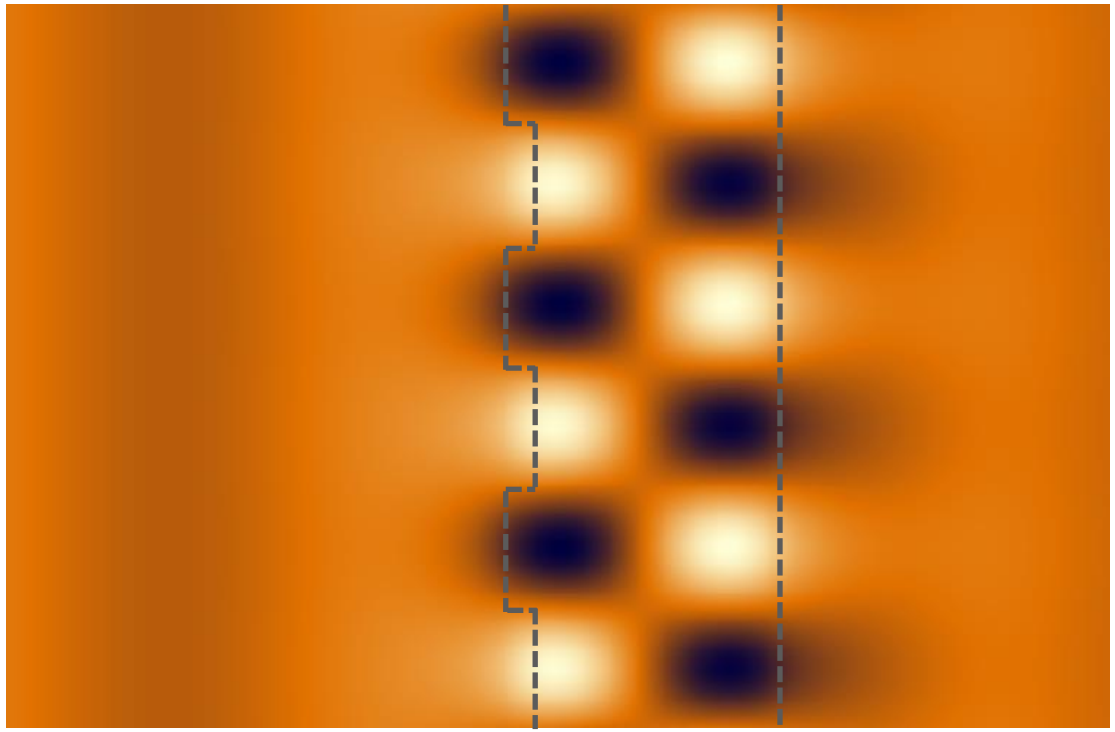
LIGHTTRANS

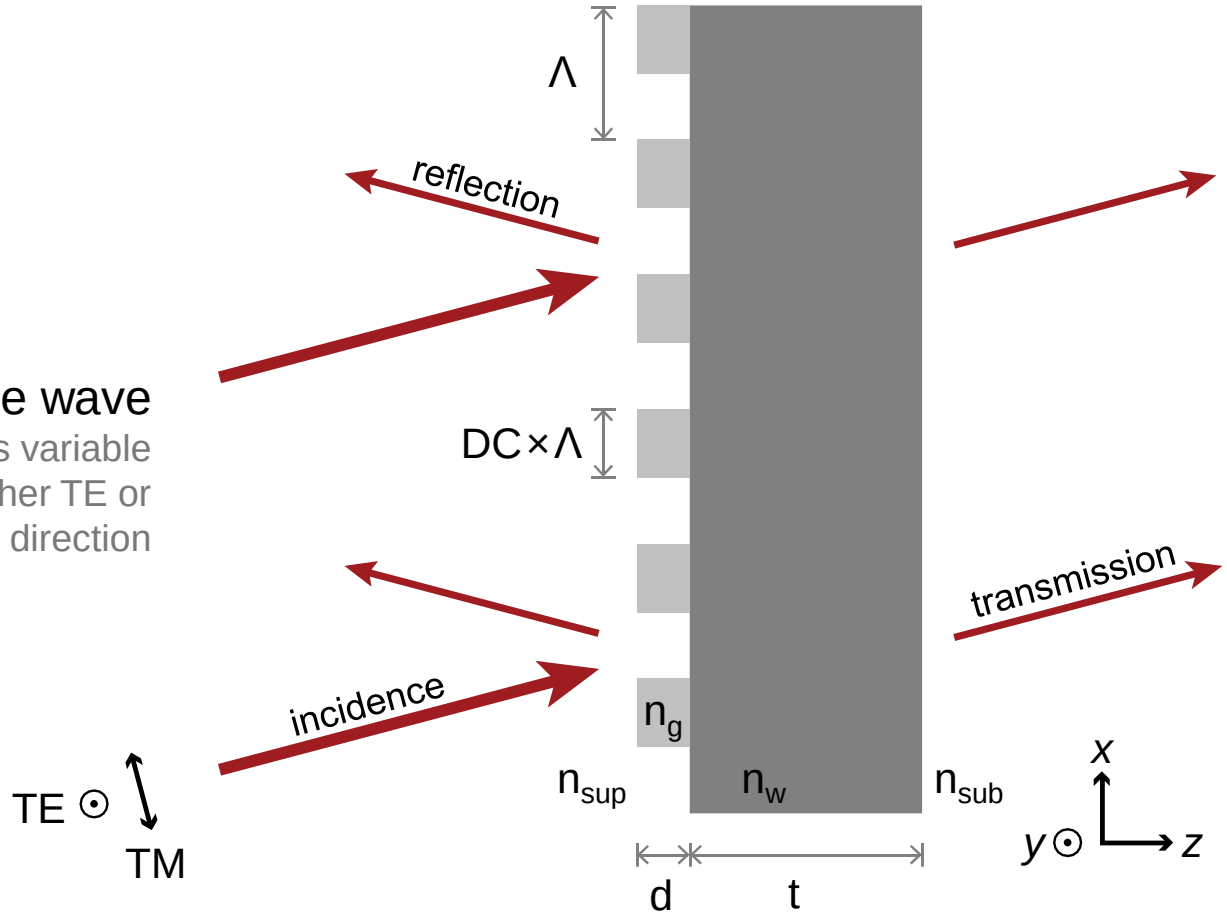
Rigorous Analysis of Resonant Waveguide Gratings

Abstract



Resonant waveguide gratings (RWG), due to their tunability in e.g. wavelength, phase, and polarization, are applied in research and industry for various purposes. The structure of an RWG contains a thin high-refractive-index waveguide film that is in contact with a grating. The waveguide supports several guided modes, and, depending on the thickness, the number of modes varies. In this example, we apply the Fourier modal method (FMM) within VirtualLab Fusion to analyze the property of RWG rigorously.

Modeling Task



grating parameters

- grating period $\Lambda = 350\,nm$
- duty cycle $DC = 0.5$
- grating height $d = 25\,nm$
- refractive indices $n_{sub} = 1.6$, $n_g = n_w = 2.4$, $n_{sup} = 1.0$

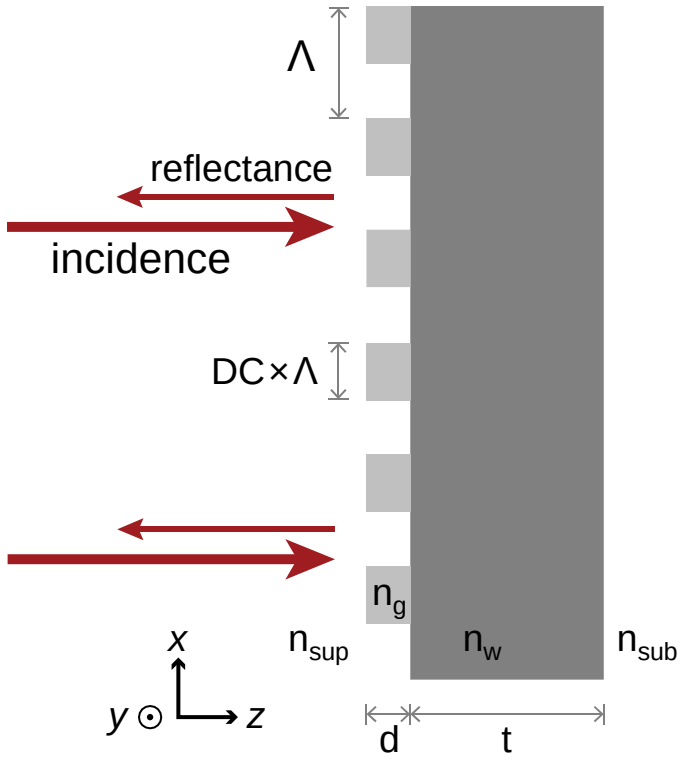
input plane wave

- wavelength λ as variable
- polarization either TE or TM direction

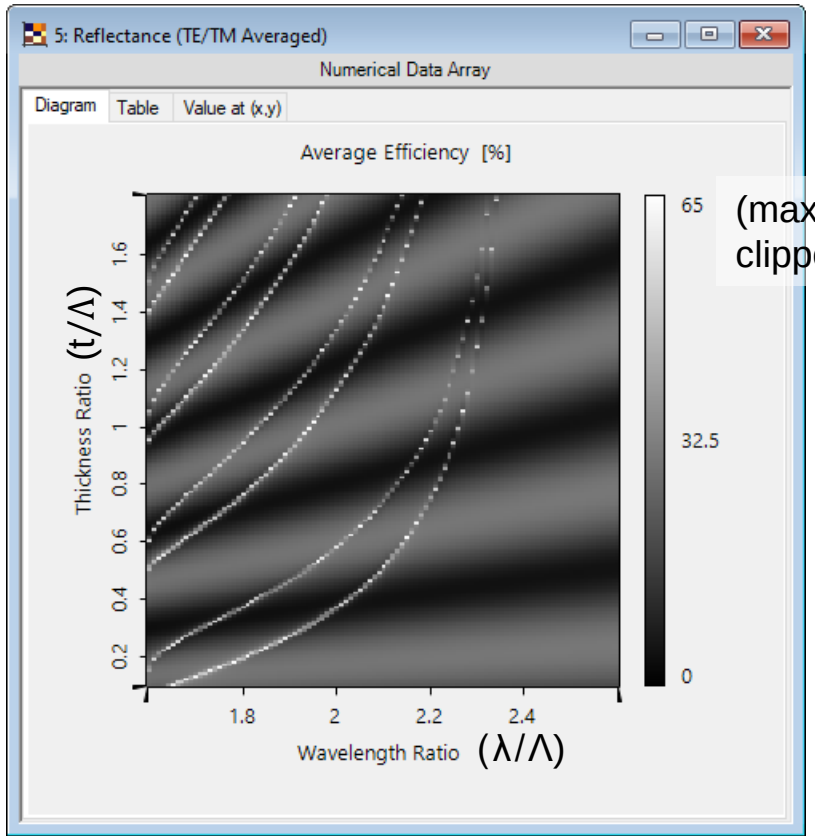
How to rigorously analyze the response (e.g. reflectance) of the resonant waveguide grating, with respect to different wavelength (λ) and waveguide thickness (t)?

Reflectance with Varying Wavelength and Thickness

wavelength (λ) range within [1.6Λ, 2.6Λ]



thickness (t) range within [0.1Λ, 1.8Λ]

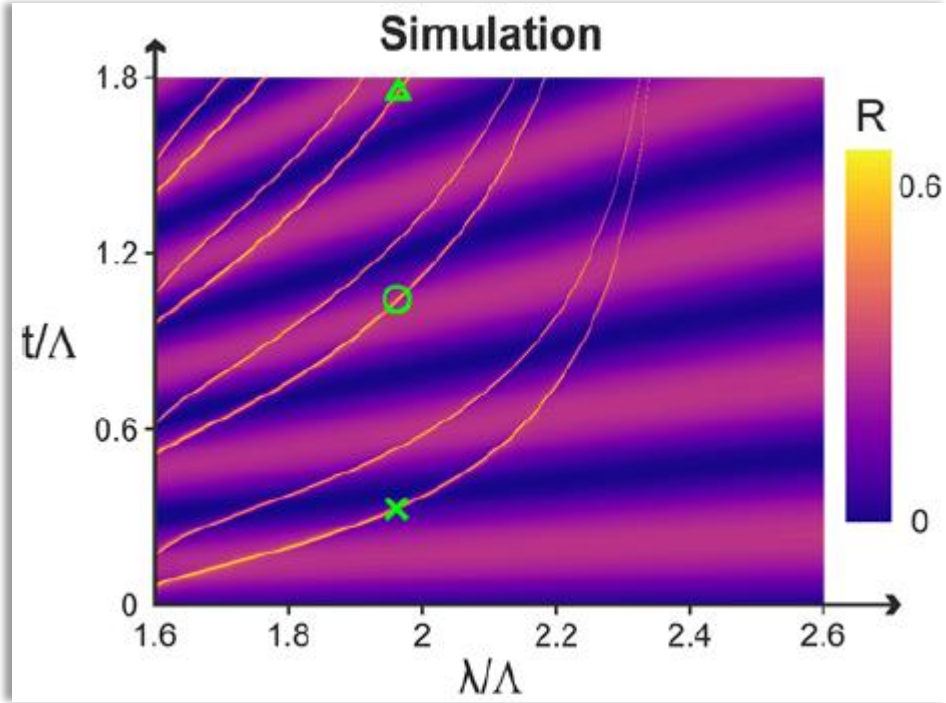


(maximum clipped to 65%)

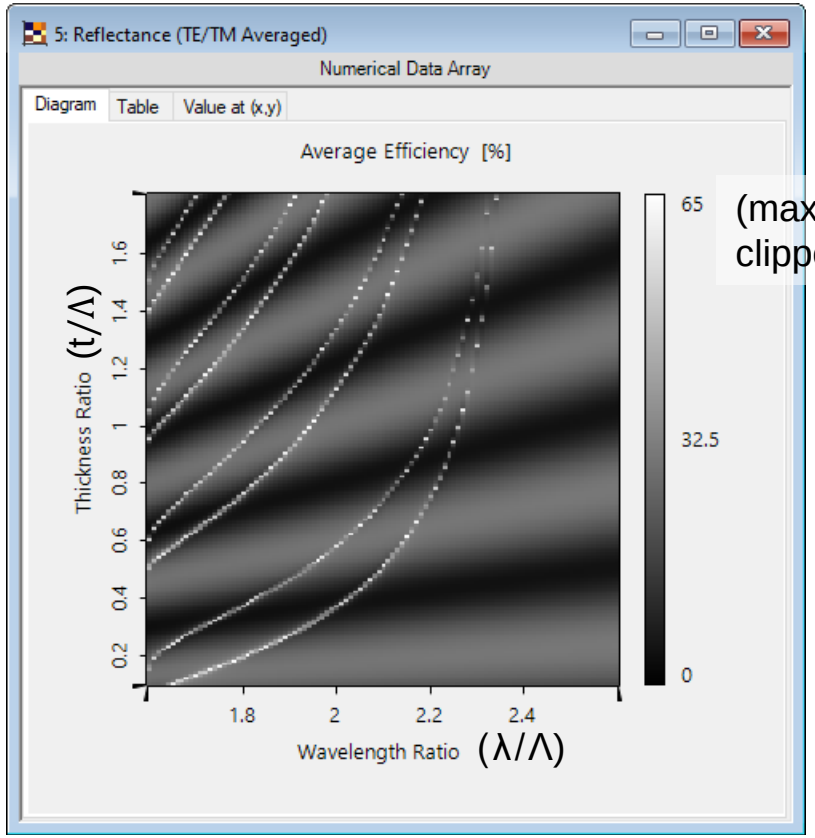
Reflectance with Varying Wavelength and Thickness

Simulation result from reference:

G. Quaranta, G. Basset, O. J. F. Martin, and B. Gallinet, Laser & Photonics Reviews 2018, 12, 1800017. [Fig. 3 a)]



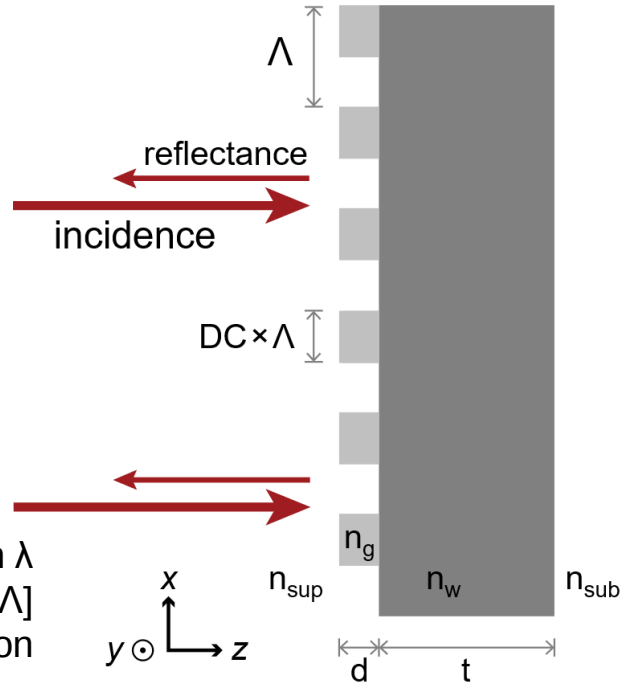
Simulation result from VirtualLab Fusion



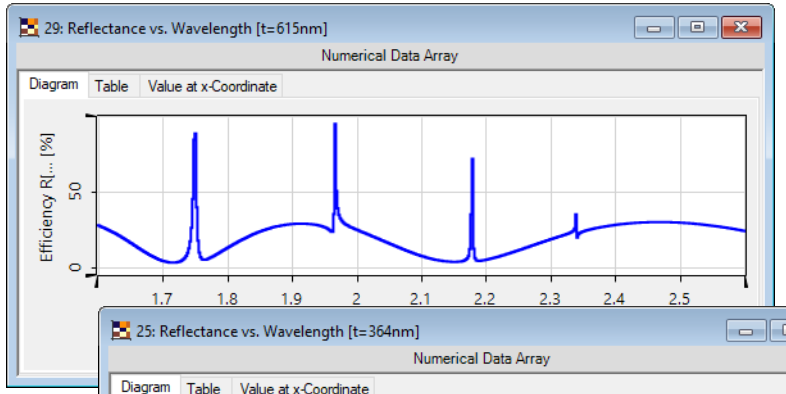
(maximum clipped to 65%)

Reflectance at Particular Waveguide Thicknesses

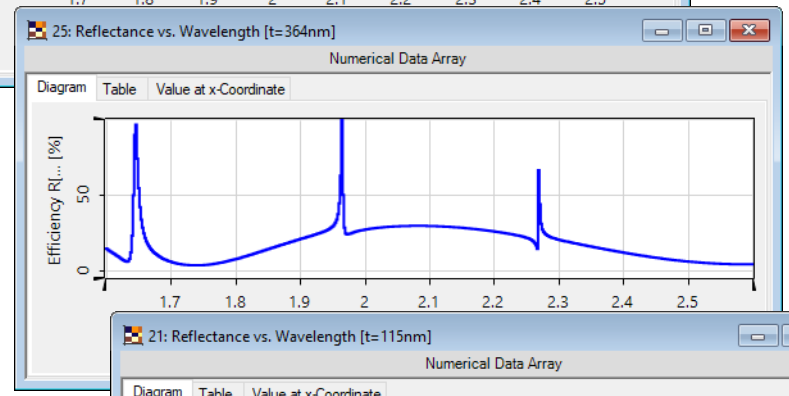
- varying wavelength λ within [1.6Λ, 2.6Λ]
  - TE polarization



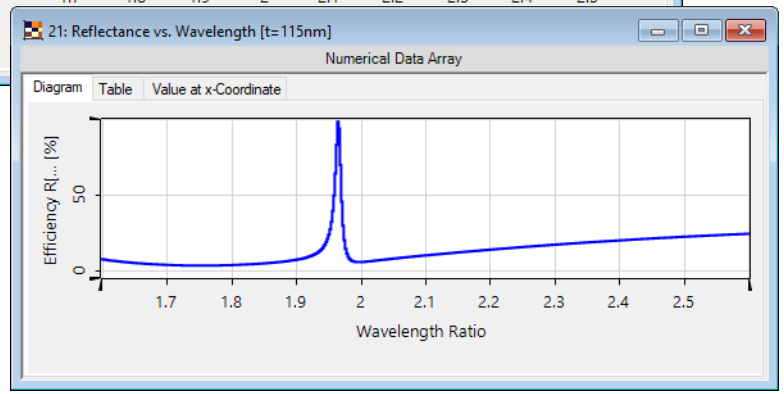
waveguide thickness t=615nm



t=364nm



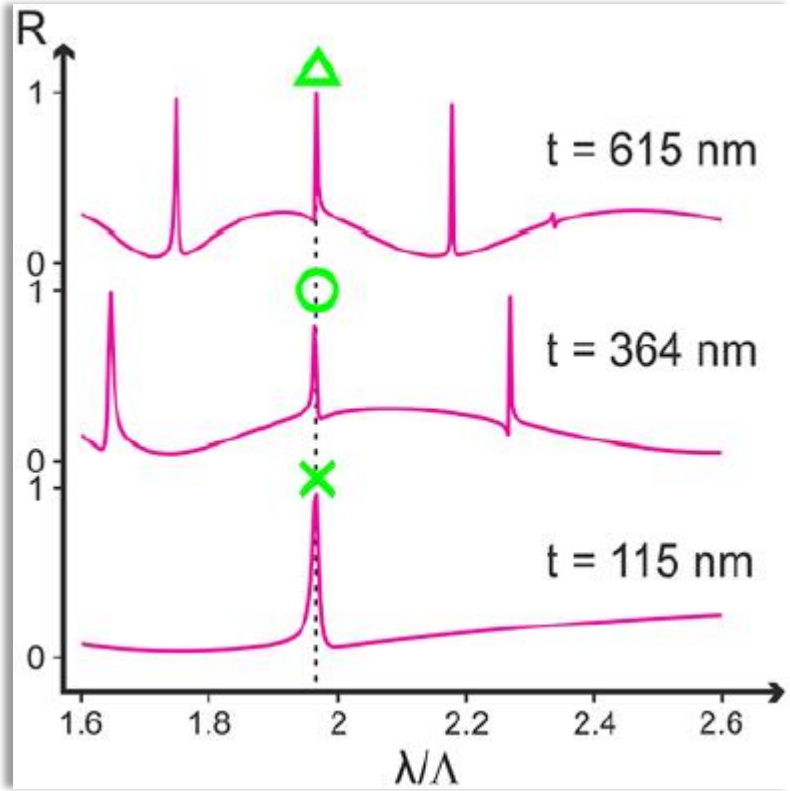
t=115nm



Reflectance at Particular Waveguide Thicknesses

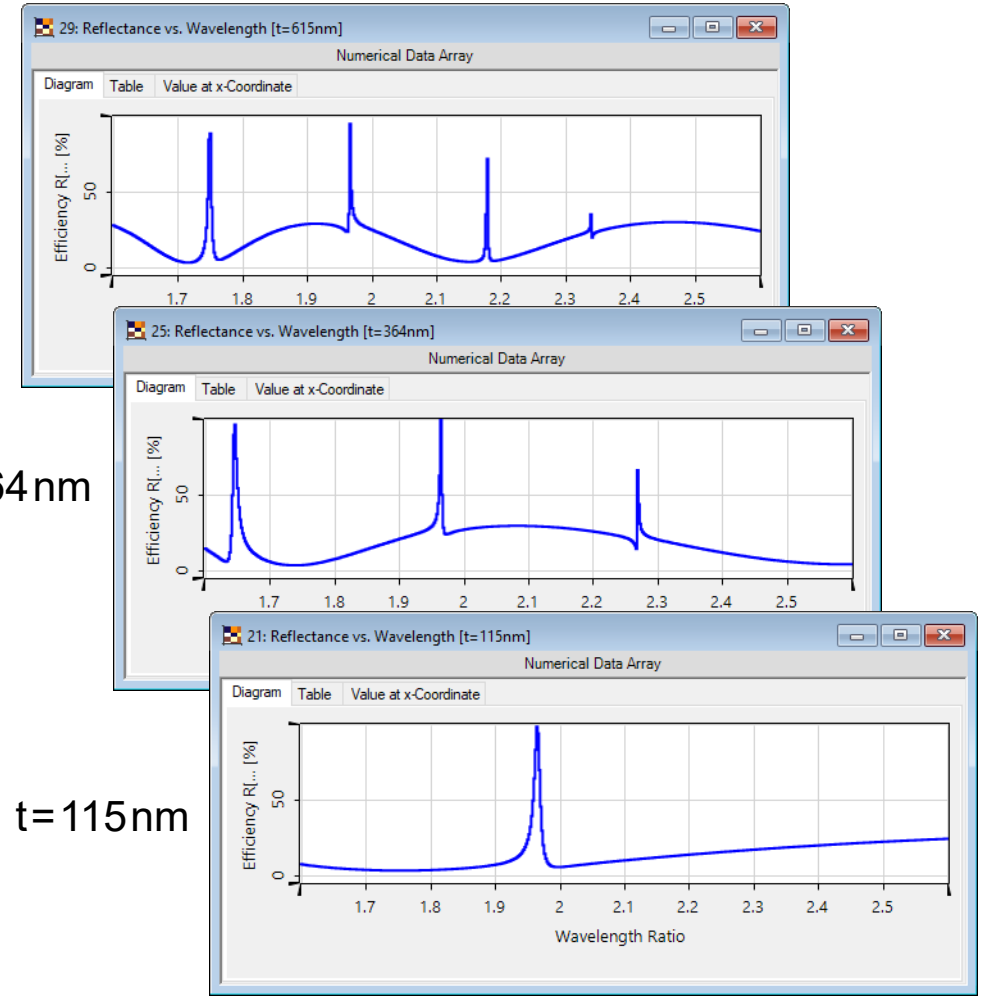
simulation result from reference:

G. Quaranta, G. Basset, O. J. F. Martin, and B. Gallinet, Laser & Photonics Reviews 2018, 12, 1800017. [Fig. 3 c)]



simulation results from VirtualLab Fusion

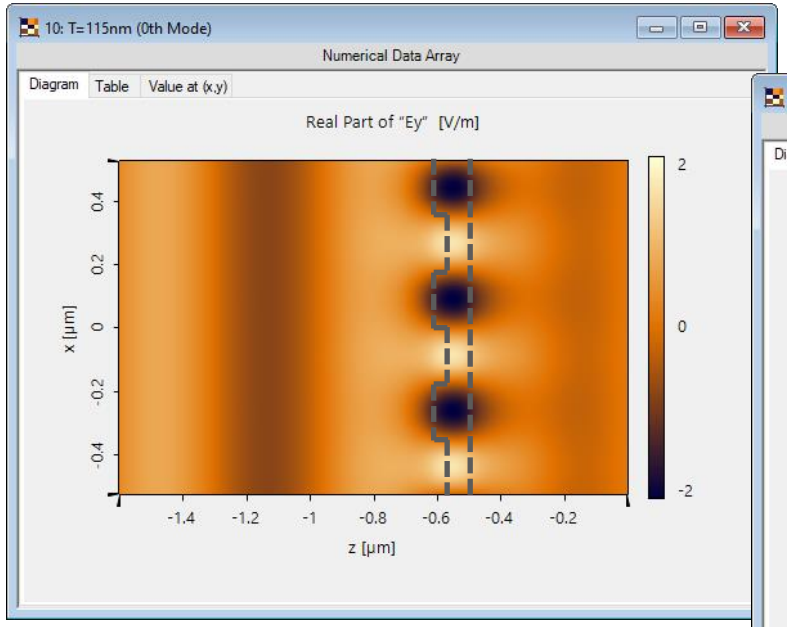
waveguide thickness t=615nm



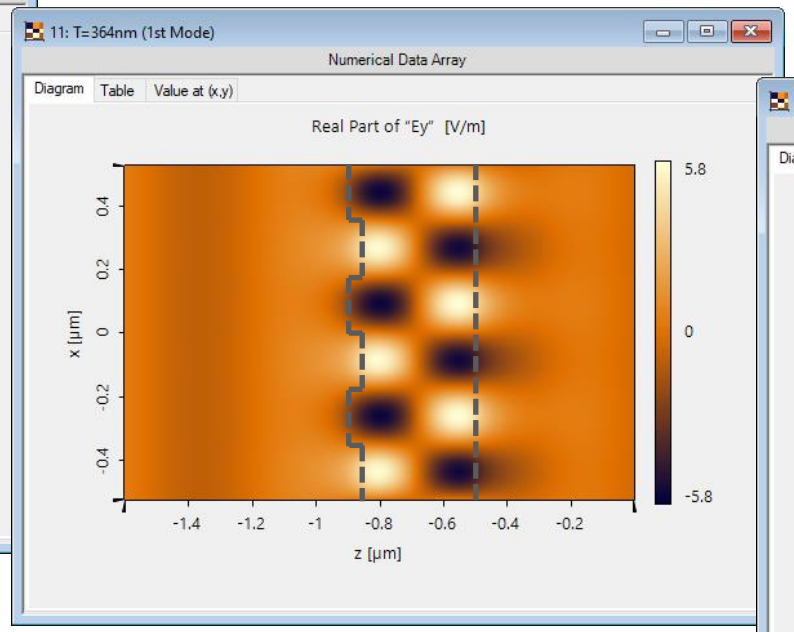
t=364nm

t=115nm

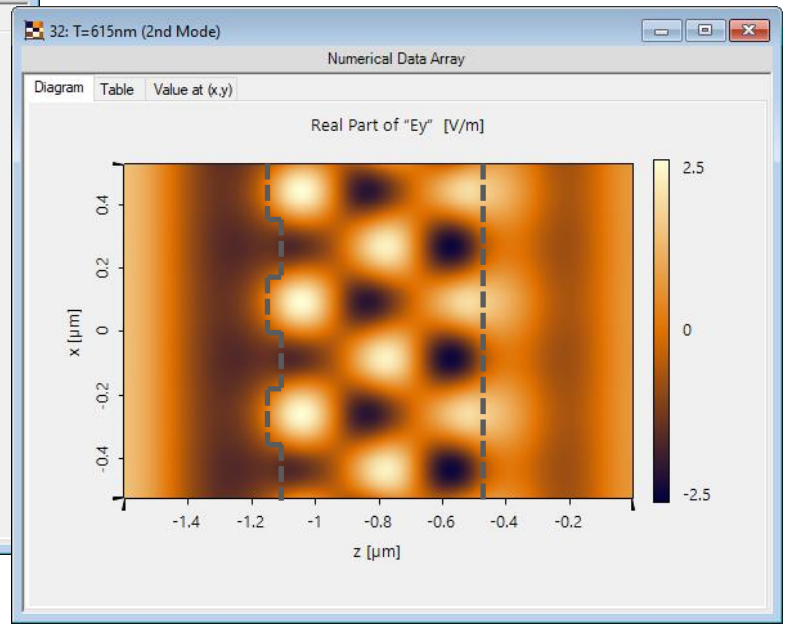
Resonance Modes Visualization (@λ=687 nm)



electric field (E_y) in the resonant waveguide grating, with thickness of 115 nm

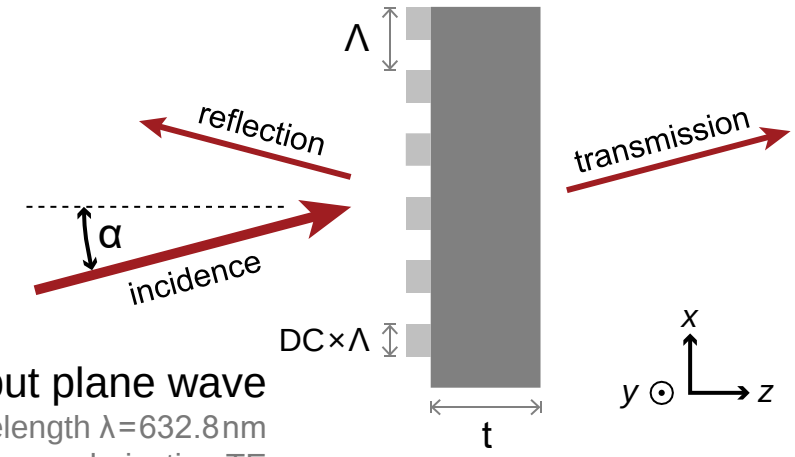


electric field (E_y) in the resonant waveguide grating, with thickness of 364 nm



electric field (E_y) in the resonant waveguide grating, with thickness of 615 nm

Angular Sensitivity Analysis (t=364nm @λ=632.8nm)



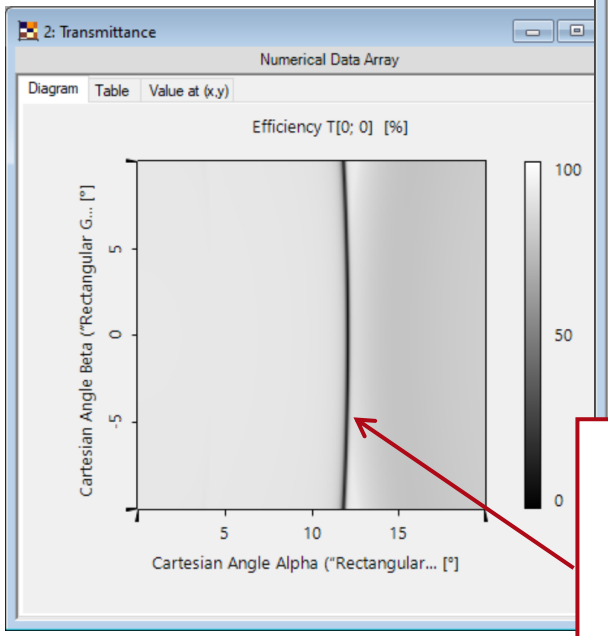
input plane wave

- wavelength λ=632.8nm
- polarization TE
- varying incidence angle
  α from 0° to 20°
  β from -10° to 10°

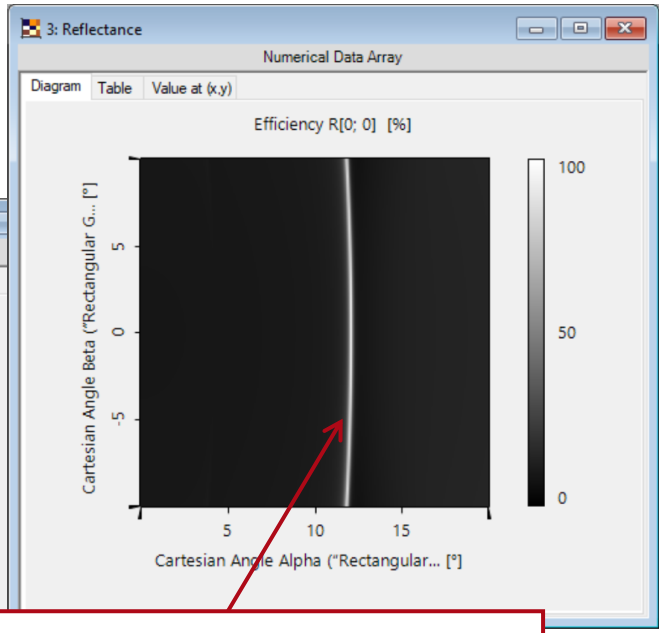
grating parameters

- period Λ=350nm
- duty cycle DC=0.5
- grating height d=25nm
- waveguide thickness t=364nm

transmittance

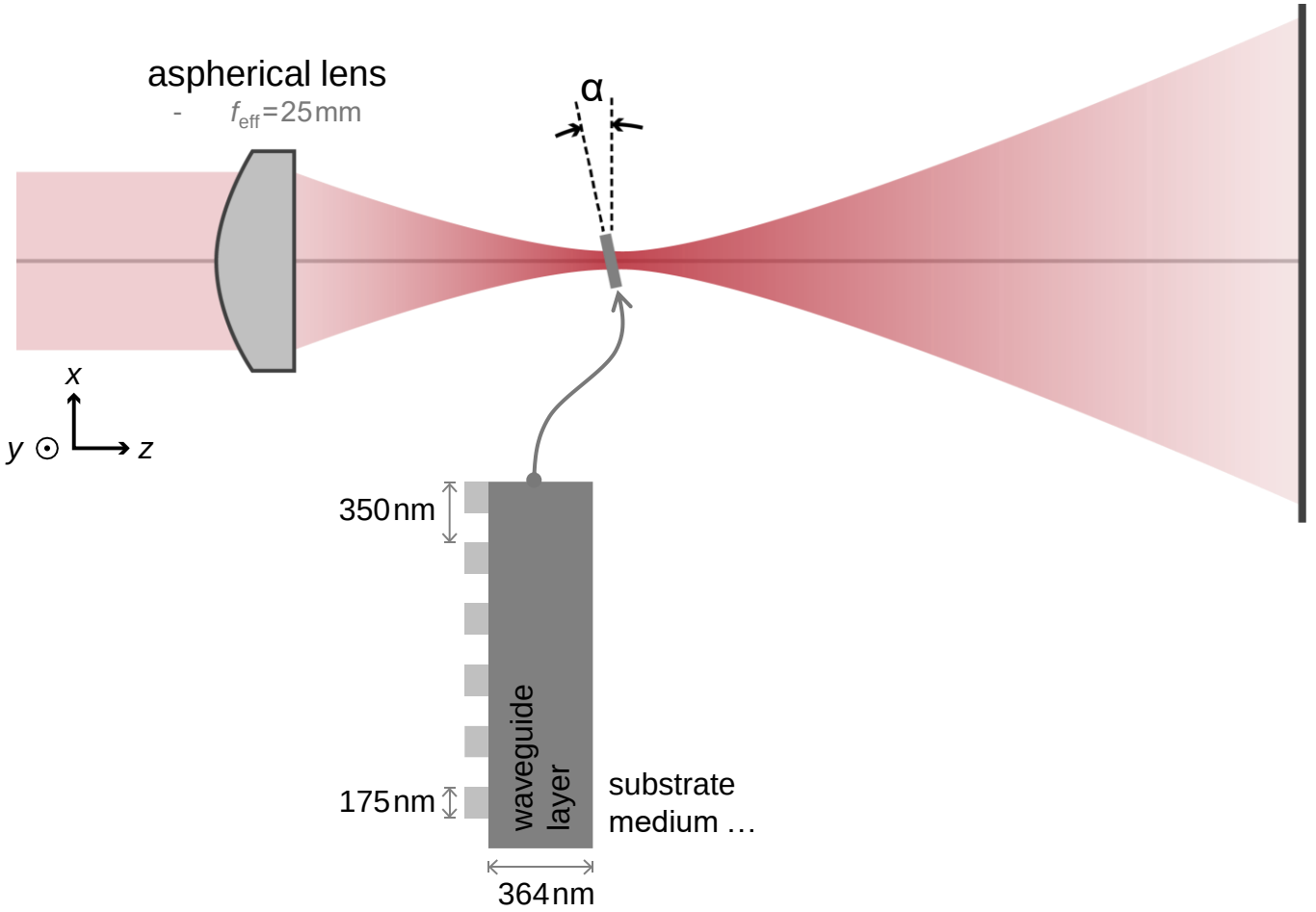


reflectance



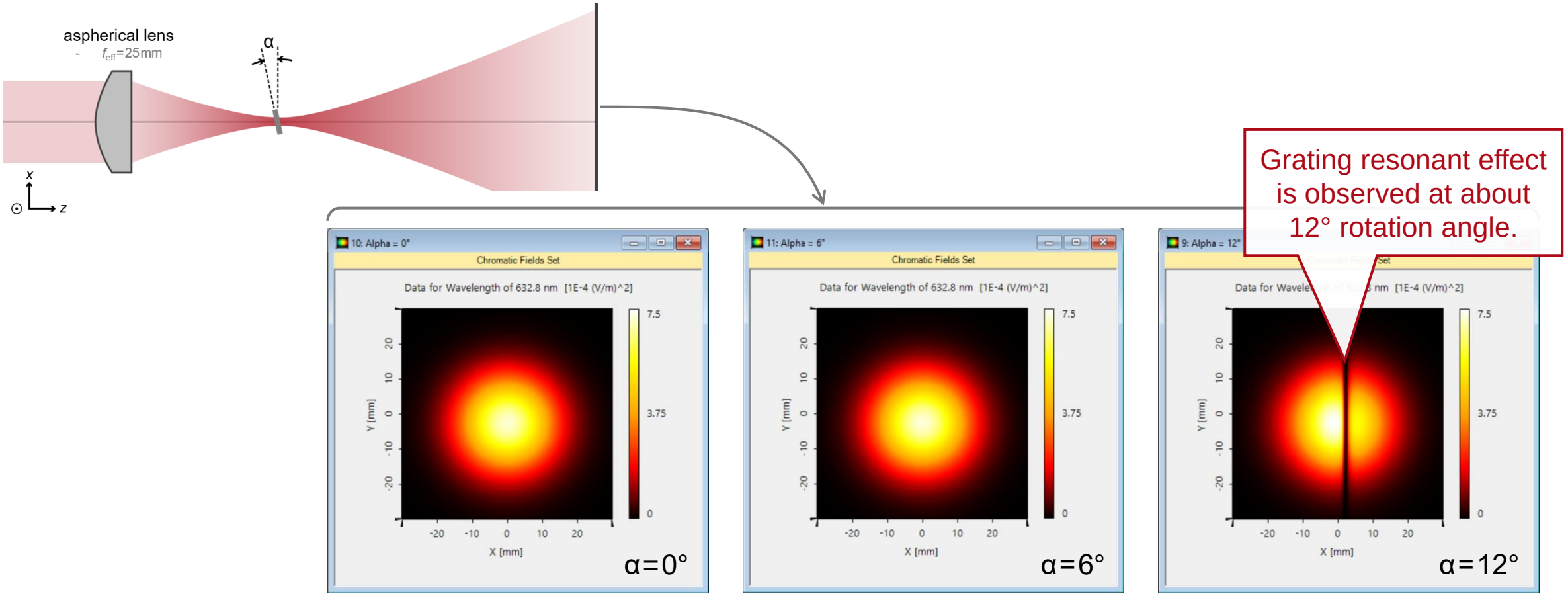
complimentary resonant effects in transmittance and reflectance for the sub-wavelength grating

Checking Resonant Effect with focused Gaussian Beam

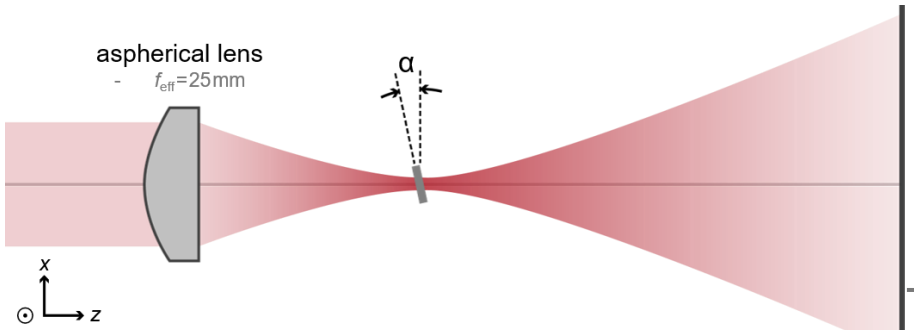


How does the far-field pattern look like behind the resonant waveguide grating, especially when it is tilted around the critical angle for waveguide resonance?

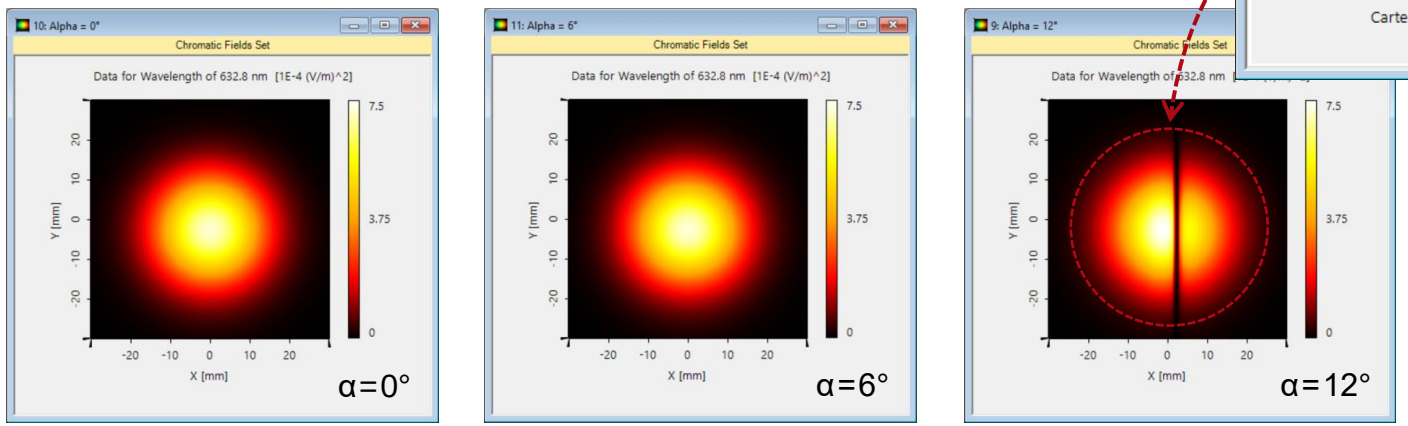
Checking Resonant Effect with focused Gaussian Beam

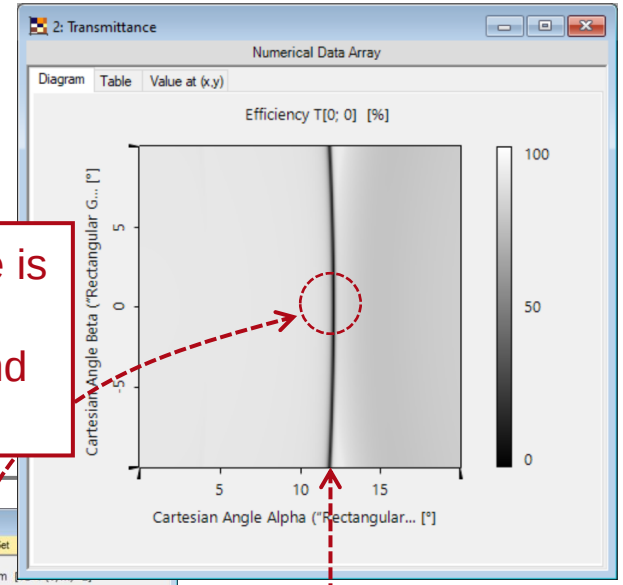


Checking Resonant Effect with focused Gaussian Beam



Clear correspondence is seen between the angular sensitivity and the far-field pattern.

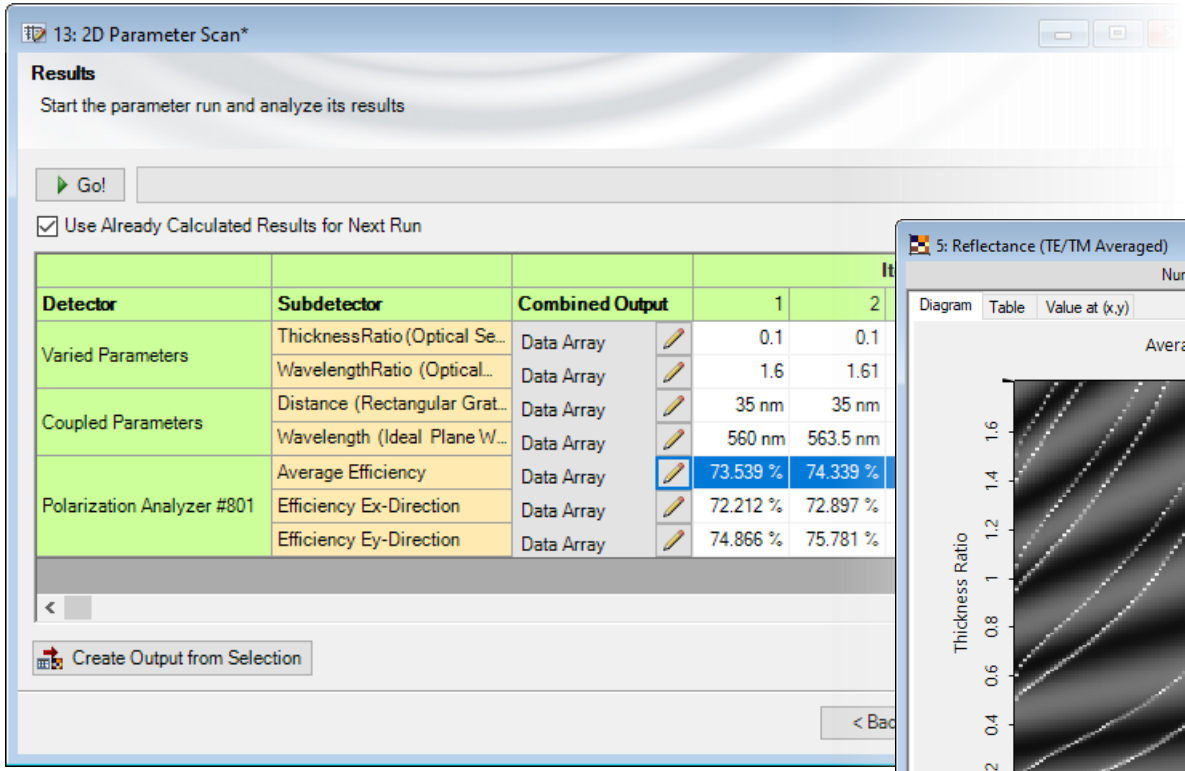




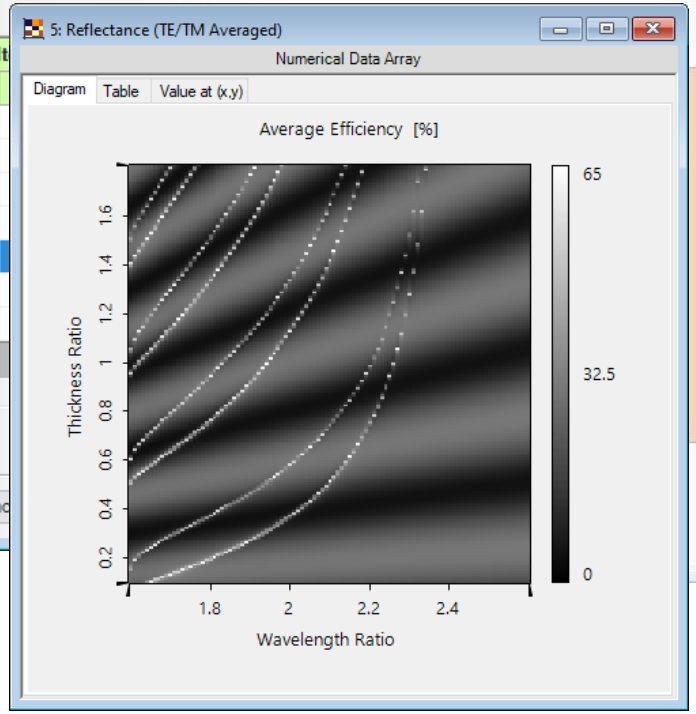
~12°

Peek into VirtualLab Fusion

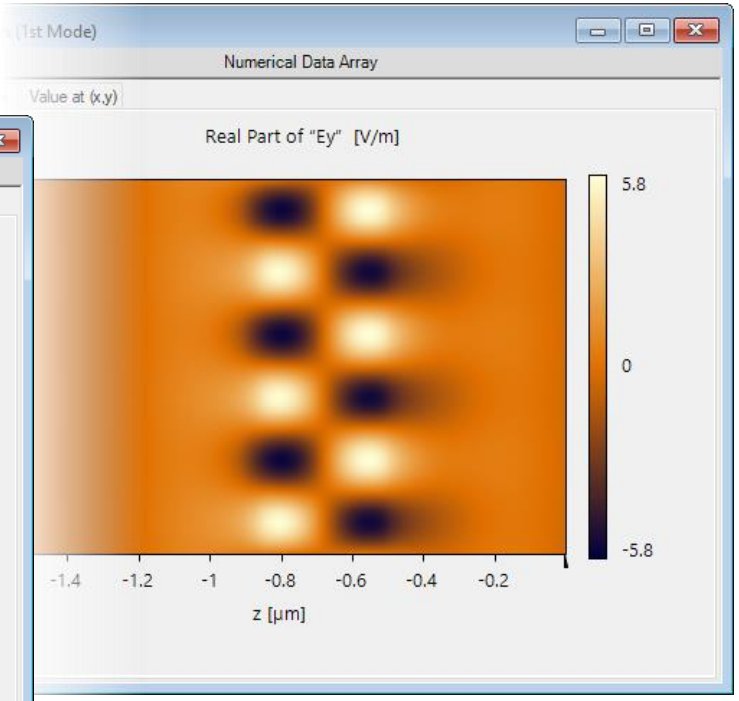
scanning of diffraction efficiency vs. specific parameter(s)



diffraction efficiency analysis, with respec to two independent parameters

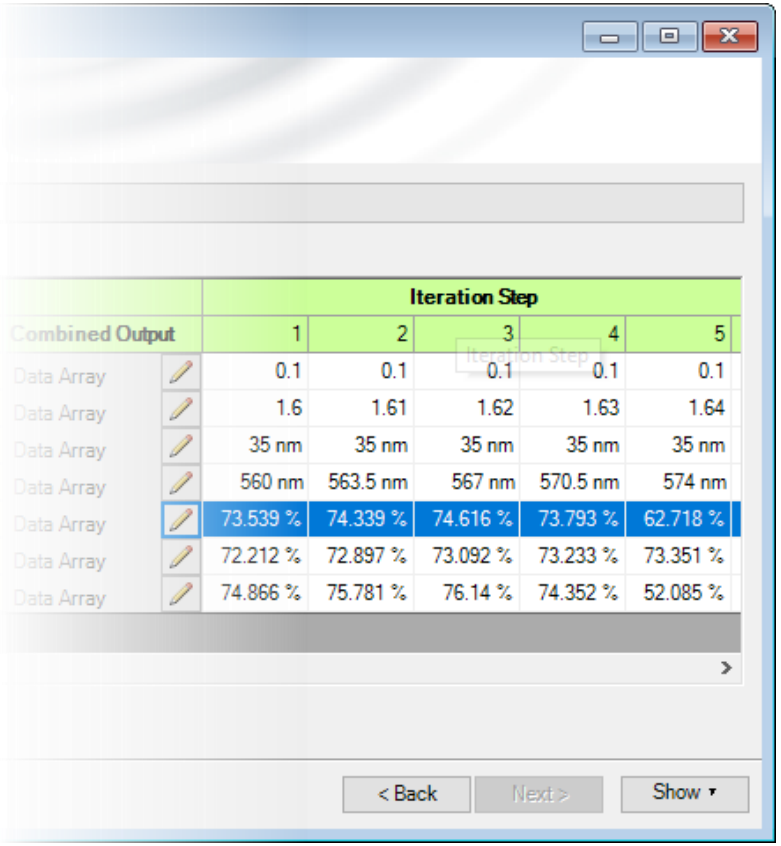


visualization of electromagnetic field distribution within grating structure

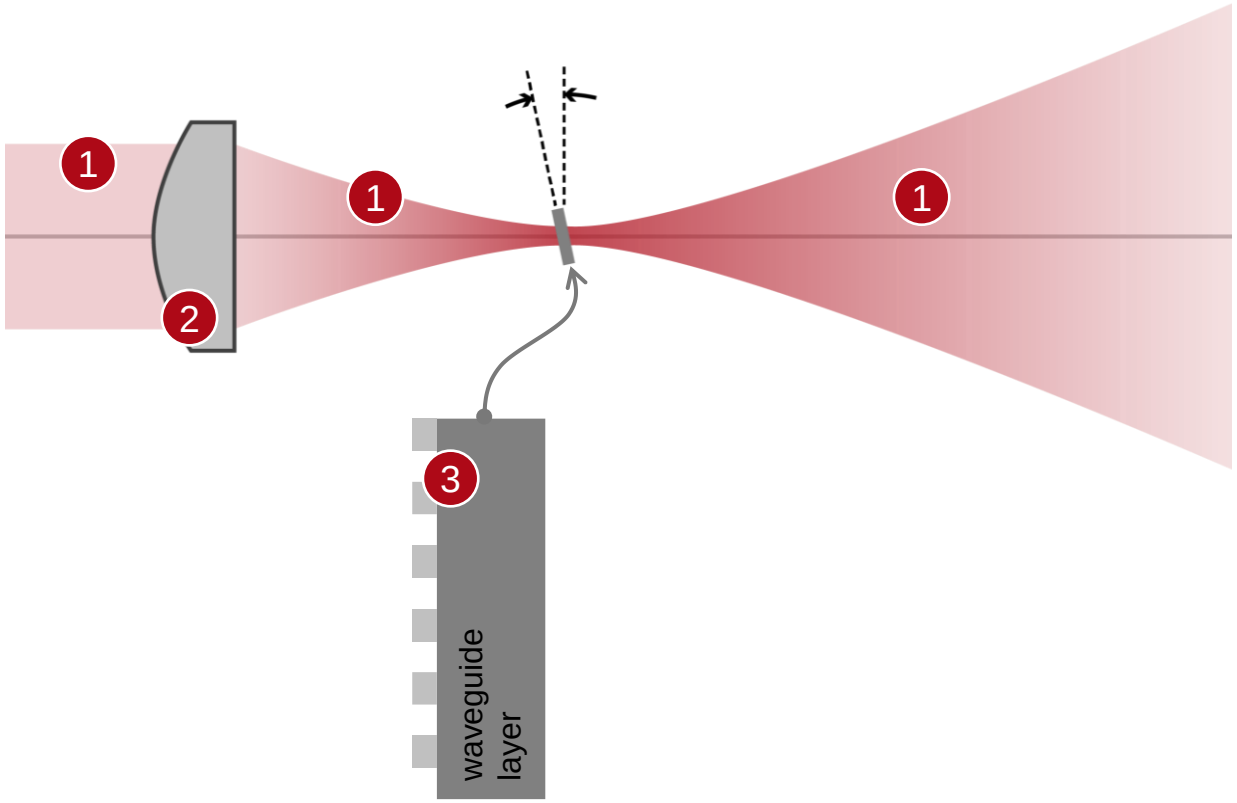


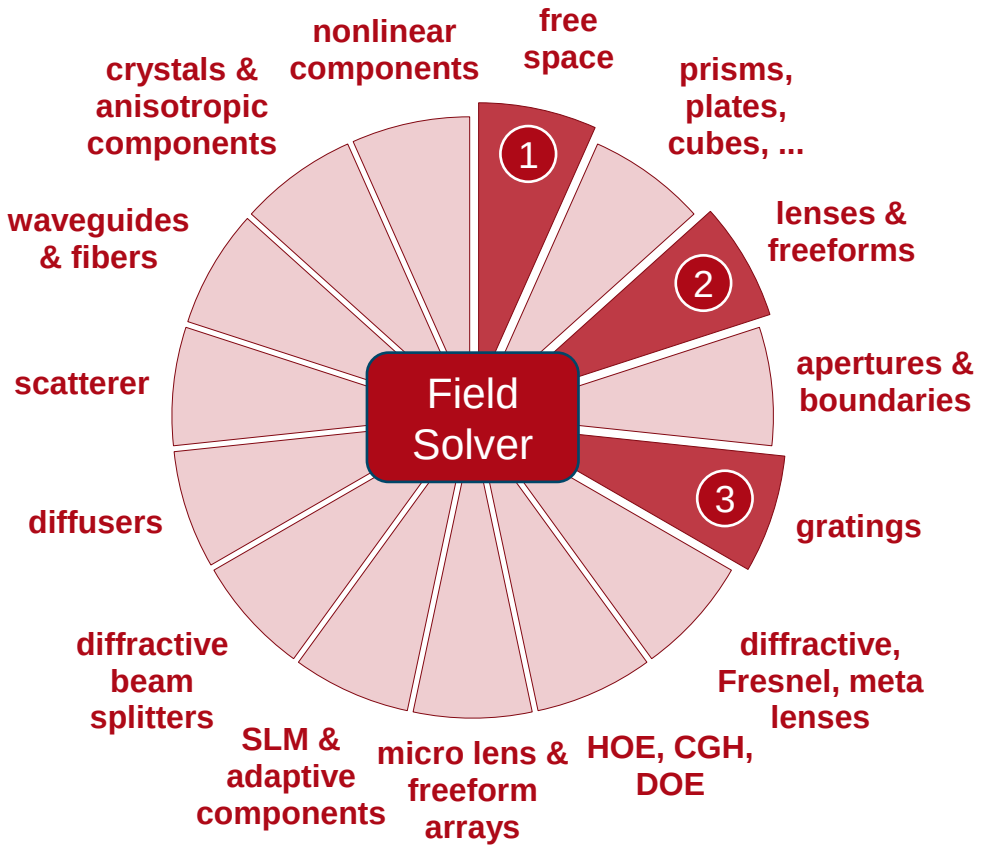
Workflow in VirtualLab Fusion

- Construct grating structure
  - Configuration of Grating Structures by Using Interfaces [Use Case]
  - Configuration of Grating Structures by Using Special Media [Use Case]
- Analyze grating diffraction efficiency
  - Grating Order Analyzer [Use Case]
- Check influence from different parameters with Parameter Run
  - Usage of the Parameter Run Document [Use Case]
- Calculate field inside grating structure



VirtualLab Fusion Technologies





Document Information

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software version	2020.1 (Build 2.8)
category	Application Use Case
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