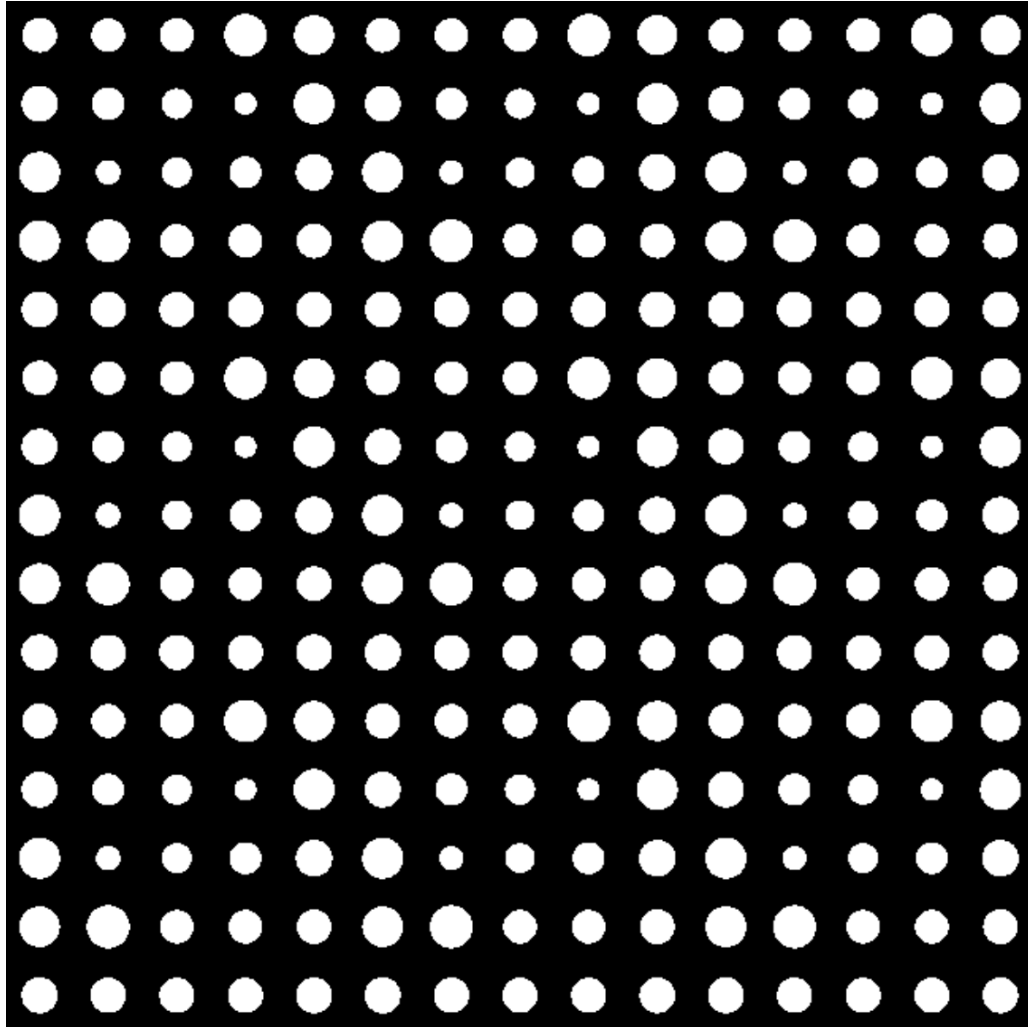


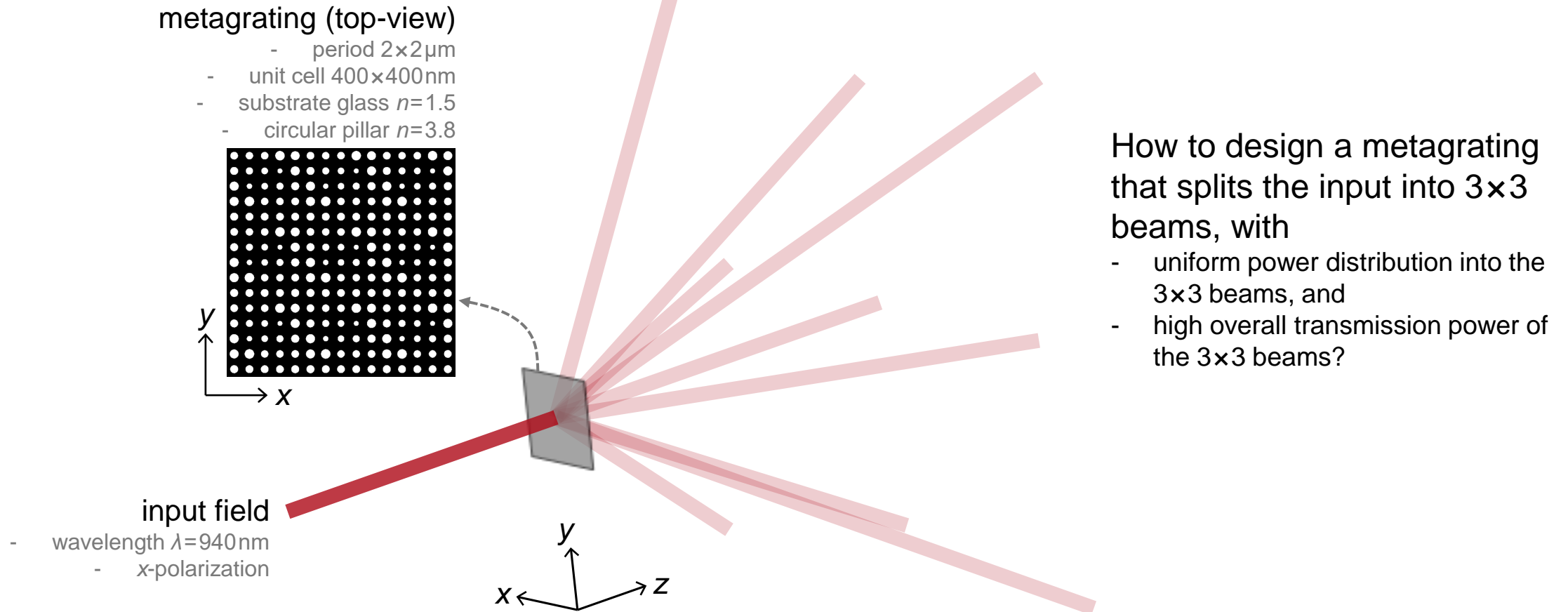
Design of 2D Non-Paraxial Beam-Splitting Metagrating

Abstract

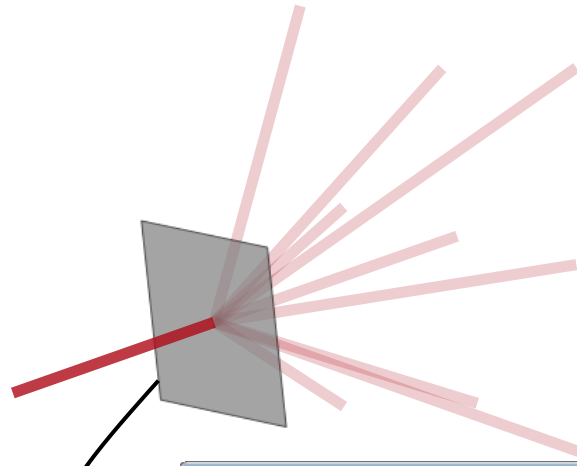


Metagratings are shown to have advantages when comparing with traditional gratings, especially in non-paraxial cases. In this example, we design a two-dimensional (2D) metagrating that splits the input into 3x3 beams. The metagrating is constructed with circular nano pillars, and in VirtualLab Fusion, 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.

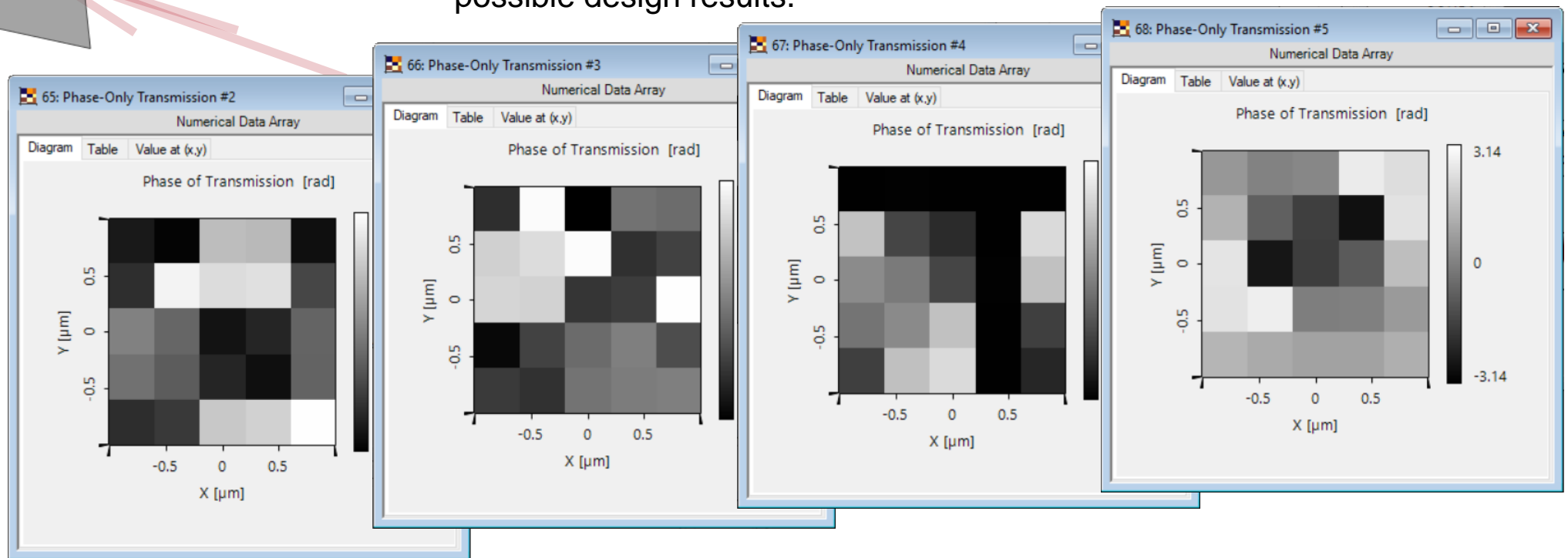
Design Task



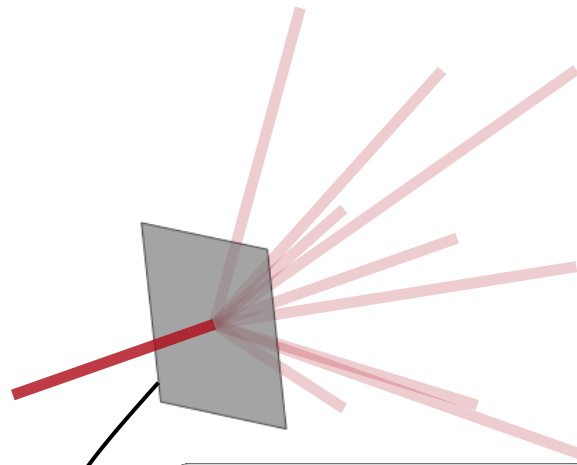
Phase-Only Transmission Design (IFTA)



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

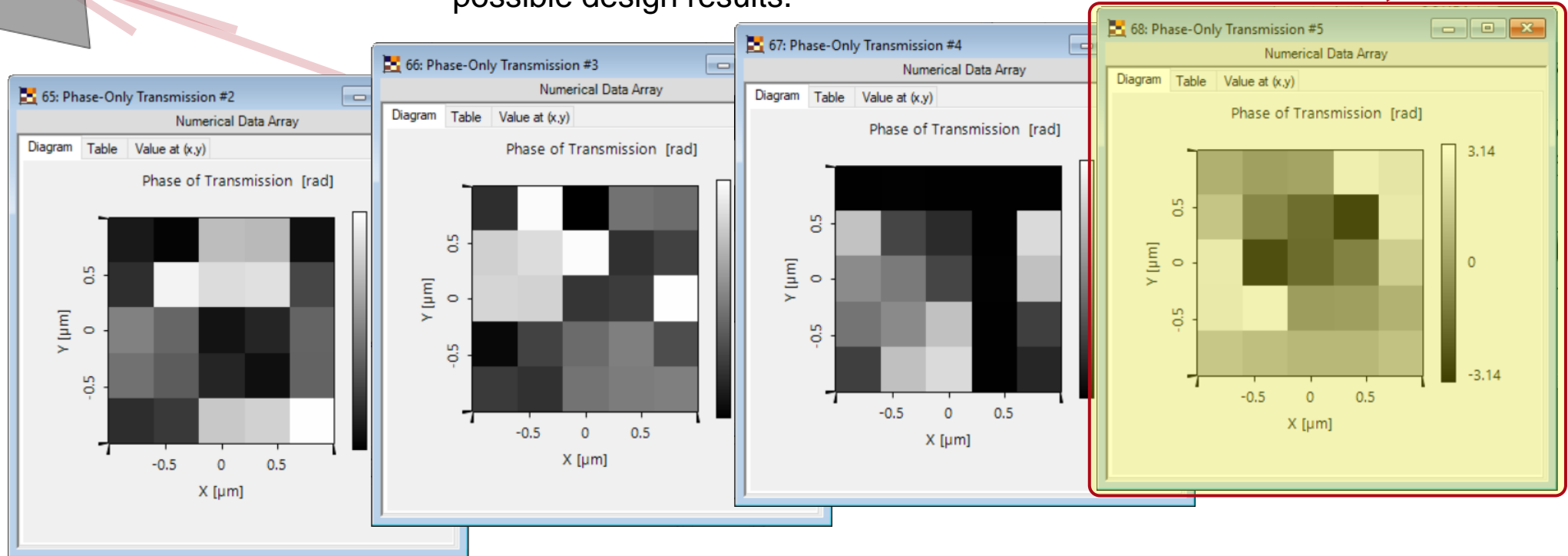


Phase-Only Transmission Design (IFTA)

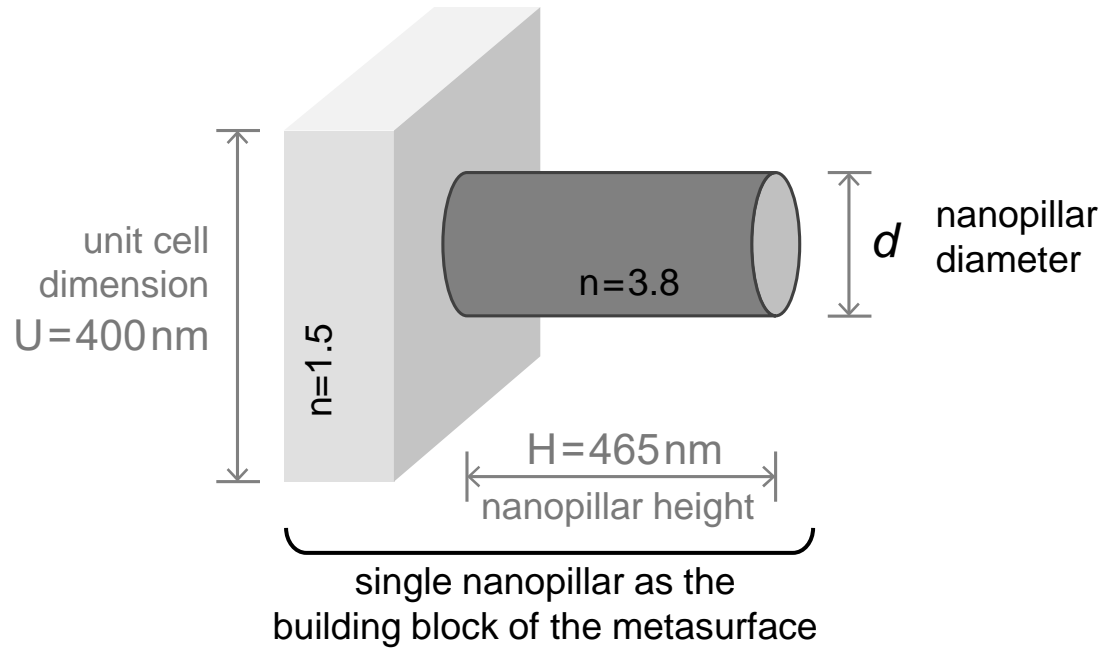


With differently random phase distributions as starting points, IFTA (iterative Fourier transform algorithm) calculates different possible design results.

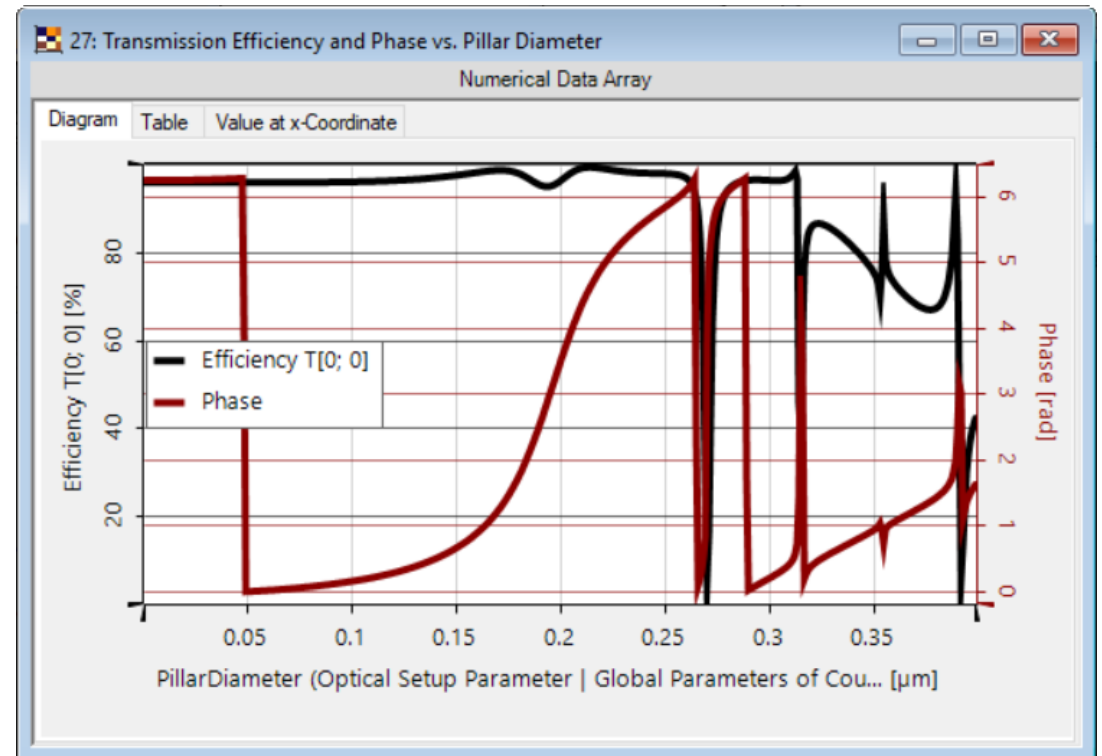
Select one of the results for further design



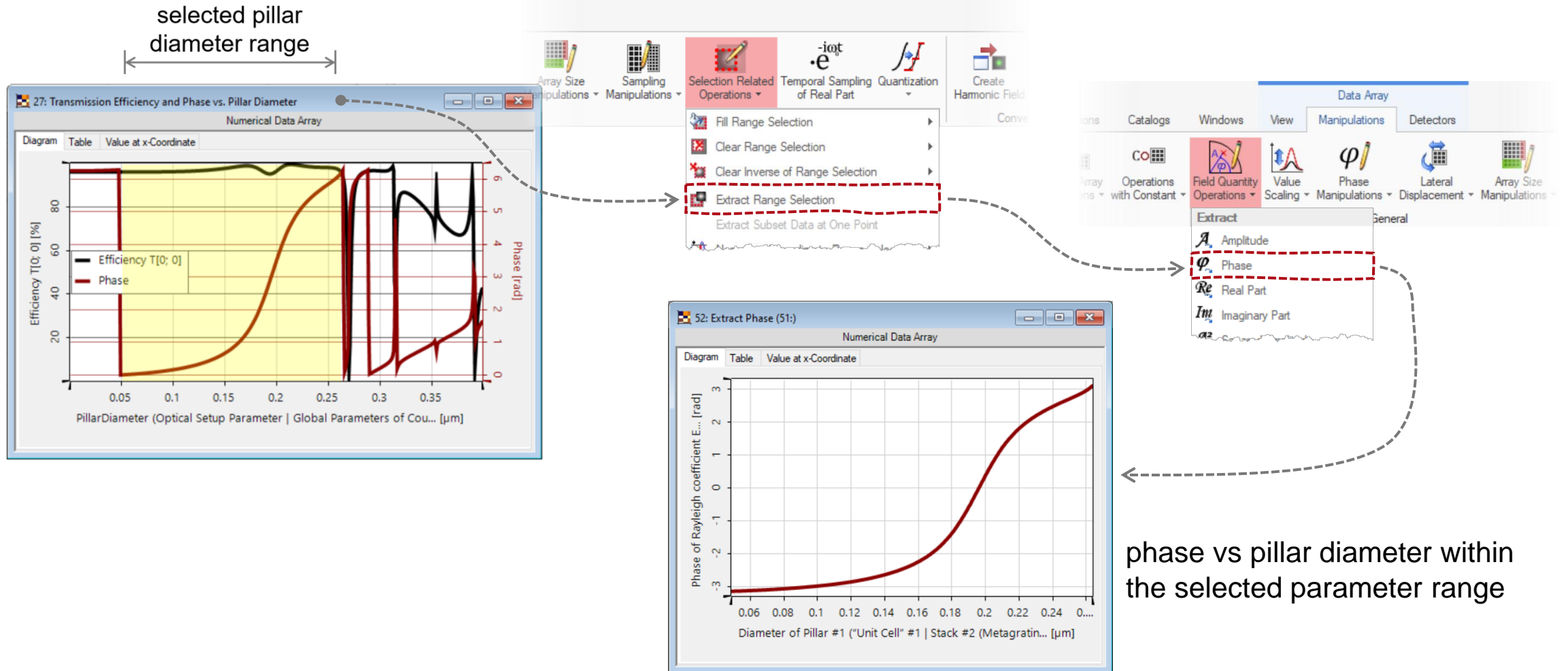
Metasurface Unit Cell Analysis



selected pillar diameter range

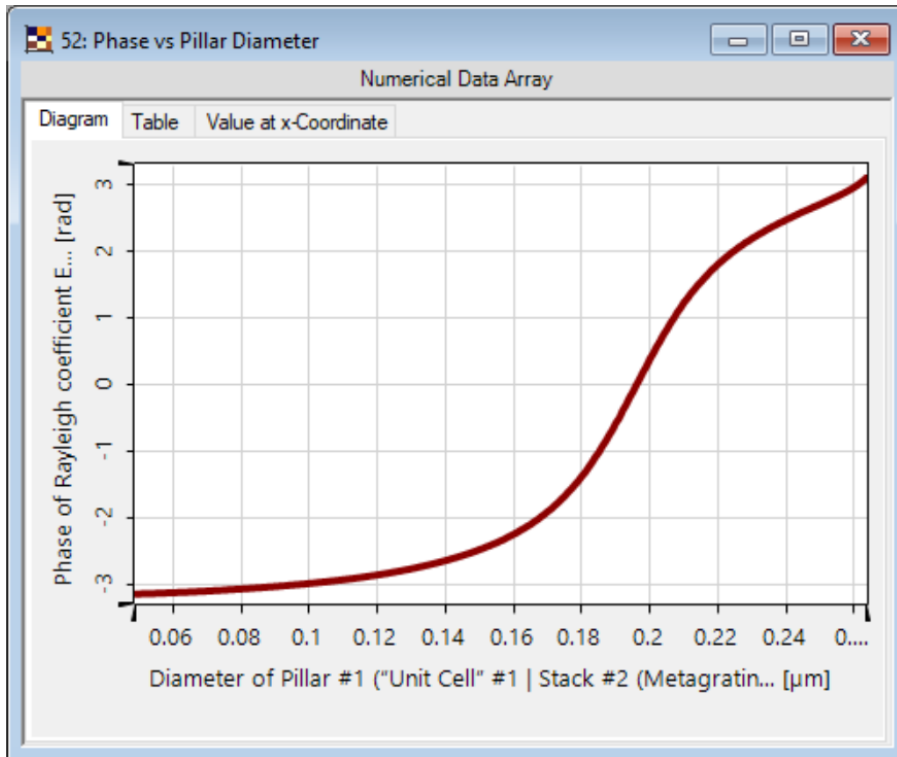


Unit Cell Parameter Range Selection



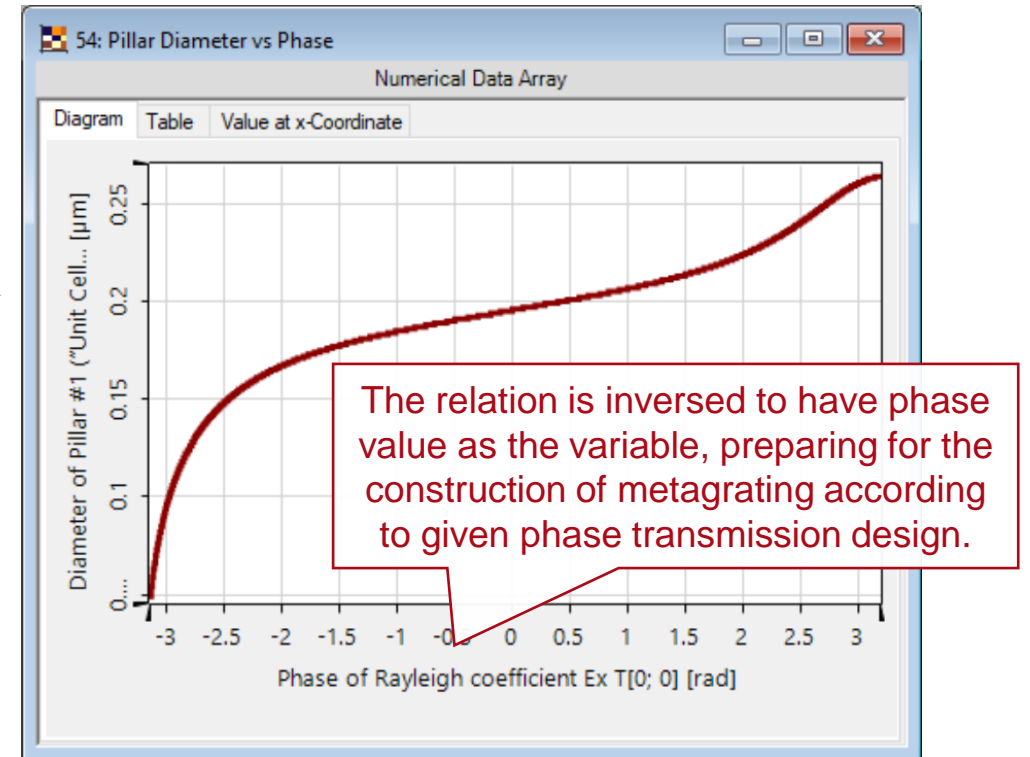
Phase vs Pillar Diameter and Its Inverse

phase value vs pillar diameter
(result from last step)



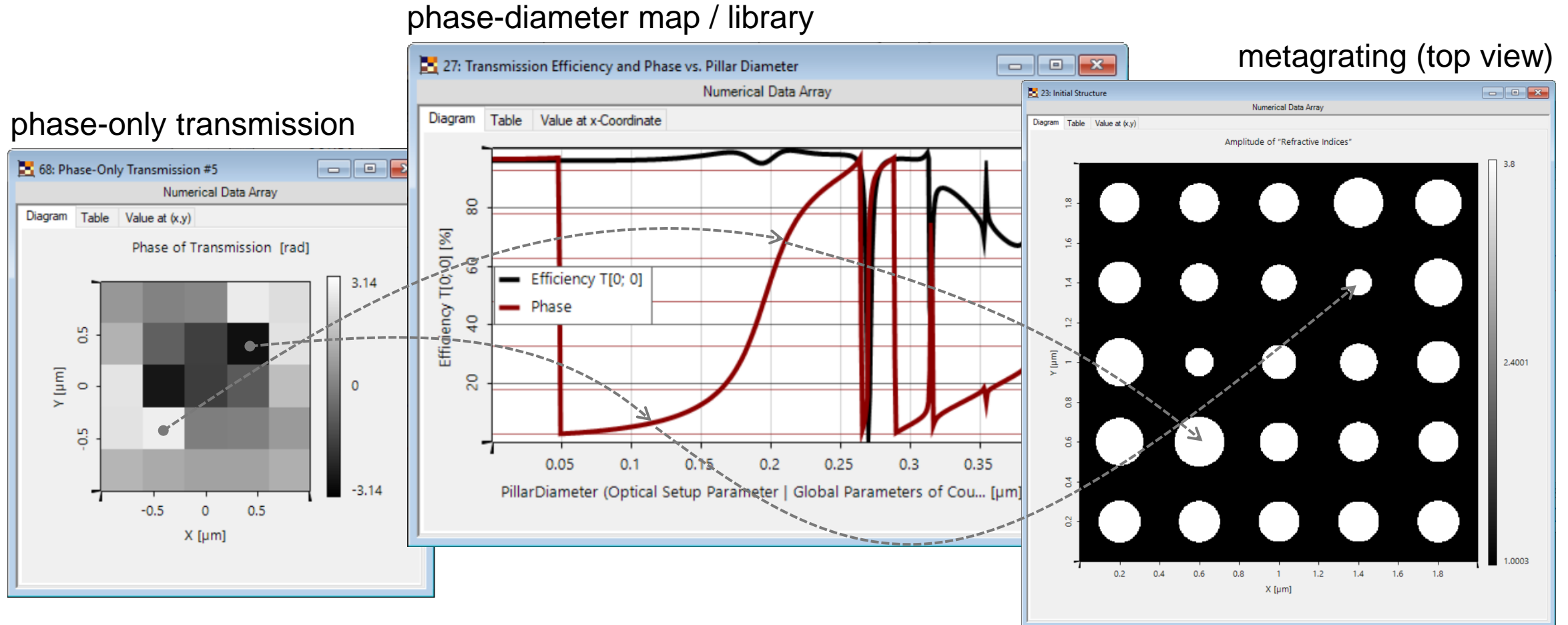
inverse

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

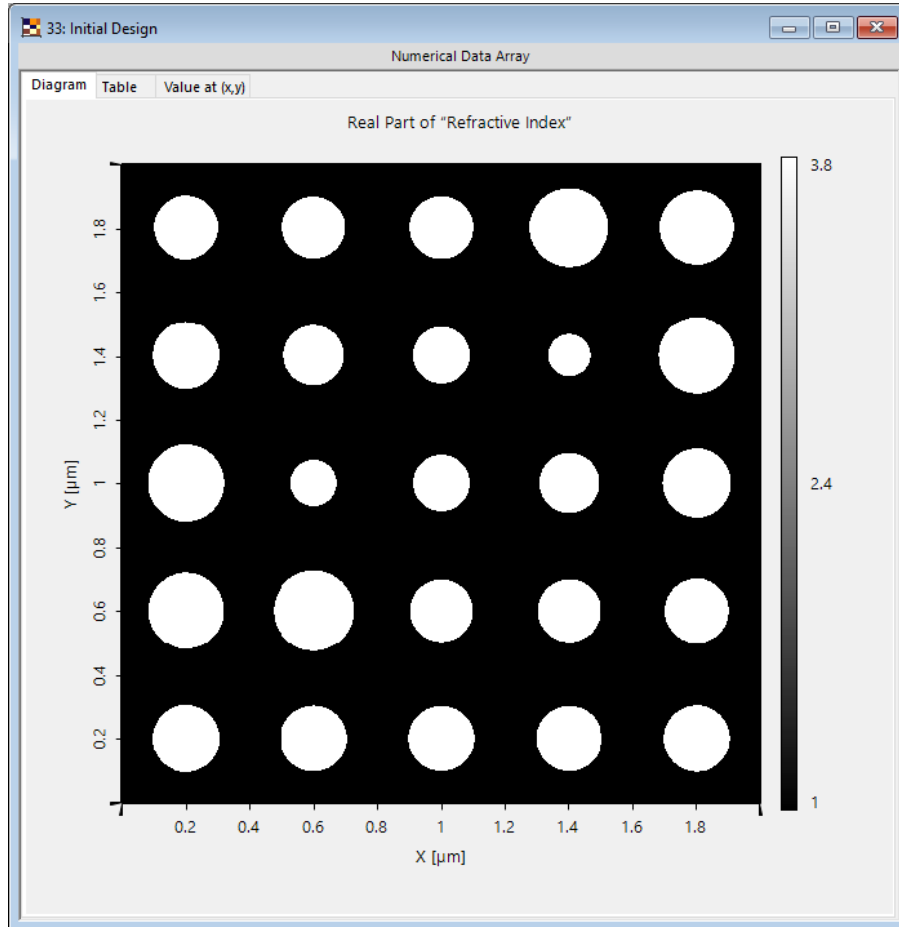
Metagrating Construction



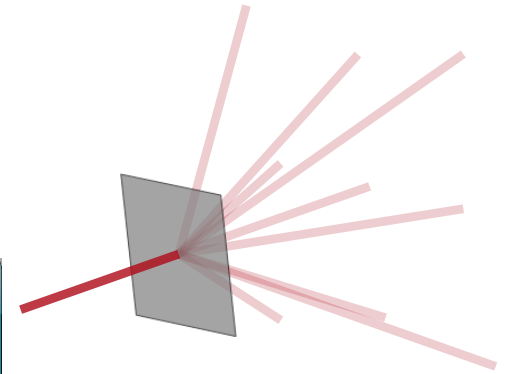
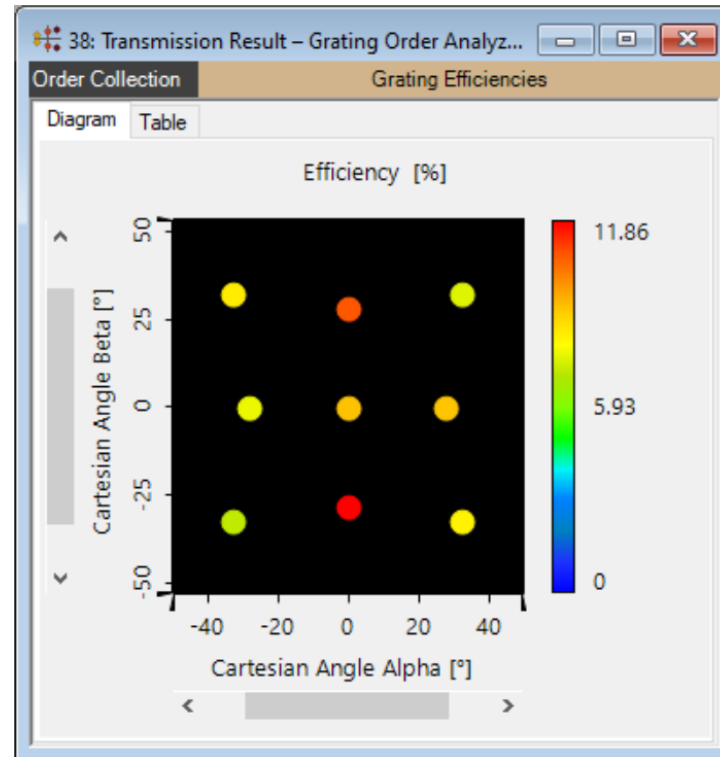
In this example, pillar distribution can be done with the VirtualLab C# Module: Appx_02_Calculate Pillar Diameters from Phase Profile.cs

Evaluation of Initial Metasurface Design

initial metagrating (top-view)



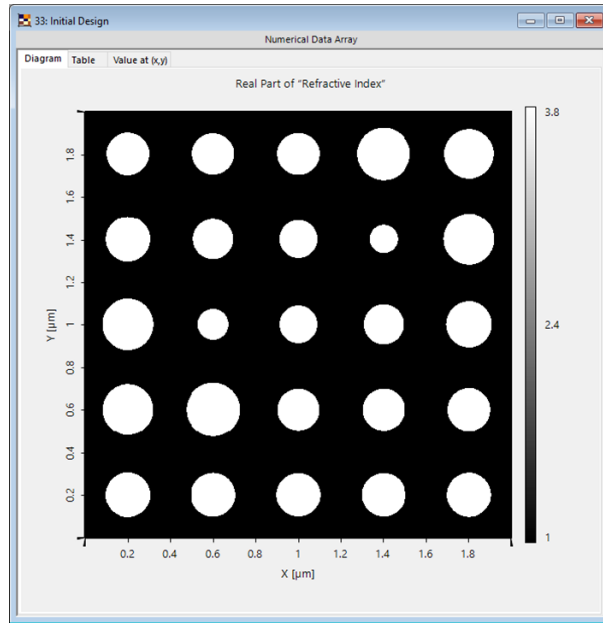
diffraction efficiencies



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

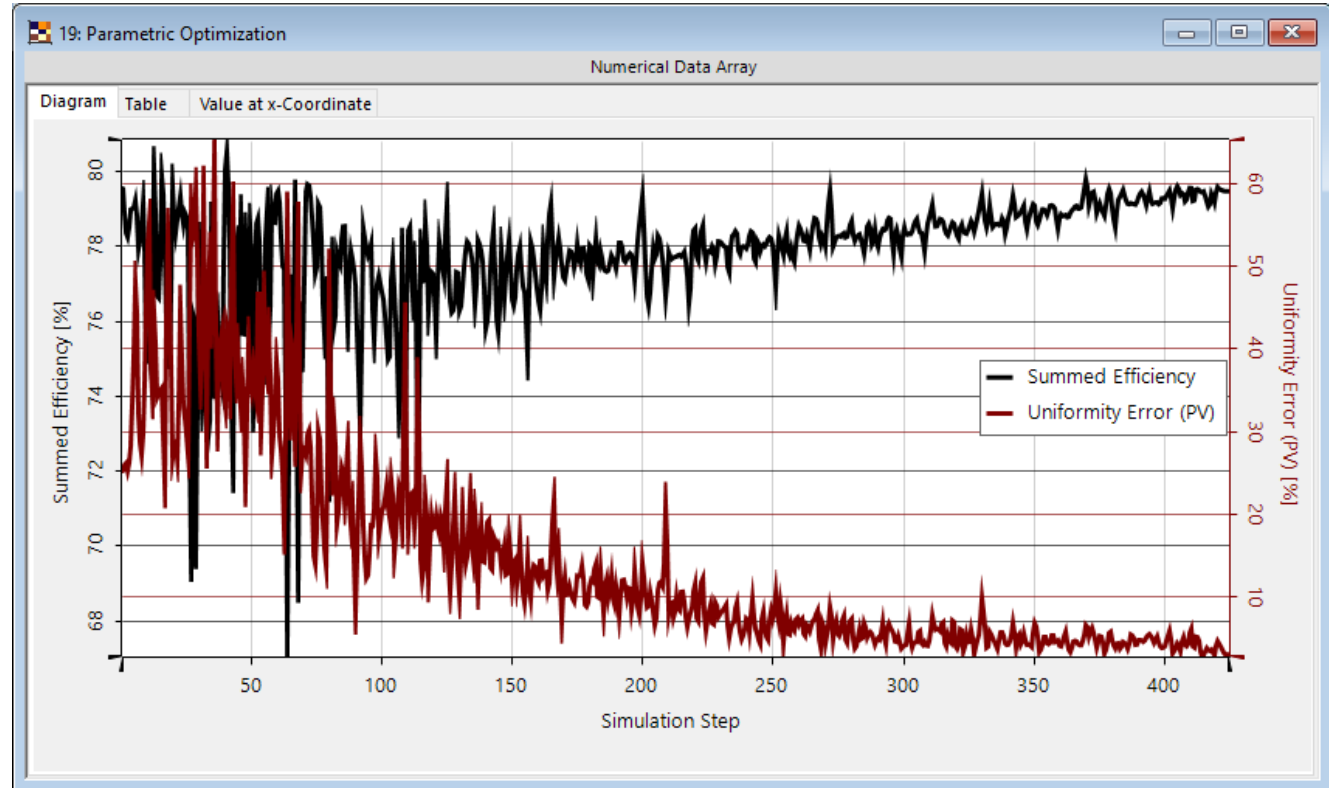
Parametric Optimization

initial metagrating



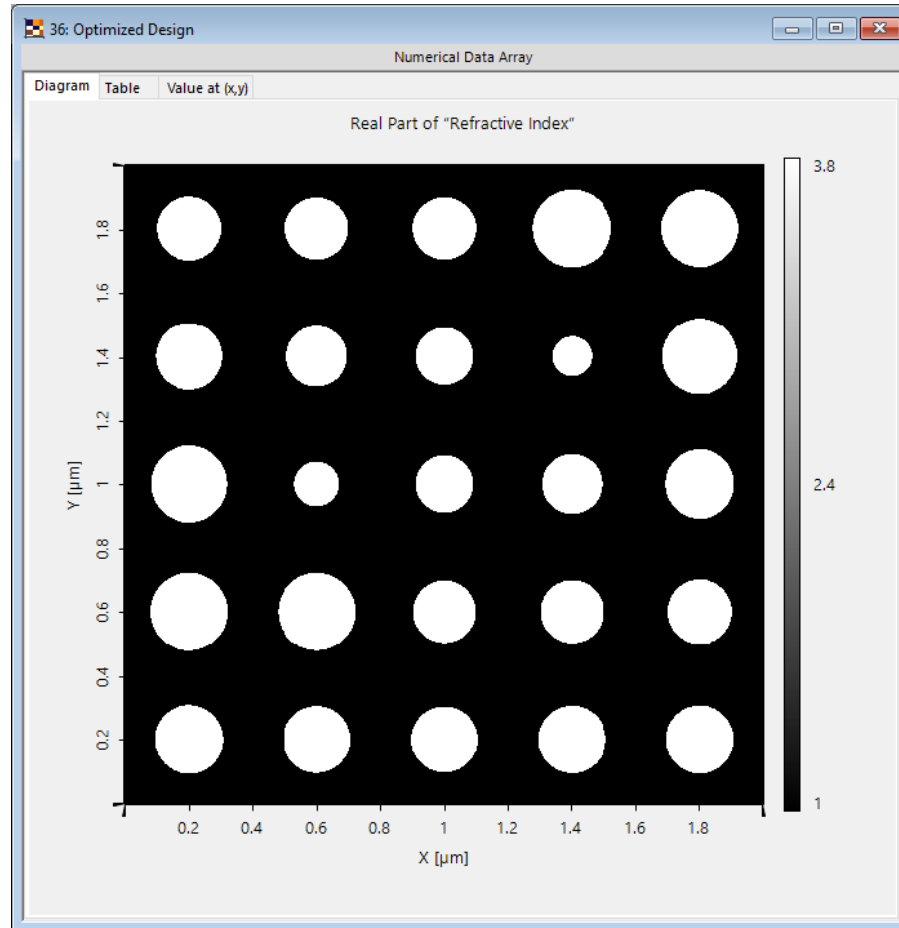
- keep pillar positions
- **vary** pillar diameters
(25 variables)

downhill simplex optimization with FMM/RCWA for grating analysis

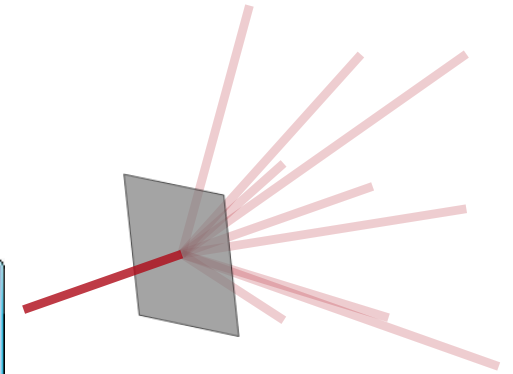
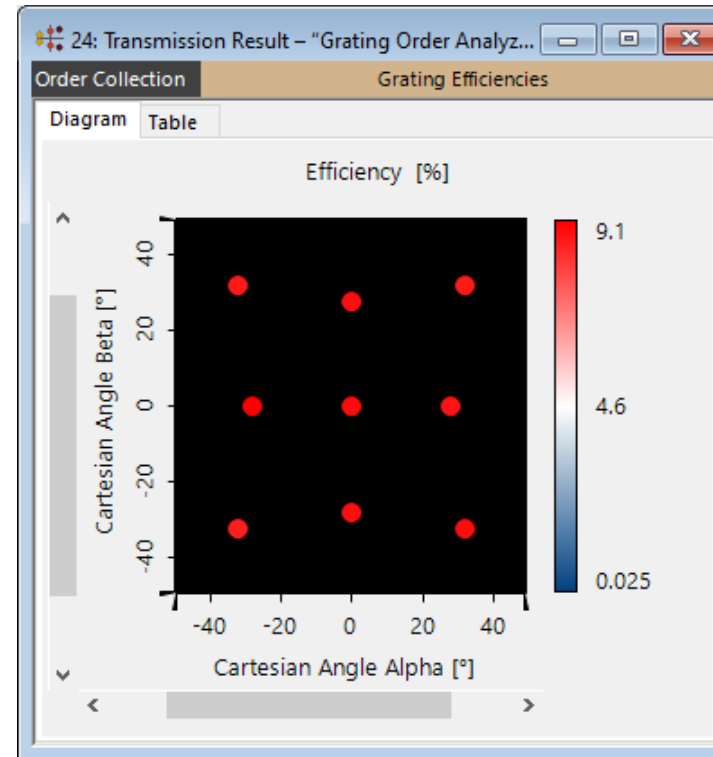


Evaluation of Optimized Metagrating Design

optimized metagrating (top-view)



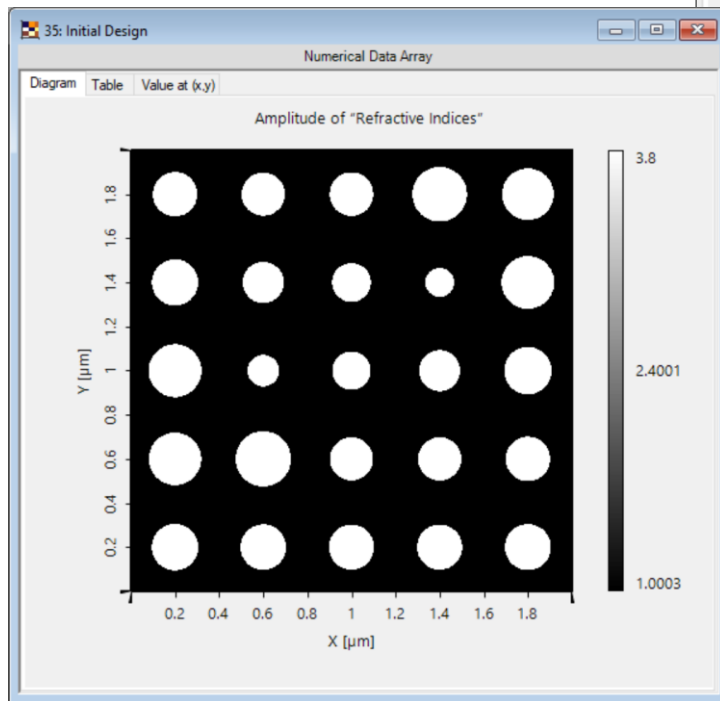
diffraction efficiencies



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

Peek into VirtualLab Fusion

flexible definition of 2D metagrating surface



Optimization Results
Start or stop the optimization routine. The results are shown in the table.

Subdetector	Simulation Step						
	1	2	3	4	5	6	
Target Function Value	0.18377	0.20019	0.18909	0.23442	0.35584	0.51472	0.231
Diameter of Pillar #1 (Metagrating #1 I...	211 nm	232.1 nm	211 nm	211 nm	211 nm	211 nm	211 r
Diameter of Pillar #2 (Metagrating #1 I...	238 nm	238 nm	261.8 nm	238 nm	238 nm	238 nm	238 r
Diameter of Pillar #3 (Metagrating #1 I...	240 nm	240 nm	240 nm	264 nm	240 nm	240 nm	240 r
Diameter of Pillar #4 (Metagrating #1 I...	210 nm	210 nm	210 nm	210 nm	231 nm	210 nm	210 r
Diameter of Pillar #5 (Metagrating #1 I...	202 nm	202 nm	202 nm	202 nm	202 nm	222.2 nm	202 r
Diameter of Pillar #6 (Metagrating #1 I...	207 nm	207 nm	207 nm	207 nm	207 nm	207 nm	227.7 r
Diameter of Pillar #7 (Metagrating #1 I...	251 nm	251 nm	251 nm	251 nm	251 nm	251 nm	251 r
Diameter of Pillar #8 (Metagrating #1 I...	143 nm	143 nm	143 nm	143 nm	143 nm	143 nm	143 r
Diameter of Pillar #9 (Metagrating #1 I...	187 nm	187 nm	187 nm	187 nm	187 nm	187 nm	187 r
Diameter of Pillar #10 (Metagrating #1...	196 nm	196 nm	196 nm	196 nm	196 nm	196 nm	196 r
Diameter of Pillar #11 (Metagrating #1...	205 nm	205 nm	205 nm	205 nm	205 nm	205 nm	205 r
Diameter of Pillar #12 (Metagrating #1...	195 nm	195 nm	195 nm	195 nm	195 nm	195 nm	195 r
Diameter of Pillar #13 (Metagrating #1...	175 nm	175 nm	175 nm	175 nm	175 nm	175 nm	175 r
Diameter of Pillar #14 (Metagrating #1...	176 nm	176 nm	176 nm	176 nm	176 nm	176 nm	176 r
Diameter of Pillar #15 (Metagrating #1...	198 nm	198 nm	198 nm	198 nm	198 nm	198 nm	198 r
Diameter of Pillar #16 (Metagrating #1...	205 nm	205 nm	205 nm	205 nm	205 nm	205 nm	205 r
Diameter of Pillar #17 (Metagrating #1...	196 nm	196 nm	196 nm	196 nm	196 nm	196 nm	196 r

Pillar Material
Name: Non-Dispersive Material (n=3.8)
Defined by Constant Refractive Index: 3.8
State of Matter: Solid

Pillar Geometry Pillar Distribution

	x-Position	y-Position	Diameter
1	-800 nm	-800 nm	216.21 nm
2	-800 nm	-400 nm	243.62 nm
3	-800 nm	0 mm	240.39 nm
4	-800 nm	400 nm	208.05 nm
5	-800 nm	800 nm	202.96 nm
6	-400 nm	-800 nm	209.68 nm
7	-400 nm	-400 nm	240.81 nm
8	-400 nm	0 mm	136.07 nm
9	-400 nm	400 nm	188.99 nm
10	-400 nm	800 nm	197.18 nm
11	0 mm	-800 nm	206.26 nm

Table Tools Import Diameter Data
Load...
Import...
Select from Documents...
Cancel Help

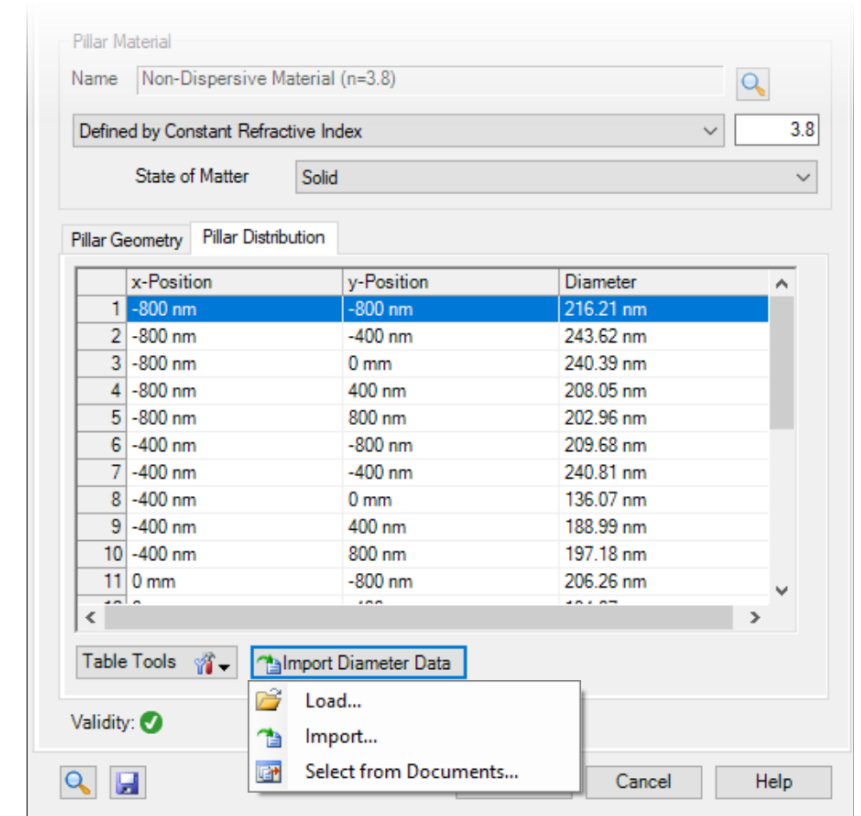
Validity:

Selection < Back Next Show

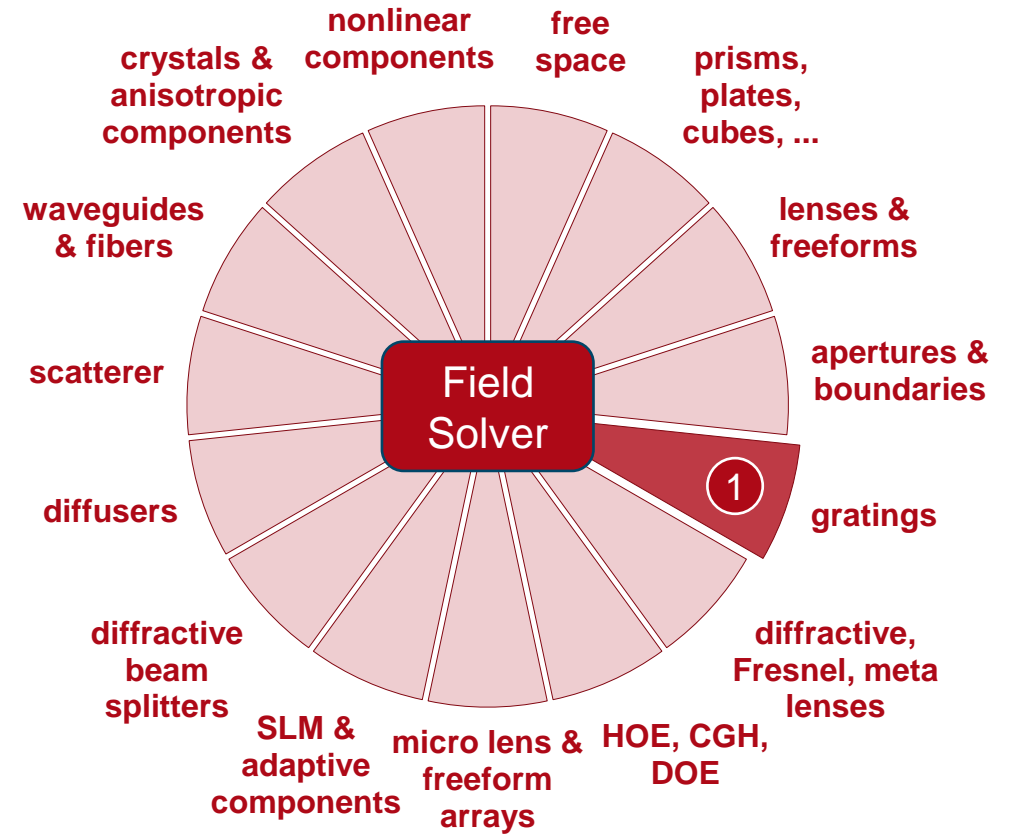
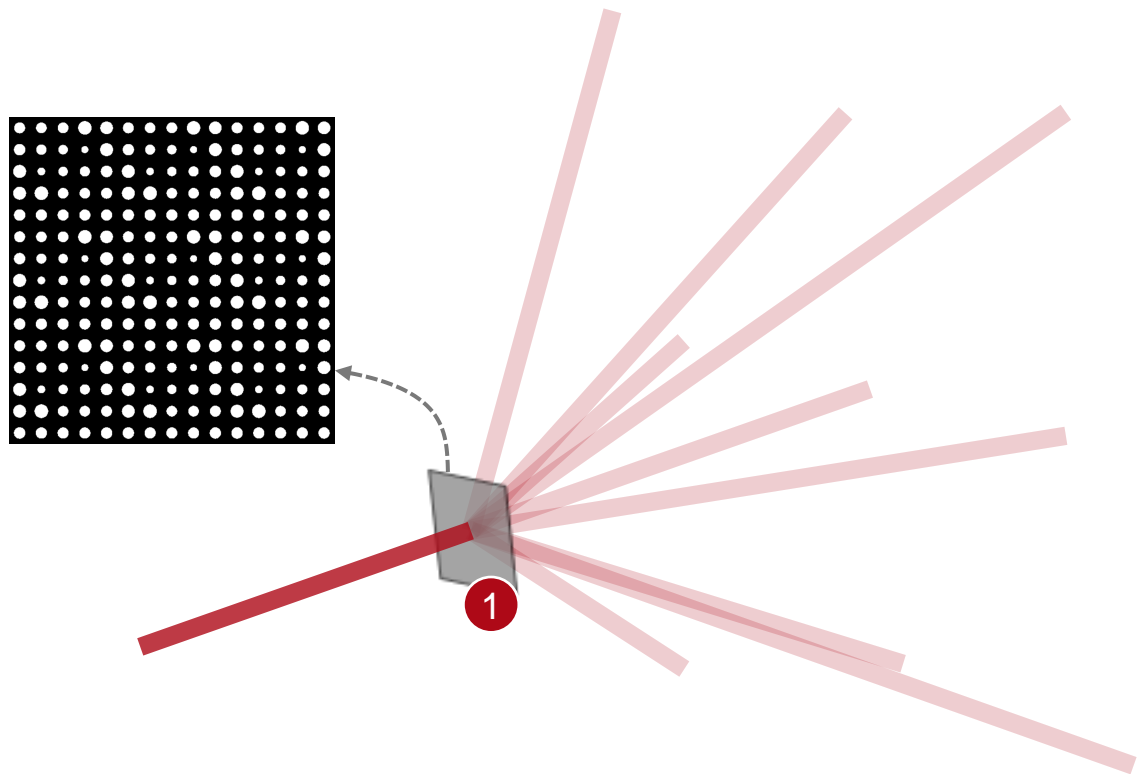
parametric optimization of metagrating structure

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

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	<ul style="list-style-type: none">- <u>Rigorous Analysis of Nanopillar Metasurface Building Block</u>- <u>Modeling and Design of Blazed Metagratings</u>