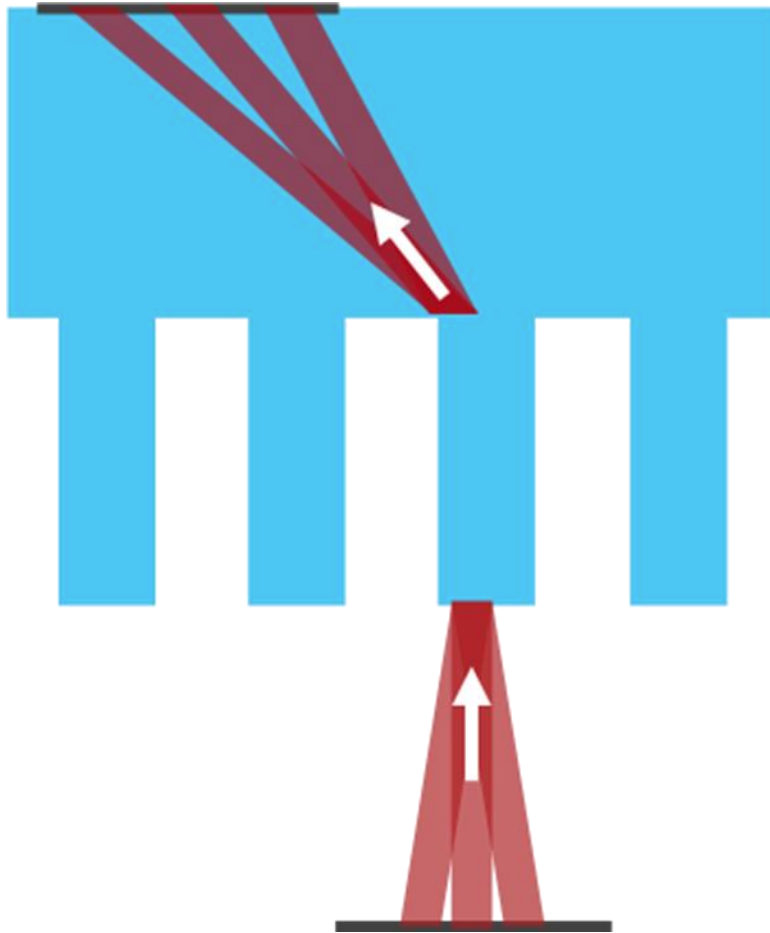


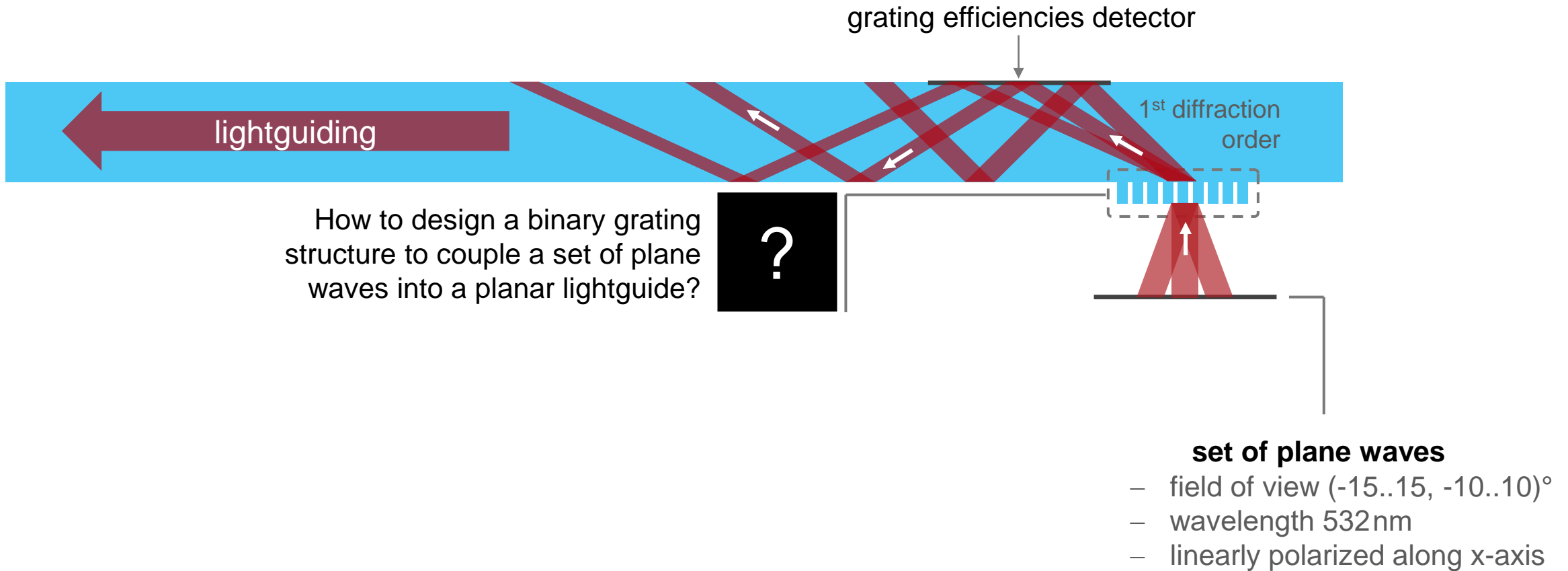
Optimization of Binary Grating for Lightguide Coupling over Desired FOV

Abstract



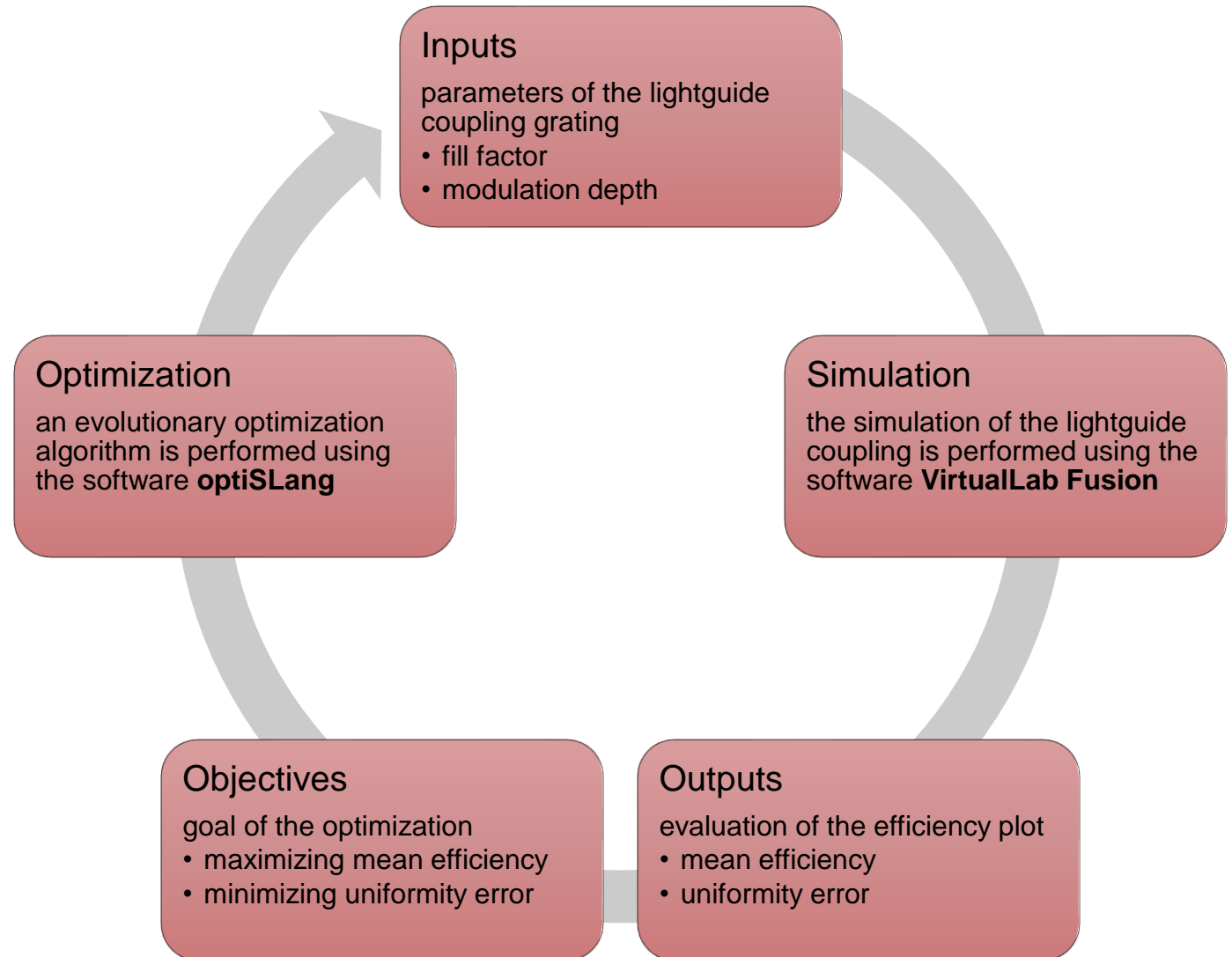
Coupling gratings are commonly used to launch light within a desired field of view (FOV) into a lightguide structure. VirtualLab Fusion can be used to investigate the performance of such coupling gratings. To obtain uniform coupling efficiencies over all the desired angles is a challenging task. The software optiSLang from Dynardo provides efficient ways to perform such optimization task, by using the rigorous grating analysis tool from VirtualLab Fusion as the computation kernel.

Optimization Task



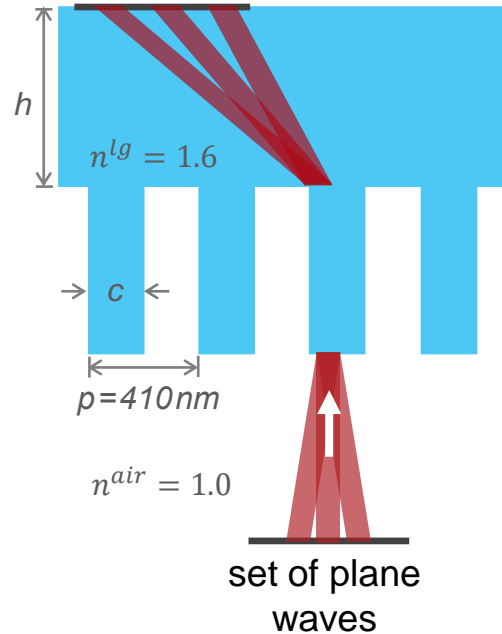
Optimization Workflow

- the following optimization workflow is applied to design a binary grating for efficient lightguide coupling
 1. Define the inputs
 2. Perform the simulation
 3. Calculate the outputs
 4. Check the objectives
 5. Perform the optimization
- depending on the optimization strategy new input parameters are defined by the algorithm
- in principle this is repeated in a loop until the objectives are achieved



Simulation Results and Configuration of the Merit Function

grating efficiencies
detector

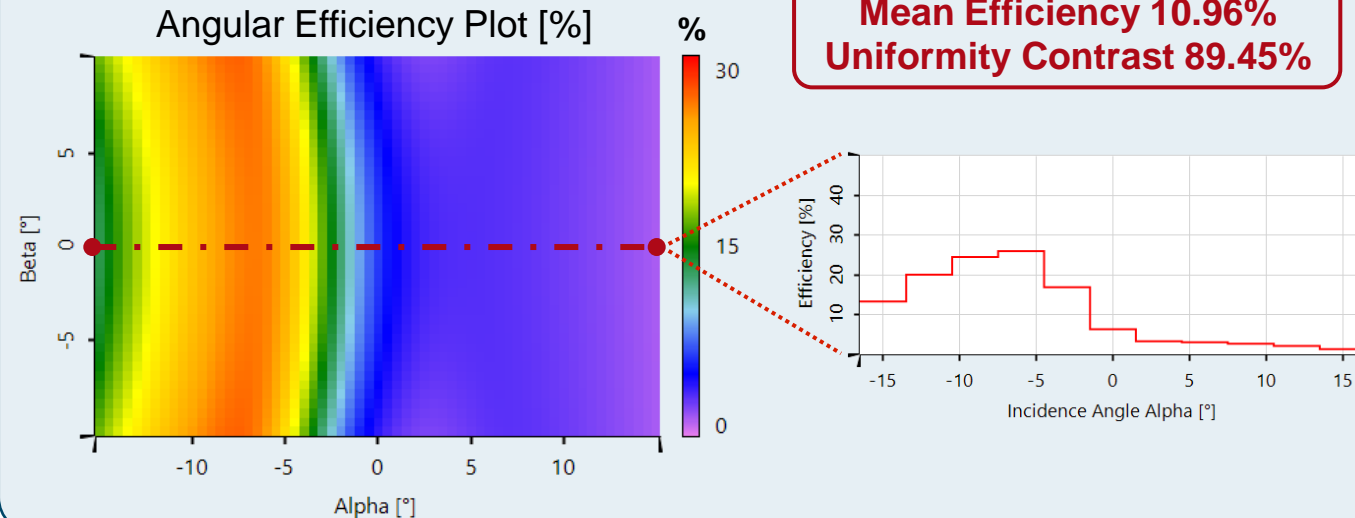


- variation of the **fill factor** c/p with the slit width c and the period p
 - **0.1% to 99.9%**
- variation of the **modulation depth** h
 - **50 nm to 1500 nm**

Initial Configuration of Grating	
fill factor	50.00%
modulation depth	400.00 nm
period	410 nm
operating order	1 st transmitted

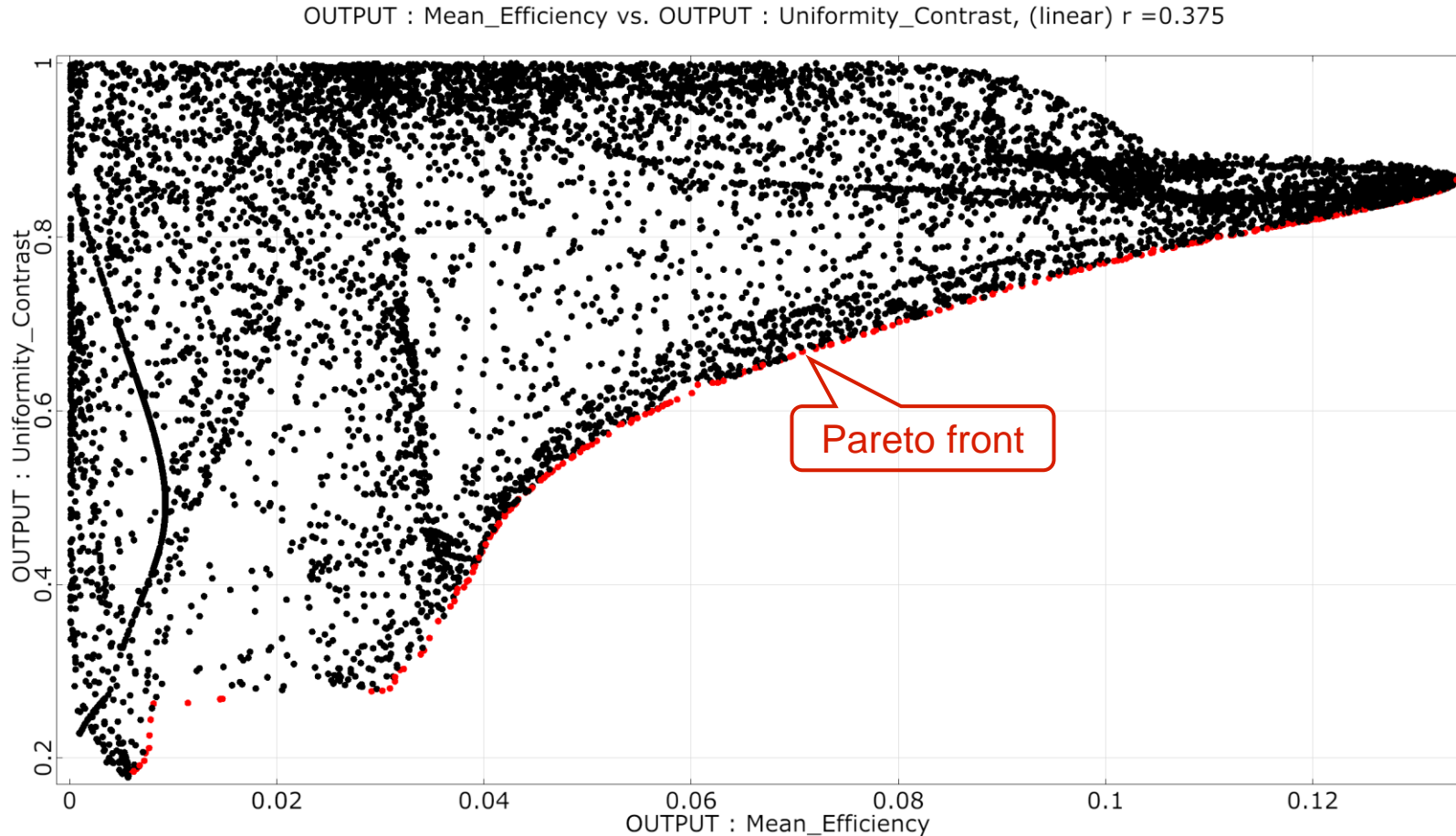
to be
varied

Grating Efficiencies Detector Result



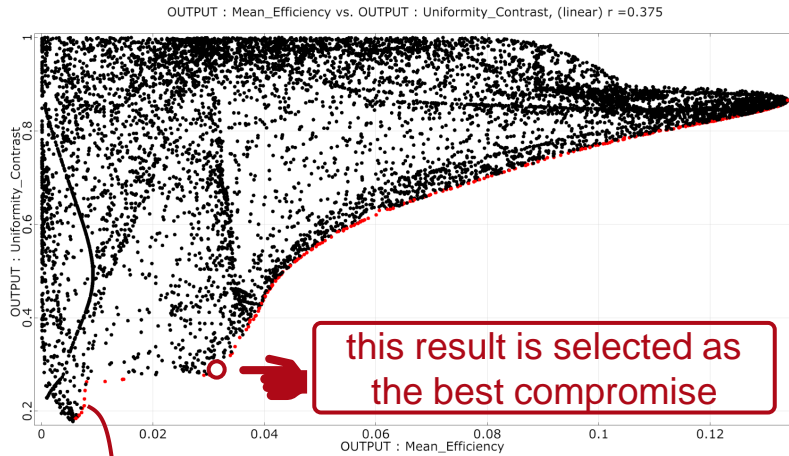
a roughly sampled
evaluation of the
incidence angles
along the period
is sufficient for the
optimization

Optimization Results of optiSLang

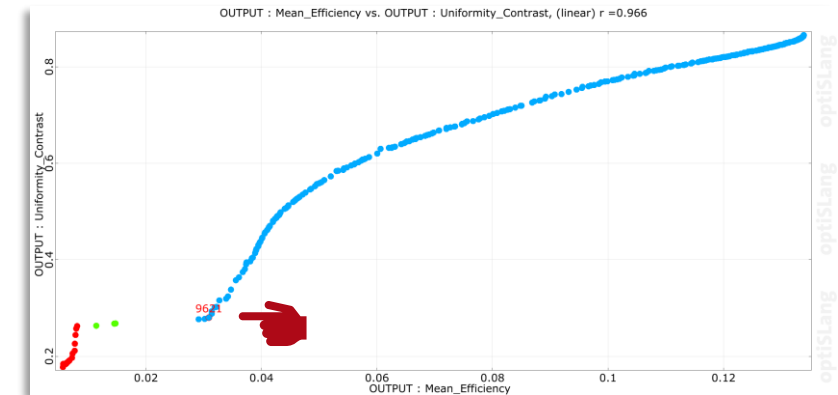
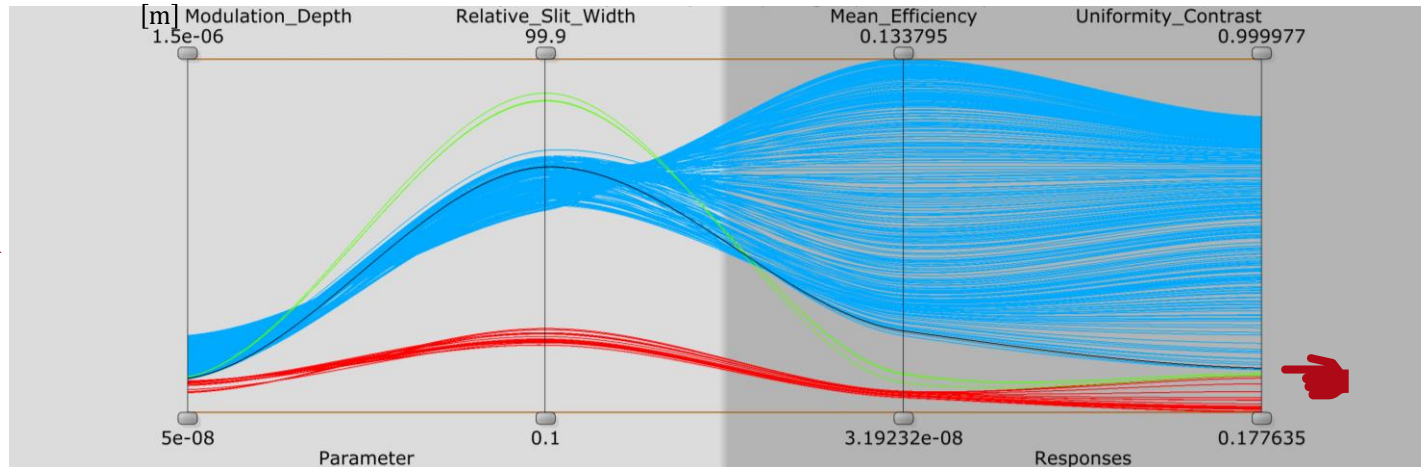


- the optimization results are plotted as a function of the merit functions
 - mean efficiency
 - uniformity contrast
- the Pareto front indicates the optimum compromise between the two merit functions

Advanced Evaluation of the Optimization Results

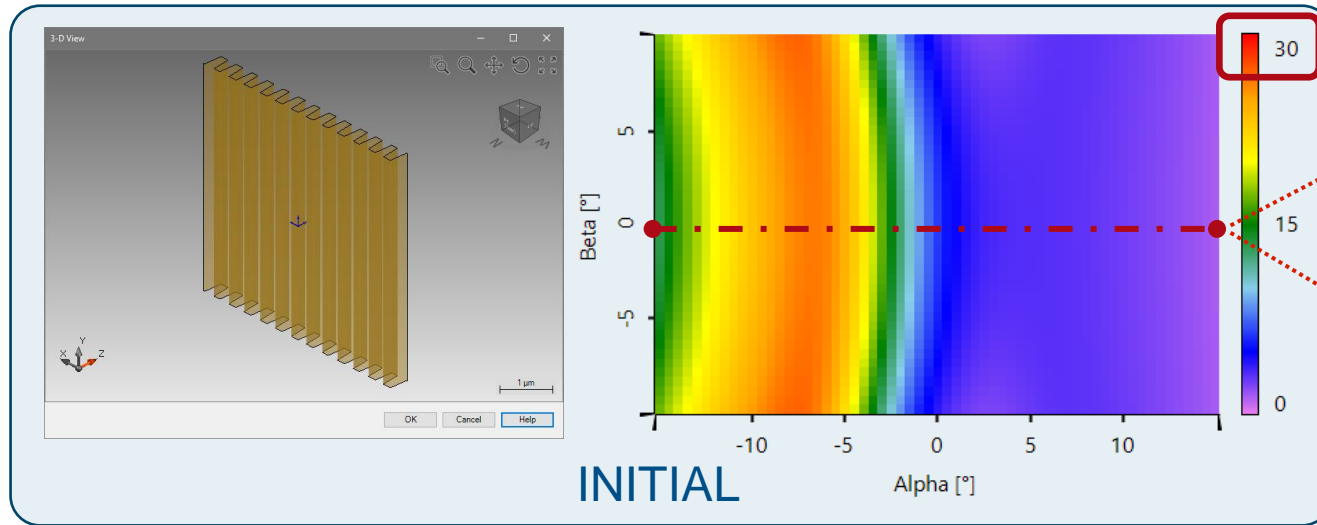


- the optimization results at the Pareto front are visualized in a *Parallel Coordinates Plot* to investigate the effect of the input parameters (responses) to the output parameters in detail
- in addition, a cluster analysis decomposes a specific parameter, e.g. the relative slit width, into a certain number of clusters yielding a better understanding how the input parameters are correlated to the output parameters
- as a result, a design is selected, which is the best compromise for a prioritized low uniformity contrast and an acceptable mean efficiency including manufacturable grating parameters

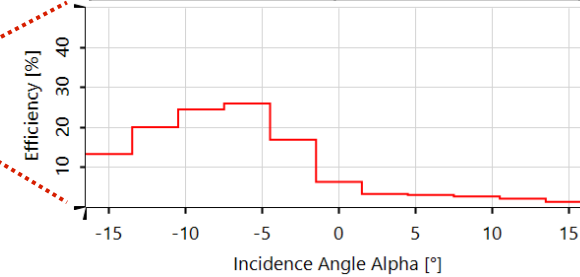


the results at the Pareto front are highlighted and color adapted according to the results of the cluster analysis

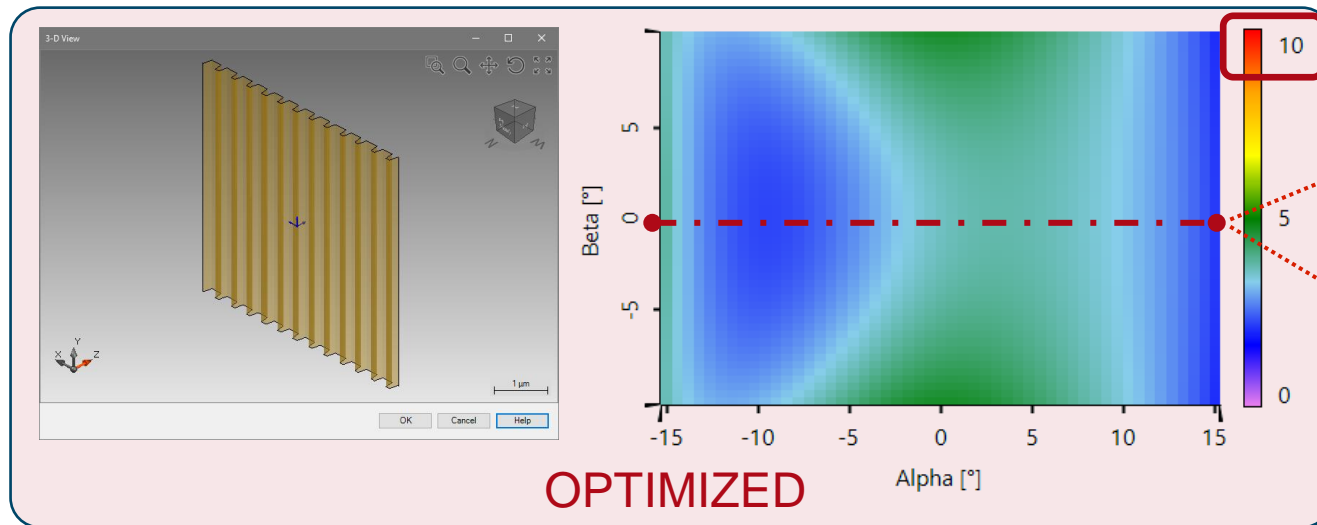
Analysis of Coupling Efficiency for Optimization Result



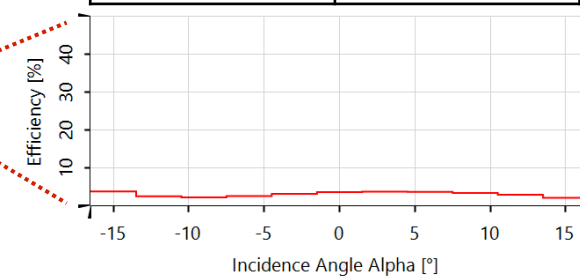
fill factor	50.00%
modulation depth	400.00nm



Mean Efficiency 10.96%
Uniformity Contrast **89.45%**



fill factor	68.43%
modulation depth	187.18nm



Mean Efficiency 3.08%
Uniformity Contrast **28.02%**

- finally, the optimization result is analyzed regarding the coupling efficiency using the software VirtualLab Fusion
- as a result, the uniformity contrast was significantly reduced but to the cost of the entire efficiency

Peek into VirtualLab Fusion

The screenshot displays the VirtualLab Fusion software interface. On the left is a 'File' menu with options: New, Open, Save, Save As, Import, Export, Global Options, Online Help, and Exit. The 'Export' option is highlighted, showing a sub-menu with 'Export as XML' (Exports all parameters of the Optical Setup into a XML file.), 'Create Batch Mode Files' (Creates all files needed to process the Optical Setup via batch files.), and 'Export to optiSLang Project' (Generates all files necessary to perform system analysis and optimization using Dynardo optiSLang.).

The main workspace shows '2: Optical Setup View #1 (D:\OneDrive\...\02_Optimized Rectangular Grating.lpd)'. It contains a diagram with three components: a 'Plane Wave' (Index 0), a 'Lightguide Coupling Detector' (Index 600), and a 'Ray Tracing System Analyzer' (Index 800). The 'Lightguide Coupling Detector' has a coordinate box showing X: 0 m, Y: 0 m, and Z: 0 m.

Below the workspace is '1: Optical Setup Editor #1 (D:\OneDrive\...\02_Optimized Rectangular Grating.lpd)'. It features tabs for Path, Detectors, Analyzers, and Logging. The 'Detectors' tab is active, displaying a table with the following data:

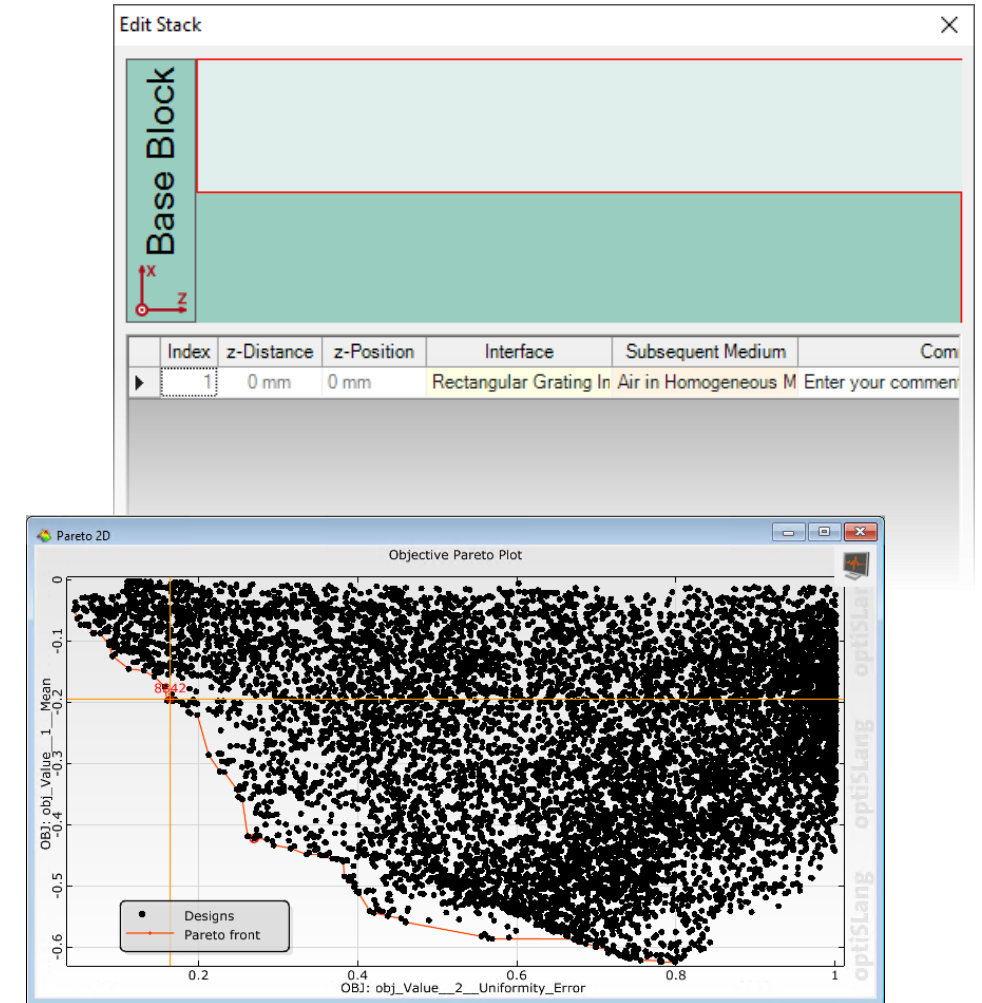
Detector		Last Optical Setup Element				Linkage			
Index	Type	Index	Type	Channel	Medium	Sum	Propagation Method	On/Off	Color
600	Lightguide Coupling Detector	0	Plane Wave	-	Air in	No	Field Tracing	On	—

At the bottom of the editor, there is a 'Simulation Engine' dropdown set to 'Field Tracing 2nd Generation' and a 'Go!' button.

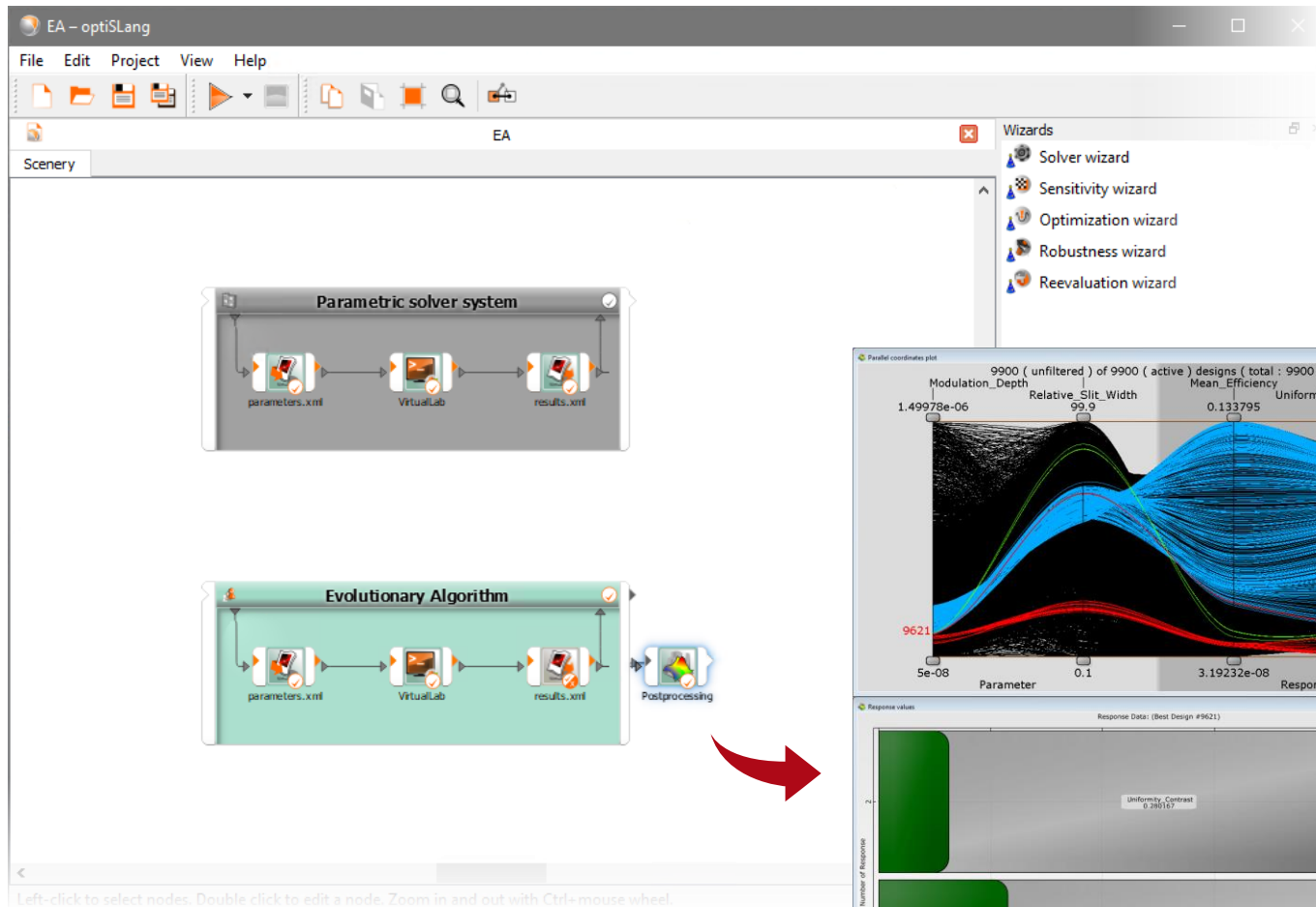
- VirtualLab Fusion is a flexible and customizable platform of modelling tools to simulate complex optical setups like e.g. coupling a set of plane waves into a lightguide
- an interconnection to the software optiSLang provides access to advanced tools for sensitivity analysis, multiobjective and multidisciplinary optimization, robustness evaluation, reliability analysis and robust design optimization

Workflow in VirtualLab Fusion

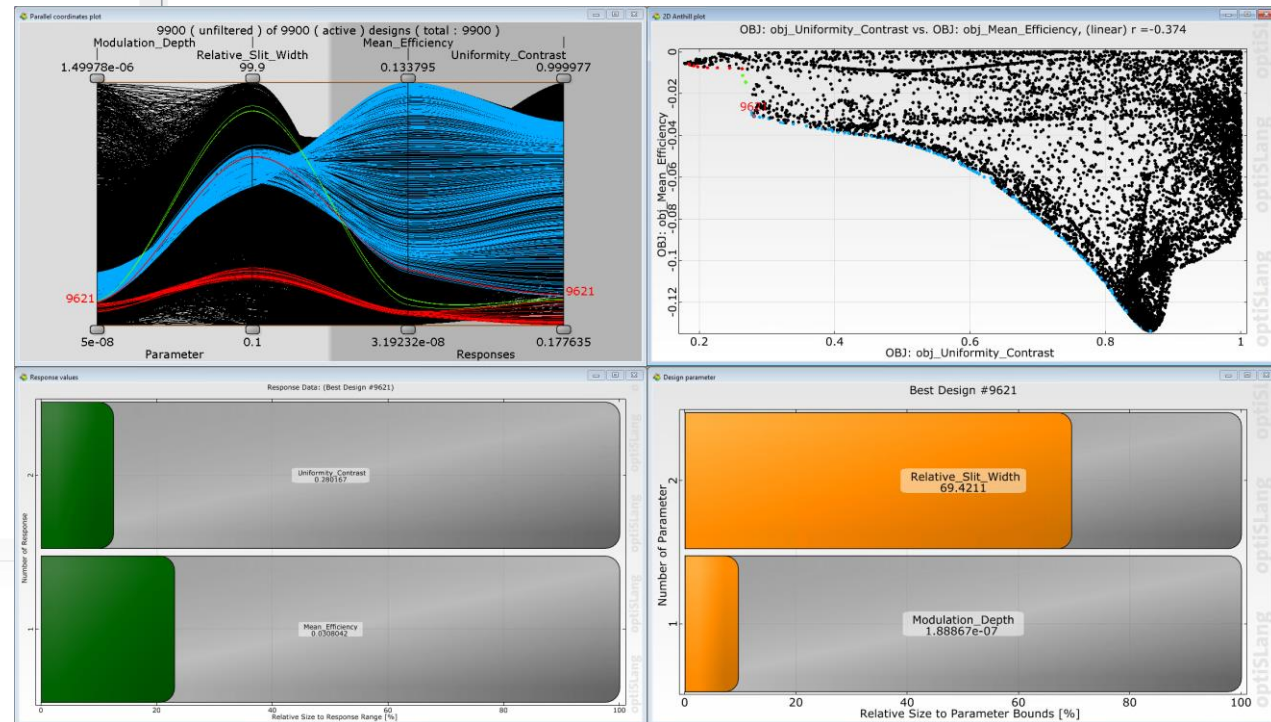
- Configuration of grating structure
 - [Configuration of Grating Structures by Using Interfaces](#) [Use Case]
 - [Configuration of Grating Structures by Using Special Media](#) [Use Case]
- Evaluation of coupling efficiency
 - [Customized Detector for Lightguide Coupling Grating Evaluation](#) [Use Case]
- Optimization of grating structure
 - [Grating Optimization in VirtualLab Fusion Using optiSLang](#) [Use Case]



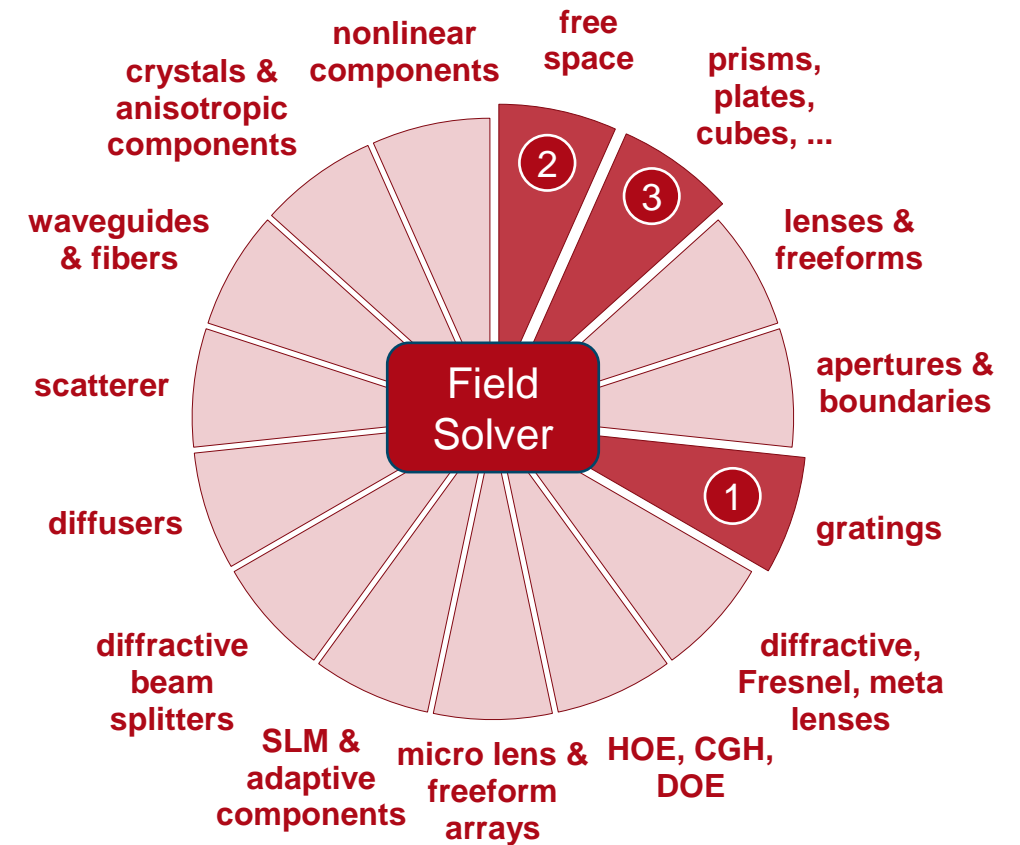
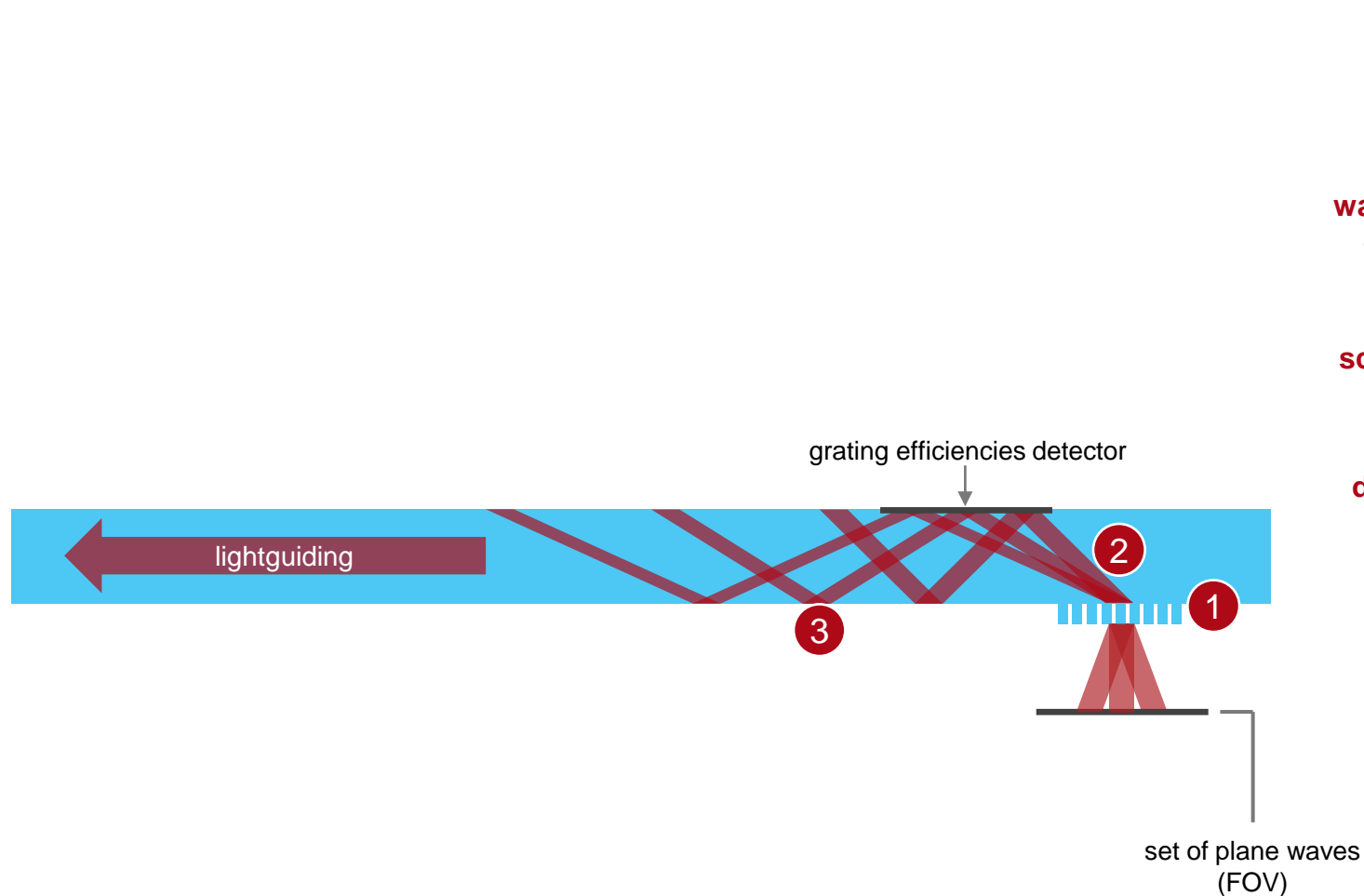
Peek into optiSLang



- optiSLang offers a broad range of features to perform Robust Design Optimization with an easy to use graphical user interface
- it makes you ready to meet the full range of parametric studies to innovate and accelerate your virtual optical system development



VirtualLab Fusion Technologies



Document Information

title	Optimization of Binary Grating for Lightguide Coupling over Desired FOV
document code	LGC.0003
version	1.1
toolbox(es)	<ul style="list-style-type: none">• VirtualLab Fusion Basic• Grating Toolbox
VL version used for simulations	2023.1 (Build 1.556
category	Application Use Case
further reading	<ul style="list-style-type: none">– Analysis of Slanted Gratings for Lightguide Coupling– Optimization of Lightguide Coupling Grating for Single Incidence Direction– RDO-Journal Article: “Innovation in Optics and Photonics – VirtualLab and OptiSLang”