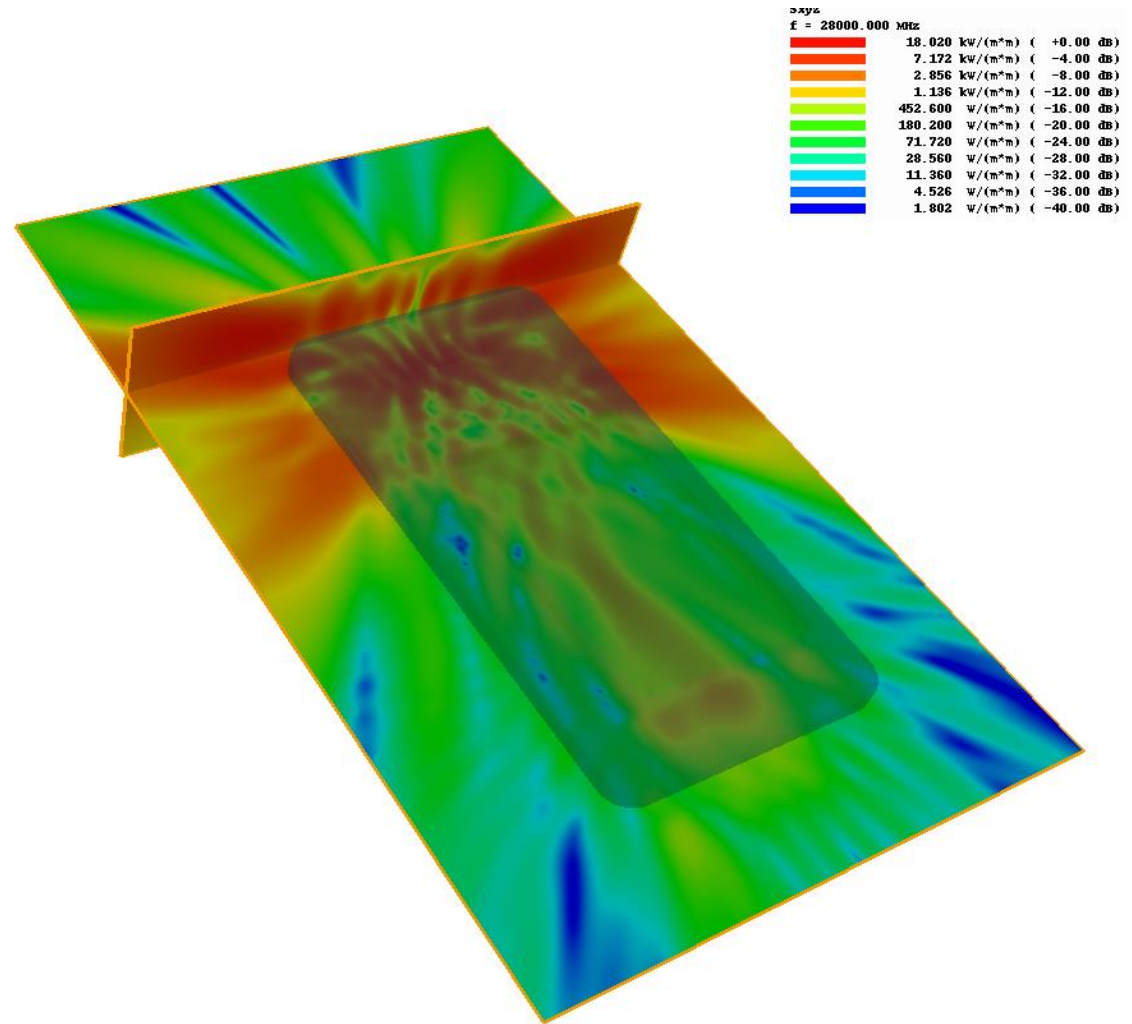# EMPIRE XPU Tutorial

## 28GHz Antenna for Mobile Phone Application

IMST

Overview

- 3D STL import
- Material Definition
- Antenna Design
- Port Definition
- Mesh Hints / Creation
- Simulation
- S-Parameter
- Power Density
- Simultaneous Excitation

Step 1: General Settings

- Start EMPIRE XPU
- Click "New Project"

- Frequency:
  - Stop Frequency: **35 GHz**
  - Target Frequency: **28 GHz**

- Loss Calculation:
  - Dielectrics: **narrow band**
  - Conductors: **narrow band lossy**

- OK
- File – Save As
  - Create new project folder
  - Choose file name
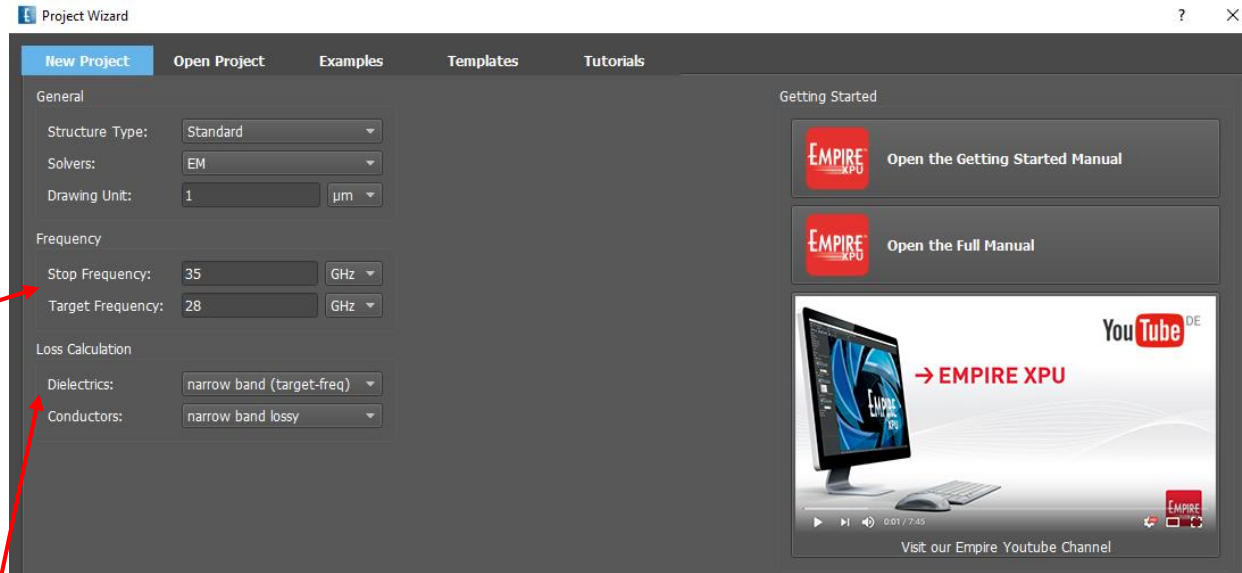
Step 2: CAD Data Import

- Click File – Import – 3D Solids – Import STL
- Select all 6 STL files in "data"** directory

- Set Simplify Objects* to **30**
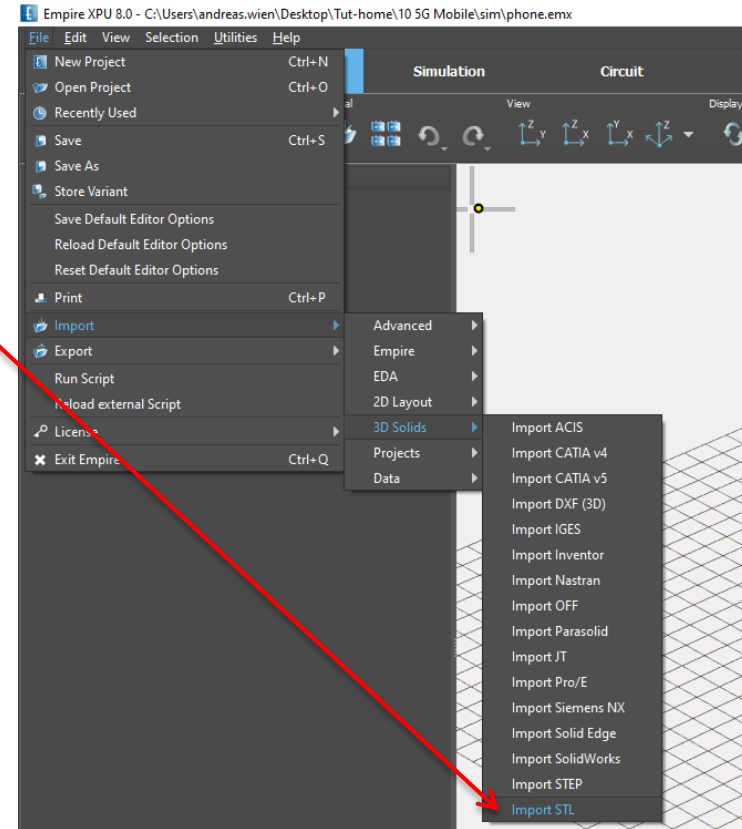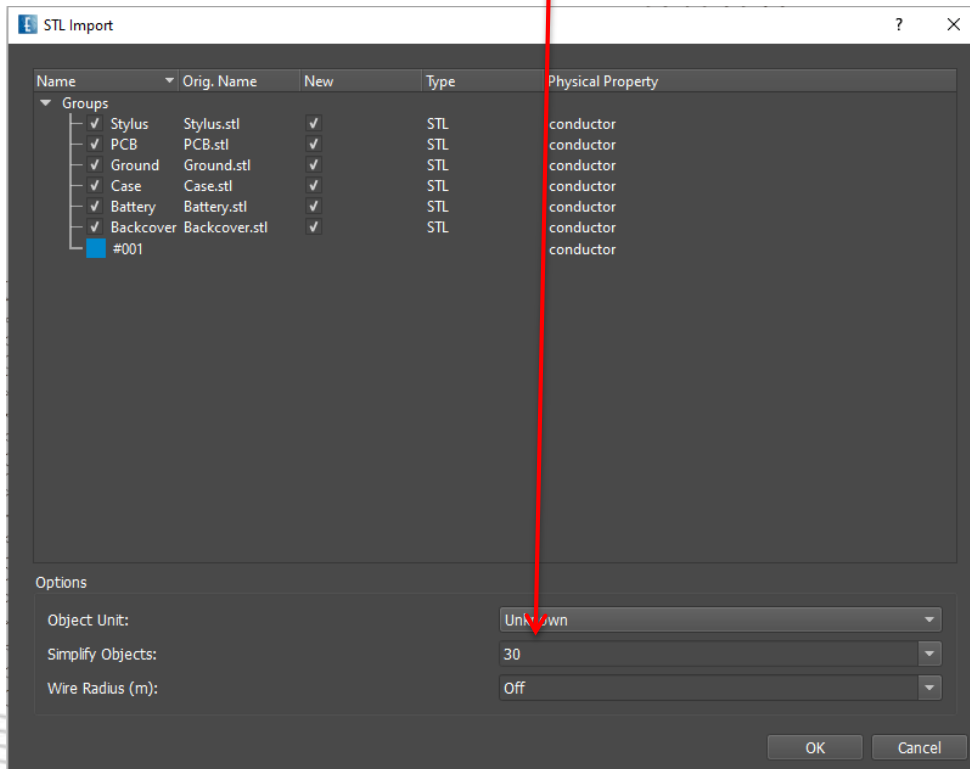
Hint:
- ** Simplification reduces the complexity of the data:
  All edges which adjacent faces have an angle difference
  smaller then 30° will be removed*
- *** Usually located at*
- *C:\EMPIRE_XPU_8.00\Tutorials\3D Design\10 5G Mobile*

Step 3: Materials

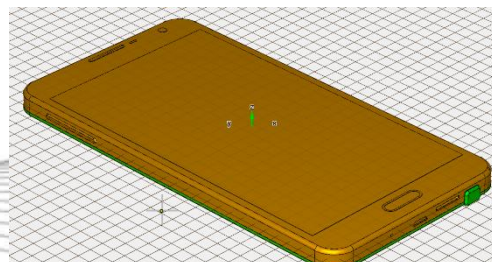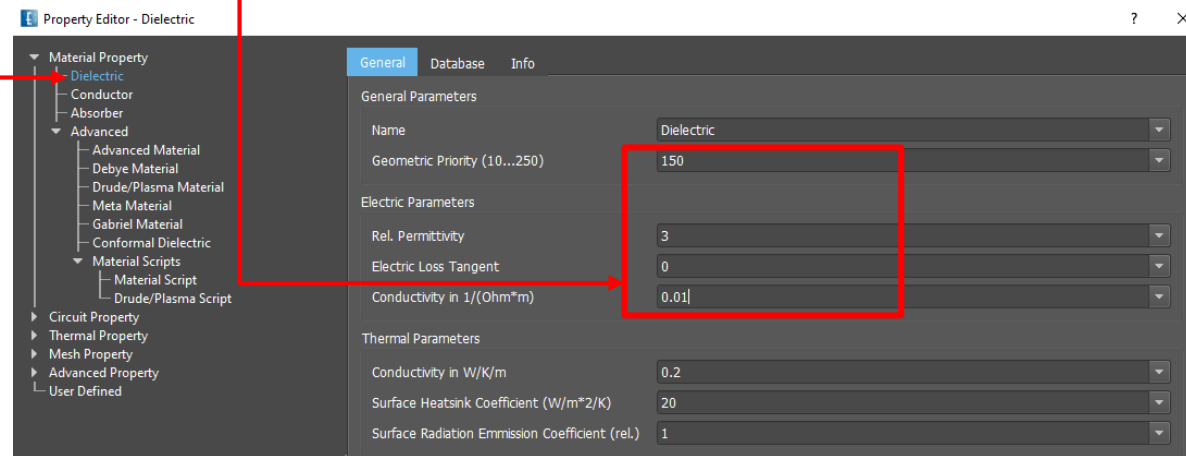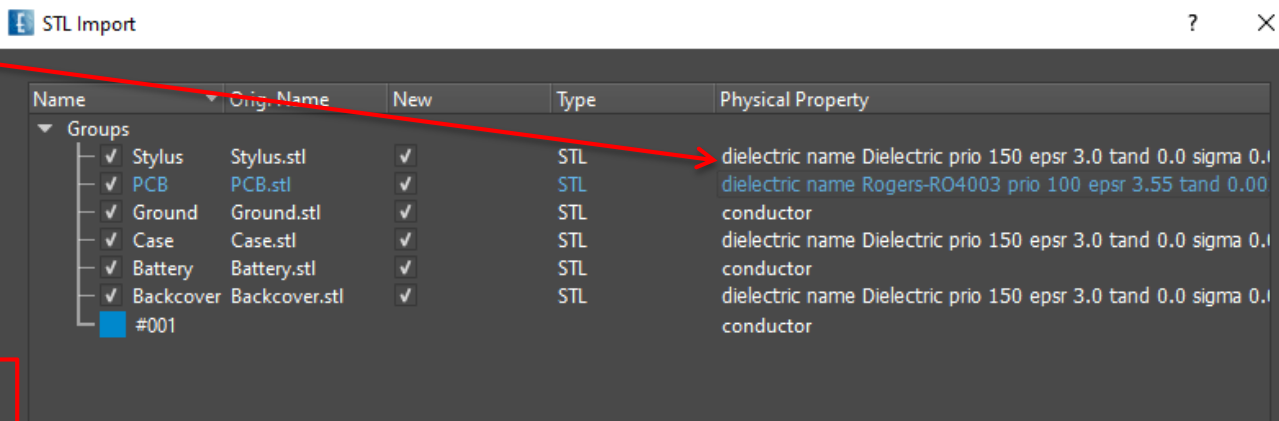- Edit Property for Groups:
  - Double Click on „conductor"

- Stylus, Case ,Backcover :
  - set Dielectric,
    Geo. Priority: 150
    rel. Permittivity: 3
    Conductivity: 0.01
    OK

- Battery, Ground:
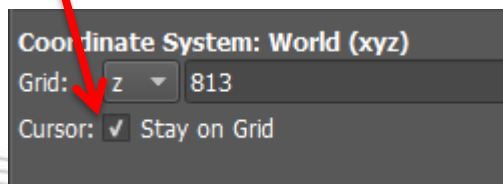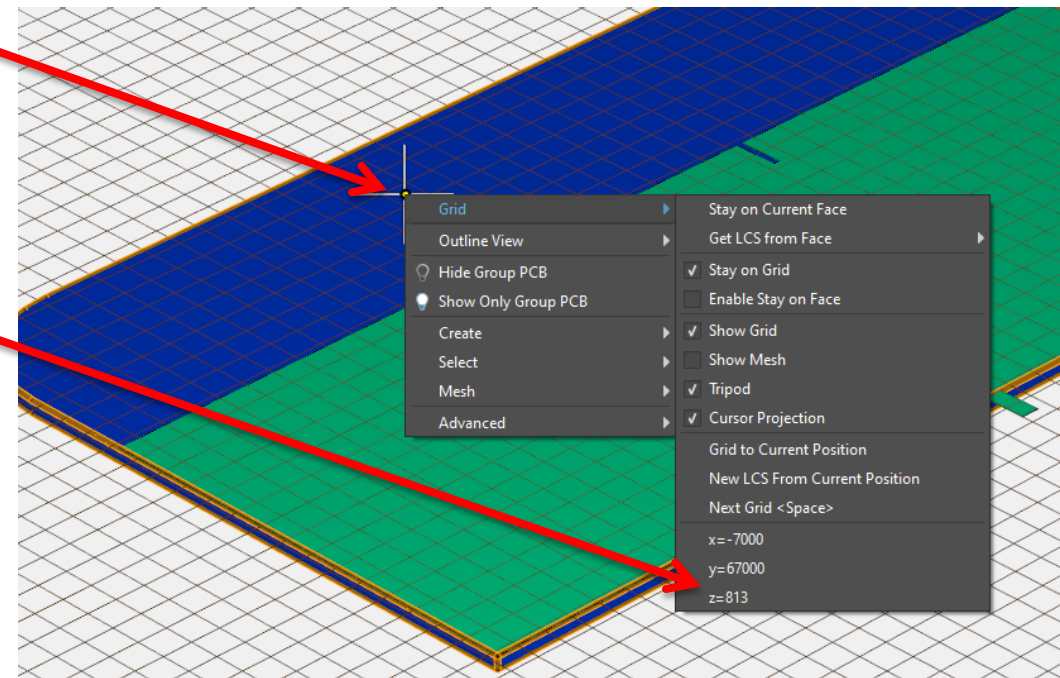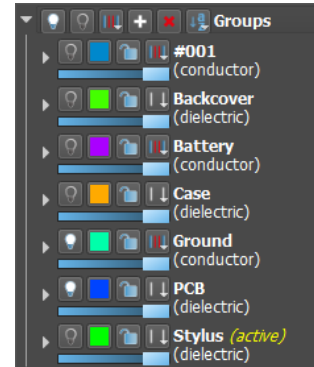 - keep Conductor

- PCB:
  - set Dielectric,
    Database
    Rogers – RO4003
    OK

- OK

Step 4: Adjust Construction Grid

- Hide all groups except Ground & PCB (click on lamp 💡)

- Right click while pointing the mouse on the PCB

- Open Grid menu
- Select z=813

- Checkmark 'Stay on Grid'

Step 5: Antenna Design

- Right click on group #001
    - Set active
    - Edit Name: set to „met0"
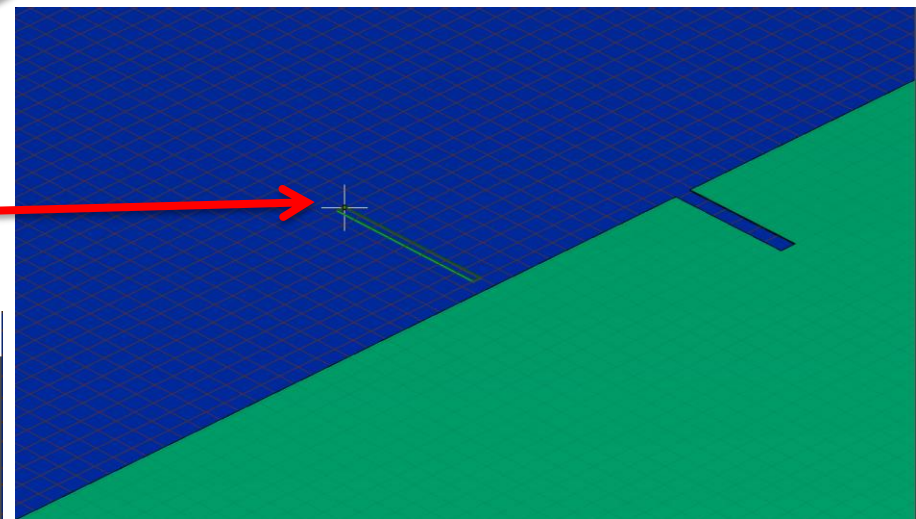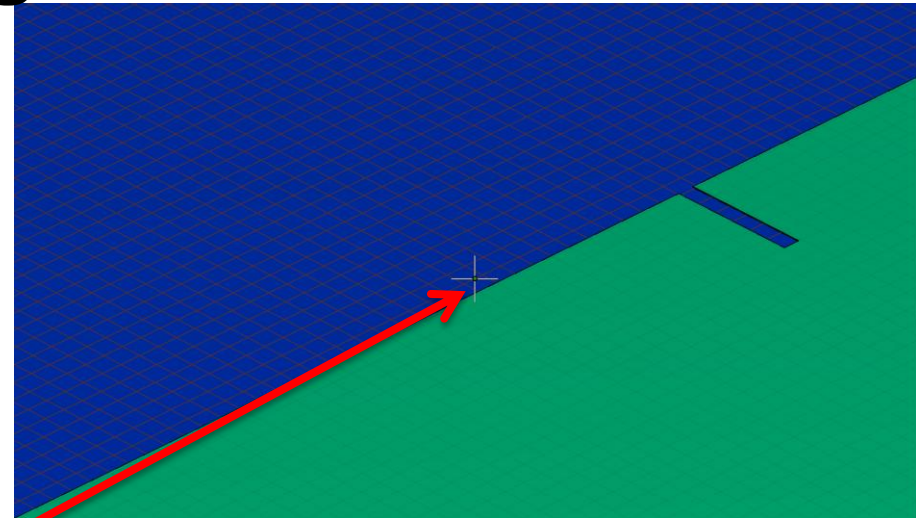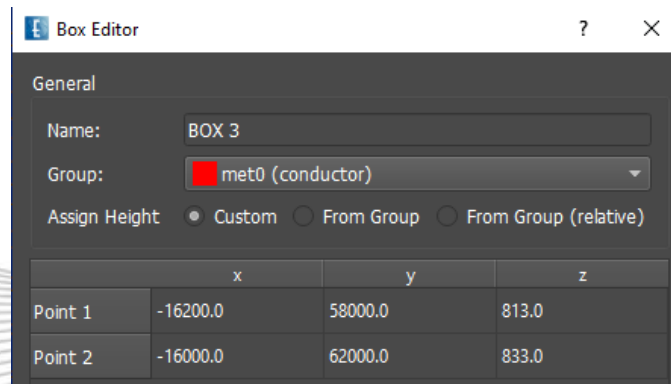   - Enable visibility
    - Set color

- Double Click Height, Set group height **z=0…20**

- Zoom to PCB area

- Click Create Box
- Click first Point: **x= -16200, y=58000**
- Click second point: **x= -16000, y=62000**

- Long left click
(assign group height)

Box Editor

General			
Name:	BOX 3		
Group:	met0 (conductor)		
Assign Height	● Custom ○ From Group ○ From Group (relative)		

	x	y	z
Point 1	-16200.0	58000.0	813.0
Point 2	-16000.0	62000.0	833.0

Step 6: Antenna Design

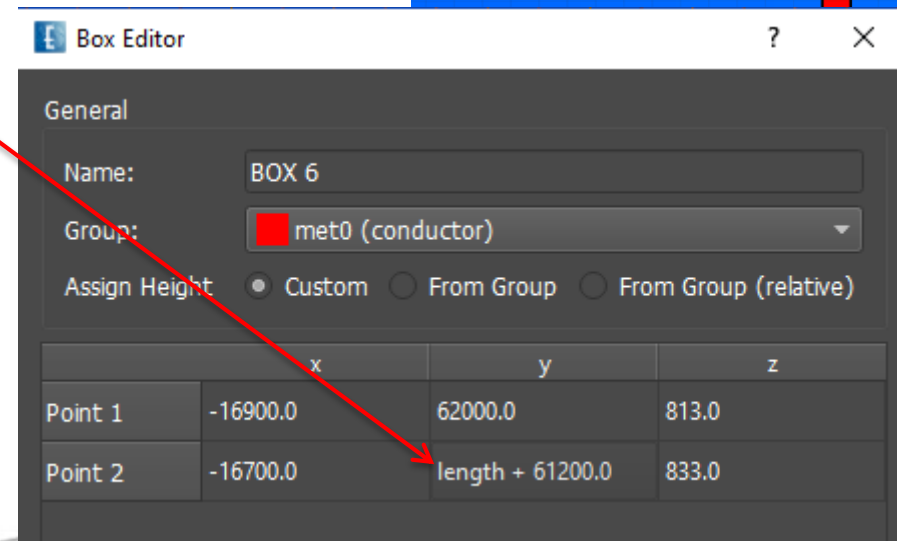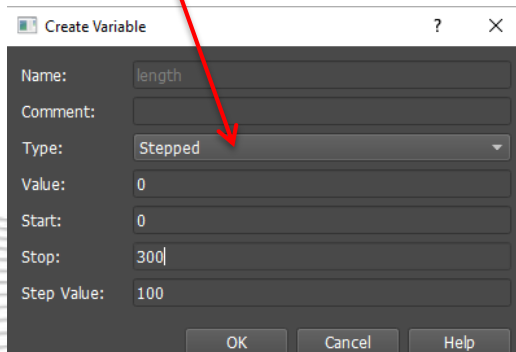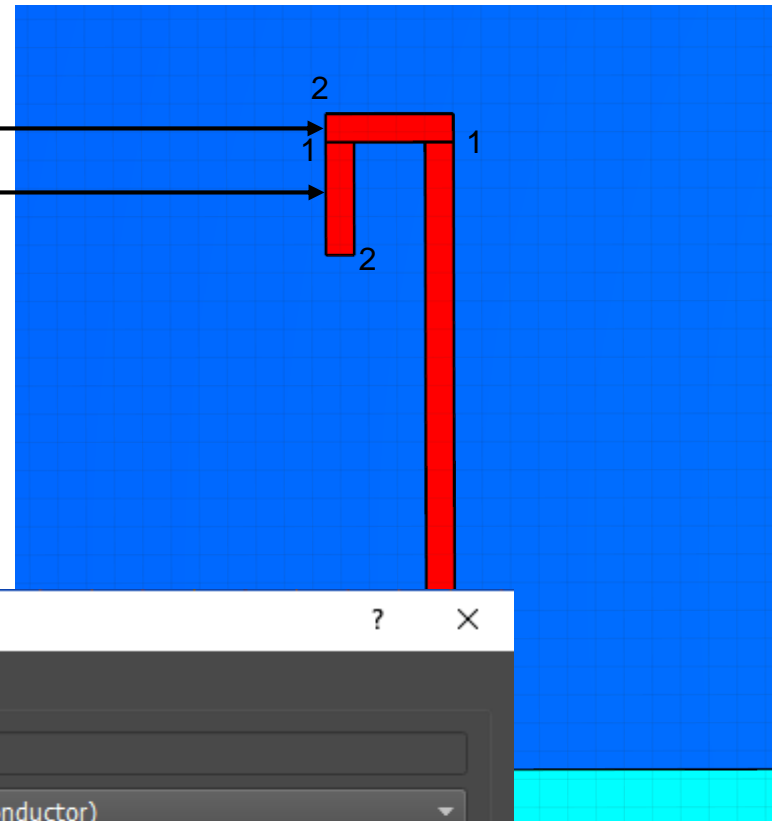Top view, zoom in, keep „Stay on Grid"

- Create two more Boxes:

Box:

- (x1,y1) = -16000, 62000
- (x2,y2) = -16900, 62200 (du=-900, dv=200)
- Long left click for group height

Box:

- (x1,y1) = -16900, 62000
- (x2,y2) = -16700, 61200 (du=200, dv=-800)
- Long left click for group height
- Add „length+" in y of Point 2

- Set Type and Stop for variable length

- Close with OK

Create Variable

Name:	length
Comment:	
Type:	Stepped
Value:	0
Start:	0
Stop:	300
Step Value:	100

OK   Cancel   Help

Box Editor

General

| Name: | BOX 6 |
| Group: | met0 (conductor) |

Assign Height   ● Custom   ○ From Group   ○ From Group (relative)

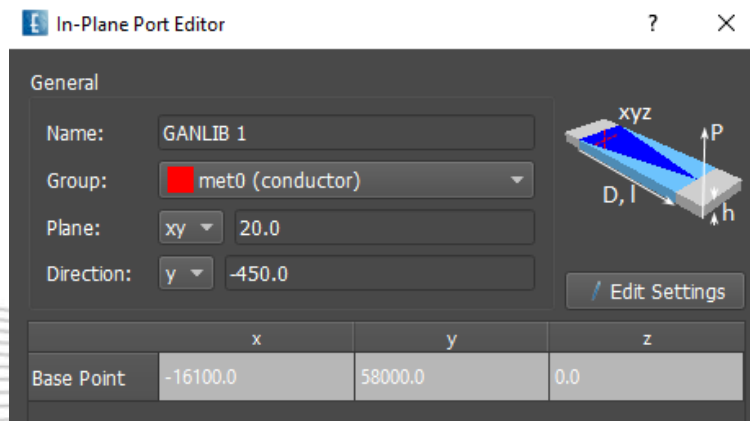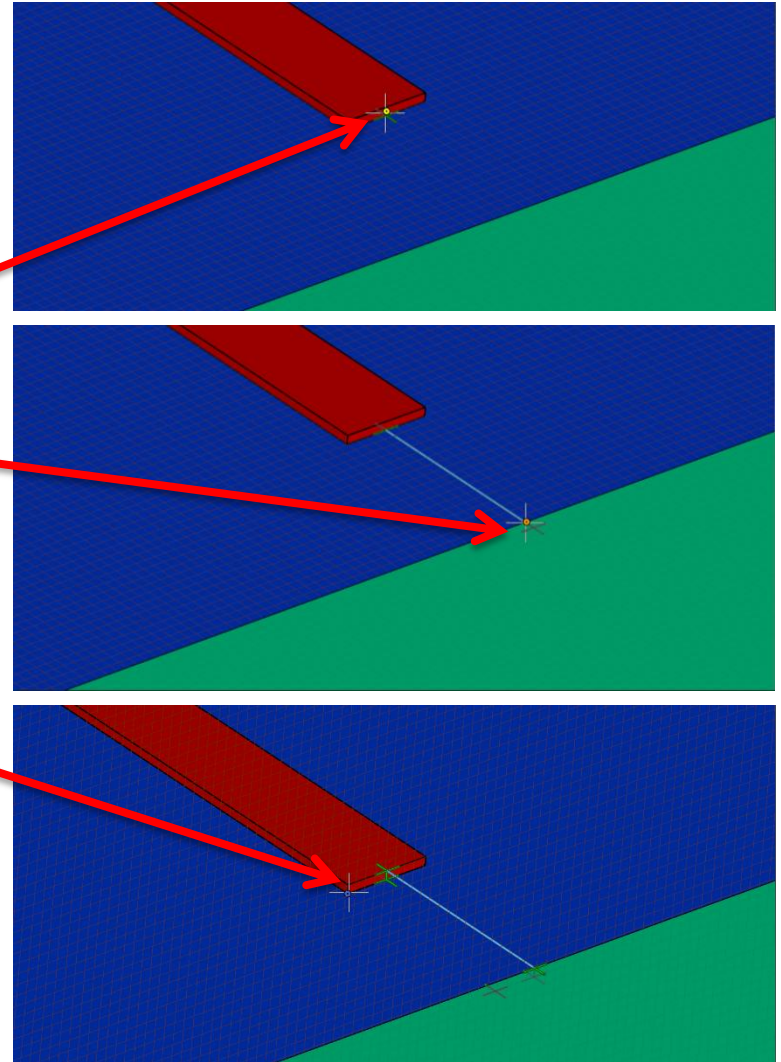|	x	y	z
Point 1	-16900.0	62000.0	813.0
Point 2	-16700.0	length + 61200.0	833.0

Step 7: Port

Switch to Iso-z-View, zoom in, keep „Stay on Grid"
- Click Create Source

- Select Lumped – In-Plane Port

- Select Start Point (center, yellow dot)
  and End Point (edge, orange dot)

- Long left click for group height

- Click on corner of antenna
  for port witdth (corner , blue dot)

- OK

In-Plane Port Editor

General

Name:	GANLIB 1	
Group:	met0 (conductor)	
Plane:	xy	20.0
Direction:	y	-450.0

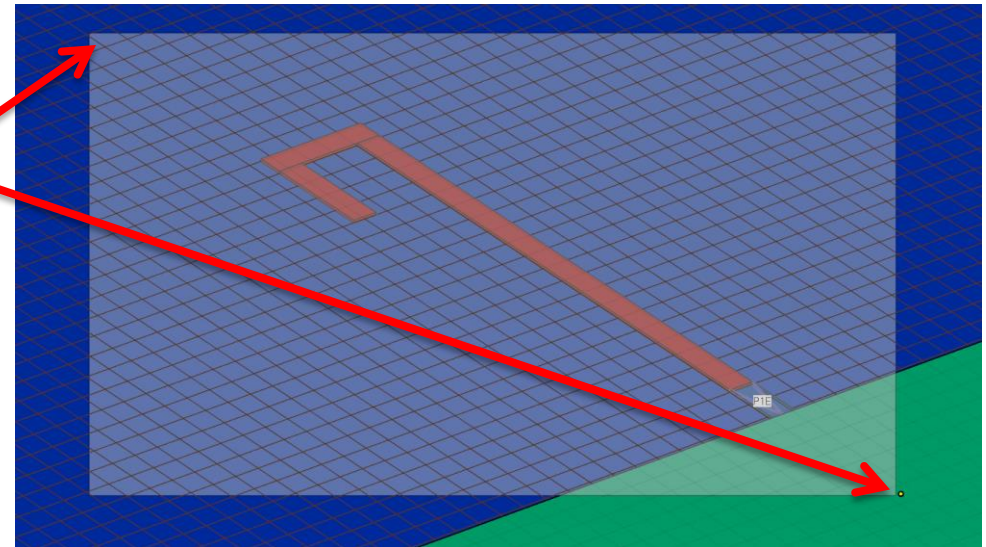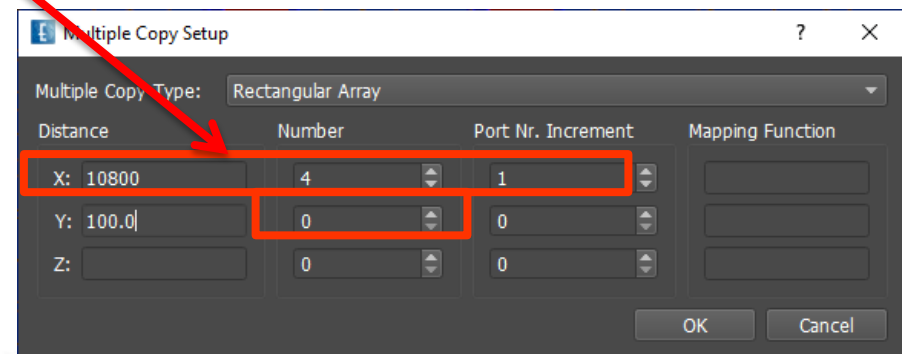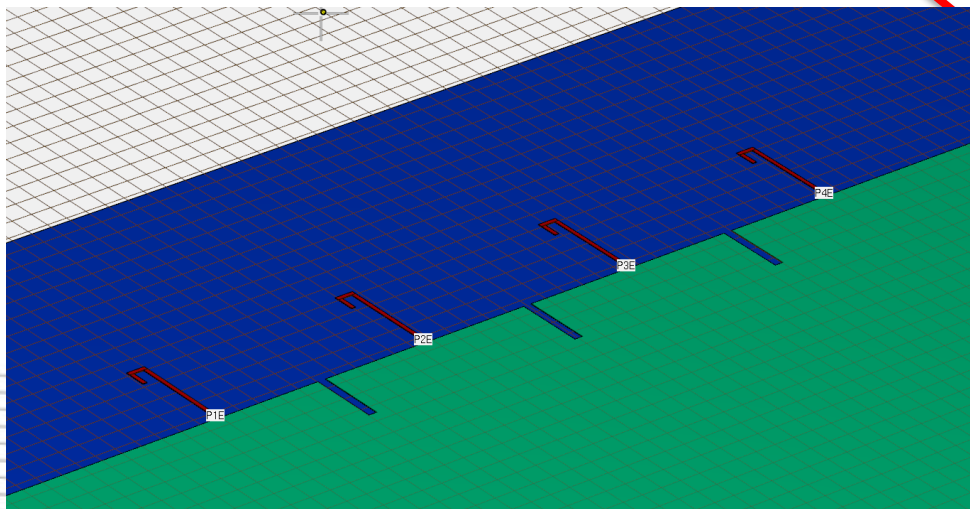|	x	y	z
Base Point	-16100.0	58000.0	0.0

Step 8: Copy Antenna

Zoom out
- Hold CTRL key & drag left mouse button over the complete antenna (right to left)*, release

- Click Multiple Copy
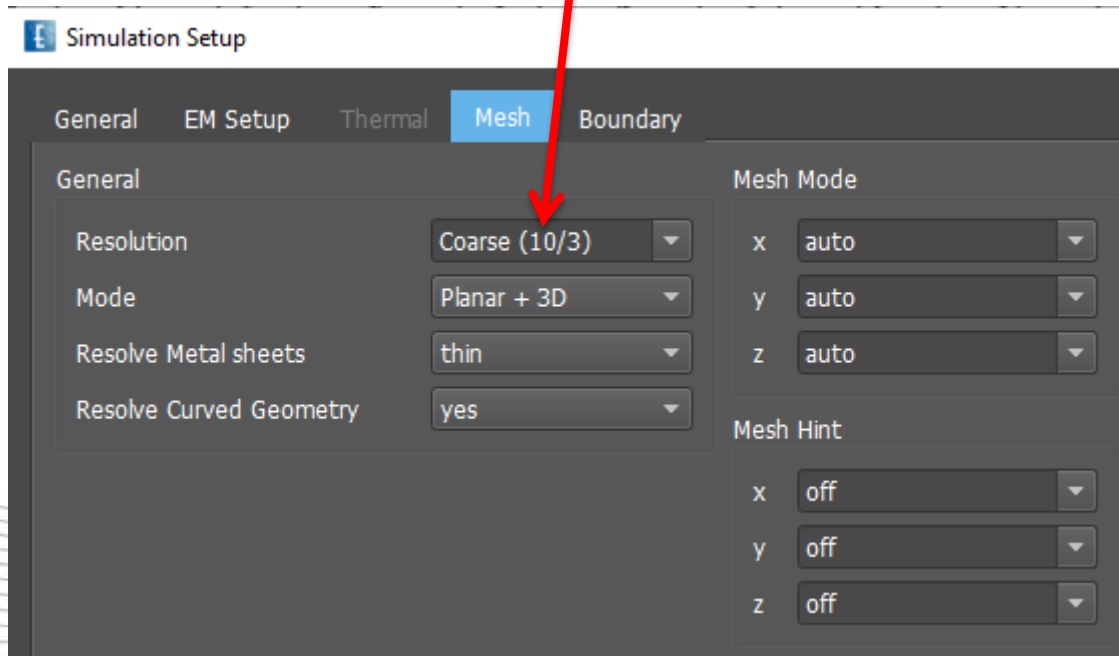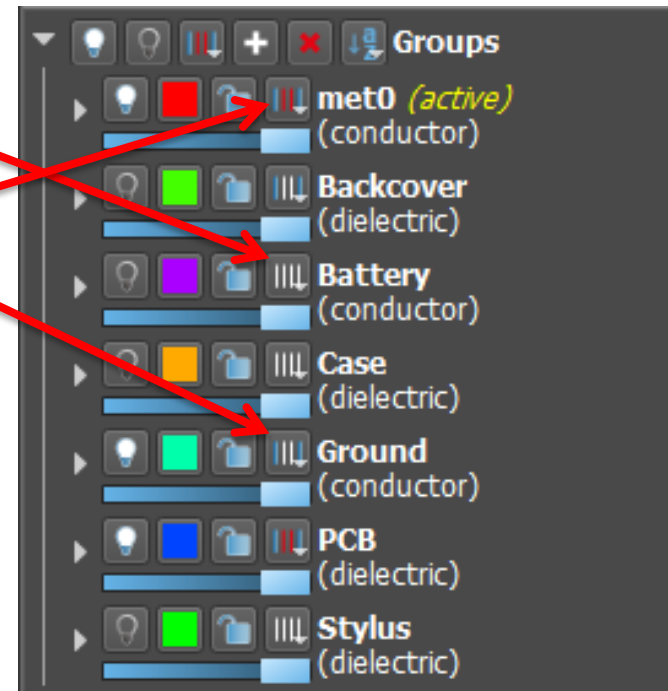- Enter Values as shown
- Press Ok

- Zoom out

Hint:*
- *Select all structures which have points inside a region: with Ctrl-Key pressed, drag with left click from right to left*
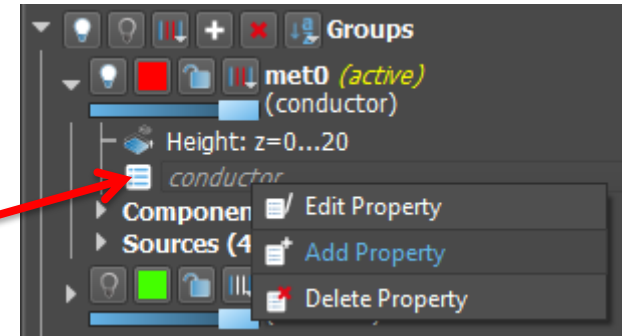

Multiple Copy Setup

| Multiple Copy Type:	Rectangular Array		
Distance	Number	Port Nr. Increment	Mapping Function
X: 10800	4	1	
Y: 100.0	0	0	
Z:	0	0	

OK   Cancel

Step 9: Mesh

- Disable automesh for groups **Battery**, **Case, Stylus**

- Set to „Edges Only" for **Backcover** and **Ground**

- Set „Edges and Interior" for **met0** and **PCB**

- Click Simulation Setup, Select „Mesh" tab

- Change Mesh Resolution to **Coarse**, OK

Simulation Setup

| General | EM Setup | Thermal | Mesh | Boundary |

General

Resolution	Coarse (10/3)
Mode	Planar + 3D
Resolve Metal sheets	thin
Resolve Curved Geometry	yes

Mesh Mode

x	auto
y	auto
z	auto

Mesh Hint

x	off
y	off
z	off

Groups

- met0 *(active)* (conductor)
- Backcover (dielectric)
- Battery (conductor)
- Case (dielectric)
- Ground (conductor)
- PCB (dielectric)
- Stylus (dielectric)

Step 10: Meshhint

- Right click on „conductor" in group met0
- Select „Add Property"

- Select „Mesh Property" – „Mesh Hint"

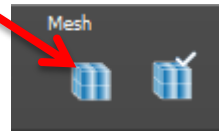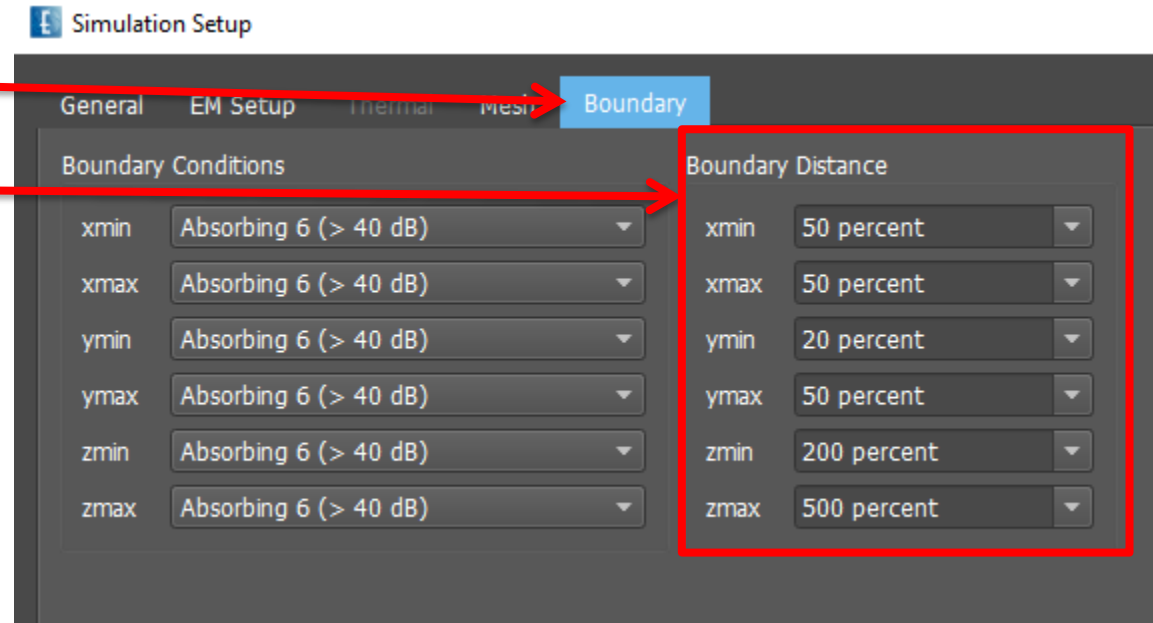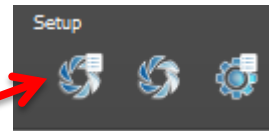- Enter Max. Interval X,Y,Z: **250**
- Press OK
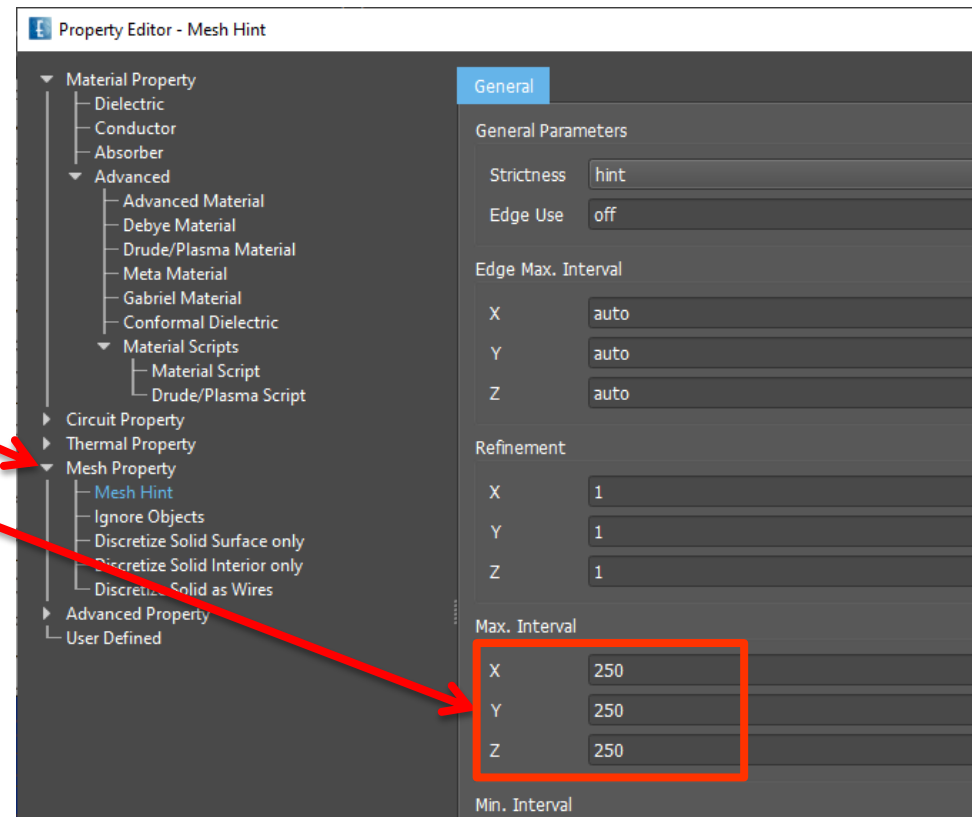
Hint:
- *With meshhint we specify the maximum cell size for the group objects area (Max. Interval)*

Step 11: Boundary Setup

- Click on Simulation Setup

- Switch to Boundary tab

- Set Distances as shown
- OK

- Click Create Mesh

Hint:
- *The Boundary Distance allows to add mesh cells at the sides of the structure when using the automesh mode*
- *Values can be in percent of the model size or absolute*

Simulation Setup

| General | EM Setup | Thermal | Mesh | **Boundary** |

Boundary Conditions

|			**Boundary Distance**	
xmin	Absorbing 6 (> 40 dB)		xmin	50 percent
xmax	Absorbing 6 (> 40 dB)		xmax	50 percent
ymin	Absorbing 6 (> 40 dB)		ymin	20 percent
ymax	Absorbing 6 (> 40 dB)		ymax	50 percent
zmin	Absorbing 6 (> 40 dB)		zmin	200 percent
zmax	Absorbing 6 (> 40 dB)		zmax	500 percent

Step 12: Field Monitor

- Click on Create Field Monitor

- Select EM-Field – Complete Volume, OK
- Open Field Monitors on the left
- Double click on Plane:
  - **set xy & Height=6100**
- Right click on FIELDMON – Add Plane
  - **set xz & Height=80000**

- Create Field Monitor
- Select EM-Far Field – Boundary
- OK
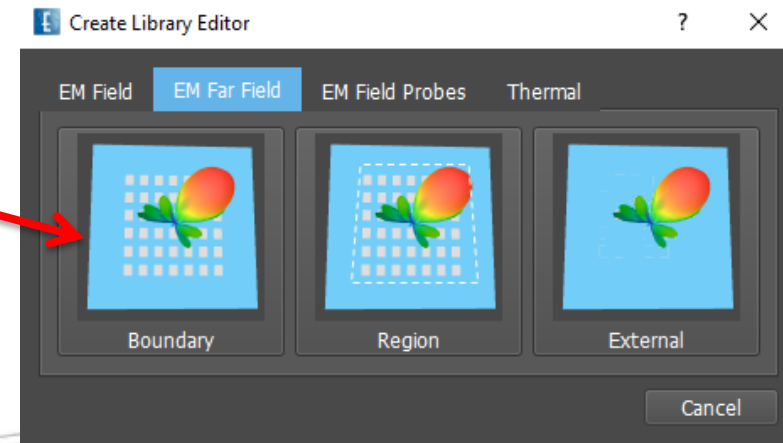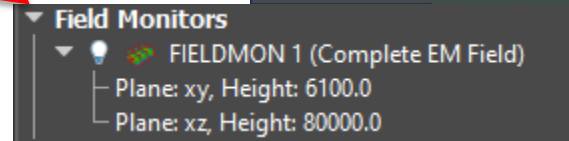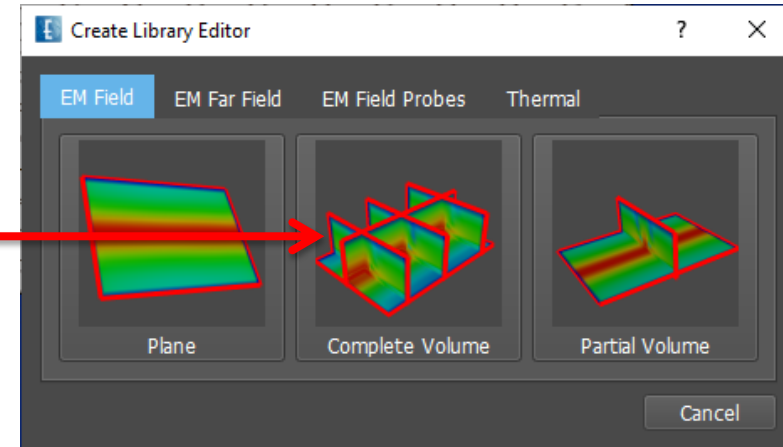
Step 13: Port Setup

- Click Port Setup Wizard
- Deselect all but Number 2
- OK

General
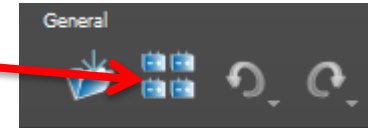
Port Editor

Table Style: Detail View ▼

| Number ▲	Excitation	Group	Amplitude	Load Impedance	Phase (Delay)	Phase Ref. Freq.	Time Delay	Broadband Phase Shift	Voltage Probe	Current Prob
1	☐	met0 (conductor)	1	50		28000000000.0	0	0	1	1
2	✓	met0 (conductor)	1	50		28000000000.0	0	0	1	1
3	☐	met0 (conductor)	1	50		28000000000.0	0	0	1	1
4	☐	met0 (conductor)	1	50		28000000000.0	0	0	1	1

Step 14: Simulation

- Select Simulation Tab
- Select Parameter Sweep Setup
- Click Create Parameter Sweep
- Click Start & Yes
- Wait for simulations to finish
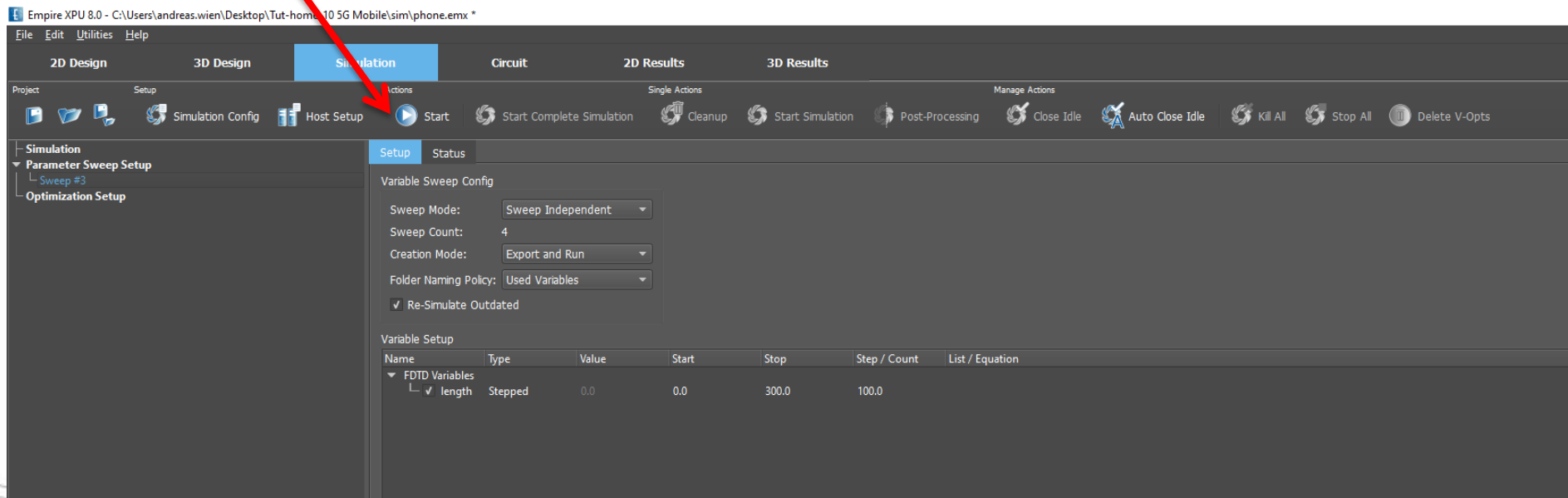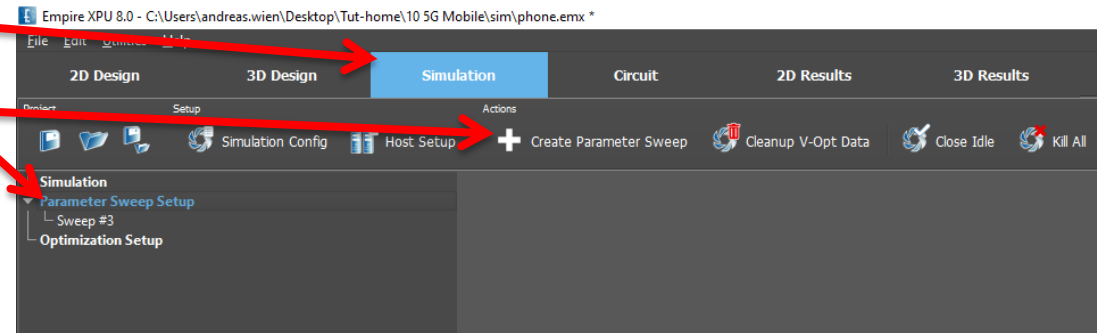
Step 15: S-Parameter

- Go to 2D Results
- Click Update

- Sort Curves by Port Number (click on Port)

- Mark all S22 Curves

- Right Click, select Show only & Autocolor

- Right Click on plot – Configure Axis
- Set frequency axis to
x-axis: 25 GHz - 35 GHz
y-axis: -40 dB - 0
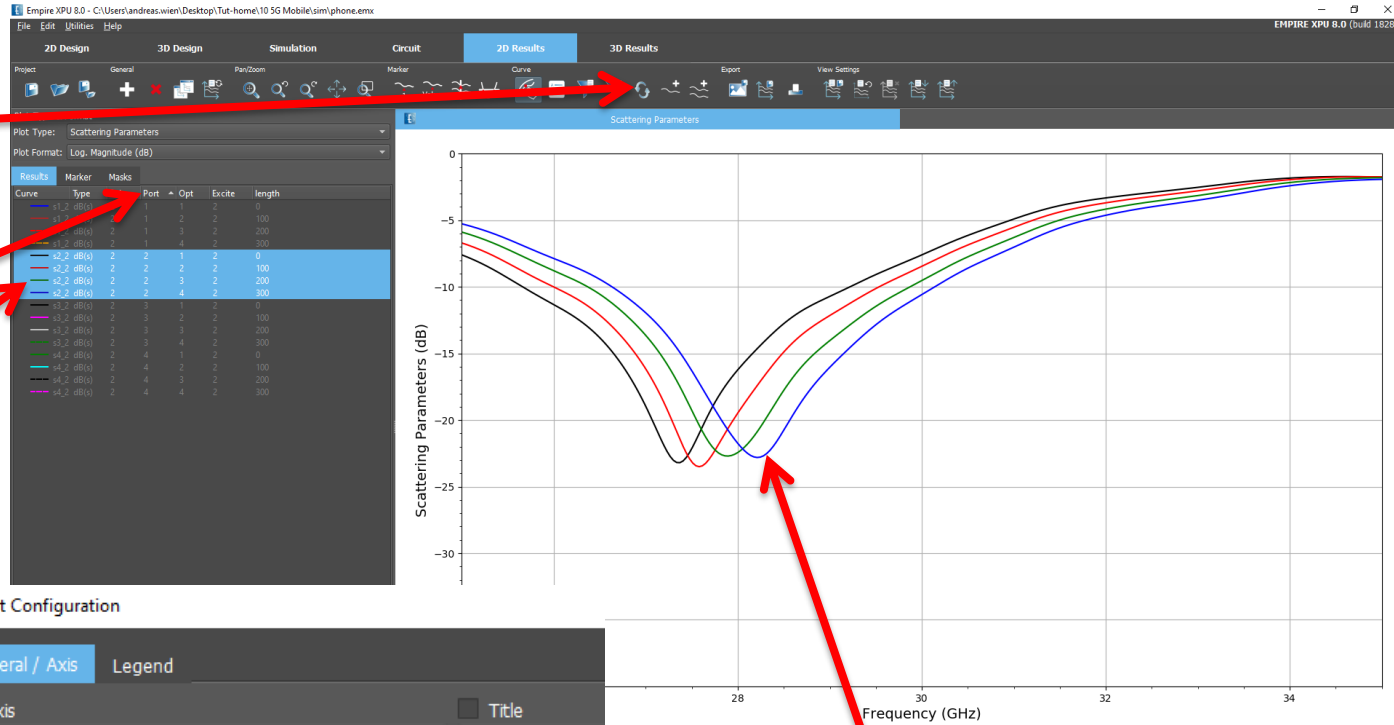
Parameter with best fit for 5G 28GHz band, length = 300

Step 16: Field Monitor Settings

- Go to 3D Results

- Open Field Monitors
- Right click on FIELDMON 1 - Edit

- Source Type: Manual
- File: (last entry): v-opt-00004-length=300\sub-2\emvolume_1.dbx

- Field: **S Power Flow (real)**

- Normalization: **Power**

- Scaling: Range: **40**
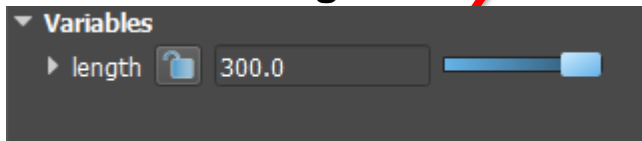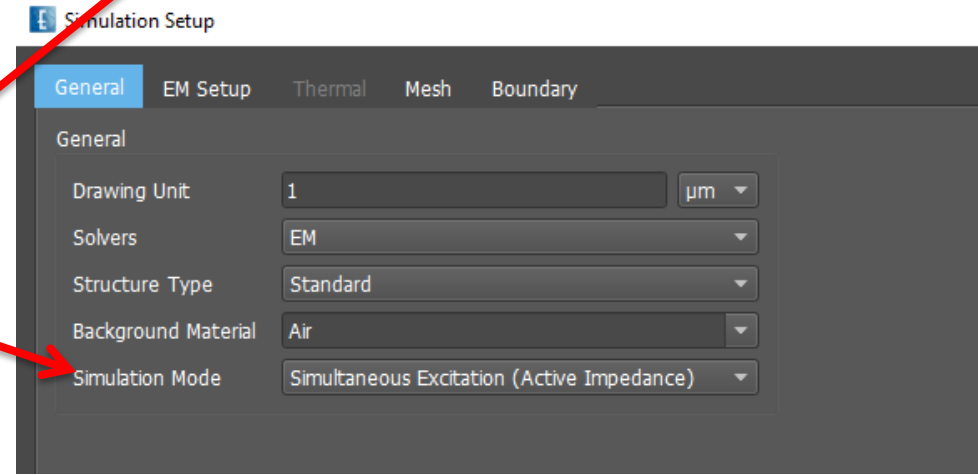- OK

- Switch off Field Monitor
  → FIELDMON 2 (EM Farfield)
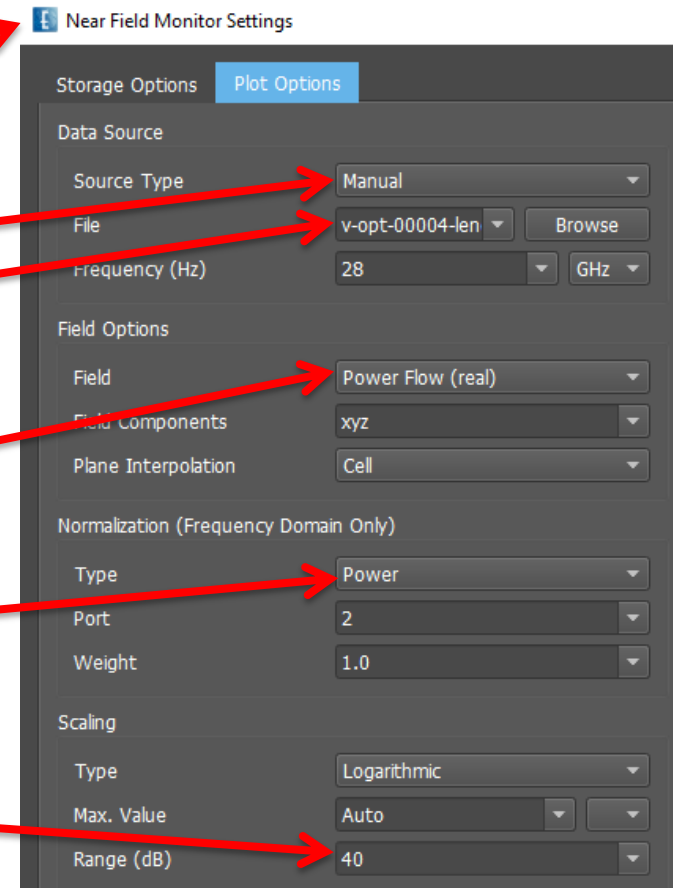
Step 17: Power Density

- Optional:
  Change
  visibility
  of phone
  objects
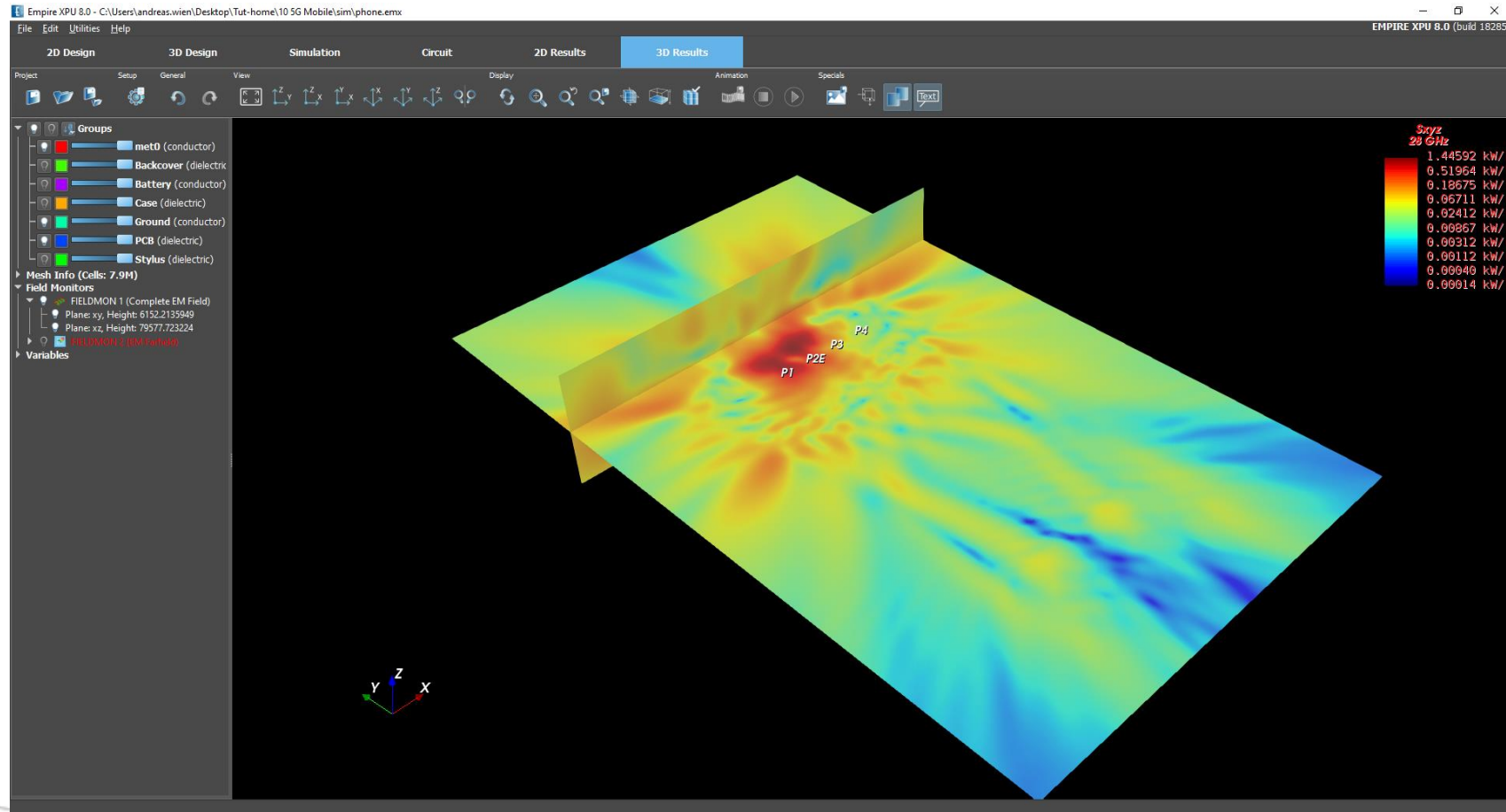
Step 18: Simulation (Simultaneous Excitation)

- Select 3D Design Mode
- Save project at new folder (e.g. all)

- Click on Simulation Setup
- Change Simulation Mode:
  Simultaneous Excitation
- OK

- Port Editor: Excitation: All on
- OK

- Set Variable: **length=300**

- Start Simulation
- OK

Step 19: Power Density (Simultaneous Excitation)

- Go back to 3D Results
- Right click on FIELDMON 1 - Edit
- File: sub-1\emvolume_1.dbx (select item from drop down list)
- OK