7-3.5 External Wall Horn Corrugations

Low gain horns, such as, Turrin horns, Scrimp horns, or Potter horns, are essentially open circuited waveguides. These antennas have high backlobes due to the small aperture and external feed tube current radiation. External corrugations reduce the feed tube currents which reduces back radiation. The program COWSDT generates the TOR file additions to CHAMP of these corrugations which replaces a portion of the exterior horn geometry.

We use a Turrin horn with a 0.74 λ radius with a gain of 12.3 dB to illustrate the method.

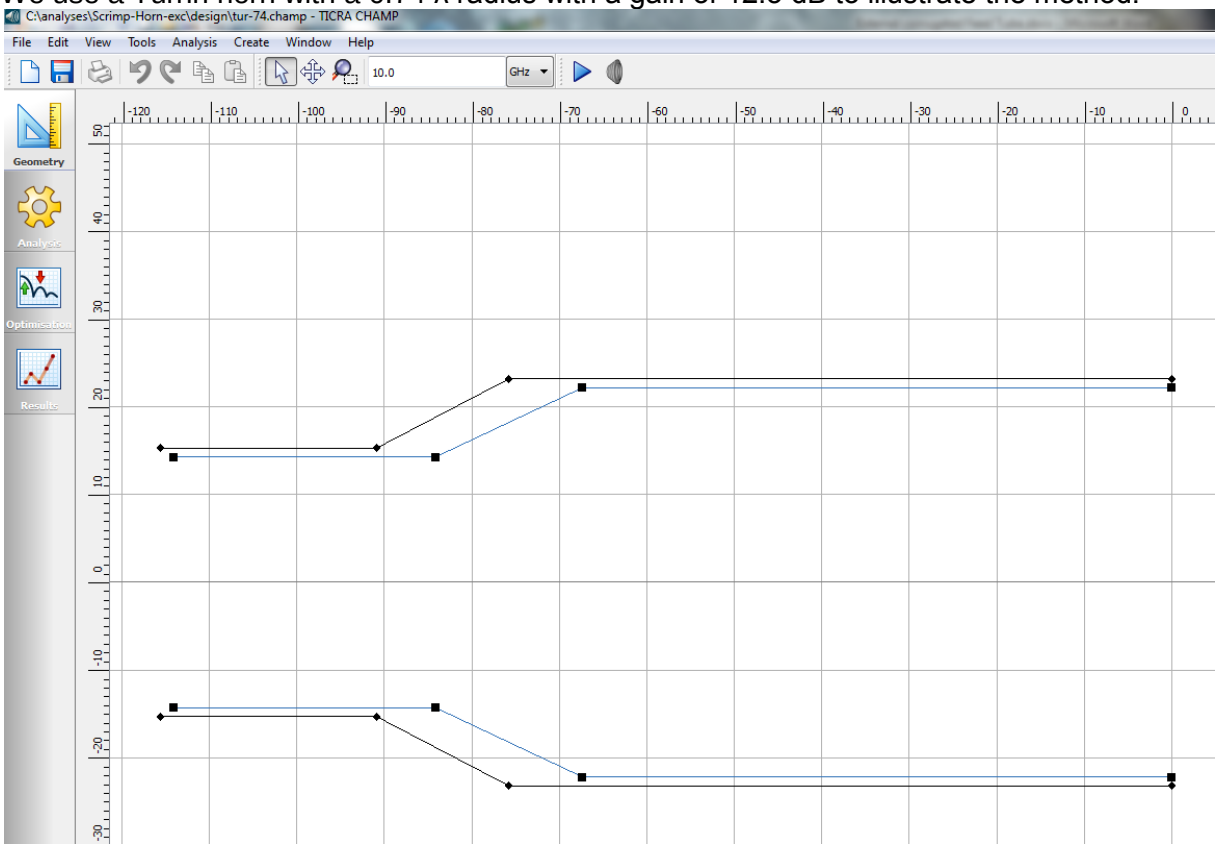


Figure 1 12.3 dB gain Turrin Horn

Figure 1 shows the CHAMP model of the Turrin horn at a center frequency of 10 GHz. The exterior wall uses 4 points using "snap to aperture". The outer tube is approximately 75.8 mm which when covered by an exterior corrugation uses 16 ridges for spacing of 5 mm (6 per wavelength). Use "save as" to generate a new project containing the corrugations along the total length (TUR-7416)

The new project file directory (TUR-7416.CHAMP_DATA) contains the last geometry.tor file which can be opened with a text editor (notepad). An input file to COWSDT has been added to the directory and edited to produce the desired output addition to the geometry.tor file to generate the corrugations.

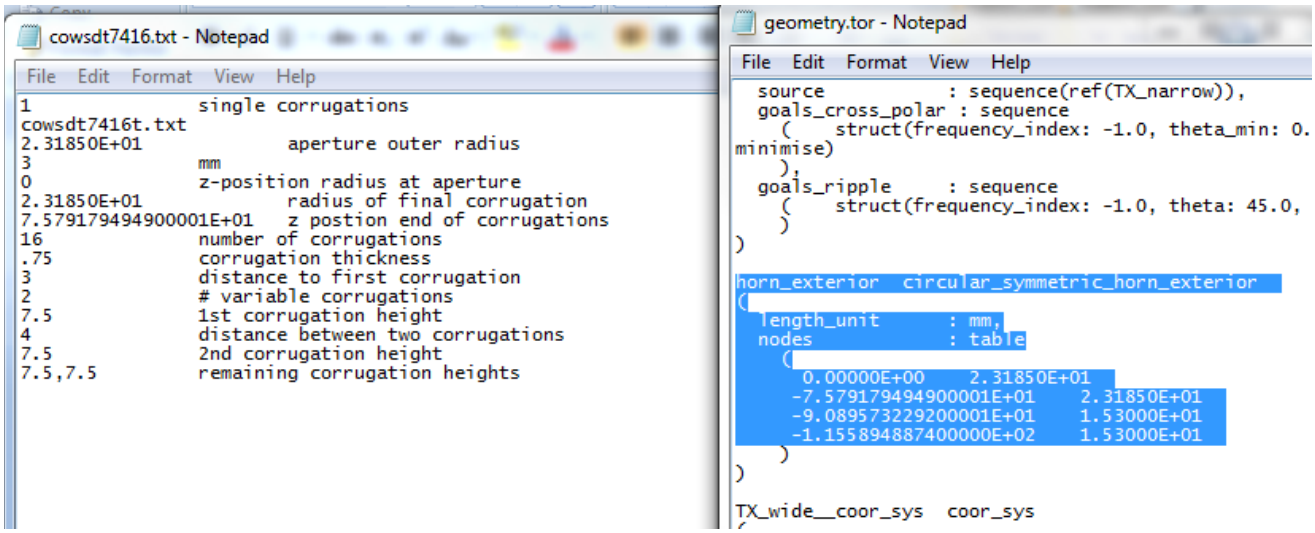


Figure 2 edit of COWSDT input file

The blue portion of the geometry.tor file contains the exterior geometry. The aperture radius is copied and length of corrugations (positive only) has been copied from the 7th blue line into the input file. The distance to the first ridge is 3 mm which can be used as an optimization variable but here is the length used as a surface to connect an exterior support dielectric tube. The input file specifies that 2 ridges and the distance between them can be used as optimization variables (up to 7 ridges and their spacing can be optimized). The remaining corrugations have a delta radius of 7.5 mm (~λ/4) in a linear taper which can be optimized if desired. The spacing between the last 14 ridges is adjusted to make the total length to satisfy 7th input line. The output file of COWSDT is specified in the second line.

Run COWSDT.EXE in a command line window in the project file directory (TUR-7416.CHAMP_DATA) (shift-right-click) and use the input file. Open cowsdt7416t.txt (notepad) and select all (edit tab) and copy. We replace the portion in blue of the geometry.tor file shown above with the output file (cowsdt7416t.txt) except the last two lines of the exterior which we will retain.

Run CHAMP by using the project (TUR-7416.CHAMP).

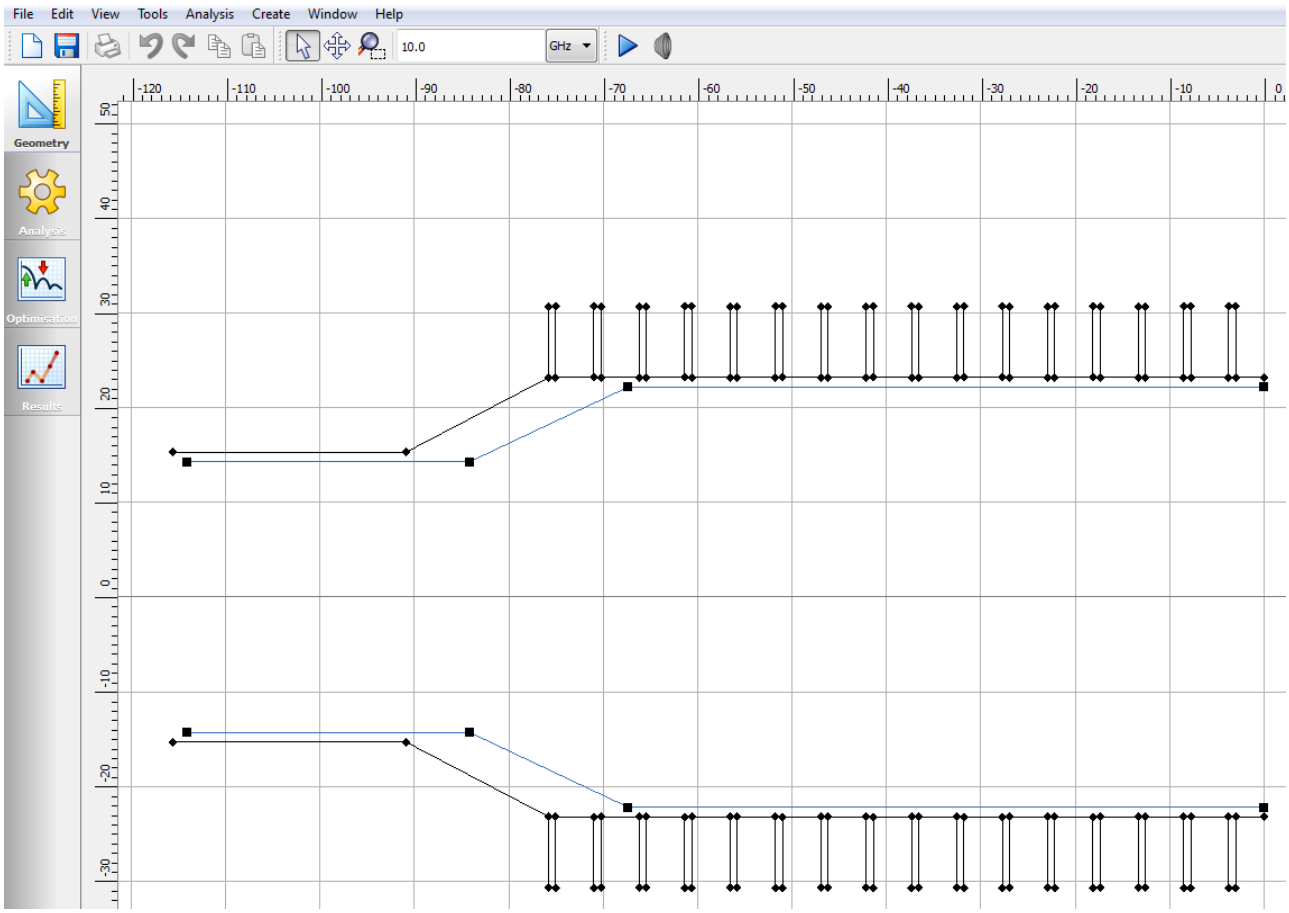


Figure 3 0.74λ radius Turrin horn with 16 ridges exterior corrugations

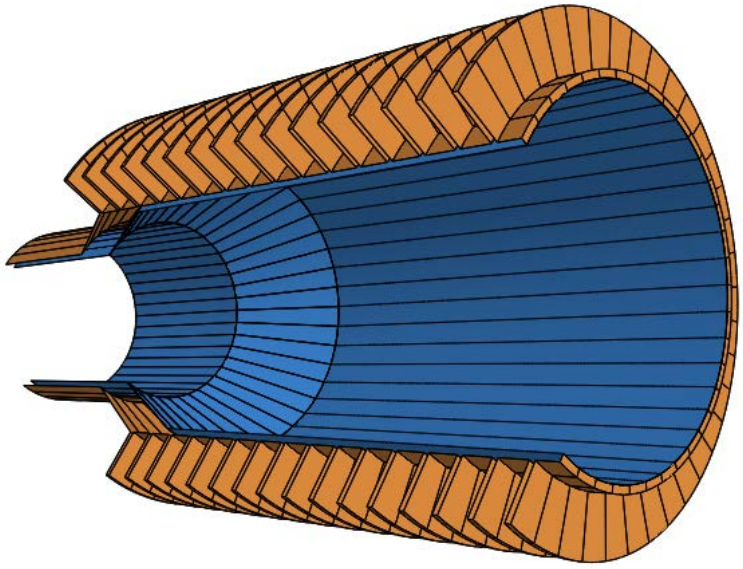


Figure 4 0.74λ radius Turrin horn with 16 ridges exterior corrugations

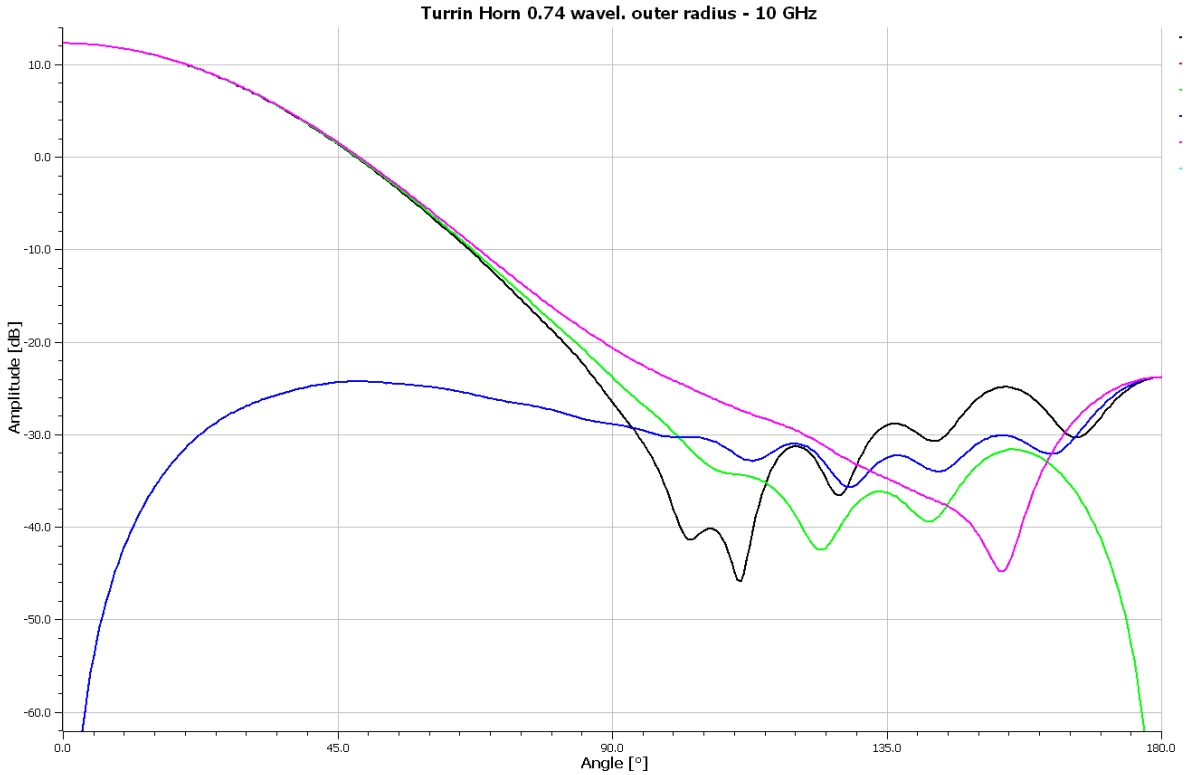


Figure 5 Center frequency response of 0.74λ radius Turrin horn

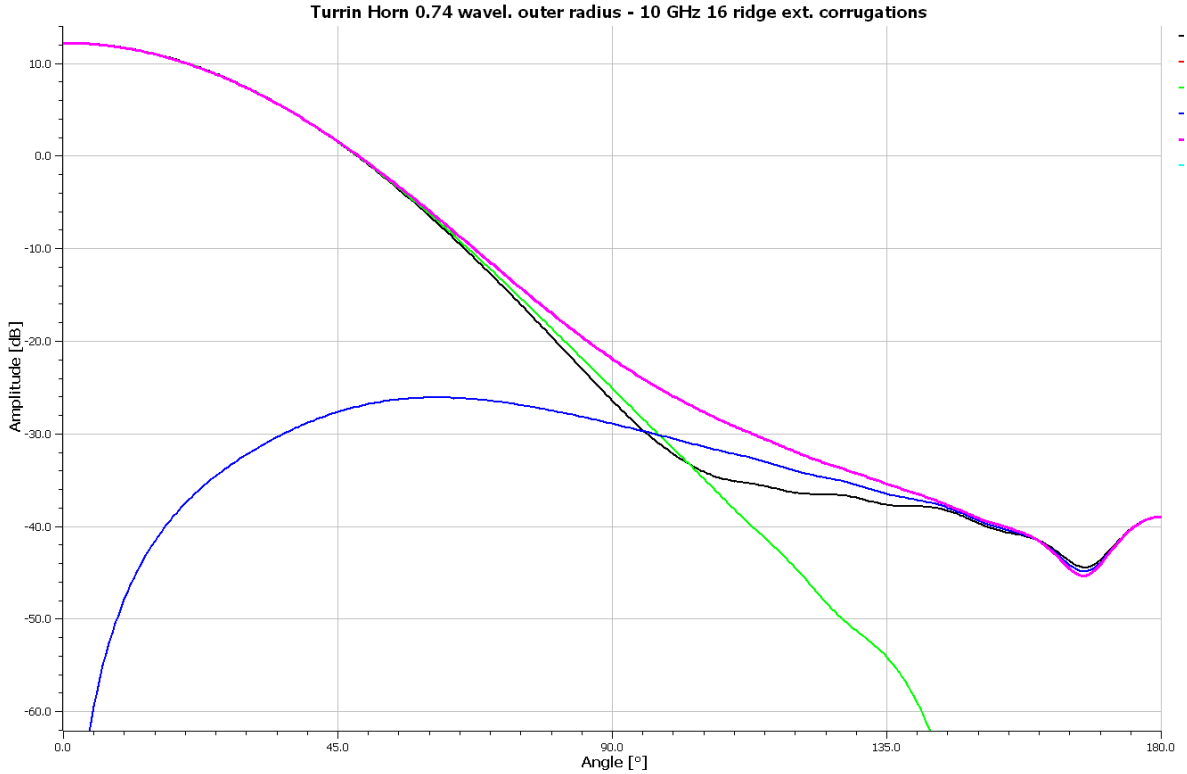


Figure 6 Center frequency response of 0.74λ radius Turrin horn w/ 16 ridge ext. corrugation

Front/back increases by 15 dB with 16 ridge external corrugation.

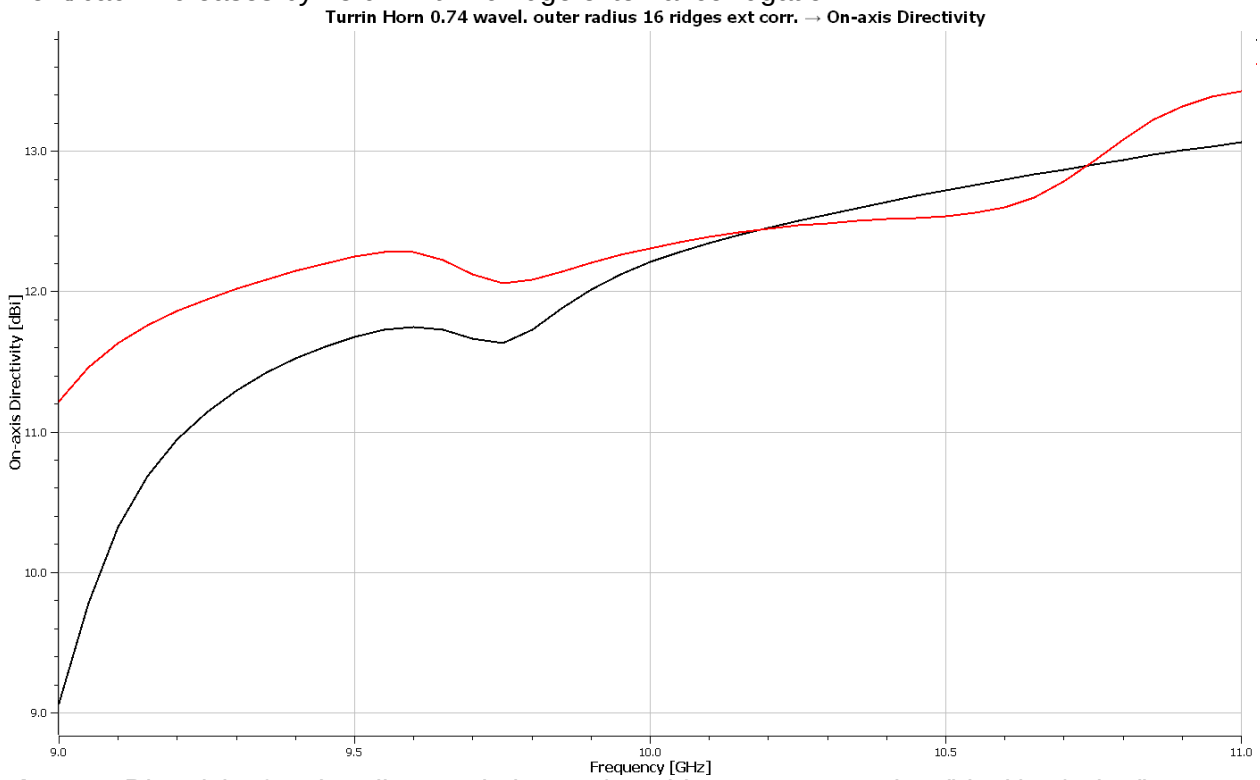


Figure 7 Directivity 0.74λ radius Turrin horn w/ 16 ridge ext. corrugation (black) w/o (red)

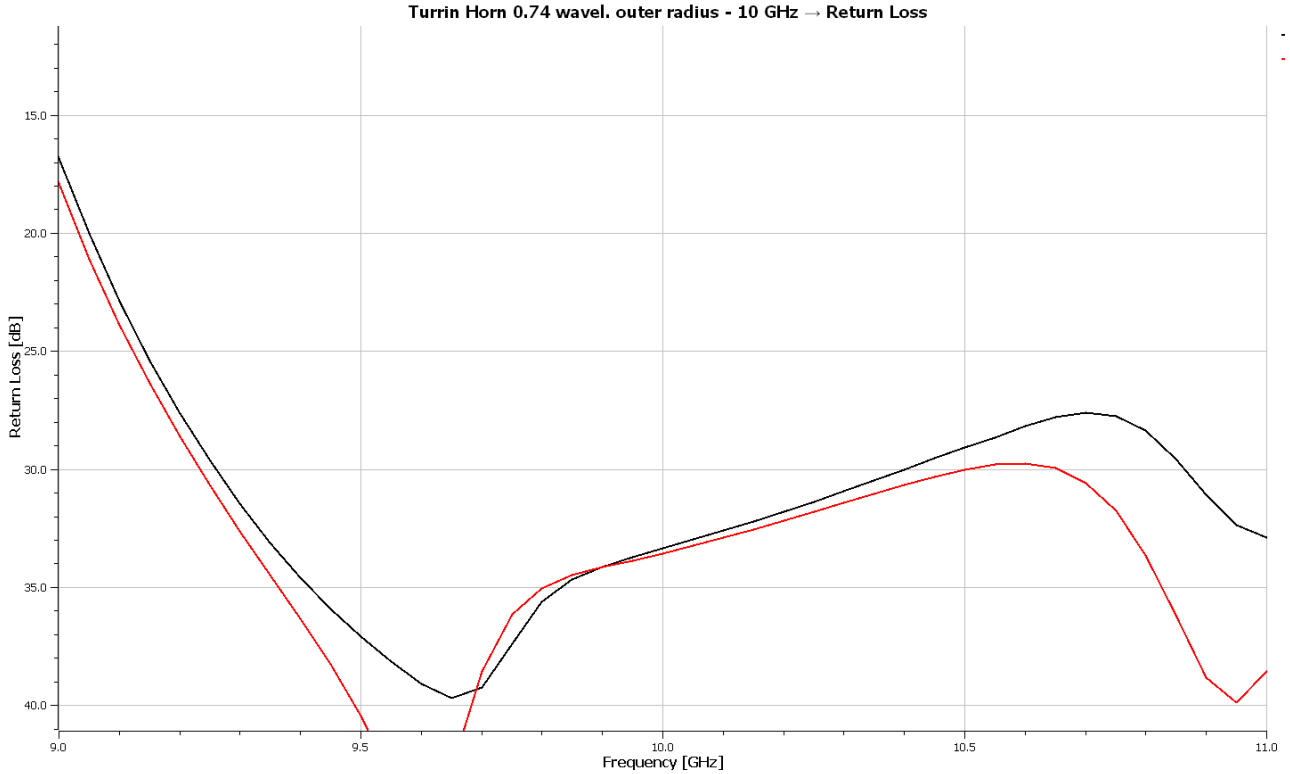


Figure 8 Return Loss 0.74λ radius Turrin horn w/ 16 ridge ext. corrugation (black) w/o (red)

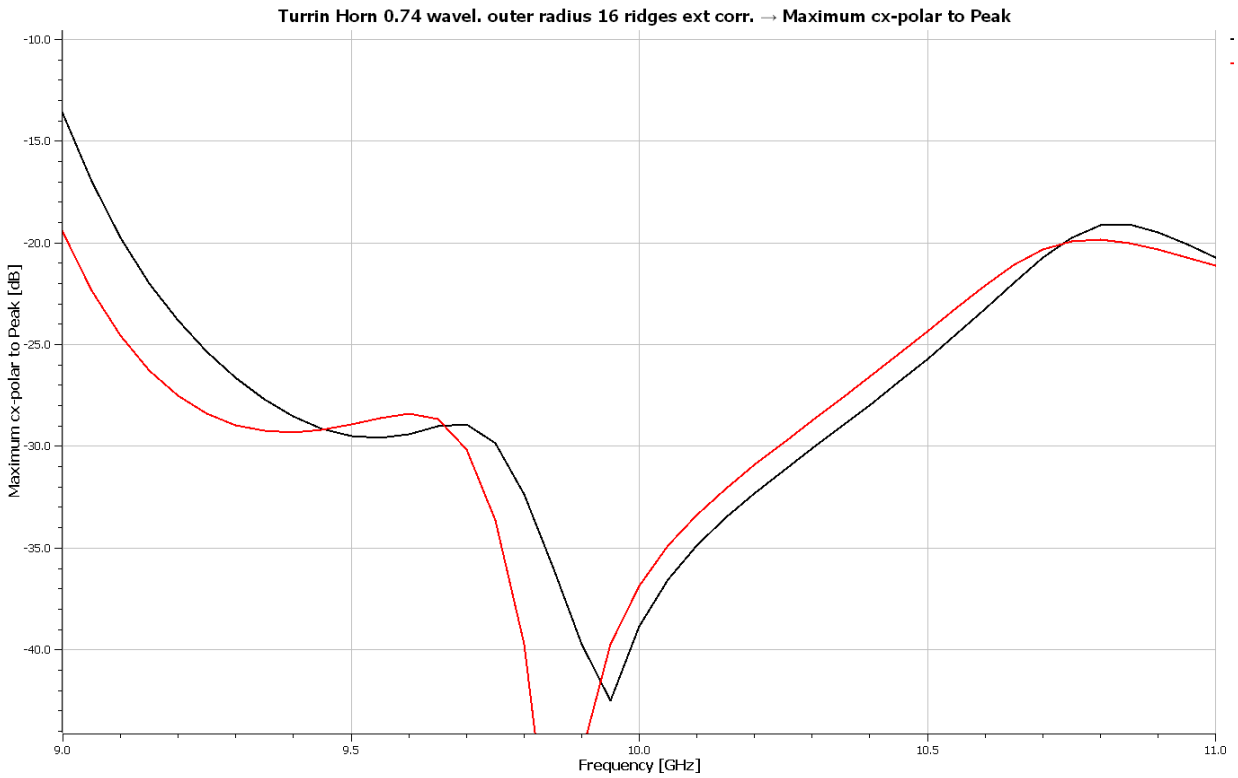


Figure 9 Max X-pol. 0.74λ radius Turrin horn w/ 16 ridge ext. corrugation (black) w/o (red)

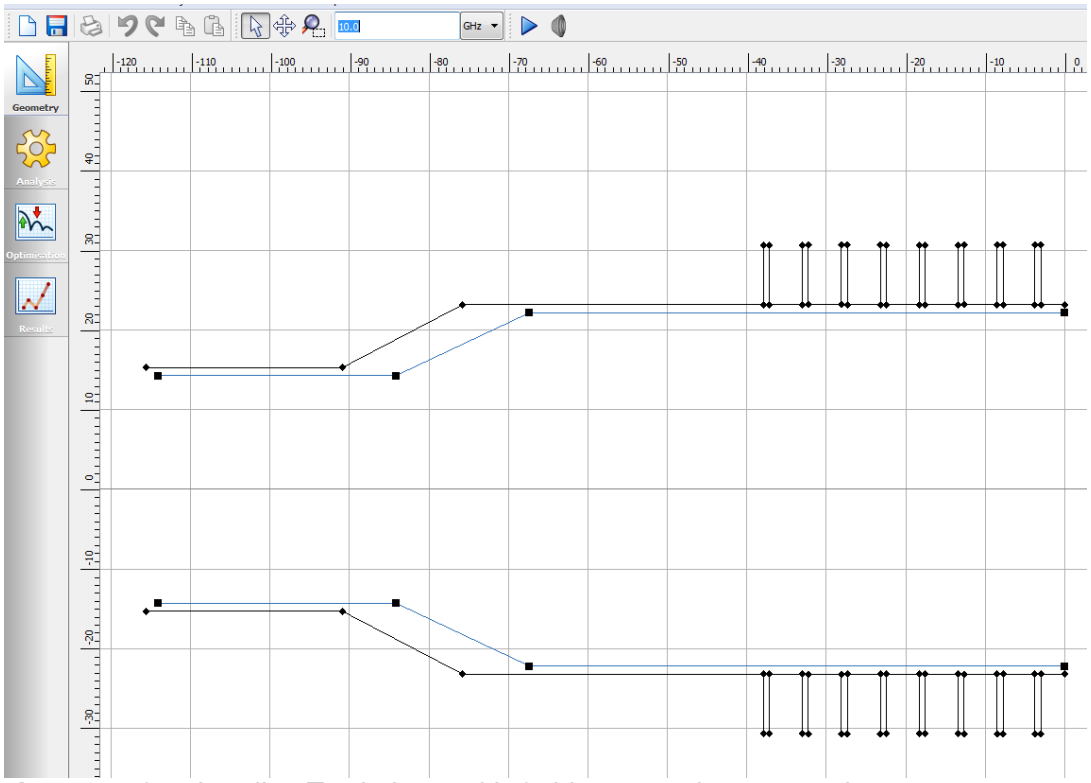


Figure 10 0.74λ radius Turrin horn with 8 ridges exterior corrugations

This horn only has 8 ridges in the external corrugation spread over half the length of the external tube. We retain the last three points in the horn exterior in geometry.tor file.

The exposed portion of the waveguide tube increases the front/back by 2 dB compared to the 16 ridges spread over the entire length.

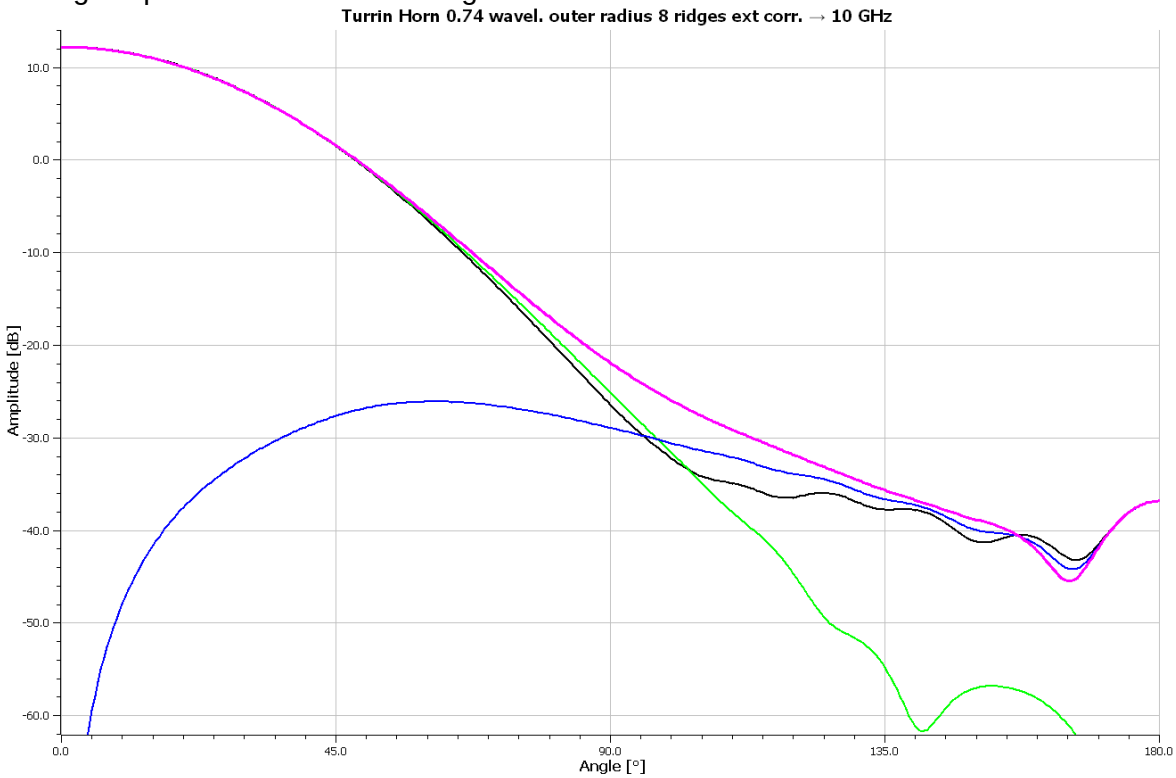


Figure 11 Center frequency response of 0.74λ radius Turrin horn w/ 8 ridge ext. corrugation

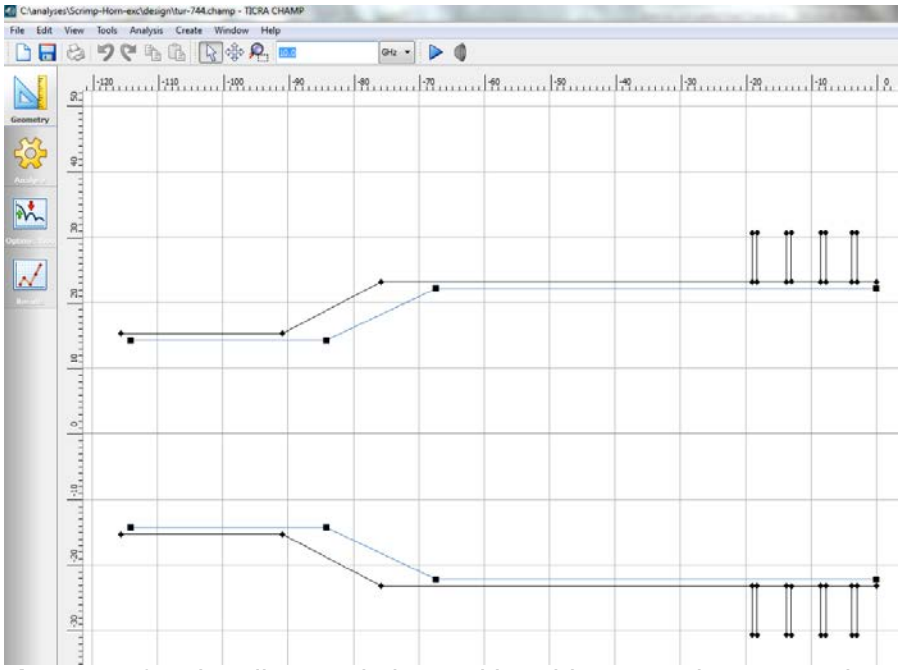


Figure 12 0.74λ radius Turrin horn with 4 ridges exterior corrugations

This horn only has 4 ridges in the external corrugation spread over one-fourth the length of the external tube. We retain the last three points in the horn exterior in geometry.tor file.

The exposed portion of the waveguide tube increases the front/back by 5 dB (10 dB) compared to the 16 ridges spread over the entire length.

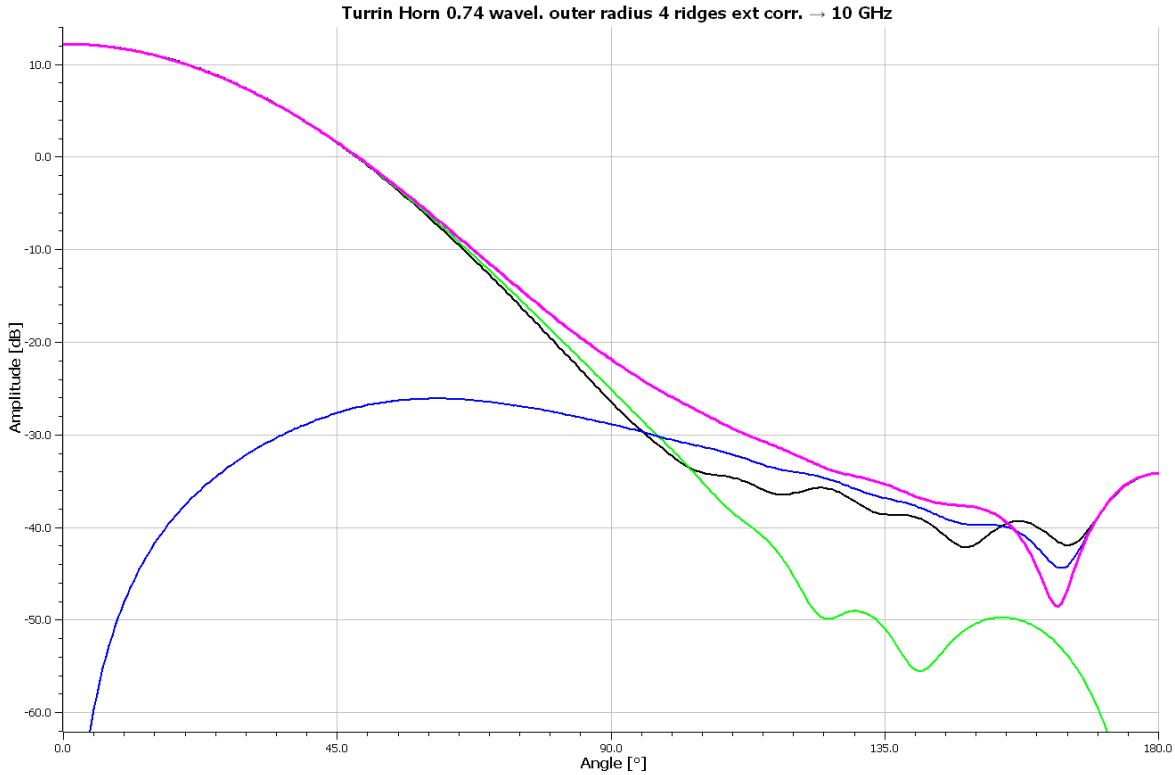


Figure 13 Center frequency response of 0.74λ radius Turrin horn w/ 4 ridge ext. corrugation

0.62 λ Radius Turrin Horn with External Corrugations

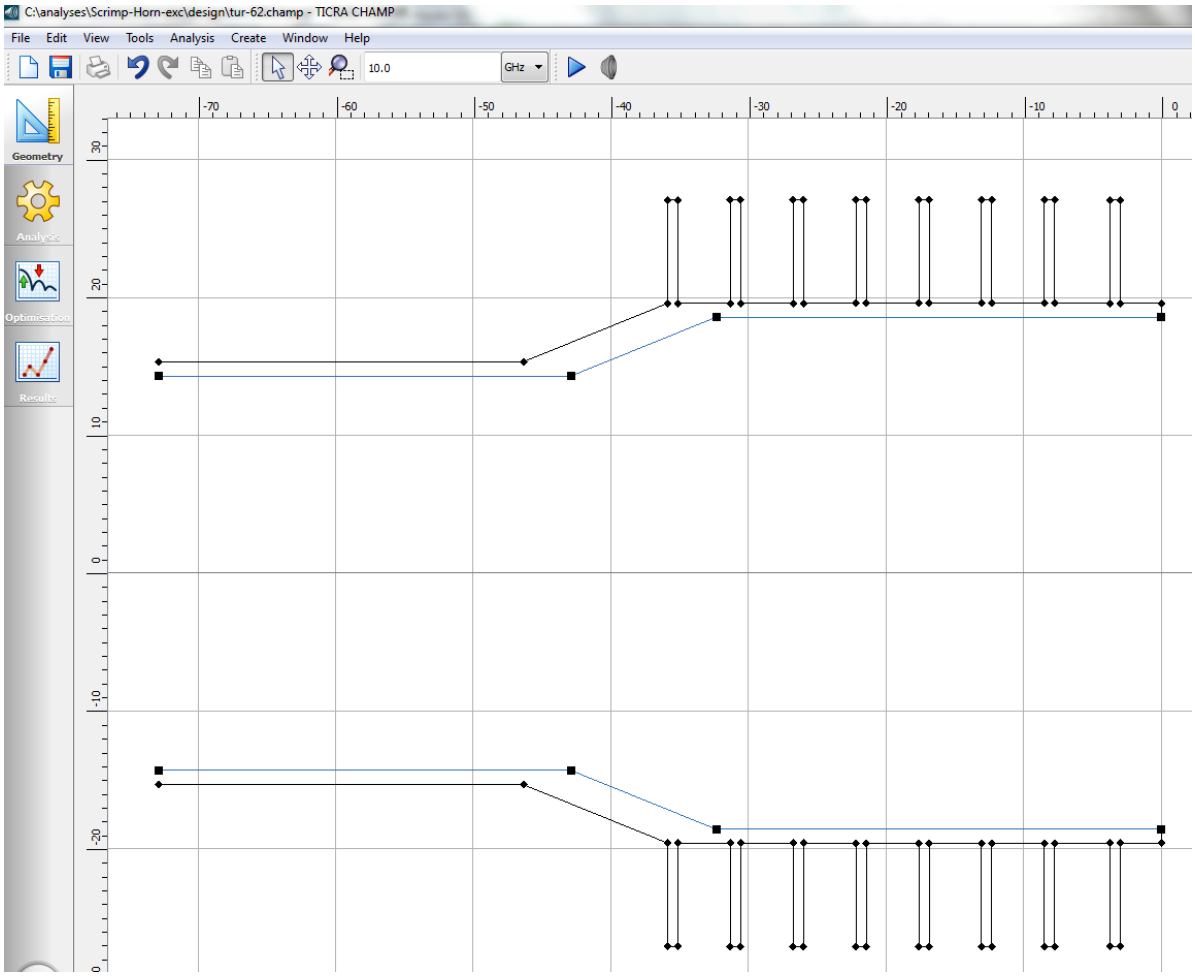


Figure 14 0.62λ radius Turrin horn with 8 ridges exterior corrugations

The smaller diameter Turrin horn has a shorter tube that can be covered with only 8 ridges. This antenna has only 11.46 dB directivity at center frequency without corrugations and the corrugations shown reduce gain to 11.07 dB but increase front/back.

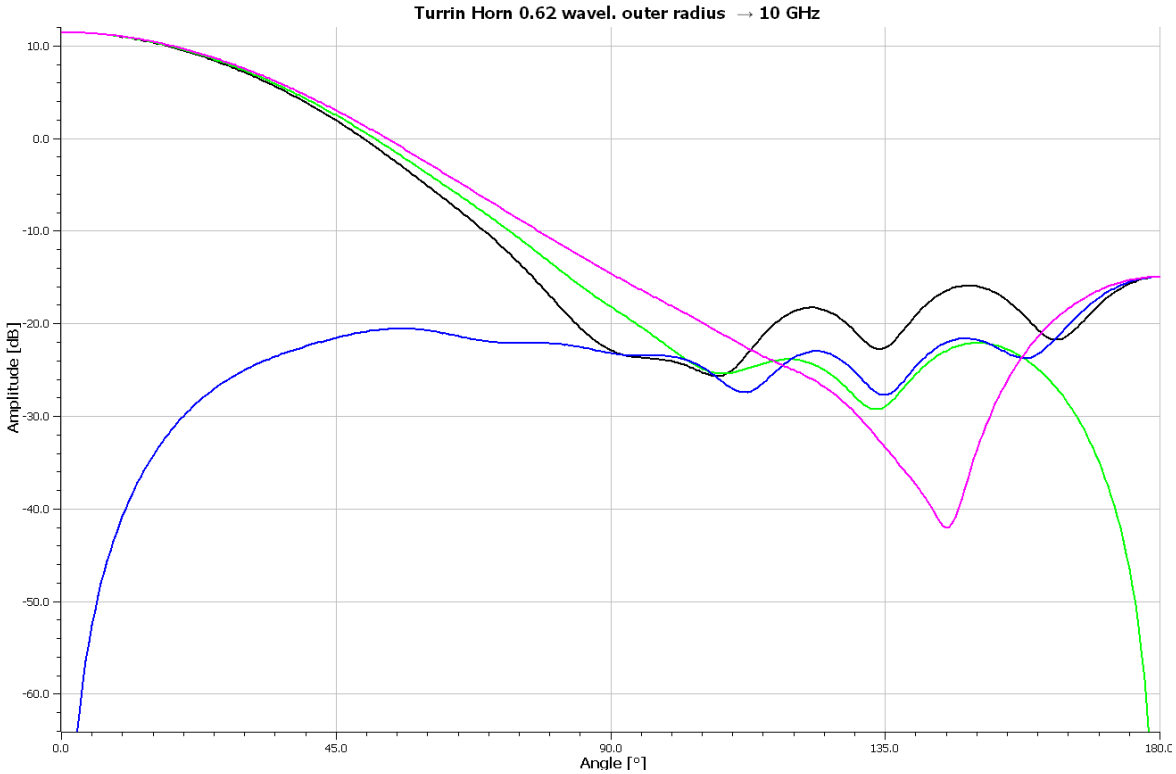


Figure 15 Center frequency response of 0.62λ radius Turrin horn

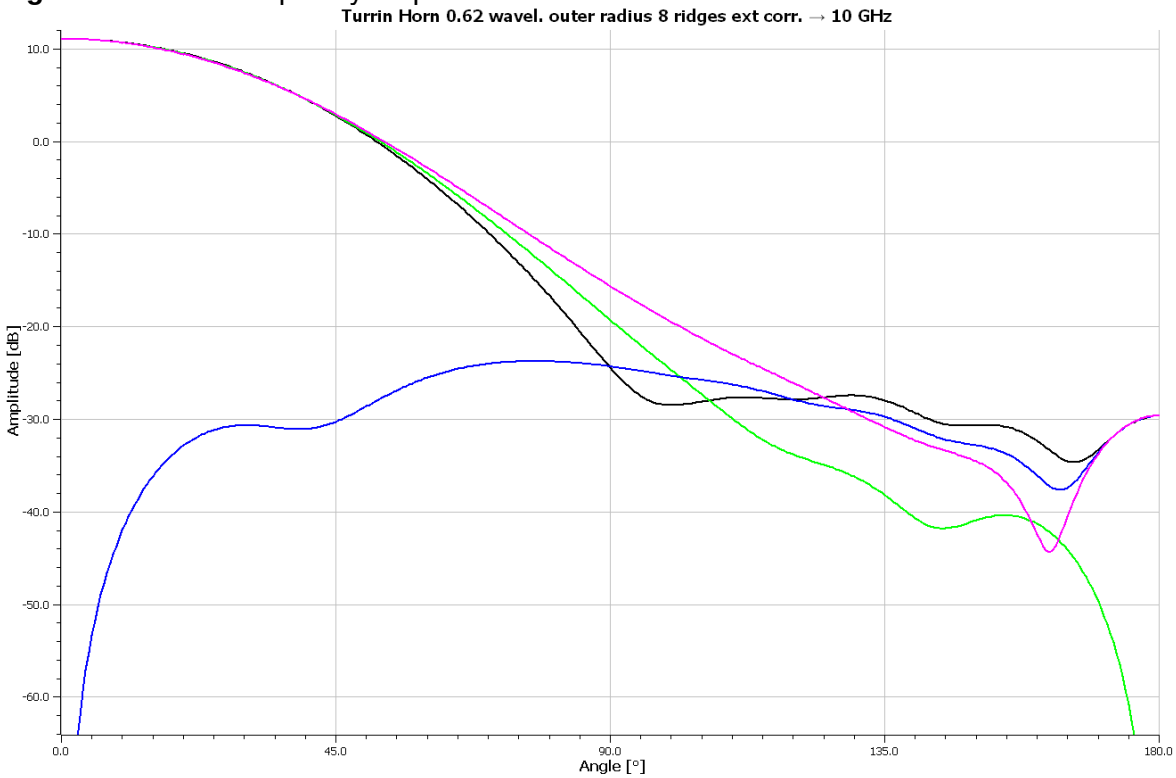


Figure 16 Center frequency response of 0.62λ radius Turrin horn w/ 8 ridge ext. corrugation

The corrugations increase front/back by 14.3 dB similar to the 15 dB of the 0.74λ radius Turrin horn. But the corrugations have decreased directivity by 0.39 dB.

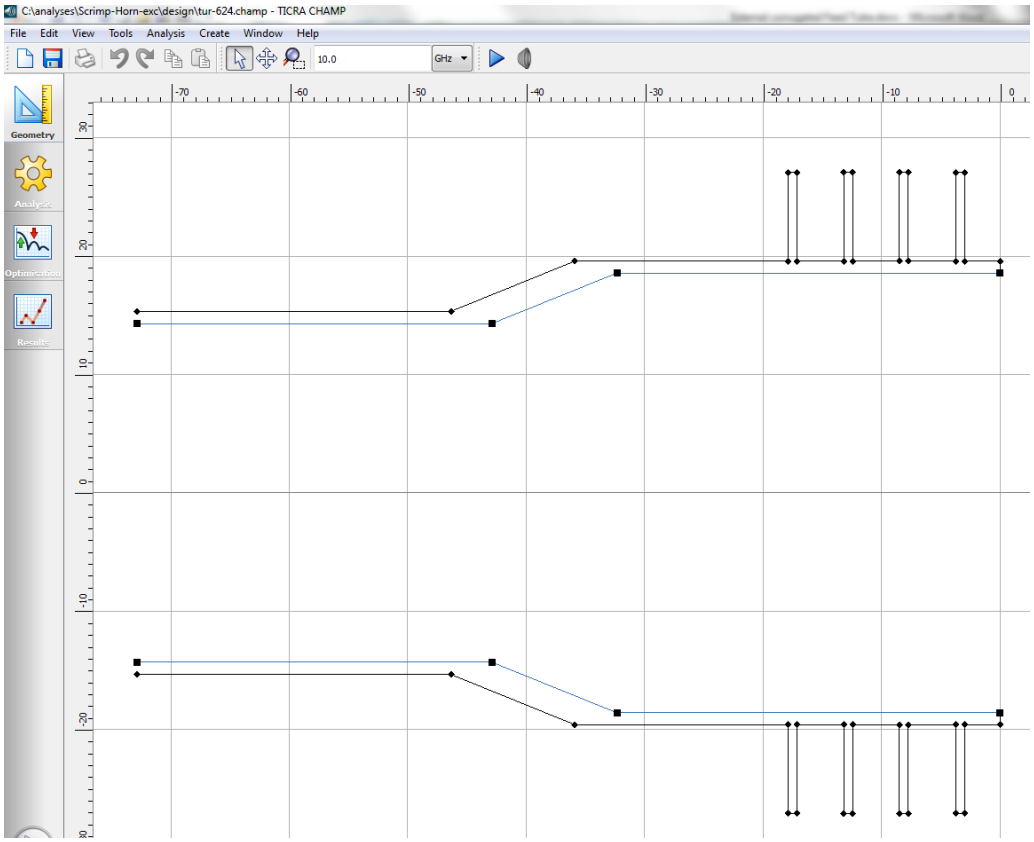


Figure 17 0.62λ radius Turrin horn with 4 ridges exterior corrugations

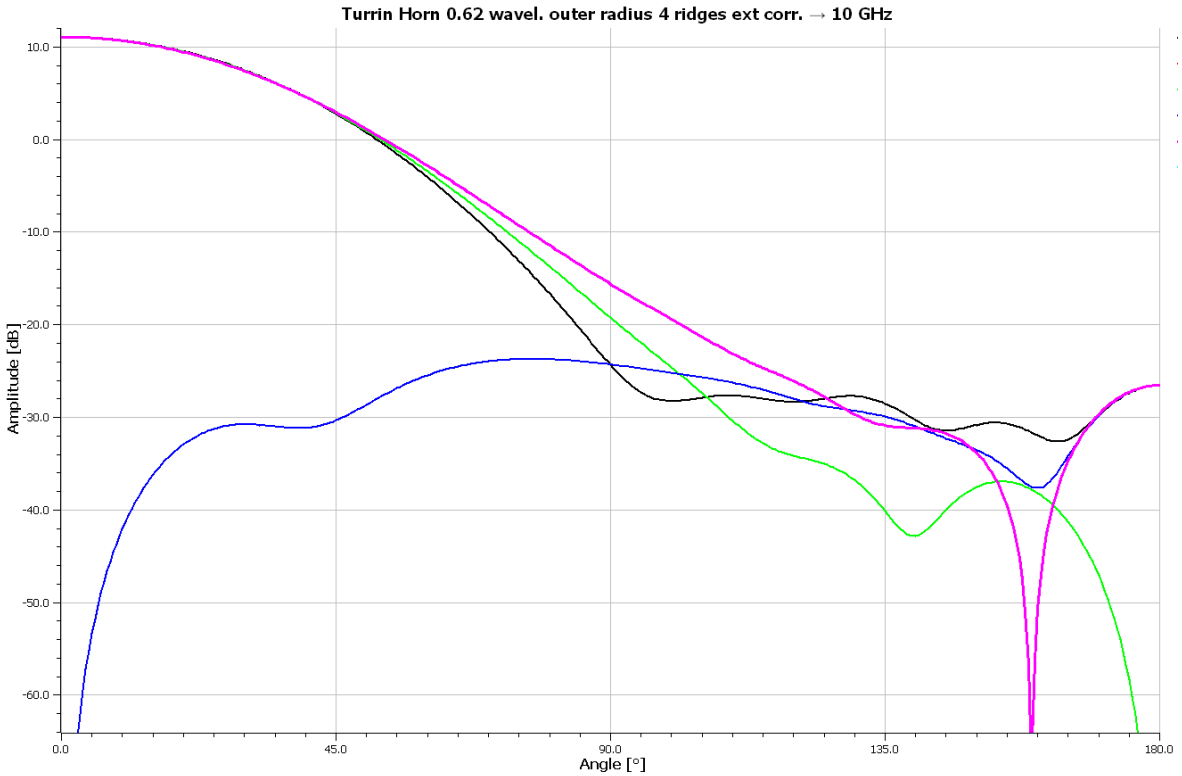
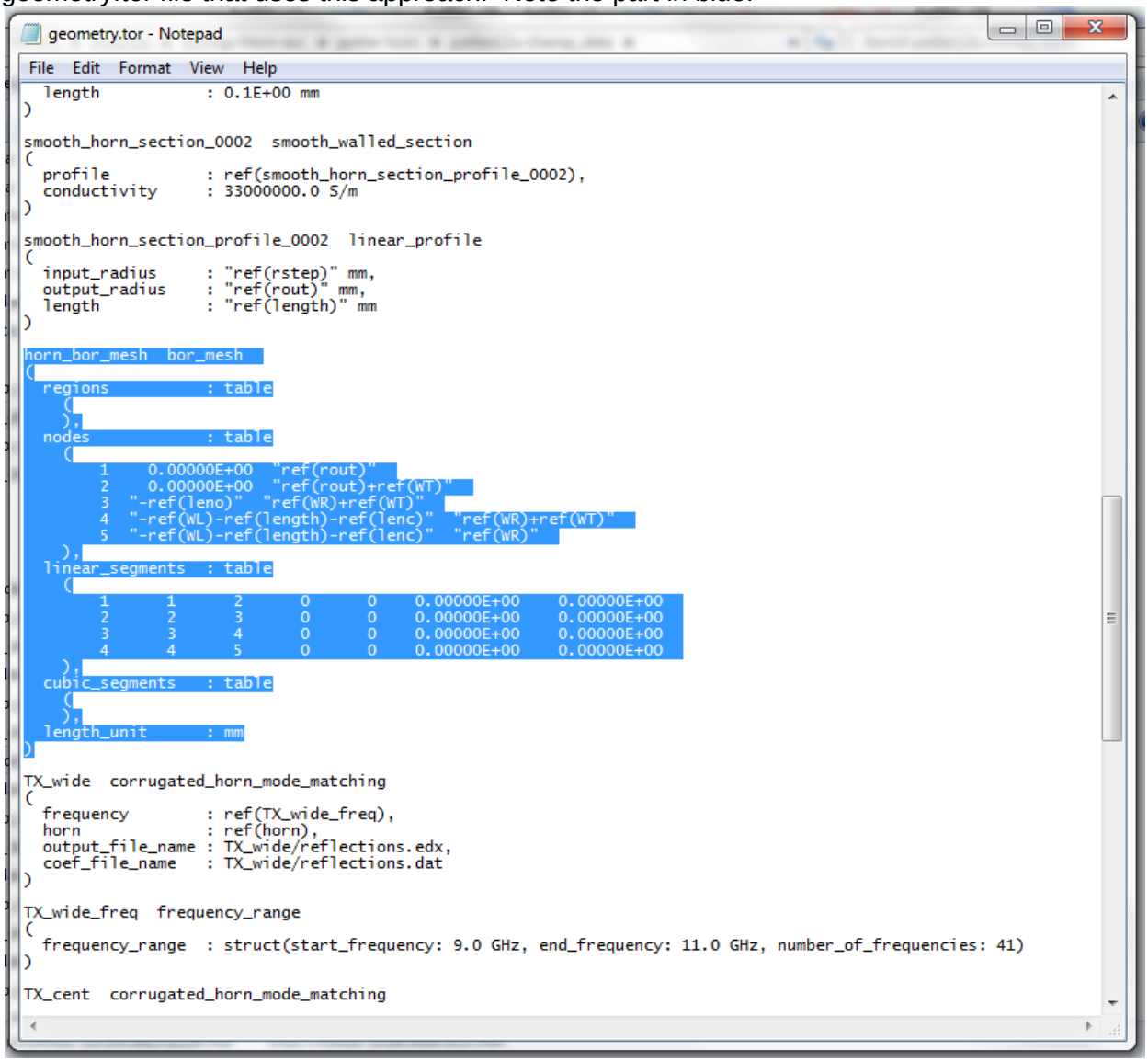


Figure 18 Center frequency response of 0.62λ radius Turrin horn w/ 4 ridge ext. corrugation

The corrugations increase front/back by 11.2 dB or exposing half the tube decreases F/B by ~3 dB.

Potter Horn with External Corrugations

The program than generates potter horn uses a "bor_mesh" for the exterior which does not match the output of COWSDT that expects an exterior circular_bor_mesh. Consider the geometry.tor file that uses this approach. Note the part in blue.



Run CHAMP of the design without modifying the geometry.tor file.

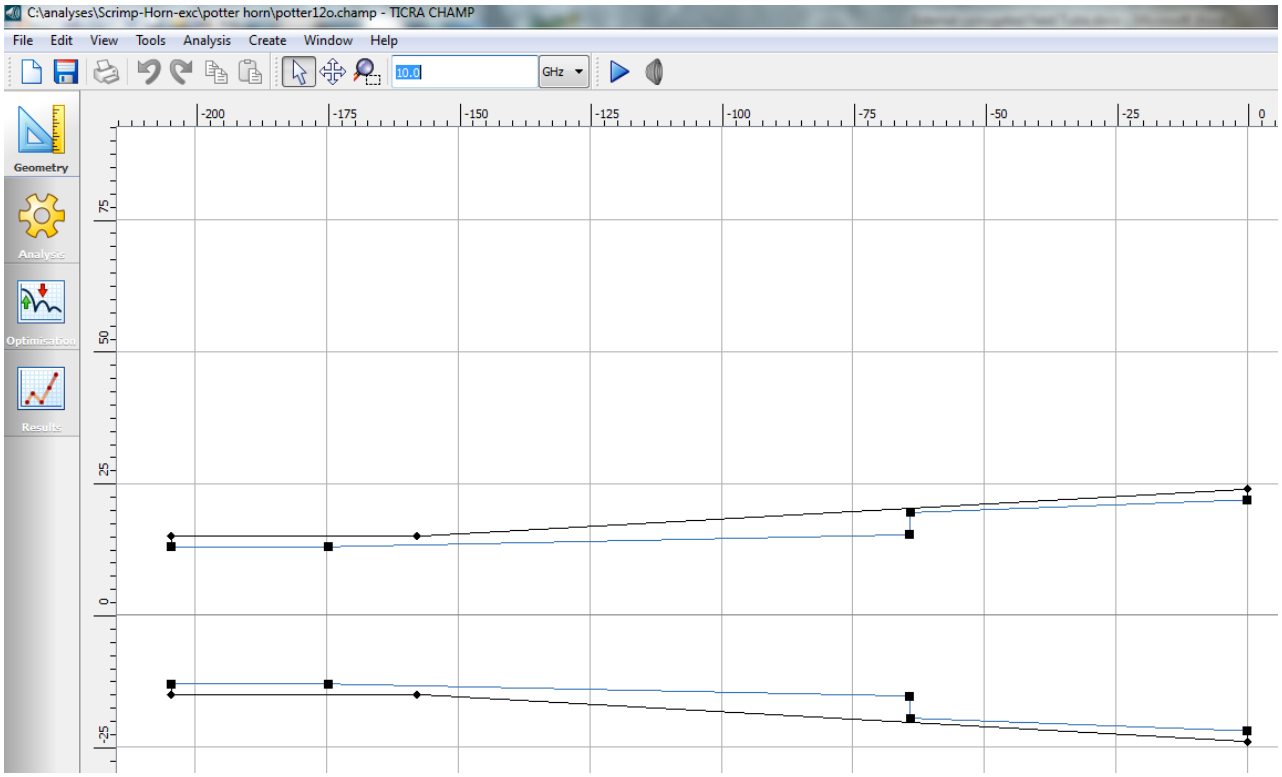


Figure 19 12 dB Gain Potter Horn Geometry

Generate a horn exterior under the "Create" tab and trace the exterior points on the geometry skipping the aperture point to add an "exterior" file to the geometry.tor file. Save design and close CHAMP.

The geometry.tor file contains this section which we will modify.

```
  origin            : struct(x: 0.0 m, y: 0.0 m, z: 0.0 mm)
)

exterior  circular_symmetric_horn_exterior
(
  length_unit       : mm,
  nodes             : table
    (
      4.969817264264427E-01    2.436607239797561E+01
     -1.582210898121275E+02    1.589091730484084E+01
     -2.054132502384396E+02    1.589091730484084E+01
     -2.052016389875394E+02    1.313649123727826E+01
    ),
  z_offset          : 0.0 mm
)
```

Open the output file of COWSDT and copy all. Replace the "exterior_circular_symmetric_horn_exterior retaining the last two points, z_offset, etc. Add the variable aperture point: 0 "ref(rout)" to the top of "exterior" bor_mesh.
Erase "horn_bor_mesh" portion and remove it from the scatterers list at the top of the geometry.tor file.

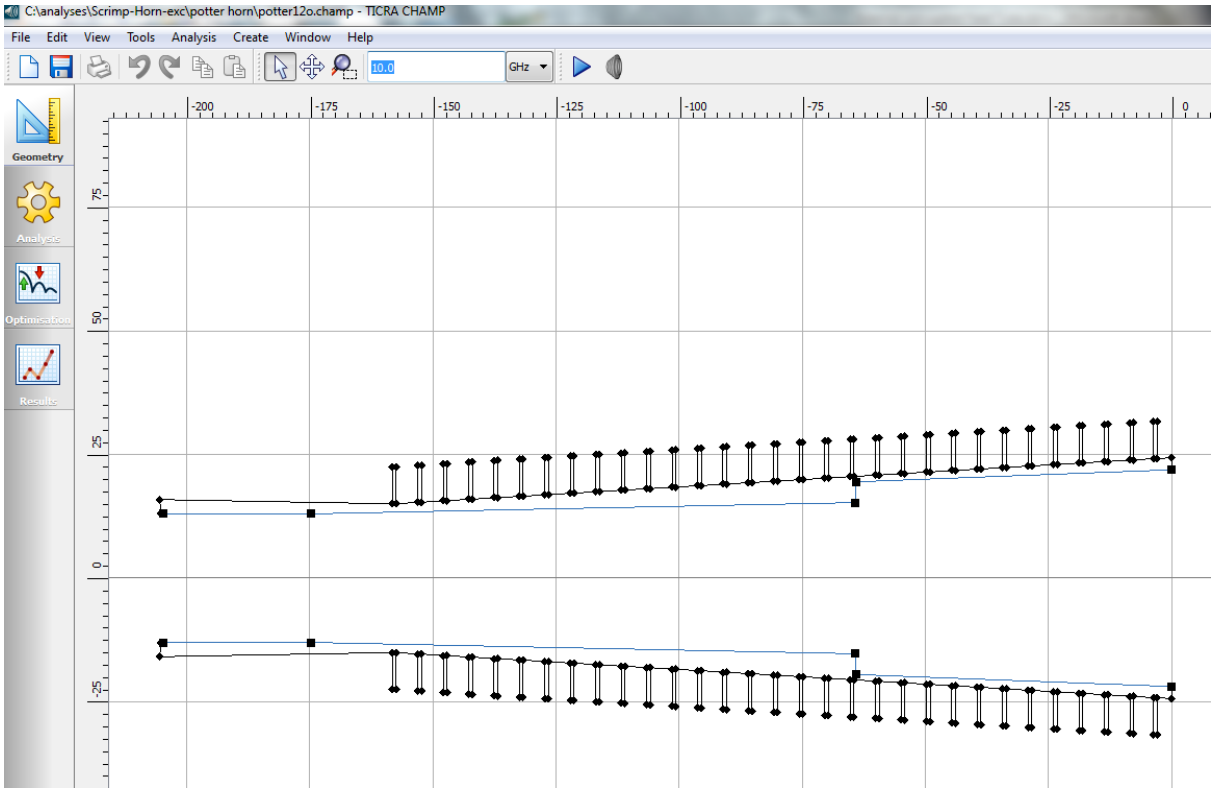


Figure 20 12 dB Gain Potter Horn Geometry with 31 ridges external corrugations

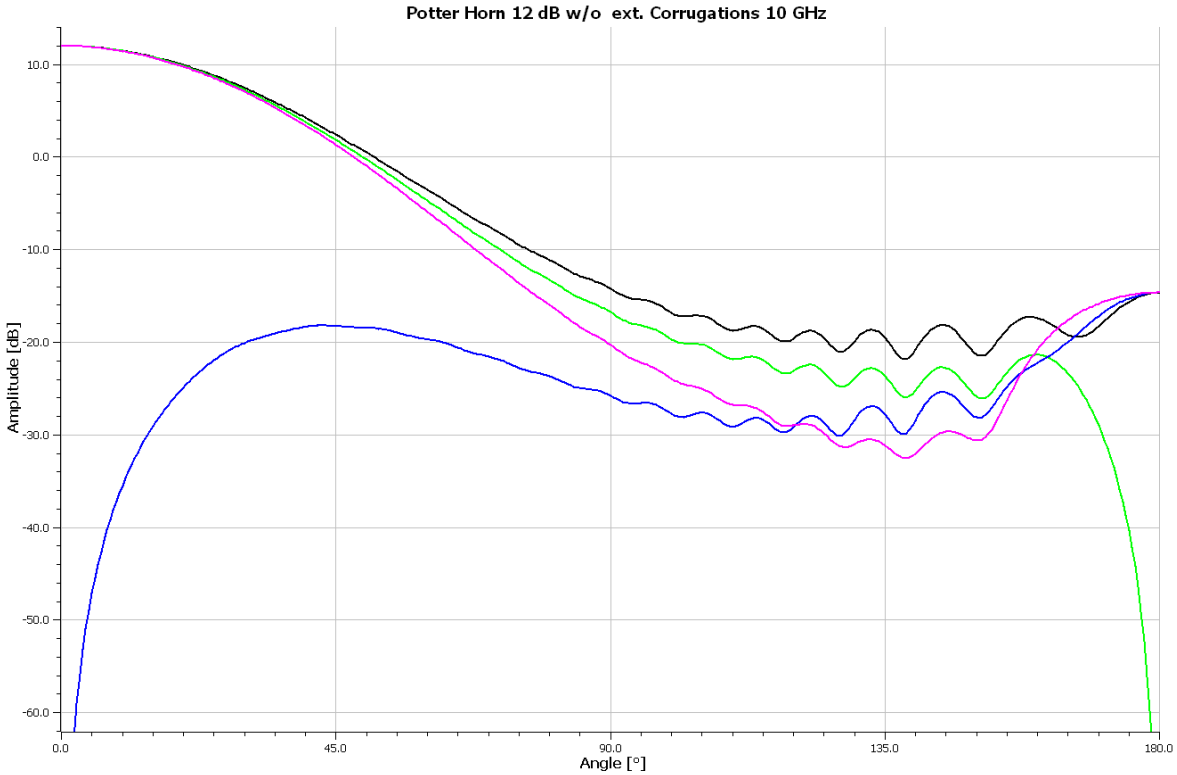


Figure 21 12 dB Gain Potter Horn Geometry without external corrugations

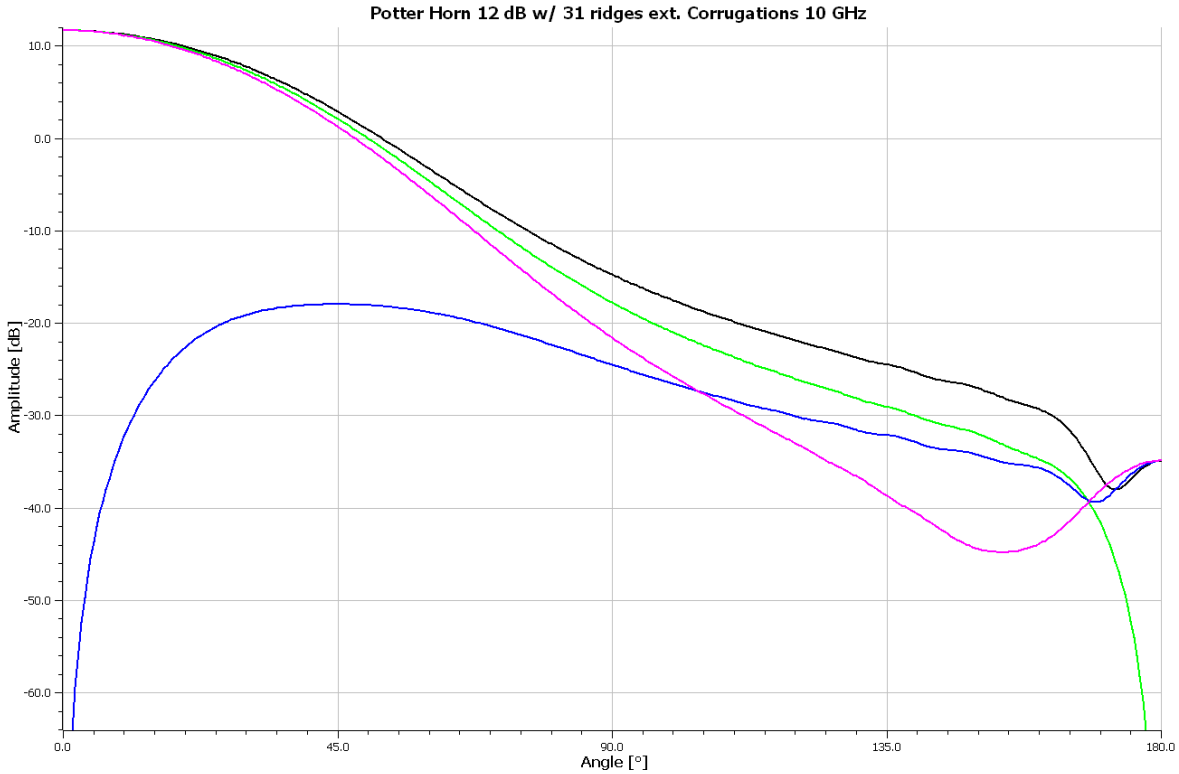


Figure 22 12 dB Gain Potter Horn Geometry with 31 ridges external corrugations

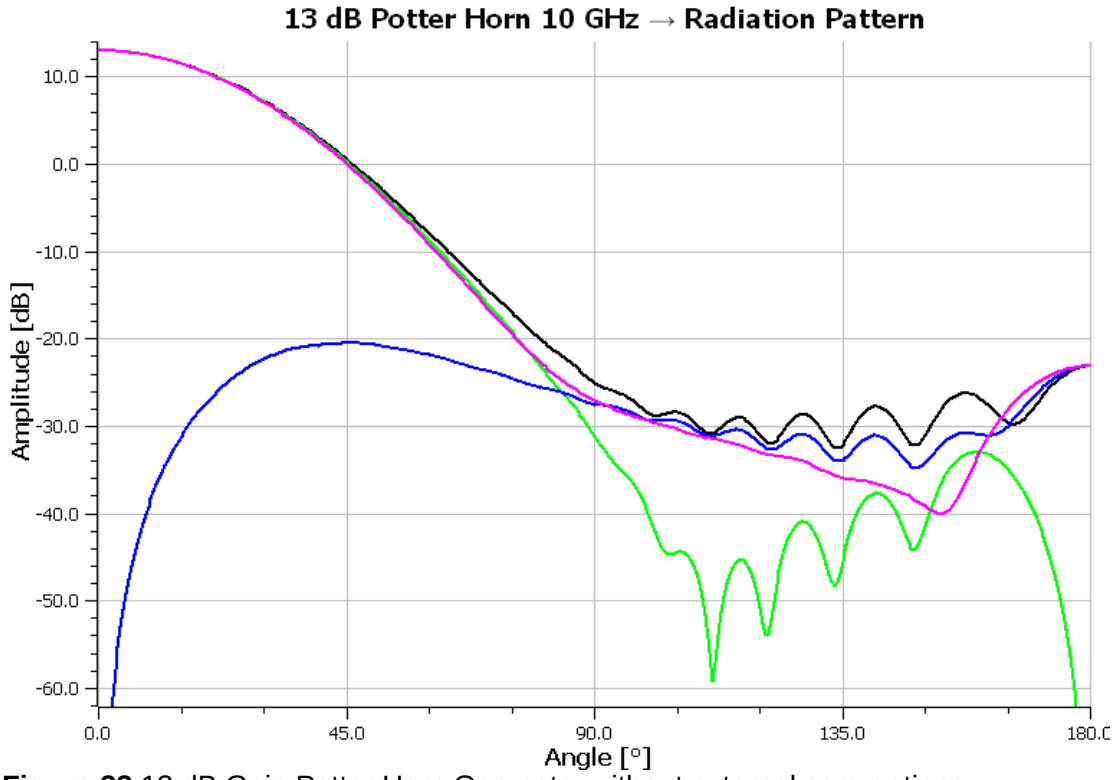


Figure 23 13 dB Gain Potter Horn Geometry without external corrugations

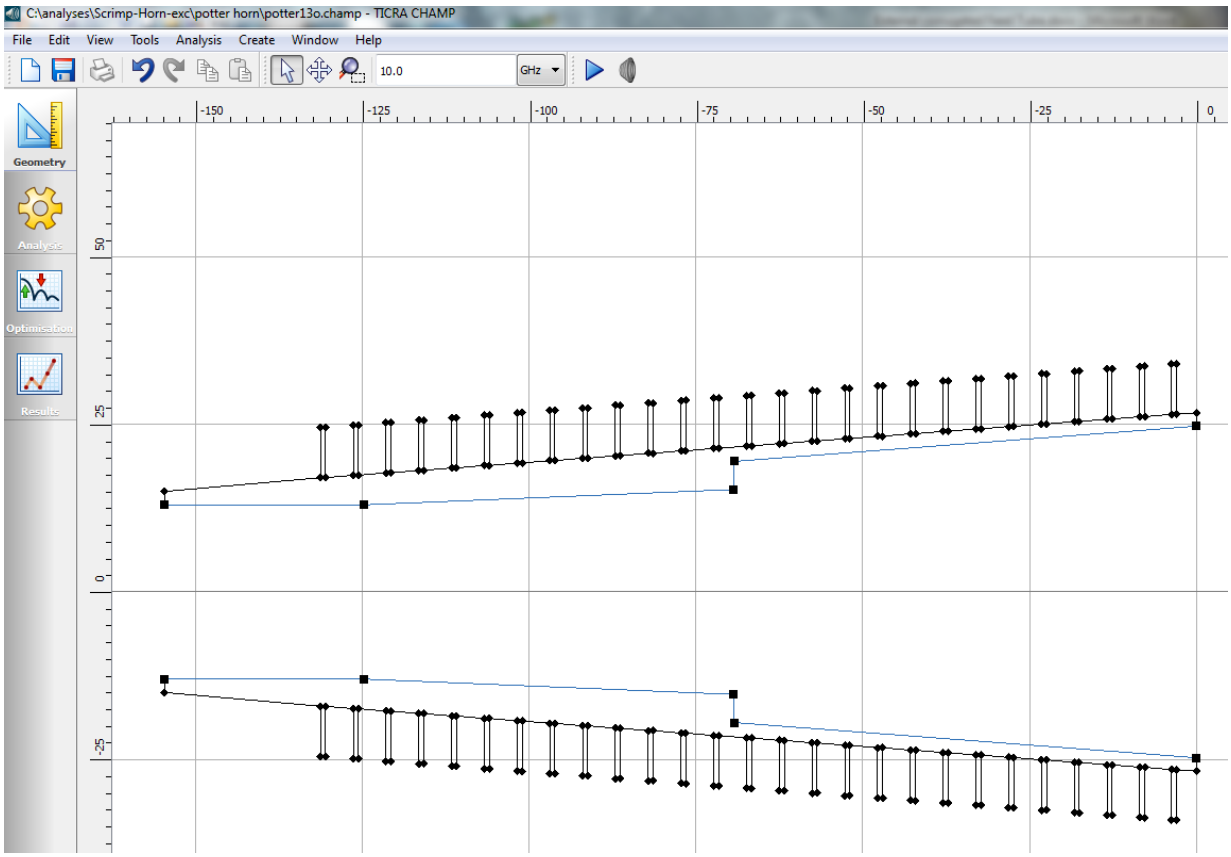


Figure 24 13 dB Gain Potter Horn Geometry with 27 ridges external corrugations

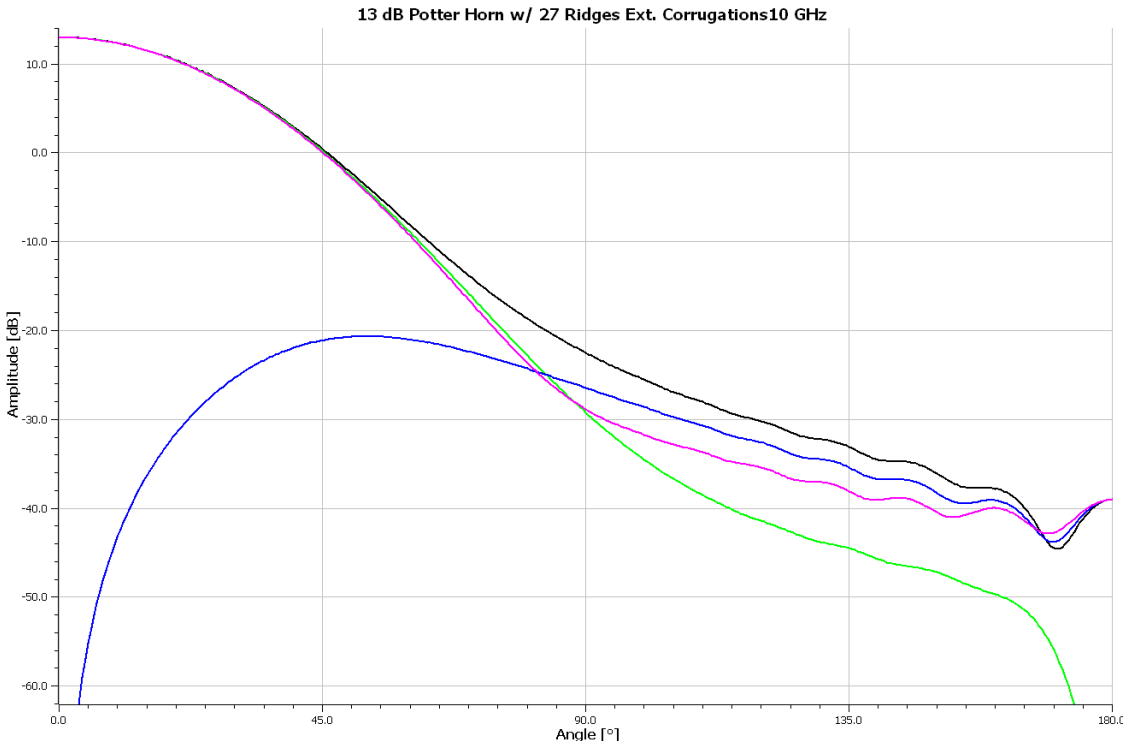


Figure 25 13 dB Gain Potter Horn Geometry with 27 ridges external corrugations

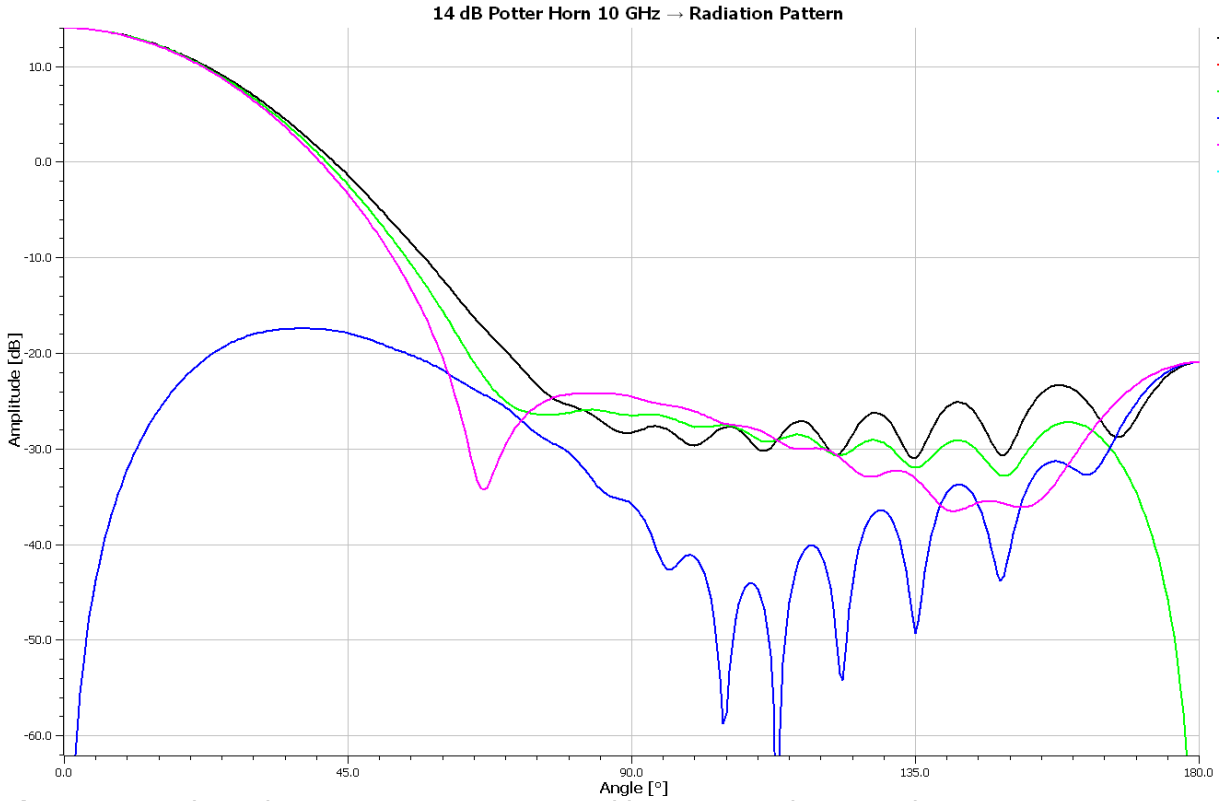


Figure 26 14 dB Gain Potter Horn Geometry without external corrugations

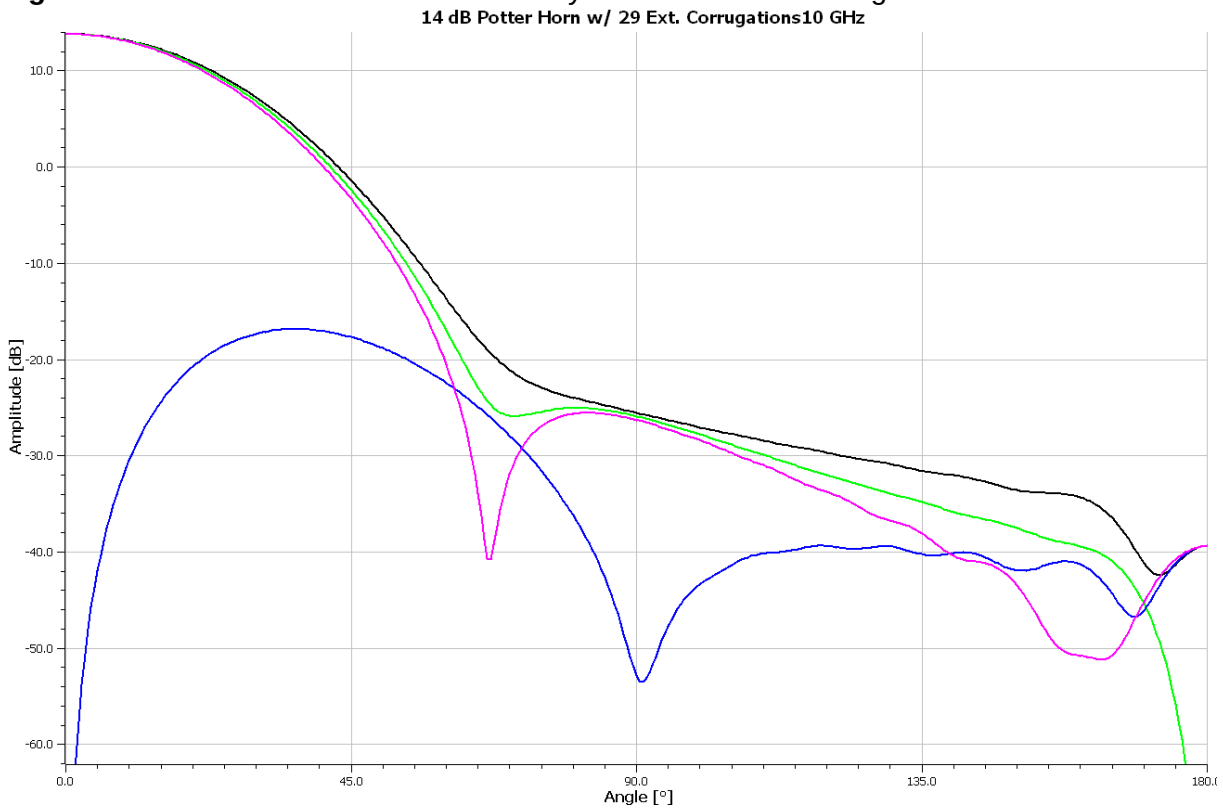


Figure 27 14 dB Gain Potter Horn Geometry with 29 ridges external corrugations

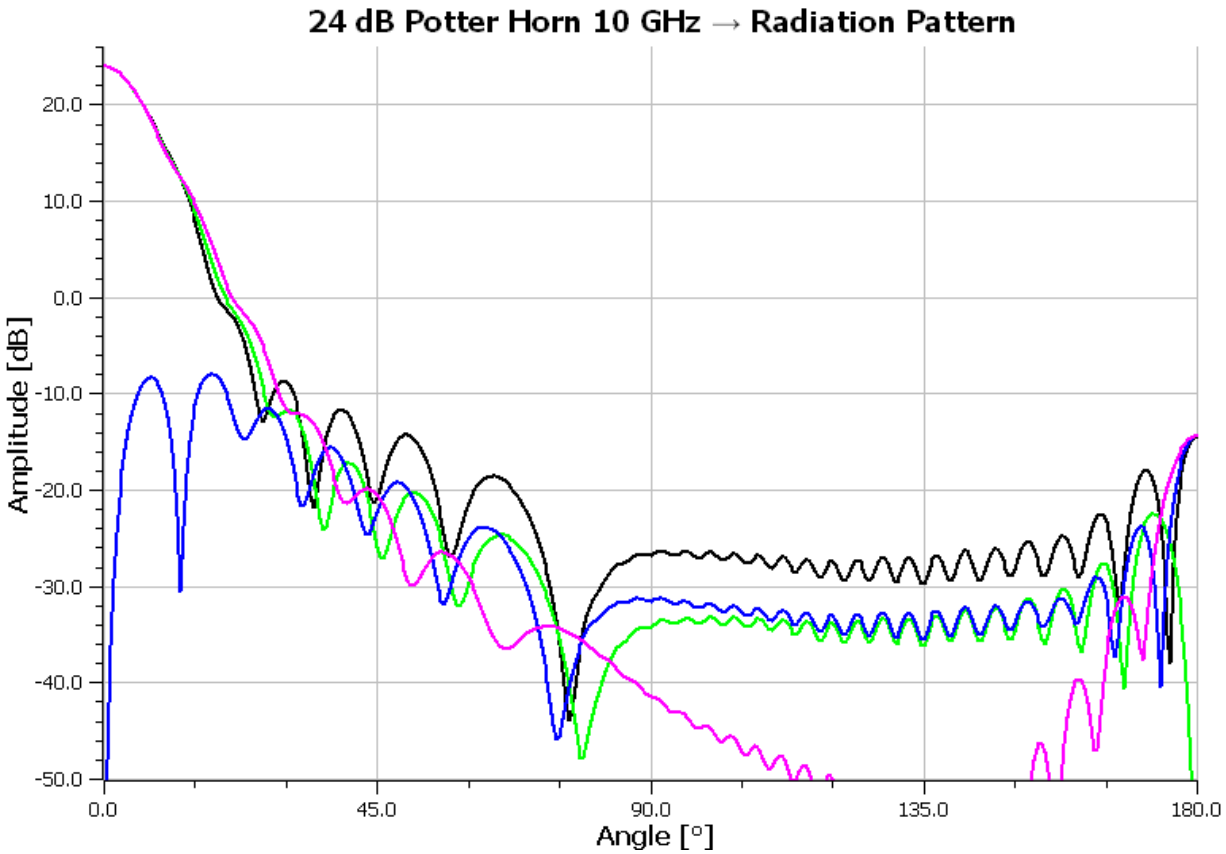


Figure 28 44 dB Gain Potter Horn Geometry without external corrugations

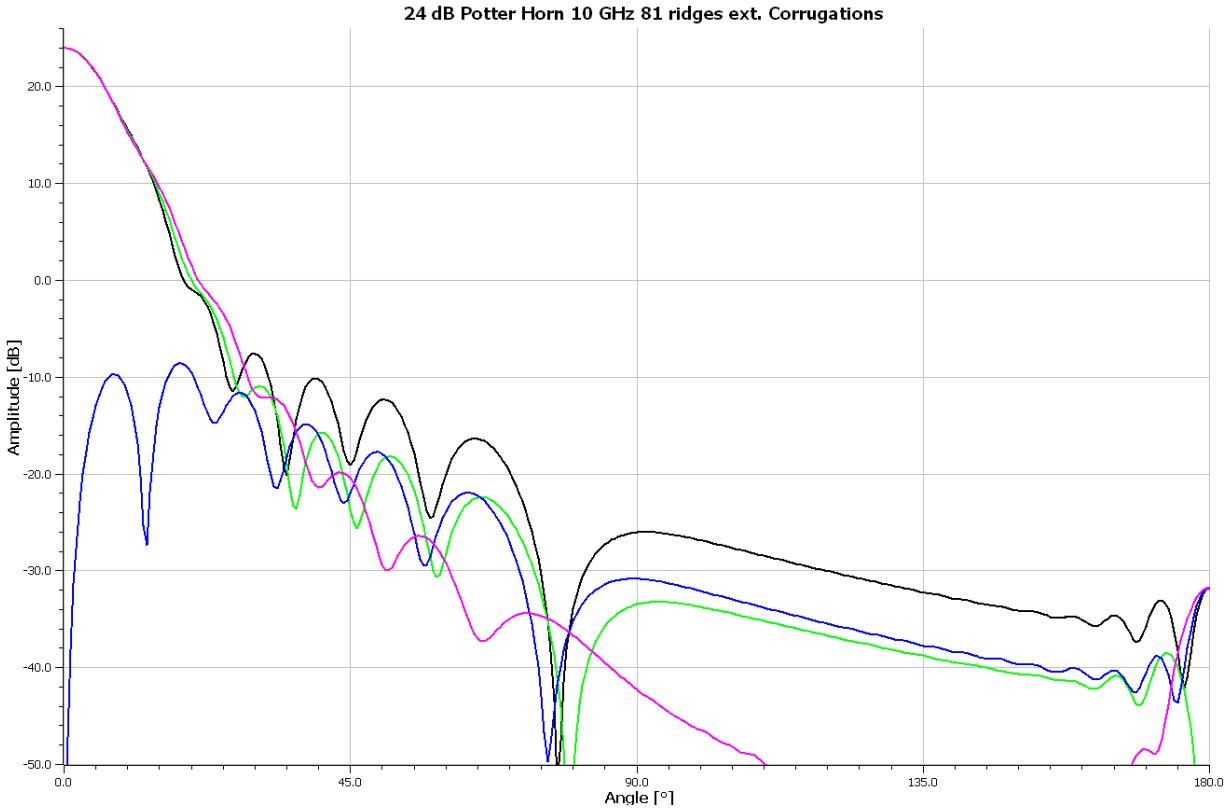


Figure 29 24 dB Gain Potter Horn Geometry with 81 ridges external corrugations

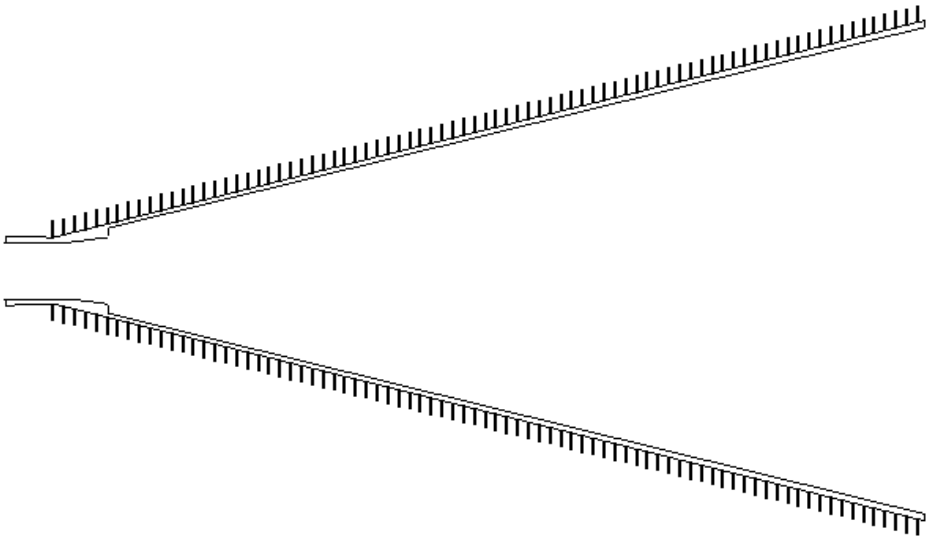


Figure 30 24 dB Gain Potter Horn with 81 ridges External Corrugations

Although it takes many corrugation ridges for a 24 dB gain horn, they reduce the backlobe significantly even with the large cone angle compared to Figure 24 of the 14 dB horn. The low level of backlobe for the horn with or without corrugations is quite and improvement may not matter.

Scrimp Horn with External Corrugations

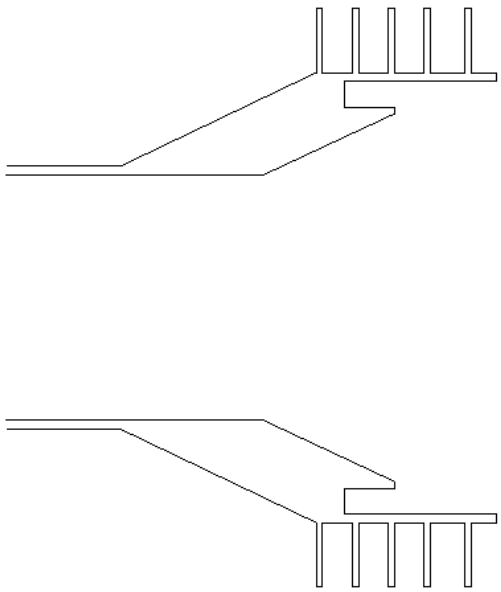


Figure 31 0.84λ radius Scrimp Horn with 5 ridge External Corrugations

The short exterior length limits the number of corrugations and cannot have a great effect on the backlobe reduction. The horn response is sensitive to its exterior and changed by corrugations.

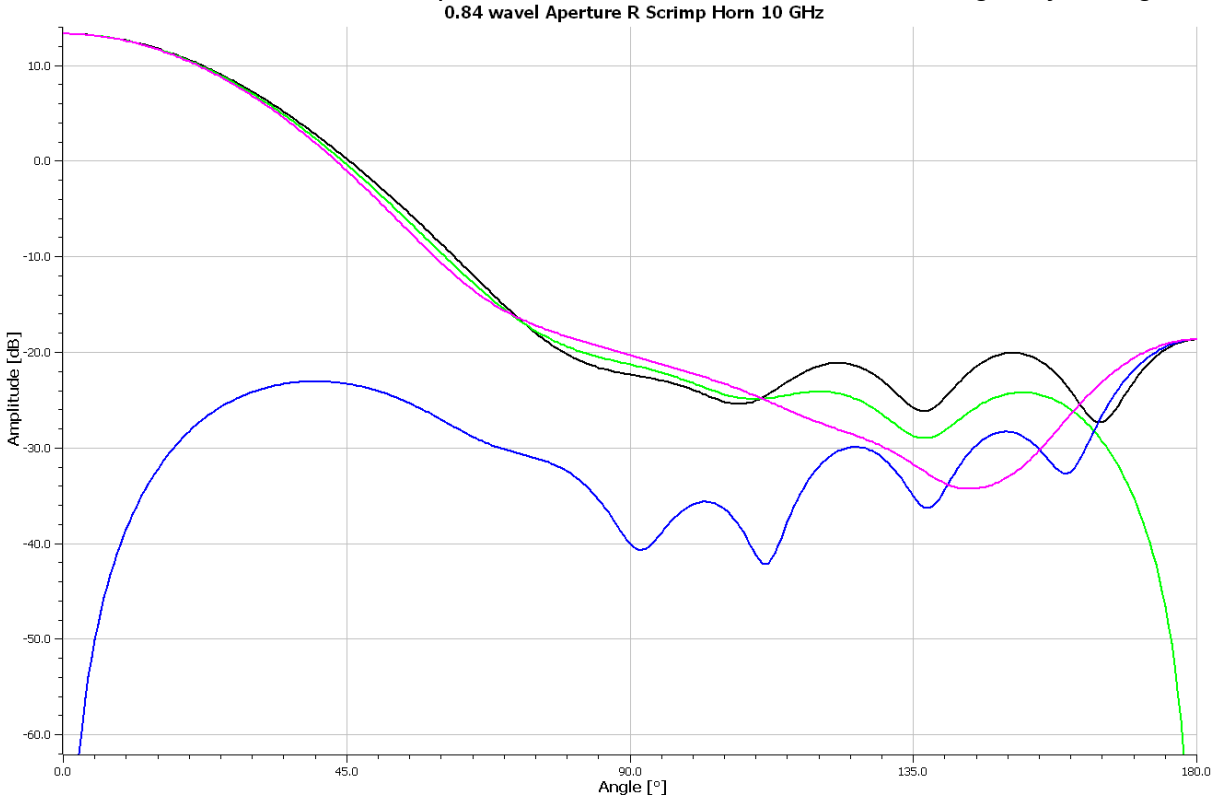


Figure 32 0.84λ radius Scrimp Horn without External Corrugations

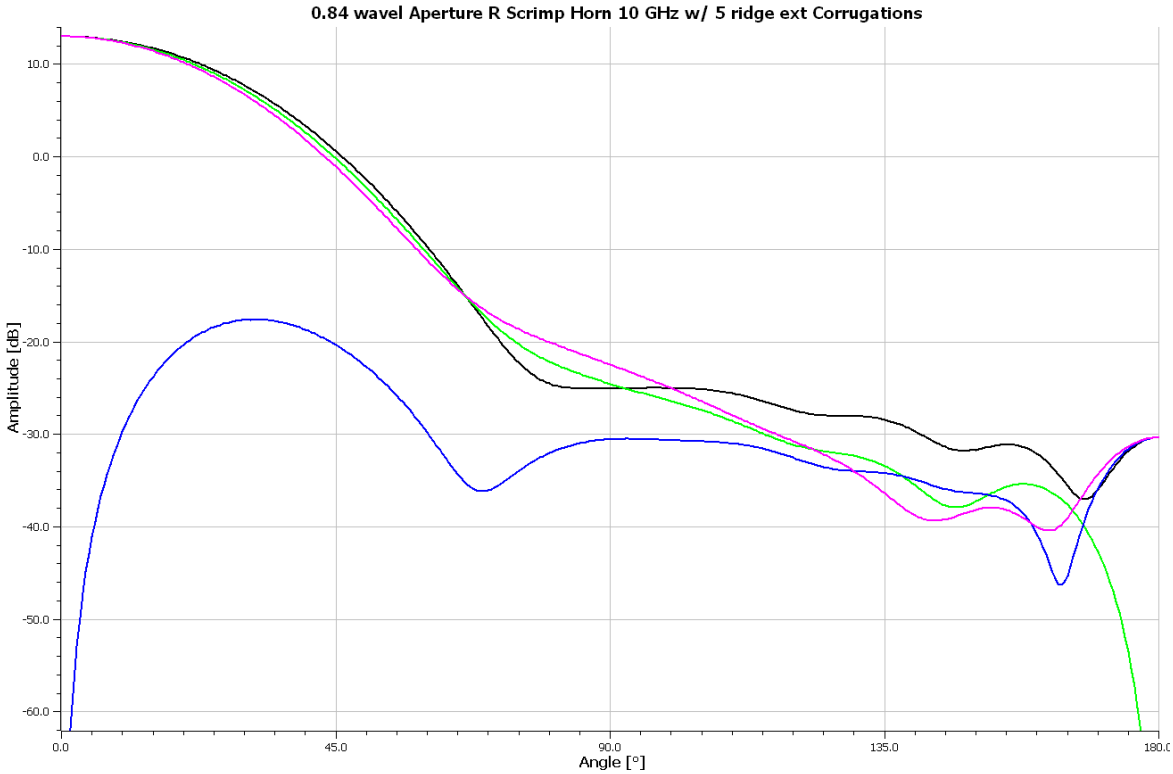


Figure 33 0.84λ radius Scrimp Horn with 5 ridge External Corrugations

Adding more corrugations along a lengthen exterior has some effect.

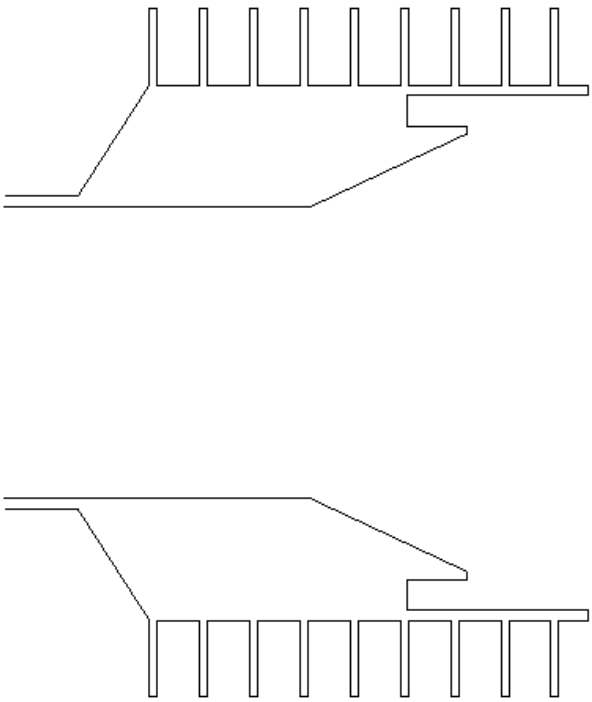


Figure 34 0.84λ radius Scrimp Horn with 9 ridge External Corrugations

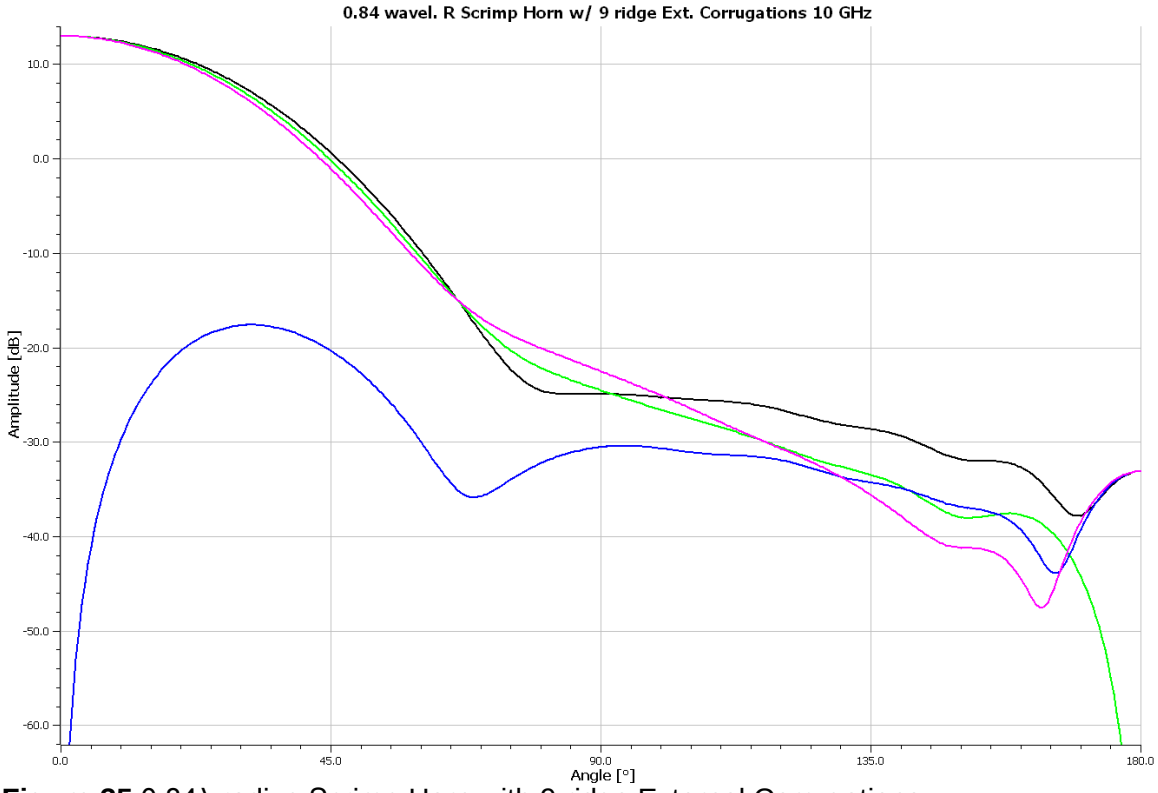


Figure 35 0.84λ radius Scrimp Horn with 9 ridge External Corrugations

External Sinusoidal Corrugations

We can alter the shape of external corrugations and achieve excellent F/B. The program COWSINDT generates the geometry.tor addition for CHAMP to generate sinusoidally shaped corrugations. It is similar to COWSDT that creates optimization variables for the up to 7 variably spaced and height corrugations with the rest evenly spaced with a linearly variable heights. A geometry. tor addition of a second program, COWSPLI, uses variables for height (*r*) along the *z*-axis for every point in linear segments to approximate a spline not available in CHAMP using *z* as the independent variable. COWSPLI starts and finishes with uncorrugated sections so that it can be located arbitrarily along the external feed tube and used in a more general optimization. Section 8-23 illustrates how the optimization of the external corrugations or the surface (a smooth spline) can be used to optimize the pattern of a small diameter reflector using a splash plate feed.

Turrin Horn 0.62λ Diameter with Sinusoidal Corrugations

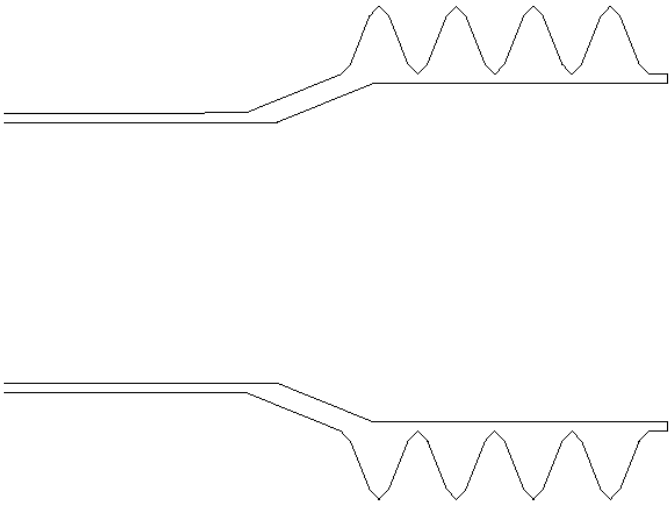


Figure 36 0.62λ radius Turrin horn with 4 sine ridges exterior corrugations

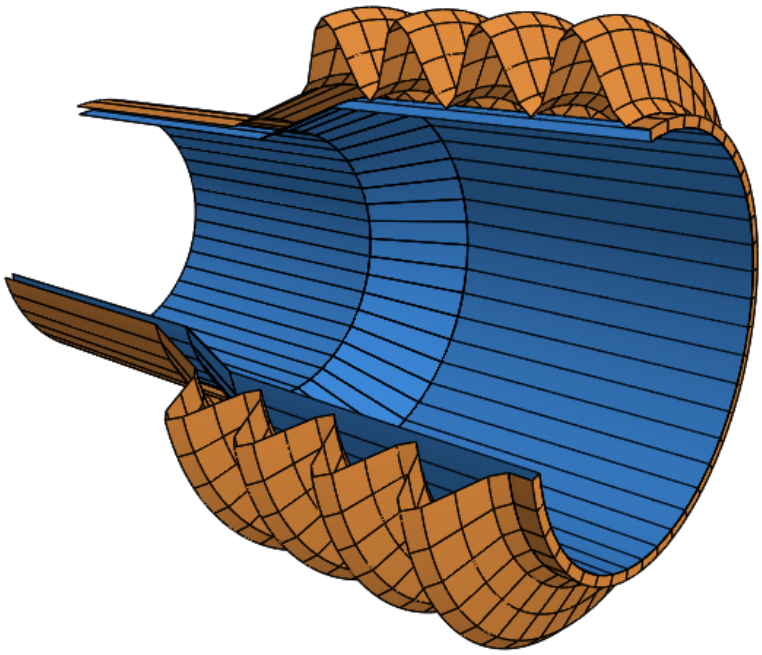


Figure 37 0.62λ radius Turrin horn with 4 sine ridges exterior corrugations

The horn shown in Figures 36 and 37 have the same length as in Figure 14 of the Turrin horn with 8 sharp ridged corrugations. The 4 sinusoidal corrugations improve the F/B, shown in Figure 38, when compared to Figure 16 of the 8 corrugations along the same length.

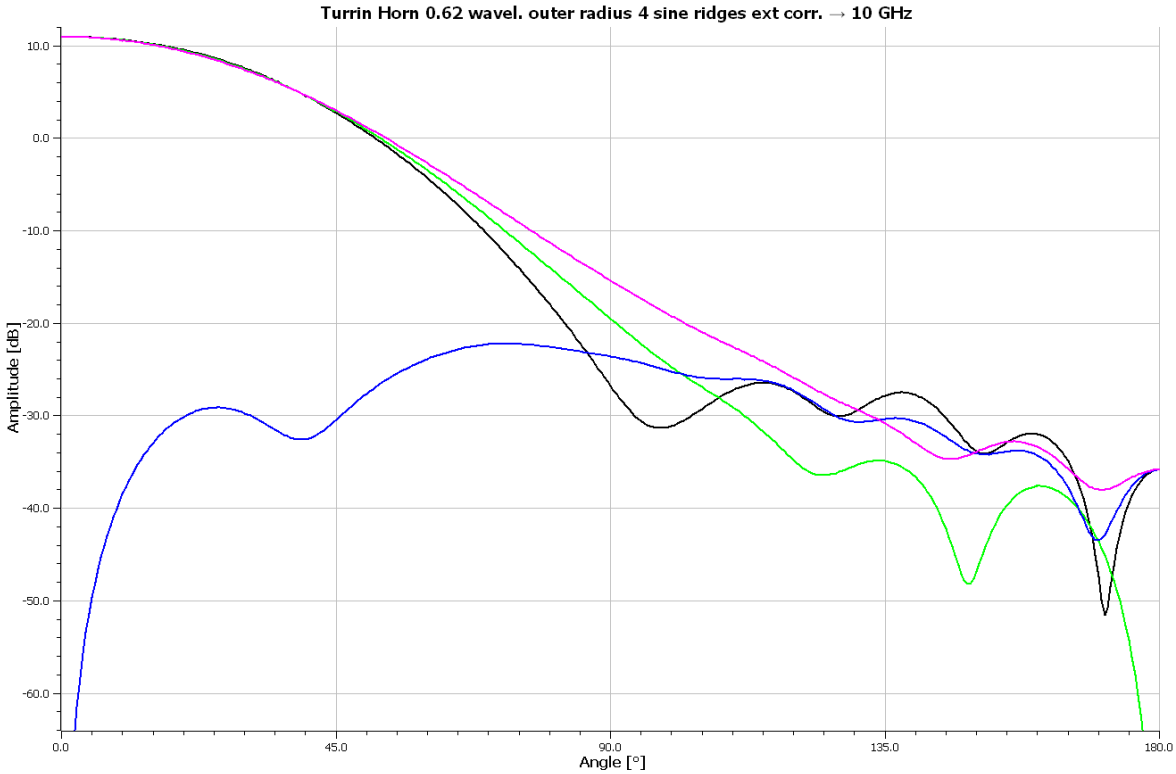


Figure 38 Center frequency response of 0.62λ radius Turrin horn w/ 4 sine ridge ext. corrugations