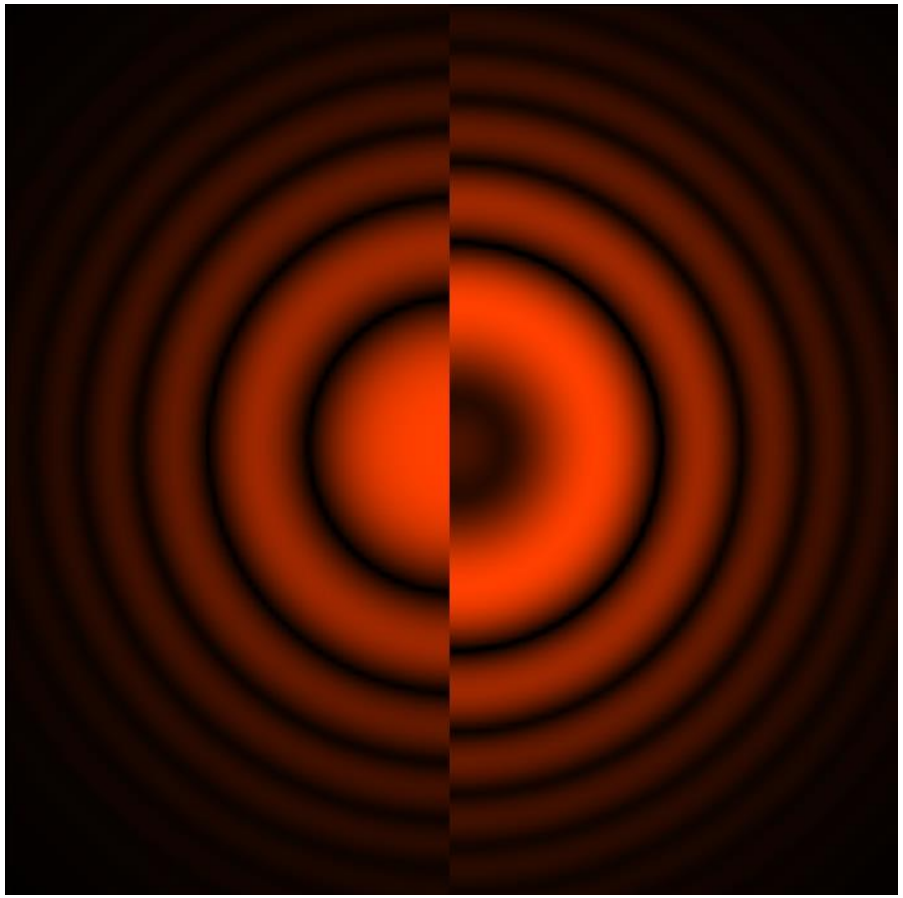
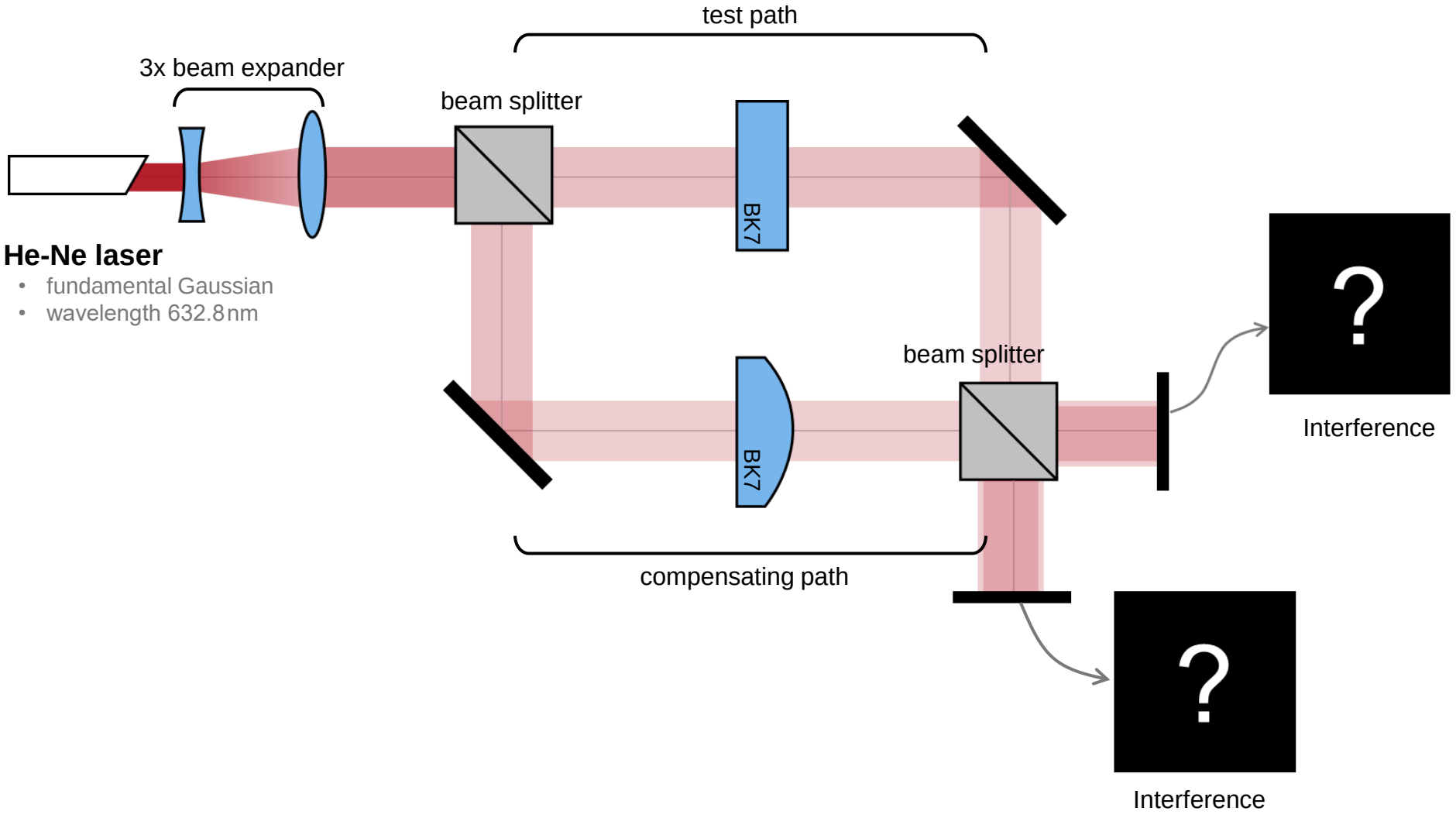
Complementary Interference Pattern in a Mach-Zehnder Interferometer

Abstract

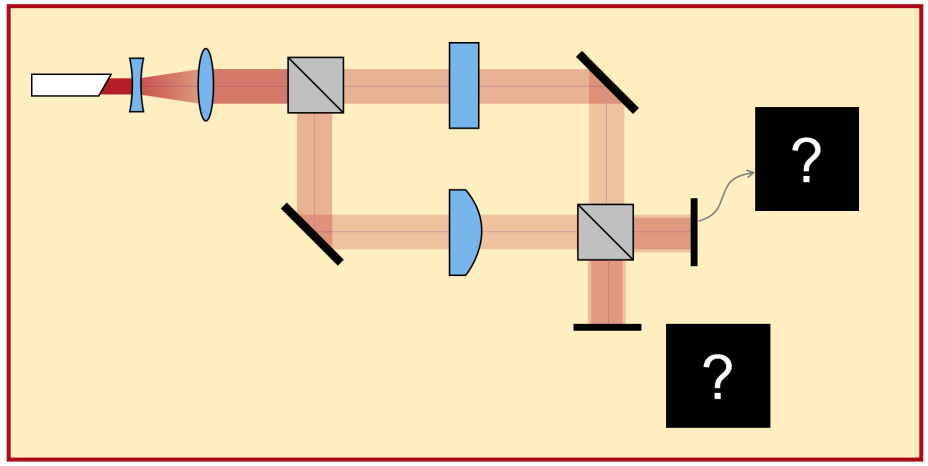


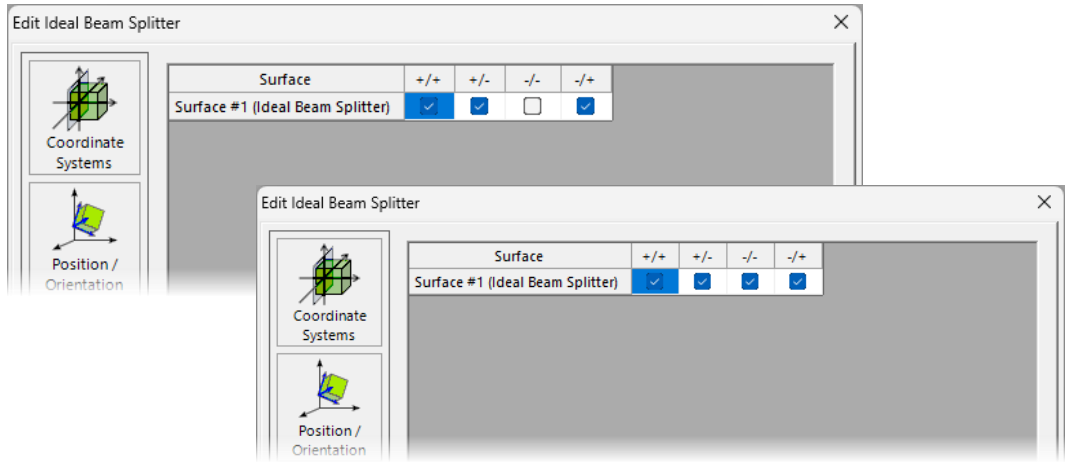
Beam splitters are crucial components for any kind of interferometry application, as they either split incident light into two beams or can be used in reverse to combine two different beams into one. While often modeled as an idealized component, to fully understand all effects these components have on the light, a real model is necessary. To demonstrate this, a Mach-Zehnder interferometer with a coherent laser source is build 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

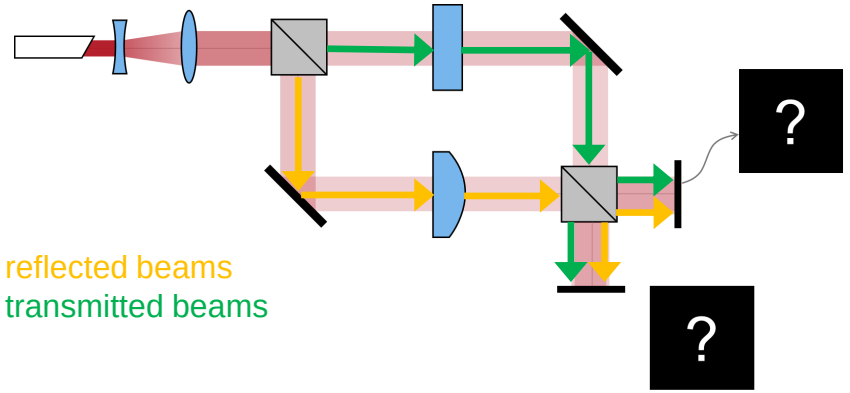


Non-Sequential Tracing



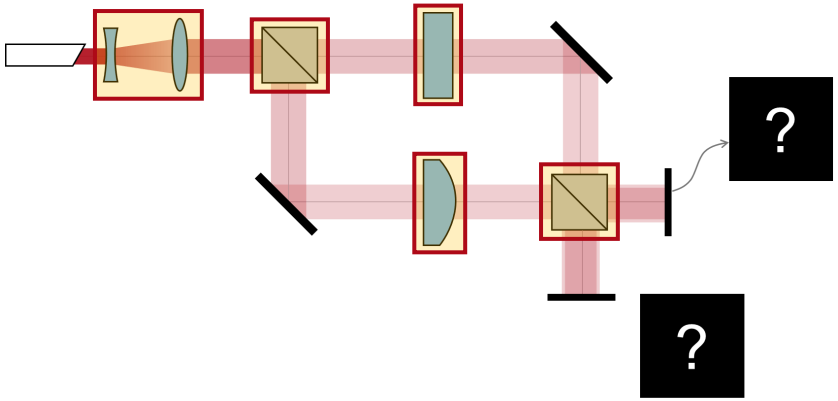


With the channel configuration mode toggle set to *Manual Configuration*, the user can specify, for each surface in the system, which channels to open for the simulation. When the simulation is run, a preliminary analysis of the active light paths will be performed (by the so-called *Light Path Finder*).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

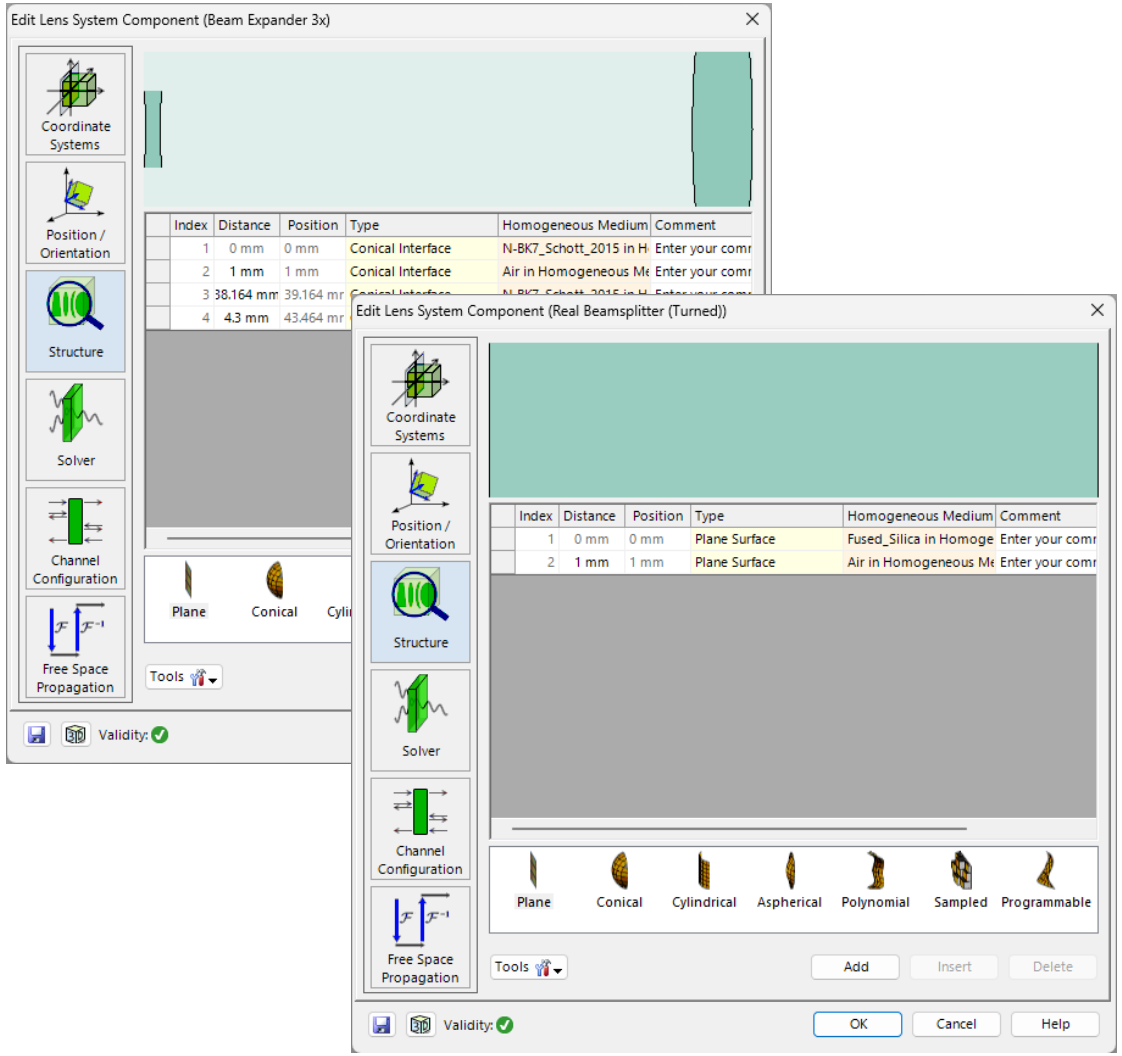


Channel Setting for Non-Sequential Tracing

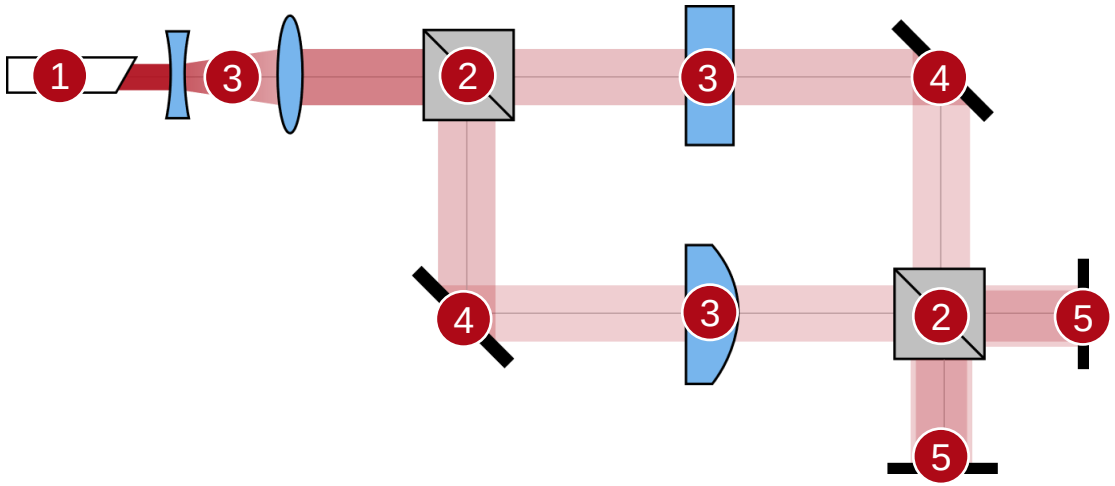
Optical Elements



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.

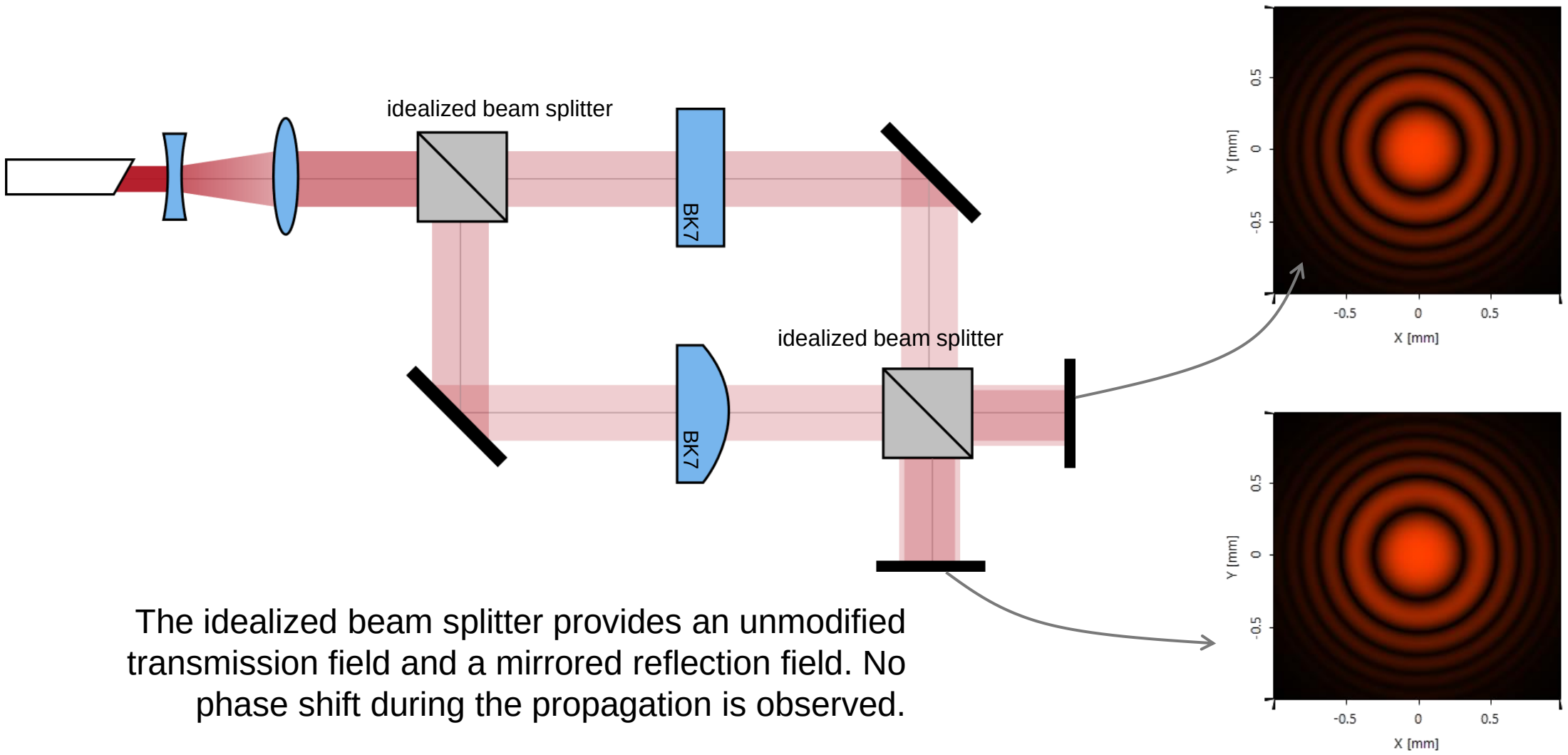


Summary – Components...



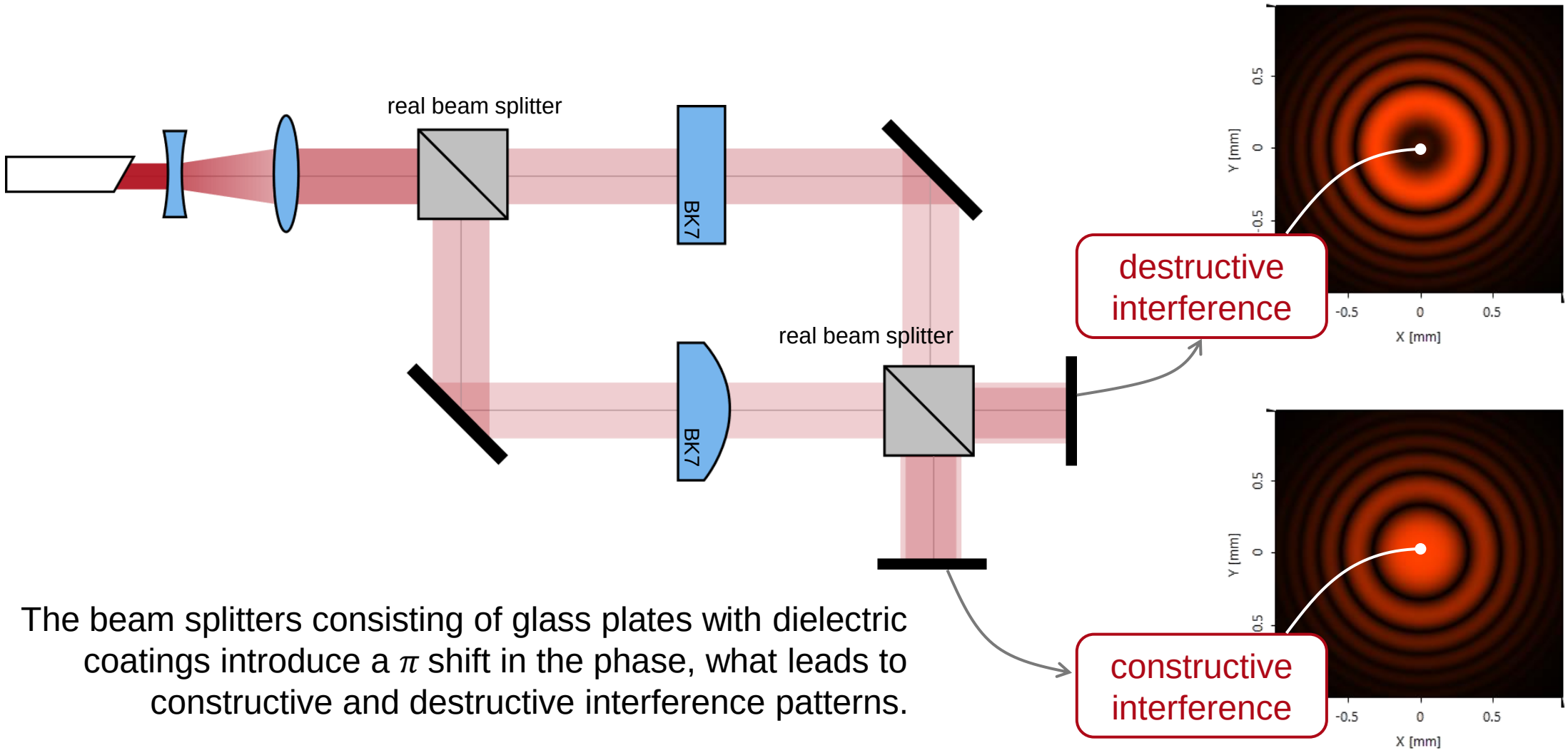
… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Magnitude
1. He-Ne laser	*Gaussian Wave*	spatial Gaussian function
2. beam splitter	• *Ideal Beam Splitter* • *Lens System Component*	• transmission function • Local Plane Interface Approximation (LPIA)
3. optical components	*Lens System Component*	Local Plane Interface Approximation (LPIA)
4. mirrors	*Ideal Mirror Component*	transmission function
6. detector	*Camera Detector*	energy density

Interference Pattern with Idealized Beam Splitters



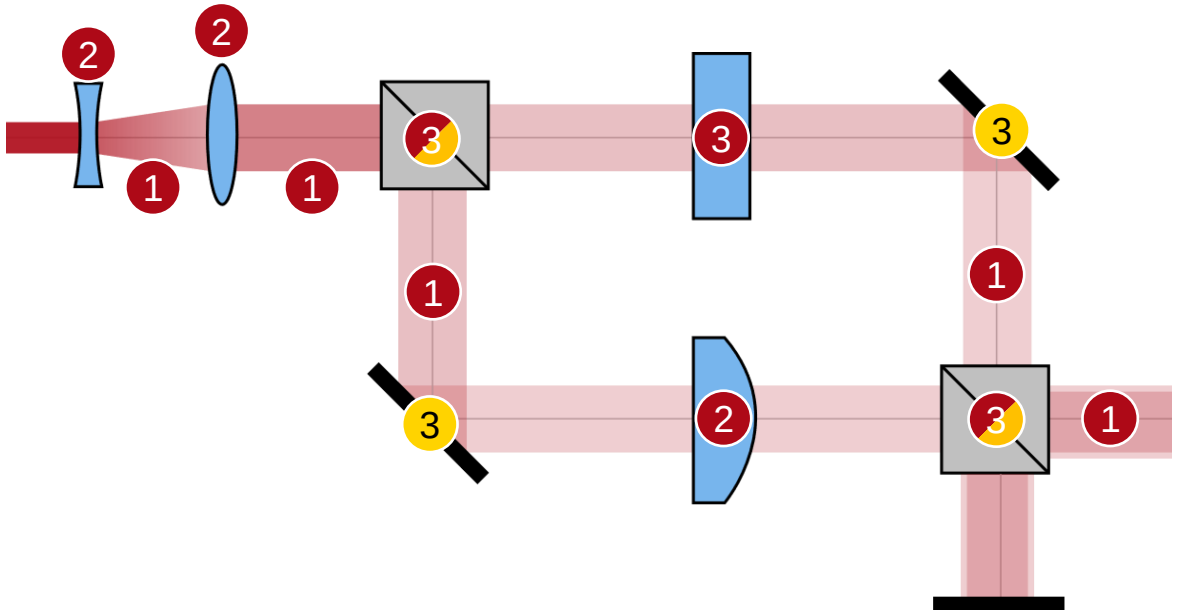
The idealized beam splitter provides an unmodified transmission field and a mirrored reflection field. No phase shift during the propagation is observed.

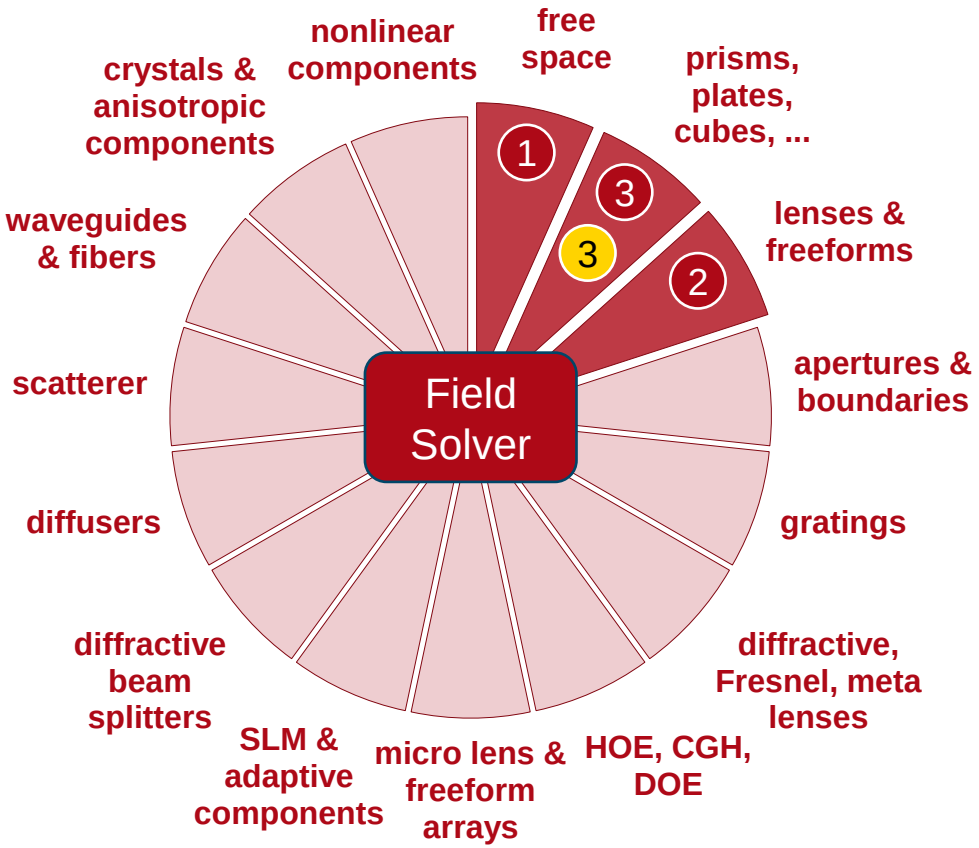
Interference Pattern with Real Beam Splitters



The beam splitters consisting of glass plates with dielectric coatings introduce a π shift in the phase, what leads to constructive and destructive interference patterns.

VirtualLab Fusion Technologies





Document Information

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