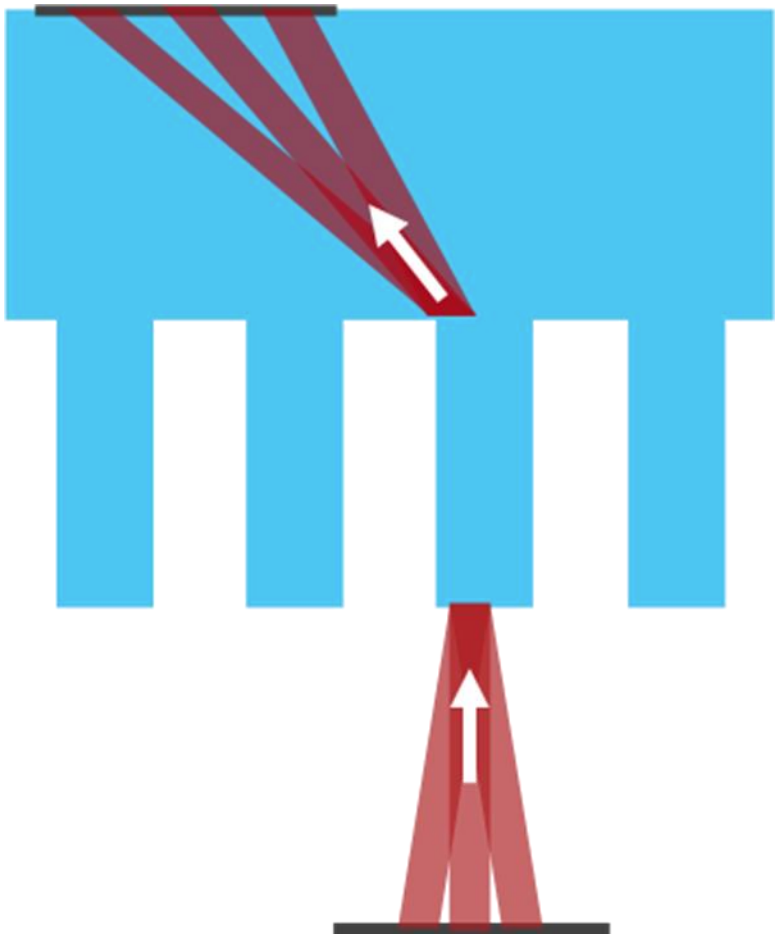
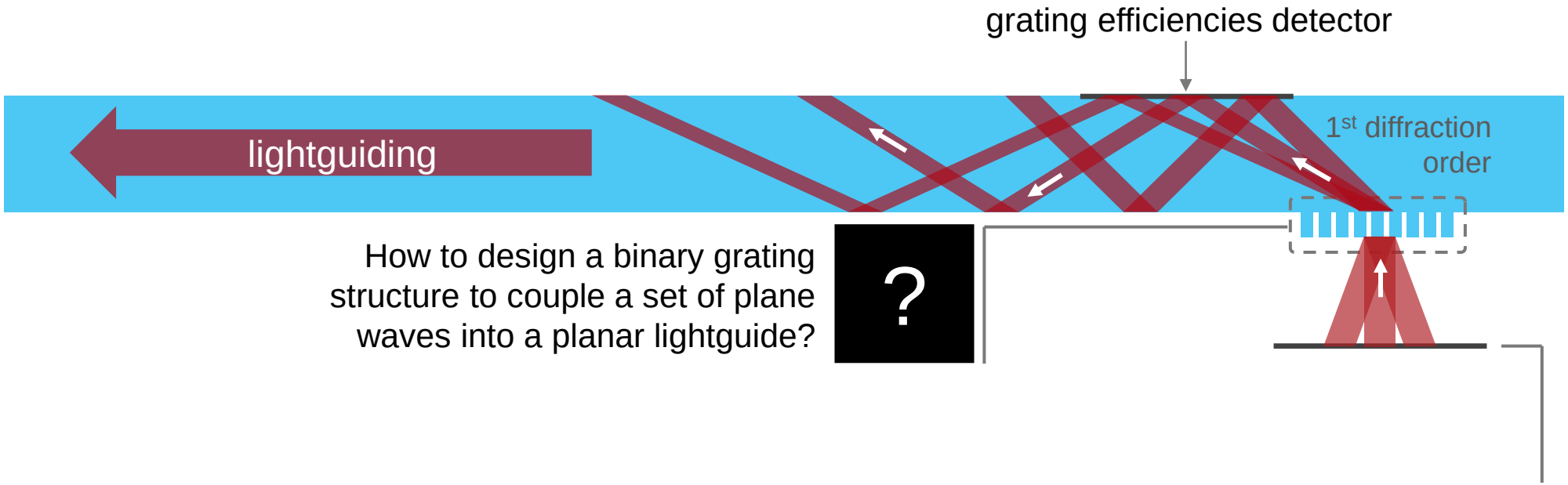
Optimization of Binary Grating for Lightguide Coupling over Desired FOV

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

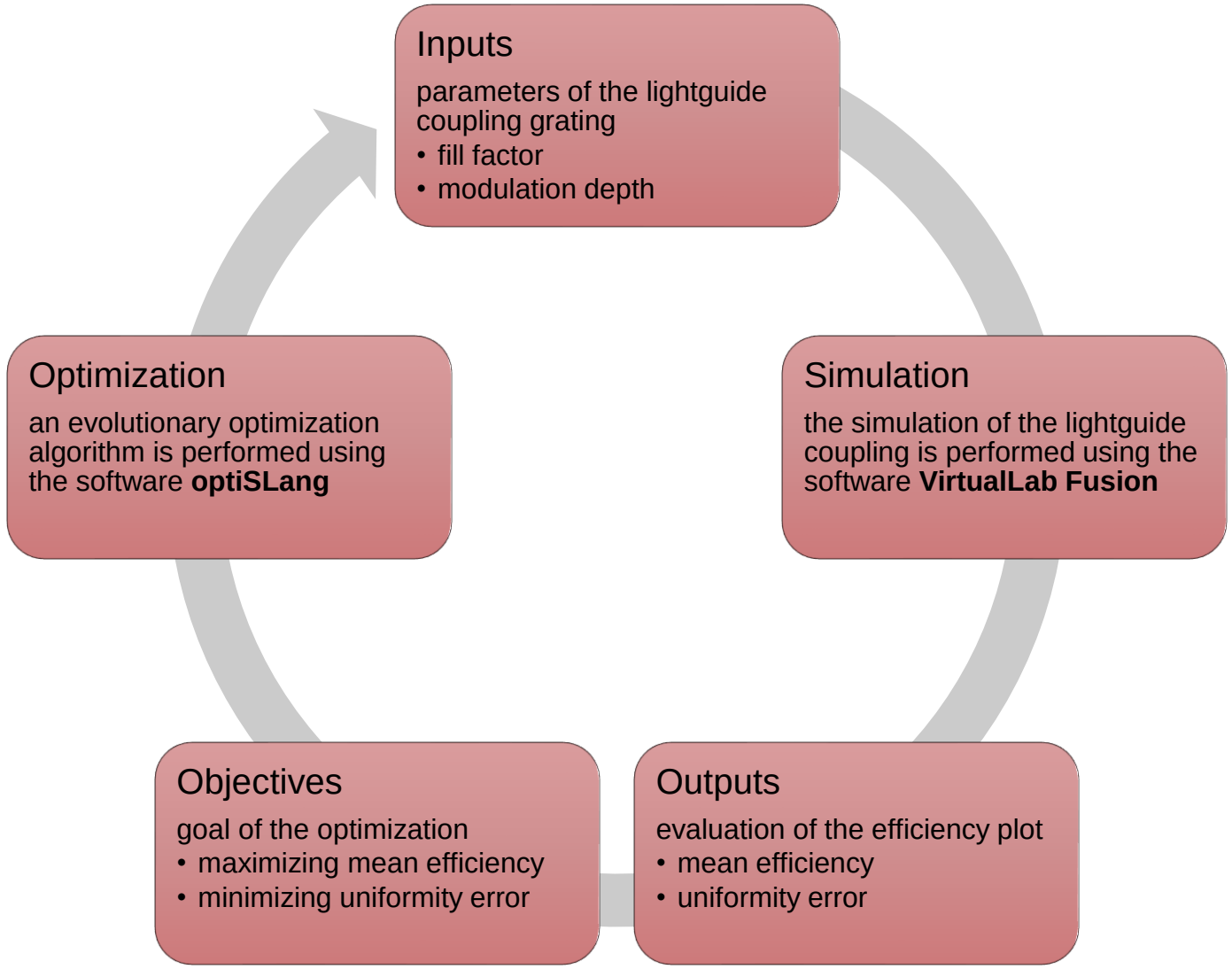


set of plane waves

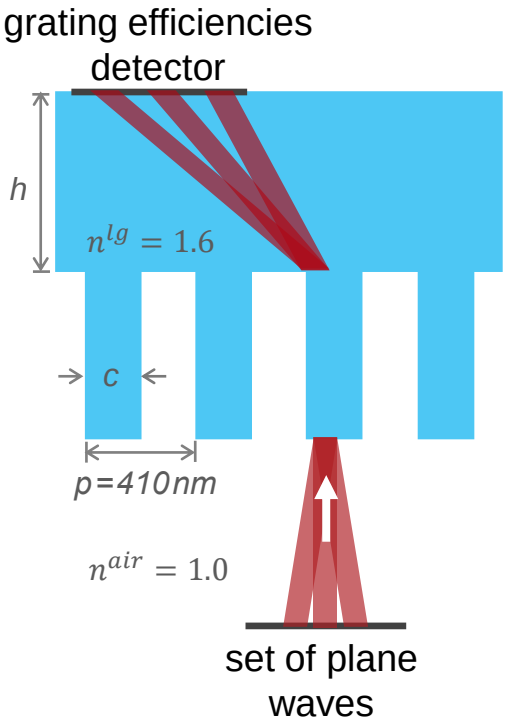
- field of view (-15..15, -10..10)°
- wavelength 532nm
- linearly polarized along x-axis

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

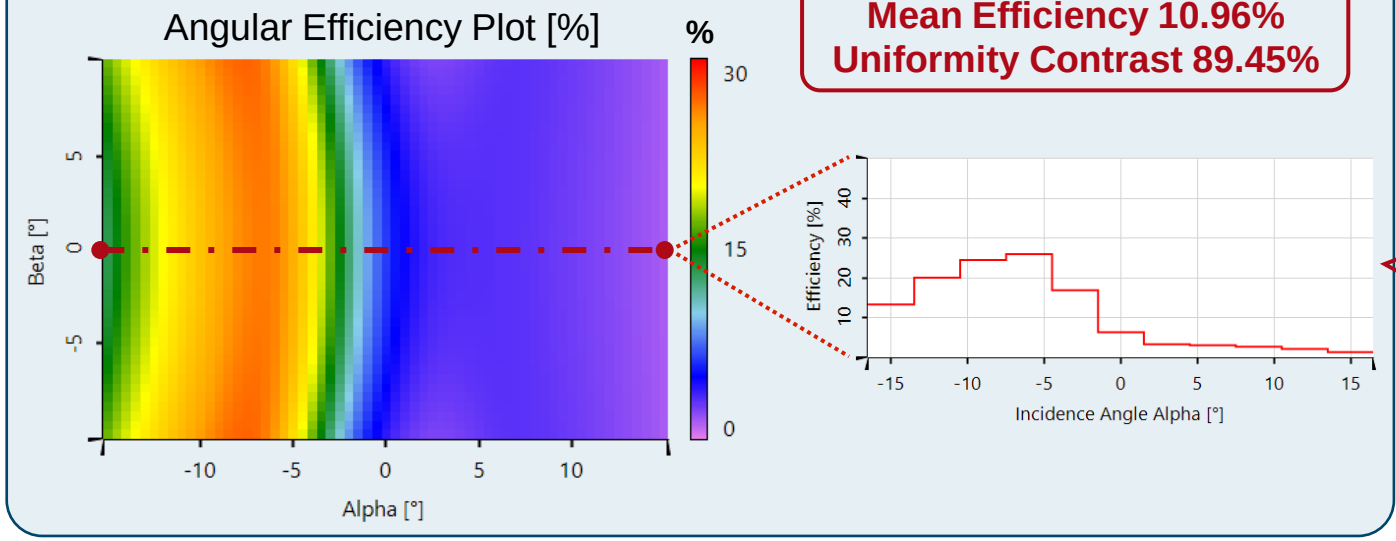


- variation of the **fill factor** *c/p* with the slit width *c* and the period *p*
  - ➢ **0.1% to 99.9%**
- variation of the **modulation depth** *h*
  - ➢ **50 nm to 1500 nm**

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

to be varied

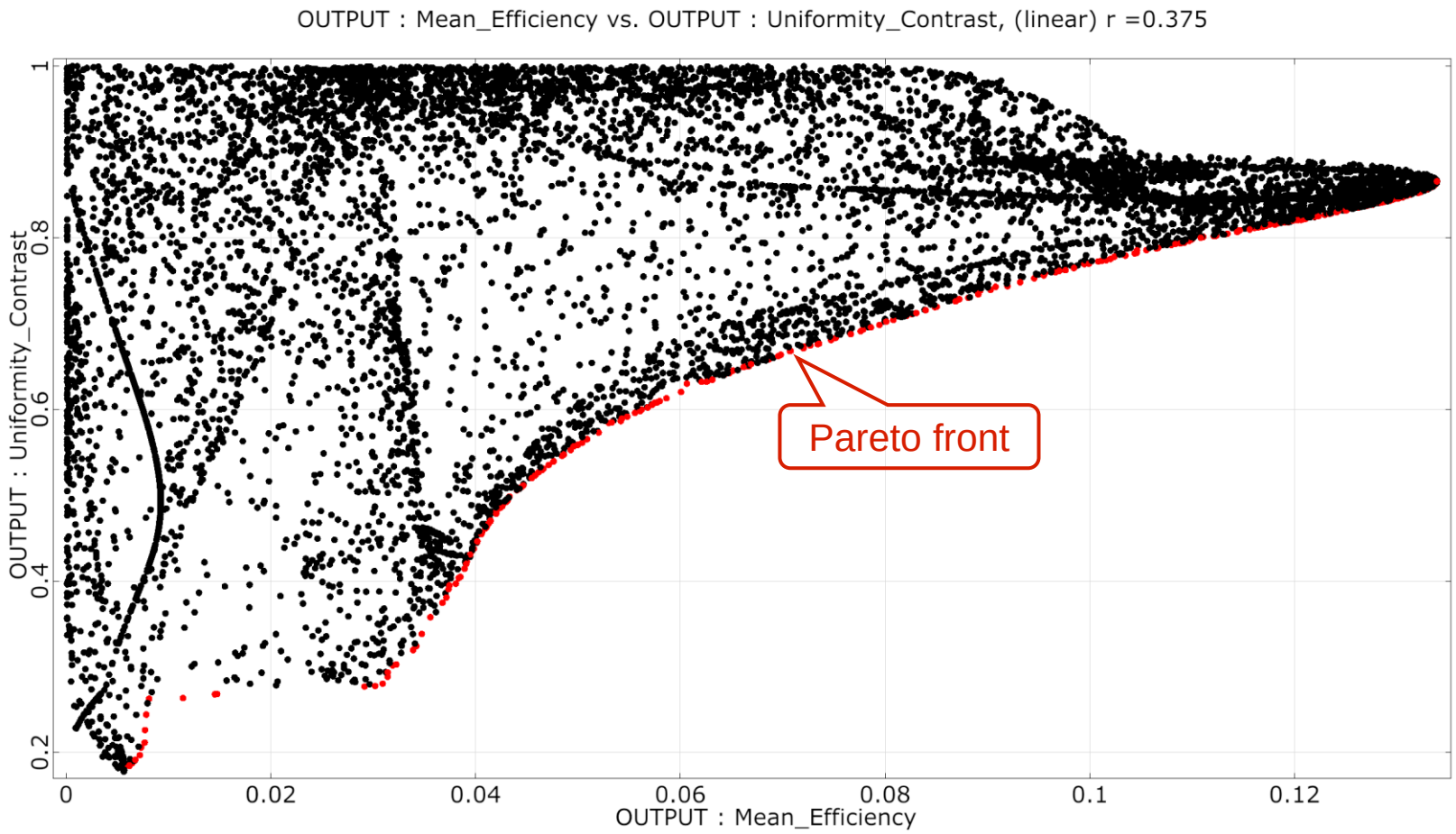
Grating Efficiencies Detector Result



Mean Efficiency 10.96%
Uniformity Contrast 89.45%

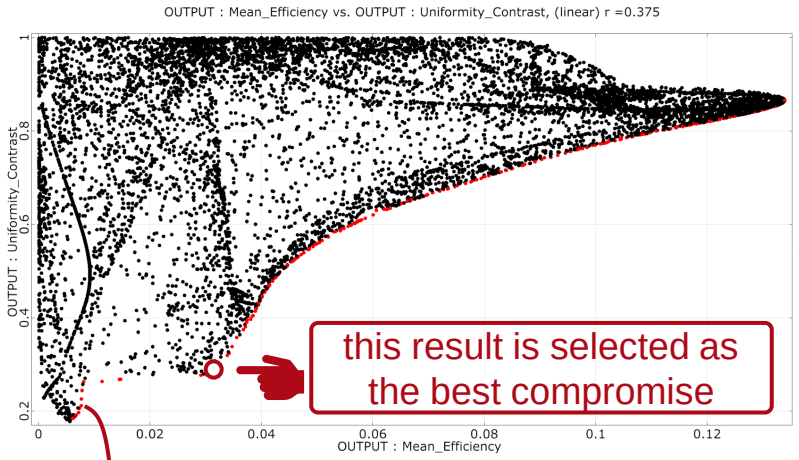
a roughly sampled evaluation of the incidence angles alonge the period is sufficient for the optimization

Optimization Results of optiSLang

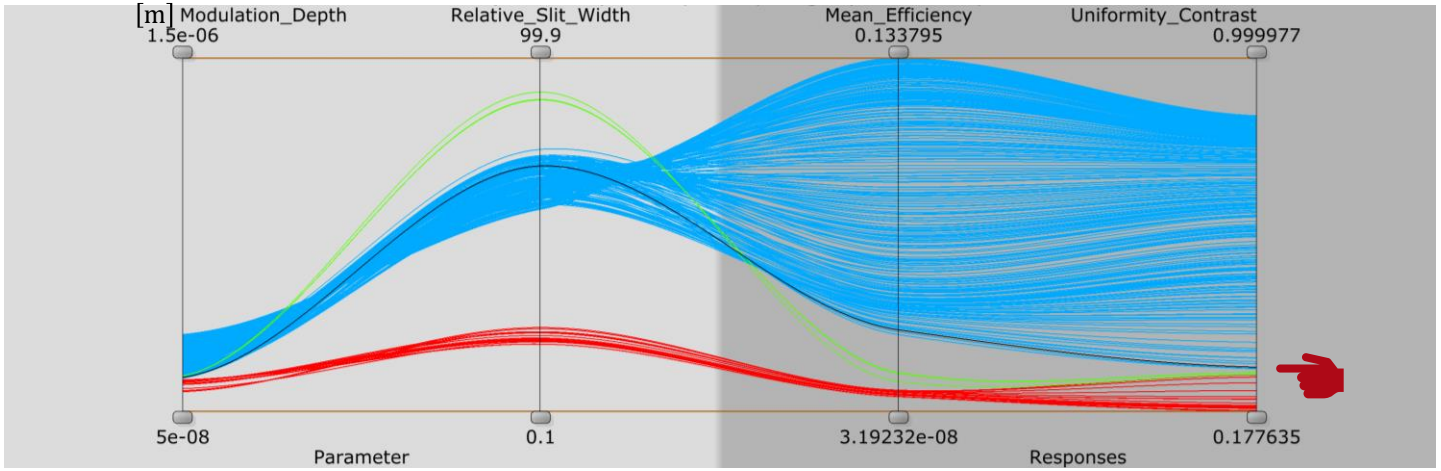


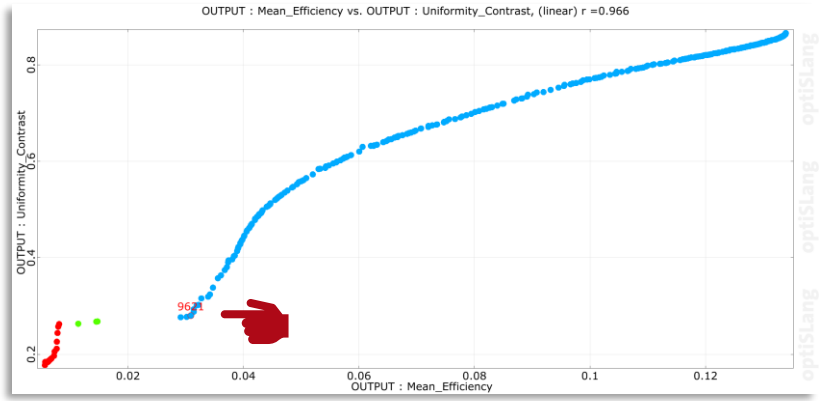
- the optimization results are plotted as a function of the merit functions
  - mean efficiency
  - uniformity contrast
- the Pareto front indicates the optimum compromise between the two merit functions

Advanced Evaluation of the Optimization Results



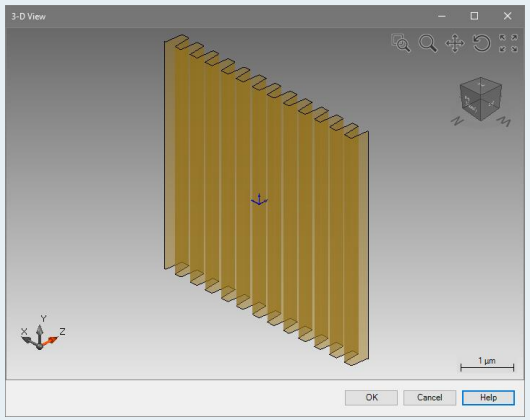
- the optimization results at the Pareto front are visualized in a *Parallel Coordinates Plot* to investigate the effect of the input parameters (responses) to the output parameters in detail
- in addition, a cluster analysis decomposes a specific parameter, e.g. the relative slit width, into a certain 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

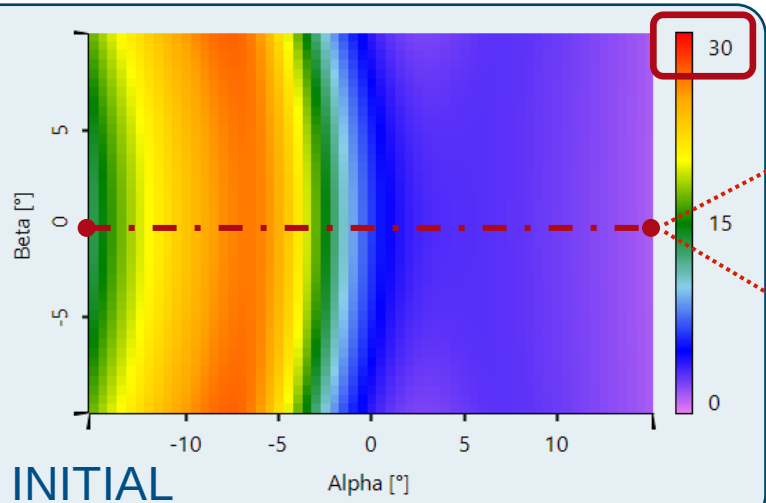




the results at the Pareto front are highlighted and color adapted according to the results of the cluster analysis

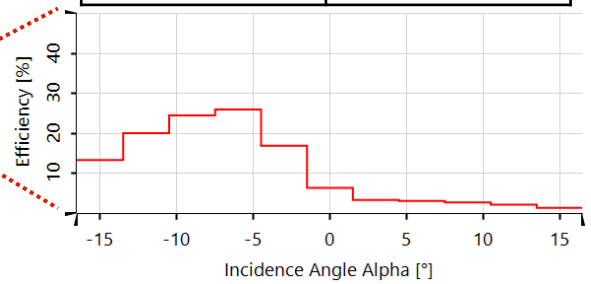
Analysis of Coupling Efficiency for Optimization Result



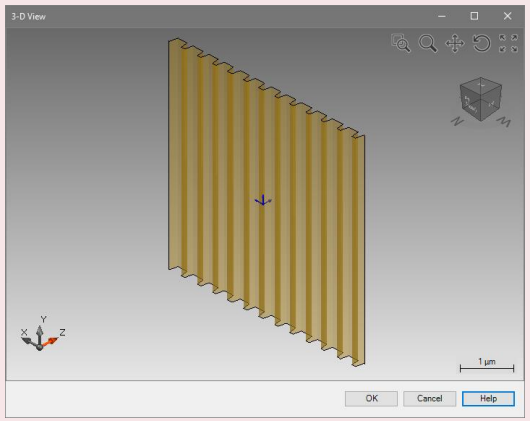


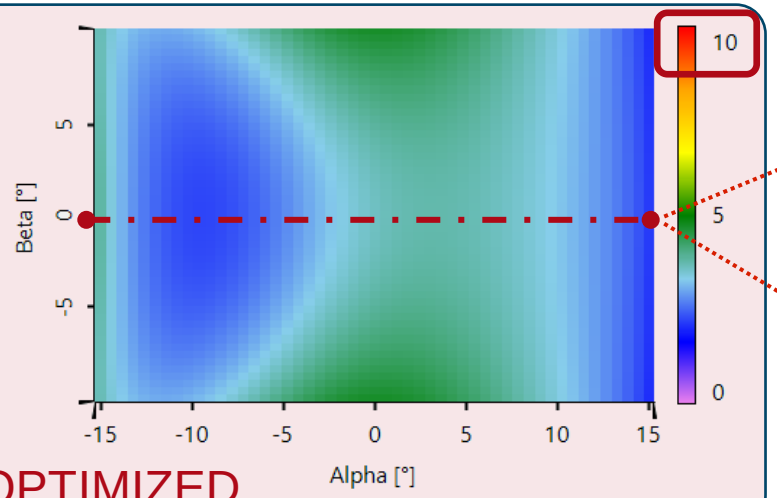
INITIAL

fill factor	50.00%
modulation depth	400.00 nm



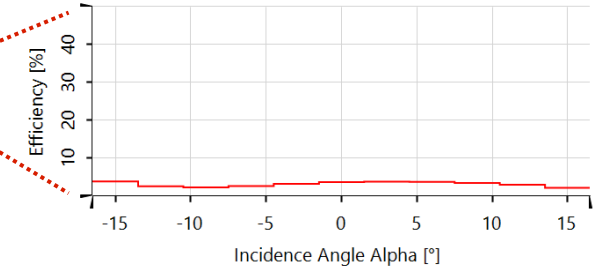
Mean Efficiency 10.96%
Uniformity Contrast **89.45%**





OPTIMIZED

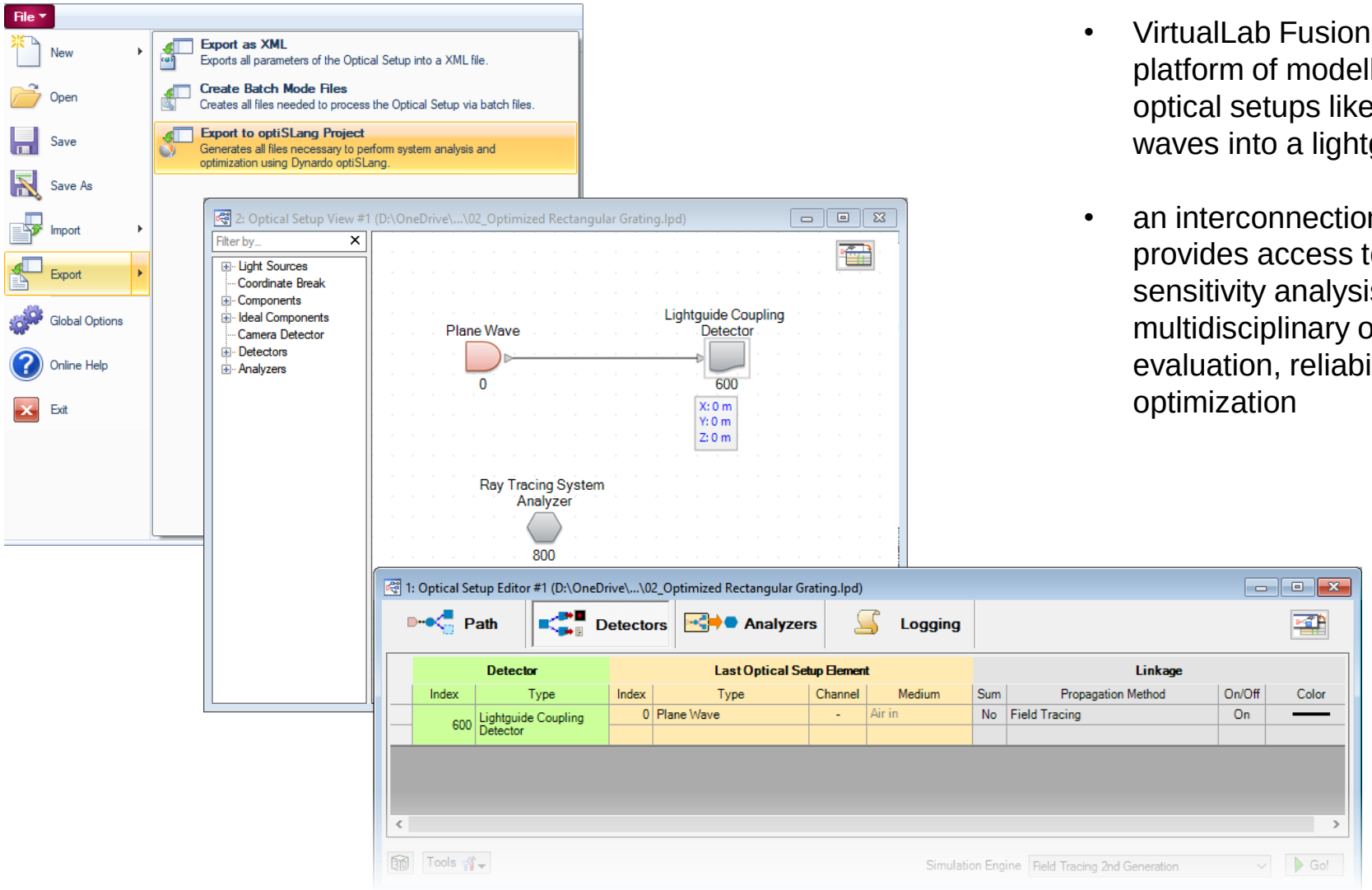
fill factor	68.43%
modulation depth	187.18 nm



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

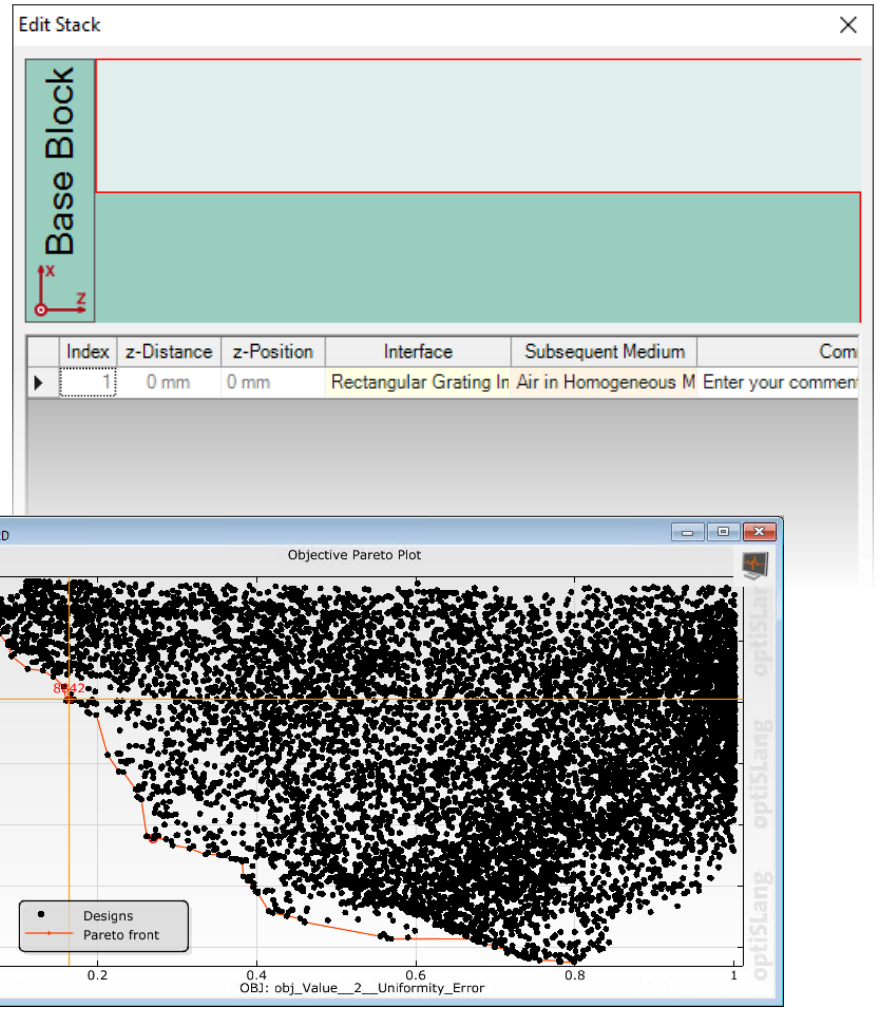


- VirtualLab Fusion is a flexible and customizable platform of modelling tools to simulate complex optical setups like e.g. coupling a set of plane waves into a lightguide

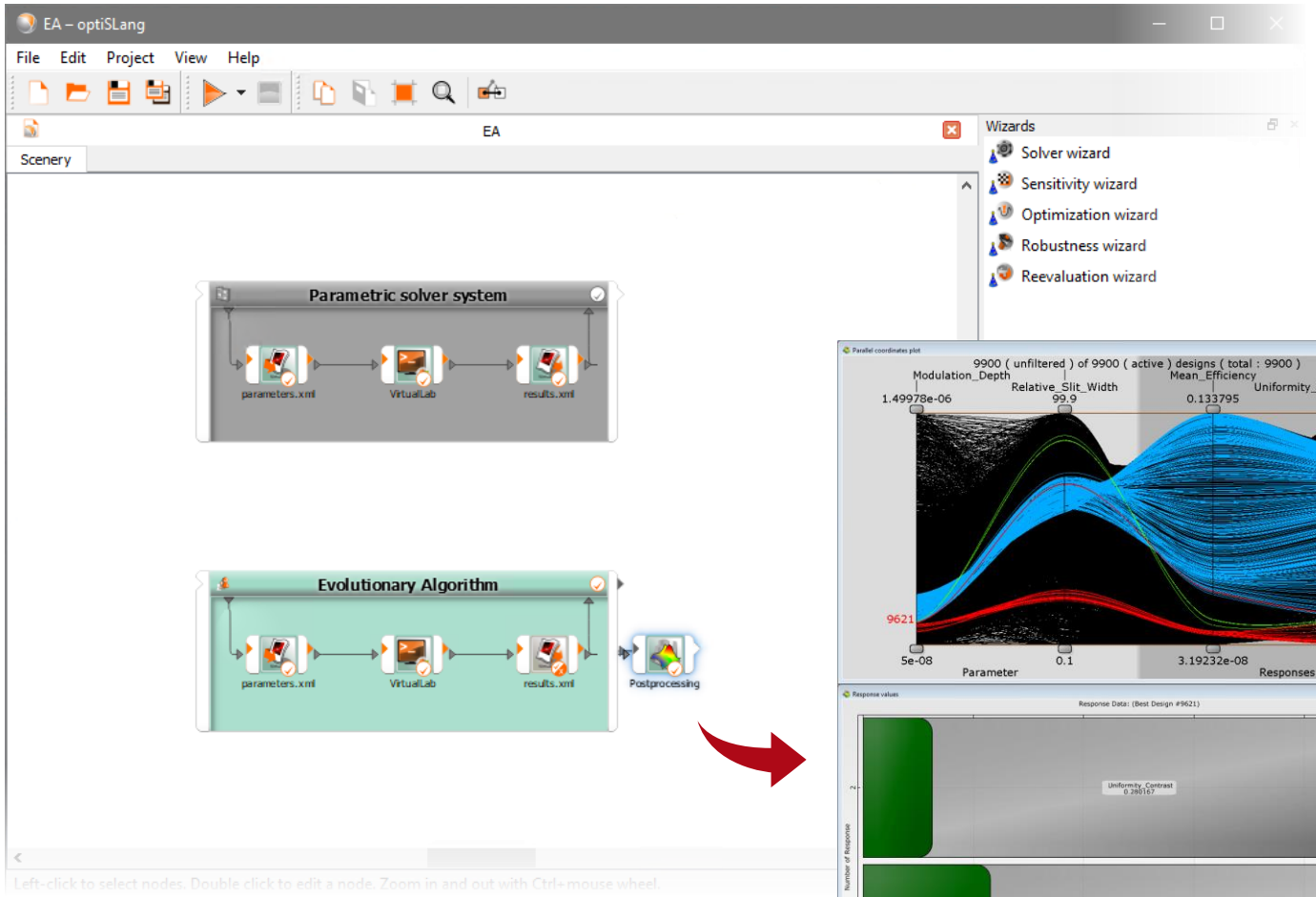
- an interconnection to the software optiSLang provides access to advanced tools for sensitivity analysis, multiobjective and multidisciplinary optimization, robustness evaluation, reliability analysis and robust design optimization

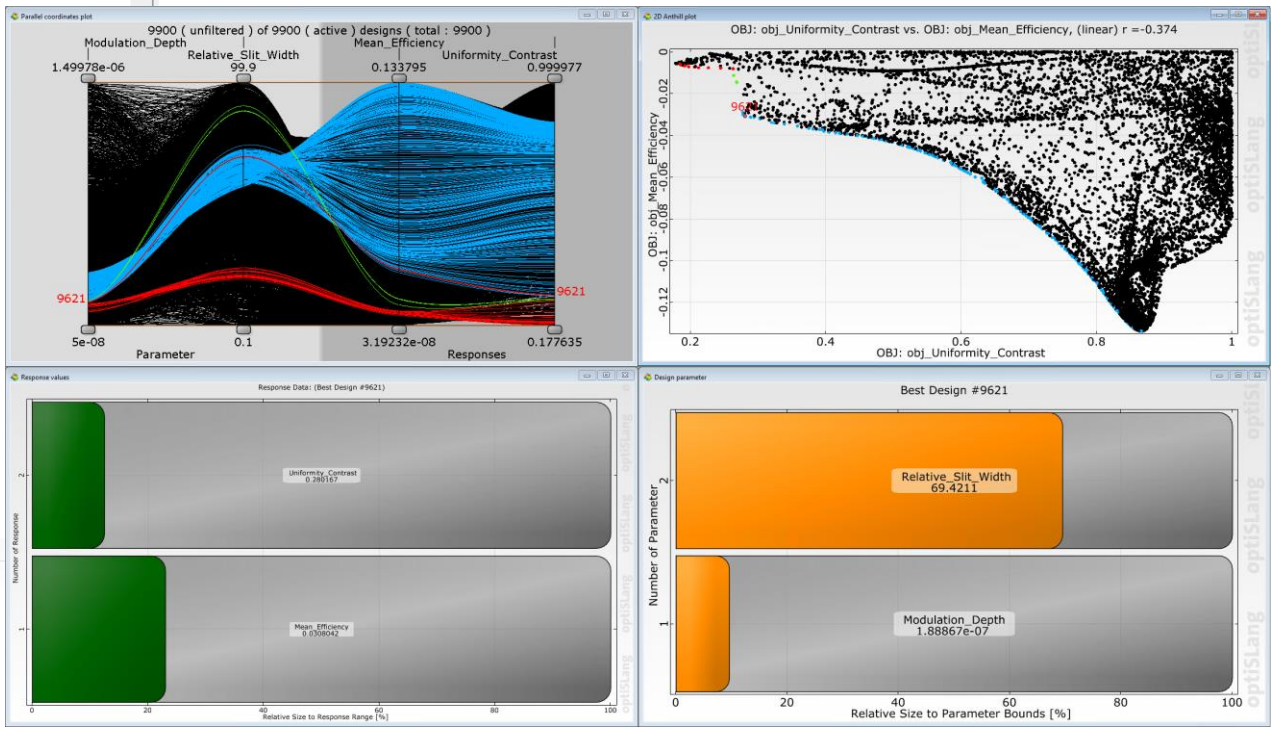
Workflow in VirtualLab Fusion

- 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]



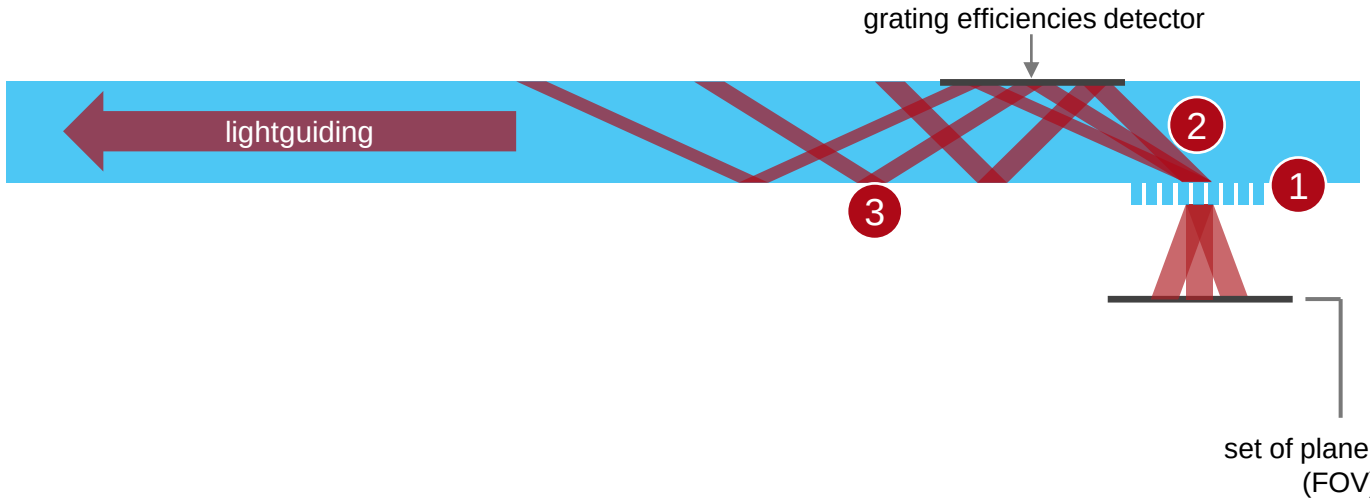
Peek into optiSLang

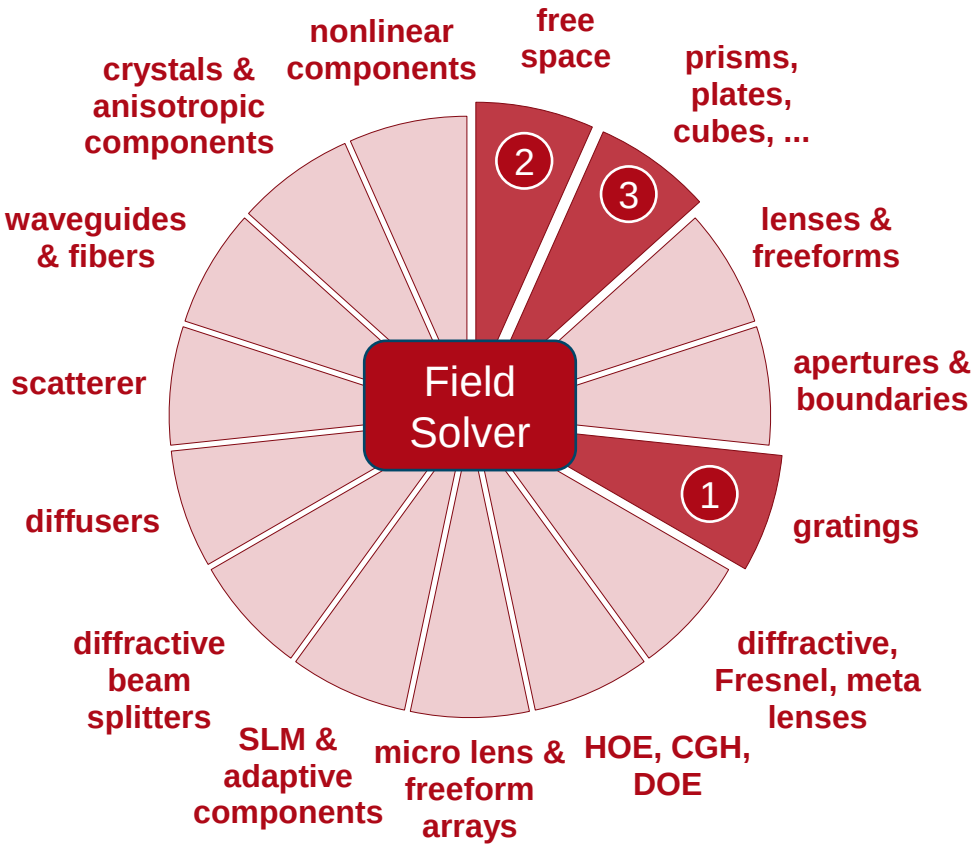




- optiSLang offers a broad range of features to perform Robust Design Optimization with an easy to use graphical user interface
- it makes you ready to meet the full range of parametric studies to innovate and accelerate your virtual optical system development

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)	• VirtualLab Fusion Basic • Grating Toolbox
VL version used for simulations	2023.1 (Build 1.556
category	Application Use Case
further reading	– 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”*