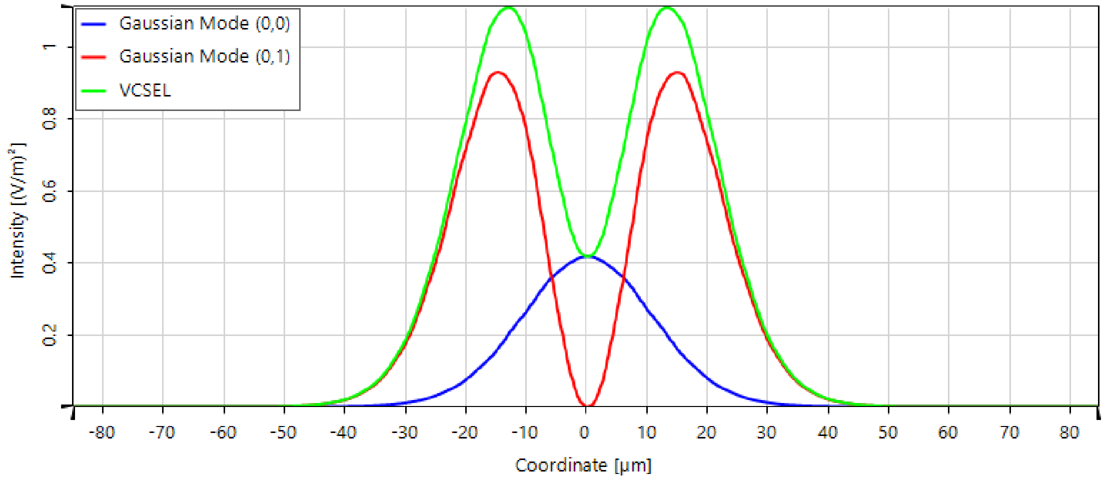
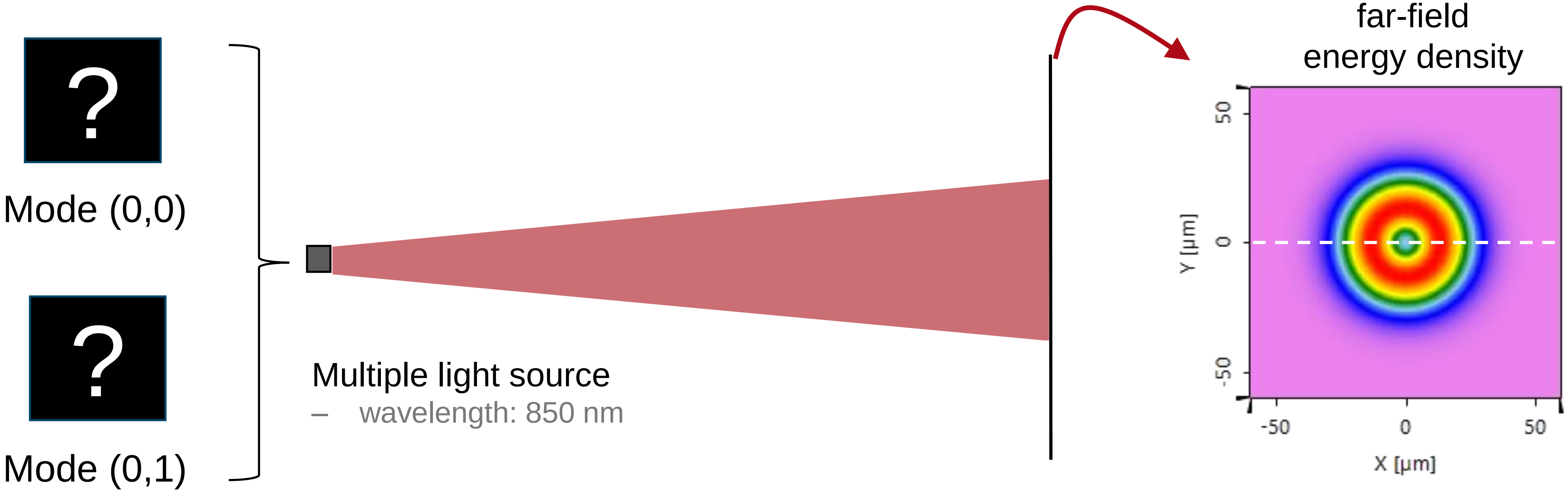
Modeling of VCSEL Source by Two Uncorrelated Laguerre-Gaussian Modes

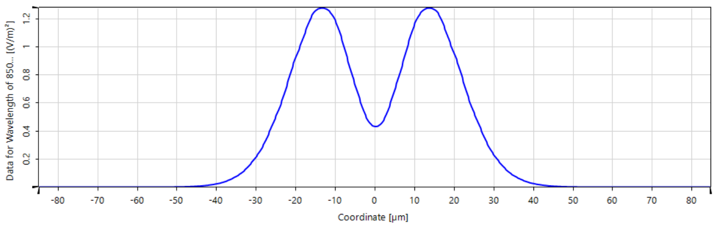
Abstract



Vertical cavity surface emitting laser (VCSEL) diodes are of interest for numerous applications, such as optical sensors and pattern generators. In order to be able to investigate these kinds of setups in VirtualLab Fusion, an appropriate source model is required. In this use case, we demonstrated how to achieve the desired intensity distribution of a specific VCSEL source via parametric optimization of two uncorrelated Gaussian modes with the help of the multiple light source.

Simulation Task

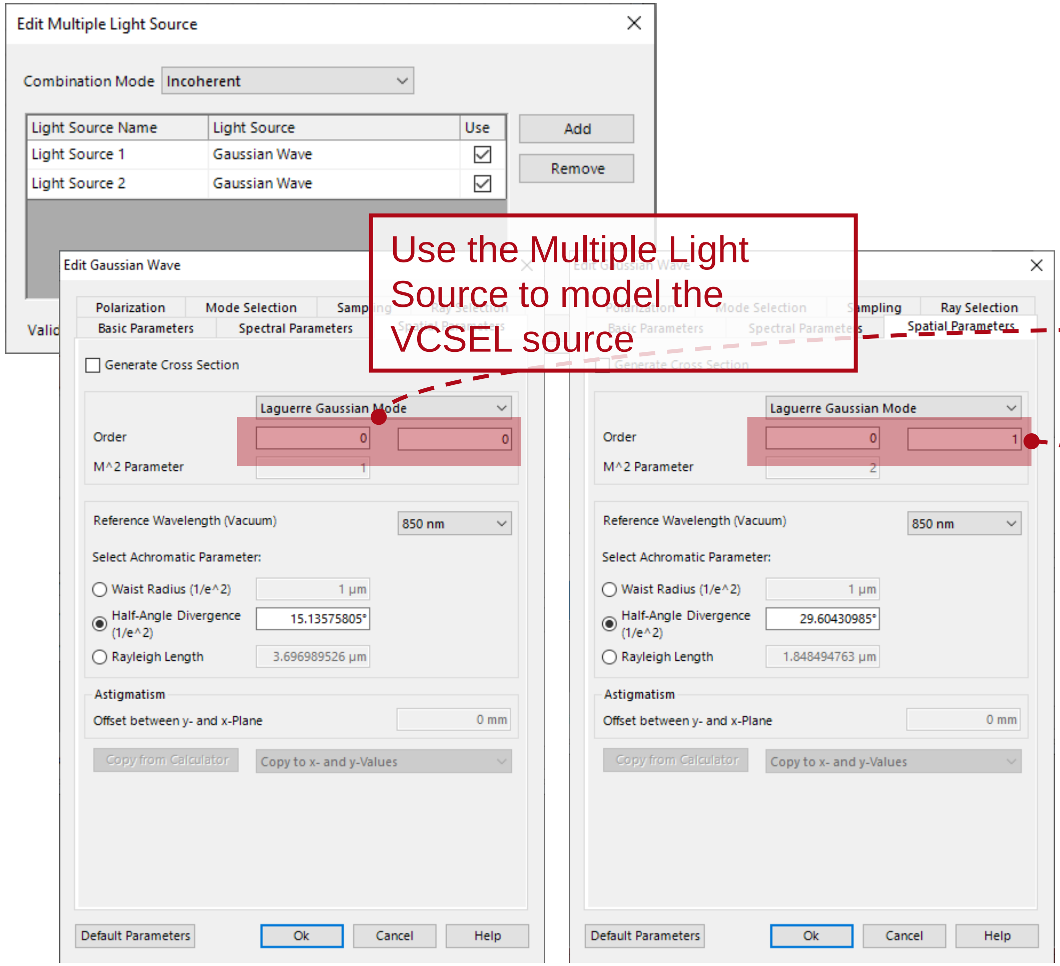




How to determine the parameters of both modes to achieve the desired far-field energy density?

Laguerre-Gaussian Modes for VCSEL Source Modeling

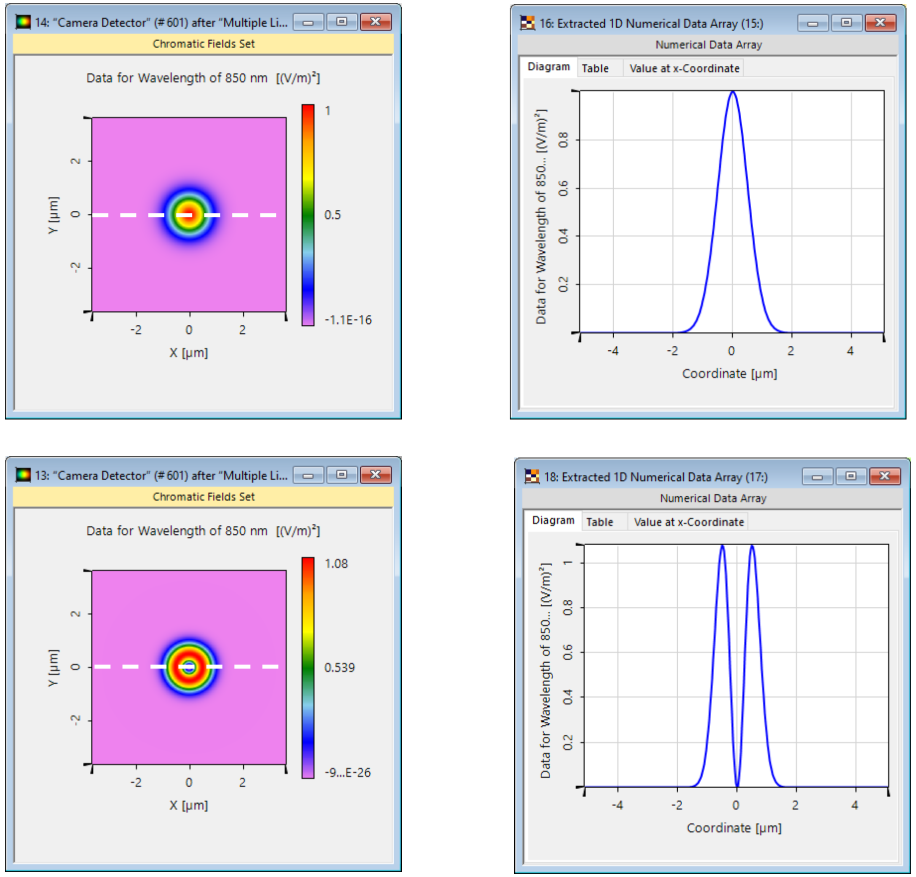
Two Laguerre-Gaussian modes (0,0) and (0,1) are used to model the VCSEL source.



Use the Multiple Light Source to model the VCSEL source

Mode 0,0

Mode 0,1

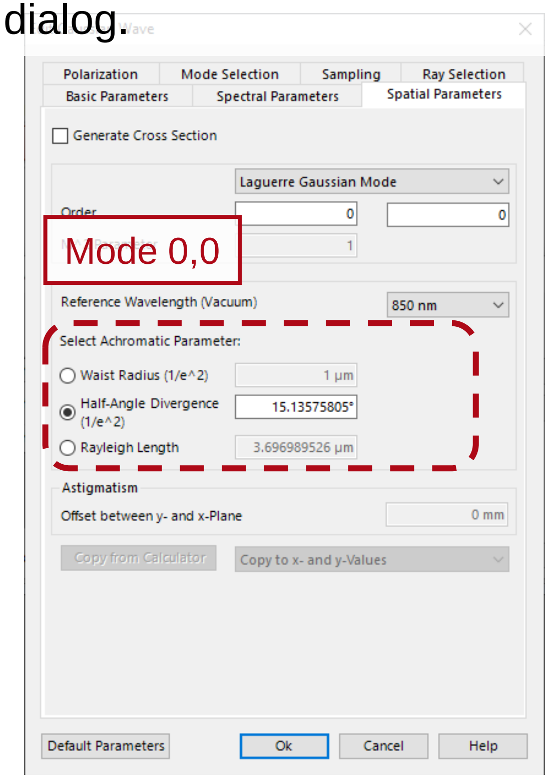


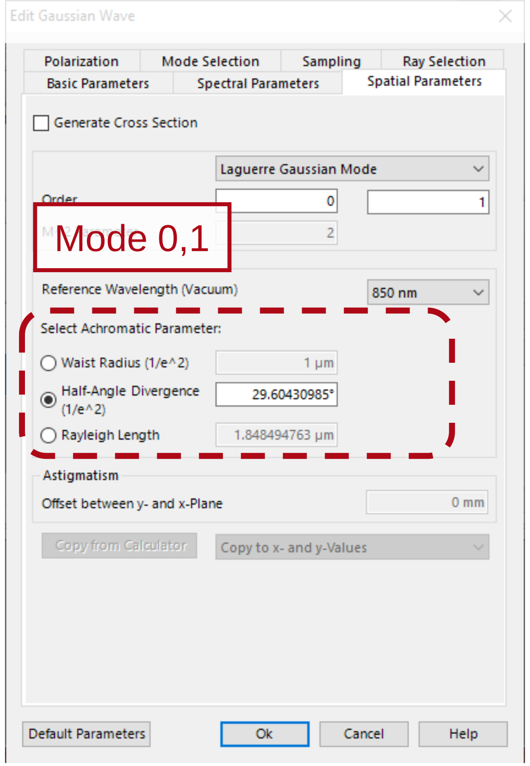
Variable Parameters of Laguerre-Gaussian Modes

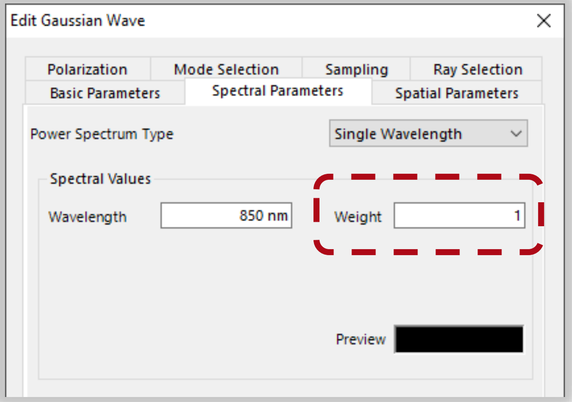
The following parameters can be set as the variables for the parametric optimization:

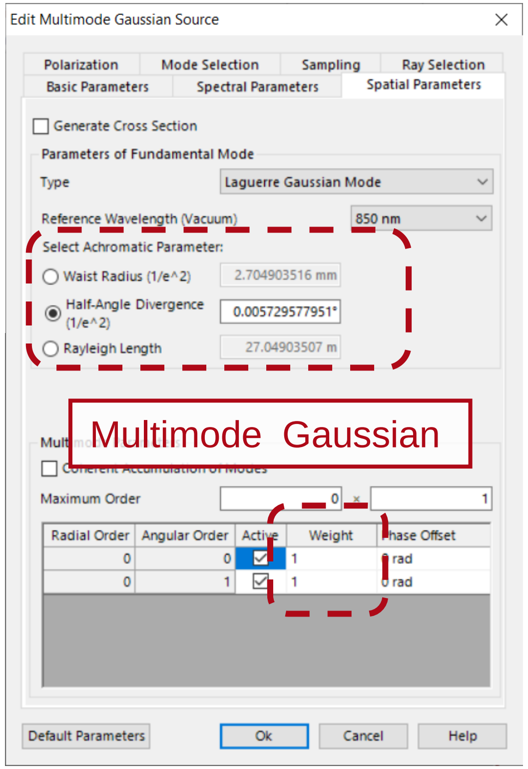
- Waist radius / Half-angle divergence / Rayleigh length
- Weight of each mode

Since the waist, divergence and Rayleigh length depend on each other, only the primary choice of the parameters can be modified, the others are computed on the fly and are displayed in the dialog.







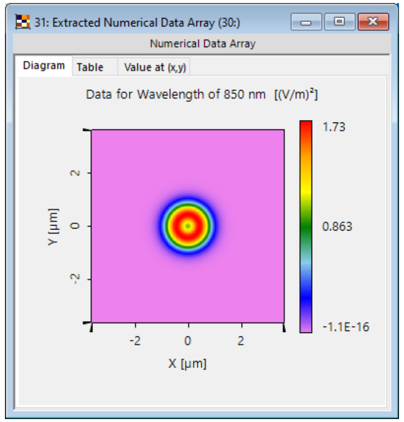


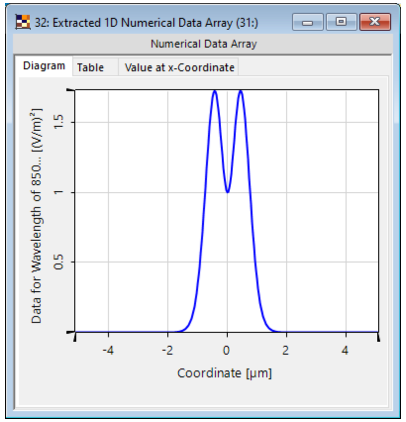
Please note: this use case can also be implemented with a Multimode Gaussian source. However, the selection range of variable parameters is more curtailed there. The beam profile parameters of the two modes can only be varied together.

Customized Diffractive Optics Merit Functions Detector

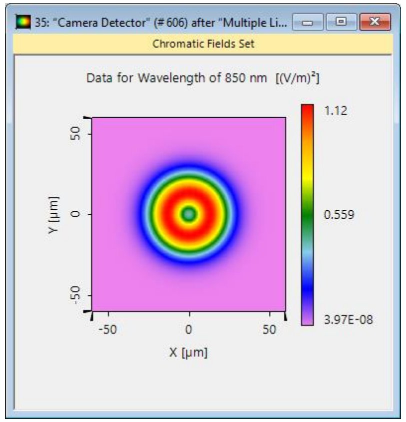
To generate appropriate merit functions for the optimization, a customized *Diffractive Optics Merit Functions* detector is applied to define the constraint specifications according to the desired output VCSEL intensity.

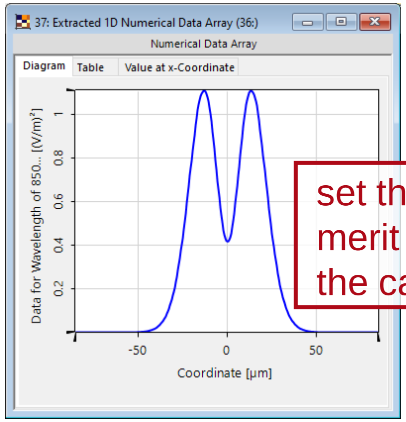
initial energy density of two uncorrelated modes in far-field

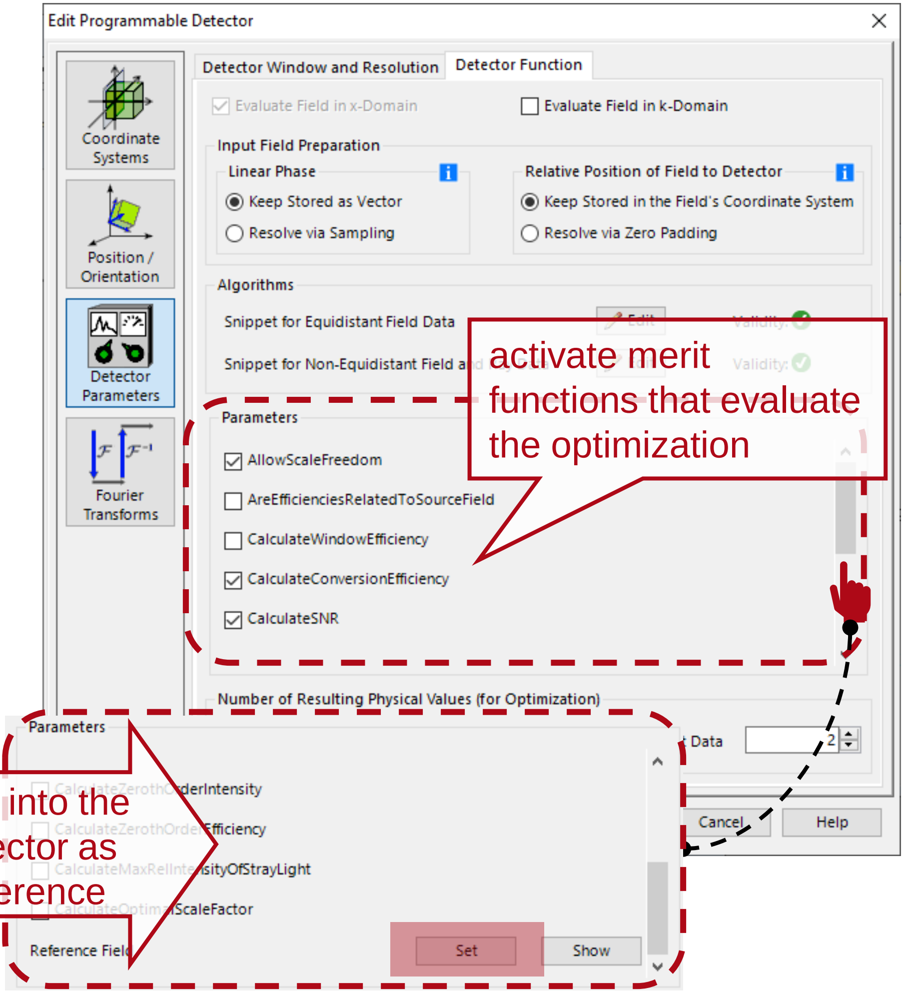




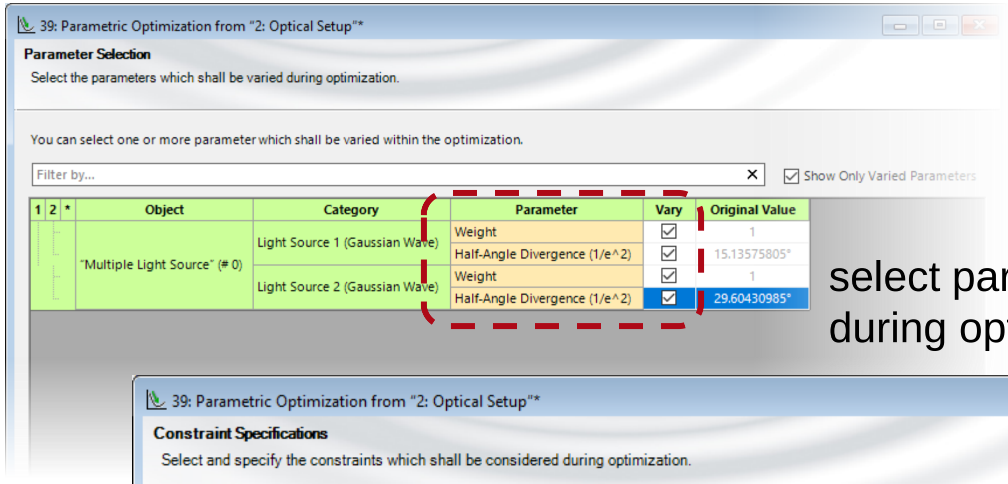
desired energy density of VCSEL source in far-field



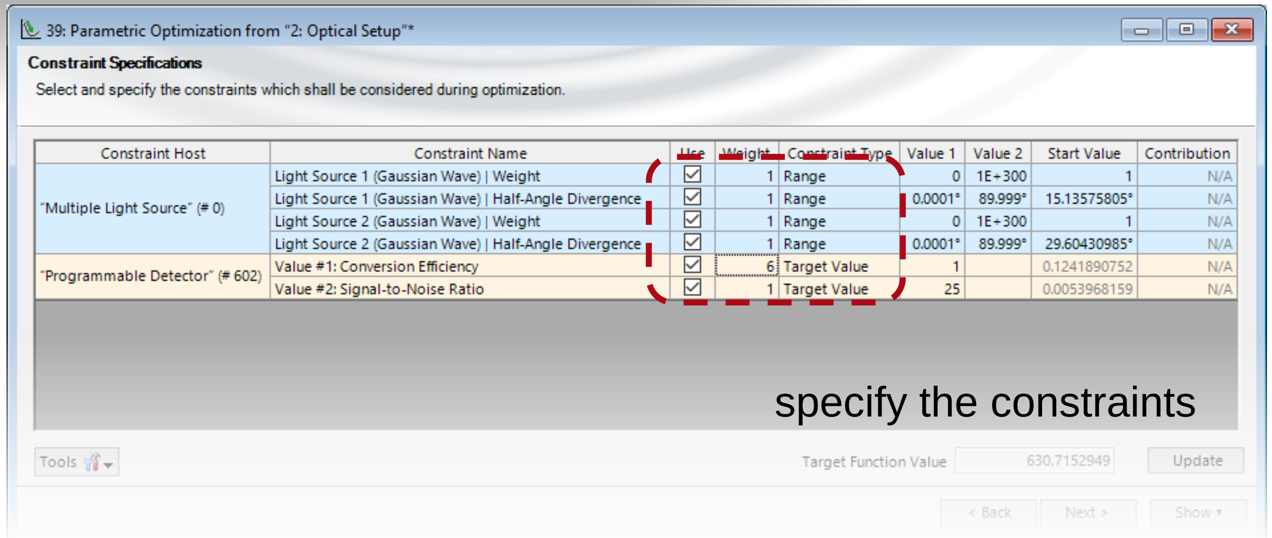




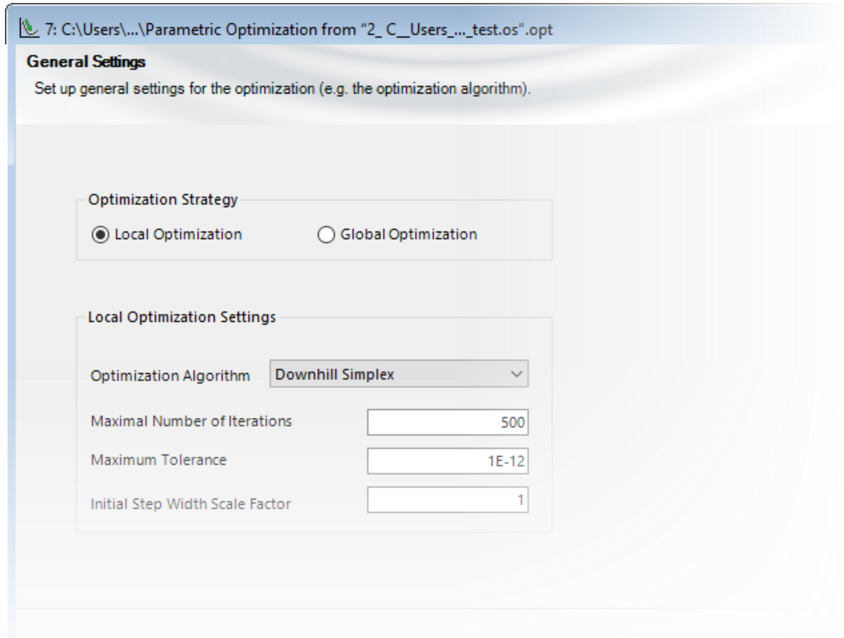
Optimize the Combination of Single Modes



select parameters to be varied during optimization



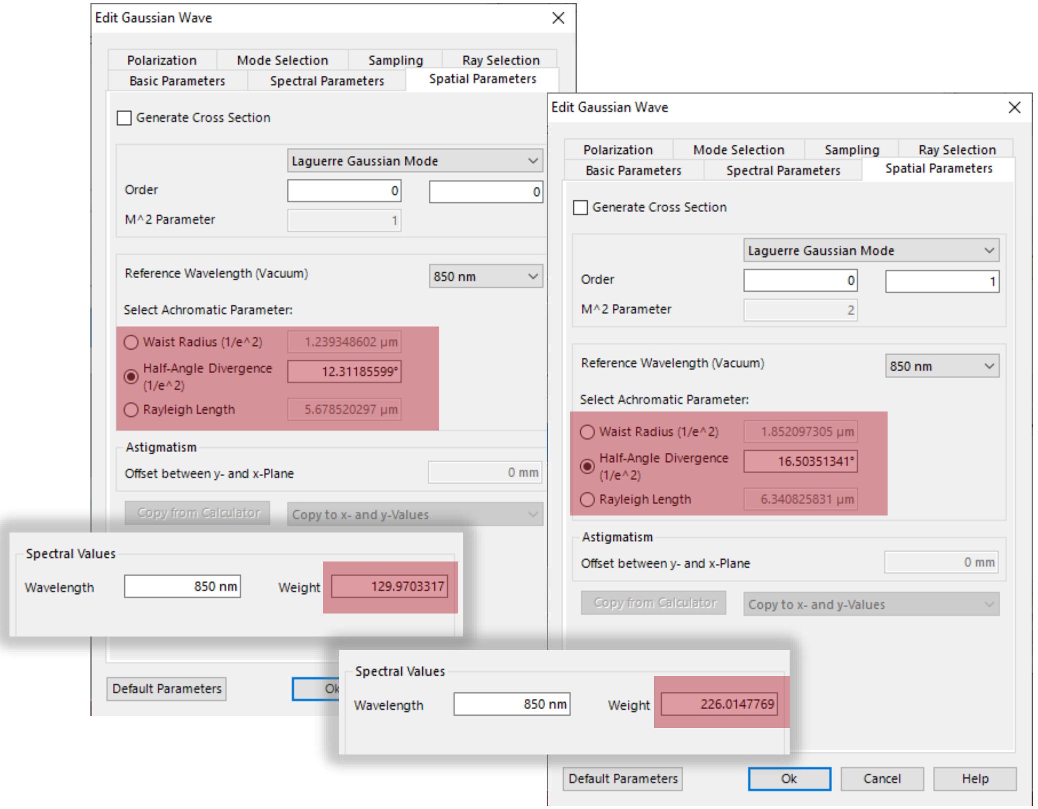
specify the constraints

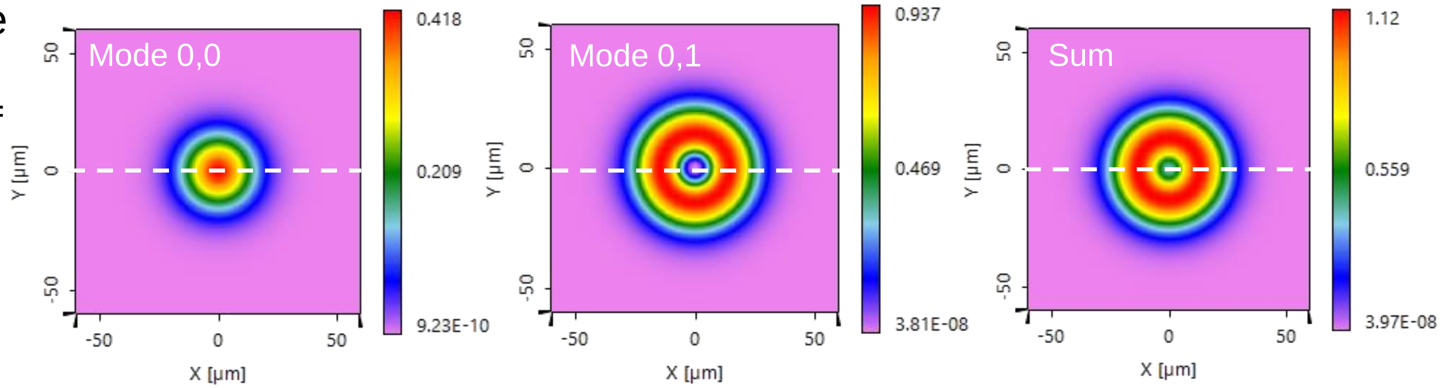


We use the parametric optimization of conversion efficiency and signal-to-noise ratio with the downhill simplex algorithm, in which the half-angle divergence, waist radius and the weight of each mode can be varied to find the combination that delivers the expected VCSEL far-field energy density.

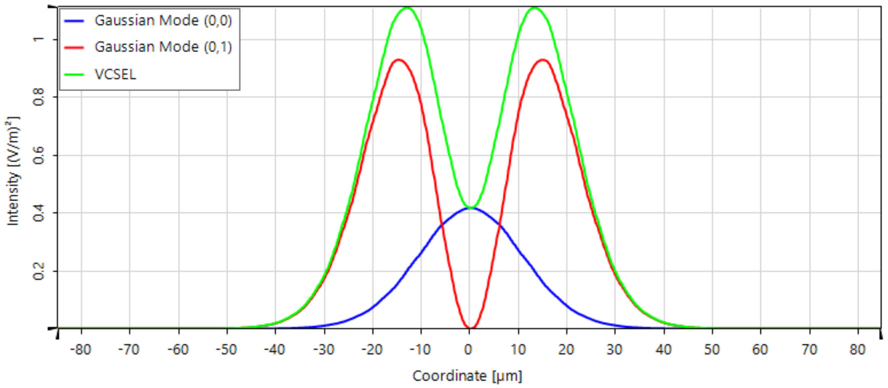
Parametric Optimization Results

After a few iterations, the two Gaussian beams have been found, with a conversion efficiency of the resulting VCSEL compared to the expected beam of over 98%.





1D intensity profile



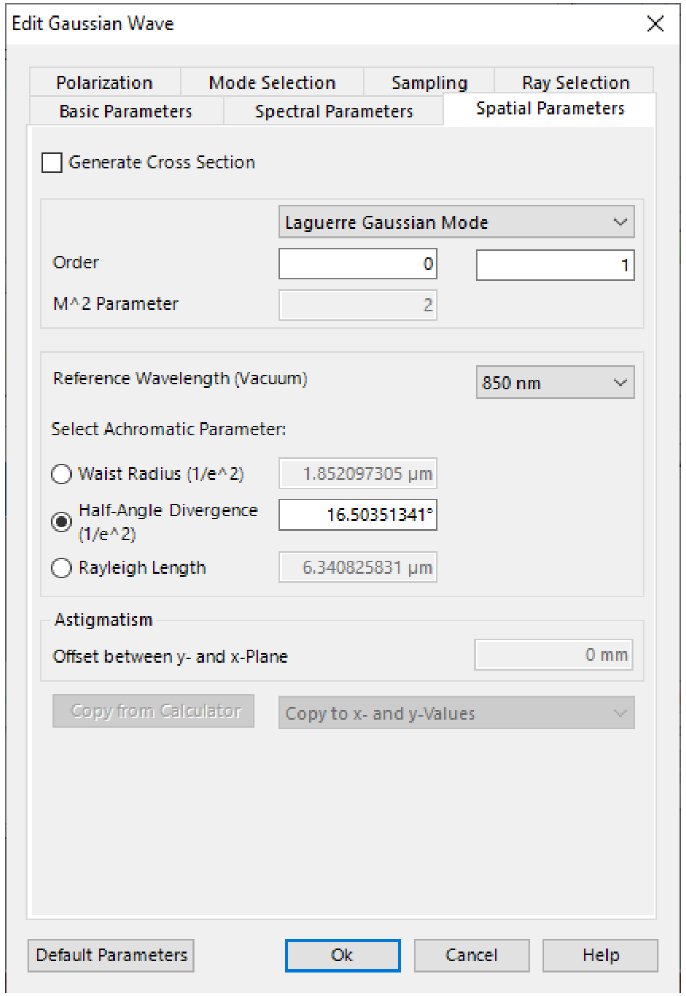
Customized diffractive optics merit functions detector result:

Detector	Sub - Detector	Result
"Programmable Detector" (# 602) after "Multiple Light Source" (# 0) (-) (Diffractive Optics Merit Functions) (Field Tracing)	Conversion Efficiency	98.35817551 %
	Signal-to-Noise Ratio	22.41279532 dB

Workflow in VirtualLab Fusion

- Set up input field
  - Basic Source Models [Tutorial Video]
  - Simulation of Multiple Light Source with VirtualLab Fusion [Use Case]

- Use Parametric Optimization to find proper parameters of two uncorrelated modes, whose combination gives desired far-field energy density of VCSEL source



Document Information

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