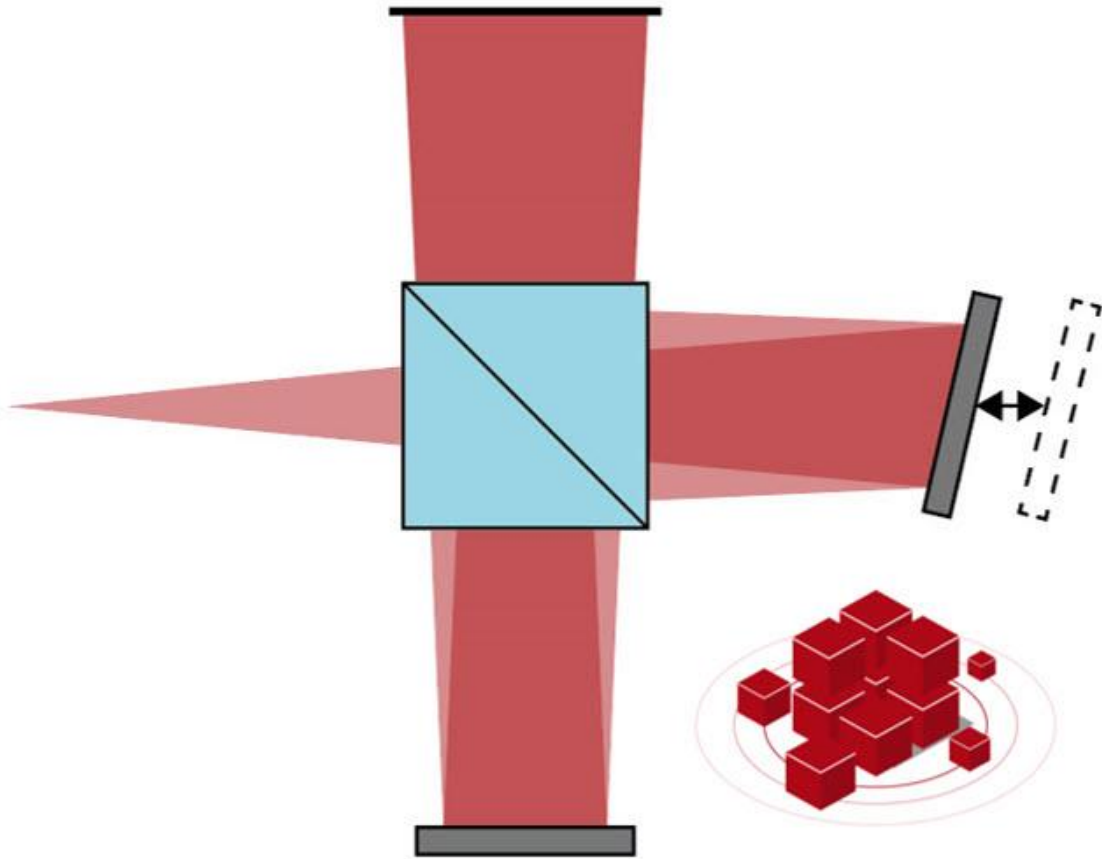


Coherence Measurement with White-Light Interferometry – Analysis Using Distributed Computing in VirtualLab Fusion

Abstract

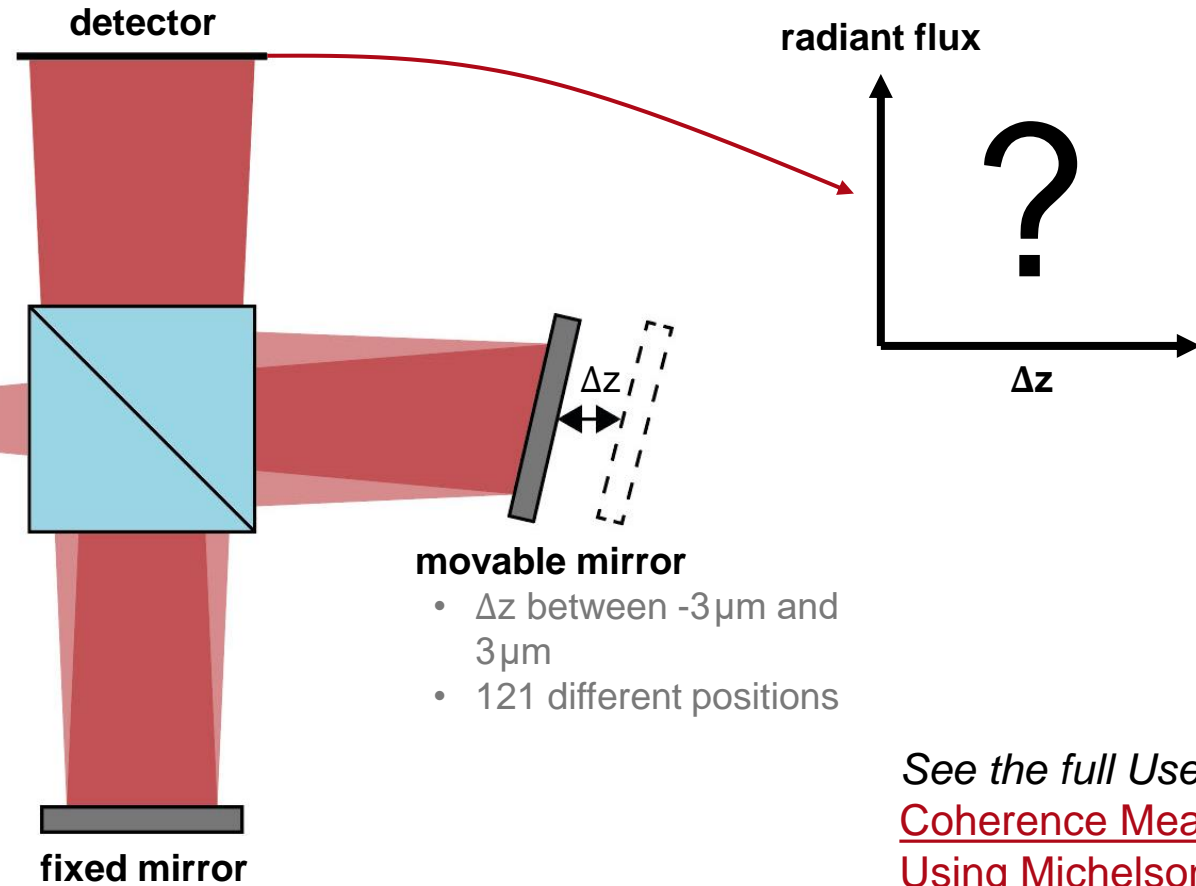
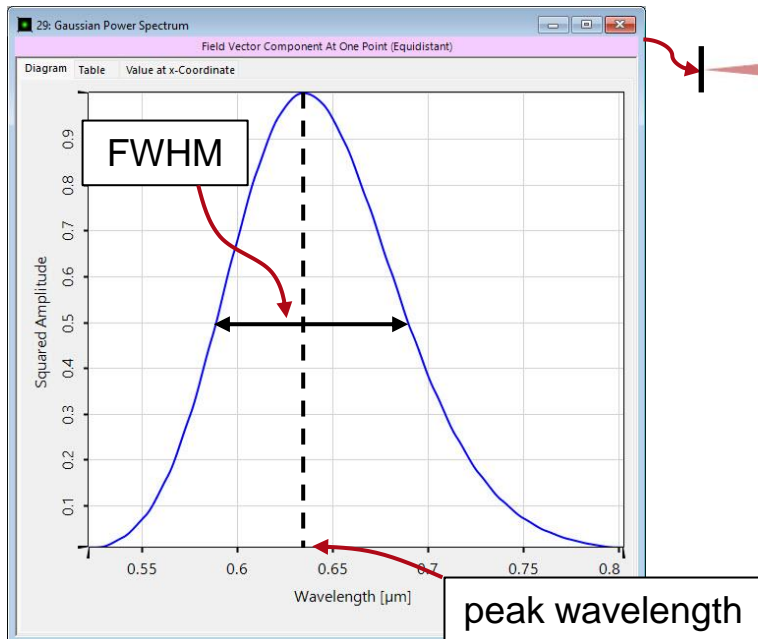


This use case demonstrates the power of distributed computing along the example of the well-known Michelson interferometer. A polychromatic source is combined with a position scan of one of the mirrors of the interferometric setup to perform a detailed coherence measurement. Using distributed computing with a network of six local multicore PCs, the simulation time of the resulting 2,904 elementary simulations can be significantly reduced from over an hour to just under 3 minutes.

Simulation Task

white-light source

- Gaussian power spectrum (sampled with 24 wavelengths)
- peak wavelength: 633nm
- full width at half maximum (FWHM): 100nm

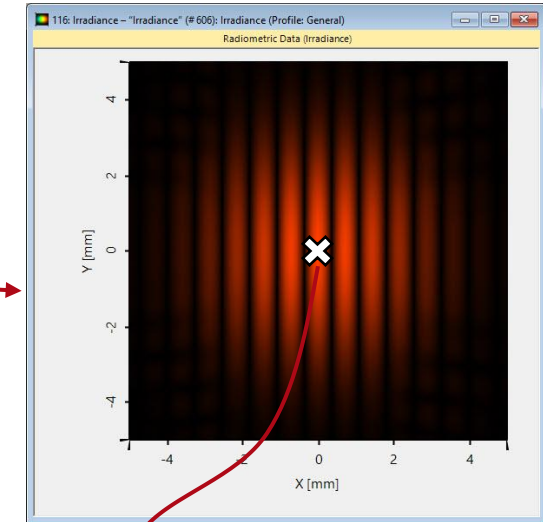
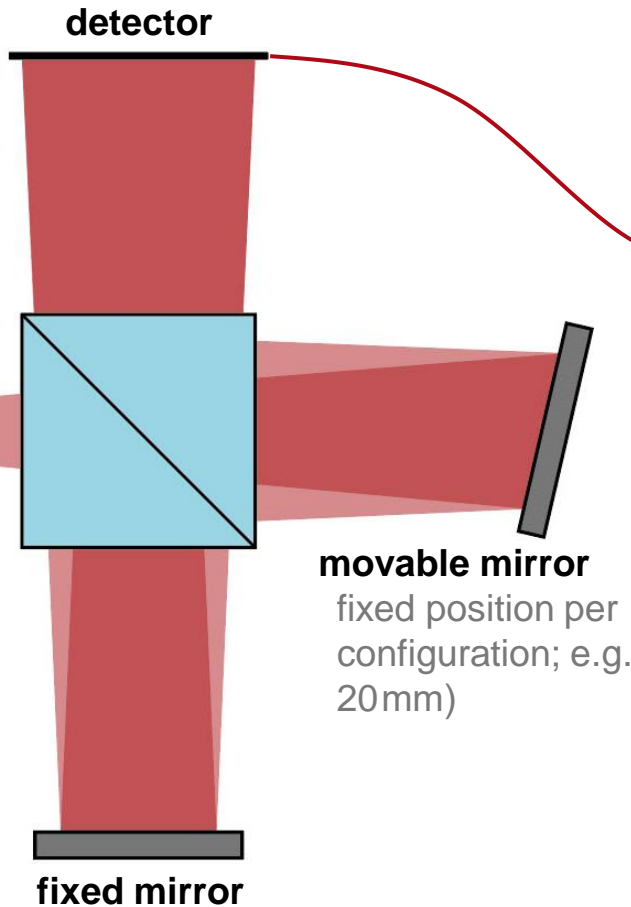


See the full Use Case:
[Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy](#)

Elementary Simulation Task

The configuration for a single wavelength and one position of the mirror represents the **elementary simulation task**.

monochromatic source
single wavelength (e.g. 633nm)



detector result:
radiant flux at the central position

Radiant Flux (Surface)	777.16 μ W
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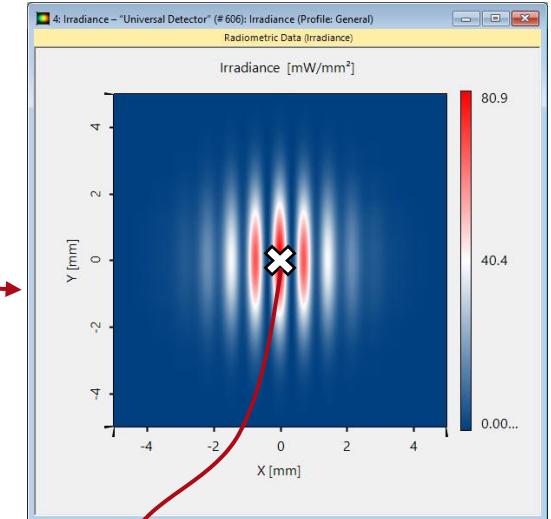
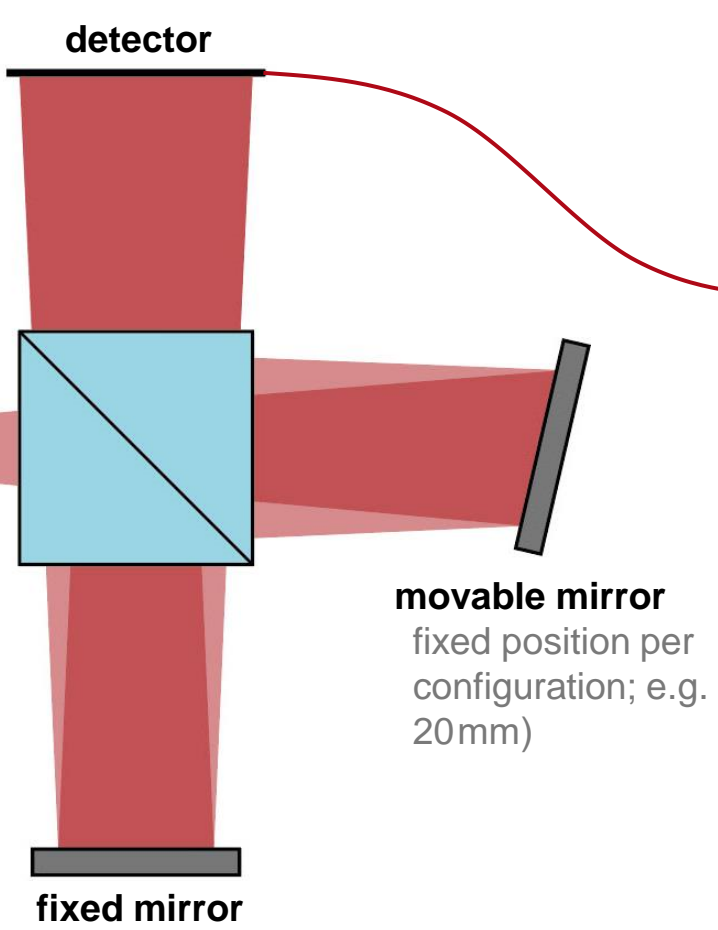
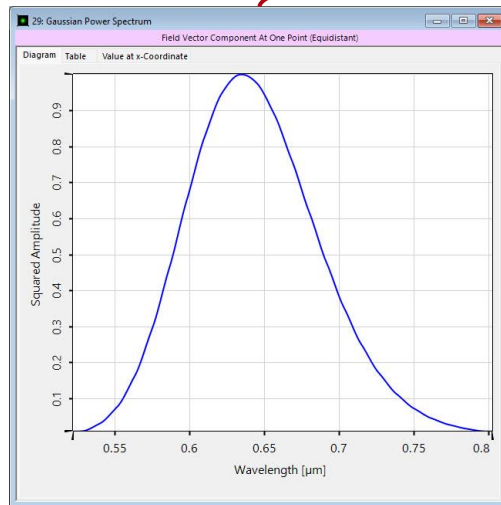
simulation time: 0.9s

Collection of Elementary Tasks #1: Wavelengths

The bandwidth is modeled by using 24 wavelengths (e.g. defined in the source).

white-light source

- Gaussian power spectrum (sampled with 24 wavelengths)
- peak wavelength 633 nm
- full width at half maximum (FWHM): 100nm



detector result:
radiant flux at the central position

Radiant Flux (Surface)	780.37 μW
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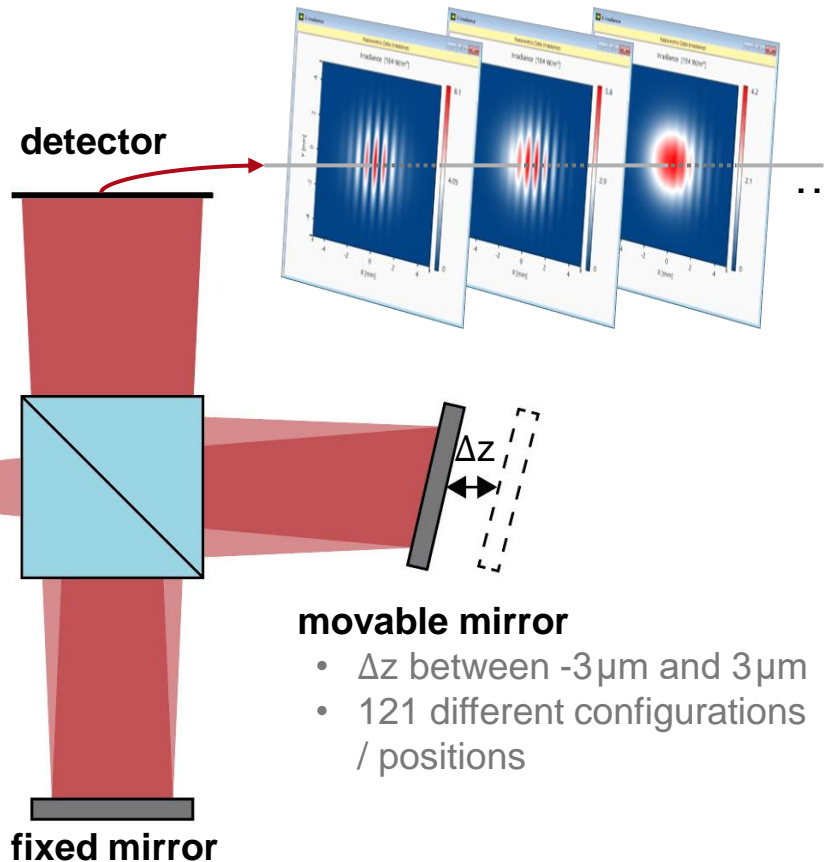
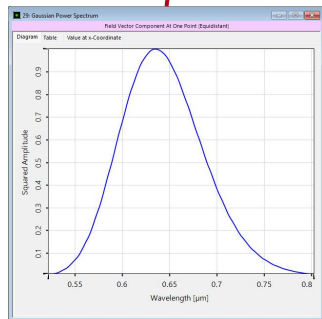
simulation time: 22s

Collection of Elementary Tasks #2: Mirror Positions

The position of the mirror is varied in 121 steps (e.g. by using a *Parameter Run* document).

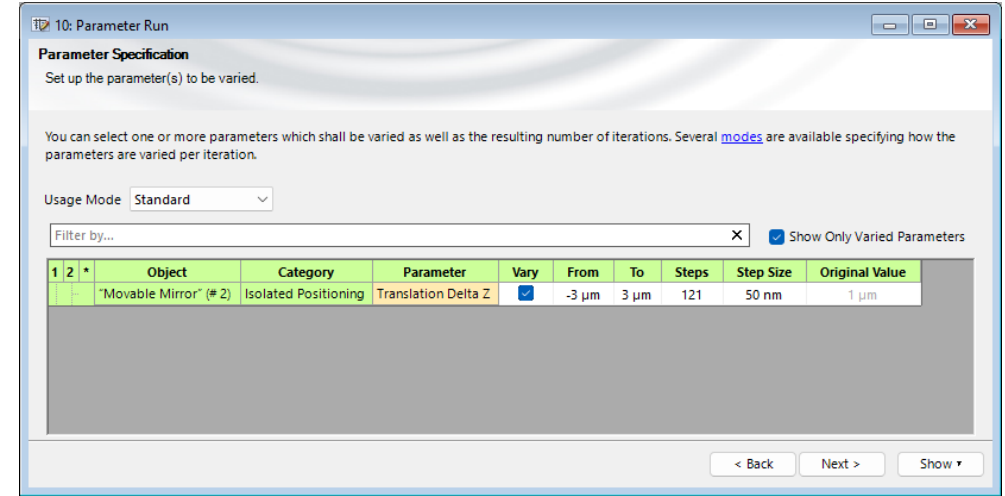
white-light source

- Gaussian power spectrum (sampled with 24 wavelengths)
- peak wavelength: 633nm
- full width at half maximum (FWHM): 50nm



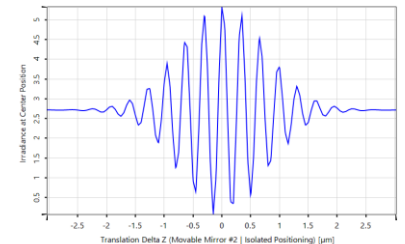
movable mirror

- Δz between $-3\mu\text{m}$ and $3\mu\text{m}$
- 121 different configurations / positions



simulation result:

irradiance value at central position for different values of distance



simulation time

(2904 simulations): 46min 55s

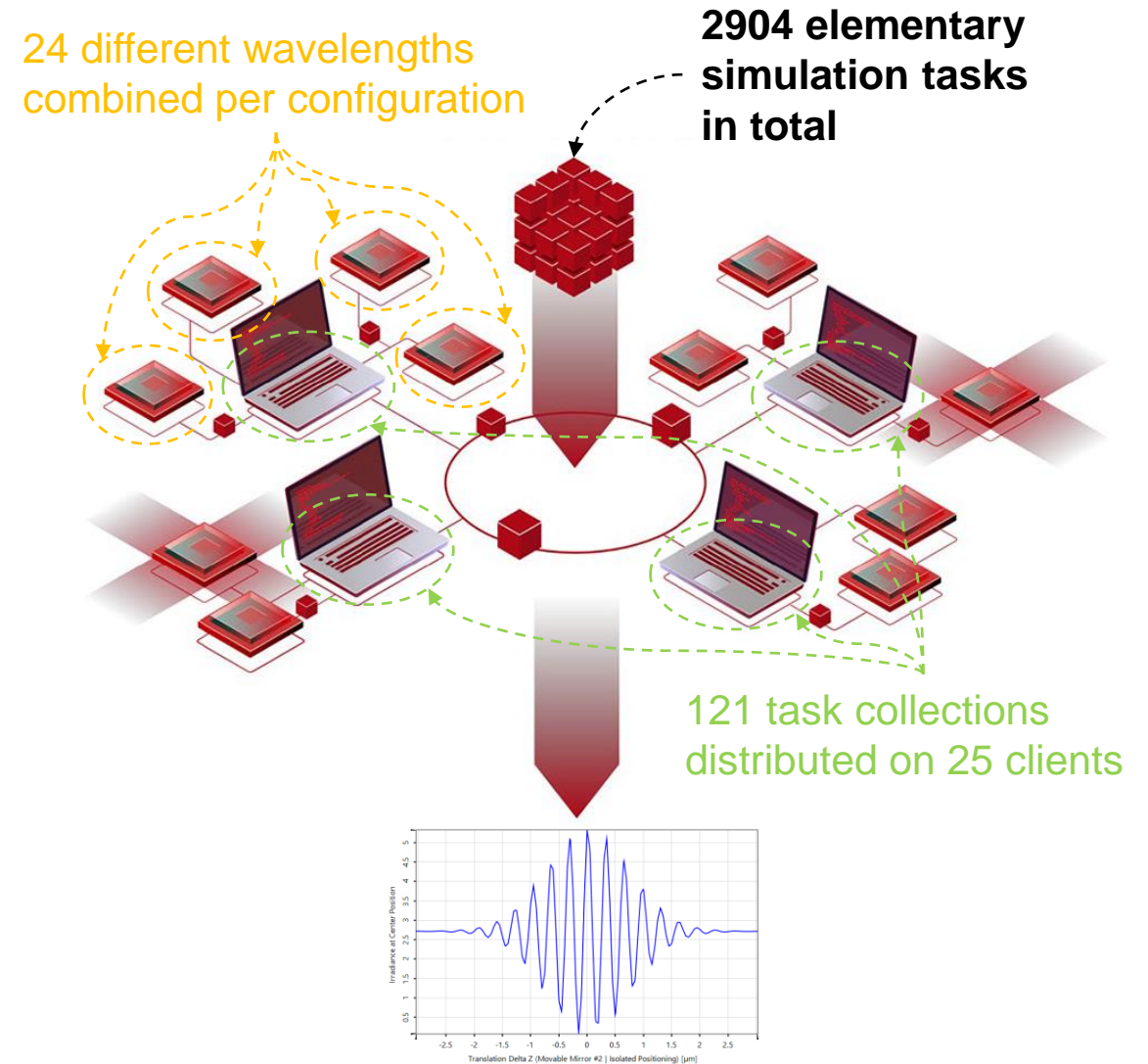
Perform Simulation by Using Distributed Computing

In this example, there are two independent parameters varied in the elementary simulation task:

- 24 wavelength samples in spectrum
- 121 different mirror positions

➔ in total 2904 elementary simulation tasks

Since a single elementary simulation (single wavelength and mirror position) takes only about 0.9 seconds, it is more efficient to combine some of the elementary simulations and simulate the collections on the DC clients. Hence, all wavelengths are combined in a single simulation (spectrum configured in the source) and a *Parameter Run* with DC is used to model the different mirror positions. This strategy reduces unnecessary overhead compared to modeling all 2904 tasks in one *Parameter Run*.



Combining Elementary Tasks of All Wavelengths

The image displays three windows from the VirtualLab Fusion software. On the left is the 'Edit White-Light Source' dialog, which includes a table of spectral values. In the center is a ray diagram showing a white-light source (0) connected to an ideal beam splitter (1), which then splits into a movable mirror (2) and a fixed mirror (3). A radiant flux detector (607) is positioned to receive light from the beam splitter. On the right is the '10: Parameter Run' window, which shows a table of parameter specifications for the movable mirror's translation delta Z.

Index	Object	Category	Parameter	Vary	From	To	Steps	Step Size	Original Value
1	2	Isolated Positioning	Translation Delta Z	<input checked="" type="checkbox"/>	-3 μm	3 μm	121	50 nm	1 μm

Using VirtualLab Fusion's flexible source model, all 24 wavelengths are combined into one spectrum and configured in the source. Hence, for each configuration (here: mirror position), all wavelength modes are propagated and re-combined at the detector, automatically.

Using Distributed Computing

The screenshot displays the Wyrowski VirtualLab Fusion 2023.2 (Build 1.242) interface. The main window is titled "Parameter Run" and shows a "Results" window for a simulation named "15: D:\LightTrans...\CoherenceMeasurement_lowBandwidth.run". The "Results" window includes a "Go!" button, a "Distributed Computing (Number of Clients: 41)" dropdown, and a table with the following data:

Detector	Subdetector	Combined Output	Iteration Step						
Varied Parameters	Translation Delta Z	Data Array	1	2	3	4	5	6	
			-3 μm	-2.95 μm	-2.9 μm	-2.85 μm	-2.8 μm	-2.75 μm	-

Below the table are buttons for "Create Output from Selection" and "Filter Rows by...".

The "Distributed Computing" panel on the right shows "Server Tools" with buttons for "Stop Server", "Add Clients on Remote Machine", and "Start File Watcher". Below this is a "Clients" table:

Status	Host Machine	Clients	CPU	RAM	Active	Disconnect
Active	lt996.lighttrans2.local	(0 of 8)	0 %	19.3 %	Active	Disconnect
Active	lt777.lighttrans2.local	(0 of 4)	6 %	6.02 %	Active	Disconnect
Active	lt998.lighttrans2.local	(0 of 8)	0 %	3.28 %	Active	Disconnect
Active	lt888.lighttrans2.local	(0 of 5)	4 %	7.67 %	Active	Disconnect
Active	lt999.lighttrans2.local	(0 of 16)	4 %	9.37 %	Active	Disconnect

Below the clients table, it shows "Number optical setups in queue: 0", "Logging" options (Disable Logging, Clear), and an "Assistant" button.

A *Parameter Run* is used to vary the mirror position, 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).

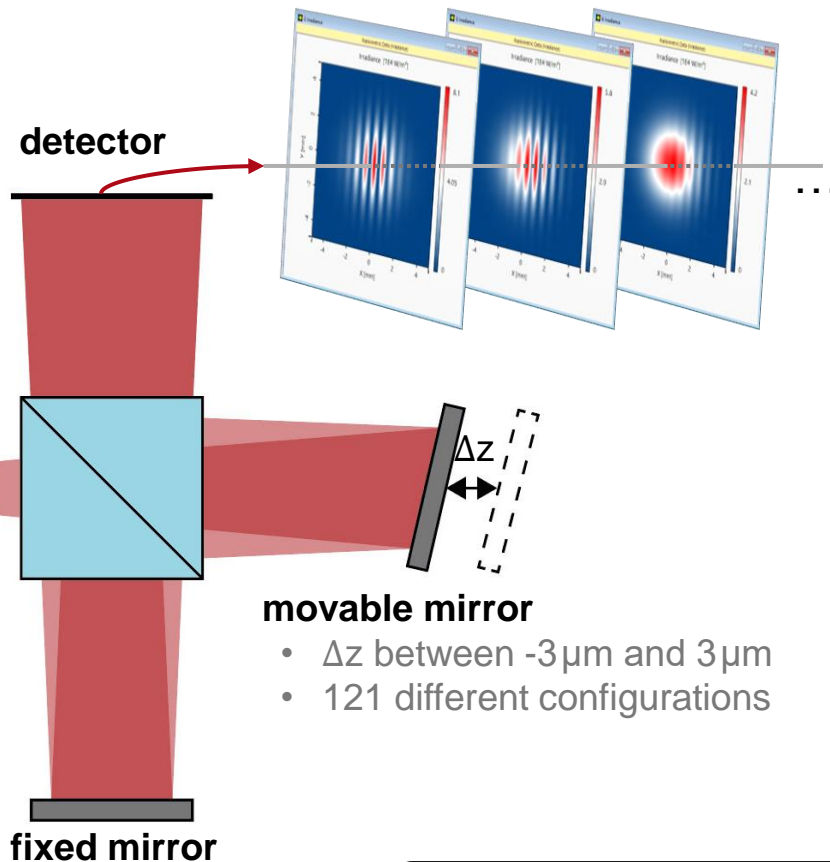
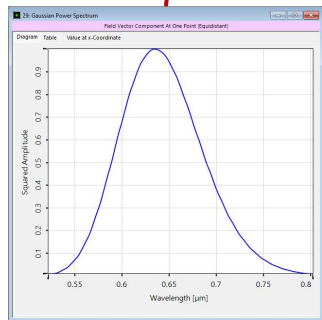
For a more in-depth tutorial on how to set up distributed computing, please see:

[Usage of Distributed Computing](#)

Simulation by Using Distributed Computing

white-light source

- Gaussian power spectrum (sampled with 24 wavelengths)
- peak wavelength: 633 nm
- full width at half maximum (FWHM): 100 nm



movable mirror

- Δz between $-3\mu\text{m}$ and $3\mu\text{m}$
- 121 different configurations

**simulation time
(2904 simulations): 2min 50s**

Parameter Run
 Parameter Specification
 Set up the parameter(s) to be varied.

You can select one or more parameters which shall be varied as well as the resulting number of iterations. Several **modes** are available specifying how the parameters are varied per iteration.

Usage Mode: Standard

Filter by: Show Only Varied Parameters

1	2	*	Object	Category	Parameter	Vary	From	To	Steps	Step Size	Original Value
			"Movable Mirror" (#2)	Isolated Positioning	Translation Delta Z	<input checked="" type="checkbox"/>	-3 μm	3 μm	121	50 nm	1 μm

Distributed Computing

Server Tools
 Stop Server Add Clients on Remote Machine Start File Watcher

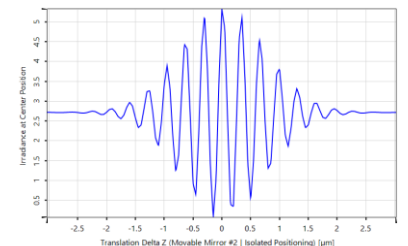
Calculation on: Local Machine Cloud

Clients

Status	Host Machine	Clients	CPU	RAM	Active	Disconnect
<input checked="" type="checkbox"/>	lt996.lighthtrans2.local	(0 of 6)	2 %	34.4 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt998.lighthtrans2.local	(0 of 5)	0 %	3.36 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	ws-lt-014.lighthtrans2.local	(0 of 4)	26 %	5.87 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt888.lighthtrans2.local	(0 of 3)	1 %	8.95 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt999.lighthtrans2.local	(0 of 3)	6 %	44.9 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt777.lighthtrans2.local	(0 of 4)	8 %	5.1 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

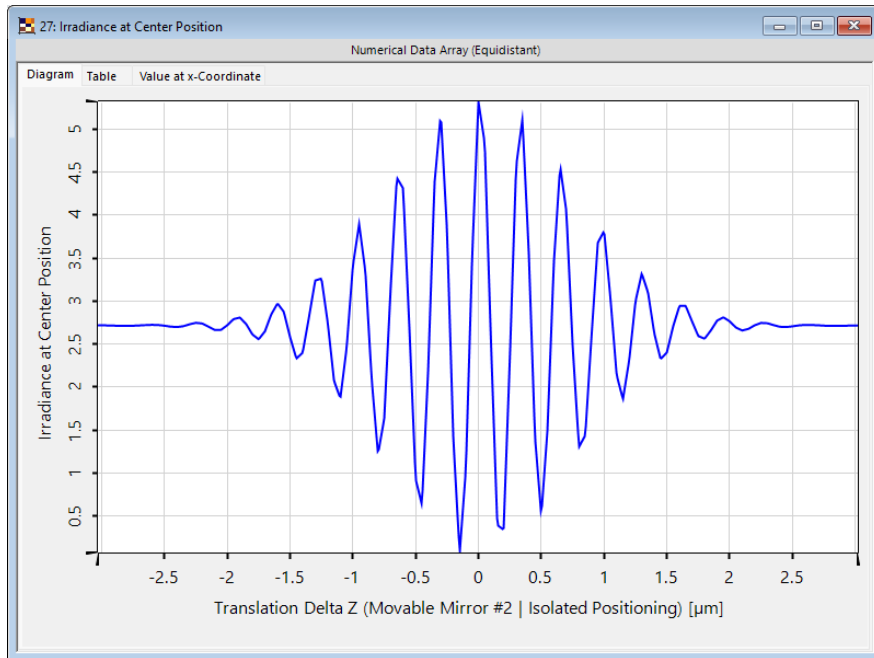
total number
clients: 25
(running on 6
computers)

simulation result:
irradiance value at
central position for
different distance
values



Comparison of Simulation Times

simulation result



simulation time

elementary simulation

~0.9s

collection of elementary
simulations (2904) on a single
computer

46min 55s

(100%)

collection of elementary
simulations (2904) via
distributed computing
(25 clients on 6 computers)

2min 50s

(6%)

→ **Distributed Computing reduces
simulation time by 94%!**

Document Information

title	Coherence Measurement with White Light Interferometry – Analysis Using Distributed Computing in VirtualLab Fusion
document code	DC.0001
document version	1.1
required packages	Distributed Computing Package
software version	2023.2 (1.242)
category	Application Use Case
further reading	<ul style="list-style-type: none">• <u>Simulation of a Test Image in an AR Waveguide Using Distributed Computing</u>• <u>Usage of Distributed Computing</u>• <u>Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy</u>