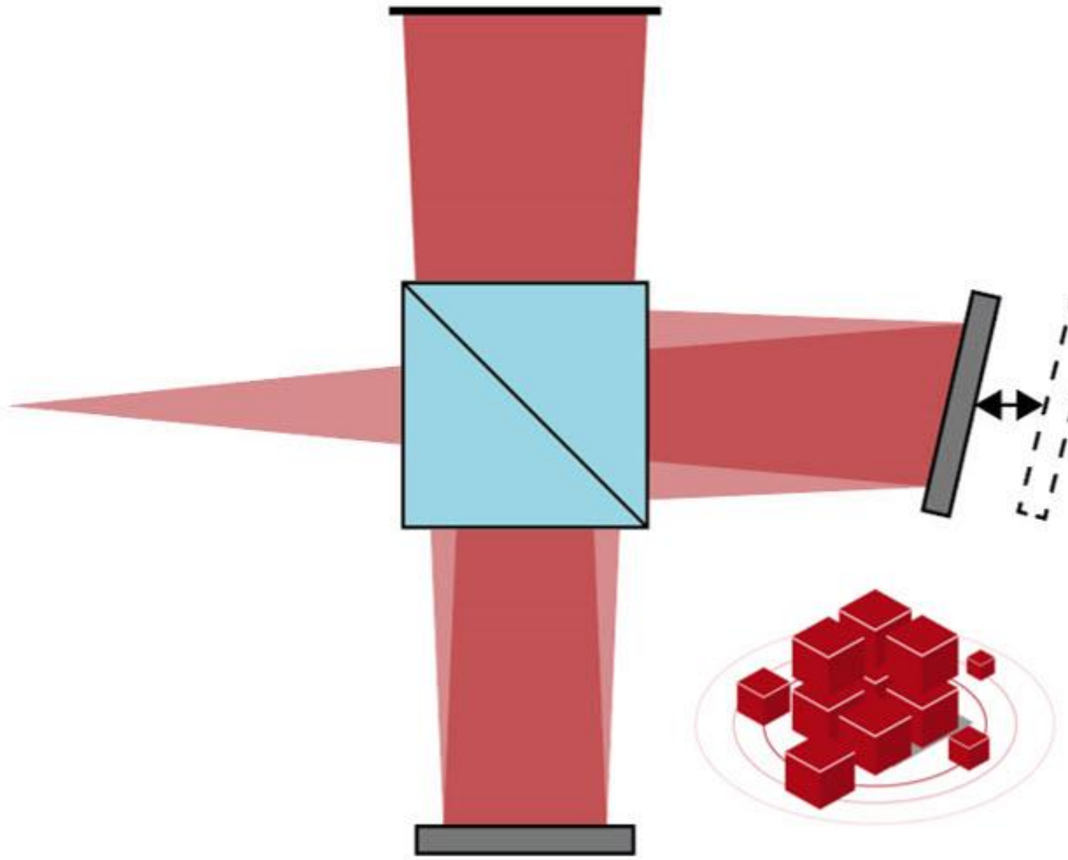
Coherence Measurement with White-Light Interferometry – Analysis Using Distributed Computing in VirtualLab Fusion

Abstract

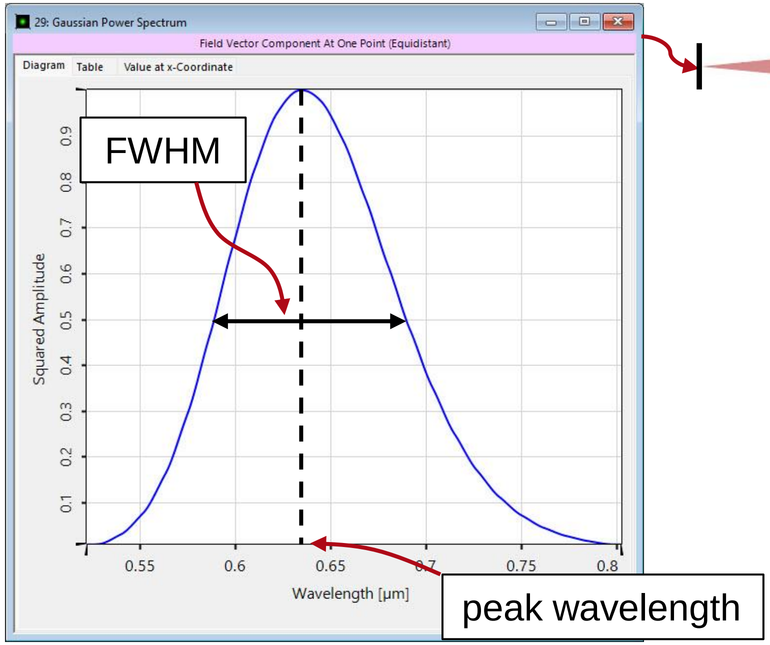


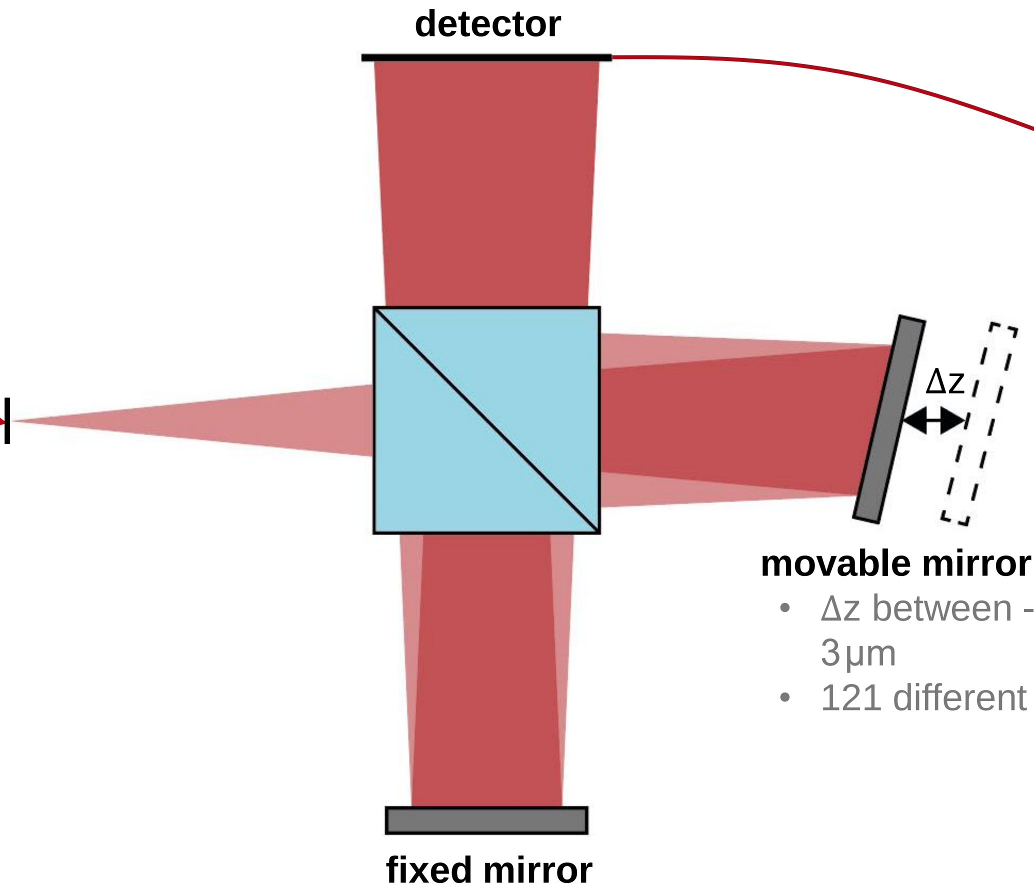
This use case demonstrates the power of distributed computing along the example of the well-known Michelson interferometer. A polychromatic source is combined with a position scan of one of the mirrors of the interferometric setup to perform a detailed coherence measurement. Using distributed computing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

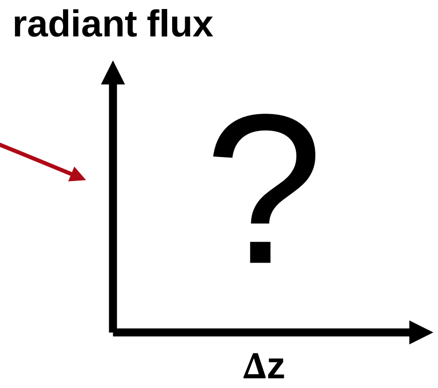
white-light source

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





- Δz between -3 µm and 3 µm
- 121 different positions



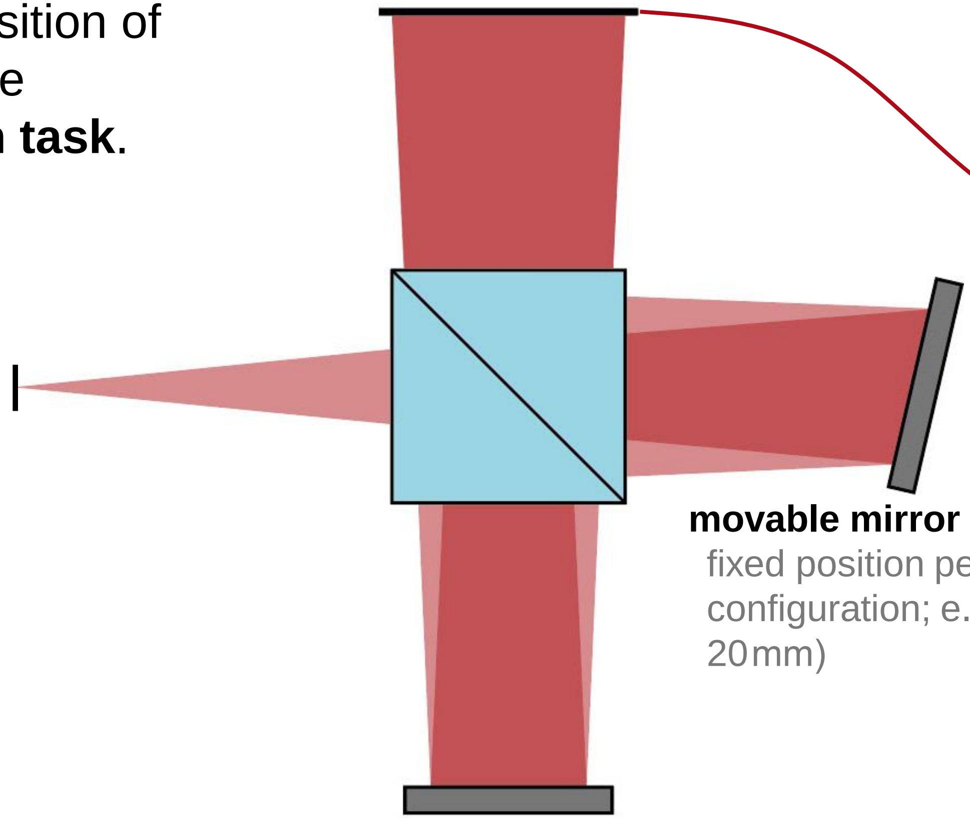
See the full Use Case:
[Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy]

Elementary Simulation Task

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

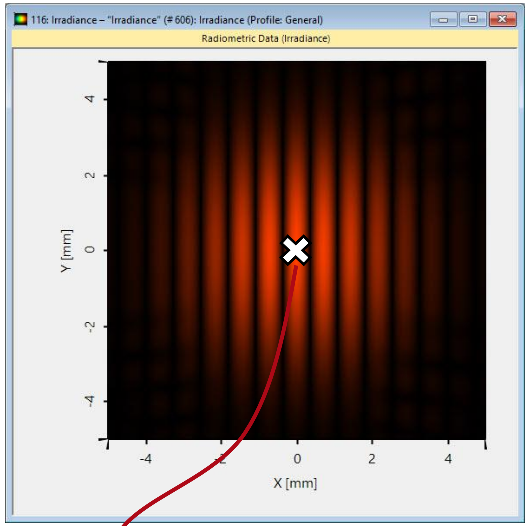
detector

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



movable mirror
fixed position per configuration; e.g. 20 mm)

fixed mirror



detector result:
radiant flux at the central position

Radiant Flux (Surface)	777.16 µW

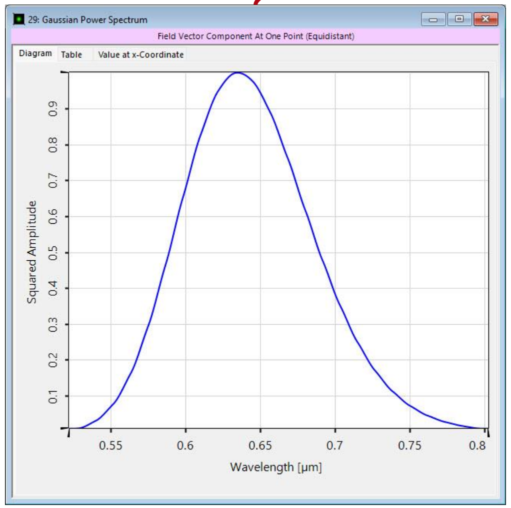
simulation time: 0.9 s

Collection of Elementary Tasks #1: Wavelengths

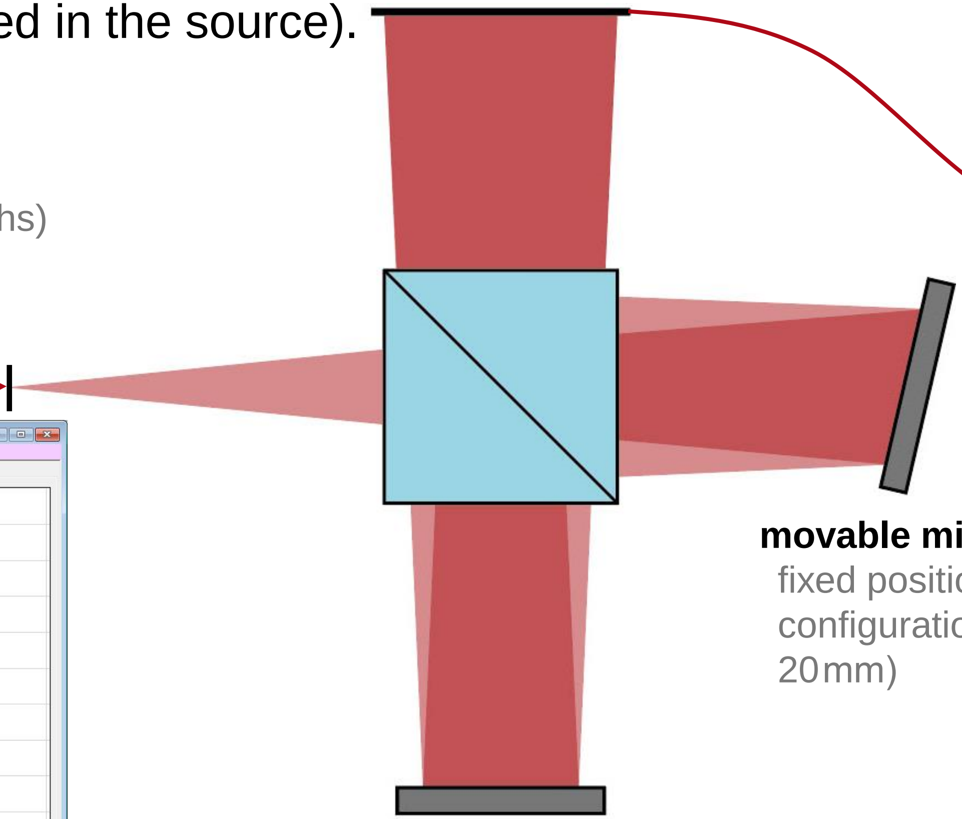
The bandwidth is modeled by using 24 wavelengths (e.g. defined in the source).

white-light source

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

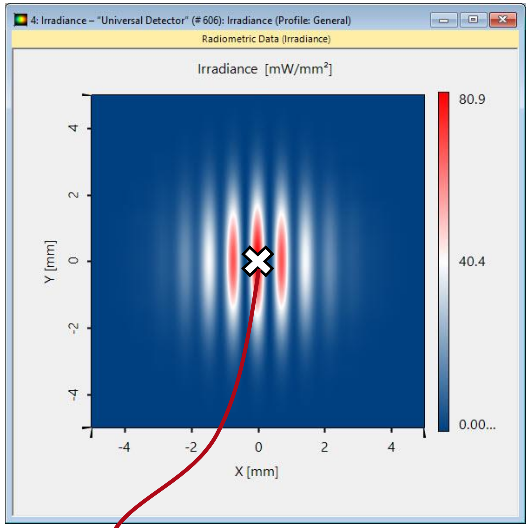


detector



movable mirror
fixed position per configuration; e.g. 20 mm)

fixed mirror



detector result:
radiant flux at the central position

Radiant Flux (Surface)	780.37 µW

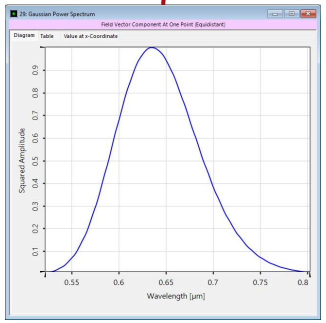
simulation time: 22 s

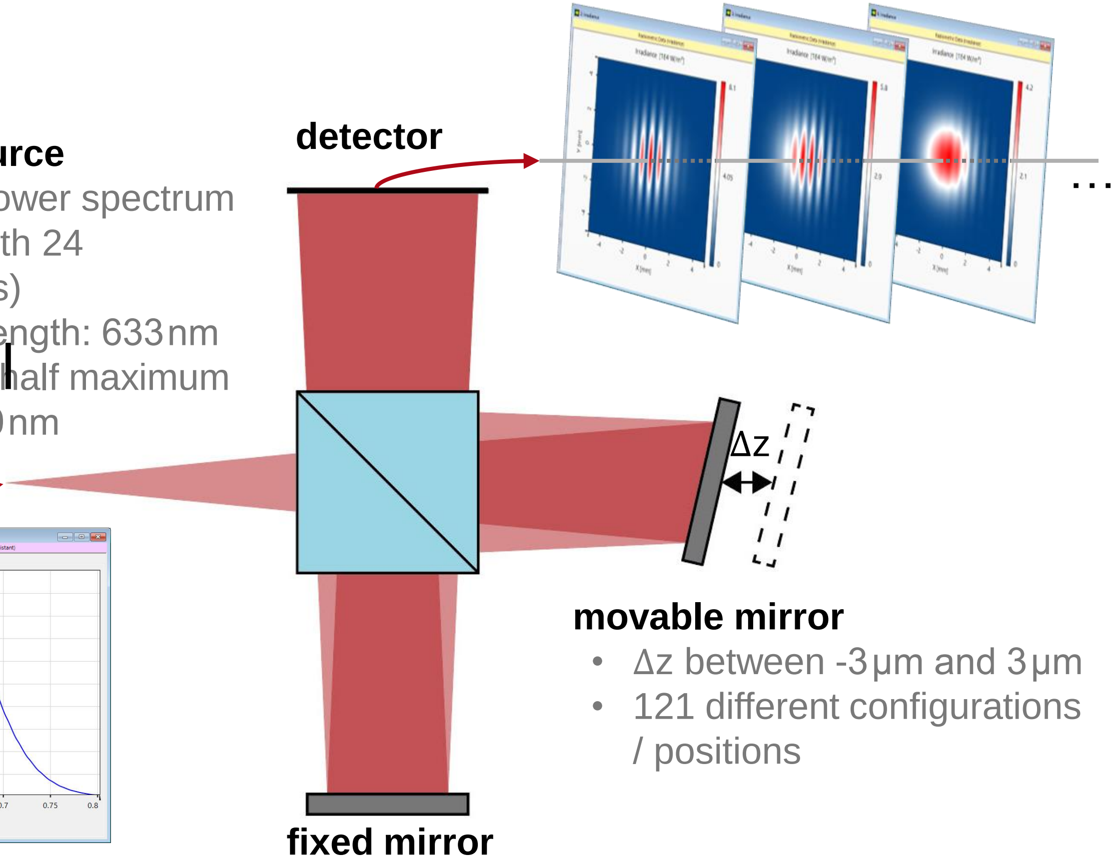
Collection of Elementary Tasks #2: Mirror Positions

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

white-light source

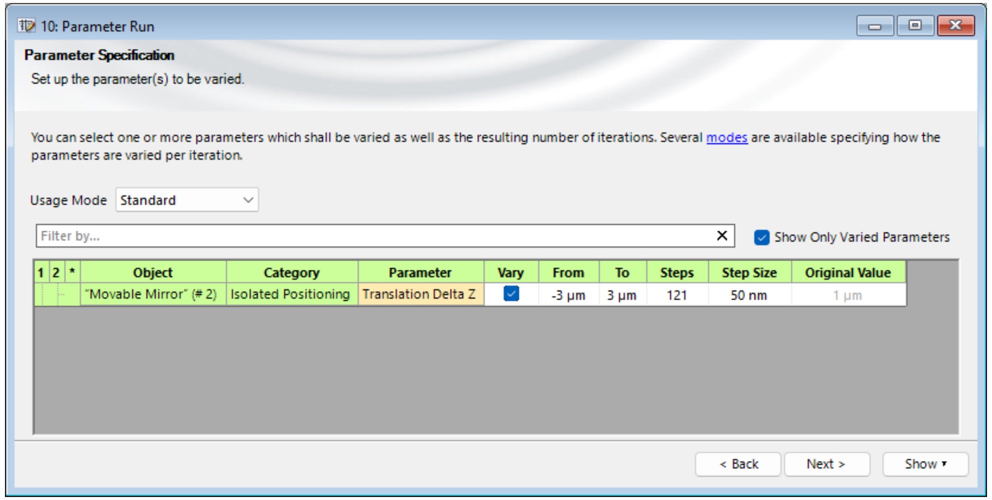
- Gaussian power spectrum (sampled with 24 wavelengths)
- peak wavelength: 633 nm
- full width at half maximum (FWHM): 50 nm



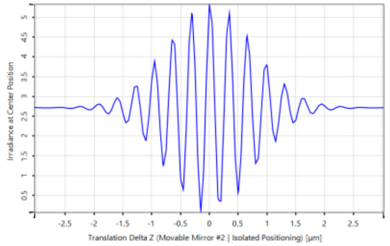


movable mirror

- Δz between -3 µm and 3 µm
- 121 different configurations / positions



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



simulation time (2904 simulations): 46 min 55 s

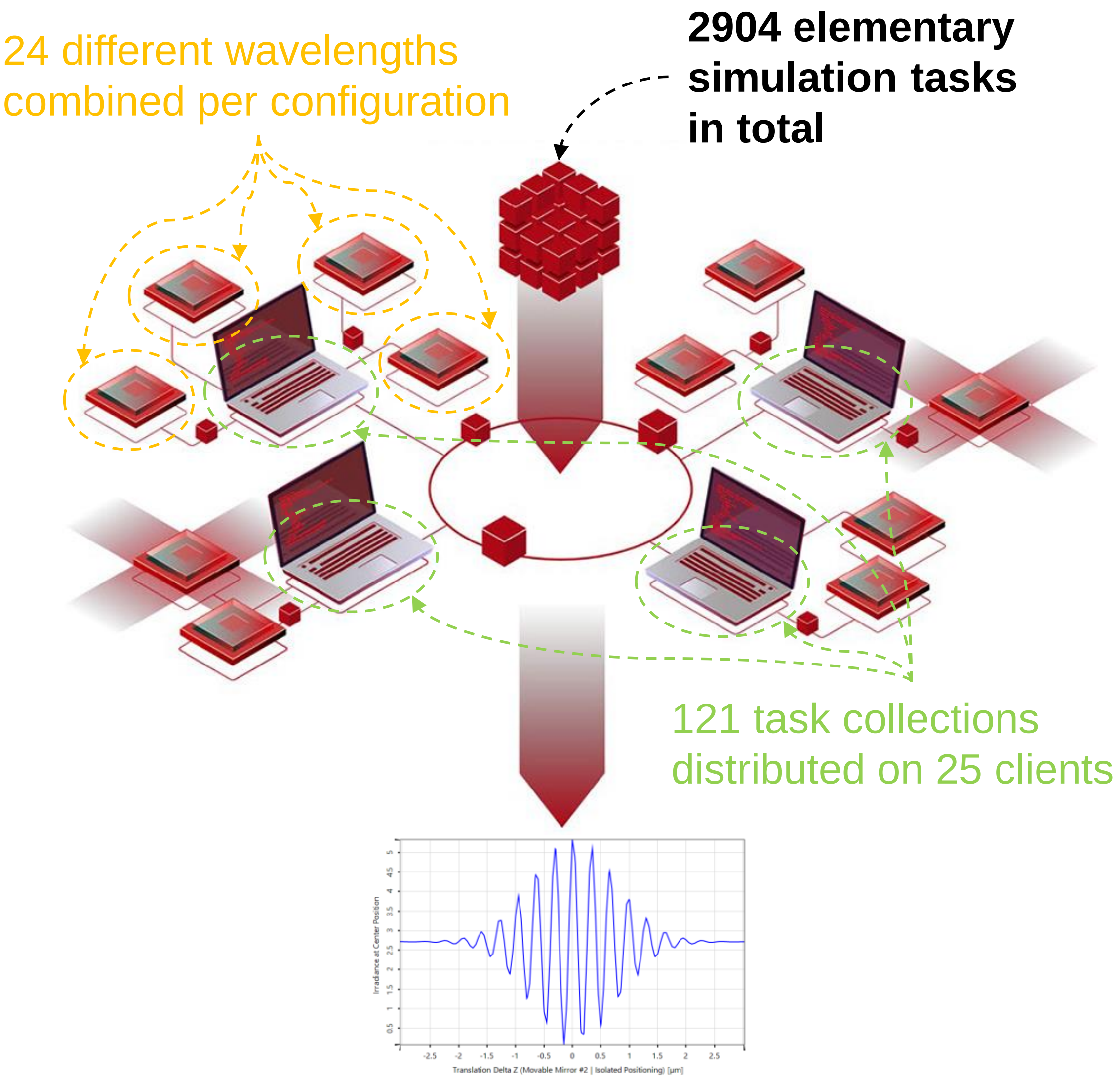
Perform Simulation by Using Distributed Computing

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

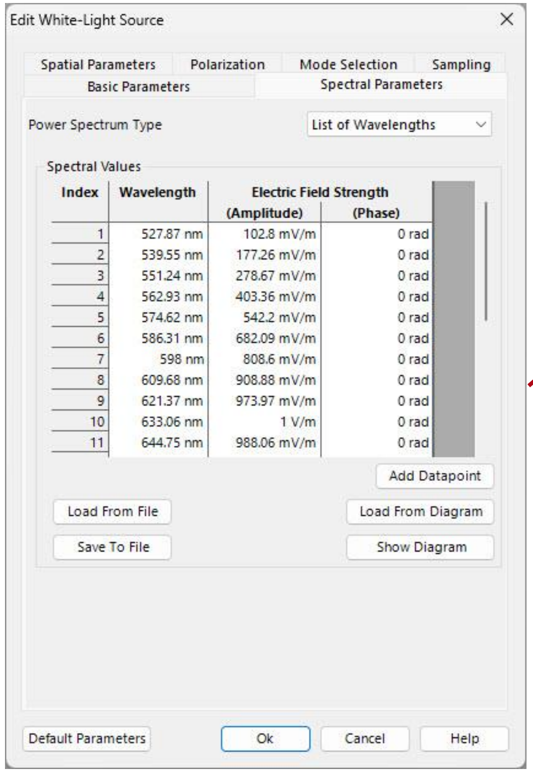
- 24 wavelength samples in spectrum
- 121 different mirror positions

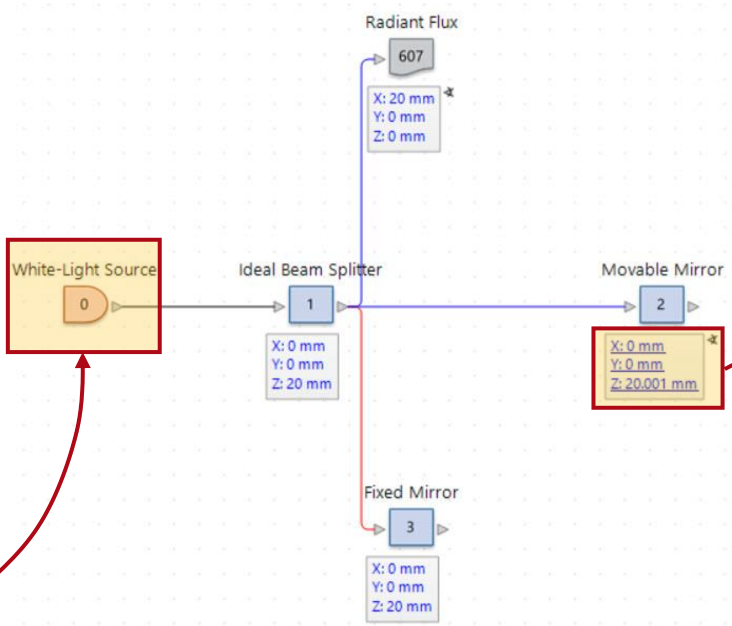
➔ **in total 2904 elementary simulation tasks**

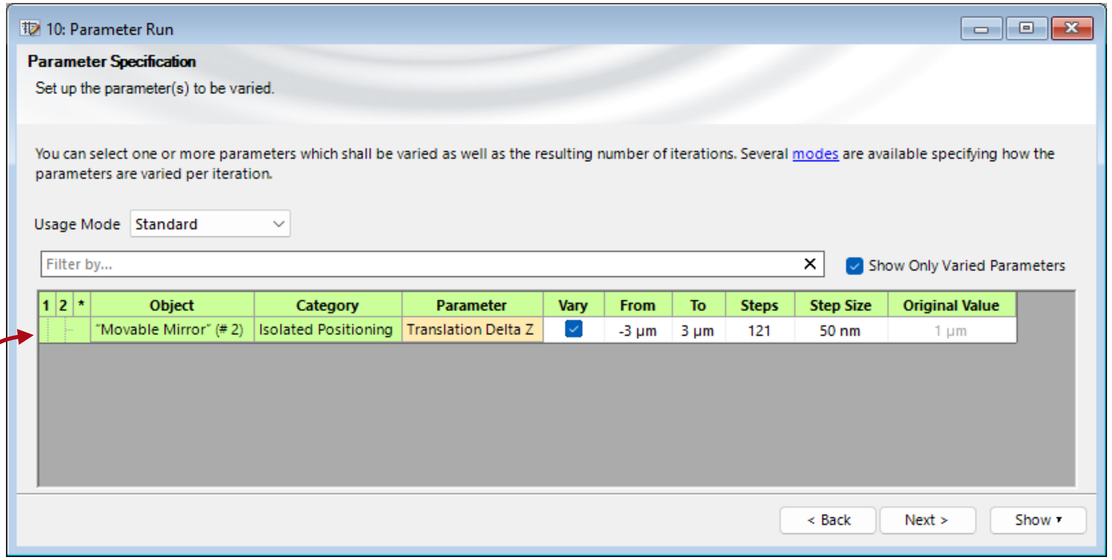
Since a single elementary simulation (single wavelength and mirror position) takes only about 0.9 seconds, it is more efficient to combine some of the elementary simulations and simulate the collections on the DC clients. Hence, all wavelengths are combined in a single simulation (spectrum configured 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

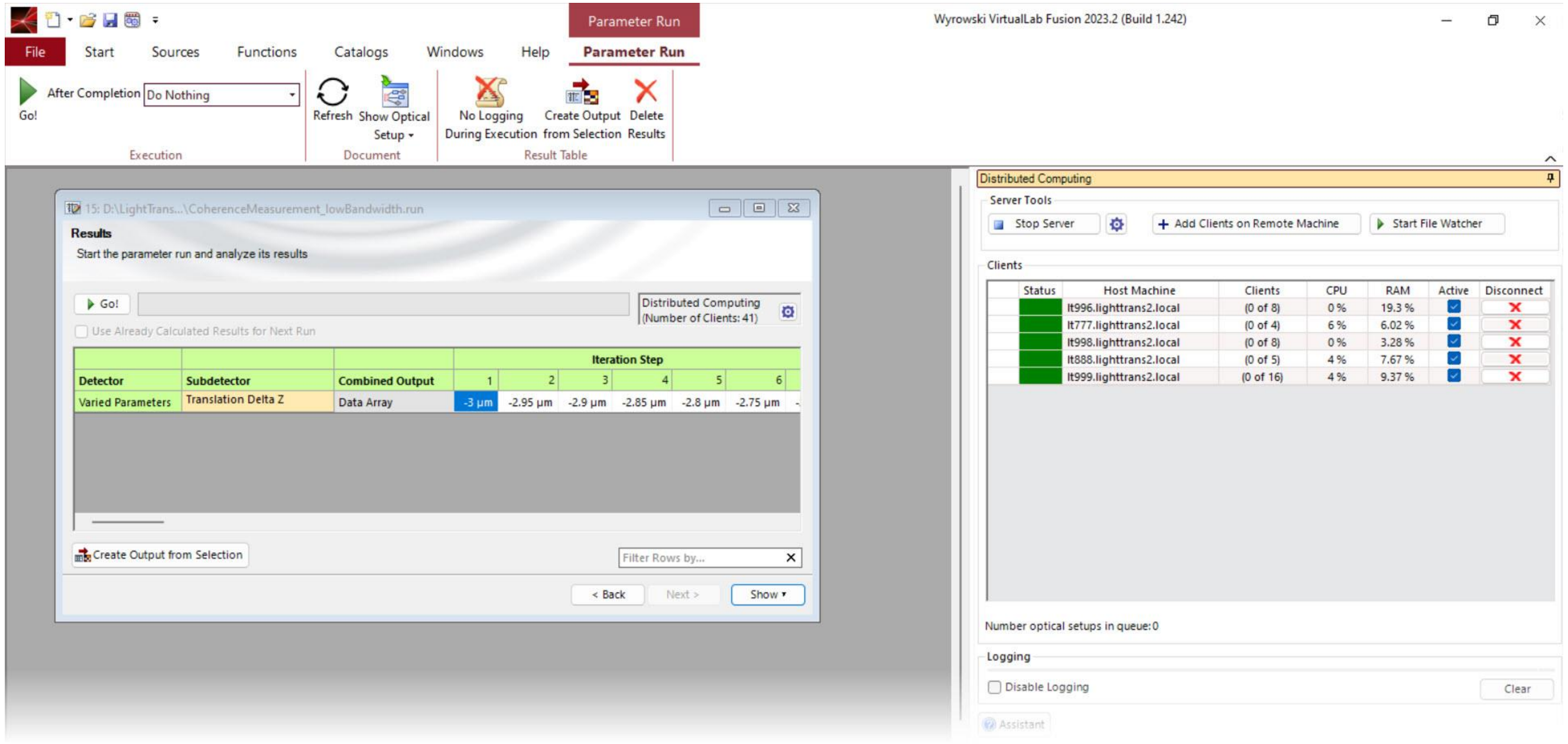






Using VirtualLab Fusion's flexible source model, all 24 wavelengths are combined into one spectrum and configured in the source. Hence, for each configuration (here: mirror position), all wavelength modes are propagated and re-combined at the detector, automatically.

Using Distributed Computing

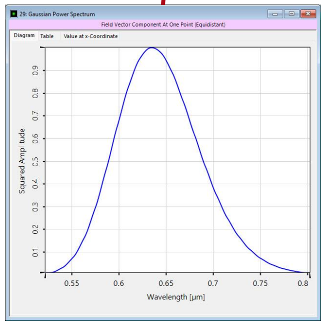


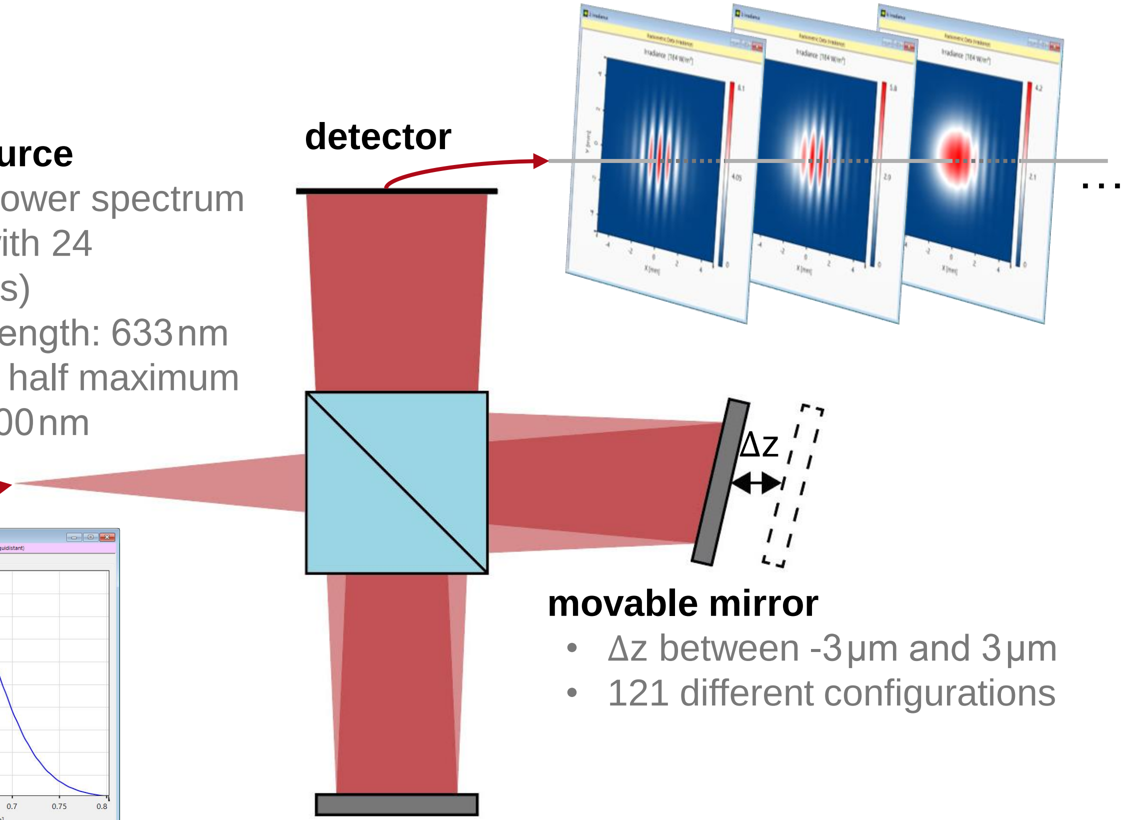
A *Parameter Run* is used to vary the mirror position, which allows the various iterations to be distributed to computers in the network. In order to enable *Distributed Computing*, simply navigate to the corresponding tab and configure the number of computers and clients available. Then start the simulation 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

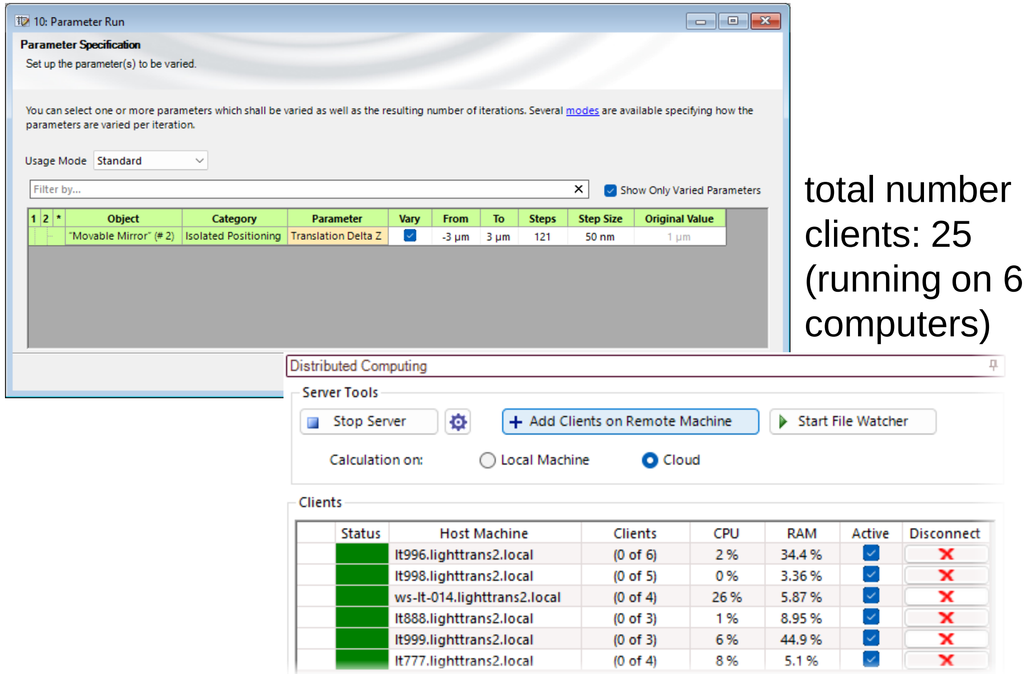
Simulation by Using Distributed Computing

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



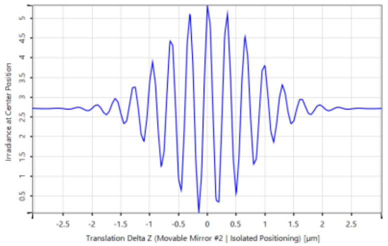


movable mirror
- Δz between -3 µm and 3 µm
- 121 different configurations



total number clients: 25 (running on 6 computers)

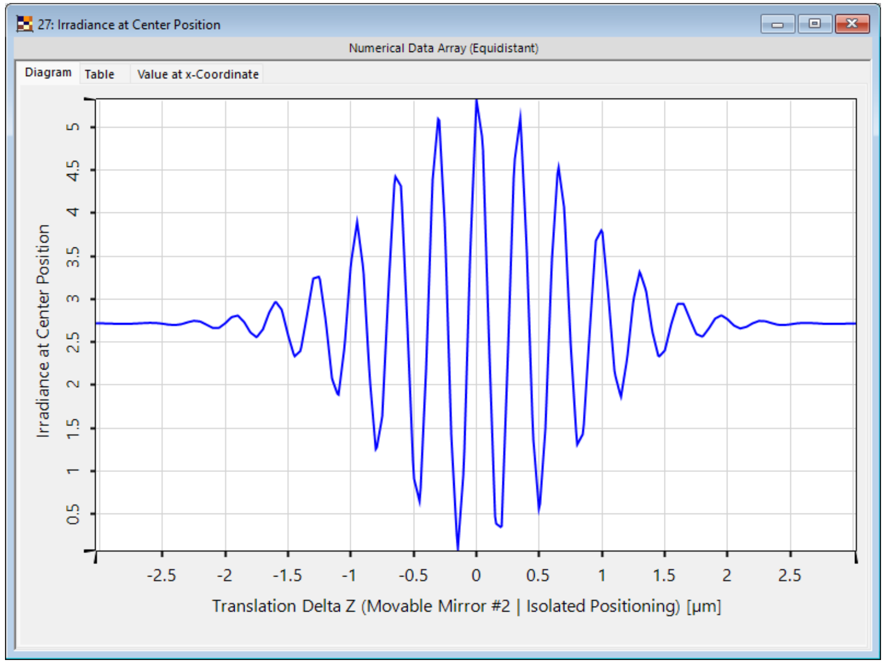
simulation result:
irradiance value at central position for different distance values



simulation time (2904 simulations): 2 min 50 s

Comparison of Simulation Times

simulation result



simulation time

elementary simulation	~0.9 s	
collection of elementary simulations (2904) on a single computer	46 min 55 s	(100%)
collection of elementary simulations (2904) via distributed computing (25 clients on 6 computers)	**2 min 50 s**	**(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	• Simulation of a Test Image in an AR Waveguide Using Distributed Computing • Usage of Distributed Computing • Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy