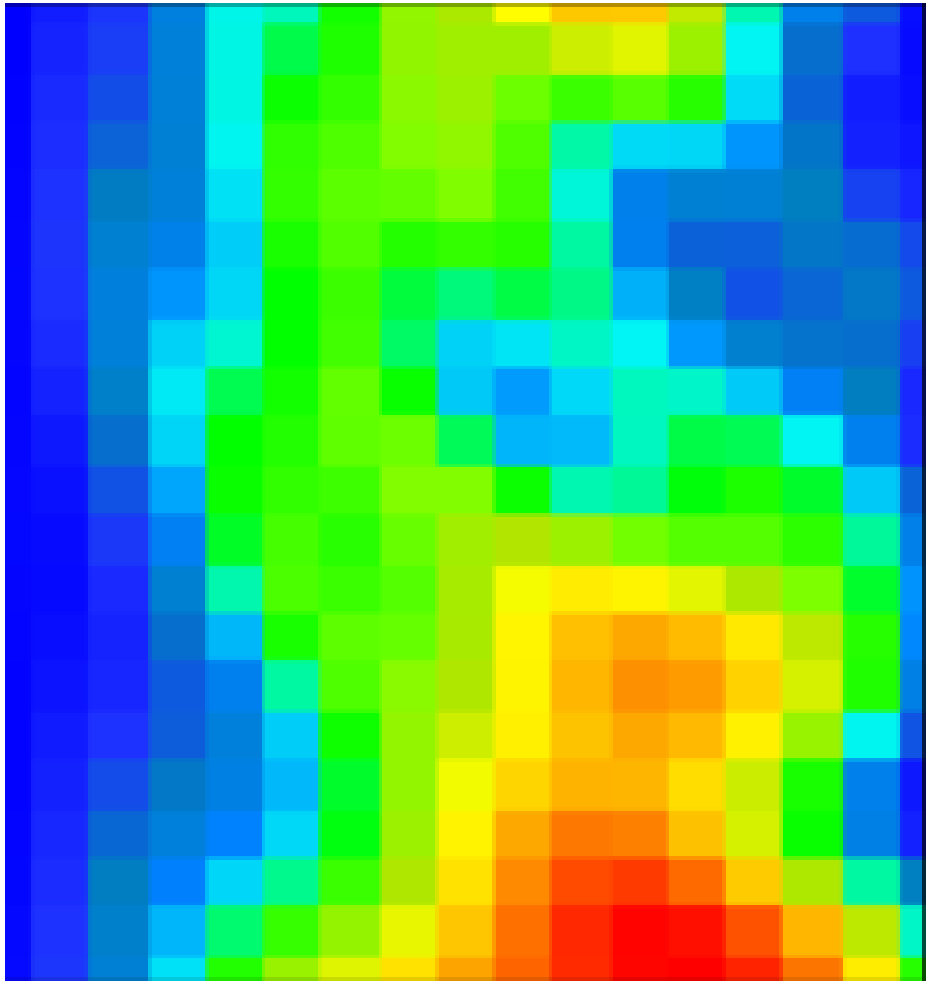
Optimization of Lightguide Coupling Grating for Single Incidence Direction

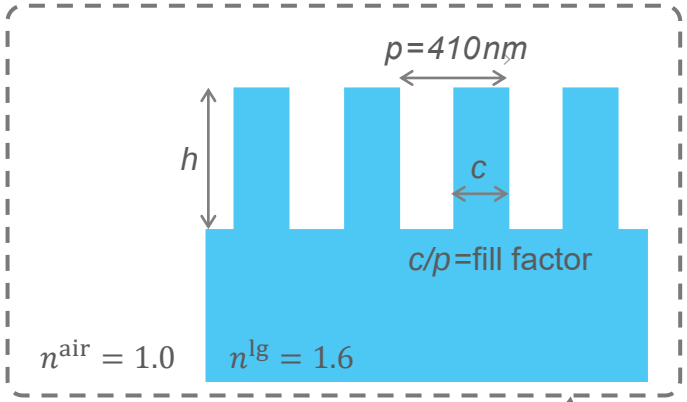
Abstract

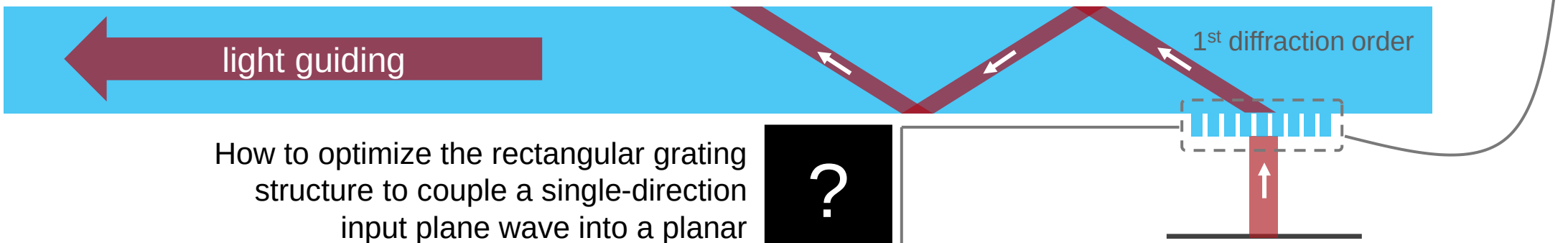


Coupling of light into a lightguide is of major interest for various applications in modern optics. In VirtualLab Fusion, with the Fourier modal method (FMM, also known as RCWA) and parametric optimization tools, one can optimize the real grating geometries in order to achieve best coupling efficiencies for specific diffraction orders. This example showcases the design strategy for optimizing a binary 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 $c/p = ?$



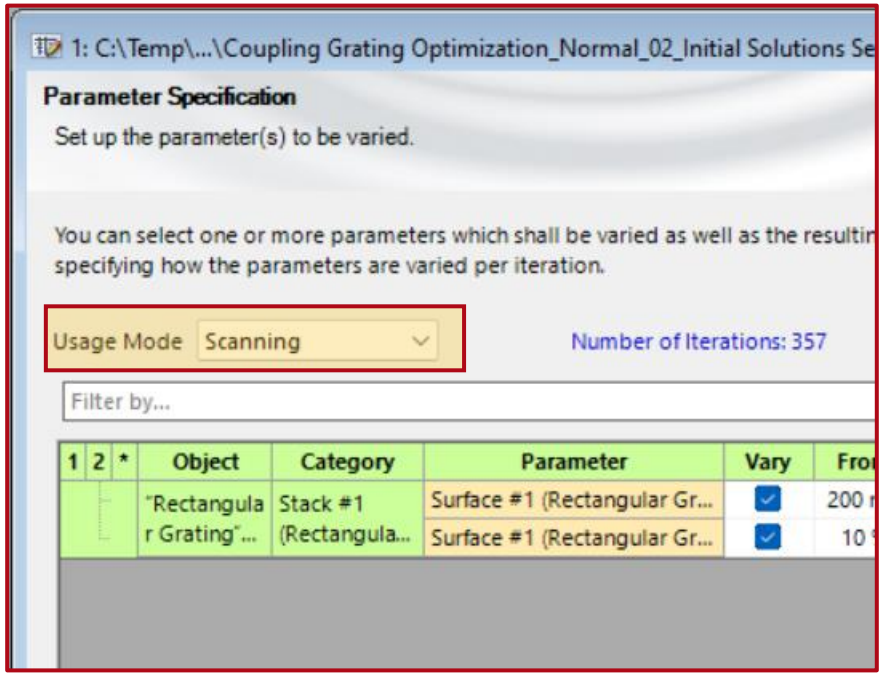


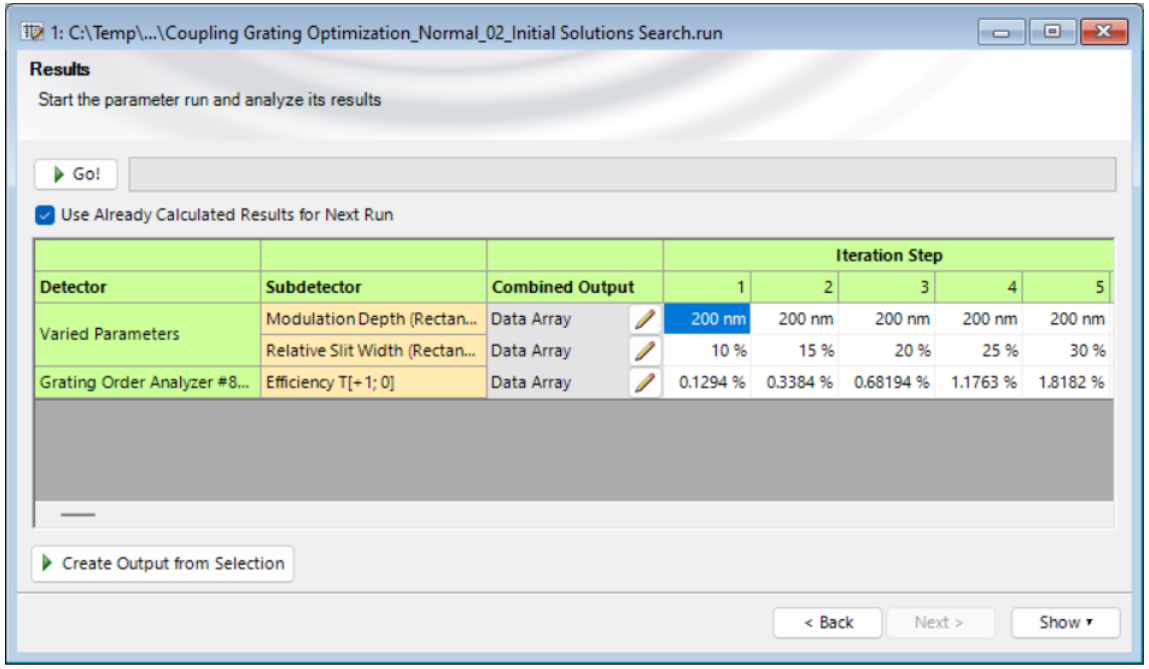
How to optimize the rectangular grating structure to couple a single-direction input plane wave into a planar lightguide with maximum efficiency?

input plane wave

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

Scanning Mode of Parameter Run

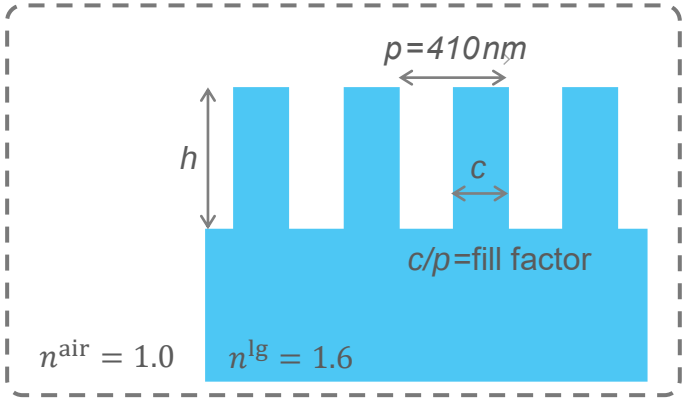




The scanning mode of VirtualLab Fusion's *Parameter Run* document allows to perform a parameter sweep over a multi-dimensional (often 2D) region of the parameter space. This sweep can be applied to analyze the grating characteristics in detail. More information under:

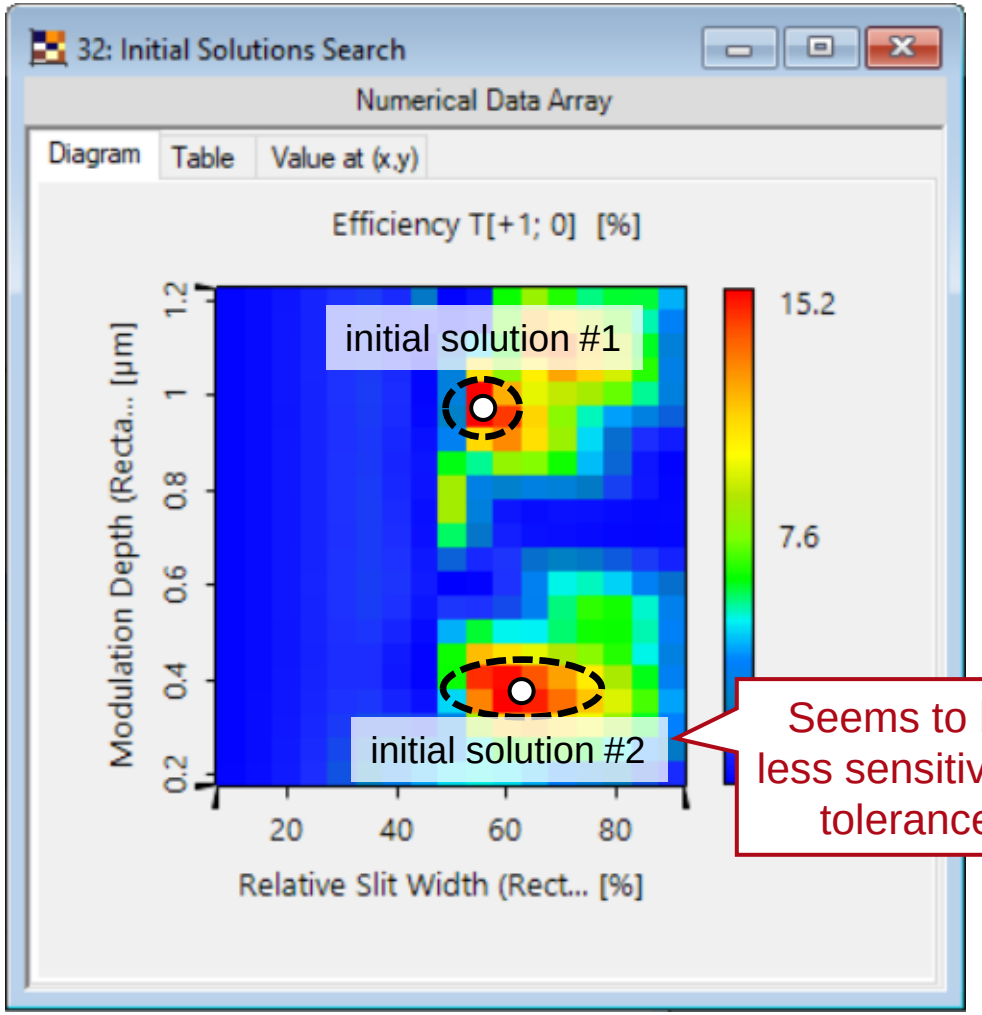
Scanning Mode of Parameter Run

Search for Initial Solutions (Normal Incidence)



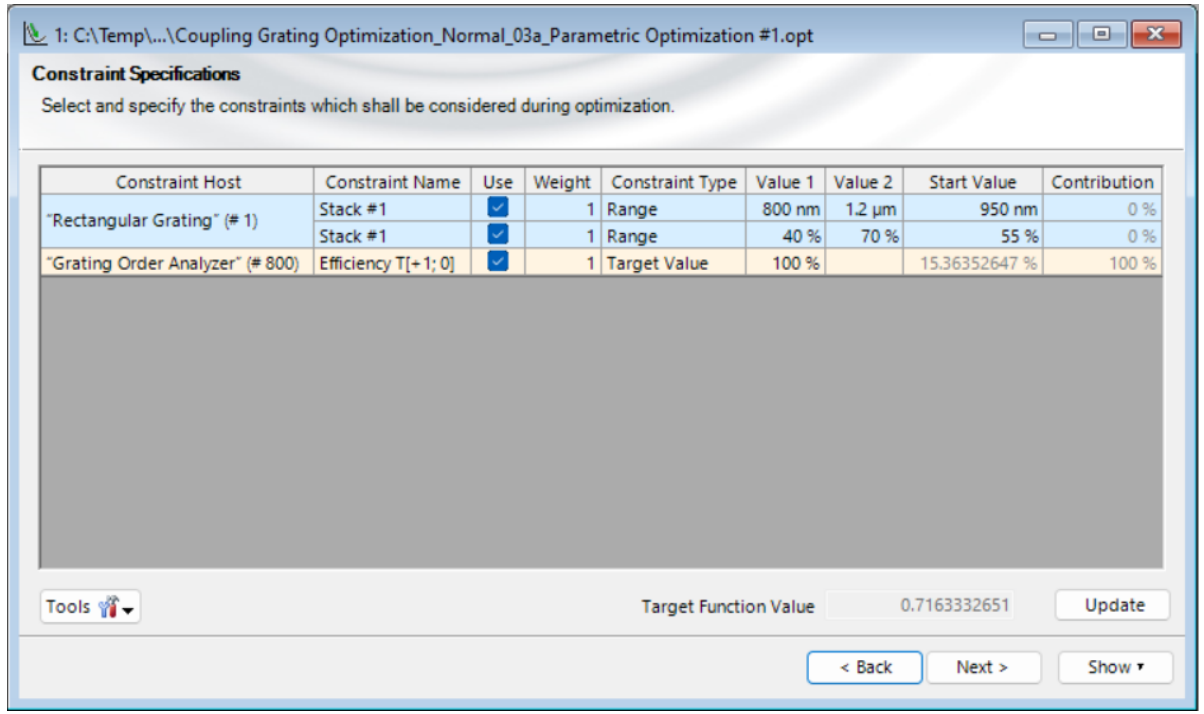
scanning over grating parameter space:

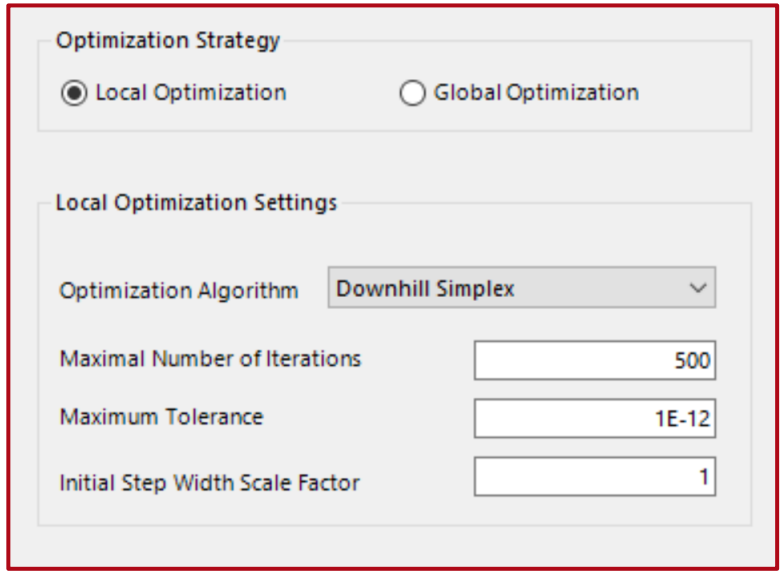
- modulation depth *h* from 200 to 1200 nm
- fill factor *c/p* from 10 to 90 %



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

Parametric Optimization

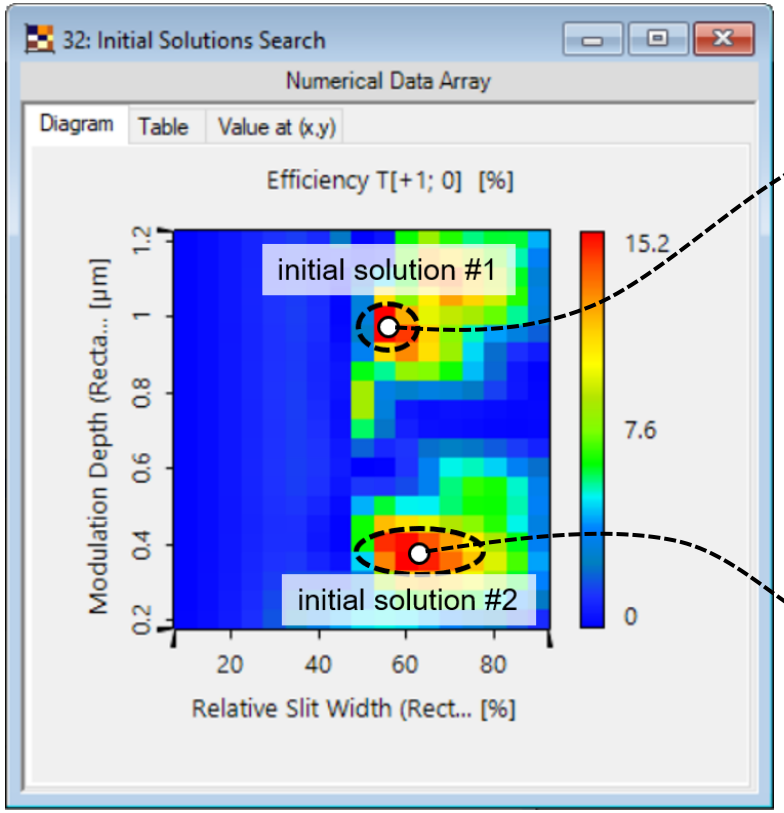




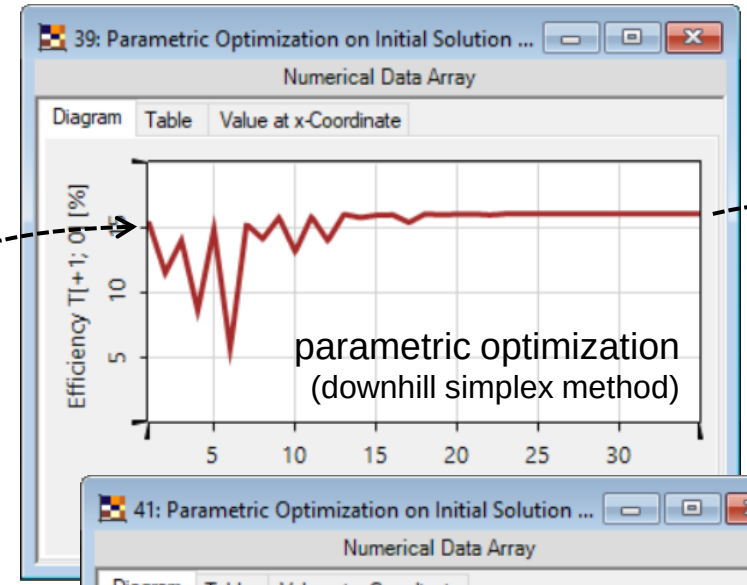
In order to find an adequate set of parameters for the grating, the *Optimization* document of VirtualLab Fusion is used. It enables to define a customized merit function, parameter constraints and weights for the target values. Find more information under:

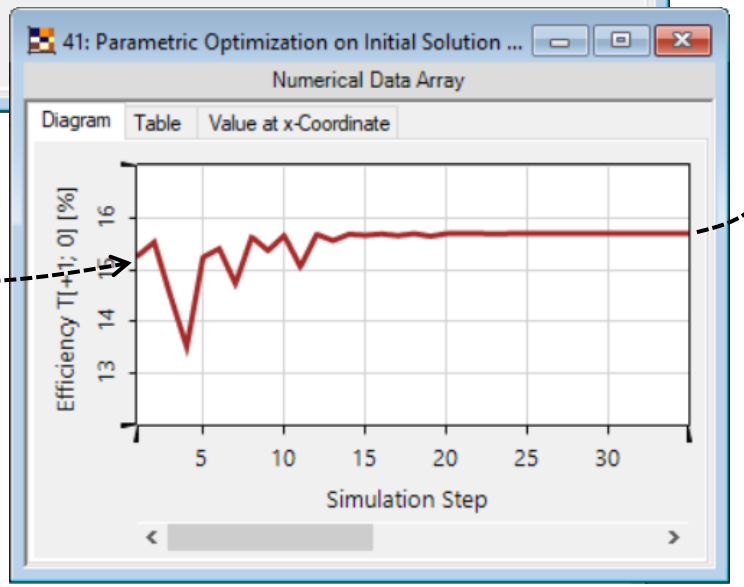
Introduction to the Parametric Optimization Document

Final Design by Parametric Optimization (Normal Incidence)



Initial solutions are used as starting point for parametric optimizations.





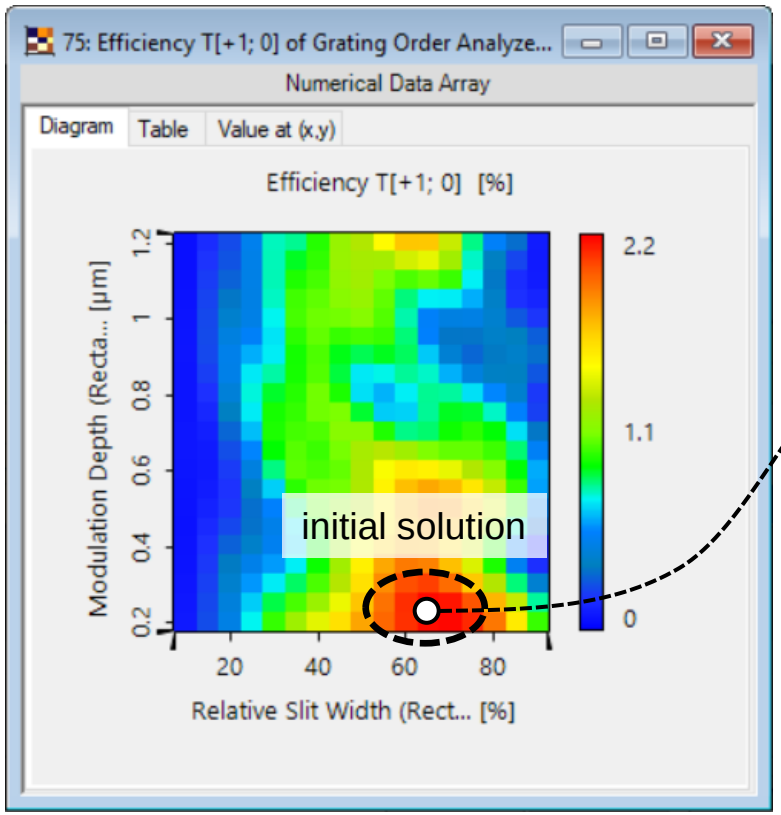
Final Design #1	
efficiency	16.1 %
modulation depth	966 nm
fill factor	56 %

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

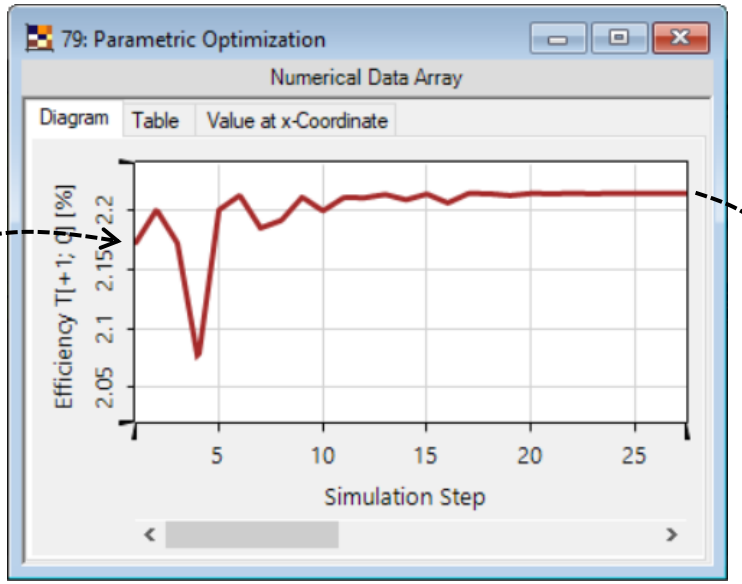
smaller aspect ratio, preferable for fabrication

Initial Solutions and Final Designs for 15° Incidence

rough scanning over parameter space



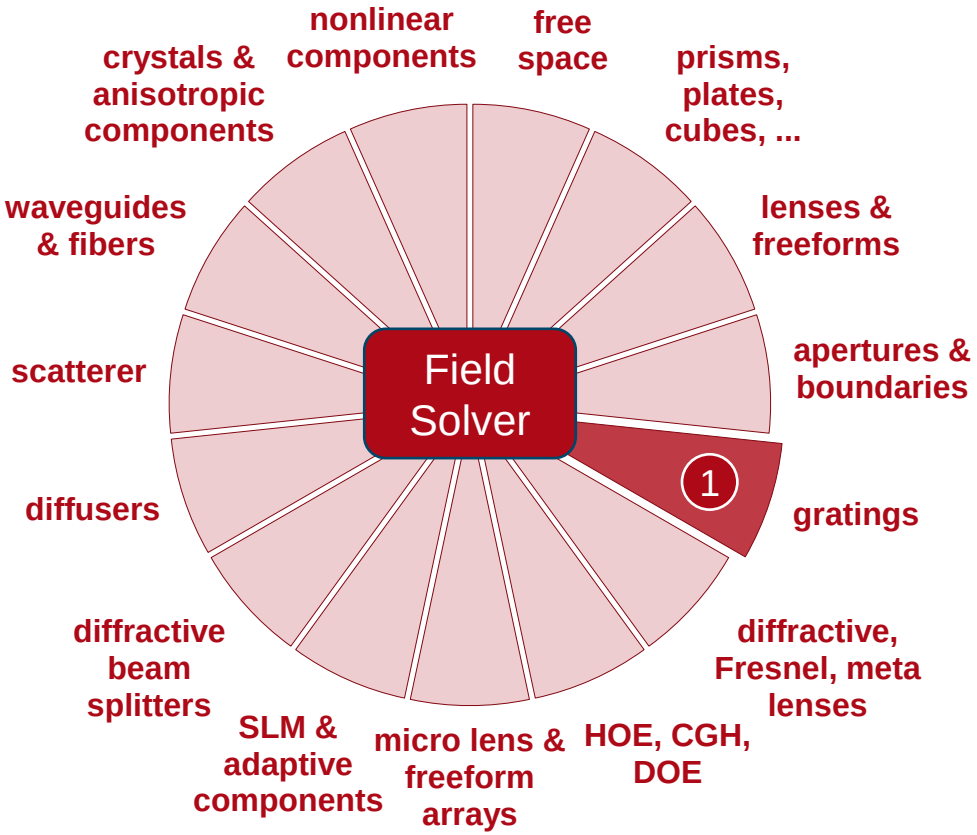
parametric optimization
(downhill simplex method)



Final Design	
efficiency	2.2 %
modulation depth	221 nm
fill factor	67.8 %

The optimized grating parameters are quite different, and the efficiency is lower.

VirtualLab Fusion Technologies



Document Information

title	Optimization of Lightguide Coupling Grating for Single Incidence Direction
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