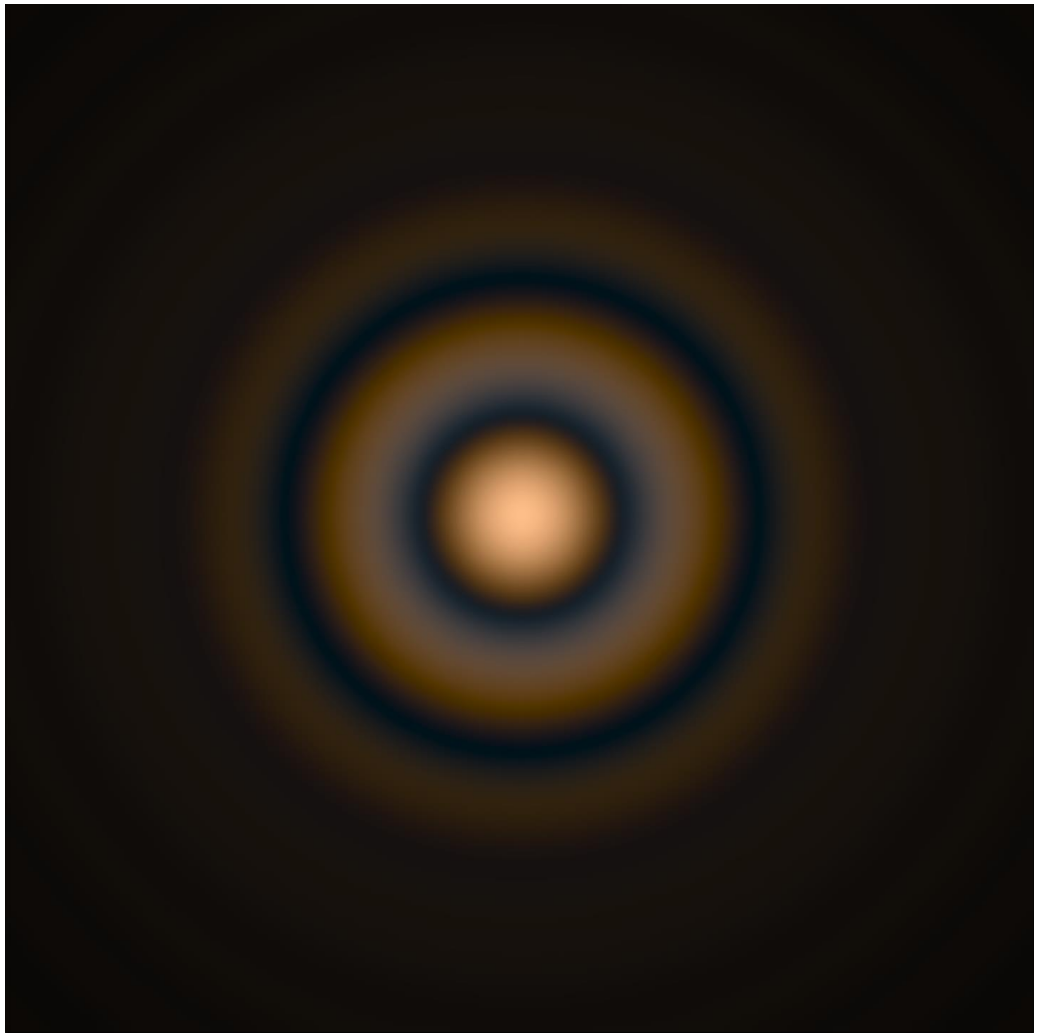
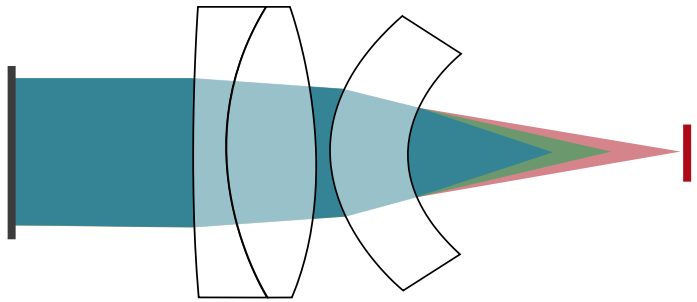
Modeling of a Hybrid Eyepiece with Diffractive Lens Surface for Chromatic Aberration Correction

Abstract

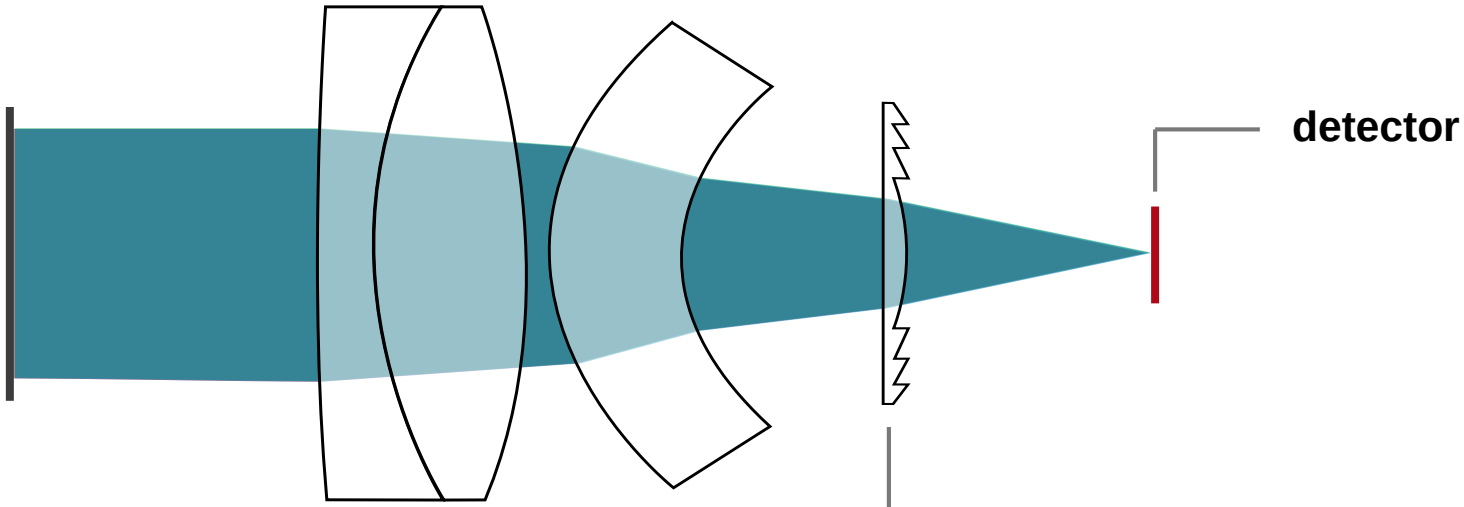


Hybrid lensese with both refractive and diffractive surfaces become a promising solution in different applications. Here we will demonstrate an example on a hybrid eyepiece, in which a diffractive lens surface is used to correct chromatic aberration. The initial design is taken from Zemax OpticStudio® and imported into VirtualLab Fusion for further investigation. The modeling can be done either based on the desired wavefront phase response, or with the actual diffractive surface structures (either in continuous or quantized way) considered.

Design and Modeling Task



How to model a hybrid lens system with diffractive surface, either as wavefront phase response, or with the actual surface structure considered?



plane wave

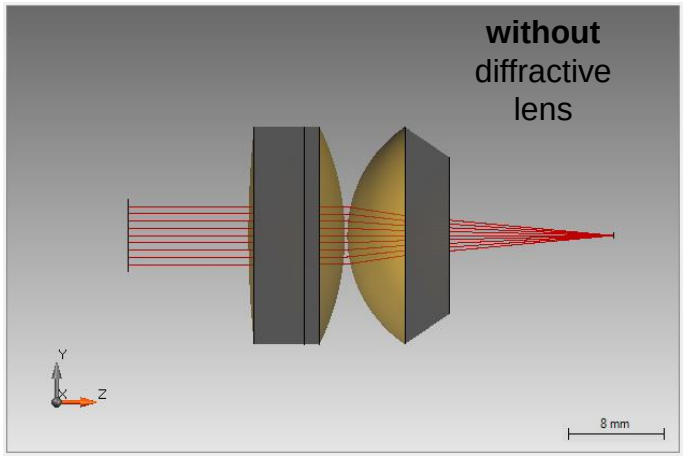
- wavelength (486, 587, 656)nm
- field of view (40)°
- linearly polarized along x-axis
- aperture 5mm×5mm

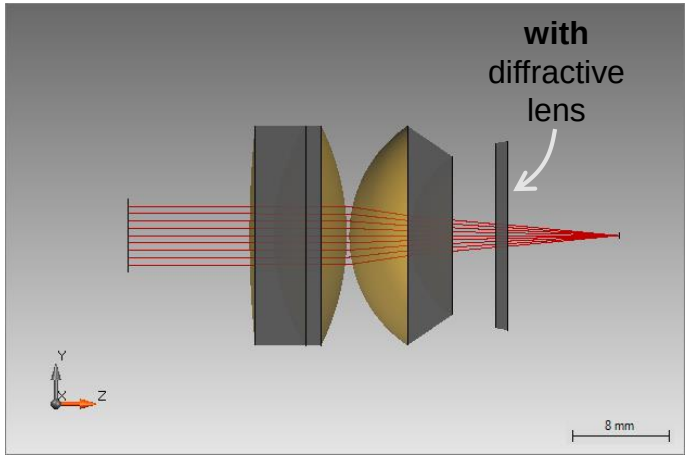
diffractive lens

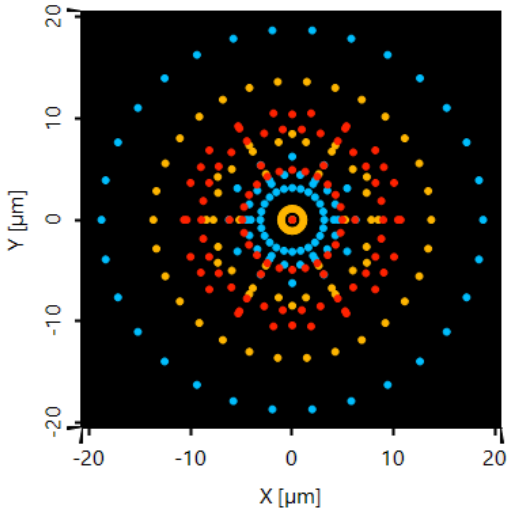
- wavefront phase response
- actual diffractive surface structure

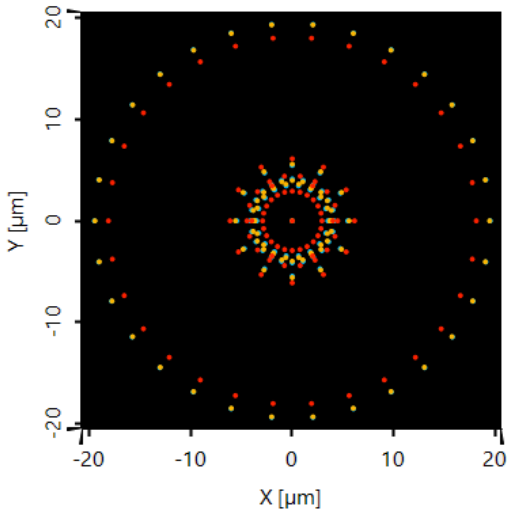
Analysis Based on Wavefront Phase Response

On-Axis Case: Ray Tracing Analysis



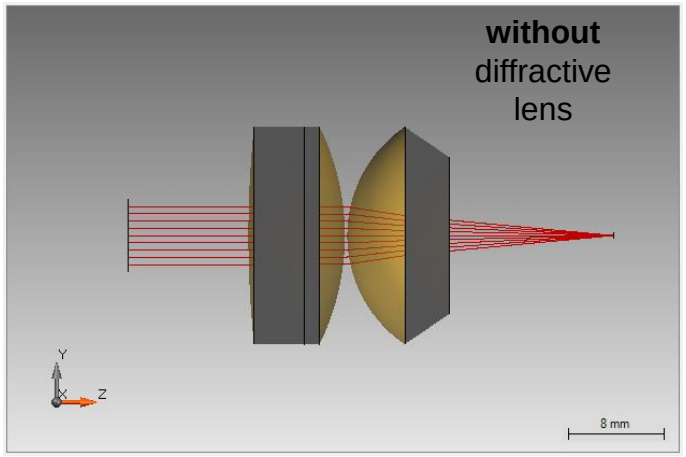


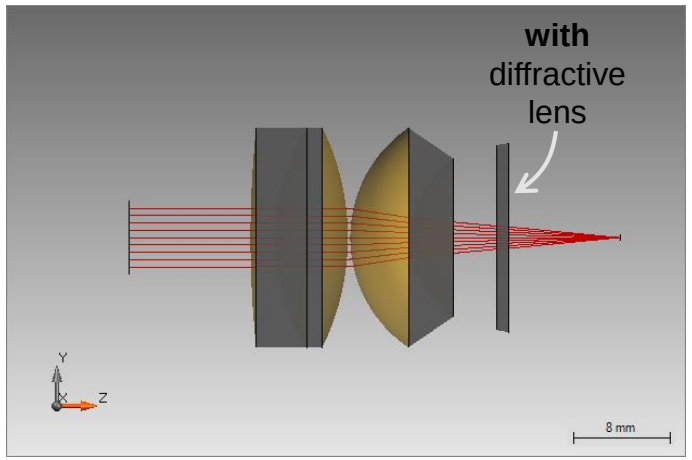




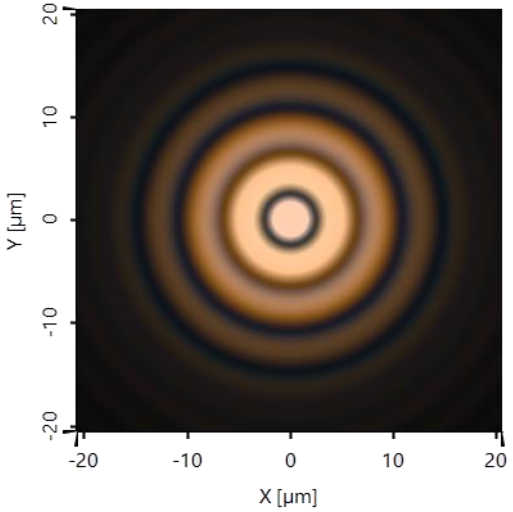
The optical setup including the wavefront surface response is originally designed with Zemax OpticStudio® using a Binary 2 surface. Such an optical system can be directly imported into VirtualLab Fusion.

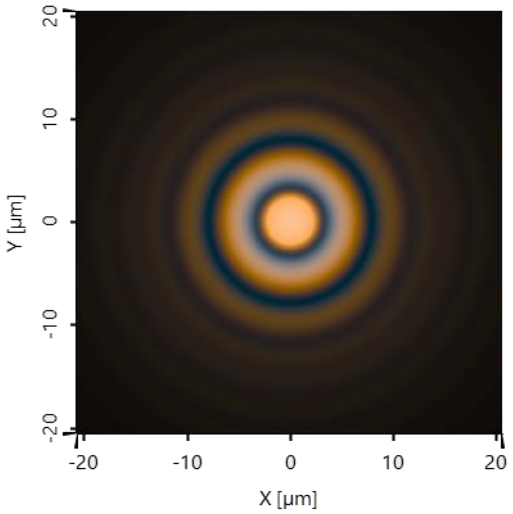
On-Axis Case: Field Tracing Analysis



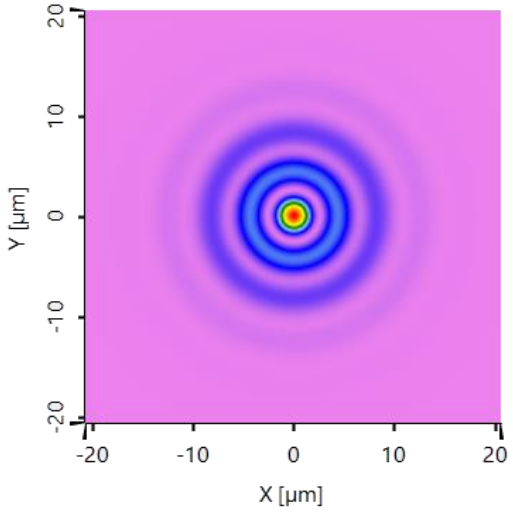


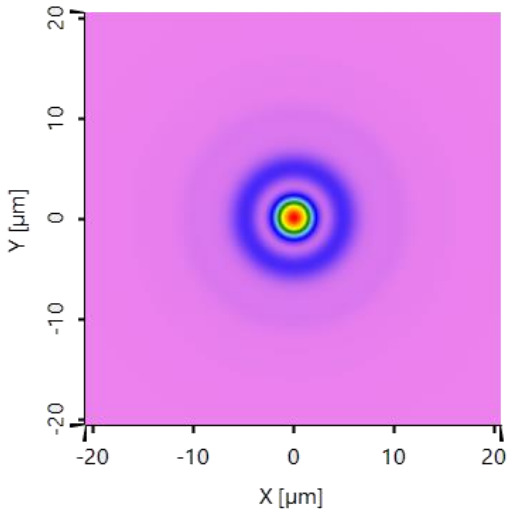
Real Color View



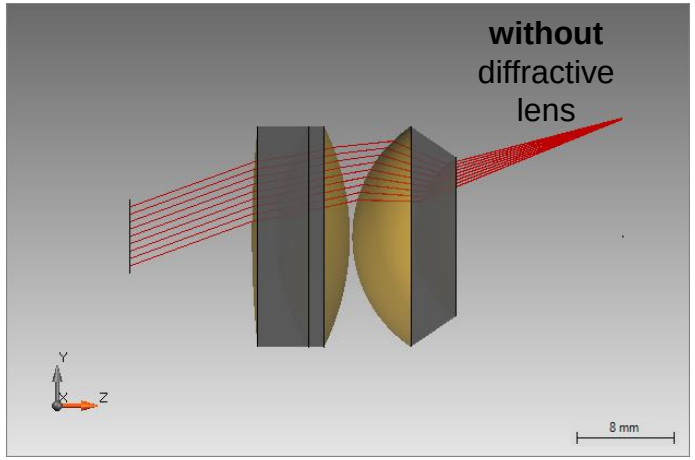


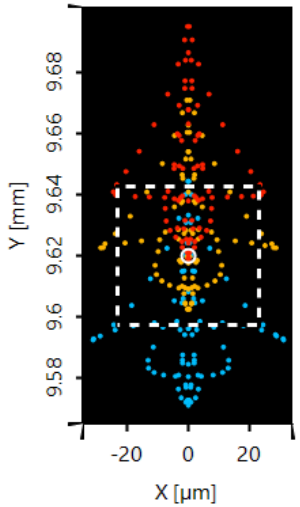
False Color View

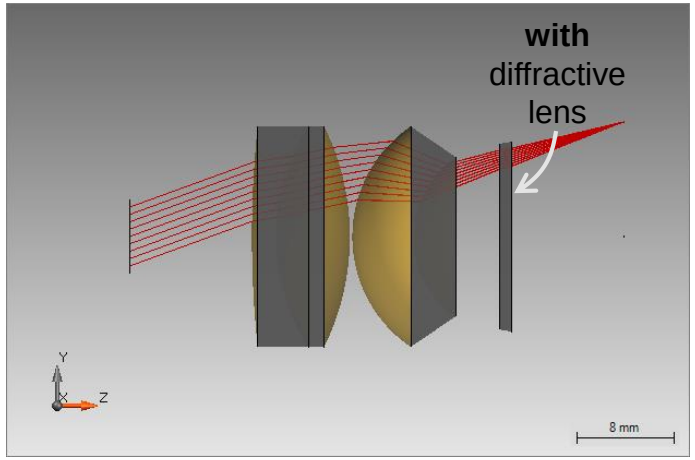


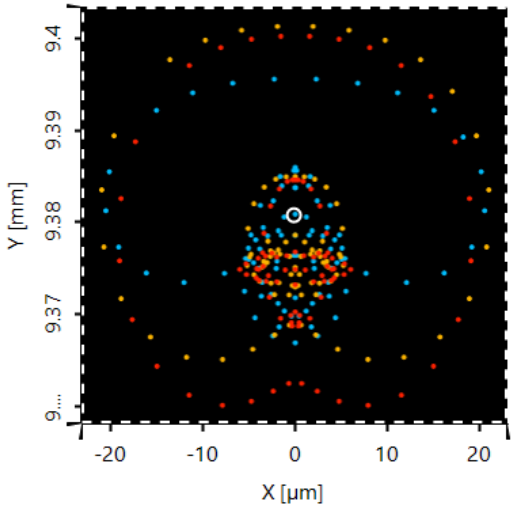


Off-Axis Case: Ray Tracing Analysis

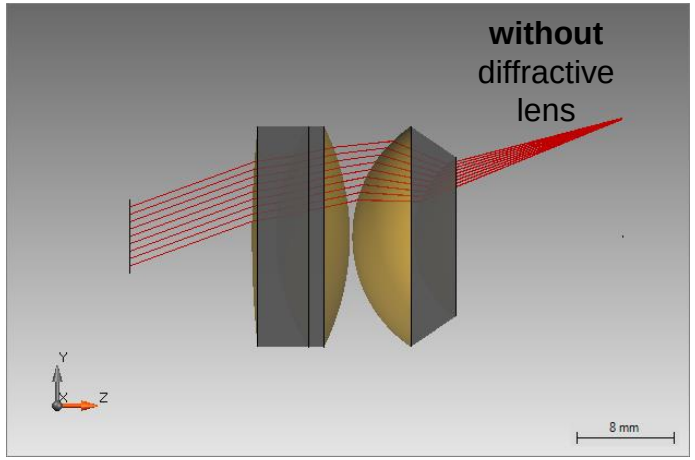


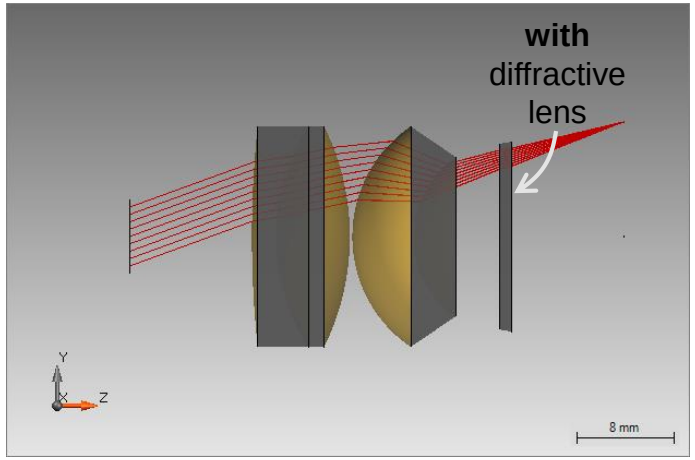




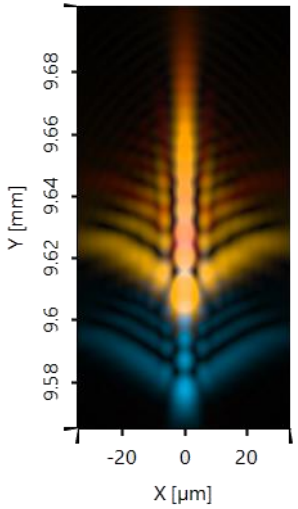


Off-Axis Case: Field Tracing Analysis

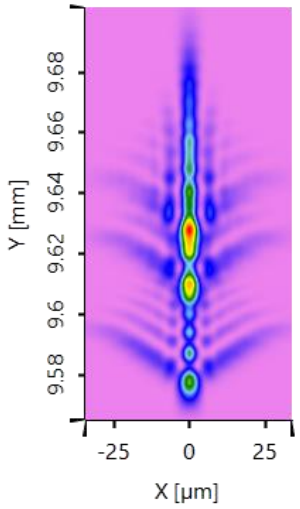


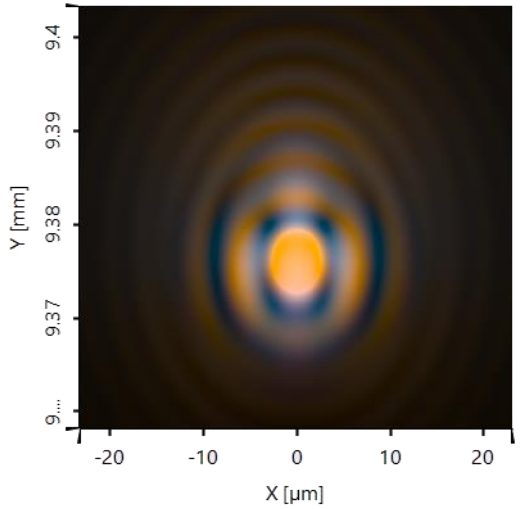


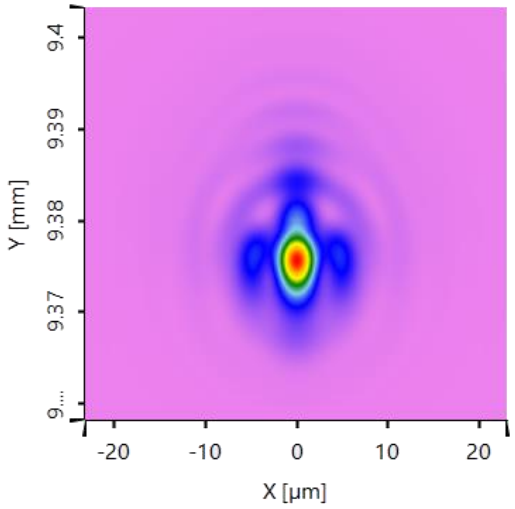
Real Color View



False Color View







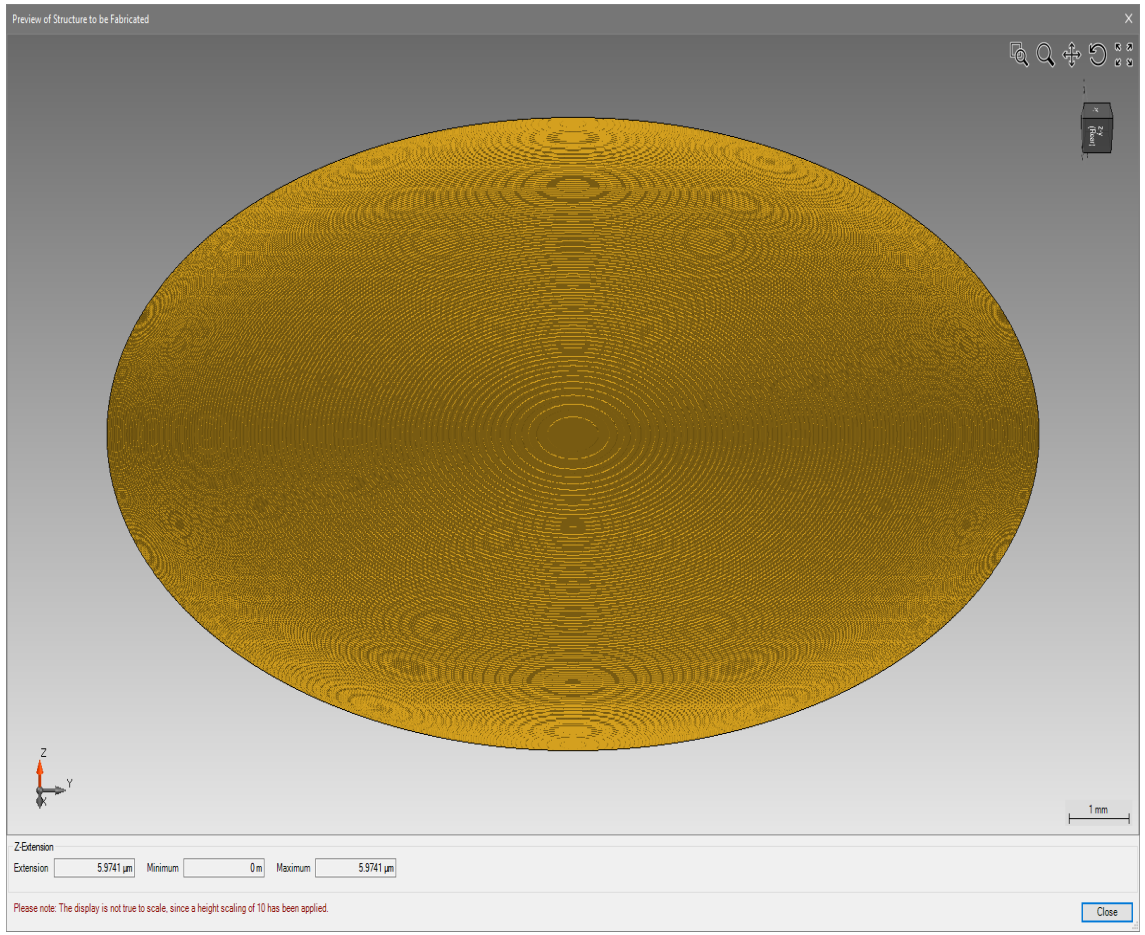
Analysis Based on Actual Surface Structures

Design of Diffractive Lens Structure

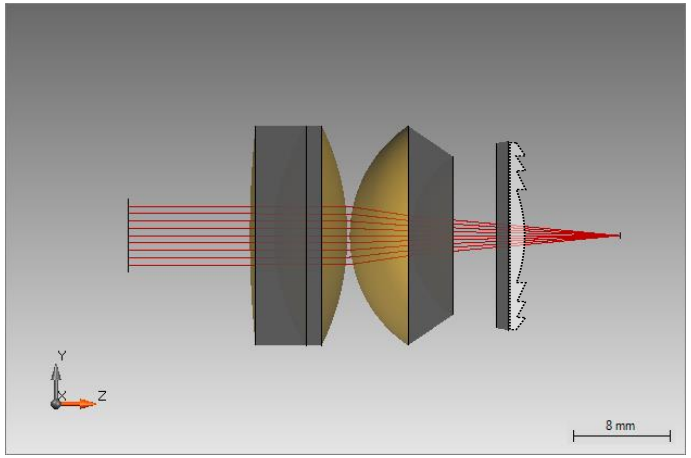
The structure profile of the diffractive layer is calculated by TEA according to the wavefront phase response:

$$h^{\mathrm{DOE}}(\rho) = \frac{\lambda}{2\pi n}\Delta\psi(\rho)^{\mathrm{DOE}}$$

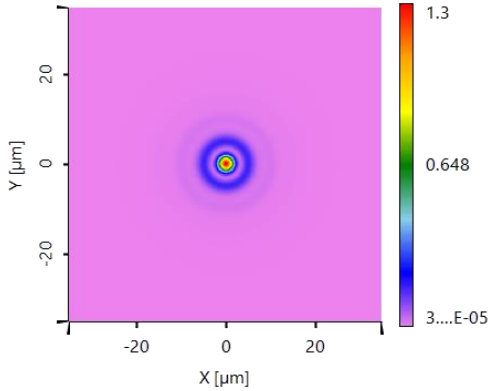
Where, $h^{\mathrm{DOE}}(\rho)$ is the structure height profile, $\Delta\psi(\rho)^{\mathrm{DOE}}$ is the wavefront phase response function, λ is the reference wavelength, and n is the refractive index of the diffractive lens.



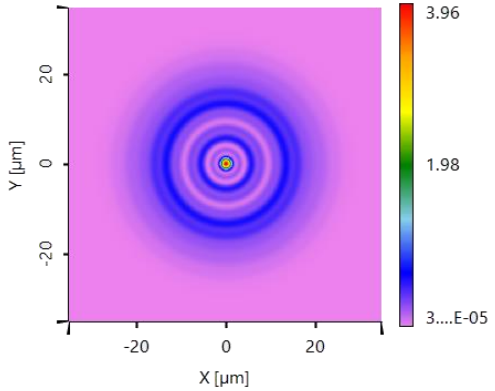
On-Axis Case: Desired and Unwanted Diffraction Orders



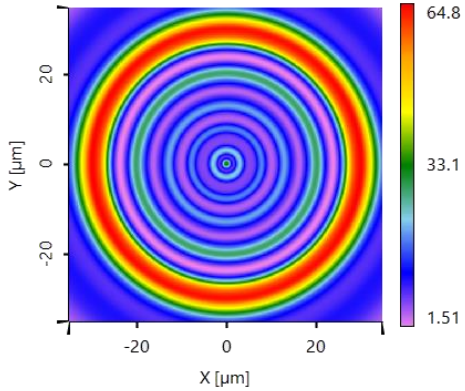
∝ Electric Energy Density
$[1E6\ (^{V}/_{m})^{2}]$

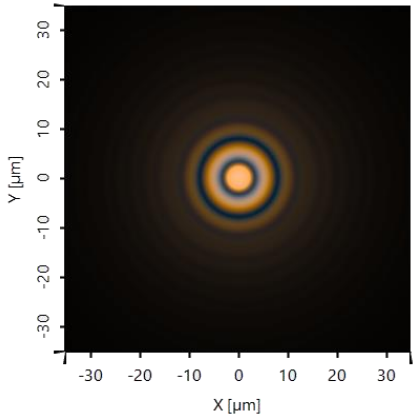


∝ Electric Energy Density
$[1E3\ (^{V}/_{m})^{2}]$

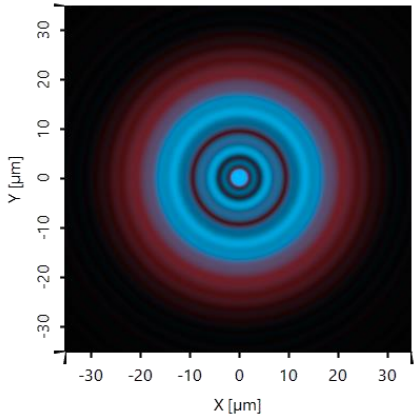


∝ Electric Energy Density
$[(^{V}/_{m})^{2}]$

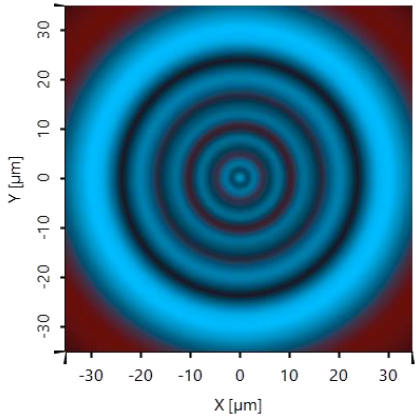




+1st diffraction order

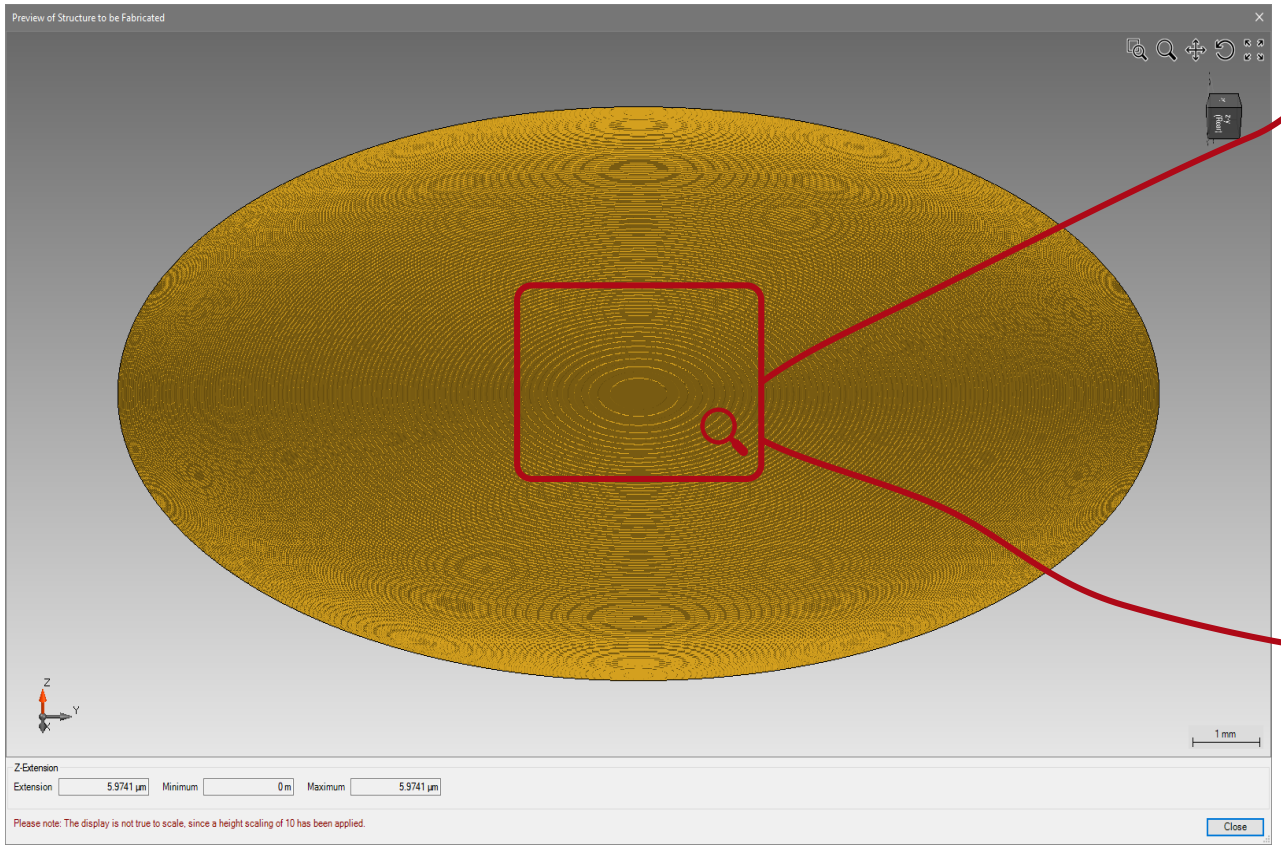


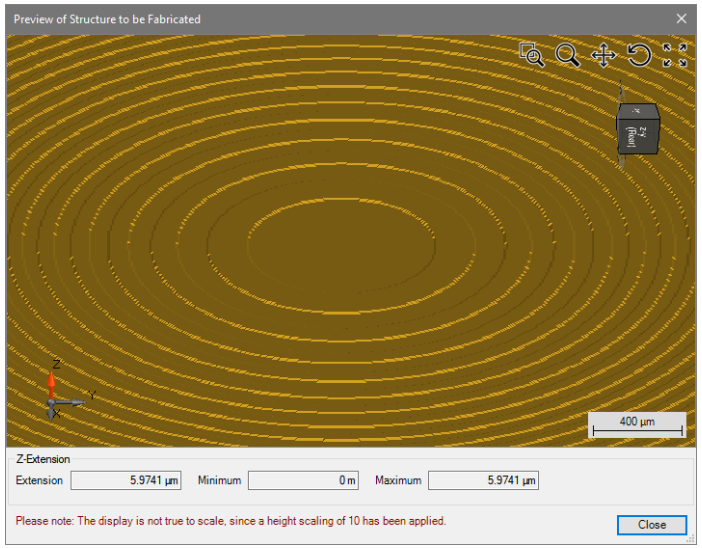
0th diffraction order



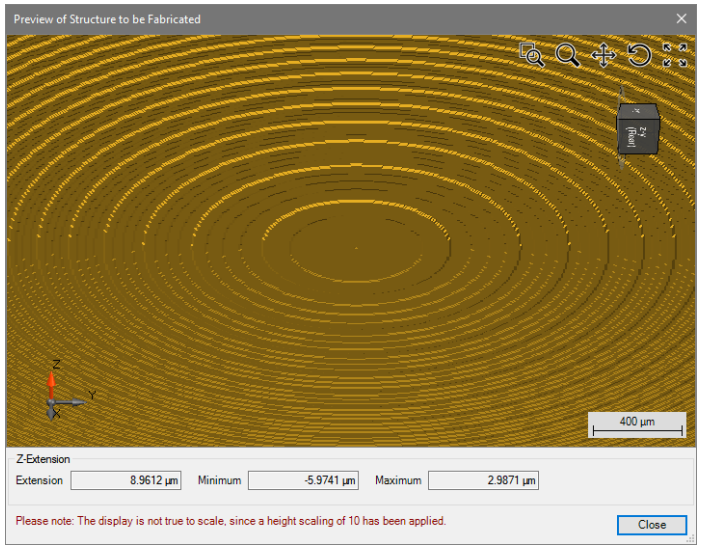
-1st diffraction order

Visualization of Quantized Diffractive Lens Structure



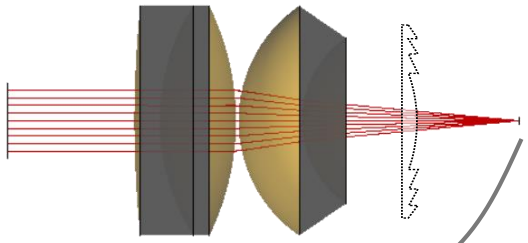


preview for 2 quantization levels

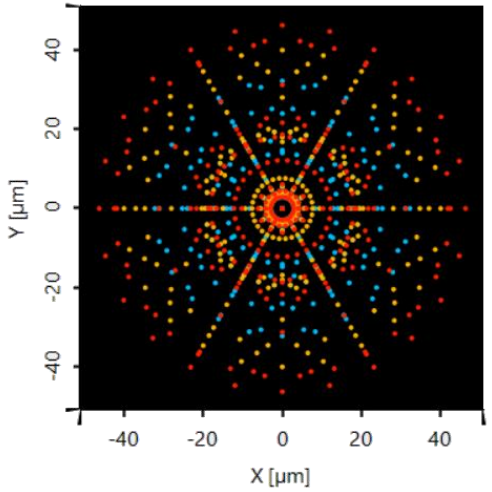


preview for 4 quantization levels

On-Axis Case: Different Quantization Schemes

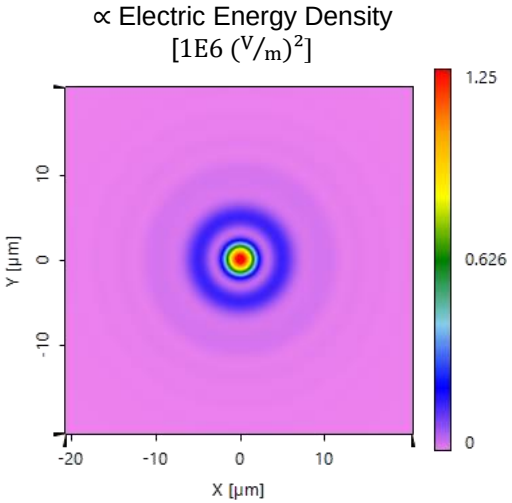


Spot Diagram

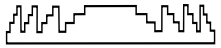


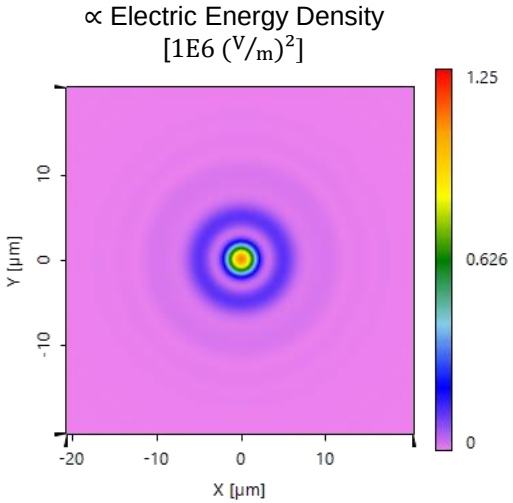
comparison of PSF

– no quantization

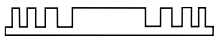


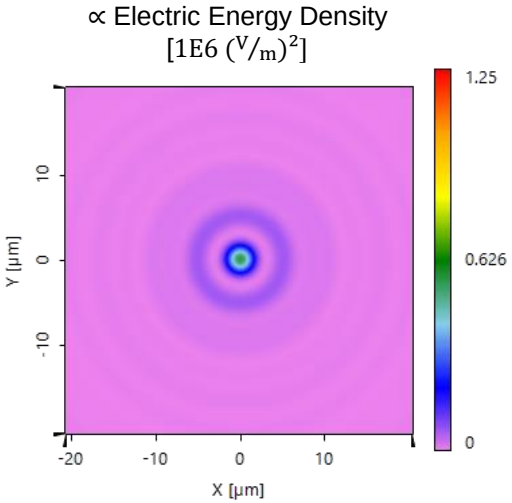
– 4 levels quantization



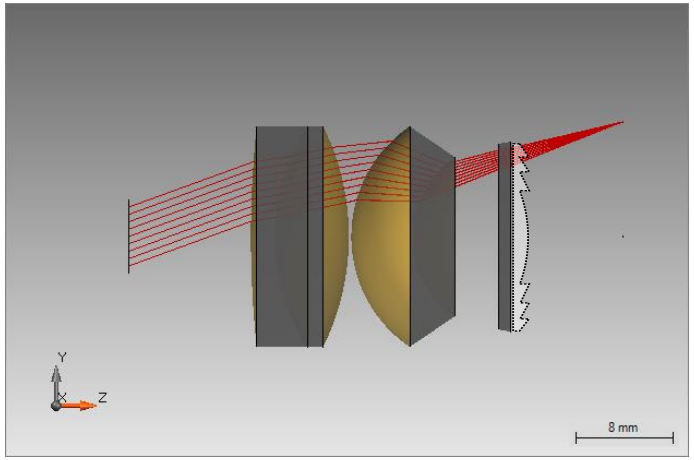


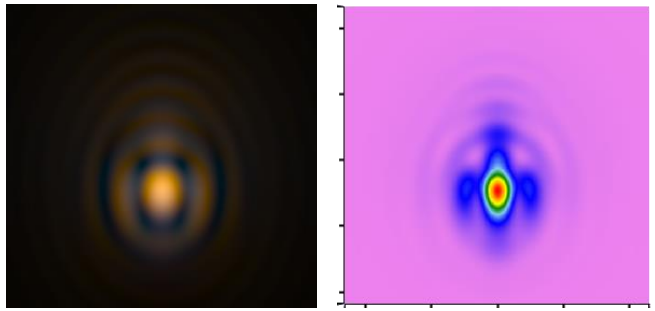
– 2 levels quantization



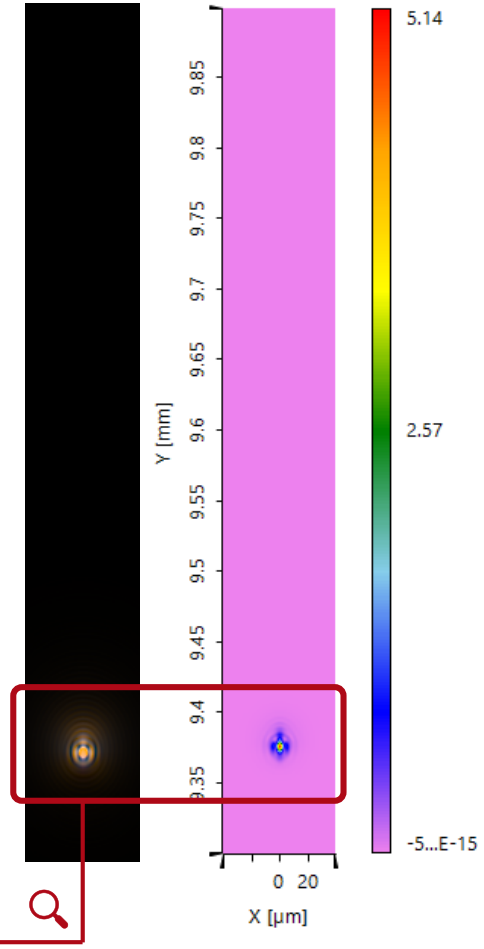


Off-Axis Case: Desired and Unwanted Diffraction Orders



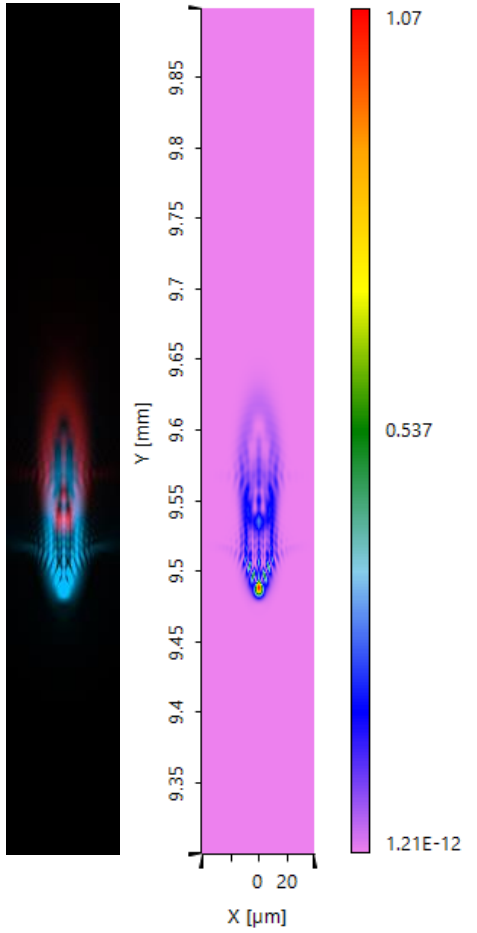


∝ Electric Energy Density
$[1E5\ (^{V}/_{m})^{2}]$



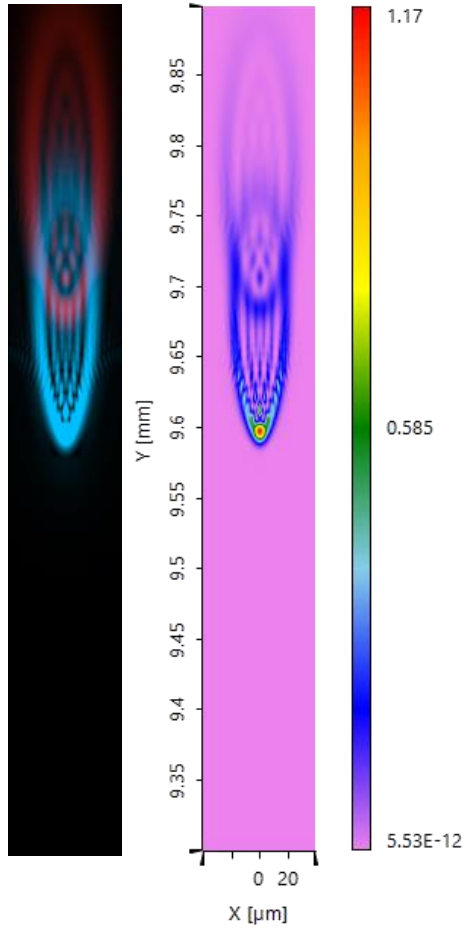
+1st diffraction order

∝ Electric Energy Density
$[1E3\ (^{V}/_{m})^{2}]$



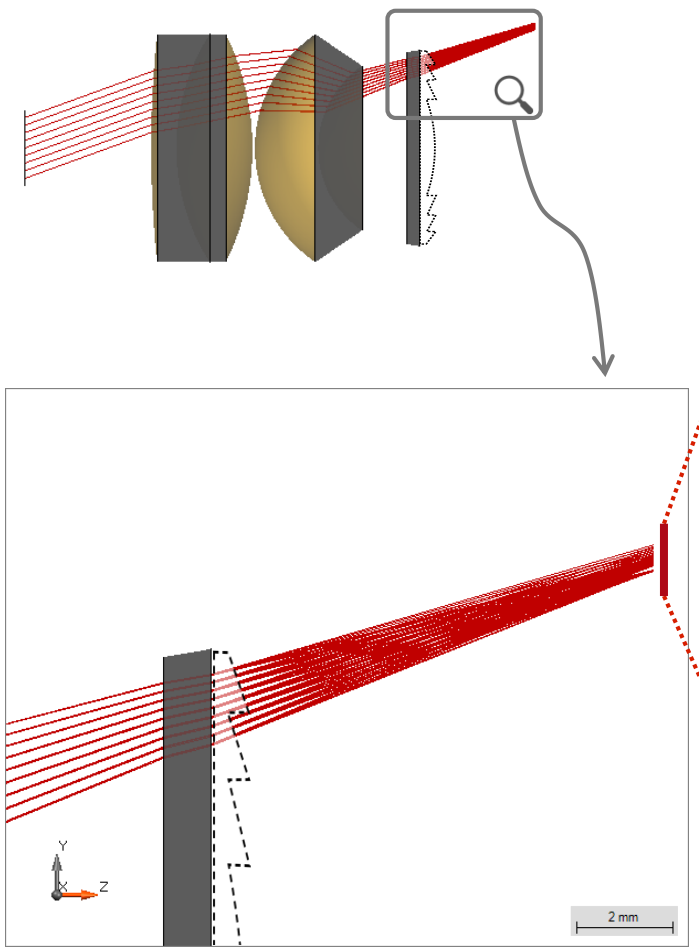
0th diffraction order

∝ Electric Energy Density
$[1E2\ (^{V}/_{m})^{2}]$

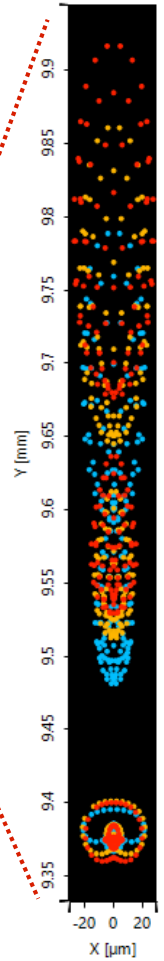


-1st diffraction order

Off-Axis Case: Different Quantization Schemes



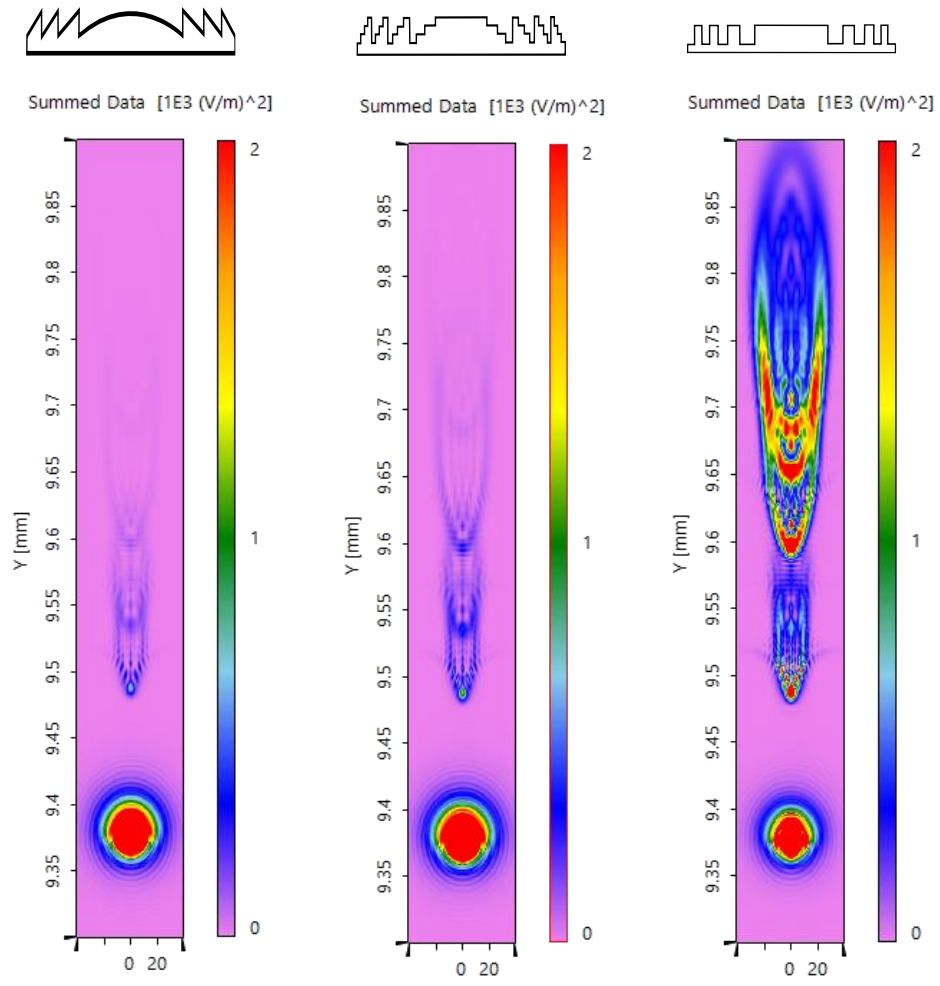
Spot Diagram



-1st diffraction order

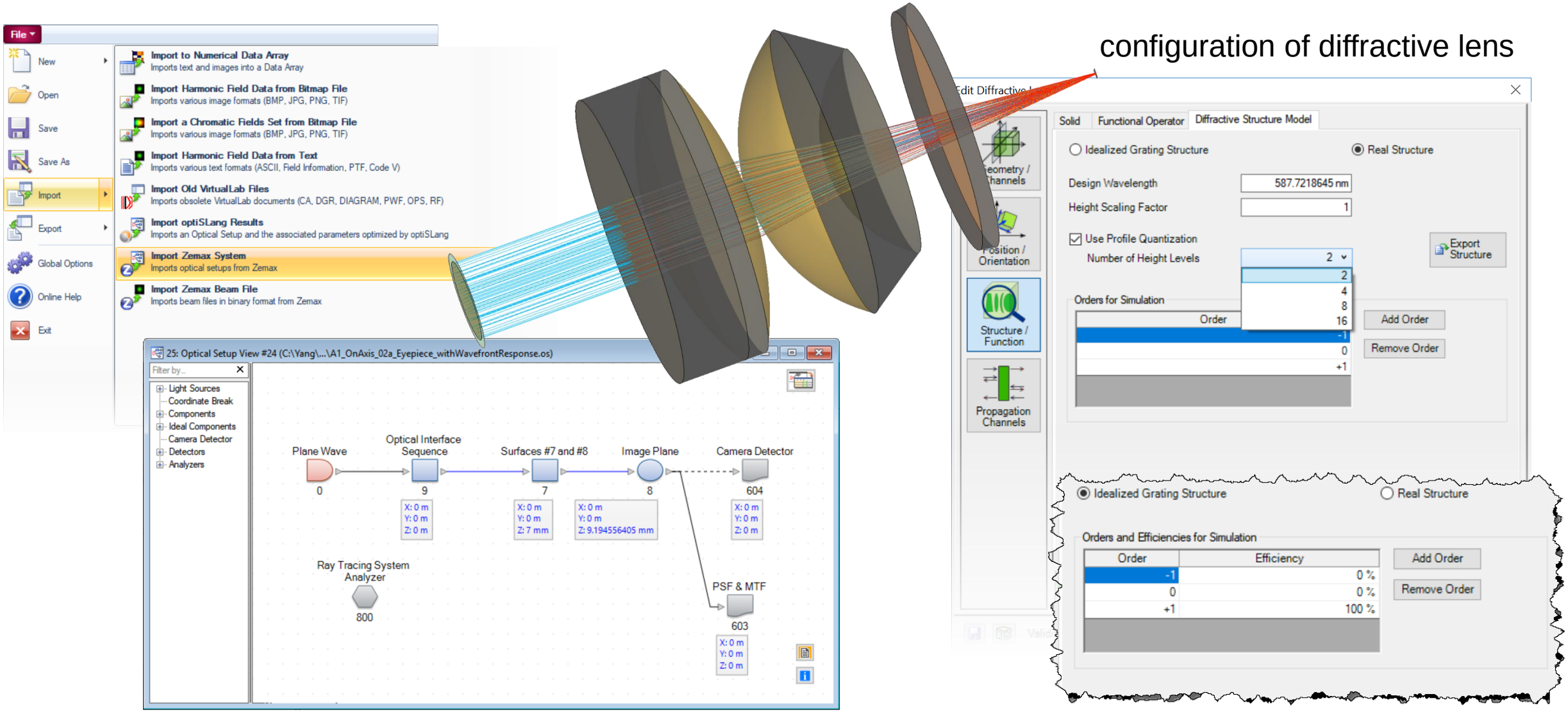
0th diffraction order

+1st diffraction order



maximum values are clipped for visualization

Peak into VirtualLab Fusion

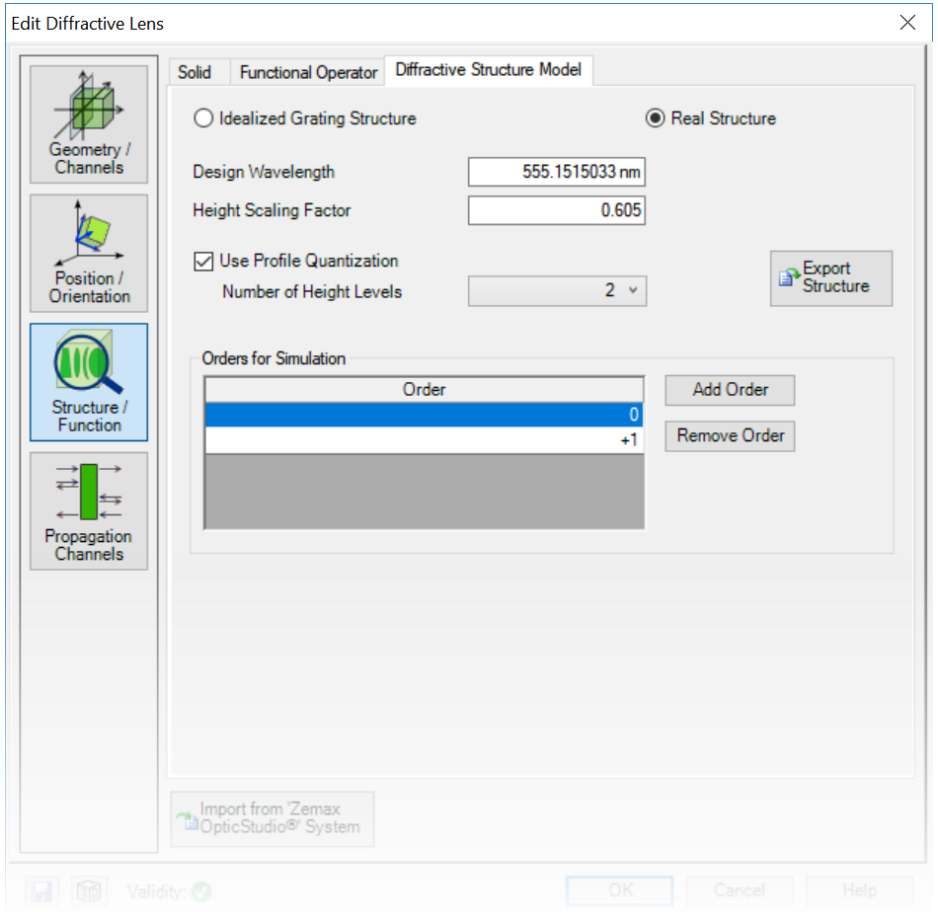


configuration of diffractive lens

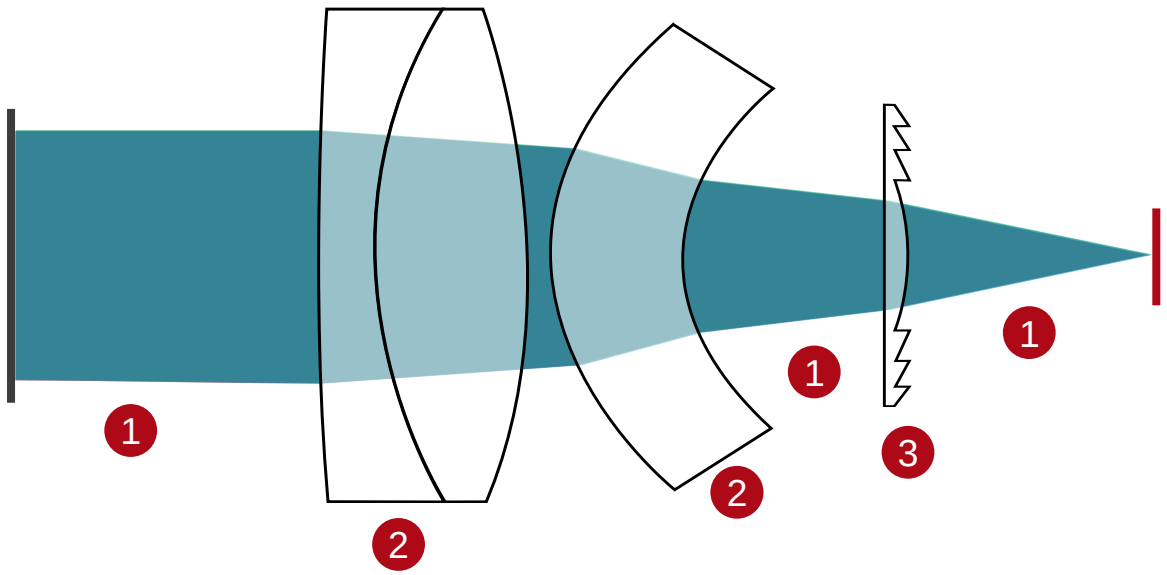
Workflow in VirtualLab Fusion

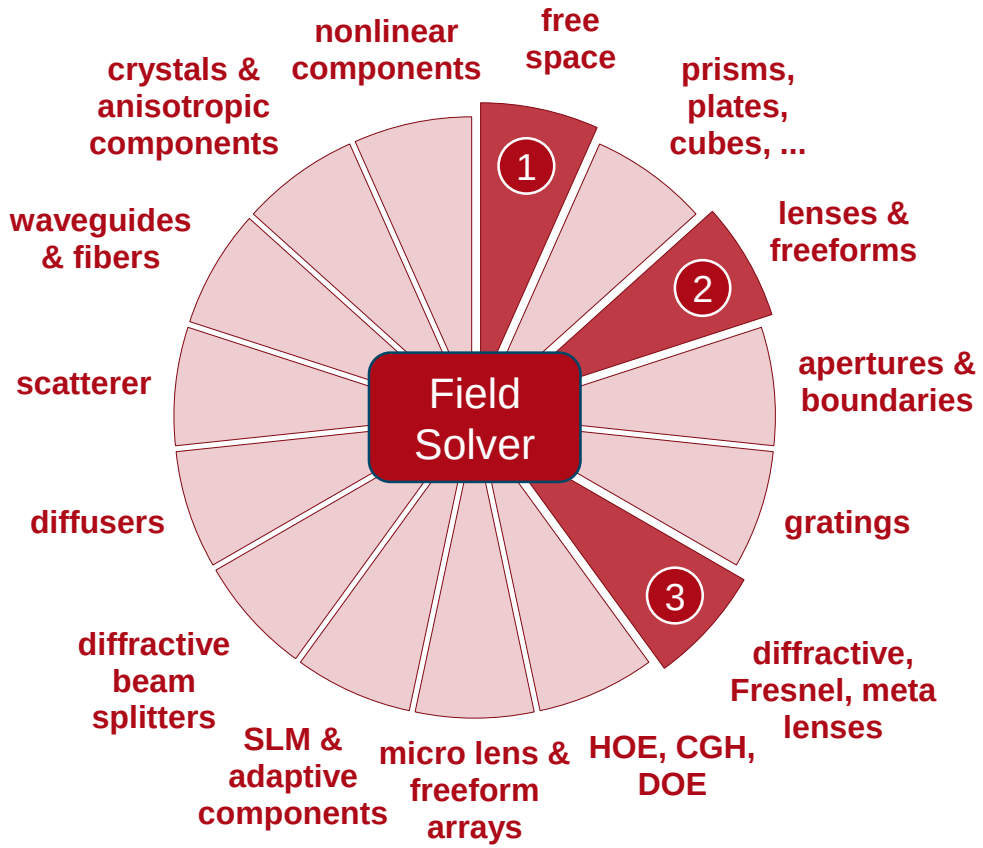
- Import lens systems from Zemax OpticStudio®
  - Import Optical Systems from Zemax [Use Case]
- Configuration of Diffractive Lenses

- Configuration of Parameter Run
  - Usage of the Parameter Run Document [Use Case]



VirtualLab Fusion Technologies





Document Information

title	Modeling of a Hybrid Eyepiece with Diffractive Lens Surface for Chromatic Aberration Correction
document code	DFL.0002
version	1.0
toolbox(es)	Starter Toolbox, Diffractive Optics Toolbox, Grating Toolbox
VL version used for simulations	VirtualLab Fusion Summer Release 2019 (7.6.0.116)
category	Application Use Case
further reading	- Design and Analysis of Intraocular Diffractive Lens - Import Optical Systems from Zemax OpticStudio®