

The background of the slide features a large, faint, light blue circular seal of Yonsei University. The seal contains a shield with a book and a torch, and the year '1885' at the bottom. The text 'YONSEI UNIVERSITY' is written around the top half of the seal, and 'YONSEI' is written around the bottom half.

# **Design Exercise 1**

## **Double Slit Experiment**

### **- FDTD Simulation -**

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

# Lumerical Solutions

## Our Products



**FDTD Solutions:** Single and multi-processor finite-difference time-domain optical design software.

[Product Details](#) | [Trial Download](#)



**MODE Solutions:** Waveguide eigenmode solver and omnidirectional broadband propagator design software.

[Product Details](#) | [Trial Download](#)



**INTERCONNECT:** Optoelectronic and photonic integrated circuit (PIC) design software package.

[Product Details](#) | [Trial Download](#)



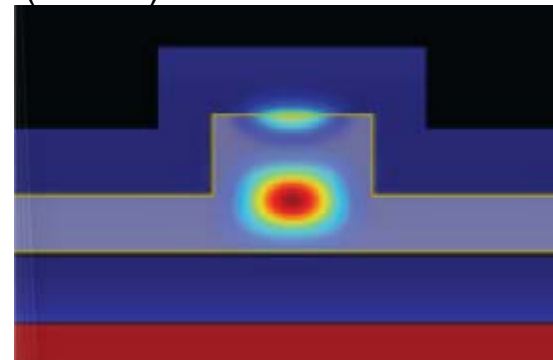
**DEVICE:** Powerful semiconductor TCAD device simulation software for silicon-based optoelectronic structures.

[Product Details](#) | [Trial Download](#)

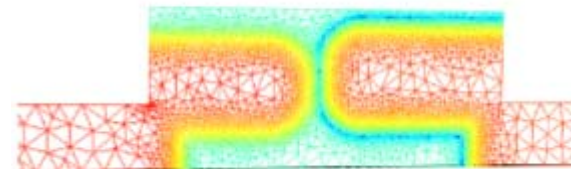
3D Maxwell solver(FDTD)



Modal analysis(MODE)



Charge transport & heat transfer(DEVICE)



# How To Download

- [www.lumerical.com](http://www.lumerical.com)

**Customer Downloads**

- Evaluate FDTD Solutions
- Evaluate MODE Solutions
- Evaluate INTERCONNECT
- Evaluate DEVICE

### FDTD Solutions

Description	Date	Download	Notes
FDTD Solutions 2016b R6 (v8.16.982) for Windows (64 bit)	2016-09-20	<a href="#">Download</a>	<a href="#">File icon</a> / <a href="#">OS</a>
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**Our Products**

- FDTD Solutions**  
[3D/2D Maxwell's solver for optical design](#)
- MODE Solutions**  
[Waveguide design environment](#)
- INTERCONNECT**  
[Photonic integrated circuit \(PIC\) simulation and analysis](#)
- DEVICE**  
[Multiphysics modeling of charge and heat transport](#)

**Trusted Technology**


Lumerical software is used in over 50 countries and has been referenced in more than 5000 academic publications and patents.

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**If you want to simulate in your laptop, registration & download are required**

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**Optional:** Help us support you better. Tell us a little more about your interest in Lumerical

E-mail address: <input type="text"/>	Application: Choose one: <input type="text"/>
Password: <input type="password"/>	Sub-application: Choose one: <input type="text"/>
Re-enter password: <input type="password"/>	Alternate email: <input type="text"/>
First name: <input type="text"/>	Organization: <input type="text"/>
Last name: <input type="text"/>	Job title: Choose one: <input type="text"/>
Country: Choose one: <input type="text"/>	Phone number: <input type="text"/>

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M. McCutcheon, Harvard University

"Lumerical's technical support is excellent and very responsive."  
M. Webster, Lightwire

# License Setting

MODE Solutions - Configure License

**Floating** Node Locked

Manage which floating license servers get checked from this tab.

Options

Server: 165,132,112,189 Port: ☒ Default ☐ Specify

☐ Configure redundant servers

\*Server can be either the hostname or IP address of a Flex license server

Actions

☒ Apply these settings to my user account only

☐ Make these settings the system defaults (requires elevation)

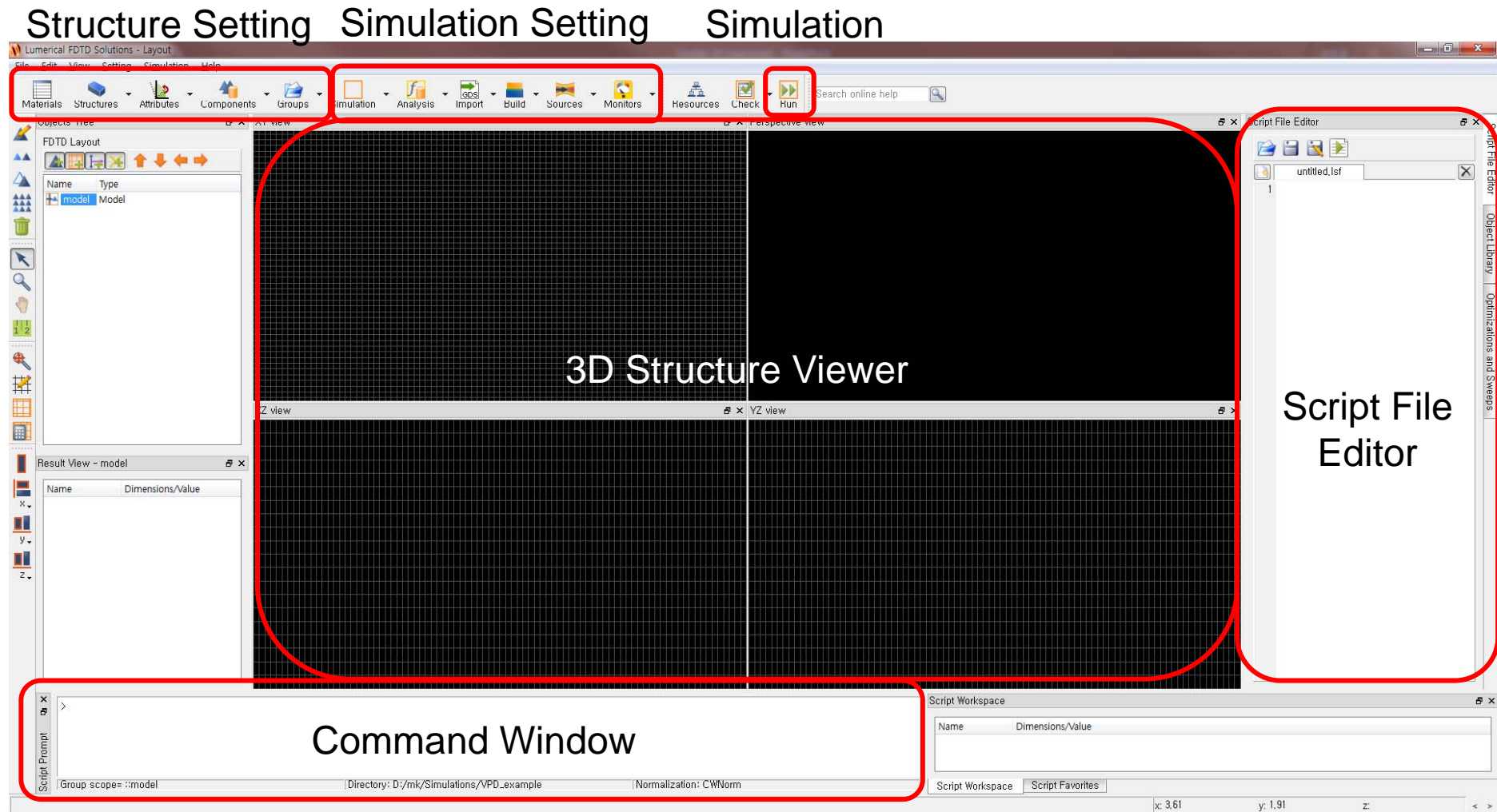
☐ Configure my account to use system defaults

[Instructions on how to activate your floating license](#)

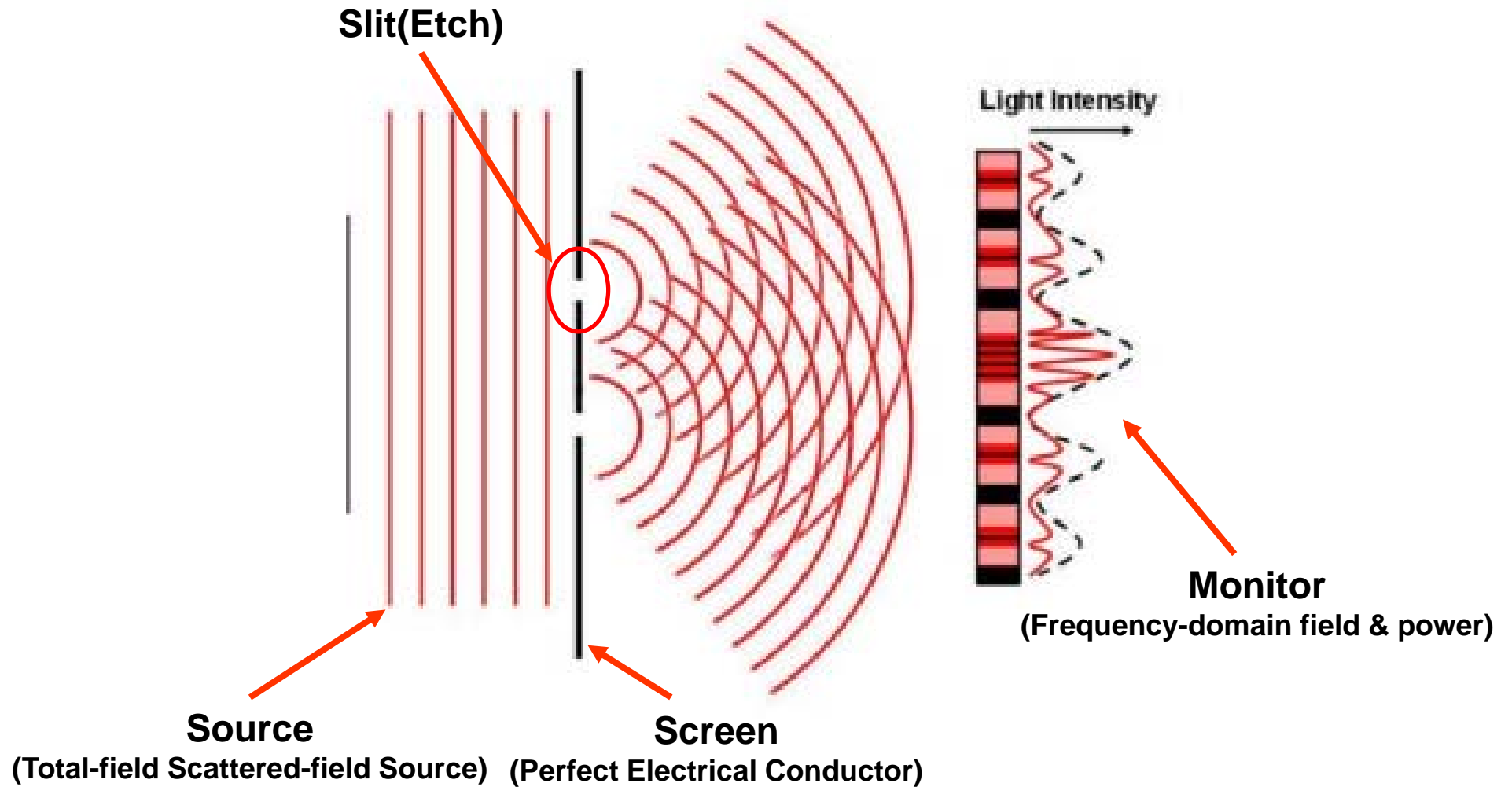
[View your active licenses in the FlexNet Publisher dashboard](#)

OK Cancel

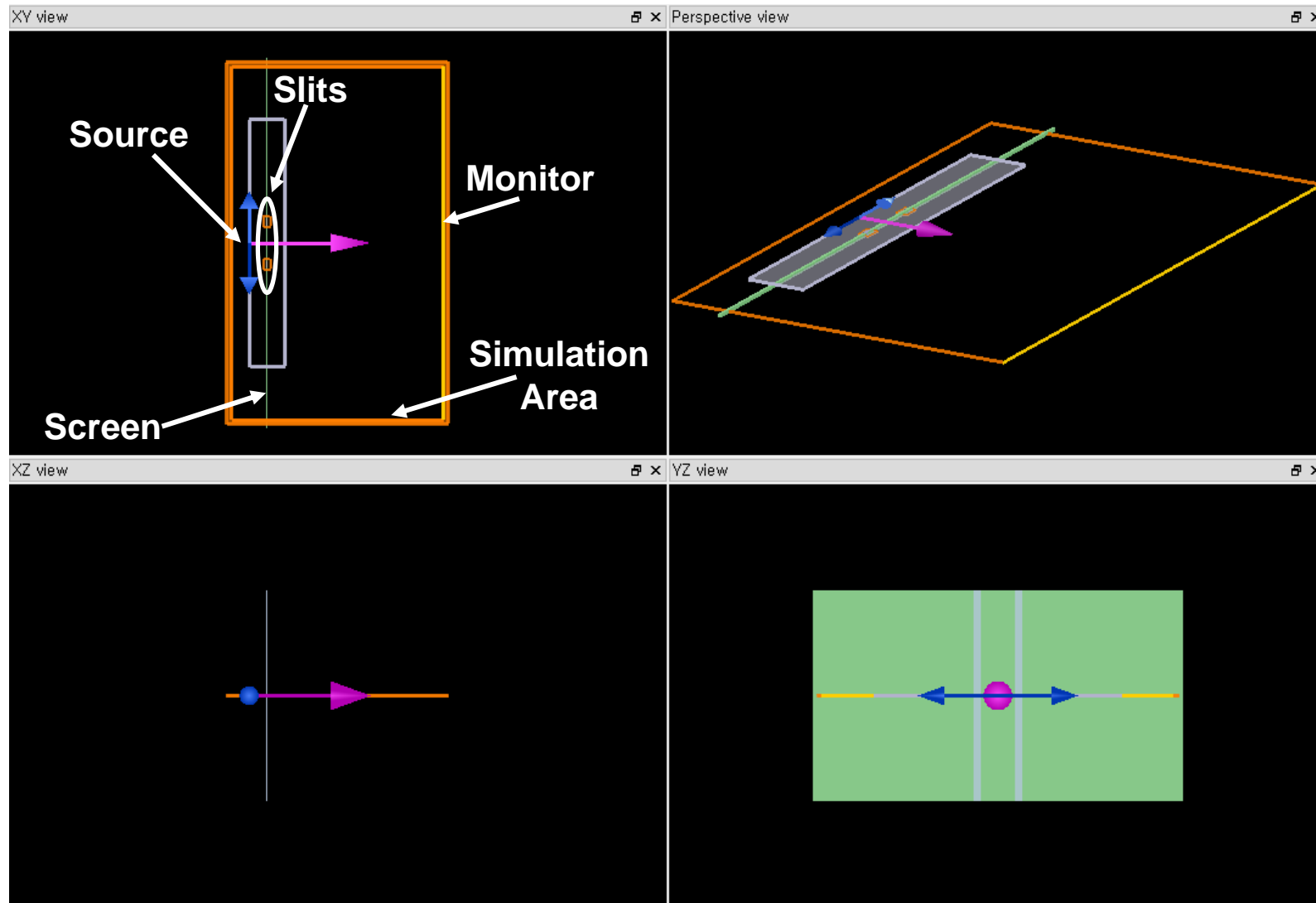
# FDTD Window



# Double Slit Experiment

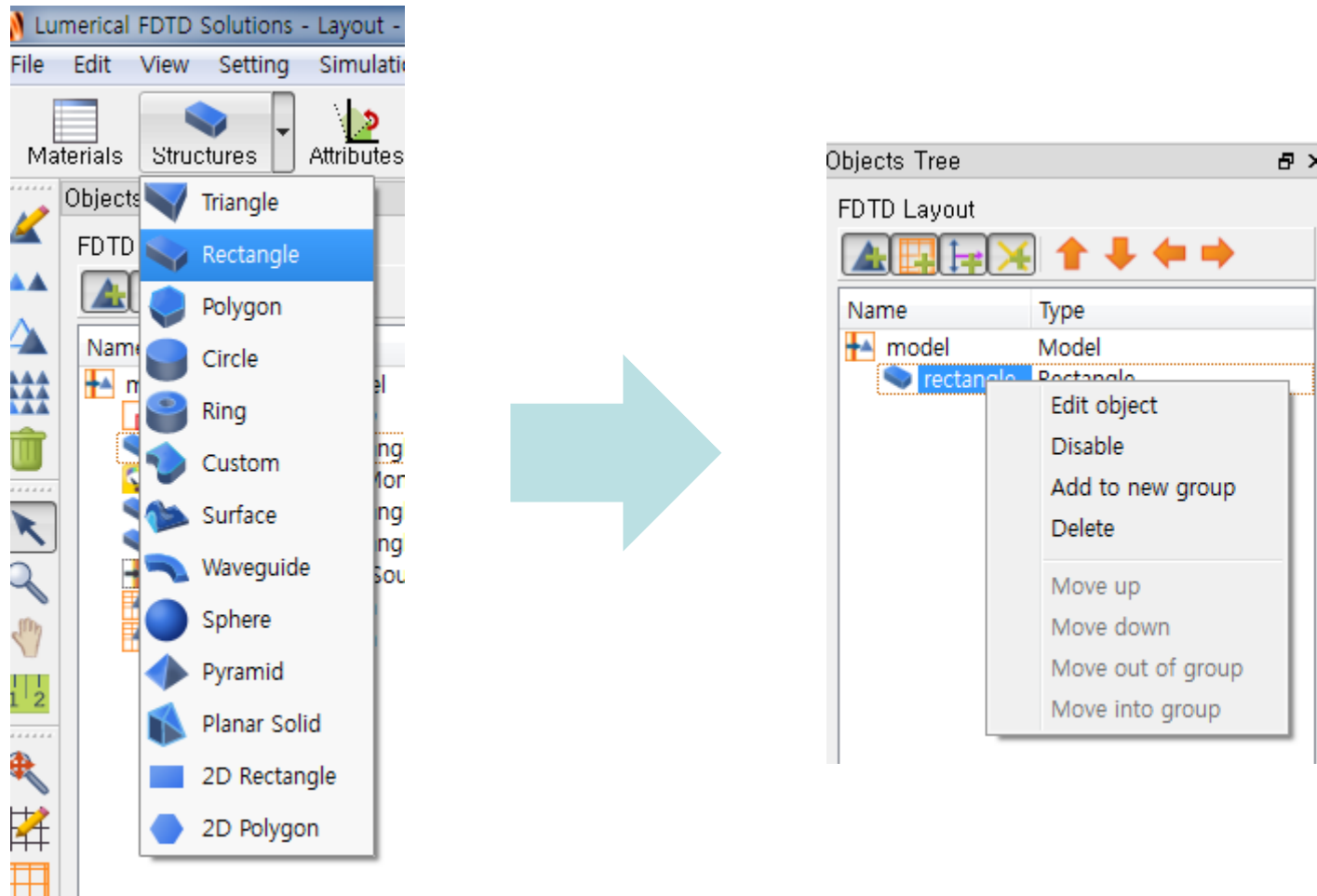


# Simulation Setup

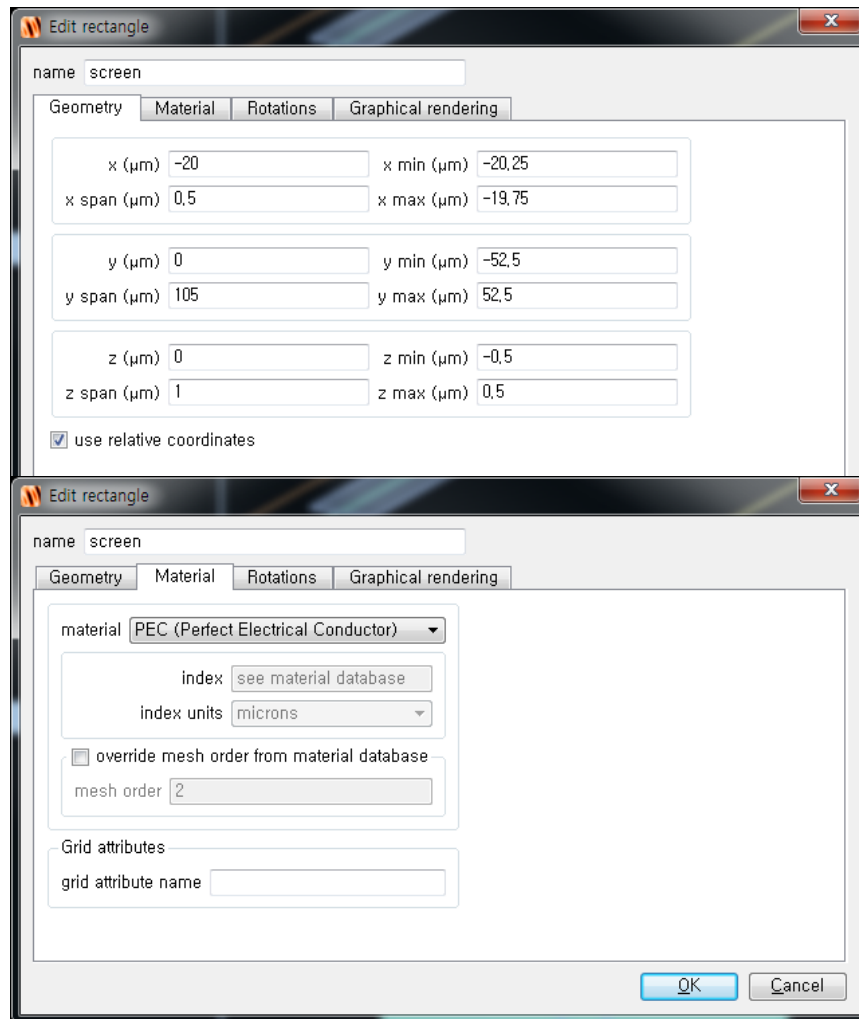




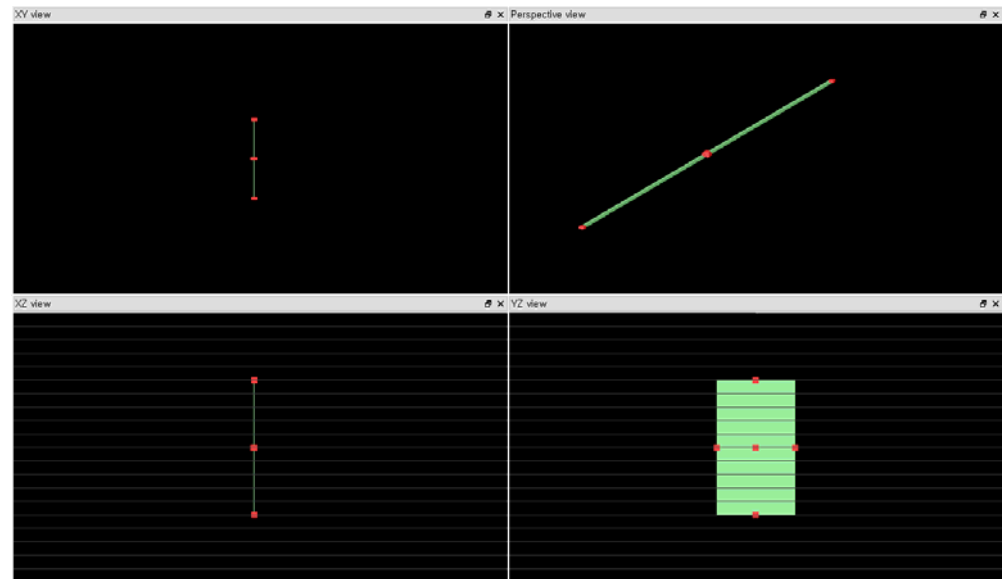
# Build Screen



# Build Screen



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



# Build Slits

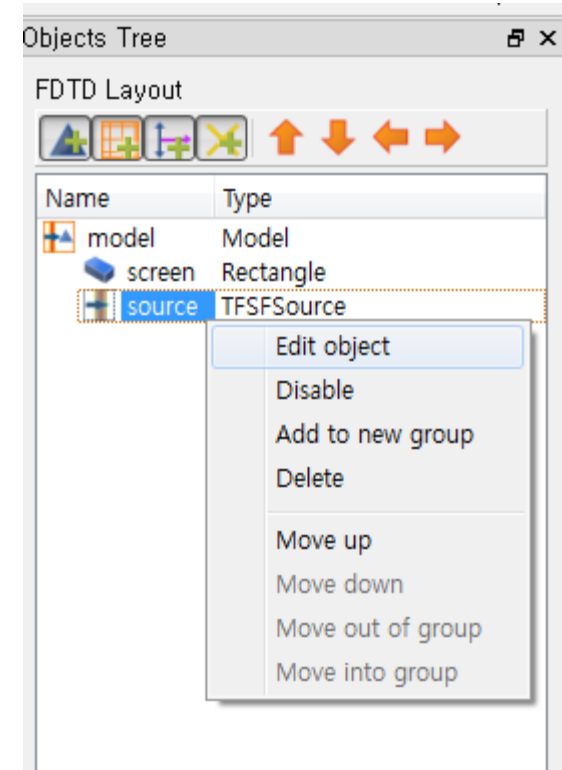
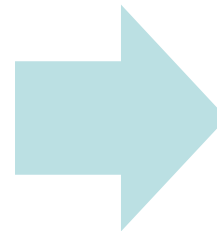
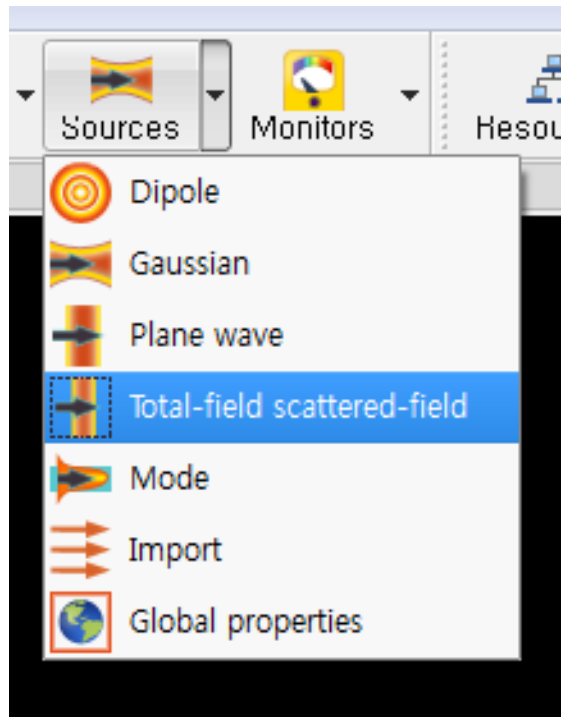
- Upper slit

The image shows two side-by-side screenshots of the 'Edit rectangle' dialog box for a geometry named 'top\_slit'. The left screenshot shows the 'Geometry' tab with coordinate fields: x (μm) -20, x min (μm) -20,25, x span (μm) 0,5, x max (μm) -19,75; y (μm) 6, y min (μm) 5, y span (μm) 2, y max (μm) 7; z (μm) 0, z min (μm) -0,5, z span (μm) 1, z max (μm) 0,5. The 'use relative coordinates' checkbox is checked. The right screenshot shows the 'Material' tab with 'etch' selected, 'index' set to 'see material database', 'index units' set to 'microns', 'override mesh order from material database' unchecked, and 'mesh order' set to 1. Both windows have 'OK' and 'Cancel' buttons at the bottom.

- Lower slit

The image shows two side-by-side screenshots of the 'Edit rectangle' dialog box for a geometry named 'bottom\_slit'. The left screenshot shows the 'Geometry' tab with coordinate fields: x (μm) -20, x min (μm) -20,25, x span (μm) 0,5, x max (μm) -19,75; y (μm) -6, y min (μm) -7, y span (μm) 2, y max (μm) -5; z (μm) 0, z min (μm) -0,5, z span (μm) 1, z max (μm) 0,5. The 'use relative coordinates' checkbox is checked. The right screenshot shows the 'Material' tab with 'etch' selected, 'index' set to 'see material database', 'index units' set to 'microns', 'override mesh order from material database' unchecked, and 'mesh order' set to 1. Both windows have 'OK' and 'Cancel' buttons at the bottom.

# Source Setup



# Source Setup

The image displays three overlapping screenshots of the 'Edit TFSF source' dialog box, illustrating the setup process for a HeNe source.

**Top Left Screenshot (General Tab):** Shows the 'General' tab with the following settings:

- name: HeNe\_source
- injection axis: x-axis
- direction: Forward
- amplitude: 1
- phase (degrees): 0
- angle theta (degrees): 0
- angle phi (degrees): 0
- polarization angle (degrees): 0

**Top Right Screenshot (Geometry Tab):** Shows the 'Geometry' tab with the following settings:

- x (μm): -20, x min (μm): -25, x span (μm): 10, x max (μm): -15
- y (μm): 0, y min (μm): -35, y span (μm): 70, y max (μm): 35
- z (μm): 0, z min (μm): 0, z span (μm): 0, z max (μm): 0
- ☒ use relative coordinates

**Bottom Screenshot (Frequency/Wavelength Tab):** Shows the 'Frequency/Wavelength' tab with the following settings:

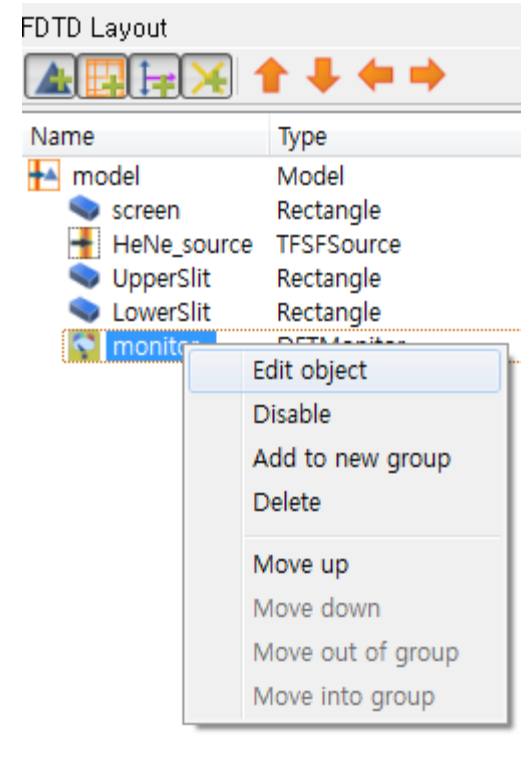
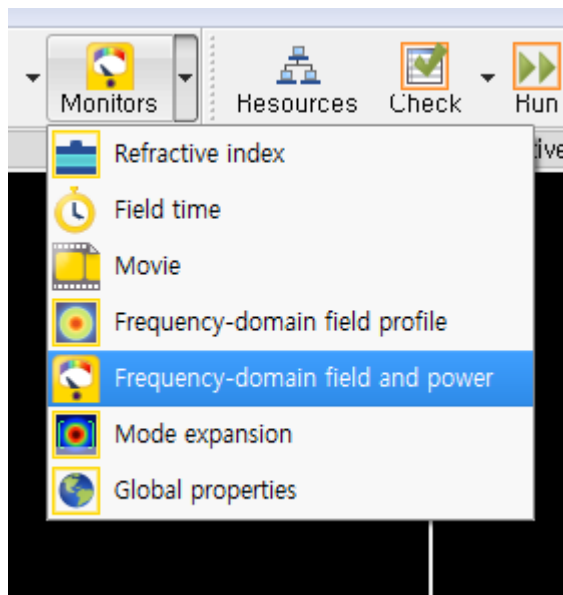
- ☒ override global source settings
- ☒ set frequency/wavelength
- ☐ set time domain
- set frequency/wavelength: wavelength (μm) 0.633, wavelength start (μm) 0.633, wavelength stop (μm) 0.633
- set time domain: pulse type standard, frequency (THz) 473.606, pulselength (fs) 4,181.11, offset (fs) 11,854.8, bandwidth (THz) 105,539
- Advanced options: ☒ eliminate discontinuities, ☒ optimize for short pulse
- Set global source settings

**Plots:**

- theta vs wavelength:** A plot showing theta (x10) on the y-axis (ranging from -1.0 to 5.0) versus lambda (microns) on the x-axis (ranging from 0.4 to 0.7). A single blue data point is visible at approximately (0.633, 0.0).
- spectrum vs wavelength:** A plot showing the spectrum on the y-axis (ranging from 0.0 to 0.6) versus lambda (microns) on the x-axis (ranging from 0.44 to 0.79). A single blue peak is visible at approximately 0.633 microns.
- spectrum vs frequency:** A plot showing the spectrum on the y-axis (ranging from 0.0 to 0.7) versus frequency (THz) on the x-axis (ranging from 330 to 580). A single blue peak is visible at approximately 473.6 THz.
- signal vs time:** A plot showing the signal on the y-axis (ranging from -0.9 to 0.2) versus time (fs) on the x-axis (ranging from 0.0 to 1.0 x 10<sup>3</sup>). A single blue peak is visible at approximately 0.0 fs.

**Wavelength setup**

# Monitor Setup



# Monitor Setup

The image displays three overlapping screenshots of the 'Edit frequency domain power monitor' dialog box, illustrating the configuration steps for a power monitor.

**Top Screenshot (General Tab):**

- Name: projection
- simulation type: All
- ☐ override global monitor settings
- ☐ use linear wavelength spacing
- ☒ use source limits
- wavelength: min/max
- minimum wavelength ( $\mu\text{m}$ ): 0.633
- maximum wavelength ( $\mu\text{m}$ ): 0.633
- frequency points: 5
- Set global monitor settings

**Bottom Left Screenshot (Geometry Tab):**

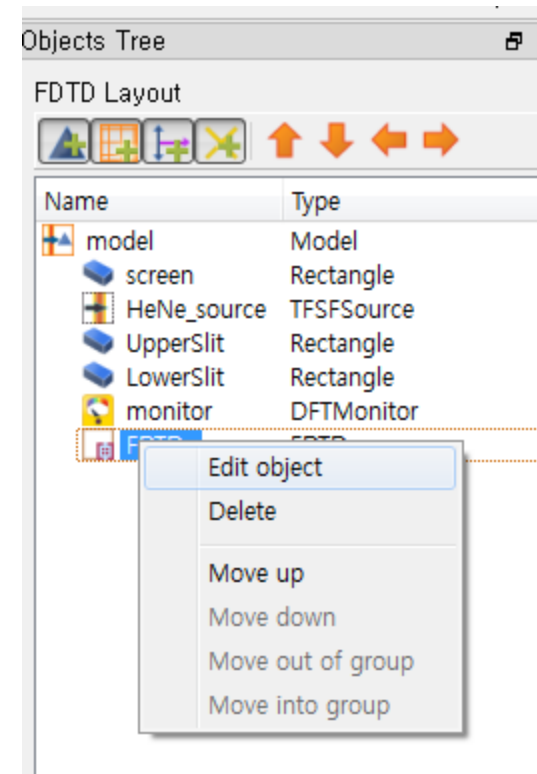
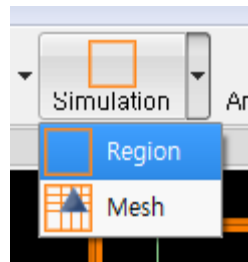
- Name: projection
- monitor type: Linear Y
- x ( $\mu\text{m}$ ): 30, x min ( $\mu\text{m}$ ): 30, x span ( $\mu\text{m}$ ): 0, x max ( $\mu\text{m}$ ): 30
- y ( $\mu\text{m}$ ): 0, y min ( $\mu\text{m}$ ): -50, y span ( $\mu\text{m}$ ): 100, y max ( $\mu\text{m}$ ): 50
- z ( $\mu\text{m}$ ): 0, z min ( $\mu\text{m}$ ): 0, z span ( $\mu\text{m}$ ): 0, z max ( $\mu\text{m}$ ): 0
- ☒ use relative coordinates
- down sample X: 1, down sample Y: 1, down sample Z: 1

**Bottom Right Screenshot (Advanced Tab):**

- Name: projection
- ☒ standard fourier transform
- ☐ partial spectral average
- ☐ total spectral average
- Fields:
  - ☒ output Ex, ☐ output Hx
  - ☒ output Ey, ☐ output Hy
  - ☒ output Ez, ☐ output Hz
- Poynting vector and power:
  - ☐ output Px, ☐ output Py, ☐ output Pz
  - ☒ output power

# Simulation Setup

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# Simulation Setup

**Simple 2D simulation**

**How much accurate simulation you want**

**Low accuracy and low memory requirements for fastest simulations.**

**How do I choose?**

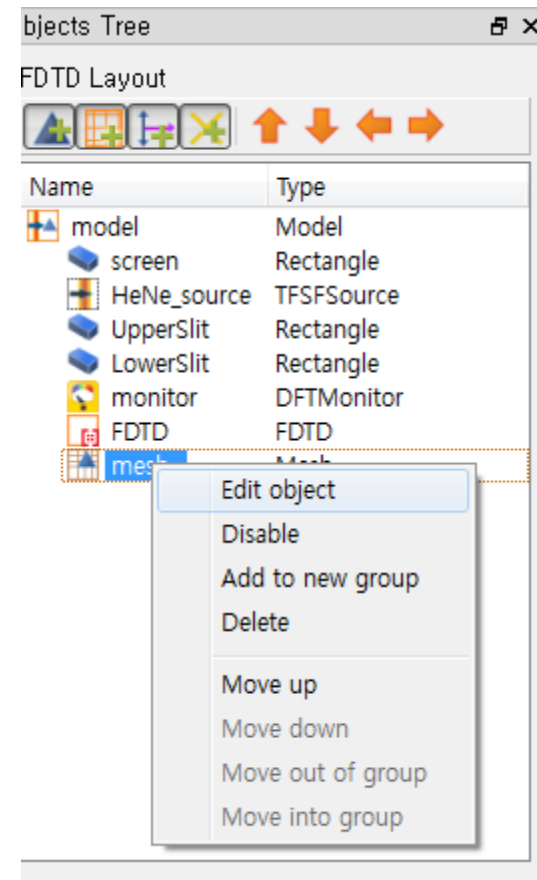
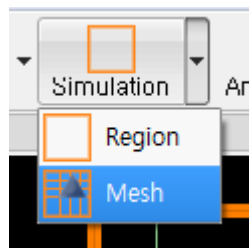
**Boundary conditions**

**Help me choose PML settings**

**OK** **Cancel**

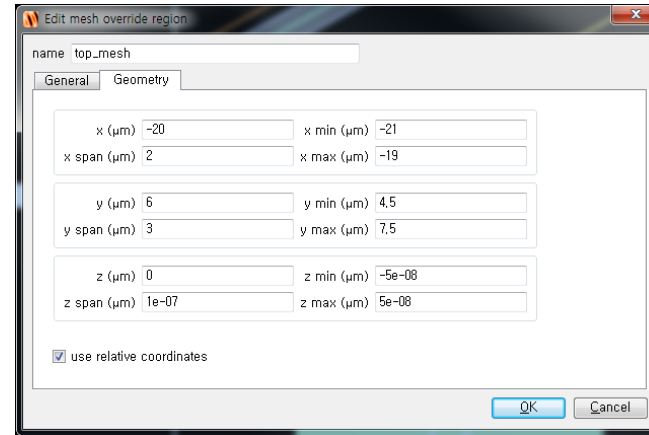
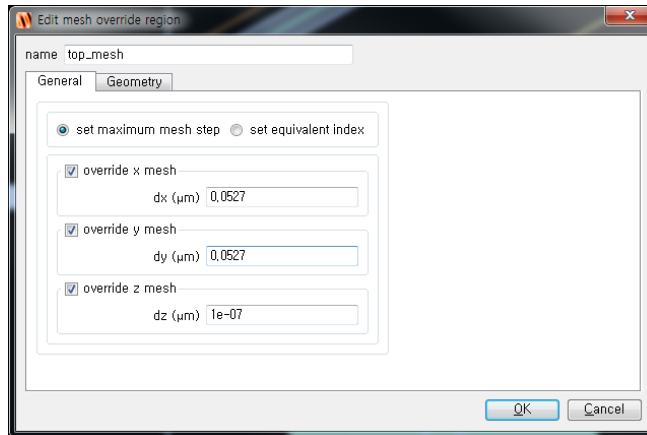
# Simulation Setup(Mesh)

- Accurate simulation is required in slits!  
→ Mesh setup

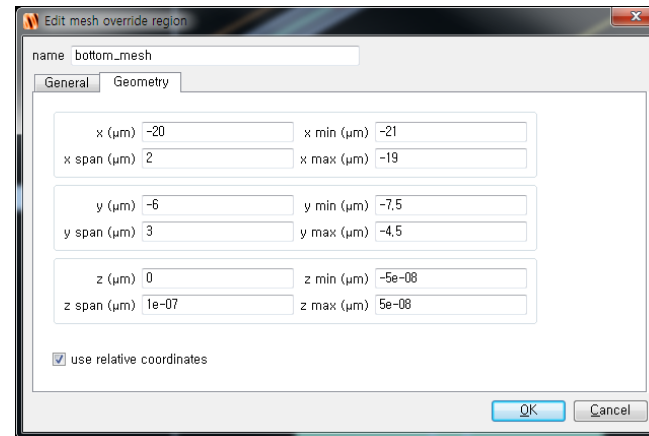
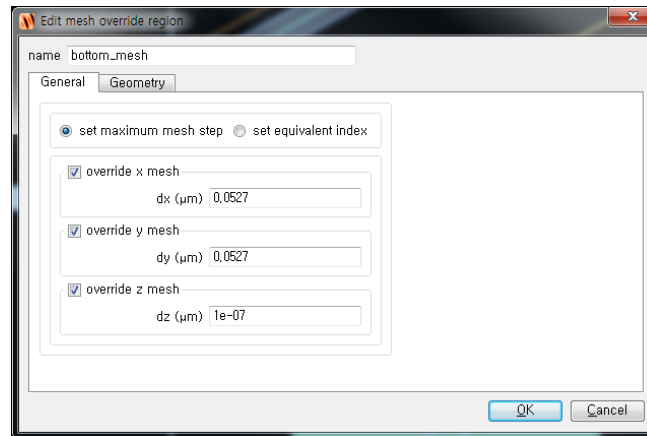


# Simulation Setup(Mesh)

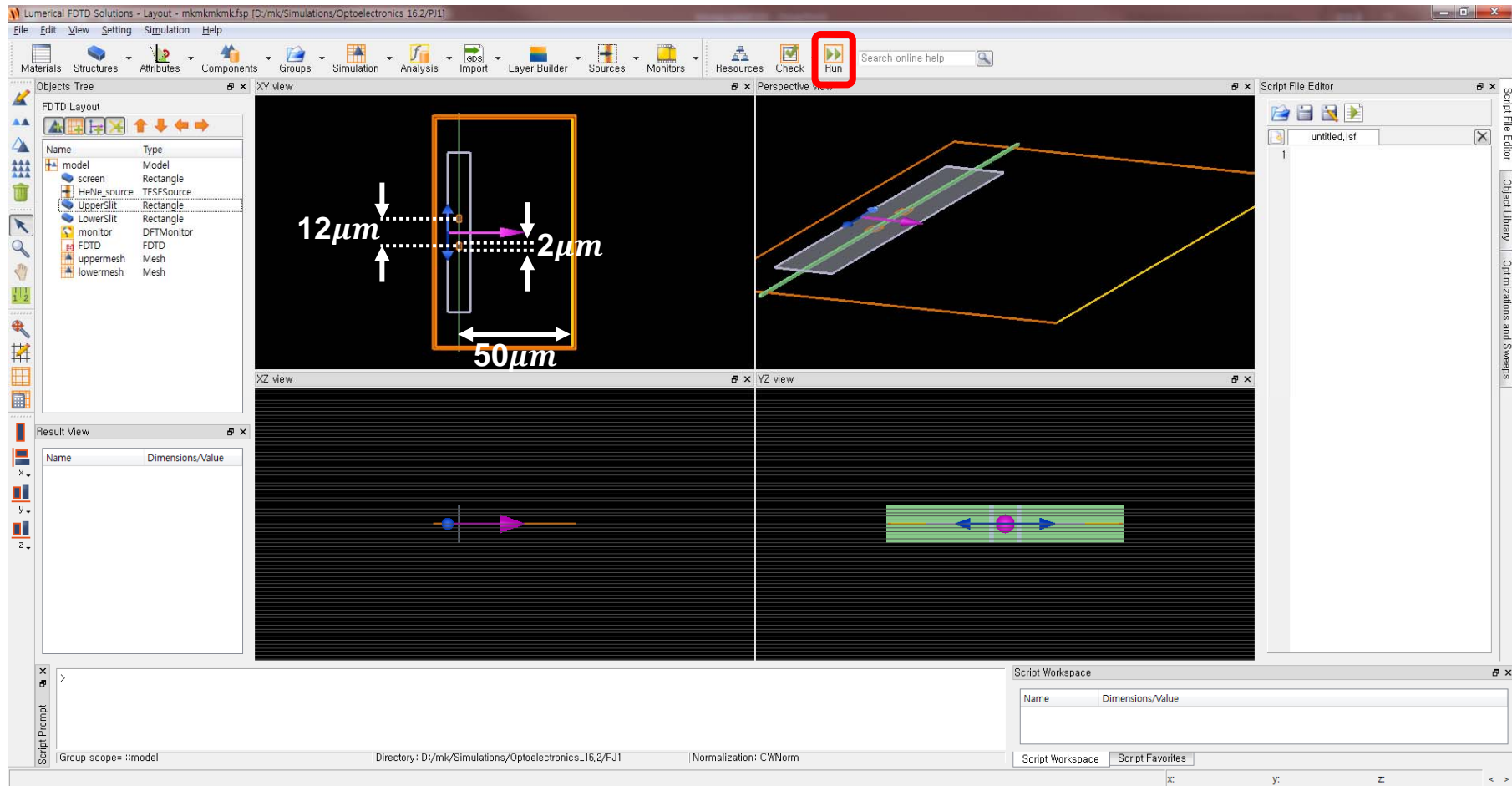
- Upper slit



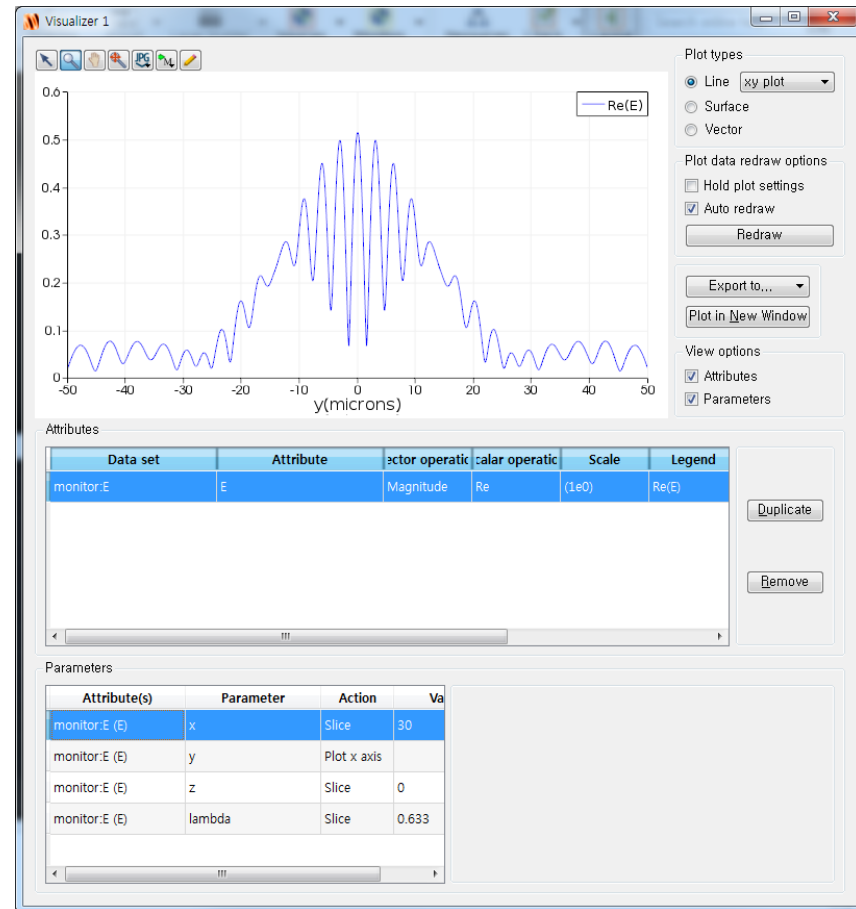
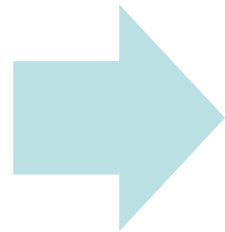
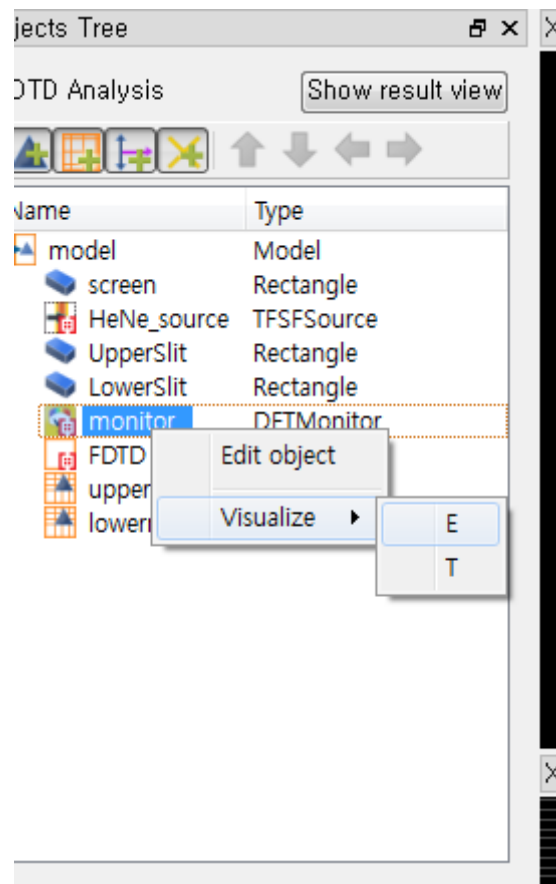
- Lower slit



# Simulation

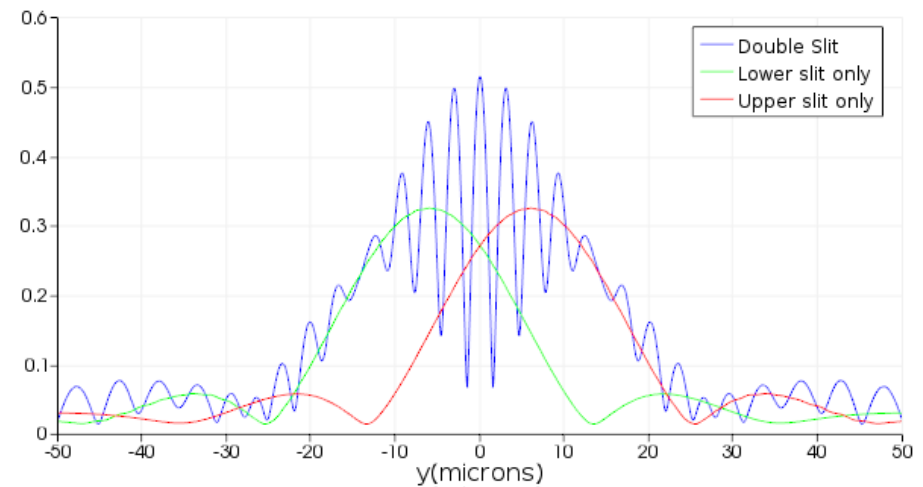
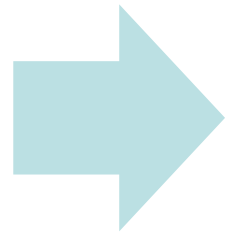
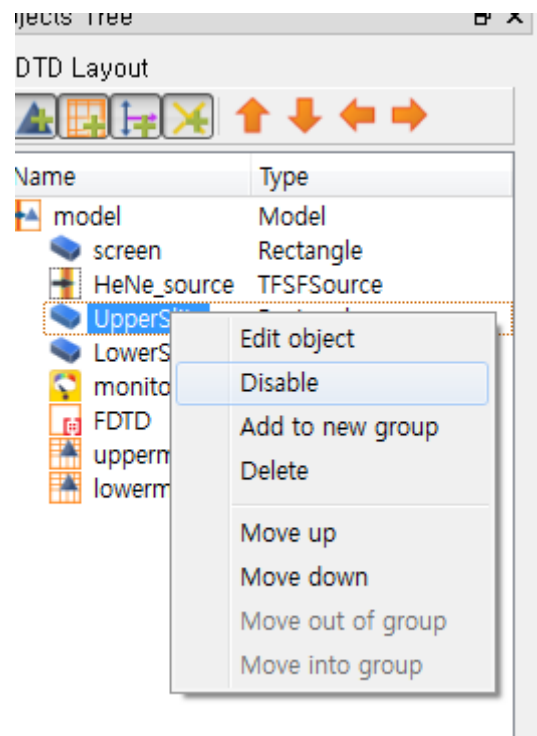


# Simulation Result

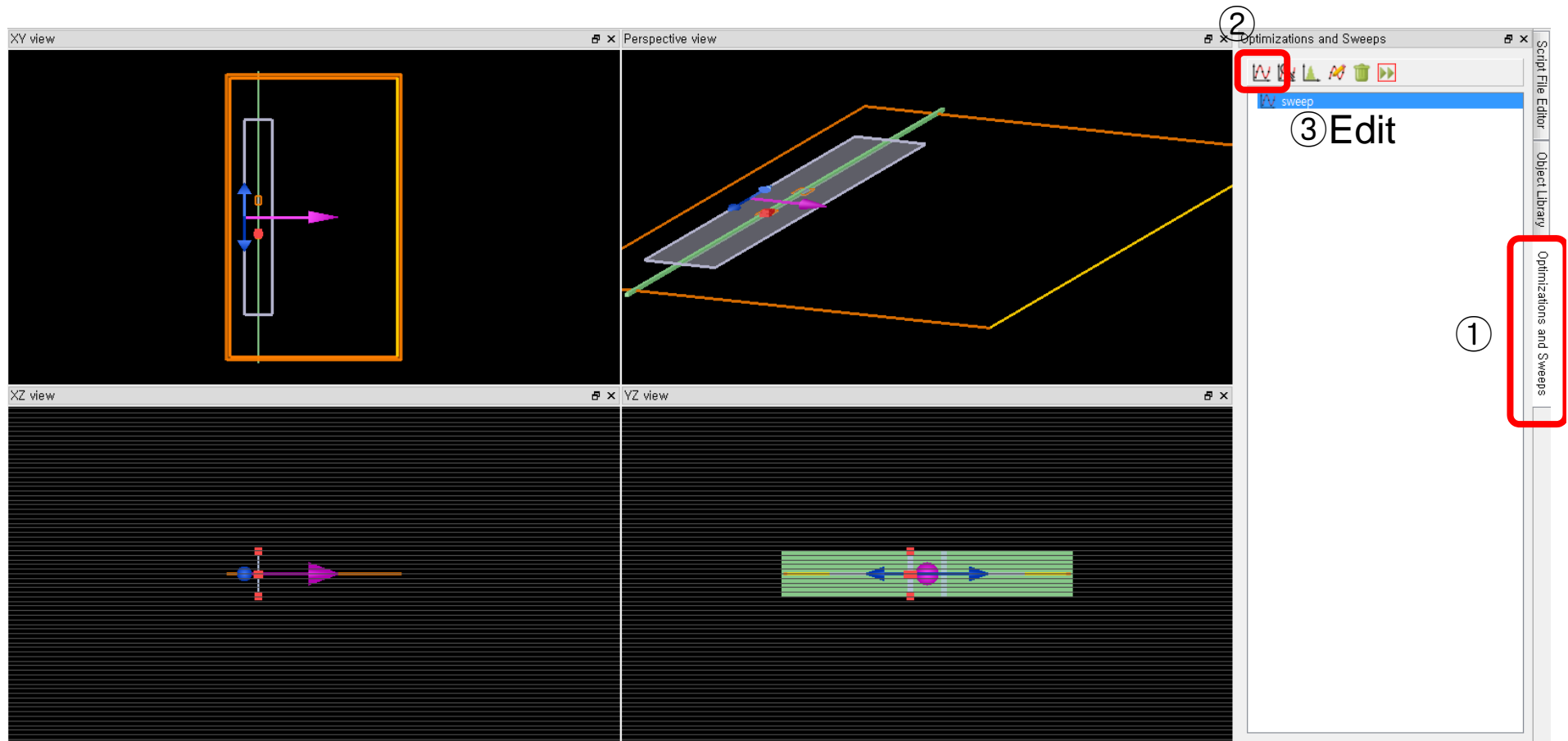


# Single Slit Experiments

- Disable one of slits → single slit experiment



# Sweep Simulation



# Slit Distance Sweep

- Sweep slit distance 4, 8, 12  $\mu\text{m}$

**Sweep position (Upper & Lower slit, mesh)**

**Get E result**

**Parameters**

Name	Parameter	Type	Start	Stop	Units
new_parameter		Number	0	0	

**Results**

Name	Result	Operation
E		

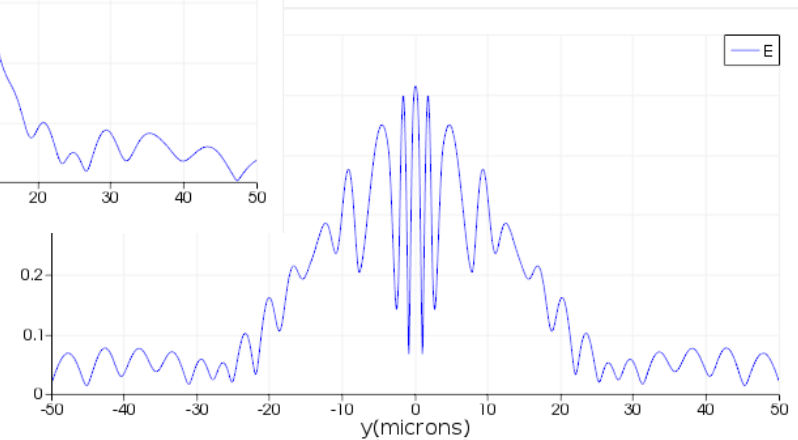
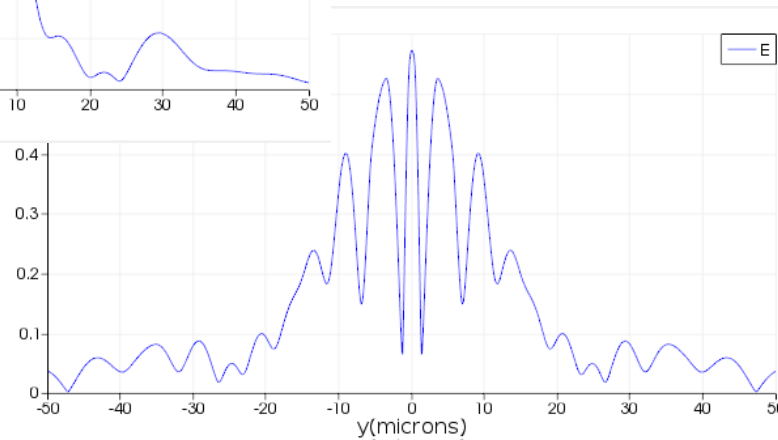
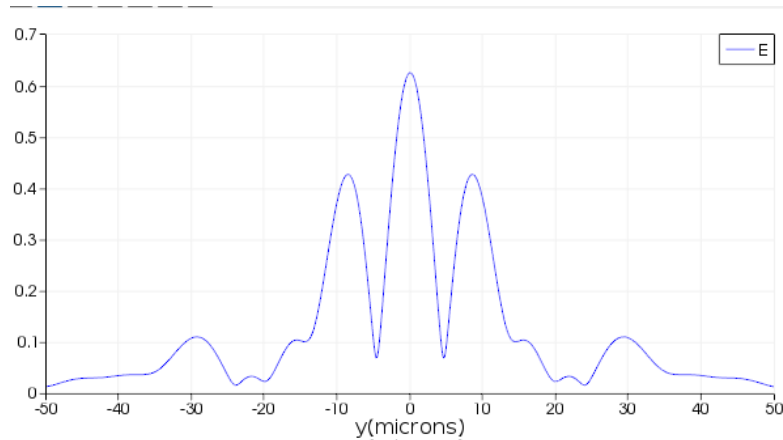
**Advanced**

☐ resave files after analysis



# Simulation Result

- $4\ \mu m$ ,  $8\ \mu m$ ,  $12\ \mu m$



# Design Exercise

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- Sweep slit width(1, 1.5, 2  $\mu m$ ) and simulate both single slit and double slit experiment.  
(Distance between two slits: 12  $\mu m$ , Distance from slit to monitor: 50  $\mu m$ )
- Sweep distance from slit to monitor(10, 30, 50  $\mu m$ ) and simulate both single and double slit experiment.  
(Distance between two slits: 12  $\mu m$ , Slit width: 2  $\mu m$ )
- Show the results respectively, and compare & analyze the results.
- Due: 10/30 in class(Hard copy)