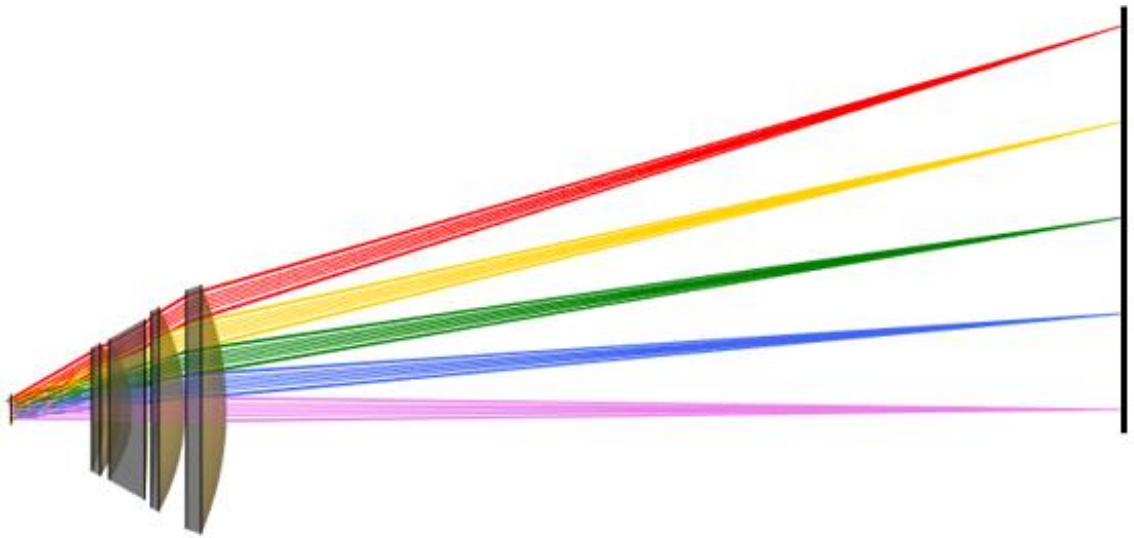
Performance Evaluation of an F-Theta Scanning Lens

Abstract

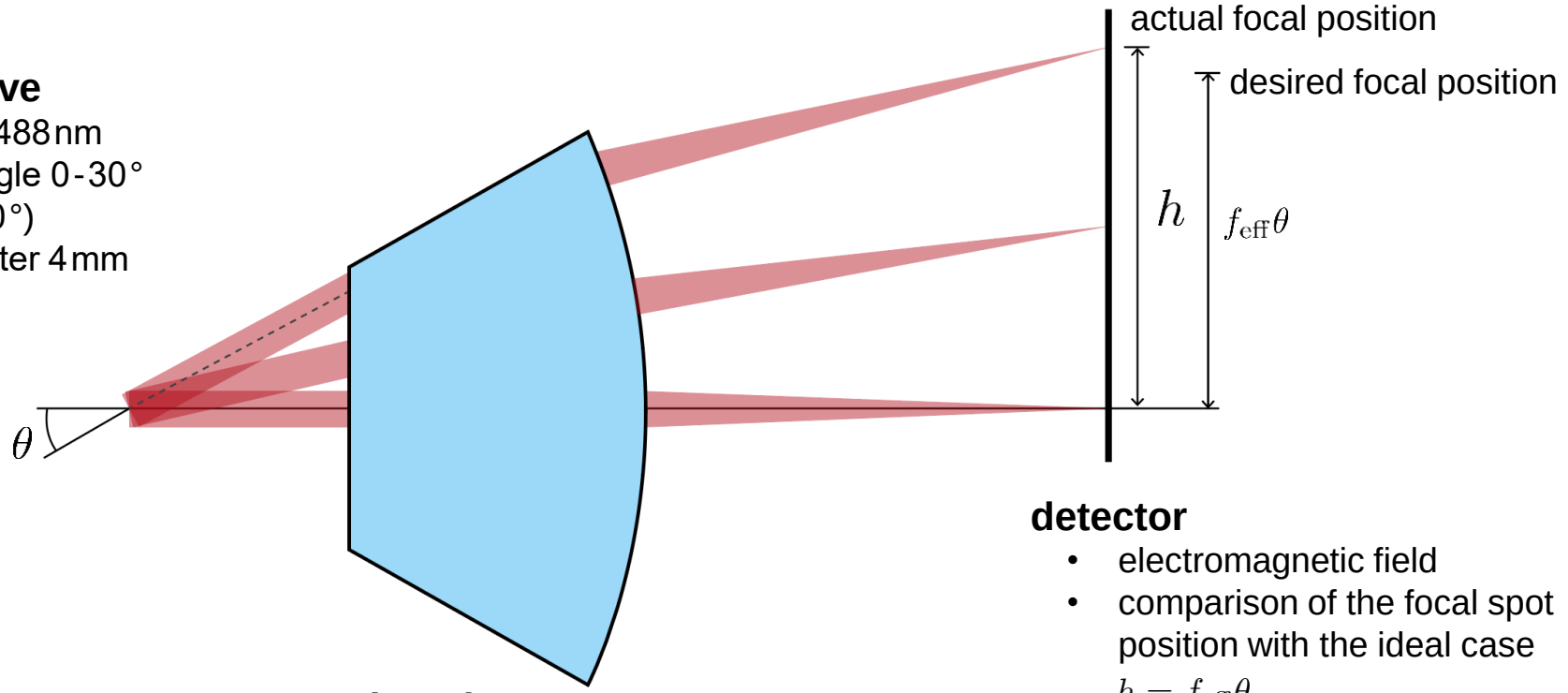


F-Theta lenses are typically used in Galvo-scanner-based laser material processing systems. With such lenses, the displacement of the focused spot along the target plane is proportional to the product of the focal length of the lens and the scan angle. However, there is no perfect F-Theta system, therefore in any given system deviations from the ideal behavior are to be expected. With the help of the scanning source in the fast physical optics modeling and design software VirtualLab Fusion, we analyze the performance of a given F-Theta lens, by measuring the deviation between actual spot position and desired value for different angles.

Modeling Task

input plane wave

- wavelength 488 nm
- scanning angle 0 - 30 °
  (full angle 60 °)
- beam diameter 4 mm



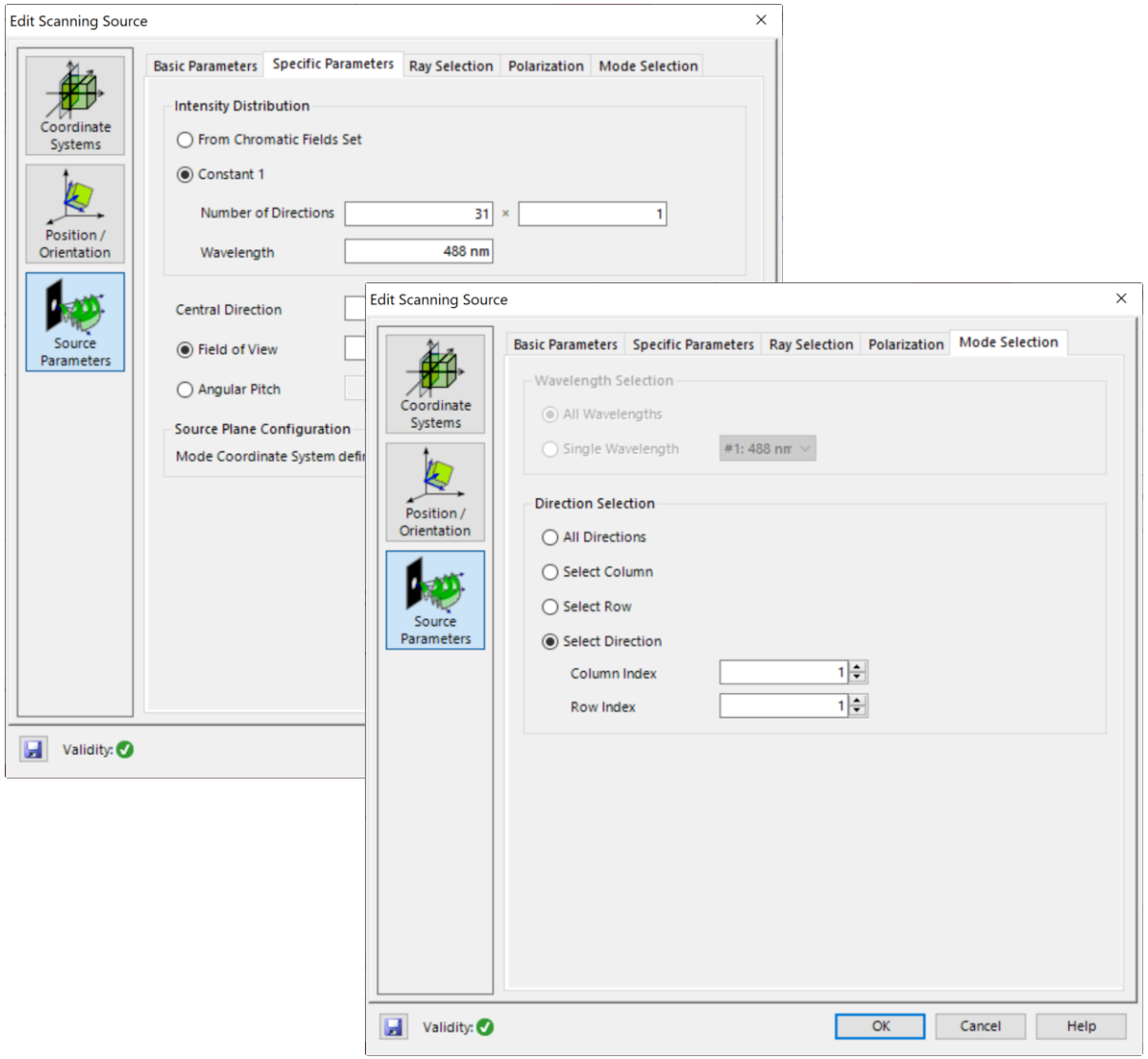
F-Theta lens

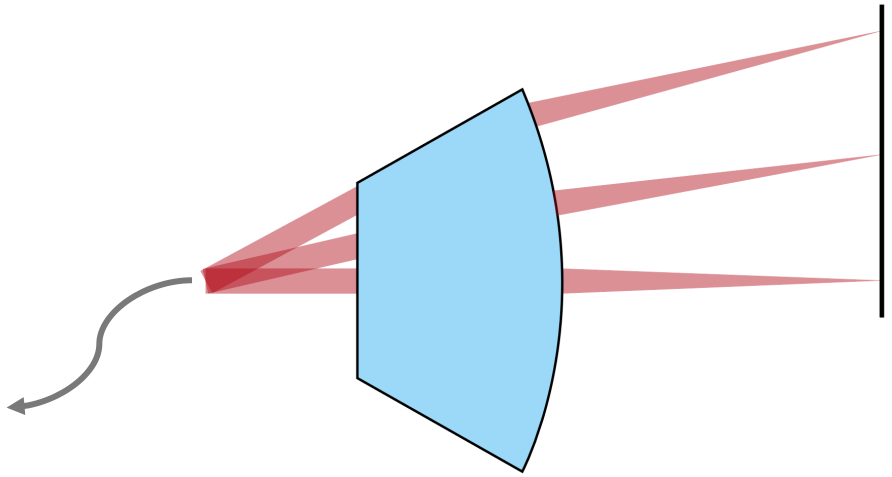
- effective focal length
  $f_{\mathrm{eff}} = 100.18\,\mathrm{mm}$
- from patent USP 4436383

detector

- electromagnetic field
- comparison of the focal spot position with the ideal case
  $h = f_{\mathrm{eff}}\theta$

System Building Blocks – Scanning Source



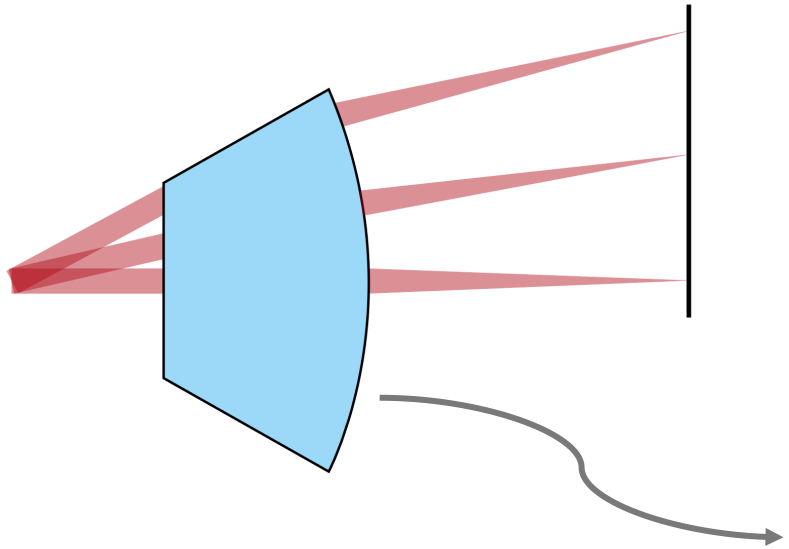


A multi-mode source that generates a set of truncated plane waves propagating in different directions can be defined with the *Scanning Source.*

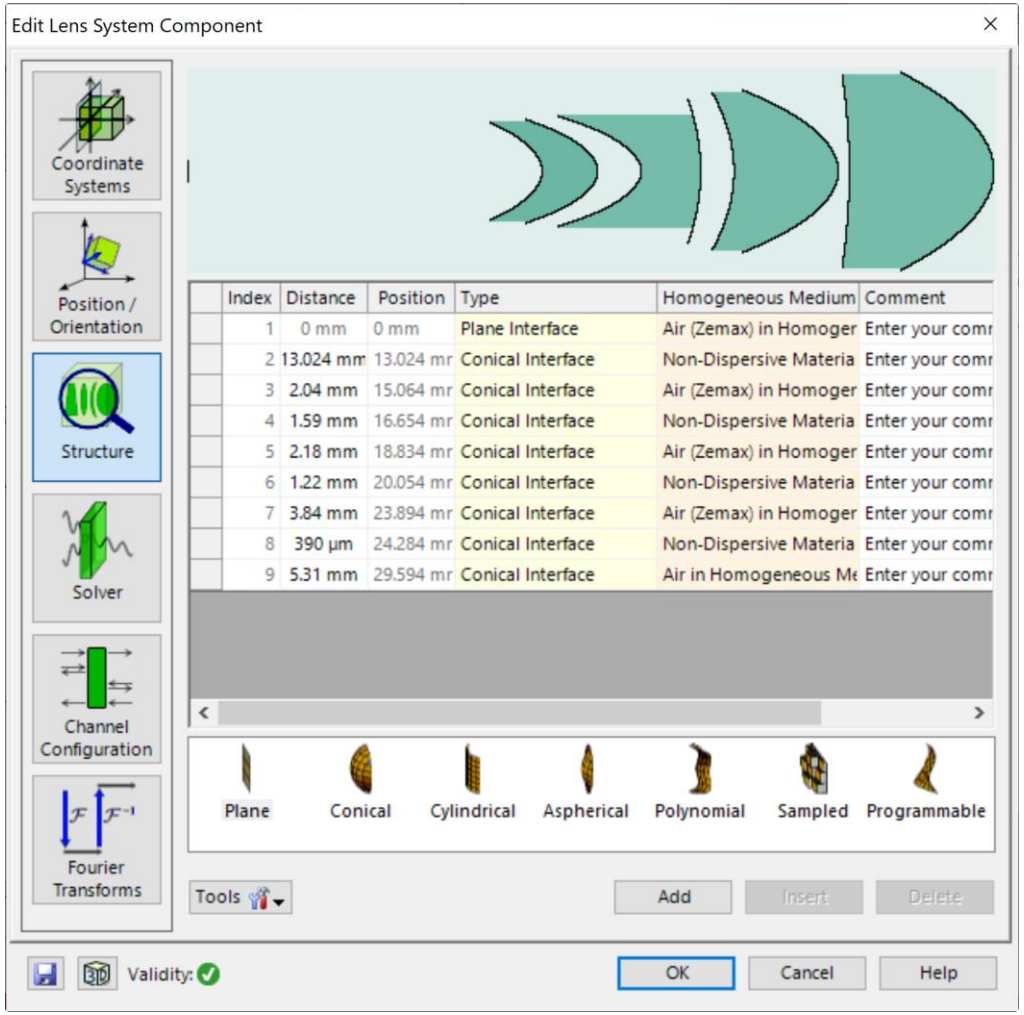
The user can specify how many modes shall be considered and define the intensity distribution. More information under:

How to Set Up a Scanning Source

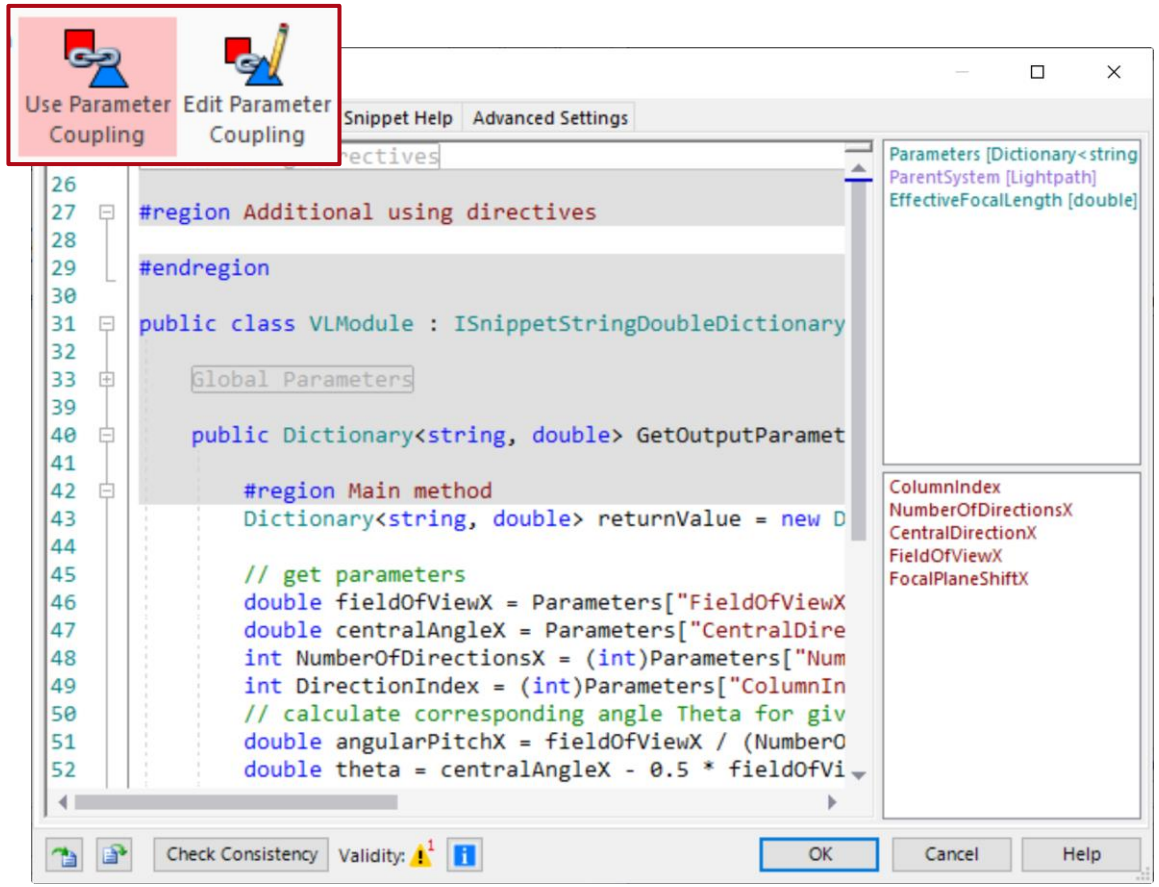
System Building Blocks – Lens System Component

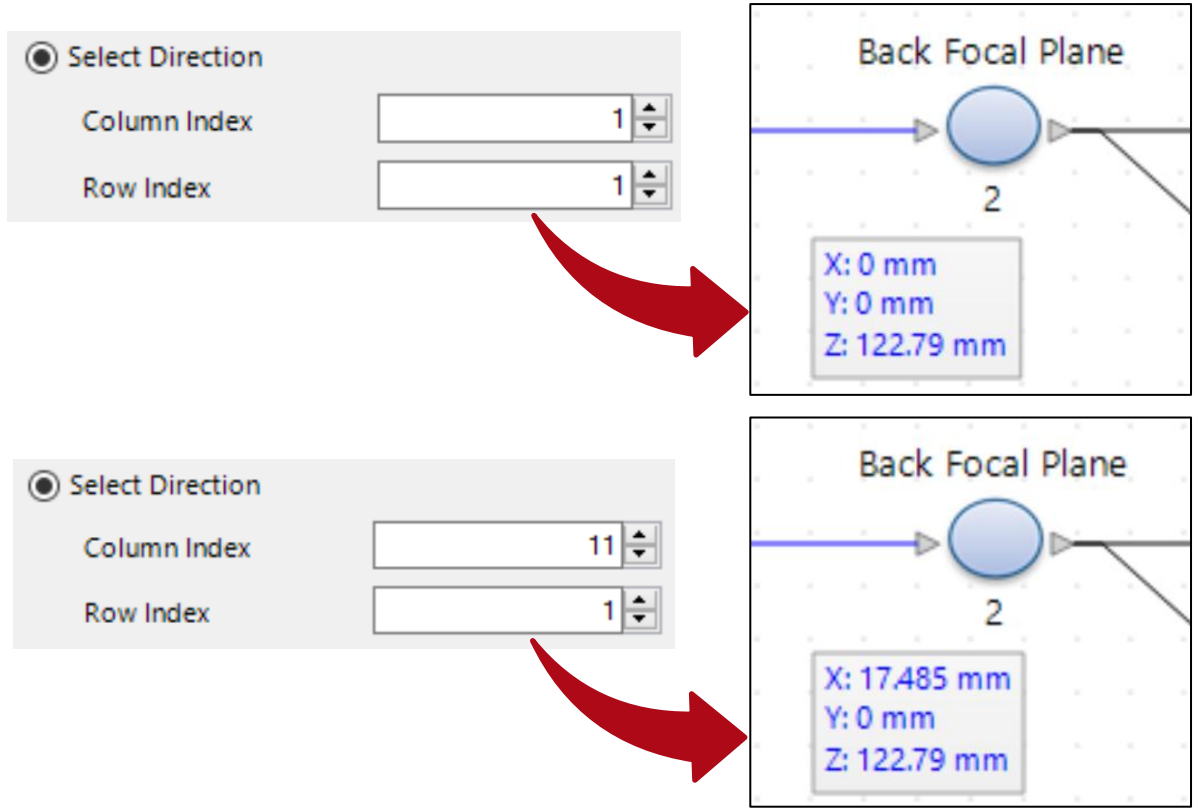


The *Lens System Component* allows for an easy definition of a component consisting of various interfaces. It is possible to include e.g. planar, spherical and cylindrical interfaces as well as to configure the media between them.



System Building Blocks – Parameter Coupling

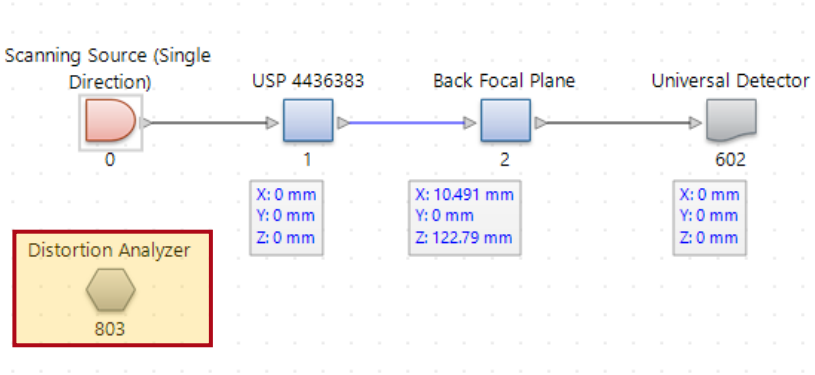




Through the *Parameter Coupling*, the values of different parameters in the system can be linked. In this use case this feature is applied to automatically center the detector around the desired focal spot. More information under:

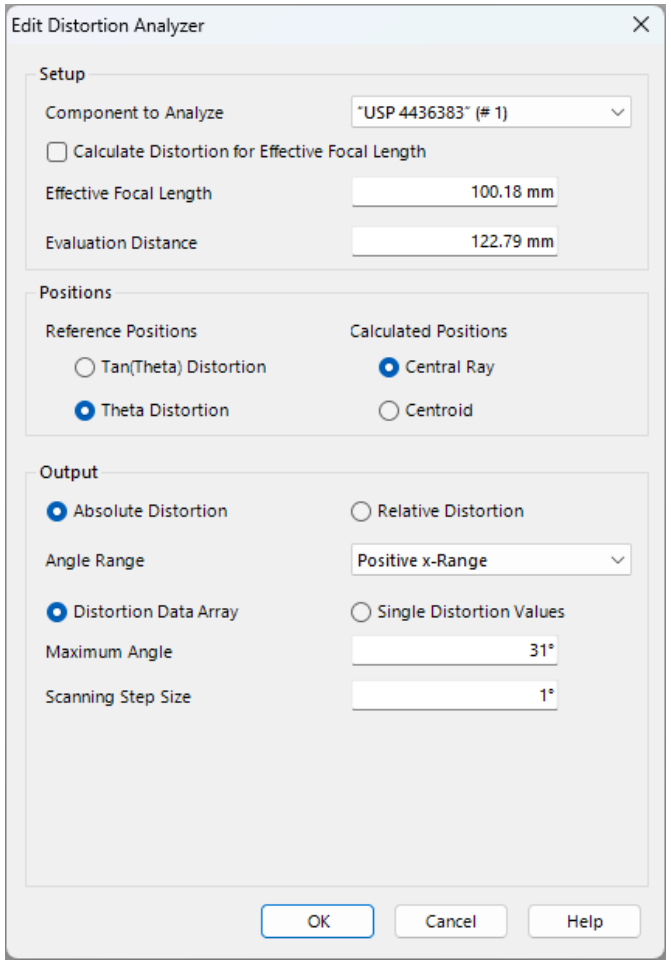
Coupling of Parameters in VirtualLab Fusion

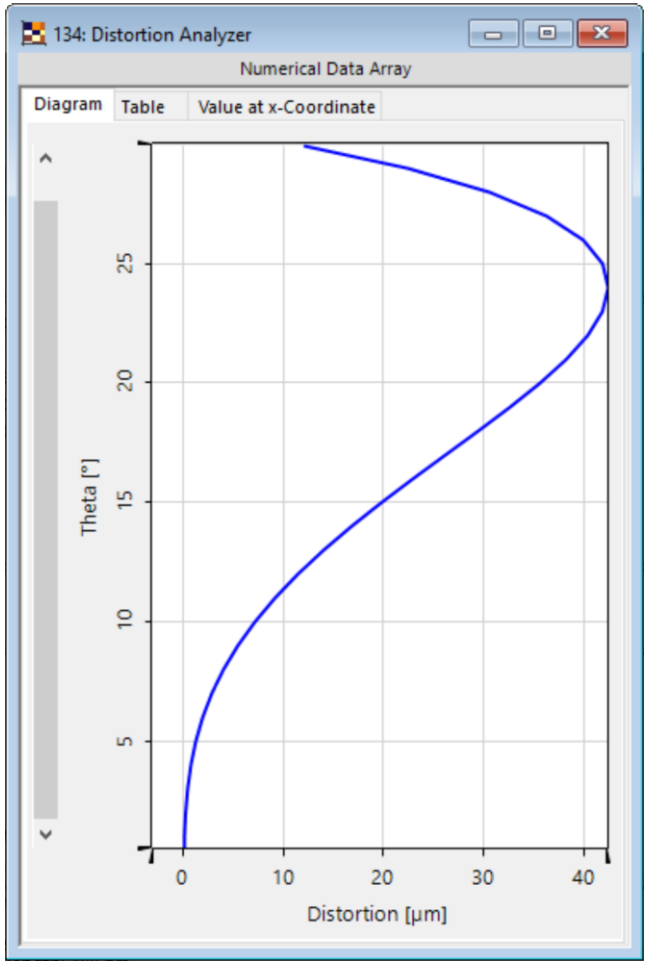
System Building Blocks – Distortion Analyzer



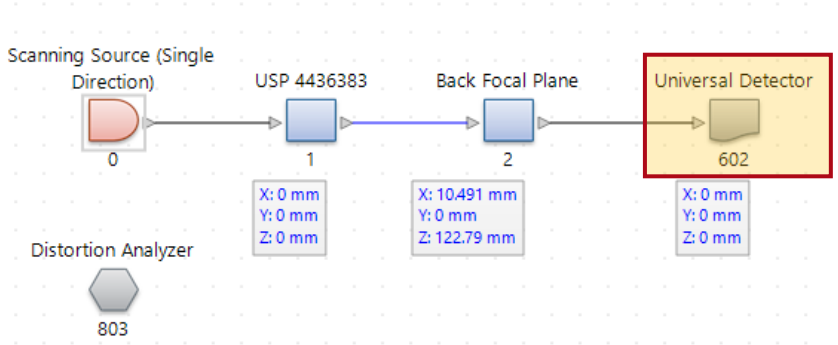
The deviation between the actual and the reference focal spot position indicates the performance of the F-Theta lens. This information can be calculated using the *Distortion Analyzer*.

While the actual focal spot position will be calculation by a simulation, the reference focal spot position can be specified to either be linear on the angle itself or its tangent.



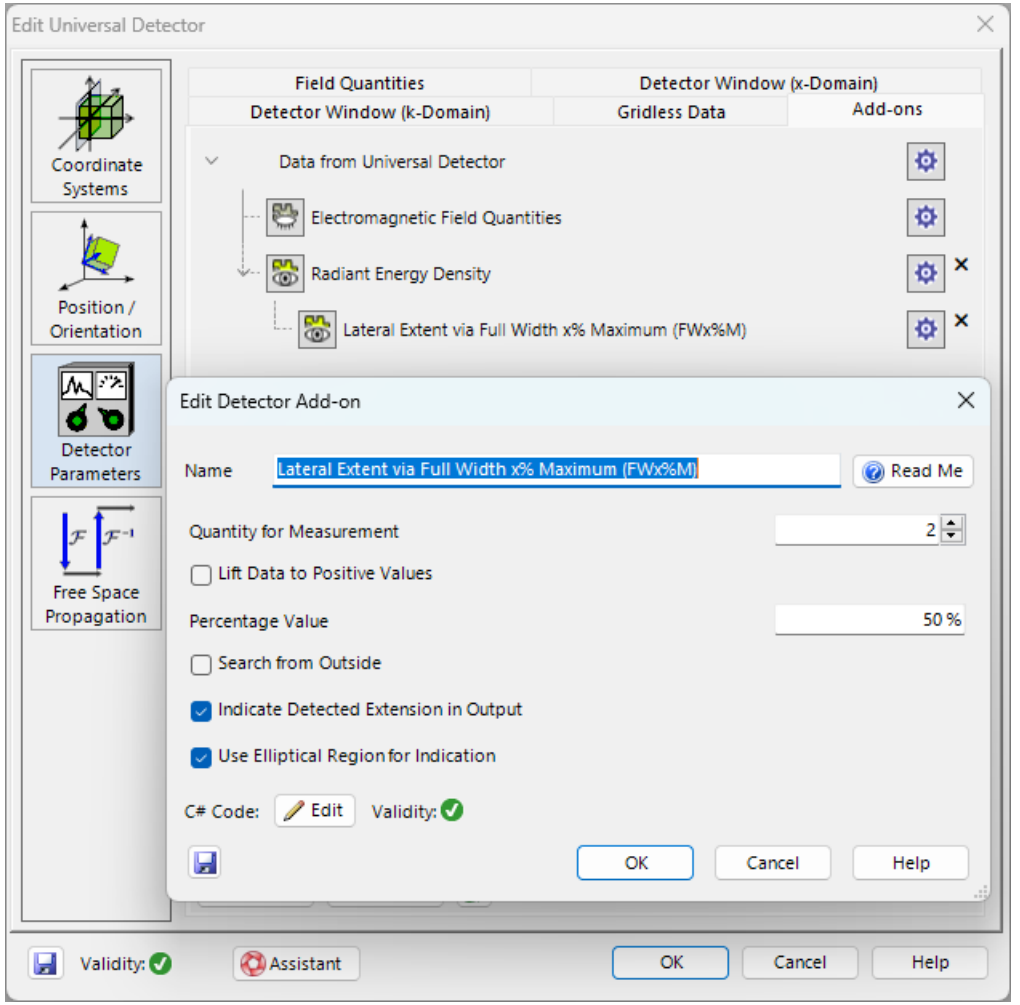


Universal Detector & Detector Add-ons

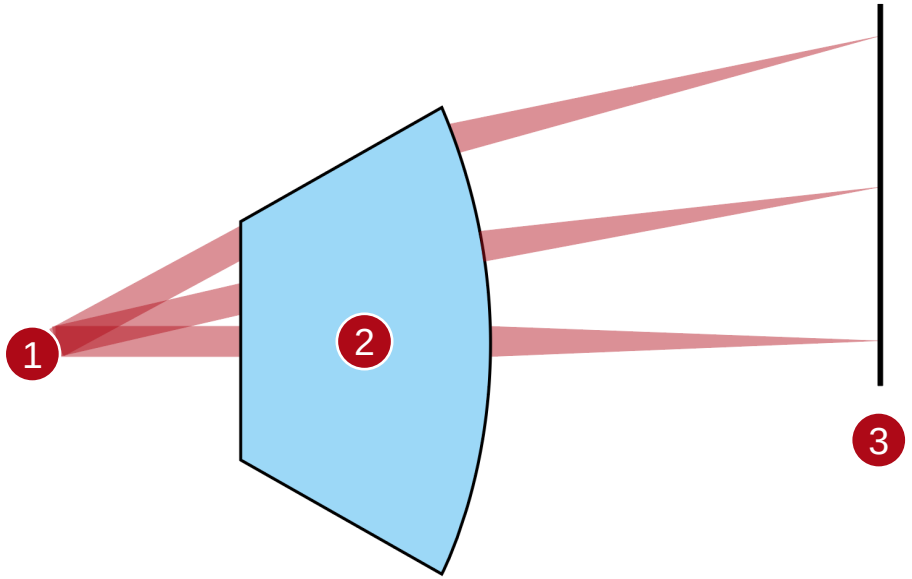


The *Universal Detector* allows the user to evaluate the impinging field and to calculate various physical quantities by using so-called *Add-ons*. The add-ons can provide each other with information (i.e., they can be nested); in our example we use the field data to calculate the radiant energy density and then use another add-on on this data to obtain the field size (FWHM). More information under:

Universal Detector



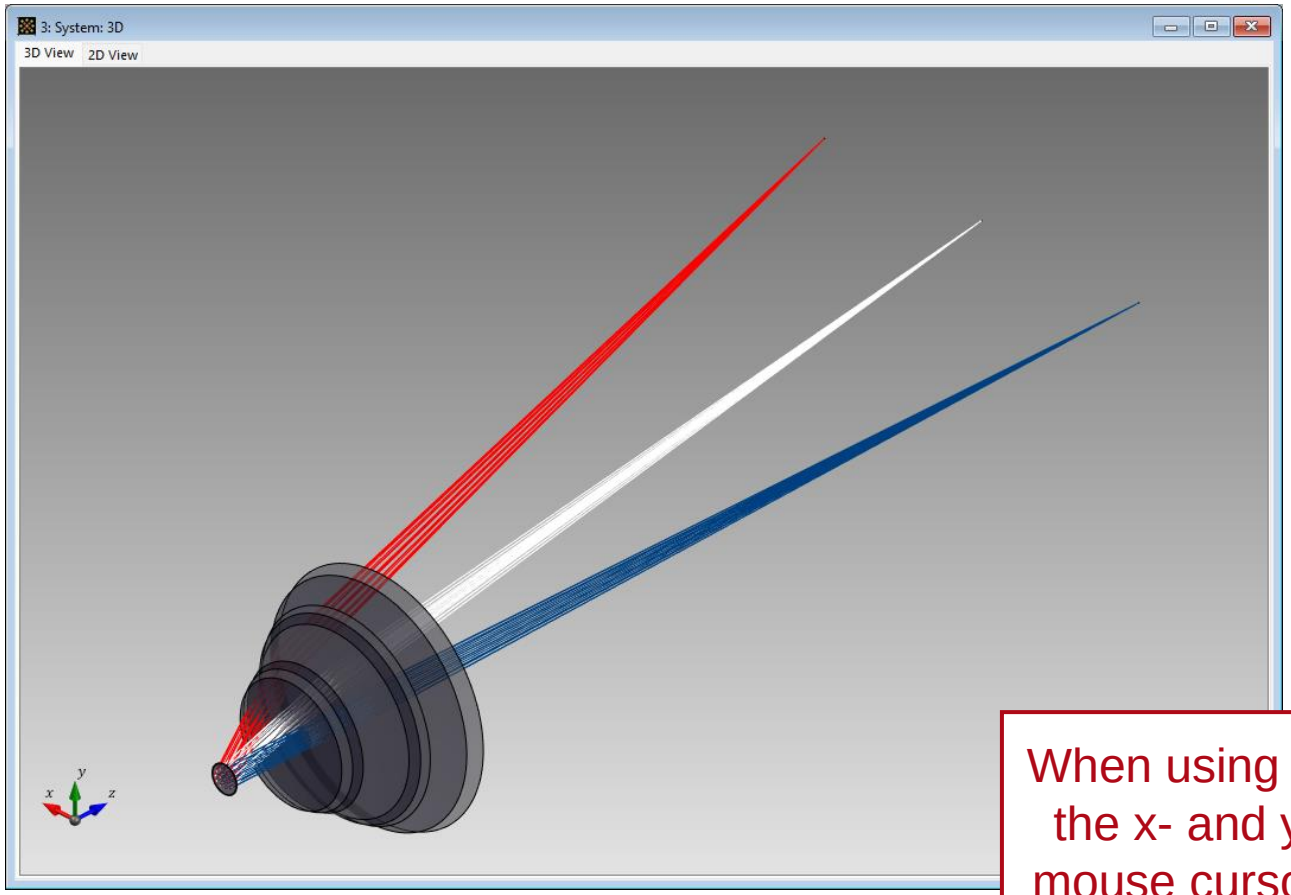
Summary – Components...

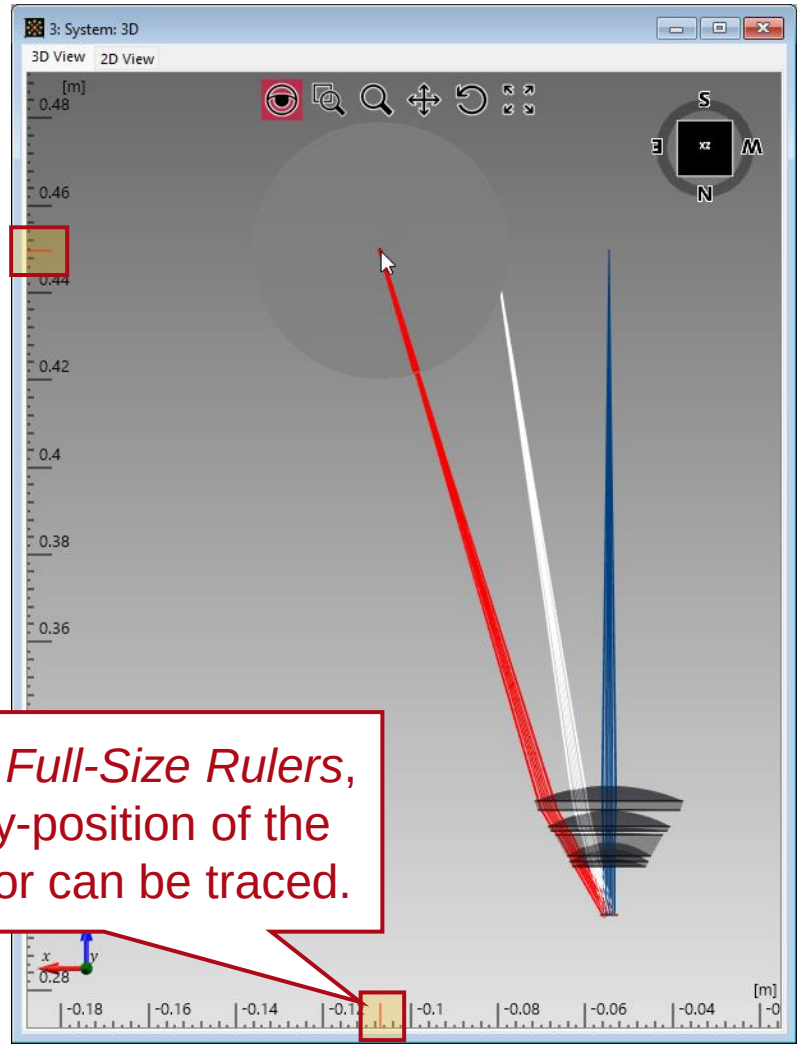


… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Value
1. source	*Scanning Source*	multiple plane-wave source modes
2. F-Theta lens	*Lens System Component*	Local Plane Interface Approximation
3. detector	*Universal Detector* with *Radiant Energy Density* add-on and *Lateral Extent* add-on	Radiant Energy Density & Full Width Half Maximum (FWHM)

System Impressions

Through the *System: 3D* visualization, the different FoV modes can be distinguished by color coding. Furthermore, the course of the field can be examined in order to position a detector at the right place.

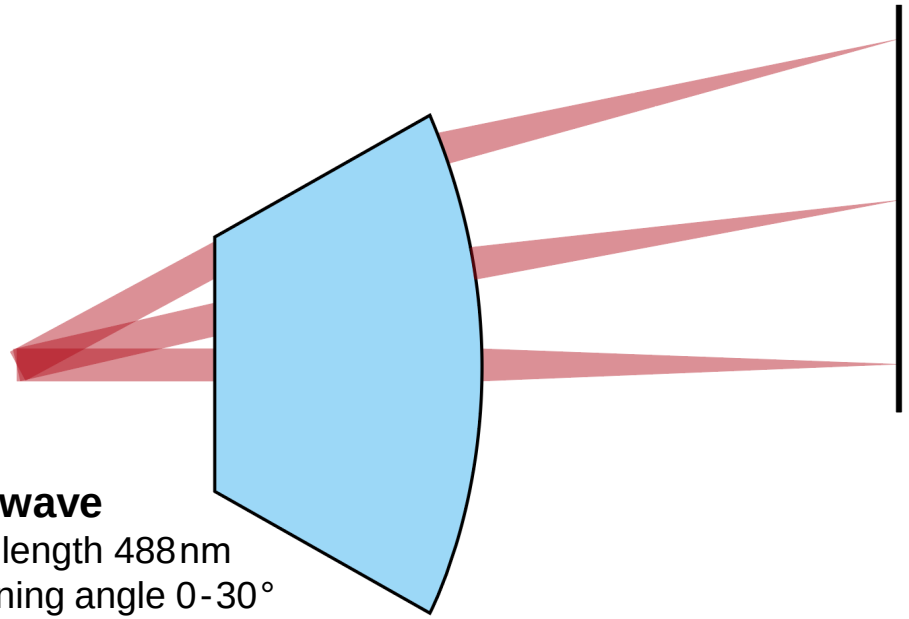




When using *Full-Size Rulers*, the x- and y-position of the mouse cursor can be traced.

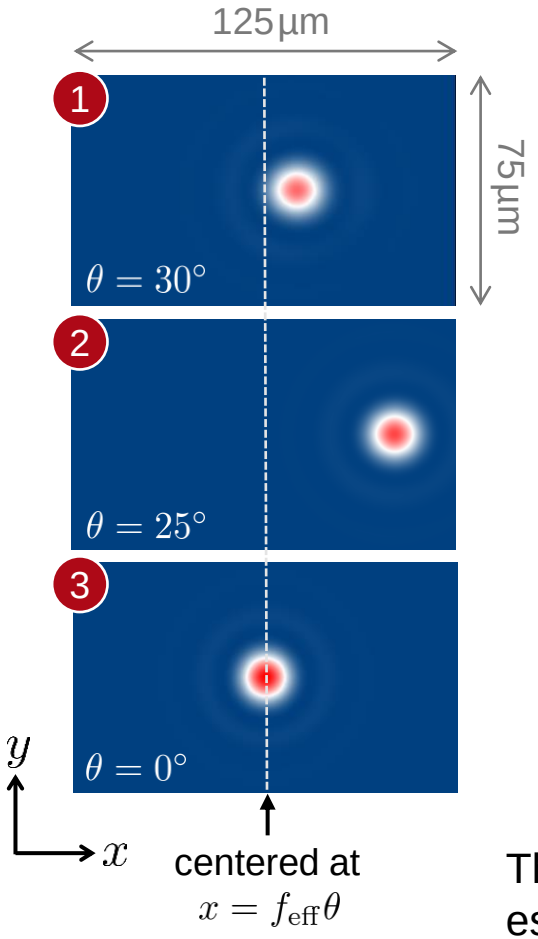
3D Visualization of the Optical System

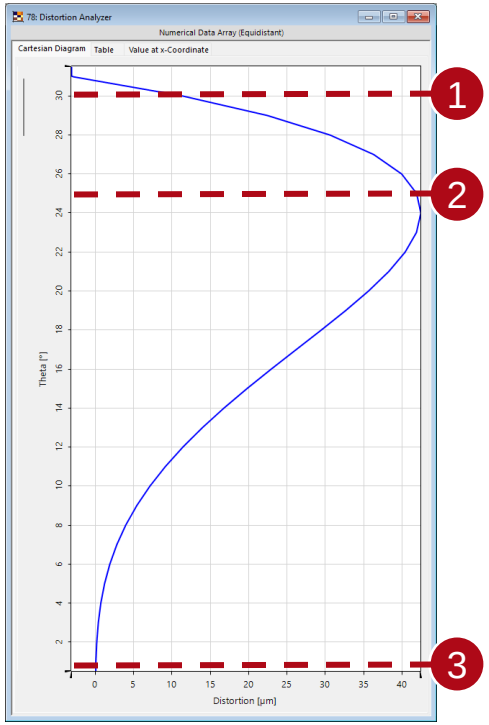
Performance Evaluation – Spot Position Deviation



input plane wave

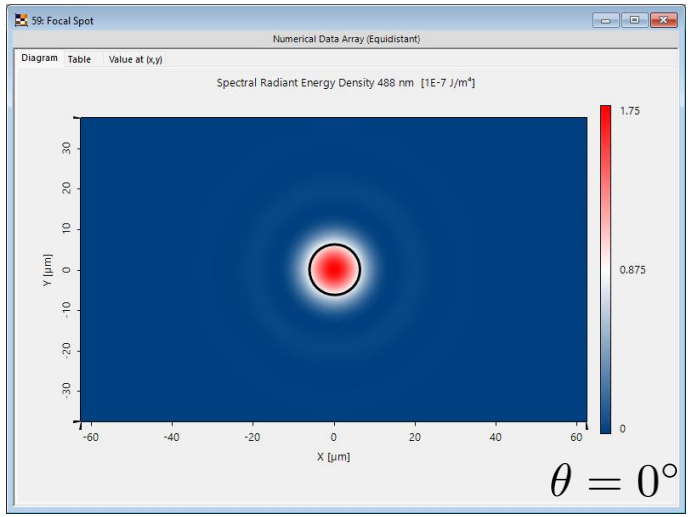
- wavelength 488 nm
- scanning angle 0 - 30° (3 steps)
- beam diameter 4 mm

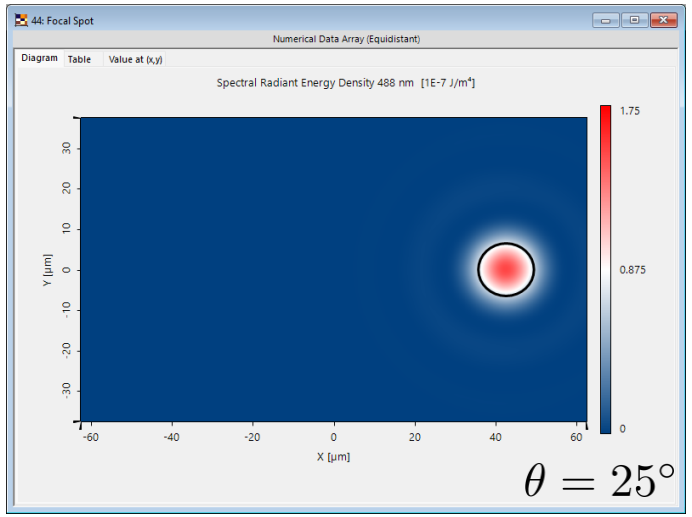


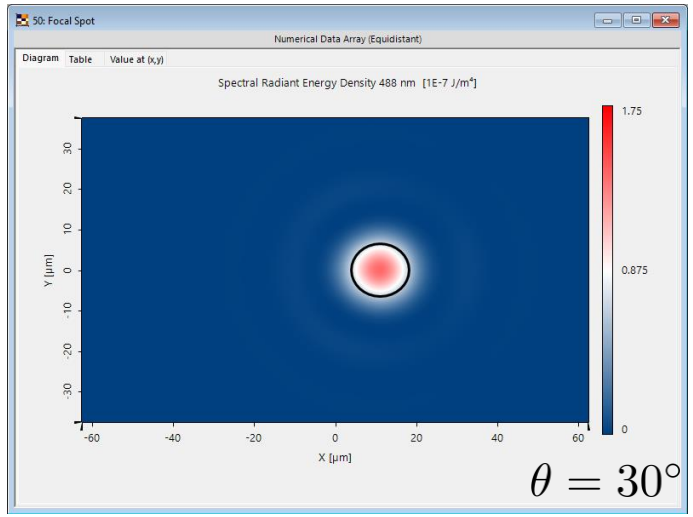


The *Distortion Analyzer* provides a quick estimate of the performance of the F-Theta lens, which can be validated by propagating the field to the focal plane.

Performance Evaluation – Spot Diameter Measurement





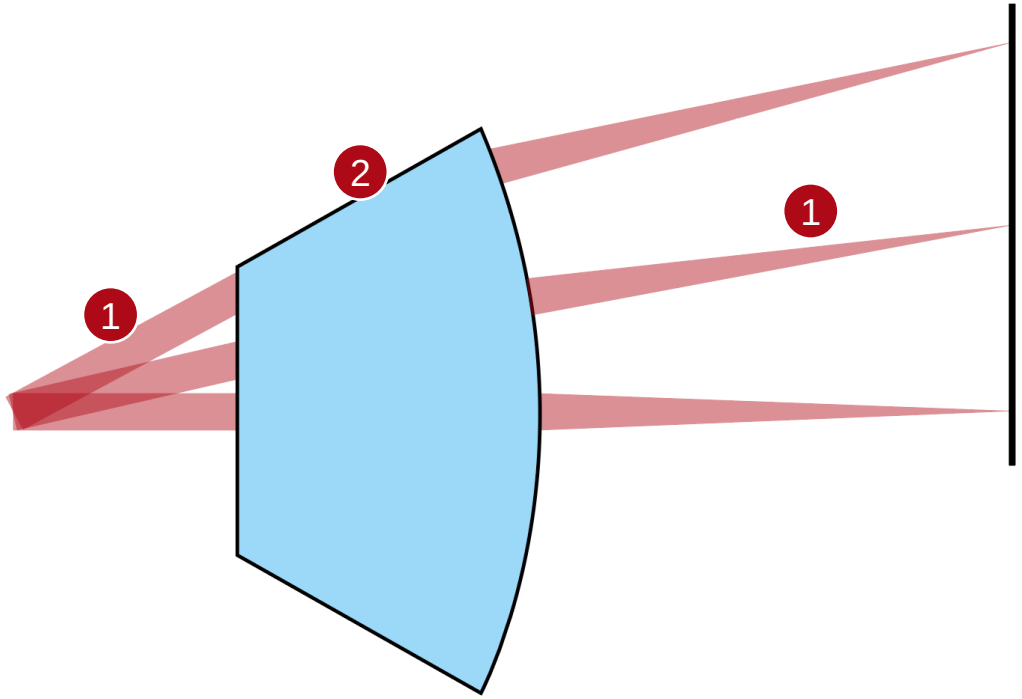


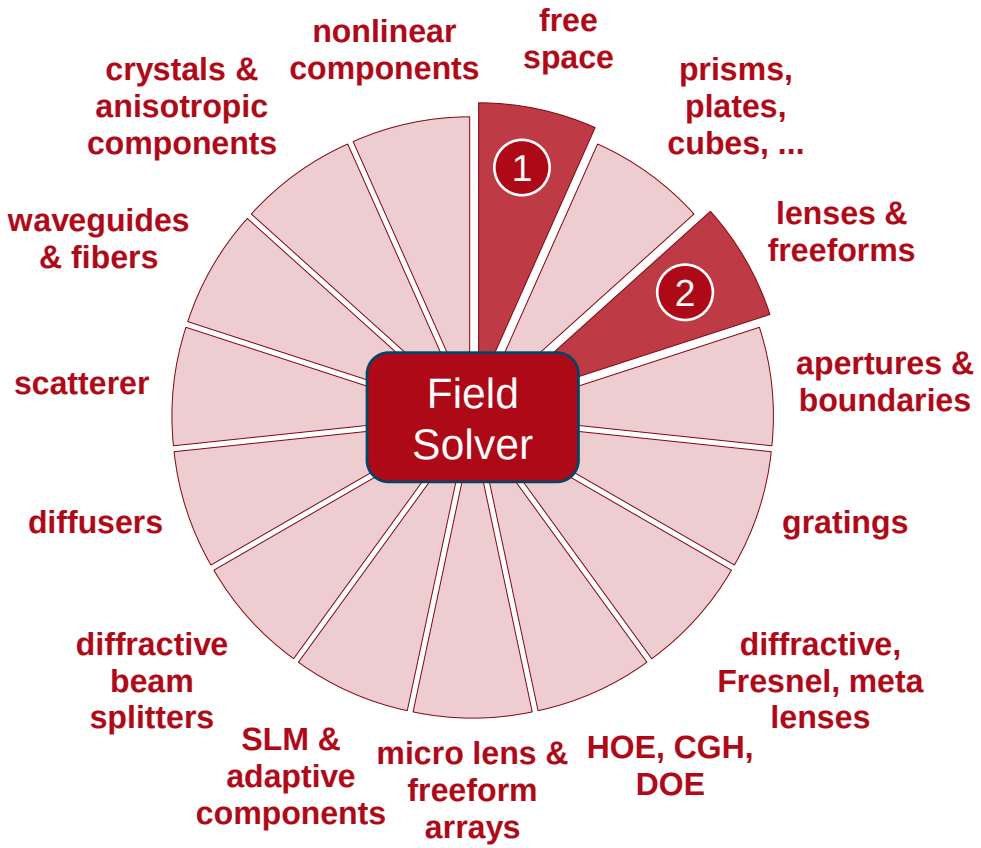
spot diameters (FWHM):

angle	diameter (x)	diameter (y)
0°	12.5µm	12.5µm
25°	13.75µm	13.0µm
30°	14.25µm	13.0µm

Furthermore, this result can be used for a more in-depth analysis of the spots generated by the F-theta system. For example, an examination of the spot size reveals that the individual foci become increasingly oval for higher input angles.

VirtualLab Fusion Technologies





Document Information

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