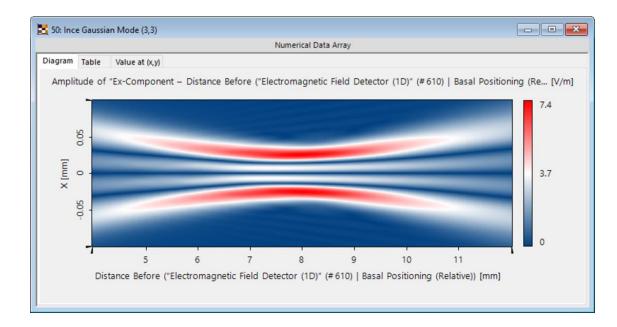


Focusing of an Ince-Gaussian Beam

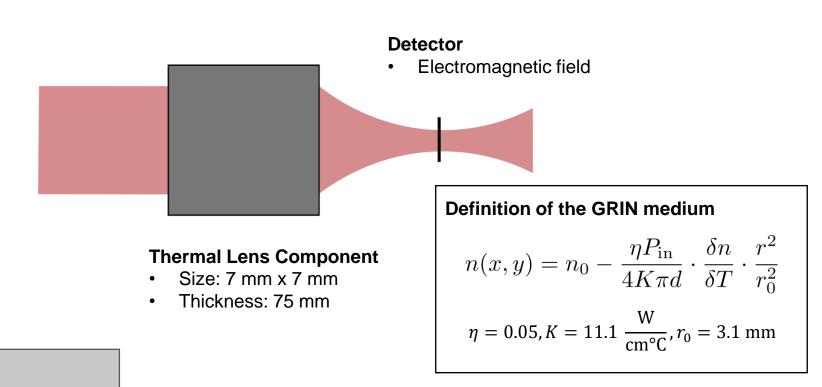
Abstract



Ince-Gaussian modes are a well-known exact and orthogonal solution family for the paraxial wave equation. This kind of source mode can be advantageous for different applications in the areas of optical tweezers and particle trapping. In this use case we demonstrate the focal properties of the Ince Gaussian Beam Source in VirtualLab Fusion by propagating the modes through a GRIN medium. This medium represents a thermal lens, an effect which can be encountered often in applications for high-energy laser beams.

Ince-Gaussian Beam (spatially)

- Ellipticity Parameter = 3
- Waist diameter = 300 µm
- Modes: (1,1), (3,3) (even)
- Wavelength: 532 nm
- Input Power: 8 kW



Ref: Koechner W. Thermal Lensing in a Nd:YAG Laser Rod. Appl Opt. 1970 Nov 1;9(11):2548-53.

Task:

Simulate the electromagnetic field of various Ince-Gaussian modes in the focal area

Building the System in VirtualLab Fusion

System Building Blocks – Source

Edit Ince Gaussian Source × Polarization Mode Selection Sampling Ray Selection Basic Parameters Spectral Parameters Generate Cross Section Algorithm Snippet Parameters WaistRadius BlilipticityParameter I ElilipticityParameter I Degree 2€	
🕡 Help	The source is modeled by calculating an individual Ince-Gaussian mode. More information about the parameters and their meaning can be found in the following use case:
Default Parameters Ok Cancel Help	Ince Gaussian Modes

System Building Blocks – Components

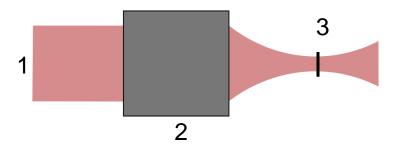
Edit Double Surface	Component		×		
Coordinate Systems Position / Orientation	Physical Extension Center Thickness 75 mm Definition Area O Individual Definition Areas for Each Surface O Uniform Definition Area for Whole Compor Shape O Rectangular Diameter 7 mm	nent	ic 7 mm Preview for Thermal Lens	X	
Structure Channel Configuration Fourier Transforms	First Surface Plane Interface Load Control Edit Medium between Surfaces Thermal Lens Control Load Control View		Extension and Section Plane View Parameters View Range (x, y, z) 3 mm 3 mm Section Plane • x-y-Plane 2 z-x-Plane 2 z- z-Position of Section Plane Diagram Table Real Part of "Refractive Index"	1 mm z-y-Plane 0 mm 1.823	
Validit	уг 🕑	OK	-1 -0.5 0 0.5 1 X [mm]	1.8217 Help	For the definition of the thermal lens, we assume a GRIN medium. More information about this can be found in: <u>Gaussian Beam Focused by a Thermal Lens</u>

System Building Blocks – Detectors

The Electromagnetic Field Detector allows for the detection of all 6 vector components of the electromagnetic field. It is possible to visualize a 1D cut through the field by setting the sampling numbers accordingly.

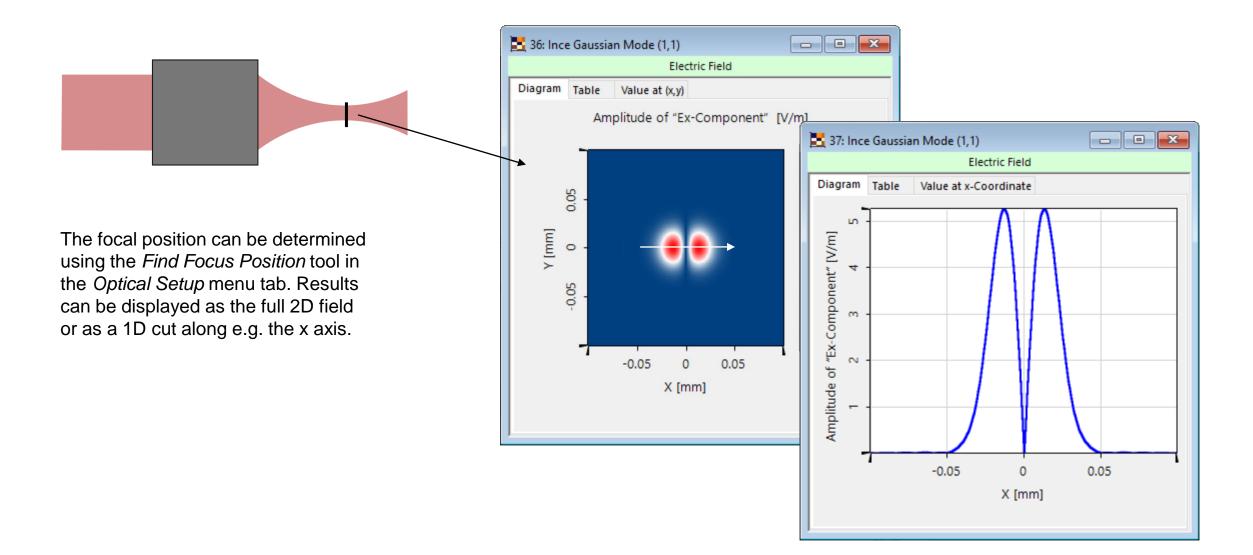
Systems Freid Components Systems Syste	Systems Field Components	Coordinate	Detector Window and Resolution	Detector Function	ld in k-Domain	Coordinate	Detector Window and Resolution Detector Function Detector Window O Scale Window Size by Factor
Orientation Field Quantities	Orientation Field Quantities	Systems		_		Systems	Set Window Size 200 μm × 2
Parameters J J J J J J J J J J J J J Fourier Transforms	Parameters Output Data Arrays Interpolation Method Nearest Neighbor Fourier Transforms	Orientation	O Amplitude Only	•	Show Separately	Orientation	Oversampling Factor
Settings	Settings	F F-1 Fourier	Interpolation Method		~	Fourier	Set Number of Sampling Points User-Defined ✓ 512 ★ ×
		Transforms				Transforms	

Summary – Elements...



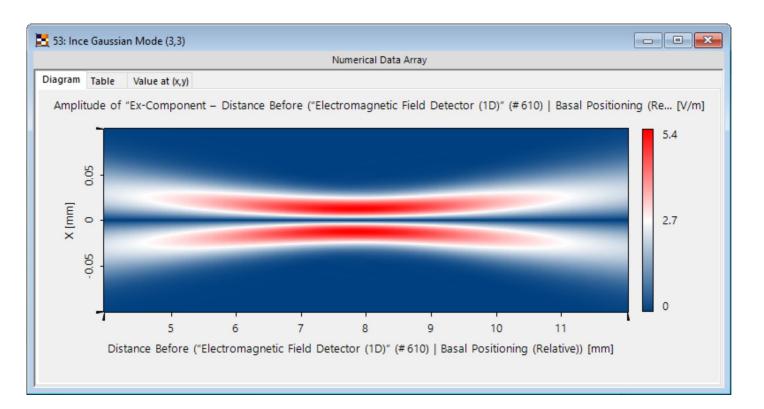
of Optical System	in VirtualLab Fusion	Model/Solver
1. Source	Ince-Gaussian Beam	Ince-Gaussian mode calculation
2. Thermal Lens	Inhomogeneous Medium Component	Runge-Kutta Algorithm
3. Detector	Electromagnetic Field Detector	Calculation of individual field component

Focus Spot – Mode (1,1)

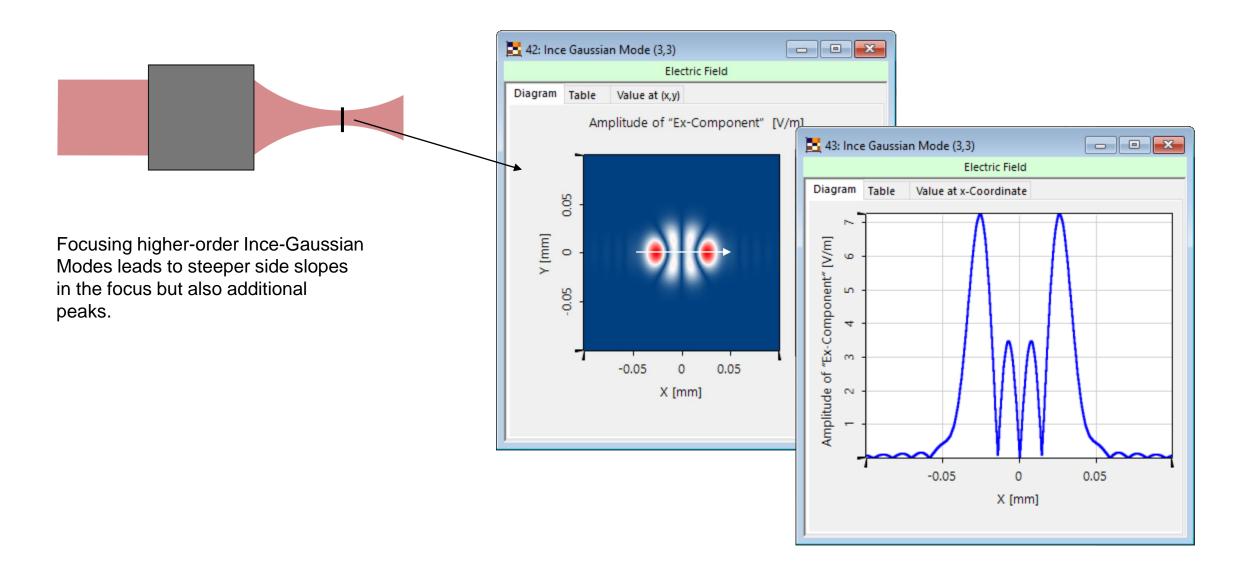


Scan – Mode (1,1)

With the *Parameter Run* the behavior of the field when propagating through the focal plane can be visualized.

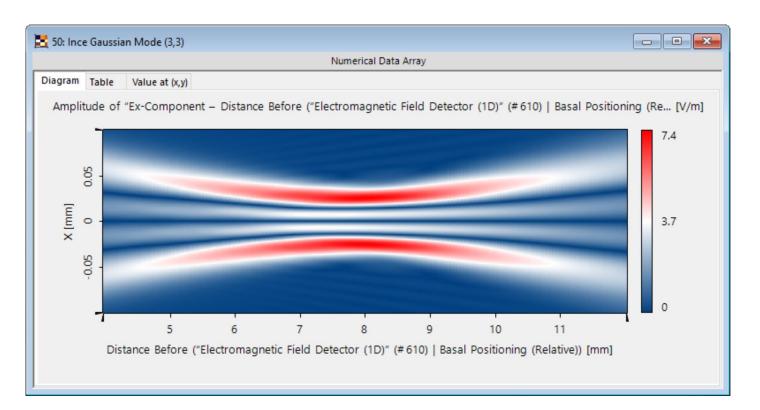


Focus Spot – Mode (3,3)



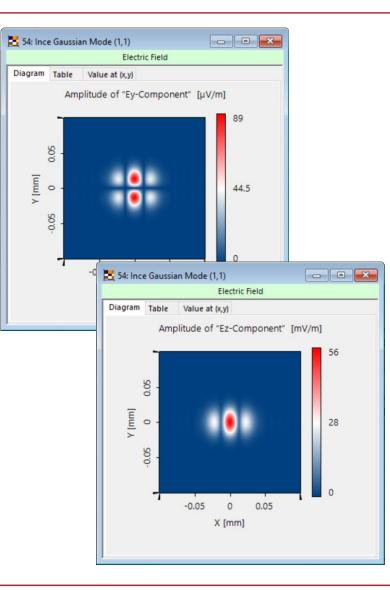
Scan – Mode (3,3)

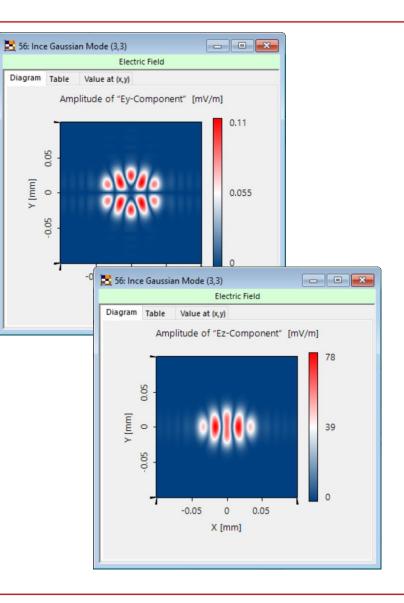
This behavior can also be seen in the *Parameter Run*.



Polarization Crosstalk

Focusing the Ince-Gaussian Beam through a thermal lens generates polarization crosstalk. Form and intensity of the crosstalk depends on the mode used and the power of the input light.





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