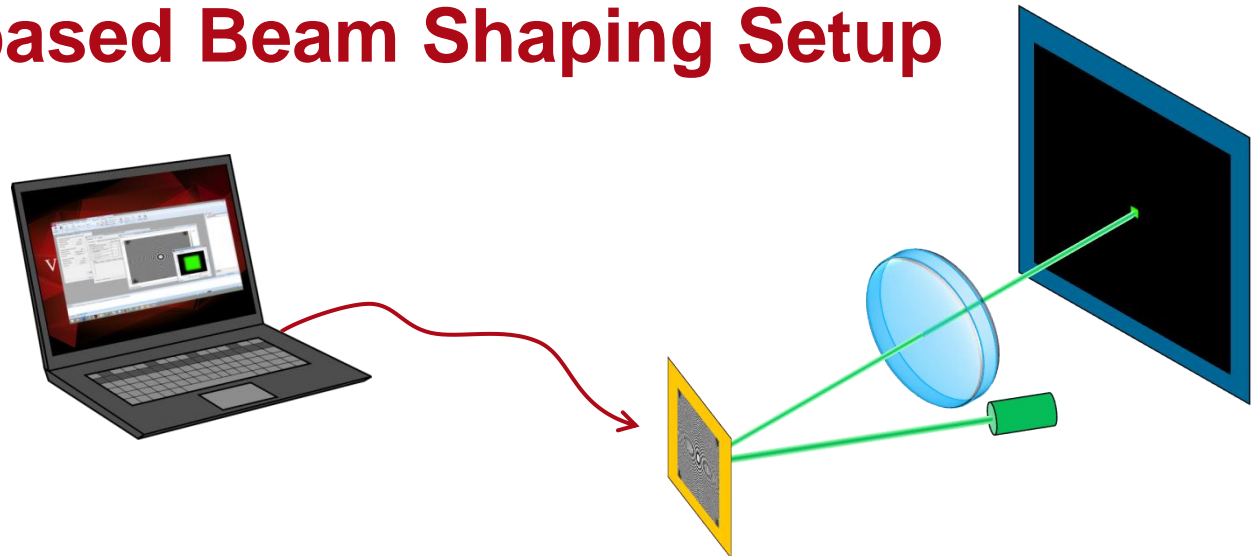


Spatial Light Modulator (SLM.0003 v1.2)

Investigation of Lens Aberrations in an SLM-based Beam Shaping Setup

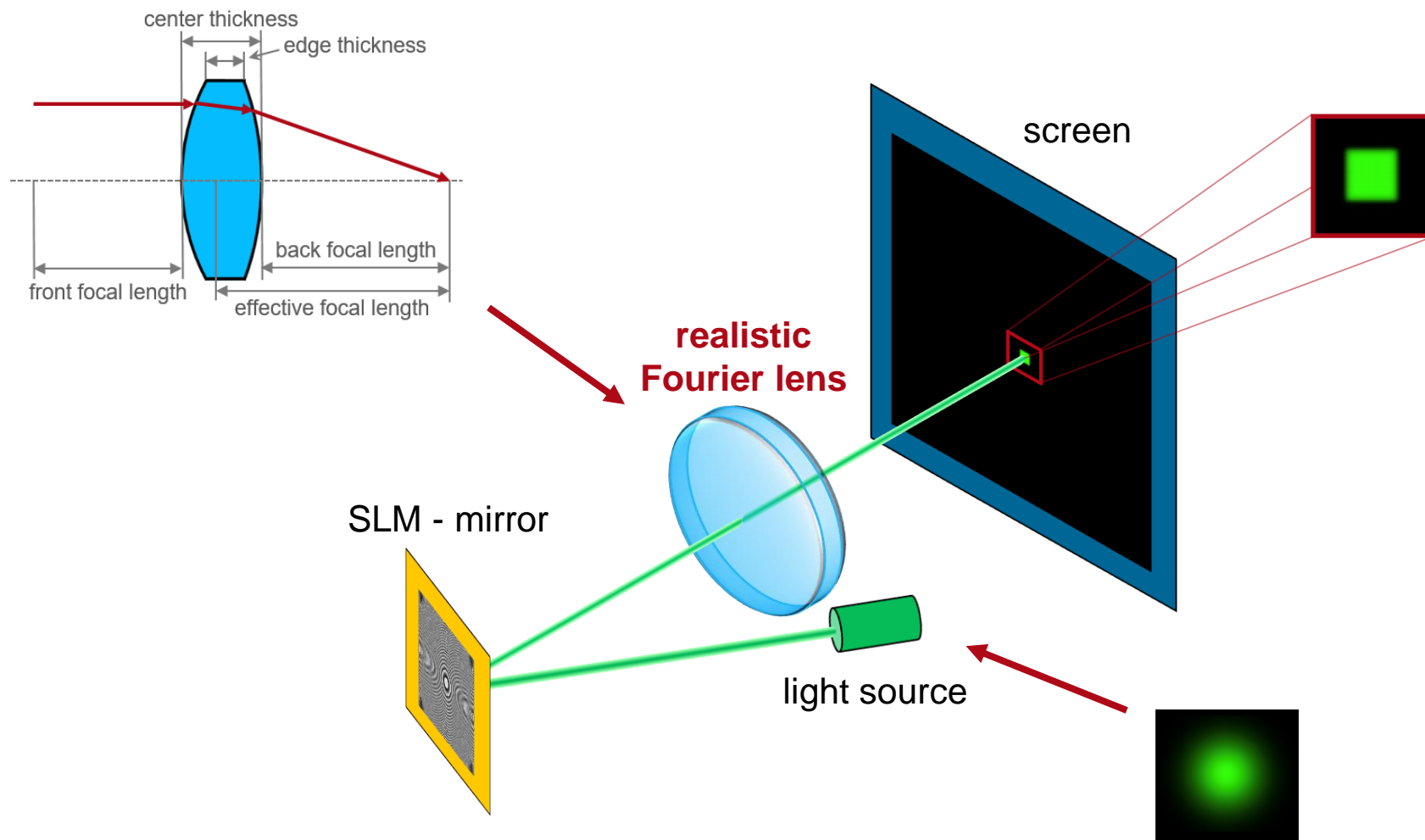


Application Example in a Nutshell

System Details

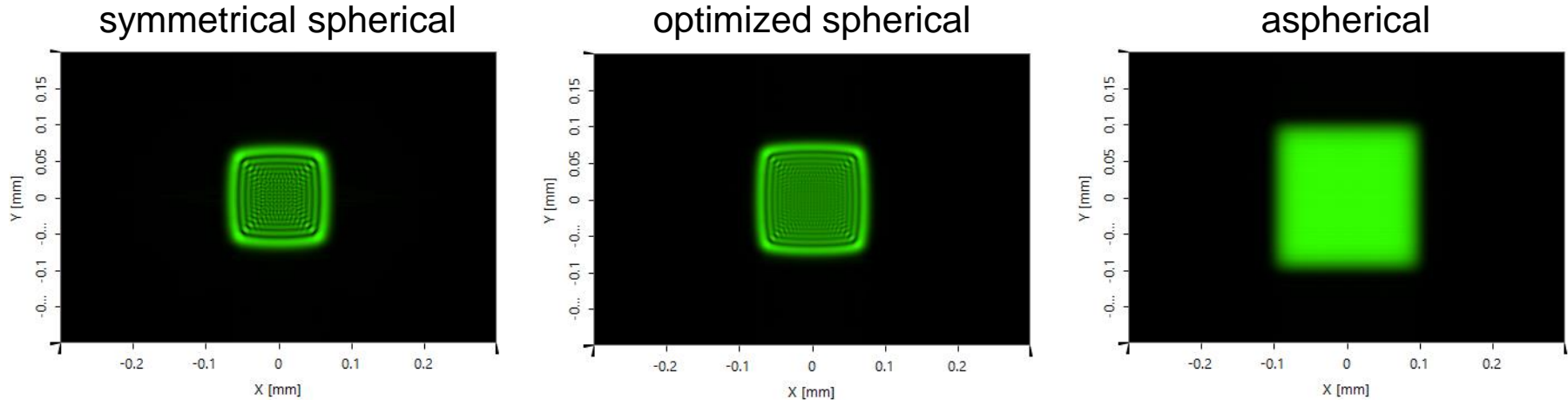
- Source
 - Gaussian laser beam
- Components
 - reflective spatial light modulator (SLM) system with subsequent 2f-setup
 - different Fourier lens designs (spherical, aspherical) providing various performances and **aberrations**
- Detectors
 - emulation of visual perception
 - Top Hat, conversion efficiency, signal-to-noise ratio
- Modelling/Design
 - Field Tracing:
 - ✓ **Evaluation of the quality of an SLM beam shaping system depending on the performance of the Fourier lens**

System Illustrations



Modelling & Design Results

Results for different real Fourier lenses:



	symmetrical spherical	optimized spherical	aspherical
conversion efficiency	56.8%	68.6%	90.8%
signal-to- noise ratio	4.25dB	6.08dB	26.9dB

Summary

Investigation of the performance of an SLM-based beam shaping system depending on the used Fourier optics.

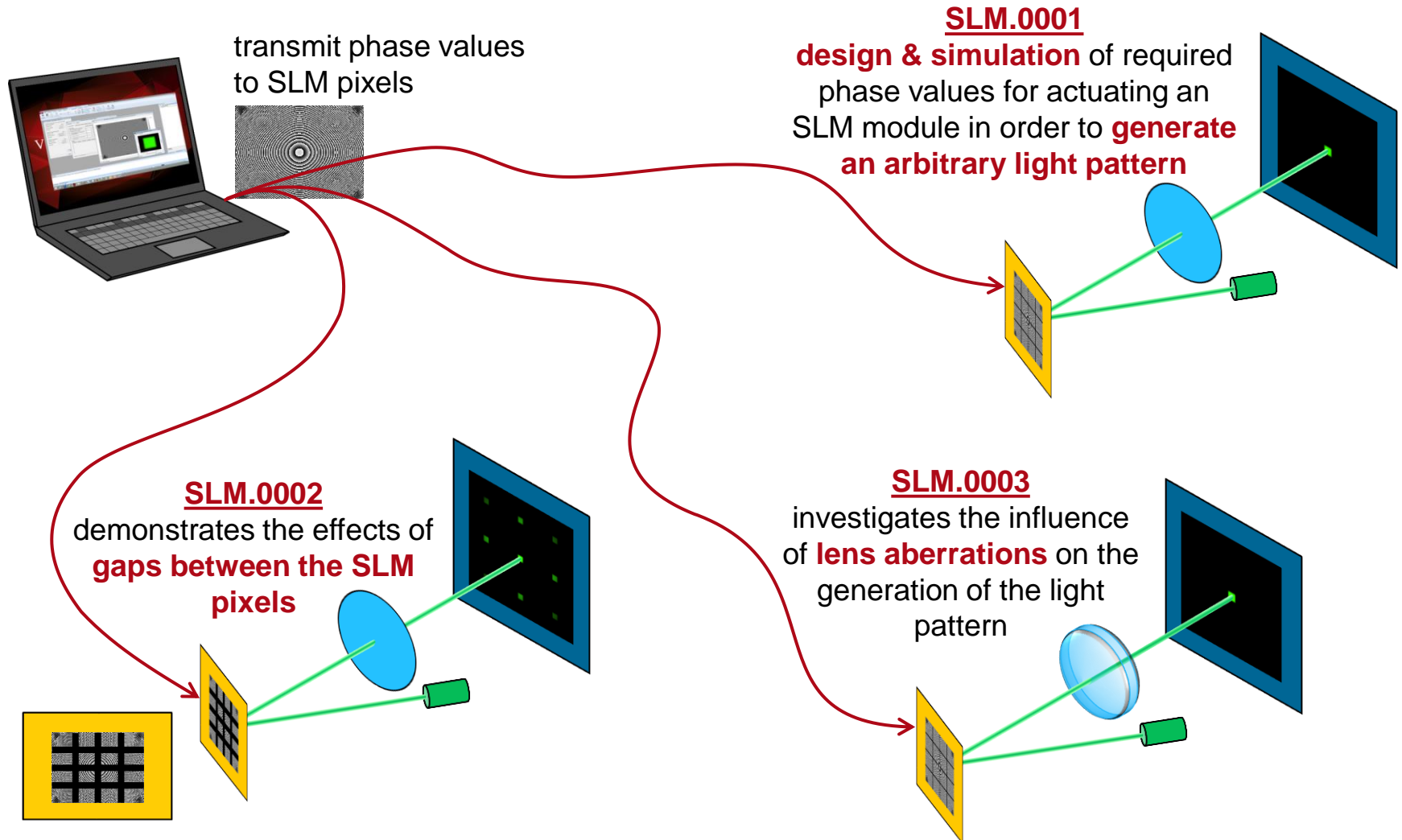
- The **ideal optical system** using a 2f-Setup is **replaced by a real lens with lens aberrations**.
- **Analysis of the influence** on the top hat quality, caused by the performance of different spherical and aspherical lenses.

Beam shaping applications require high performance and low aberration optical systems, such as aspherical lenses.

Application Example in Detail

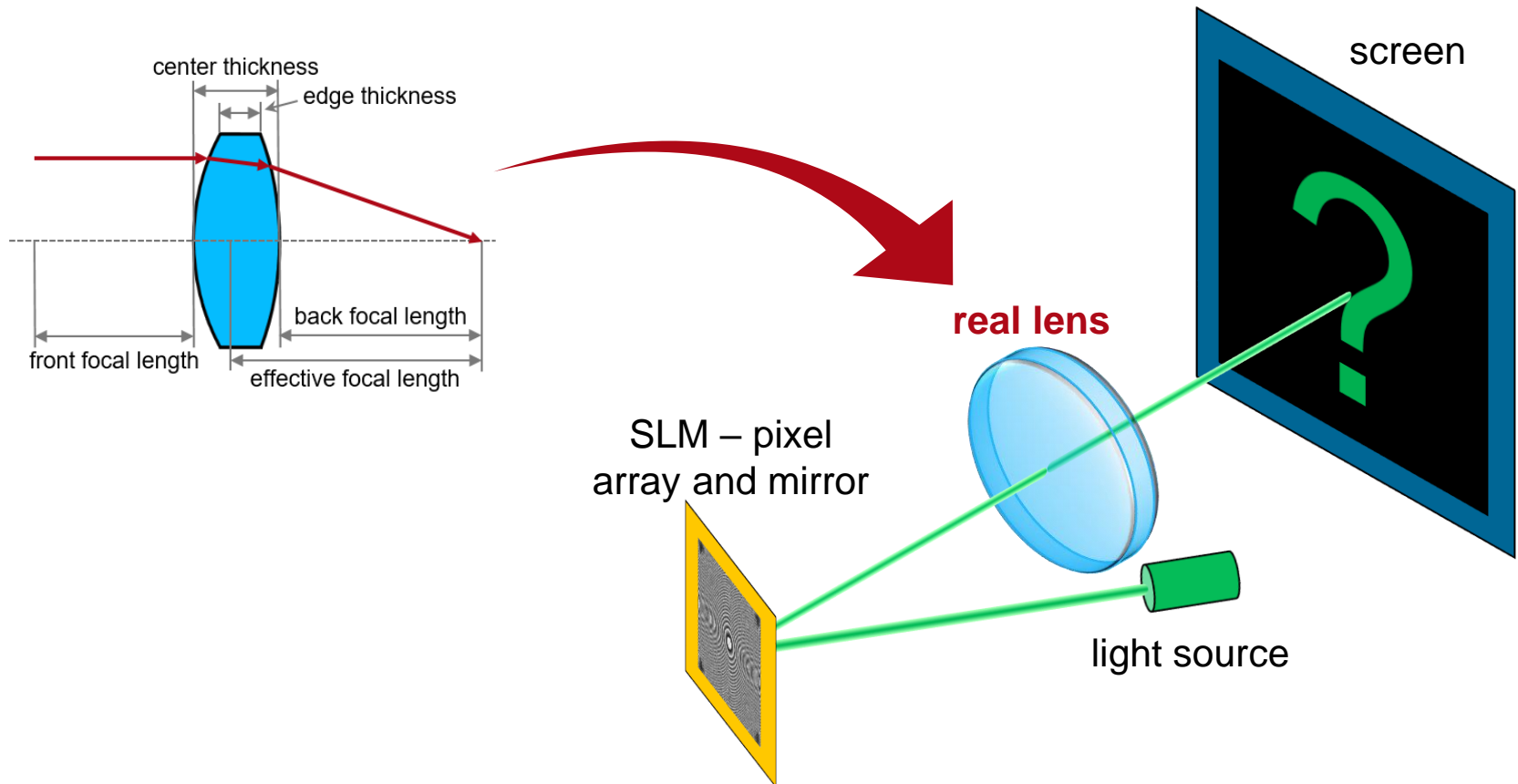
System Parameter

Context of This Application Example

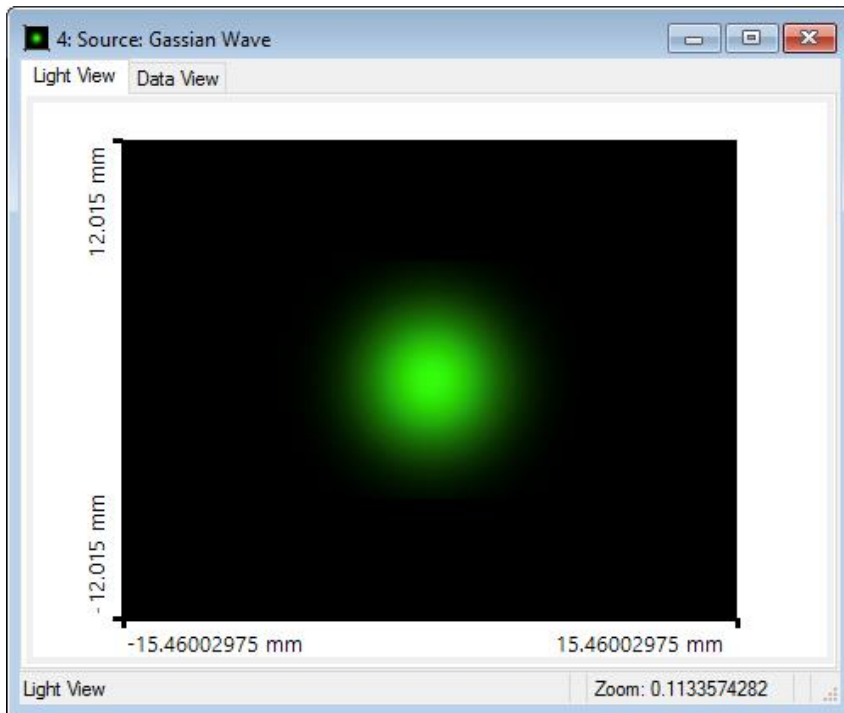


Simulation Task

In the previous scenarios the ideal Fourier optical setup (**2f-Setup**), was utilized. In the following, this element is **replaced by realistic lenses**, exhibiting various optical aberrations.



Specs: Collimated Input Laser Beam



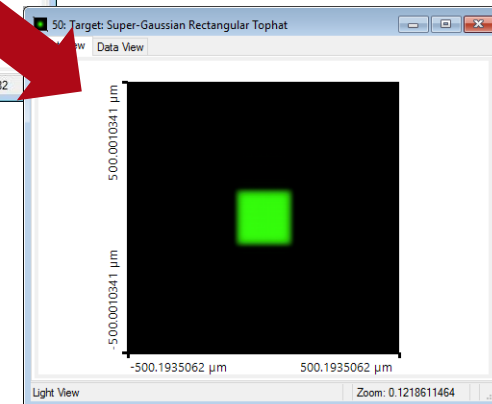
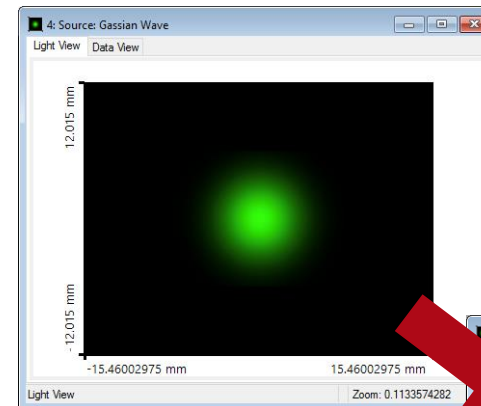
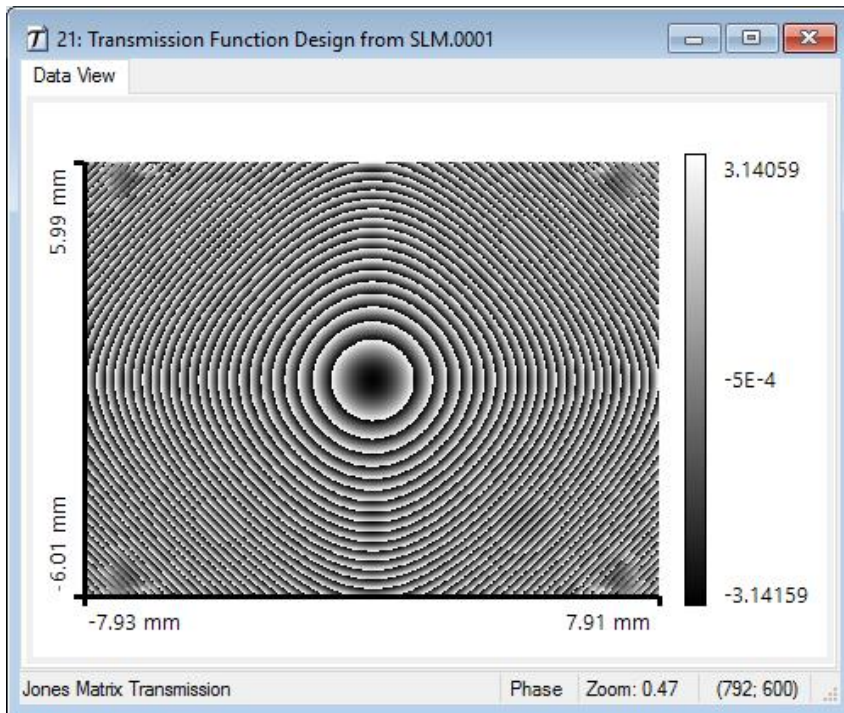
Single Mode Laser

Parameter	Value & Unit
wavelength	532 nm
beam radius ($1/e^2$)	3.3 mm
divergence angle of beam intensity	$0.003^\circ \times 0.003^\circ$ (full angle $1/e^2$)
M ² -value	1

identical to SLM.0001, SLM.0002

Specs: SLM Transmission Function

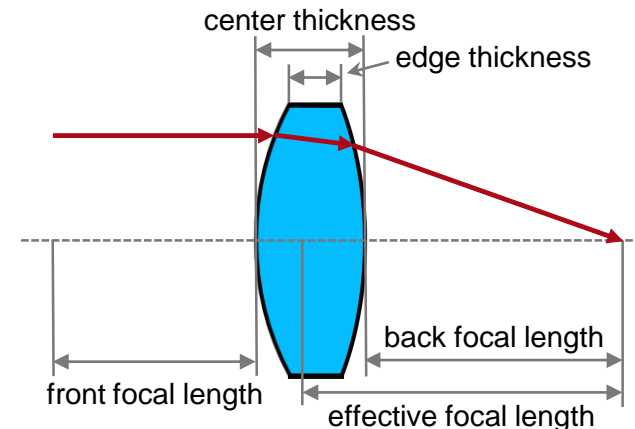
Transmission function to retrieve the desired top hat beam shape (designed in *SLM.0001*).



From Ideal to Real Lenses

- The ideal 2f-lens **is replaced by a real Fourier lens.**
- Thus **aberrations (e.g. spherical) occur**, depending on the performance of the used lens.
- For description of real lenses, a **couple of parameters** are necessary.
- The real lenses are chosen such, that the **effective focal length is similar to the 2f-Setup.**
- The parameters in the table e.g. exhibit the ideal specifications of the former used ideal 2f-Setup.

Parameter	Value & Unit
eff. focal length	50 mm
back focal length	50 mm
front focal length	50 mm
center thickness	0
edge thickness	0

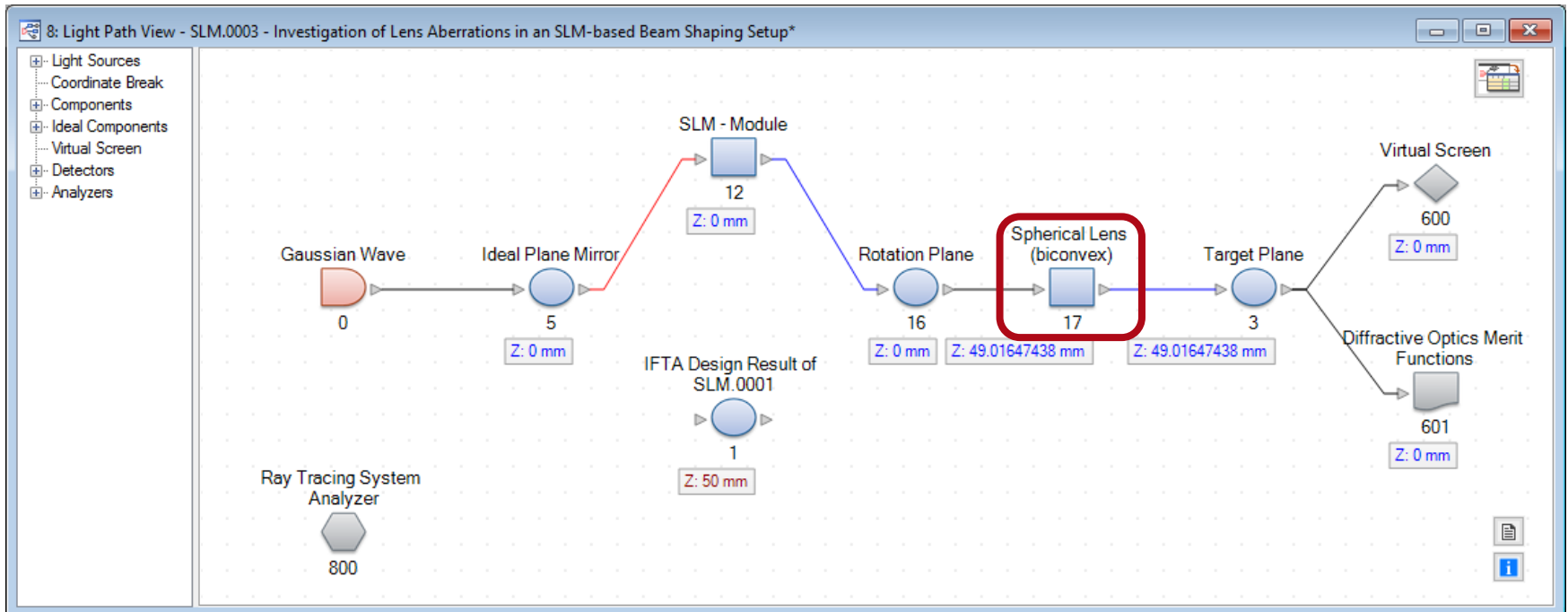


Application Example in Detail

Simulations & Results

Simulation of SLM in VirtualLab

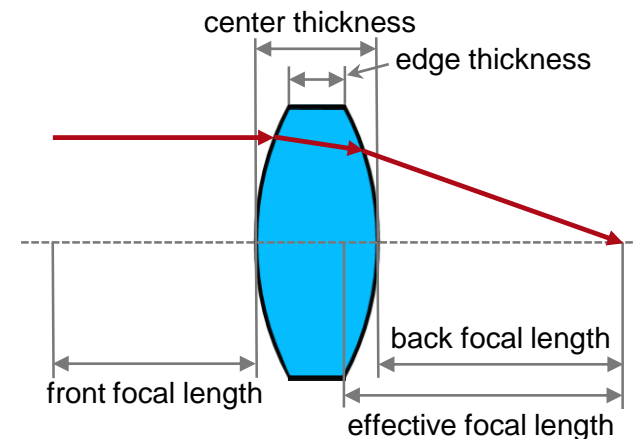
- Due to the embedded components, VirtualLab allows for an easy realization of the **reflective setup** (e.g. mirrors, real lenses, etc.).
- A **real lens** (e.g. biconvex spherical lens) is used as a Fourier lens.
- A rotation plane was added in order to optimize the computation.



Specs: Biconvex Spherical Lens

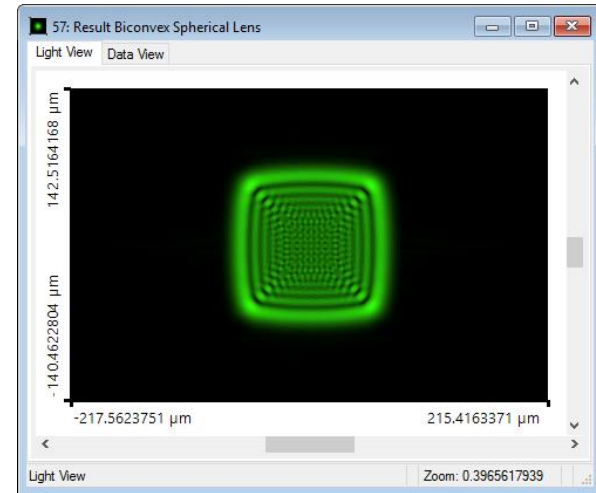
- First, a simple **biconvex spherical** lens with the same radii of curvature is used.
- Due to the **symmetrical shape** front and back focal length are identical.
- The parameters are for a wavelength of 532nm.
- The lens is made of N-BK7.
- The effective focal length is calculated by VirtualLab's **Lens Calculator**

Parameter	Value & Unit
eff. focal length	50 mm
back focal length	49.02 mm
front focal length	49.02 mm
center thickness	2.96 mm
edge thickness	1 mm



Result: Biconvex Spherical Lens

- The resulting **top hat beam is superimposed by an interference pattern**, which arises due to occurring aberrations.
- Low conversion efficiency (56.8%) and signal-to-noise ratio.
- A symmetrical biconvex lens **does not offer an appropriate transformation performance.**



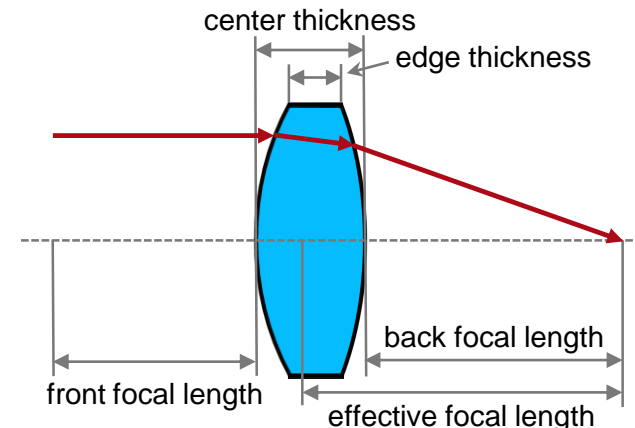
Detector	Sub - Detector	Result
Diffractive Optics Merit Functions #601 after Target Plane #3 (0)	Conversion Efficiency (Classic Field Tracing)	56.90777031 %
	Signal-to-Noise Ratio (Classic Field Tracing)	4.267082071 dB

Specs: Optimized Spherical Lens

- Second, an **optimized spherical lens** will be utilized.
- The radii of curvature are optimized in order **to minimize wavefront aberrations**.
- The optimization results in different radii of curvature and thus in an unsymmetrical lens shape.
- Again, the lens consists of N-BK7.

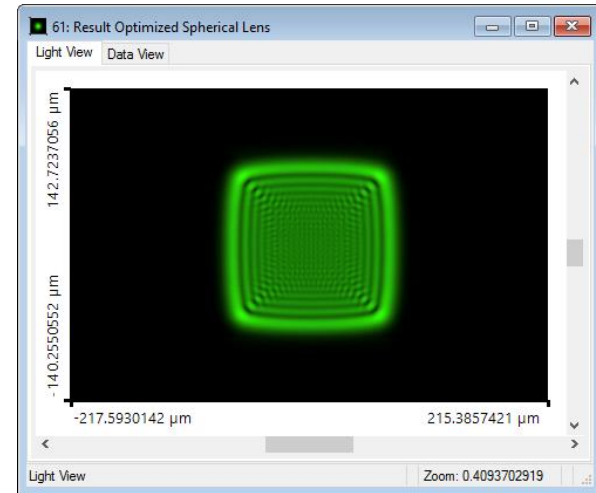
For further information about lens optimization using VirtualLab, please refer example [BDS.0003](#).

Parameter	Value & Unit
eff. focal length	50.95 mm
back focal length	49.26 mm
front focal length	50.70 mm
center thickness	2.94 mm
edge thickness	1 mm



Result: Optimized Spherical Lens

- Again, an interference pattern arises due to **spherical aberrations**.
- Mediocre conversion efficiency (68.6%) and signal-to-noise ratio.
- An optimized spherical lens **does also not offer an appropriate transformation performance**.

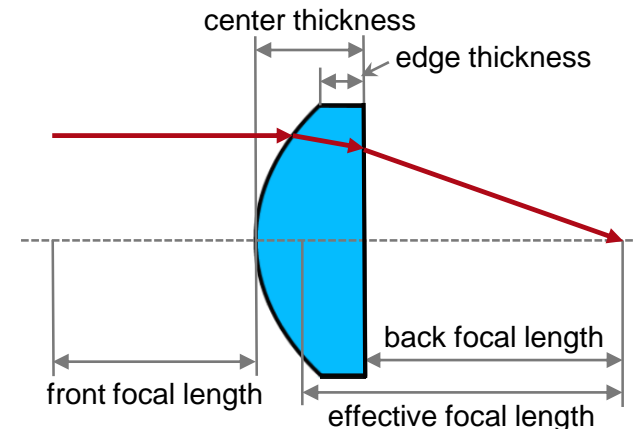


Detector	Sub - Detector	Result
Diffractive Optics Merit Functions #601 after Target Plane #3 (0)	Conversion Efficiency (Classic Field Tracing)	68.49951867 %
	Signal-to-Noise Ratio (Classic Field Tracing)	6.074698638 dB

Specs: Aspherical Lens

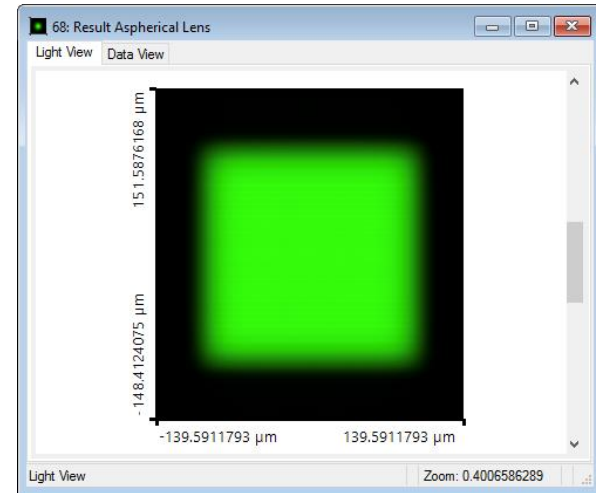
- Third, an **aspherical lens from Asphericon** (type: A25-50LPX) is integrated in the SLM setup.
- This aspherical lens is also made of N-BK7.
- This lens was imported from VirtualLab's **Lens Catalog**.

Parameter	Value & Unit
eff. focal length	49.20mm
back focal length	45.25mm
front focal length	47.15mm
center thickness	6mm
edge thickness	2.86 mm



Result: Aspherical Lens

- The **result exhibits the desired top hat beam shape.**
- Further, an excellent conversion efficiency (90.8%) and high signal-to-noise ratio are measured.
- The aspherical lens **transforms the SLM function in an almost aberration free top hat beam.**



Detector	Sub - Detector	Result
Diffractive Optics Merit Functions #601 after Target Plane #3 (0)	Conversion Efficiency (Classic Field Tracing)	90.69881808 %
	Signal-to-Noise Ratio (Classic Field Tracing)	26.90654978 dB

Summary

Investigation of the performance of an SLM-based beam shaping system depending on the used Fourier optics.

- The **ideal optical system** using a 2f-Setup (Fresnel integral) is **replaced by a real spherical lens**.
- **Analysis of the influence** on the top hat quality, caused by the performance of different spherical and aspherical lenses.

Beam shaping applications require for high performance and low aberration optical systems, such as aspherical lenses.

Further Readings

Further Readings

- Get Started Videos:
 - [Introduction to the Light Path Diagram](#)
- Documents Correlated with This Application Examples
 - [SLM.0001: Design of SLM Phase Modulation for Top Hat Generation](#)
 - [SLM.0002: Simulation of Light Diffraction at Pixels of an SLM](#)