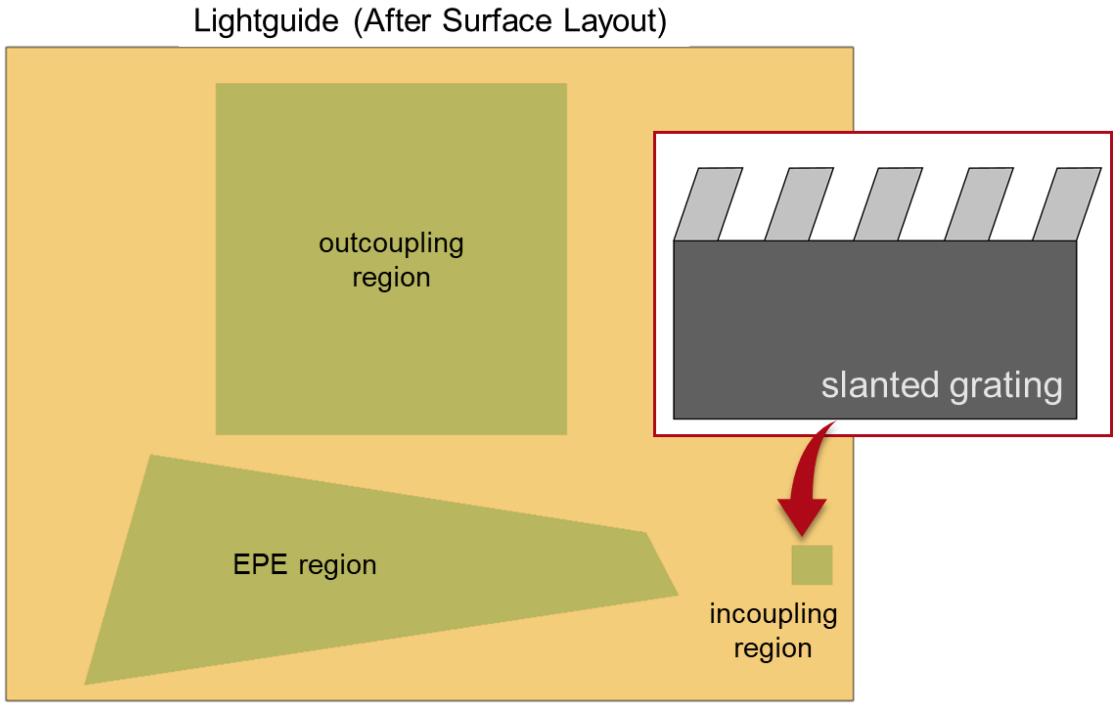
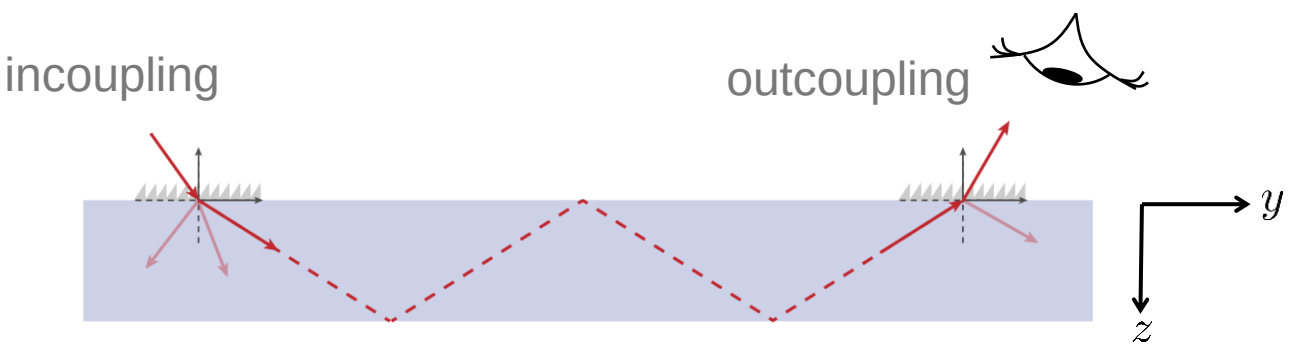
How to Set Up a Lightguide with Real Grating Structures

Abstract

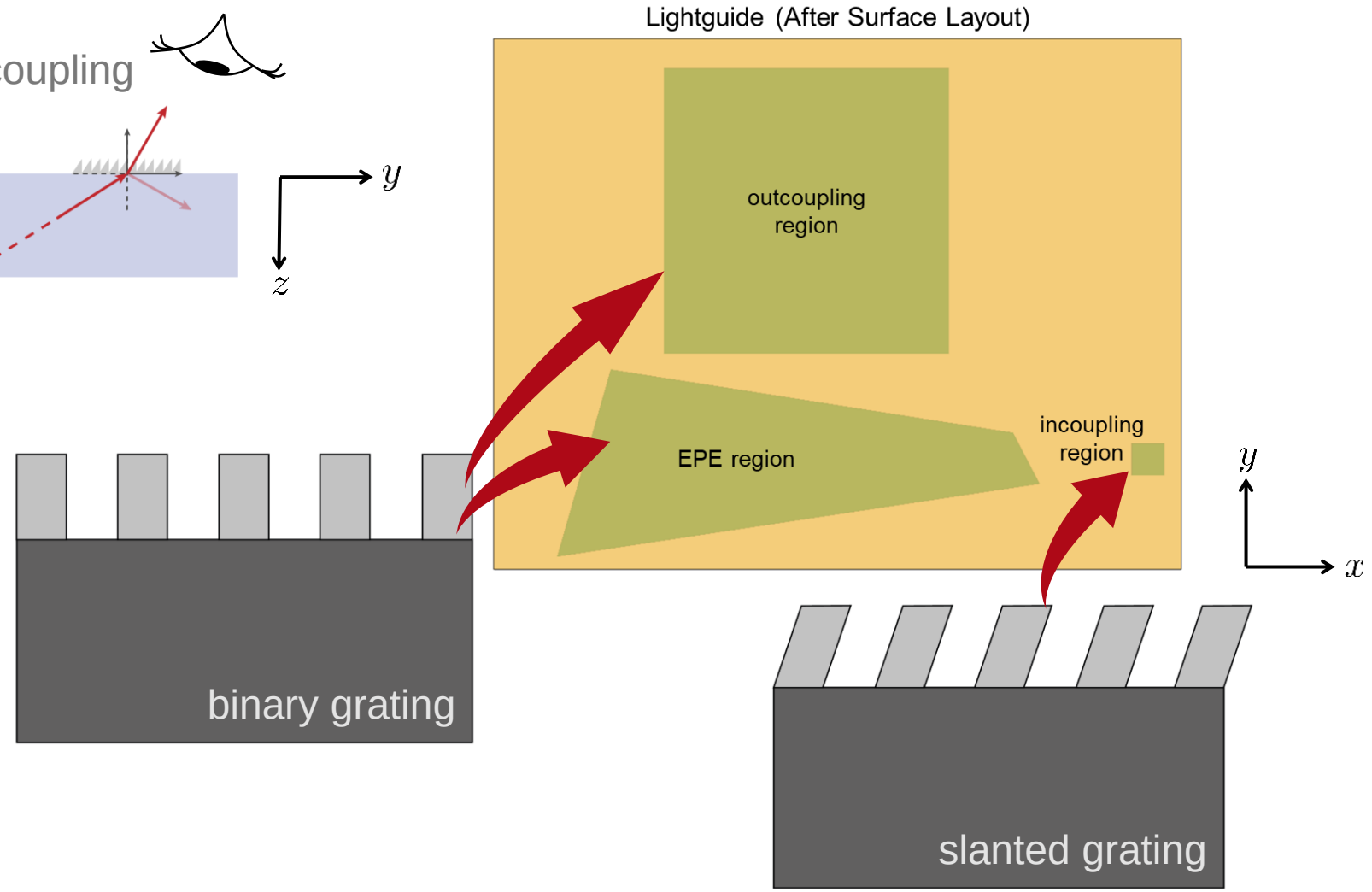


VirtualLab Fusion enables the modeling of complex lightguide configurations in the field of AR&MR devices by utilizing the *Light Guide component.* Local grating areas (so-called regions) can be defined on the surfaces of the lightguide for coupling and pupil expansion purposes. The effect of the grating on the field can be modeled either rigorously or with a functional idealization that requires the user to manually enter the values of the efficiencies of the different orders. In this use case, we focus on how to import a previously designed real grating structure into the lightguide component and discuss all relevant settings and the pre-calculation of lookup tables.

Task Description



- How to import and configure real grating structures onto surfaces of a lightguide?
- How to perform a preliminary calculation of its lookup table?

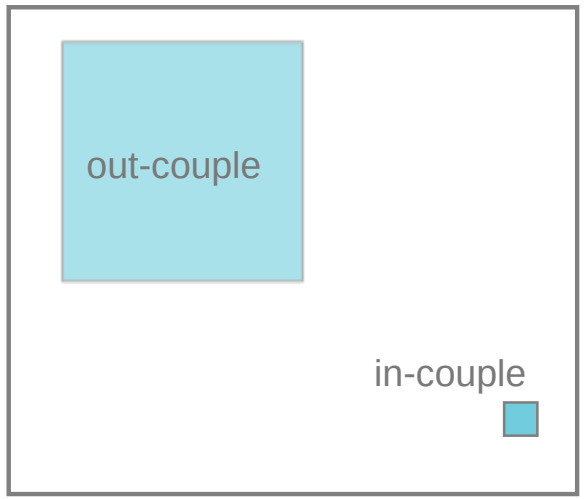


Systematic Lightguide Design

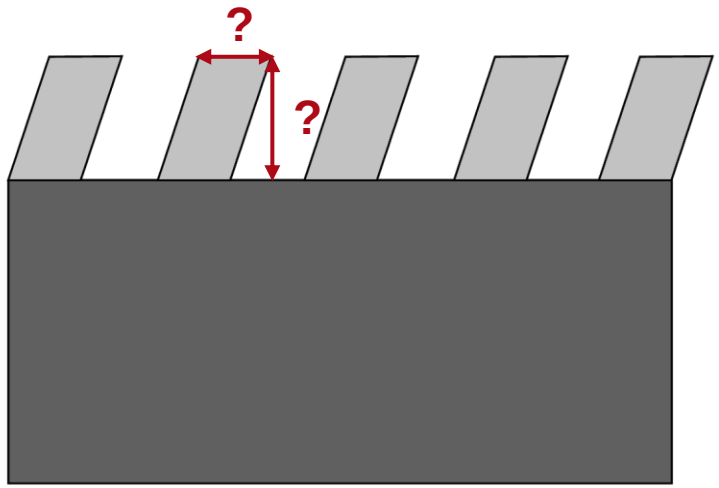
For each design step we recommend a systematic strategy to tackle the desired task.

Step 1: Lightguide **Layout** Design

Step 2: Lightguide **Grating** Design

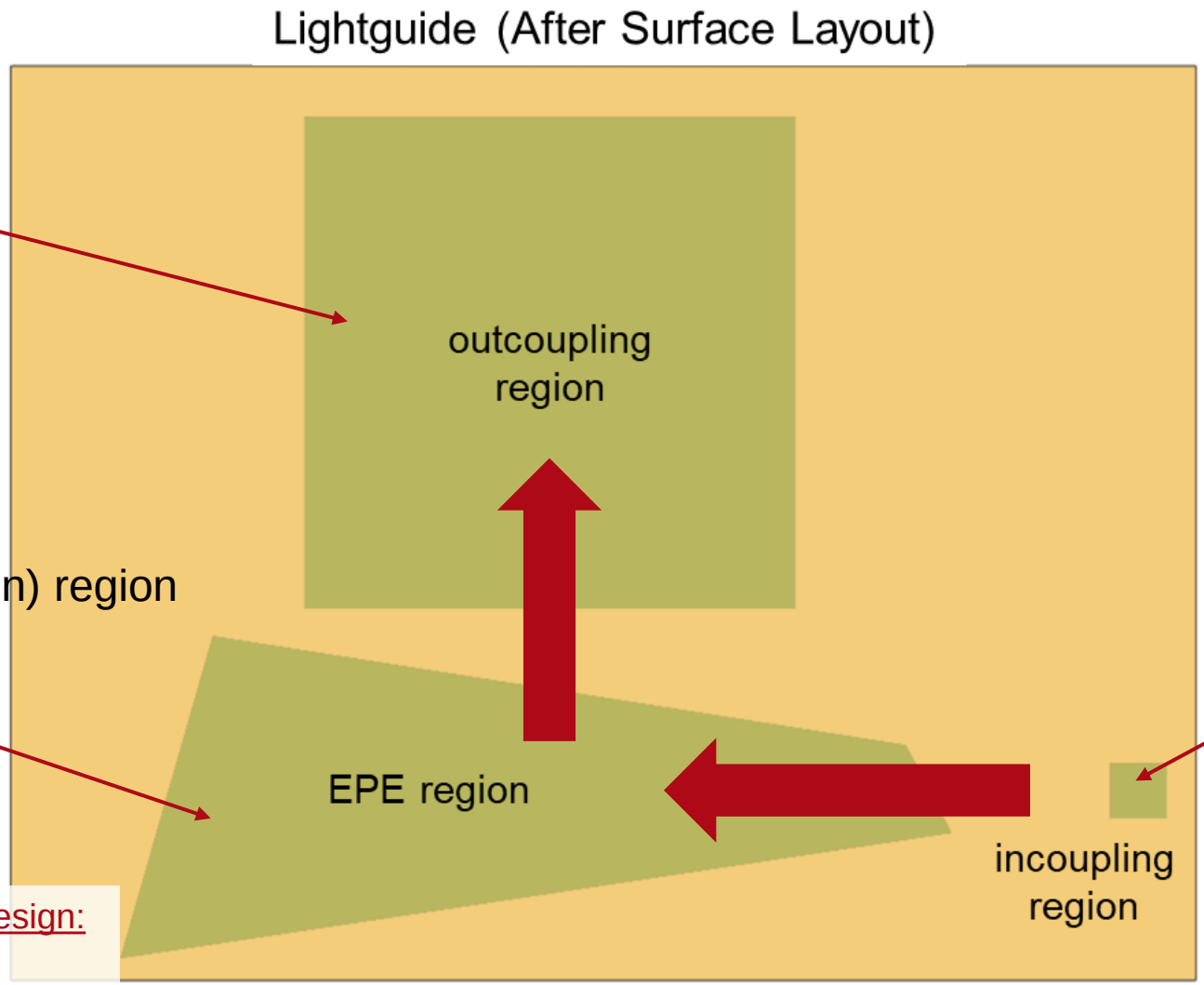


e.g: grating periods, positions, …



e.g: shape, height, fill factor, …

Lightguide Layout Design



outcoupling region
- grating period
- grating orientation
- lateral extension

EPE (exit pupil expansion) region
- position and complex shape
- grating orientation
- grating period

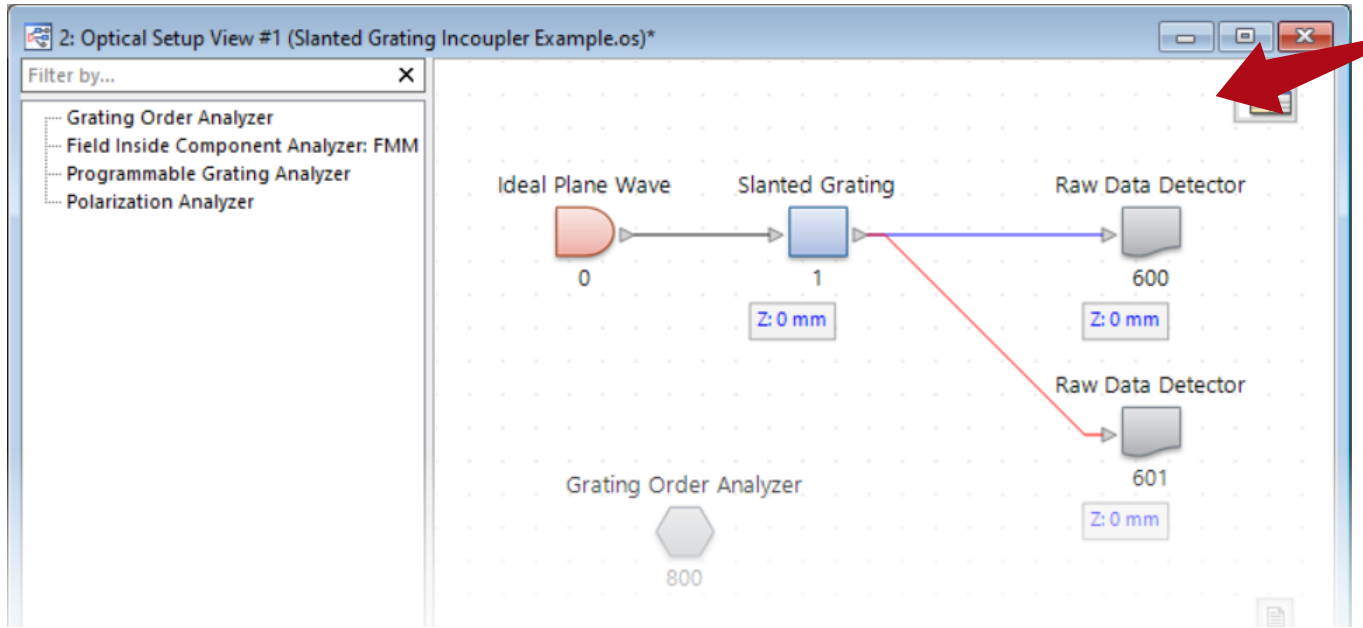
incoupling region
- grating period
- lateral extension

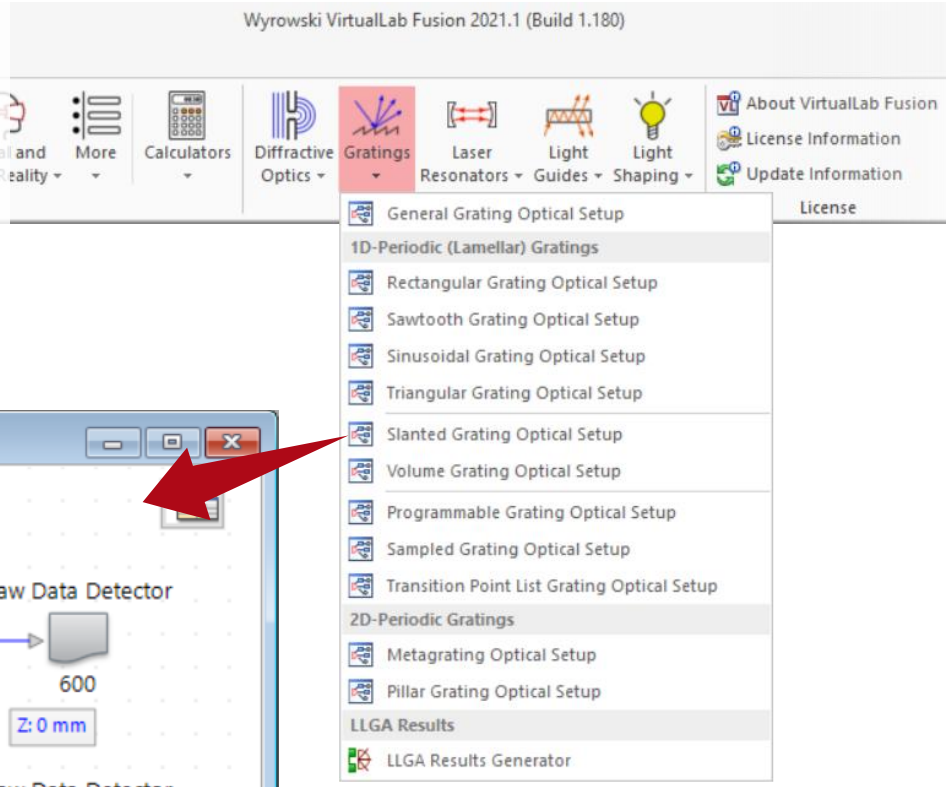
See the full use case for layout design: *Light Guide Layout Design Tool*

Design and Analysis of Gratings in a Grating-Specific OS

In VirtualLab Fusion we recommend to investigate the desired grating structures in a special evaluation environment for gratings, before application on the lightguide surface.

- This can be accessed via the "*Gratings*" drop-down list.
- It enables to focus on the analysis and optimization of the grating's diffraction properties, like the diffraction angles, efficiencies and Rayleigh matrices.

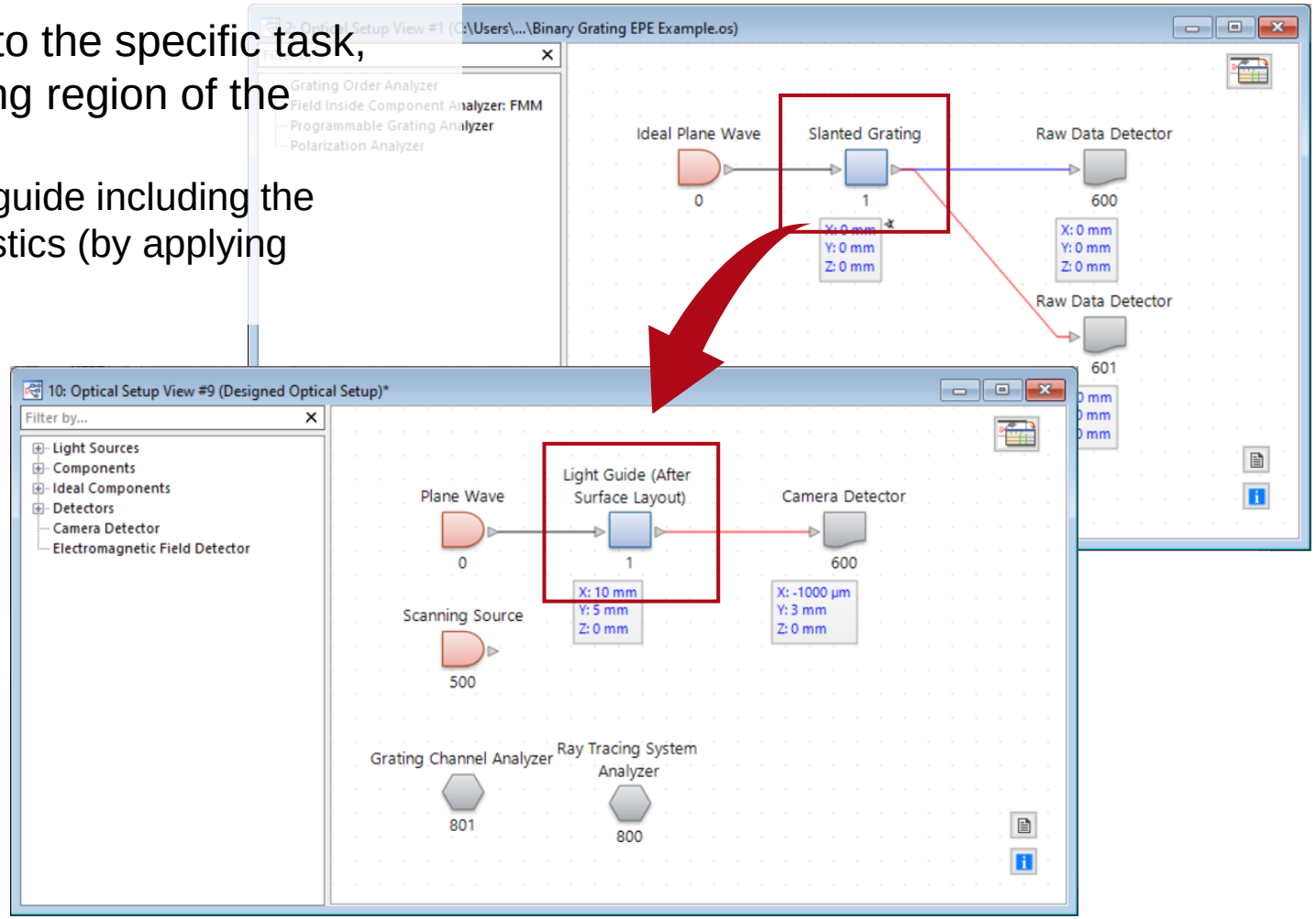




Design and Analyze the Lightguide in Lightguide Optical Setup

After the gratings are designed according to the specific task, they can be imported into the corresponding region of the lightguide setup.

- This enables to analyze the whole lightguide including the rigorously calculated grating characteristics (by applying complex-valued Rayleigh-matrices).

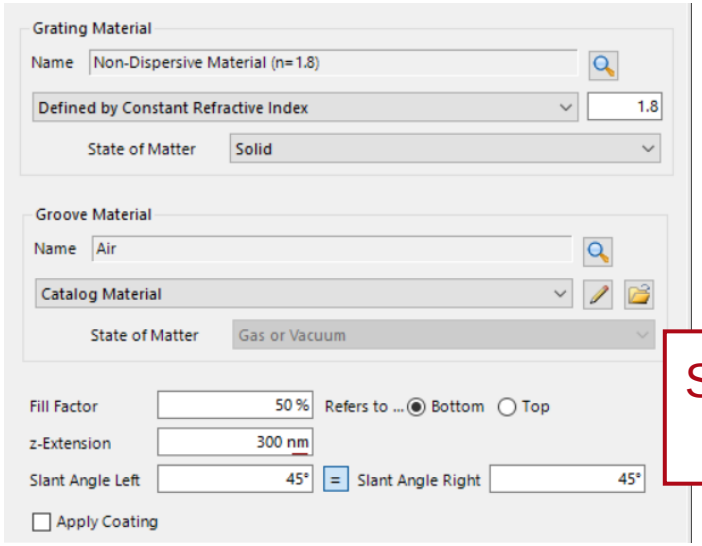


Configuration of the Incoupling Grating

For the incoupler, a 1D-periodic grating structure with slanted grating ridges is used. It can be constructed by using an inbuilt modulated medium.

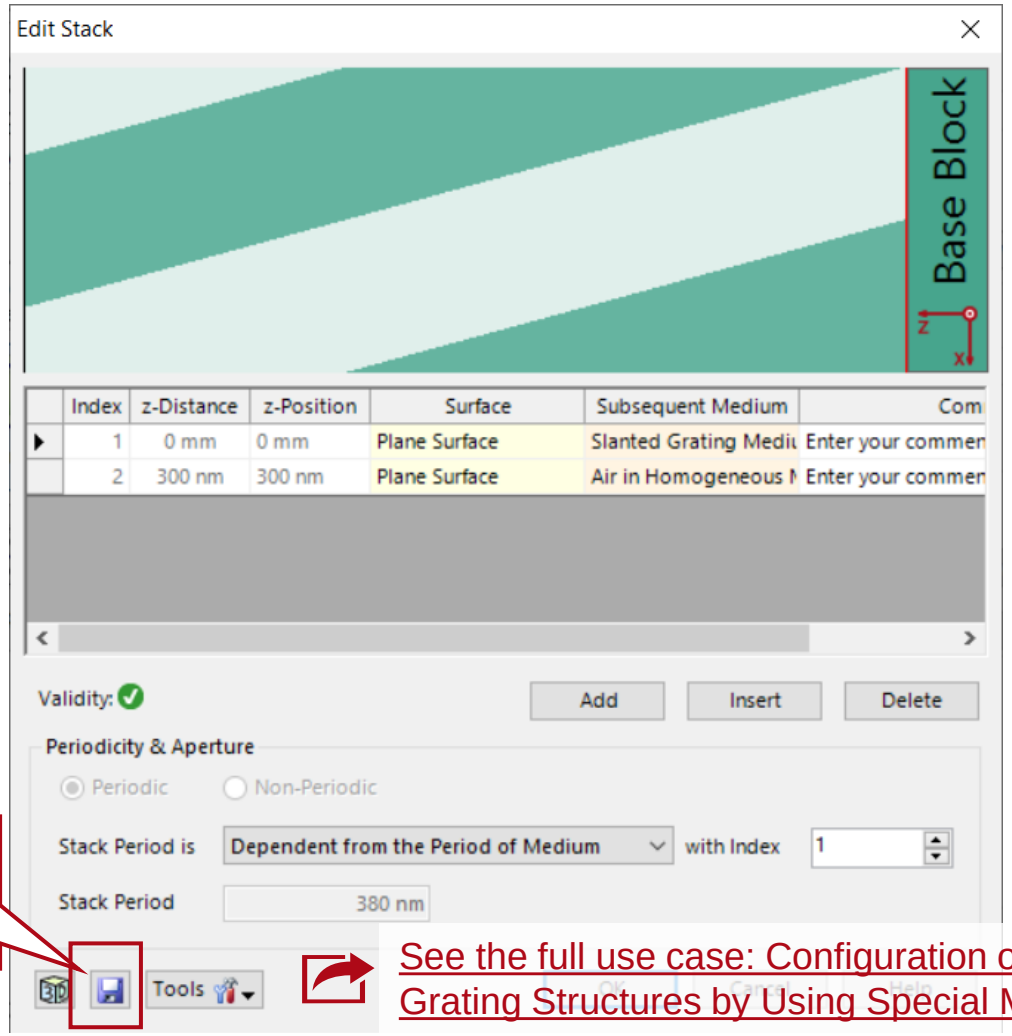
Available parameters:

- period*
- z-extension* (modulation depth along z-axis)
- fill factor (with respect to either bottom or top in non-parallel case)
- slant angles of sidewalls (either linked or individual)



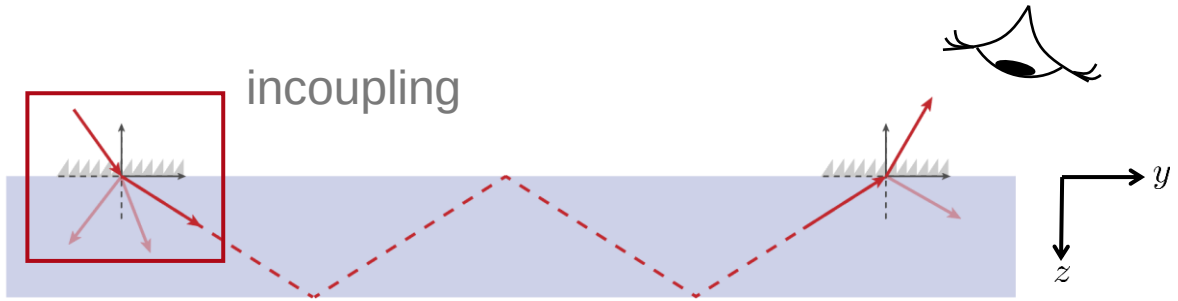
* calculated from the layout design

Save the grating in the *User-Defined* catalog

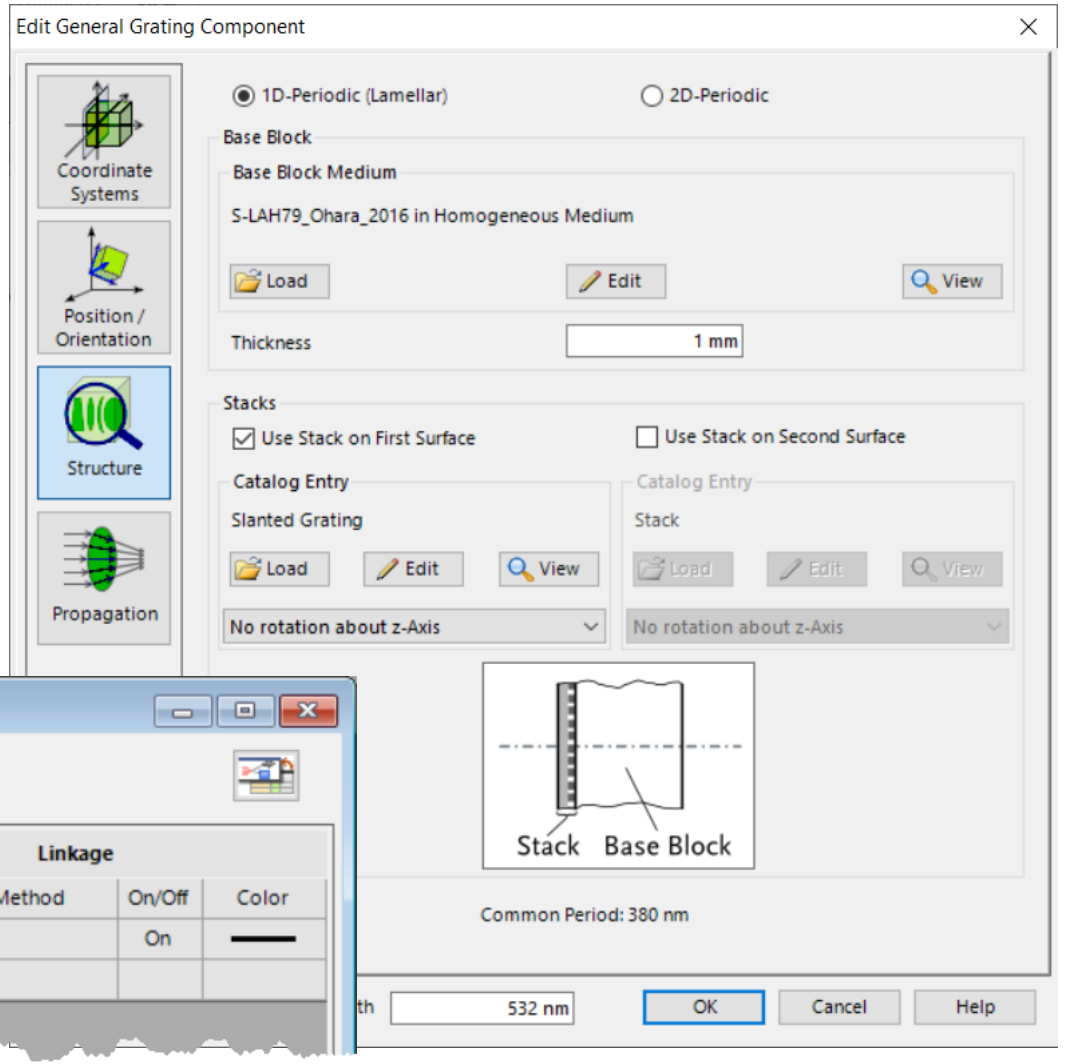


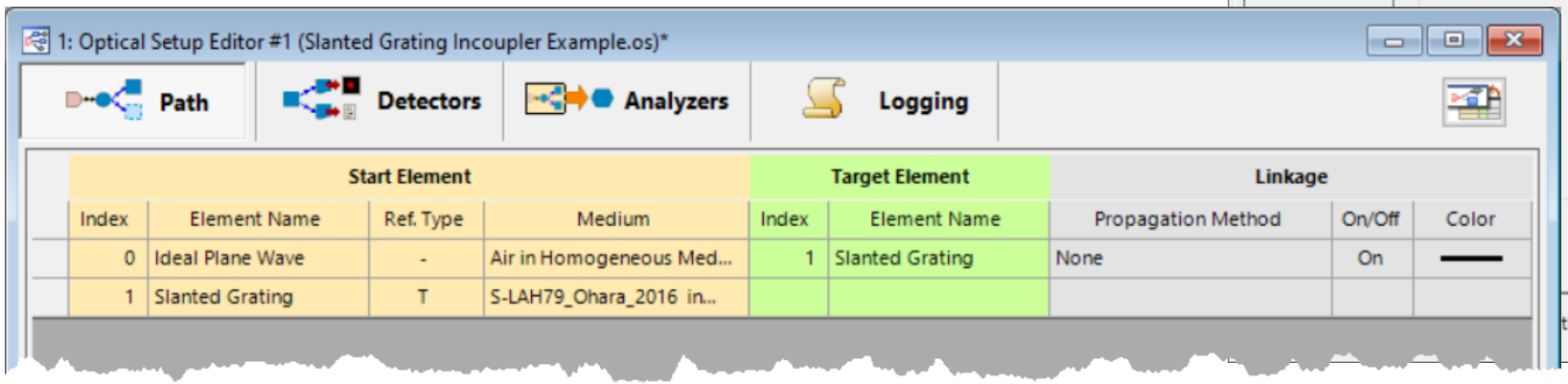
See the full use case: Configuration of Grating Structures by Using Special Media

Configuration of the Incoupling Grating



In order to synchronize the settings of the grating-specific and lightguide setup, the *Base Block Medium* should coincide with the material used for the lightguide. Further the location and orientation of the periodic structure have to be set according to the situation in the corresponding lightguide setup.





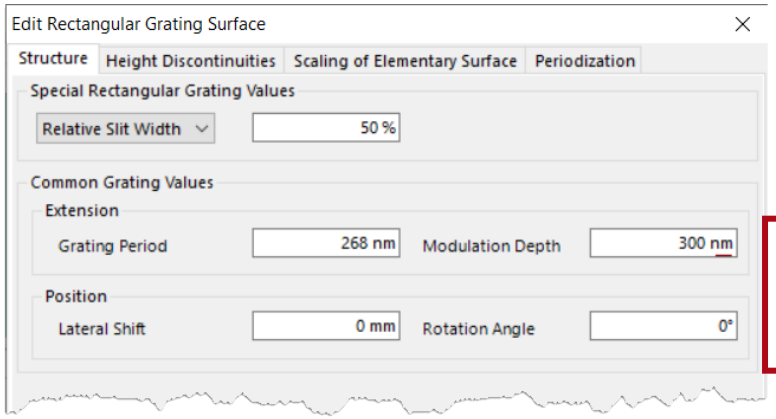
Configuration of the EPE/Outcoupling Grating

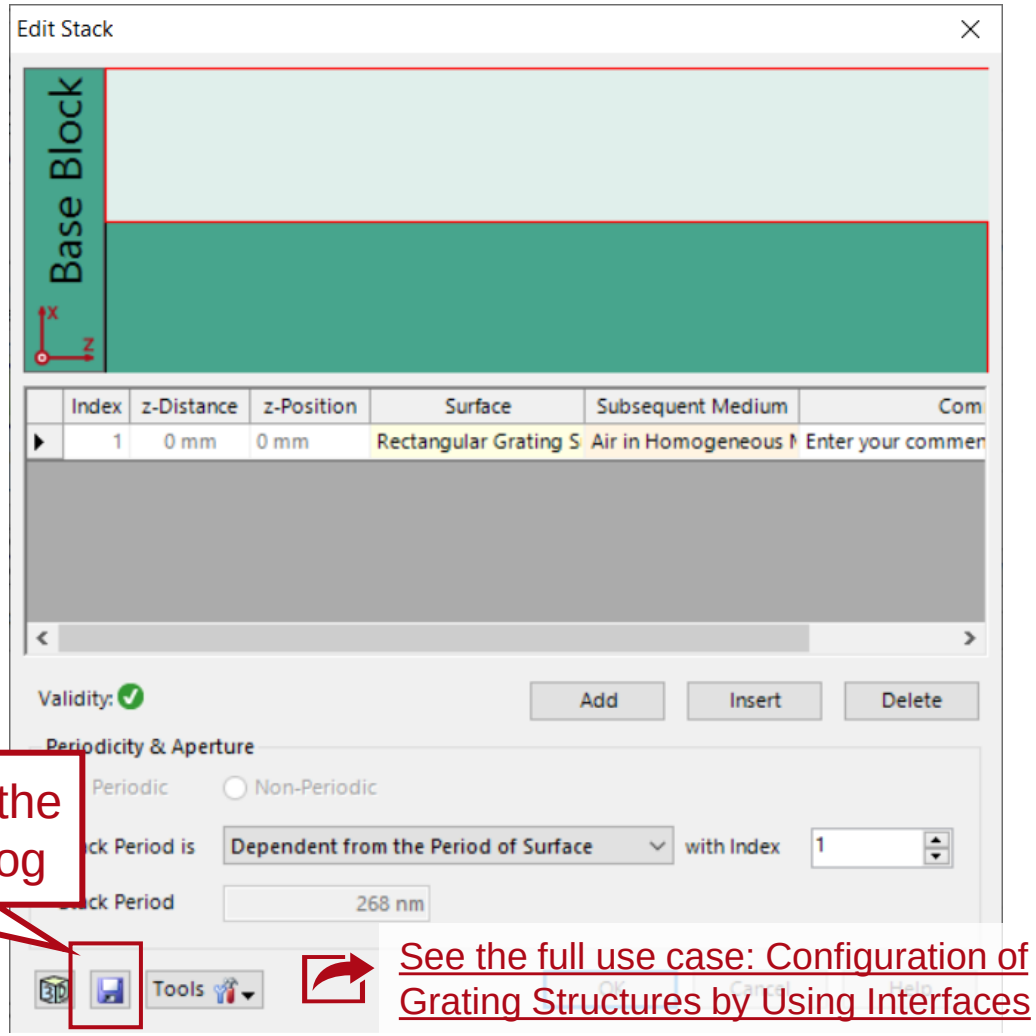
For the EPE/outcoupling grating, a binary rectangular structured grating is used (modeled by *Rectangular Grating Interface*).

Available parameters:

- period*
- modulation depth along z-axis
- fill factor

* calculated from the layout design

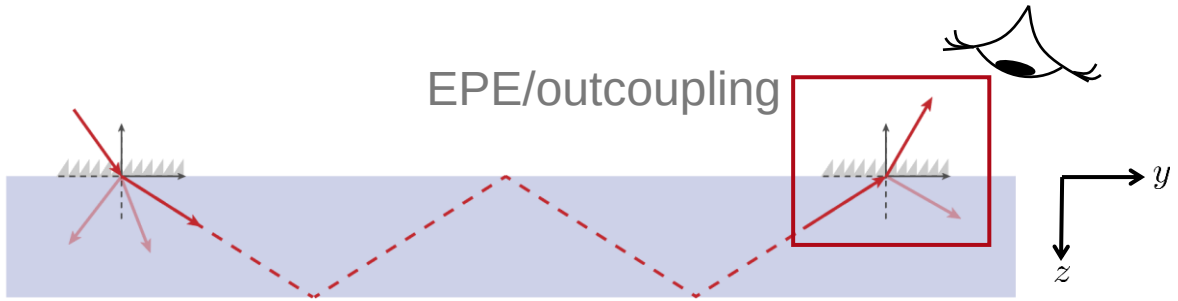




Save the grating in the *User-Defined* catalog

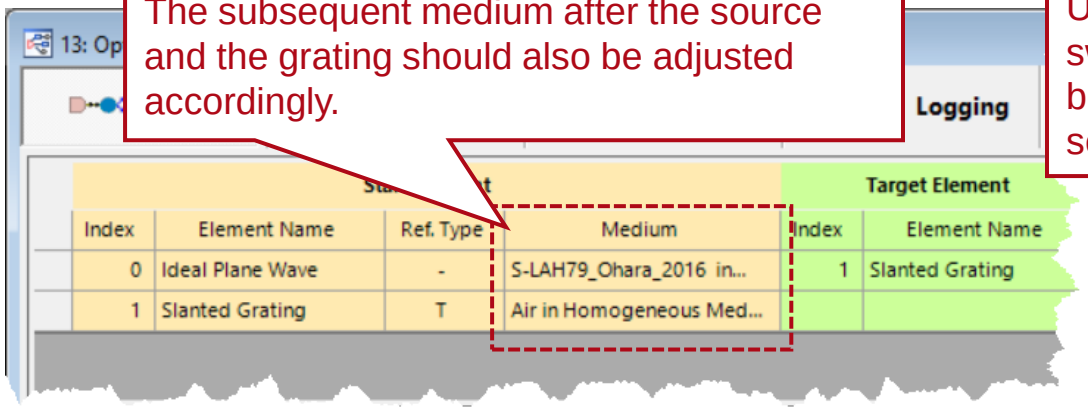
[See the full use case: Configuration of Grating Structures by Using Interfaces]

Configuration of the EPE/Outcoupling Grating

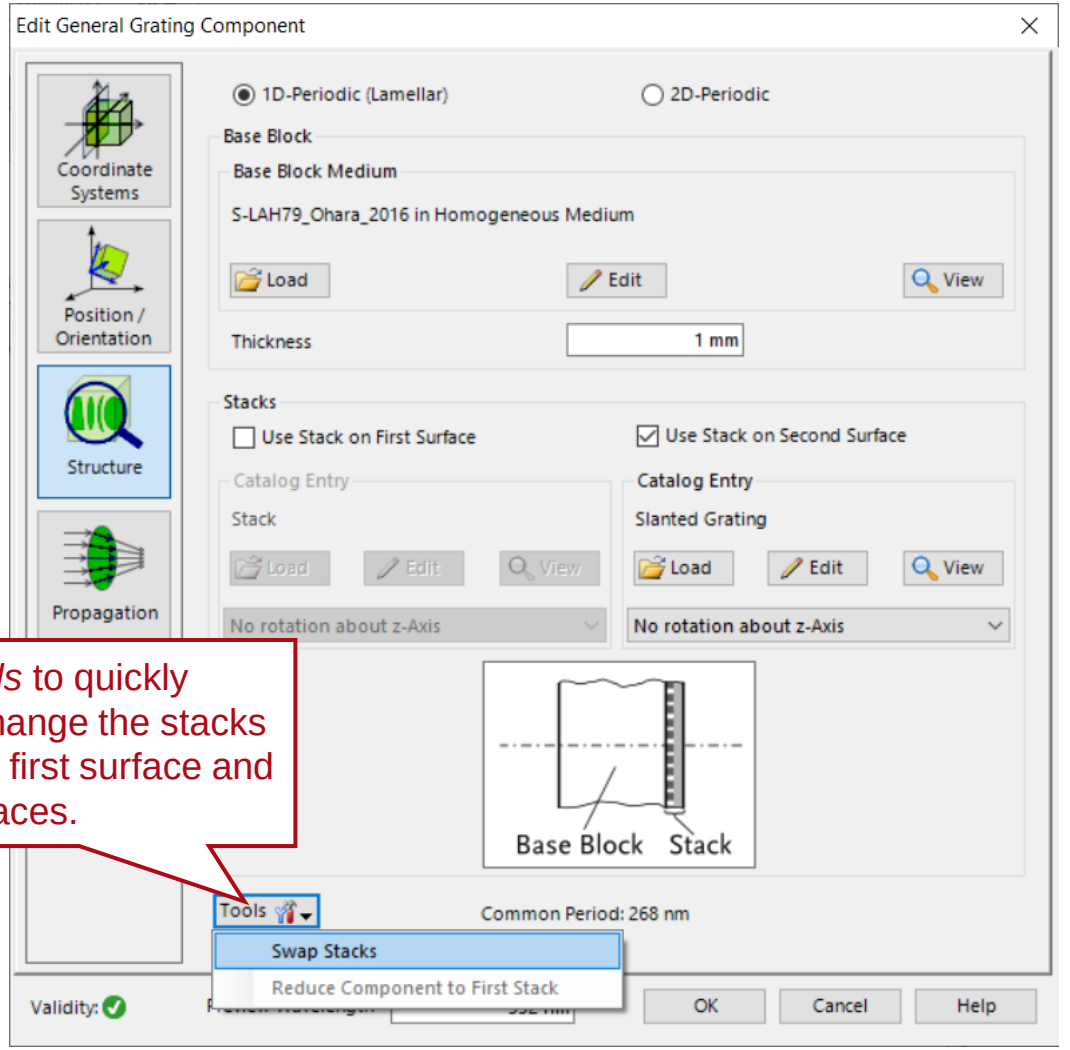


In order to model the EPE or outcoupler individually, the actual situation, means location of grating, direction of impinging light and materials have to be configured properly. In this case, the light is already inside the glass and the grating is configured on the second surface of the substrate.

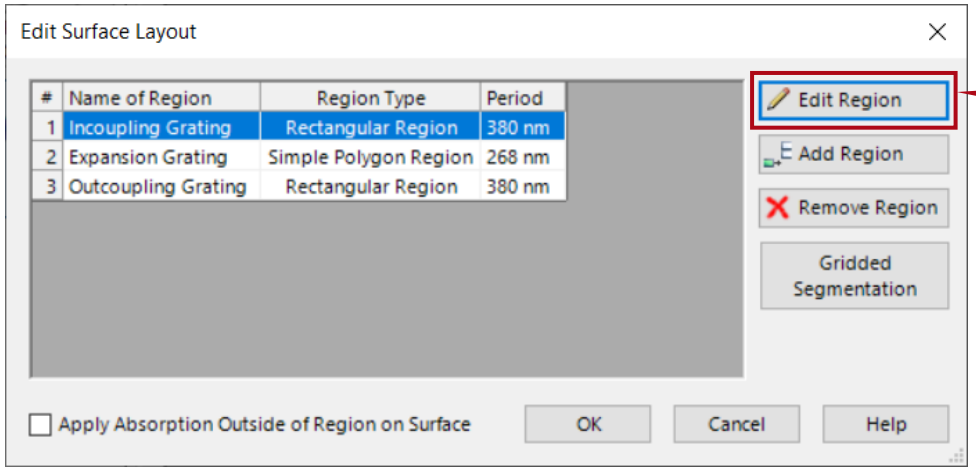
The subsequent medium after the source and the grating should also be adjusted accordingly.

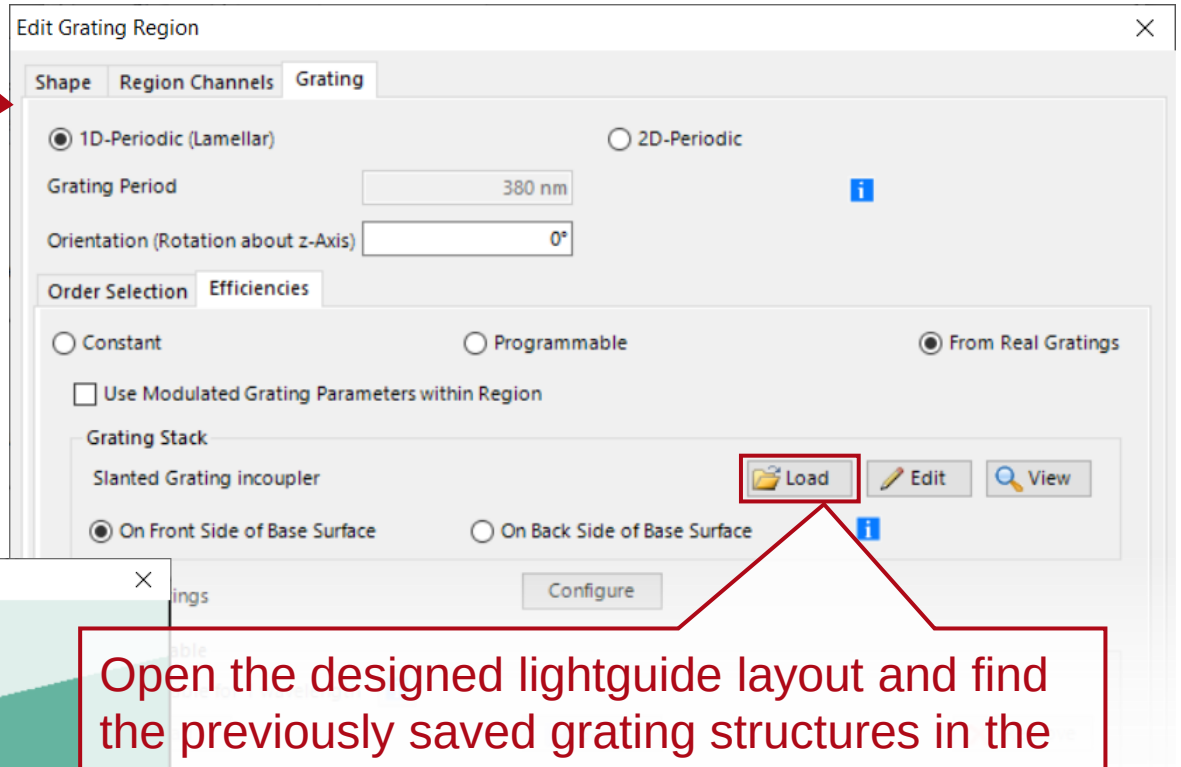


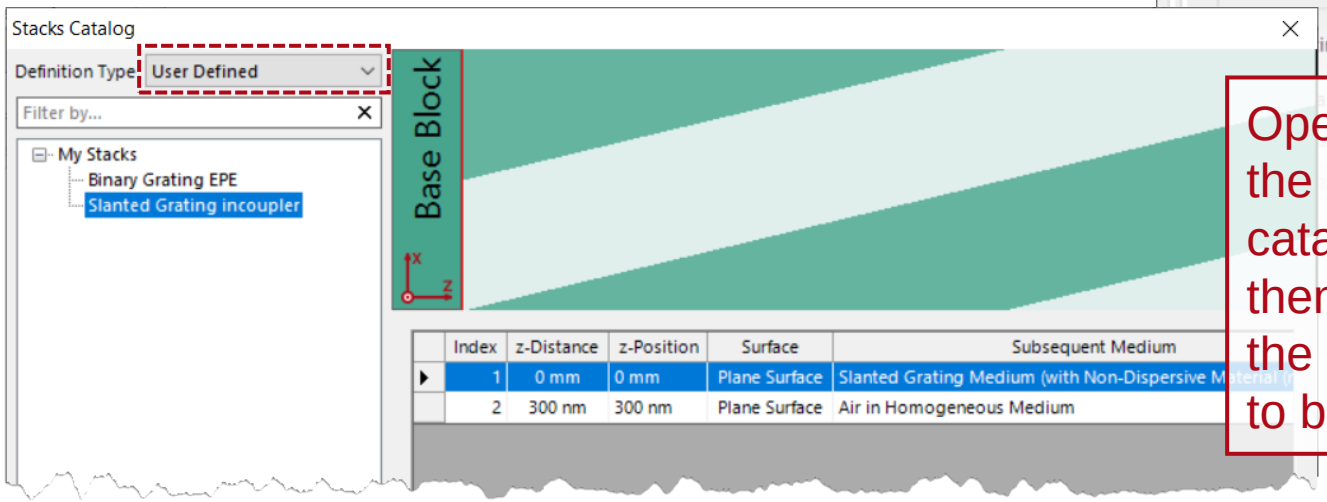
Use the *Tools* to quickly swap/interchange the stacks between the first surface and second surfaces.



Import the Gratings into Lightguide Component

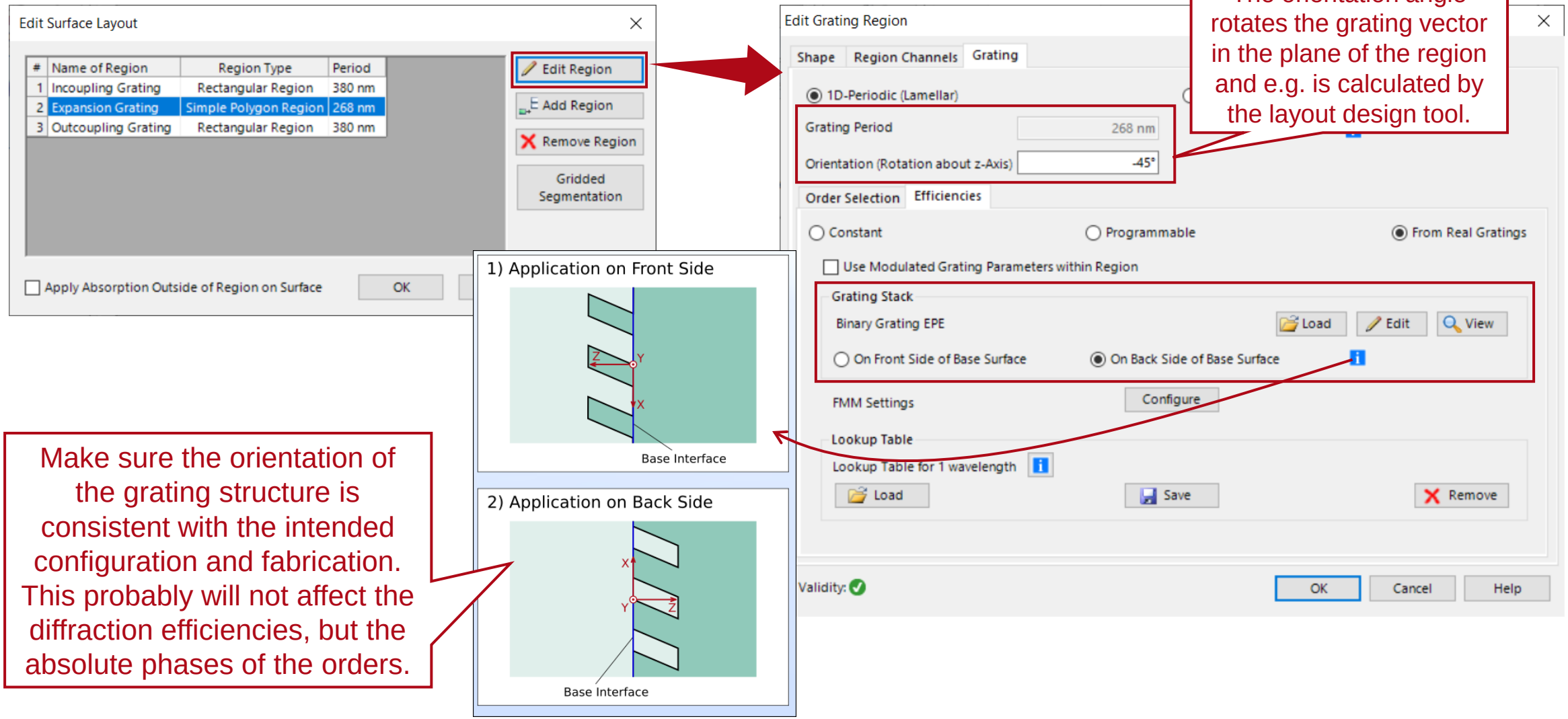






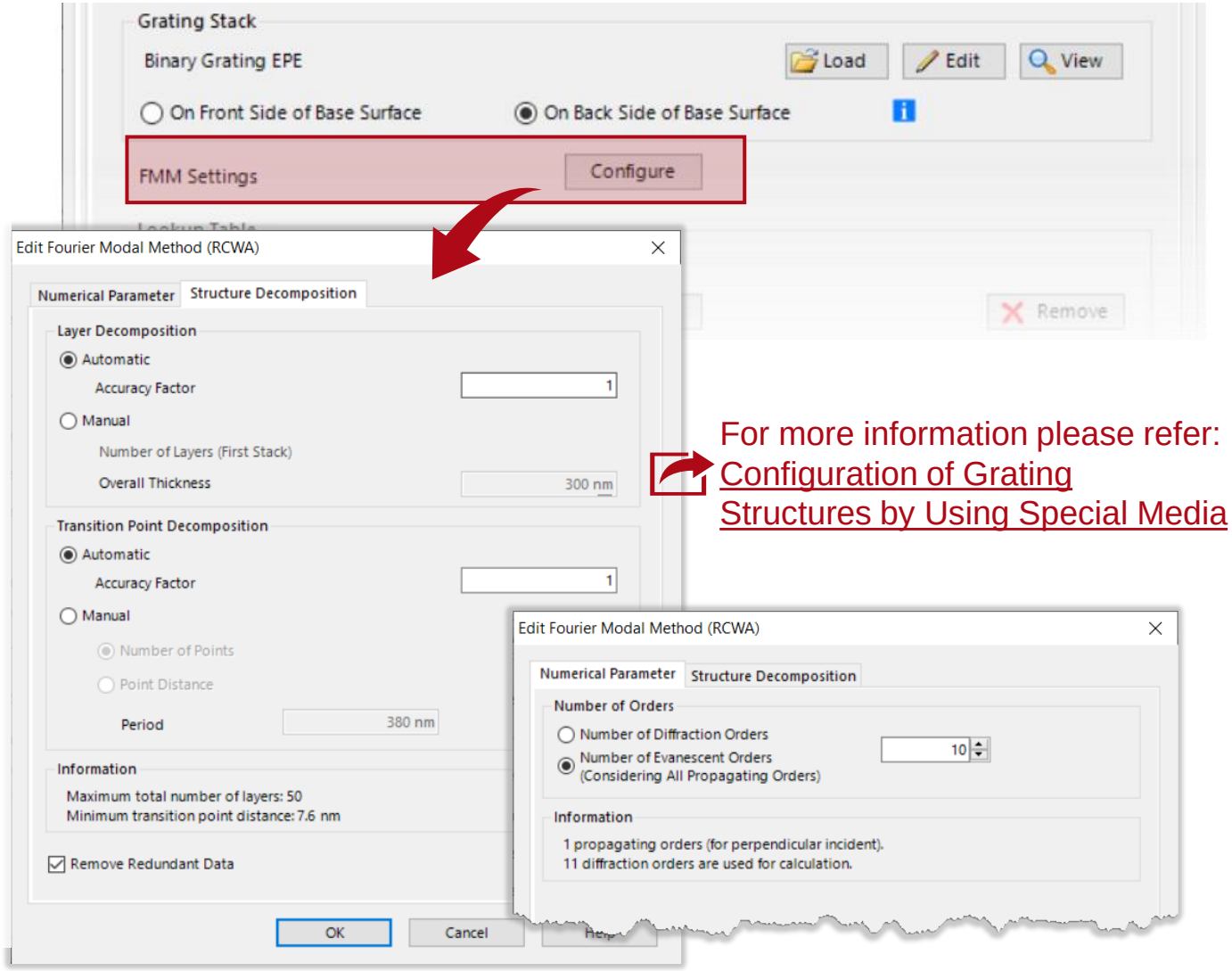
Open the designed lightguide layout and find the previously saved grating structures in the catalog under *User Defined* stacks. Load them into the corresponding grating regions of the lightguide after choosing the *Efficiencies* to be calculated *From Real Gratings*.

Import the Gratings into Lightguide Component



FMM Settings

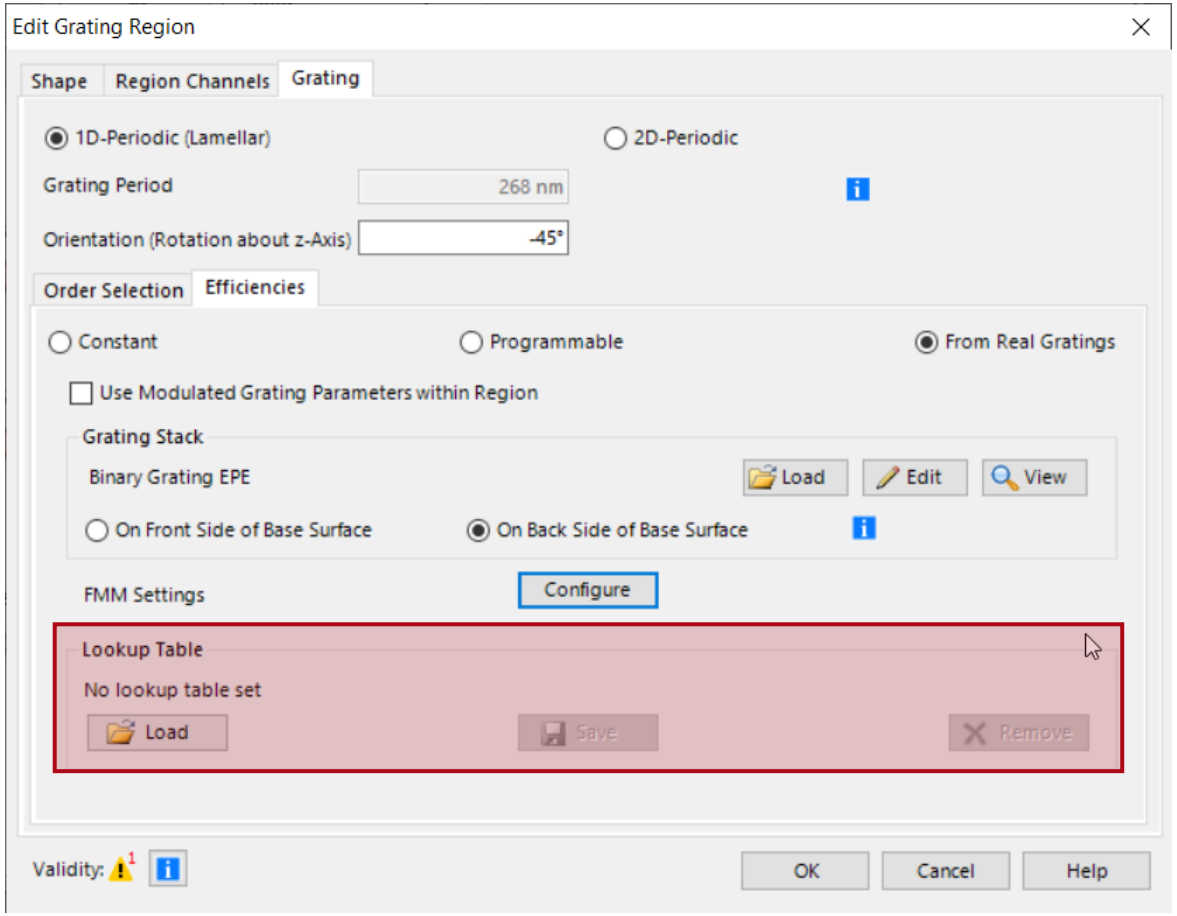
- One of the main numerical parameters that control the accuracy of the FMM solver is the number of diffraction orders considered. The user can choose to either enter a total number, or for the algorithm to automatically use all propagating orders (finite number) and the specified number of evanescent orders (infinite in reality). The proper setting strongly depends on the intended grating shape and material.
- The FMM solver requires the structure to be presented as a series of parallel layers with a binary distribution of the refractive index in each layer. Particularly for smooth structures, this constitutes an approximation. The Layer Decomposition and *Transition Point Decomposition* settings can be used to adjust the discretization of the structure.
- Information about the number of layers (discretization in z-direction) and the distance of transition points (discretization in x-direction) are provided at the bottom of the window.



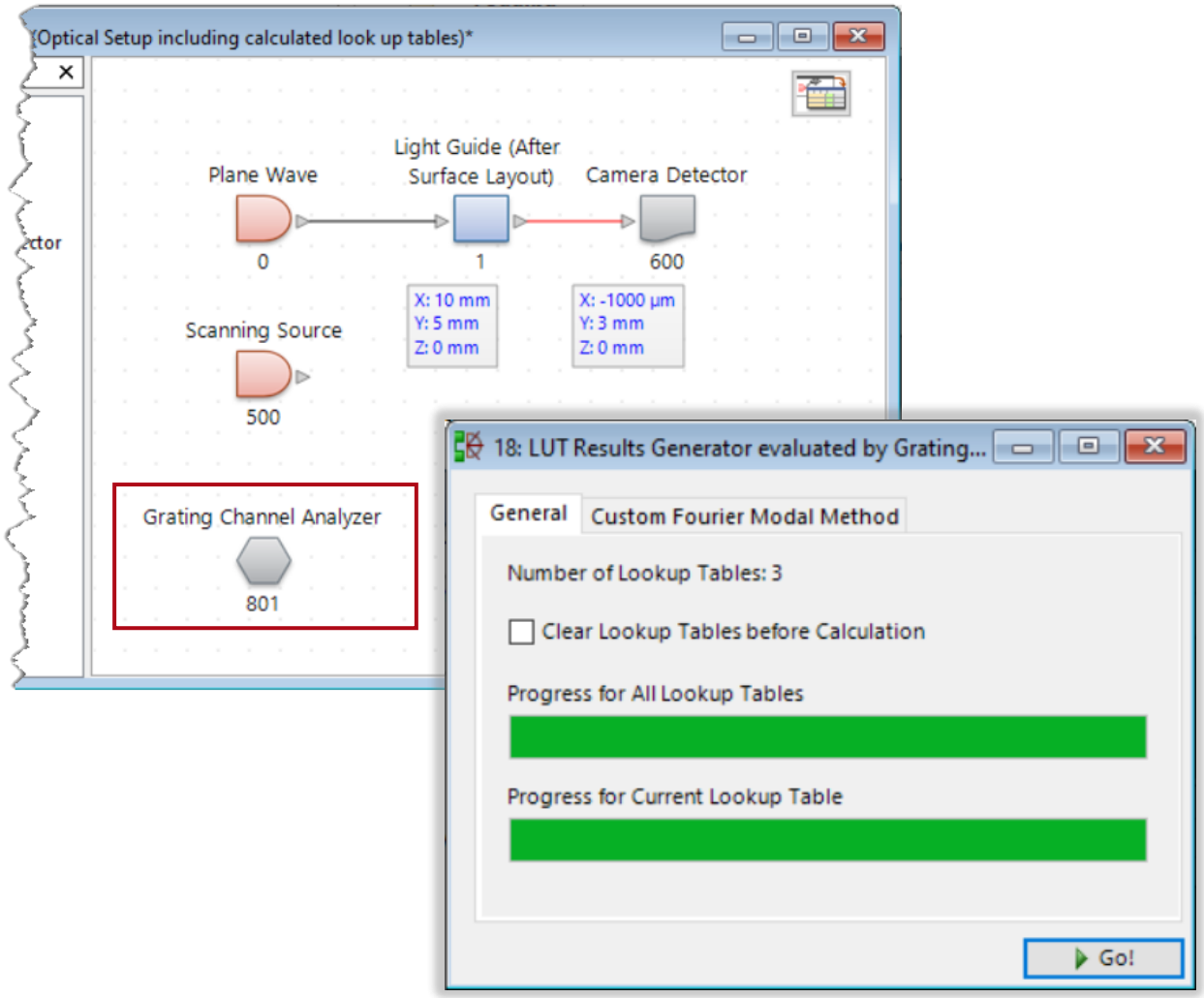
For more information please refer:
Configuration of Grating Structures by Using Special Media

Lookup Table

- After the simulation with real gratings was run for the first time, the calculated grating characteristics (complex valued Rayleigh-matrices) are automatically stored in a *Lookup Table* (LUT).
- Hence, theses values do not have to be calculated again for a following simulation.
- If any system parameter is modified, which can affect the grating characteristic (namely wavelength and directions of incidence), the new information are added to the LUT when the simulation is run again.
- The calculated lookup table can be saved for later use and loaded into the same or a different system where the same grating configuration is employed.
- If any grating parameter is changed, the LUT is cleared automatically and filled with the newly calculated data.



Calculate Lookup Table in advance



- The *Grating Channel Analyzer* can be used for generating the lookup tables in advance.
- This also facilitates generating the necessary lookup tables for a specific set-up while the user is working on other tasks, or when the computer is not being occupied by other processes.
- Alternatively, the lookup table can also be calculated on a different computer.
- The *Grating Channel Analyzer* also allows for the usage of your own customized FMM instead of the inbuilt code of VirtualLab Fusion.

Document Information

title	How to Set Up a Lightguide with Real Grating Structures
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software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	- Construction of a Light Guide - Modeling of a “HoloLens 1”-Type Layout with Light Guide Component - Flexible Region Definition - Specification of Diffraction Orders and Efficiencies for Grating Regions - Light Guide Layout Design Tool - k-Domain Layout Visualization - Simulation of Lightguide with 1D-1D Pupil Expander and Real Gratings