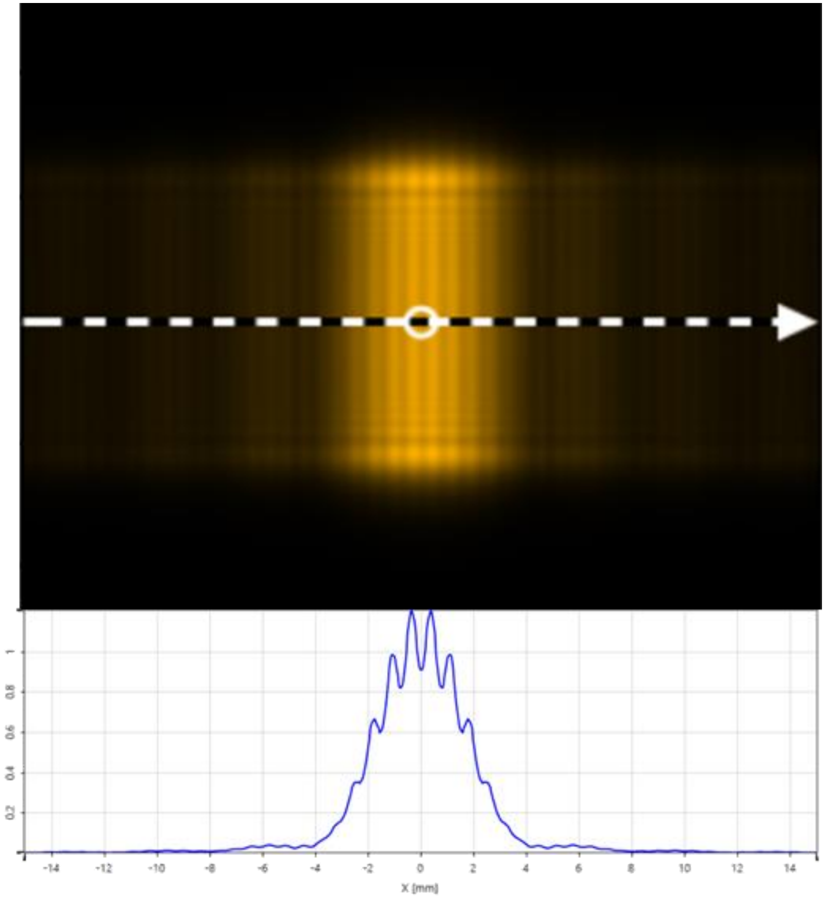
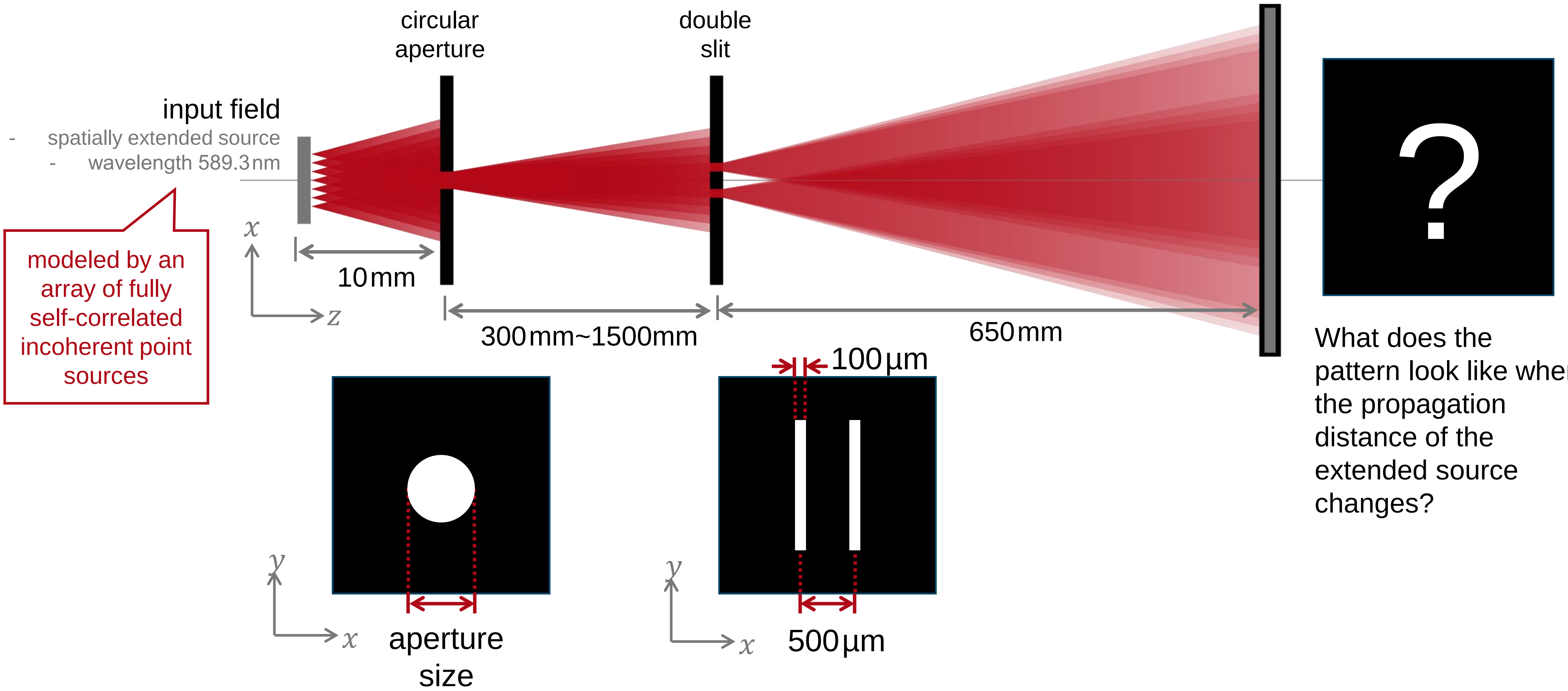
Demonstration of van Cittert-Zernike Theorem

Abstract



Young's double-slit experiment was carried out with a spatially extended, partially coherent source. In this document, we use the Multiple Light Source to set up the extended source so that the disturbances at the slits are a mixture of incoherent and coherent radiation, and the vibrations are therefore partially correlated. The characteristic blurred interference fringe is obtained, and the van Cittert-Zernike theorem, which studies how the complex degree of coherence varies with propagation distance, is demonstrated.

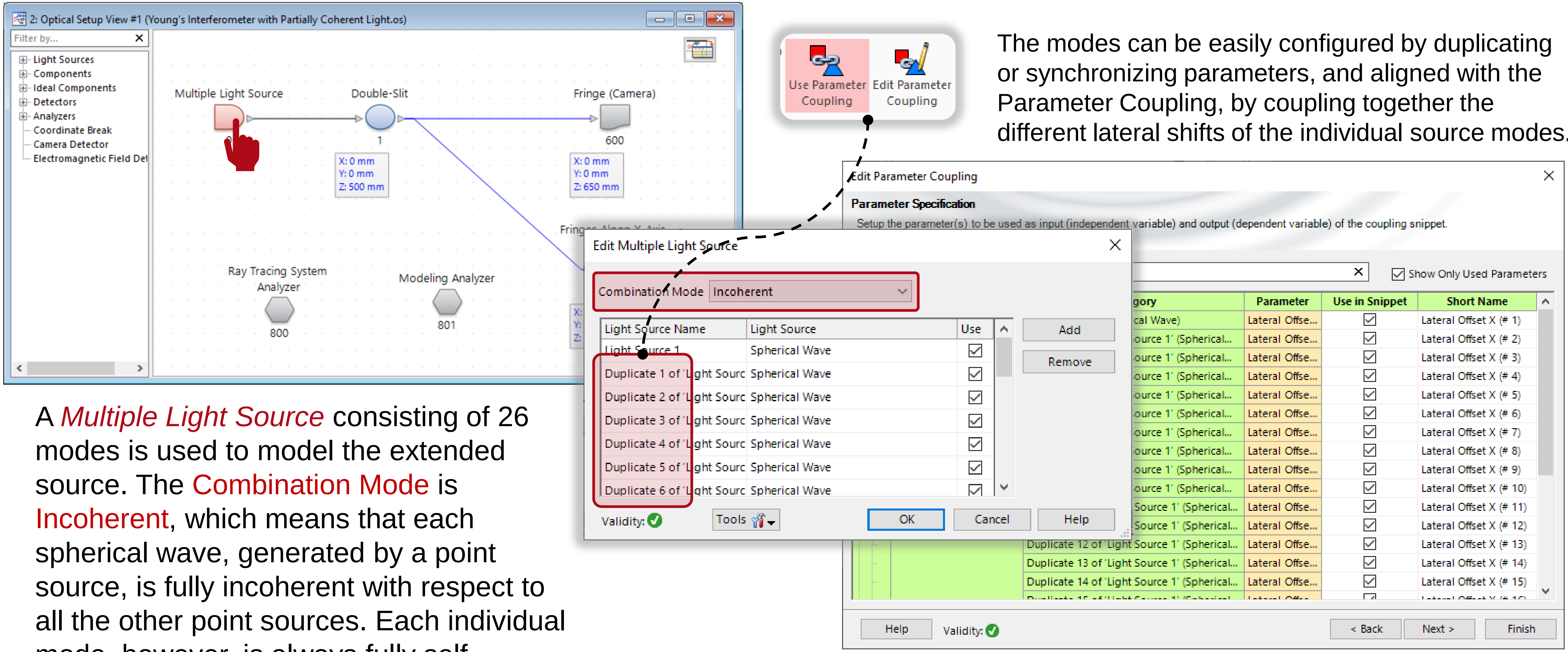
Modeling Task



What does the pattern look like when the propagation distance of the extended source changes?

Building the System in VirtualLab Fusion

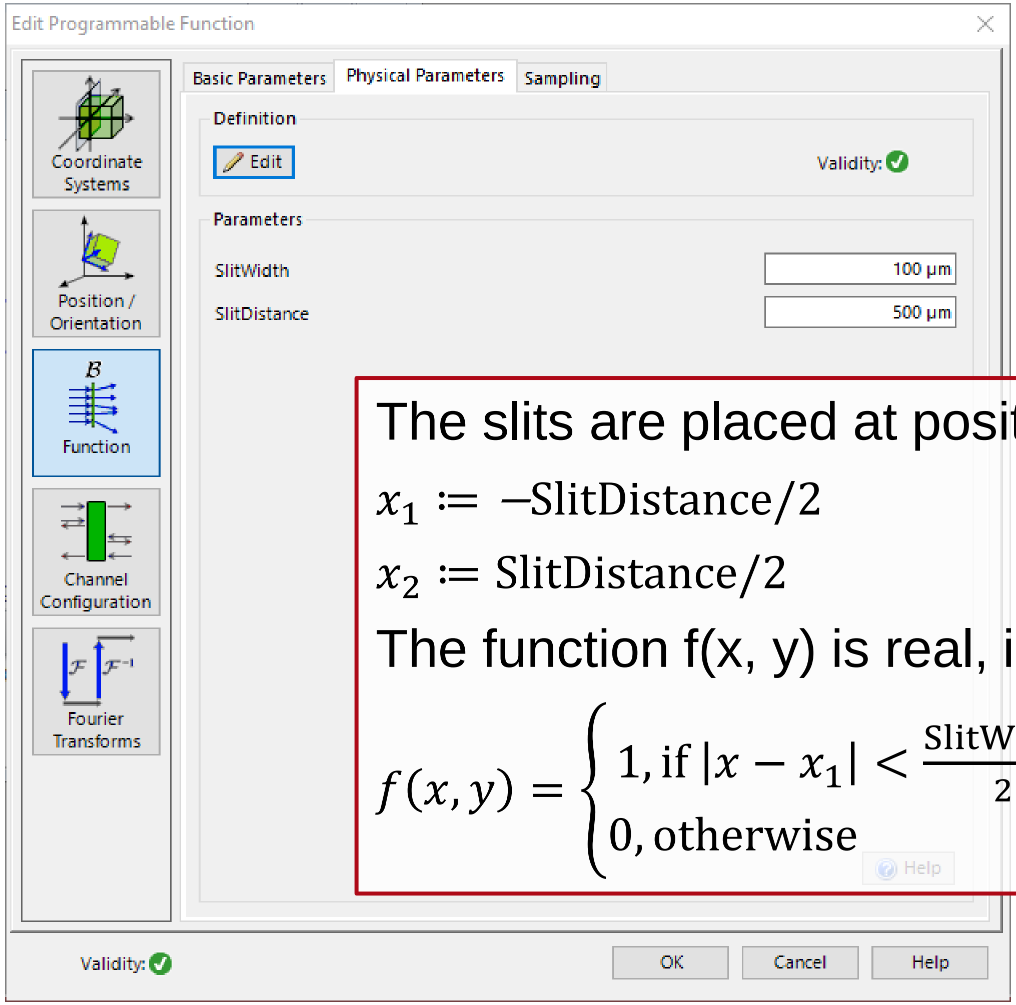
System Building Blocks – the Extended Source



The modes can be easily configured by duplicating or synchronizing parameters, and aligned with the Parameter Coupling, by coupling together the different lateral shifts of the individual source modes.

A *Multiple Light Source* consisting of 26 modes is used to model the extended source. The Combination Mode is Incoherent, which means that each spherical wave, generated by a point source, is fully incoherent with respect to all the other point sources. Each individual mode, however, is always fully self-correlated.

System Building Blocks – the Double Slit Transmission



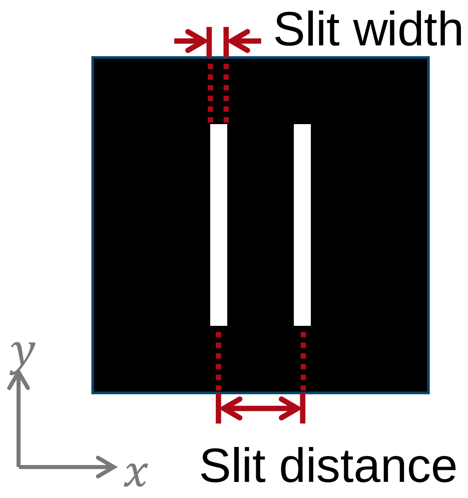
The slits are placed at positions:

$$x_1 \coloneqq -\mathrm{SlitDistance}/2$$

$$x_2 \coloneqq \mathrm{SlitDistance}/2$$

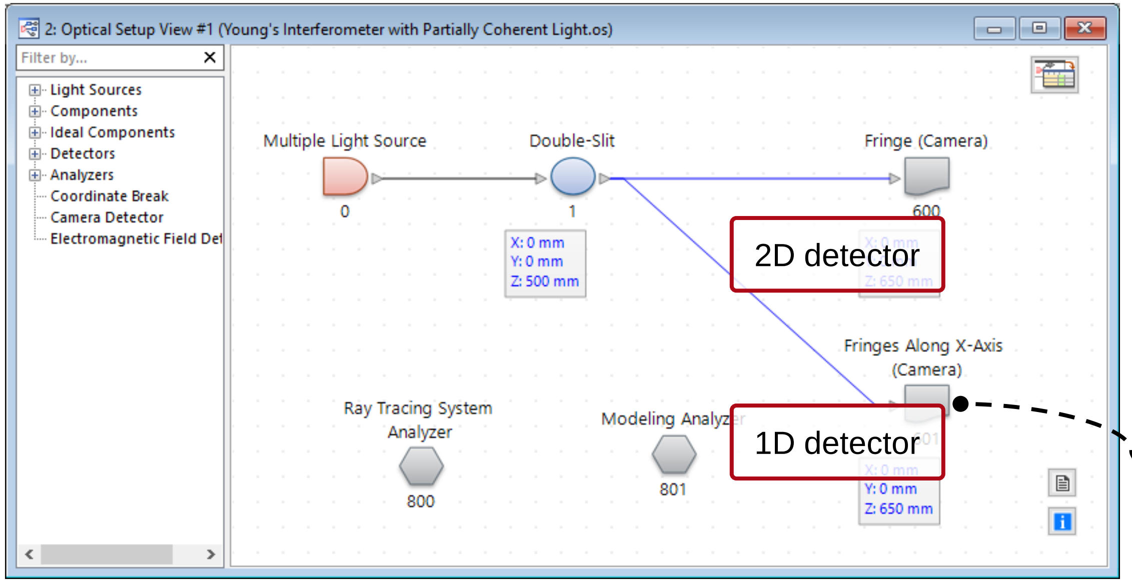
The function f(x, y) is real, independent of y:

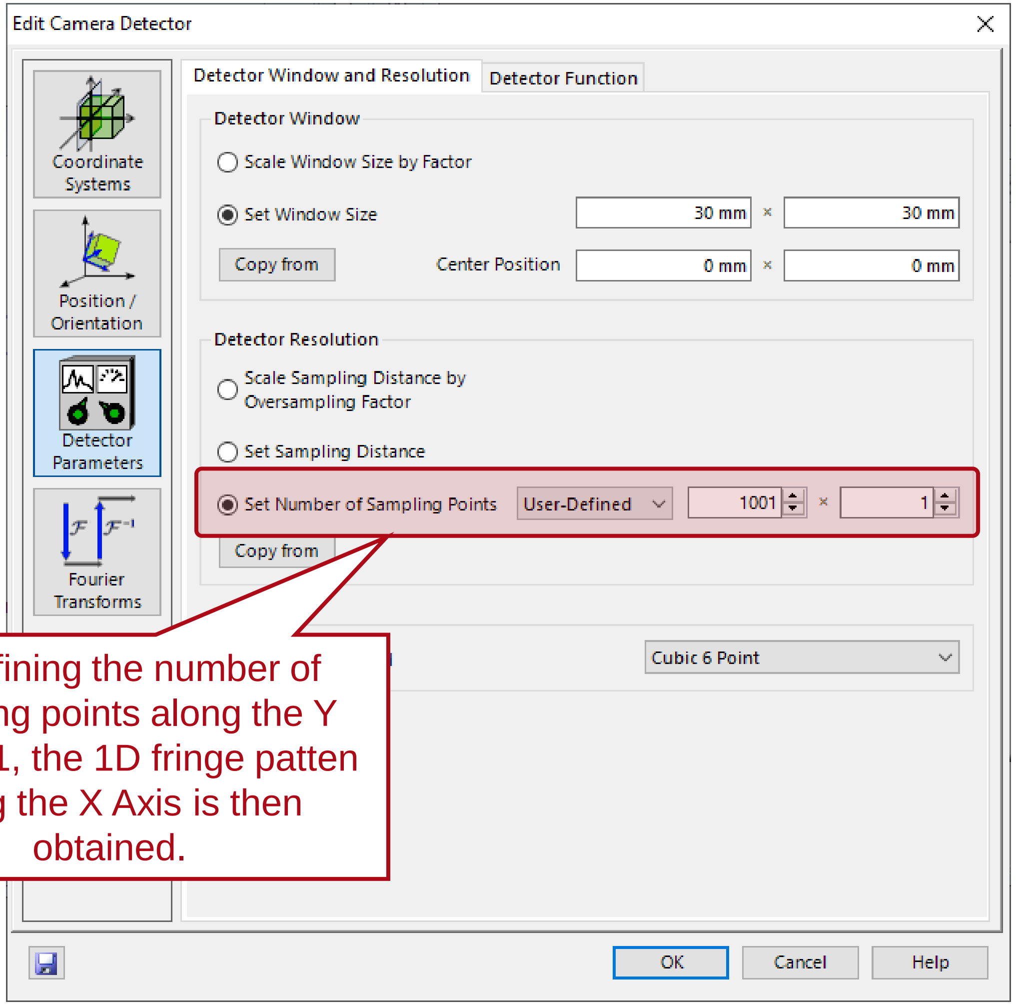
$$f(x,y) = \begin{cases} 1, \text{if } |x - x_1| < \dfrac{\mathrm{SlitWidth}}{2} \text{ or} |x - x_2| < \dfrac{\mathrm{SlitWidth}}{2} \\ 0, \text{otherwise} \end{cases}$$



see the full Application Use Case:
"Programming a Double Slit Function"

System Building Blocks – 1D and 2D Pattern Detection

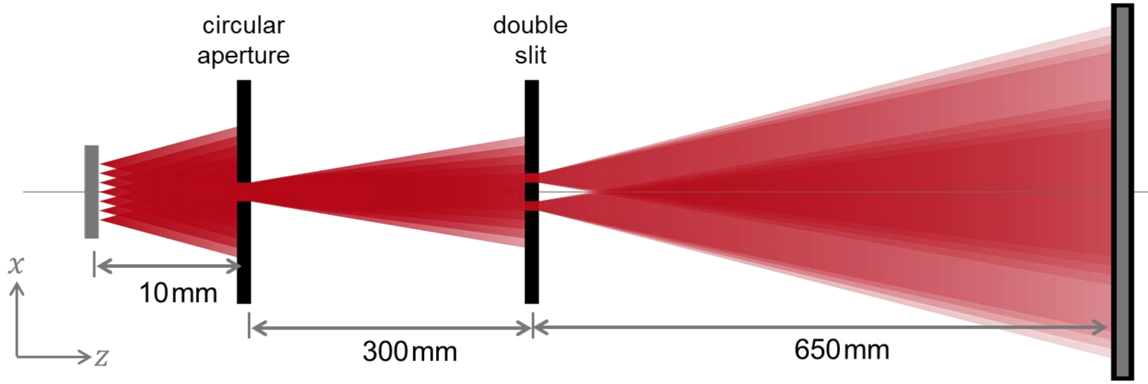


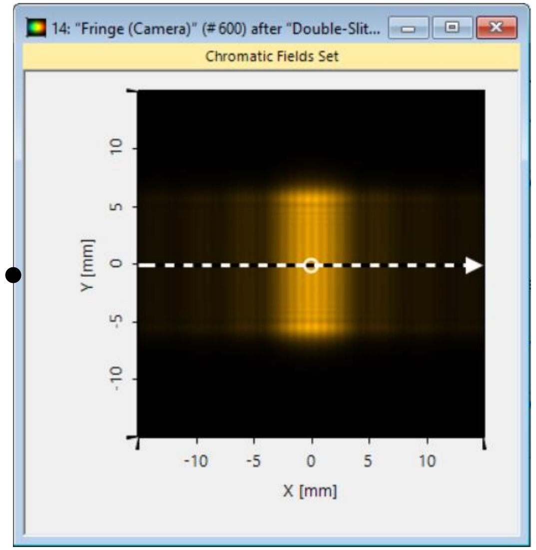


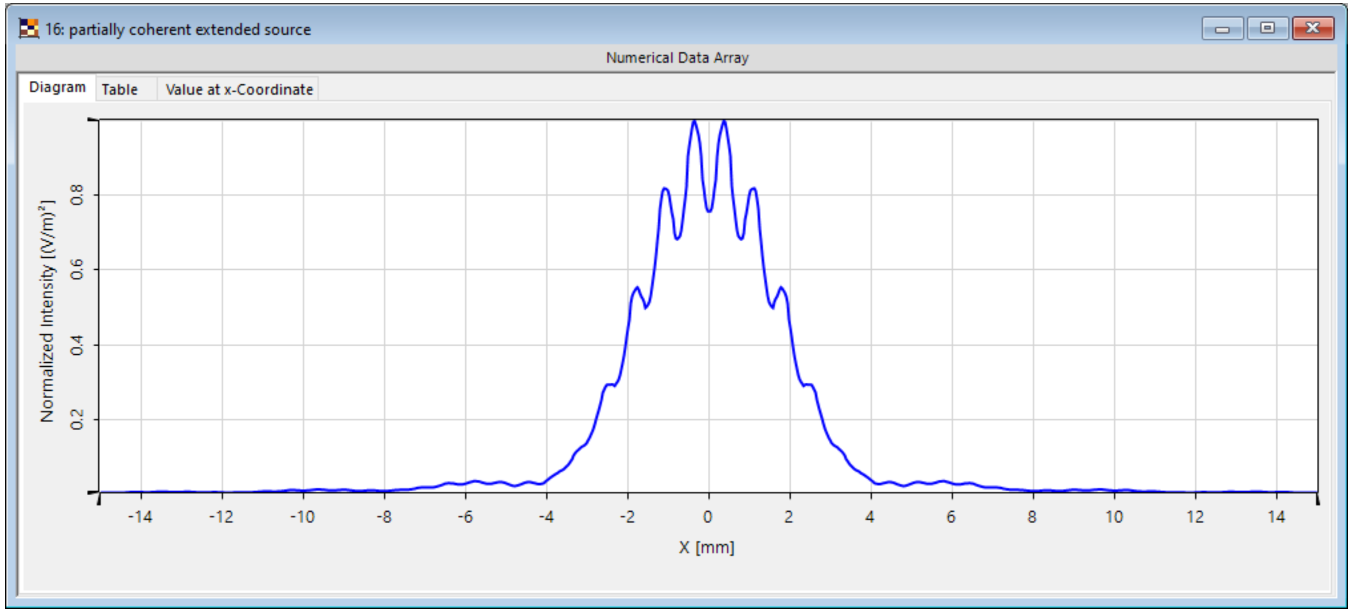
By defining the number of sampling points along the Y Axis as 1, the 1D fringe patten along the X Axis is then obtained.

Simulation with VirtualLab Fusion

Interference with Extended Source

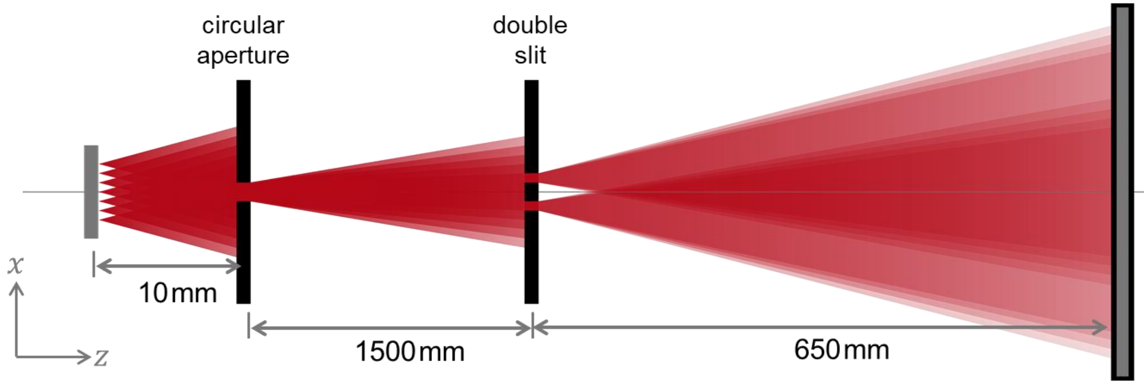


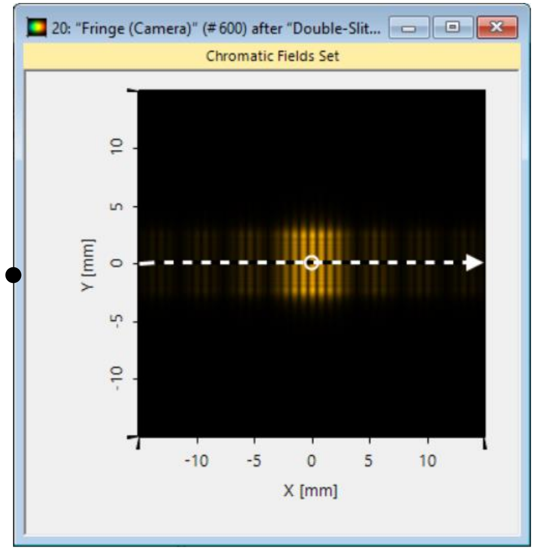


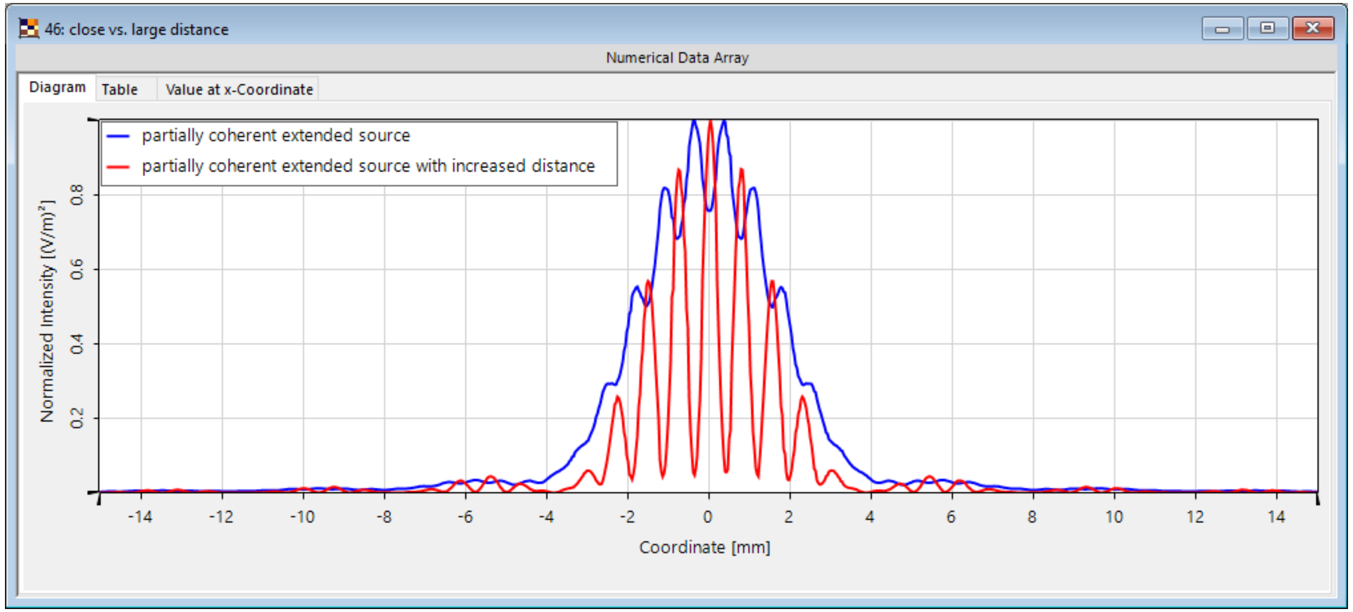


The partial coherence of the physical extended source which leads to a blurring of the interference fringes is here modeled with the set of self-correlated but mutually incoherent point sources presented in the previous slide. The interference patterns of each of the point sources do not coincide, causing the characteristic loss of contrast.

Visualization of van Cittert–Zernike Theorem

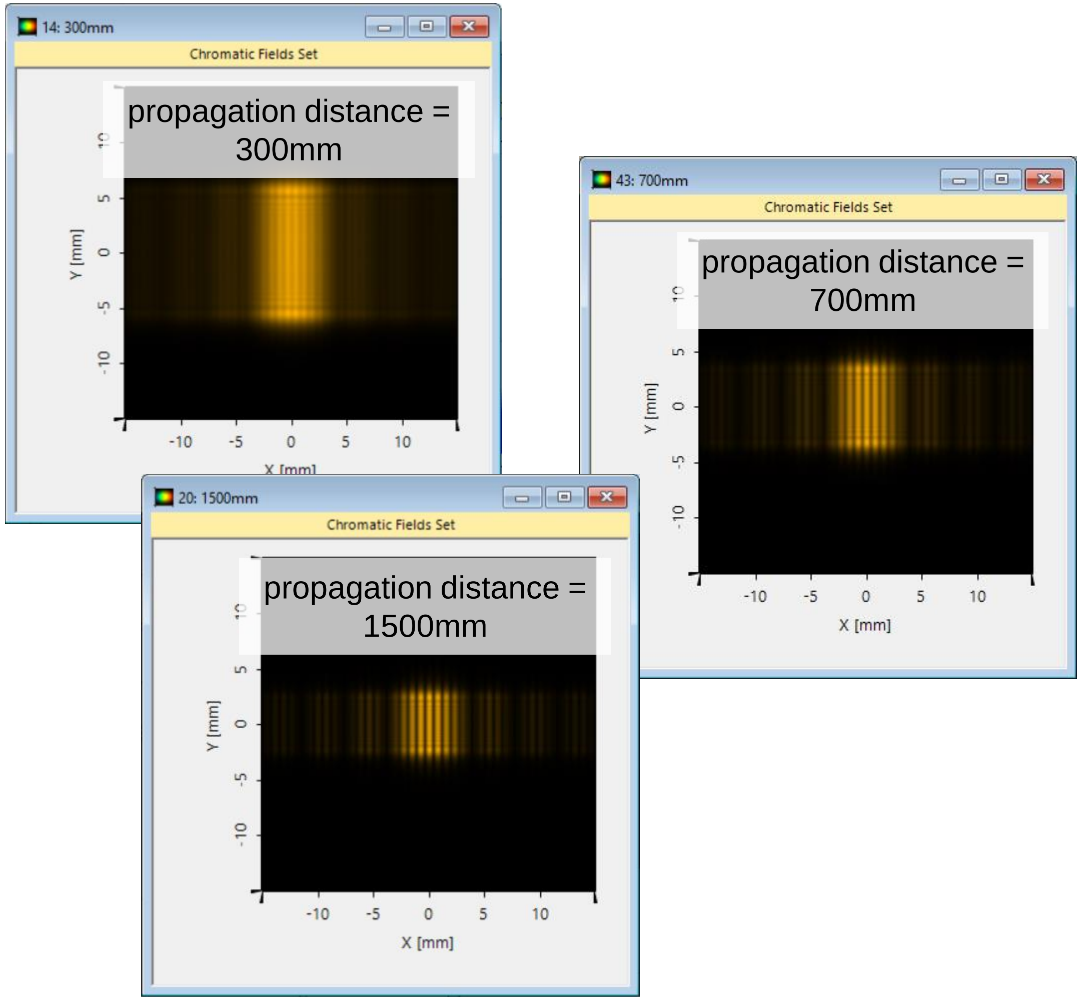


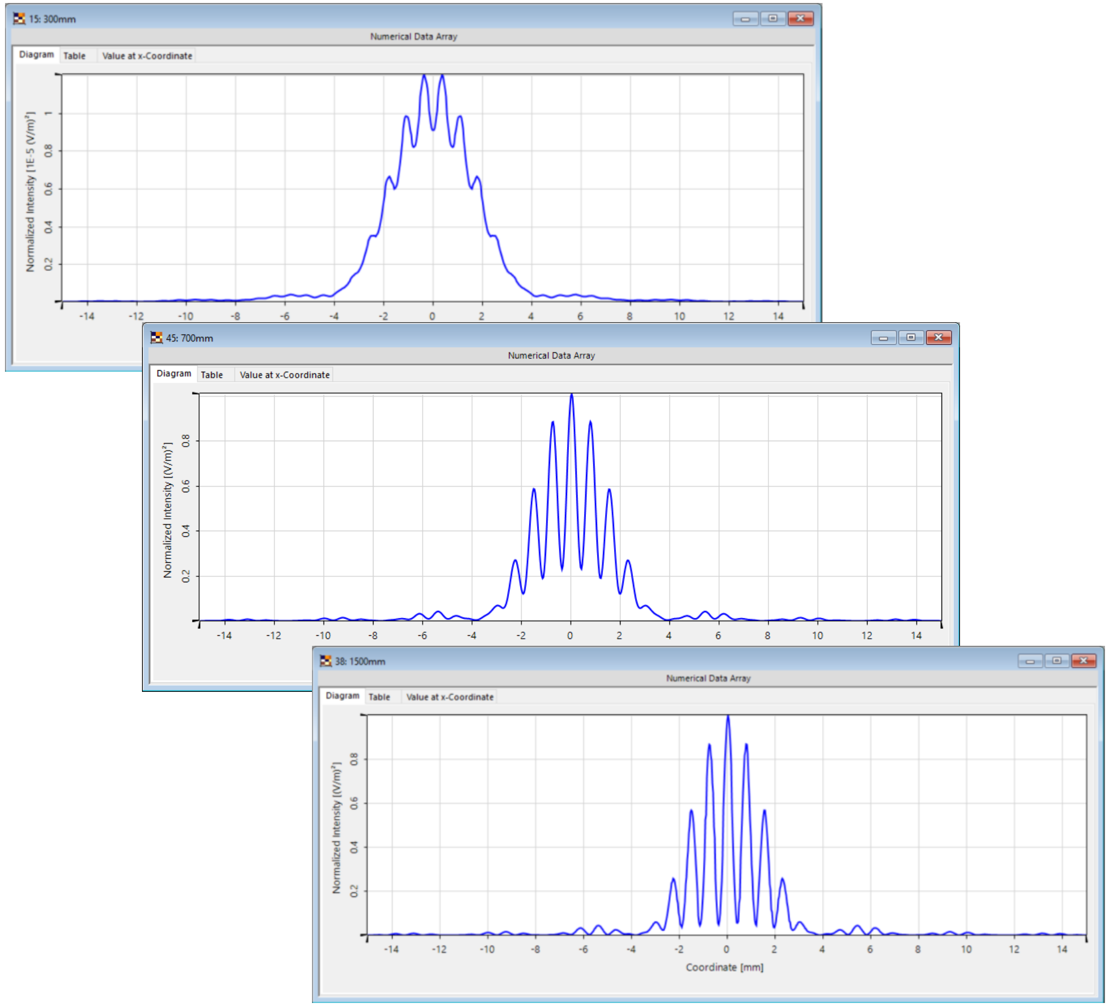




By increasing the propagation distance in front of the double slit to 1500mm, we demonstrate the predictions of the van Cittert-Zernike theorem, in that the light generated from two incoherent sources will appear coherent from far away. This is evidenced by the increase in contrast that occurs for a larger distance in front of the double slit.

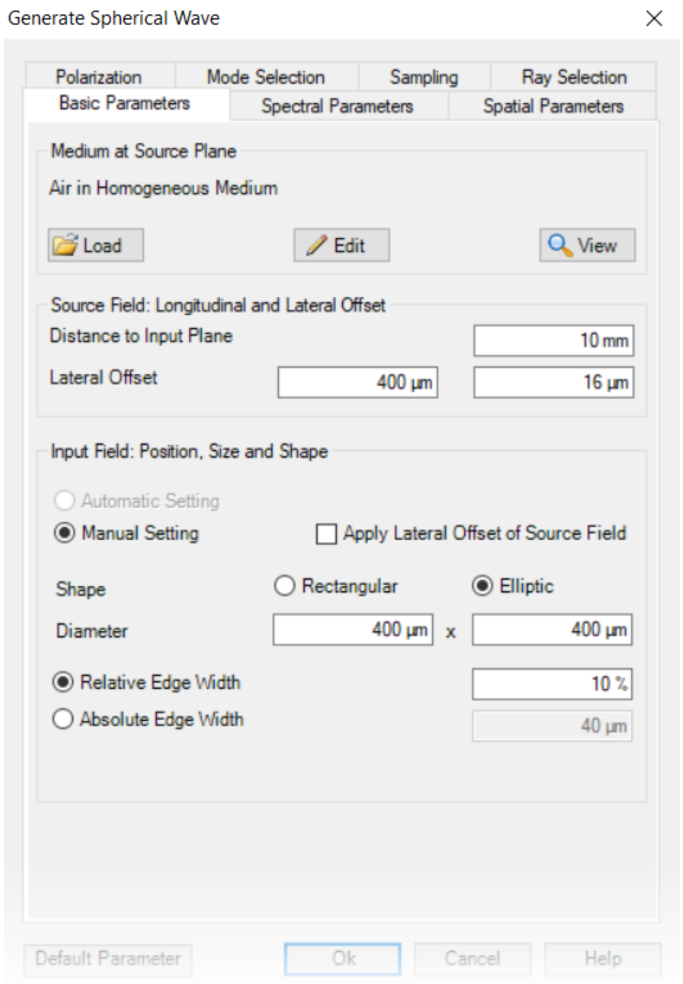
Investigate Fringe Visibility by Varying Distance



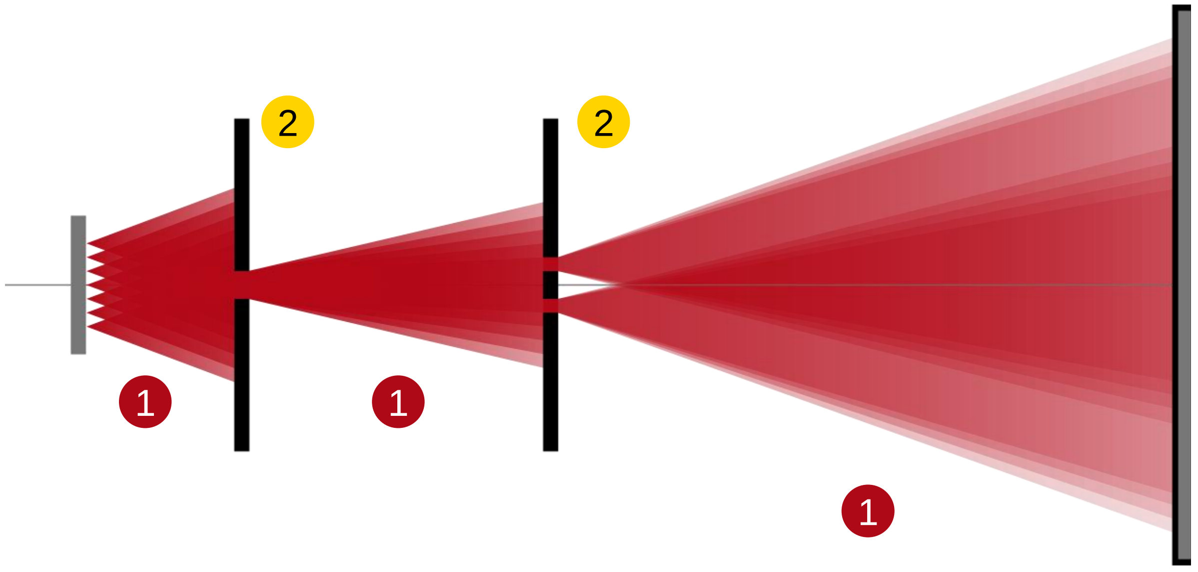


Workflow in VirtualLab Fusion

- Set up input field
  - Simulation of Multiple Light Source with VirtualLab Fusion[Use Case]
- Programming a double-slit function
  - Programming a Double-Slit Function [Use Case]
- Check influence from different parameters with Parameter Run
  - Usage of the Parameter Run Document [Use Case]
  - Scanning Mode of Parameter Run [Use Case]



VirtualLab Fusion Technologies



Document Information

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further reading	- Simulation of Multiple light Source with VirtualLab Fusion - Young's Interferometer Experiment - Modeling Spatially Extended Sources with the Shifted Elementary-Field Method