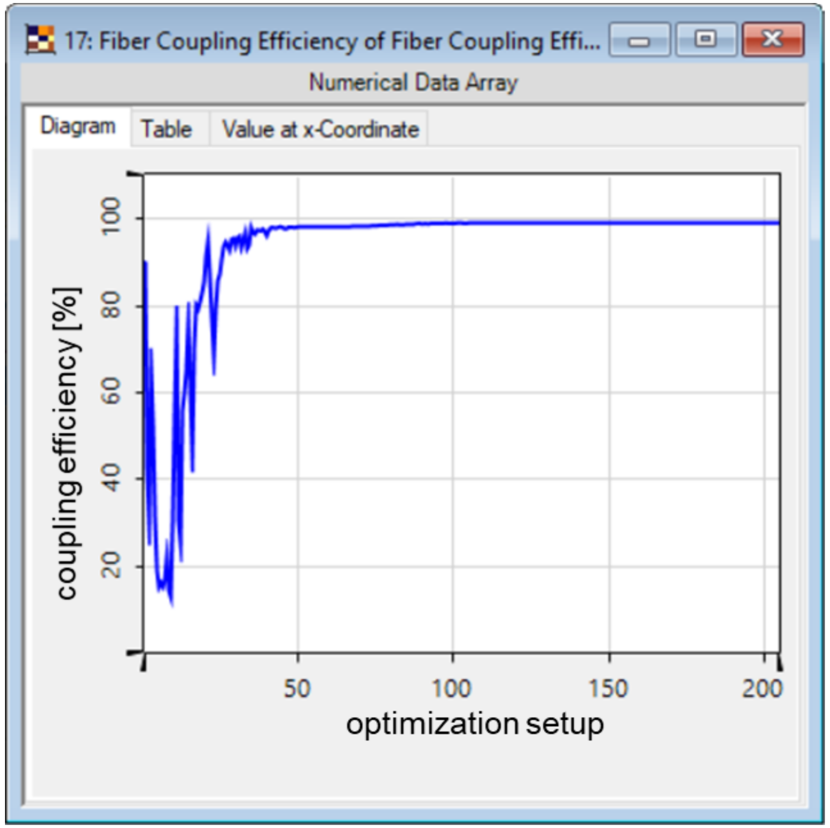
# Parametric Optimization of Fiber Coupling Lenses

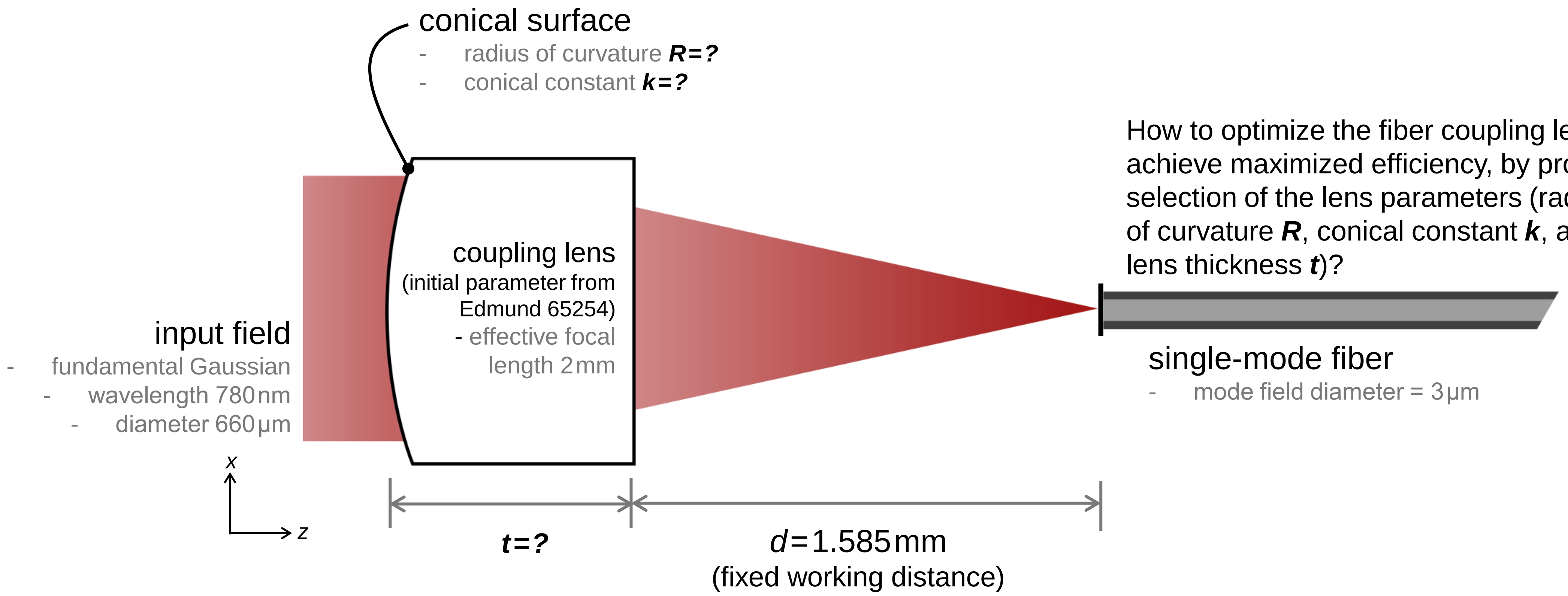
# Abstract





In modern optics, fibers can be found in various optical system. To have an efficient use of light power, the fiber coupling lens must be well-designed, to ensure that the focal spot matches to the propagating mode inside the fiber. With the fast-physical optics simulation and the parametric optimization in VirtualLab Fusion, we show the design of a lens with conical surface for the task of coupling light into a single-mode fiber.

# Design Task

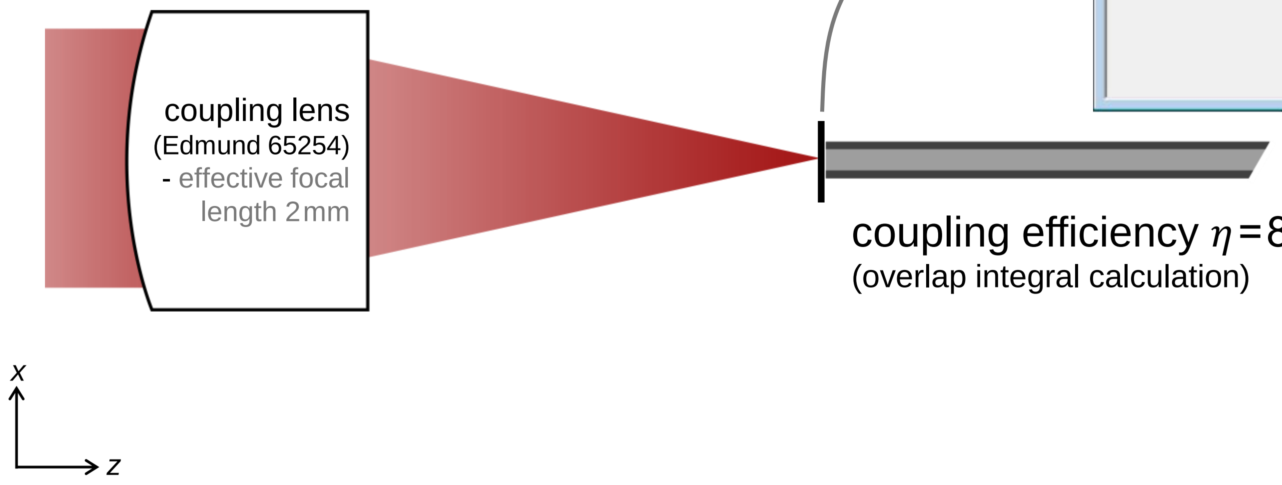



How to optimize the fiber coupling lens to achieve maximized efficiency, by proper selection of the lens parameters (radius of curvature ***R***, conical constant ***k***, and lens thickness ***t***)?

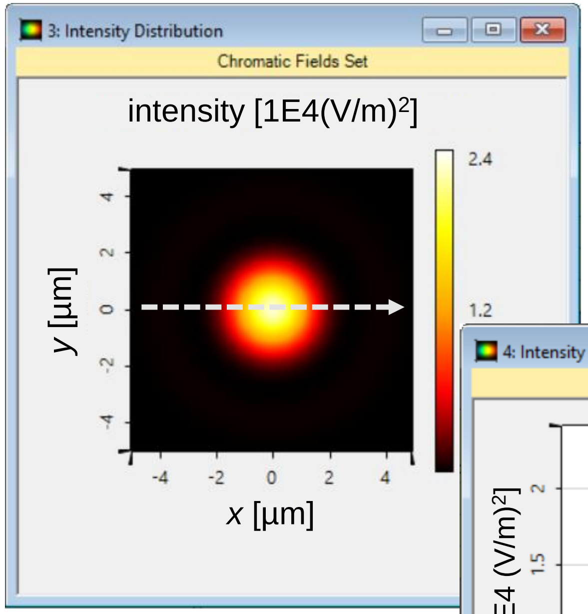
# Evaluation of Initial Lens

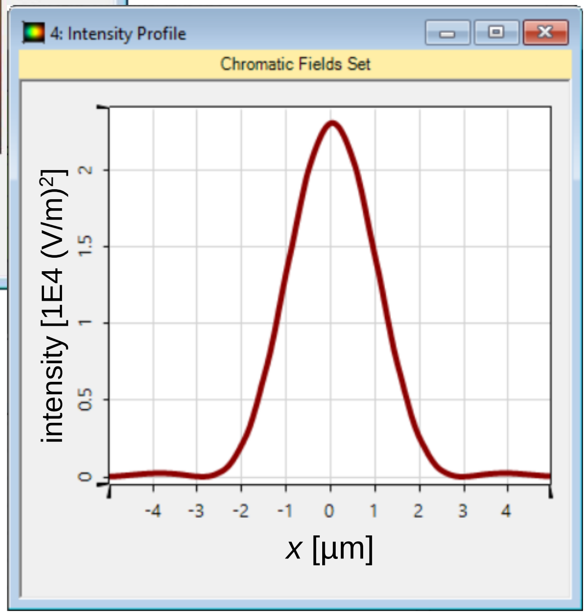
## Initial lens parameters

- radius of curvature $\boldsymbol{R}=1.7\,\mathrm{mm}$
- conical constant $\boldsymbol{k}=0$
- lens thickness $\boldsymbol{t}=0.8\,\mathrm{mm}$




coupling efficiency $\eta=88.4\,\%$
(overlap integral calculation)



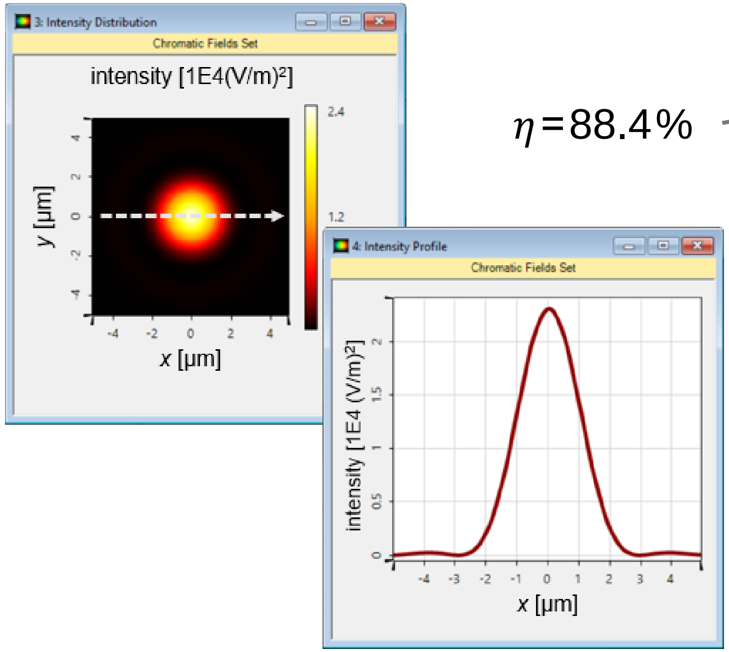




The coupling efficiency obtained from the initial spherical lens is not optimal, due to mismatch to the mode inside the single-mode fiber.

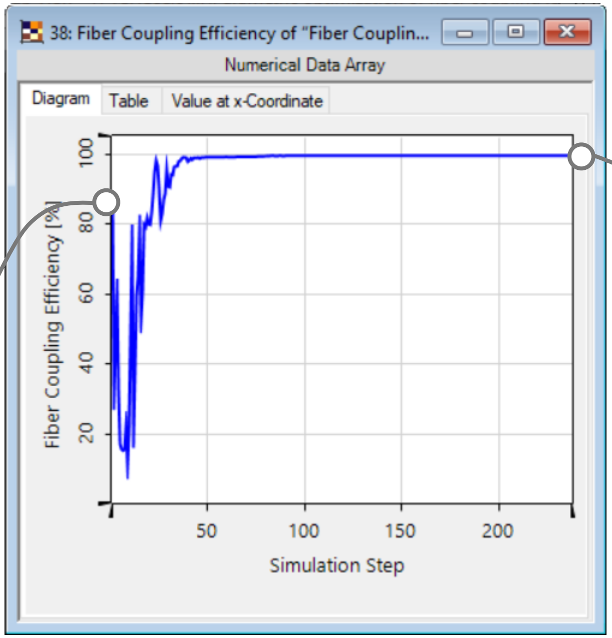
# Parametric Optimization

Initial lens parameters

- radius of curvature $\boldsymbol{R}$=1.7mm
- conical constant $\boldsymbol{k}$=0
- lens thickness $\boldsymbol{t}$=0.8mm

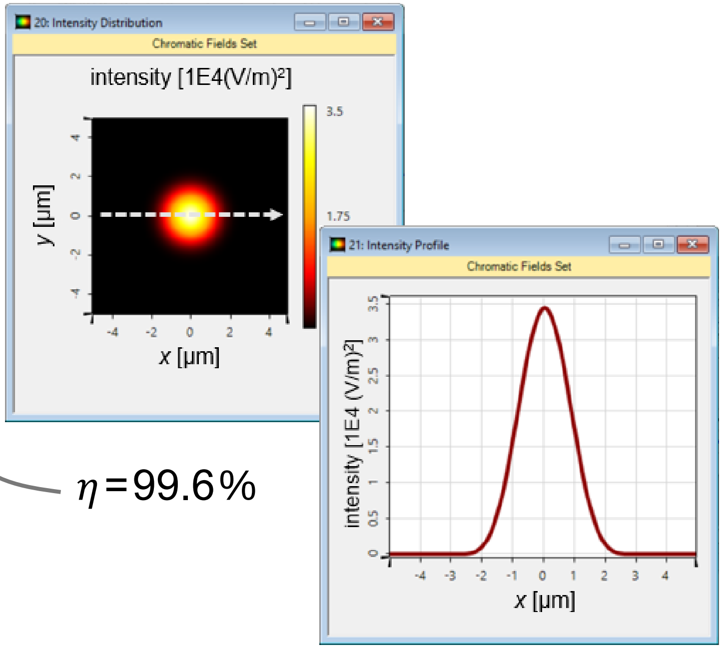



$\eta$=88.4%




parametric optimization of coupling efficiency with downhill simplex algorithm

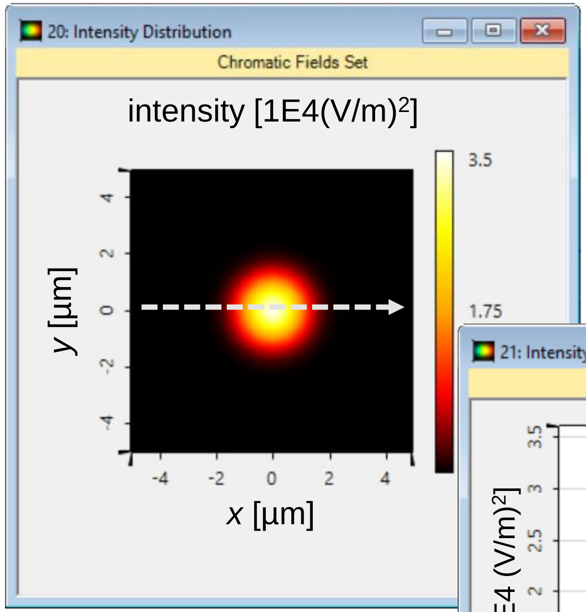
$\eta$=99.6%



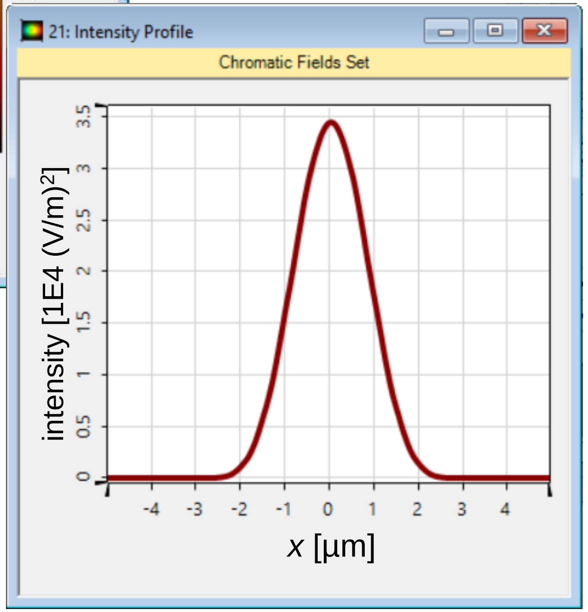

optimized lens parameters

- radius of curvature $\boldsymbol{R}$=1.608mm
- conical constant $\boldsymbol{k}$=-0.7139
- lens thickness $\boldsymbol{t}$=0.6311mm

# Evaluation of Optimized Lens




The coupling efficiency increases to almost the ideal theoretical value after optimization of the lens.




optimized lens parameters

- radius of curvature $\boldsymbol{R}$=1.608mm
- conical constant $\boldsymbol{k}$=-0.7139
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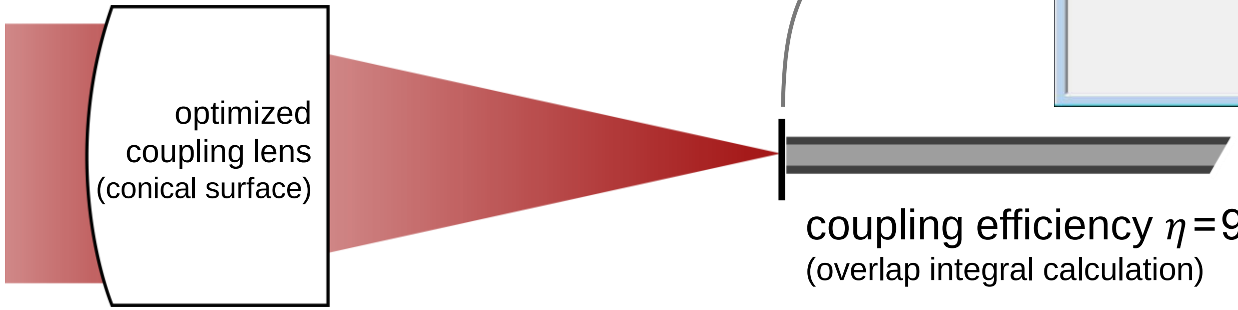
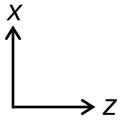
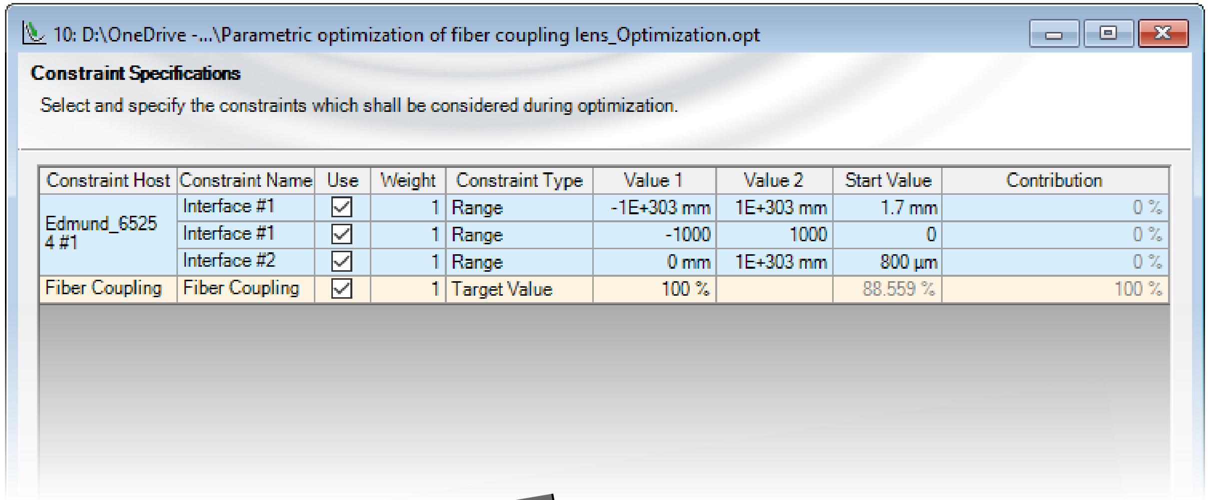



coupling efficiency $\eta$=99.6%
(overlap integral calculation)

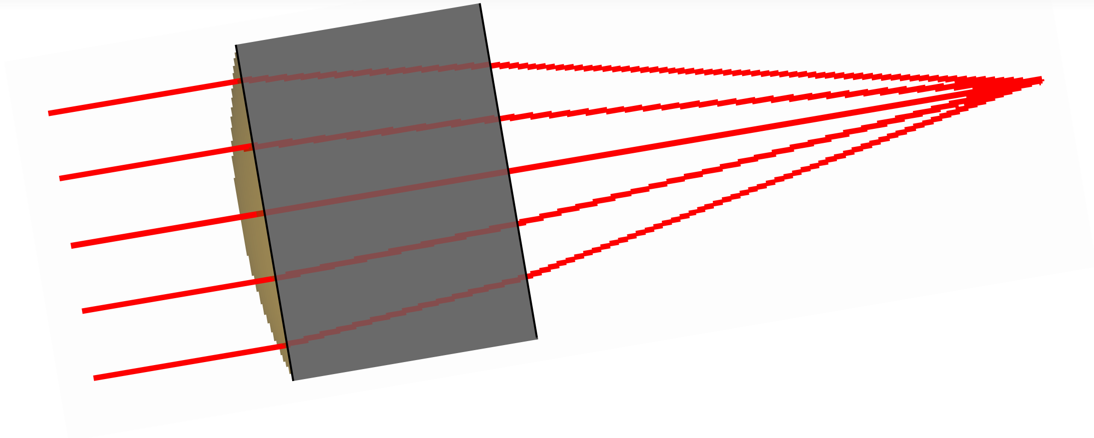


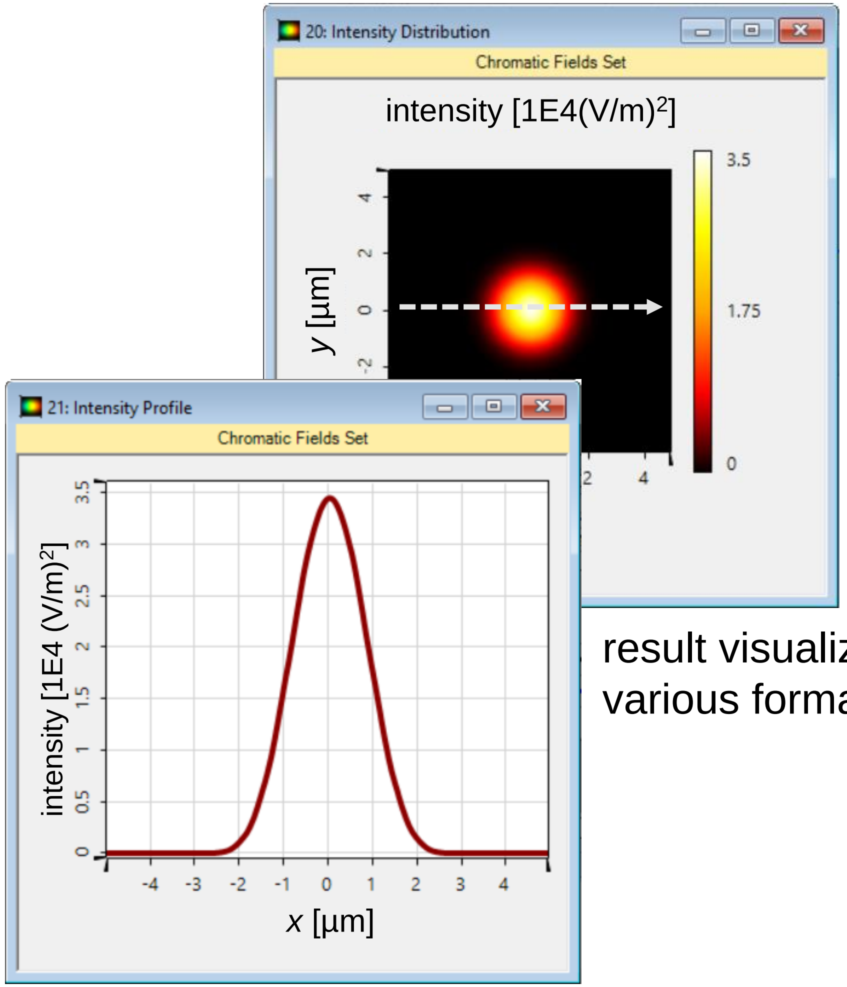
# Peak into VirtualLab Fusion

parametric optimization with flexible variables and merit functions definition




| Constraint Host | Constraint Name | Use | Weight | Constraint Type | Value 1 | Value 2 | Start Value | Contribution |
|---|---|---|---|---|---|---|---|---|
| Edmund_6525 4 #1 | Interface #1 | ☑ | 1 | Range | -1E+303 mm | 1E+303 mm | 1.7 mm | 0 % |
| | Interface #1 | ☑ | 1 | Range | -1000 | 1000 | 0 | 0 % |
| | Interface #2 | ☑ | 1 | Range | 0 mm | 1E+303 mm | 800 µm | 0 % |
| Fiber Coupling | Fiber Coupling | ☑ | 1 | Target Value | 100 % | | 88.559 % | 100 % |

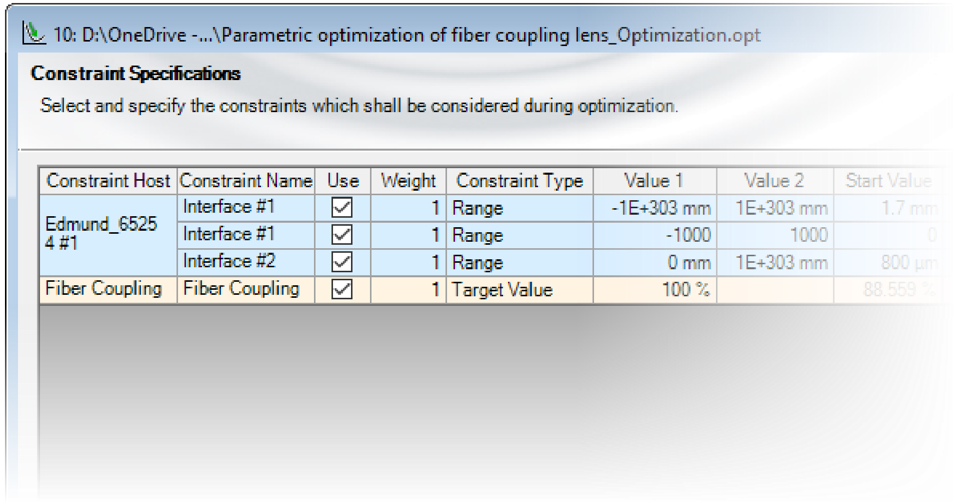




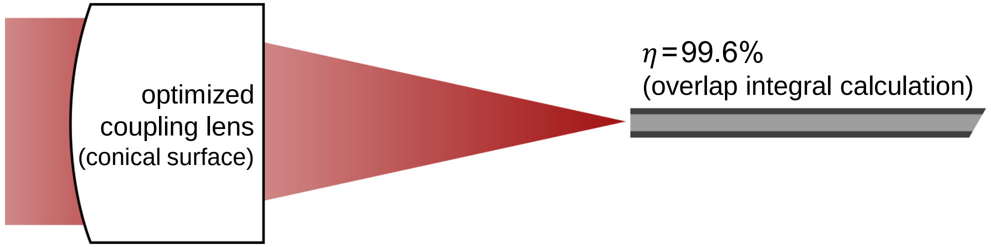

result visualization in various formats

# Workflow in VirtualLab Fusion

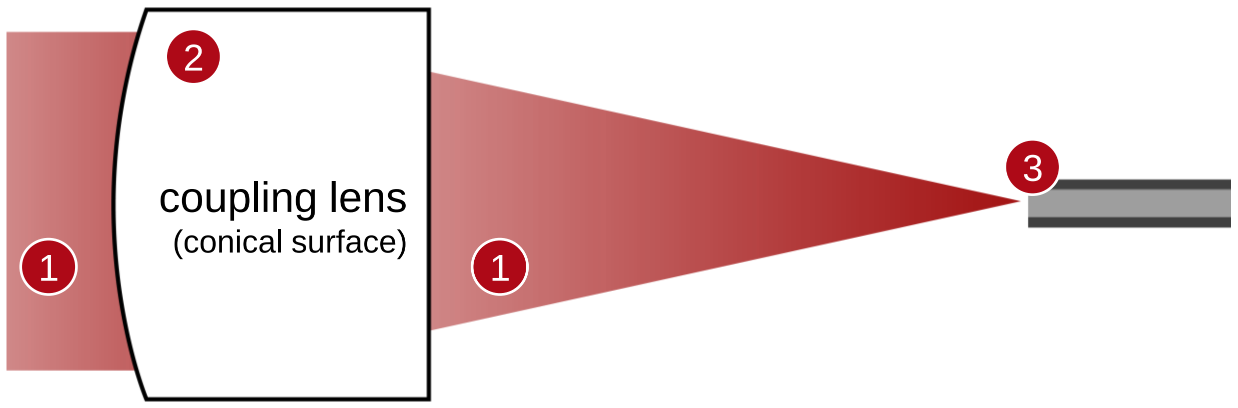
- Set up input Gaussian field
  - Basic Source Models [Tutorial Video]
- Import initial coupling lens from Zemax file
  - Import Optical Systems from Zemax [Use Case]
- Evaluate fiber coupling efficiency with initial lens
  - Optimal Working Distance for Coupling Light into Single-Mode Fibers [Use Case]
- Use Parametric Optimization to find proper values for selected lens parameters

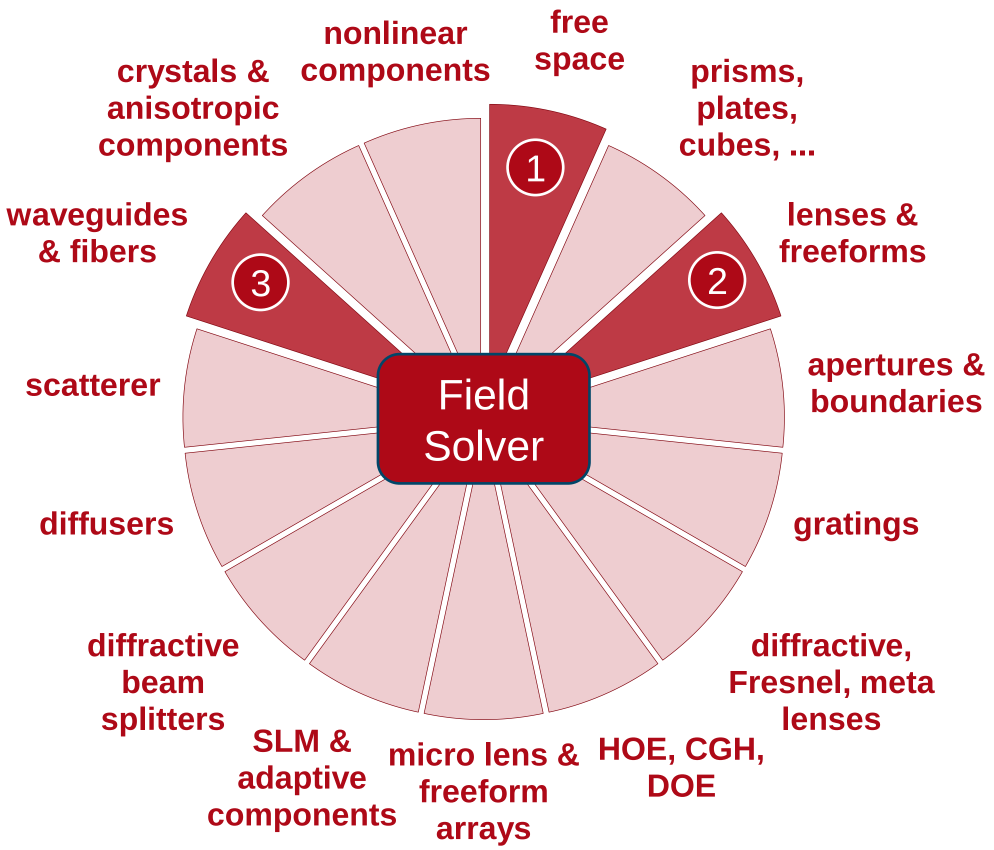



| Constraint Host | Constraint Name | Use | Weight | Constraint Type | Value 1 | Value 2 | Start Value |
|---|---|---|---|---|---|---|---|
| Edmund_65254 #1 | Interface #1 | ☑ | 1 | Range | -1E+303 mm | 1E+303 mm | 1.7 mm |
| | Interface #1 | ☑ | 1 | Range | -1000 | 1000 | 0 |
| | Interface #2 | ☑ | 1 | Range | 0 mm | 1E+303 mm | 800 µm |
| Fiber Coupling | Fiber Coupling | ☑ | 1 | Target Value | 100 % | | 88.559 % |



# VirtualLab Fusion Technologies



# Document Information

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|---|---|
| title | Parametric Optimization of Fiber Coupling Lenses |
| document code | FCP.0003 |
| version | 3.0 |
| edition | VirtualLab Fusion Basic |
| software version | 2020.2 (Build 1.116) |
| category | Application Use Case |
| further reading | - Optimal Working Distance for Coupling Light into Single-Mode Fibers<br>- Comparison of Different Lenses for Fiber Coupling |