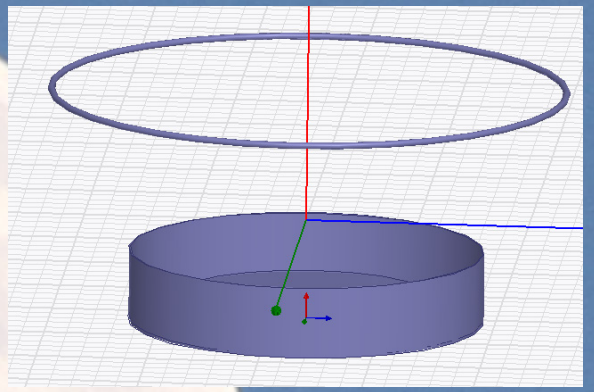
Circularly Polarized Patch Feed for 1296 MHz

Swedish EME-meeting May 2013

SM6FHZ and SM6PGP

Outline



- Prerequisite
- Features
- Design considerations
  - Size
  - Choke
  - BFR
- Performance
- Mechanical dimensions
- Realization
- On the air experience
- Conclusions

Why?

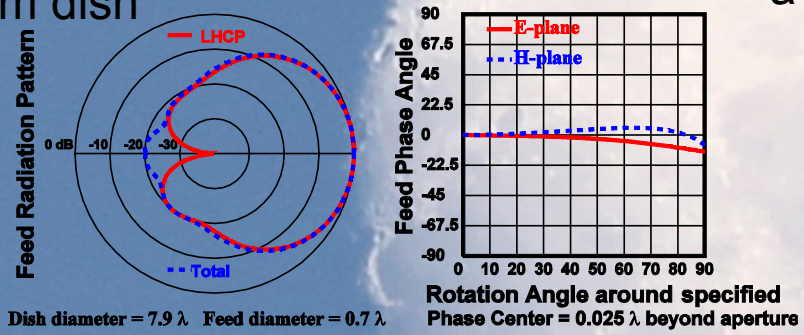
- SM6PGP wanted to use his 1.8 m dish on 23 cm EME
- He felt that a W/G feed was far too bulky in this small dish
- He figured that a patch feed with quadrature feeding might be the answer
- Together we set the goals and limitations for dimensions and performance
- Using the 70 cm feeds as a starting point the simulations soon showed a feasible design with good performance

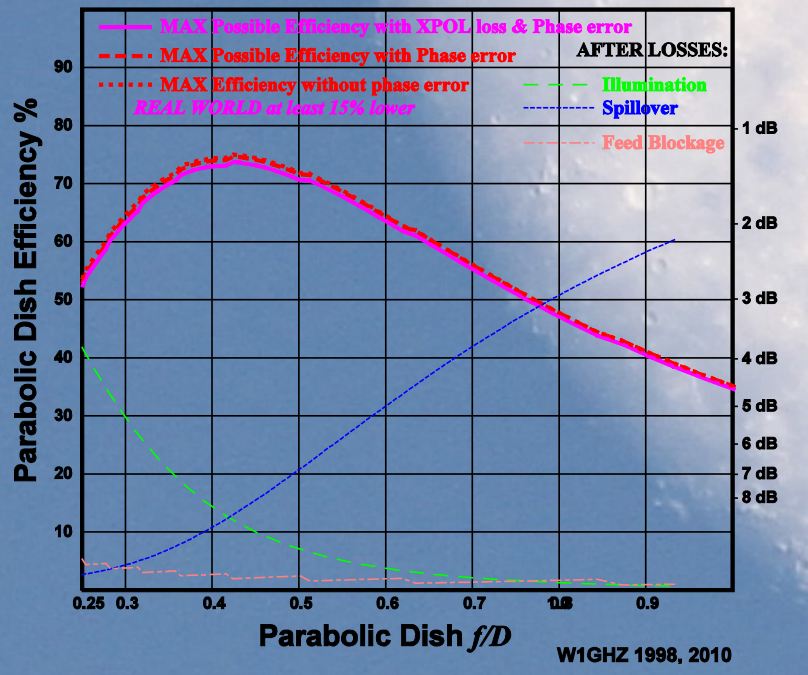
Features

- Compact circularly polarized patch feed suitable for small dishes
- Top notch performance
- Focus on easy manufacturing and low tolerance sensitivity
- Suitable for f/D from 0.28 to 0.45 covered in two variants
- Comprising a choke (baffle) structure as well as a Beam Forming Ring

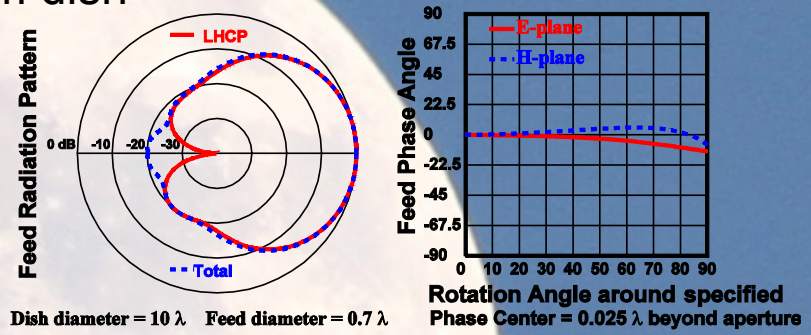
InDish Performance with BFR

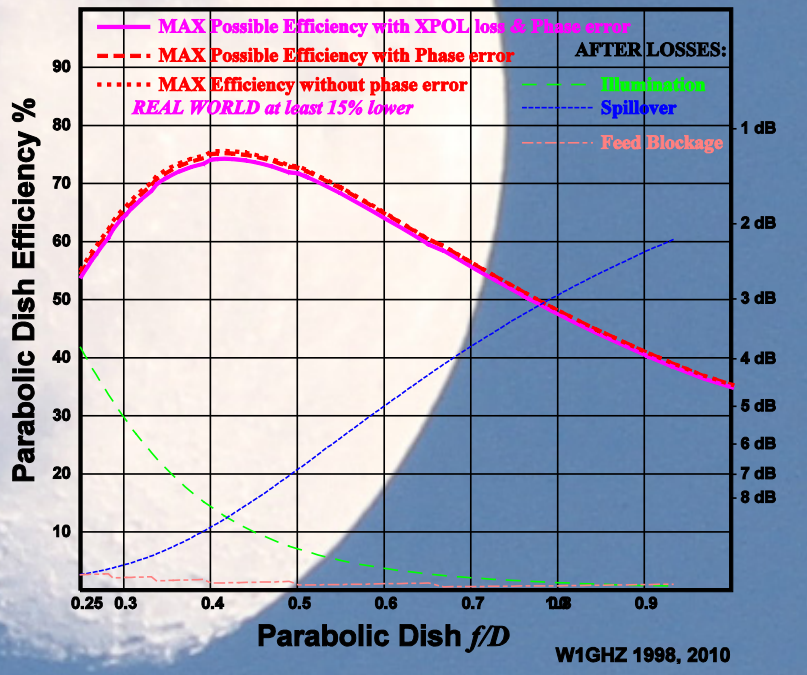
Performance in a 1.8 m dish





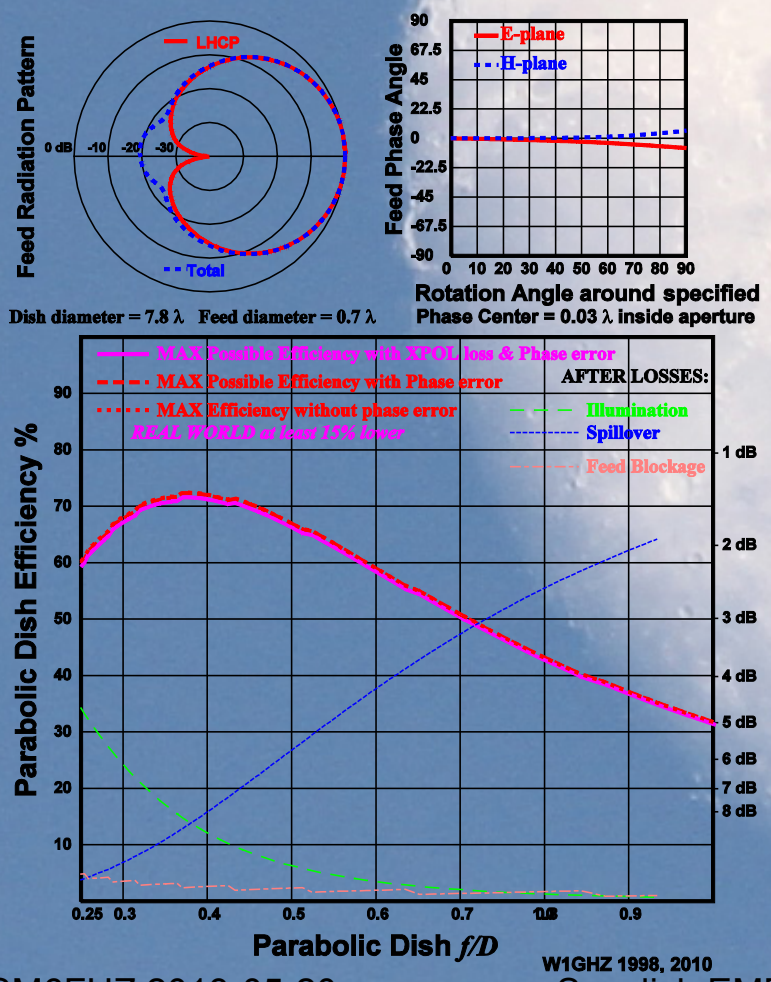
Performance in a 2.3 m dish



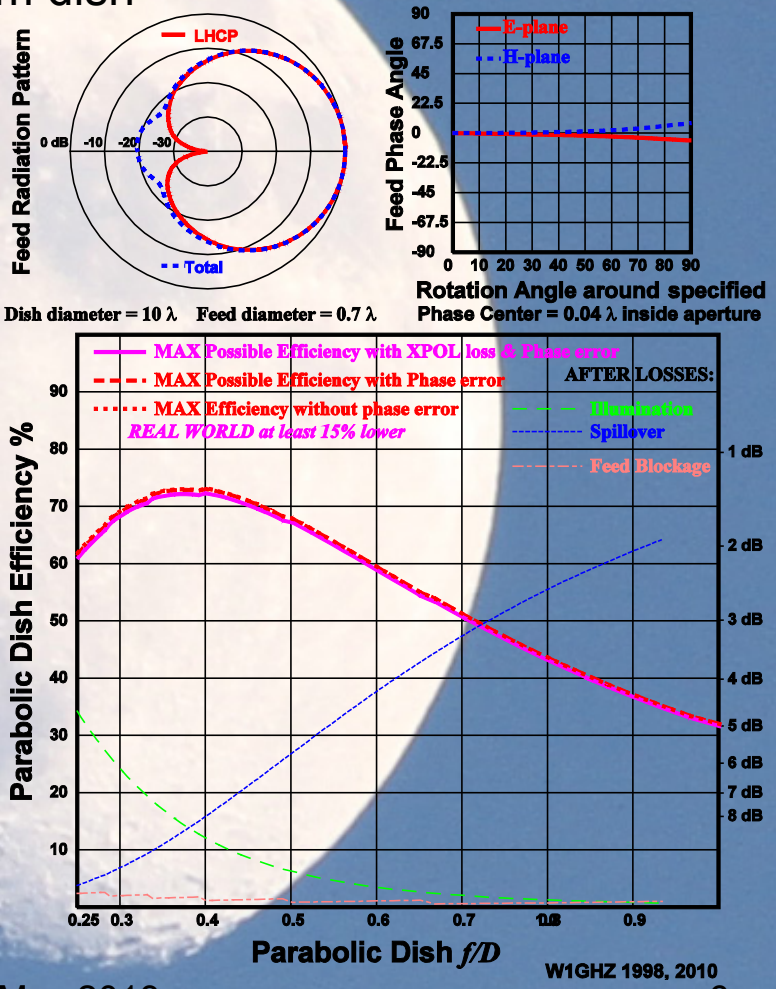


InDish Performance without BFR

Performance in a 1.8 m dish

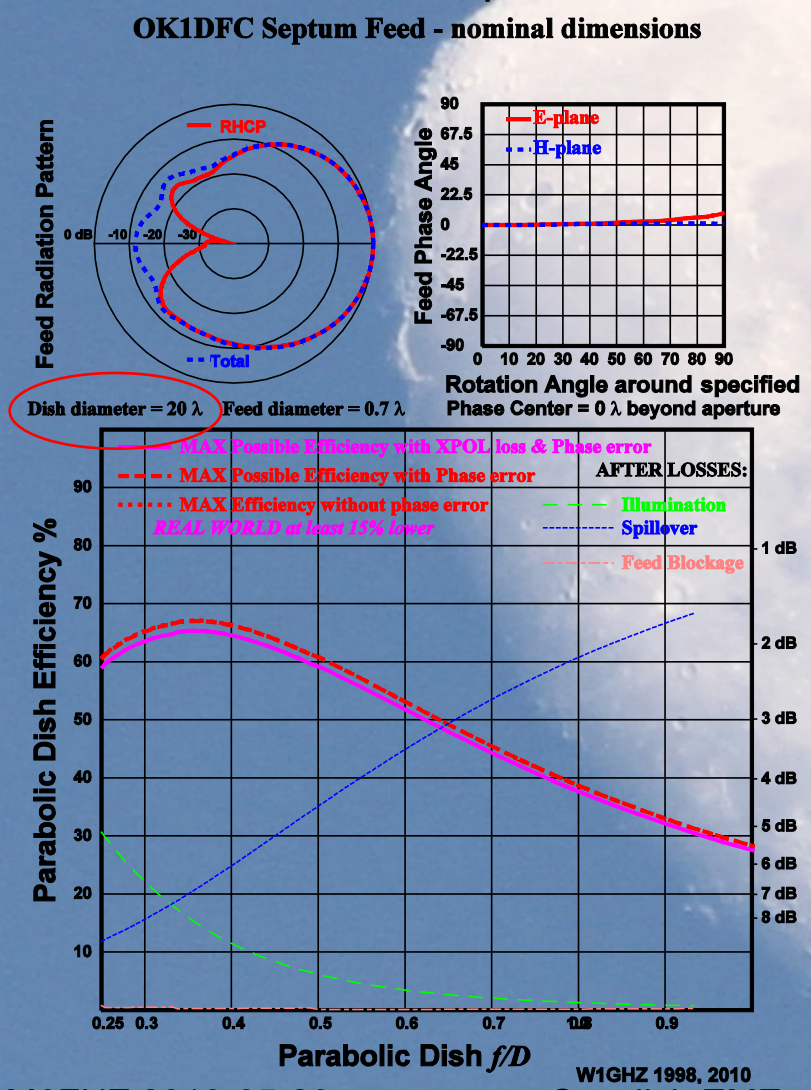


Performance in a 2.3 m dish

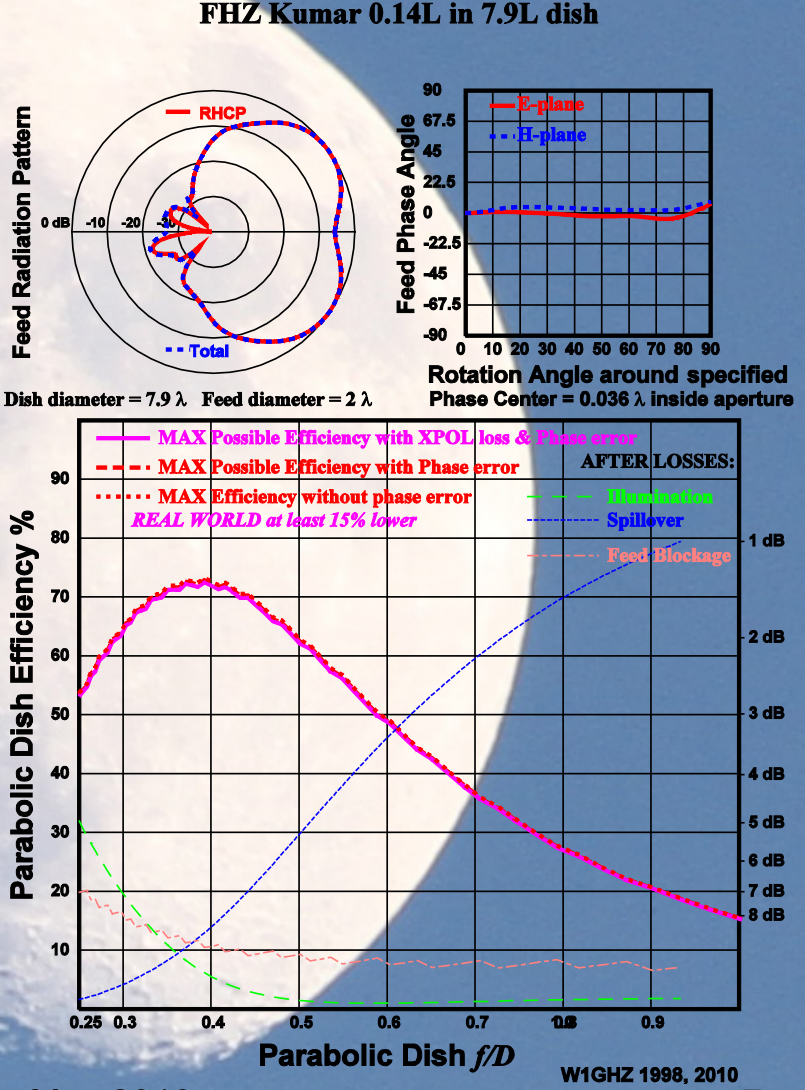


InDish Performance for two alternatives

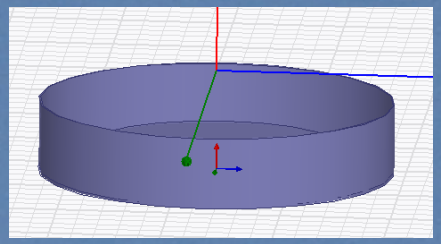
Performance with a DFC Septum feed



Performance with a FHZ Kumar feed



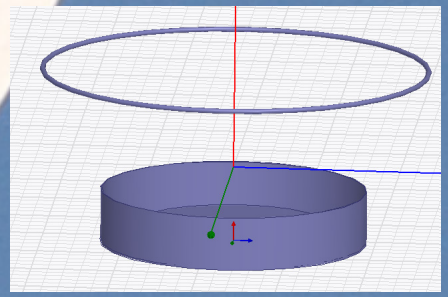
Why a choke

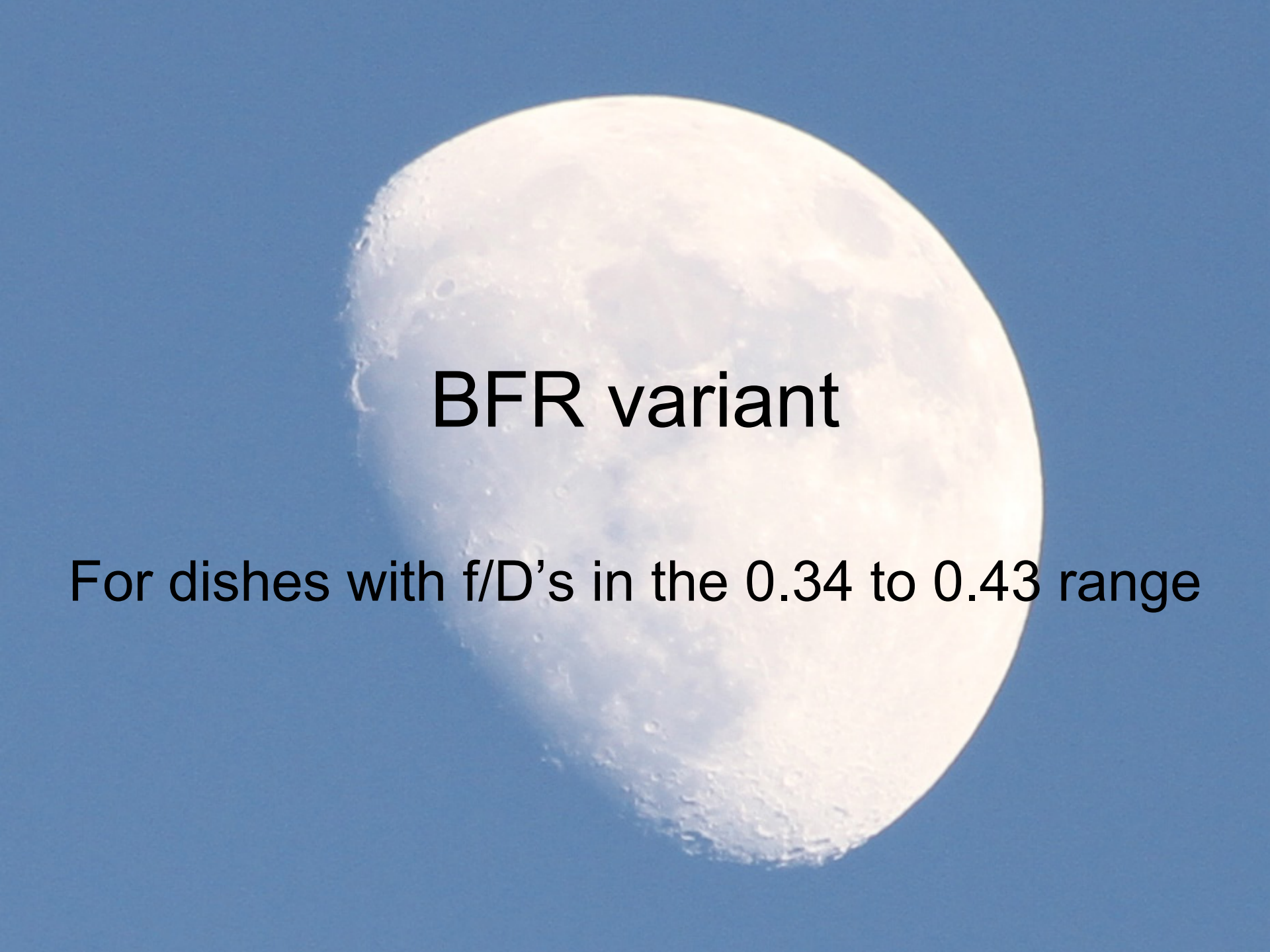


- The simulations on 70 cm feeds in 2010 showed that a patch feed did not have equal Beam Width in the two cardinal cuts. This need to be taken care of in order to get good efficiency together with decent noise performance.
- It was demonstrated on 70 cm that a choke (or baffle if you like) made the BW almost equal in all cuts.
- The choke also improved the Front to Back Ratio and phase error.

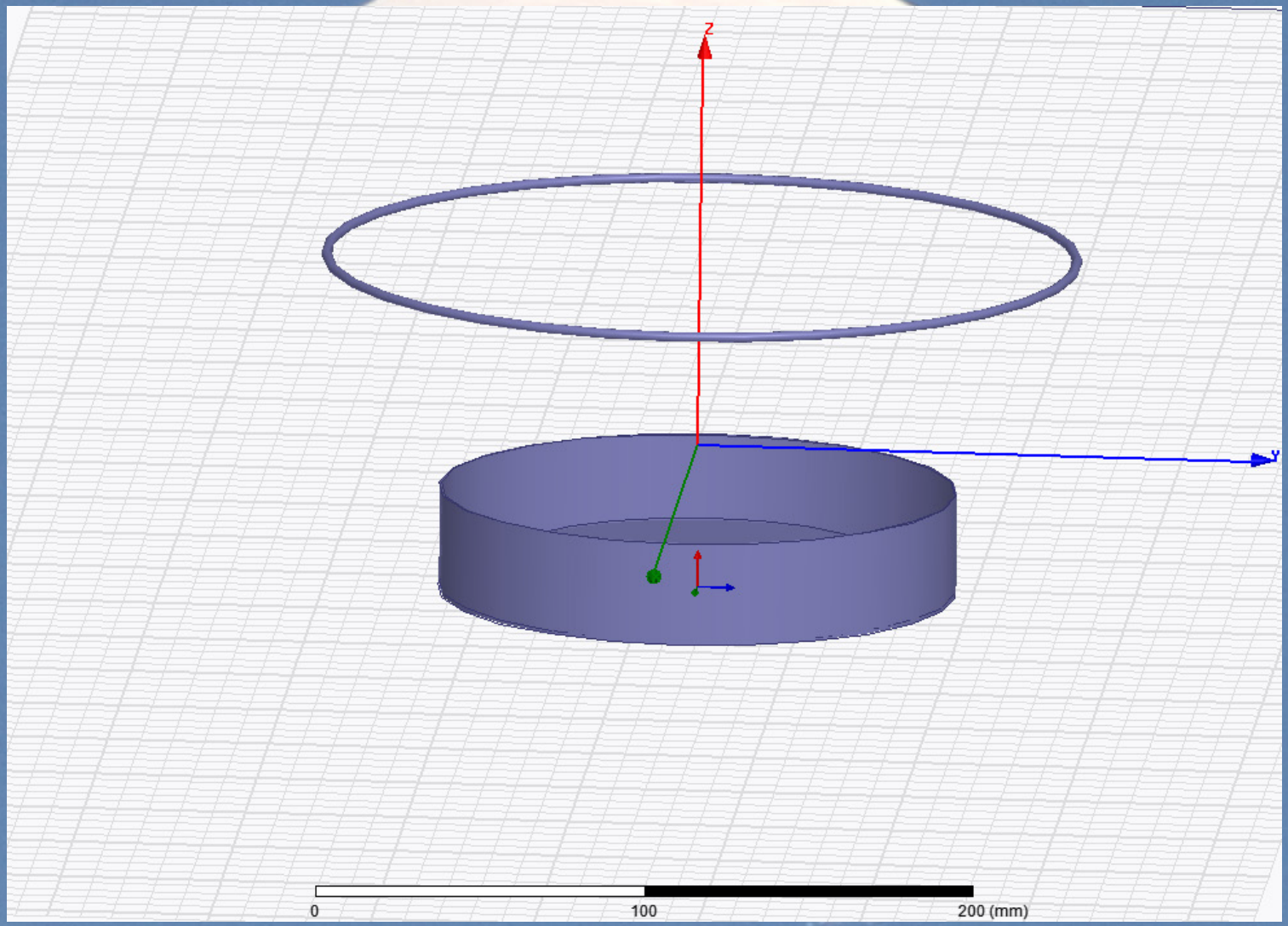
BFR - choke interaction

- The BFR sharpens up the main lobe
  - This leads to higher efficiency for f/D's around 0.4
  - It also enhances the side radiation for the feed improving the antenna temperature with less ground noise pick-up
- The BFR does not affect the good properties from the choke

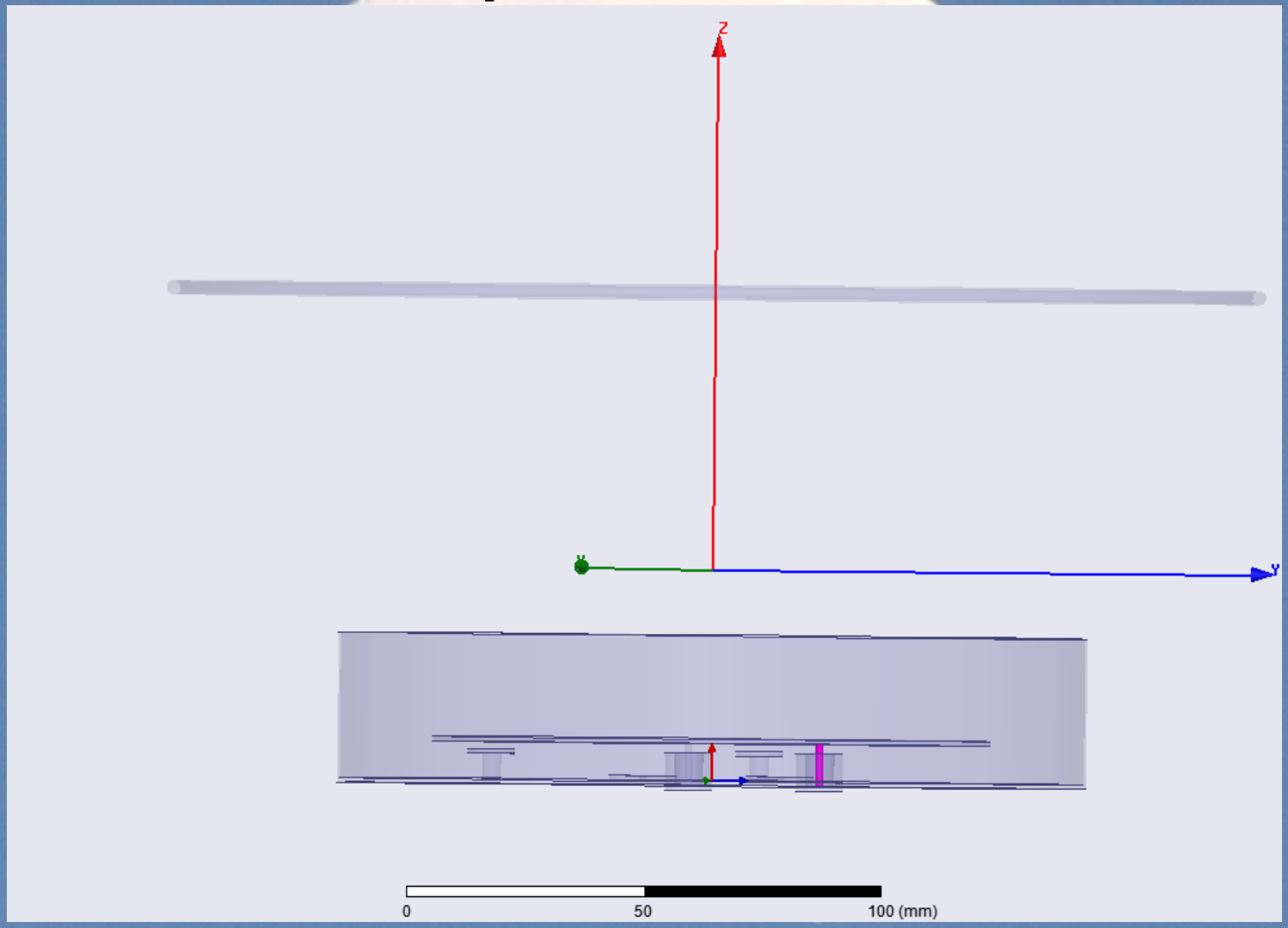



BFR variant
For dishes with f/D’s in the 0.34 to 0.43 range

Solid model from the simulation



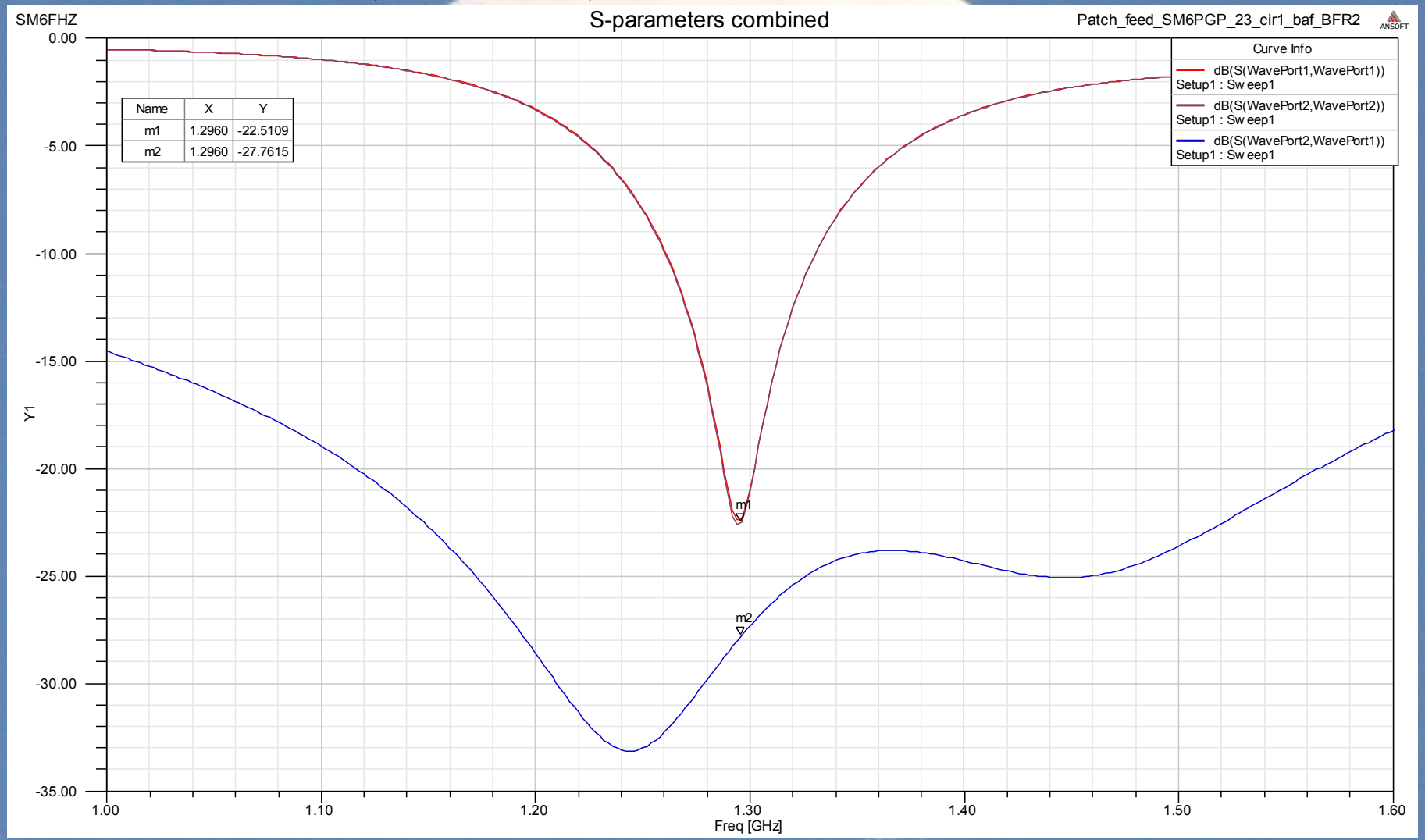
Transparent model



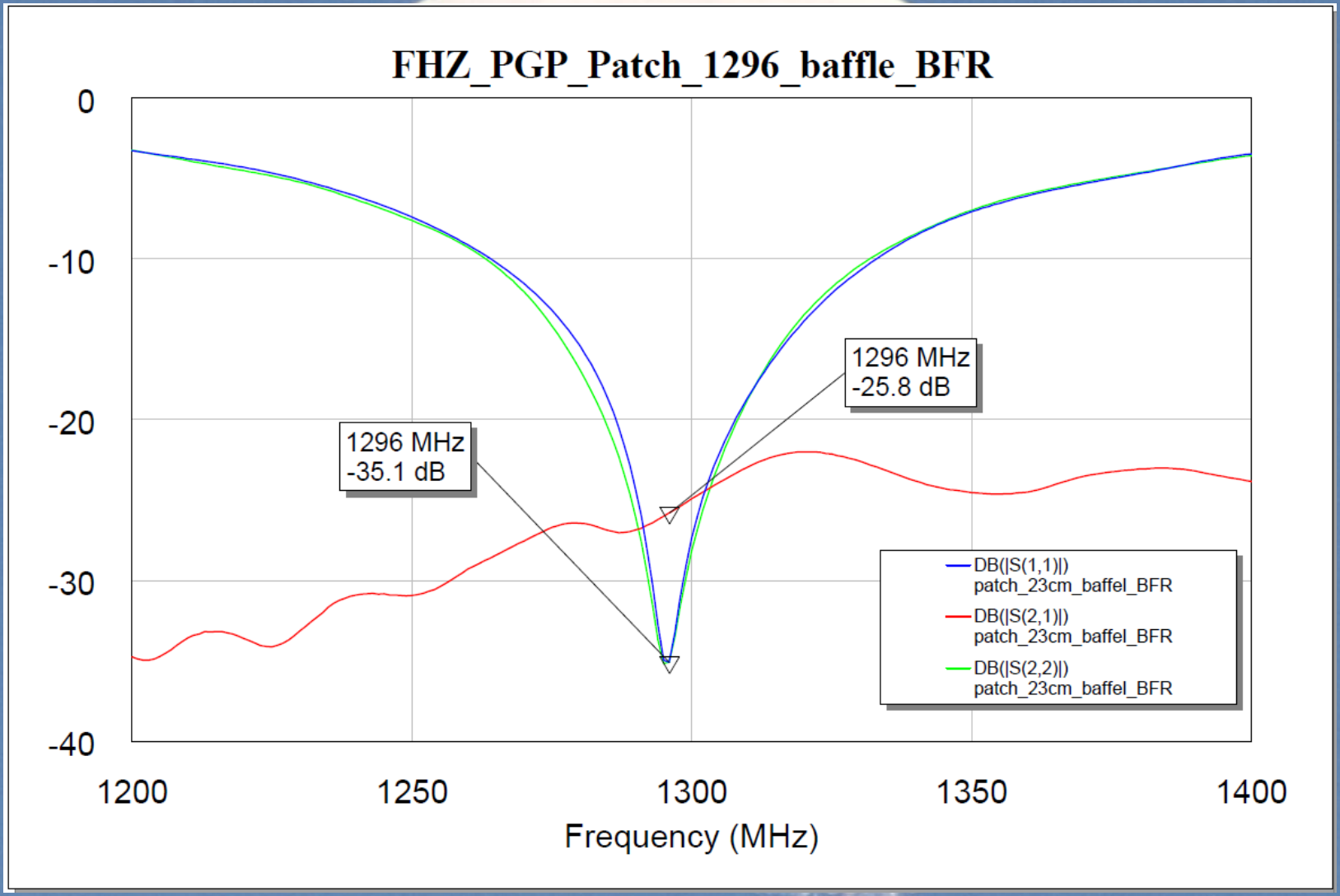
Dimensions with BFR

- Reflector 160 mm outer diam, 1 mm thick Cu or brass
- Baffle inner height 31 mm
- Baffle thickness 0.5 mm
- Patch 119 mm diam, 1 mm thick, 8 mm up from reflector (surface to surface)
- Probe 23.5 mm from center, ¼" coax w 1.6 mm inner conductor. Outer conductor stops 2 mm from the patch
- Phase is center 51 mm above the reflector
- BFR 232 mm diam (centre of body) , 104 mm above reflector (centre of body) , 3 mm Cu or Al tube

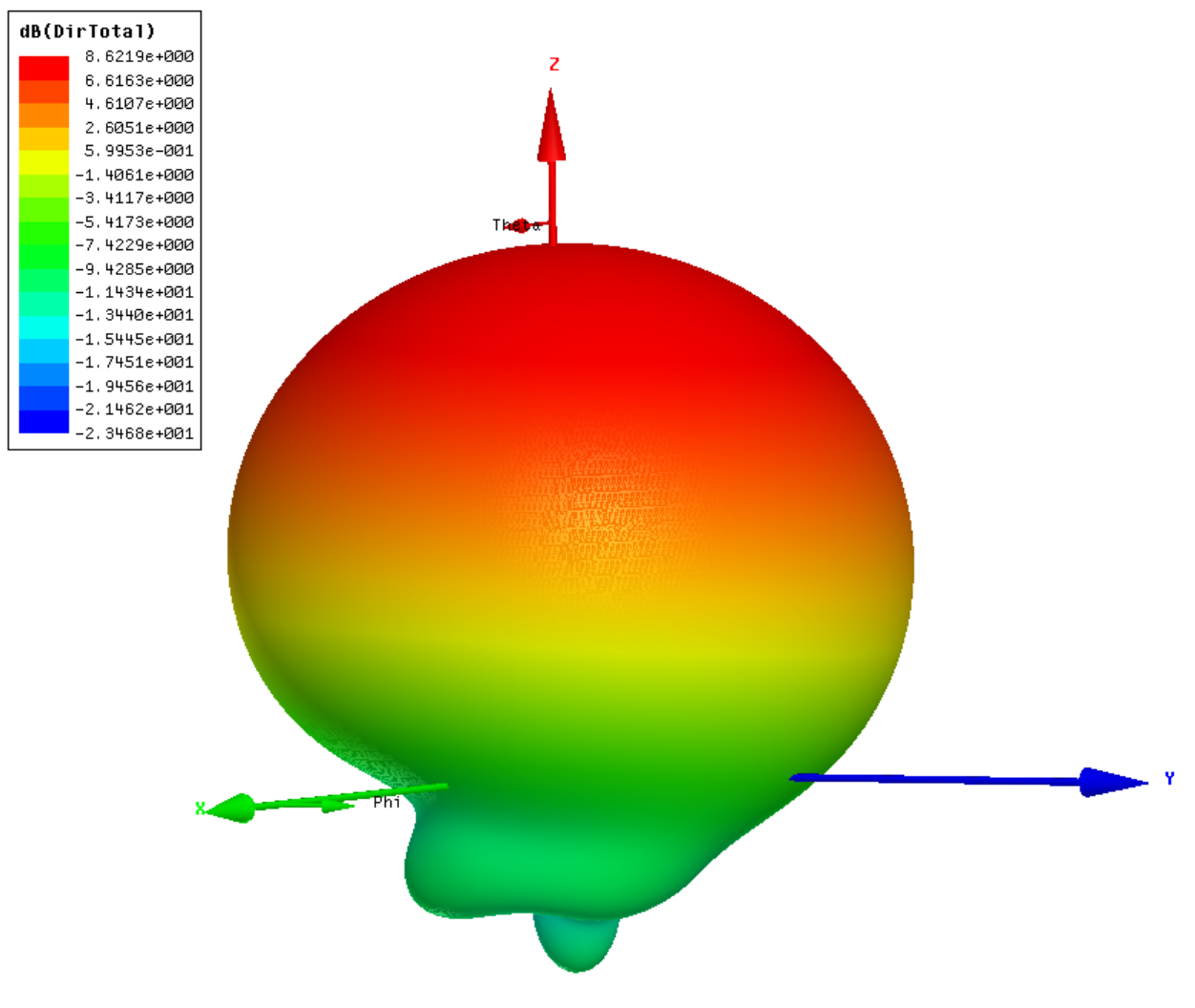
S11, S22, S21 combined



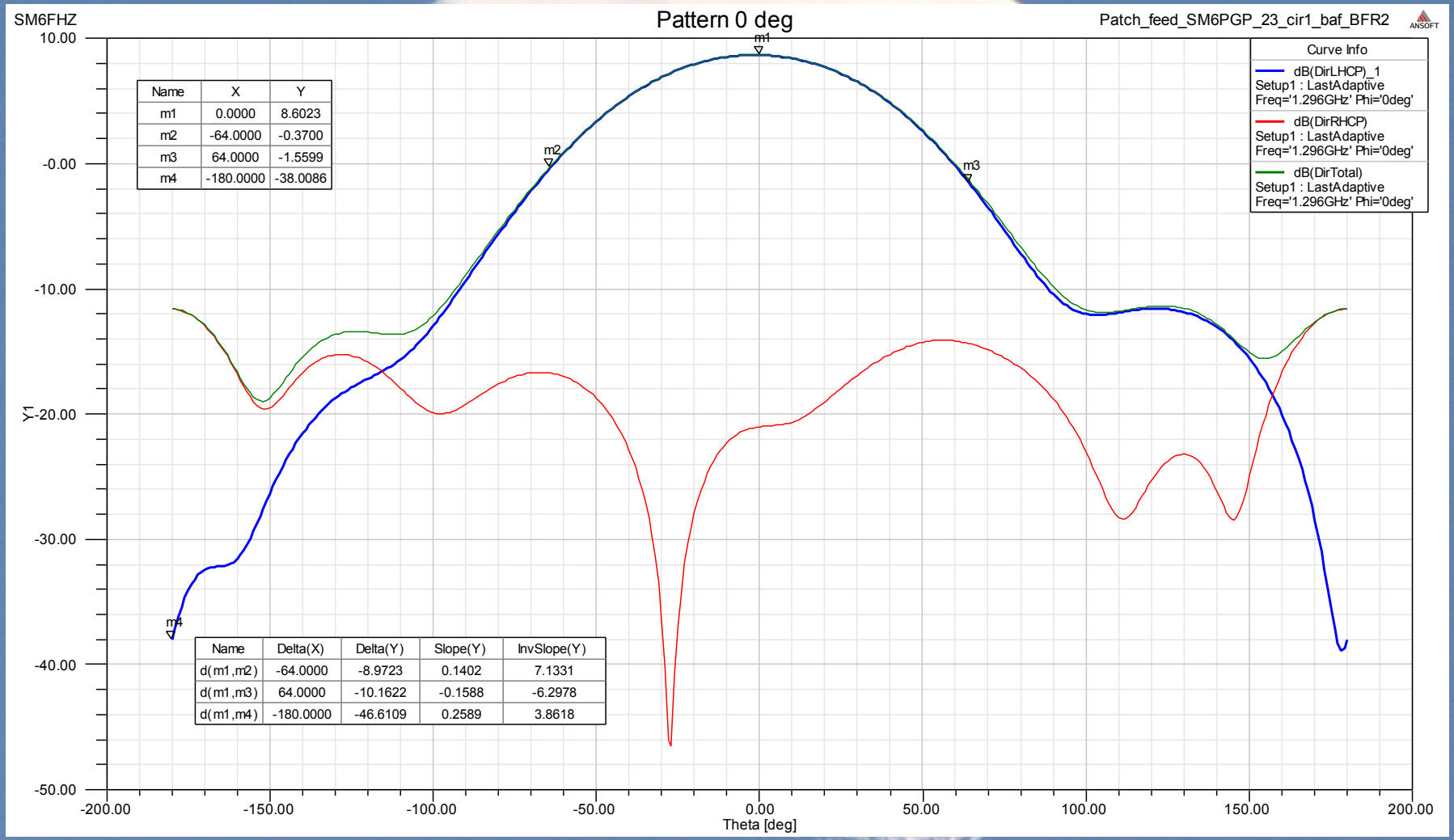
SM6PGP measurements on live model



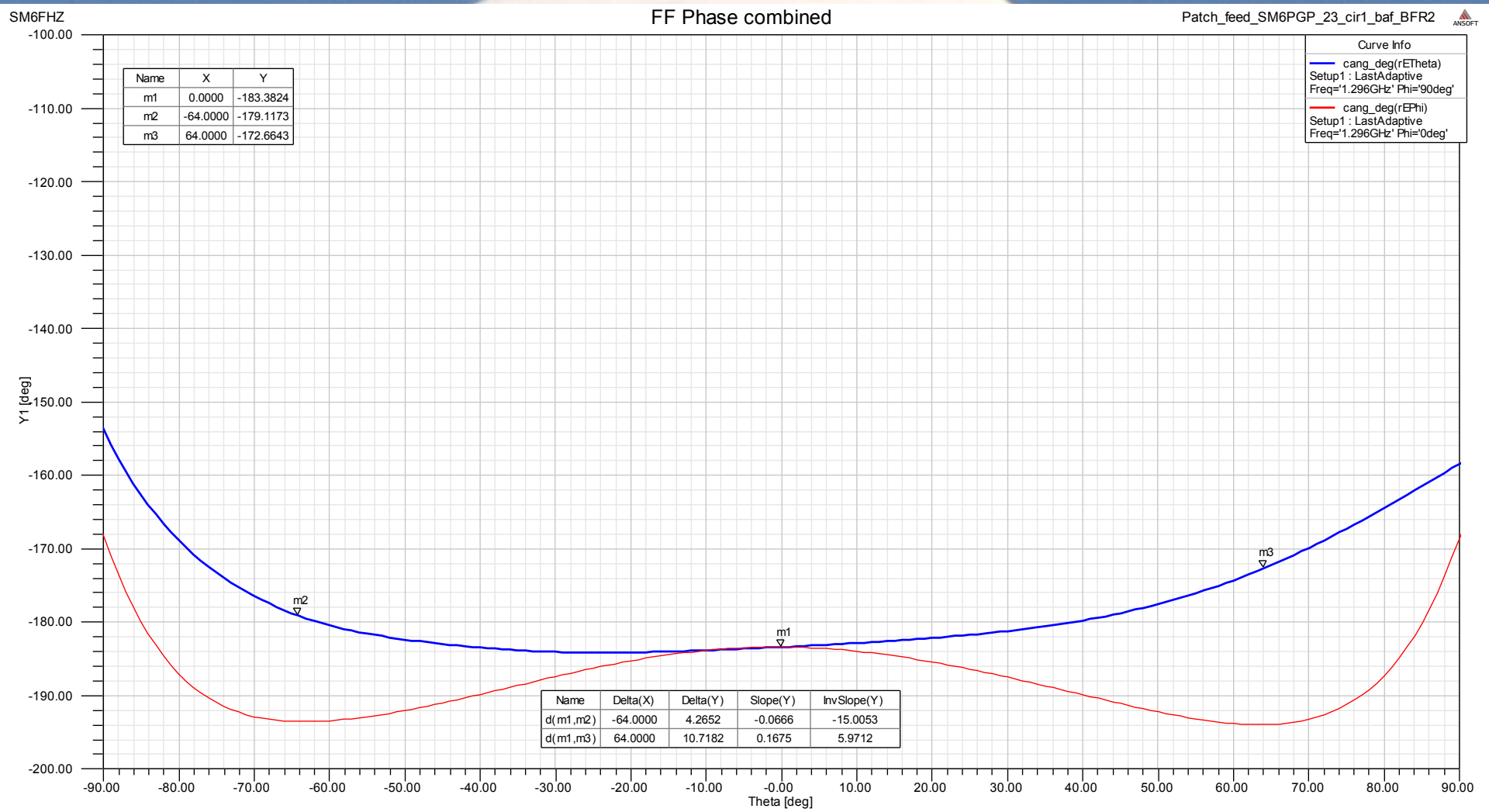
3D Total Power Far Field pattern



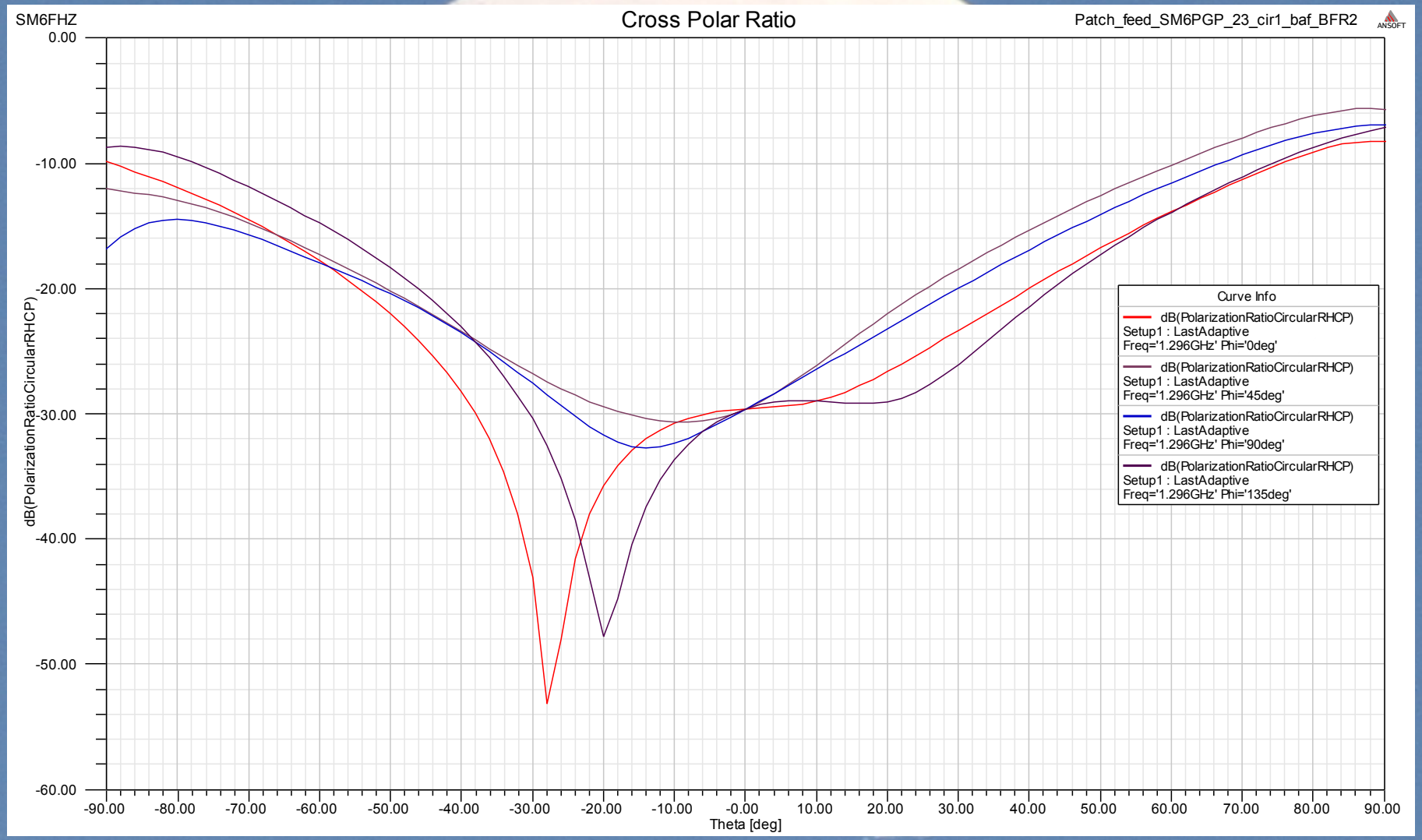
Far Field Pattern 0 deg



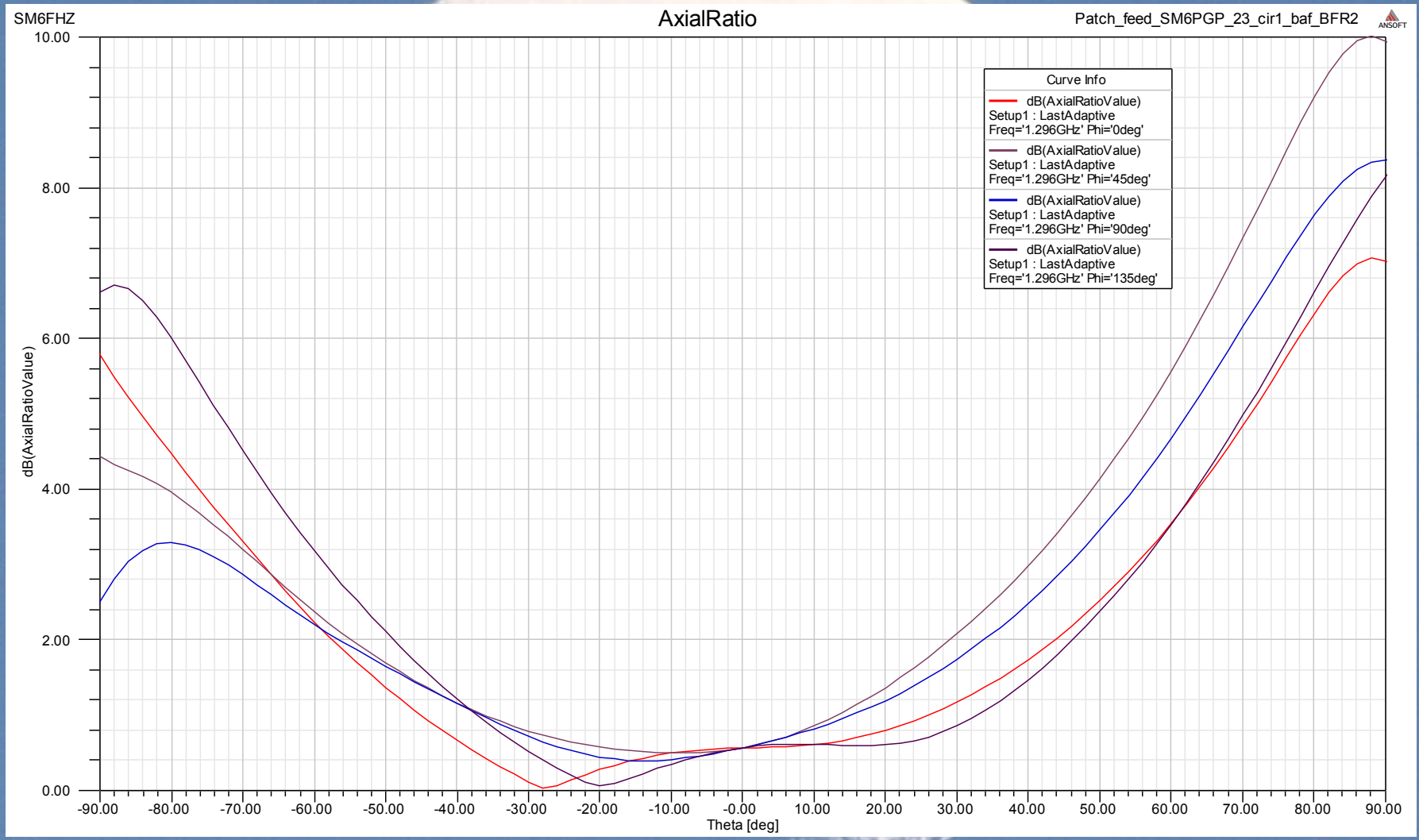
Far Field Phase



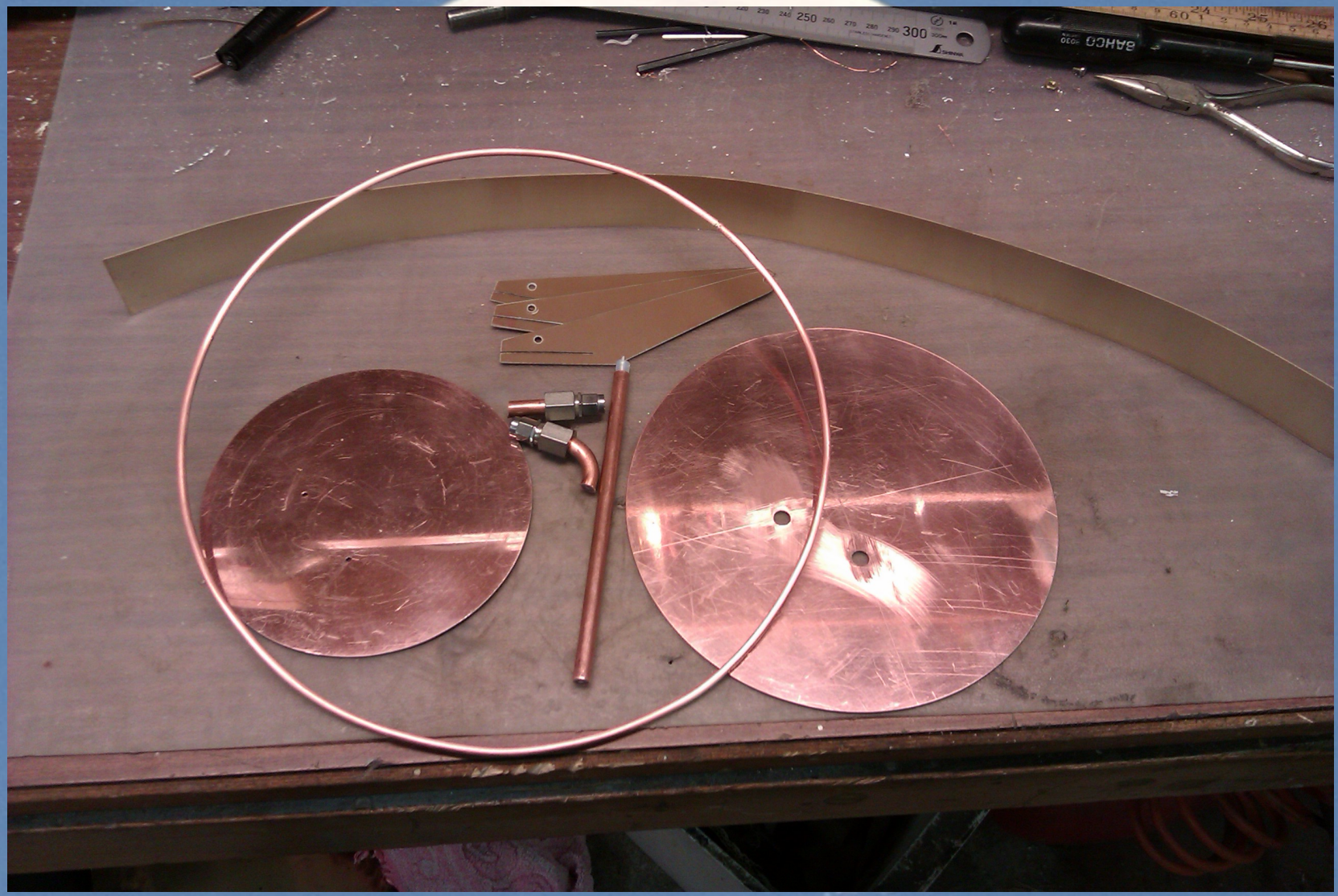
Cross Polar Ratio



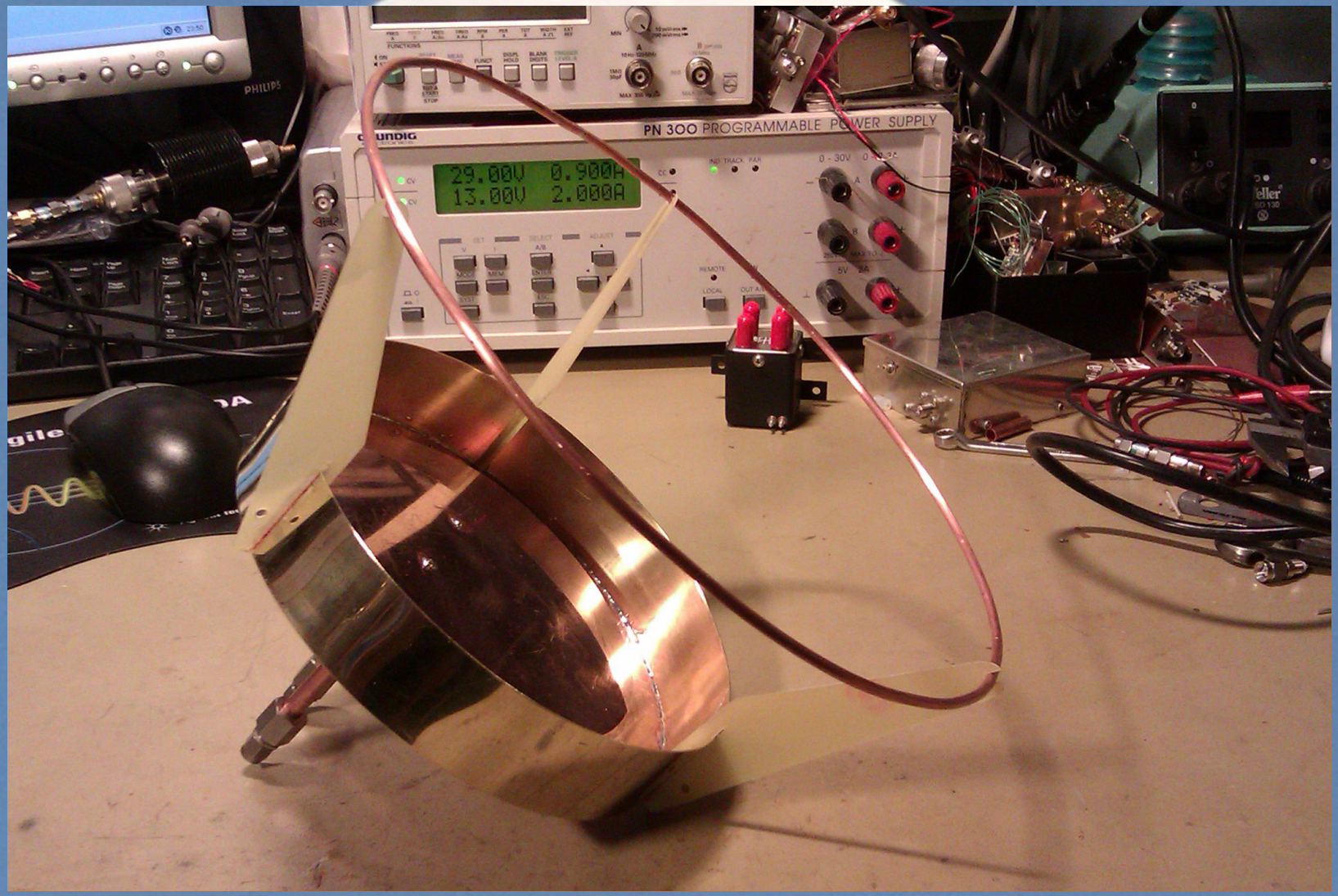
Axial Ratio

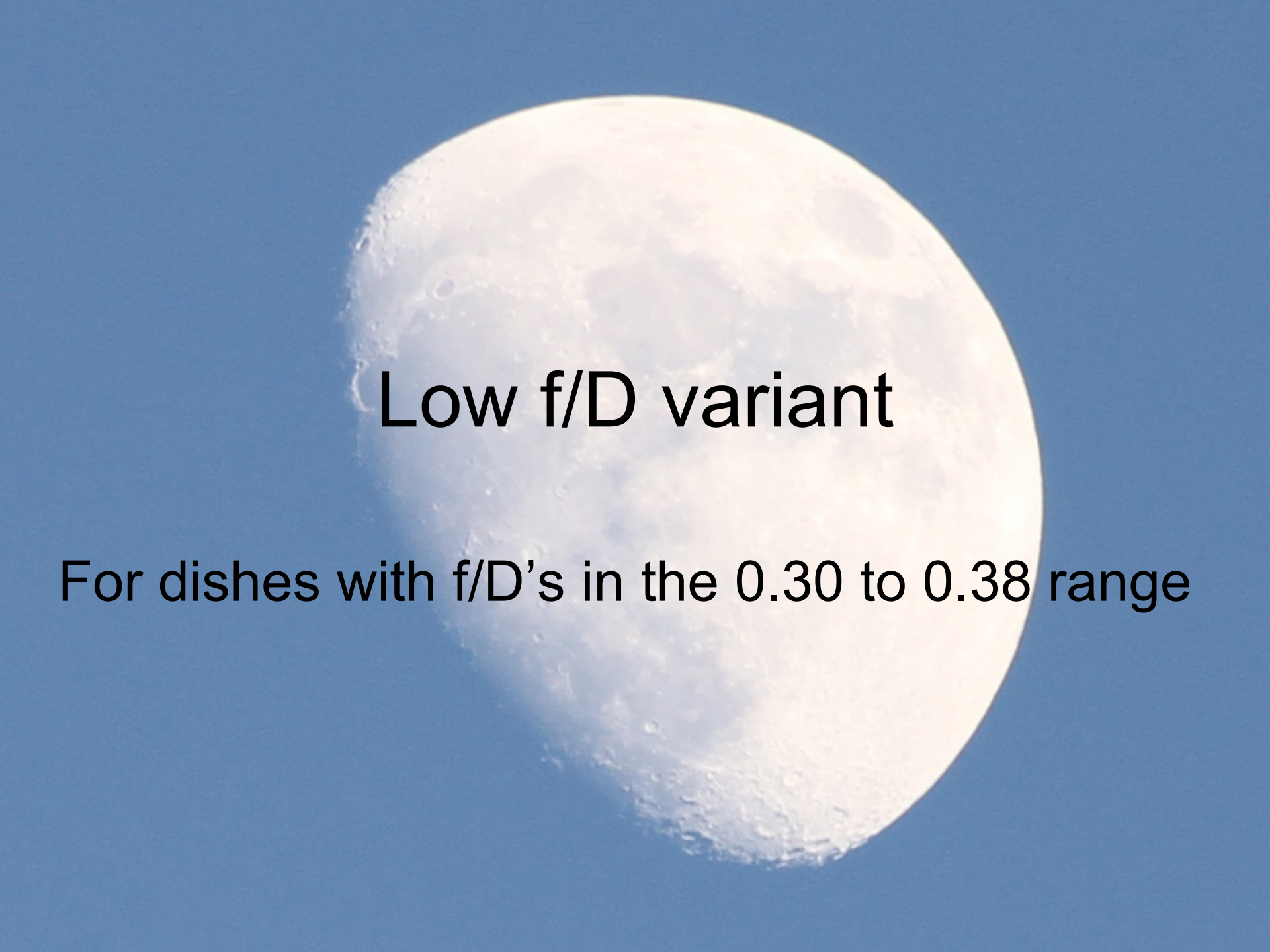

SM6FHZ
AxialRatio
Patch_feed_SM6PGP_23_cir1_baf_BFR2
ANSOFT
Curve Info
dB(AxialRatioValue)
Setup1 : LastAdaptive
Freq='1.296GHz' Phi='0deg'
dB(AxialRatioValue)
Setup1 : LastAdaptive
Freq='1.296GHz' Phi='45deg'
dB(AxialRatioValue)
Setup1 : LastAdaptive
Freq='1.296GHz' Phi='90deg'
dB(AxialRatioValue)
Setup1 : LastAdaptive
Freq='1.296GHz' Phi='135deg'
dB(AxialRatioValue)
10.00
8.00
6.00
4.00
2.00
0.00
-90.00
-80.00
-70.00
-60.00
-50.00
-40.00
-30.00
-20.00
-10.00
-0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
Theta [deg]

Parts cut to fit



Realization

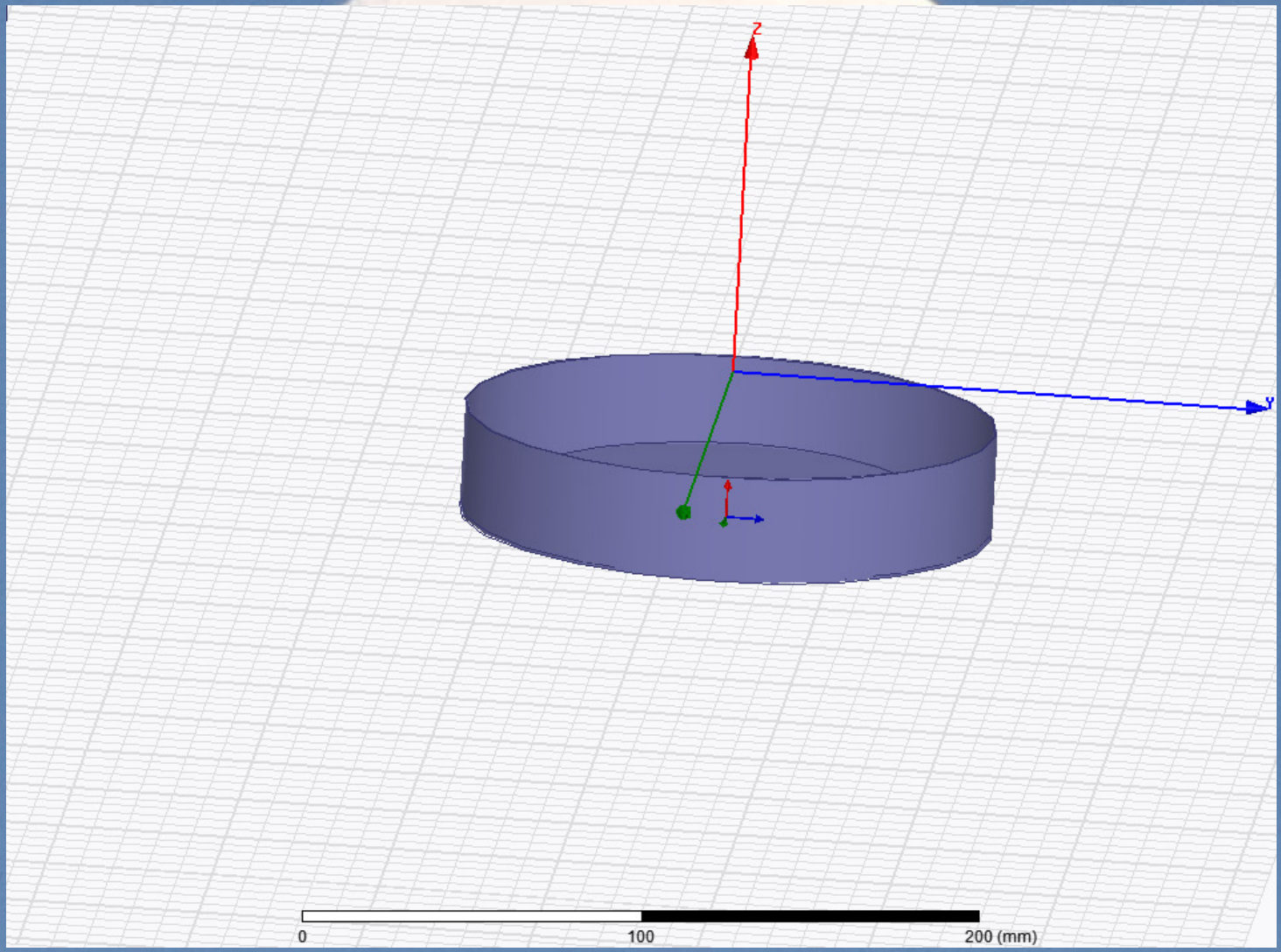




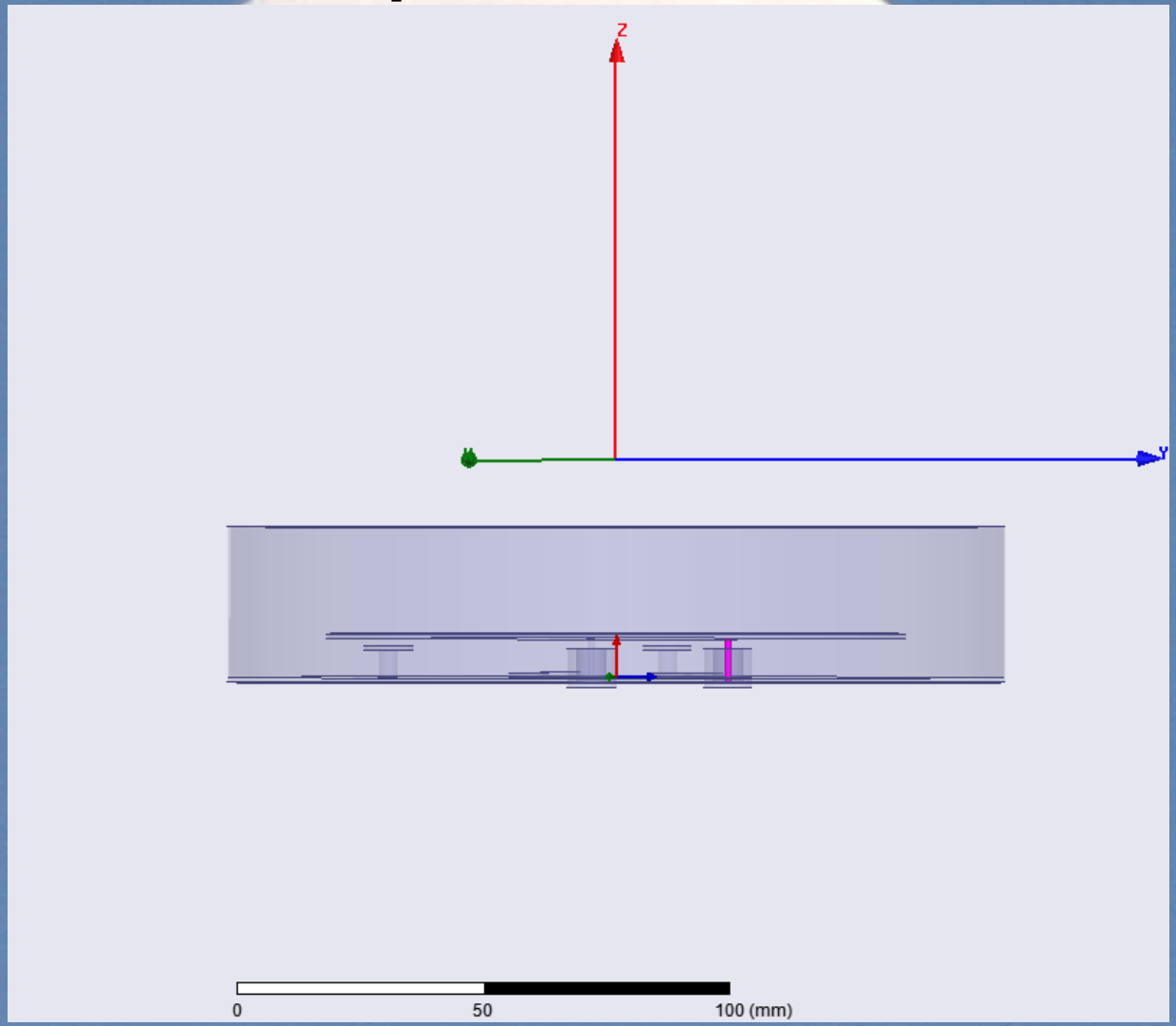
Low f/D variant

For dishes with f/D’s in the 0.30 to 0.38 range

Solid model from the simulation



Transparent model



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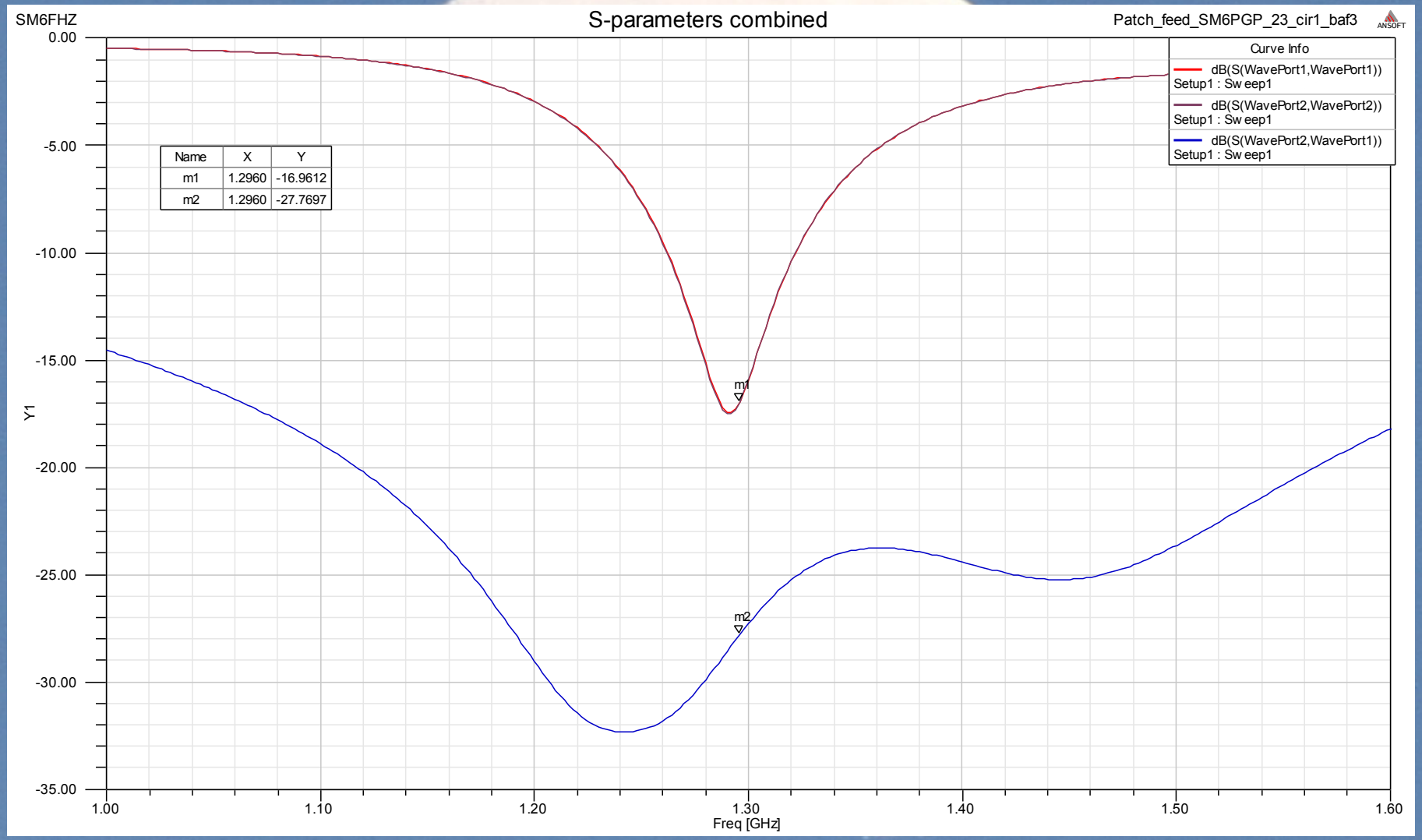
- Phase center 36 mm above the reflector

S11, S22, S21 combined



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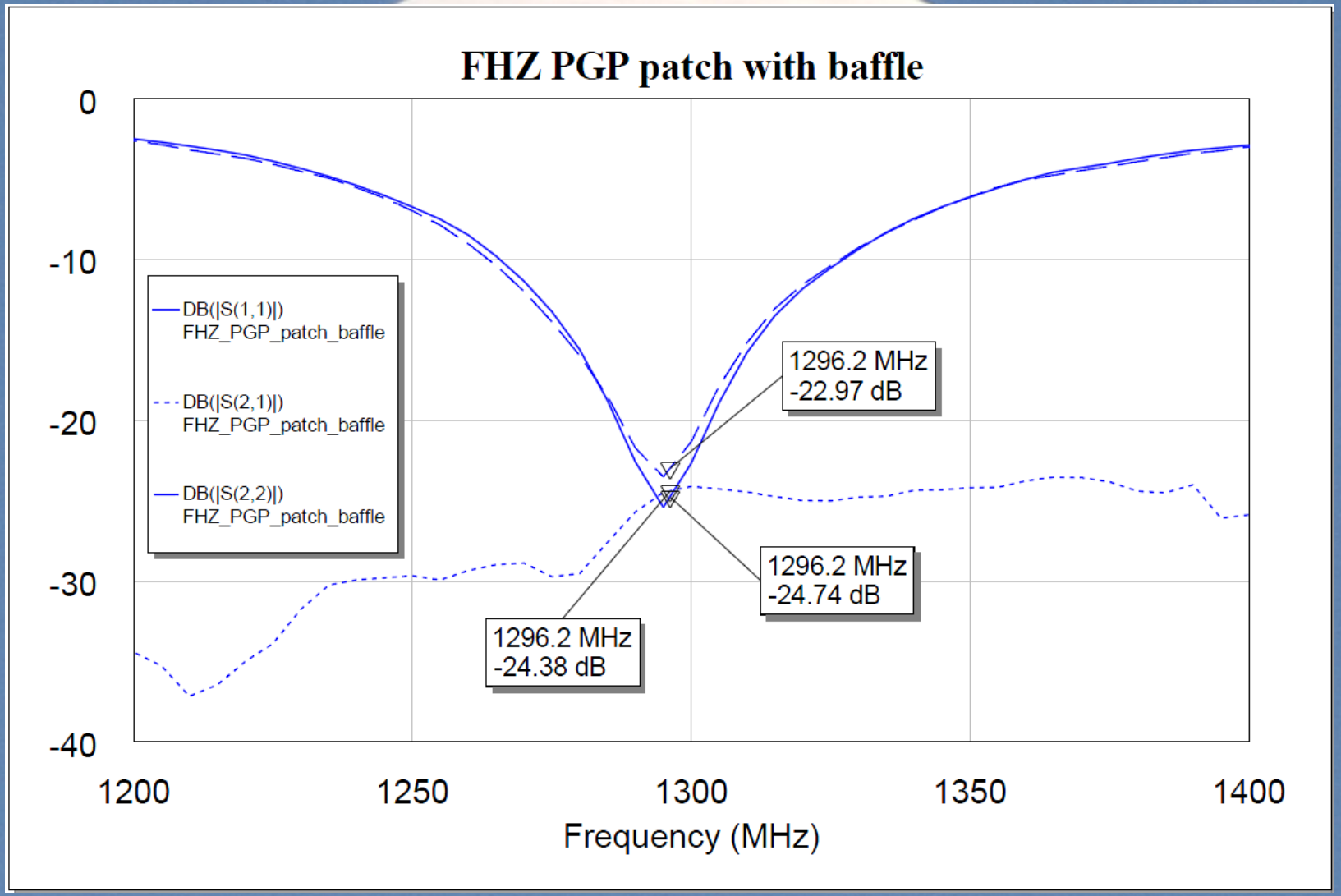

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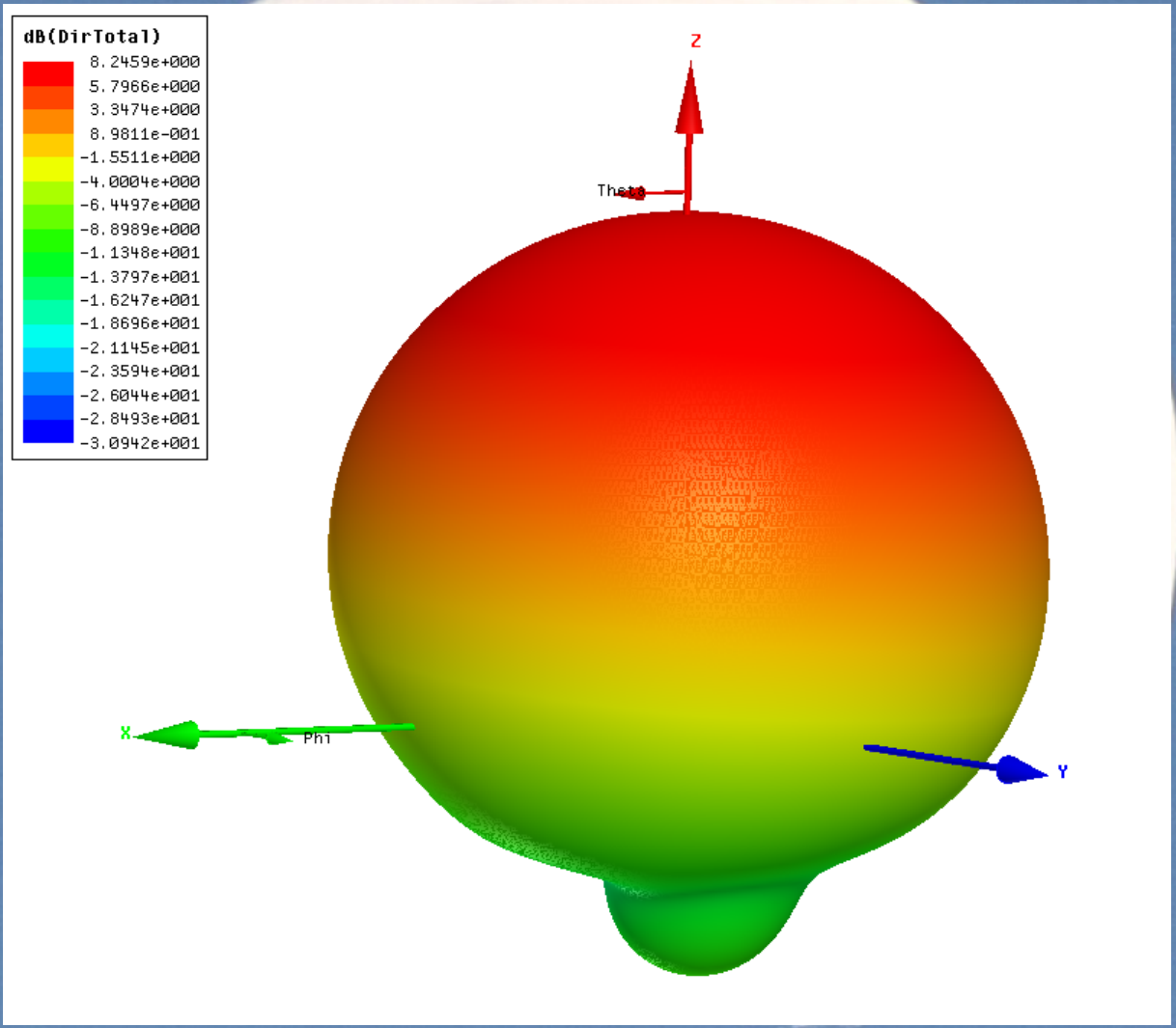
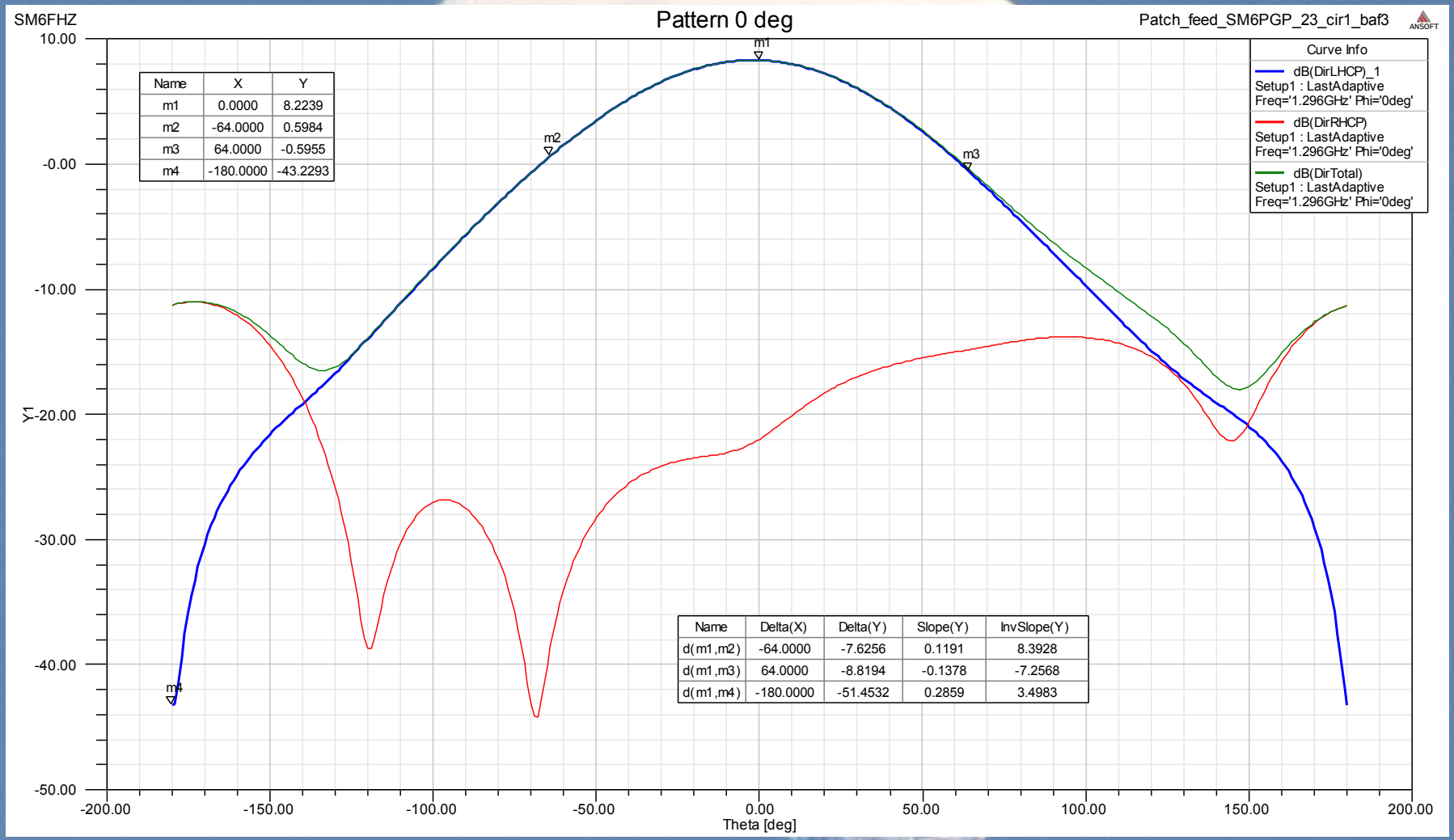
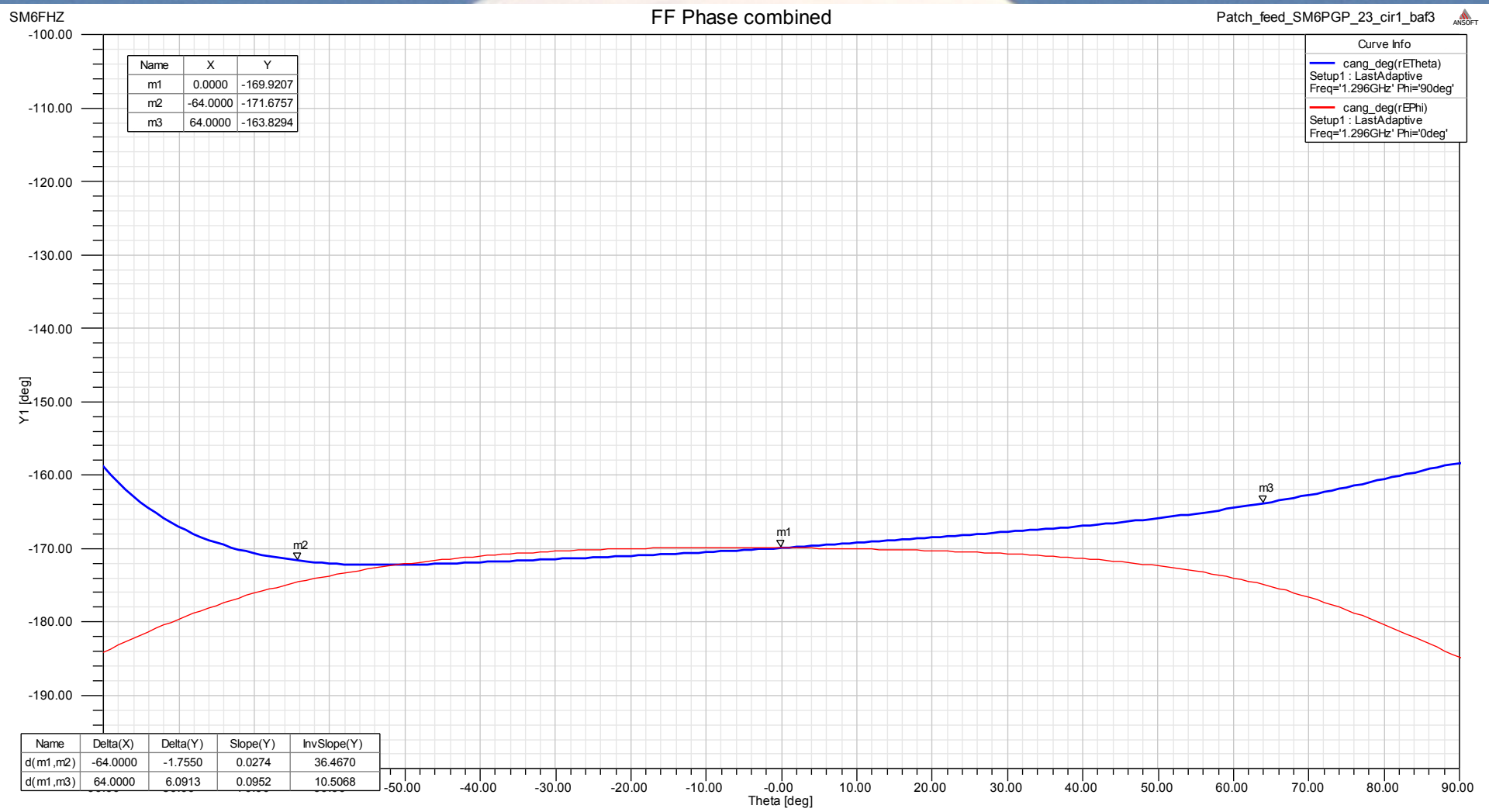


Far Field Pattern 0 deg



Far Field Phase



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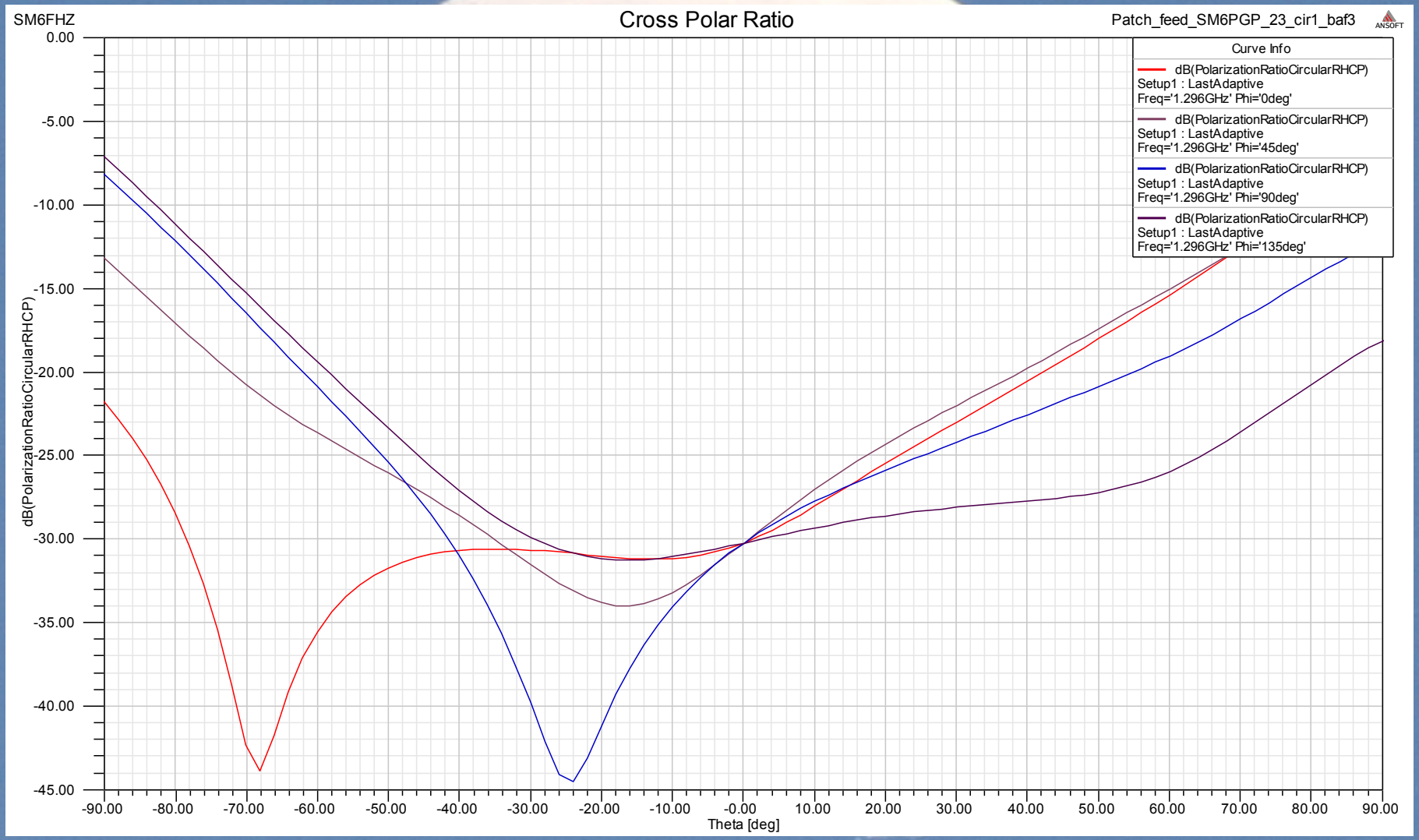
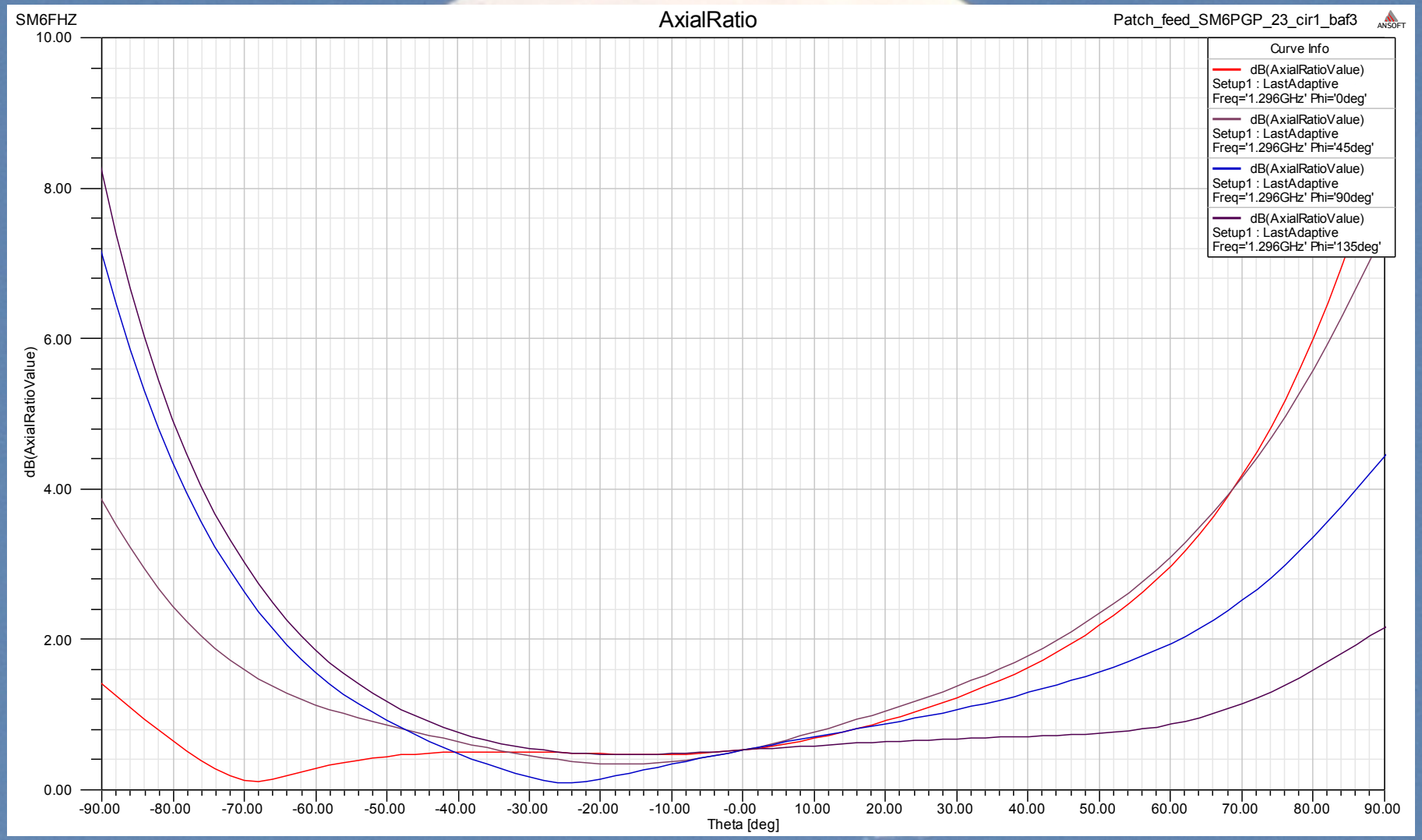


Axial Ratio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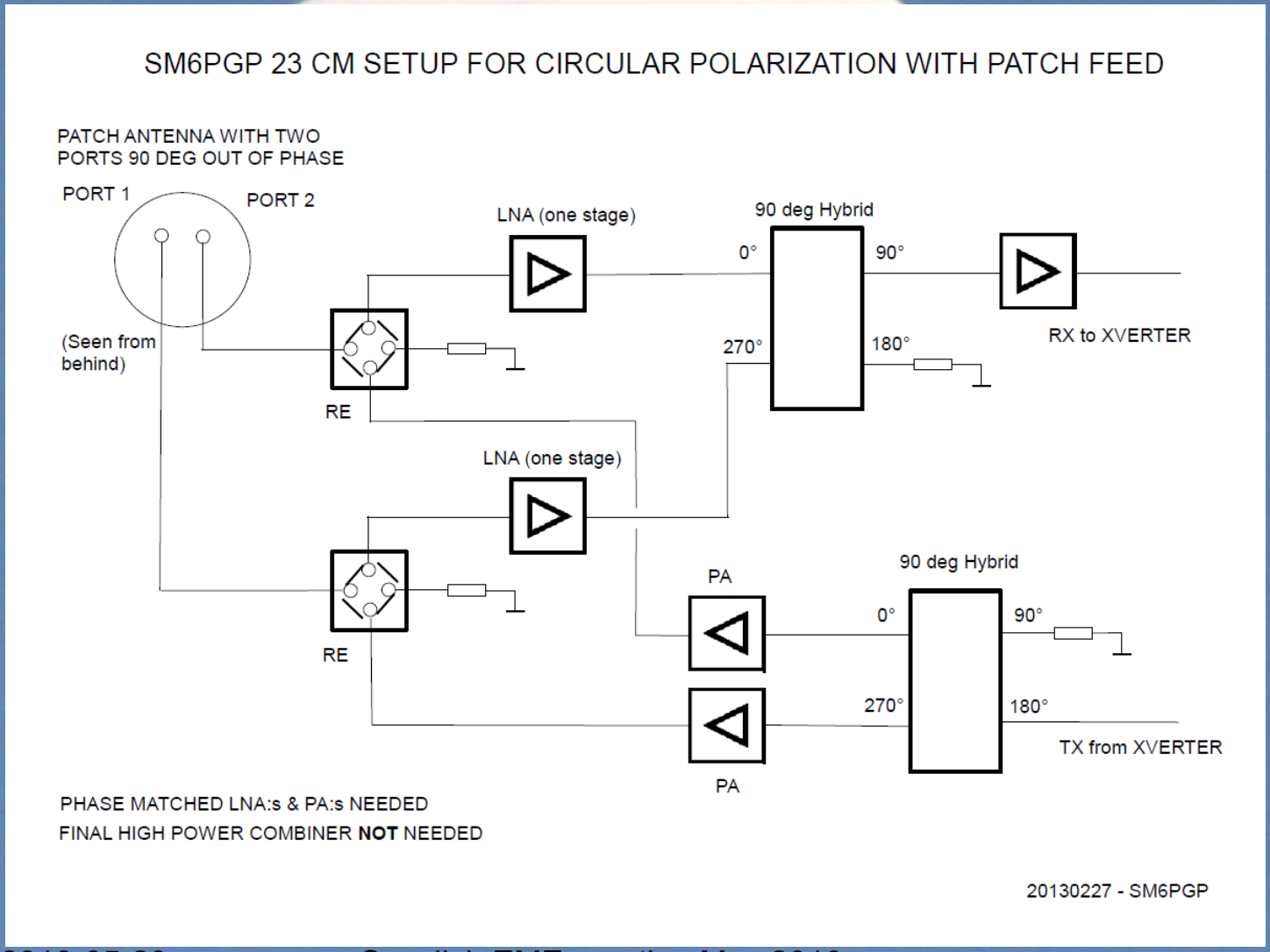
dB(AxialRatioValue)
Setup1 : LastAdaptive
Freq='1.296GHz' Phi='90deg'
dB(AxialRatioValue)
Setup1 : LastAdaptive
Freq='1.296GHz' Phi='135deg'
dB(AxialRatioValue)
10.00
8.00
6.00
4.00
2.00
0.00
-90.00
-80.00
-70.00
-60.00
-50.00
-40.00
-30.00
-20.00
-10.00
-0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
80.00
90.00
Theta [deg]

Feeding of the patch

- In order to get circular polarization you need to feed the two probes in quadrature i.e. 90 deg phase difference between the two probes with coherent signals
- This can be accomplished by a branch line coupler (3 dB hybrid) directly to the probes and gives RHCP on one port and LHCP on the other port of the hybrid
- It can also be done with the hybrids on the low power side and phase and amplitude matched PA's and Pre Amps and thus make use of spatial power combination of the two PA's. See SM6PGP solution
- All phase and amplitude errors introduced in the complete feeding network will be a part of the axial ratio of the radiated polarization i.e. keep track of all phase and amplitude variations (e.g. cable lengths etc)

One good way to set it up



SM6PGP live model in dish

SM6PGP results

- 1.8 m solid dish (0.4 f/D)
- 7.5 dB solar noise with 0.4 dB LNA
- Heard OK2DL and LX1DB on SSB via the moon.
- Hears the ON0EME beacon weak on CW. Hard to get full call.
- Four JT65 and two CW initials worked with a Tx power of 300 W at the feed so far. More than 10 different CW stations heard during the Dubus 23 cm event this year

Conclusions

- This feed may be an enabler for new stations with smaller dishes to get on the moon on 23 cm
- Easy manufacturing, low cost and minimal dimensions together with good performance makes it an attractive alternative for the smaller dishes
- An excellent choice for feeding your small dish for the up-coming SK6OSO EME event (July 13/14, 2013)
  - Feed it in quadrature for circular polarization. Also an excellent choice for linear polarization in deep dishes, use each port separately for linear polarization (i.e. V&H) for terrestrial communication.
- Again, is not easy to feed a small, flat dish in an efficient way. For the smaller dishes, go for a f/D in the 0.3 to 0.4 range
- For the larger dishes the Kumar type W/G feed is still the king of feeds for the lower f/D's


Thank you for your attention
Hope to see you via EME on 23 cm from SK6OSO