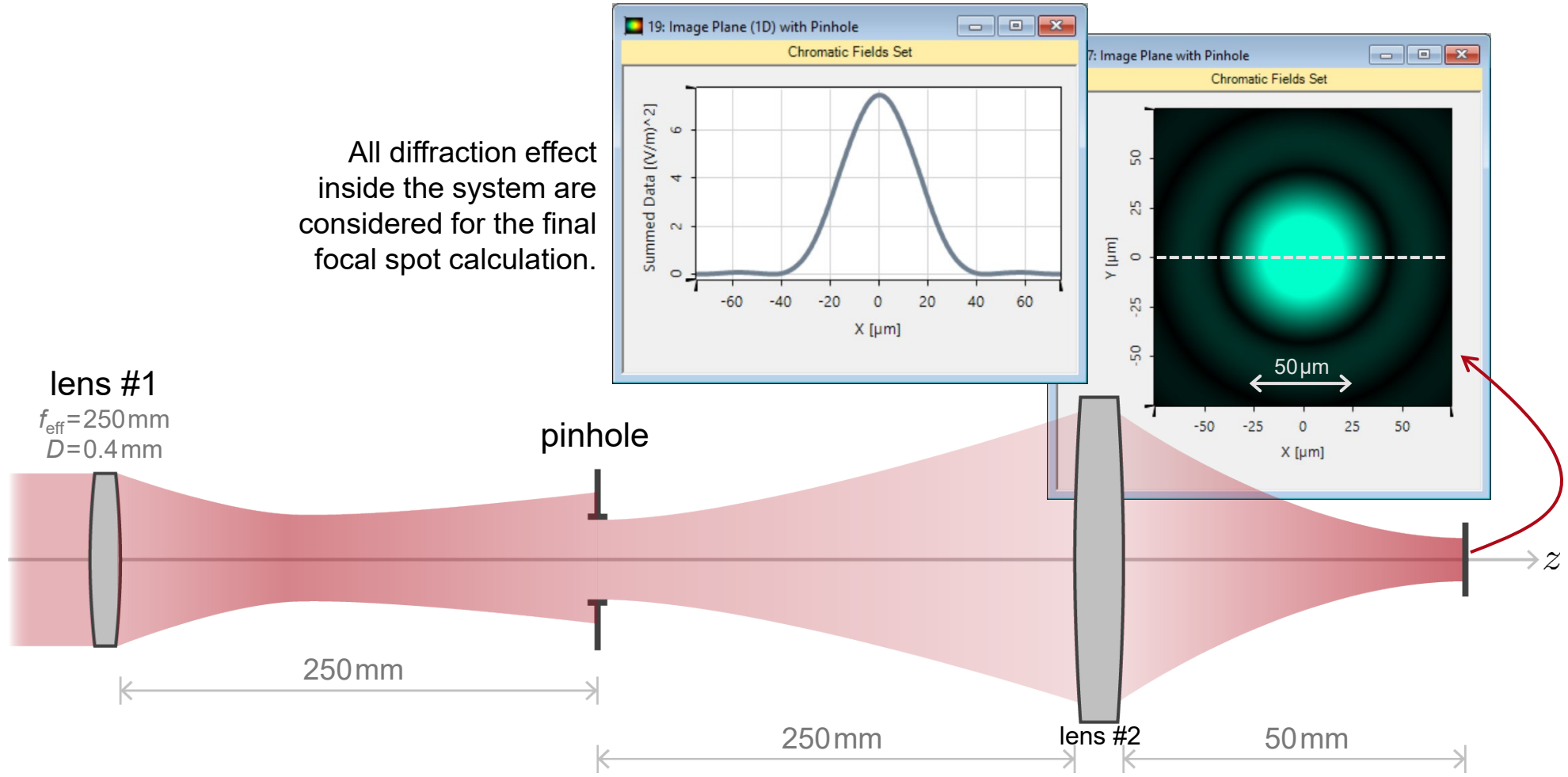
Focused beam behind lens #1 is larger than the lens diameter – diffraction plays the major role!



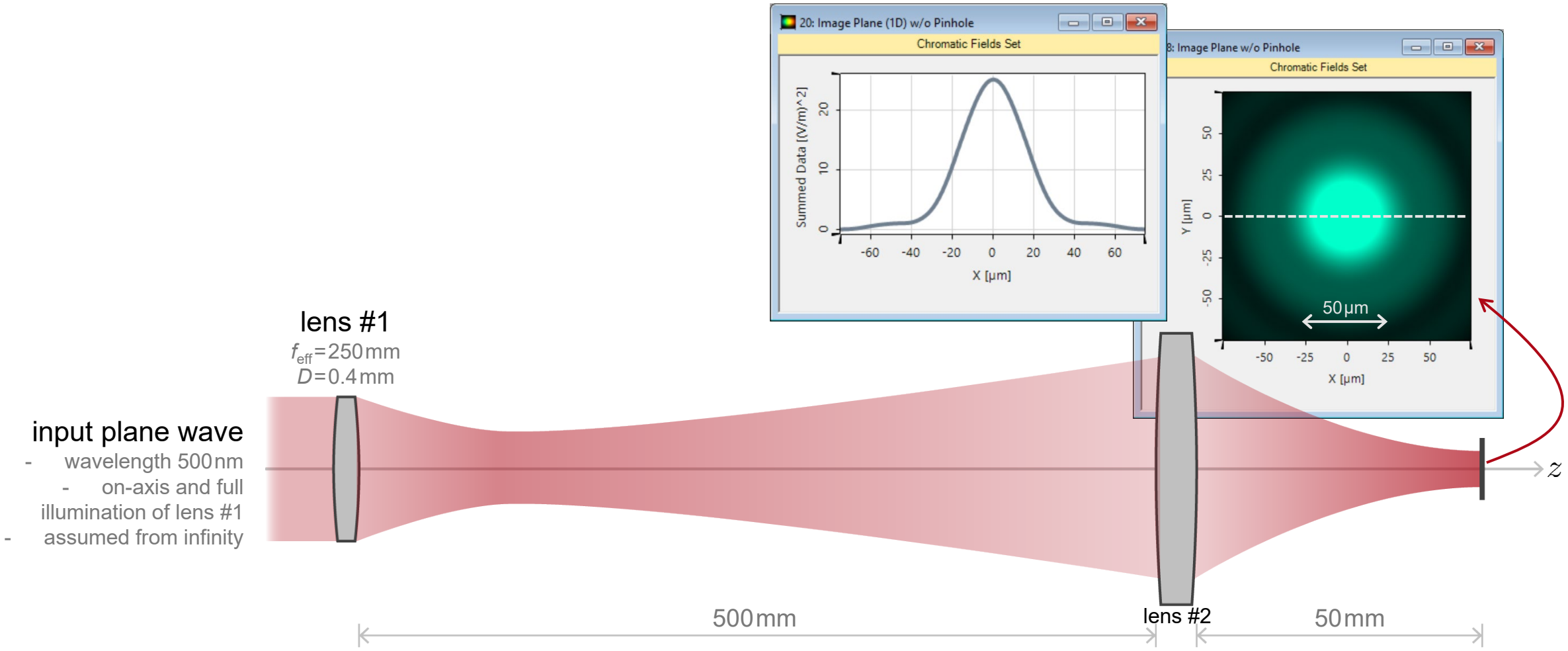
Due to the truncation, the divergence of the resulting beam changes accordingly.

Focal Spot at Image Plane

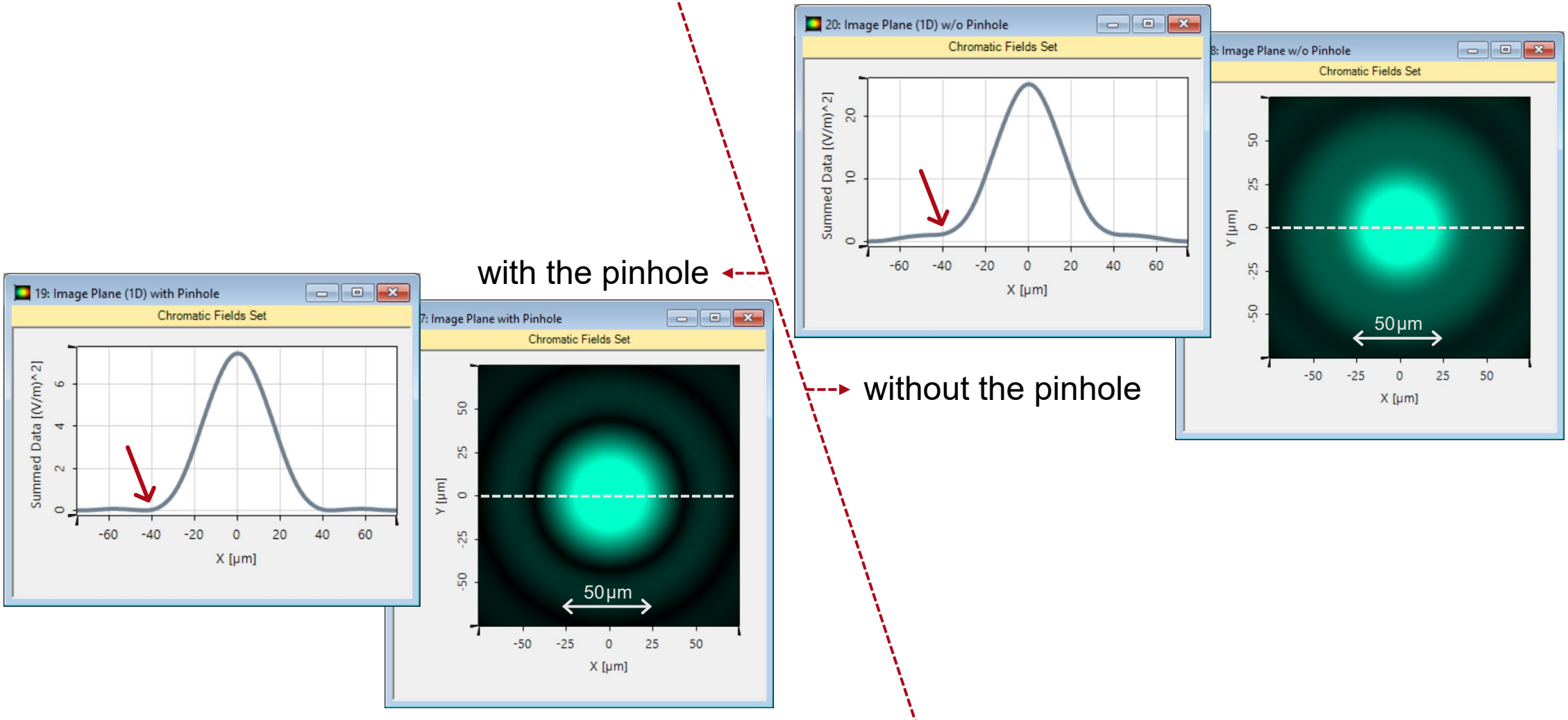
All diffraction effect inside the system are considered for the final focal spot calculation.



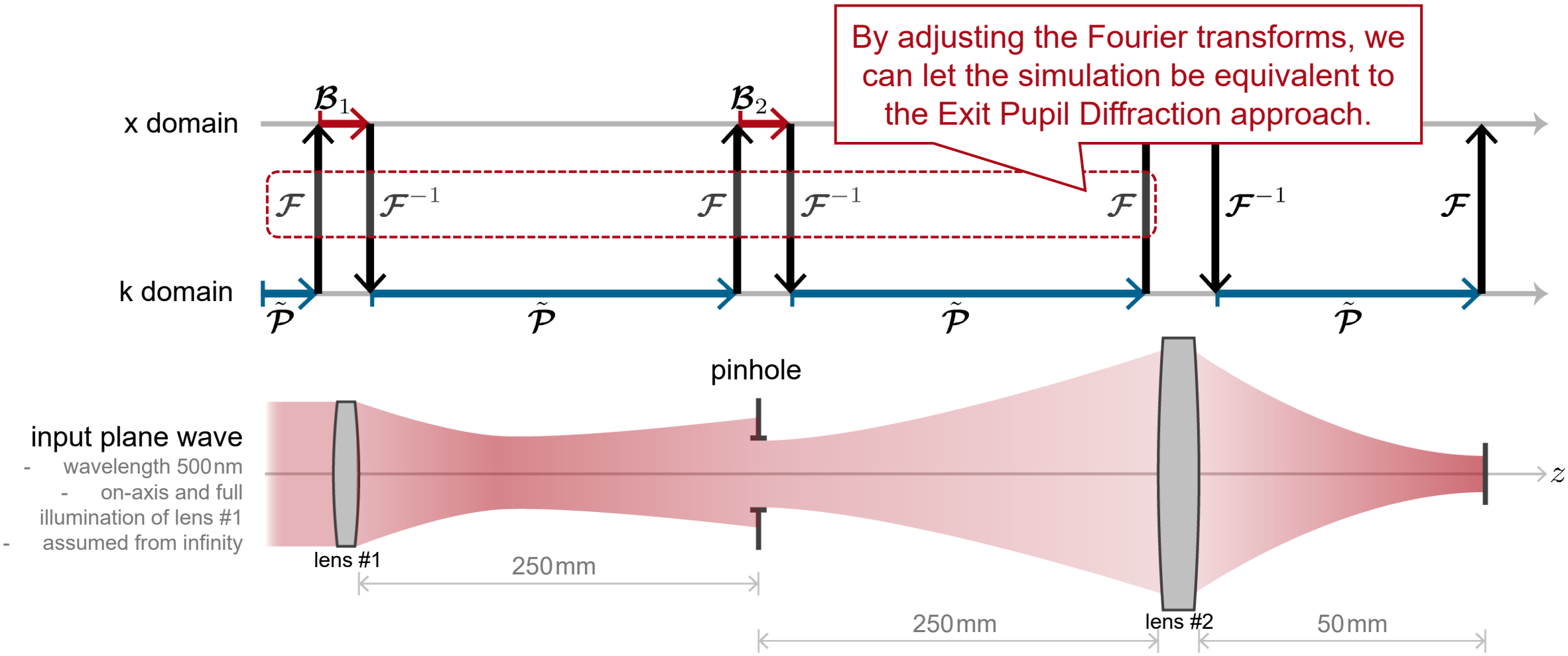
Focal Spot at Image Plane – without Pinhole



Comparison: with / without Pinhole

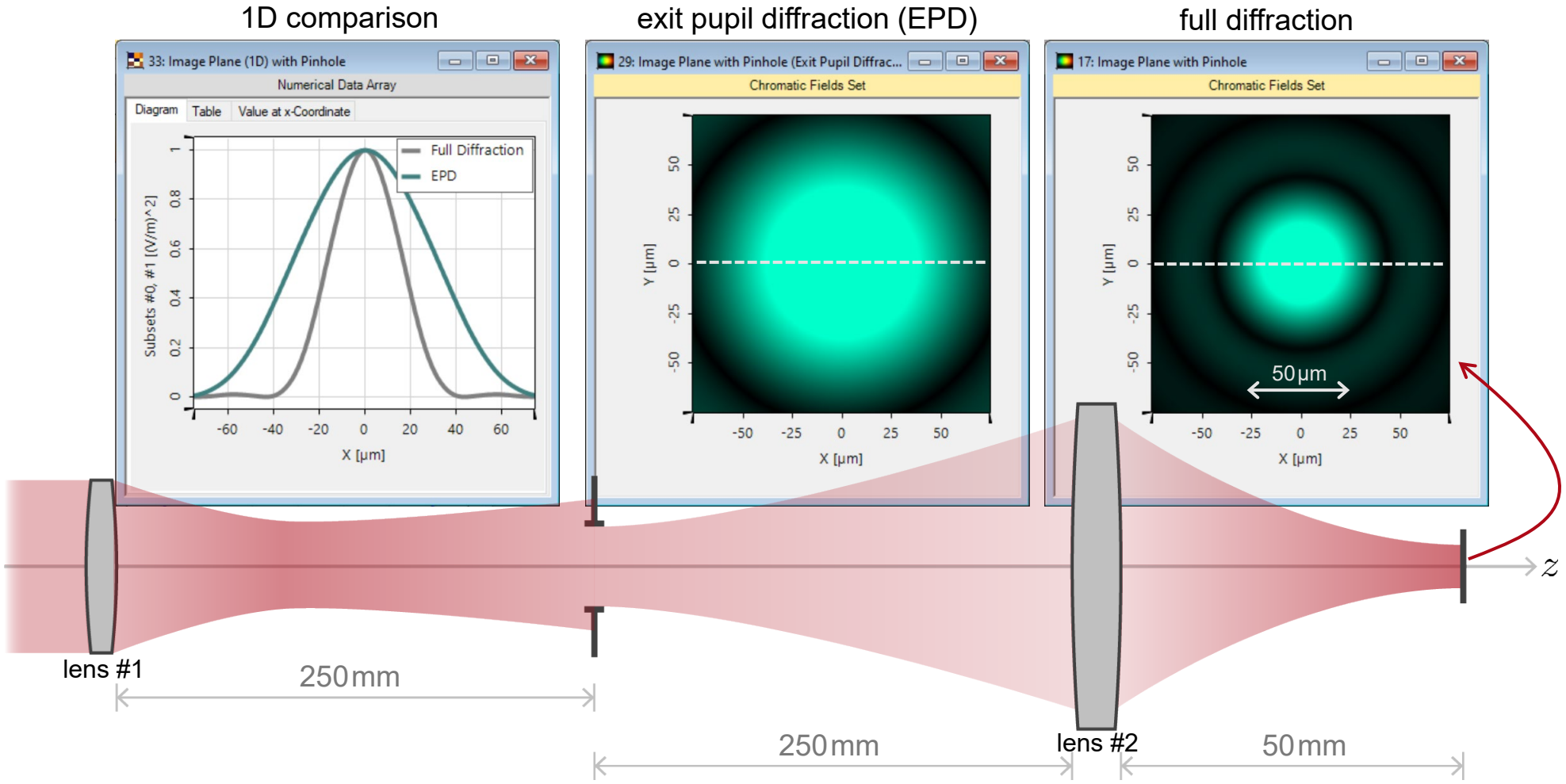


Appendix: Exit Pupil Diffraction (EPD) Approach



Appendix: Exit Pupil Diffraction (EPD) Approach

- input plane wave
  - wavelength 500 nm
  - on-axis and full illumination of lens #1
- assumed from infinity



Appendix: Exit Pupil Diffraction (EPD) Approach

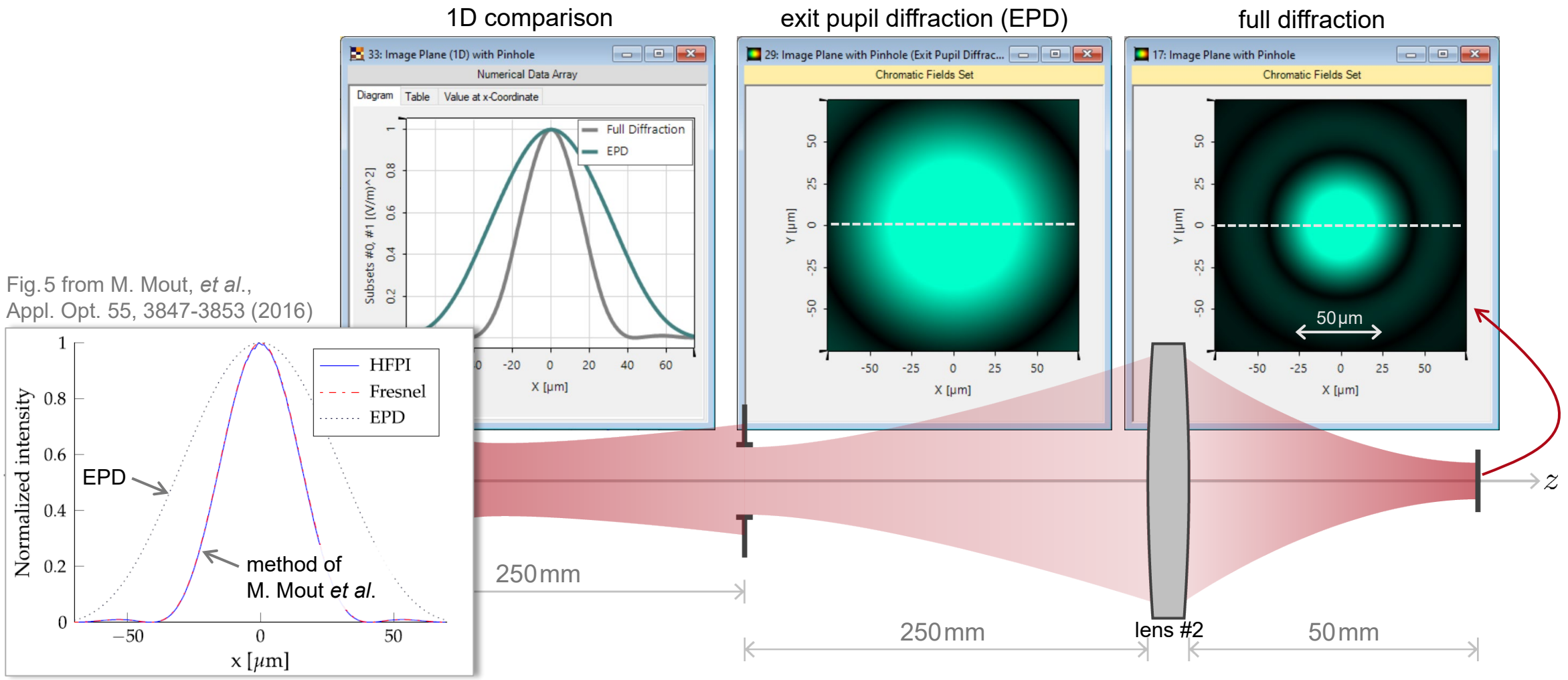
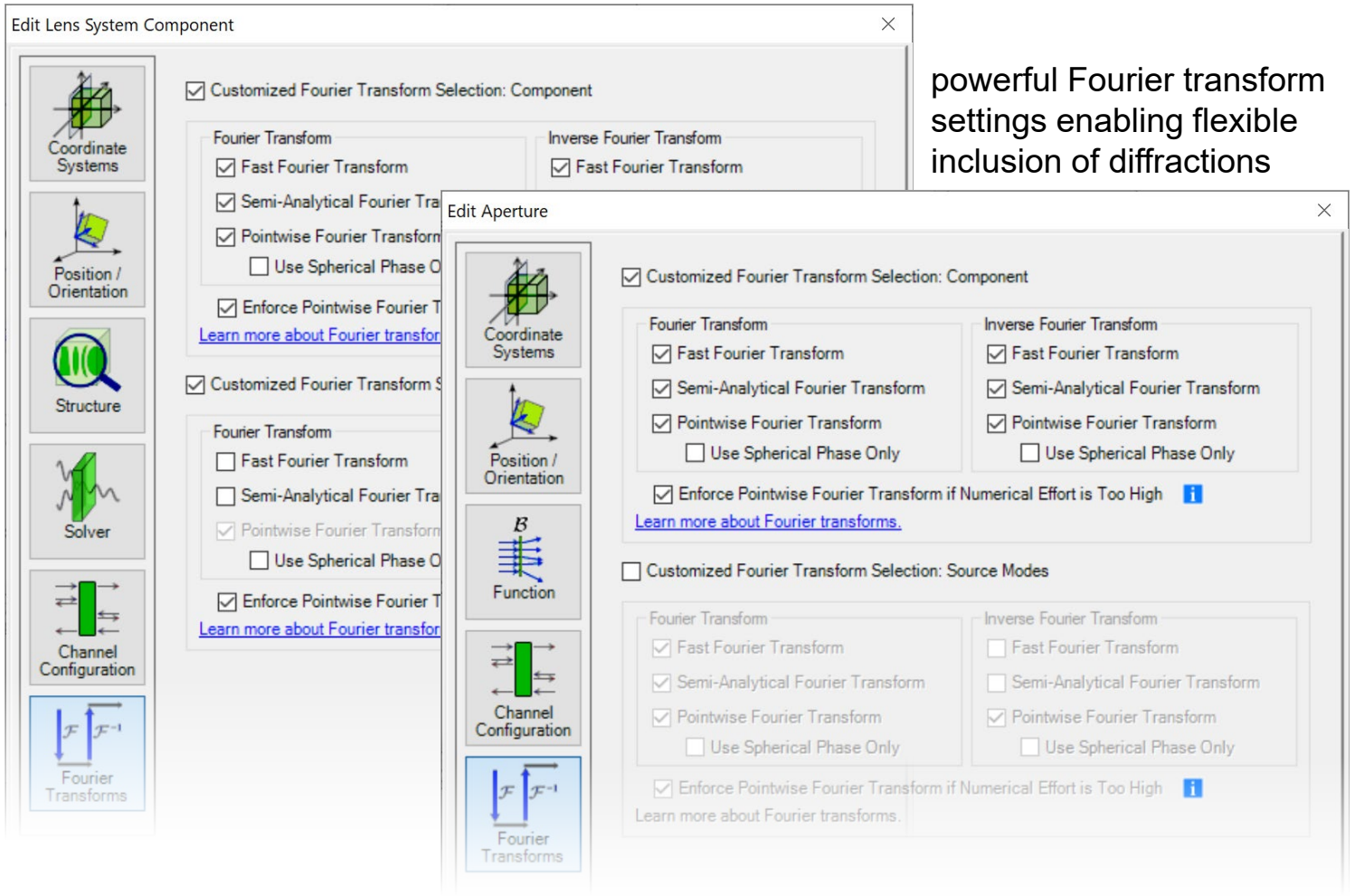
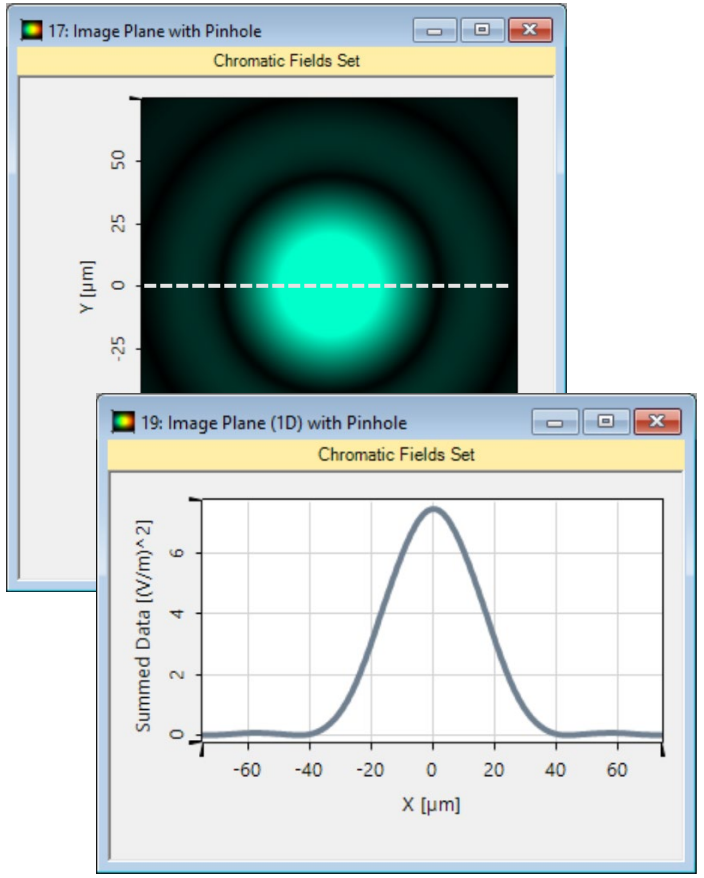


Fig. 5 from M. Mout, *et al.*, Appl. Opt. 55, 3847-3853 (2016)

Peek into VirtualLab Fusion



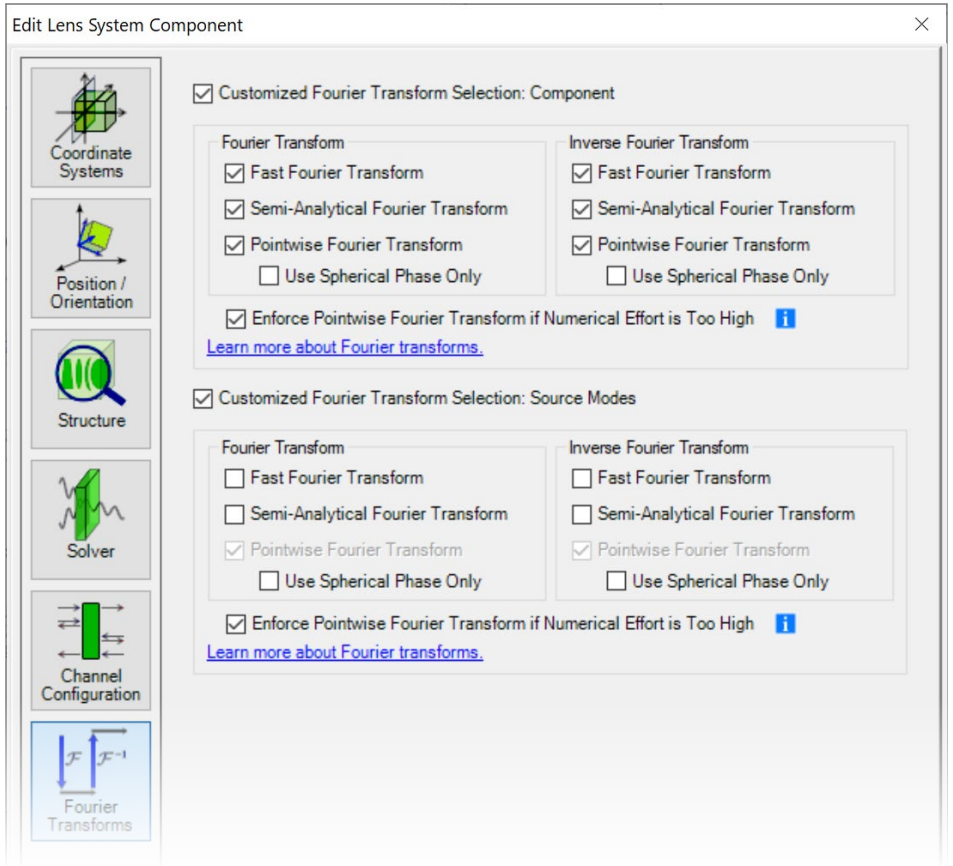
powerful Fourier transform settings enabling flexible inclusion of diffractions



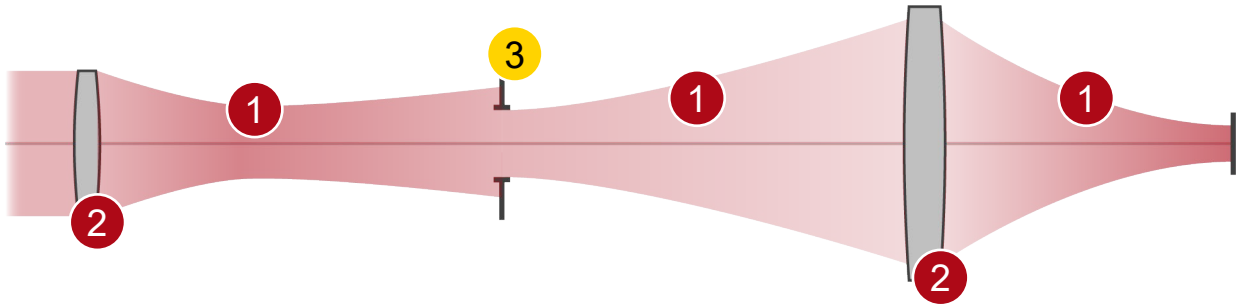
field visualization and analysis

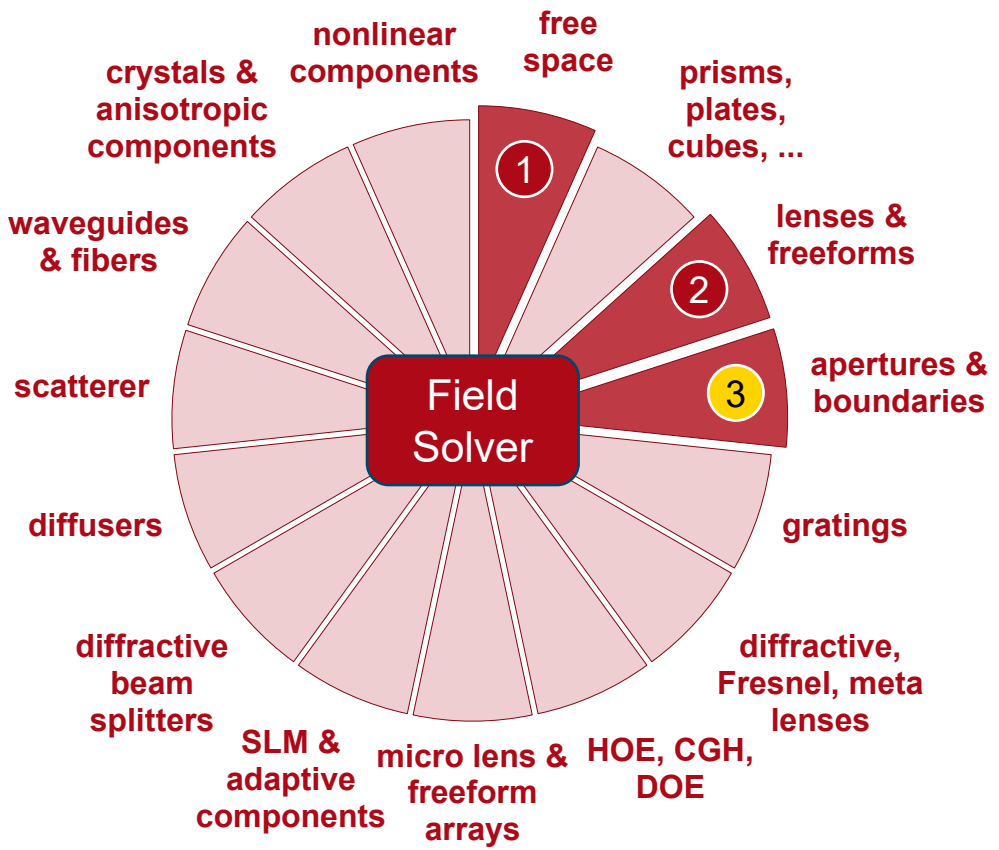
Workflow in VirtualLab Fusion

- Set the position and orientation of components
  - LPD II: Position and Orientation [Tutorial Video]
- Set the Fourier transforms properly according to the situation
- Use parameter run to scan along z axis
  - Usage of the Parameter Run Document [Use Case]



VirtualLab Fusion Technologies





Document Information

title	Pinhole Modeling in a Low-Fresnel-Number System
document code	MISC.0080
version	1.0
edition	VirtualLab Fusion Basic
software version	2020.1 (Build 1.202)
category	Application Use Case
further reading	- Laser Beam “Clean-Up” with Spatial Filter - Automatic Selection of Fourier Transform Techniques in Free-Space Propagation Operator