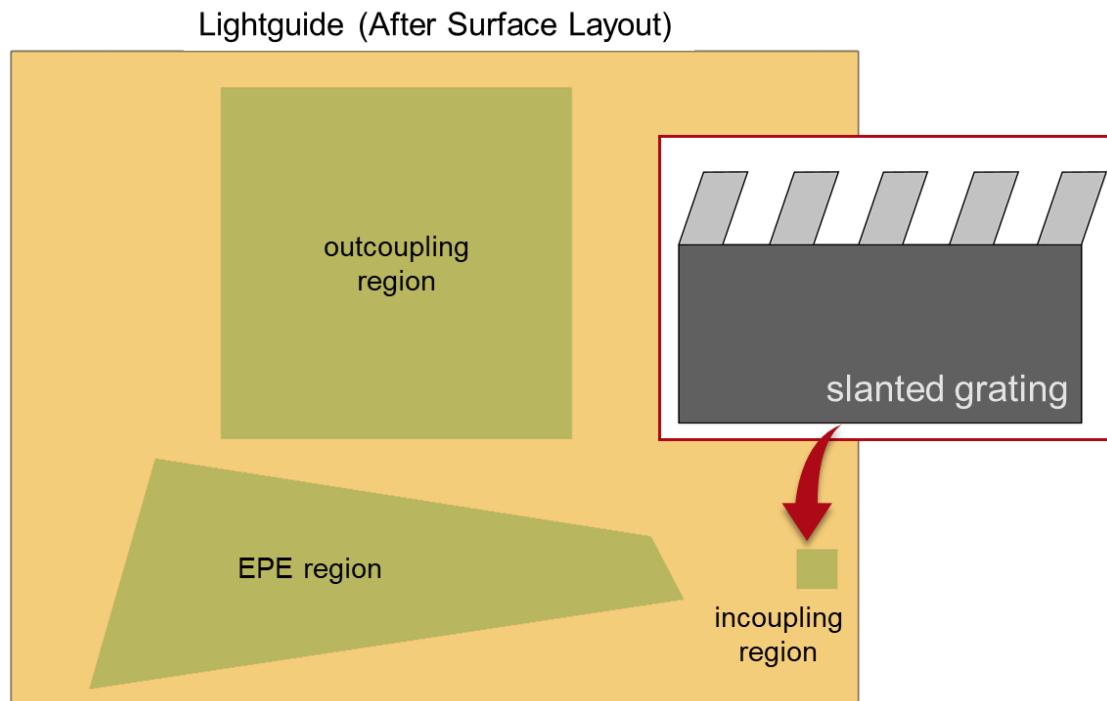


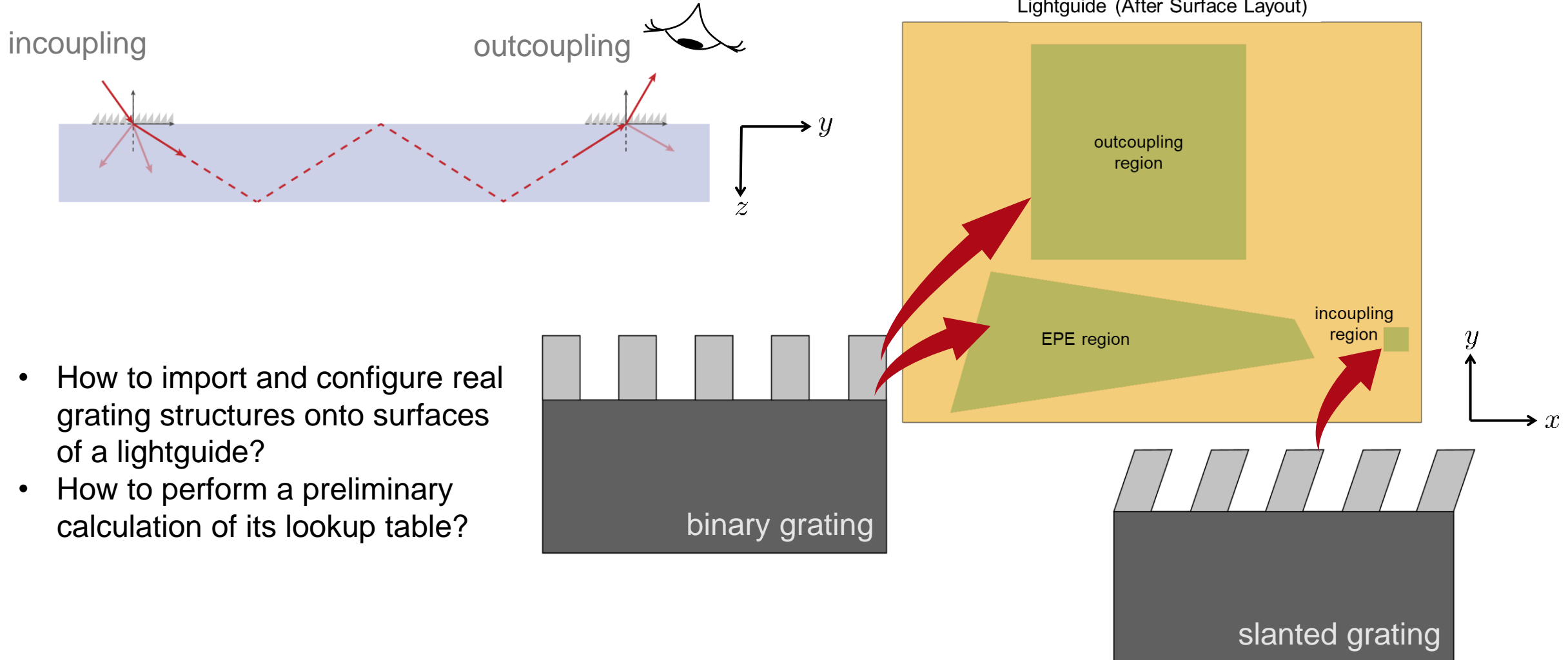
How to Set Up a Lightguide with Real Grating Structures

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?

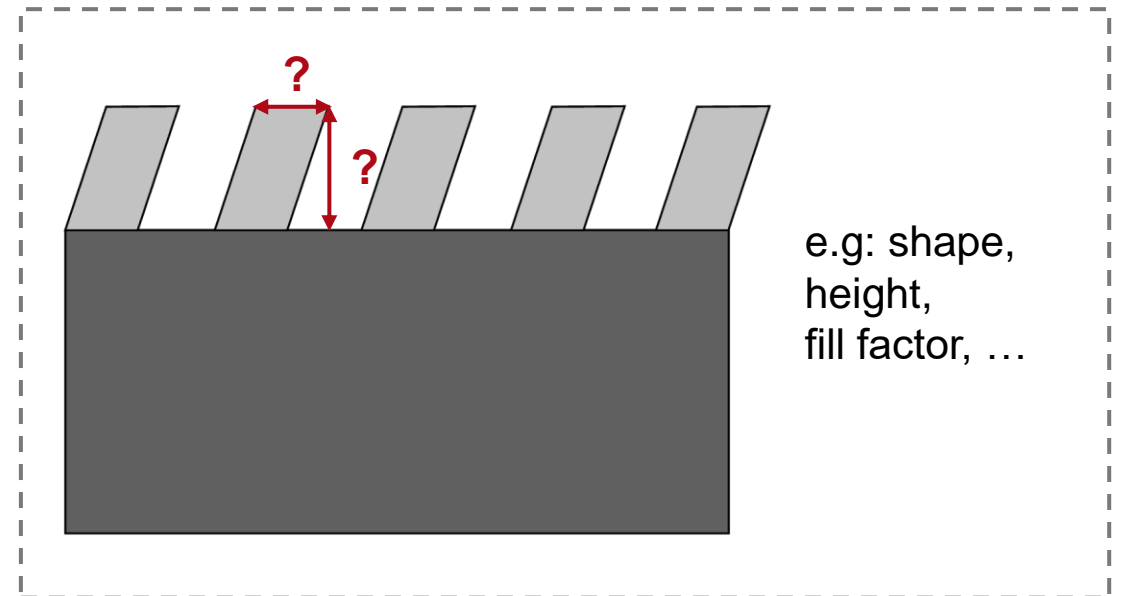
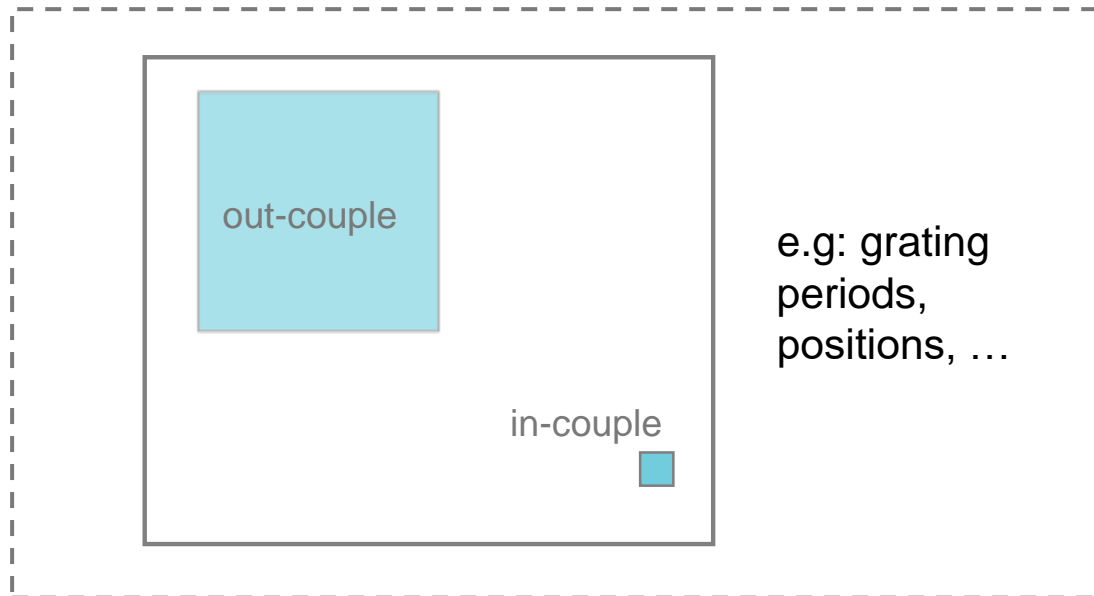
Systematic Lightguide Design

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

Step 1: Lightguide
Layout Design



Step 2: Lightguide
Grating Design



Lightguide Layout Design

Lightguide (After Surface Layout)

outcoupling region

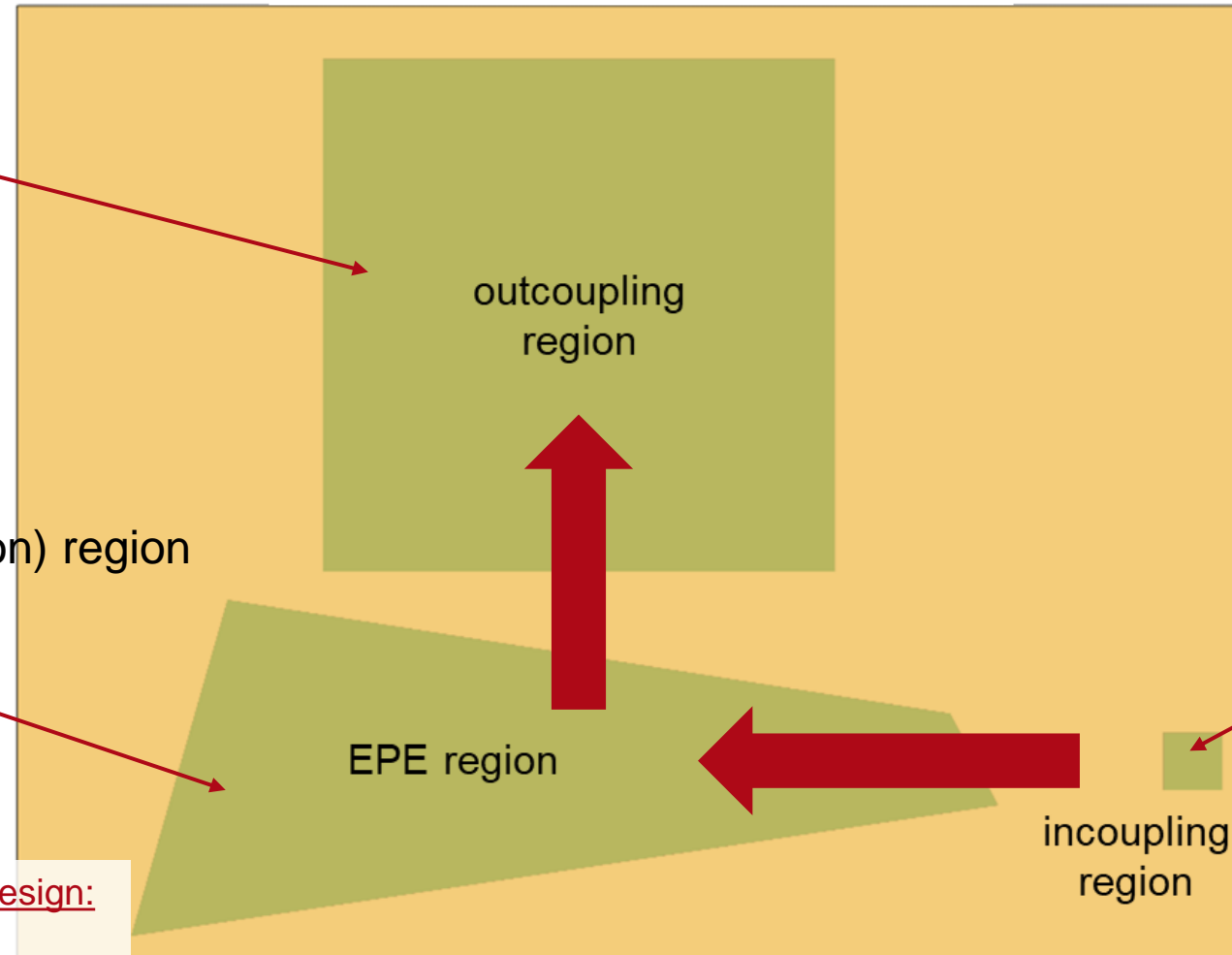
- grating period
- grating orientation
- lateral extension

EPE (exit pupil expansion) region

- position and complex shape
- grating orientation
- grating period

incoupling region

- grating period
- lateral extension

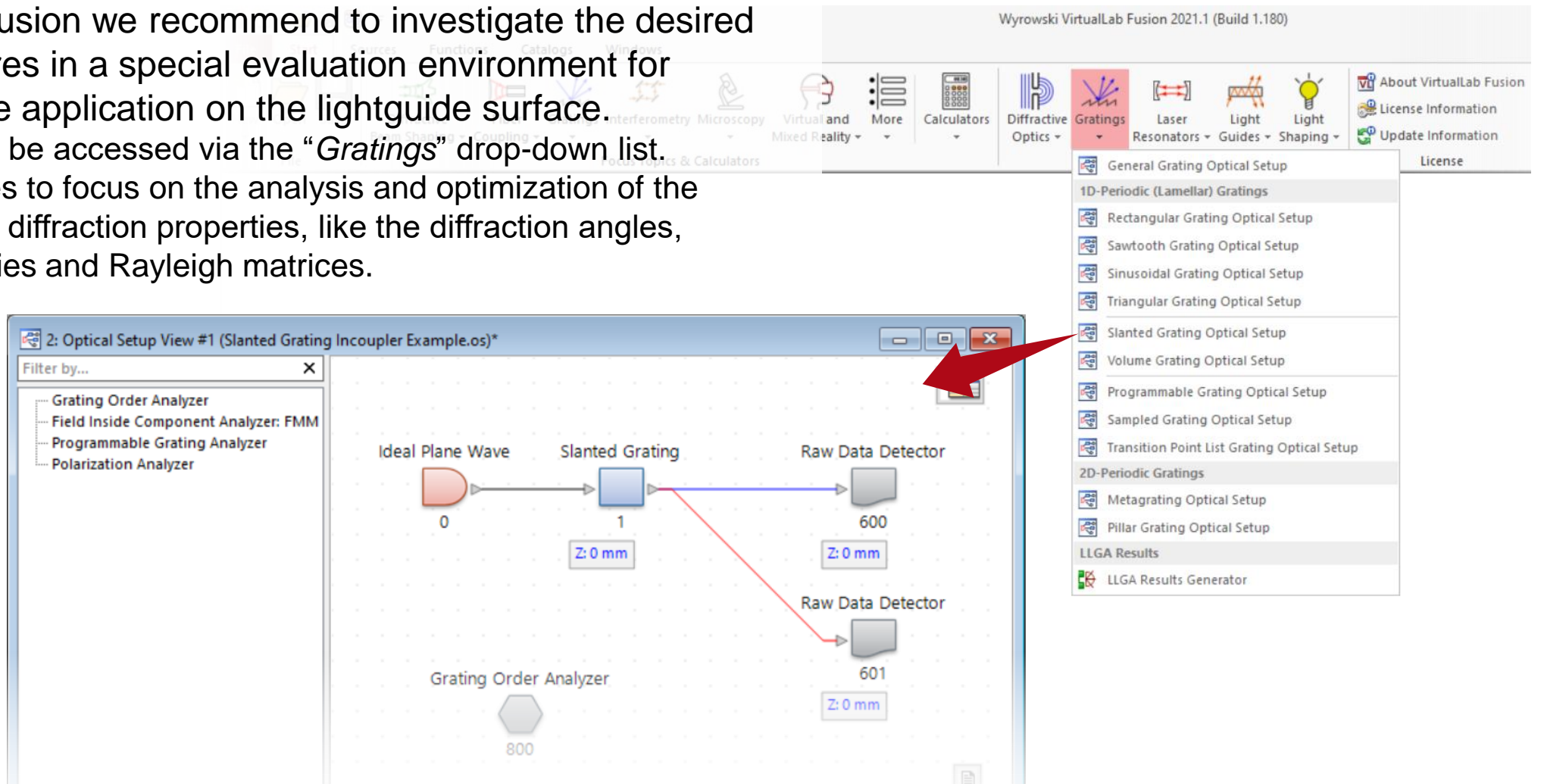


[See the full use case for layout design:
Light Guide Layout Design Tool](#)

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.

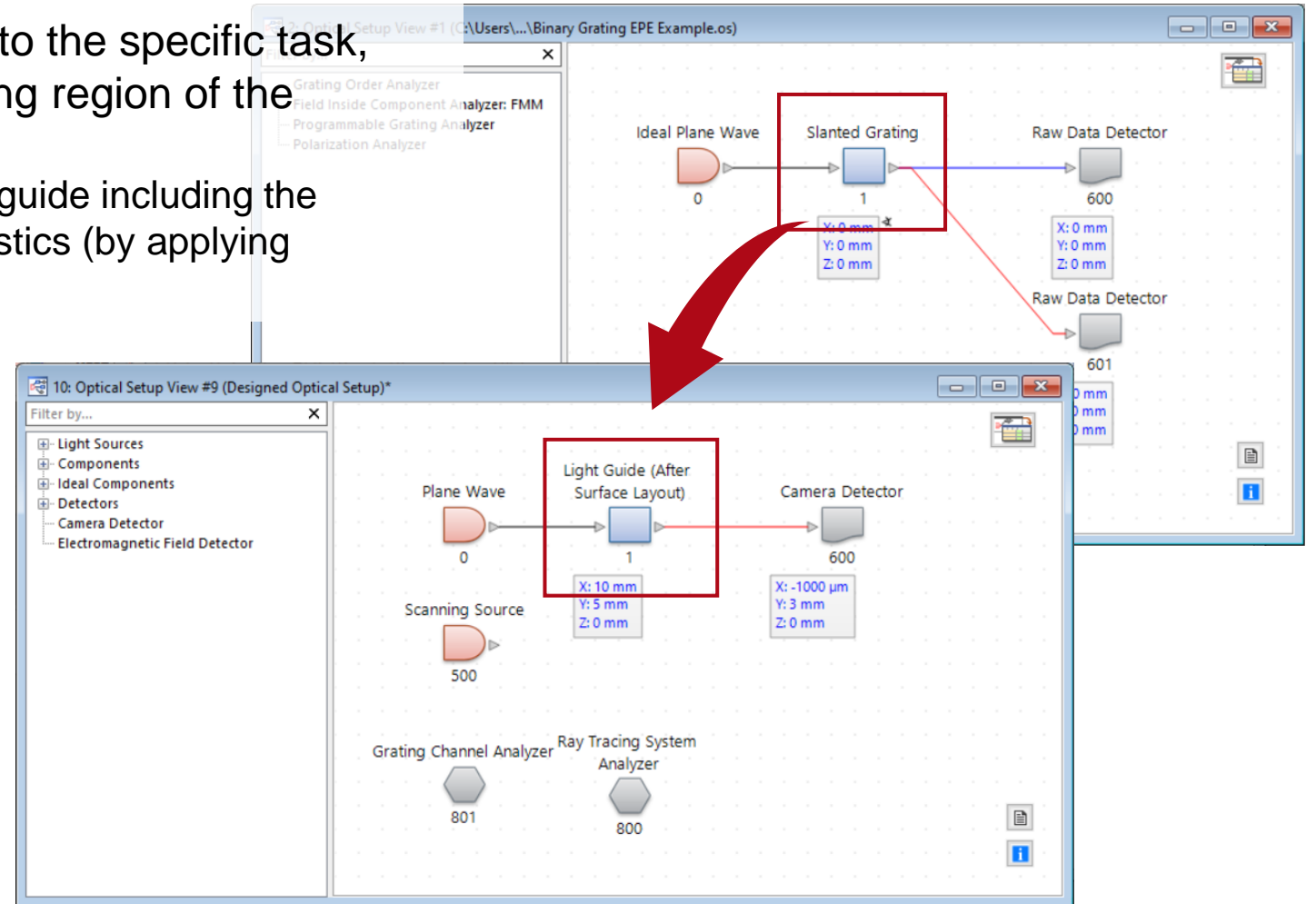
- This can be accessed via the “Gratings” drop-down list.
- It enables to focus on the analysis and optimization of the grating’s diffraction properties, like the diffraction angles, efficiencies and Rayleigh matrices.



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)

Grating Material
Name: Non-Dispersive Material (n=1.8)
Defined by Constant Refractive Index: 1.8
State of Matter: Solid

Groove Material
Name: Air
Catalog Material
State of Matter: Gas or Vacuum

Fill Factor: 50% Refers to ... Bottom Top
z-Extension: 300 nm
Slant Angle Left: 45° Slant Angle Right: 45°
 Apply Coating

* calculated from the layout design

Save the grating in the *User-Defined* catalog

Edit Stack

Index	z-Distance	z-Position	Surface	Subsequent Medium	Comment
1	0 mm	0 mm	Plane Surface	Slanted Grating Medium	Enter your comment
2	300 nm	300 nm	Plane Surface	Air in Homogeneous Medium	Enter your comment

Validity: Valid

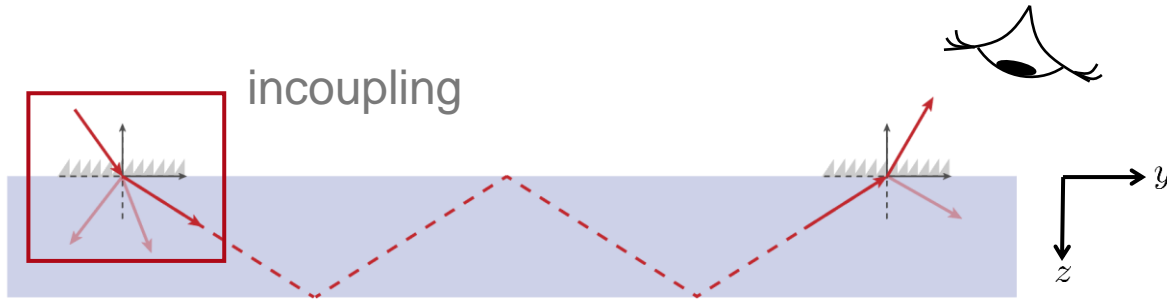
Periodicity & Aperture
 Periodic Non-Periodic
Stack Period is: Dependent from the Period of Medium with Index: 1
Stack Period: 380 nm

Buttons: Add, Insert, Delete

Tools: Tools

[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.

Edit General Grating Component

1D-Periodic (Lamellar)
 2D-Periodic

Base Block
 Base Block Medium
 S-LAH79_Ohara_2016 in Homogeneous Medium

Thickness

Stacks
 Use Stack on First Surface Use Stack on Second Surface

Catalog Entry
 Slanted Grating

No rotation about z-Axis

Stack Base Block

Common Period: 380 nm

1: Optical Setup Editor #1 (Slanted Grating Incoupler Example.os)*

Path Detectors Analyzers Logging

Start Element				Target Element		Linkage		
Index	Element Name	Ref. Type	Medium	Index	Element Name	Propagation Method	On/Off	Color
0	Ideal Plane Wave	-	Air in Homogeneous Med...	1	Slanted Grating	None	On	—
1	Slanted Grating	T	S-LAH79_Ohara_2016 in...					

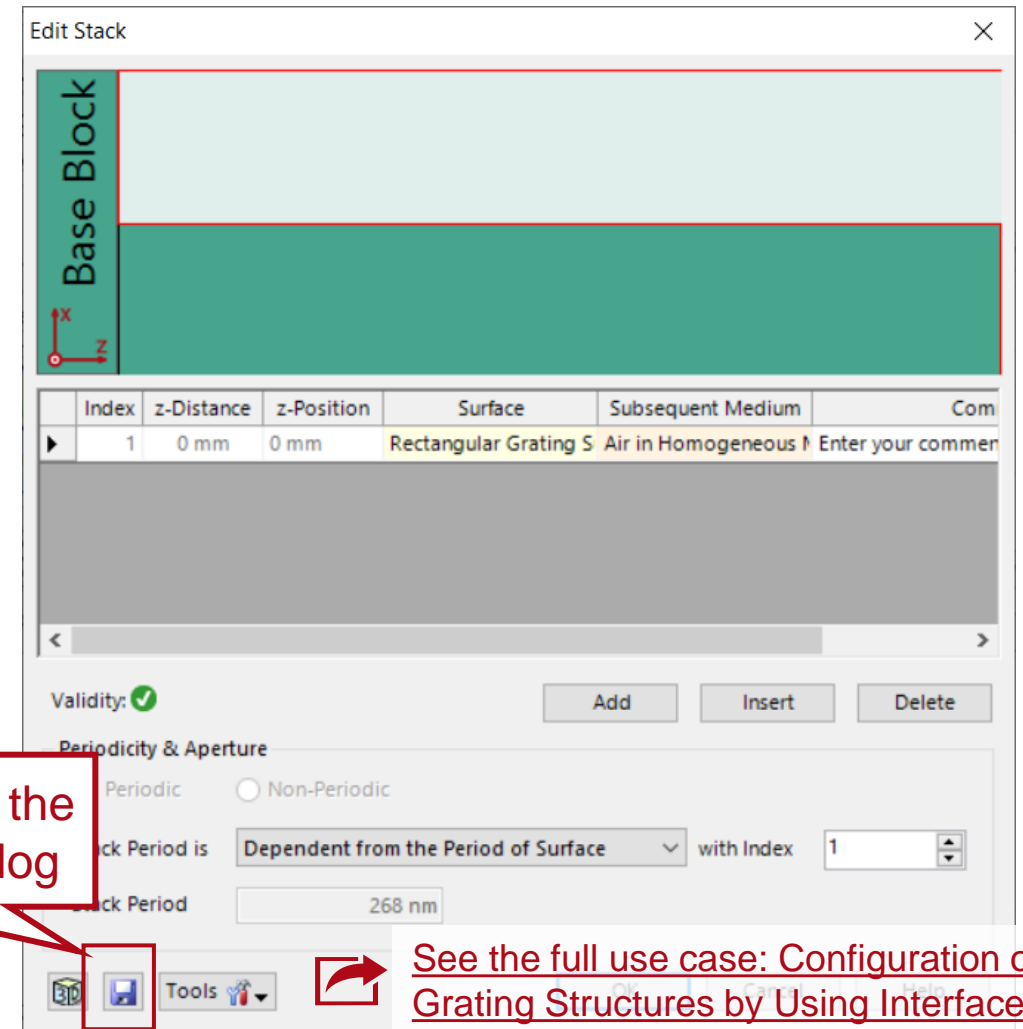
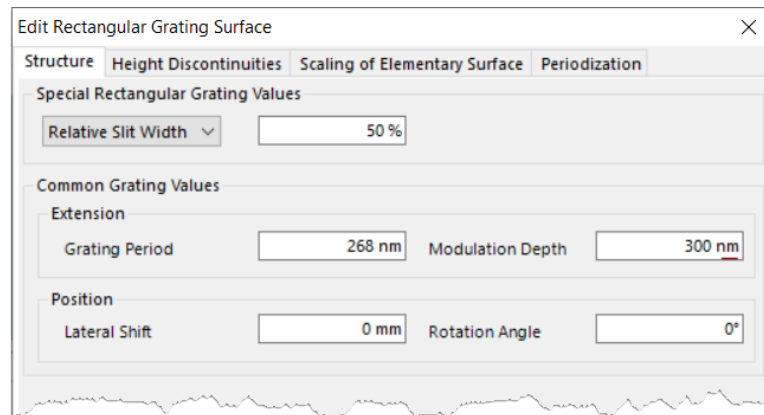
Configuration of the EPE/Outcoupling Grating

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

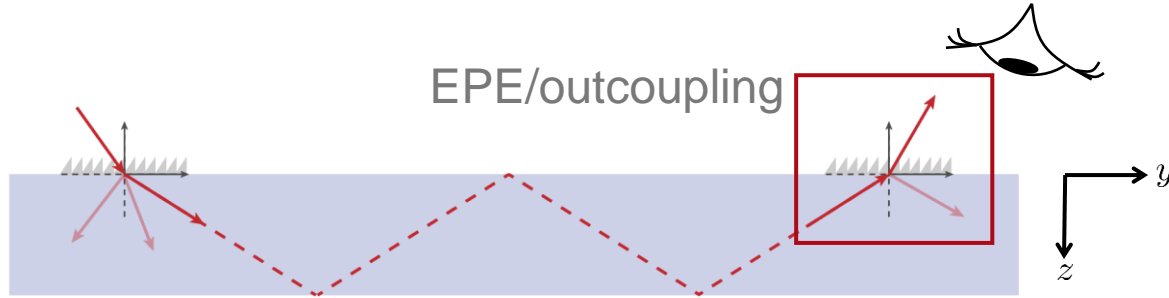
* calculated from the layout design



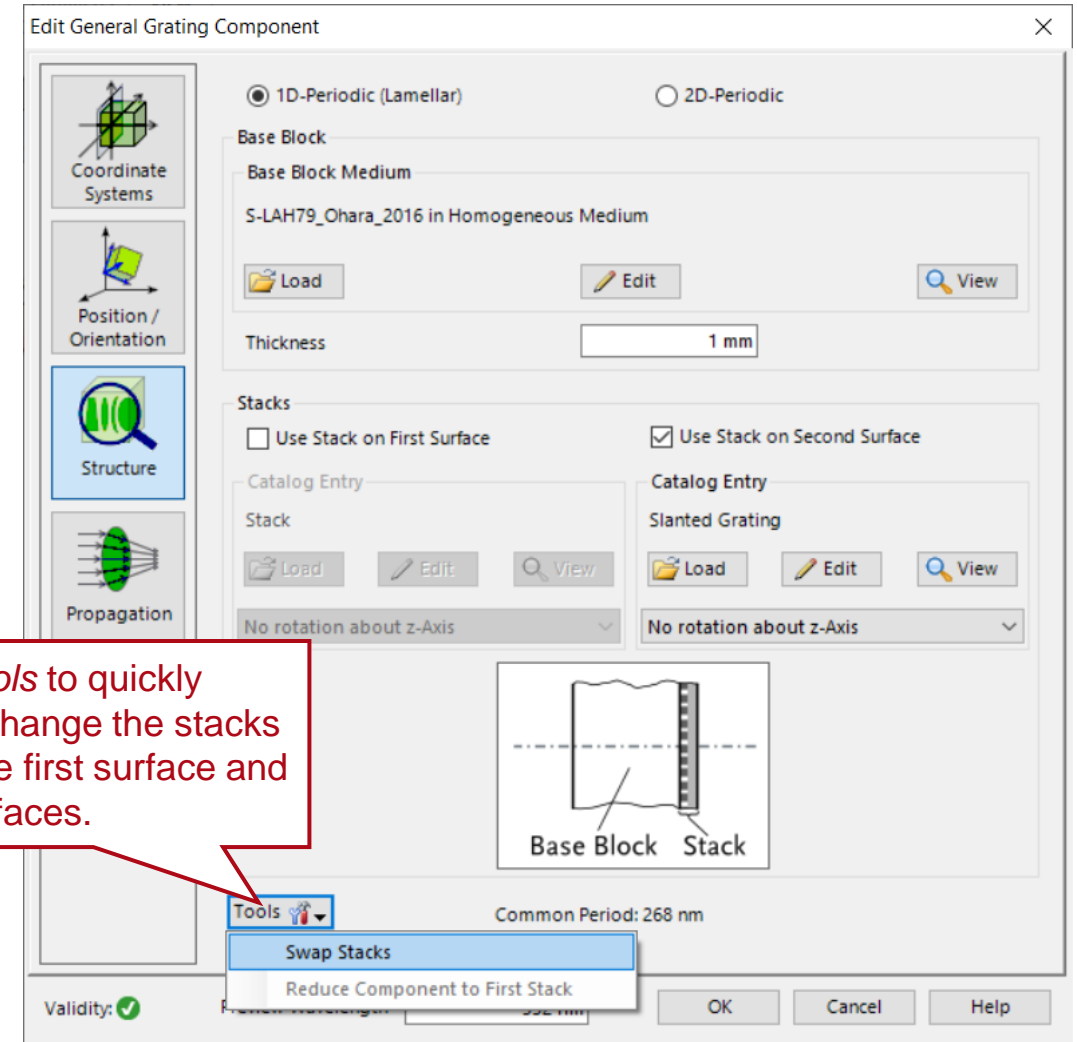
Save the grating in the *User-Defined* catalog

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.

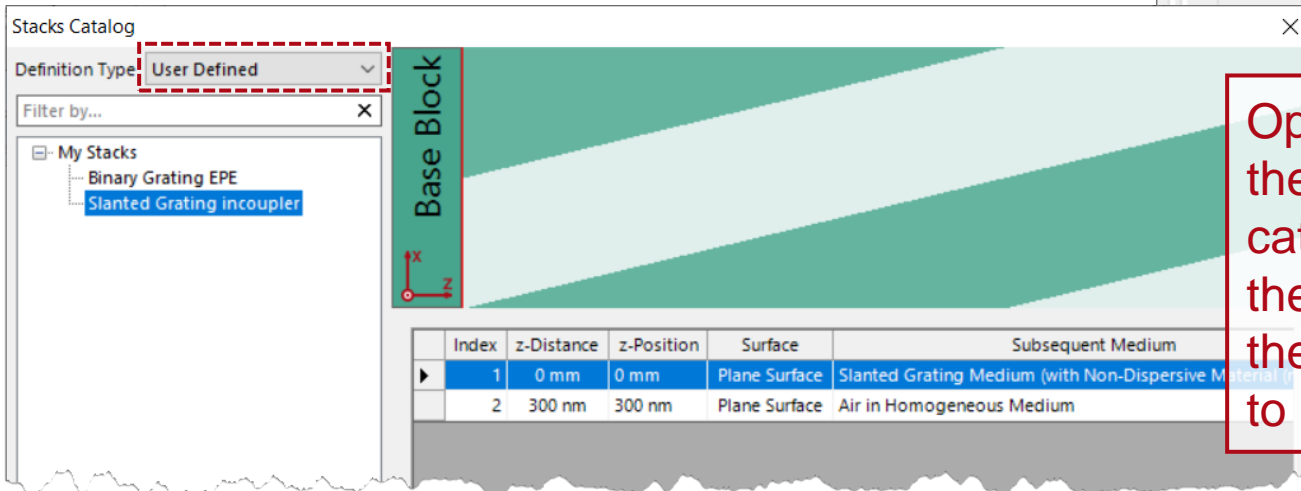
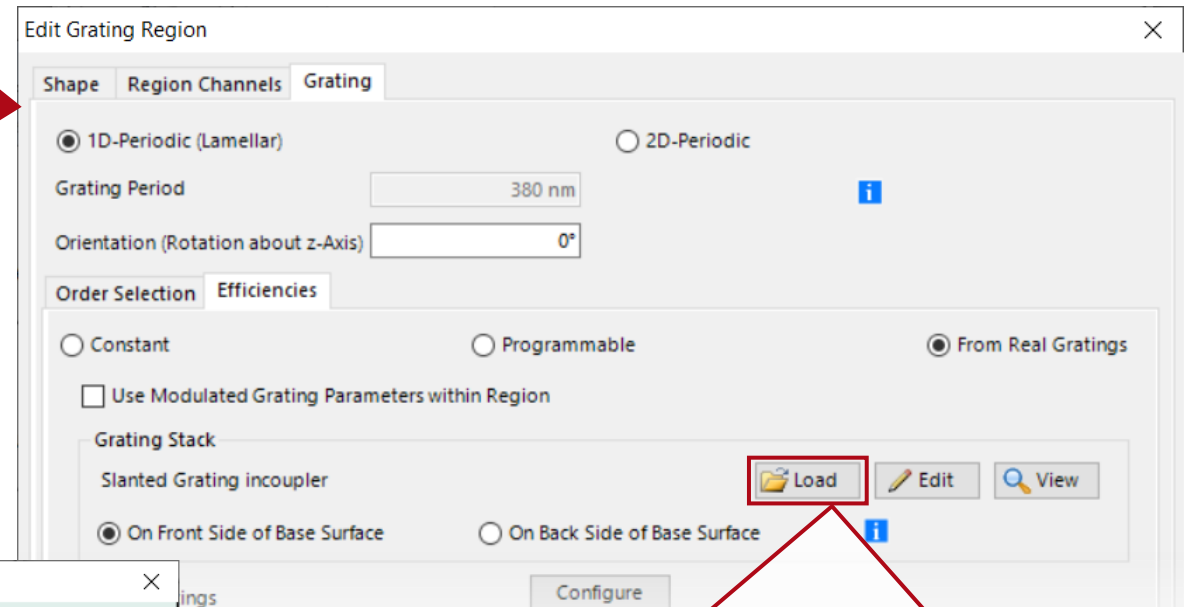
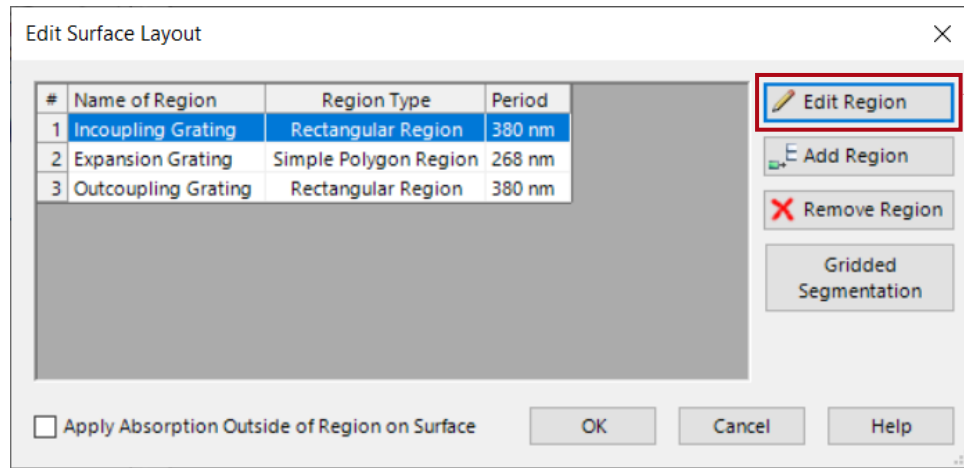


The subsequent medium after the source and the grating should also be adjusted accordingly.

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

Stack			Target Element		
Index	Element Name	Ref. Type	Medium	Index	Element Name
0	Ideal Plane Wave	-	S-LAH79_Ohara_2016 in...	1	Slanted Grating
1	Slanted Grating	T	Air in Homogeneous Med...		

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

Edit Surface Layout

#	Name of Region	Region Type	Period
1	Incoupling Grating	Rectangular Region	380 nm
2	Expansion Grating	Simple Polygon Region	268 nm
3	Outcoupling Grating	Rectangular Region	380 nm

Apply Absorption Outside of Region on Surface

OK

Edit Region
Add Region
Remove Region
Gridded Segmentation

Edit Grating Region

Shape Region Channels Grating

1D-Periodic (Lamellar)

Grating Period: 268 nm
Orientation (Rotation about z-Axis): -45°

Order Selection Efficiencies

Constant Programmable From Real Gratings

Use Modulated Grating Parameters within Region

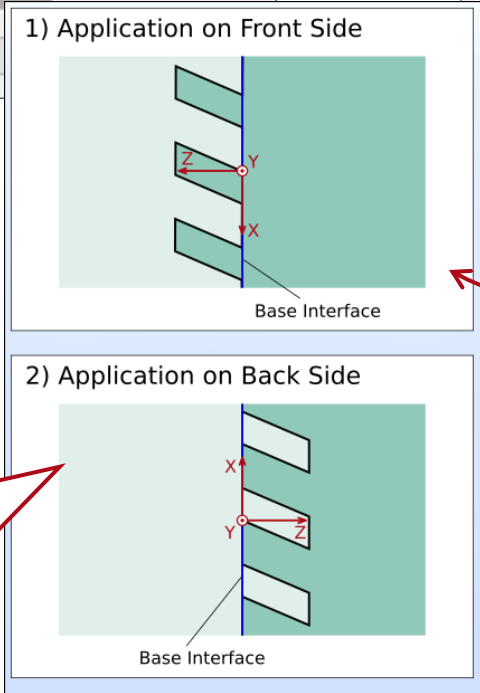
Grating Stack
Binary Grating EPE
 On Front Side of Base Surface On Back Side of Base Surface

FMM Settings

Lookup Table
Lookup Table for 1 wavelength

Validity:

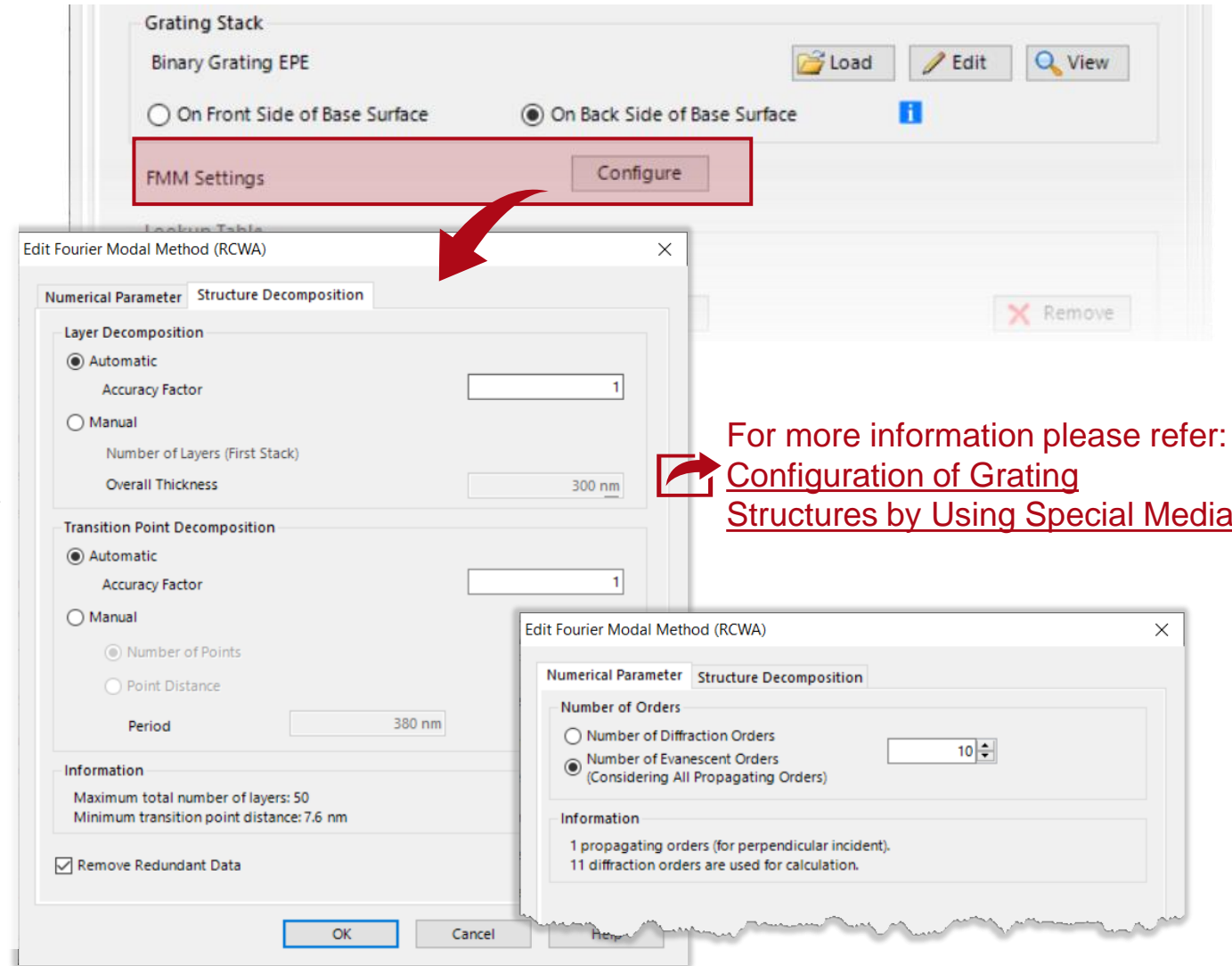
The orientation angle rotates the grating vector in the plane of the region and e.g. is calculated by the layout design tool.



Make sure the orientation of the grating structure is consistent with the intended configuration and fabrication. This probably will not affect the diffraction efficiencies, but the absolute phases of the orders.

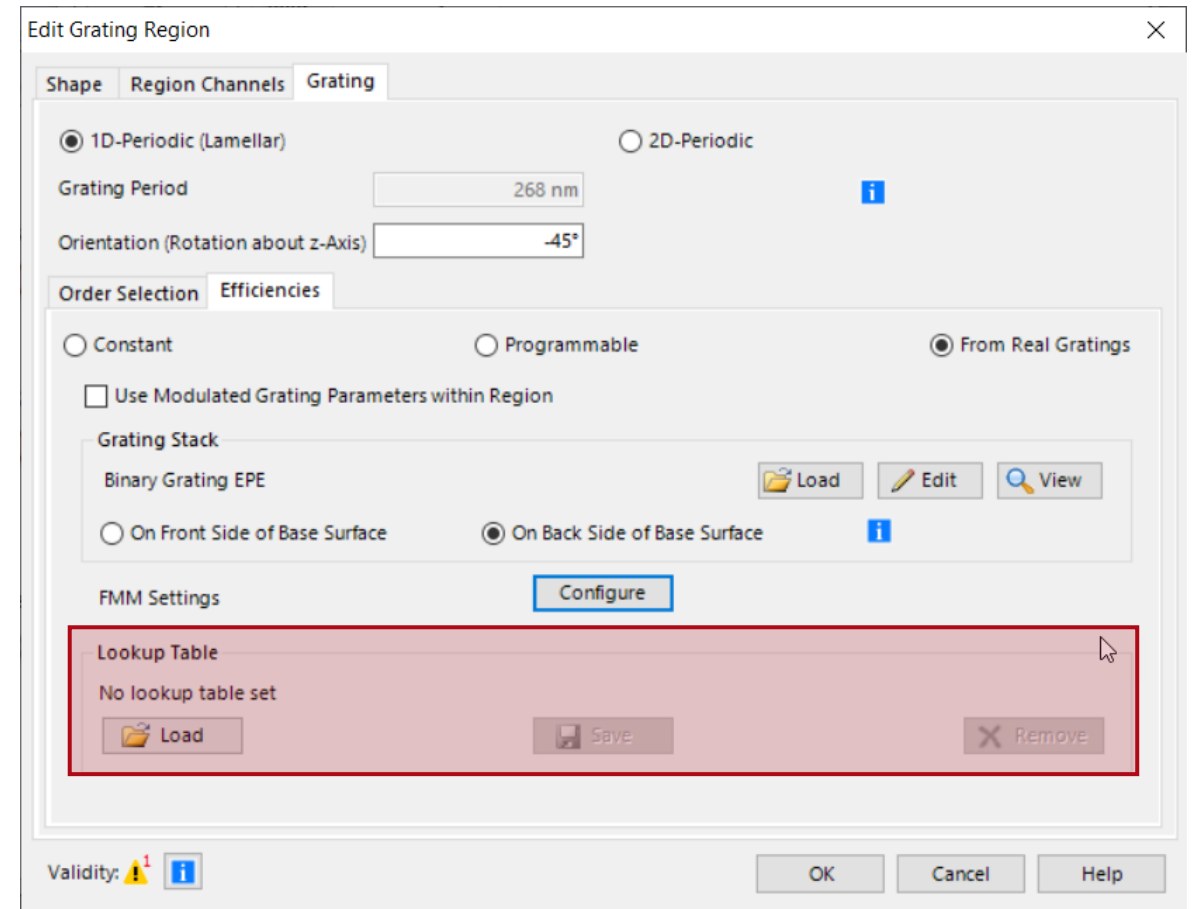
FMM Settings

- 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.

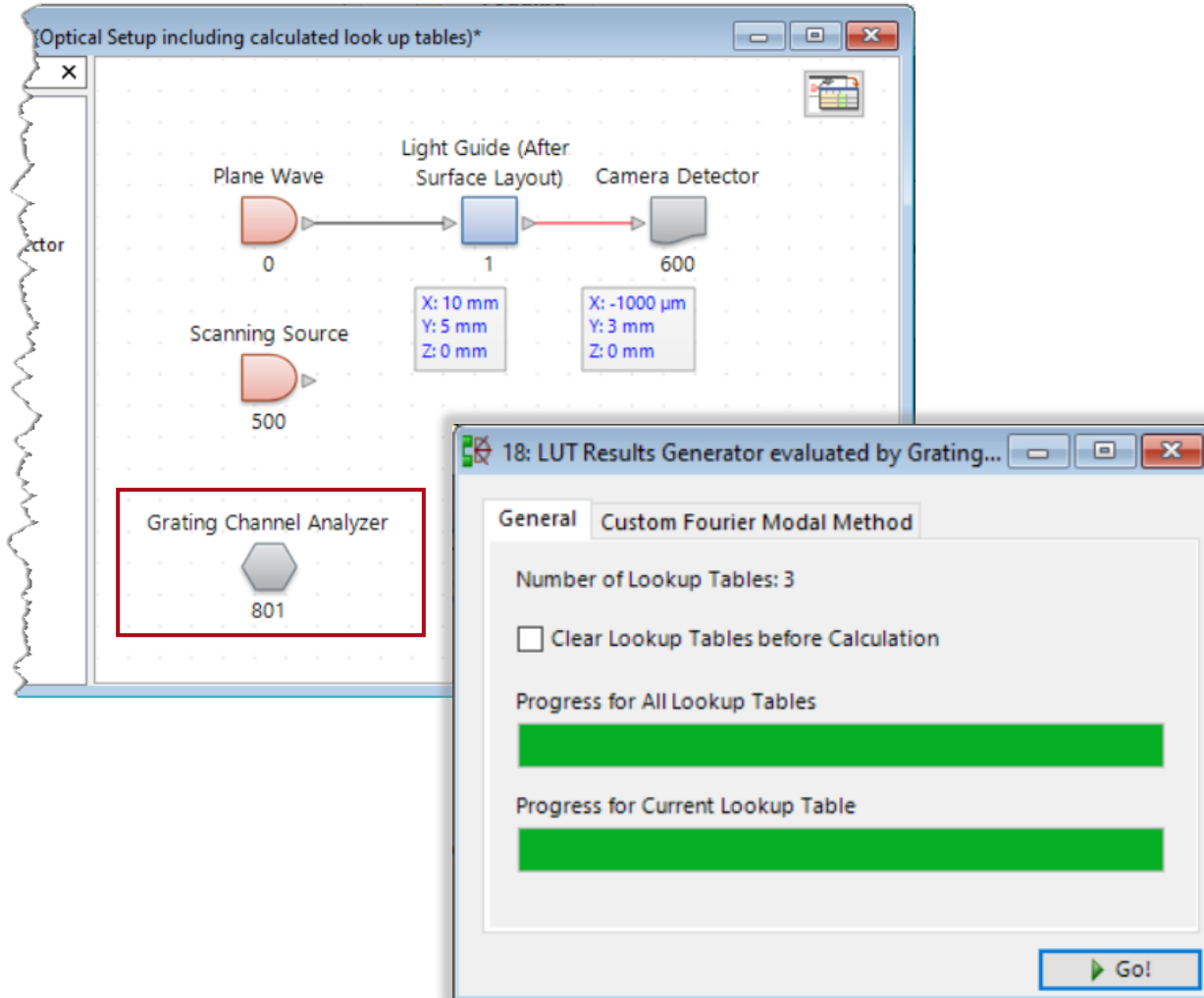


Lookup Table

- 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, these 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

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software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	<ul style="list-style-type: none">- <u>Construction of a Light Guide</u>- <u>Modeling of a “HoloLens 1”-Type Layout with Light Guide Component</u>- <u>Flexible Region Definition</u>- <u>Specification of Diffraction Orders and Efficiencies for Grating Regions</u>- <u>Light Guide Layout Design Tool</u>- <u>k-Domain Layout Visualization</u>- <u>Simulation of Lightguide with 1D-1D Pupil Expander and Real Gratings</u>