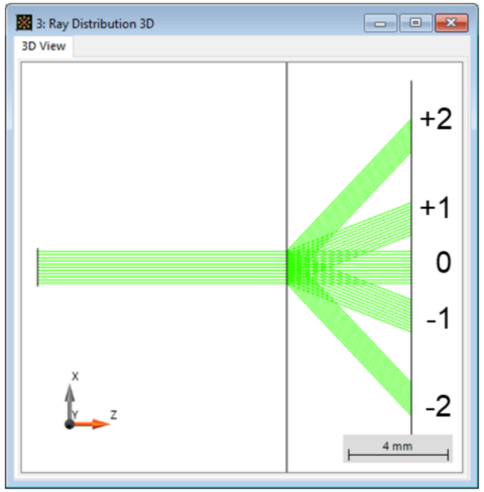
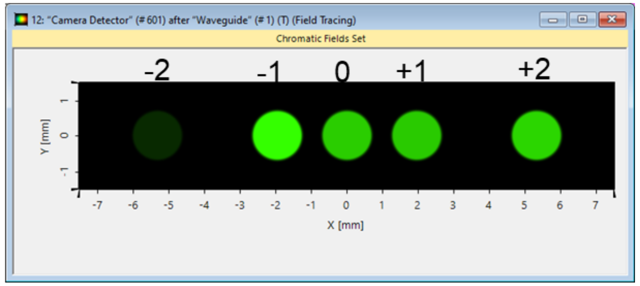
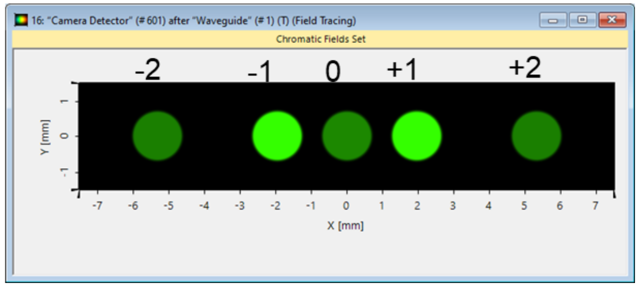
Specification of Diffraction Orders and Efficiencies for Grating Regions

Abstract



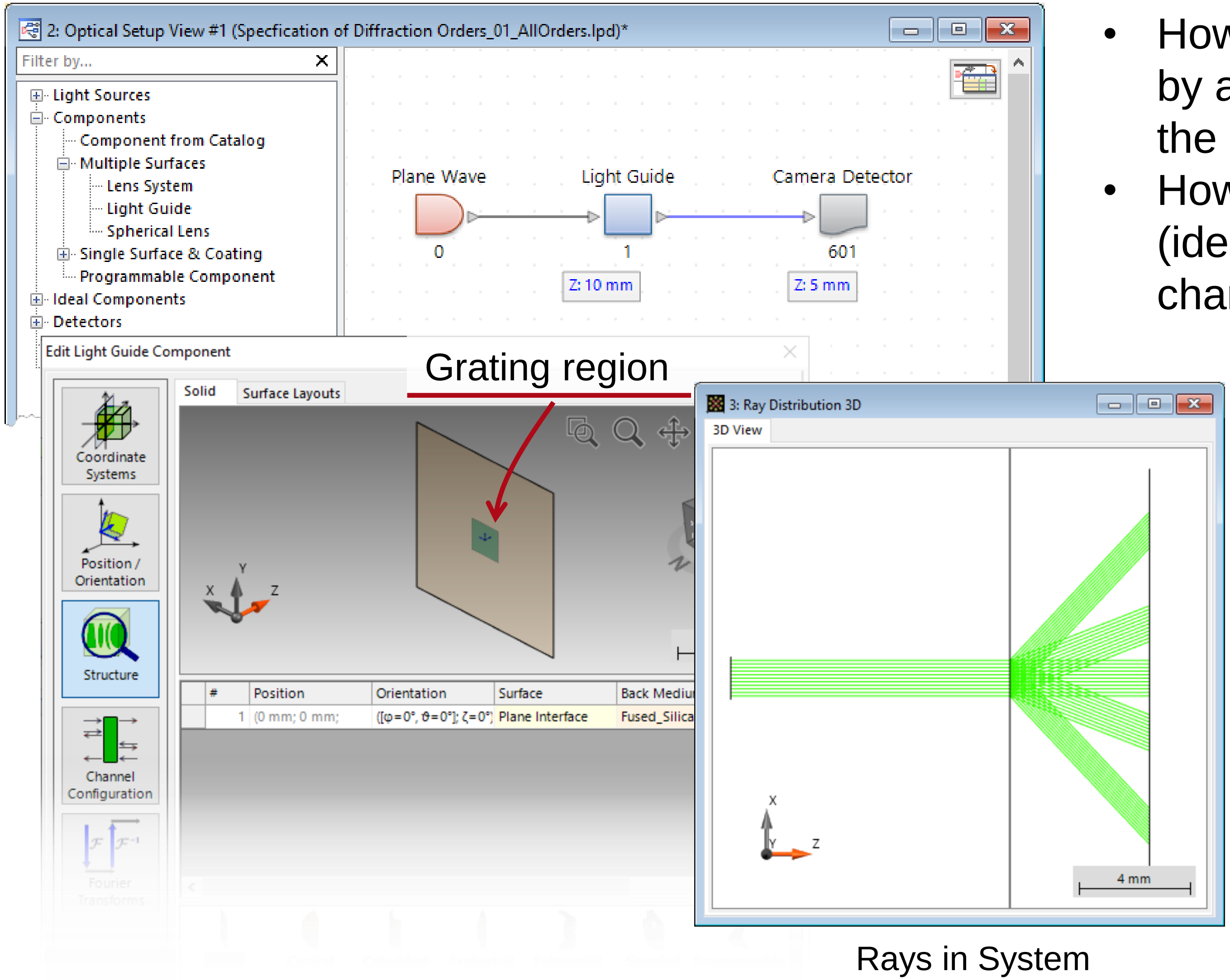




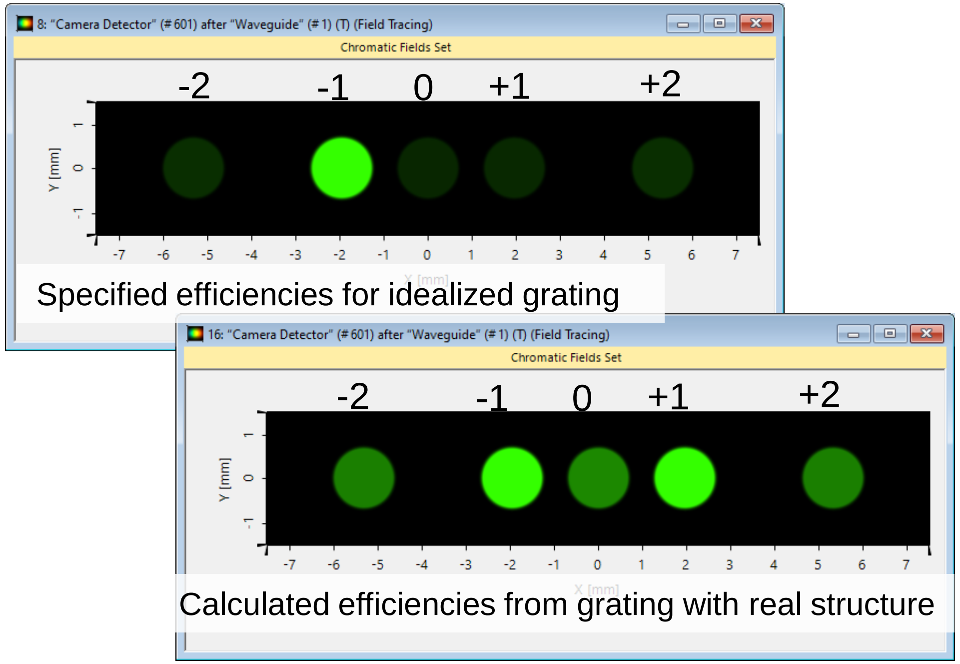
For the simulation of AR & MR devices VirtualLab Fusion offers the Light Guide component. Grating regions can be defined on the surfaces of the light guide for coupling purposes. These regions are very flexible in their configuration: the shape of the region, its channels, the parameters of the grating and how many grating orders are to be traced through the system, as well as the method used to simulate the interaction of light with the grating, can all be adjusted at will by the user. In this use case we focus on the configuration of grating-related aspects: selecting which grating orders to simulate and the different mechanisms to determine their efficiencies (idealized or rigorous).

Modeling Task

- How to specify which diffraction orders generated by a given grating region are to be traced through the system in the simulation?
- How to employ the different methods available (idealized or rigorously modeled with FMM) to characterize the efficiencies of the grating orders?

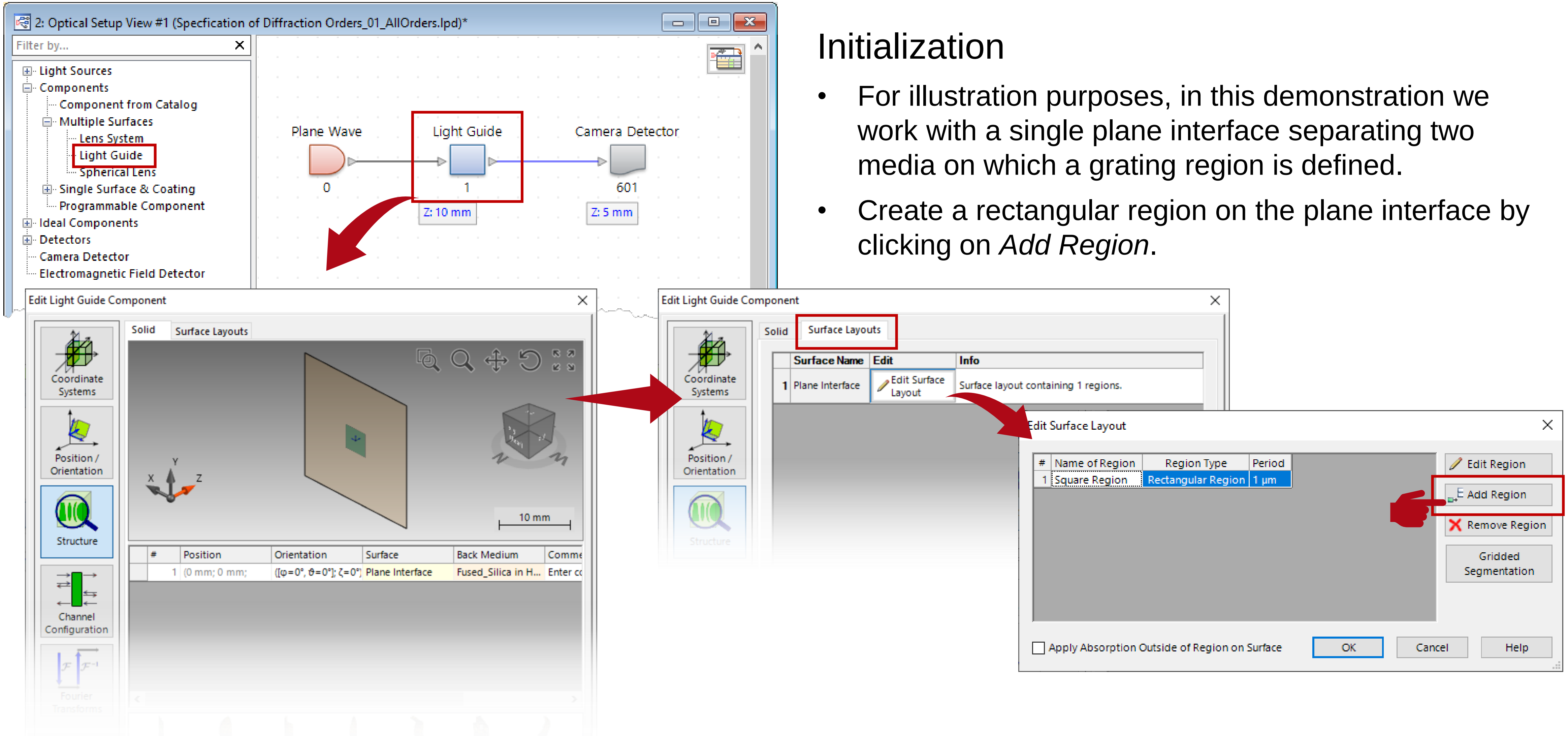


Rays in System



Field Tracing Result

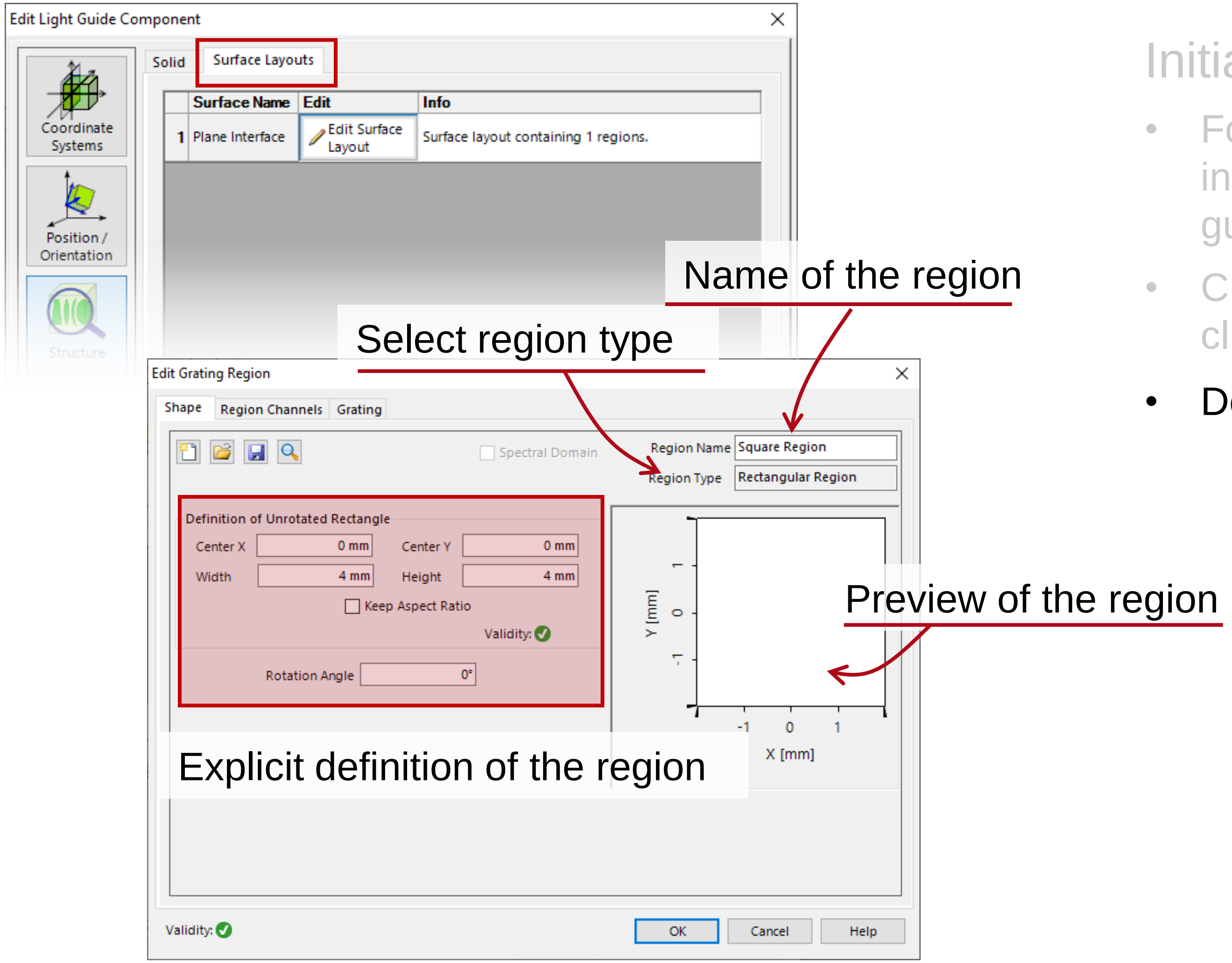
System Construction



Initialization

- For illustration purposes, in this demonstration we work with a single plane interface separating two media on which a grating region is defined.
- Create a rectangular region on the plane interface by clicking on *Add Region*.

Region Definition

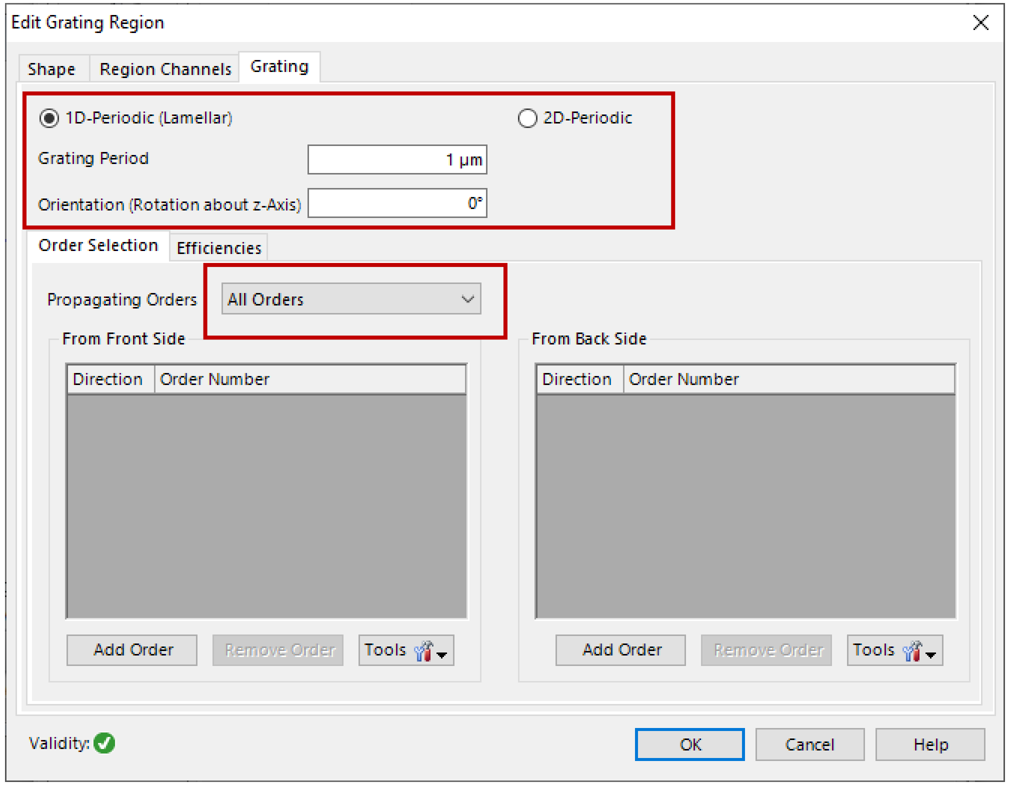


Initialization

- For illustration purposes, we work with a single plane interface, i.e., we just consider one surface of the light guide.
- Create a rectangular region on the plane interface by clicking on Add Region.
- Define a rectangular region with a size of 4 × 4 mm.

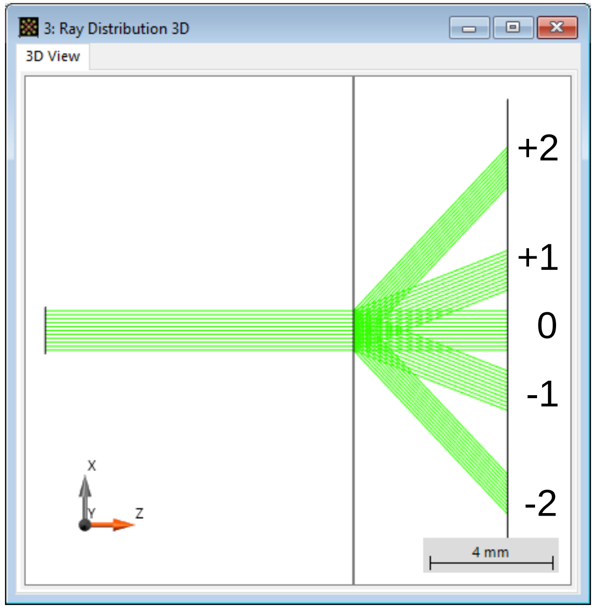
See the full use case for region configuration: *Flexible Region Definition*

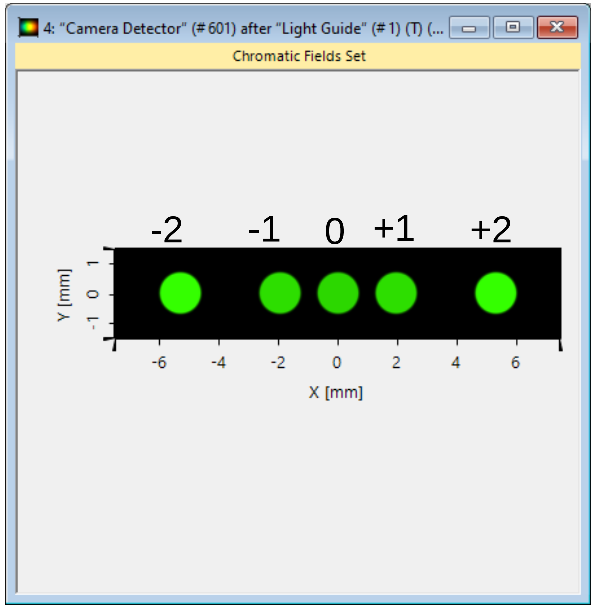
Selection of Grating Orders and Simulation



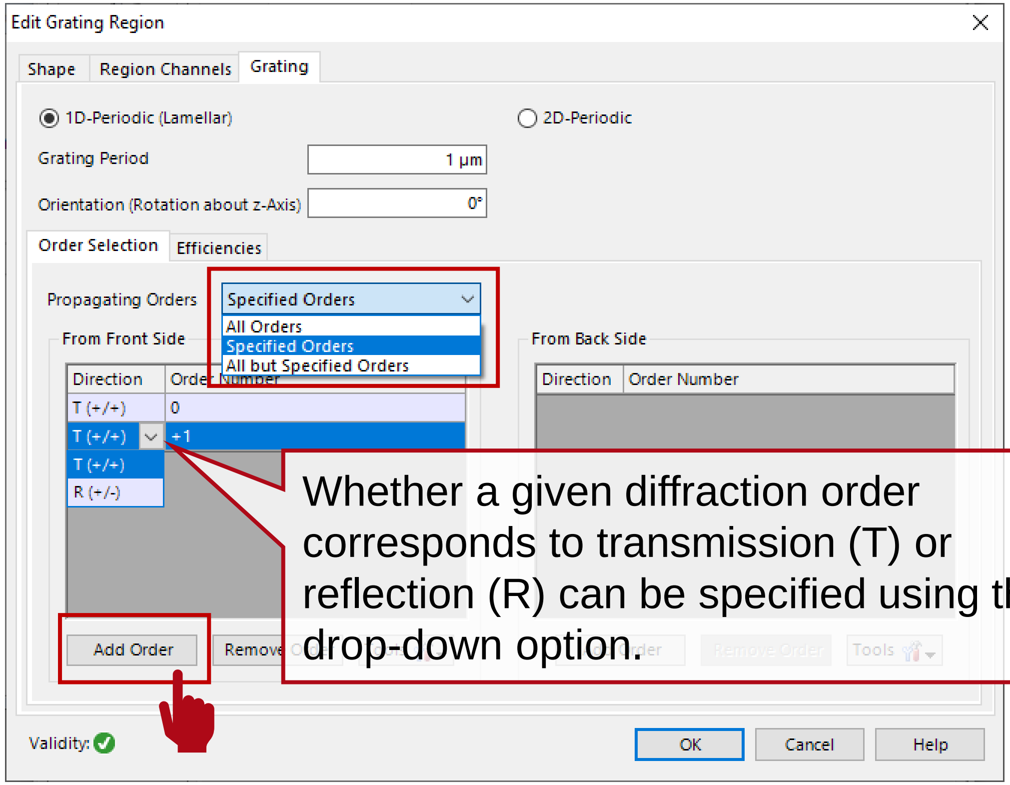
Grating order definition

- Define an ideal linear grating with period of 1 µm (five propagating diffraction orders for 532 nm wavelength in fused silica).
- Under the tab *Order Selection*, follow default setting with *All Orders* at first.
- Run *Rays in System* and *Field Tracing* simulations.





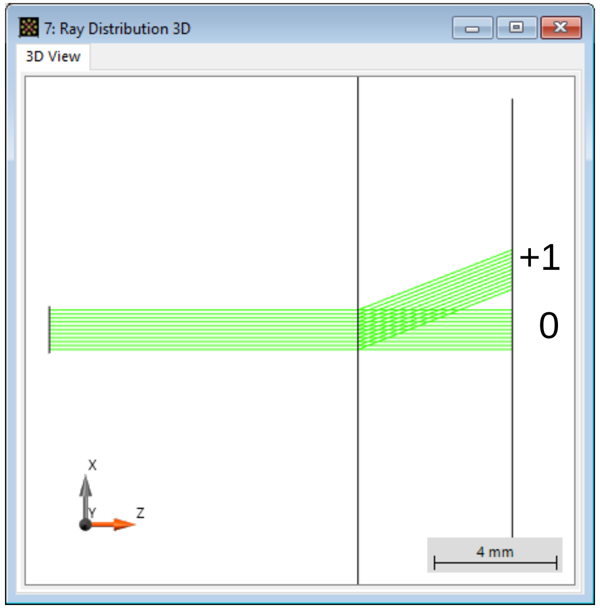
Selection of Grating Orders and Simulation

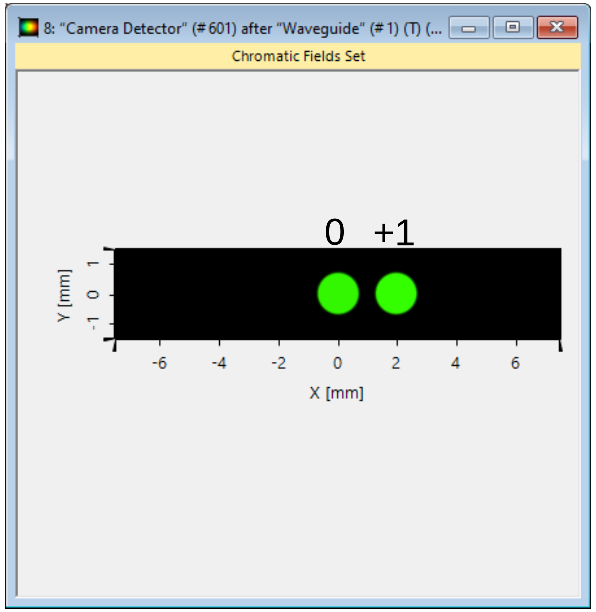


Whether a given diffraction order corresponds to transmission (T) or reflection (R) can be specified using the drop-down option.

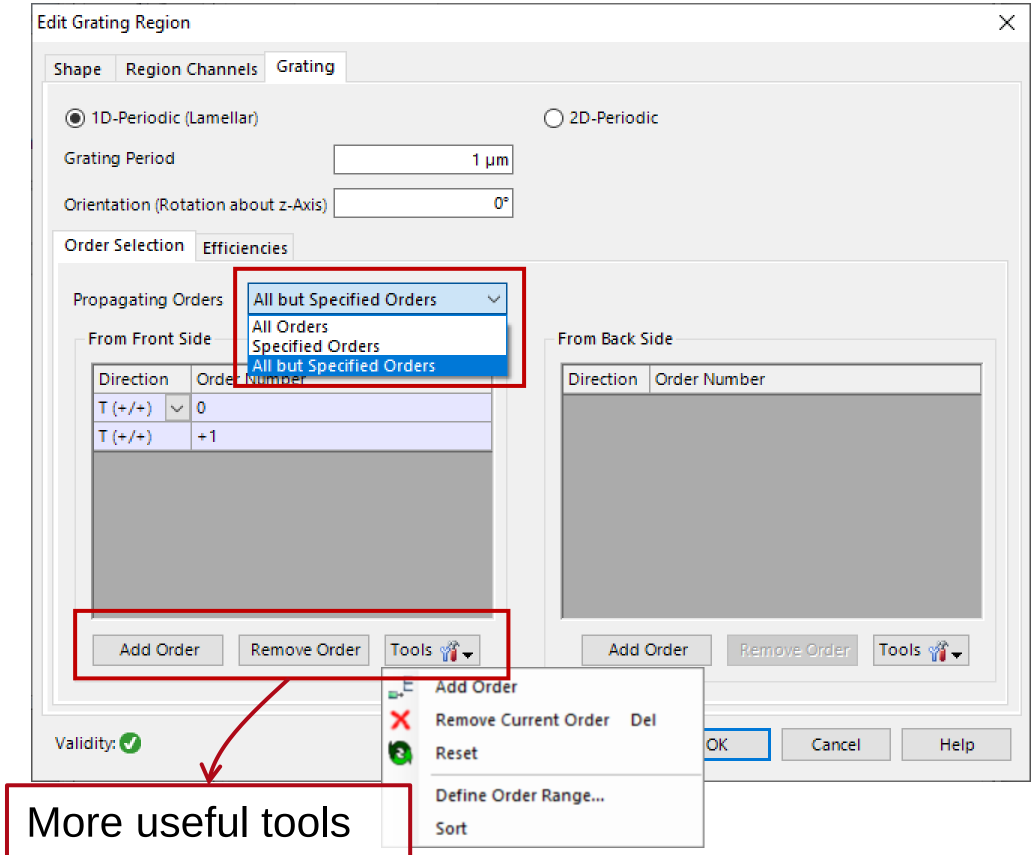
Grating order definition

- In the tab *Order Selection*, change to *Specified Orders* using the drop-down list, and click on *Add Order* to include e.g., the 0th and 1st transmission orders.





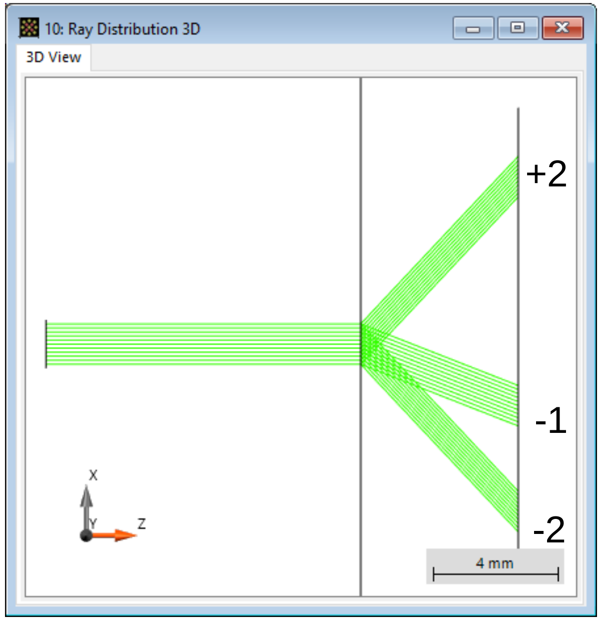
Selection of Grating Orders and Simulation

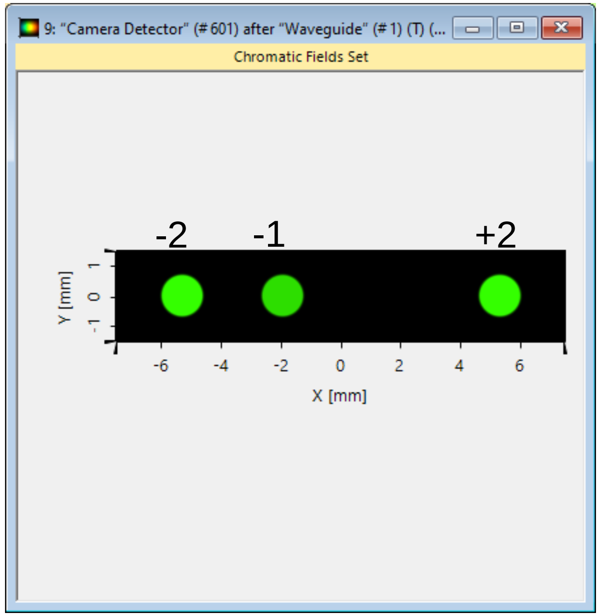


More useful tools are available for order settings.

Grating order definition

- Next, select *All but Specified Orders*, here we also give e.g., the 0th and 1st transmission orders.
- Run *Rays in System* and *Field Tracing* simulations, then all orders except for the specified ones will be propagated.



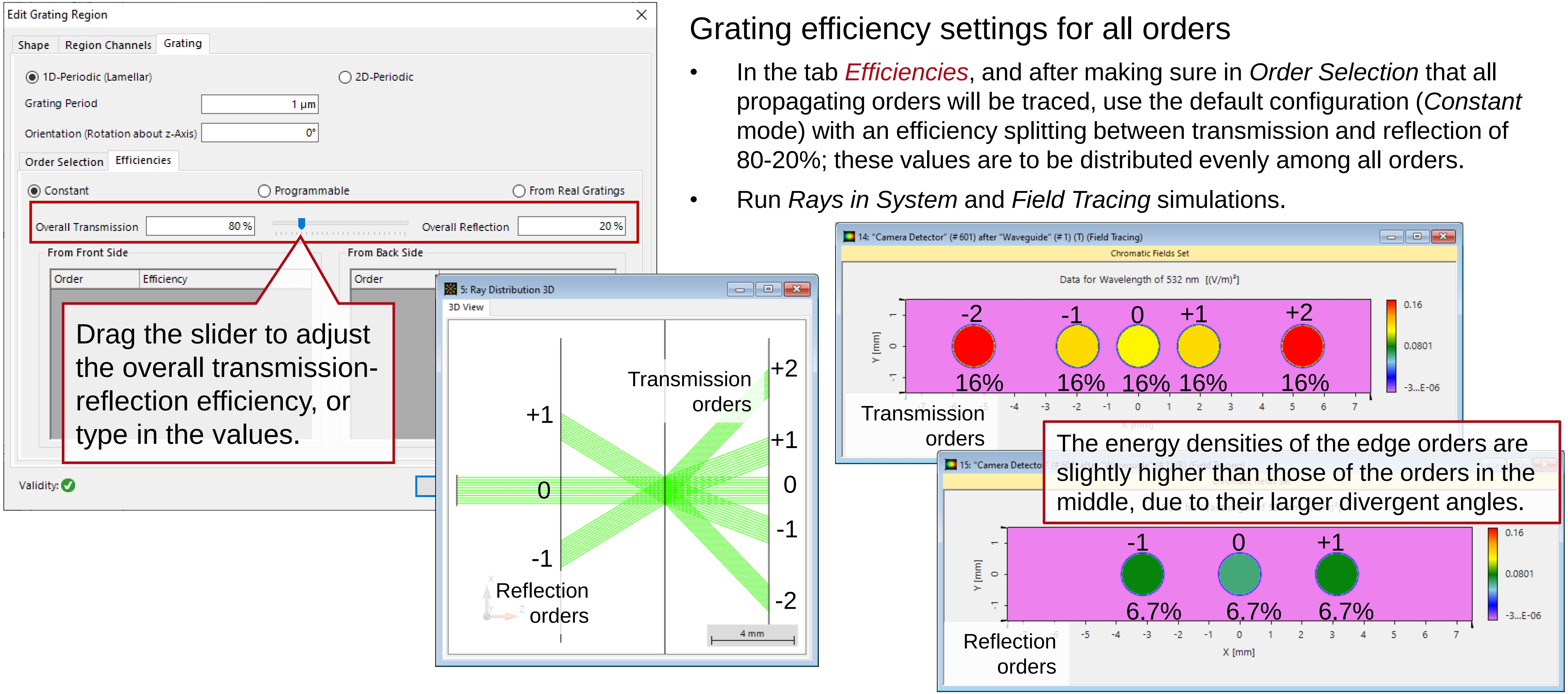


Efficiency Settings for Idealized and Real Gratings

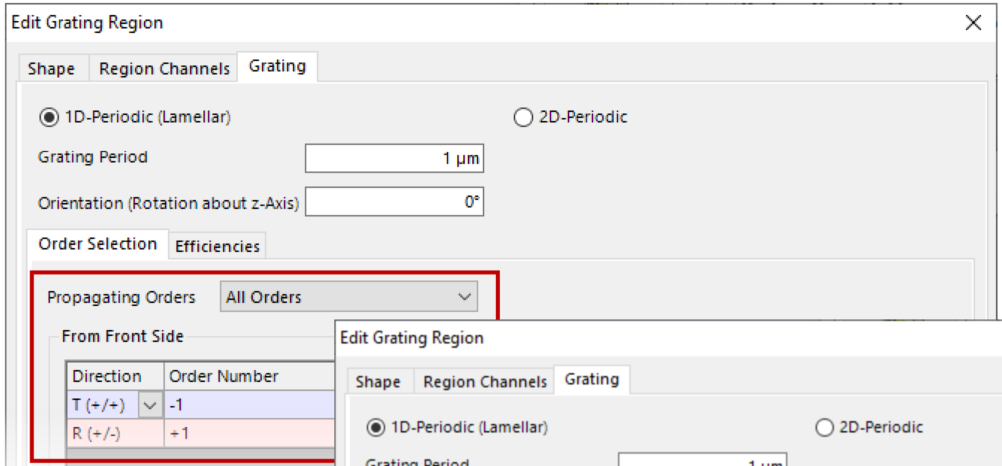
Idealized Grating Efficiency Settings

Grating efficiency settings for all orders

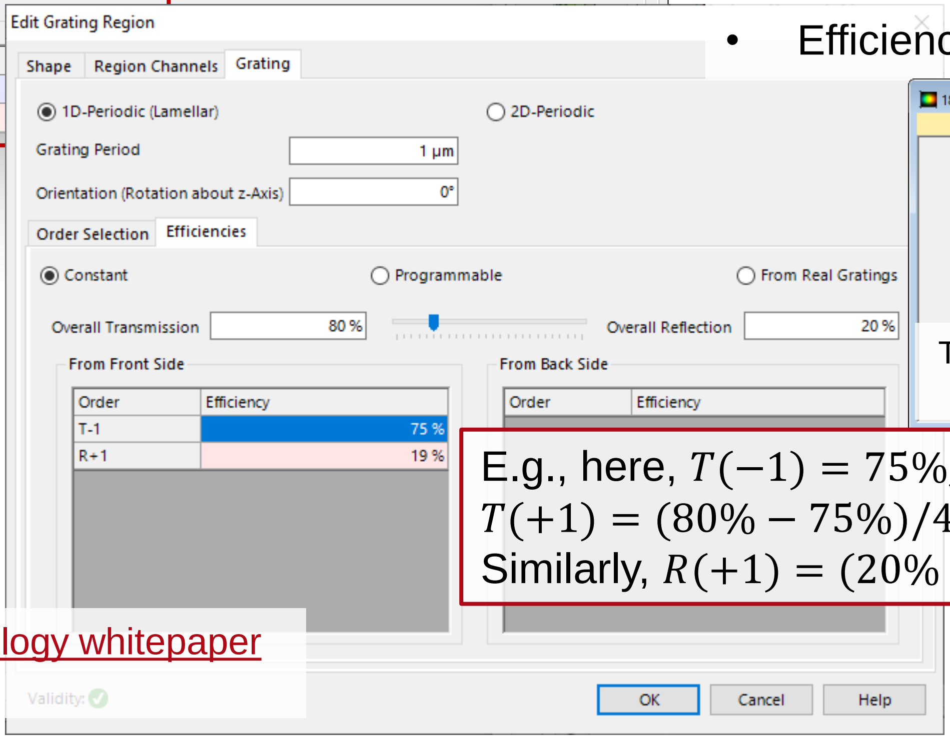
- In the tab *Efficiencies*, and after making sure in *Order Selection* that all propagating orders will be traced, use the default configuration (*Constant* mode) with an efficiency splitting between transmission and reflection of 80-20%; these values are to be distributed evenly among all orders.
- Run *Rays in System* and *Field Tracing* simulations.



Idealized Grating Efficiency Settings

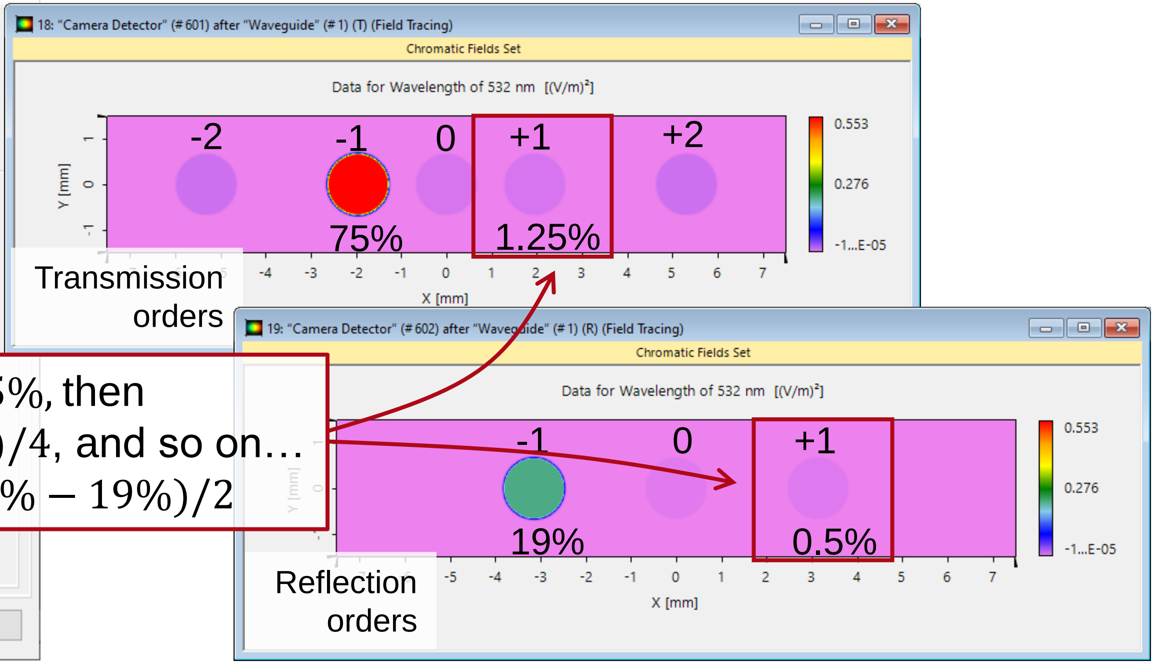


All orders will be traced in this simulation, but only these two orders have specified efficiencies.



Grating efficiency settings for certain orders

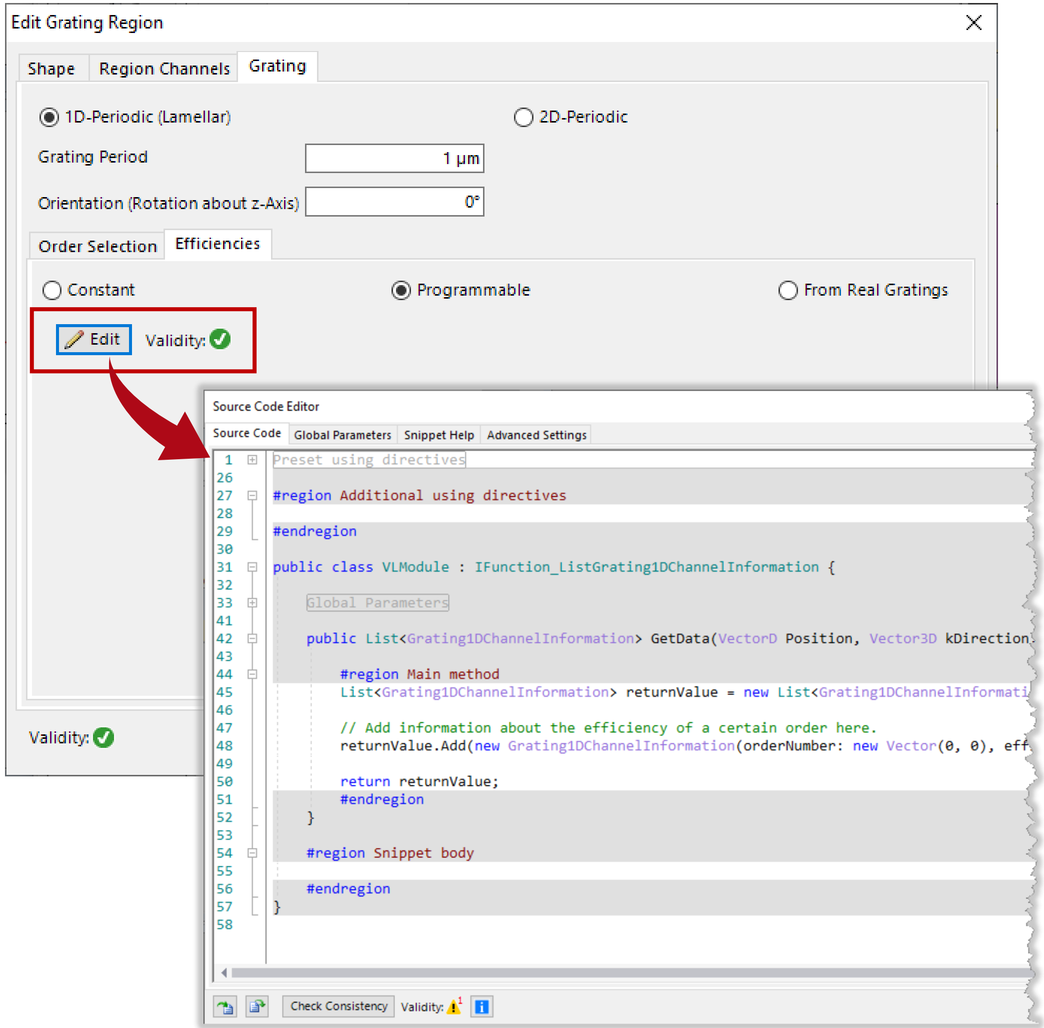
- To define certain orders with given efficiencies, one must specify these orders first in the *Order Selection* tab.
- Then define the efficiency for the specified diffraction orders, e.g., $T(-1) = 75\%$ and $R(+1) = 19\%$,under the *Efficiencies* tab.
- Efficiencies of unspecified orders will be uniformly distributed.



E.g., here, $T(-1) = 75\%$, then $T(+1) = (80\% - 75\%)/4$, and so on…
Similarly, $R(+1) = (20\% - 19\%)/2$

Check this technology whitepaper for more info

Programmable Efficiencies



- The *Programmable* option for the efficiencies uses the same assumption as the *Constant* option (see previous slides) in order to establish the vectorial behavior on the basis of the efficiency values.

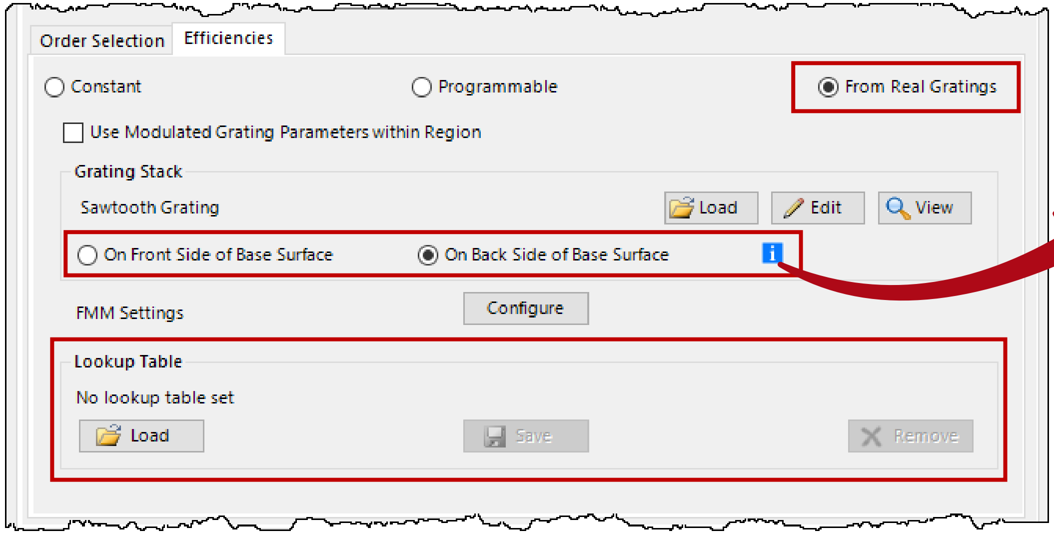
- However, the *Programmable* mode gives the user more flexibility to assign an efficiency value which can depend on other system parameters, like the wavelength, the incident plane-wave direction, and other user-defined global parameters.

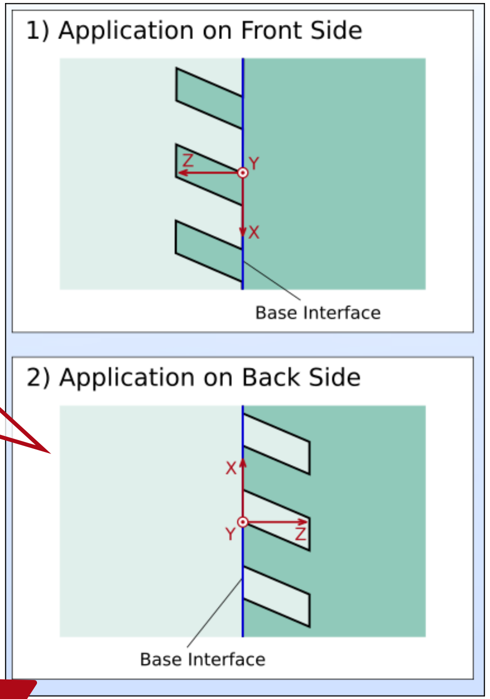
- The *Edit* button opens the *Source Code Editor* to enter the corresponding snippet of code. It also comes with a validity indicator and other tabs where, for instance, additional parameters (in several data formats) can be declared for subsequent use in the code.

Real Grating Efficiency Settings

- It is also possible to define the real structure of the grating, so that the (vectorial) interaction of the light with the grating is rigorously calculated using the Fourier Modal Method (FMM), with the *From Real Gratings* option.

The orientation of the grating structure can also be selected. In case *On Back Side of Base Surface* is chosen, its coordinate system coincides with that of the interface.

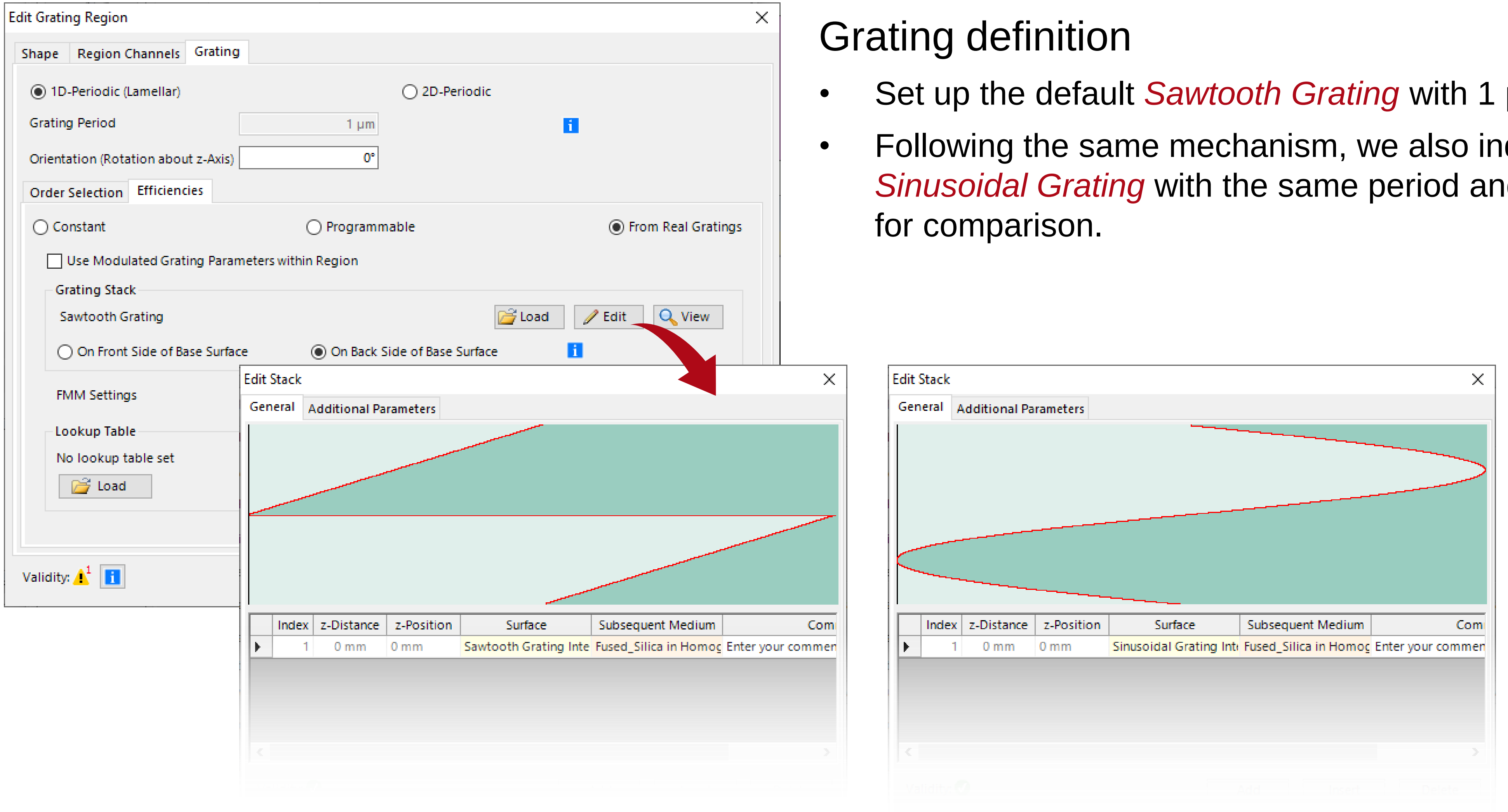




- After the simulation has been run once with the real grating, the calculated information of how that grating transforms the incoming field is automatically stored in a *Lookup Table* (LUT), so that the same (potentially numerically costly) simulation does not have to be repeated superfluously again.
- If any system parameters which can affect the grating response are modified (wavelength, plane-wave directions) the new information is added to the LUT when the simulation is run again.
- The calculated lookup table can be saved for later use in the same or in a different system where the same grating and configuration are employed.

[Check this technology whitepaper for more info on the FMM solver]

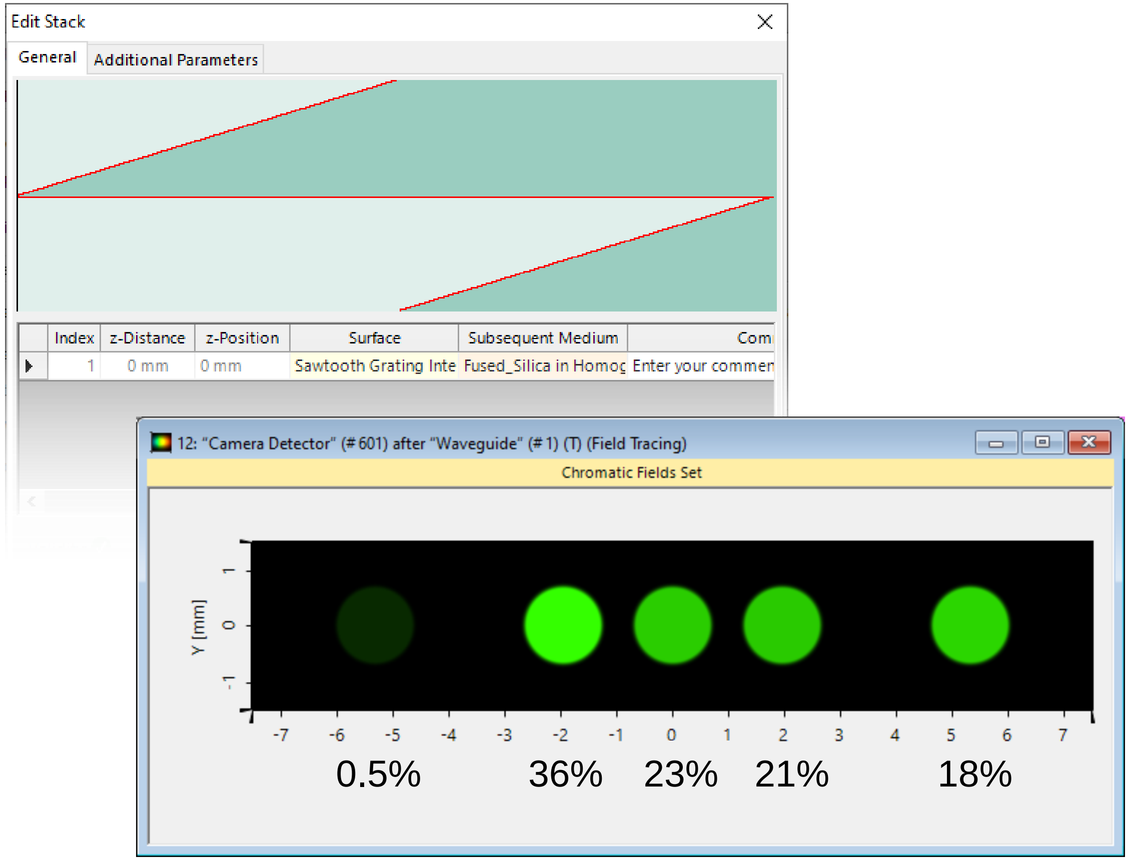
Configuration of Real Grating Structure



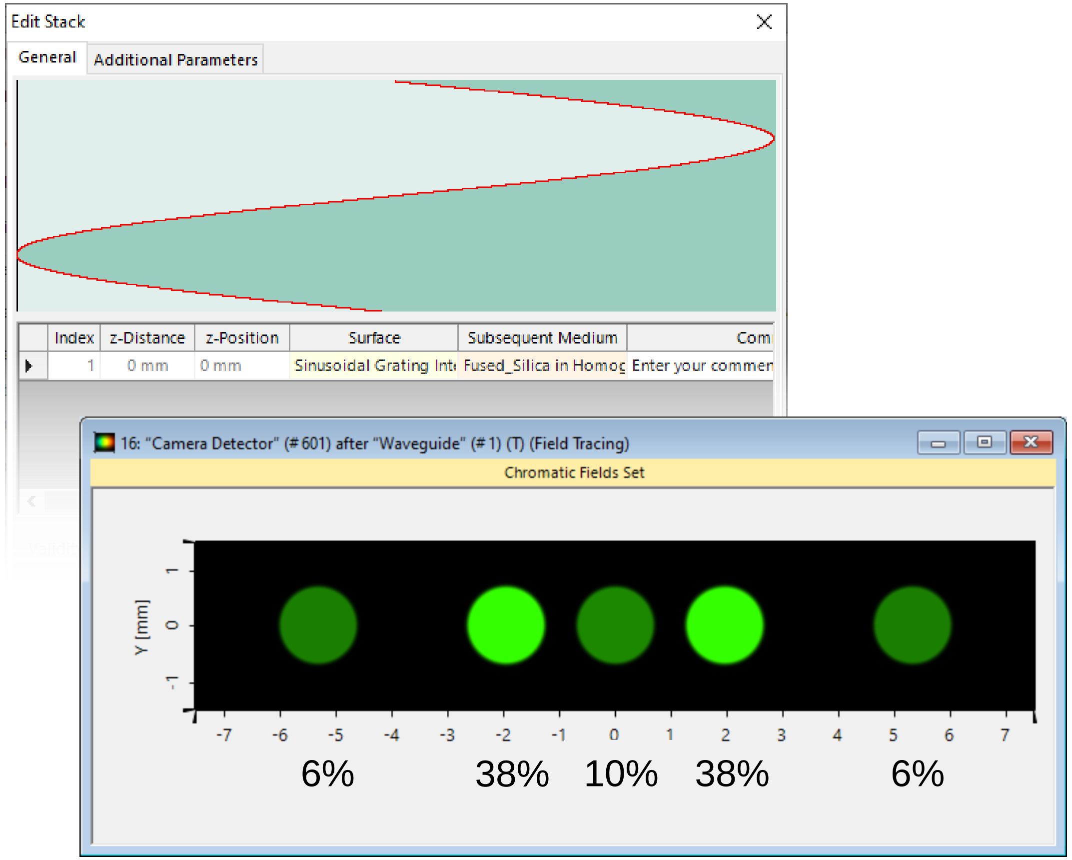
Grating definition

- Set up the default *Sawtooth Grating* with 1 µm modulation depth.
- Following the same mechanism, we also independently set up a *Sinusoidal Grating* with the same period and modulation depth, for comparison.

Field Tracing Simulation



Sawtooth grating shows asymmetry in diffraction efficiencies



Sinusoidal grating provides symmetric efficiencies around zeroth order

Document Information

title	Specification of Diffraction Orders and Efficiencies for Grating Regions
document code	LIG.0003
version	1.0
VL version used for simulations	VirtualLab Fusion Advanced 2021.1 (Build 1.180)
category	Feature Use Case
further reading	- Flexible Region Definition - Configuration of Grating Structures by Using Special Media - Configuration of Grating Structures by Using Interfaces