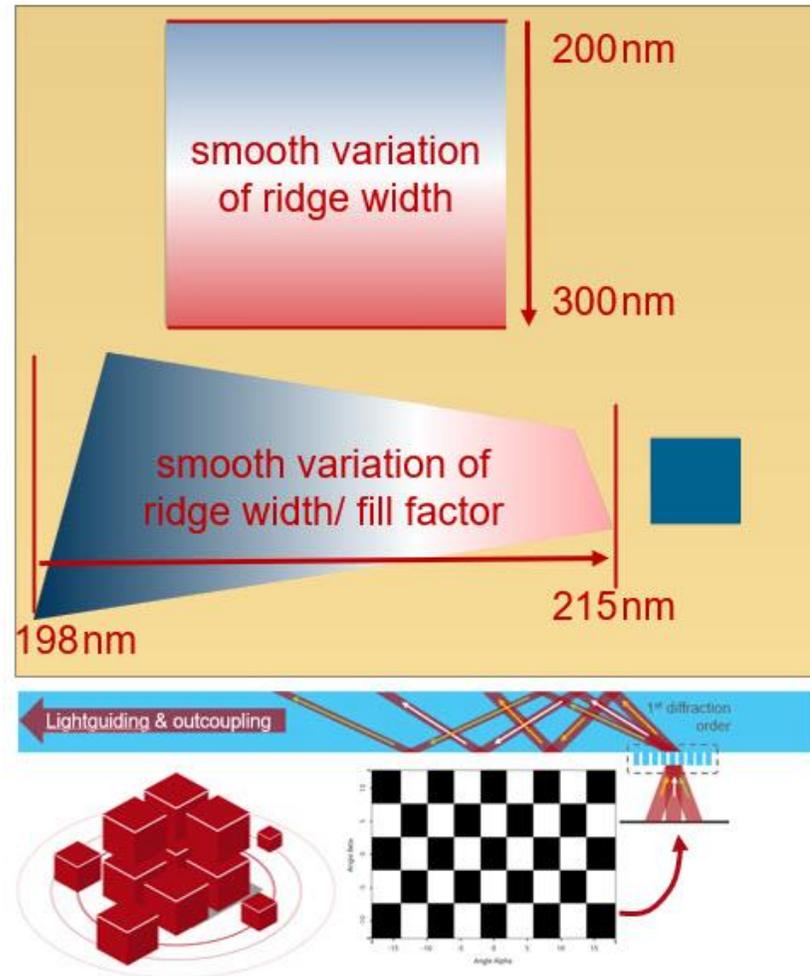


# **Simulation of a Test Image in an AR Waveguide Using Distributed Computing**

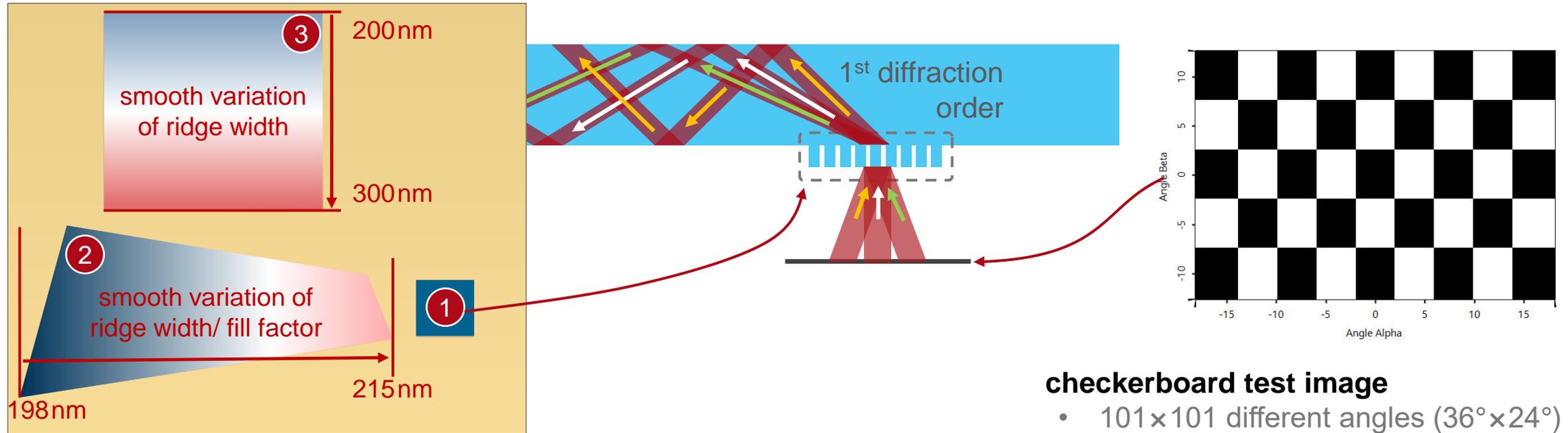
# Abstract



Modeling waveguide combiners for augmented and mixed reality (AR, MR) applications is notoriously challenging due to the complexity of the optical configurations and the multiple source modes representing the field of view (FOV), among others. Hence, detailed analyses, e.g. of the optical performance of the angular characteristics, can be quite time consuming as many source modes and field angles must be considered. In this Use Case, we use a checkerboard test image with 101 by 101 sampling points (i.e. angles) to investigate the angular performance of a waveguide, leading to 10201 individual elementary simulations.

By using a network of five multi-core PCs providing 41 clients, the simulation time is reduced to about 4 hour (compared to ~43 hours previously).

# Simulation Task



## lightguide with continuously varied grating parameters:

### incoupler ①

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

### expander (EPE) ②

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

### outcoupler ③

- period: 380 nm
- width of grating ridge: 200–300 nm
- height: 124 nm
- grating orientation: 90°

### checkerboard test image

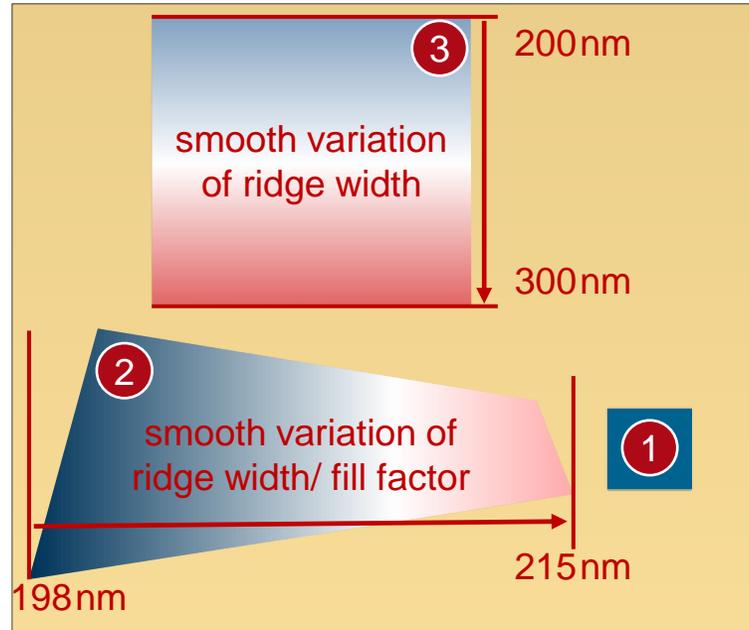
- 101×101 different angles (36°×24°) varying parameter

→ in total 10201 elementary simulation tasks

# Elementary Simulation Task

## source:

- plane wave
- wavelength: 532nm
- on-axis propagation ( $\alpha, \beta = 0^\circ$ )
- polarization:  $E_x$



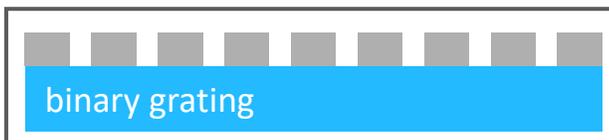
## detector result :

radiant flux within eyebox

Radiant Flux (Surface)	0.67864 pW
------------------------	------------

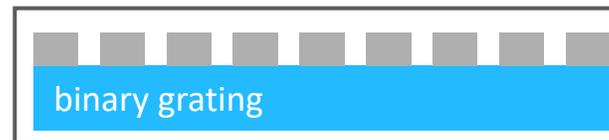
simulation time: ~12s

## incoupler: 1



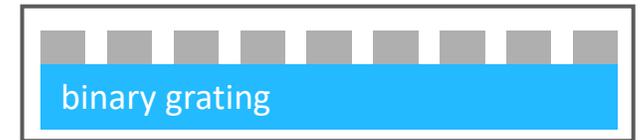
- period: 380nm
- width of grating ridge: 190nm
- height: 100nm
- grating orientation:  $0^\circ$

## expander (EPE): 2



- period: 268.7nm
- width of grating ridge: 198–215nm
- height: 50nm
- grating orientation:  $45^\circ$

## outcoupler: 3

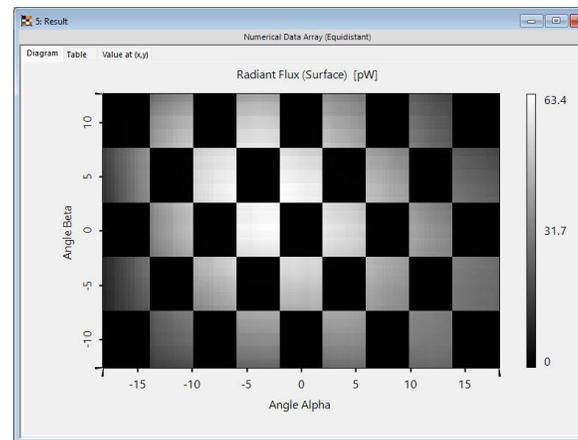
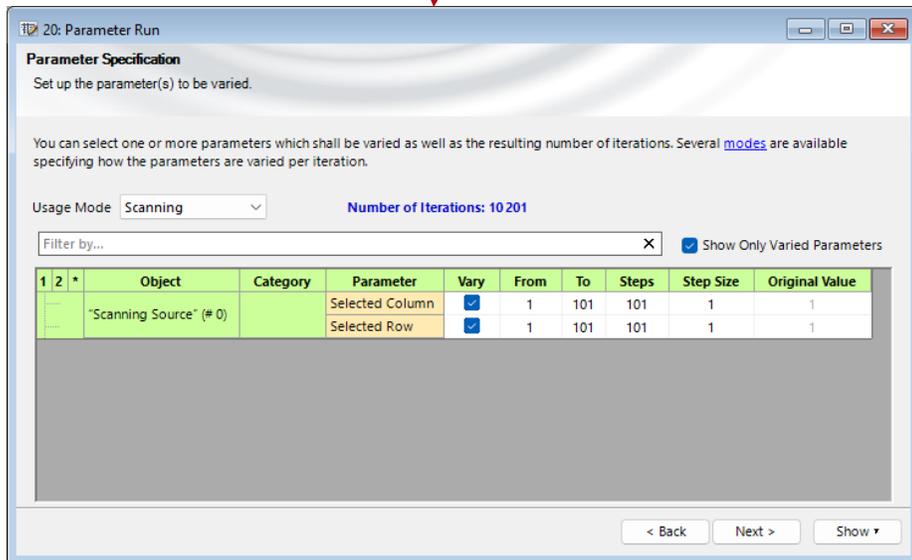


- period: 380nm
- width of grating ridge: 200–300nm
- height: 124nm
- grating orientation:  $90^\circ$

# Collection of Elementary Tasks: Angles of Incidence of FOV



varying parameter:  
101 × 101 different angles (36° × 24°)  
→ 10201 elementary simulation tasks



simulation time  
(10201 simulations): ~43h

simulation result:  
radiant flux over FOV angles\*

5 \*Note: 21 × 21 directions are stored in the look-up tables of the gratings with continuously variated parameters.

# Using Distributed Computing

The screenshot displays the software interface for Wyrowski VirtualLab Fusion 2023.2 (Build 1.242). The main window is titled "Parameter Run" and shows a "Results" window for a parameter run. The "Results" window contains a table with the following data:

Detector	Subdetector	Combined Output	Iteration Step			
	Selected Column	Data Array	1	2	3	4
Varied Parameters	Selected Row ("Scanning S...	Data Array	1	2	3	4
"Universal Detector" (# 627...	Efficiency	Data Array	0.10692 %	0.11112 %	0.11547 %	0.11821 %

The "Distributed Computing" panel on the right shows a table of clients with the following data:

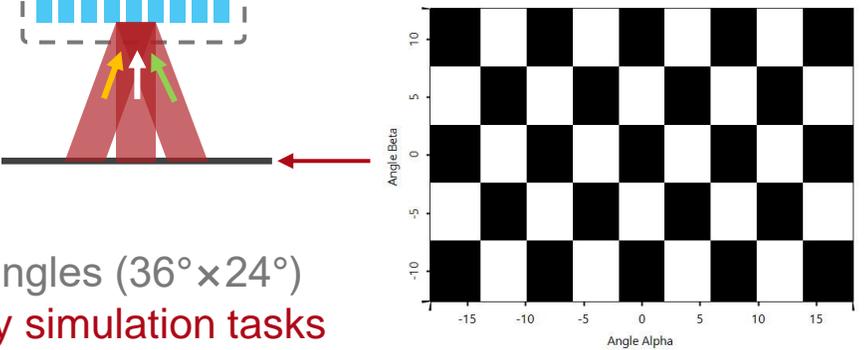
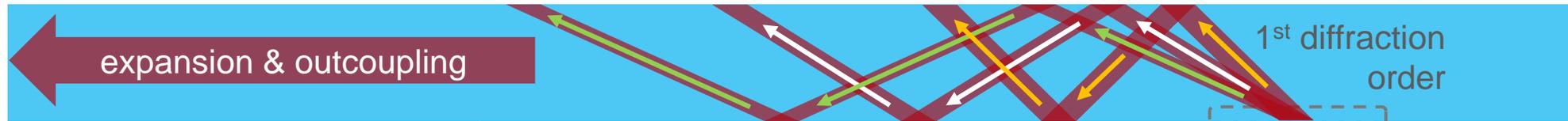
Status	Host Machine	Clients	CPU	RAM	Active	Disconnect
Active	lt996.lighttrans2.local	(0 of 8)	0 %	19 %	Active	Disconnect
Active	lt777.lighttrans2.local	(0 of 4)	1 %	5.95 %	Active	Disconnect
Active	lt998.lighttrans2.local	(0 of 8)	0 %	3.13 %	Active	Disconnect
Active	lt888.lighttrans2.local	(0 of 5)	1 %	7.59 %	Active	Disconnect
Active	lt999.lighttrans2.local	(0 of 16)	0 %	9.18 %	Active	Disconnect

A *Parameter Run* is used to vary the angle of the current FOV mode, which allows the various iterations to be distributed to computers in the network. In order to enable *Distributed Computing*, simply navigate to the corresponding tab and configure the number of computers and clients available. Then start the simulation as usual, the transfer of data to the clients and the collection of the results is done automatically (in the same way as for a locally performed parameter sweep).

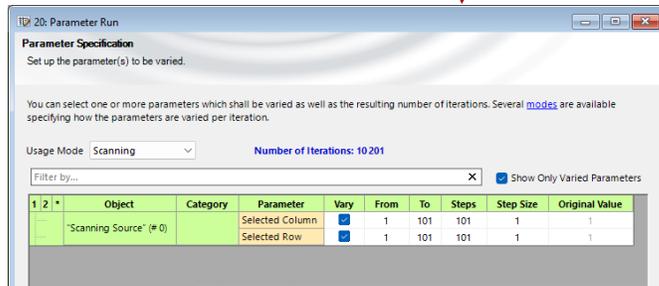
For a more in-depth tutorial on how to set up distributed computing, please see:

[Usage of Distributed Computing](#)

# Simulation by Using Distributed Computing



varying parameter:  
 $101 \times 101$  different angles ( $36^\circ \times 24^\circ$ )  
 → 10201 elementary simulation tasks



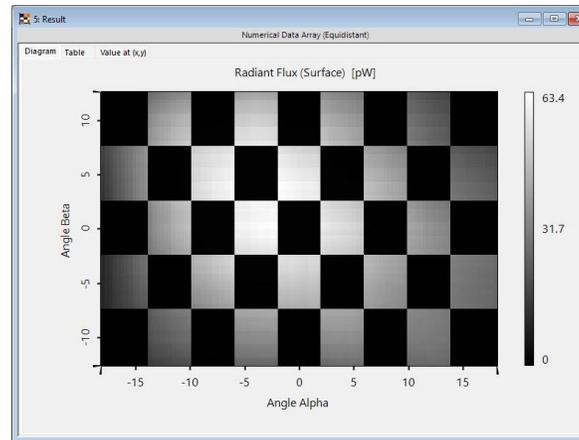
number of clients: 41  
 (on 5 different computers)

Distributed Computing

Server Tools

Stop Server    + Add Clients on Remote Machine    Start File Watcher

Status	Host Machine	Clients	CPU	RAM	Active	Disconnect
■	It996.lighthtrans2.local	(0 of 8)	100 %	16.2 %	✓	✗
■	It777.lighthtrans2.local	(0 of 4)	89 %	9.72 %	✓	✗
■	It998.lighthtrans2.local	(0 of 8)	100 %	9.72 %	✓	✗
■	It888.lighthtrans2.local	(0 of 5)	92 %	8.79 %	✓	✗
■	It999.lighthtrans2.local	(0 of 16)	100 %	8.72 %	✓	✗

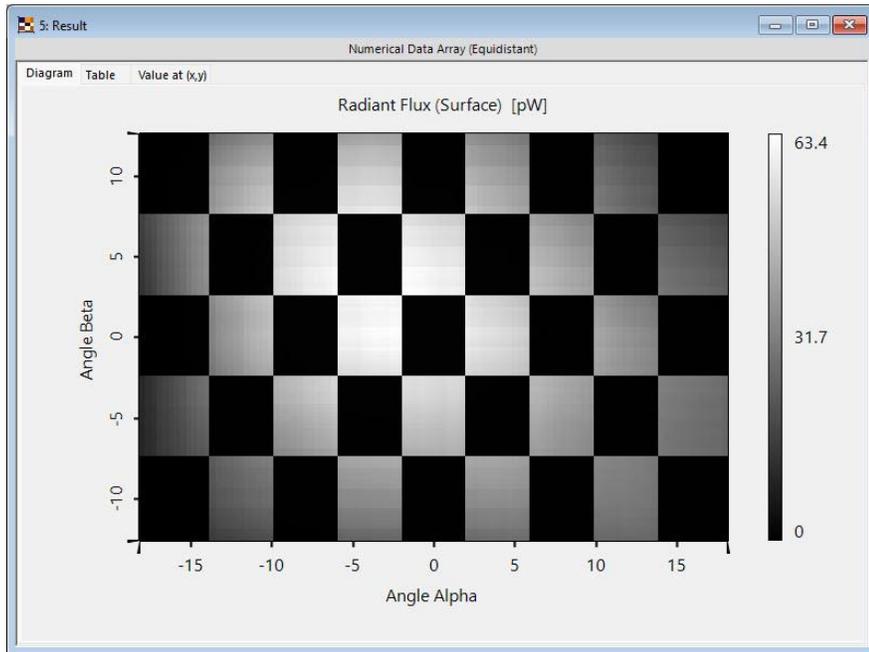


**simulation time**  
 (10201 simulations): 4h 10min

**simulation result:**  
 radiant flux over FOV angles

# Comparison of Simulation Times

simulation result



simulation time

elementary simulation

~12s

---

collection of elementary simulations (10201) on one computer

~43h (100%)

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collection of elementary simulations (10201) via distributed computing (41 clients on 5 computers)

**4h 10min (9%)**

→ **Distributed Computing reduces the simulation time by 91%!**\*

*\*Note: As the elementary simulation only takes a few seconds, the reduction in simulation time is limited due to the network overhead.*

# Document Information

title	Simulation of a Test Image in an AR Waveguide Using Distributed Computing
document code	DC.0003
document version	1.1
required packages	<ul style="list-style-type: none"><li>• Grating Package</li><li>• Lightguide Package</li><li>• Distributed Computing Package</li></ul>
software version	2023.2 (1.242)
category	Application Use Case
further reading	<ul style="list-style-type: none"><li>• <a href="#"><u>Usage of Distributed Computing</u></a></li><li>• <a href="#"><u>Optimization of Lightguide with Continuously Modulated Grating Regions</u></a></li><li>• <a href="#"><u>Coherence Measurement in Michelson Interferometer –Analysis by using Distributed Computing in VirtualLab Fusion</u></a></li></ul>