

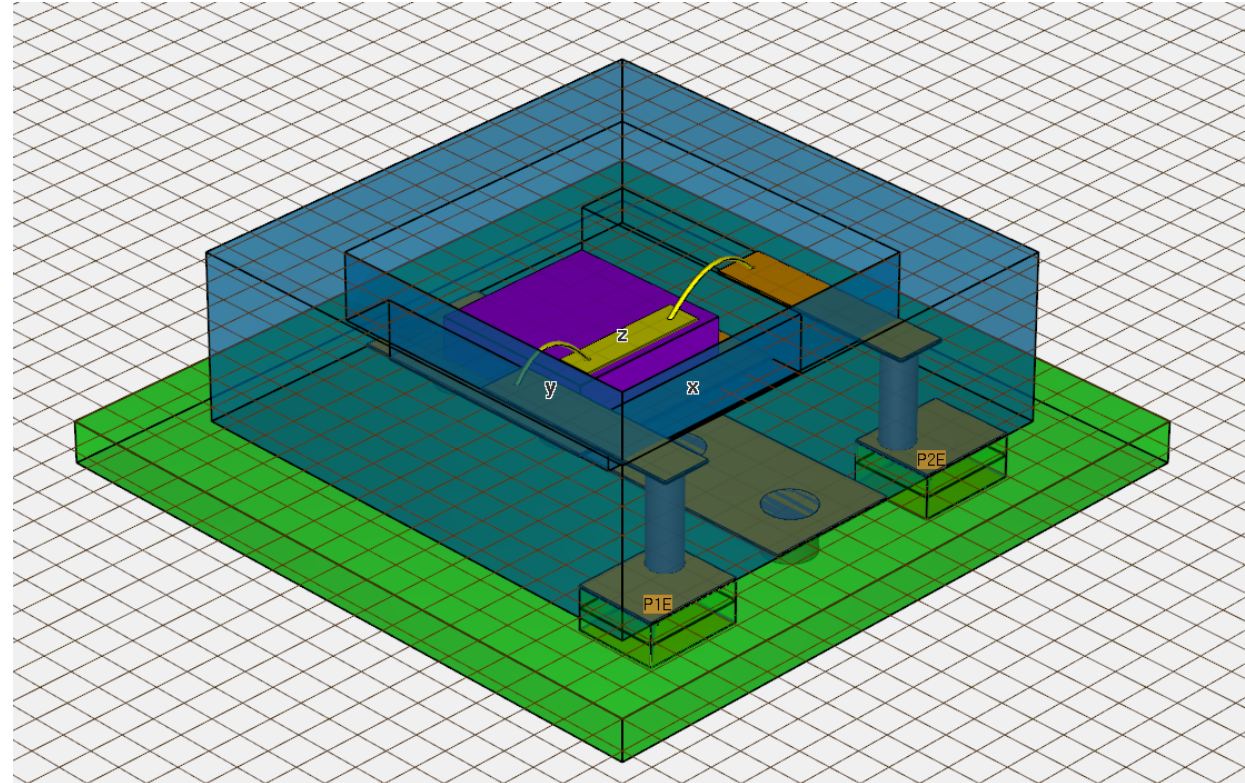
EMPIRE XPU Tutorial

3D Design – Package Simulation




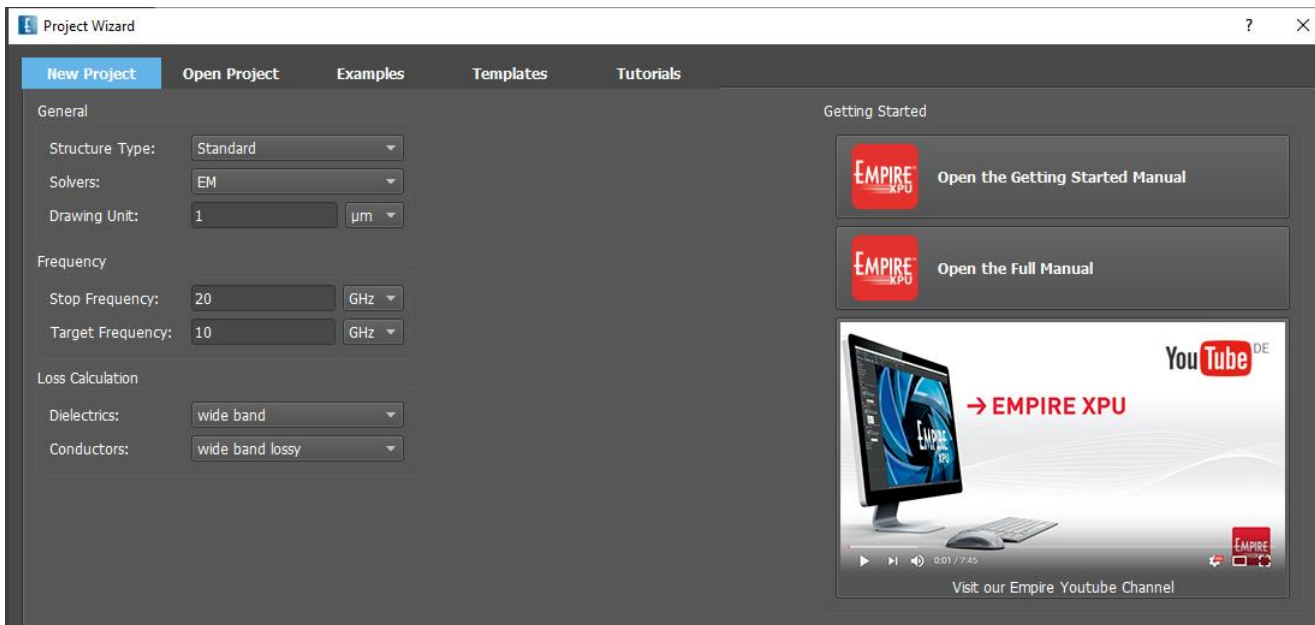
Overview: Topics

- Start New Project
- 3D structure definition
- Port library elements
- Bond wires, via holes
- Equidistant meshing
- S-Parameters, impedances



Step 1: Start

- Start Empire 
- Click “New Project”
- Set „Loss Calculation“, Dielectrics and Conductors to “wide band lossy“, OK
- File → Save as
- Create new directory “package” and save file

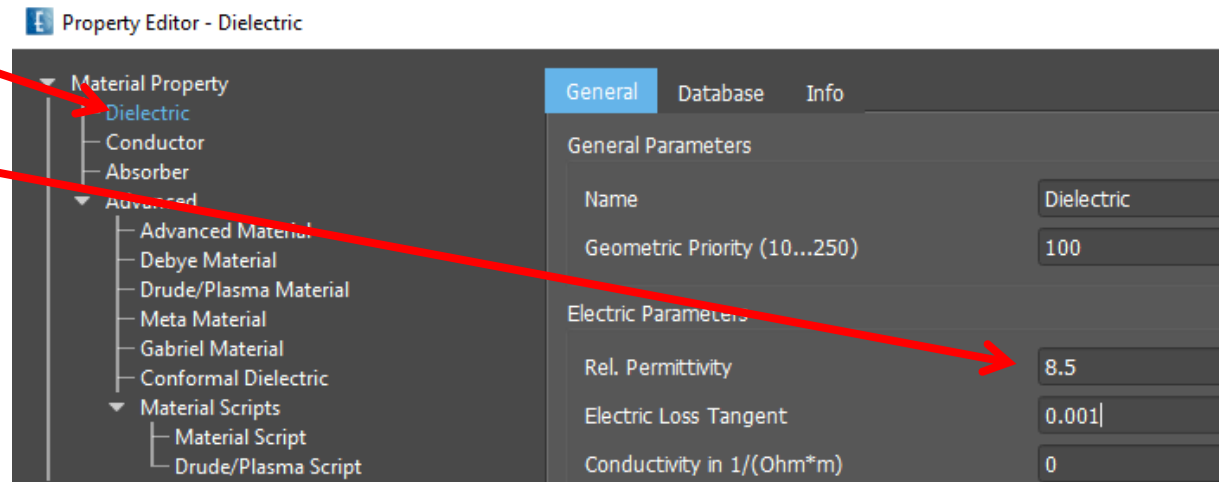
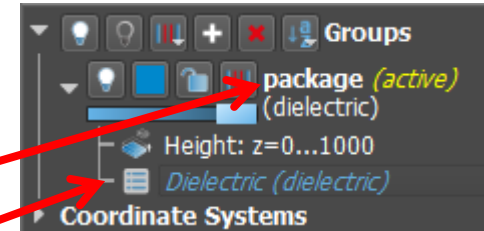


Comments:

- *Loss calculation using broadband surface models for conductors and Debye models for dielectrics*

Step 2: Ceramic

- Open Groups list
- Change* group name to „package“
- Change** property to Dielectric,
- Enter Permittivity 8.5, Loss Tangent 0.001
- OK

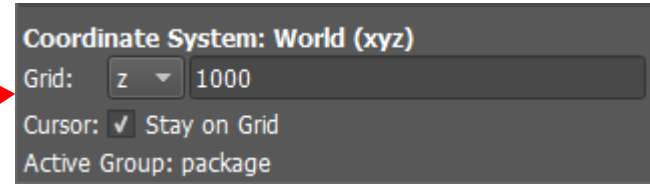



Comments:

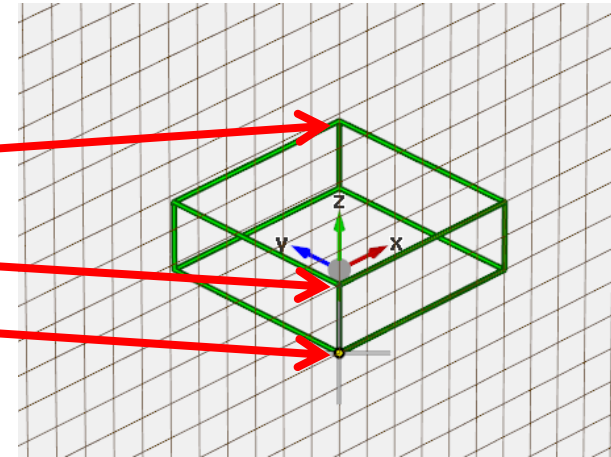
- *Right click, “Edit Name”
- **Double left click on property “conductor”

Geometric Priority used for intersecting objects (default Dielectric 100 < default Conductor 200)

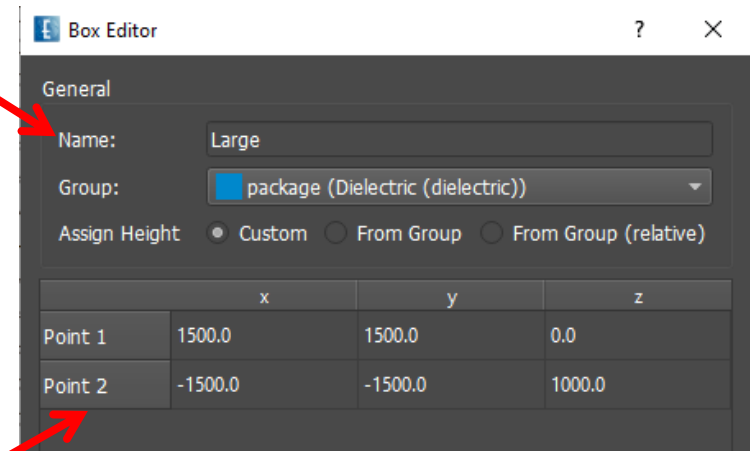
Step 3: Package 1



- Set $z=1000$, enable „Stay on Grid“
- Zoom in *
- Click „Create Box“ 
- Click at $x=+1500, y=+1500$
- Click at $x=-1500, y=-1500$
- Click at $z=0$
- Check Settings, Name: „Large“



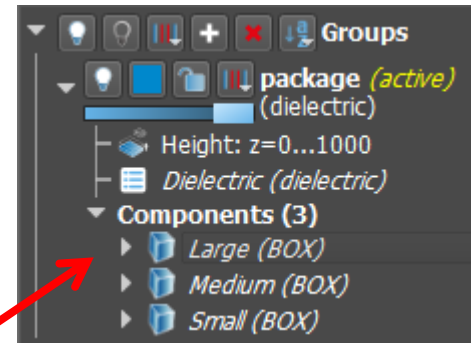
- „Create Box“ : $x=+1000, y=+1000$
 $x=-1000, y=-1000$
 $z=600$
Name: „Medium“
- „Create Box“ : $x=+700, y=+1000$
 $x=-700, y=-600$
 $z=250$
Name „Small“






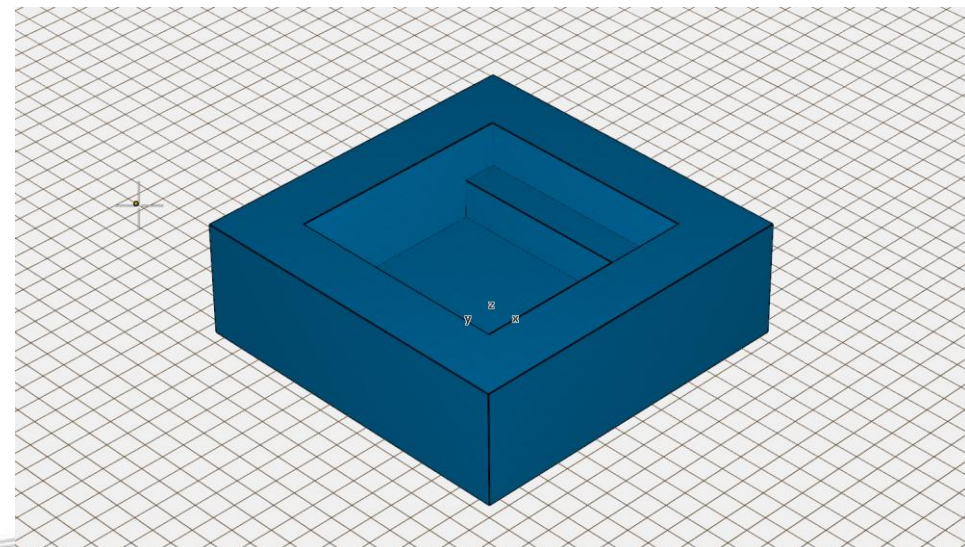
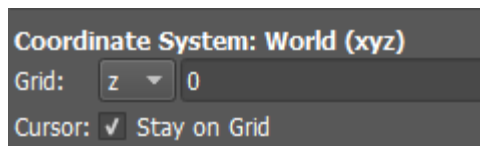
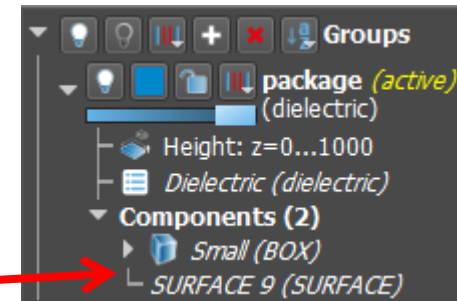
Comments:

- Turn mouse wheel forward to access values or
- Click at arbitrary points and edit values after creation in Box Editor

Step 4: Package 2



- Open Group package, Components
- Left click on „Large“ object
- Ctrl+Left click on „Medium“ object
- Subtract,  confirm with yes*
- Left click on „SURFACE“ object
- Ctrl+Left click on „Small“ object
- Subtract 
- Set Grid z=0, Zoom extents 

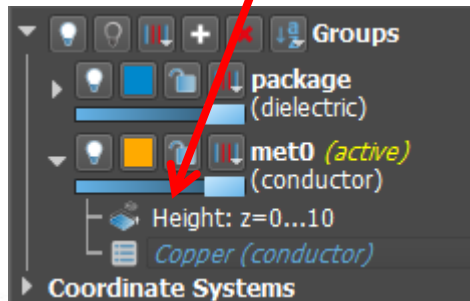
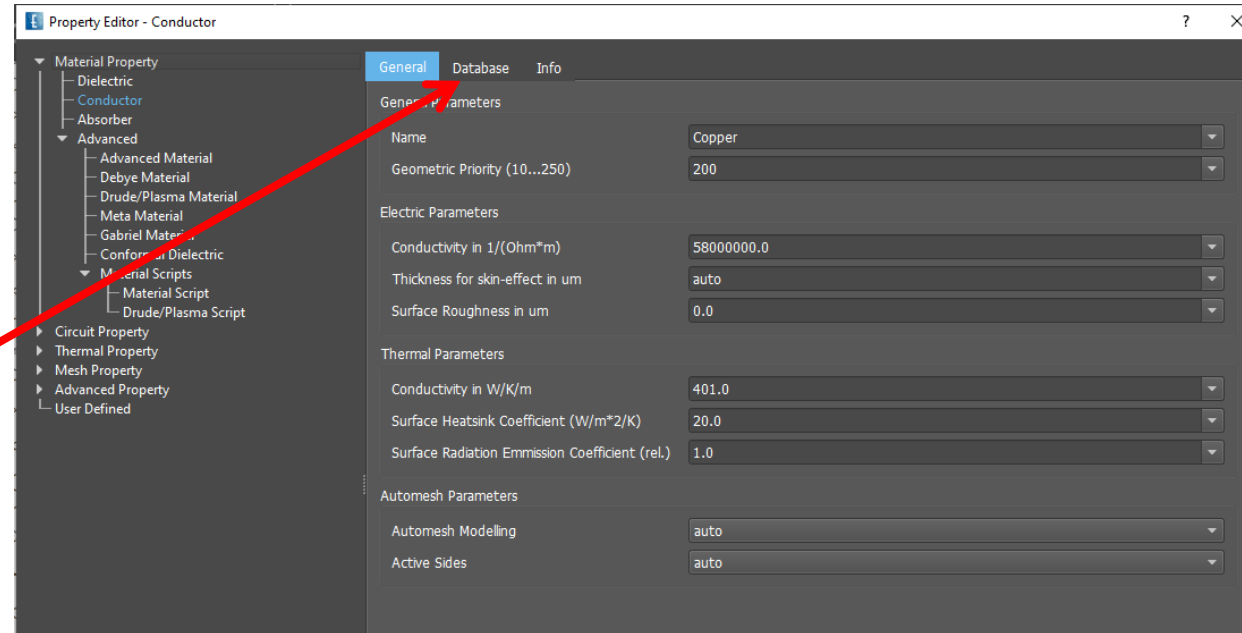


Comments:

* Initial objects (Boxes) are converted to “Solid” to allow Boolean operations

Step 5: Footprint 1

- Create group (+) for footprint rename to met0, recolor
- Double click on „conductor“
- Change property of this group: open Database, select Copper → Copper
- Close Window
- Double click on height
- Set Height z=0...10



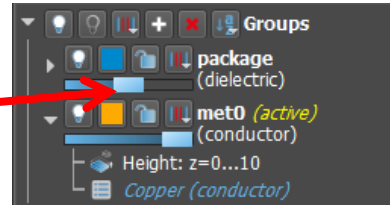
Comments:


Copper can be found in Database

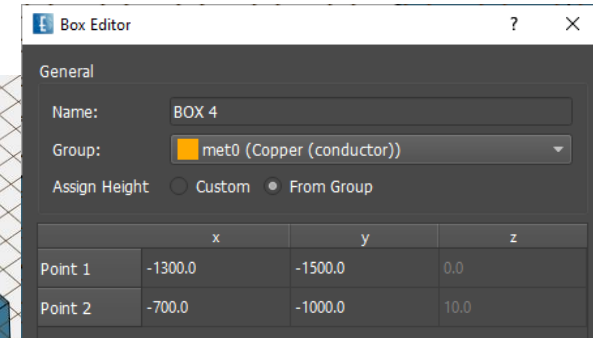
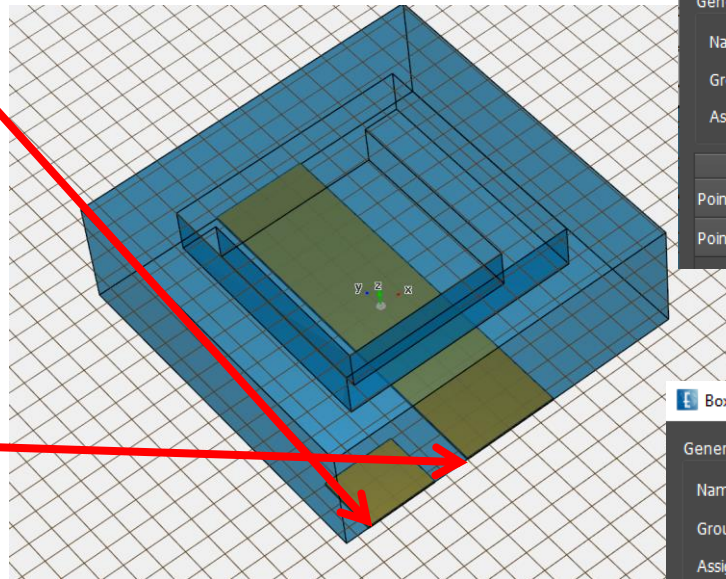
Conductor geometric priority is higher than Dielectric by default


Step 6: Footprint 2

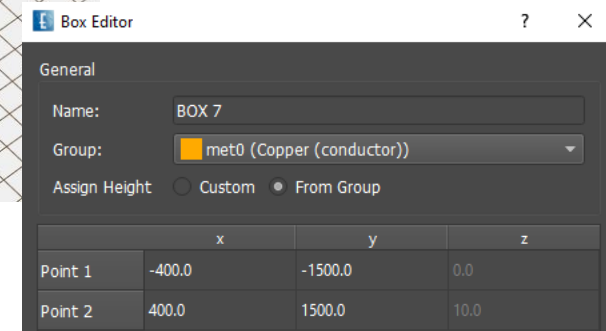
- Adjust Transparency slider of package group



- Click “Create Box” 
- Left click at $x=-1300, y=-1500$
- Left click at $du=600, dv=500$
- Long left click to use height from group



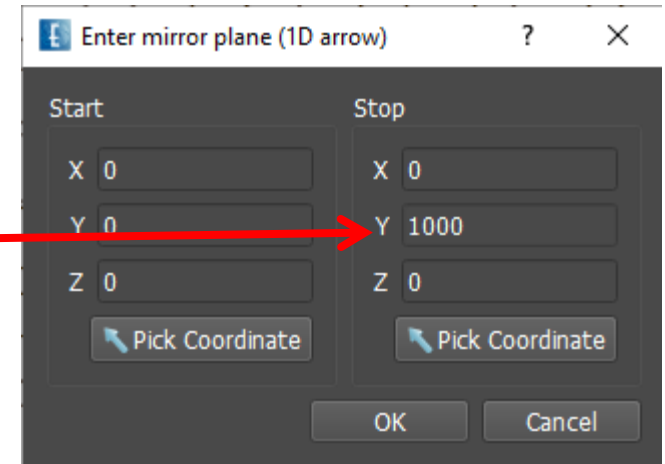
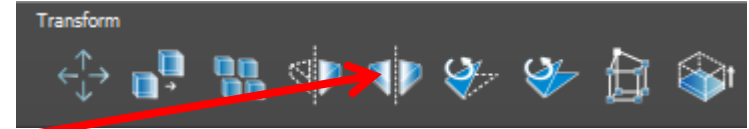
- Click „Create Box“ 
- Left click at $x=-400, y=-1500$
- Left click at $du=800, dv=3000$
- Long left click to use height from group



- Check values in Box editor

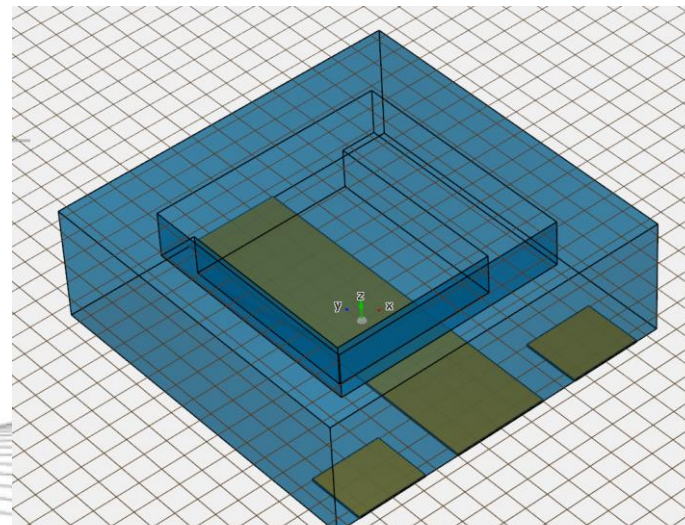
Step 7: Footprint 3

- Switch off group “package”
- Click on small box
- Press Copy & Mirror
- Enter a 1D arrow
 Keep x values
 Set Stop y: 1000
 to define a mirror axis
- Click OK
- Switch on group “package”



Comments:

- *Objects used for RF-in, RF-out and GND*



Step 8: Intermediate Metals

- Set z=250, keep checkmark
- Click „Create Box“
- Left click at x=-700, y=-400
- Left click at x=700, y=1000
- Long left click to use group height

Coordinate System: World (xyz)
 Grid: z 250
 Cursor: Stay on Grid
 Active Group: met0

Box Editor

General

Name: BOX 9

Group: met0 (Copper (conductor))

Assign Height: Custom From Group From Group (relative)

	x	y	z
Point 1	-700.0	-400.0	250.0
Point 2	700.0	1000.0	260.0

- Set z=600, keep checkmark
- Click „Create Box“
- Left click at x=-1000, y=-1300
- Left click at x=-700, y=0
- Long left click
- Click „Create Box“
- Left click at x=+700, y=-1300
- Left click at x=1000, y=0
- Long left click

Coordinate System: World (xyz)
 Grid: z 600
 Cursor: Stay on Grid
 Active Group: met0

Box Editor

General

Name: BOX 13

Group: met0 (Copper (conductor))

Assign Height: Custom From Group From Group (relative)

	x	y	z
Point 1	-1000.0	-1300.0	600.0
Point 2	-700.0	0.0	610.0

Box Editor

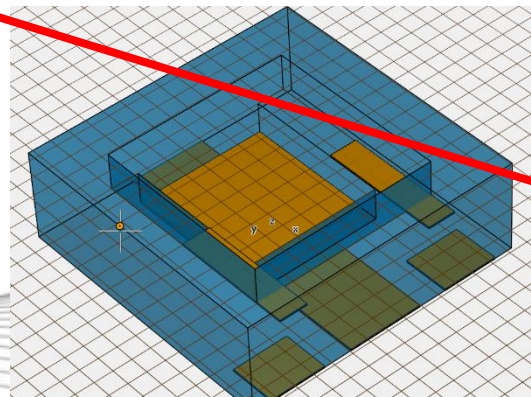
General

Name: BOX 14

Group: met0 (Copper (conductor))

Assign Height: Custom From Group From Group (relative)

	x	y	z
Point 1	700.0	-1300.0	600.0
Point 2	1000.0	0.0	610.0

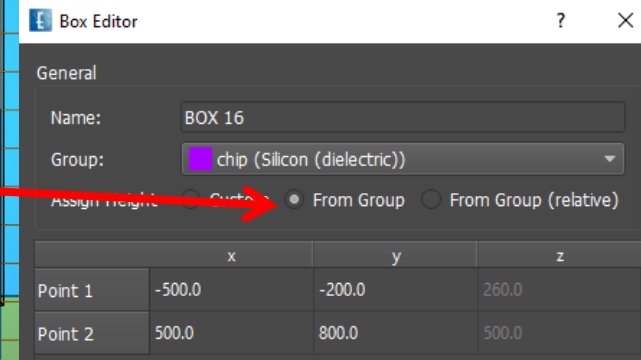
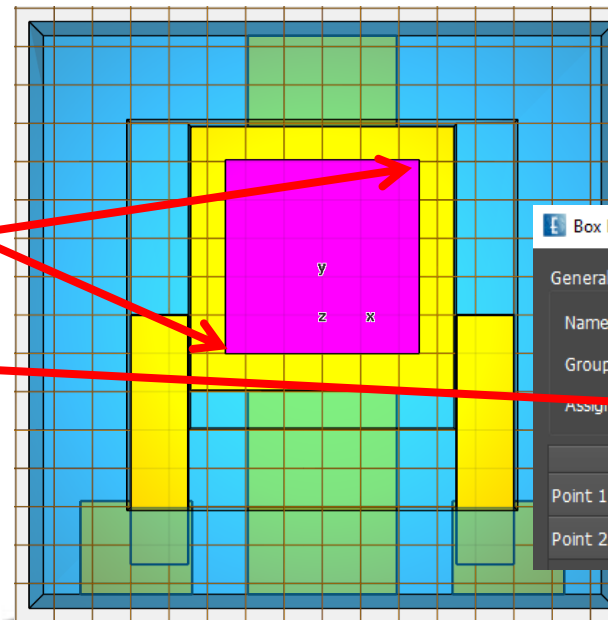
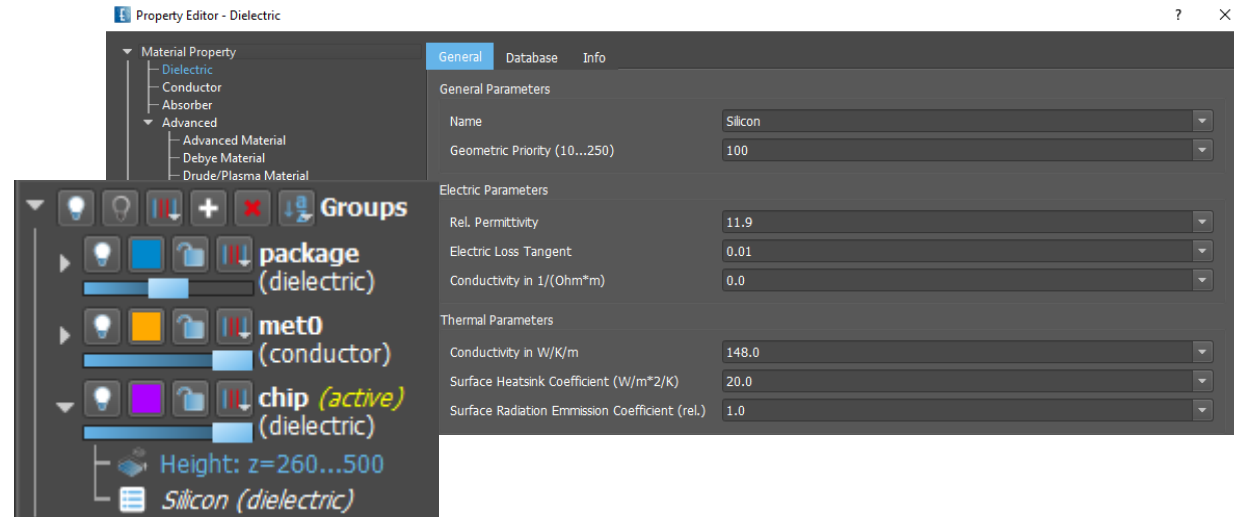


Step 9: Chip

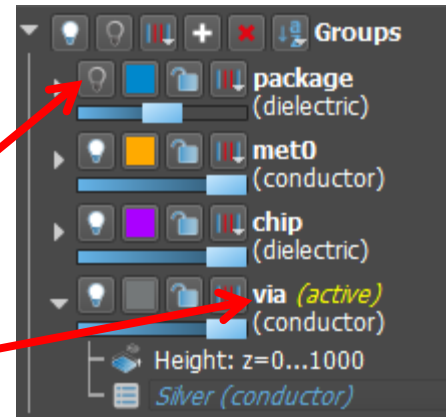
- Create group “chip” for chip (adjust name & color)
- Set property to Silicon (Dielectric, select from Database → Common)
- Set Height z=260... 500
- Switch to top view
- Click Create Box
- Left click at x=-500,y=-200
- Left click at x=500, y=800
- Long click
- Select “From Group”

Comments:

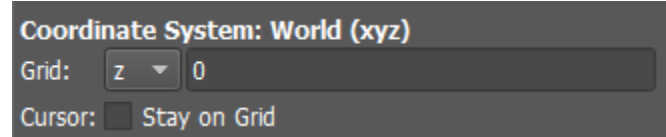
- Coordinate Snap depends on current zoom factor. Zoom in by turning mouse wheel forward to access coordinates




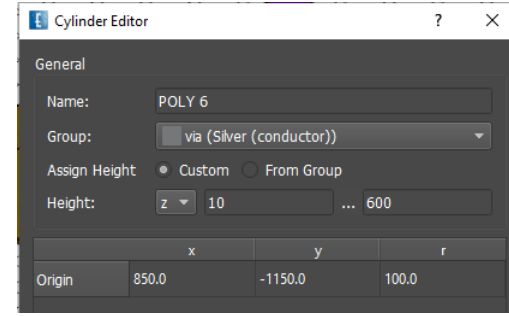
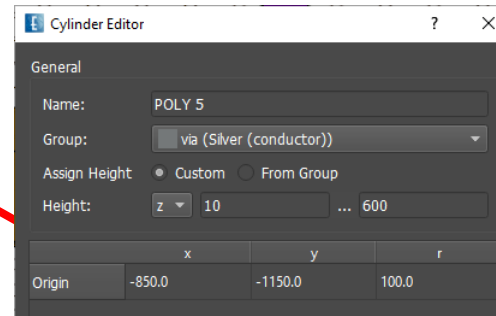
Step 10: Via 1




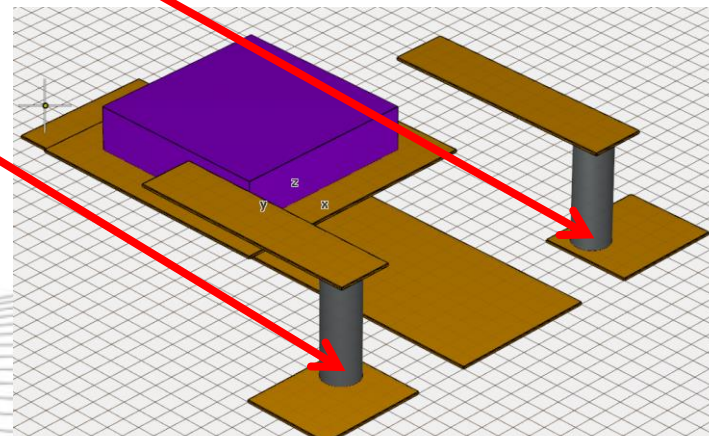
- Create "via" group for via holes
- Set property to Silver (select from Database->Metal)
- Switch off group „package“, zoom in
- Uncheck „Stay on Grid“*



- Click „Create Cylinder“ 
- Left click at $x=850, y=-1150$
- Left click at $r=100$
- Left click at $z=600$




- Click „Create Cylinder“ 
- Left click at $x=-850, y=-1150$
- Left click at $r=100$
- Left click at $z=600$





Comments:


- * Without checkmark object surface will be used as plane for snap & object creation

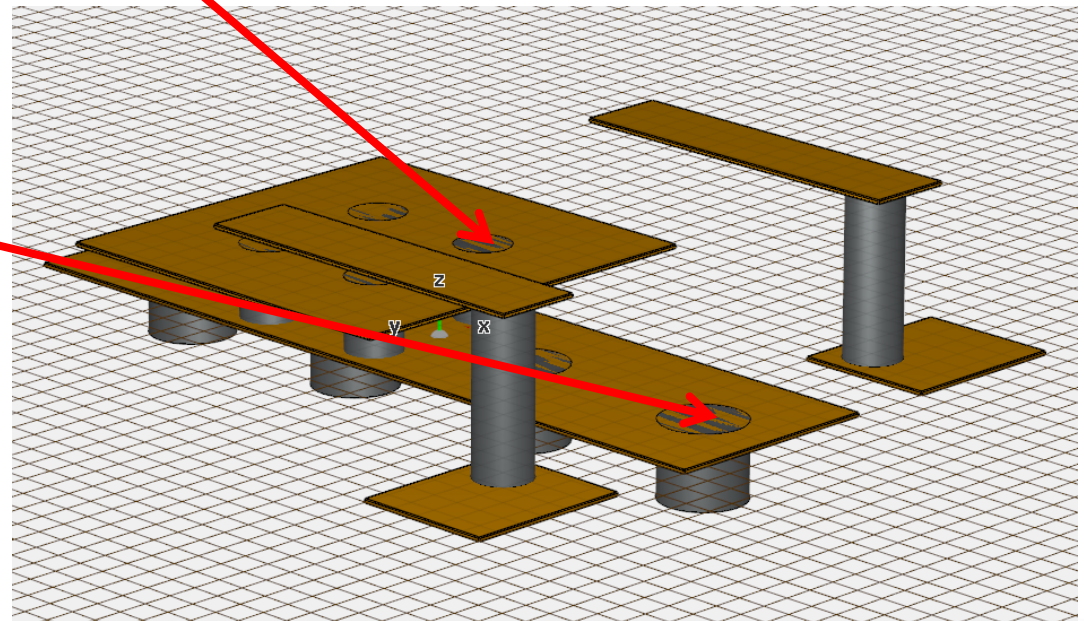
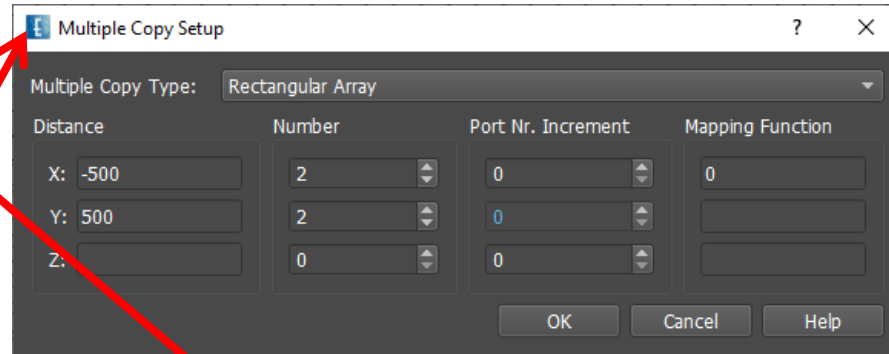
Step 11: Via 2

- Switch off group „chip“
- Click „Create Cylinder“ 
- Left click at x=250, y=50
- Left click at r=100
- Left click at z=0

- Left click on via 
- Click Multiple Copy
- Enter X: -500 2
- Enter Y: 500 2

- Click „Create Cylinder“ 
- Left click at x=0, y=-1250
- Left click at r=150
- Left click at z=-250*

- Left click on via 
- Click Multiple Copy
- Enter X: 0 1
- Enter Y: 800 4

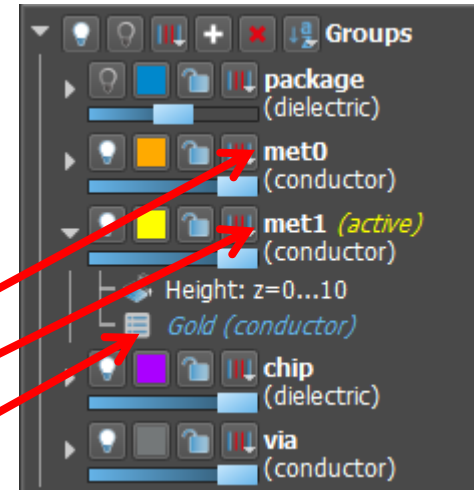



Comments:

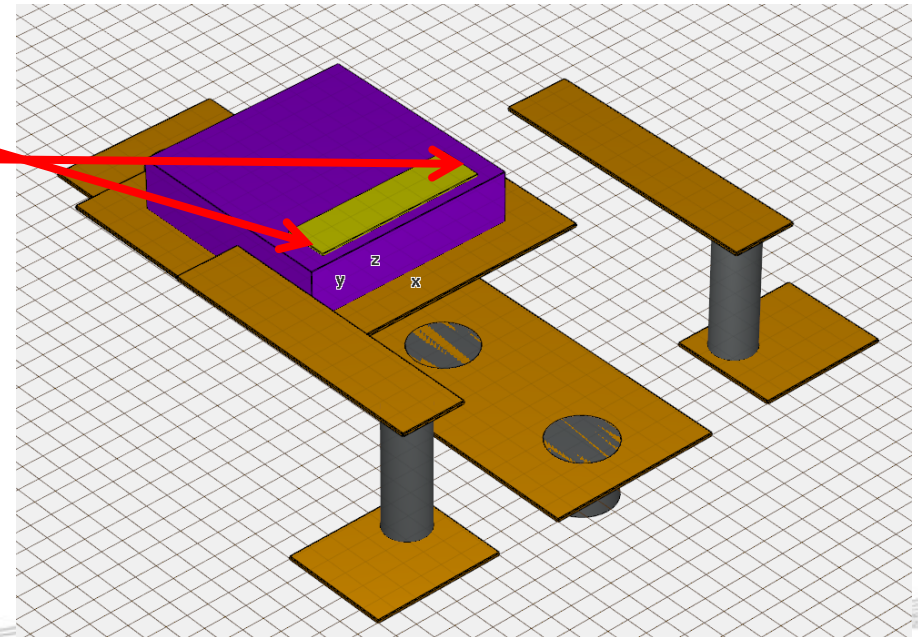
* If value can not be accessed due to snap, rotate a bit (drag right button)

Step 12: MSL on Chip

- Switch on group „chip“
- Right Click on group met0, Clone Groups
- Right Click on new group, Rename to met1
- Change property to Gold (Metal Database)



- Click Create Strip 
- Click at $x=-400$, $y=-50$, $z=500$
- Click at $x=+400$, $y=-50$, $z=500$
- Long click to finish
- Long click to use group height
- Edit Settings $w=200$,
- Close Windows, OK



Comments:

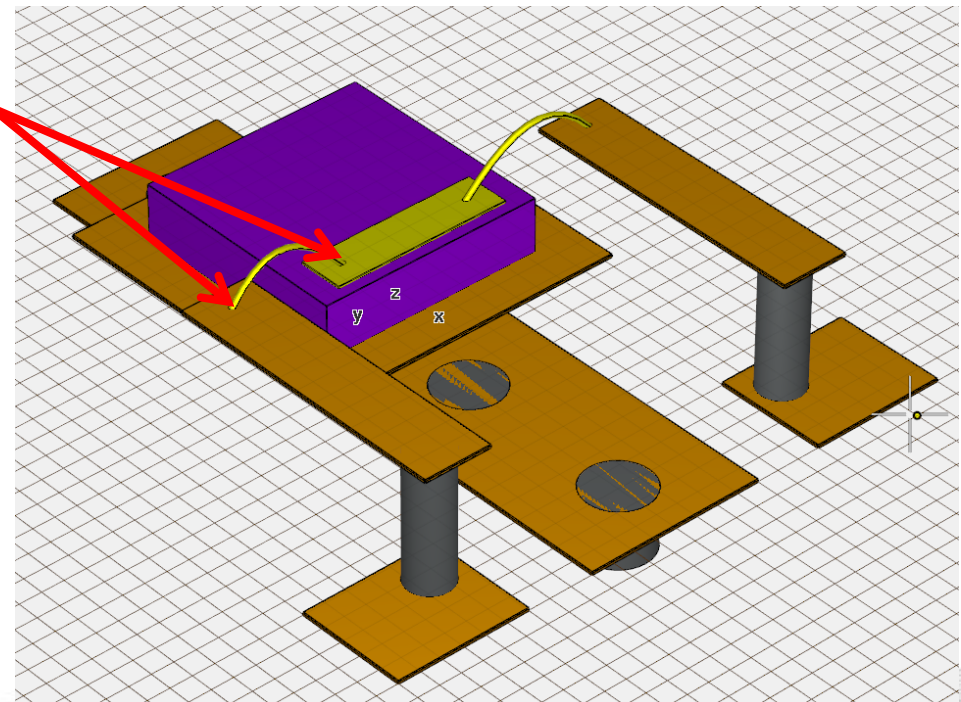
A new group is used for the new material. Note that the group height is copied too.

Step 13: Bond Wires



- Click „Create Library Object“
- Select „3D Wire“ – „Bond“
- Click at $x=-850, y=-100, z=610$
- Click at $x=-300, y=-50, z=510$
- Edit Settings, Set Diameter = 25

- Click „Create Library Object“
- Select „3D Wire“ – „Bond“
- Left click at $x=+300, y=-50, z=510$
- Left click at $x=+850, y=-100, z=610$
- Press Parameters, Set Diameter = 25

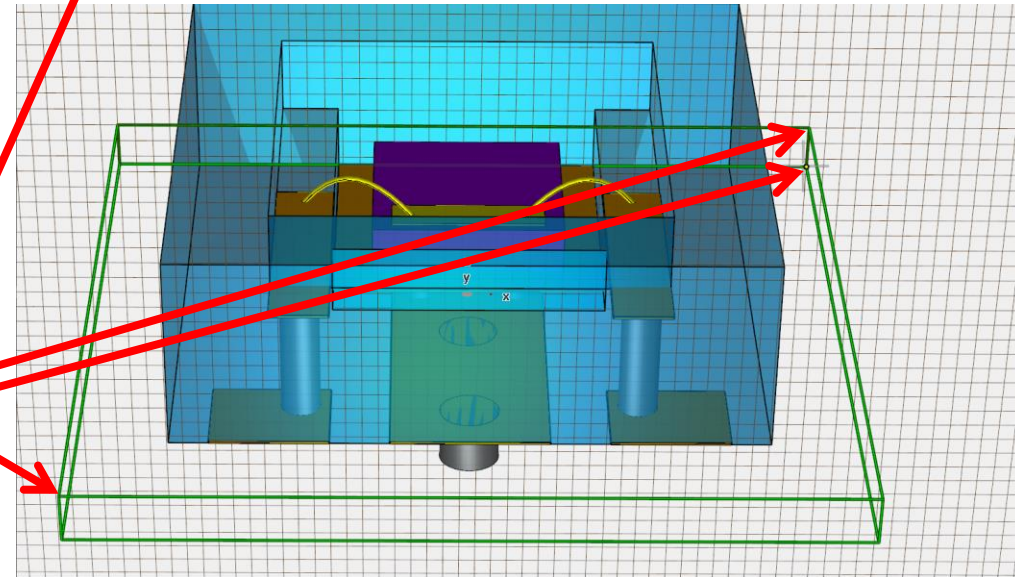
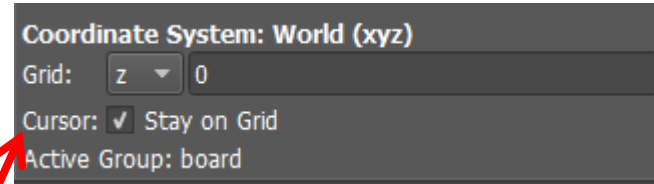


Comments:

- *Angles determines slope of the bond*
- *Number determines support points*

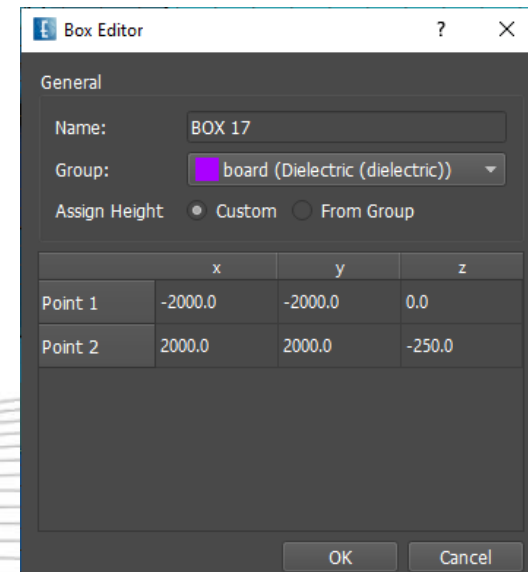
Step 14: Board

- Add group, name board
- Set property Dielectric, Permittivity = 3
- Set z=0 and checkmark to stay on grid
- Create Box
- First point $x=-2000, y=-2000$
- Second point $x=2000, y=2000$
- Height $z=-250$





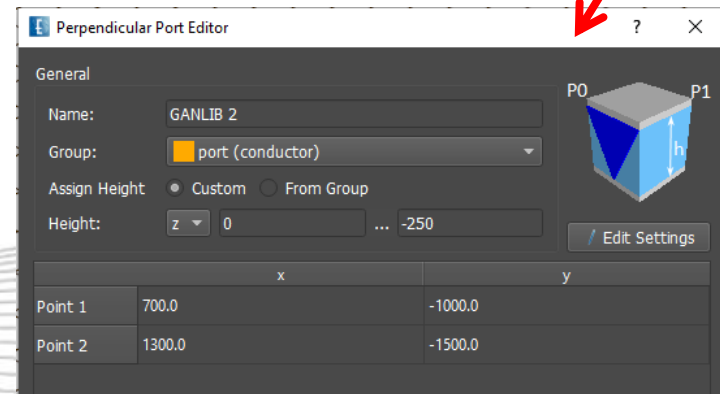
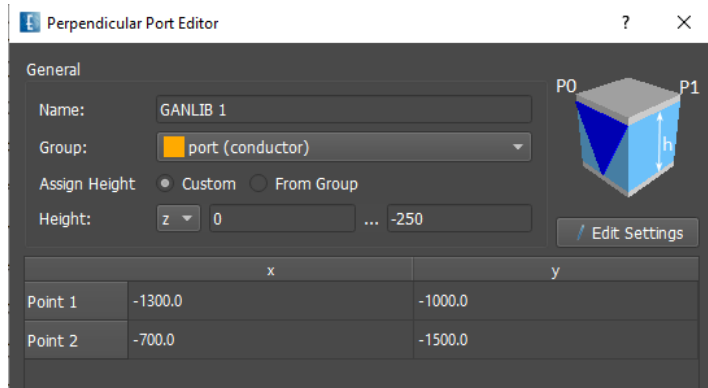
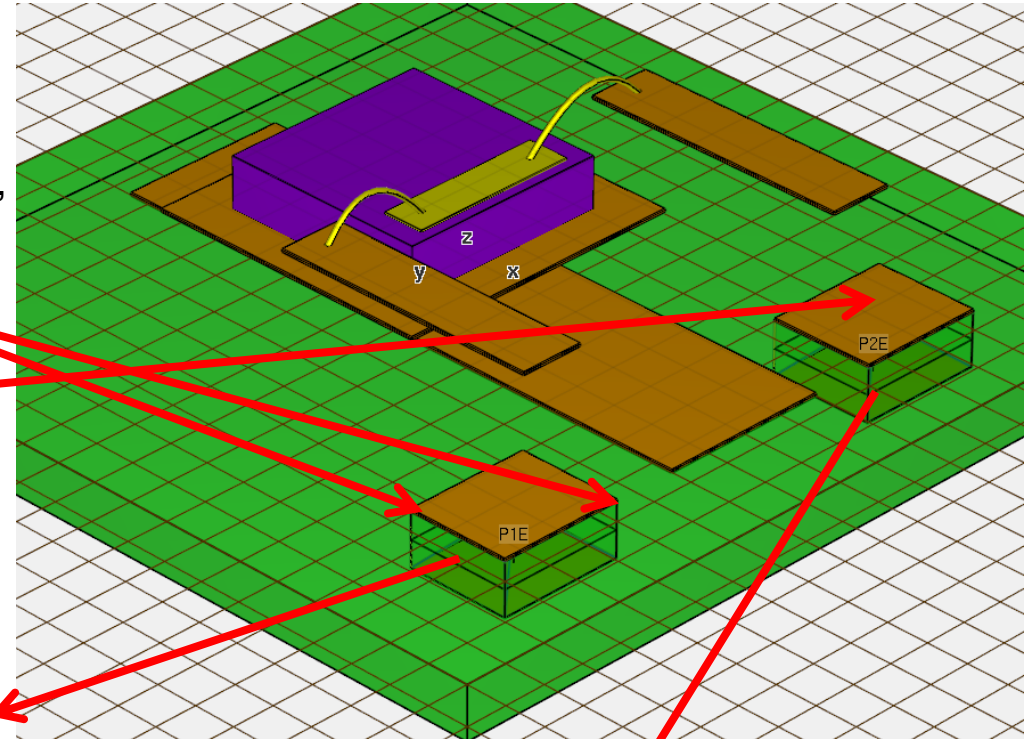
Comments:

- Switch to front view and rotate (drag right button down)
- Zoom in/out if necessary (Wheel or page up/down keys)
- Pan if necessary (Drag middle button or arrow keys $\leftarrow \uparrow \rightarrow \downarrow$)



Step 15: Ports

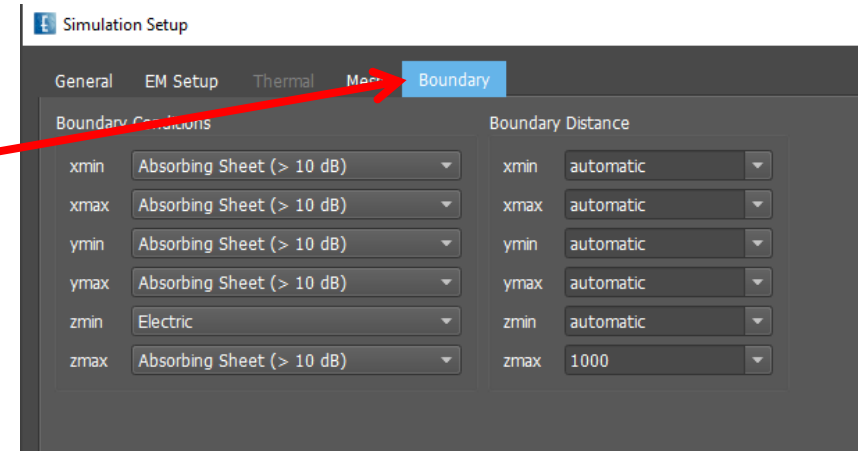
- Add group, name port
- Switch off „package“, „via“
- Click “Create Source” , Tab „Lumped“, “Perpendicular Port” 
- 2 Left clicks at pad corners
- Left click at z=-250
- Repeat Create Source for 2nd pad



Comments:

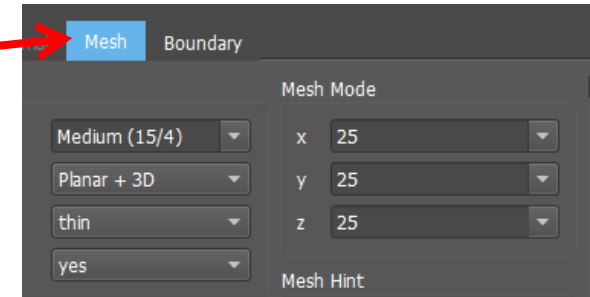
- Port numbers will be increased automatically

Step 16: Simulation Setup

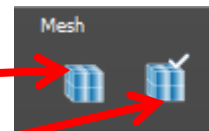


- Click “Simulation Setup“
- Select Tab: “Boundary“,
- Set „Boundary Distance“ $z_{max} = 1000^*$
- Set “Boundary Conditions“:
 - $z_{min} = \text{“electric”}$
 - others = “Absorbing Sheet” **

- Select Tab: “Mesh“, set Mesh Mode : 25 for x,y,z
- Close Window



- Click “Create Mesh“
- Confirm to resize
- Check Meshed 3D structure***



Comments:

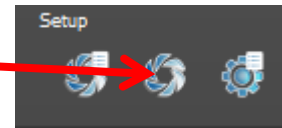
* to use 1mm additional space at z_{max}

** No radiation is expected, so simple sheet boundary conditions may be applied, ground plane at z_{min}

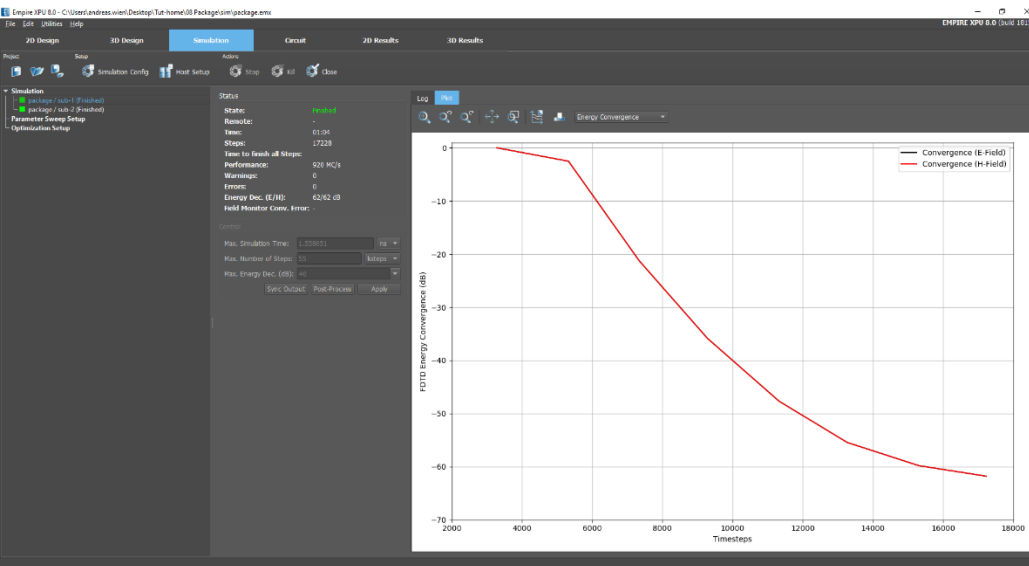
*** Verify discrete structure after meshing is always recommended

Step 17: Simulation

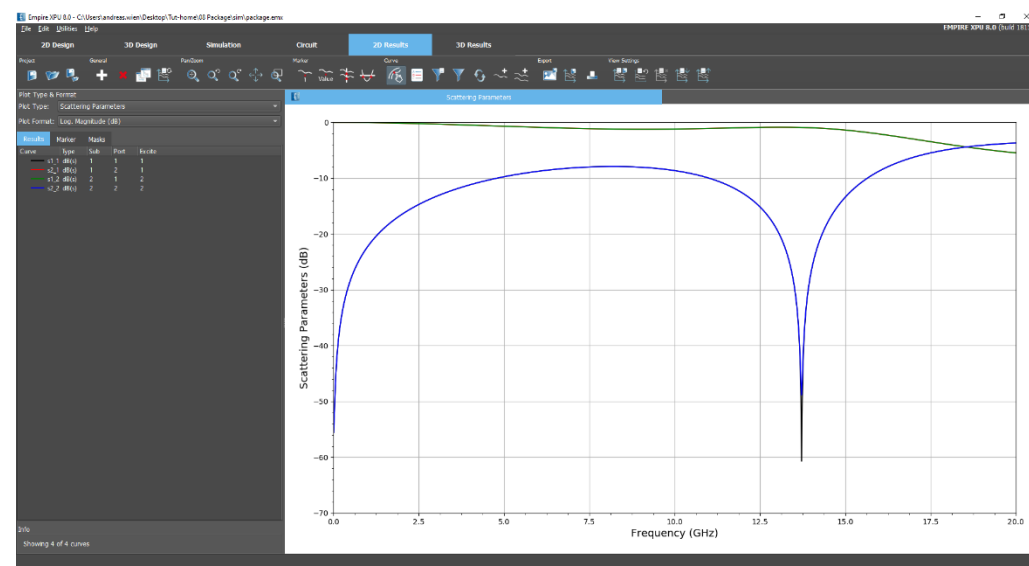
- Click „Start Simulation“
- Confirm OK



Simulation Tab: Energy vs. timesteps



2D Results Tab: S-Parameter



Comments:

- There will be as many subsequent simulation as exciting ports
- Complete S-Matrix