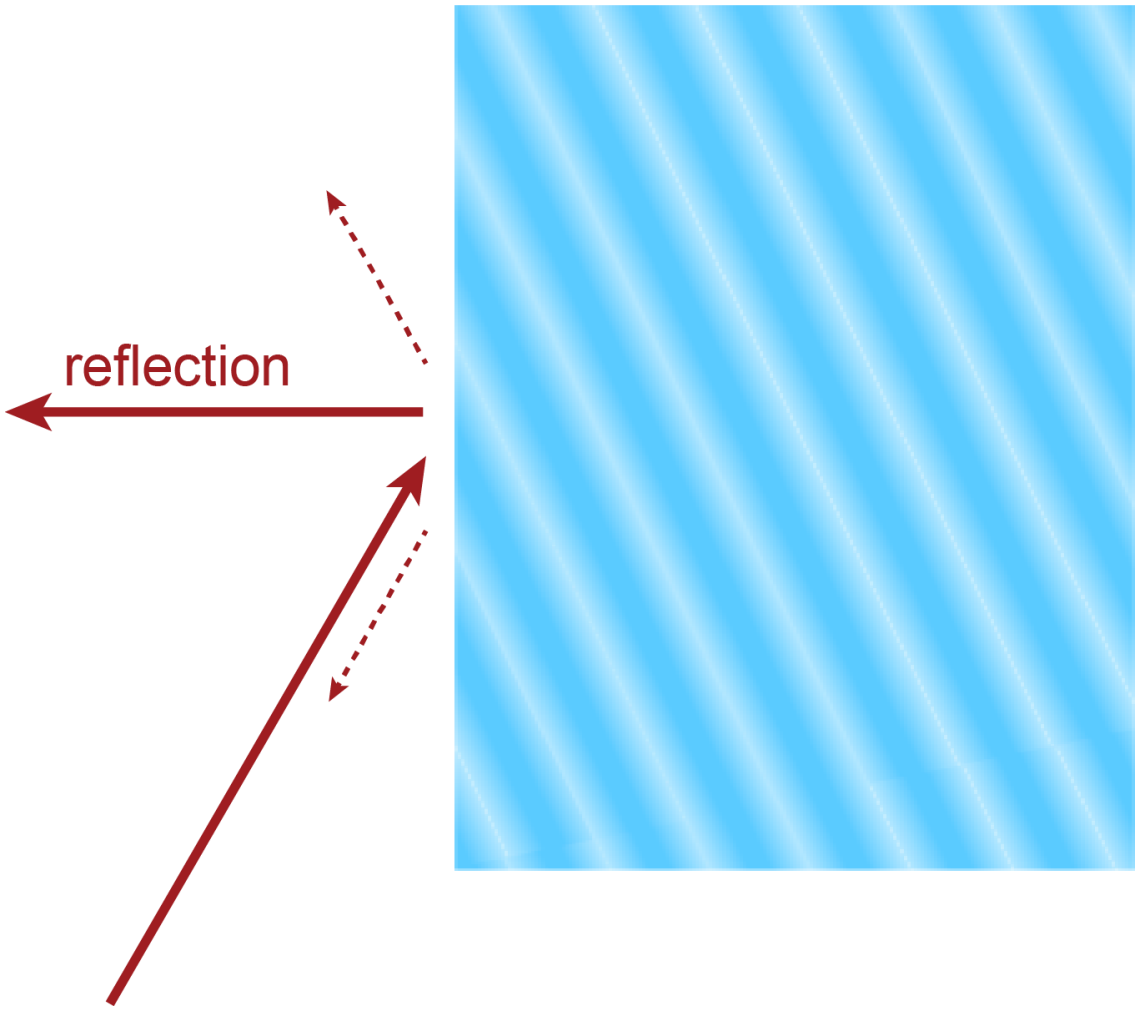
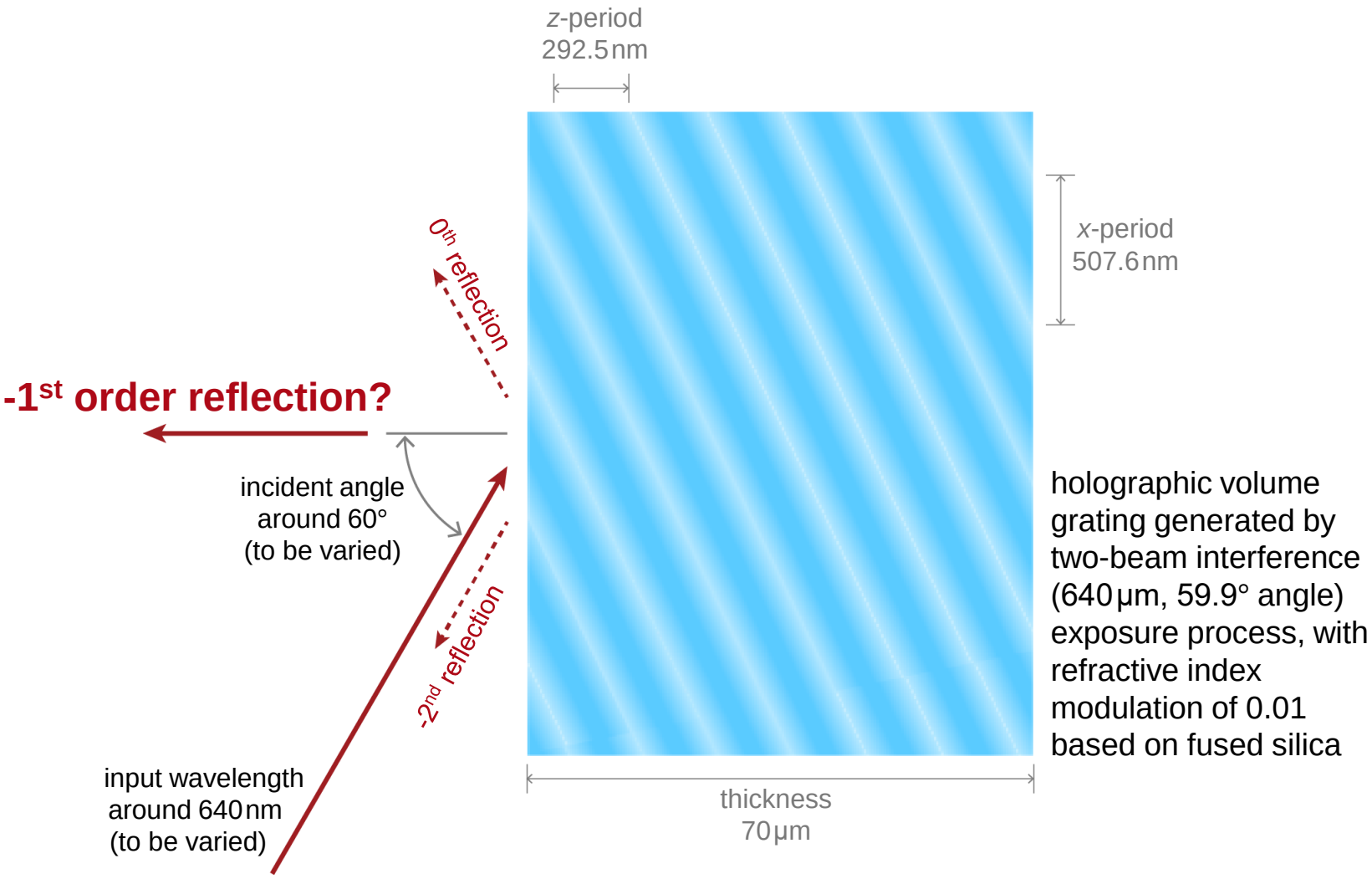
# Holographically Generated Volume Grating

# Abstract



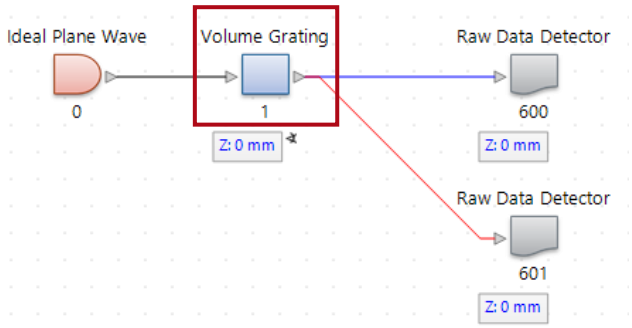

Holographic generated volume gratings, with a thickness much larger than the wavelength, normally exhibit a narrow bandwidth for the particular design wavelength and angle. Following the two-beam interference exposure process, a volume grating inside fused silica is generated and simulated with the rigorous Fourier modal method (FMM) in VirtualLab Fusion. Both the spectral and angular dependent reflection property of the grating are analyzed.

# Modeling Task

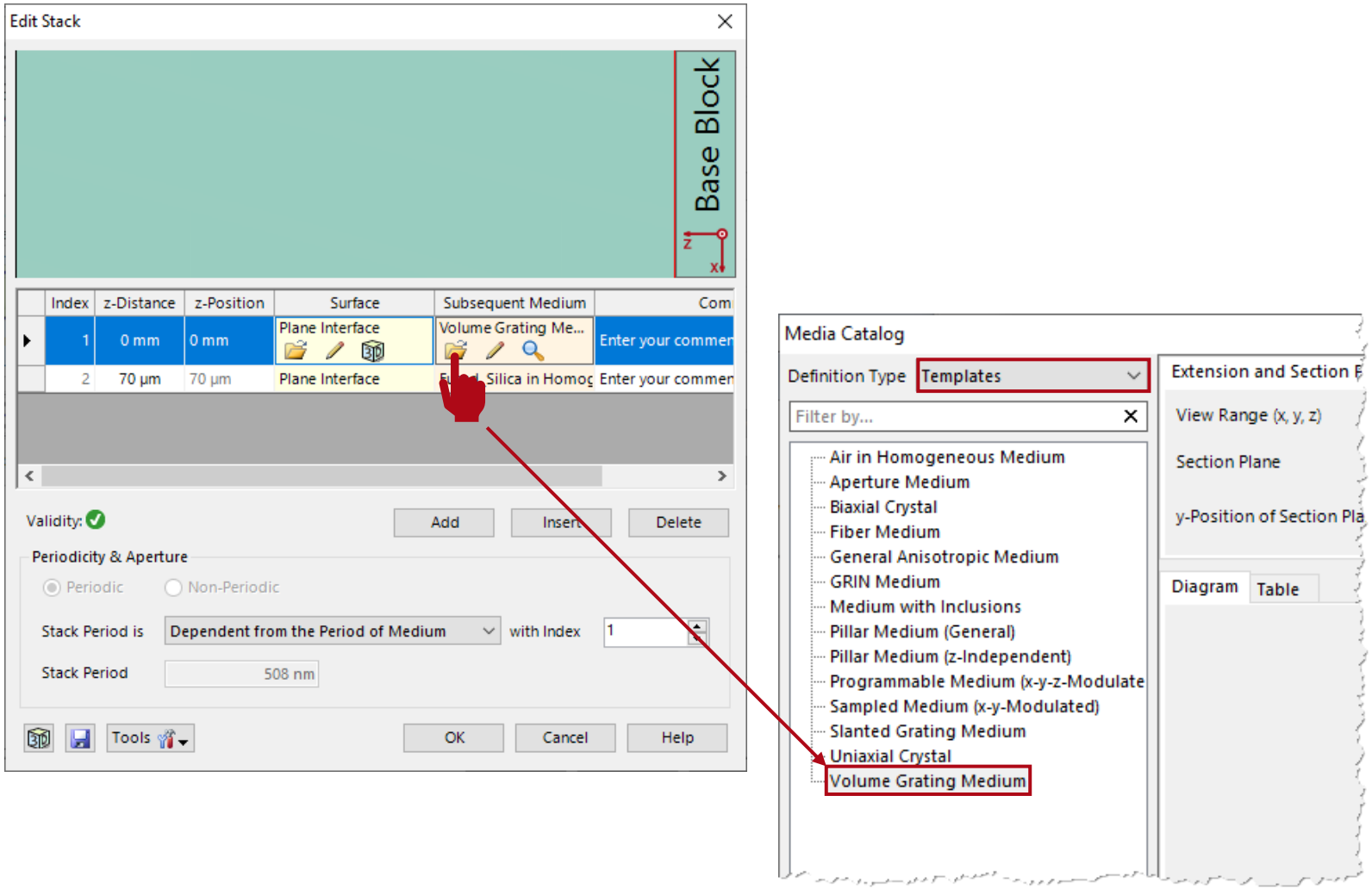



holographic volume grating generated by two-beam interference (640μm, 59.9° angle) exposure process, with refractive index modulation of 0.01 based on fused silica

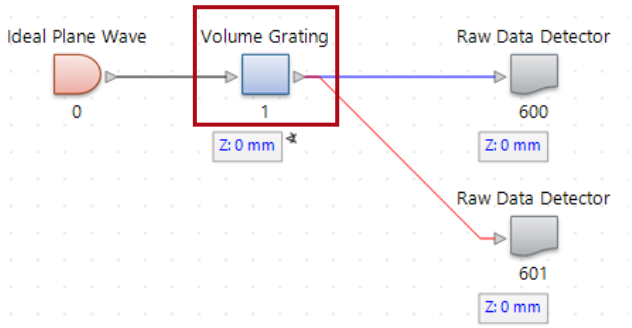
# Holographic Volume Grating



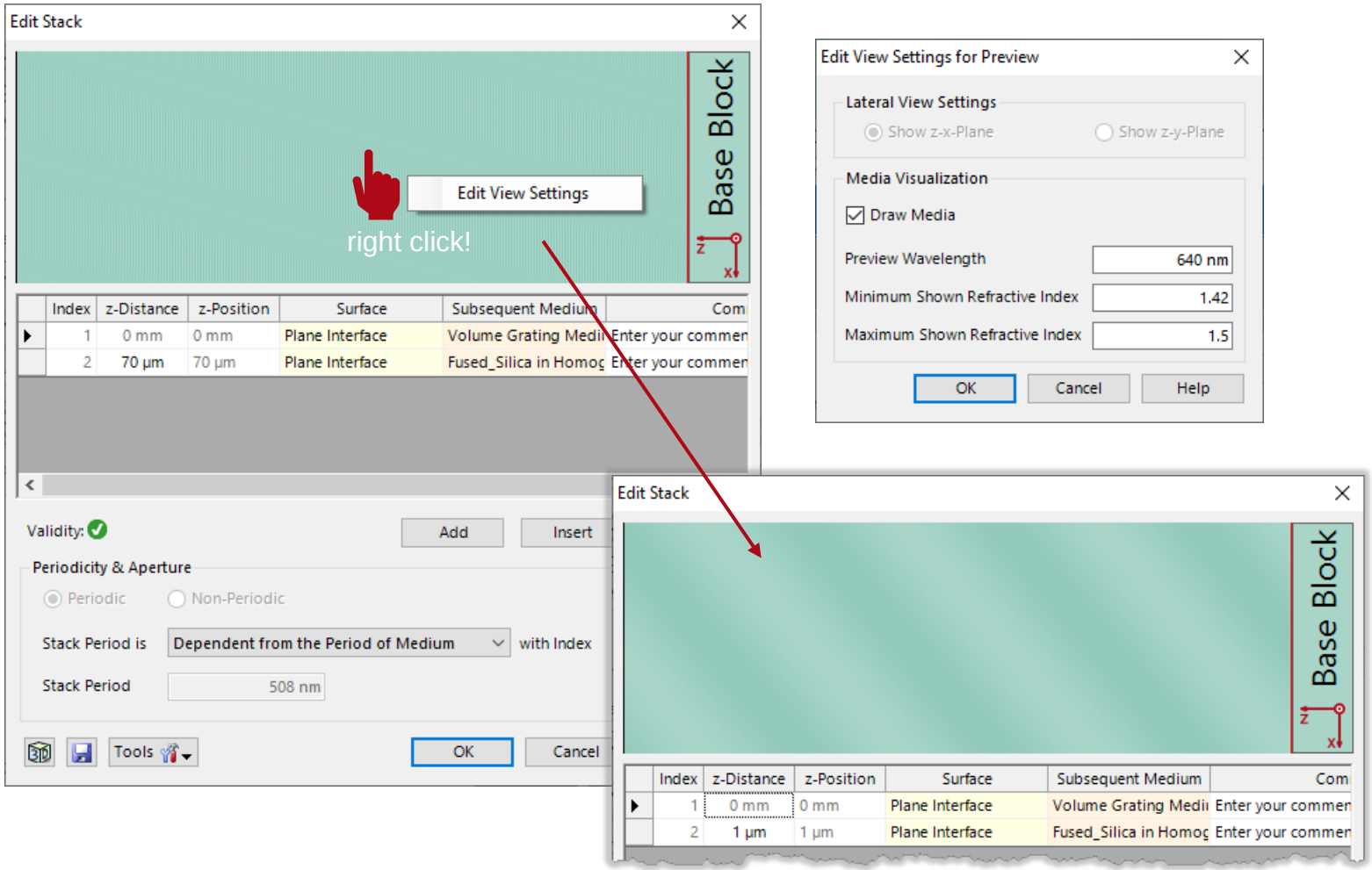

The holographic volume grating is generated by a specialized medium defined between two plane interfaces. It allows to configure the modulations of the refractive index, which was e.g., generated by holographic exposure. It can be found via *Templates > Volume Grating Medium*.



# Holographic Volume Grating

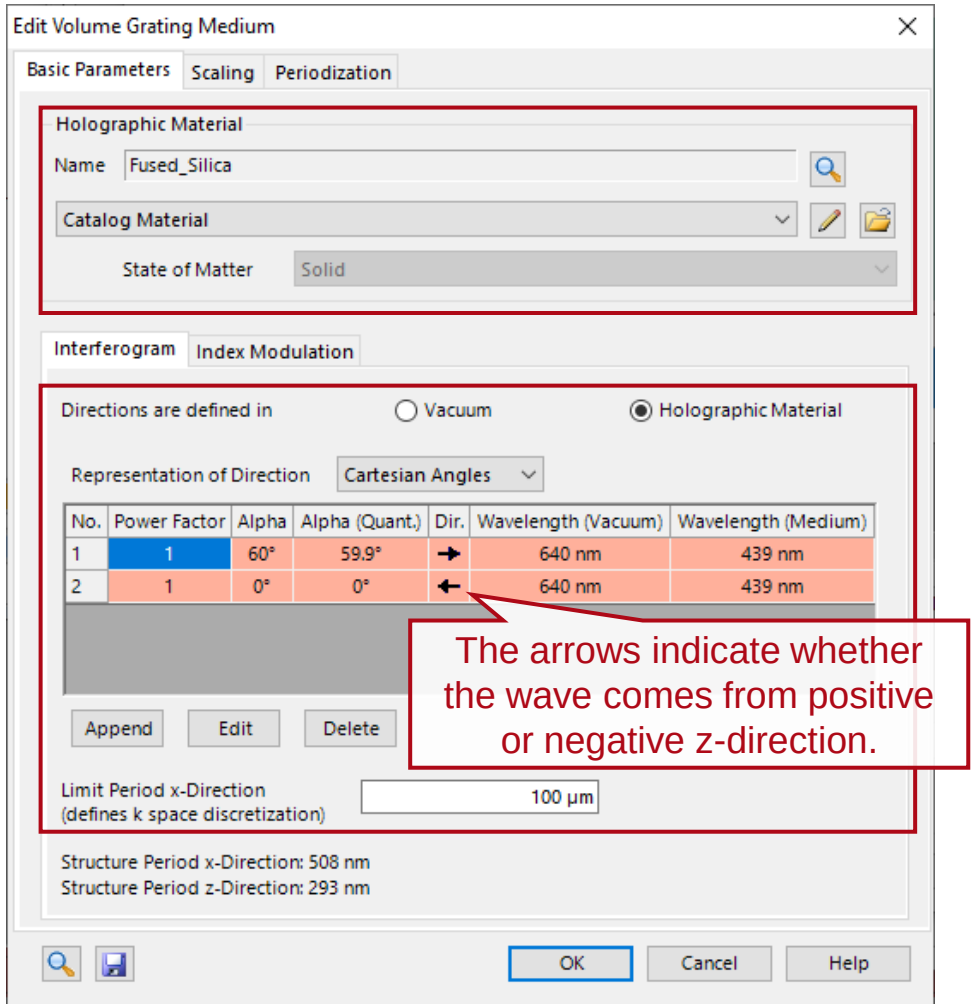



After adjusting the thickness and editing the view settings appropriately, the preview of the periodic grating structure can be seen.



# Volume Grating Medium

- In order to describe the volume grating VirtualLab simulates the interference pattern of a certain number on impinging waves.
- First, a *Holographic Material* has to be chosen, that provides the initial index of refraction.
- Further, the period and orientation of the index modulation are controlled by the angle of incidence (alpha), the wavelength of reference and signal wave.
- Moreover, by introducing a quantized k-space respectively incidence angle, the numerical effort can be reduced significantly.

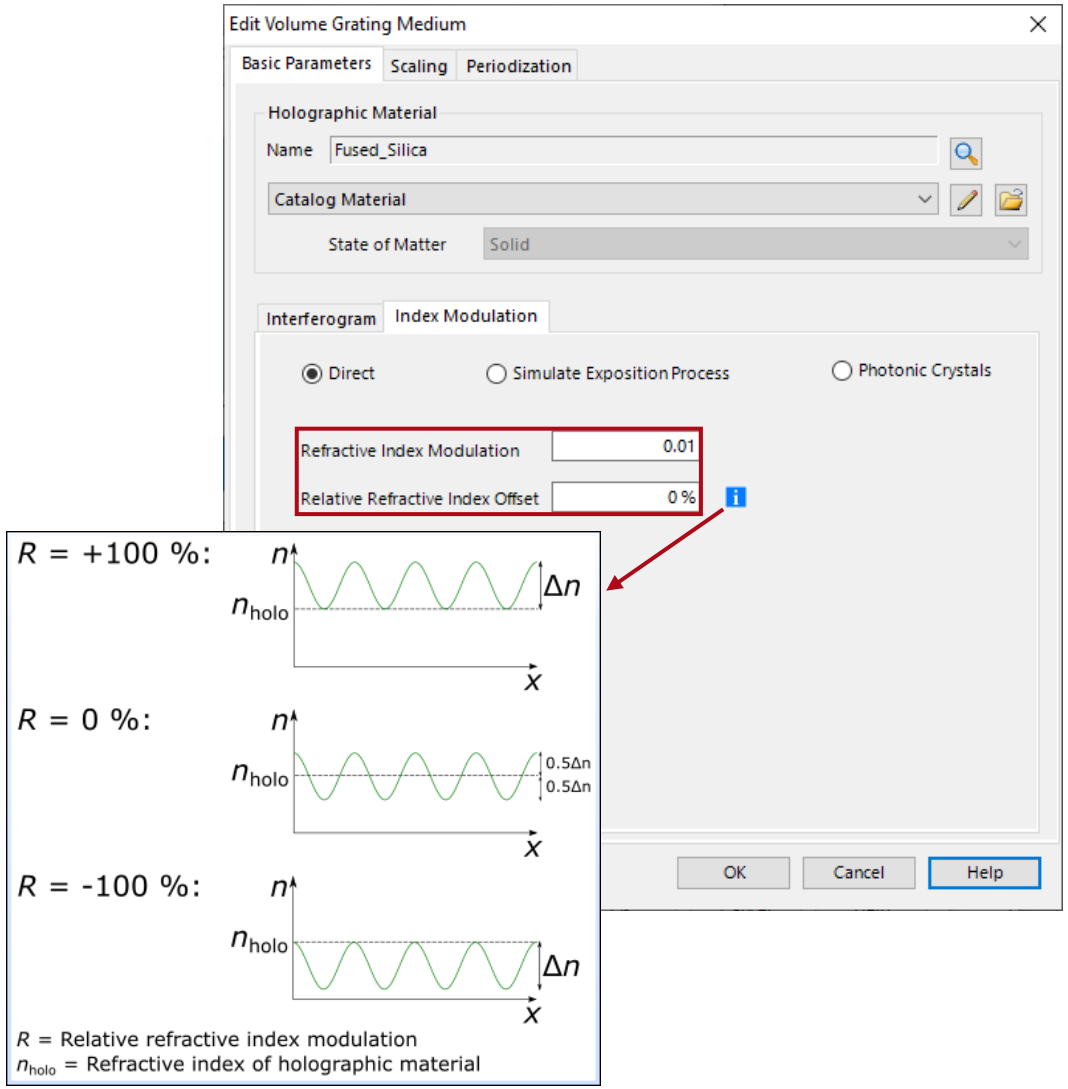


# Volume Grating Medium

- In this case the desired *Refractive Index Modulation* $\Delta n$ and the *Relative Refractive Index Offset* $R$ is defined by direct modulation mode. The refractive index $n(x, y)$ at a certain position is then calculated via

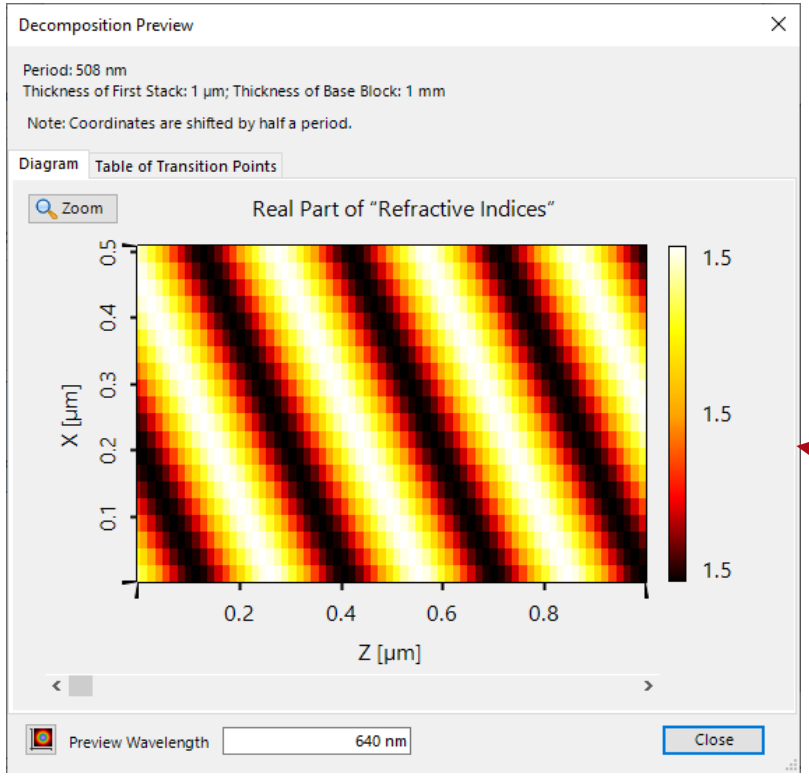
$$n(x, z) = n_{holo} + \left(\frac{\bar{w}(x, y)}{w_{max}} + \frac{R - 1}{2}\right) \cdot \Delta n$$

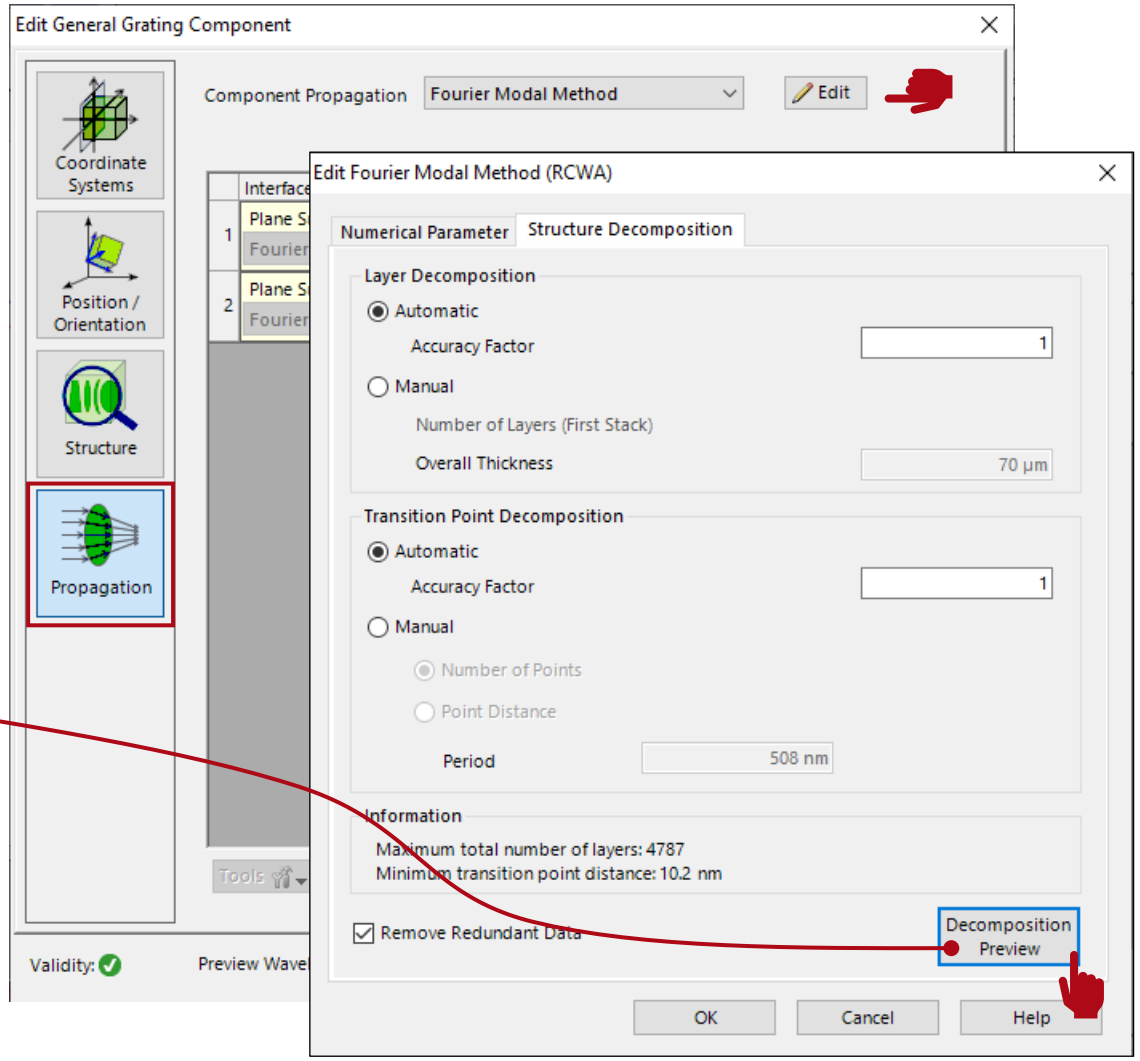
  $w_{max}$ can be an arbitrary value, as it cancels out in this case. $n_{holo}$ is the refractive index of the holographic material.
- For $R = +100\%$, the refractive index modulation is added to $n_{holo}$, for $R = -100\%$, it is subtracted from $n_{holo}$ and for intermediate values it is something in between. In particular, the case $R = 0$ means that the refractive indices range from $n_{holo} - \frac{\Delta n}{2}$ to $n_{holo} + \frac{\Delta n}{2}$.
- The effect of the *Relative Refractive Index Offset* $R$ is shown in the following experiment (Diffraction Efficiency vs. Wavelength)



# Advanced Options & Information

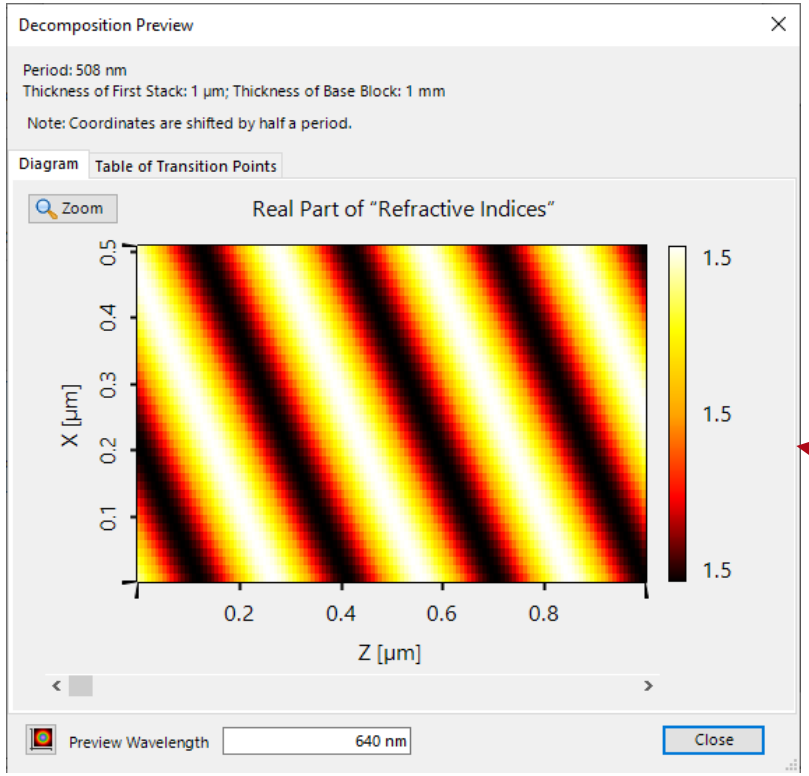
For the modeling, the modulation of the index has to be decomposed, what is done automatically. This can be checked and if necessary adjusted on the Structure Decomposition page.

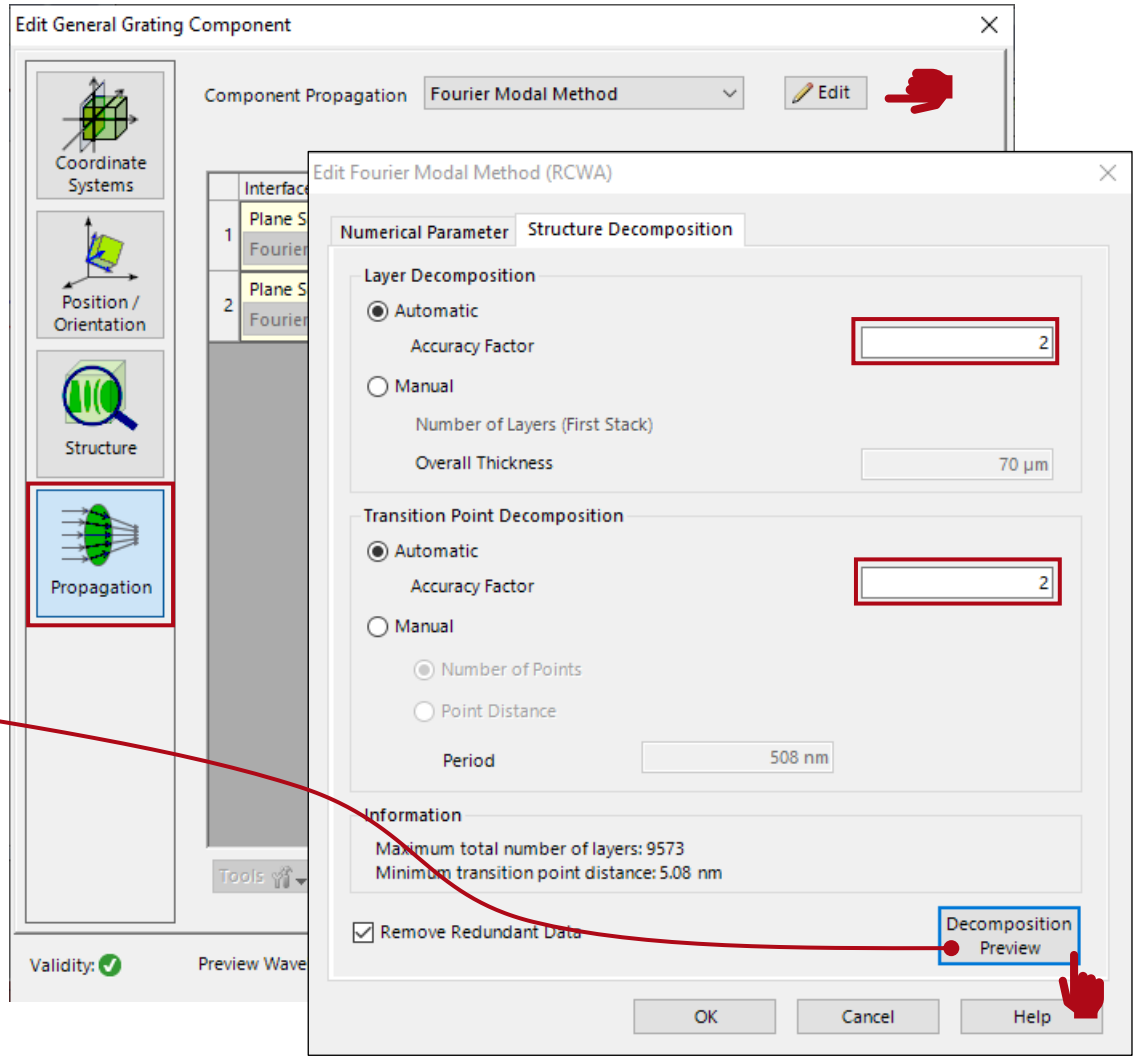


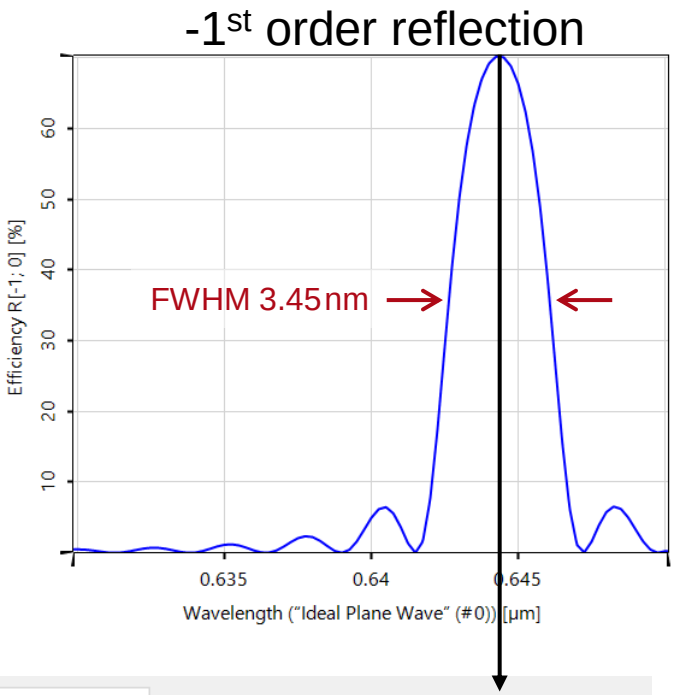
# Advanced Options & Information

If the numbers of layers and transition points are increased (e.g., by a factor of 2), the discretization becomes smoother, at the expense of an increased numerical effort.

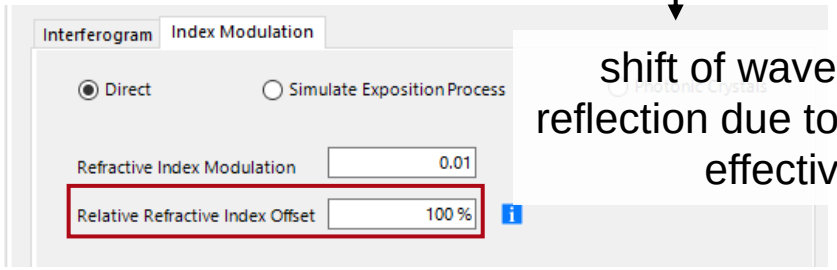


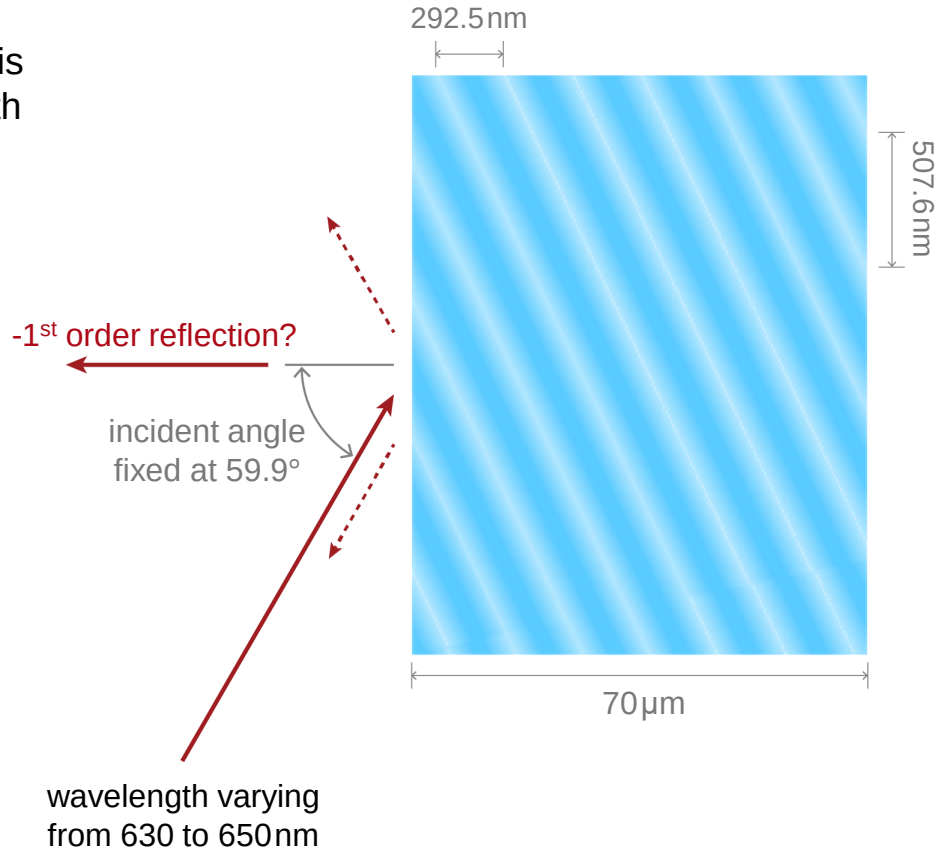
# Diffraction Efficiency vs. Wavelength




rigorous FMM analysis
for varying wavelength



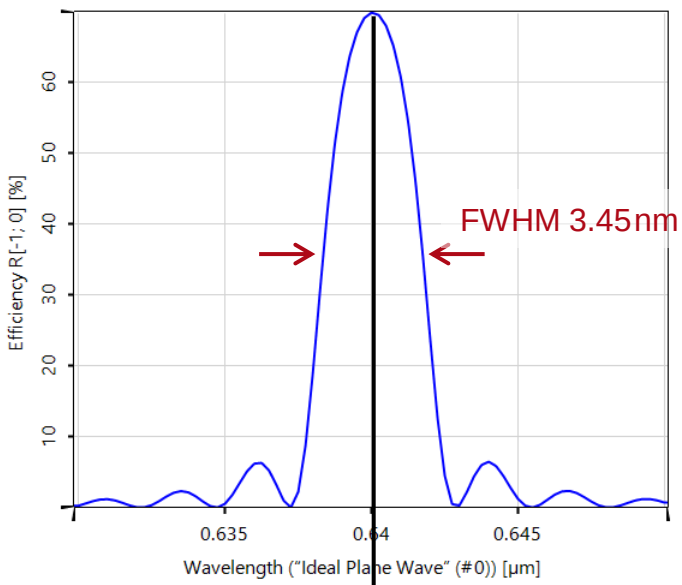

shift of wavelength dependent
reflection due to locally increased
effective refraction index



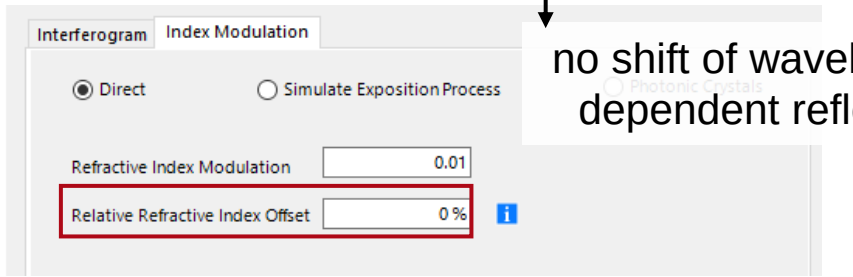

wavelength varying
from 630 to 650nm

# Diffraction Efficiency vs. Wavelength

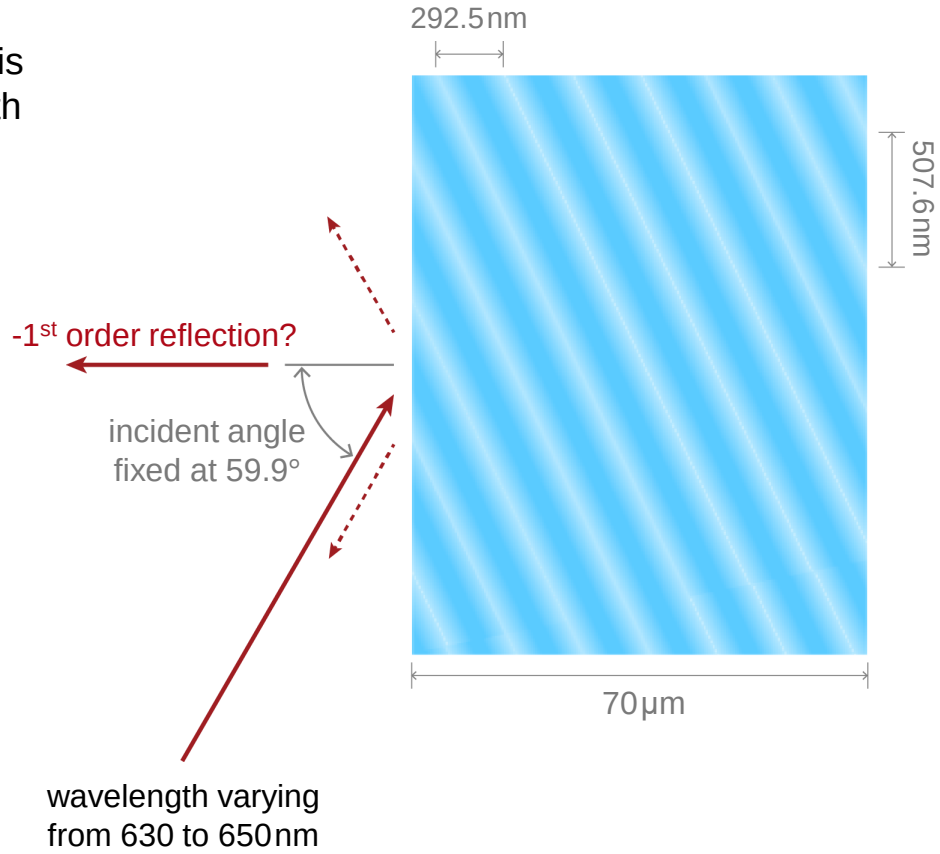
-1st order reflection




rigorous FMM analysis
for varying wavelength

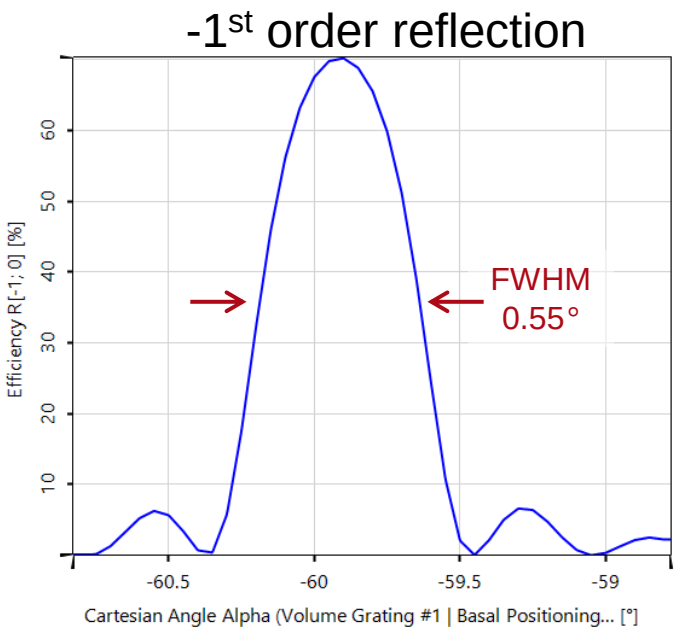



no shift of wavelength
dependent reflection

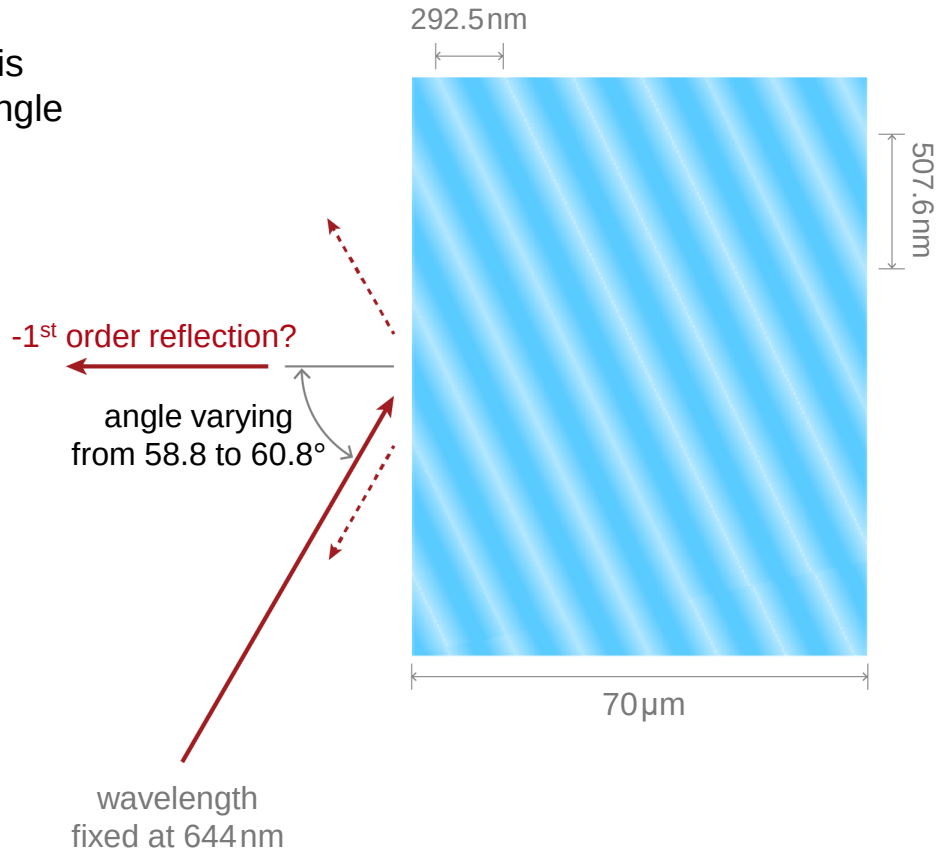



wavelength varying
from 630 to 650nm

# Diffraction Efficiency vs. Angle of Incidence




rigorous FMM analysis
for varying incident angle



# Document Information

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|---|---|
| title | Holographically Generated Volume Grating |
| document code | GRT.0003 |
| document version | 2.0 |
| software edition | VirtualLab Fusion Advanced |
| software version | 2021.1 (Build 1.180) |
| category | Feature Use Case |
| further reading | - Configuration of Grating Structures by Using Special Media<br>- Grating Order Analyzer<br>- Modeling of Gratings within Optical System - Discussion at Examples |