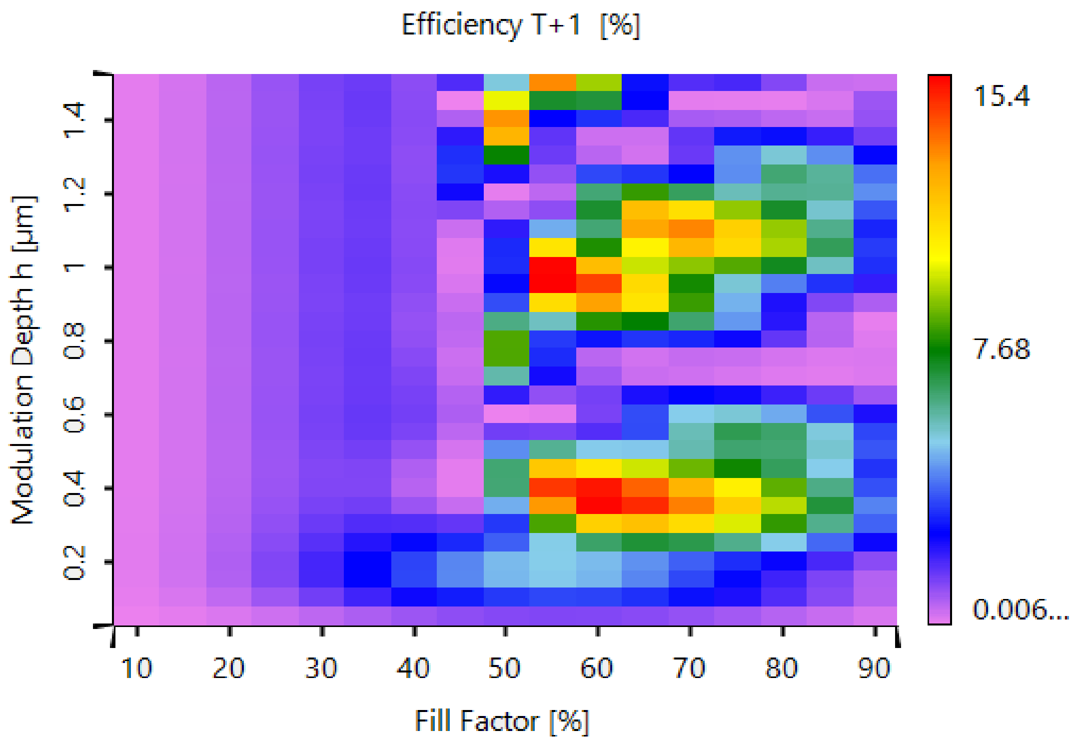
Optimization of Lightguide Coupling Grating for Single Incidence Direction

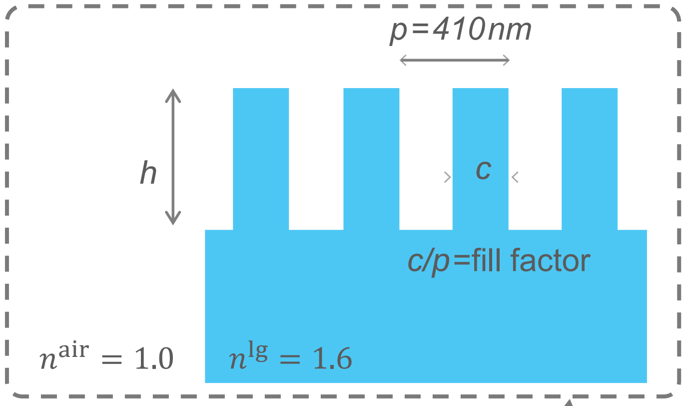
Abstract

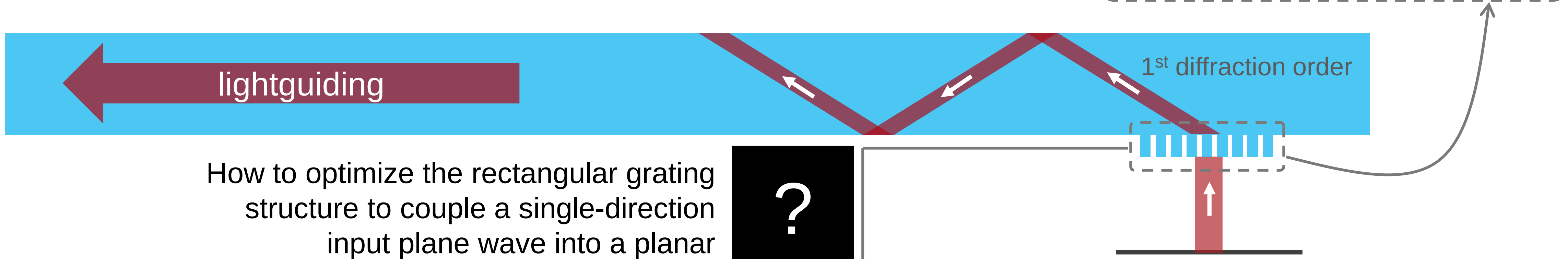


Coupling of light into a lightguide is of major interest for various applications in modern optics. In VirtualLab Fusion, with the Fourier modal method and parametric optimization tools, one can optimize the real grating geometries so to achieve best coupling efficiencies for specific diffraction orders. This example shows the design strategy for optimizing a rectangular grating for one specific incidence direction to obtain the optimum lightguide coupling efficiency.

Optimization Task

- grating period $p = 410\,\text{nm}$
- modulation depth $h = ?$
- fill factor $c/p = ?$



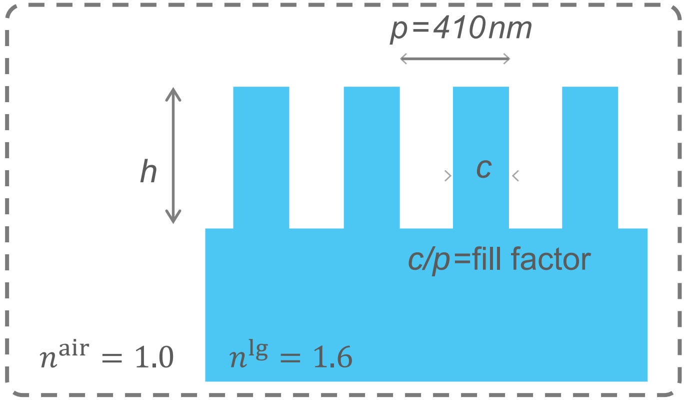


How to optimize the rectangular grating structure to couple a single-direction input plane wave into a planar lightguide with maximum efficiency?

input plane wave

- wavelength 532 nm
- angle of incidence 0° or 15°
- linearly polarized along x-axis

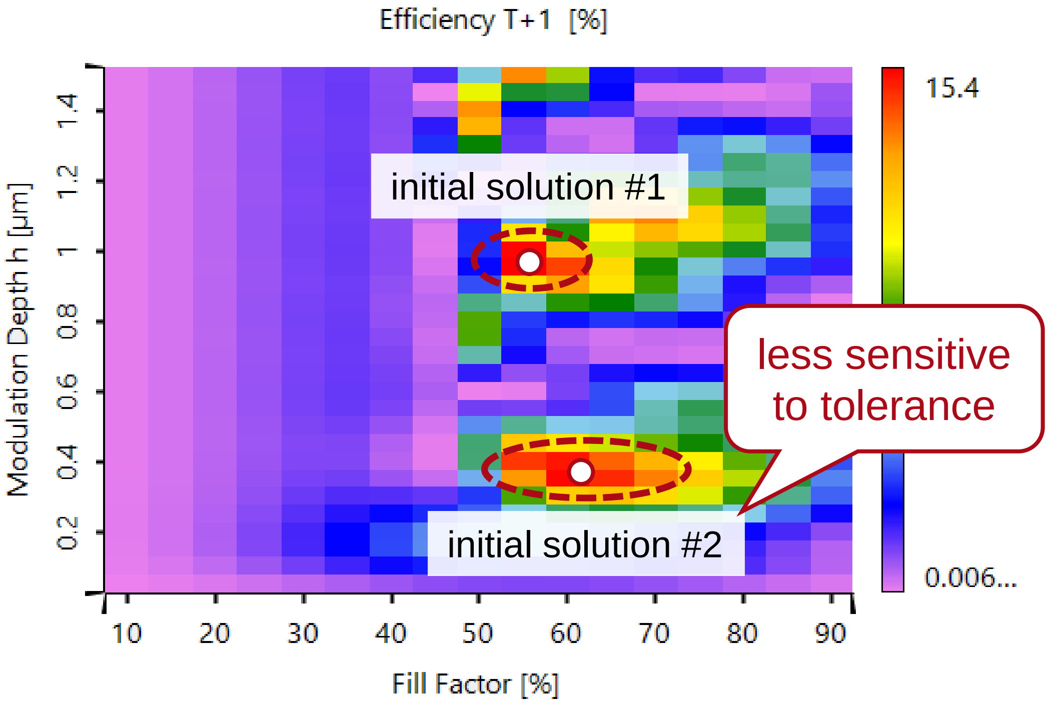
Search for Proper Initial Solution (Normal Incidence)



scanning over grating parameter space:

- modulation depth *h* from 400 to 1500 nm
- fill factor *c/p* from 10 to 90 %

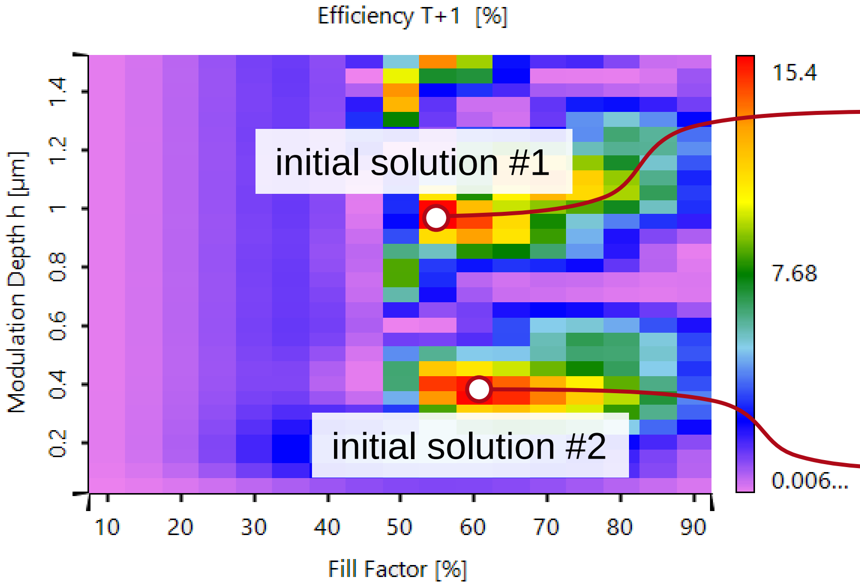
grating diffraction efficiency calculated with Fourier modal method (FMM) in VirtualLab Fusion



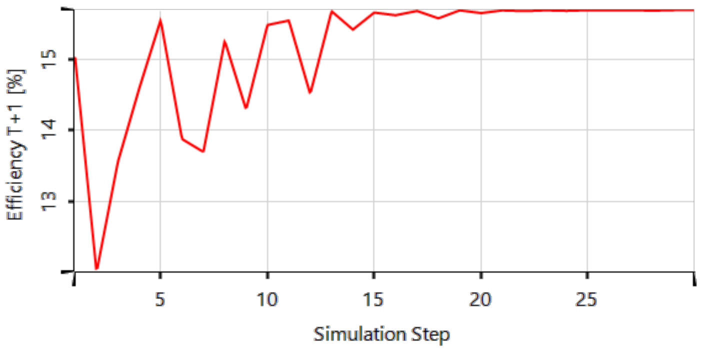
Using a rough scanning over grating parameter space, one can find possible initial solutions and avoid missing the global optimum.

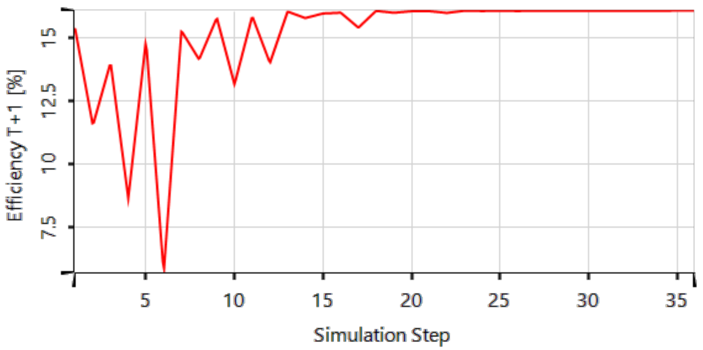
Further Optimization from Initial Solution (Normal Incidence)

scanning over parameter space



parametric optimization
(downhill simplex method)





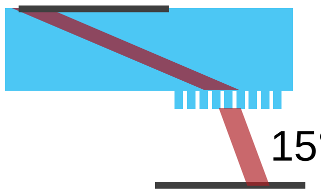
Final Optimized Result #1	
efficiency	16.1%
modulation depth	966nm
fill factor	55.9%

Final Optimized Result #2	
efficiency	15.7%
modulation depth	374nm
fill factor	59.2%

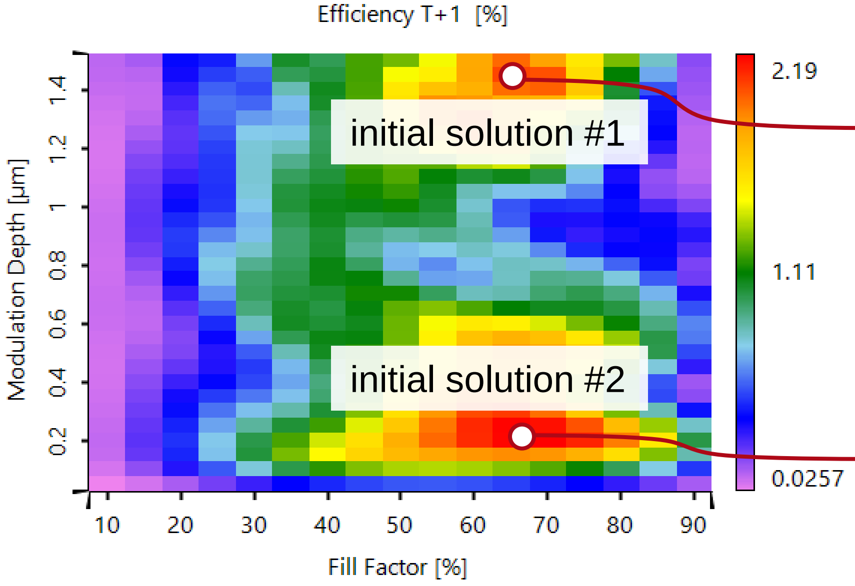
smaller aspect ratio, preferable for fabrication

Starting with either initial solution, a subsequent parametric optimization is used to obtain the finally optimized grating structure.

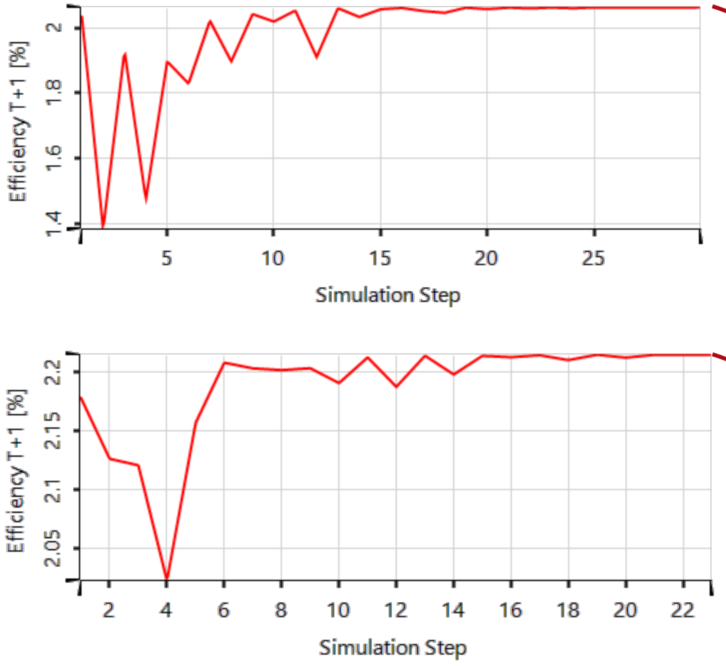
Grating Optimization for Inclined Incidence 15°



scanning over parameter space



parametric optimization
(downhill simplex method)

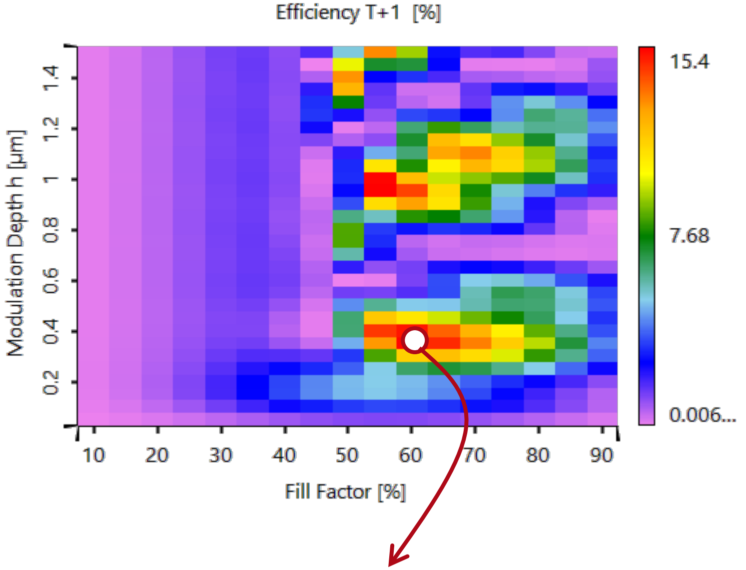


Final Optimized Result #1	
efficiency	2.06%
modulation depth	1440nm
fill factor	67.4%

Final Optimized Result #2	
efficiency	2.22%
modulation depth	222nm
fill factor	67.9%

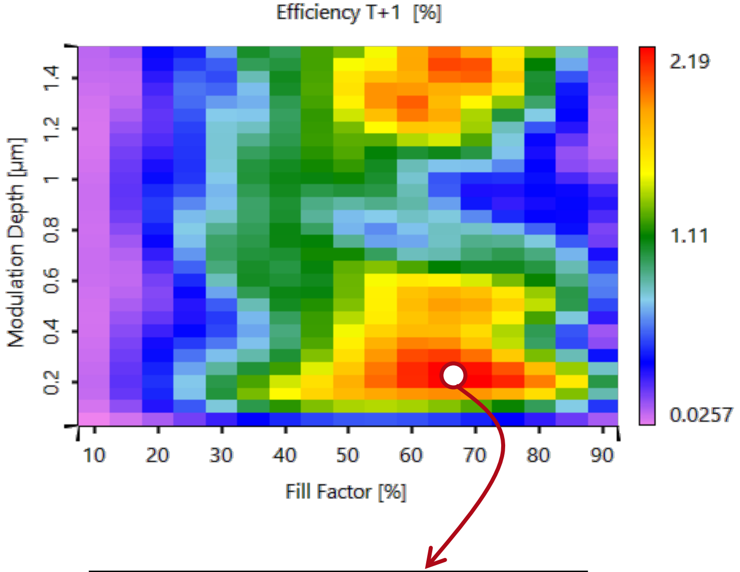
Comparison between Optimized Grating Structures

- Normal incidence



Final Optimized Result	
efficiency	15.7%
modulation depth	374 nm
fill factor	59.2%

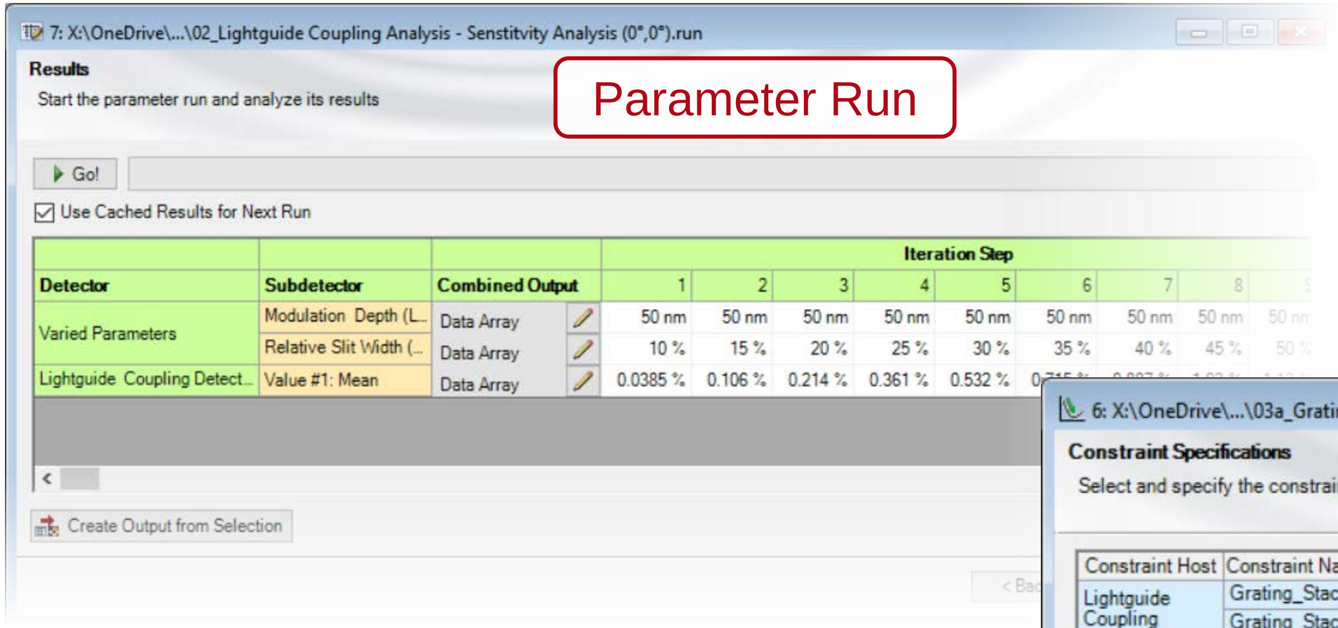
- 15° inclined incidence

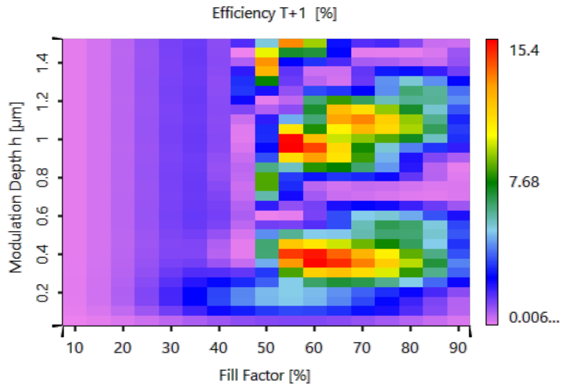


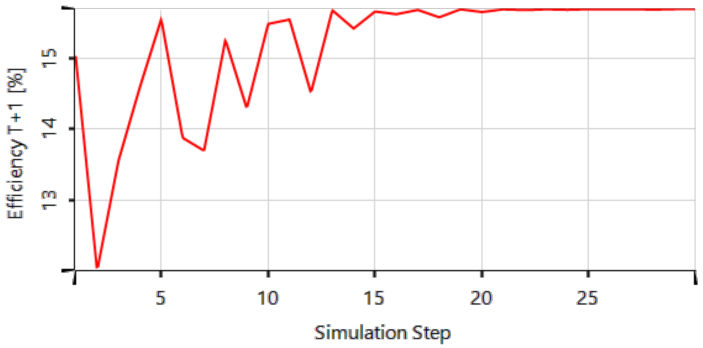
Final Optimized Result	
efficiency	2.22%
modulation depth	222 nm
fill factor	67.9%

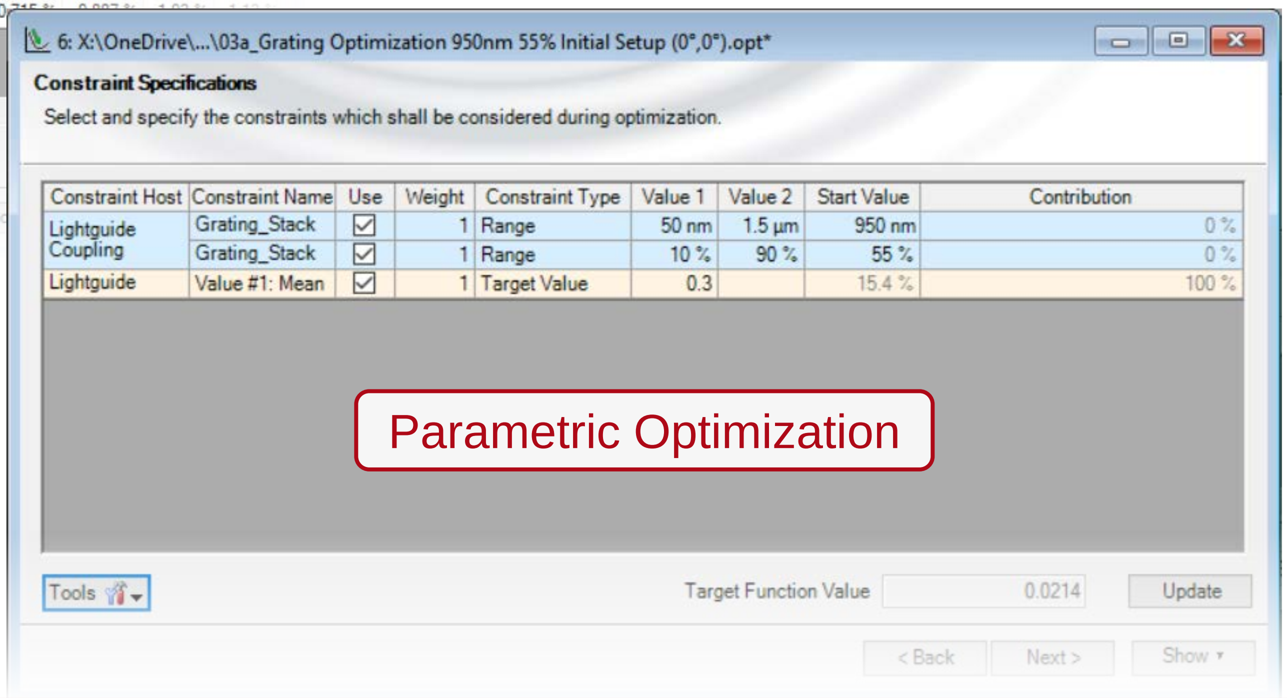
- The highest efficiencies obtained for different incidence angles are quite different.
- Optimized grating structures are also different.

Peek into VirtualLab Fusion





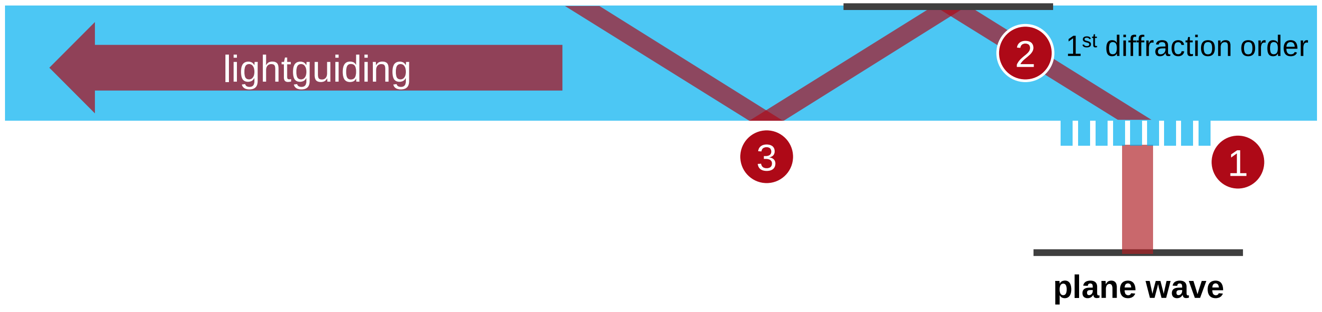


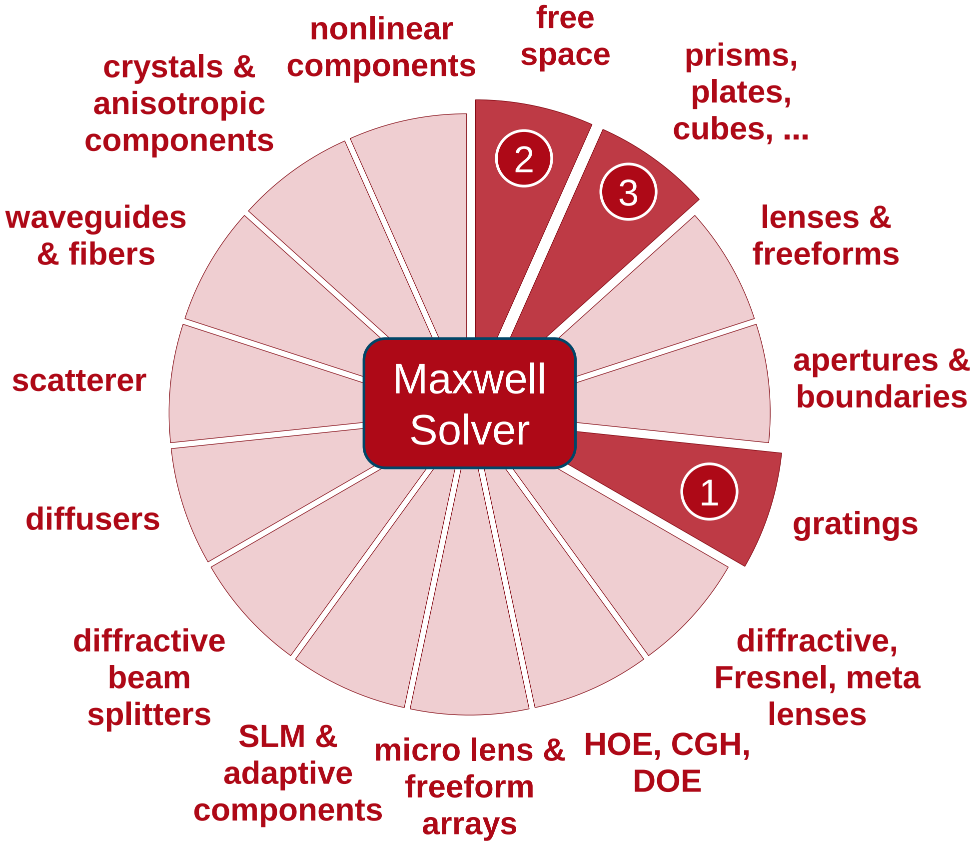


Workflow in VirtualLab Fusion

- Configuration of lightguide coupling grating structure
  - Configuration of Grating Structures by Using Special Media [Use Case]
  - Configuration of Grating Structures by Using Interfaces [Use Case]
- Analyze coupling grating diffraction efficiency
  - Customized Detector for Lightguide Coupling Grating Evaluation [Use Case]
- Rough scanning of parameters to find initial solutions
- Further optimization of grating structure based on parametric optimization

VirtualLab Fusion Technologies





Document Information

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category	Application Use Case
further reading	- Analysis of Slanted Gratings for Lightguide Coupling