New Spiral Load RF Design

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Outline

- Motivation
- Straight Load Model
- Design Process
  - Straight to Spiral Model
  - Spiral Model with WR90 Transition
  - Spiral Model with Vacuum Holes
  - Spiral Model with Pumping Port
- Reflection Optimisation
- Final RF Model
- Conclusion & Future Work

Reminder

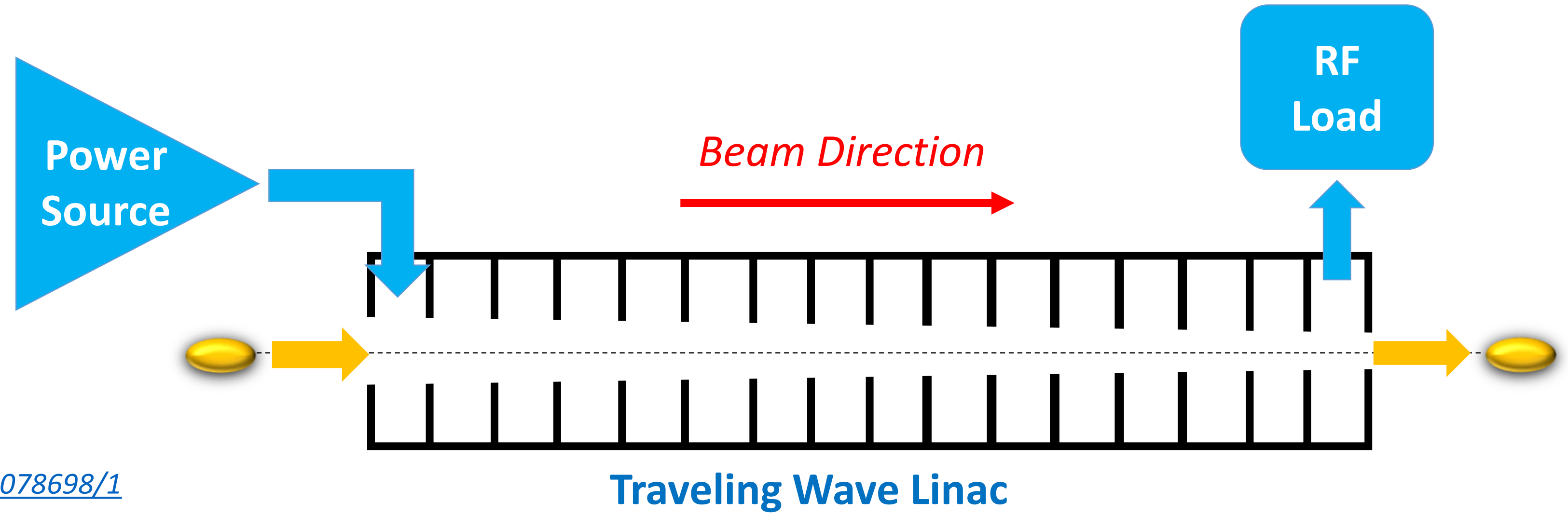
- ***Why do we use RF loads?***

In order to absorb remaining RF power passing through the RF system. (Not used for beam acceleration or dissipated on resistive walls.)

(Ex: TD26CC P_{in}= 43.3MW – unloaded for 100MV/m)*

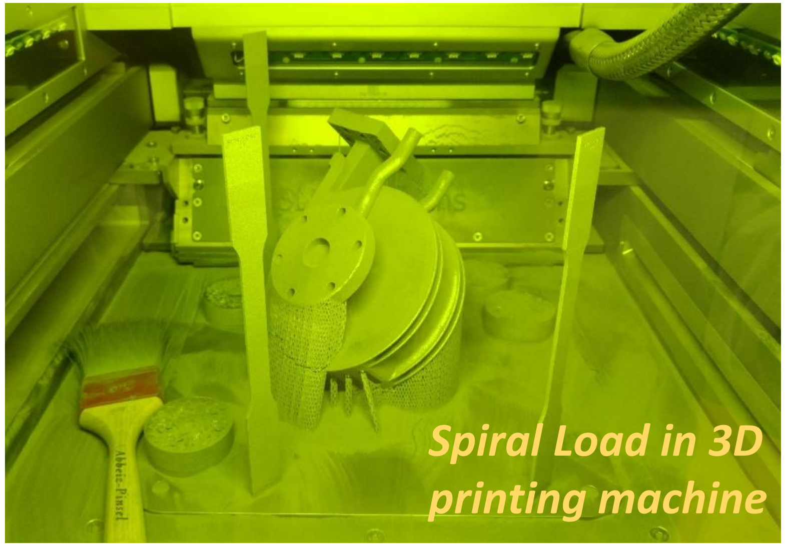
- ***Where do we use RF loads?***

At the RF output of traveling wave type structures.



*https://edms.cern.ch/document/1078698/1

X-Band RF Loads (produced by Additive Manufacturing)



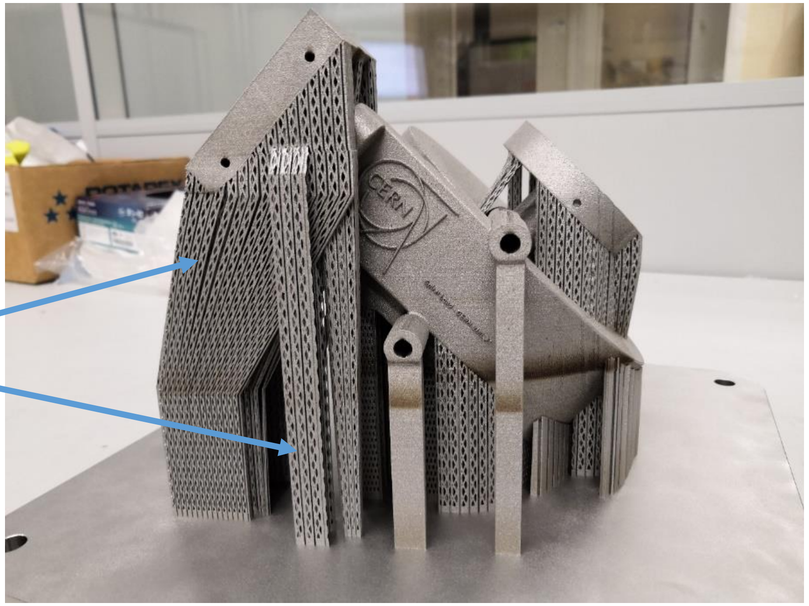
*

*Photos from Romain Gerard

- We have several RF spiral loads which were designed (CLIACOMP0071 , CLIACOMP0094), fabricated (at CERN or Vendor companies) and tested successfully. *(Materials; Stainless-Steel "316L", Titanium alloy "Ti6A14V")*
- For more info, please see the document; https://edms.cern.ch/document/2323664/1
- The current designs allow to produce only one load during an additive manufacturing cycle because of 45° oblique placing and 3D printing machine dimensions.

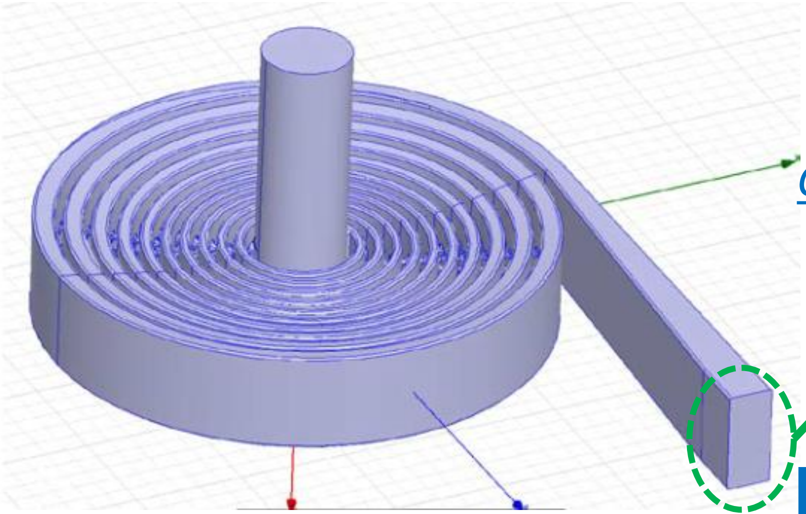
Support parts (removing after production)

*



Motivation

- The aim of this study is to optimise the internal cross-section of RF loads in order to create a stackable design to increase number of products per additive manufacturing cycle and so decreasing the unit price.

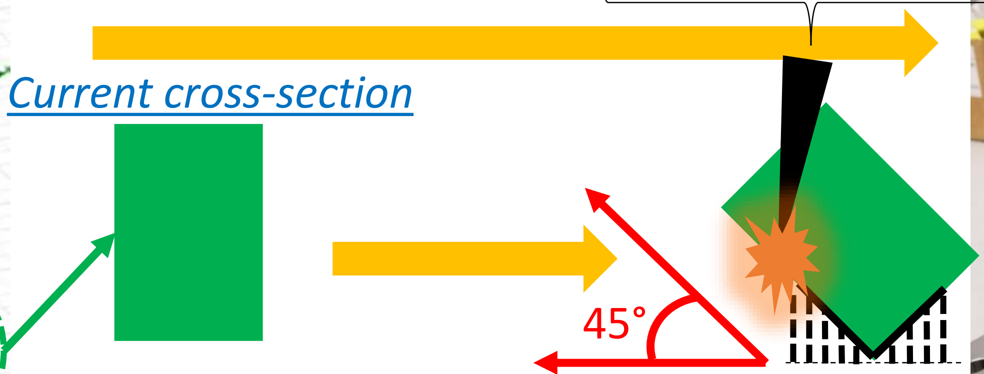


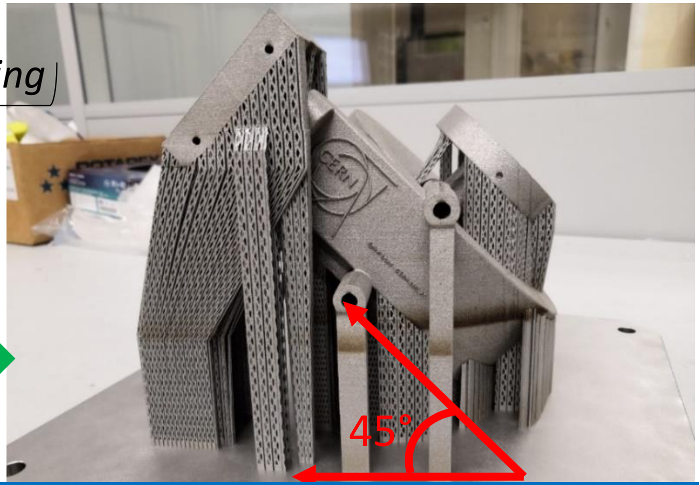
*

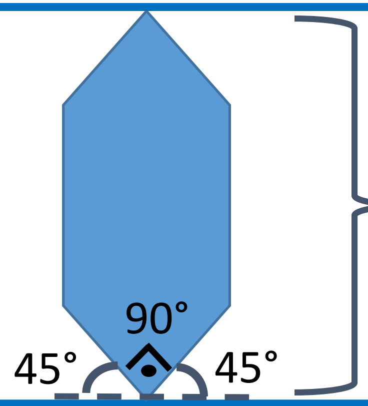
Previous RF Design with rectangular internal cross section

with 45° oblique placing to allow additive manufacturing

Current cross-section







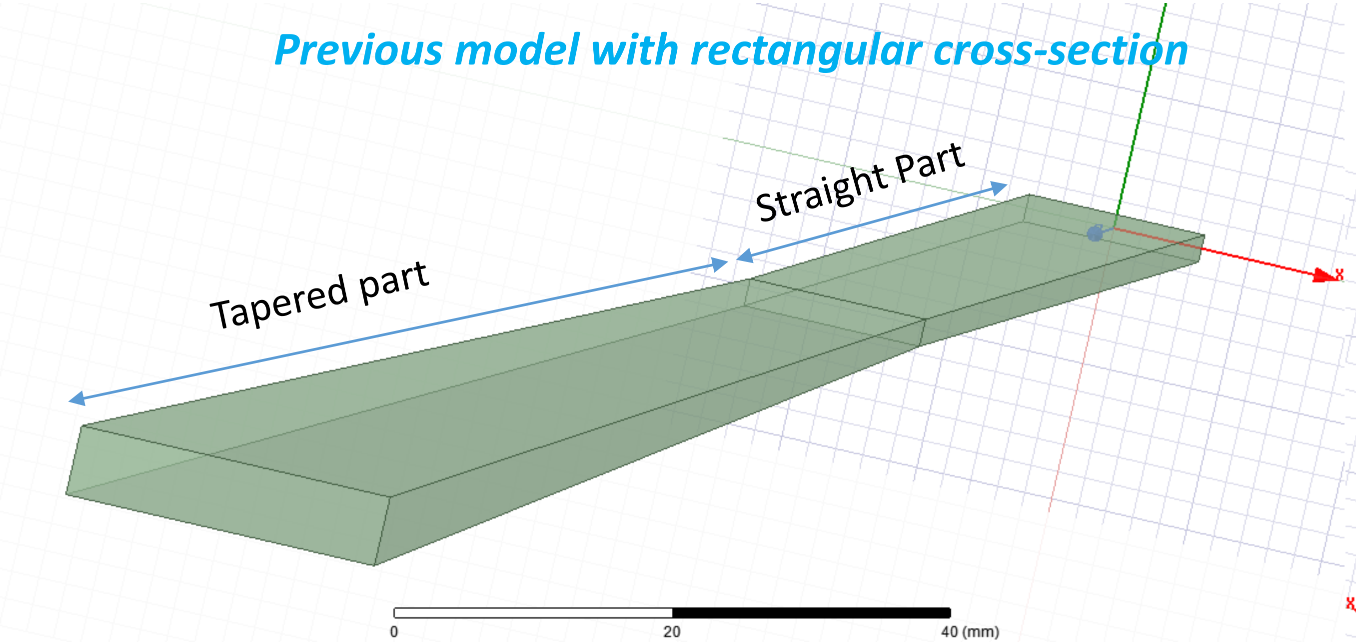
New cross-section

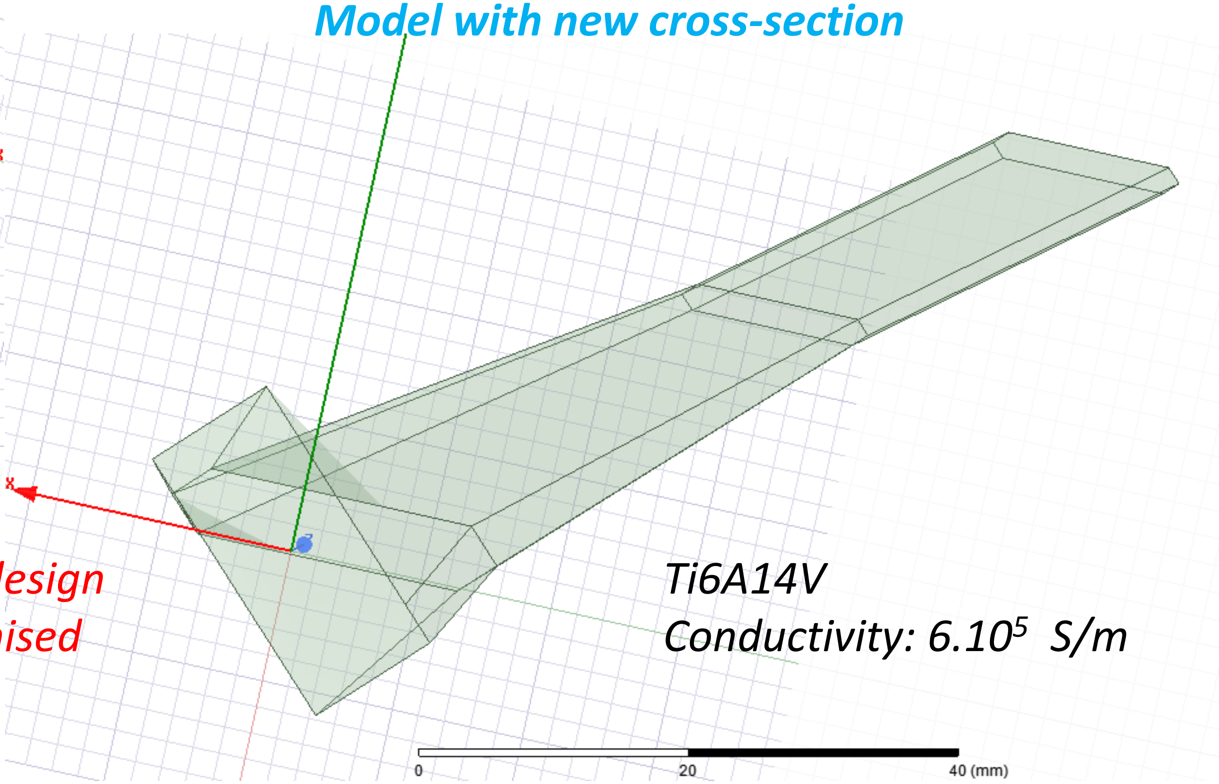
- *Placing directly (without 45°)*
- *Less space allowing stackable design (allows producing more than one load during one manufacturing cycle)*
- *Material saving with reducing material for support parts (cost reducing)*

**Development of X Band High Power RF Load for CLIC Applications Using Additive Manufacturing Techniques; D'Alessandro, Gian Luigi (https://cds.cern.ch/record/2139981?ln=en)*

Straight Model Reference Design

Parametric Design



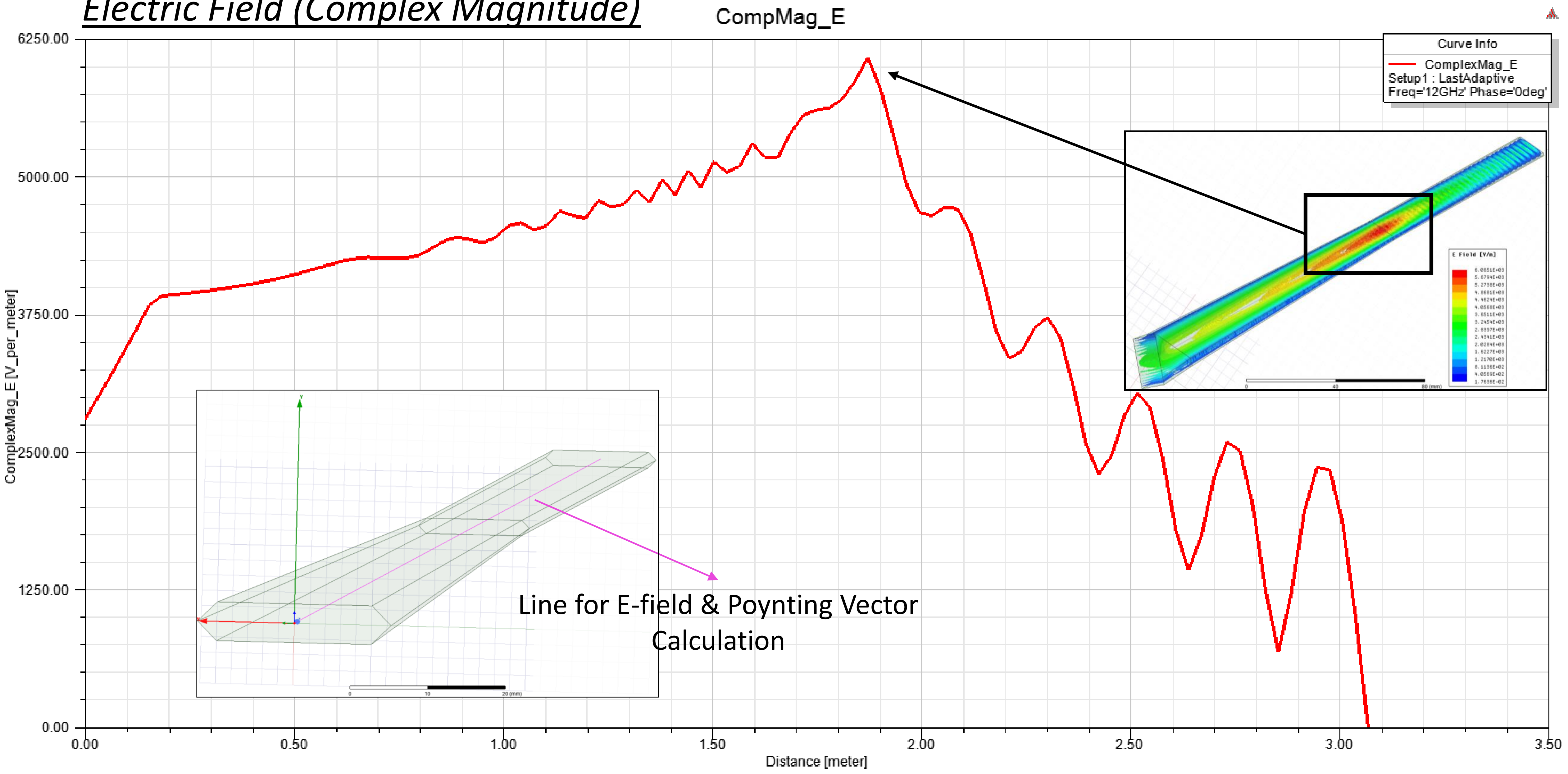


The dimensions of previous design were used directly and optimised with the new cross-section.

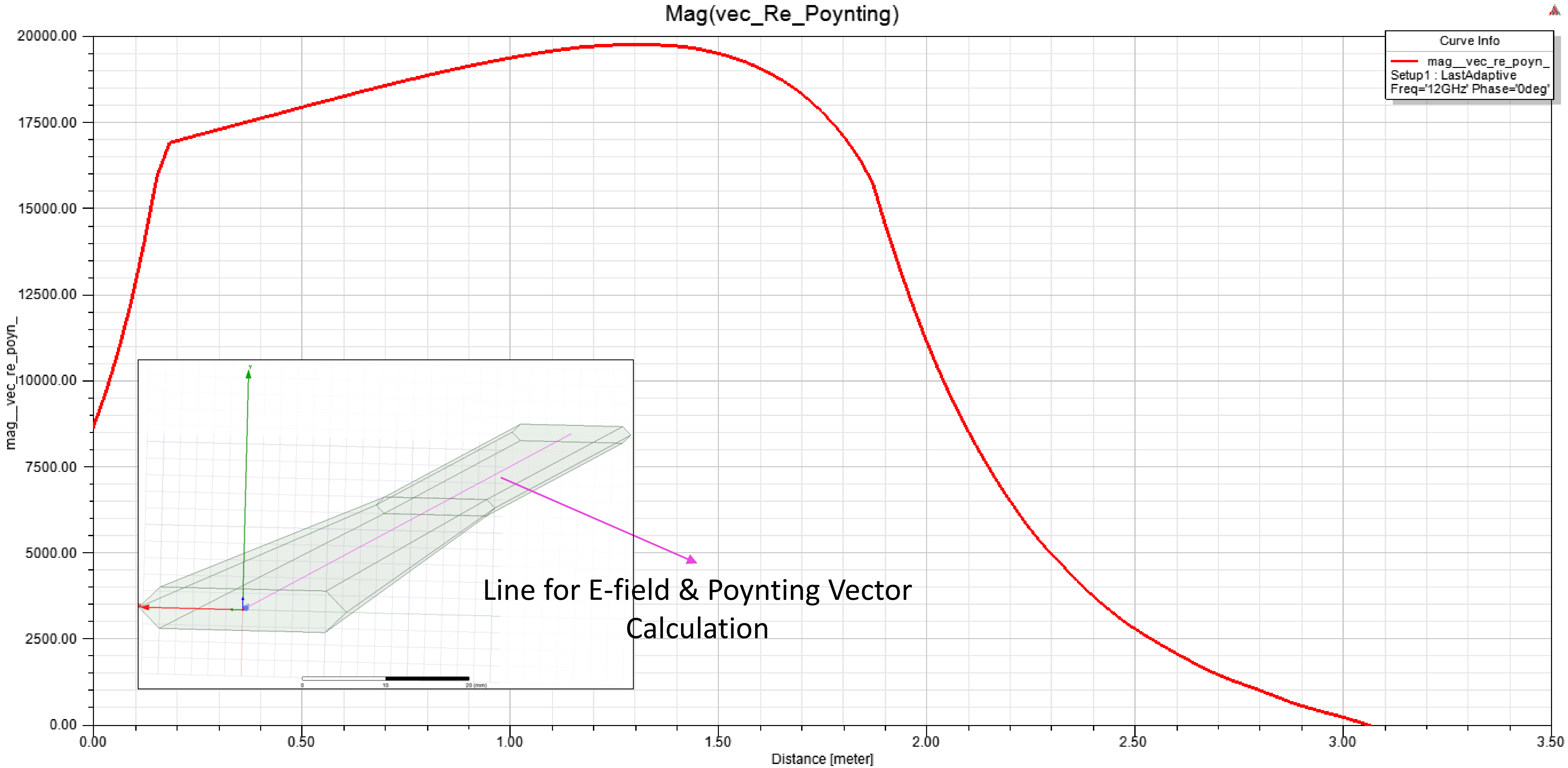
Ti6A14V
Conductivity: 6.10^5 S/m

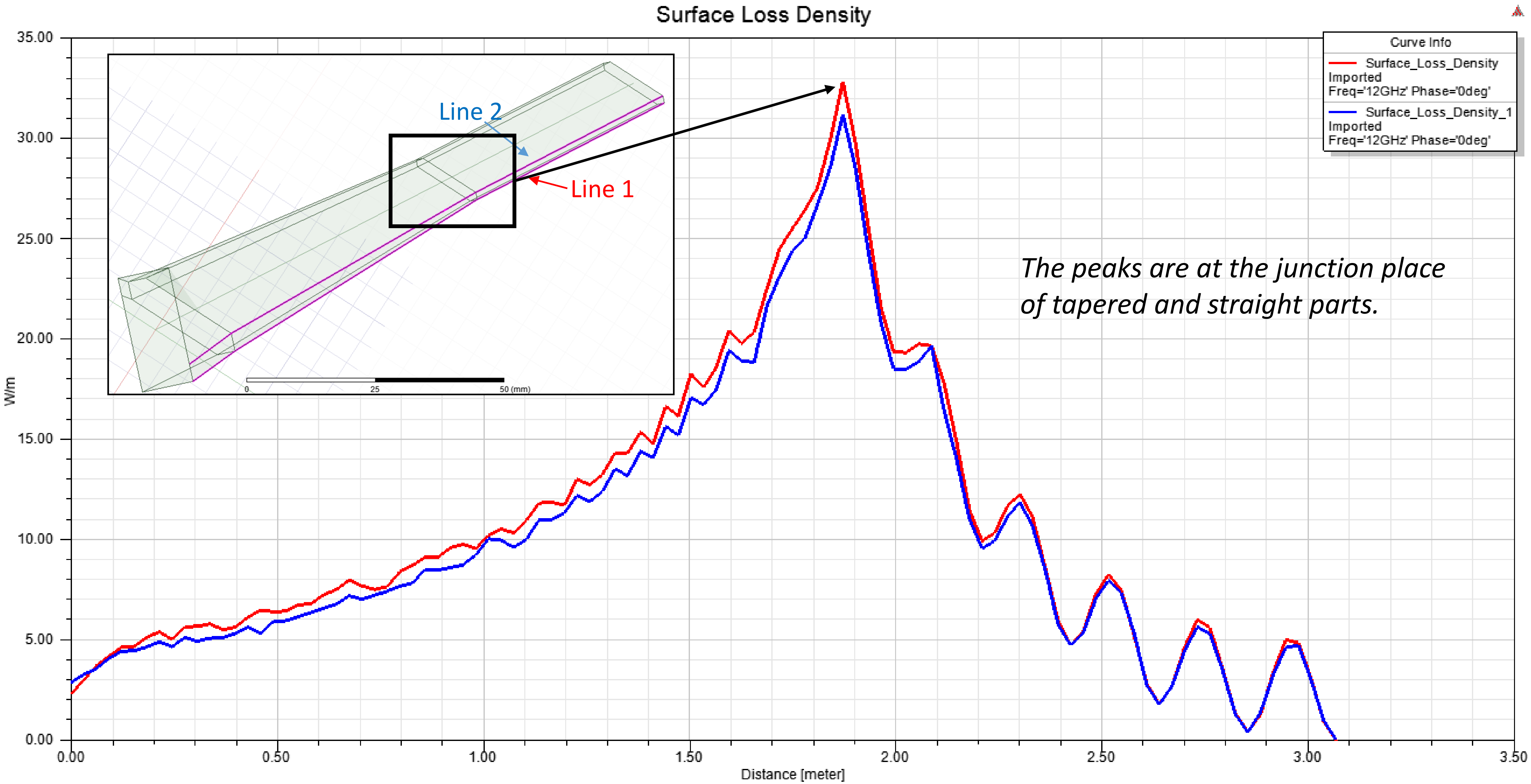
Development of X Band High Power RF Load for CLIC Applications Using Additive Manufacturing Techniques; D'Alessandro, Gian Luigi (https://cds.cern.ch/record/2139981?ln=en)

Electric Field (Complex Magnitude)



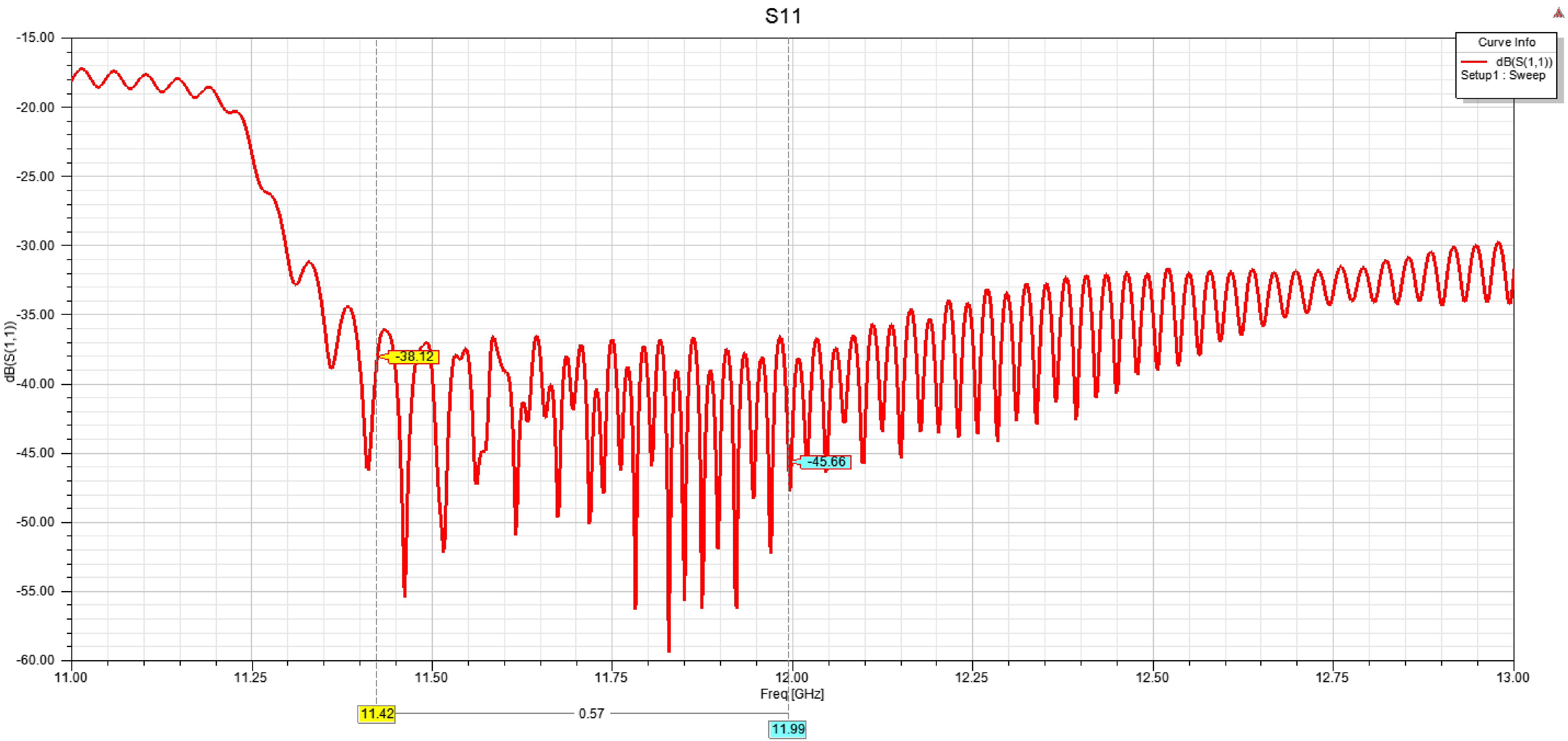
Poynting Vector





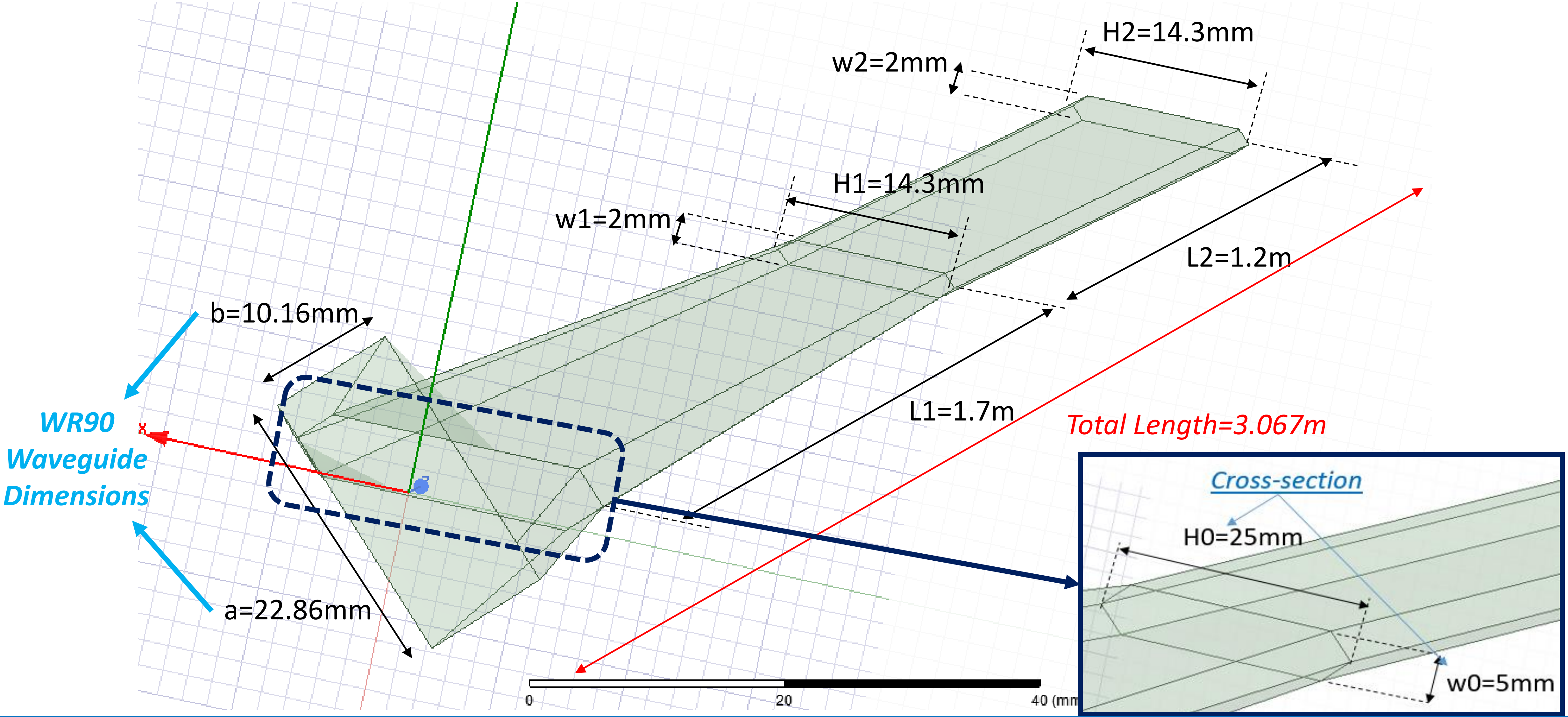
The peaks are at the junction place of tapered and straight parts.

Reflection

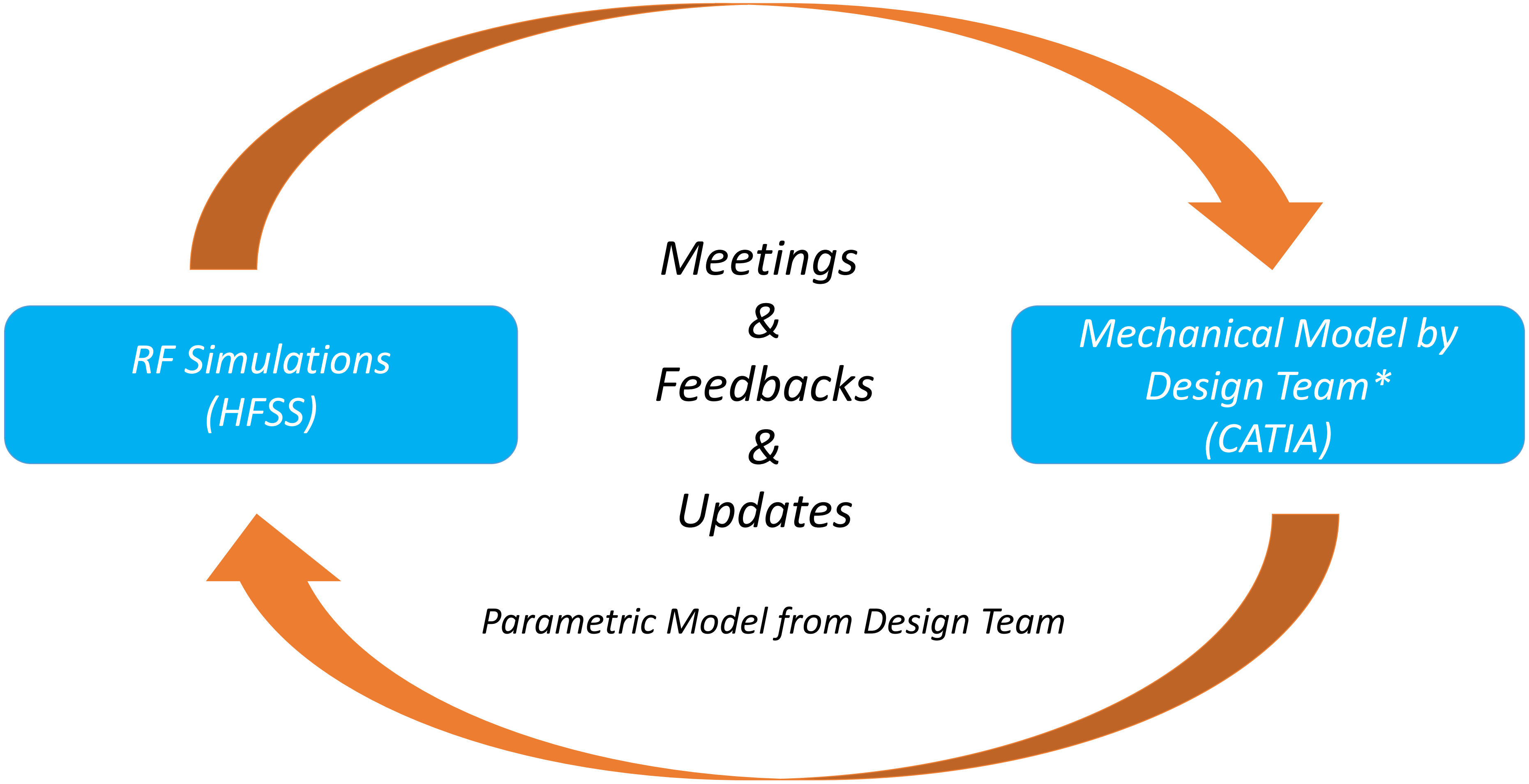


S11
Curve Info
dB(S(1,1))
Setup1 : Sweep
dB(S(1,1))
-15.00
-20.00
-25.00
-30.00
-35.00
-40.00
-45.00
-50.00
-55.00
-60.00
-38.12
-45.66
11.00
11.25
11.50
11.75
12.00
12.25
12.50
12.75
13.00
Freq [GHz]
11.42
0.57
11.99

Straight Model on HFSS-Parameters

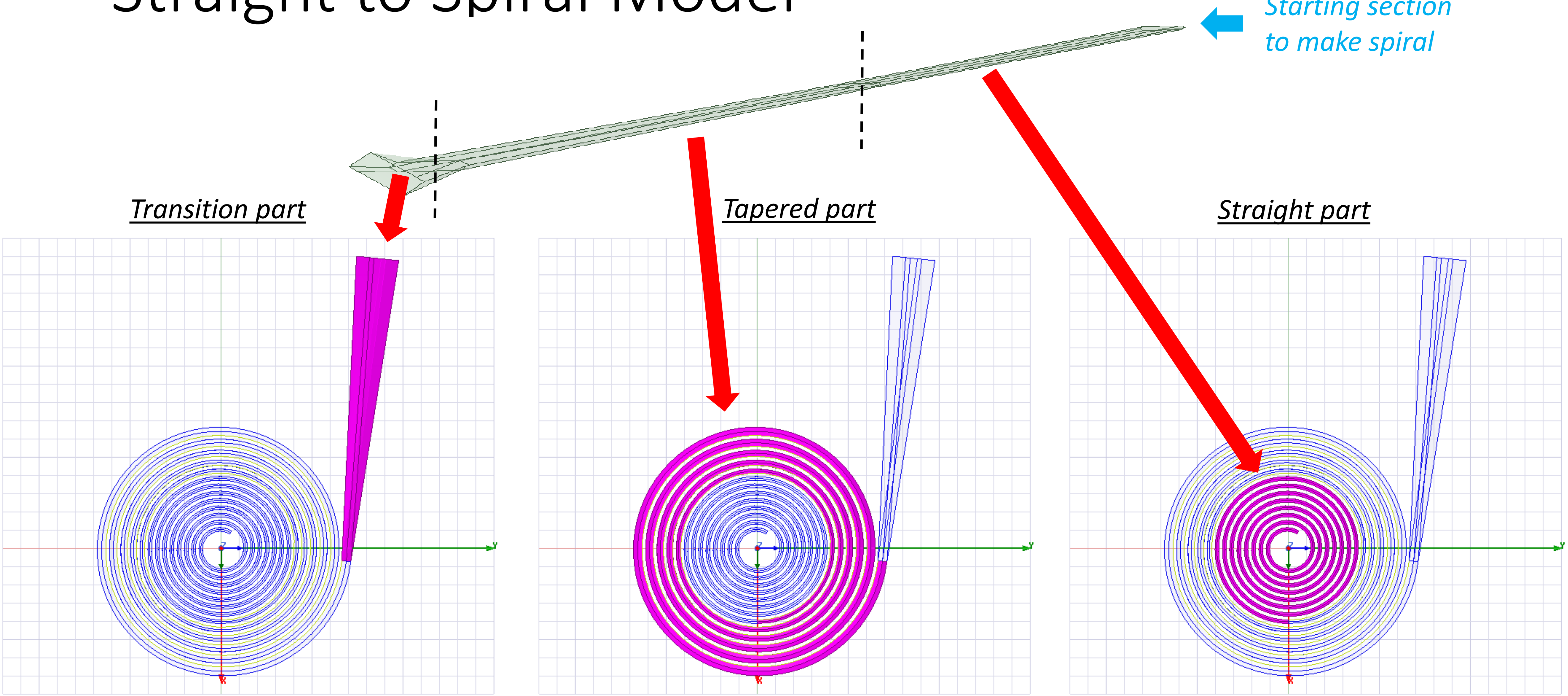


Design Process



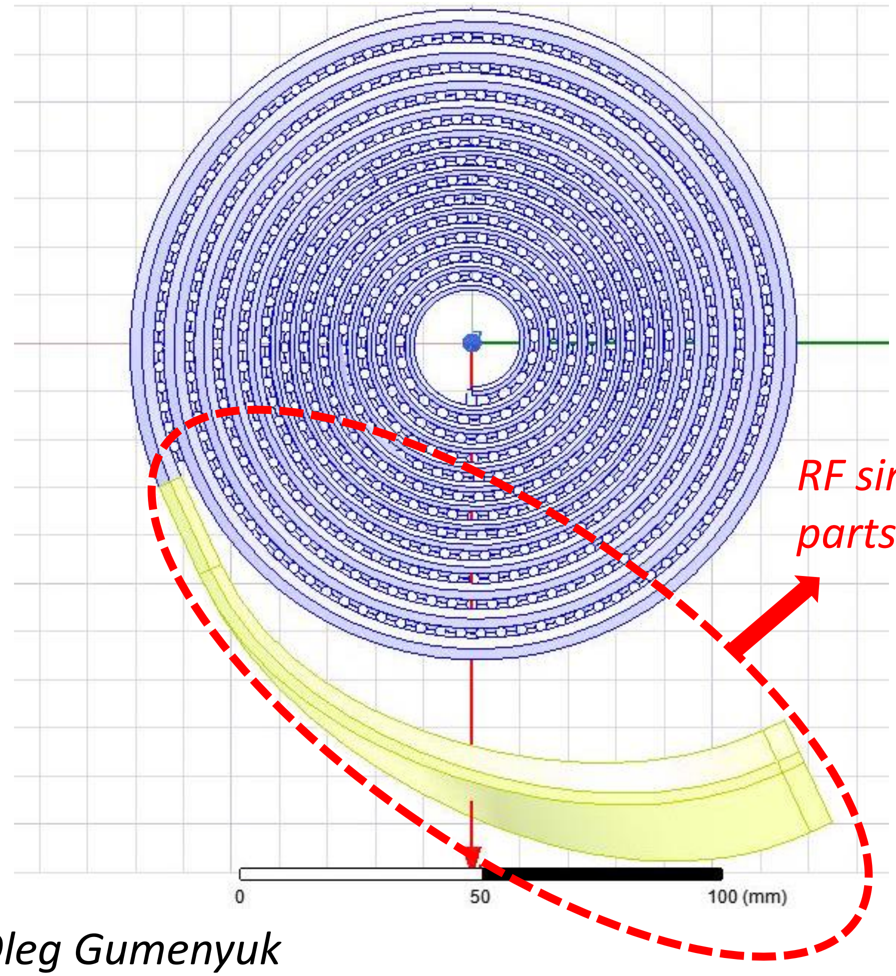
*Oleg Gumenyuk, Benoit Riffaud, Romain Gerard

Straight to Spiral Model

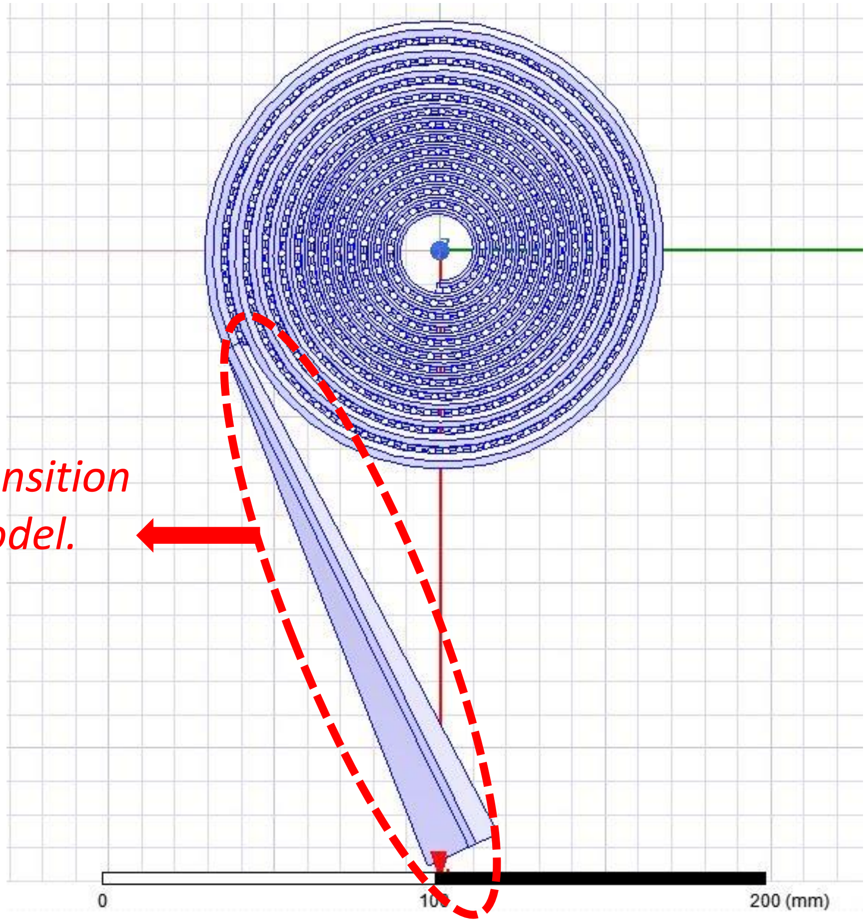


Straight Model with WR90 Transition

Model with Bent Transition

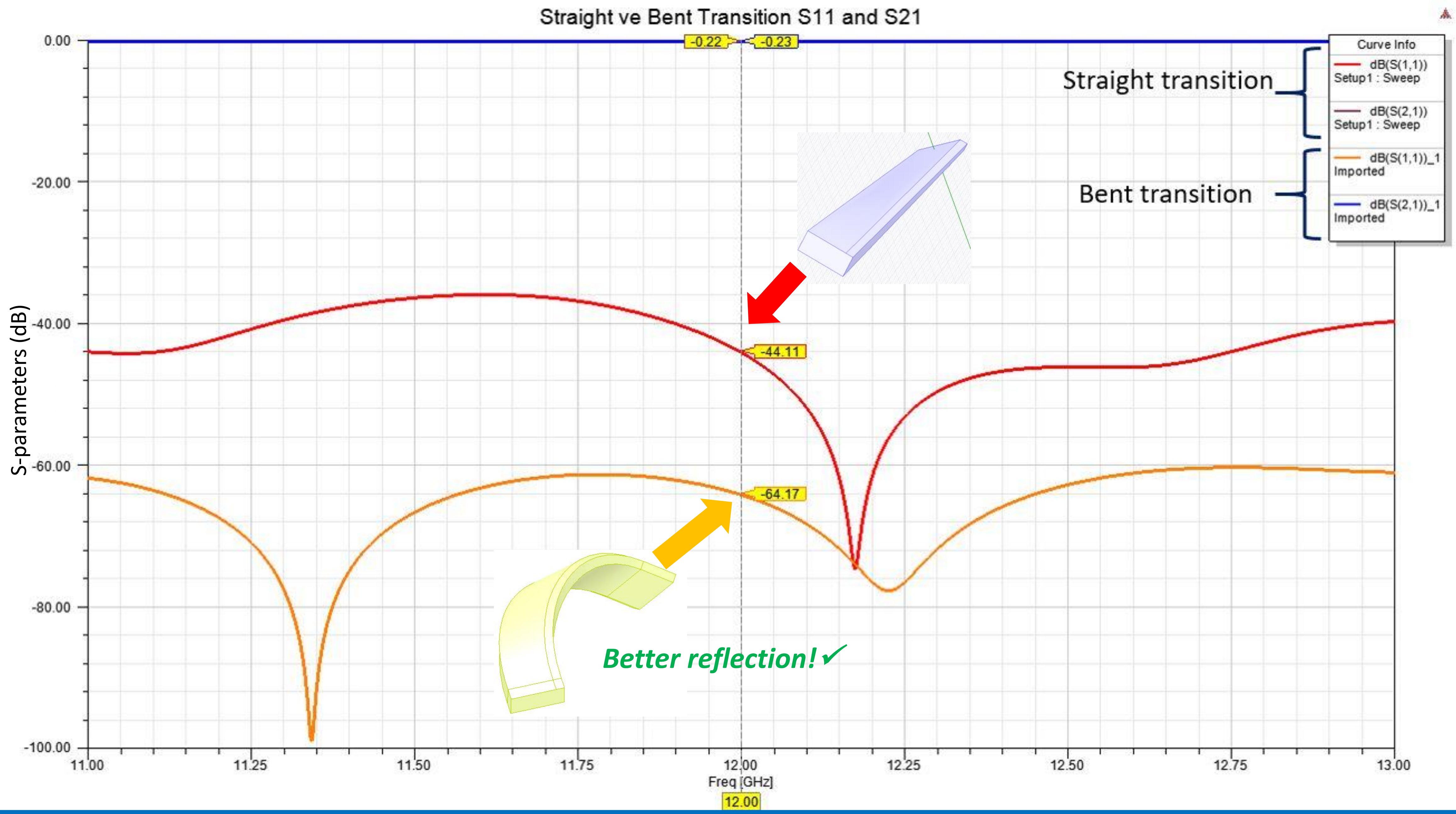


Model with Straight Transition

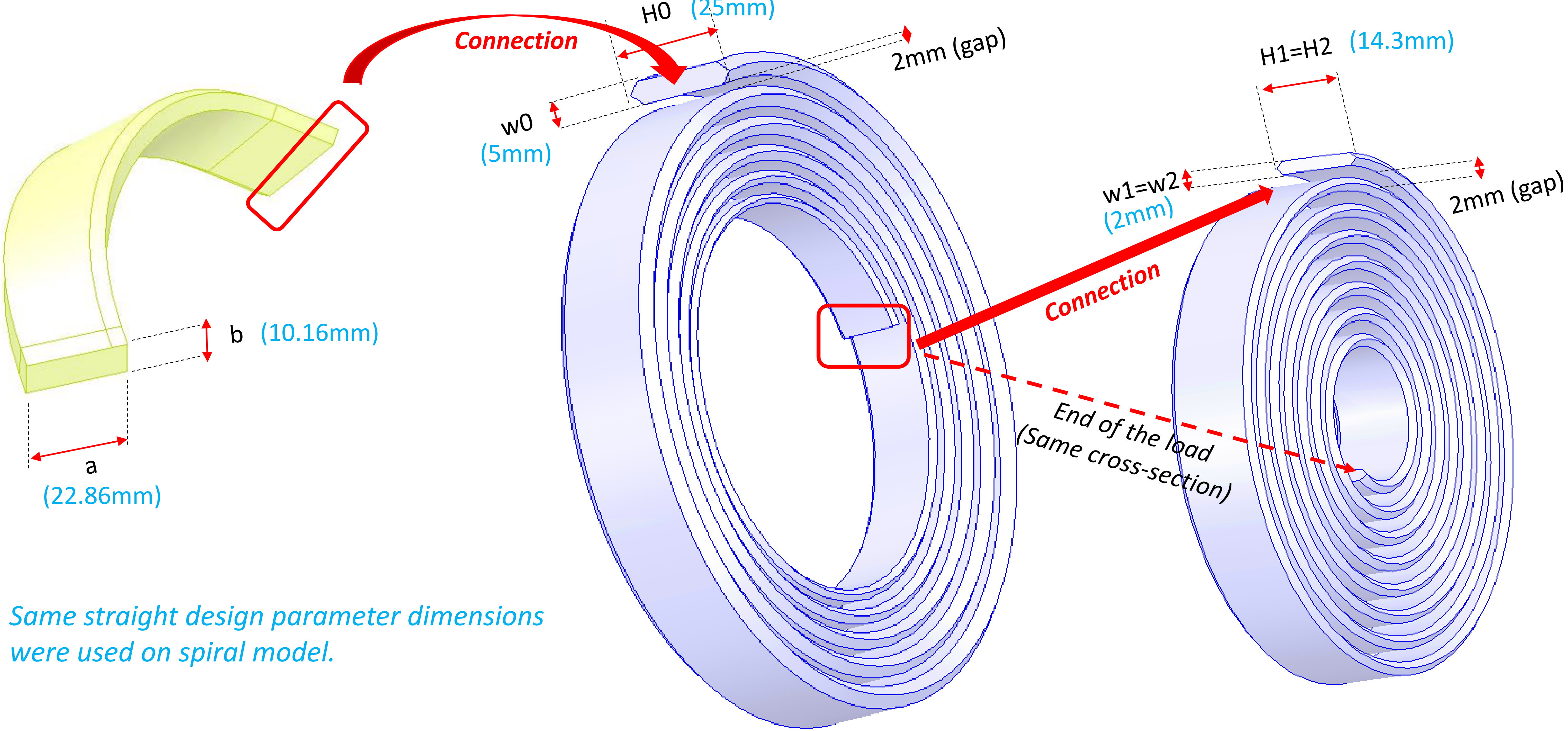


RF simulations for transition parts to select the model.

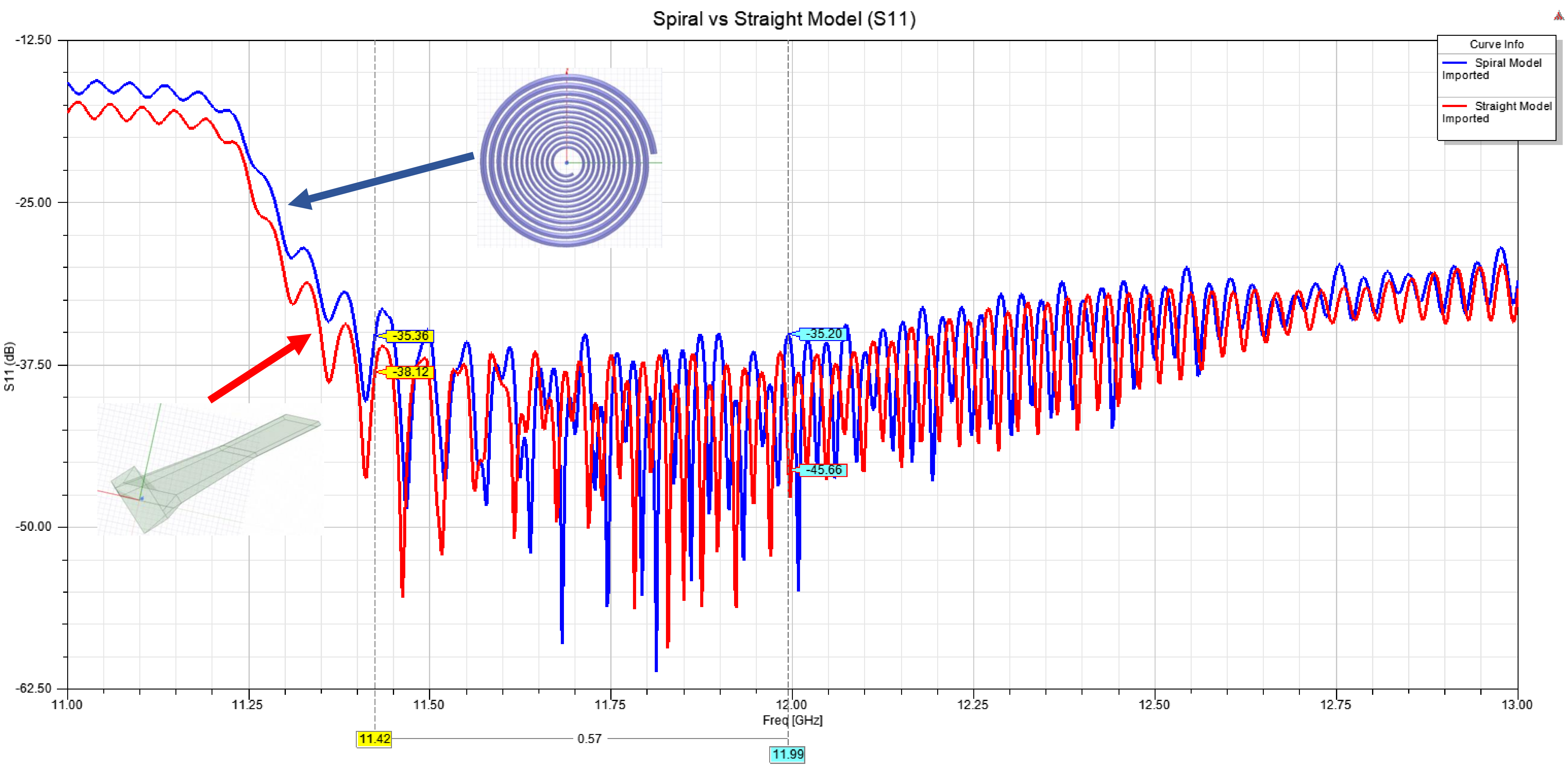
Oleg Gumenyuk


Straight ve Bent Transition S11 and S21
S-parameters (dB)
0.00
-20.00
-40.00
-60.00
-80.00
-100.00
11.00
11.25
11.50
11.75
12.00
12.25
12.50
12.75
13.00
Freq [GHz]
12.00
-0.22
-0.23
-44.11
-64.17
Curve Info
dB(S(1,1))
Setup1 : Sweep
dB(S(2,1))
Setup1 : Sweep
dB(S(1,1))_1
Imported
dB(S(2,1))_1
Imported
Straight transition
Bent transition
Better reflection!✓

Spiral Model Dimension Parameters

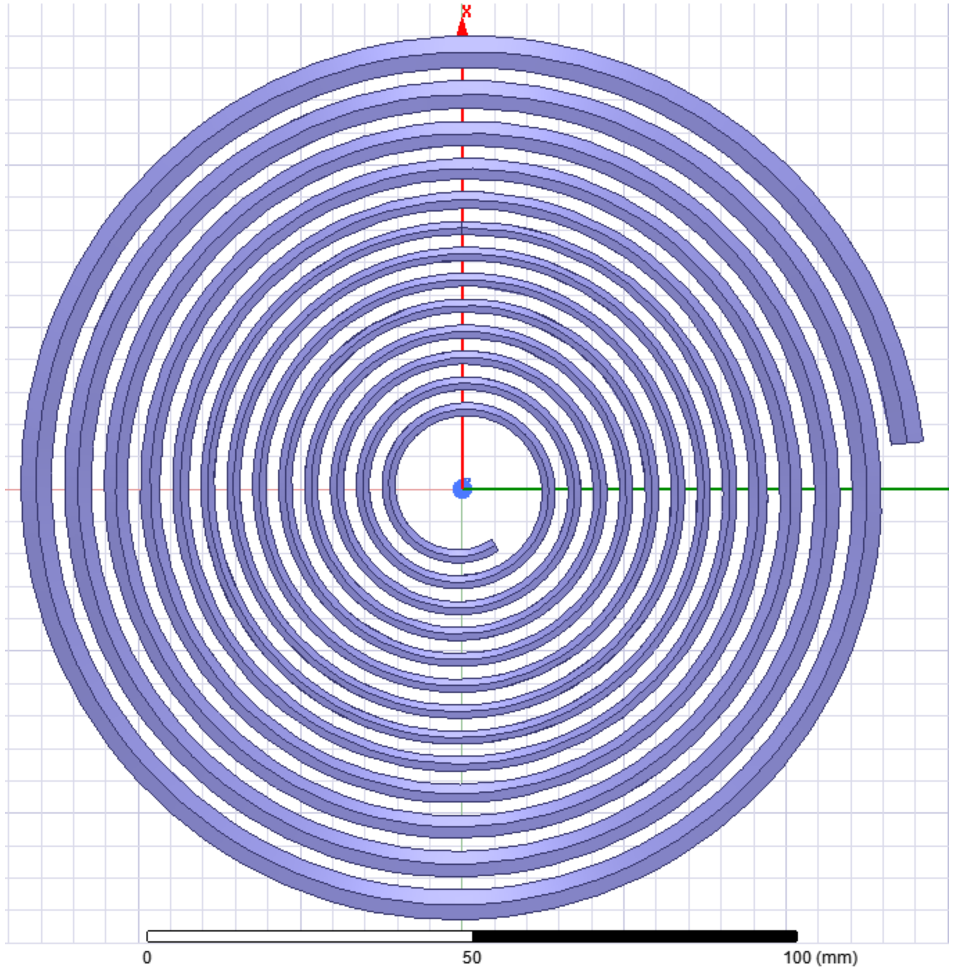


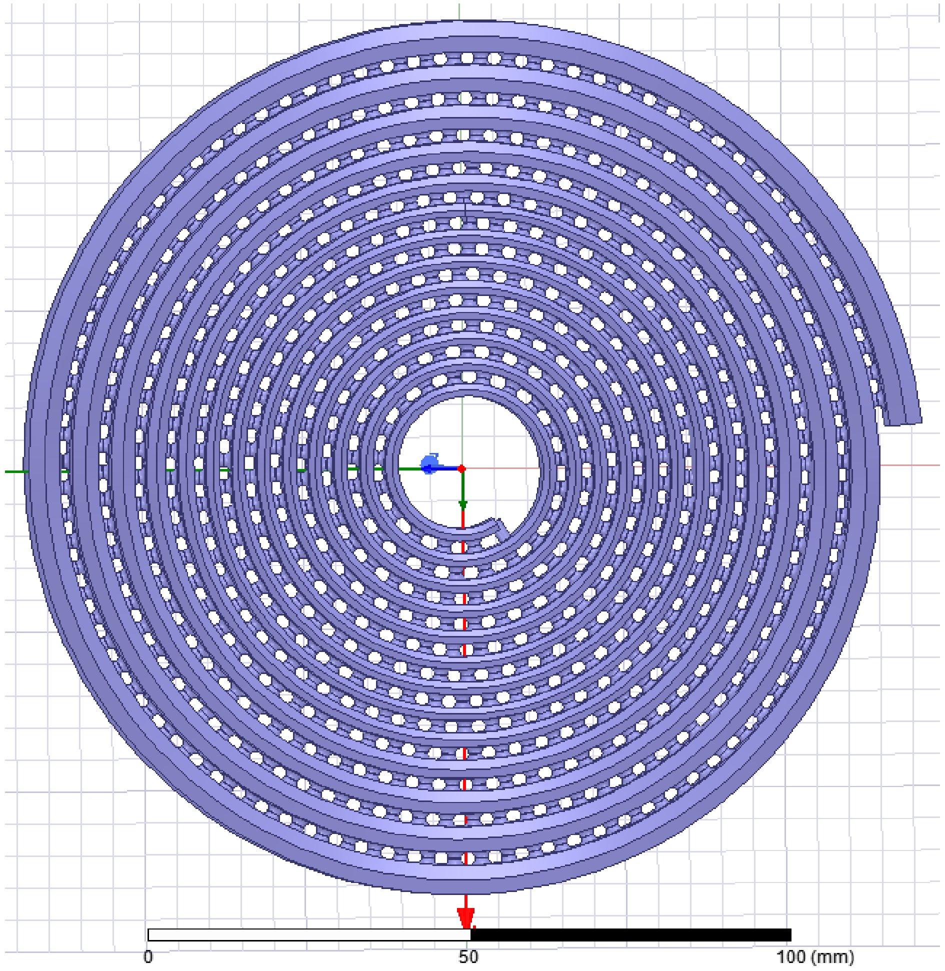
Same straight design parameter dimensions were used on spiral model.


Spiral vs Straight Model (S11)
Curve Info
Spiral Model Imported
Straight Model Imported
S11 (dB)
-12.50
-25.00
-37.50
-50.00
-62.50
11.00
11.25
11.50
11.75
12.00
12.25
12.50
12.75
13.00
Freq [GHz]
-35.36
-38.12
-35.20
-45.66
11.42
0.57
11.99

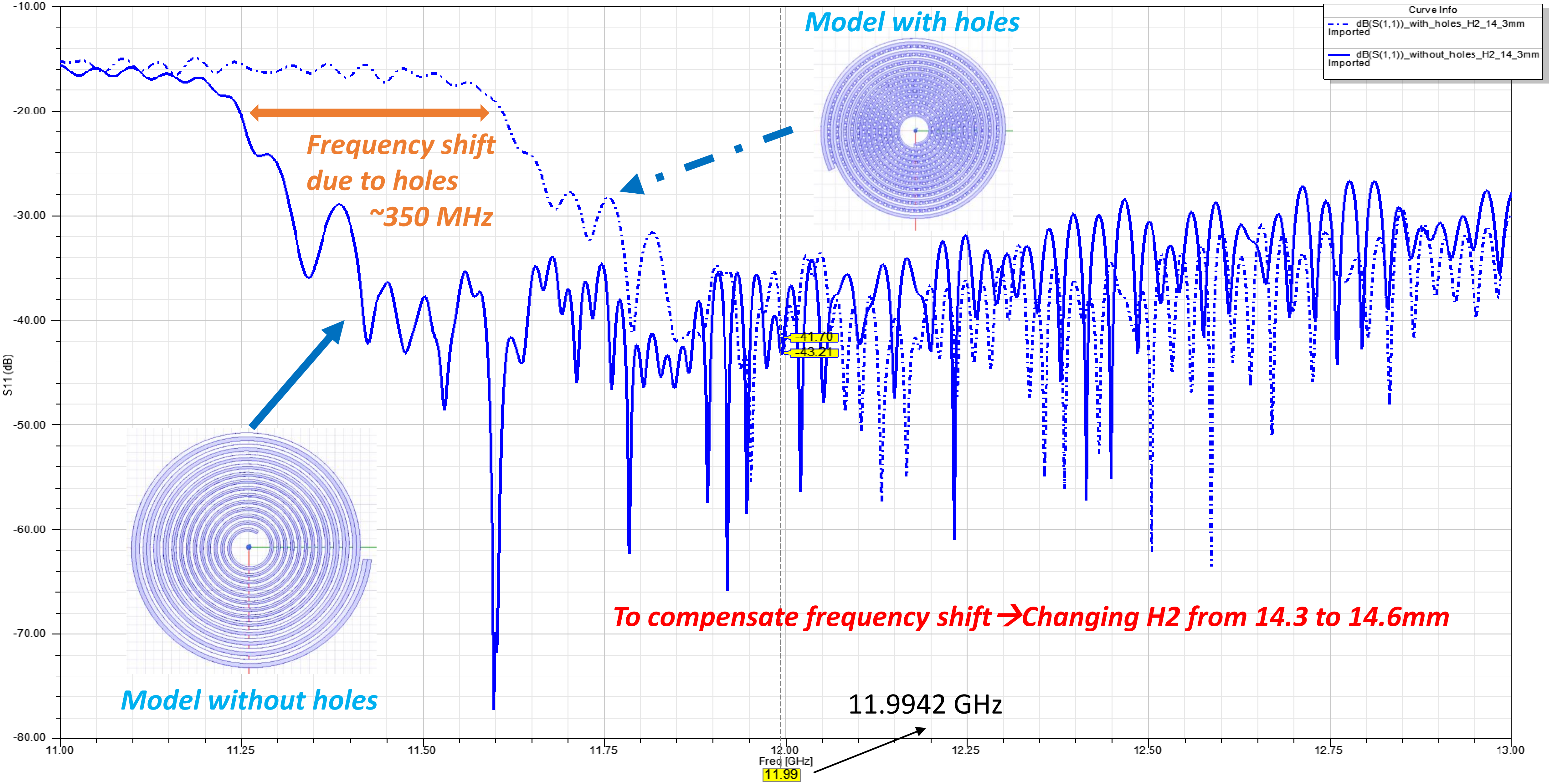
Spiral Model with Vacuum Holes

vacuum holes with 2mm diameter

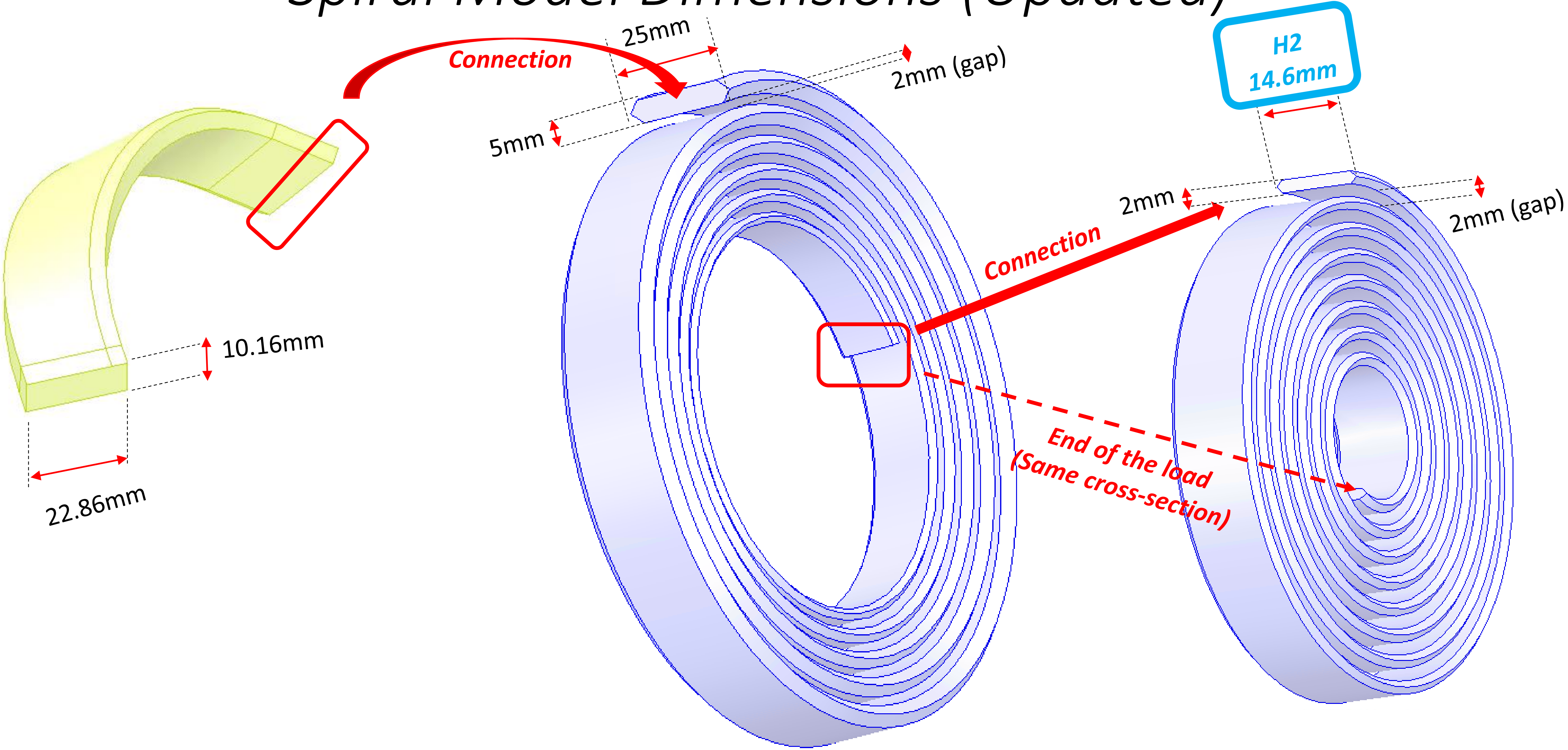




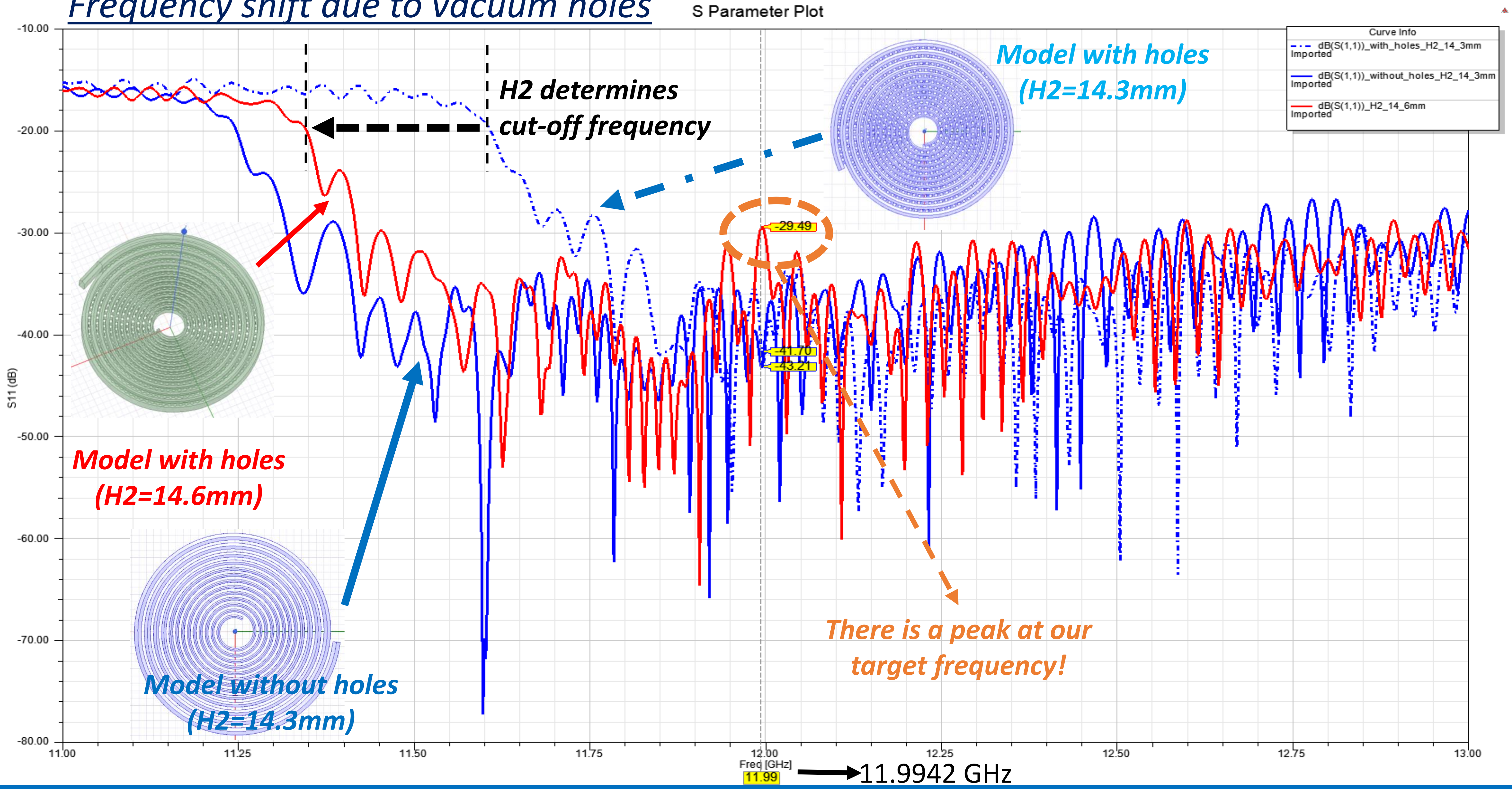
Frequency shift due to vacuum holes



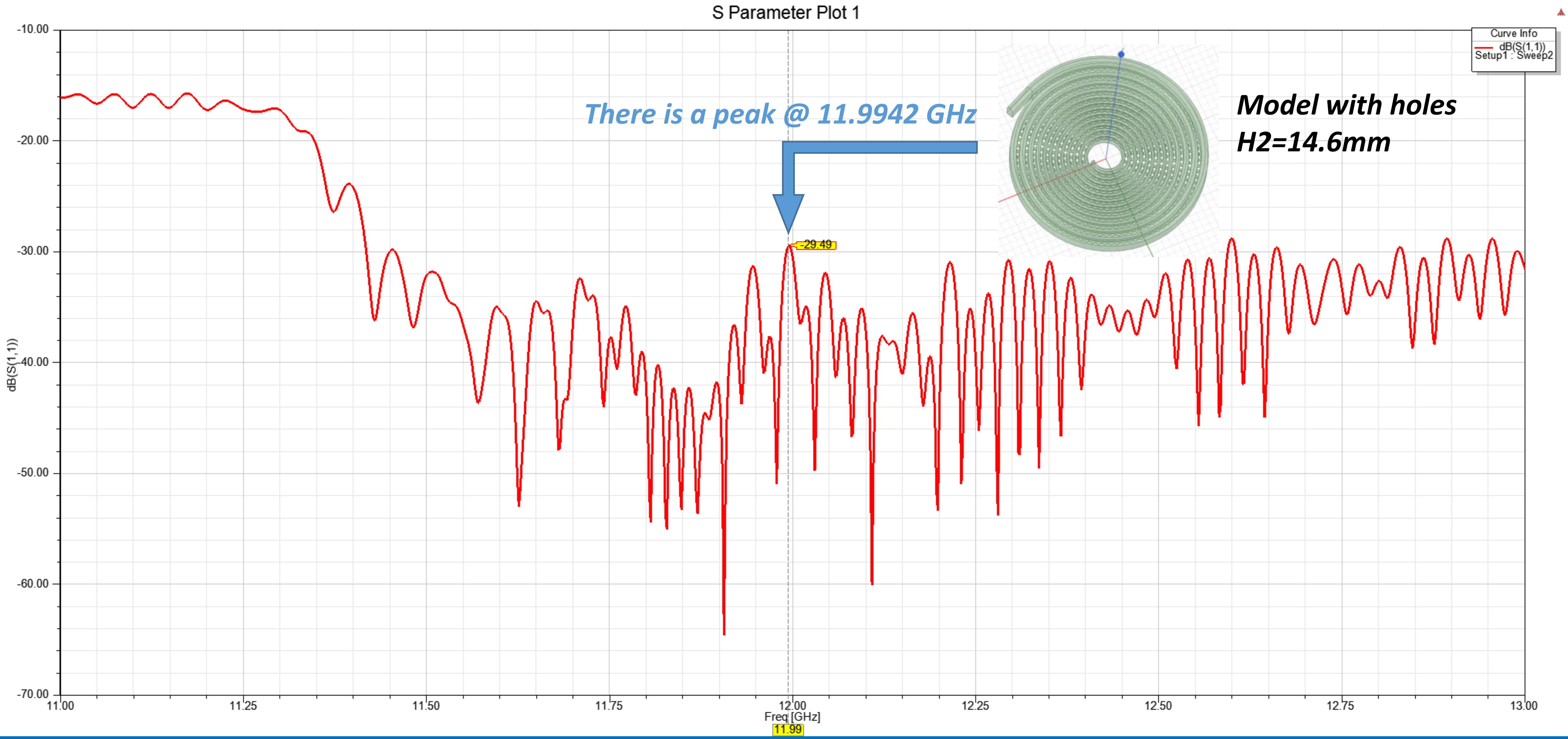
Spiral Model Dimensions (Updated)



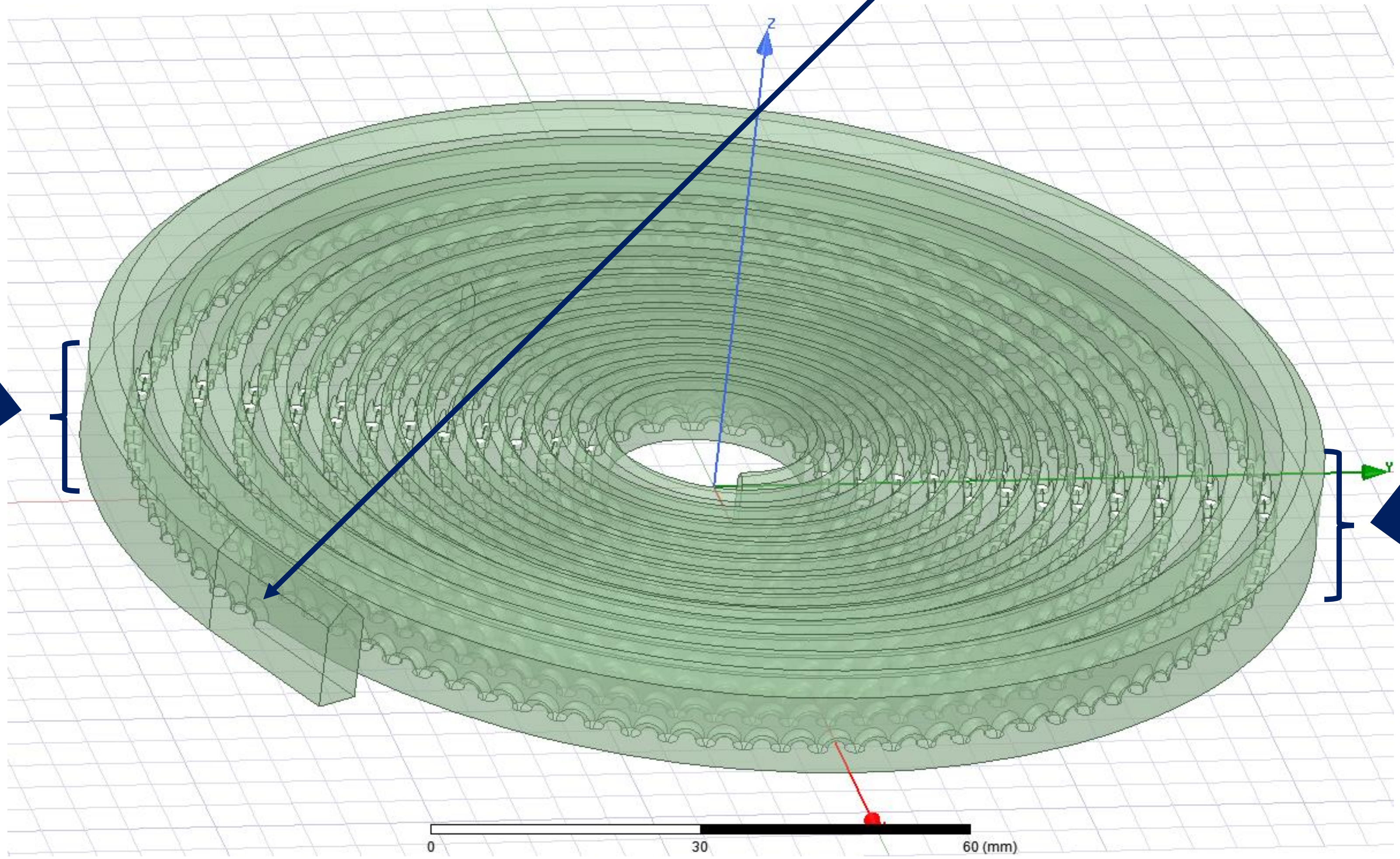
Frequency shift due to vacuum holes



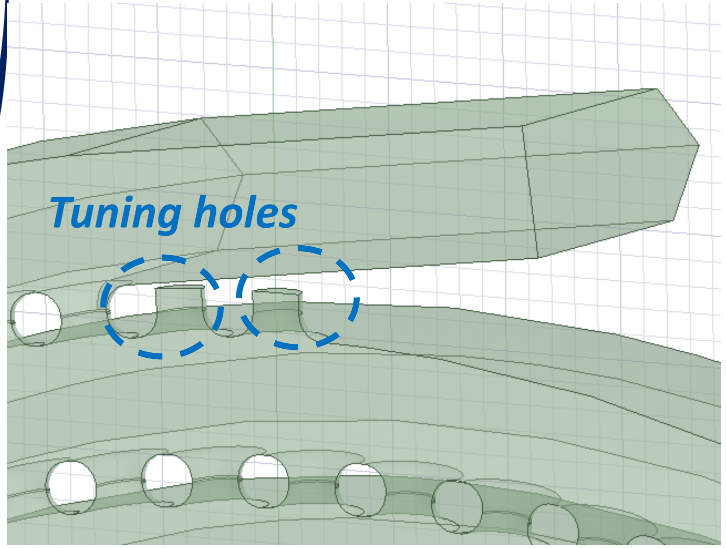
Reflection Improvement on HFSS



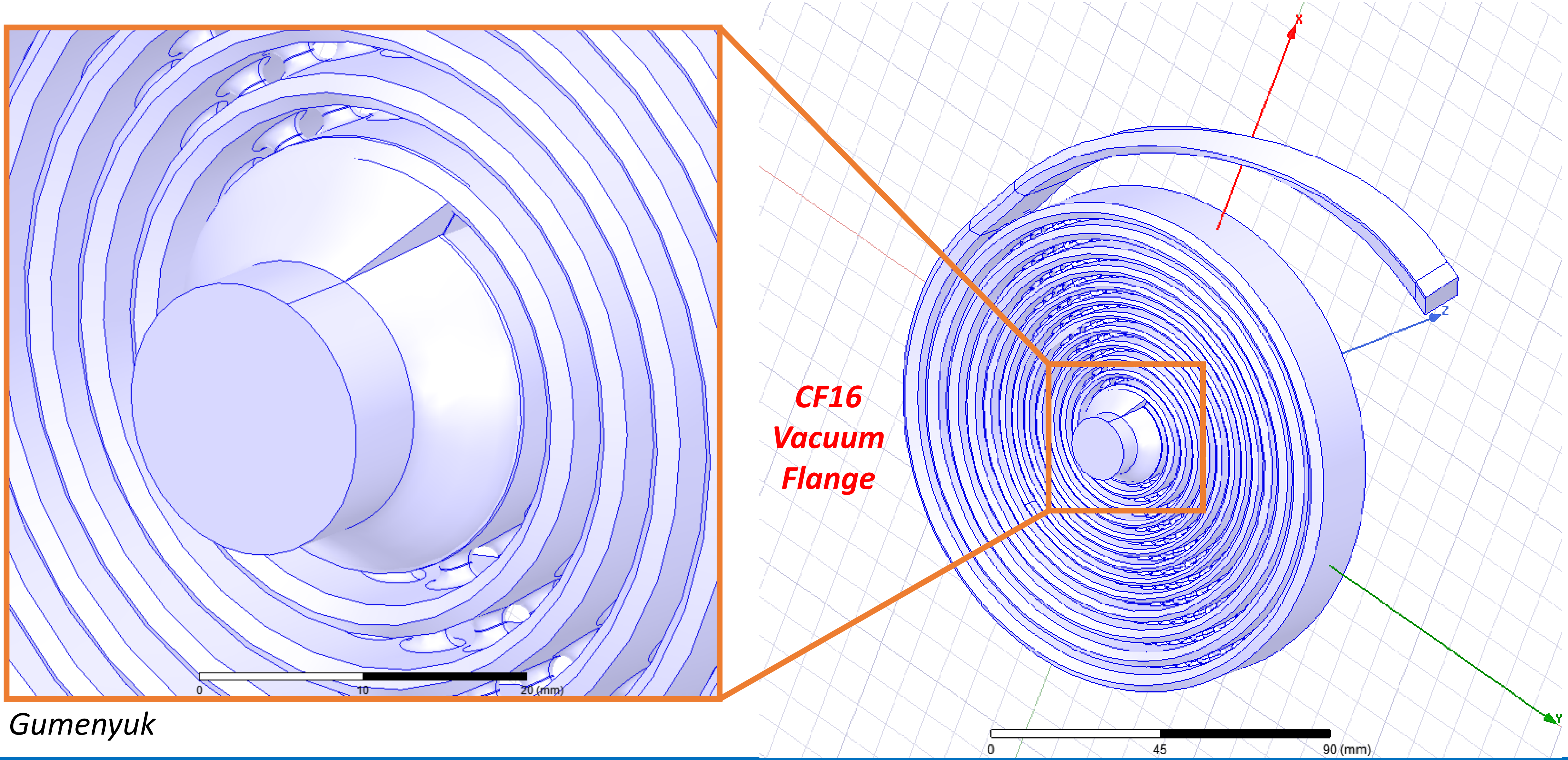
Inner waveguide of model has vacuum holes both sides.
Outer face of model has vacuum holes only one side, this causes reflection cumulation at the last hole (under transition part).



To overcome this; we have added different number of tuning holes to see how reflection changes.

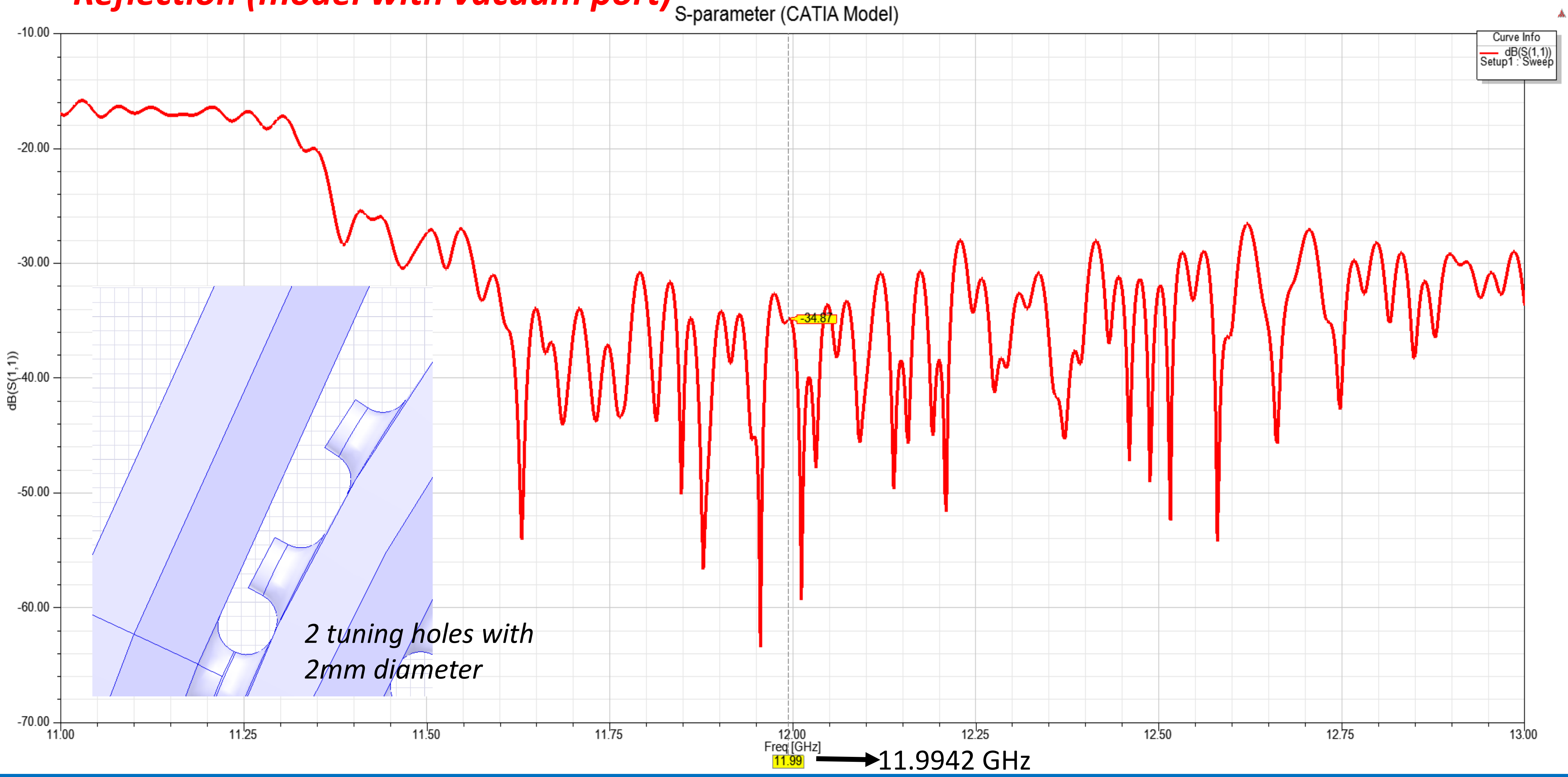


Spiral Model with Pumping Port

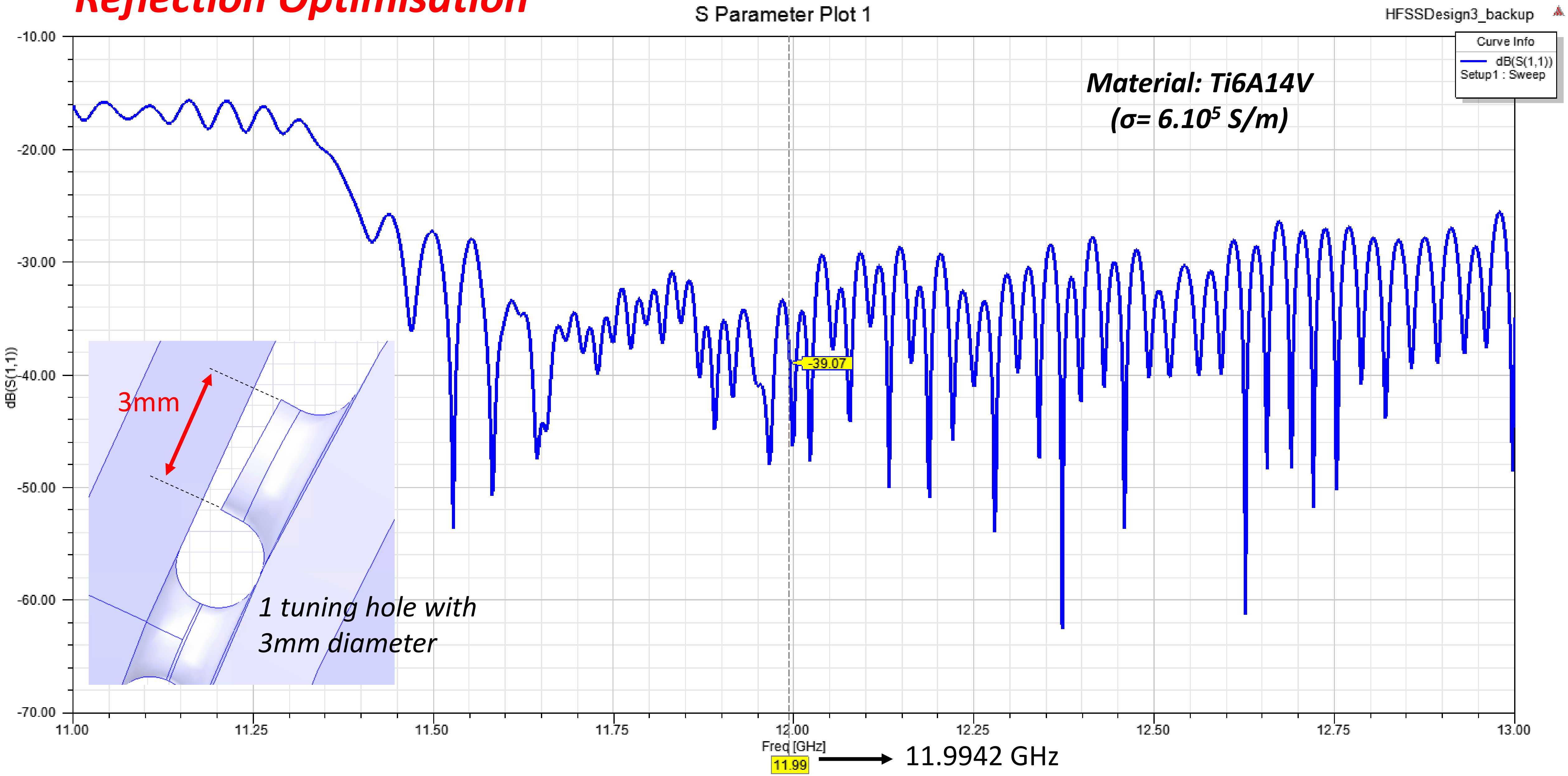


Oleg Gumenyuk

Reflection (model with vacuum port)

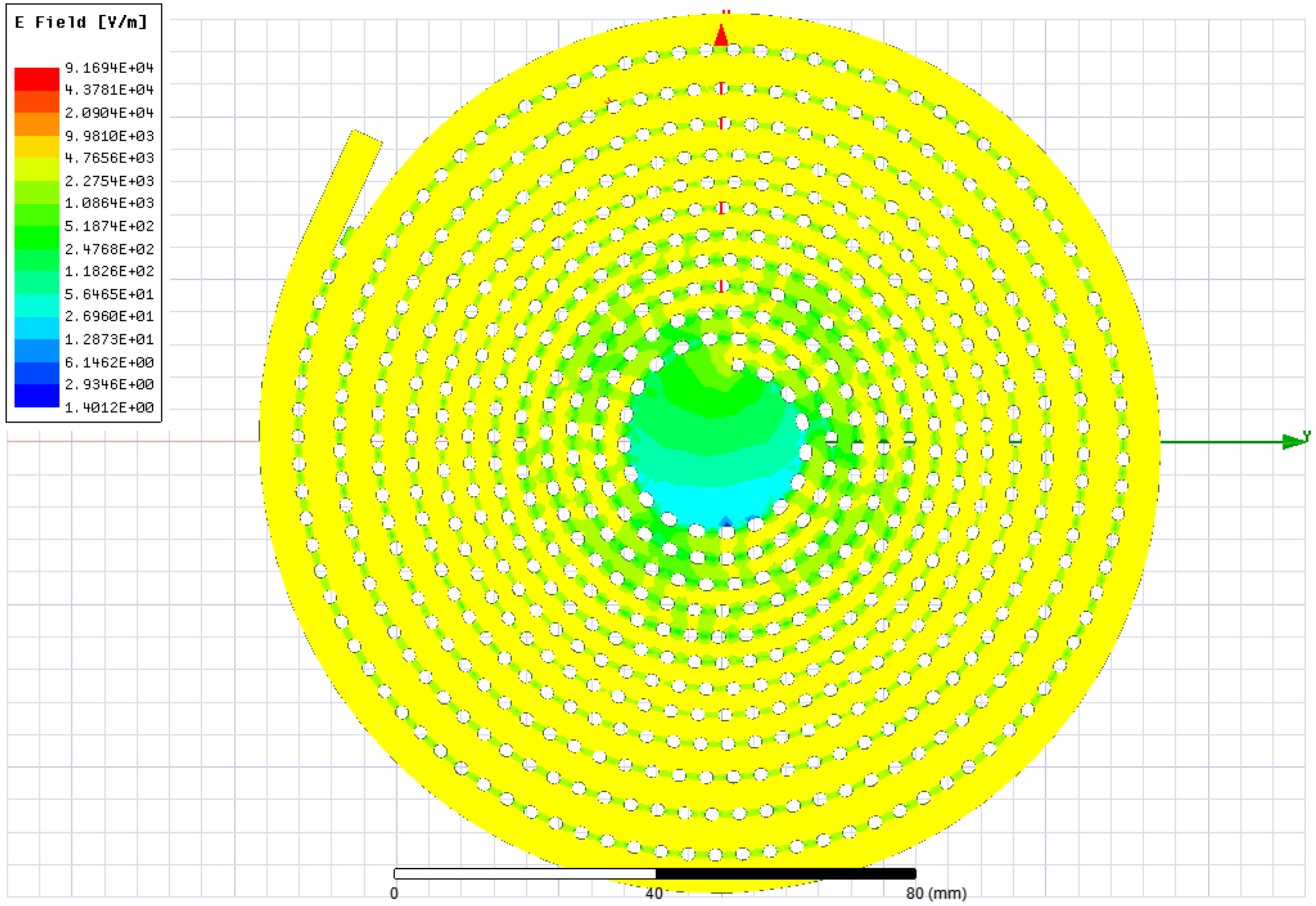


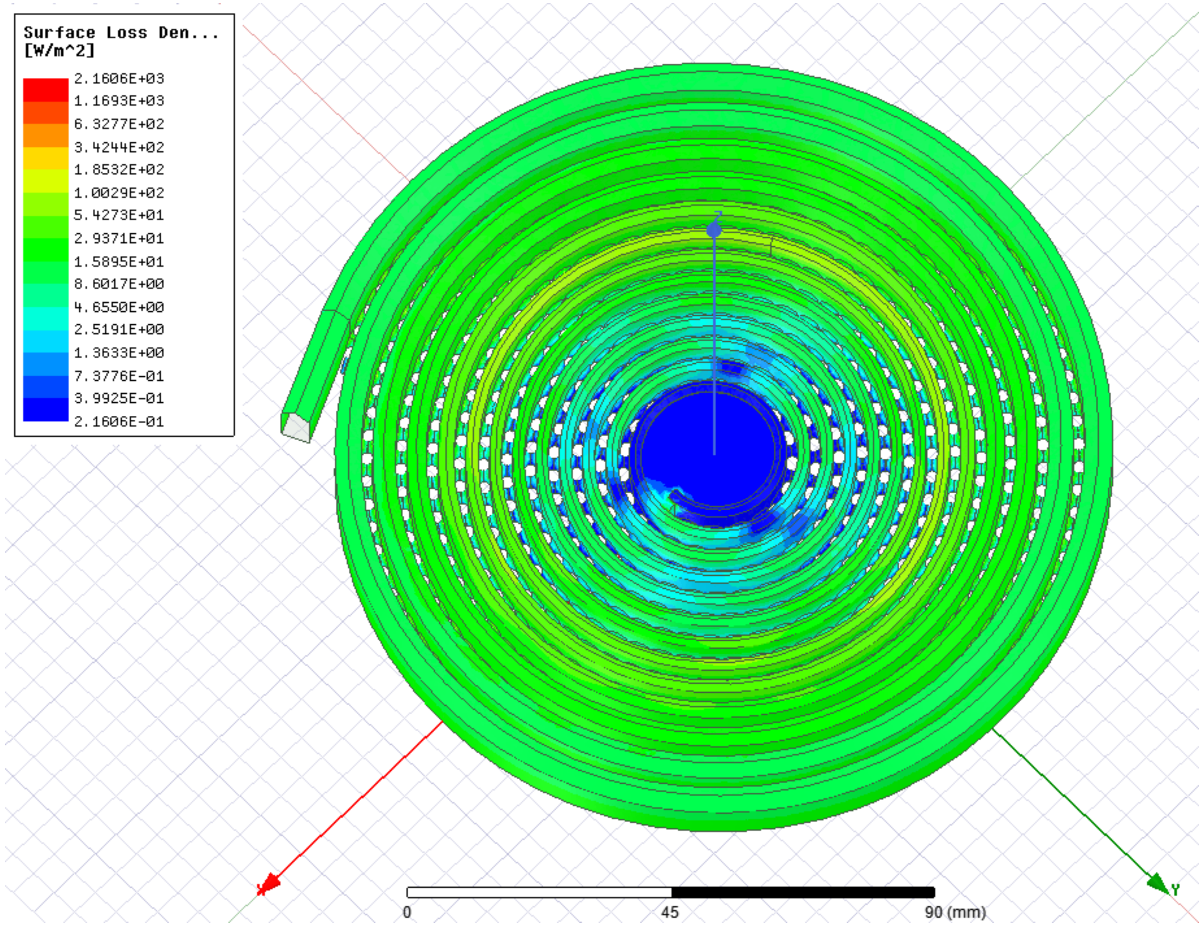
Reflection Optimisation



11.9942 GHz

Electric Field & Surface Loss Density @12GHz

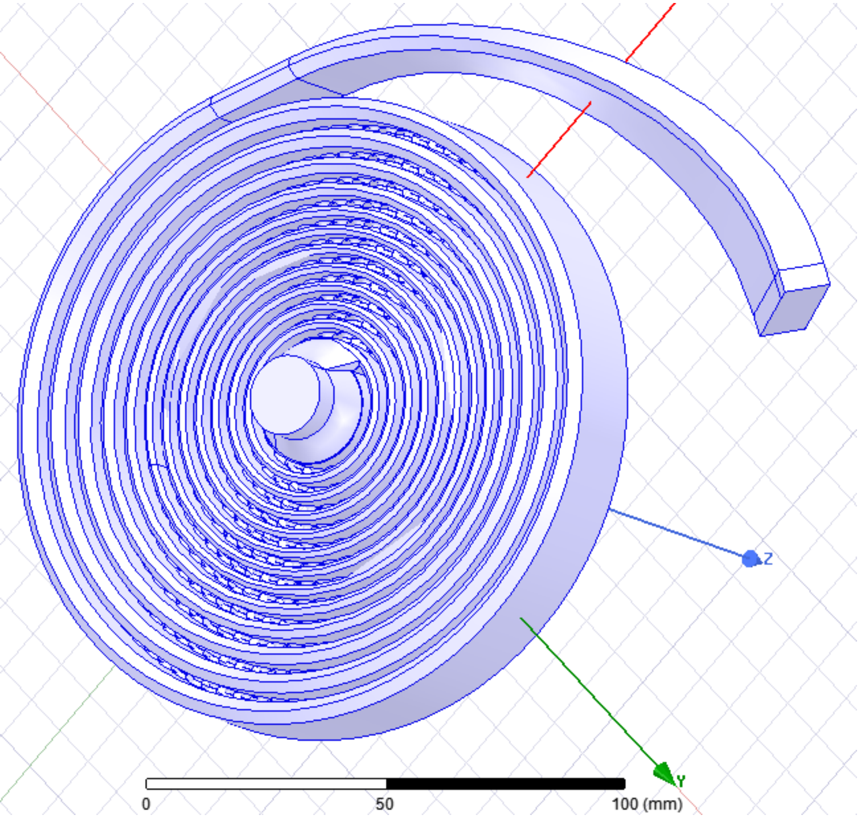




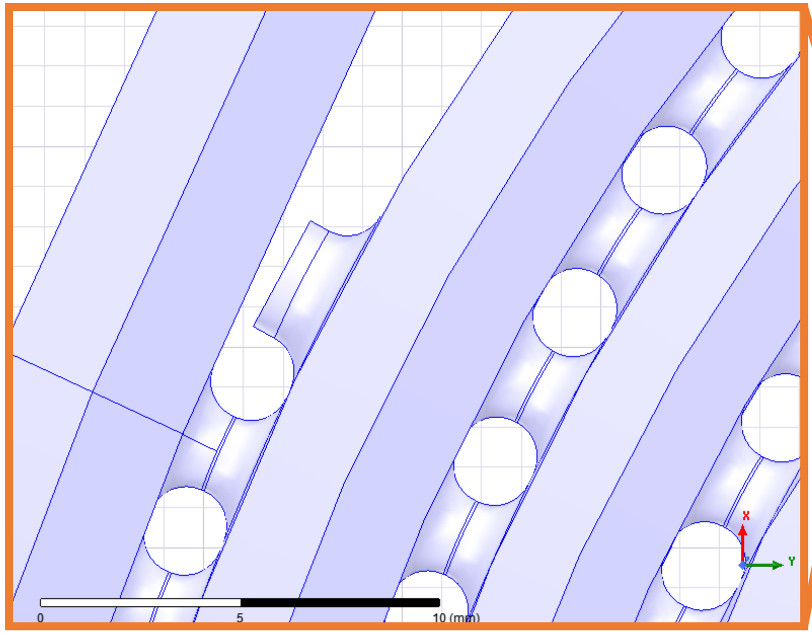
Input Power=1W

Final Model (in HFSS)

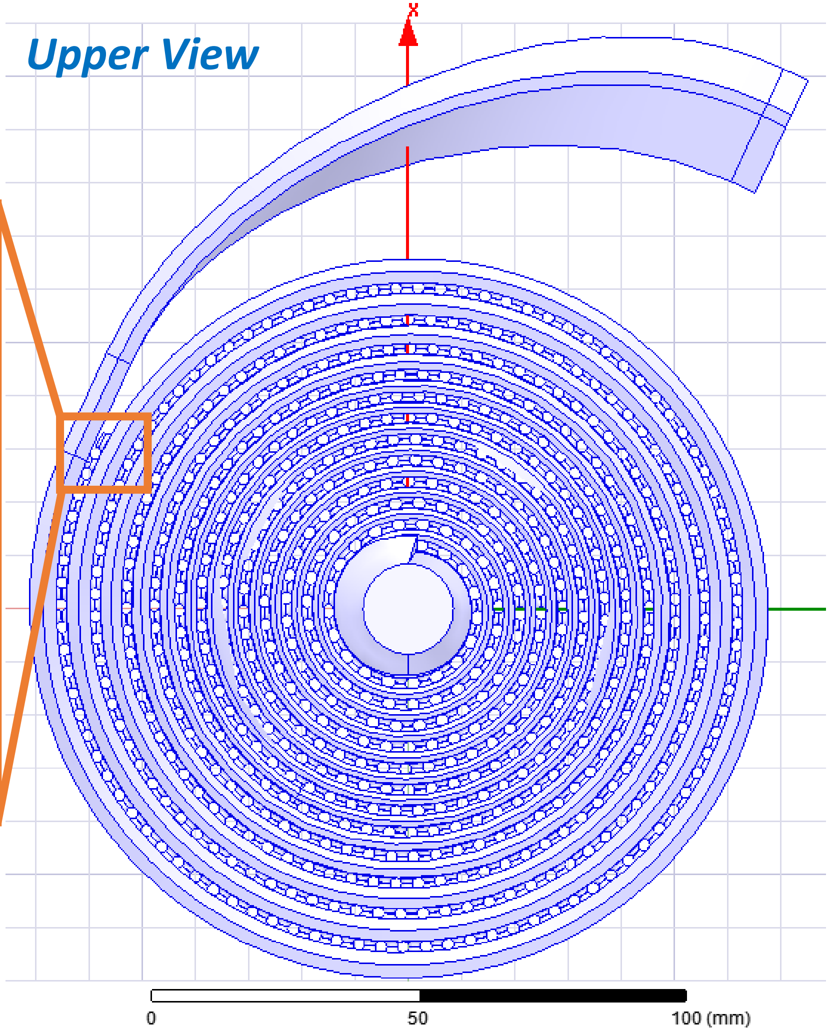
Side View



Tuning hole



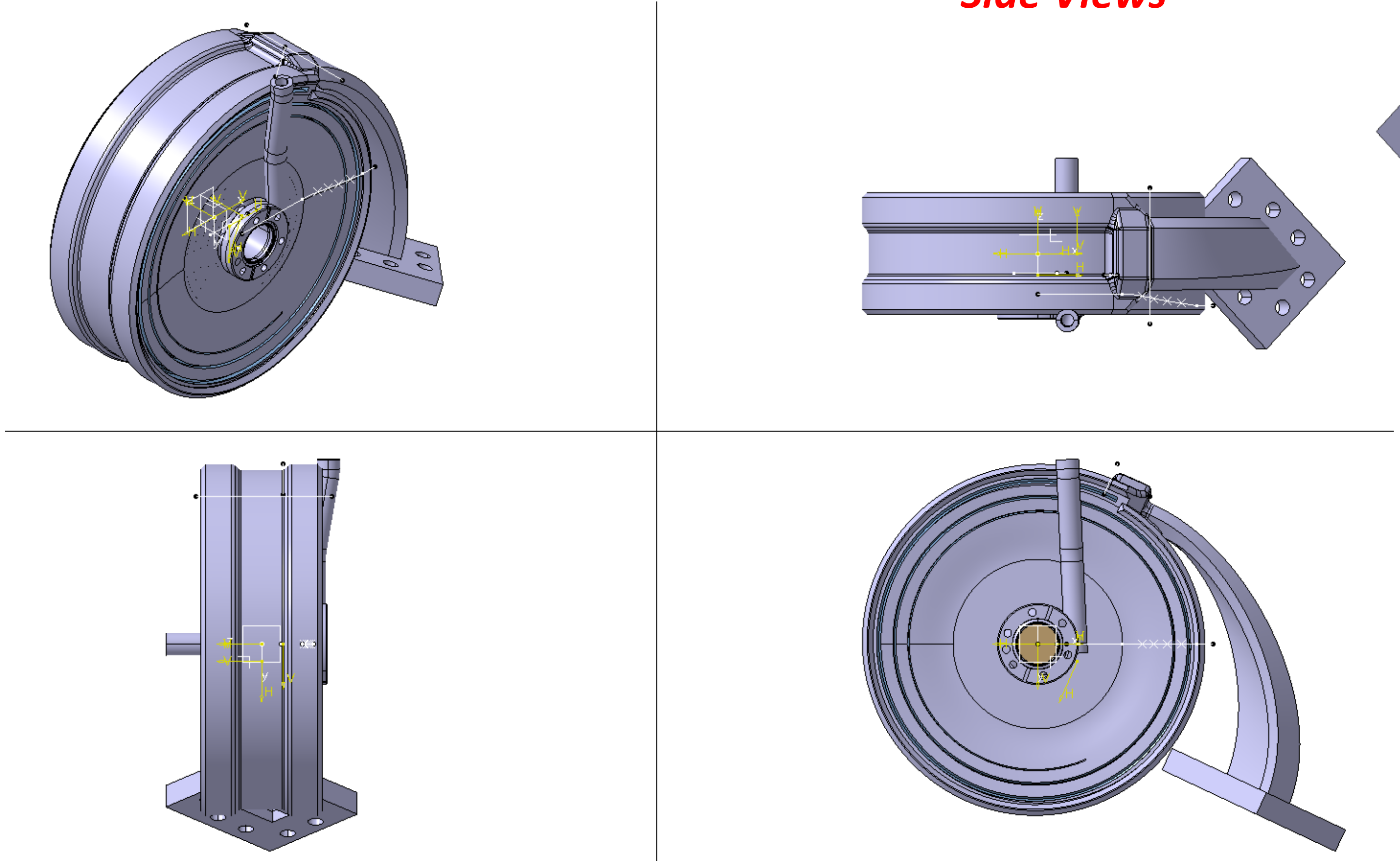
Upper View



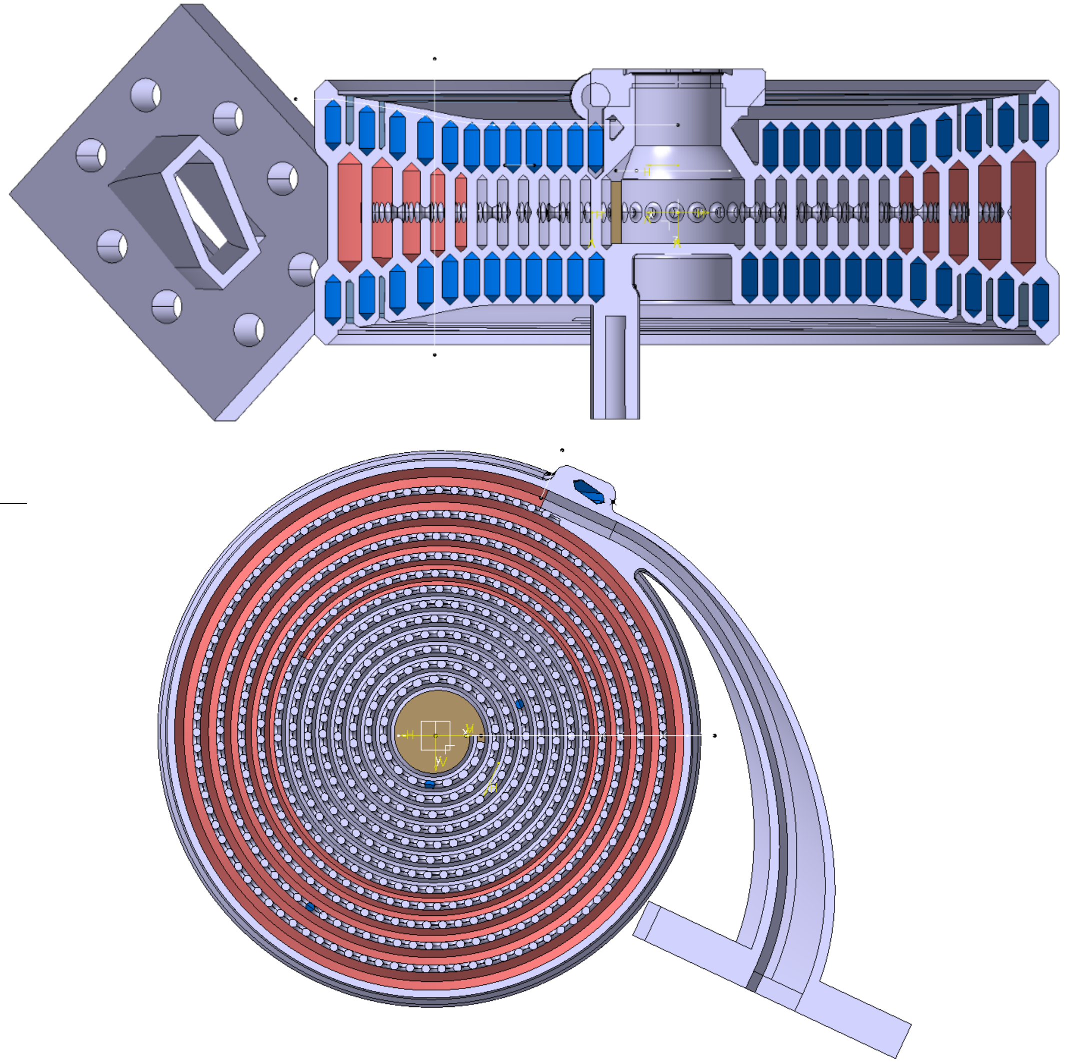
Mechanical Design by Oleg Gumenyuk

Final Model (in CATIA)

Side Views



Internal Views



Conclusion & Future Work

- RF Design of spiral load with new cross-section is ready!

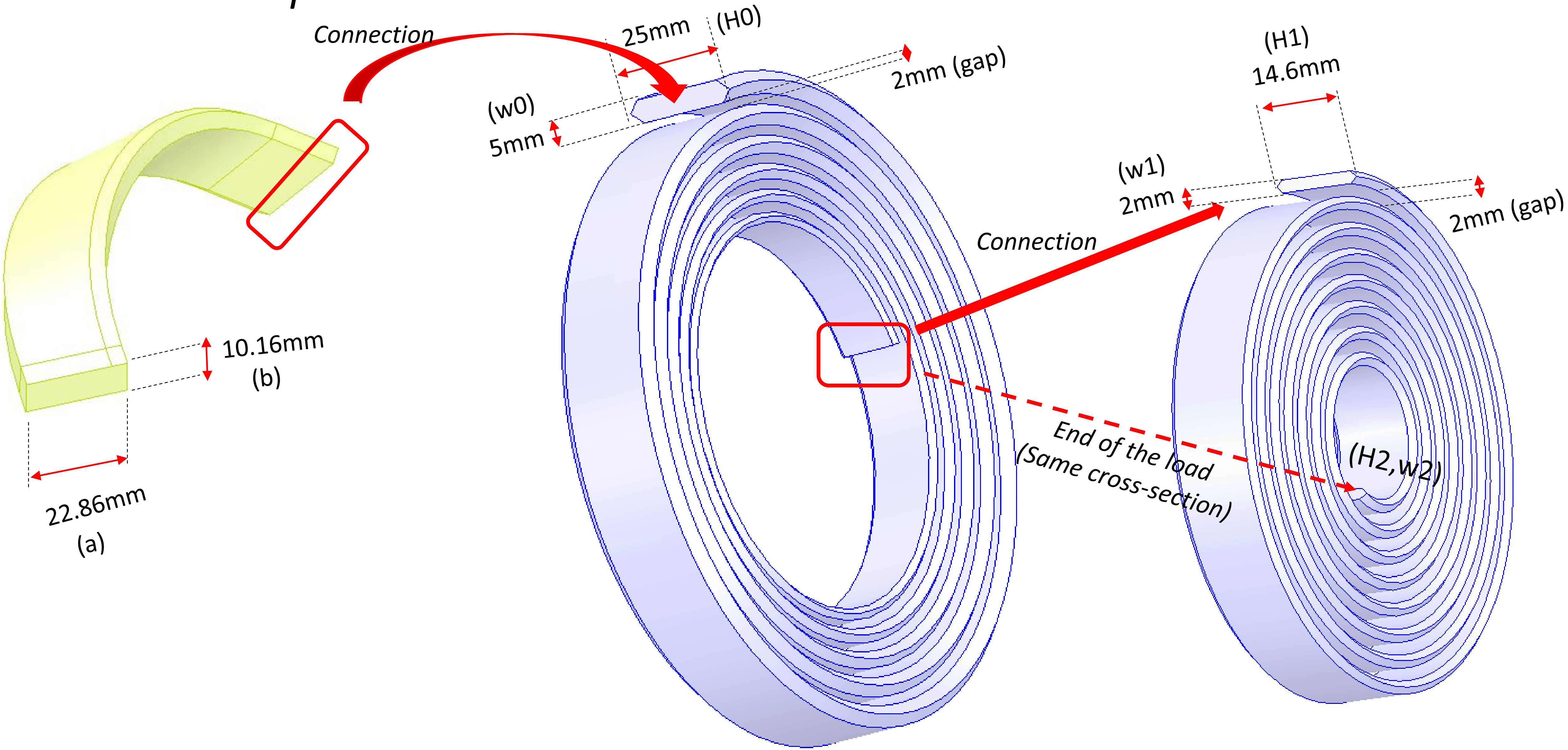
  (https://edms.cern.ch/document/2404437/1)
- Cooling Circuit Integration
- Mechanical Design (Ongoing by Pedro Morales Sanchez)
- Thermal Simulations
- Production by Additive Manufacturing
- RF Test

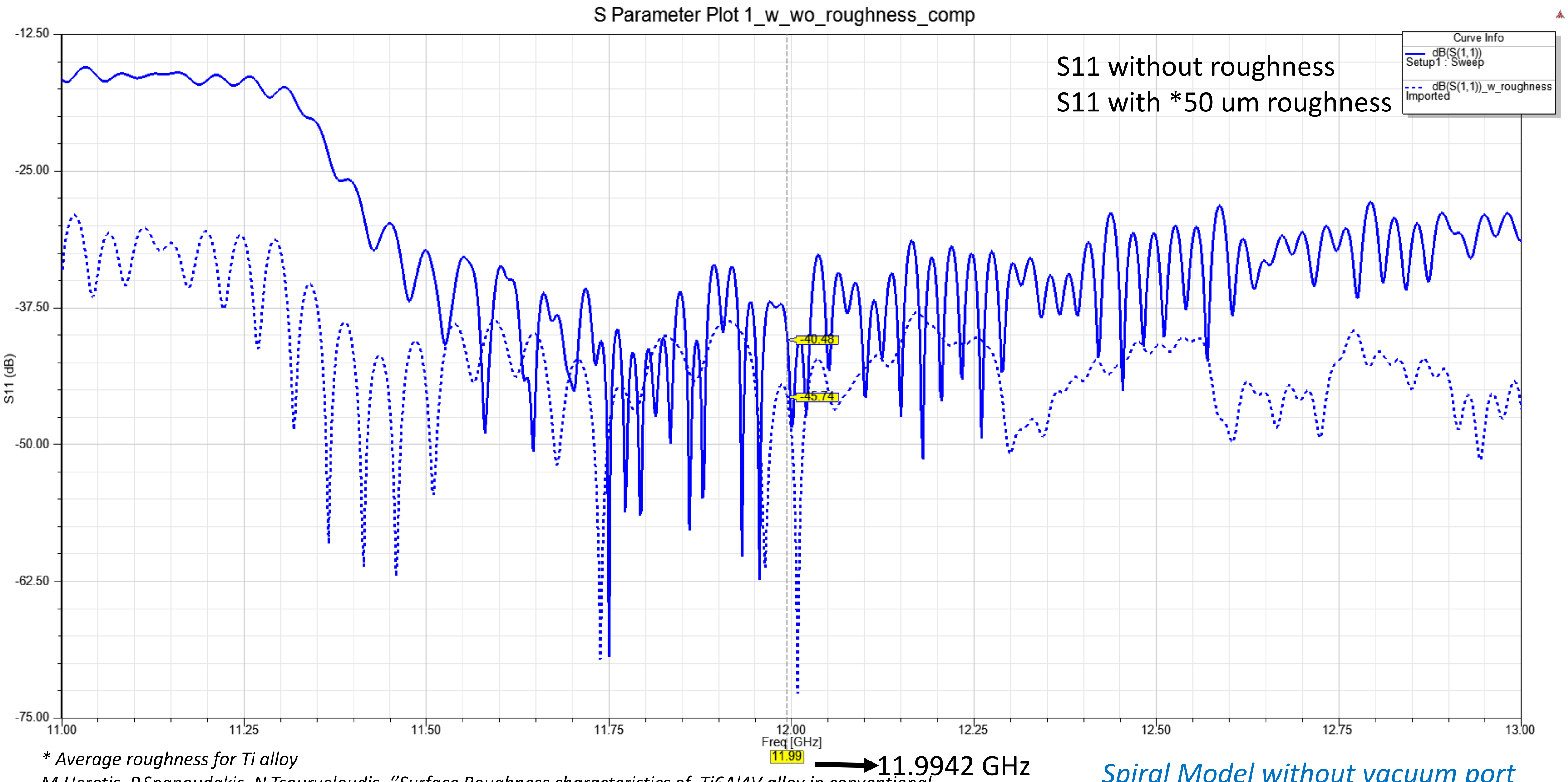
Thank you for your attention!

Special thanks to;
Nuria Catalan Lasheras, Benoit Riffaud, Oleg Gumenyuk,
Romain Gerard, Joel Sauza Bedolla, Pedro Morales Sanchez

Backup Slides

Spiral Model Dimensions-Final Version





** Average roughness for Ti alloy*

M.Heretis, P.Spanoudakis, N.Tsourveloudis, ''Surface Roughness characteristics of Ti6Al4V alloy in conventional lathe and mill machining'', Technical University of Crete, p.5 2009

Spiral Model without vacuum port