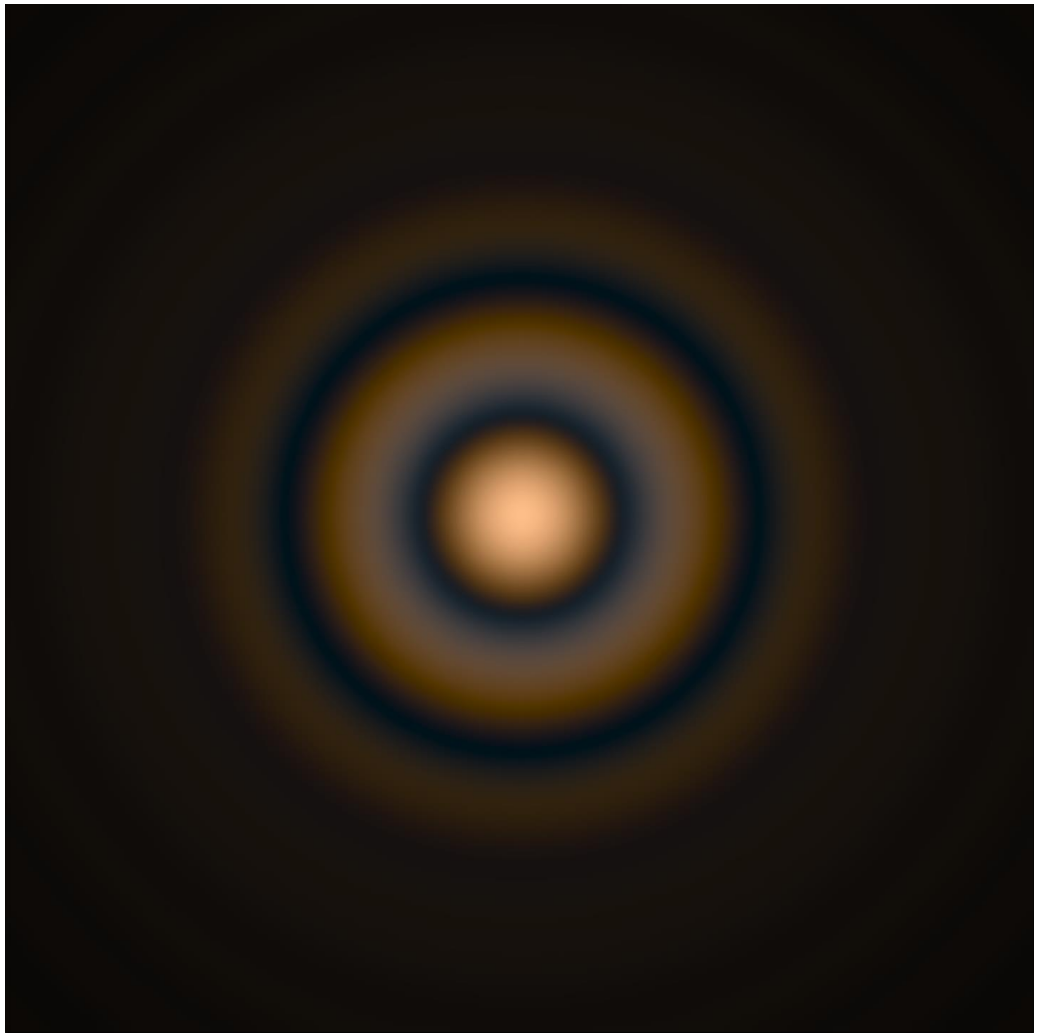
Chromatic Aberration Correction by an Idealized Diffractive Lens in a Hybrid Eyepiece Model

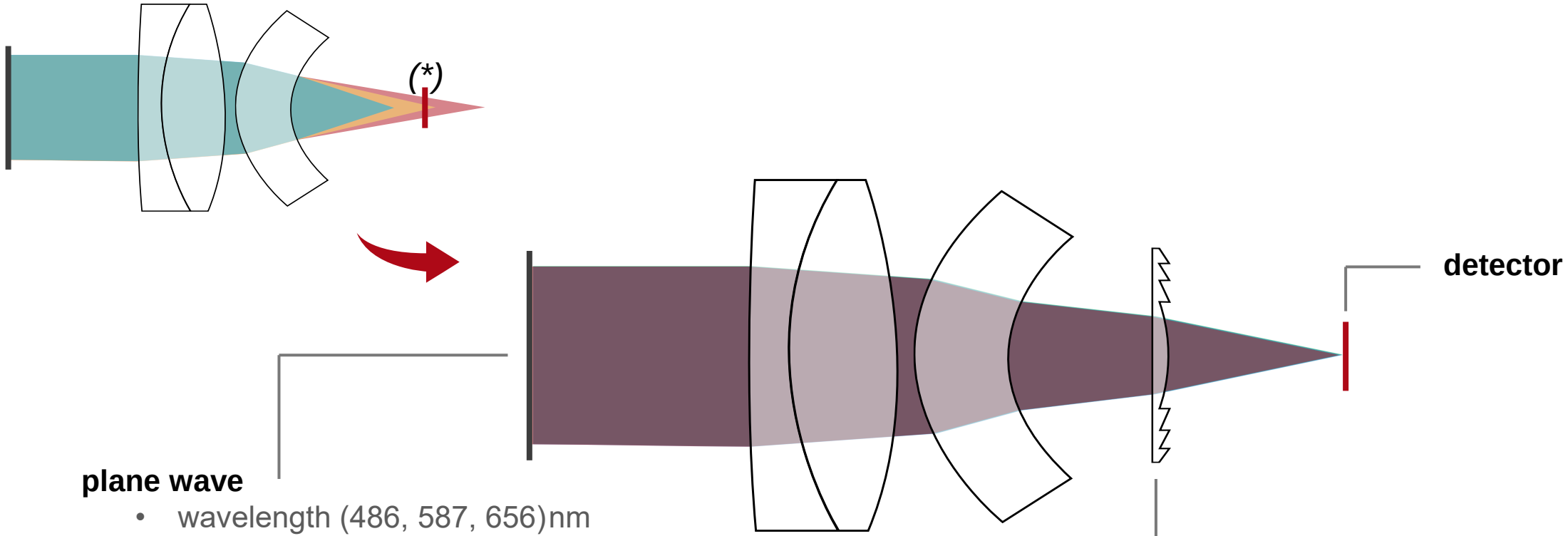
Abstract



Hybrid lenses 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. In this Use Case the diffractive lens surface is modeled with an ideal surface defined by the diffraction orders, the diffraction efficiency of each order and the wavefront phase response.

Design and Modeling Task

(*) focal position determined by minimized spot diameter of summated field



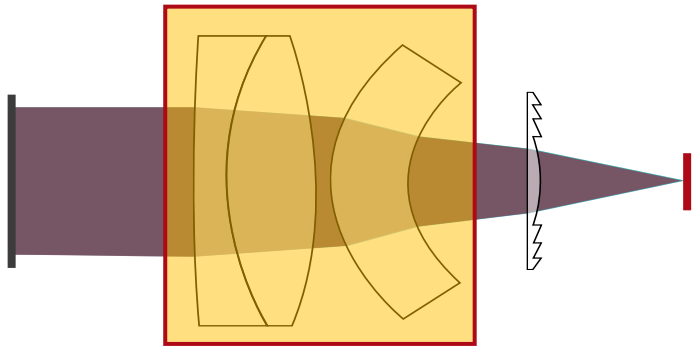
plane wave

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

ideal diffractive lens

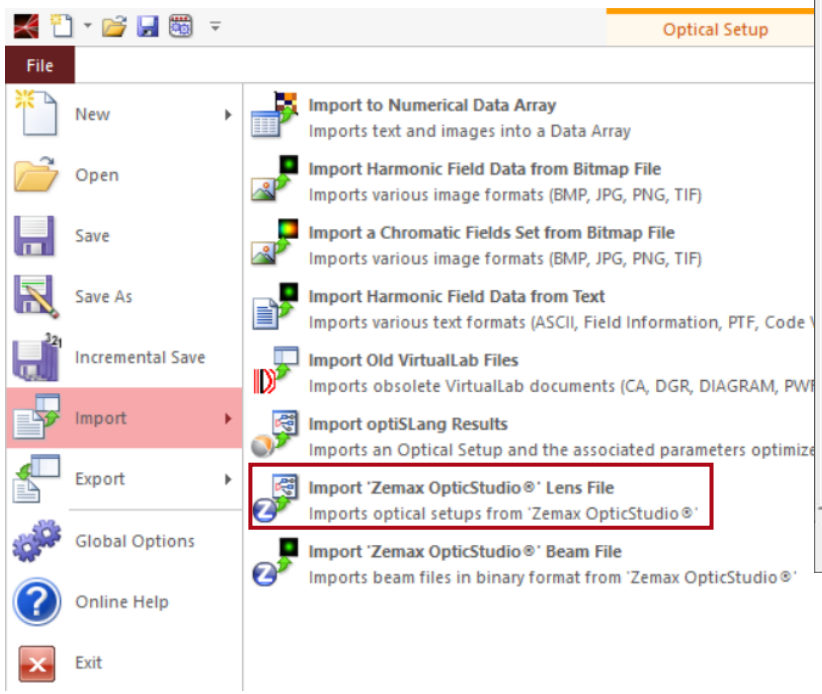
- wavefront phase response
- diffraction orders
- diffraction efficiency of each order

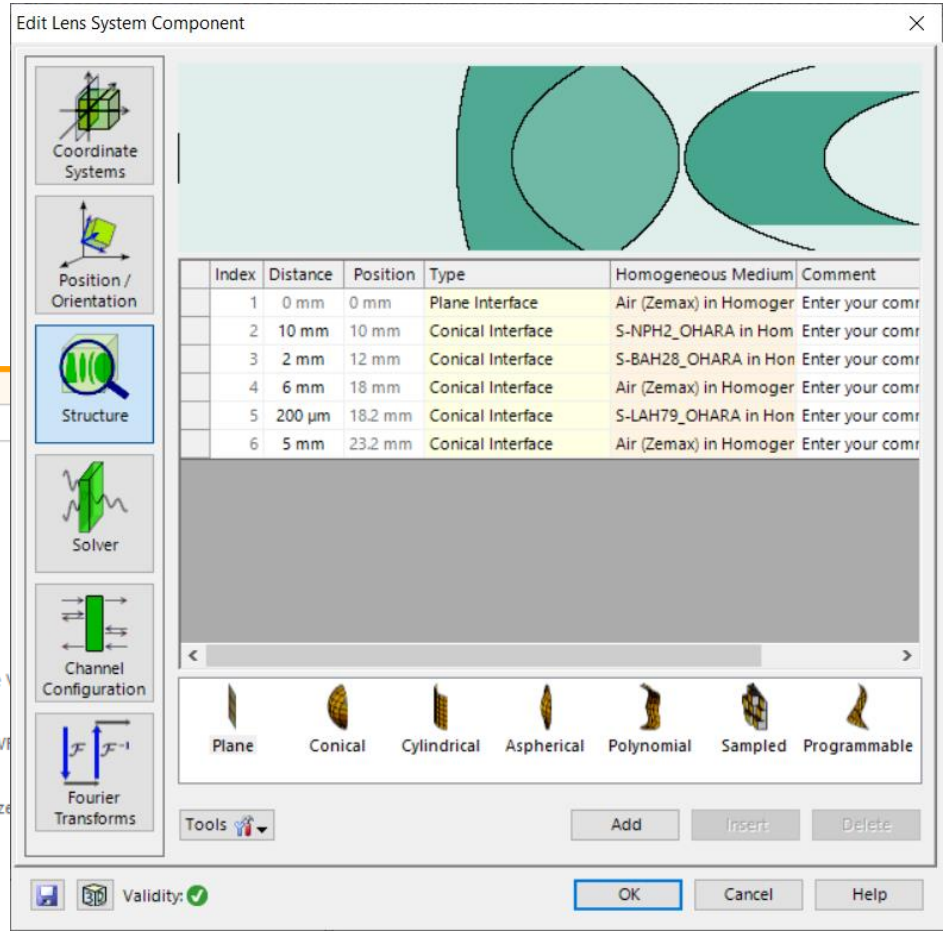
Imported Lens File



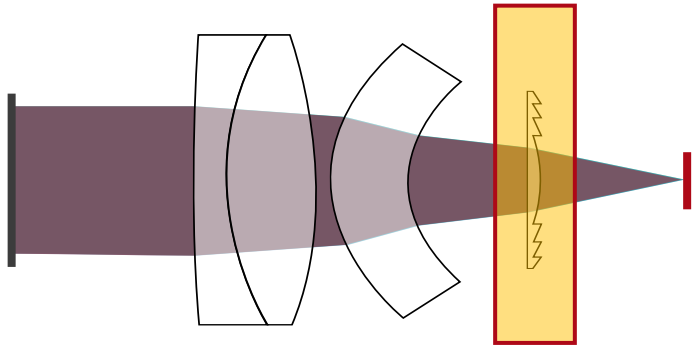
The initial design is taken from Zemax OpticStudio® and imported into VirtualLab Fusion.

More information:
[Import Optical Systems from Zemax OpticStudio®]





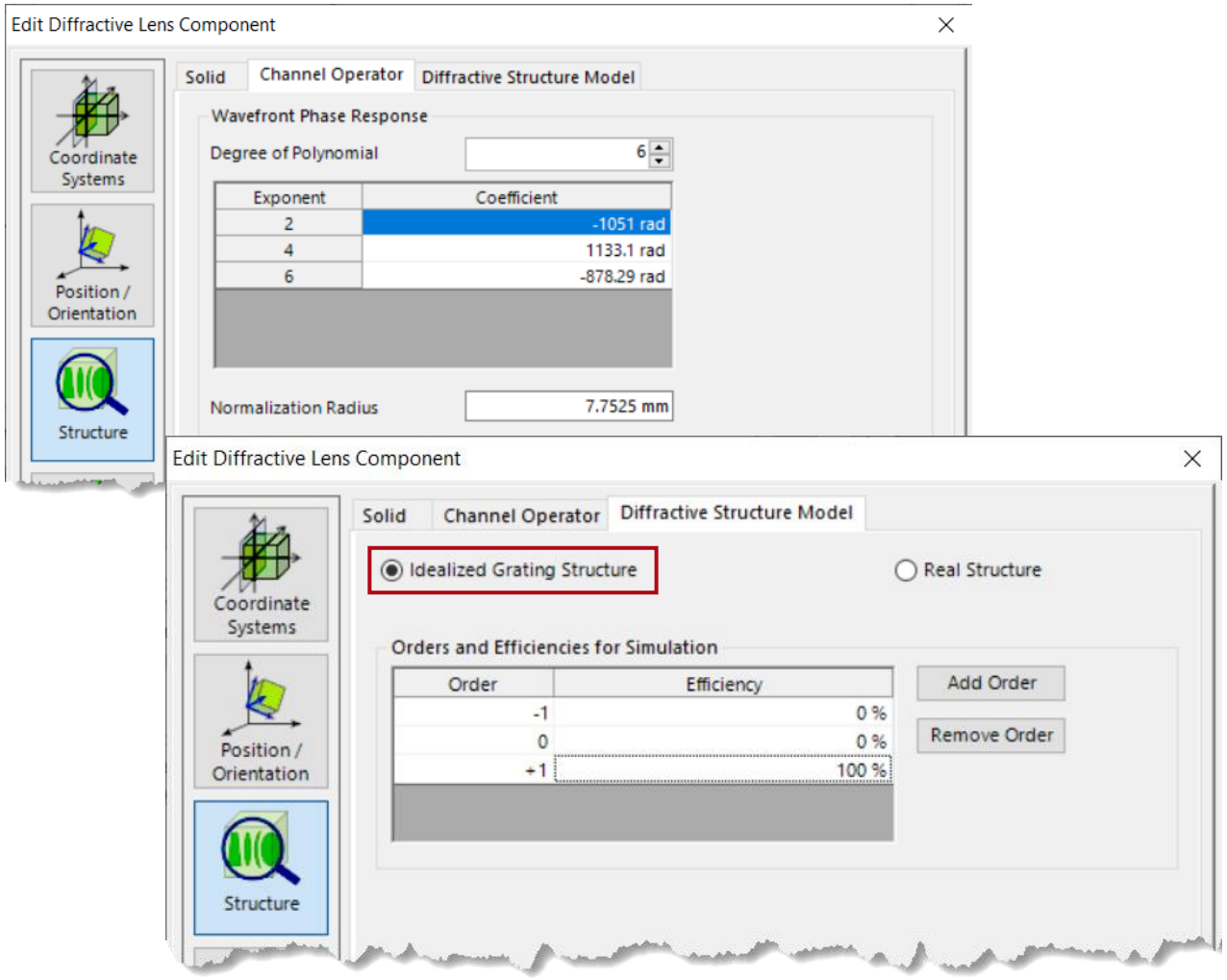
Parameter Setting of Idealized Diffractive Lens



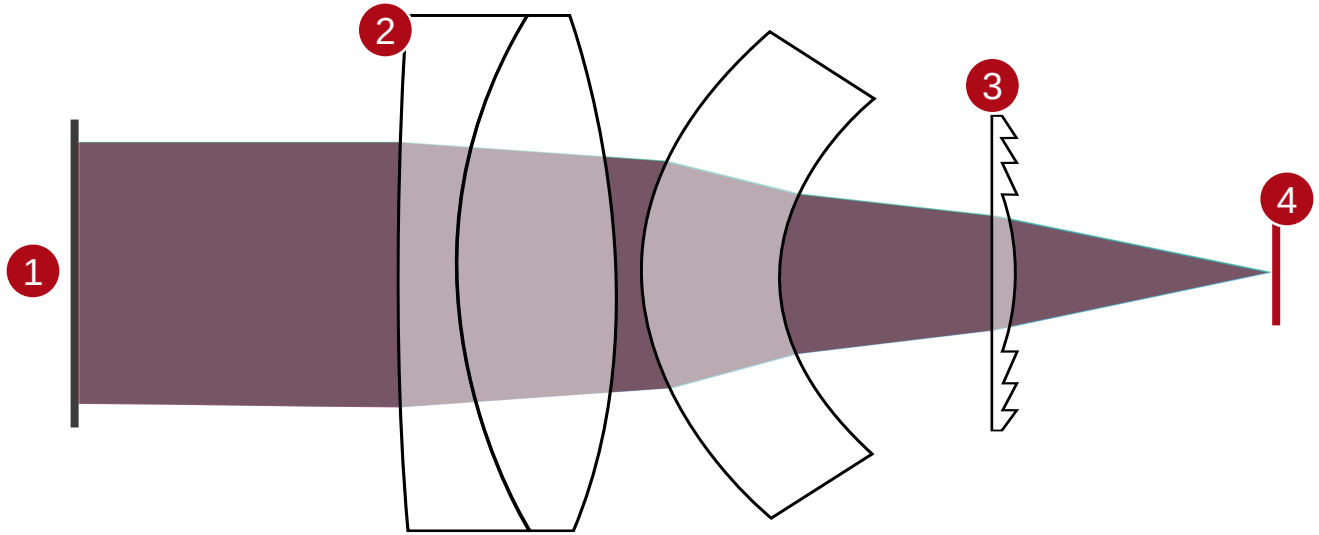
- The desired optical function of the diffractive lens is defined as *Wavefront Phase Response*, which can be configured in the *Channel Operator* tab or imported from OpticStudio's *binary 2* surface.

- For idealized diffractive lens the regarded diffraction orders and their efficiencies must be defined.

More information under: Diffractive Lens Component

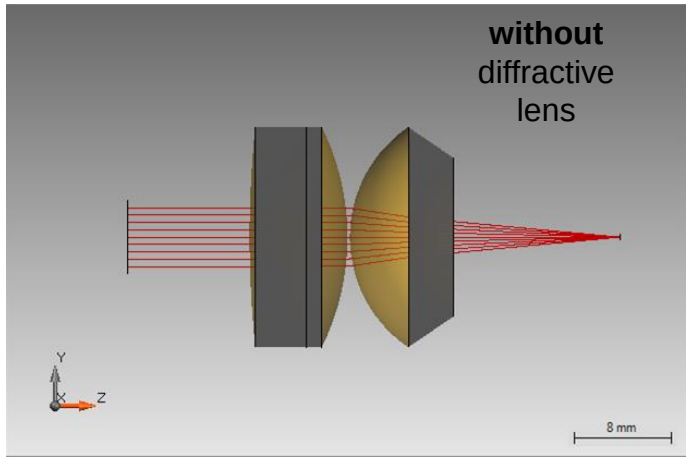


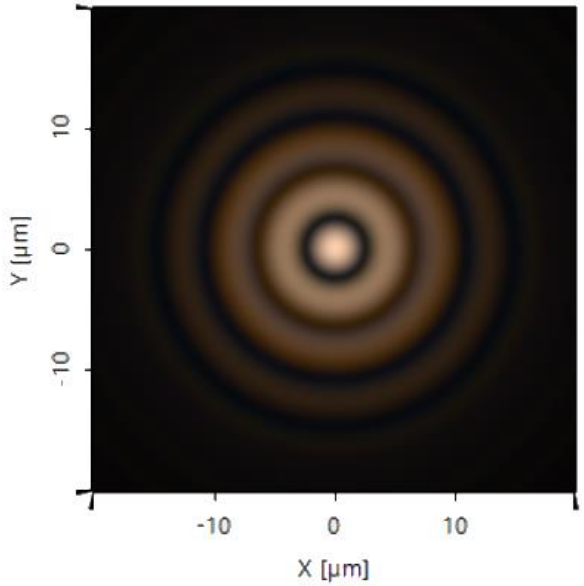
Summary – Components...



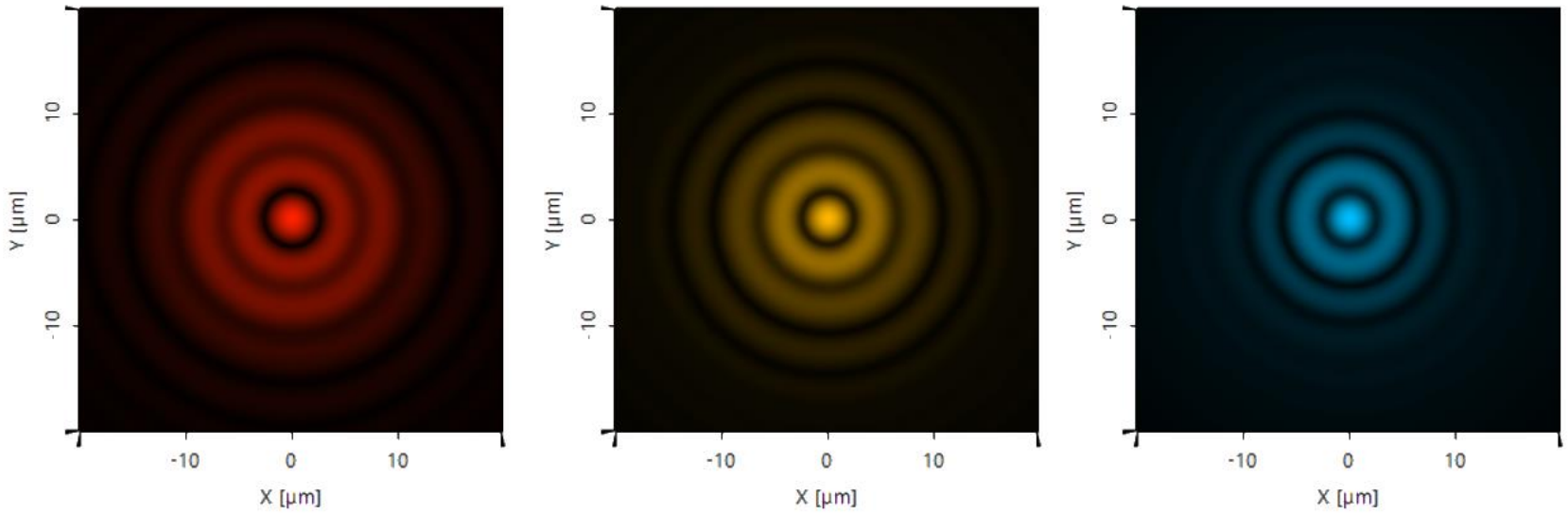
… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Value
1. source	*Plane Wave*	truncated Ideal Plane Wave
2. eye-piece	*Lens System Component*	Local Plane Interface Approximation (LPIA)
3. diffractive element	*Diffractive Lens Component*	LLGA (with Idealized Grating Functions)
4. detector	*Camera Detector*	coherent summation of the E-field

On-Axis Case: Refractive Lens



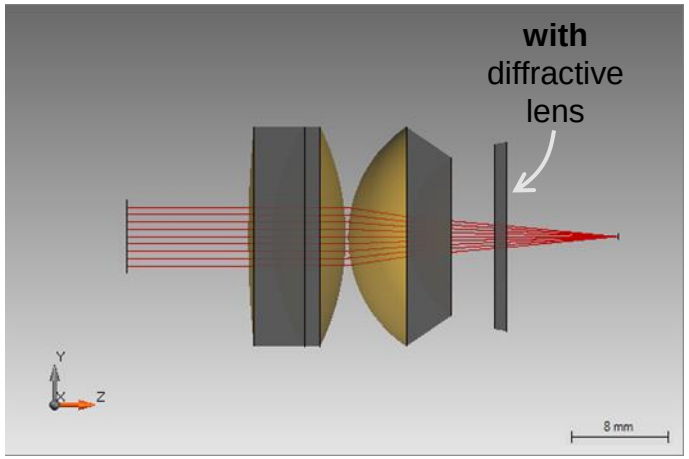


$\lambda = 656.45\,\text{nm}$ $\lambda = 587.72\,\text{nm}$ $\lambda = 486.27\,\text{nm}$

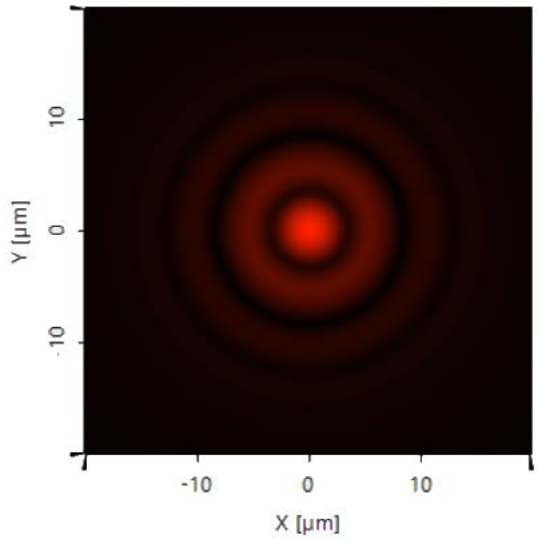


We use a plane wave source with spectral values 486.27 nm, 587.72 nm, 656.45 nm.
The results show the field at the same detector position, but because of dispersion effects, the lens exhibits different effective focal lengths. Hence, the diameter of the focal spot at the detector plane differs for each color.

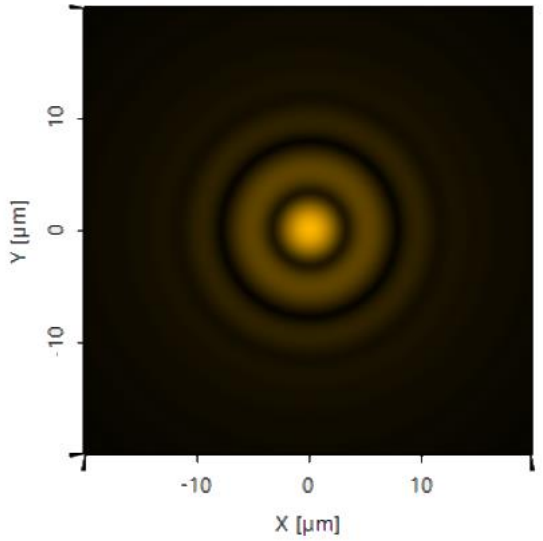
On-Axis Case: Idealized Diffractive Lens



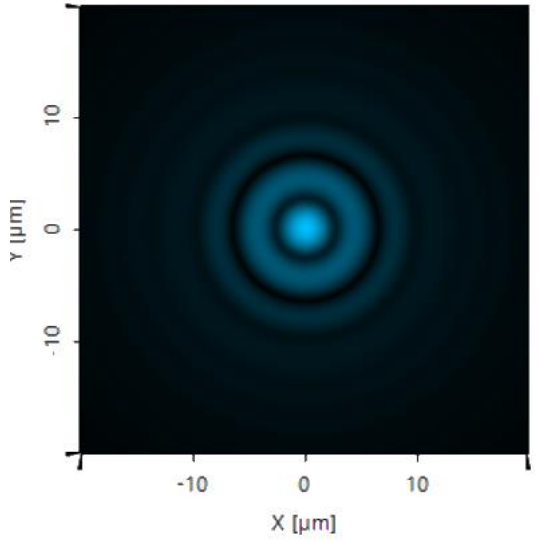
$\lambda = 656.45\,\mathrm{nm}$

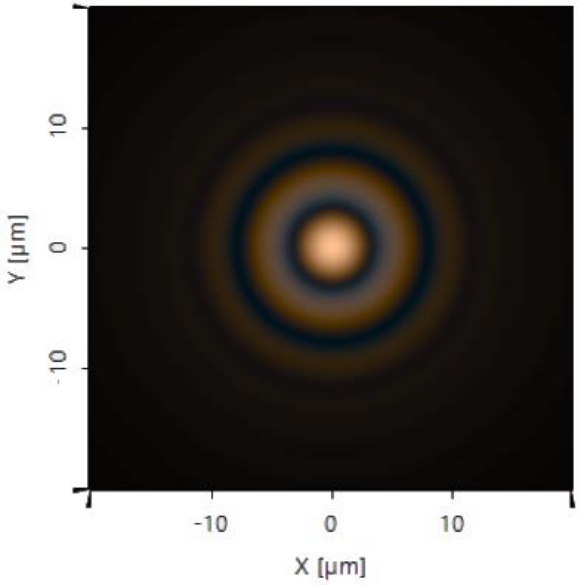


$\lambda = 587.72\,\mathrm{nm}$



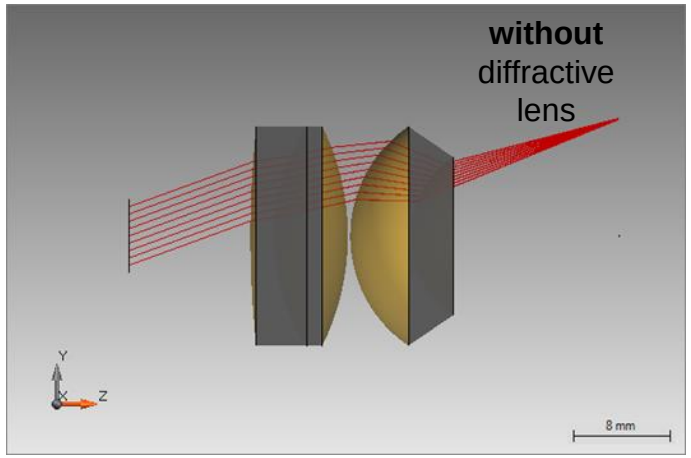
$\lambda = 486.27\,\mathrm{nm}$



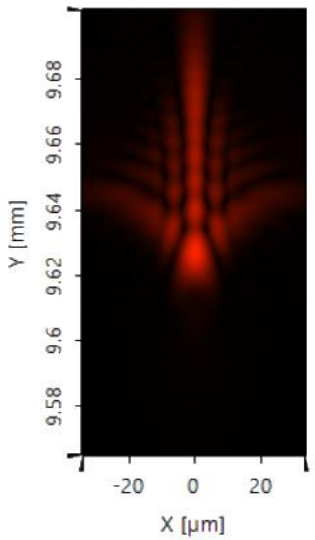


Through the introduction of the diffractive lens, this can be unified and all wavelengths focus onto the detector plane. The chromatic aberration therefore is corrected and the focal spot appears much smaller in the process.

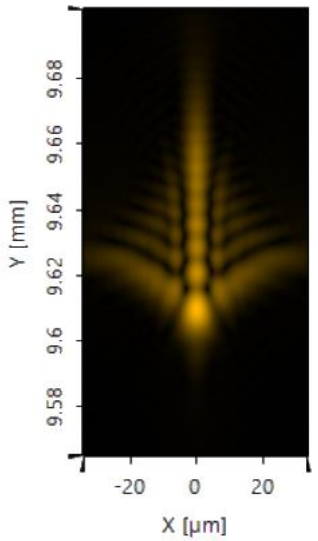
Off-Axis Case: Refractive Lens



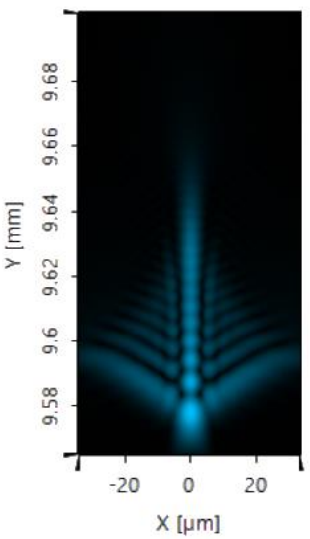
$\lambda = 656.45\,\mathrm{nm}$

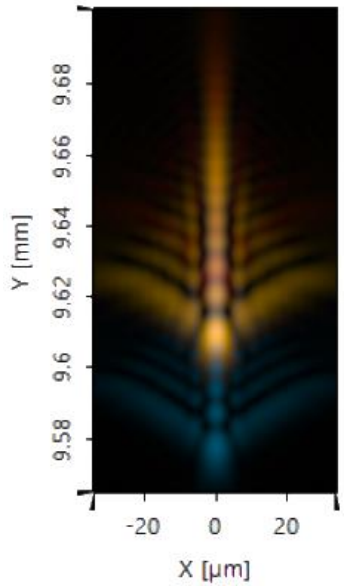


$\lambda = 587.72\,\mathrm{nm}$



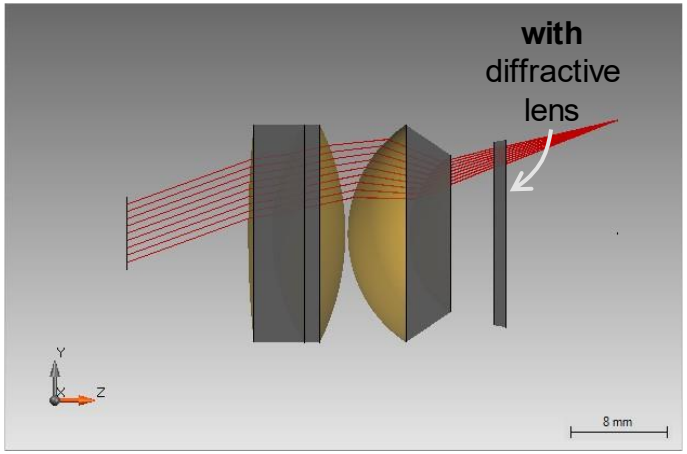
$\lambda = 486.27\,\mathrm{nm}$



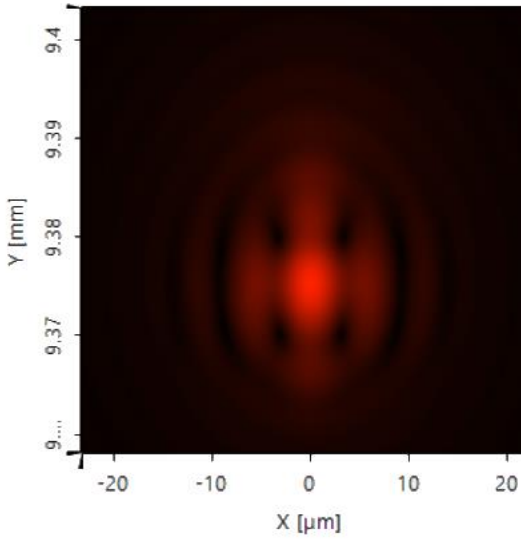


For the off-axis case, the same principle applies. Though in this case, the issue is escalated as there is even a lateral wavelength depended shift.

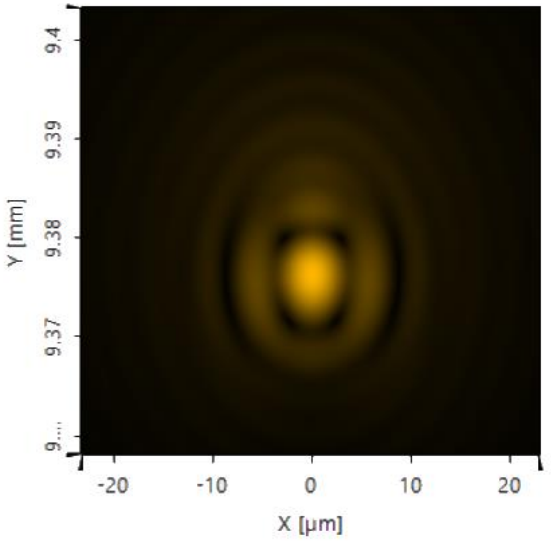
Off-Axis Case: Idealized Diffractive Lens



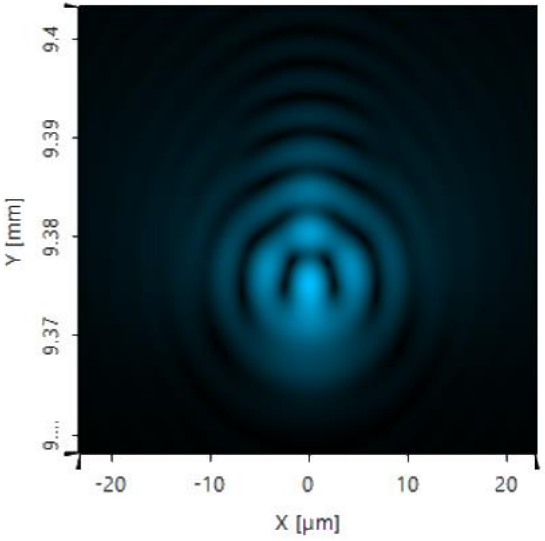
$\lambda = 656.45\,\mathrm{nm}$

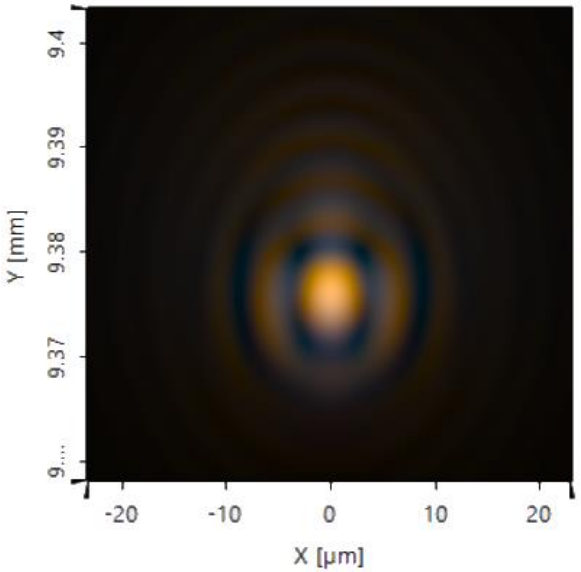


$\lambda = 587.72\,\mathrm{nm}$



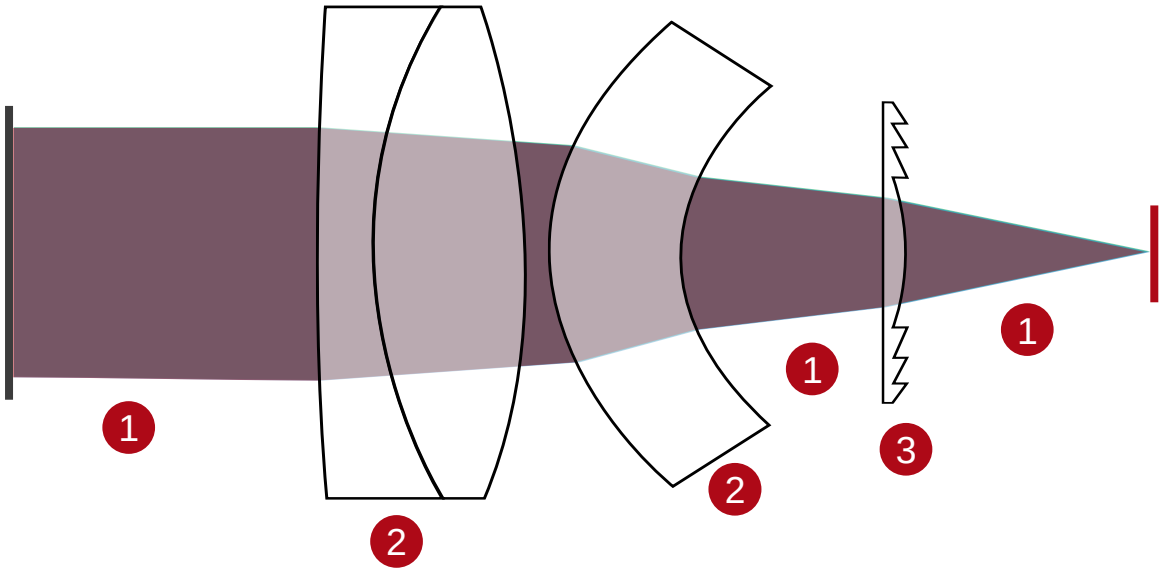
$\lambda = 486.27\,\mathrm{nm}$

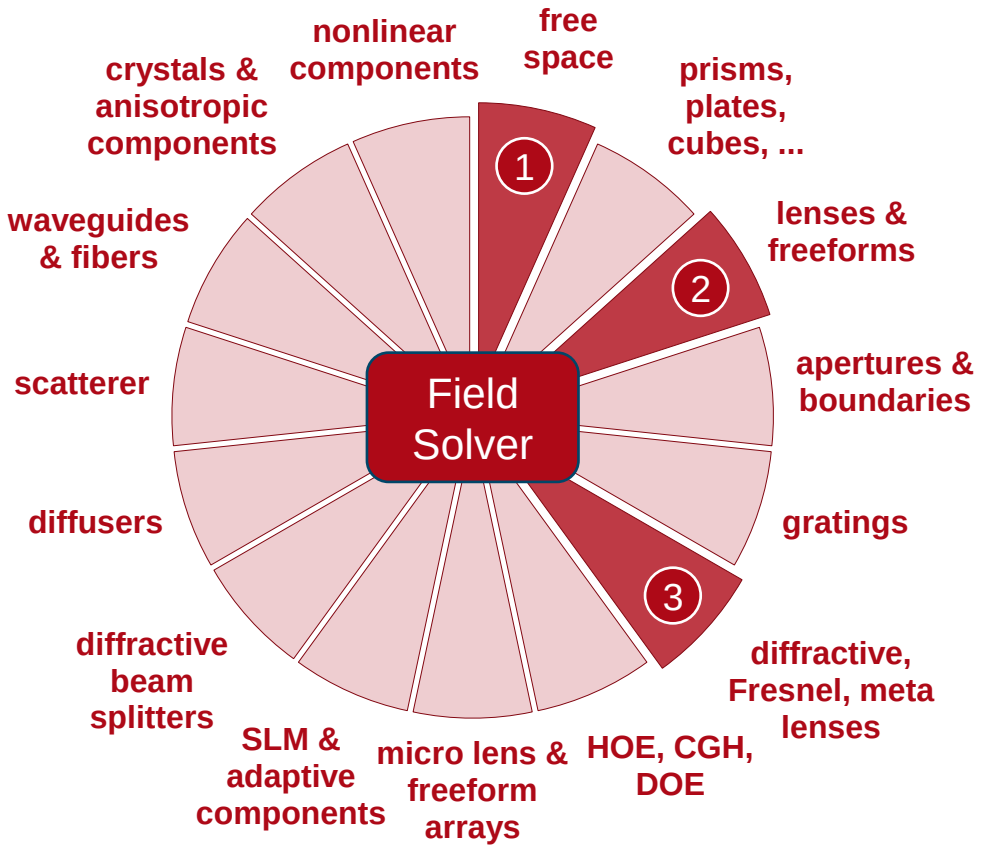




Through the introduction of the diffractive lens both effects can be corrected, leading to an optimized focal spot when using off-axis illumination.

VirtualLab Fusion Technologies





Document Information

title	Chromatic Aberration Correction by Ideal Diffractive Lens in a Hybrid Eyepiece Model
document code	DFL.0002
document version	2.0
software edition	• VirtualLab Basic (idealized component only) • VirtualLab Advanced • Diffractive Optics Toolbox Gold
software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	• Design and Analysis of Intraocular Diffractive Lens • Diffractive Lens Component • Import Optical Systems from Zemax OpticStudio®