Unexplored Areas of 432 MHz Feeds

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Wanted properties of a dish feed

- Optimum illumination of the dish
- No radiation outside the dish, either at the sides or backwards
- Low loss
- Minimal dimensions for less blocking as well as mechanical reasons
- Clean polarization properties (low cross polar radiation)
- Stable phase properties as function of illumination angle (Theta) in all Phi-cuts

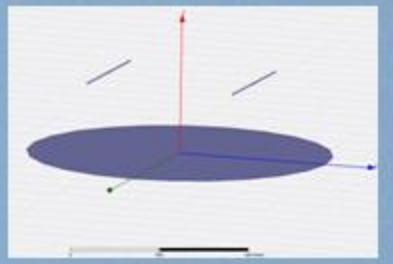
Basic Radiating Elements

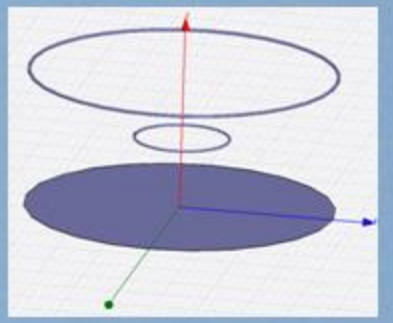
- Dipole
- Loop
- Patch
- Annular Ring
- Are there any fundamental differences between the basic radiating elements?
  - Not really. All have a broader radiation in the H-plane than in the E-plane.
  - It is more or less up to your preferences. Some small differences in the implementation may guide your choice.
  - Some of them are more suited for the implementation of dual polarization in a single element.

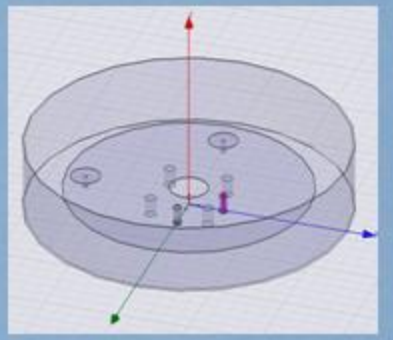
How to Tame the Feed

Main Beam Properties

- Stacking of dipoles in H-plane will equalize the Beam Width (BW) by narrowing the H-plane.
  - E.G. The standard dual dipole feed. Works very well.
- A Beam Forming Ring (BFR) according to Kildal will equalize the BW by narrowing the H-plane.
  - Works equally well on dipoles, loops or patches.
- A baffle (choke) on the reflector edge will equalize the BW by widening the E-plane.
  - A side effect is that the side and back wards radiation is reduced.
  - Works equally well on dipoles, loops or patches.
  - E.G. The 432 MHz loop feed described by OK1DFC.







How to Tame the Feed

Feed Size

- The size of the radiating element is determined by the design frequency and thereby the wavelength.
  - I some cases you can make it smaller by capacitive loading. It is not recommended, as it tends to increase the cross polar radiation.
- Left is the reflector. Large size gives more narrow BW, smaller size gives wider BW.
  - A deep dish needs a wider BW and a shallow dish needs a more narrow BW for optimum illumination.
- Smaller size reflector tends to reduce the front to back ratio (FBR) of the feed. A choke helps in this case.
- Larger size reflectors (typically 1 wl) will increase the blockage.
  - A small size shallow dish needs a large reflector feed for reducing the spill-over but will then increase the blockage. At lower frequencies and small dishes, it is beneficial with a deeper dish (f/D ~0.35).

How to Tame the Feed

Unwanted radiation

- **Cross Polar Radiation**
  - The Cross Polar Radiation shall be as low a possible, as it “steals” power from the wanted polarization. A CPR of 10 dB takes away about 0.4 dB of your power from the wanted polarization.
  - You will not see this reduction when measuring solar noise as it contains all polarizations. Your EME returns are mainly one polarization at a time.
  - Cross Polar Radiation is most cases exited by any asymmetries in the feed. It can in some cases be reduced by using a baffle on the reflector.
- **Side and Back Lobes**
  - Side and back lobes are any radiation, in any polarization, that is not directed towards the dish surface. Parts of the main lobe can “miss” the reflector as well, if the dish is over illuminated.
  - This unwanted radiation both steals power as well as picks up noise from the surroundings.
  - The back lobe is most of the time not directed towards ground and by that does not pick up much noise, but it does not radiate power towards the dish. This power is lost. A FBR of 10 dB gives a loss of about 0.4 dB
  - Strong back lobes are mostly seen on feeds with small reflectors. A baffle on the reflector does help here as well.

How to Tame the Feed

Feed Losses

- In the receive case we want to keep the losses as low as possible in order to avoid increasing the antenna noise temperature.
- In most contemporary feed designs the resistive losses are very low.
- Simulations show very low losses, they almost disappear in the accuracy of the simulations.
- Use materials with good conductivity, make all junctions with good connection and use high quality dielectrics.
- Most of the resistive losses close to the feed come from the relay, any cabling used and connectors and coax adapters.

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

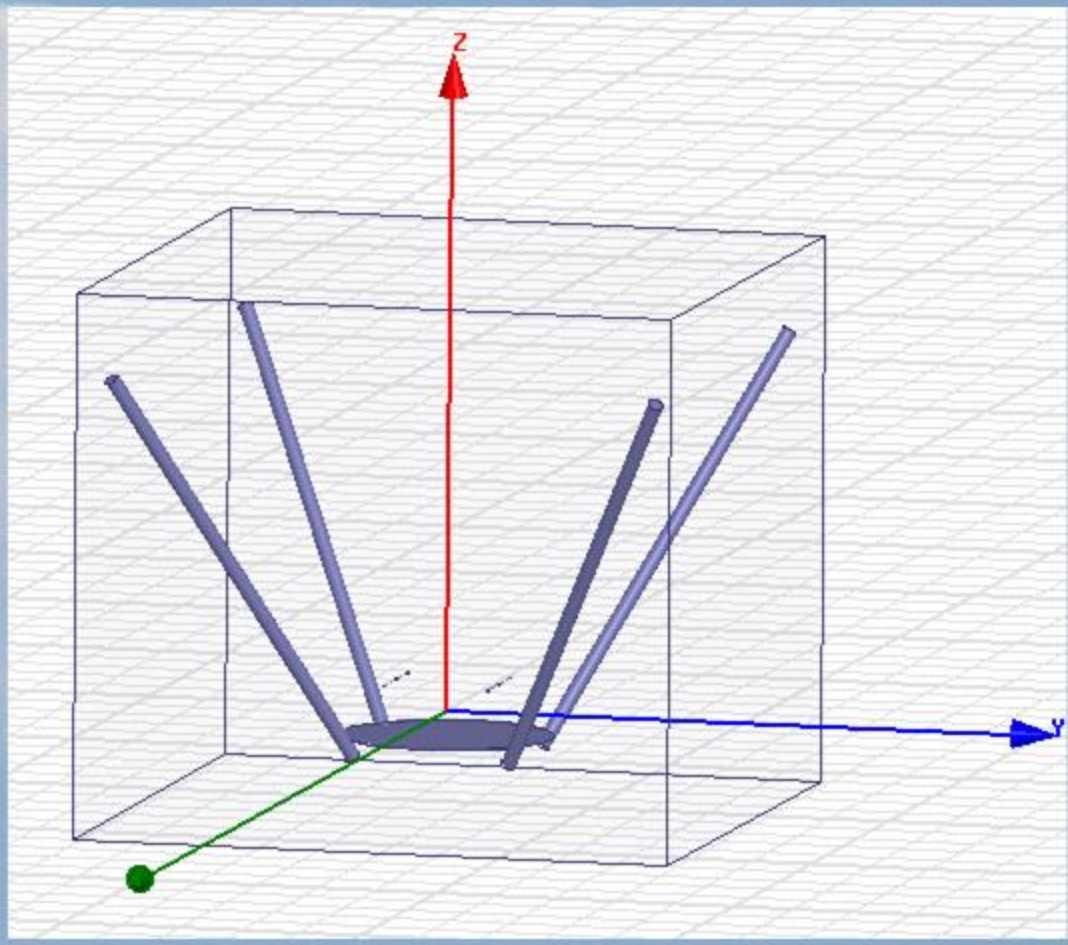
Dish Reflexion

- How bad can it get?
  - 432 MHz, +10 dBi feed in a 5.5m 0.37 f/D dish will result in 12.9 dB Return Loss (RL) from the dish itself.
  - 432 MHz, +8.3 dBi feed in a 10m, 0.4 f/D dish will result in 20.6 dB RL.
  - 1296 MHz, VE4MA type feed in a 5.5m, 0.37 f/D dish will result in 28 dB RL.
  - 1296 MHz, W2IMU type feed in a 8m, 0.45 f/D dish will result in 26 dB RL.
  - 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.
- How to handle the reflexion.
  - G3LTF has made a paper on how to tune a Dual Dipole feed in the dish by using a stub.
  - K5GW reports that moving the feed back and forth can result in a position that the inherent reflexion in the feed and the reflexion from the dish cancel. Keep track of the phase centre using this method.
  - OK1DFC reports going from 30 dB RL on the feed in free space to 50 dB RL with the feed in the dish when in the focal point.
  - Additional hints on how to handle this reflexion are welcome!

Putting the Feed in a Dish

Feed Supports

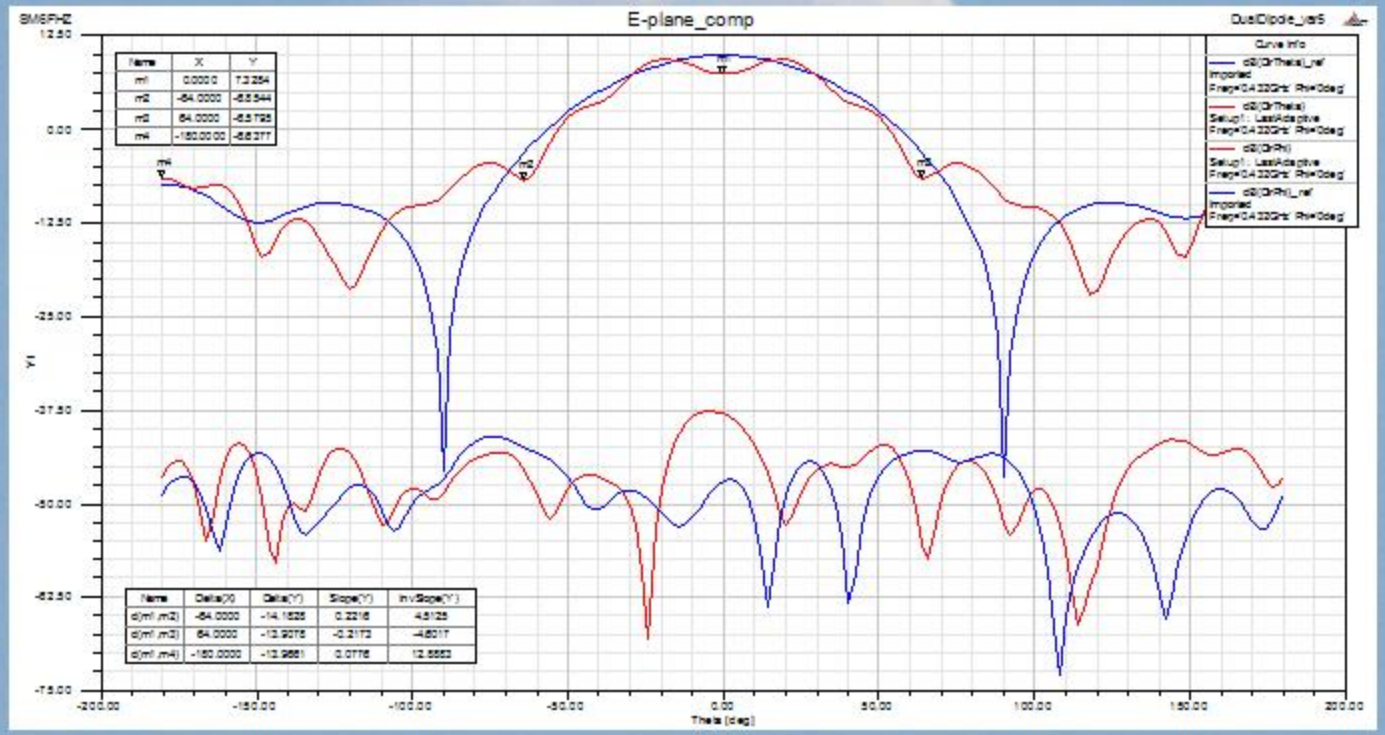
- Model
  - Dual Dipole Feed
  - Four metallic tubes (50mm diameter, 1600mm long)



Putting the Feed in a Dish

Feed Supports

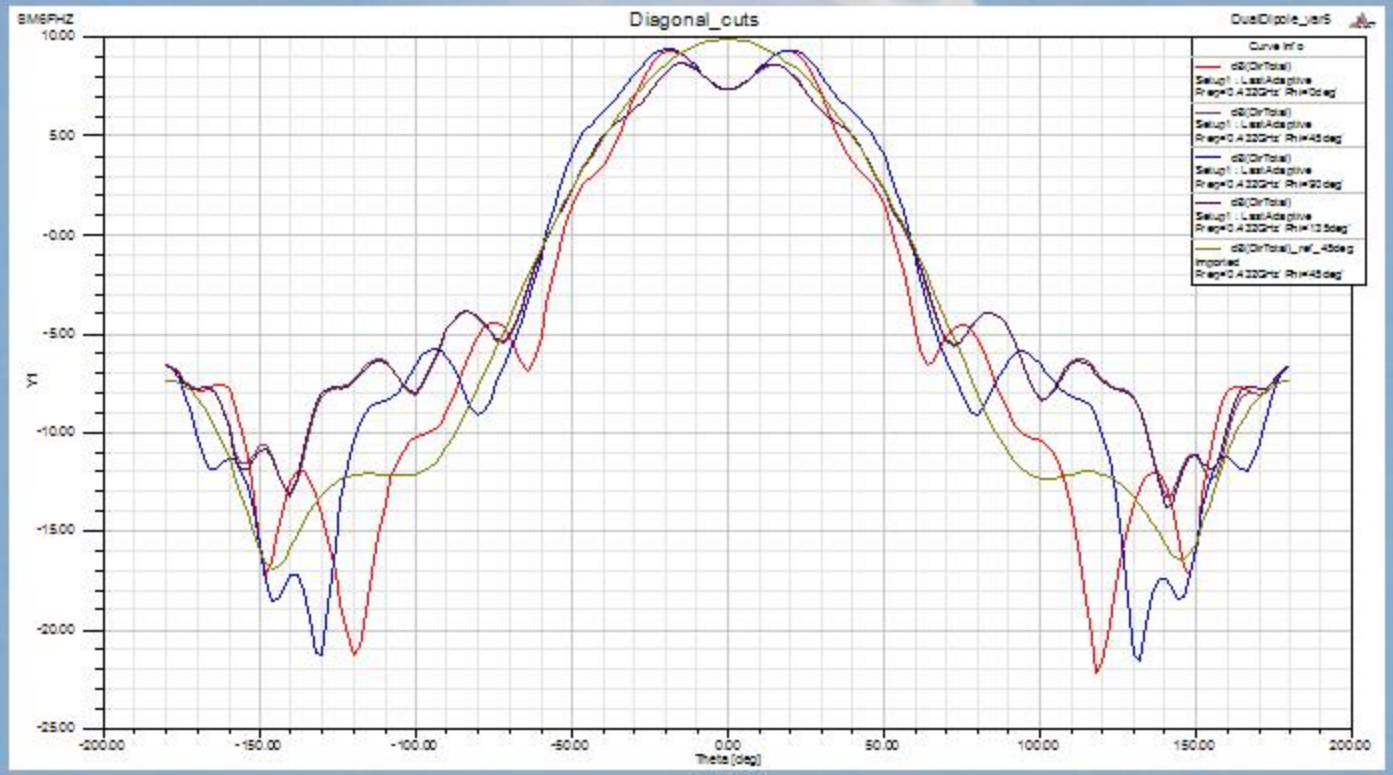
- E-plane Radiation Pattern, Co and Cross pol
  - Blue curve; reference, Red curve; with supports



Putting the Feed in a Dish

Feed Supports

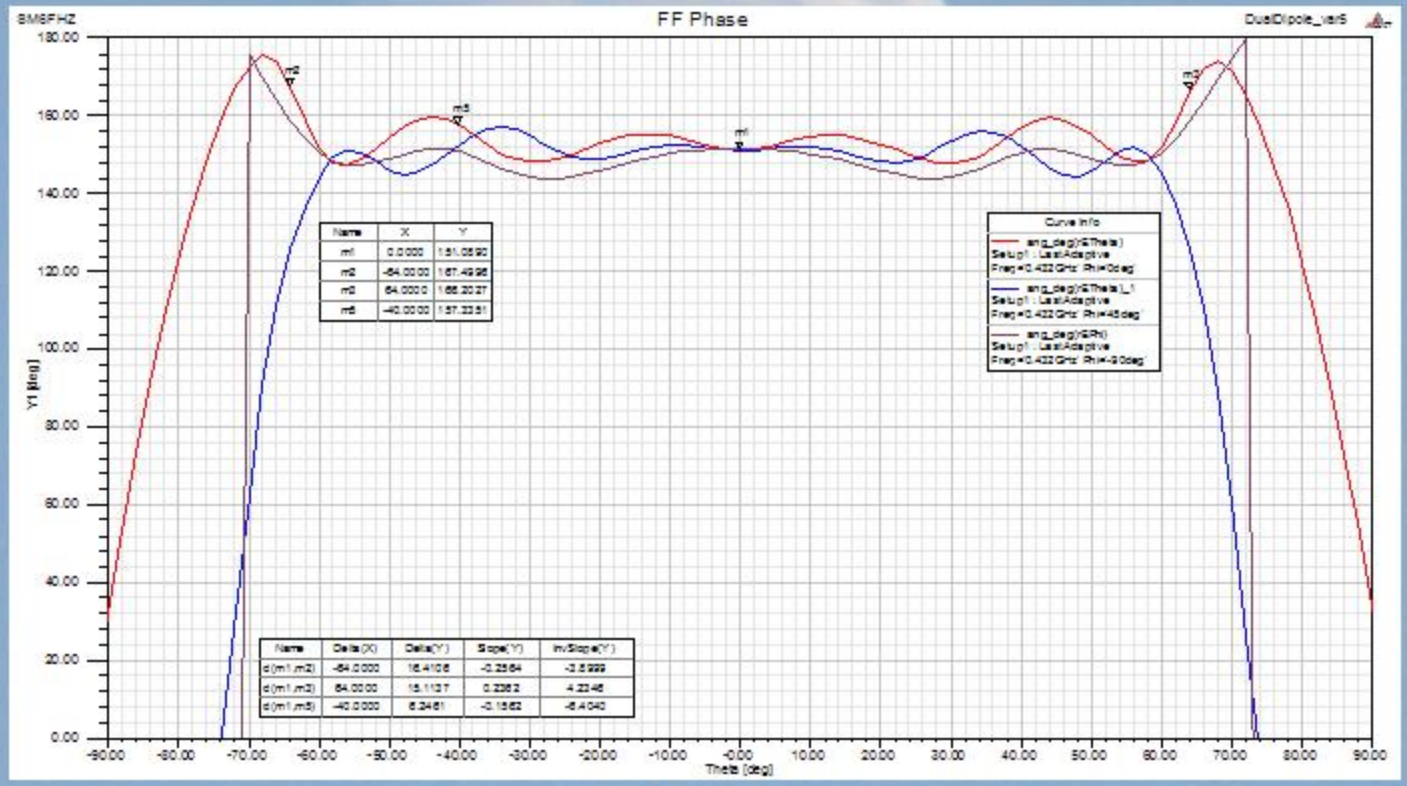
- Diagonal-plane Total Power Radiation Patterns
  - Olive-green curve; reference 45 deg cut, other curves; with supports



Putting the Feed in a Dish

Feed Supports

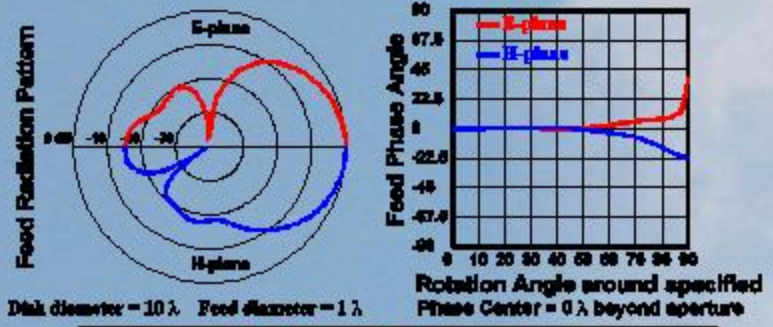
- Far Field Phase variation with support legs
  - Red: E-plane (0 deg cut), Blue: 45 deg cut, Brown: H-plane (-90 deg cut)

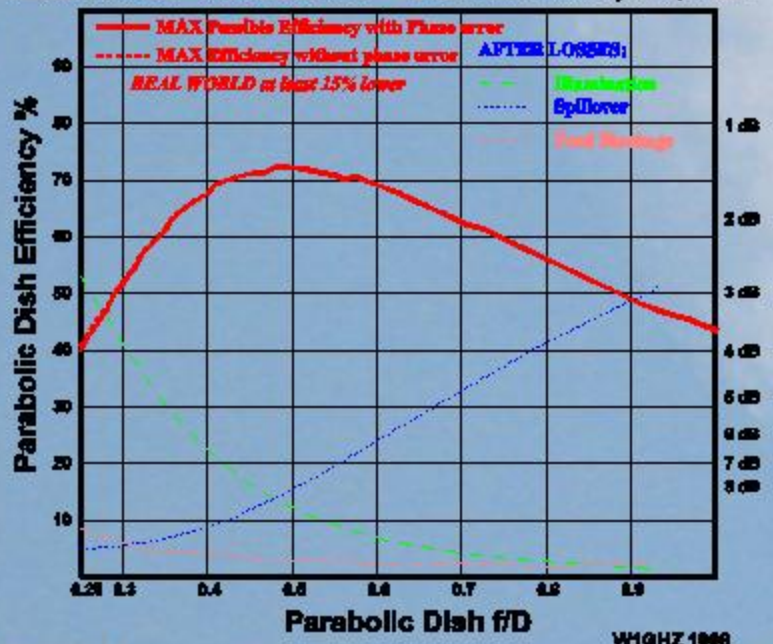


Putting the Feed in a Dish

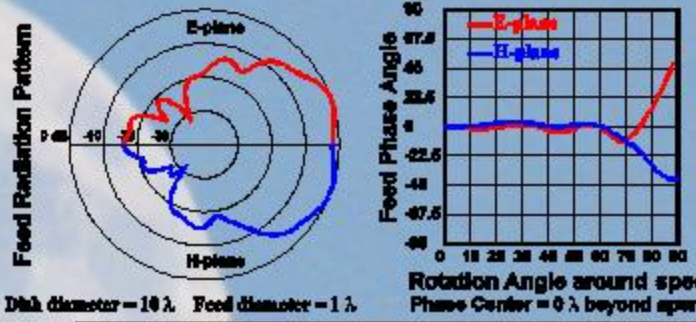
Feed Supports; InDish Performance

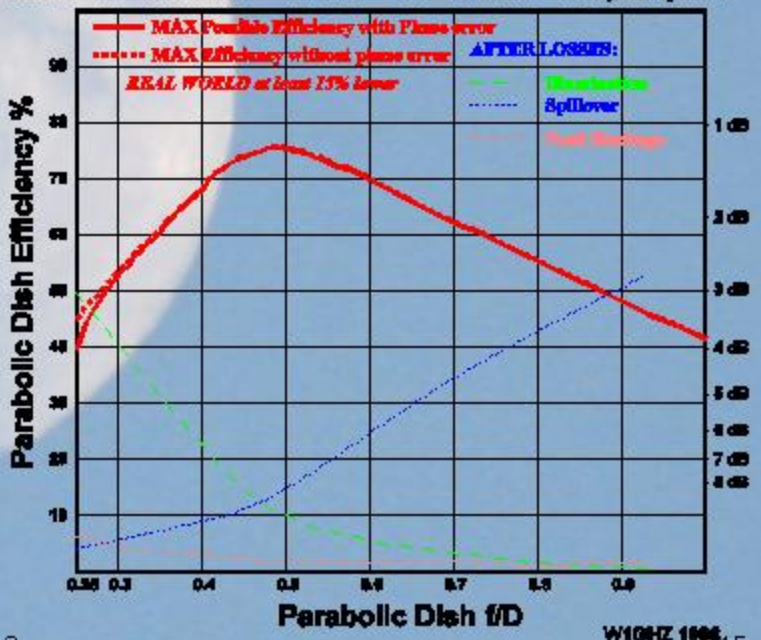
Dual Dipole circular reflector





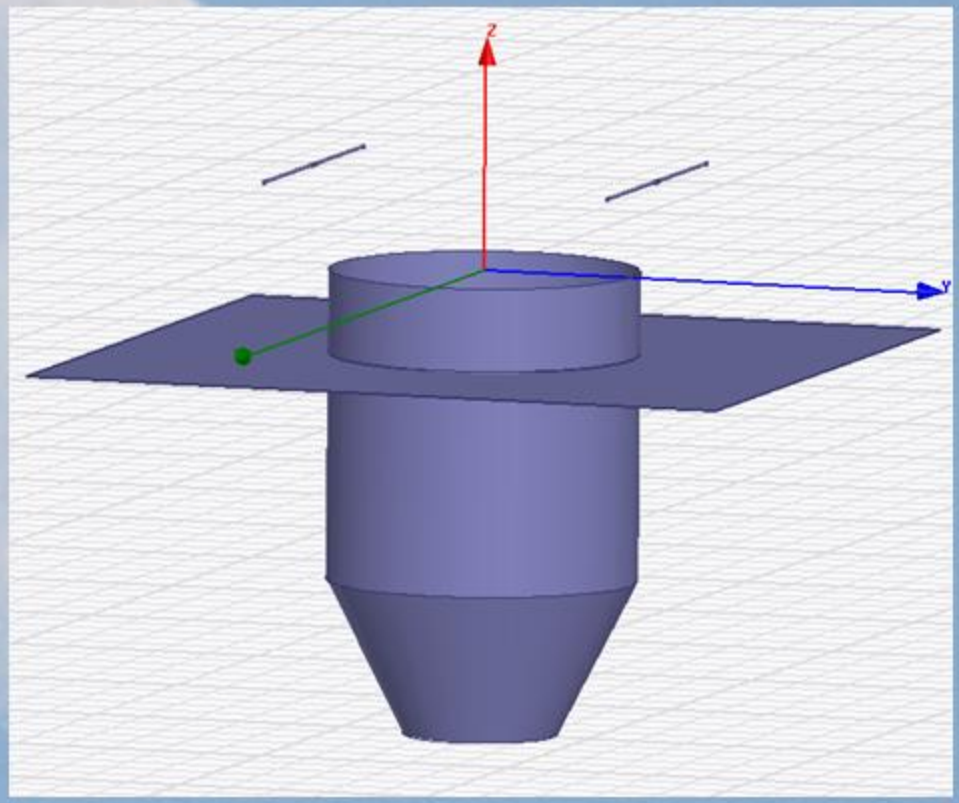
Dual Dipole w. support legs





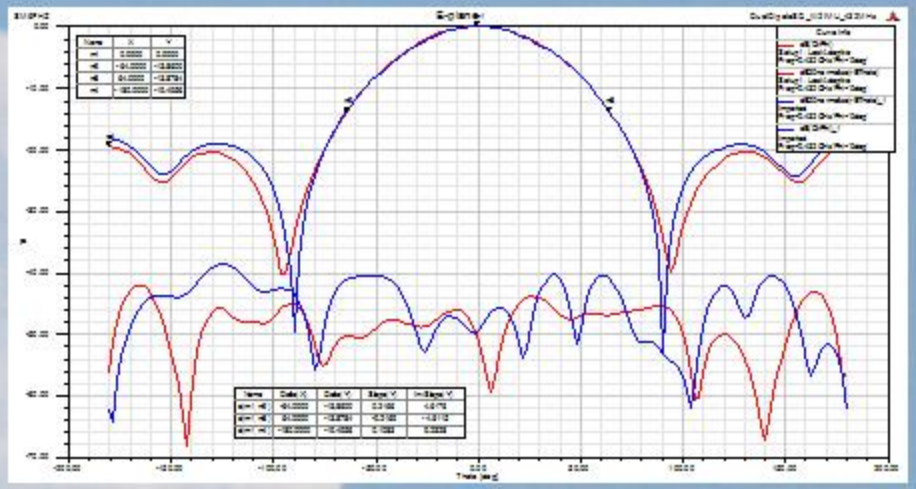
Dual band configuration

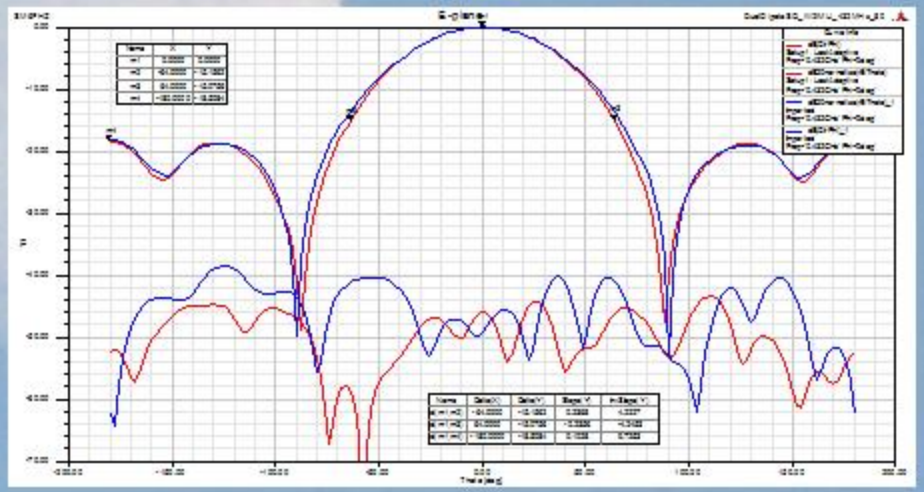
- The simulation model consists of two dipoles above a square reflector and the WG mouth part of the Dual Mode feed. The mouth of the 23 cm feed is 60 or 80 mm above the reflector surface.



Dual band configuration

The blue curves are the reference feed without 23 cm horn and the red curves are the pattern for the feed with the 23 cm feed horn 60 mm (upper) and 80 mm (lower) above the reflector surface.

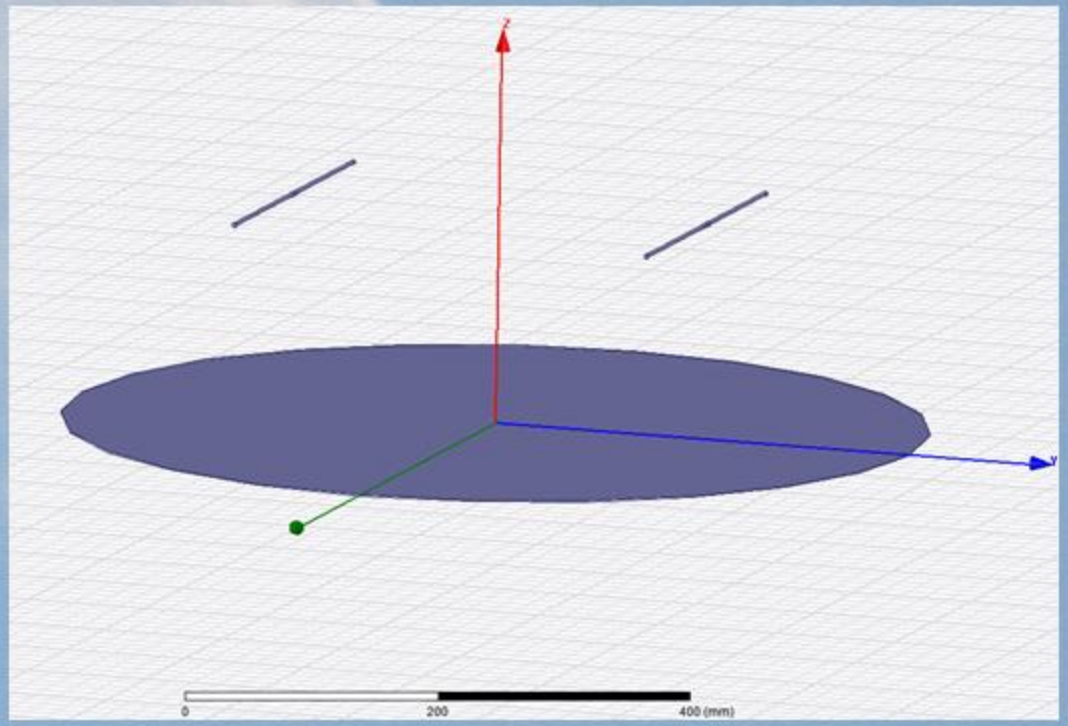




Tolerances

How sensitive is the RF-performance of the feeds to mechanical tolerances?

- Reflector size
- Dipole height
- Dipole length

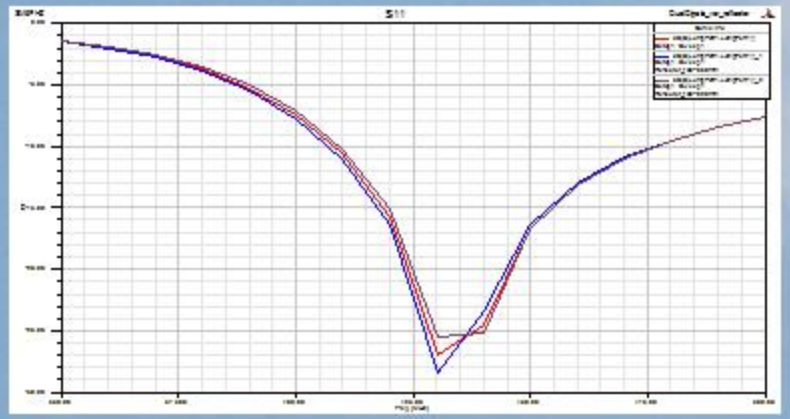


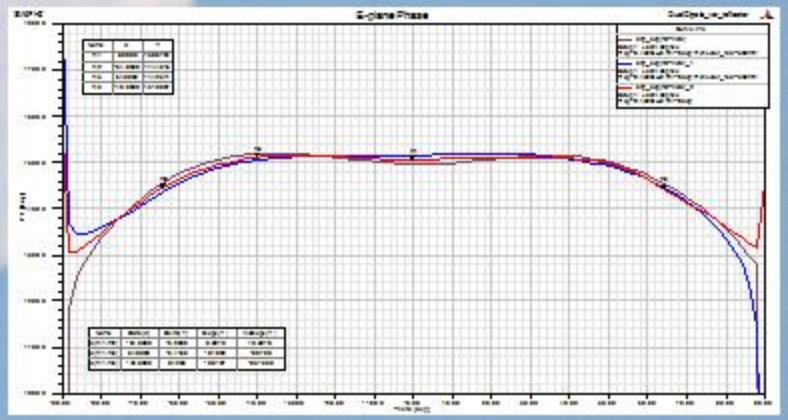
Tolerances

Reflector size

A variation of plus / minus 20 mm on the reflector radius.

Not much impact on the performance.



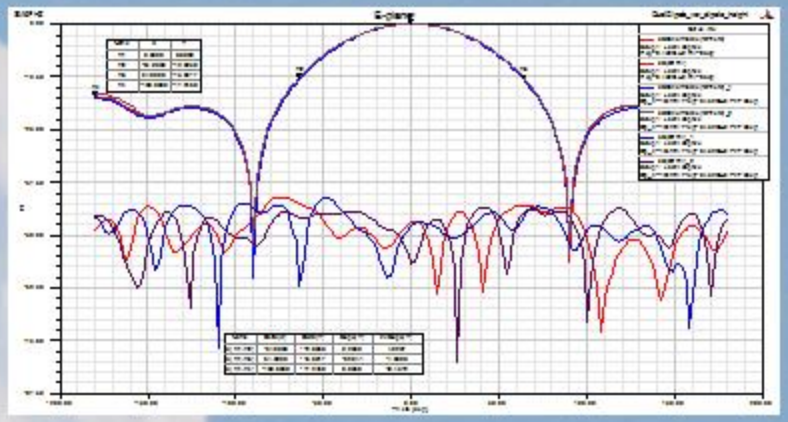


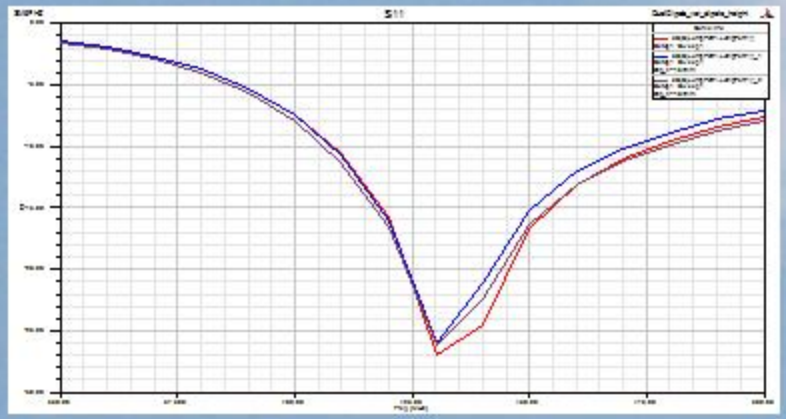
Tolerances

Dipole height

A variation of plus / minus 10 mm on the dipole height.

Not much impact on the performance.





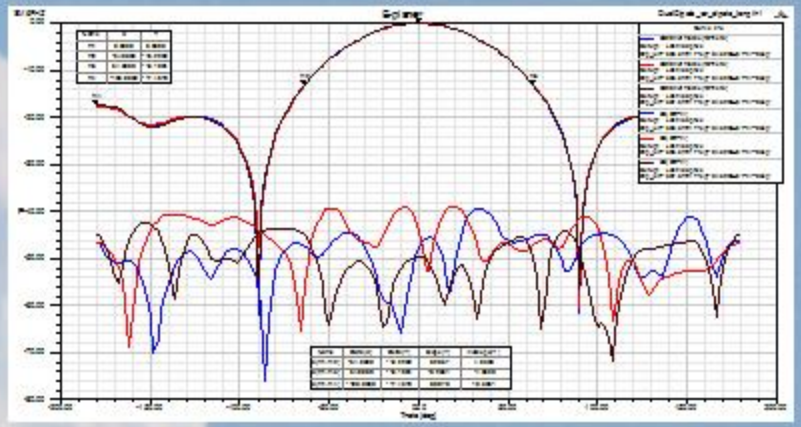
Tolerances

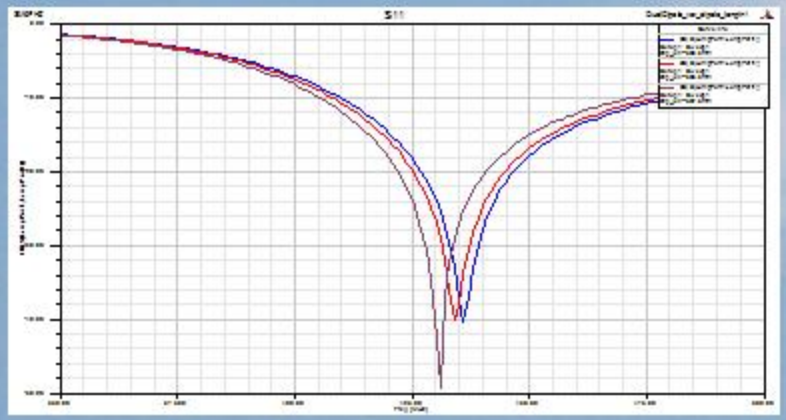
Dipole length

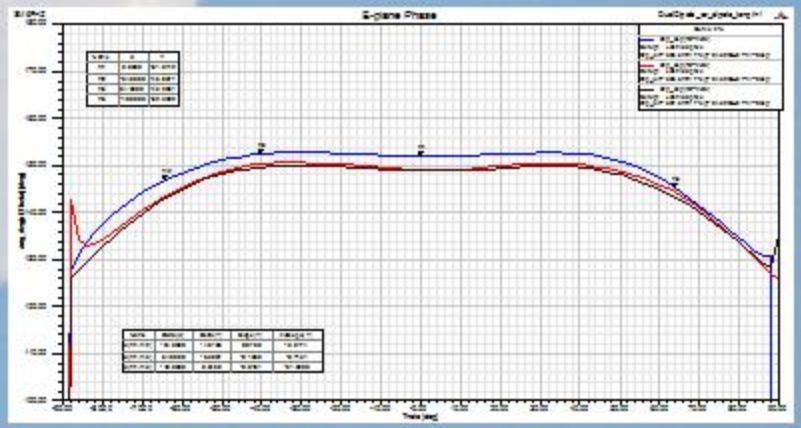
A variation of plus / minus 2 mm on the dipole length.

Not much impact on the radiation performance.

The resonance frequency moves a expected.







Summing up

- Choose carefully the feed for your dish. There is a lot of performance to be gained by finding the optimal feed for your situation.
- There are pitfalls in choosing the feed but they can be avoided with some care in the choosing process.
- The performance of a feed changes when put into a dish, but can be handled.
- The Dual Band configuration comprising the W2IMU Dual Mode feed (23 cm) and the Dual Dipole feed (70 cm) works very well on 70 cm.
- Moderate variations in dimensions on the most common 70 cm feeds are not disastrous for the radiation performance of the feed.


Thank you for your attention
See you all via 70 cm EME!

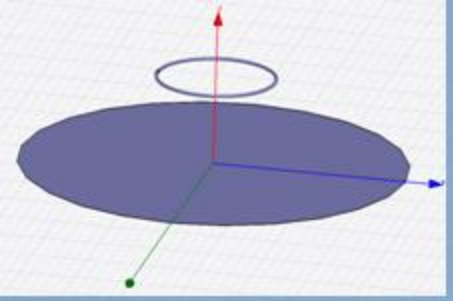
Extras

Just in case…

Putting a feed into a dish

You need to adopt the choice of feed to your dish

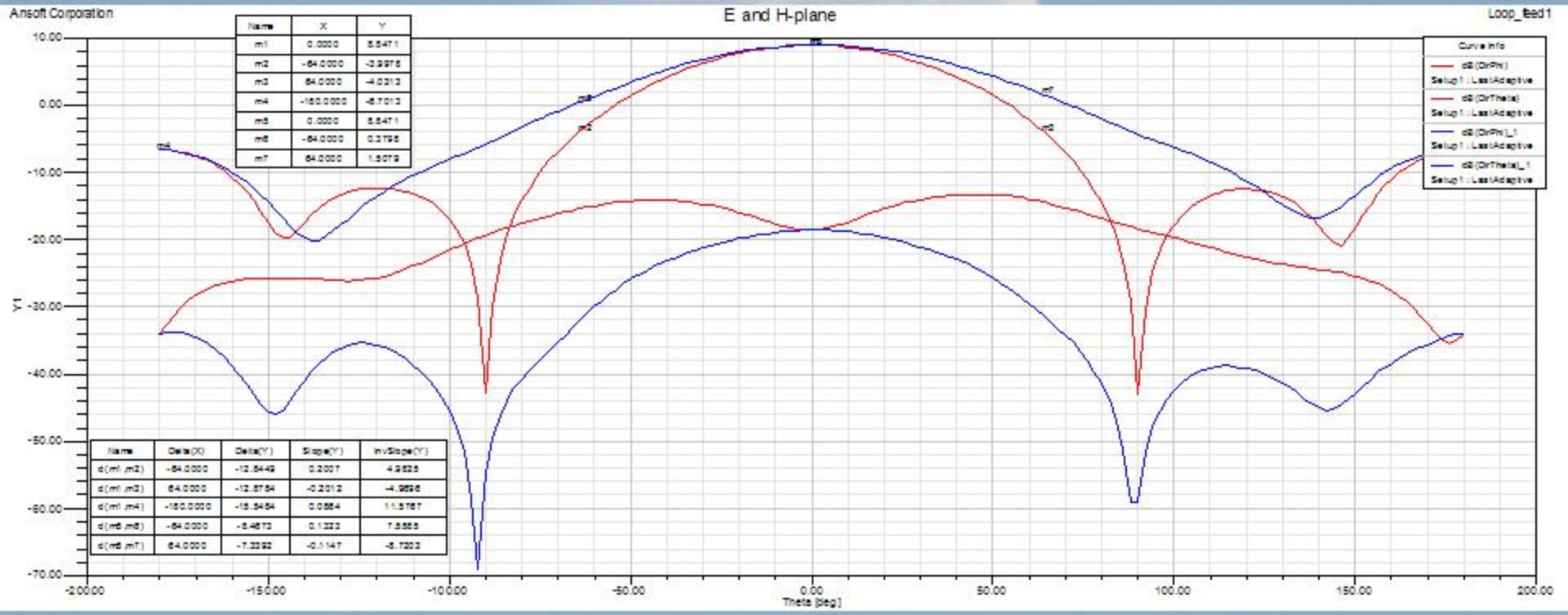
- An larger feed reflector will give a more narrow pattern and is more suitable for a more shallow dish and in turn a small feed reflector gives a wider beam and suites a deeper dish
- A smaller reflector gives a lower FBR and can in bad cases “steal” power from the illumination i.e. direct the power where you want it – your dish surface
- A smaller (<7-8 WL diam.) shallow dish is difficult to feed as you will get a substantial blockage from the feed needed
- An very deep dish is also difficult to feed with good performance

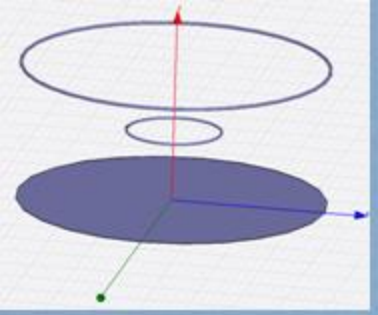


Taming a feed

The starting point for a loop feed

- Standard one WL loop, one quarter WL over one WL diameter reflector
- Described by XE1XA in 1986
- Unequal E- and H-plane illumination of the dish

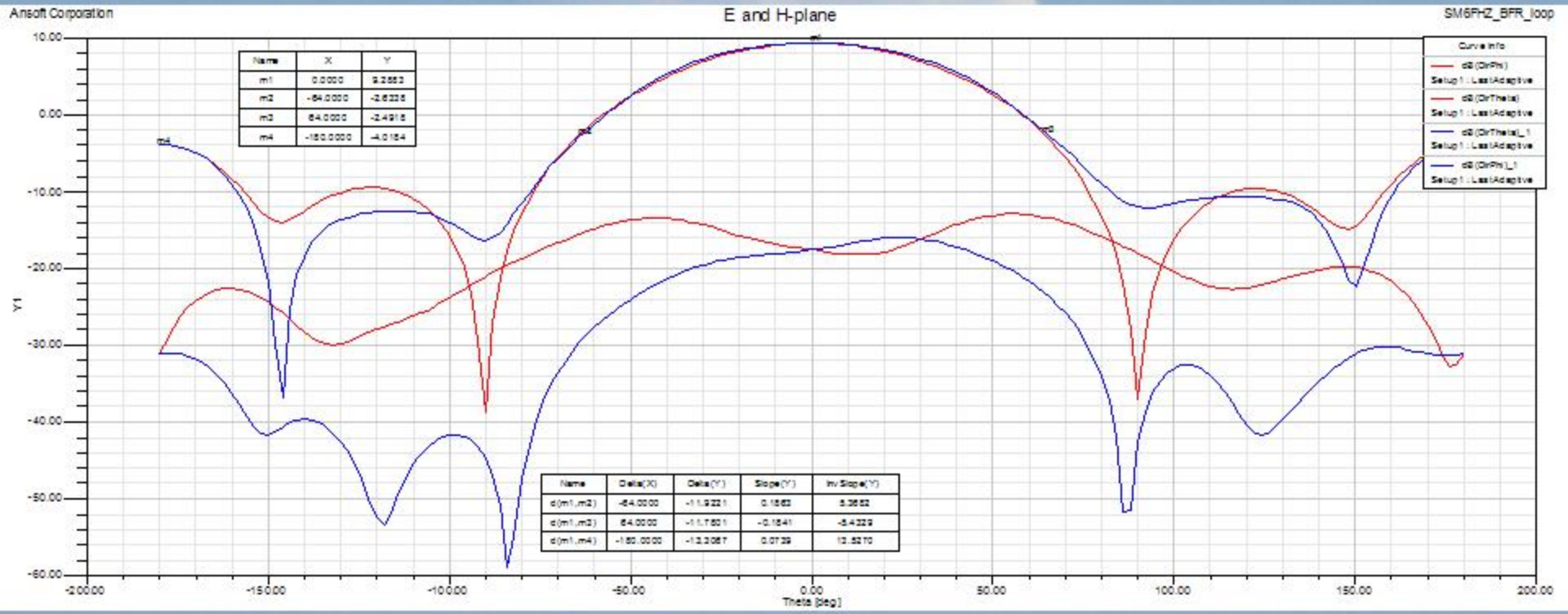


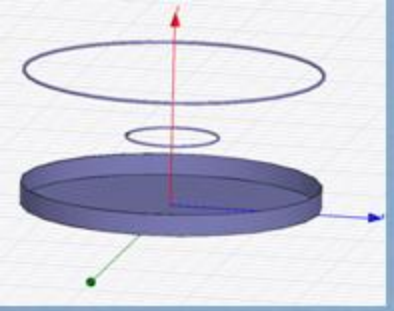


Taming a feed

Introducing a BFR (Beam Forming Ring)

- The BFR was described by Kildal in 1982
- The BFR acts on the H-plane with no or minor effects on the E-plane
- The BFR makes the H-plane more narrow, resembling the E-plane
- Improves the antenna noise temperature and antenna efficiency (on f/D ~0.45 dishes)

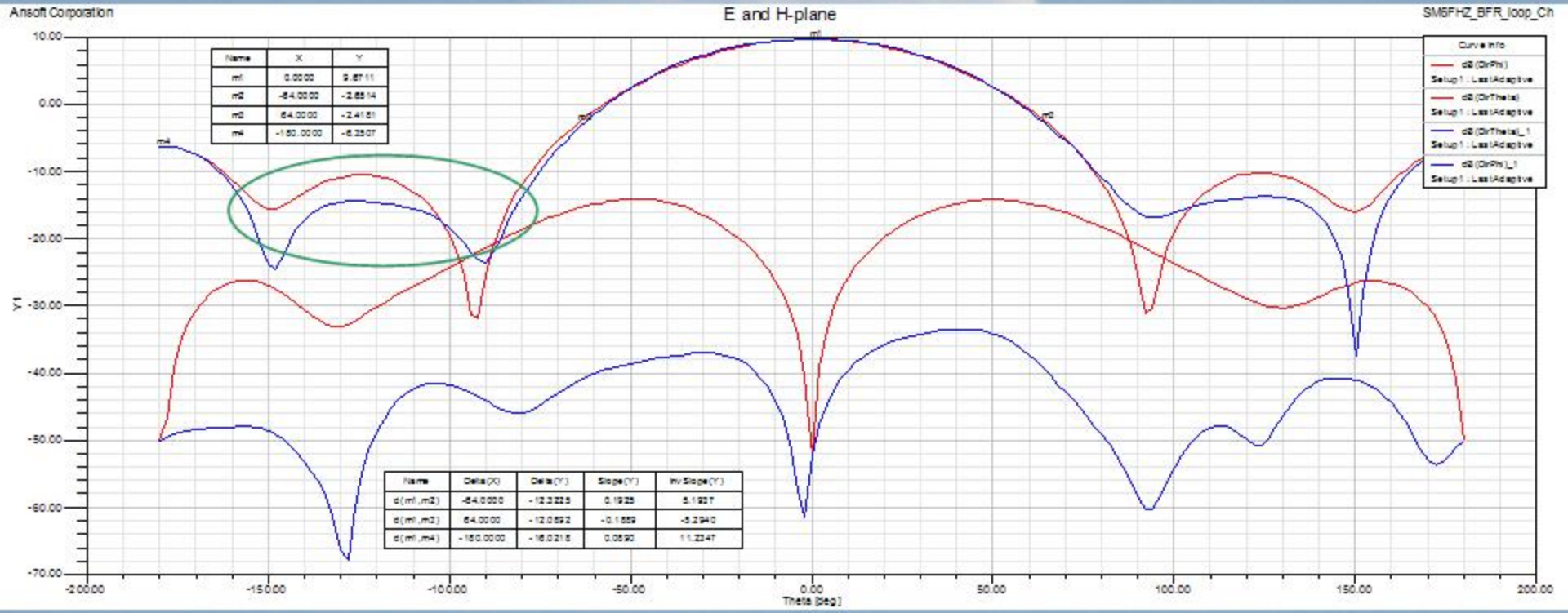


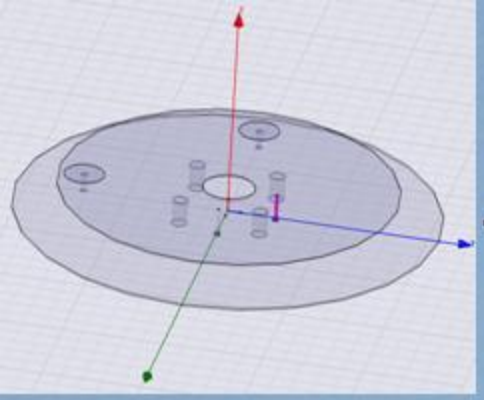


Taming a feed

Adding a choke (baffle) to the reflector

- The choke (or baffle if you like) reduces the scattering and diffraction from the reflector edge of the feed
- Minor effect on the pattern out to +/- 70 deg (when used together with the BFR)
- By this you reduce the spill over (mainly in the 80 to 150 deg offset region) resulting in a reduced antenna noise temperature
- Improves the FBR as well as cross polar discrimination

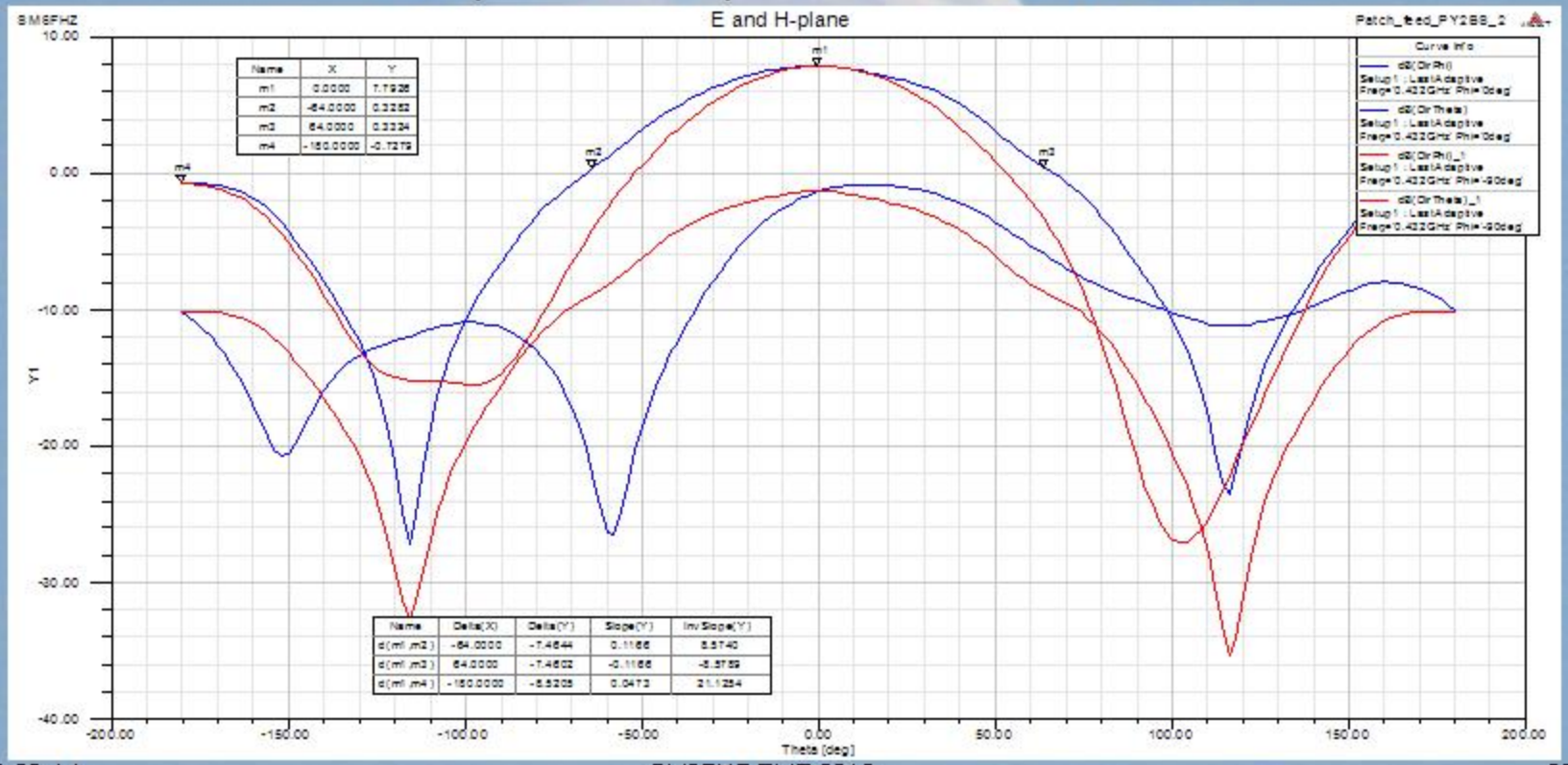


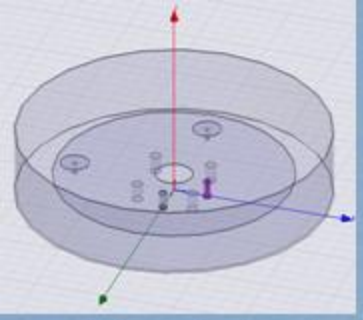


Taming a feed

The starting point for a patch feed

- Capacitively loaded patch, over 0.6 WL diameter reflector
- Low CPR
- Low FBR
- Unequal E- and H-plane illumination of the dish

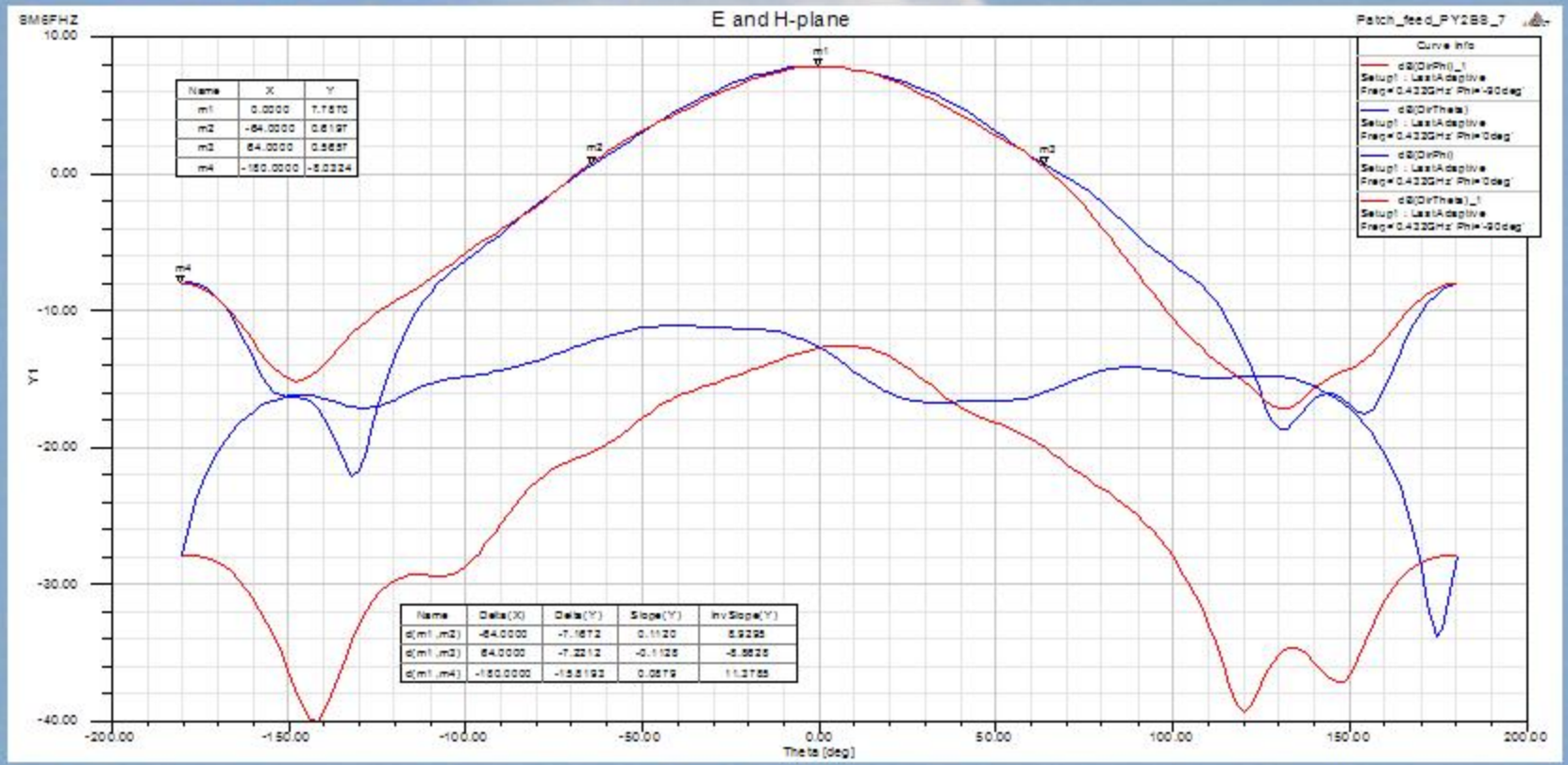




Taming a feed

Adding a choke (baffle) to the reflector

- The choke (or baffle if you like) act on the E-plane mostly, widening it to resemble the H-plane
- It cleans up the cross-polar radiation patterns as well
- It also improves the front to back ratio (FBR)



Feed comparison

- 8 feeds described in literature plus 5 modified feeds.
  - Dipole based, loop based and patch based feeds were examined.
- None of the feeds were real bad and some of them shined.
- For flat dishes the dual dipole is a good choice. Both the version with square and circular reflector are good.
- For deep dishes the feeds with a small reflector and some kind of baffle or cavity performed best.
- The variety of feeds makes it possible to find a feed that suites your specific need.

Conclusions from the Feed Comparison

- The ”classic feed” designs are good
- Some designs do not fully keep to what they promise
- It can still be done a lot to improve the efficiency on 70 cm dish feeds depending on the properties of Your dish
- You need to make a choice of feed that is suitable for the size and f/D for Your dish