As Accurate as Needed, as Fast as Possible: New VirtualLab Fusion 2023.2!

Speaker: Olga Baladron-Zorita, Senior Optical Engineer at LightTrans International GmbH

Links of Interest

- LightTrans website: www.LightTrans.com
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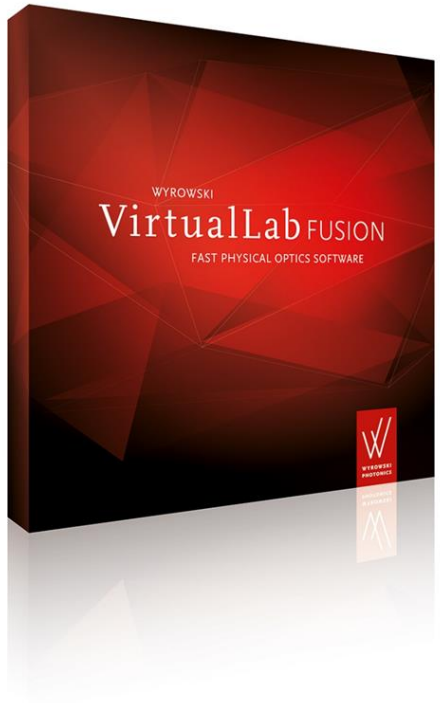
- **New! VirtualLab Fusion 2023.2:** https://www.lighttrans.com/products-services/virtuallab-fusion/virtuallab-fusion-release-2023-2.html

Who We Are

LIGHTTRANS

Founded 1999

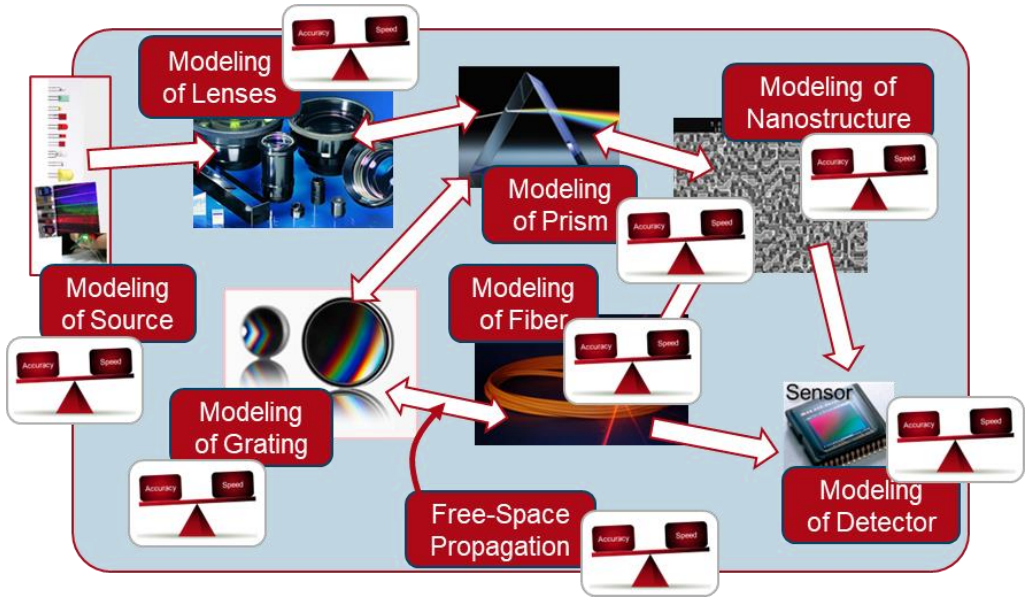
General Distributor of the
Optical Modeling and Desing Software
VirtualLab Fusion

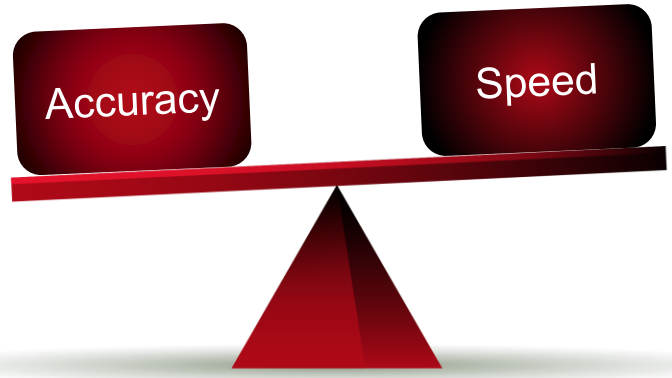


WYROWSKI PHOTONICS

Founded 2014

Developer of the
Optical Modeling and Desing Software
VirtualLab Fusion





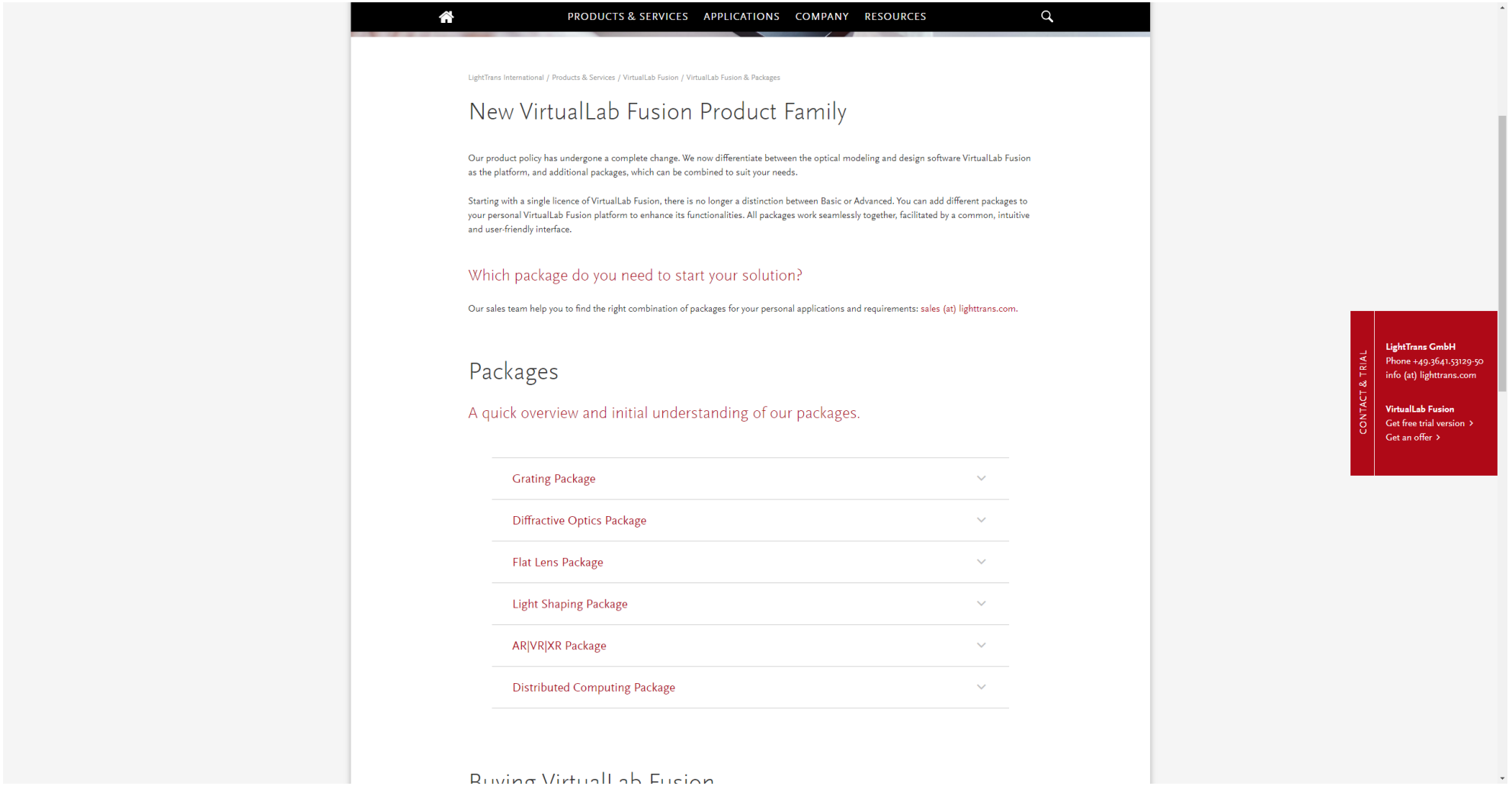
As accurate as needed.
As fast as possible.

Control of the accuracy-speed balance…

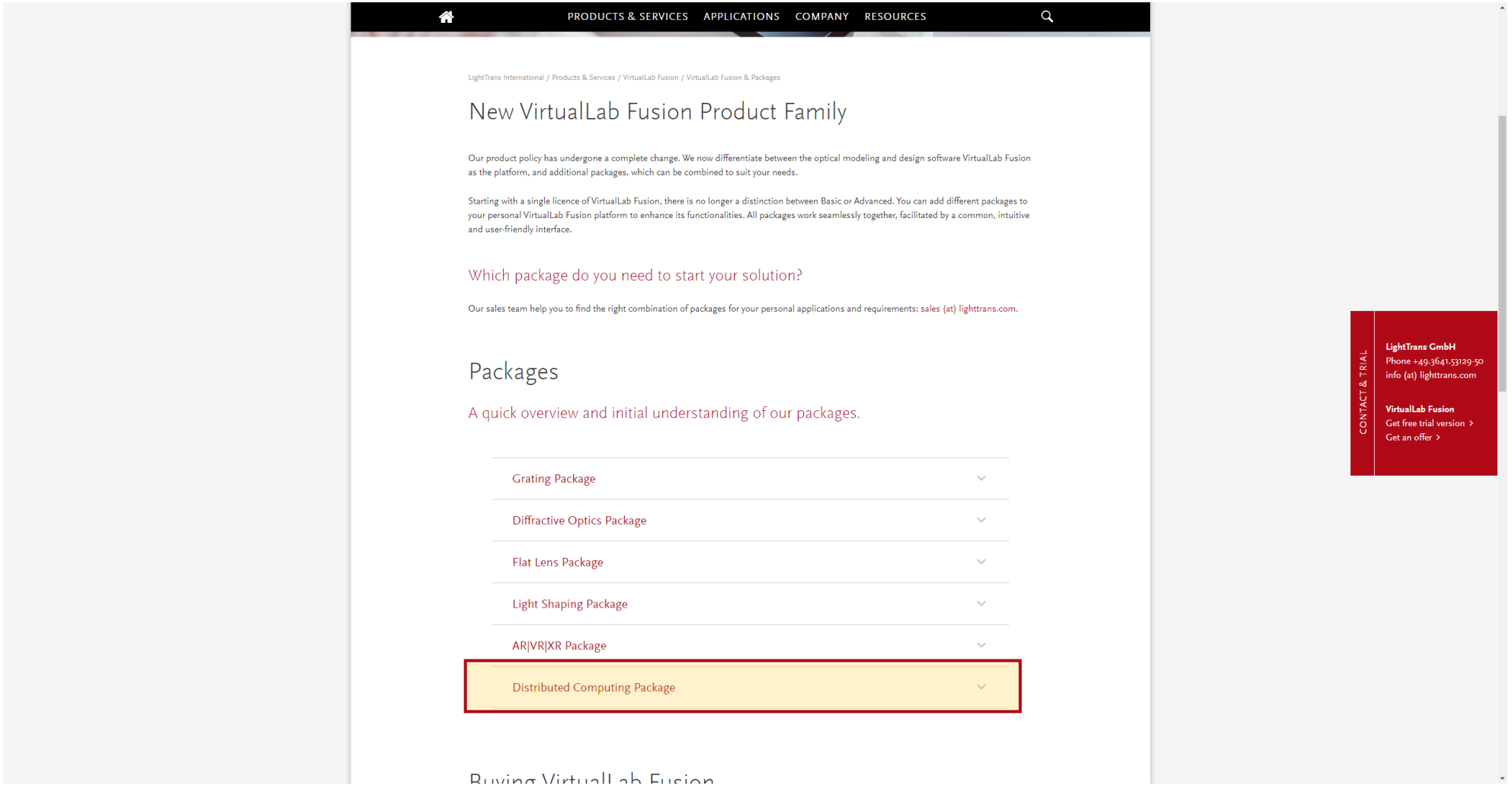
… through pool of interoperable modeling techniques on a single platform

New License Model

New License Model: VirtualLab Fusion + Packages



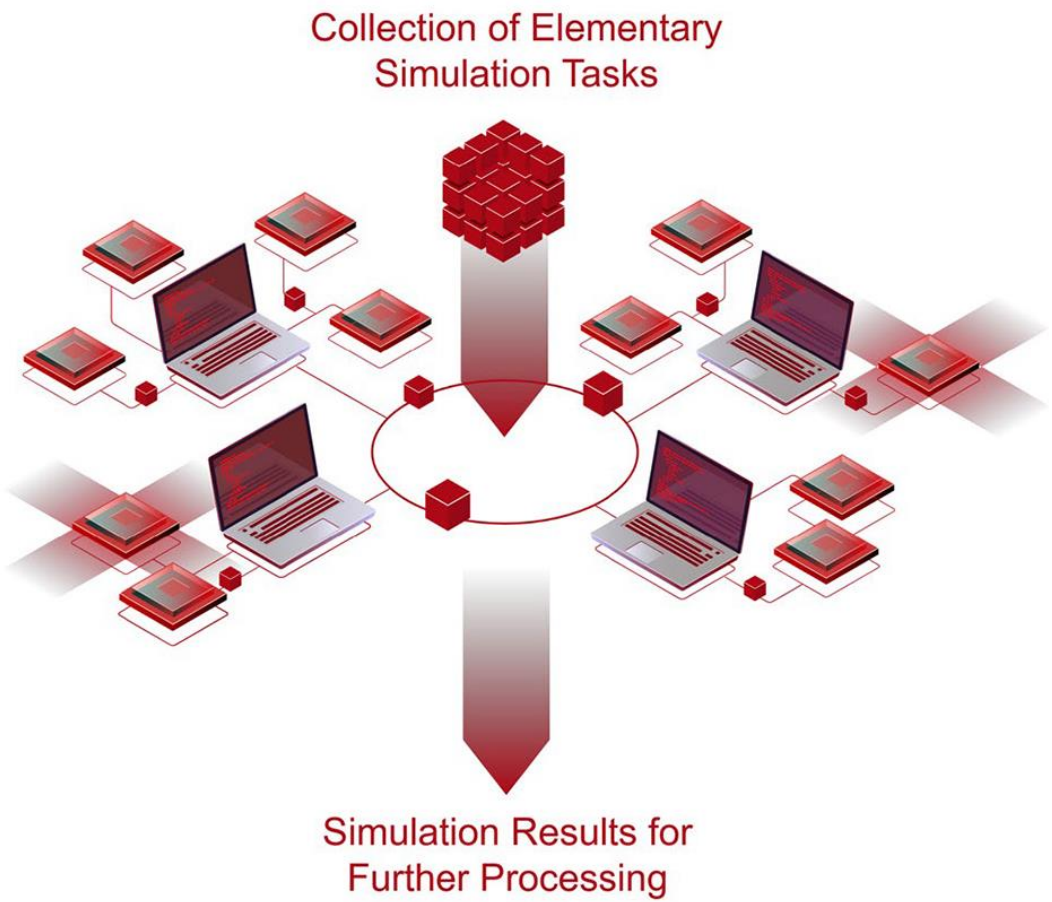
New License Model: VirtualLab Fusion + Packages

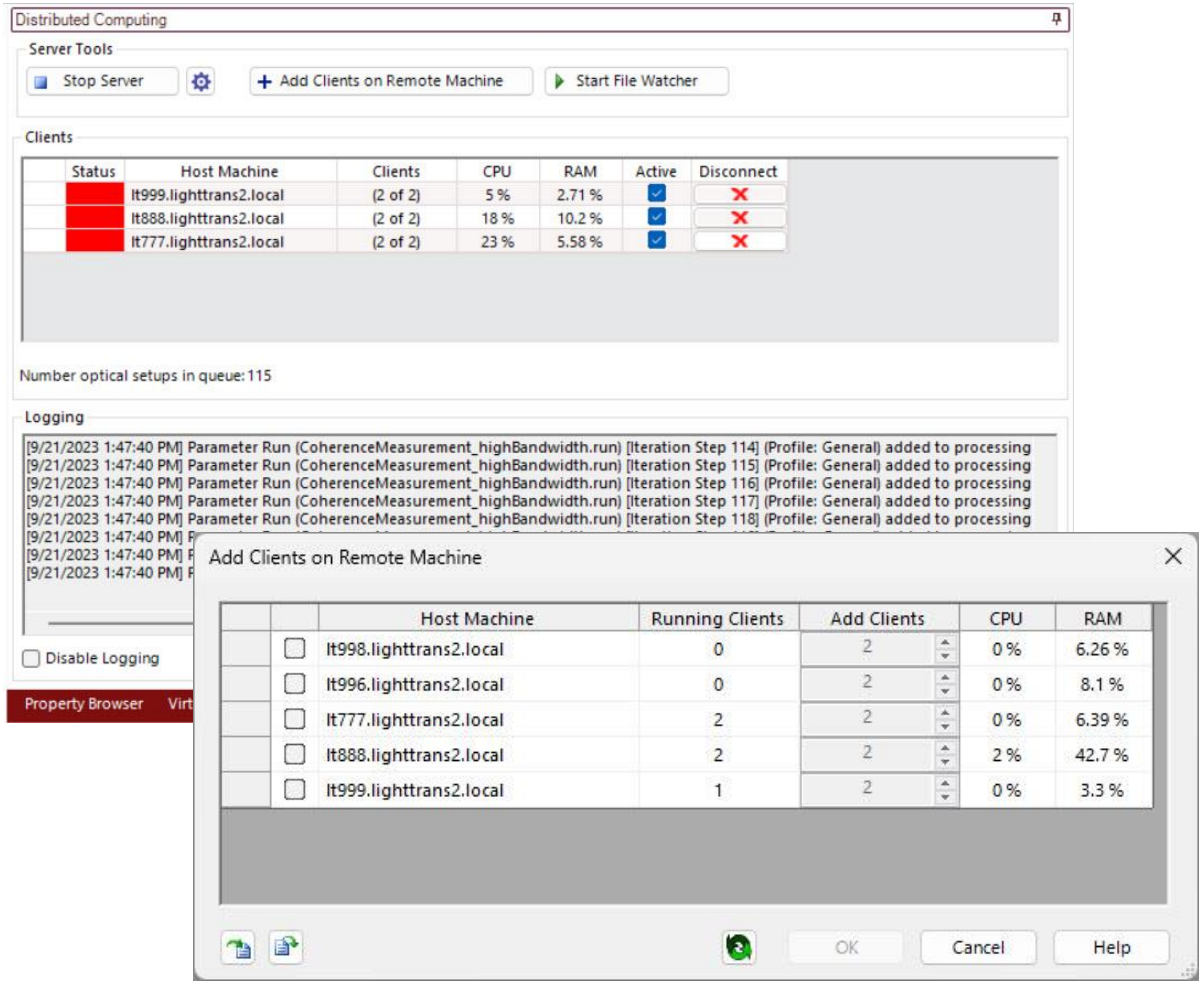


Distributed Computing

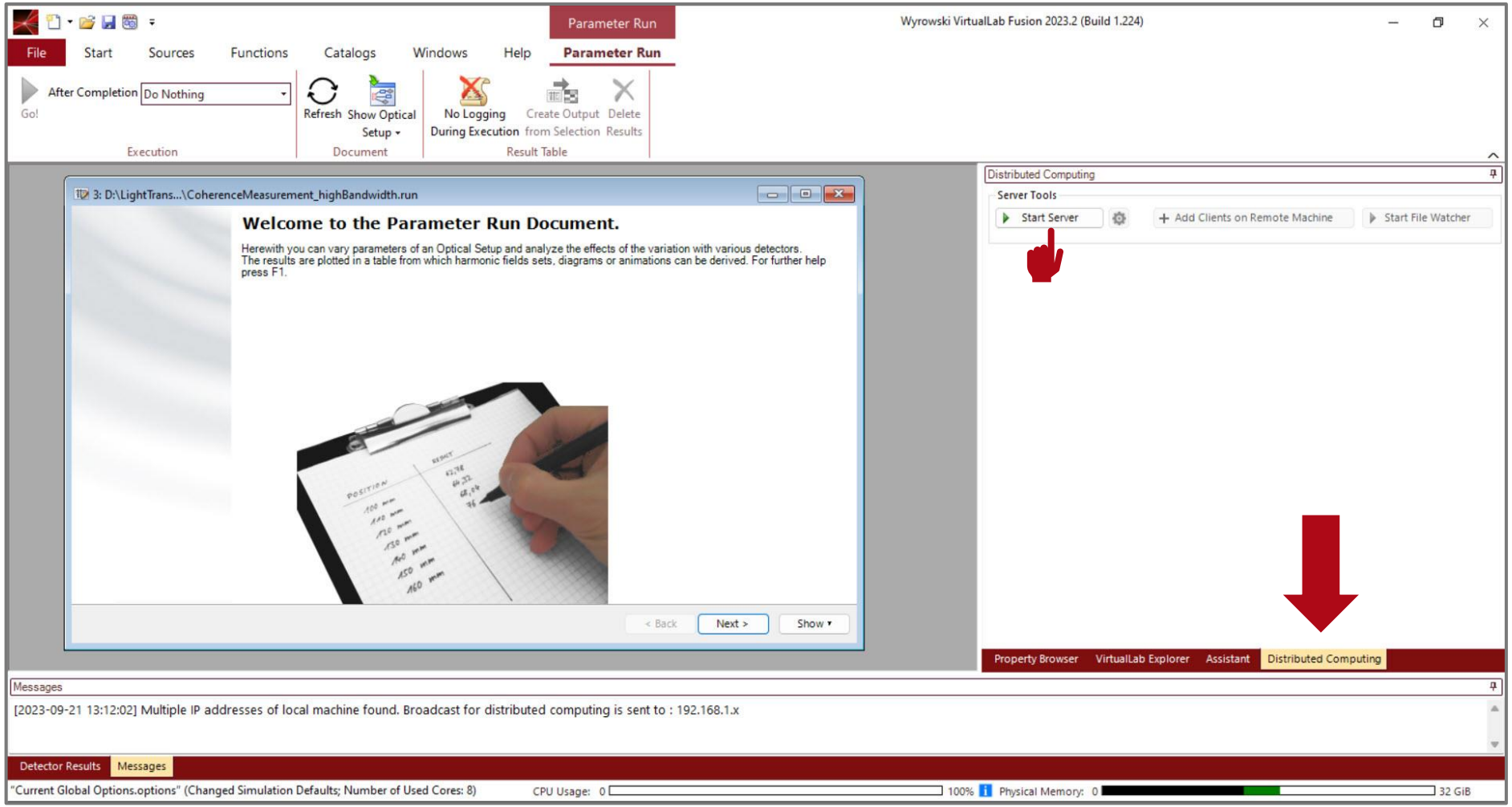
New Package!

New Distributed Computing Package





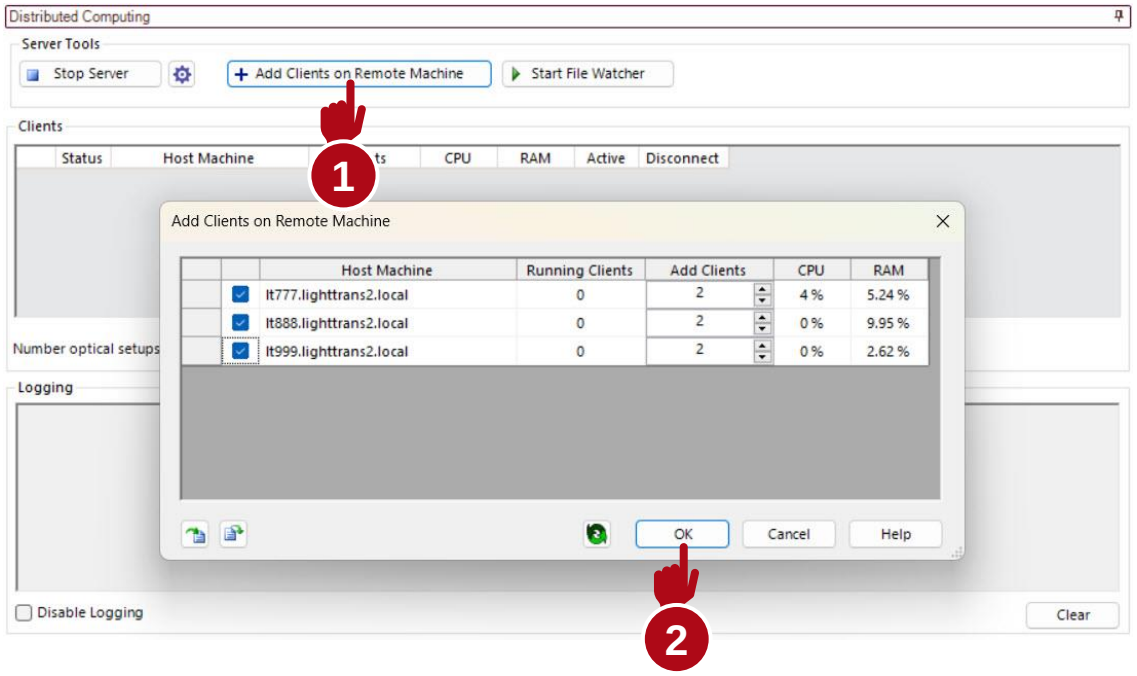
How to Start Distributed Computing in VLF?



When the *Distributed Computing Package* is available, a new tab will appear on the right side of the main menu.

Activate *Distributed Computing* by clicking *Start Server*.

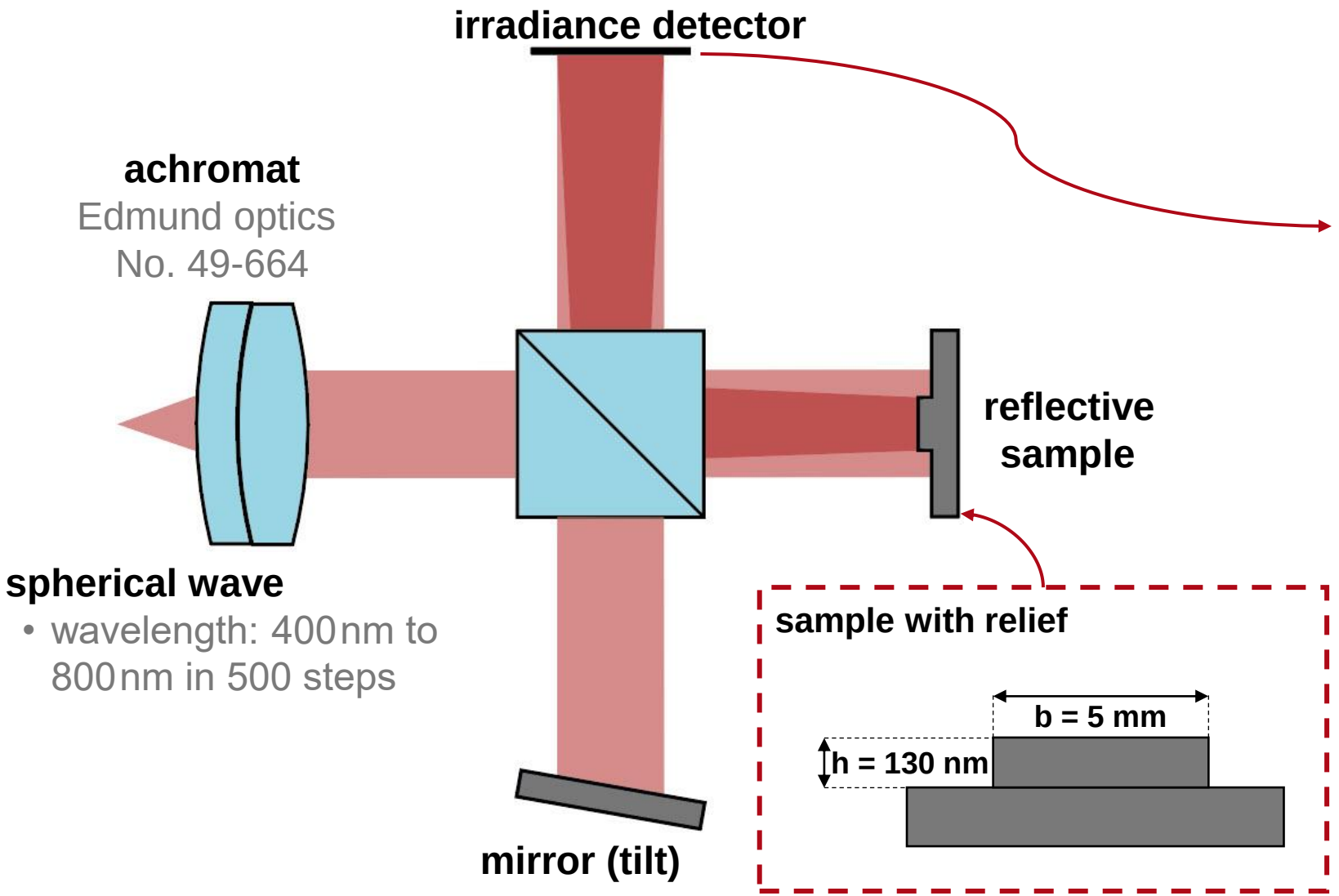
Adding Clients



You can distribute the individual elementary simulation tasks among the different machines in your network, with multiple *Clients* per machine.

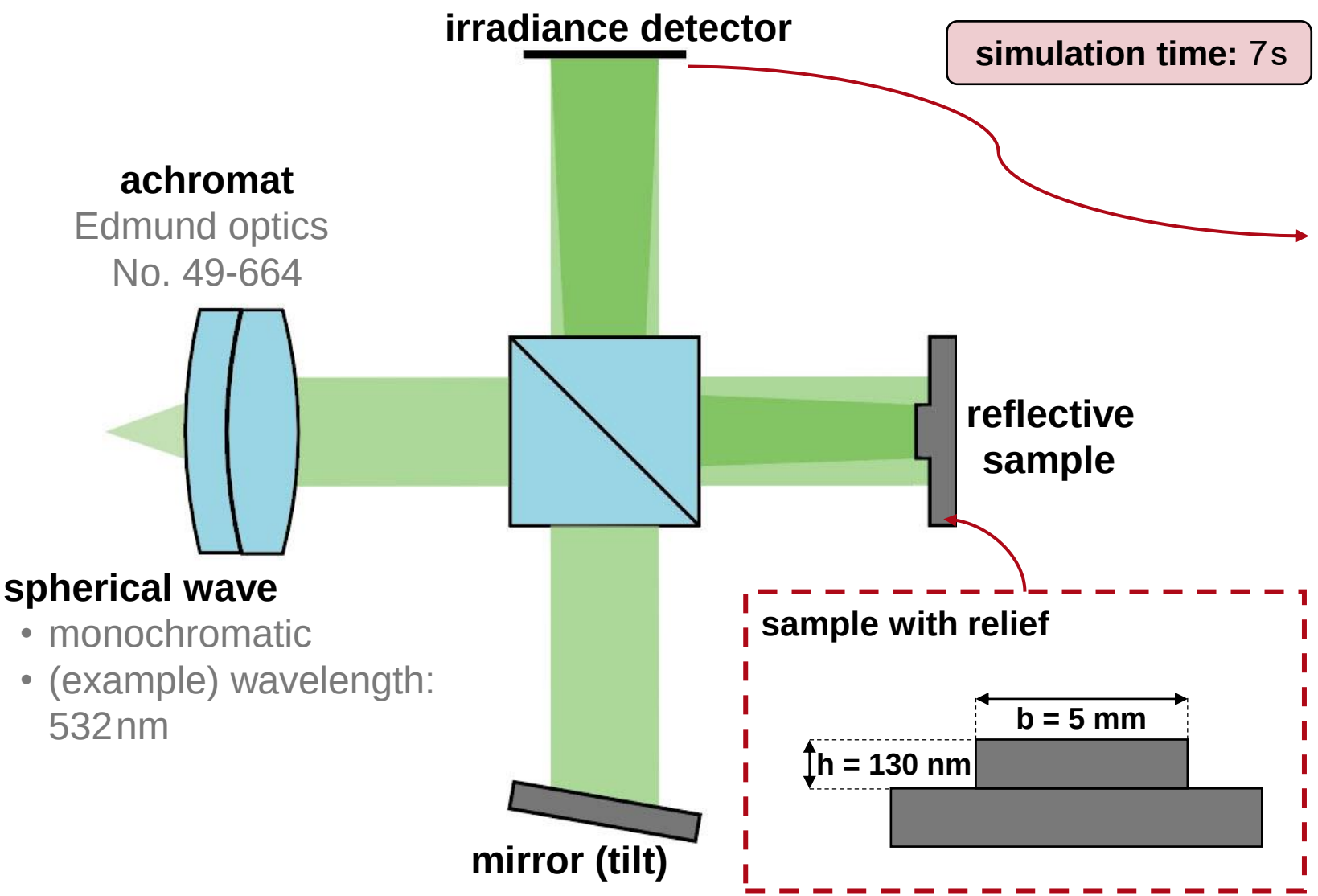
Diffraction in White-Light Interferometer: Simulation with Distributed Computing

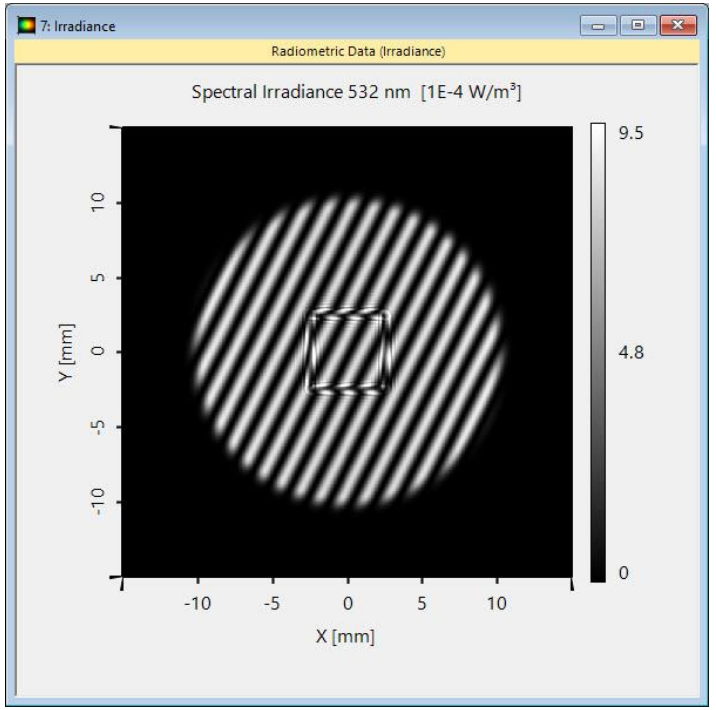
Simulation Task



How to calculate the interference pattern with diffraction for light with multiple wavelengths fast?

Elementary Simulation Task

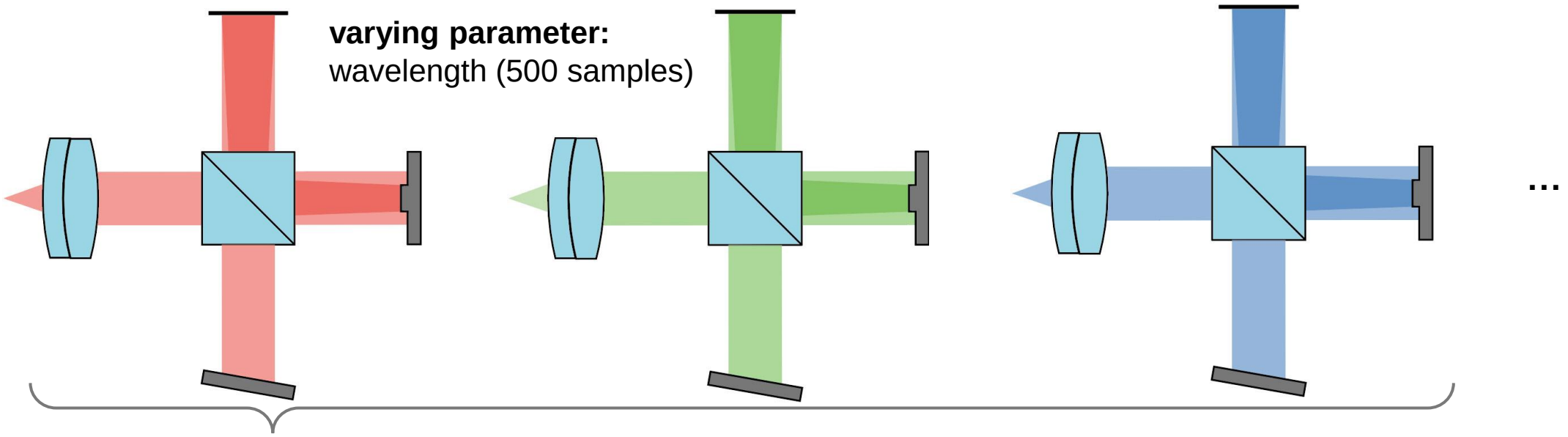




For a detailed analysis of the elementary system, see:

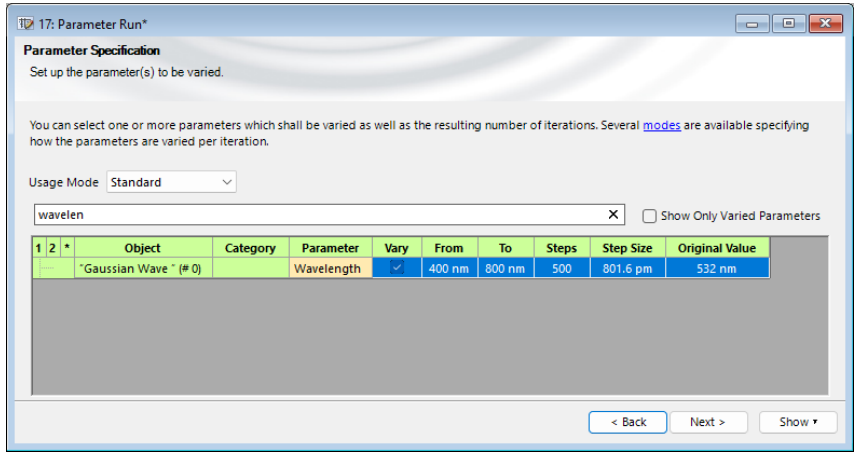
Investigation of Diffraction in Interferometer Caused by Sharp Relief

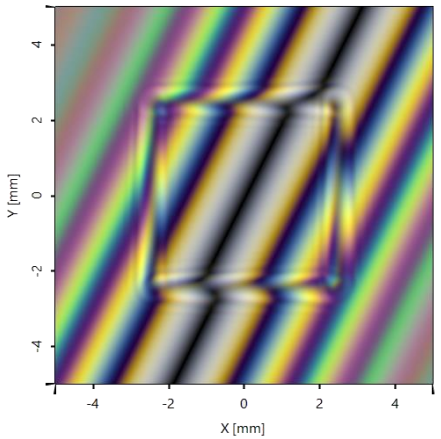
Collection of Elementary Tasks: Variation of Wavelength



varying parameter:
wavelength (500 samples)

...

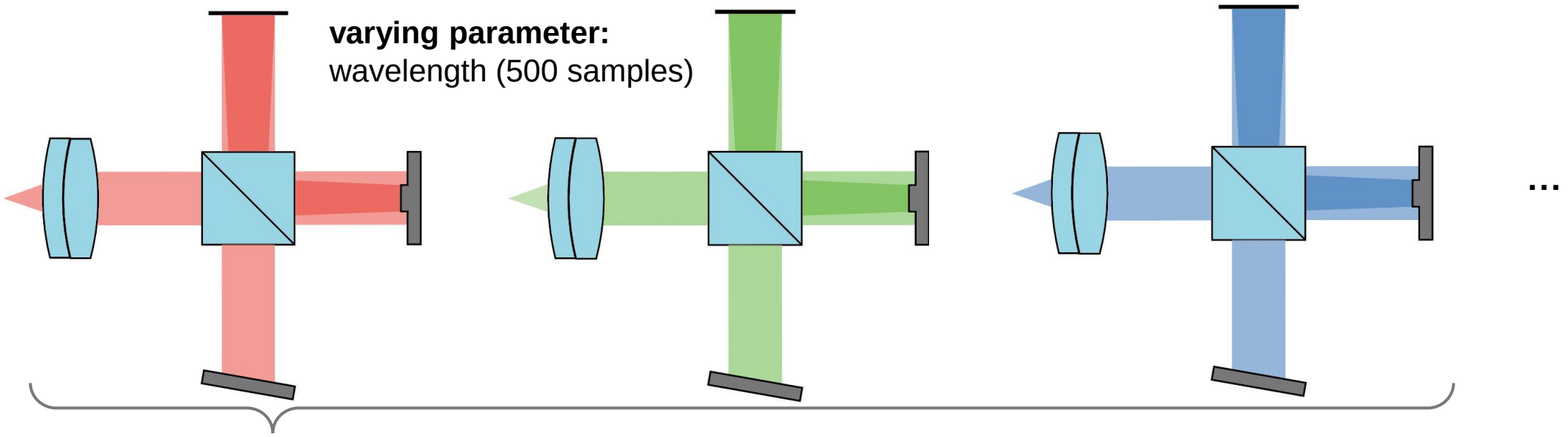




simulation result:
irradiance of all wavelength modes.

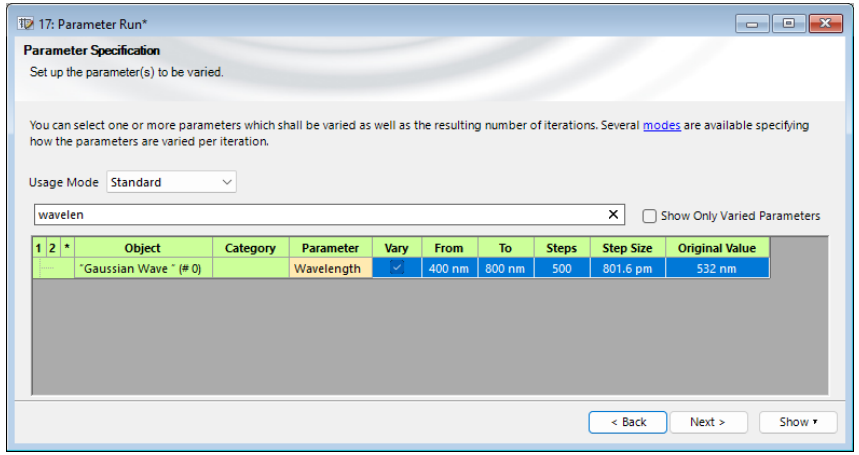
simulation time (500 simulations): 57 min

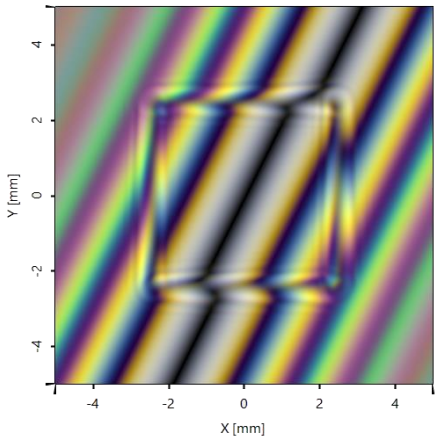
Collection of Elementary Tasks: Variation of Wavelength



varying parameter:
wavelength (500 samples)

...





simulation result:
irradiance of all wavelength modes.

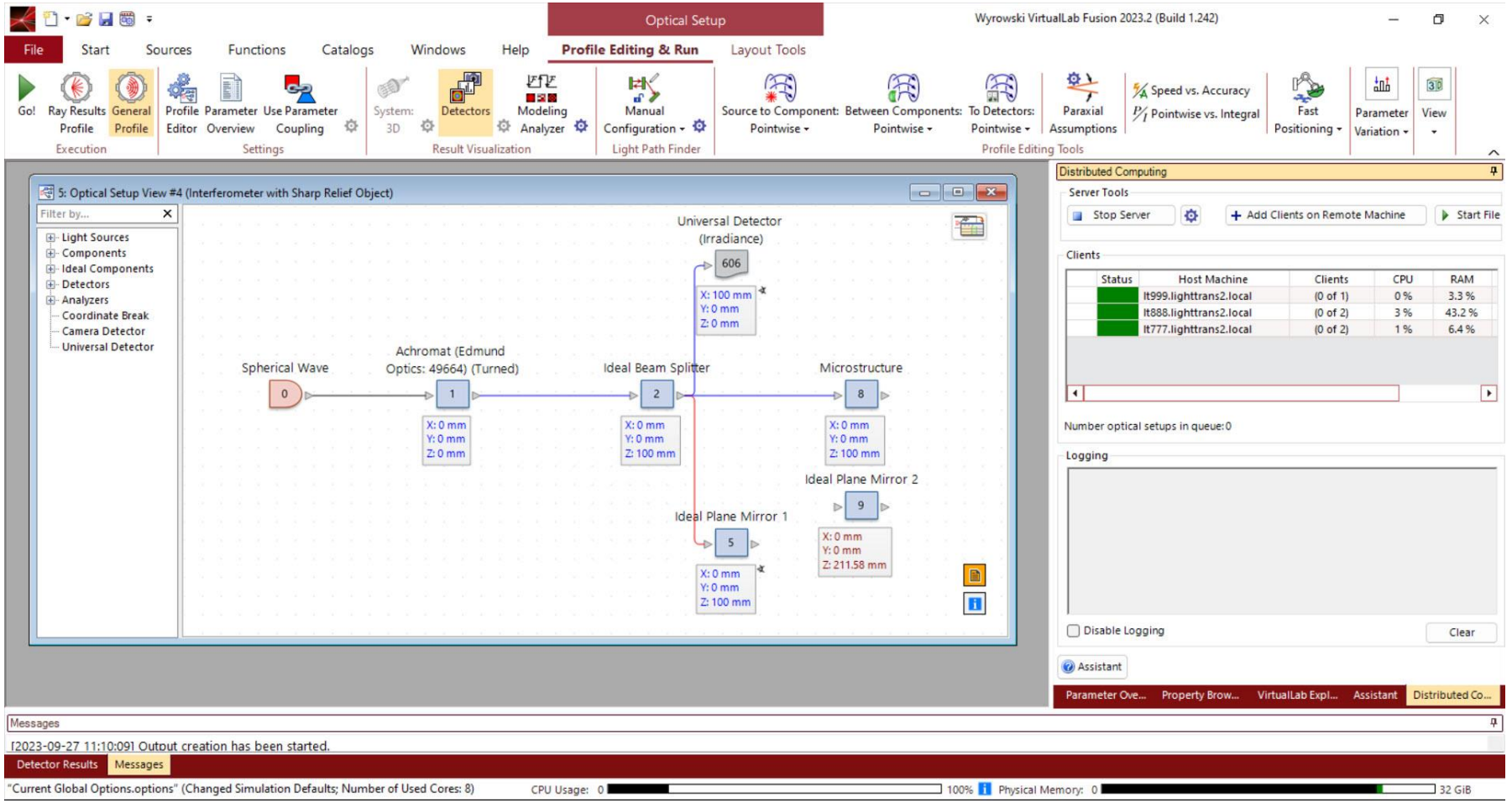
simulation time (500 simulations): 57 min

Distributed Computing

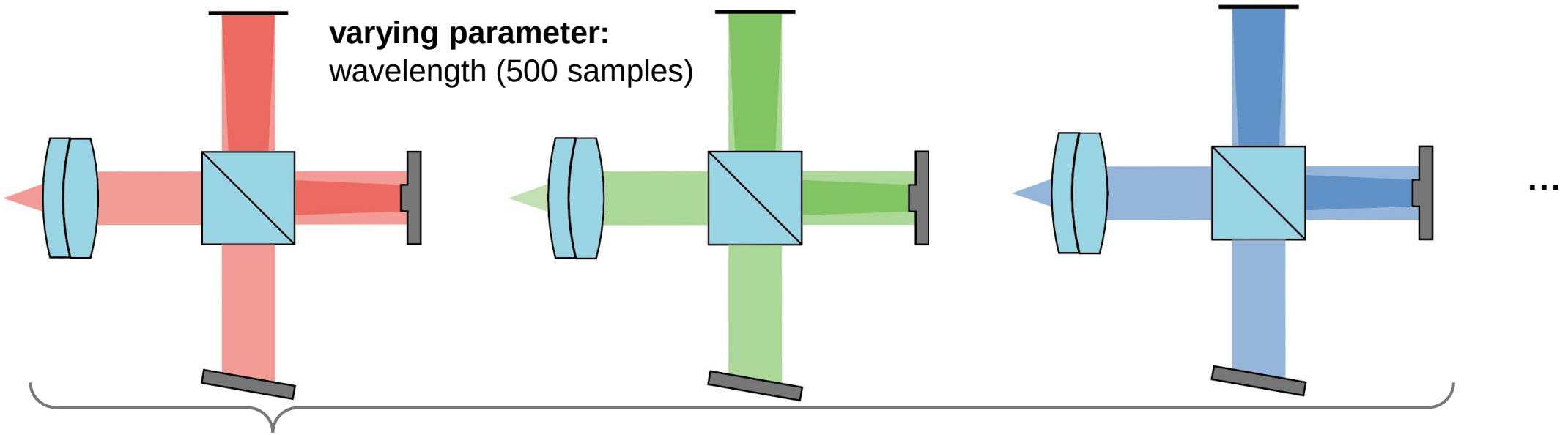
Computation time of complex tasks that require many individual simulations (such as parameter sweeps etc.) can be drastically reduced by using *Distributed Computing*. In this case, the individual simulations can be distributed to different workstations, each with several clients.

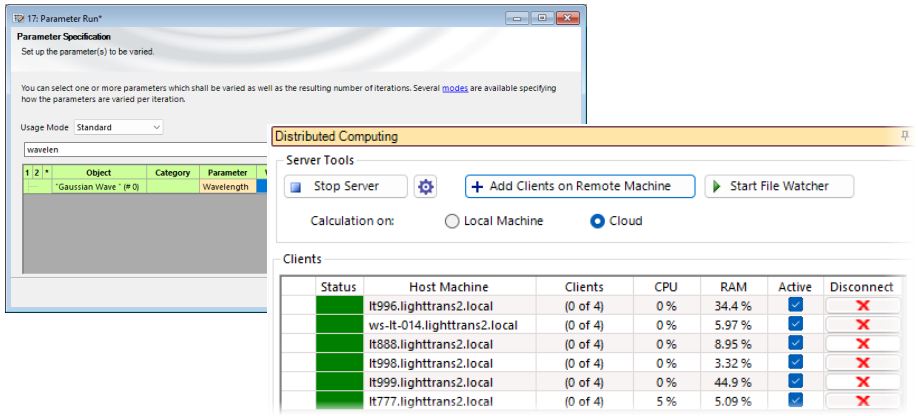
More information under:

[Usage of Distributed Computing]

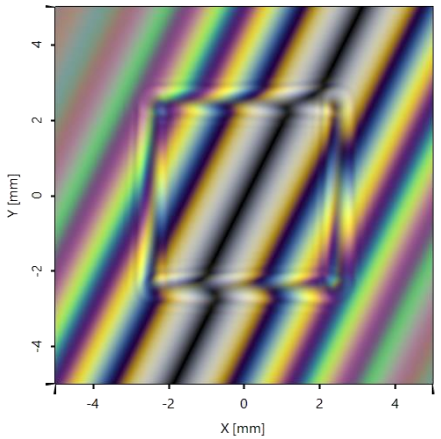


Collection Simulation Using Distributed Computing





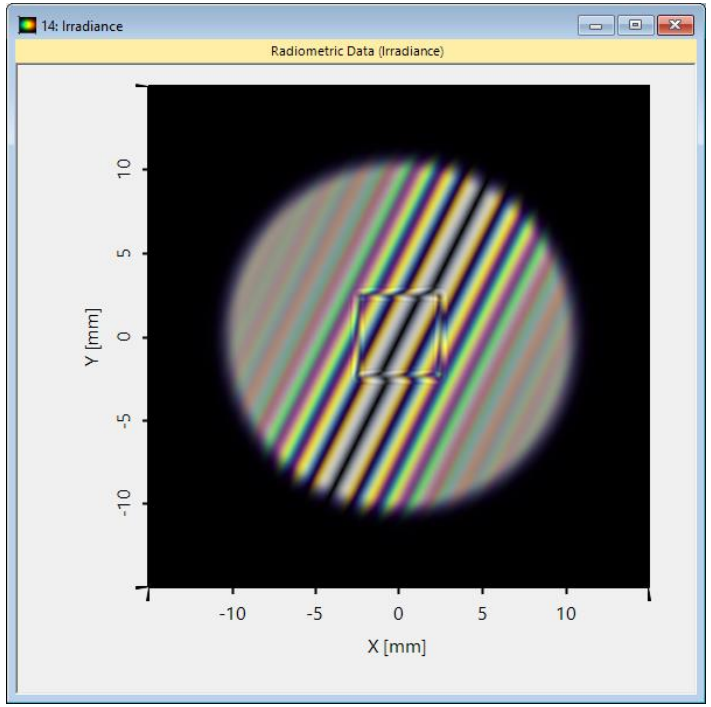
number of clients: 24



simulation result:
irradiance of all wavelength modes

simulation time (500 simulations): 3 min 50 s

Overview Simulation Times



simulation result

	simulation time	
elementary simulation	7 s	
collection of elementary simulations (500) on one machine	57 min	(100%)
collection of elementary simulations (500) via distributed computing (24 clients)	**3 min 50 s**	**(7%)**

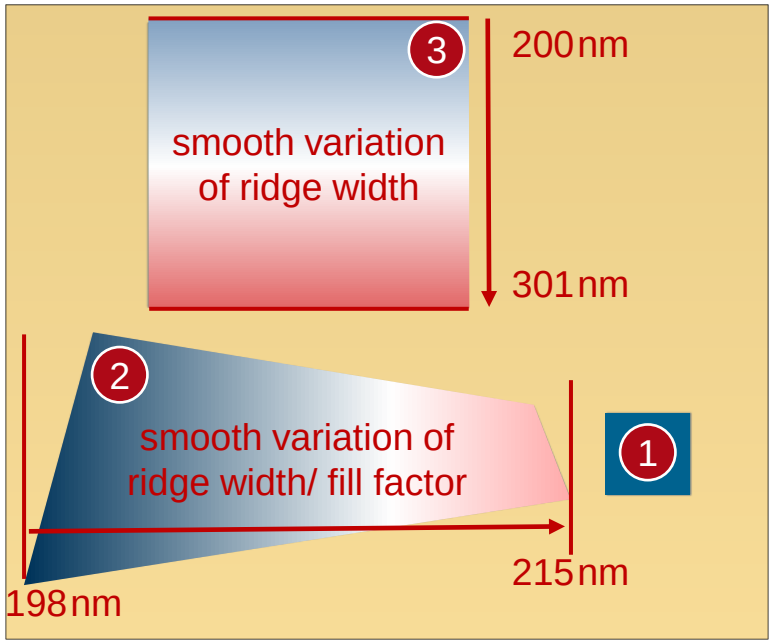
93% lower calculation time!!!

Analysis of AR Device Using Test Image: Simulation with Distributed Computing

Elementary Simulation Task

source (Plane Wave):

- wavelength: 532 nm
- on-axis propagation (α,β = 0°)
- polarization: E_x



detector result :
efficiency within eyebox

Efficiency	0.79652 %

simulation time: 8 s

1 incoupler:

- period: 380 nm
- width of grating ridge: 190 nm
- height: 100 nm
- grating orientation: 0°

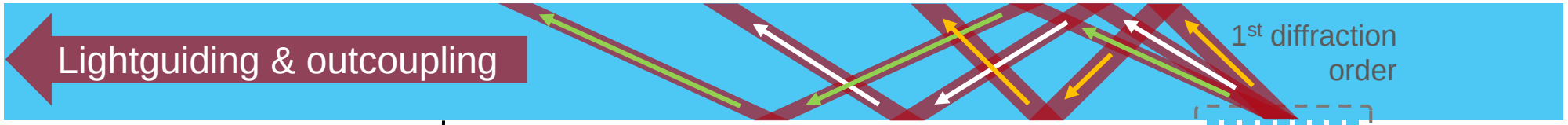
2 expander (EPE):

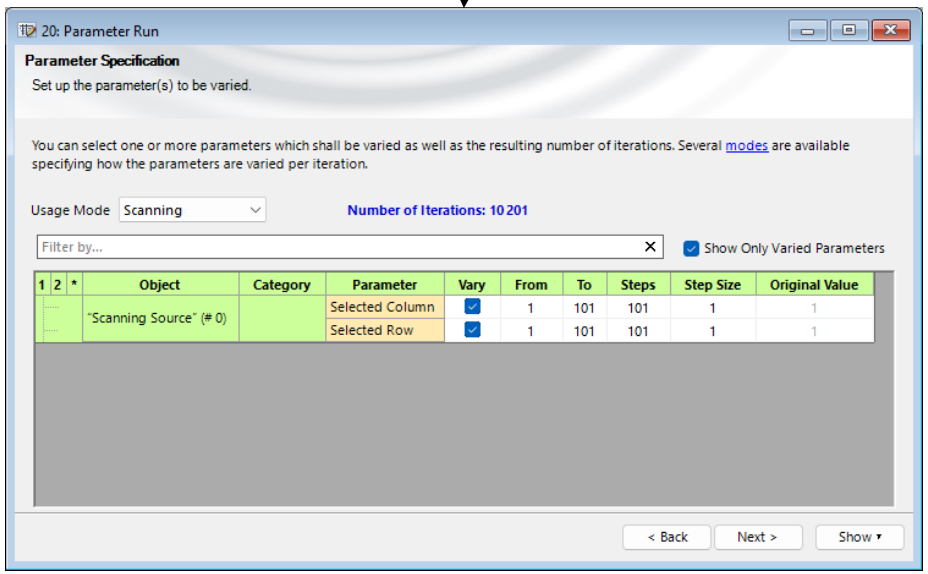
- period: 268.7 nm
- width of grating ridge: 198–215 nm
- height: 50 nm
- grating orientation: 45°

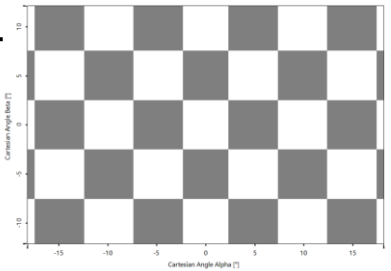
3 outcoupler:

- period: 380 nm
- width of grating ridge: 200–301 nm
- height: 124 nm
- grating orientation: 90°

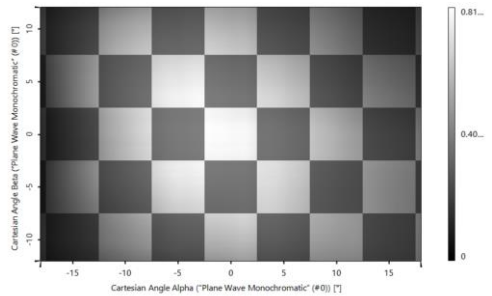
Collection of Elementary Tasks: FOV







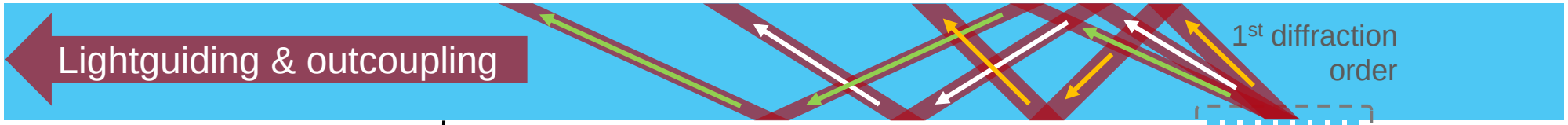
varying parameter:
101 x 101 different FOV (36° x 24°)
➔10201 elementary simulation tasks

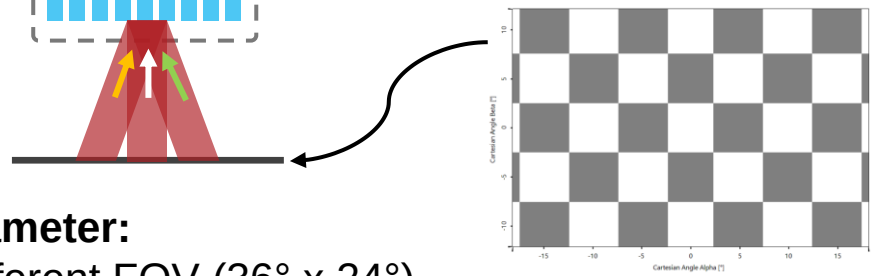


simulation result:
efficiencies over FOV angles.

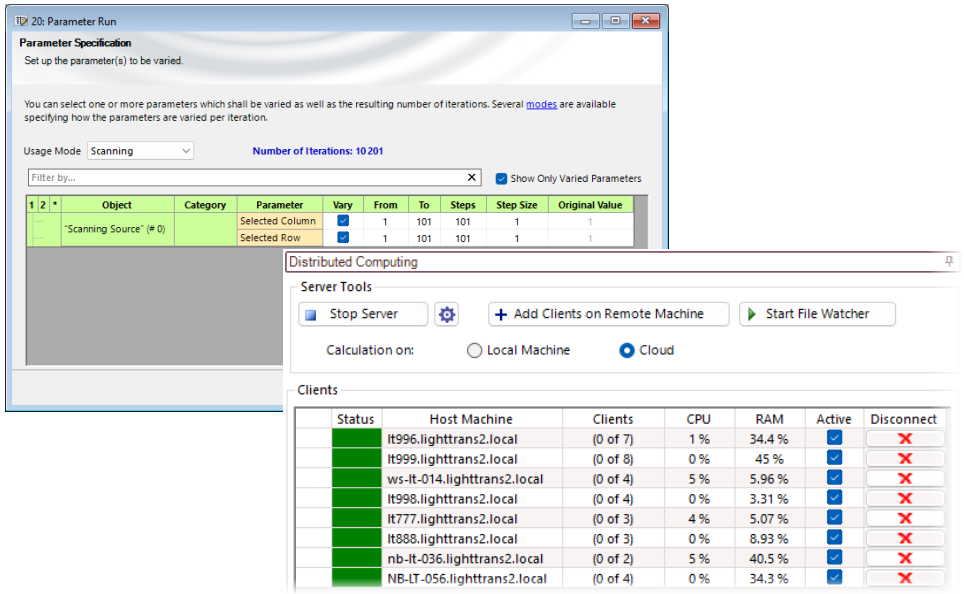
simulation time
(10201 simulations): 31 h 10 min

Collection Simulation Using Distributed Computing

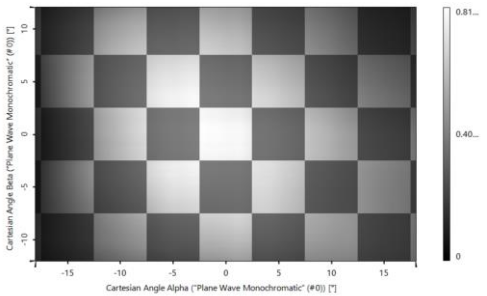




varying parameter:
101 x 101 different FOV (36° x 24°)
➔10201 elementary simulation tasks



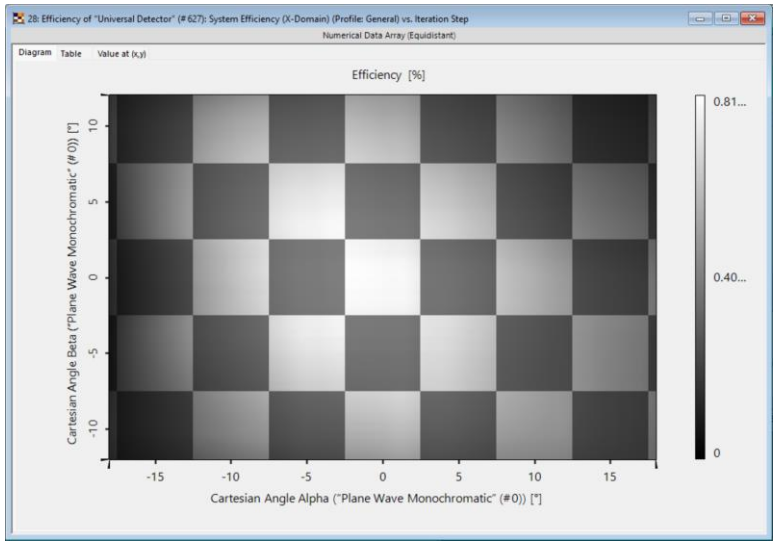
number of clients: 35



simulation result:
efficiencies over FOV angles.

simulation time (10201 simulations): 1h 5min

Overview Simulation Times



simulation result

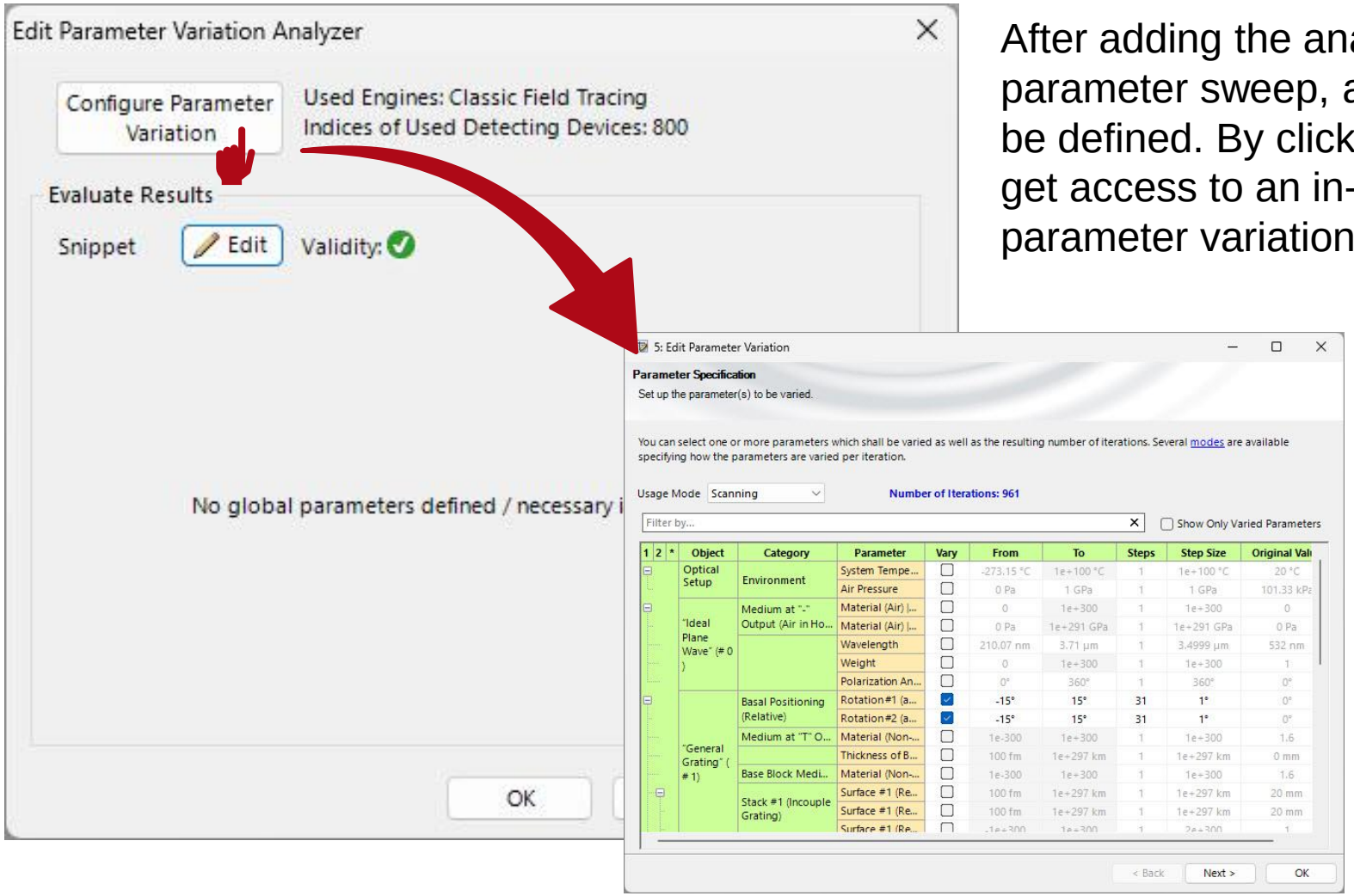
	simulation time	
elementary simulation	8 s	
collection of elementary simulations (10201) on one machine	31 h 10 min	(100%)
collection of elementary simulations (10201) via distributed computing (35 clients)	**1 h 5 min**	**(3%)**

96% lower calculation time!!!

Parameter Variation Analyzer

New Analyzer!

Defining the Parameter Variation

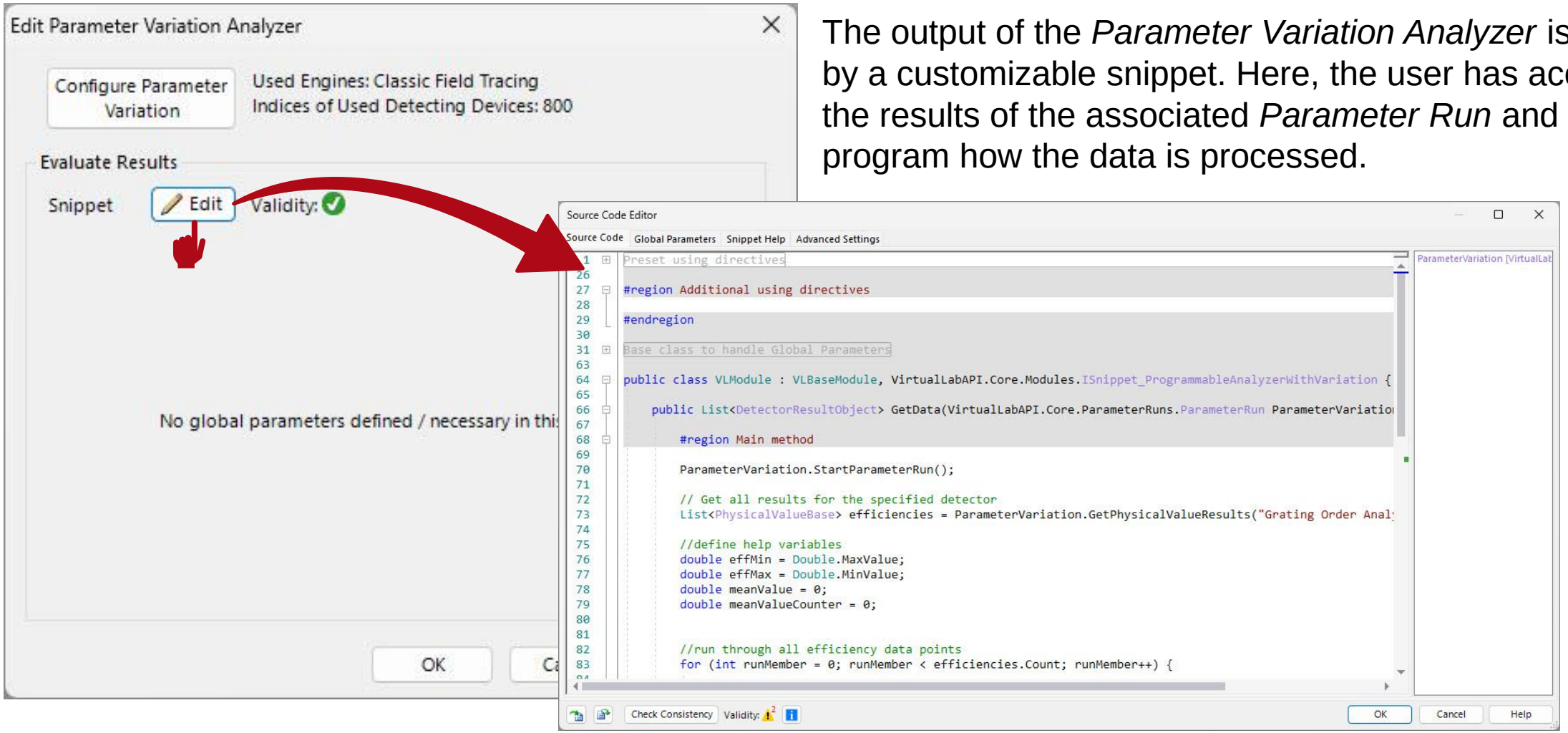


After adding the analyzer to the optical system, the parameter sweep, and the evaluation of the results must be defined. By clicking *Configure Parameter Variation you* get access to an in-built *Parameter Run* document, where parameter variation can be configured.

For a detailed introduction on how to operate the *Parameter Run* document, please see:

Usage of the Parameter Run Document

Evaluation of the Results



The output of the *Parameter Variation Analyzer* is defined by a customizable snippet. Here, the user has access to the results of the associated *Parameter Run* and needs to program how the data is processed.

Robustness Optimization of Slanted Grating with Parameter Variation Analyzer

Simulation Task

plane wave

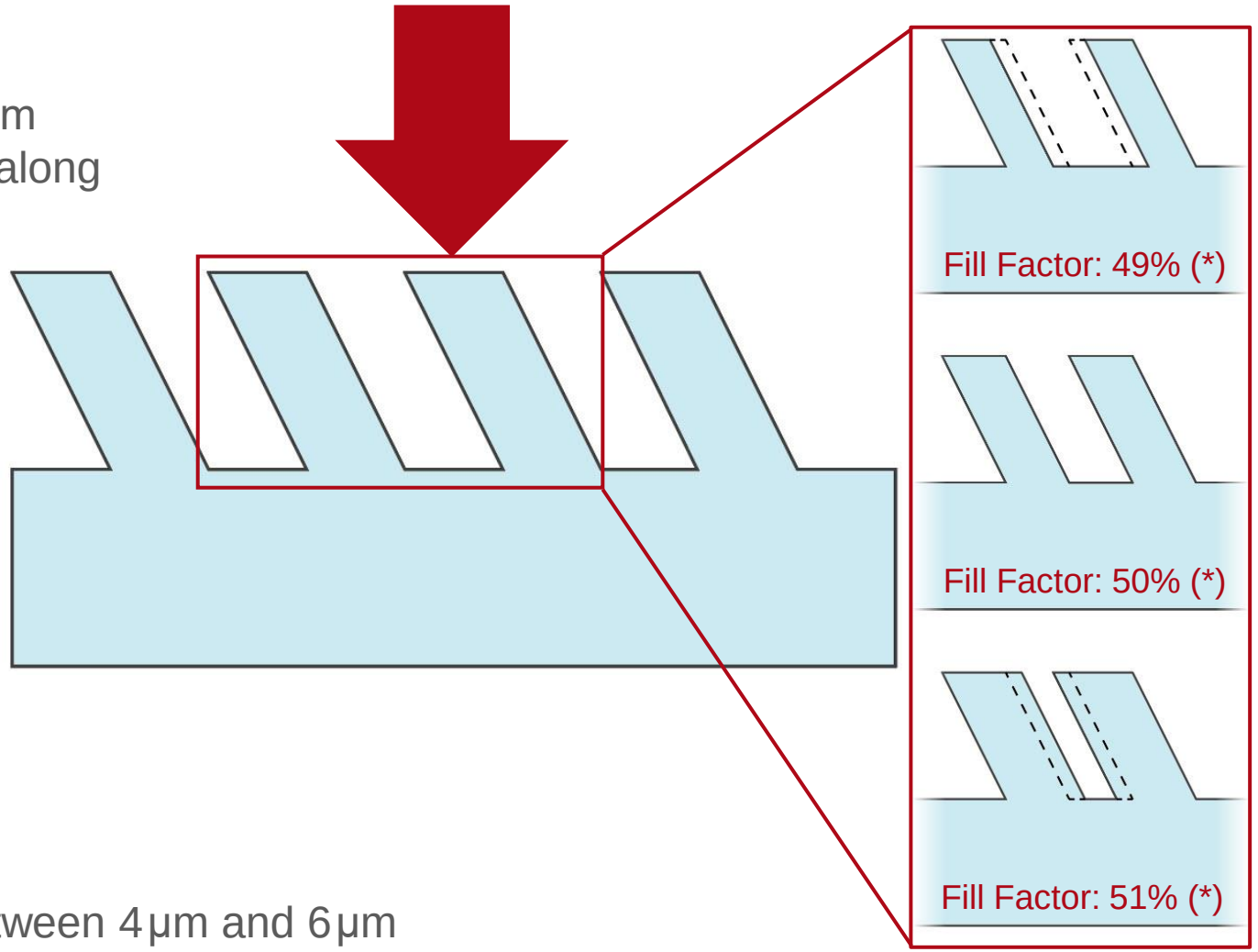
- wavelength: 532 nm
- linearly polarized along x-axis

slanted grating

- operation order: +1st (transmission)
- fill factor: 49%, 49.5%, 50%, 50.5%, 51%
- medium in front: air
- medium behind: n=1.6

optimization parameters

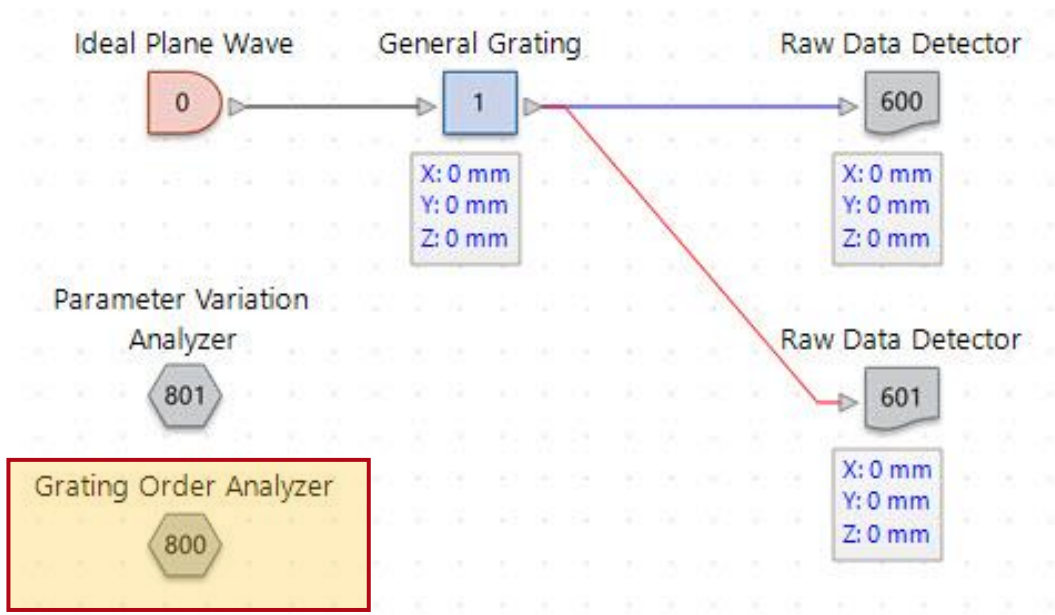
- grating height: varied between 4 µm and 6 µm
- period: varied between 8 µm and 12 µm

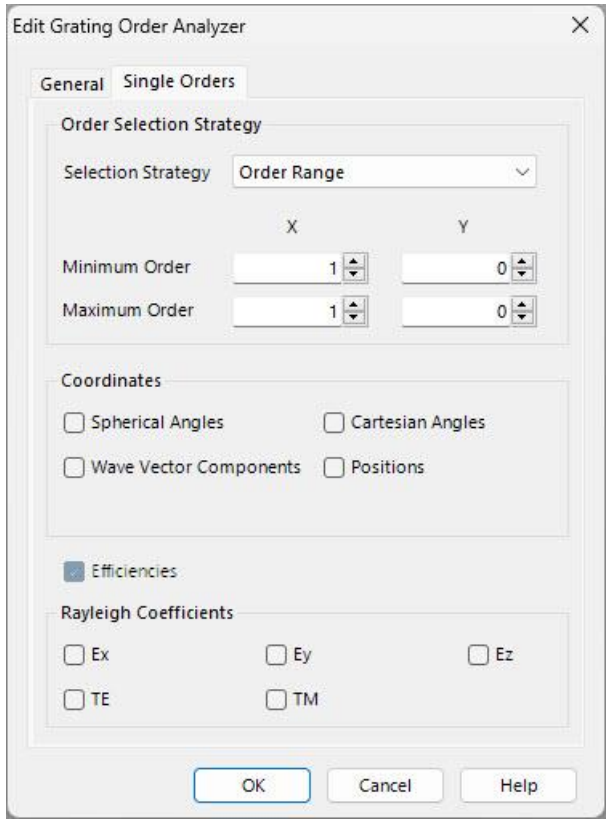


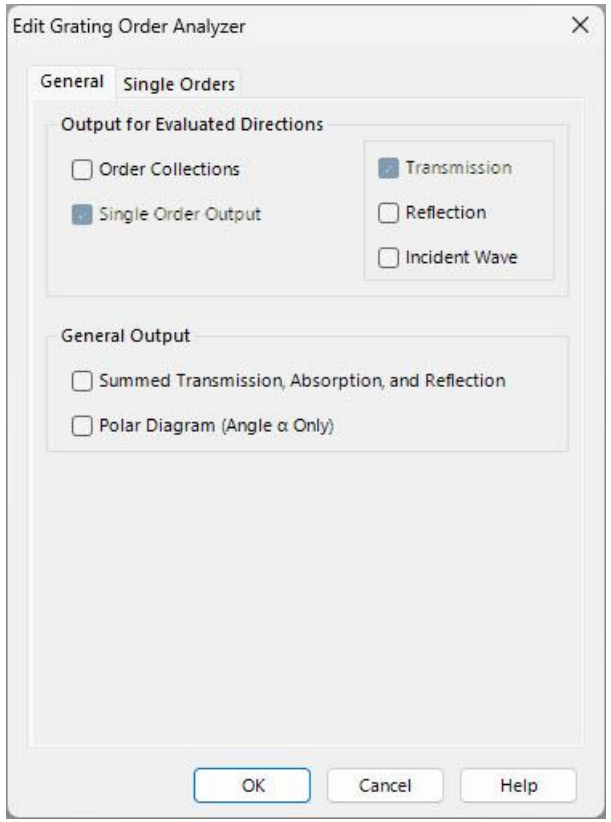
(*) figures slightly exaggerated for illustration purposes

To perform a robustness analysis, efficiencies from 5 different fill factors between 49% and 51% will be combined in two merit functions: uniformity contrast & mean efficiency.

Grating Order Analyzer







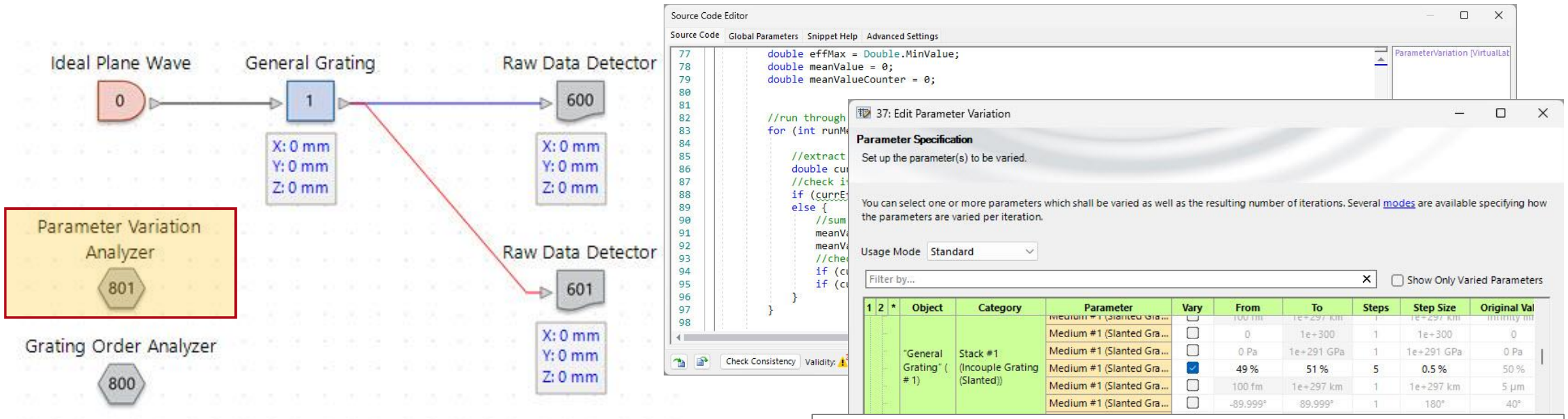
The *Grating Order Analyzer* can be used to investigate the order efficiencies of any given grating. Find more information under:

Grating Order Analyzer

resulting efficiency in the *Detector Results* tab:

Efficiency T[+1; 0]	11.997 %

Parameter Variation Analyzer



Since results of different grating parameter have to be taken into account, the *Parameter Variation Analyzer* is used to calculate the according merits. With this tool the efficiencies of the grating with different fill factors will be calculated and the resulting mean efficiency and uniformity contrast automatically determined. For more information, see:

Parameter Variation Analyzer

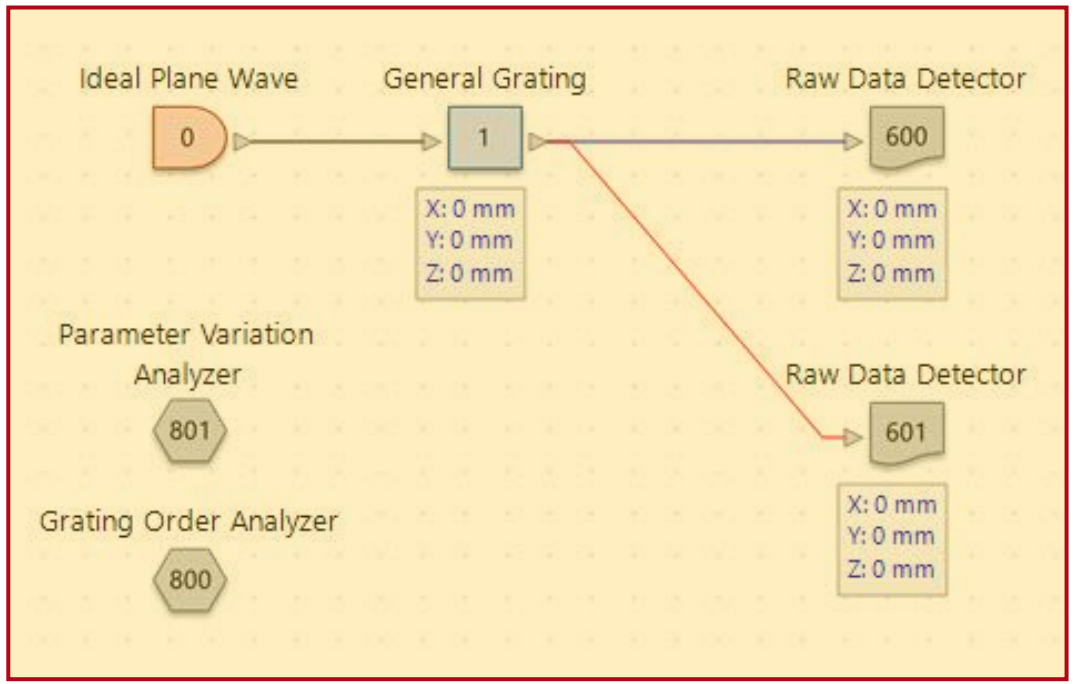
merit functions:

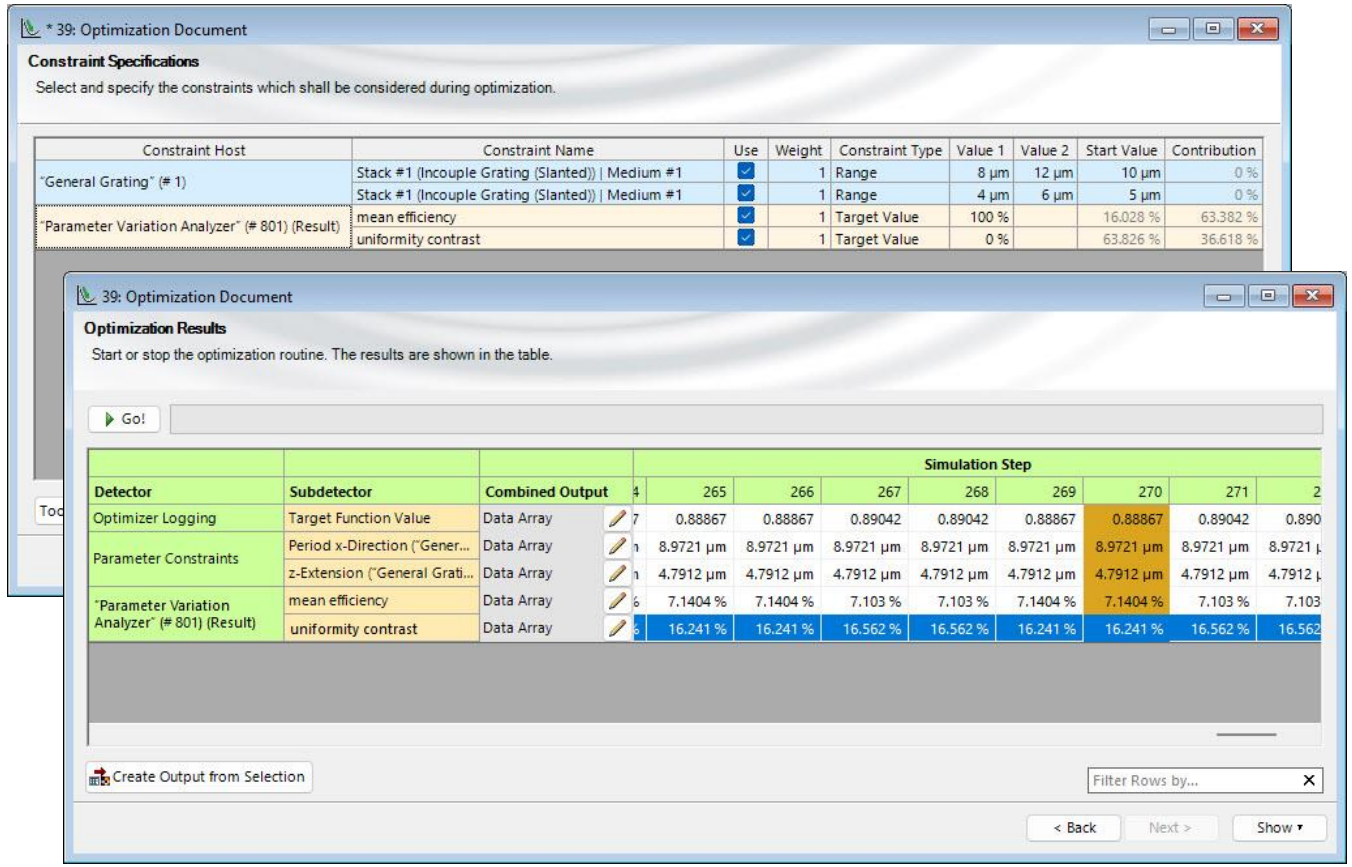
mean efficiency (to be maximized): $\eta_{\text{mean}} = \frac{\Sigma_i^n \eta_i}{n}$

uniformity contrast (to be minimized): $u = \frac{\eta_{\max} - \eta_{\min}}{\eta_{\max} + \eta_{\min}}$

With η_i being the 1st order transmission efficiency for an individual fill factor.

Parametric Optimization





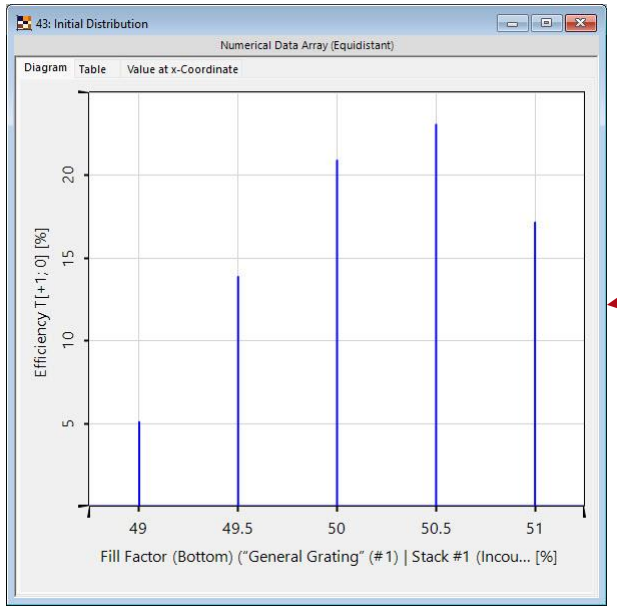
Now, the grating can be optimized by using the in-build *Parametric Optimization*. An efficiency of 100% (to maximize this value) und uniformity contrast of 0% (to minimize this value) are used as target values for the merit function.

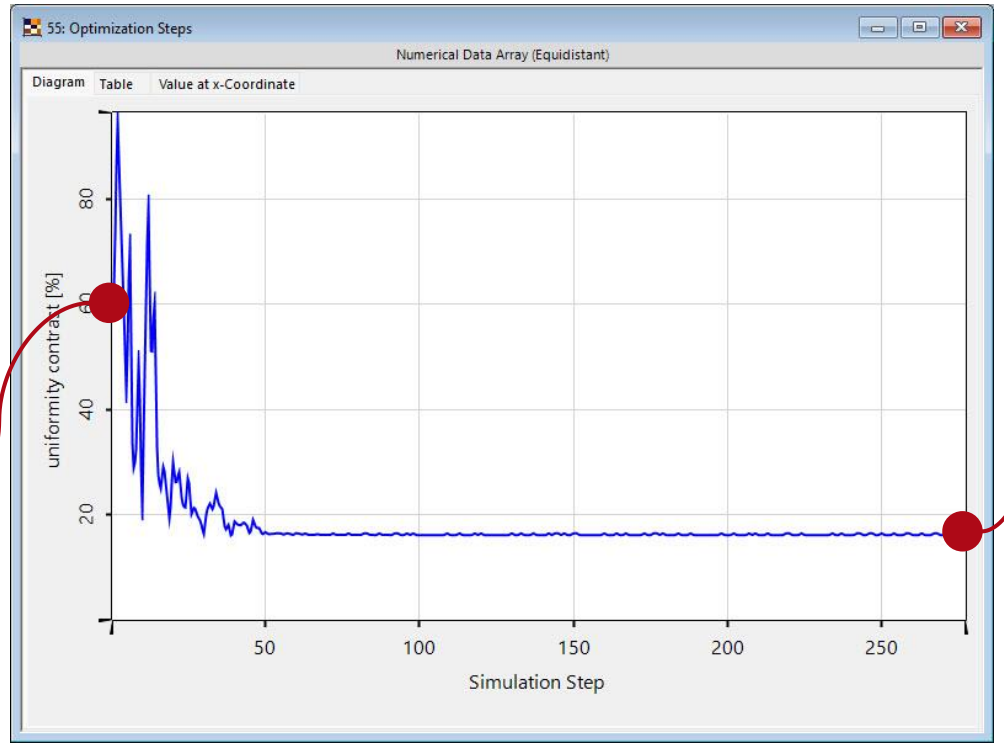
More information under:
Introduction to the Parametric Optimization Document

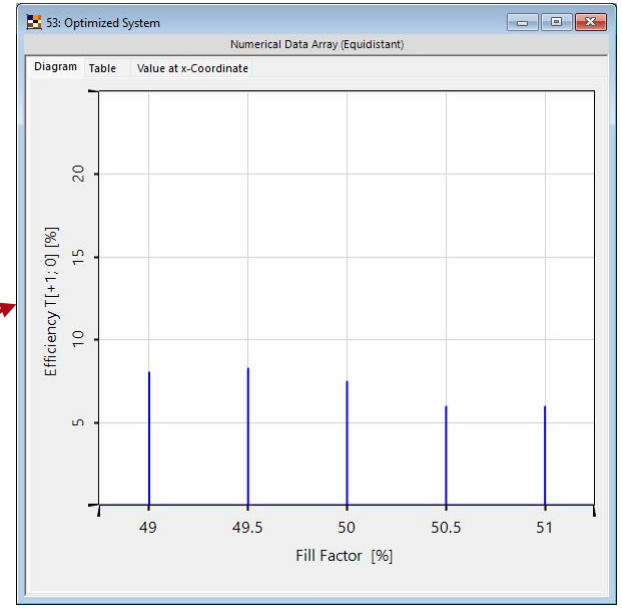
Optimization Result

initial design:

- mean efficiency: 16.03%
- uniformity contrast: 63.83%







optimized design:

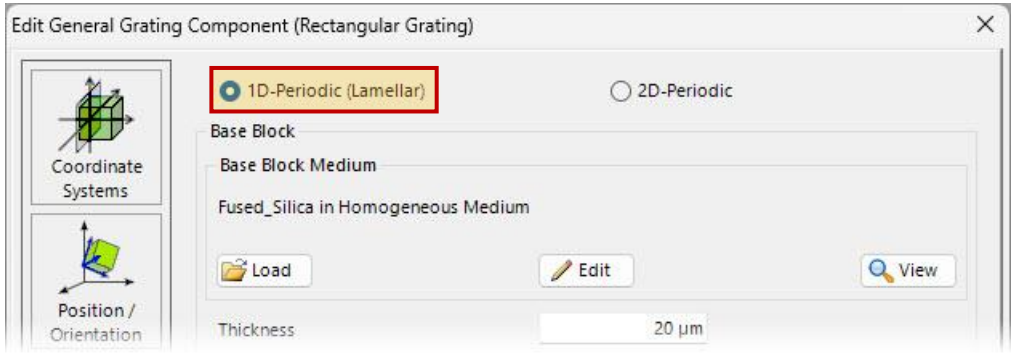
- mean efficiency: 7.14%
- uniformity contrast: 16.241%

Eventually, the optimization results in a trade-off between the mean efficiency and the uniformity contrast. With the chosen weights, some efficiency is sacrificed for a lower uniformity contrast. By adjusting the weights, the result can be influenced towards better efficiency or uniformity.

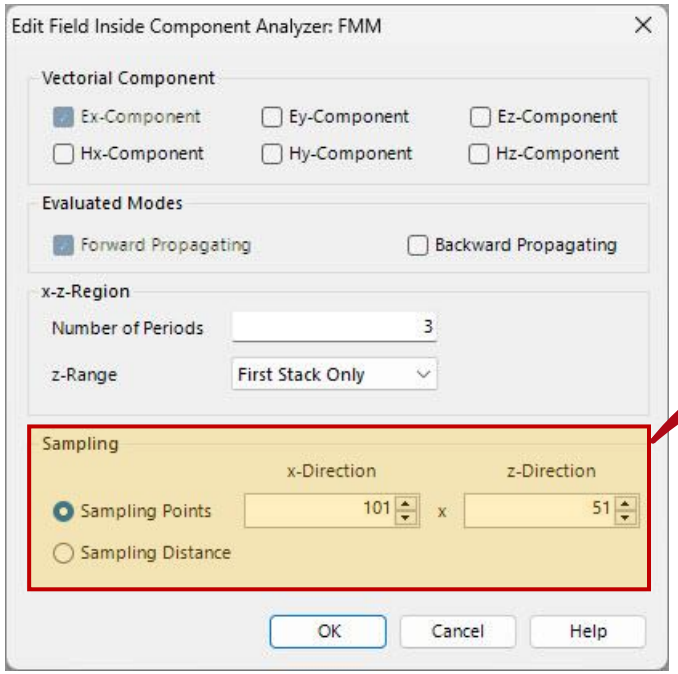
Field Inside Component: FMM

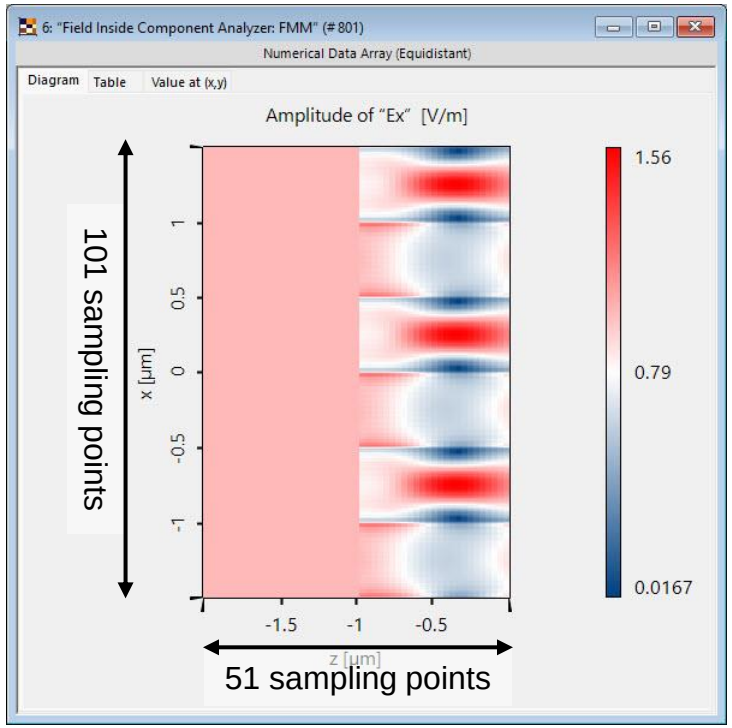
Now 3D!

Sampling of the Output Data: 1D-Periodic Gratings (Lamellar)

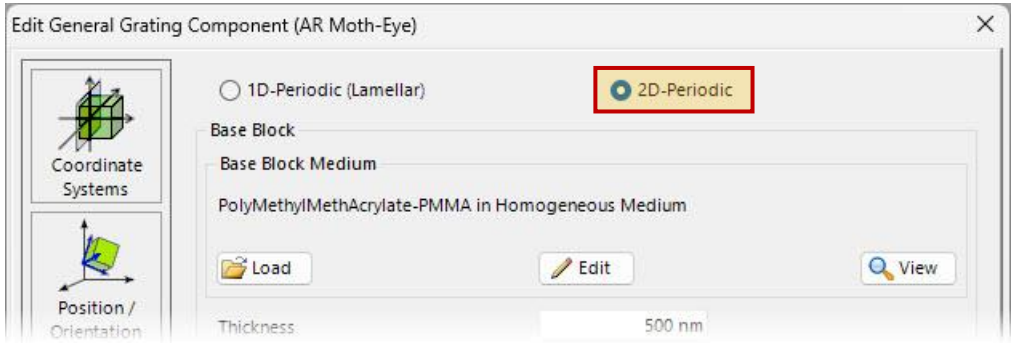


For *1D-Periodic (Lamellar)* gratings, the analyzer generates a 2D cross-sectional image with the parameters specified in the *Sampling* section of the dialog.

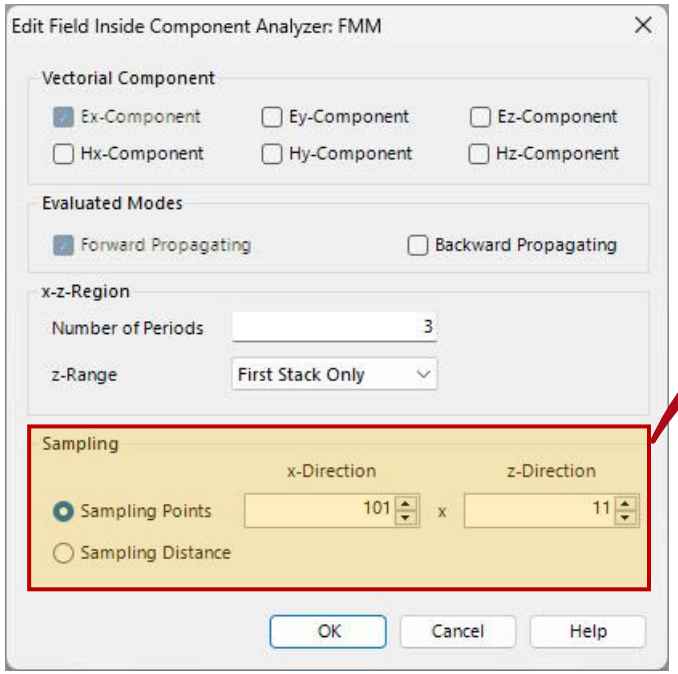


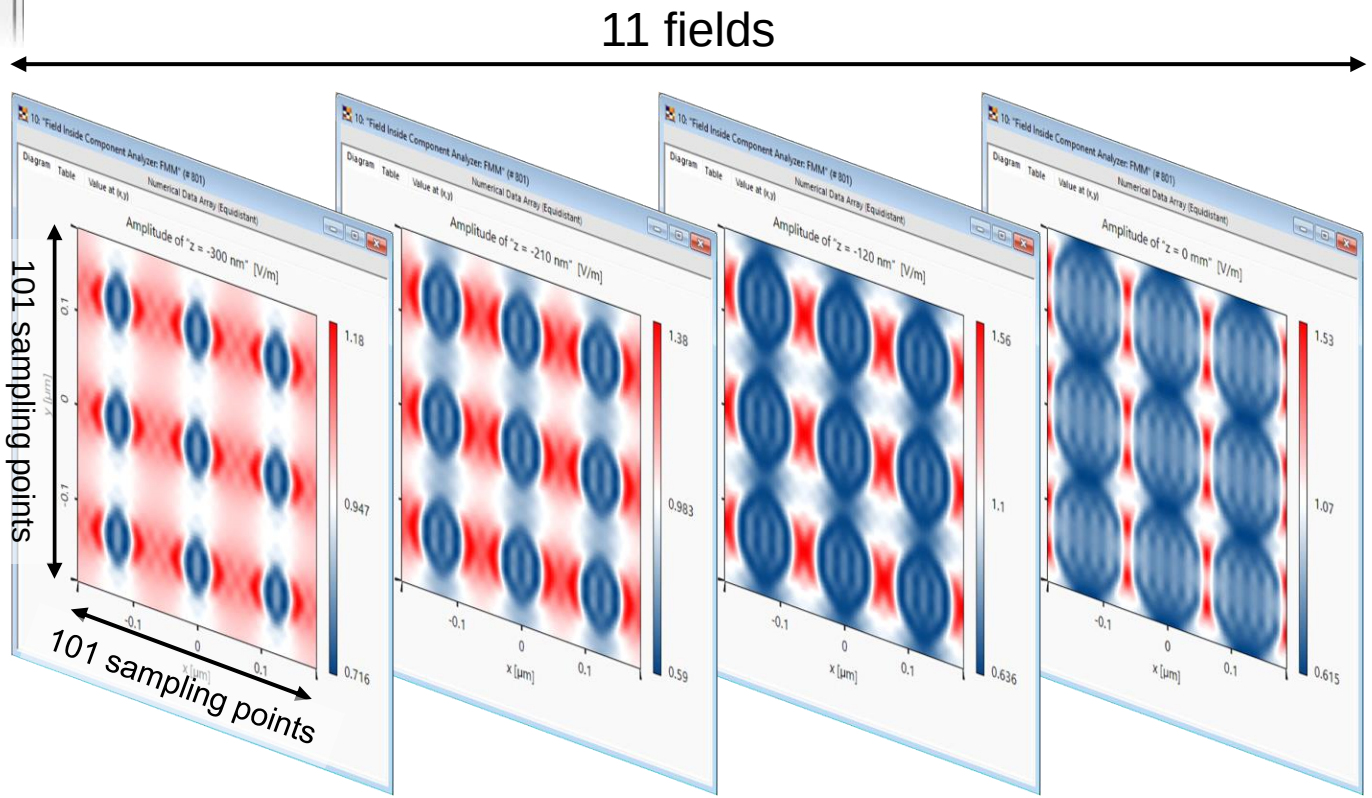


Sampling of the Output Data: 2D-Periodic Gratings



When the analyzed grating is set to *2D-Periodic*, the *Field Inside Component Analyzer: FMM*, will instead generate a series of quadratic cross-sections through the structure, with the sampling parameter in z-direction dictating the number of cuts performed.



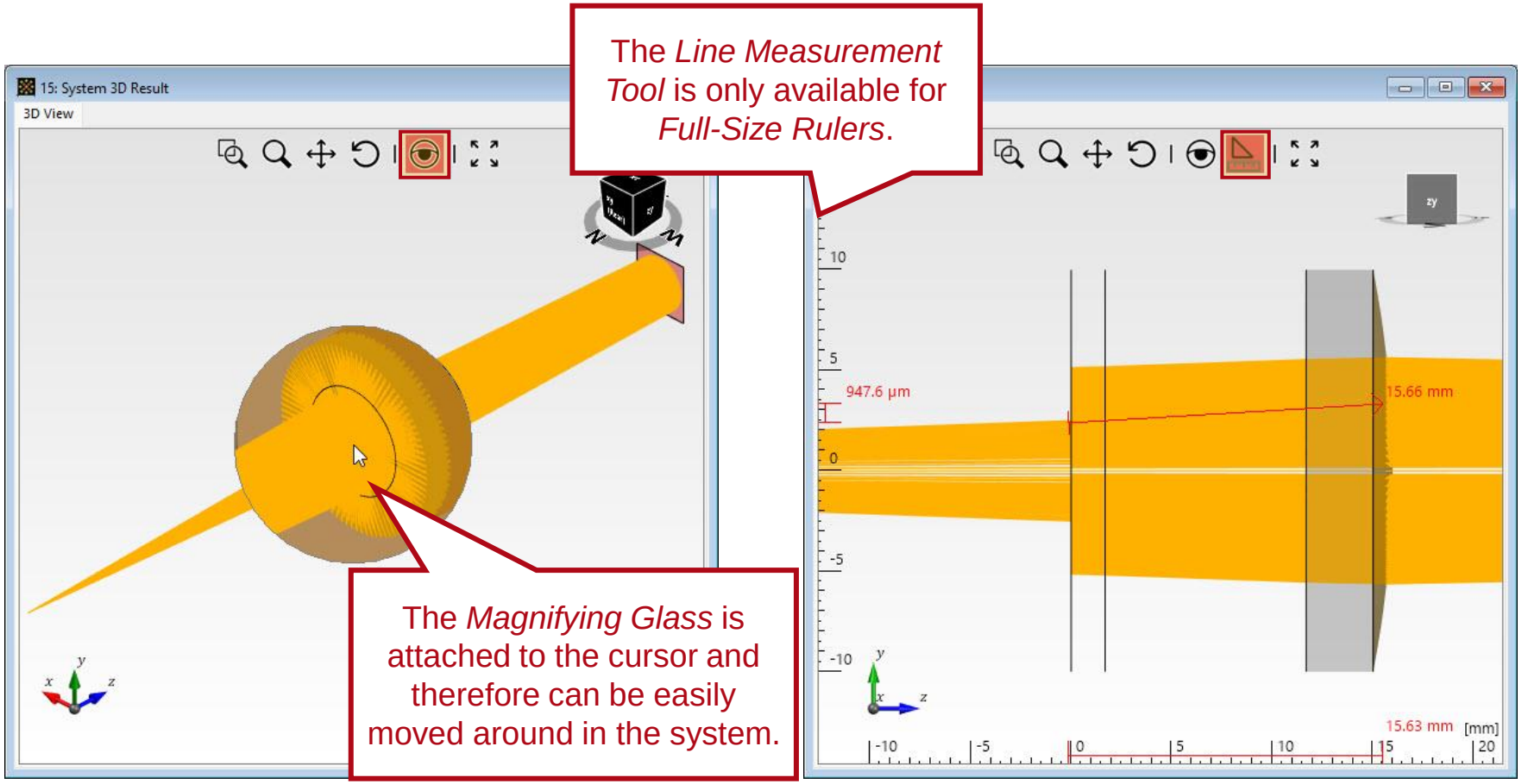


3D System View

Measure Distances!

Measure Distances in 3D View!

In order to improve the usability, there are a few additional features that we would like to highlight.



Use the *Magnifying Glass* in the *Tool Bar* to zoom into details without changing the actual system view.

The *Line Measuring Tool* allows for an easy analysis of the distances and sizes of the various components.

… And So Much More!

Release Notes 2023.2