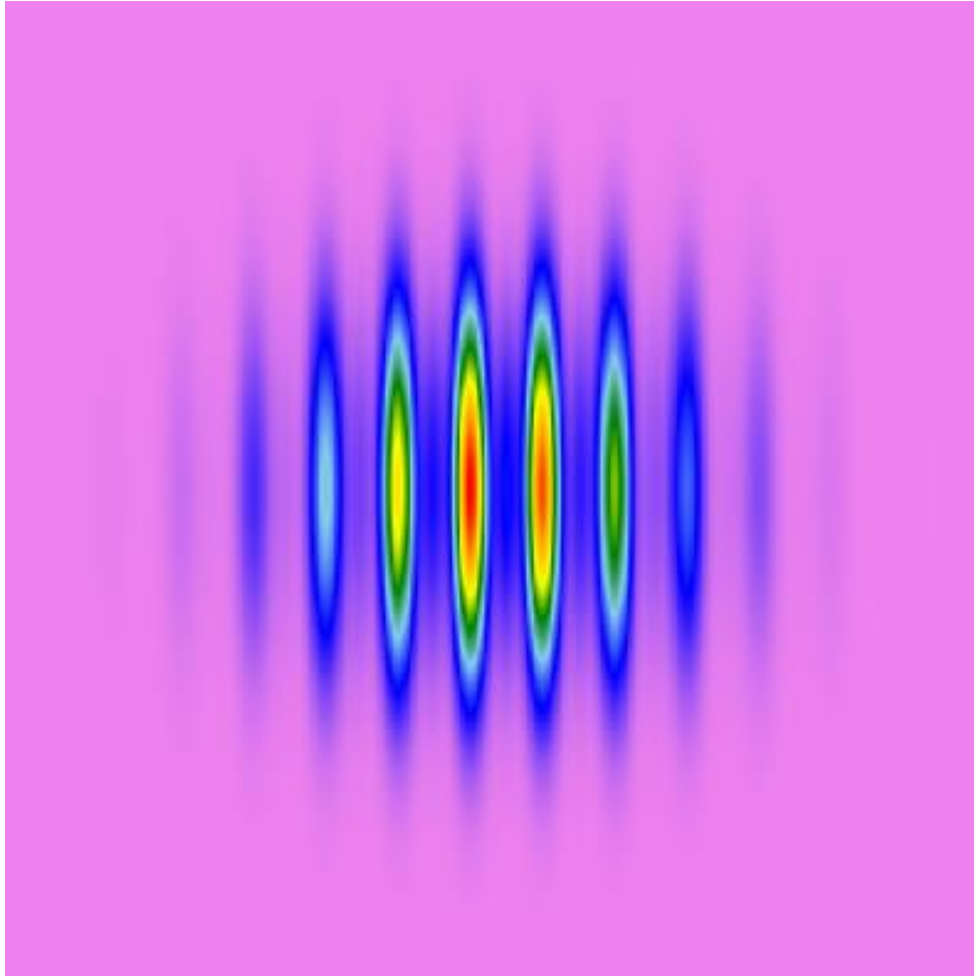


Optical System for Investigation of Micro-Structured Wafer

Abstract



In the semiconductor industry, wafer inspection systems are used to detect defects on a wafer and find their positions. To ensure the necessary image resolution for the microstructures, the inspection system often employs a high-NA objective and works in the UV wavelength range. As an example, a complete wafer inspection system including high-NA focusing and light interaction with microstructures is modeled, and the formation of the image is demonstrated.

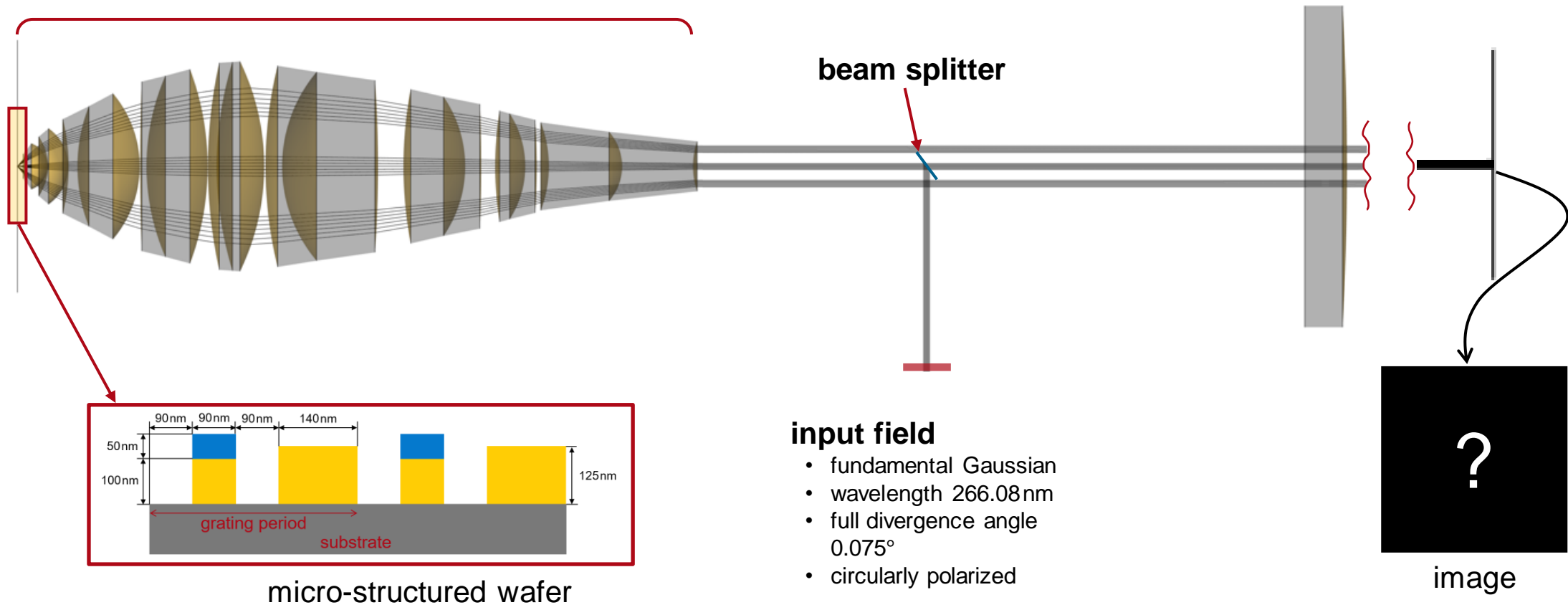
Task Description

inspection objective

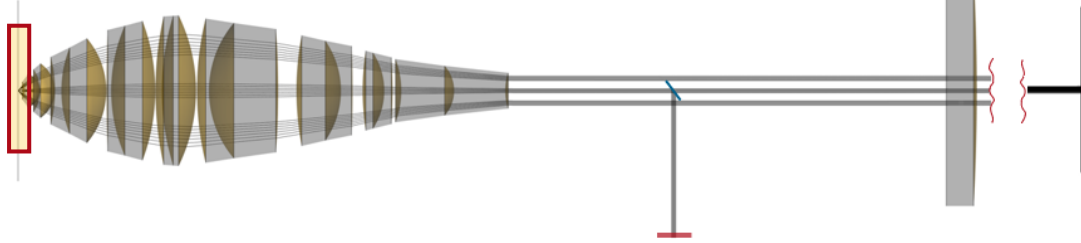
- NA = 0.9
- effective focal length 2mm
- back focal length 750 μ m

imaging lens

- Newport SPX031AR.10
- effective focal length 500mm



Micro-Structured Wafer



Grating structures, such as the periodic structure used on the wafer, are modeled by defining appropriately shaped surfaces and media in a *Stack*. This *Stack* can then be imported into a variety of different components, depending on the intended use. In this case we have loaded the *Stack* into a *Grating Component* in a general *Optical Setup*, in order to simulate the entire system. For more information, see:

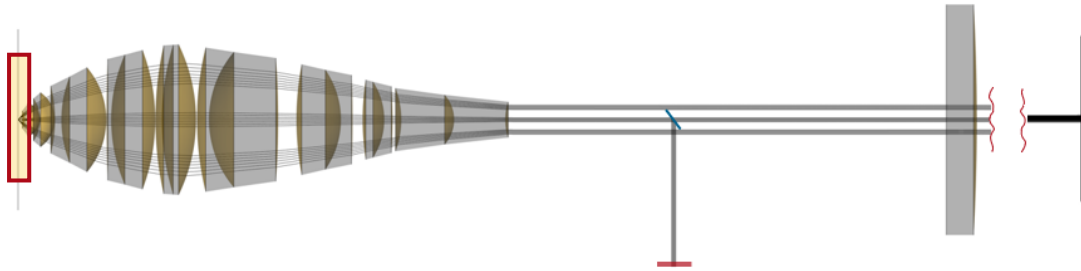
[Grating Component for General Optical Systems](#)

The screenshot shows the 'Edit Grating Component' dialog box in Zemax software. The 'Component Size' is set to 20 mm x 20 mm. The 'Reference Surface (all Channels)' is set to 'Plane Surface'. The 'Aperture' is set to 'On Front Side of'. The 'Grating Stack' is configured with a '1D-Periodic (Laminate)' structure. The 'Grating Period' is 410 nm. The 'StructuredWafer' is set to 'On Front Side of'. The 'Homogeneous Medium' is 'Air (ZEMAX) in Homogeneous Medium'. A 'Preview for StructuredWafer' window is open, showing a 3D view of the grating structure and a table of the stack configuration.

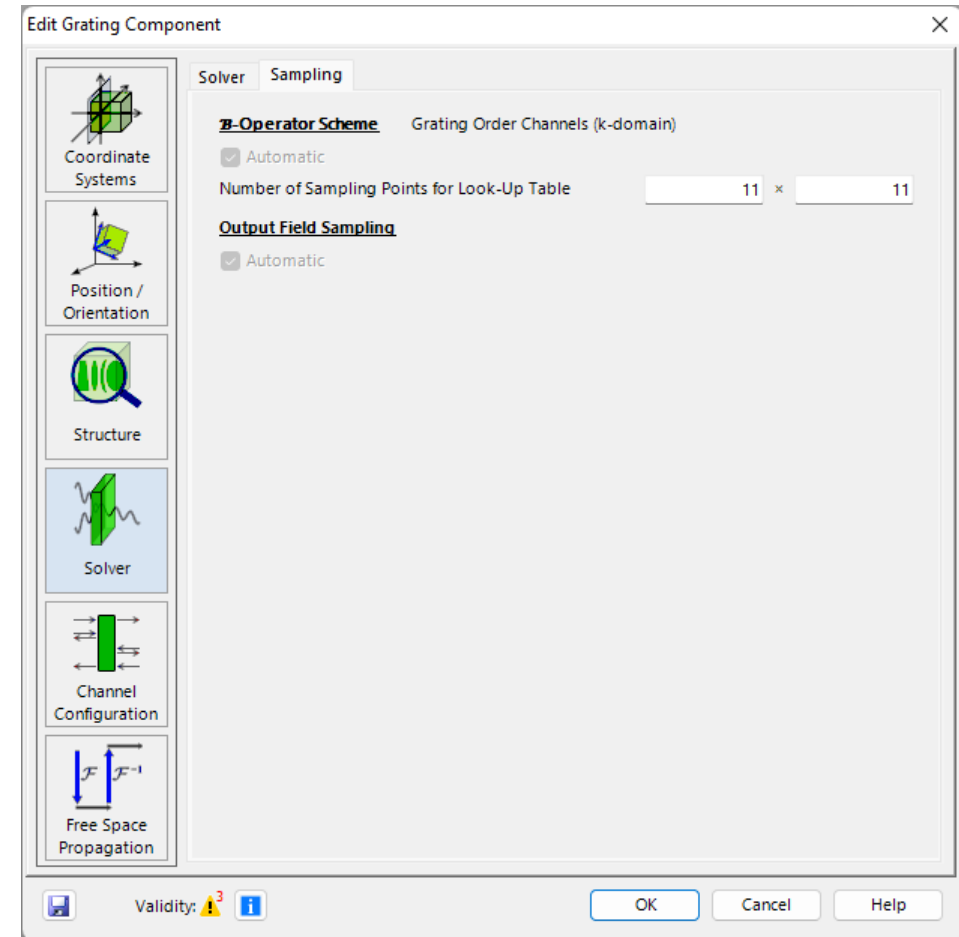
Index	z-Distance	z-Position	Surface	Subsequent Medium
1	0 mm	0 mm	Plane Interface	Gold-Au_(1997+1985) in Homogeneous Medium
2	0 mm	0 mm	Transition Point List Interface	Molybdenum-Mo_(1997+1985) in Homogeneous Me
3	0 mm	0 mm	Transition Point List Interface	Air (ZEMAX) in Homogeneous Medium

Periodic Stack; Stack Period: 410 nm x 410 nm

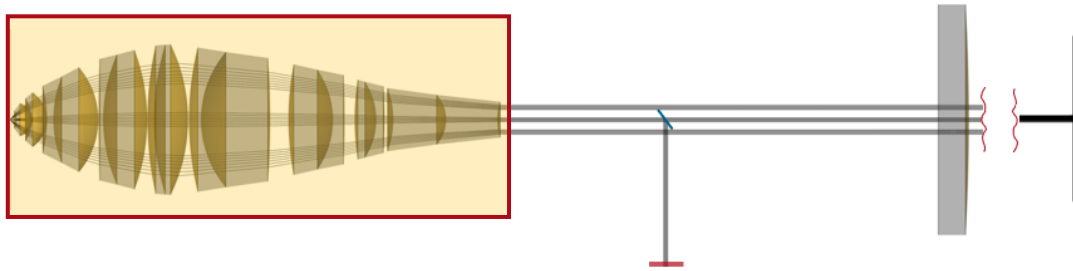
Angular Response of the Micro-Structured Wafer



The *Grating Component* uses the Fourier Modal Method (FMM), also known as Rigorous Coupled Wave Analysis (RCWA), which operates in the k-domain. When impinging with High-NA beams, a sufficient number of sampling points in the k-domain needs to be considered to resolve angular sensitive effects. In the *Solver* area of the *Grating Component* users can easily adjust this parameter to ensure a fast but accurate simulation.



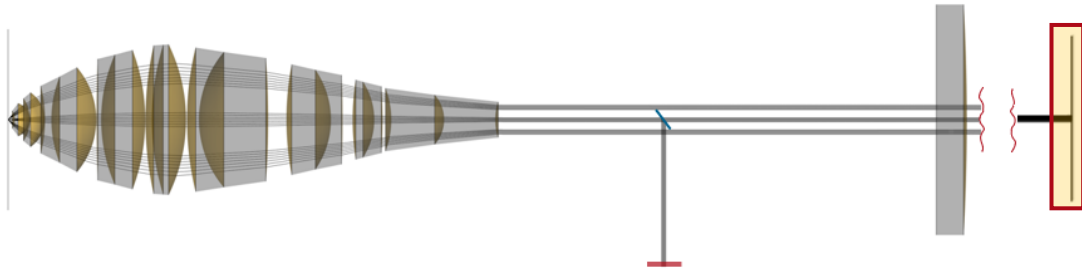
High-NA Objective Lens



The *Lens System Component* allows for the easy definition of a component consisting of an alternating sequence of smooth surfaces and homogeneous, isotropic media. In terms of both the interfaces and the materials, it is possible to choose ready-made entries from the in-built catalogs or to customize your own for maximum flexibility.

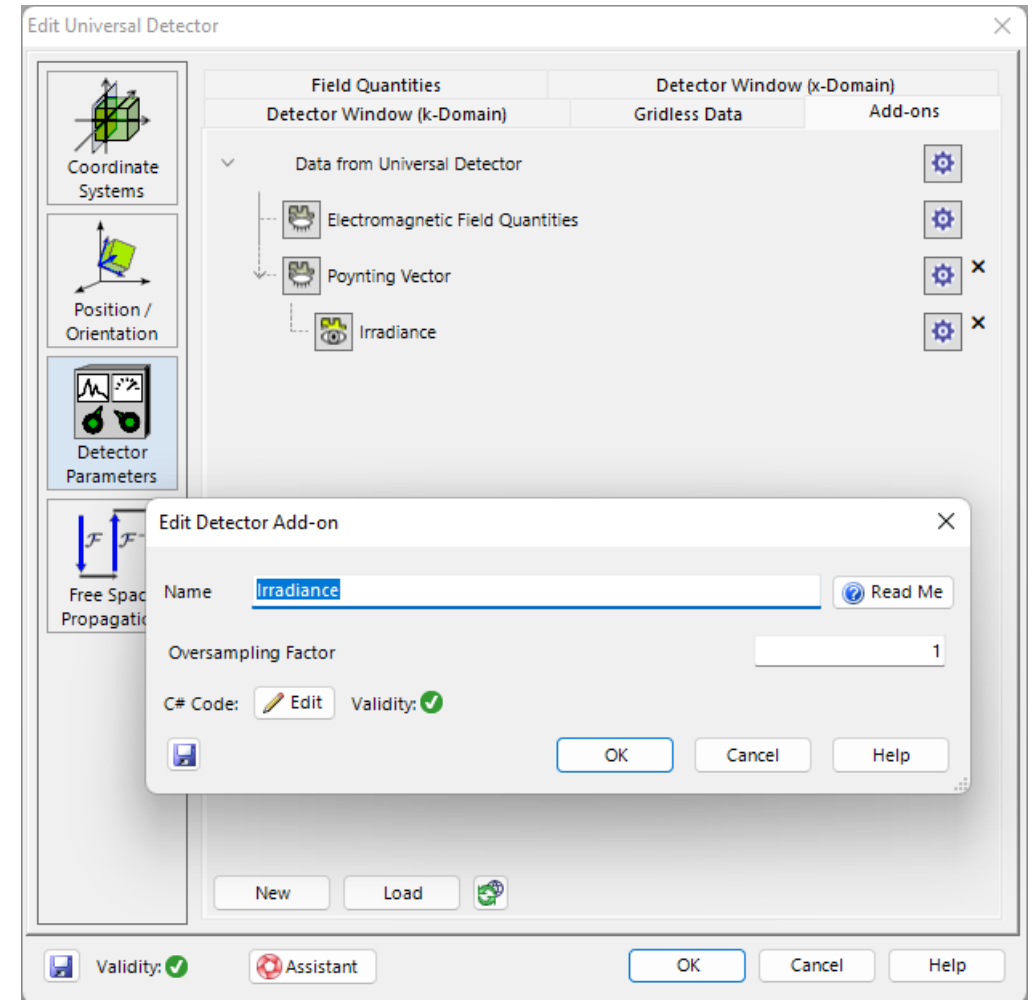
Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	F_SILICA_MISC in Homo	Zemax Interf
2	5.6249 mm	5.6249 mm	Conical Interface	CAF2_MISC in Homoger	Zemax Interf
3	5.8111 mm	11.436 mm	Conical Interface	Air (ZEMAX) in Homoge	Zemax Interf
4	962 μ m	12.398 mm	Conical Interface	F_SILICA_MISC in Homo	Zemax Interf
5	910.4 μ m	13.308 mm	Conical Interface	CAF2_MISC in Homoger	Zemax Interf
6	2.3792 mm	15.688 mm	Conical Interface	Air (ZEMAX) in Homoge	Zemax Interf
7	1.1185 mm	16.806 mm	Conical Interface	F_SILICA_MISC in Homo	Zemax Interf
8	1.2646 mm	18.071 mm	Conical Interface	CAF2_MISC in Homoger	Zemax Interf
9	4.8927 mm	22.963 mm	Conical Interface	Air (ZEMAX) in Homoge	Zemax Interf
10	2.0188 mm	24.982 mm	Conical Interface	CAF2_MISC in Homoger	Zemax Interf
11	7.6088 mm	32.591 mm	Conical Interface	F_SILICA_MISC in Homo	Zemax Interf
12	1.3191 mm	33.91 mm	Conical Interface	Air (ZEMAX) in Homoge	Zemax Interf
13	100 μ m	34.01 mm	Conical Interface	CAF2_MISC in Homoger	Zemax Interf

Universal Detector & Detector Add-ons

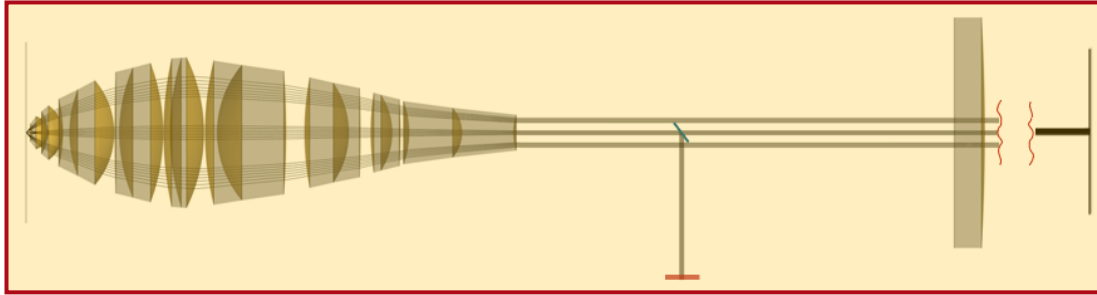


The *Universal Detector* allows the evaluation of the impinging field and the calculation of various physical quantities through so-called *Add-ons*. One of the provided *Add-ons* provides as a result the irradiance in space domain. For more information, see:

[Universal Detector](#)

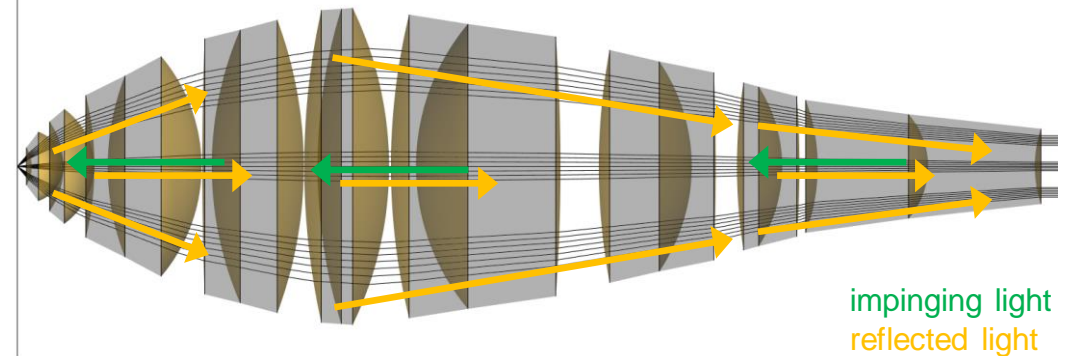
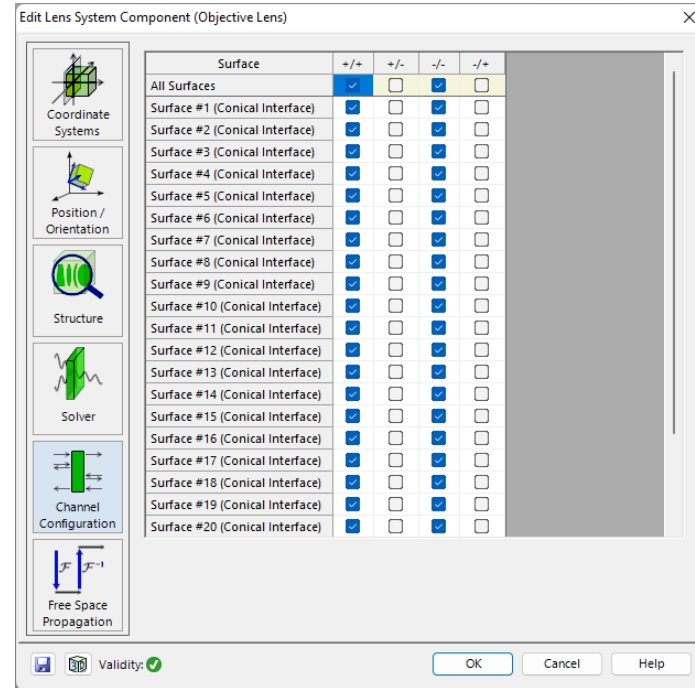


Non-Sequential Tracing

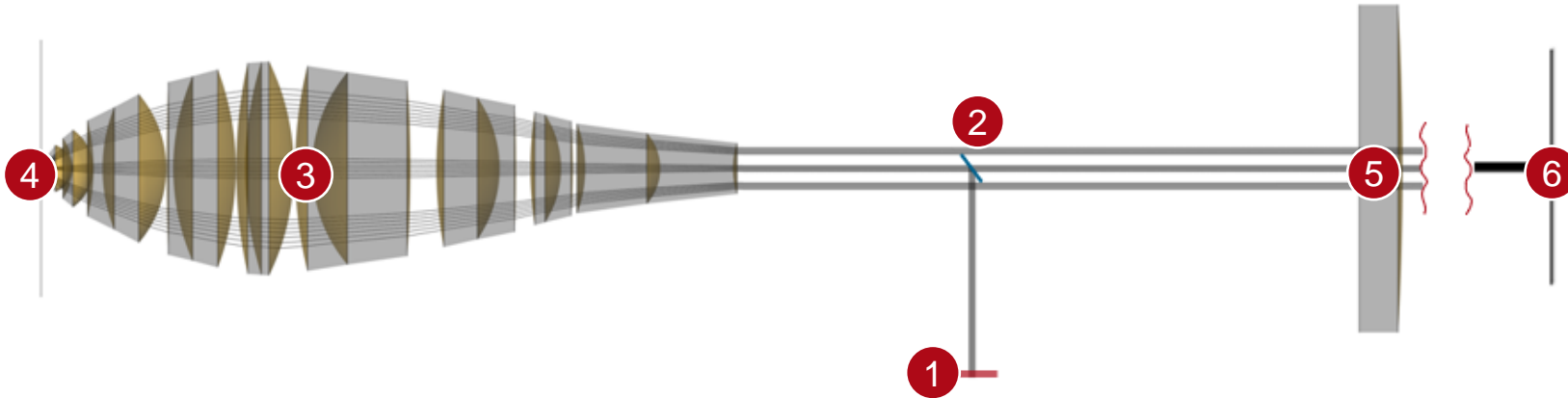


With the channel configuration mode toggle set to *Manual Configuration*, the user can specify, for each surface in the system, which channels to open for the simulation. When the simulation is run, a preliminary analysis of the active light paths will be performed (by the so-called *Light Path Finder*). The field will then be traced along these light paths by the engine, to the detectors present in the system.

Channel Setting for Non-Sequential Tracing

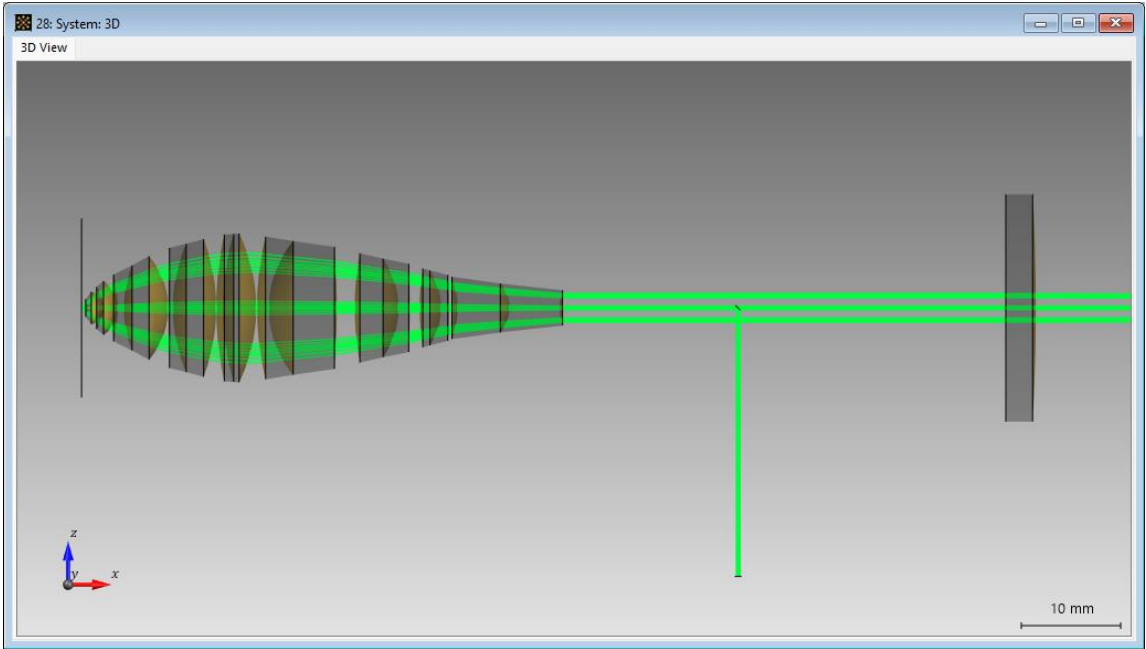
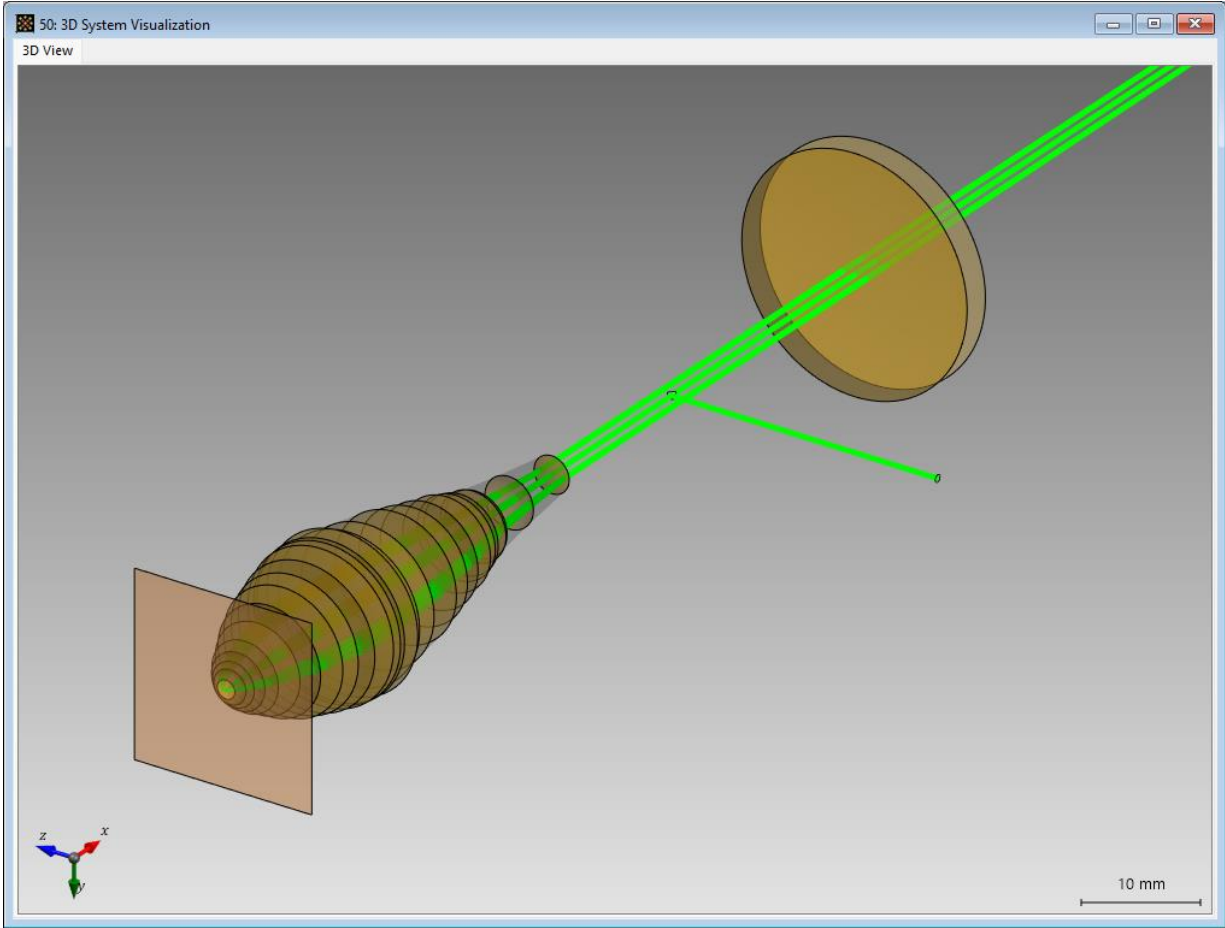


Summary – Components...

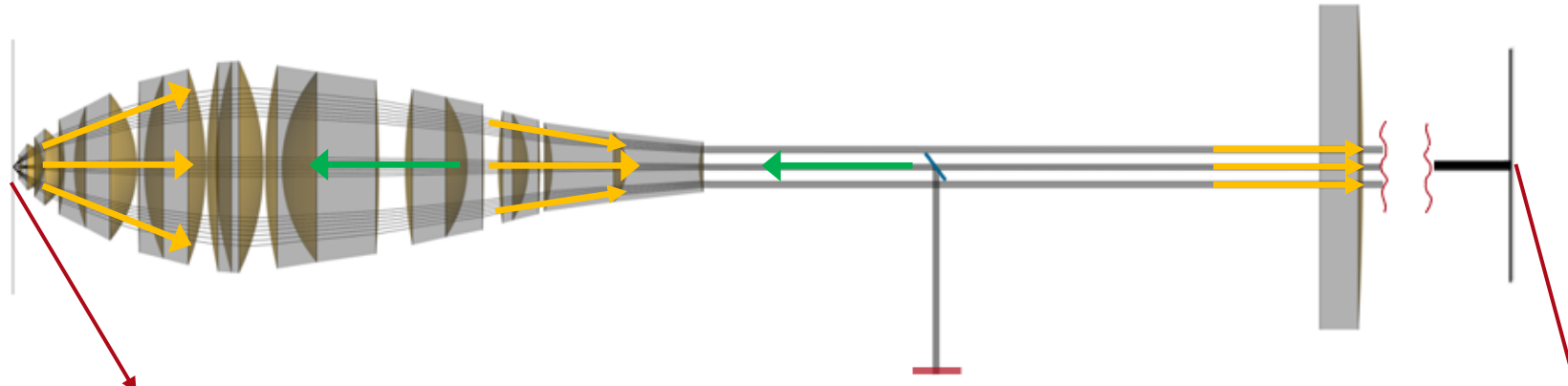


... of Optical System	... in VirtualLab Fusion	Model/Solver/Detected Magnitude
1. source	<i>Gaussian Wave</i>	spatial Gaussian function
2. beam splitter	<i>Ideal Beam Splitter</i>	transmission function
3. inspection objective	<i>Lens System Component</i>	Local Plane Interface Approximation (LPIA)
4. wafer	<i>Grating Component</i>	Fourier Modal Method (FMM)/Rigorous Coupled Wave Analysis (RCWA)
5. imaging lens	<i>Lens System Component</i>	Local Plane Interface Approximation (LPIA)
6. detector	<i>Universal Detector with Irradiance Add-on</i>	irradiance

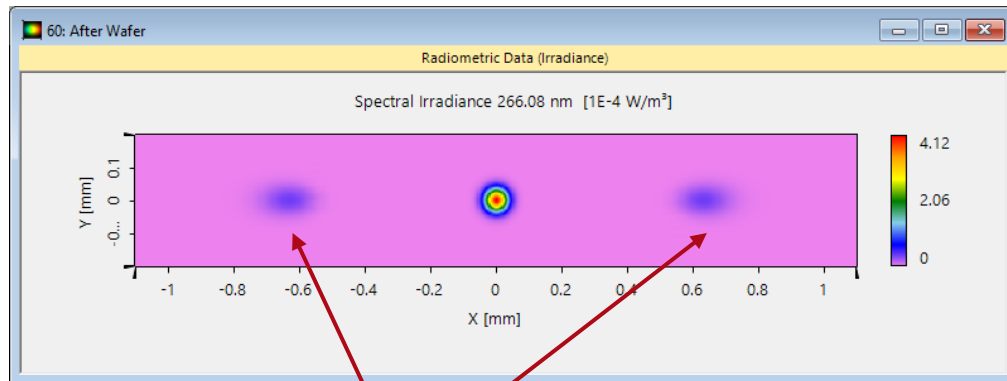
System Impressions



Field Tracing Results

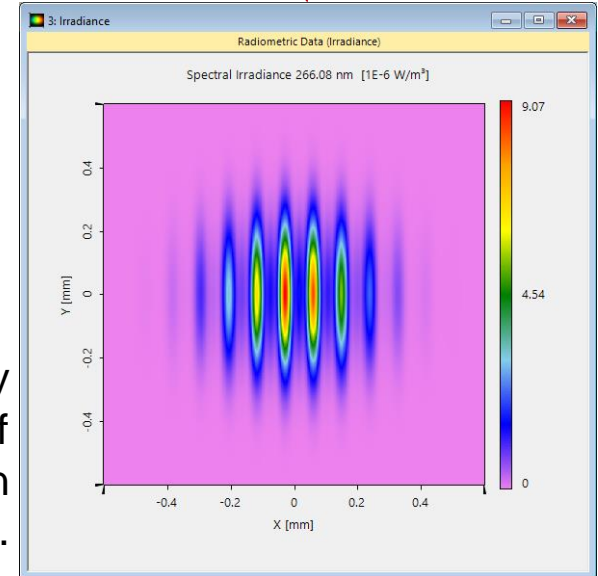


~ 100 μ m behind micro-structured wafer

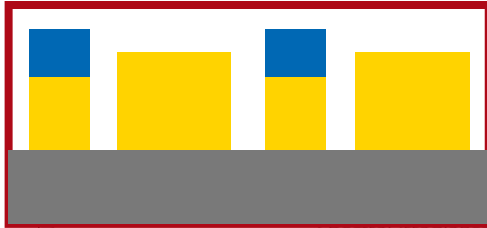


1st diffraction orders

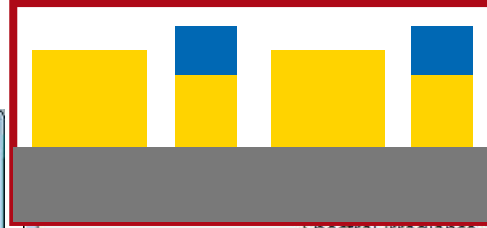
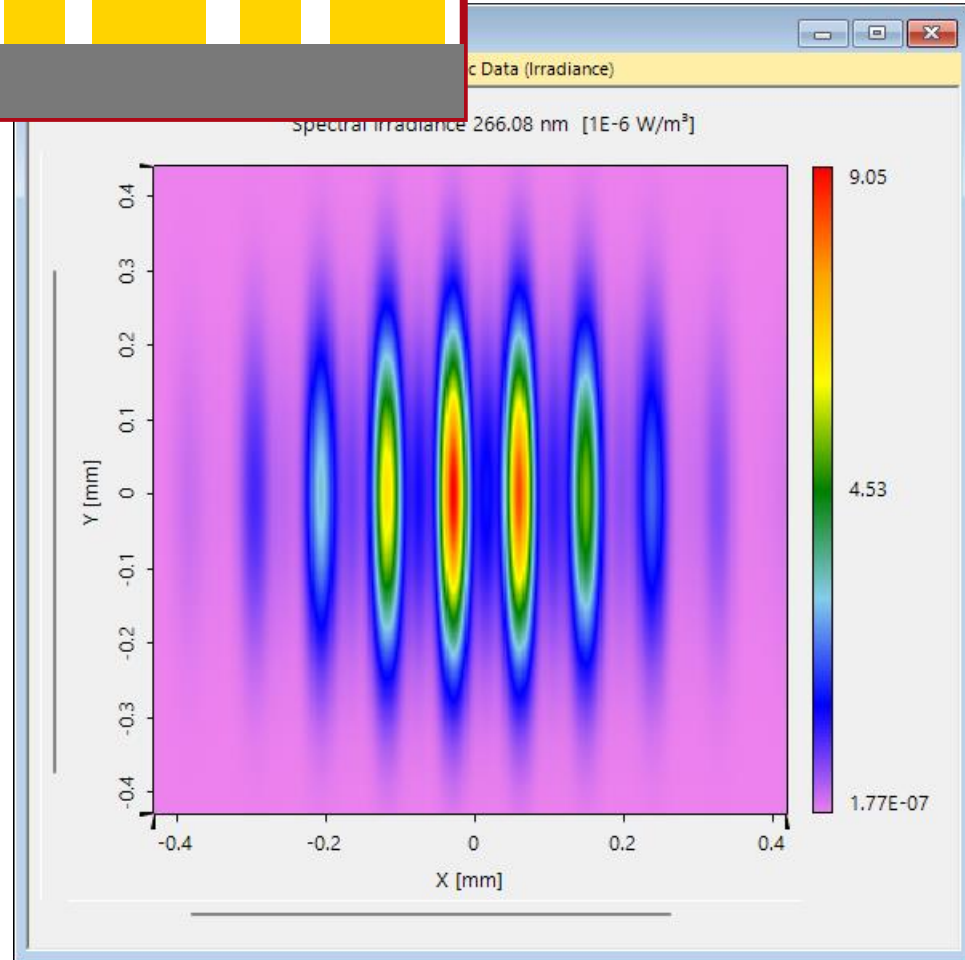
Image is formed by interference of different diffraction orders.



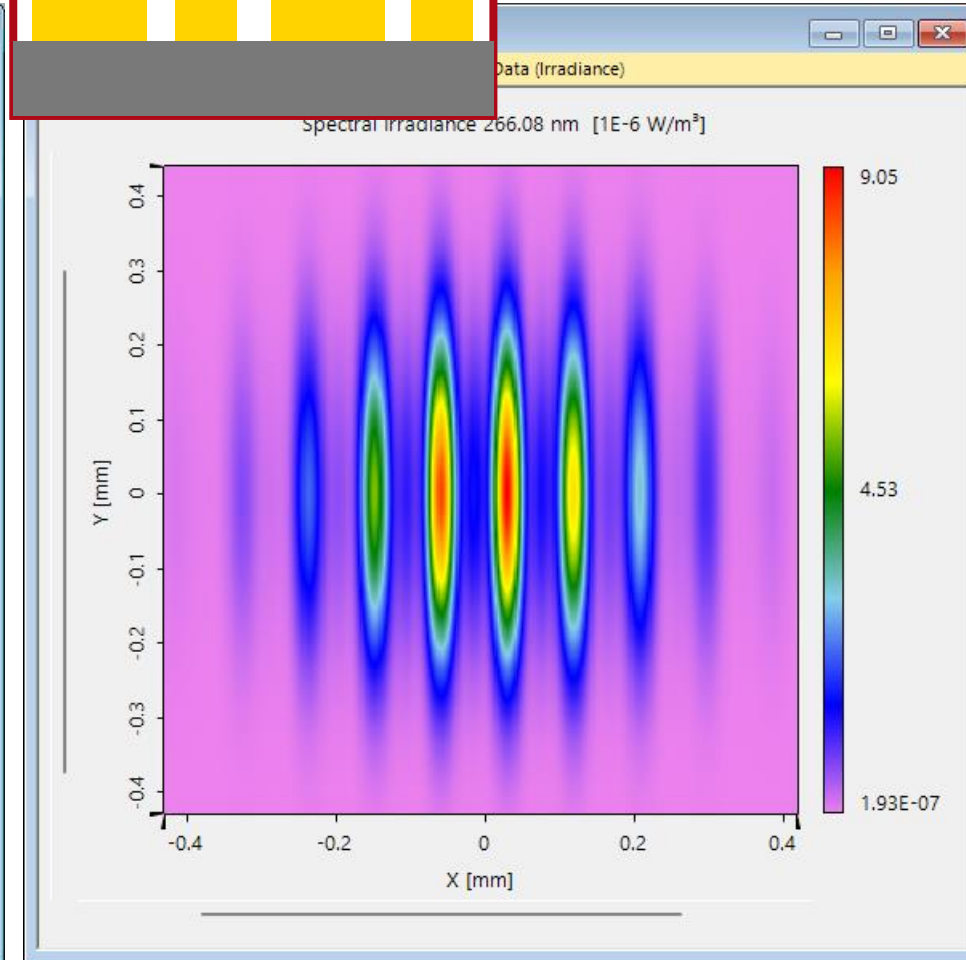
Asymmetry of the Result



Reference

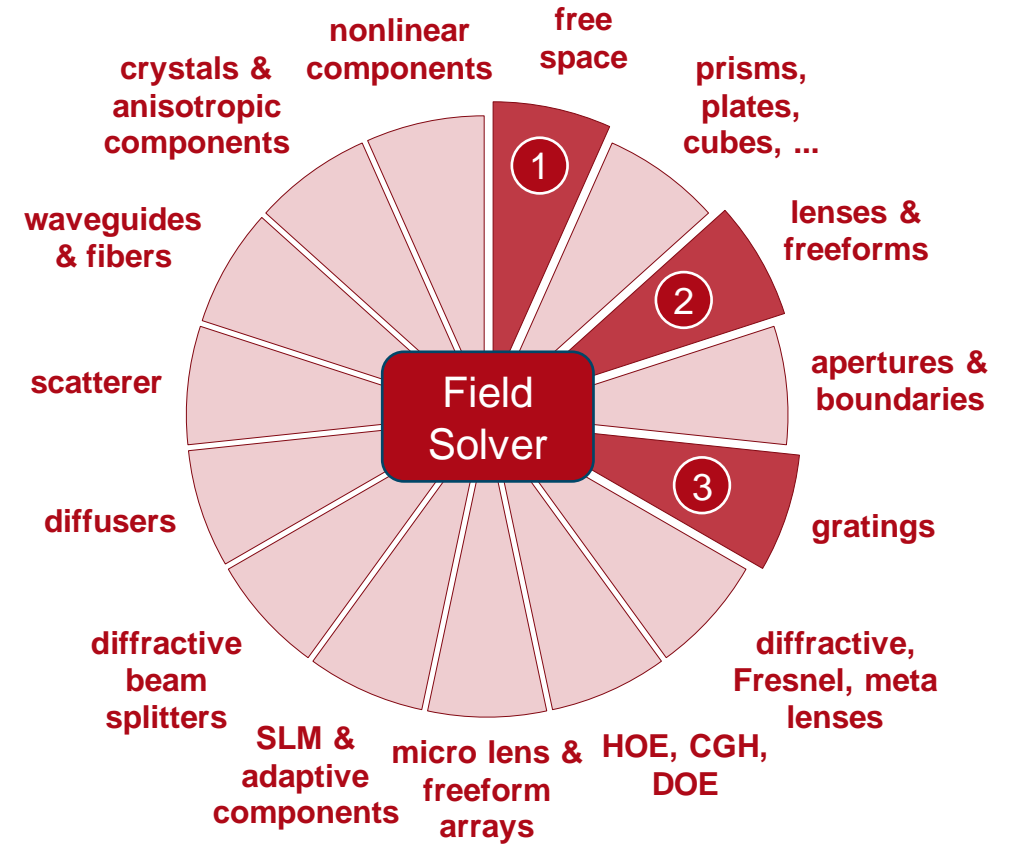
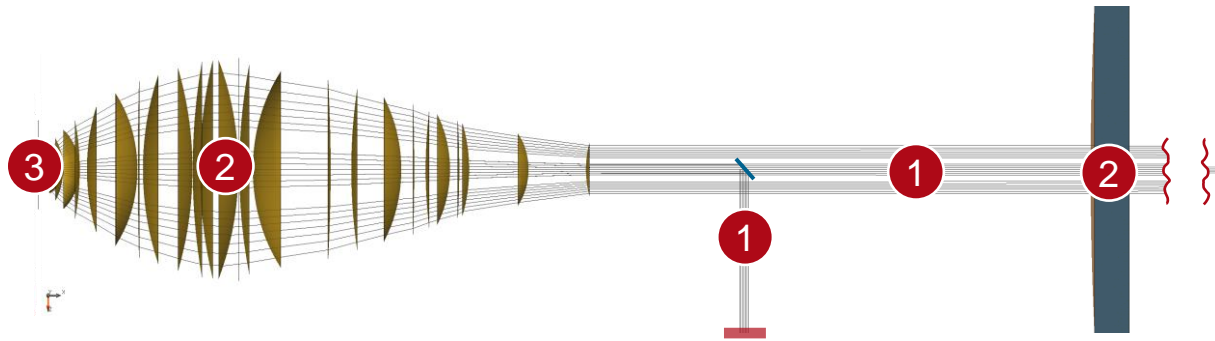


Mirrored Structure



The asymmetric nature of the grating also leads to a slight asymmetry in the interference. Whether the grating is mirrored can be identified in the result, which will also appear mirrored.

VirtualLab Fusion Technologies



Document Information

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