

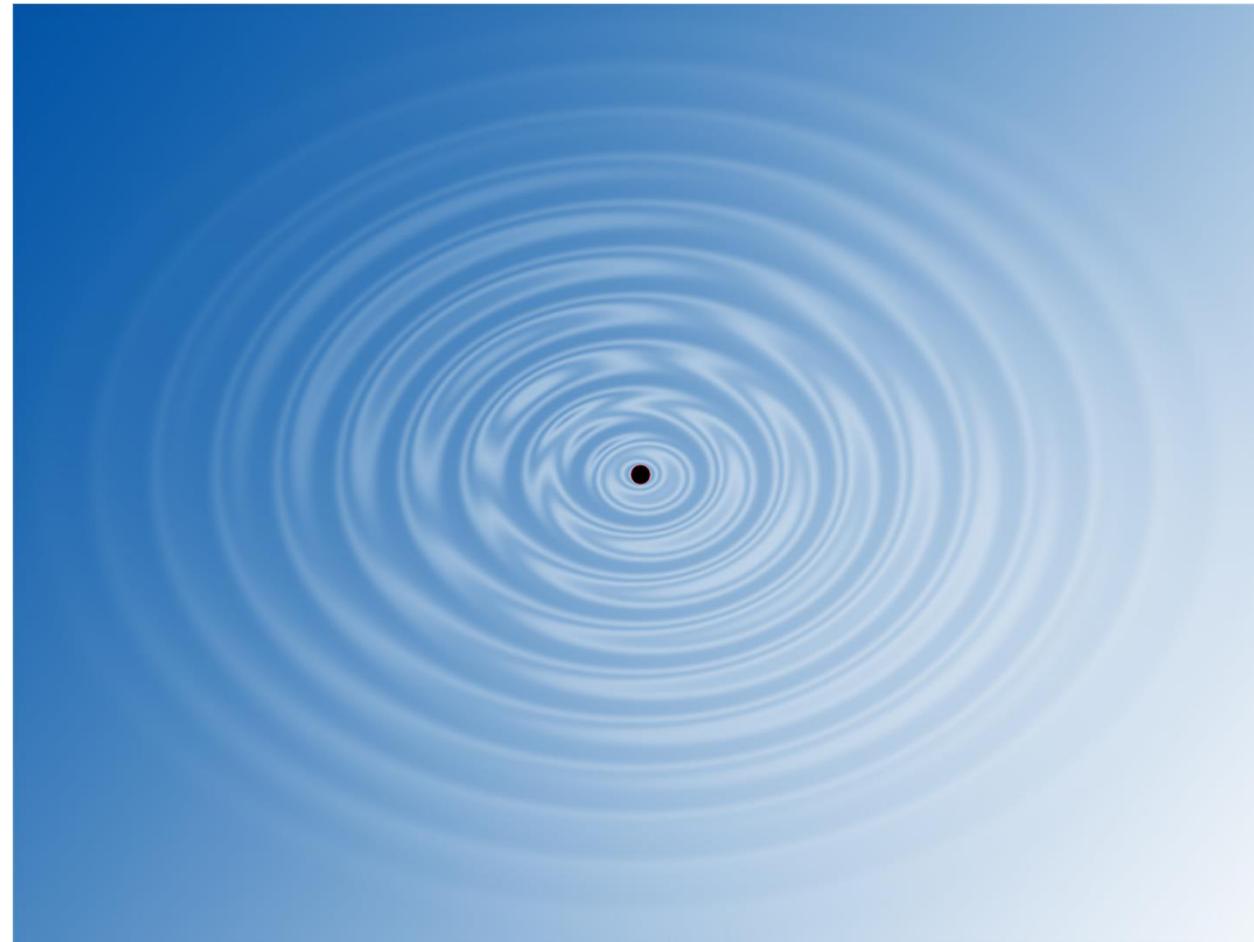


# P&S COMSOL® Design Tool

## Week 2: EM Introduction & Introduction to COMSOL

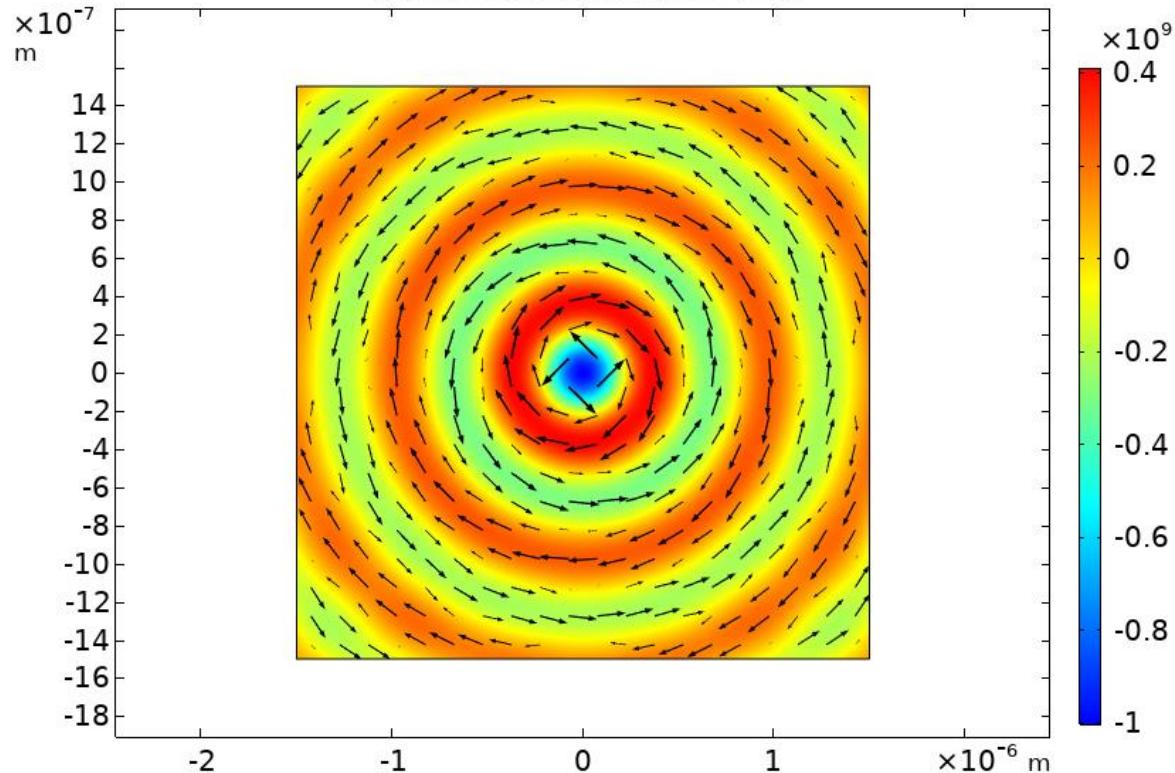
Taichiro Fukui, Maximilian Bosch

# COMSOL: Last Time – Point Source Field



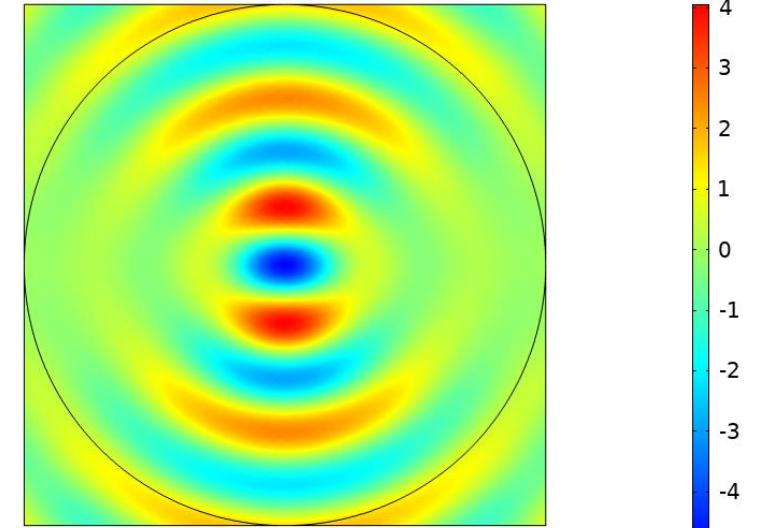
# COMSOL: Last Time – Point Source Field

freq(1)=4.9965E5 GHz Surface: Electric field, z-component (V/m)  
Arrow Surface: Magnetic field



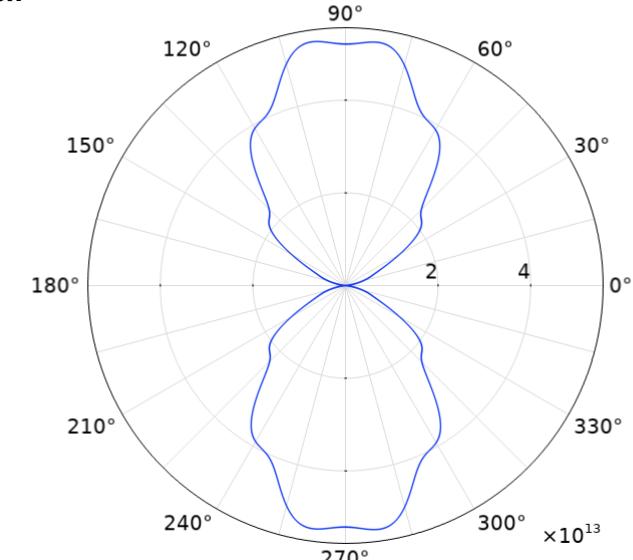
Using line current

freq(1)=4.9965E5 GHz Surface: Electric field, x-component (V/m)

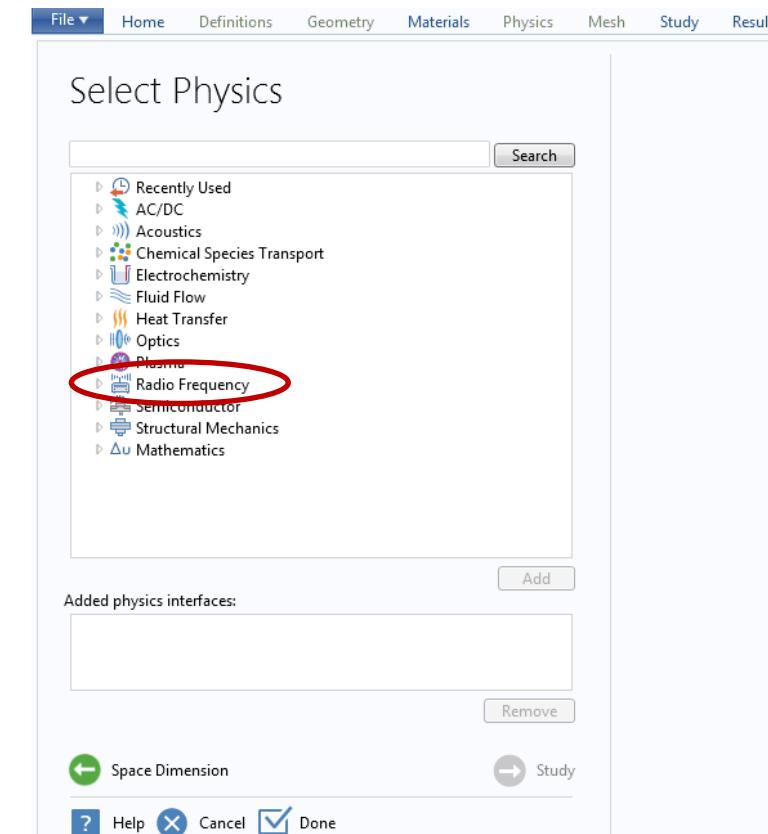
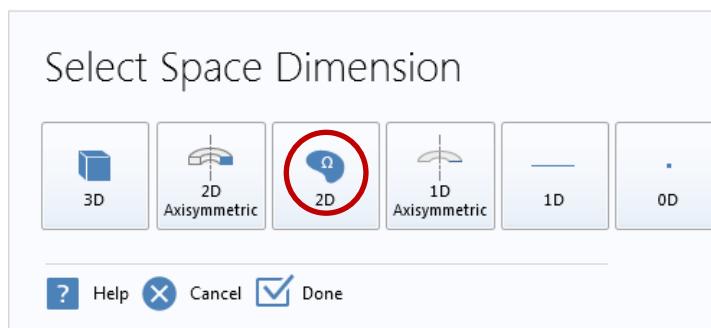
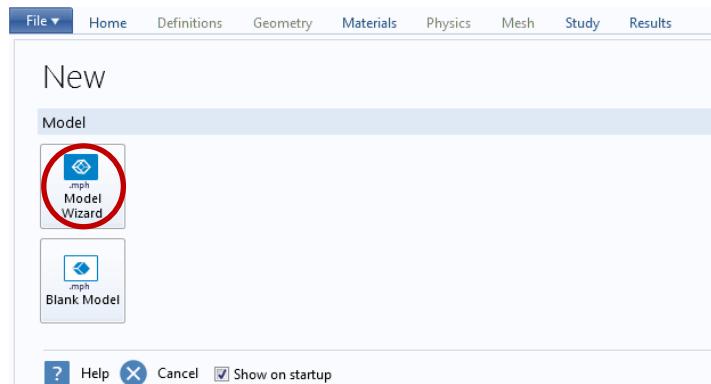


Using electrical  
dipole

Line Graph:  $\sqrt{\text{emw.Poavx}^2 + \text{emw.Poavy}^2}$  (W/m<sup>2</sup>)



# COMSOL: Last Time



# COMSOL: Last Time

File ▾ Home Definitions Geometry Materials Physics Mesh Study Results

## Select Physics

The screenshot shows the 'Select Physics' dialog box. On the left, there is a tree view of available physics interfaces. The 'Electromagnetic Waves, Frequency Domain (emw)' node under 'Radio Frequency' is highlighted with a red oval. Below the tree, a list of 'Added physics interfaces' shows 'Electromagnetic Waves, Frequency Domain (emw)'. At the bottom, there are buttons for 'Space Dimension' (with arrows), 'Study' (with arrows), and 'Help', 'Cancel', 'Done'.

Recently Used  
AC/DC  
Acoustics  
Chemical Species Transport  
Electrochemistry  
Fluid Flow  
Heat Transfer  
Optics  
Plasma  
Radio Frequency  
Electromagnetic Waves, Frequency Domain (emw)  
Electromagnetic Waves, Time Explicit (ewte)  
Electromagnetic Waves, Transient (temw)  
Transmission Line (tl)  
Semiconductor  
Structural Mechanics  
Mathematics

Search

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.

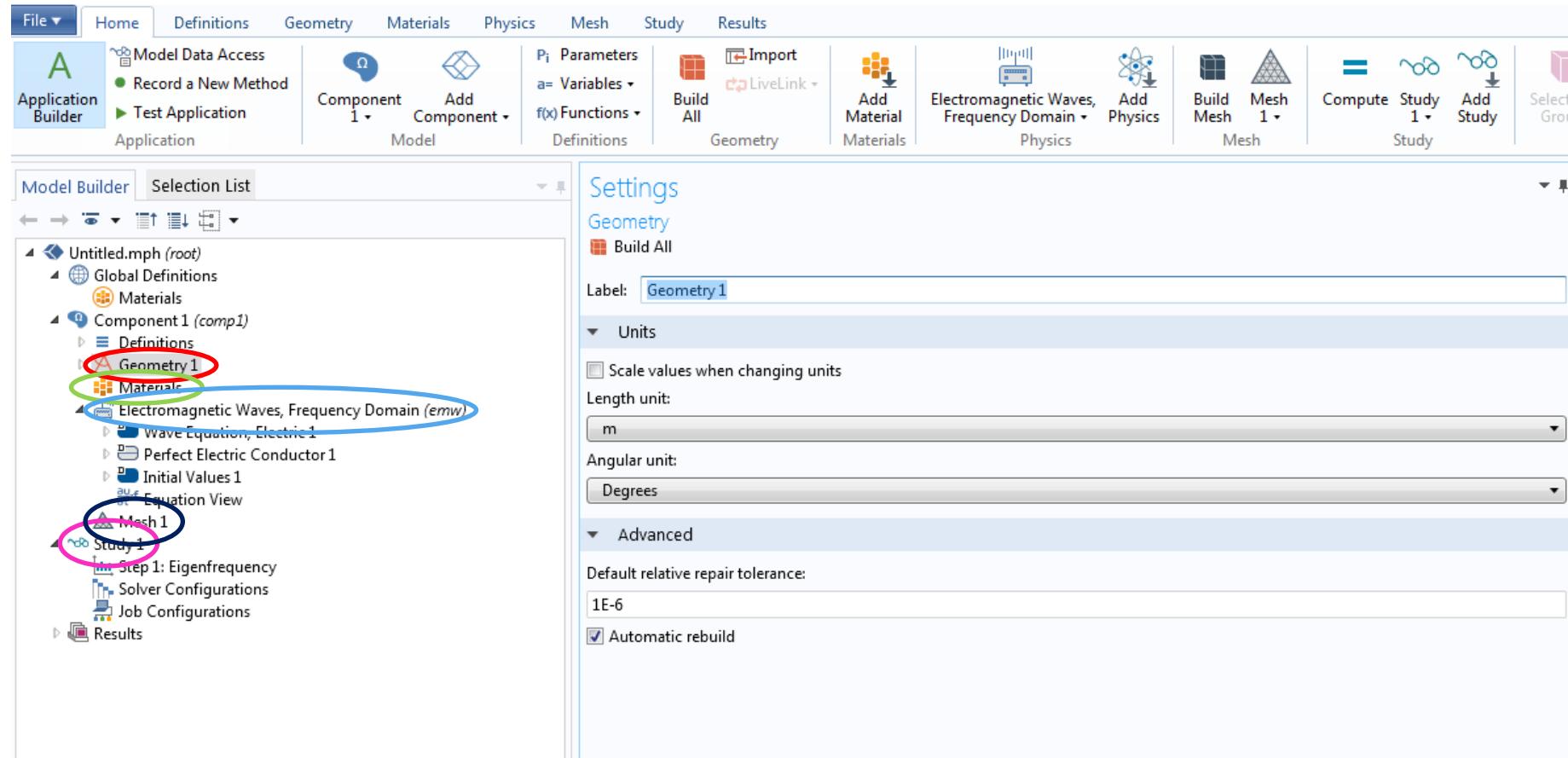
Added physics interfaces:  
Electromagnetic Waves, Frequency Domain (emw)

Add Remove

Space Dimension Study

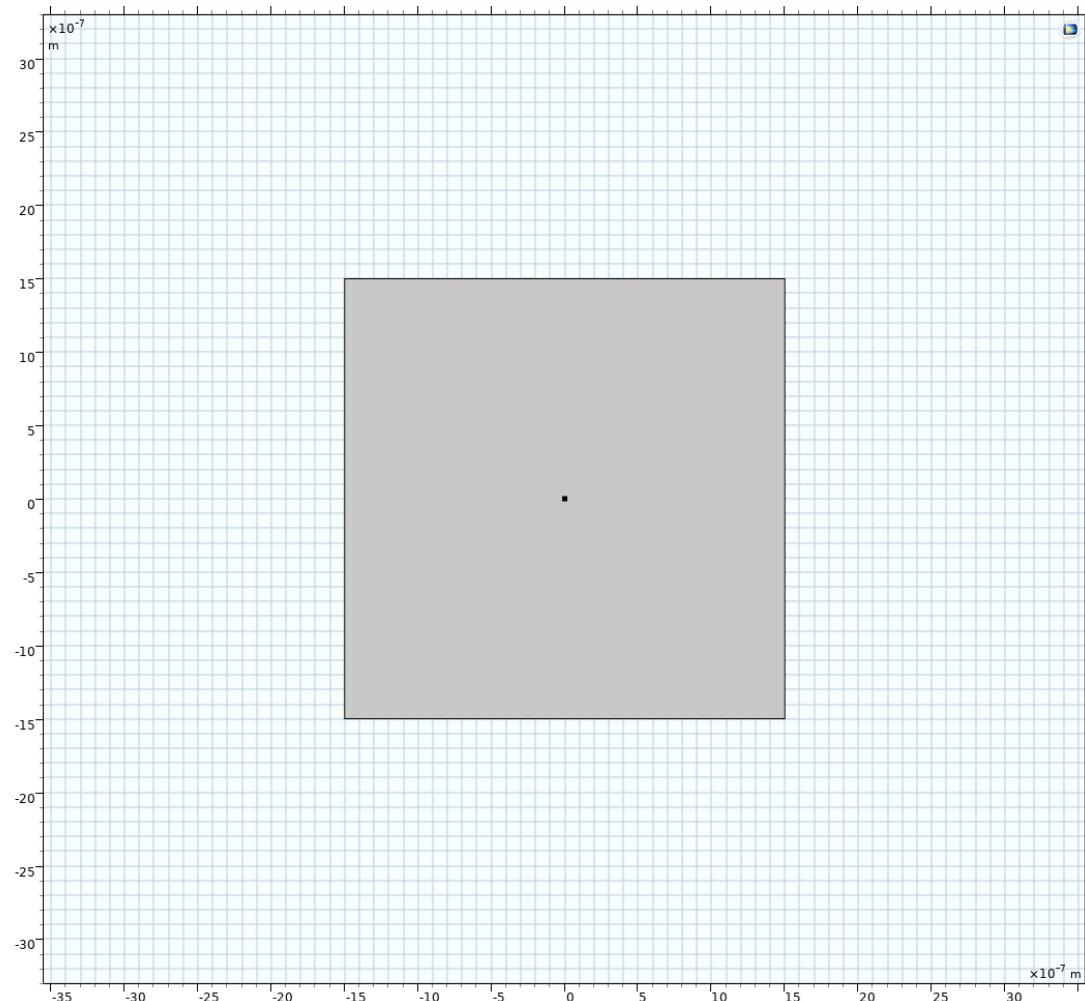
Help Cancel Done

# COMSOL: Last Time



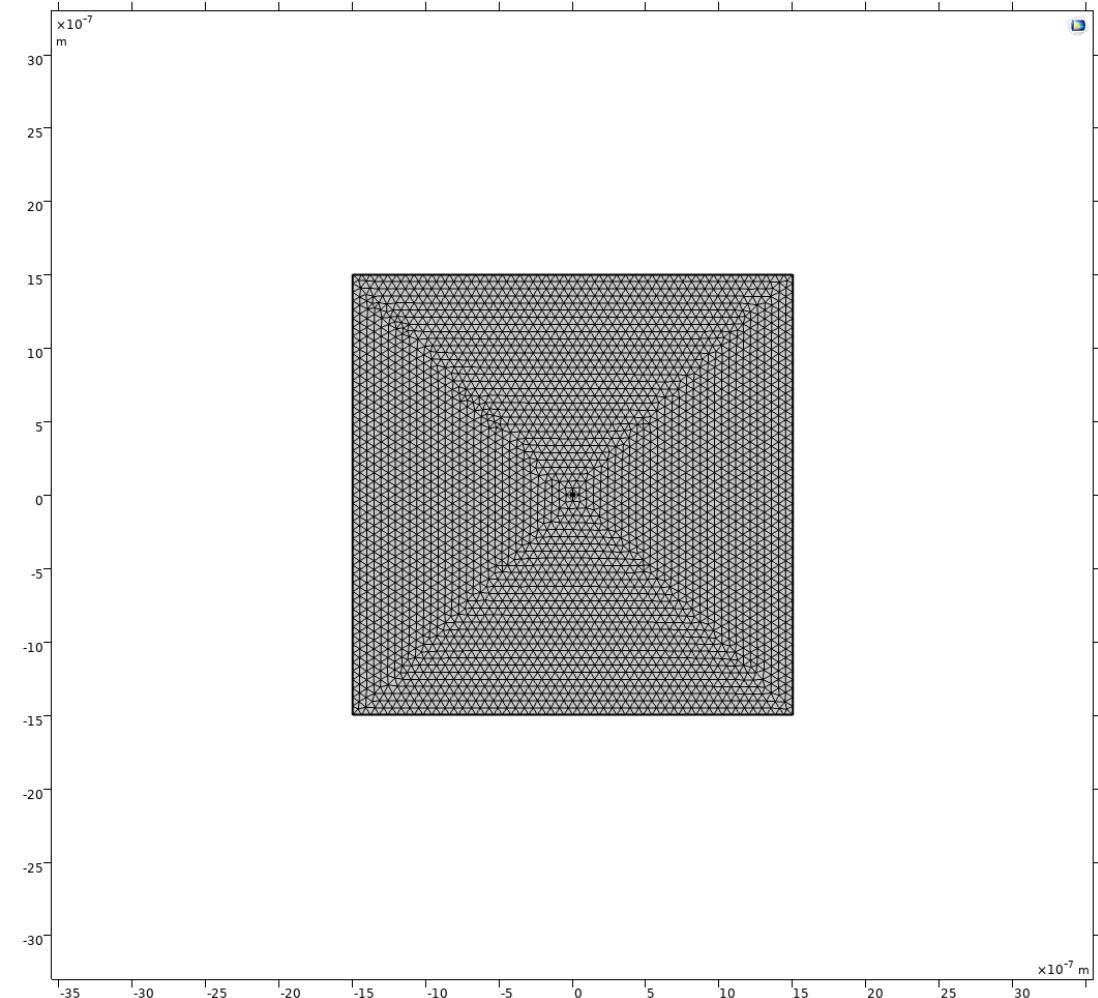
# COMSOL: Last Time

- Define simulation domain
- Build geometry



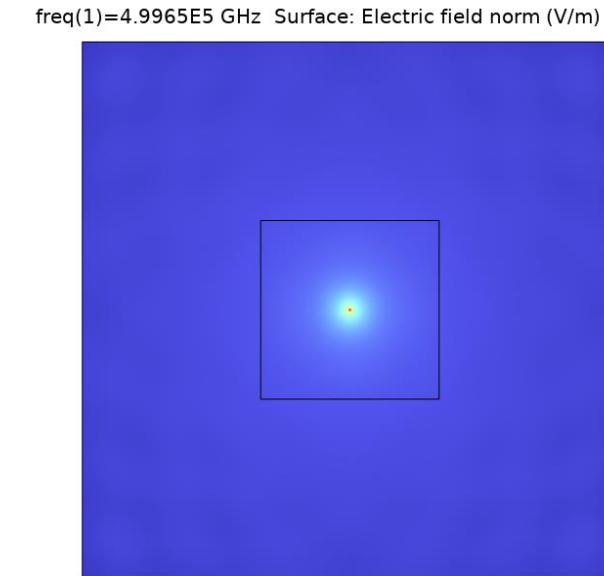
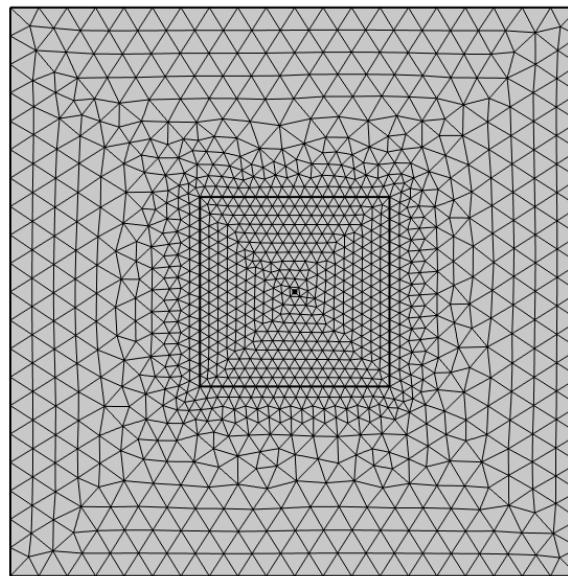
# COMSOL: Last Time

- Discretization of simulation domain
  - Build mesh
- Mesh size determines accuracy of solution
  - Too large mesh  $\Rightarrow$  wrong results
- Accuracy vs. simulation time
  - **Today:** Optimization by manual refinement

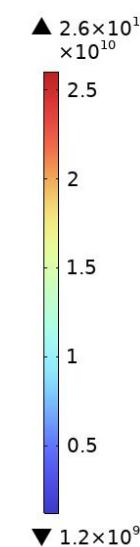


# COMSOL: Today

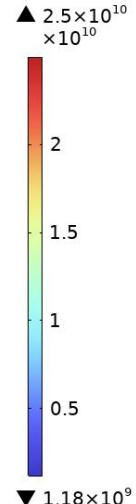
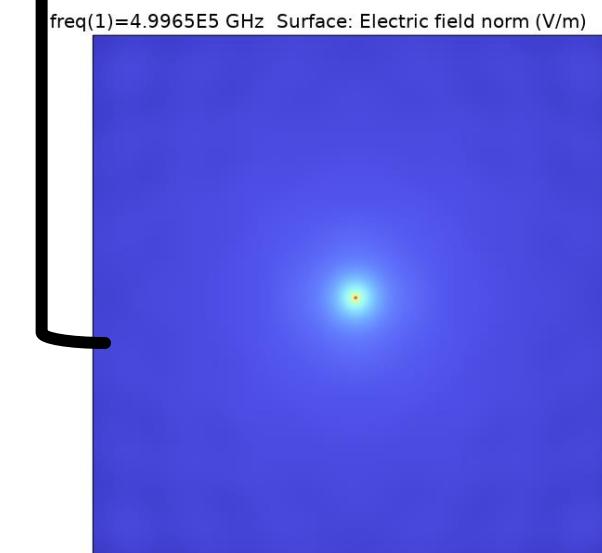
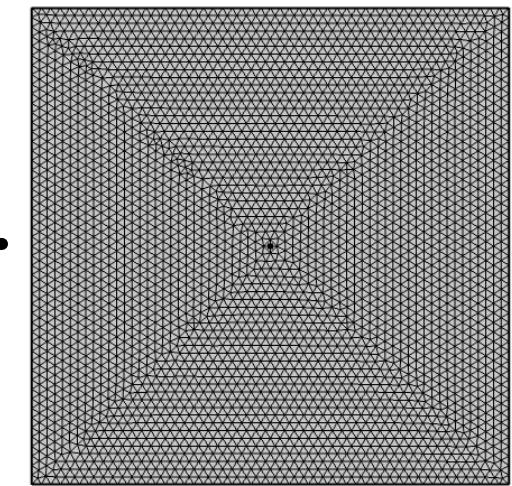
- Accuracy vs computation time
  - Too coarse mesh: incorrect results
  - Too fine mesh: unnecessary large computation time
- Applying manual refinement
  - Refining **only in the region of interest**



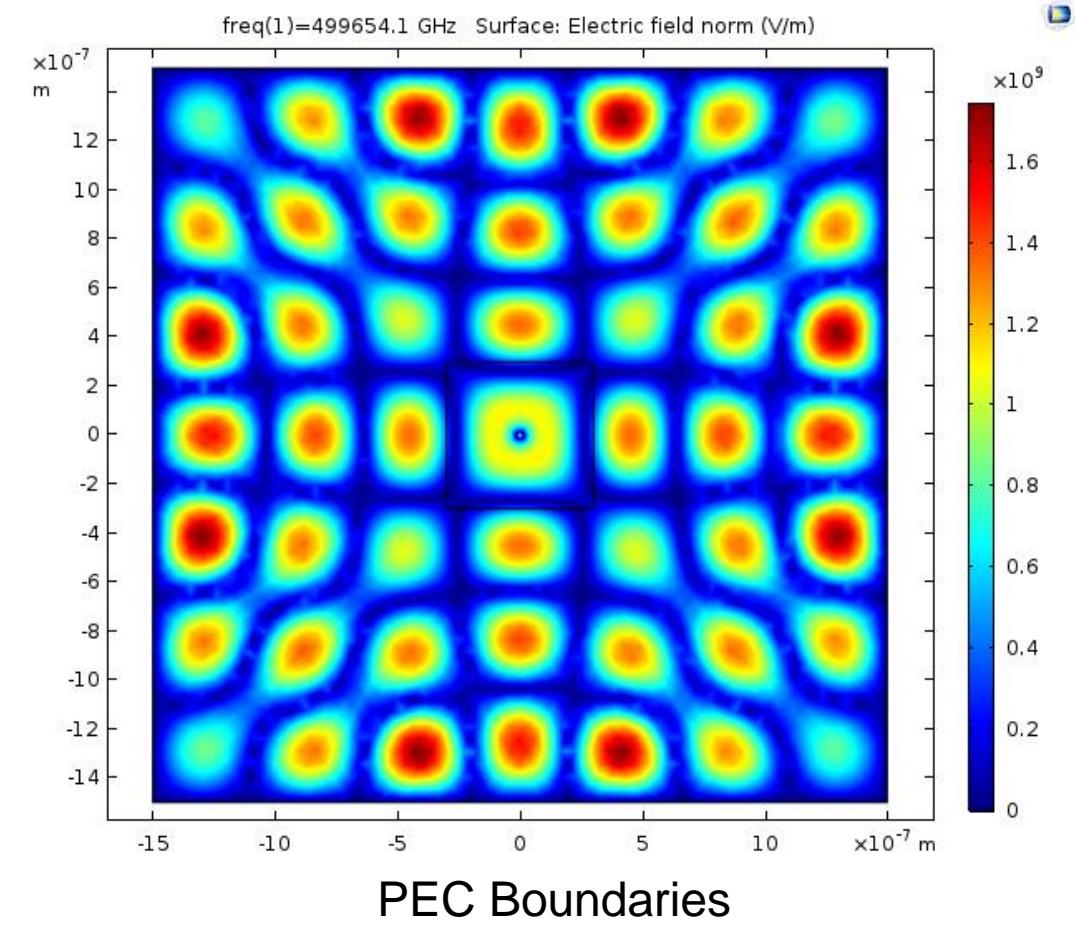
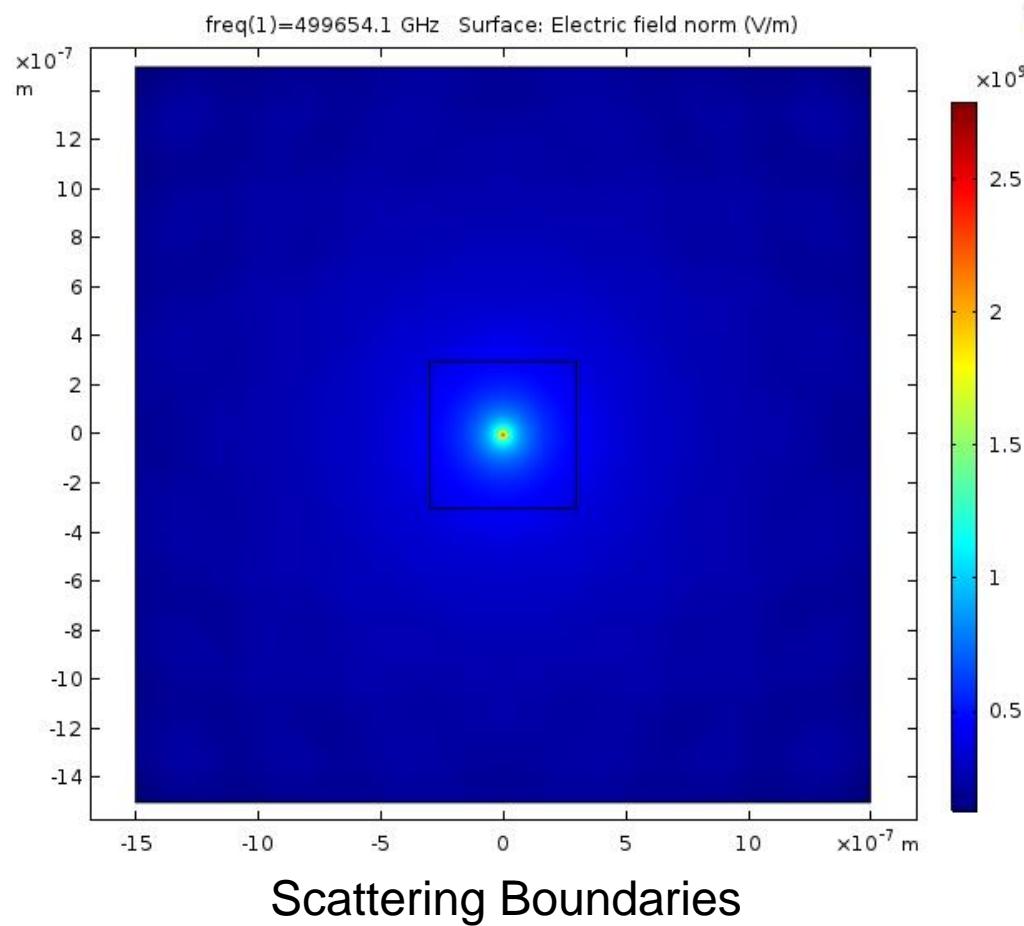
~ 4s



~ 10s

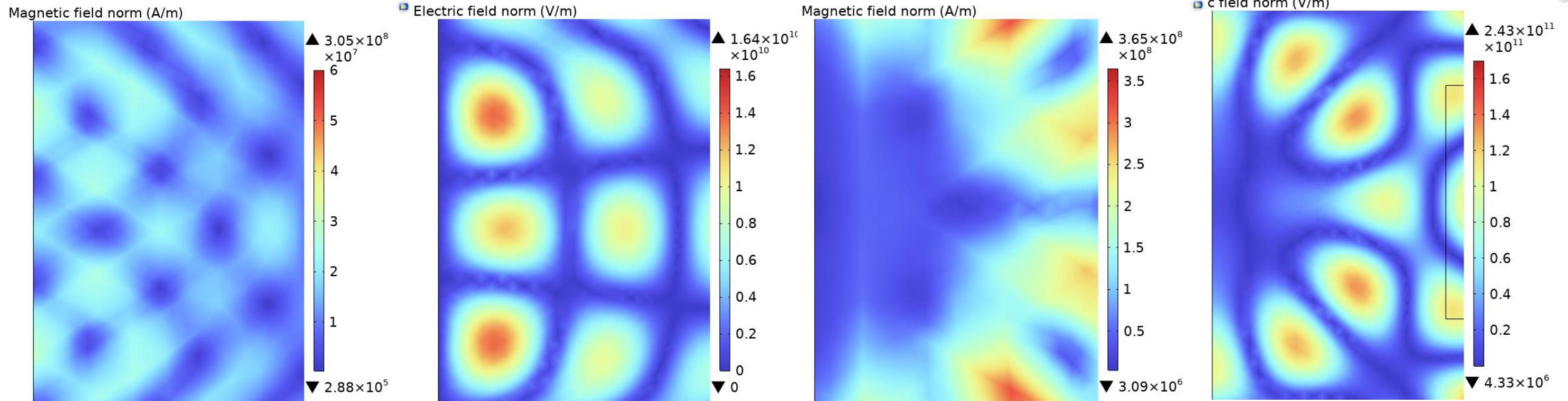


# COMSOL: Last Time



# COMSOL: Today

- Distinction between PEC and PMC

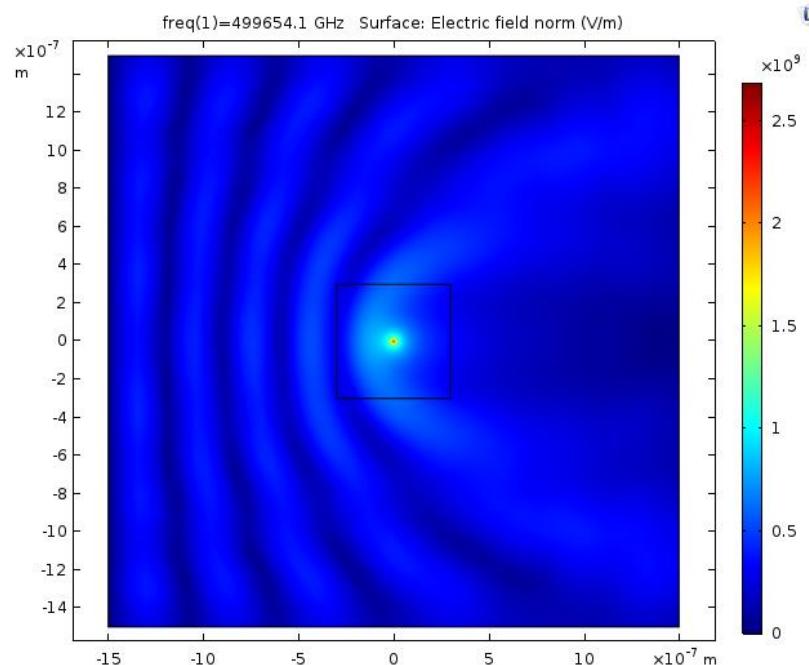


**PEC**  
 $E = 0, H \neq 0$  at boundaries

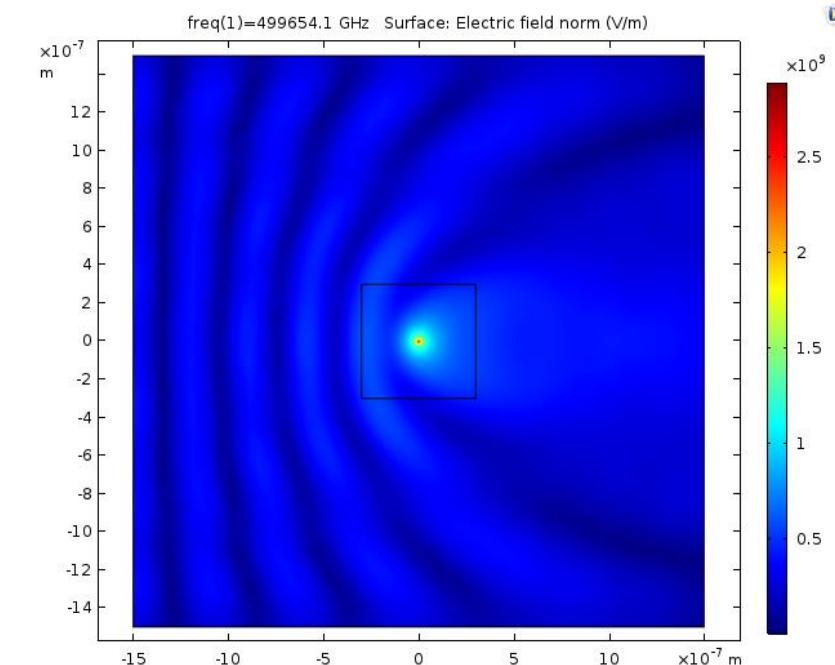
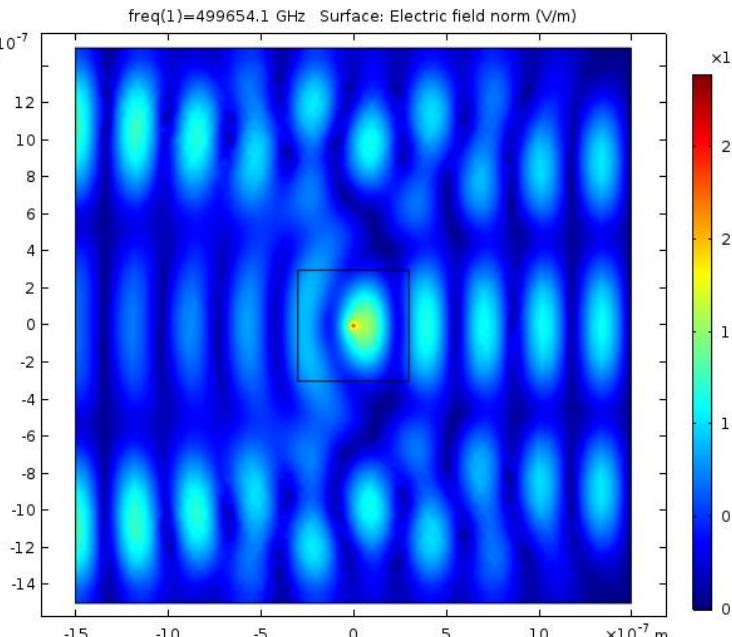
**PMC**  
 $H = 0, E \neq 0$  at boundaries

# COMSOL: Today

- Mirror effect by using different boundary conditions

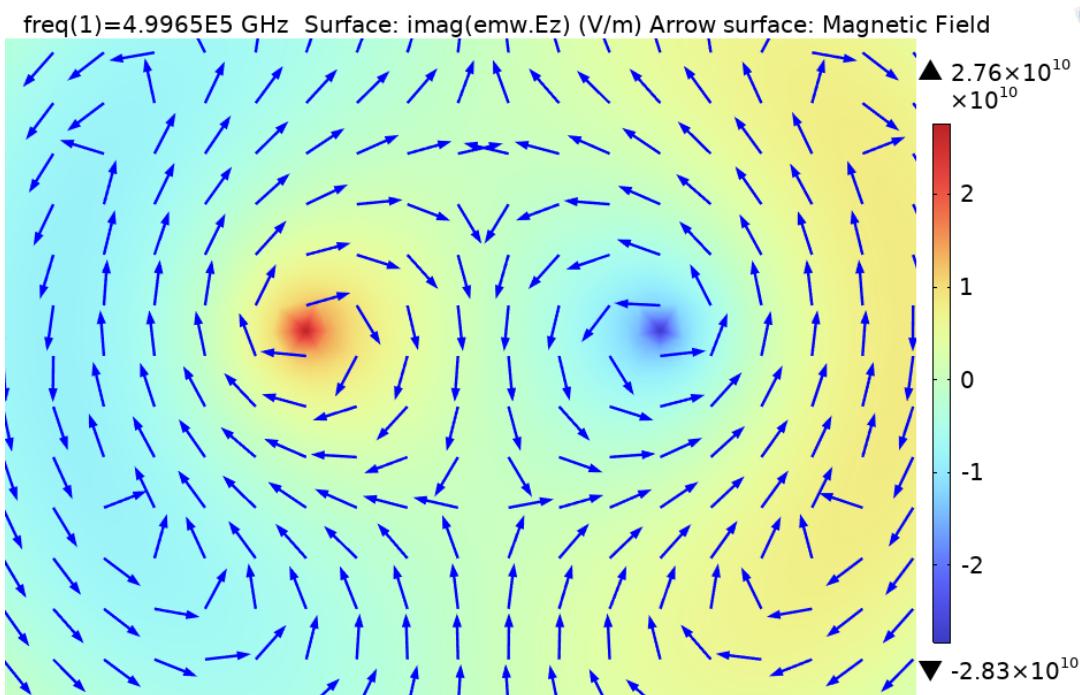


Can you see the difference?  
Can you guess the boundary  
conditions?

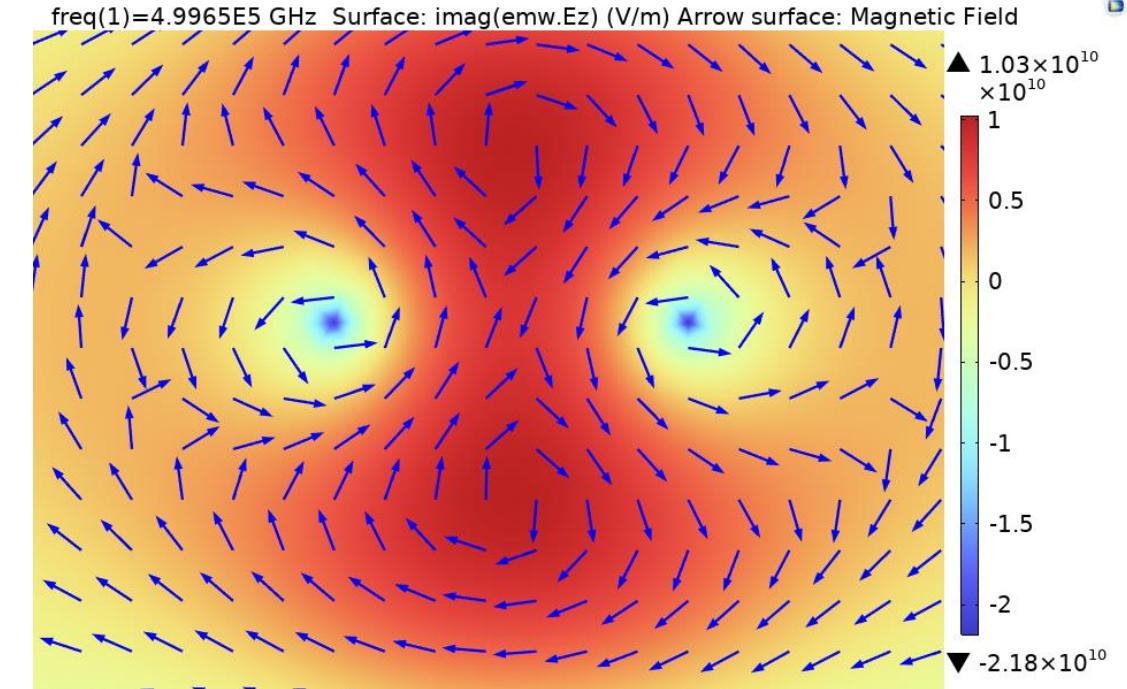


# COMSOL: Today

- Double Source



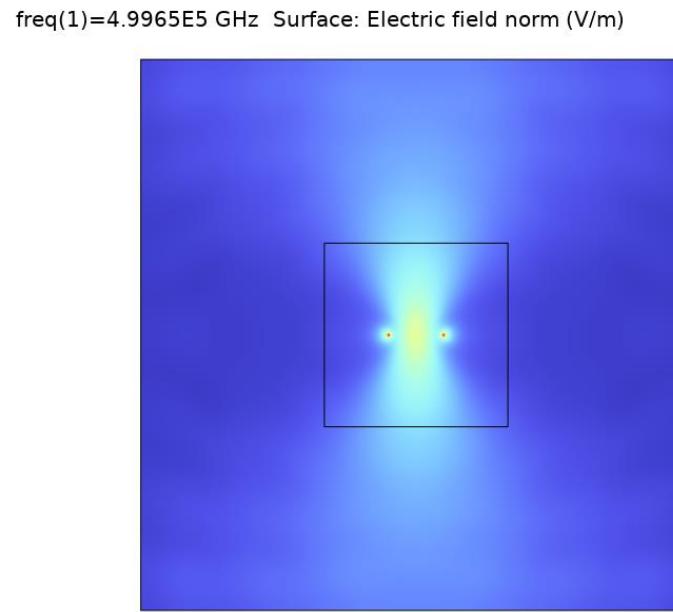
With two currents in opposite direction



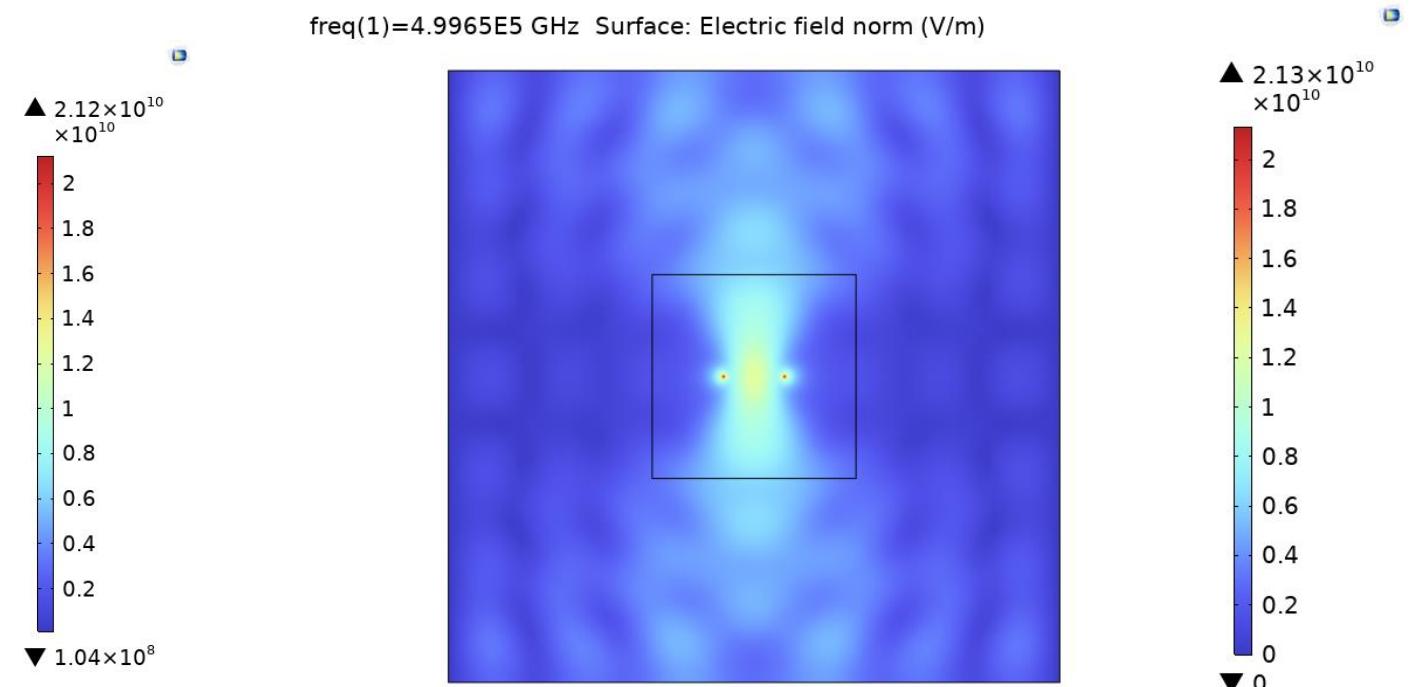
With two currents in same direction

# COMSOL: Today

- Effects of BCs
  - PECs behave as a mirror interface



SBCs everywhere



PECs at which  
boundary?

# COMSOL: Today

- Optimizing a parameter → parameter sweep
  - It allows us to evaluate our model's properties w.r.t this parameter

