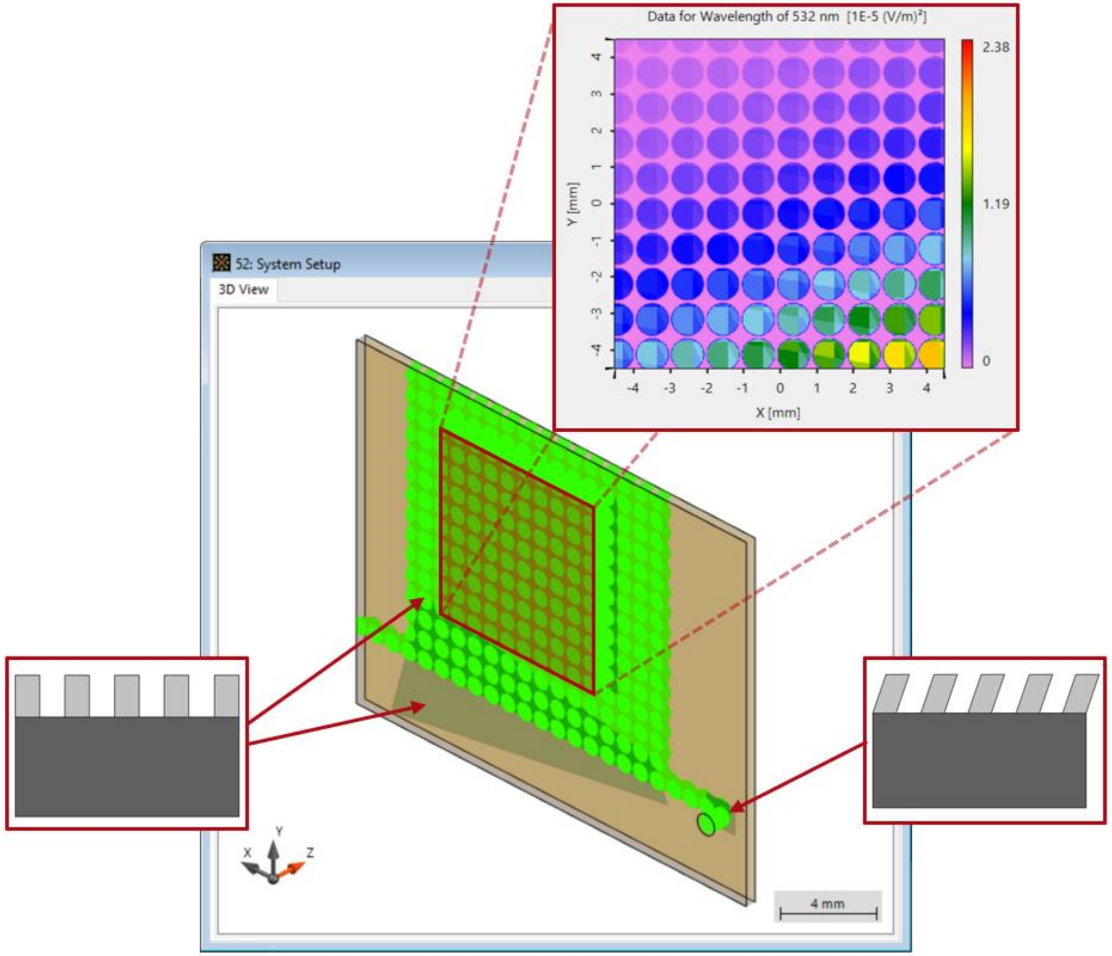
Simulation of Lightguide with 1D-1D Pupil Expander and Real Gratings

Abstract

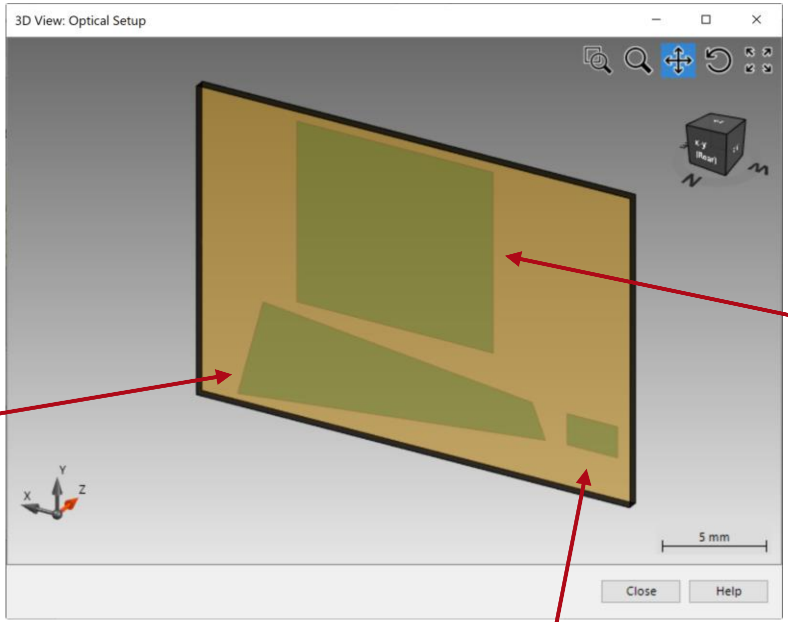


With the development of new applications in the area of augmented & mixed reality (AR & MR) the use of light guide systems has seen growing interest. In order to guide the light from the source to the intended eyebox a configuration with a separated 1D-1D pupil expansion in combination with different kinds of surface relief gratings are used. The design of these gratings in regard to efficiency and uniformity is therefore one of the major challenges in the design process of AR/MR devices. In this use case we demonstrate how to include real grating structures in VirtualLab Fusion, from the initial grating design to the application on the lightguide surface.

Task Description

Source
- 532 nm wavelength
- 1 mm × 1 mm diameter

Lightguide
- material: S-LAH79
- 500 µm thickness

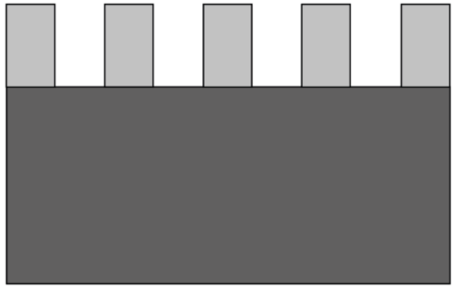


Eye Pupil Expander
- rectangular grating
- 268.7 nm period
- angle 45°
- material: resin (n=1.8)

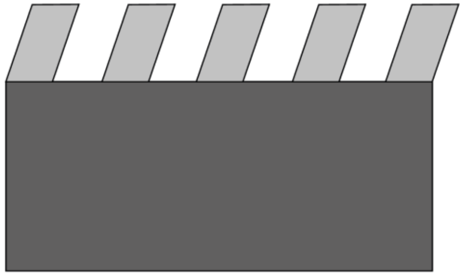
Outcoupling Grating
- rectangular grating
- 380 nm period
- hill factor 50%
- material: resin (n=1.8)
- height: 130 nm

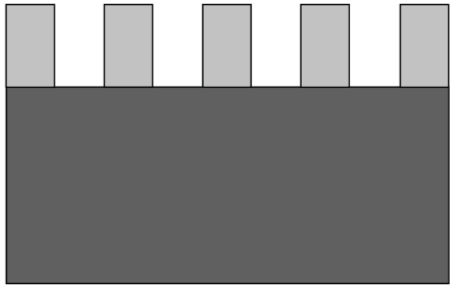
Configuration A:
fill factor 50%
height: 300 nm

Configuration B:
fill factor 58%
height: 200 nm

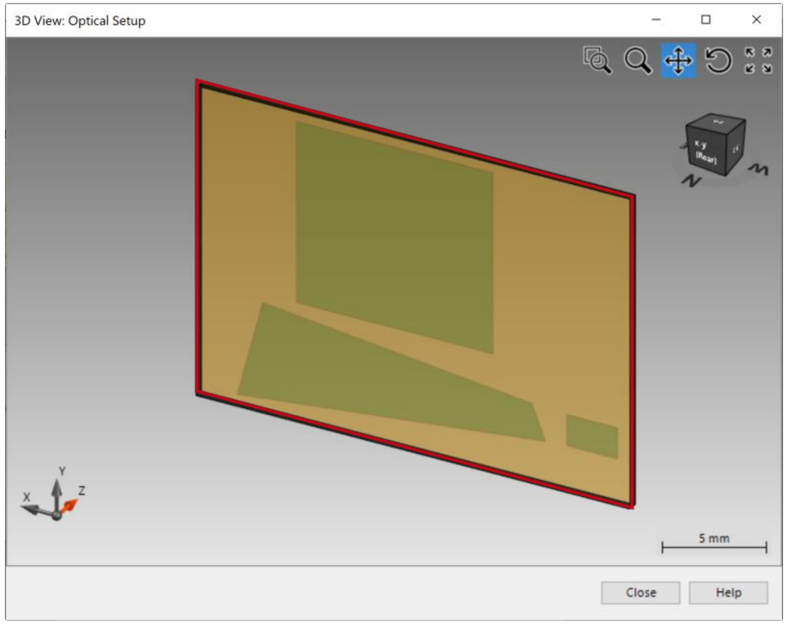


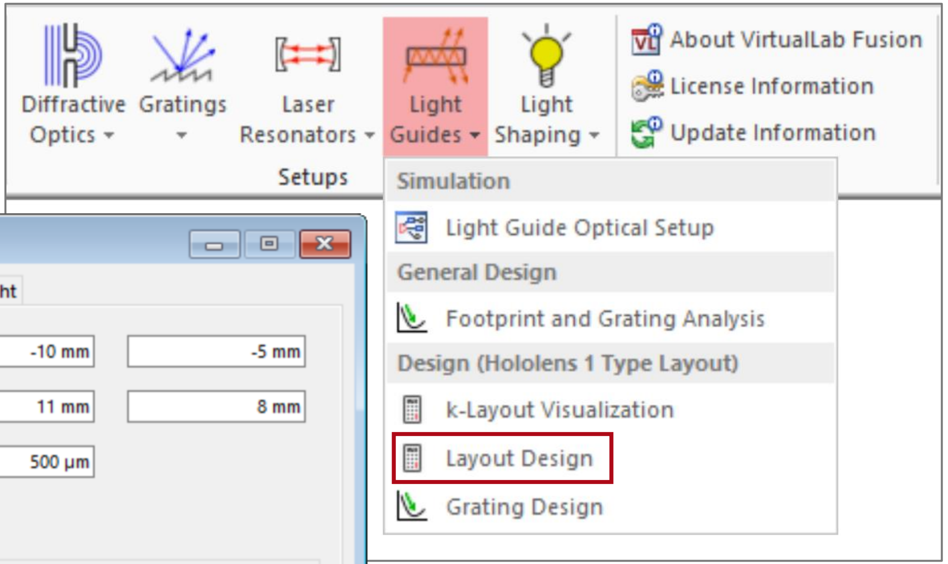
Incoupling grating
- slanted grating
- 380 nm period
- material: resin (n=1.8)

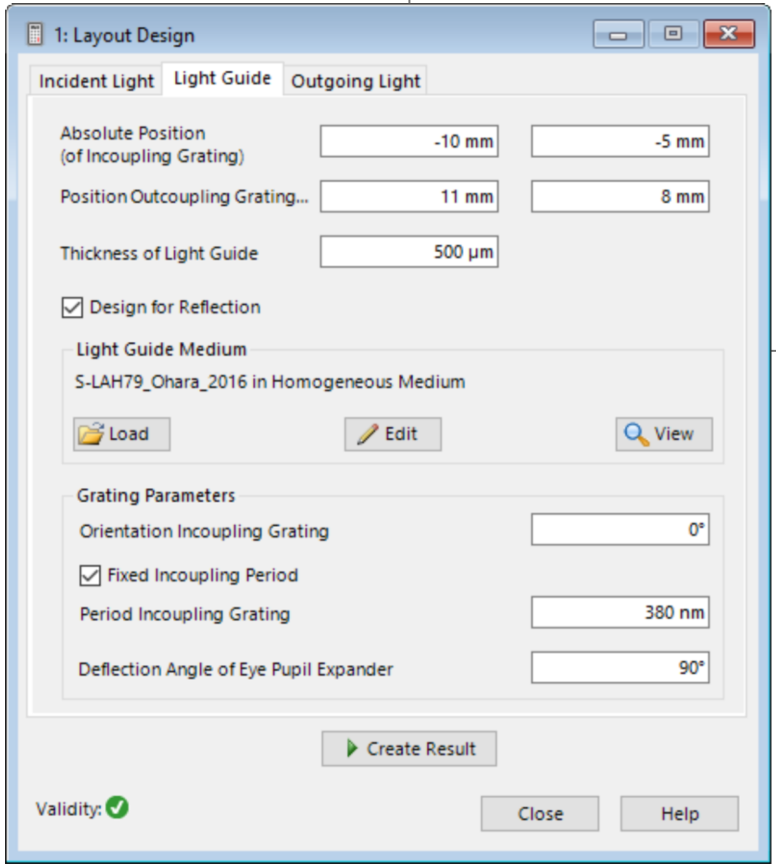




System Building Blocks – Light Guide Component



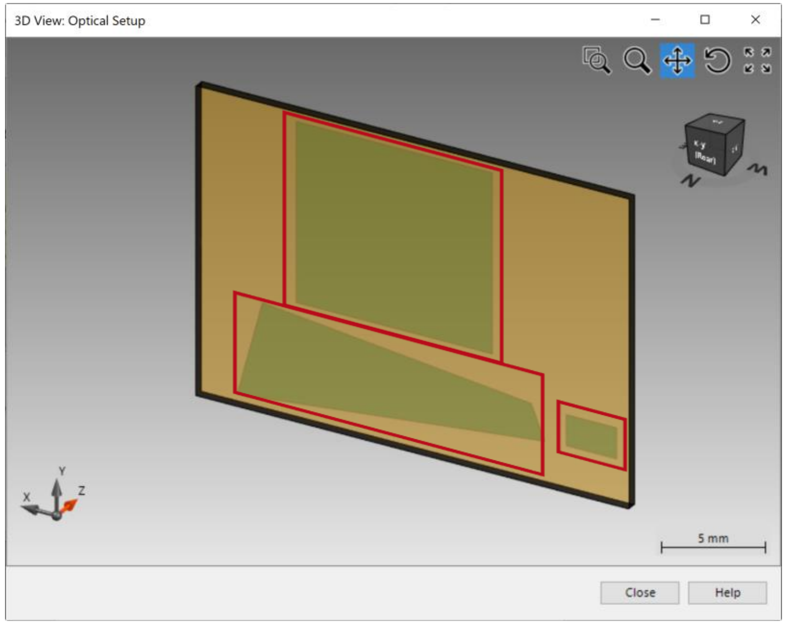


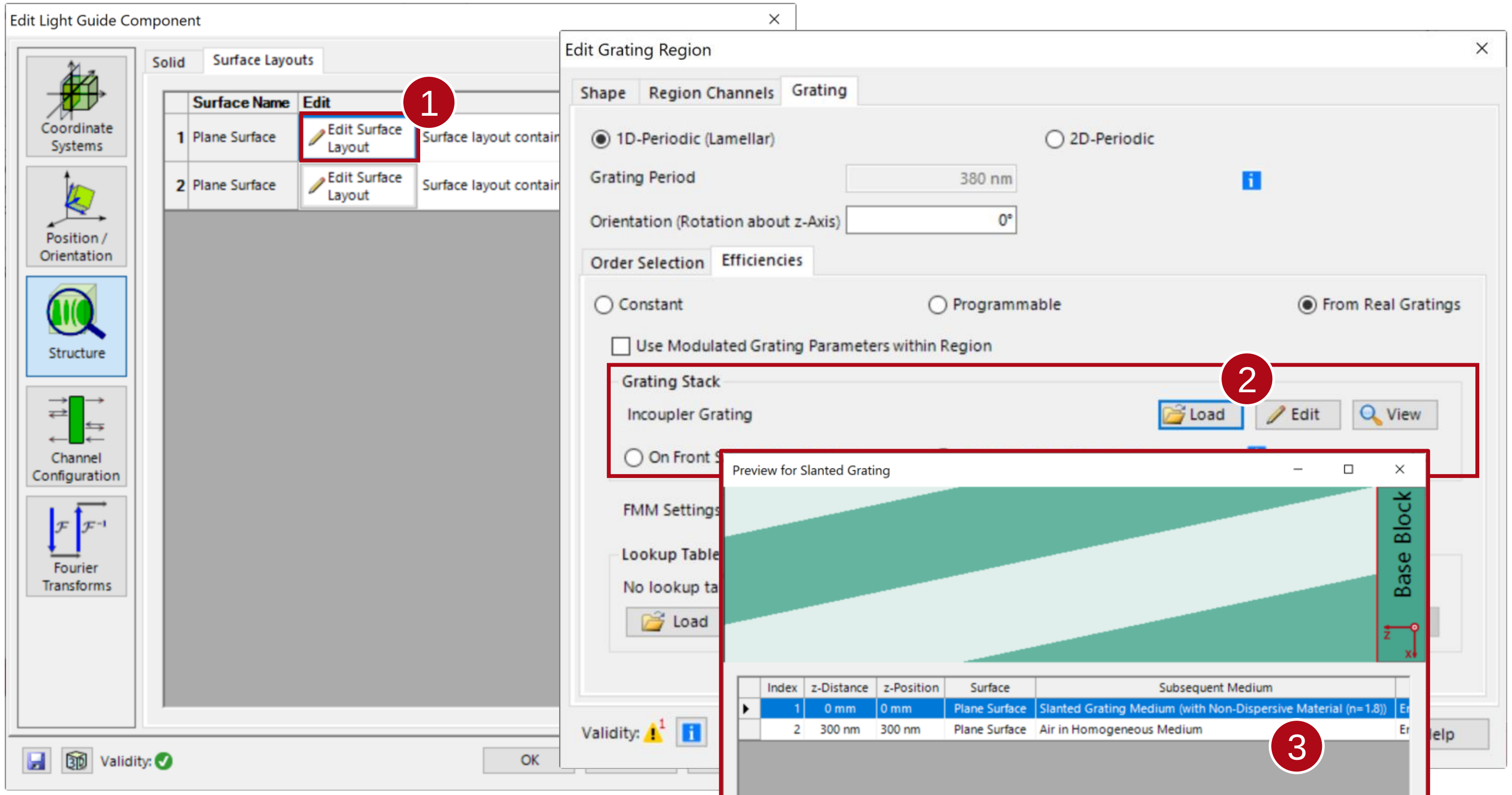


The shown configuration with the *Light Guide Component* can be generated with the *Layout Design* tool, very handily. More information on this topic can be found under (Light Guide Toolbox Gold needed):

Light Guide Layout Design Tool

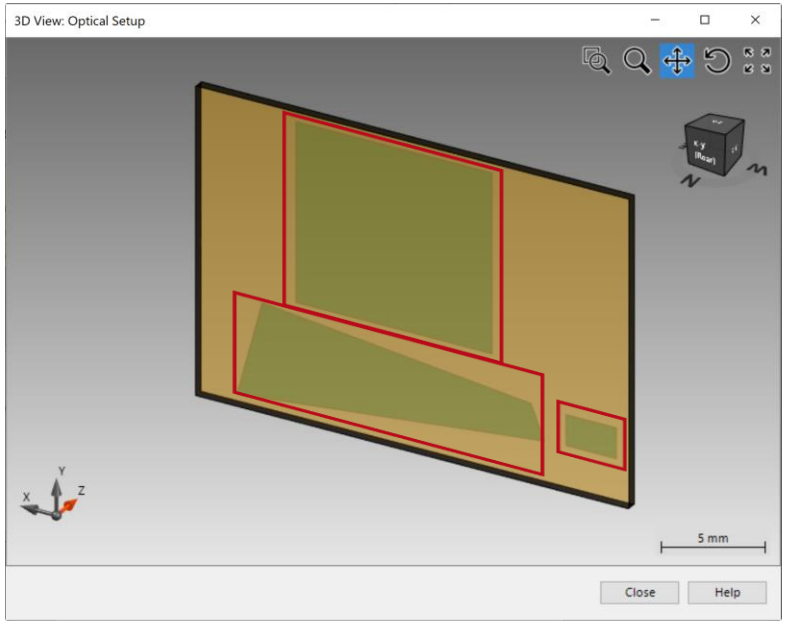
System Building Blocks – Components



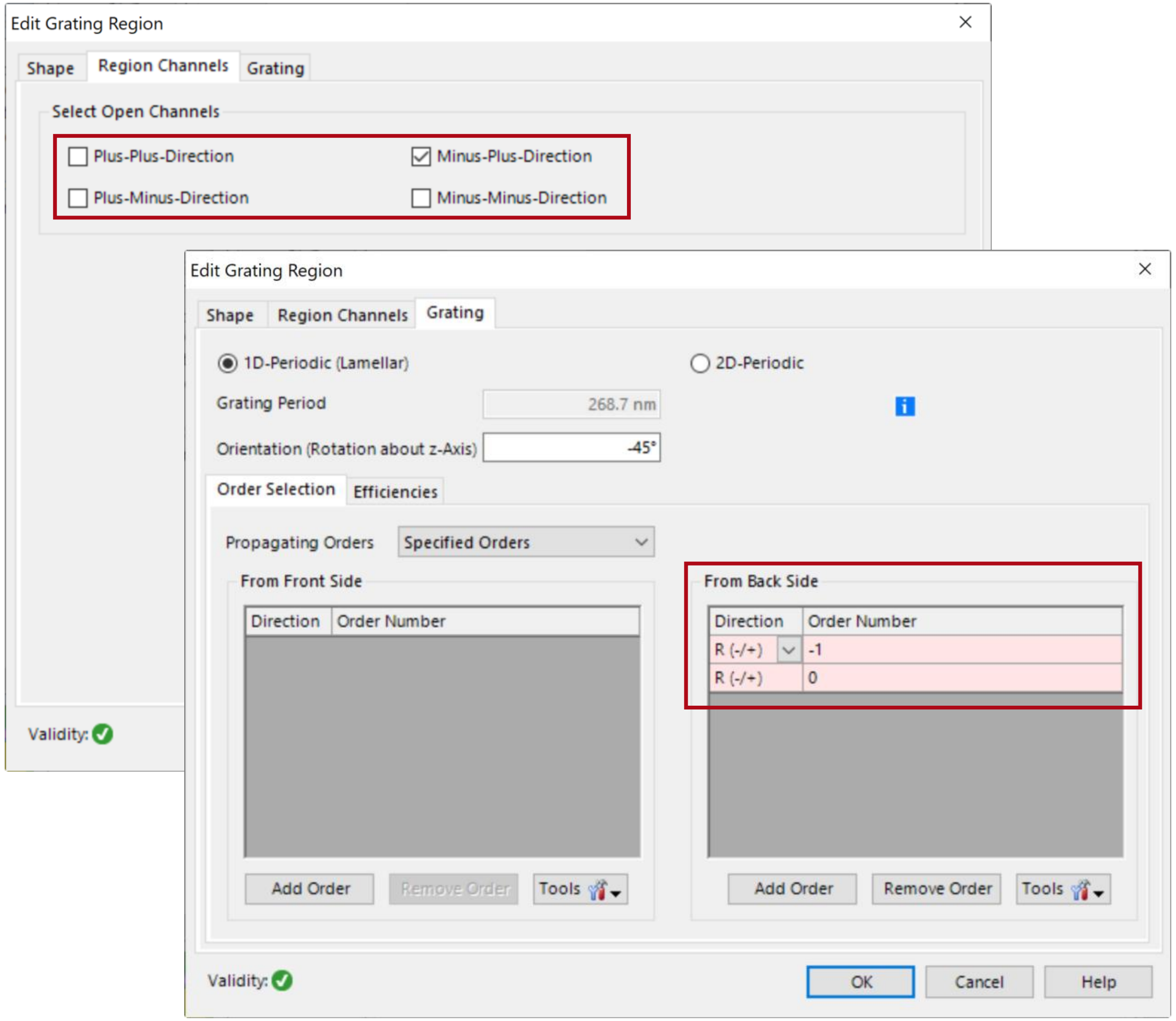


The characteristics of the individual gratings can be investigated in detail with the help of the grating-specific optical setup. Afterwards the designed grating can be loaded into the corresponding region of the *Light Guide Component*. More information in the following Use Case: Construct a Lightguide Component from Real Gratings

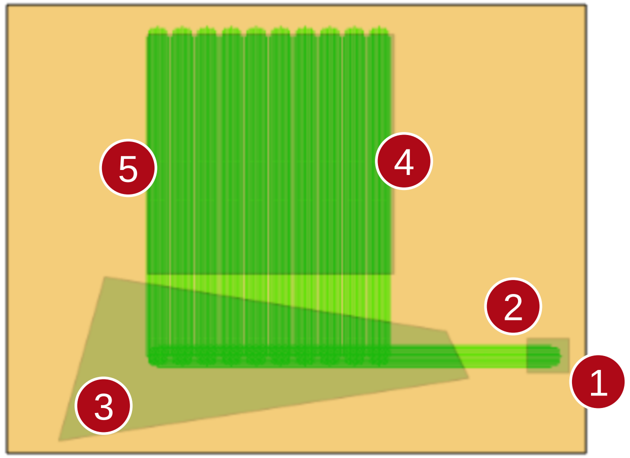
System Building Blocks – Channel Configuration

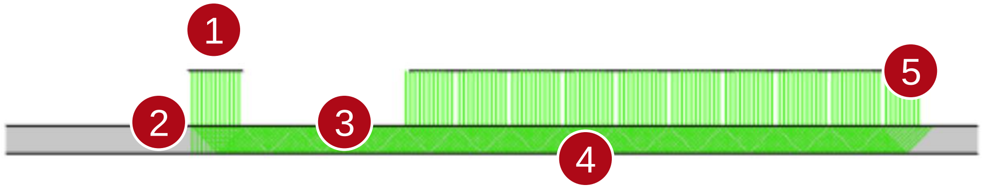


For each individual grating region it is possible to configure the specific channels and diffraction orders that will be considered during the simulation of the desired lightguide.



Summary – Components...

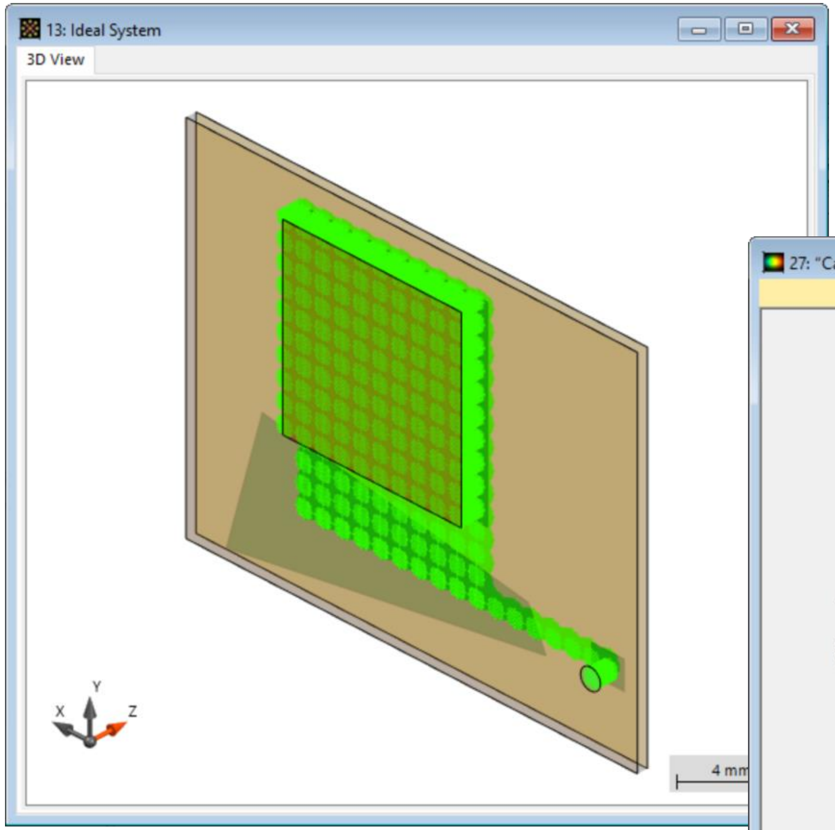




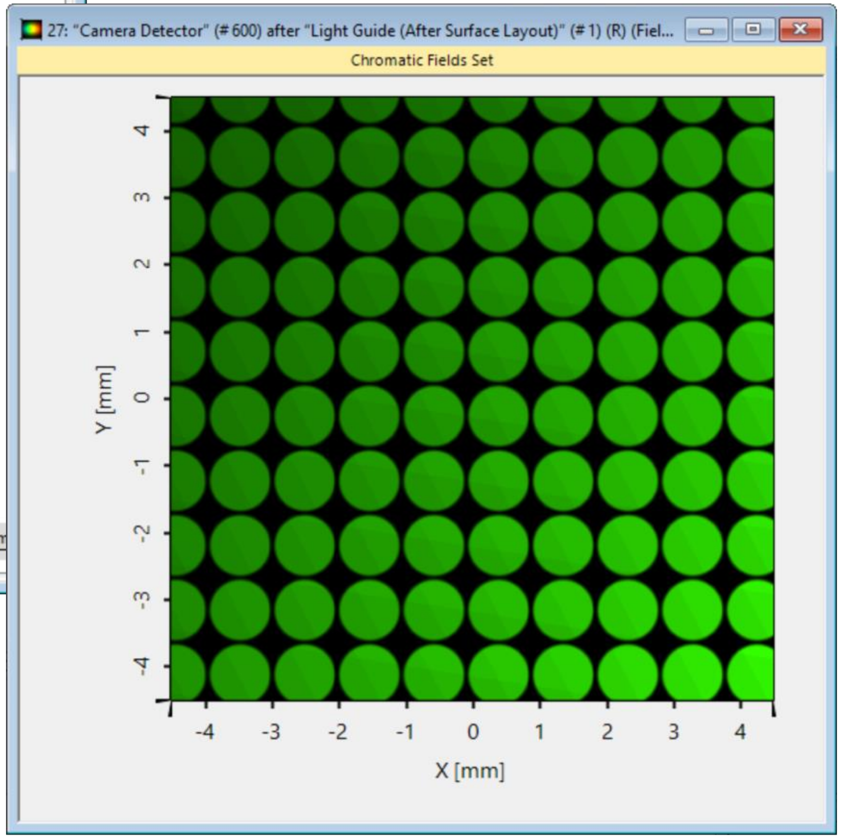
… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Value
1. Source	*Plane Wave* Source	Truncated Ideal Plane Wave
2. Incoupler	*Slanted Grating* in *Rectangular Region*	Fourier Modal Method
3. Eye Pupil Expansion	*Rectangular Grating* in *Simple Polygon Region*	Fourier Modal Method
4. Outcoupler	*Rectangular Grating* in *Rectangular Region*	Fourier Modal Method
5. Eye	*Camera Detector*	Energy Density

Simulation Results

Reference – Ideal Case

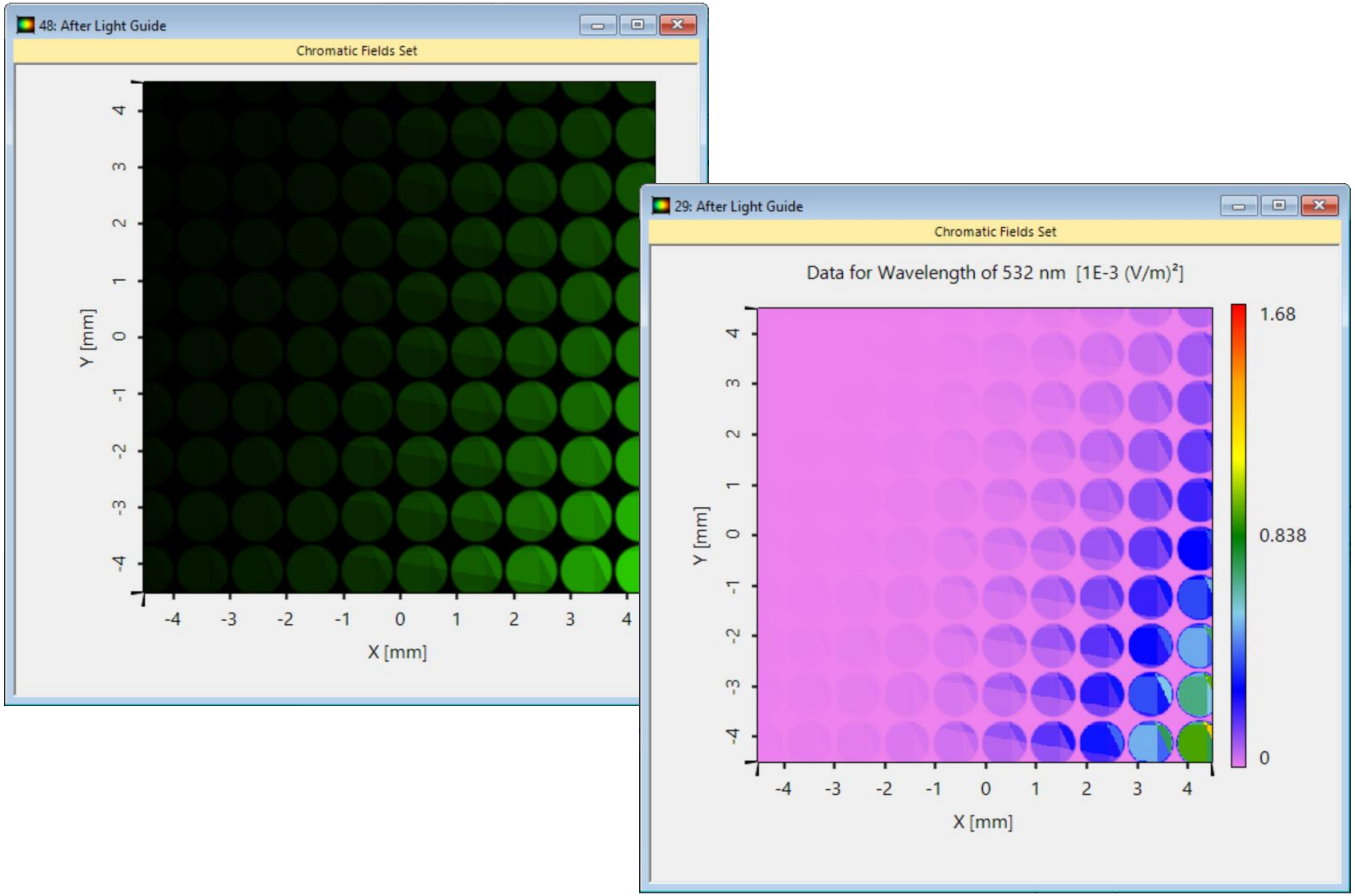


Results from a system with idealized gratings (10% efficiency for the reflected +1st order of the EPE and 10% for the -1st transmitted order of the outcoupling grating and 90% for the 0th order in both cases).



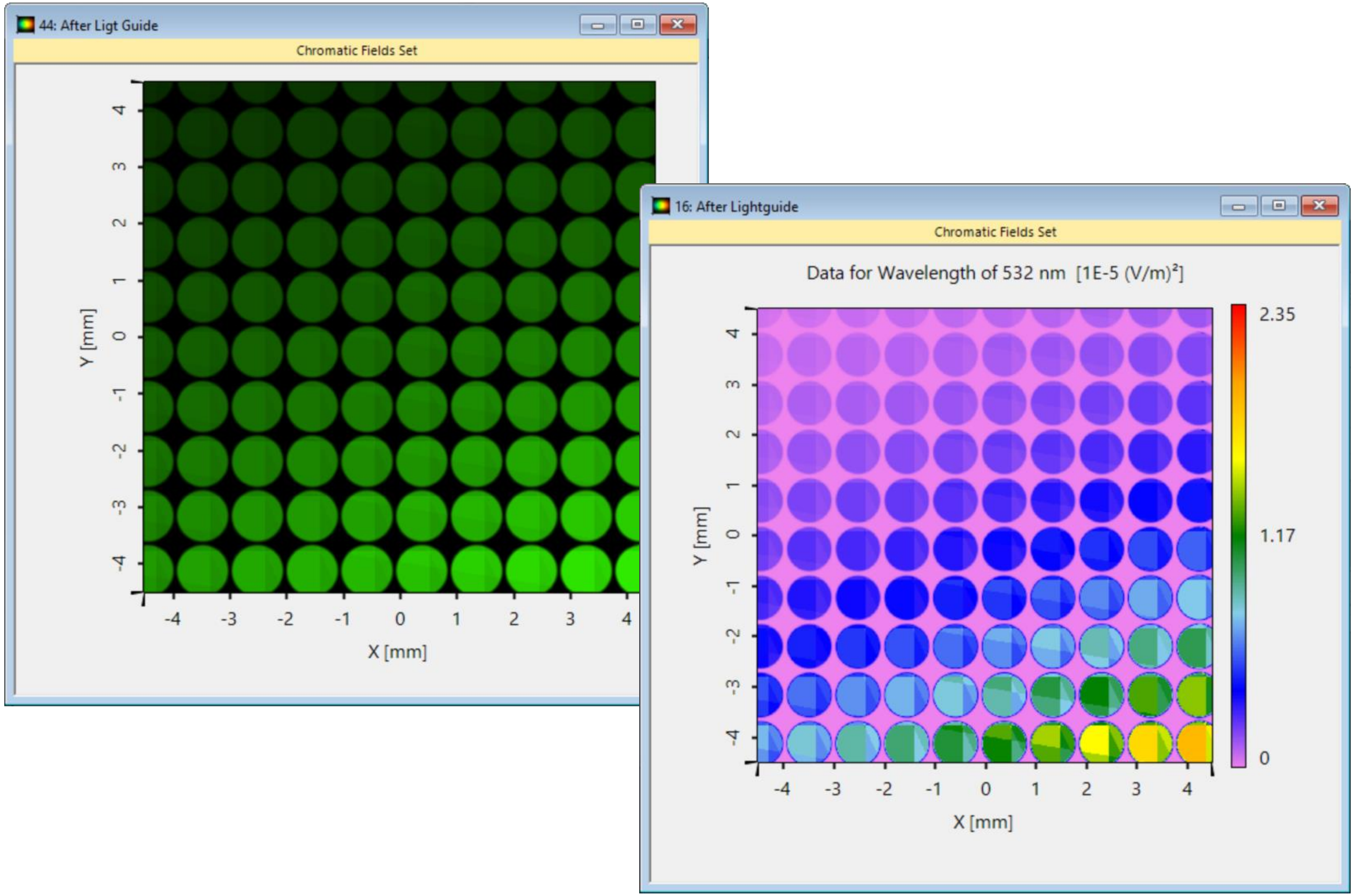
Results – Configuration A

To demonstrate the effects of grating efficiency on the overall characteristics of the lightguide we used two different configurations of the EPE grating. In configuration A we use gratings with a higher efficiency for the +1st order, which is diffracted towards the outcoupler. This means, most of the light will be diffracted after only a few interactions. Hence, while the overall efficiency will be higher, the uniformity of the distribution in the eyebox may suffer.

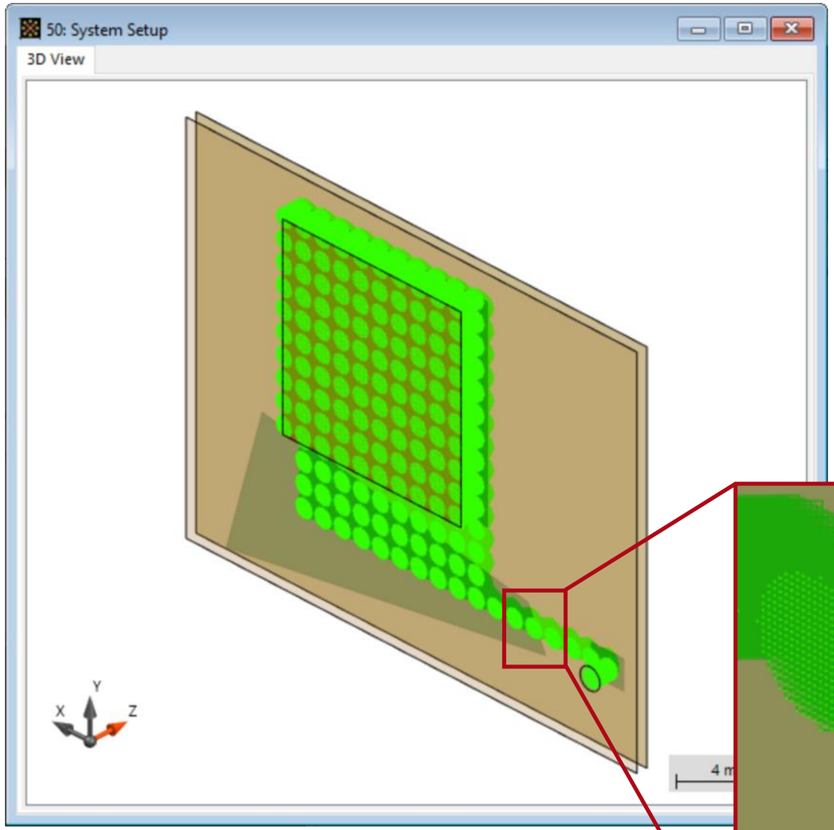


Results – Configuration B

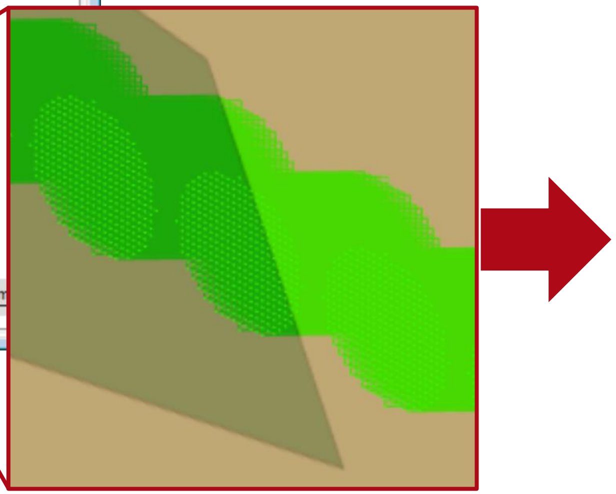
When using gratings with a lower efficiency of the +1st order in the EPE, a smaller fraction of the total energy will be diffracted towards the outcoupler with each interaction. This results in better uniformity, at the cost of reduced efficiency.

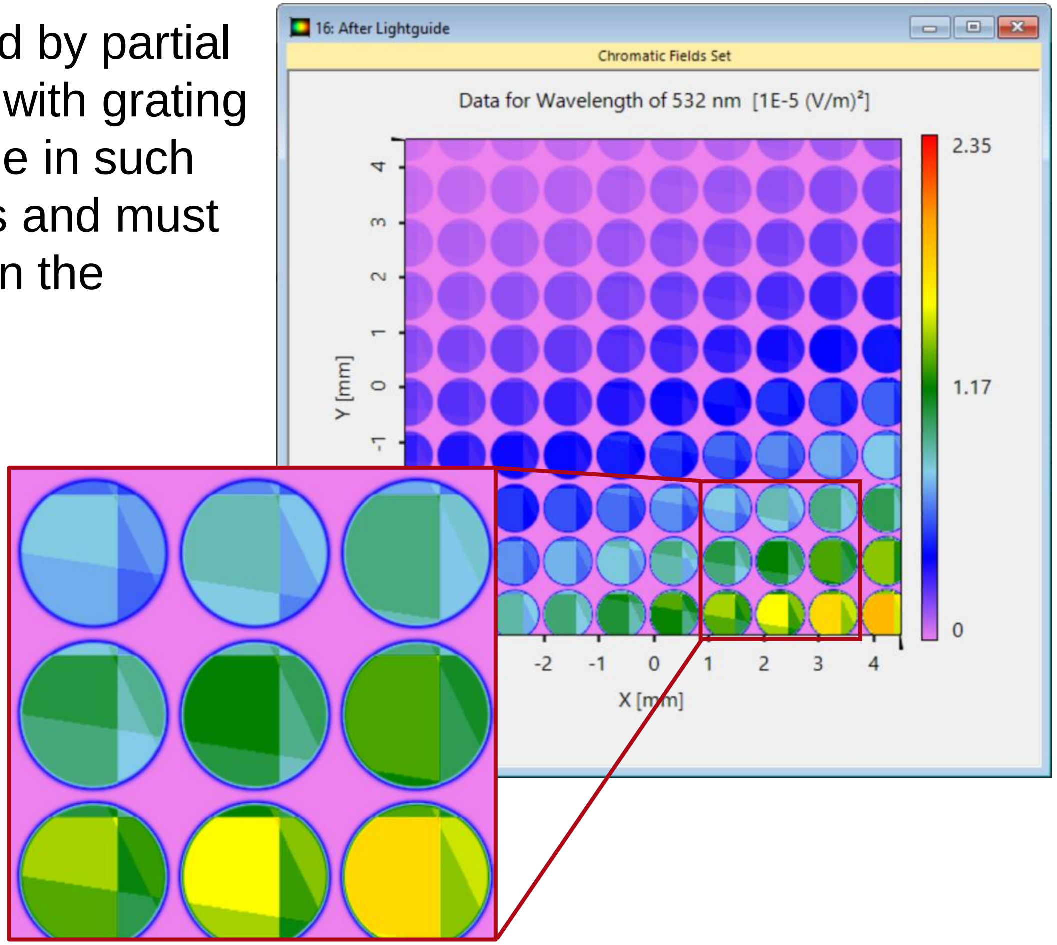


Aperture Effects

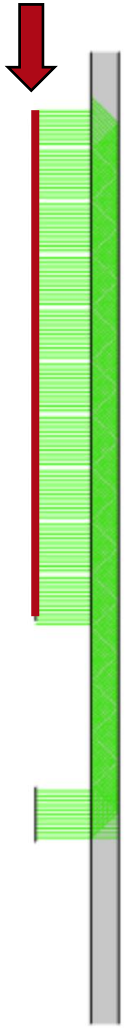


Aperture effects caused by partial interactions of a beam with grating regions are unavoidable in such complex configurations and must be taken into account in the simulation, accurately.

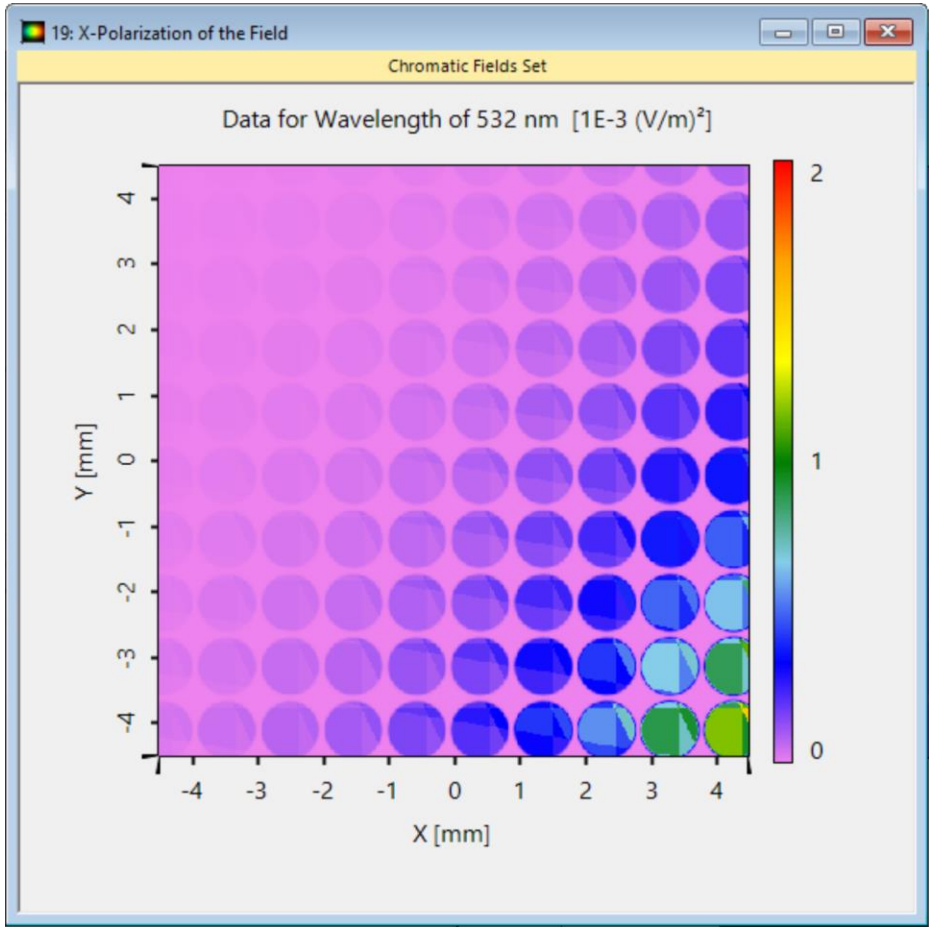




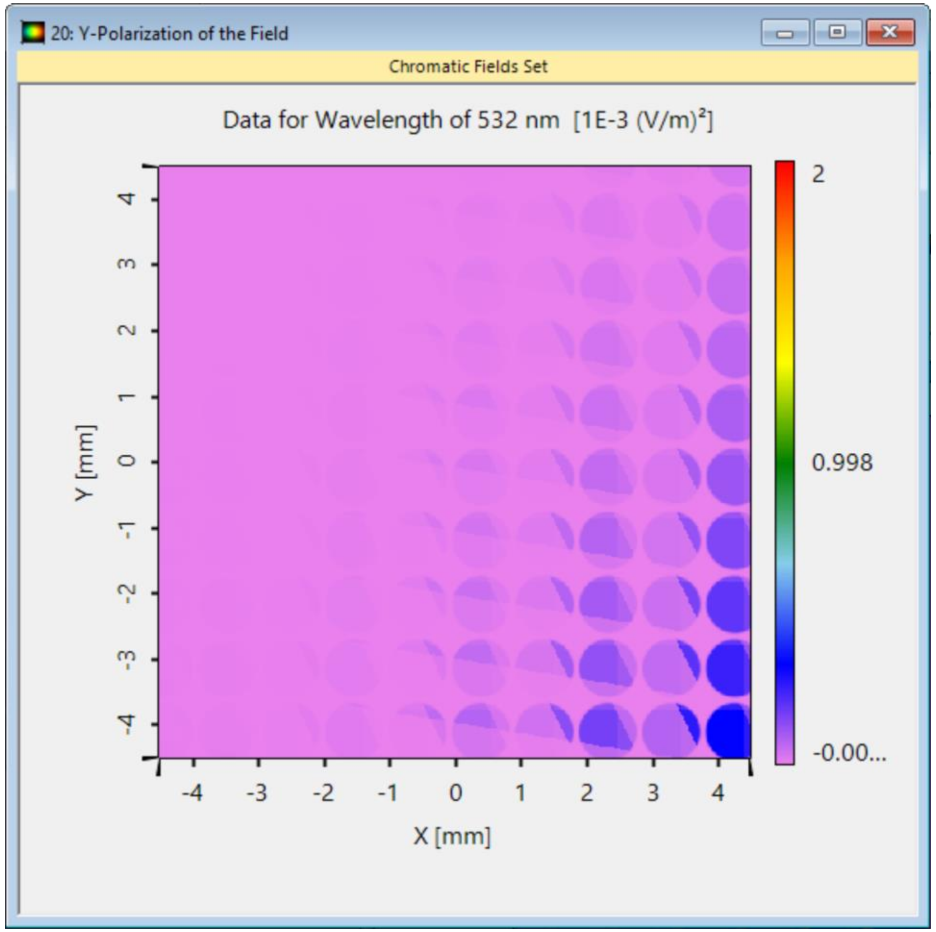
Polarization Effects in Eyebox



Ex:



Ey:



Propagation through the light guide with numerous interactions with real (and therefore polarization sensitive) gratings will affect the polarization state of each individual footprint. Due to the physical optics techniques of VirtualLab Fusion, these effects are considered, accurately.

Document Information

title	Simulation of Lightguide with 1D-1D Pupil Expander with Real Gratings
document code	LIG.0006
document version	1.0
software version	2021.1 (Build 1.180)
software edition	VirtualLab Fusion Advanced, Light Guide Toolbox Silver Edition
category	Application Use Case
further reading	- Construct a Lightguide Component from Real Gratings - Construction of a Light Guide - Modeling of a "HoloLens 1"-Type Layout with Light Guide Component - Specification of Diffraction Orders and Efficiencies for Grating Regions - Light Guide Design Tool

VirtualLab Fusion Technologies