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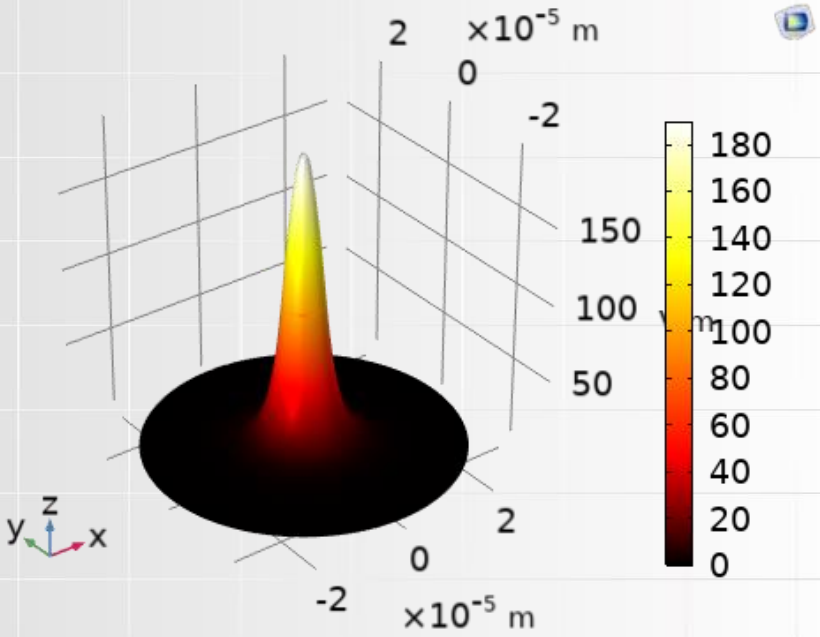
LaslonDef - Wrocław 2024

Photonic simulations using COMSOL

Hands on workshop

Part 1. Mode analysis optical fibers and waveguides



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unite! University Network for Innovation, Technology and Engineering

HR EXCELLENCE IN RESEARCH

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Optical fibers - introduction

Optical fibers

- Optical fibers confine the light on the small area (order of tens of μm^2)
- Optical fibers can guide the light on the large distances (order of thousands of km)
- An optical fiber can support set of guided modes (one, few, many)
- Different physical mechanisms can used to confine the light:
  - total internal reflection
  - modified total internal reflection
  - photonic bandgap

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Optical fibers - numerical model

Input

- Wavelength

- Geometry of optical fiber
- Refractive index profile (material properties)

Output

- Effective refractive index
- Mode profile

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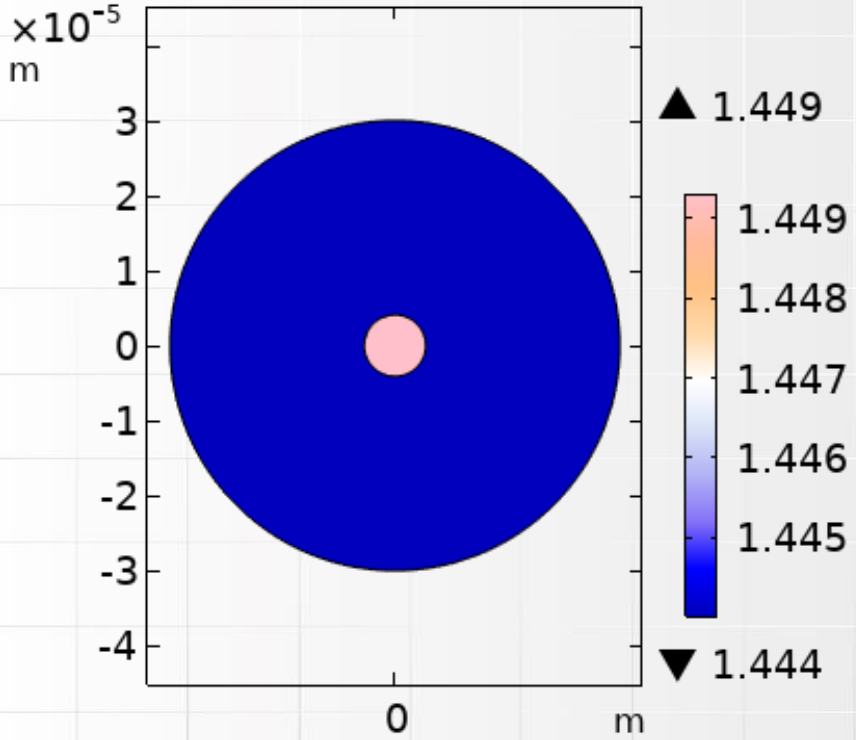
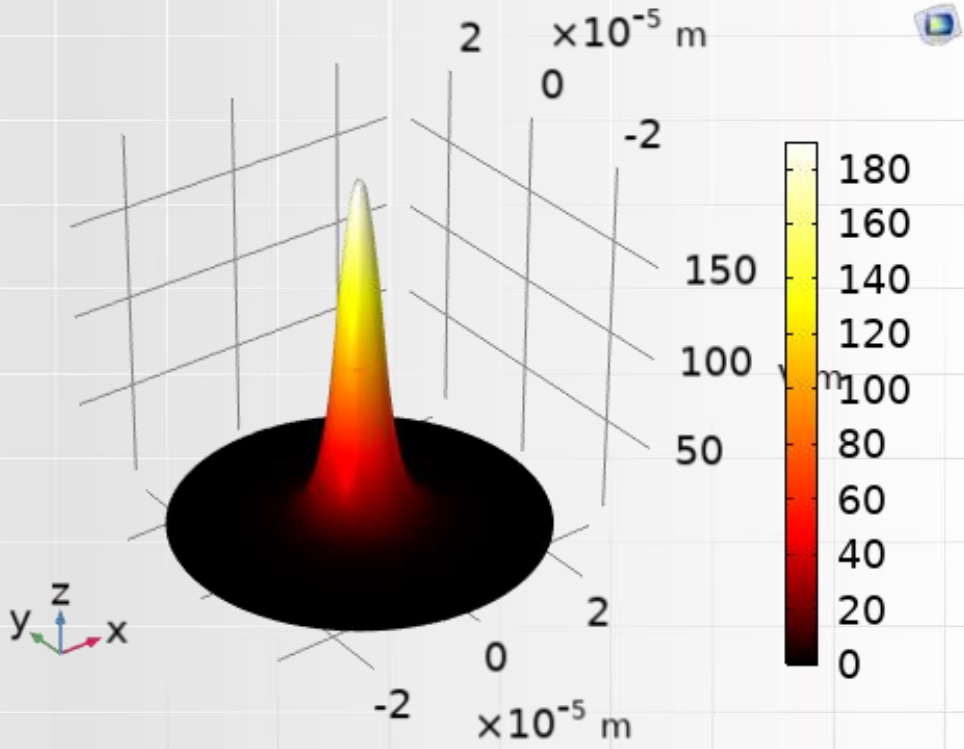
Optical fibers – numerical model

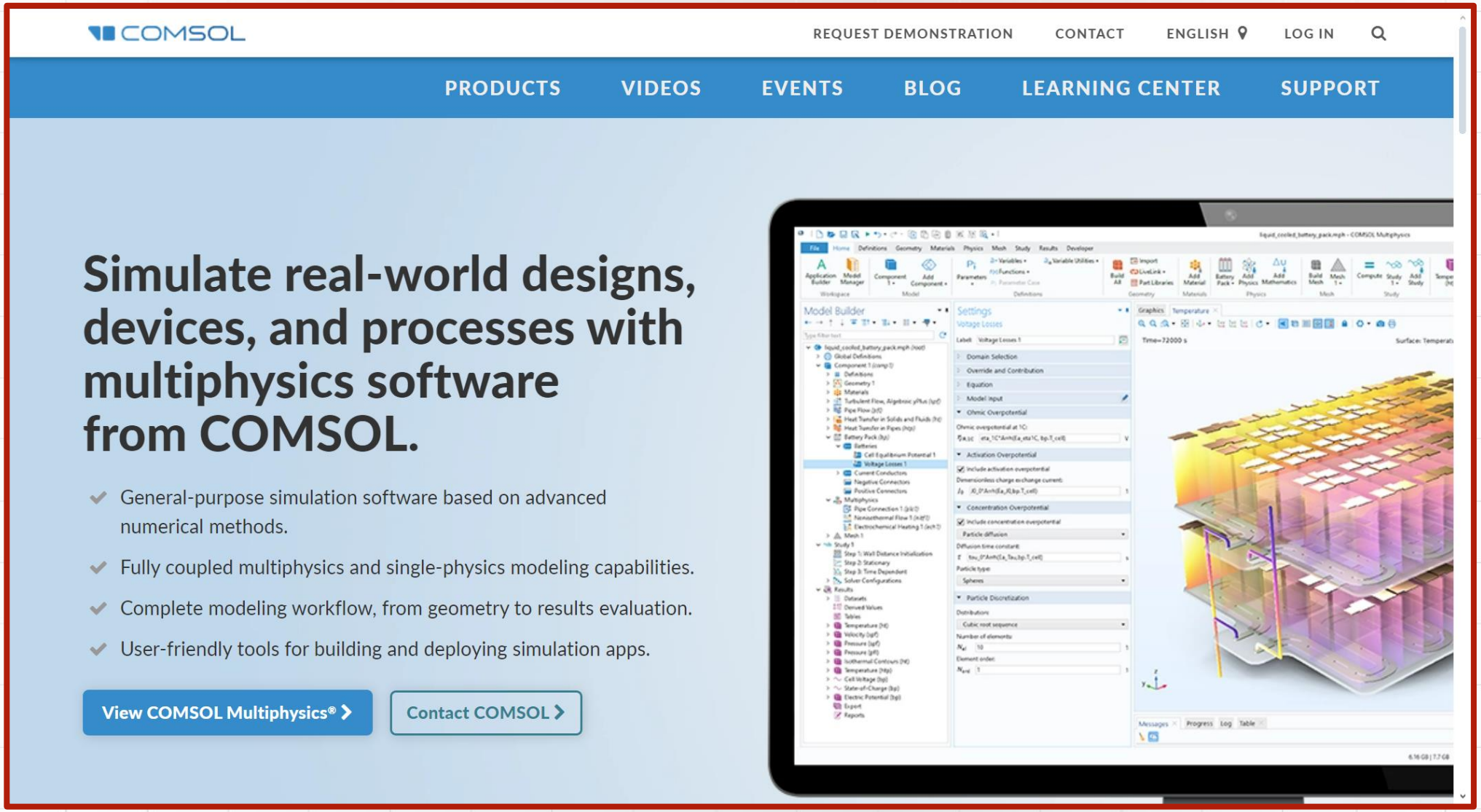
Refractive index profile



Electric field distribution of fundamental guided mode



Comsol Multiphysics



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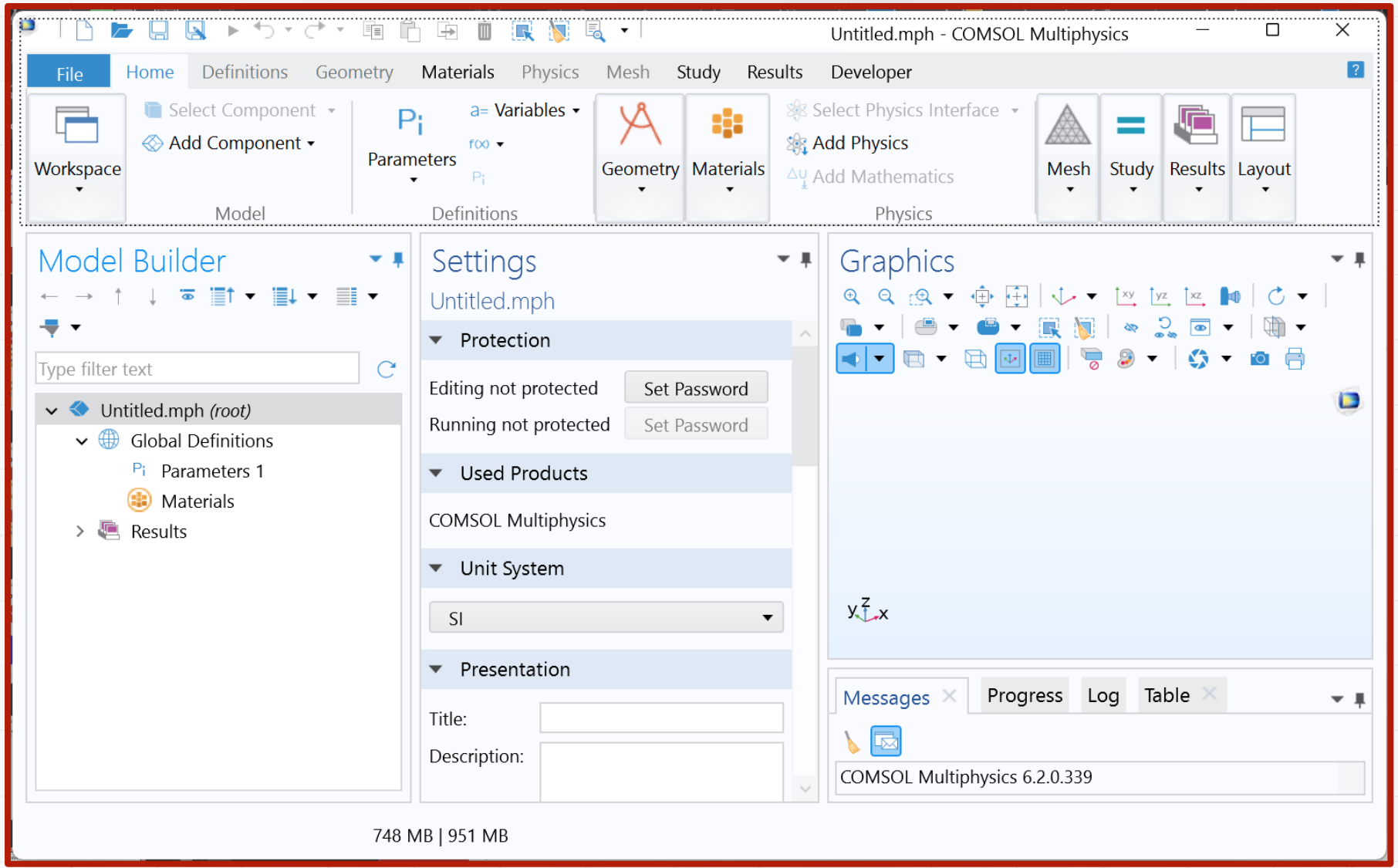
Comsol Multiphysics



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Comsol Multiphysics - Model Builder

Numerical model recipe

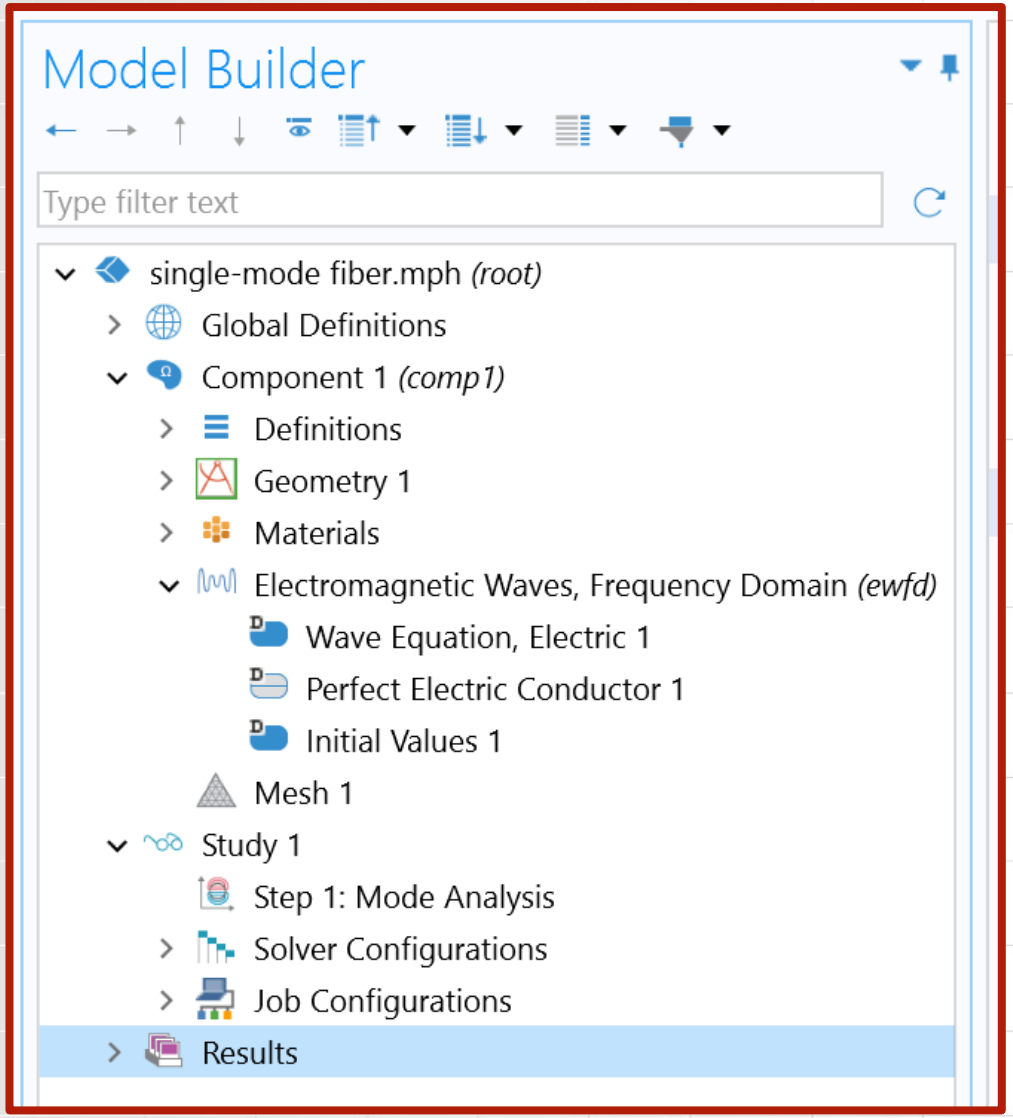
- Parameters
- Geometry
- Material properties
- Physics (problem definiton)
- Mesh

Study

- Selected type of study steps

Results

- Postprocessing of obtained data



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Single-mode fiber

Light

- Wavelength — $\lambda = 1.55$ µm

Fiber parameters

- Refractive index profile — step-index
- Core radius — $r_{co} = 4.1$ µm
- Core refractive index — $n_{co} = 1.4977$
- Cladding refractive index — $n_{cl} = 1.4440$
- Refractive indicies given at 1.55 µm — n@1.55 µm

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Outline

Setting up the mode analysis simulation
(geometry, material properties, boundary conditions)

Performing convergence tests (parametric sweep)

Using symmetries to reduce the problem

Scripting simulations using MATLAB LiveLink