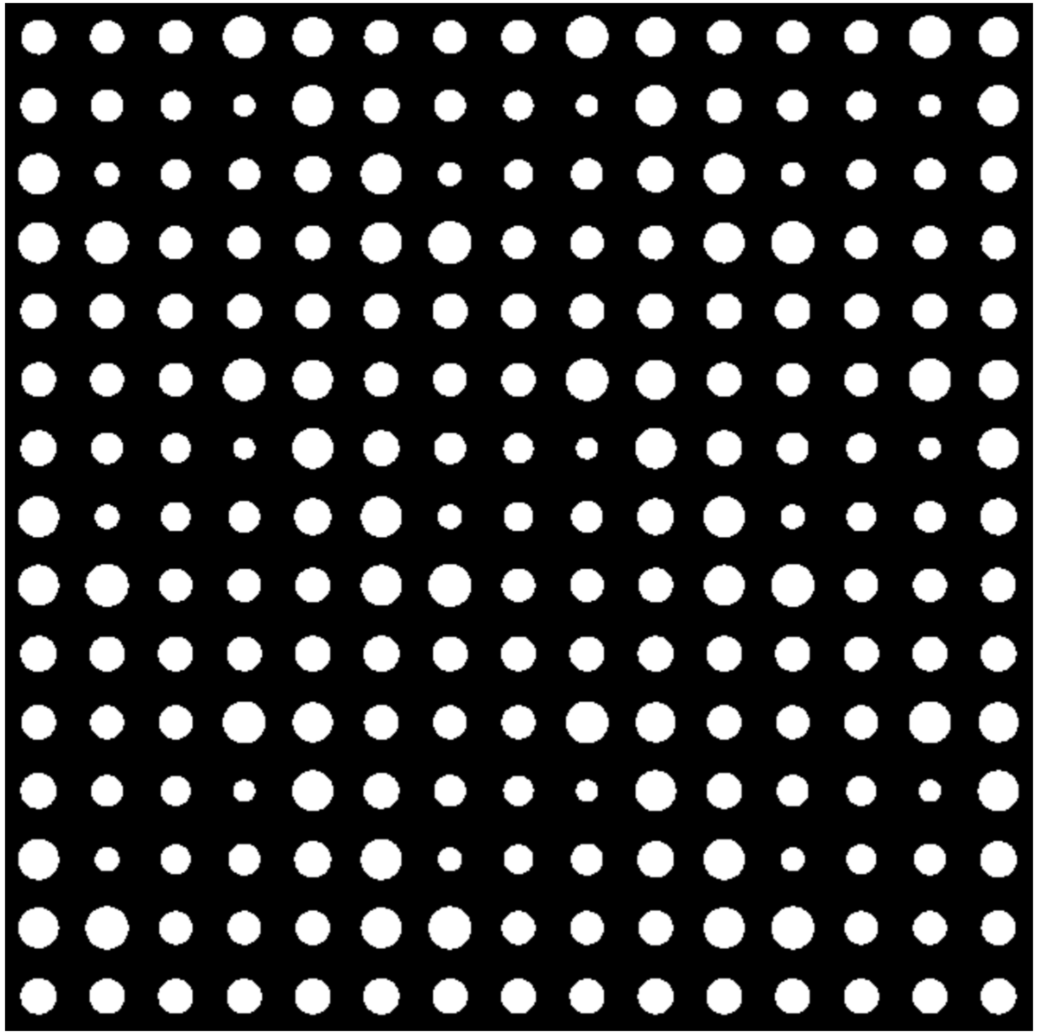
# Design of 2D Non-Paraxial Beam-Splitting Metagrating

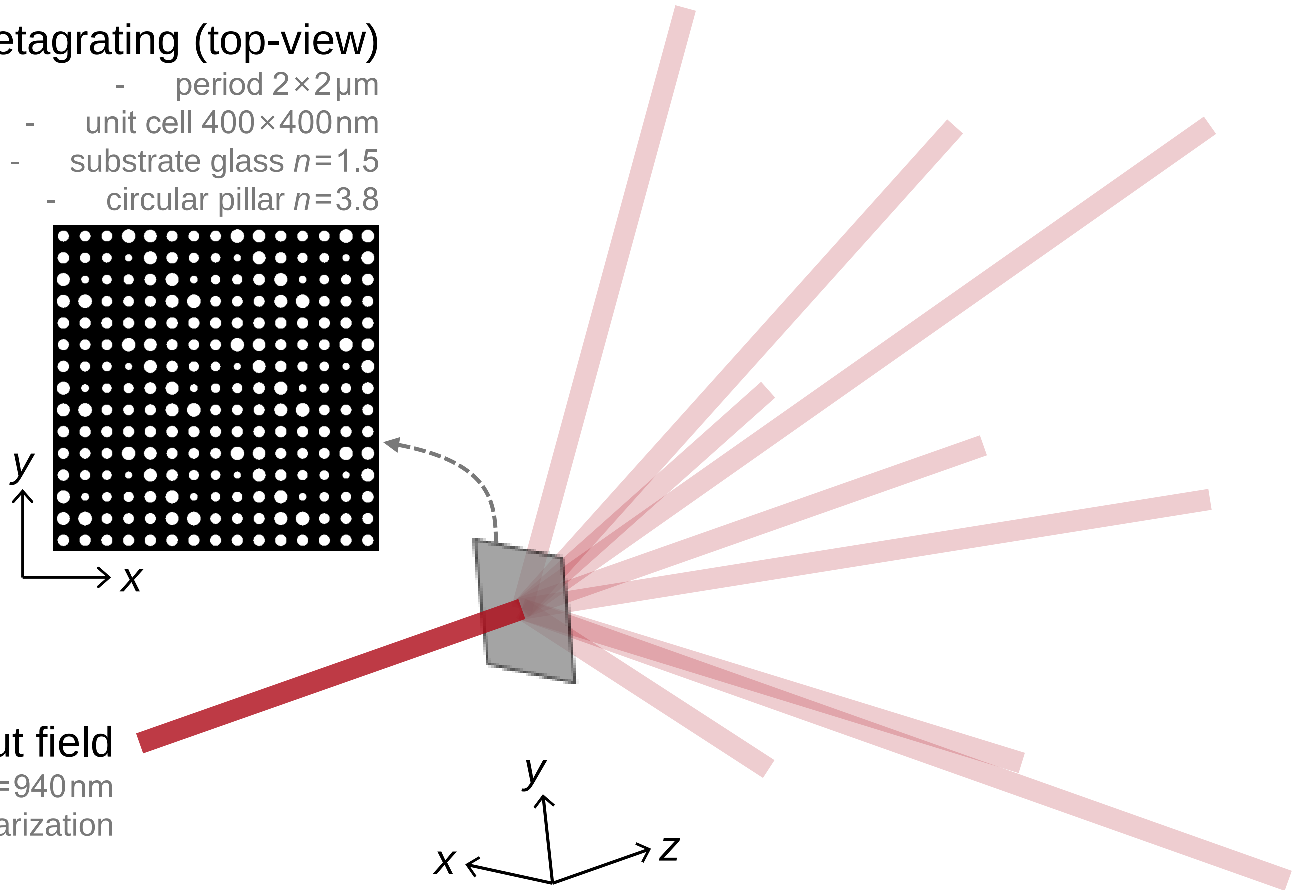
# Abstract



Metagratings are shown to have advantages when comparing with traditional gratings, especially in non-paraxial cases. In this example, we design a two-dimensional (2D) metagrating that splits the input into 3x3 beams. The metagrating is constructed with circular nano pillars, and in VirtualLab Fusion, we use FMM/RCWA to evaluate the diffraction efficiency of the metagrating. And, we show how to use the parametric optimization tool to improve the uniformity of the diffraction efficiencies.

# Design Task

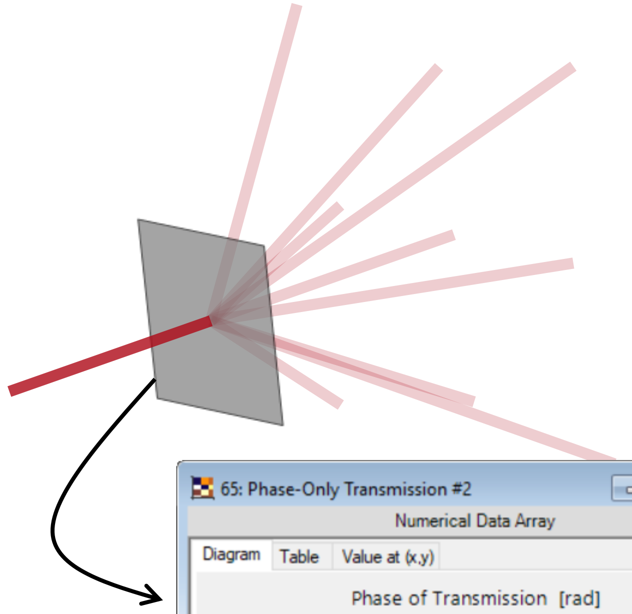
metagrating (top-view)
- period 2×2 µm
- unit cell 400×400 nm
- substrate glass $n$=1.5
- circular pillar $n$=3.8



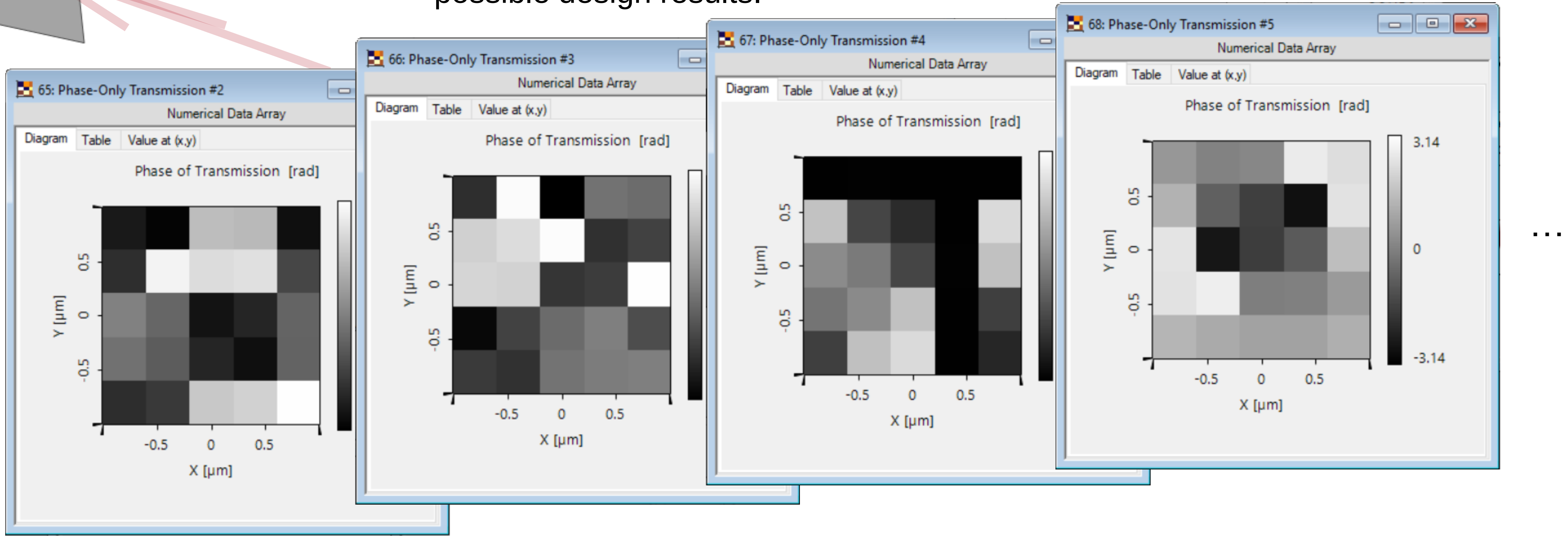

input field
- wavelength $\lambda$=940 nm
- $x$-polarization

How to design a metagrating that splits the input into 3×3 beams, with
- uniform power distribution into the 3×3 beams, and
- high overall transmission power of the 3×3 beams?

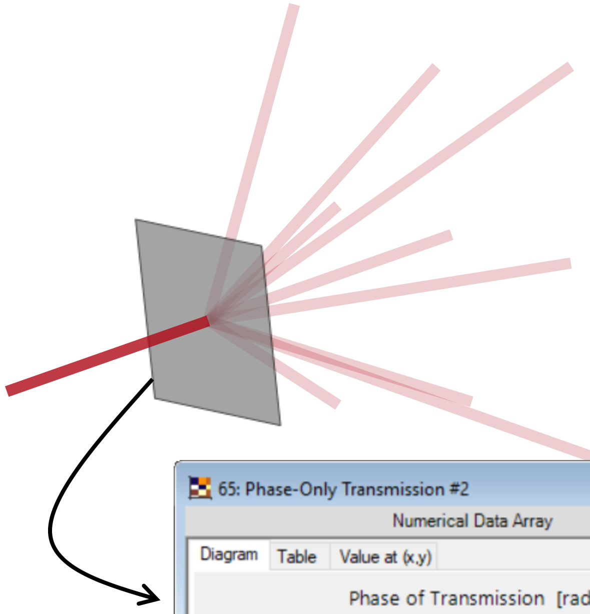
# Phase-Only Transmission Design (IFTA)



With differently random phase distributions as starting points, IFTA (iterative Fourier transform algorithm) calculates different possible design results.

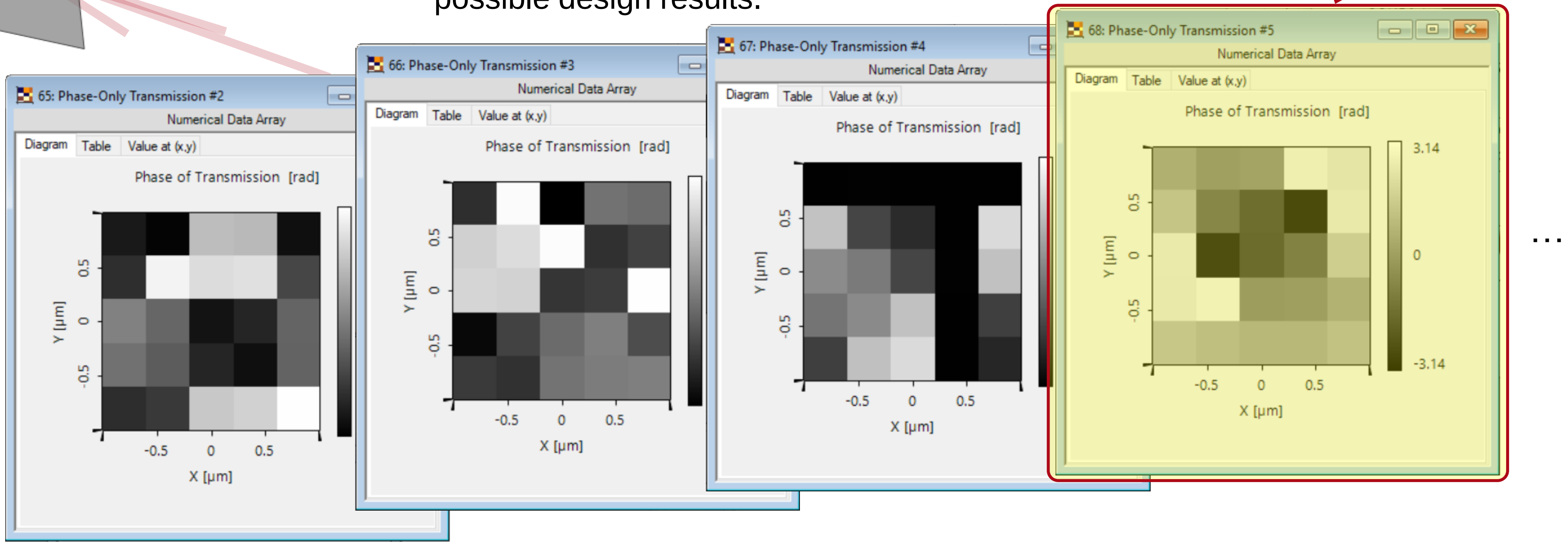


# Phase-Only Transmission Design (IFTA)

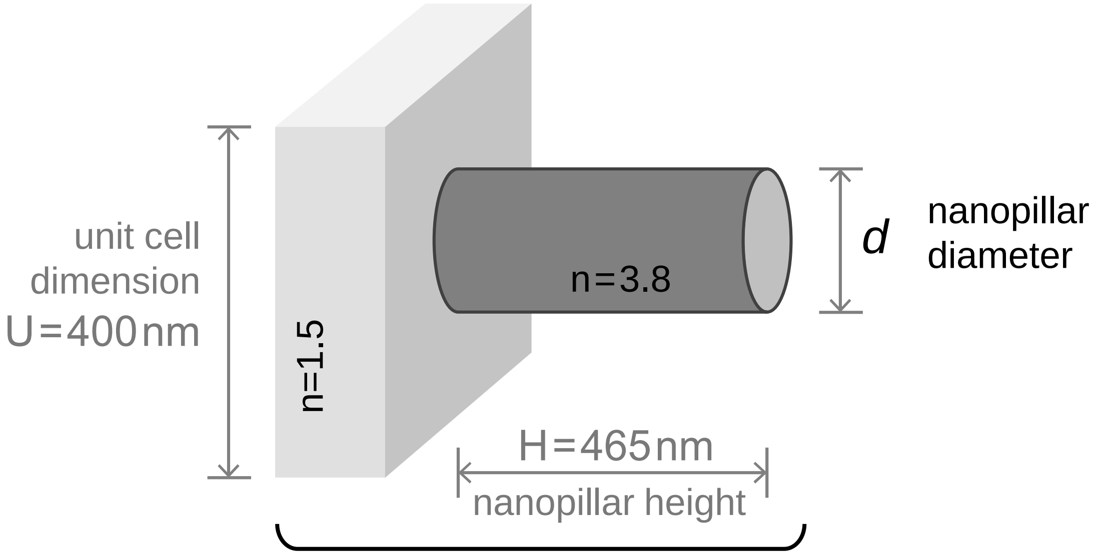


With differently random phase distributions as starting points, IFTA (iterative Fourier transform algorithm) calculates different possible design results.

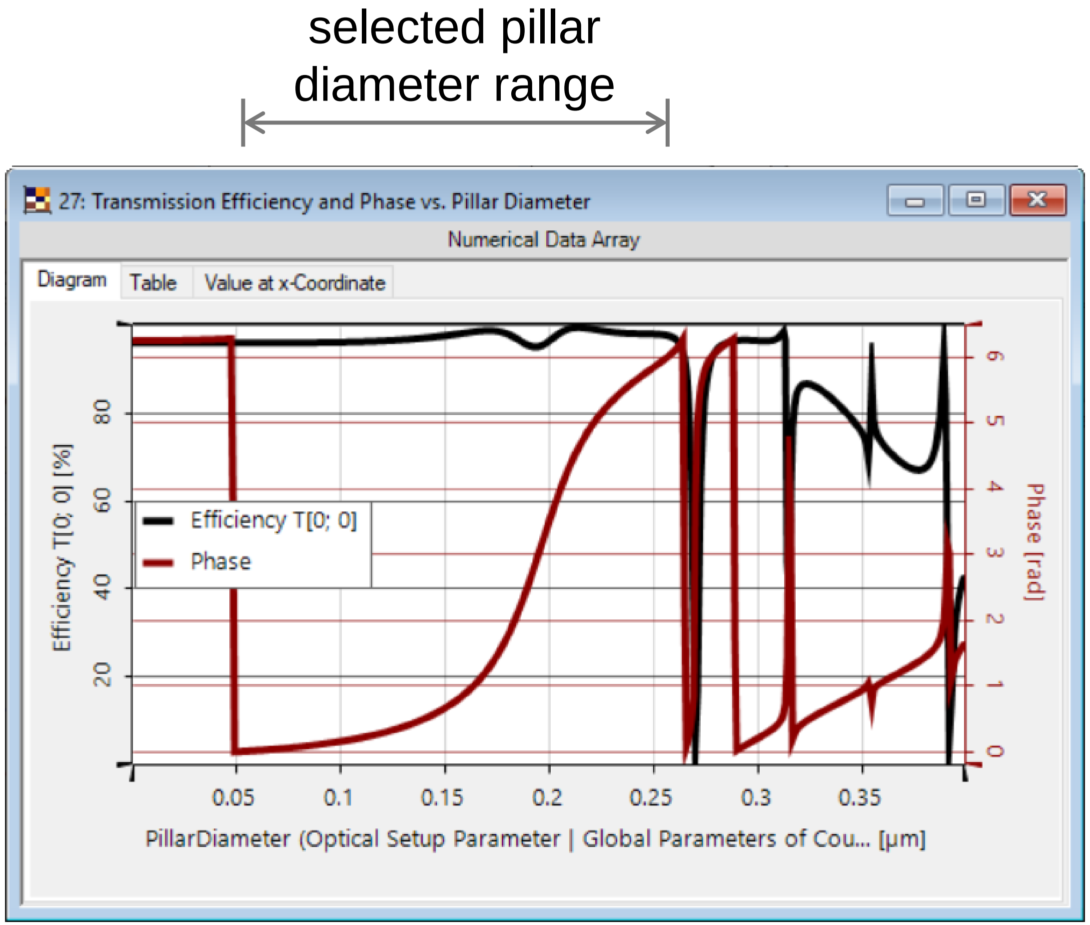
Select one of the results for further design



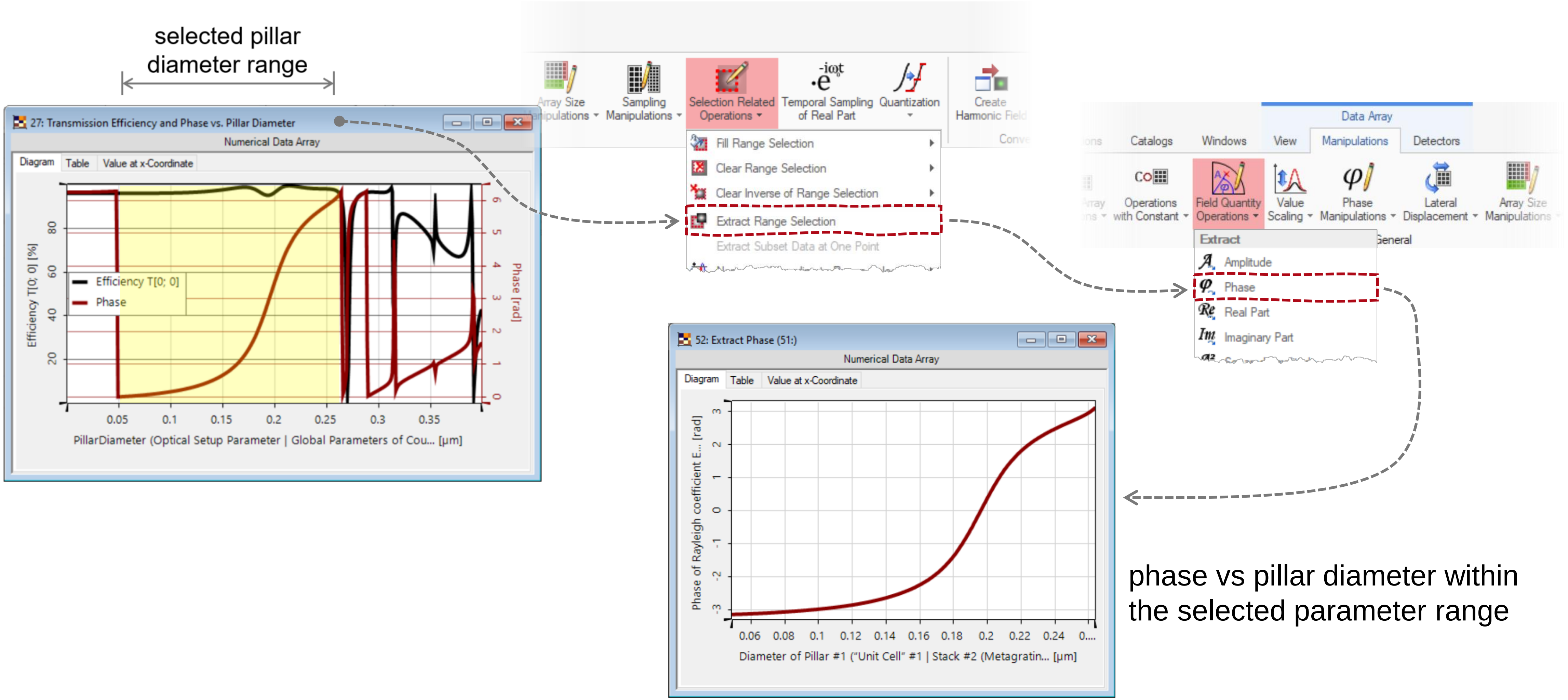
# Metasurface Unit Cell Analysis




single nanopillar as the building block of the metasurface

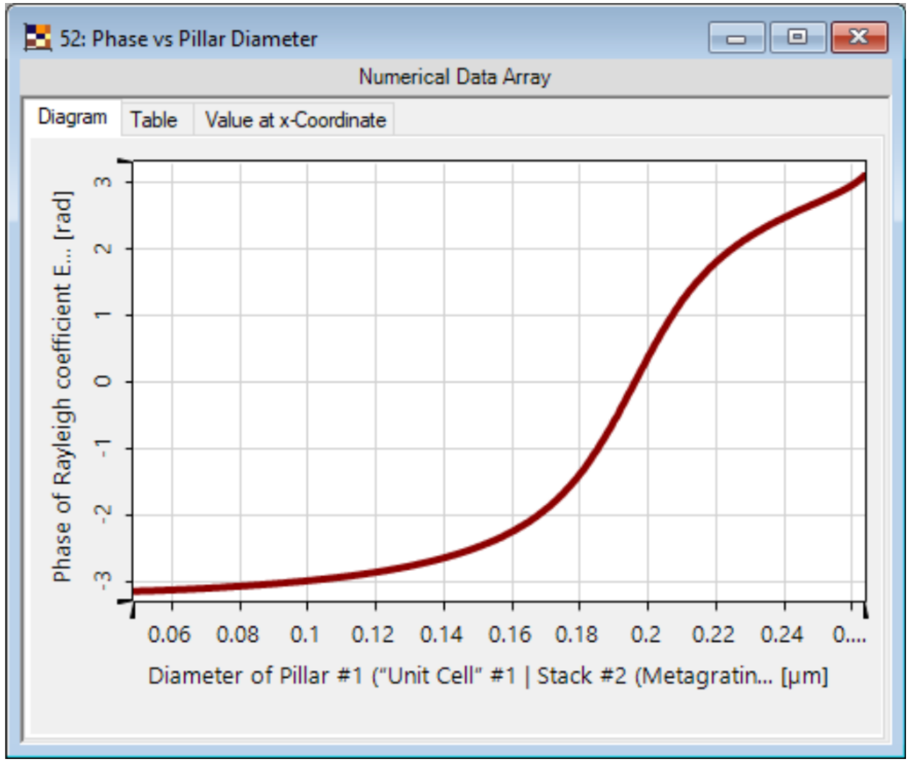


# Unit Cell Parameter Range Selection



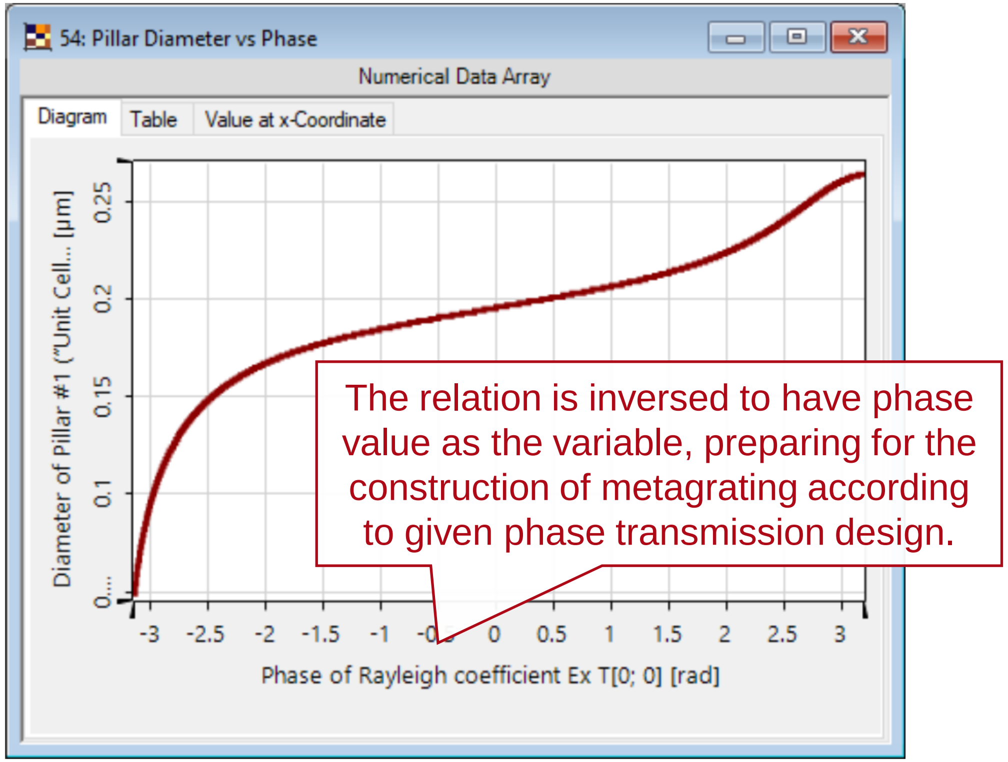
# Phase vs Pillar Diameter and Its Inverse

phase value vs pillar diameter
(result from last step)



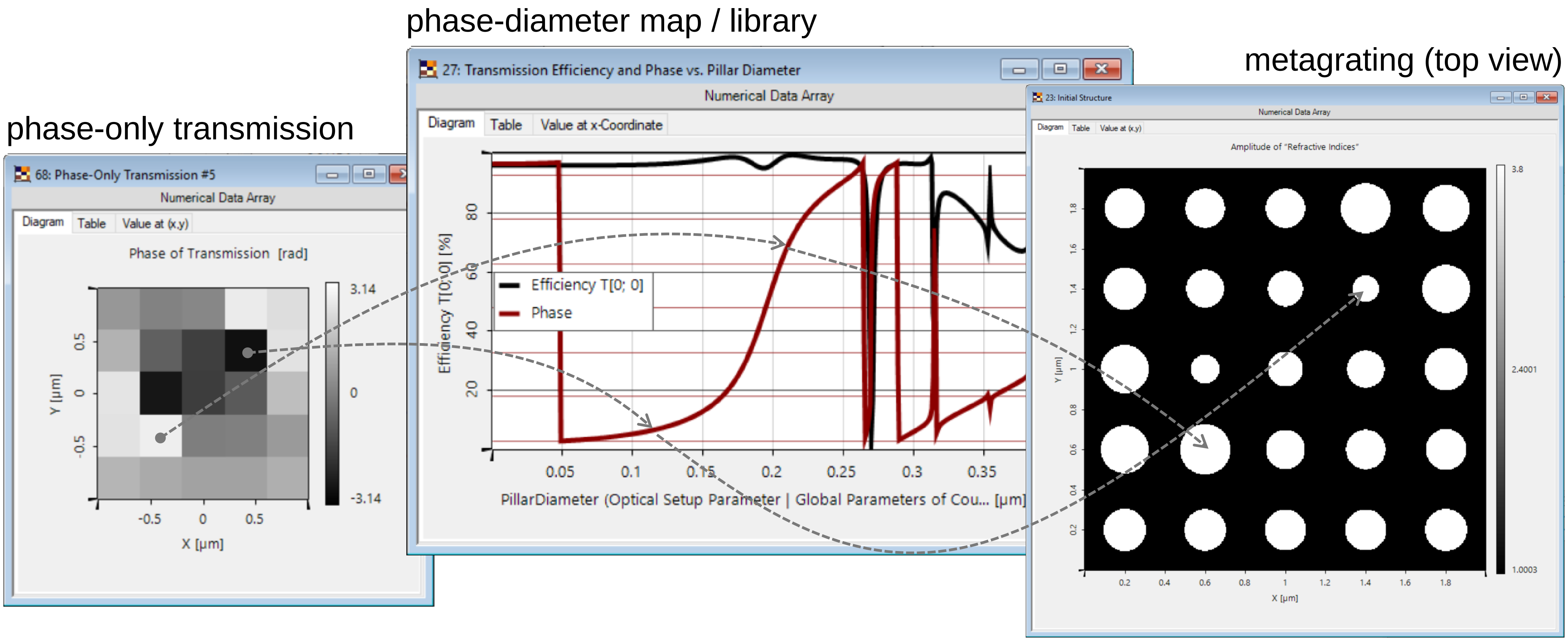

inverse

pillar diameter vs phase value




In this example, function inversion can be done with the VirtualLab C# Module: Appx_01_Calculate Inverse of 1D Function.cs

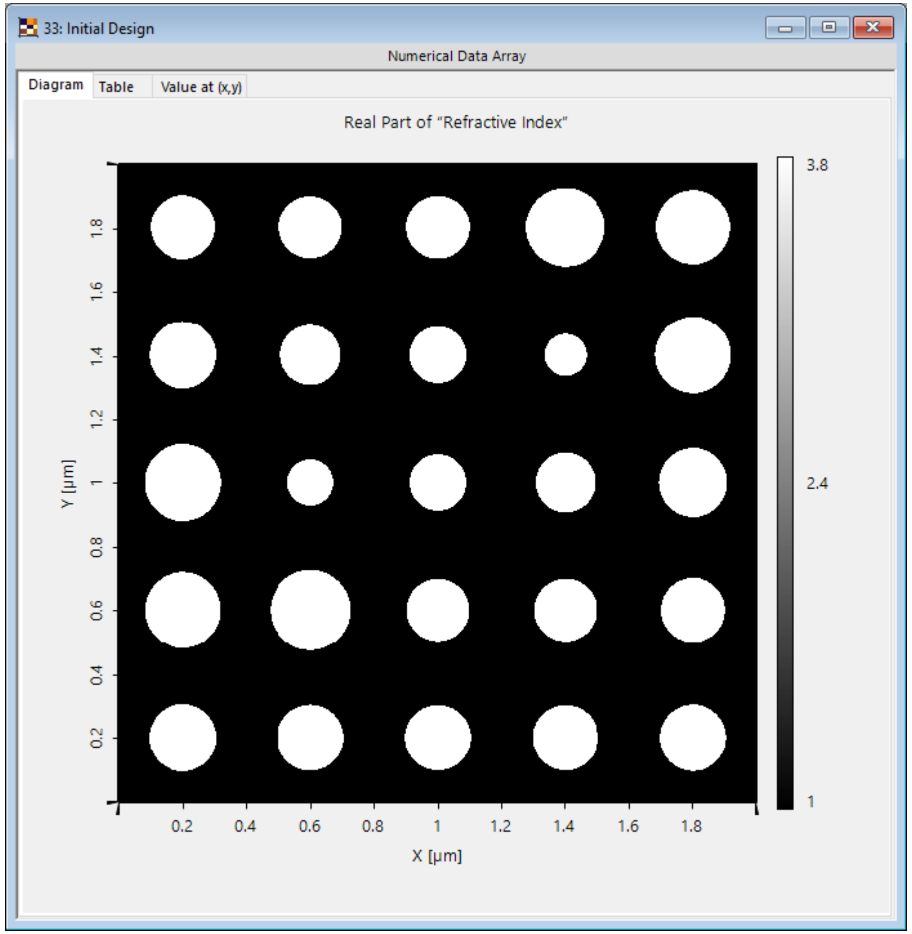
# Metagrating Construction



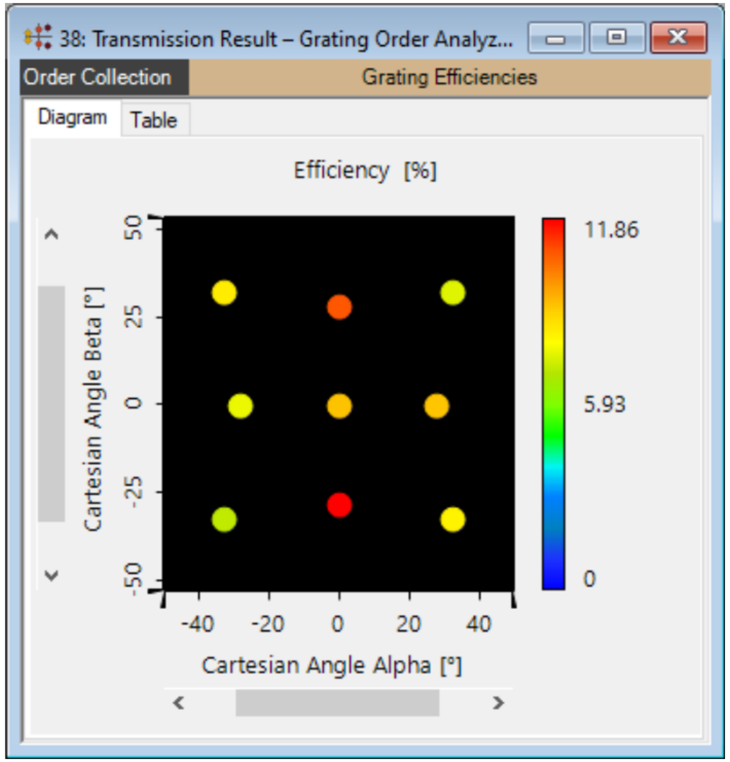

In this example, pillar distribution can be done with the VirtualLab C# Module: Appx_02_Calculate Pillar Diameters from Phase Profile.cs

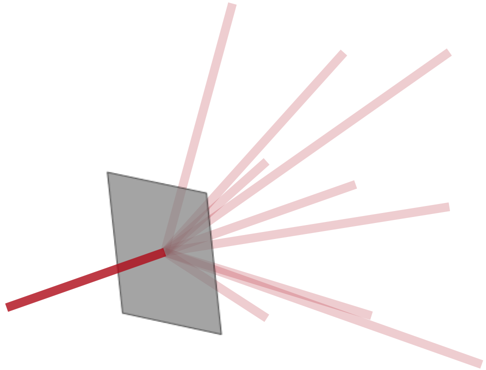
# Evaluation of Initial Metasurface Design

initial metagrating (top-view)




diffraction efficiencies

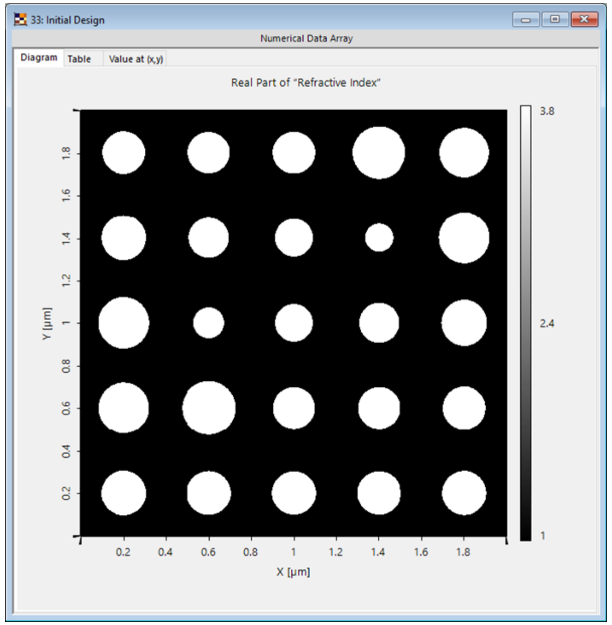


| | |
|---|---|
| overall efficiency | 79.6% |
| uniformity error (PV) | 25.3% |
| uniformity error (RMS) | 16.9% |

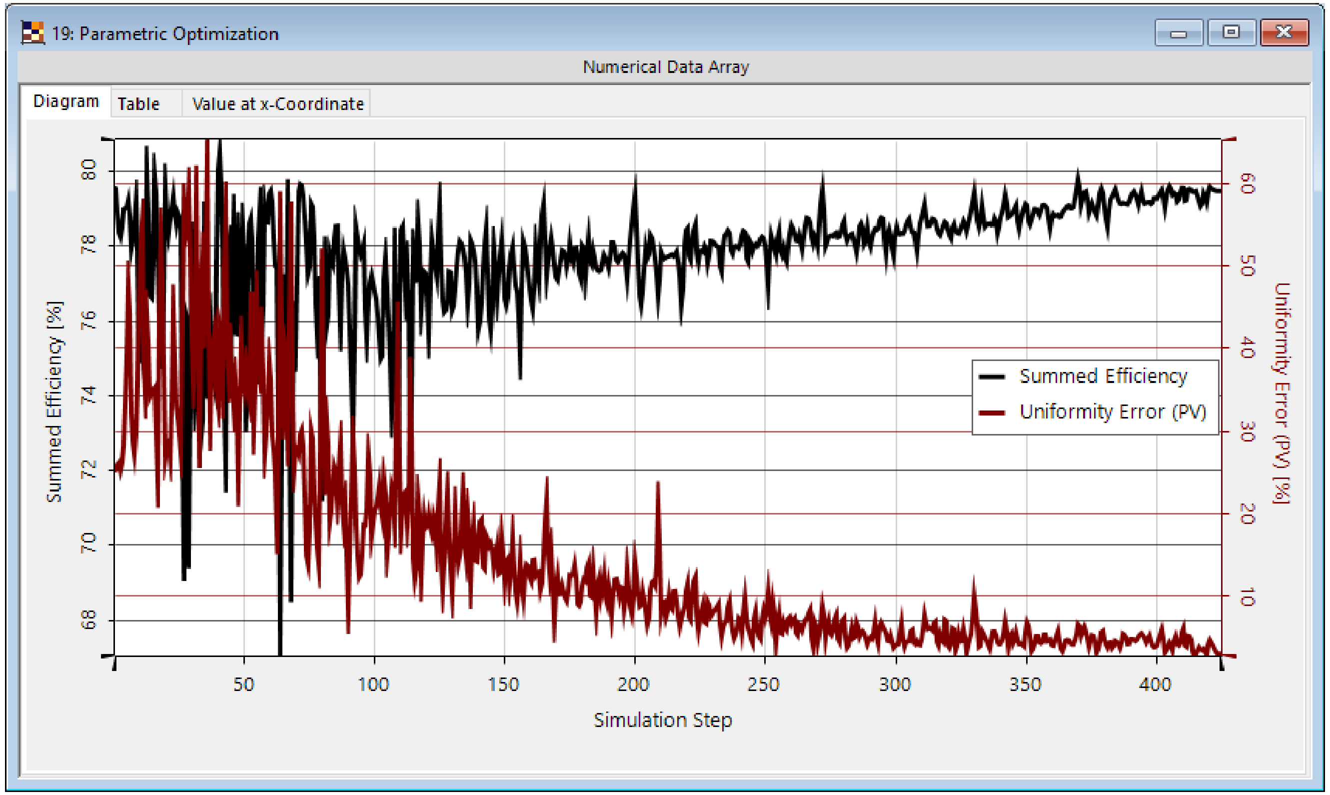
# Parametric Optimization

initial metagrating



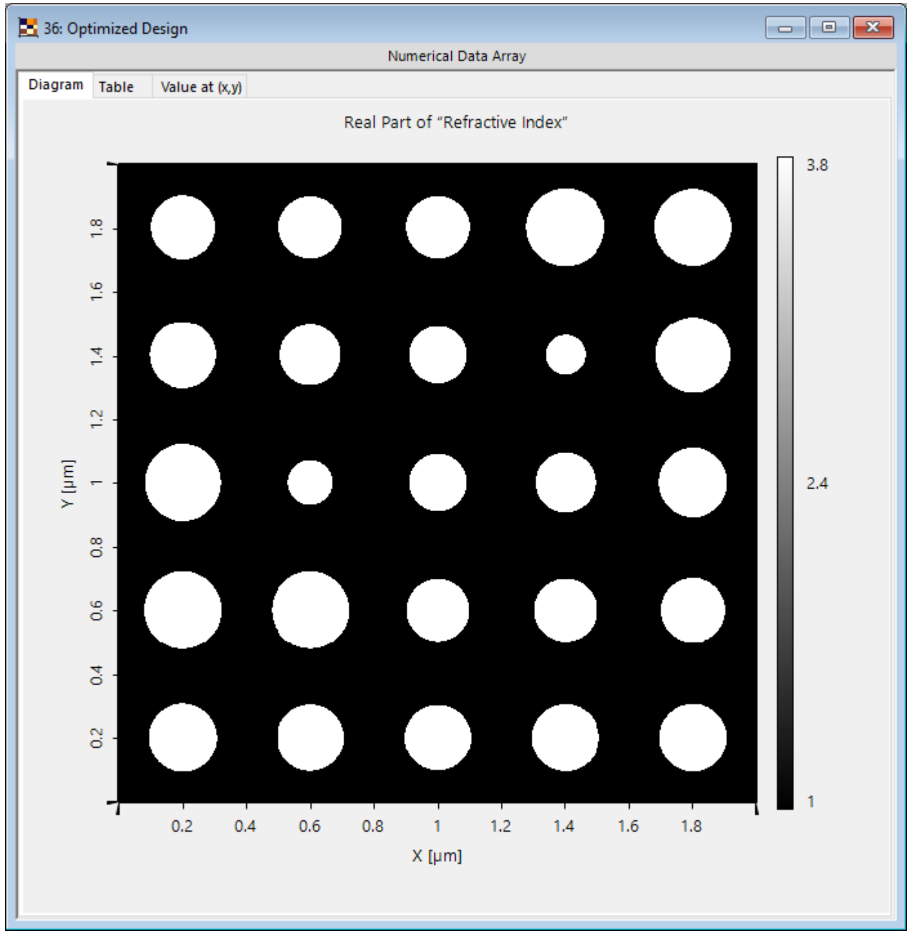

- keep pillar positions
- **vary** pillar diameters (25 variables)

downhill simplex optimization with FMM/RCWA for grating analysis

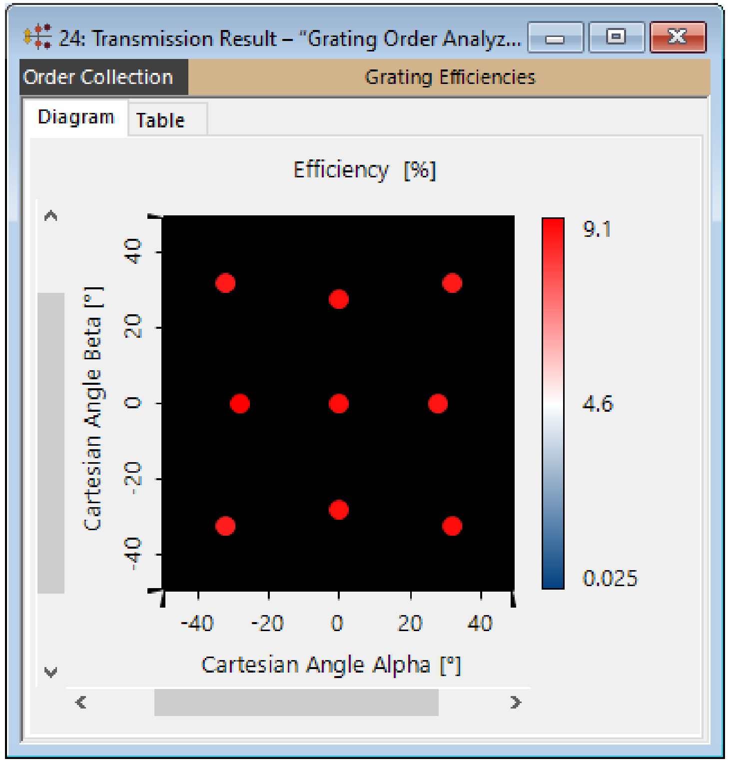


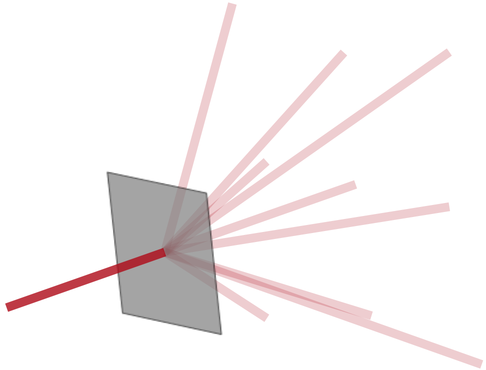
# Evaluation of Optimized Metagrating Design

optimized metagrating (top-view)




diffraction efficiencies

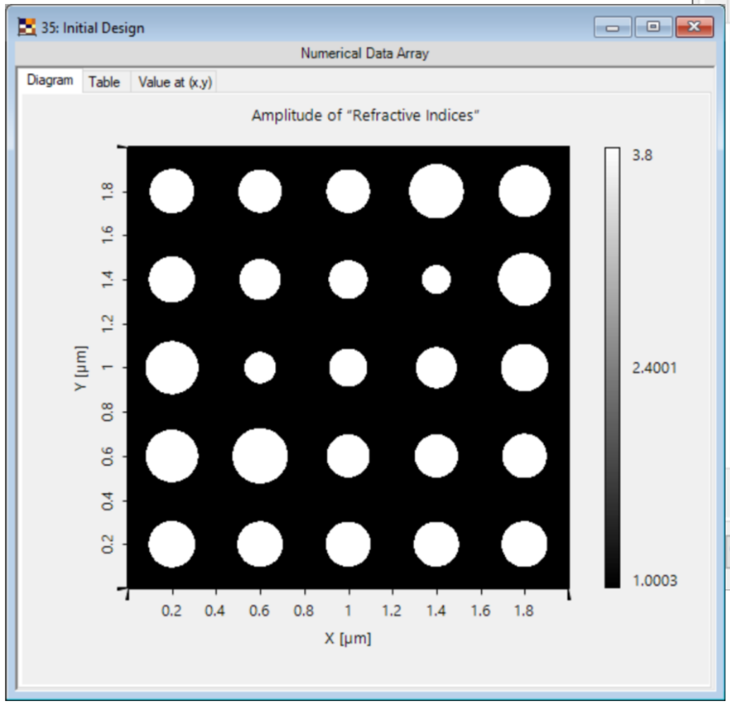


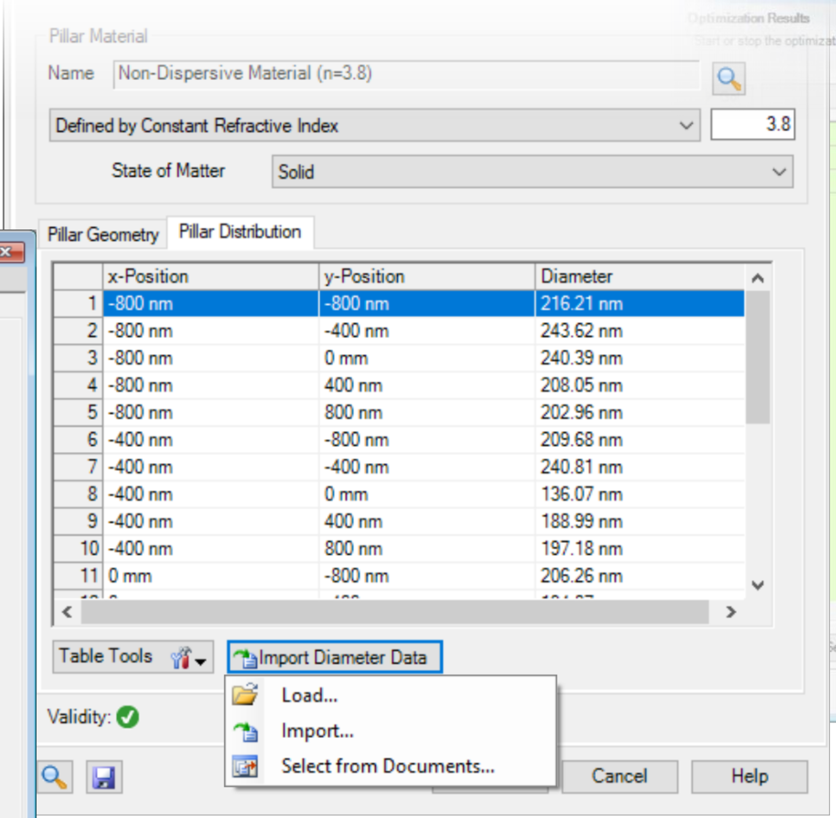



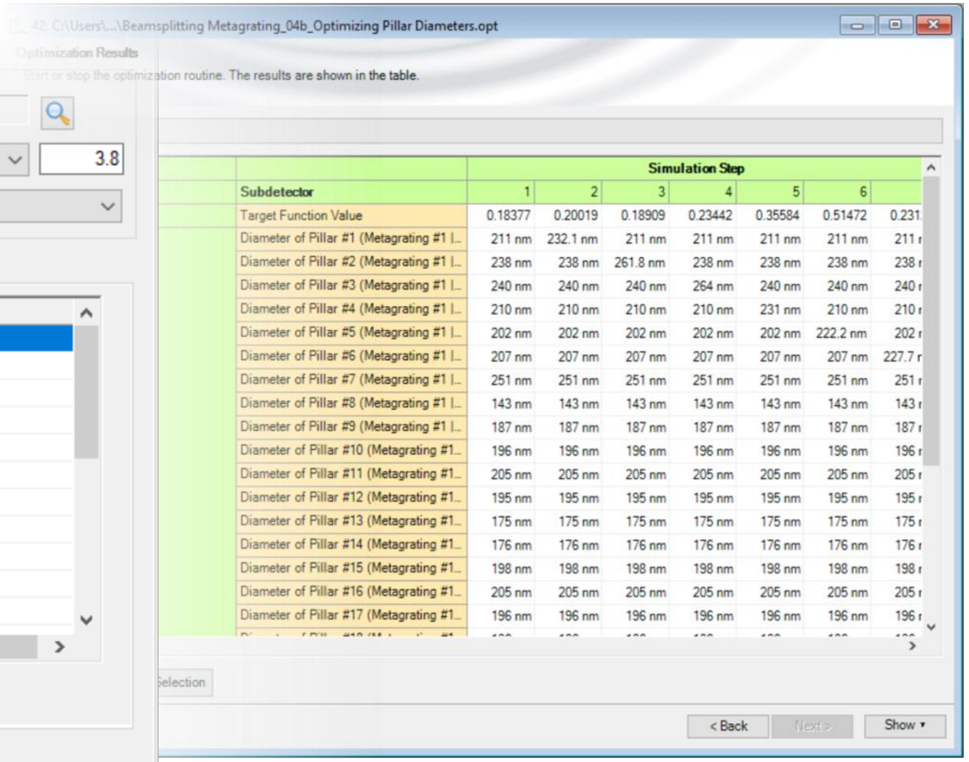
| | |
|---|---|
| overall efficiency | 79.5% |
| **uniformity error (PV)** | **3.1%** |
| uniformity error (RMS) | **1.8%** |

# Peek into VirtualLab Fusion

flexible definition of 2D metagrating surface



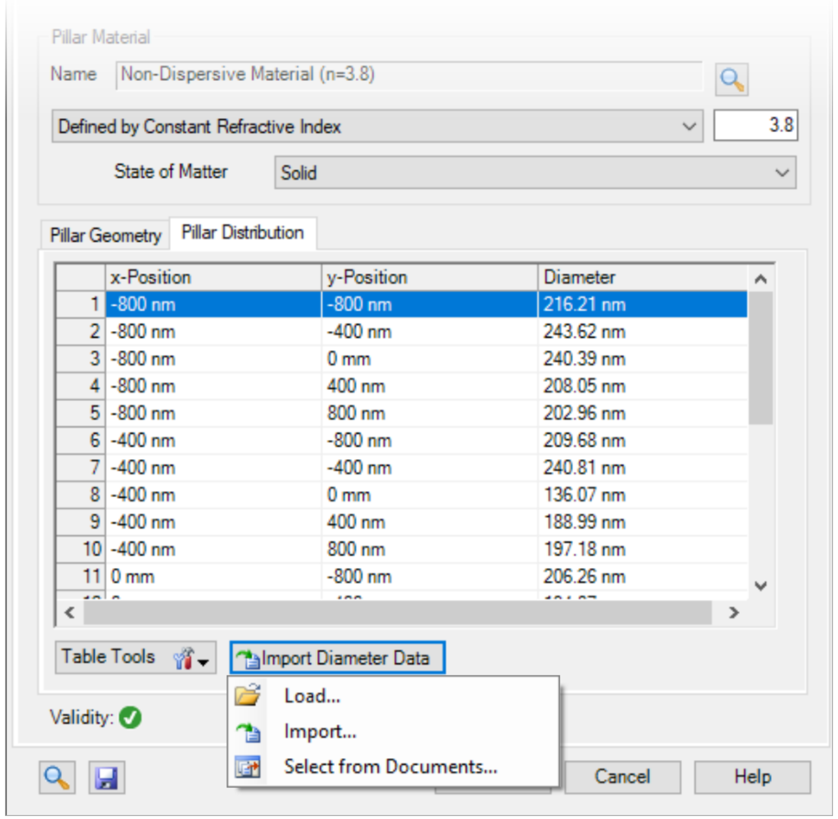



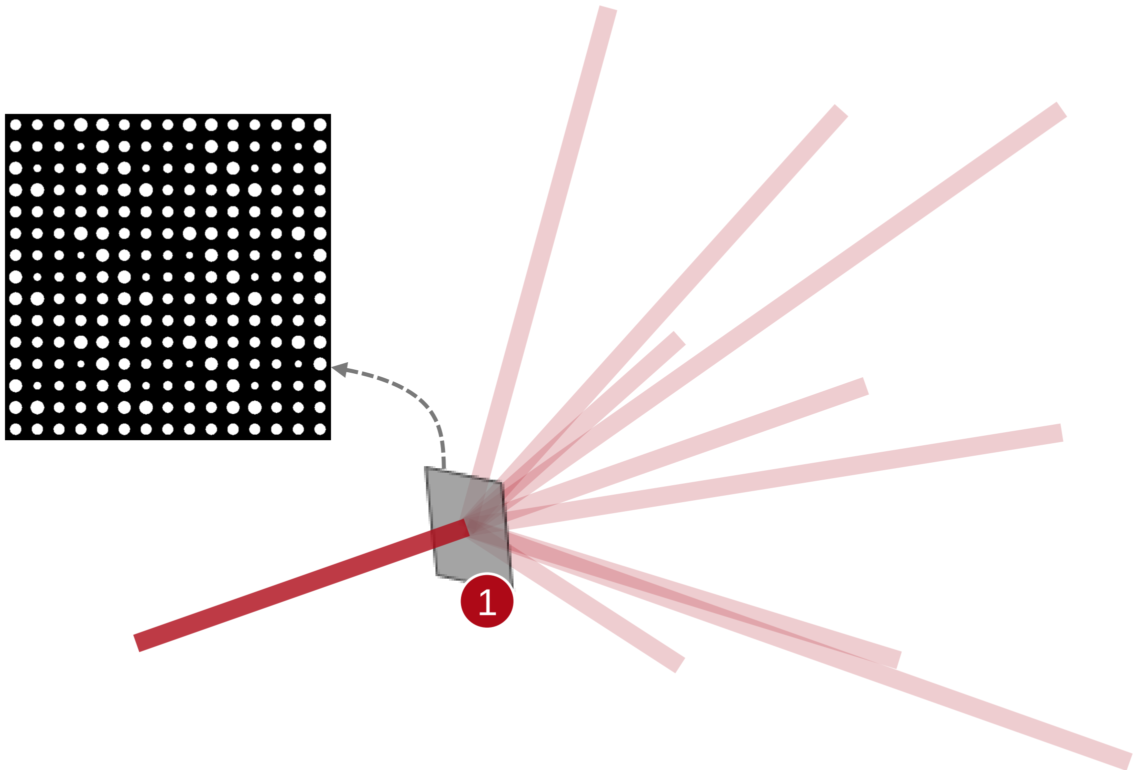

parametric optimization of metagrating structure

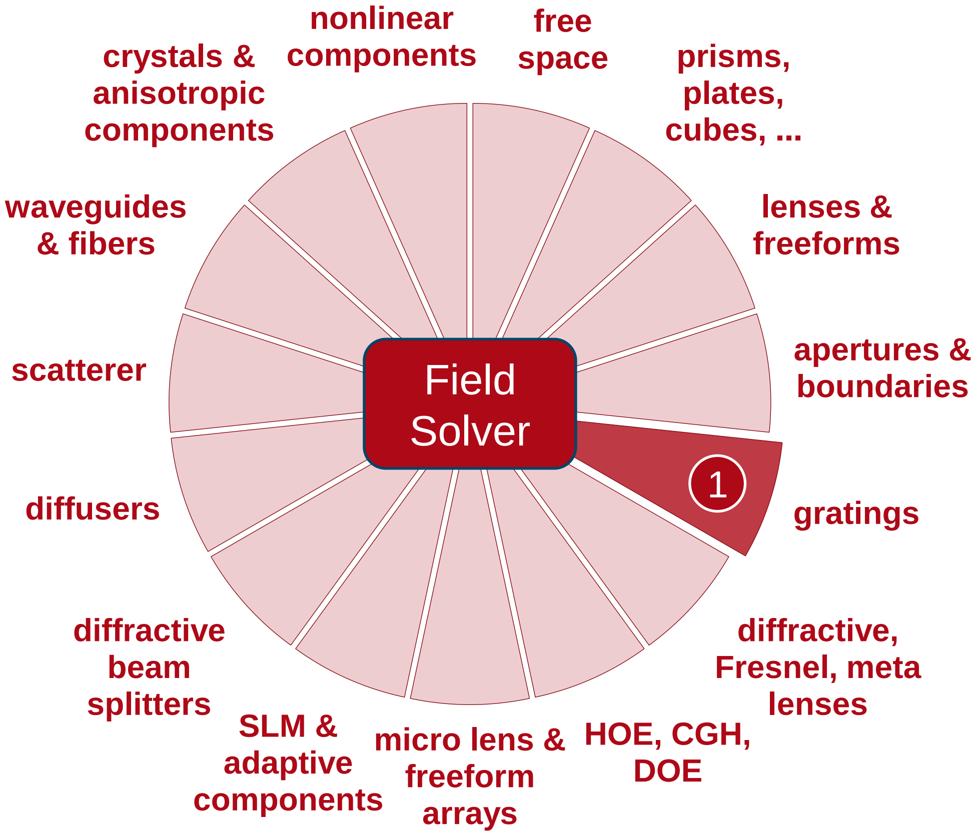
# Workflow in VirtualLab Fusion

- Analyze metasurface unit cell
  - Rigorous Analysis of Nanopillar Metasurface Building Block [Use Case]
- Construct metagratings
  - Metagrating Construction - Discussion at Examples [Use Case]
- Analyze grating diffraction efficiency
  - Grating Order Analyzer [Use Case]
- Parametric optimization of grating structure
  - Parametric Optimization [Tutorial Video]



# VirtualLab Fusion Technologies



# Document Information

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|---|---|
| title | Design of 2D Non-Paraxial Beam-Splitting Metagrating |
| document code | GRT.0021 |
| version | 1.1 |
| edition | VirtualLab Fusion Advanced |
| software version | 2021.1 (Build 1.180) |
| category | Application Use Case |
| further reading | - Rigorous Analysis of Nanopillar Metasurface Building Block<br>- Modeling and Design of Blazed Metagratings |