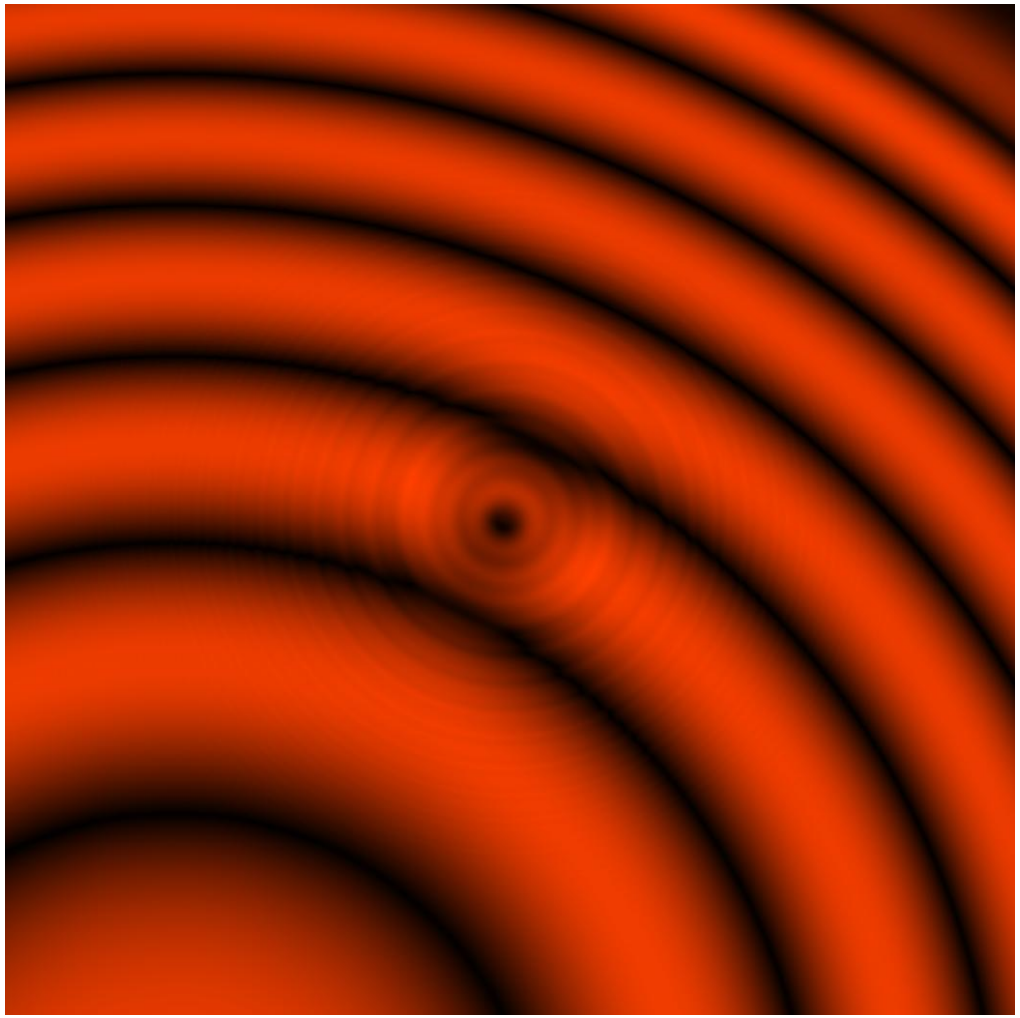
Mach-Zehnder Interferometer with Small Defects

Abstract



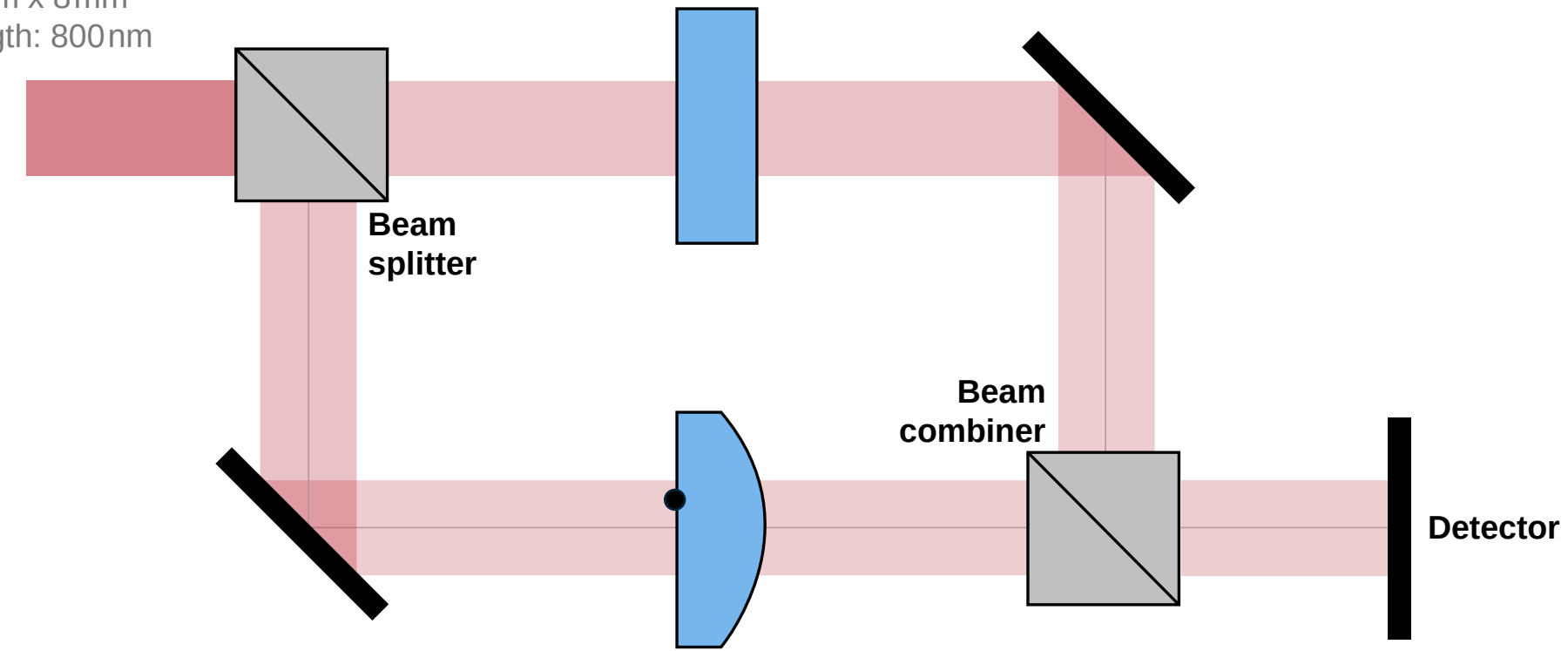
In real optical systems, component defects from exposure will affect overall performance. From a simulation perspective, propagating large fields with diffraction effects caused by tiny defects is highly challenging. This use case demonstrates VirtualLab Fusions multi-scale simulation approach by introducing small defects into a Mach–Zehnder interferometer and analyzing the resulting interference pattern.

Application Scenario

Application Scenario: System

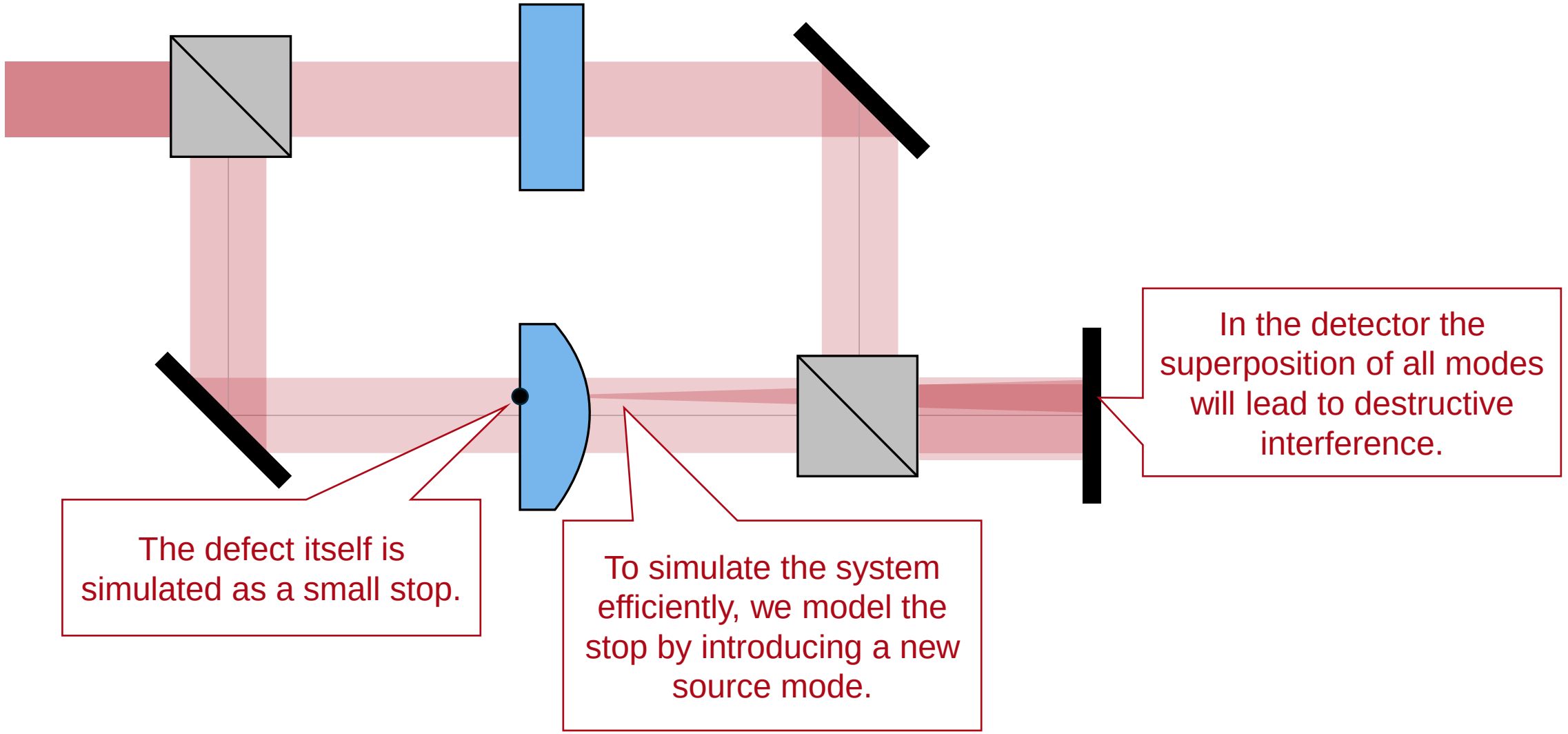
Plane wave source
- size: 8 mm x 8 mm
- wavelength: 800 nm

Phase-delaying plate
- Thickness: 2 mm

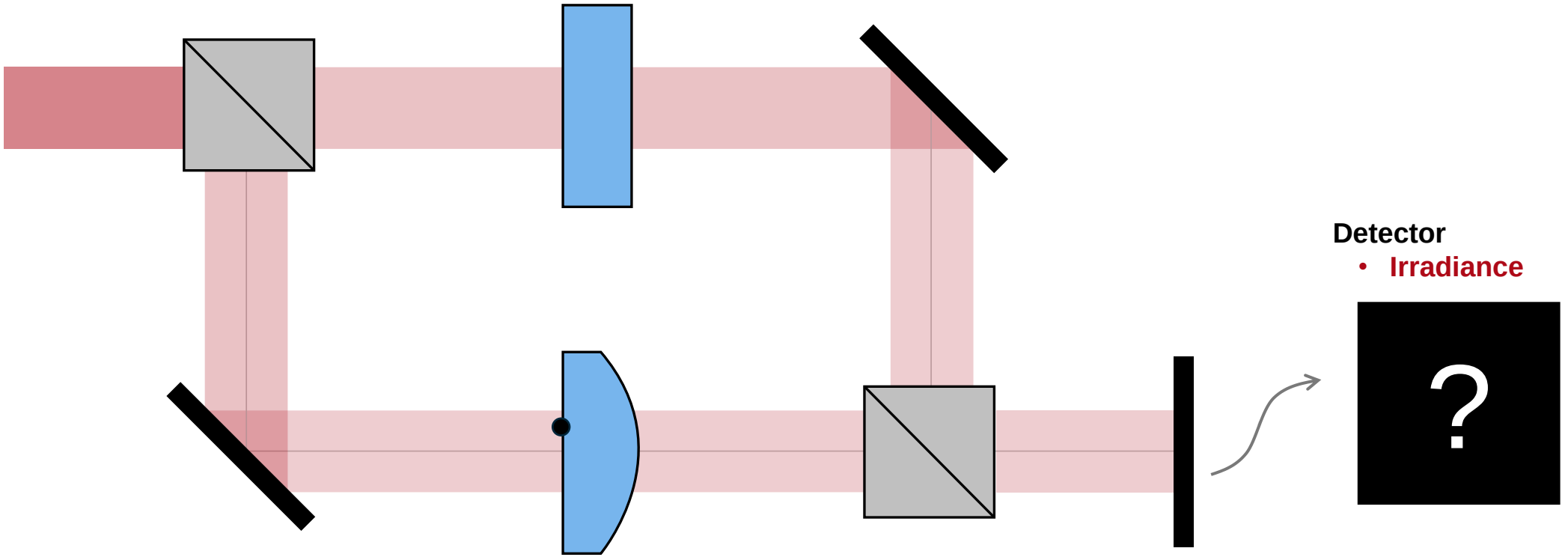


Plane-convex lens with defect
- Radius of curvature (convex-part) : 1 m
- Center thickness: 2 mm
- Size of defect: 50 µm - 300 µm

Application Scenario: System



Application Scenario: Task



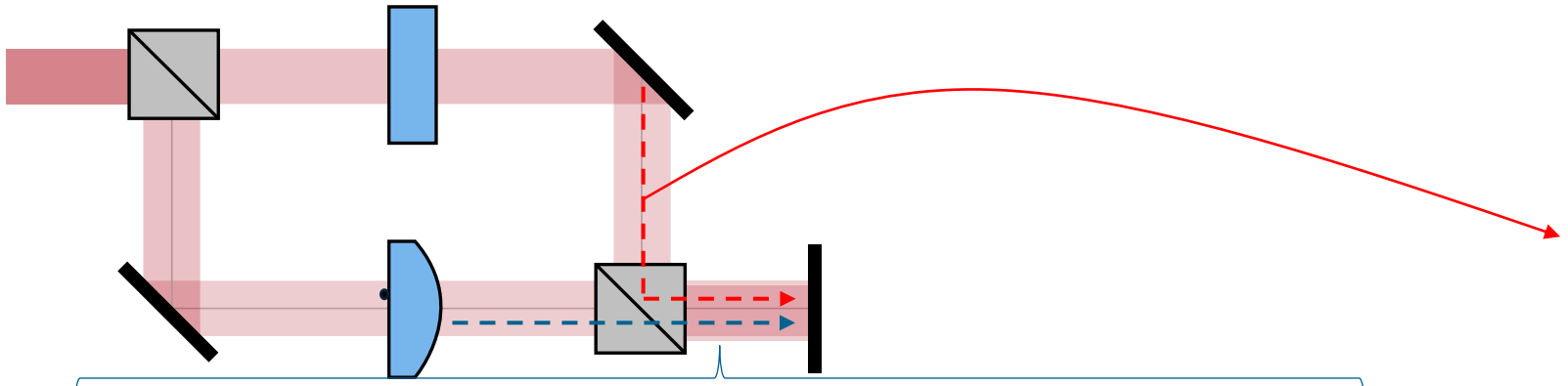
Task 1: Compare the detector-plane irradiance for a system with a 300 µm defect to a case with no defect.

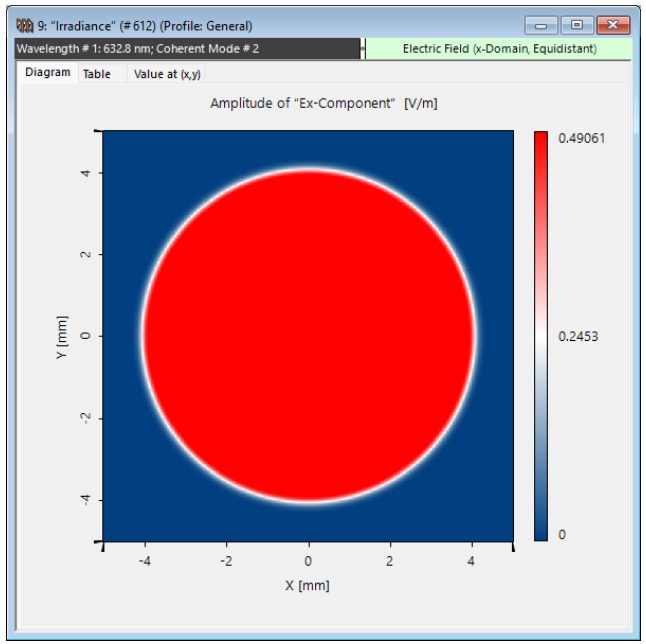
Task 2: Reduce the defect size to 100 µm and 50 µm and calculate irradiance pattern.

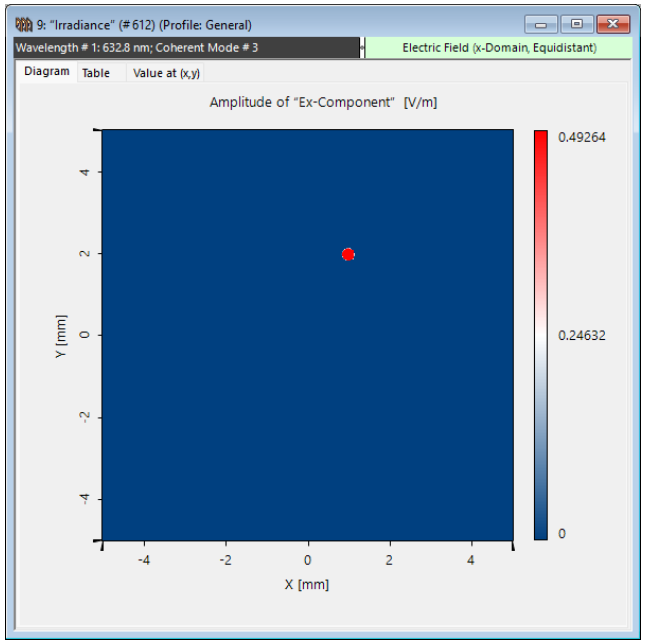
Results

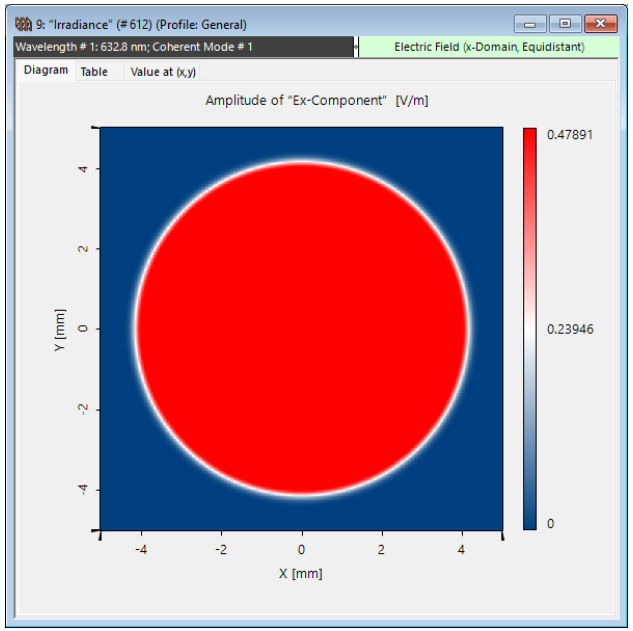
Task 1: Compare Irradiance Pattern

Field per Mode at Detector (without Diffraction)

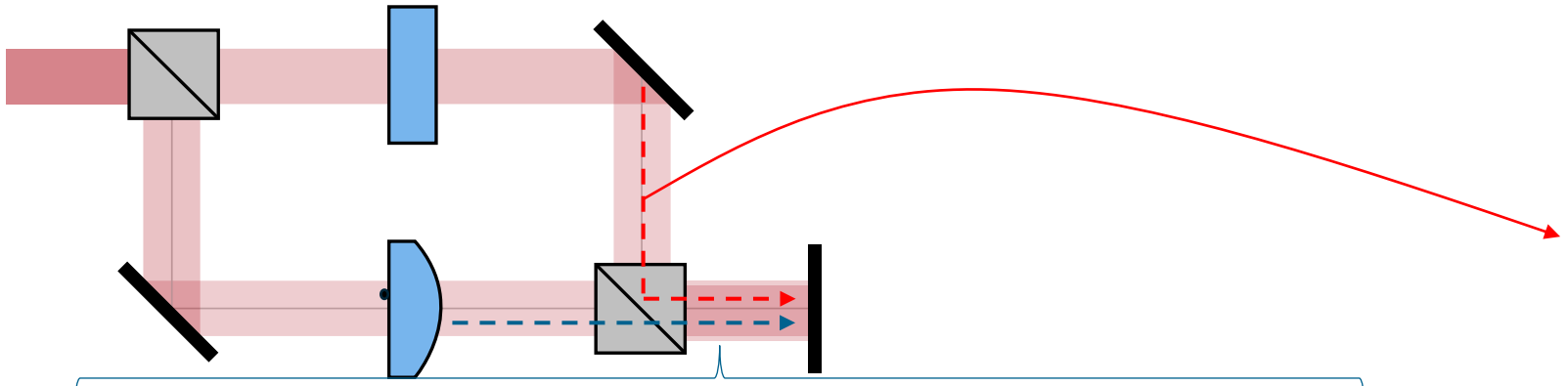


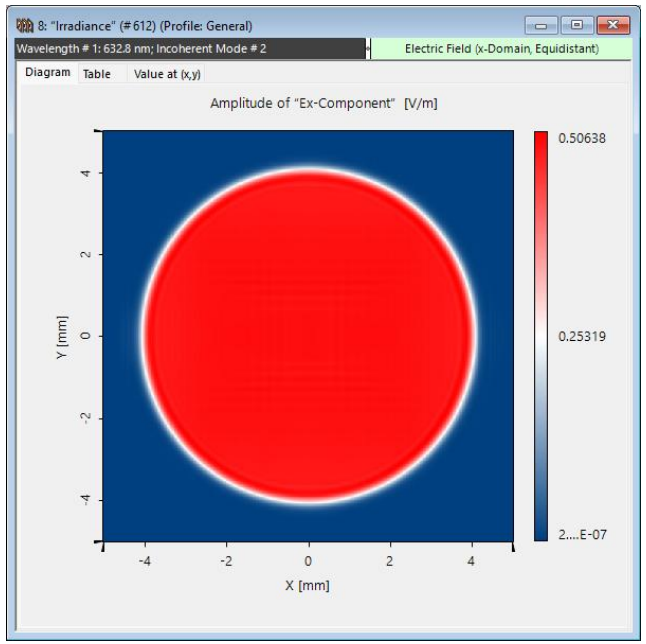


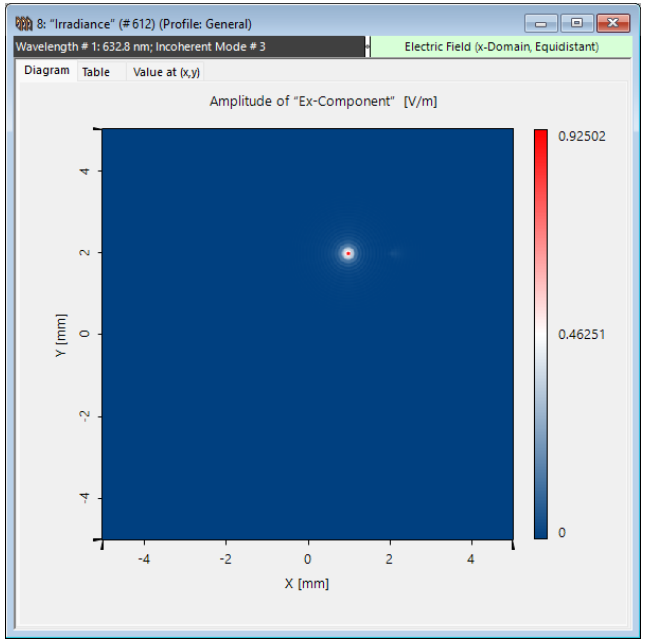


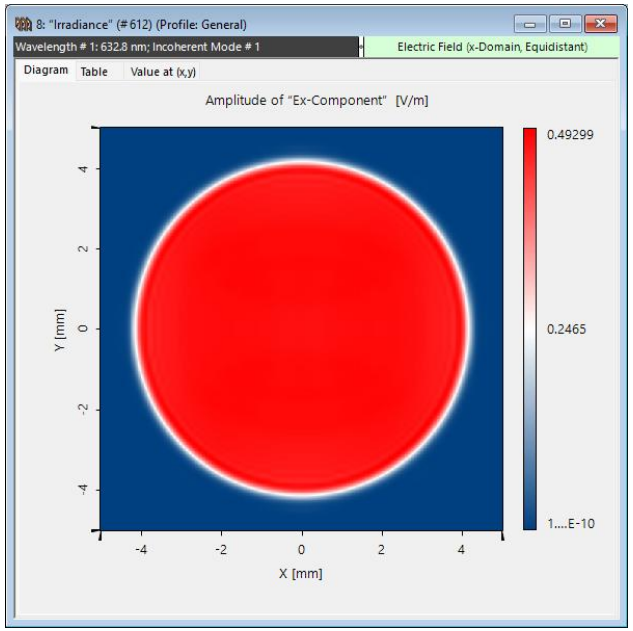


Field per Mode at Detector (with Diffraction)

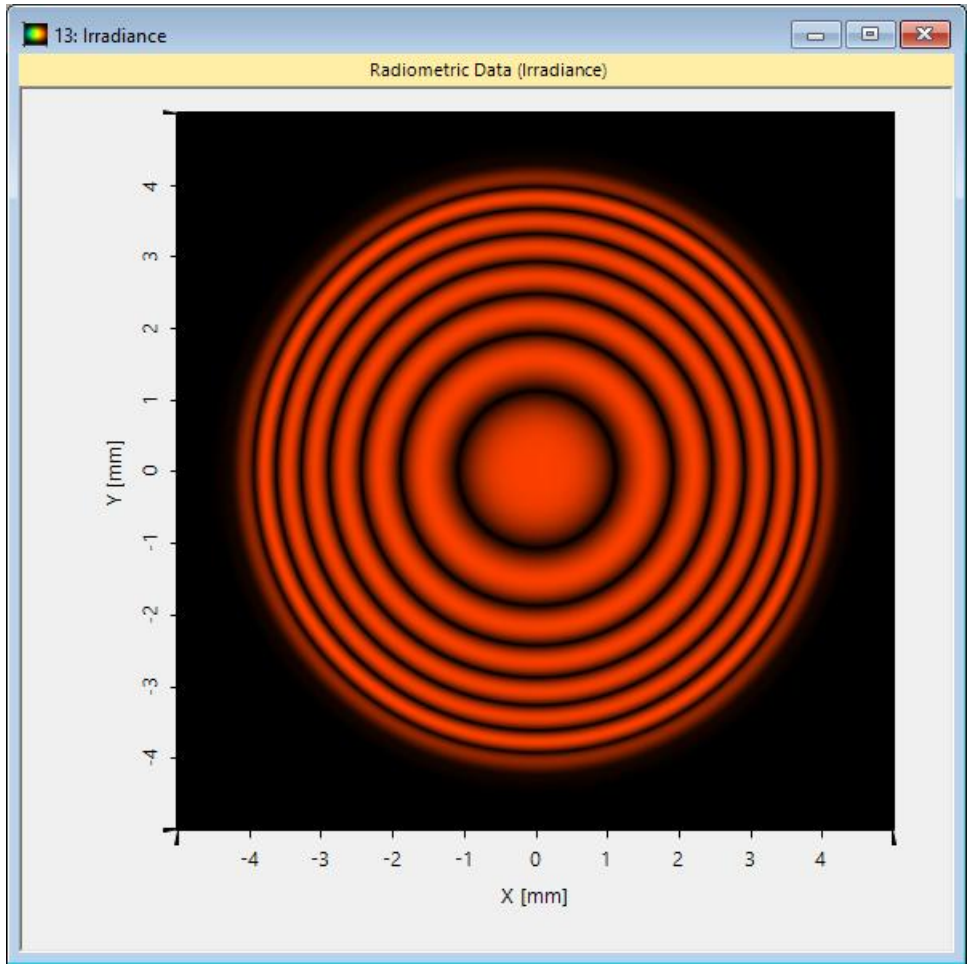




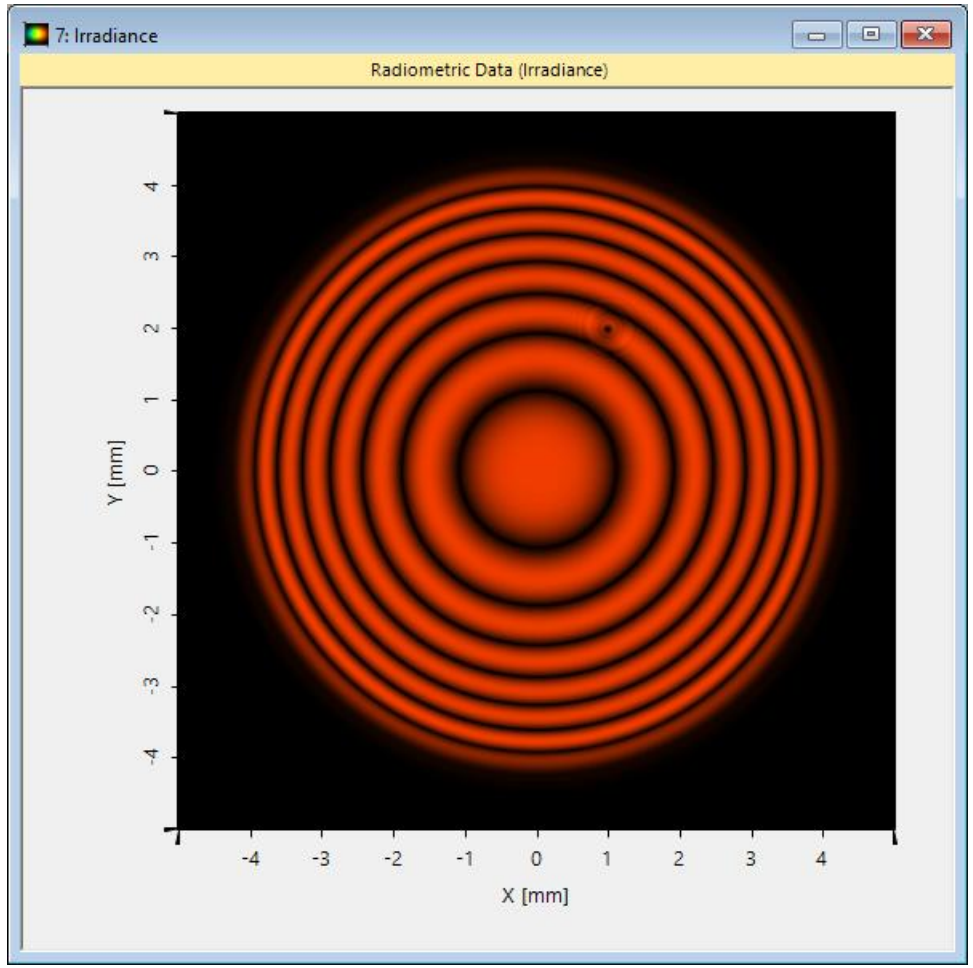




Comparison (Modes Added)

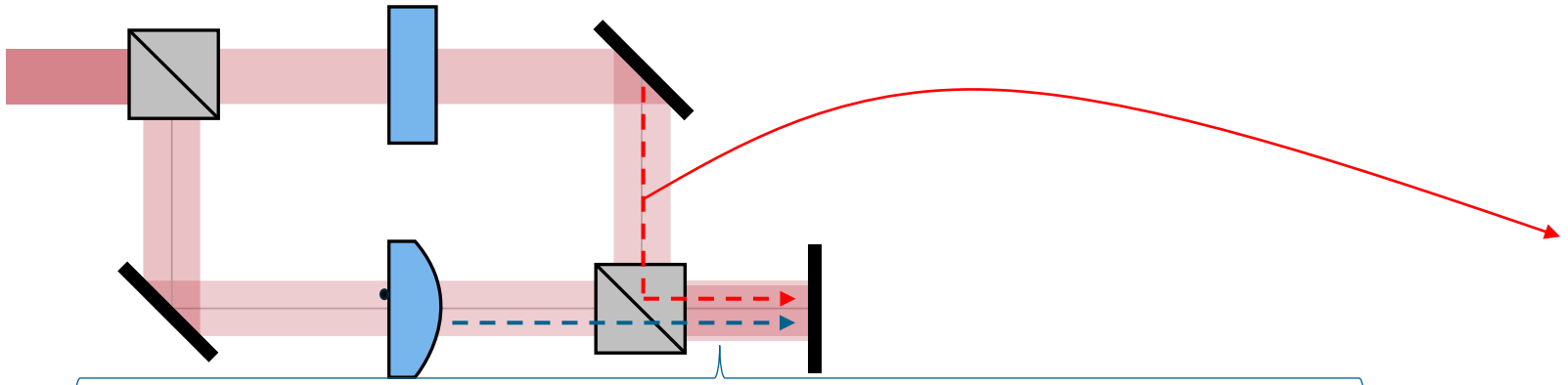


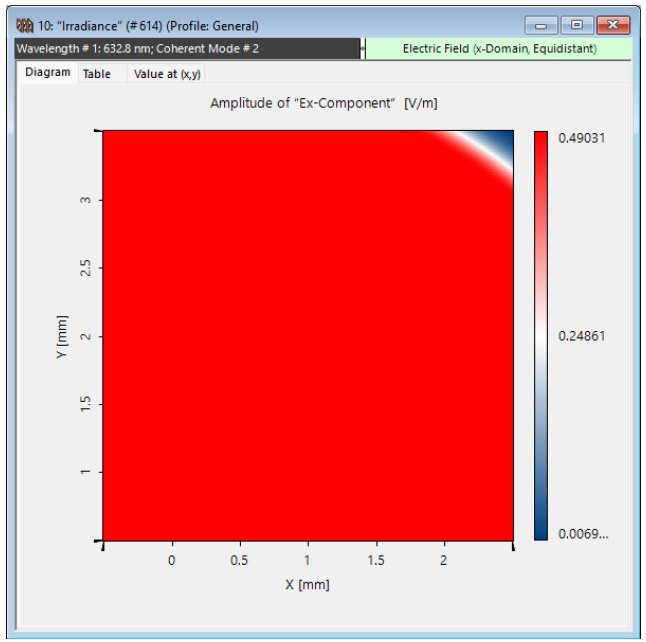
Irradiance without consideration of the defect (only perturbated fields added)

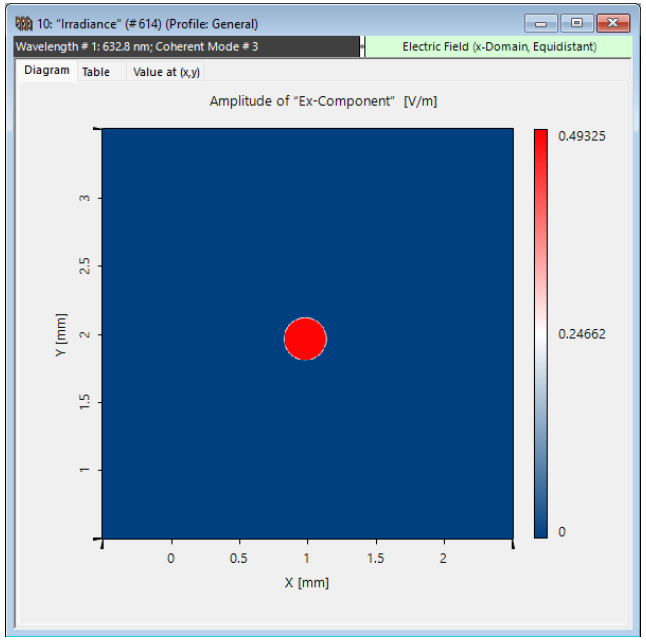


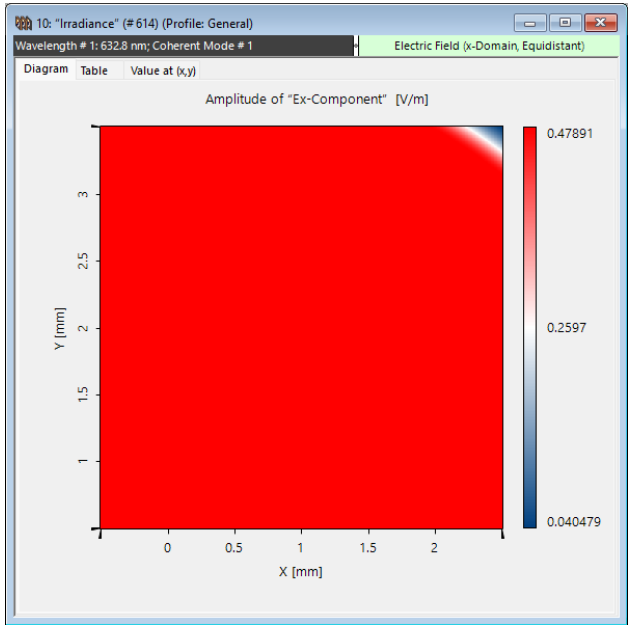
Irradiance with consideration of defect (all fields added)

Field per Mode at Detector (without Diffraction) - Zoom

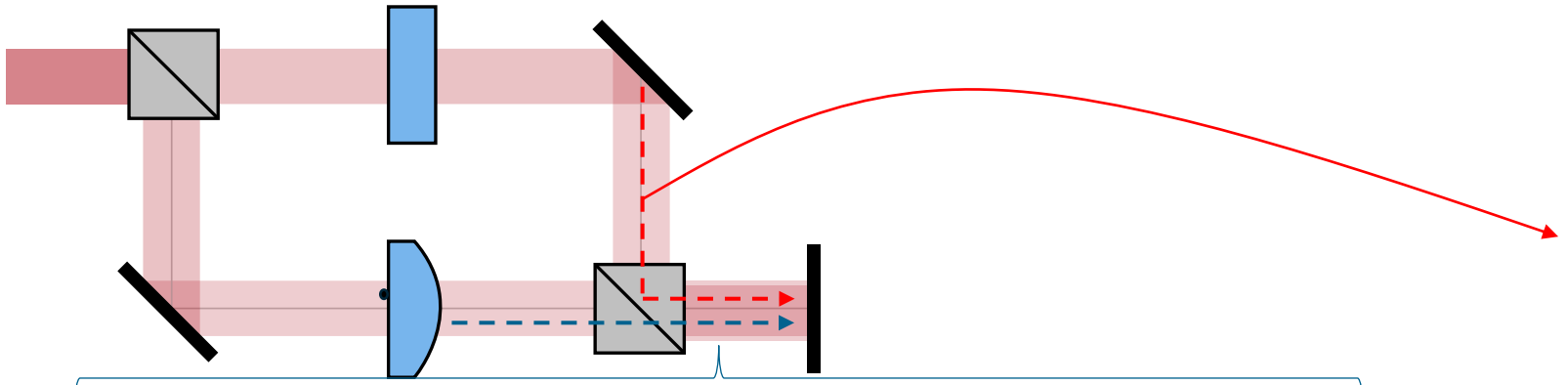


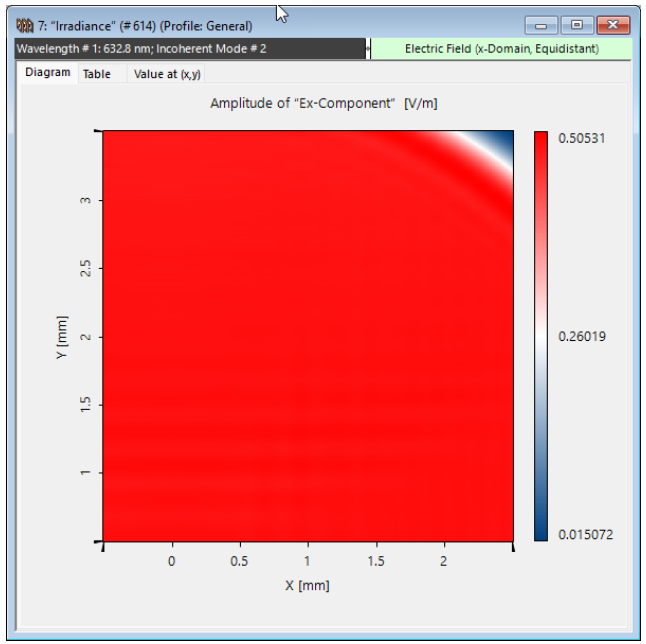


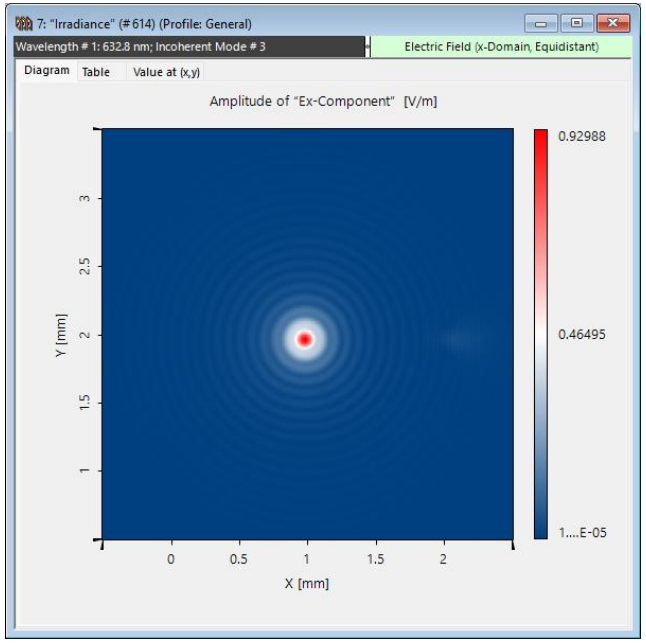


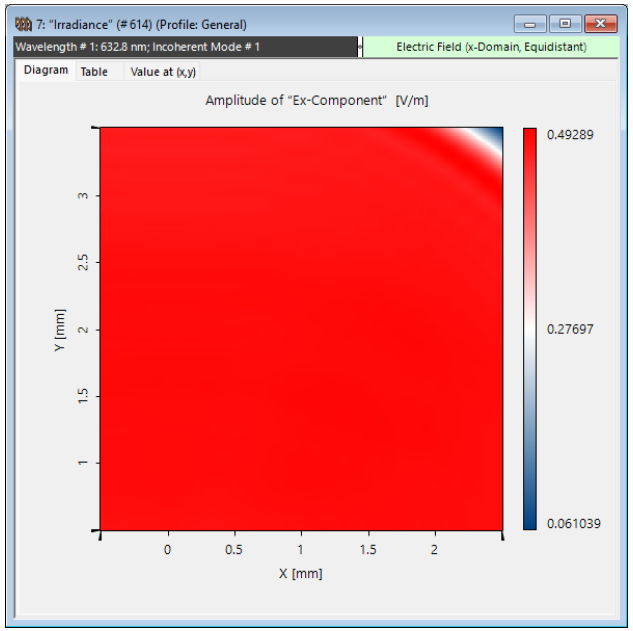


Field per Mode at Detector (with Diffraction)- Zoom

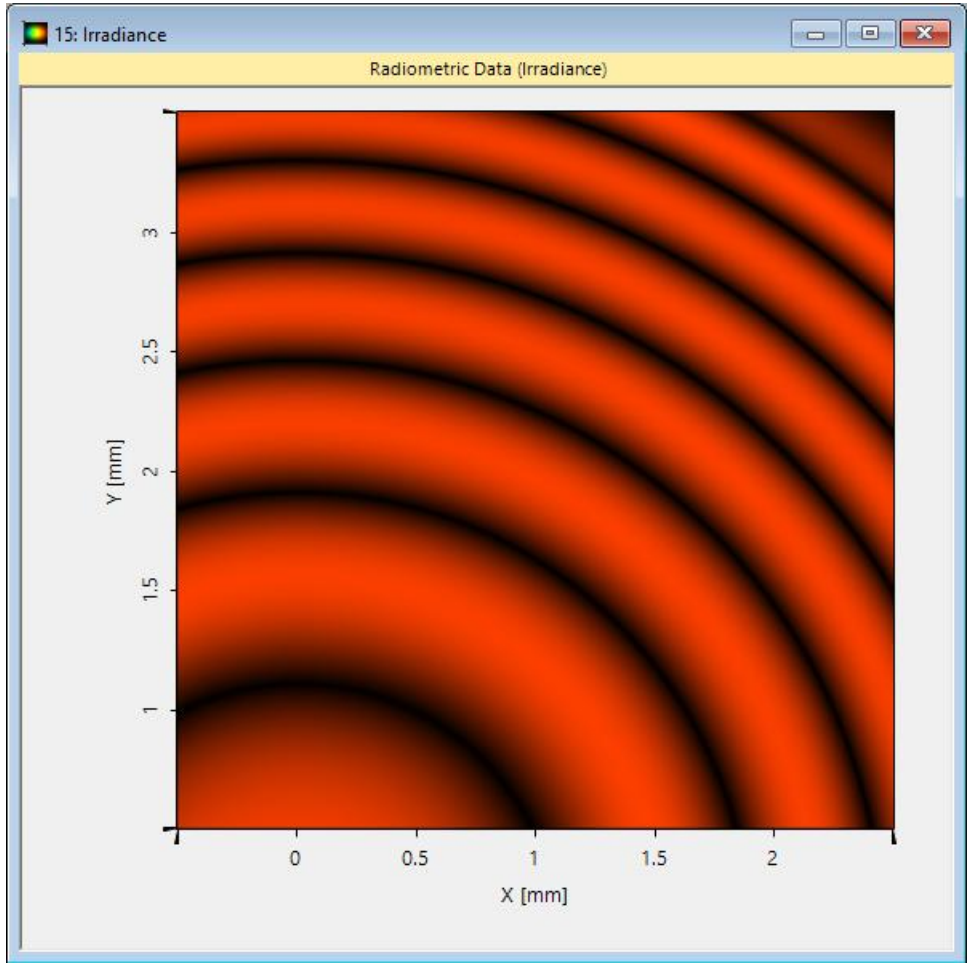




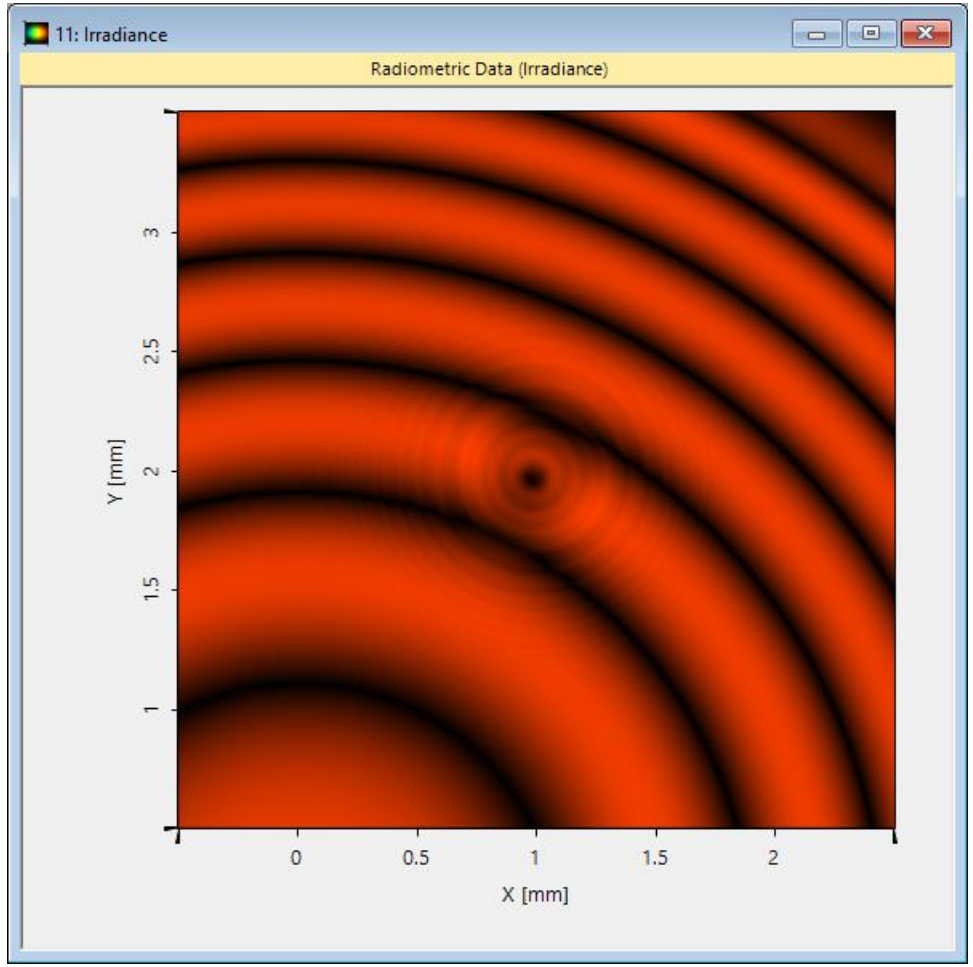




Comparison (Modes Added) - Zoom



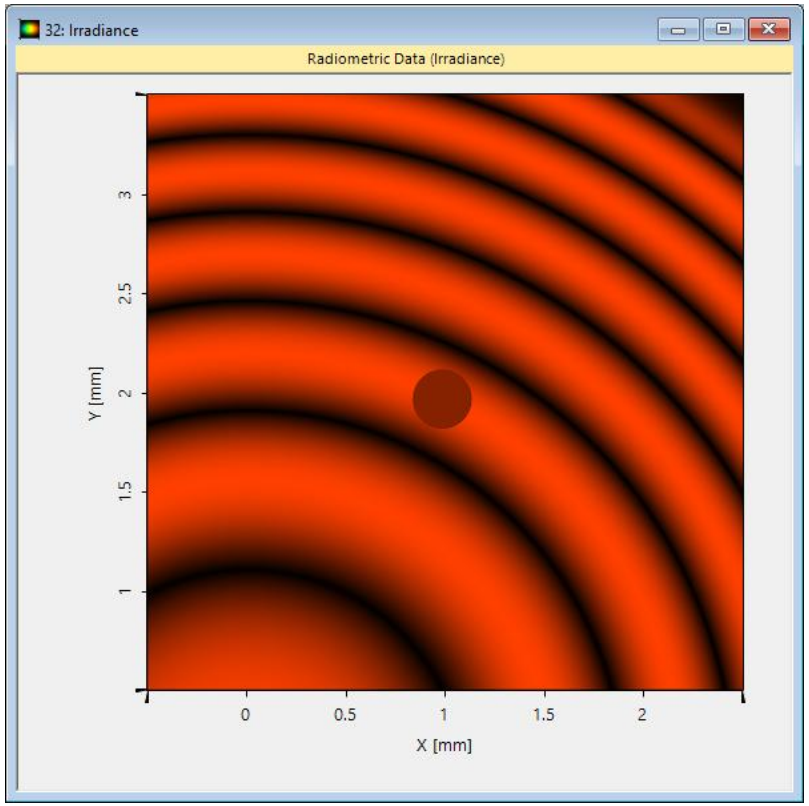
Irradiance without consideration of the defect (only perturbated fields added)



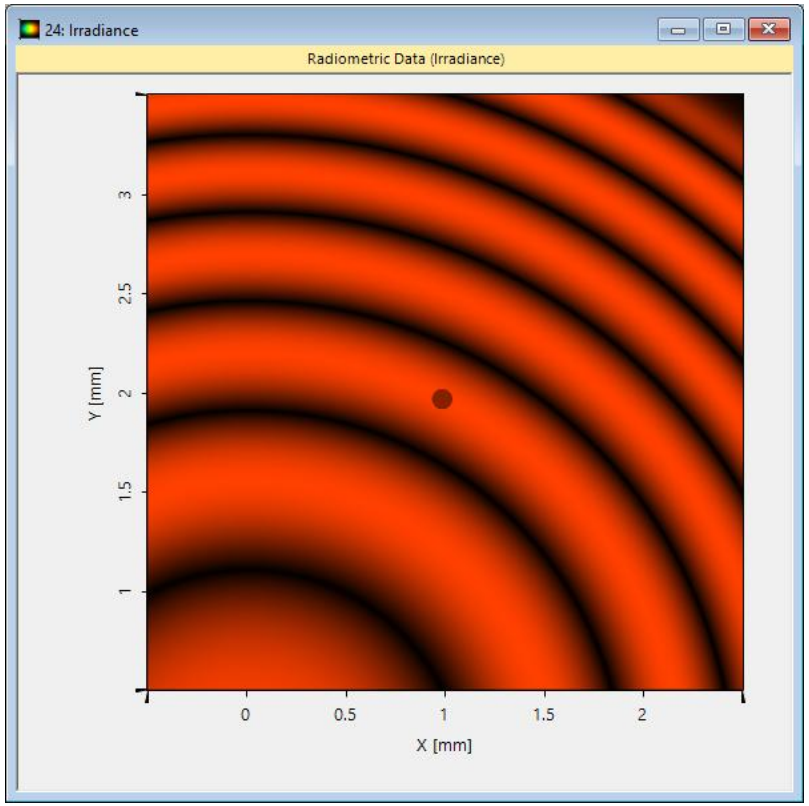
Irradiance with consideration of defect (all fields added)

Task 2: Reduce Defect Size

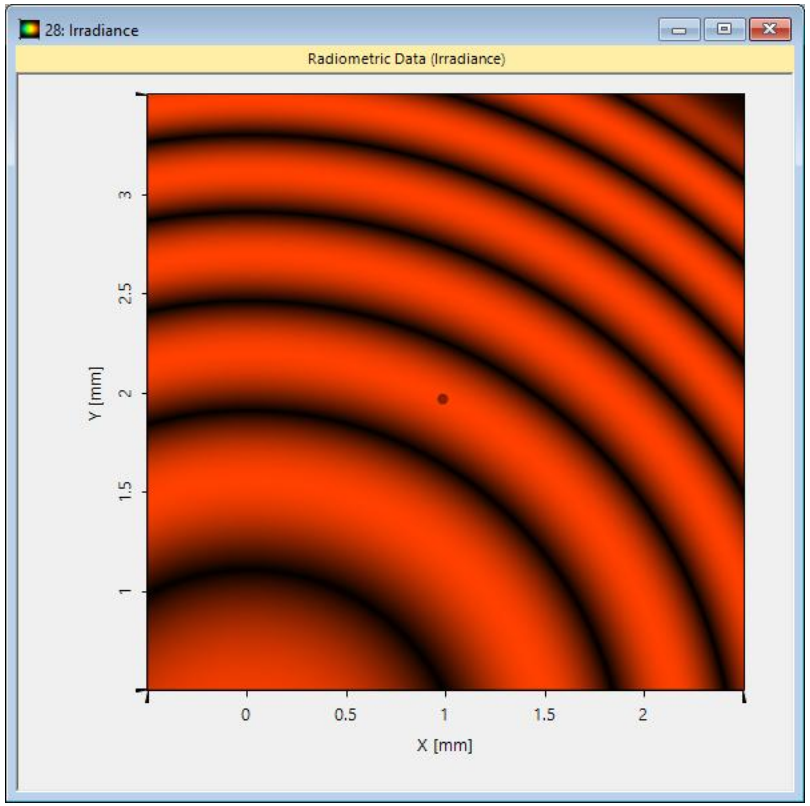
Variation of Defect Size without Considering Diffraction



300 µm defect size

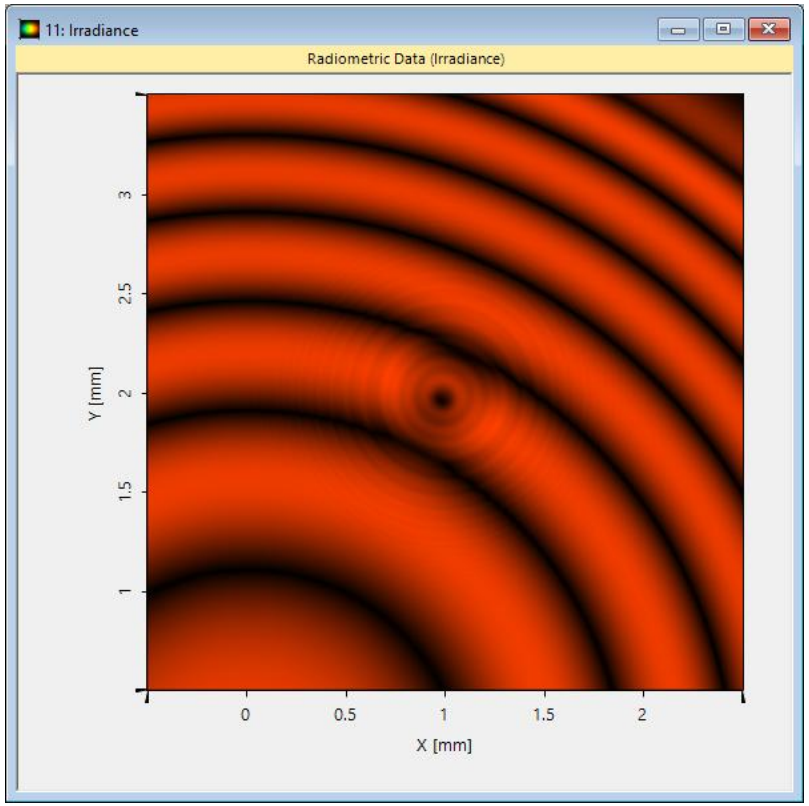


100 µm defect size

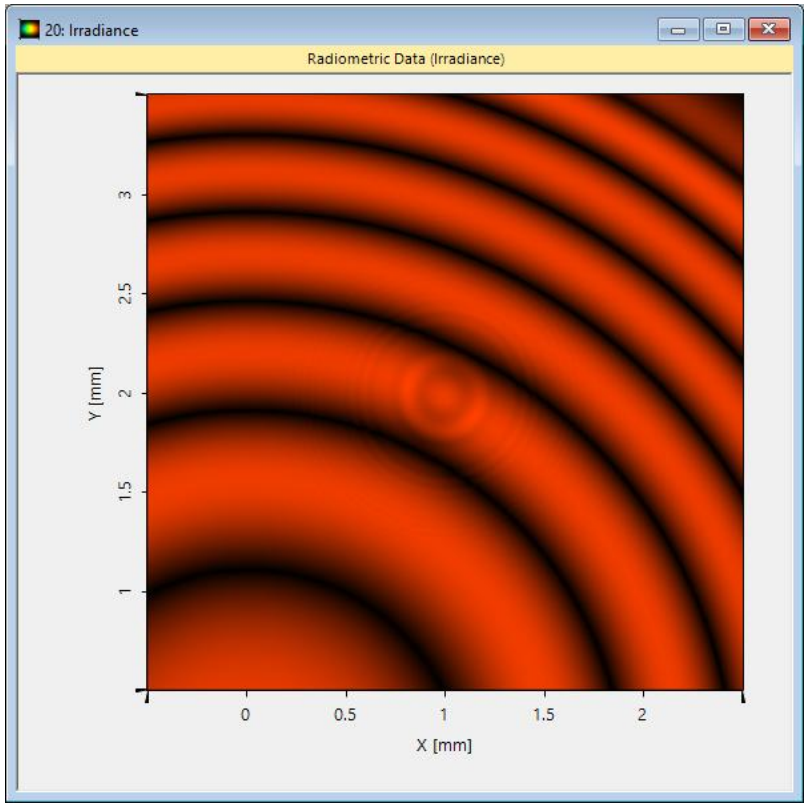


50 µm defect size

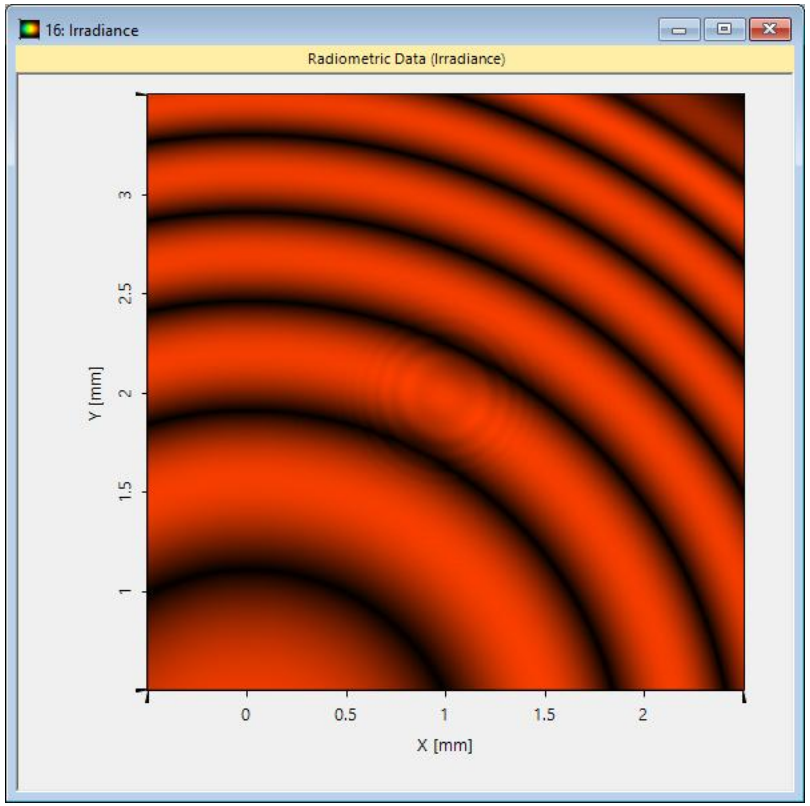
Variation of Defect Size with Considering Diffraction



300 µm defect size



100 µm defect size



50 µm defect size

Workflows

LP Mode Source

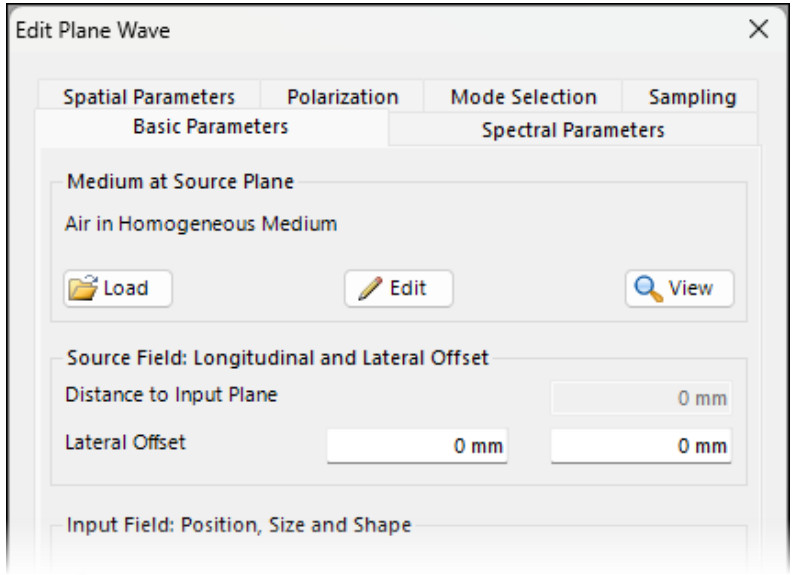
Source selection

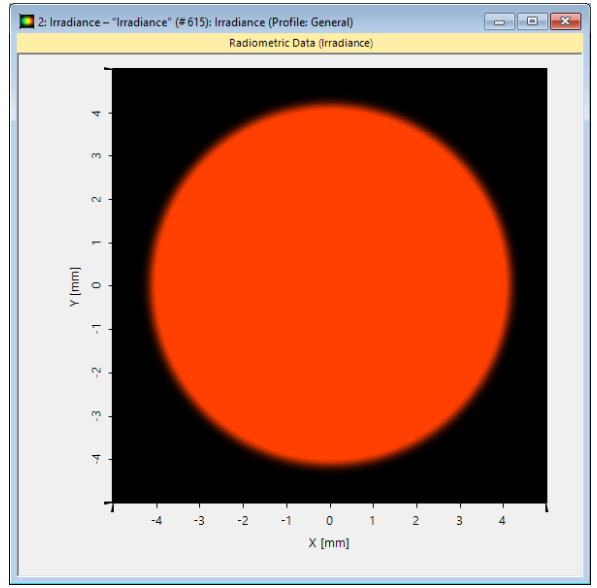
System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Plane Wave





System Setup

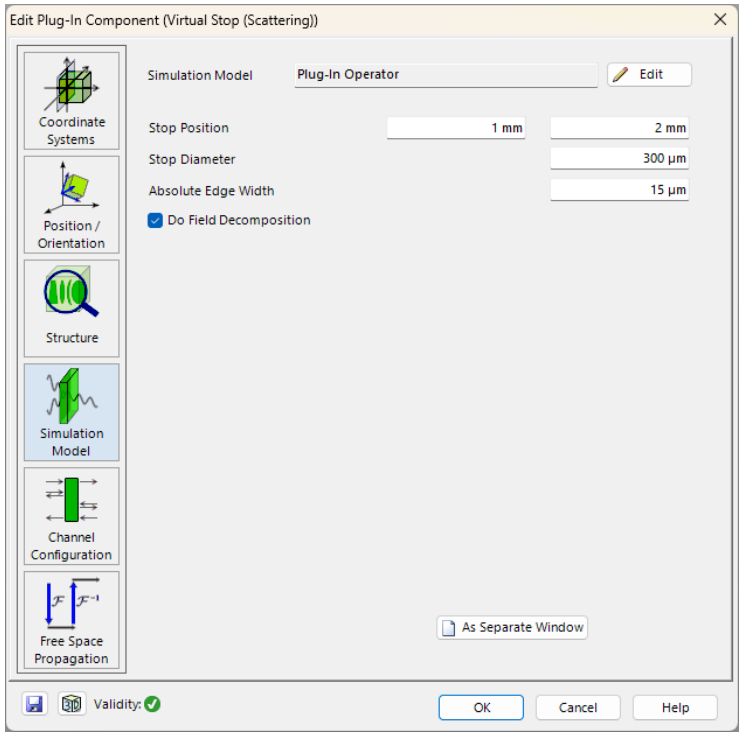
Source selection

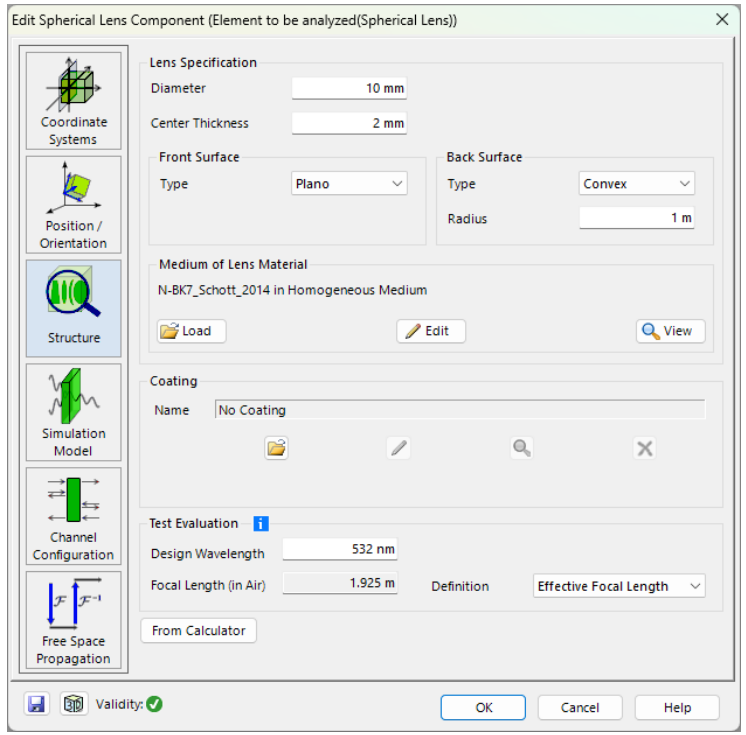
System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Model lens by Spherical Lens component
- Include defect by Virtual Stop component





Detector Selection

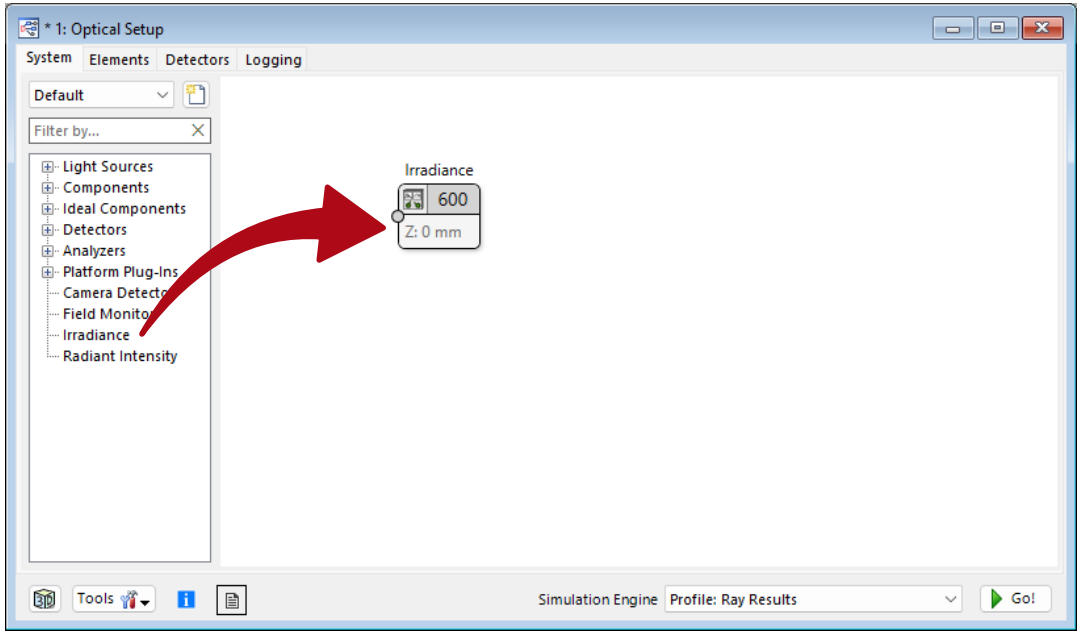
Source selection

System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Add Irradiance detector to your system.



Document Information

Title	Mach-Zehnder Interferometer with Small Defects
Document code	USC.0464
Publication date	05.09.2025
Required packages	-
Software version	2025.2 (Build 1.118)*
Category	Use Case
Further reading	- Laser-Based Michelson Interferometer and Interference Fringe Exploration - Fizeau Interferometer for Optical Testing

* *The files attached to this document require the specific version or later.*

Marketing Picture