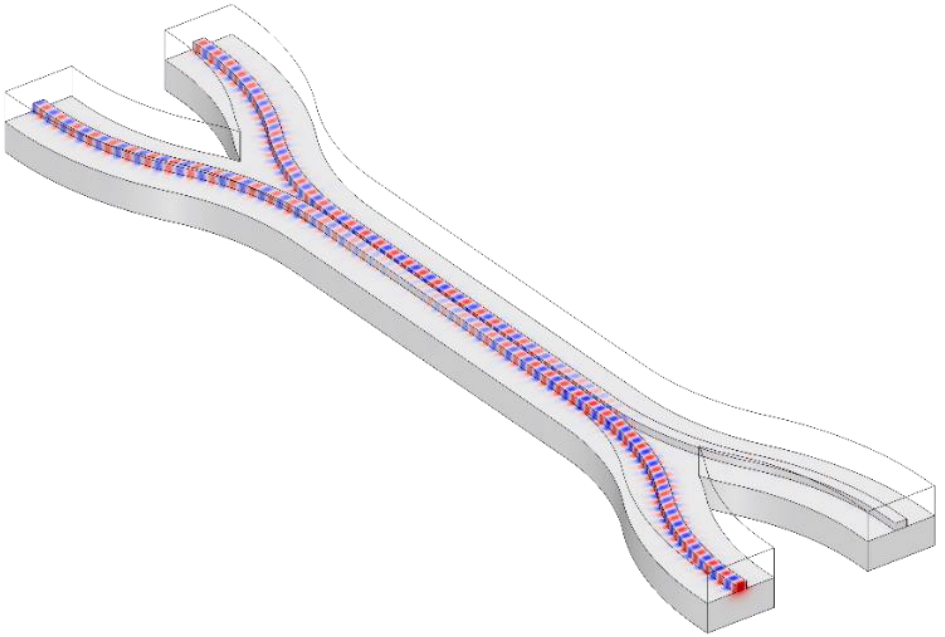
ETH zürich

P&S COMSOL® Design Tool
Lecture 1: Introduction to Optical Simulations

Guillaume Zajac, Xinzhi Zhang

Welcome to the P&S:
COMSOL Design Tool – Design of Optical Components



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Outline for Today

- **General organization**
  - Presence check
  - Protection concept
  - Learning objectives
- **Why do we need simulations?**
  - Electromagnetics in our daily life
  - EM Simulation
    - What will you be able to do...
  - Examples
- **Tutorial**
  - Introduction to the Software

Learning Objectives

- In this course, we aim to teach you the process of optical component design
- You will learn to:

… **develop** a component idea into a specific design problem

… **create** the correct simulation environment (model the photonic device)

… **analyze** simulation results and **interpret** different physical effects involved

… **evaluate** the design according to initial specifications and recommend improved solution

… **summarize** the results and report them

Semester Outline

- Simulation concept
  - EM review
  - 2D EM simulation
- Intro to COMSOL tools
  - Wave optics
  - Mode solver
  - Boundary mode solver
- Project
  - Presentation
  - Report

Semester Outline

- Simulation concept
  - EM review
  - 2D EM simulation
- Intro to COMSOL tools
  - Wave optics
  - Mode solver
  - Boundary mode solver

6 weeks

- Project
  - Presentation
  - Report

6 weeks
Final presentation: Monday, 26.05.2025
Report : Monday, 18.06.2025

If there is a conflict, please let us know early

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Projects

- Design a passive optical structure for given specifications
  - In pairs or individually
  - A list of possible projects will be given / implement own idea

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Projects

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  - In pairs or individually
  - A list of possible projects will be given / implement own idea

- Steps of Project

1. Build model
2. Set physics and boundary conditions
3. Simulate
4. Evaluate preliminary results
5. Optimize
6. Analyze and report

Projects

- Design a passive optical structure for given specifications
  - In pairs or individually
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- Steps of Project

1. Build model
2. Set physics and boundary conditions
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4. Evaluate preliminary results
5. Optimize
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- Evaluation

1. **Presentation** (12 minutes talk and 3 minutes questions, **Monday 26.05.2025**)
2. **Written report** (<10 pages with pictures and references, **Monday, 16.06.2025**)

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Practical Information – Administrative

- Time: Mondays from **13:15h** to ~**15:00 h**
- Location: **ETZ D96.1**
- Our availability: office hours ETZ K-floor

(*Send email to schedule a meeting*)

Guillaume	(ETZ K 94)	→ zajac@ief.ee.ethz.ch
Xinzhi	(ETZ K 94)	→ xinzhi.zhang@ief.ee.ethz.ch

Practical Information – Online Material

- Online material
  - https://blogs.ethz.ch/ps_comsol/
    - Presentations
    - Exercises
    - Literature
- Literature
  - B. Salah and M. Teich, *Fundamental of Photonics*, 2nd ed., 2007.
  - K. Okamoto, *Fundamentals of optical waveguides*, 2nd ed., Elsevier, 2006.

About us

- Xinzhi Zhang
  - Graphene EO-Modulators

- Guillaume Zajac
  - PICs fully implemented in ferroelectric platforms
    - MZI and IQ modulators for data encoding
    - Ring resonators and frequency combs for wavelength multiplexing
    - Passive devices (GC, EC) for efficient fiber to chip coupling
  - Integration with electronics for CMOS compatibility

Questions?

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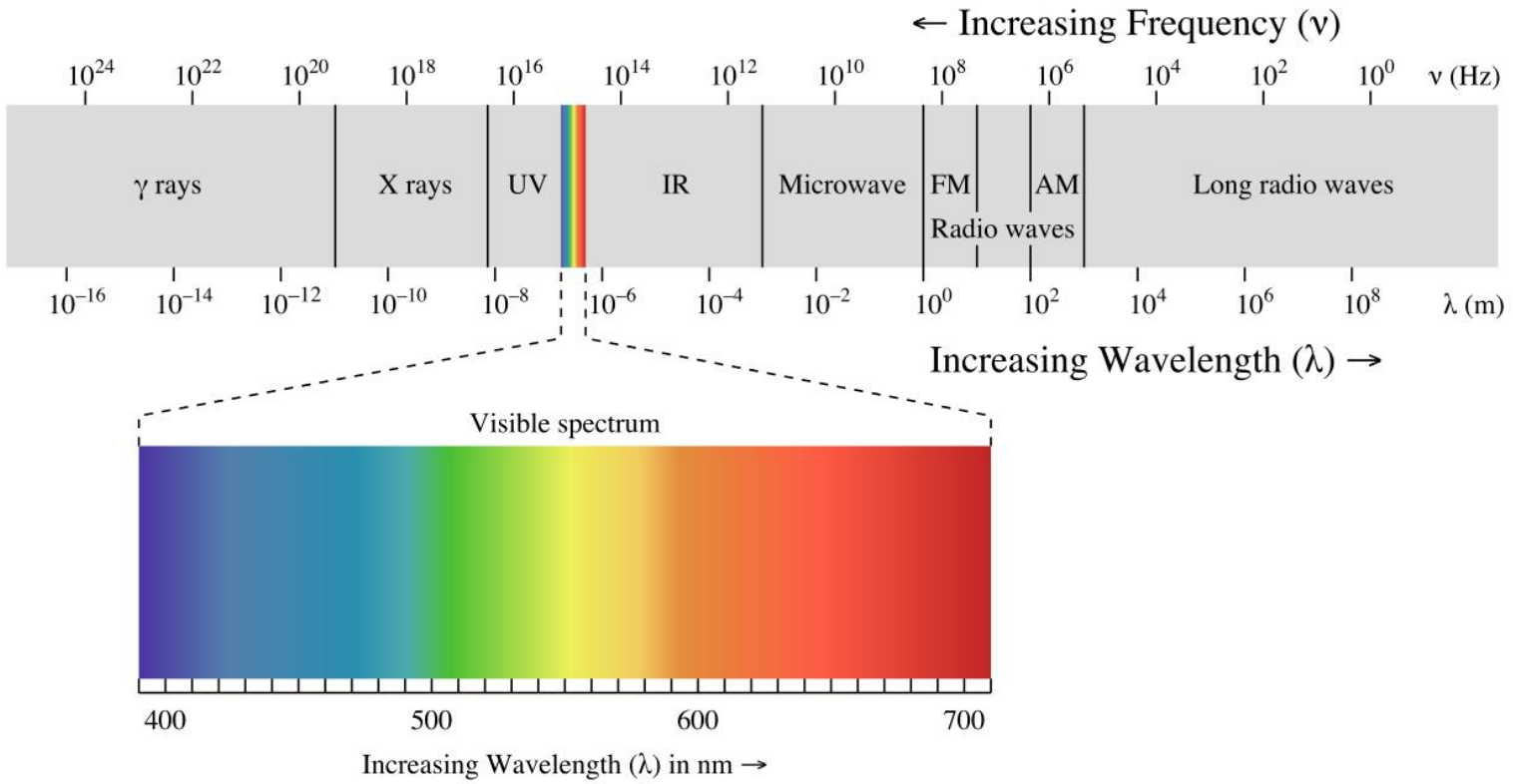
Electromagnetics in Our Daily Life



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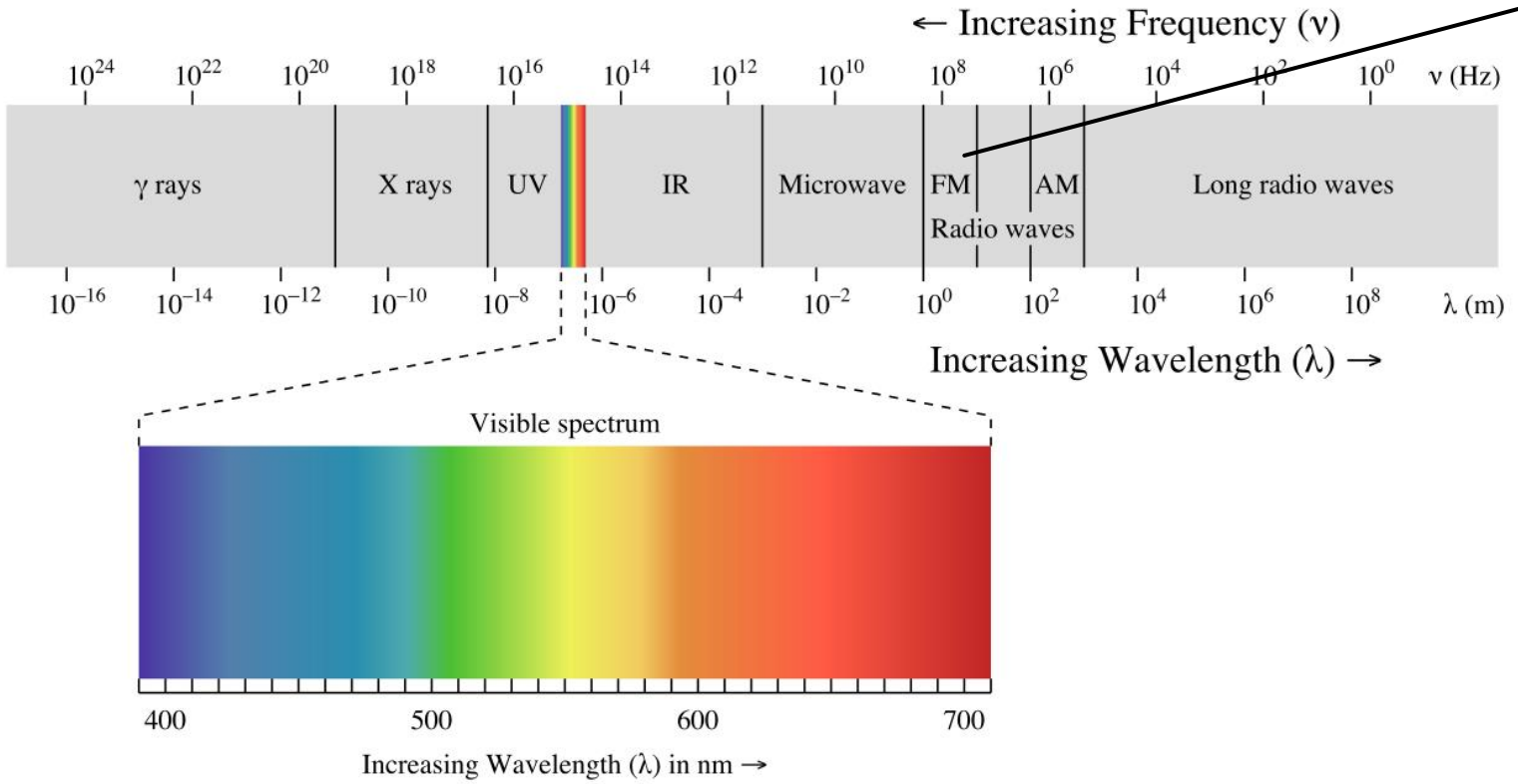

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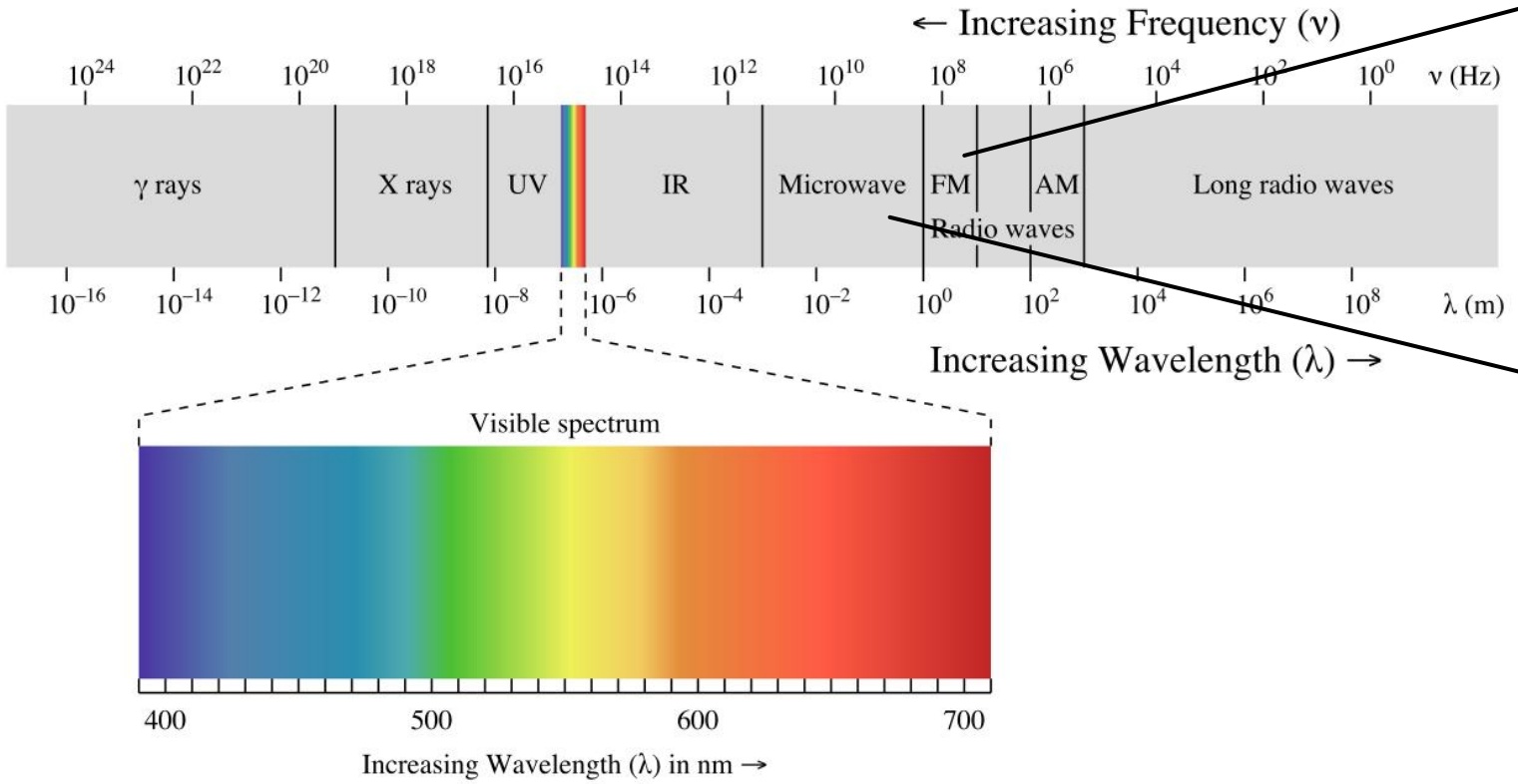

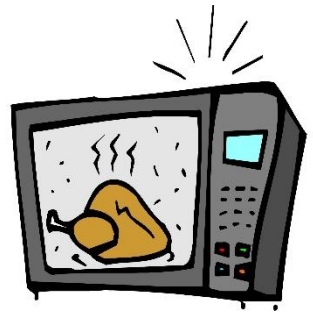

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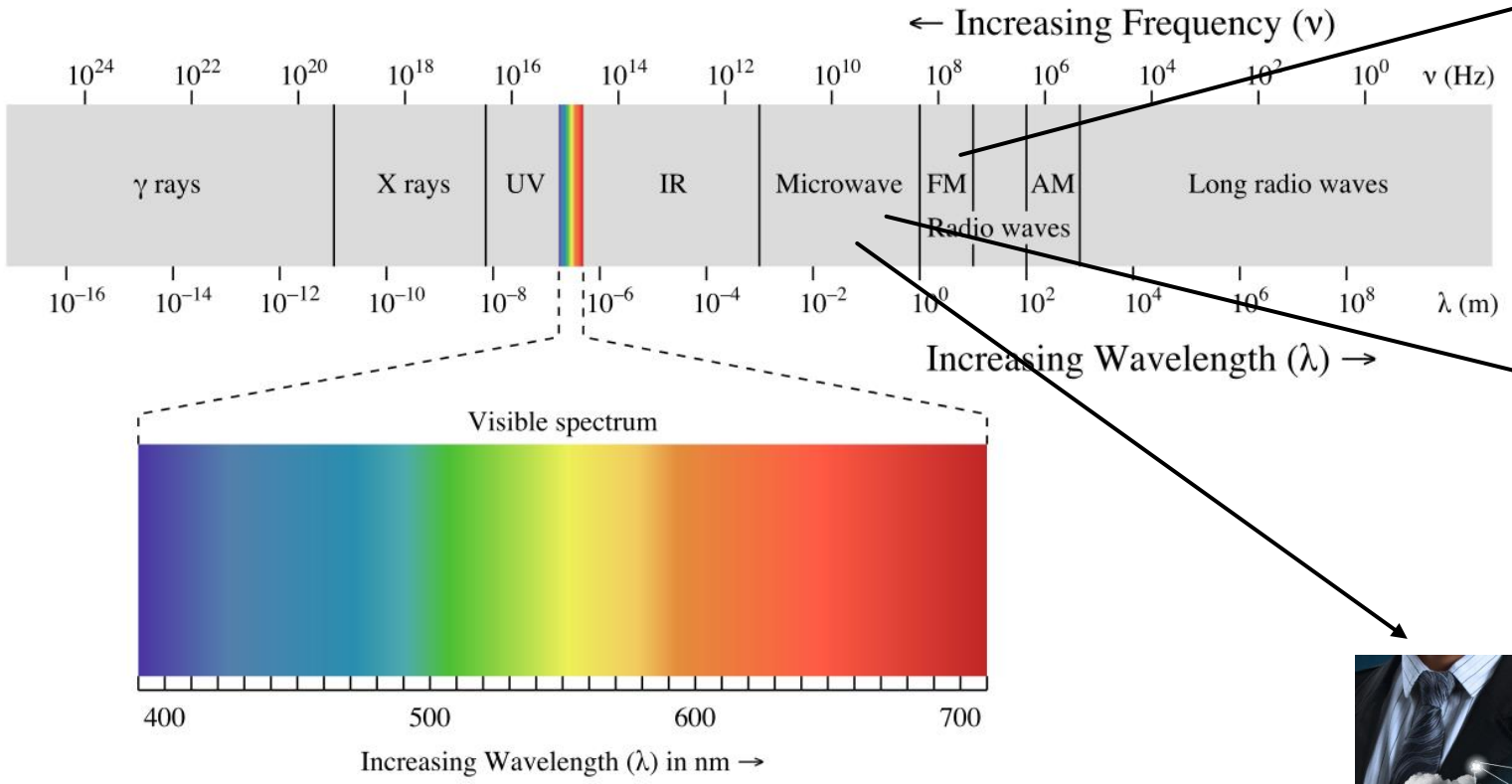

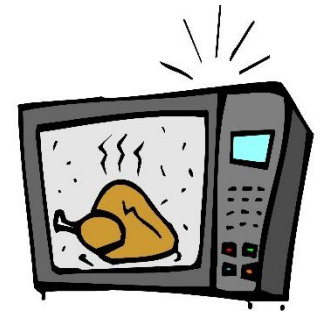

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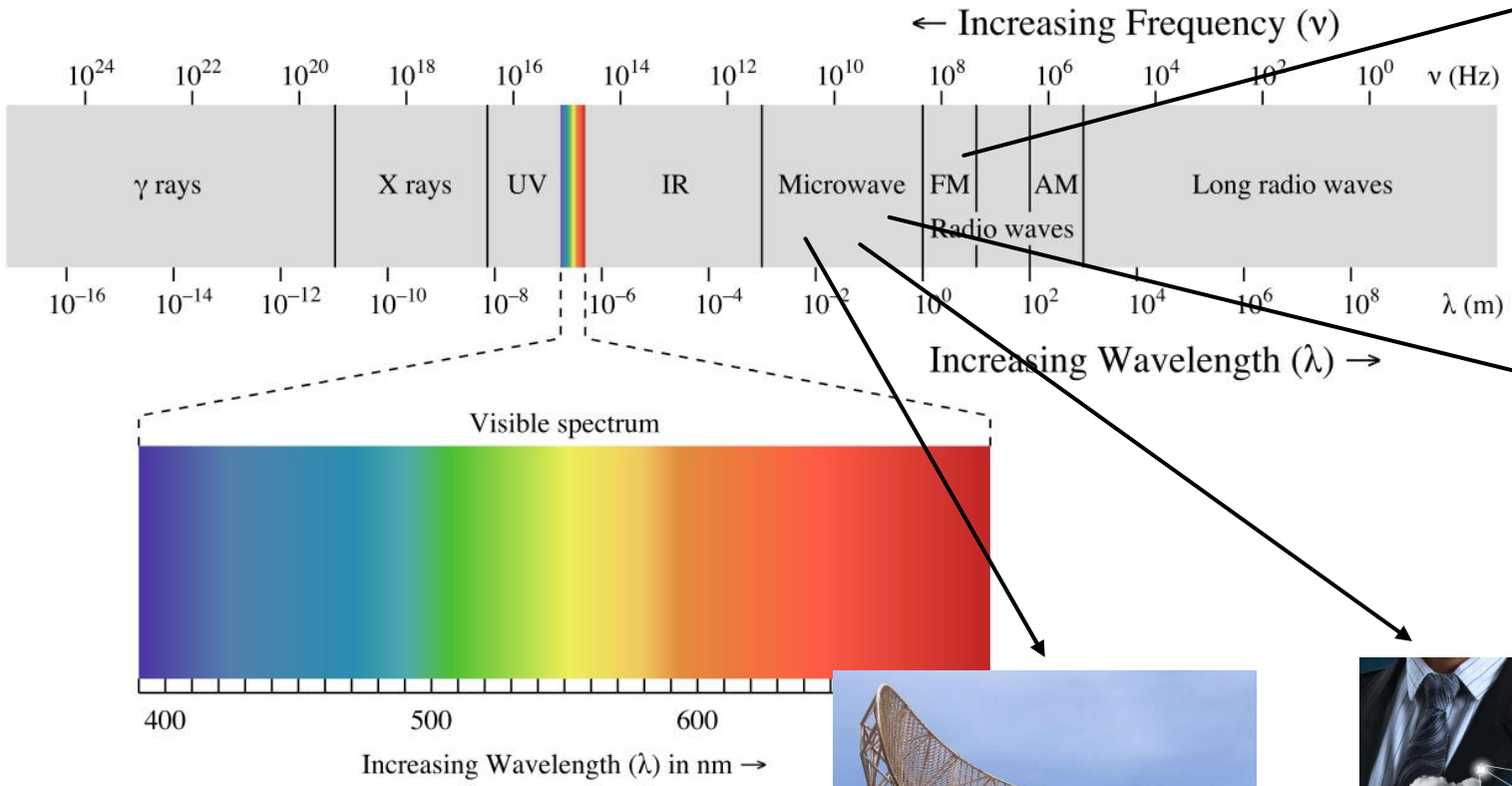

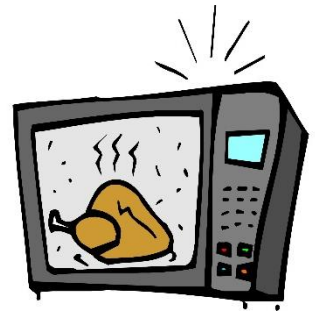

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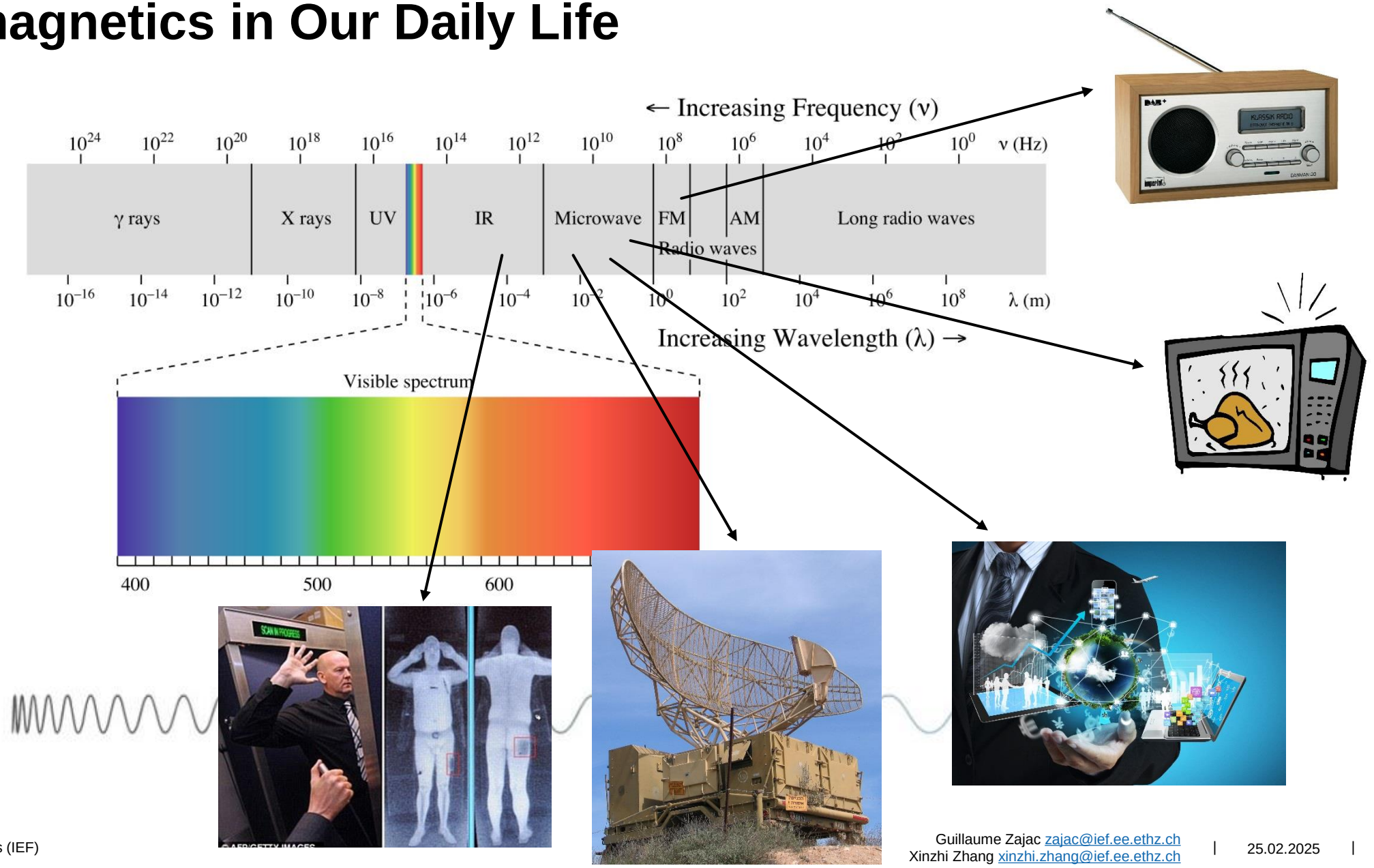

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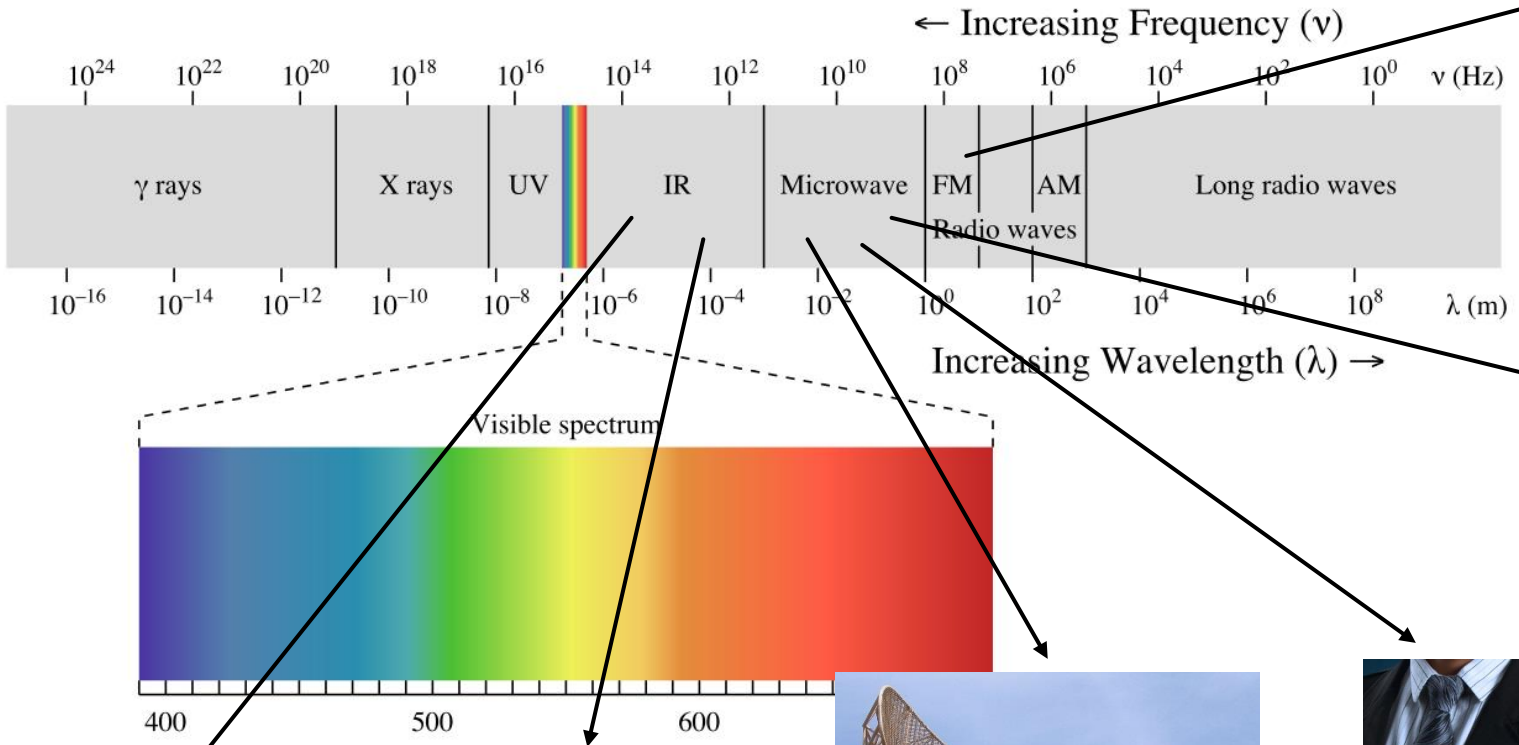

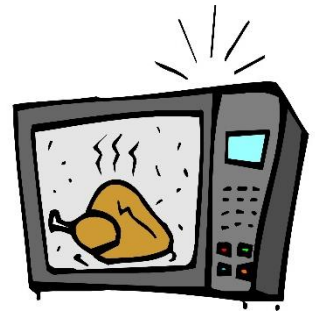

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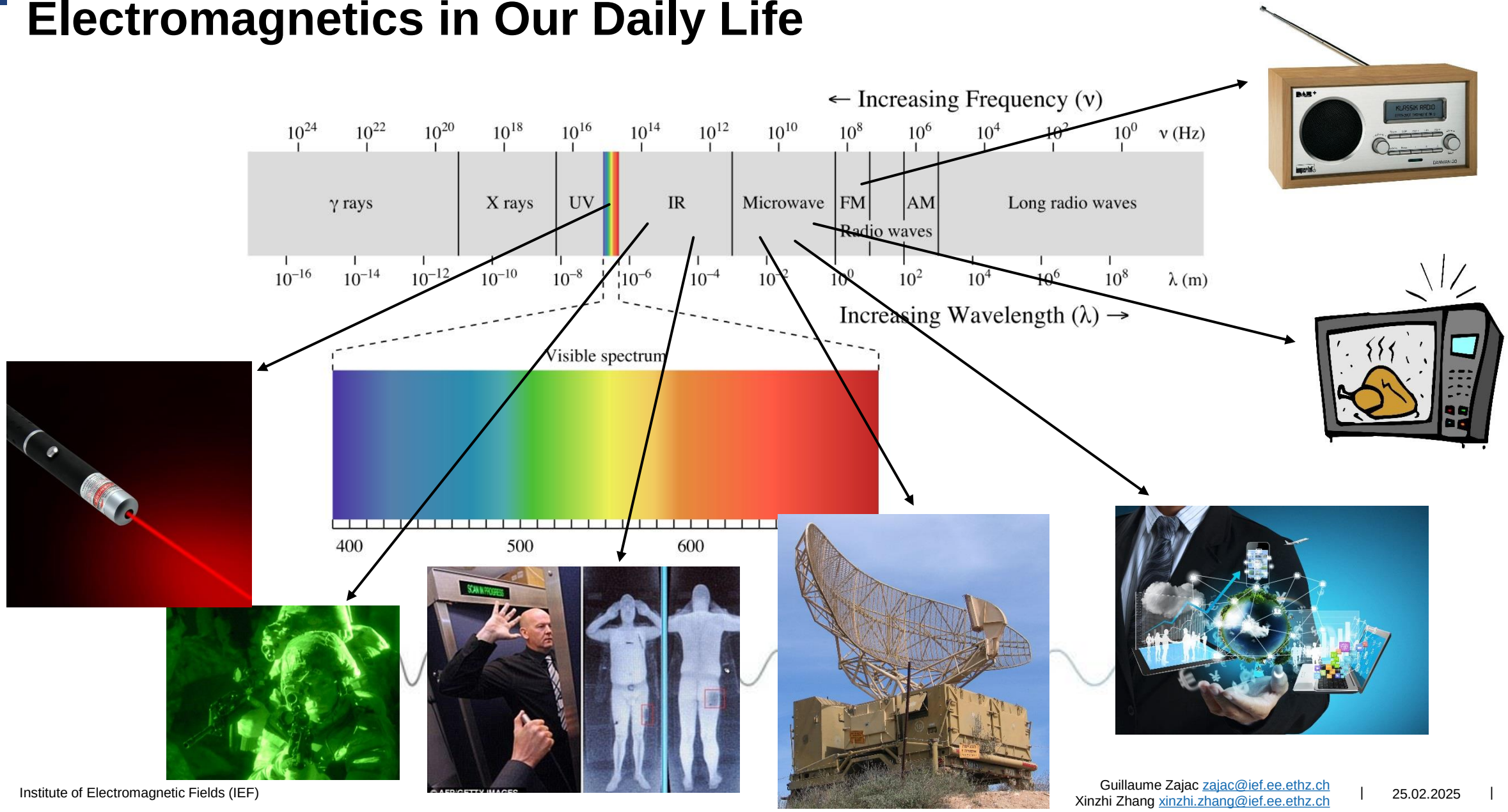

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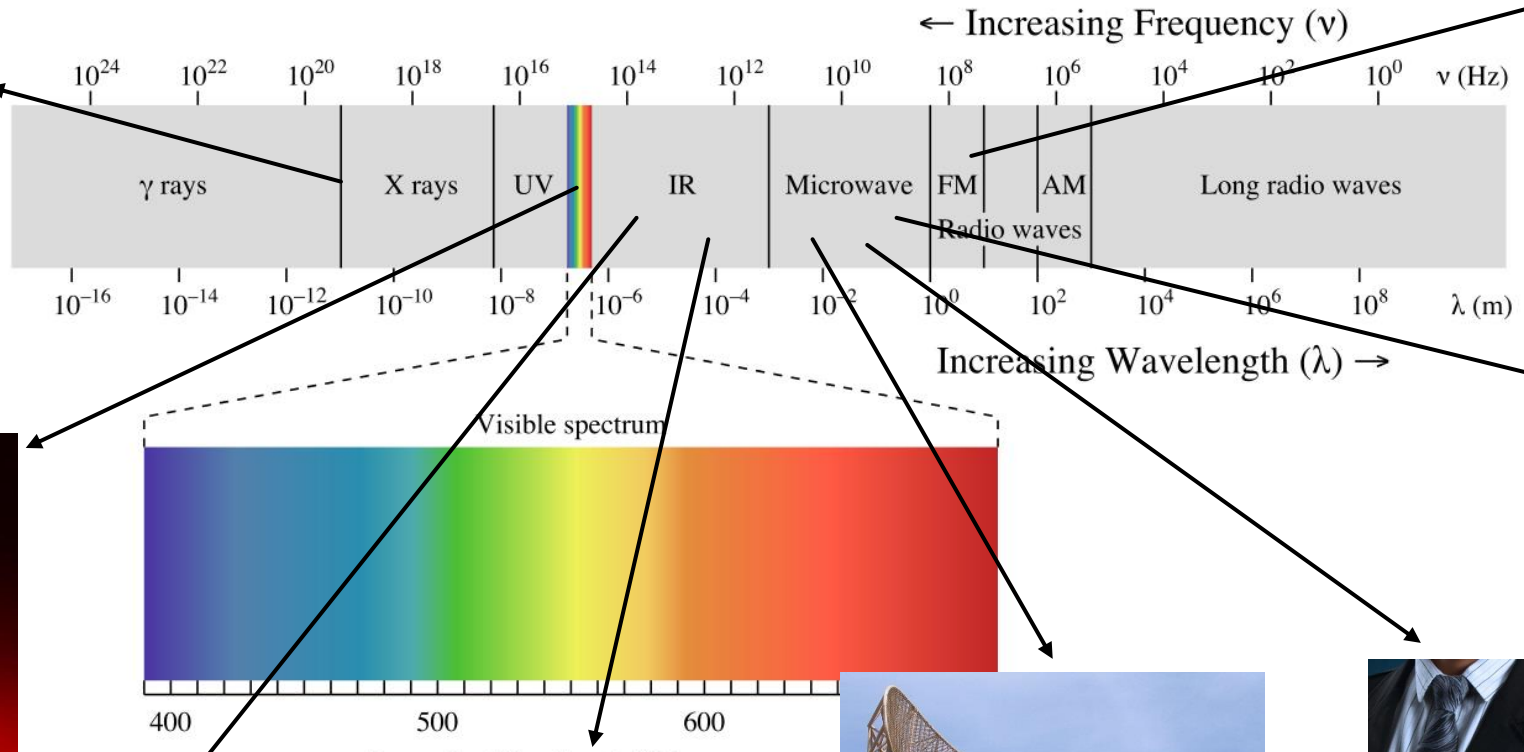

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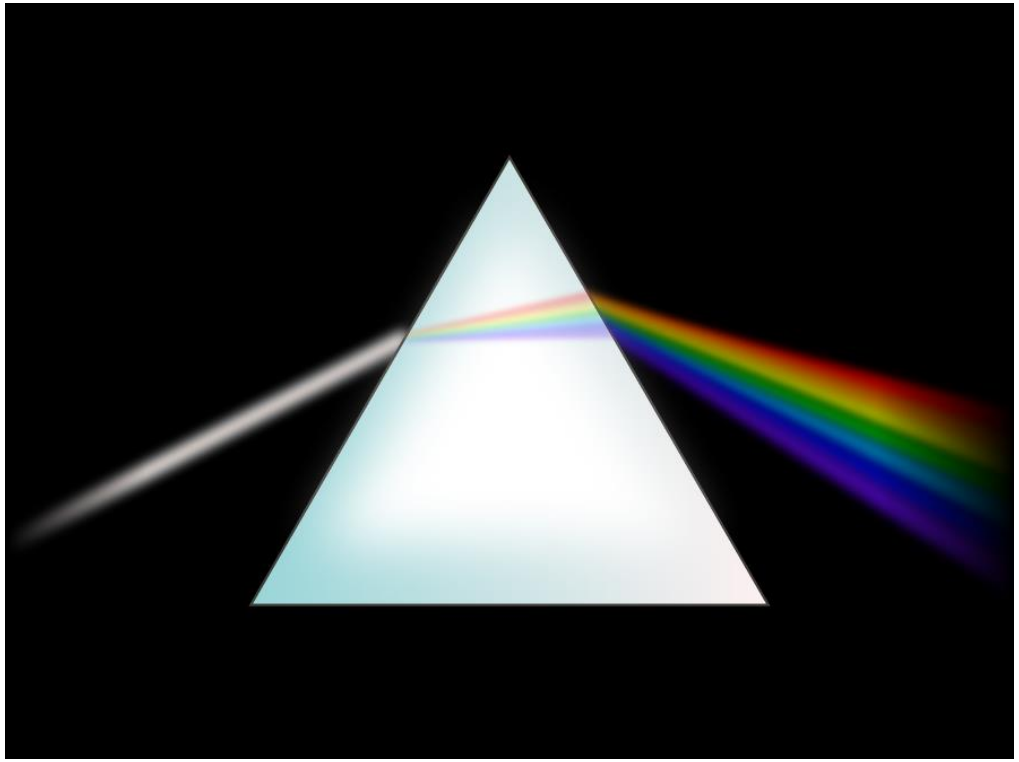
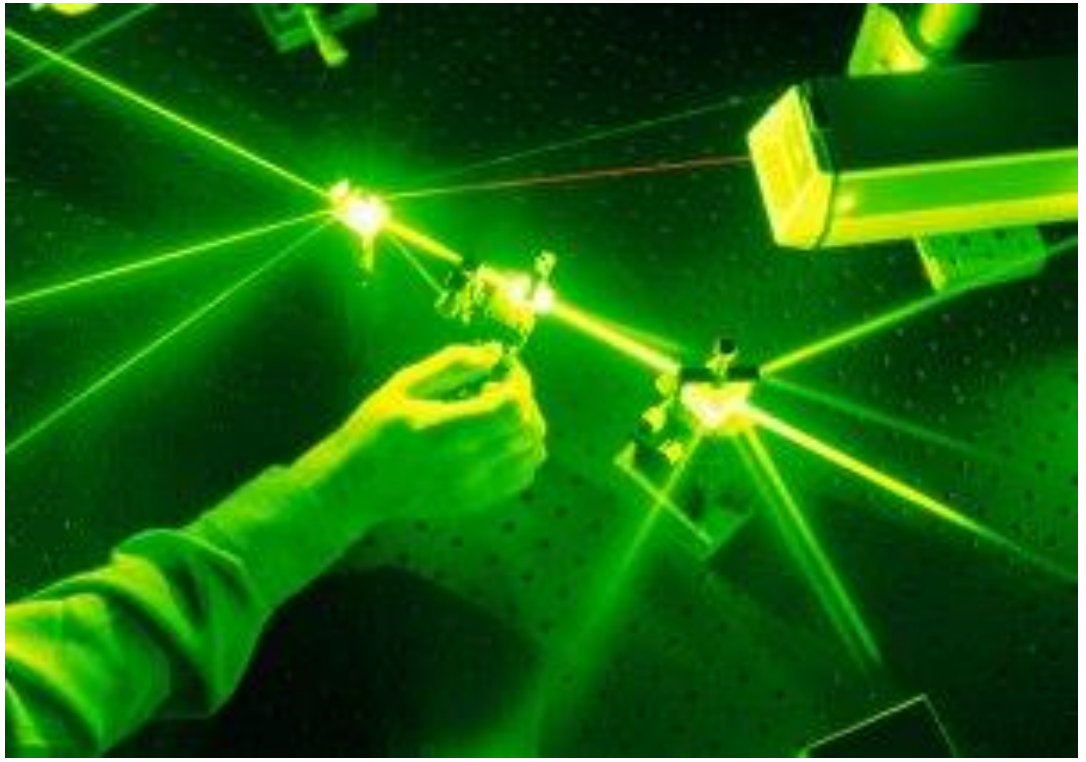
Photonics

- Photonics – studying the properties of light





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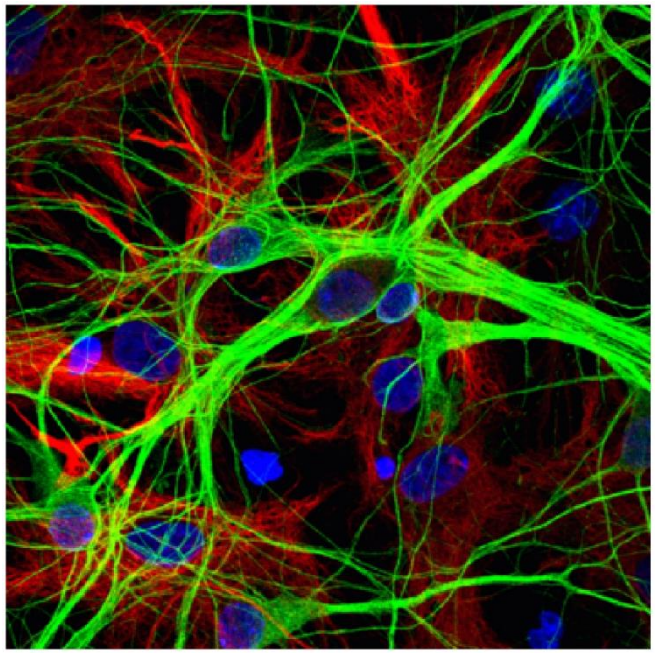
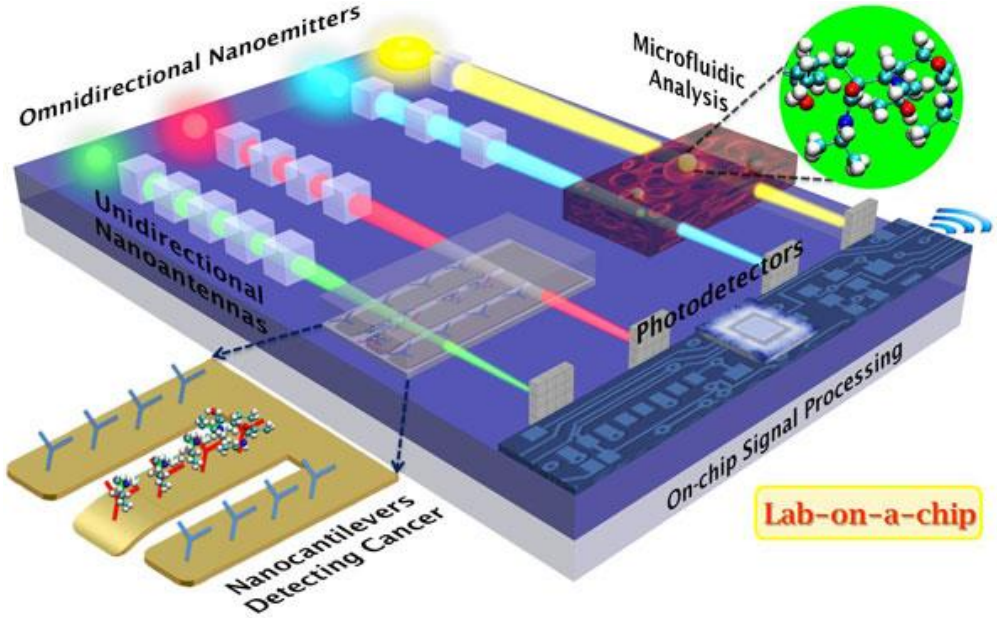
Photonics Today

- Photonics – studying the properties of light
- Where do we use it today?
  - ***Biology – Lab-on-Chip***





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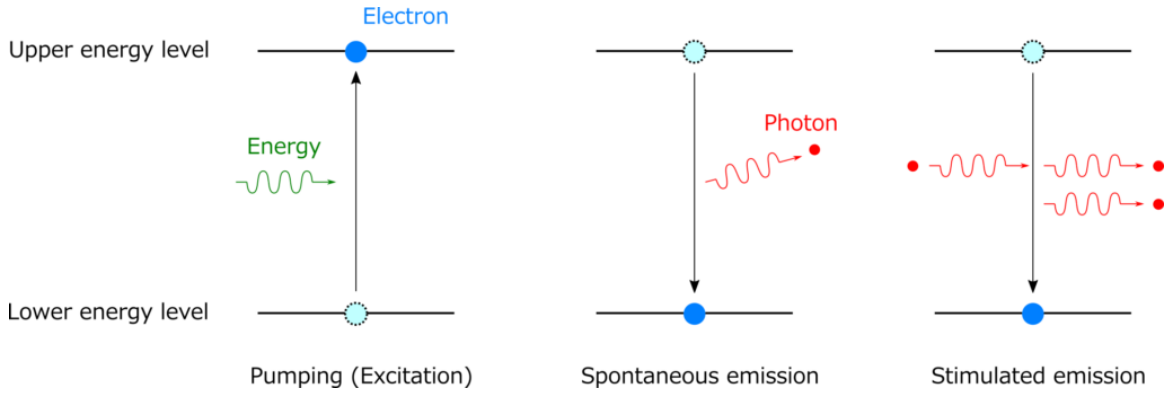
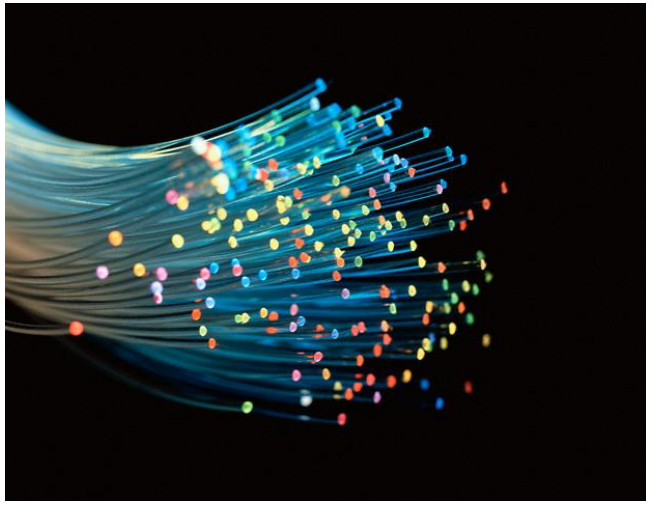
  - *Biology – Lab-on-Chip*
  - ***Quantum effects***

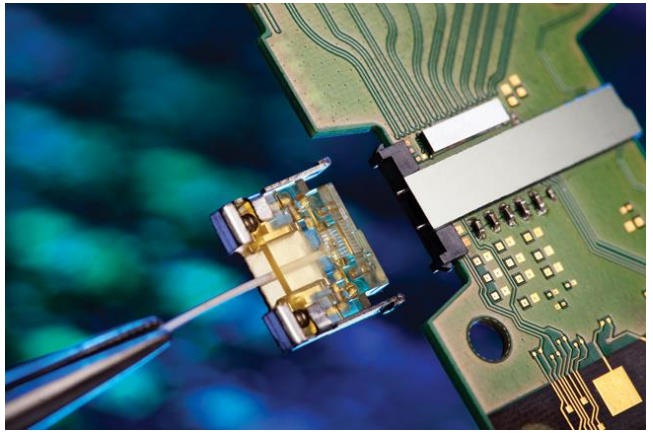


Laser Pointer

Photonics Today

- Photonics – studying the properties of light
- Where do we use it today?
  - *Biology – Lab-on-Chip*
  - *Quantum effects*
  - ***Telecommunications***
    - ***Fiber replaces traditional copper wires***
    - ***5G***





Source: Intel

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Communication: From Radio to Fiber

- Radio waves
  - Copper wires (TV/Phone)
  - Broadcasting

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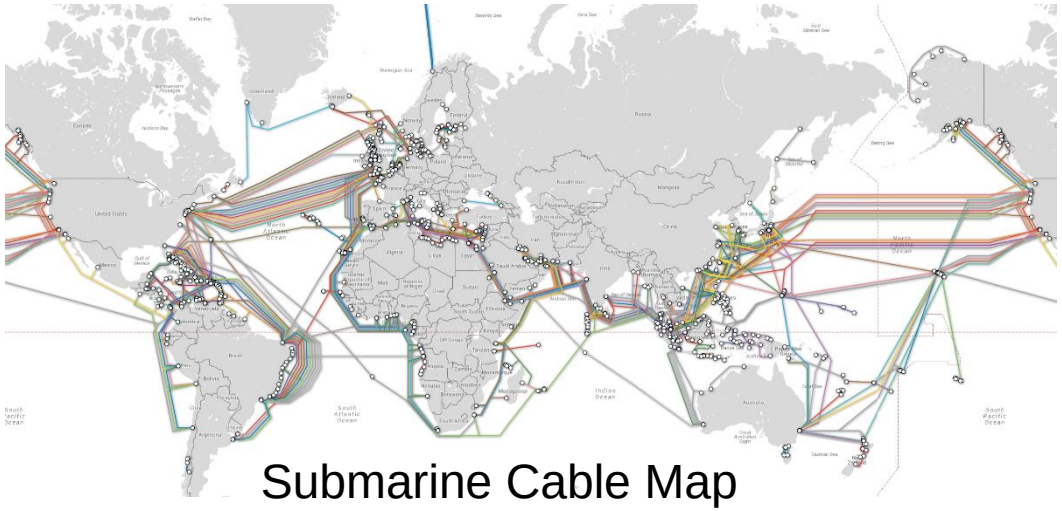
Communication: From Radio to Fiber

- Radio waves
  - Copper wires (TV/Phone)
  - Broadcasting

- Fiber optics (NIR)
  - Advantages
    - Large bandwidth
    - Low losses
  - Fiber deployment
    - Long distances: Submarine Cables
    - Short distances: Server



Submarine Cable Map

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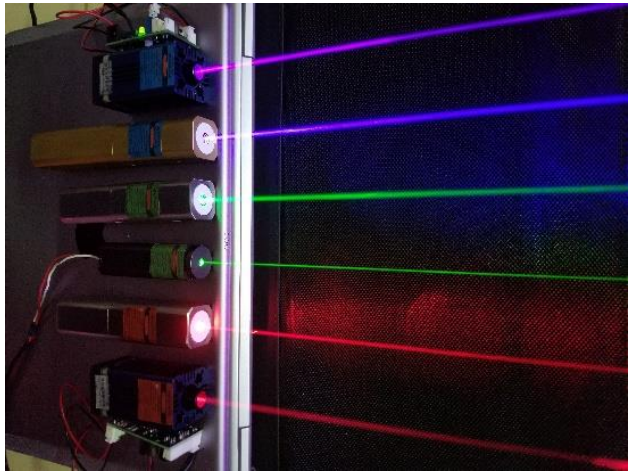
Photonics for Communications: Basic Principles

1: Light generation



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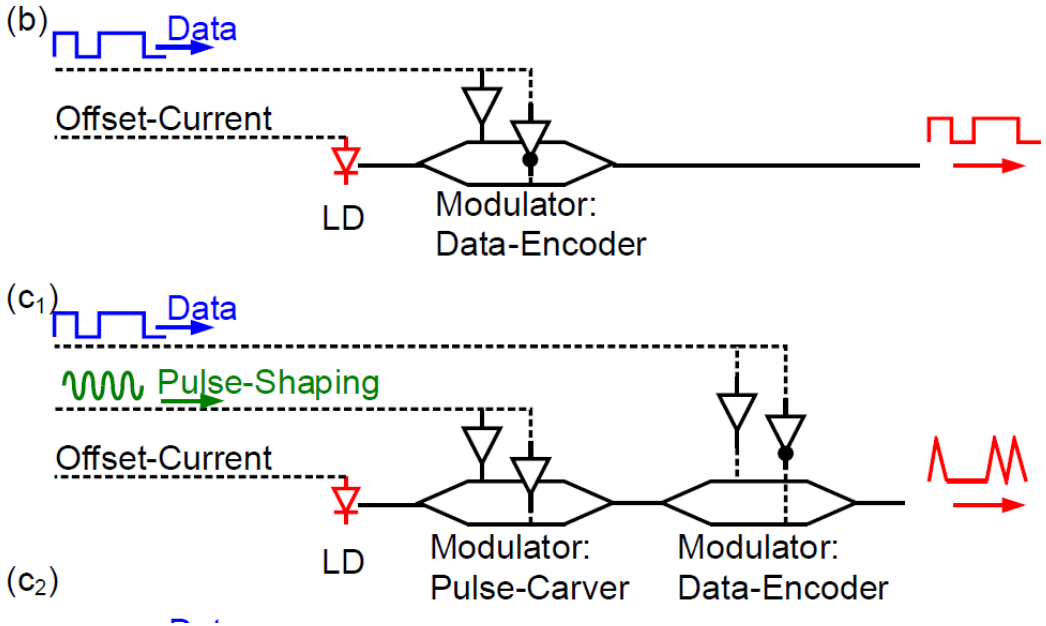
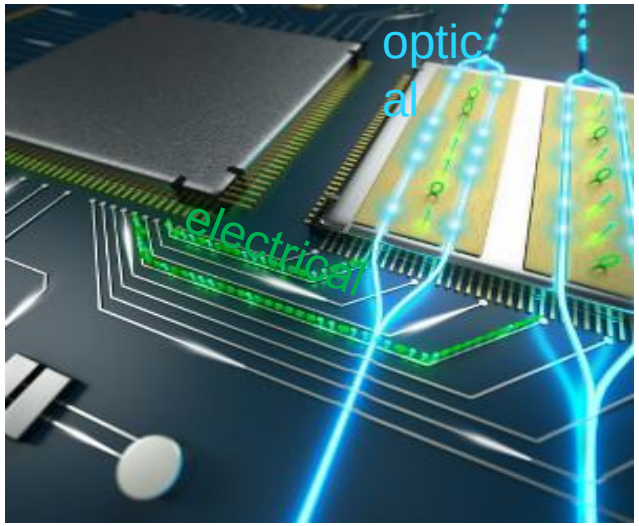
Photonics for Communications: Basic Principles

1: Light generation

2: Light modulation for data encoding





Modulator: From electrical data to optical data

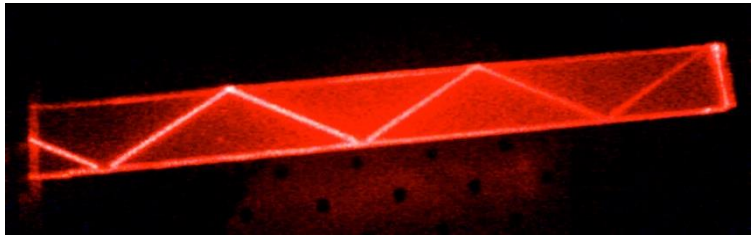
Photonics for Communications: Basic Principles

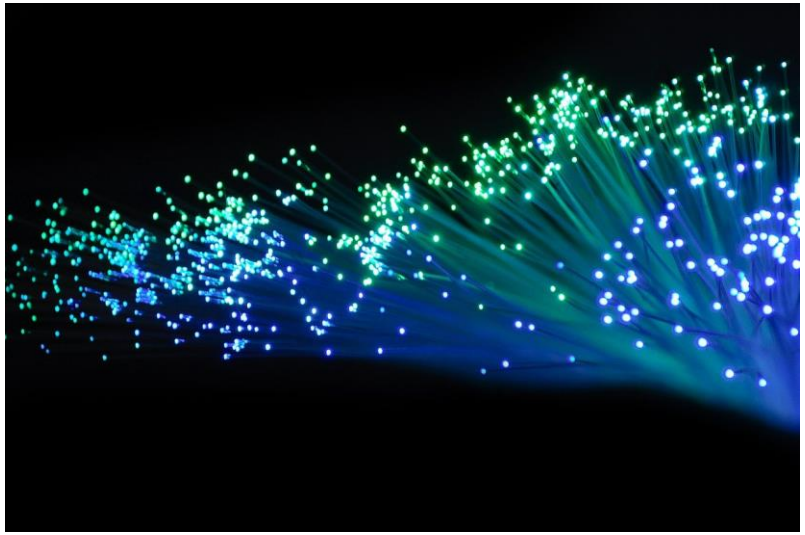
1: Light generation

2: Light modulation for data encoding

3: Light guiding, waveguides and optical fibers

Fiber guides light





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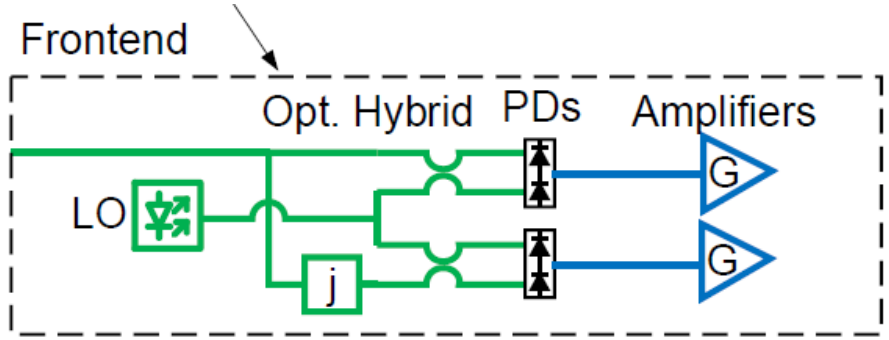
Photonics for Communications: Basic Principles

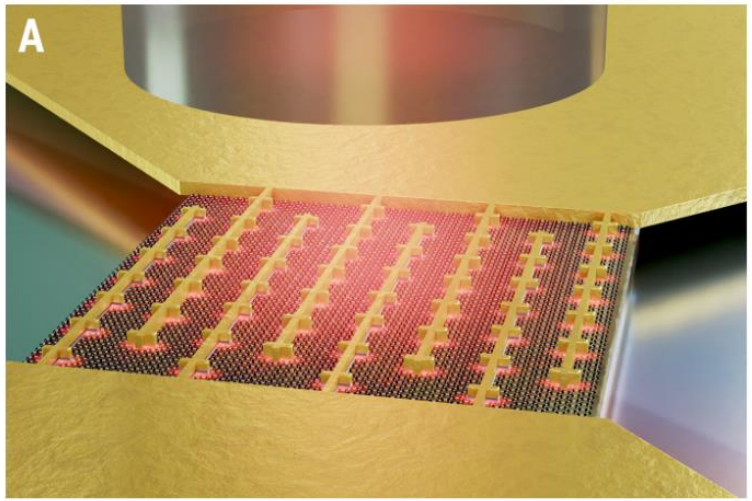
1: Light generation

2: Light modulation for data encoding

3: Light guiding, waveguides and optical fibers

4: Light detection and data demapping





Detector: From optical data to electrical data

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Why do we need simulations?

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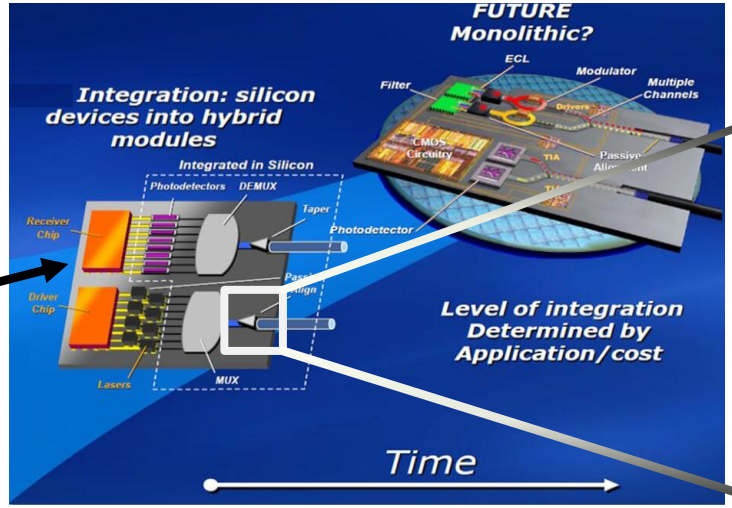
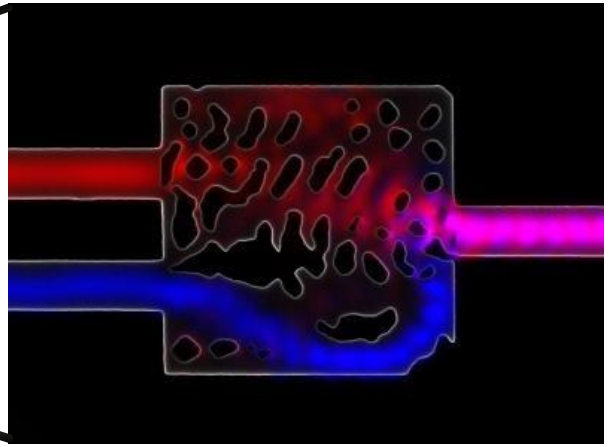
Why Simulate?

- Implementation of devices
  - Devices need a design**!**
  - Fabrication & characterization (test)
  - Improvement of the design

} Time & money





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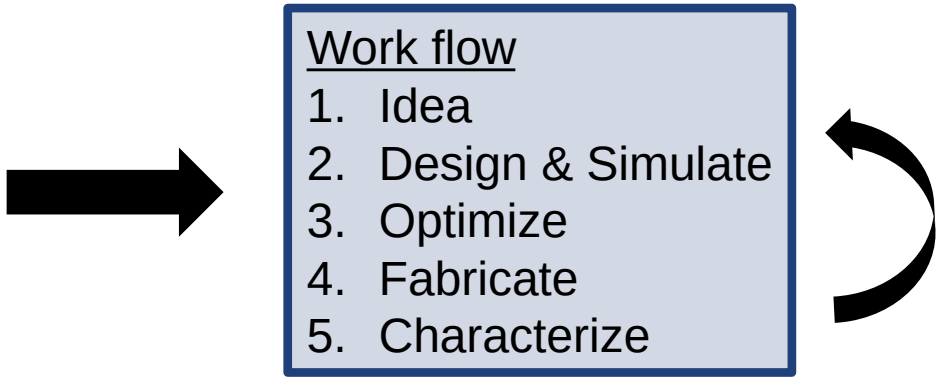
Why Simulate?

- Implementation of devices
  - Devices need a design**!**
  - Fabrication & characterization (test)
  - Improvement of the design

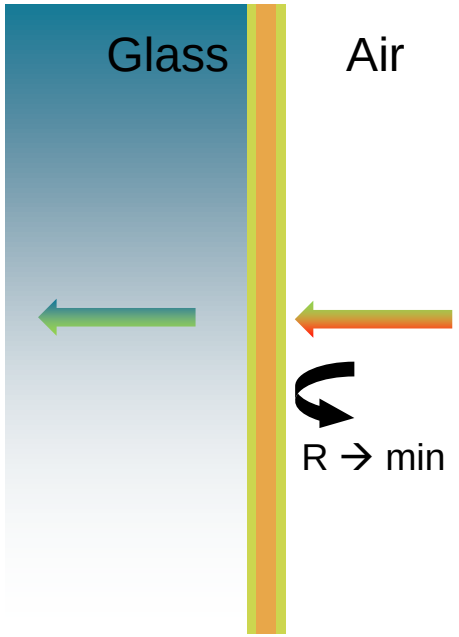
} Time & money

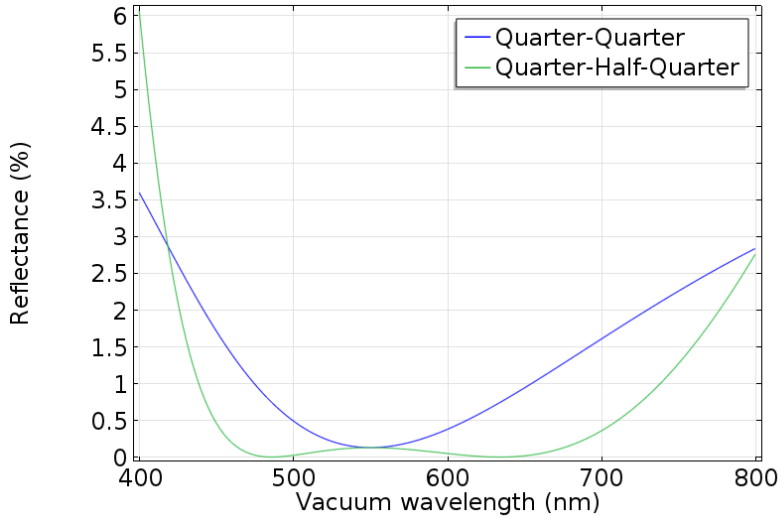
- We perform simulations to…
  - Shorten the developing time
    - Fast
    - Cost effective
  - Test physical models
  - Confirm experimental data
  - Investigate ideas



What you will be able to simulate…

- Anti – reflection coating

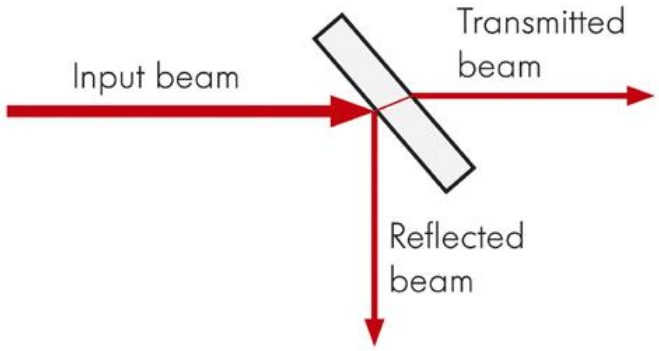




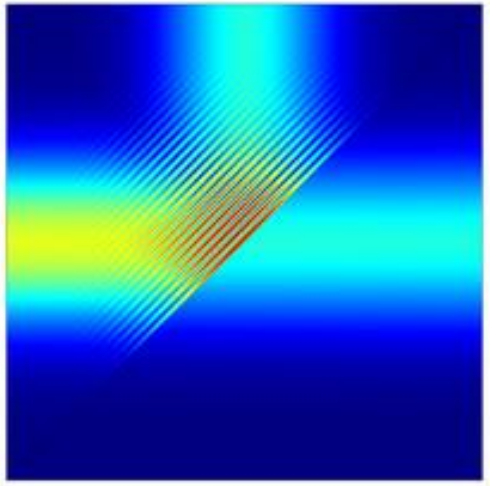
What you will be able to simulate…

- Beam Splitter

1.



2. & 3.



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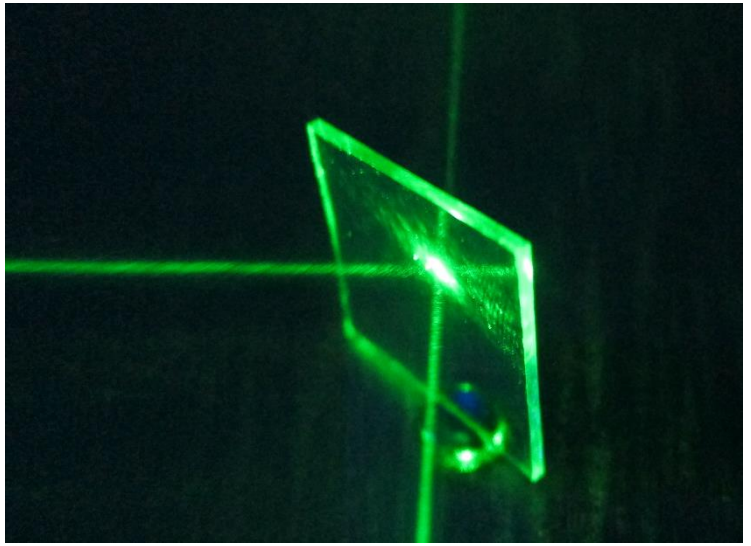
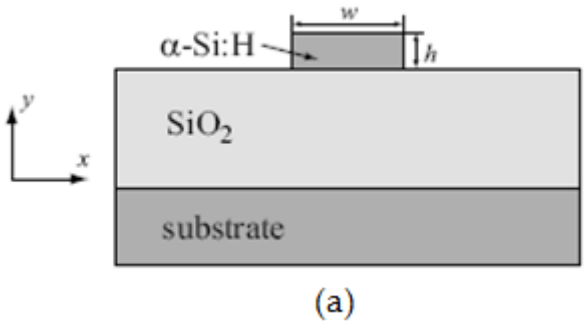


What you will be able to simulate…

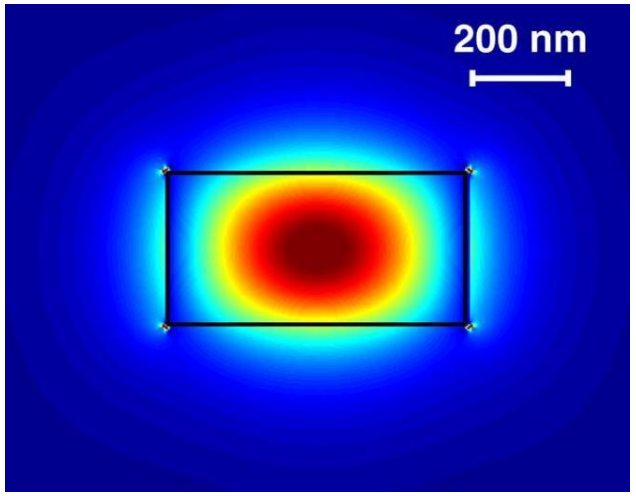
- Silicon waveguide

1.



(a)

2. & 3.



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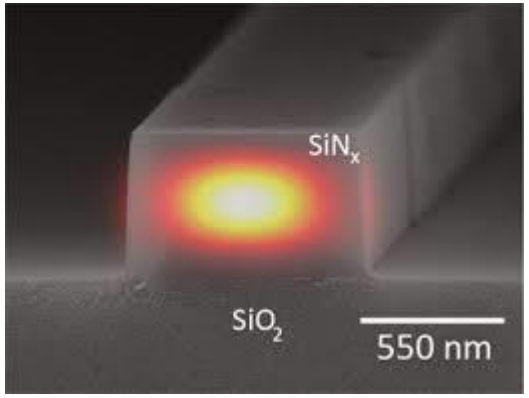

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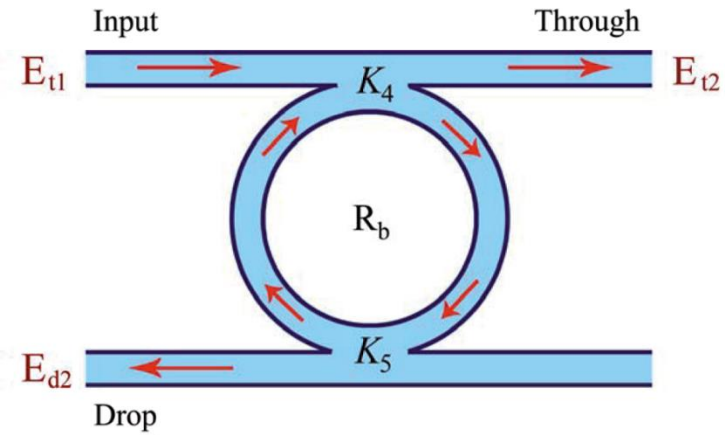
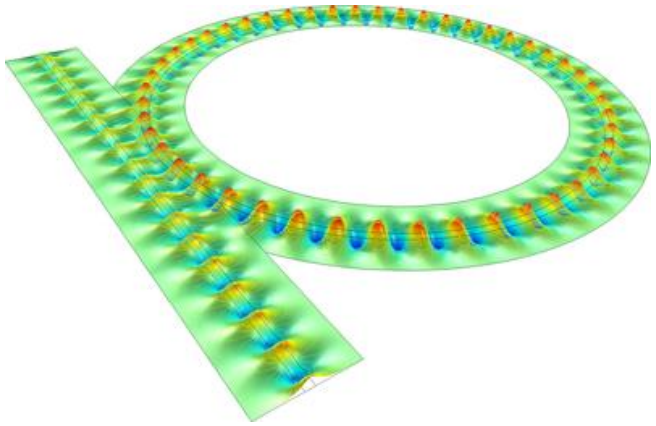
What you will be able to simulate…

- Optical add-drop filters

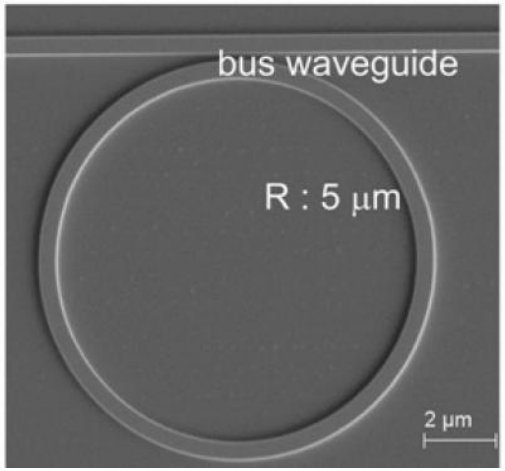
1.



2. & 3.



4.

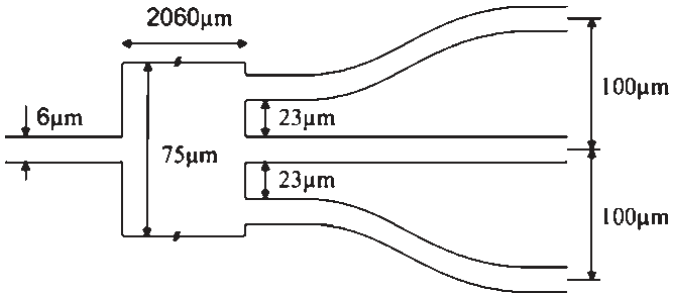


Guillaume Zajac zajac@ief.ee.ethz.ch
Xinzhi Zhang xinzhi.zhang@ief.ee.ethz.ch

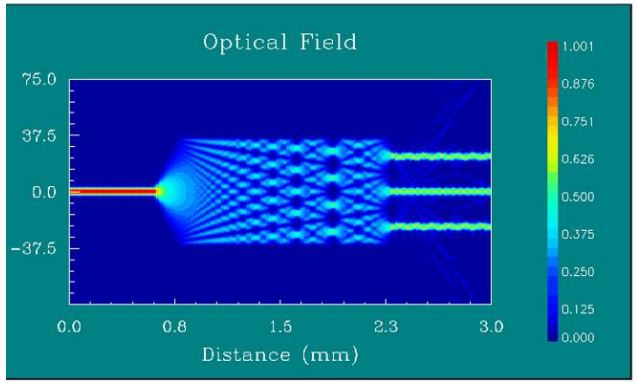
What you will be able to simulate…

- Multi-mode interferometer

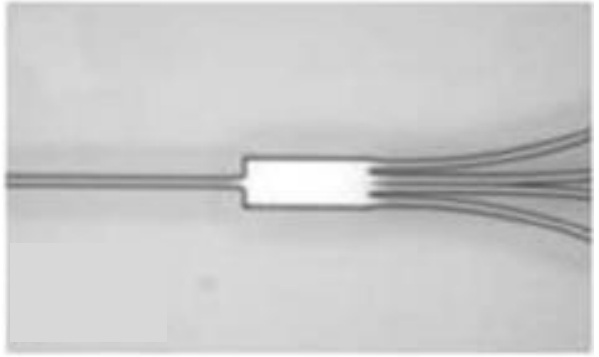
1.



2. & 3.



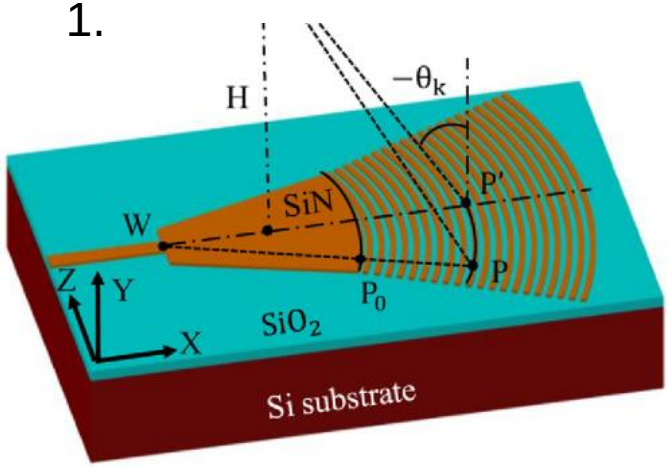
4.



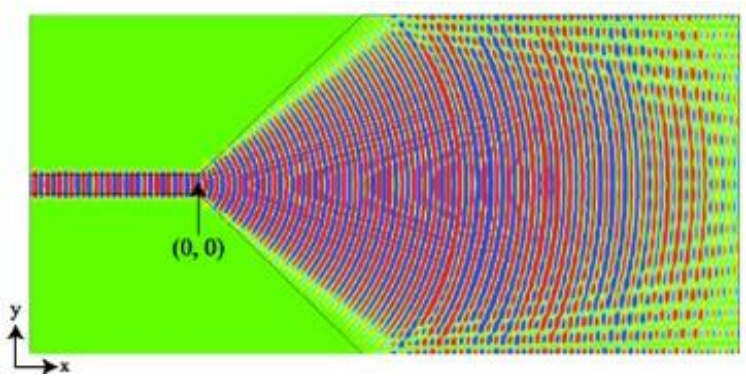
What you will be able to simulate…

- Grating coupler

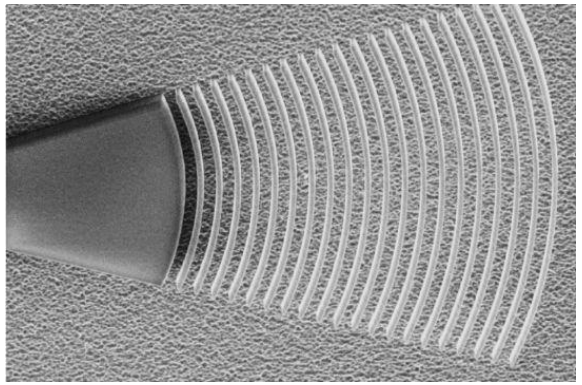
1.



2. & 3.



4.



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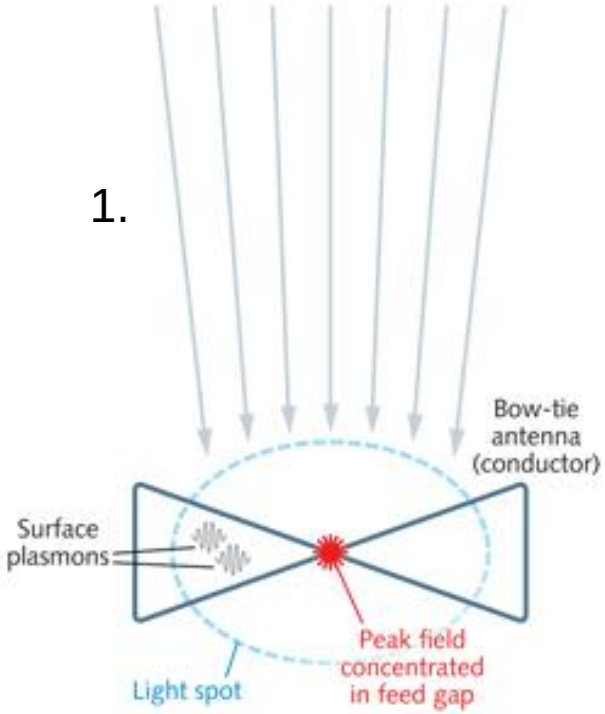
Xinzhi Zhang xinzhi.zhang@ief.ee.ethz.ch

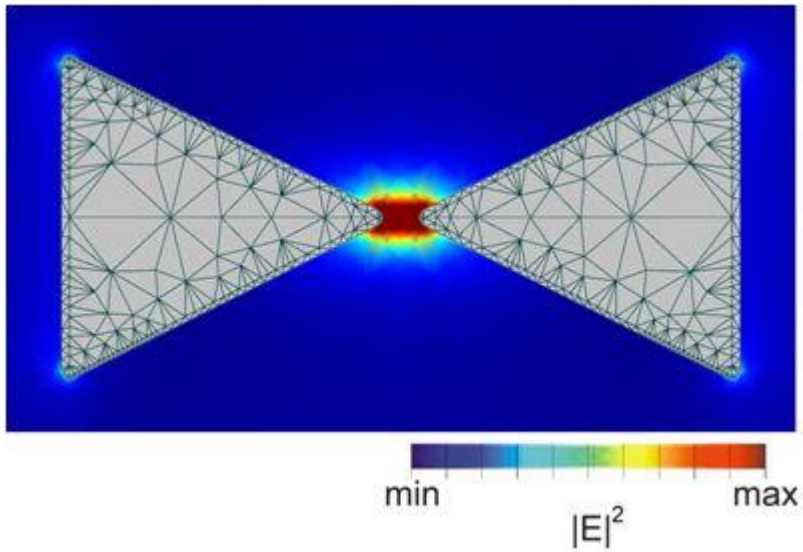
What you will be able to simulate…

- Optical Antennas

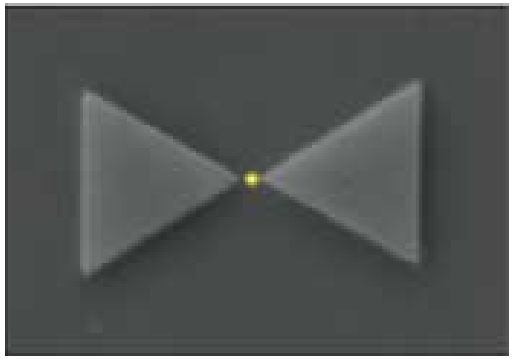
1.



2. & 3.



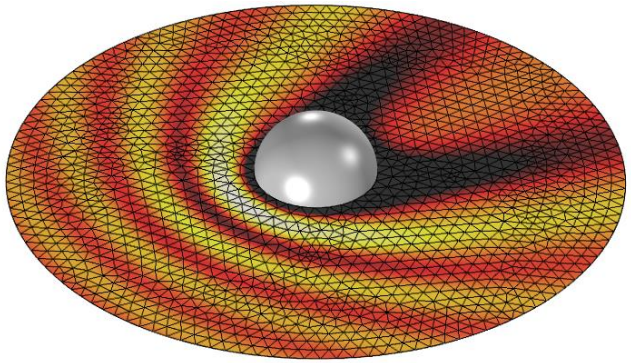
4.



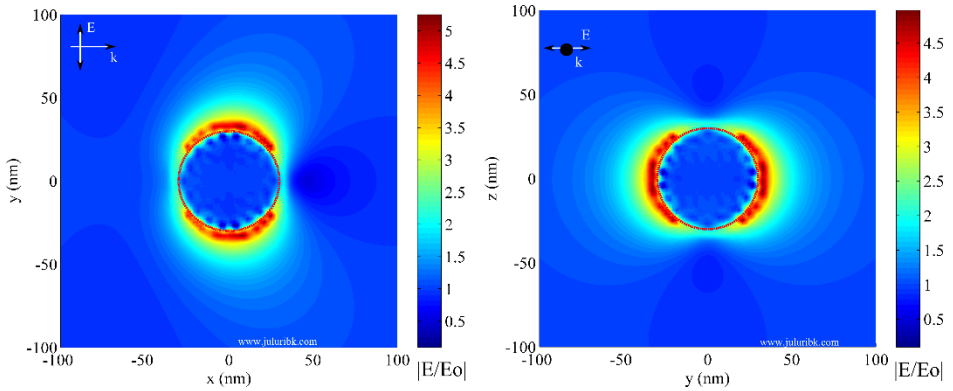
What you will be able to simulate…

- Scattering from metallic nanoparticle

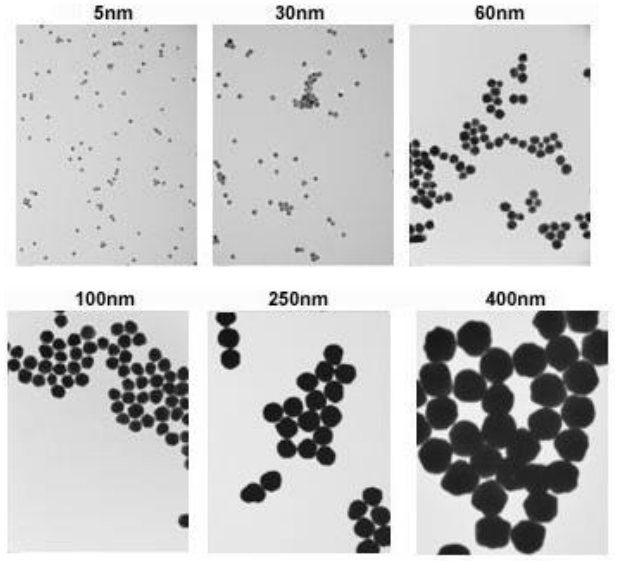
1.



2. & 3.



4.



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Questions?

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Xinzhi Zhang xinzhi.zhang@ief.ee.ethz.ch

Tutorial

Guillaume Zajac zajac@ief.ee.ethz.ch
Xinzhi Zhang xinzhi.zhang@ief.ee.ethz.ch

Starting COMSOL

- Every Student has access to Linux Server

Connection to Linux Server

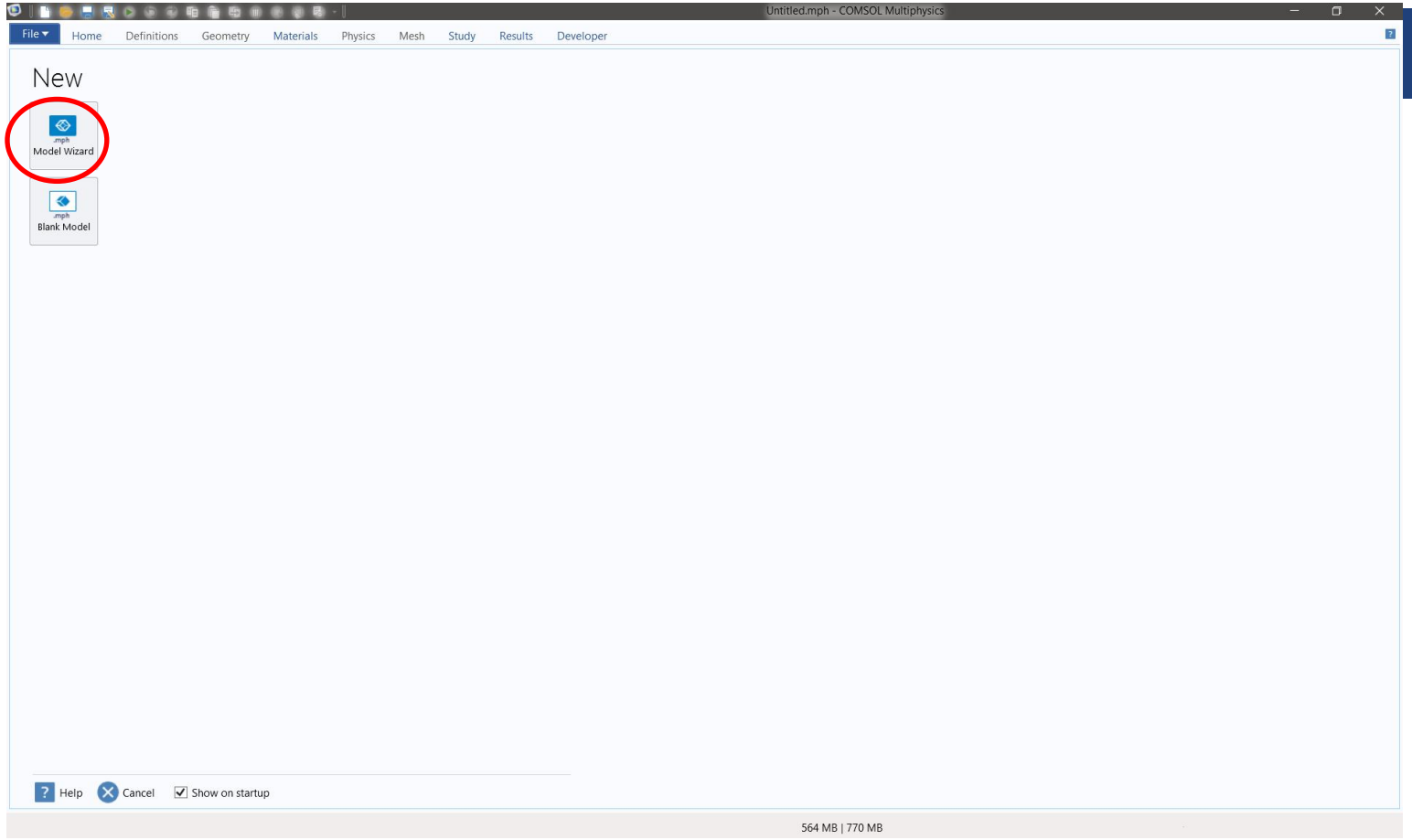
1) Download and install Cisco Anyconnect: https://ethz.ch/content/dam/ethz/special-interest/hest/isg-hest-dam/documents/pdf/vpn-de.pdf
   Available for Windows, MacOS & Linux

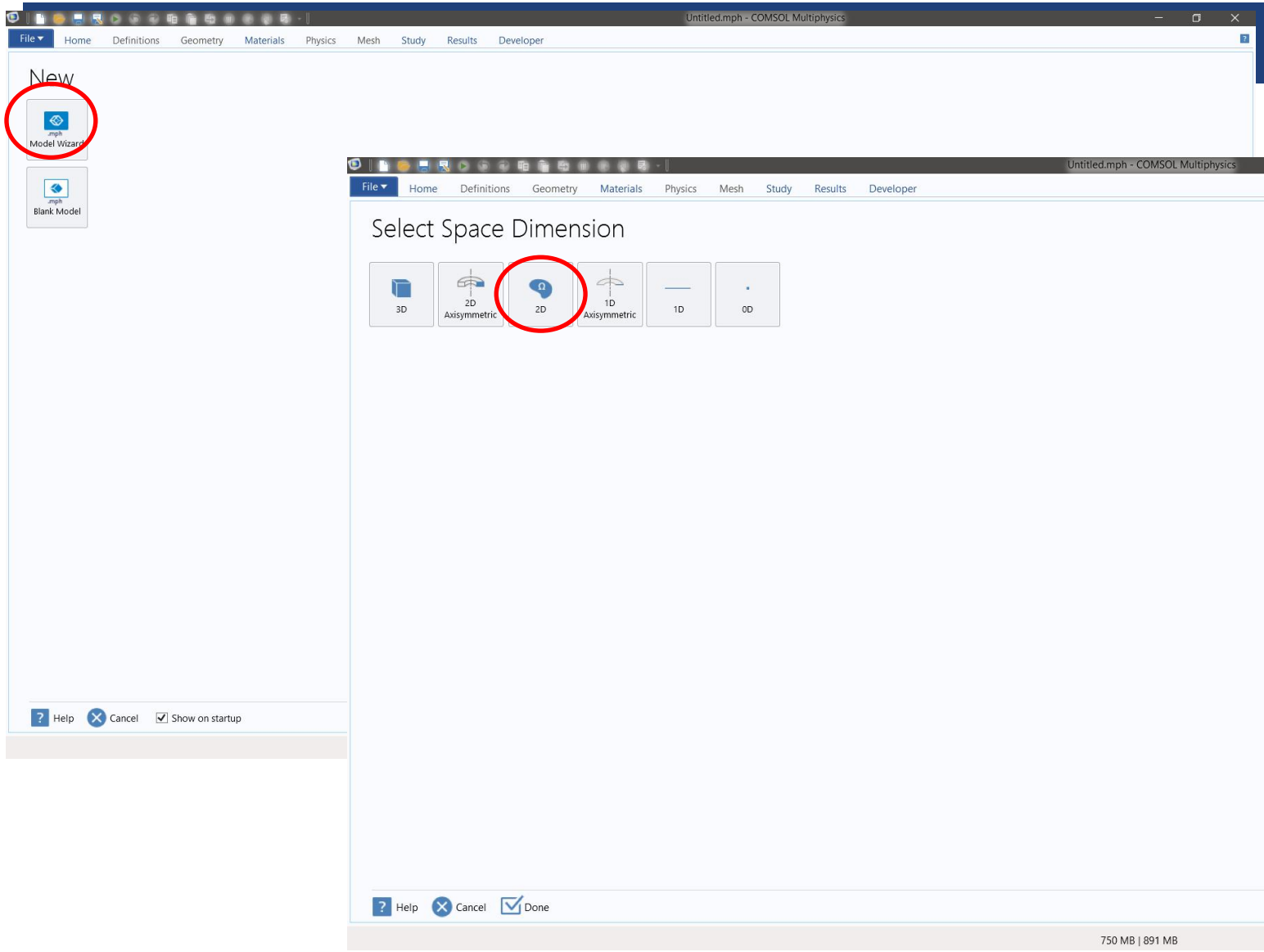
2) Connect to ETH network using Ciso Anyconnect

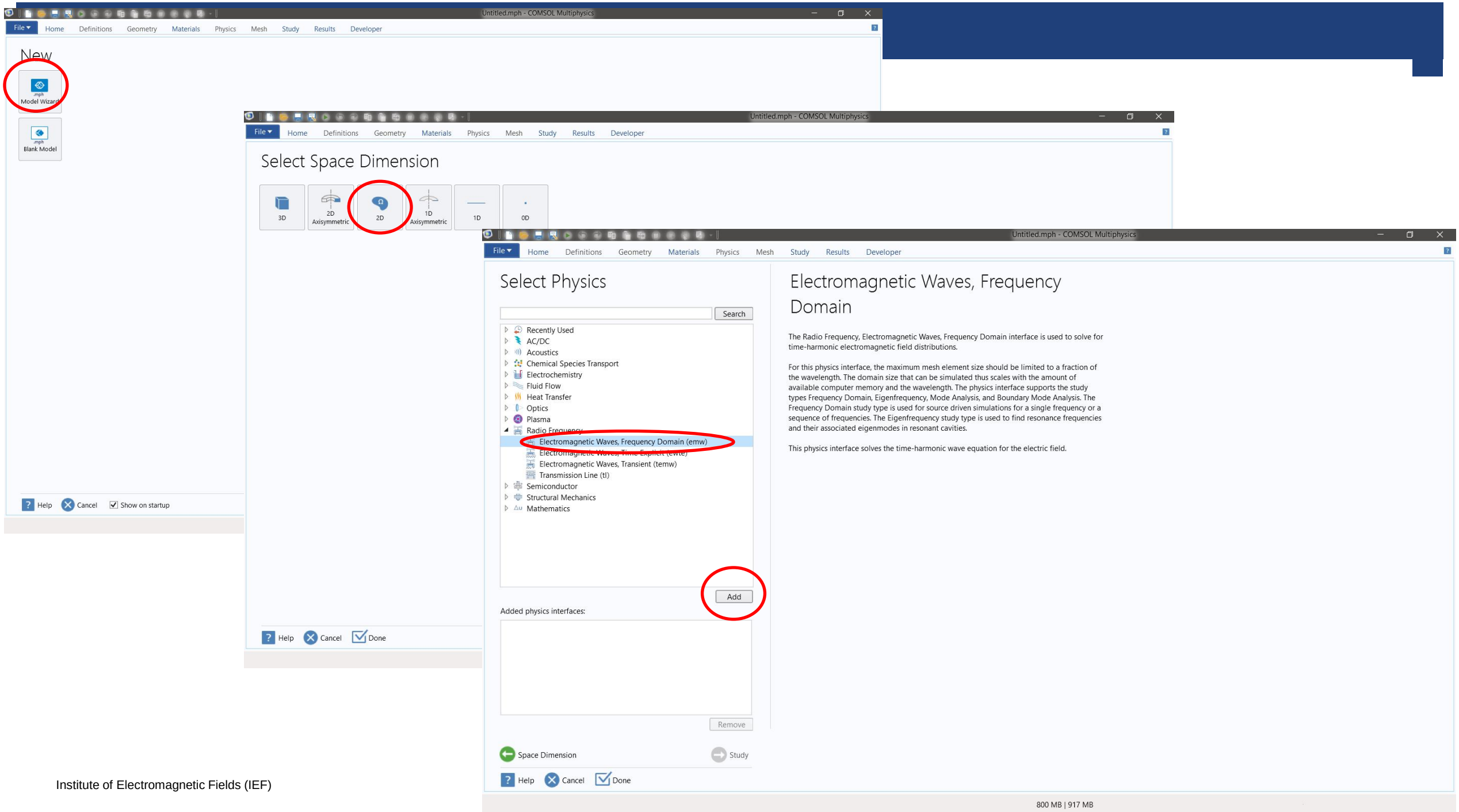
3) Connect to Linux Server
   - Linux & Mac: using terminal type «ssh username@itet-ief-l0.ethz.ch -X»
   - Windows, Linux, MacOS: using any remote desktop with xserver capability (e.g. Remote Desktop for Windows, Windows App for MacOS)

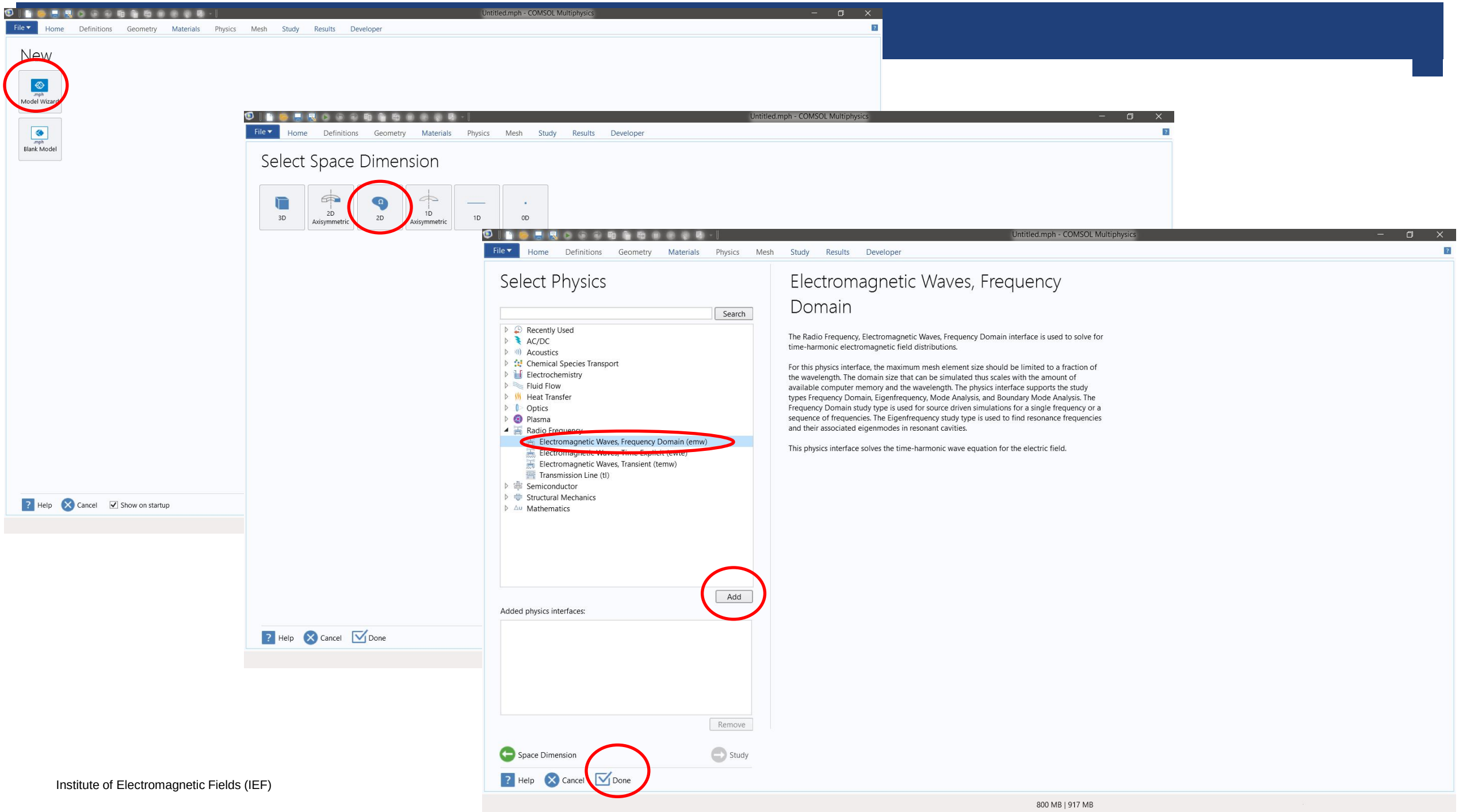
4) Enter Username and Password

5) Start COMSOL
   type: «comsol» into the terminal


Untitled.mph - COMSOL Multiphysics
File
Home
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Developer
New
Model Wizard
Blank Model
Help
Cancel
Show on startup
564 MB | 770 MB


Untitled.mph - COMSOL Multiphysics
File
Home
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Developer
New
Model Wizard
Blank Model
Help
Cancel
Show on startup
Untitled.mph - COMSOL Multiphysics
File
Home
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Developer
Select Space Dimension
3D
2D Axisymmetric
2D
1D Axisymmetric
1D
0D
Help
Cancel
Done
750 MB | 891 MB


Untitled.mph - COMSOL Multiphysics
File
Home
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Developer
New
Model Wizard
Blank Model
Help
Cancel
Show on startup
Select Space Dimension
3D
2D Axisymmetric
2D
1D Axisymmetric
1D
0D
Help
Cancel
Done
Select Physics
Search
Recently Used
AC/DC
Acoustics
Chemical Species Transport
Electrochemistry
Fluid Flow
Heat Transfer
Optics
Plasma
Radio Frequency
Electromagnetic Waves, Frequency Domain (emw)
Electromagnetic Waves, Transient (temw)
Transmission Line (tl)
Semiconductor
Structural Mechanics
Mathematics
Add
Added physics interfaces:
Remove
Space Dimension
Study
Help
Cancel
Done
Electromagnetic Waves, Frequency Domain
The Radio Frequency, Electromagnetic Waves, Frequency Domain interface is used to solve for time-harmonic electromagnetic field distributions.
For this physics interface, the maximum mesh element size should be limited to a fraction of the wavelength. The domain size that can be simulated thus scales with the amount of available computer memory and the wavelength. The physics interface supports the study types Frequency Domain, Eigenfrequency, Mode Analysis, and Boundary Mode Analysis. The Frequency Domain study type is used for source driven simulations for a single frequency or a sequence of frequencies. The Eigenfrequency study type is used to find resonance frequencies and their associated eigenmodes in resonant cavities.
This physics interface solves the time-harmonic wave equation for the electric field.
800 MB | 917 MB


Untitled.mph - COMSOL Multiphysics
File
Home
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Developer
New
Model Wizard
Blank Model
Help
Cancel
Show on startup
Select Space Dimension
3D
2D Axisymmetric
2D
1D Axisymmetric
1D
0D
Help
Cancel
Done
Select Physics
Search
Recently Used
AC/DC
Acoustics
Chemical Species Transport
Electrochemistry
Fluid Flow
Heat Transfer
Optics
Plasma
Radio Frequency
Electromagnetic Waves, Frequency Domain (emw)
Electromagnetic Waves, Transient (temw)
Transmission Line (tl)
Semiconductor
Structural Mechanics
Mathematics
Add
Added physics interfaces:
Remove
Space Dimension
Study
Help
Cancel
Done
Electromagnetic Waves, Frequency Domain
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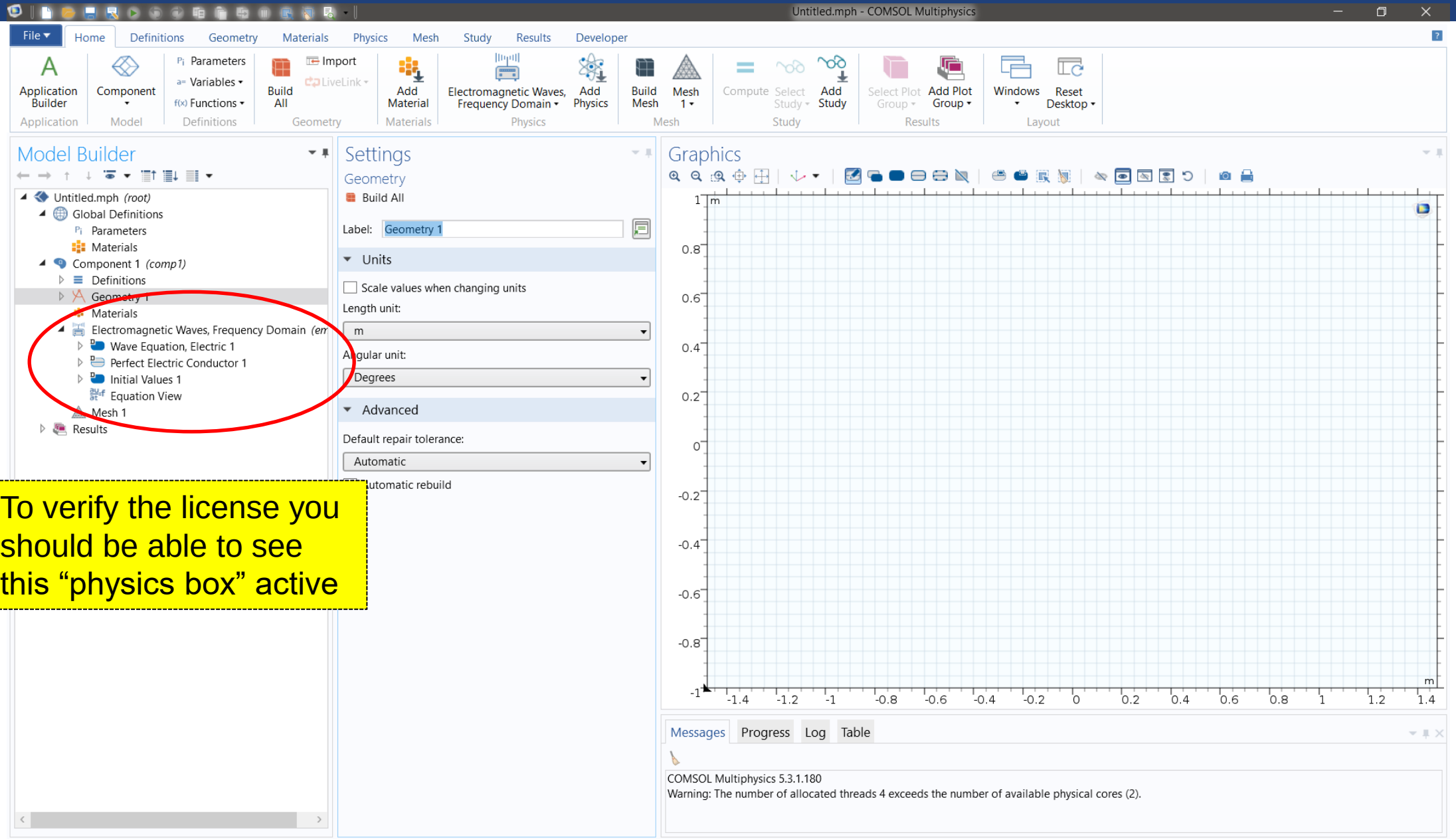
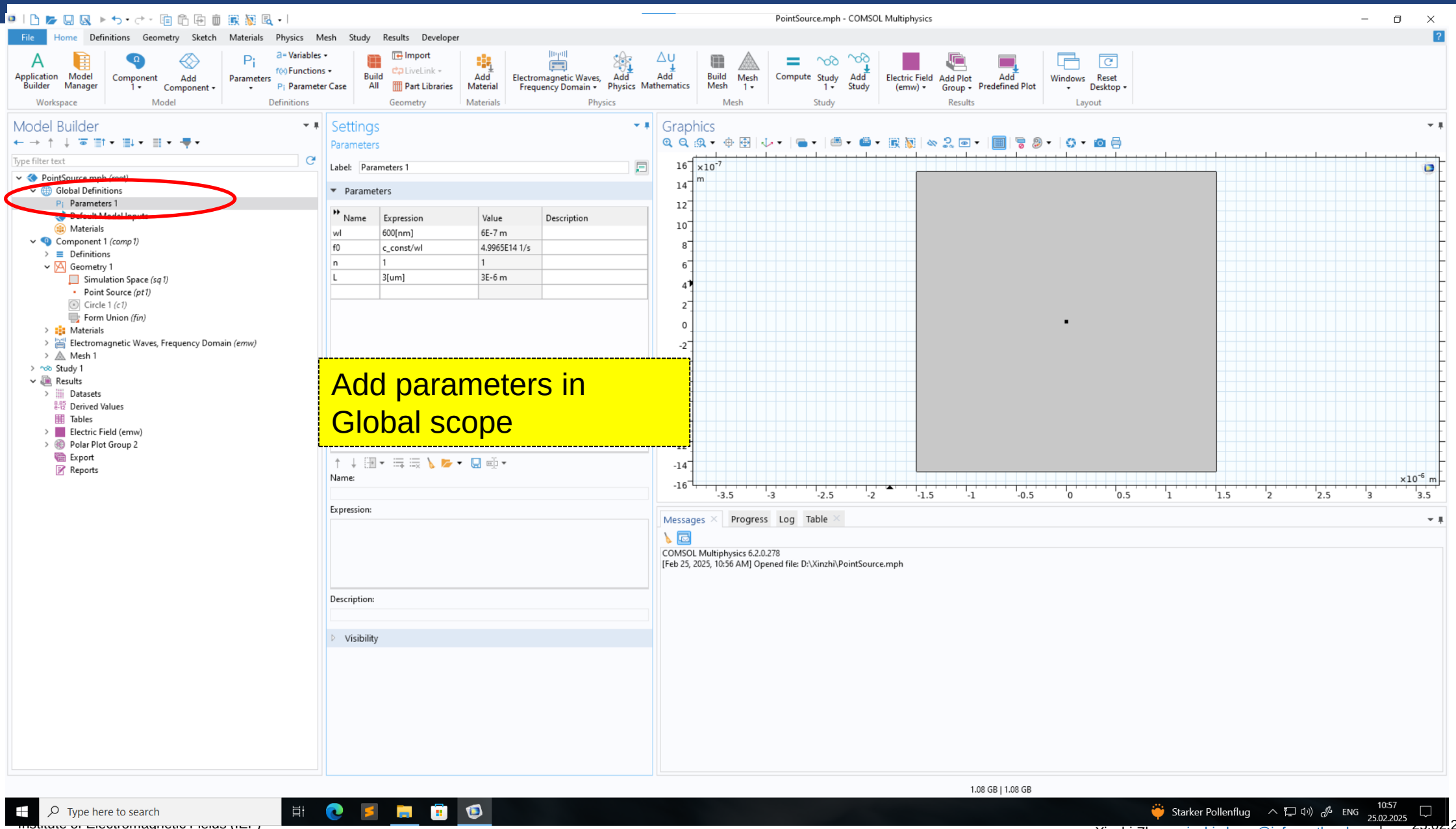
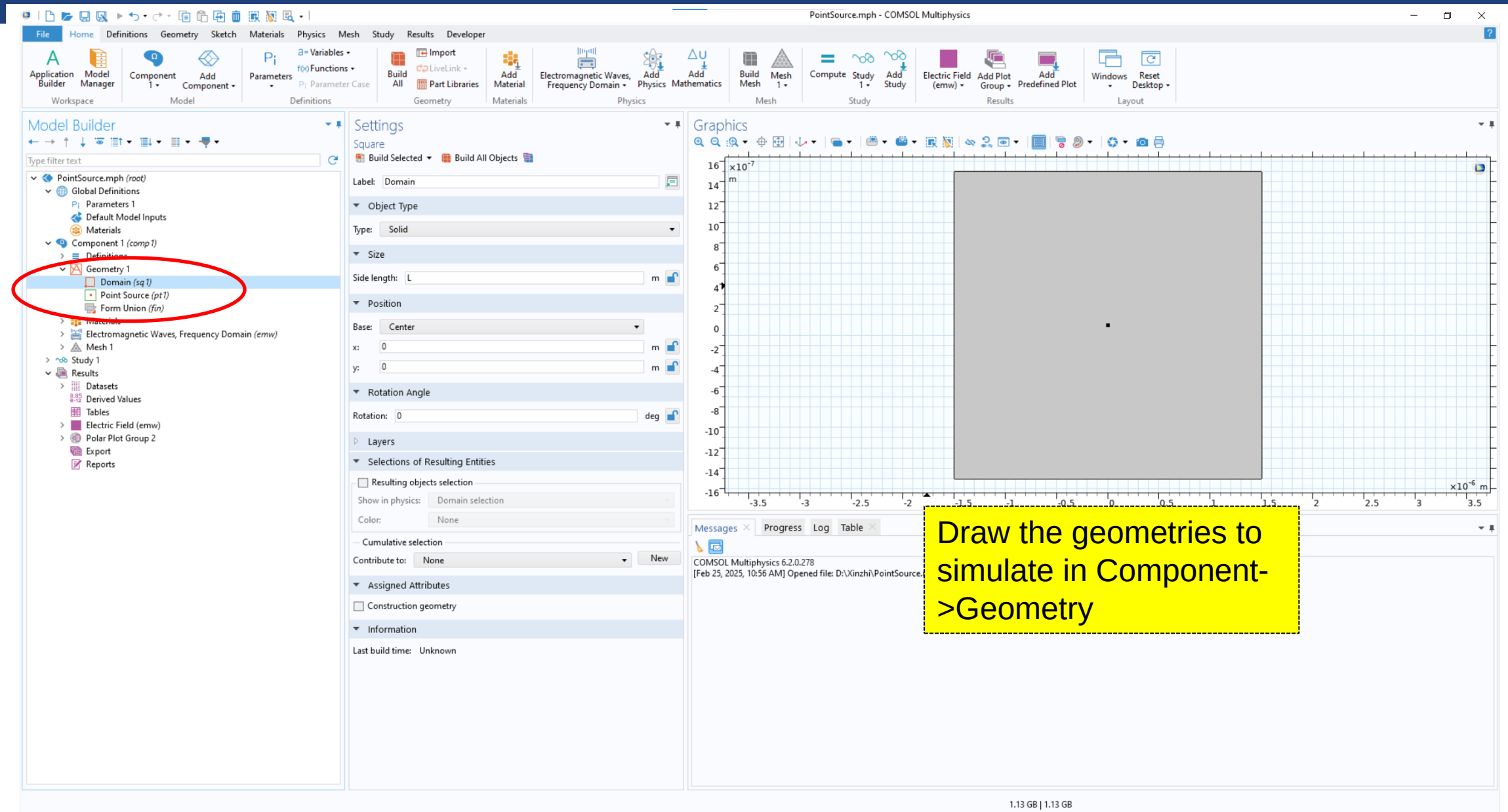
This physics interface solves the time-harmonic wave equation for the electric field.
800 MB | 917 MB

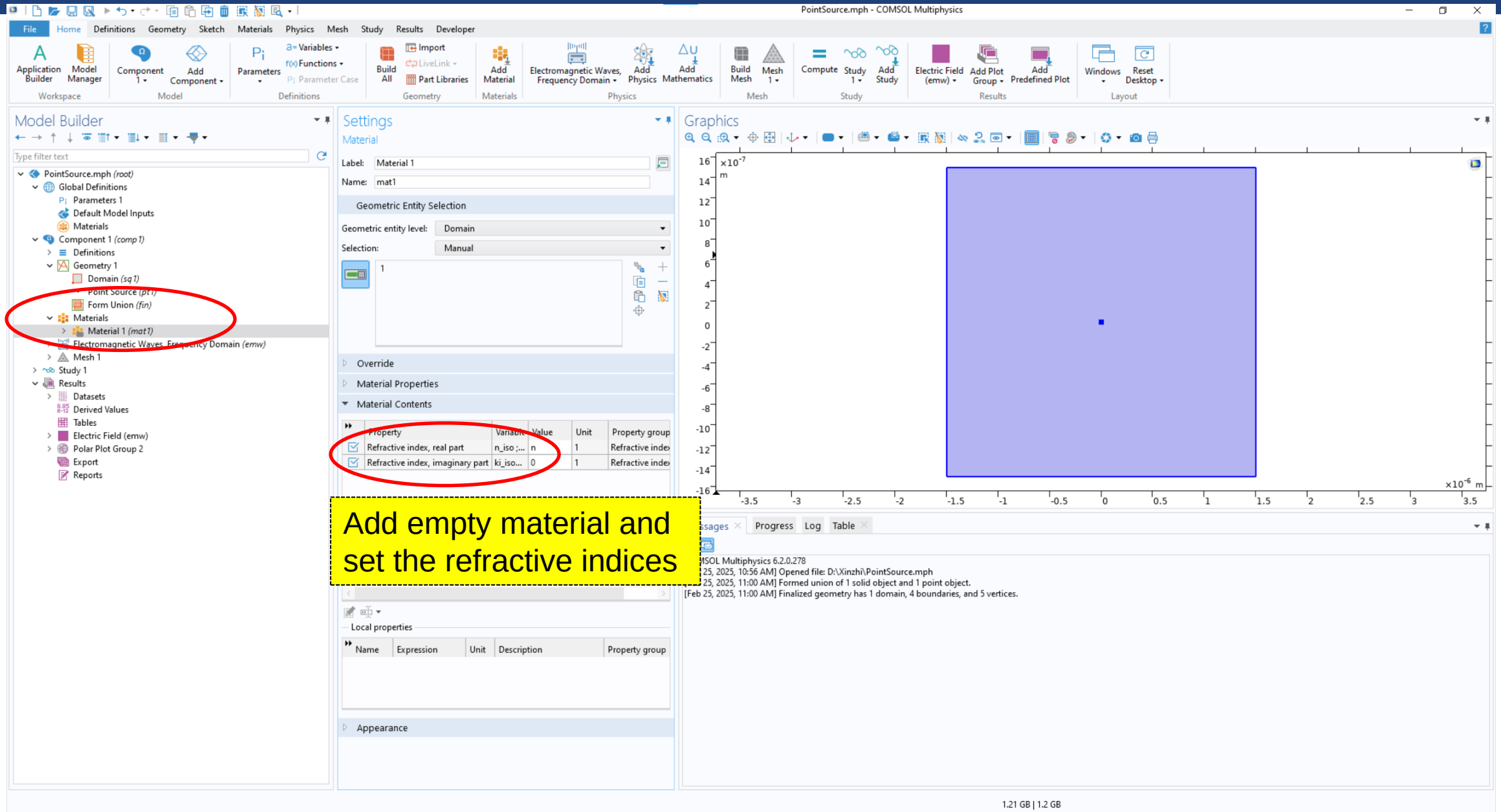


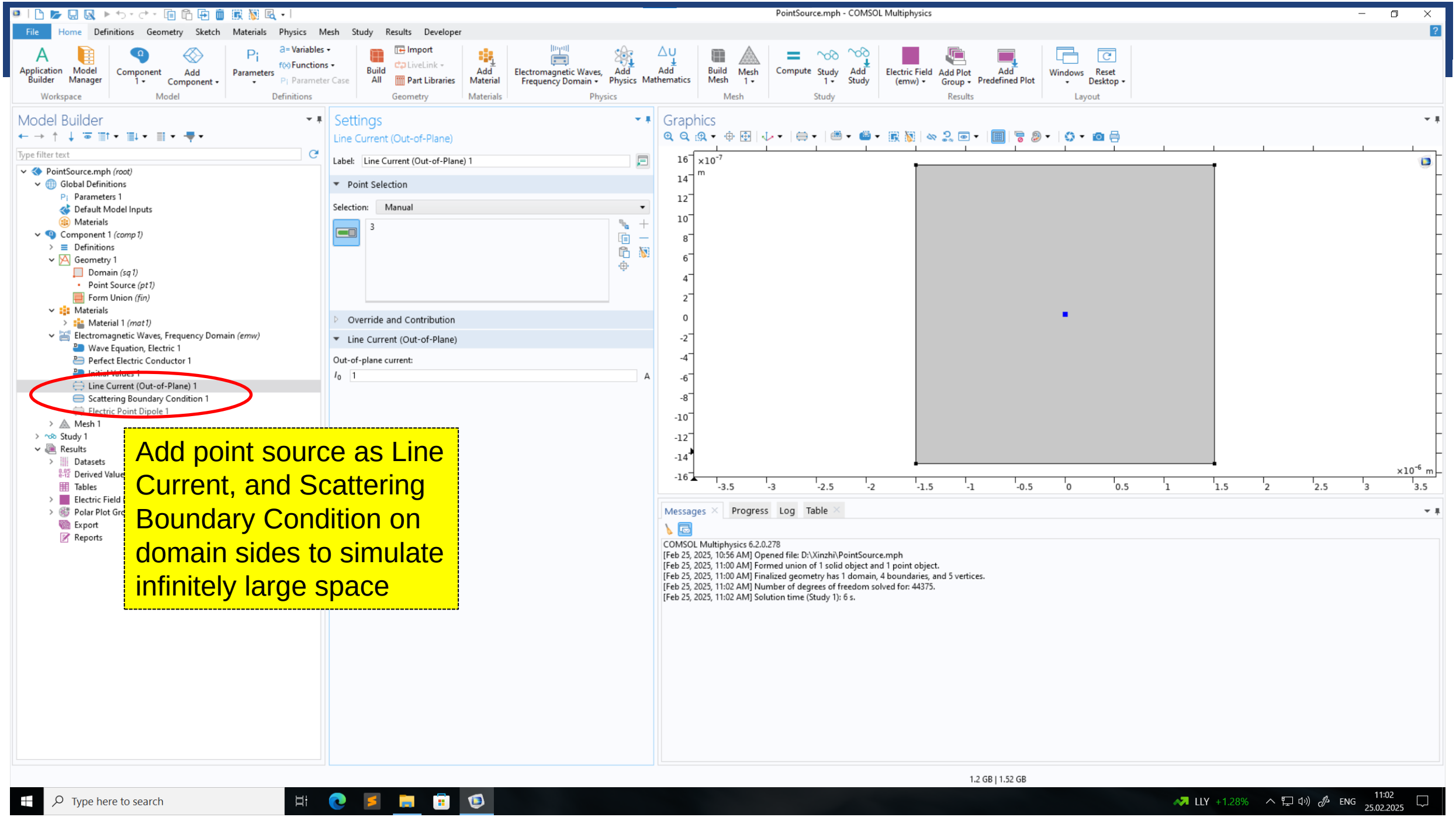
To verify the license you should be able to see this “physics box” active



Add parameters in Global scope


PointSource.mph - COMSOL Multiphysics
File Home Definitions Geometry Sketch Materials Physics Mesh Study Results Developer
Application Builder
Model Manager
Component 1
Add Component
Parameters
Variables
Functions
Parameter Case
Build All
Import
LiveLink
Part Libraries
Add Material
Electromagnetic Waves, Frequency Domain
Add Physics
Add Mathematics
Build Mesh
Mesh 1
Compute
Study 1
Add Study
Electric Field (emw)
Add Plot Group
Add Predefined Plot
Windows
Reset Desktop
Workspace
Model
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Layout
Model Builder
Type filter text
PointSource.mph (root)
Global Definitions
Parameters 1
Default Model Inputs
Materials
Component 1 (comp 1)
Definitions
Geometry 1
Domain (sq 1)
Point Source (pt 1)
Form Union (fin)
Materials
Electromagnetic Waves, Frequency Domain (emw)
Mesh 1
Study 1
Results
Datasets
Derived Values
Tables
Electric Field (emw)
Polar Plot Group 2
Export
Reports
Settings
Square
Build Selected
Build All Objects
Label: Domain
Object Type
Type: Solid
Size
Side length: L m
Position
Base: Center
x: 0 m
y: 0 m
Rotation Angle
Rotation: 0 deg
Layers
Selections of Resulting Entities
Resulting objects selection
Show in physics: Domain selection
Color: None
Cumulative selection
Contribute to: None
New
Assigned Attributes
Construction geometry
Information
Last build time: Unknown
Graphics
×10-7 m
×10-6 m
Messages
Progress
Log
Table
COMSOL Multiphysics 6.2.0.278
[Feb 25, 2025, 10:56 AM] Opened file: D:\Xinzhi\PointSource.
Draw the geometries to simulate in Component->Geometry
1.13 GB | 1.13 GB
Type here to search
SMI index +0.34%
ENG
11:00
25.02.2025


PointSource.mph - COMSOL Multiphysics
Model Builder
Settings
Material
Graphics
Add empty material and set the refractive indices


PointSource.mph - COMSOL Multiphysics
File Home Definitions Geometry Sketch Materials Physics Mesh Study Results Developer
Application Builder
Model Manager
Component 1
Add Component
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Variables
Functions
Parameter Case
Build All
Import
LiveLink
Part Libraries
Add Material
Electromagnetic Waves, Frequency Domain
Add Physics
Add Mathematics
Build Mesh
Mesh 1
Compute
Study 1
Add Study
Electric Field (emw)
Add Plot Group
Add Predefined Plot
Windows
Reset Desktop
Workspace
Model
Definitions
Geometry
Materials
Physics
Mesh
Study
Results
Layout
Model Builder
Type filter text
PointSource.mph (root)
Global Definitions
Parameters 1
Default Model Inputs
Materials
Component 1 (comp 1)
Definitions
Geometry 1
Domain (sq 1)
Point Source (pt 1)
Form Union (fin)
Materials
Material 1 (mat 1)
Electromagnetic Waves, Frequency Domain (emw)
Wave Equation, Electric 1
Perfect Electric Conductor 1
Line Current (Out-of-Plane) 1
Scattering Boundary Condition 1
Electric Point Dipole 1
Mesh 1
Study 1
Results
Datasets
Derived Values
Tables
Electric Field
Polar Plot Group
Export
Reports
Settings
Line Current (Out-of-Plane)
Label: Line Current (Out-of-Plane) 1
Point Selection
Selection: Manual
3
Override and Contribution
Line Current (Out-of-Plane)
Out-of-plane current:
I_0 1 A
Add point source as Line Current, and Scattering Boundary Condition on domain sides to simulate infinitely large space
Graphics
×10^-7 m
×10^-6 m
Messages
Progress
Log
Table
COMSOL Multiphysics 6.2.0.278
[Feb 25, 2025, 10:56 AM] Opened file: D:\Xinzhi\PointSource.mph
[Feb 25, 2025, 11:00 AM] Formed union of 1 solid object and 1 point object.
[Feb 25, 2025, 11:00 AM] Finalized geometry has 1 domain, 4 boundaries, and 5 vertices.
[Feb 25, 2025, 11:02 AM] Number of degrees of freedom solved for: 44375.
[Feb 25, 2025, 11:02 AM] Solution time (Study 1): 6 s.
1.2 GB | 1.52 GB
Type here to search
LLY +1.28%
ENG
11:02
25.02.2025

PointSource.mph - COMSOL Multiphysics

File Home Definitions Geometry Sketch Materials Physics Mesh Study Results Developer

Application Builder | Model Manager | Component 1 | Add Component | Parameters | Variables | Functions | Parameter Case | Build All | Import | LiveLink | Part Libraries | Add Material | Electromagnetic Waves, Frequency Domain | Add Physics | Add Mathematics | Build Mesh | Mesh 1 | Compute | Study 1 | Add Study | Electric Field (emw) | Add Plot Group | Add Predefined Plot | Windows | Reset Desktop

Workspace | Model | Definitions | Geometry | Materials | Physics | Mesh | Study | Results | Layout

Model Builder

Type filter text

- PointSource.mph *(root)*
  - Global Definitions
    - Parameters 1
    - Default Model Inputs
    - Materials
  - Component 1 *(comp 1)*
    - Definitions
    - Geometry 1
      - Domain *(sq 1)*
      - Point Source *(pt 1)*
      - Form Union *(fin)*
    - Materials
      - Material 1 *(mat 1)*
    - Electromagnetic Waves, Frequency Domain *(emw)*
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Line Current (Out-of-Plane) 1
      - Scattering Boundary Condition 1
      - Electric Point Dipole 1
    - Mesh 1
      - Size
      - Free Triangular 1
        - Size 1
        - Size 2
  - Study 1
  - Results
    - Datasets
    - Derived Values
    - Tables
    - Electric Field (emw)
    - Polar Plot Group 2
    - Export
    - Reports

Settings

Size

Build Selected | Build All

Label: Size 1

Geometric Entity Selection

Geometric entity level: Entire geometry

Element Size

Calibrate for: General physics

Predefined: Normal

Custom

Element Size Parameters

Maximum element size: wl/10 m

Minimum element size: From sequence m

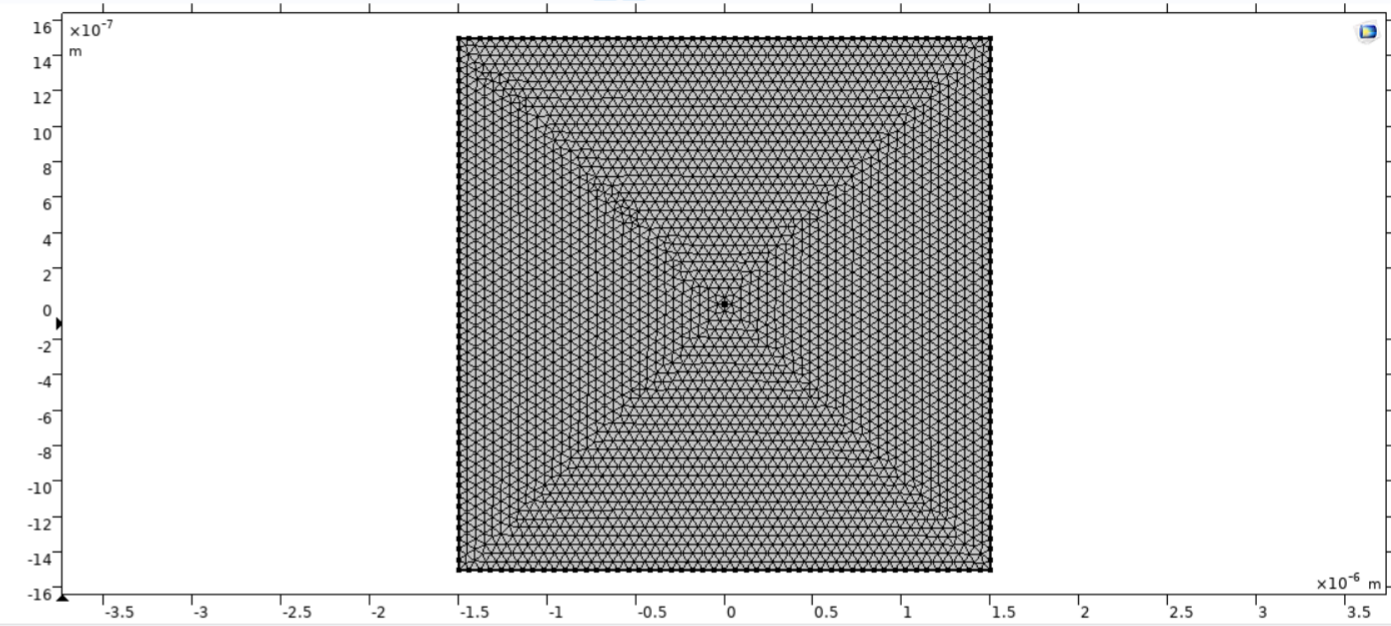
Maximum element growth rate: From sequence

Curvature factor: From sequence

Resolution of narrow regions: From sequence

Set the maximum mesh size to wl/10 and use free triangular shape to discretize the domain

Graphics



Messages | Progress | Log | Table

```
COMSOL Multiphysics 6.2.0.278
[Feb 25, 2025, 10:56 AM] Opened file: D:\Xinzhi\PointSource.mph
[Feb 25, 2025, 11:00 AM] Formed union of 1 solid object and 1 point object.
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[Feb 25, 2025, 11:02 AM] Number of degrees of freedom solved for: 44375.
[Feb 25, 2025, 11:02 AM] Solution time (Study 1): 6 s.
```

1.23 GB | 1.55 GB

Type here to search

INJ -2.71% ENG 11:05

PointSource.mph - COMSOL Multiphysics

File Home Definitions Geometry Sketch Materials Physics Mesh Study Results Developer

Application Builder | Model Manager | Component 1 | Add Component | Parameters | Variables | Functions | Parameter Case | Build All | Import | LiveLink | Part Libraries | Add Material | Electromagnetic Waves, Frequency Domain | Add Physics | Add Mathematics | Build Mesh | Mesh 1 | Compute | Study 1 | Add Study | Electric Field (emw) | Add Plot Group | Add Predefined Plot | Windows | Reset Desktop

Workspace | Model | Definitions | Geometry | Materials | Physics | Mesh | Study | Results | Layout

Model Builder

Type filter text

- PointSource.mph *(root)*
  - Global Definitions
    - Parameters 1
    - Default Model Inputs
    - Materials
  - Component 1 *(comp 1)*
    - Definitions
    - Geometry 1
      - Domain *(sq 1)*
      - Point Source *(pt 1)*
      - Form Union *(fin)*
    - Materials
      - Material 1 *(mat 1)*
    - Electromagnetic Waves, Frequency Domain *(emw)*
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Line Current (Out-of-Plane) 1
      - Scattering Boundary Condition 1
      - Electric Point Dipole 1
    - Mesh 1
      - Size
      - Free Triangular 1
        - Size 1
        - Size 2
  - Study 1
    - Step 1: Frequency Domain
    - Solver Configurations
  - Results
    - Datasets
    - Derived Values
    - Tables
    - Electric Field (emw)
    - Polar Plot Group 2
    - Export
    - Reports

Settings

Frequency Domain

Compute | Update Solution

Label: Frequency Domain

Study Settings

Frequency unit: GHz

Frequencies: f0 GHz

Load parameter values:

Browse | Read File

Reuse solution from previous step: Auto

Results While Solving

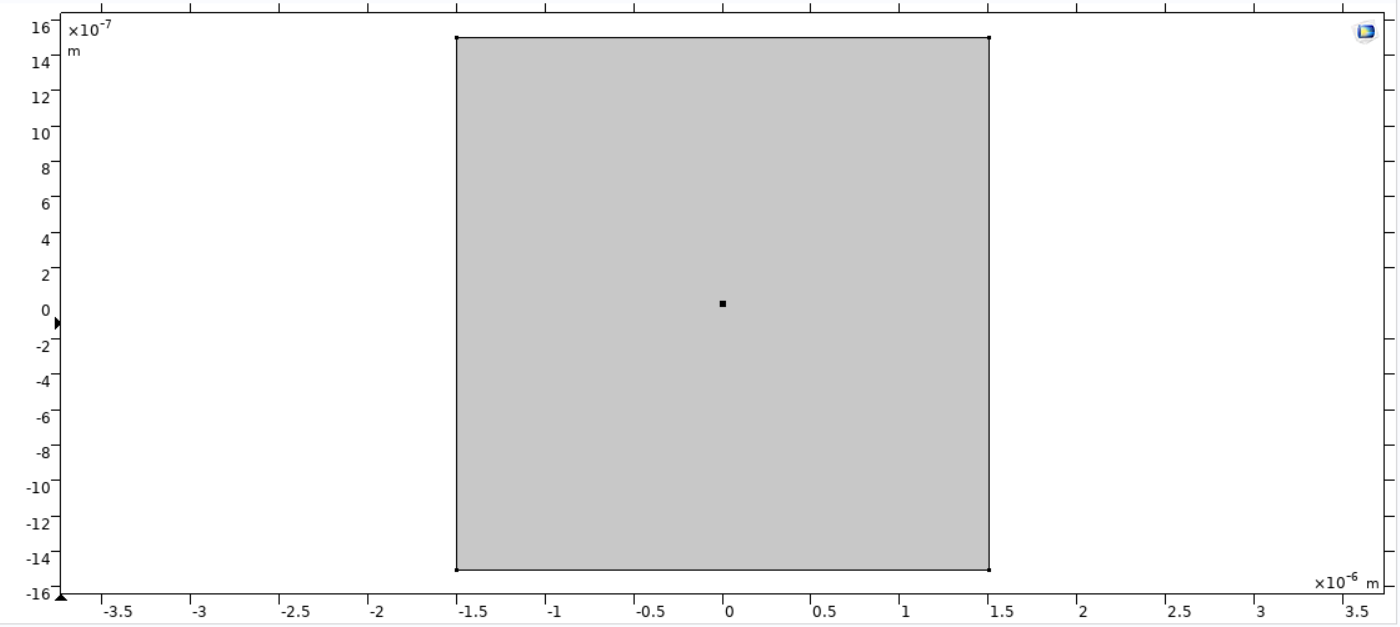
Physics and Variables Selection

Modify model configuration for study step

Physics interface	Solve for	Equation form
Electromagnetic Waves, Frequency...	☑	Automatic (Frequency do...

In Frequency Domain Study step, change frequency to f0, and compute.

Graphics



Messages | Progress | Log | Table

```
COMSOL Multiphysics 6.2.0.278
[Feb 25, 2025, 10:56 AM] Opened file: D:\Xinzhi\PointSource.mph
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[Feb 25, 2025, 11:02 AM] Number of degrees of freedom solved for: 44375.
[Feb 25, 2025, 11:02 AM] Solution time (Study 1): 6 s.
```

1.24 GB | 1.56 GB

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INR/CHF -0.71% ENG 11:06 25.02.2025

PointSource.mph - COMSOL Multiphysics

File | Home | Definitions | Geometry | Sketch | Materials | Physics | Mesh | Study | Results | Developer | Electric Field (emw)

Plot | Plot In | Surface | Surface with Height | Arrow Surface | Line | Contour | Streamline | Arrow Line | Mesh | Annotation | More Plots | Color Expression | Deformation | Height Expression | Filter | Material Appearance | Selection | More Attributes | Evaluate | First Point for Cut Line | Second Point for Cut Line | Image | Animation

Plot | Add Plot | Attributes | Select | Export

Model Builder

Type filter text

- PointSource.mph *(root)*
  - Global Definitions
    - Parameters 1
    - Default Model Inputs
    - Materials
  - Component 1 *(comp 1)*
    - Definitions
    - Geometry 1
      - Domain *(sq 1)*
      - Point Source *(pt 1)*
      - Form Union *(fin)*
    - Materials
      - Material 1 *(mat 1)*
    - Electromagnetic Waves, Frequency Domain *(emw)*
      - Wave Equation, Electric 1
      - Perfect Electric Conductor 1
      - Initial Values 1
      - Line Current (Out-of-Plane) 1
      - Scattering Boundary Condition 1
      - Electric Point Dipole 1
    - Mesh 1
      - Size
      - Free Triangular 1
        - Size 1
        - Size 2
  - Study 1
    - Step 1: Frequency Domain
    - Solver Configurations
  - Results
    - Datasets
    - Derived Values
    - Tables
    - Electric Field (emw)
      - Surface
    - Polar Plot Group 2
    - Export
    - Reports

Settings

Surface

Plot

Label: Surface

Data

Dataset: From parent

Expression

Expression:

emw.normE

Unit:

V/m

Description:

Electric field norm

Title

Range

Coloring and Style

Coloring: Color table

Color table: RainbowLightClassic

Color legend

Color table transformation: None

Color table type: Continuous

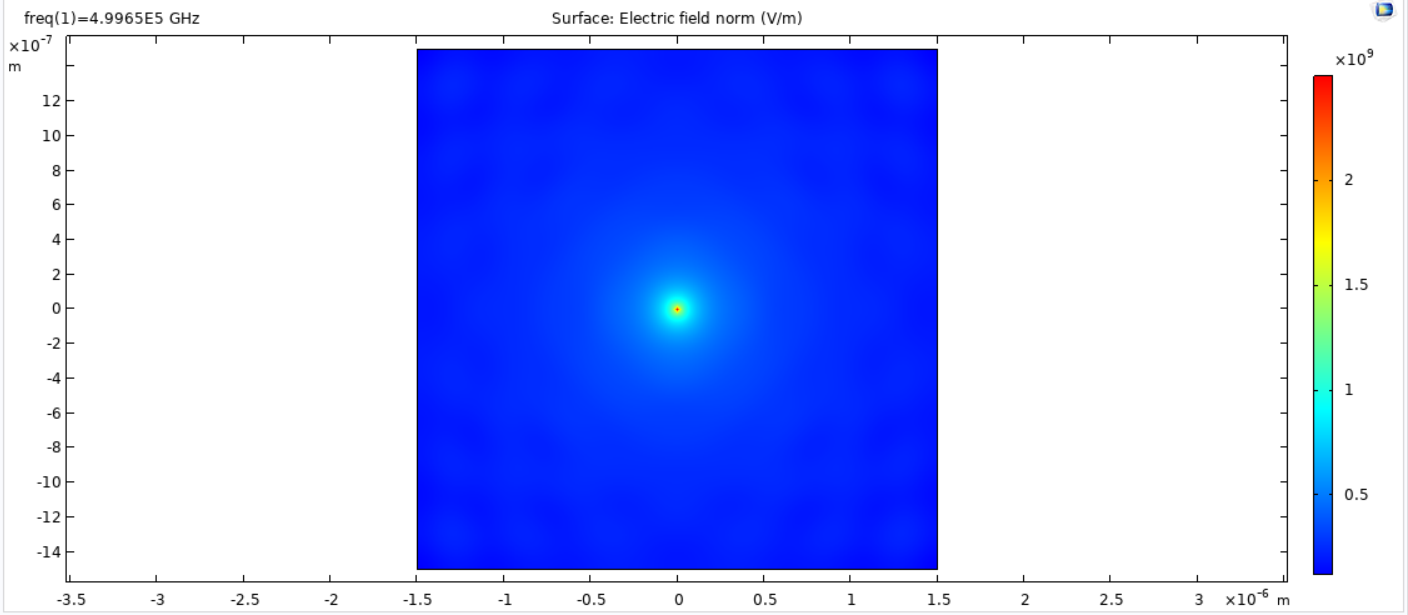
Scale: Linear

Wireframe

Quality

In Results, the electric field is plotted. The plotted variable can be changed in Electric Field -> Surface.

Graphics



Messages | Progress | Log | Table

```
COMSOL Multiphysics 6.2.0.278
[Feb 25, 2025, 10:56 AM] Opened file: D:\Xinzhi\PointSource.mph
[Feb 25, 2025, 11:00 AM] Formed union of 1 solid object and 1 point object.
[Feb 25, 2025, 11:00 AM] Finalized geometry has 1 domain, 4 boundaries, and 5 vertices.
[Feb 25, 2025, 11:02 AM] Number of degrees of freedom solved for: 44375.
[Feb 25, 2025, 11:02 AM] Solution time (Study 1): 6 s.
```

1.26 GB | 1.58 GB

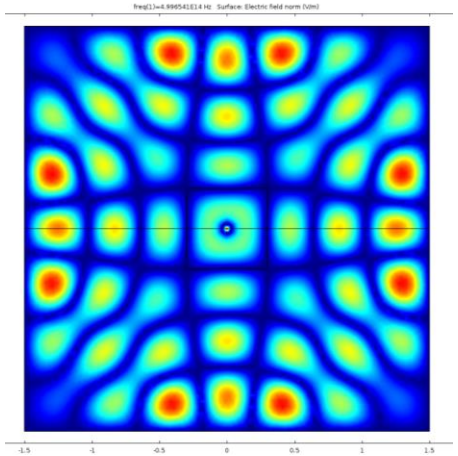
Type here to search

Baustelle in 1 / Züric... ENG 11:07 25.02.2025

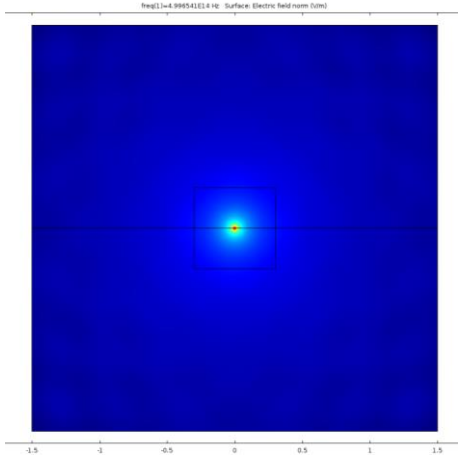
COMSOL: Boundary Condition

- Purpose of boundary conditions → define simulation domain

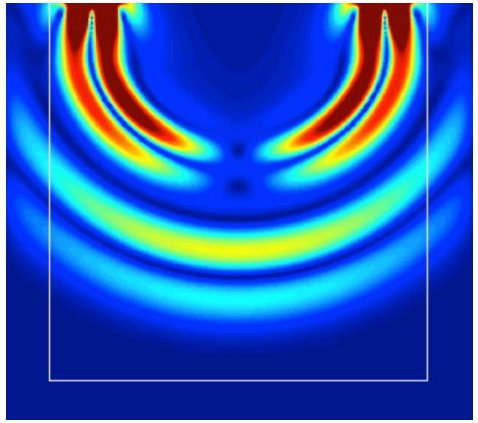
- Types of boundary conditions in COMSOL
  - Perfect Electric Conductor (PEC)
  - Perfect Magnetic Conductor (PMC)
  - Scattering Boundary Condition
  - Periodic Boundaries Condition (PBC)
  - Perfectly Matched Layer (PML)



PEC Boundaries



Scattering Boundaries



PML Boundaries

Reminder:

Please log out from the Linux server after simulation is finished.