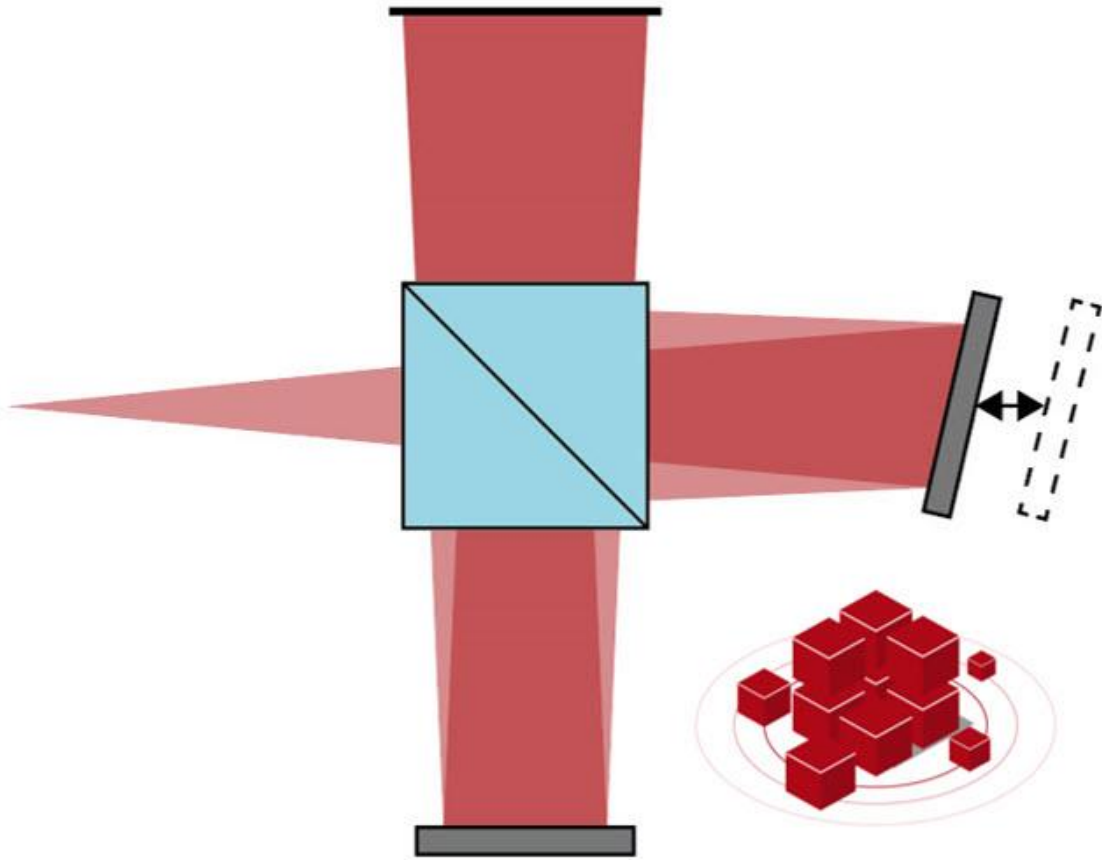


Coherence Measurement with White-Light Interferometry – Analysis Using Distributed Computing in VirtualLab Fusion

Abstract

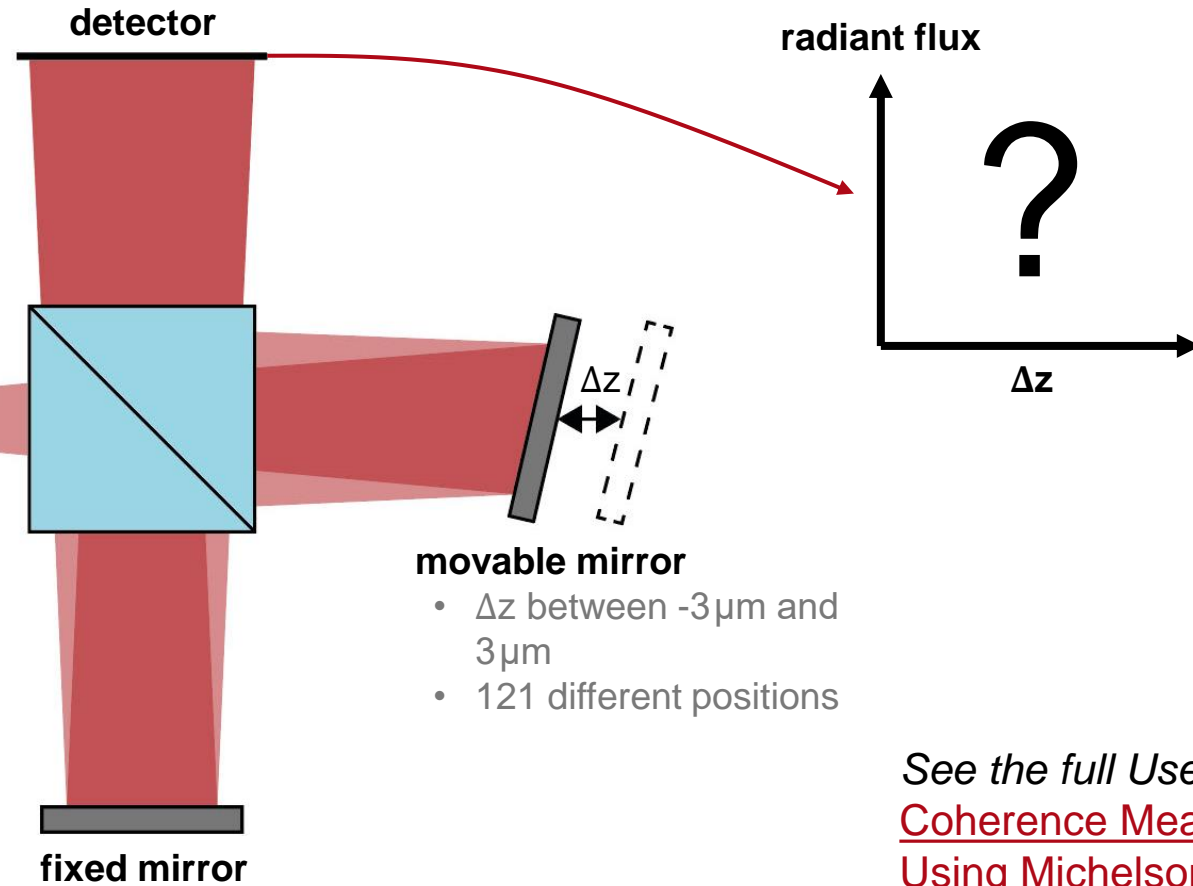
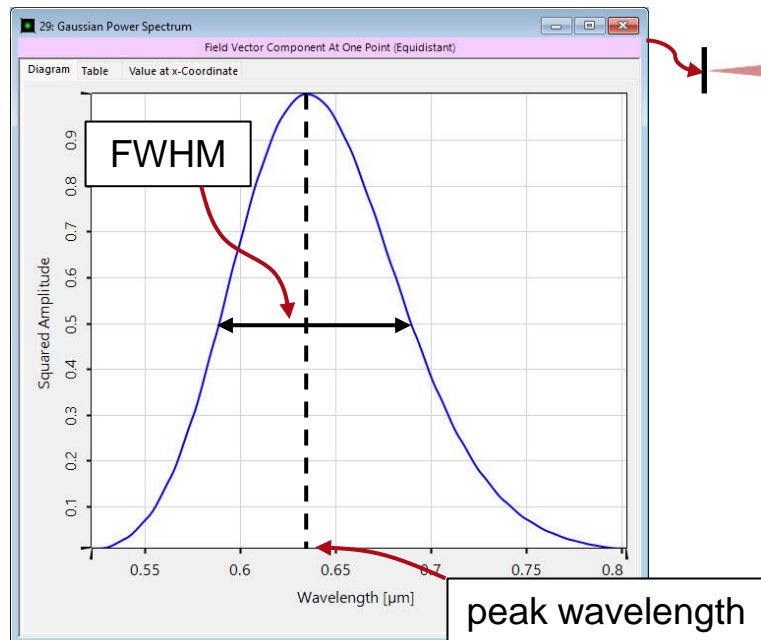


This use case demonstrates the power of distributed computing along the example of the well-known Michelson interferometer. A polychromatic source is combined with a position scan of one of the mirrors of the interferometric setup to perform a detailed coherence measurement. Using distributed computing 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

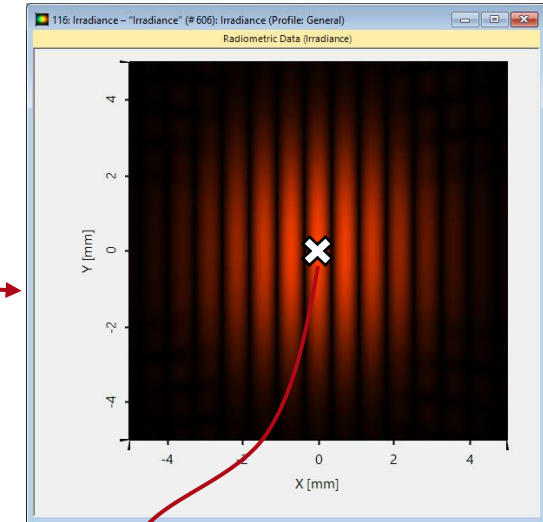
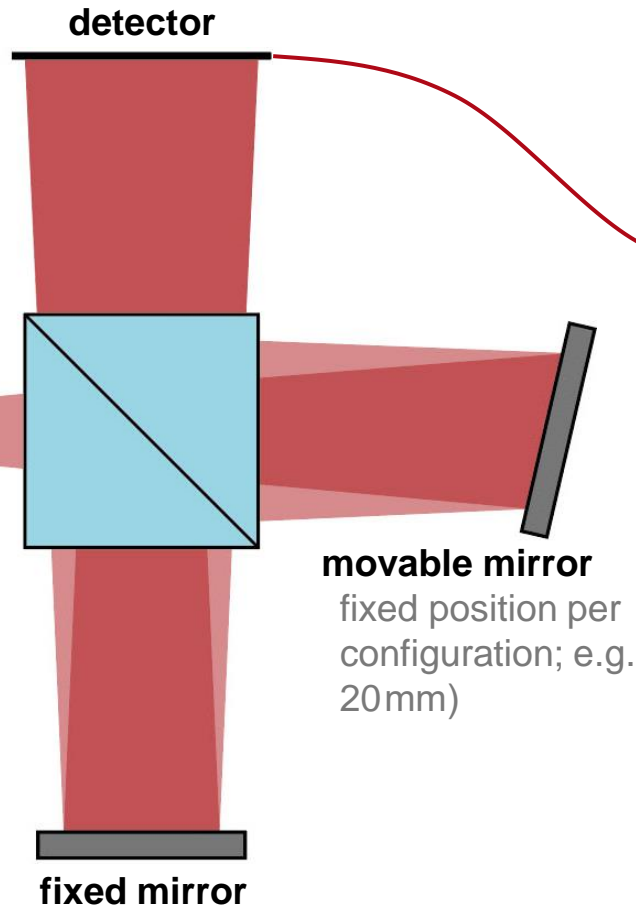


See the full Use Case:
[Coherence Measurement
Using Michelson
Interferometer and Fourier
Transform Spectroscopy](#)

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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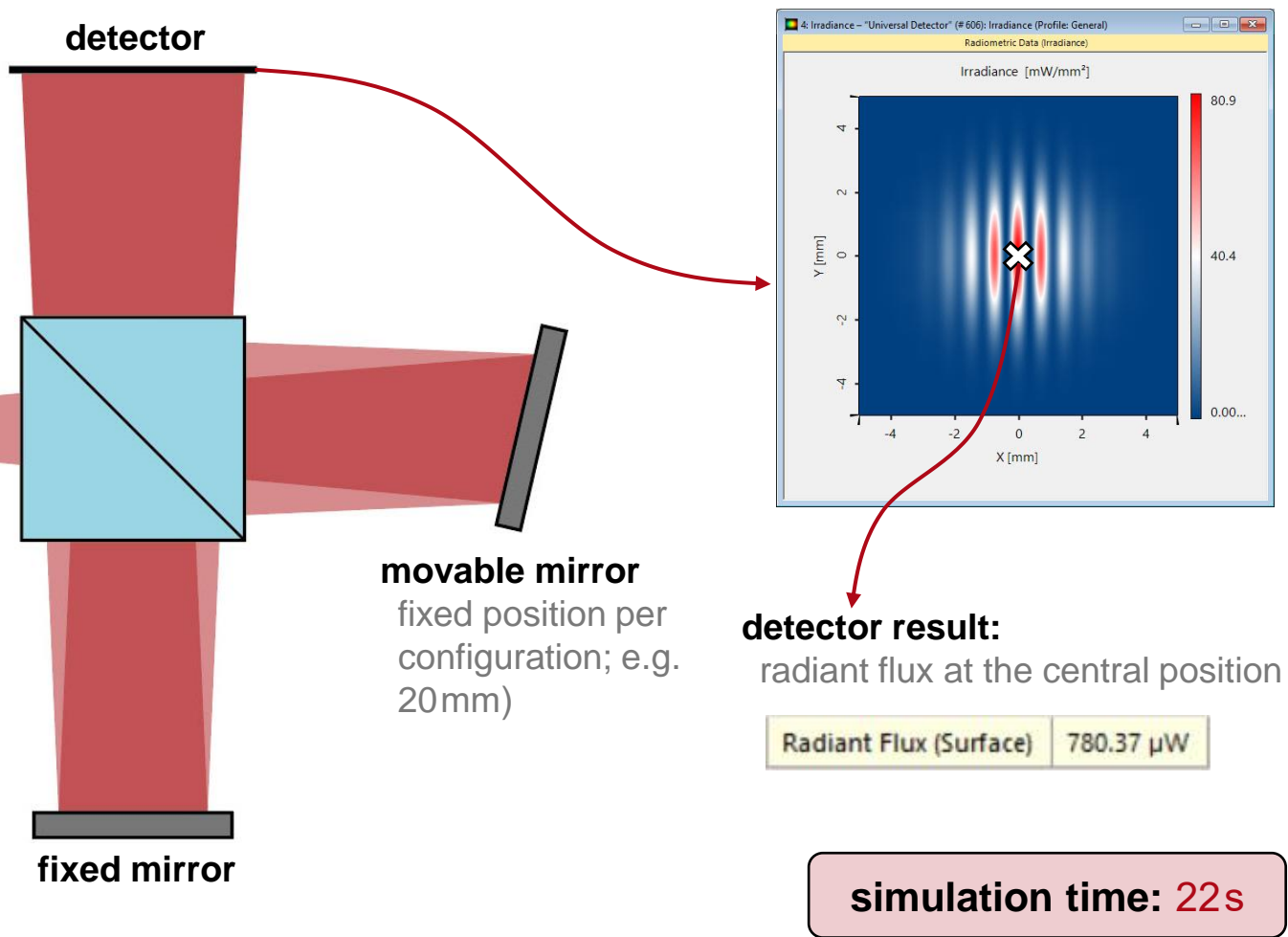
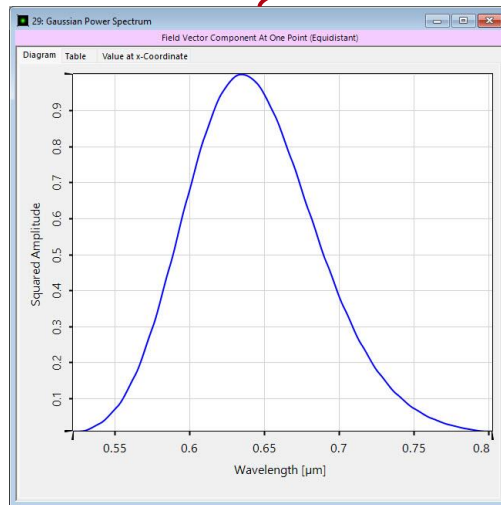
simulation time: 0.9s

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 633nm
- full width at half maximum (FWHM): 100nm

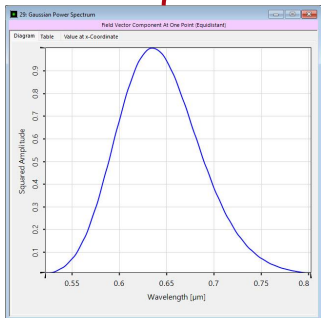


Collection of Elementary Tasks #2: Mirror Positions

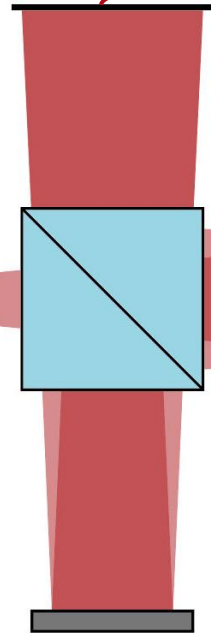
The position of the mirror is varied in 121 steps (e.g. by using a *Parameter Run* document).

white-light source

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



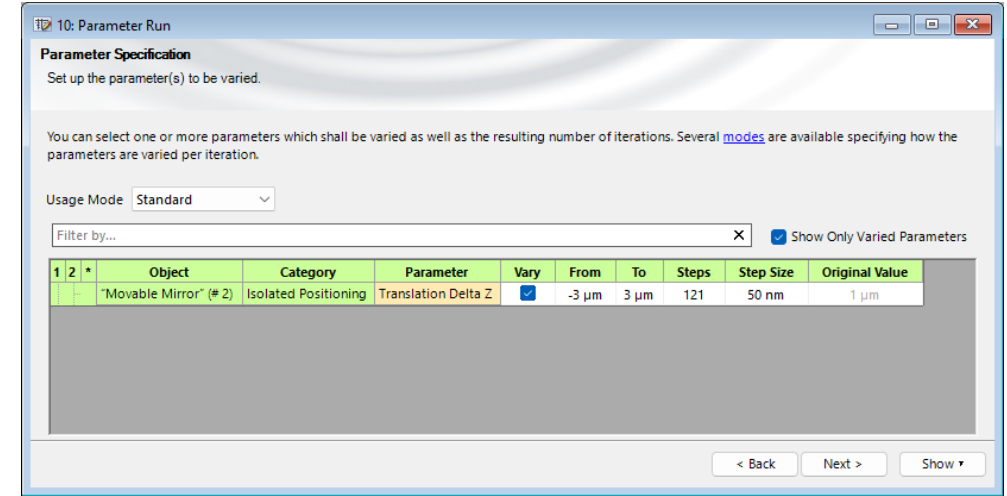
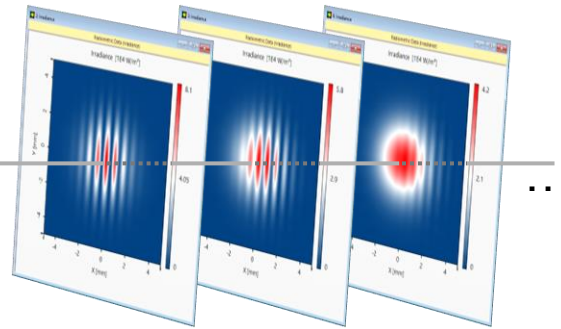
detector



fixed mirror

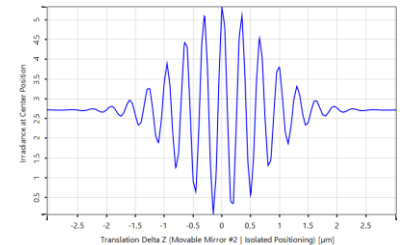
movable mirror

- 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

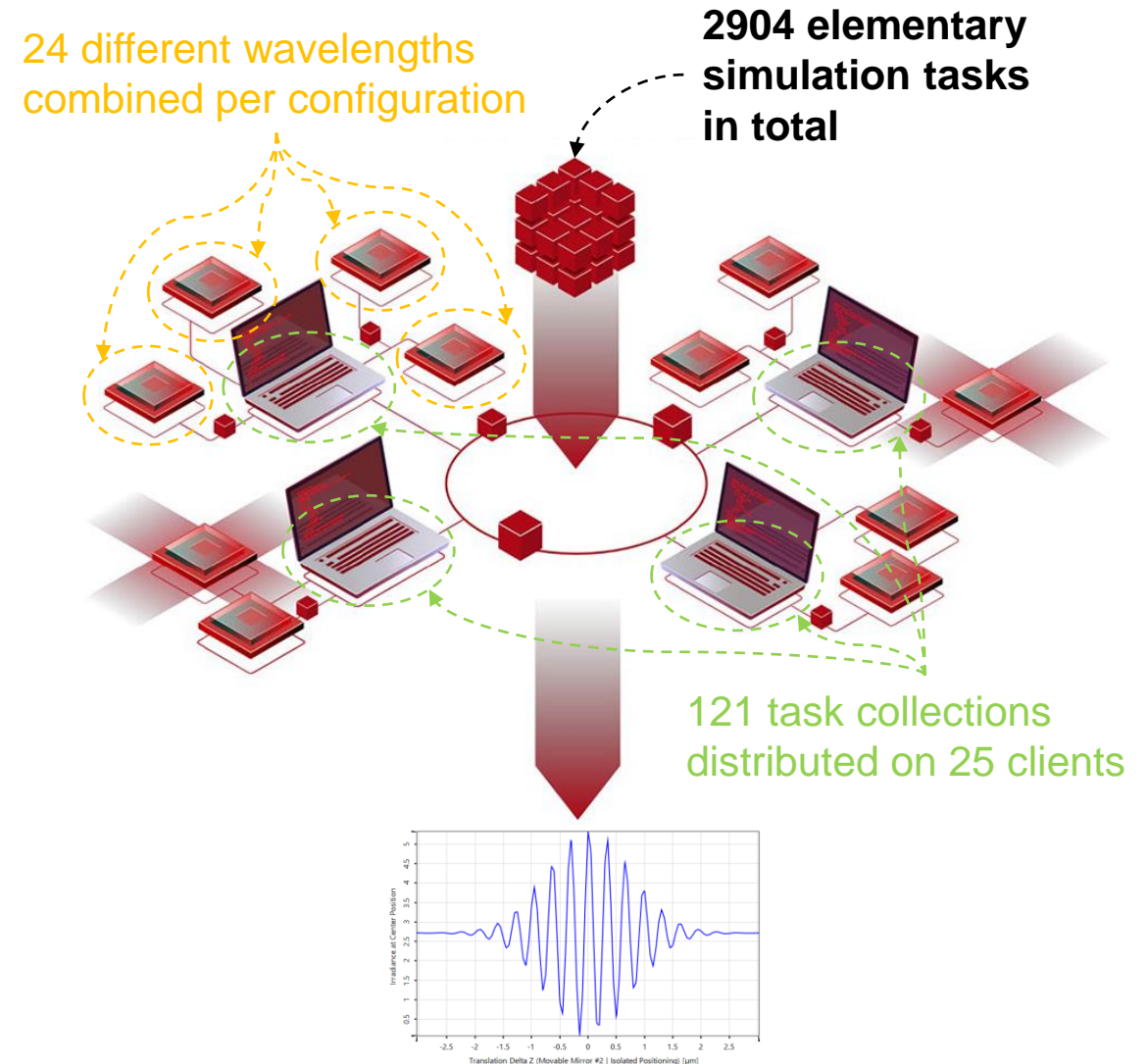
Perform Simulation by Using Distributed Computing

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 diagram illustrates an optical setup for combining elementary tasks of all wavelengths. A **White-Light Source** (0) emits light that passes through an **Ideal Beam Splitter** (1). The light is then split into two paths: one leading to a **Movable Mirror** (2) and another leading to a **Fixed Mirror** (3). The light from both mirrors is recombined and detected by a **Radiant Flux** detector (607). The **White-Light Source** is configured with 11 spectral values, and the **Movable Mirror** is configured to vary its position (Translation Delta Z) over 121 steps.

Edit White-Light Source

Index	Wavelength	Electric Field Strength (Amplitude)	Electric Field Strength (Phase)
1	527.87 nm	102.8 mV/m	0 rad
2	539.55 nm	177.26 mV/m	0 rad
3	551.24 nm	278.67 mV/m	0 rad
4	562.93 nm	403.36 mV/m	0 rad
5	574.62 nm	542.2 mV/m	0 rad
6	586.31 nm	682.09 mV/m	0 rad
7	598 nm	808.6 mV/m	0 rad
8	609.68 nm	908.88 mV/m	0 rad
9	621.37 nm	973.97 mV/m	0 rad
10	633.06 nm	1 V/m	0 rad
11	644.75 nm	988.06 mV/m	0 rad

Parameter Specification

Set up the parameter(s) to be varied.

Usage Mode: Standard

Filter by...

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 μ m	3 μ m	121	50 nm	1 μ m

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 recombined at the detector, automatically.

Using Distributed Computing

The screenshot displays the Wyrowski VirtualLab Fusion 2023.2 (Build 1.242) software interface. The main window is titled "Parameter Run" and shows a "Results" panel on the left and a "Distributed Computing" panel on the right.

Results Panel:

- Buttons: Go!, Refresh, Show Optical Setup, No Logging, Create Output, Delete.
- Execution: After Completion (Do Nothing), Go!
- Document: Refresh, Show Optical Setup.
- Result Table: No Logging, Create Output, Delete.

Distributed Computing Panel:

- Server Tools: Stop Server, Add Clients on Remote Machine, Start File Watcher.
- Clients Table:

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

Number optical setups in queue: 0

Logging: ☐ Disable Logging, Clear

Assistant:

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).

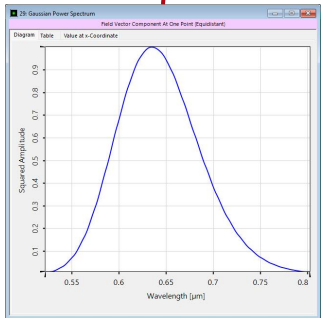
For a more in-depth tutorial on how to set up distributed computing, please see:

[Usage of Distributed Computing](#)

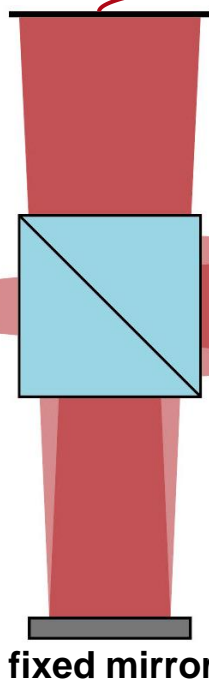
Simulation by Using Distributed Computing

white-light source

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



detector



movable mirror

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

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

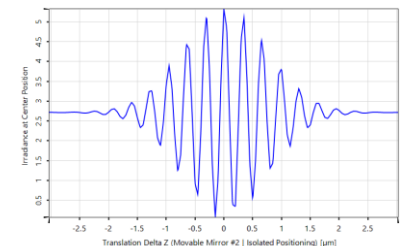
Figure 3: Screenshot of the software interface. The top window is the 'Parameter Run' dialog box, showing the 'Parameter Specification' section with a table of parameters. The bottom window is the 'Distributed Computing' window, showing the 'Server Tools' section with buttons for 'Stop Server', 'Add Clients on Remote Machine', and 'Start File Watcher'. It also shows a table of 'Clients' with columns for Status, Host Machine, Clients, CPU, RAM, Active, and Disconnect.

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

Status	Host Machine	Clients	CPU	RAM	Active	Disconnect
<input checked="" type="checkbox"/>	lt996.lighttrans2.local	(0 of 6)	2 %	34.4 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt998.lighttrans2.local	(0 of 5)	0 %	3.36 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	ws-lt-014.lighttrans2.local	(0 of 4)	26 %	5.87 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt888.lighttrans2.local	(0 of 3)	1 %	8.95 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt999.lighttrans2.local	(0 of 3)	6 %	44.9 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
<input checked="" type="checkbox"/>	lt777.lighttrans2.local	(0 of 4)	8 %	5.1 %	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

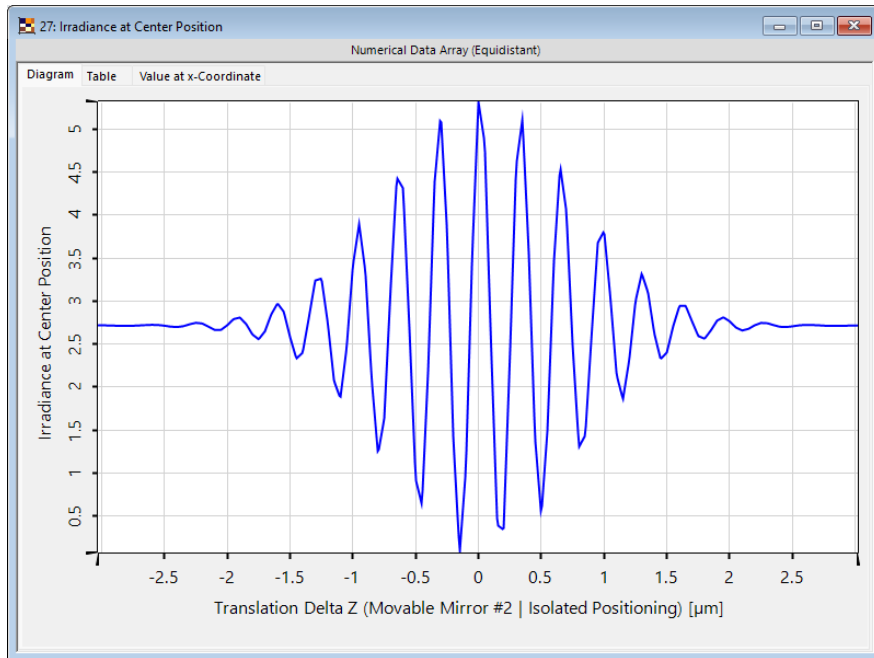
total number
clients: 25
(running on 6
computers)

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
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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>