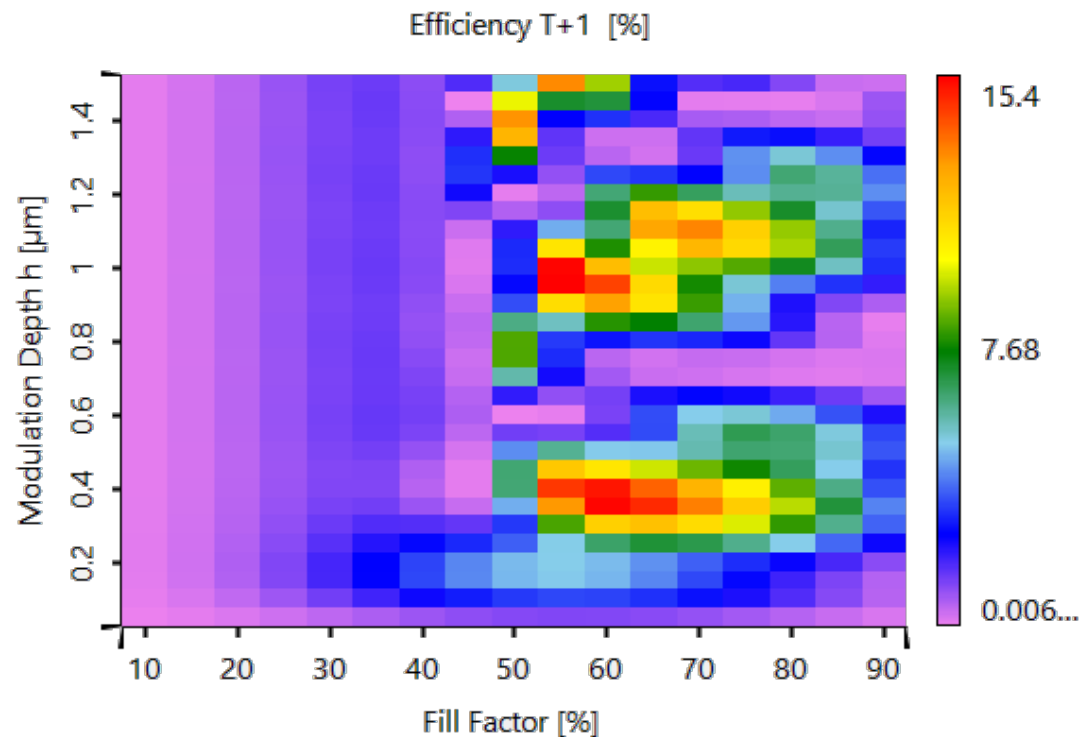


# **Optimization of Lightguide Coupling Grating for Single Incidence Direction**

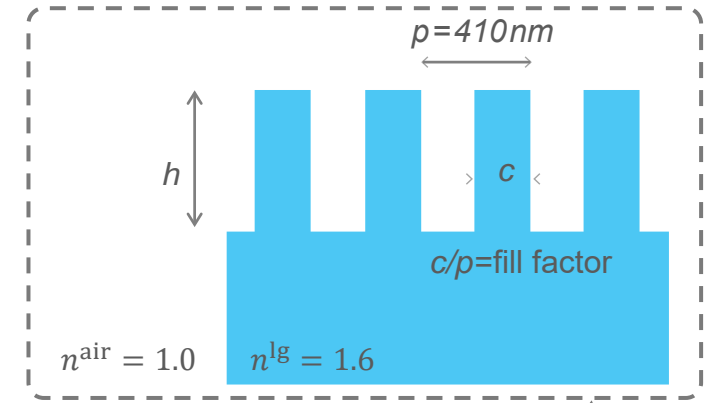
# Abstract



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  $c/p=?$



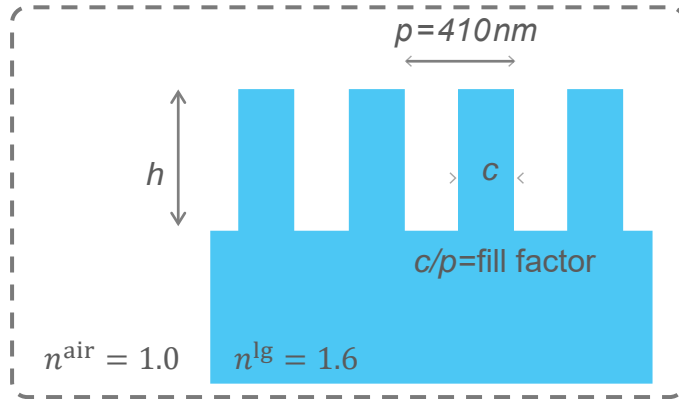
How to optimize the rectangular grating structure to couple a single-direction input plane wave into a planar lightguide with maximum efficiency?



**input plane wave**

- wavelength 532nm
- angle of incidence  $0^\circ$  or  $15^\circ$
- linearly polarized along x-axis

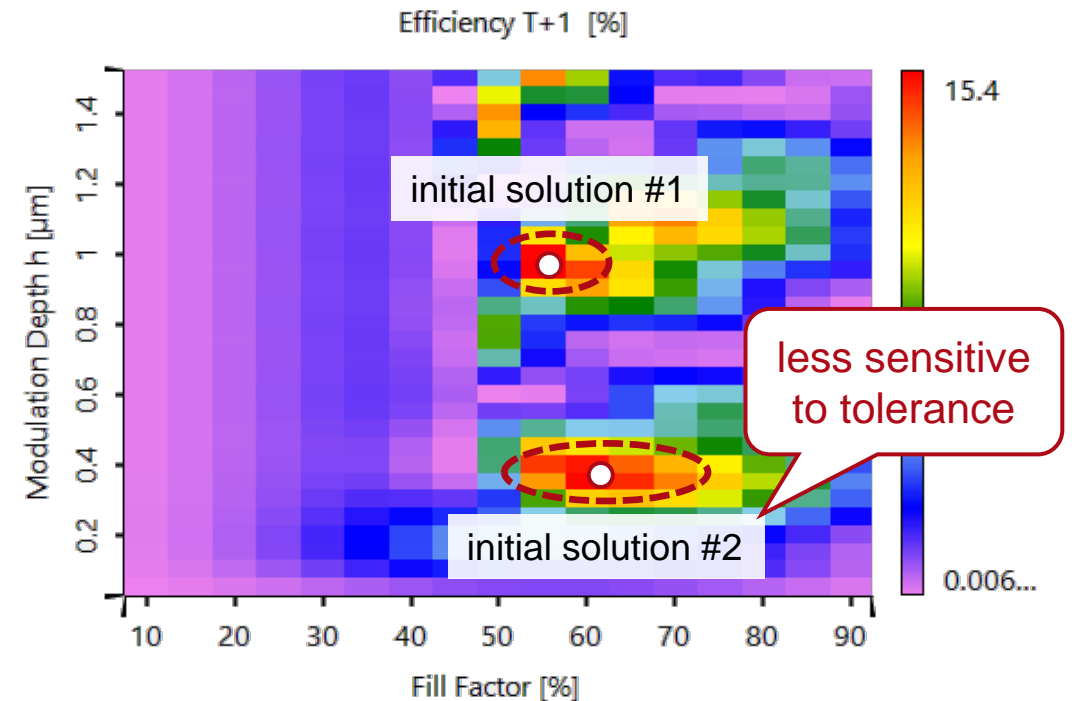
# Search for Proper Initial Solution (Normal Incidence)



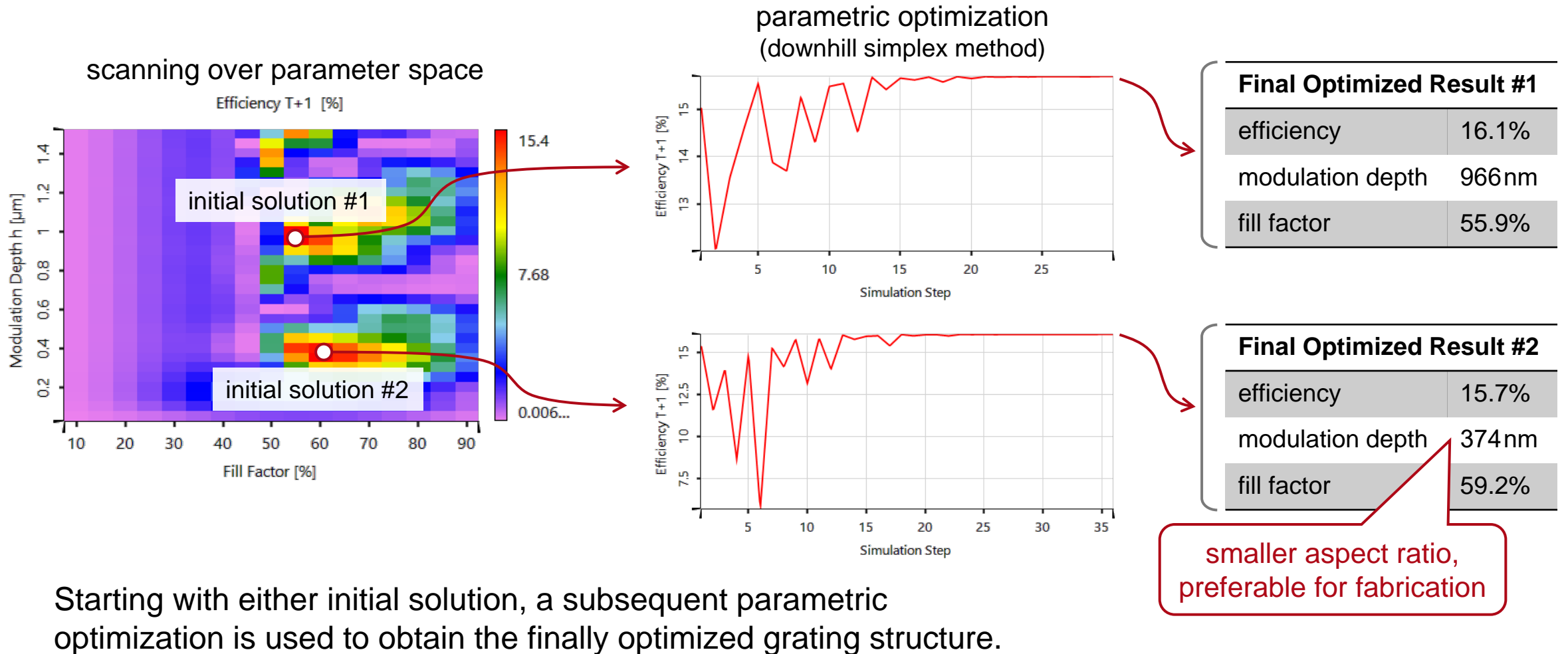
- scanning over grating parameter space:
- modulation depth  $h$  from 400 to 1500nm
  - fill factor  $c/p$  from 10 to 90%

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

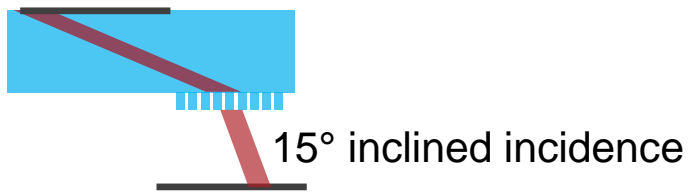
grating diffraction efficiency calculated with Fourier modal method (FMM) in VirtualLab Fusion



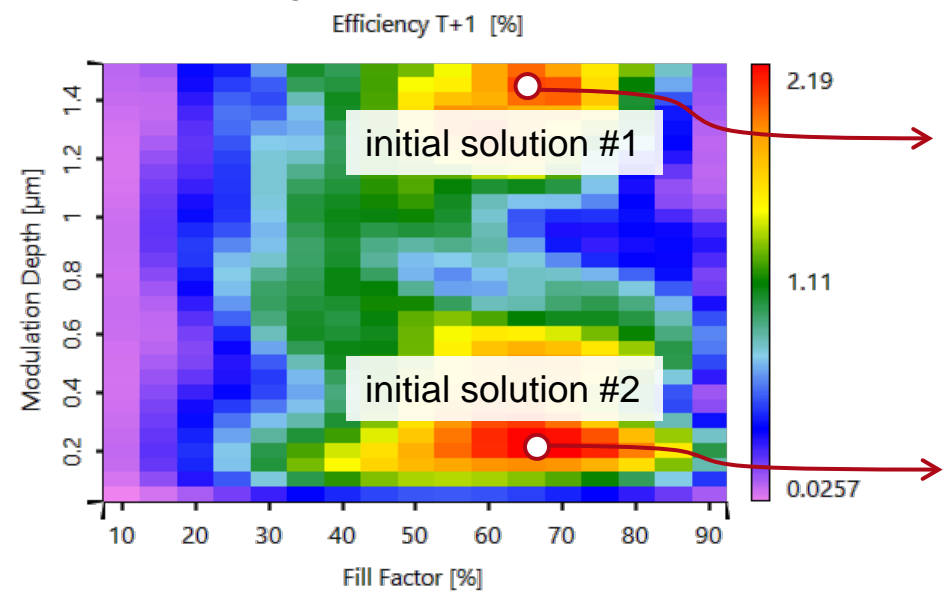
# Further Optimization from Initial Solution (Normal Incidence)



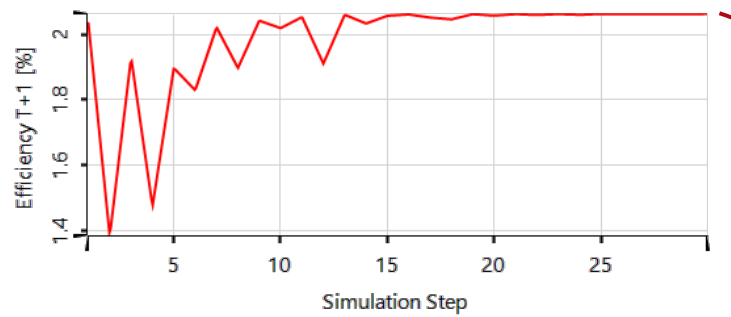
# Grating Optimization for Inclined Incidence 15°



scanning over parameter space

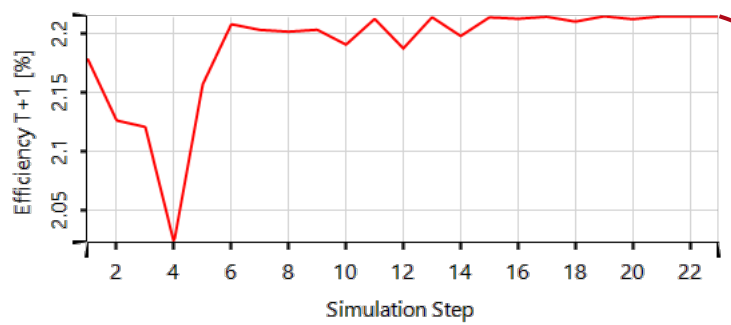


parametric optimization  
(downhill simplex method)



**Final Optimized Result #1**

efficiency	2.06%
modulation depth	1440nm
fill factor	67.4%

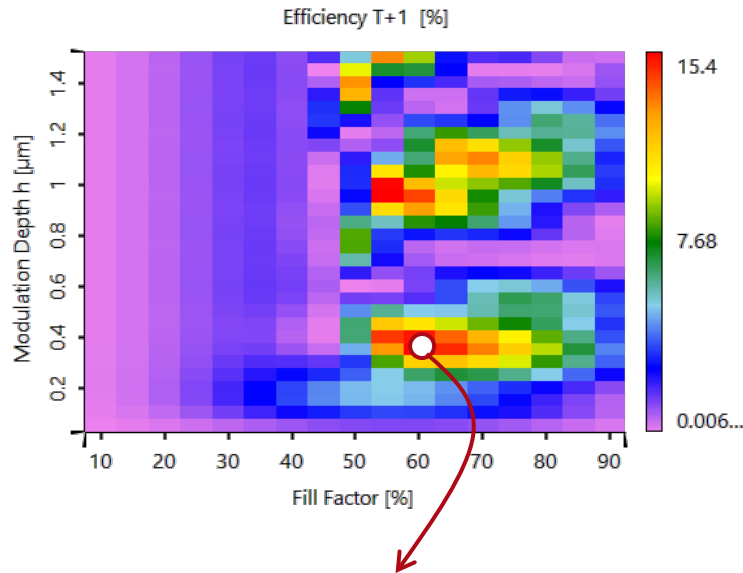


**Final Optimized Result #2**

efficiency	2.22%
modulation depth	222nm
fill factor	67.9%

# Comparison between Optimized Grating Structures

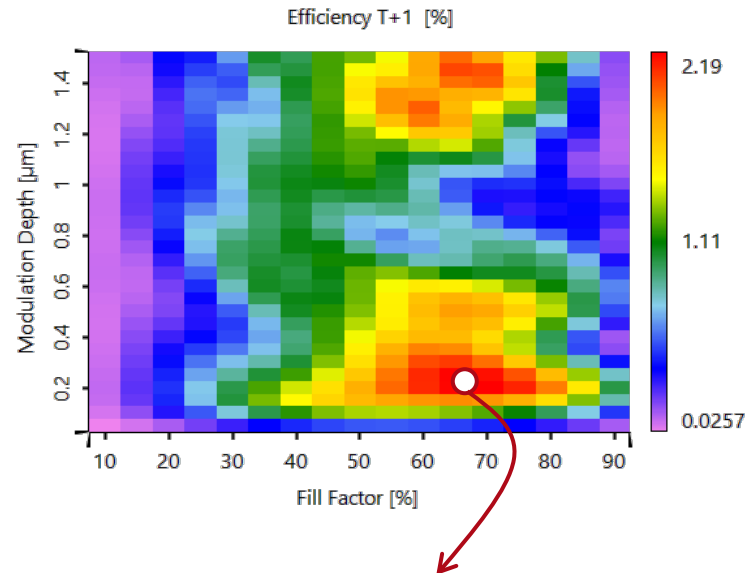
- Normal incidence



## Final Optimized Result

efficiency	15.7%
modulation depth	374nm
fill factor	59.2%

- 15° inclined incidence



## Final Optimized Result

efficiency	2.22%
modulation depth	222nm
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

7: X:\OneDrive\...\02\_Lightguide Coupling Analysis - Sensitivity Analysis (0°,0°).run

**Results**  
Start the parameter run and analyze its results

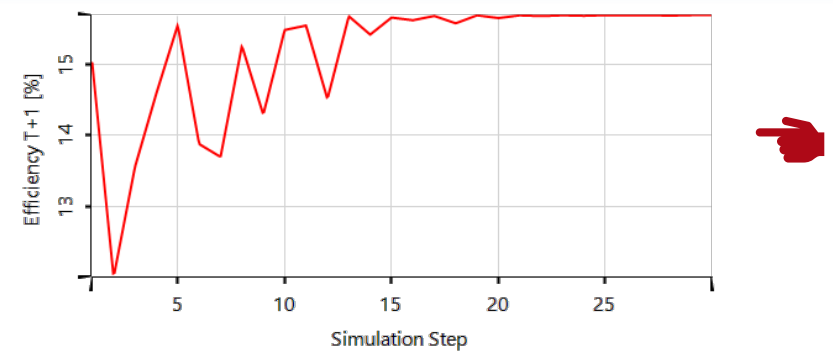
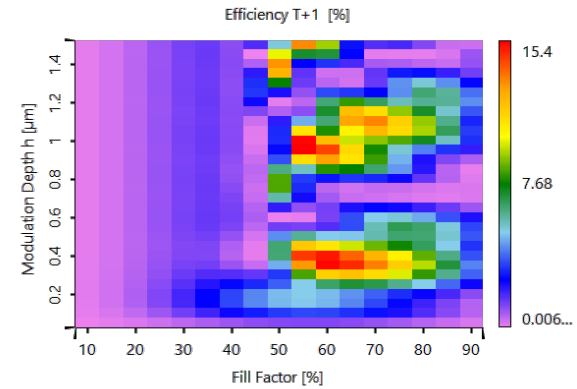
Go!

Use Cached Results for Next Run

Detector	Subdetector	Combined Output	Iteration Step									
			1	2	3	4	5	6	7	8	9	
Varied Parameters	Modulation Depth (L...	Data Array	50 nm	50 nm	50 nm	50 nm	50 nm	50 nm	50 nm	50 nm	50 nm	
	Relative Slit Width (...)	Data Array	10 %	15 %	20 %	25 %	30 %	35 %	40 %	45 %	50 %	
Lightguide Coupling Detect...	Value #1: Mean	Data Array	0.0385 %	0.106 %	0.214 %	0.361 %	0.532 %	0.745 %	0.907 %	1.08 %	1.26 %	

Create Output from Selection

Parameter Run



6: X:\OneDrive\...\03a\_Grating Optimization 950nm 55% Initial Setup (0°,0°).opt\*

**Constraint Specifications**  
Select and specify the constraints which shall be considered during optimization.

Constraint Host	Constraint Name	Use	Weight	Constraint Type	Value 1	Value 2	Start Value	Contribution
Lightguide Coupling	Grating_Stack	<input checked="" type="checkbox"/>	1	Range	50 nm	1.5 µm	950 nm	0 %
Lightguide	Grating_Stack	<input checked="" type="checkbox"/>	1	Range	10 %	90 %	55 %	0 %
Lightguide	Value #1: Mean	<input checked="" type="checkbox"/>	1	Target Value	0.3		15.4 %	100 %

Tools

Target Function Value

Parametric Optimization

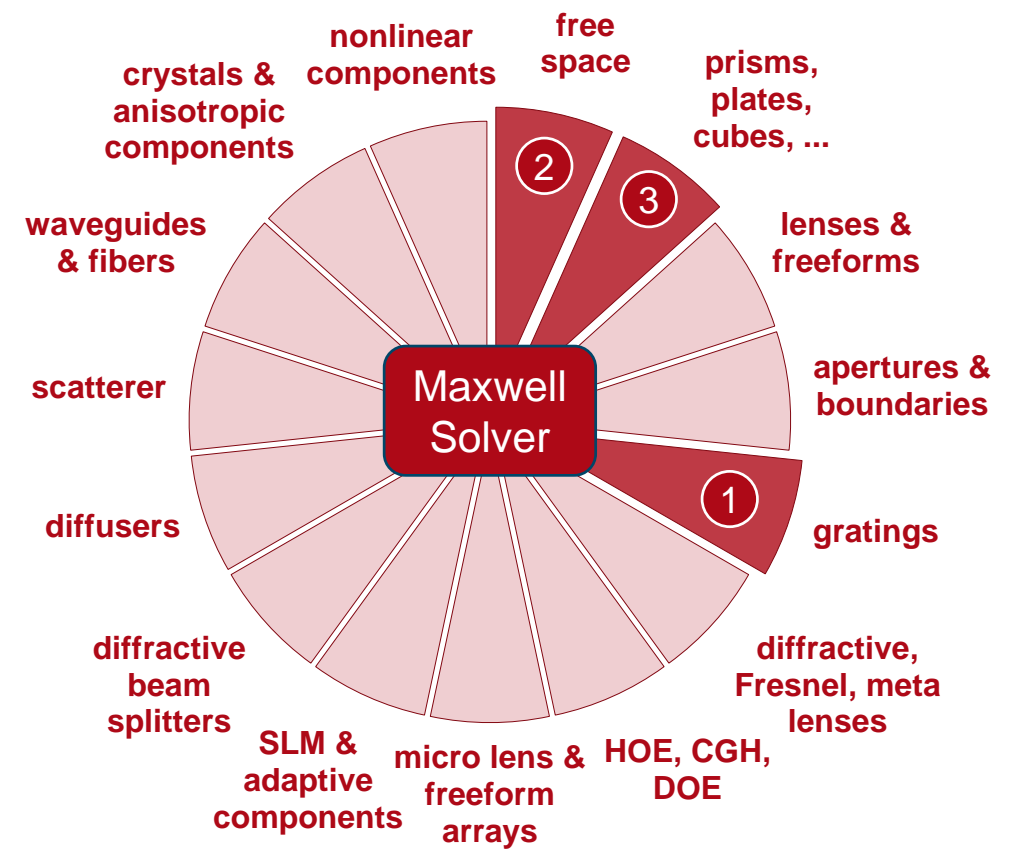
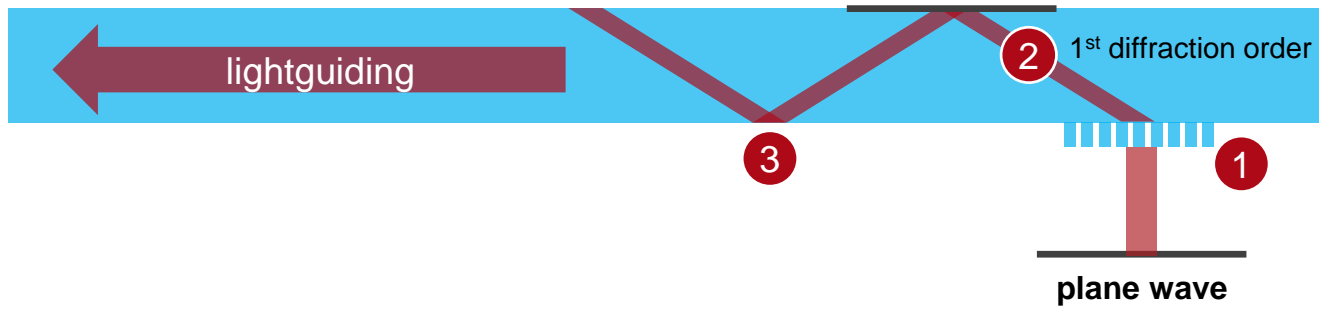


# Workflow in VirtualLab Fusion

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- 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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title	Optimization of Lightguide Coupling Grating for Single Incidence Direction
document code	LGC.0002
version	1.0
toolbox(es)	Starter Toolbox, Grating Toolbox
VL version used for simulations	7.4.0.49
category	Application Use Case
further reading	- <a href="#"><u>Analysis of Slanted Gratings for Lightguide Coupling</u></a>