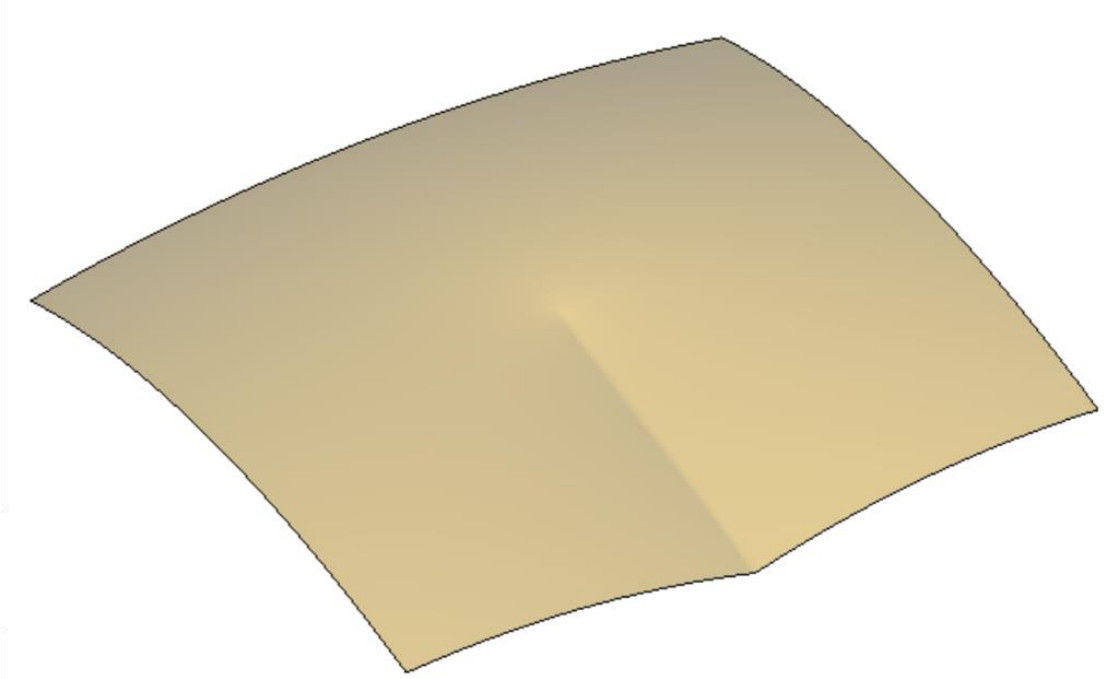
Measurement of Orbital Angular Momentum (OAM) with Freeform Optical Elements

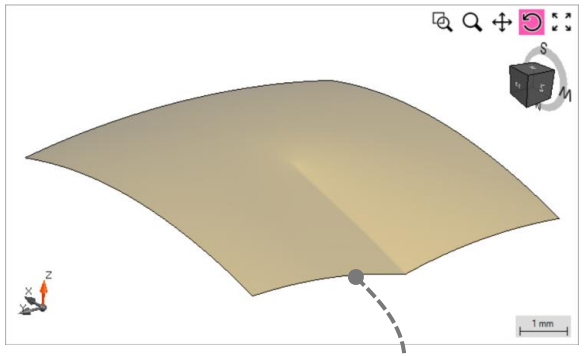
Abstract

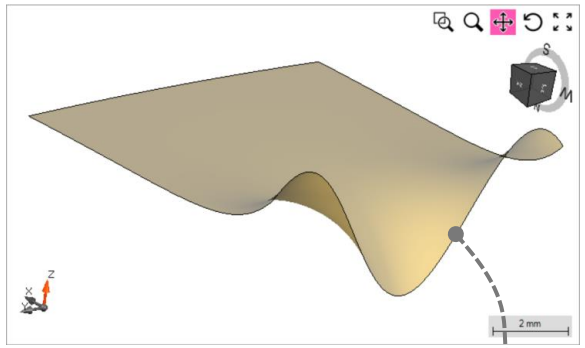


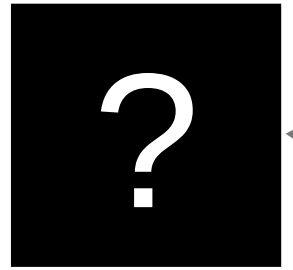
Optical beams carrying orbital angular momentum (OAM) have been shown useful in telecommunication, because of their capacity to encode many (theoretically unbounded) information states. Despite of this advantage, decoding information – measuring the OAM – is often challenging. Following the work of M. P. J. Lavery *et al*., we build up an optical setup, with two freeform optical elements that transform the OAM into linear phases, in VirtualLab Fusion. With this setup, we demonstrate the efficient OAM measurement.

Modeling Task

How to measure the OAM carried by optical beams with specially designed freeform elements?







input OAM beam
- Laguerre Gaussian
- wavelength 632.8 nm
- waist radius 750 µm
- azimuthal order L
-1, 0, +1, …

freeform lens #1

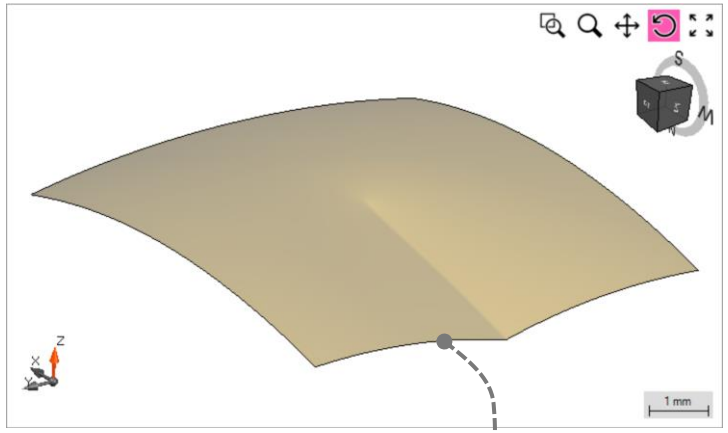
freeform lens #2

Fourier lens

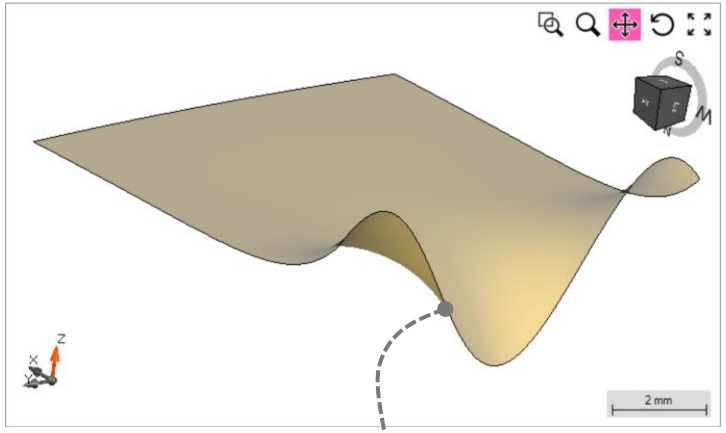
concept and freeform lens parameters follow from M. P. J. Lavery, *et al*., Opt. Express 20, 2110-2115 (2012)

Modeling Task

$$z_1(x,y) = \frac{a}{f(n-1)}\left[y\tan^{-1}\left(\frac{y}{x}\right) - x\ln\left(\frac{\rho}{b}\right) + x - \frac{1}{2a}\rho^2\right]$$



$$z_2(x,y) = \frac{ab}{f(n-1)}\left[\exp\left(-\frac{x}{a}\right)\cos\left(\frac{y}{a}\right) + \frac{1}{2ab}\rho^2\right]$$

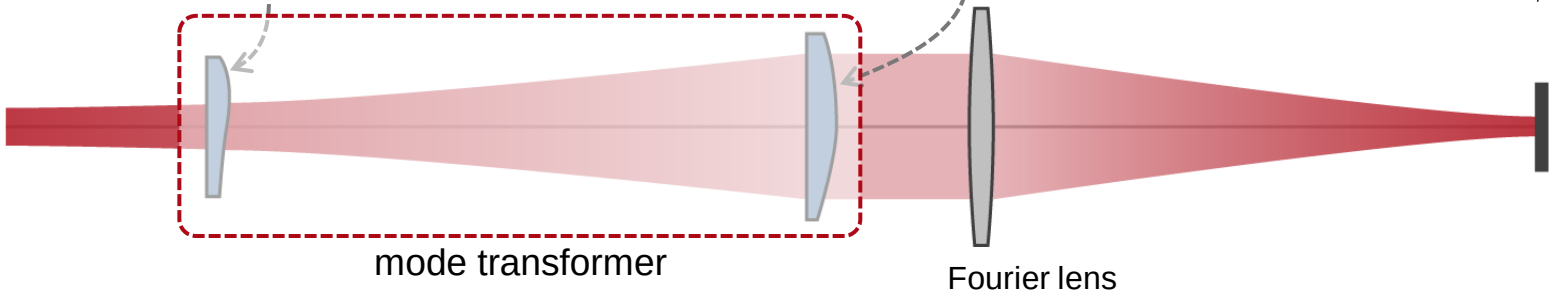


In the height profiles z_1 and z_2, we define

$$\rho = \sqrt{x^2 + y^2}\,,$$

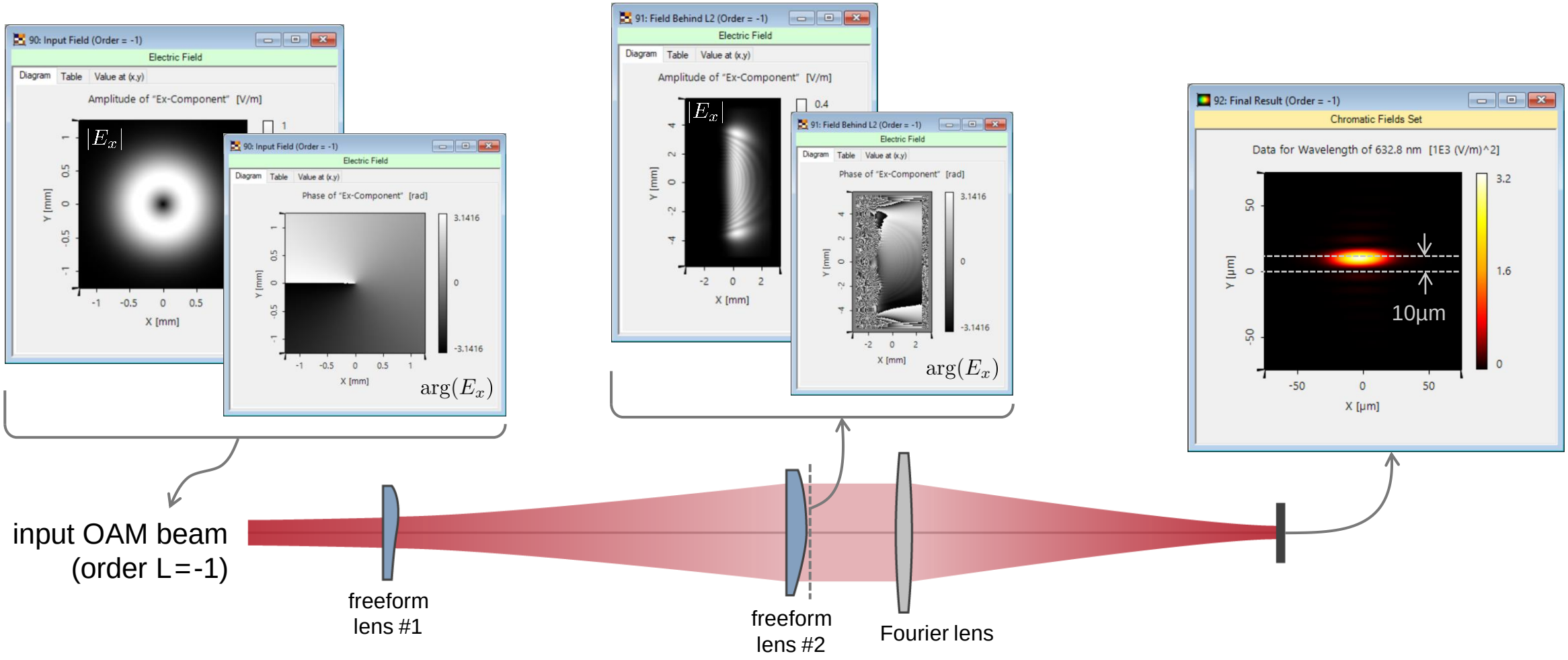
and with the following parameters

- n =1.489 at design wavelength;
- f =300 mm;
- b =4.7 mm;
- D =8 mm;
- $a = D/2\pi$.

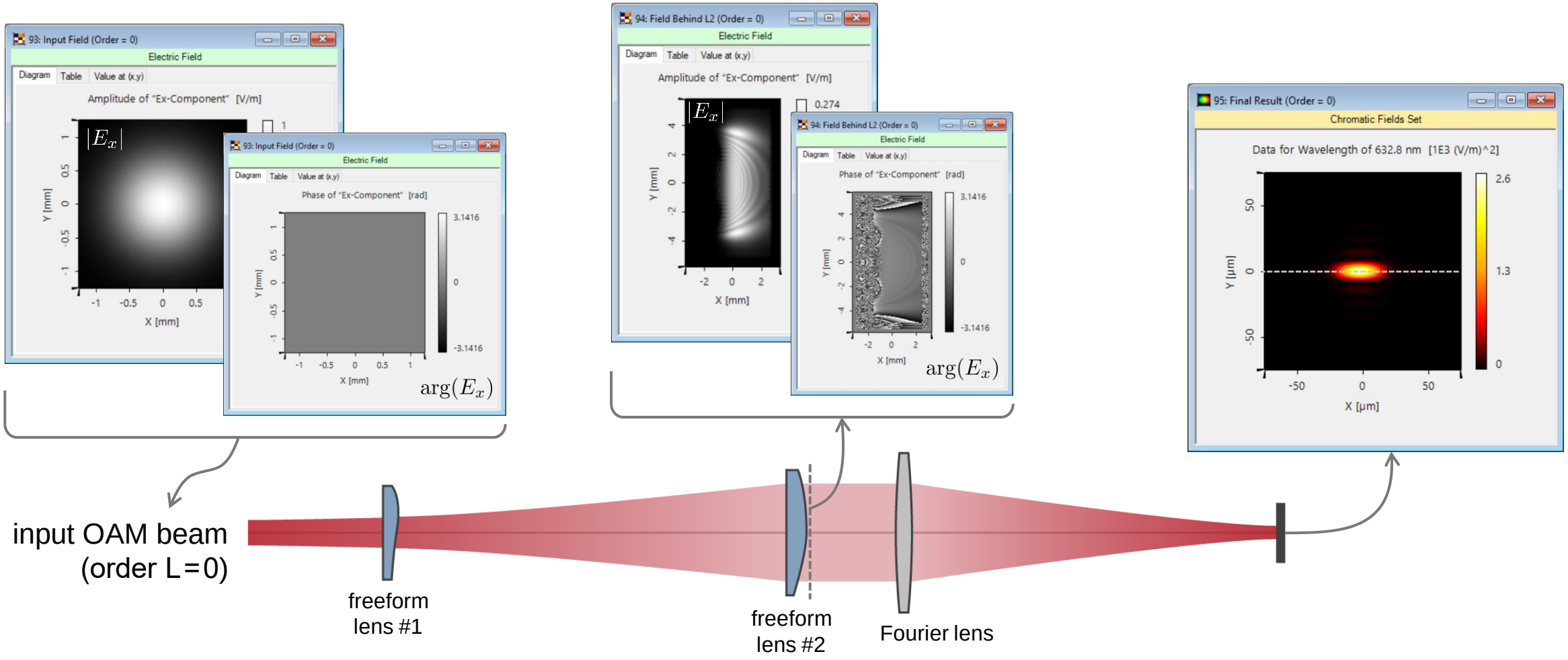


concept and freeform lens parameters follow from M. P. J. Lavery, *et al*., Opt. Express 20, 2110-2115 (2012)

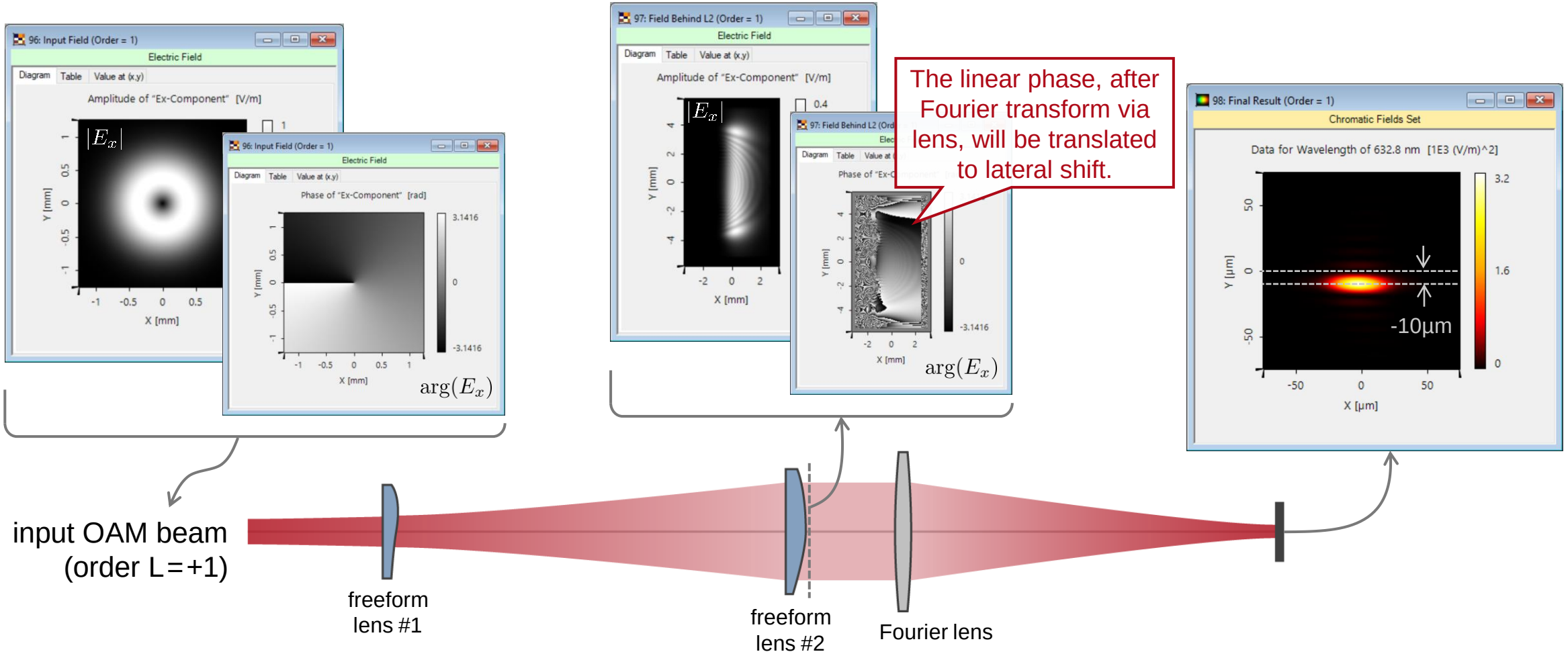
Simulation Result with Input L=-1



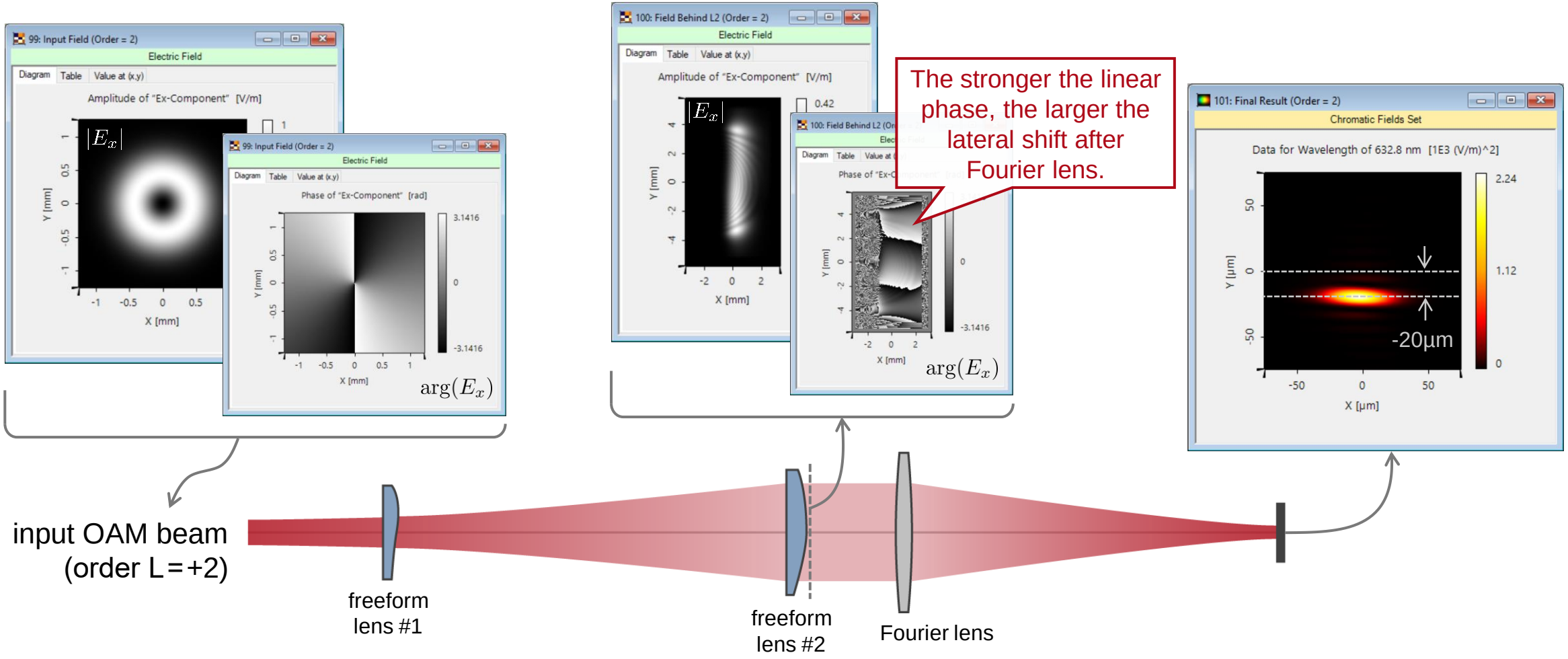
Simulation Result with Input L=0



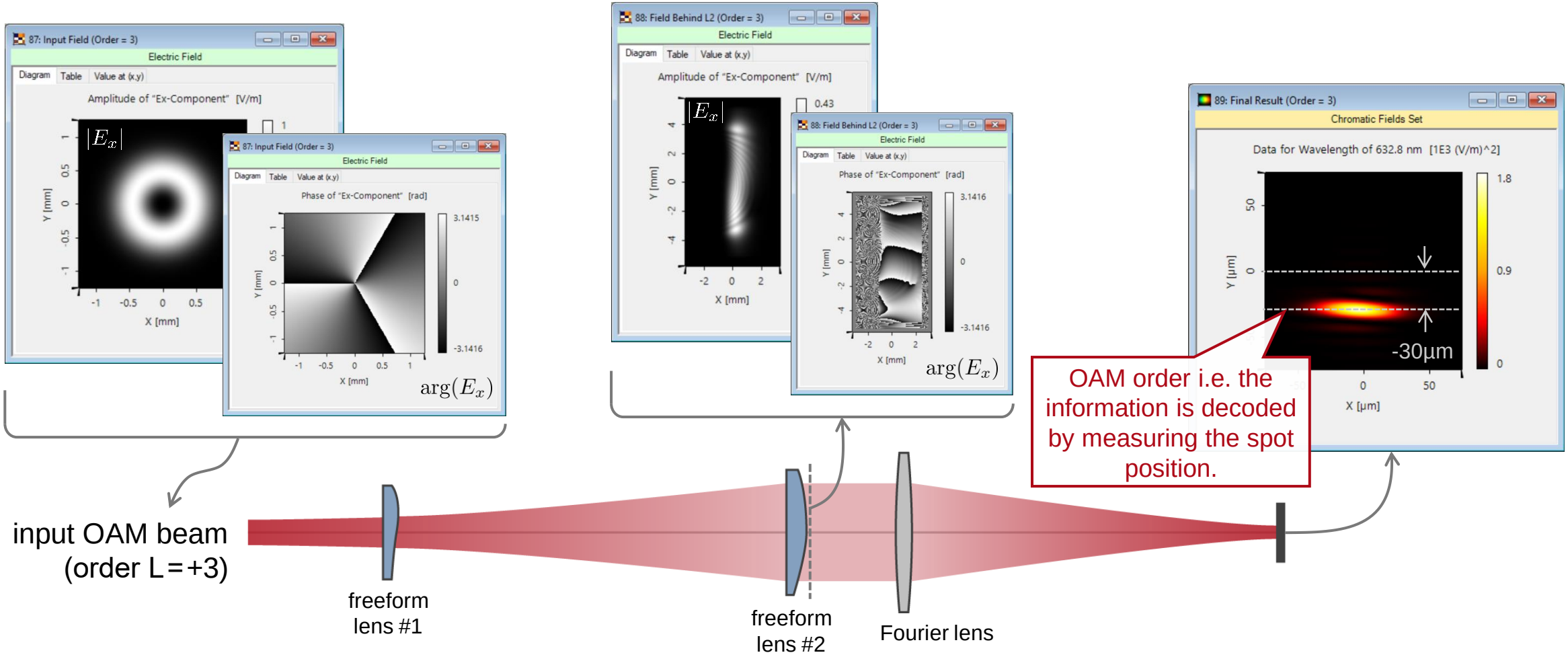
Simulation Result with Input L=+1



Simulation Result with Input L=+2

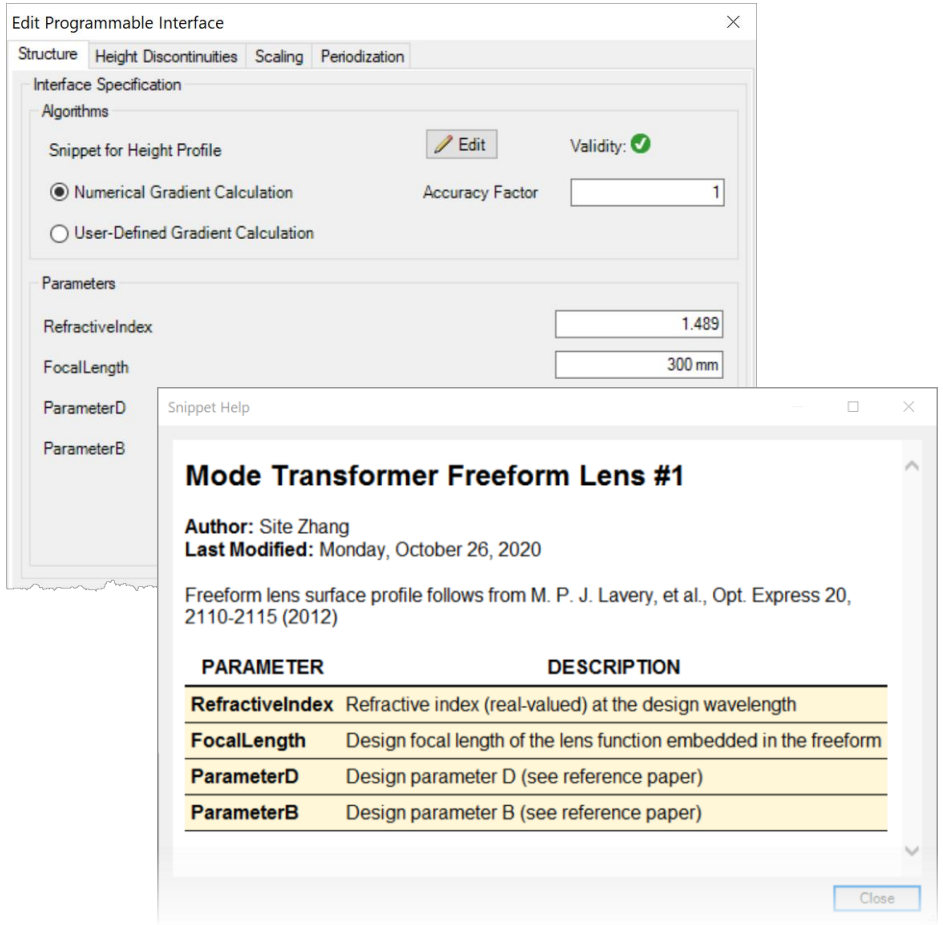


Simulation Result with Input L=+3

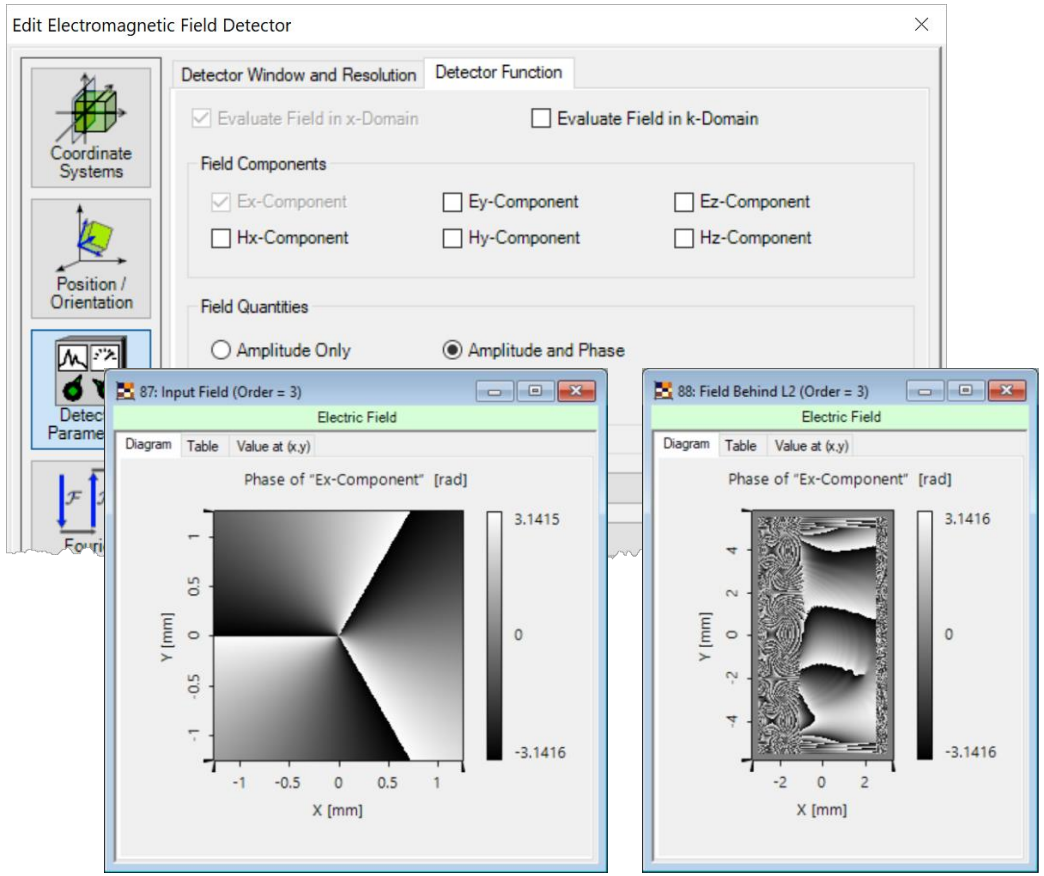


Peek into VirtualLab Fusion

flexible definition of microsctructure surfaces



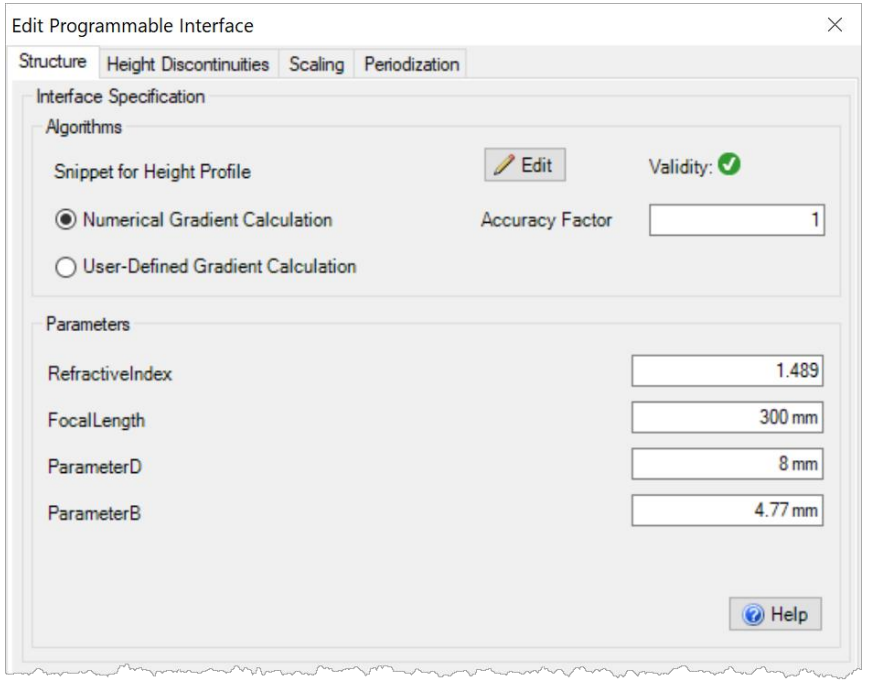
visualization of field quantities (e.g., the phase)



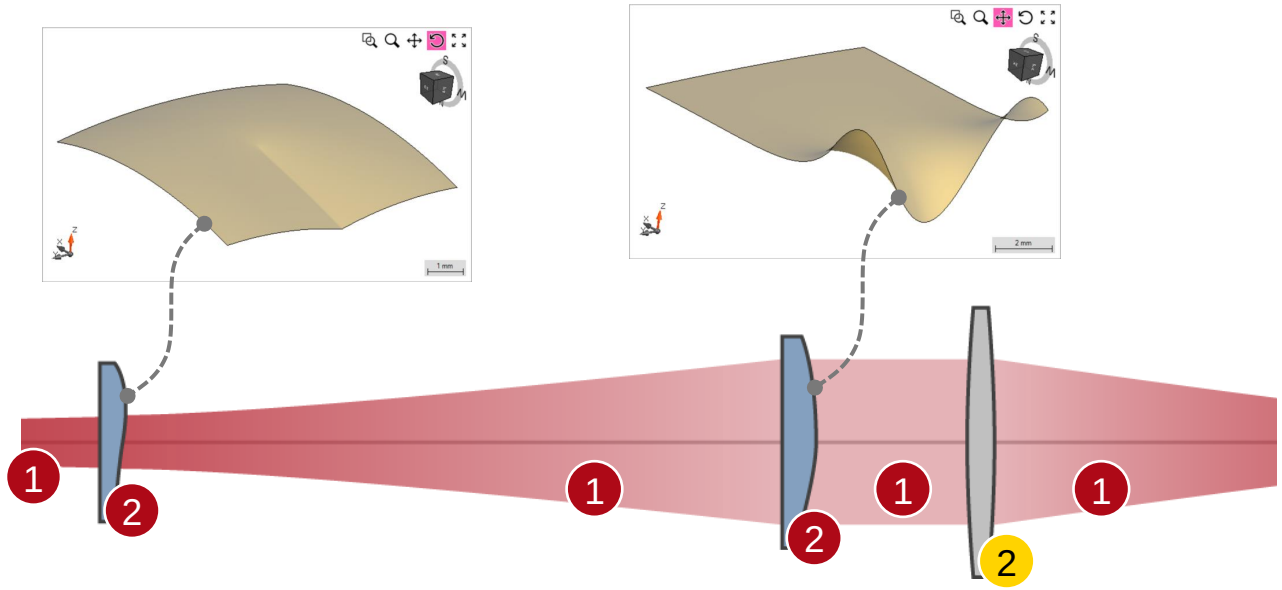
Workflow in VirtualLab Fusion

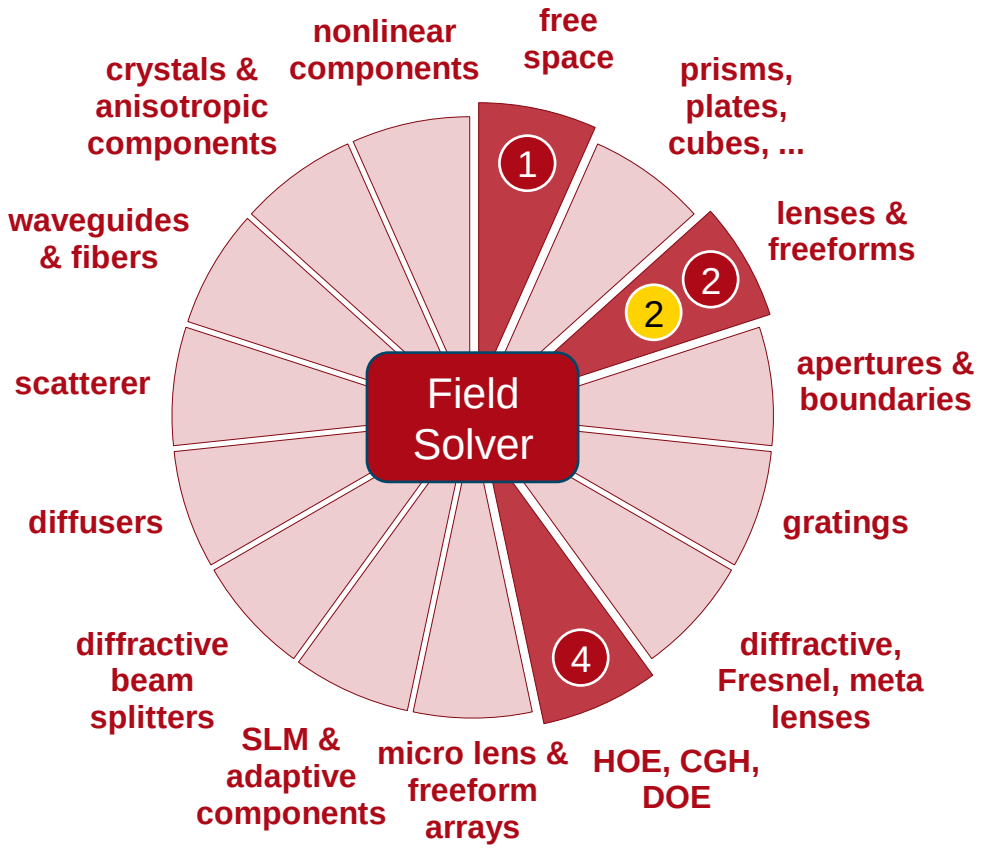
- Customize microstructure surfaces
  - How to Work with the Programmable Interface & Example (Spherical Surface) [Use Case]

- Set the Fourier transforms properly
  - Fourier Transform Settings – Discussion at Examples [Use Case]



VirtualLab Fusion Technologies





Document Information

title	Measurement of Orbital Angular Momentum (OAM) with Freeform Optical Elements
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category	Application Use Case
further reading	- Generation of Optical Beams Carrying Orbital Angular Momentum (OAM) - How to Work with the Programmable Interface & Example (Spherical Surface)