G.014 Rigorous analysis of diffractive 1:6 beam splitter.

The application scenario shows how to perform a rigorous analysis of a diffractive 1:6 beam splitter optimized by the diffractive optics toolbox.

Keywords: Grating, Grating Component, Fourier Modal Method, diffractive beam splitter, Computer Generated Hologram (CGH), Phase Plate

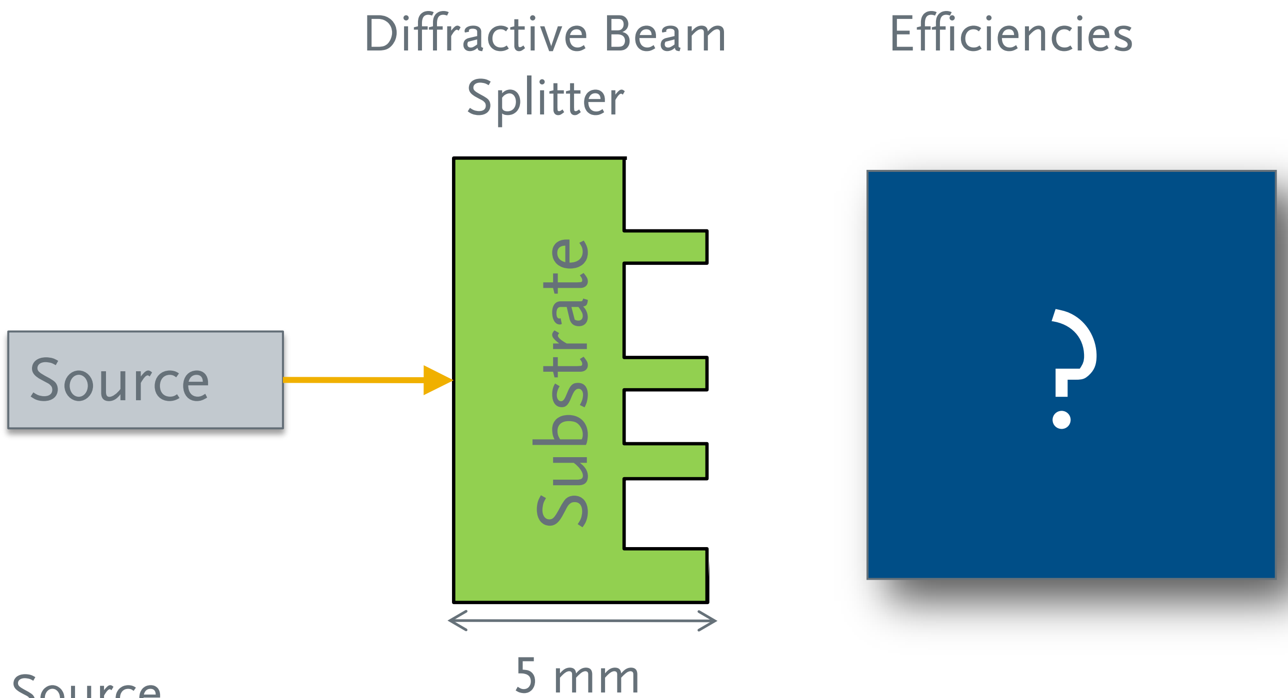
Required Toolboxes: Grating Toolbox

Related Application Scenarios: 246.01

Related Tutorials: G.001a (Usage of Grating Components),
144.01 (Structure Design)

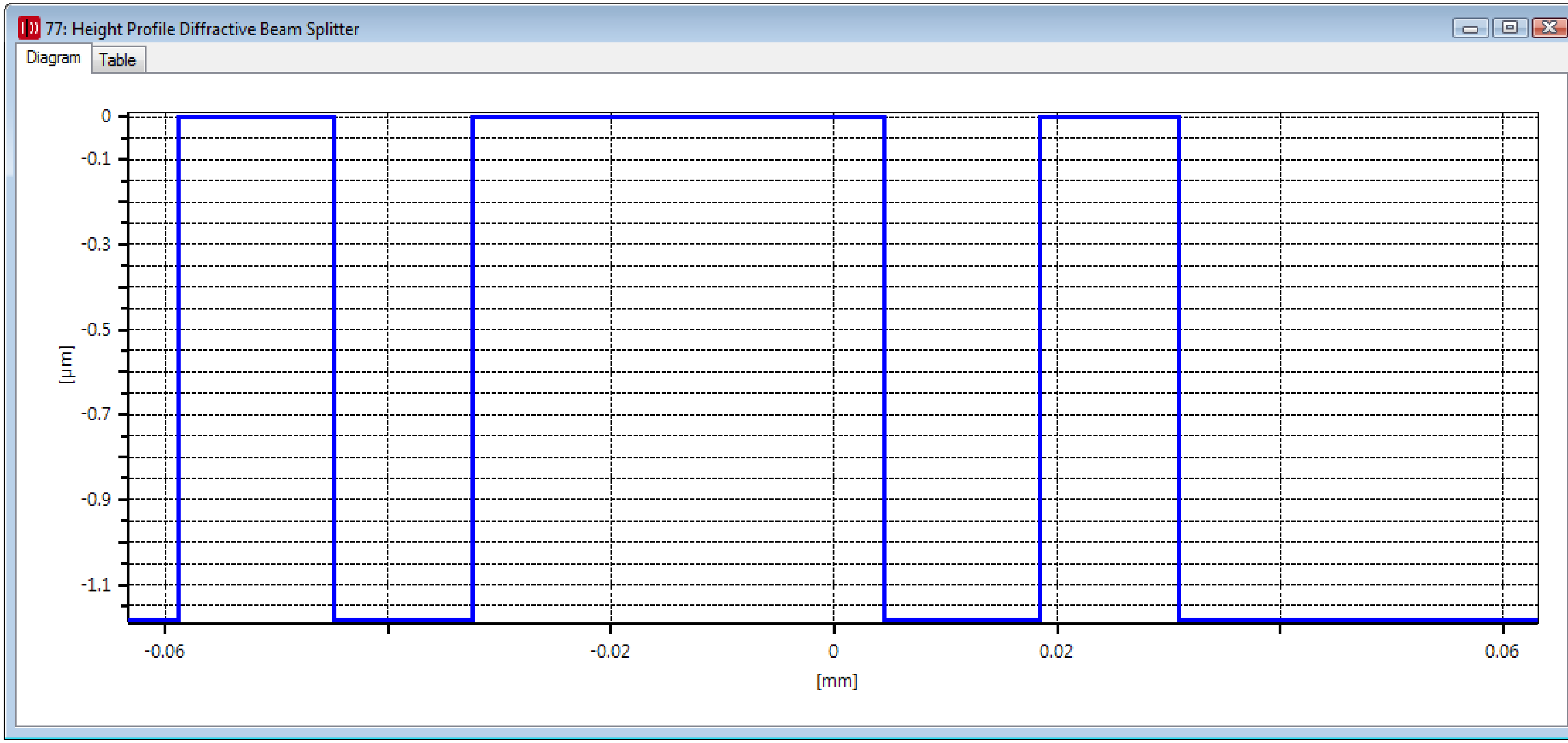
LIGHTTRANS

Modeling Task



Plane Wave Source
Wavelength: 1064 nm
Polarization: Linearly polarized
Incident angle: 0°

Modeling Task



Sample height profile of a diffractive 1:6 beam splitter as optimized by the IFTA algorithm of VirtualLab™.

Modeling Task

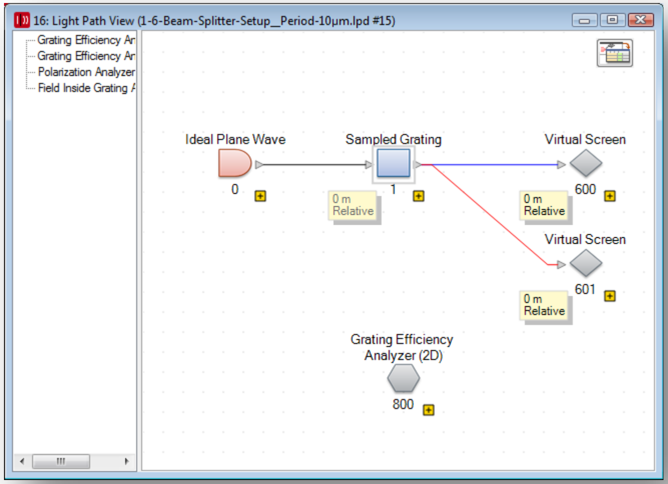
- Beam Splitter was optimized using paraxial approximations. Since the beam splitter is paraxial the period is very large (126.5 µm).

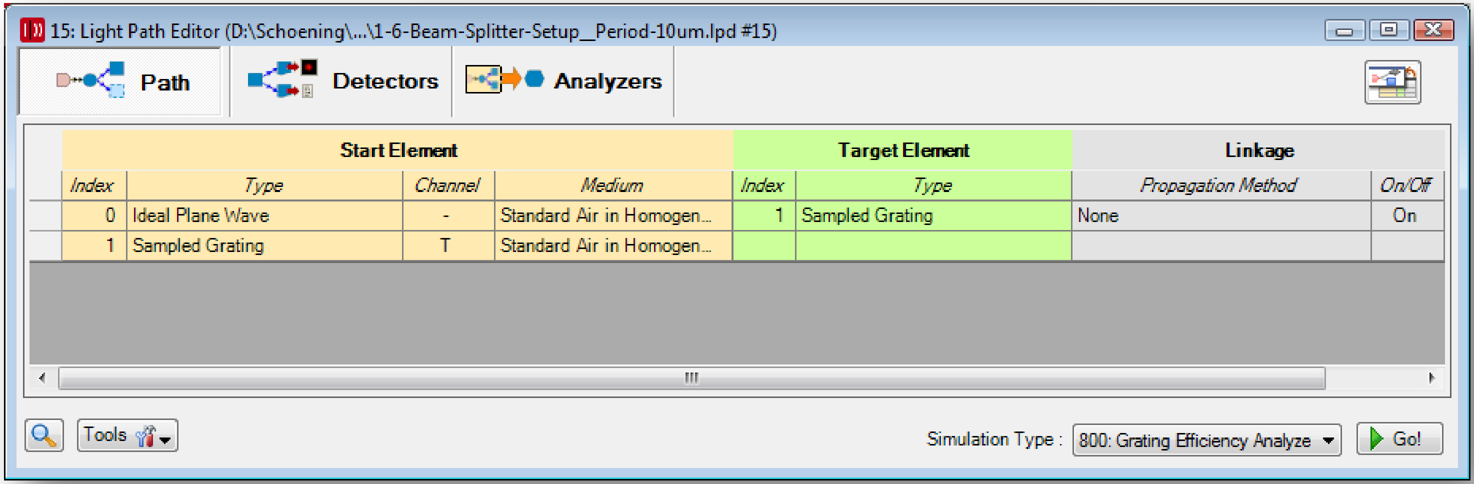
- It should be checked down to which period the paraxial design model will still be valid. Thus, for comparison the grating is analyzed by means of the rigorous Fourier Modal Method (FMM).

Modeling in VirtualLab™

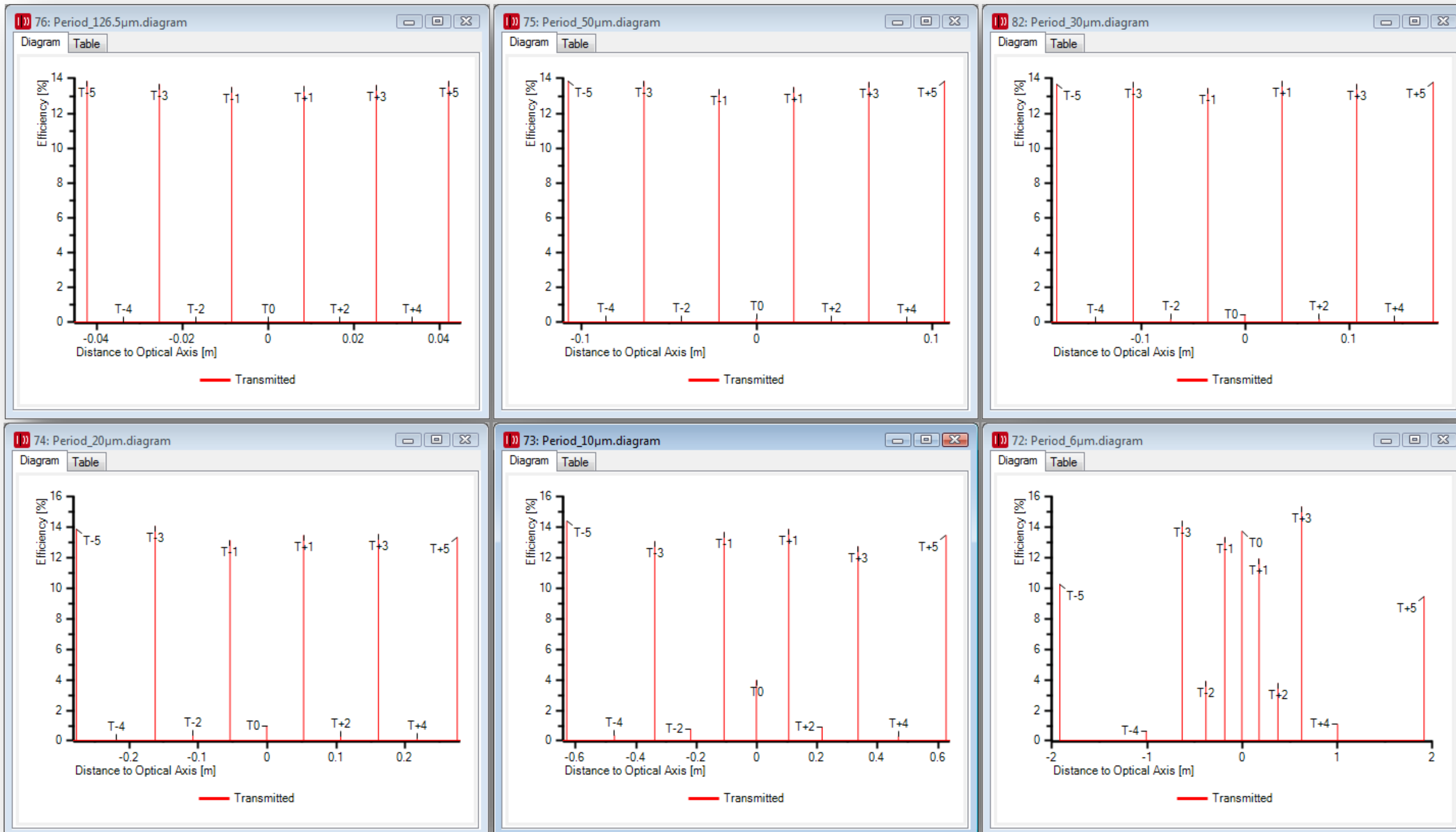
- The transmission as generated by the IFTA optimization document can be converted into a Sampled Interface (in a Double Interface Component) using Design > Structure Design (see Tutorial 144.01).
- For the rigorous analysis, this sampled interface can then be placed in a stack of a Grating Component.
- The sampled interface is scaled to different periods using the *Scaling in x-Direction* and adapting its *Period* accordingly. These two settings are available in the edit dialog of any interface.

Light Path Diagram





Simulation Results for FMM



Diffraction efficiencies for the following periods:

126.5 µm	50 µm	30 µm
20 µm	10 µm	6 µm

Conversion to wavelength units

Period in µm	Period in λ	Smallest Feature in µm	Smallest Feature in λ
126.5 µm	118.9 λ	12.43 µm	11.7 λ
50 µm	47.0 λ	4.91 µm	4.6 λ
30 µm	28.2 λ	2.95 µm	2.8 λ
20 µm	18.8 λ	1.97 µm	1.8 λ
10 µm	9.4 λ	0.98 µm	0.9 λ
6 µm	5.6 λ	0.59 µm	0.6 λ

Conclusion

- VirtualLab™ allows rigorous analysis of arbitrary surface gratings.
- If the smallest features become smaller than roughly three times the wavelength, rigorous analysis shows a larger uniformity error than designed, a zeroth order as well as non-vanishing even orders.
- This provides strong evidence that the Thin Element Approximation (TEA) is not valid for these conditions.
- Thus optical elements designed with the IFTA optimization (which uses TEA) should be verified with the rigorous FMM if the smallest feature size is less than three times the wavelength.