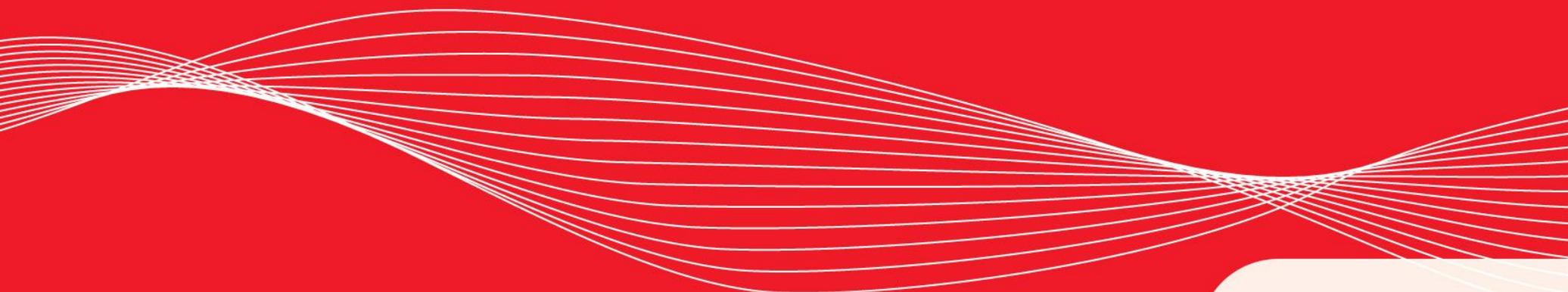


# EMPIRE XPU Tutorial

## Waveguide Exciter



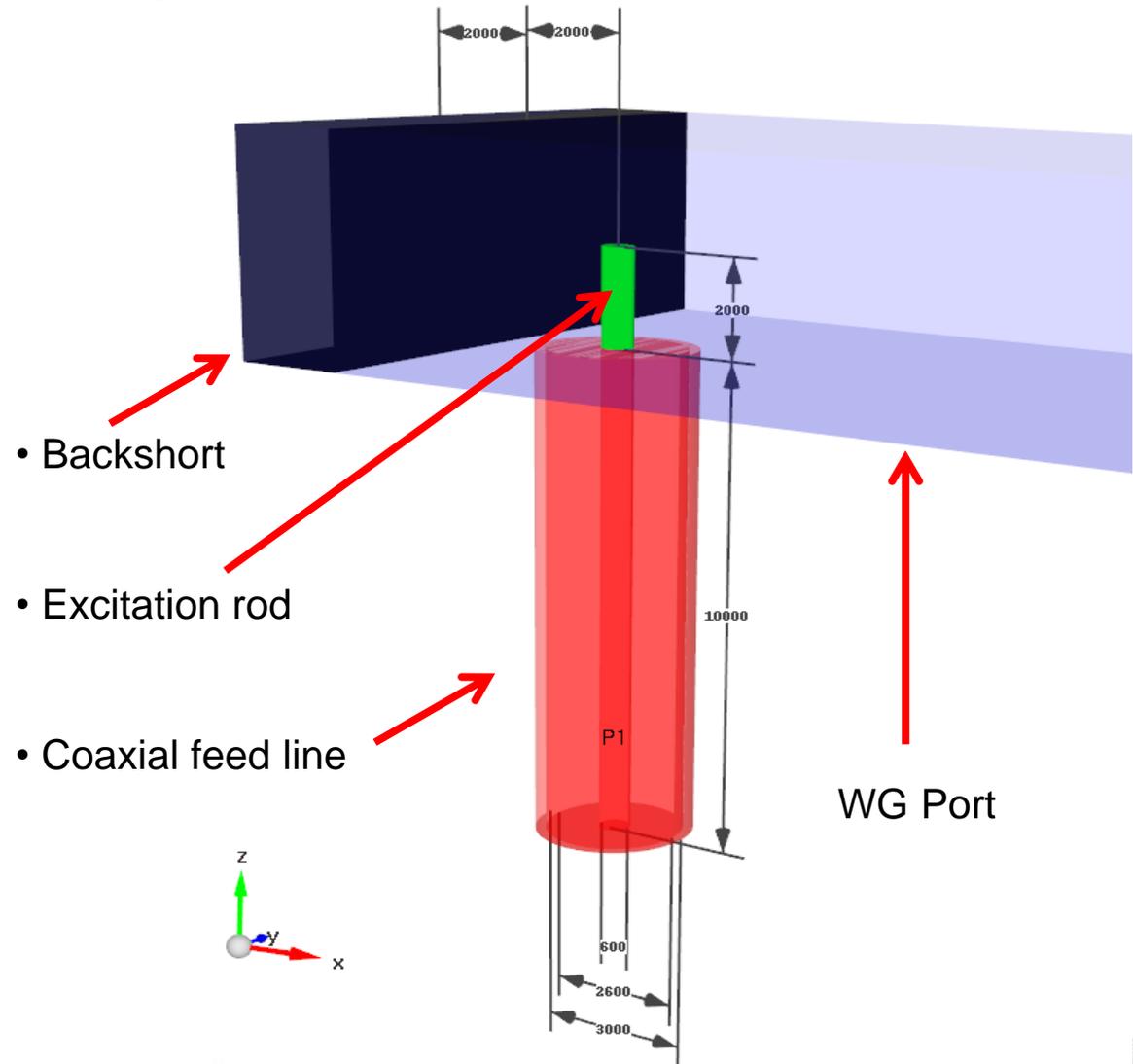
# Topics and outline

## Drawing Interface:

- Basic Features
- Waveguide Ports
- Coaxial Ports
- Priority Concept
- Parametric Objects

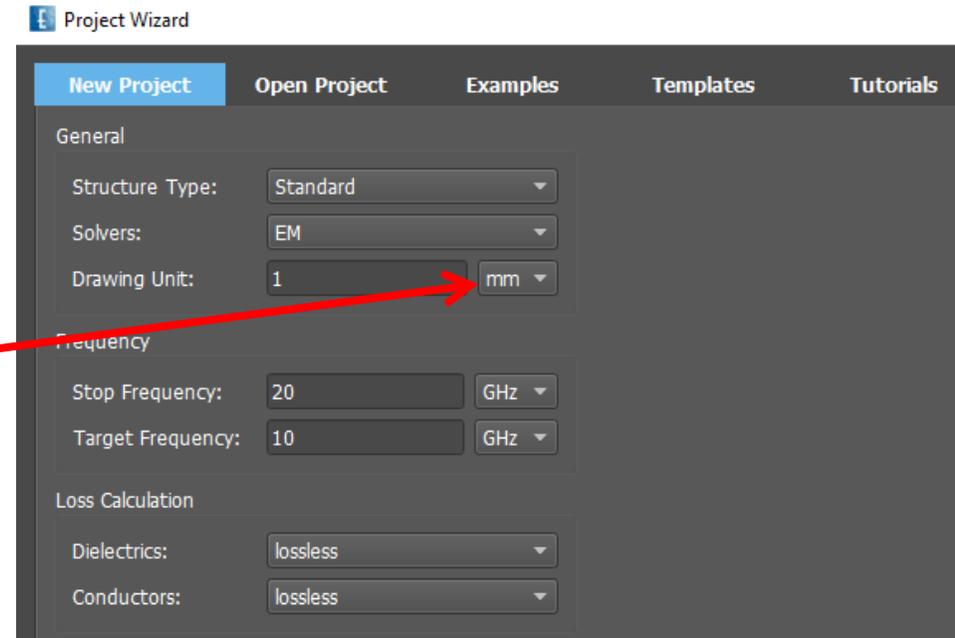
## Processing Interface:

- Preprocessing
- Simulation Control
- Postprocessing
- Optimization



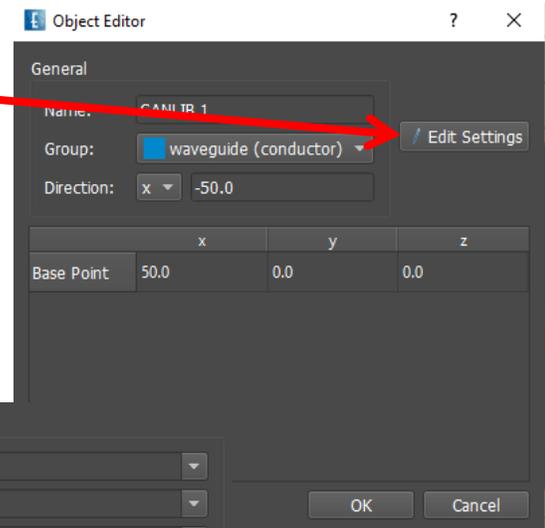
# Step 1: Start

- Start Empire XPU 
- Select „New Project“ Tab
- Change „Drawing Unit“ to mm
- Click OK
  
- Select File → “Save As”
- Create new folder (e.g. on Desktop), save file

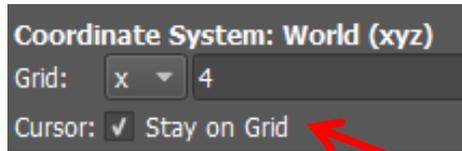


# Step 2: Create Waveguide

- Right click on #001, „Edit Name“ to „waveguide“
- Change grid from z=0 to x=0 (yz plane)
- Click Icon ‘Create Source’
- Select ‘Waveguide’ -> ‘Rectangular waveguide’
- Left click at x=0, y=-5, z=-2.5
- Left click at dv=10, dw=5
- Zoom out\* & left click to confirm du=50
- Click „Edit Settings“ in the editor
- In „Geometry“ adjust „Width“ to 10.67 (mm)
- Set „Height“ to ‘0.5\*w’
- In „Port Definition“ set „Port Excitation“ to Off
- Close Windows (OK)
- Zoom Extends (shortcut z)

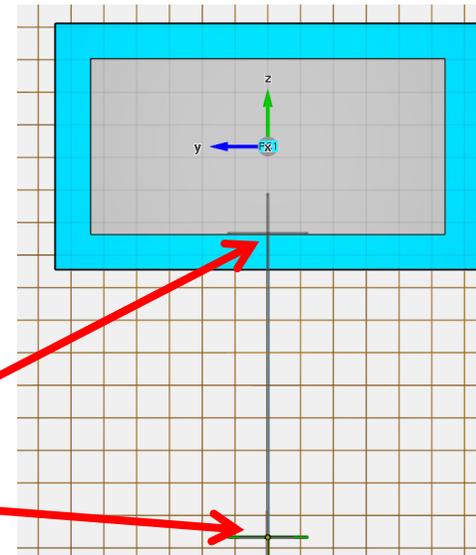


# Step 3: Coaxial Port



- Set grid to x=4 and checkmark „Stay on Grid“
- Press „Add Group“
- Change group name to “Coax”

- Click Icon ‘Create Source’
- Select ‘Coax’ → ‘Coax’
- Switch to „Side view“ & Opposite view, zoom out
- Left click at x=4, y=0, z=-2.6675\* (feed position, edge center snap)
- Left click at x=4, y=0, z=-12 (load position)
- 2x left click at any position (to define further parameter as text input)
- Click „Edit Settings“ and set: di: 0.6 , dd: 2.6 , da: 3 , lr: 2
- Close windows (OK)
- Switch to Iso z view

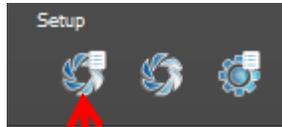


Geometry			
Inner	Diameter	di=	0.6
Dielectric	Diameter (>di)	dd=	2.6
Outer	Diameter (>dd)	da=	3.0
	Rod length (>=0)	lr=	2.0

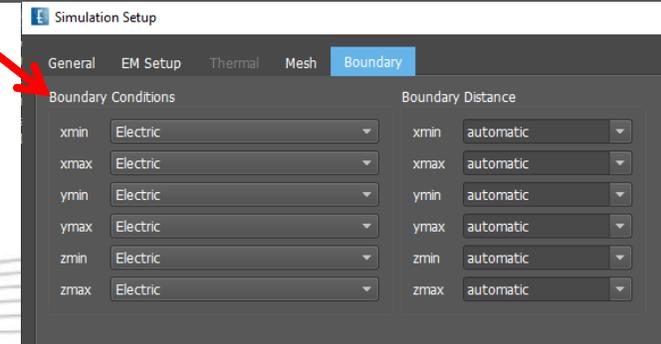
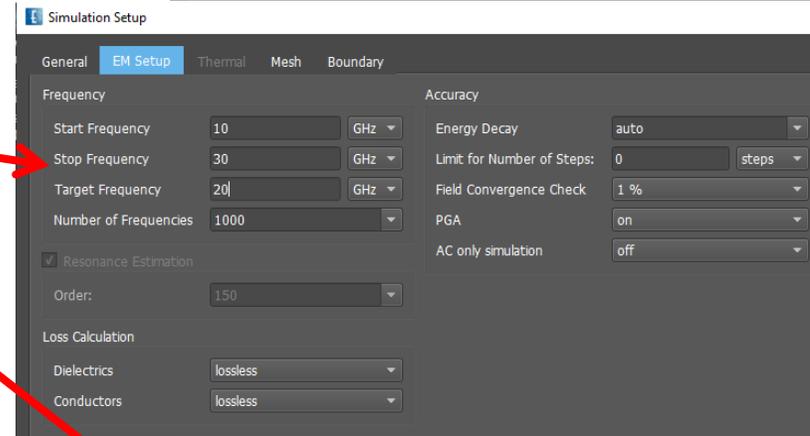
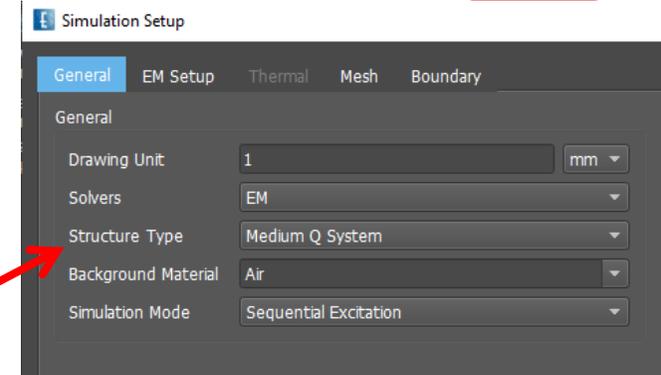
Comment:

- \* Snap on inner edge of waveguide

# Step 4: Simulation setup



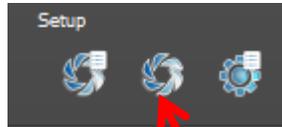
- Select Icon Simulation Setup
- Set “Structure Type” to Medium Q System’
- „EM Setup“: Start: 10 GHz
- Stop: 30 GHz, Target: 20 GHz
- „Boundary“: Conditions: Set all to Electric
- Close window with OK



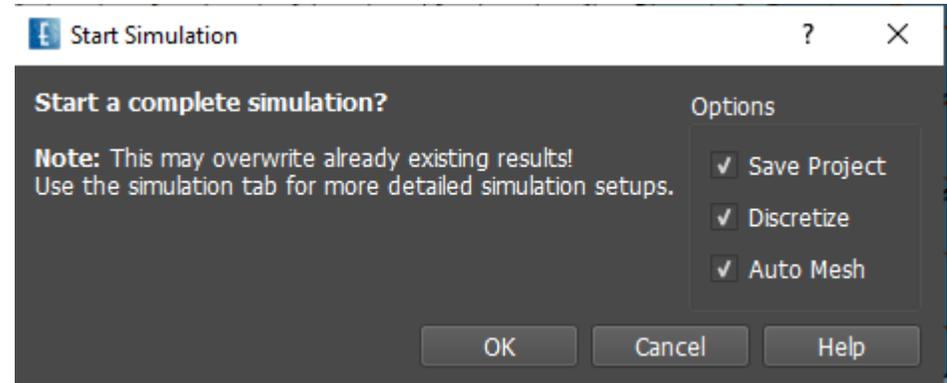
## Simulation setup:

- *Geometry: 1 unit in the drawing equals 1 mm, here*
- *Structure Type: Information about the structure for automatic meshing and end criteria*
- *Frequency: Determines the range of the DFT, the pulse width used is derived by maximum cell size*
- *Accuracy – Resolution Medium (15/4): Maximum cell size determined by 15 cells per wavelength at Stop Frequency, using at least 4 cells per object or gap*
- *Boundary conditions:*
  - *electric defines infinite ground plane,  $E_t=0$ , (magnetic  $H_t=0$ )*
  - *Absorbing N emulates open space (N should be larger in the main radiation direction)*

# Step 5: Simulation

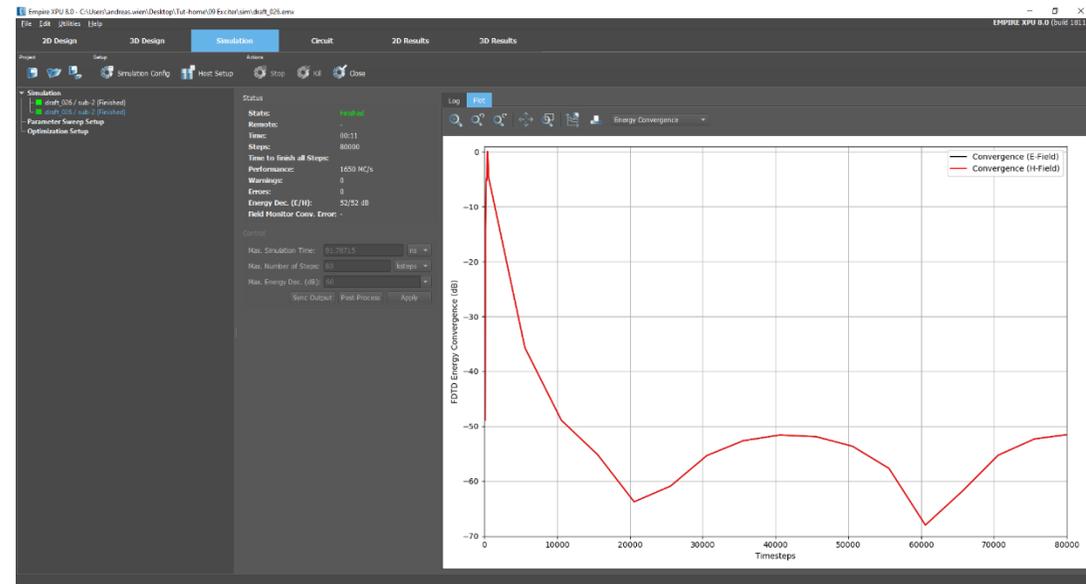


- Click “Start Simulation”  
→ ‘OK’



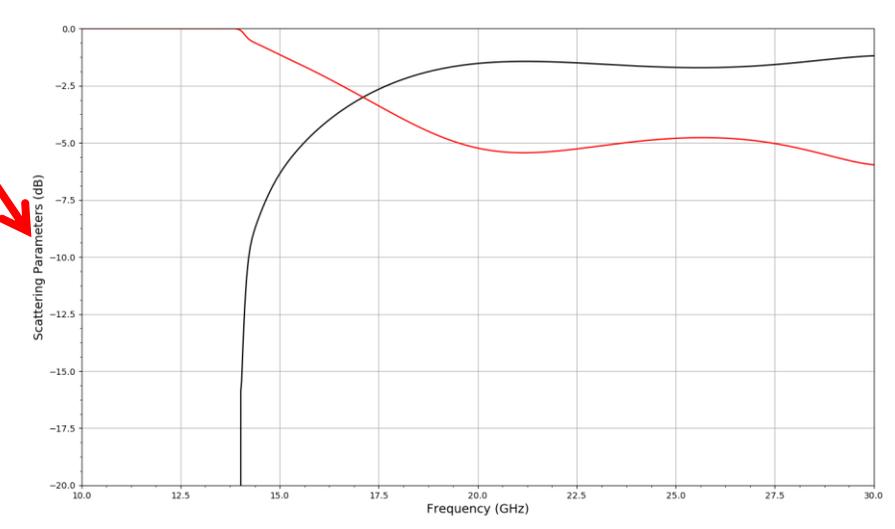
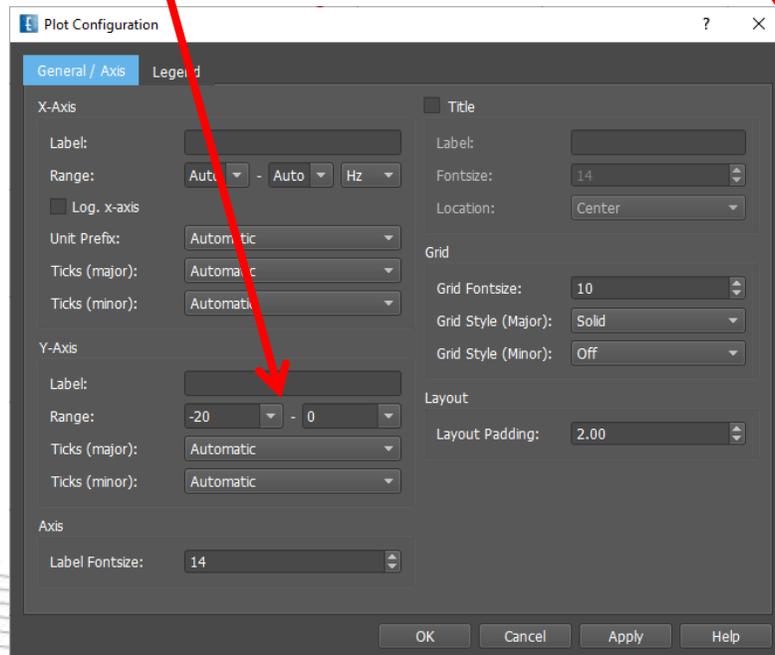
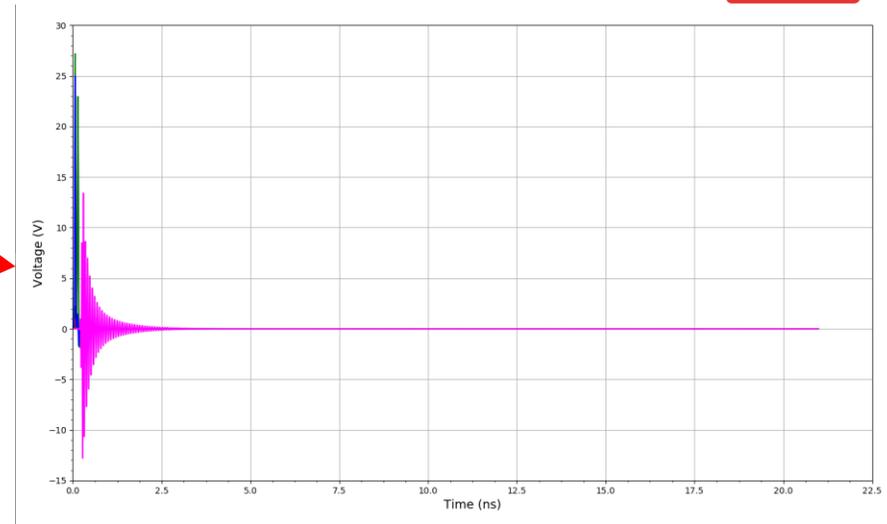
## Meshing and simulation:

- The created mesh lines are displayed on the bars at the right and at the bottom in 2D Design
- The simulation domain is marked by the red lines which indicate electric condition in 2D Design
- With “Start Simulation” the structure is checked, meshed and prepared for simulation
- As soon as the “Energy Convergence” plot comes up the simulation starts, the evolution of the time signal is shown
- When the end criteria has been reached, the “State” is marked as “Finished”
- In the Simulation Tab, the log window reports on the cut-off frequency and mode used for the simulation of the waveguide port



# Step 6: Results

- Switch to “2D Results tab”
- Plot Type “Voltage (Time Domain)”
- Plot Type “Scattering Parameters”
- Right click in plot area, “Configure Plot”, and set Y-Axis range to -20 to 0, OK



# Step 7: Backshort

## Create new group

- Return to 3D Design tab
- Create new group “Backshort”
- Adjust transparency sliders

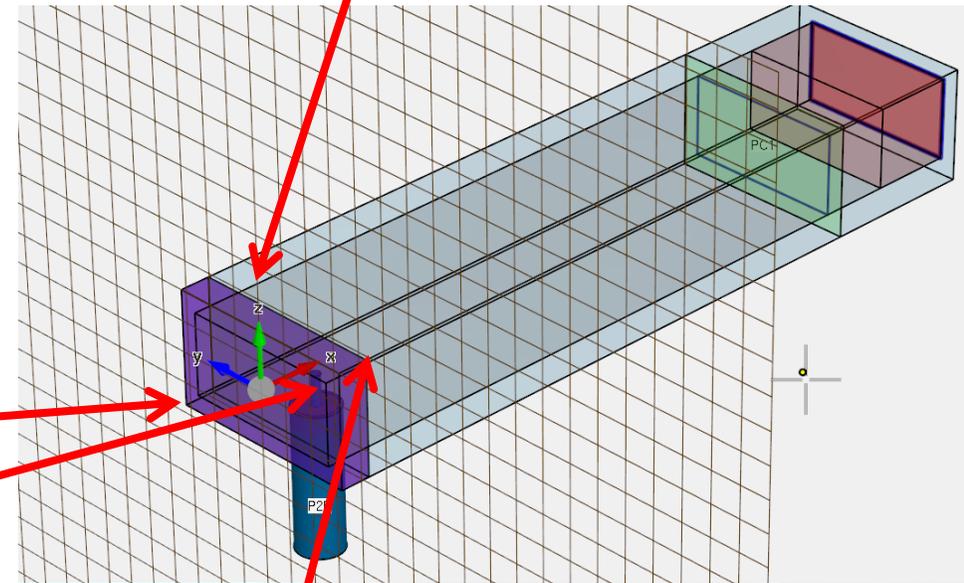
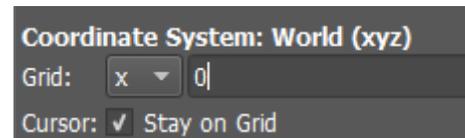


Backshort

Waveguide

## Draw backshort box

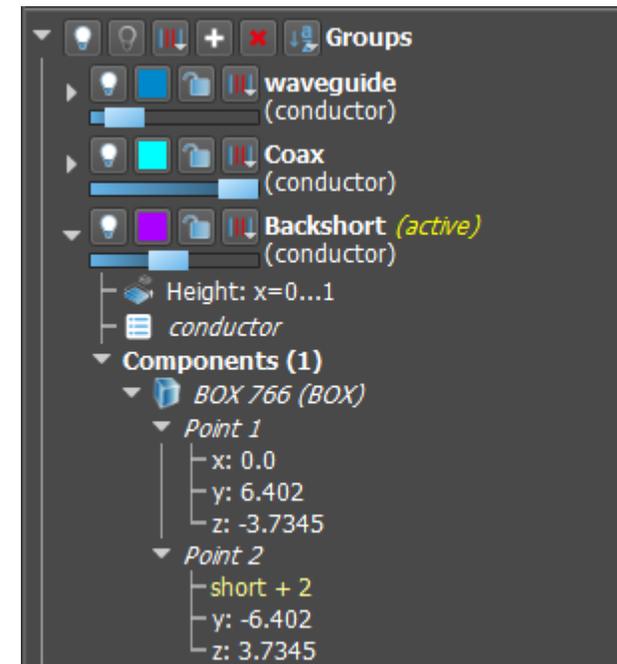
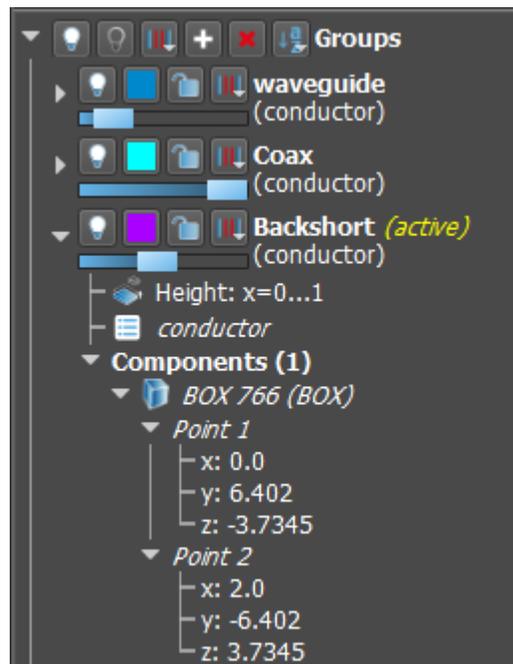
- Set grid x=0, keep checkmark for stay on grid snap
- Select Icon 'Create box'
- Left click at waveguide corner
- Left click at opposite waveguide corner
- Left click at du=2 position
- OK



# Step 8: Variables 1

## Define Variable *short* for the backshort distance

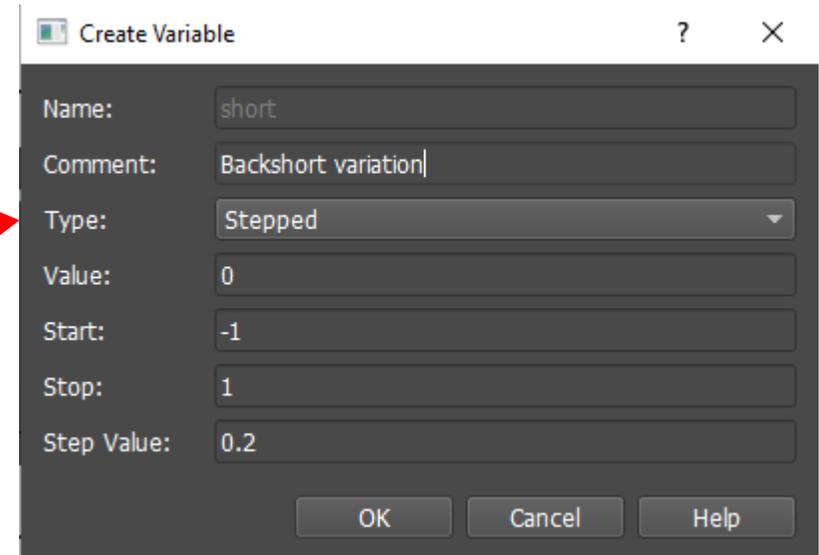
- Open Component in “Backshort” group
- Double click on x-value of Point 2: Enter string “short + 2”



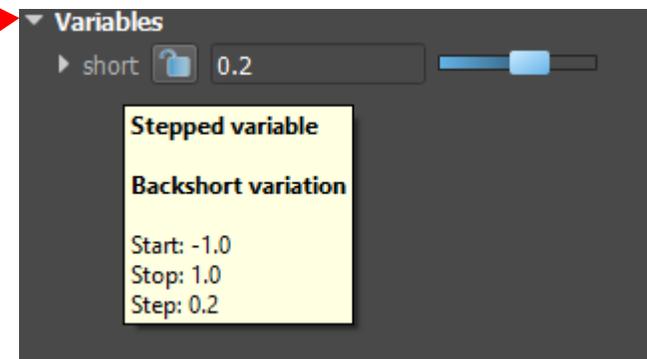
# Step 9: Variables 2

## Define parameter range for the backshort distance

- Set Type and Values
- Optionally enter a comment
- Close OK



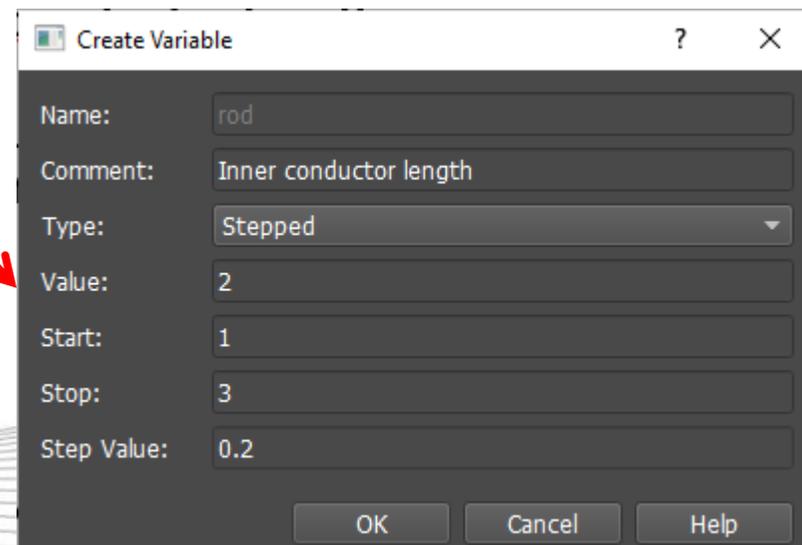
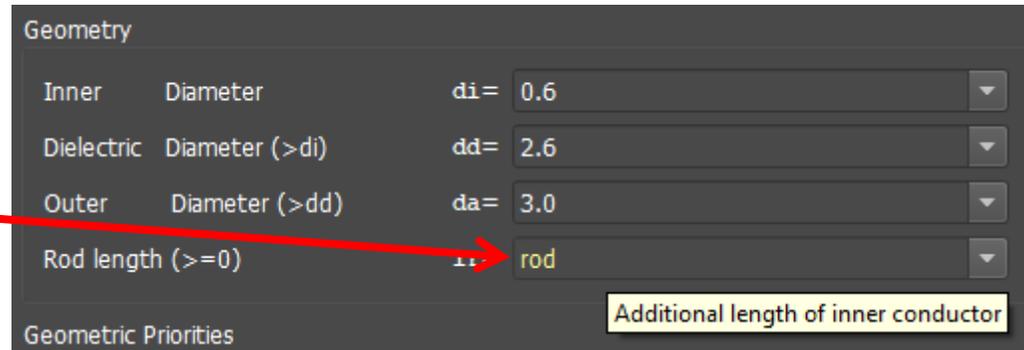
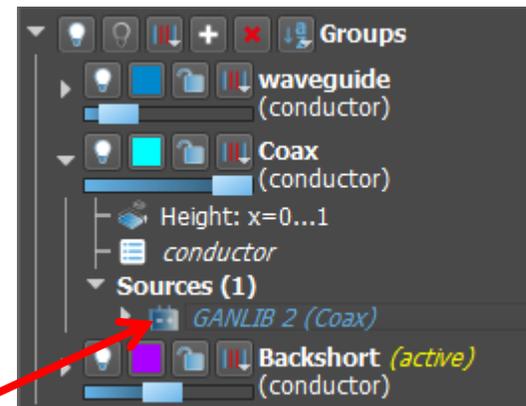
- Open Variables on the left
- Move slider to verify range
- Reset short = 0



# Step 10: Variables 3

## Define Parameter *rod* for the Coaxial inner conductor length

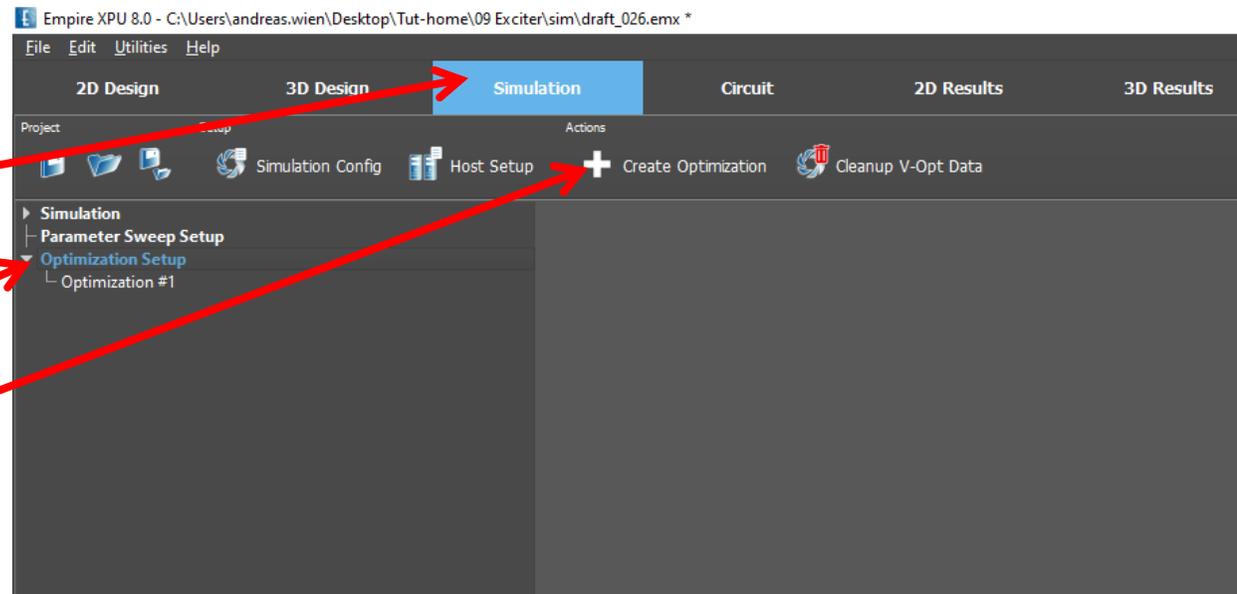
- Open Group Coax
- Open Sources(1), double click on icon
- Click “Edit Settings”
- Enter *rod* in ‘Rod length’
- Click OK
- Set New Parameter range
- Optionally enter a comment
- Close Windows (OK)
- Save the project



# Step 11: Optimization 1

## Setting up the optimization

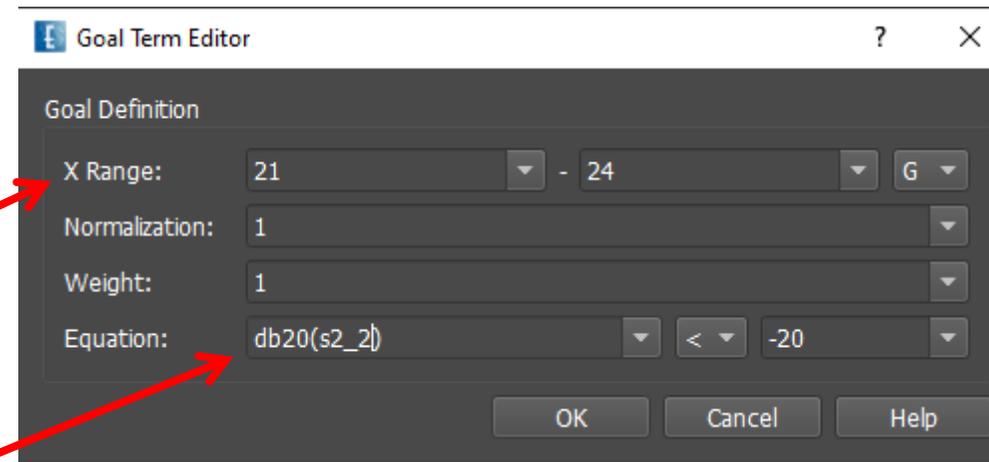
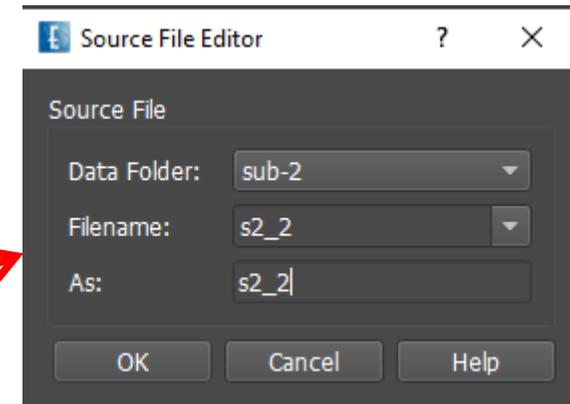
1. Click Simulation tab
2. Click Optimization Setup
3. Click Create Optimization



# Step 12: Optimization 2

## Defining the source file

- Right Click in “Goal” Window – Add Source
- Enter s2\_2 in “Filename” and “As”, OK
- Right Click in “Goal” Window – Add Goal
- Define the frequency range: 21 – 24 in X Range using “G” as unit
- Set Equation  $\text{db20}(\text{s2\_2})$ , OK

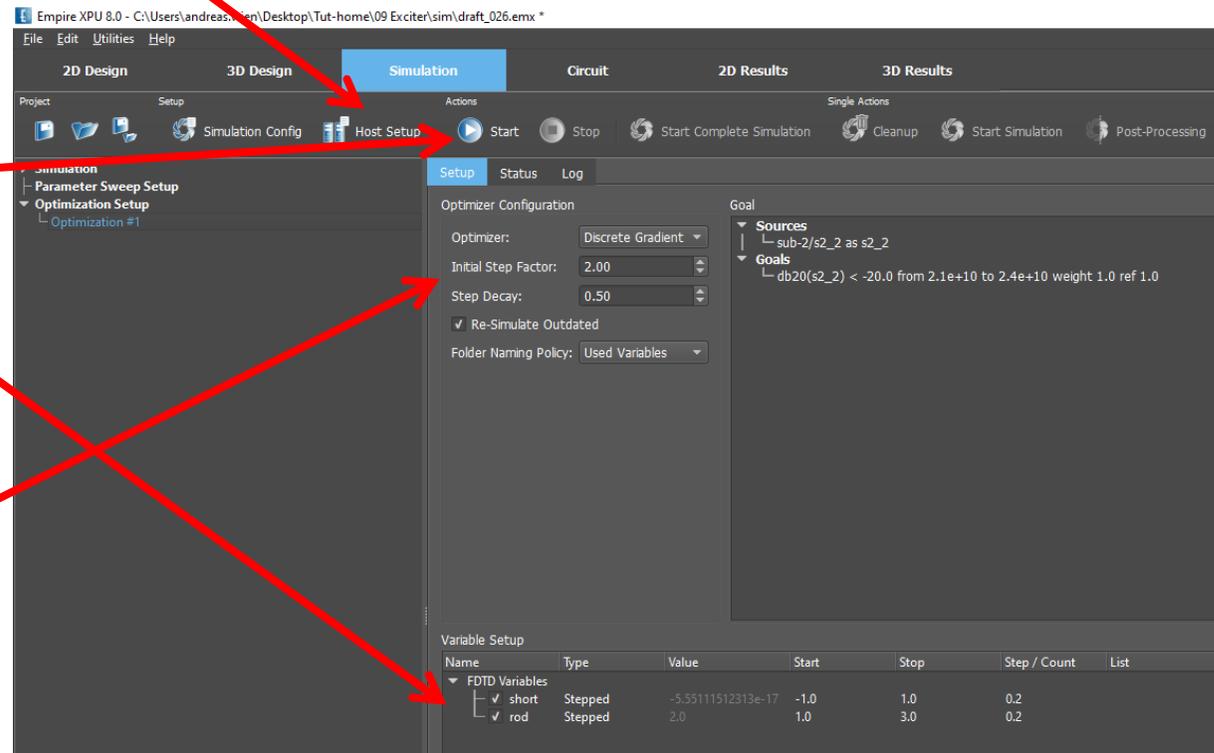


*Goal: from 21GHz to 24GHz the matching should be less than -20dB*

# Step 13: Optimization 3

## Starting the optimization

- Optionally click “Host Setup” to select remote computers for simulation (you can use multiple PC’s from your network in parallel if you have multiple licenses)
- Keep localhost, if there are no further Empire Servers available
- Check Sources and Goal
- Press Start optimization



*Optimization Iteration (each opt. parameter is varied +/-) here two parameters (rod and short) with 200µm*

*Initial Step Factor set to 2; a 400µm stepping is performed in first iteration If there is no improvement with a 400µm step, a refinement with a Decay of ½ is performed => 200µm stepping in second iteration*

# Step 14: Optimization Status

Status Tab

Access to individual simulation log window

Current average deviation  
Status of Current simulation  
Current variable values

Optimizer Status

Status: **Running**

Goal (Min.): 0.355134

Item (Min.): #00012 (v-opt-00012)

Sim Dir	Goal	Status	Notes	short	rod
✓ #00001 (v-opt-00001)	16.7621	Complete		-5.55112e-17	2
✓ #00002 (v-opt-00002)	13.7313	Complete		-5.55112e-17	2.4
✓ #00003 (v-opt-00003)	17.7591	Complete		0.4	2
✓ #00004 (v-opt-00004)	15.8128	Complete		-0.4	2
✓ #00005 (v-opt-00005)	10.6386	Complete		-5.55112e-17	2.8
✓ #00006 (v-opt-00006)	11.6309	Complete		-0.4	2.4
✓ #00007 (v-opt-00007)	9.99335	Complete		-5.55112e-17	3
✓ #00008 (v-opt-00008)	6.56276	Complete		-0.4	2.8
✓ #00009 (v-opt-00009)	5.70912	Complete		-0.4	3
✓ #00010 (v-opt-00010)	2.13453	Complete		-0.8	2.8
✓ #00011 (v-opt-00011)	1.00233	Complete		-0.8	3
✓ #00012 (v-opt-00012)	0.355134	Complete		-1	2.8
✓ #00013 (v-opt-00013)		v-opt-00013 / D..		-1	3

# Step 15: Optimization Log

- Every parameter variation is computed in a new subdirectory v-opt-000xx-par-name ...
- Optimized values rod = 3 mm short = -1 mm in subdirectory:v-opt-00013-rod=3-short=-1

```

Setup  Status  Log
***
*** Starting Optimization
*** Date and Time: 14-11-2019 11:31:01
***

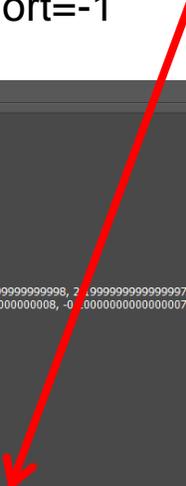
Optimizer: Discrete Gradient
Goal:
*****
SOURCE sub-2/s2_2 as s2_2

TERM db20(s2_2) < -20.0 from 2.1e+10 to 2.4e+10 weight 1.0 ref 1.0
*****

Parameter: rod 2.0 [1.0, 1.2, 1.3999999999999999, 1.5999999999999999, 1.7999999999999998, 1.9999999999999998, 2.1999999999999997, 2.3999999999999999, 2.6000000000000001, 2.8000000000000003, 3.0000000000000004]
Parameter: short -5.55111512313e-17 [-1.0, -0.8000000000000000, -0.6000000000000000, -0.4000000000000000, -0.2000000000000000, -5.5511151231257827e-17, 0.1999999999999999, 0.3999999999999999, 0.5999999999999999, 0.8000000000000000]

14-11-2019 11:31:28 : Average Deviation is 16.762 for v-opt-00001-rod=2-short=-5.55112e-17
14-11-2019 11:31:42 : Average Deviation is 13.731 for v-opt-00002-rod=2.4-short=-5.55112e-17
14-11-2019 11:31:55 : Average Deviation is 17.759 for v-opt-00003-rod=2-short=-0.4
14-11-2019 11:32:12 : Average Deviation is 15.813 for v-opt-00004-rod=2.8-short=-0.4
14-11-2019 11:32:33 : Average Deviation is 10.639 for v-opt-00005-rod=2.8-short=-5.55112e-17
14-11-2019 11:32:47 : Average Deviation is 11.631 for v-opt-00006-rod=2.4-short=-0.4
14-11-2019 11:33:11 : Average Deviation is 9.993 for v-opt-00007-rod=3-short=-5.55112e-17
14-11-2019 11:33:24 : Average Deviation is 6.563 for v-opt-00008-rod=2.8-short=-0.4
14-11-2019 11:33:43 : Average Deviation is 5.709 for v-opt-00009-rod=3-short=-0.4
14-11-2019 11:33:53 : Average Deviation is 2.135 for v-opt-00010-rod=2.8-short=-0.8
14-11-2019 11:34:13 : Average Deviation is 1.002 for v-opt-00011-rod=3-short=-0.8
14-11-2019 11:34:26 : Average Deviation is 0.355 for v-opt-00012-rod=2.8-short=-1
14-11-2019 11:34:40 : Average Deviation is 0.000 for v-opt-00013-rod=3-short=-1

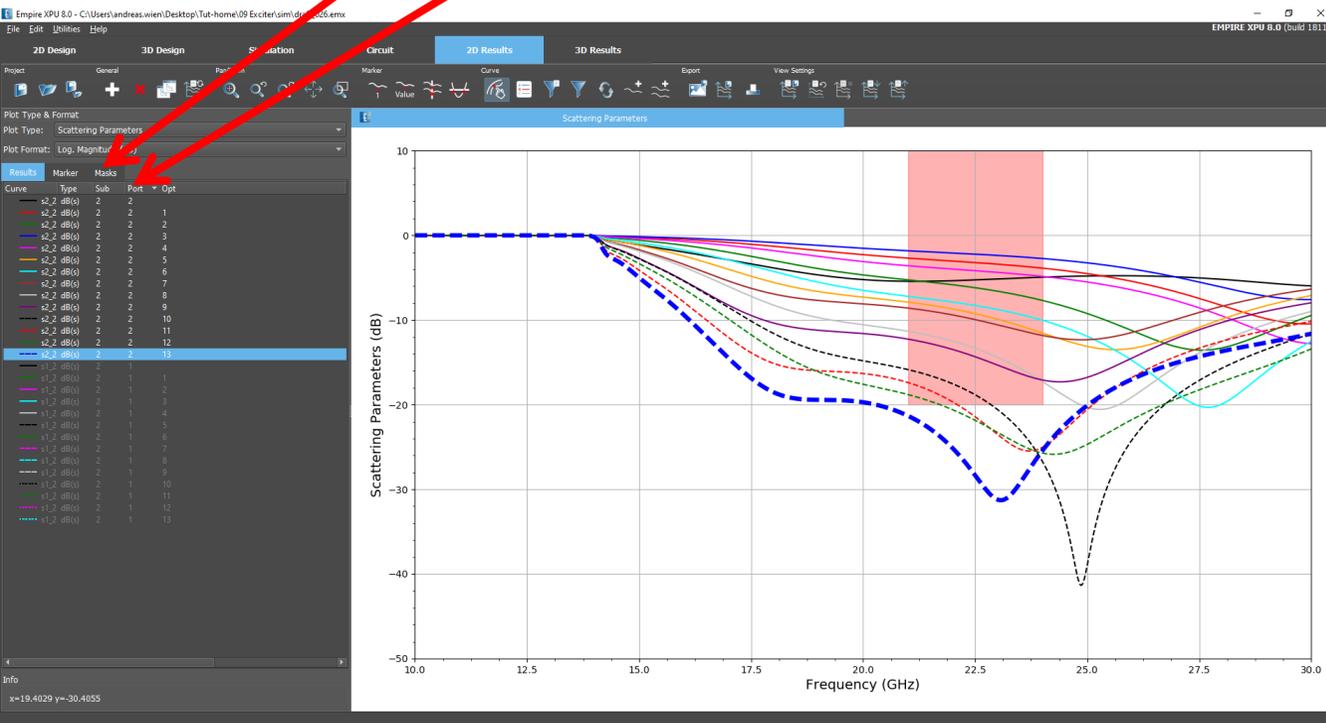
14-11-2019 11:34:40 : Optimization finished with Average Deviation: 0.000 and Parameters: {'short': -1.0, 'rod': 3.0000000000000004}
  
```



# Step 16: Optimization Results

## Optimized S-Parameters

- Switch to “2D Results” tab. “Plot Type” Scattering Parameters
- Sort list: 2x Left Click on “Port”. Click & Drag all s2\_2 curves to select
- Right click on List, “Show only & Autocolor”, Click Autoscale
- Switch to Mask Tab, right click – Add Mask, edit values

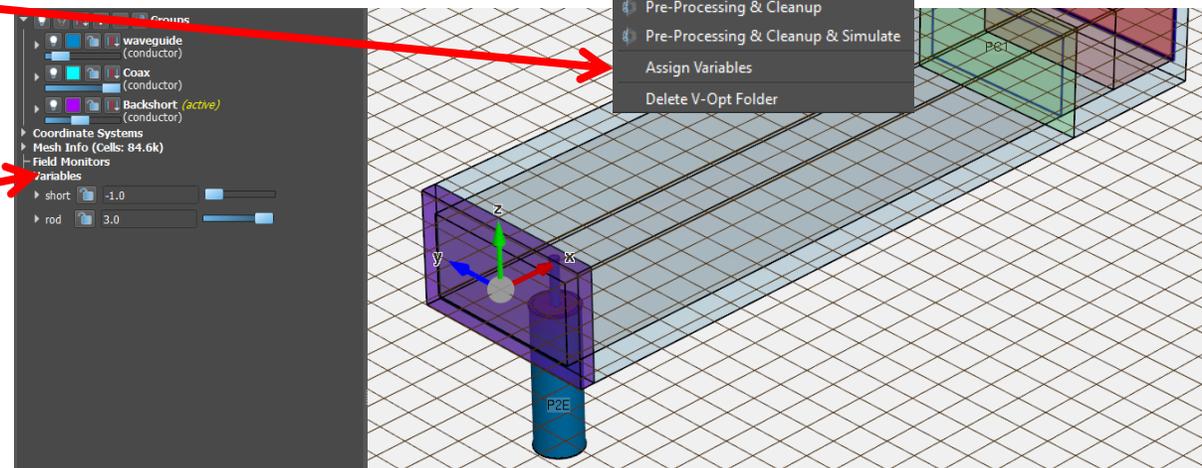


	X (GHz)	Y (dB)	Y_2 (dB)
1	21.0	-20.0	-inf
2	24.0	-20.0	-inf

# Step 17: Optimized Structure

- Switch to Simulation Tab
- Click on Optimization #1
- In Status Tab, right click on last row
- Select “Assign Variables”
- Switch to 3D Design Tab
- Open Variable List

Sim Dir	Goal	Status	Notes	short	rod
✓ #00001 (v-opt-00001)	16.7621	Complete		-5.55112e-17	2
✓ #00002 (v-opt-00002)	13.7313	Complete		-5.55112e-17	2.4
✓ #00003 (v-opt-00003)	17.7591	Complete		0.4	2
✓ #00004 (v-opt-00004)	15.8128	Complete		-0.4	2
✓ #00005 (v-opt-00005)	10.6386	Complete		-5.55112e-17	2.8
✓ #00006 (v-opt-00006)	11.6309	Complete		-0.4	2.4
✓ #00007 (v-opt-00007)	9.99335	Complete		-5.55112e-17	3
✓ #00008 (v-opt-00008)	6.56276	Complete		-0.4	2.8
✓ #00009 (v-opt-00009)	5.70912	Complete		-0.4	3
✓ #00010 (v-opt-00010)	2.13453	Complete		-0.8	2.8
✓ #00011 (v-opt-00011)	1.00233	Complete		-0.8	3
✓ #00012 (v-opt-00012)	0.355134	Complete		-1	2.8
✓ #00013 (v-opt-00013)	0	Complete		-1	3



Variables are now set to optimized values (-1, 3)