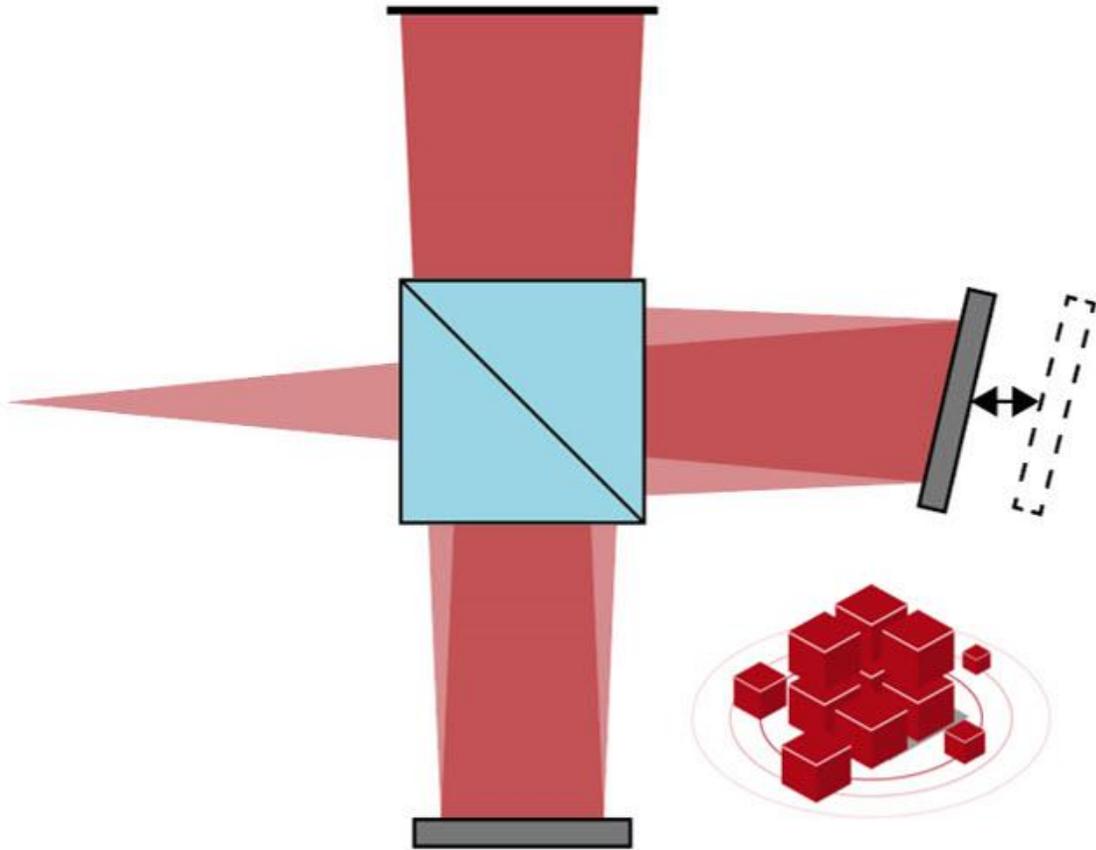


Coherence Measurement with White-Light Interferometry – Analysis Using Distributed Computing in VirtualLab Fusion

Abstract

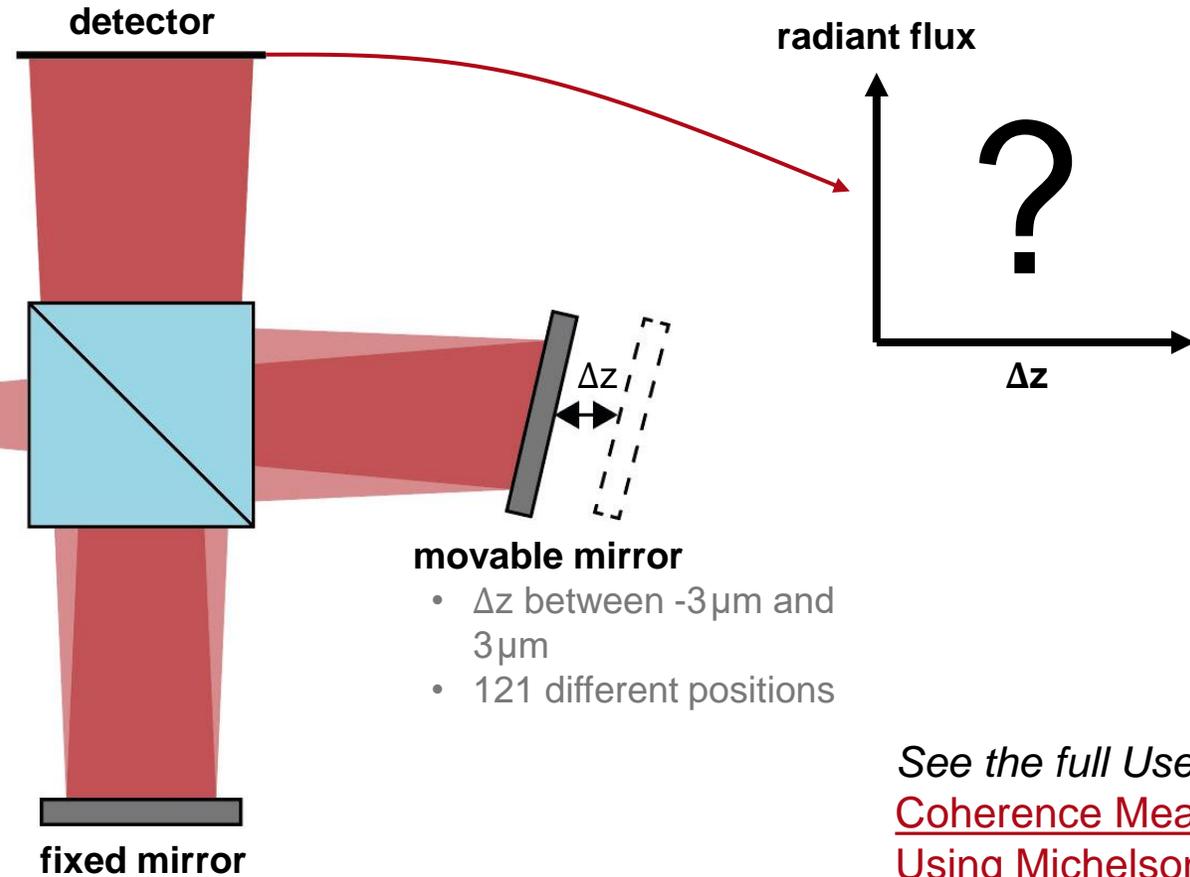
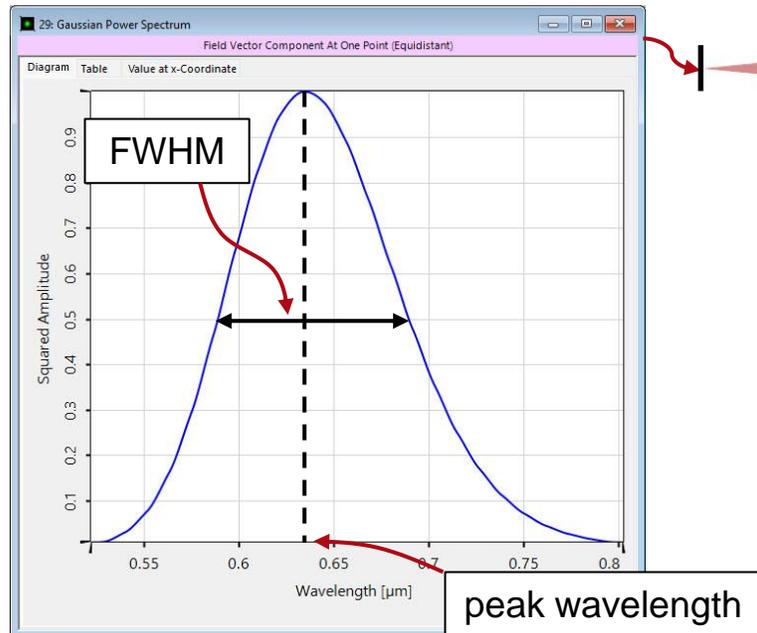


This use case demonstrates the power of distributed computing along the example of the well-known Michelson interferometer. A polychromatic source is combined with a position scan of one of the mirrors of the interferometric setup to perform a detailed coherence measurement. Using distributed computing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

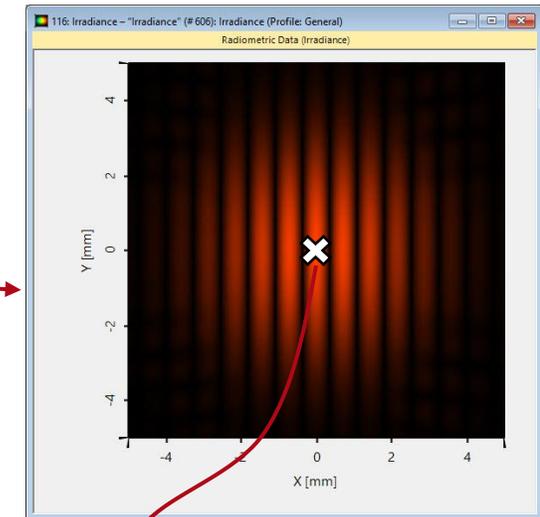
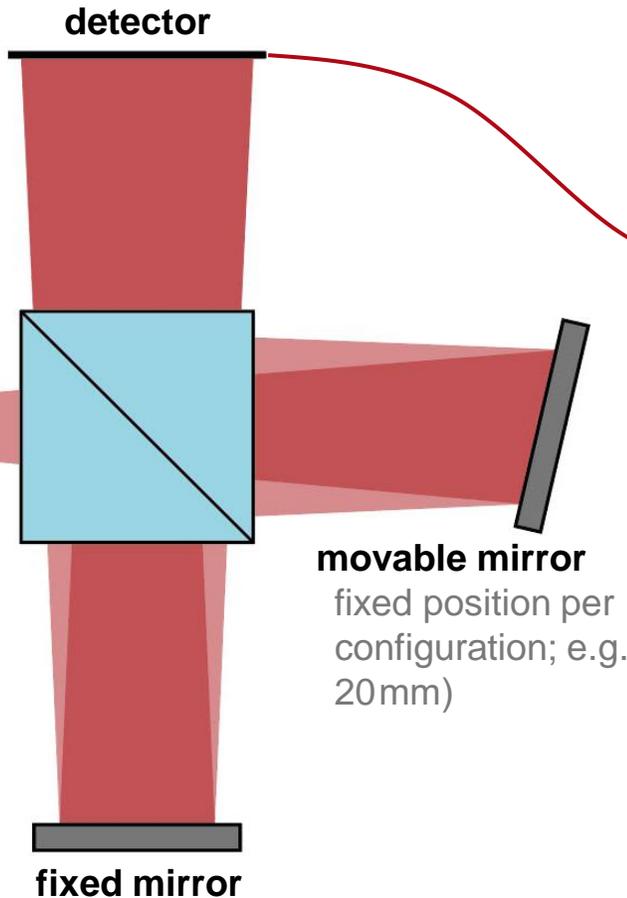


See the full Use Case:
[Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy](#)

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 |
|------------------------|----------------|

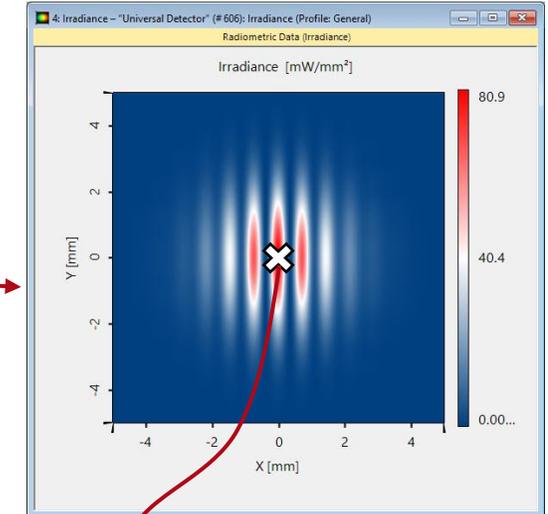
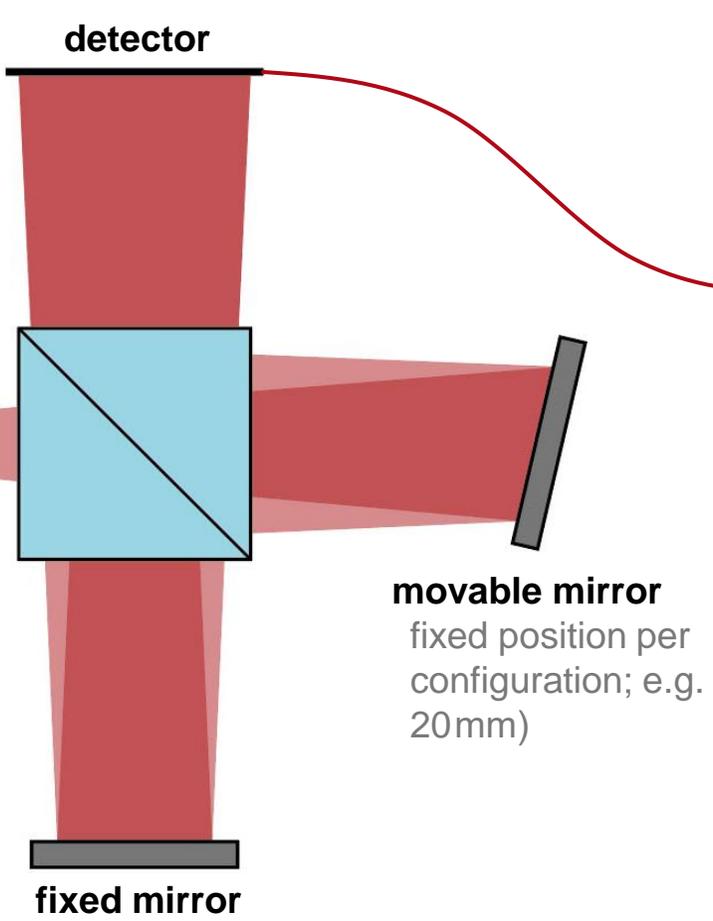
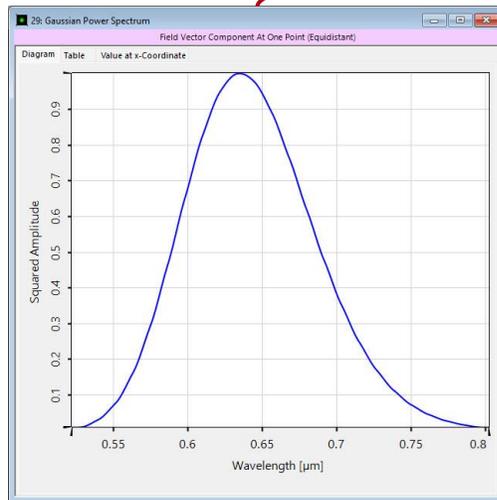
simulation time: 0.9s

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 |
|------------------------|-----------|

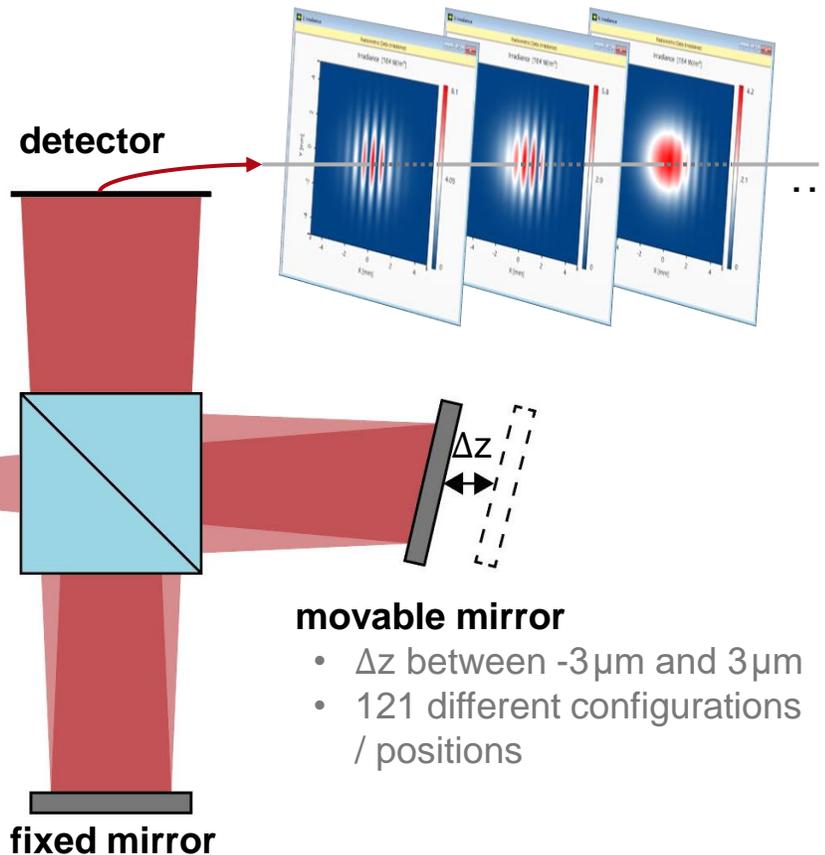
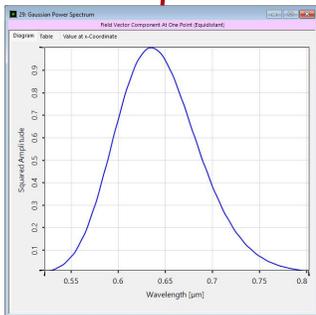
simulation time: 22s

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).

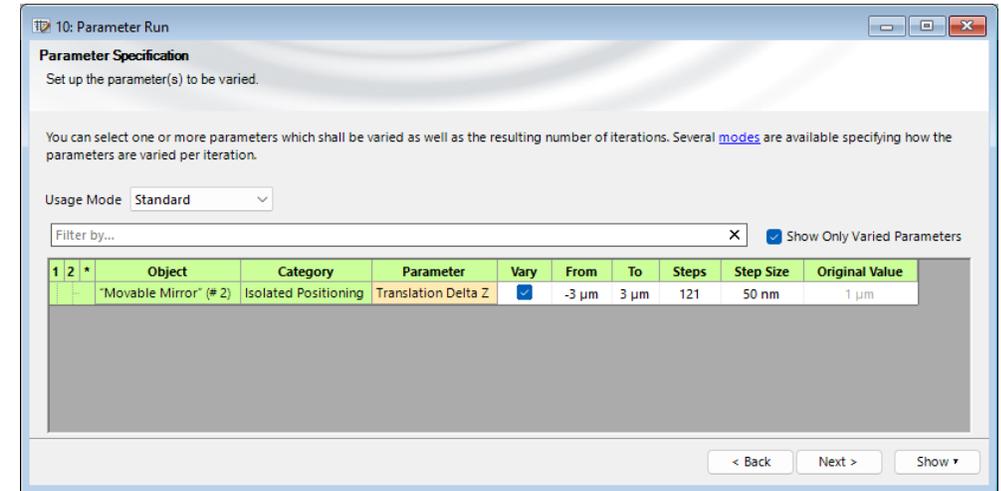
white-light source

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



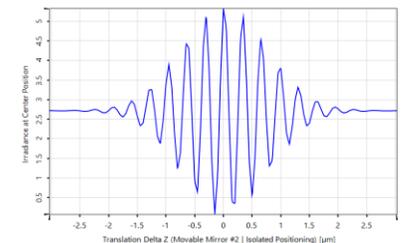
movable mirror

- 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

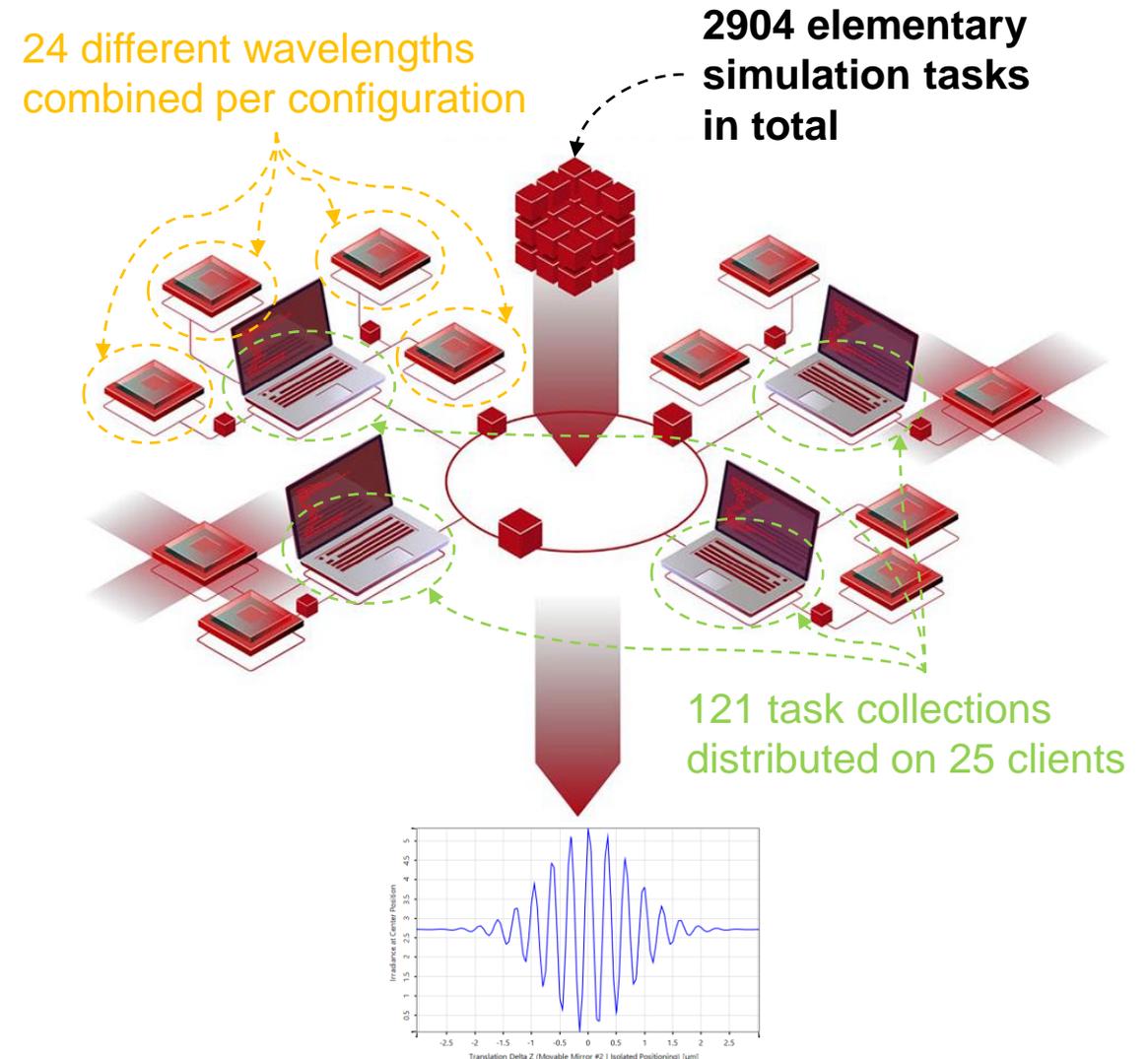
Perform Simulation by Using Distributed Computing

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 the configuration and execution of a white-light source in VirtualLab Fusion. On the left, the 'Edit White-Light Source' dialog shows a table of spectral values. The central diagram illustrates the optical setup: a white-light source (0) is connected to an ideal beam splitter (1), which splits the light into two paths. One path goes to a fixed mirror (3) and the other to a movable mirror (2). The light is then detected by a radiant flux detector (607). On the right, the '10: Parameter Run' window shows the parameter specification for the movable mirror's translation delta Z, which is set to vary from -3 μm to 3 μm in 121 steps.

| 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 |

| 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 |

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 checkbox for "Use Already Calculated Results for Next Run", 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" (Stop Server, Add Clients on Remote Machine, Start File Watcher) and 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).

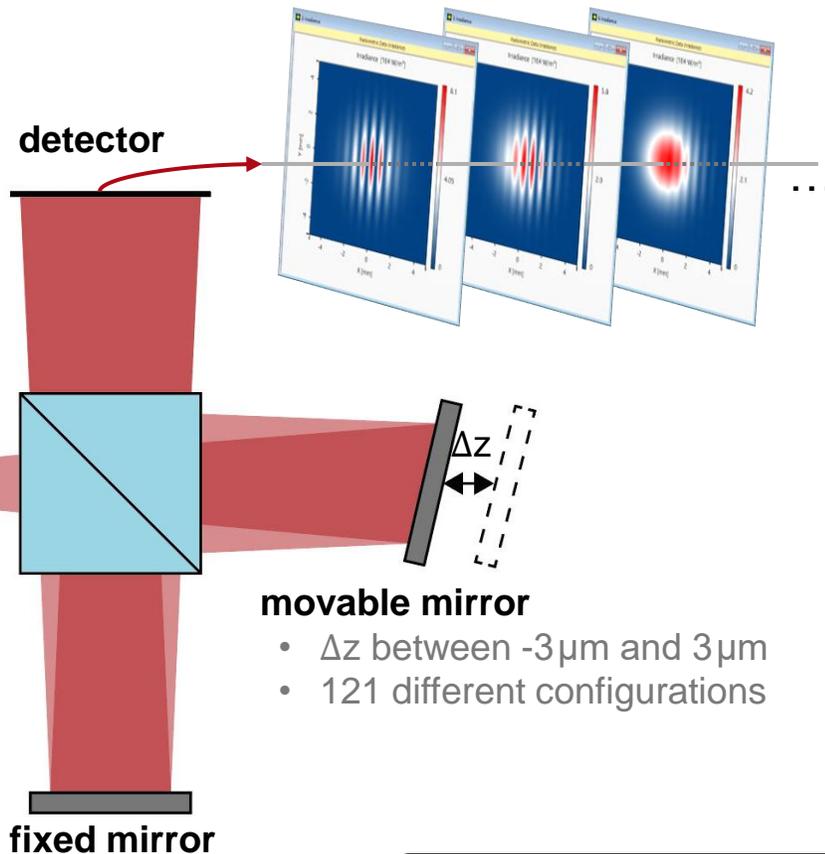
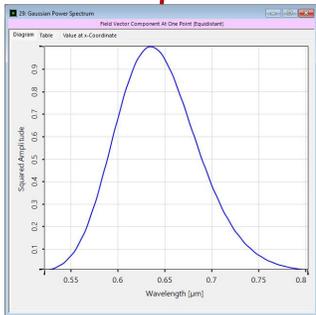
For a more in-depth tutorial on how to set up distributed computing, please see:

[Usage of Distributed Computing](#)

Simulation by Using Distributed Computing

white-light source

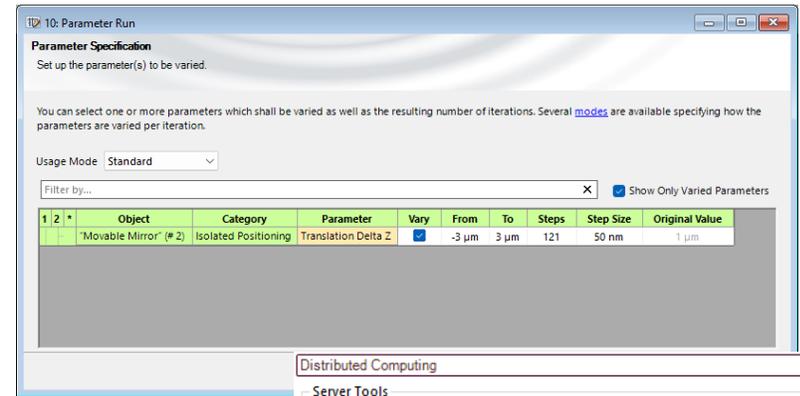
- Gaussian power spectrum (sampled with 24 wavelengths)
- peak wavelength: 633 nm
- full width at half maximum (FWHM): 100 nm



movable mirror

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

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



total number
clients: 25
(running on 6
computers)

Distributed Computing

Server Tools

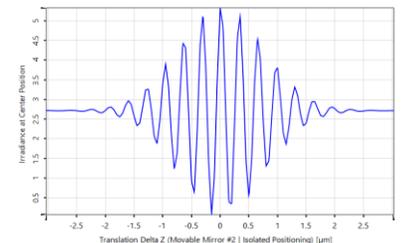
Stop Server Add Clients on Remote Machine Start File Watcher

Calculation on: Local Machine Cloud

Clients

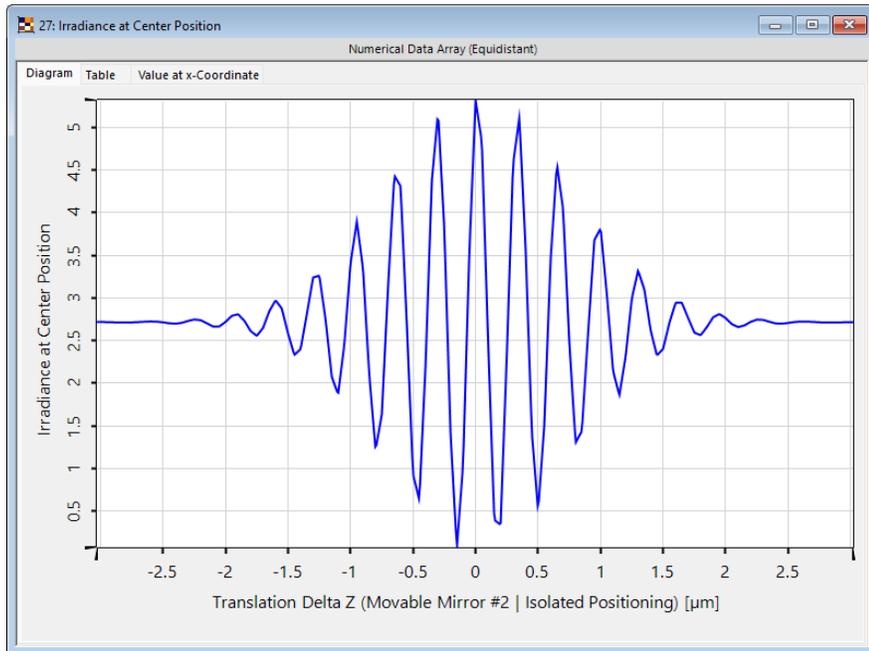
| Status | Host Machine | Clients | CPU | RAM | Active | Disconnect |
|-------------------------------------|------------------------------|----------|------|--------|-------------------------------------|-------------------------------------|
| <input checked="" type="checkbox"/> | lt996.lighthtrans2.local | (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"/> |

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

| | |
|-------------------|---|
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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> |