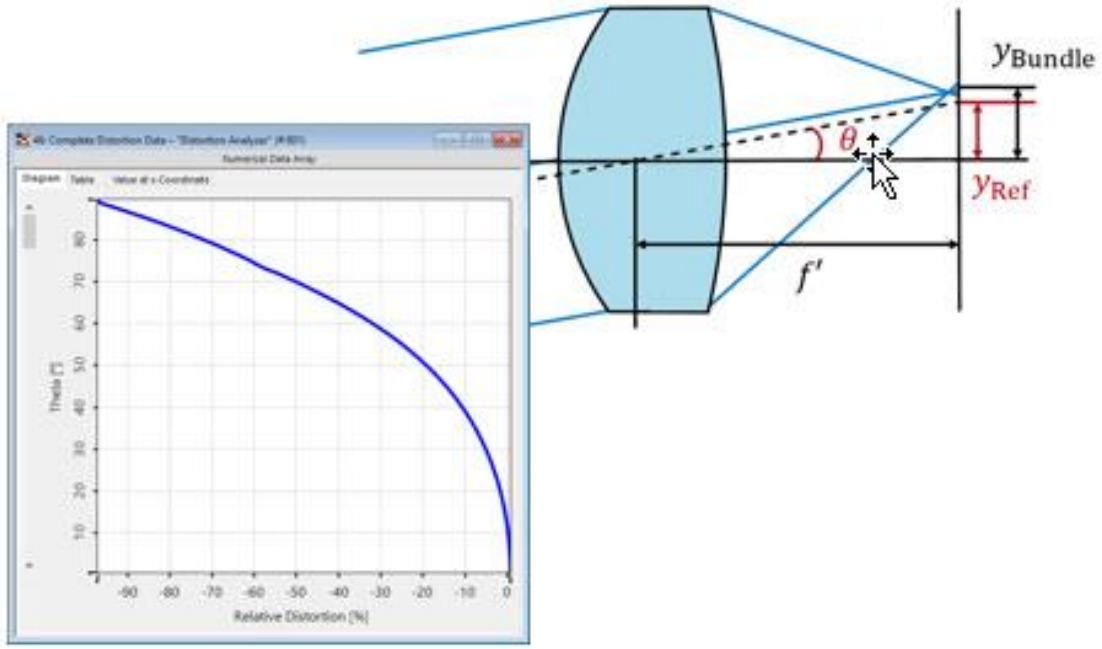
Distortion Analyzer

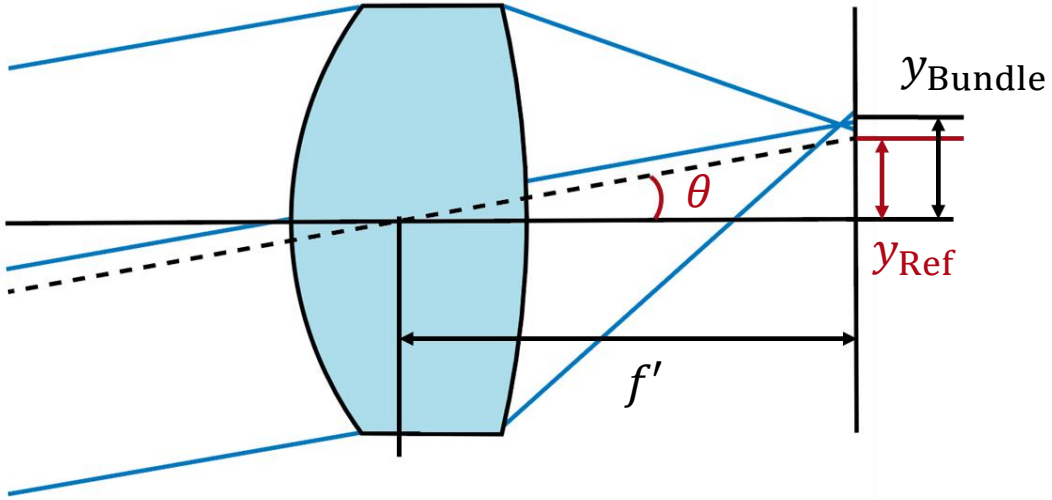
Abstract

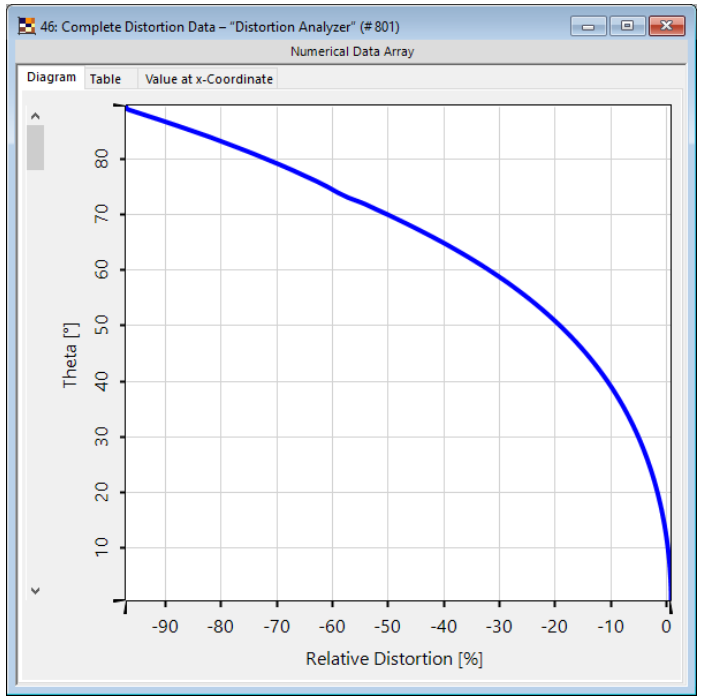


Lenses are an integral part of imaging system design. It is therefore essential for any optical engineer to be able to analyze their performance in detail. One well-known detrimental effect is distortion, which leads to a deviation of the lateral position of the beam with respect to the reference position at the focal plane. In this use case we introduce a tool to investigate this effect, using a spherical lens as an example.

Definition of Distortion

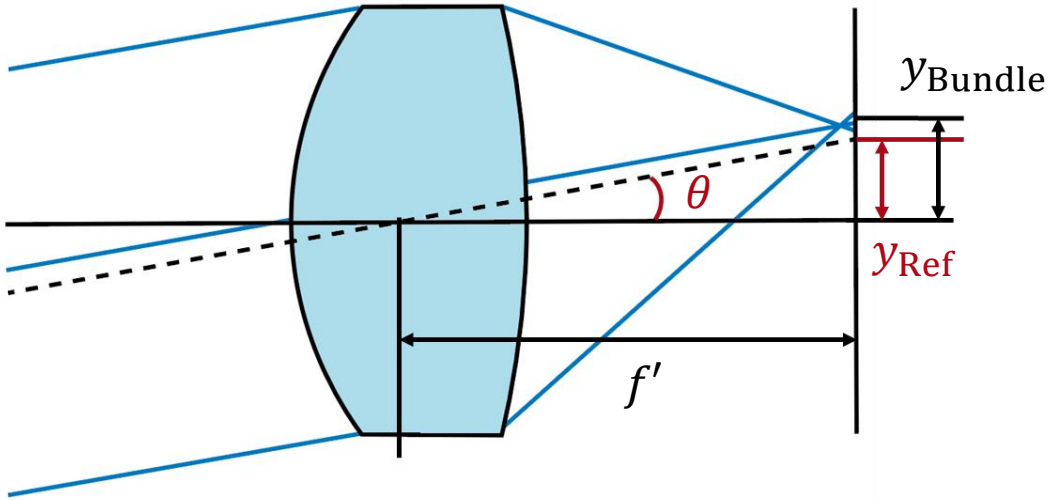
Distortion corresponds to the spherical aberration of the chief ray. It is defined as the deviation of the lateral position of the ray bundle with respect to a reference position at the focal plane. Using the effective focal length (f') of a scanning lens, one can calculate the reference position at the focal plane, which mainly depends on the angle of incidence.





f': effective focal length
θ: incidence angle
y_{Bundle} : lateral position of ray bundle
y_{Ref} : lateral position of reference ray

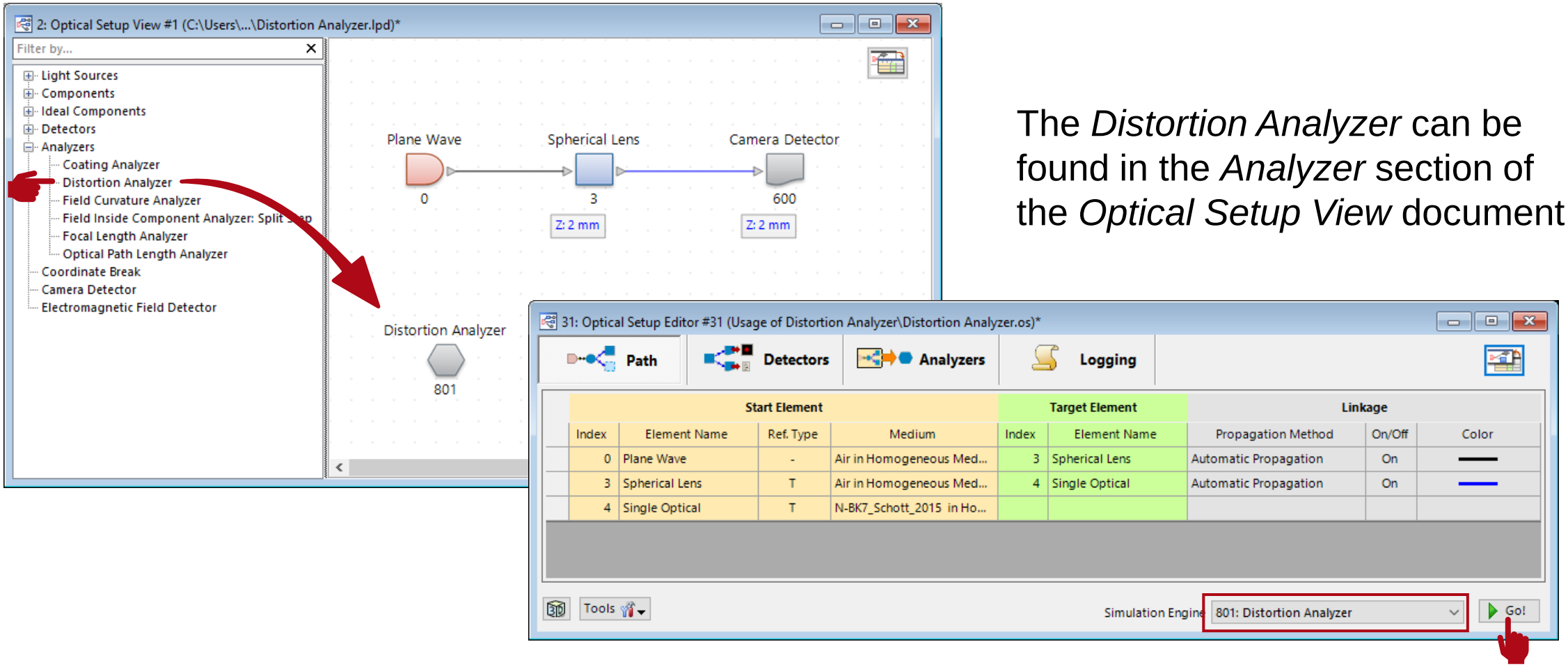
Definition of Distortion



$$\mathrm{Distortion} = \frac{y_{\mathrm{Bundle}} - y_{\mathrm{Ref}}}{y_{\mathrm{Ref}}}$$

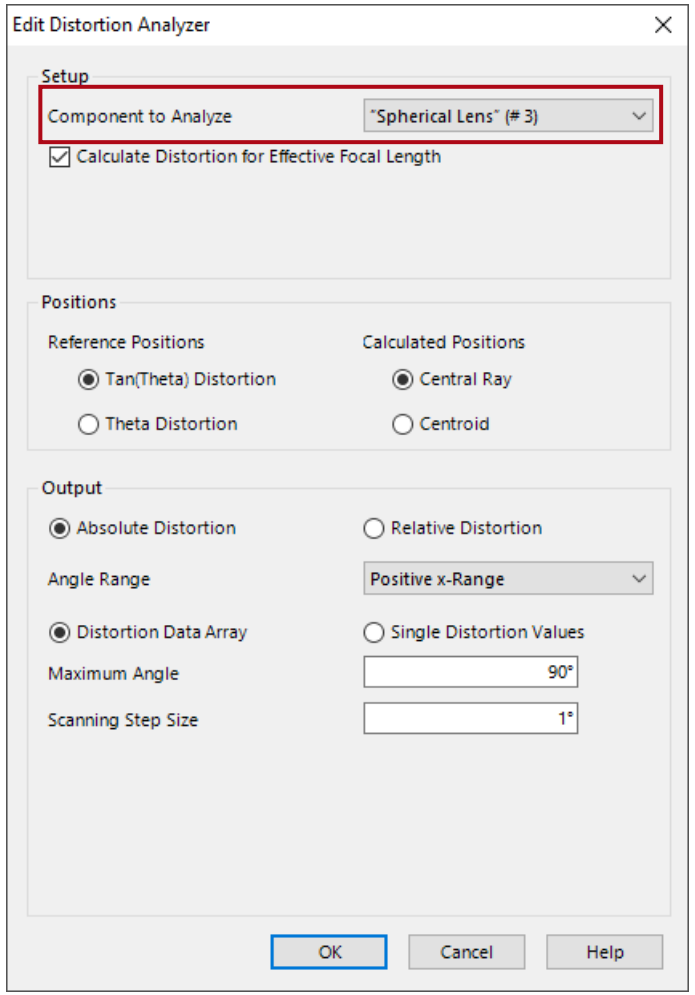
- F-tan(theta) distortion: $y_{\mathrm{Ref}} = f' \cdot \tan(\theta)$
- F-theta distortion: $y_{\mathrm{Ref}} = f' \cdot \theta$
- ray bundle position (y_{Bundle}):
  - *Central ray*: connects the outer point of the field of view and the center of the pupil
  - *Centroid*: physically relevant is the energy centroid

Where to Find the Distortion Analyzer



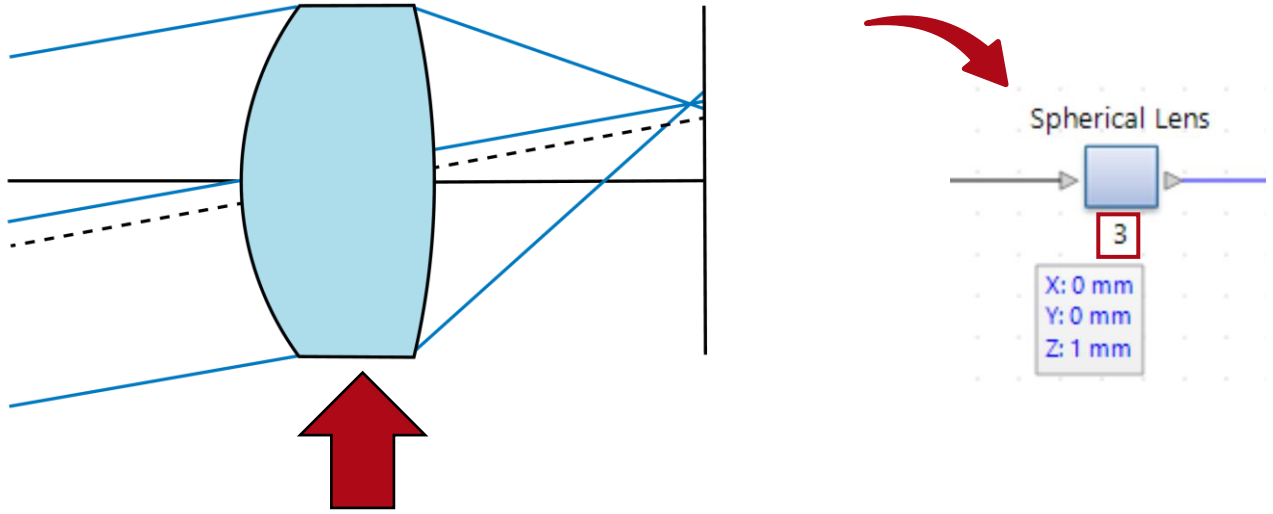
The *Distortion Analyzer* can be found in the *Analyzer* section of the *Optical Setup View* document.

Component to Analyze

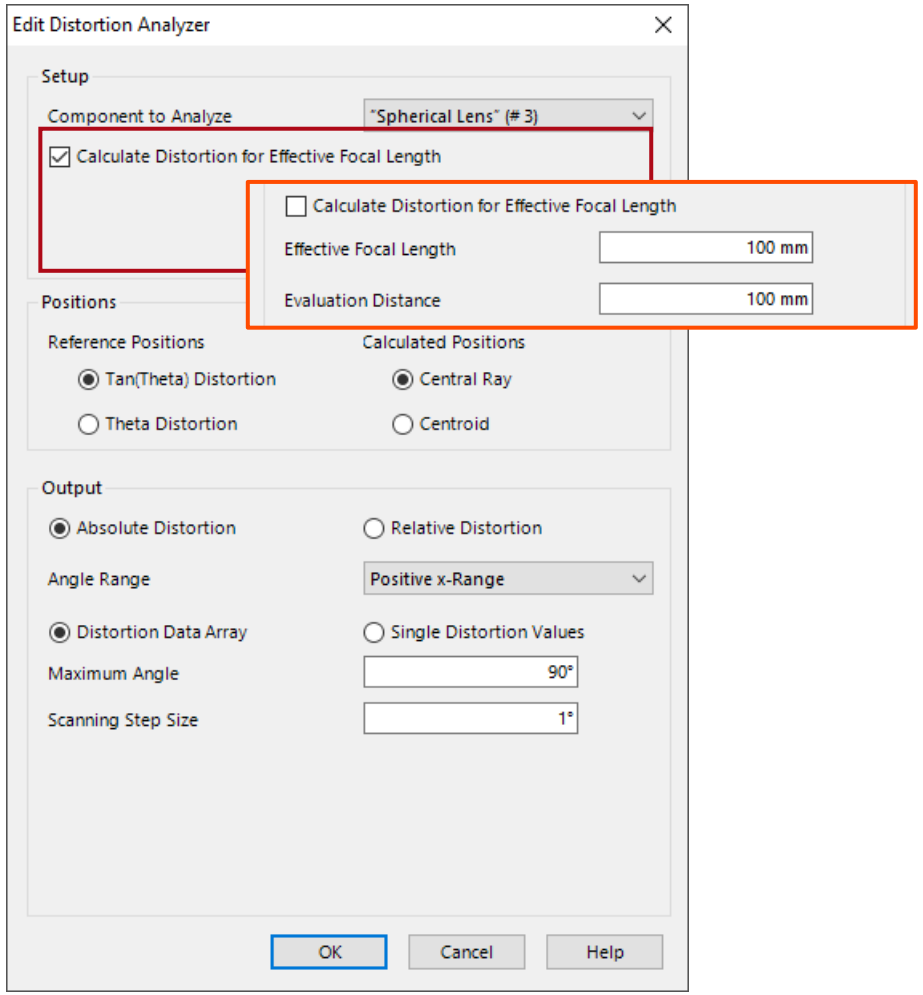


The *Distortion Analyzer* calculates the distortion of a beam introduced by a lens or objective for a defined angular range. It works independently from the actual optical system and its parameters and hence, the specific parameters need to be defined inside the analyzer.

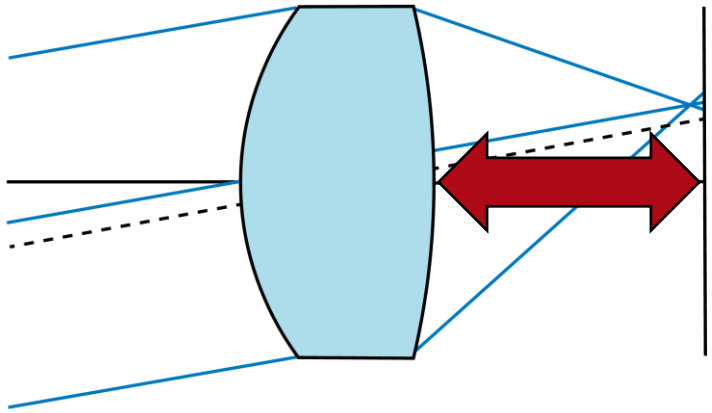
Component to Analyze: Define which component shall be analyzed. A dropdown-menu will show all available options. In case there are multiple components with the same name, the index below the component will help distinguishing them.



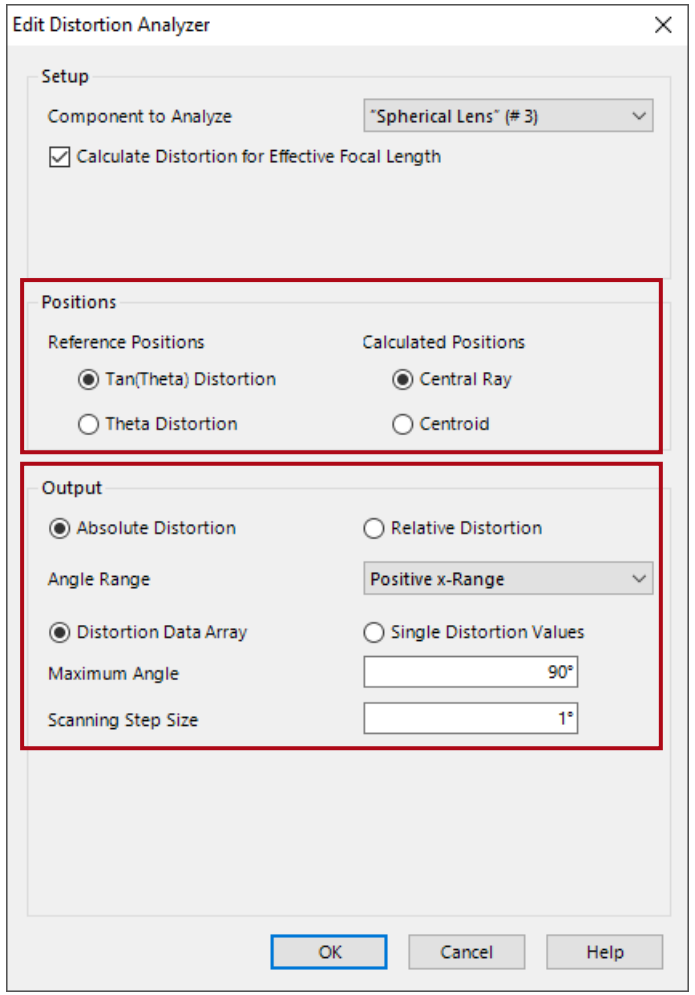
Effective Focal Length



Calculate Distortion for Effective Focal Length: If this option is checked, the effective focal length (f') is determined automatically by evaluating the selected component. Otherwise, the *Evaluation Distance* can be set according to the user's requirements.



Settings of the Analyzer



Positions (distortion type, see page 4)

- reference position
- calculated ray bundle position

Output (result display)

- *Absolute Distortion* [m] or *Relative Distortion* [%]

- *Angle Range*: Defines along which direction the distortion is scanned (x- or y-axis of the component, in both cases the positive or the negative range can be used).

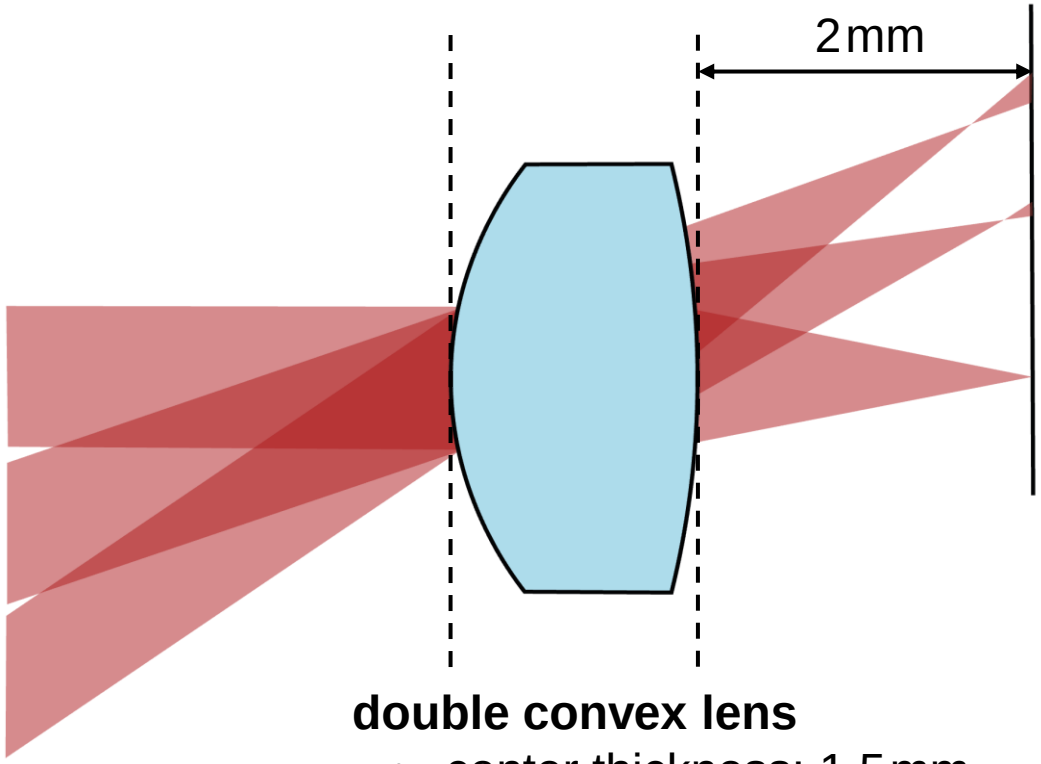
- *Distortion Data Array*: You can scan a complete angular range and the results are returned as a data array – or as set of data arrays if the light source of the system emits more than one wavelength.

- *Single Distortion Values*: In this case the relevant angles can be configured, directly. This mode enables the optimization of the distortion of certain angles with the *Parametric Optimization.*

Example: Distortion of a Spherical Lens

input field

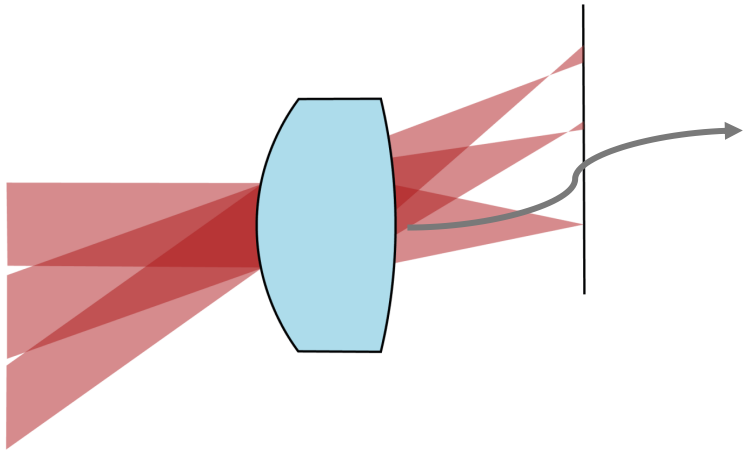
- incident angle: 0–90°
- wavelengths:
  - 532nm



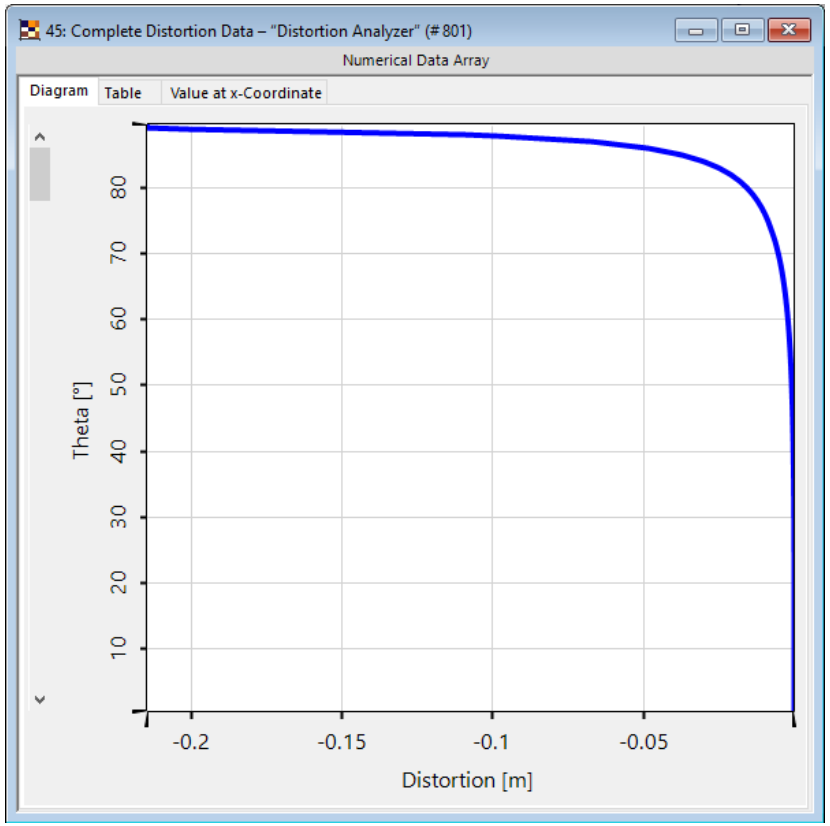
double convex lens

- center thickness: 1.5mm
- r1: 4mm
- r2: 3.5mm
- material: N-BK7

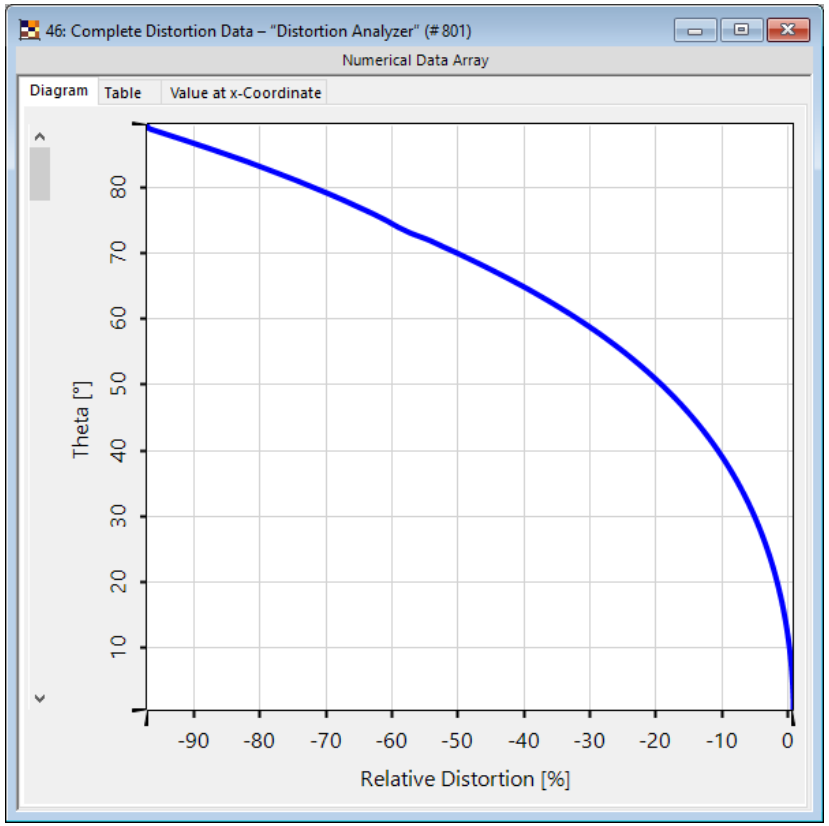
Example: Spherical Lens Distortion



Absolute Distortion



Relative Distortion



Document Information

title	Distortion Analyzer
document code	SWF.0003
document version	3.0
software edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	- Evaluation of an F-Theta Scanning Lens - Field Curvature Analyzer