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TE Mode Ridged Waveguide Cavities for ADMX Research

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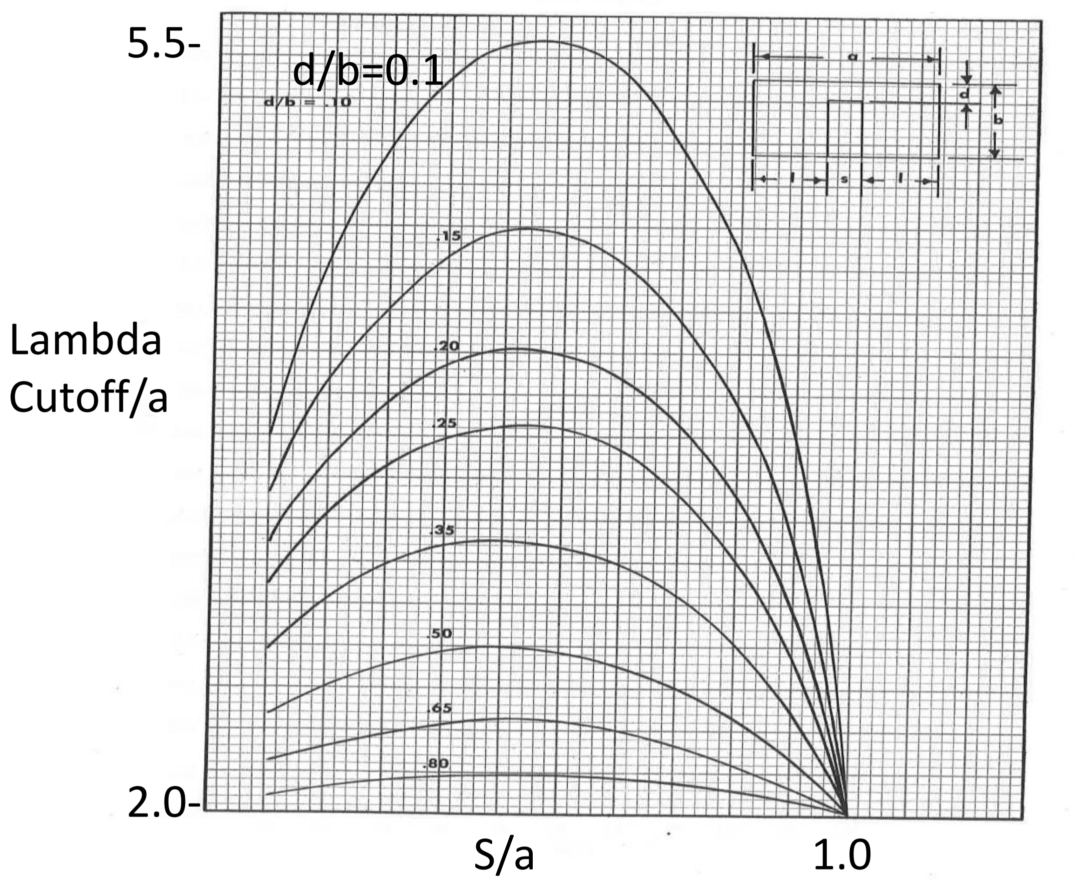
Introduction

- 1. Background on Ridged Wave guide
- 2. Advantages of Ridged WG cavities
- 3. Cavity designs that cover the range from 2 to 20 GHz
- 4. Discussion of the effect of tolerances on the cavity
- 5. Summary

Background on Ridged Wave guide: Single Ridge TE10 Cutoff Chart



- 1. Chart demonstrates that you can get very large bandwidths depending on the width of the ridge and the depth of penetration of the ridge.
- 2. By working in the middle of the chart, it demonstrates a bandwidth of 2.75 before other modes begin.
- 3. For the Ridge waveguide cavity in this study, I have used a S/a value of 0.5 and nearly square waveguide.

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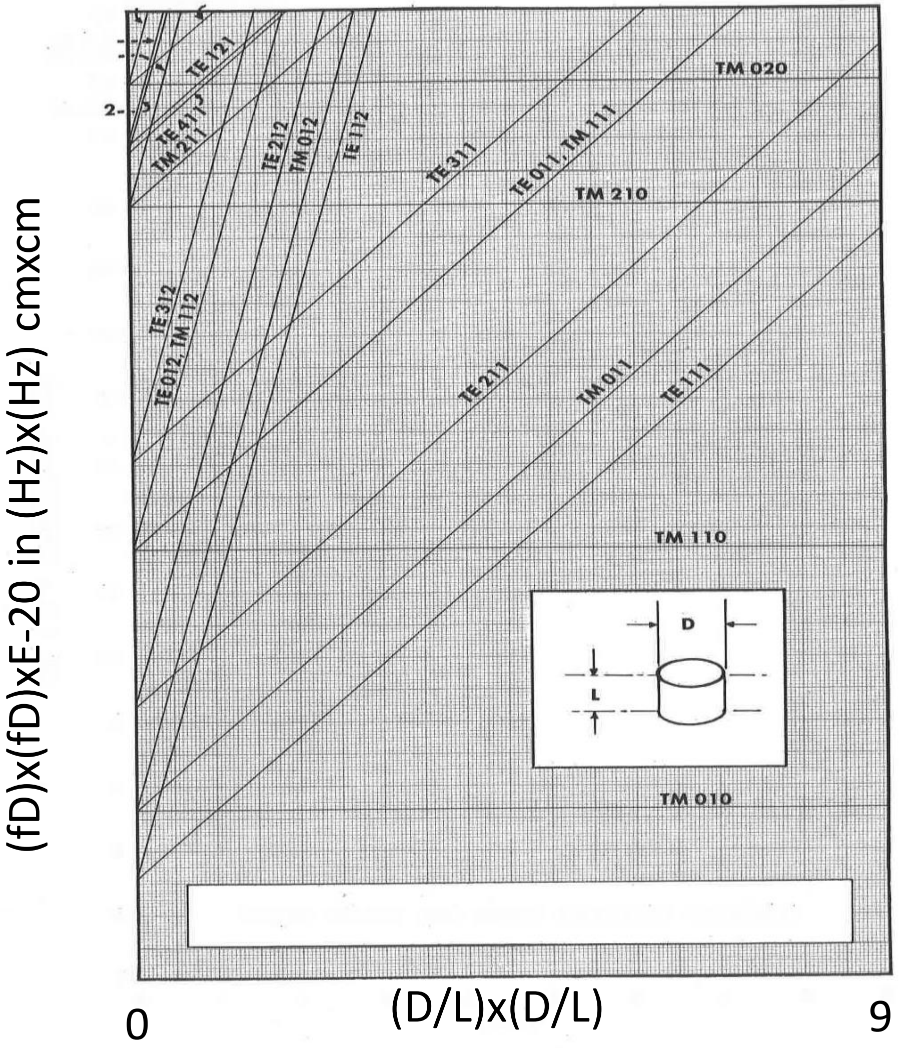
Background Continued: frequency Mode chart

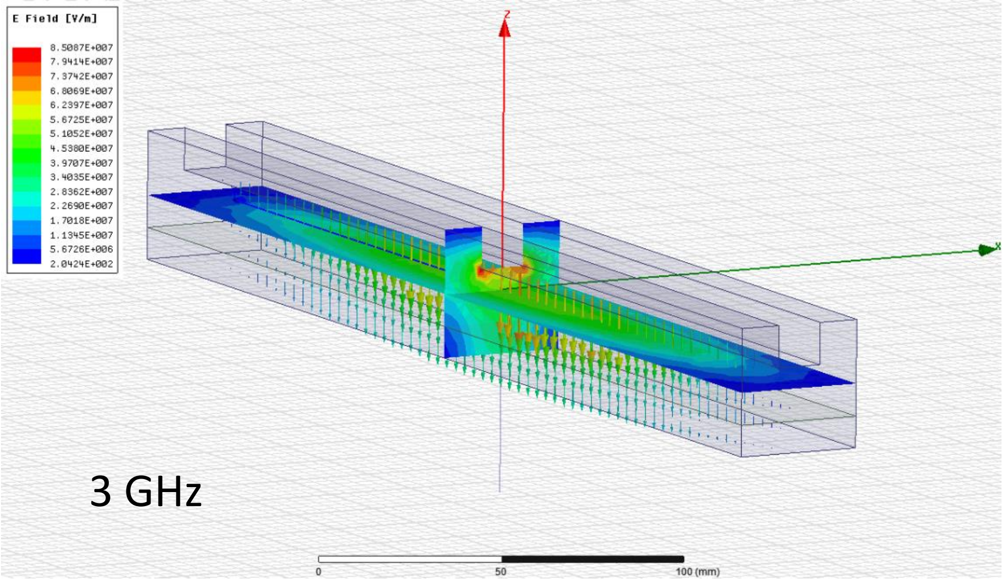


- The chart is for the modes in a right circular cylinder. However, except for the frequency scale it would apply to a square waveguide (type used in this study). The only thing that would be different is the labelling of the modes. TE11 becomes TE10 in square WG and the scale would be lower, and TM01 becomes the TM11.
- The other thing to note is that as the length (L) becomes very long the TE11 (sqTE10) become the lowest order mode on the chart.
- The ridged WG cavities because of their large bandwidths will allow these cavity designs to have a frequency range of over 2. The designs that will be shown are circular ,i.e., a straight ridged WG is formed into a circle closing on itself.
- The circular form of the cavity allows the termination of the cavity to be matched at its cutoff frequency with constant E along its circumference.

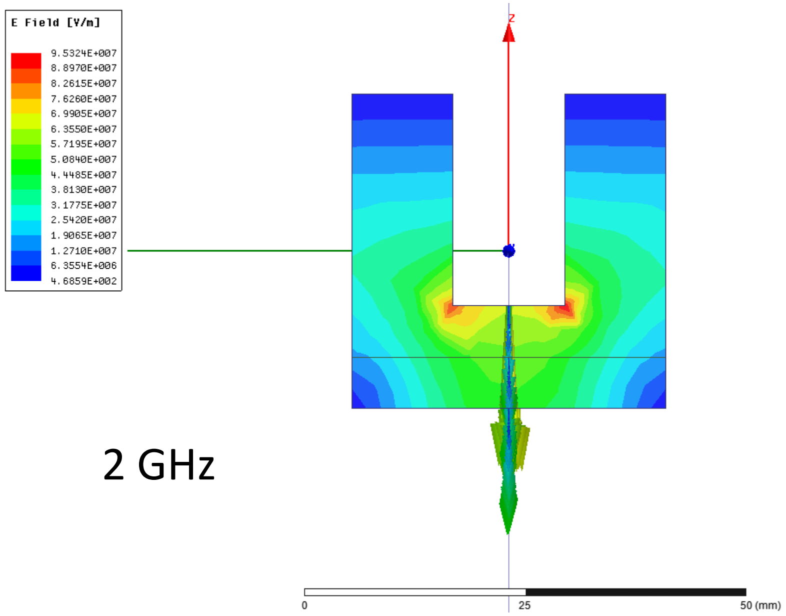
TE101 Mode Ridged Waveguide for ADMX Studies

Advantages of Ridged WG:

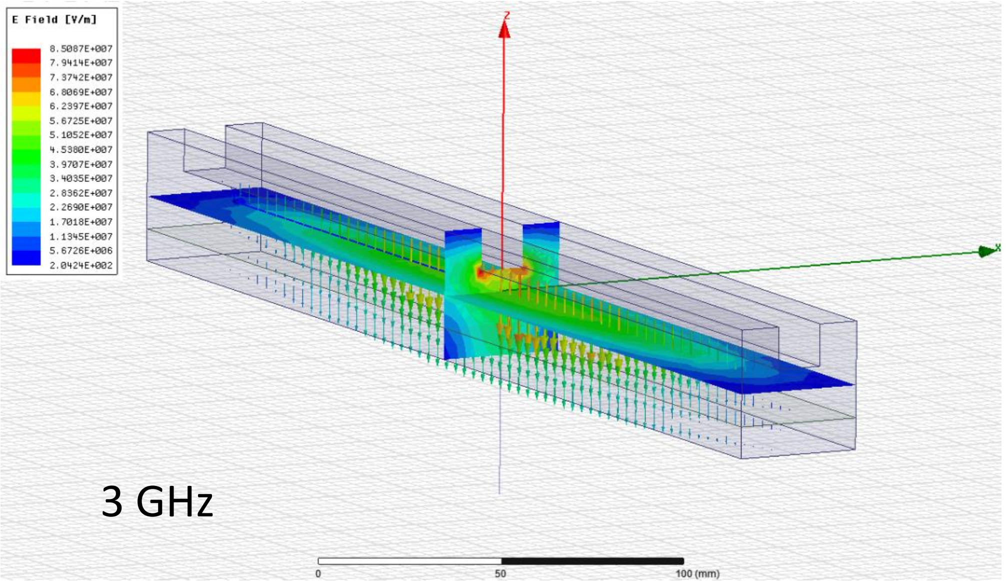
1. Lowest order mode; no crossing modes
2. The width and depth of the ridge as well as the width and height of the WG determines the frequency.
3. There is no need to verify the mode. It will always be the lowest.
4. Possibility 2 to 5, 5 to 10 and 10 to 20 GHz cavities nested inside each other can be made to fit into one 50 cm bore magnet. If the merit factor and Qo fall of the far the frequency ends. The cavity could be maded into smaller groups to fit the magnet.



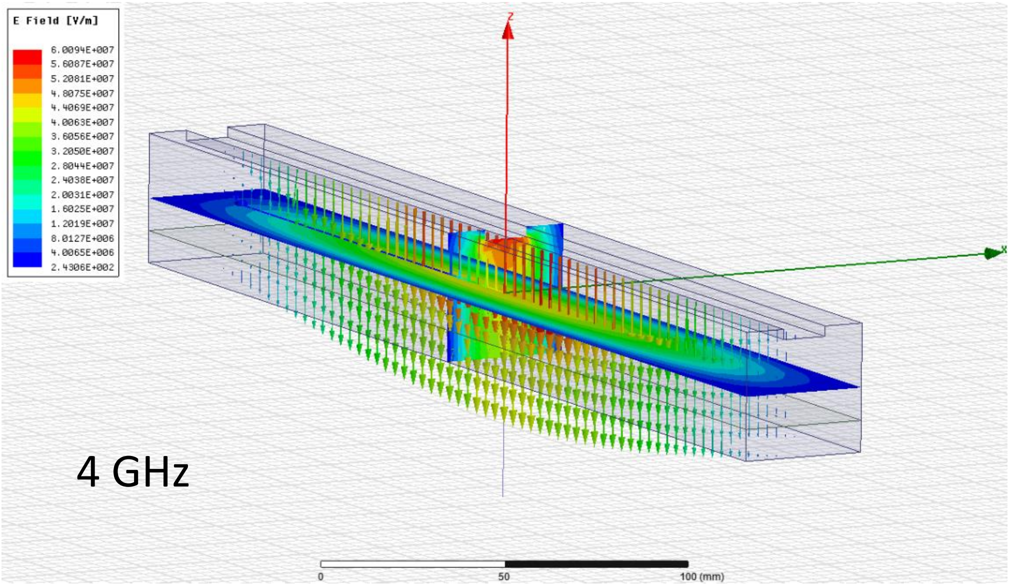
The lowest mode for straight ridge WG shown above is the TE101. If it is long enough it can still have bandwidth of over 2. However, the circular design will have even higher bandwidth because the modes must satisfy the boundary of only TE10 n evenallowed.



2 GHz



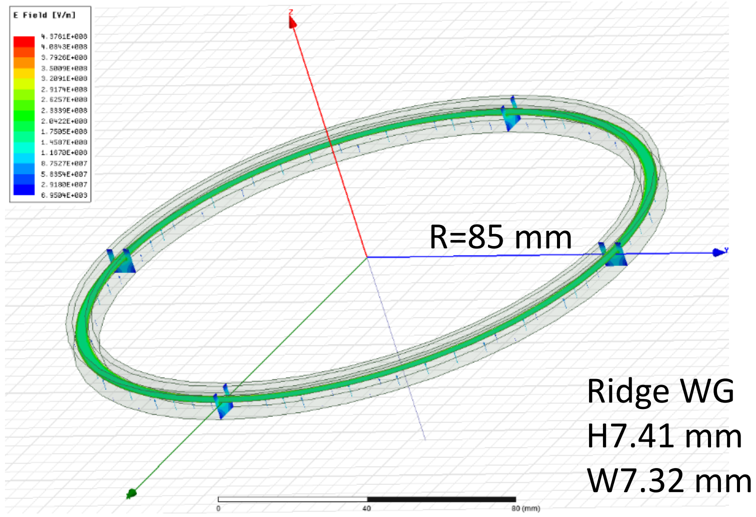
3 GHz

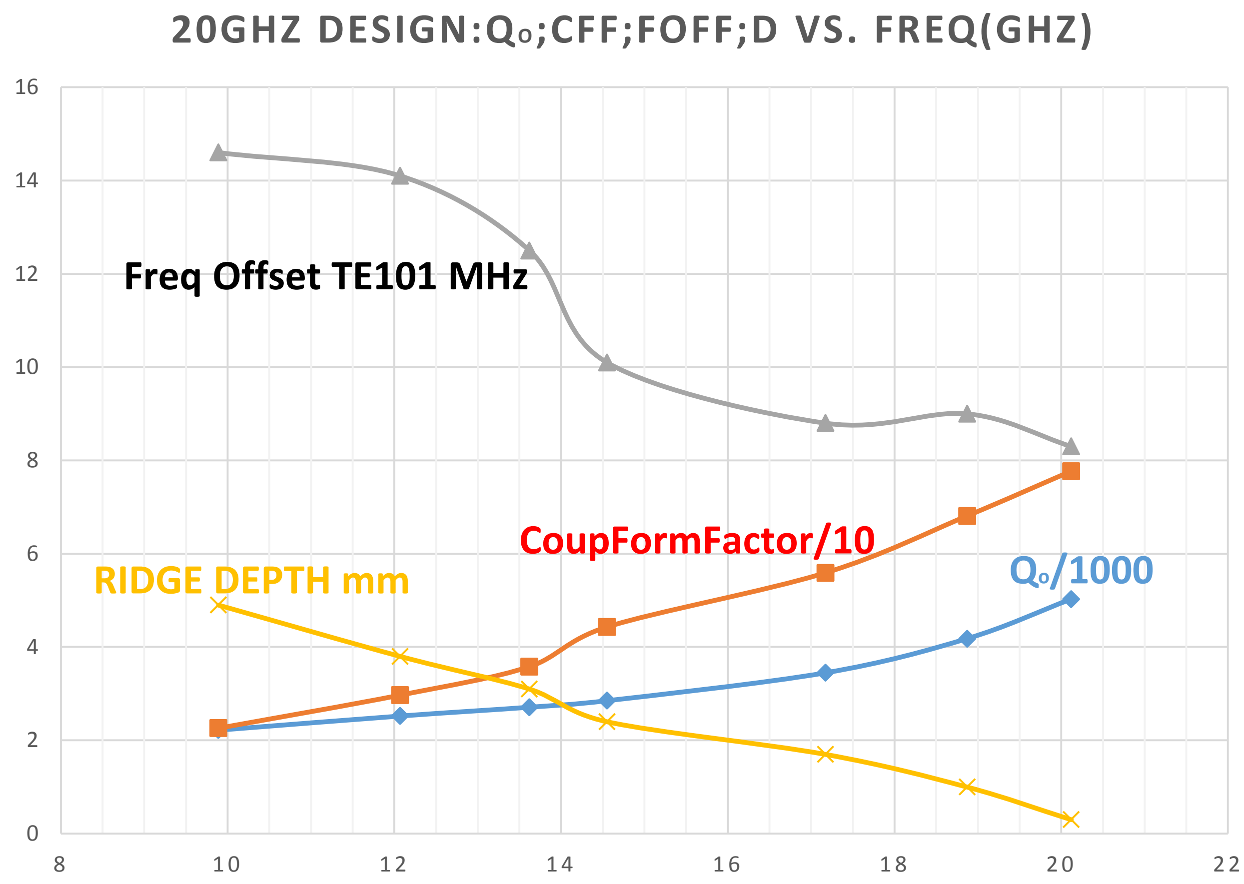


4 GHz

Straight Ridged WG cavity that covers the frequency range of 2-4 GHz.

20 GHz Circular Ridged WG Design Parameters



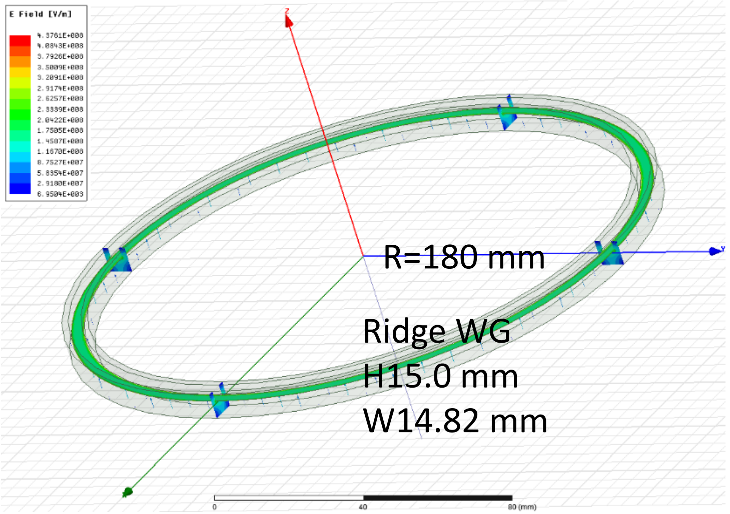


The Coupling Form Factor of 0.8 is quite high a 20 GHz. It only drops down to 0.5 at 14 GHz. This should may make it useful over larger frequency range.

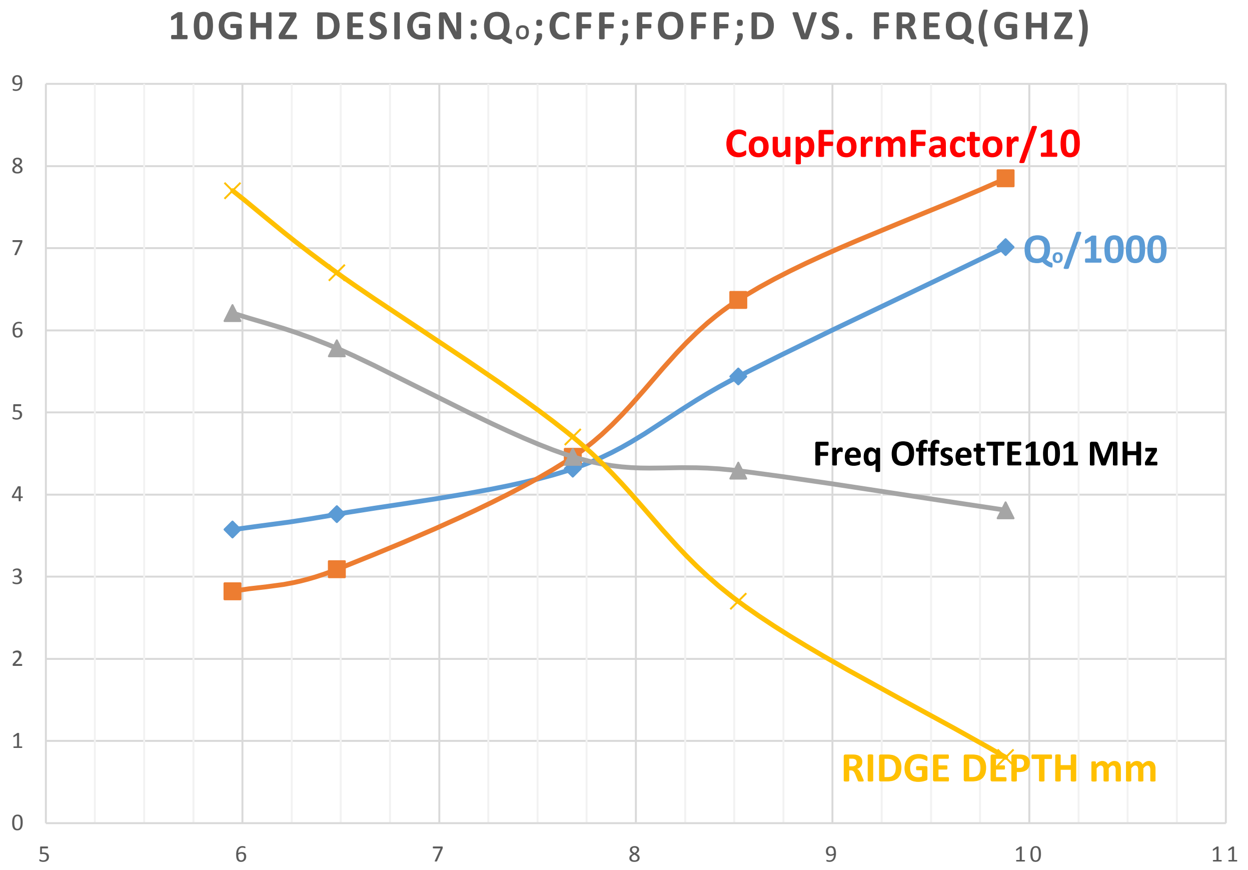
The Freq Offset is the difference in frequency of dominant TE100 and the next crossing resonance of the TE101.

The large frequency differences shown may make the design more tolerant in tolerances.

10 GHz Circular Ridged WG Design Parameters



The Coupling Form Factor of 0.8 is quite high a 10 GHz. It only drops down to 0.5 at 7.9 GHz. This should may make it useful over larger frequency range.
The Freq Offset is the difference in frequency of dominant TE100 and the next crossing resonance of the TE101.
The large frequency differences shown may make the design more tolerant in tolarences.



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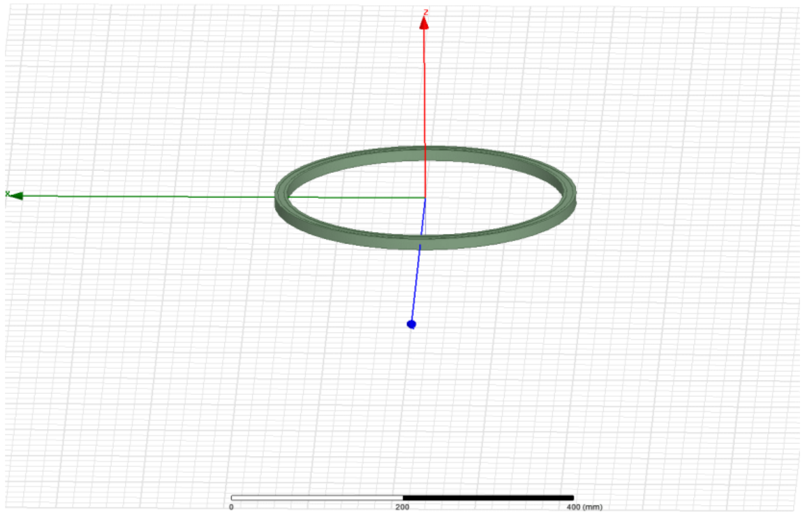
Circular Ridge WG Cavities Feathers

- The circular form of the ridged WG cavity allows the termination of the cavity to be matched at its cutoff frequency. There is no phase or amplitude difference along its circumference.
- This also means that cavity resonances must be matched in phase and only TE10neven modes are allowed. This will eliminate half of the crossing modes.
- The circular designs shown have demonstrated large bandwidths free of crossing modes of over a factor 2.
- Cavities of different frequencies and radii can be nested together in one plane of the ADMX magnet to fill in most of the available space.
- Cavities of the same frequency and different radii can also be nested together to fill in most of the space. Now, because the lowest mode is operates at cutoff, they will have the same lowest frequencies, but will have different tuning curves.



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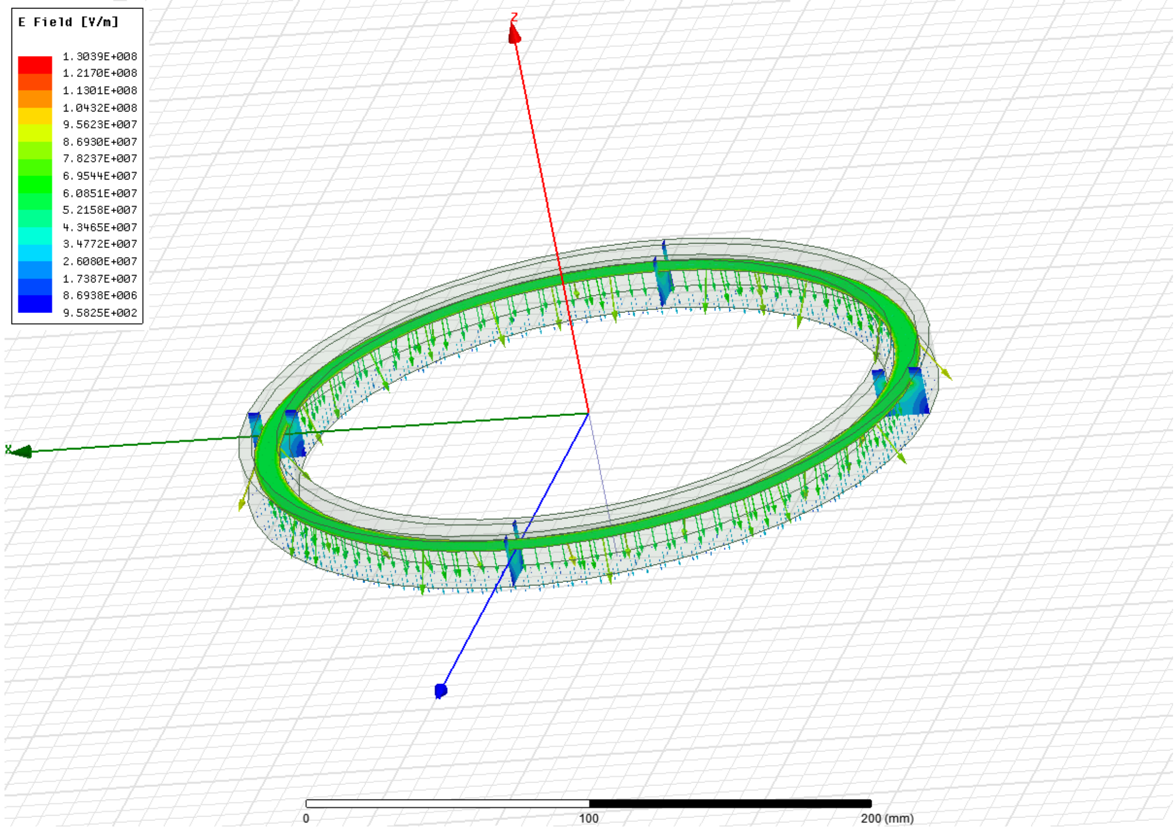
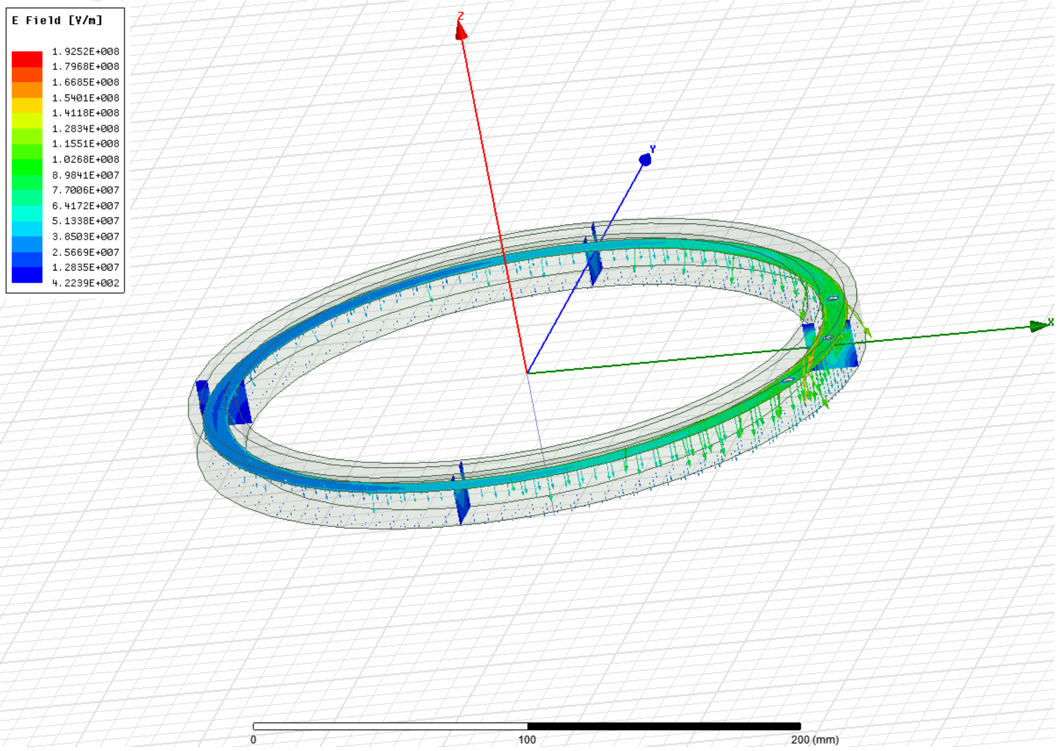
Field Distribution with no Tubular perturbations to the cavity.

Things to note with no tolerance errors in the simulation without the insertion of small tubular perturbations in the geometry:
The color is a uniform light green throughout the simulation and the arrows are all about the same length. This is expected because the cavity is at the cutoff mode of the cavity WG. The amplitude and phase are constant throughout the cavity.



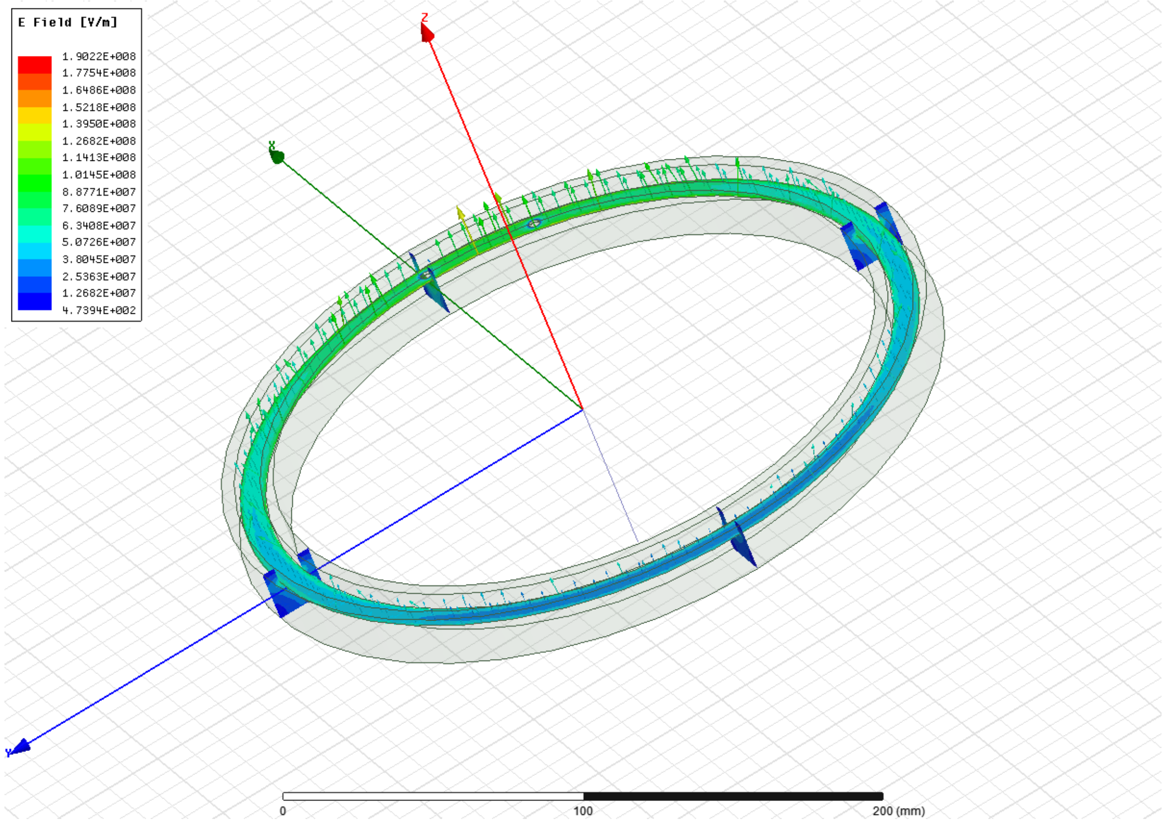
Cavity with 3 tube holes r=2,d=1 mm perturbations on center line of Ridge

Things to note with 3 tubular holes:
The color is a no longer uniform. It goes from light green to dark blue. The arrows vary in size, but not in their direction.
This, (I believe) is to be expected because Of the large difference between the dominant in frequency TE100 and the nearest crossing mode the TE101as shown above.
The perturbation corresponds to tolerance of 7.5 um.
The Coupling Form factor (CFF) was only reduced by 10 % to .44 and the Q was reduced by less than 1 %.



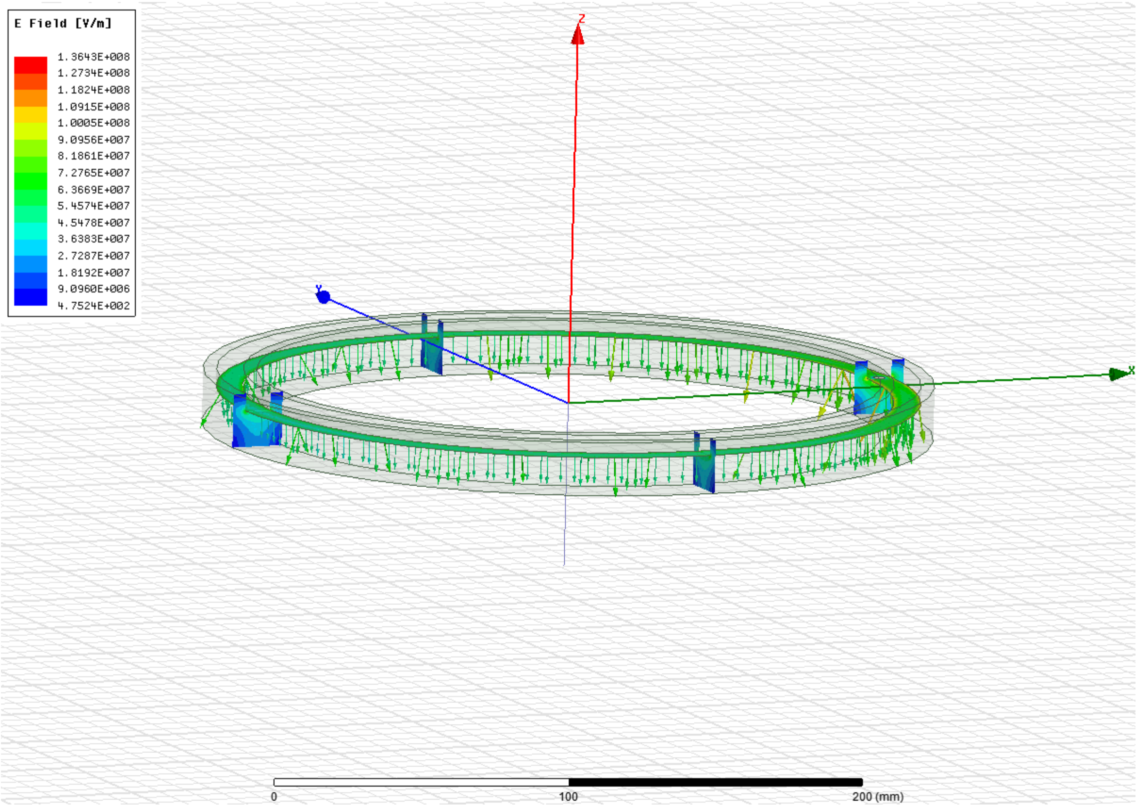
Cavity with 2 tube holes r=2,d=1 mm perturbations on center line of Ridge

Things to note with 2 tubular holes:
The color is a no longer uniform. It goes from light green to light blue. The arrows vary in size, but not in their direction.
This, (I believe) is to be expected because Of the large difference in frequency between the dominant TE100 and the nearest crossing mode the TE101as shown above.
The perturbation corresponds to tolerance of 5 um.
The Coupling Form factor (CFF) was only reduced by 7 % to .45 and the Q was reduced by less than 1 %.



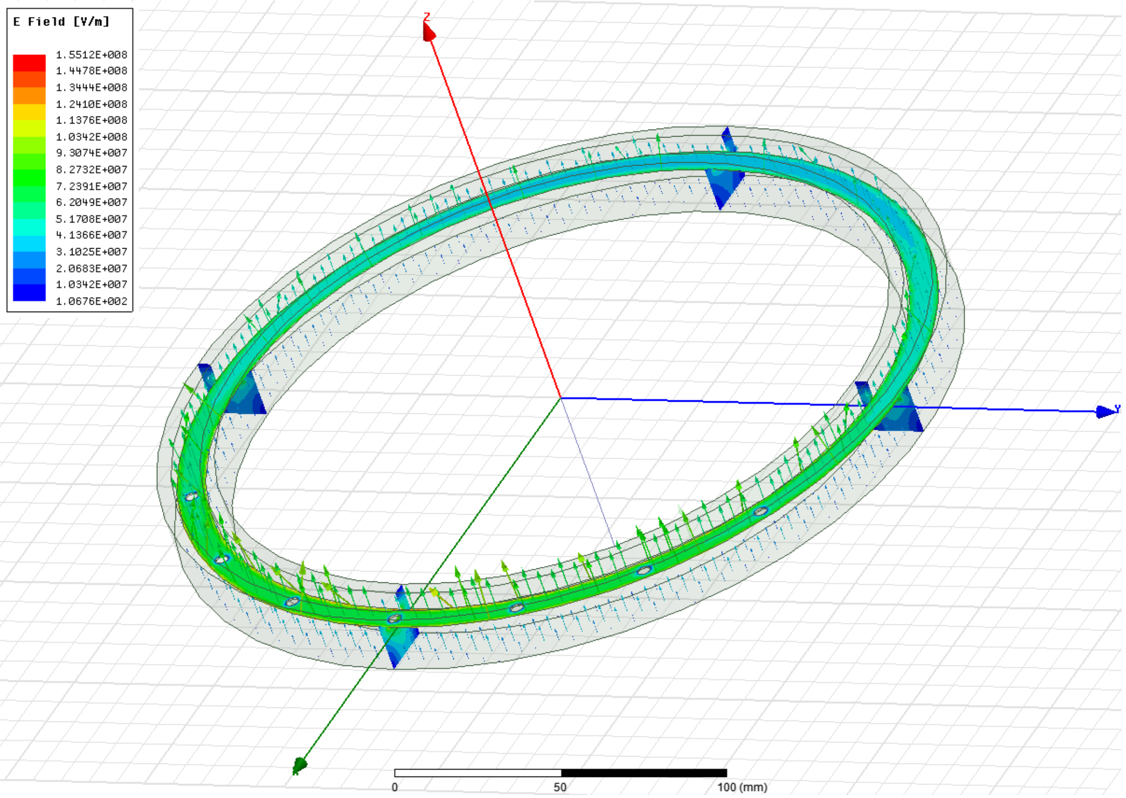
Cavity with 1 tube holes r=2,d=1 mm perturbations on center line of Ridge

Things to note with 1 tubular holes:
The color is fairly uniform. It goes from light green to light blue to maybe one color level lower. The arrows vary in size maybe 10-15 %, but not in their direction.
This, (I believe) is to be expected because Of the large difference in frequency between the dominant TE100 and the nearest crossing mode the TE101as shown above.
The perturbation corresponds to tolerance of 2.5 um.
The Coupling Form factor (CFF) was only reduced by 7 % to .46 and the Q was reduced by less than 1 %.



Cavity with 7 tube holes r=2,d=0.5 mm perturbations on center line of Ridge

Things to note with 7 tubular holes:
The hole size is smaller. The color is a no longer uniform. It goes from light green to light blue. The arrows vary in size, but not in their direction.
This, (I believe) is to be expected because Of the large difference between the in frequency dominant TE100 and the nearest crossing mode the TE101as shown above.
The perturbation corresponds to tolerance of 9 um.
The Coupling Form factor (CFF) was only reduced by 7 % to .43 and the Q was reduced by less than 1 %.



Nesting of Circular Ridged WG Cavities and Conducting contact between the ridge and Cavity

Illustration of a high vacuum metal seal; made in the form of a C, made of thin SS tubing cut in the form of a C. They can be coated with copper or other good conducting metals. We are also going to look at a flat thinned wall bellow coated with copper.

Nesting of different radii in the same plane of the ADMX magnet. Cavities could be of the same or different frequencies.

Summary

The designs shown in this report demonstrate that Circular and straight ridged WG cavities can cover a large range in frequency. In this report the designs have covered the frequency range 2 to 20 GHz

The designs have shown large differences in frequencies between the dominant TE100 resonance and the nearest crossover resonance the TE101 resonance. This could be very important in reducing the tolerance requirements of the cavities.

The designs have shown that tolerances of 2.5 to 9 um will not distort the electric fields to where the cavities are not useful for ADMX research.