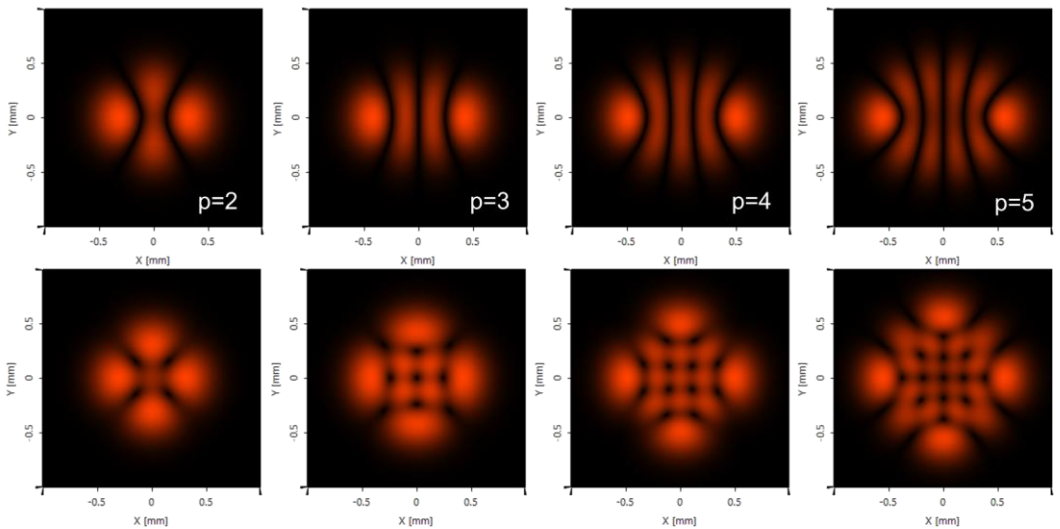
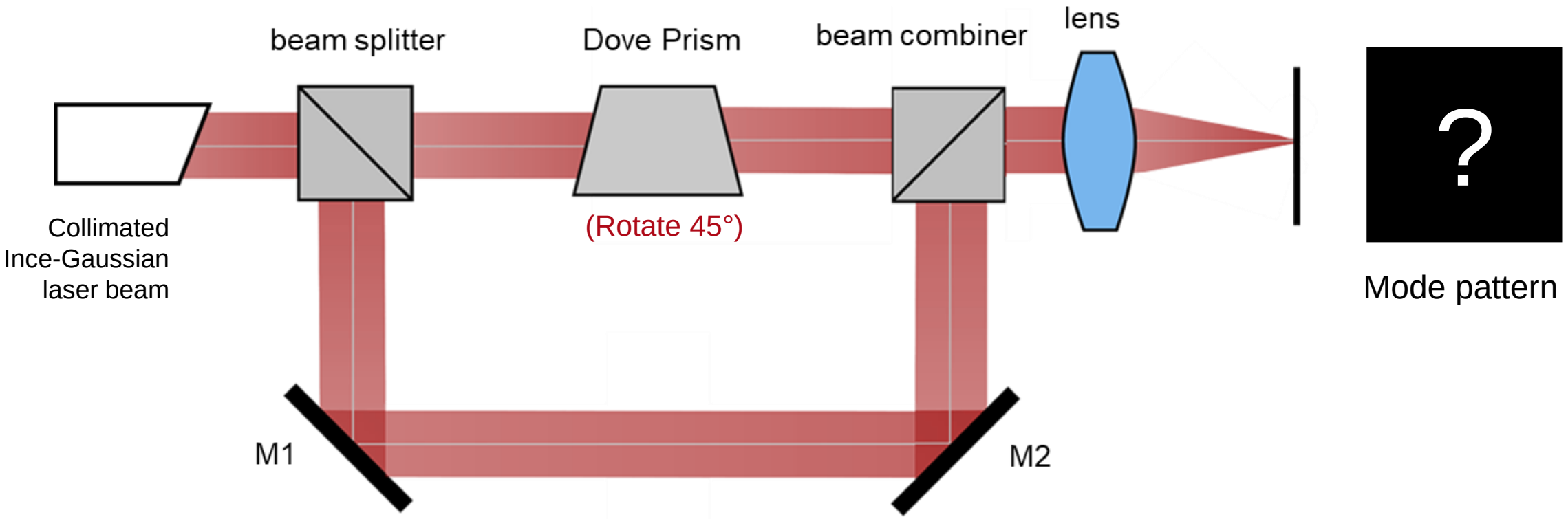
Observation of Vortex Array Laser Beam Generation from Ince-Gaussian Beam

Abstract



Ince-Gaussian modes are the third complete family of exact and orthogonal solutions of the paraxial wave equation alongside the Hermite-Gaussian and Laguerre-Gaussian modes. Ince-Gaussian modes have a diversiform transverse pattern. In this document, following in the steps of Chu et al. [Opt. Express 16, 19934-19949 (2008)], a Dove prism-embedded unbalanced Mach-Zehnder interferometer is used to simulate the generation of vortex array laser beams based on Ince-Gaussian modes. The resulting vortex array laser beam generated by the proposed interferometric setup maintains its beam profile during propagation, also through a focus. Thus, the proposed vortex array laser beams hold great promise for application in optical tweezers and atom traps in the form of two-dimensional arrays.

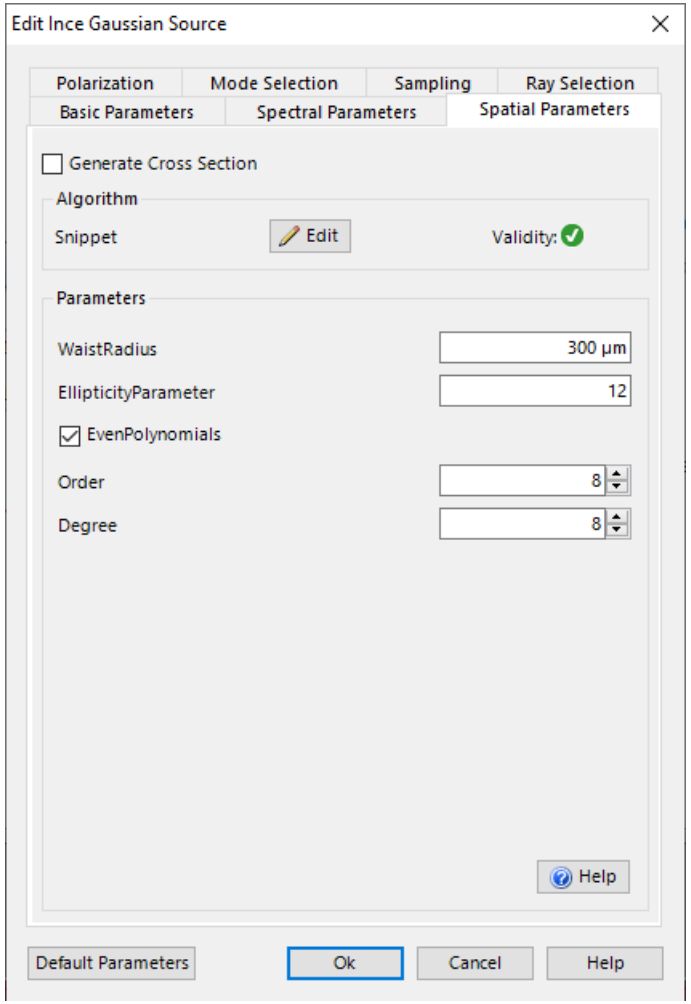
Task Description

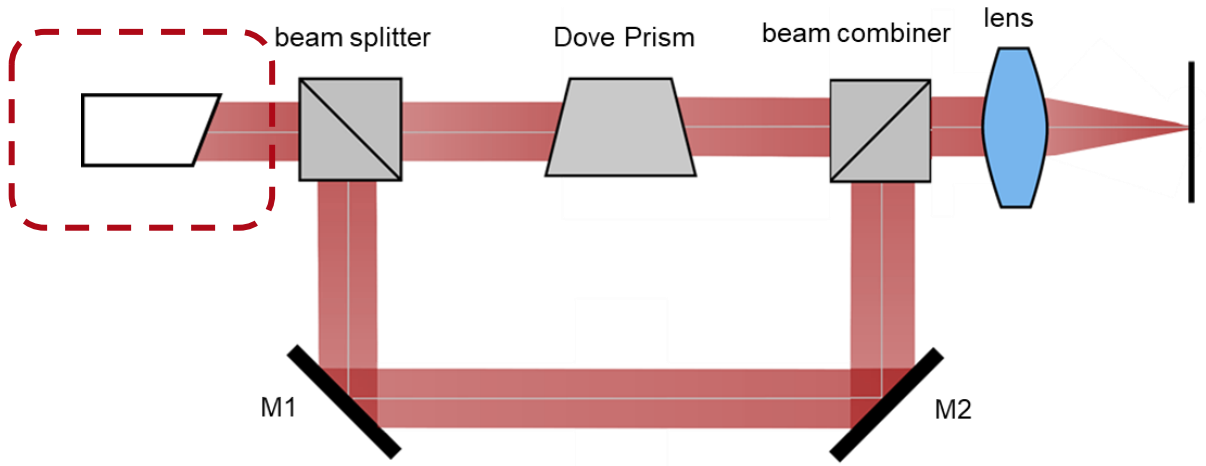


Ref: Shu-Chun Chu, Chao-Shun Yang, and Kenju Otsuka, "Vortex array laser beam generation from a Dove prism-embedded unbalanced Mach-Zehnder interferometer," Opt. Express 16, 19934-19949 (2008)

Building the System in VirtualLab Fusion

System Building Blocks – Source



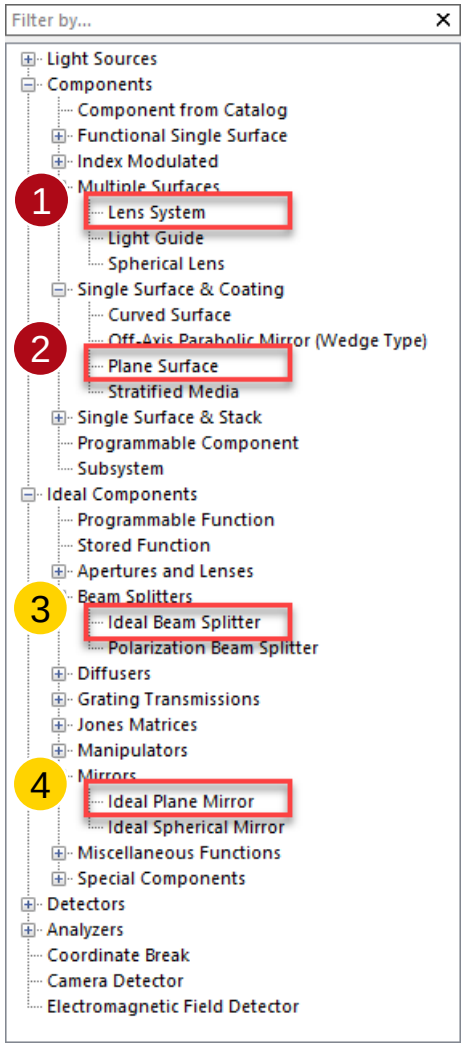


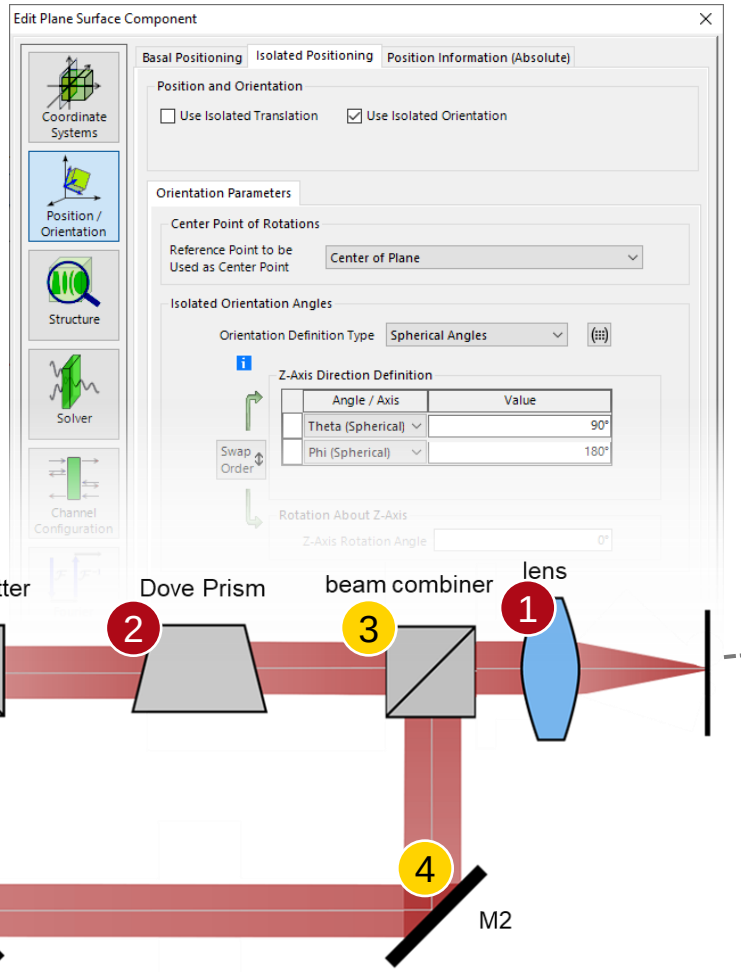
The Ince-Gaussian source can be found in *Light Sources -> Basic Source Models*, and offers the following adjustable parameters

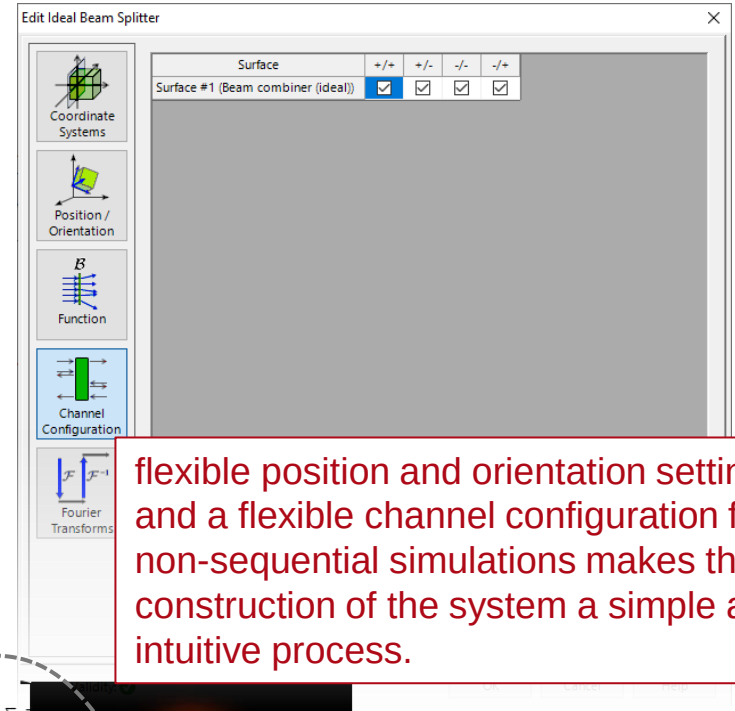
- Waist radius
- Ellipticity parameter
- Order of mode polynomial
- Degree of mode polynomial

A more detailed explanation of the meaning of the parameters and configuration of the source can be found here: Ince-Gaussian Modes

System Building Blocks – Components and Detector

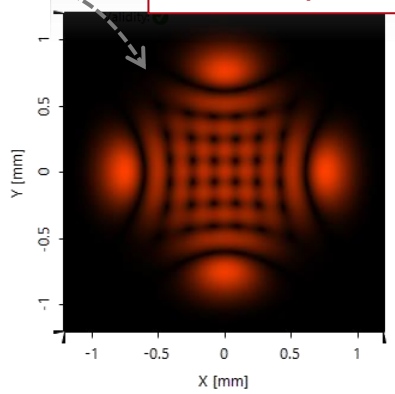






idealized component

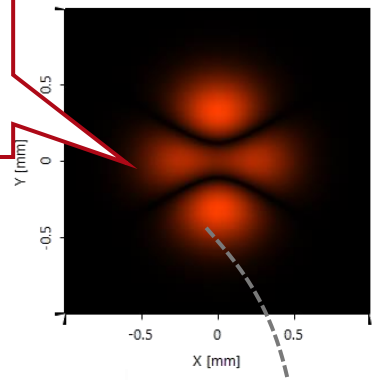
flexible position and orientation settings and a flexible channel configuration for non-sequential simulations makes the construction of the system a simple and intuitive process.

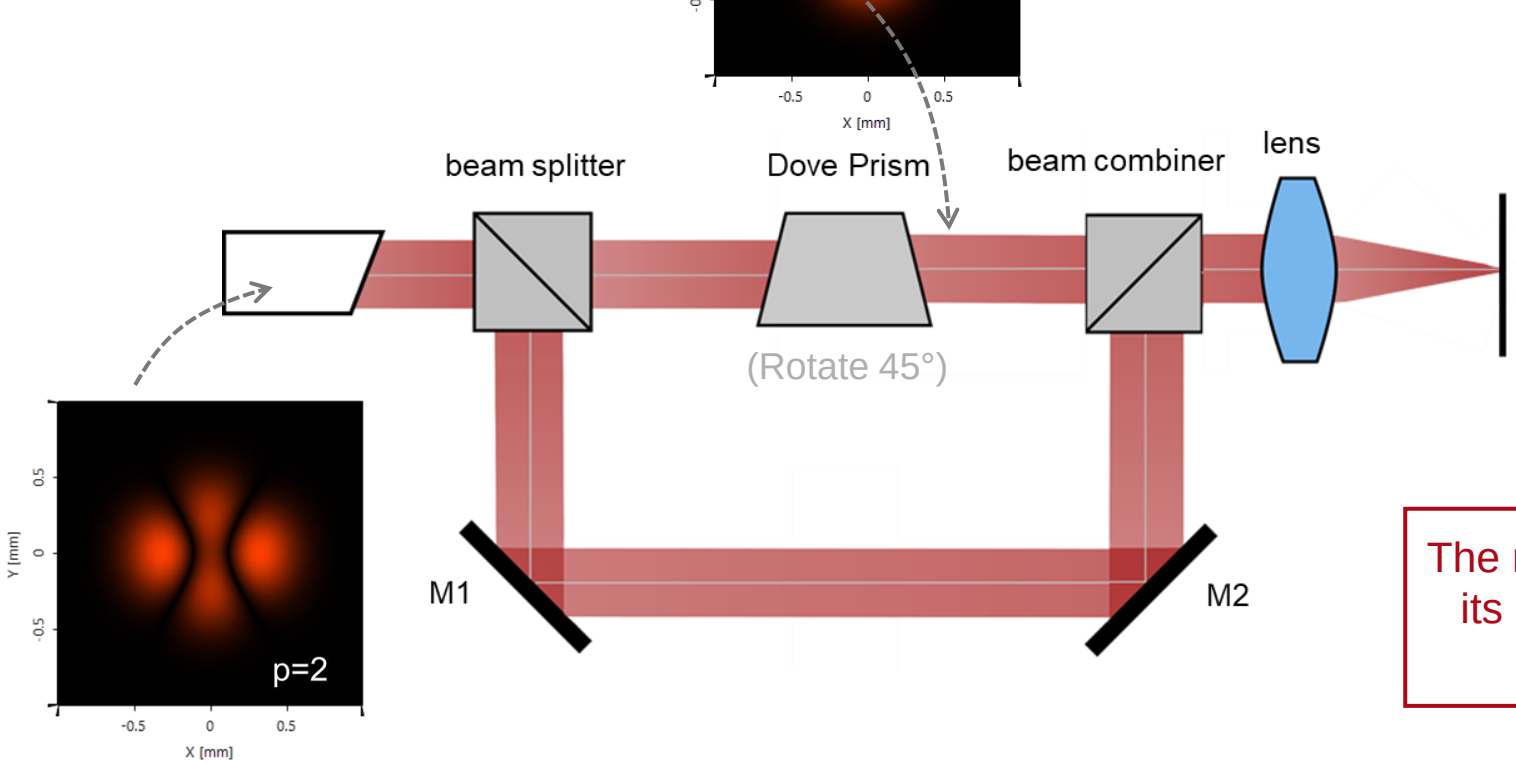


Direct observation of the mode pattern

Simulation of Vortex Array Laser Beam Generation

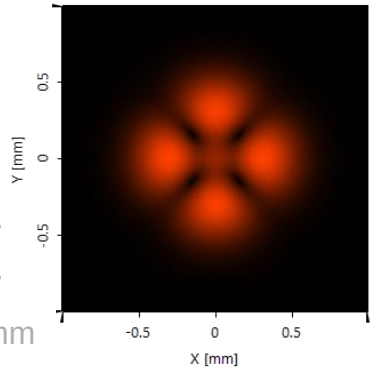
Mode pattern rotated 90° after it propagates through the dove prism.





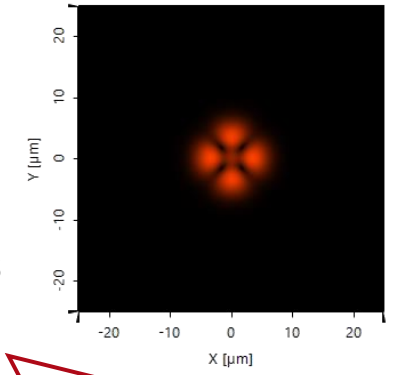
mode pattern after beam combiner

Window size 2mm x 2mm



mode pattern at focus

Window size 50um x 50um

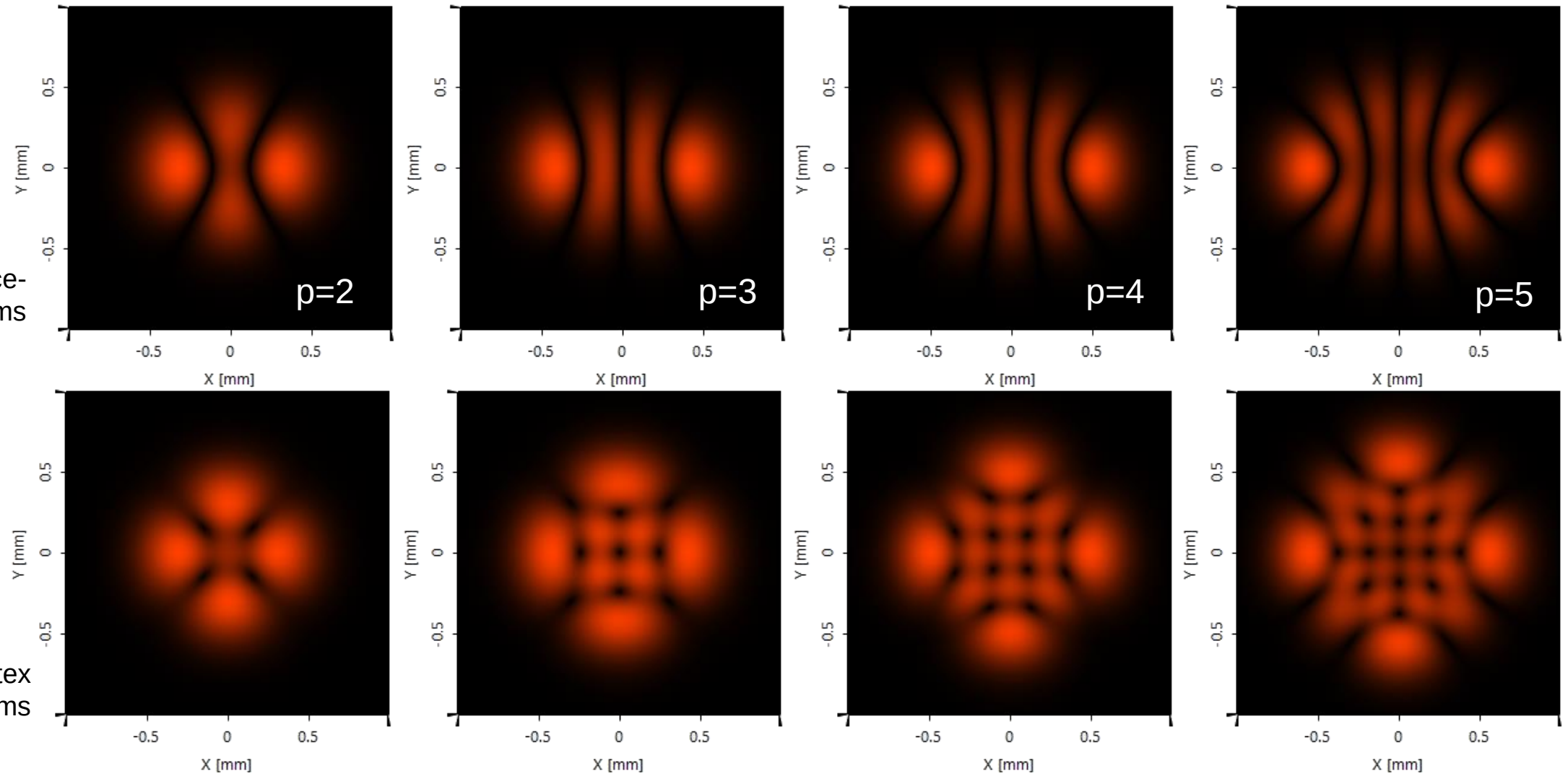


The resulting vortex array laser beam maintains its beam profile during both propagation and focusing.

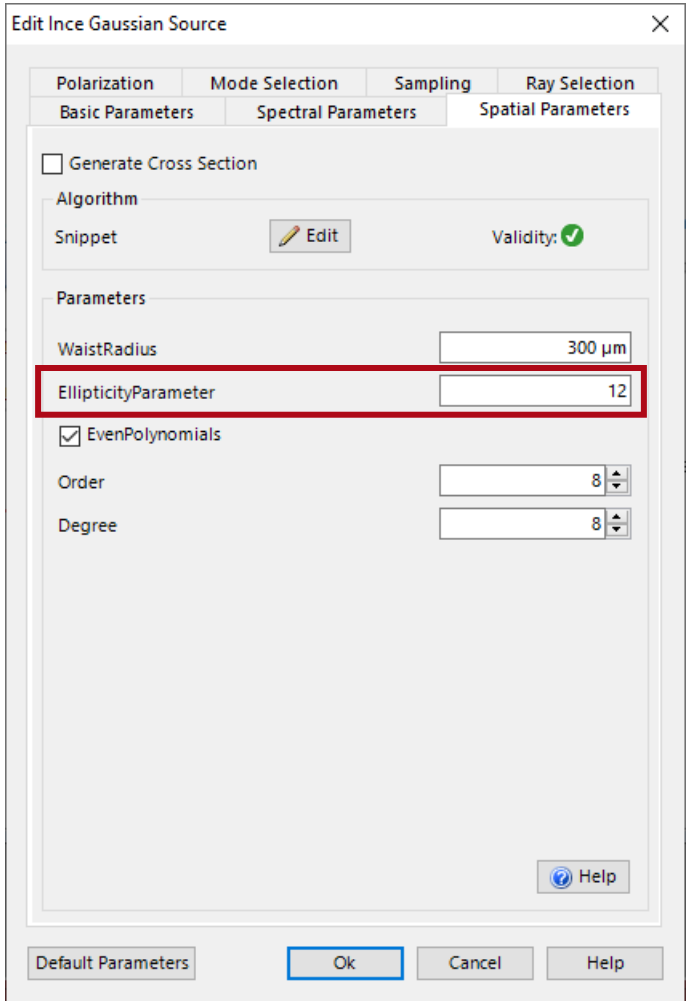
Generated Vortex Array Using Different Mode Orders in Source

incident Ince-Gaussian beams

generated vortex array beams

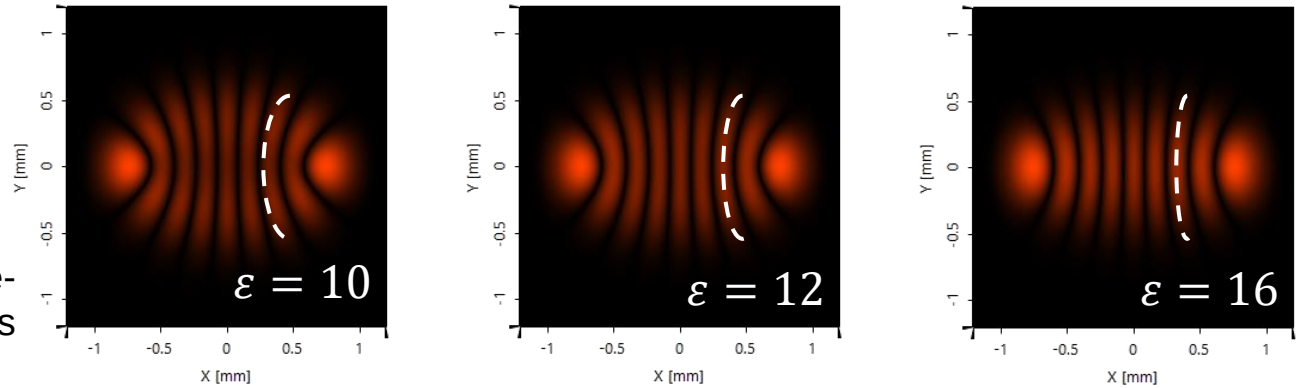


Effect of Ellipticity Parameter on Vortex Array Pattern

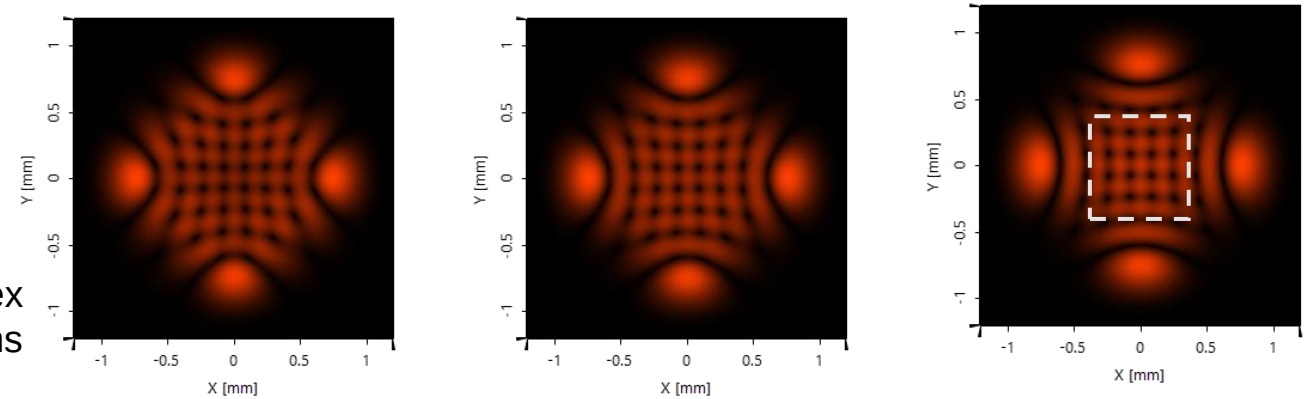


A larger value of the ellipticity parameter ε of the incident Ince-Gaussian laser beam reduces the curvature of the mode parabola, with the result that the generated vortices form a less distorted (squarer) array.

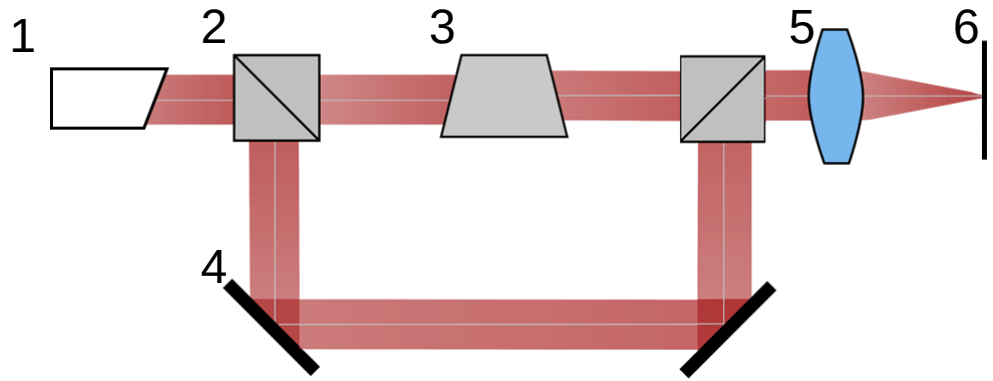
incident Ince-Gaussian beams



generated vortex array beams



Summary – System Building Blocks...

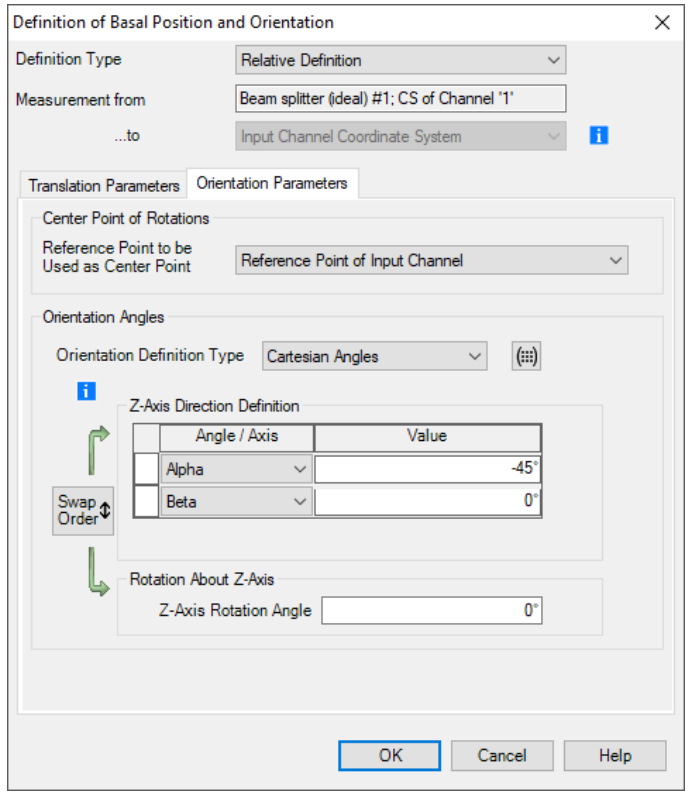


… of Optical System	… in VirtualLab Fusion	Source Model/Component Solver
1. Source	Ince Gaussian Source	Ince-Gaussian mode calculation
2. Beam Splitter	Ideal Beam Splitter	-
3. Dove Prism	Plane Interfaces	Fresnel Matrix
4. Mirror	Ideal Mirror	Local Plane Interface Approximation
5. Lens	Ideal Lens	-
6. Detector	Camera Detector	-

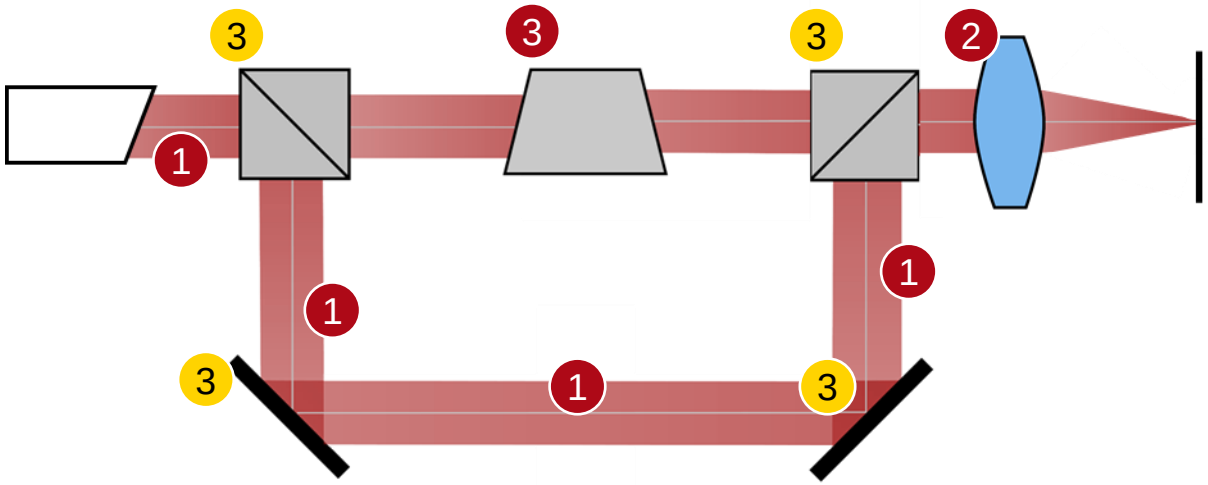
Workflow in VirtualLab Fusion

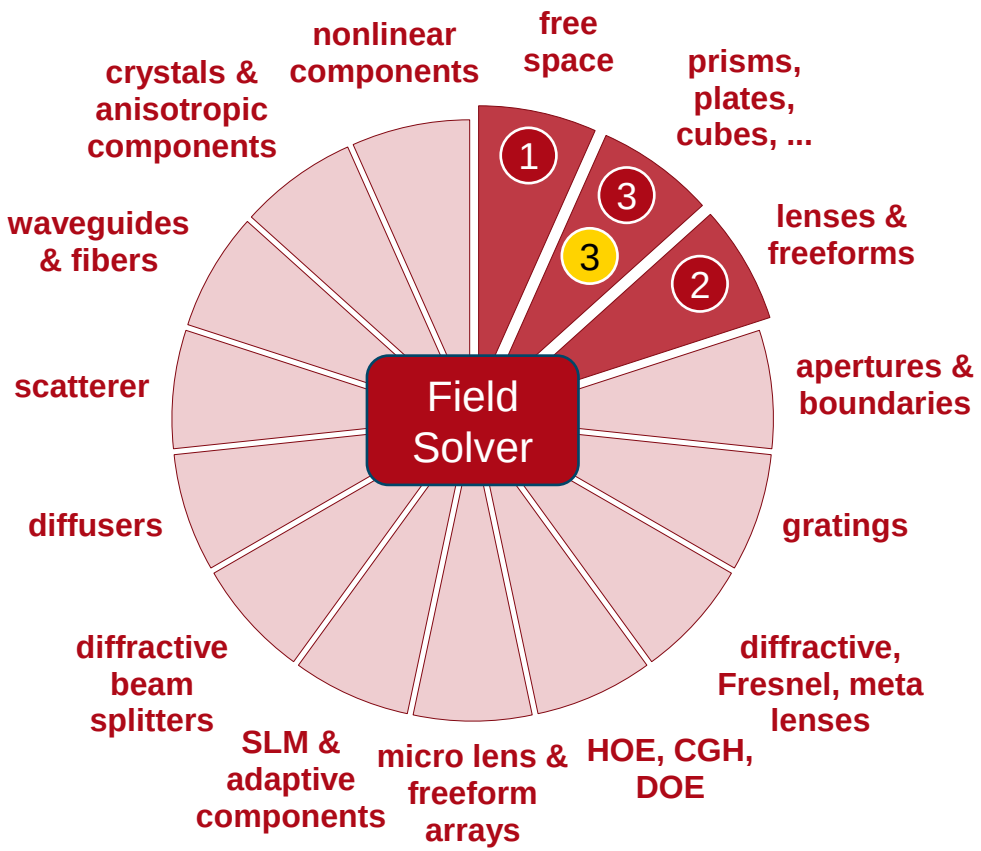
- Set up input field
  - Basic Source Models [Tutorial Video]
  - Ince-Gaussian Modes [Use Case]
- Construct real components using surfaces

- Define position and orientation of components
  - LPD II: Position and Orientation [Tutorial Video]
- Set channels properly for non-sequential tracing
  - Channel Setting for Non-Sequential Tracing [Use Case]



VirtualLab Fusion Technologies





Document Information

title	Observation of Vortex Array Laser Beam Generation from Ince-Gaussian Beam
document code	SRC.0003
version	1.0
edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.176)
category	Application Use Case
further reading	- Mach-Zehnder Interferometer - Ince-Gaussian Modes