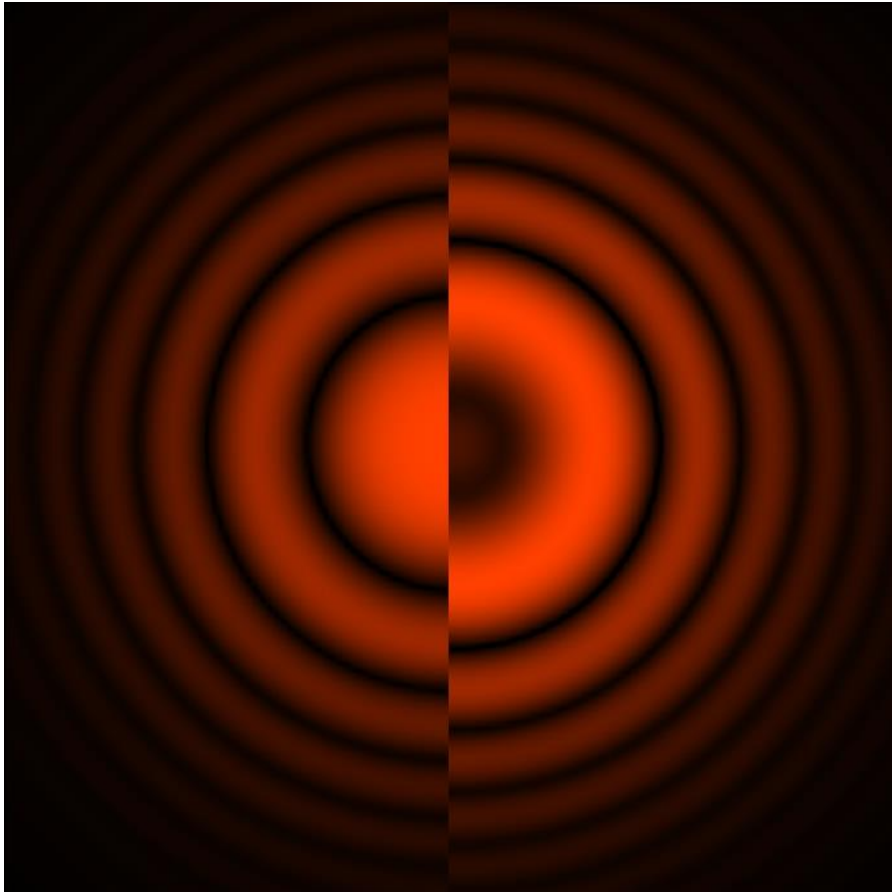


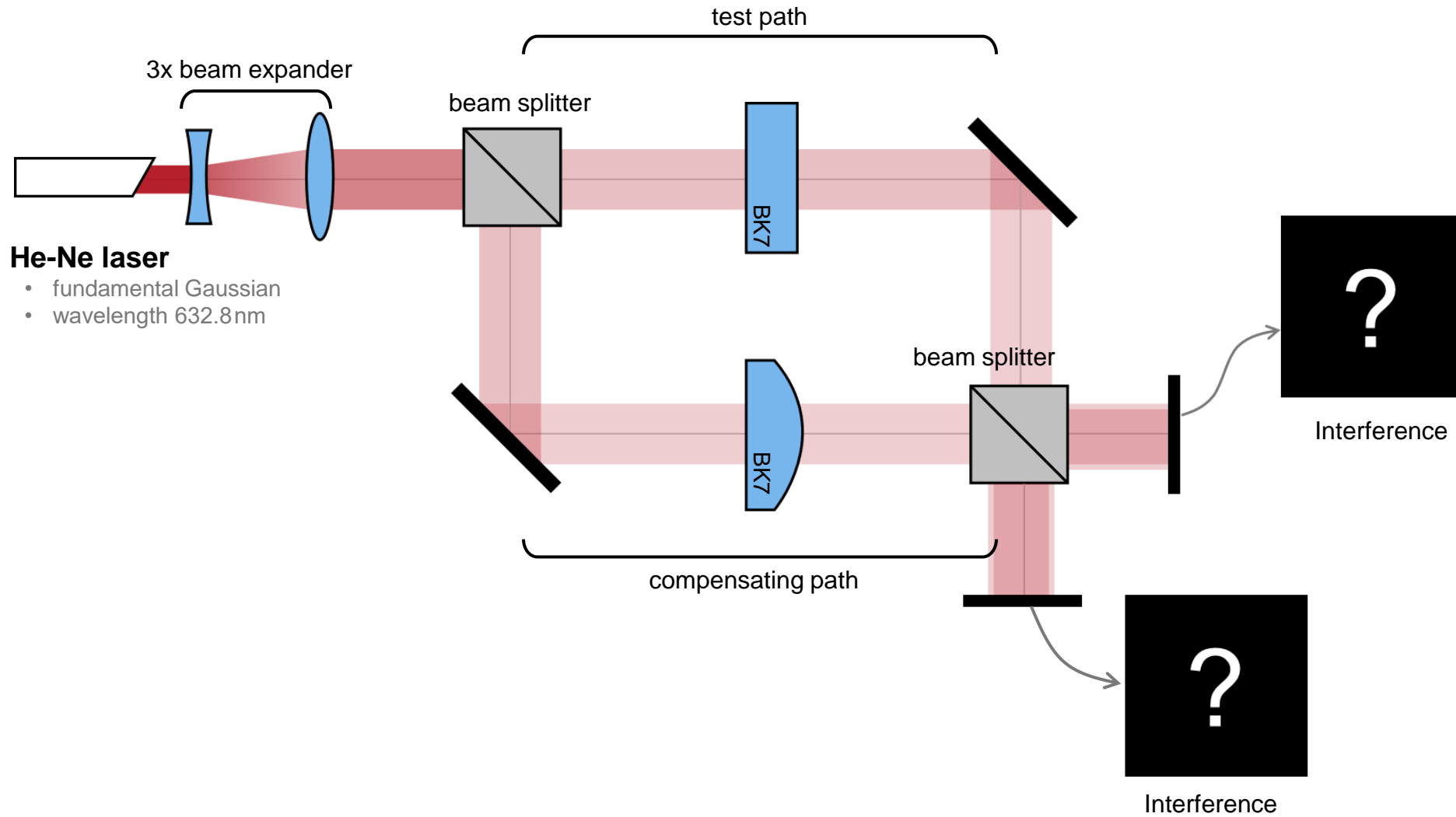
Complementary Interference Pattern in a Mach-Zehnder Interferometer

Abstract

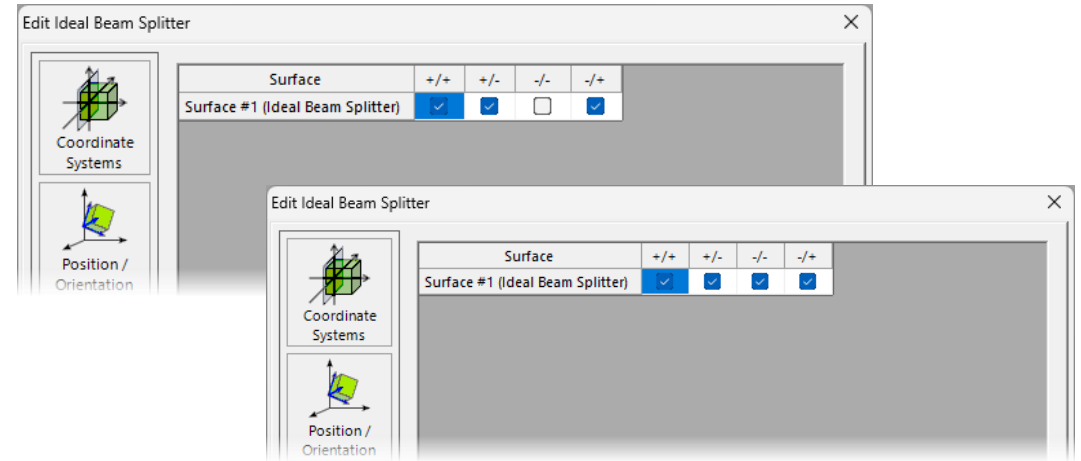
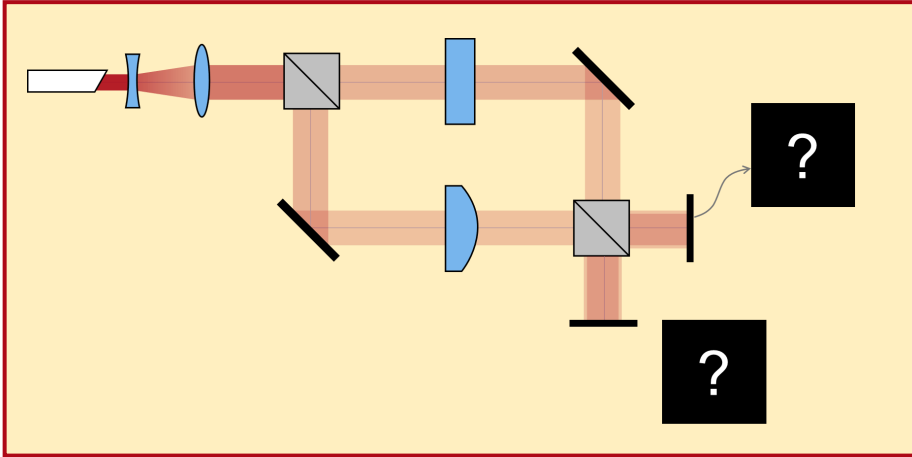


Beam splitters are crucial components for any kind of interferometry application, as they either split incident light into two beams or can be used in reverse to combine two different beams into one. While often modeled as an idealized component, to fully understand all effects these components have on the light, a real model is necessary. To demonstrate this, a Mach-Zehnder interferometer with a coherent laser source is built up in VirtualLab Fusion and analyzed by using a non-sequential modeling approach. The different behavior of idealized and prism beam splitters is investigated, revealing a complementary interference pattern caused by a relative phase shift.

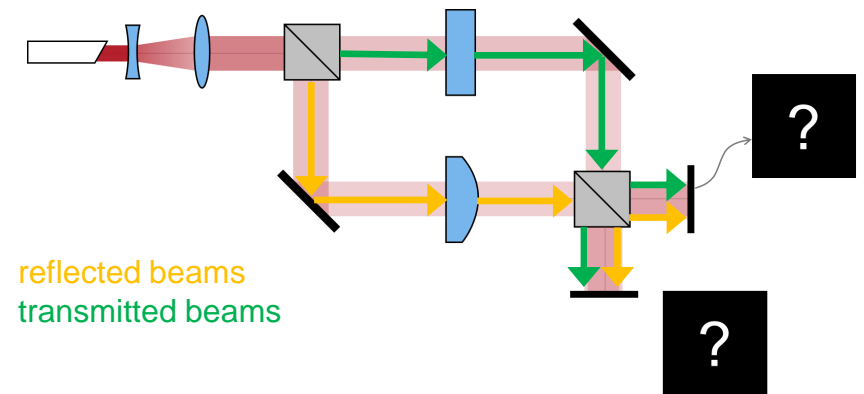
Modeling Task



Non-Sequential Tracing

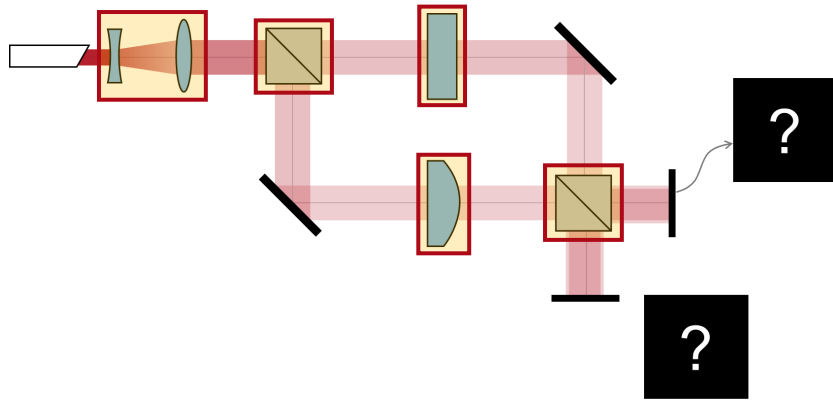


With the channel configuration mode toggle set to *Manual Configuration*, the user can specify, for each surface in the system, which channels to open for the simulation. When the simulation is run, a preliminary analysis of the active light paths will be performed (by the so-called *Light Path Finder*). The field will then be traced along these light paths by the engine, to the detectors present in the system.



Channel Setting for Non-Sequential Tracing

Optical Elements



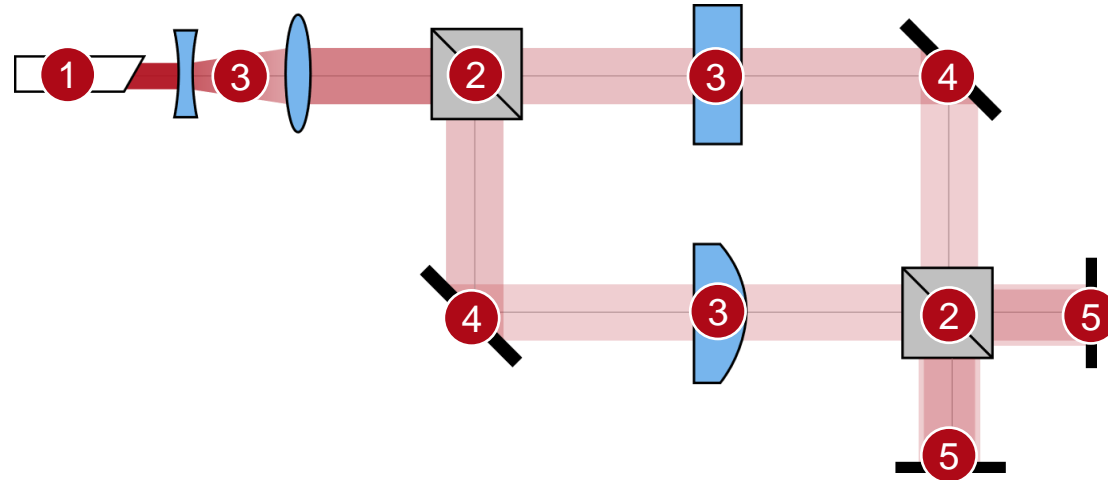
The *Lens System Component* allows the user to easily define a component consisting of an alternating sequence of smooth surfaces and homogeneous, isotropic media. For both interfaces and materials, you can choose ready-made entries from the built-in catalogs or customize your own for maximum flexibility.

The screenshot shows two overlapping windows from the 'Edit Lens System Component' software. The top window is titled 'Edit Lens System Component (Beam Expander 3x)' and the bottom window is titled 'Edit Lens System Component (Real Beamsplitter (Turned))'. Both windows feature a sidebar with icons for 'Coordinate Systems', 'Position / Orientation', 'Structure', 'Solver', 'Channel Configuration', and 'Free Space Propagation'. The main area contains a table with columns for Index, Distance, Position, Type, Homogeneous Medium, and Comment. Below the table are icons for 'Plane', 'Conical', and 'Cylindrical' surfaces. The bottom window also includes icons for 'Aspherical', 'Polynomial', 'Sampled', and 'Programmable' surfaces. At the bottom of the windows are buttons for 'Add', 'Insert', 'Delete', 'OK', 'Cancel', and 'Help'.

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	N-BK7_Schott_2015 in H	Enter your comr
2	1 mm	1 mm	Conical Interface	Air in Homogeneous Me	Enter your comr
3	38.164 mm	39.164 mm	Conical Interface	N-BK7_Schott_2015 in H	Enter your comr
4	4.3 mm	43.464 mm			

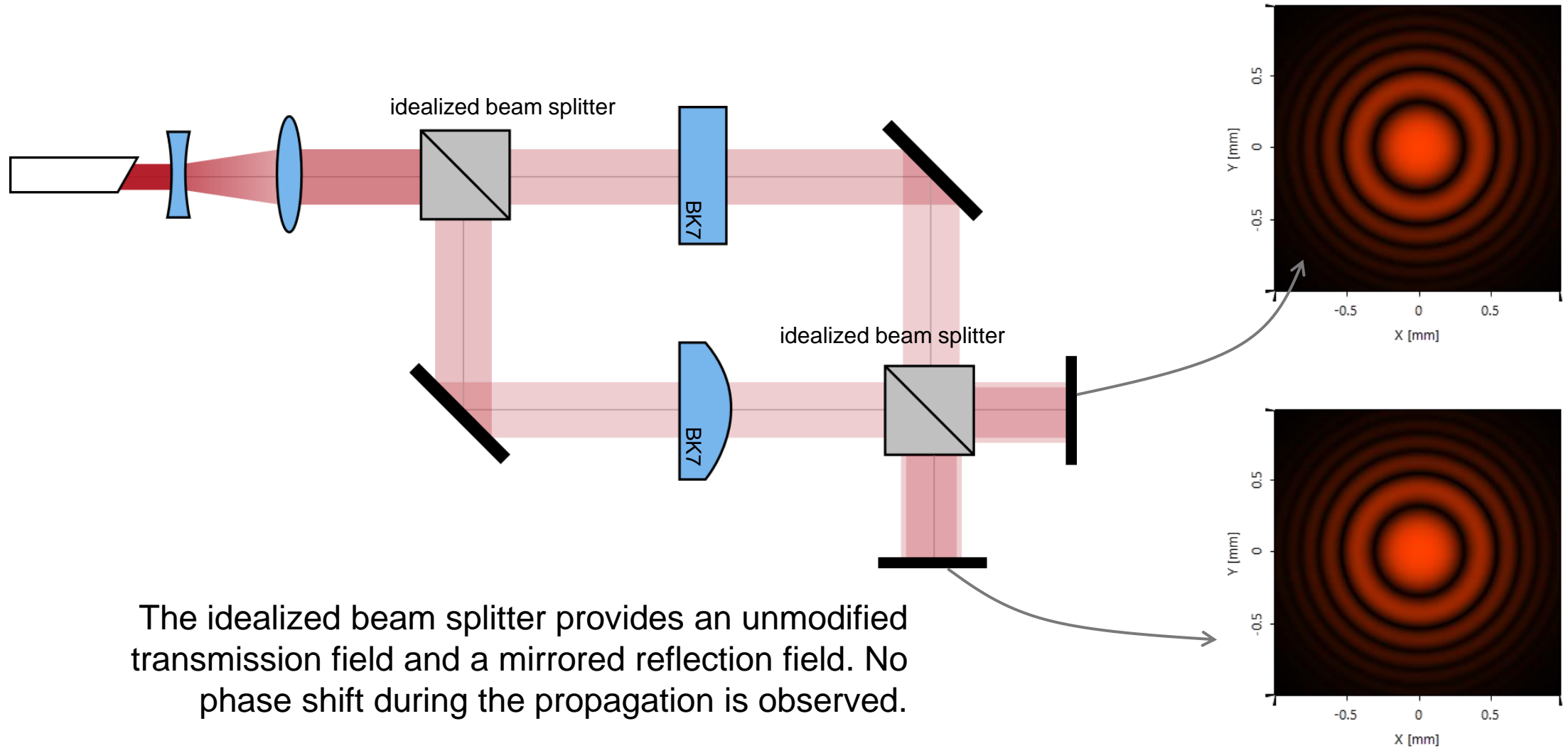
Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Plane Surface	Fused_Silica in Homoge	Enter your comr
2	1 mm	1 mm	Plane Surface	Air in Homogeneous Me	Enter your comr

Summary – Components...



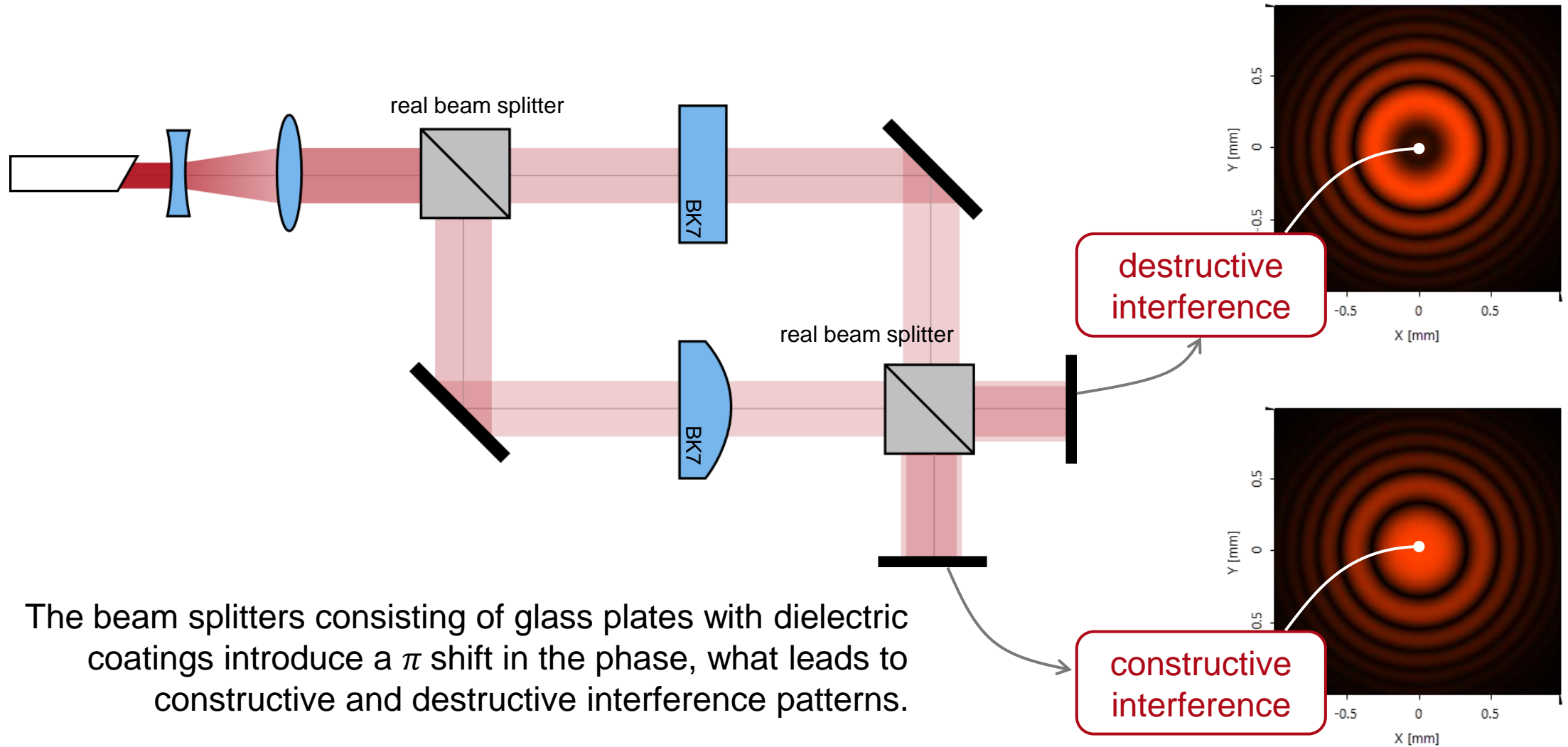
... of Optical System	... in VirtualLab Fusion	Model/Solver/Detected Magnitude
1. He-Ne laser	<i>Gaussian Wave</i>	spatial Gaussian function
2. beam splitter	<ul style="list-style-type: none"> • <i>Ideal Beam Splitter</i> • <i>Lens System Component</i> 	<ul style="list-style-type: none"> • transmission function • Local Plane Interface Approximation (LPIA)
3. optical components	<i>Lens System Component</i>	Local Plane Interface Approximation (LPIA)
4. mirrors	<i>Ideal Mirror Component</i>	transmission function
6. detector	<i>Camera Detector</i>	energy density

Interference Pattern with Idealized Beam Splitters

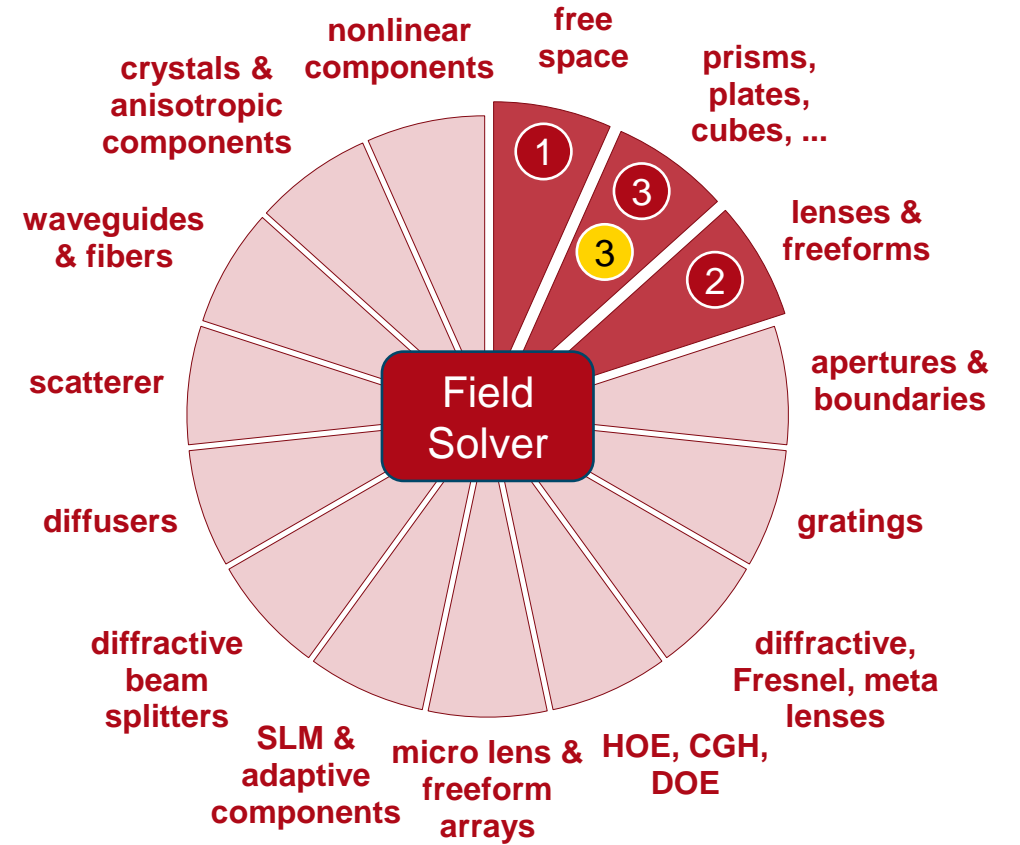
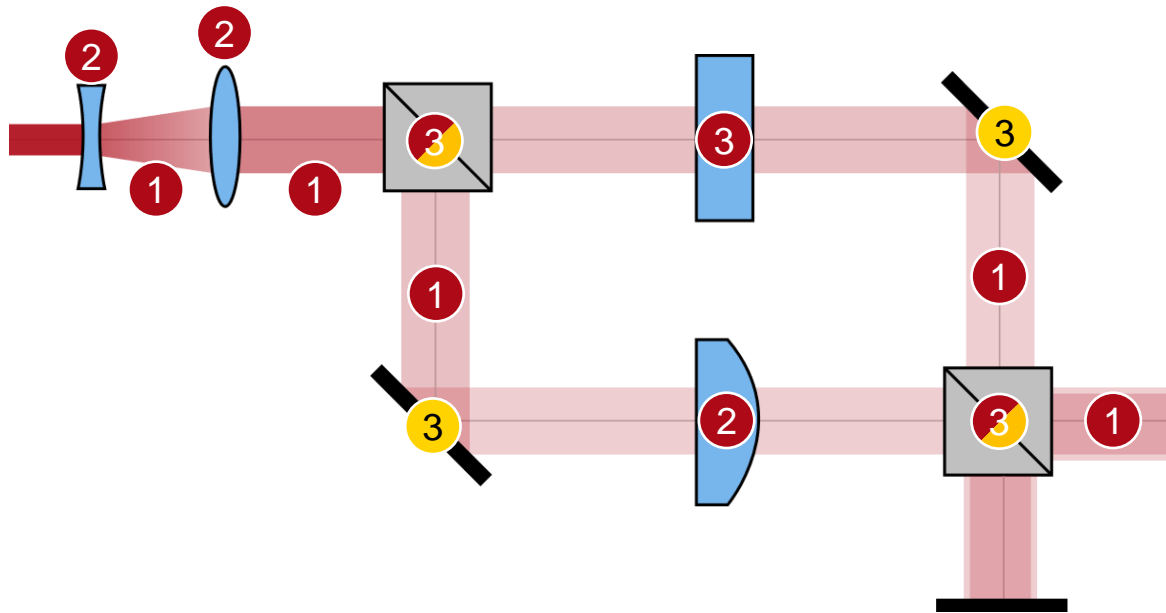


The idealized beam splitter provides an unmodified transmission field and a mirrored reflection field. No phase shift during the propagation is observed.

Interference Pattern with Real Beam Splitters



VirtualLab Fusion Technologies



idealized component

Document Information

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software version	2023.1 (Build 1.556)
category	Application Use Case
further reading	<ul style="list-style-type: none">• <u>Mach-Zehnder Interferometer</u>• <u>Laser-Based Michelson Interferometer and Interference Fringe Exploration</u>