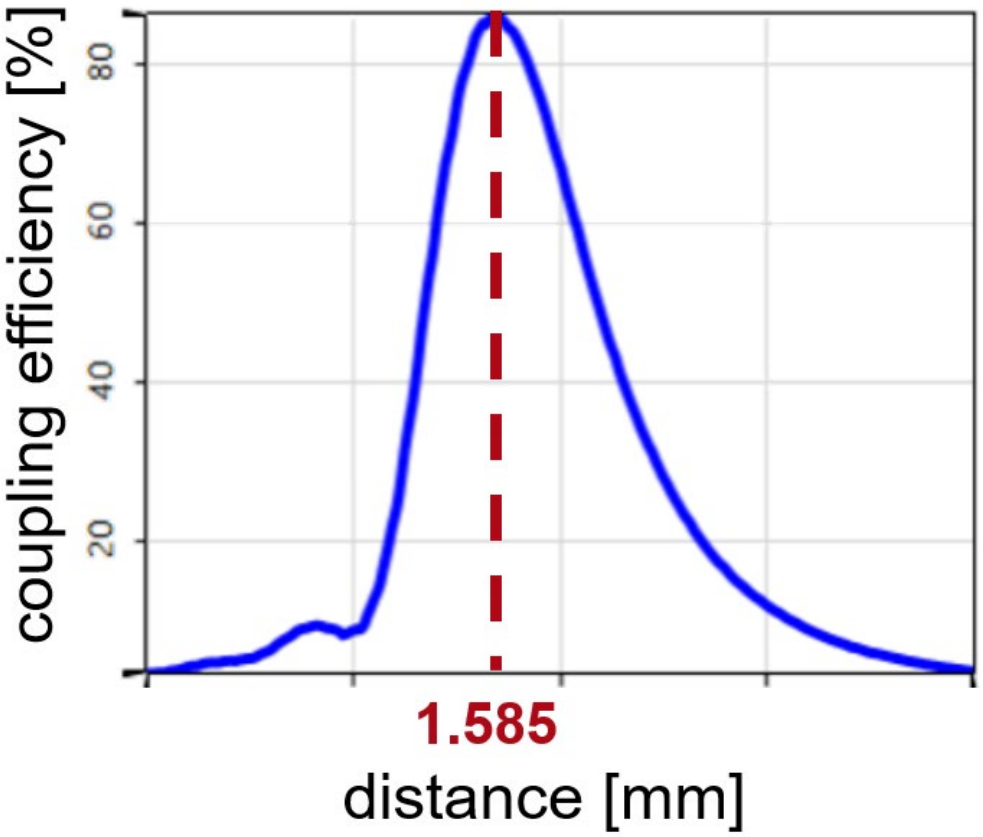
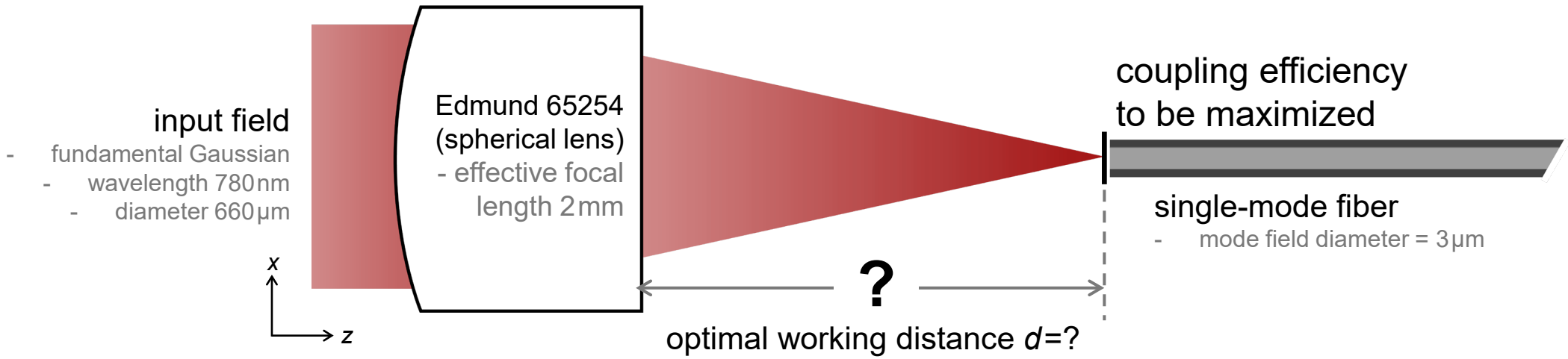
Optimal Working Distance for Coupling Light into Single-Mode Fibers

Abstract



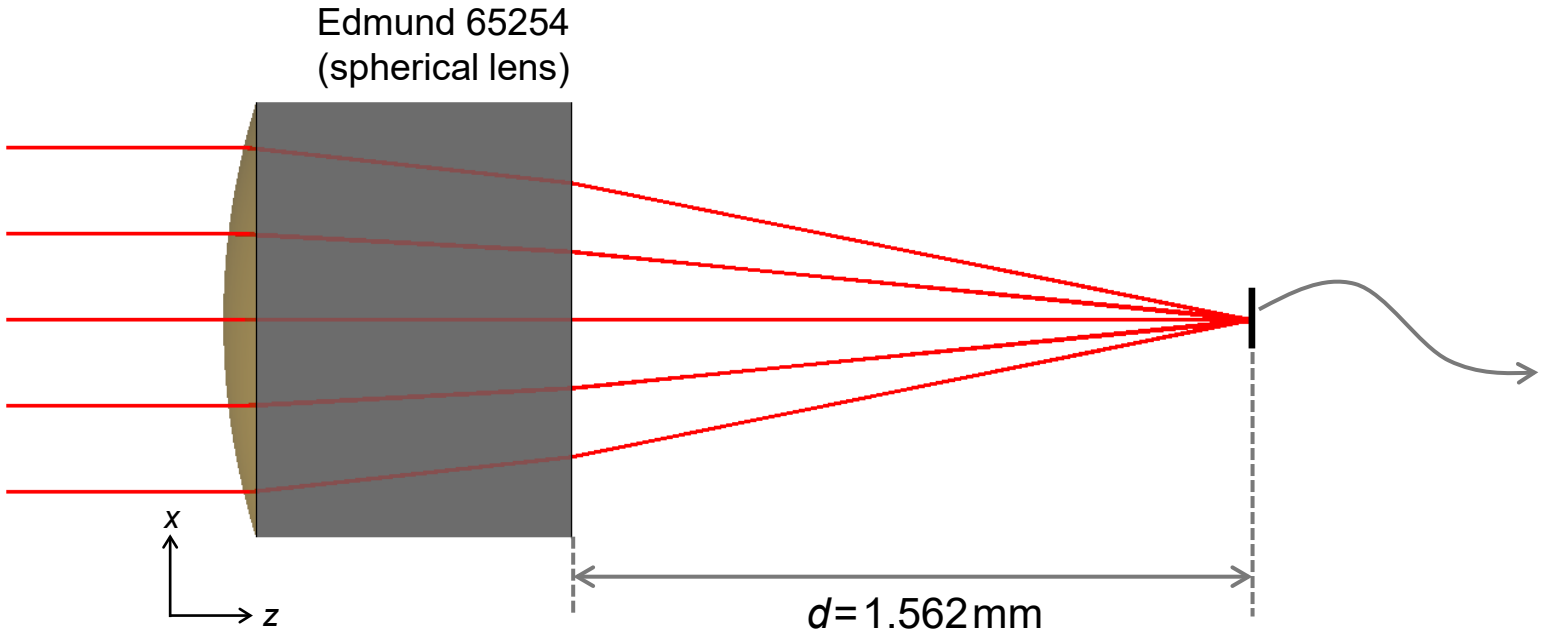
Single-mode optical fibers are widely used in different applications, and they play a crucial role in long-distance optical communication. Launching light into such kind of single-mode fibers can be a challenging task in practice. In this example, we select one commercially available lens, and show how to find the optimal working distance to achieve maximum coupling efficiency. Particularly, we demonstrate that the optimal working distance found by field tracing differs from the focal distance predicted by ray optics.

Modeling Task

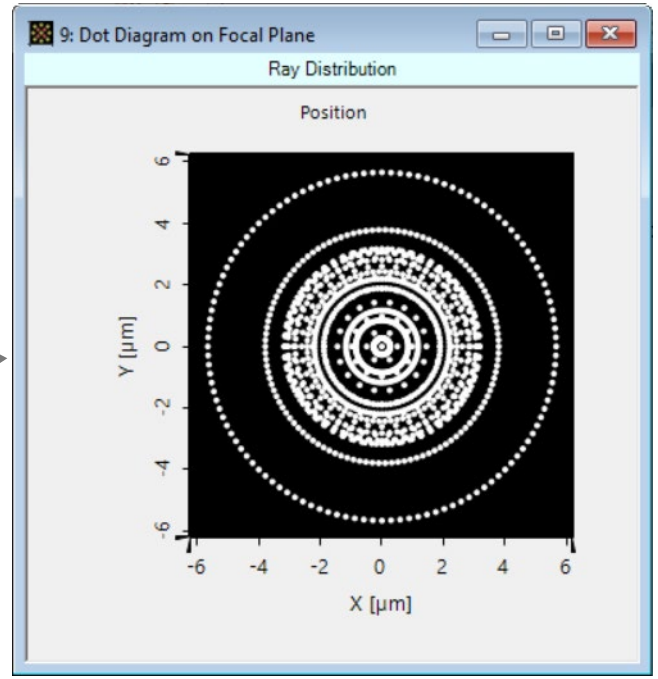


- Is it the best solution to place the fiber end at the ray-optics focal plane behind the lens?
- How to find the optimal working distance to achieve maximum coupling efficiency?

Focal Distance Found by Using Ray Tracing



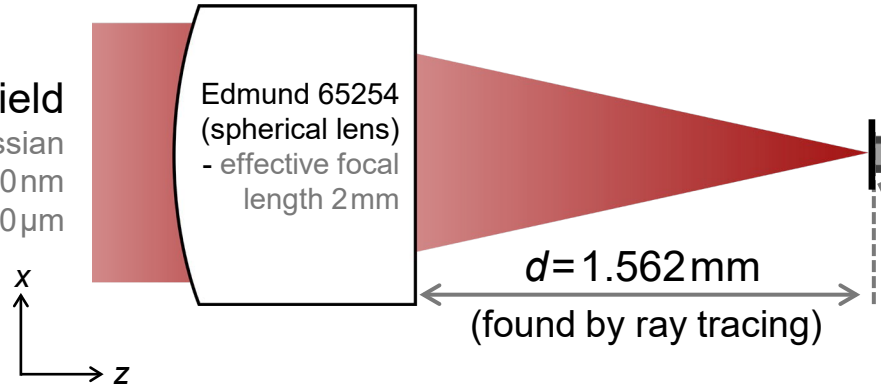
Focal distance for the spherical lens is found first by using ray tracing in VirtualLab Fusion.



The beam diameter (RMS) evaluated with ray tracing is 5.81 µm.

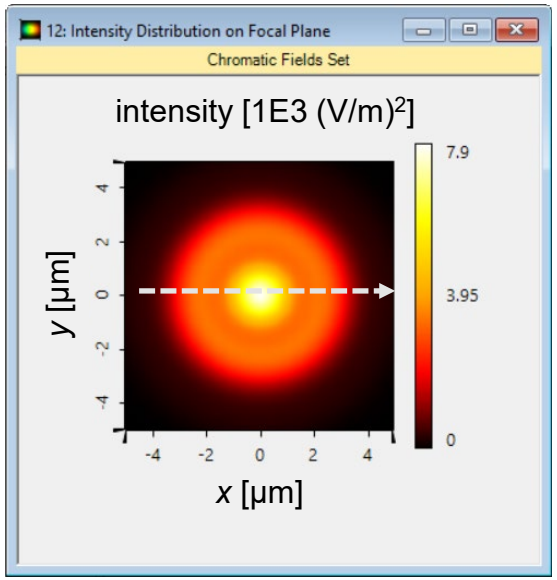
Field Tracing Evaluation at Ray-Optics Focal Distance

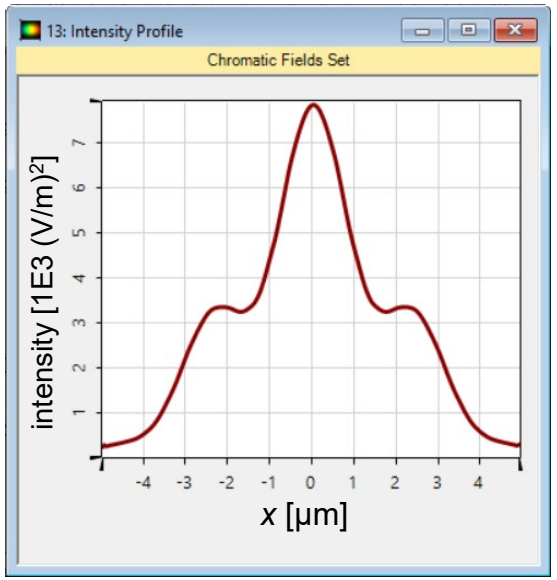
input field
- fundamental Gaussian
- wavelength 780 nm
- diameter 660 µm



coupling efficiency $\eta = 32.2\%$
(overlap integral calculation)

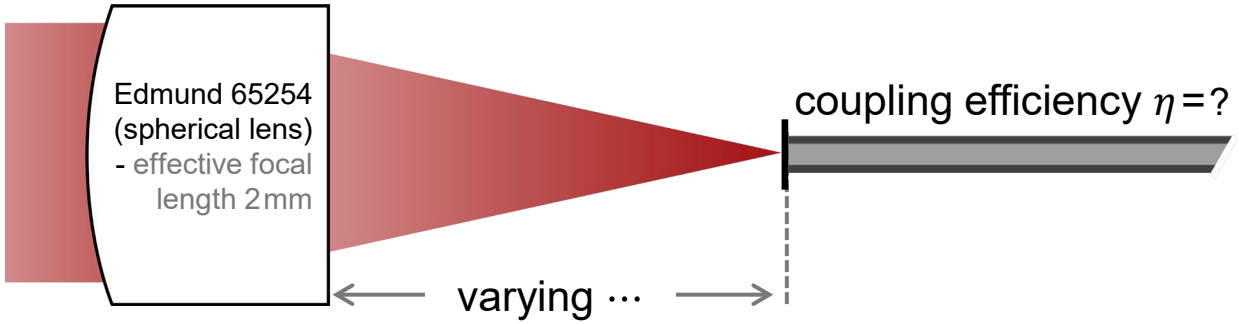
Field tracing in VirtualLab Fusion provides access to the full field information at any desired plane in the system.

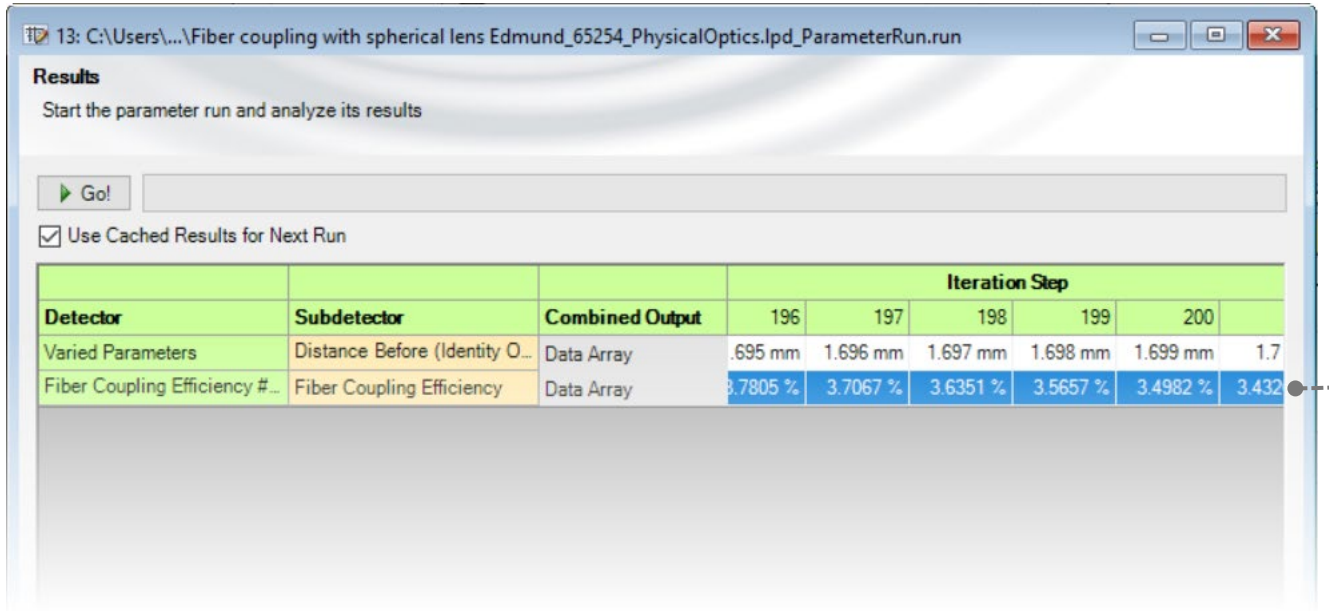


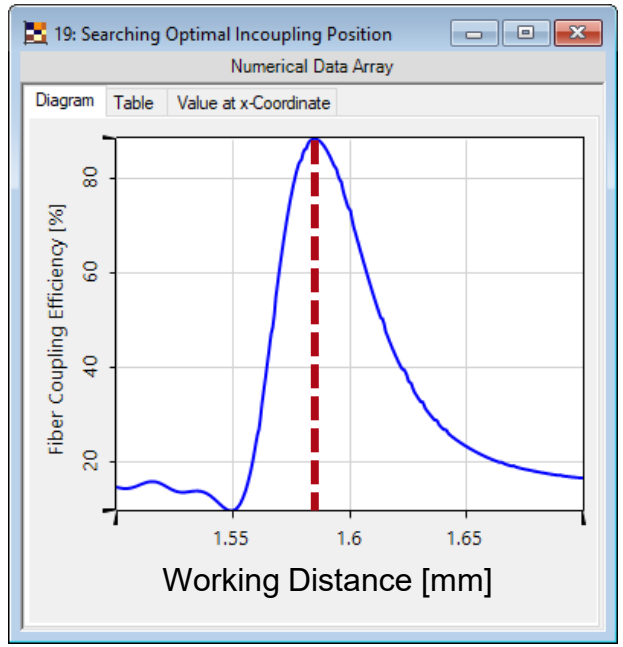


Find Optimal Working Distance by Using Field Tracing

input field
- fundamental Gaussian
- wavelength 780 nm
- diameter 660 µm



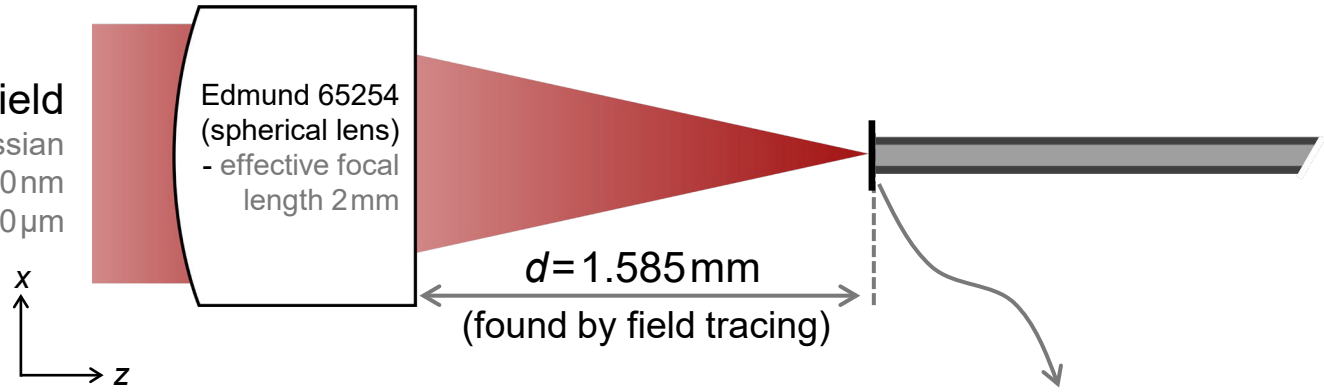




The optimal working distance found by field tracing is 1.585 mm.

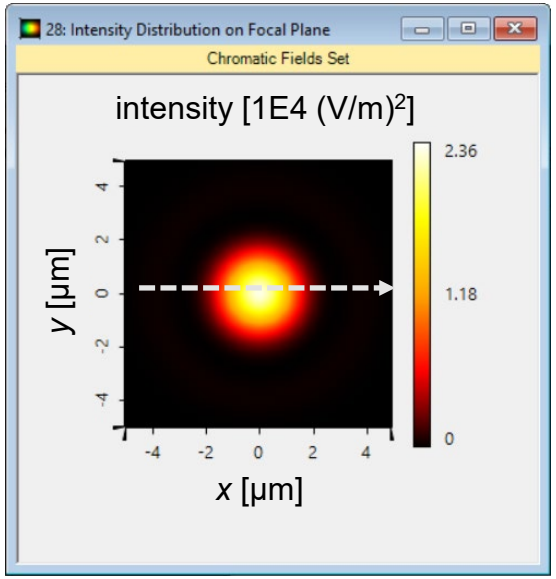
Evaluation at Optimal Working Distance

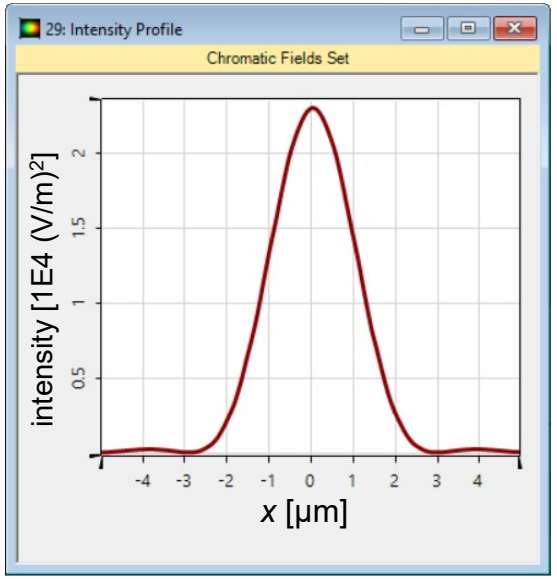
input field
- fundamental Gaussian
- wavelength 780 nm
- diameter 660 µm



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

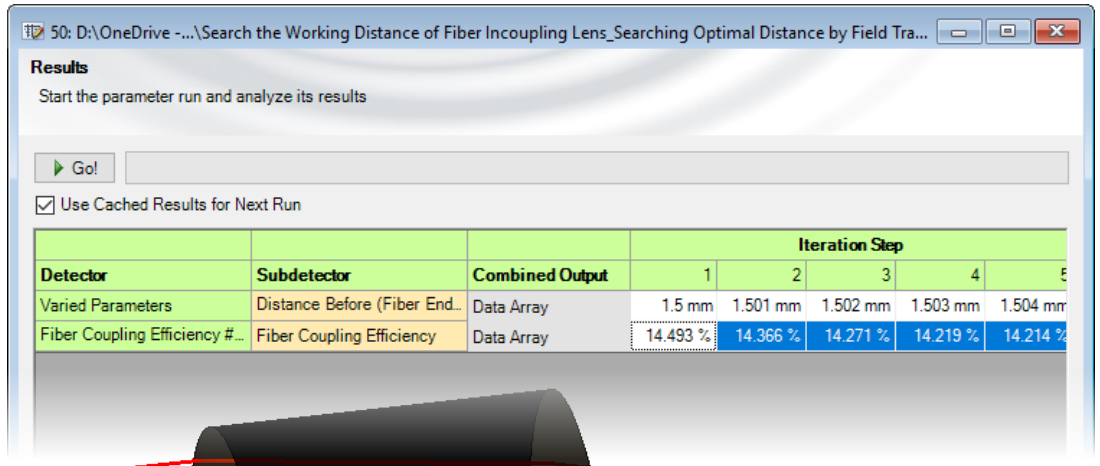
The focal spot with highest coupling efficiency has similar shape with the fiber mode.

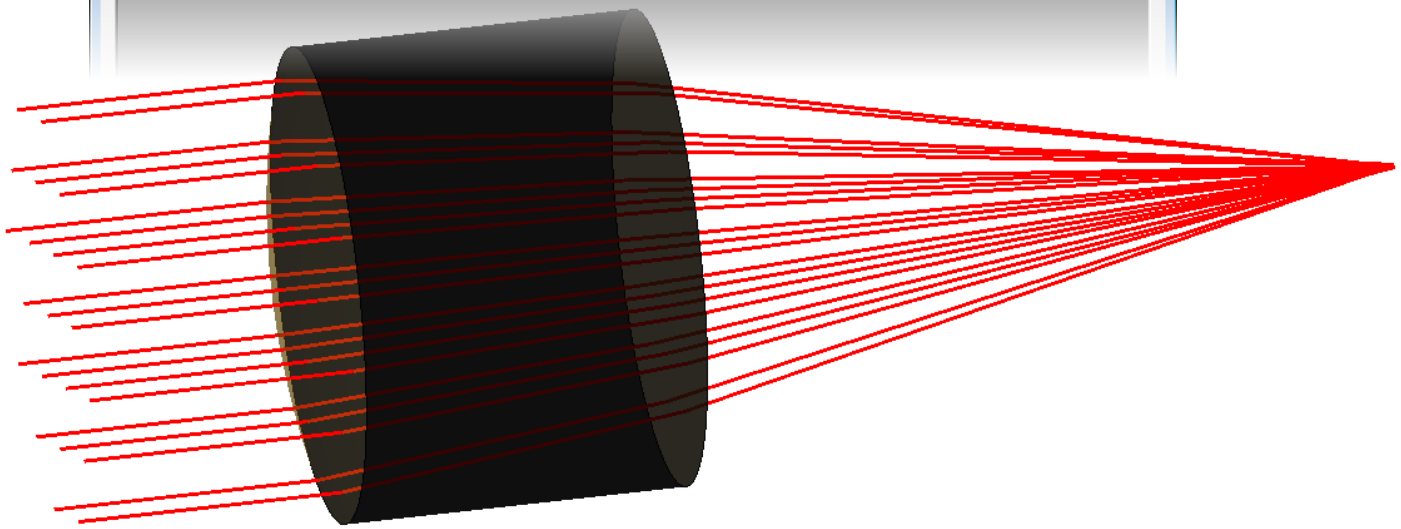




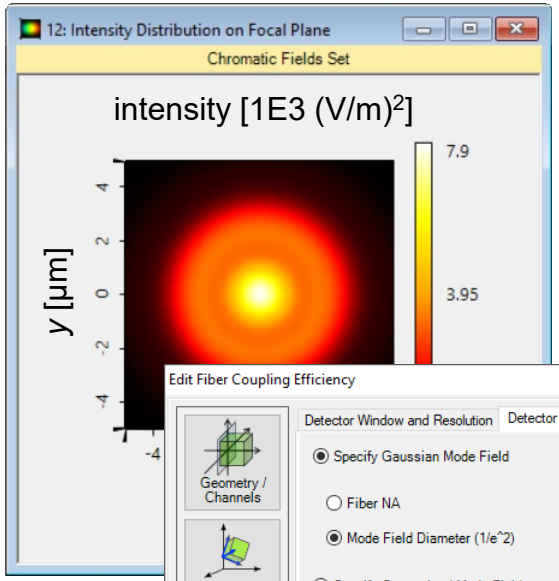
Peek into VirtualLab Fusion

Parameter Run for selected variables in system

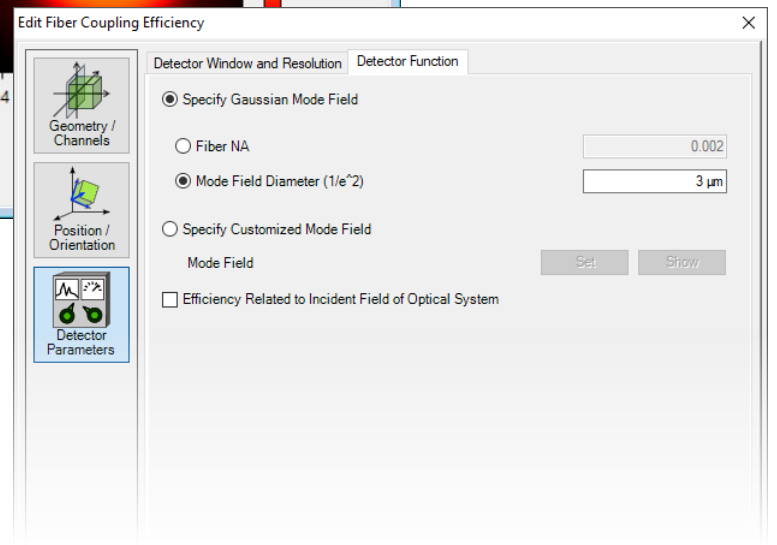




ray tracing system analysis

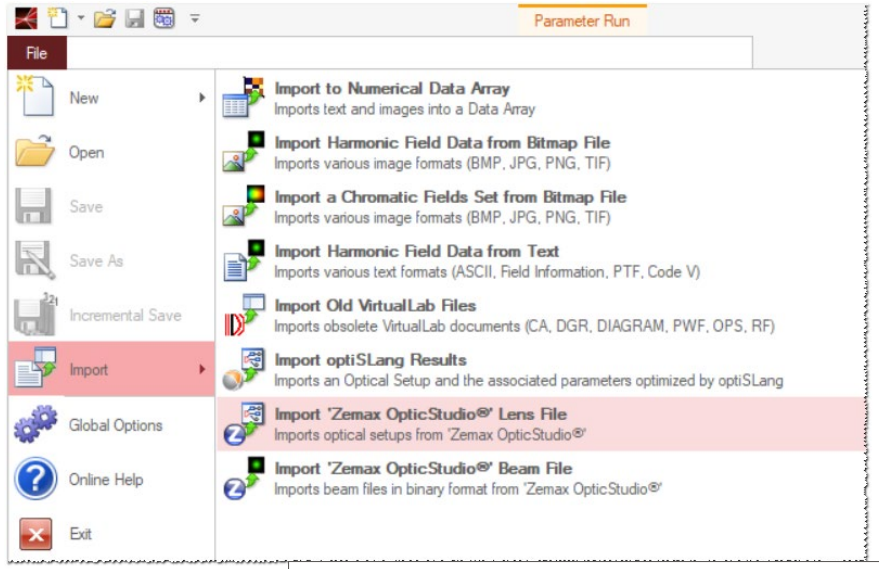


visualization and analysis

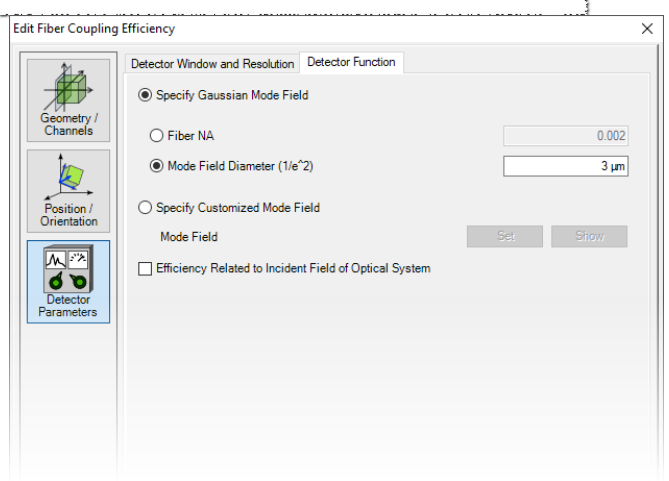


Workflow in VirtualLab Fusion

- Set up input Gaussian field
  - Basic Source Models [Tutorial Video]
- Import coupling lens from Zemax file
  - Import Optical Systems from Zemax [Use Case]
- Find focal distance using ray optics

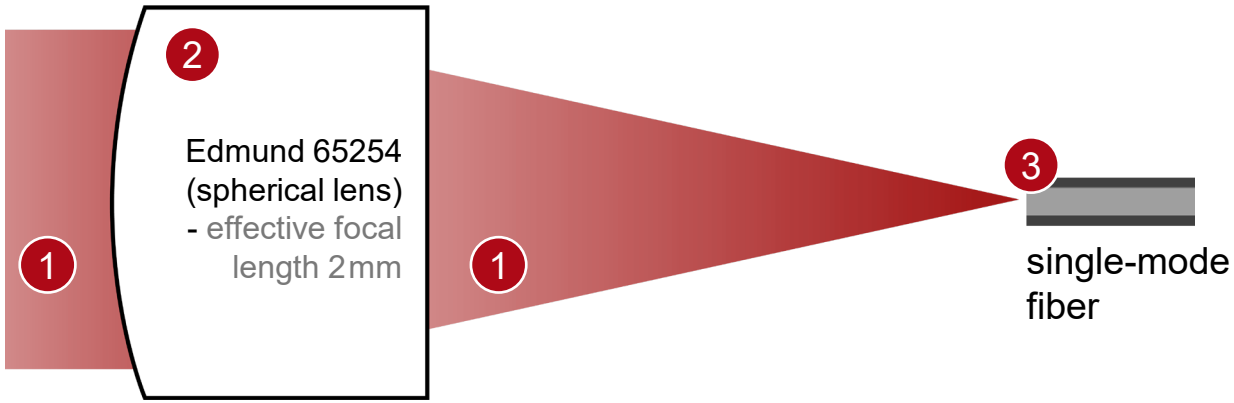


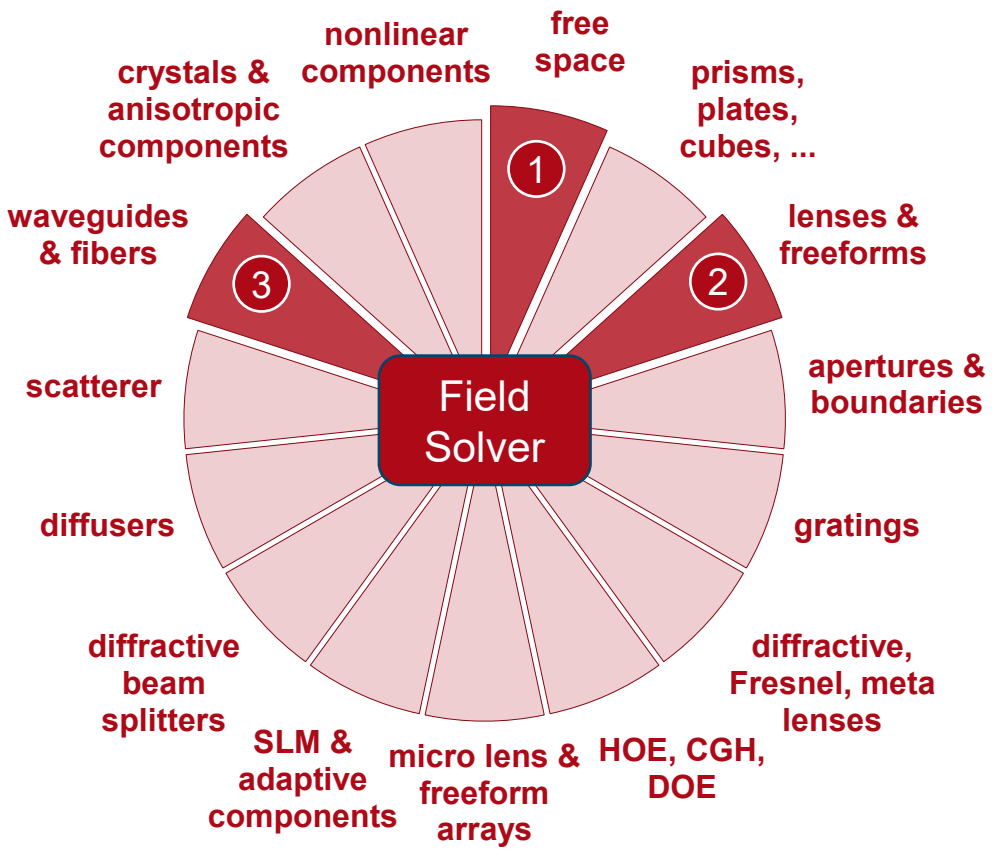
- Evaluate fiber coupling efficiency for initial working distance with field tracing



- Use Parameter Run to find optimal working distance
  - Usage of the Parameter Run Document [Use Case]

VirtualLab Fusion Technologies





Document Information

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further reading	- Comparison of Different Lenses for Fiber Coupling - Parametric Optimization of Fiber Coupling Lens