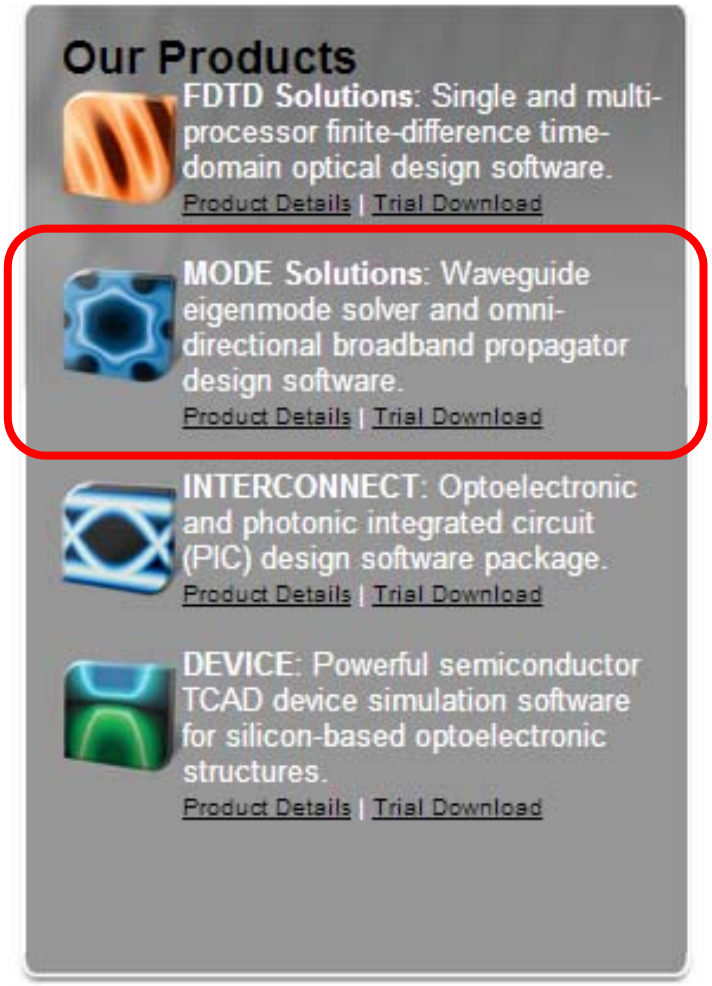
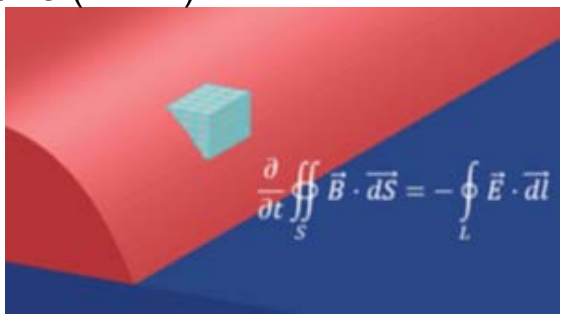
Waveguide and Directional Coupler
MODE Simulation

High-Speed Circuits & Systems Lab.
Dept. of Electrical and Electronic Engineering
Yonsei University

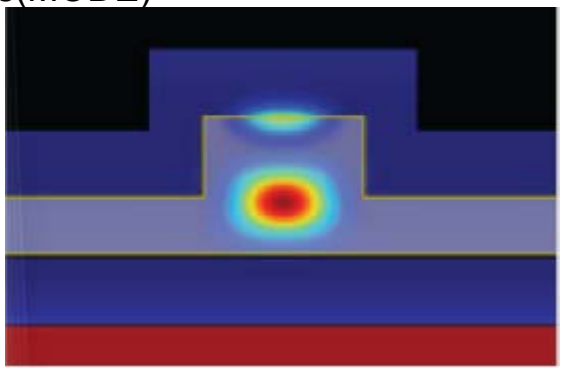
Lumerical Solutions



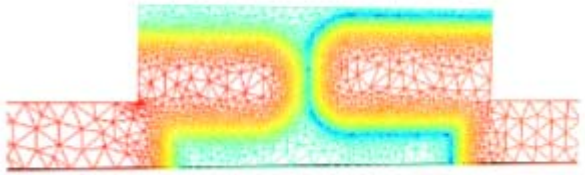
3D Maxwell solver(FDTD)



Modal analysis(MODE)

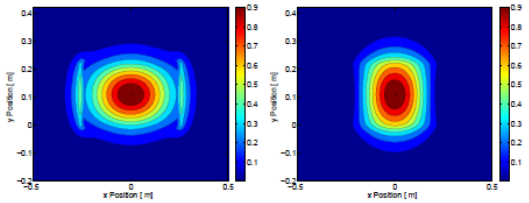


Charge transport & heat transfer(DEVICE)

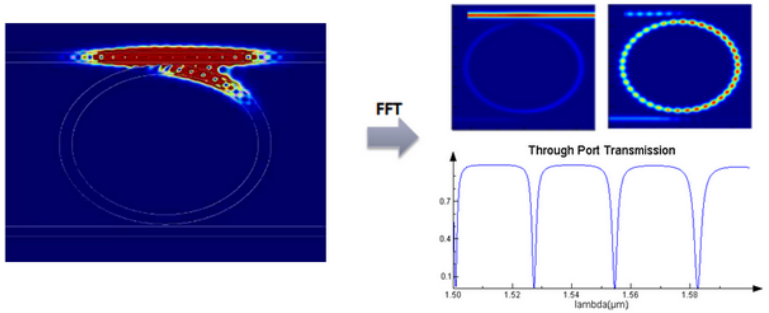


Lumerical MODE Solution

- **FDE(Finite Difference Eigenmode) solver**
  -Calculate physical properties of **waveguide modes**
  -Solve Maxwell's equations for cross-sectional mesh



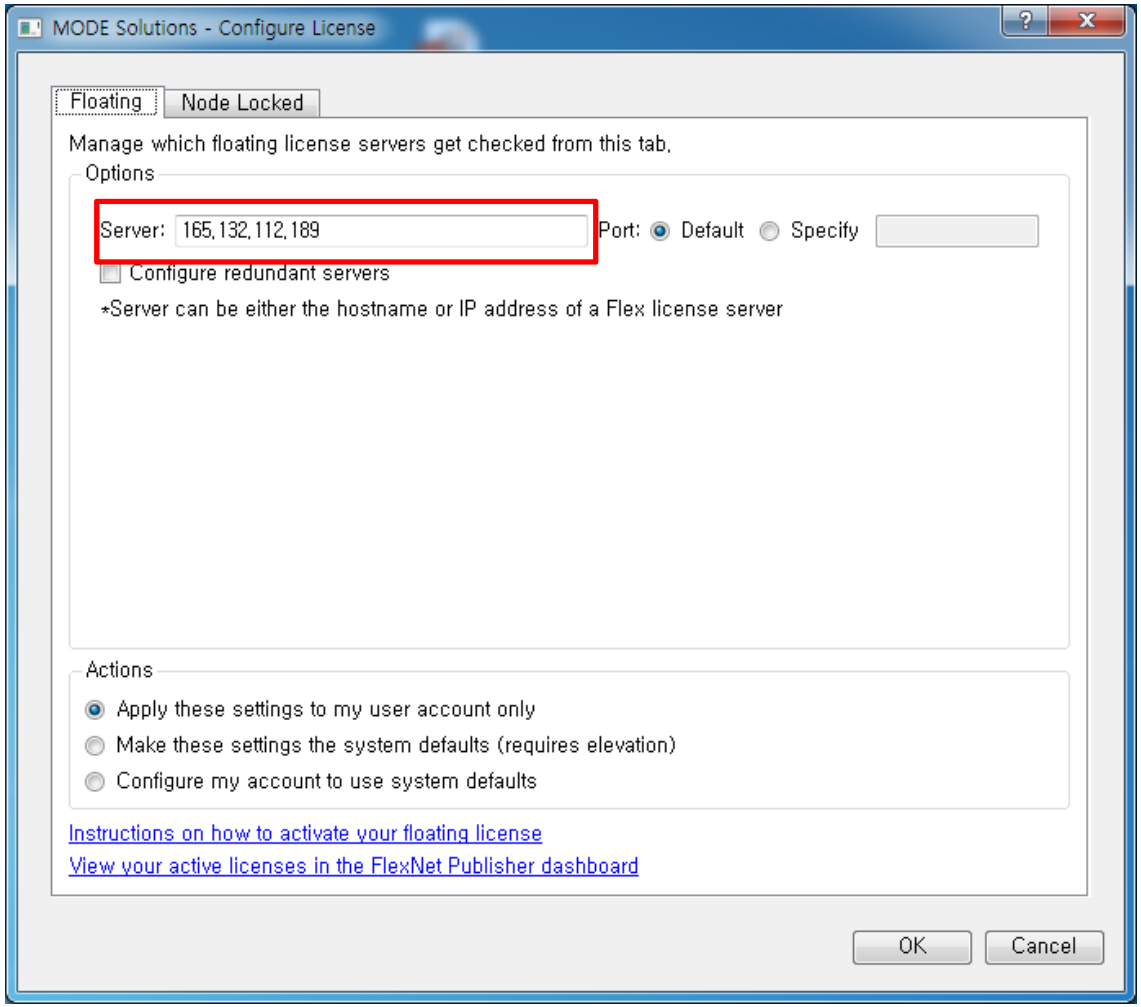
- **2.5D varFDTD(Finite Difference Time Domain)**
  -**Time domain simulation with approximation**
  -2D simulation speed with 3D accuracy



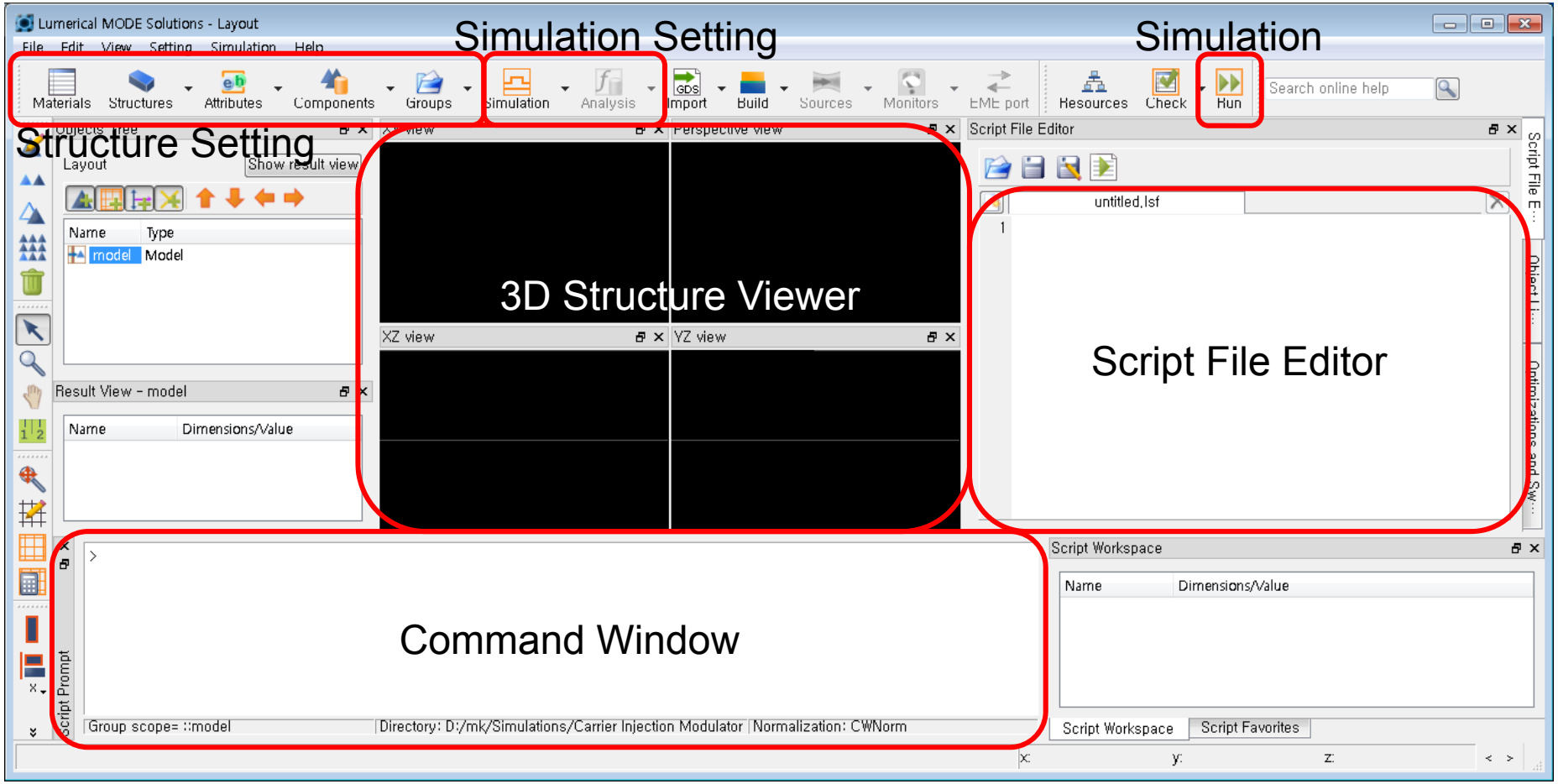
- **EME(Eigenmode Expansion) solver**
  -Frequency domain simulation

Most simulations will be held with these solvers

License Setting

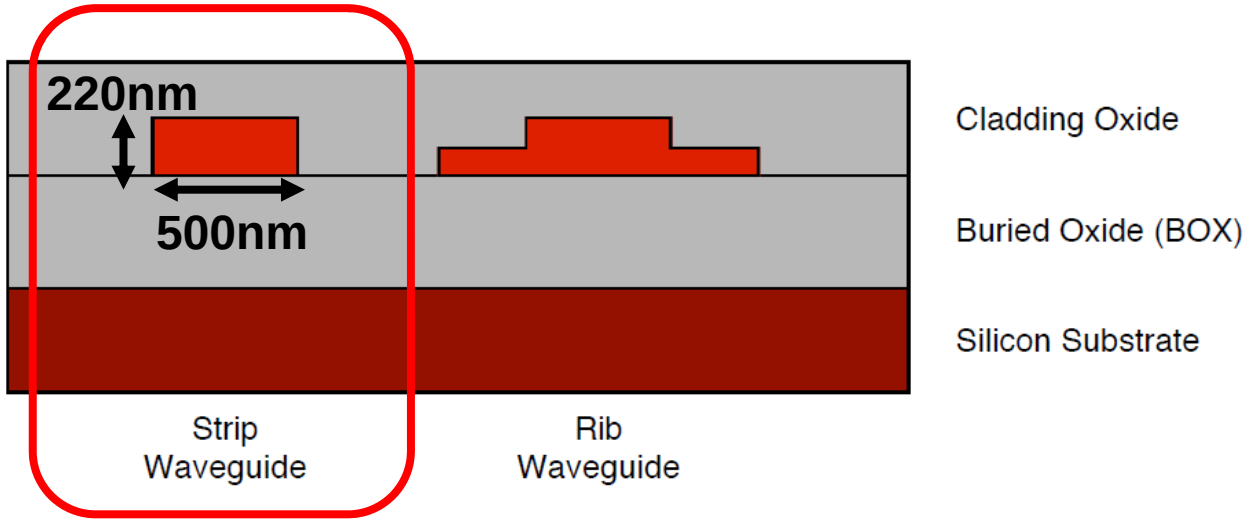


MODE Window

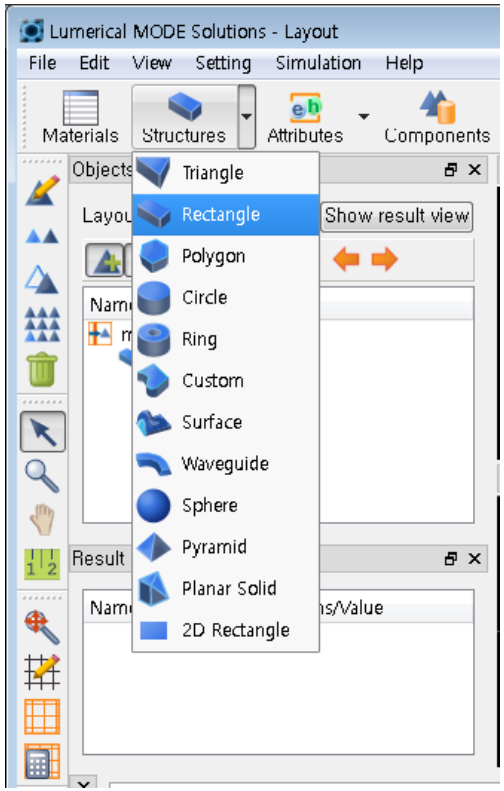

Lumerical MODE Solutions - Layout
File Edit View Setting Simulation Help
Simulation Setting
Simulation
Structure Setting
Materials
Structures
Attributes
Components
Groups
Simulation
Analysis
Import
Build
Sources
Monitors
EME port
Resources
Check
Run
Search online help
Layout
Show result view
Name
Type
model
Model
Result View - model
Name
Dimensions/Value
3D Structure Viewer
XZ view
YZ view
Script File Editor
untitled.lsf
Script File E...
Object Li...
Optimizations and Sw...
Command Window
Script Prompt
Group scope= ::model
Directory: D:/mk/Simulations/Carrier Injection Modulator
Normalization: CWNorm
Script Workspace
Name
Dimensions/Value
Script Workspace
Script Favorites
x:
y:
z:

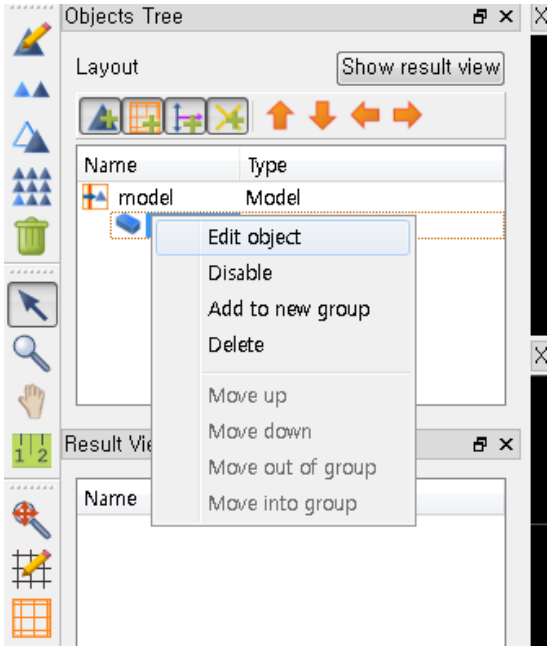
Waveguide Structure

- **Drawing structure**
  - Example) Make strip waveguide
  - Height: 220 nm
  - Width: 500 nm
  - Length: 30 μm
  - Core material: Si
  - Cladding material: SiO_2



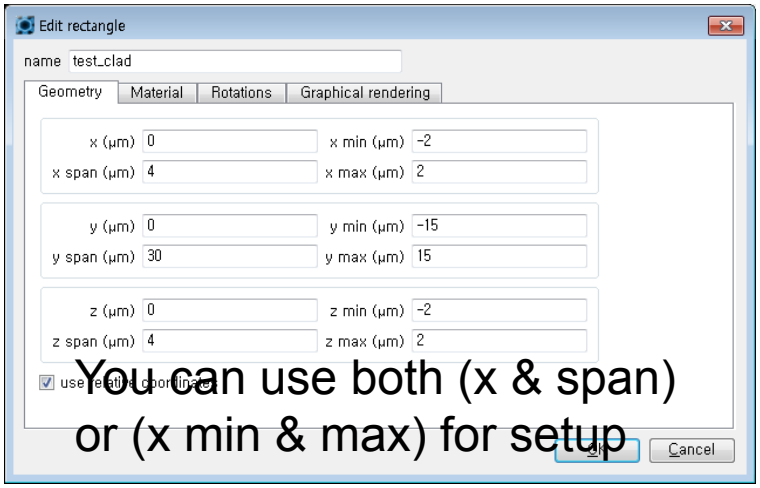
Structure Build(GUI)



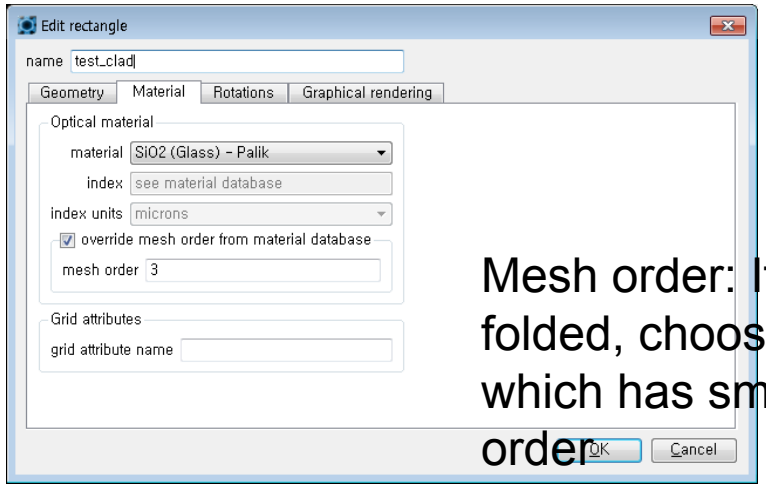


Structure Build(GUI)

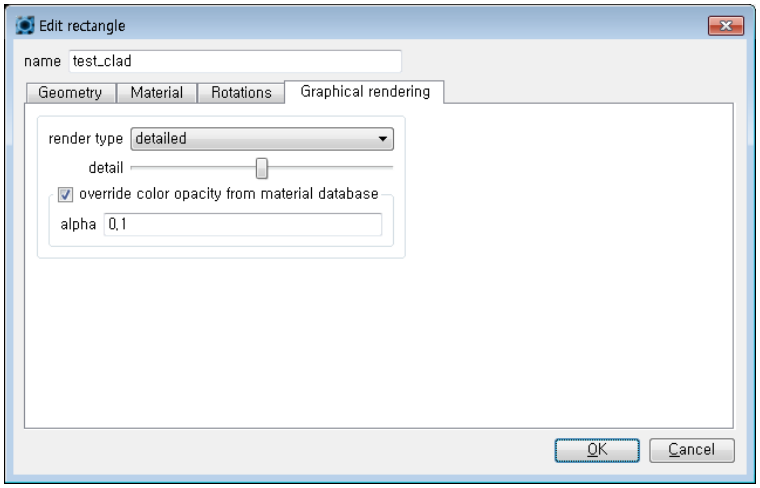
- **Cladding**



You can use both (x & span) or (x min & max) for setup

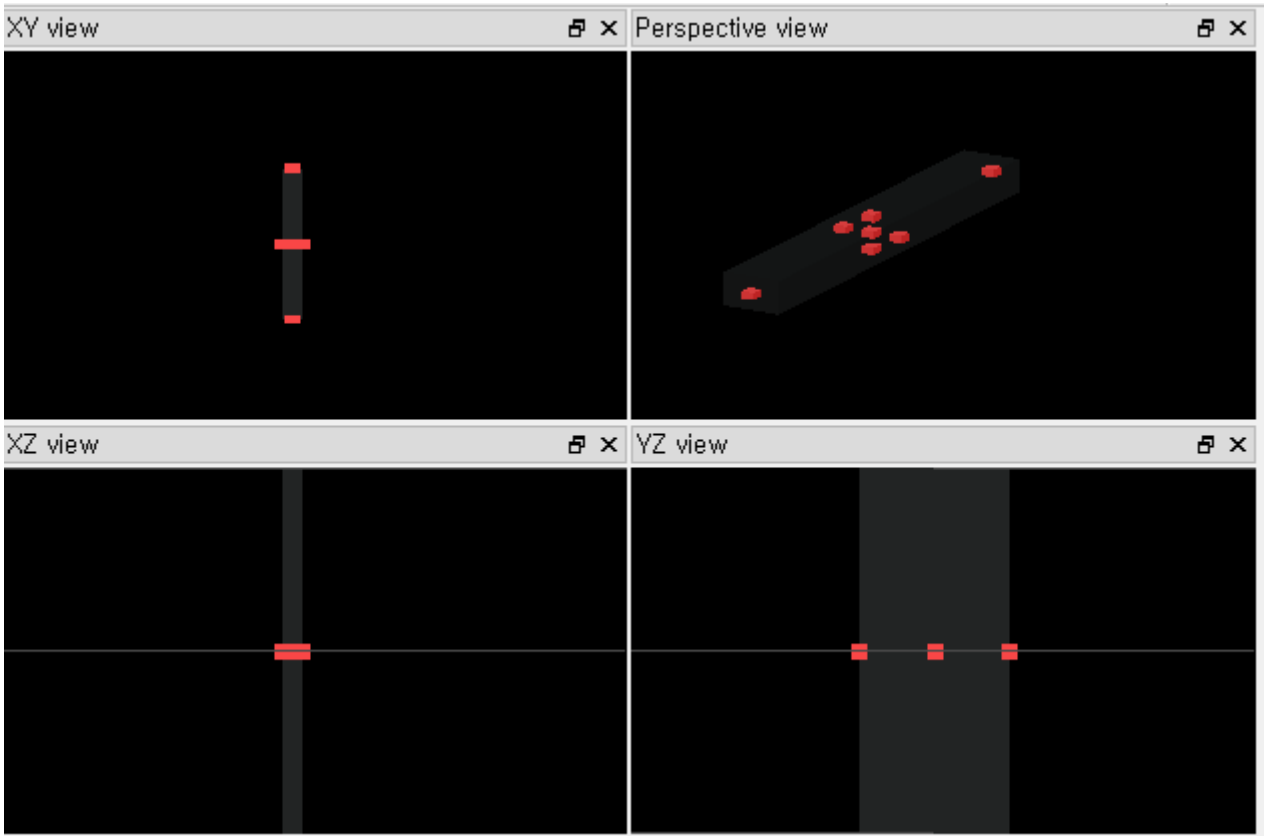


Mesh order: If materi
folded, choose mater
which has smaller me
order



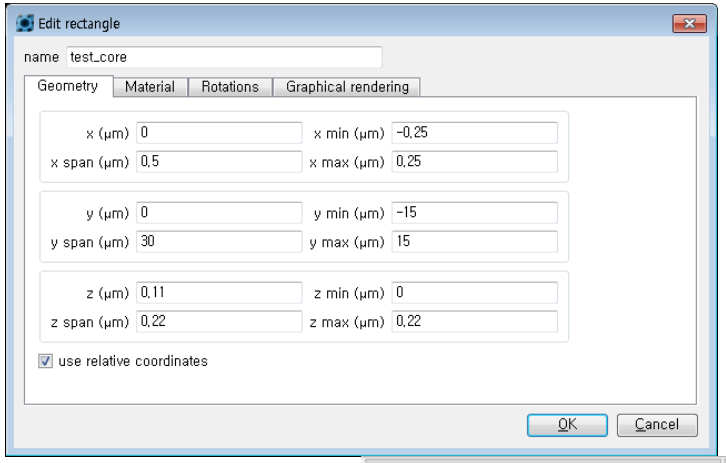
Structure Build(GUI)

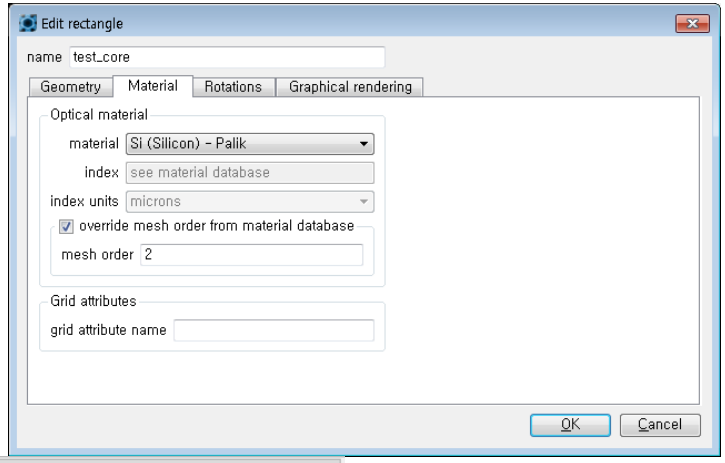
- **Cladding**

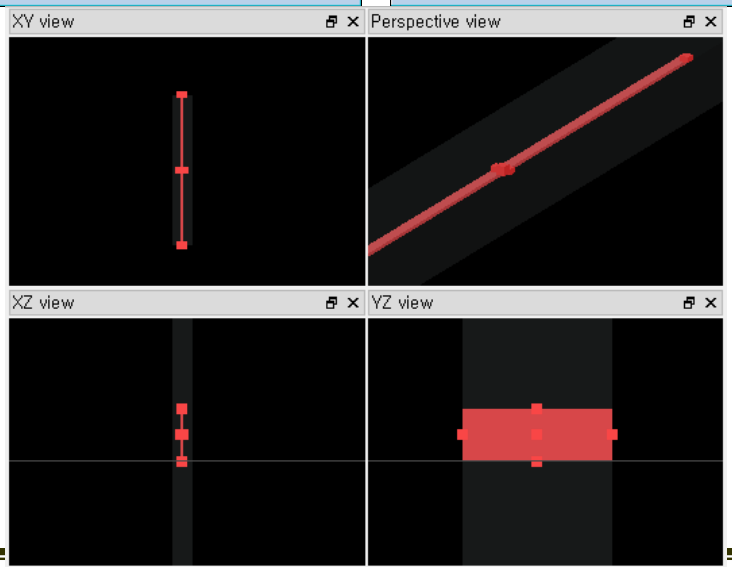


Structure Build(GUI)

- **Core**

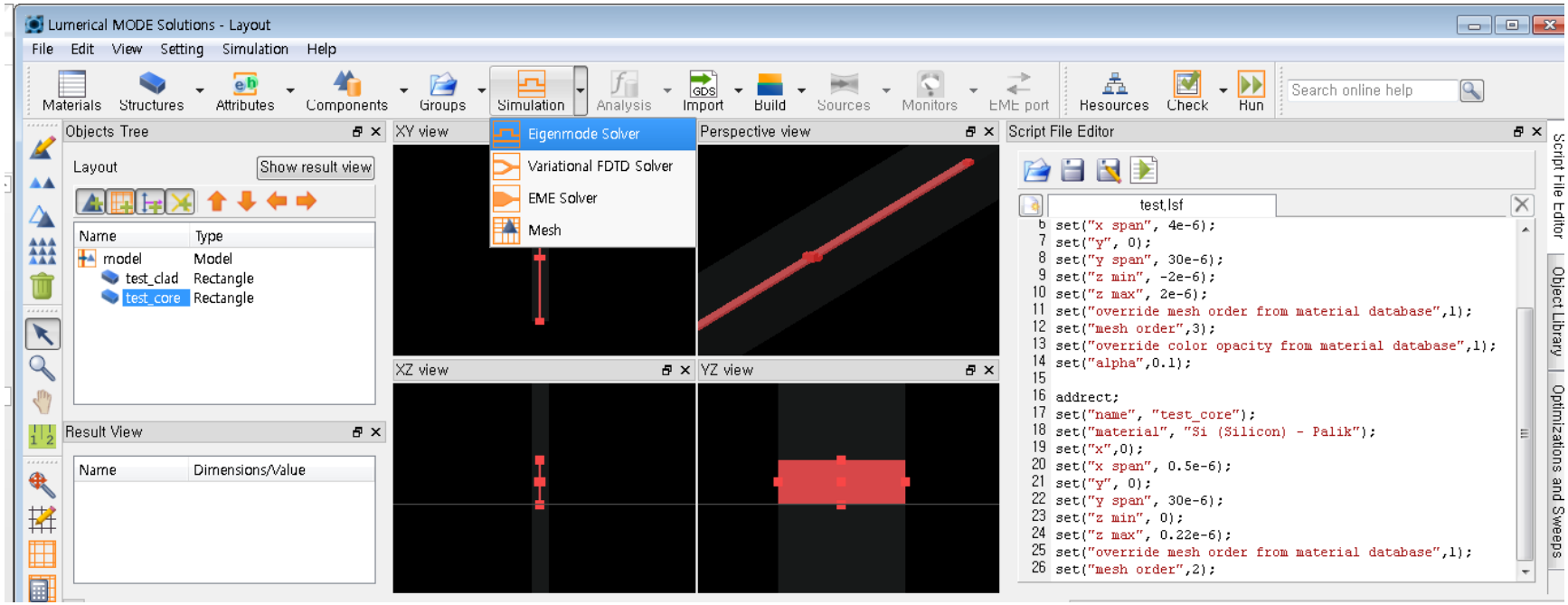




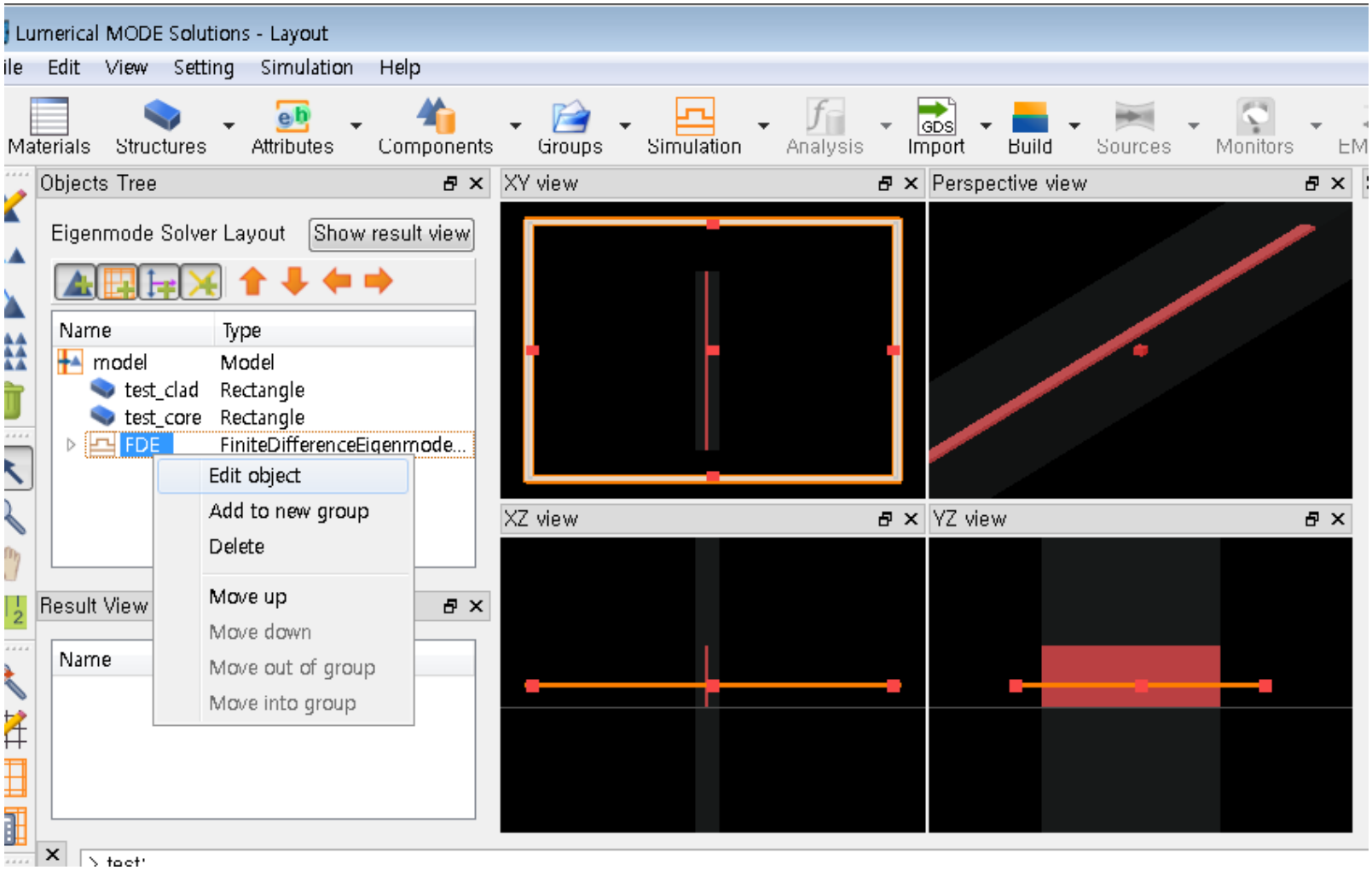


Simulation Setup(GUI)

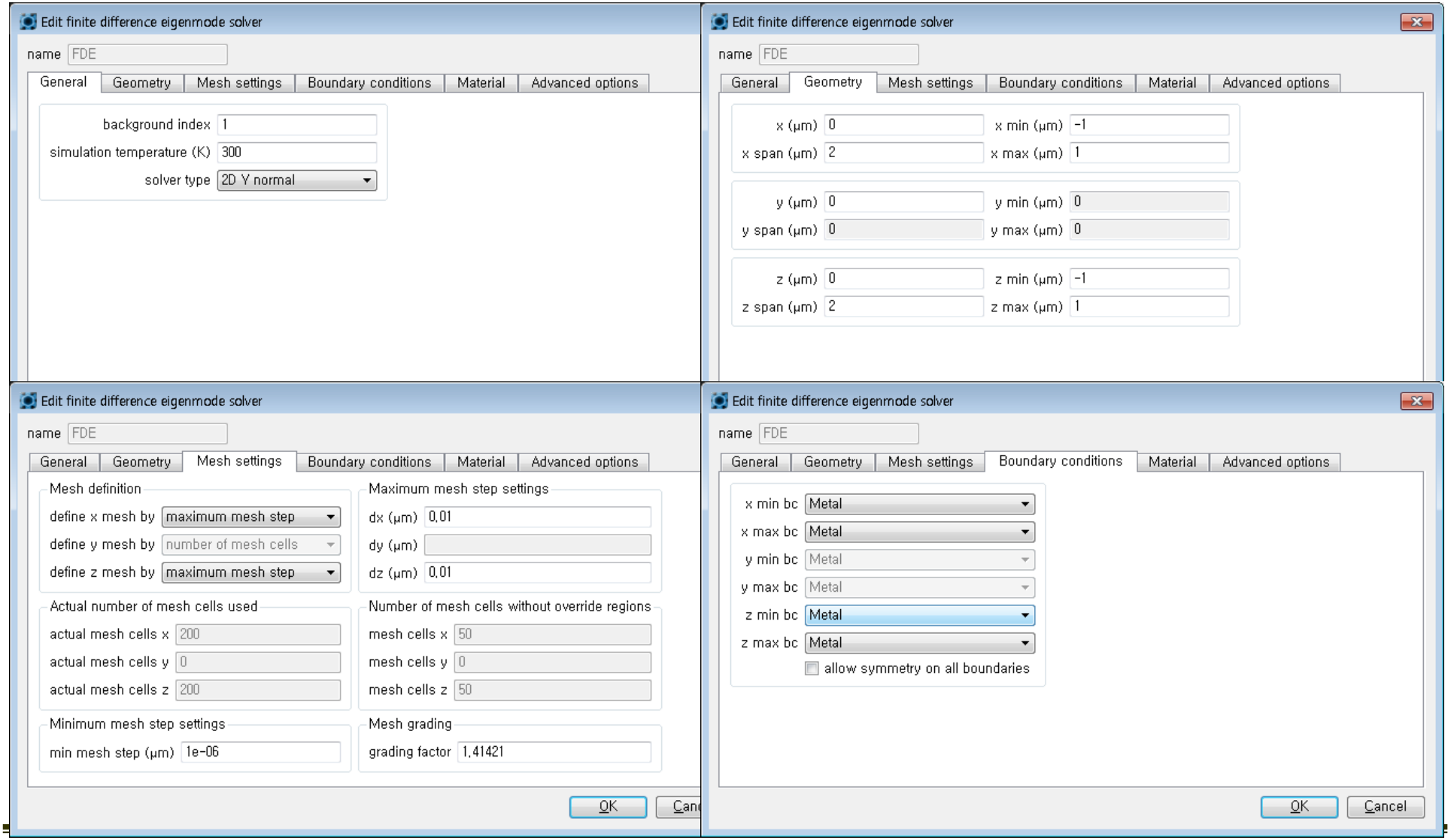
- **Eigenmode Solver**



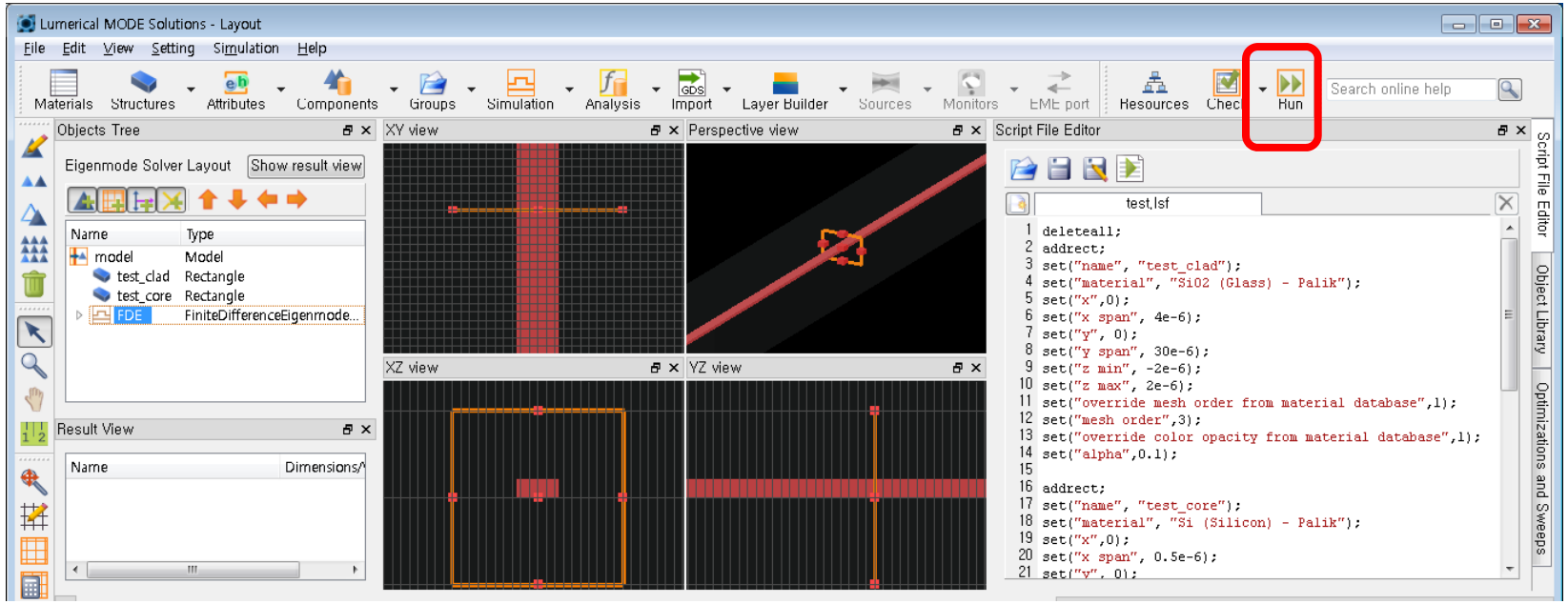
Simulation Setup(GUI)



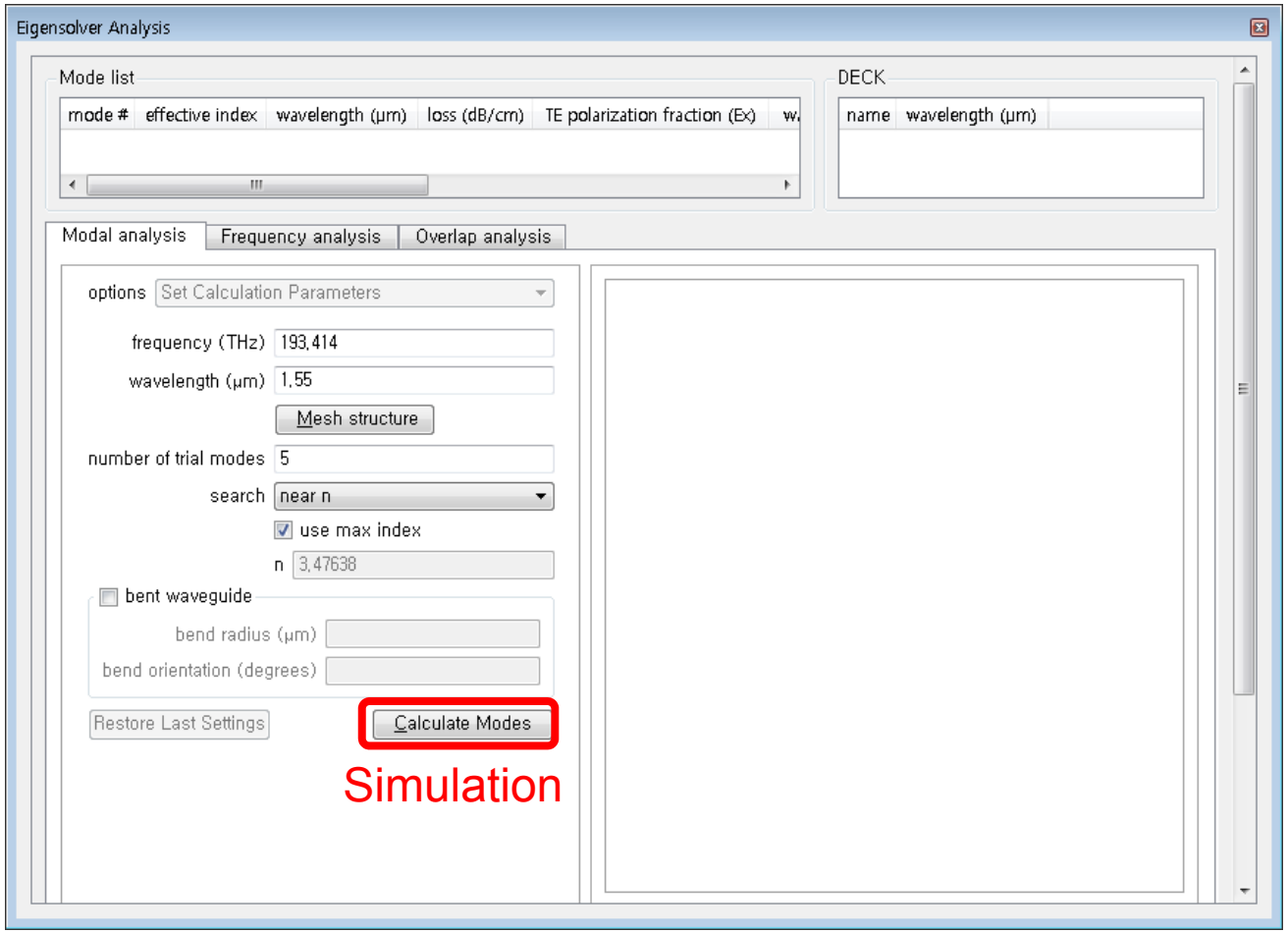
Simulation Setup(GUI)



Simulation Setup(GUI)



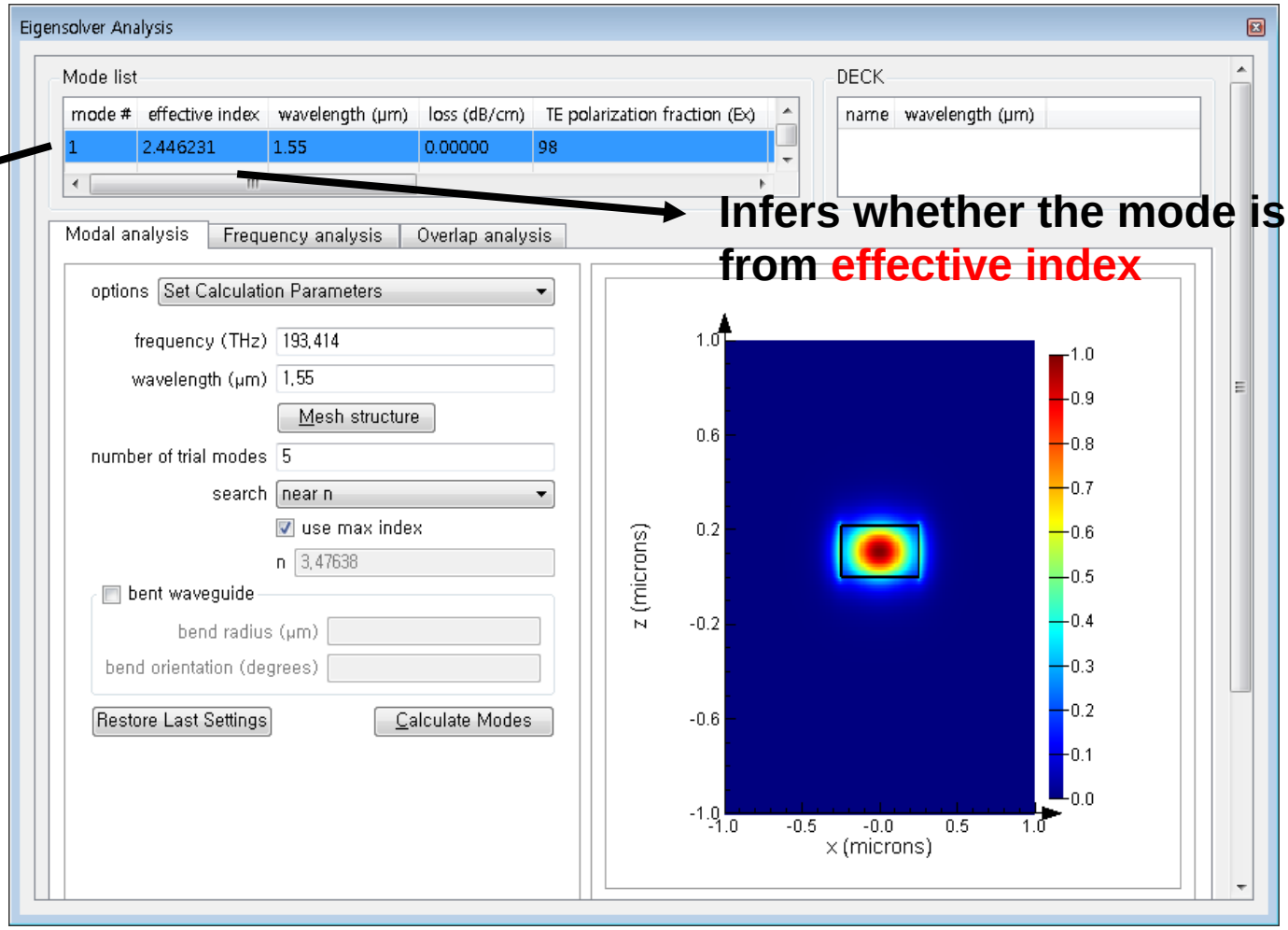
Simulation Setup(GUI)



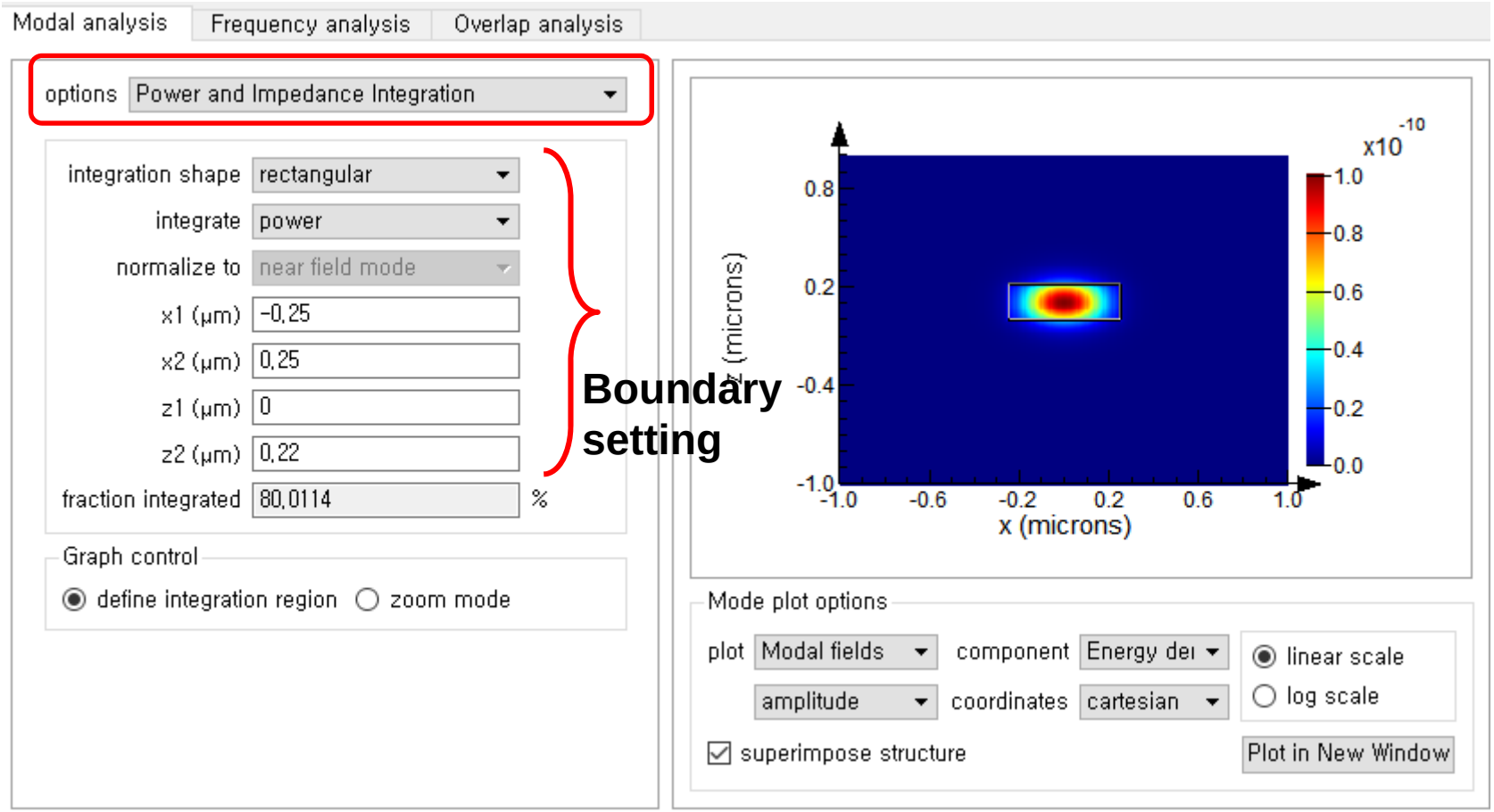
MODE Solutions

Calculated modes

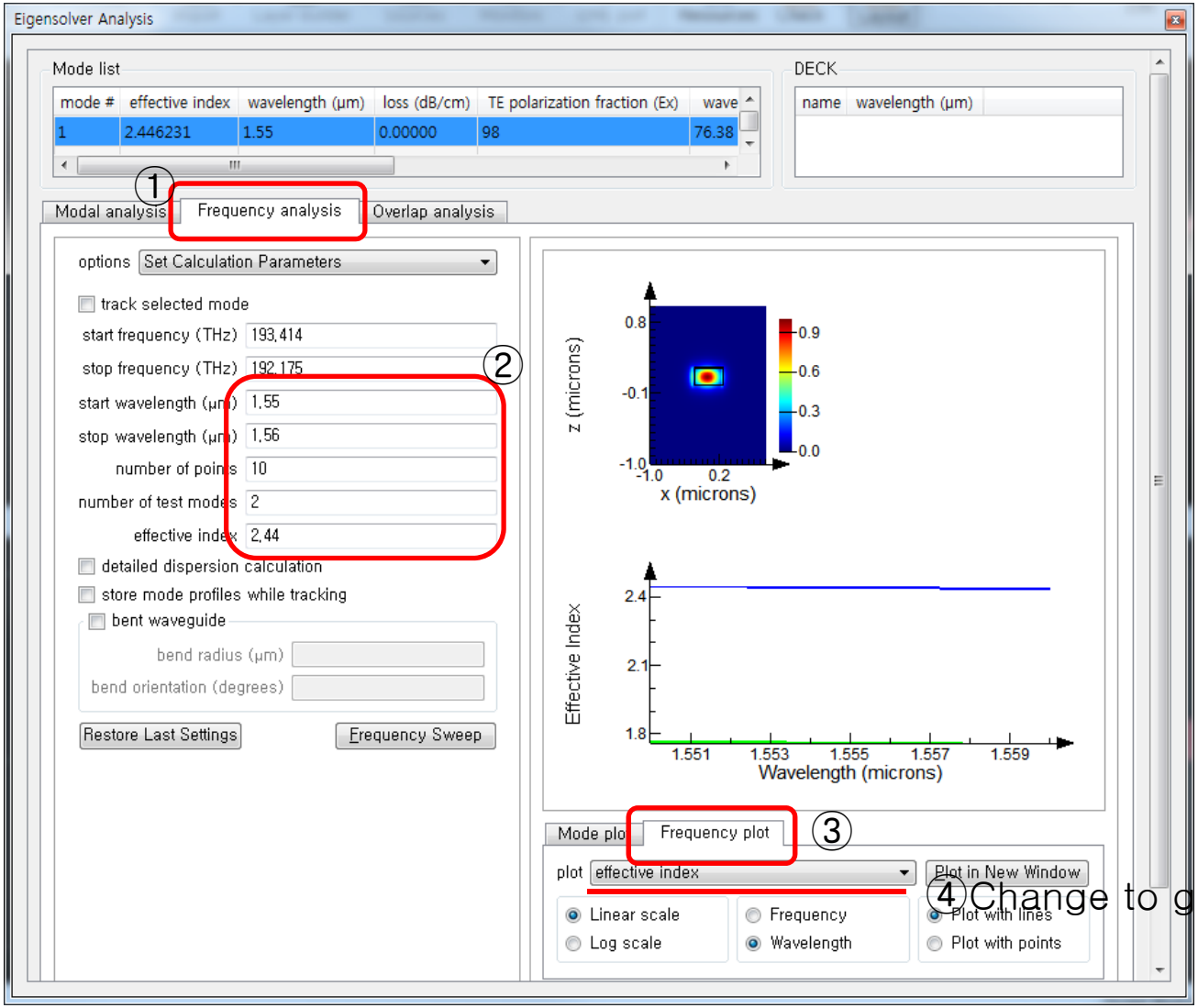
Infers whether the mode is true or not from effective index



Confinement Factor

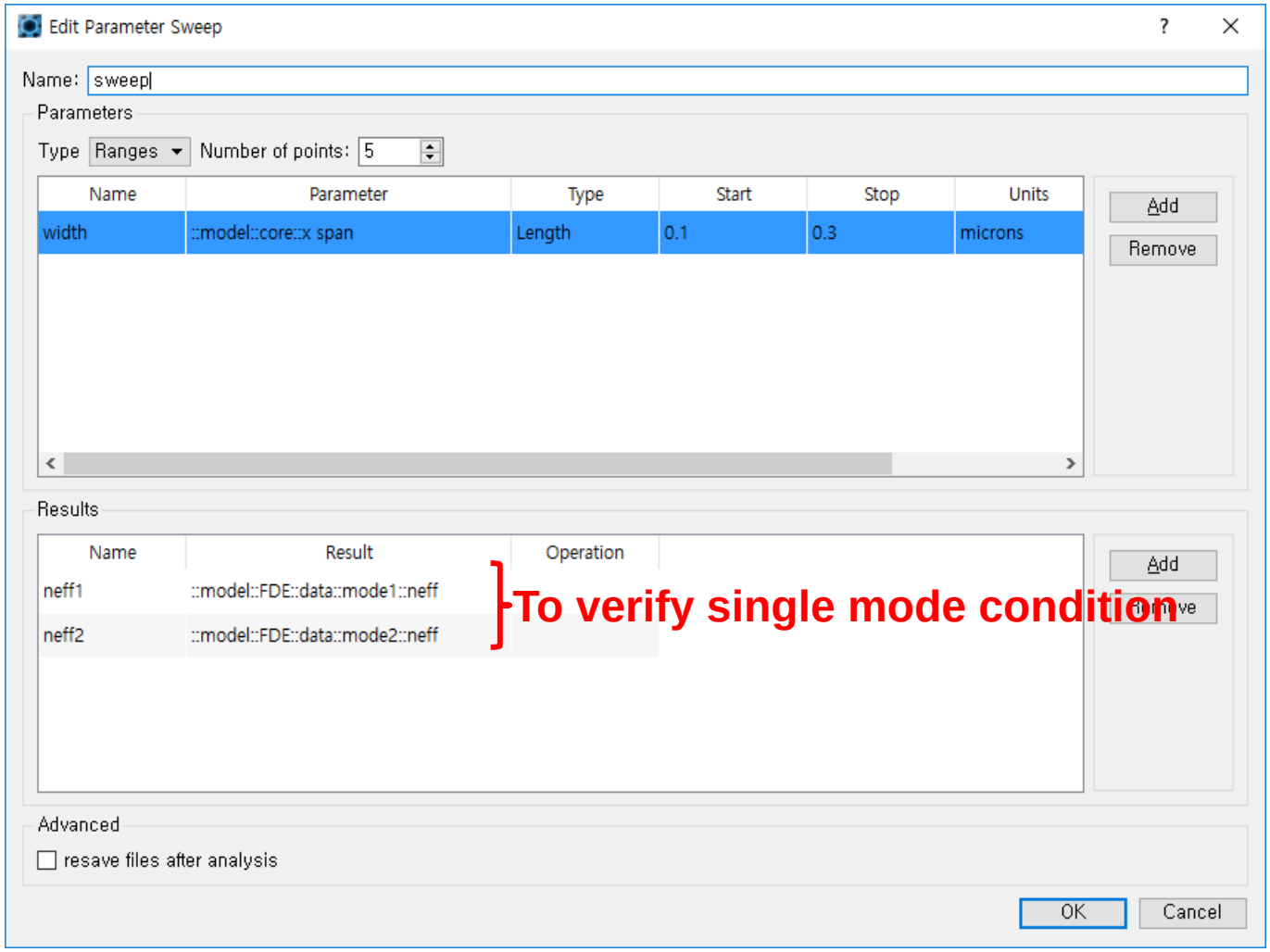


Group Index(n_g)

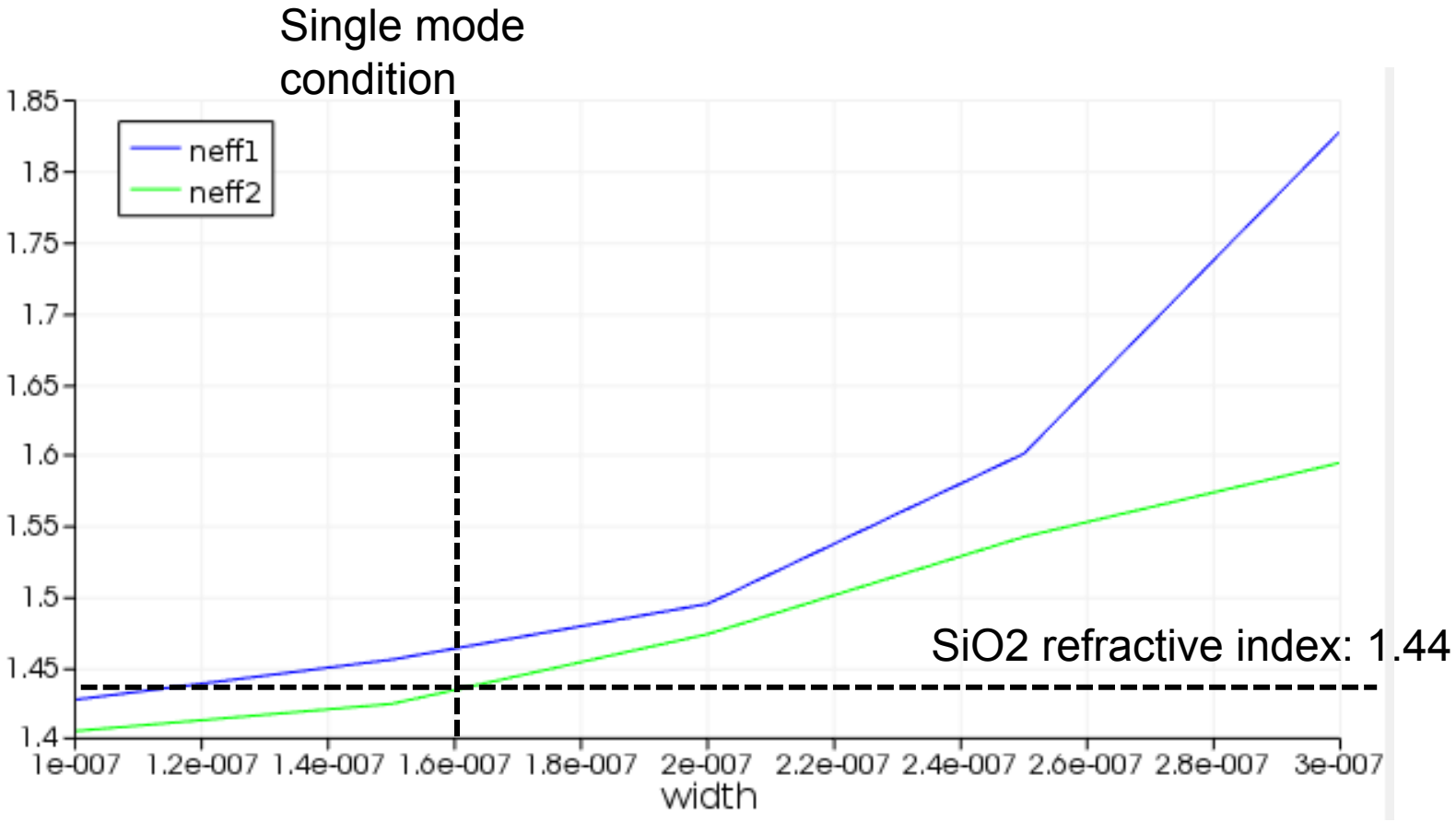


Sweep Width

Sweep waveguide width from 100nm to 300nm with 50nm step



Sweep Results

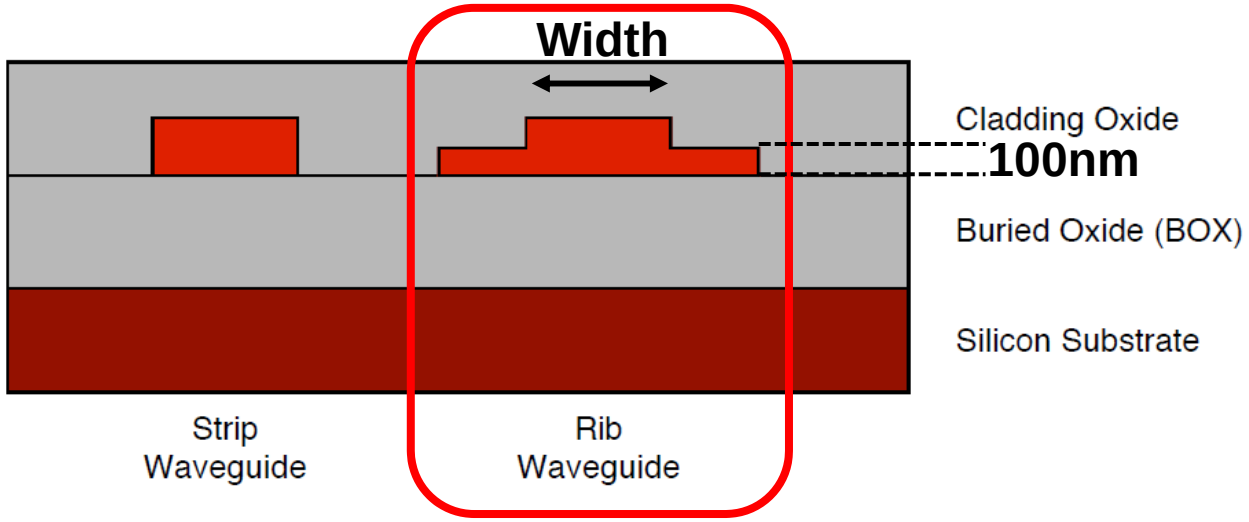


Design Exercise 2-1

What is the single-mode condition for the given thickness of rib waveguide? Also, calculate group index(n_g) for the single-mode rib waveguide.

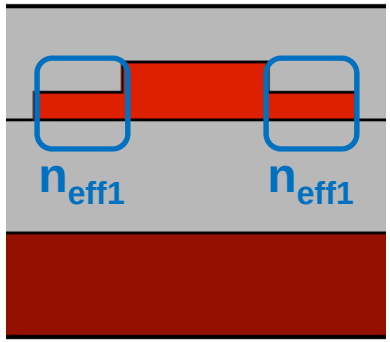
-220nm thick & 100nm slab at 1550nm

Due: 27 Nov. in class



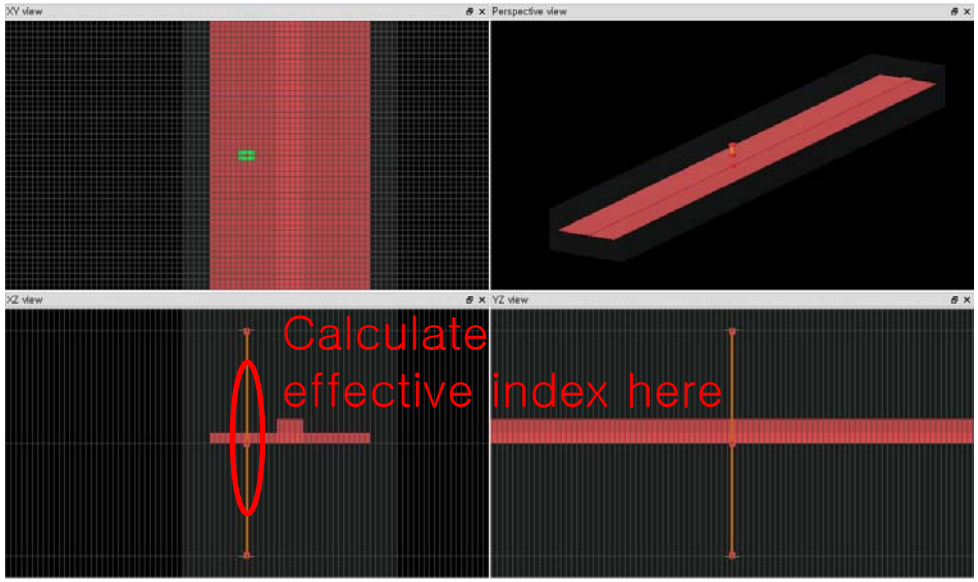
Tips for Design Exercise 2-1

- **Condition for guidance of rib waveguide**
  :$n_{eff\_total} > n_{eff1}$
  :Making same environment as strip waveguide



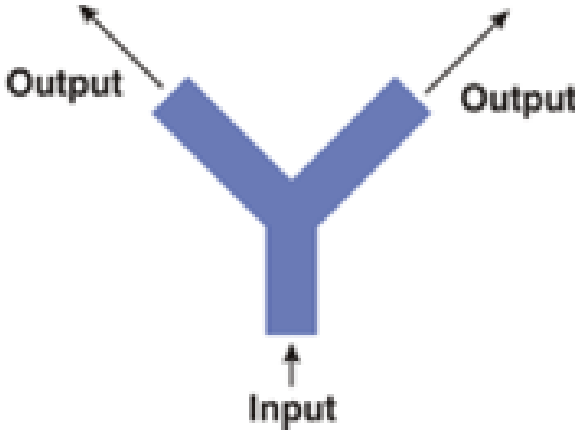
Rib
Waveguide

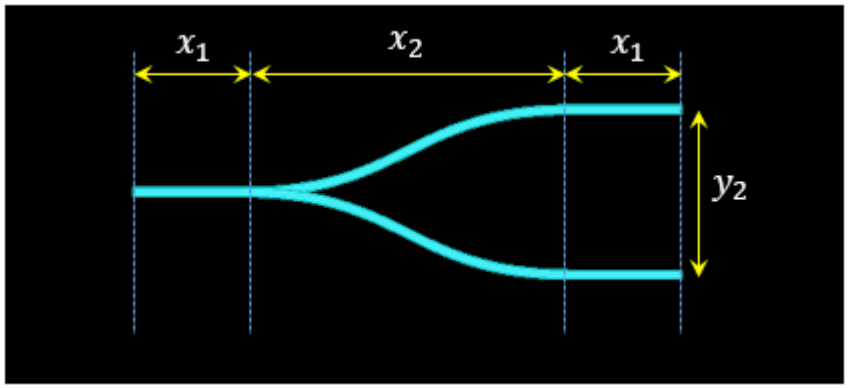
- **How to get n_{eff1}**
  :Use 1-D Z:X prop simulation in FDE solver



Waveguide coupler

- Y-branch coupler

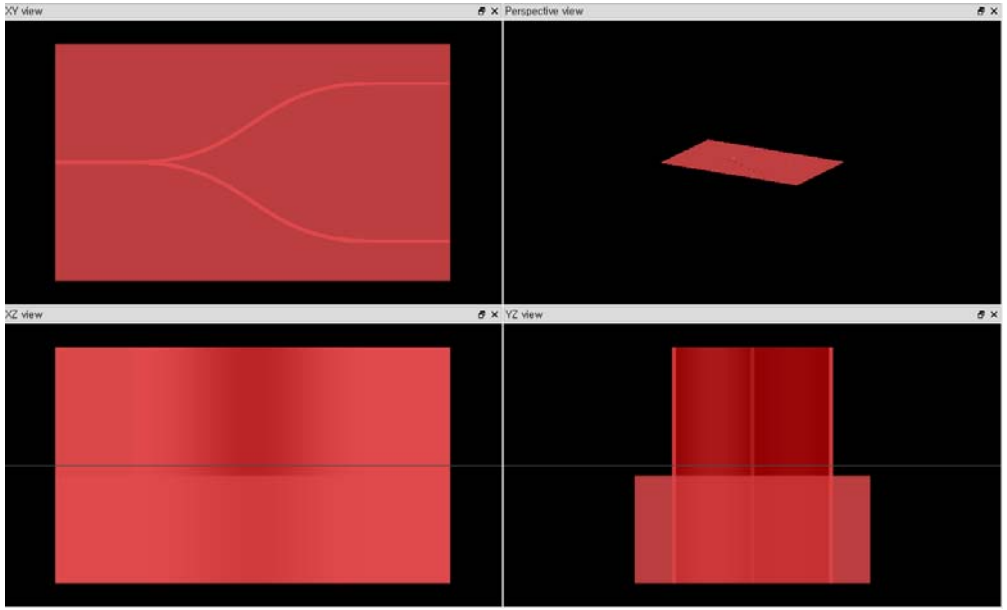


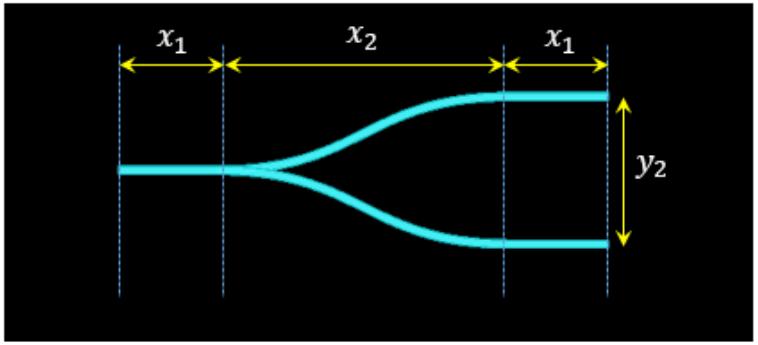


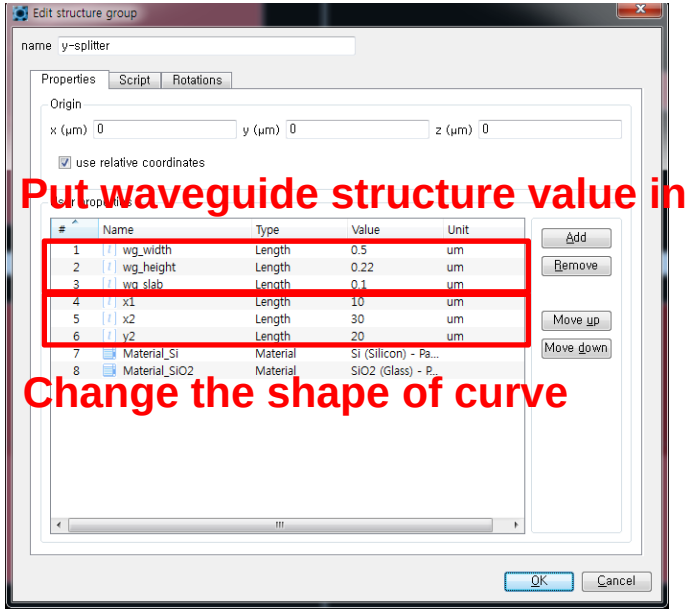
- Ideally 50:50 power splitter
- Bezier Curve
- Curve shape change due to x2, y2

Y-branch coupler

- **Waveguide structure group**



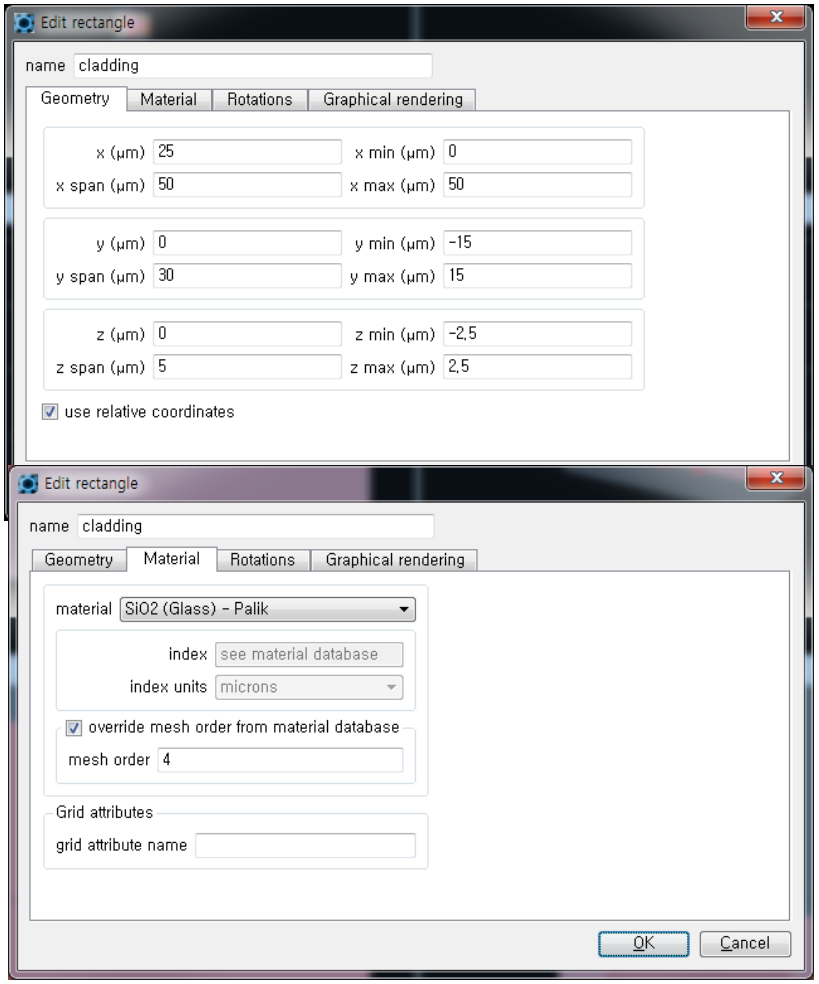


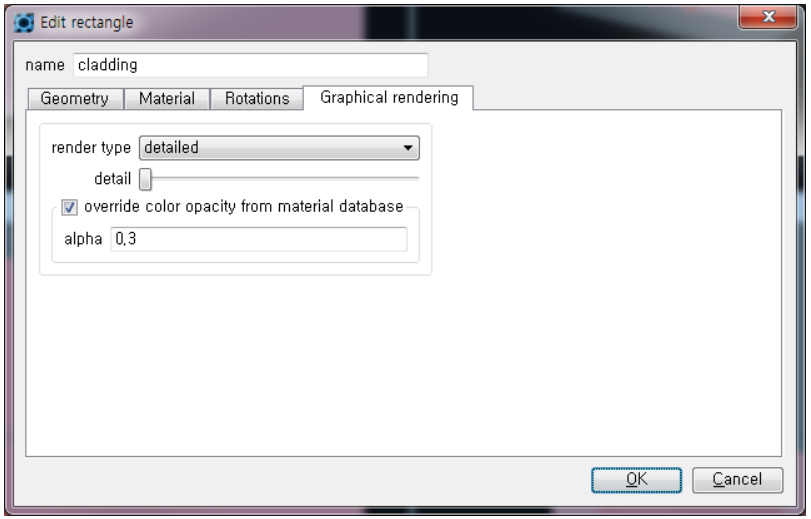


- **Download y_splitter.lms file at YSCEC**

Structure (cladding)

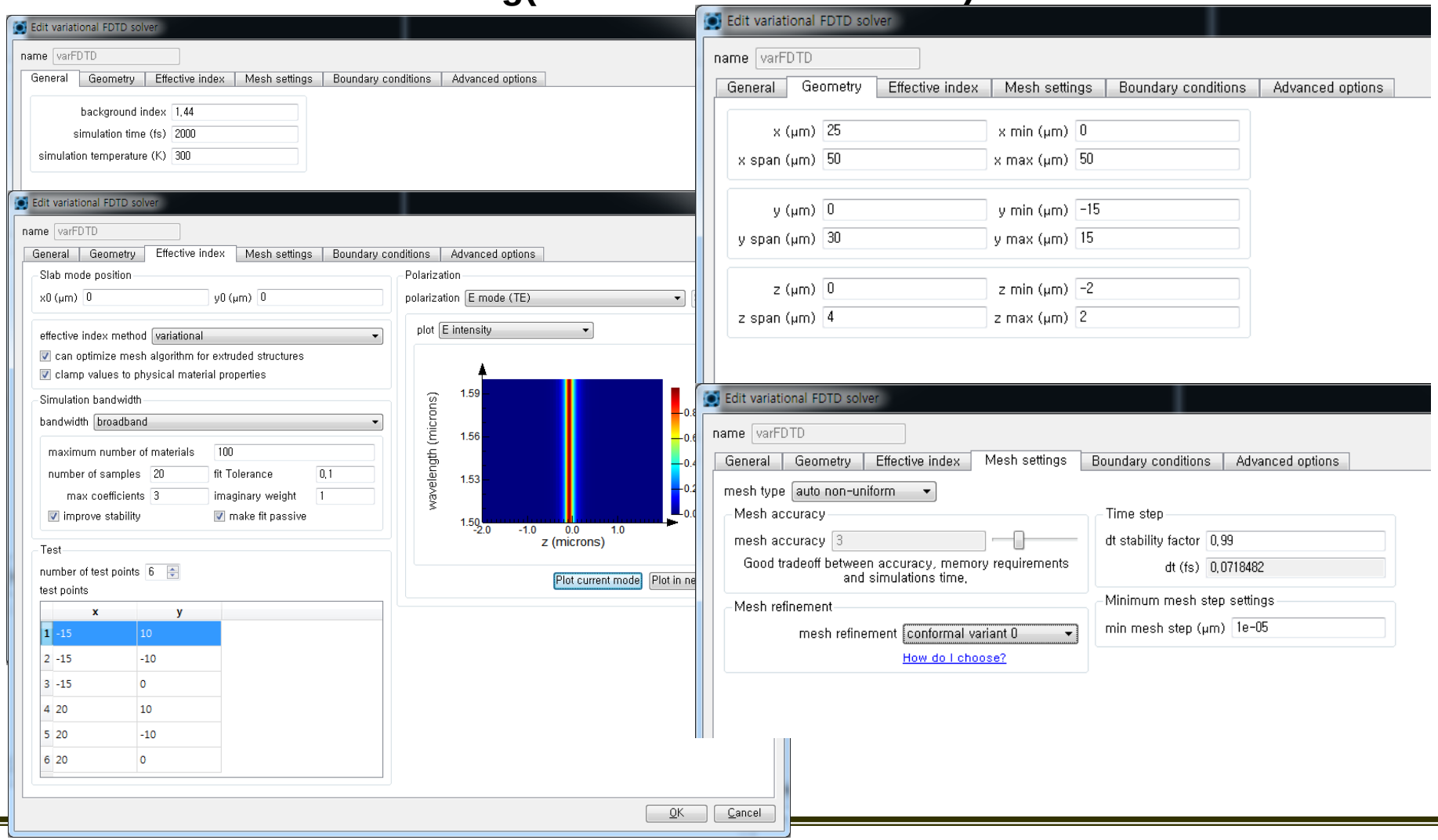
- **Rectangular**





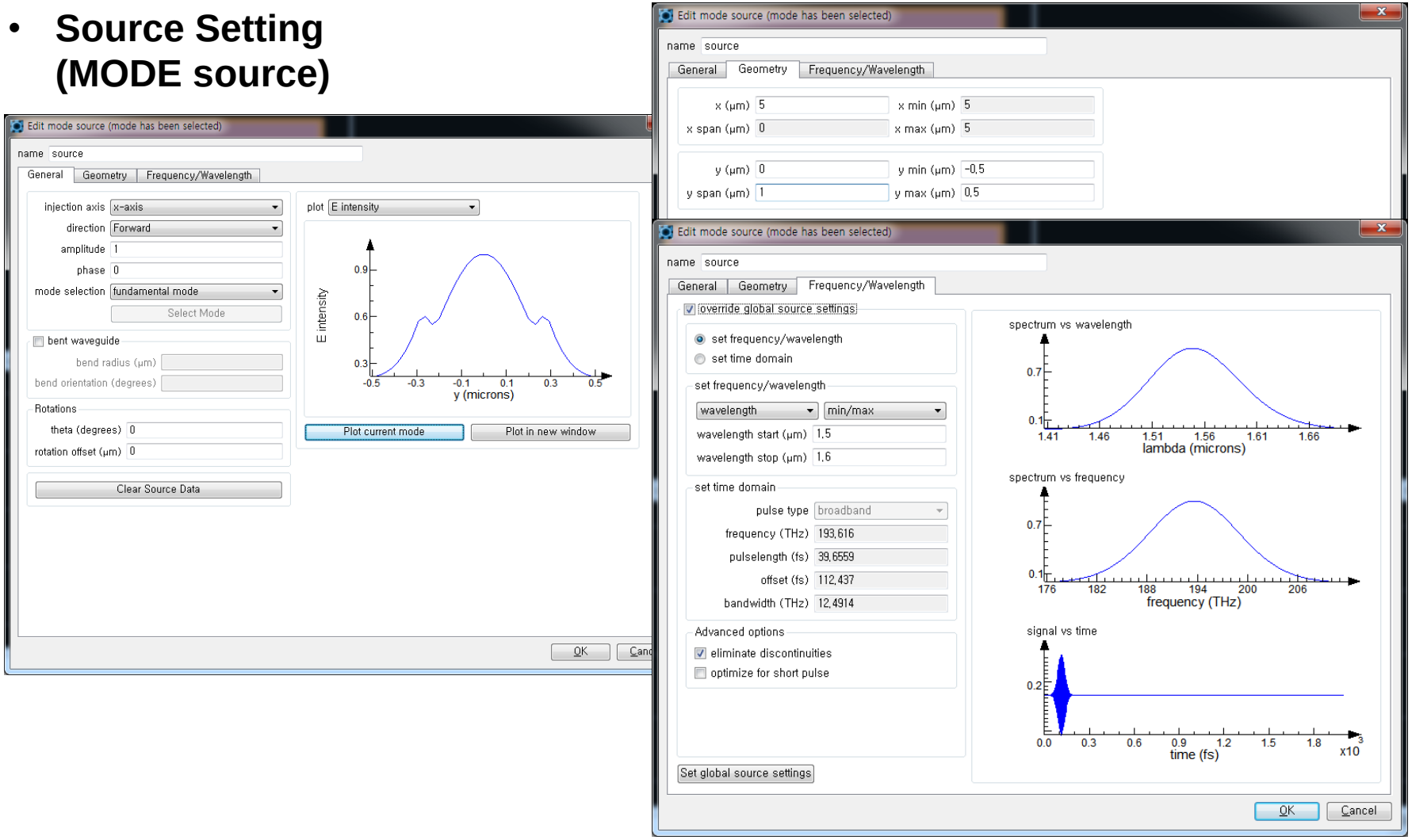
Simulation Setup

- **2.5D FDTD Solver Setting(Variational FDTD Solver)**



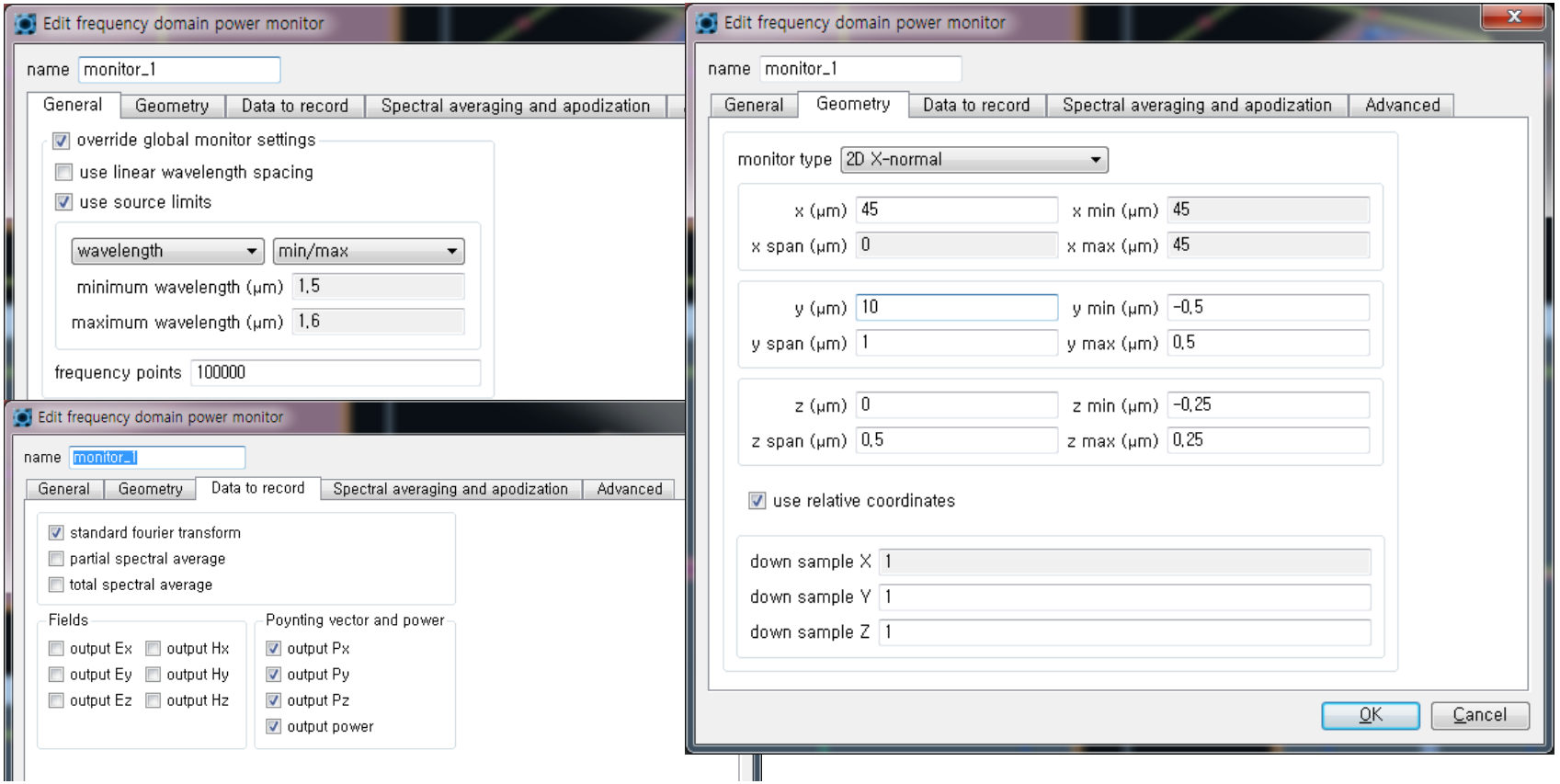
Simulation Setup

- **Source Setting (MODE source)**



Simulation Setup

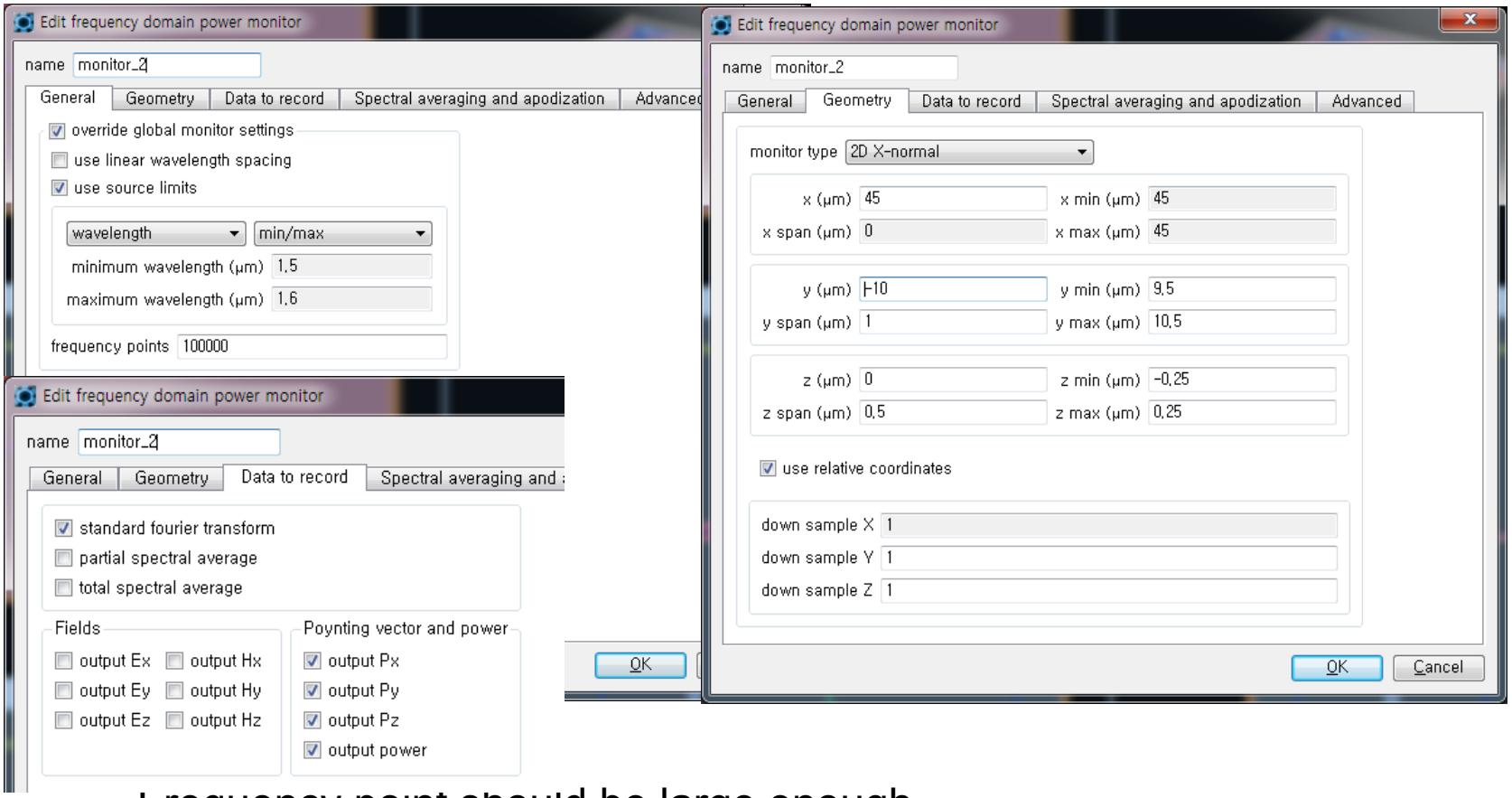
- **Monitor 1 Setting (Frequency domain field and power)**



-Frequency point should be large enough

Simulation Setup

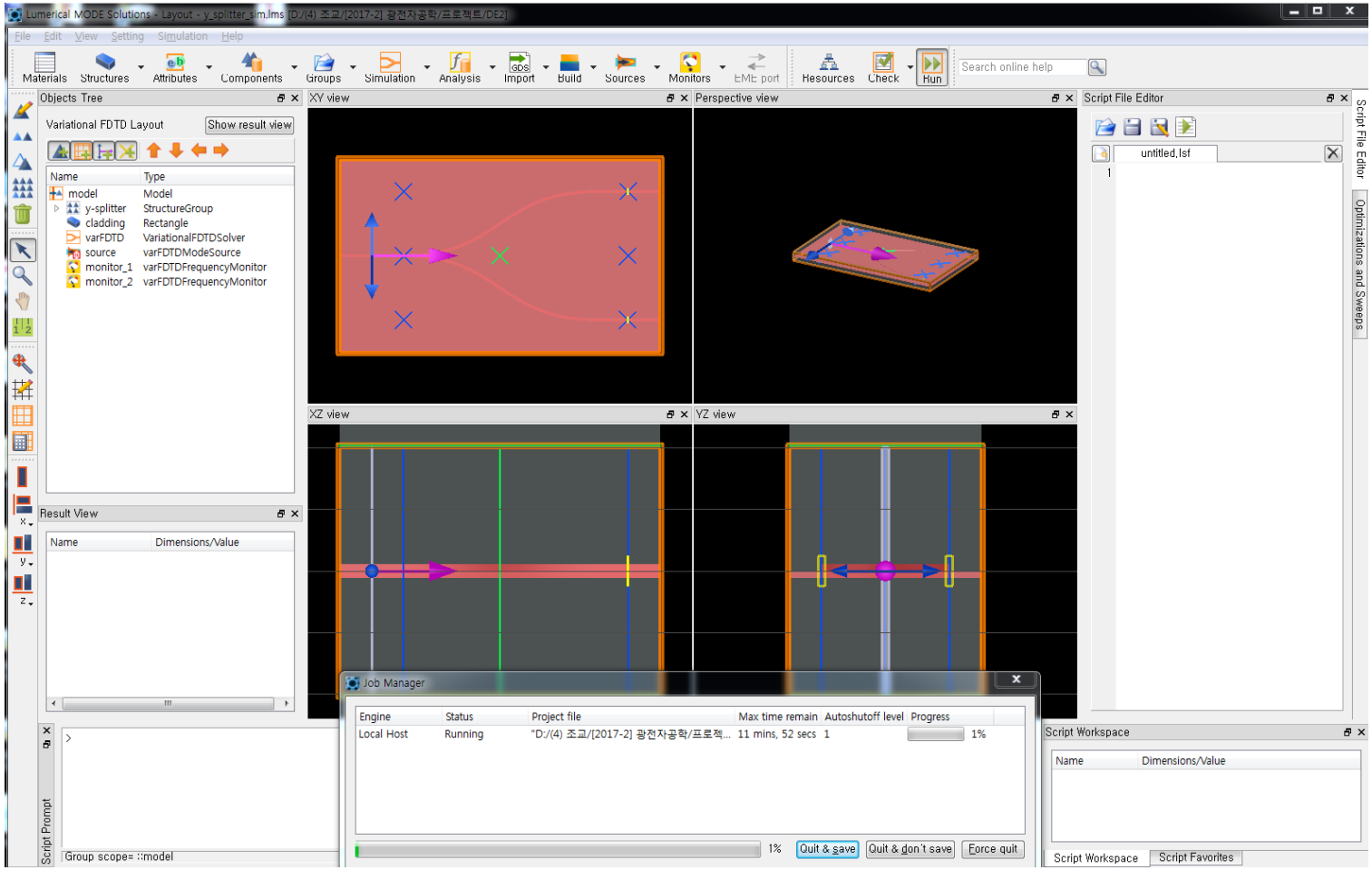
- **Monitor 2 Setting (Frequency domain field and power)**



-Frequency point should be large enough

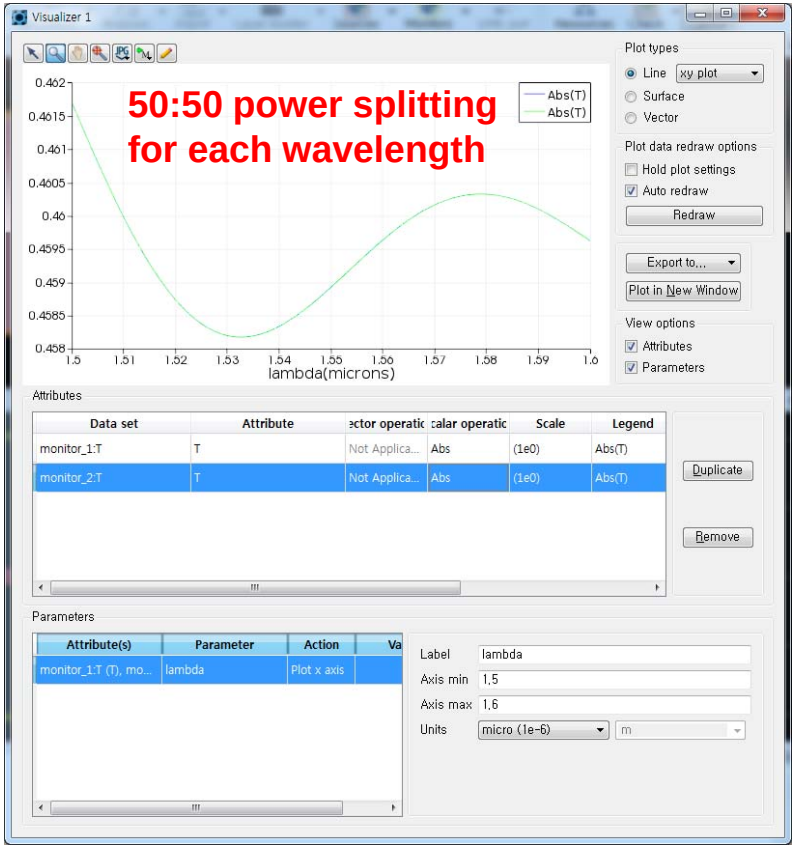
Run Simulation

- **After setup, run simulation**



Result

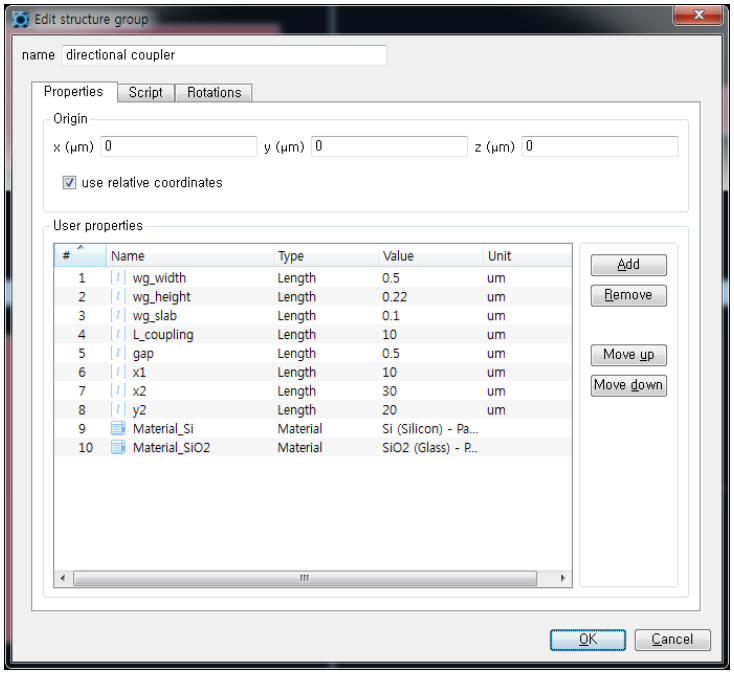
- **Monitor 1 (Right click) → Visualize → T**
- **Monitor 2 (Right click) → add to visualizer 1 → T**

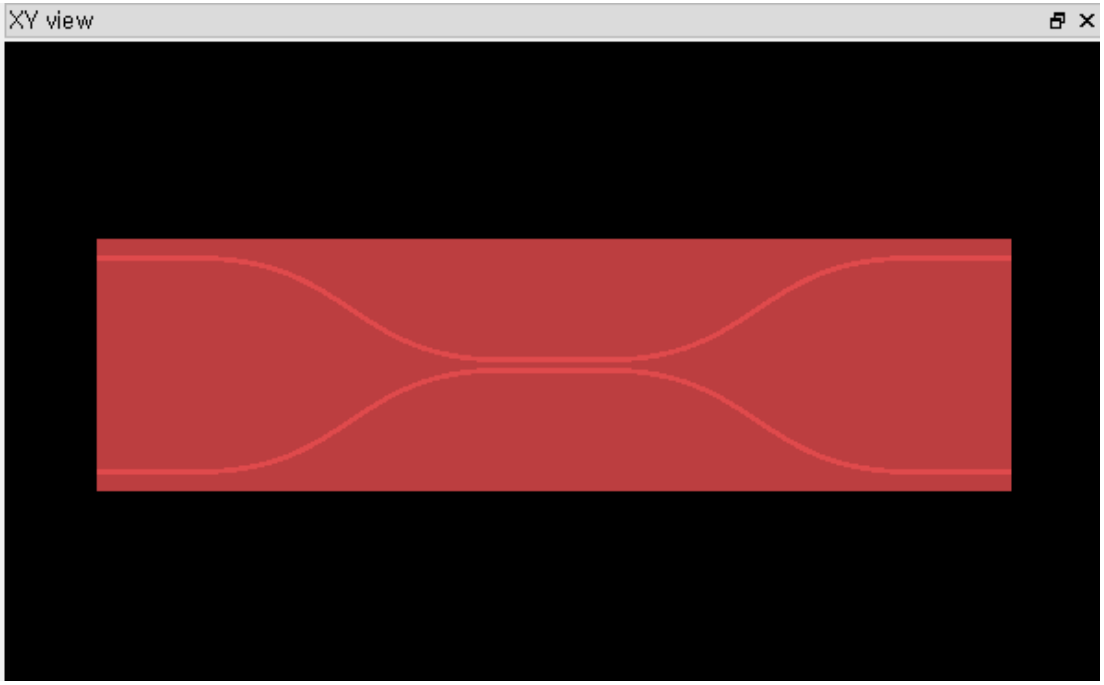


Design Exercise 2-2

Design rib waveguide type Directional Coupler. Use waveguide width from the result of Design Exercise 2-1.

-220nm thick & 100nm slab at 1550nm





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