A Novel 5 Step Septum Feed Suite

Swedish EME-meeting May 2013

SM6FHZ and SM6PGP

Updated Post Conference Edition

Outline

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- Design criteria / considerations
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  - Septum
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  - Probes
- Performance overview
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  - Mechanical dimensions (for each feed)
  - Detailed information (for each feed)
- 23 cm 0.795 L W/G feed performance
- 9 cm 0.748 L W/G feed performance
- 6 cm 0.749 L W/G feed performance
- 3 cm 0.692 L W/G feed performance
- 3 cm 0.795 L W/G feed performance
- Realization
- On the air experience
- Lessons Learned
- Conclusions

Prerequisite

- I was in need for a new 23 cm feed to retrofit my 30 year old, ill built and corroded W2IMU feed. Then a need for feeds for the higher bands arose. What to do about that?
- Several existing 23 cm designs were available. I felt the performance had a potential to be improved with proper optimization using contemporary EM-simulation S/W
- Focus was put on f/D 0.32 to 0.42 (my 5.5 m dish is 0.37 f/D)
- N2UO adaptation of the W2IMU Dual Mode feed satisfies the need in the area of f/D's from ~0.42 to ~0.55
- The existing feeds for higher bands are mostly scaled versions of 23 cm feeds. I saw a opening for feeds specifically designed and optimized for the specific band to get the best possible performance
- I have learnt a lot about septums, chokes and wave guides along the way and have had a lot of fun and been frustrated as well at times

Features

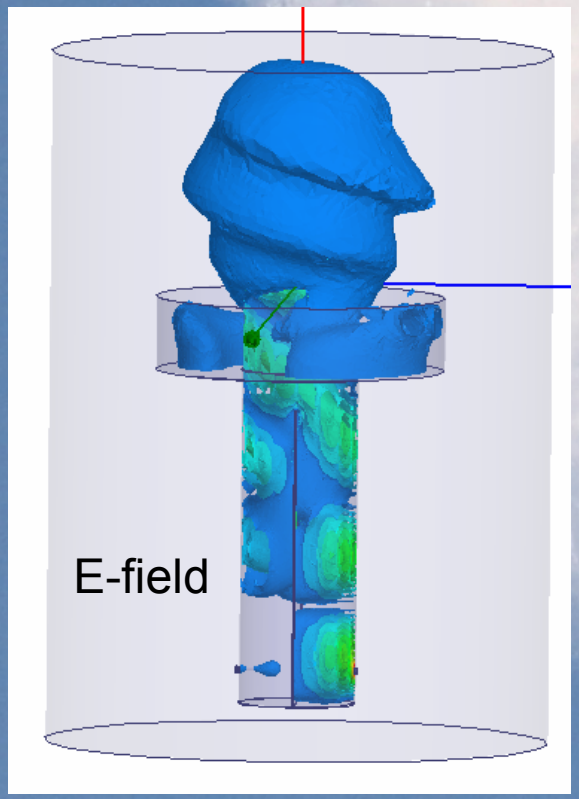
- Two 23 cm 5 step septum feeds for different f/D ranges
- 9, 6 and 3 cm feeds from standard metric as well as inch size plumbing copper or brass tubes
- Unprecedented top notch performance
- Focus on easy manufacturing and low tolerance sensitivity
- Suitable for f/D's ranging from 0.32 to 0.42 plus ~0.5 f/D for the 3 cm Dual Mode Feed
- The three 3 cm feeds cover both 10368 and 10450 MHz
- All comprising a Kumar choke or Dual Mode structure depending on the f/D the feed is aiming for

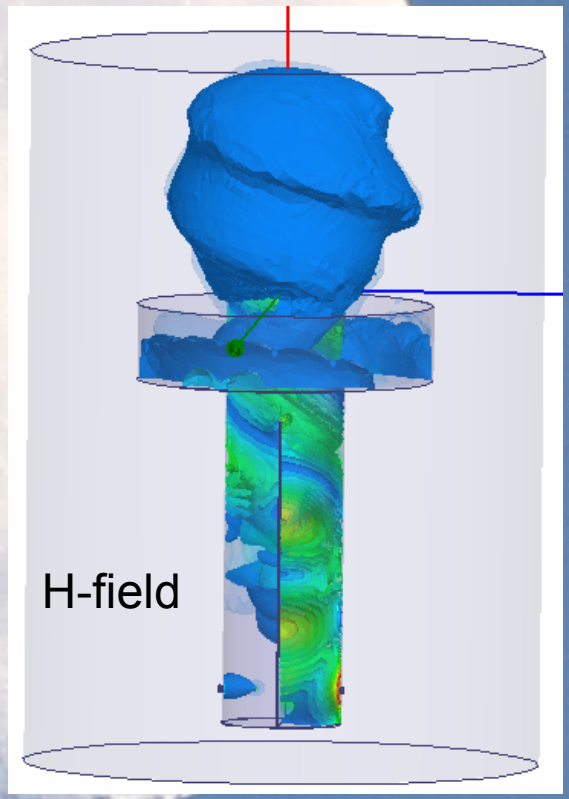
Design criteria

- We strive for
  - Optimum amplitude feed pattern
  - Flat phase response across the full dish surface (small phase errors)
  - Low axial ratio across the full dish surface (low cross polarization)
- We can not get all of this optimized at the same time, so we have to look for the best compromise.
- The W1GHZ feed efficiency evaluation S/W “Phase_CP” has been used for this evaluation.
  - This means that these results can be compared to the results of other feeds evaluated using the same S/W.
  - Phase_CP is the latest version of Pauls evaluation S/W and takes Cross Polar Radiation as well as radiation in the diagonal cuts into consideration for the performance calculation. The earlier version did not do that. This gives a more correct picture of the performance of each feed.
  - Phase_CP can be used for both circularly and linearly polarized feeds with great success

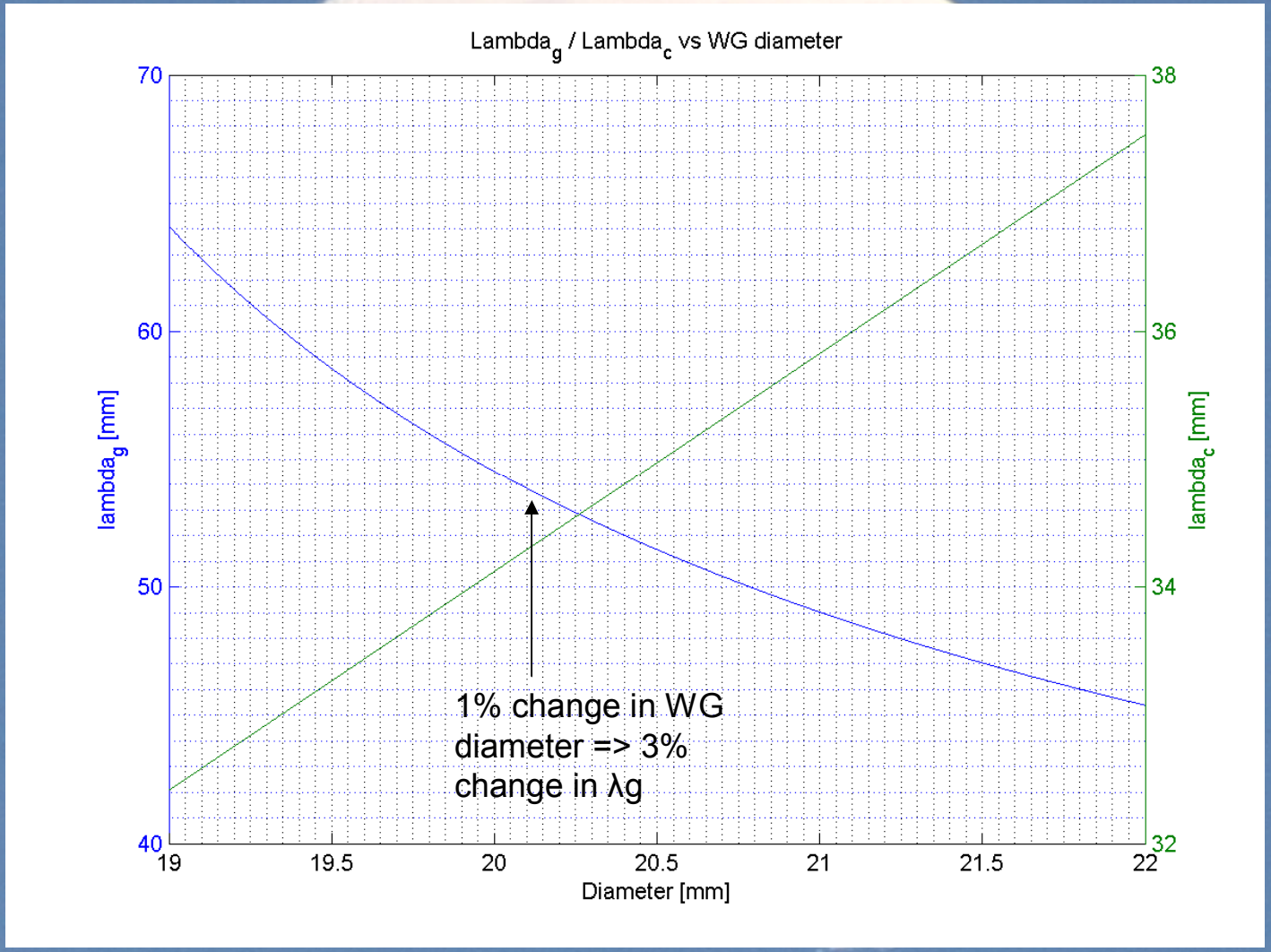
Wave Guide modes

- The lowest mode that propagate in a circular WG is called TE11.



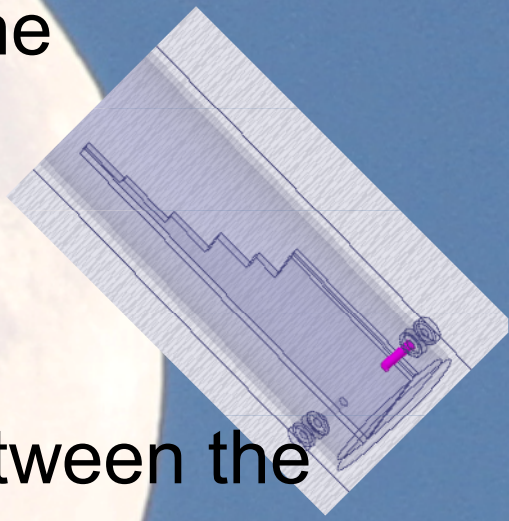


Wave Guide size and λg (10368 MHz)/ λc for TE11

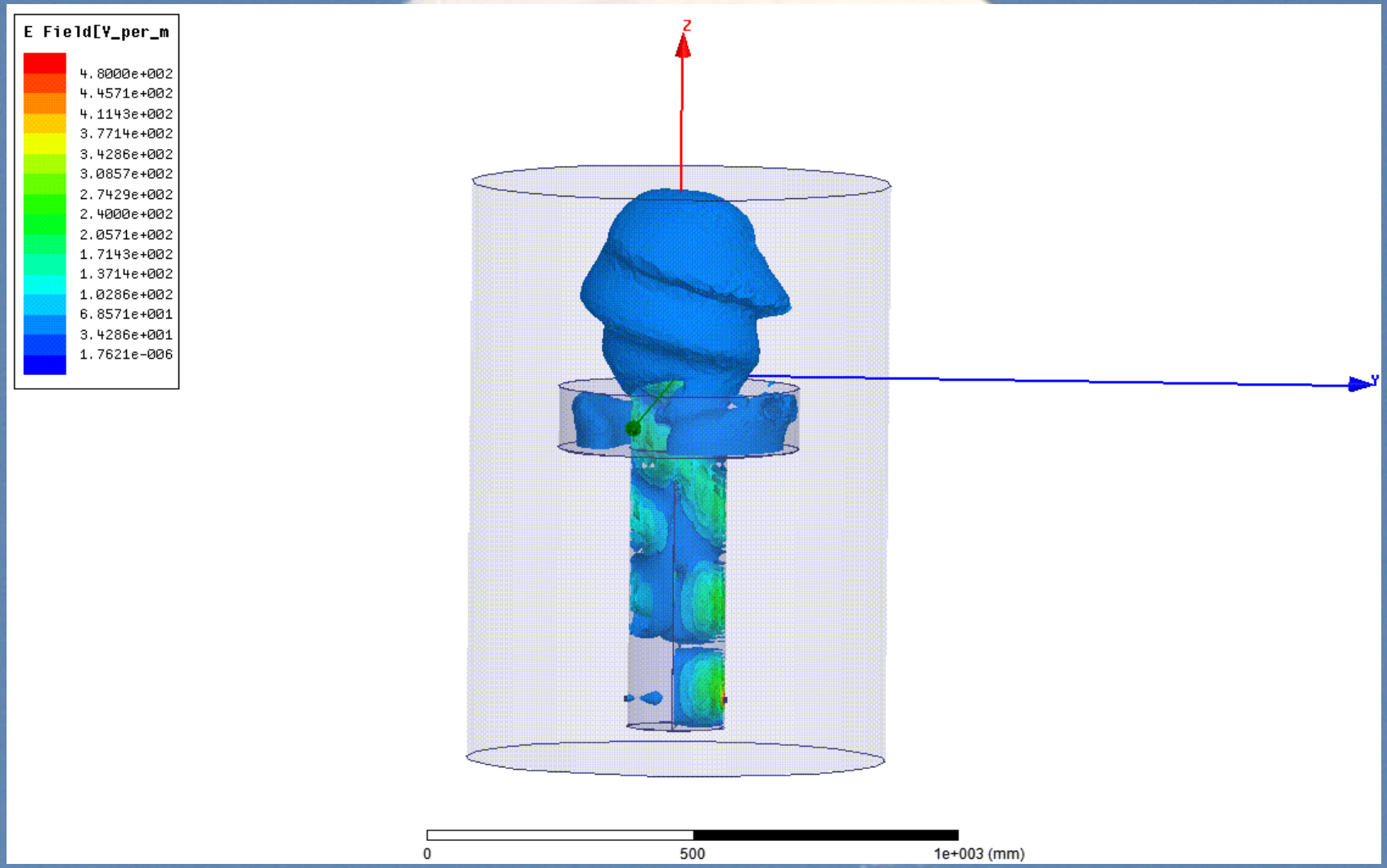


Septum considerations

- The septum shall generate a circularly polarized wave in a way that it contains only one polarization direction in each port.
  This ensures that we have
  - Good Axial Ratio
  - Low Cross Polar Radiation
- It shall also ensure good isolation between the two ports, Tx and Rx
- It shall do this over a reasonable band width
- In these designs this is accomplished by using a 5 step septum plate

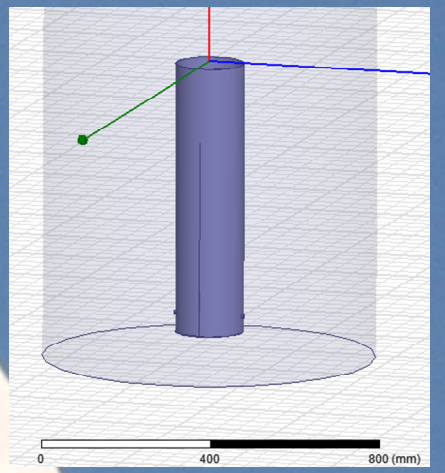


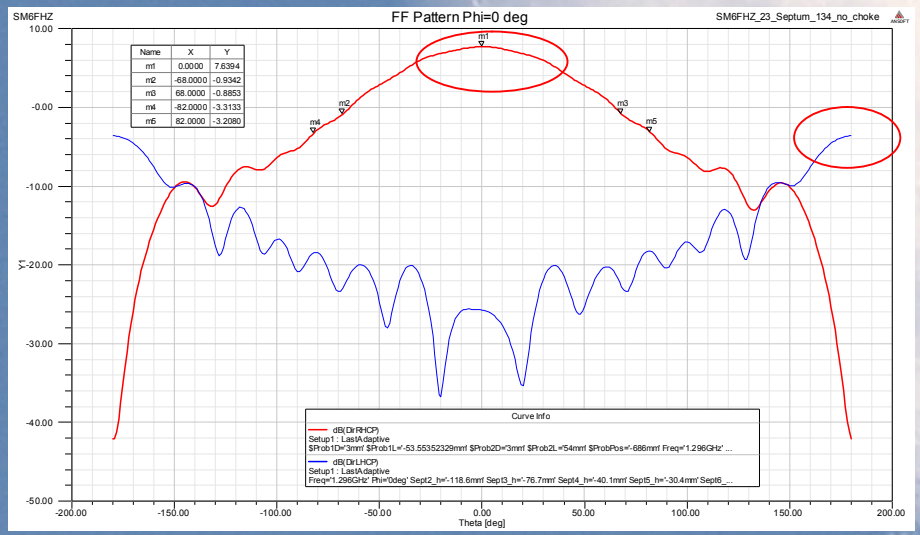
E-field variation over a full cycle



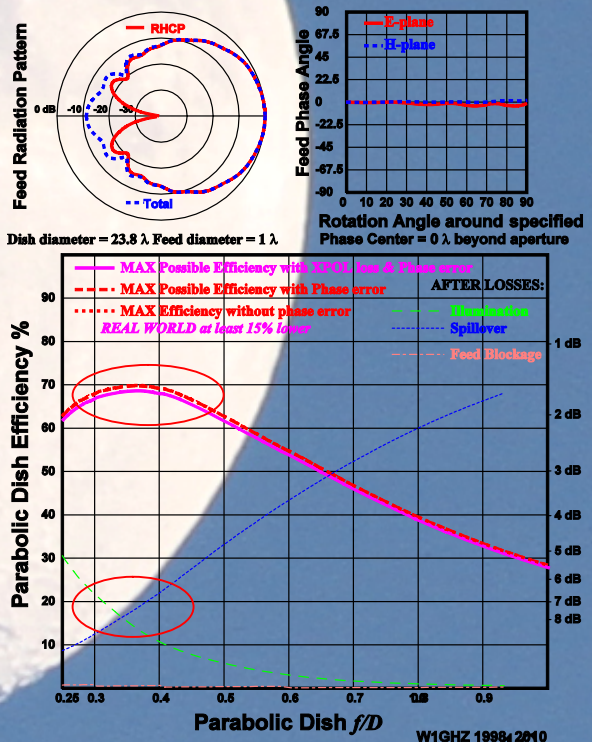
Feed without choke

- No beam shaping in Co-pol
- High Cross-pol level in 180 deg
- Mediocre efficiency
- High noise temperature

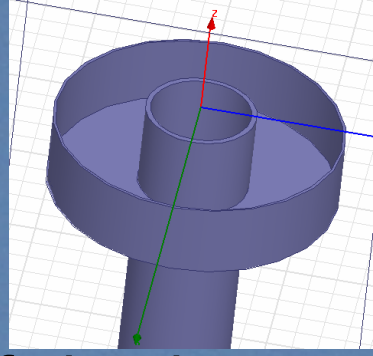




SM6FHZ 23 cm septum feed w/o choke

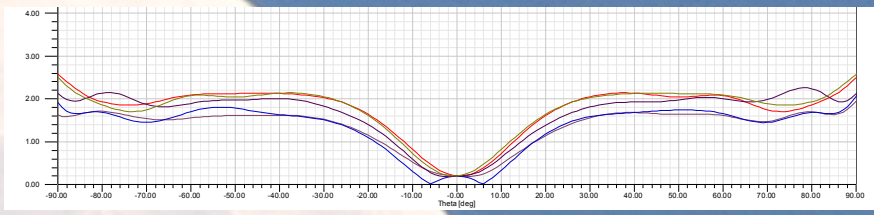


Why a Kumar choke?



- The Kumar choke is a efficient yet simple way of shaping the radiation pattern of the feed.
- It was first described by Dr. A. Kumar [Reduce Cross-Polarization In Reflector-Type Antennas, Microwaves, March 1978] and has been used by VE4MA in his feed designs.
- It has some limitations and interactions with the other parts of the feed.
  - The Axial Ratio at angular offsets from bore sight is controlled by the choke
  - The Return Loss and Isolation is not affected by the choke
  - The radiation pattern can be controlled by the position and the size of the choke
- Less elaborate than the Scalar choke but comparable or superior performance
- It can be optimized using EM-simulation SW.

Septum - choke interaction



- Axial ratio optimization
  - The septum sets the Axial Ratio at bore site and the choke governs the performance at angular off-sets from bore sight
  - The choke does not change the axial ratio at bore sight very much
- A well functioning septum is essential for getting a decent axial ratio also off bore sight

Choke impact on radiating pattern

- There is a contradiction between the wanted amplitude pattern and the phase error with respect to illumination angle
- By adjusting the choke position and dimensions you can find the best compromise
- Moving the choke with respect to the W/G mouth does not directly scale the feed pattern for other f/D's. There is a price to pay.
- The best way to strive for optimal performance at other f/D's is to change the dimension of the W/G mouth
- There are limitations on how much you can change the dimension of the W/G and maintaining the same W/G propagation mode
- W2IMU uses this in his "Dual Mode Feed" going to a higher mode as well as the first mode in the outer WG-section in an controlled way

FF Pattern quick comparison
Choke position relative WG-mouth

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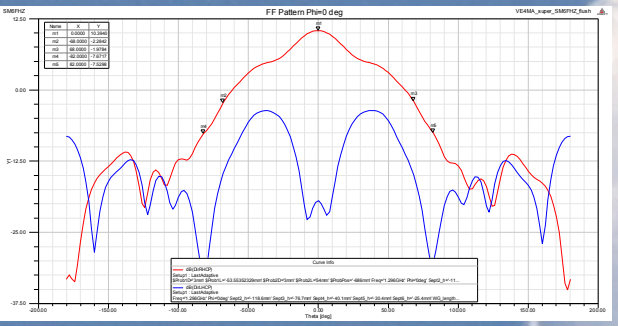

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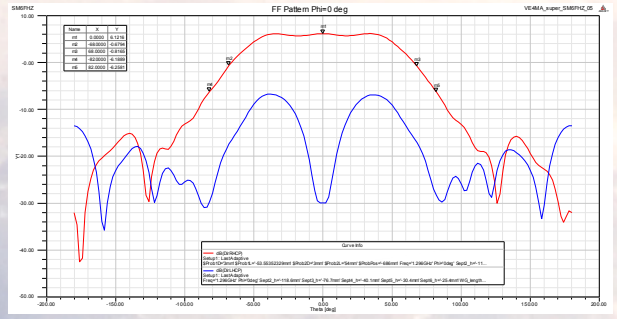

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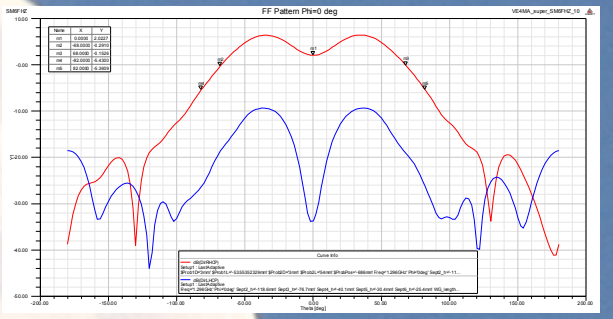

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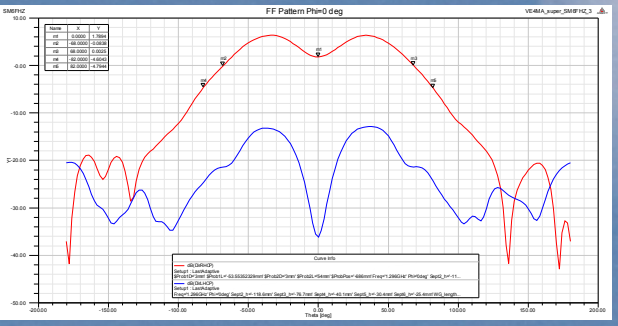

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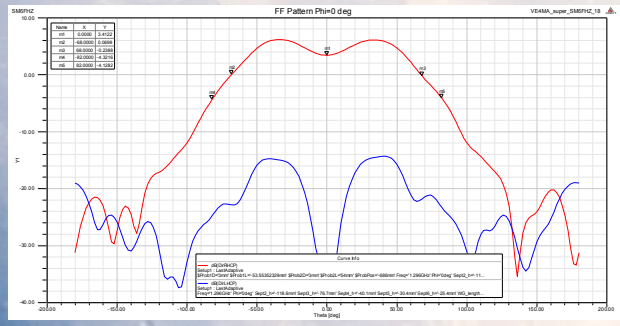

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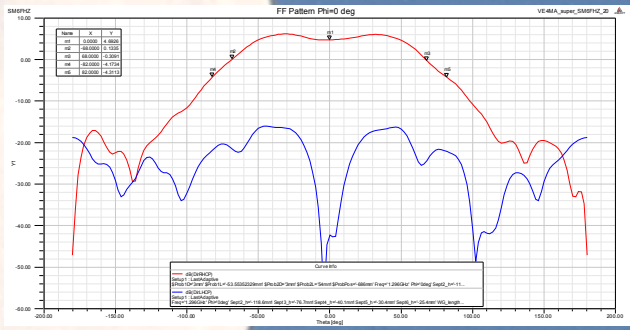

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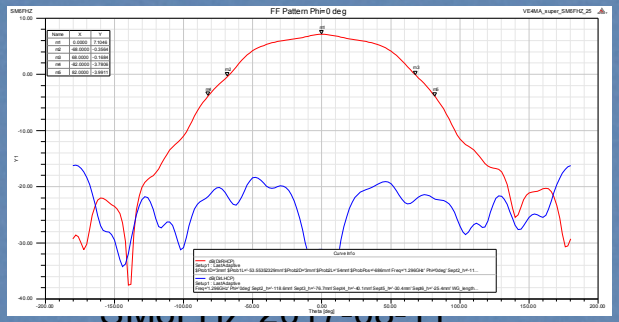

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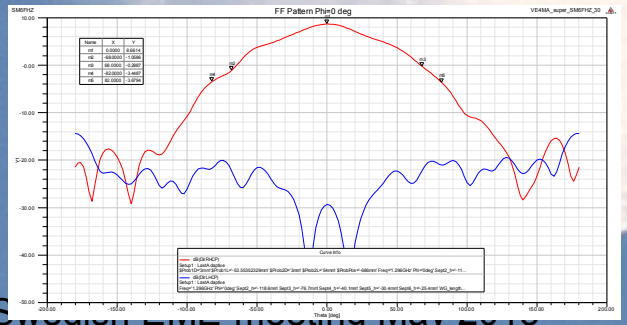

FF Phase error quick comparison
Choke position relative WG-mouth

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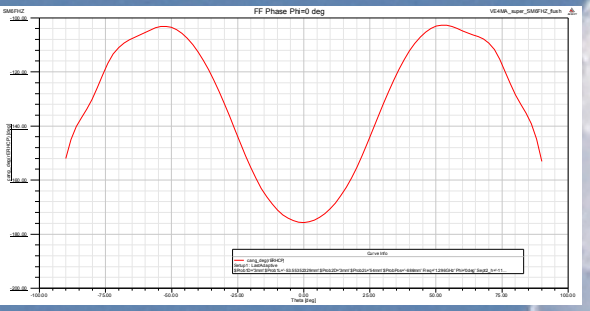

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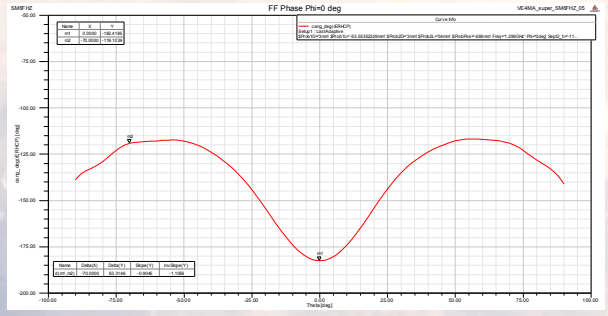

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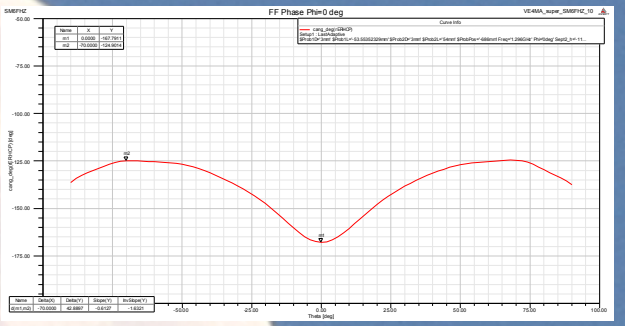

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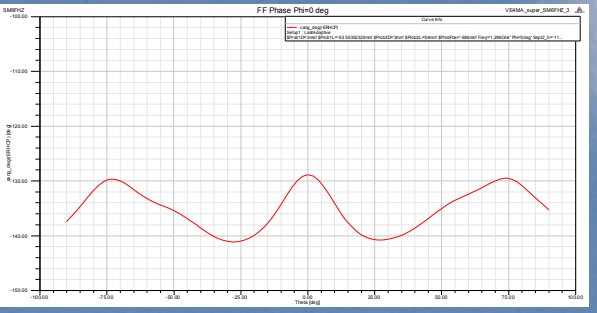

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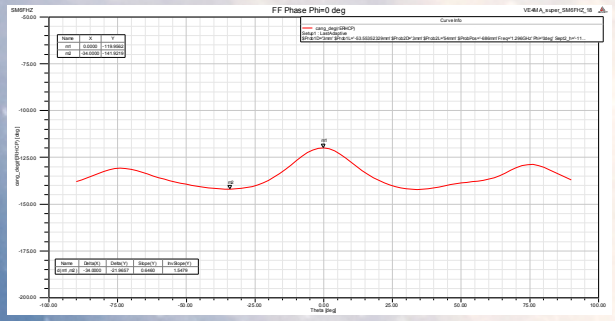

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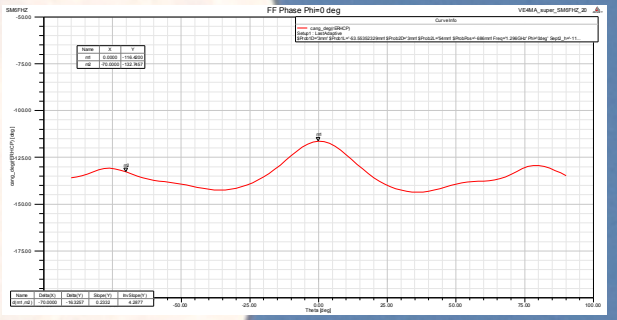

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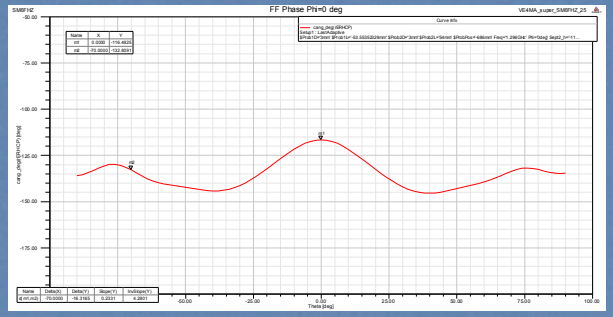

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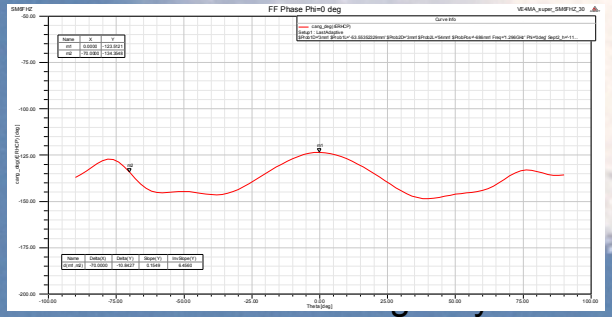

Rev PF1

Axial Ratio quick comparison
Choke position relative WG-mouth

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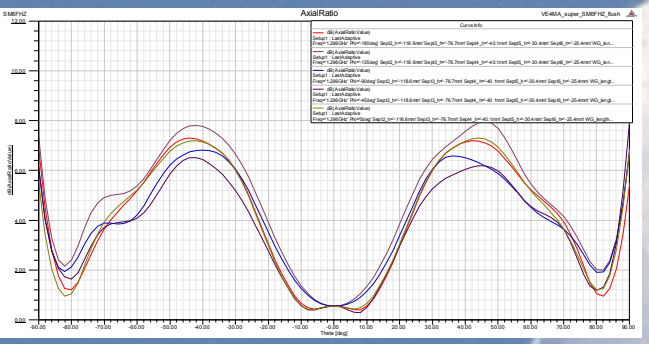

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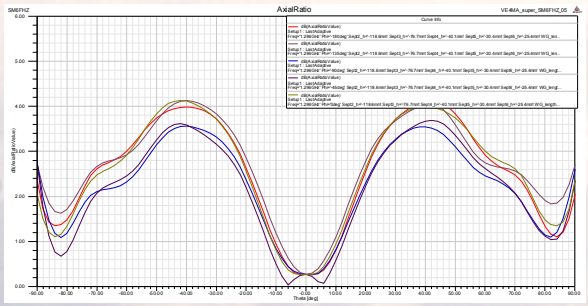

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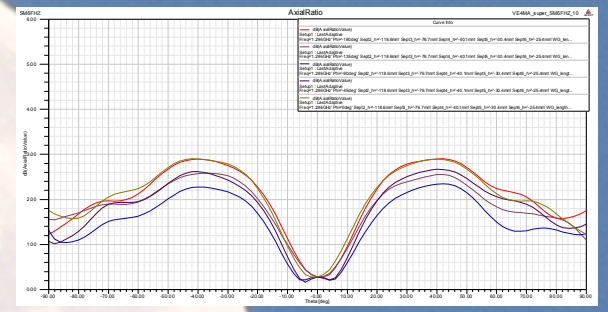

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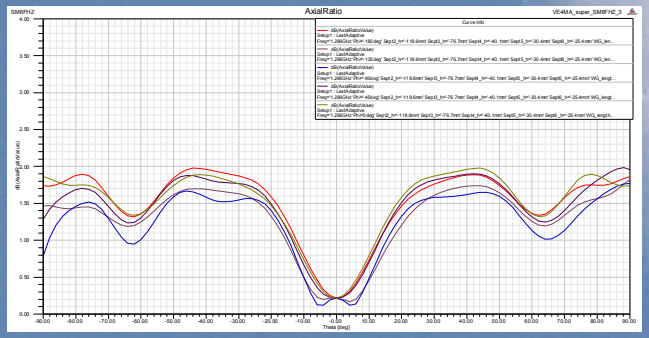

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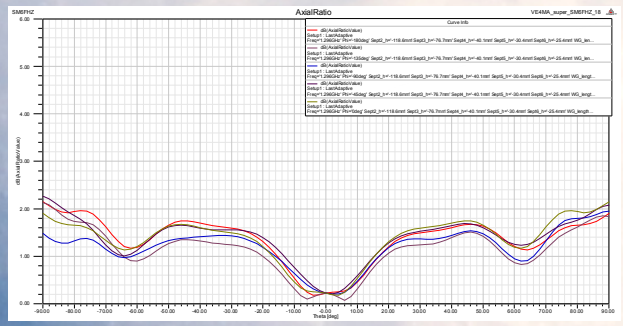

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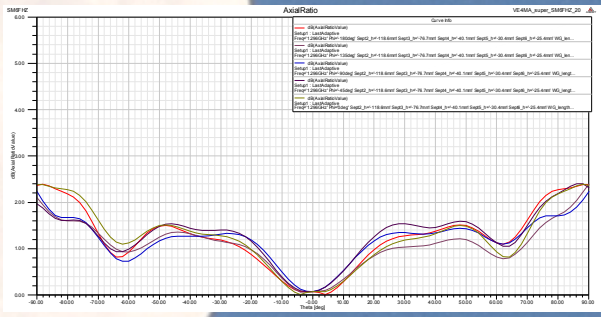

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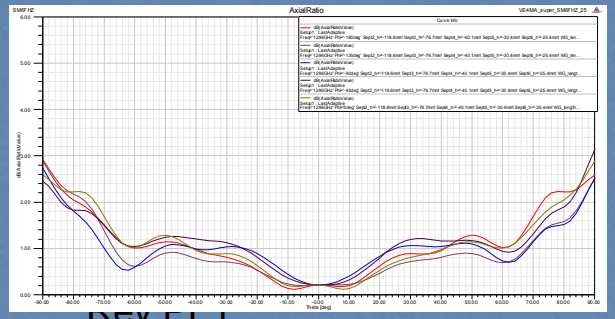

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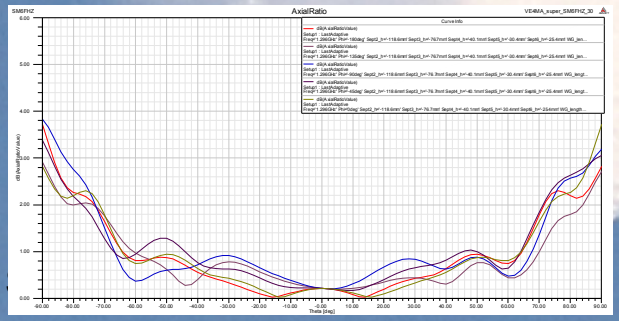


Putting the Feed in a Dish

Dish Reflexion

- Pointing your feed into the dish will result in a reflected wave from the dish entering the feed.
- The level of the reflexion coefficient (Γ) will be dependant on the gain of the feed (G), lambda (λ) , and the focal length of the dish (f).

$$\Gamma = \frac{G\lambda}{4\pi f}$$

Putting the Feed in a Dish

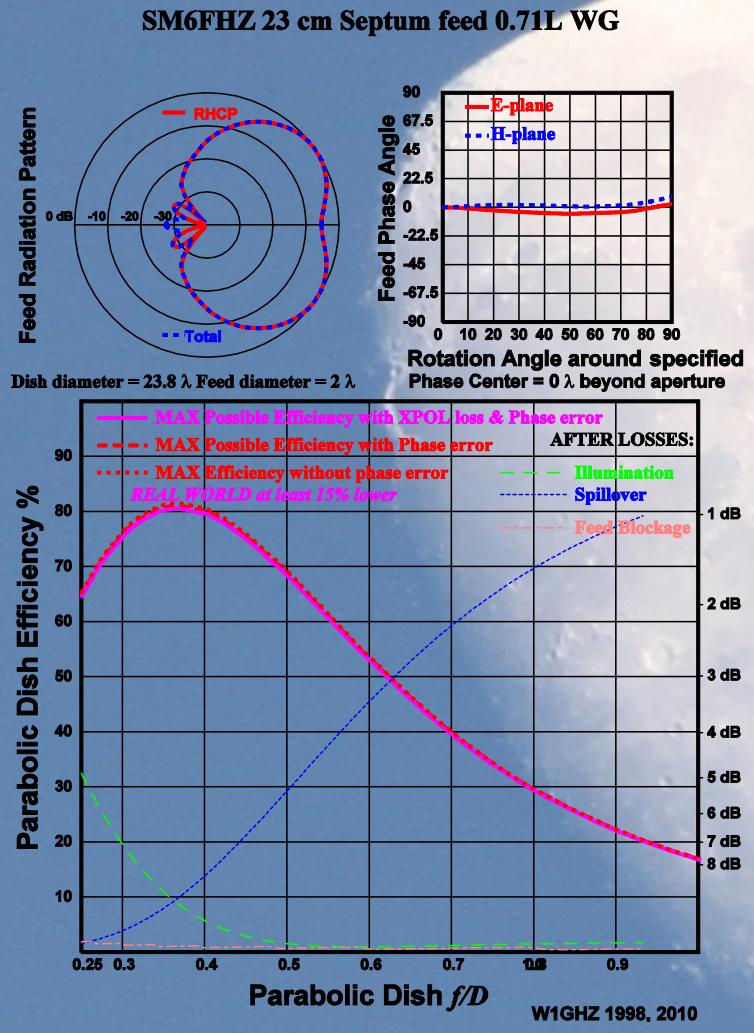
Dish Reflexion

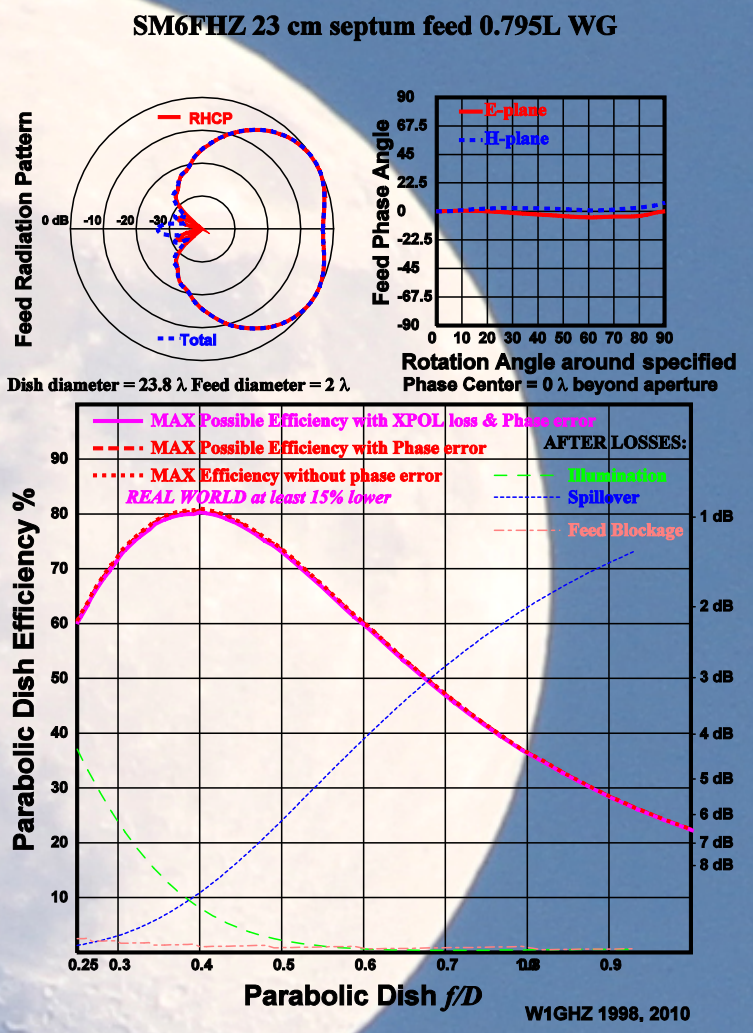
- How bad can it get?
  - With a linear feed you will see the reflected wave on the Tx port but with a circular polarized feed the reflected wave will show up in the Rx port due to the phase reversal upon the reflexion in the dish surface. This affects the isolation between Tx and Rx.
  - 1296 MHz, VE4MA type feed in a 5.5m, 0.37 f/D dish will result in 29 dB RL.
  - 1296 MHz, W2IMU type feed in a 8m, 0.45 f/D dish will result in 26 dB RL.
  - 5760 MHz, VE4MA type feed in a 5.5m, 0.37 f/D dish will result in >40 dB RL.
  - 5760 MHz, VE4MA type feed in a 2m, 0.37 f/D dish will result in 33 dB RL.
  - 10368 MHz, VE4MA type feed in a 5.5m, 0.37 f/D dish will result in 47 dB RL.
  - 10368 MHz, VE4MA type feed in a 2m, 0.37 f/D dish will result in 38 dB RL.
- A spread-sheet can be found on my web page for your own further testing.
- RA3AQ proposes using a small metal coin in the centre of the feed aperture in order to fine tune the isolation in situ. This need to be done specifically for each installation but can yield excellent isolation over a narrow frequency band
- Summary.
  - This reflexion is not a major problem on the higher bands on larger dishes.
  - If the reflexion is down below the 30 dB RL region you may consider to address it.

InDish Performance

A quick look at all 6 feeds

InDish Performance 23 cm (5.5 m dish)

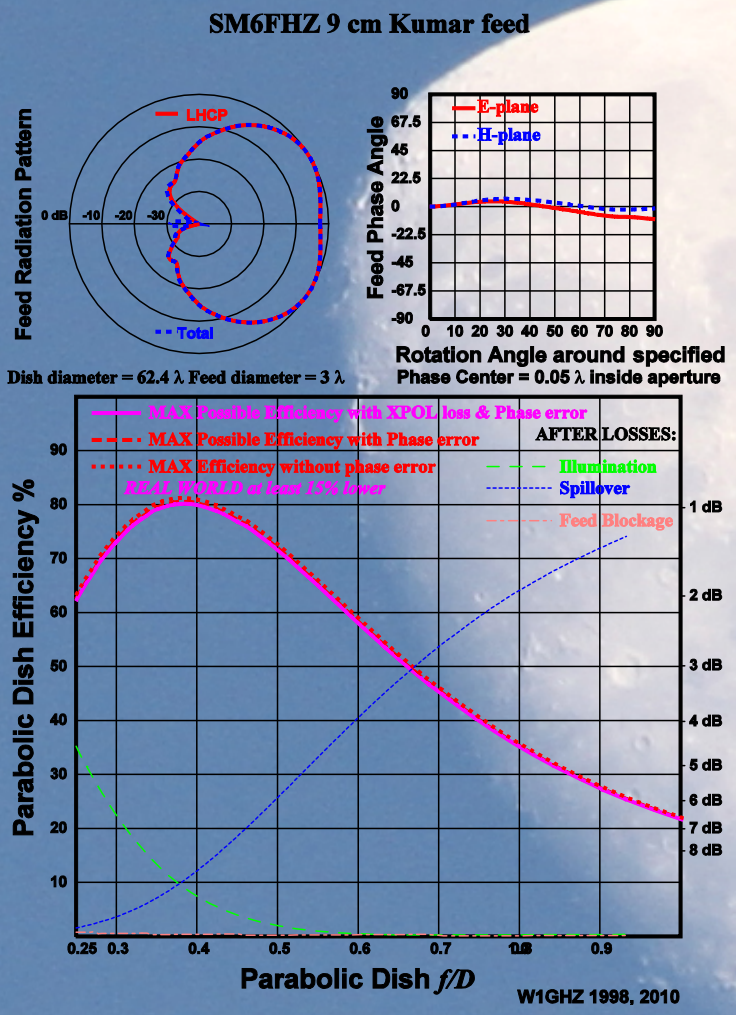




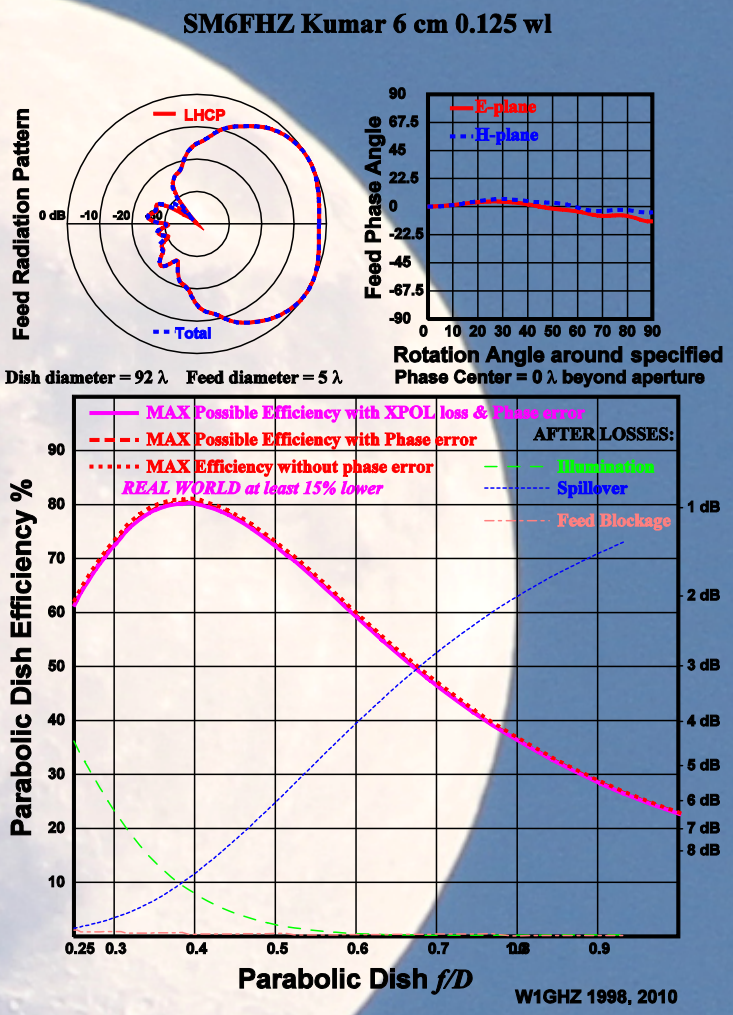
23 cm 0.71 L W/G feed performance

23 cm 0.795 L W/G feed performance

InDish Performance 9/6 cm

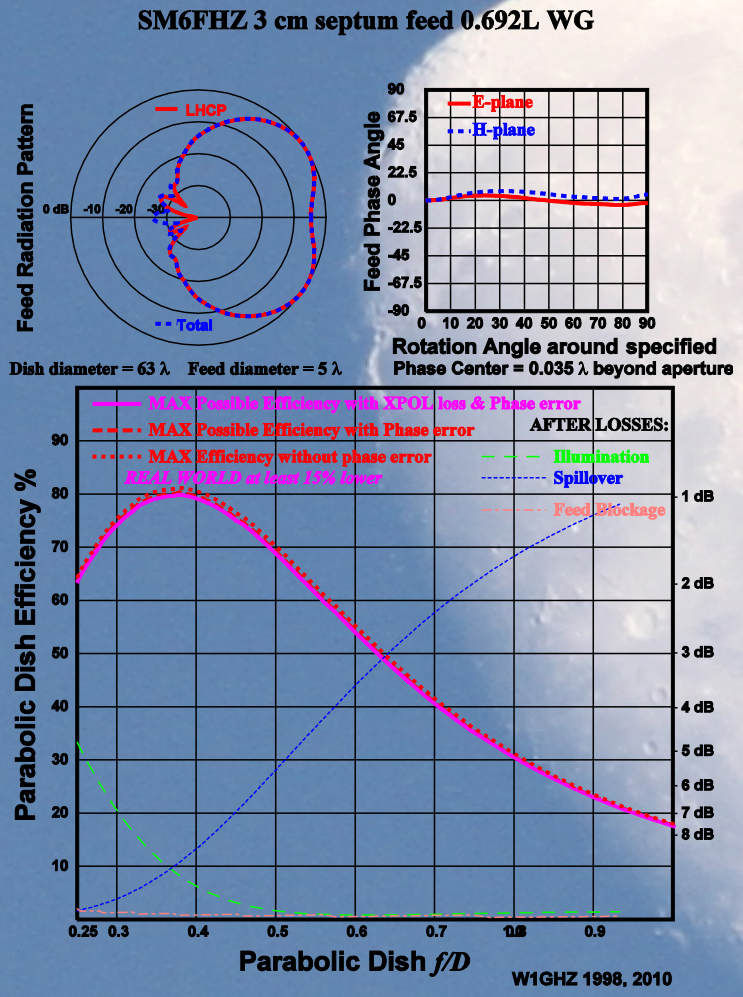


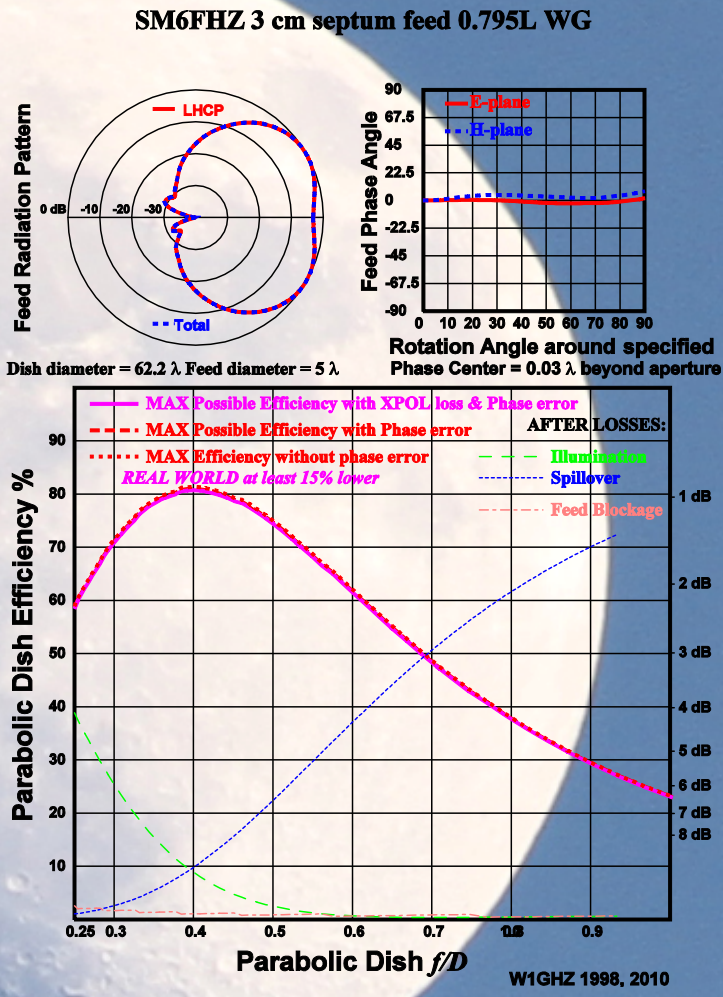
9 cm feed performance
(5.5m dish)



6 cm feed performance
(5.5 m dish)

InDish Performance 3 cm (1.8 m dish)





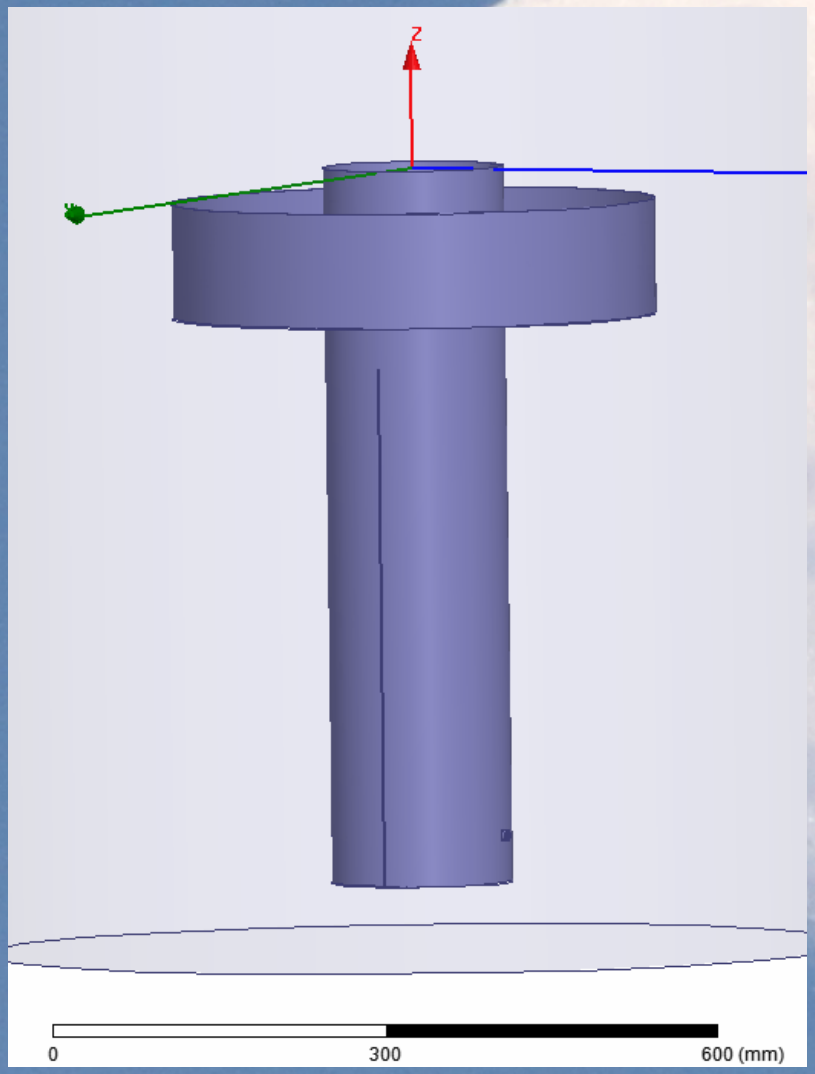
3 cm 0.692 L W/G feed performance

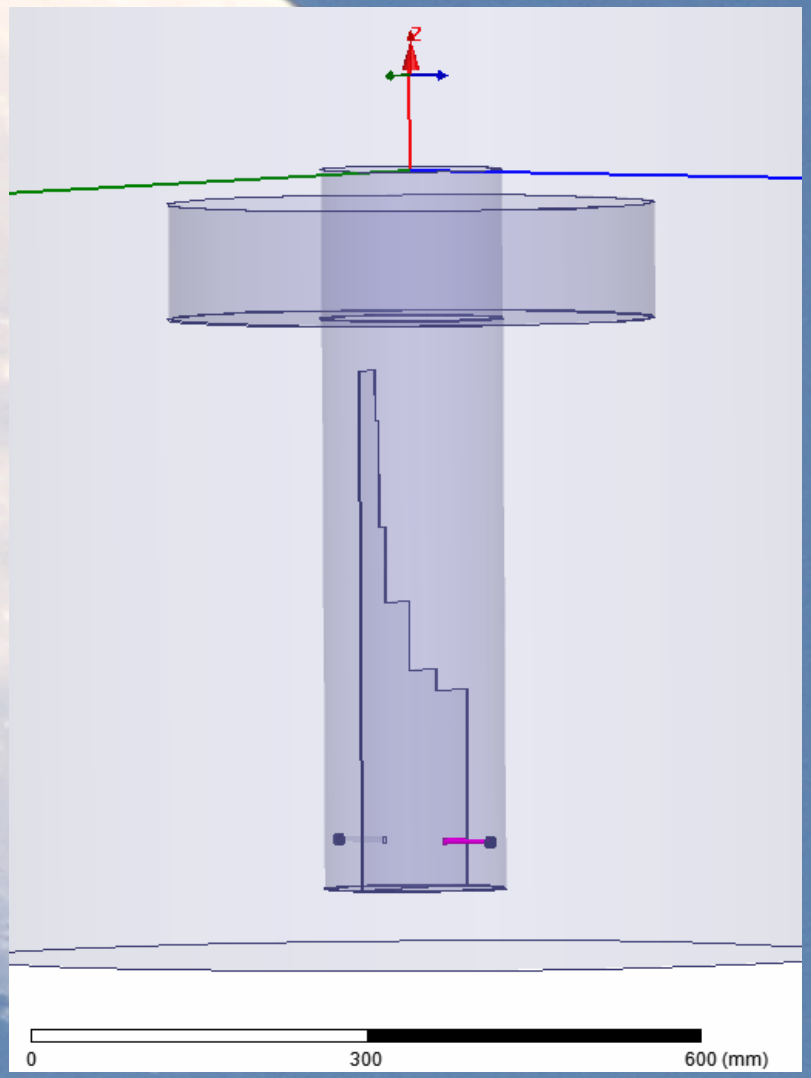
3 cm 0.795 L W/G feed performance

SM6FHZ 23 cm 5 step septum feed

0.71 lambda W/G

Solid and transparent models from the simulation (23 cm 0.71 wl WG)





WG and choke dimensions (23 cm 0.71 wl WG)

Phase center -5.0

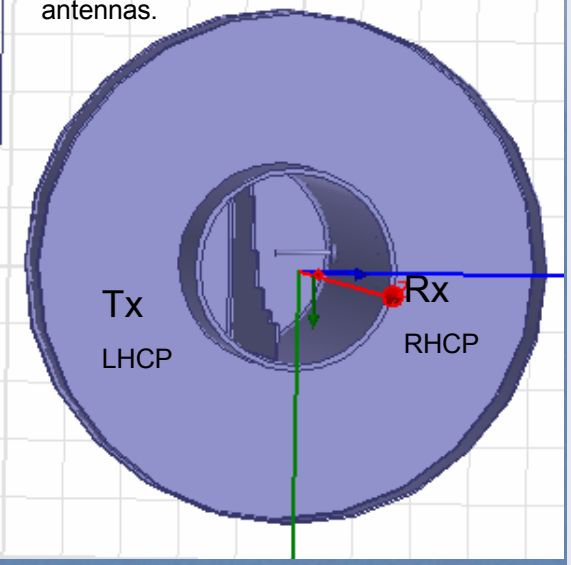
31

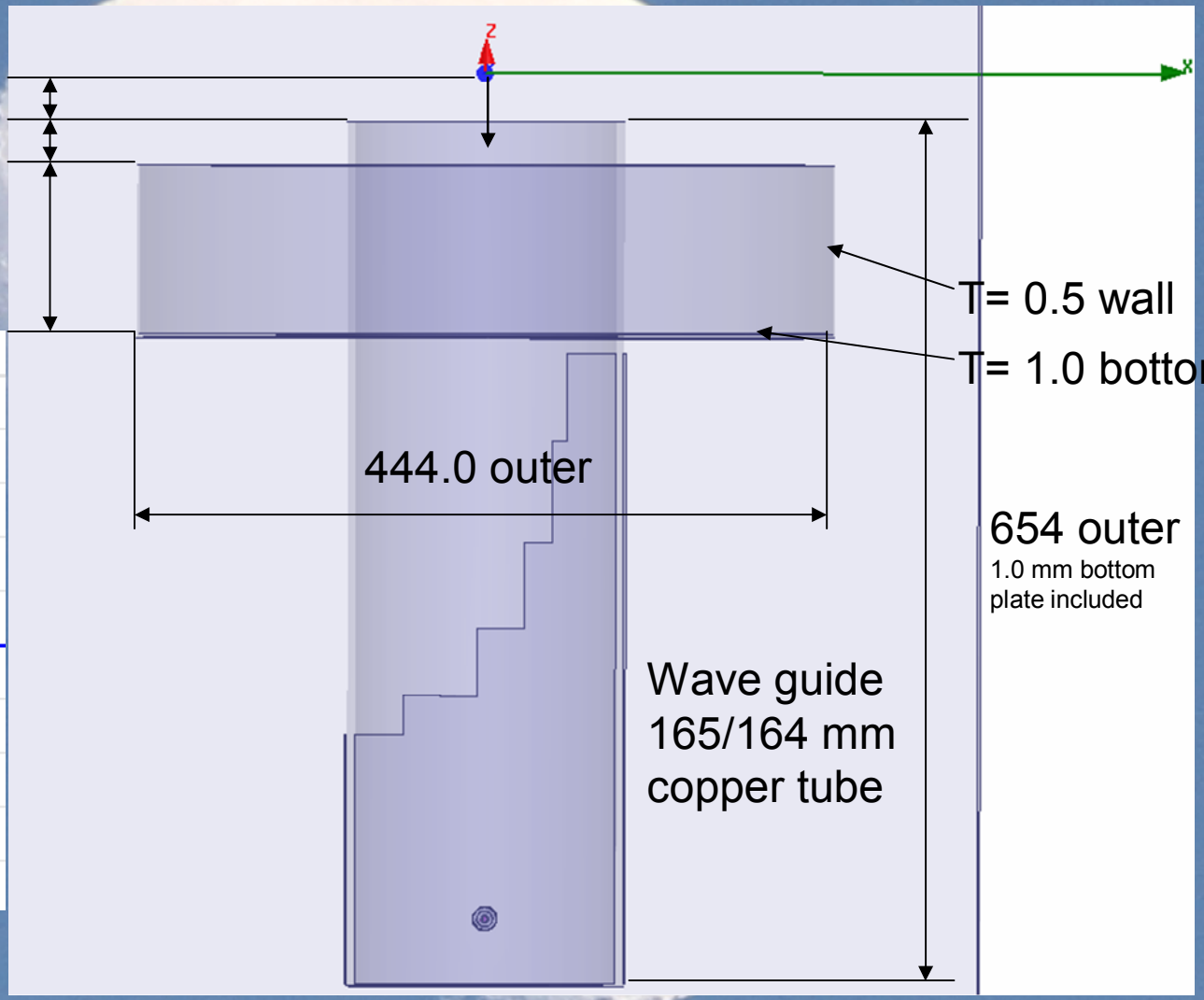
105.0 outer

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

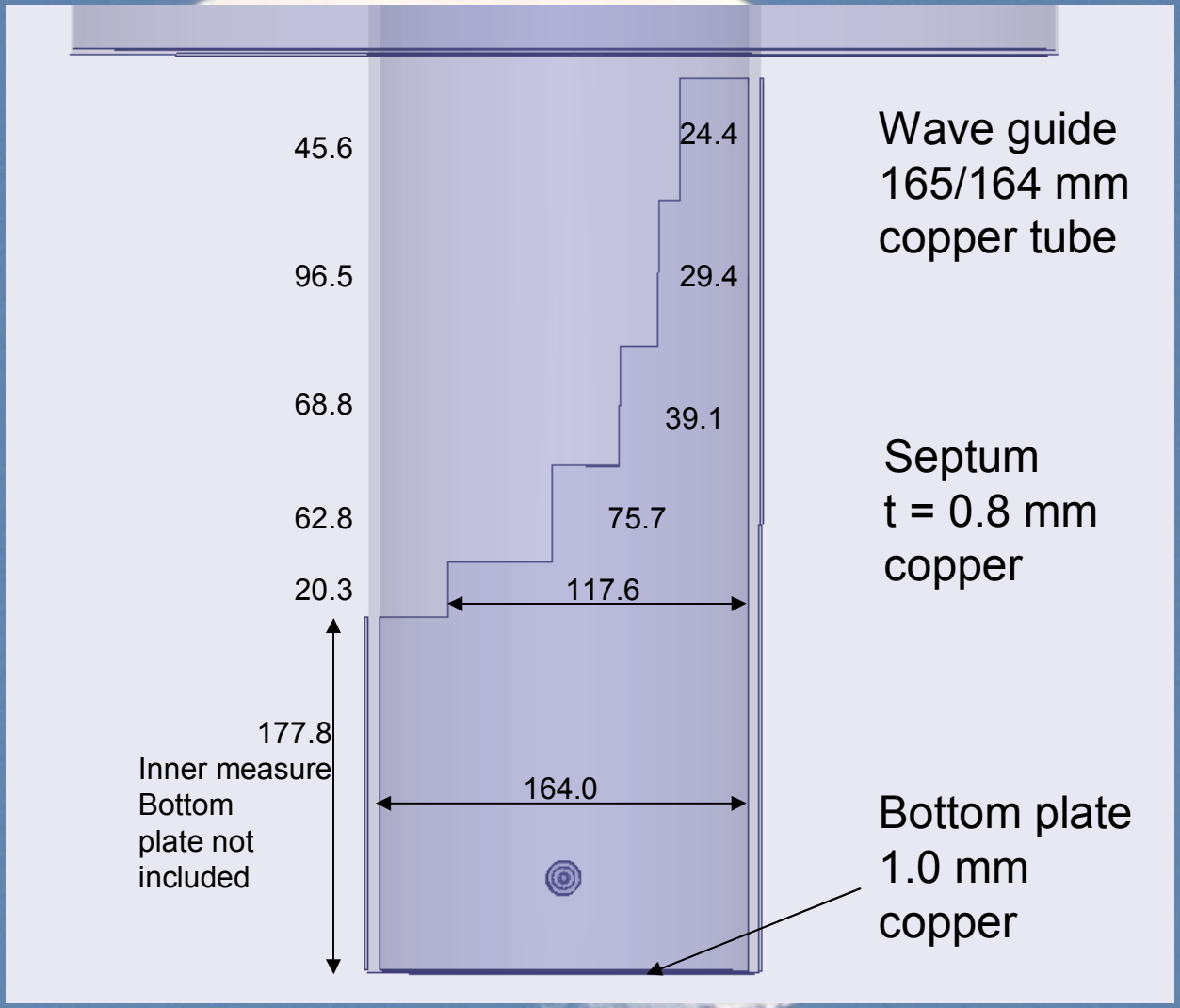
Tx RHCP in space
Rx LHCP in space

Take polarization reversal into account when using reflector antennas.

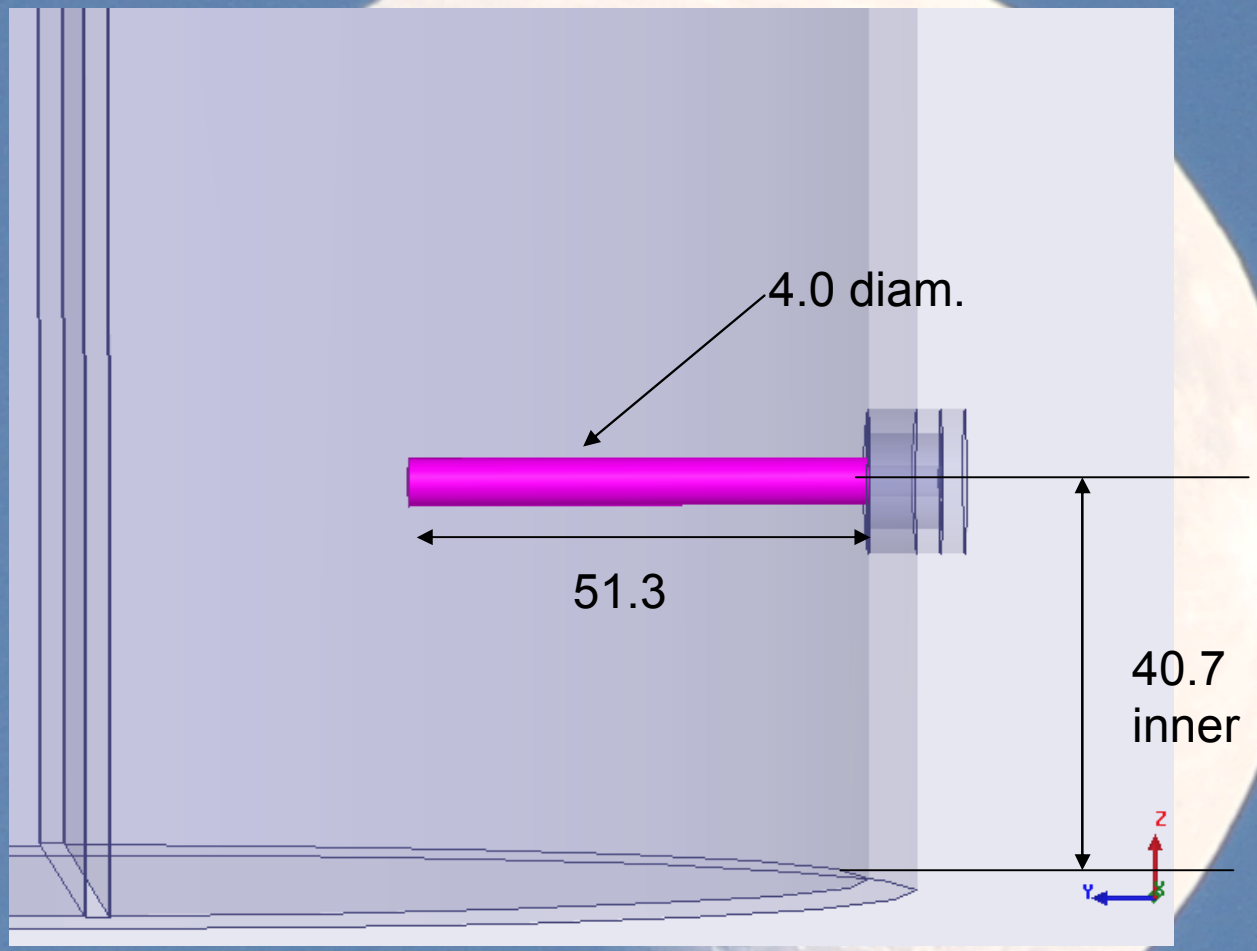




Septum dimensions (23 cm 0.71 wl WG)

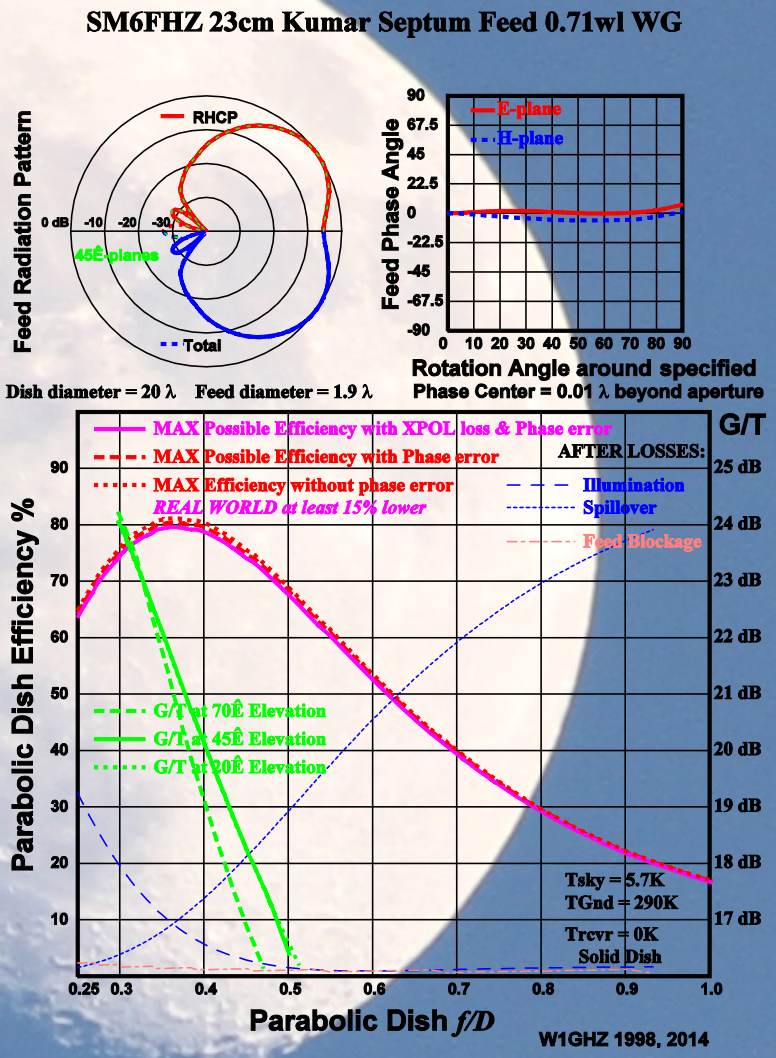


Probe dimensions (23 cm 0.71 wl WG)



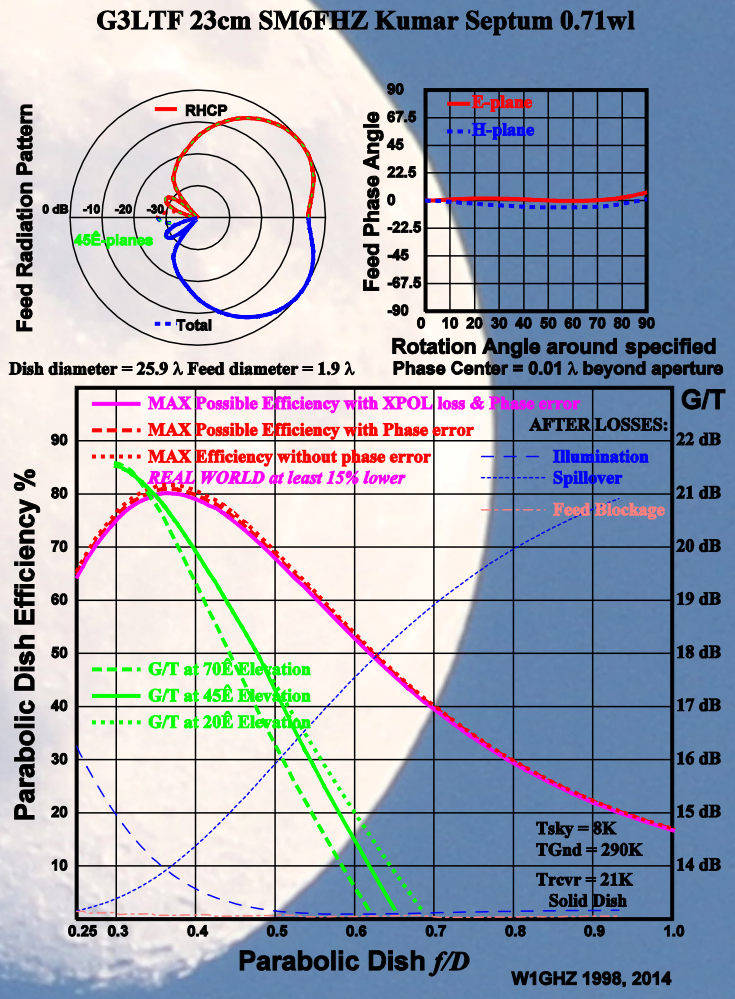
InDish performance including G/T

- InDish performance including G/T
- Graph produced by W1GHZ “Feed_GT” SW
- Possible to compare with graph on page 3 in W1GHZ EME 2014 presentation
- ~0.7 dB G/T advantage for this feed at 45 deg elevation and less sensitive to different elevations

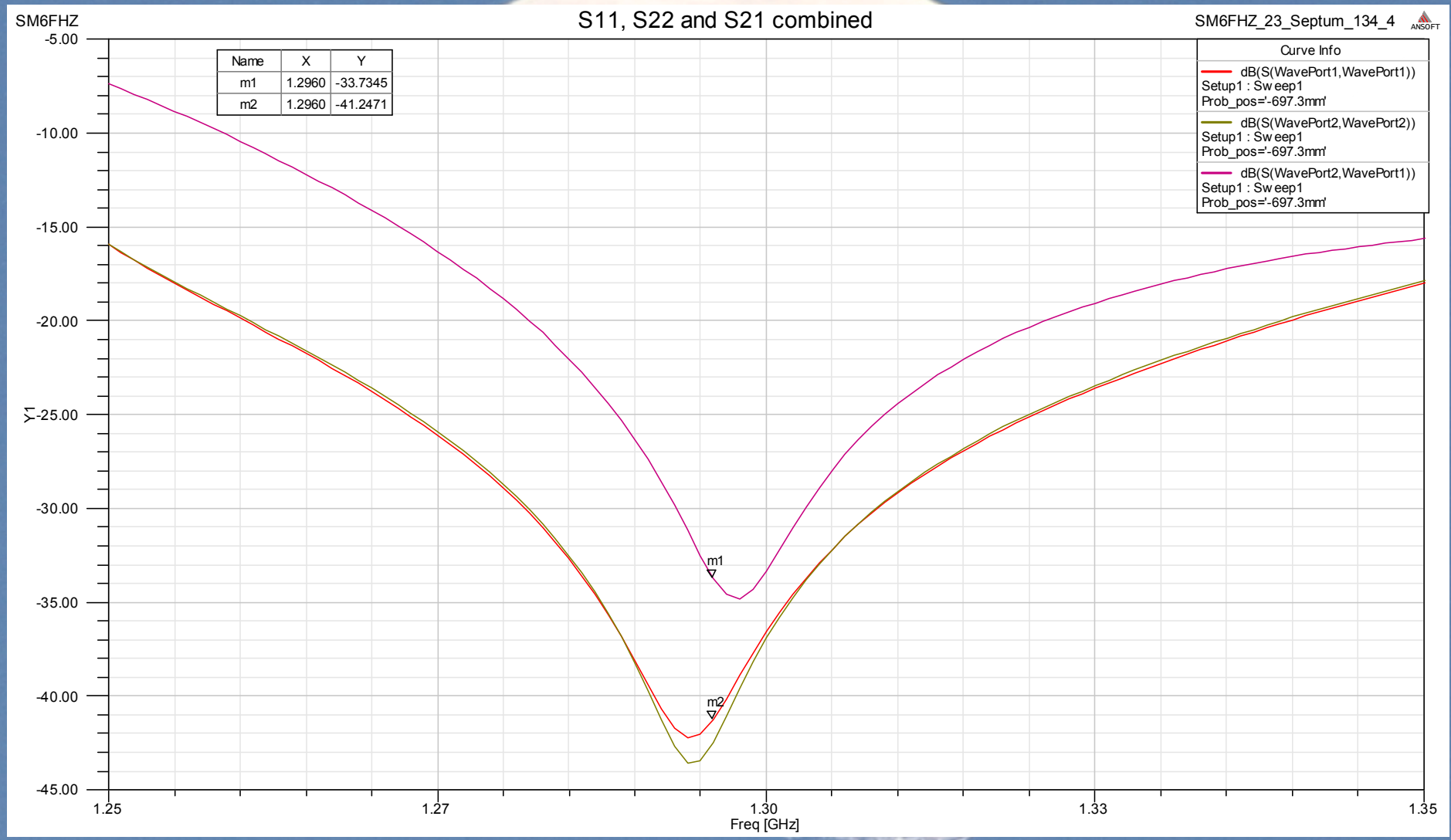


G3LTF dish performance

- Calculated performance for G3LTF dish with this feed
- Graph produced by W1GHZ “Feed_GT” SW
- Possible to compare with graph on page 17 in W1GHZ EME 2014 presentation
- ~0.4 dB G/T advantage for this feed at 45 deg at an f/D of 0.37

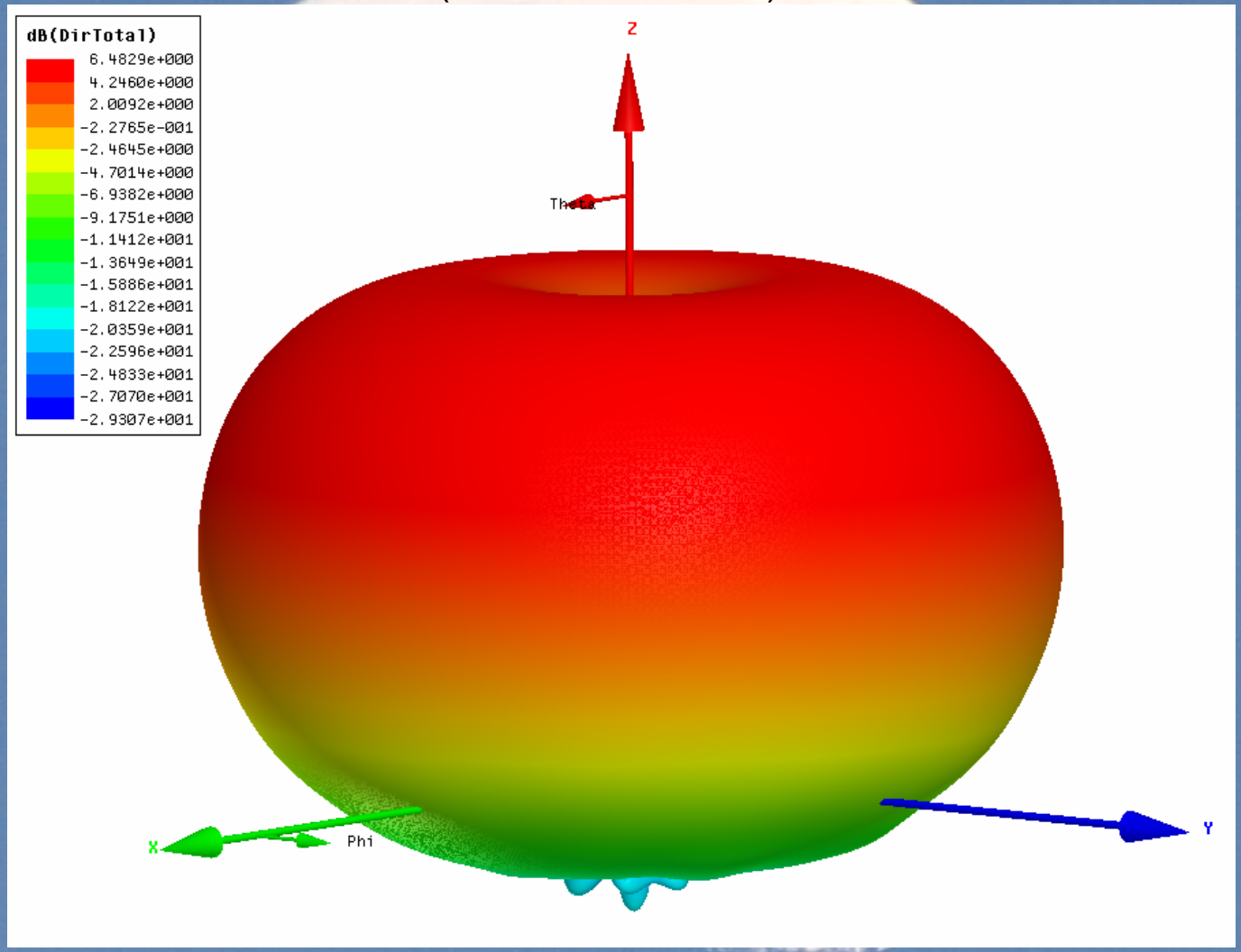


S11, S22, S21 combined (23 cm 0.71 wl WG)

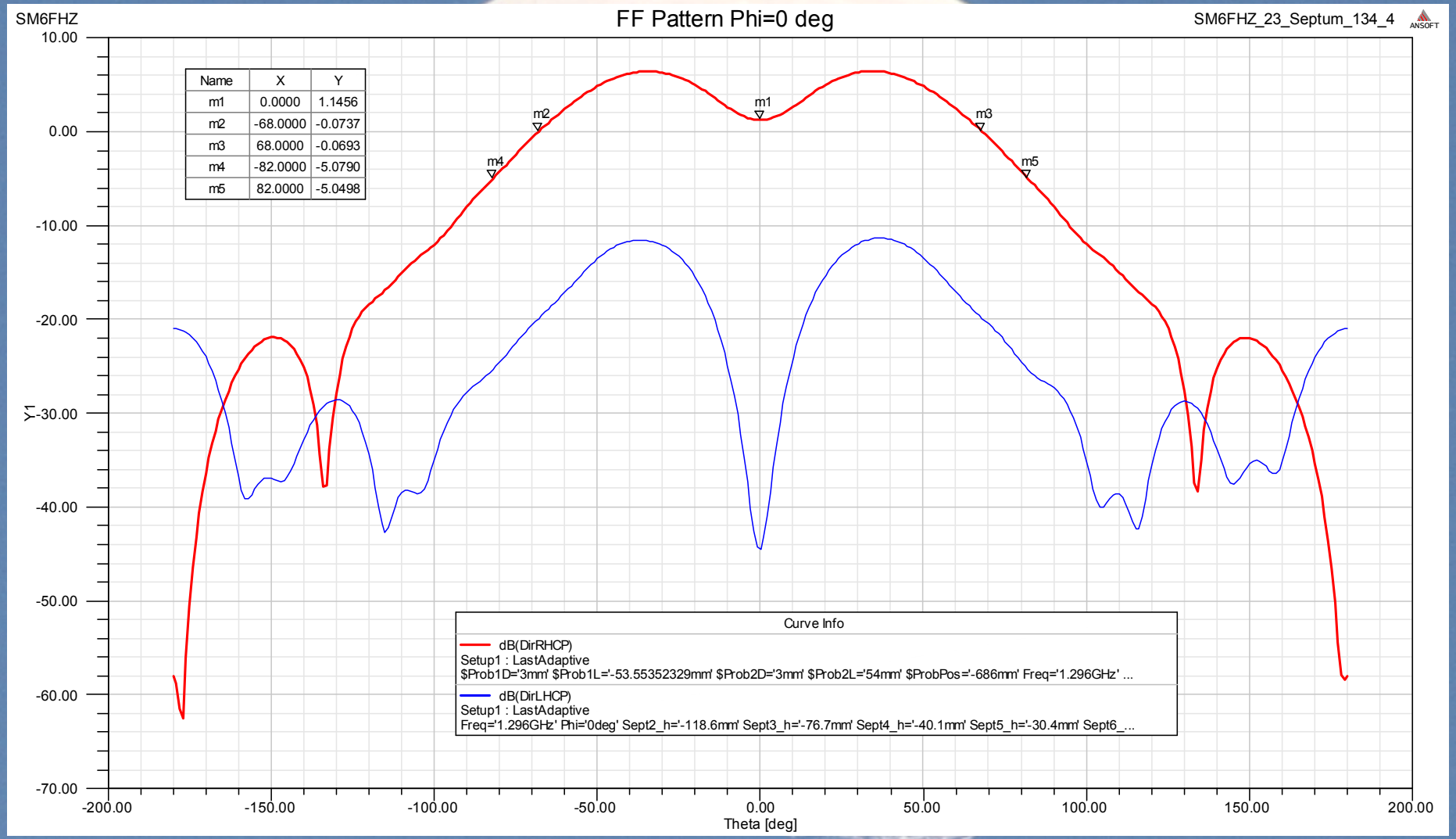


3D Total Power Far Field pattern

(23 cm 0.71 wl WG)

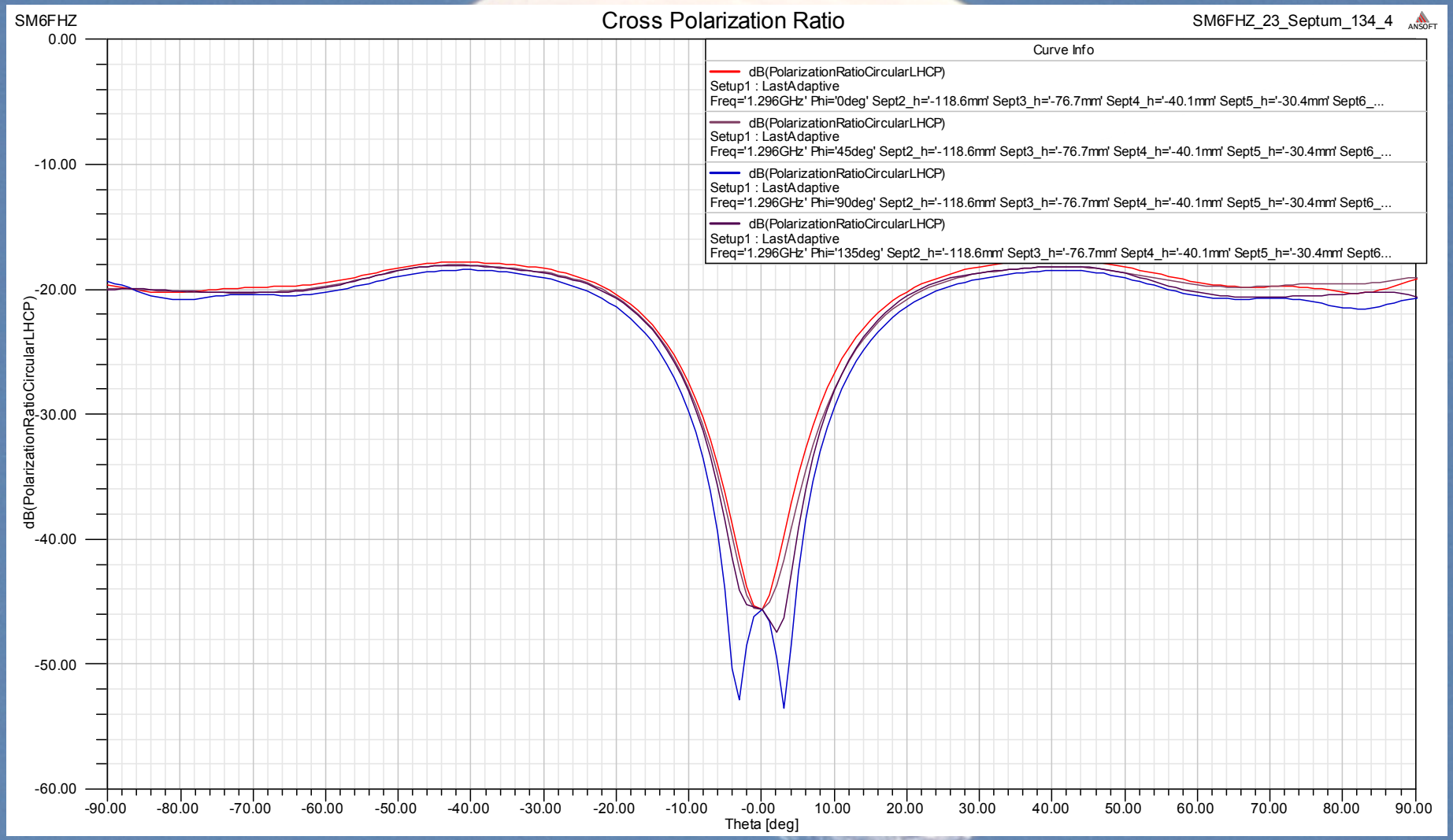


Far Field Pattern 0 deg (23 cm 0.71 wl WG)

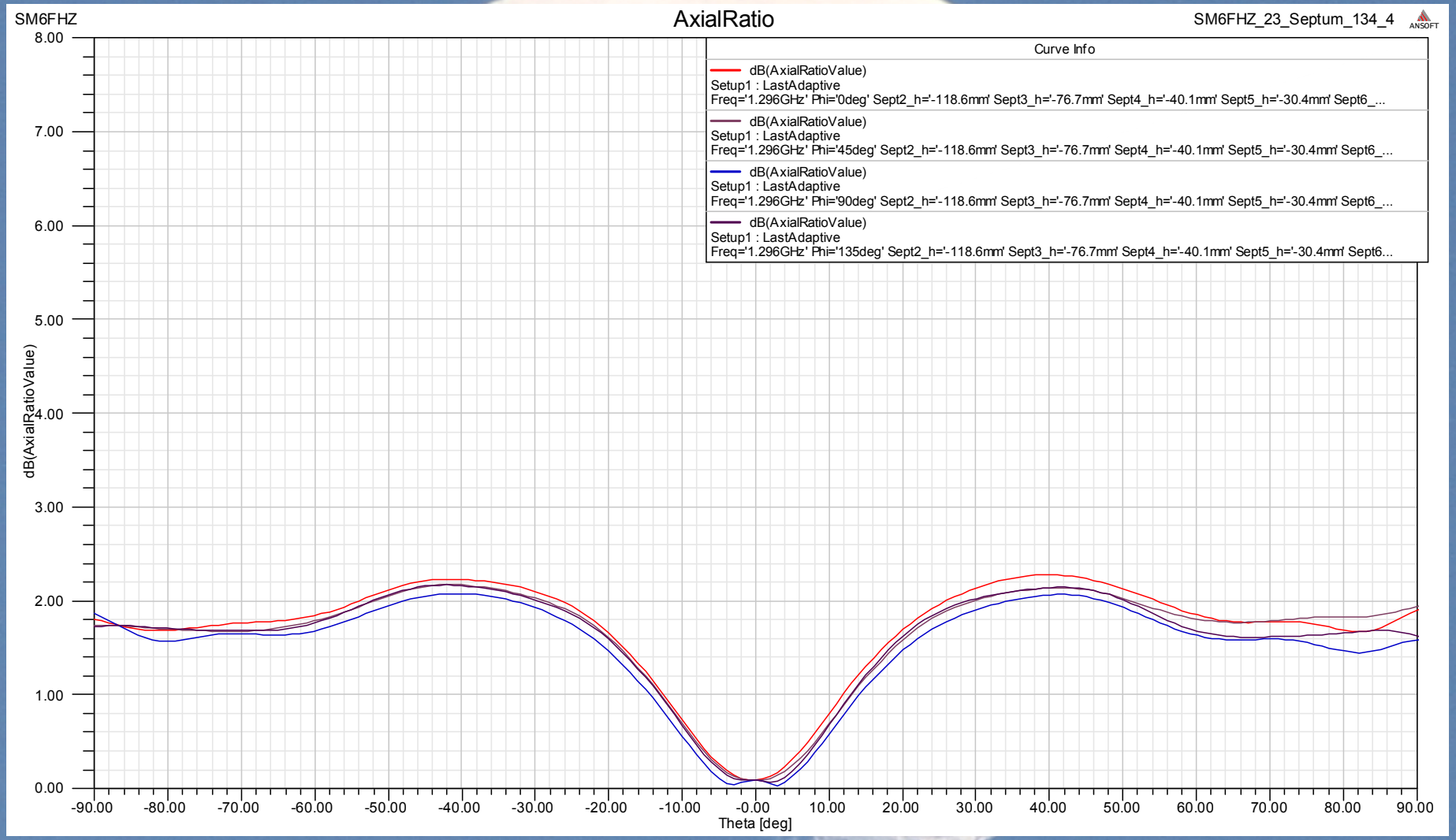


Far Field Phase error (23 cm 0.71 wl WG)

Cross Polar Ratio (23 cm 0.71 wl WG)



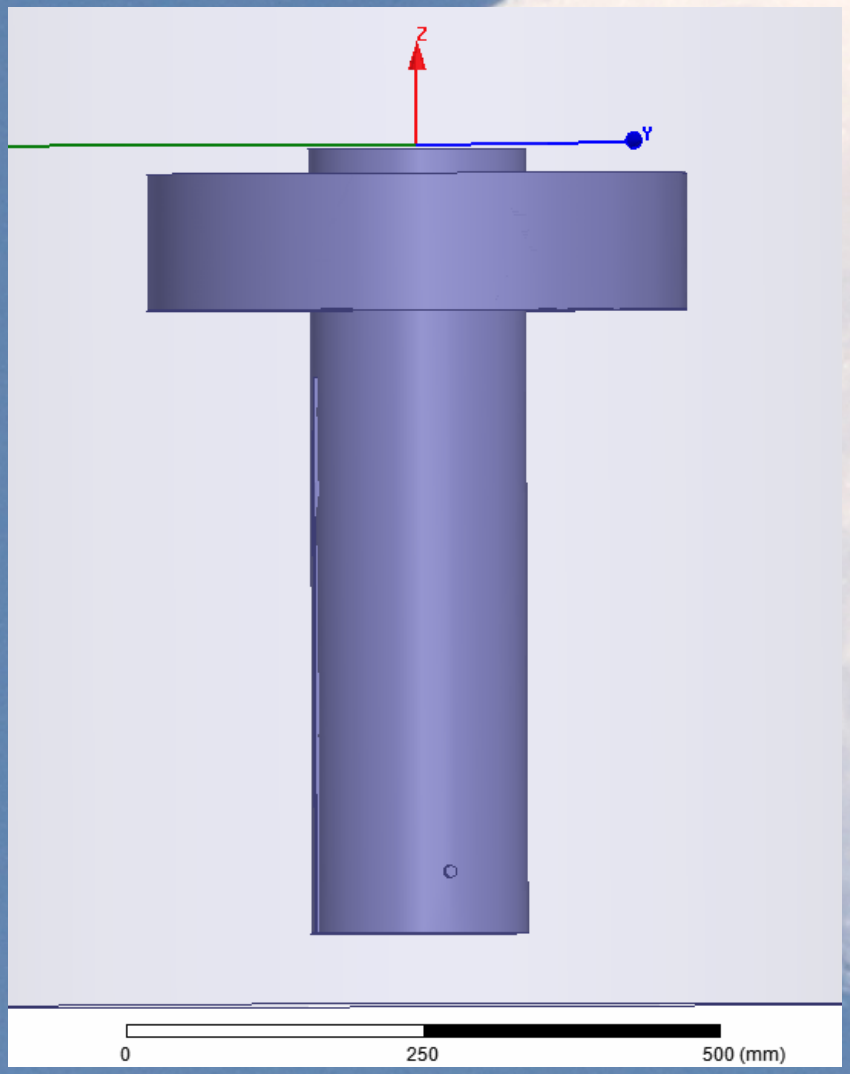
Axial Ratio (23 cm 0.71 wl WG)

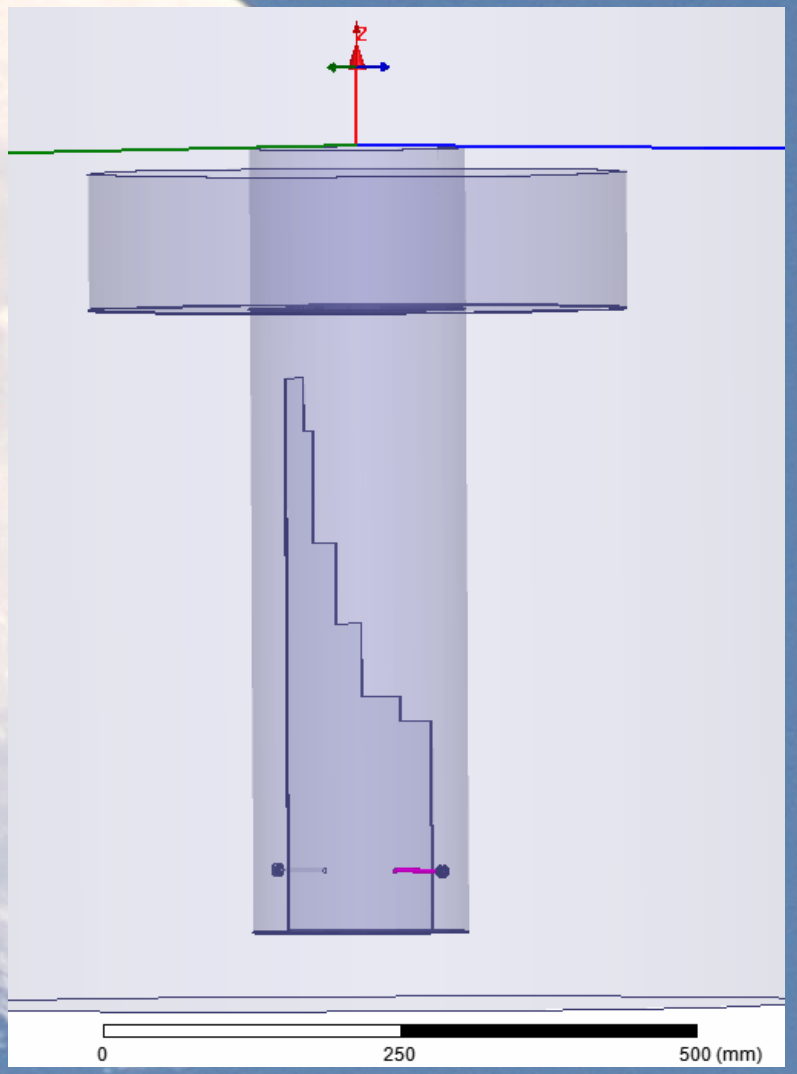


SM6FHZ 23 cm 5 step septum feed

0.795 lambda W/G

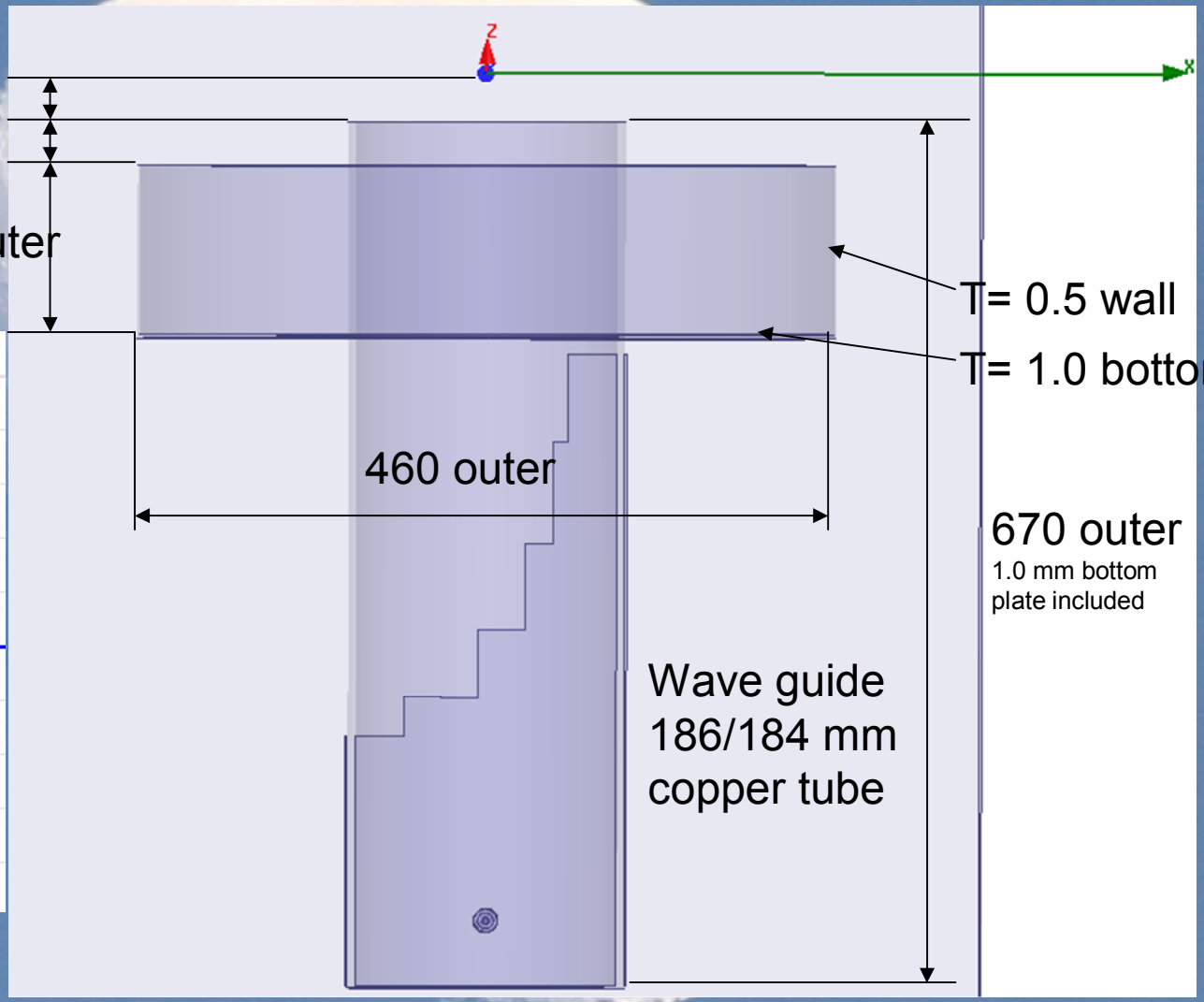
Solid and transparent models from the simulation (23 cm 0.795 wl WG)





WG and choke dimensions

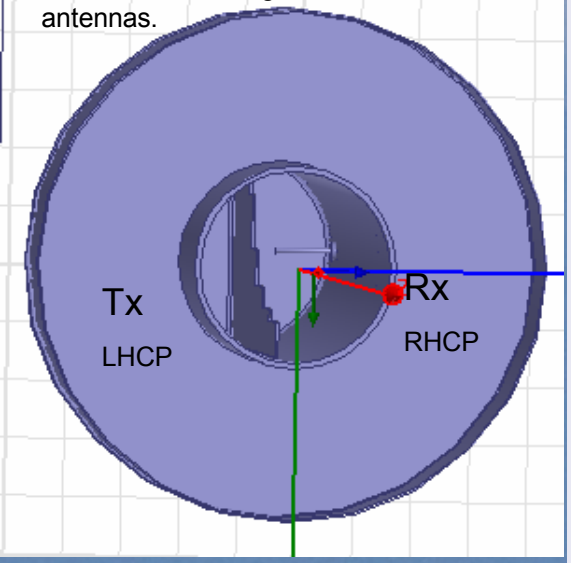
(23 cm 0.795 wl WG)



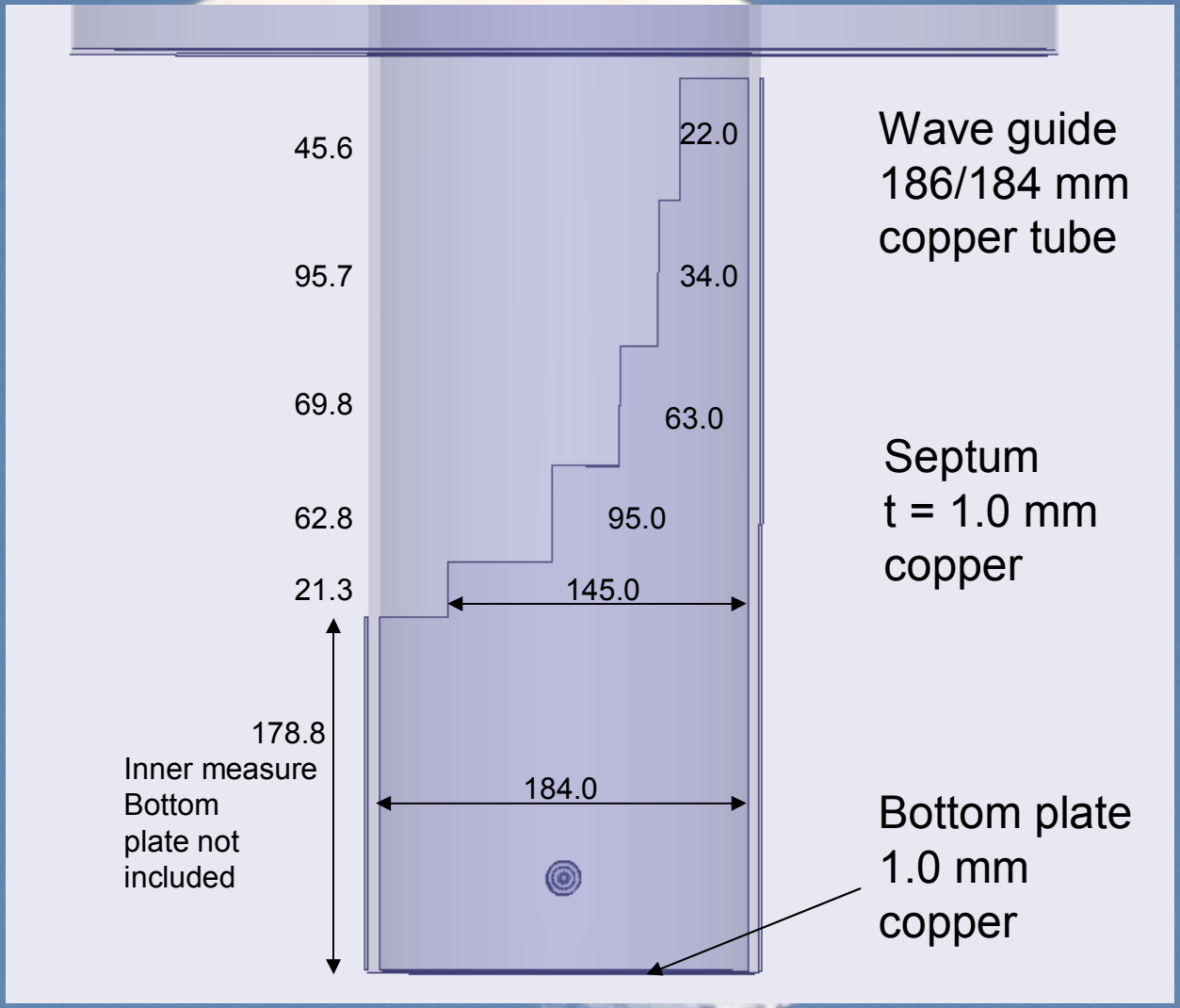
Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

Tx RHCP in space
Rx LHCP in space

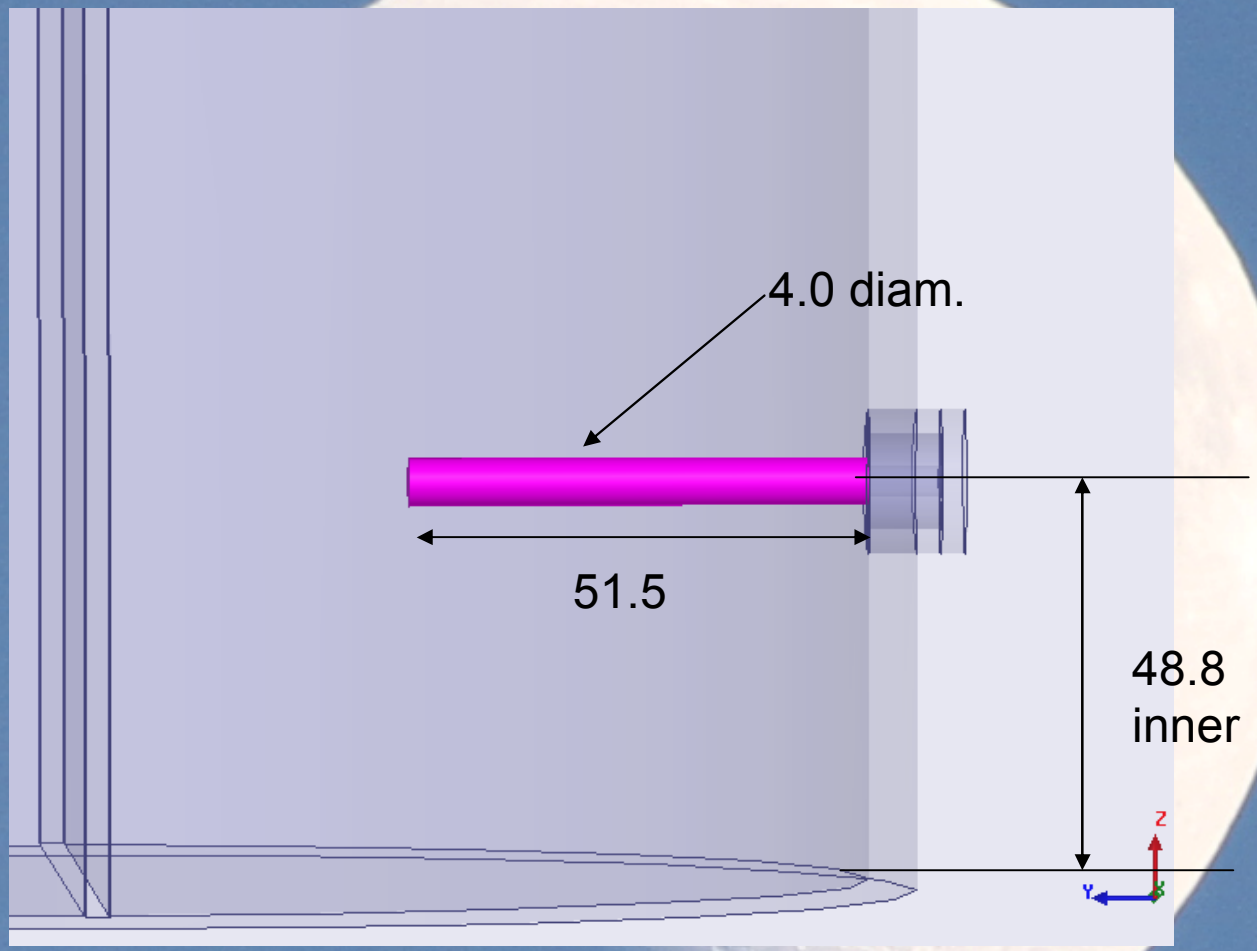
Take polarization reversal into account when using reflector antennas.



Septum dimensions (23 cm 0.795 wl WG)

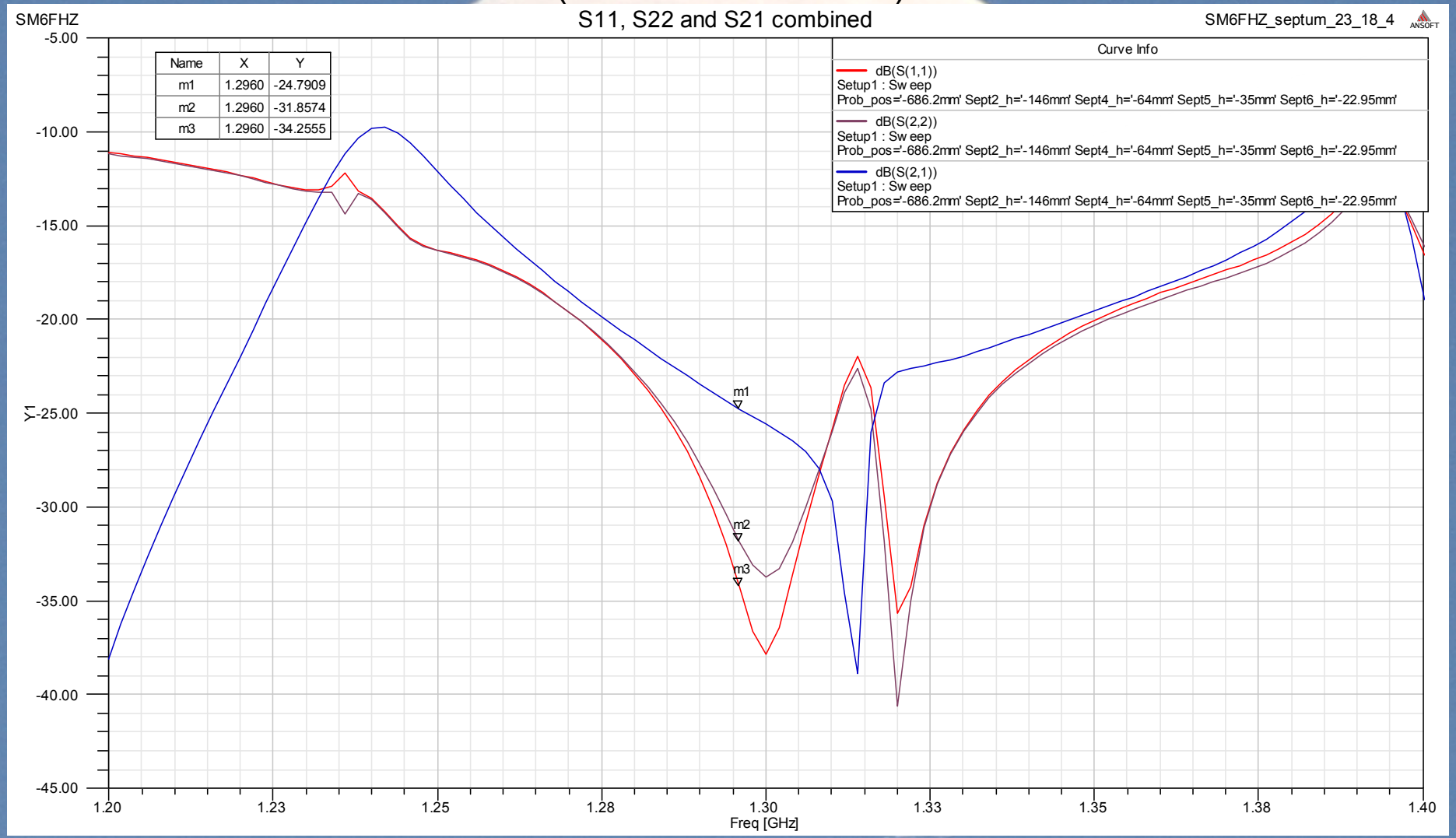


Probe dimensions (23 cm 0.795 wl WG)



S11, S22, S21 combined

(23 cm 0.795 wl WG)



Complex impedance Rx-port

(23 cm 0.795 wl WG)

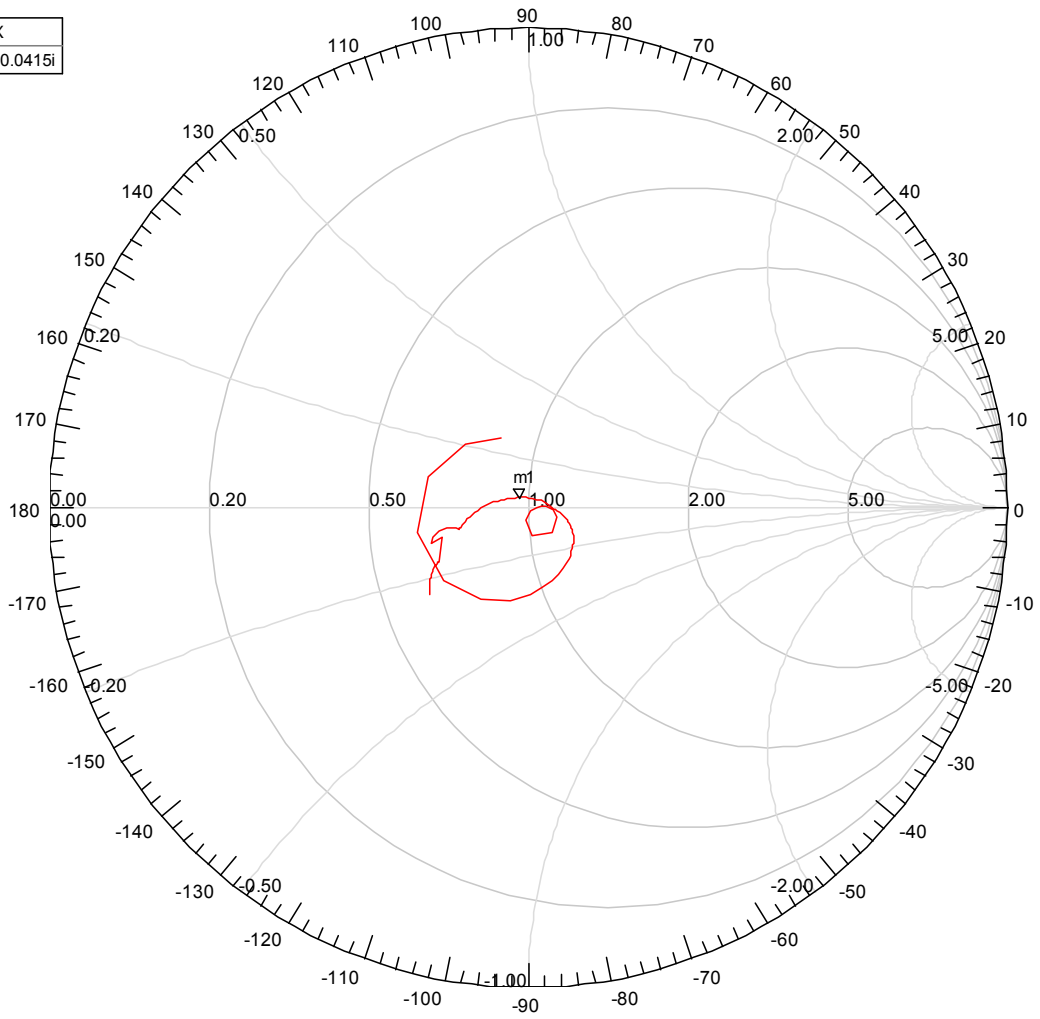
SM6FHZ

Smith Chart Rx-port

SM6FHZ_septum_23_18_4

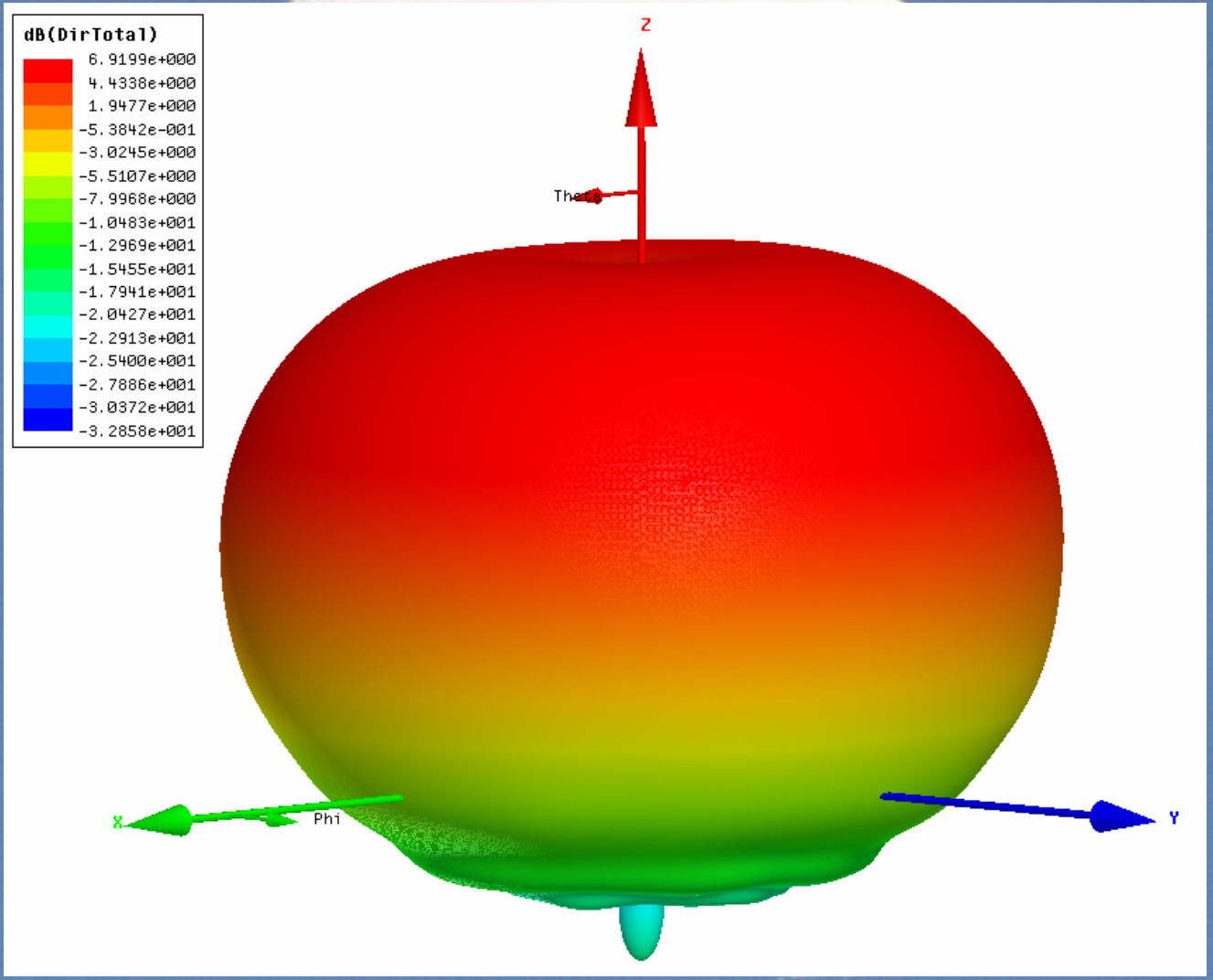
Name	Freq	Ang	Mag	RX
m1	1.2970	123.2444	0.0255	0.9715 + 0.0415i

Curve Info
S(2,2)
Setup1 : Sweep

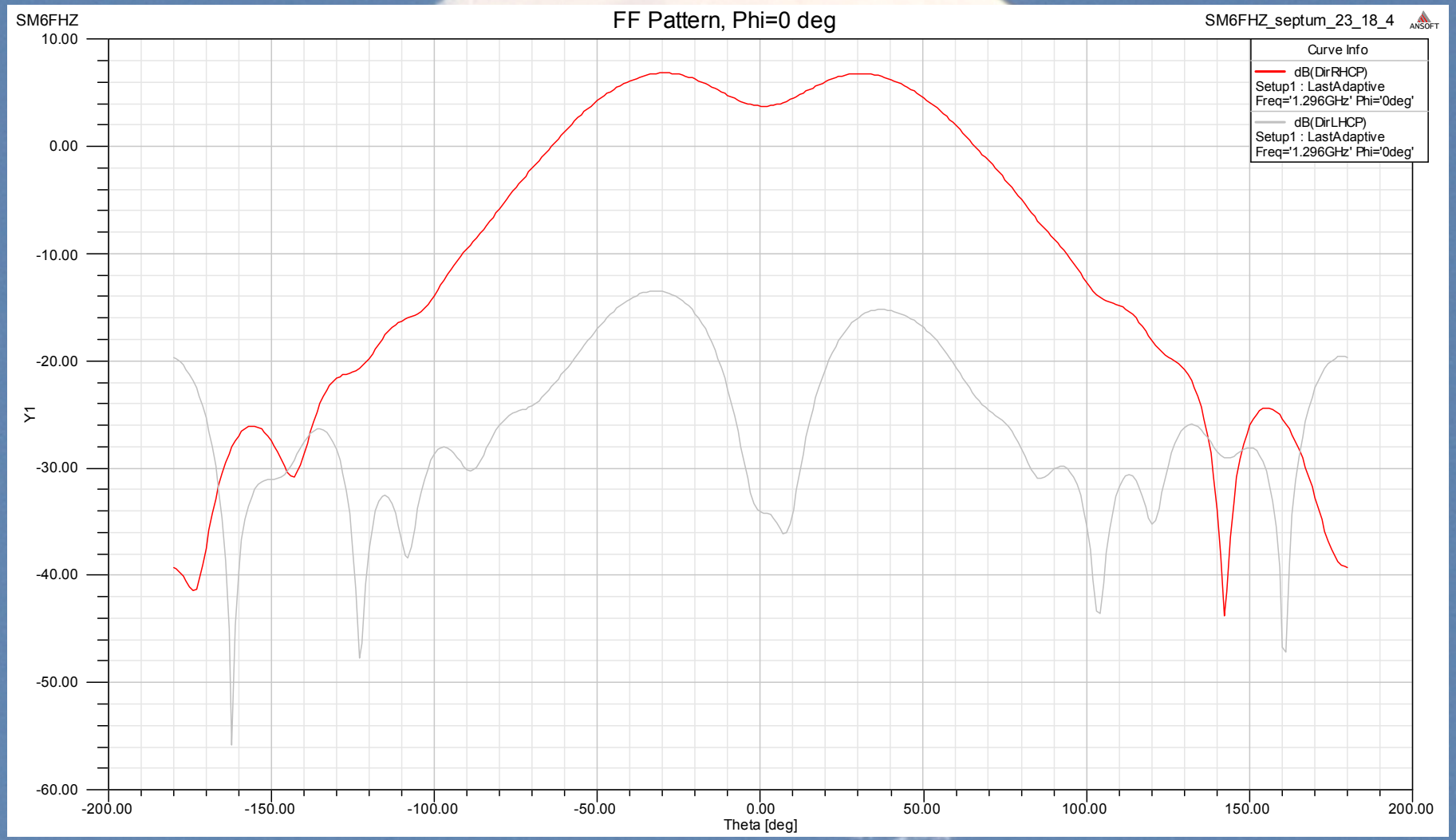


3D Total Power Far Field pattern

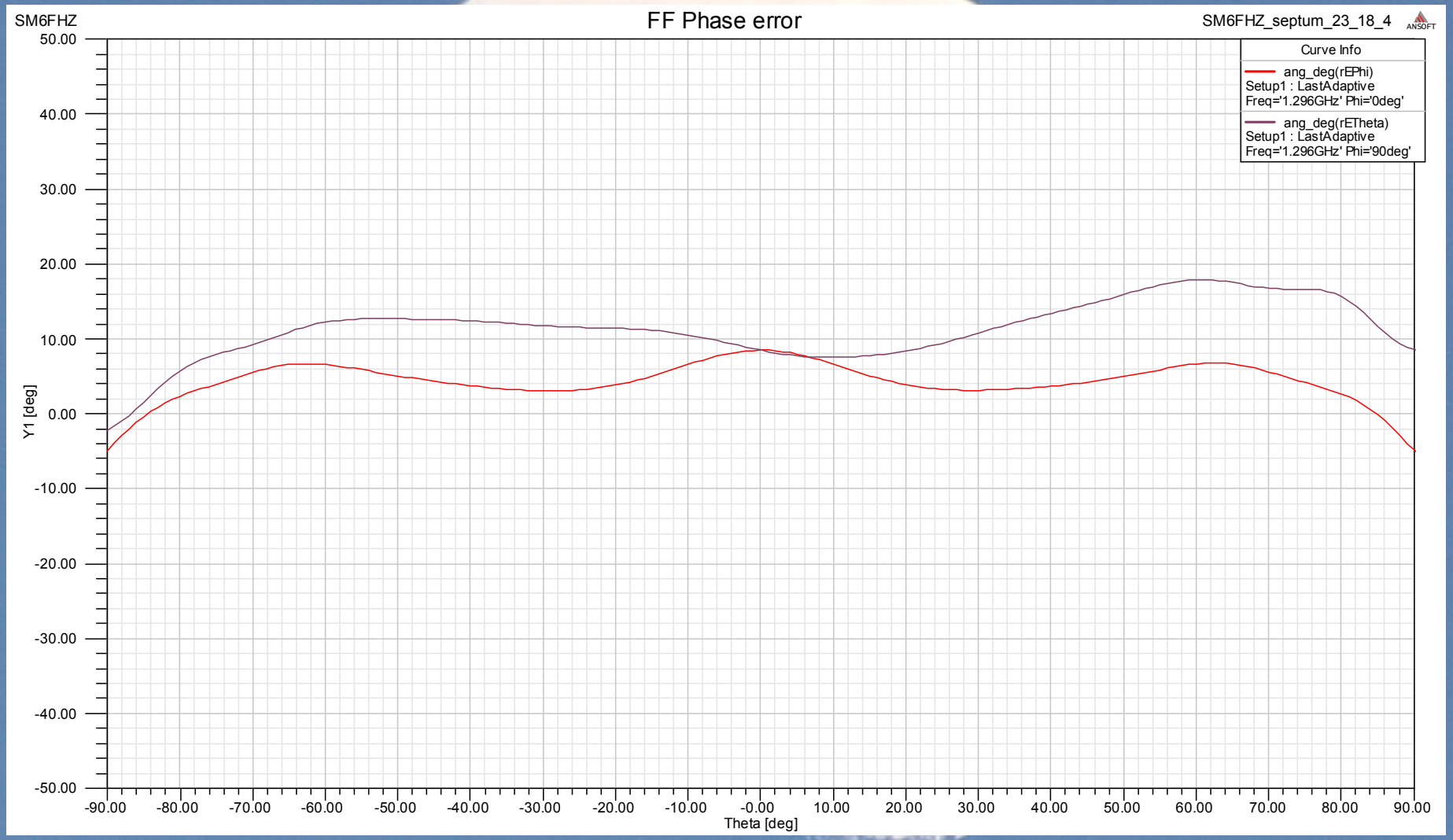
(23 cm 0.795 wl WG)



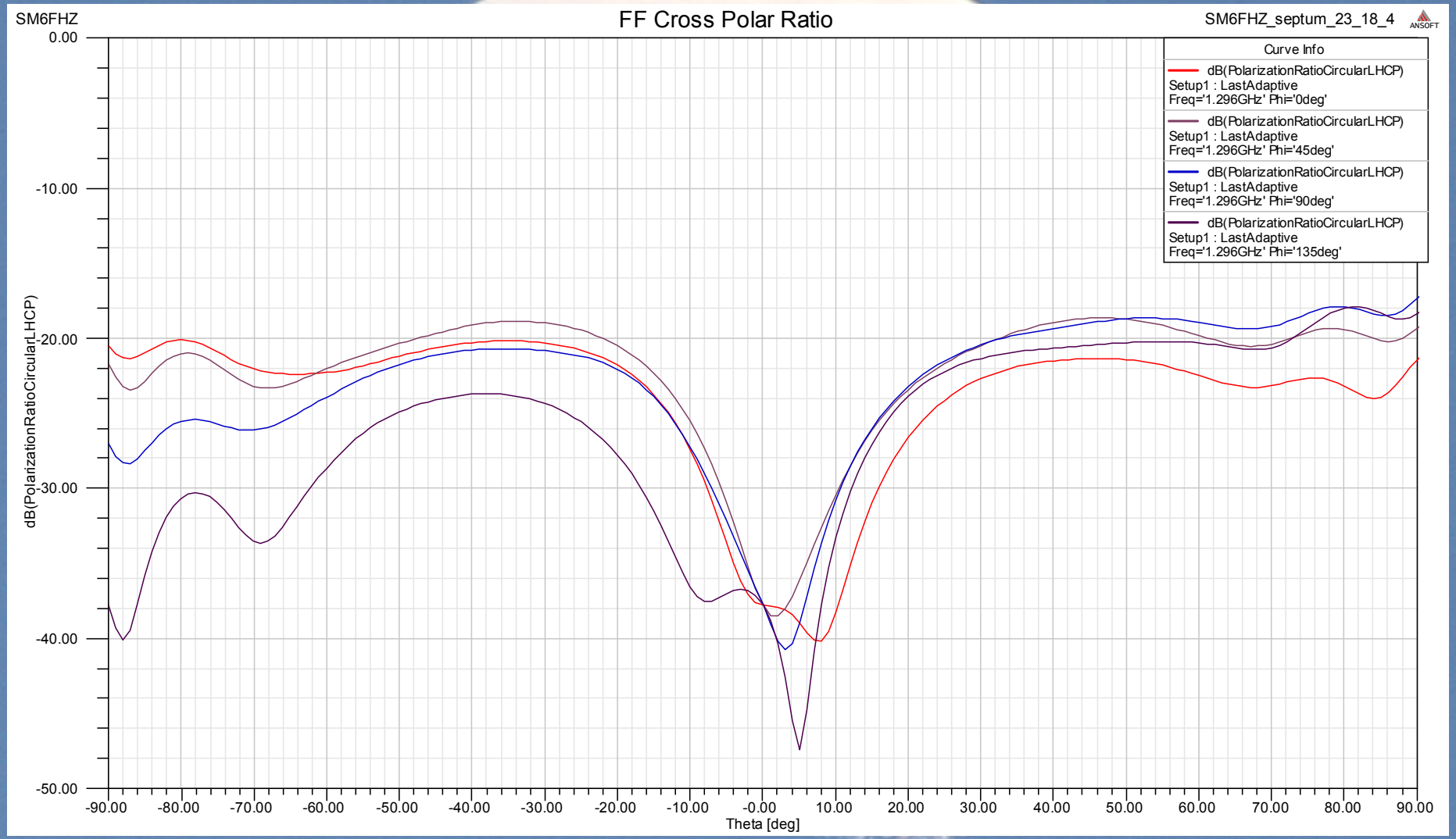
Far Field Pattern 0 deg (23 cm 0.795 wl WG)



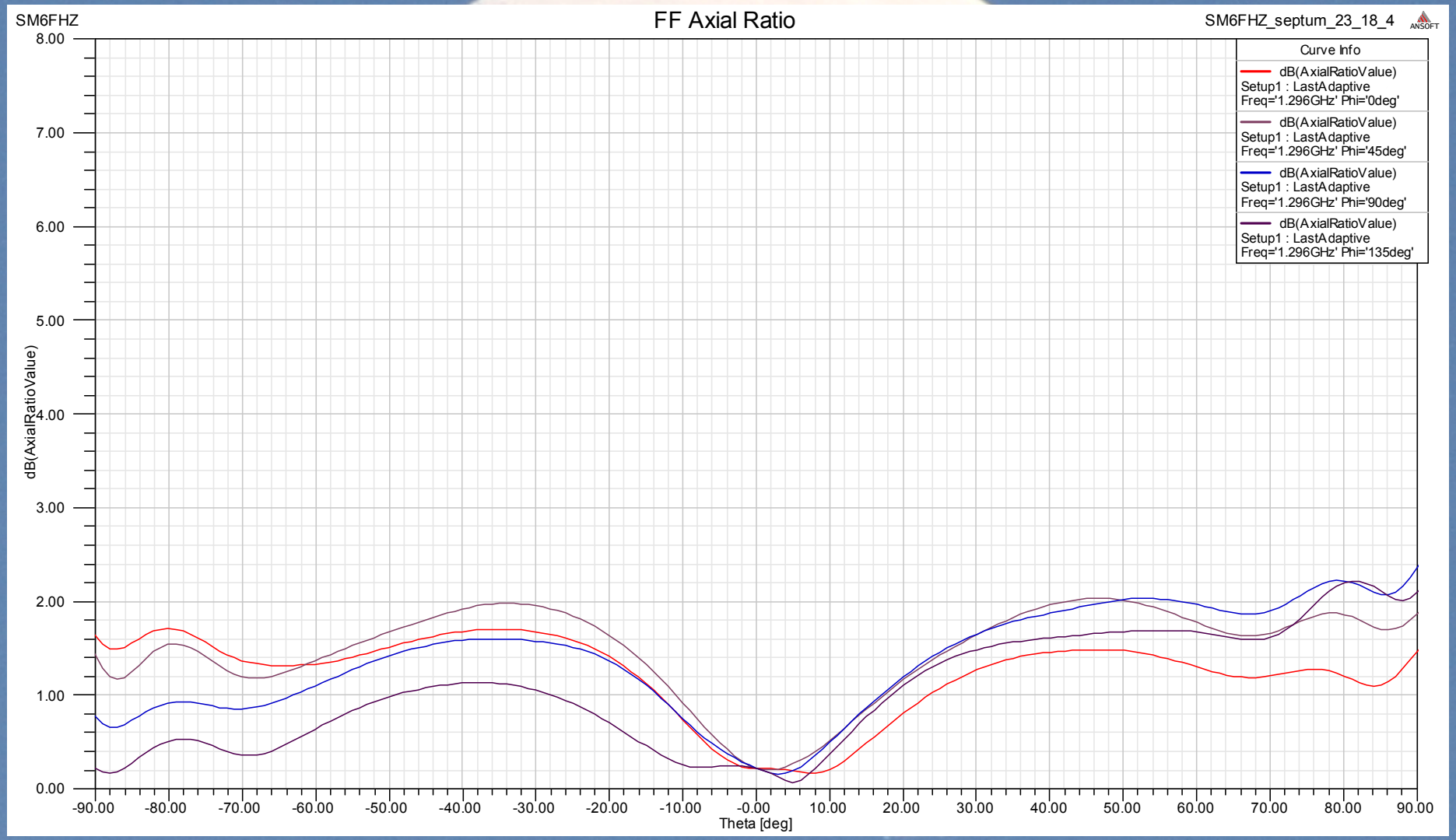
Far Field Phase error (23 cm 0.795 wl WG)



Cross Polar Ratio (23 cm 0.795 wl WG)



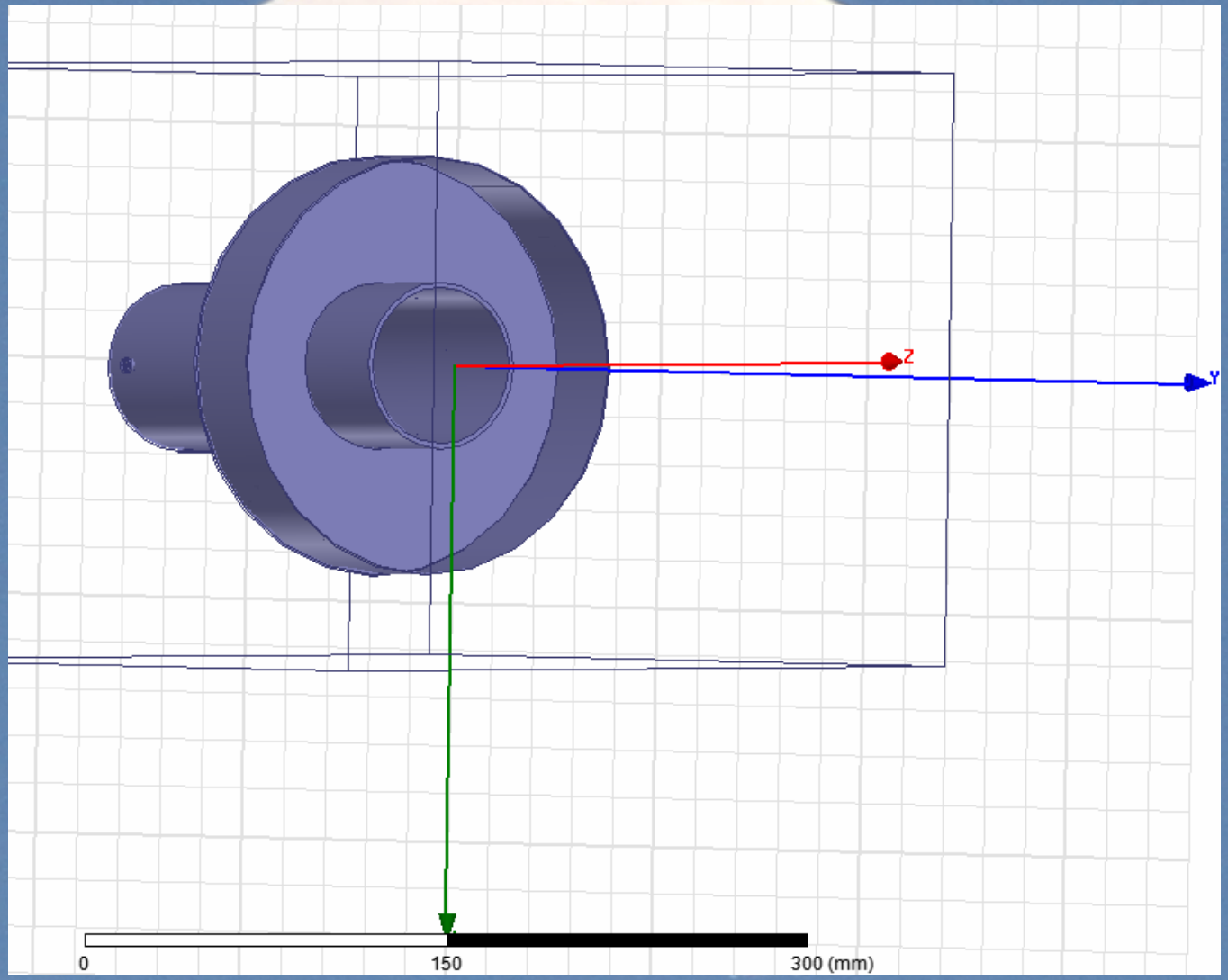
Axial Ratio (23 cm 0.795 wl WG)



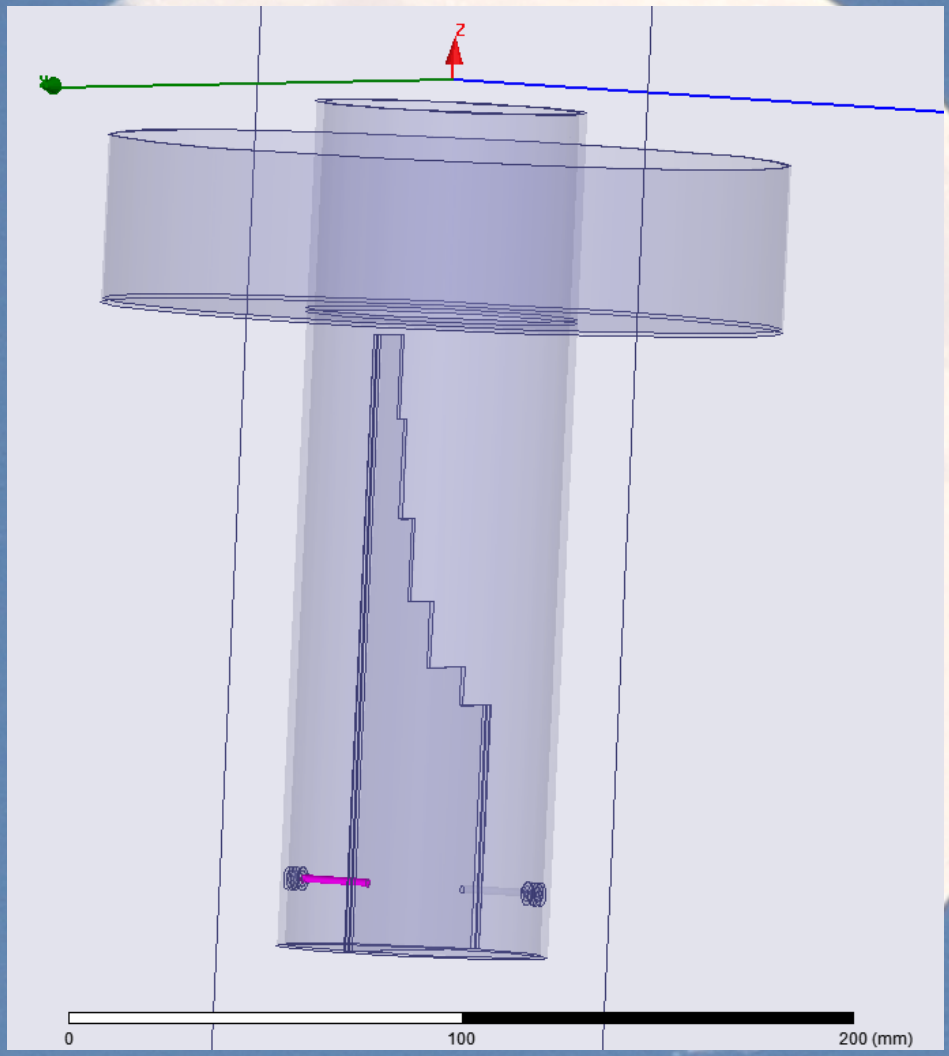
SM6FHZ 9 cm 5 step septum feed

0.748 lambda W/G

Model (9 cm 0.748 wl WG)



Transparent model (9 cm 0.748 wl WG)



WG and choke dimensions (9 cm 0.748 wl WG)

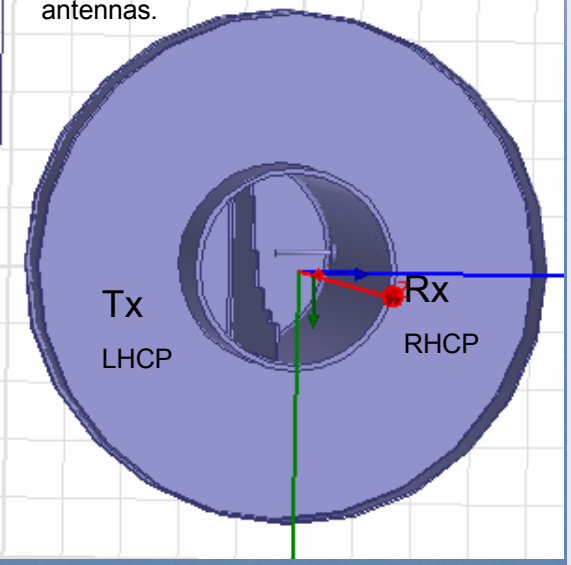
Phase center 3.3
11

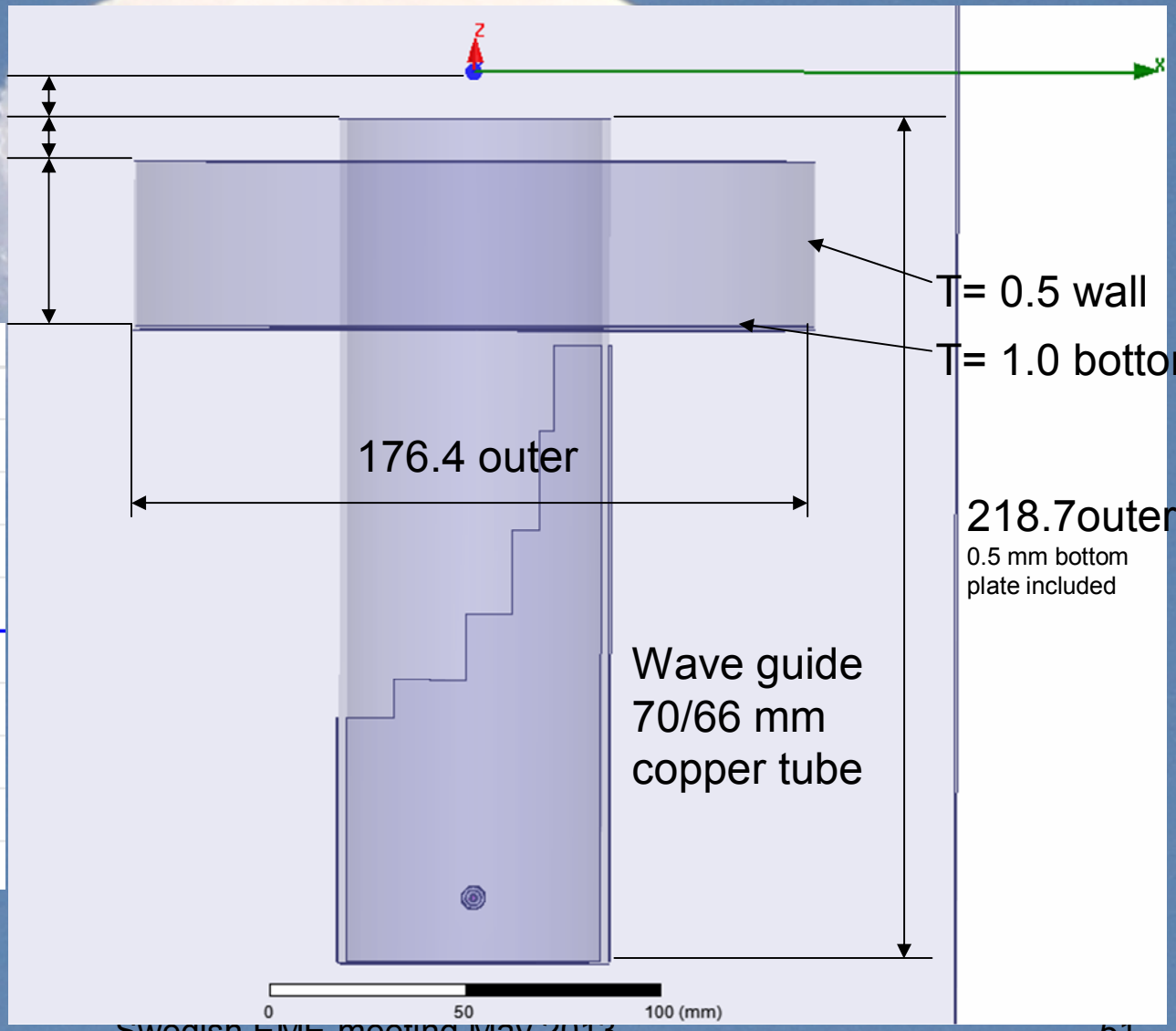
Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

Tx RHCP in space
Rx LHCP in space

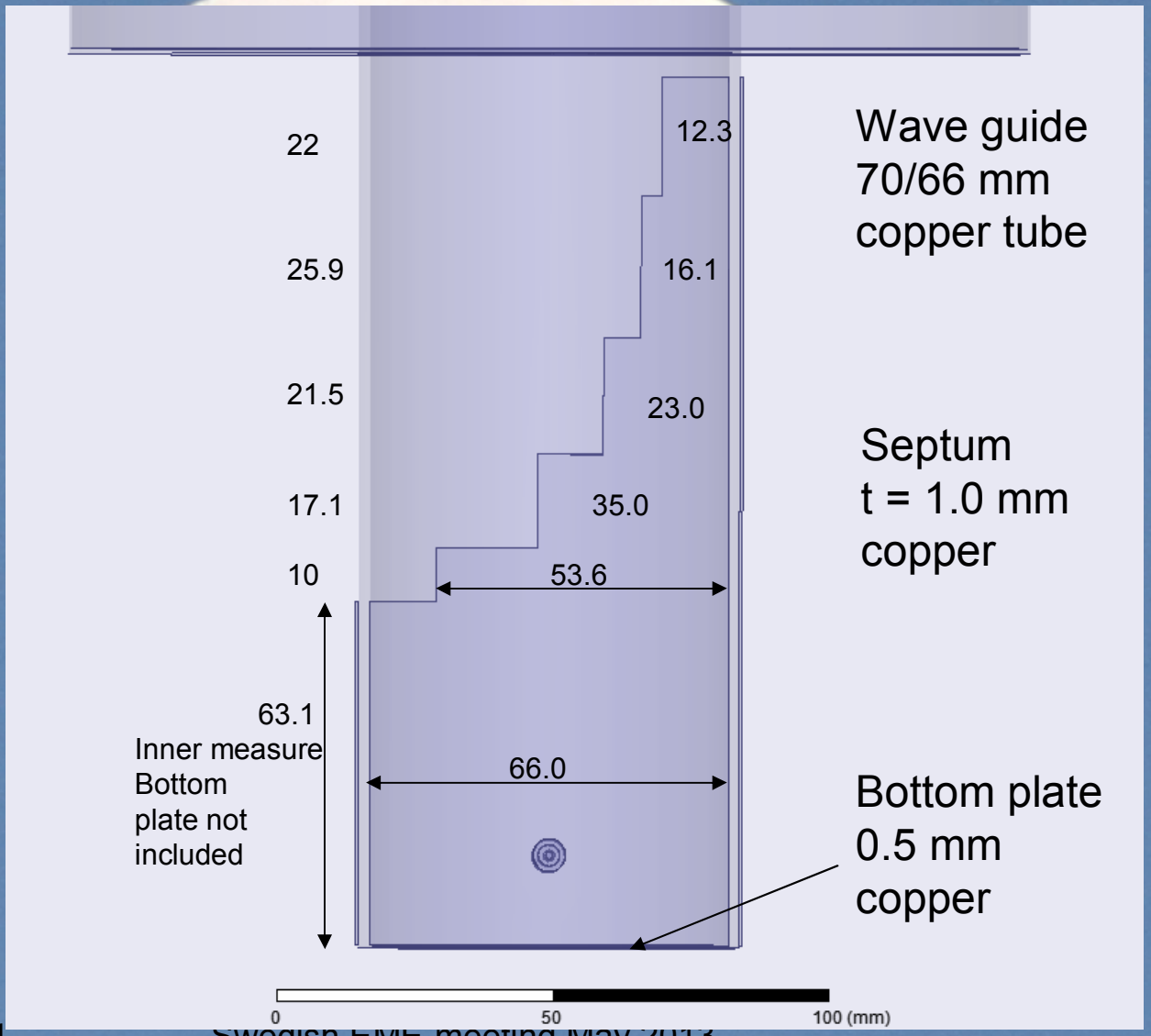
43.5
outer

Take polarization reversal into account when using reflector antennas.

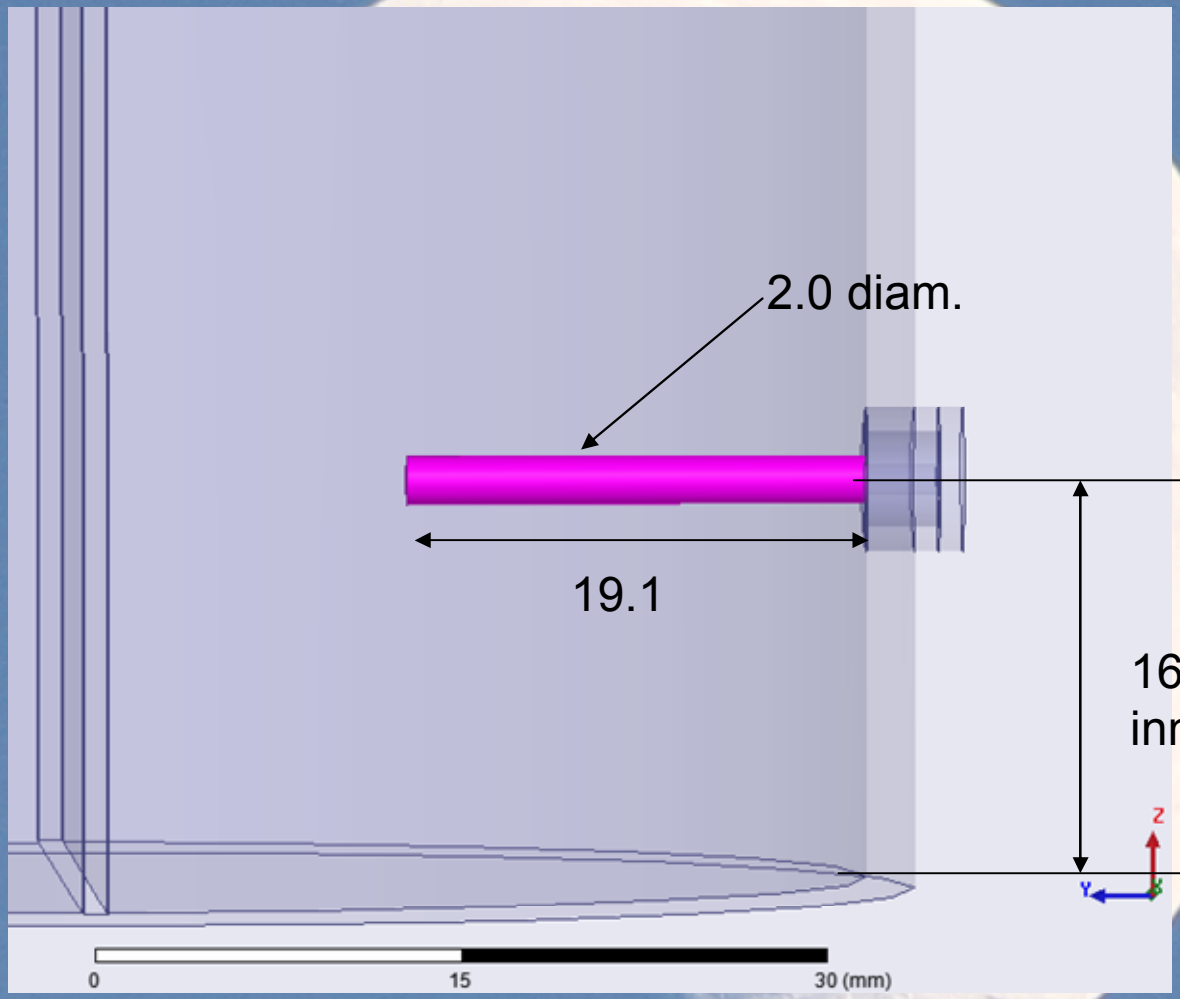




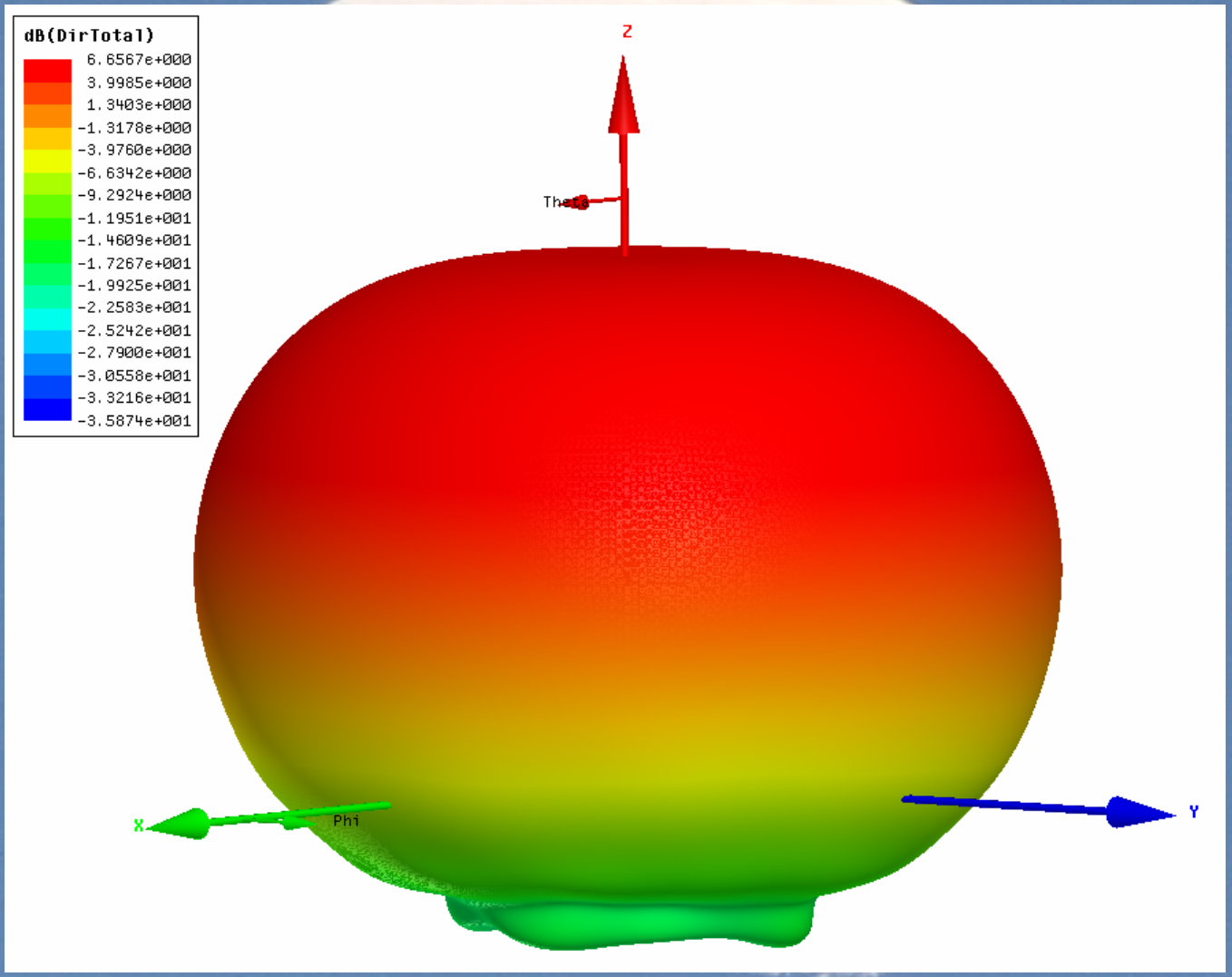
Septum dimensions (9 cm 0.748 wl WG)



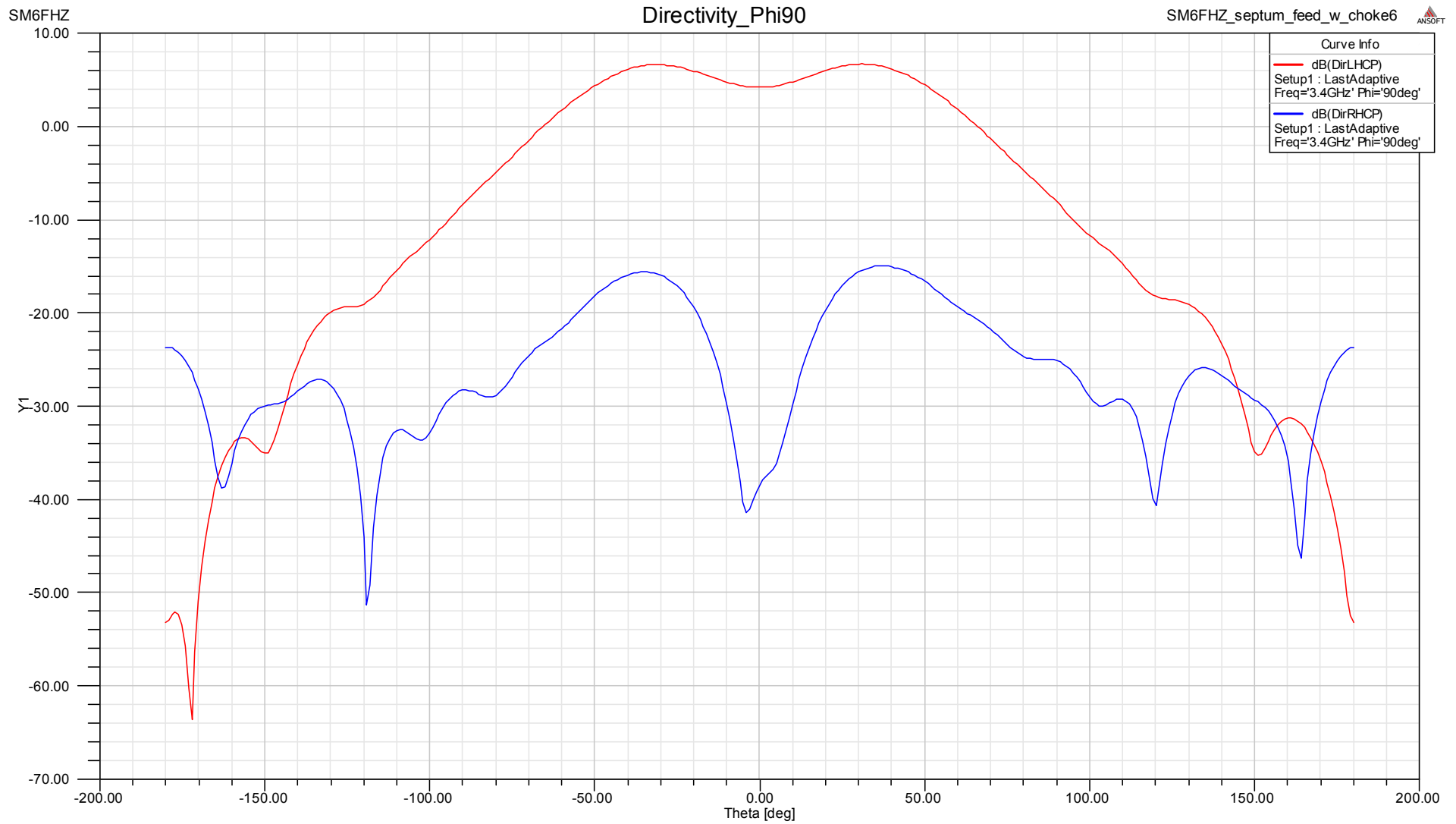
Probe dimensions (9 cm 0.748 wl WG)



FF 3D Total Power pattern (9 cm 0.748 wl WG)

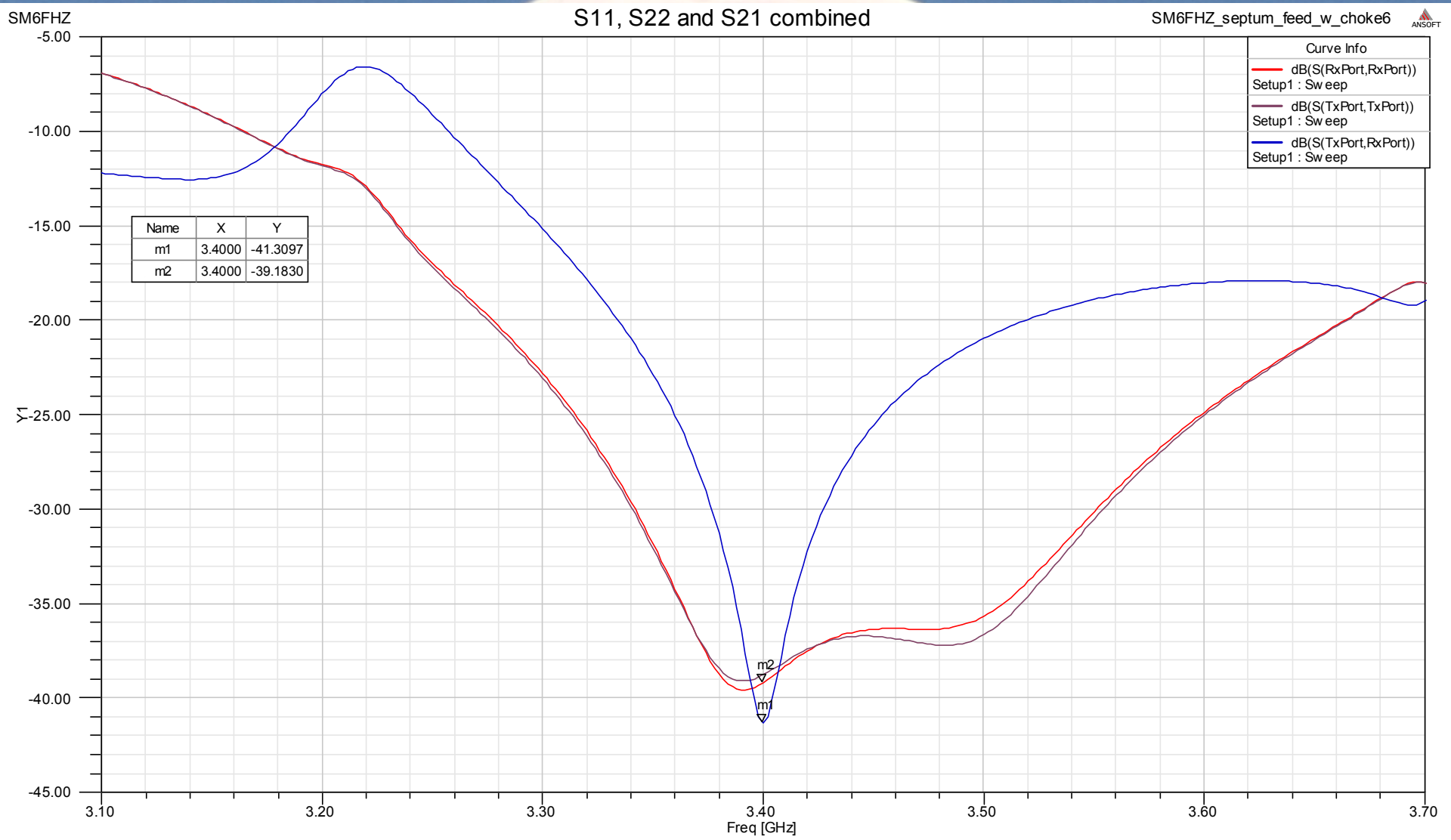


FF Directivity pattern (9 cm 0.748 wl WG)



S11, S22 and S21 combined

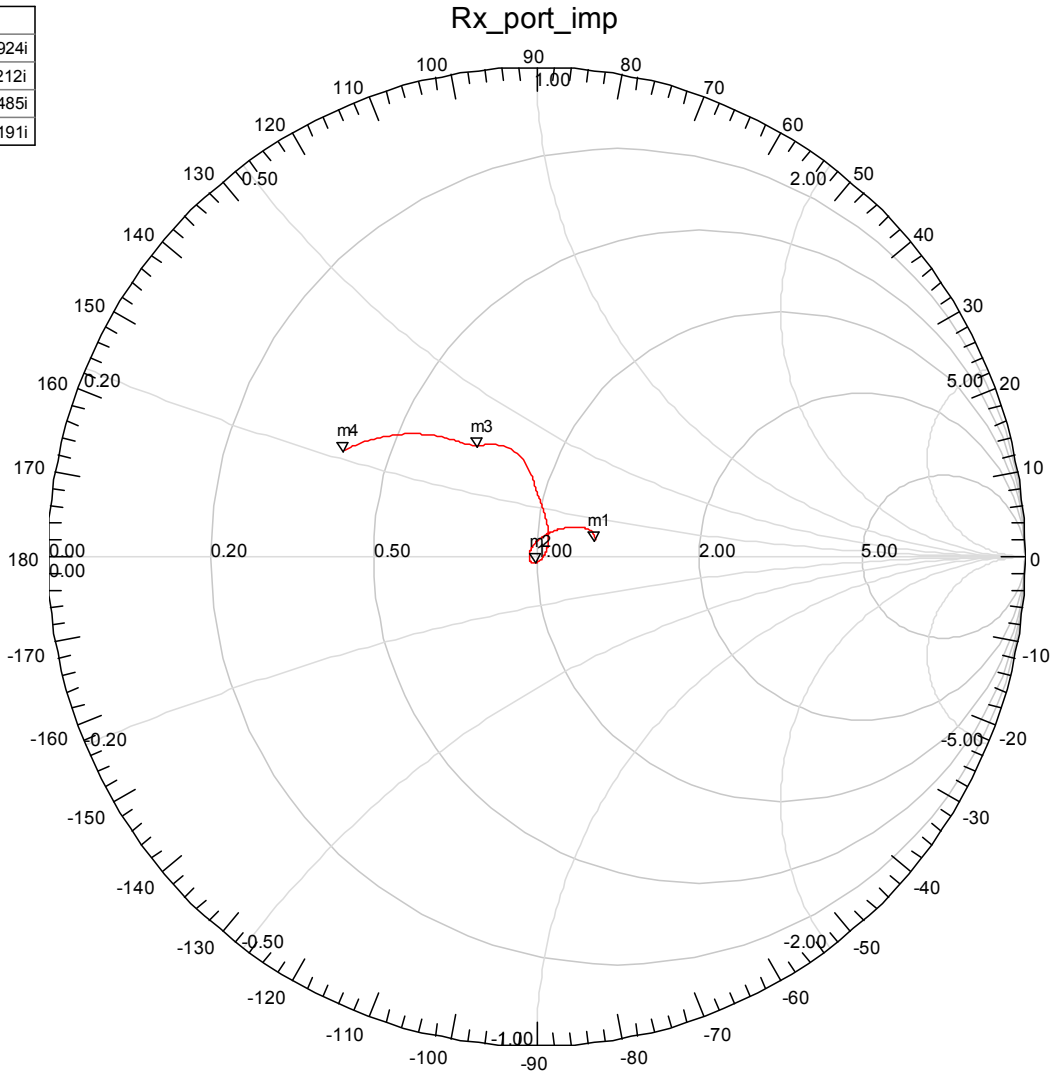
(9 cm 0.748 wl WG)



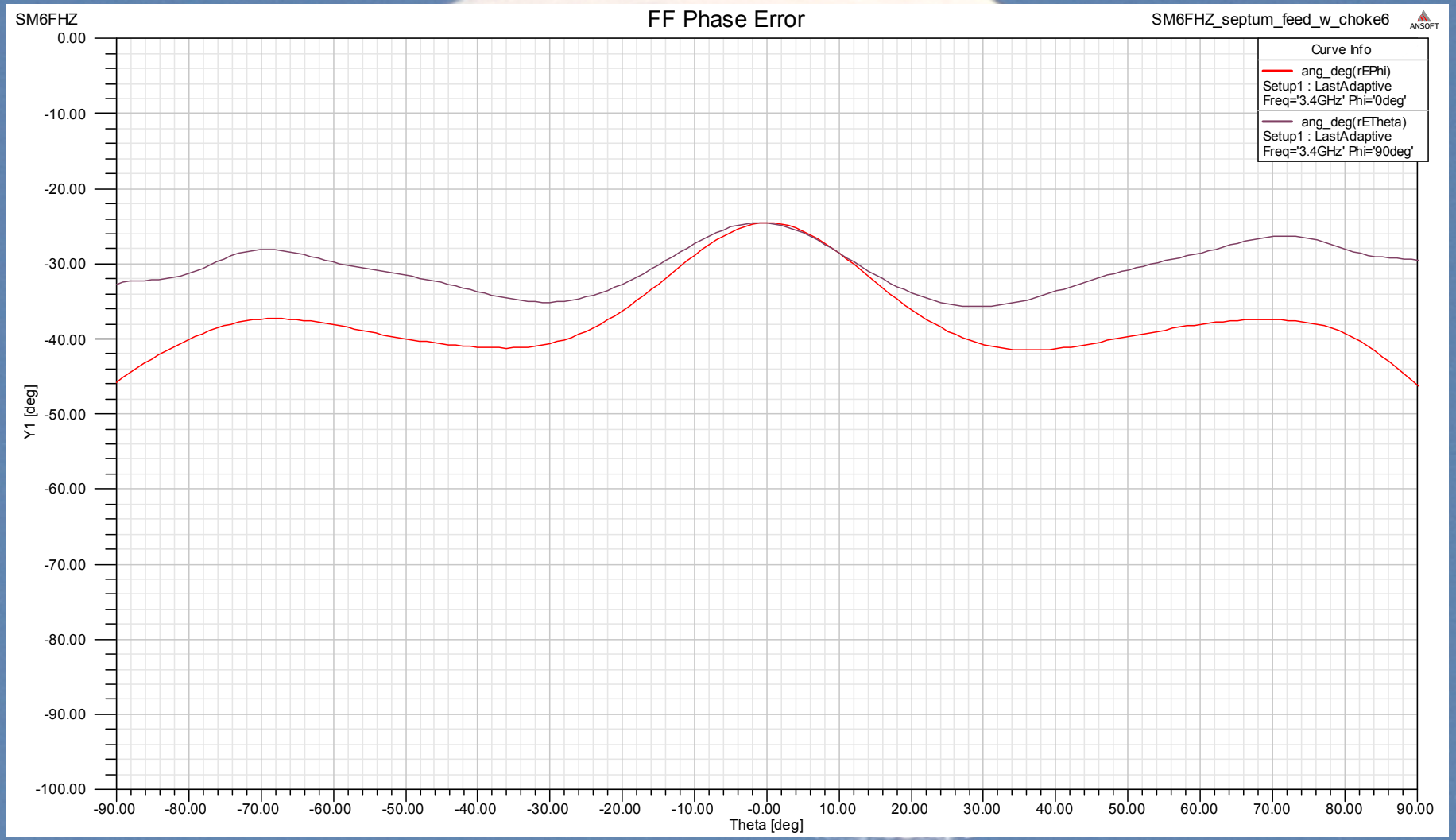
Complex impedance Rx-port

(9 cm 0.748 wl WG)

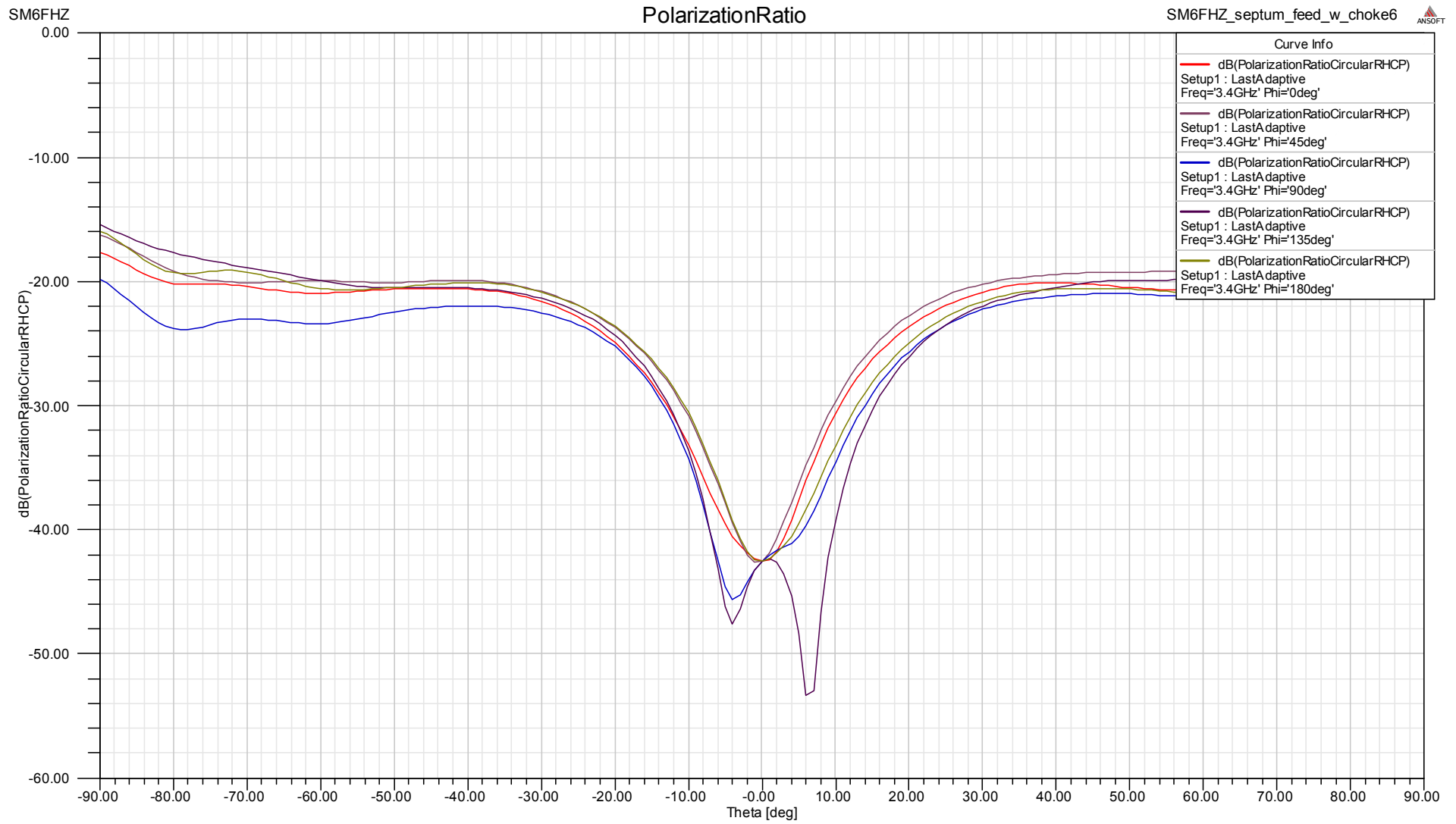
Name	Freq	Ang	Mag	RX
m1	3.7000	16.6154	0.1253	1.2692 + 0.0924i
m2	3.4000	-73.3845	0.0110	1.0061 - 0.0212i
m3	3.2000	117.7322	0.2570	0.7156 + 0.3485i
m4	3.1000	151.0225	0.4496	0.4012 + 0.2191i



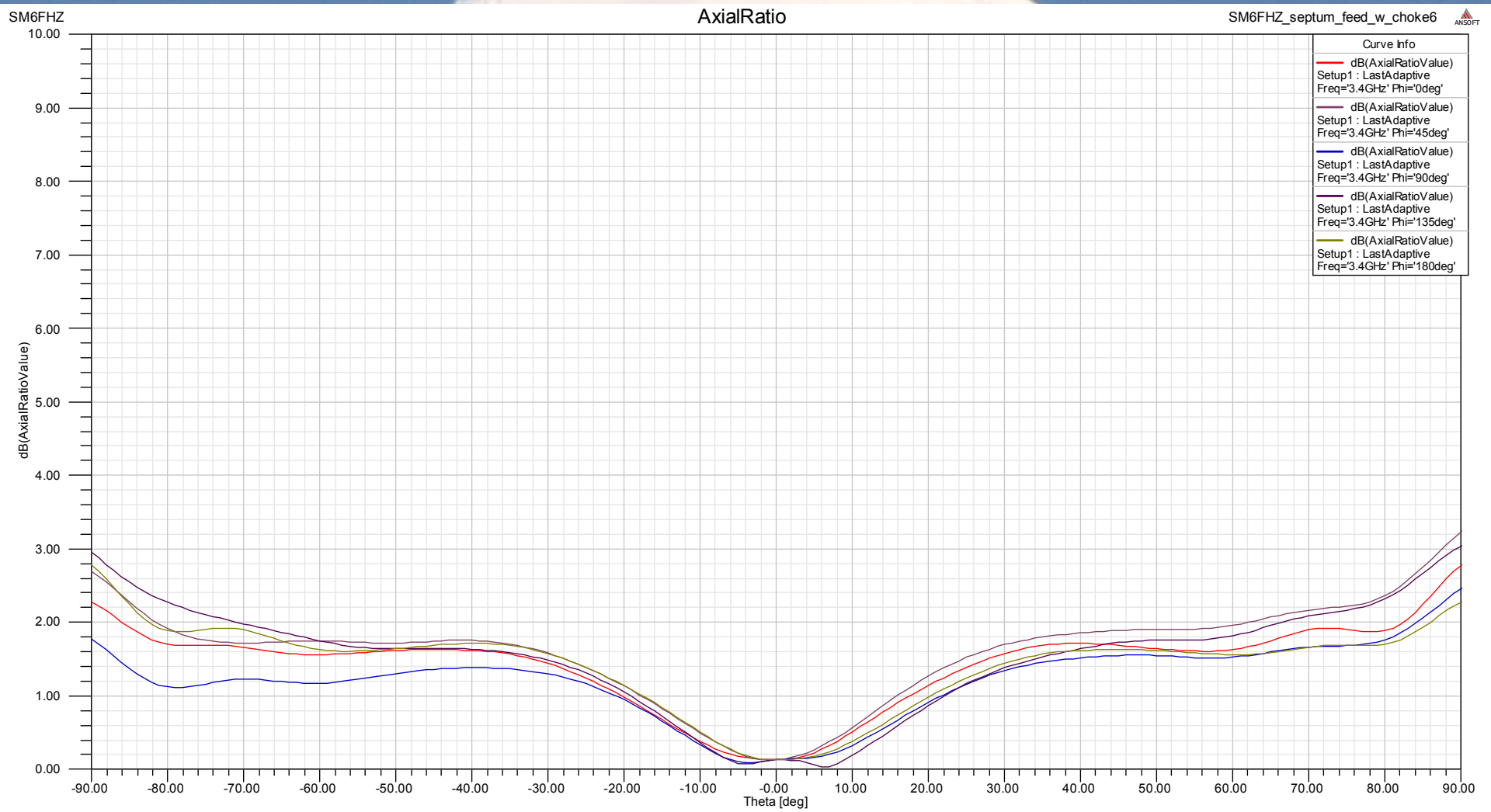
FF Phase error (9 cm 0.748 wl WG)



Cross Polarization Ratio (9 cm 0.748 wl WG)



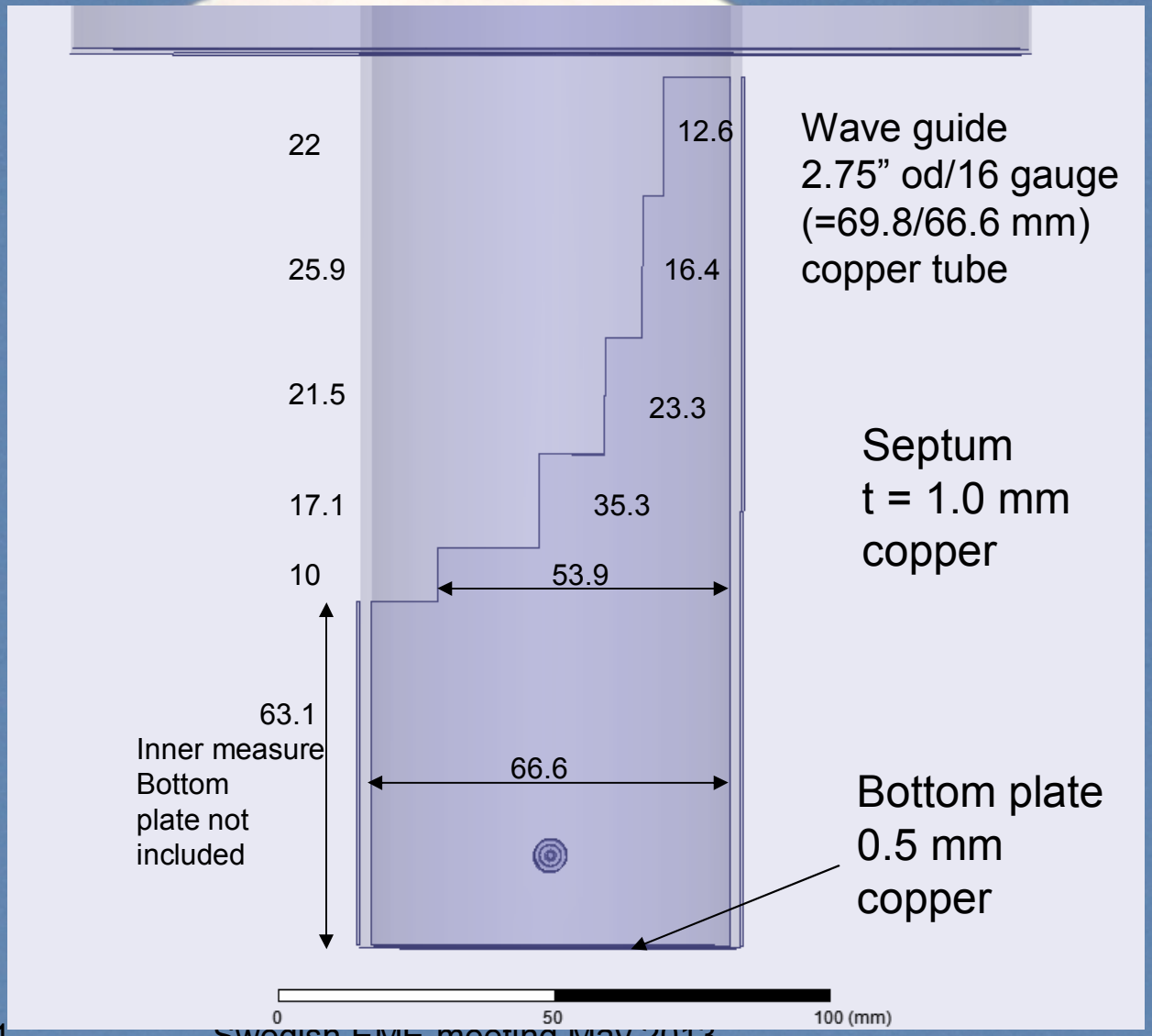
Axial Ratio (9 cm 0.748 wl WG)



Septum dimensions **inch tube**

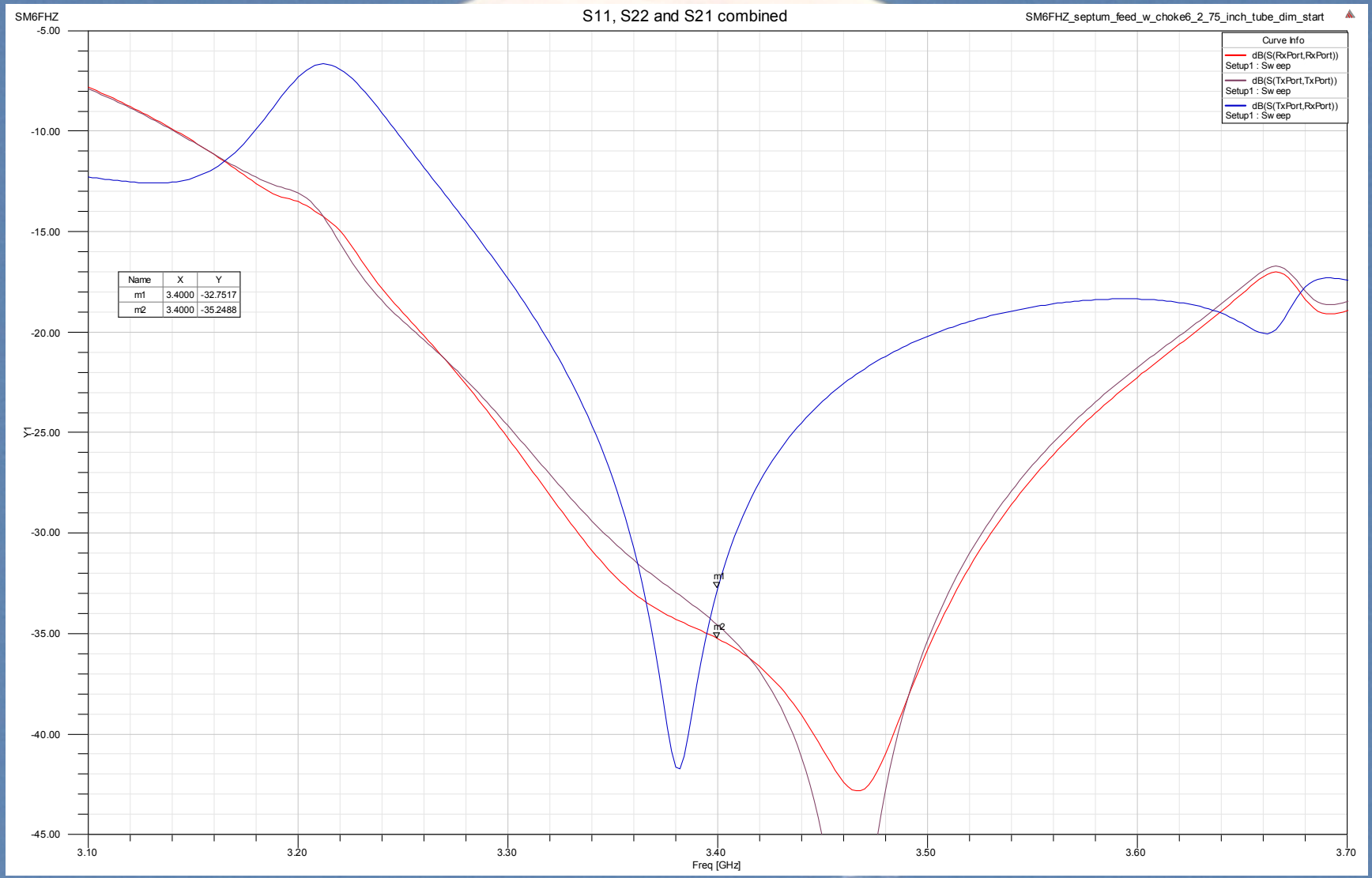
(**Inch tube** 2.75”/16 gauge wall, 9 cm 0.755 wl WG)

If using the 2.75” od 16 gauge wall tube, **without any compensations,** the dimensions will look like this. The S-parameters will be as shown in the following slide. The radiating performance does not change a lot. The phase centre moves 1mm outwards from the feed mouth.



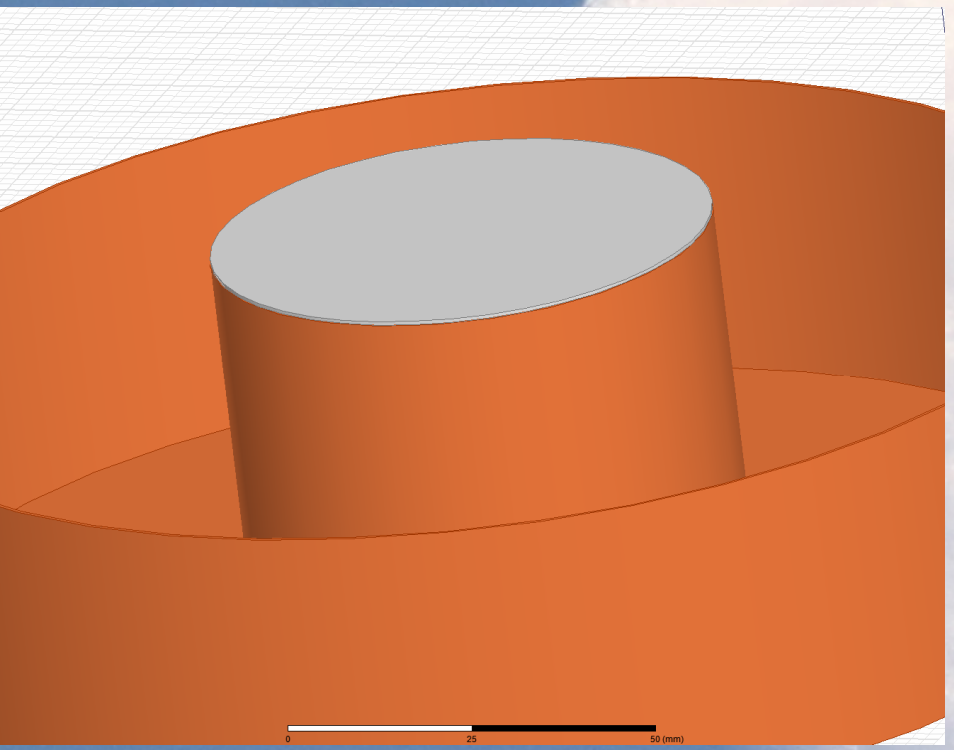
S11, S22 and S21 combined

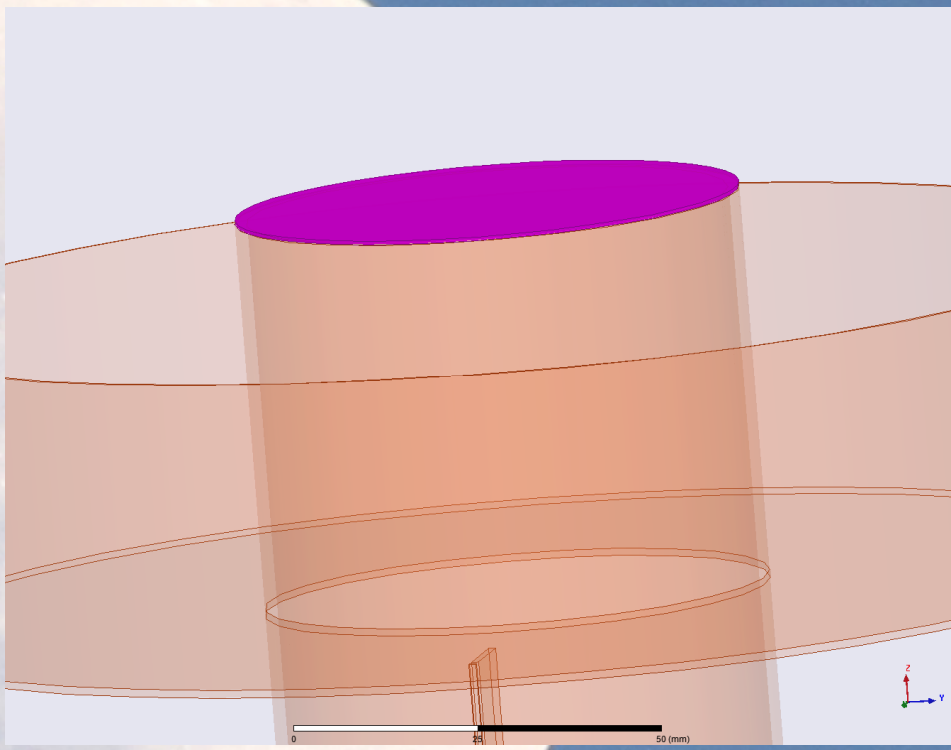
(Inch tube 2.75” od/16 gauge wall, 9 cm 0.755 wl WG, no compensation)



Model Teflon radome

(Inch tube 2.75”/16 gauge wall, 9 cm 0.755 wl WG with Teflon radome)



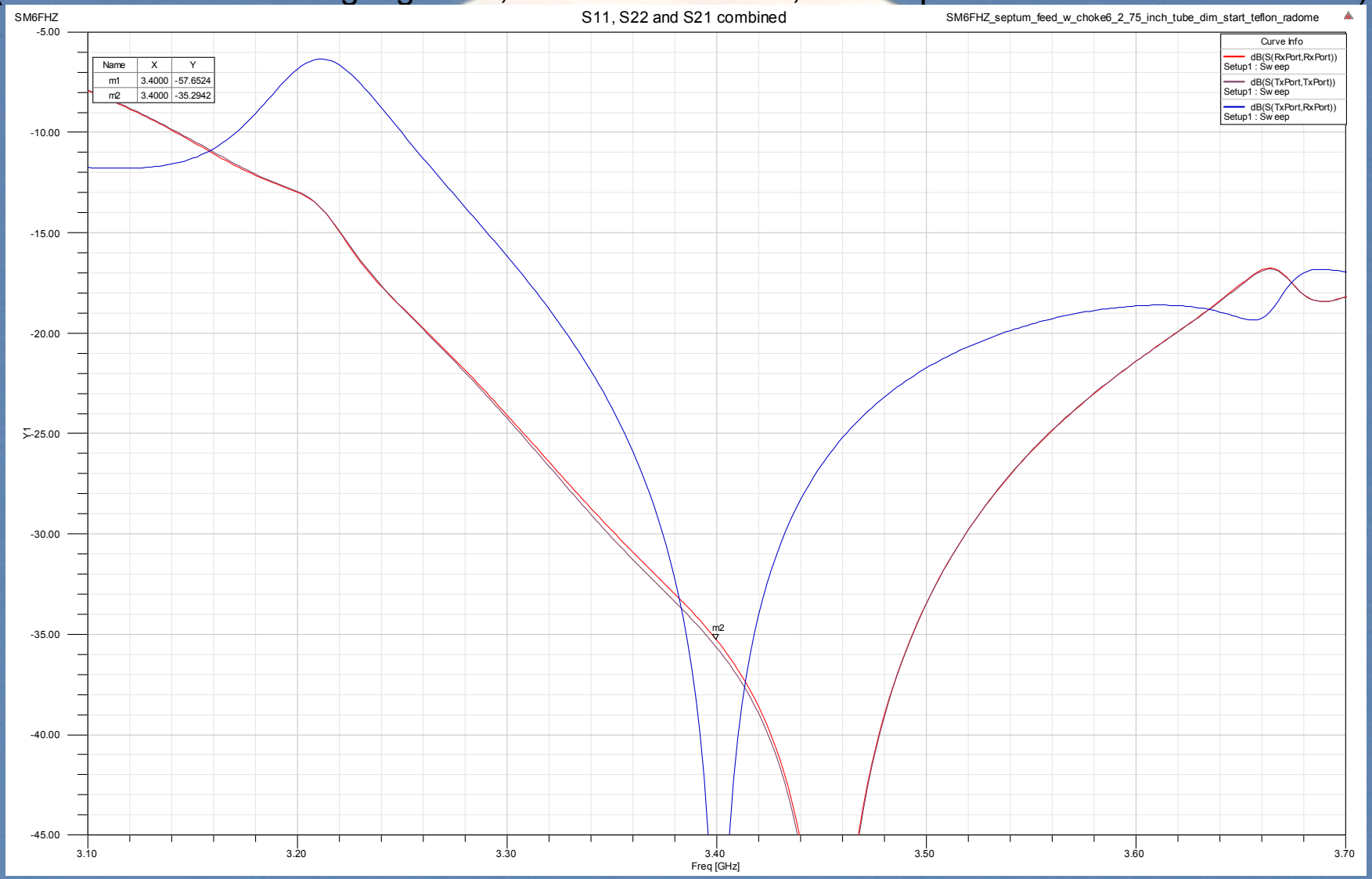


Radome is 0.5mm Teflon sheet in front of the WG mouth. No other compensation for moving from metric tube size to inch based tube size is applied. Septum dimensions are per the uncompensated feed.

For S-parameters please see the next slide. Radiating performance is not much affected.

S11, S22 and S21 combined

(**Inch tube** 2.75” od/16 gauge wall, 9 cm 0.755 wl WG, no compensation with Teflon radome)



WG and choke dimensions

(**Inch tube** 2.75” od/16 gauge wall, 9 cm 0.755 wl WG, WG length compensated)

Phase center 2.3

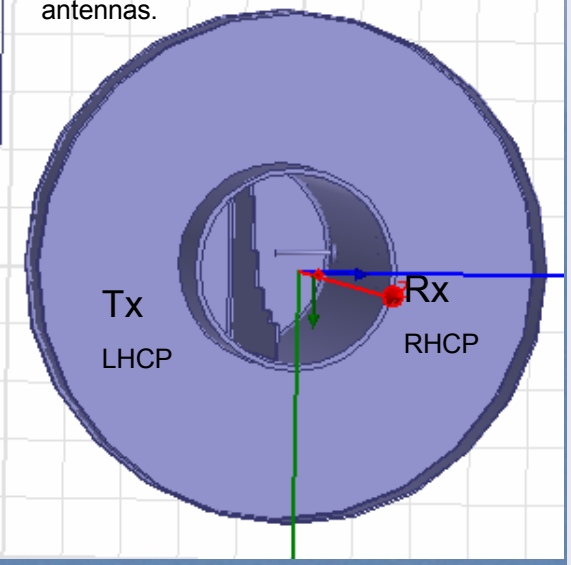
9.5

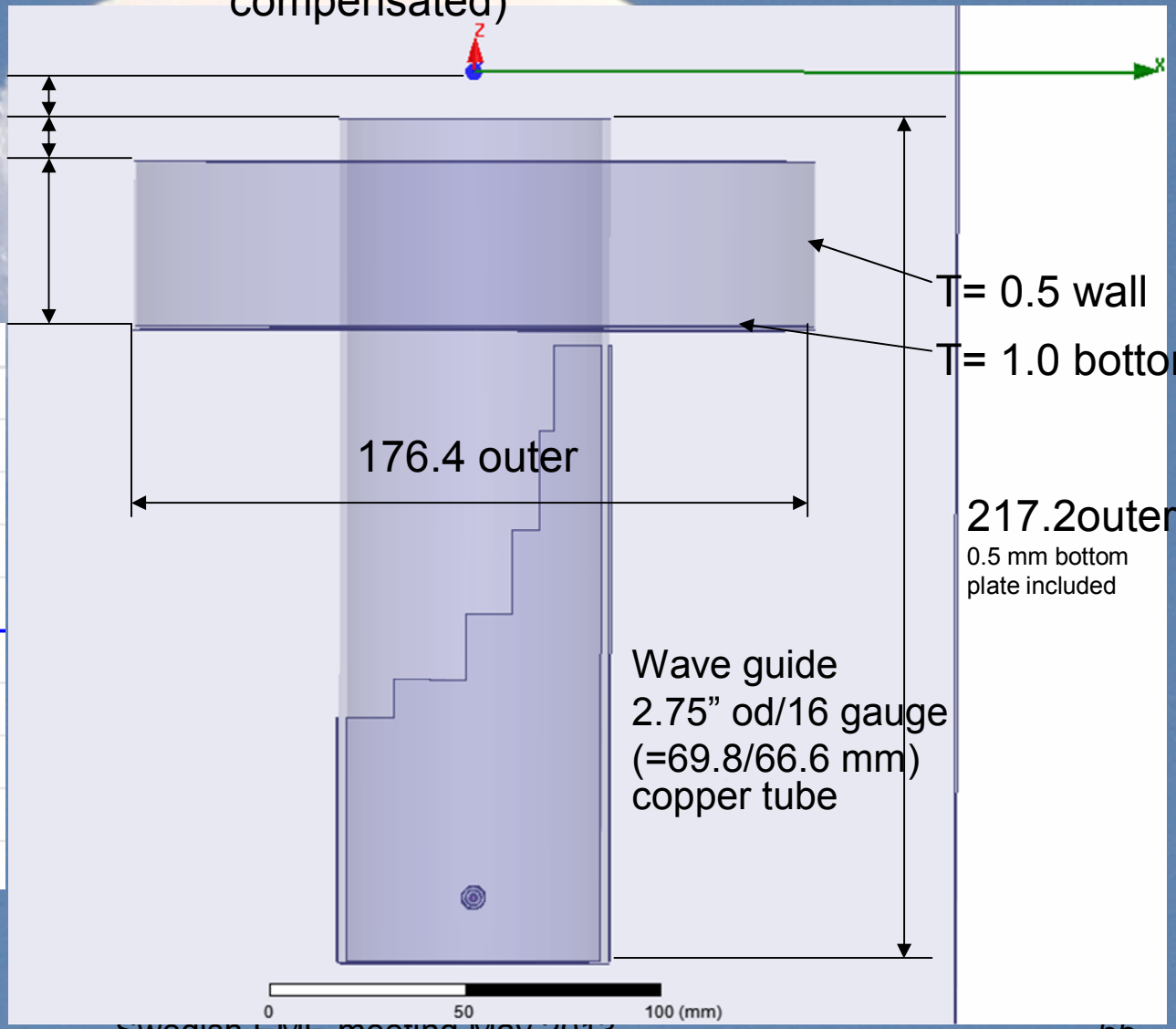
43.5 outer

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

Tx RHCP in space
Rx LHCP in space

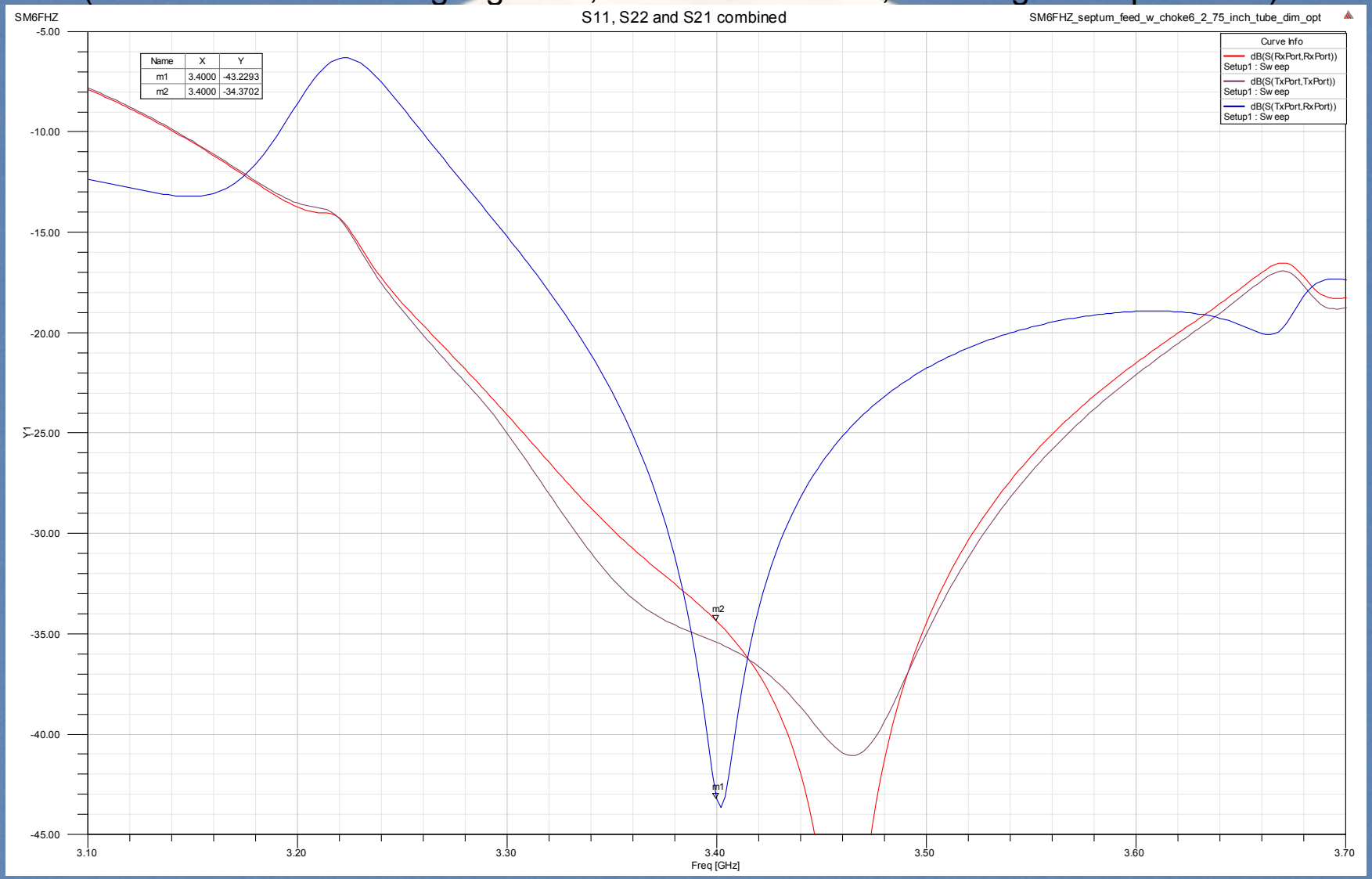
Take polarization reversal into account when using reflector antennas.



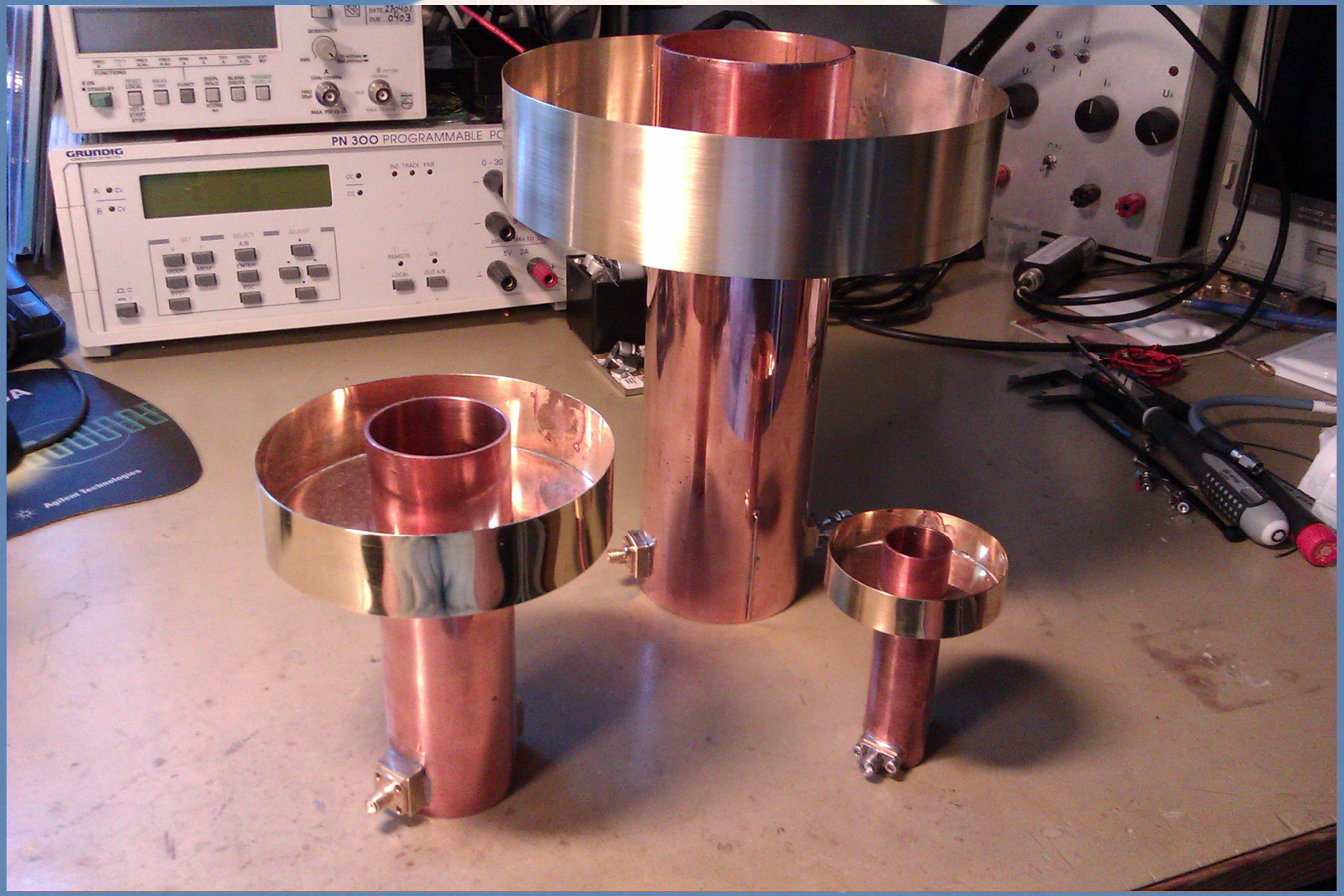


S11, S22 and S21 combined

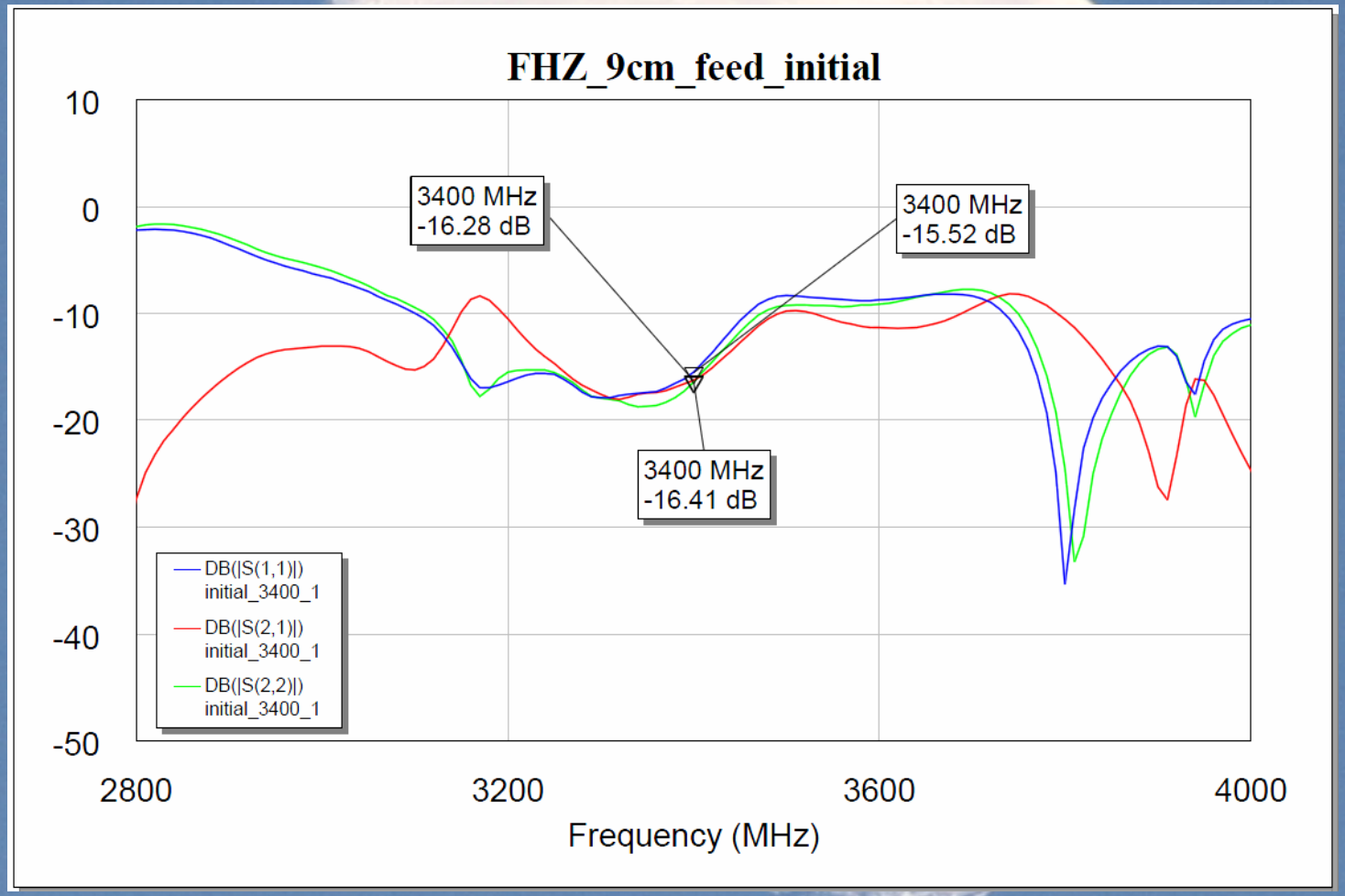
(**Inch tube** 2.75” od/16 gauge wall, 9 cm 0.755 wl WG, WG length compensated)



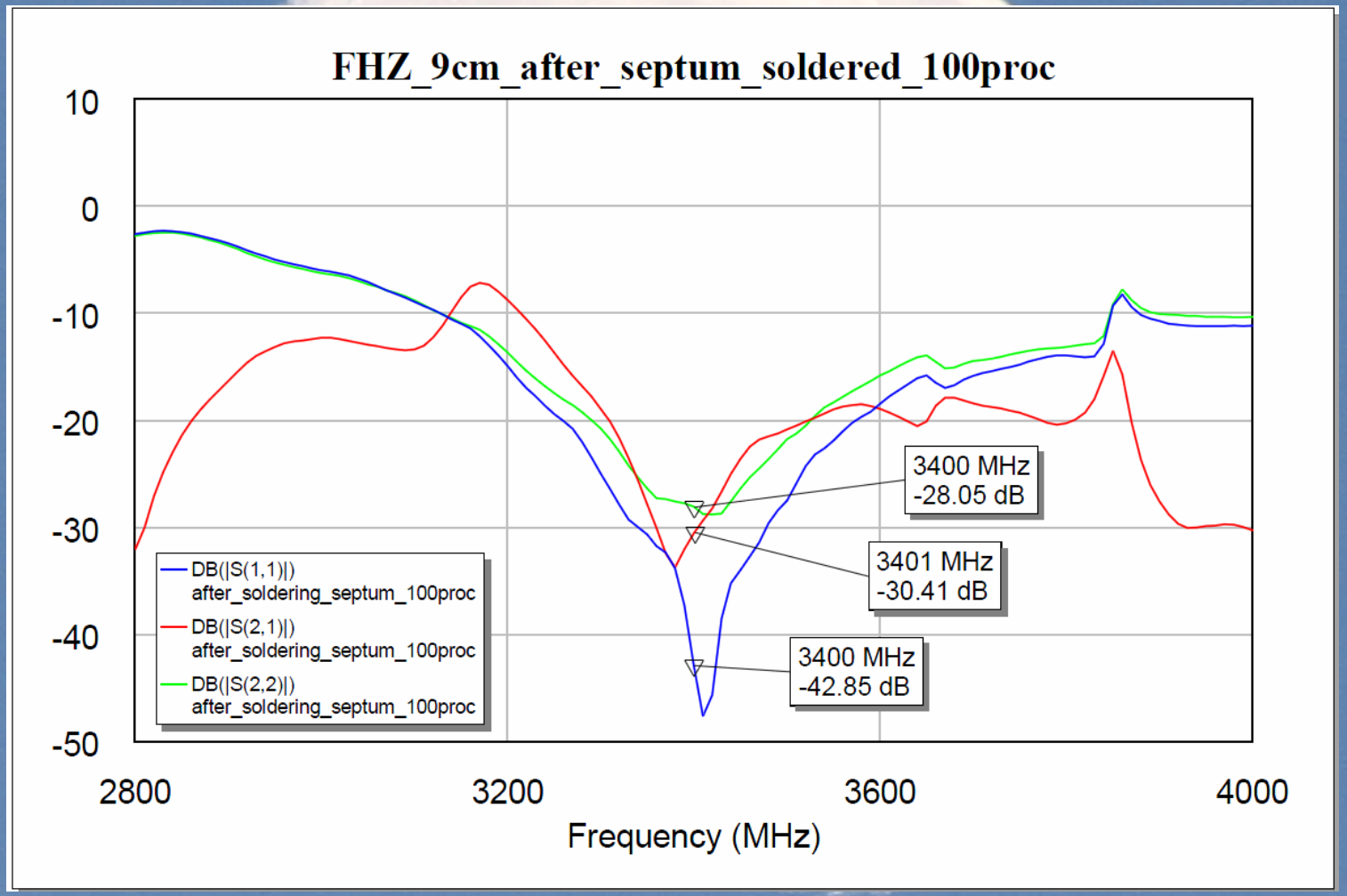
Realization
9, 6 and 3 cm feeds comparison



Measured performance with partial septum soldering (9 cm 0.748 wl WG)



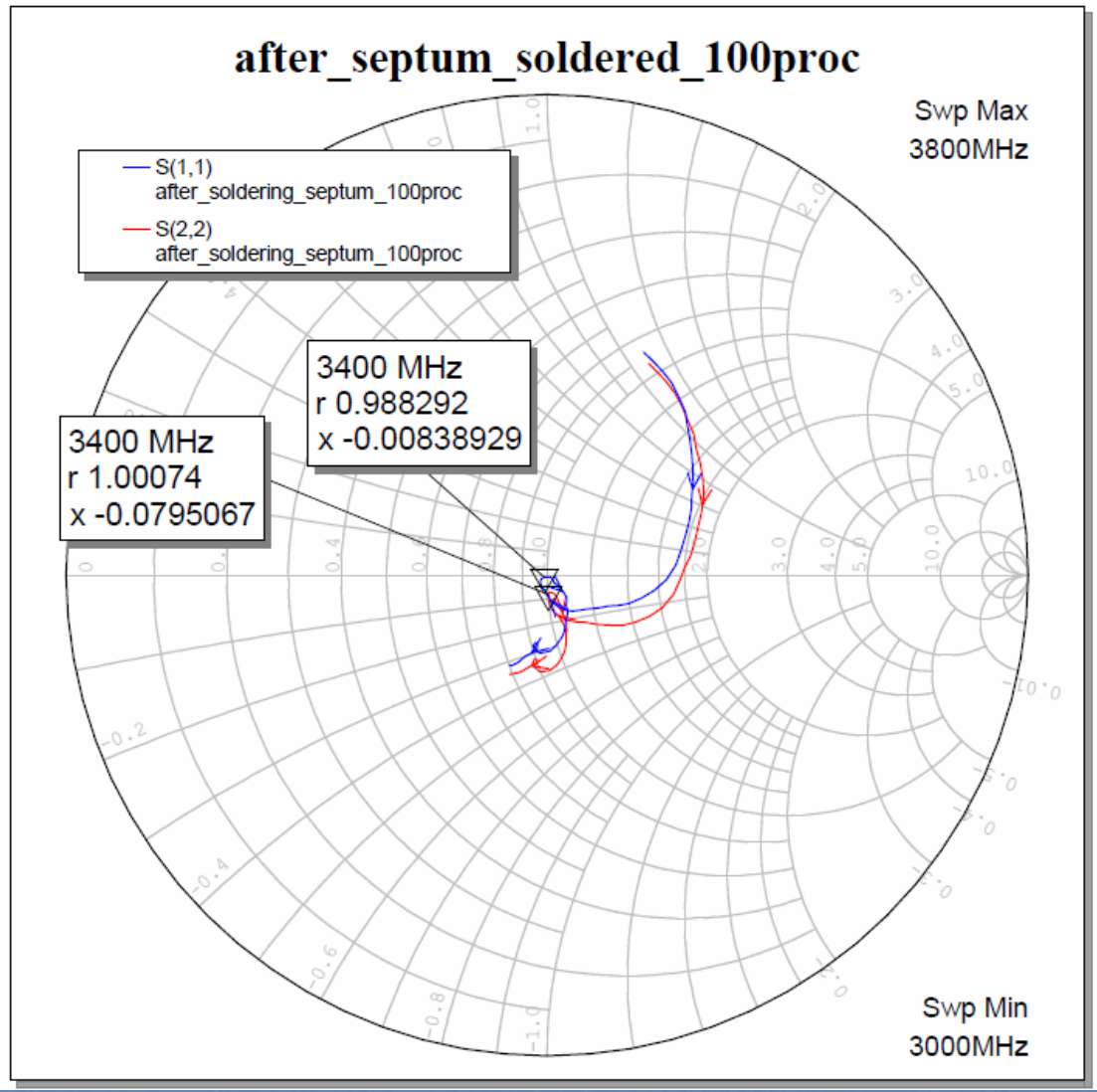
Measured performance (9 cm 0.748 wl WG)



Measured complex impedance

(9 cm 0.748 wl WG)

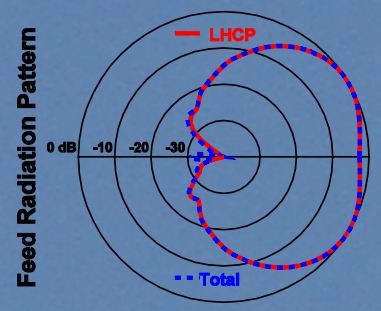
- Reference plane about 15 mm (~0.25 WL in teflon) out from the simulated case.
- SMA connector on feed included in measurement.
- Measurement sweep 200 MHz wider than simulation sweep
- Very good agreement between simulated and measured performance.

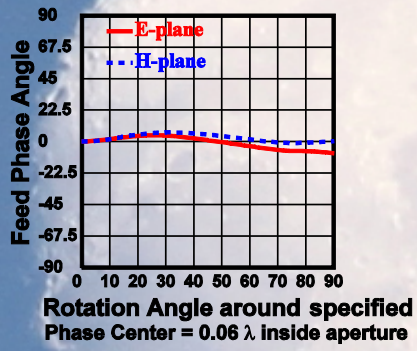


InDish Performance, 1.8 and 2.2 m dish

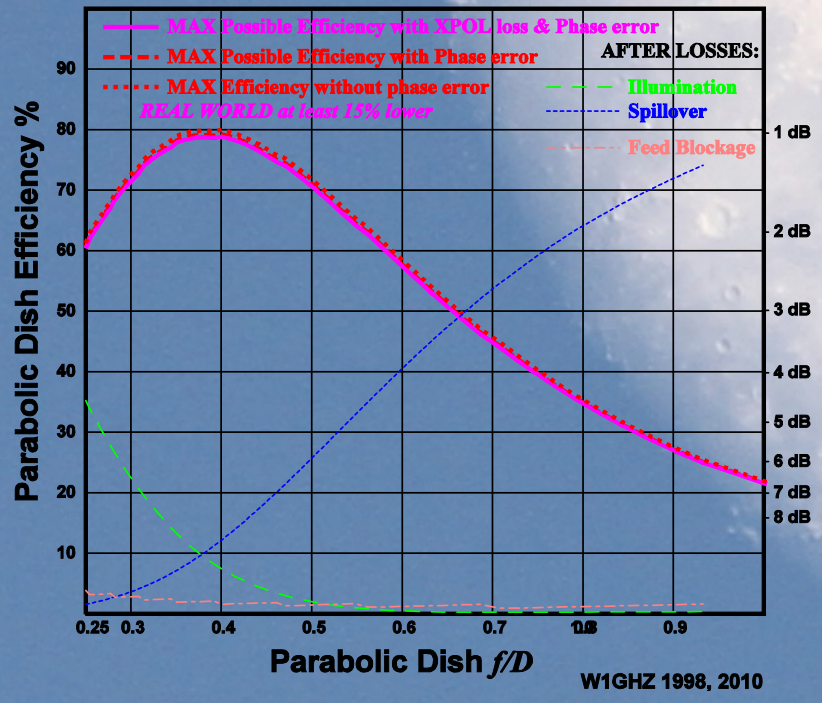
(9 cm 0.748 wl WG)

SM6FHZ 9 cm septum feed in 1.8 m dish

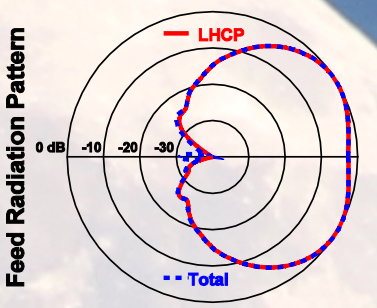


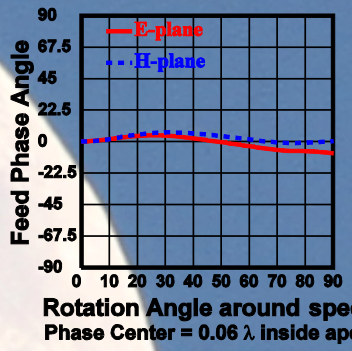


Dish diameter = 20.4 λ Feed diameter = 2 λ

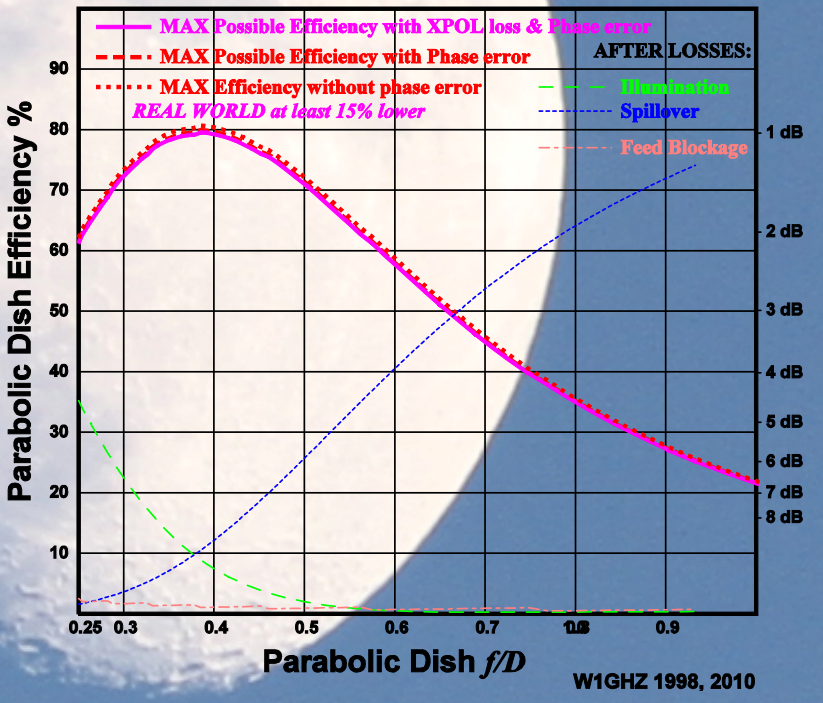


SM6FHZ 9 cm septum feed in 2.2 m dish





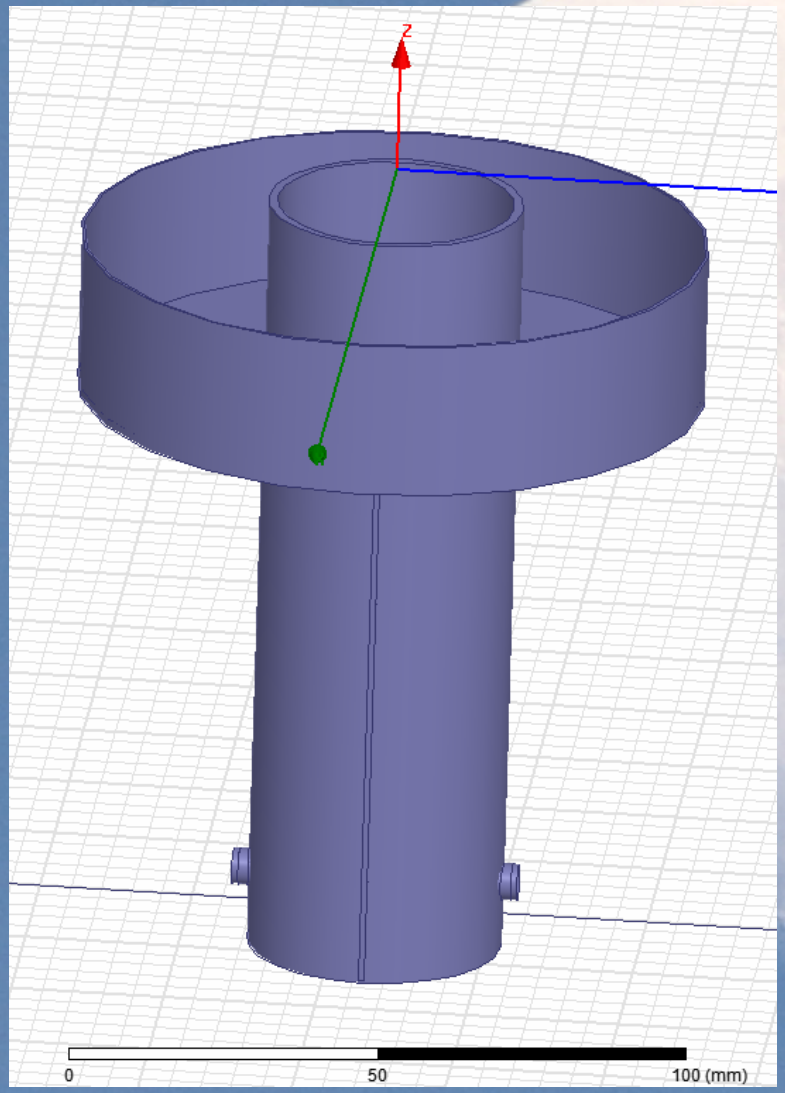
Dish diameter = 24.9 λ Feed diameter = 2 λ

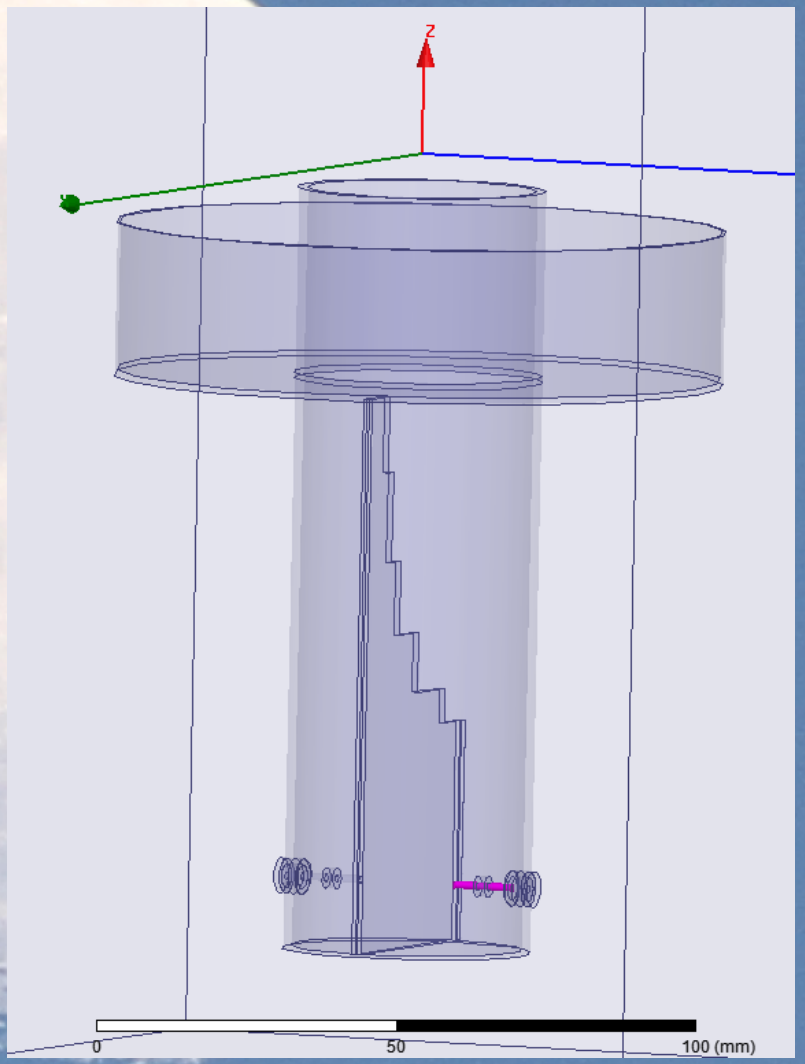


SM6FHZ 6 cm 5 step septum feed

0.749 lambda W/G

Solid and transparent models from the simulation (6 cm 0.749 wl WG)



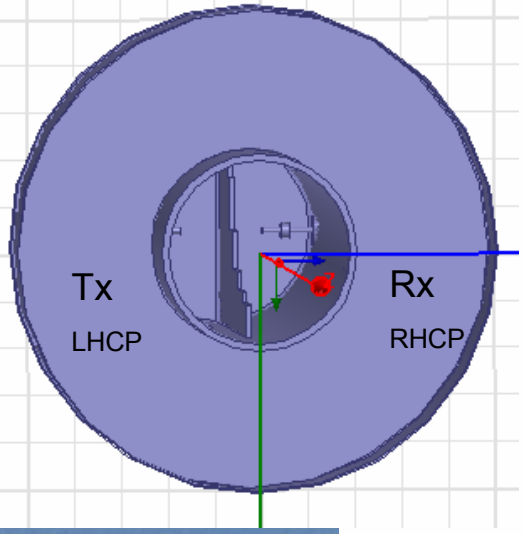


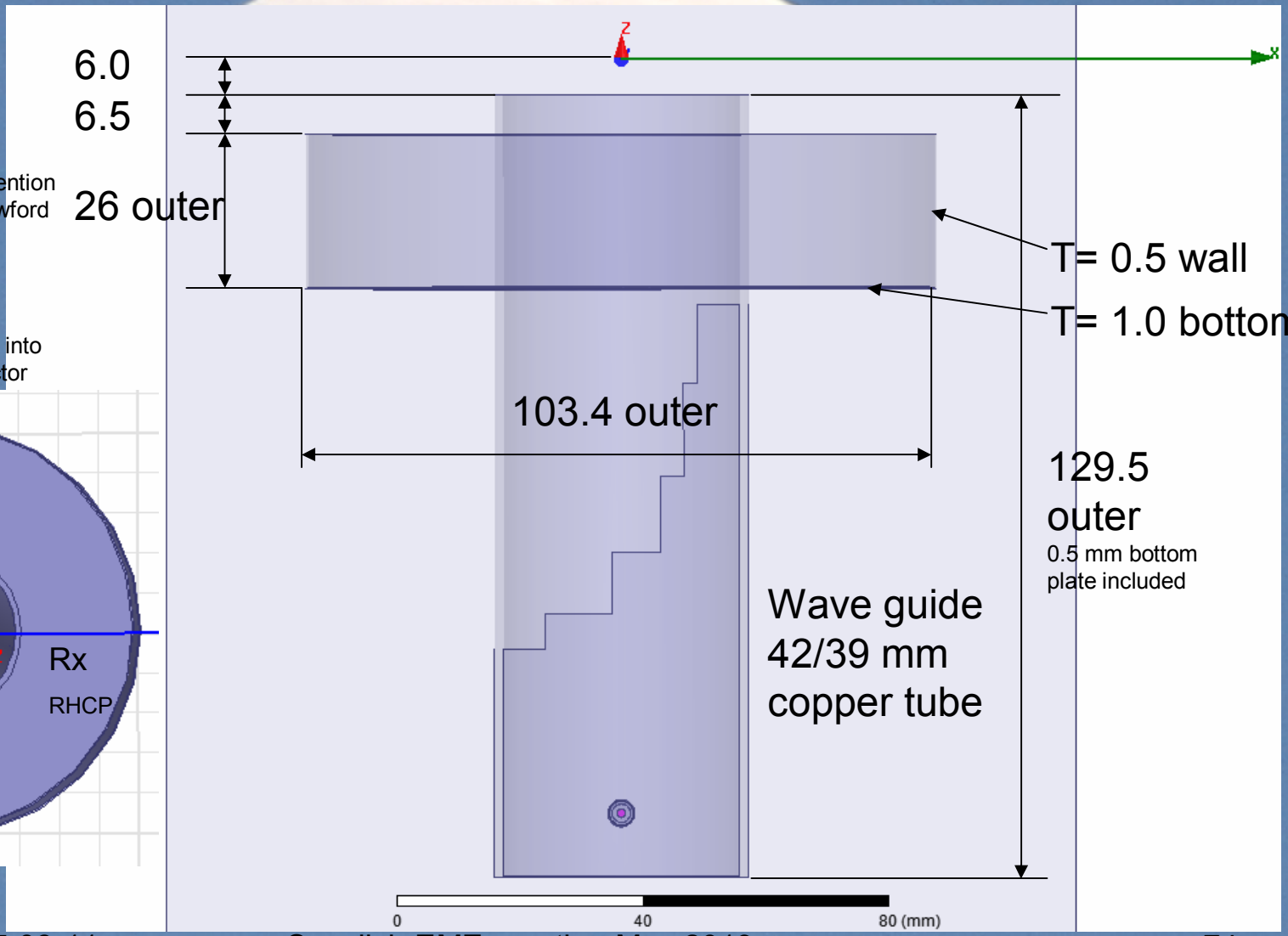
WG and choke dimensions (6 cm 0.749 wl WG)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

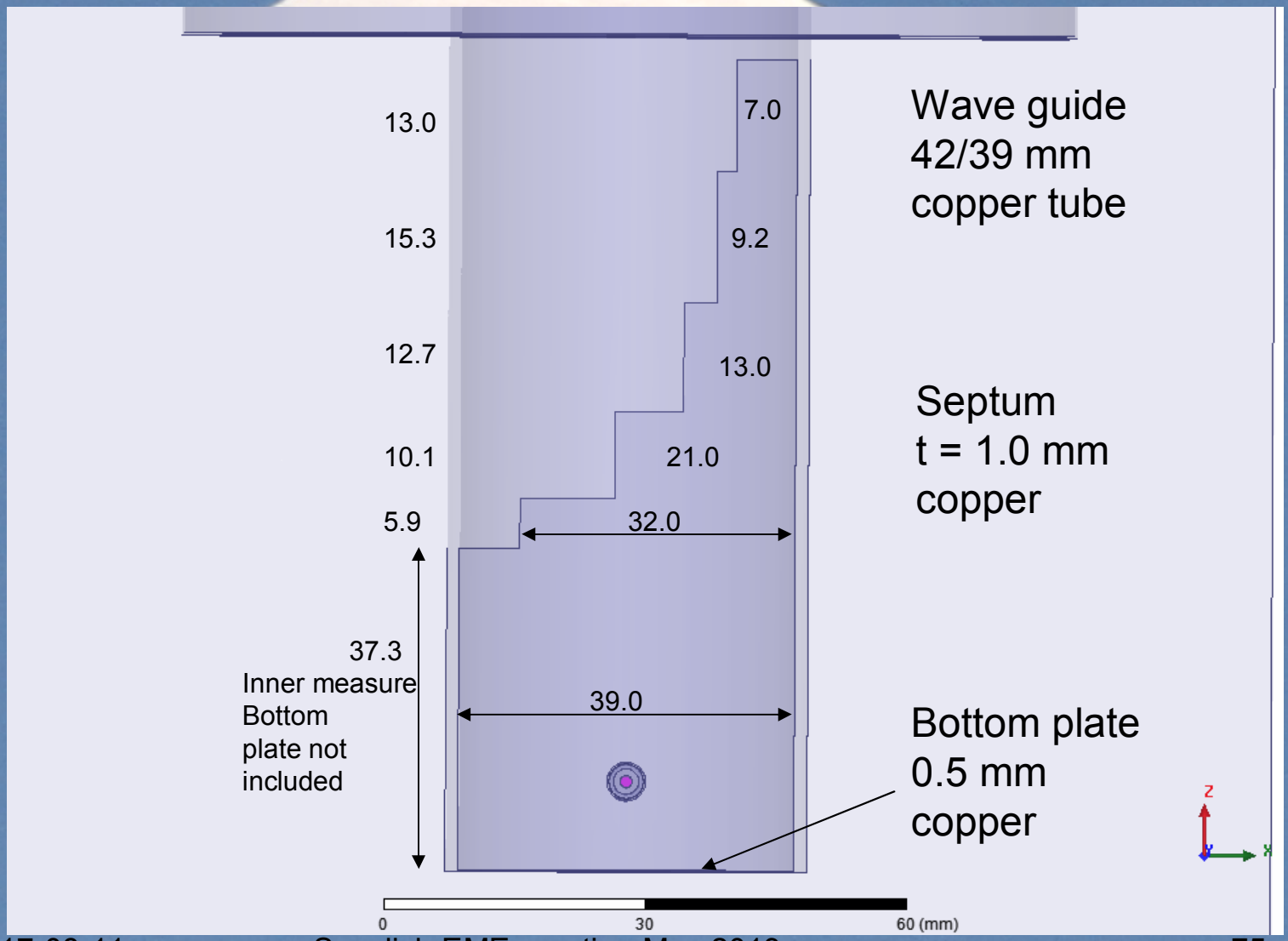
Tx RHCP in space
Rx LHCP in space

Take polarization reversal into account when using reflector antennas.

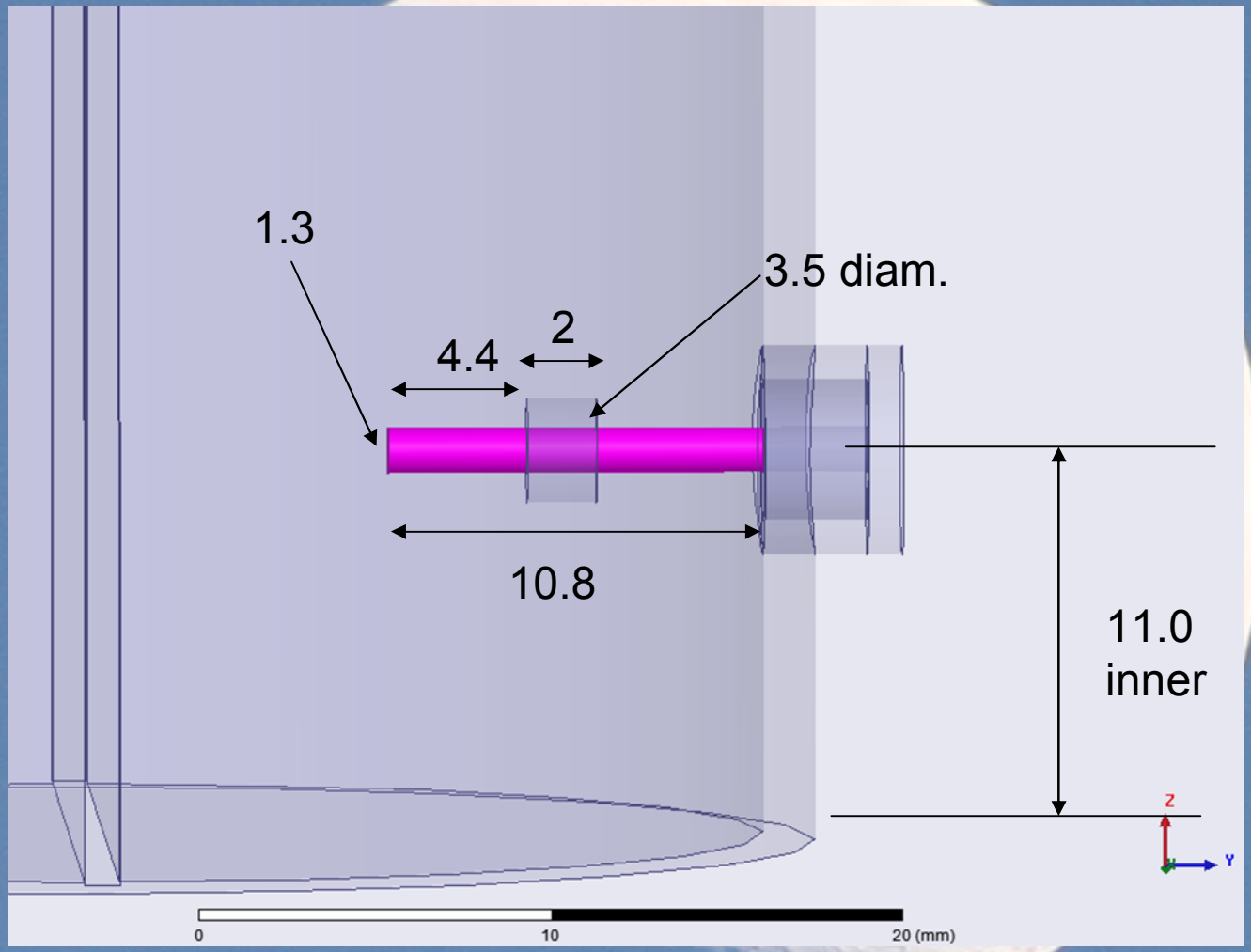




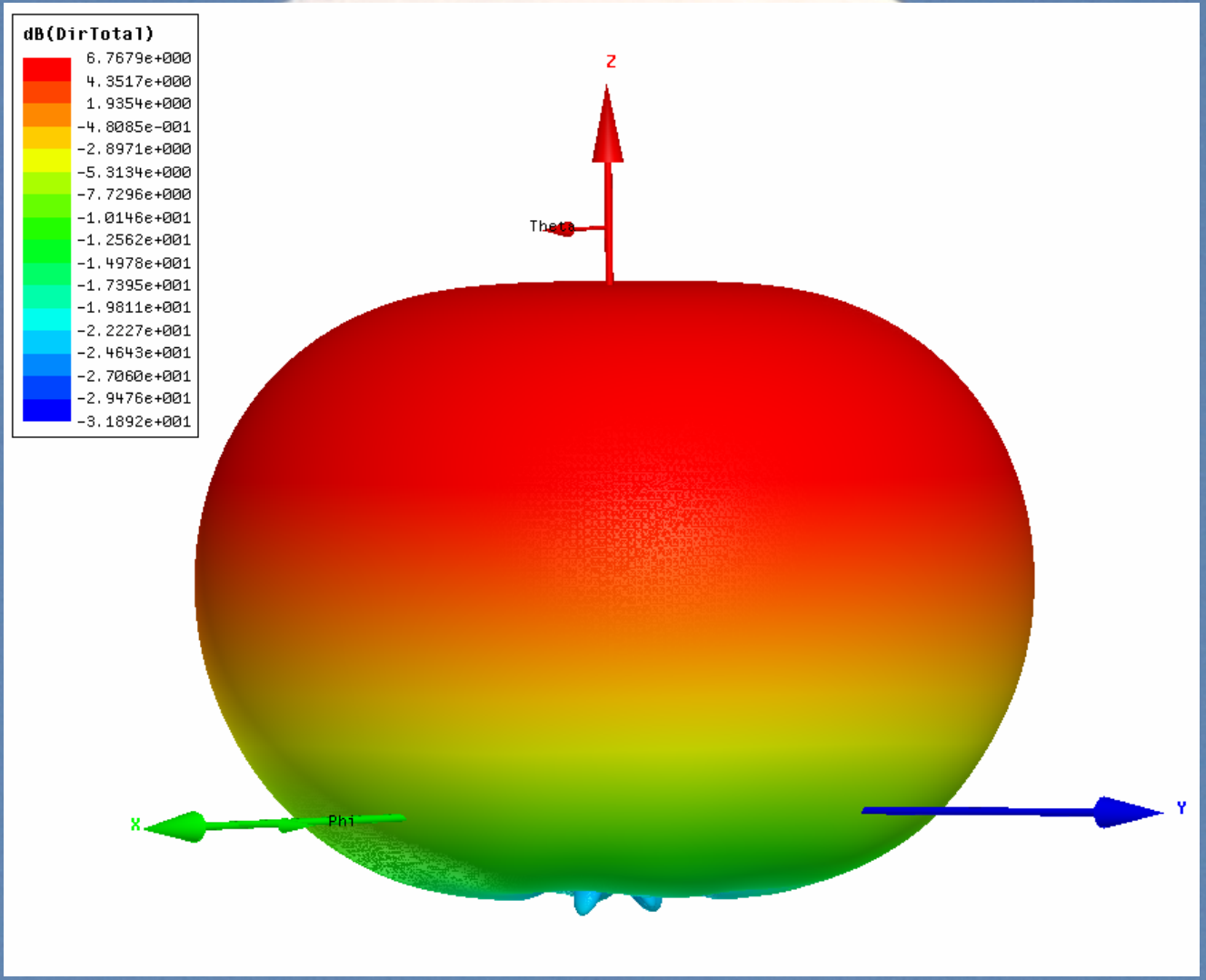
Septum dimensions (6 cm 0.749 wl WG)



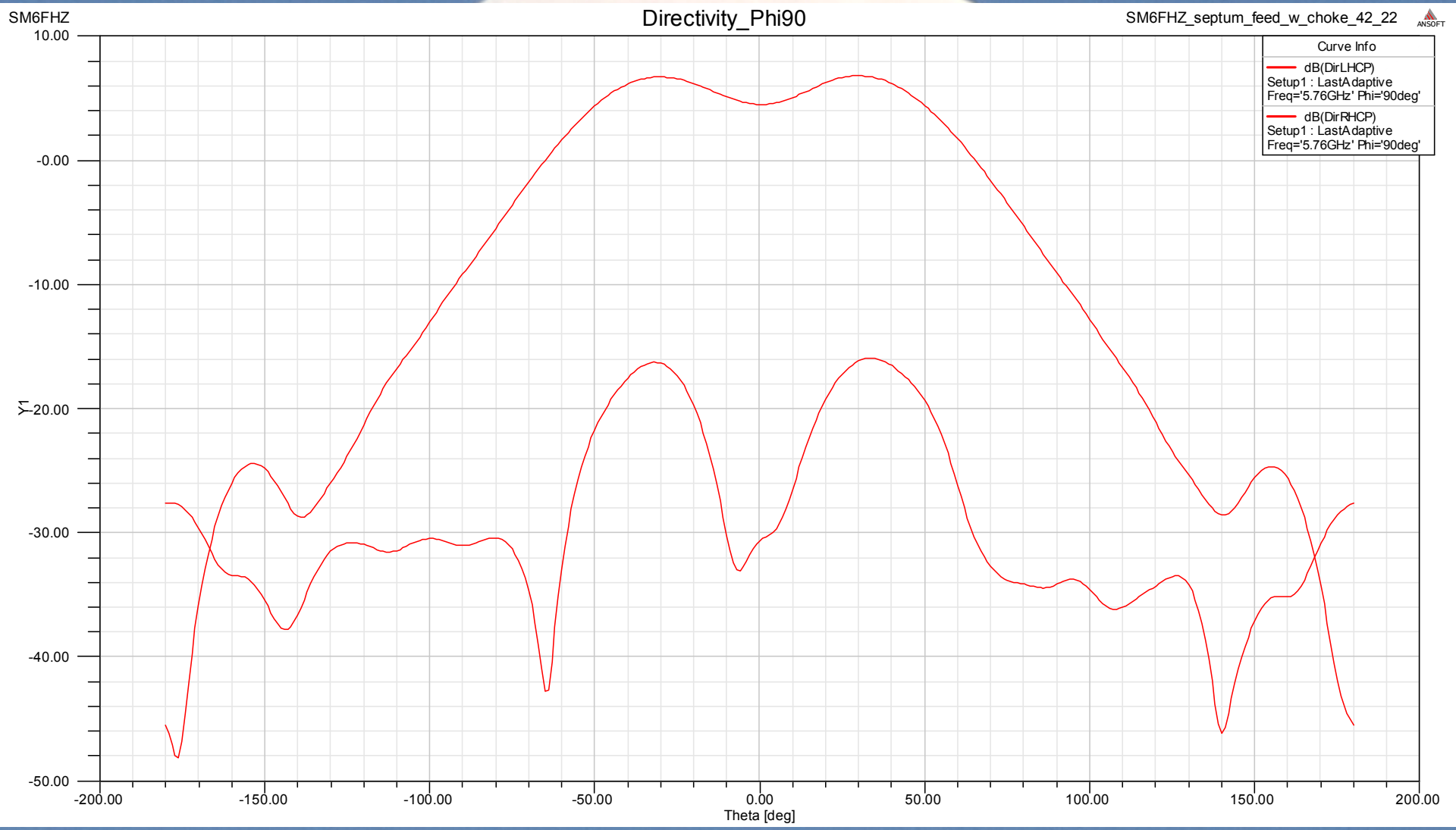
Probe dimensions (6 cm 0.749 wl WG)



FF 3D Total Power pattern (6 cm 0.749 wl WG)

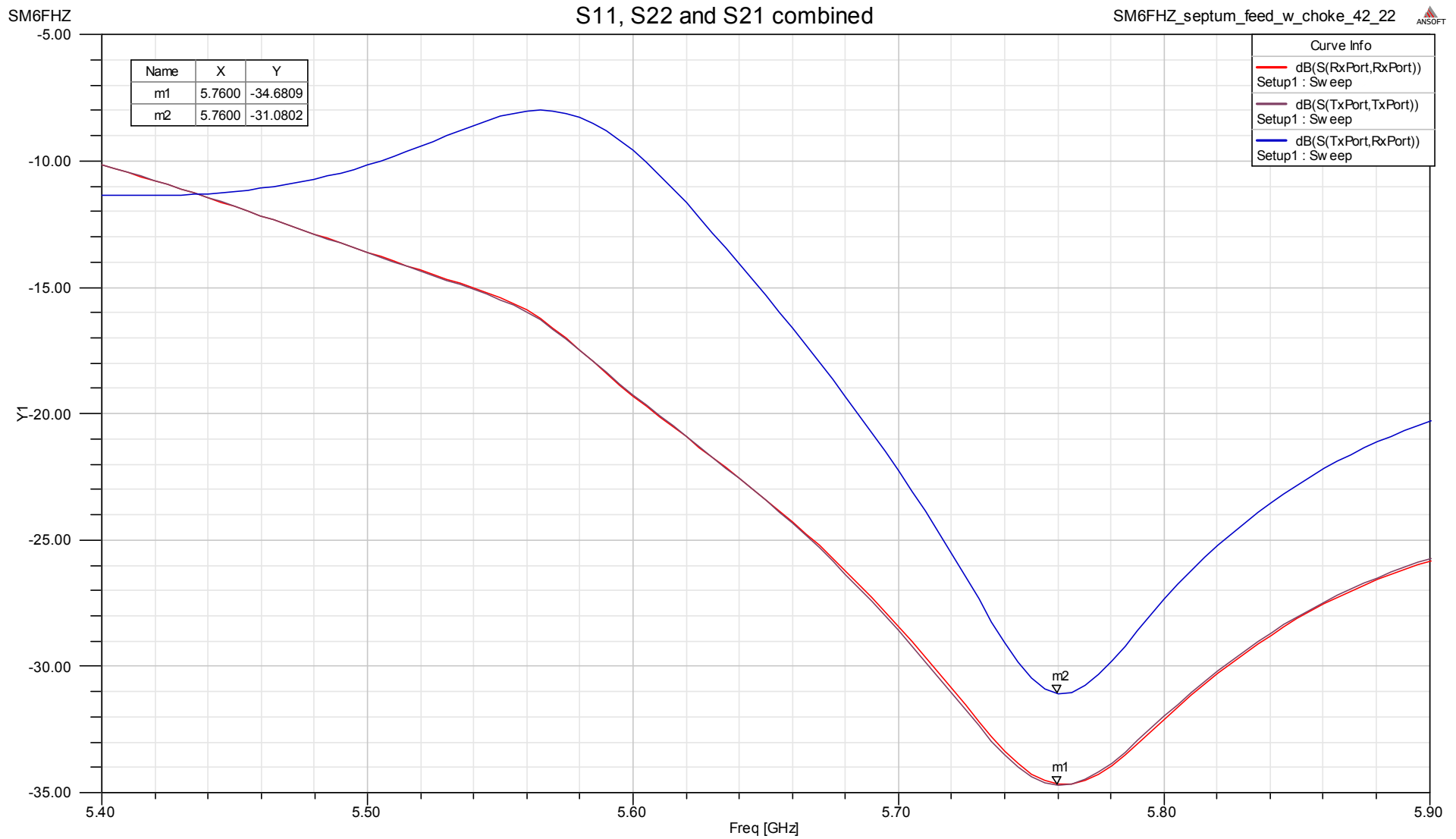


FF Directivity pattern (6 cm 0.749 wl WG)



S11, S22 and S21 combined

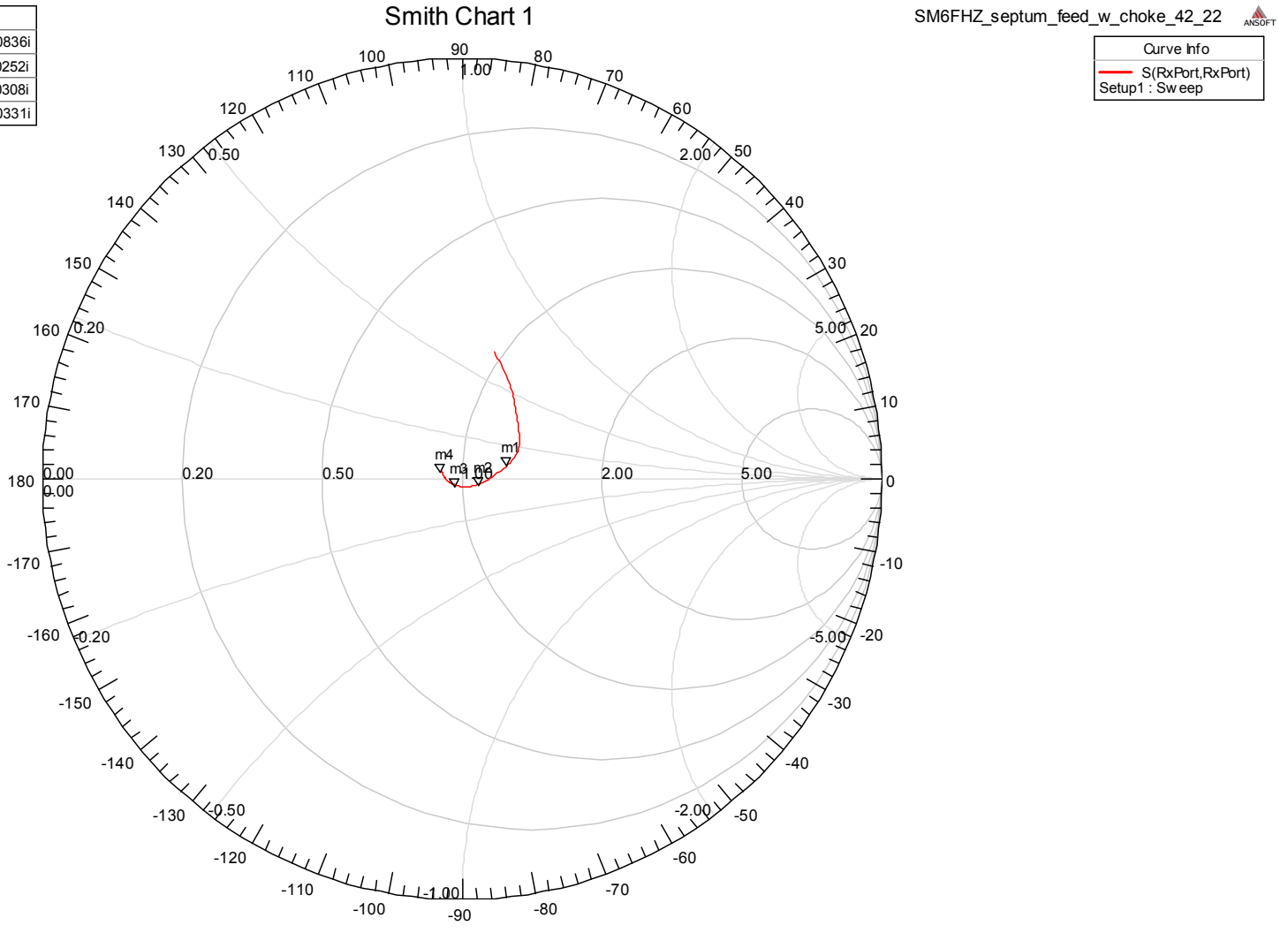
(6 cm 0.749 wl WG)



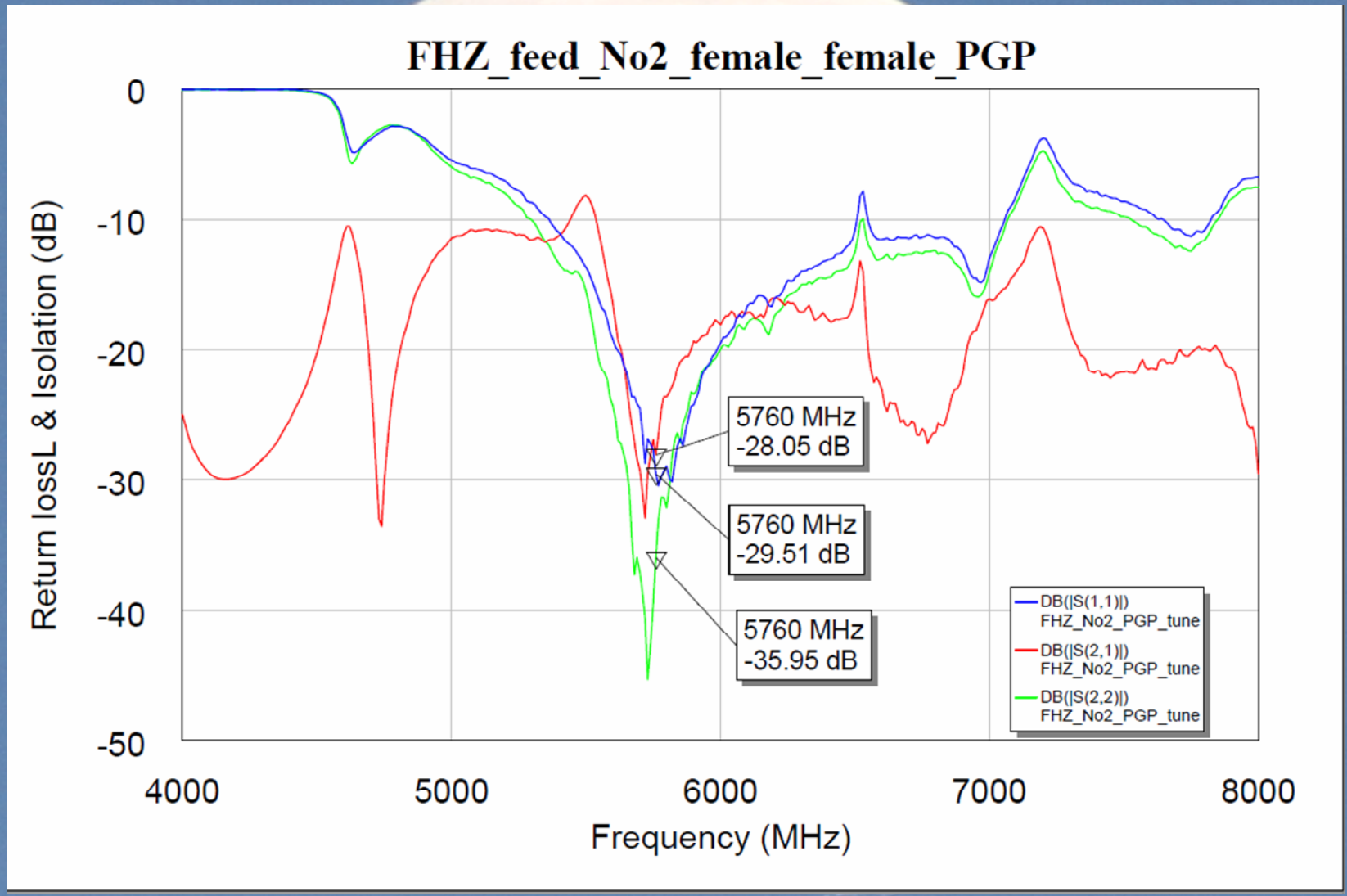
Complex impedance Rx-port

(6 cm 0.749 wl WG)

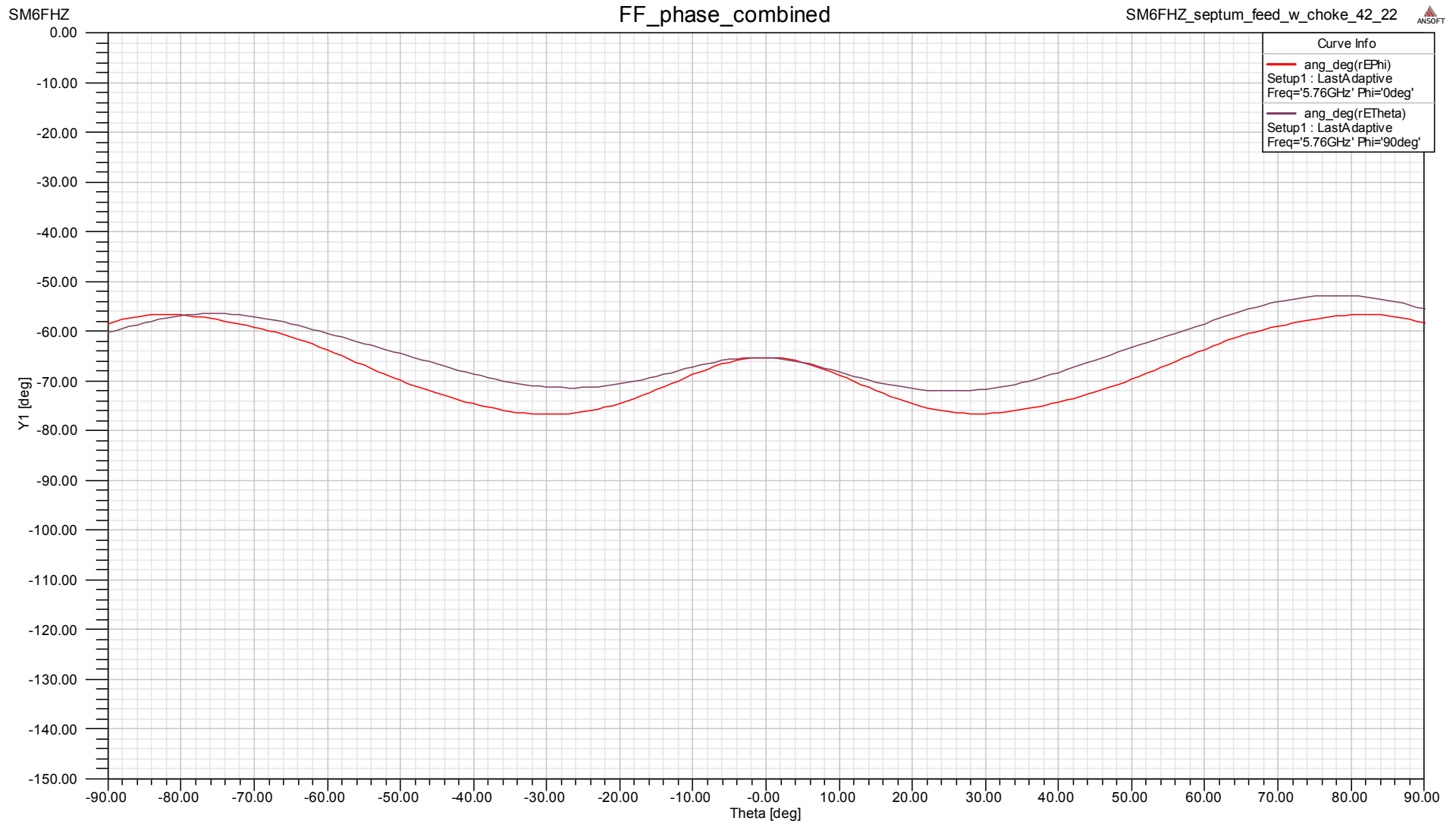
Name	Freq	Ang	Mag	RX
m1	5.5950	16.9581	0.1139	1.2414 + 0.0836i
m2	5.6900	-15.5465	0.0432	1.0866 - 0.0252i
m3	5.7850	-131.4701	0.0212	0.9719 - 0.0308i
m4	5.9000	159.2115	0.0512	0.9081 + 0.0331i



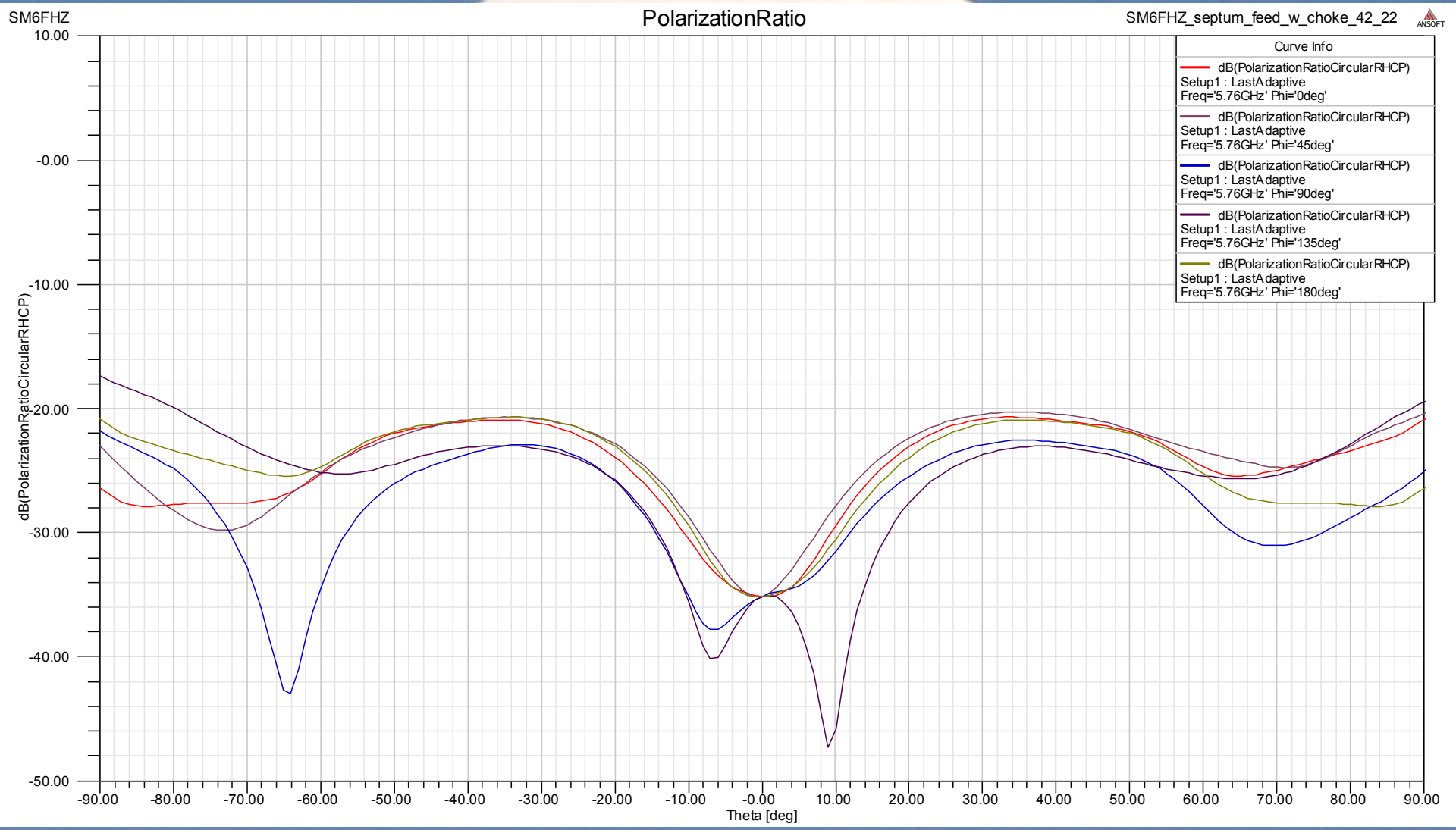
Measurements (6 cm 0.749 wl WG)



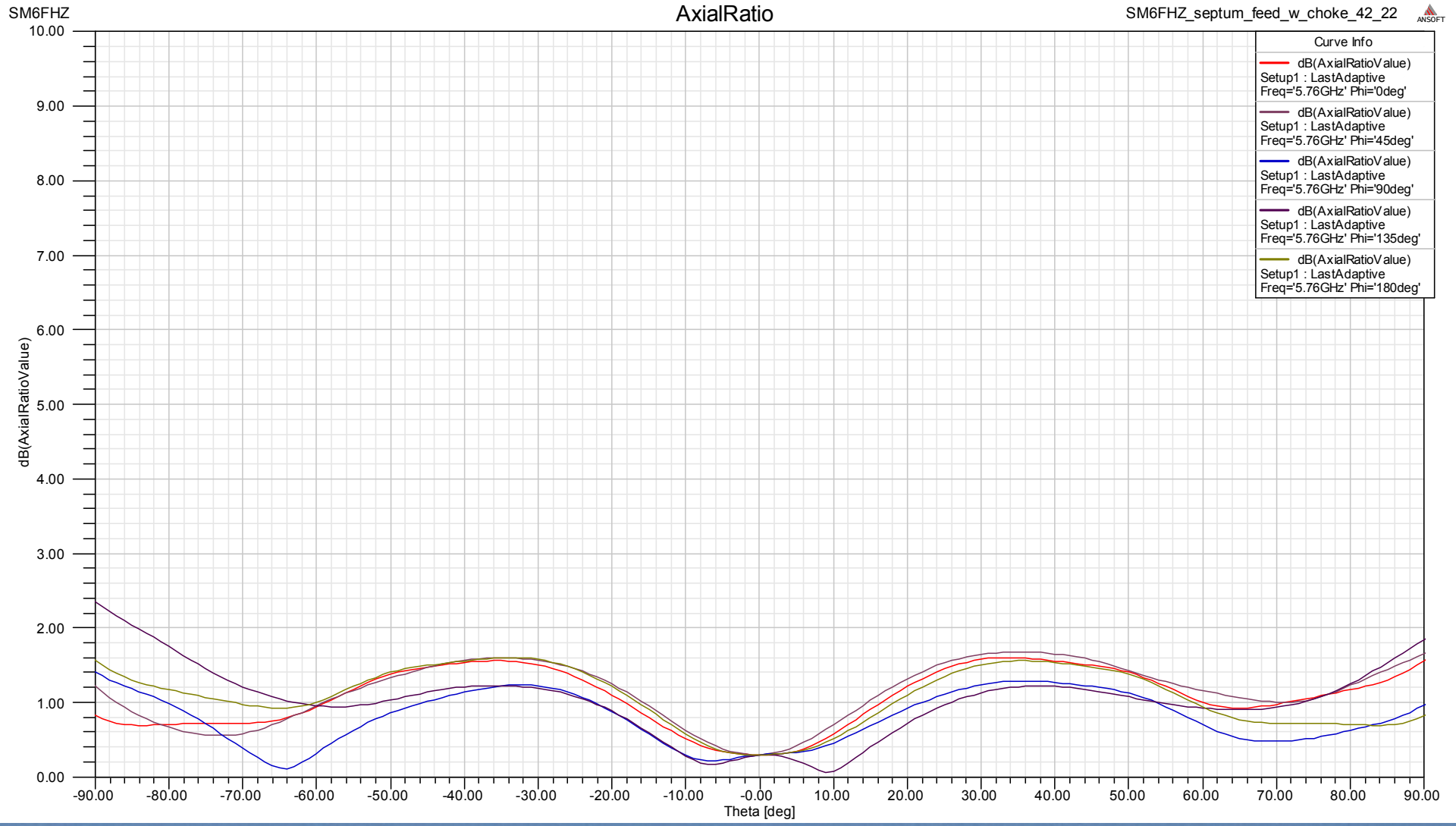
FF Phase error (6 cm 0.749 wl WG)



Cross Polarization Ratio (6 cm 0.749 wl WG)

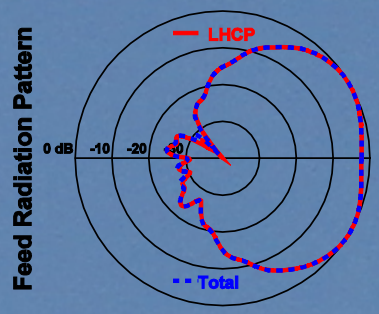


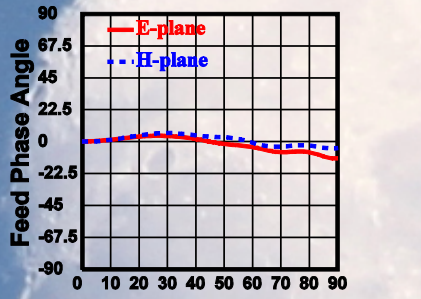
Axial Ratio (6 cm 0.749 wl WG)



InDish Performance (6 cm 0.749 wl WG)

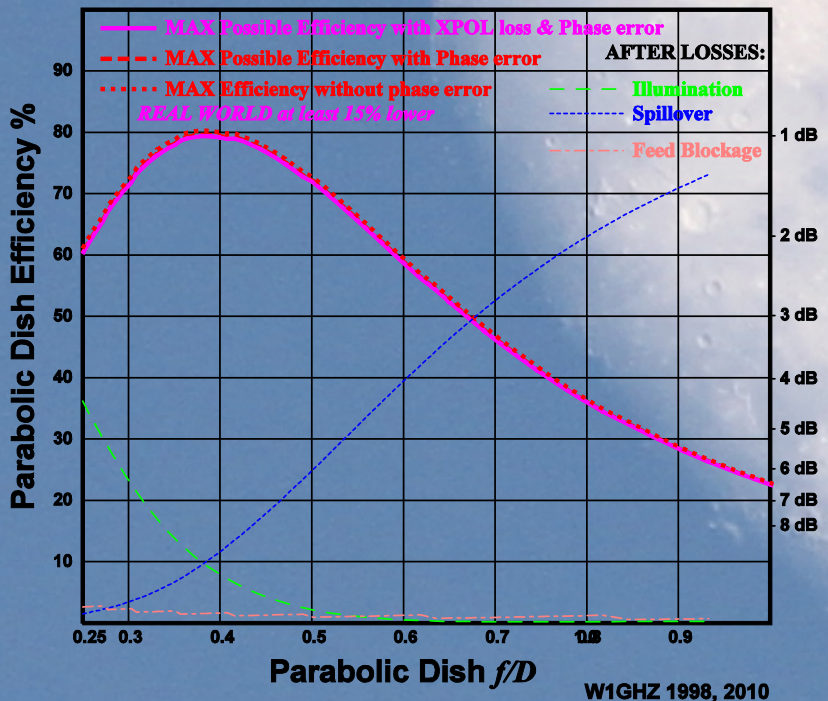
PGP 1.8 m dish w. FHZ 6 cm Kumar feed





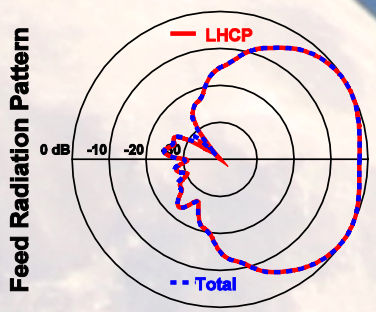
Rotation Angle around specified Phase Center = 0 λ beyond aperture

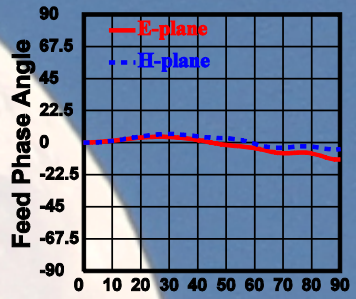
Dish diameter = 34.6 λ Feed diameter = 3 λ



W1GHZ 1998, 2010

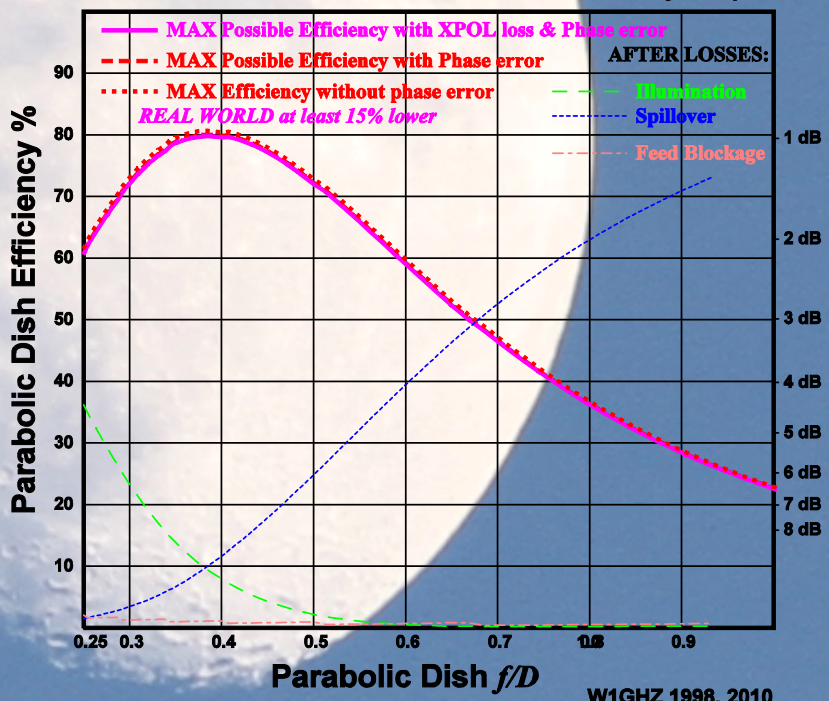
PGP 2.2 m dish w. FHZ Kumar 6 cm feed





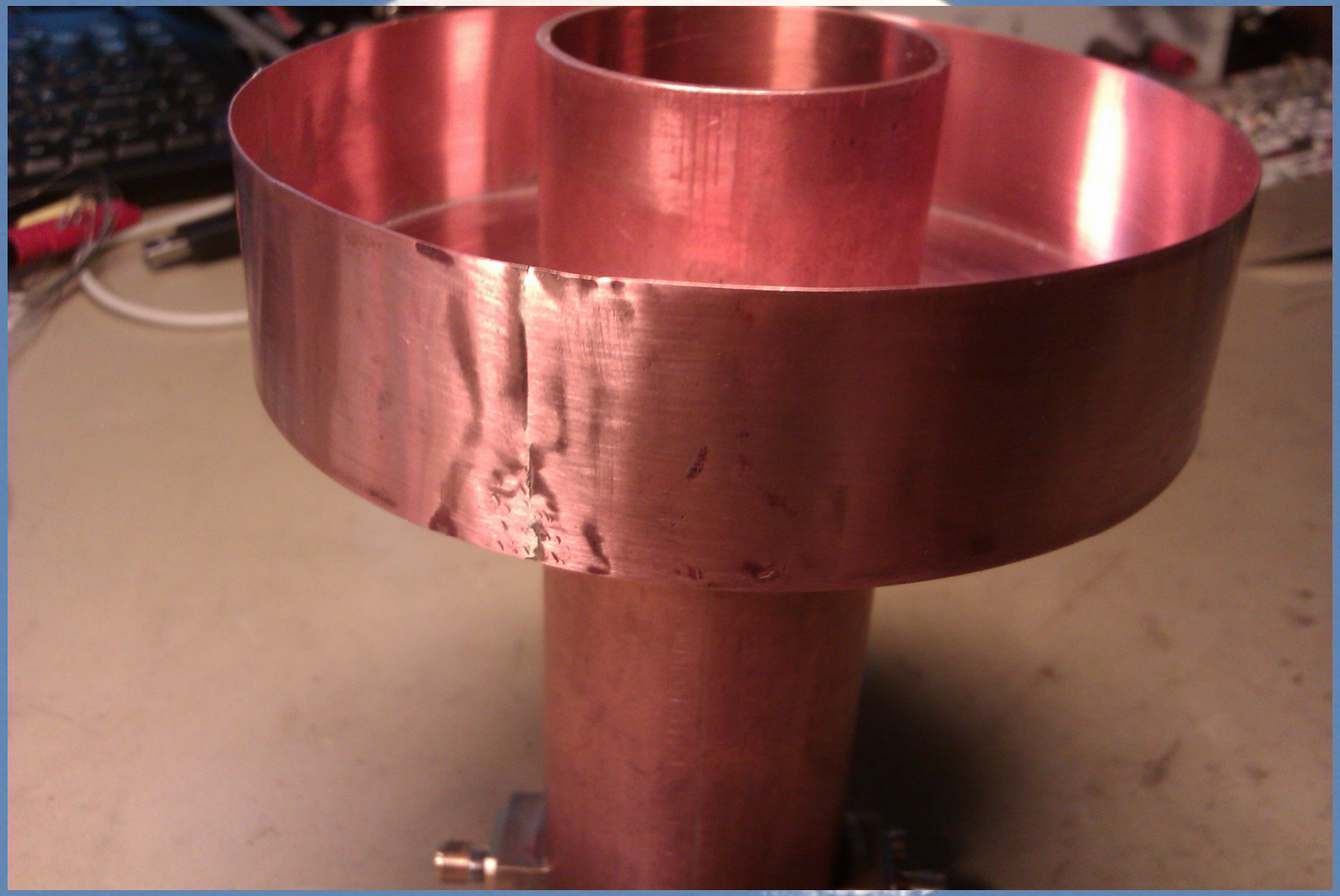
Rotation Angle around specified Phase Center = 0 λ beyond aperture

Dish diameter = 42.2 λ Feed diameter = 3 λ



W1GHZ 1998, 2010

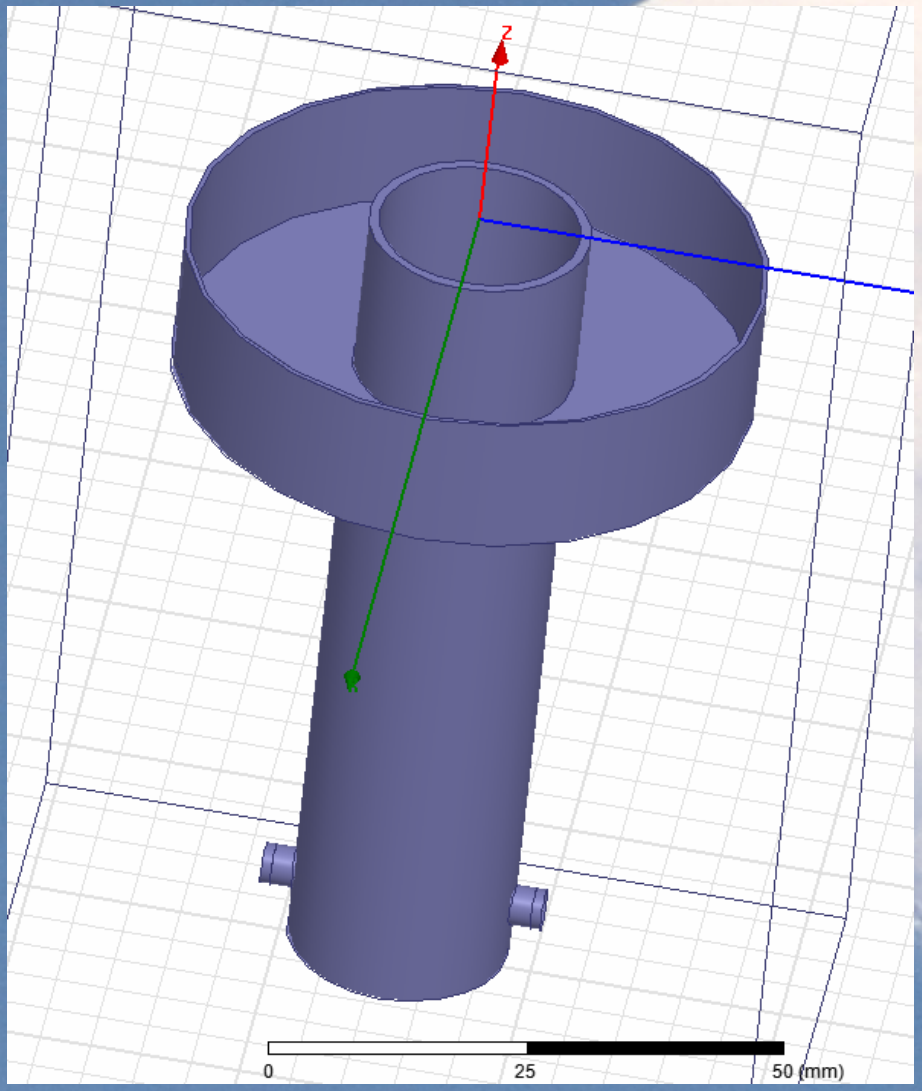
Realization (6 cm 0.749 wl WG)

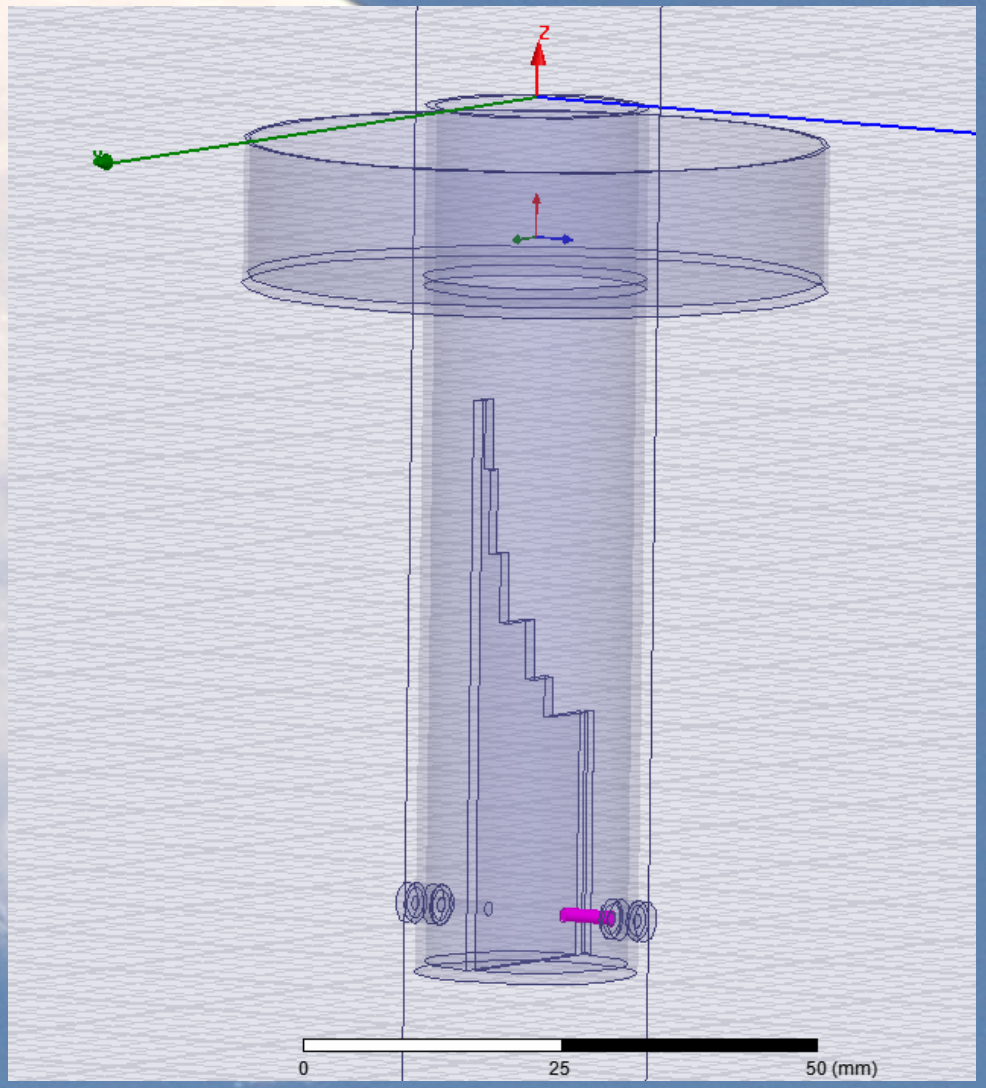


SM6FHZ 3 cm 5 step septum feed

0.692 lambda W/G

Solid and transparent models from the simulation (3 cm 0.692 wl WG)



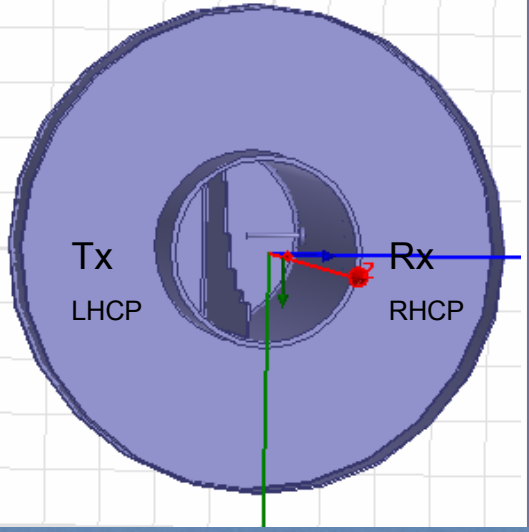


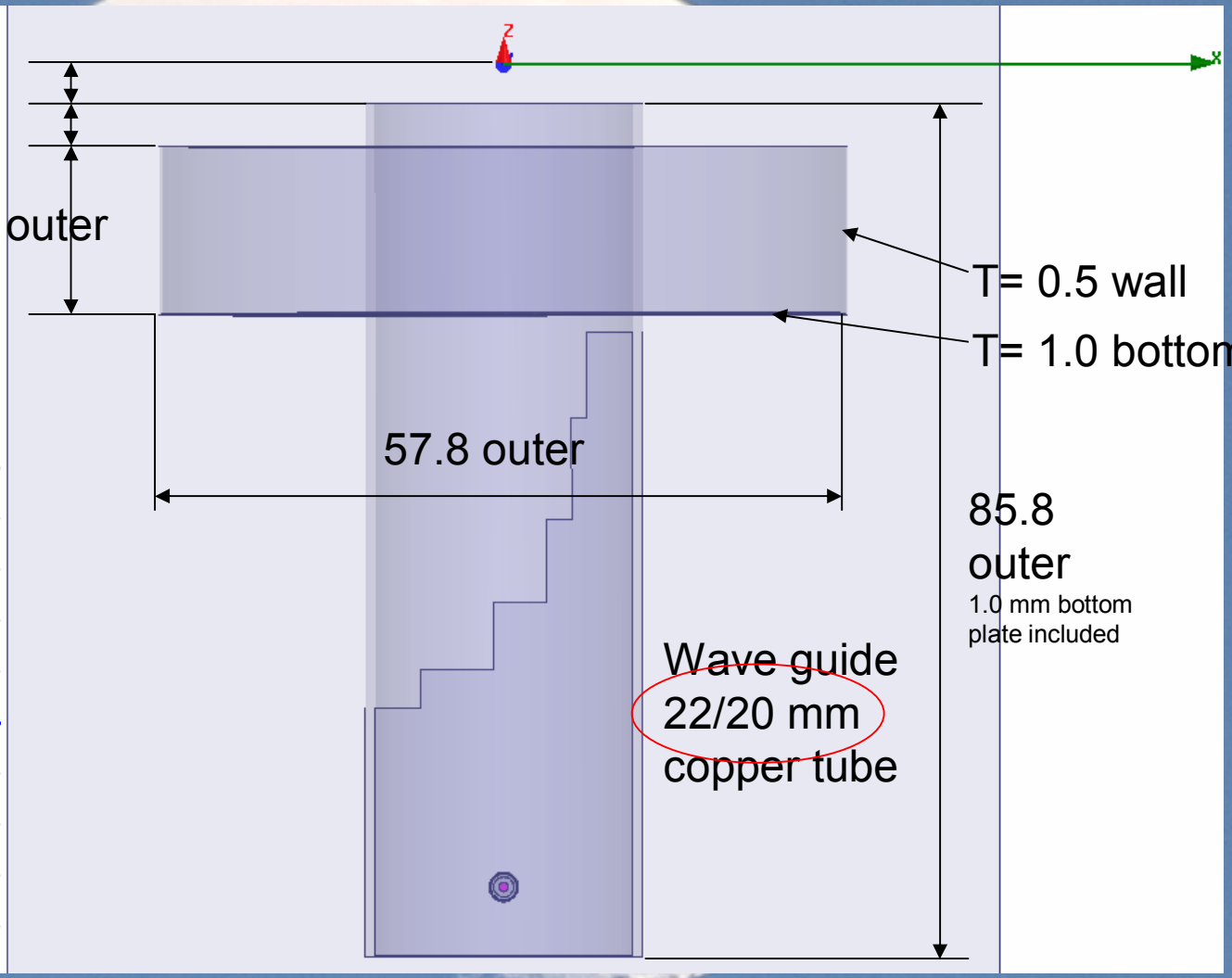
WG and choke dimensions (3 cm 0.692 wl WG)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

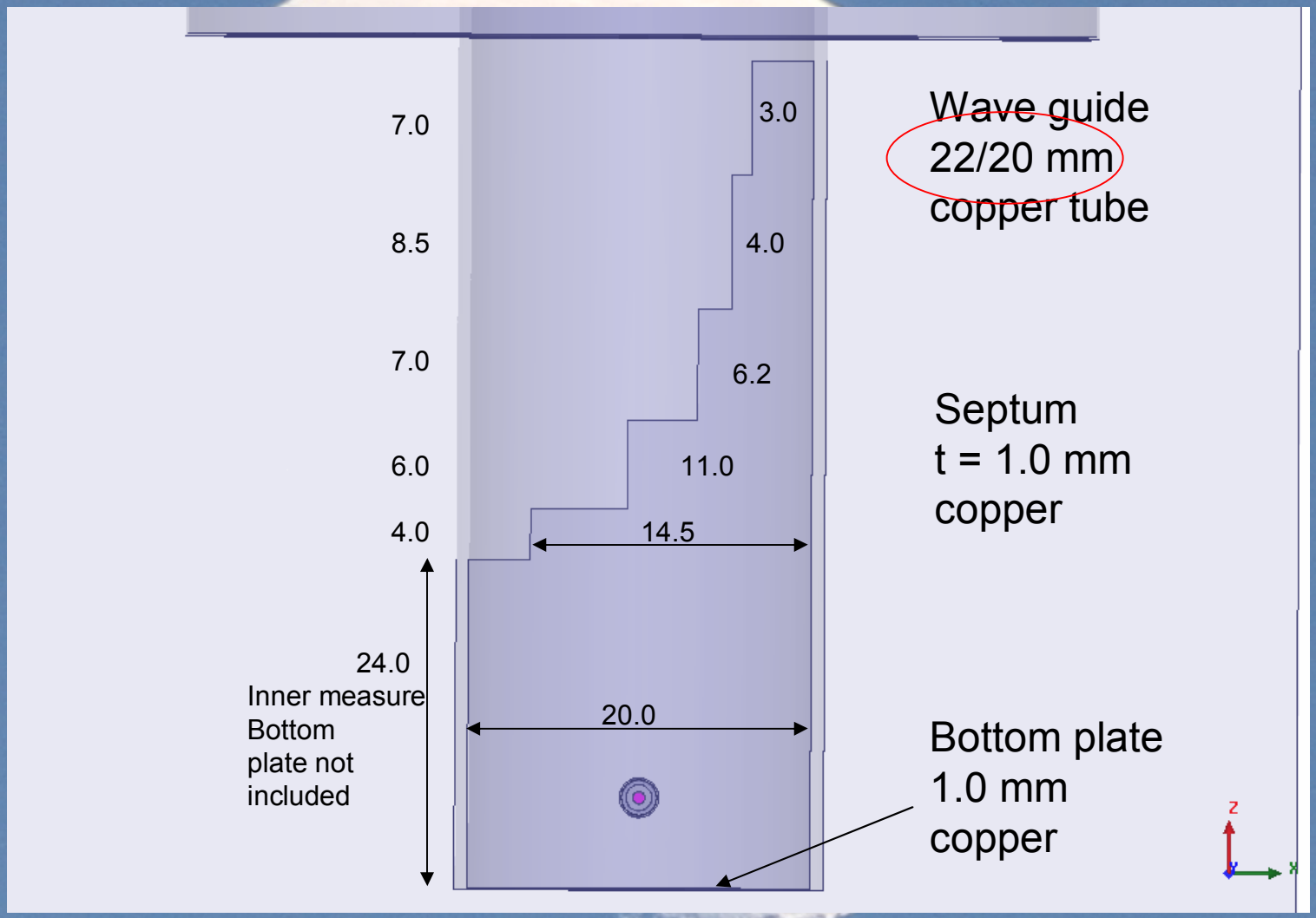
Tx RHCP in space
Rx LHCP in space

Take polarization reversal into account when using reflector antennas.

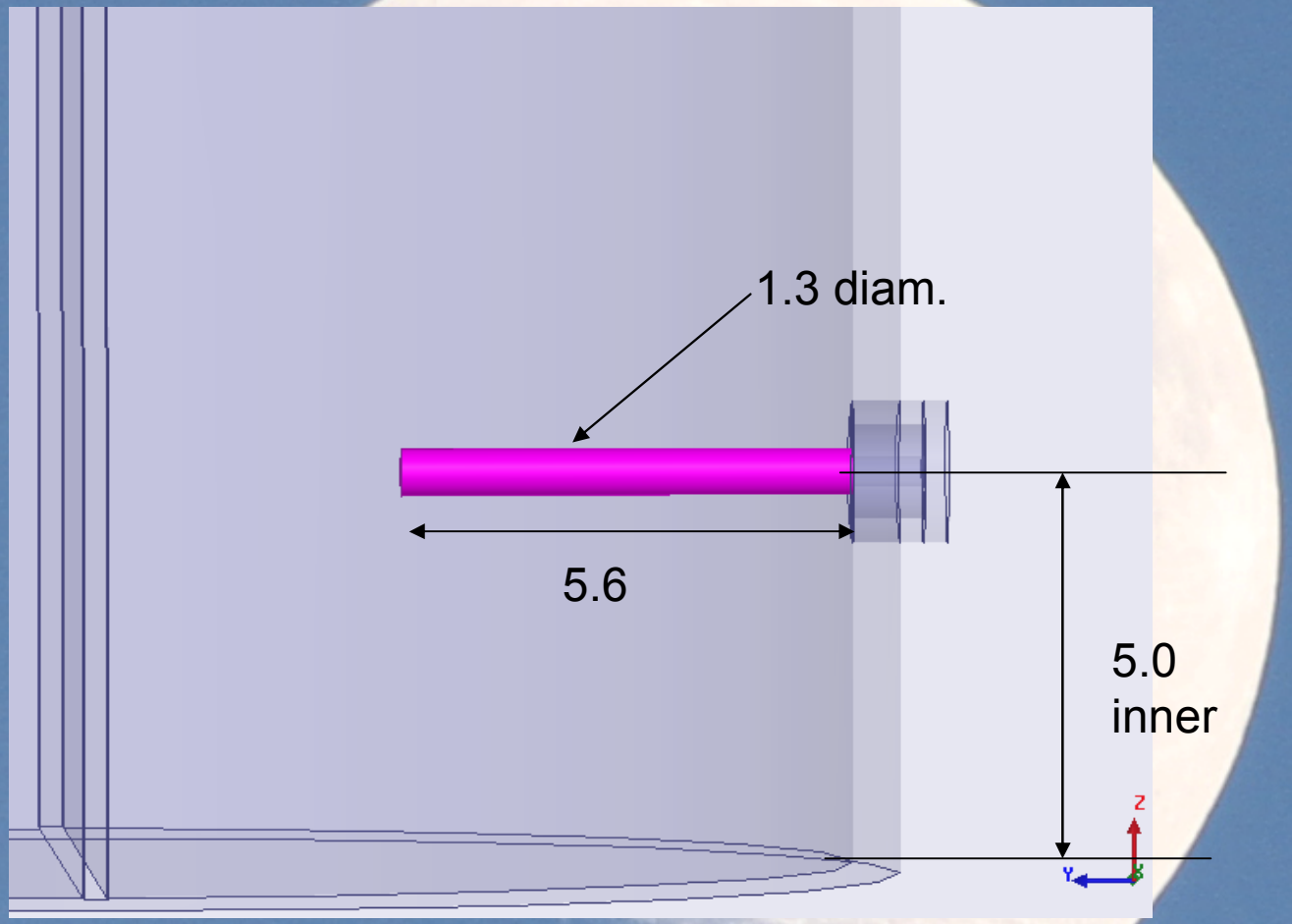




Septum dimensions (3 cm 0.692 wl WG)

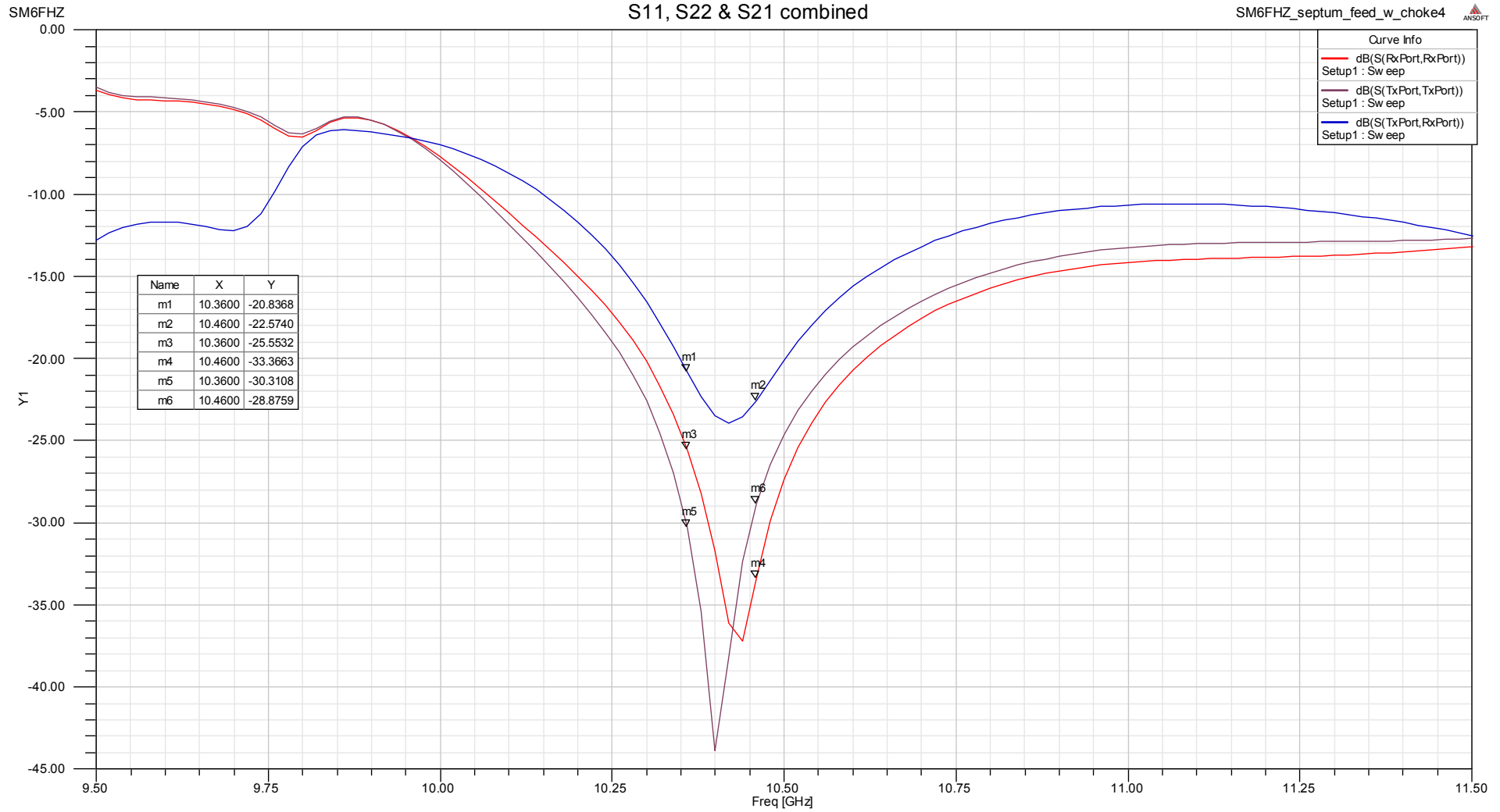


Probe dimensions (3 cm 0.692 wl WG)



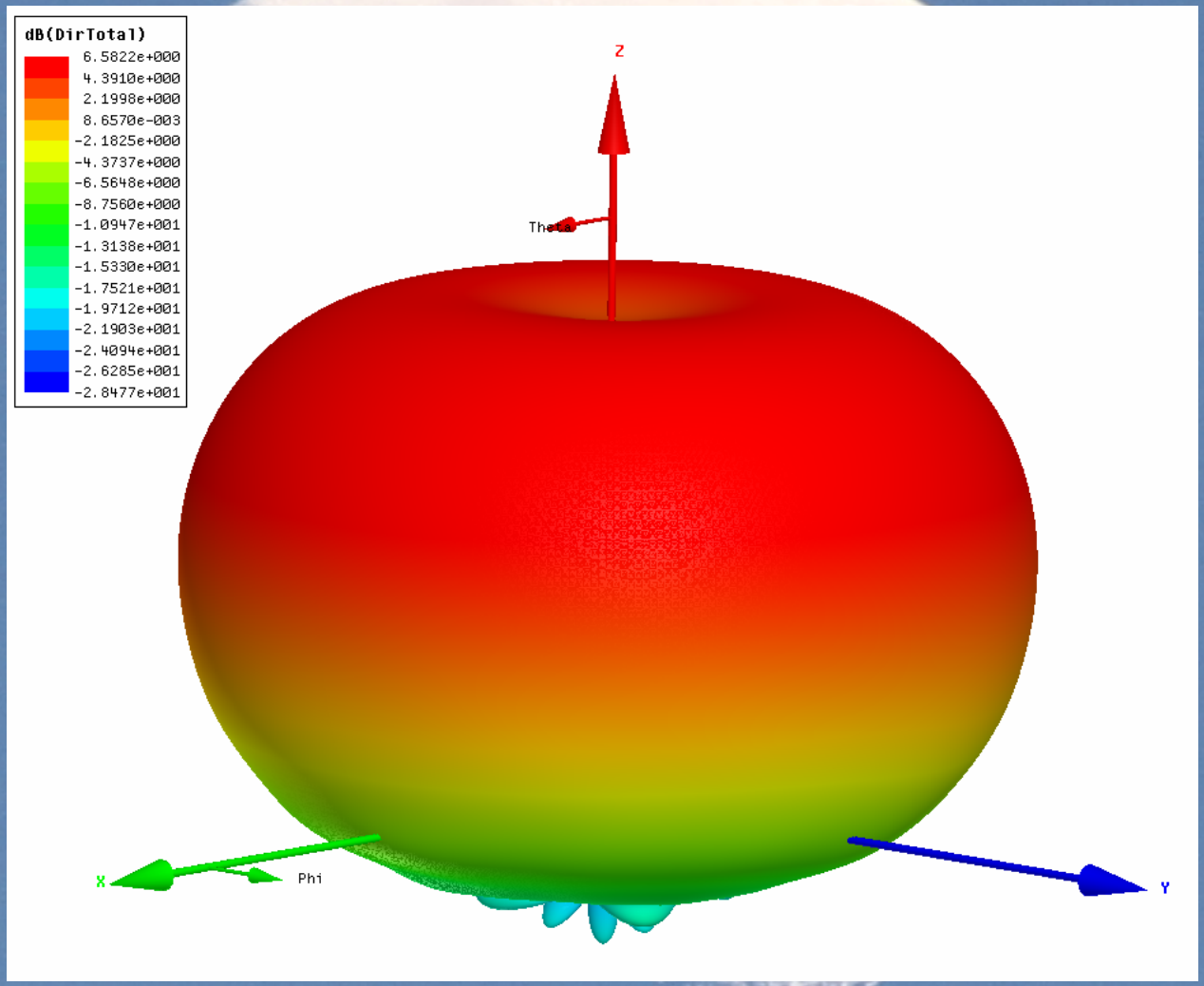
S11, S22, S21 combined

(3 cm 0.692 wl WG)

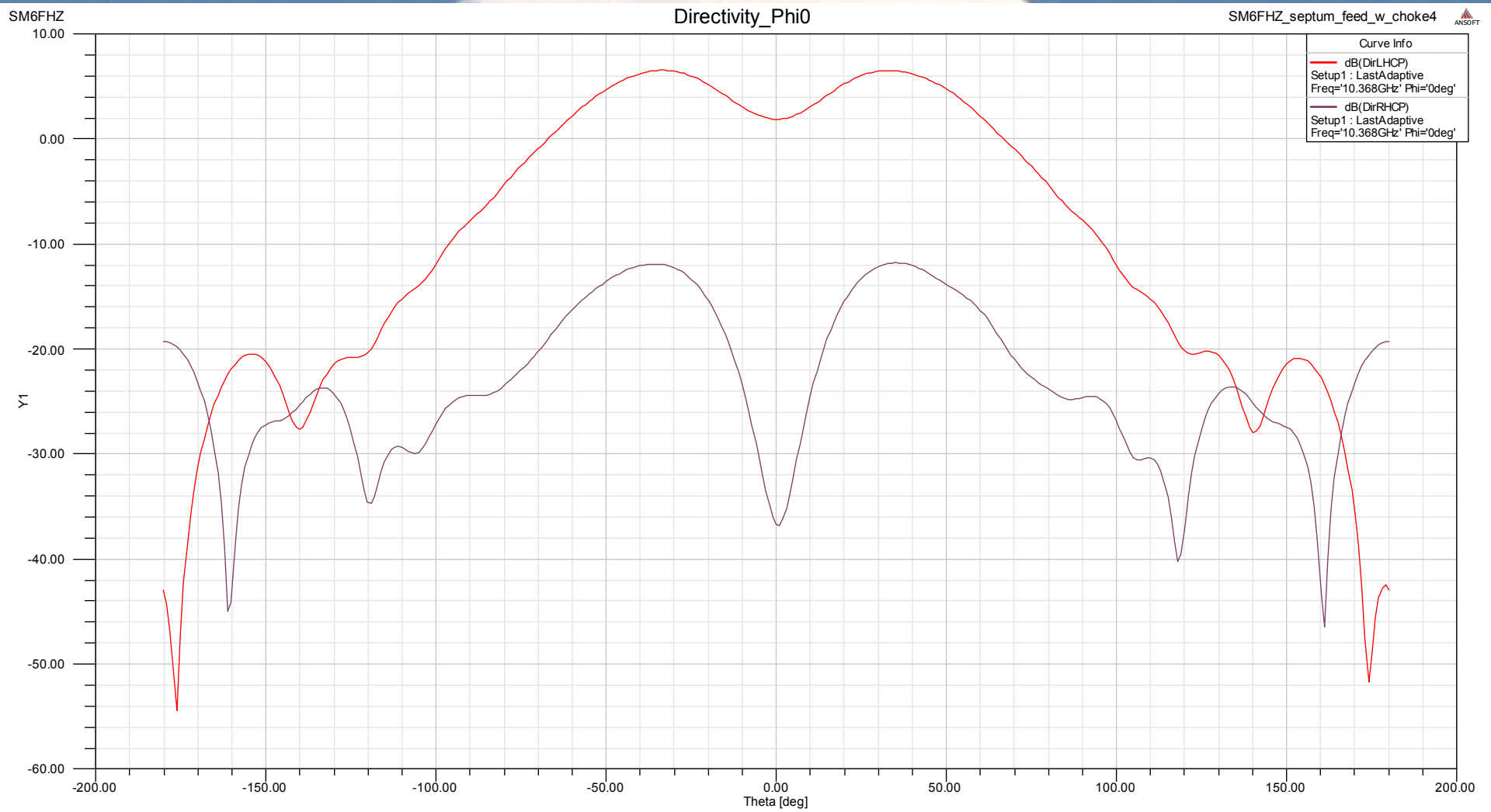


3D Total Power Far Field pattern

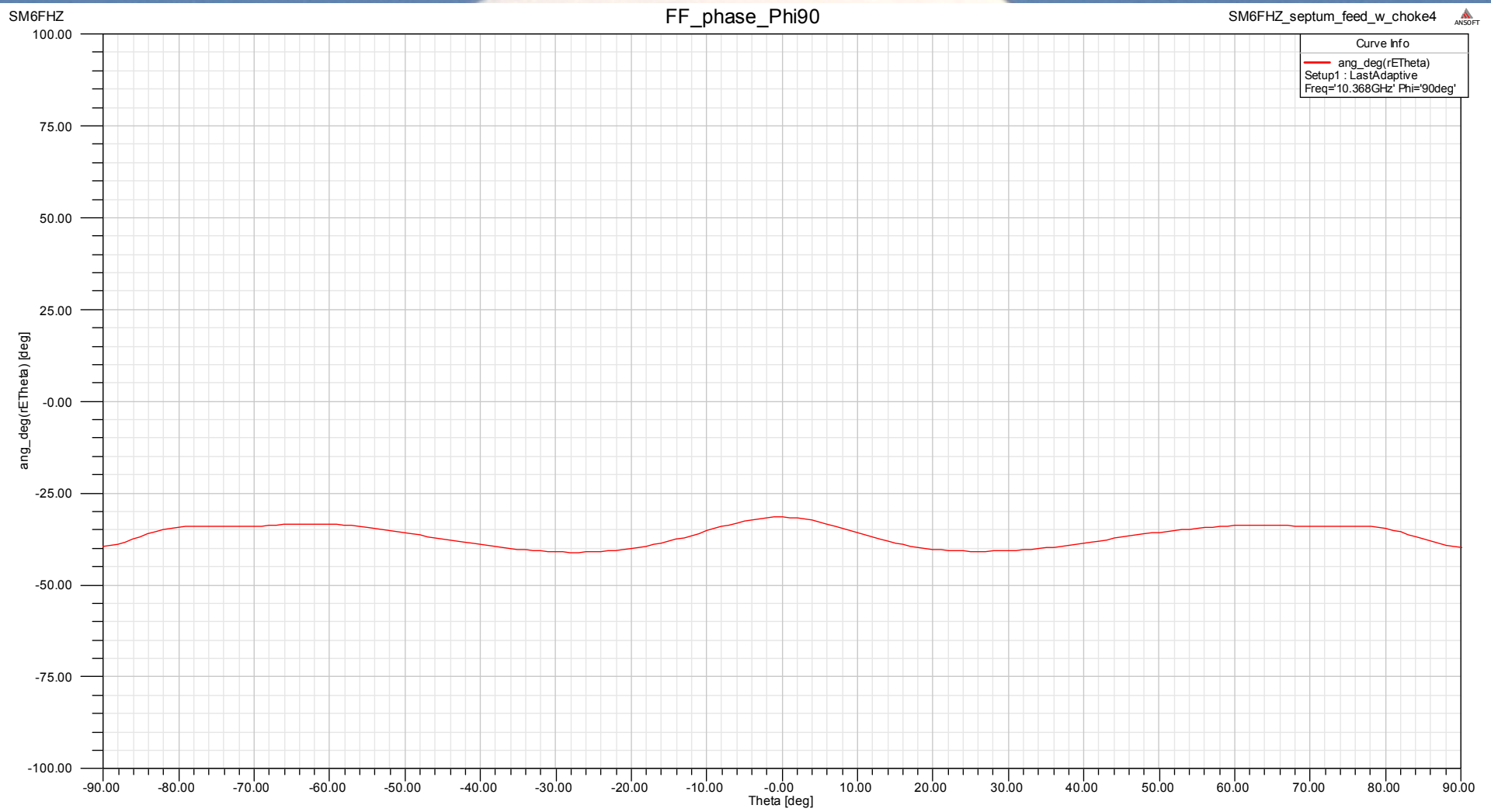
(3 cm 0.692 wl WG)



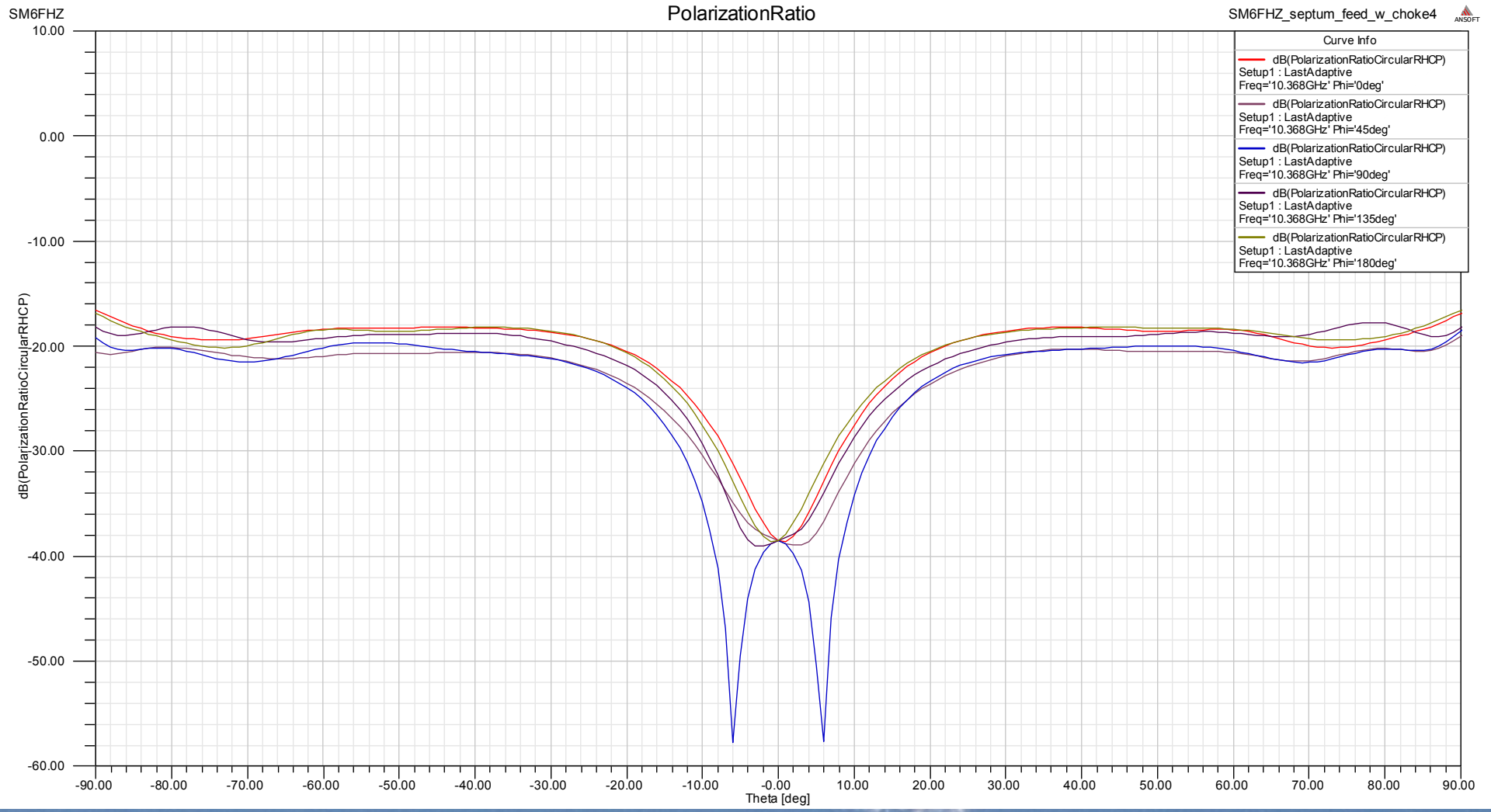
Far Field Pattern 0 deg (3 cm 0.692 wl WG)



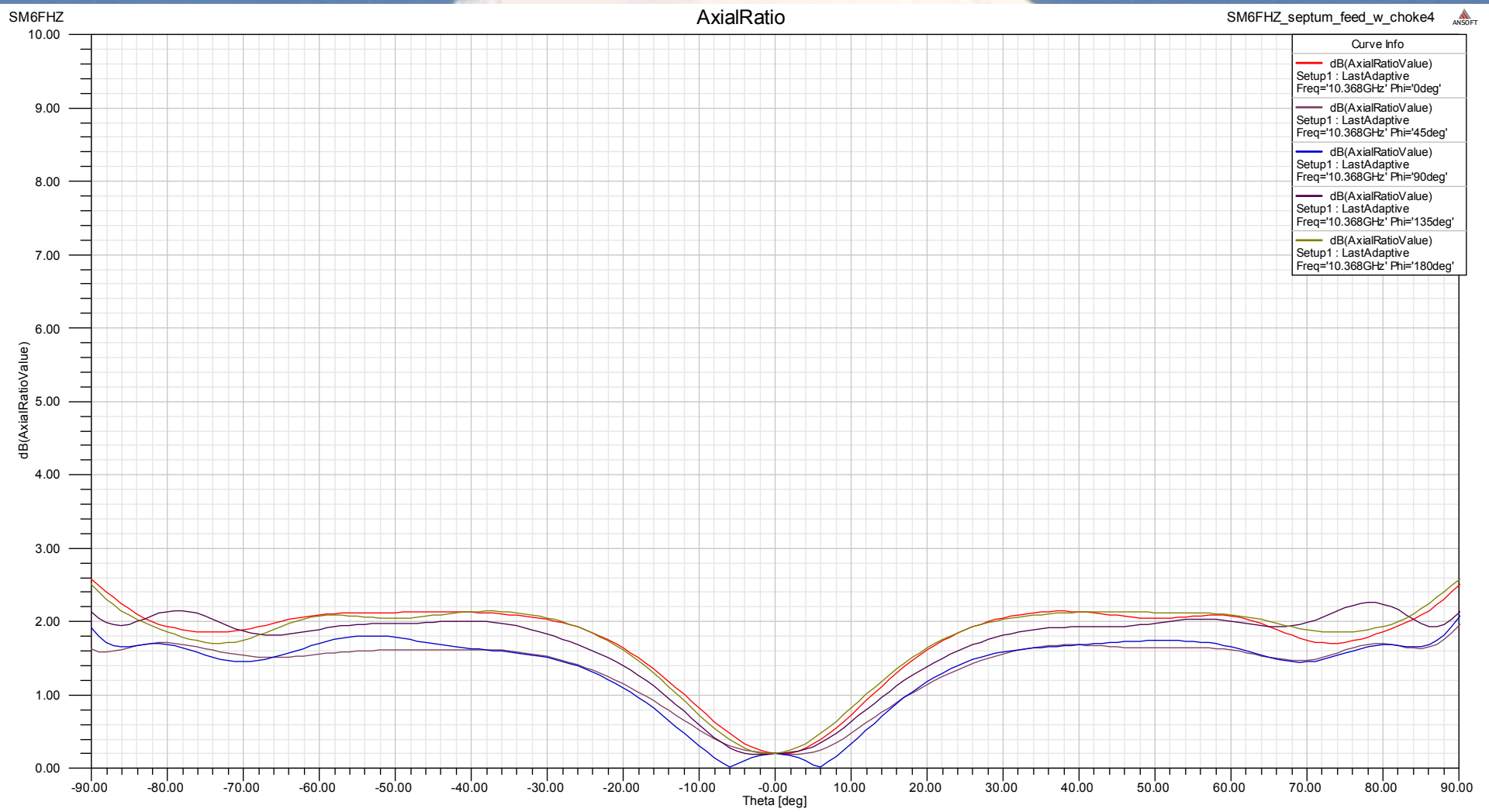
Far Field Phase (3 cm 0.692 wl WG)



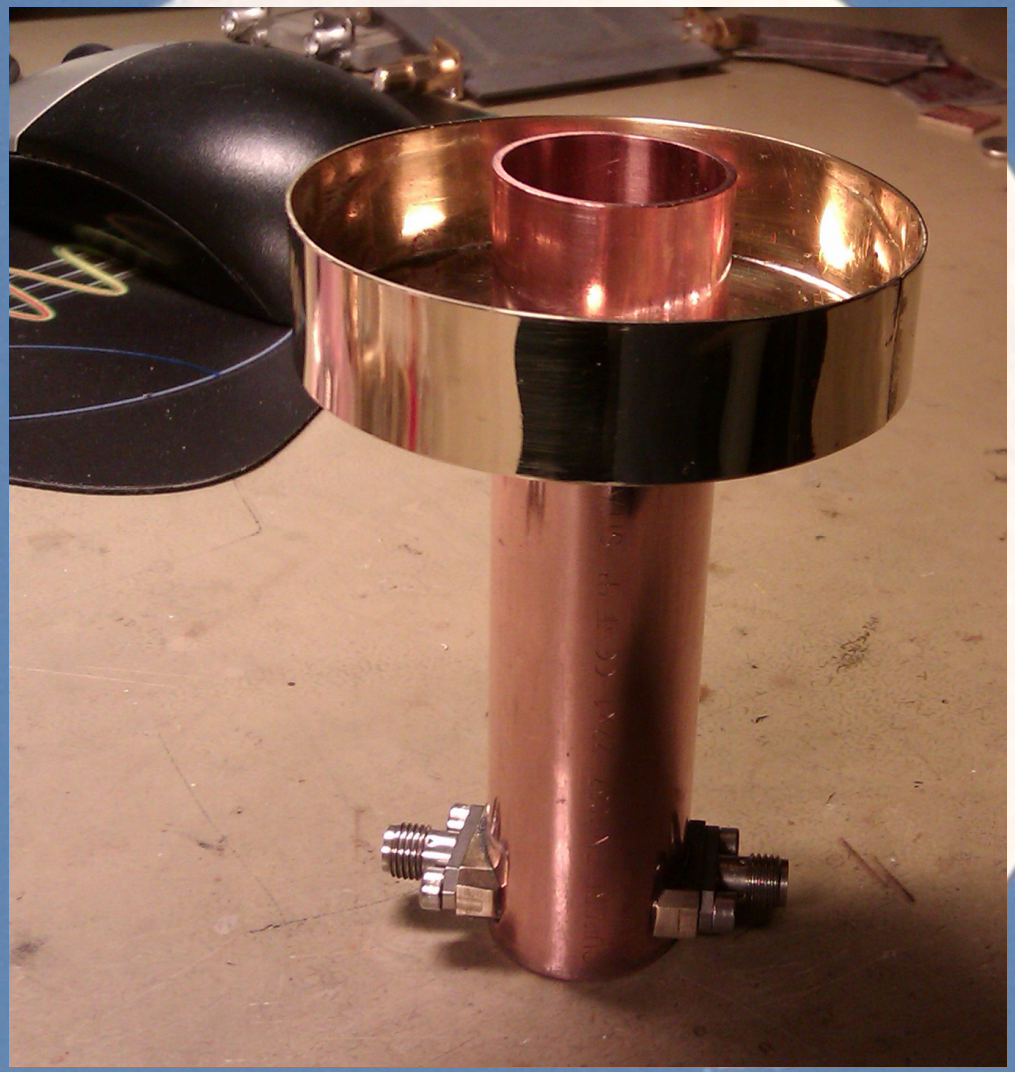
Cross Polar Ratio (3 cm 0.692 wl WG)



Axial Ratio (3 cm 0.692 wl WG)



Realization (3 cm 0.692 wl WG)



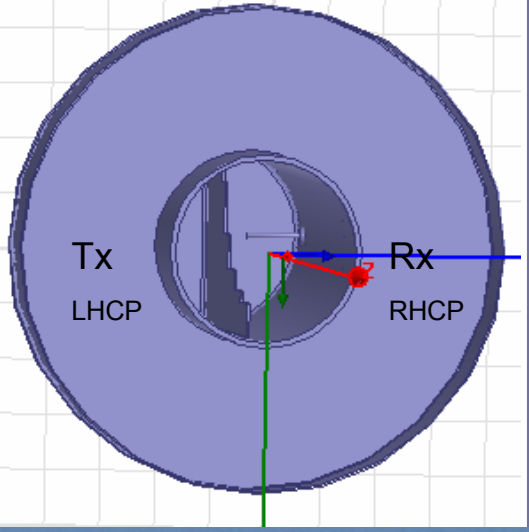
+0.2 mm WG-diam, +1 mm septum, +1 mm WG-length (3 cm 0.692 wl WG)

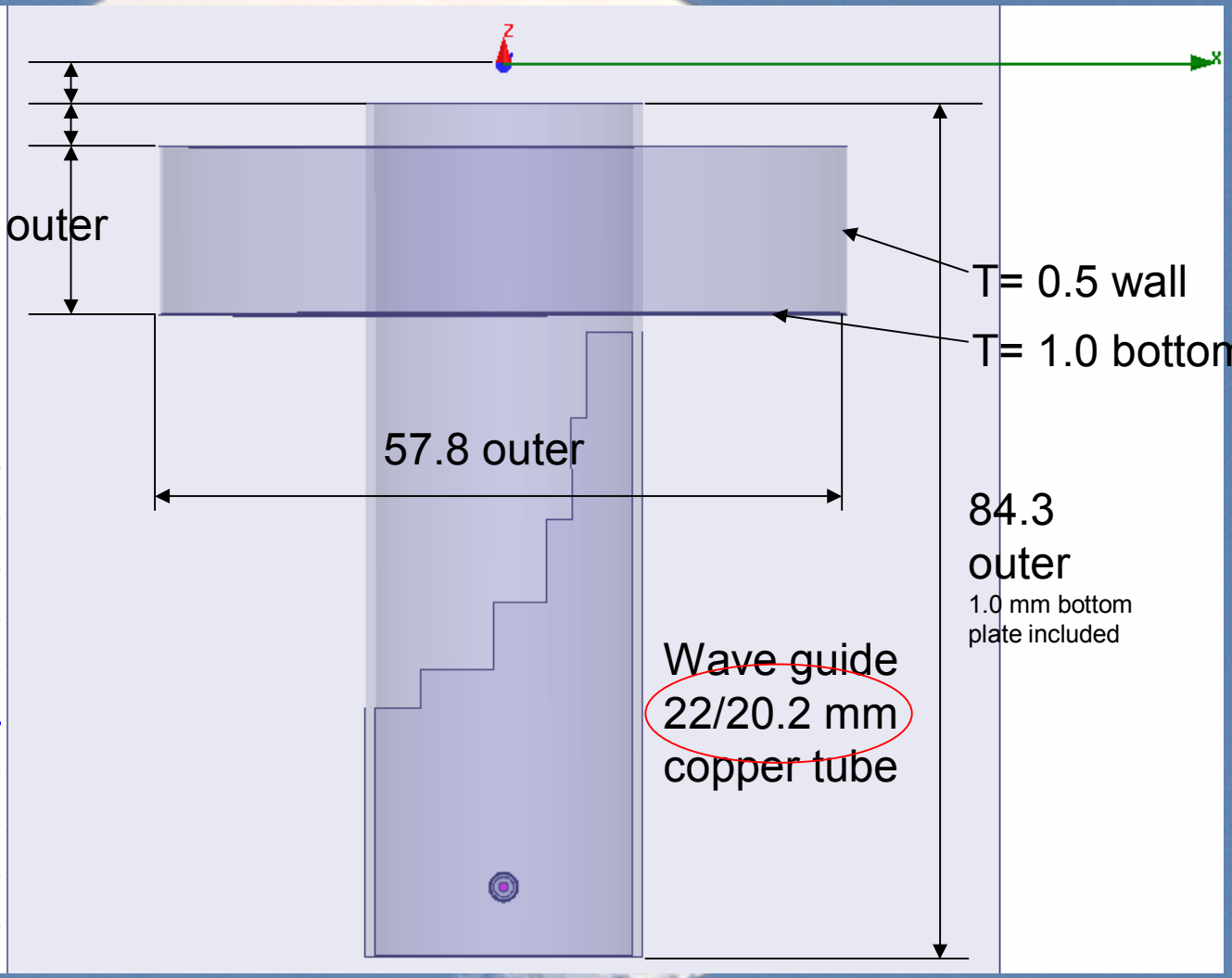
WG and choke dimensions (3 cm 0.692 wl WG)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

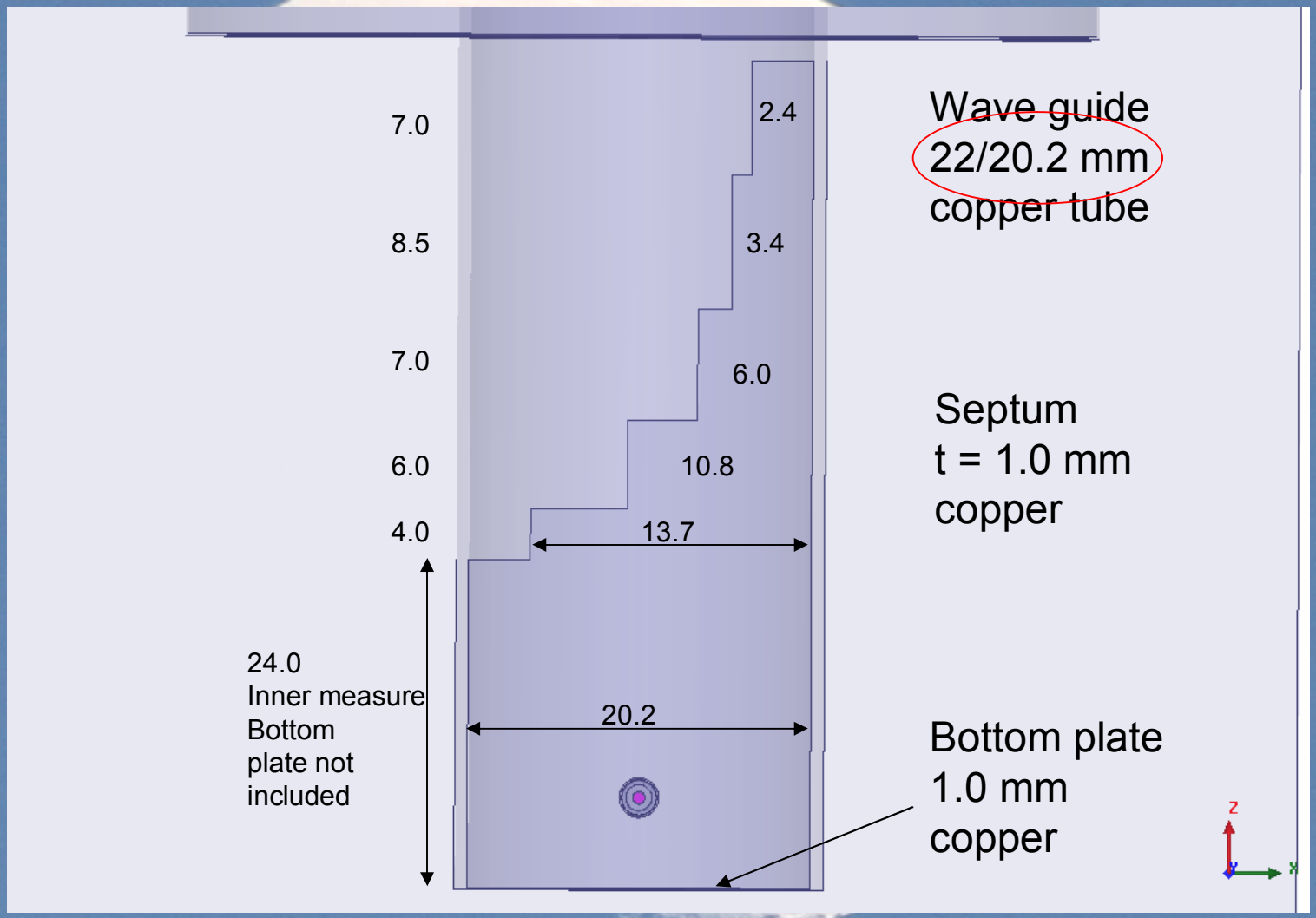
Tx RHCP in space
Rx LHCP in space

Take polarization reversal into account when using reflector antennas.

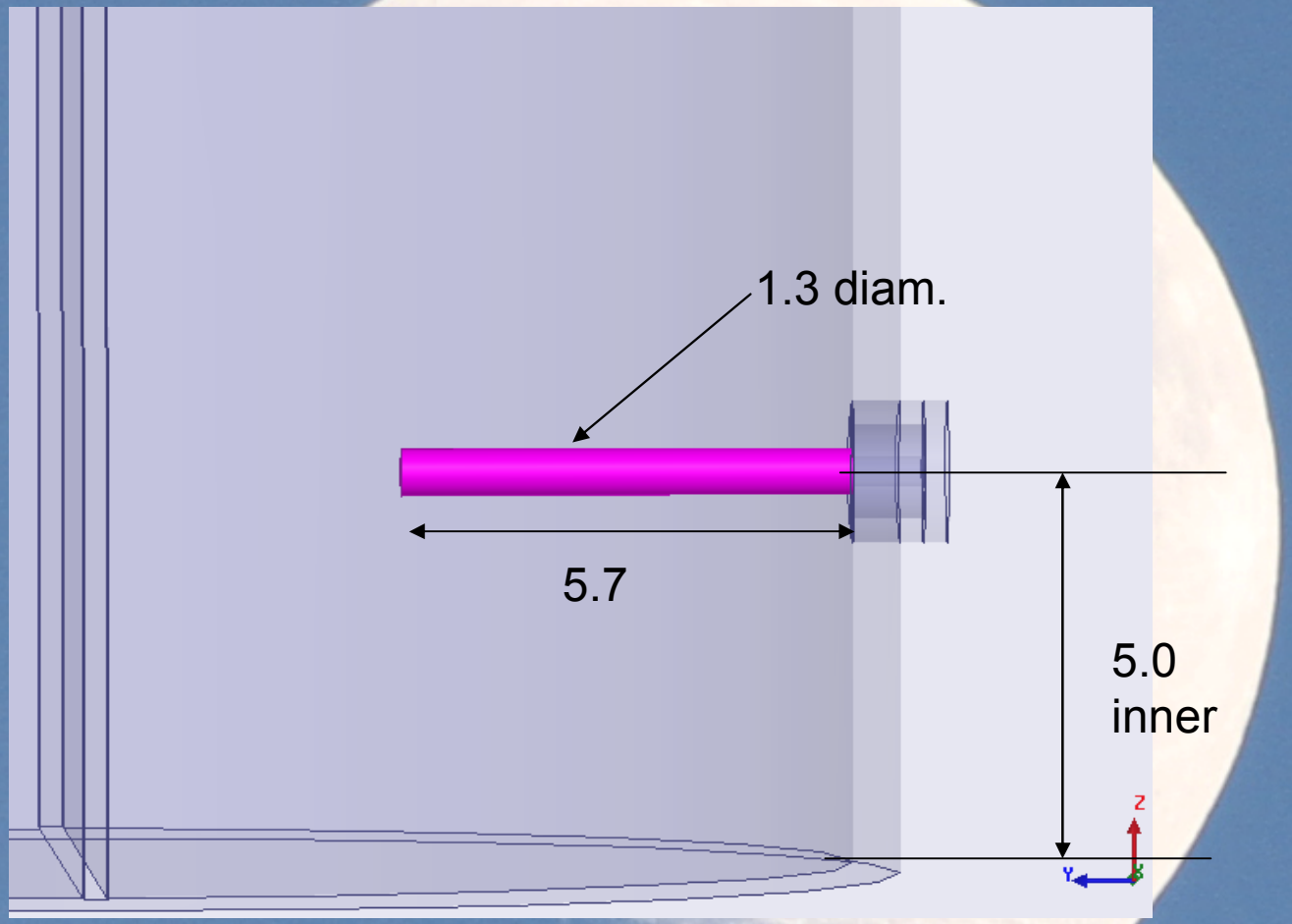




Septum dimensions (3 cm 0.692 wl WG)

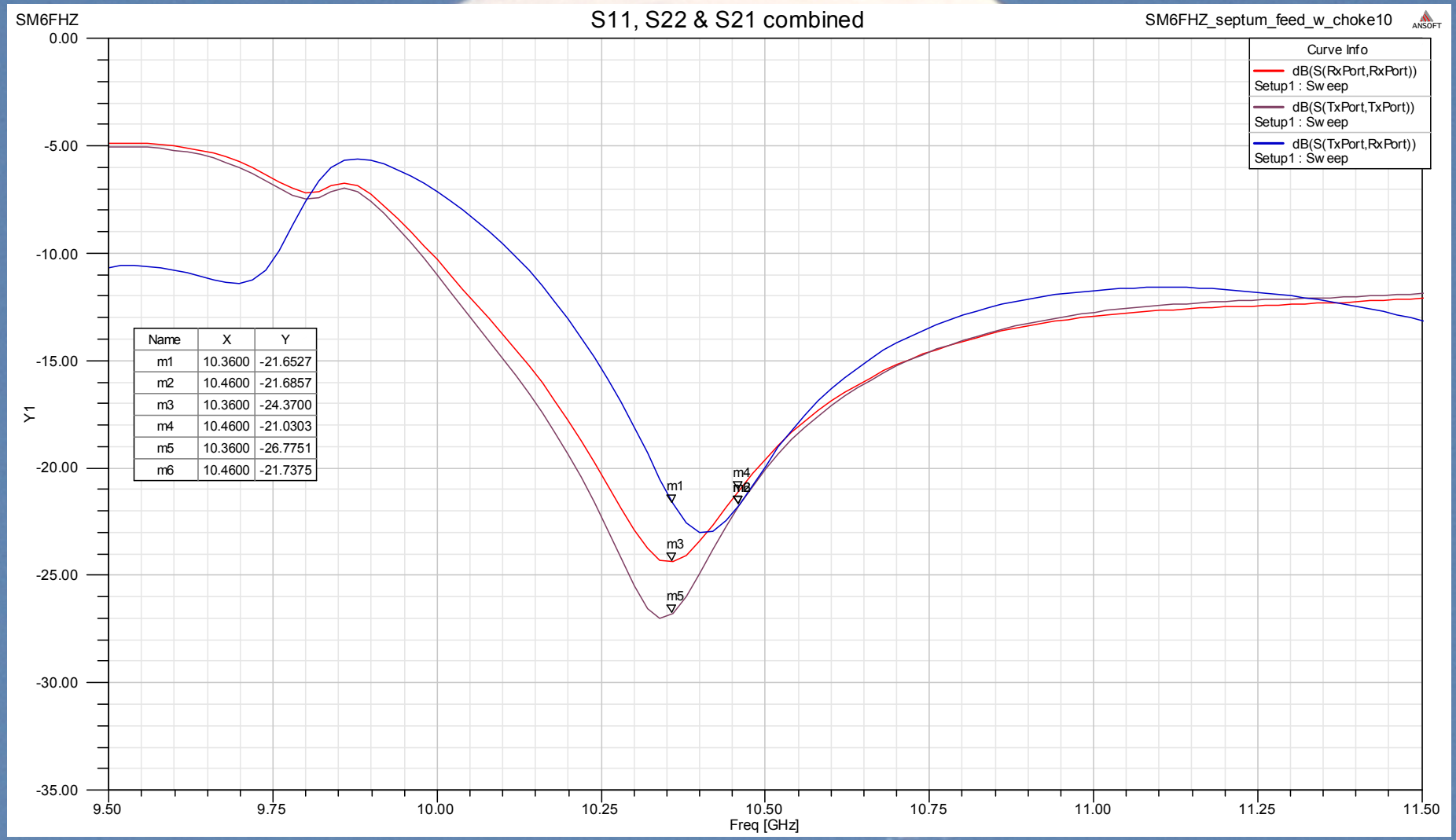


Probe dimensions (3 cm 0.692 wl WG)

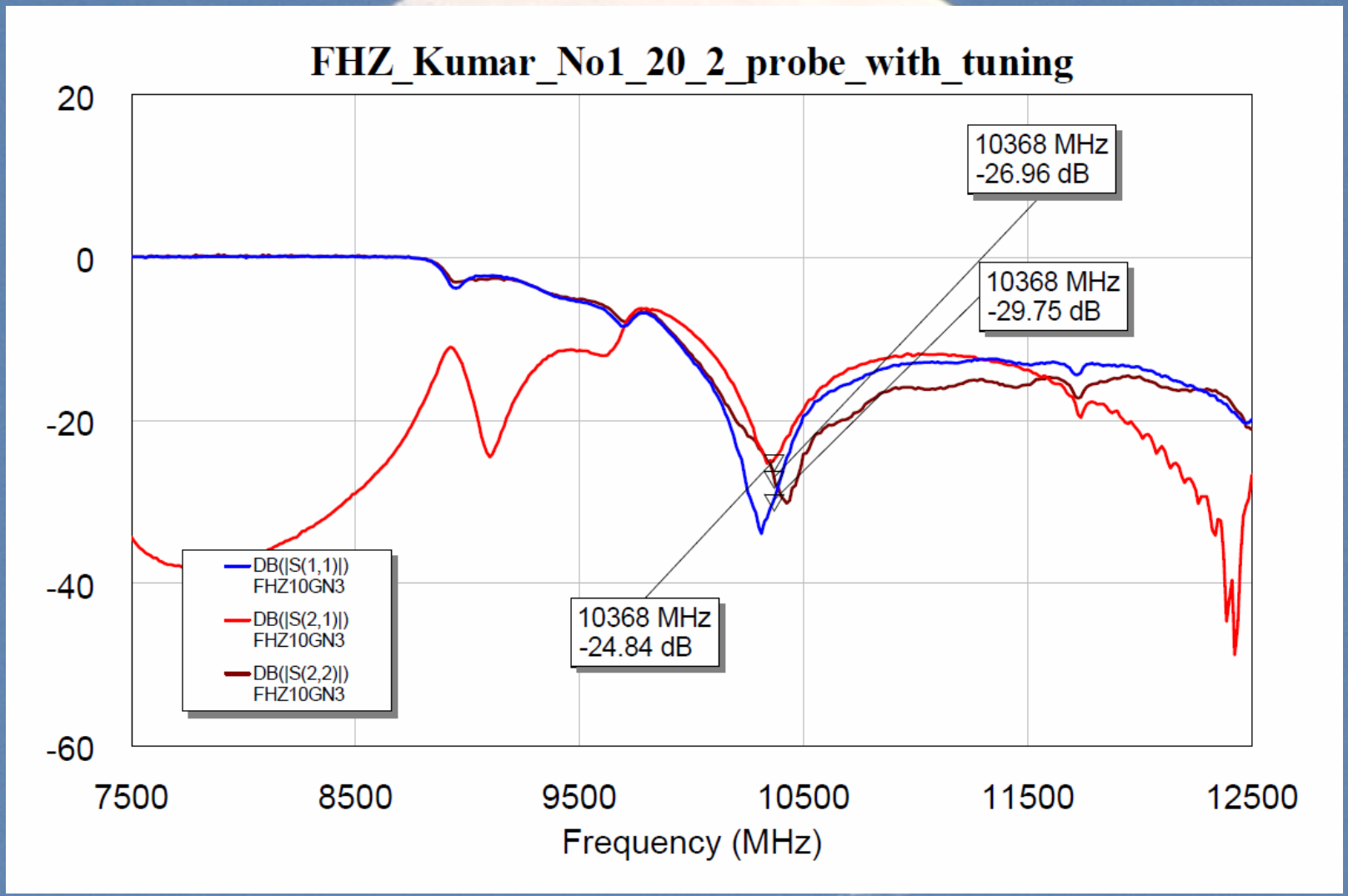


20,2 mm WG-inner diam optimized

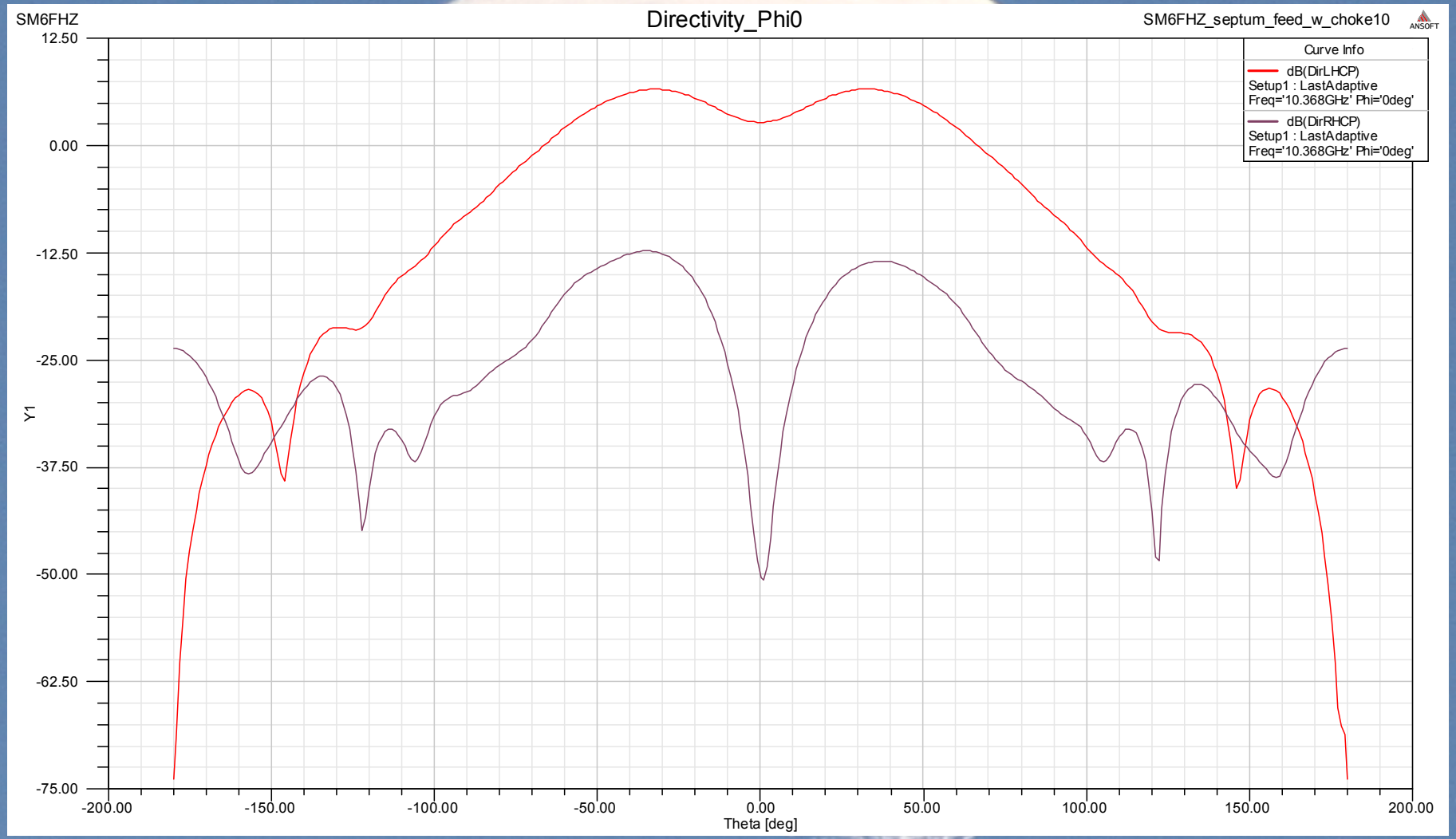
(3 cm 0.692 wl WG)



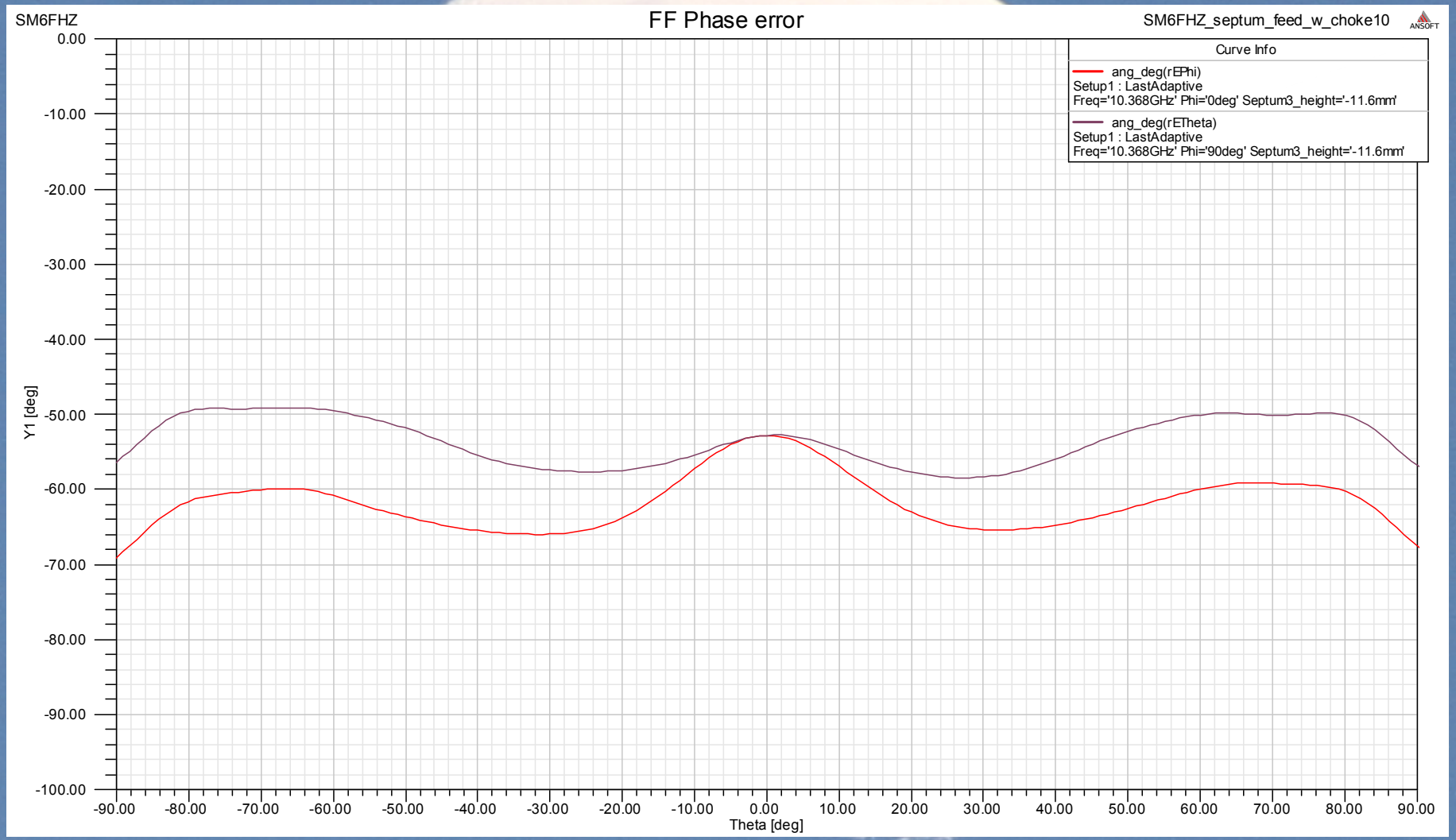
Measurements (3 cm 0.692 wl WG)



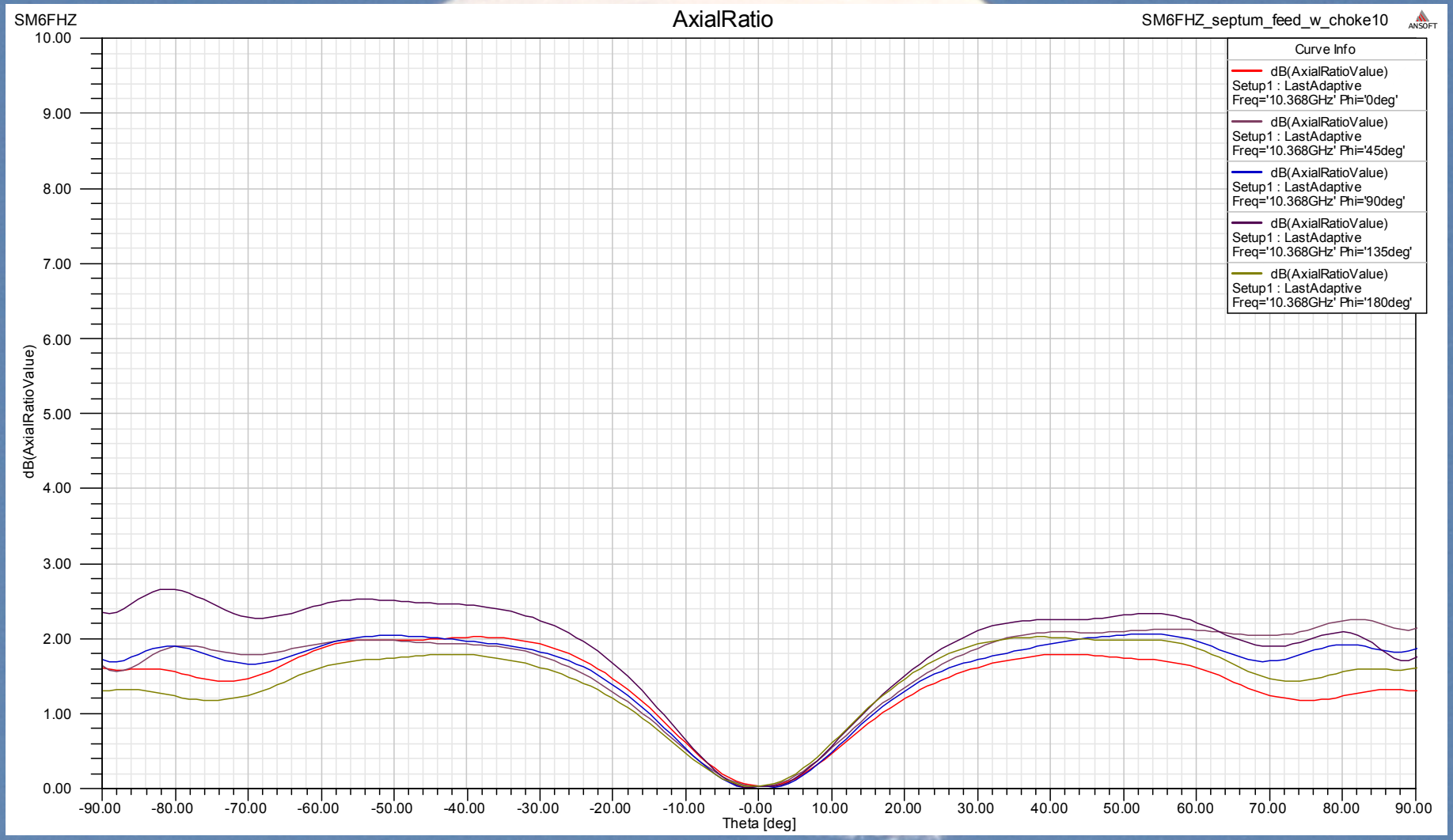
Far Field Pattern 0 deg (3 cm 0.692 wl WG)



FF Phase error (3 cm 0.692 wl WG)



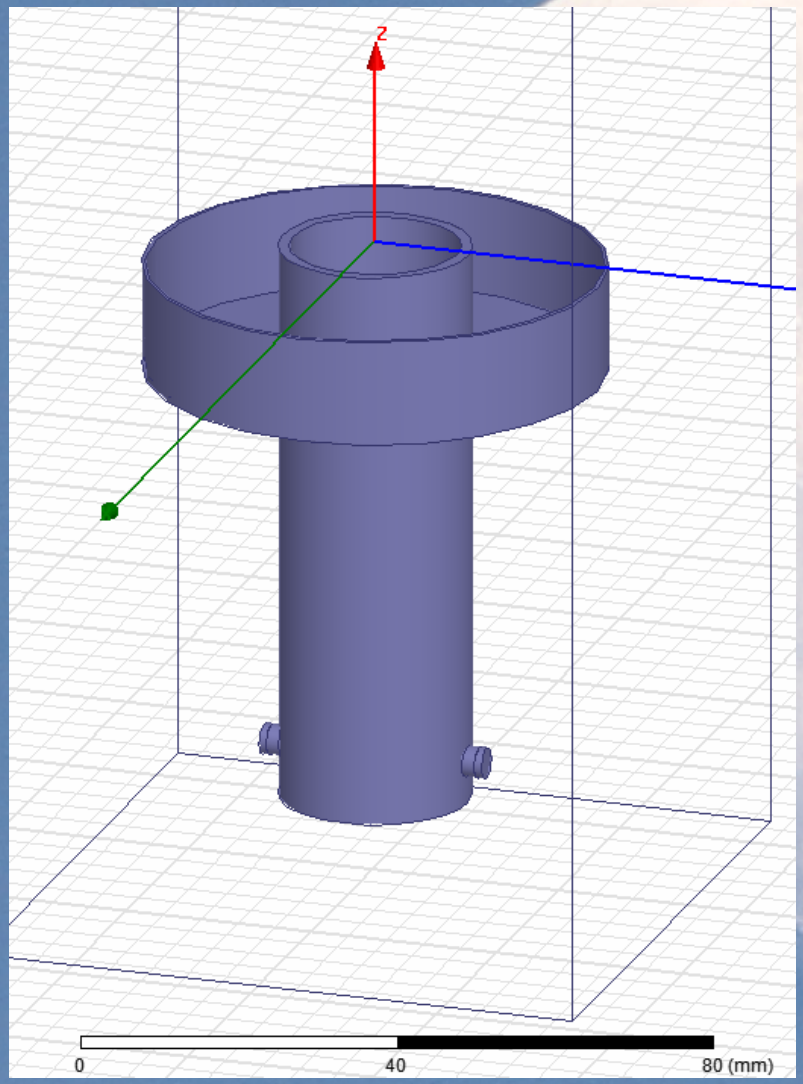
Axial Ratio (3 cm 0.692 wl WG)

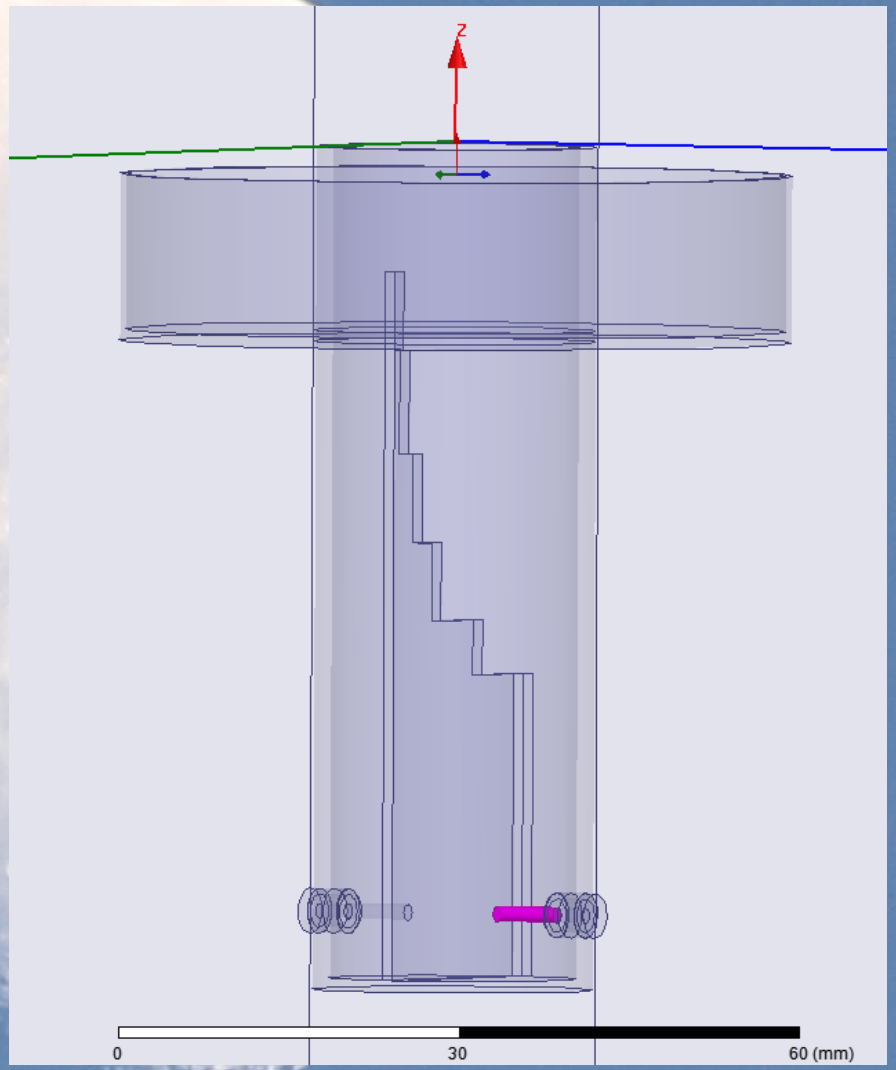


SM6FHZ 3 cm 5 step septum feed

0.795 lambda W/G

Solid and transparent models from the simulation (3 cm 0.795 wl WG)



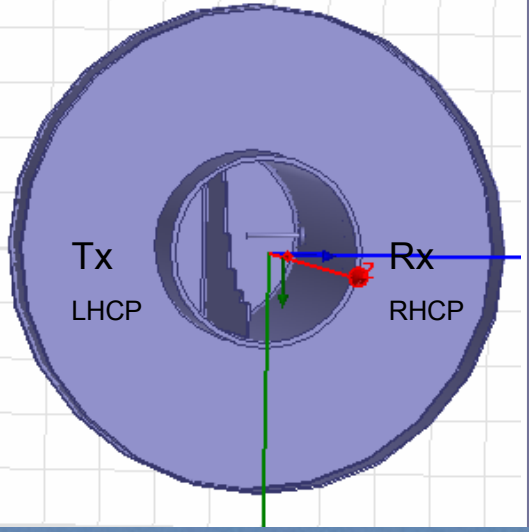


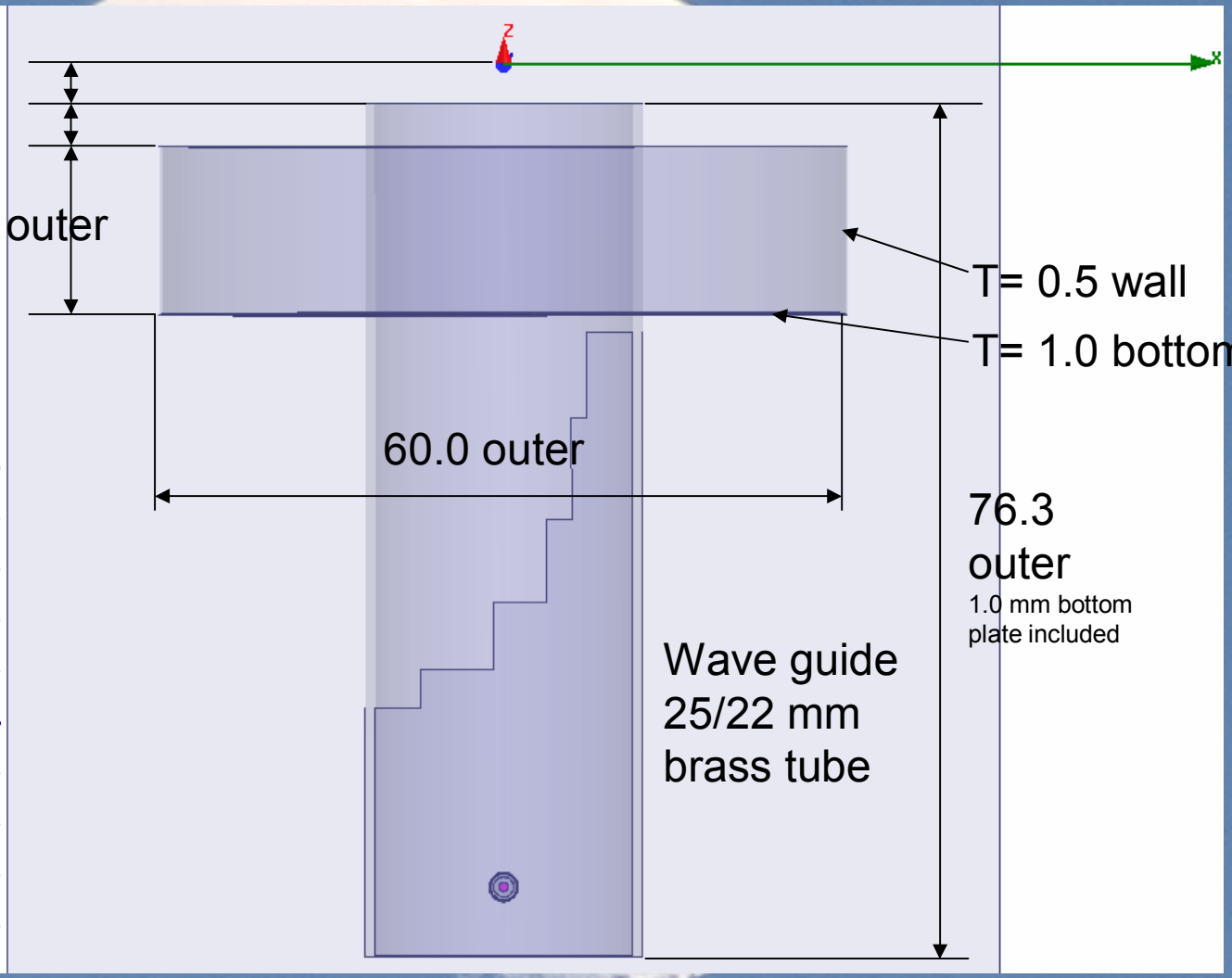
WG and choke dimensions (3 cm 0.795 wl WG)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

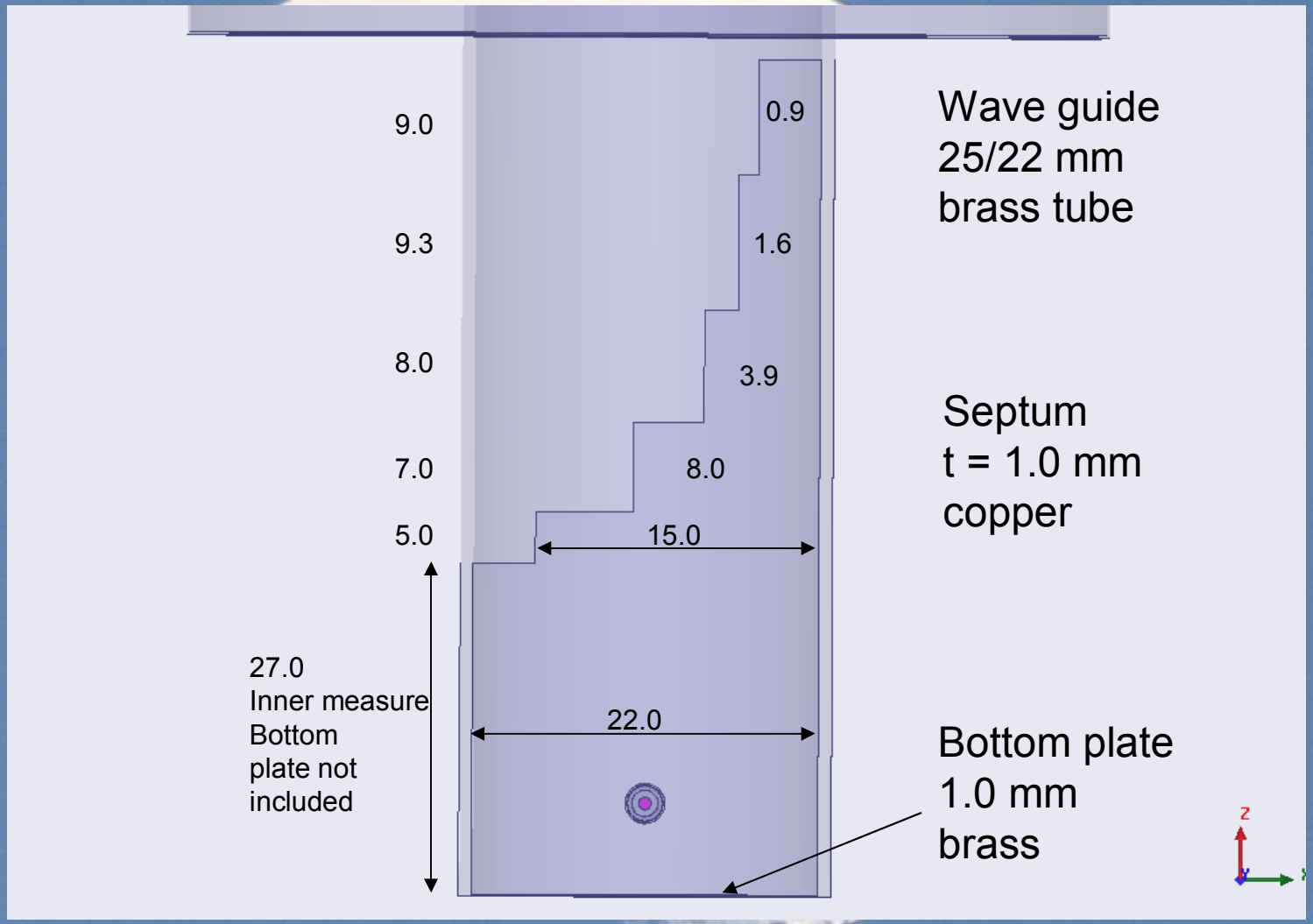
Tx RHCP in space
Rx LHCP in space

Take polarization reversal into account when using reflector antennas.

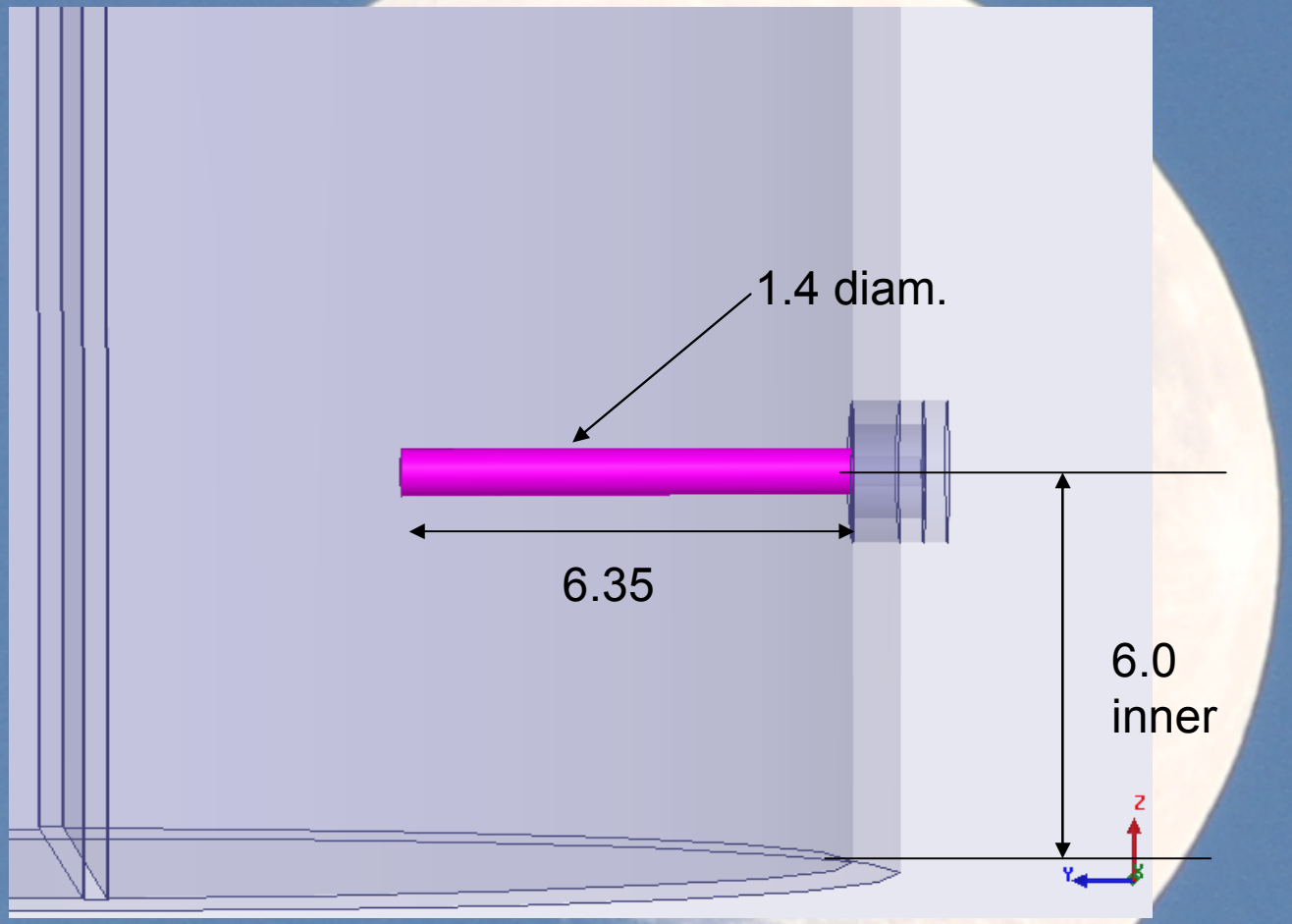




Septum dimensions (3 cm 0.795 wl WG)

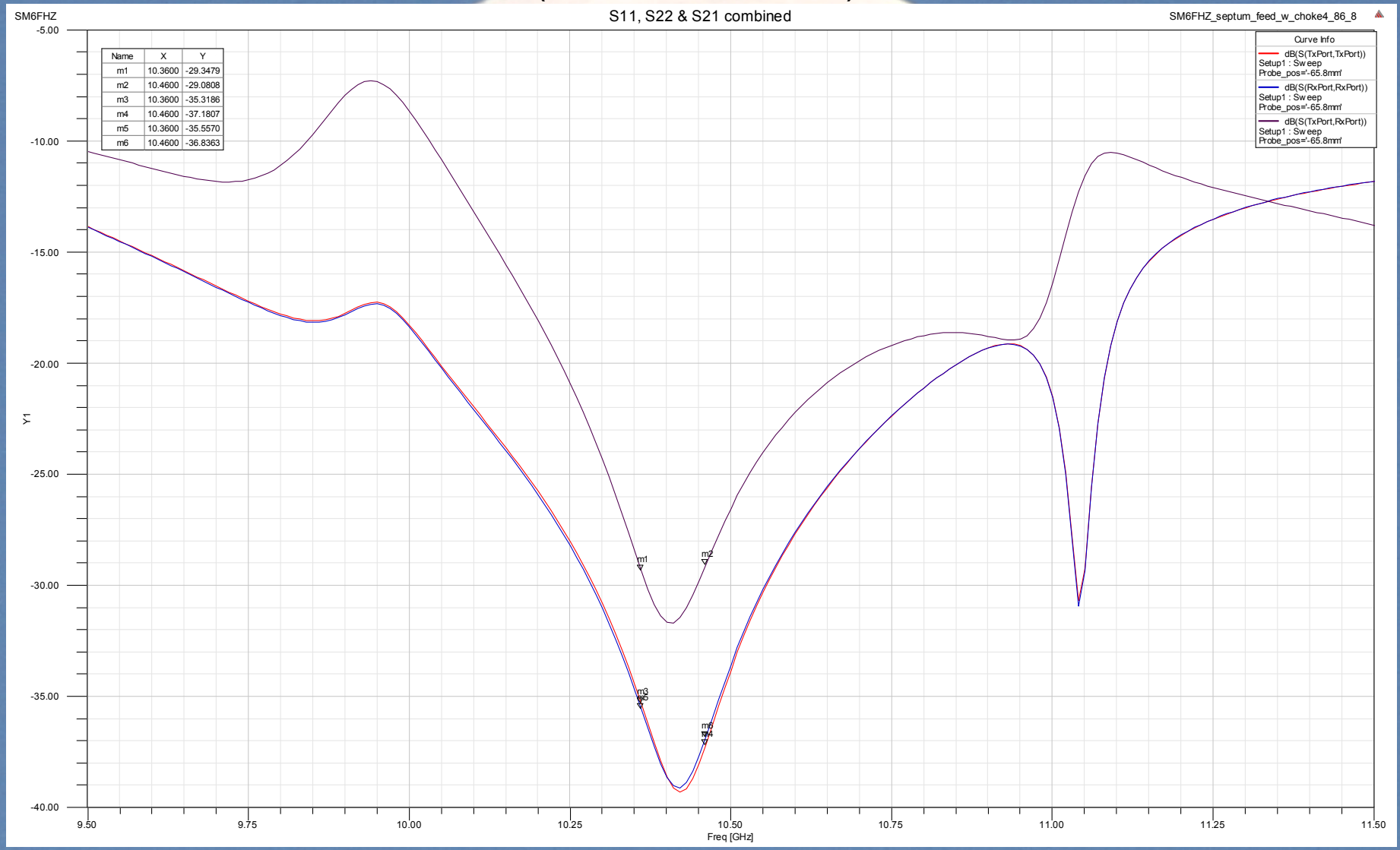


Probe dimensions (3 cm 0.795 wl WG)



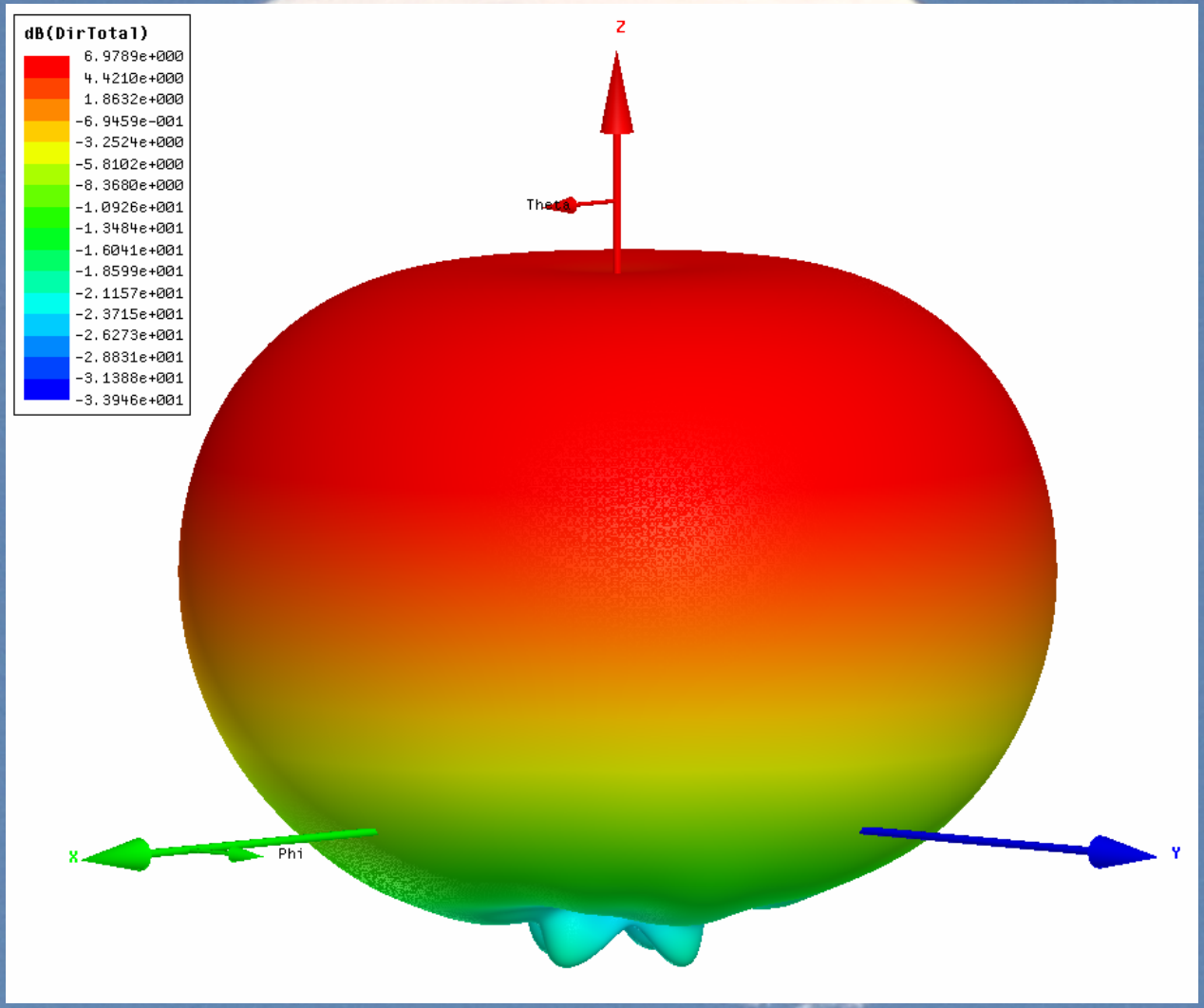
S11, S22, S21 combined

(3 cm 0.795 wl WG)

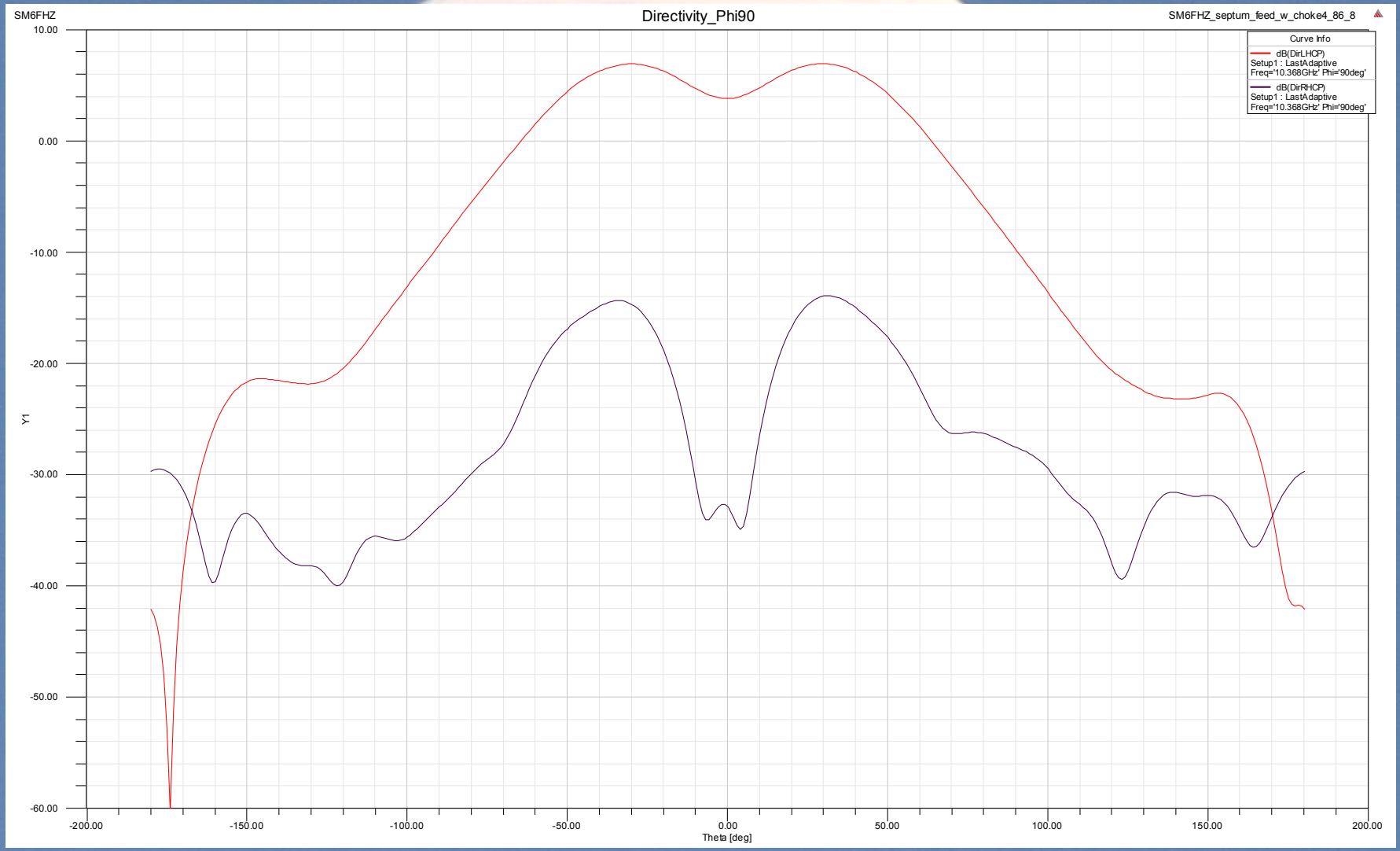


3D Total Power Far Field pattern

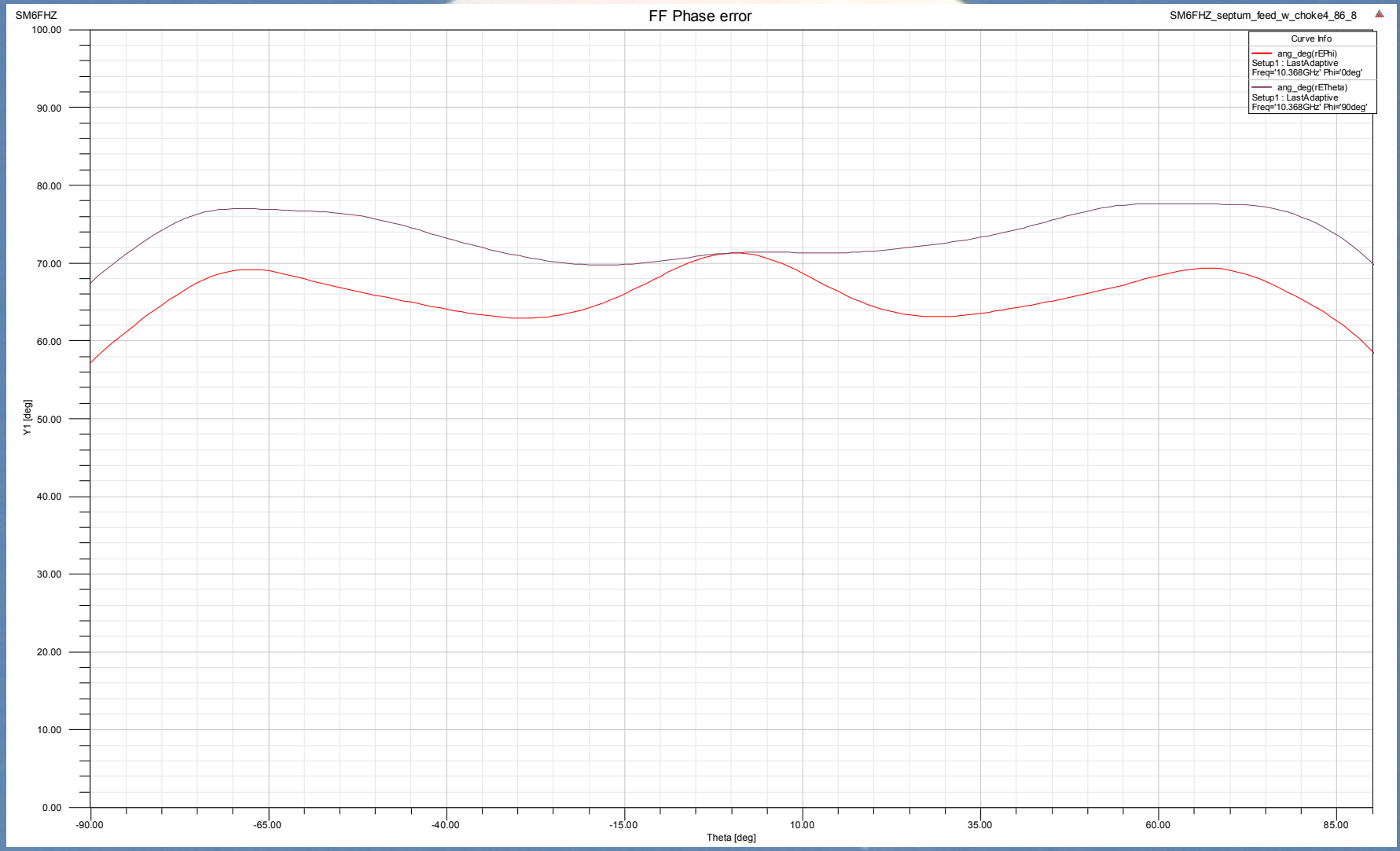
(3 cm 0.795 wl WG)



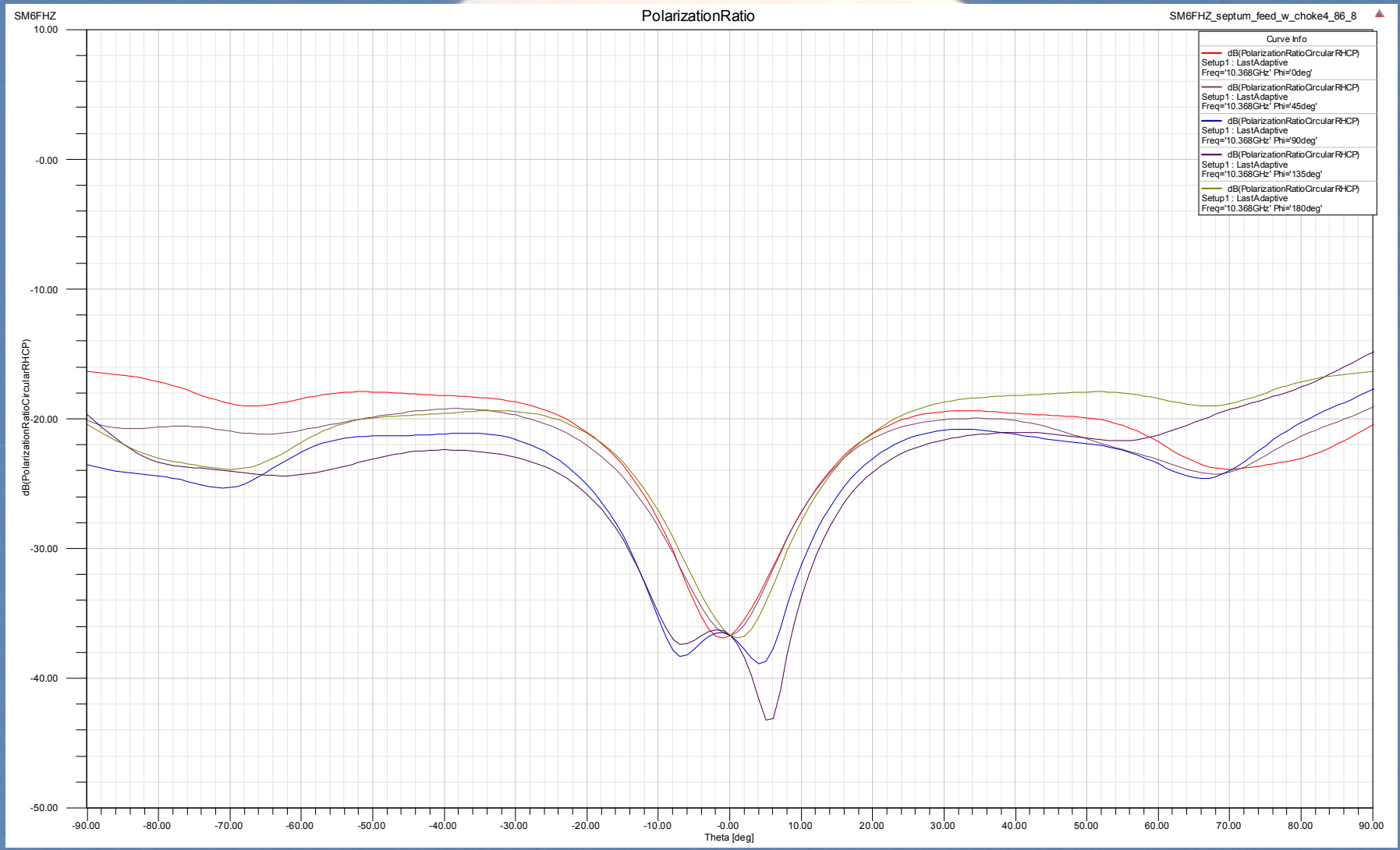
Far Field Pattern 0 deg (3 cm 0.795 wl WG)



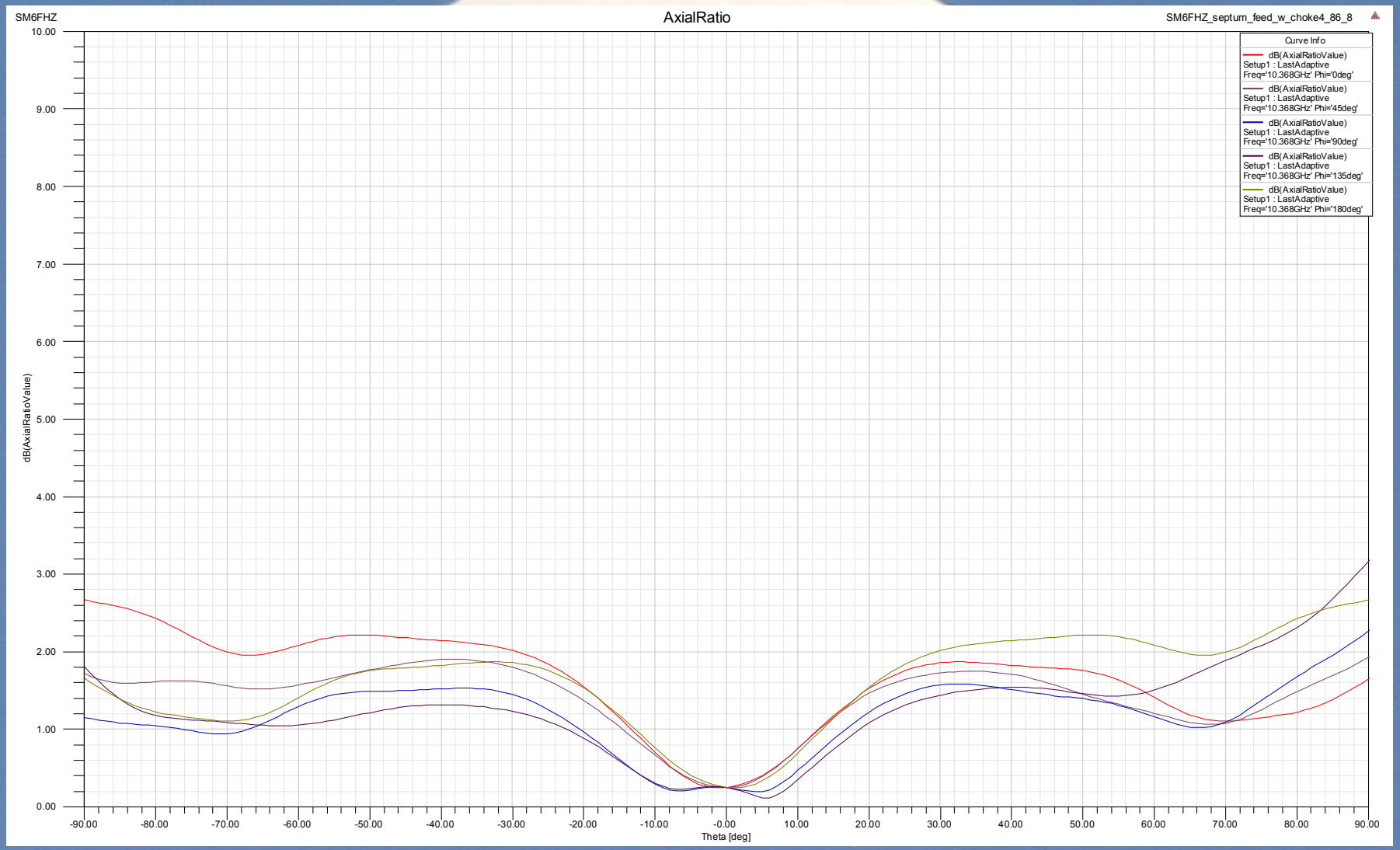
Far Field Phase error (3 cm 0.795 wl WG)

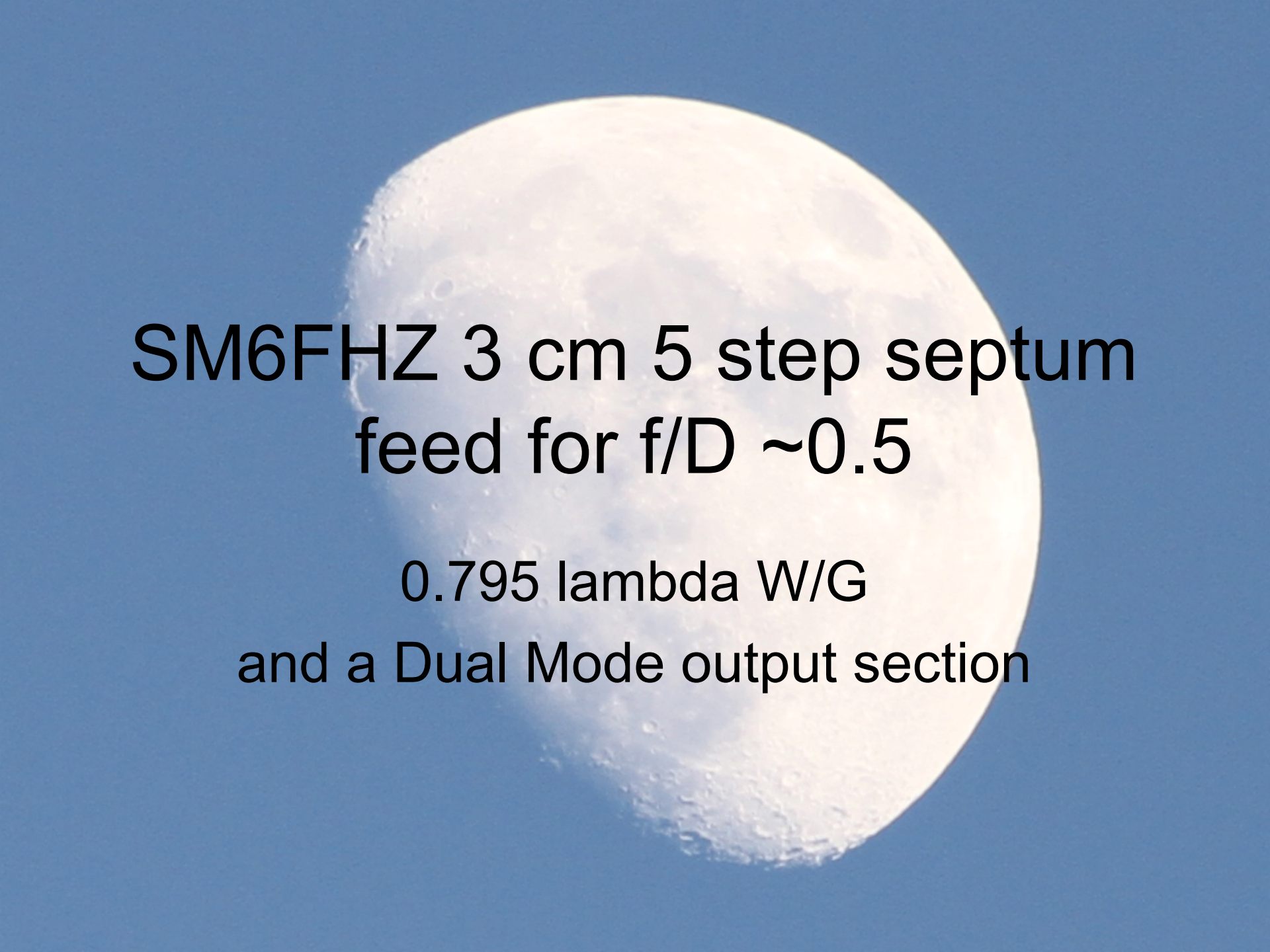


Cross Polar Ratio (3 cm 0.795 wl WG)



Axial Ratio (3 cm 0.795 wl WG)



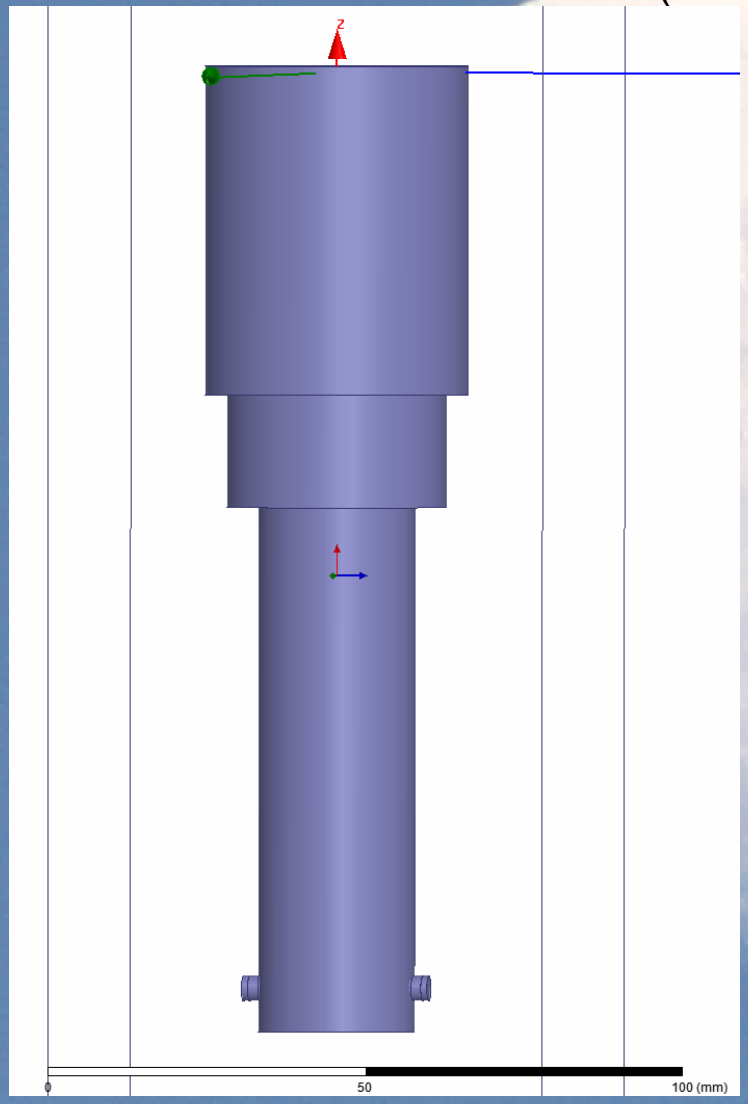


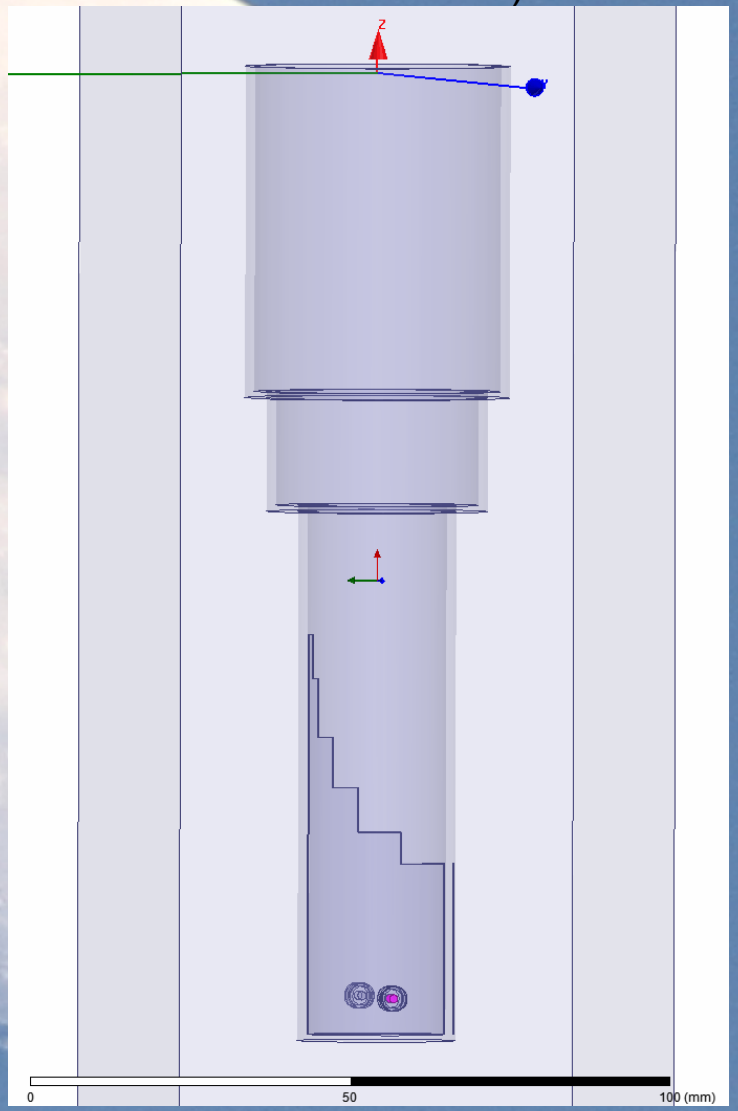
SM6FHZ 3 cm 5 step septum feed for f/D ~0.5

0.795 lambda W/G

and a Dual Mode output section

Solid and transparent models from the simulation (3 cm 0.795 wl WG Dual Mode 39mm)





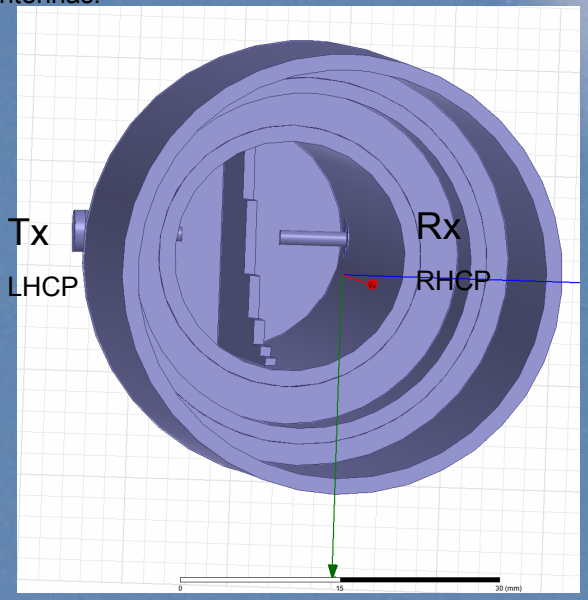
WG and choke dimensions

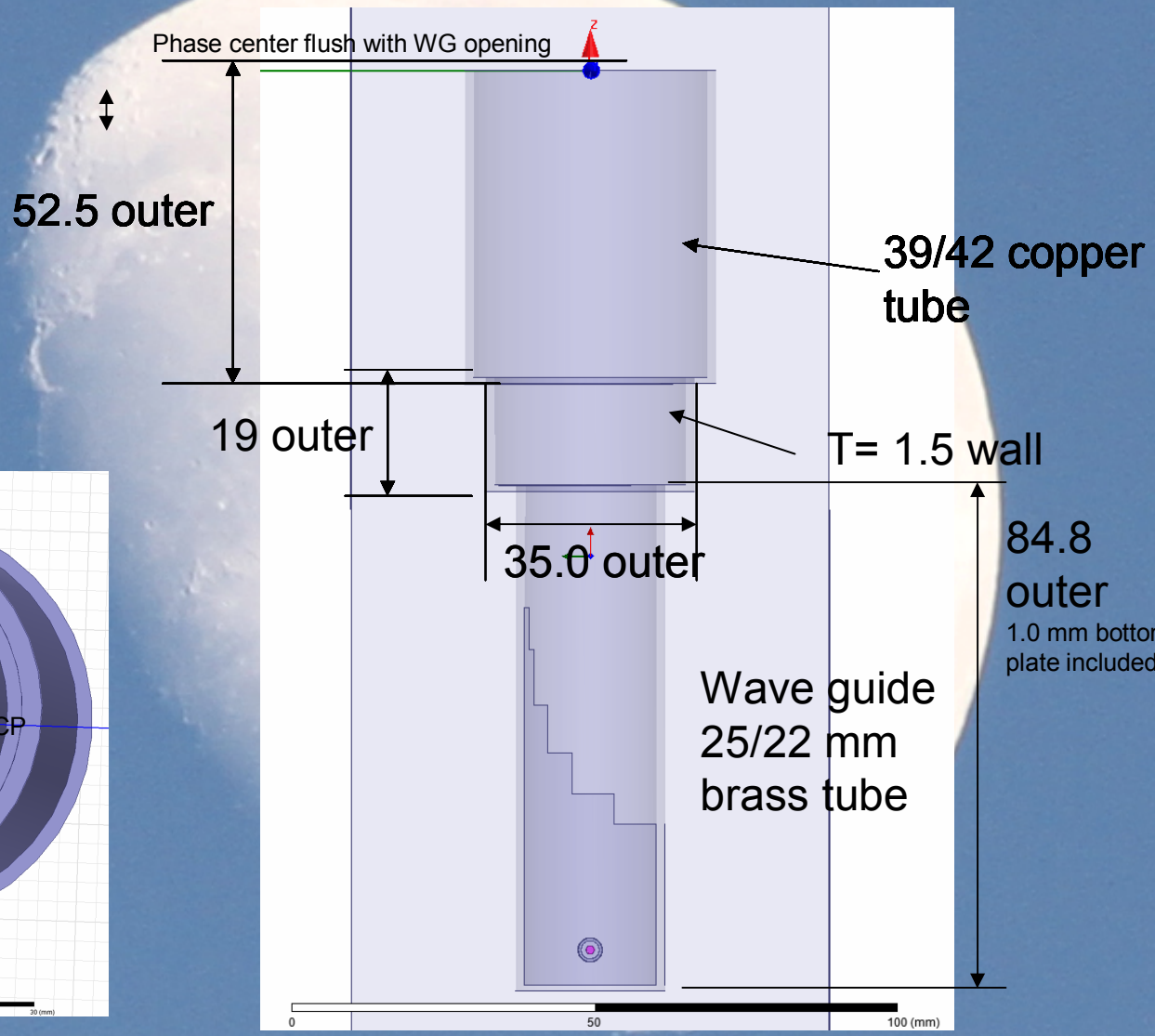
(3 cm 0.795 wl WG Dual Mode 39mm)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

Tx RHCP in space
Rx LHCP in space

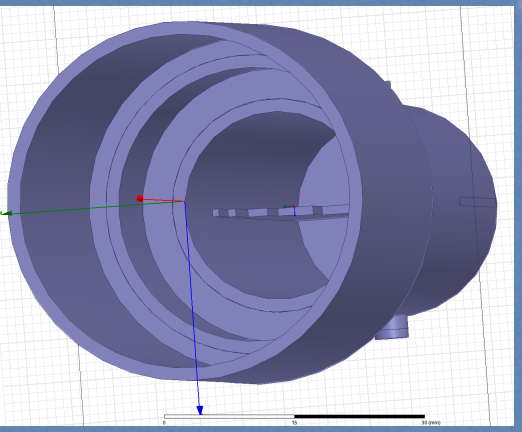
Take polarization reversal into account when using reflector antennas.

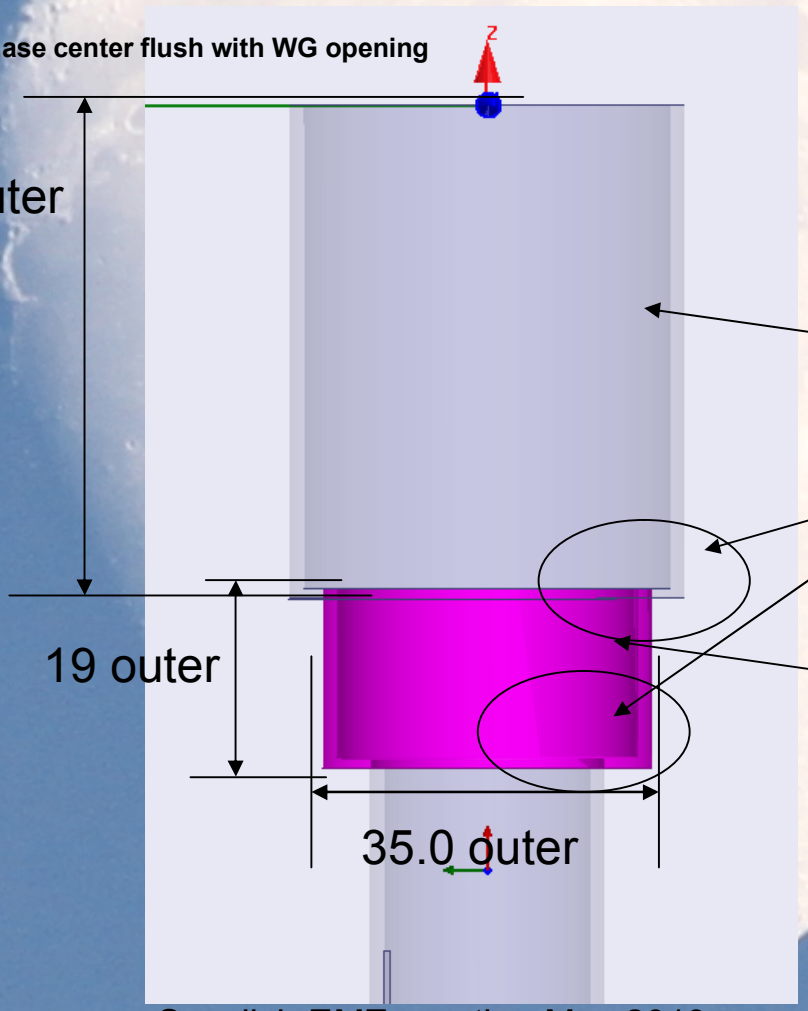




Detail of WG / transformer and output section

(3 cm 0.795 wl WG Dual Mode 39mm)





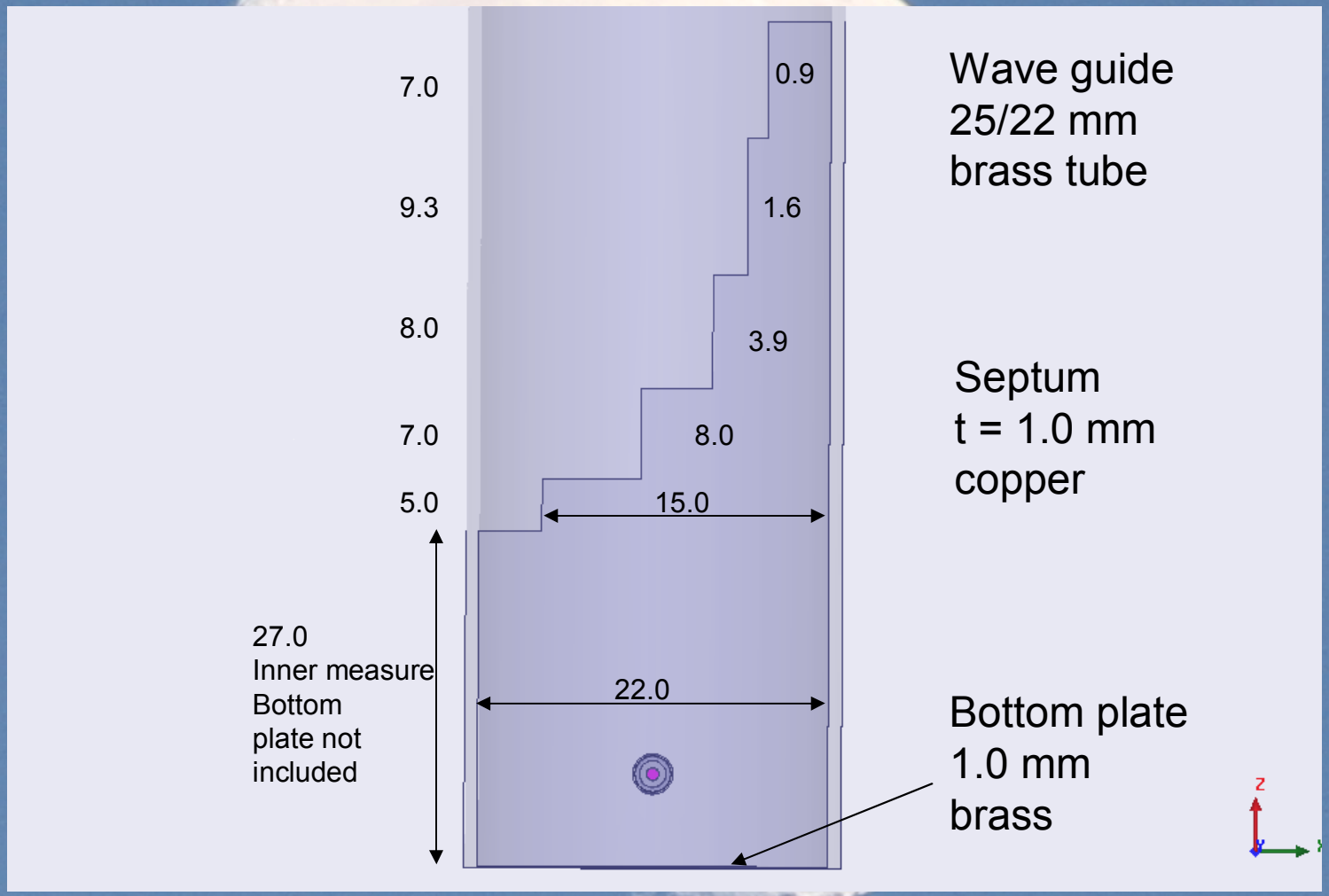
39/42 copper tube

1 mm overlap between tubes of transformer and wave guide and output section respectively.

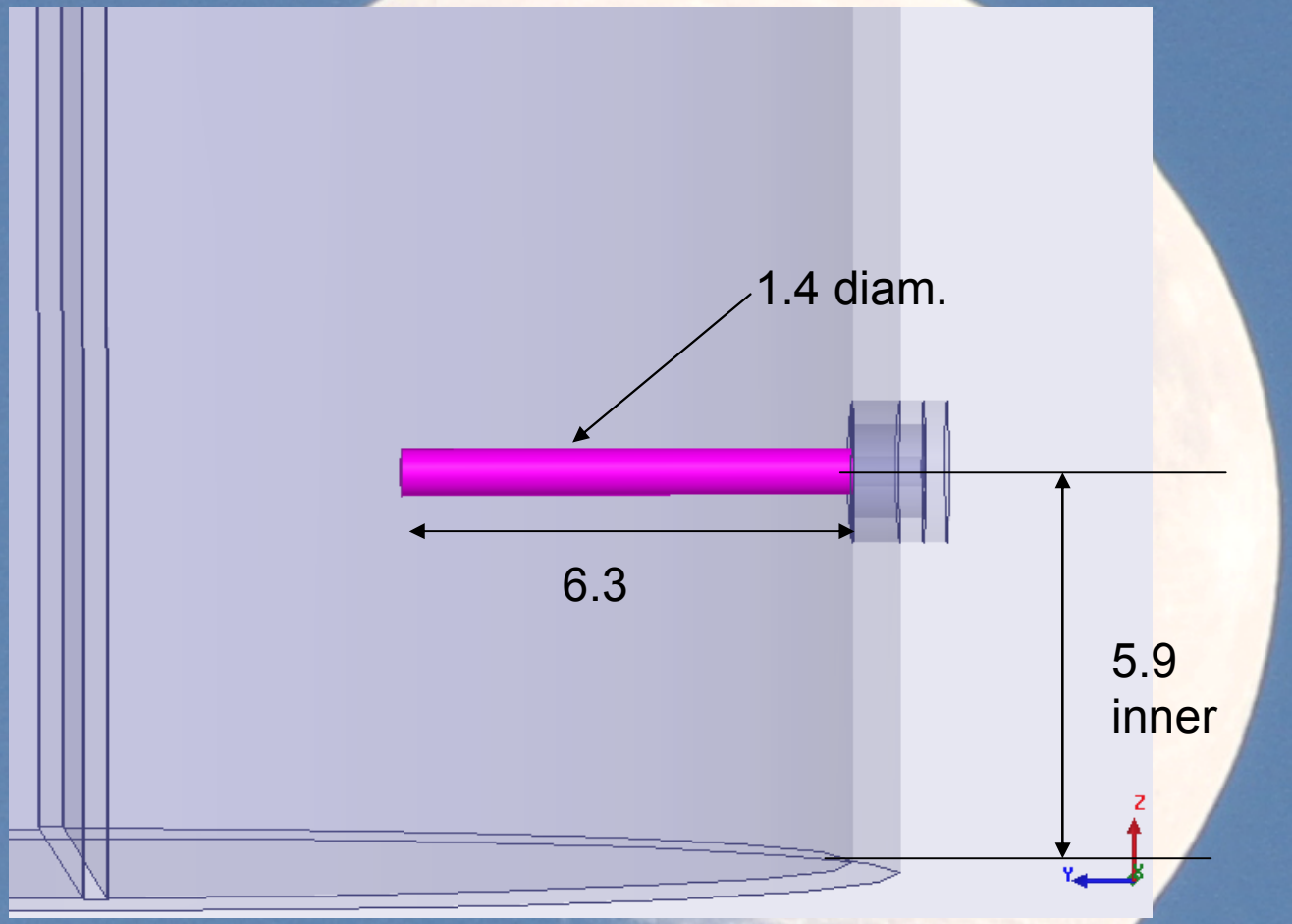
Transformer section made from 32/35 copper tube or turned from 40 mm solid brass stock to fit with WG and output section. If a tube is used, fittings between the transformer section and the wave guide and output section respectively need to be made from brass or copper.

Septum dimensions

(3 cm 0.795 wl WG Dual Mode 39mm)

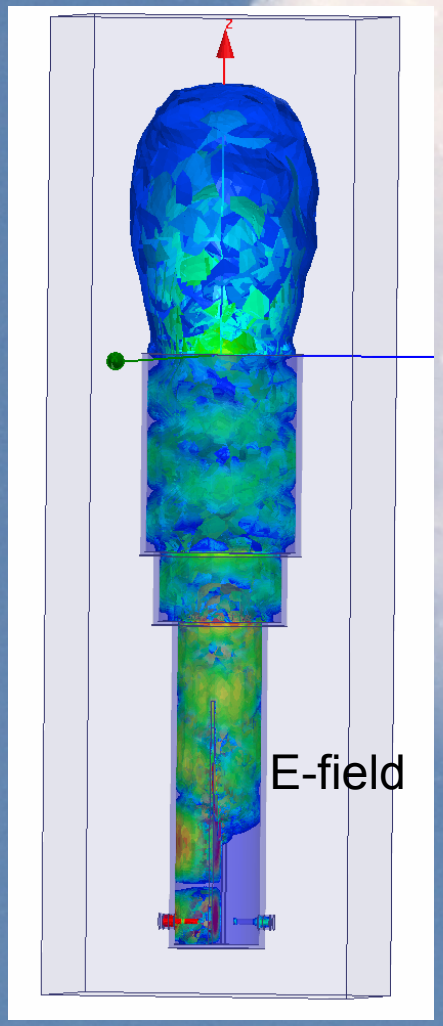


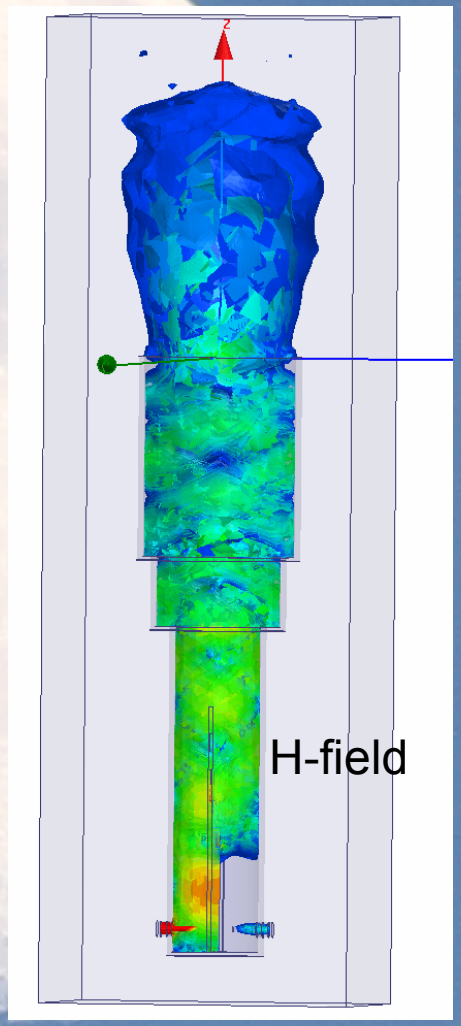
Probe dimensions (3 cm 0.795 wl WG Dual Mode 39mm)



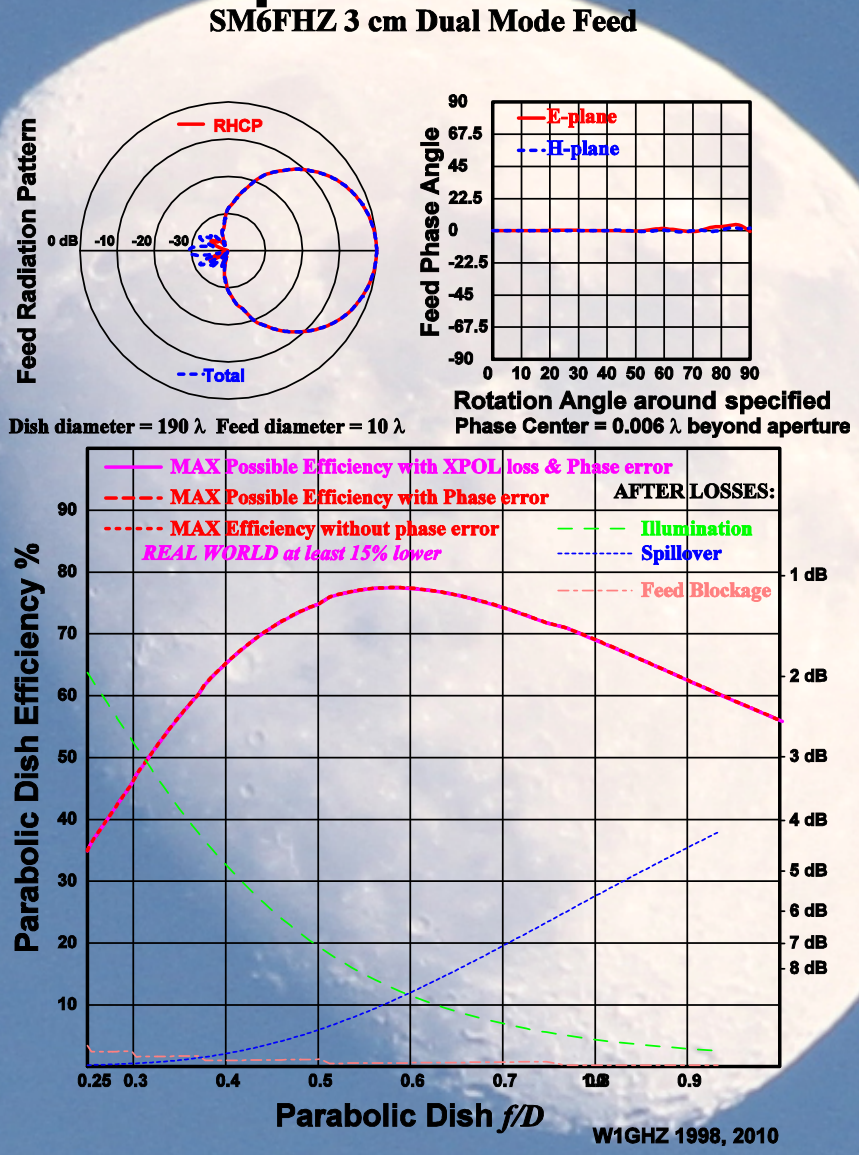
Wave Guide propagation modes

in SM6FHZ 10 GHz Dual Mode Feed at 0 degrees



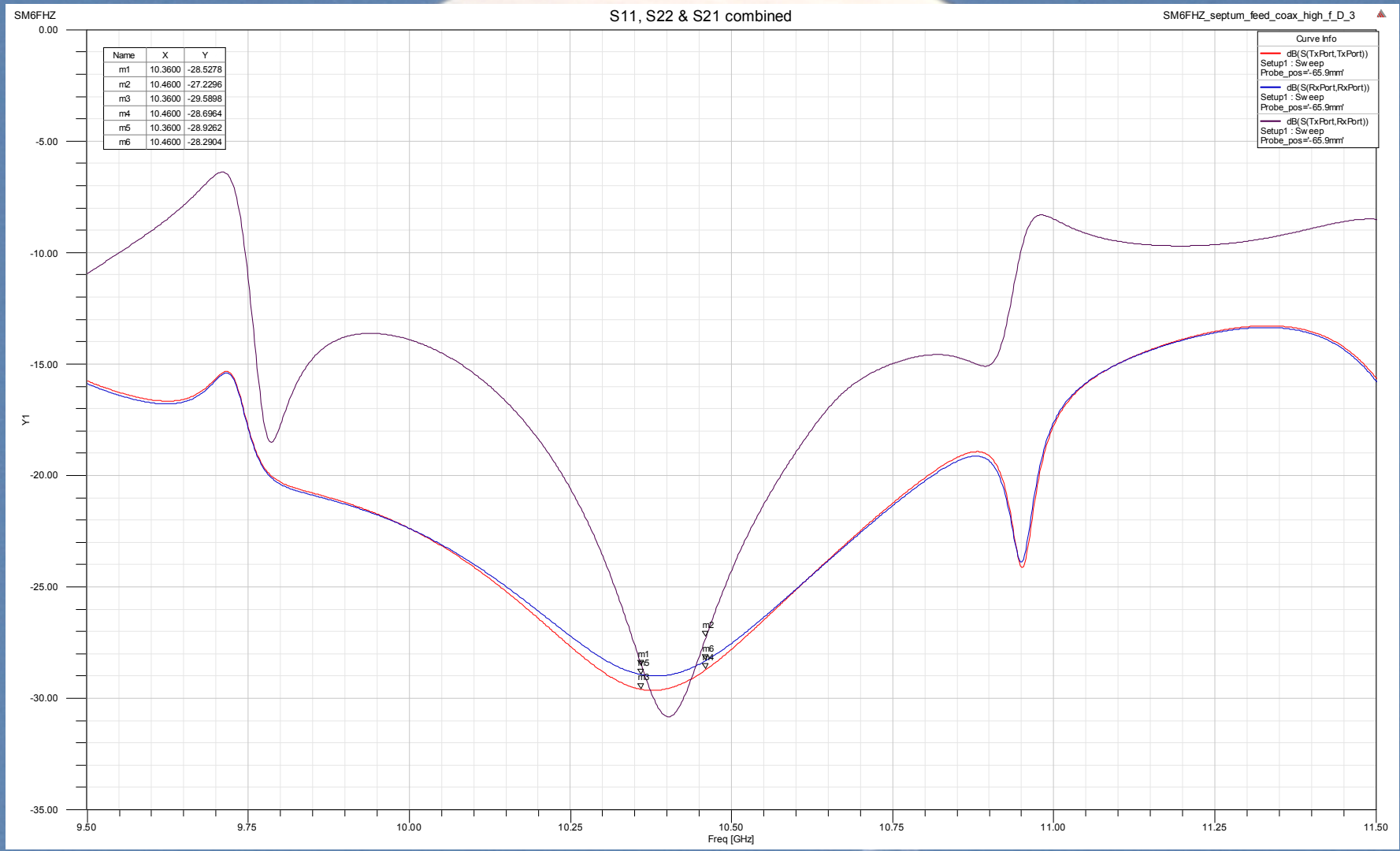


InDish performance



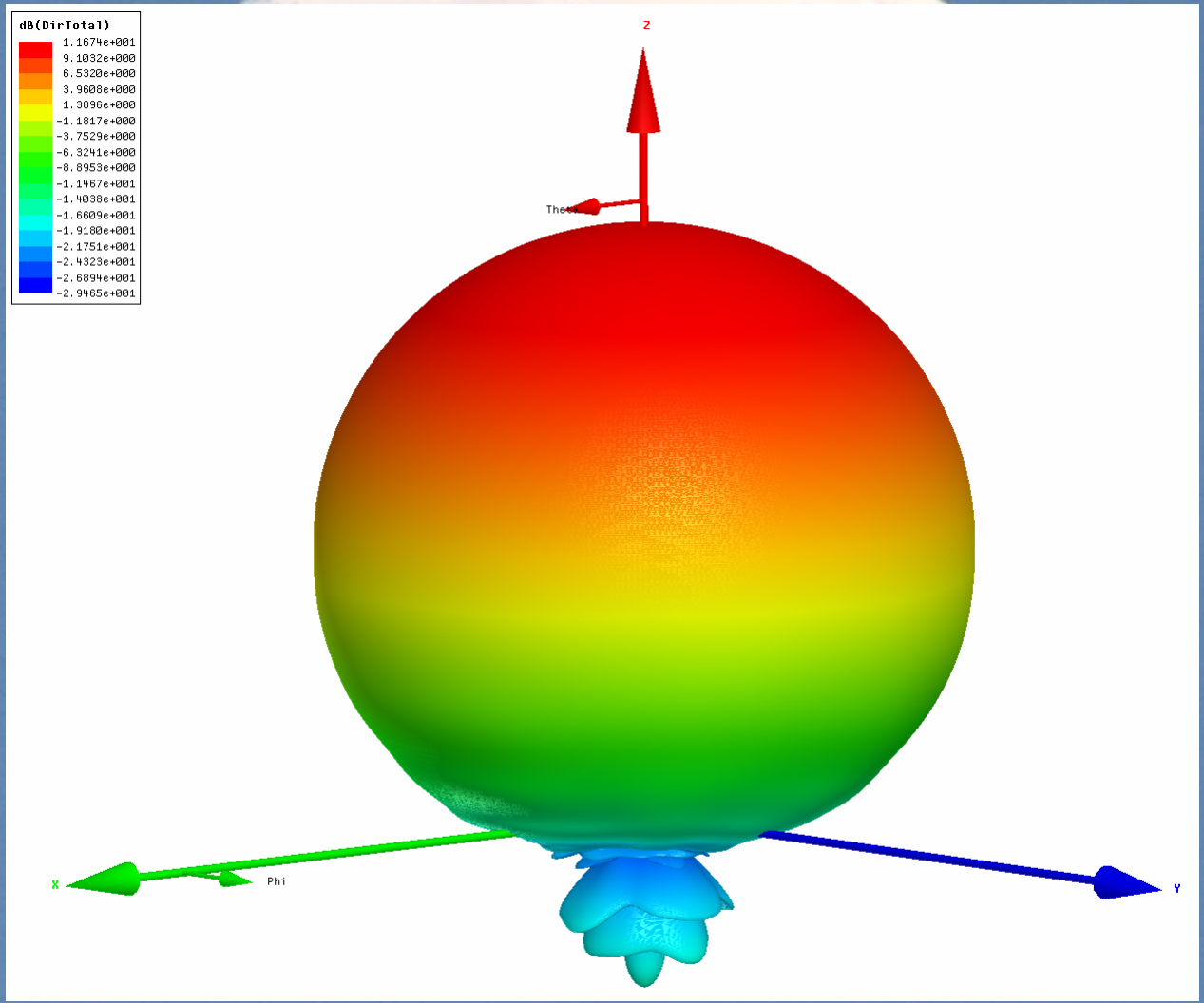
S11, S22, S21 combined

(3 cm 0.795 wl WG Dual Mode 39mm)



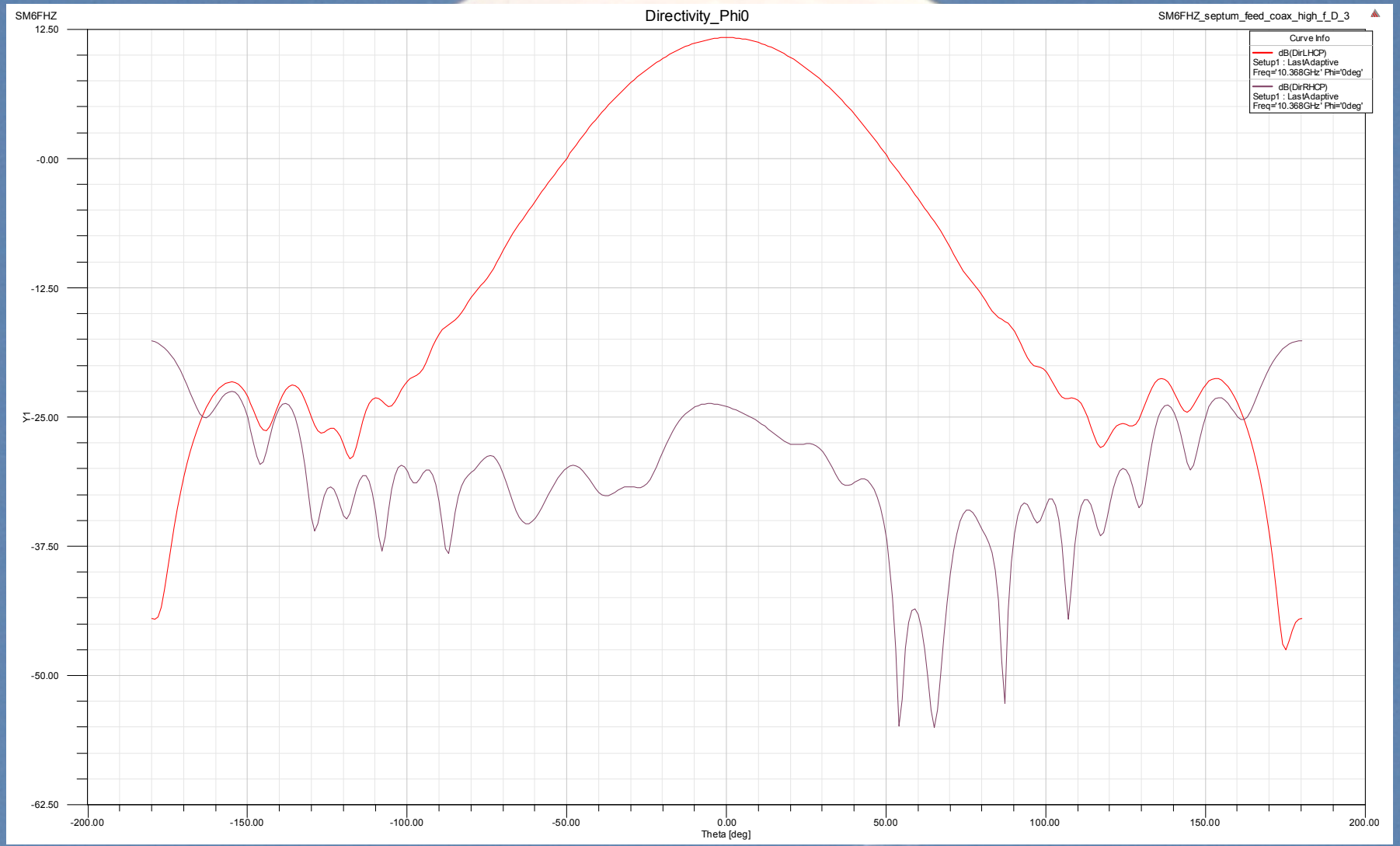
3D Total Power Far Field pattern

(3 cm 0.795 wl WG Dual Mode 39mm)



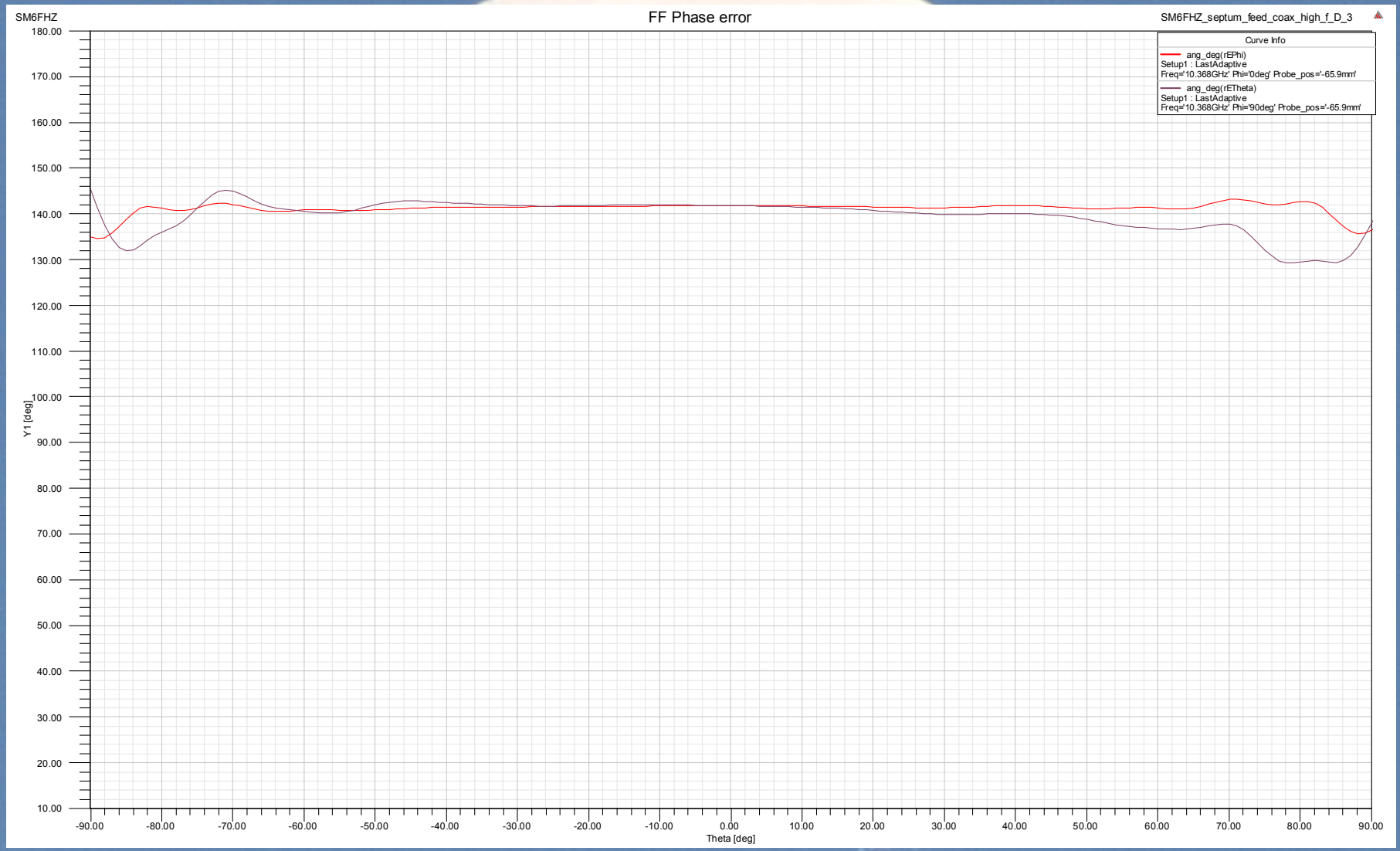
Far Field Pattern 0 deg

(3 cm 0.795 wl WG Dual Mode 39mm)



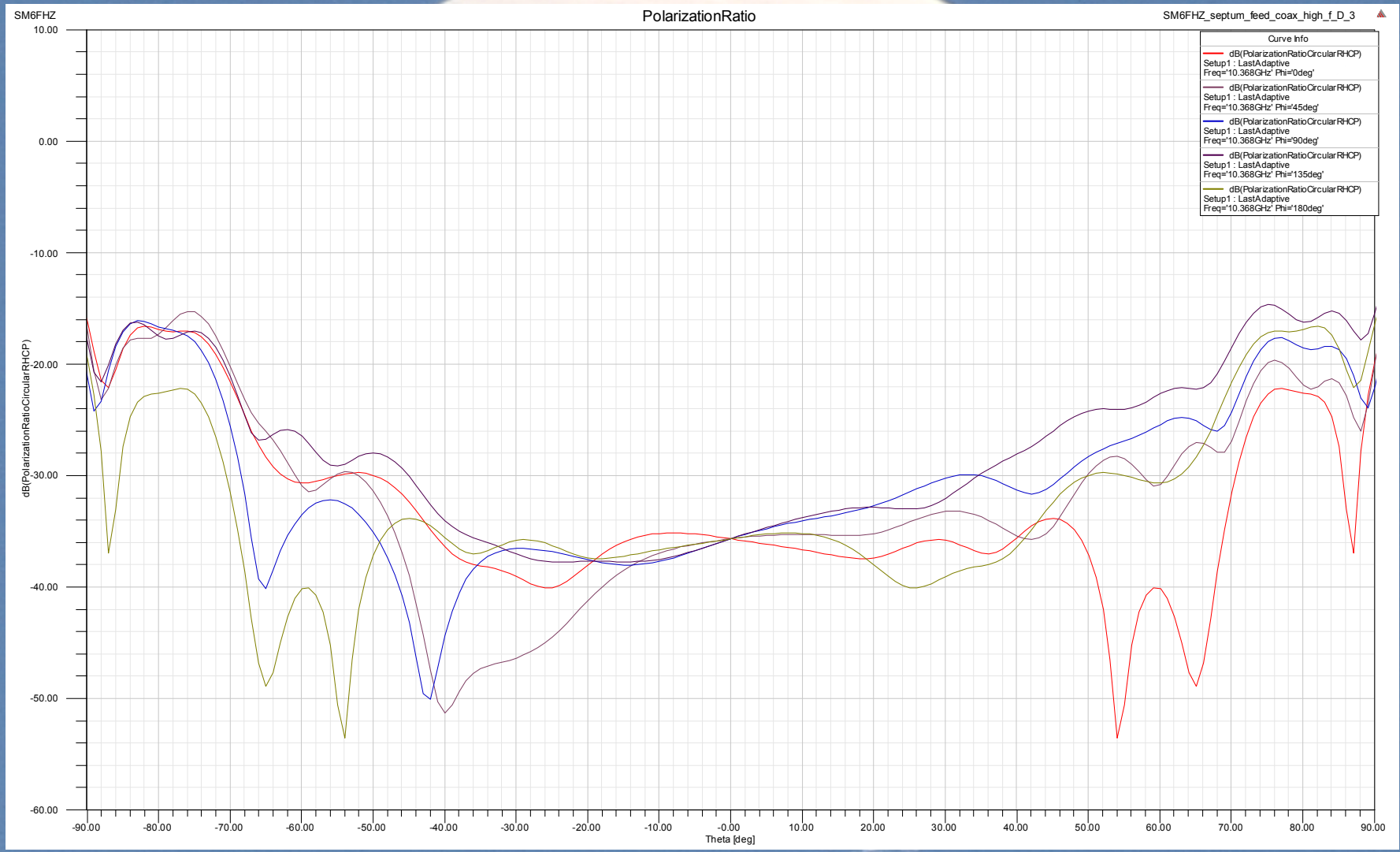
Far Field Phase error

(3 cm 0.795 wl WG Dual Mode 39mm)

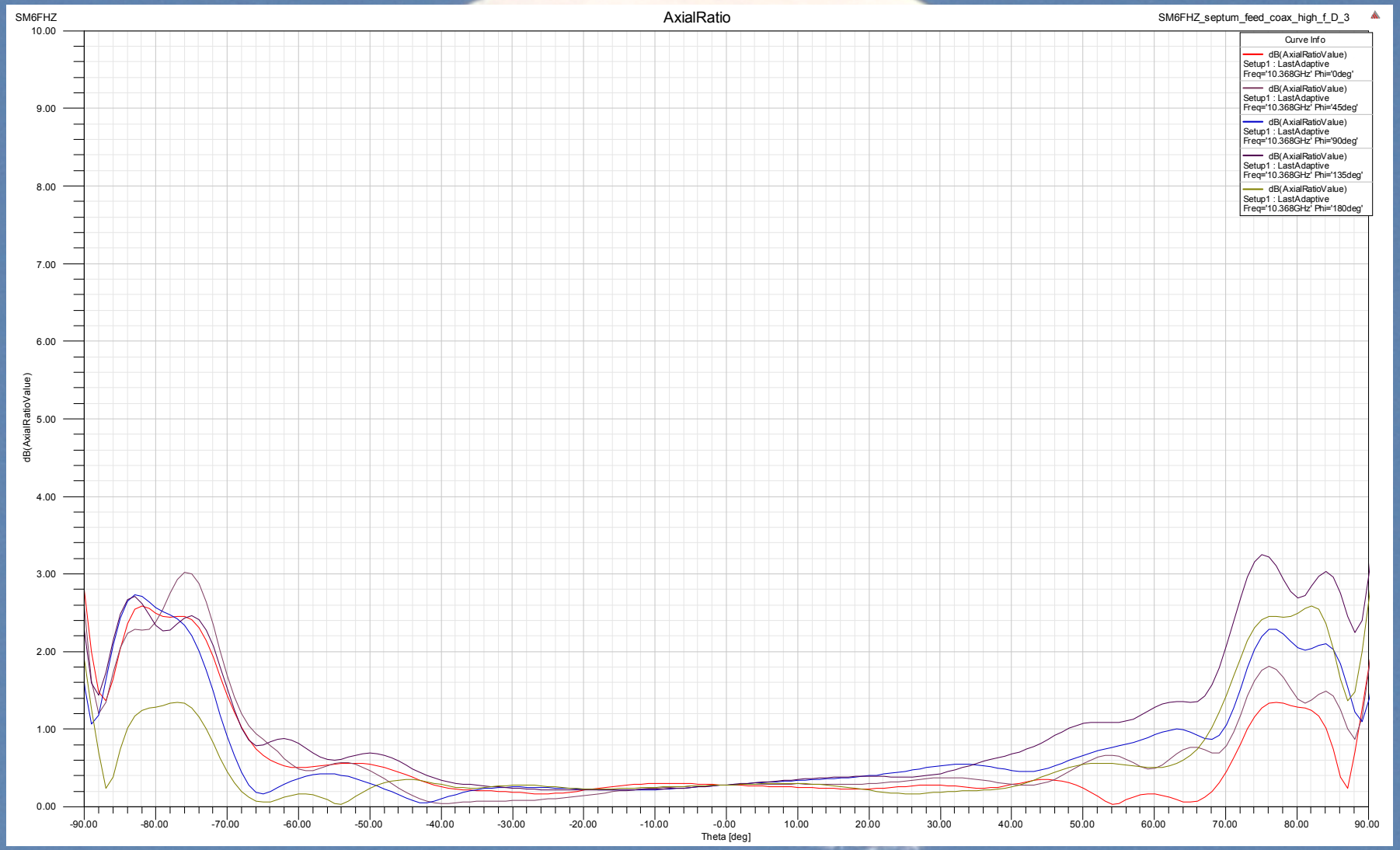


Cross Polar Ratio

(3 cm 0.795 wl WG Dual Mode 39mm)



Axial Ratio (3 cm 0.795 wl WG Dual Mode 39mm)

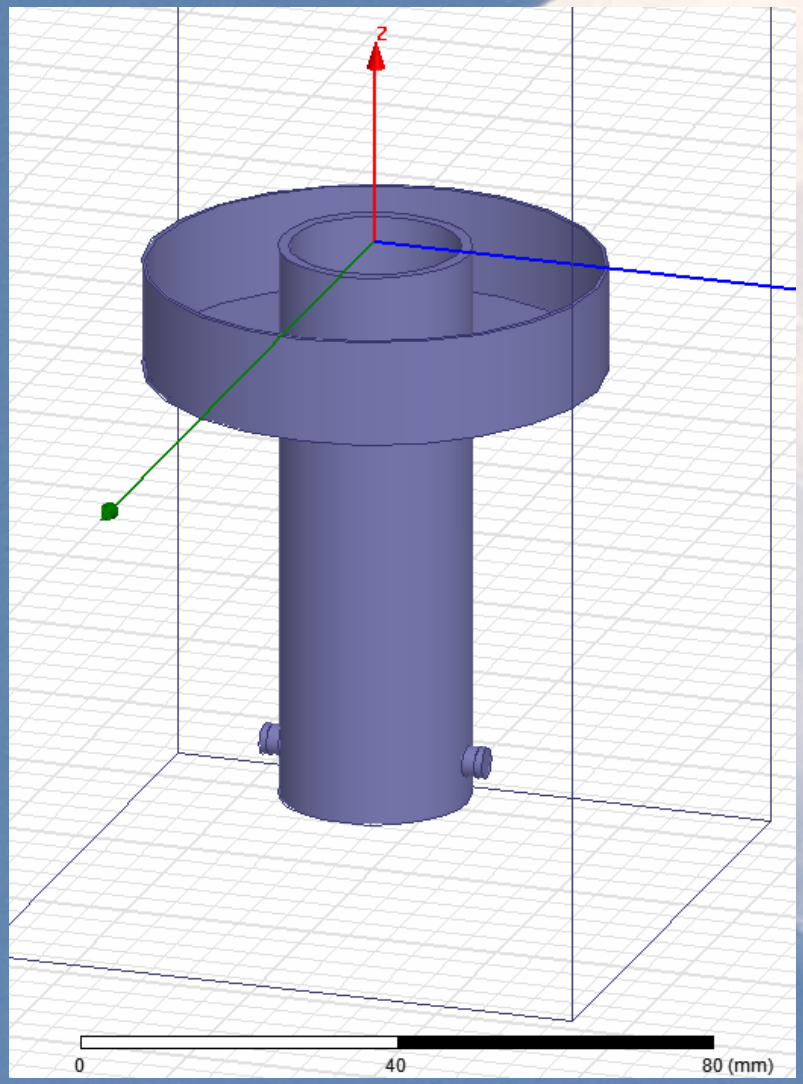


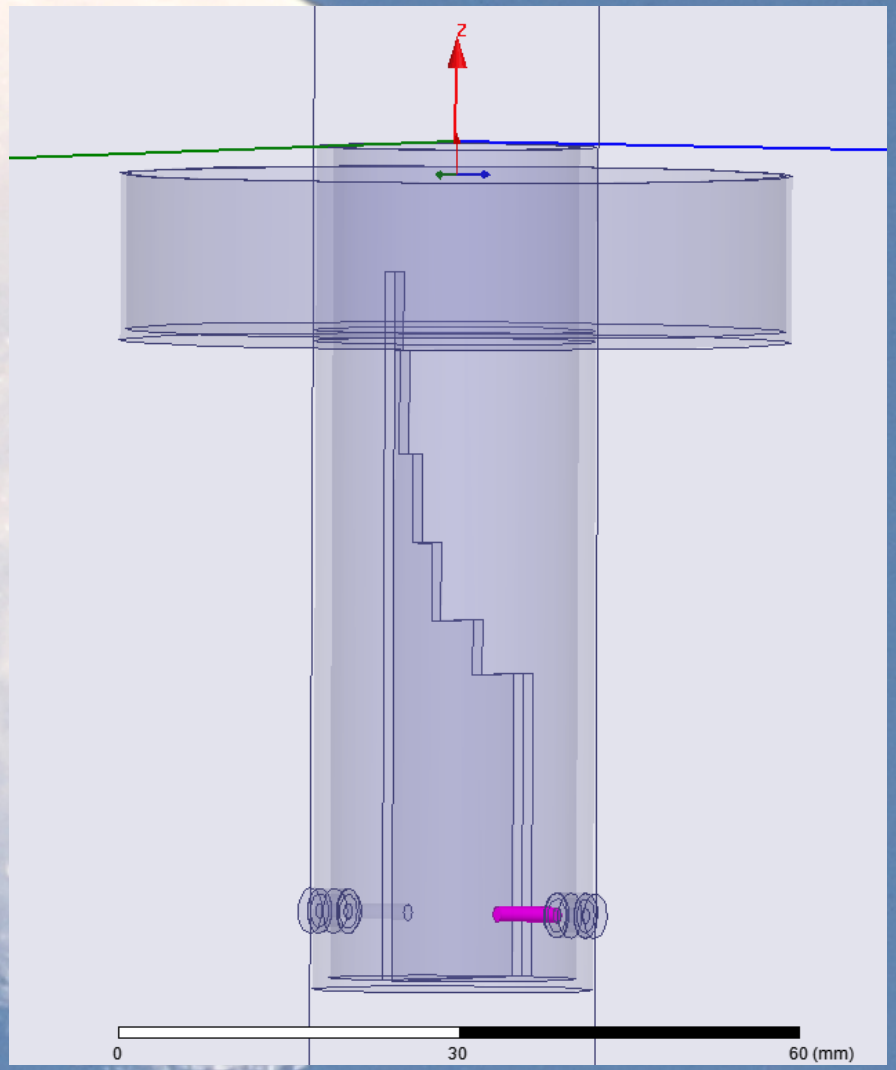
SM6FHZ 3 cm 5 step septum feed

0.795 lambda W/G

Using standard one inch brass / copper tubing

Solid and transparent models from the simulation (3 cm 0.795 wl WG inch tube)





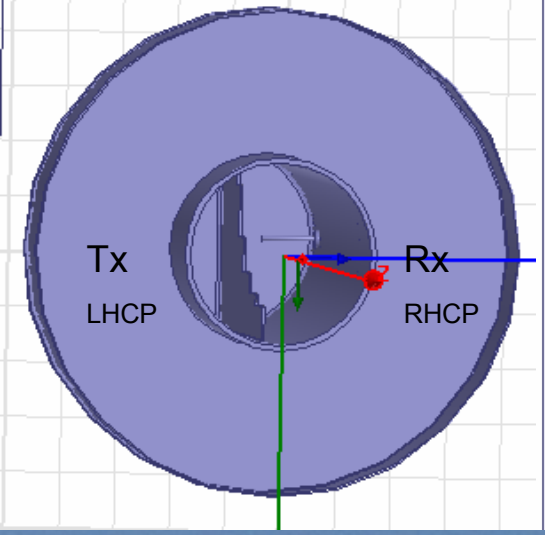
WG and choke dimensions

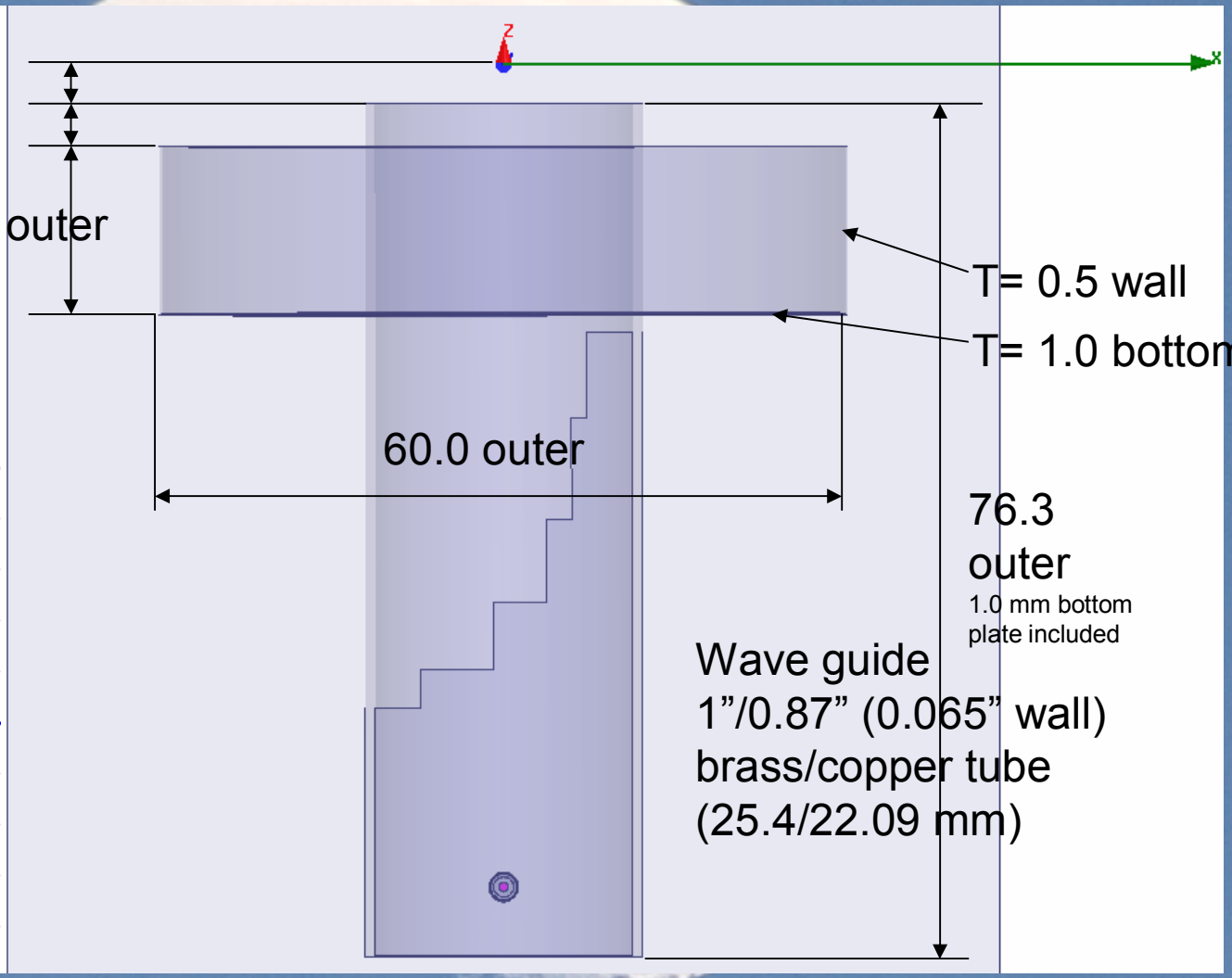
(3 cm 0.795 wl WG inch tube)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

Tx RHCP in space
Rx LHCP in space

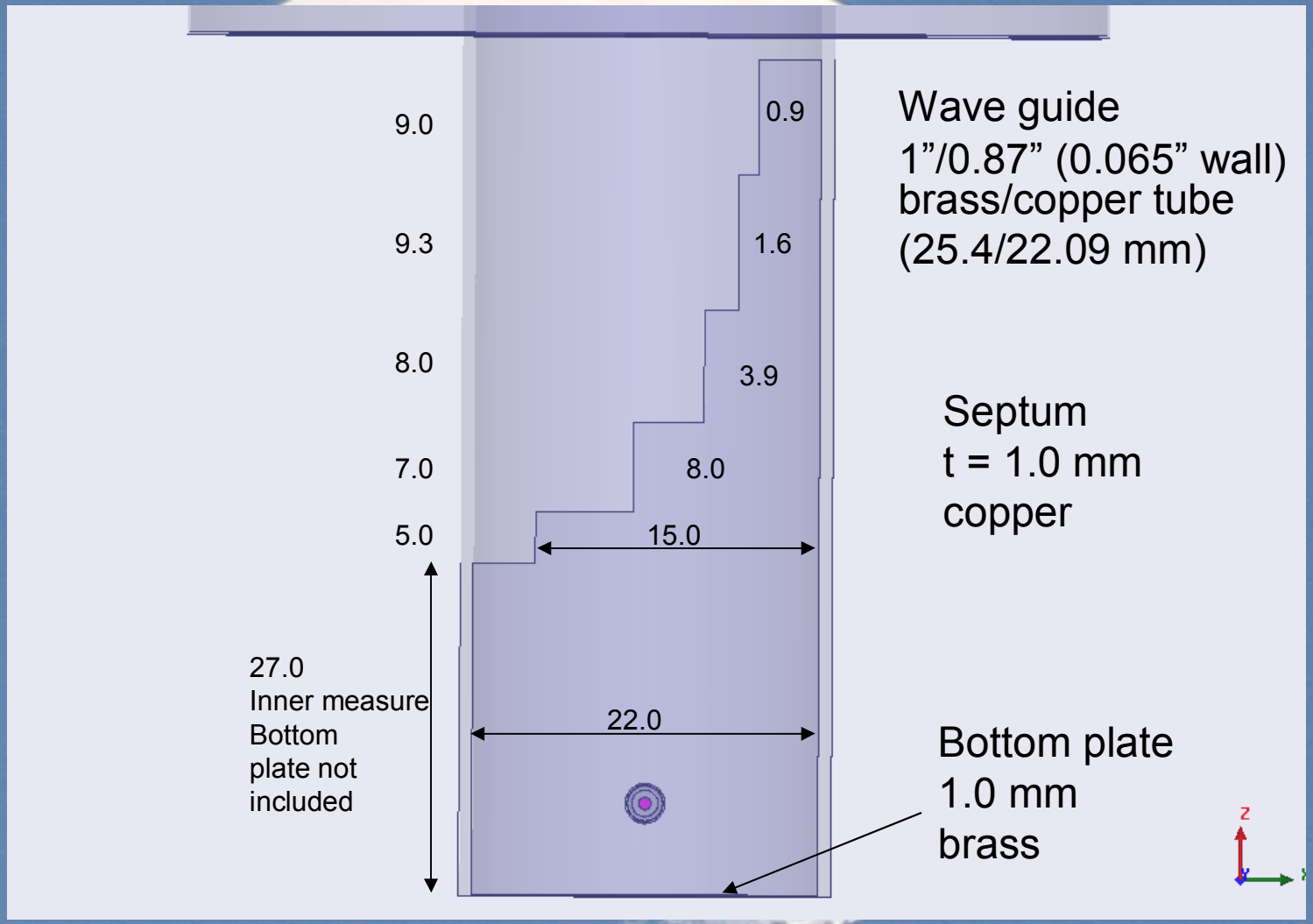
Take polarization reversal into account when using reflector antennas.



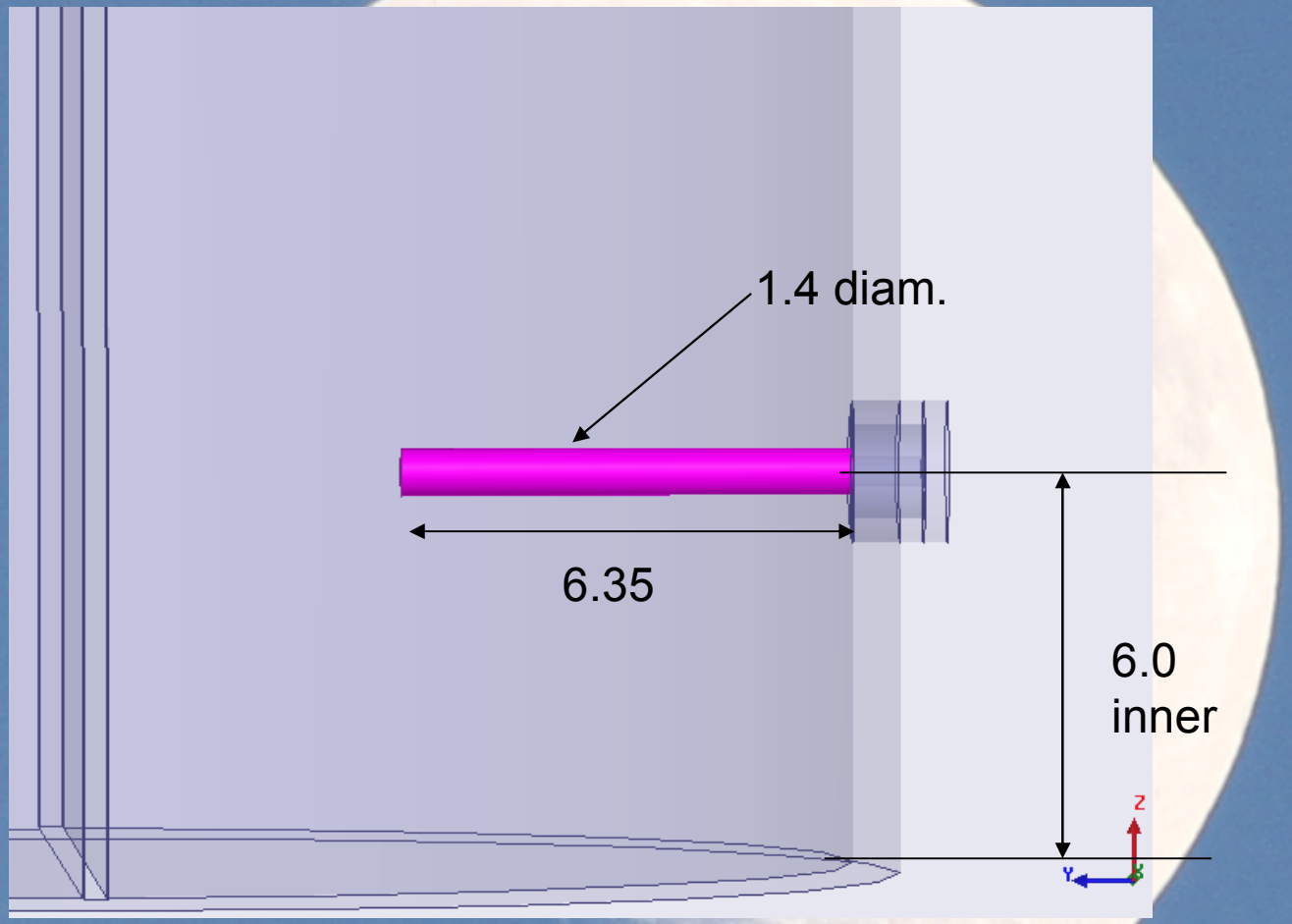


Septum dimensions

(3 cm 0.795 wl WG inch tube)

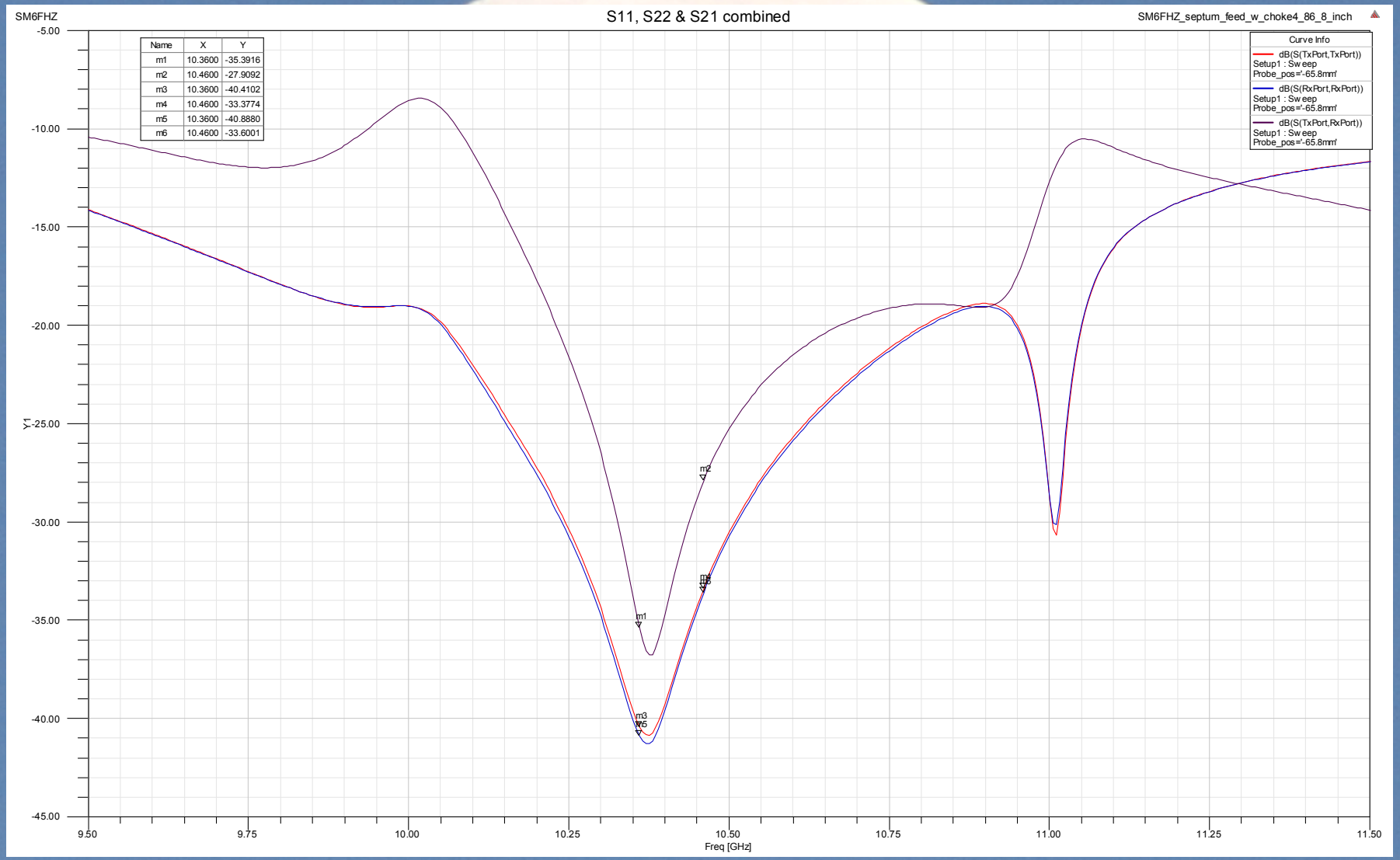


Probe dimensions (3 cm 0.795 wl WG inch tube)



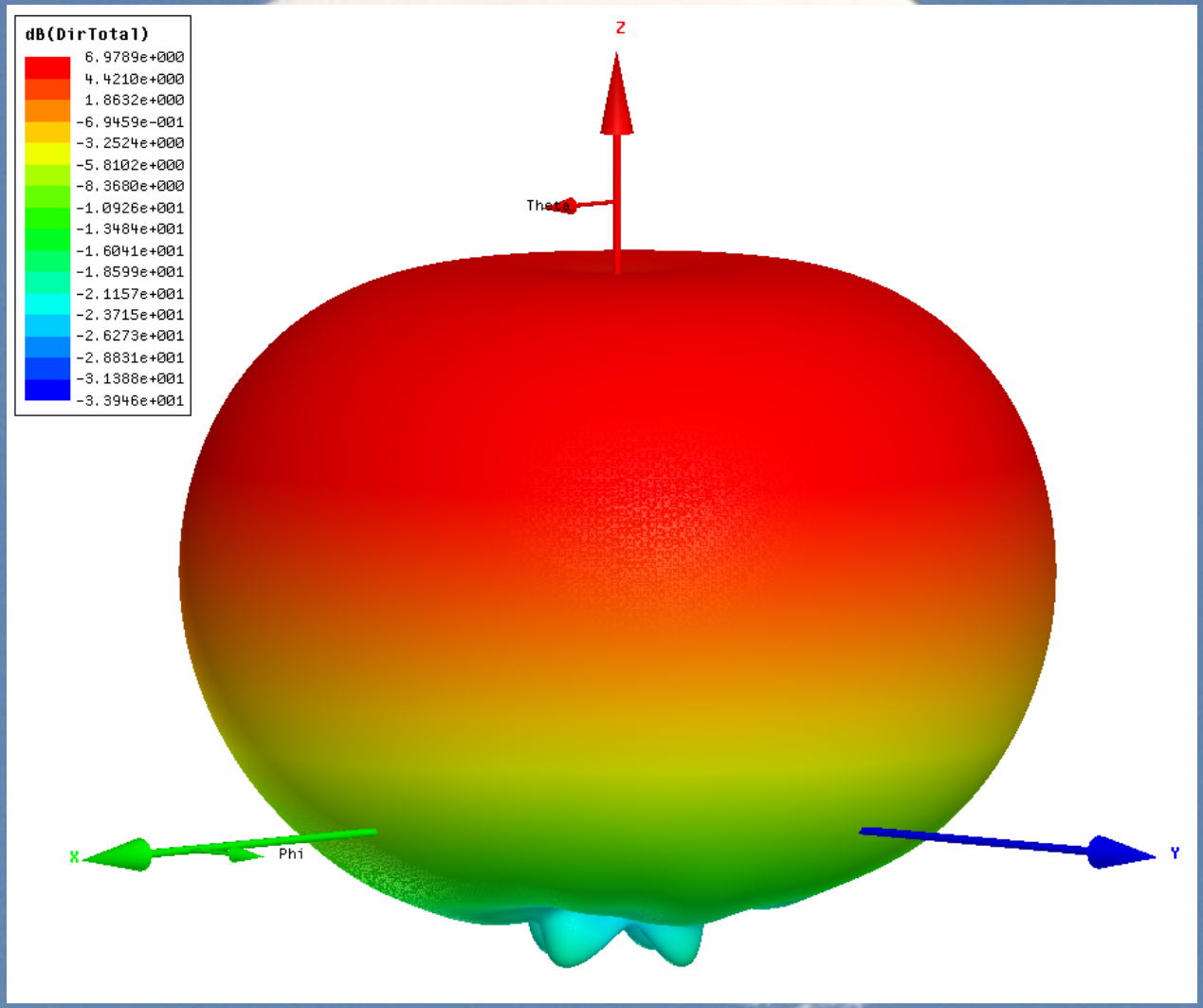
S11, S22, S21 combined

(3 cm 0.795 wl WG inch tube)



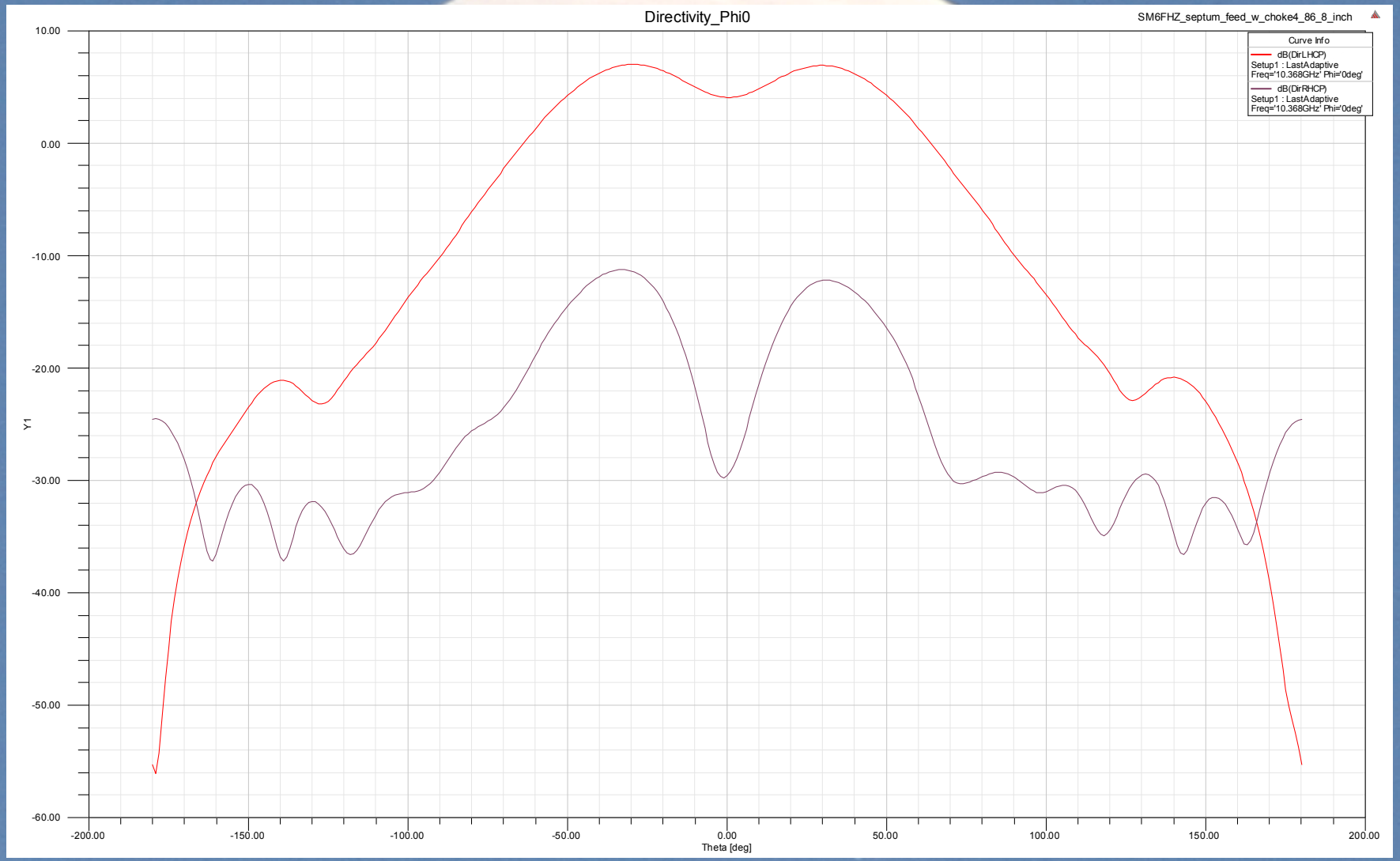
3D Total Power Far Field pattern

(3 cm 0.795 wl WG inch tube)



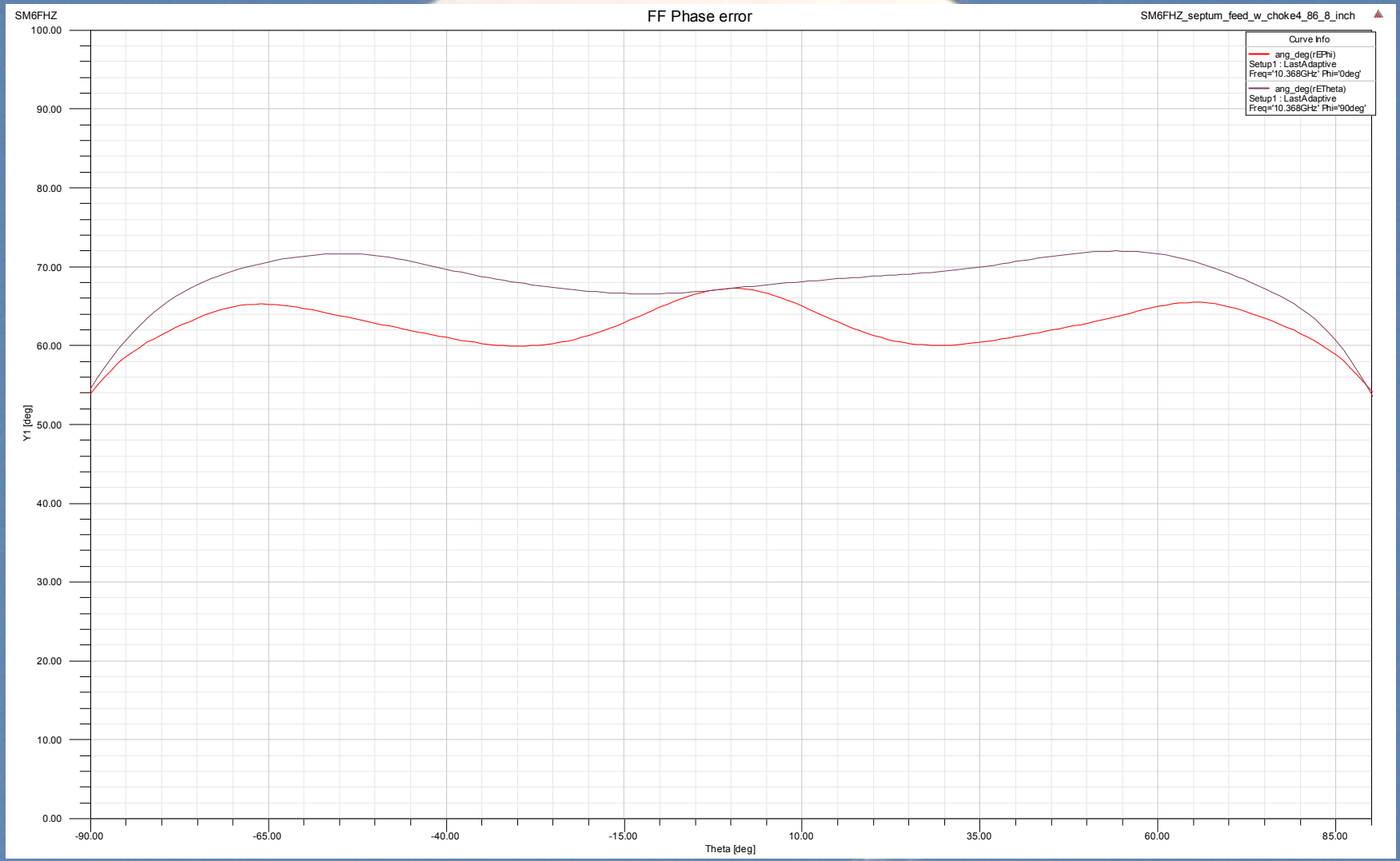
Far Field Pattern 0 deg

(3 cm 0.795 wl WG inch tube)

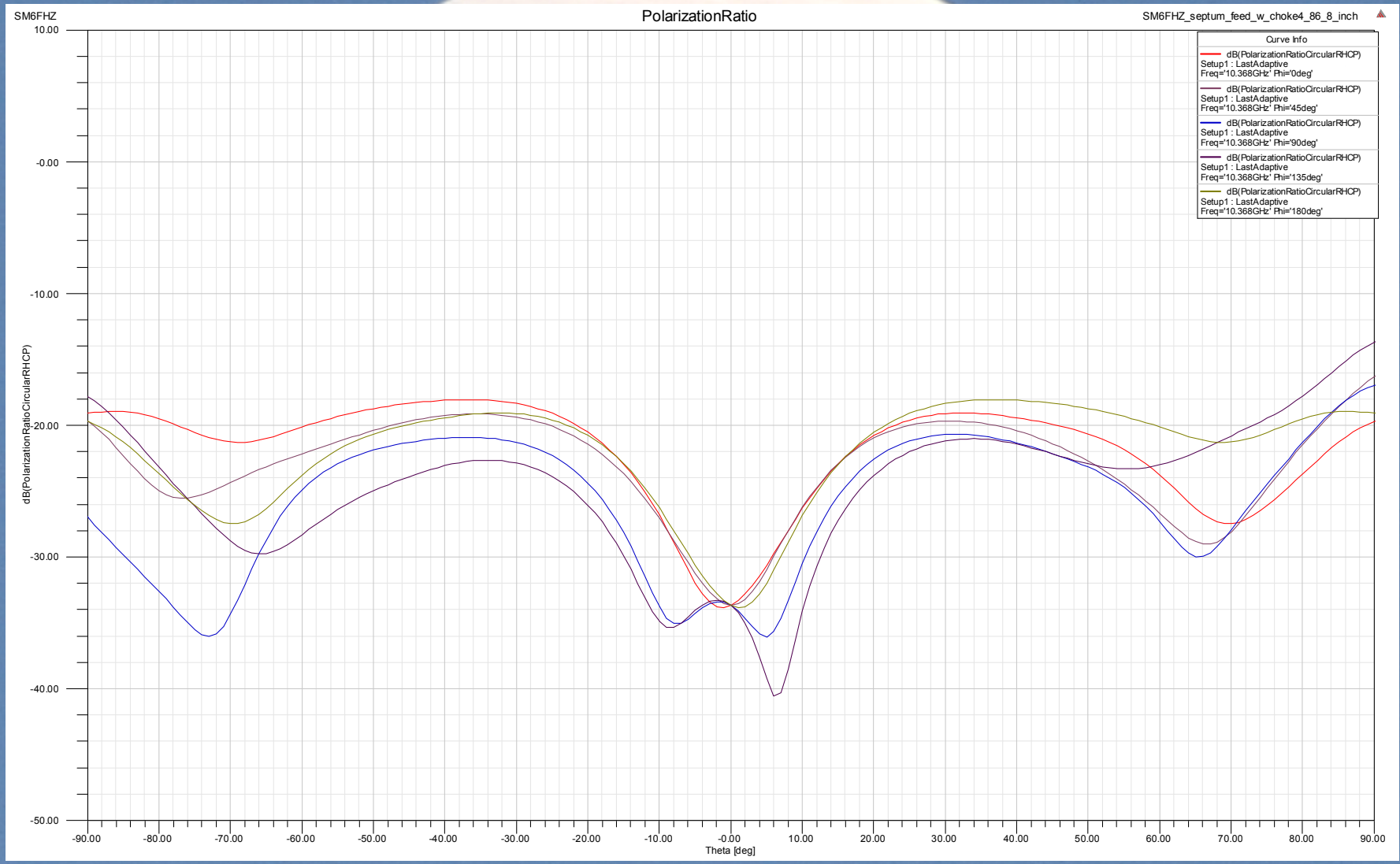


Far Field Phase error

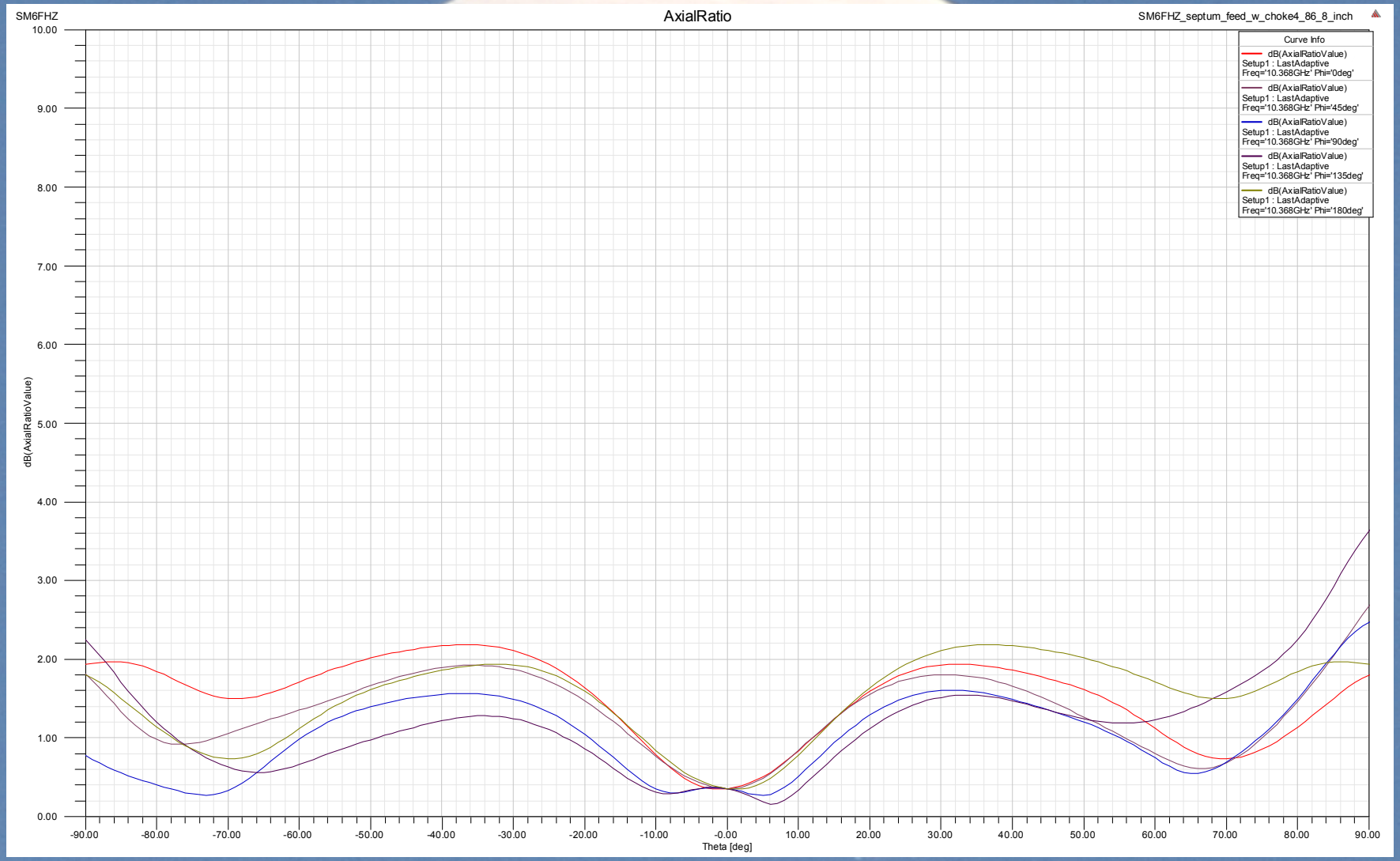
(3 cm 0.795 wl WG inch tube)



Cross Polar Ratio (3 cm 0.795 wl WG inch tube)



Axial Ratio (3 cm 0.795 wl WG inch tube)



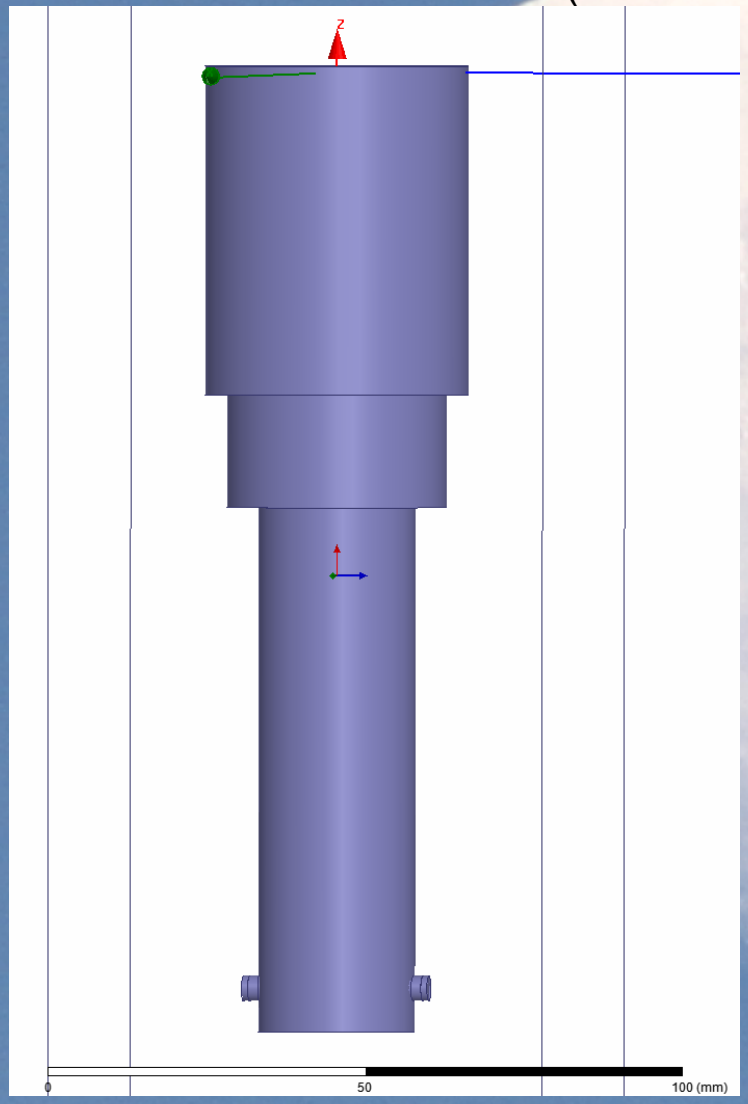
SM6FHZ 3 cm 5 step septum feed for f/D ~0.5

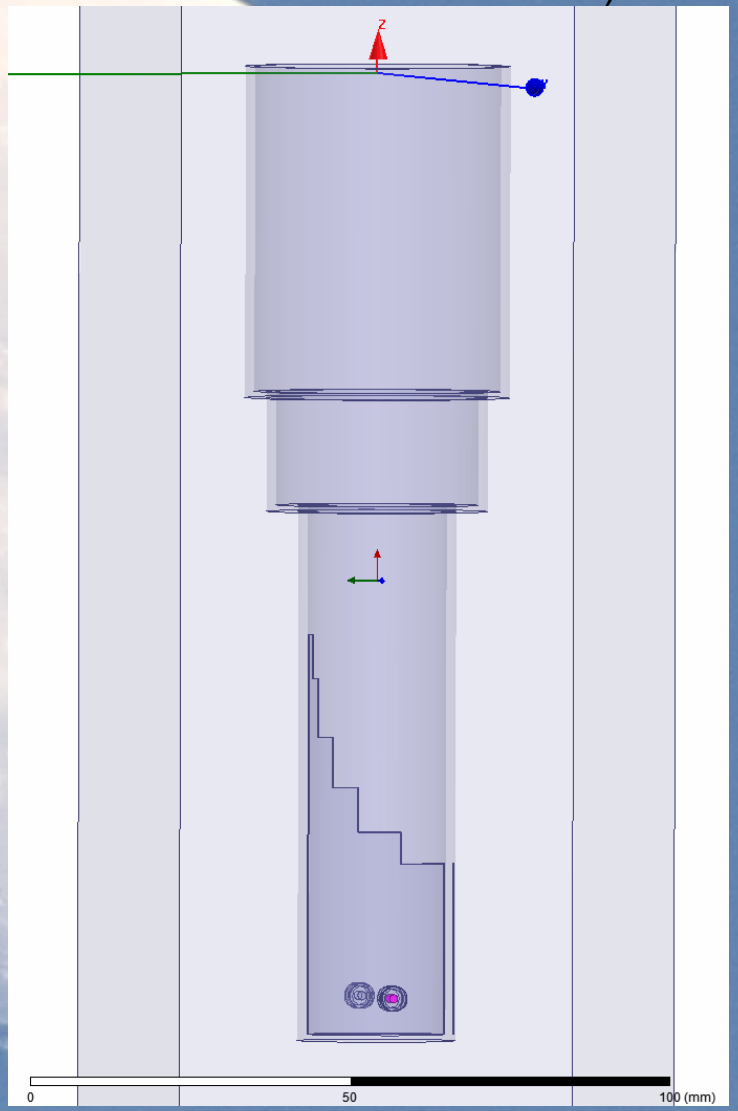
0.795 lambda W/G

and a Dual Mode output section

Using standard one inch brass / copper tubing

Solid and transparent models from the simulation (3 cm 0.795 wl WG Dual Mode 39mm inch tube)





WG and choke dimensions

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)

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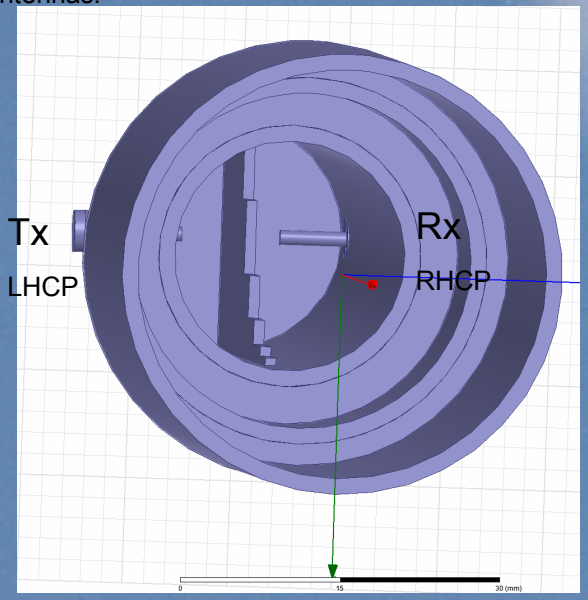
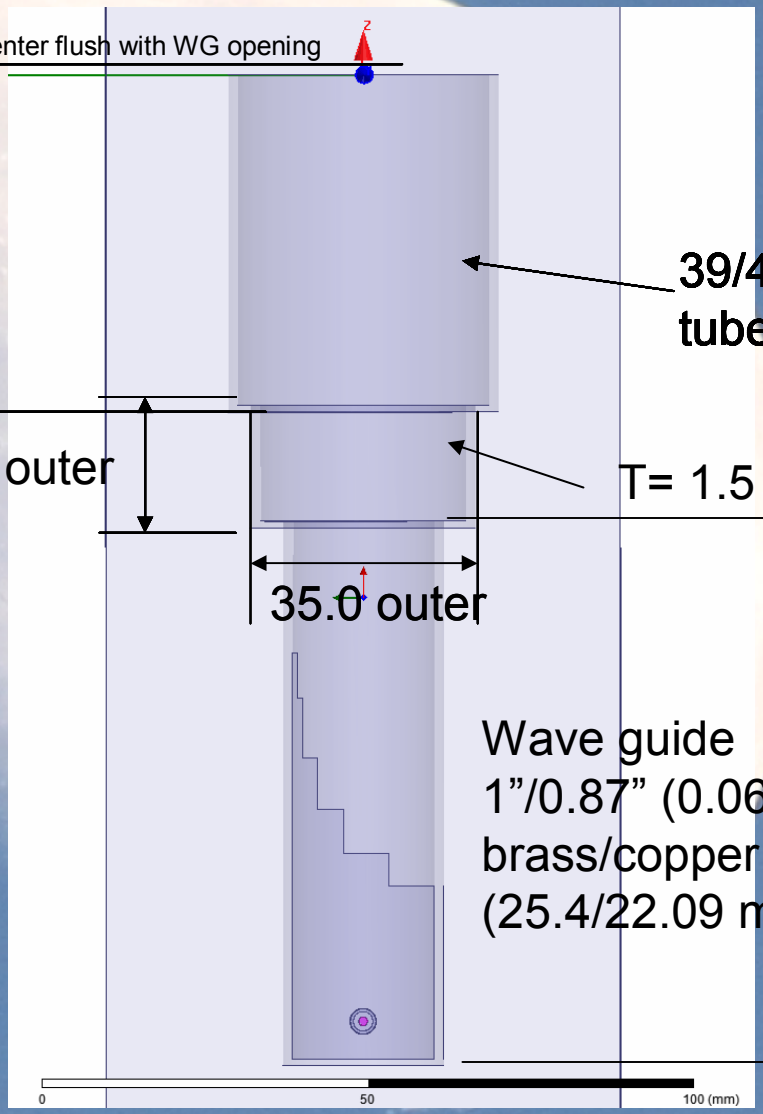
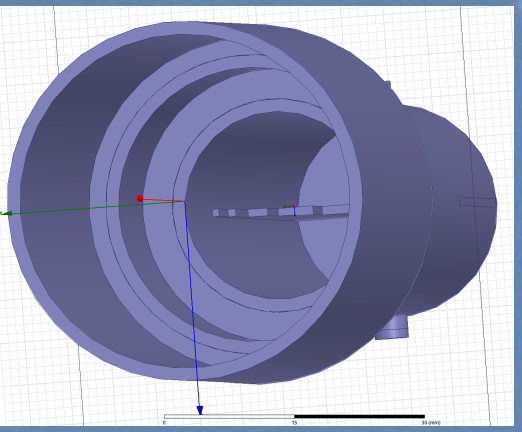
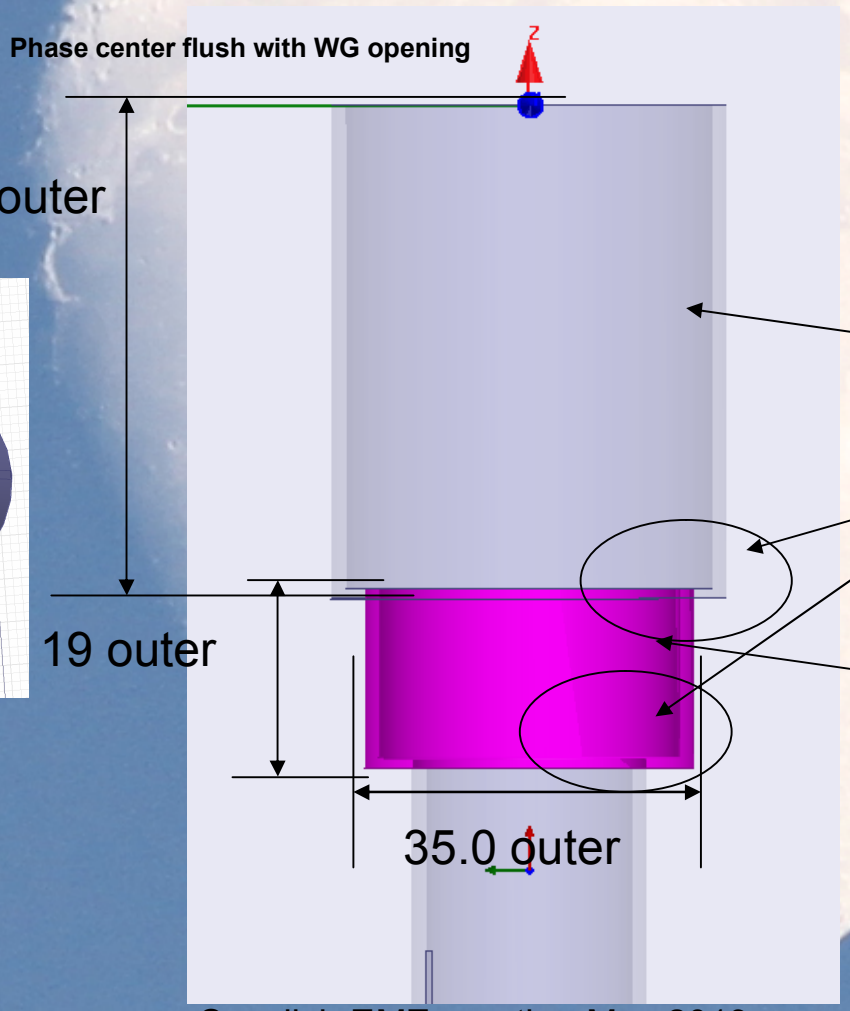




Detail of WG / transformer and output section

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)





39/42 brass /copper tube

1 mm overlap between tubes of transformer and wave guide and output section respectively.

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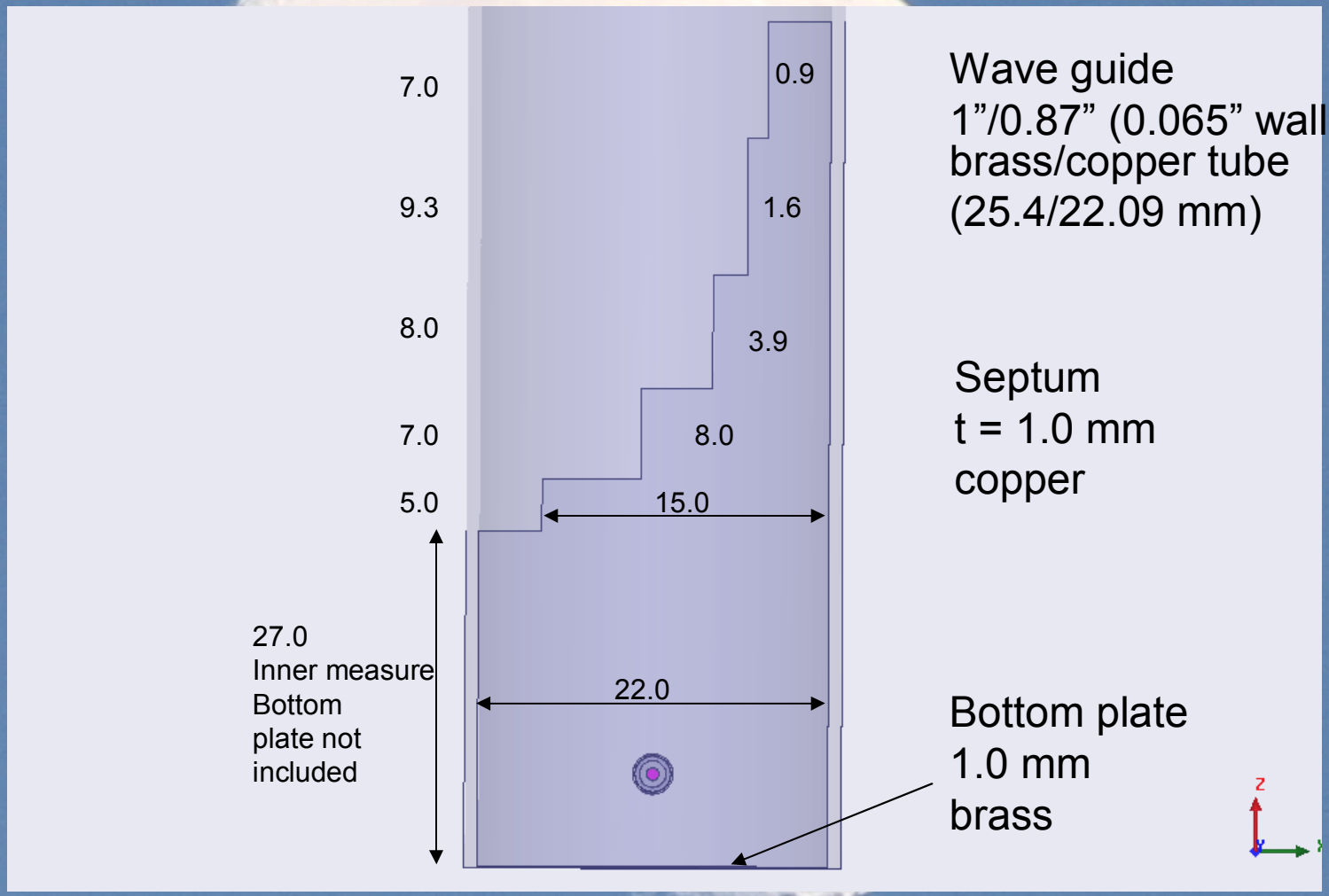
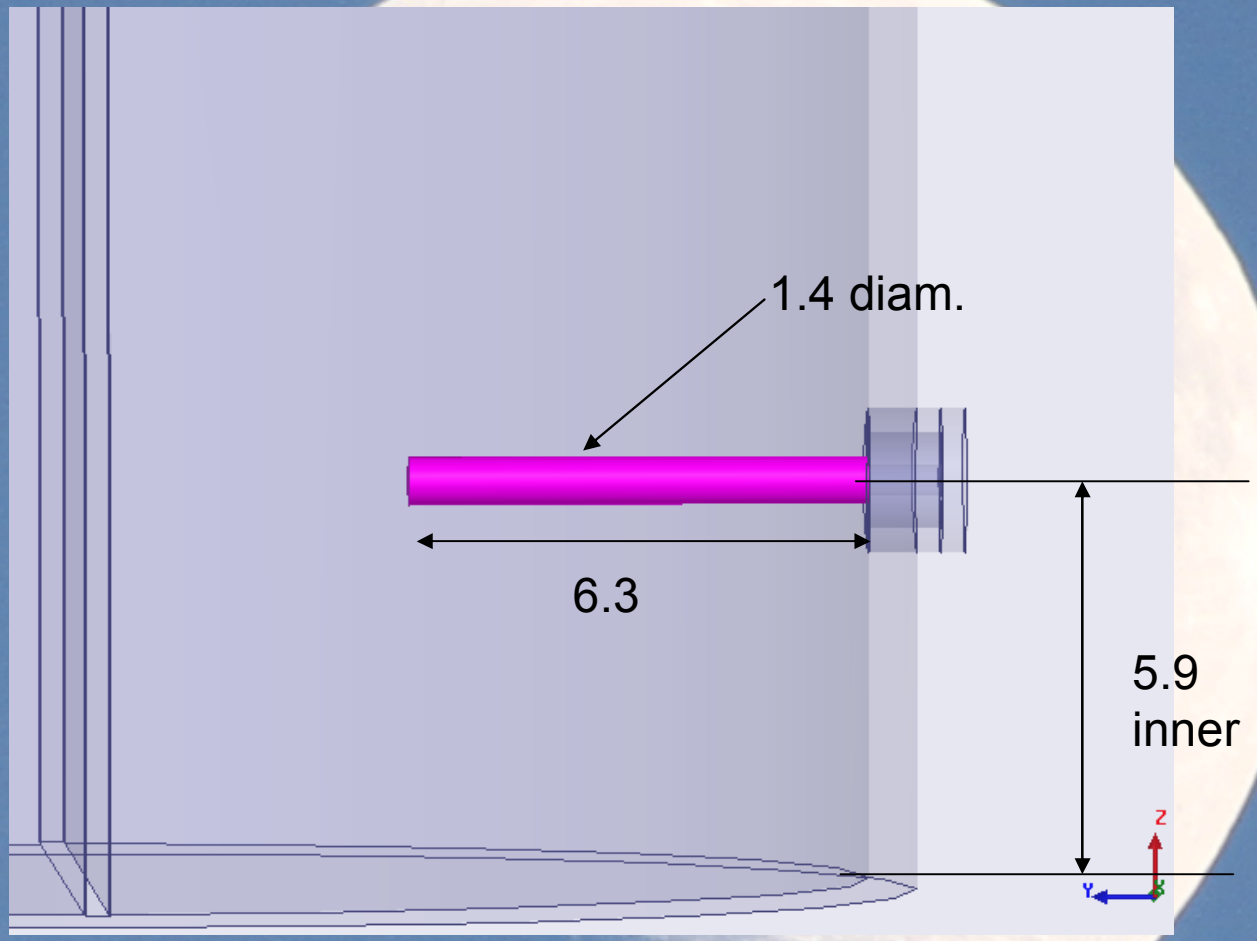
Septum dimensions

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)

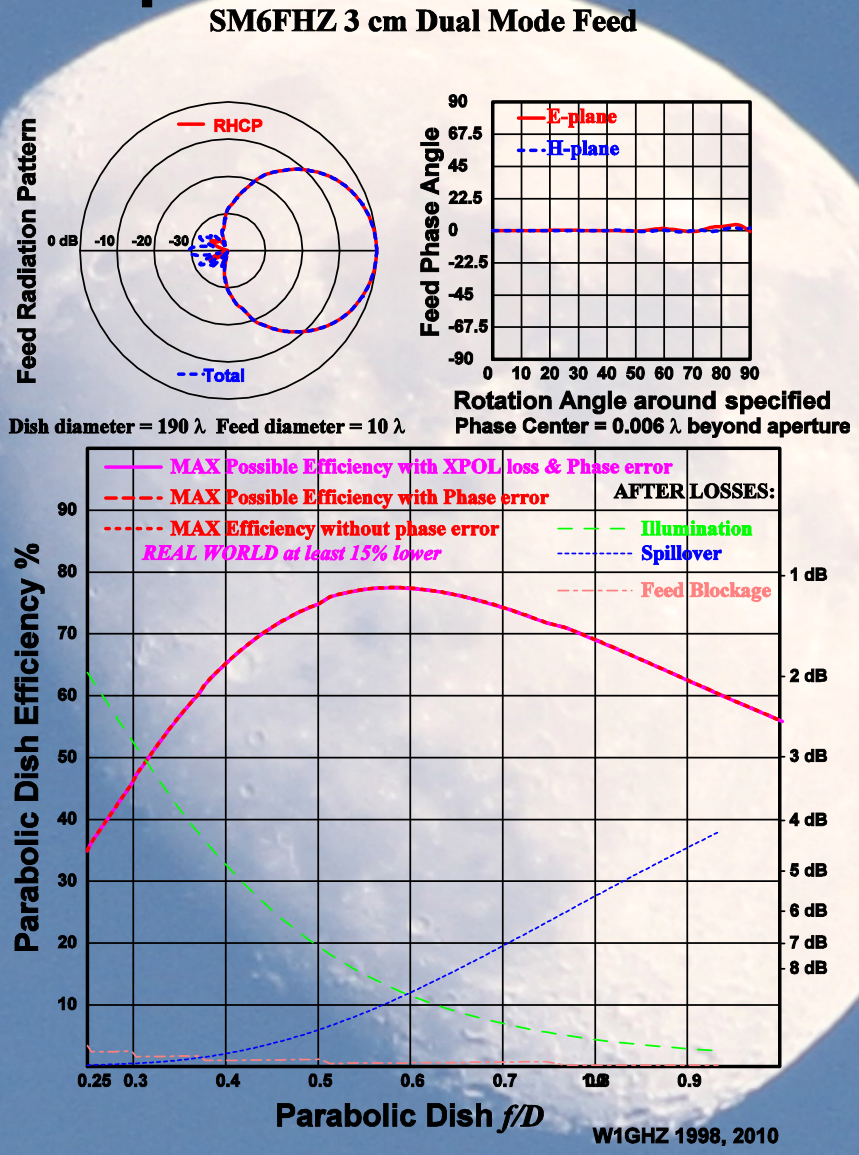


Probe dimensions

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)

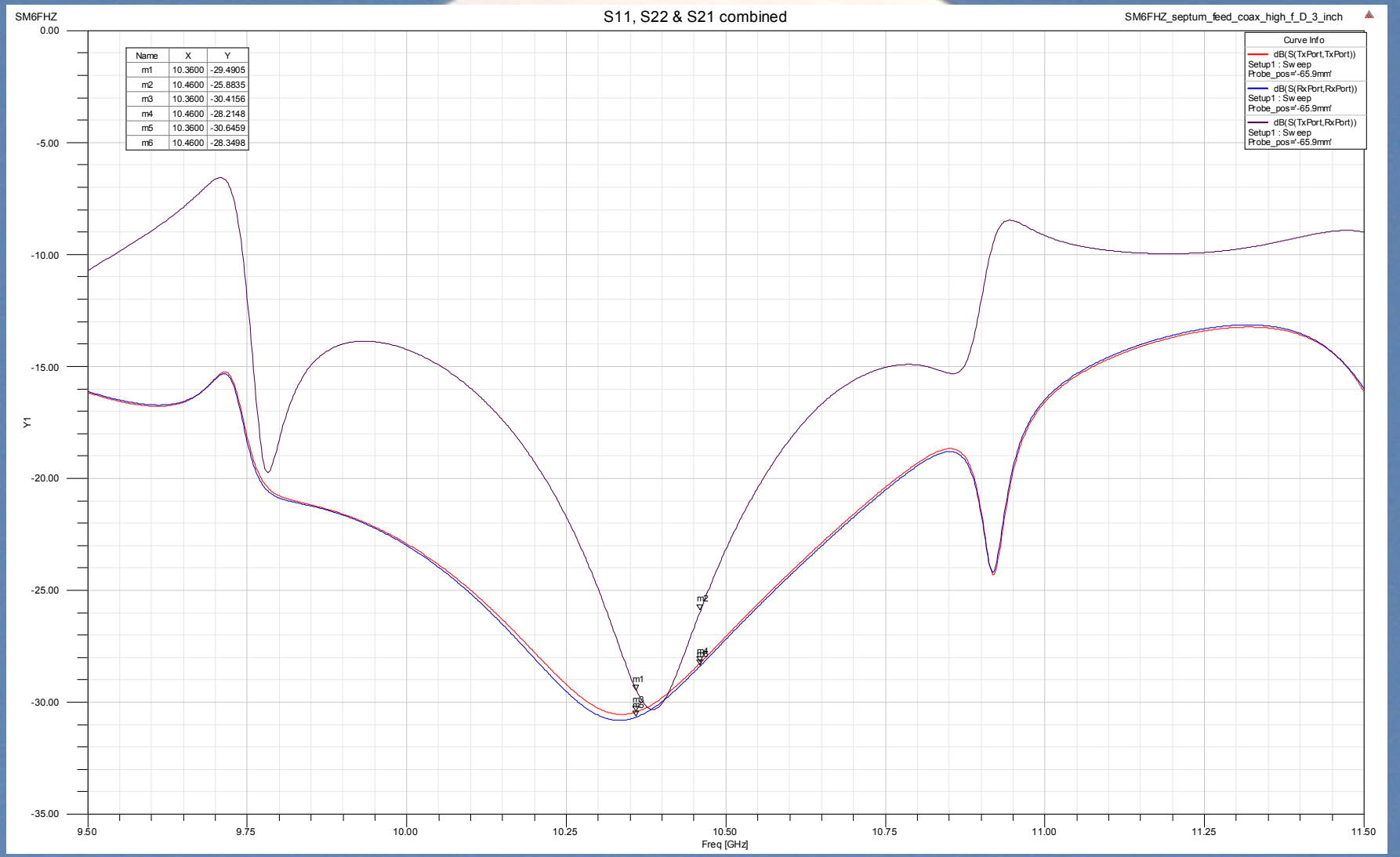


InDish performance inch tube



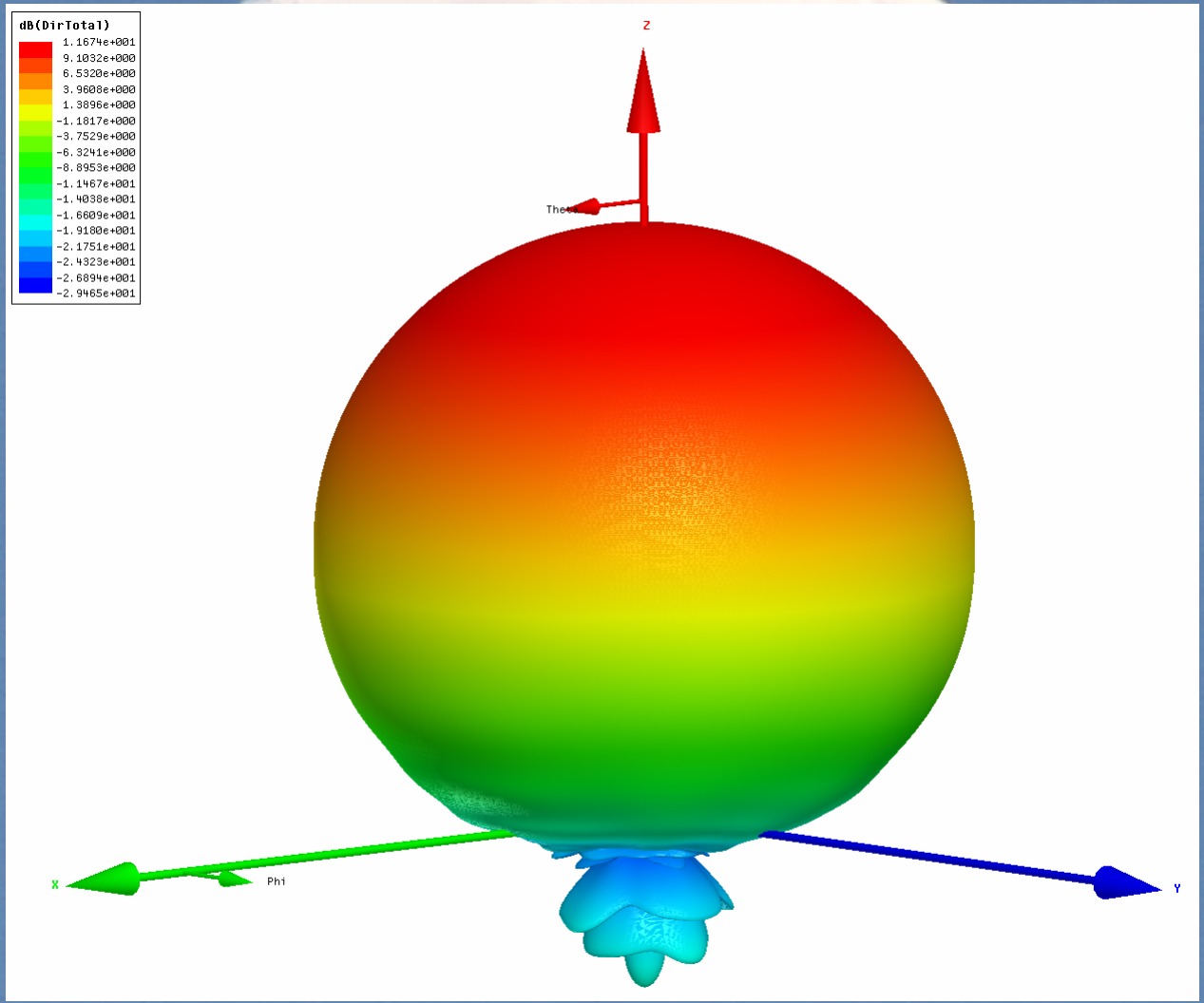
S11, S22, S21 combined

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)



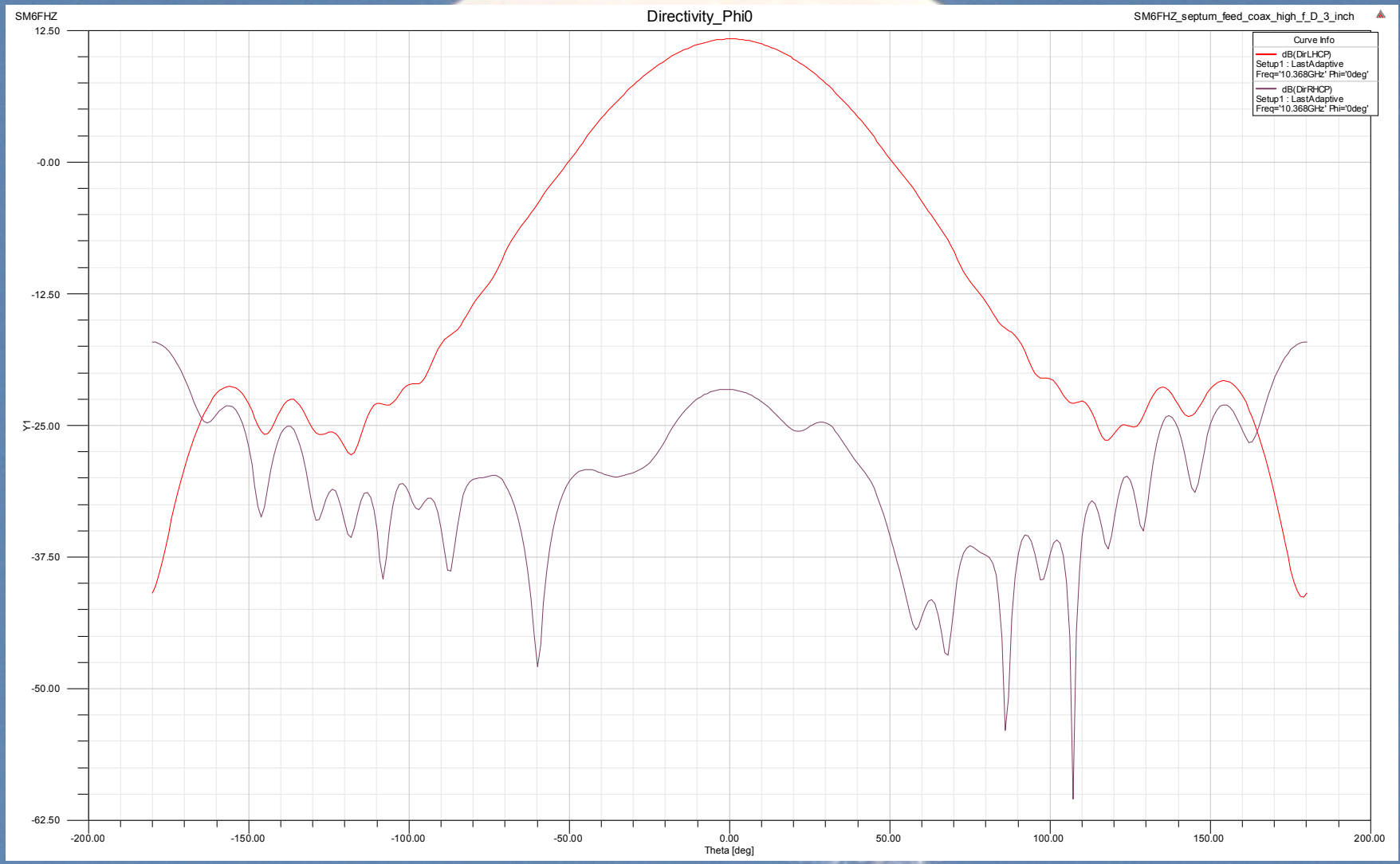
3D Total Power Far Field pattern

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)



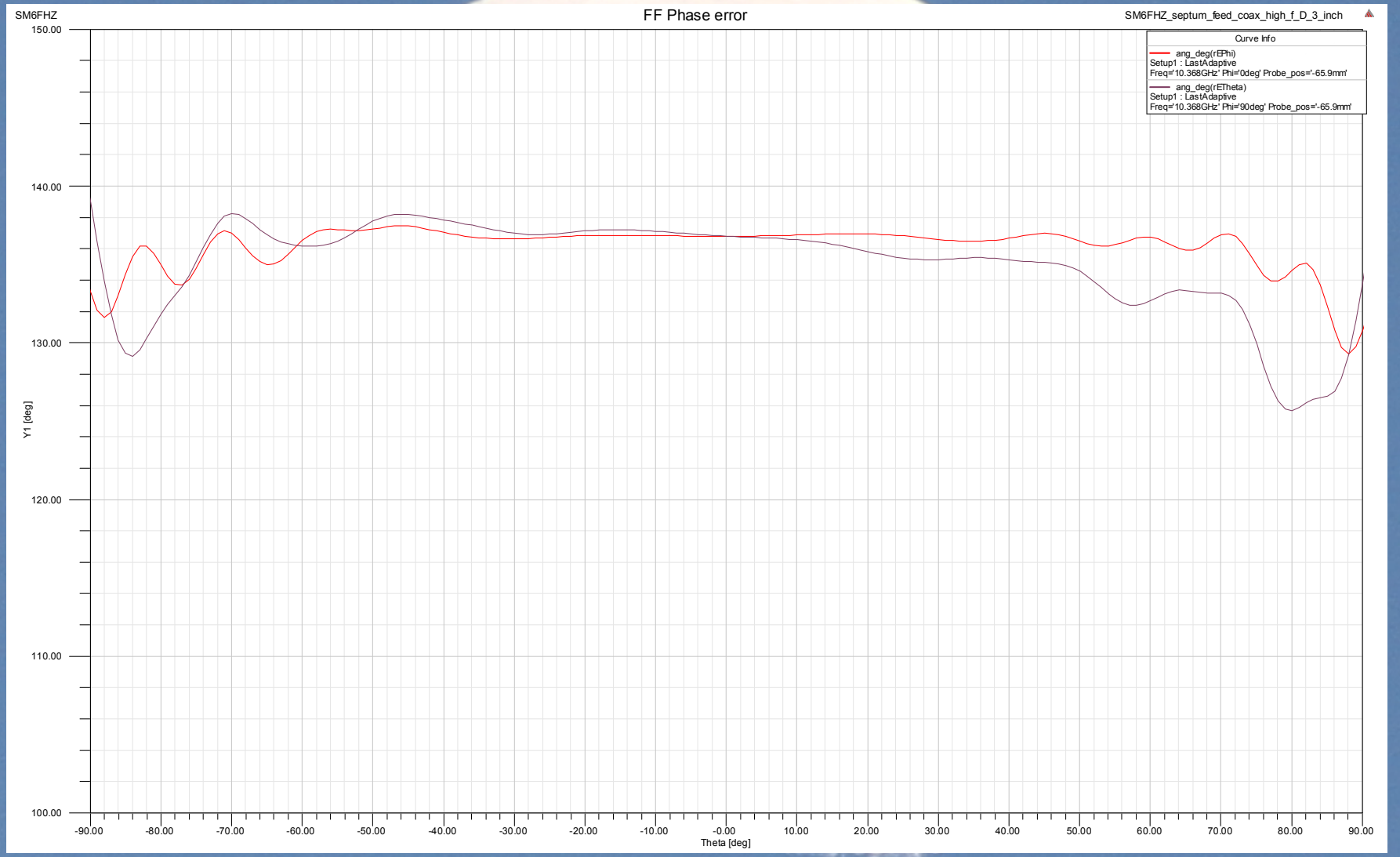
Far Field Pattern 0 deg

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)



Far Field Phase error

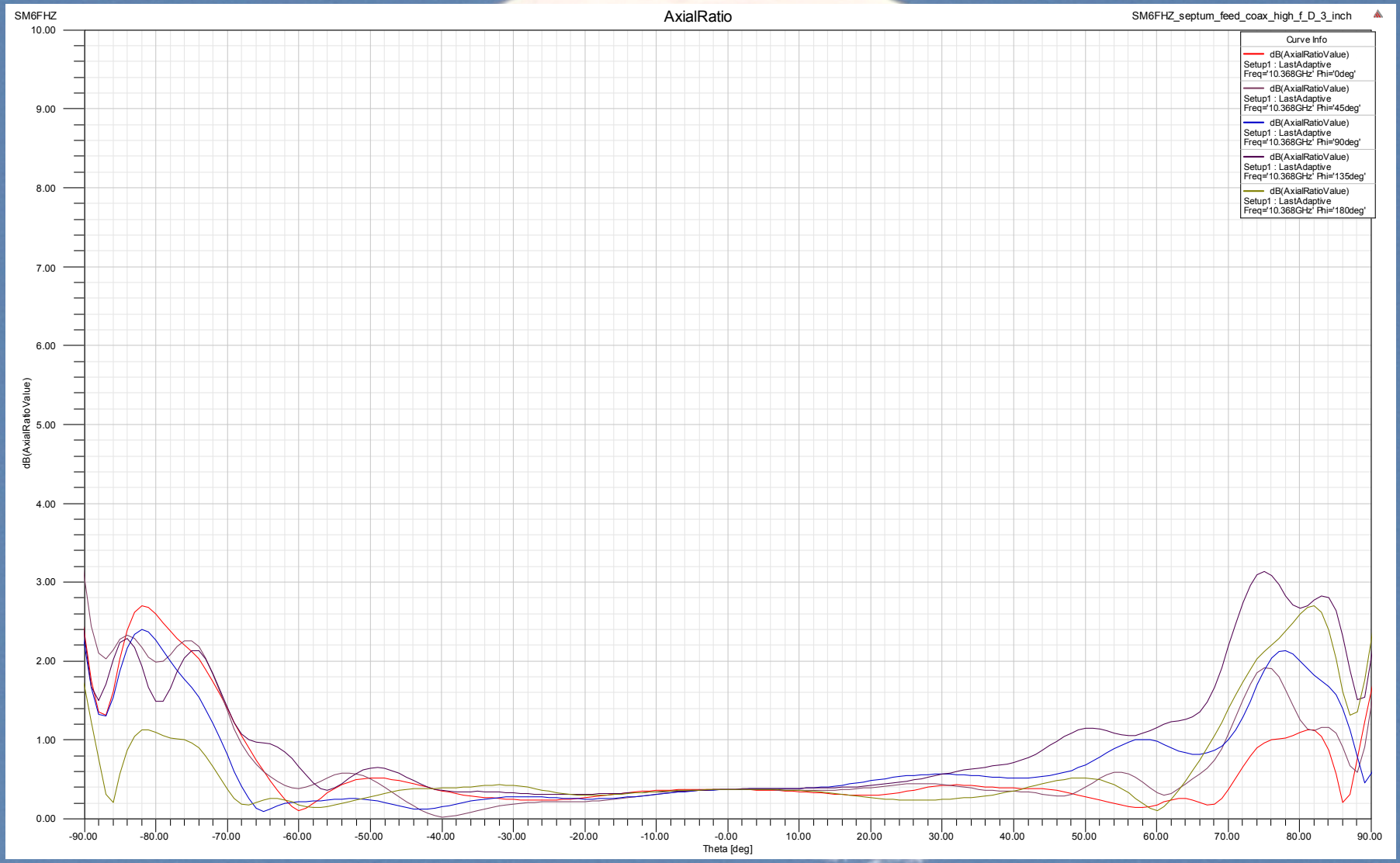
(3 cm 0.795 wl WG Dual Mode 39mm inch tube)

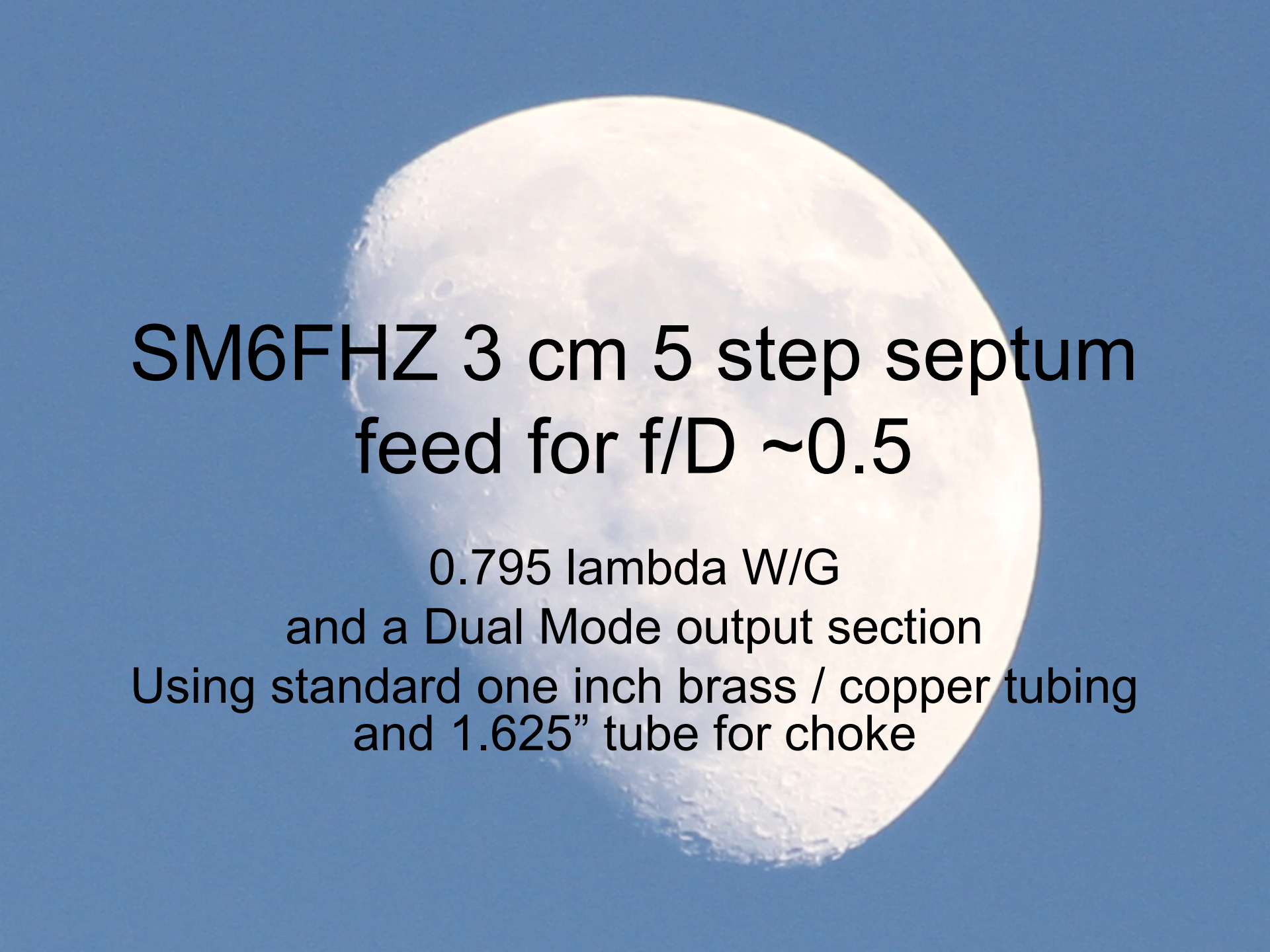


Cross Polar Ratio

(3 cm 0.795 wl WG Dual Mode 39mm inch tube)

Axial Ratio (3 cm 0.795 wl WG Dual Mode 39mm inch tube)





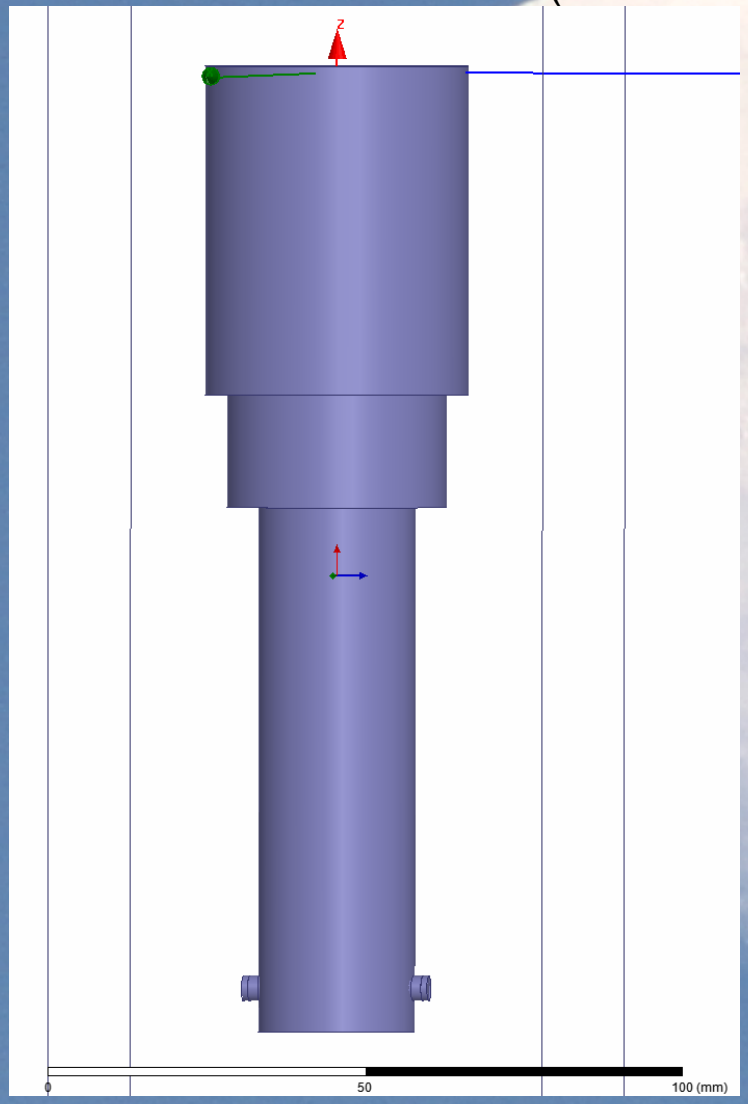
SM6FHZ 3 cm 5 step septum feed for f/D ~0.5

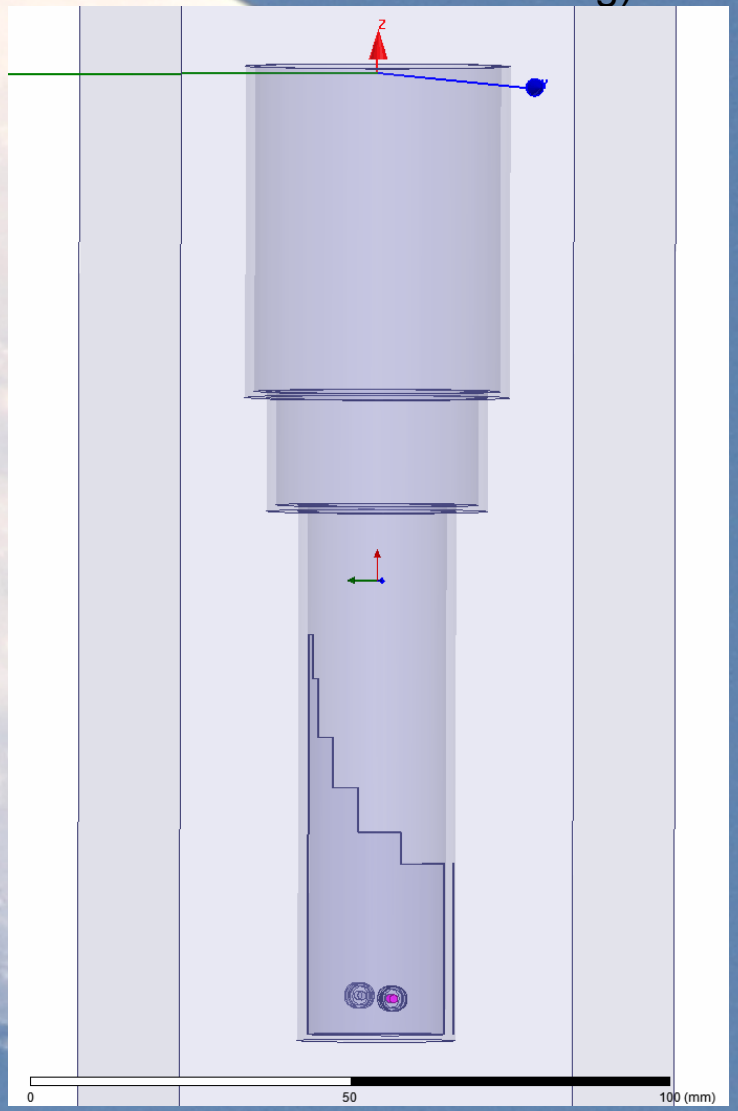
0.795 lambda W/G

and a Dual Mode output section

Using standard one inch brass / copper tubing and 1.625” tube for choke

Solid and transparent models from the simulation (3 cm 0.795 wl WG Dual Mode 39mm inch tubing)





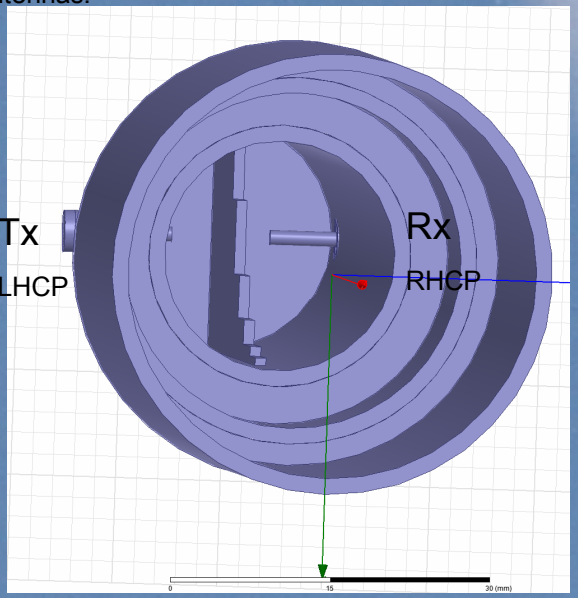
WG and choke dimensions

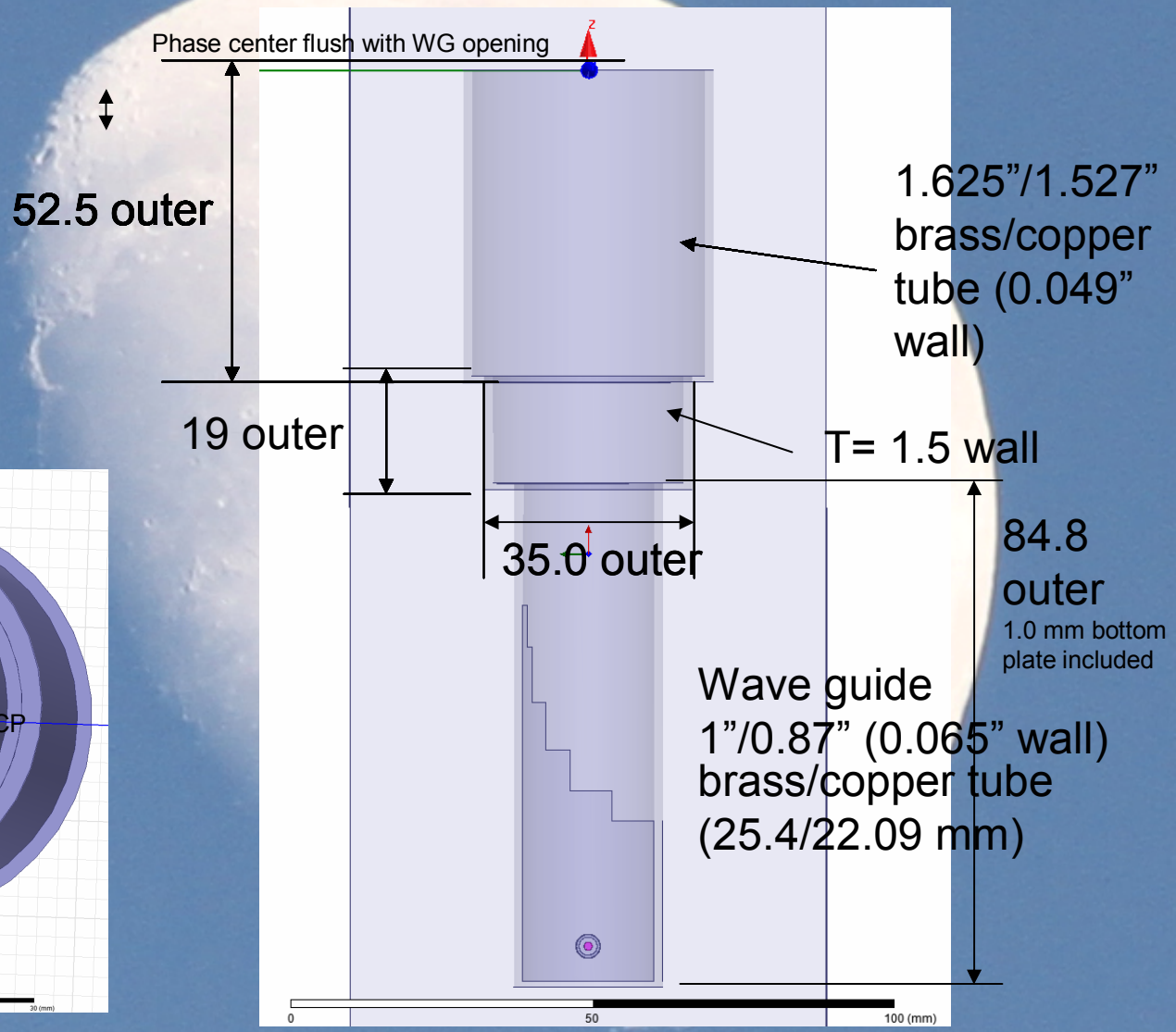
(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)

Circular polarization convention for EME according to Crawford Hill Bulletin No 1:

Tx RHCP in space
Rx LHCP in space

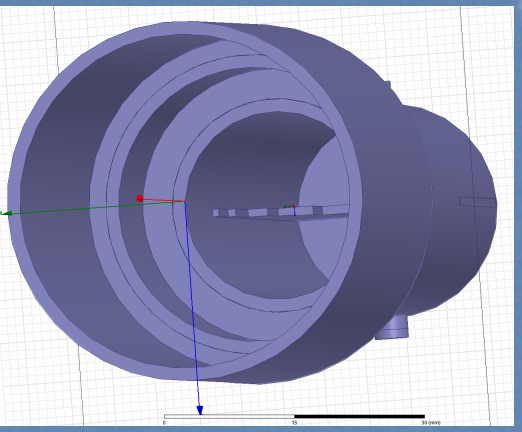
Take polarization reversal into account when using reflector antennas.

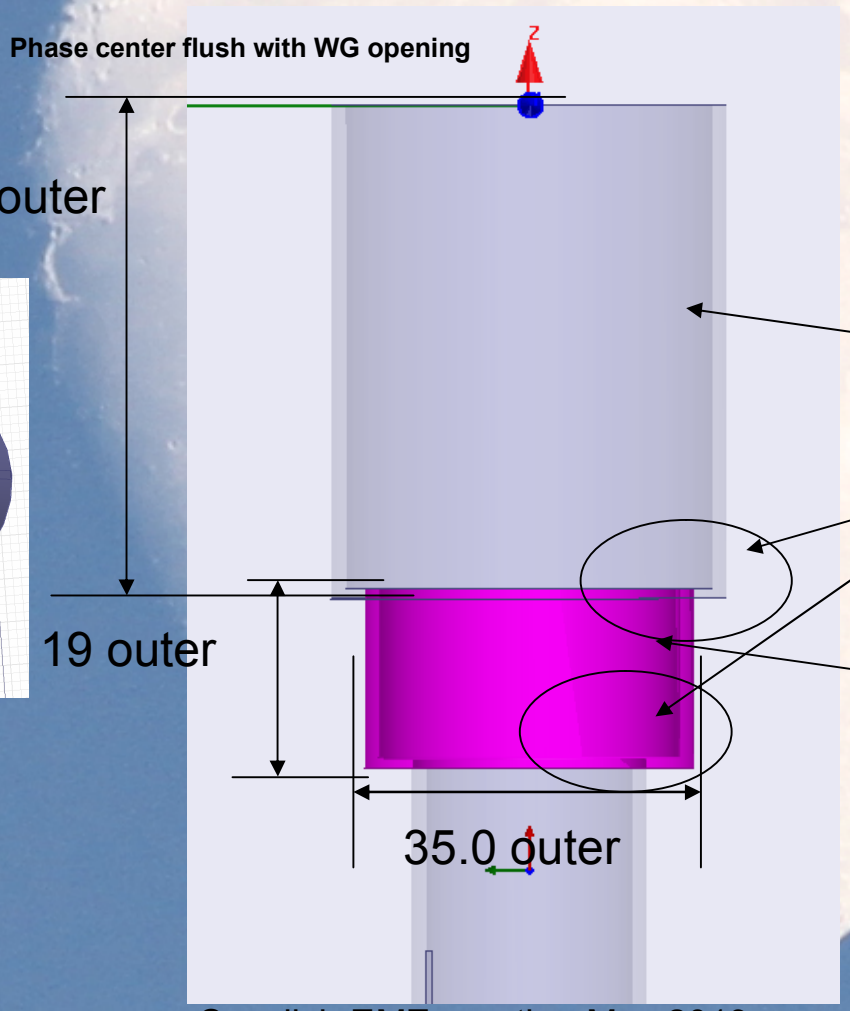




Detail of WG / transformer and output section

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)





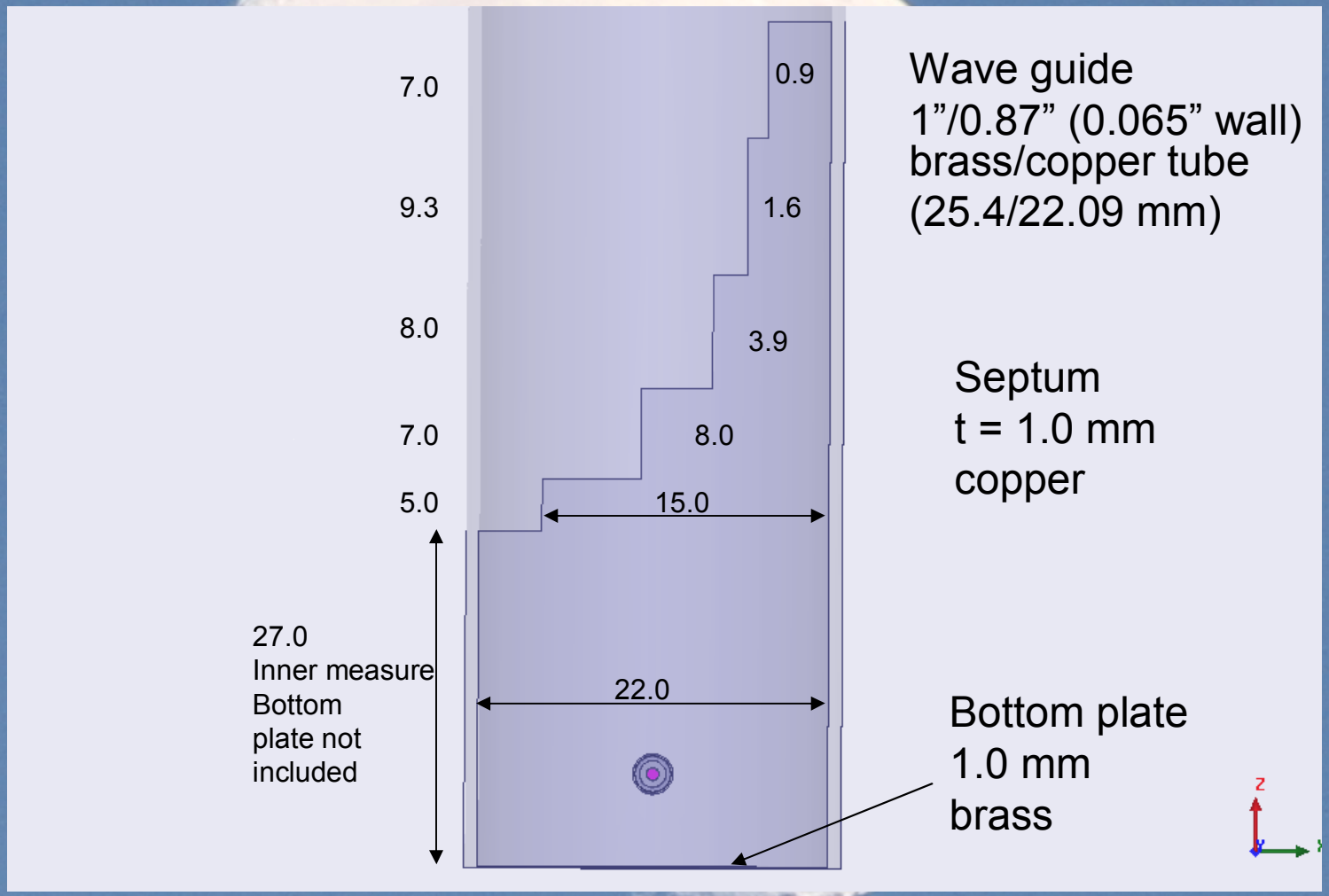
1.625”/1.527” brass/copper tube (0.049” wall)

1 mm overlap between tubes of transformer and wave guide and output section respectively.

Transformer section made from 32/35 copper tube or turned from 40 mm solid brass stock to fit with WG and output section. If a tube is used, fittings between the transformer section and the wave guide and output section respectively need to be made from brass or copper.

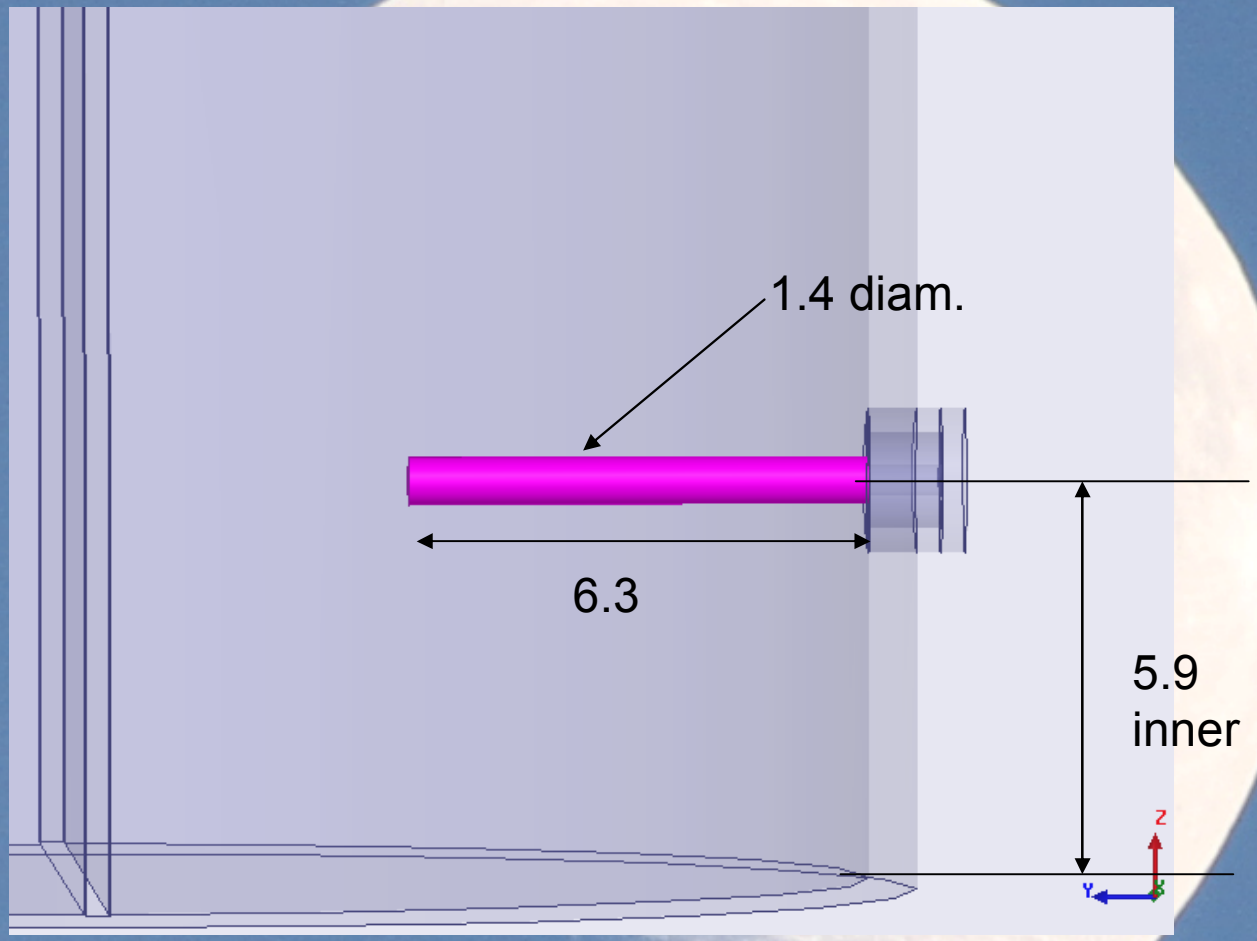
Septum dimensions

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)

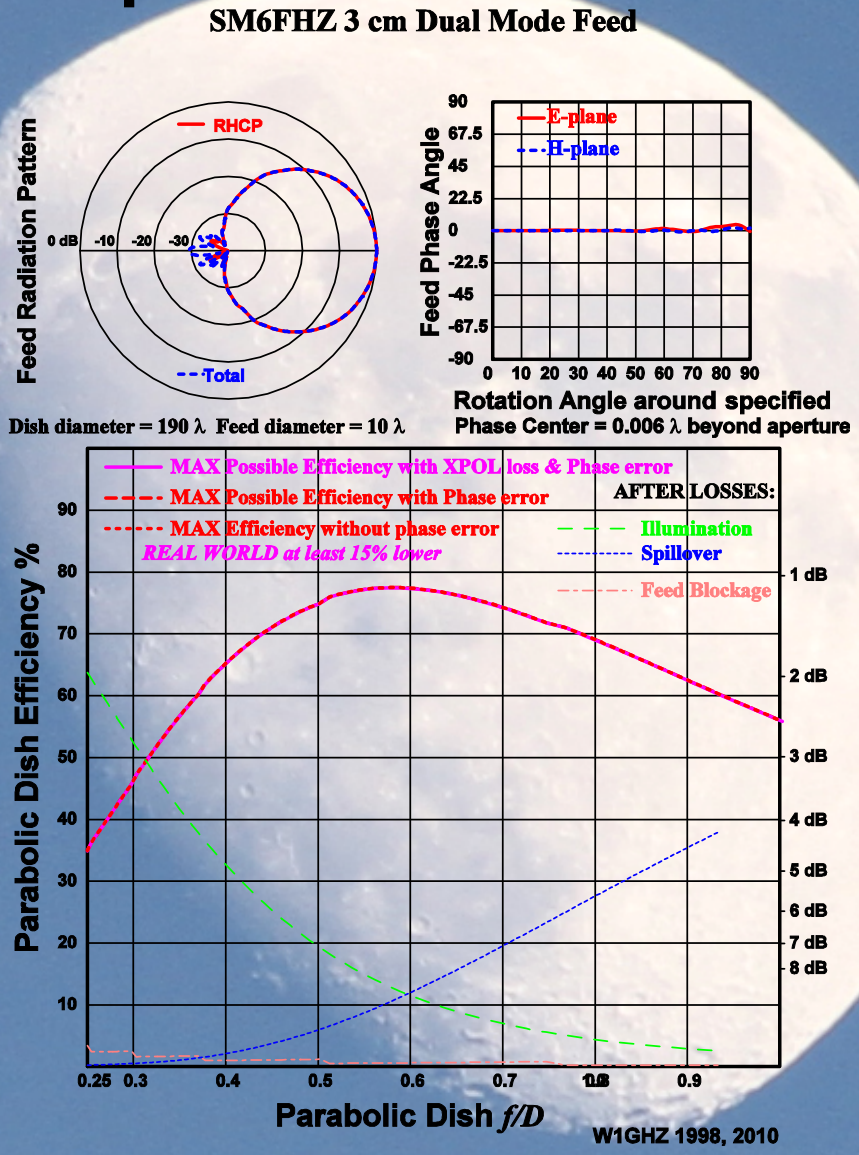


Probe dimensions

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)

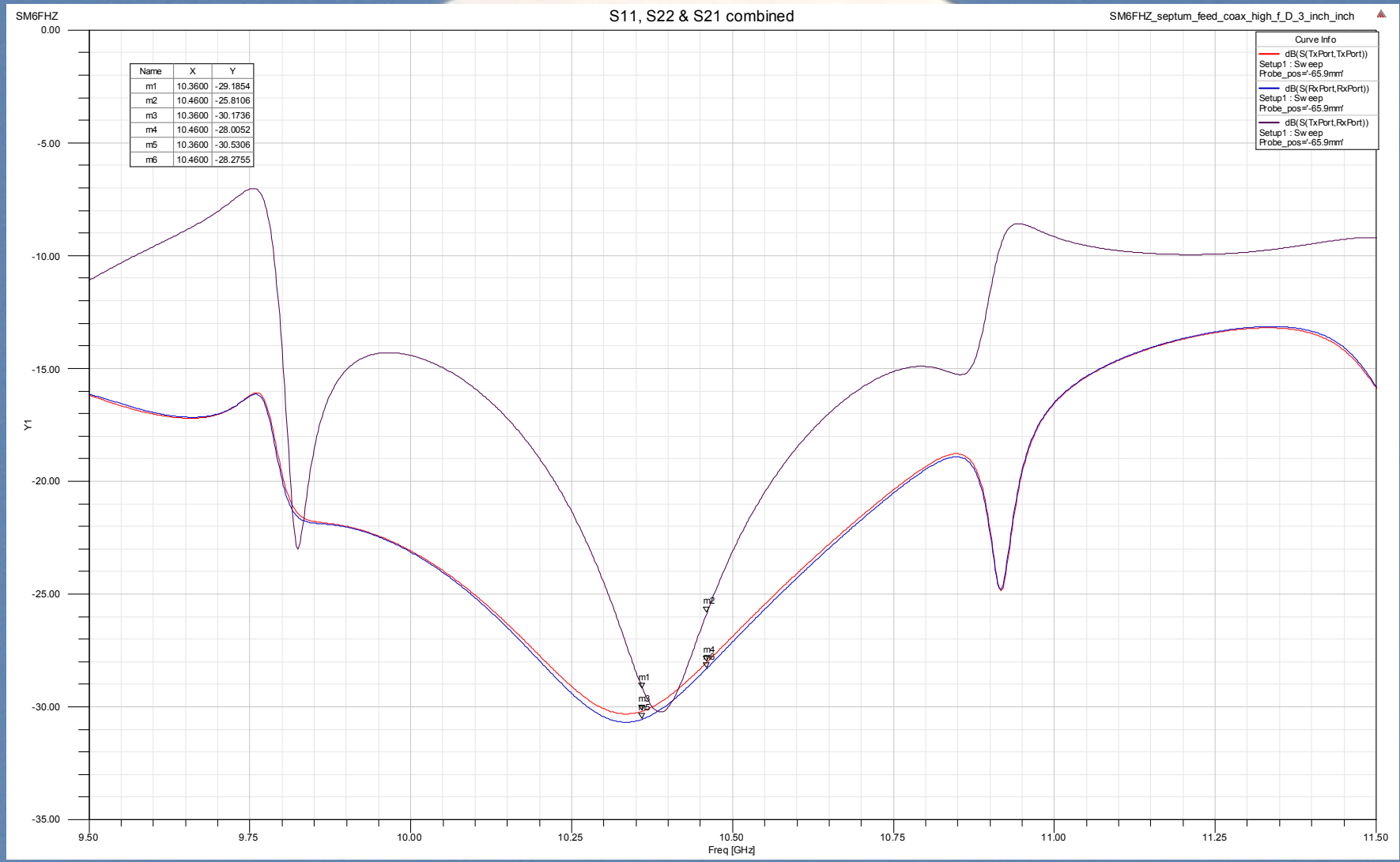


InDish performance inch tubing



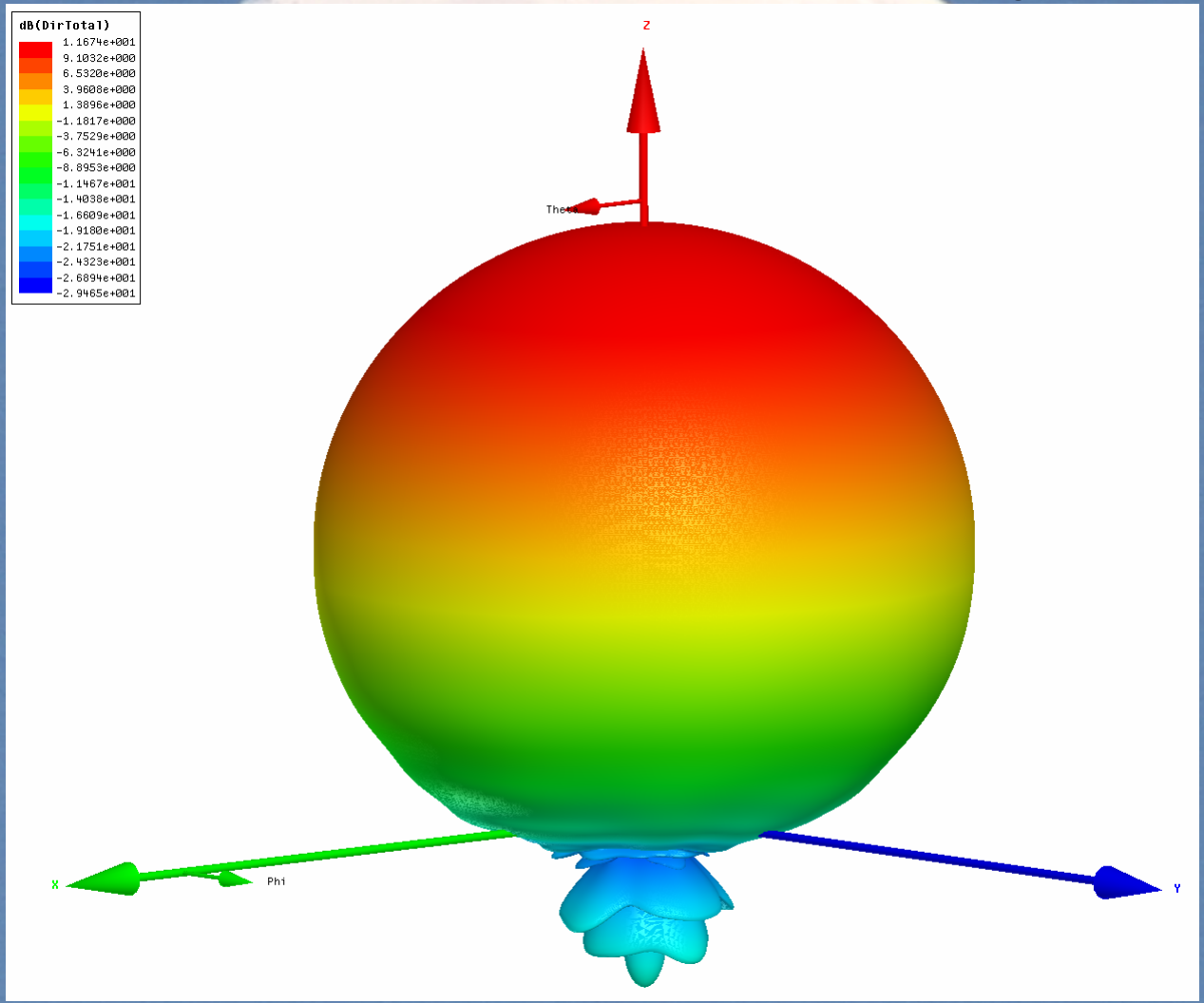
S11, S22, S21 combined

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)



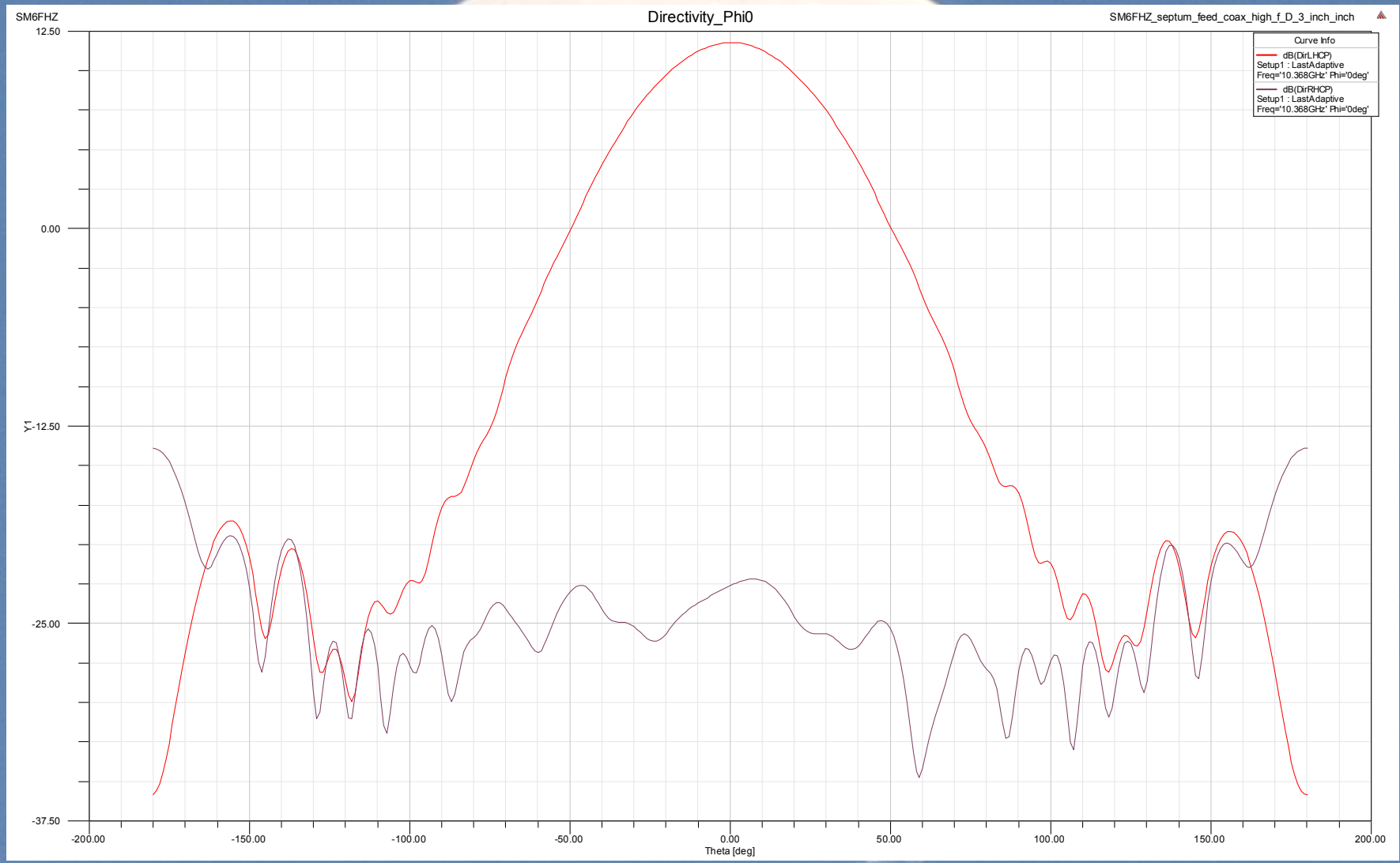
3D Total Power Far Field pattern

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)



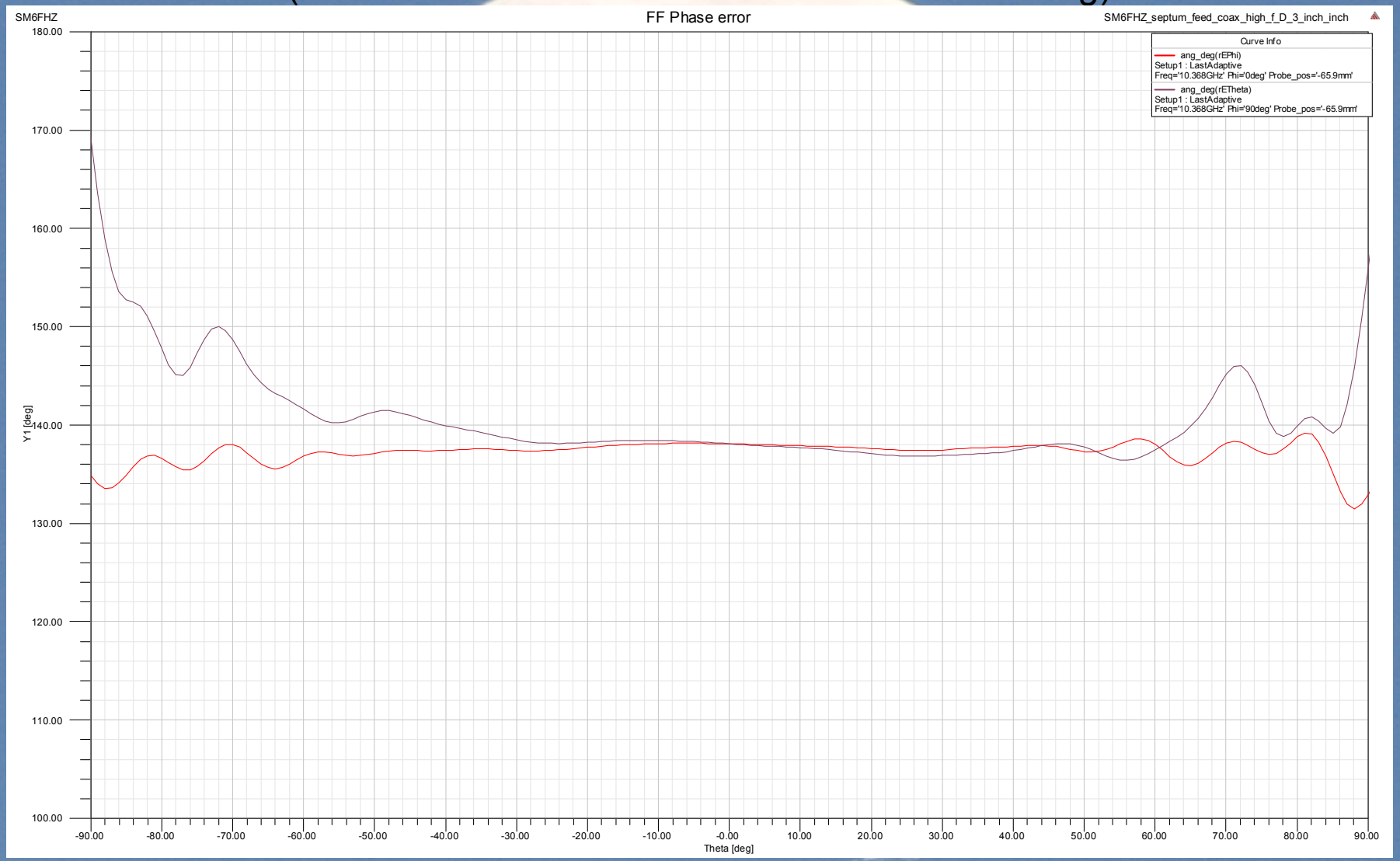
Far Field Pattern 0 deg

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)



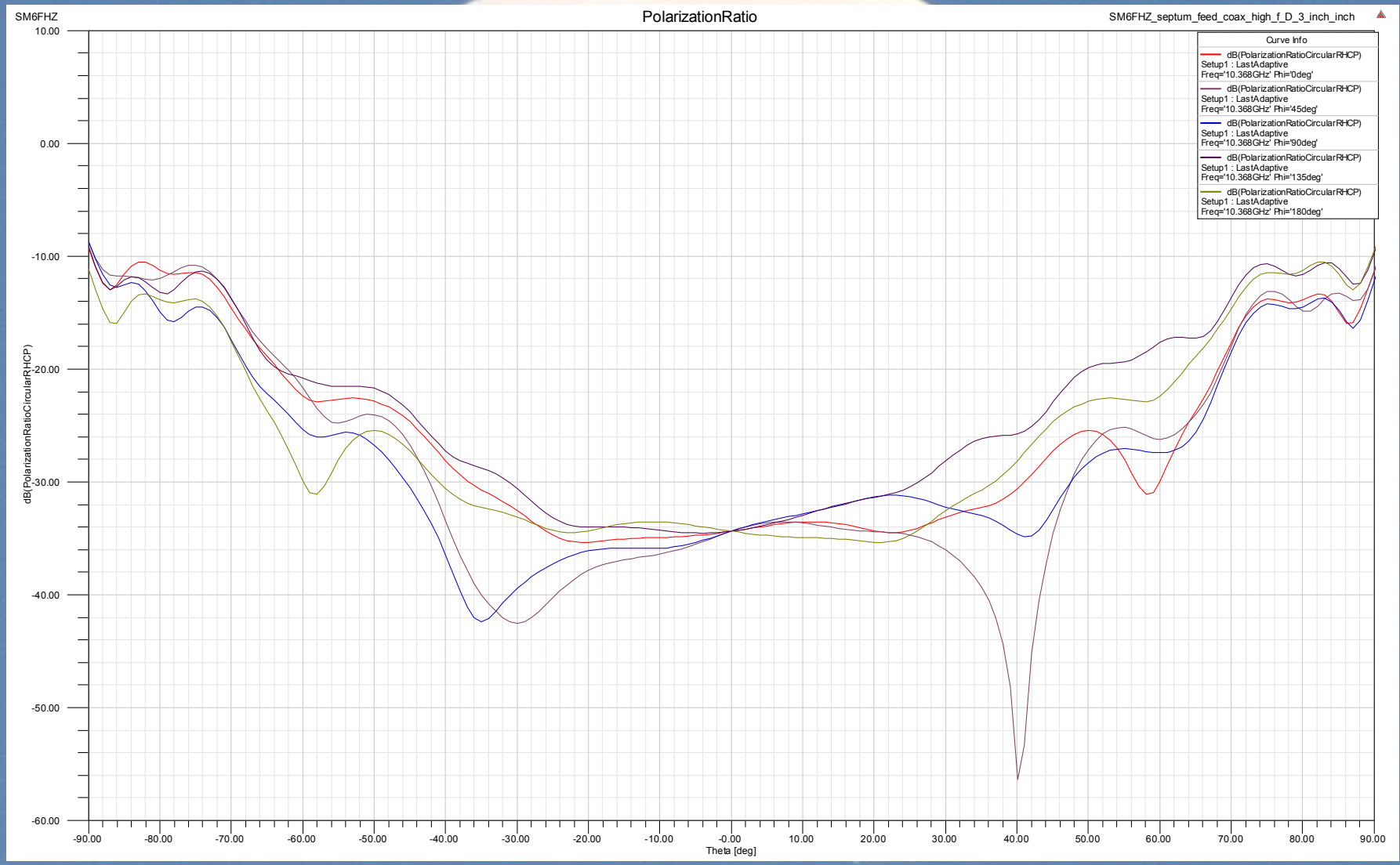
Far Field Phase error

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)

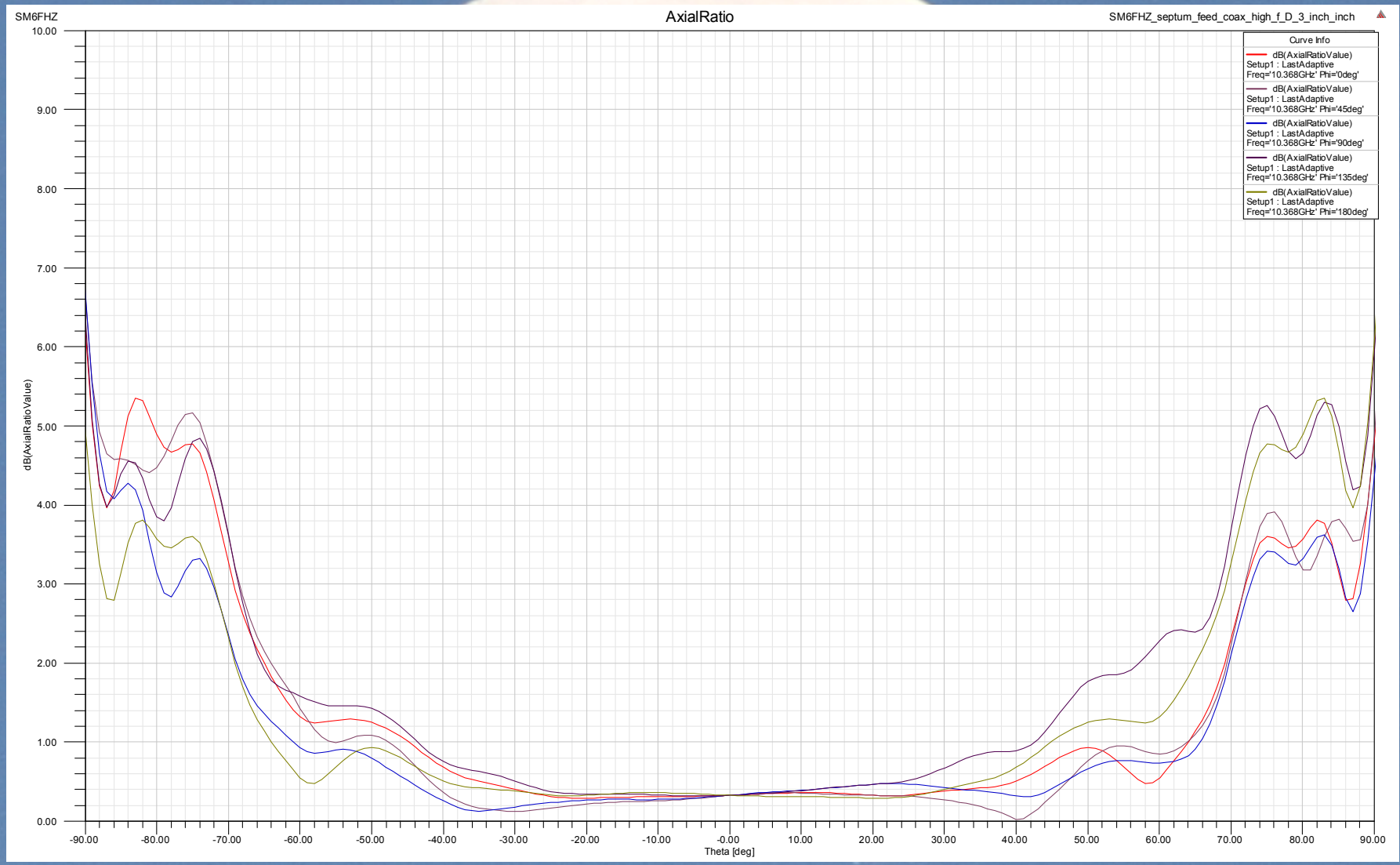


Cross Polar Ratio

(3 cm 0.795 wl WG Dual Mode 39mm inch tubing)



Axial Ratio (3 cm 0.795 wl WG Dual Mode 39mm inch tubing)



On the air experience 9 cm

- SM6PGP 9 cm
  - 9.9 dB sun noise and 0.12 dB moon noise
  - 8 CW and 1 JT initials
  - Moon returns well readable with 250 W at the feed in an 1.8 m solid dish

On the air experience 6 cm

- SM6FHZ 6 cm
  - 17 dB sun noise and 1.1 dB moon noise.
  - 20 initials
  - Nice returns from the moon with 17 W at the feed of the 5.5 m solid dish
- SM6PGP 6 cm
  - 12 dB sun noise and 0.3 dB moon noise
  - 11 initials
  - Moon returns readable with 90 W at the feed in an 1.8 m solid dish

On the air experience 3 cm

- SM6PGP 3 cm
  - 10 dB sun noise and 0.3 dB moon noise
  - 4 stations heard (positively identified on CW) via the moon
  - Antenna 1.8 m solid dish

Lessons Learned

- Scaling feed dimensions from a one band design to another band is at your own risk
  - The materiel used (thickness etc) plays a important role. It is not obvious how to scale material thickness. I argue that you will not know what radiation pattern you will get if scaled.
- Soldering of the septum to 100% is crucial
  - This is true for all soldering joints in the feed
- The inner WG diameter is sensitive to tolerances
  - 0.2 mm larger diameter on 10 GHz moved the optimum isolation >100 MHz down

Conclusion

- 7 new septum feeds from 23 cm to 3 cm have been presented
- All of them show very good performance
- The feeds for 3 cm are circularly polarized as well
- The 9 cm, 6 cm and 3 cm feeds are based on standard metric Cu or brass tubes for easy manufacturing
- So far three of the feeds have been built, measured and used. All of them show very good correlation between simulated and measured performance.

Acknowledgements

- Thanks to all who inspired me to do this work and that gave me so many good ideas:
  - W1GHZ, Paul
  - VE4MA, Barry
  - W2IMU, Dick
  - SM6PGP, Hannes
  - WD5AGO, Tommy
  - N2UO, Marc
  - RA3AQ, Dmitry
  - G3LTF, Peter
  - G3WDG, Charlie
  - G4BAO, John
  - OK1DFC, Zdenek
  - Plus many others

References

- Copper tubes (9 cm, 6 cm and 3 cm feeds) can be found here:
  - http://www.rinkabyror.se/artiklar/ror-och-rordelar/harda-kopparror-prisol/
  - http://www.engineeringtoolbox.com/copper-tube-working-pressure-d_20.html
  - http://www.onlinemetals.com/merchant.cfm?id=84&step=2&top_cat=79
  - http://www.hpb.se/vvs/156-koppar
  - www.collegeengineering.co.uk


Thank you for your attention
See you all via the moon on the higher bands

Revision history

- Rev A; As presented at The Swedish EME Meeting, May 2013
- Rev B, June 2013; Post conference edition including:
  - 9 cm feed
  - Editorial updates
- Rev C, December 2013; Post conference edition including:
  - Updated dimensions for the 3 cm 0.792 wl feed resulting in improved isolation
  - Including a 3 cm Dual Mode Septum feed for f/D's ~0.5
  - Editorial updates to enhance readability
  - References slide included
- REV D, December 2013; Post conference edition including:
  - 3 cm Septum Feeds using standard one inch as well as 1.625" plumbers tubing
  - E- and H-field in SM6FHZ 10 GHz Dual Mode Feed included
  - Reference slide updated with more links to sources for copper and brass tubes
- REV E, August 2014; Post conference edition including:
  - Additional performance information for the 23 cm Kumar Septum Feed 0.71 wl including G/T data and comparison
  - 3 cm Septum Feed for f/D 0.5 dimension correction
- REV PF1, August 2017; Post conference edition including:
  - Phase centre of 9 cm feed corrected
  - 9 cm feed with inch based tube, three alternatives presented
  - References updated with more sources for inch based tubes
  - Acknowledgements updated