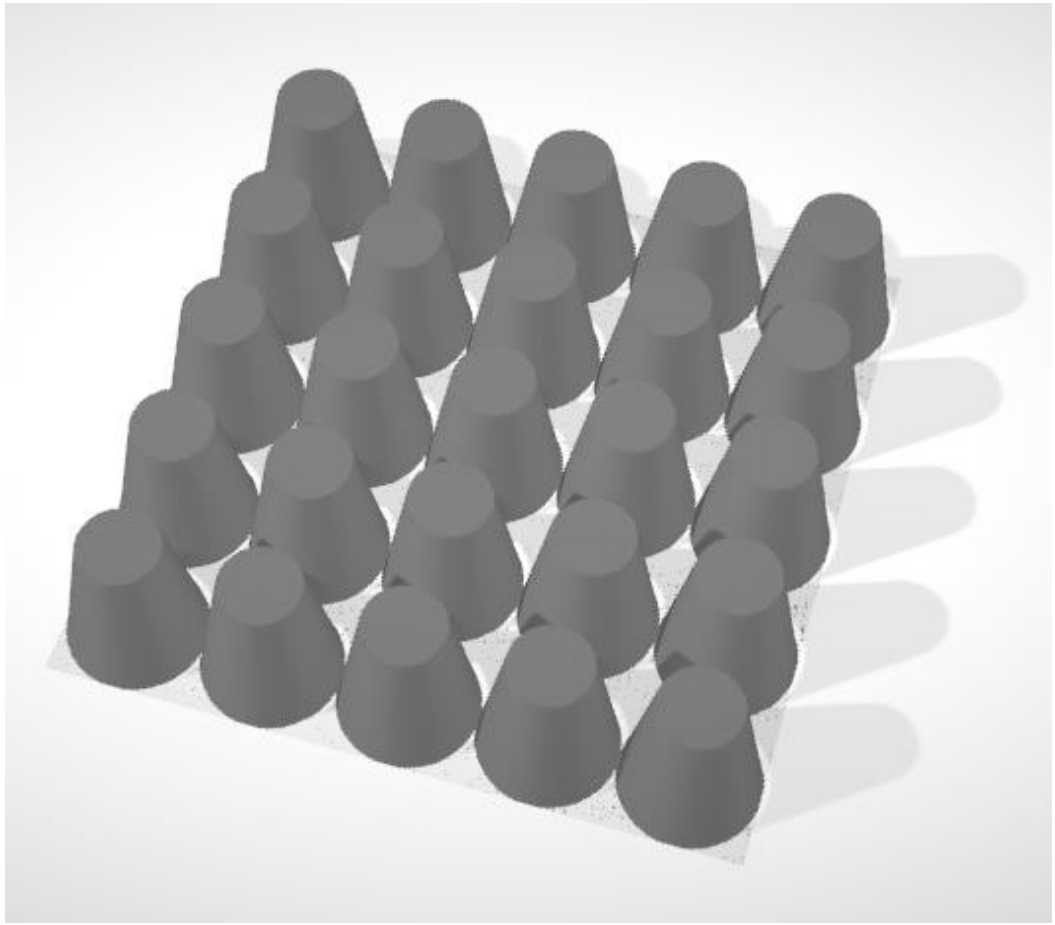
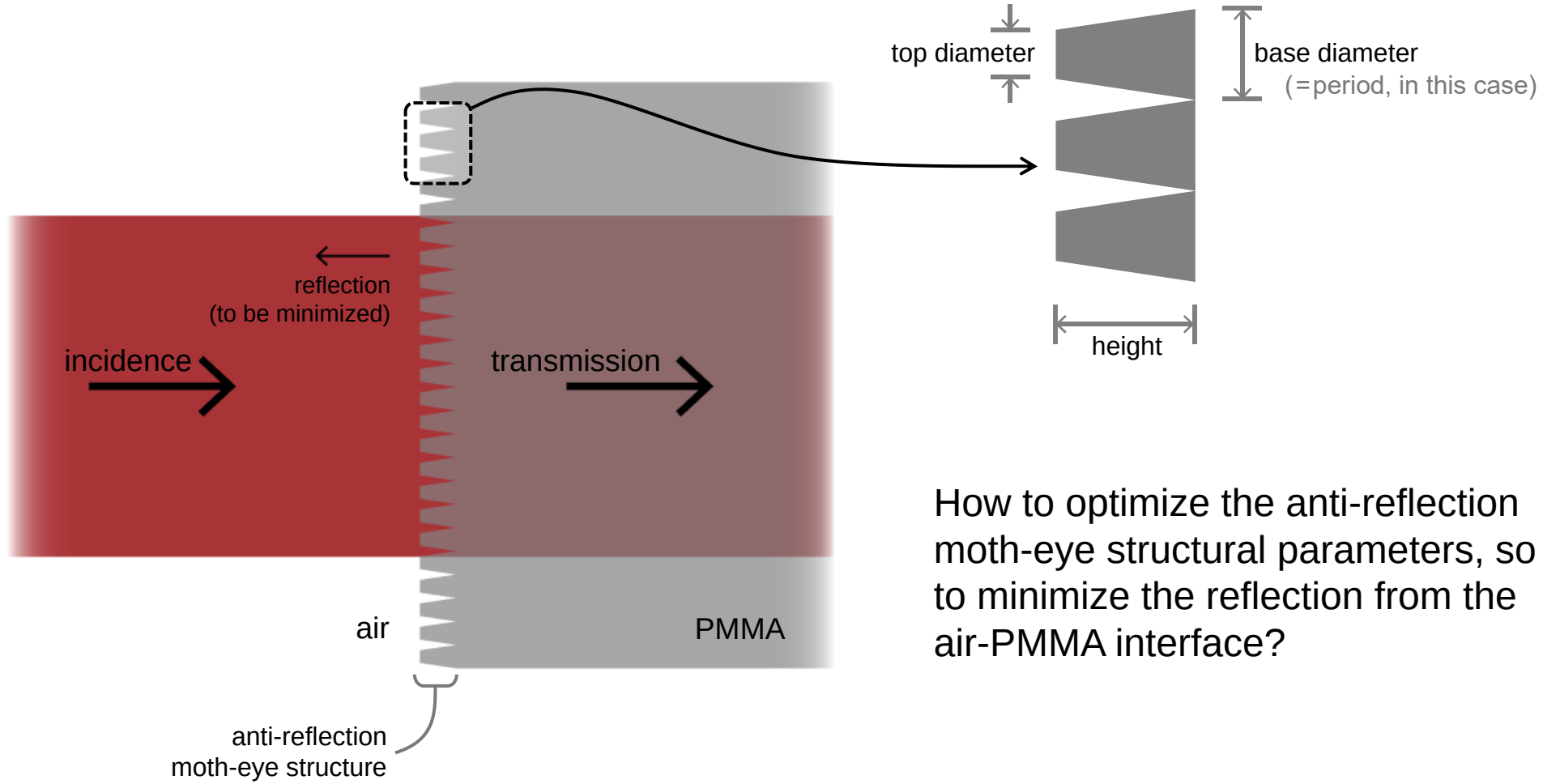
# Rigorous Analysis and Design of Anti-Reflective Moth-Eye Structures

# Abstract



The suppression of reflection at surfaces is of interest for numerous optical applications. One very interesting approach of controlling the reflection at surfaces is the usage of anti-reflective nano- and micro-structures, which are motivated by nature (moth-eye). These structures with feature sizes in the sub-wavelength domain exhibit unique properties concerning wavelength and angular dependency. In this document, the analysis and design of deterministic anti-reflective structures in VirtualLab Fusion is presented.

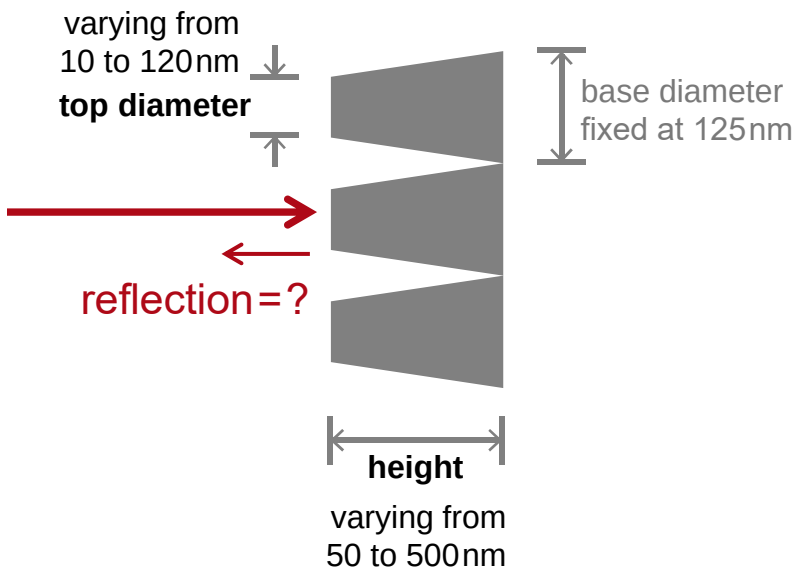
# Design Task

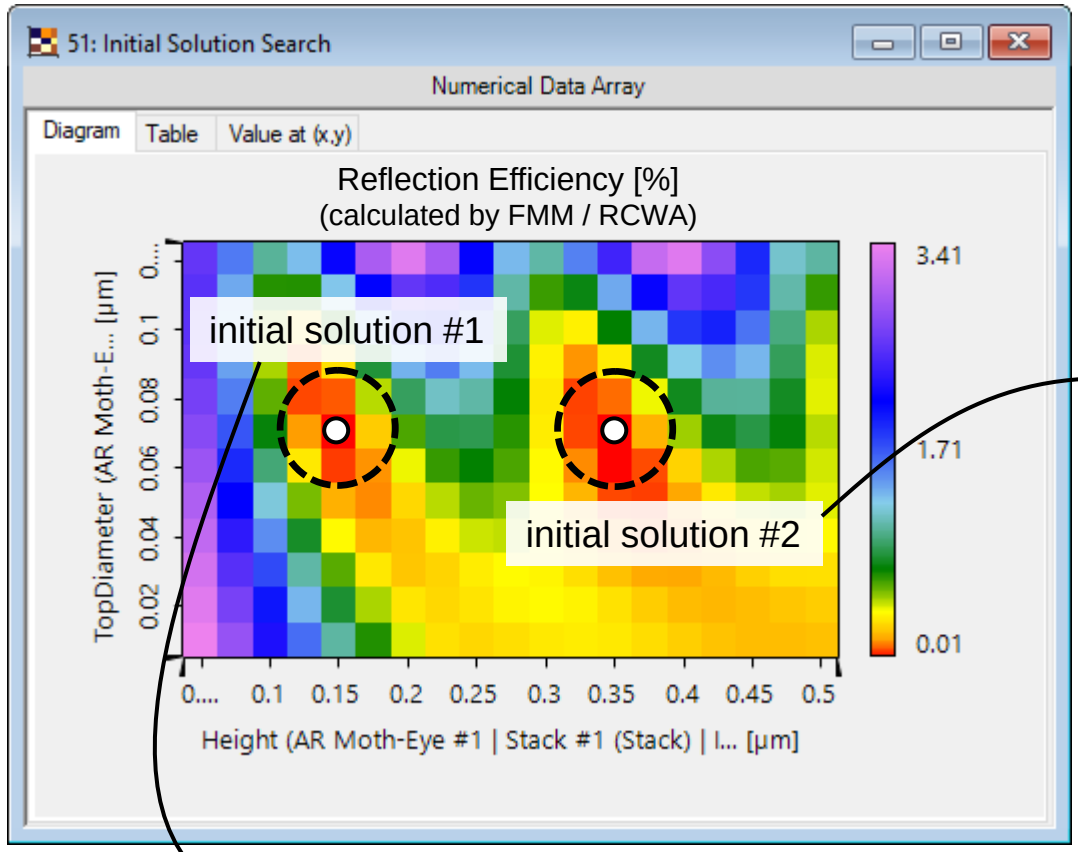



input plane wave
- wavelength 532nm
- normal incidence

How to optimize the anti-reflection moth-eye structural parameters, so to minimize the reflection from the air-PMMA interface?

# Scanning over Parameter Space for Initial Solutions

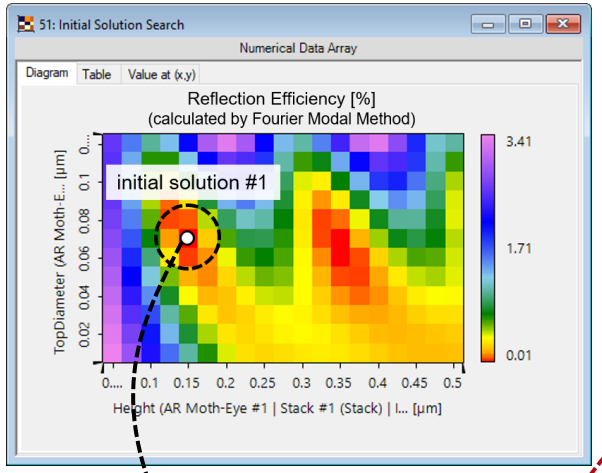


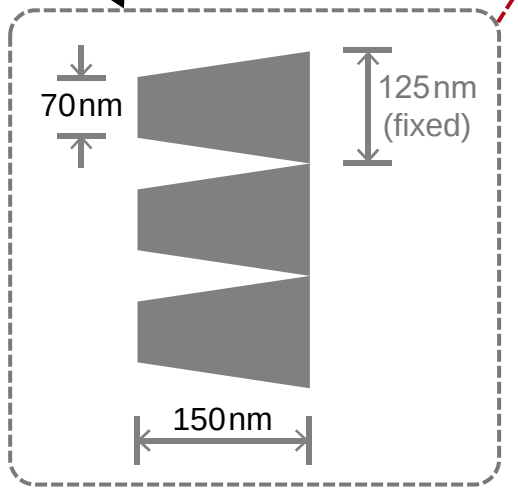




relatively higher aspect ratio and maybe not the first choice for fabrication

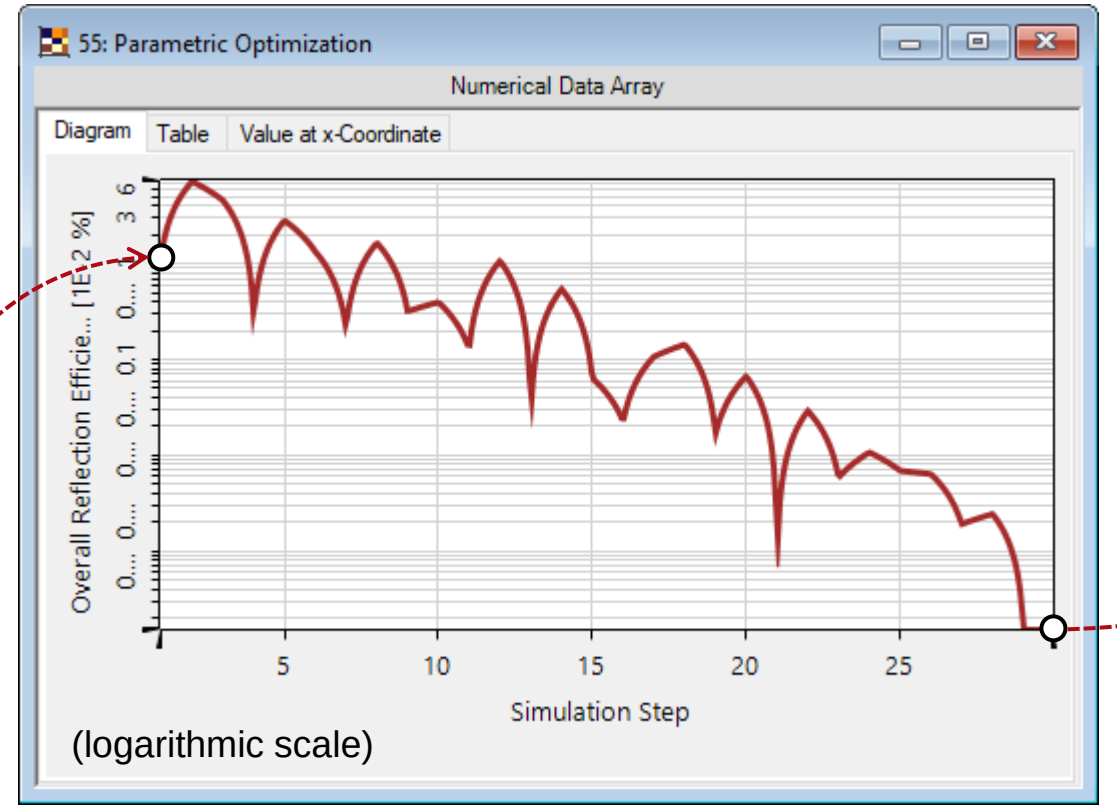
relatively smaller aspect ratio and therefore preferable for fabrication

# Parametric Optimization for Initial Solution #1



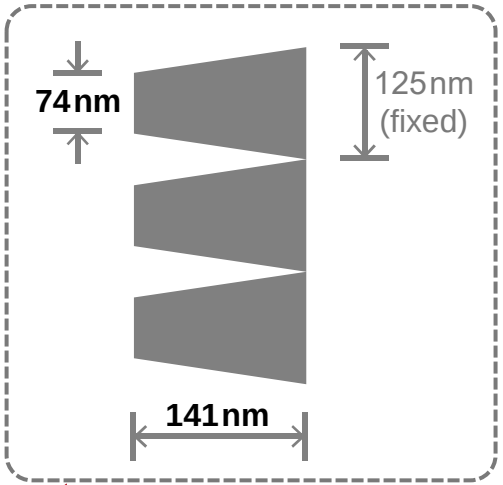




parametric optimization by downhill simplex method
(each iteration calculated by FMM / RCWA)

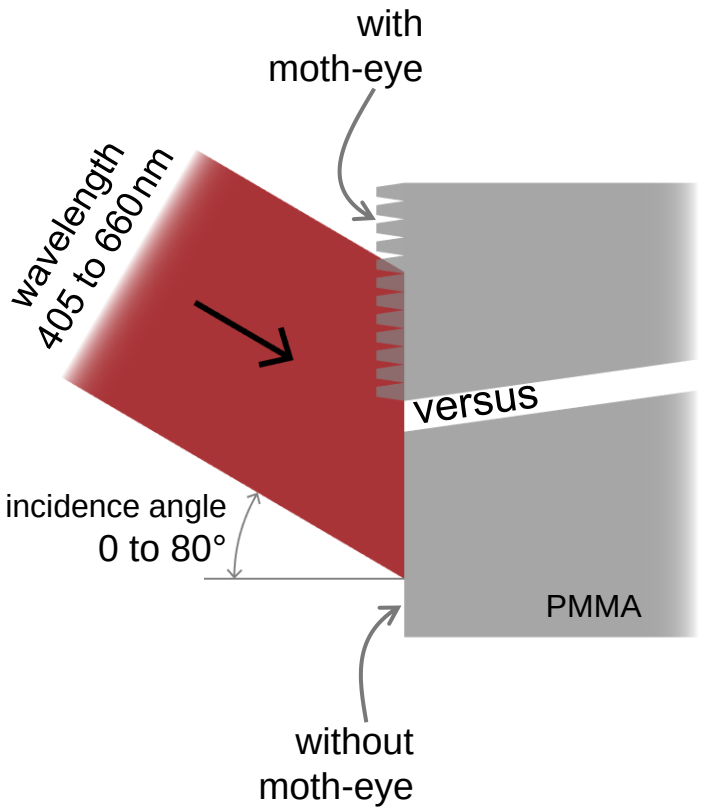



(logarithmic scale)

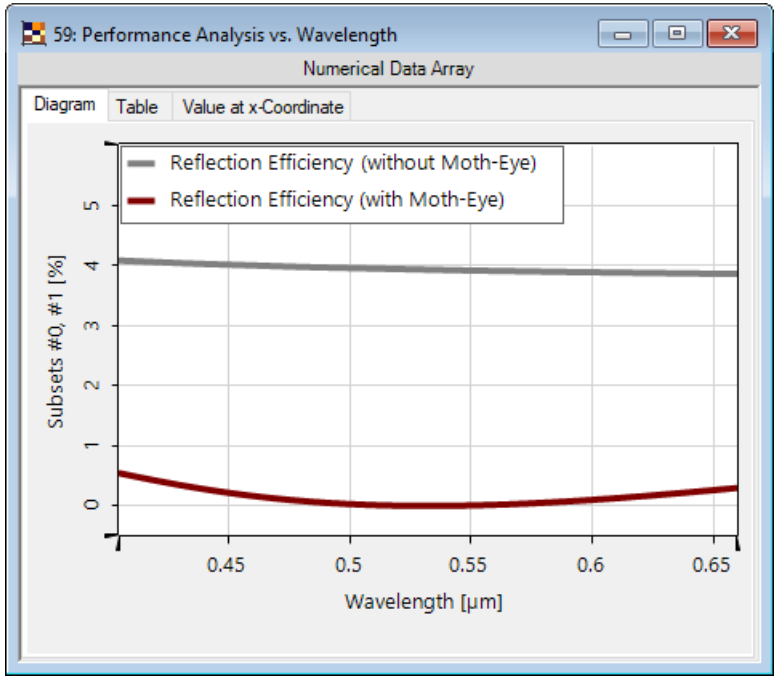
final design #1



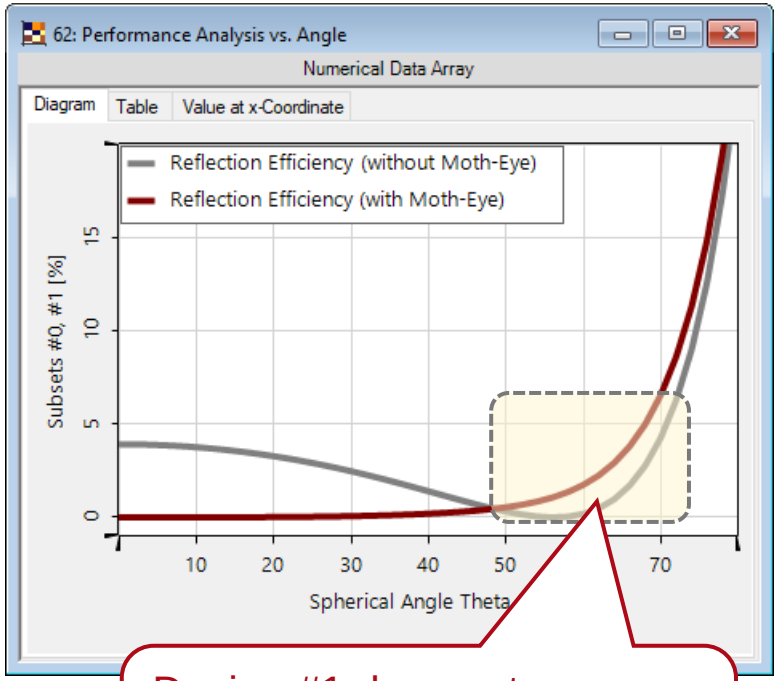
# Performance Analysis of Final Design #1




reflection efficiency vs. wavelength
(at normal incidence)

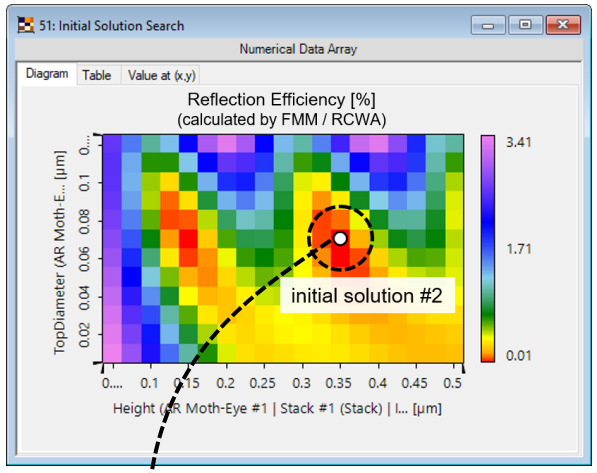


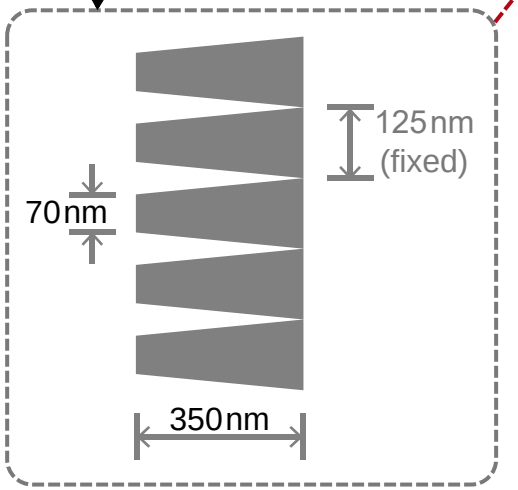

reflection efficiency vs. angle
(at 532nm wavelength)



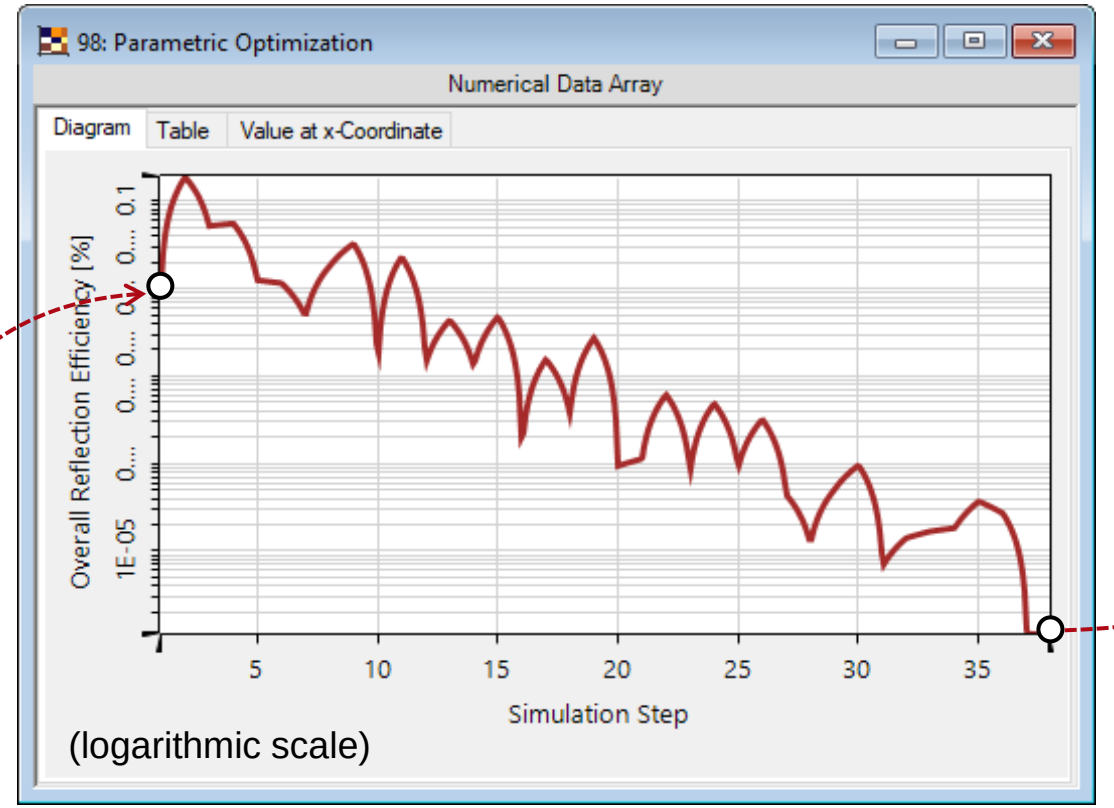

Design #1 does not suppress reflection effectively for incidence over 50°.

# Parametric Optimization for Initial Solution #2

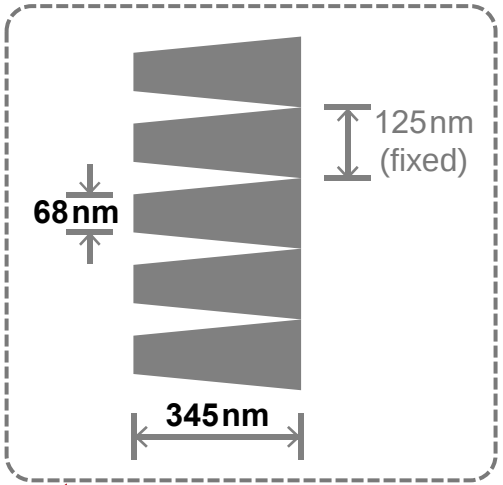


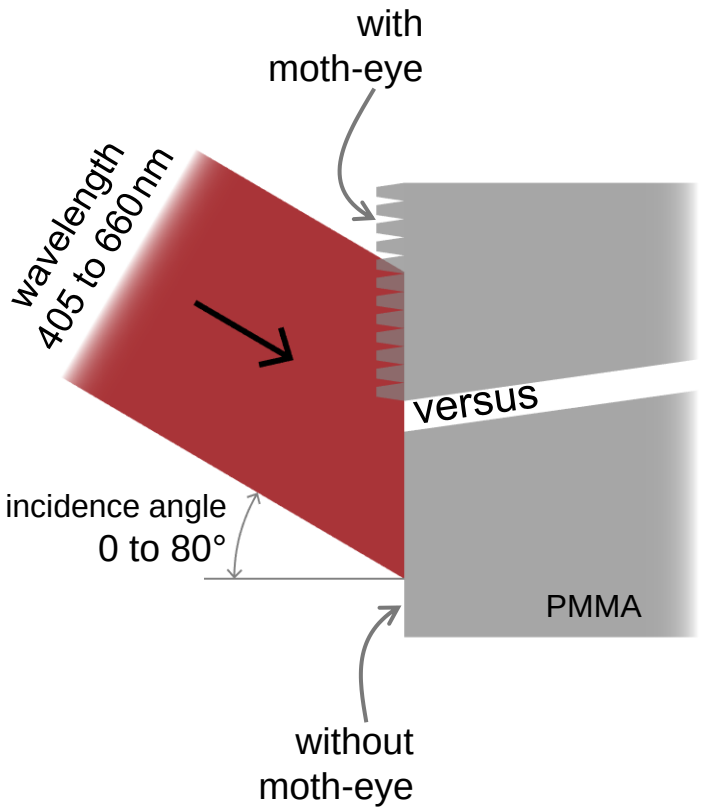

parametric optimization by downhill simplex method
(each iteration calculated by FMM / RCWA)



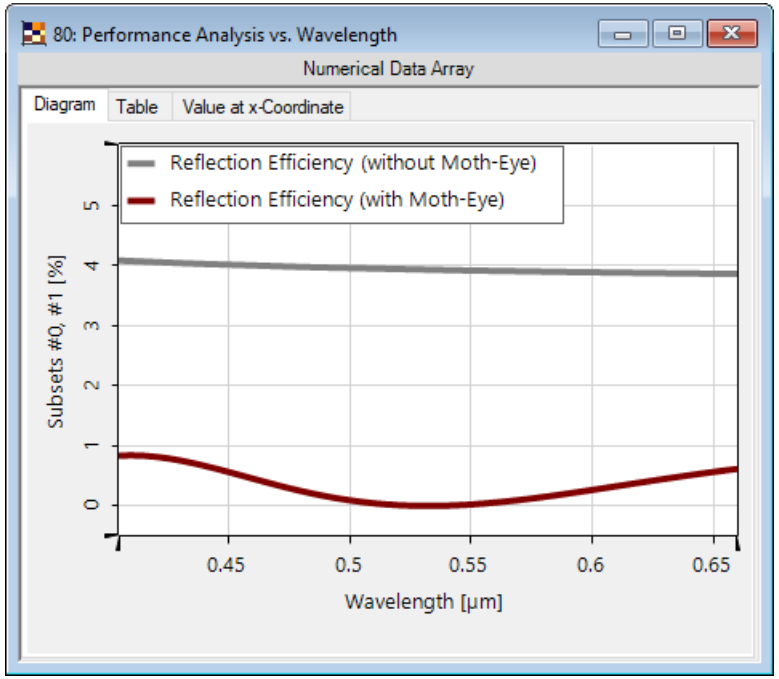

final design #2



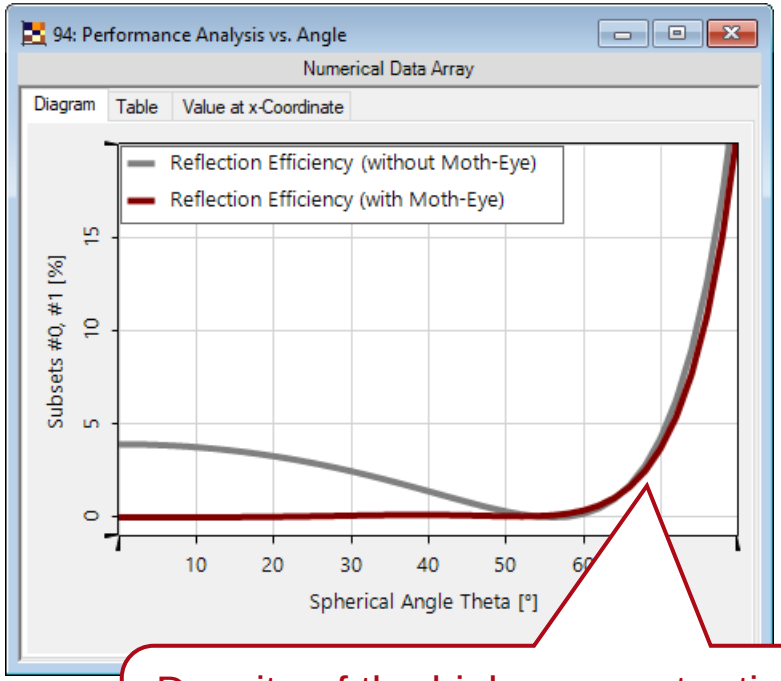
# Performance Analysis of Final Design #2




reflection efficiency vs. wavelength
(at normal incidence)



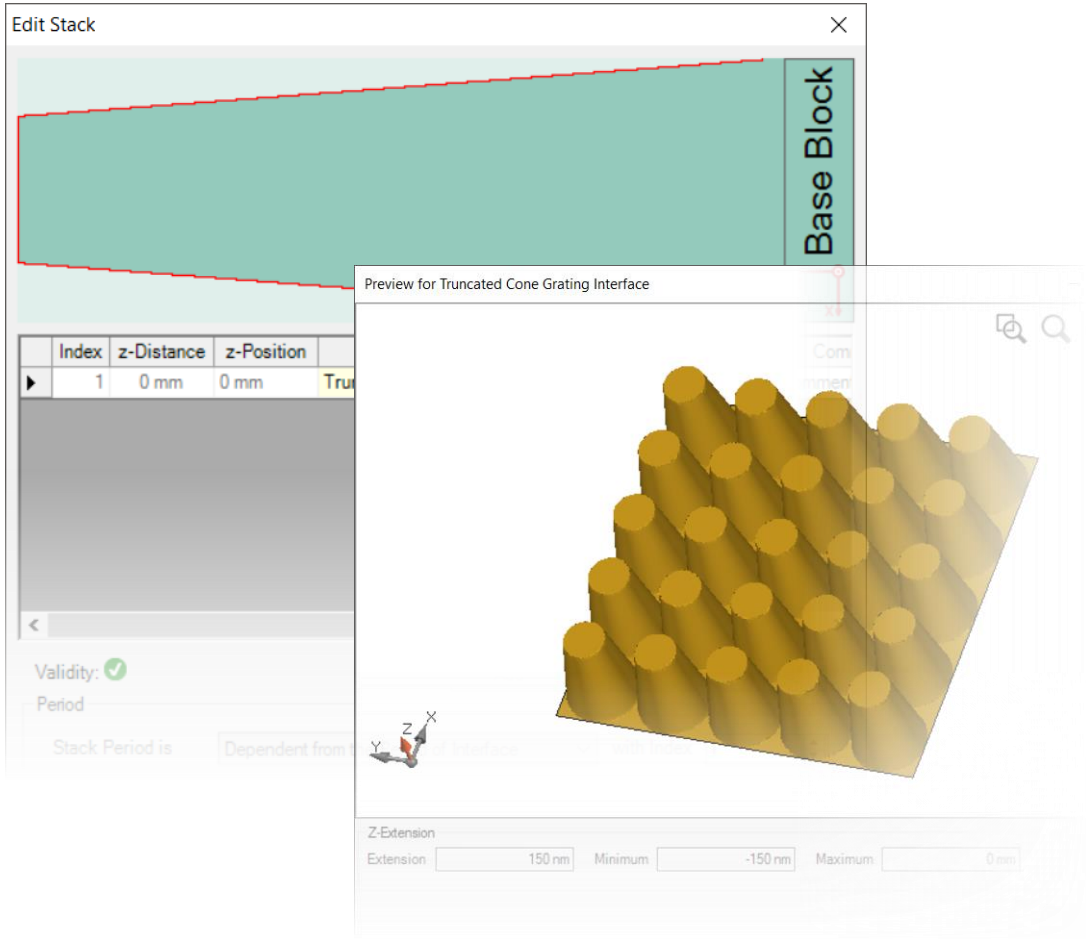

reflection efficiency vs. angle
(at 532nm wavelength)




Despite of the higher aspect ratio, design #2 suppresses reflection better for higher incidence angles.

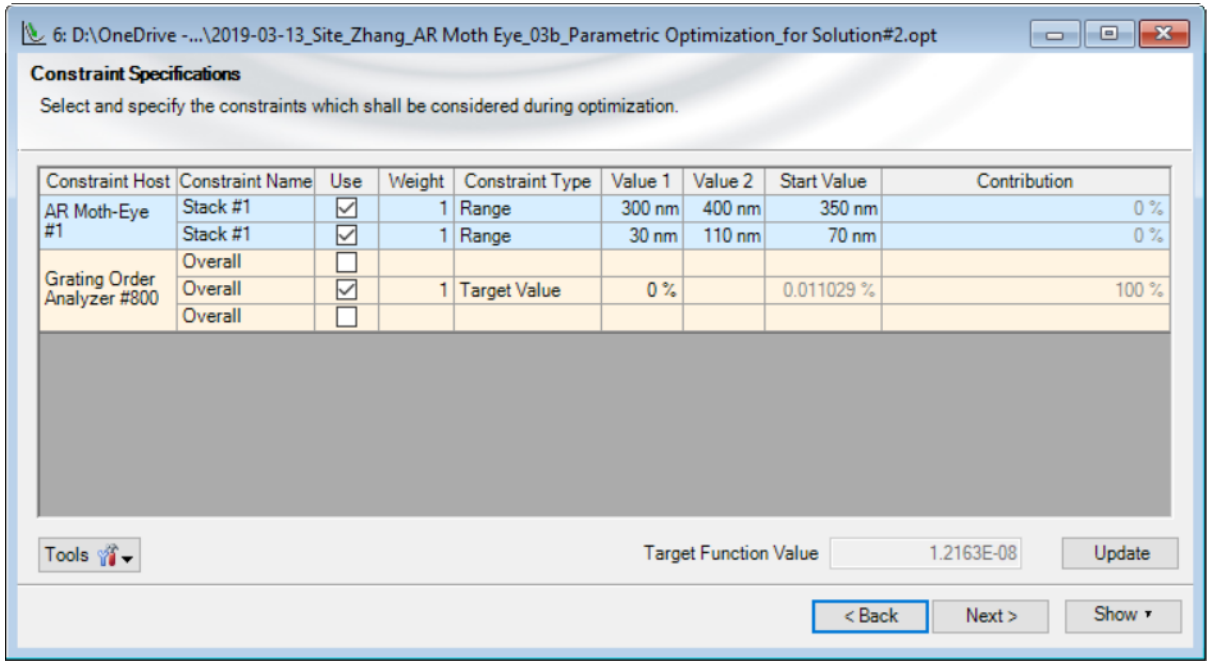
# Peek into VirtualLab Fusion

grating structure editor with preview



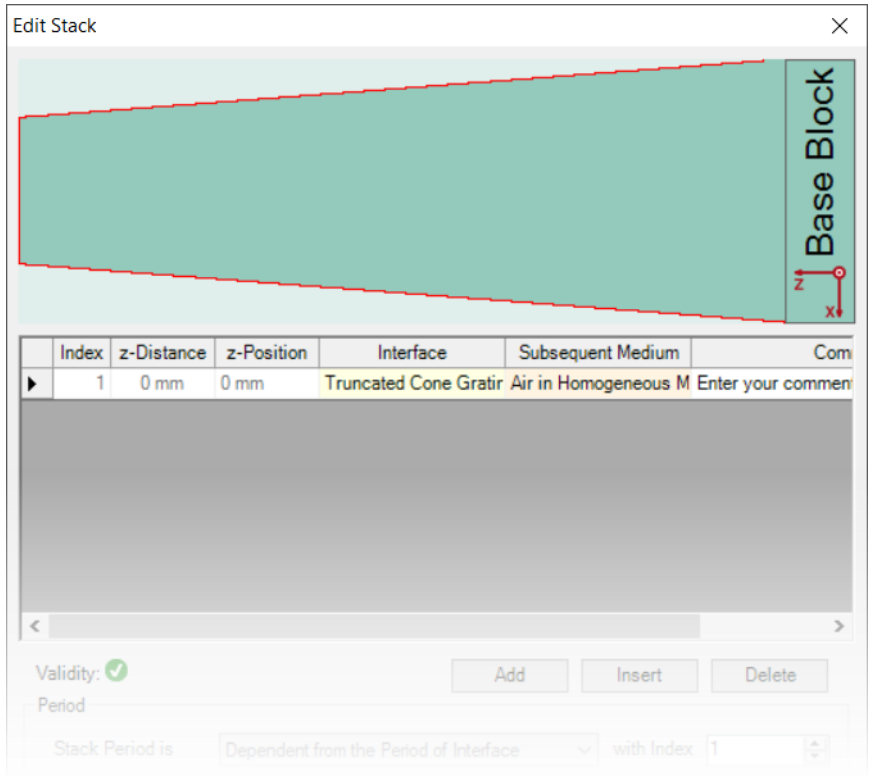

parametric optimization tools

with flexible variable and merit function definition

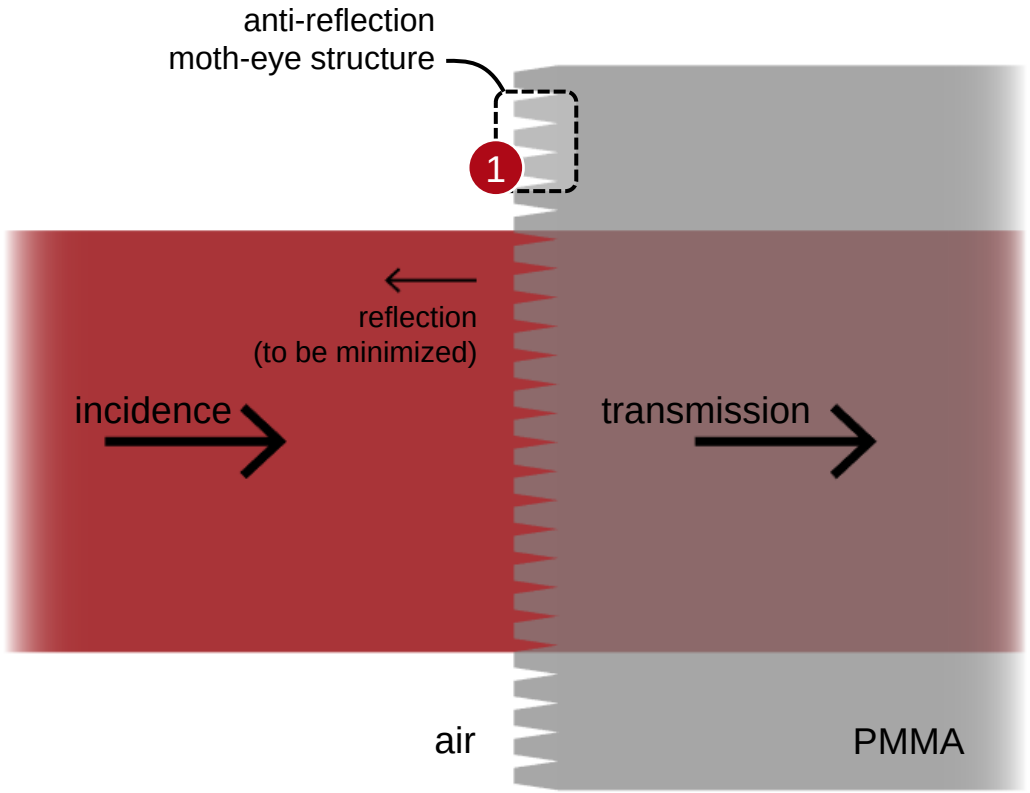


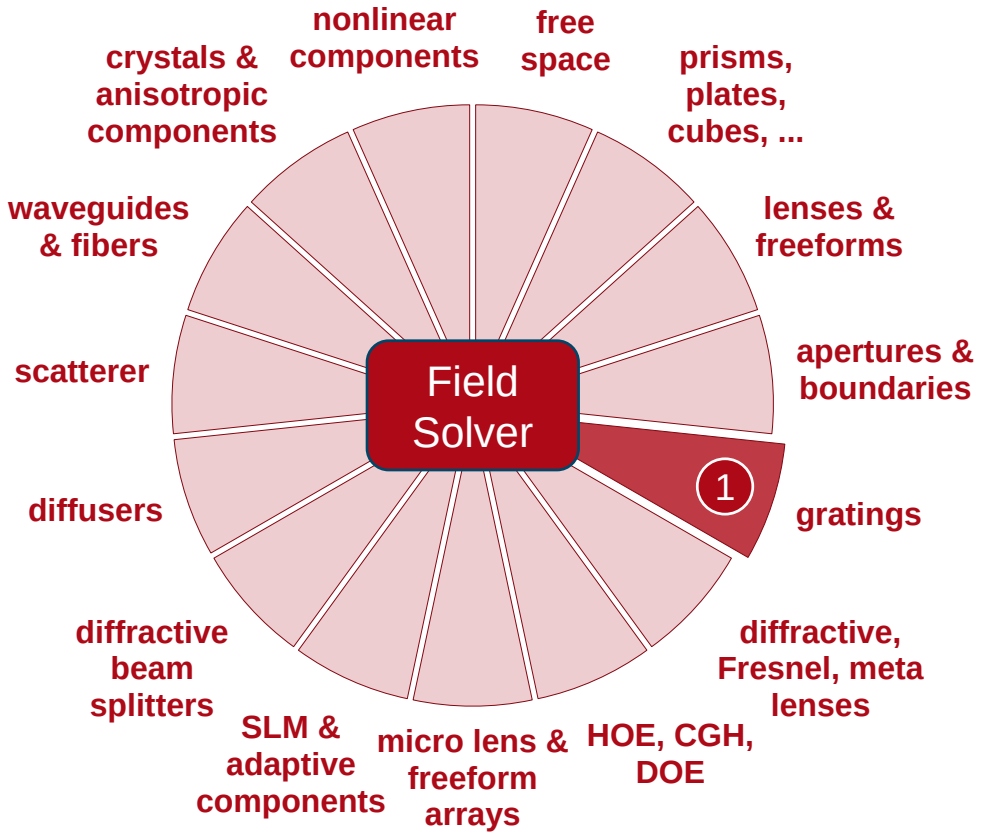
# Workflow in VirtualLab Fusion

- 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]
- Search for initial solutions with Parameter Run
  - Usage of the Parameter Run Document [Use Case]
- Find final design with Parametric Optimization



# VirtualLab Fusion Technologies



# Document Information

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