COMSOL CONFERENCE 2016 BOSTON


*Integrity ★ Service ★ Excellence*

# A Novel Type of Pattern Synthesis Implementation using Corrugated Apertures

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# Outline

- Previous Work
- Motivation
- Concepts
- Challenges
- Antenna Design
- Conclusions
- Future Work

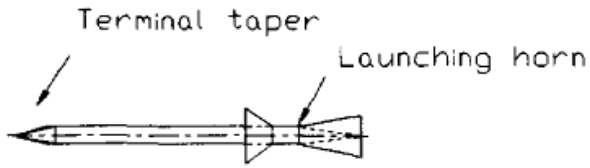
# Motivation

- Antenna Pattern synthesis implementations
  - Amplitude and Phase Synthesis
  - Shaped Apertures

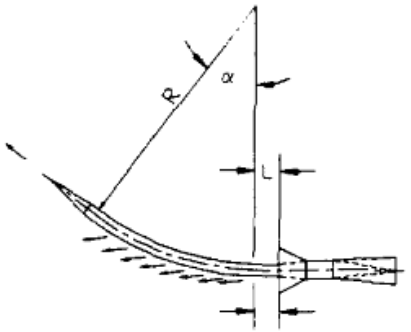
# Previous Work

**Naftali Herscovici - The Shaped-Beam Polyrod Antenna,**
***IEEE Antennas and Propagation Magazine.* Vol. 36, No.2. April,1994, pp.55-57.**
**Antenna Designer's Notebook**

| $R$ (in) | $L$ (in) | $\alpha$(°) | Tip Angle (°) | Squint (°) |
|---|---|---|---|---|
| 5.5 | 0.5 | 30 | 20.5 | 8 |




TOP VIEW




SIDE VIEW

# Previous Work

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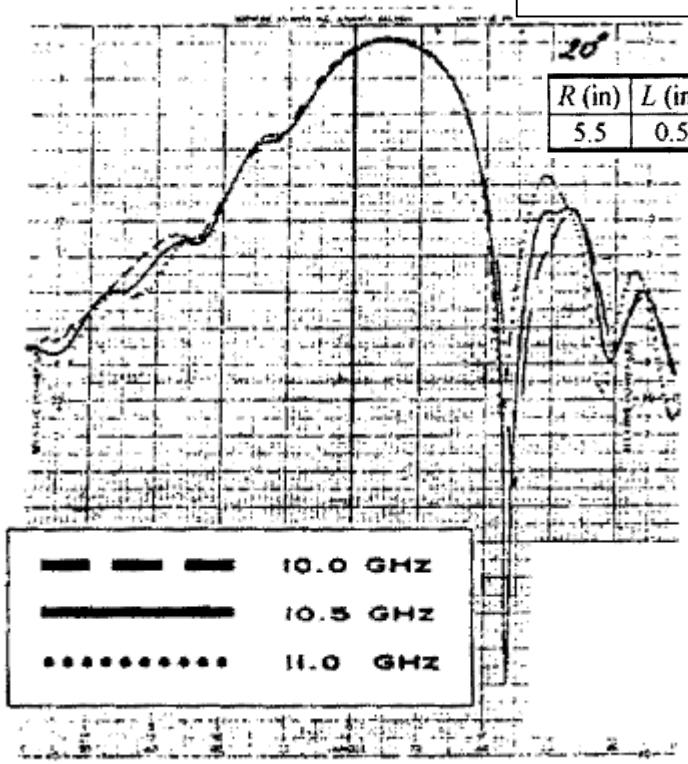
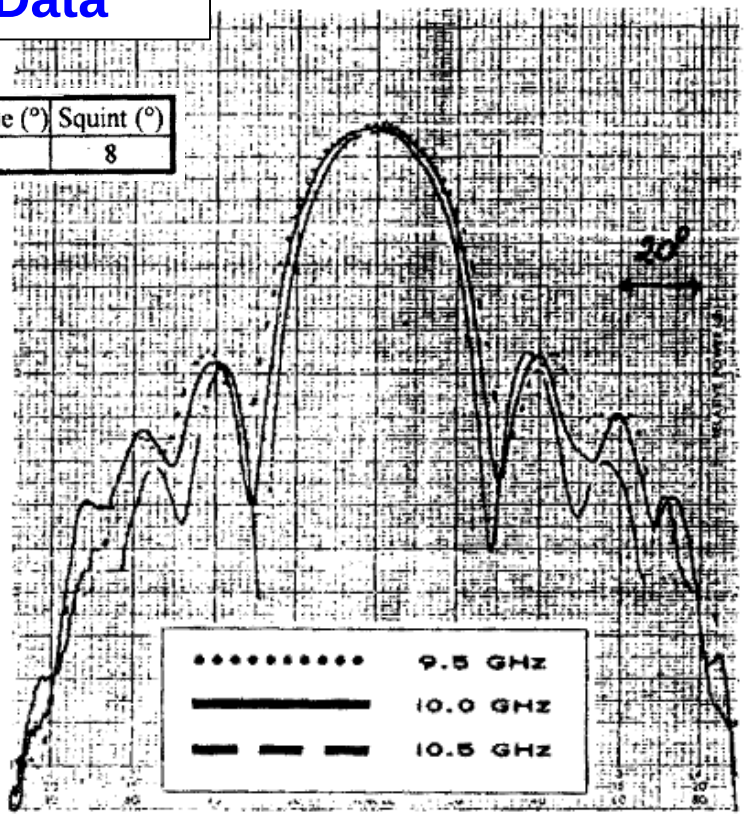
**Antenna Designer's Notebook**

## Measured Data

| *R* (in) | *L* (in) | $\alpha$(°) | Tip Angle (°) | Squint (°) |
|---|---|---|---|---|
| 5.5 | 0.5 | 30 | 20.5 | 8 |



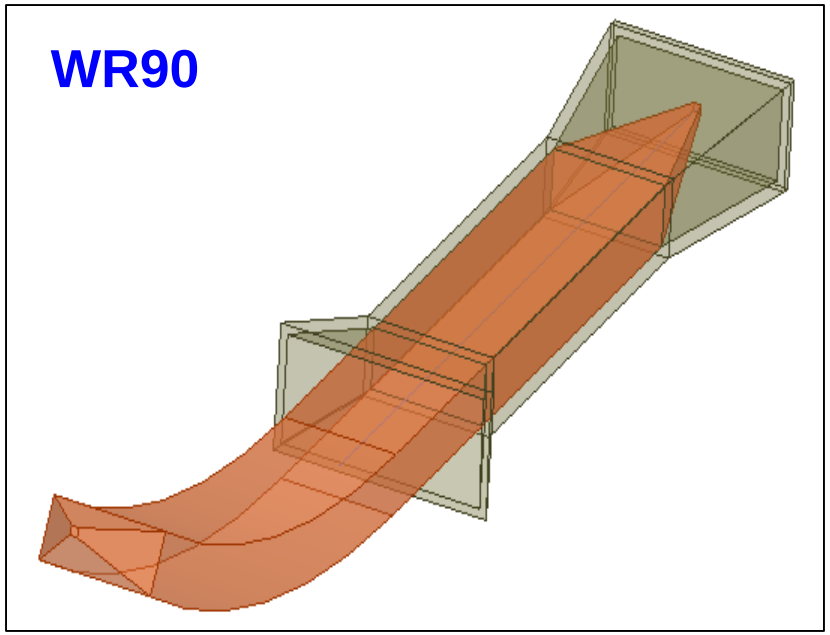

**Elevation Patterns**



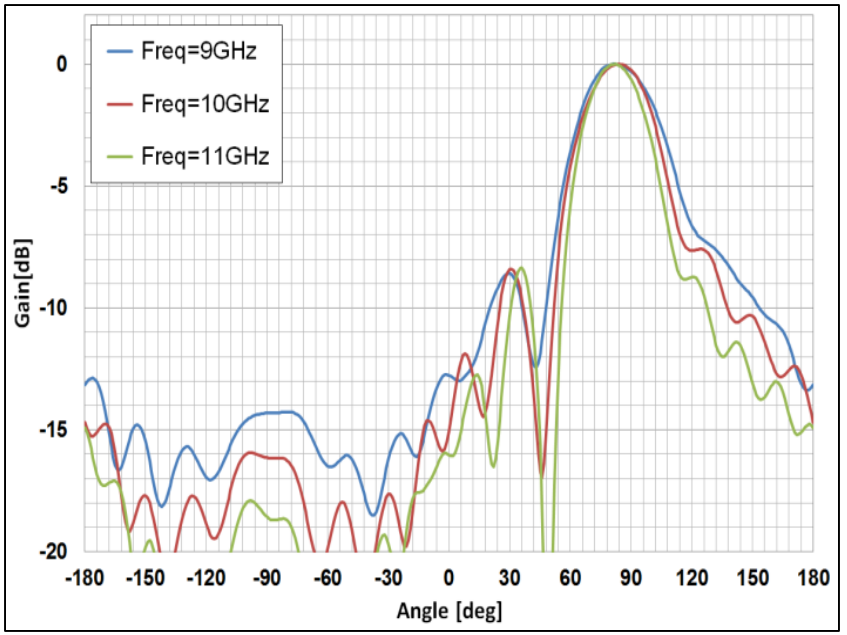

**Azimuth Patterns**

# The Dielectric Rod Cosecant Antenna

## Validation of the Empirical Design



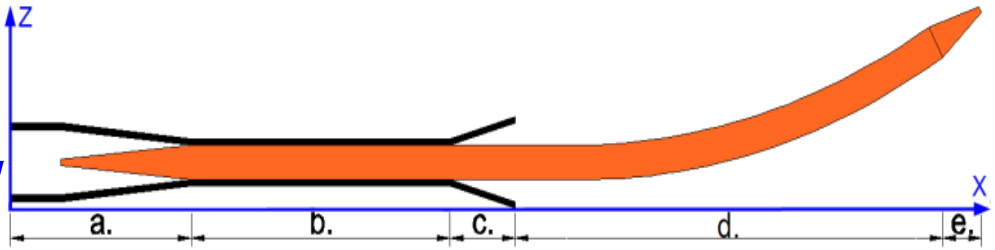

HFSS Model




Elevation Radiation Patterns

# Antenna 2D Profile Definition

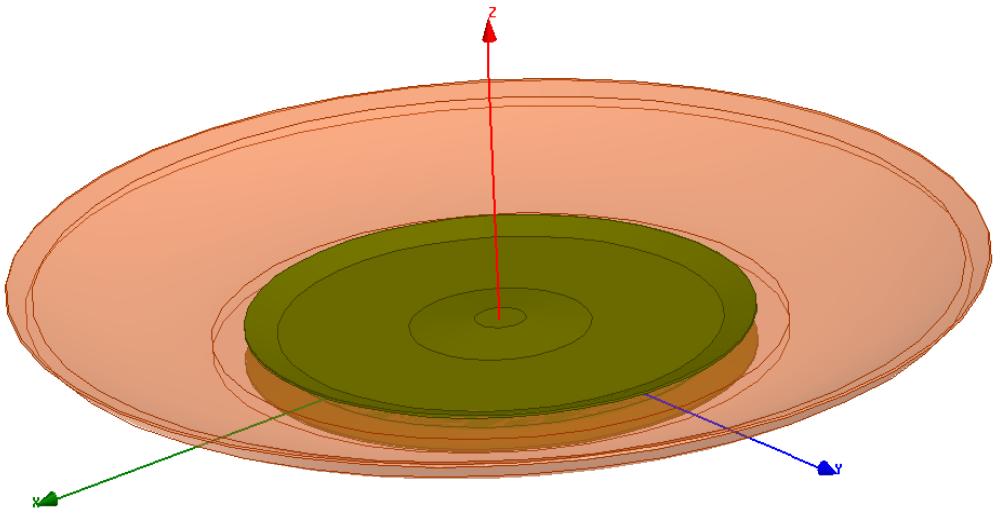
## 2D Profile View




**Major functional parts:**

a. feeding section
b. parallel plate waveguide section
c. launching section
d. shaped Polyrod Antenna
e. matching tip

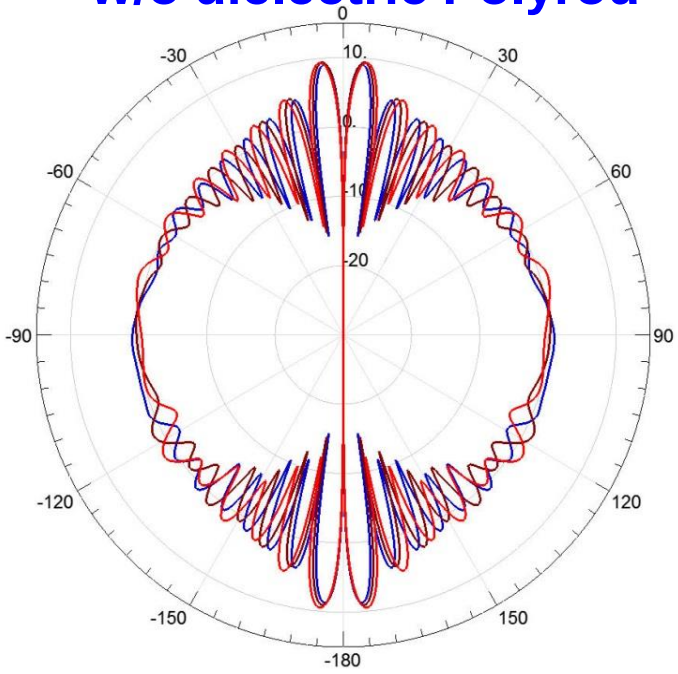
## 3D View



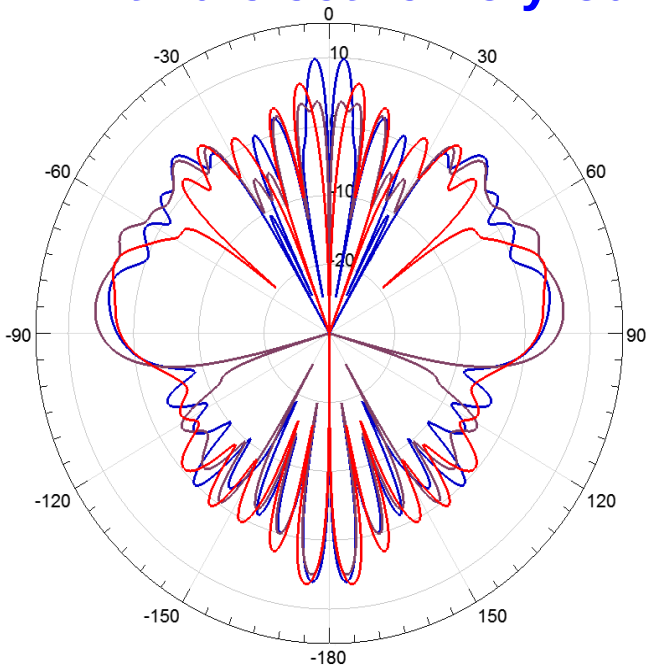
# FEM Analysis
# Radiation Pattern Shapes

## Frequencies: 9.5 , 10.0 and 10.5 GHz

**w/o dielectric Polyrod**




**With dielectric Polyrod**




## Challenges

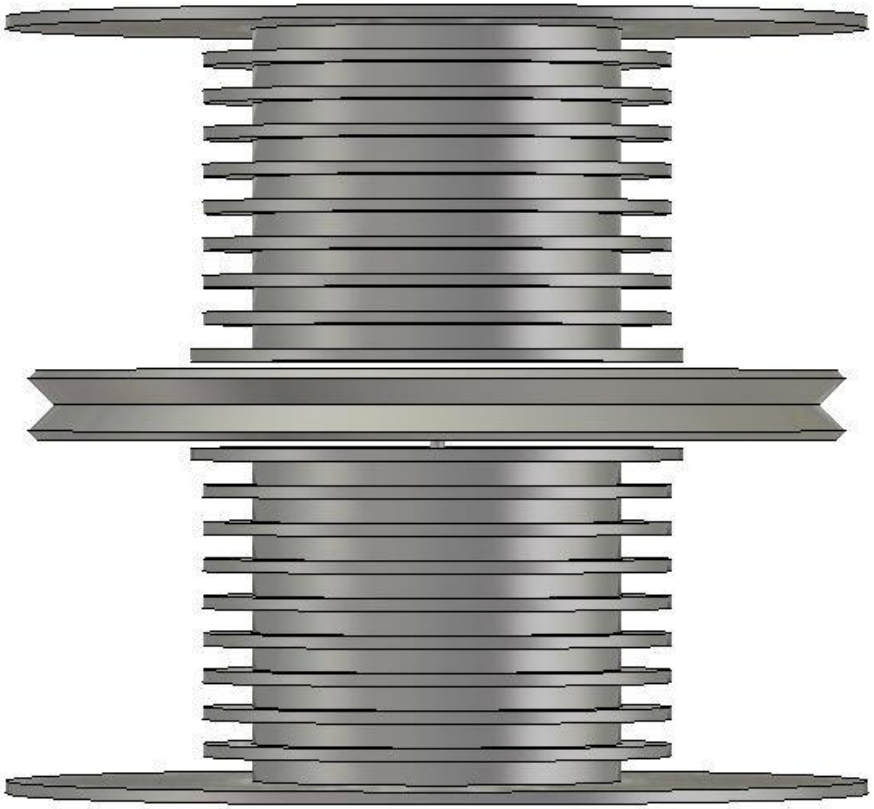
- Beam approaches cosecant shape, but requires more systematic work to approach the cosecant square shape.
- Sidelobes near the axis of symmetry ($\vartheta=0^{O}$ & $\vartheta=180^{O}$) are too high.

# Optimization Challenges

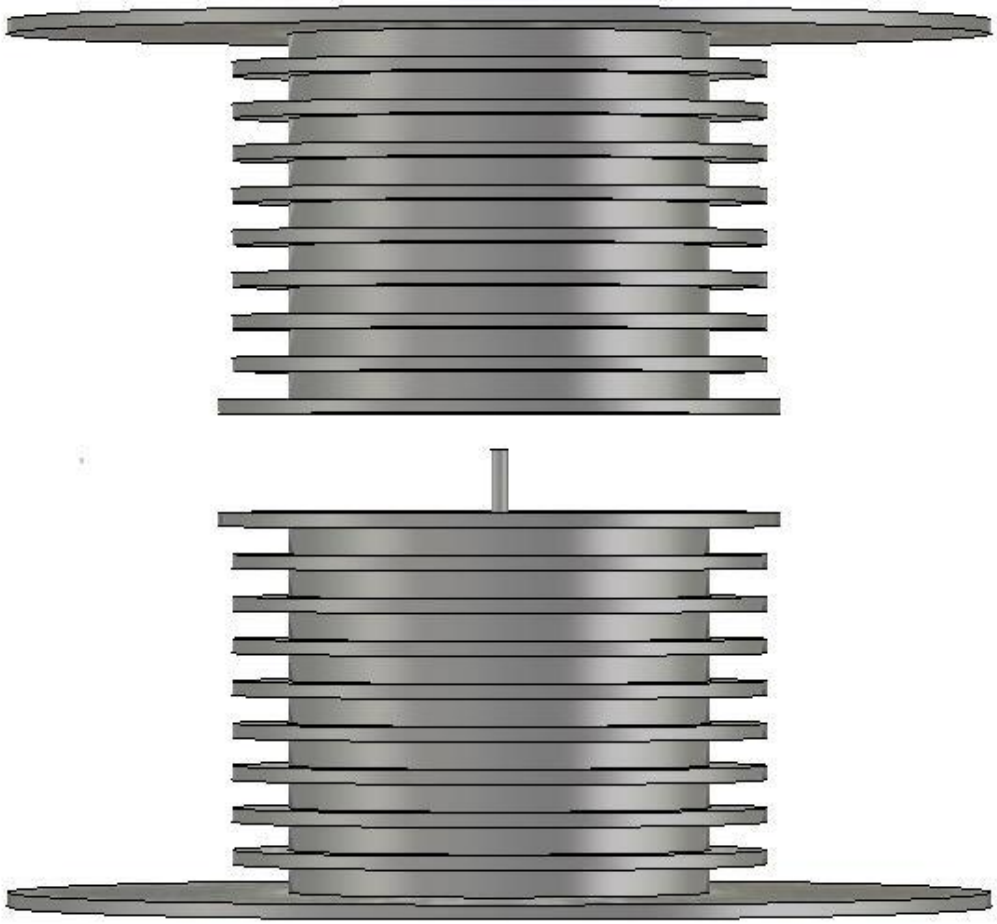
- Many design parameters
- Assess and prioritize various parameter impacts
- Implementation limitation
- Use discrete parameters for optimization
- Large Computational Volume

**Use Cylindrical Symmetry (BOR)**

# Case Study – Cylindrical Short Backfire Antenna



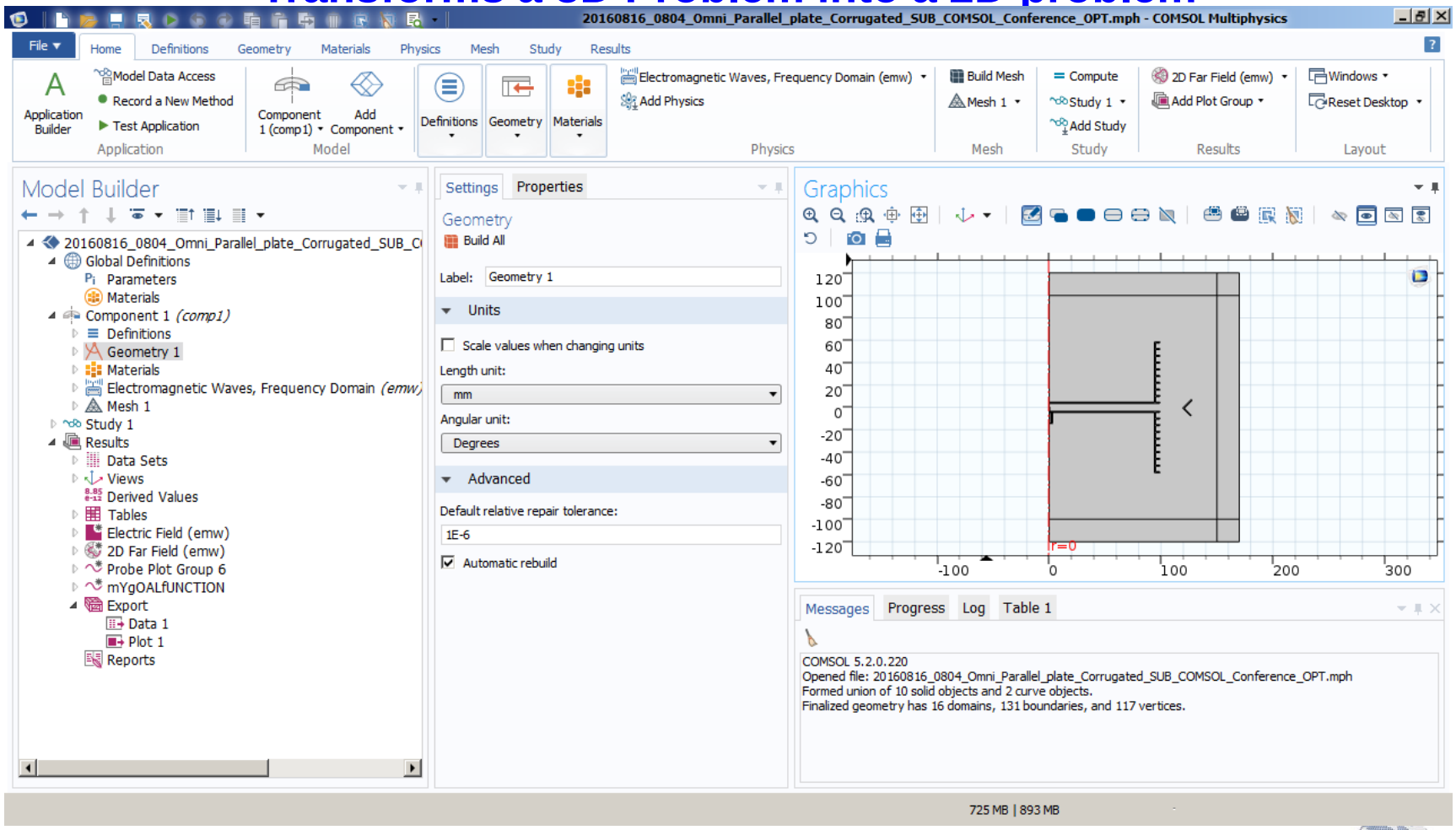
# Case Study – Cylindrical Short Backfire Antenna



# COMOSOL BOR MODULE

A&E PARTNERSHIP

## Body of Revolution Method (BOR )
## Transforms a 3D Problem into a 2D problem

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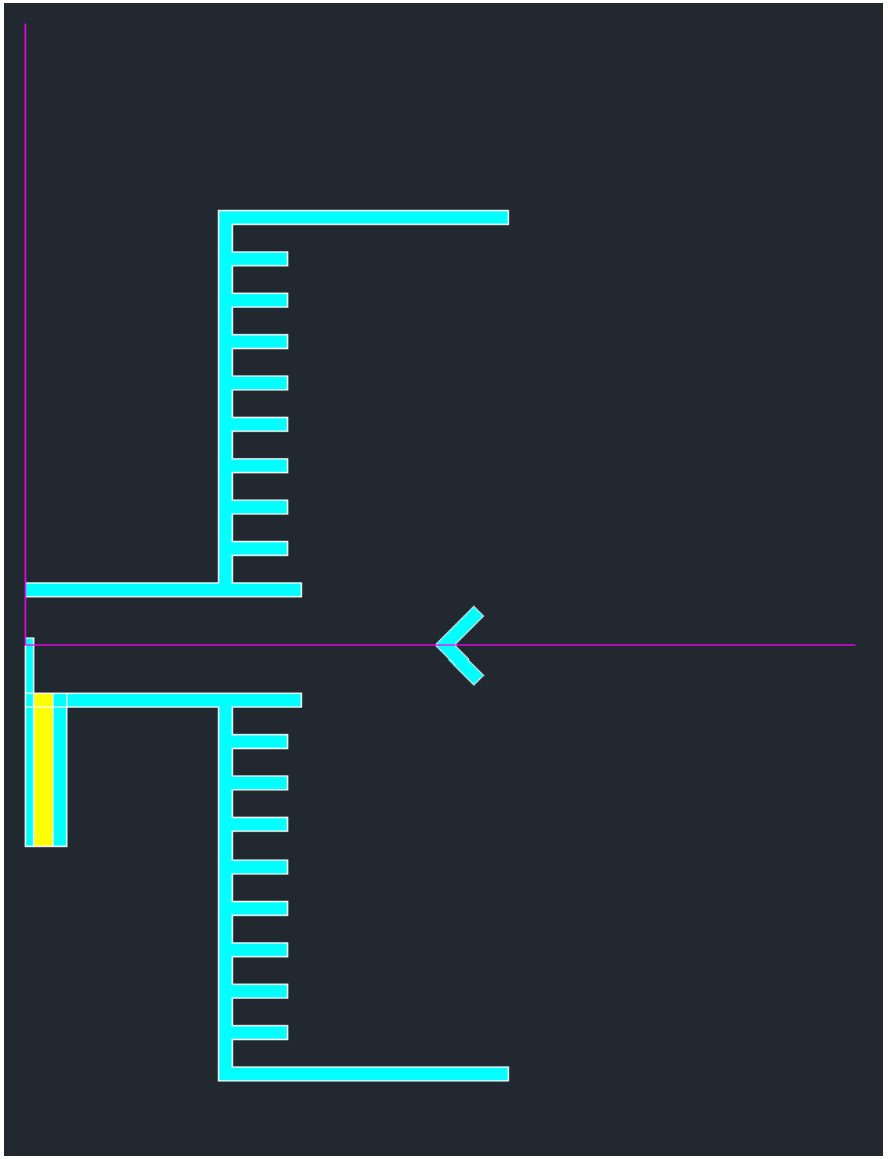
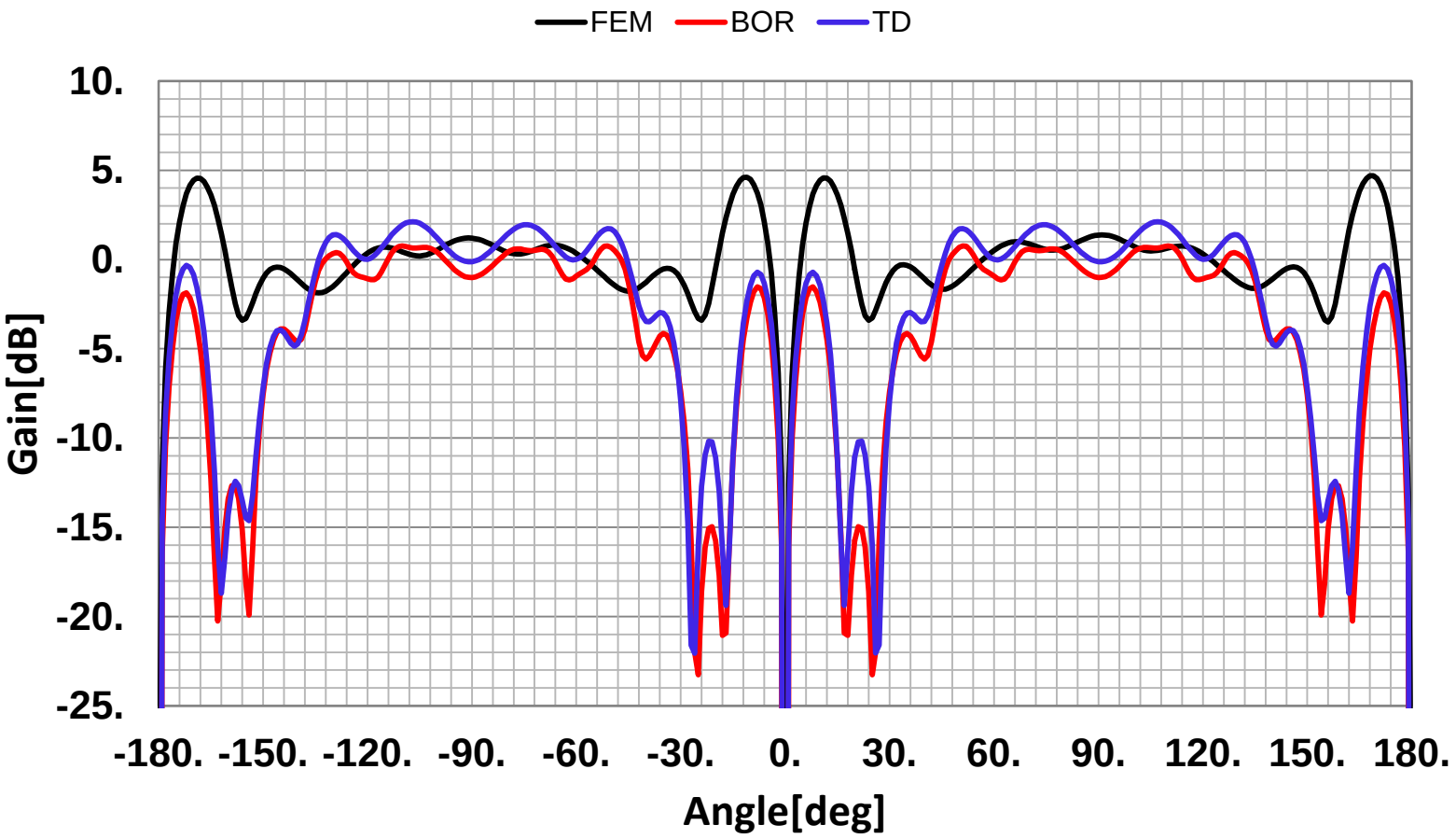
# COMOSOL ANTENNA MODEL



# FEM,TD & BOR - COMPARISON

A&E PARTNERSHIP

## 3D FEM,TD vs BOR - 14.4GHz

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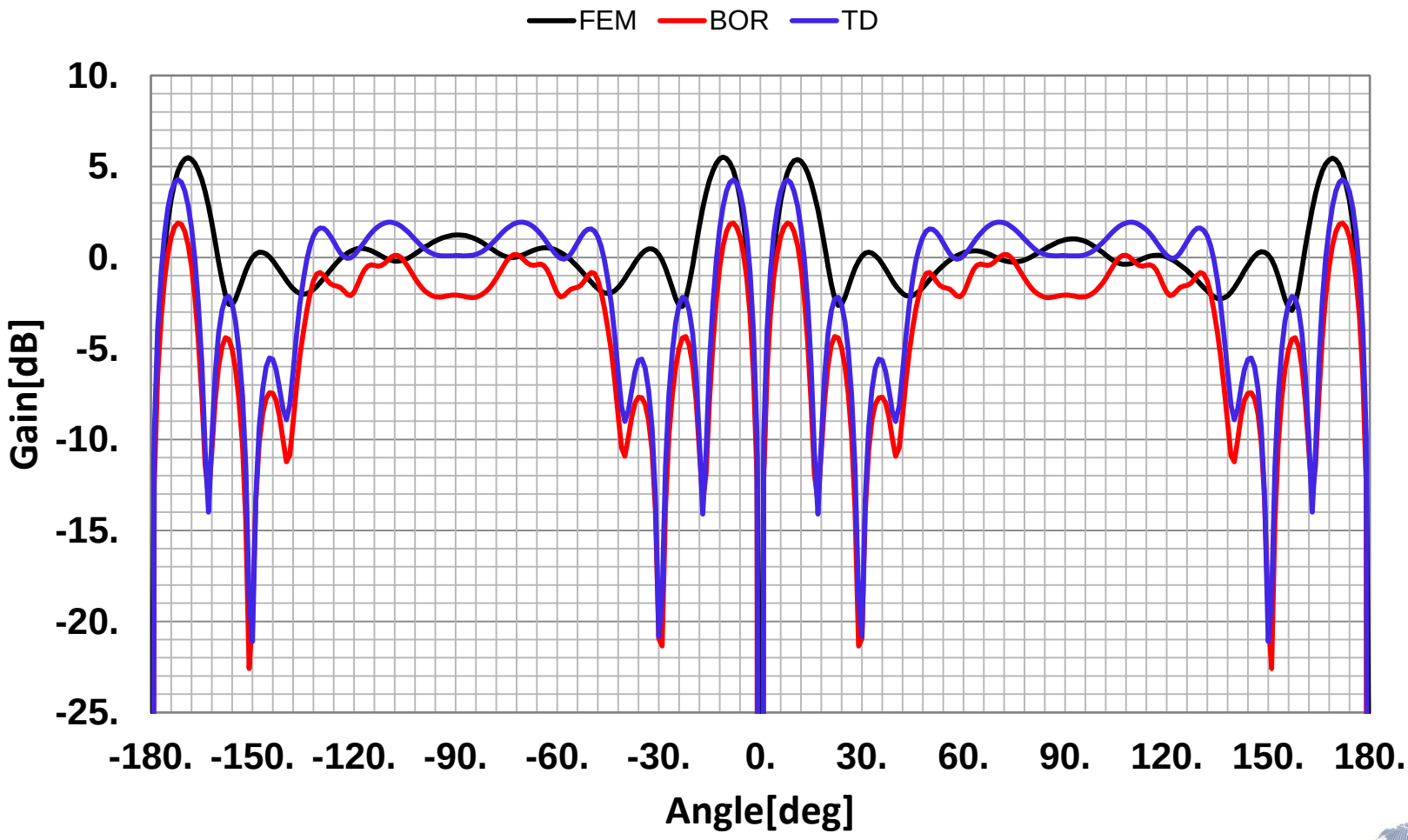
# FEM,TD & BOR - COMPARISON

A&E PARTNERSHIP

## 3D FEM,TD vs BOR - 14.9GHz

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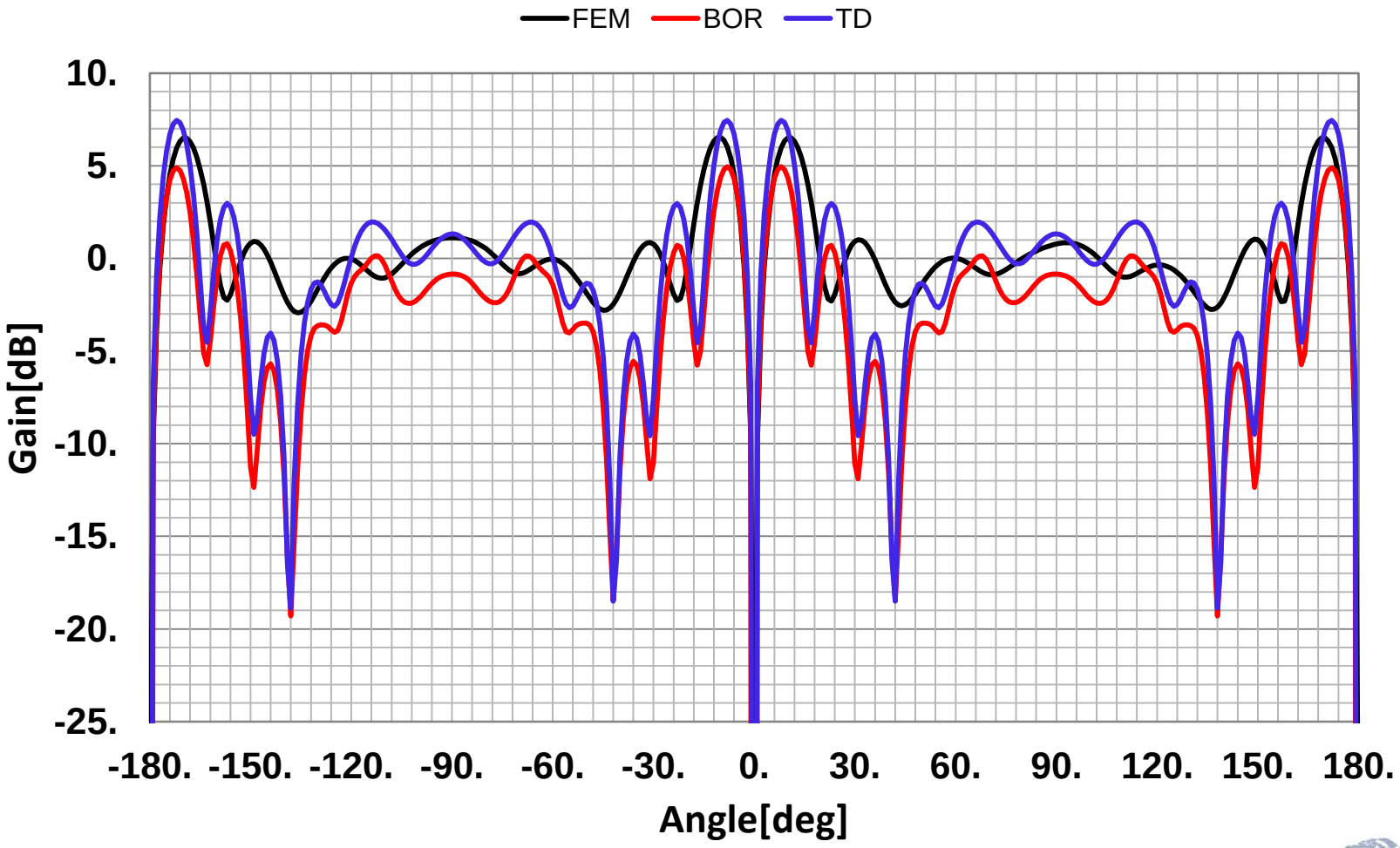
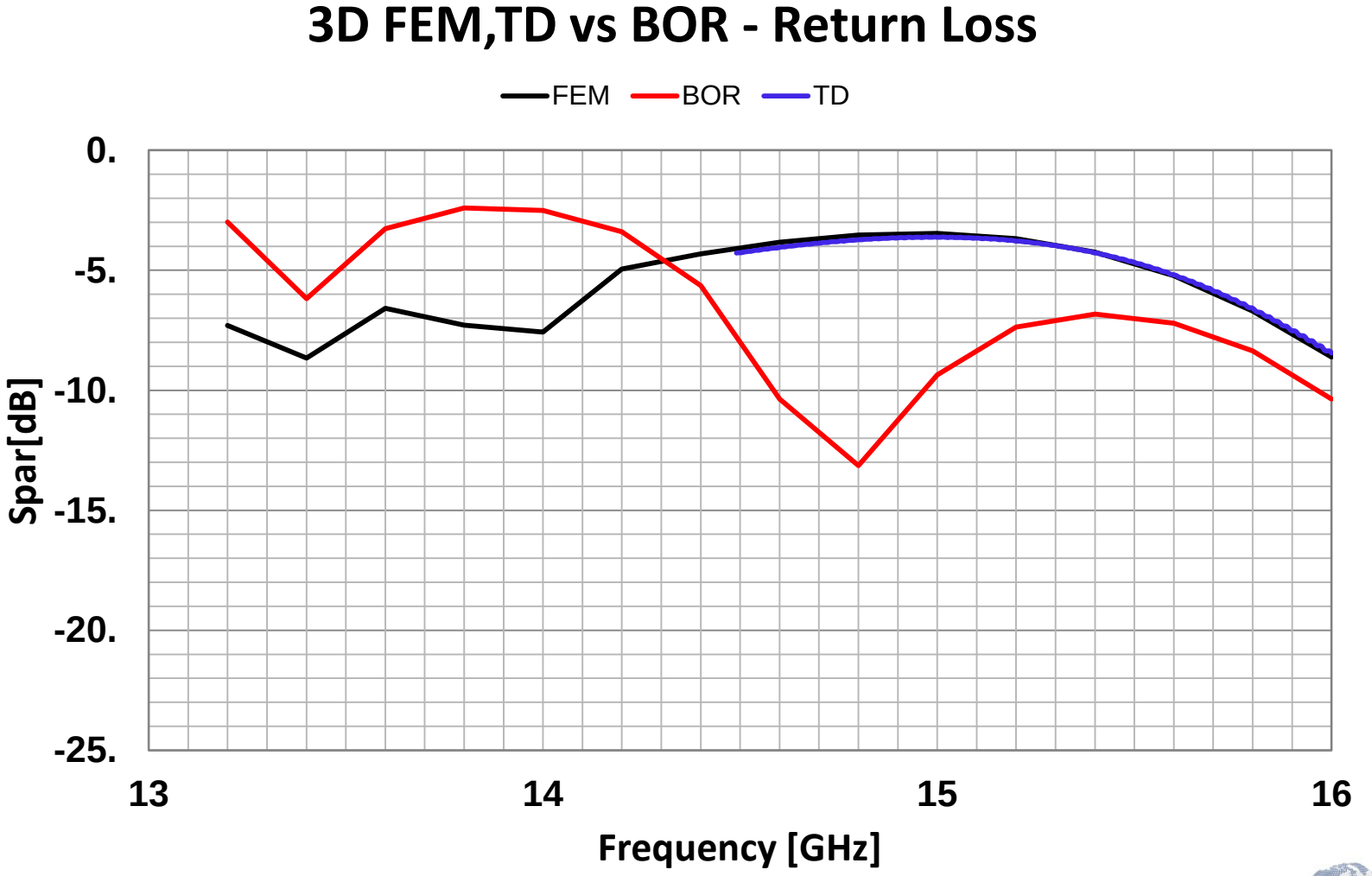
# FEM,TD & BOR - COMPARISON

A&E PARTNERSHIP

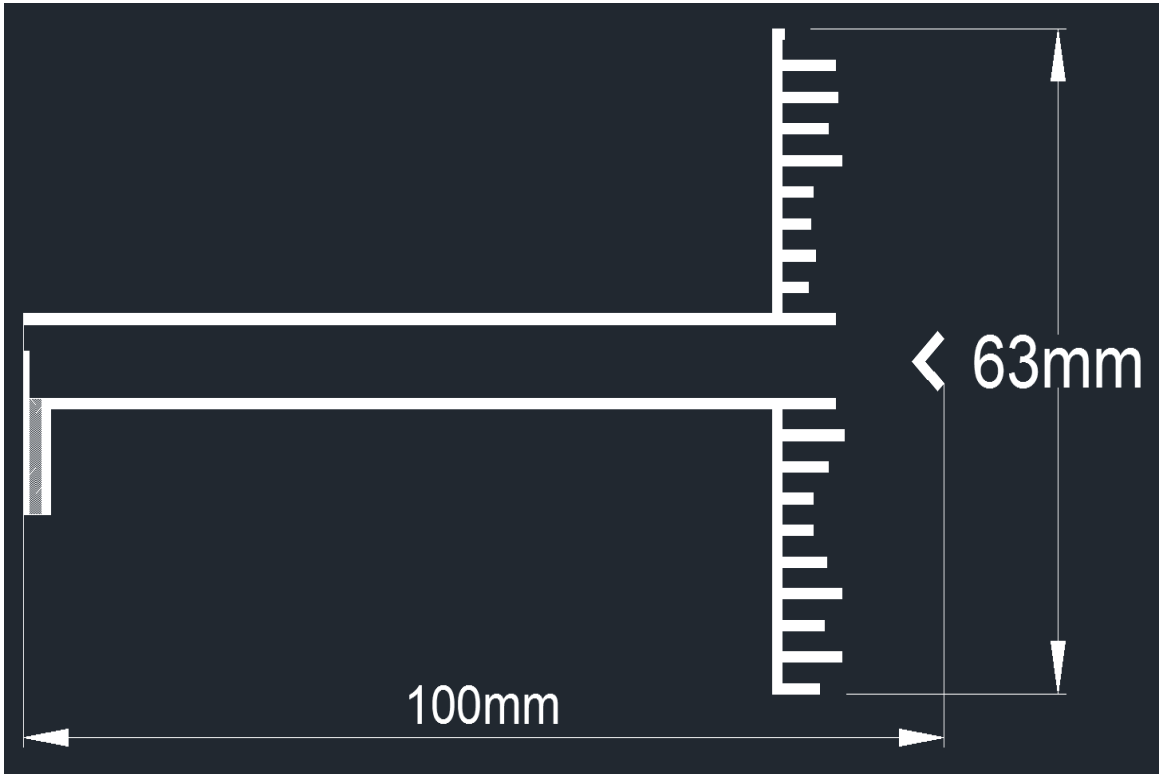
## 3D FEM,TD vs BOR - 15.4GHz



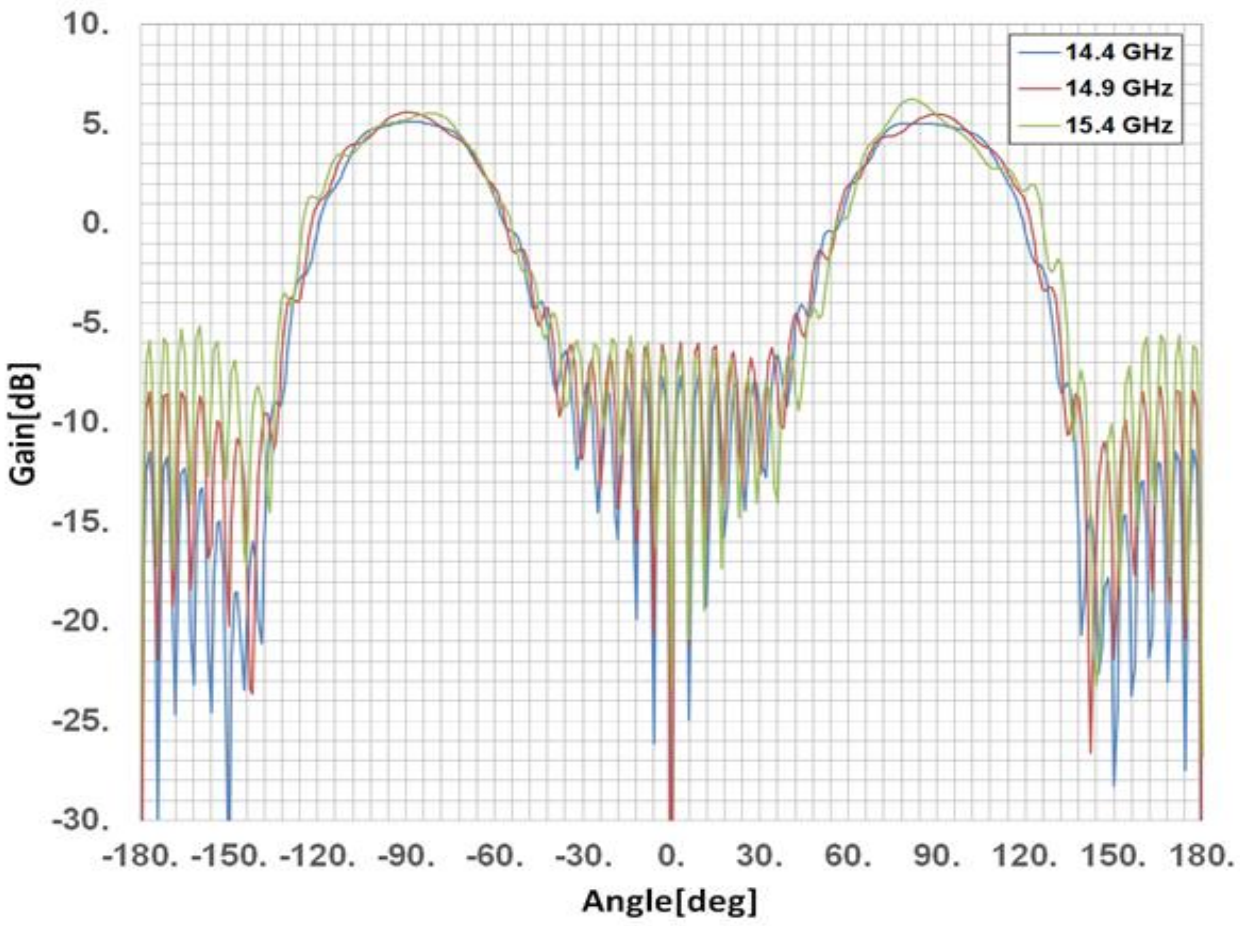
# FEM & BOR - COMPARISON



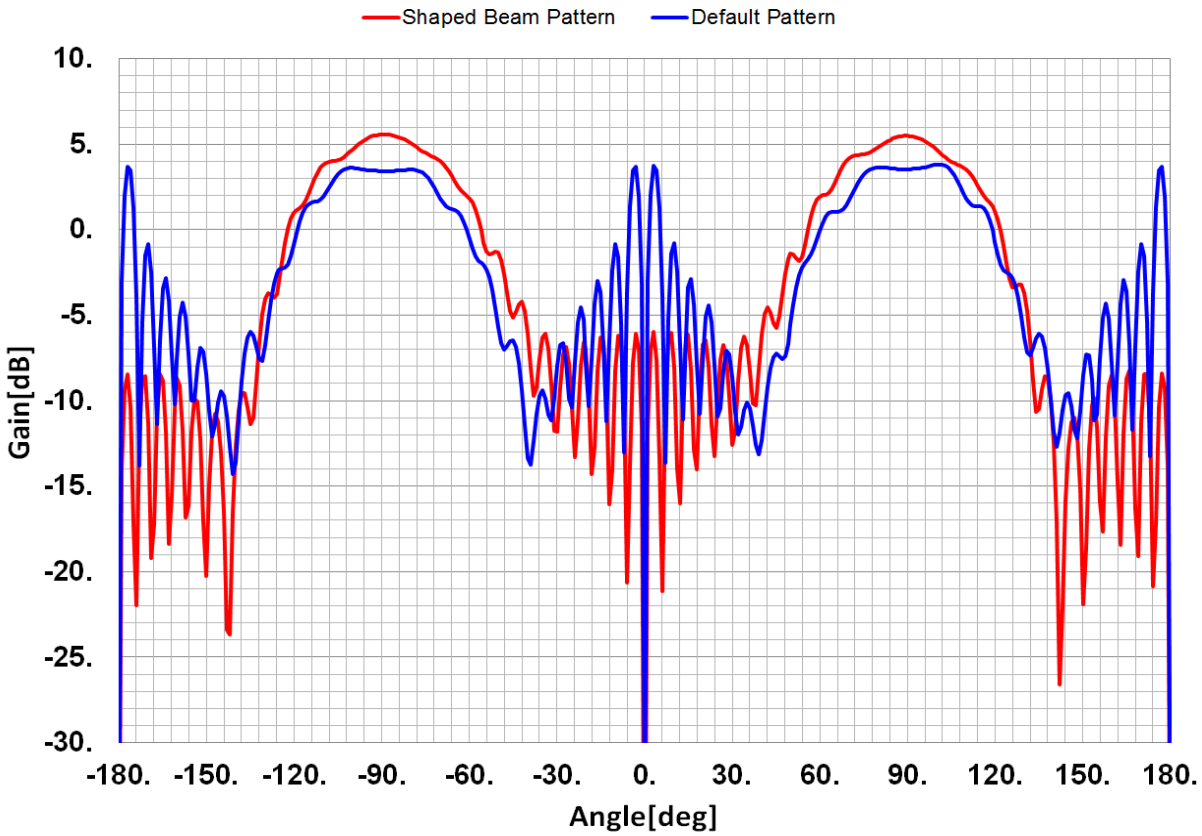
## COMSOL Optimized BOR Geometry



# Shaped Beam Cylindrical Array Optimization Results



## Shaped Beam Cylindrical Array
## Comparison between the initial geometry and the optimized results




**Improved gain and sidelobe level**

# Conclusions

- Optimization the performance of shaped beam antennas using COMSOL BOR module was performed.
- The optimization results produced an antenna with higher beam efficiency (Higher Gain and lower sidelobes)
- The corrugated ridges were proved to be an efficient tool for pattern shaping.
- The COMSOL BOR module was validated to be an appropriate method to be used in the optimization process.

# Future Work

- Optimize the performance of shaped beam antennas using COMSOL BOR for $Cosec^2$ pattern in elevation.
- Investigate possibility for broadband behavior.