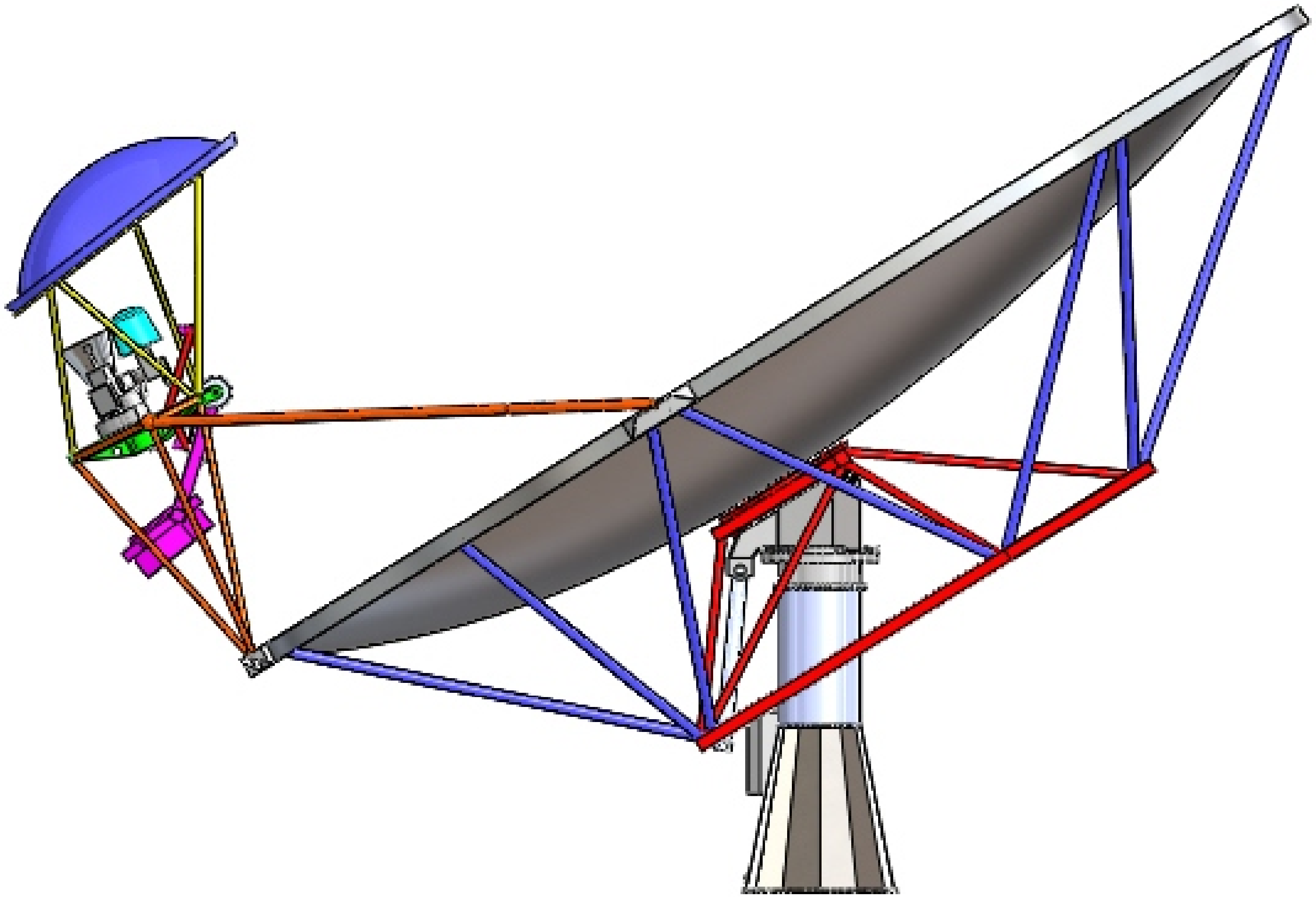
Single Pixel Feeds

Bill Imbriale - JPL

The US SKA TDP is considering Dual Offset Shaped Optics with a feed indexer

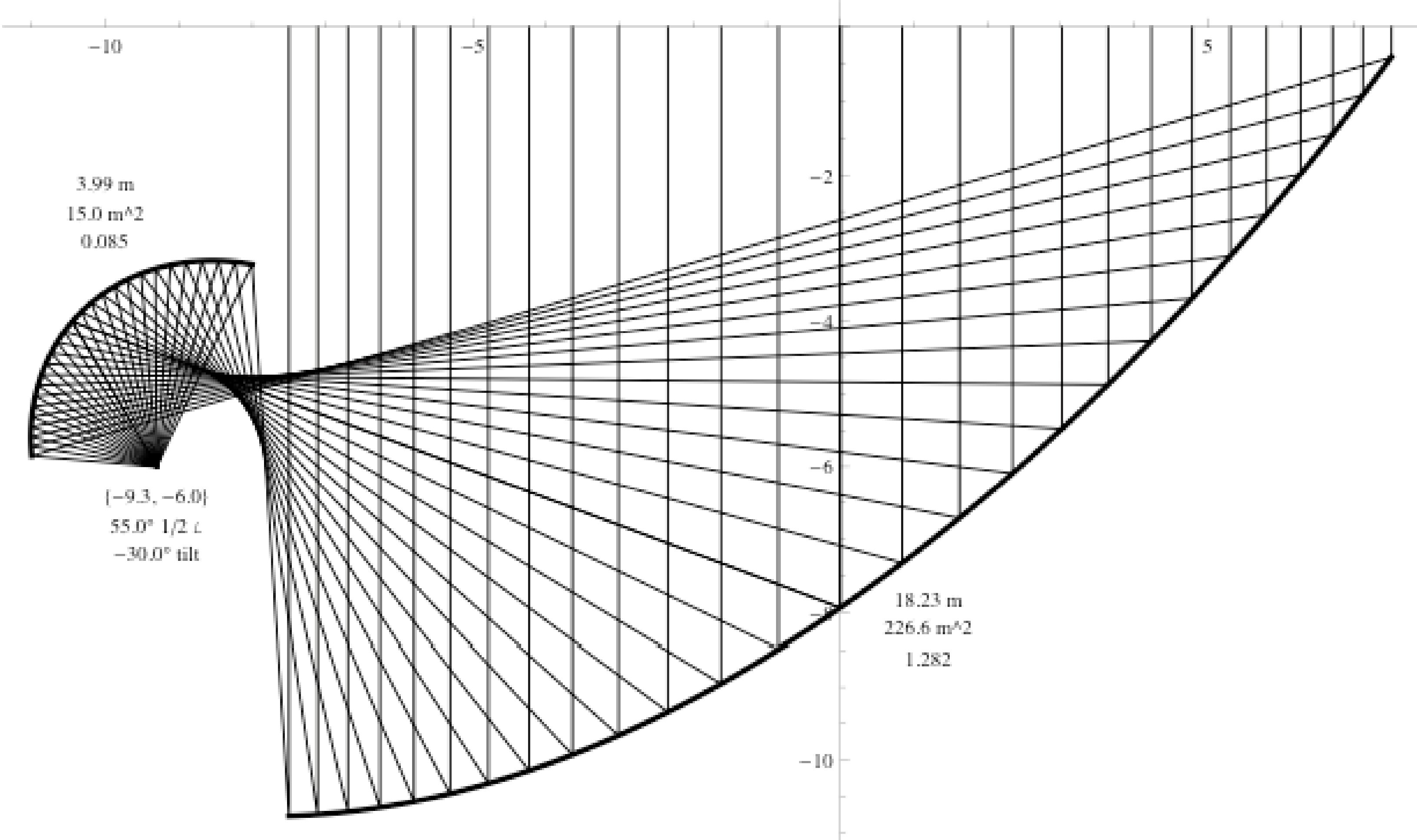


Why Shaping

- Dual reflector shaping is utilized to both increase the aperture efficiency and reduce the noise temperature. The aperture efficiency is increased by making the aperture illumination more uniform. Noise temperature is decreased capturing more of the feed energy in the subreflector and thus by reducing the amount of energy that is spilled past the subreflector.

DVA-1 Optics, Ray Trace

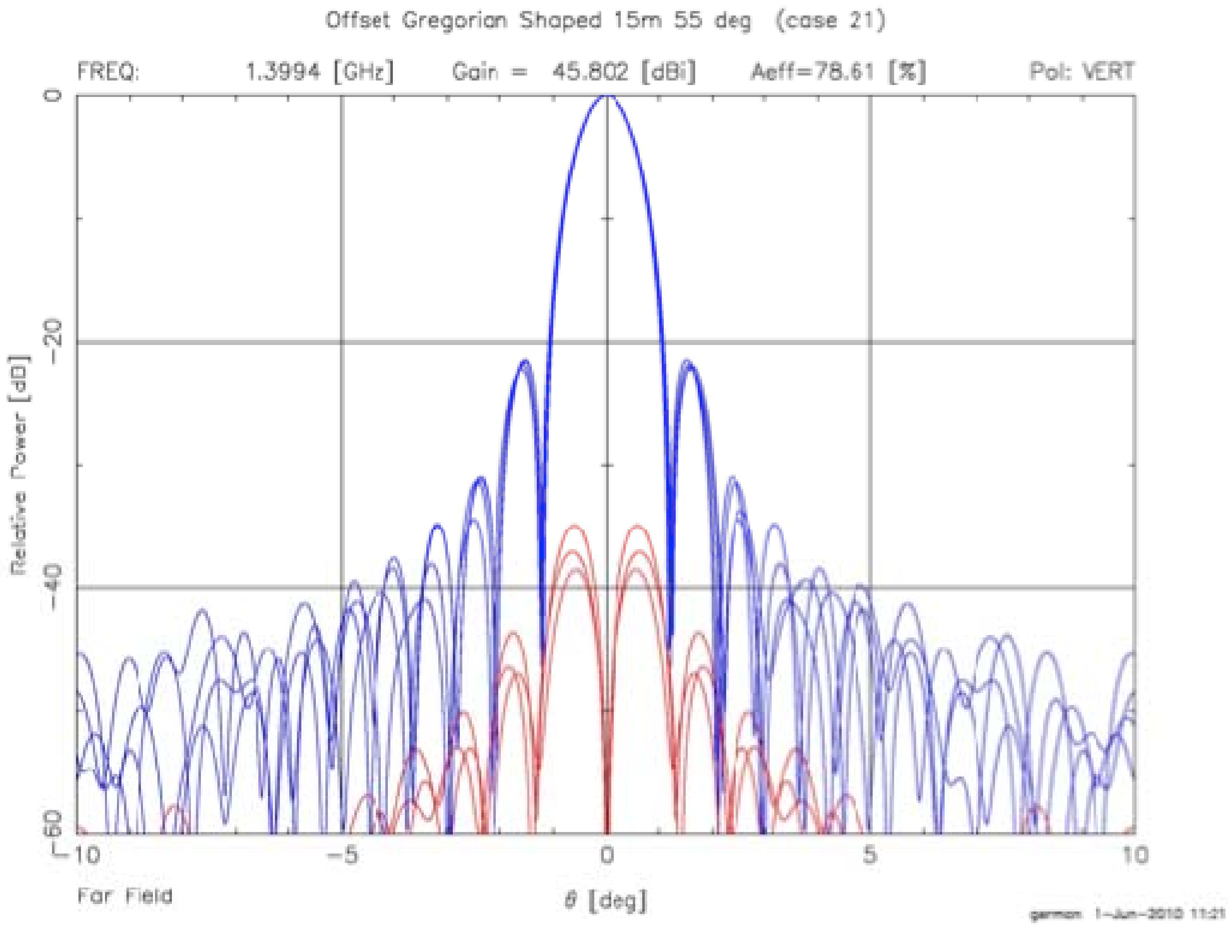
Reflector system cross section in the symmetry plane



DVA-1 Optics, Configuration

- Offset, Gregorian, Shaped Reflectors
- Wide Opening Angle At Focus
  - Accommodates wide band feeds
- Large Secondary
  - Good low frequency performance
- -16 db. feed edge taper on secondary
- Shaping chosen for -21 db. first sidelobe
- Very Low Spillover, Both Reflectors

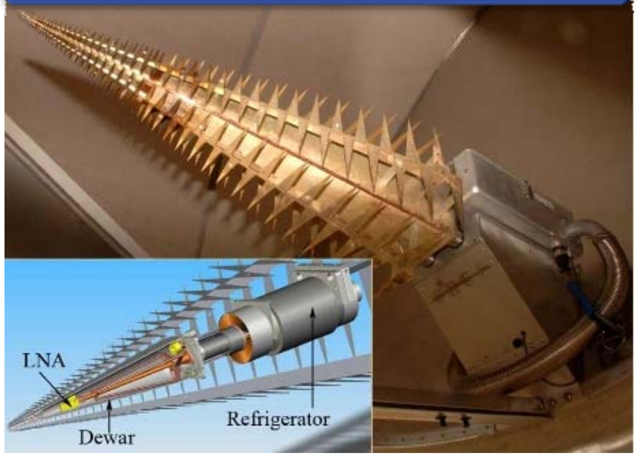
DVA-1 Optics, Beam Pattern



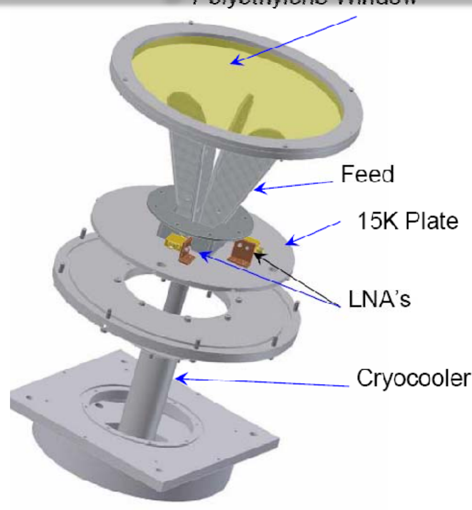
US SKA TDP
DVA-1

Wide Band Single Pixel Feeds considered for 12m additional feeds being considered for 15m

ATA Feed

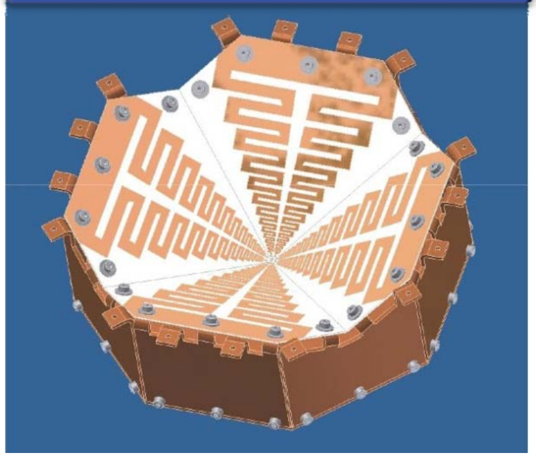


Lindgren Feed



QSC Feed

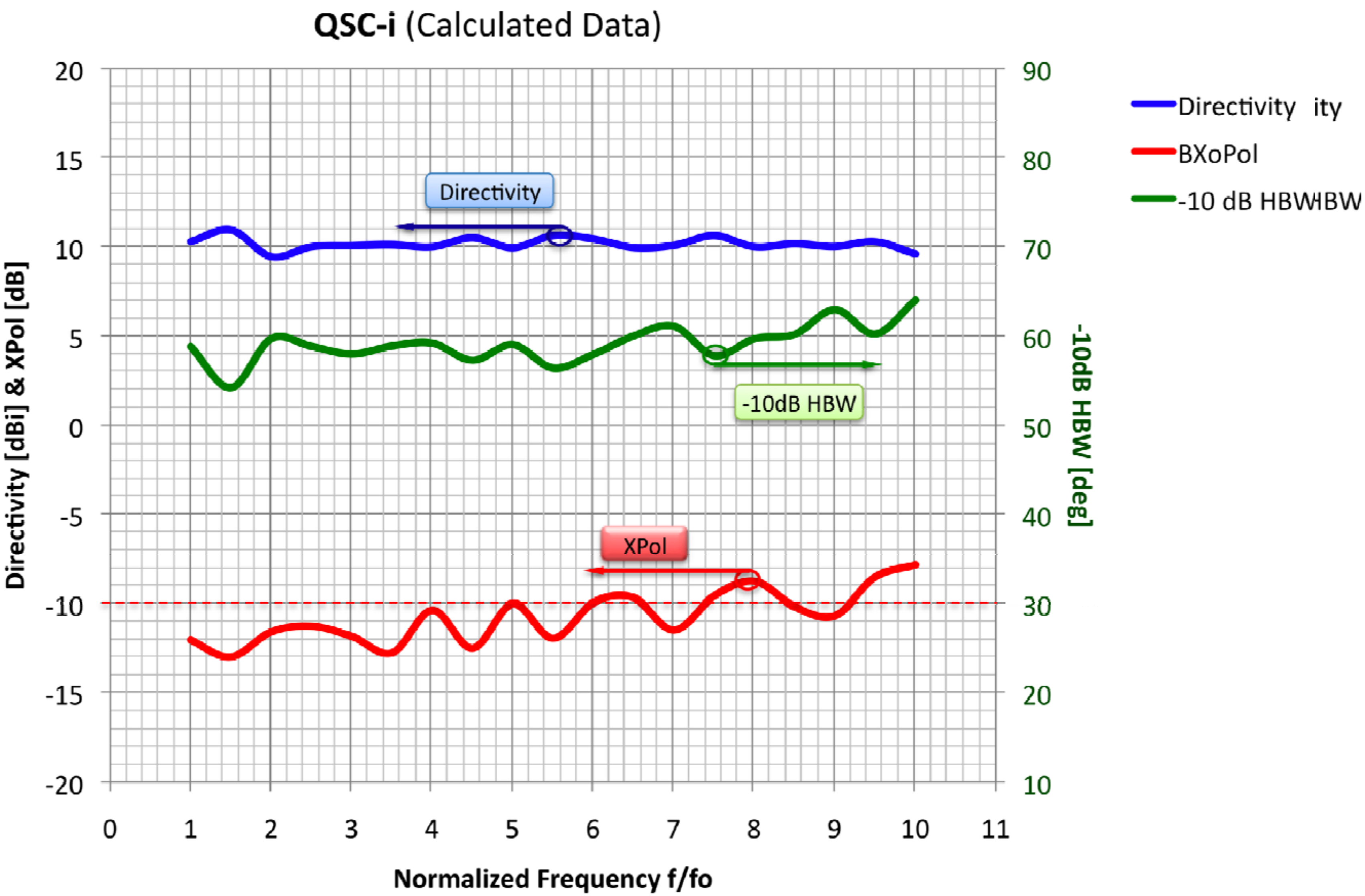
Eleven Feed



Significant Observation

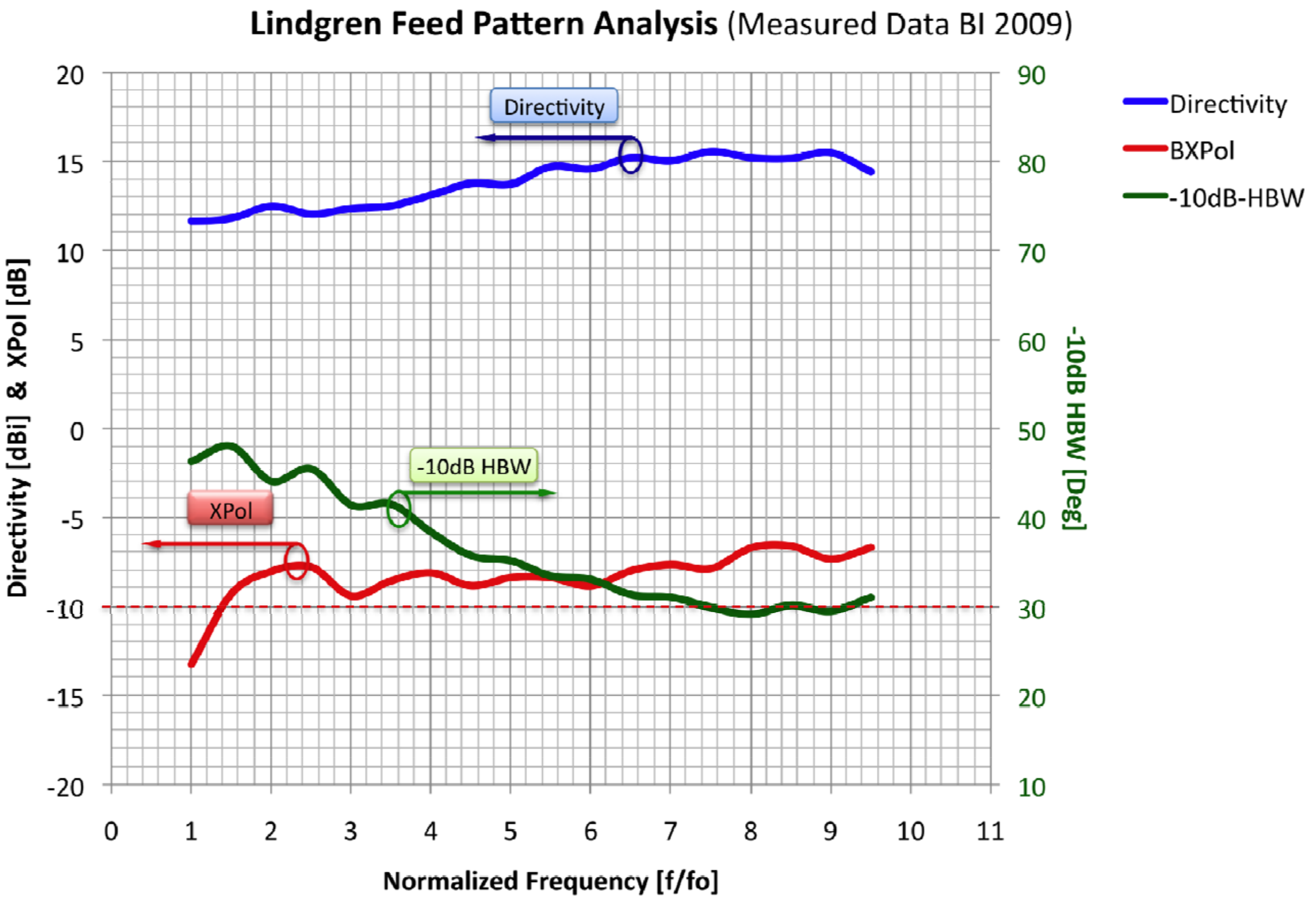
- Each feed has different characteristics (Gain, beamwidth, cross-pol, etc) so a single reflector optics design will not be optimum for all feeds

US SKA TDP
DVA-1



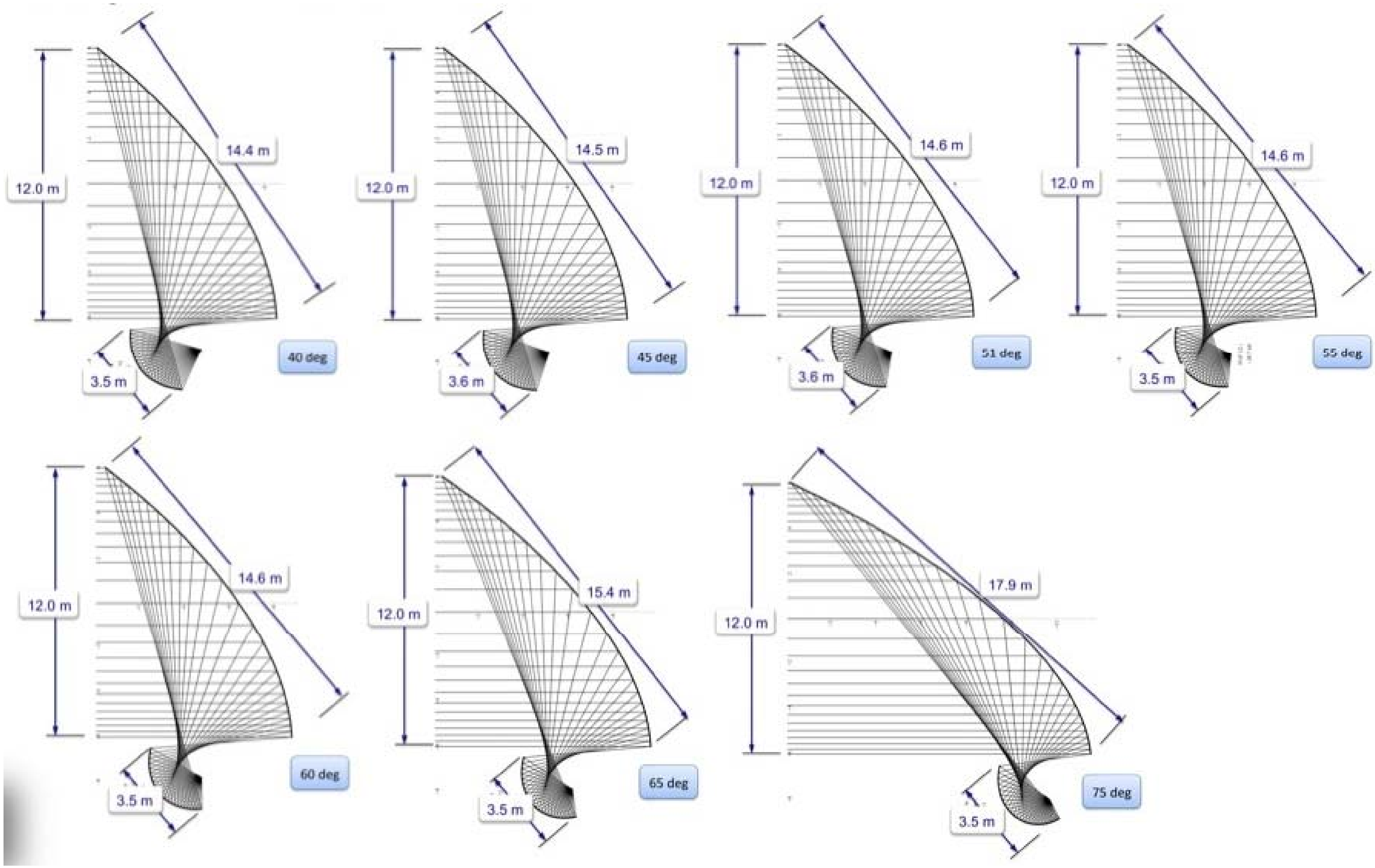
US SKA TDP
DVA-1

Quad-Ridge (Lindgren)

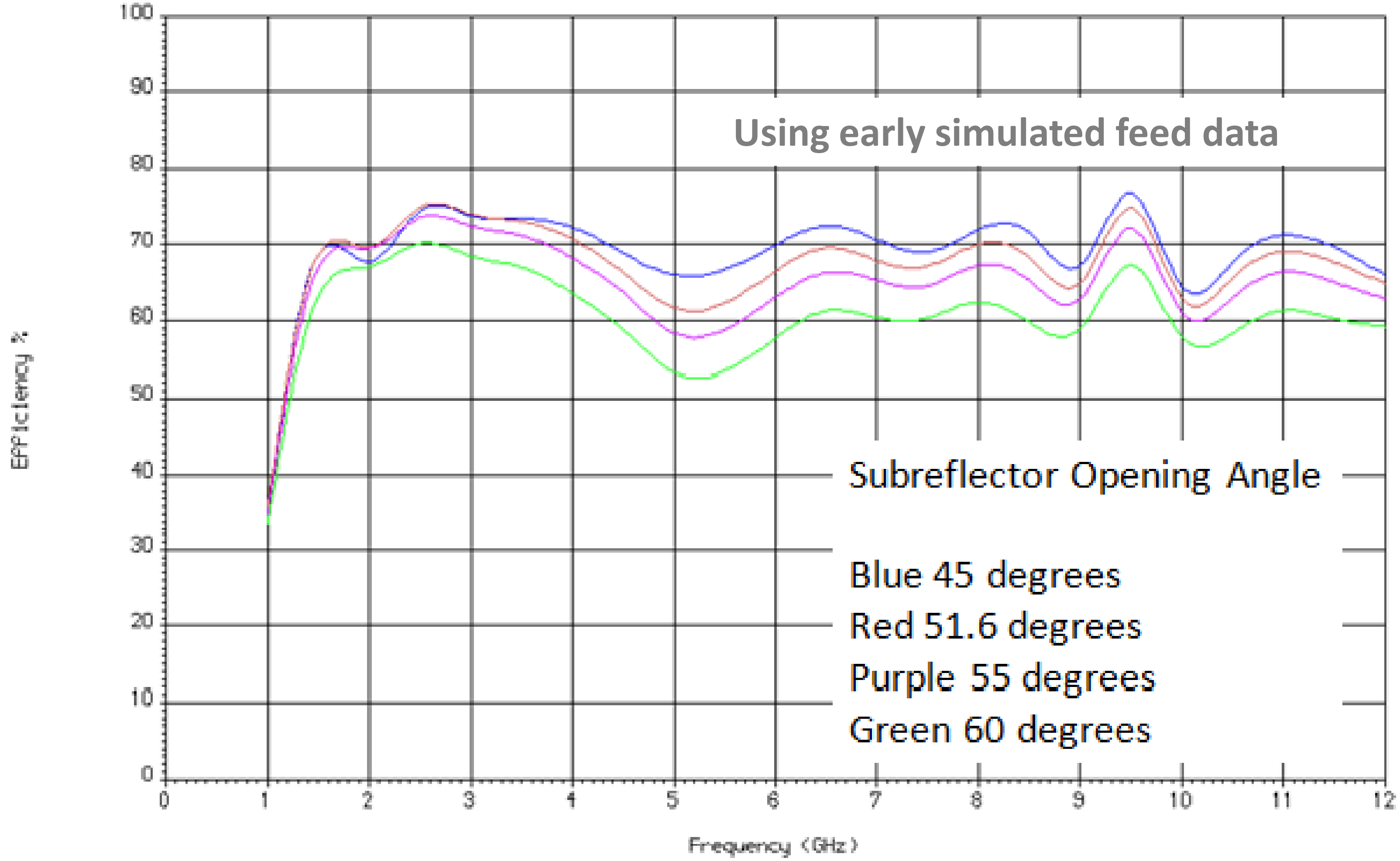


US SKA TDP
DVA-1

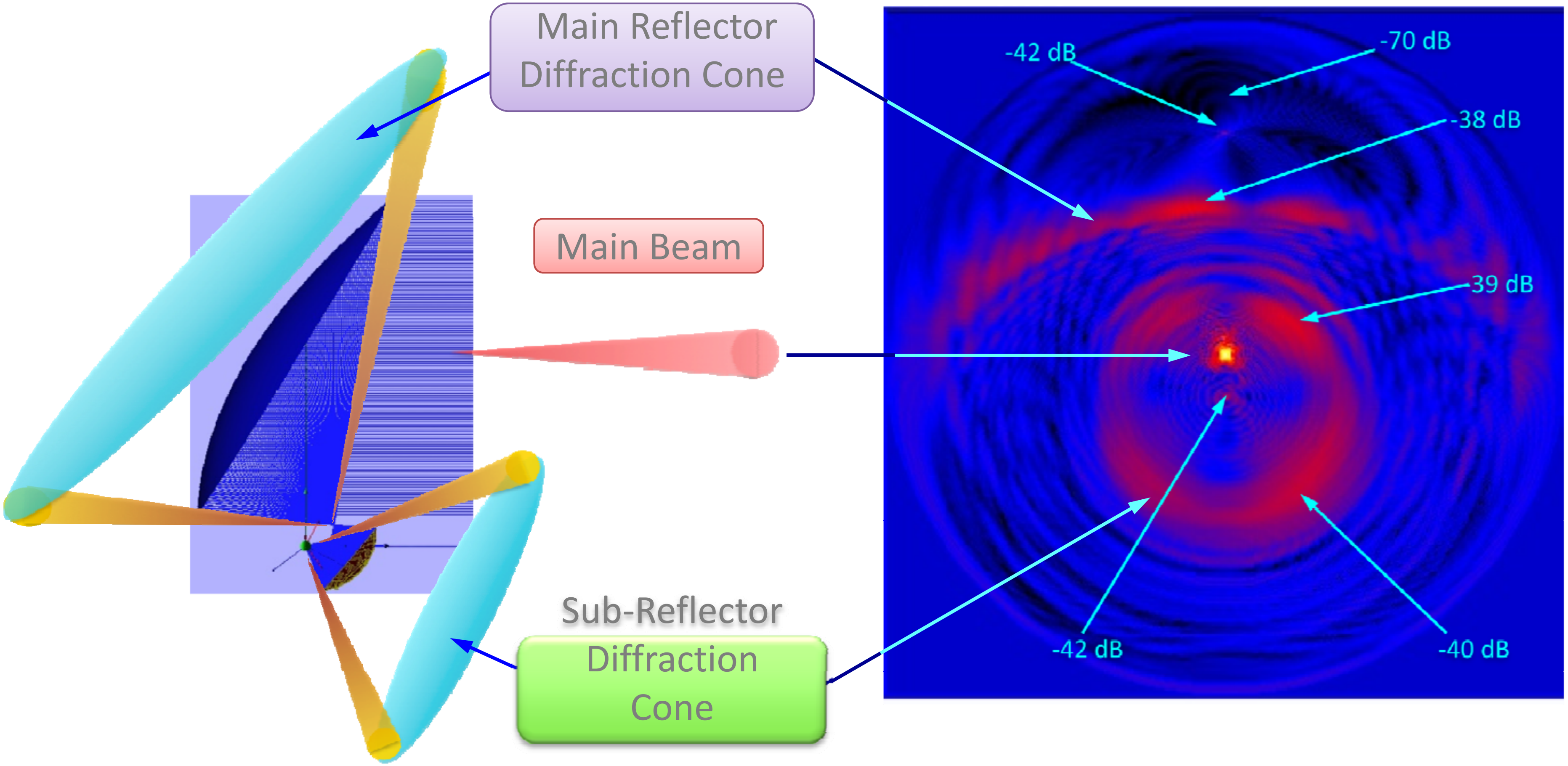
12m Offset Gregorian Design



ATA Efficiency in a 12-meter antenna



Offset Gregorian Optics



ATA Noise Temperature

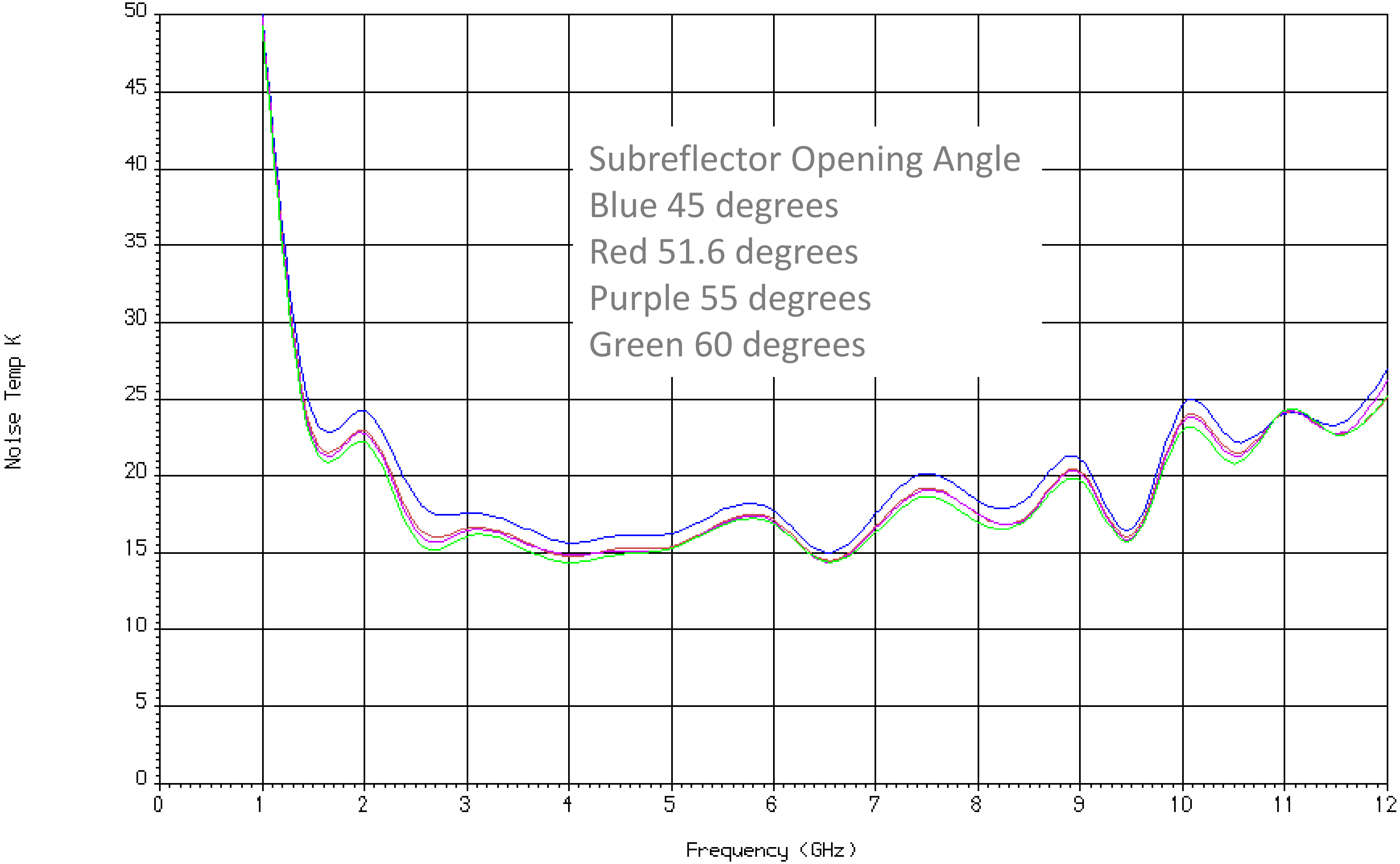
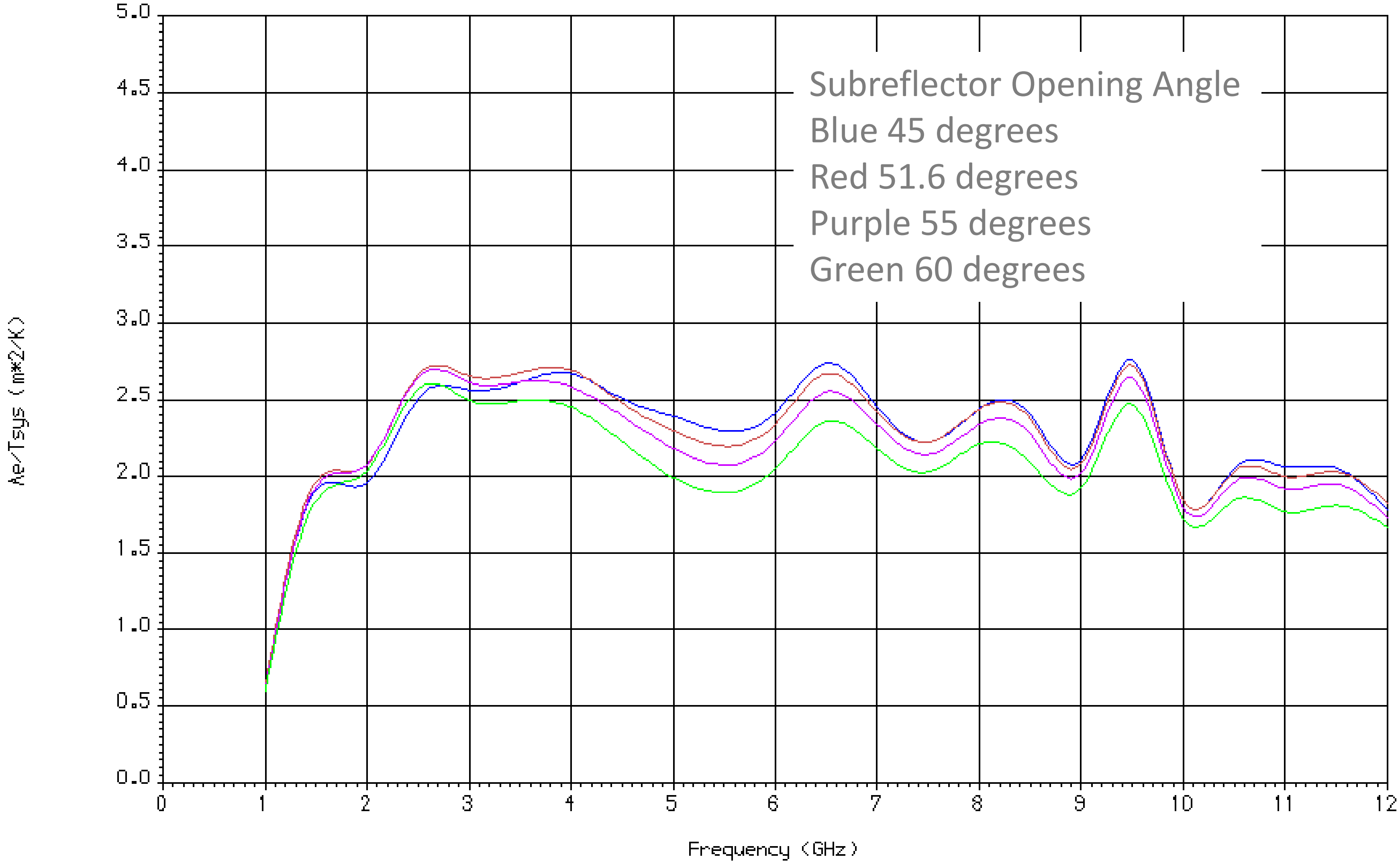


Figure 33. ATA Calculated Feed (Noise Temperature)

Ae/Tsys using simulated ATA feed data



What are we going to build for DVA-1

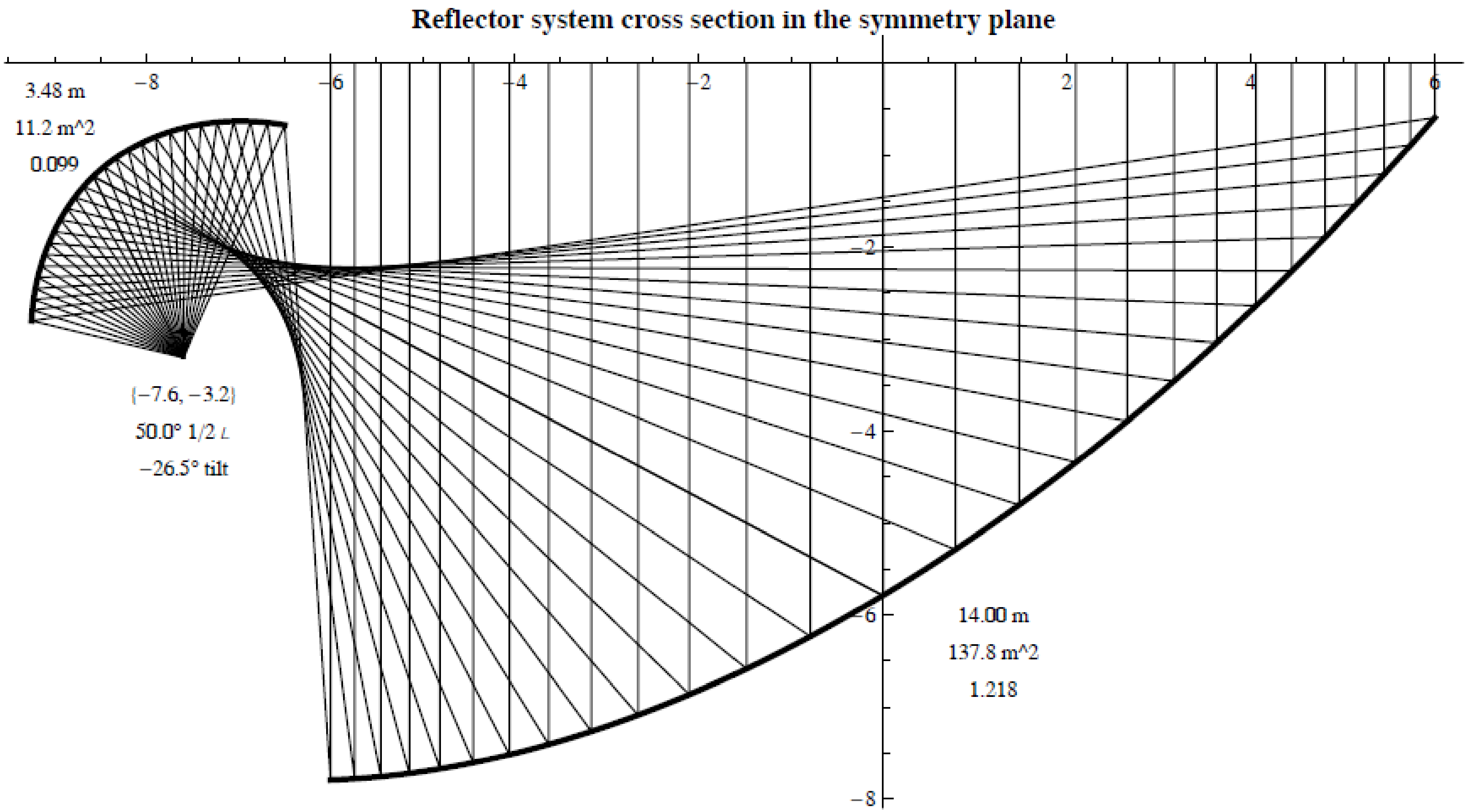
Make use of Variable Optics

Variable subreflector opening angle
with same main reflector

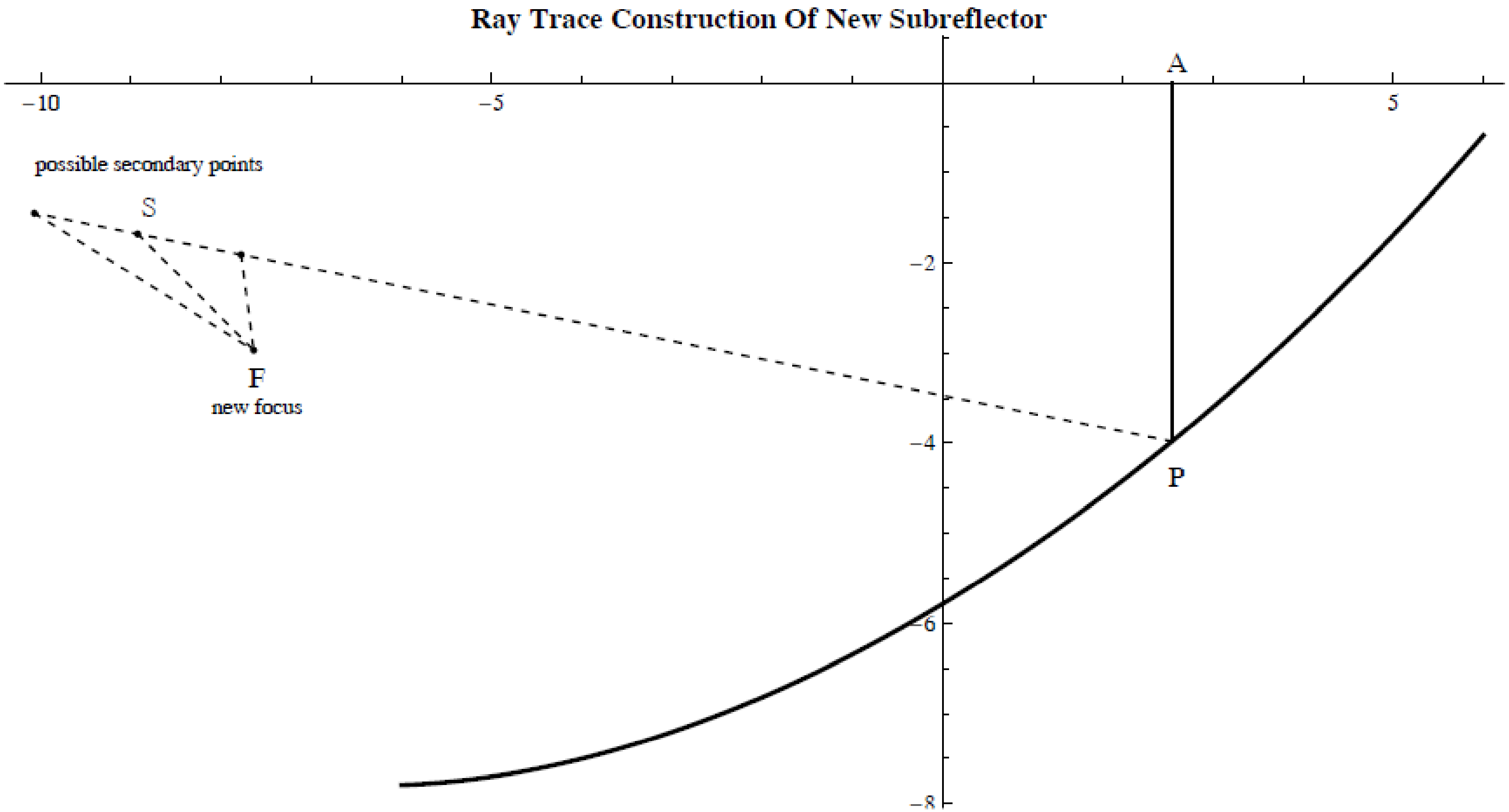
Therefore we can proceed to build the main
reflector and test the various feeds with
different subreflectors

US SKA TDP
DVA-1

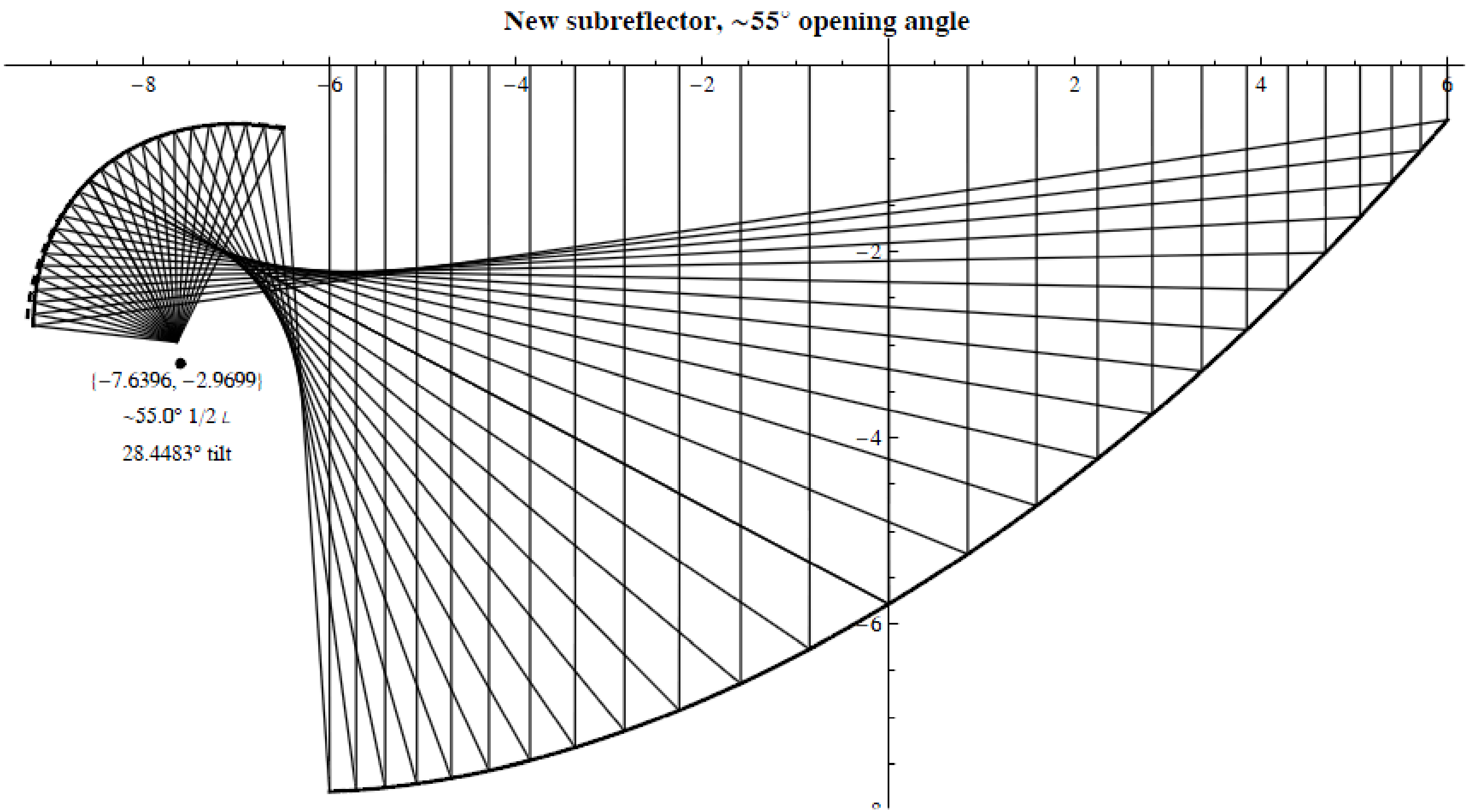
To illustrate the technique
Dual reflector shaped for 50 Degree Subreflector Opening Angle



Ray Trace Construction of New Subreflector
With 55 degree opening angle
Same 50 degree Main reflector

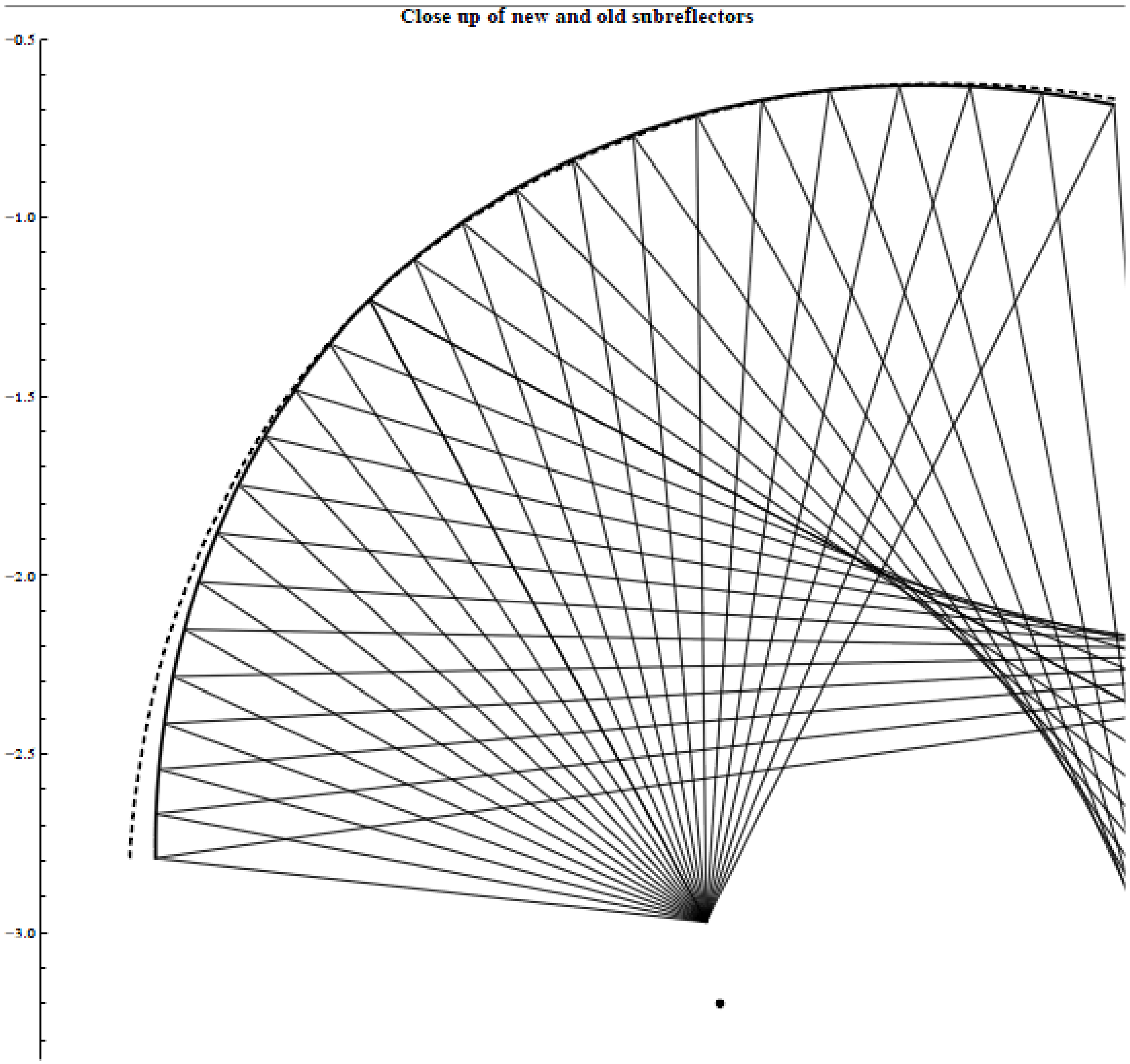


New subreflector, ~55° Opening Angle



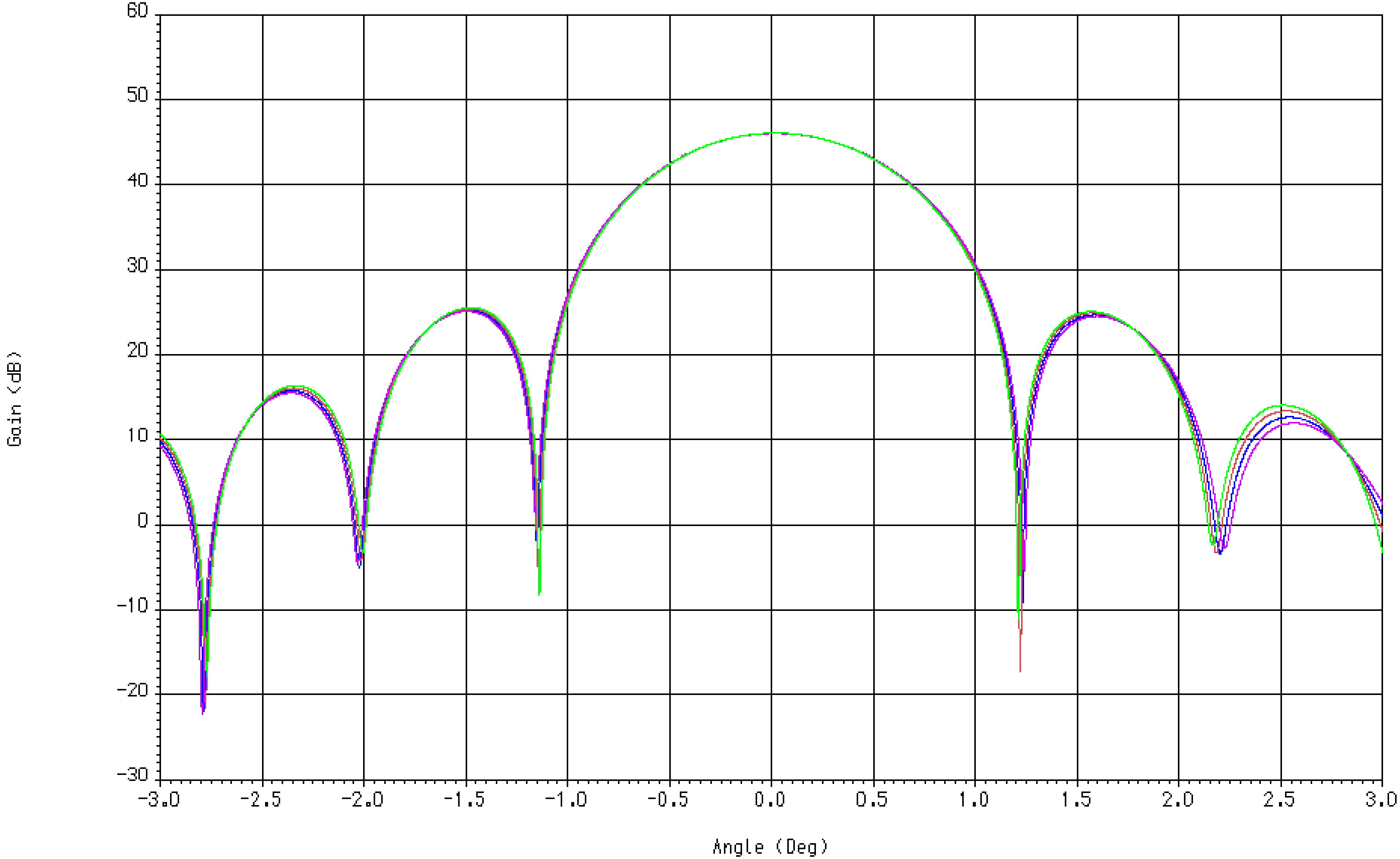
US SKA TDP
DVA-1

Close up of New and Old Subreflector

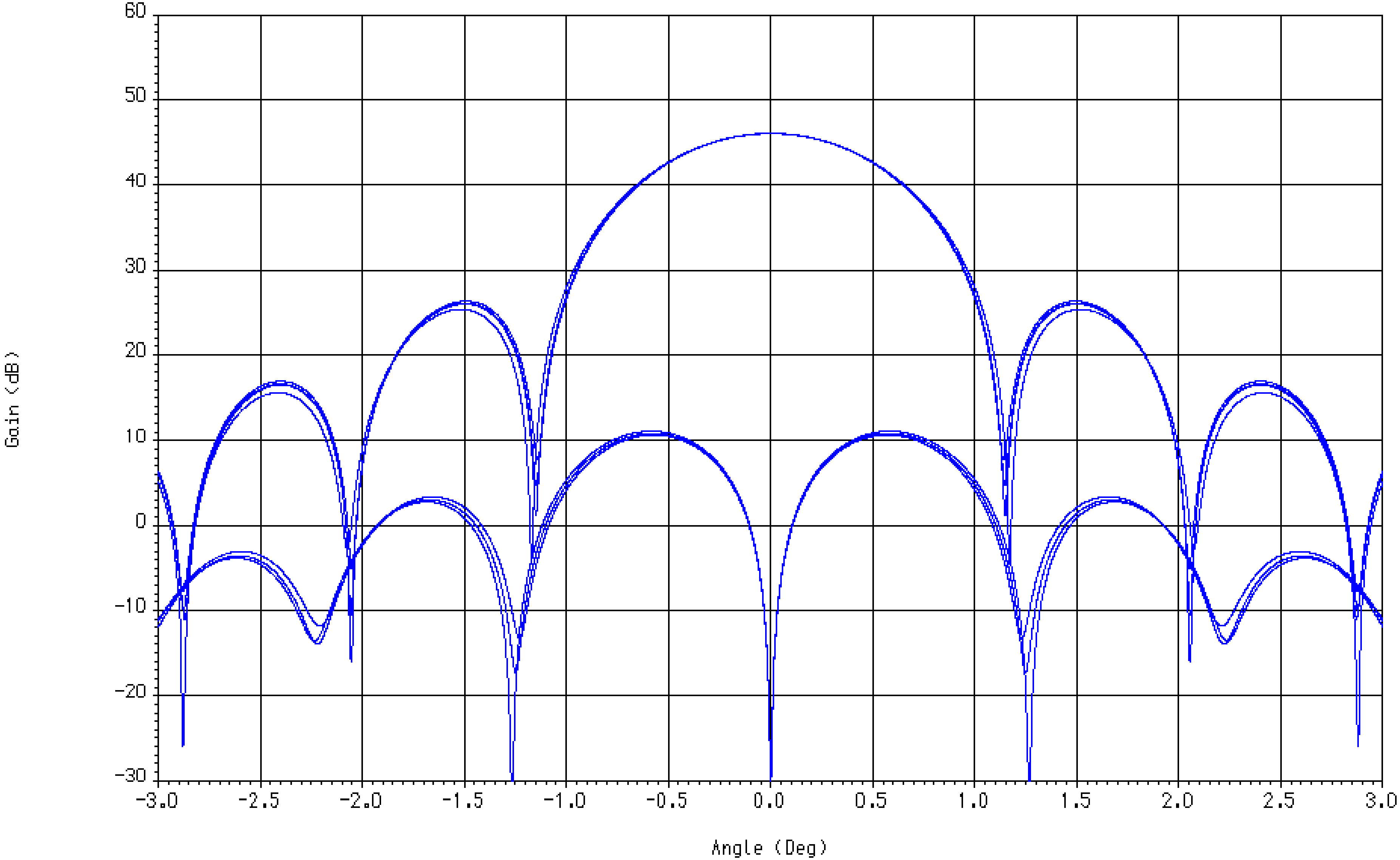


US SKA TDP
DVA-1

Phi = 0.0 degrees – 35,45,55,and 65 degree sub - -16dB edge taper



Phi = 90.0 degrees – 35,45,55,and 65 degree sub - -16dB edge taper



Ideal Feed

- For Separating Feed and Dish the Performance parameters were calculated with an “ideal” feed, i.e. the feed shape for which the reflector optics was designed
- Modeled as a cos Q type pattern with -16 dB edge taper

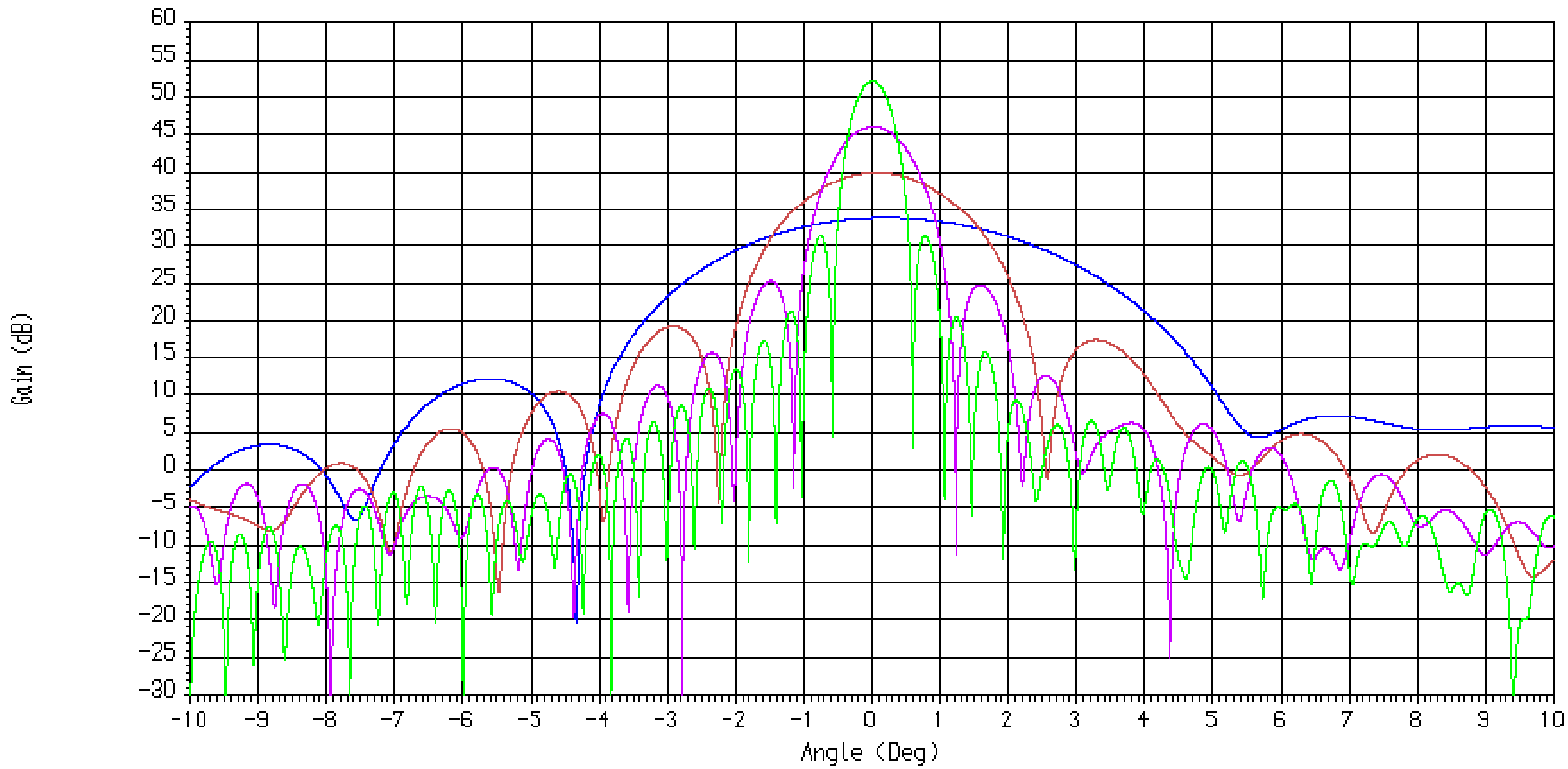


Figure 1.1 Near-in patterns for the ideal feed for 0.35, 0.7, 1.4 and 2.8 GHz

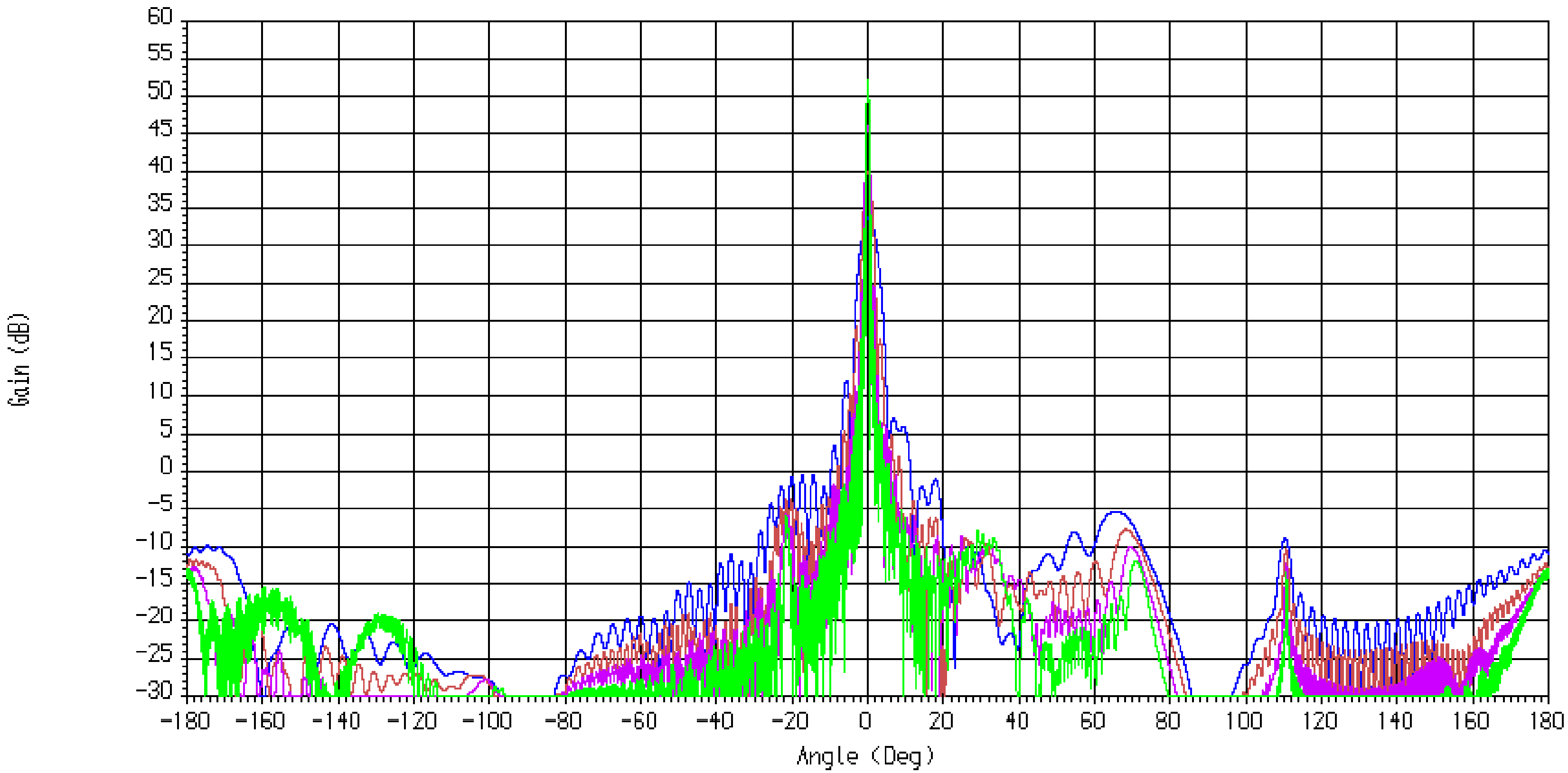


Figure 1.2 Full Patterns in the offset plane for 0.35, 0.7, 1.4 and 2.8 GHz

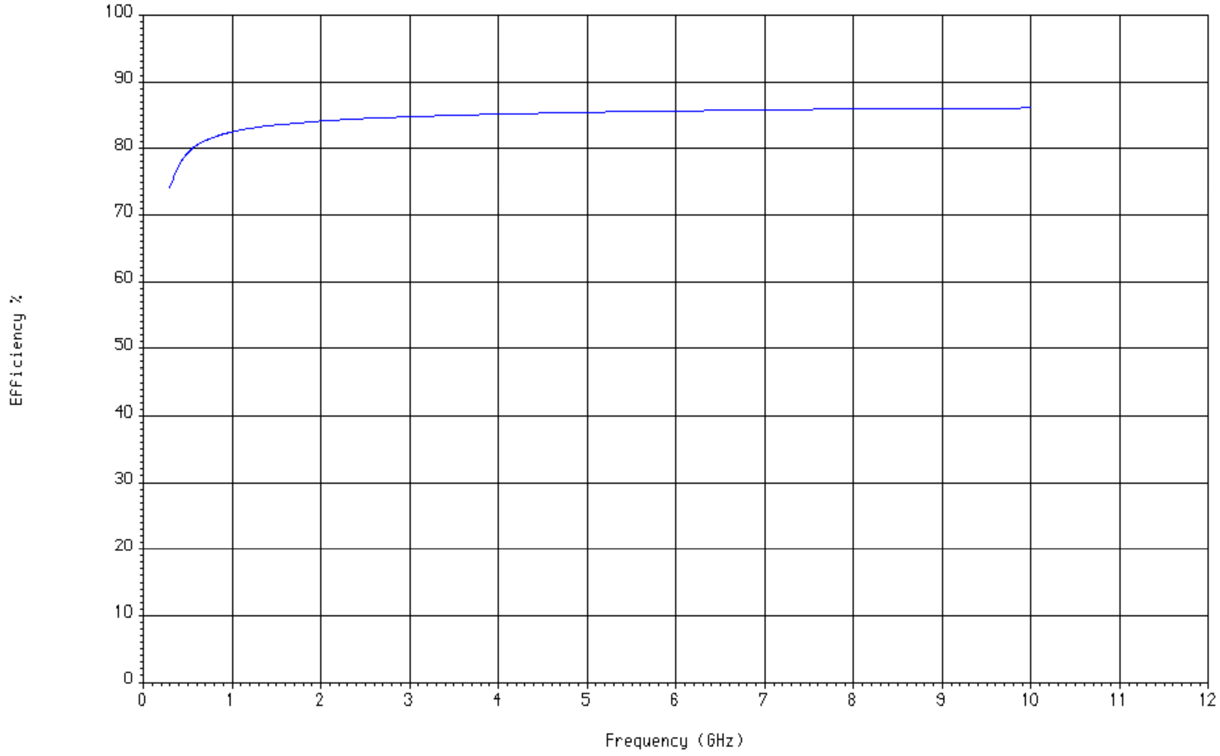


Figure 1.3 Efficiency as a function of frequency

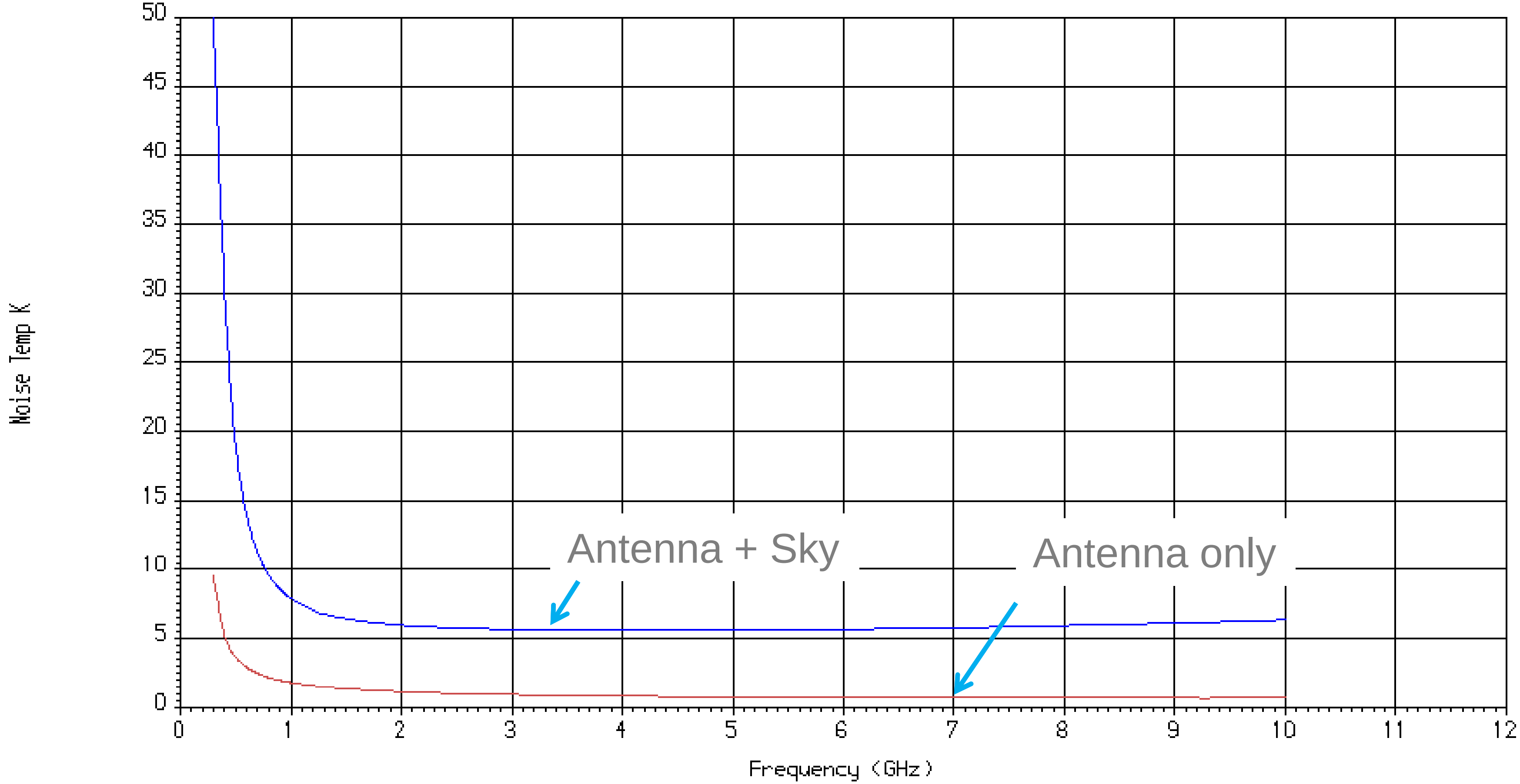


Figure 1.4 Noise Temperature as a function of frequency

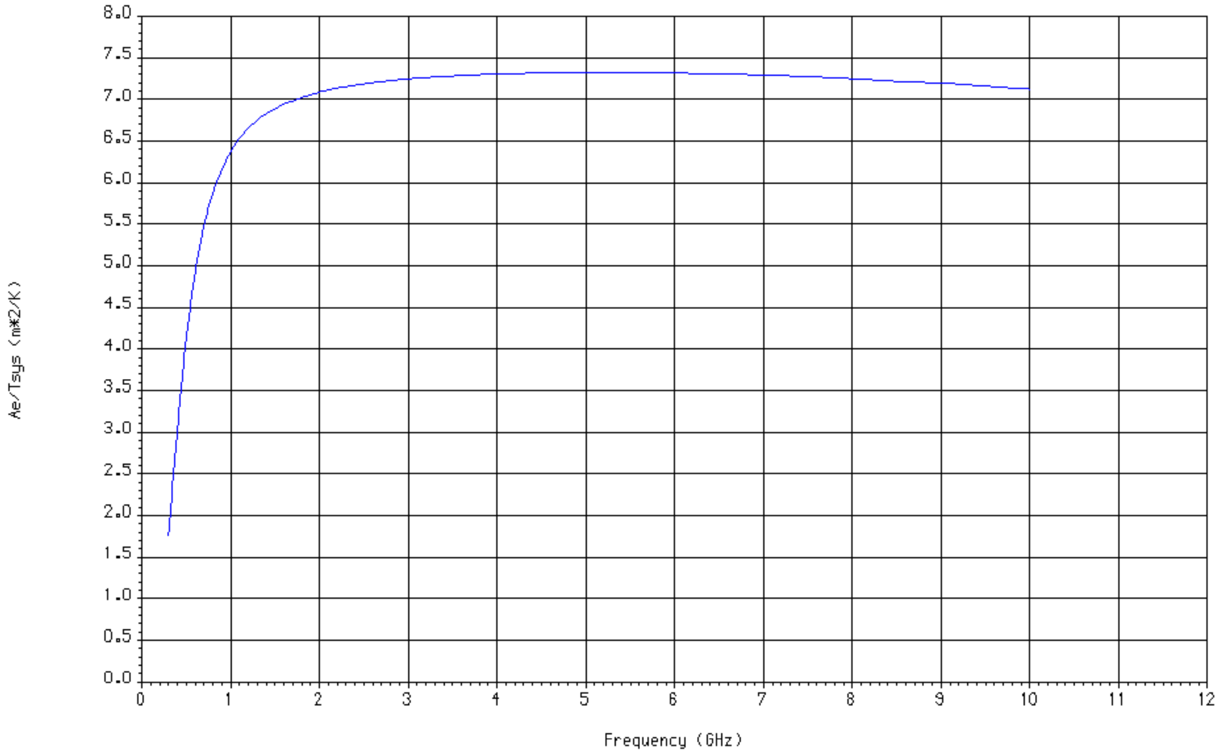


Figure 1.5 Ae/Tsys as a function of frequency

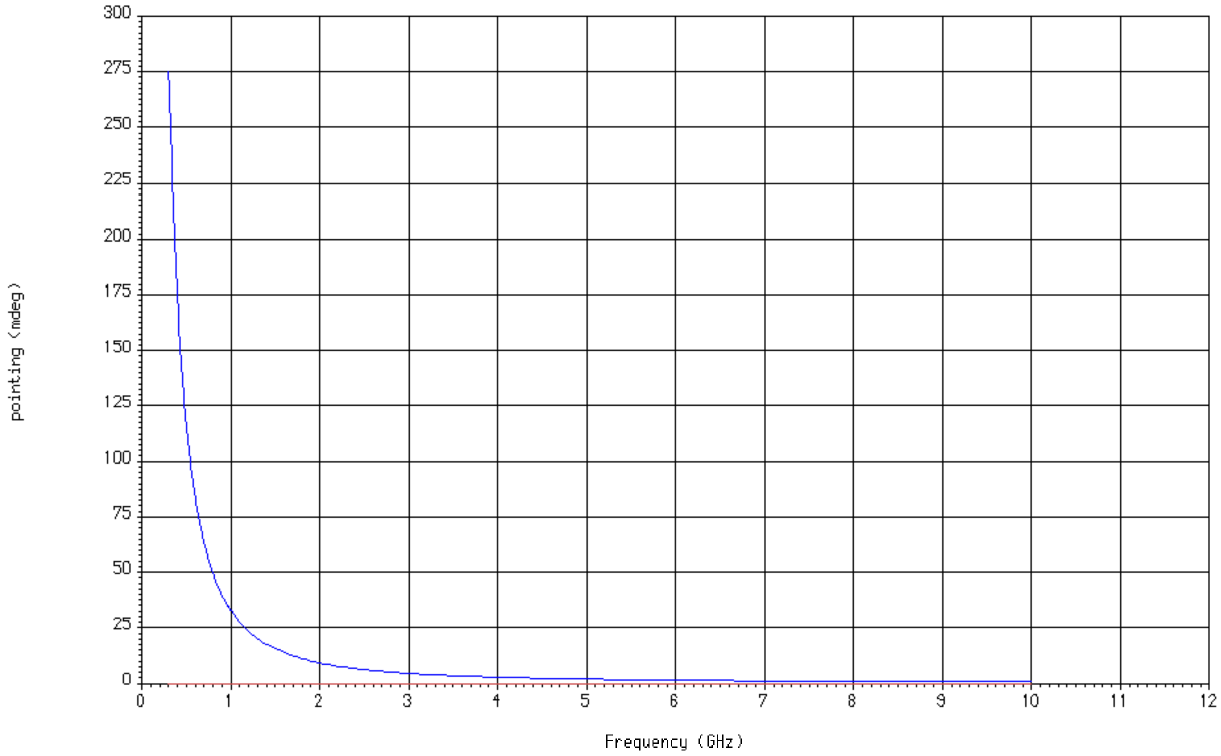


Figure 1.6 pointing offset in the offset plane

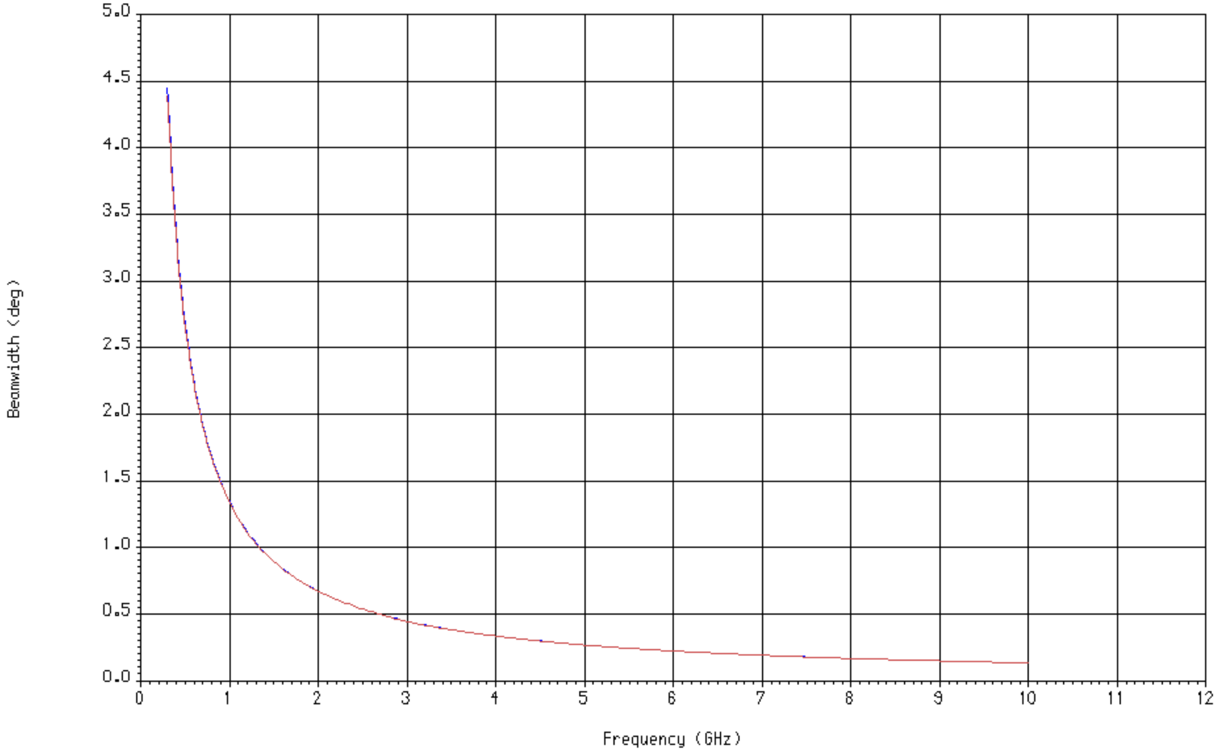


Figure 1.7 E- and H-plane beamwidths as a function of frerquency

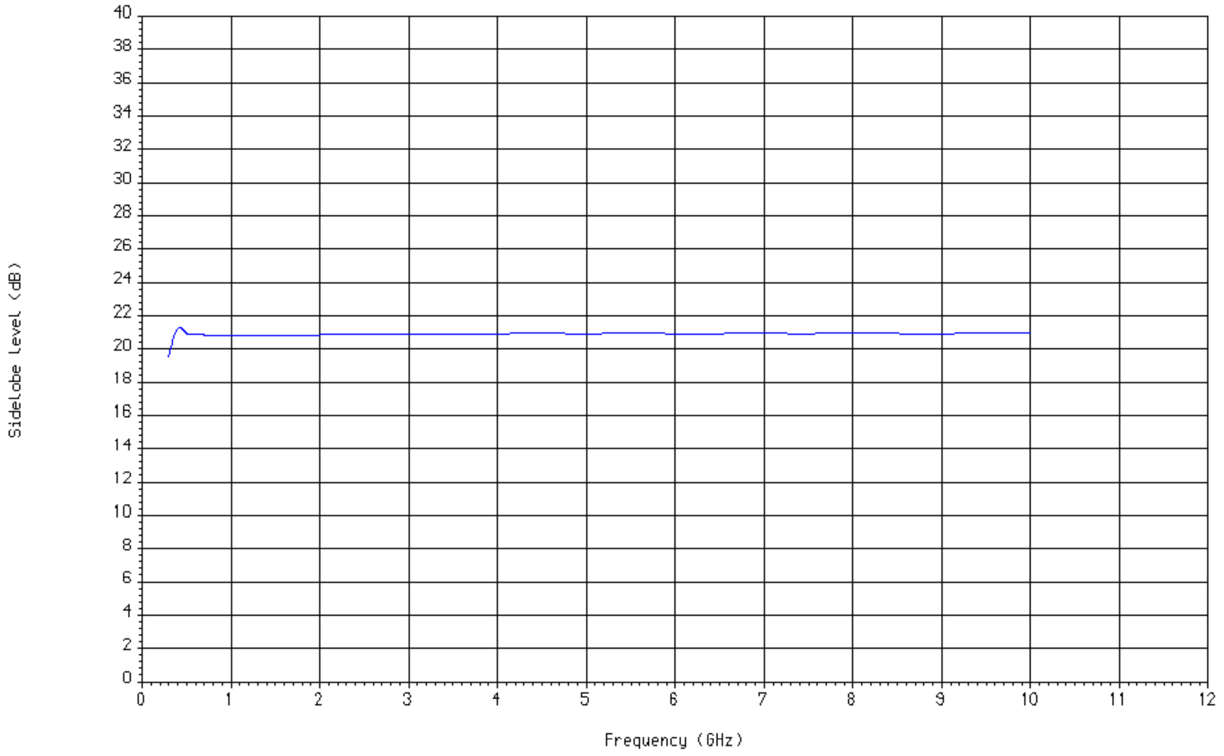


Figure 1.8 Peak sidelobe level as a function of frequency

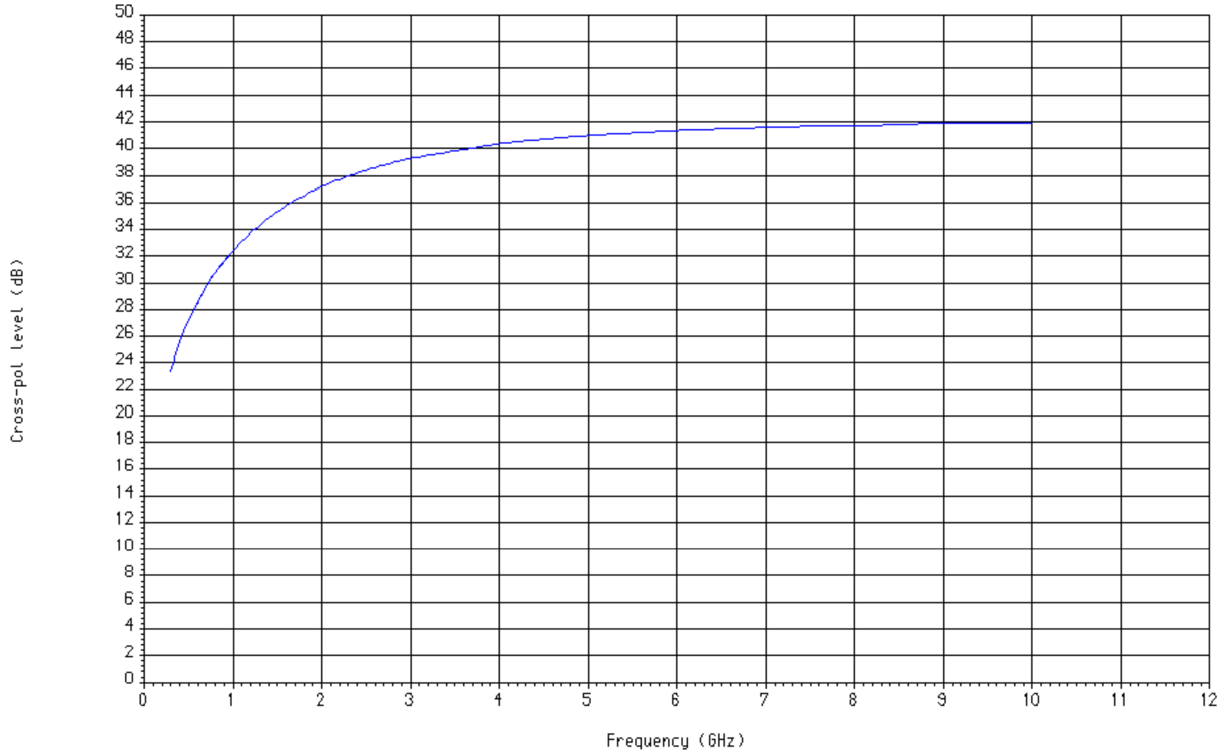
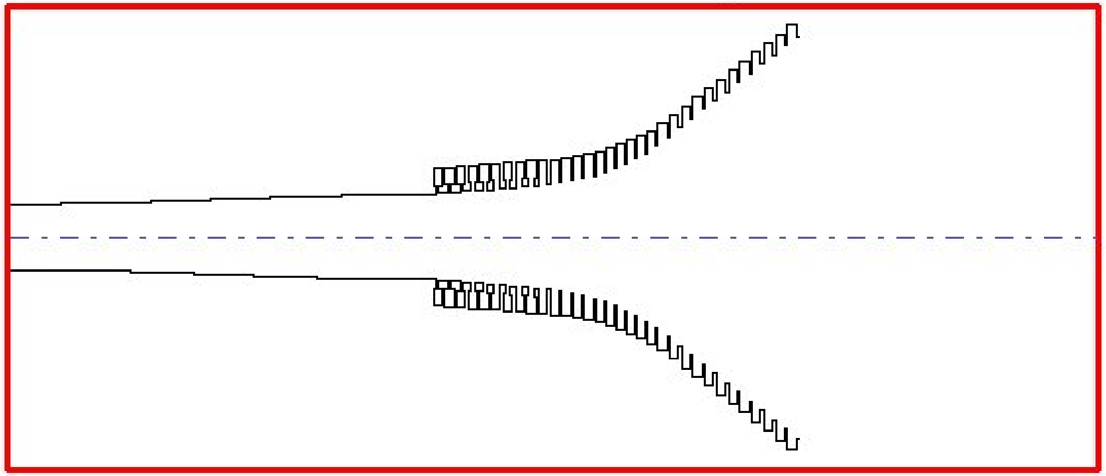


Figure 1.9 Peak cross polarization as a function of frequency

Major Questions

- It is well known that a narrow band corrugated horn performs significantly better than a wide band feed
- What about an Octave Band horn?
  - To minimize the number of horns to cover a given frequency band
- How much better??
- Is it worth it???

Wideband Horn 45 degree flair

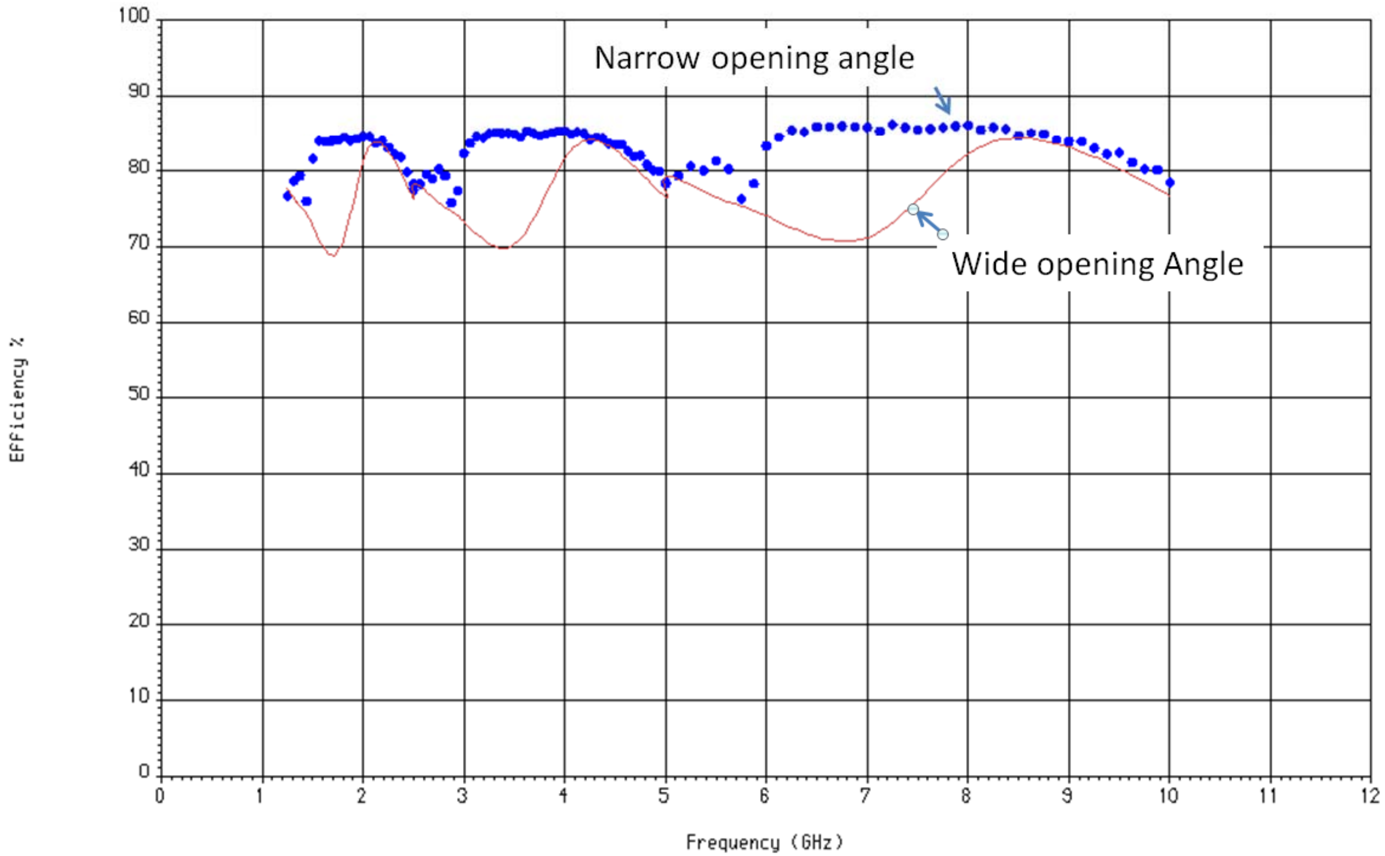


For narrow subreflector
opening angles
~40 degrees

Ring-Loaded Feed

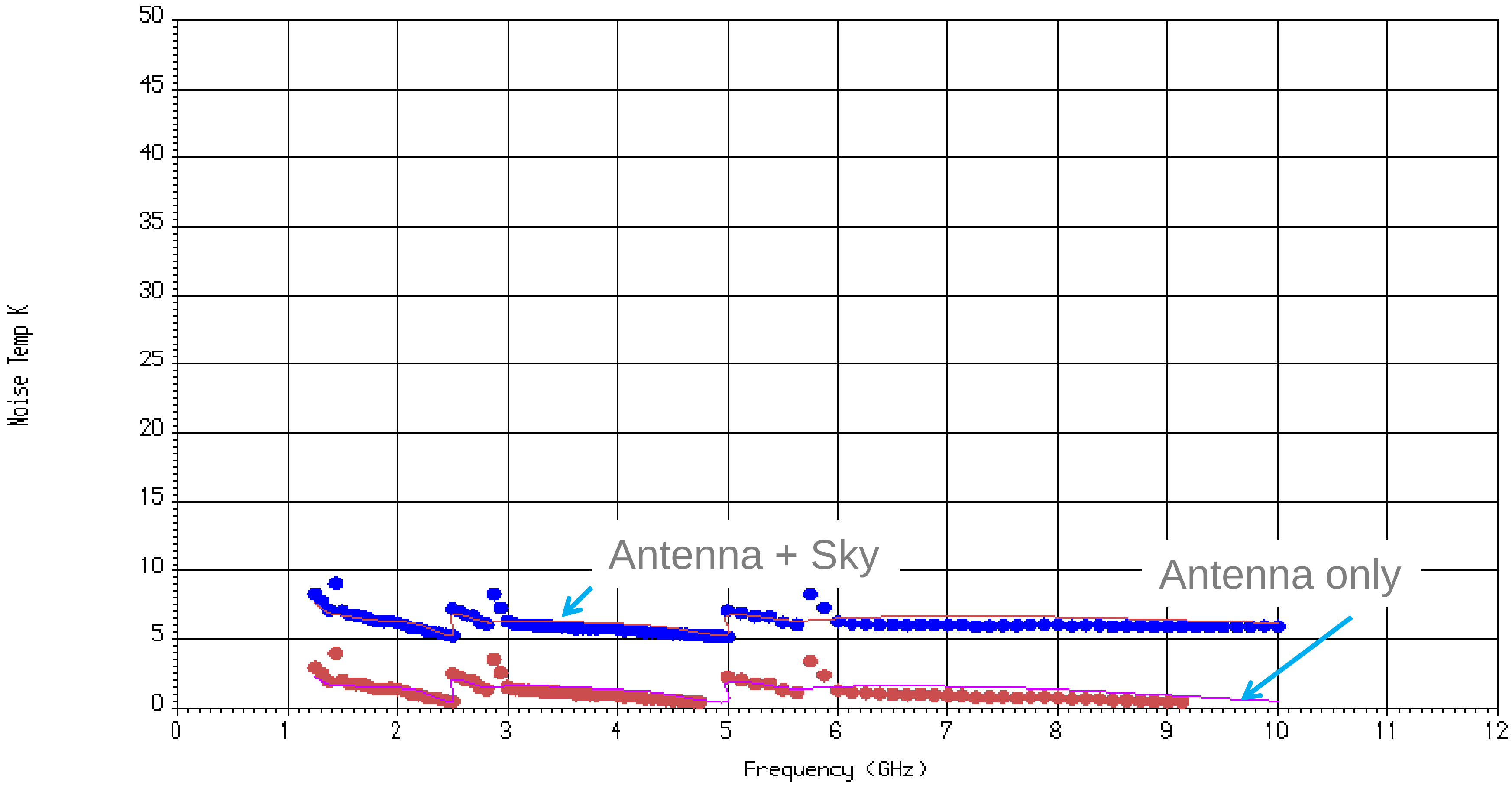
57 degree horn by G. Cortes
Suitable for wider subreflector
Opening angles
~55 to 65 degrees

Octave Band Horns Efficiency



US SKA TDP
DVA-1

Octave Band Corrugated Horns Noise Temperature



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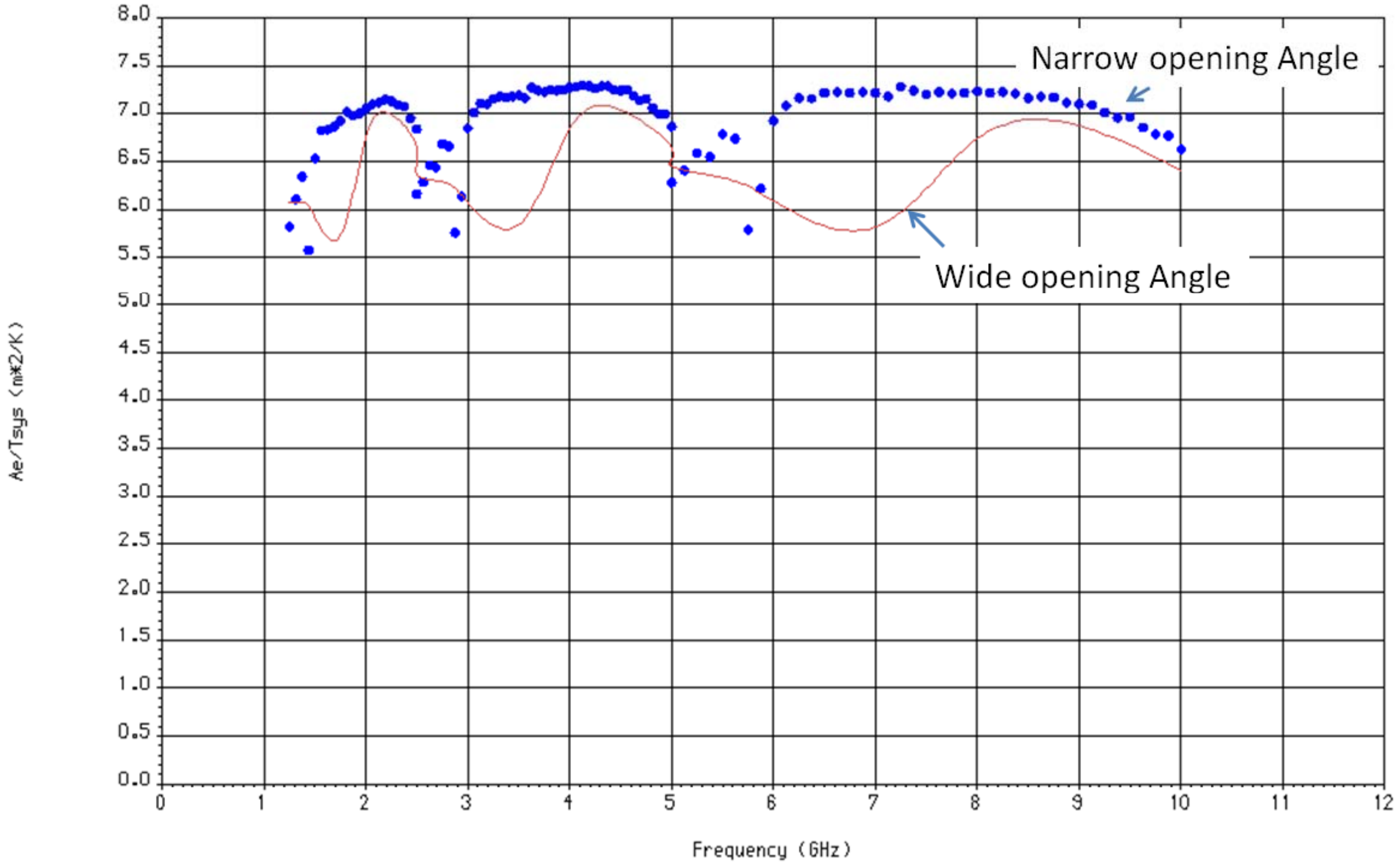
Ae/Tsys for the Octave Band Horns



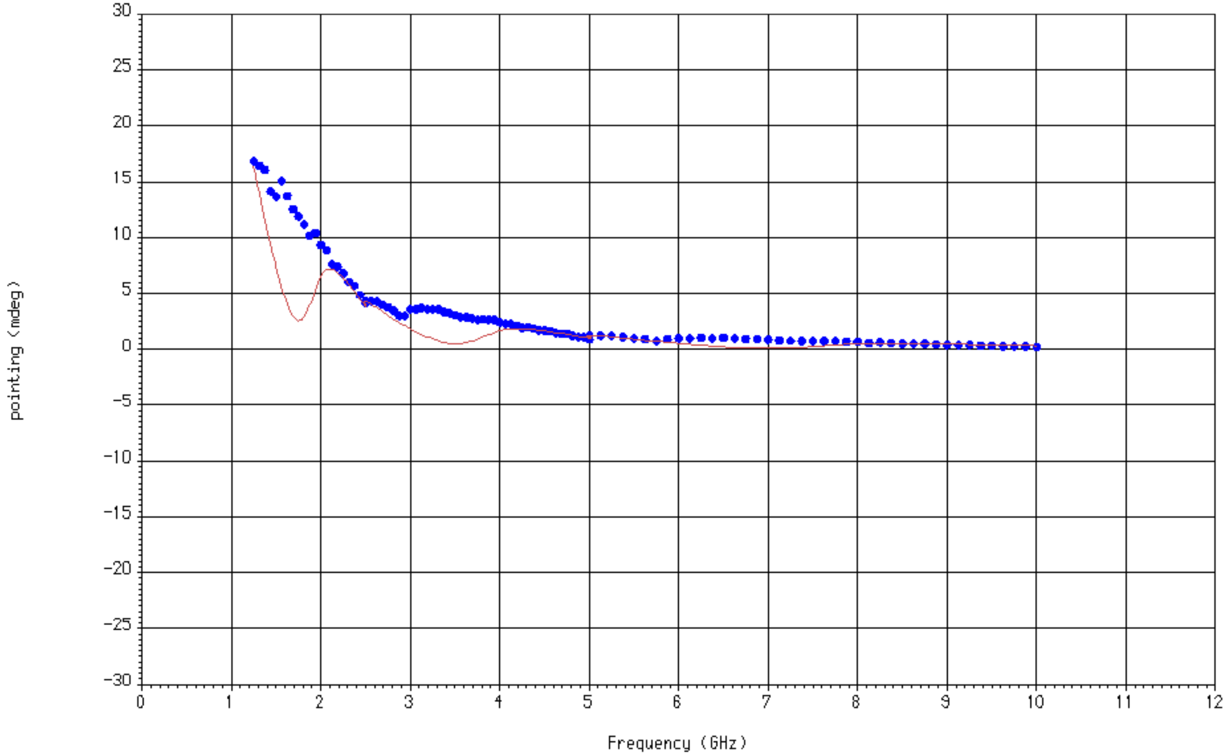


Figure 1.15 Pointing offset for both feeds

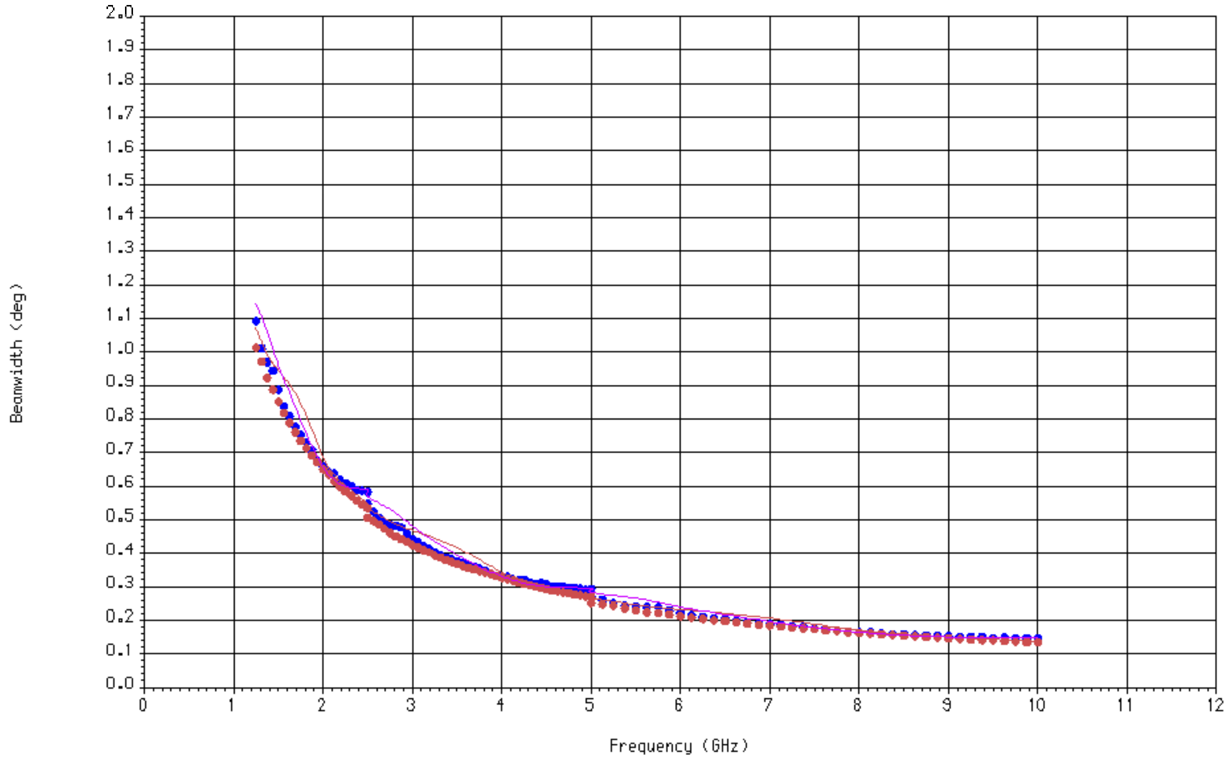


Figure 1.16 E and H-plane beamwidths for both feeds

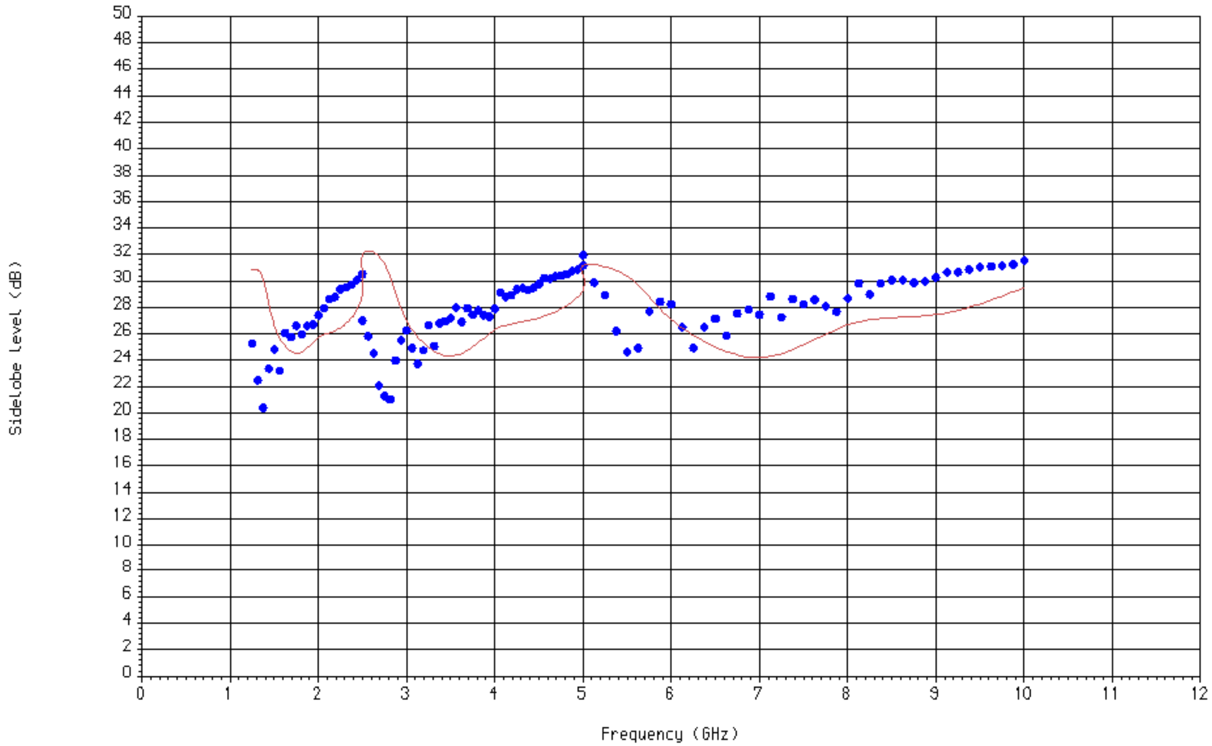


Figure 1.17 Peak sidelobe level for both feeds

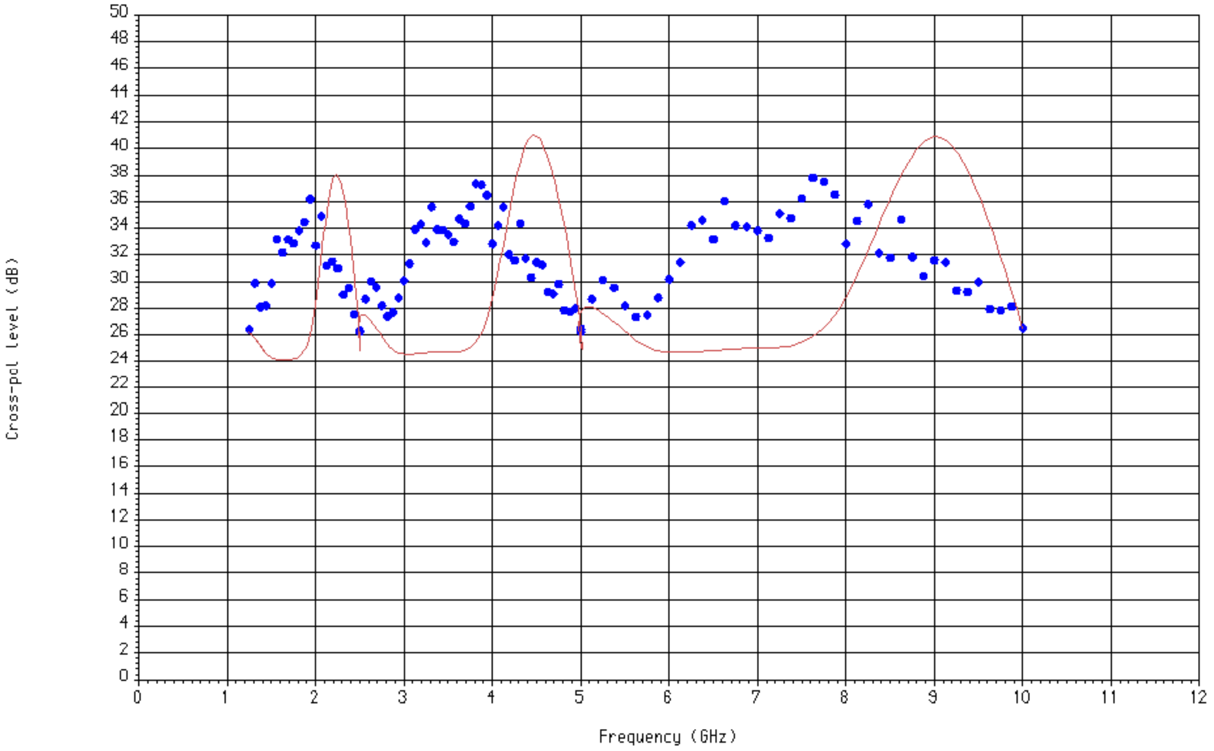
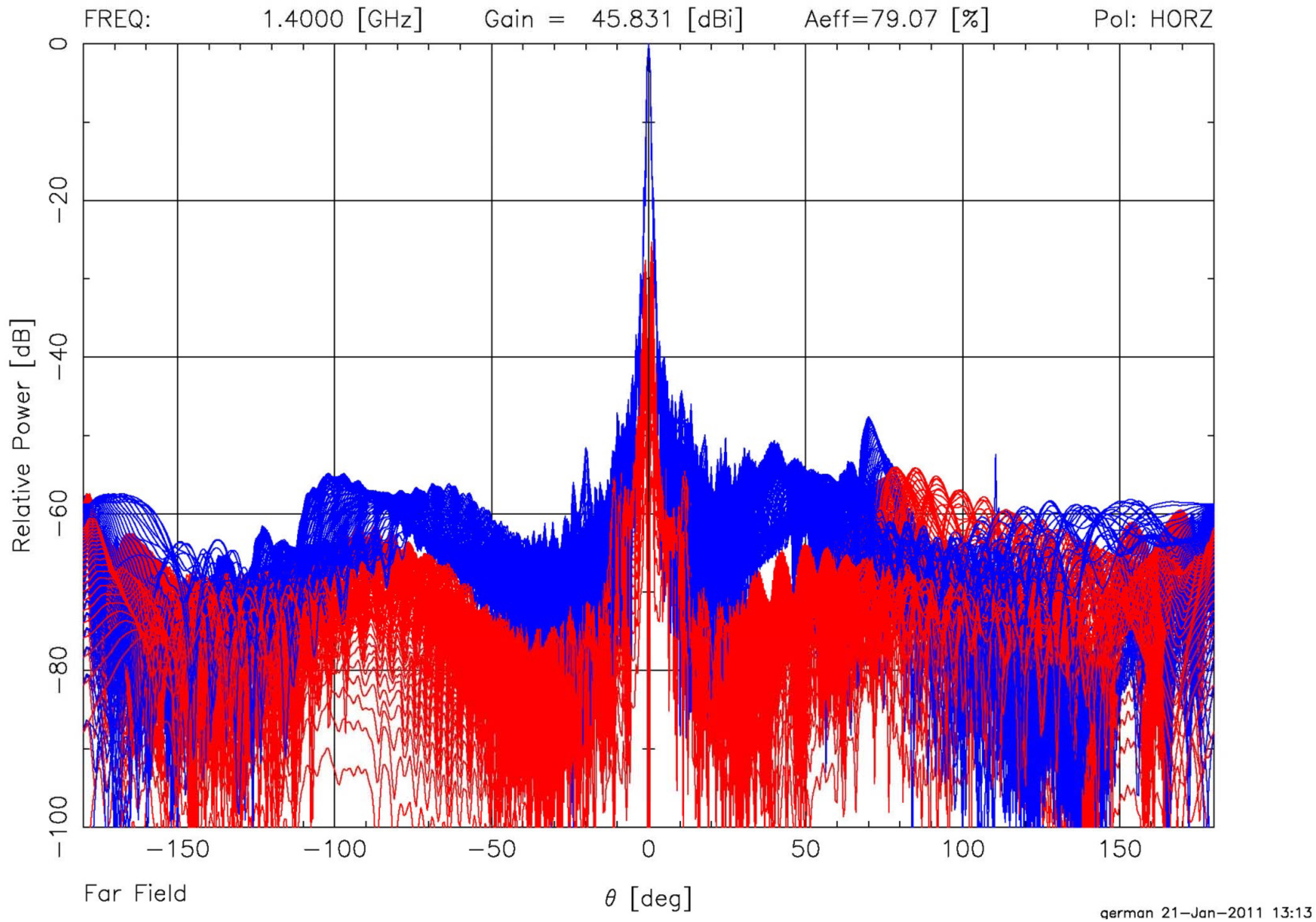
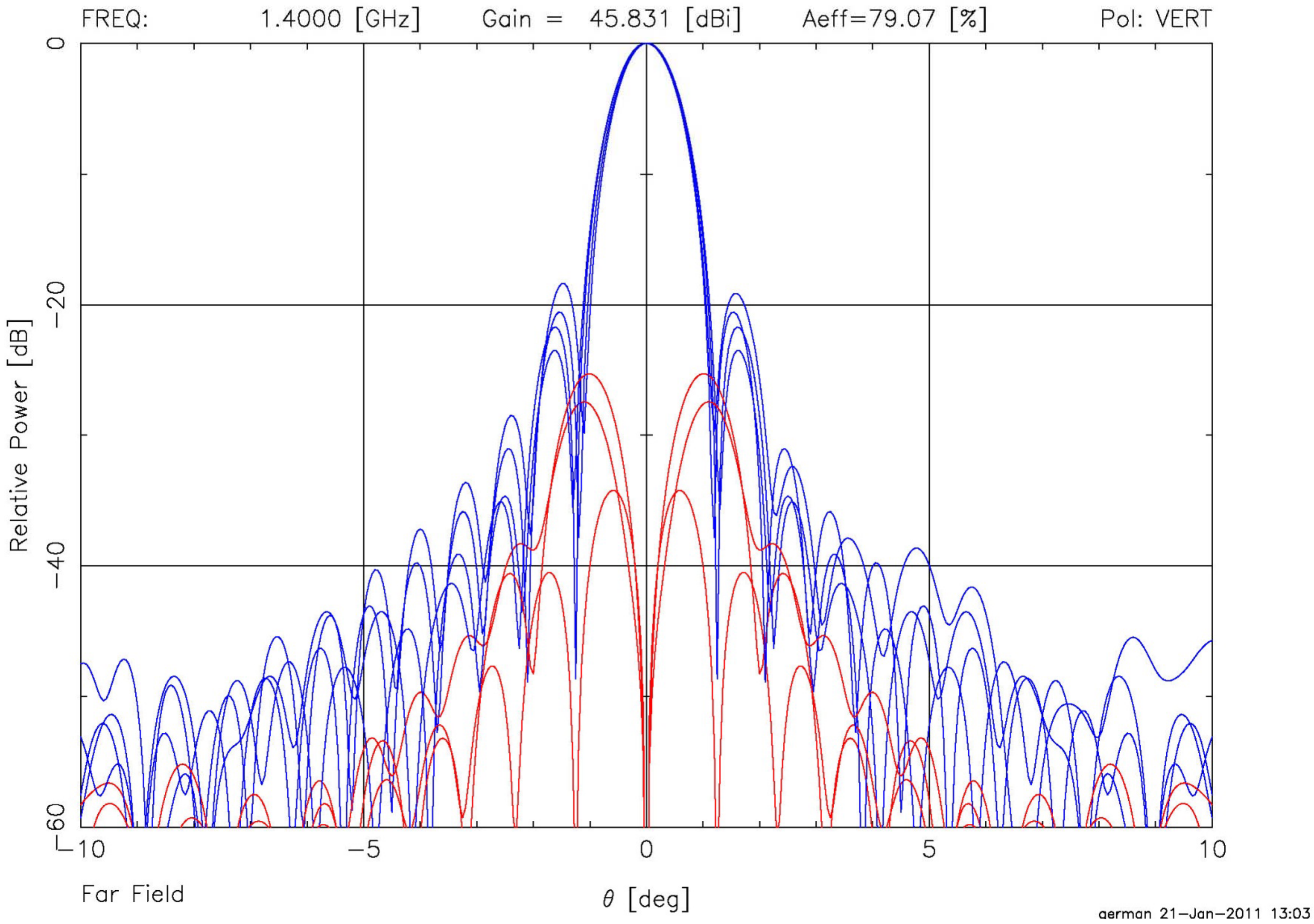


Figure 1.18 Peak cross polarization levels for both feeds

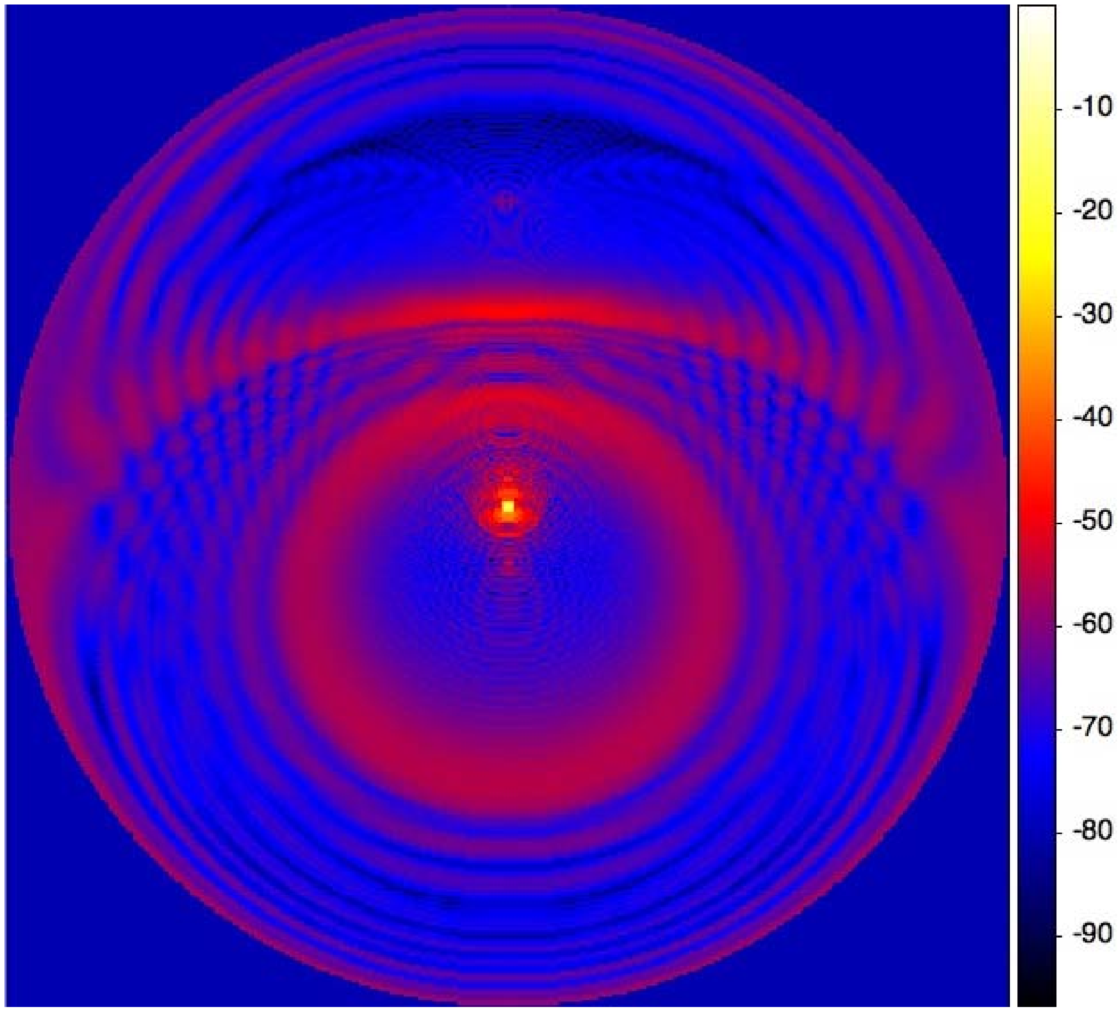
Wide angle Radiation pattern cuts at 1.4 GHz of the 15m Shaped Offset Gregorian 55°sub optics with a ring-loaded corrugated horn.

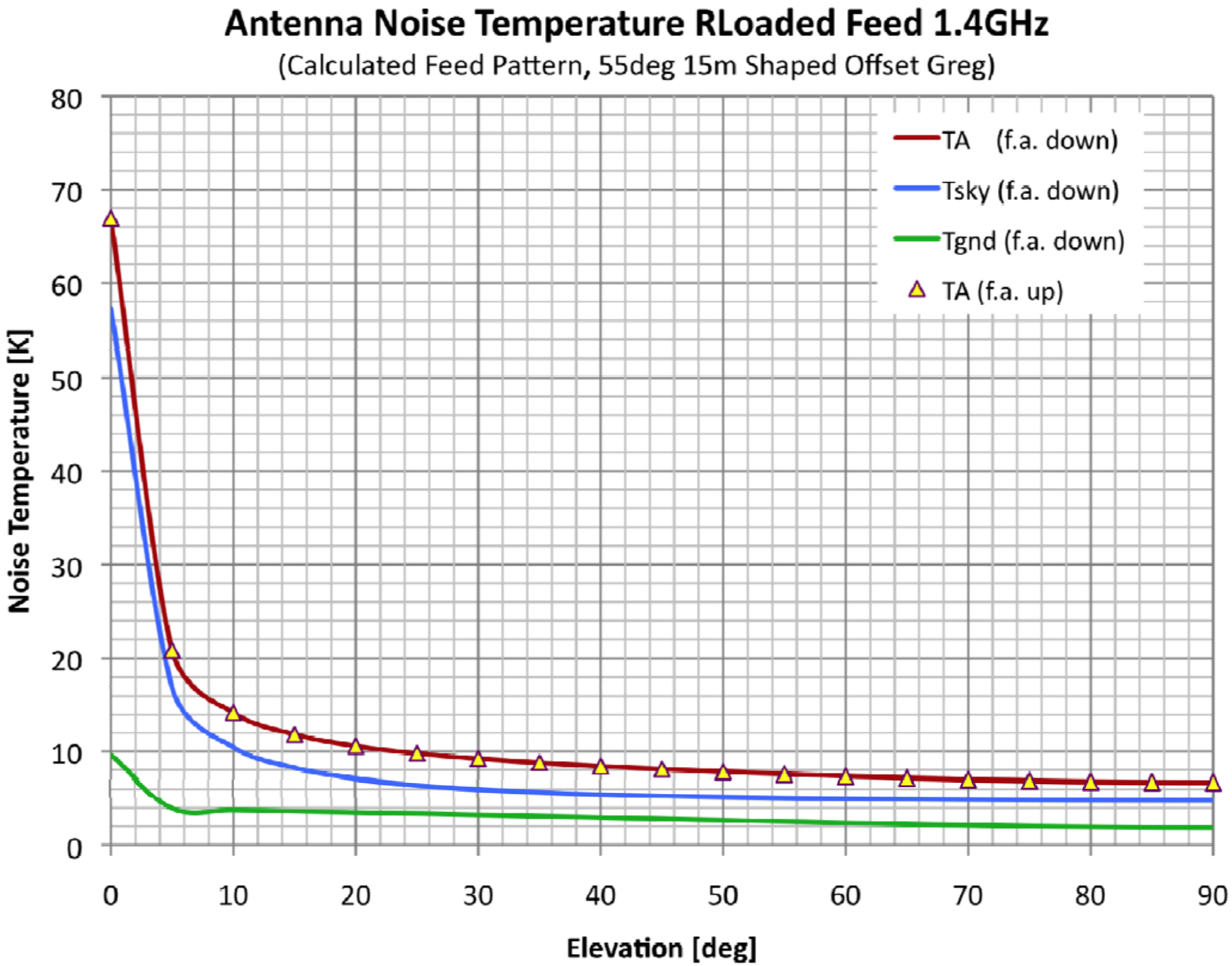


Near main beam radiation pattern cuts at 1.4 GHz of the 15m Shaped Offset Gregorian 55°sub optics with a ring-loaded corrugated horn.



Full antenna pattern map at 1.4 GHz for the 15m Shaped Offset Gregorian 55°sub optics with a ring-loaded corrugated horn. The scale is the relative power in dB with respect to the main beam





Antenna Noise Temperature (1.4 GHz) vs. Elevation for the 15m Shaped Offset Gregorian

Figure 1.19 CIT Quad-ridge Flared Horn (QRFH)

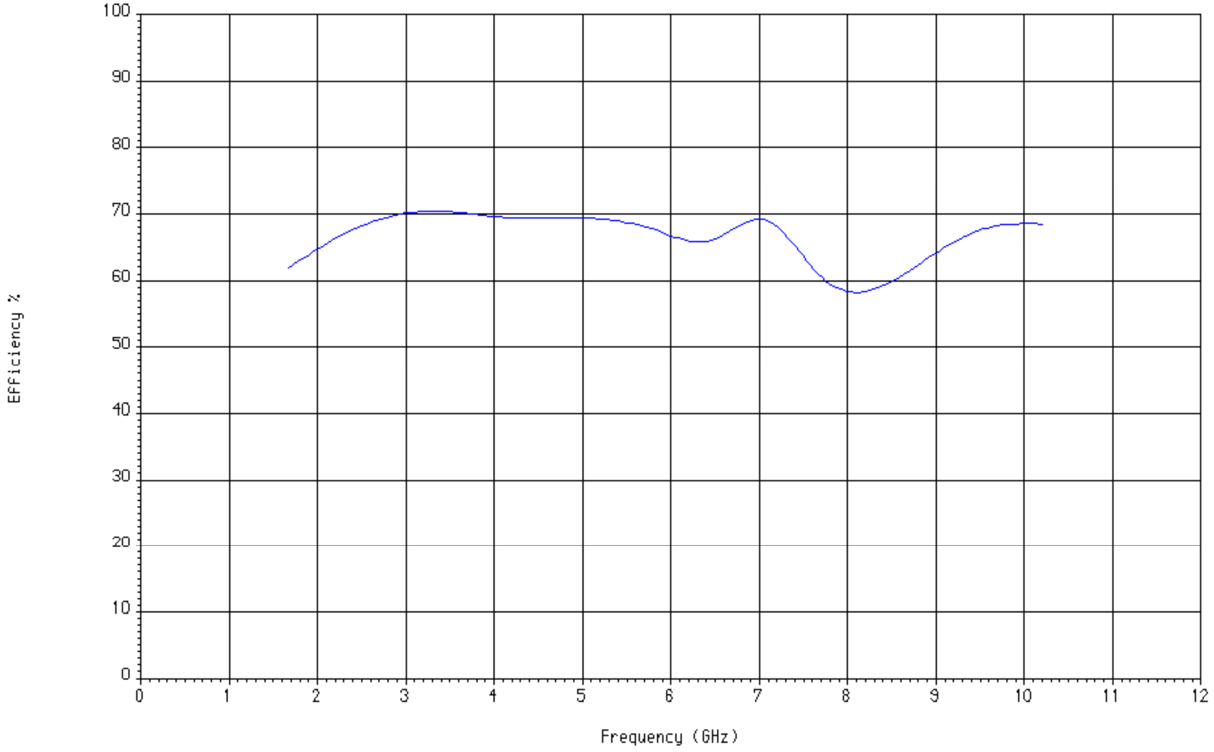


Figure 1.20 Quad ridged feed efficiency as a function of frequency

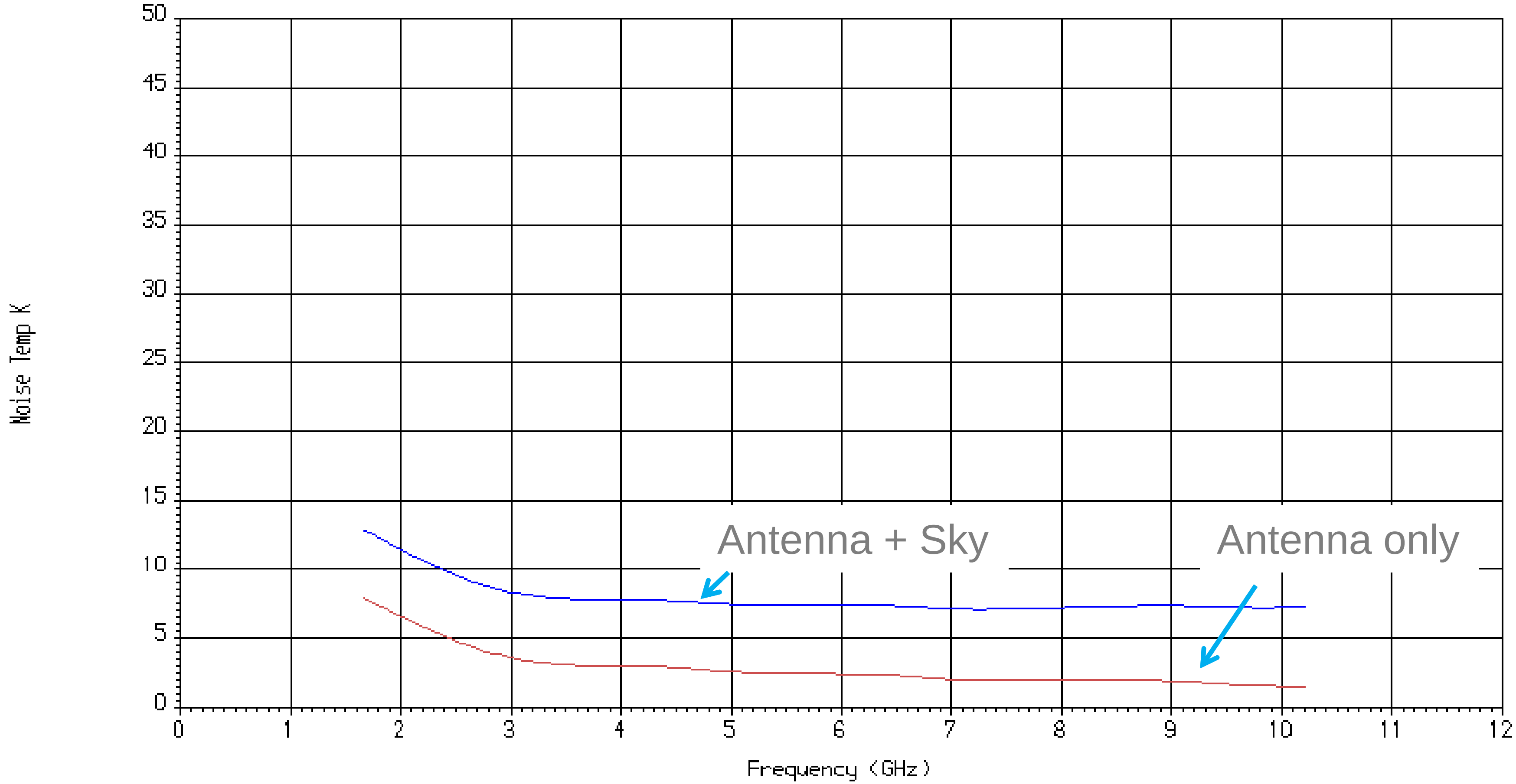


Figure 1.21 Quad ridged feed Noise Temperature as a function of frequency

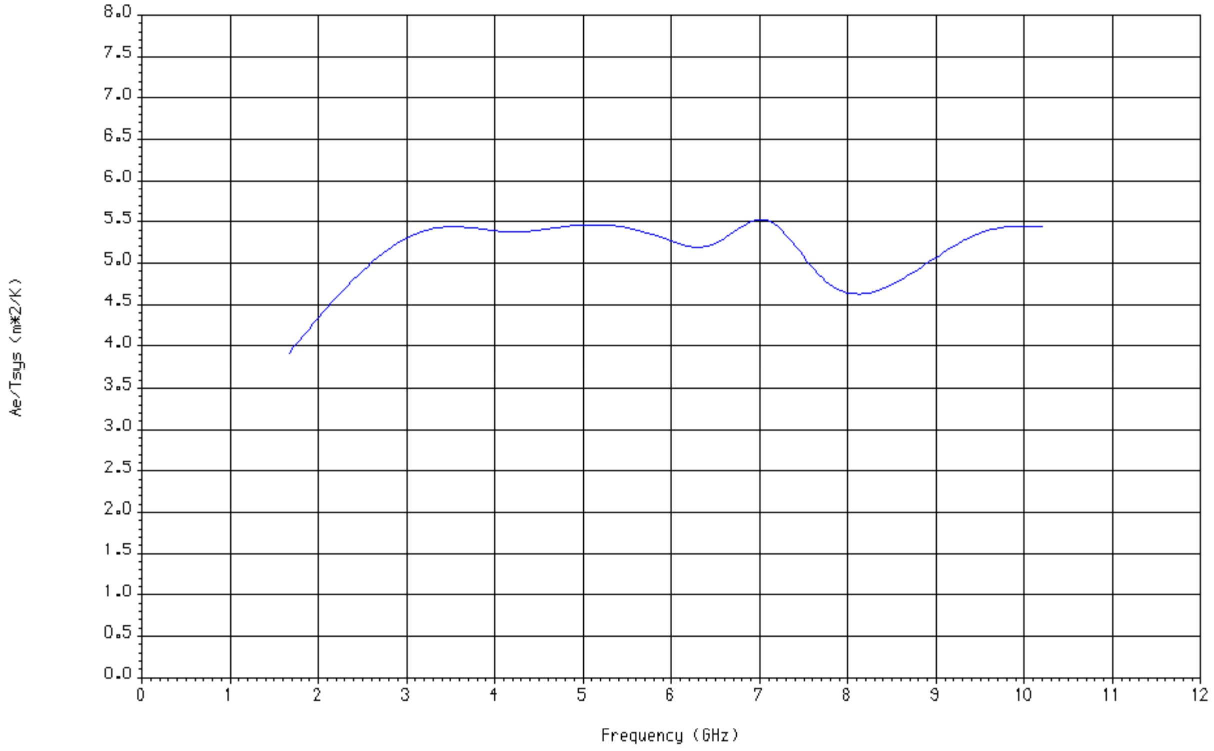


Figure 1.22 Ae/Tsys of the Quad ridged feed as a function of frequency

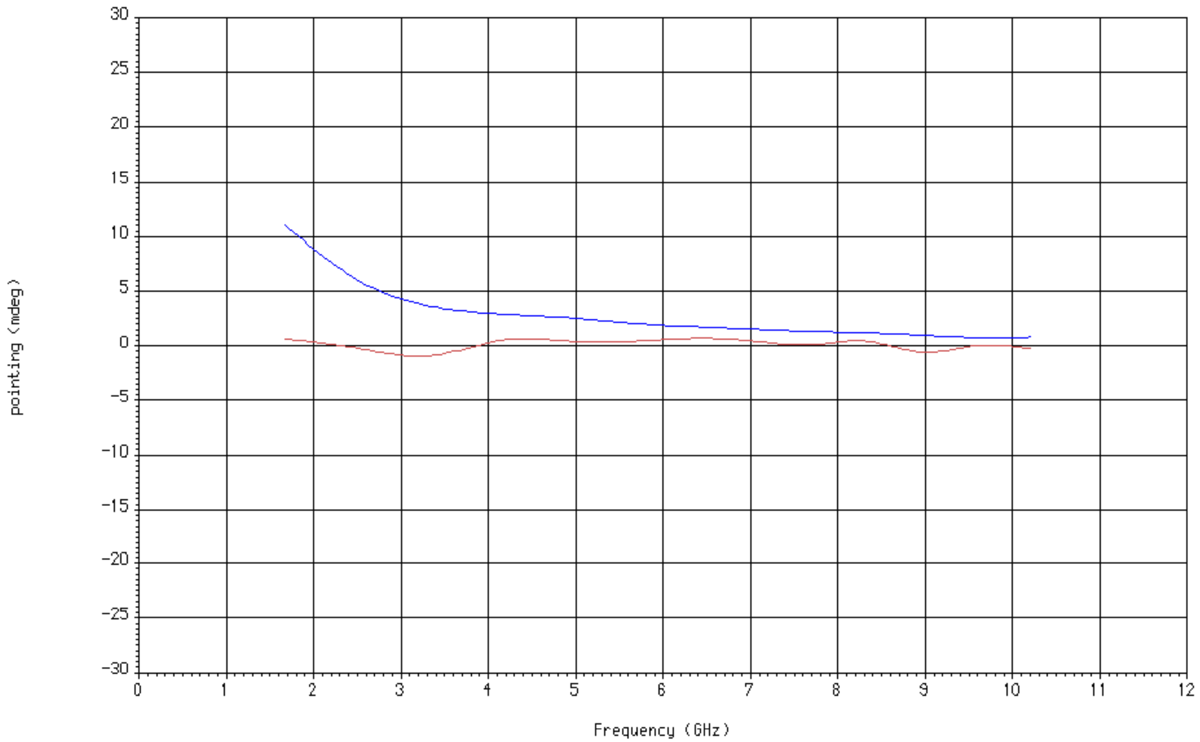


Figure 1.23 Pointing offset of the Quad ridged feed as a function of frequency

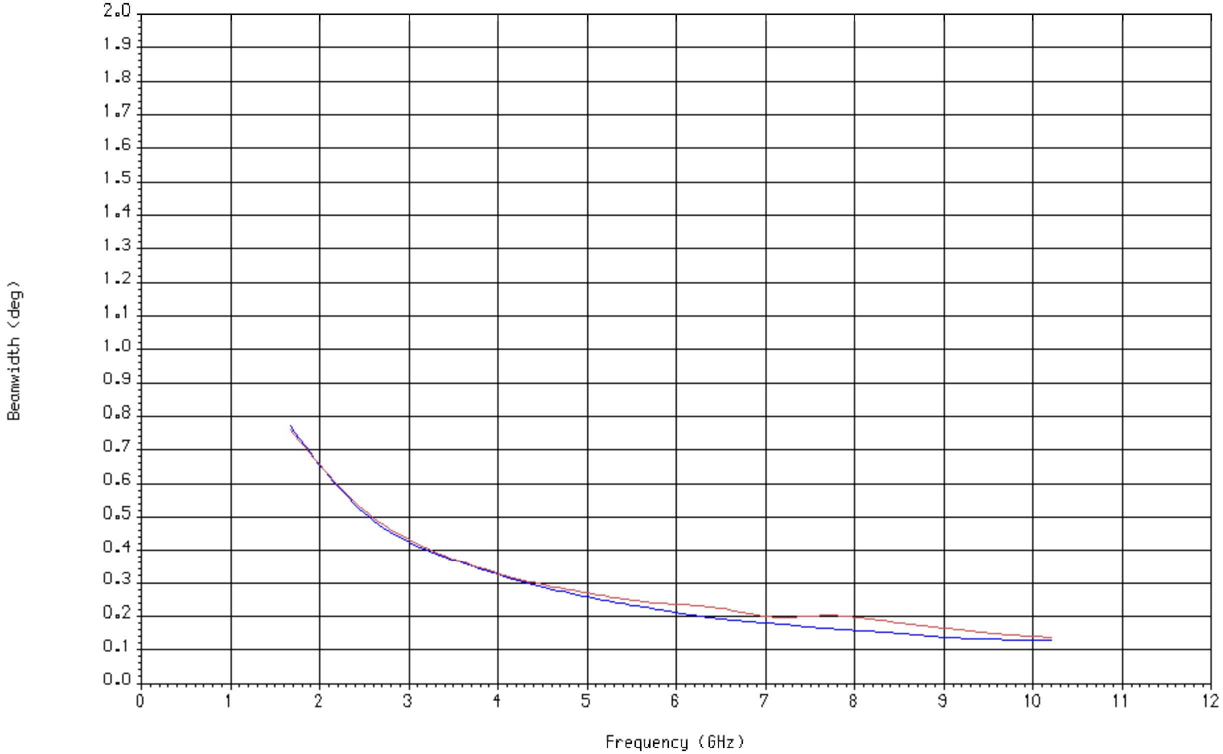


Figure 1.24 E- and H-plane beamwidths as a function of frequency

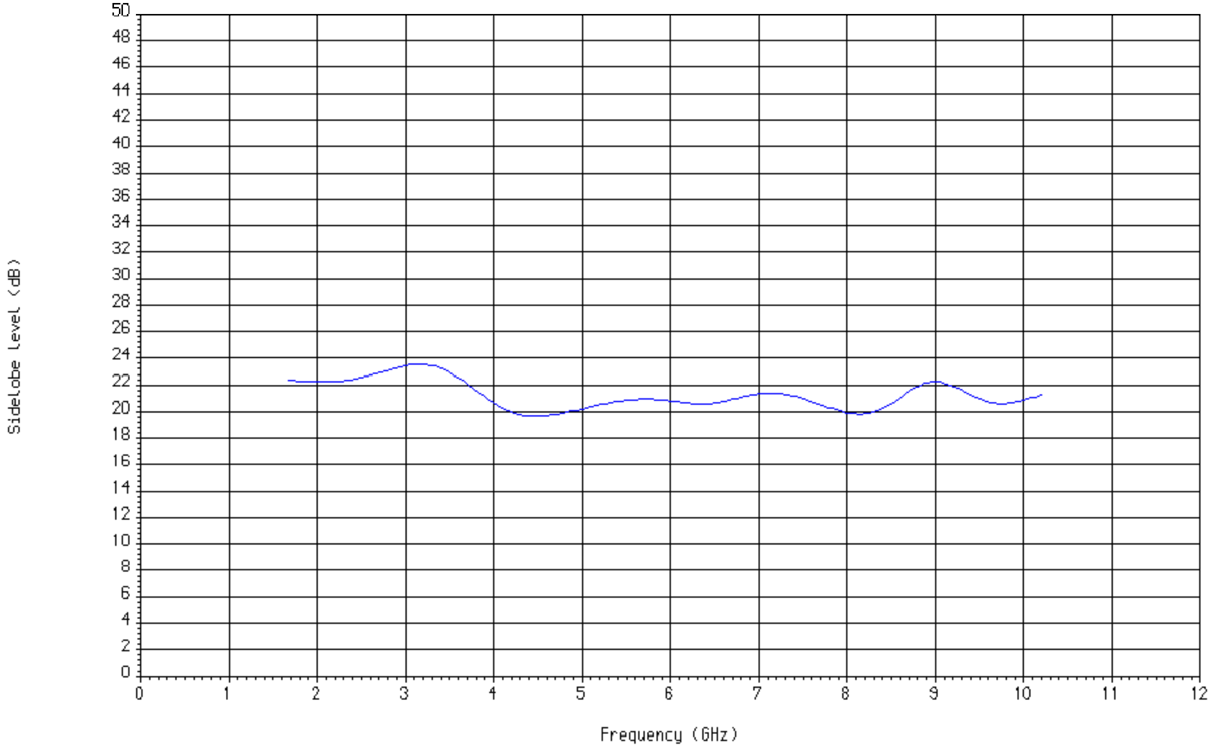


Figure 1.25 Sidelobe level as a function of frequency

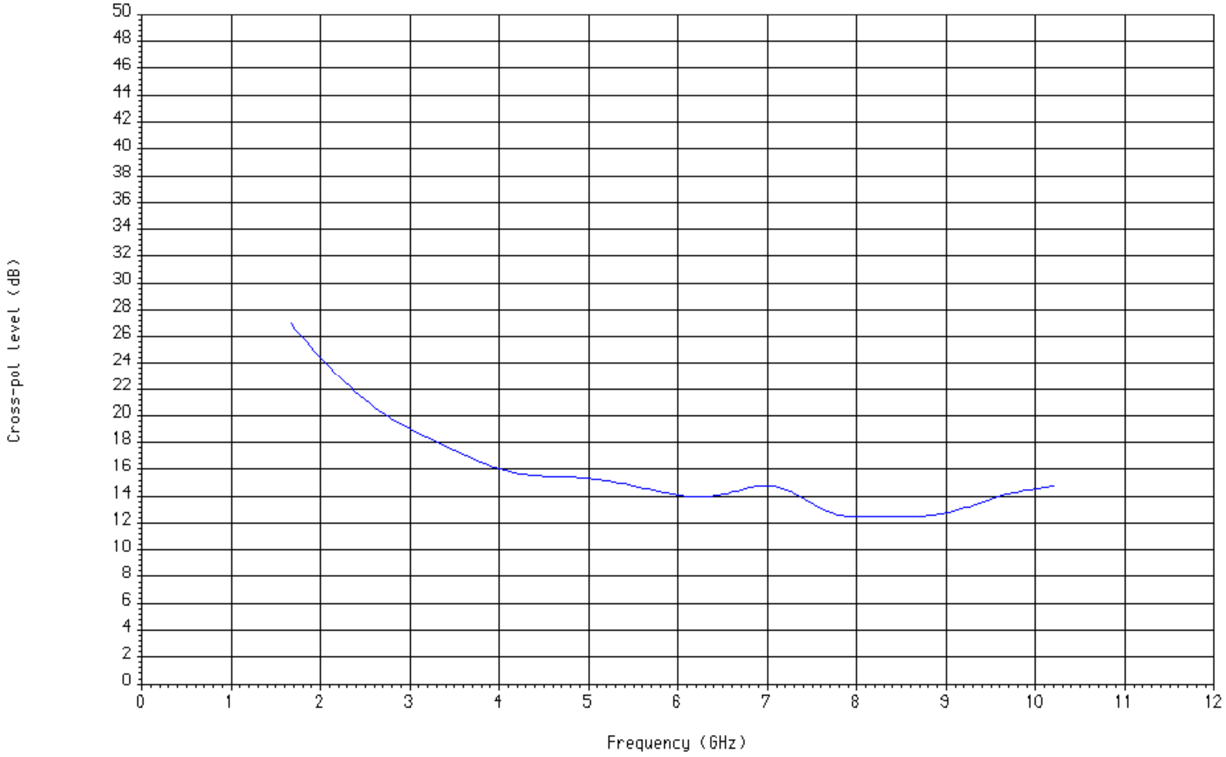


Figure 1.26 Cross polarization level as a function of frequency


QSC Feed

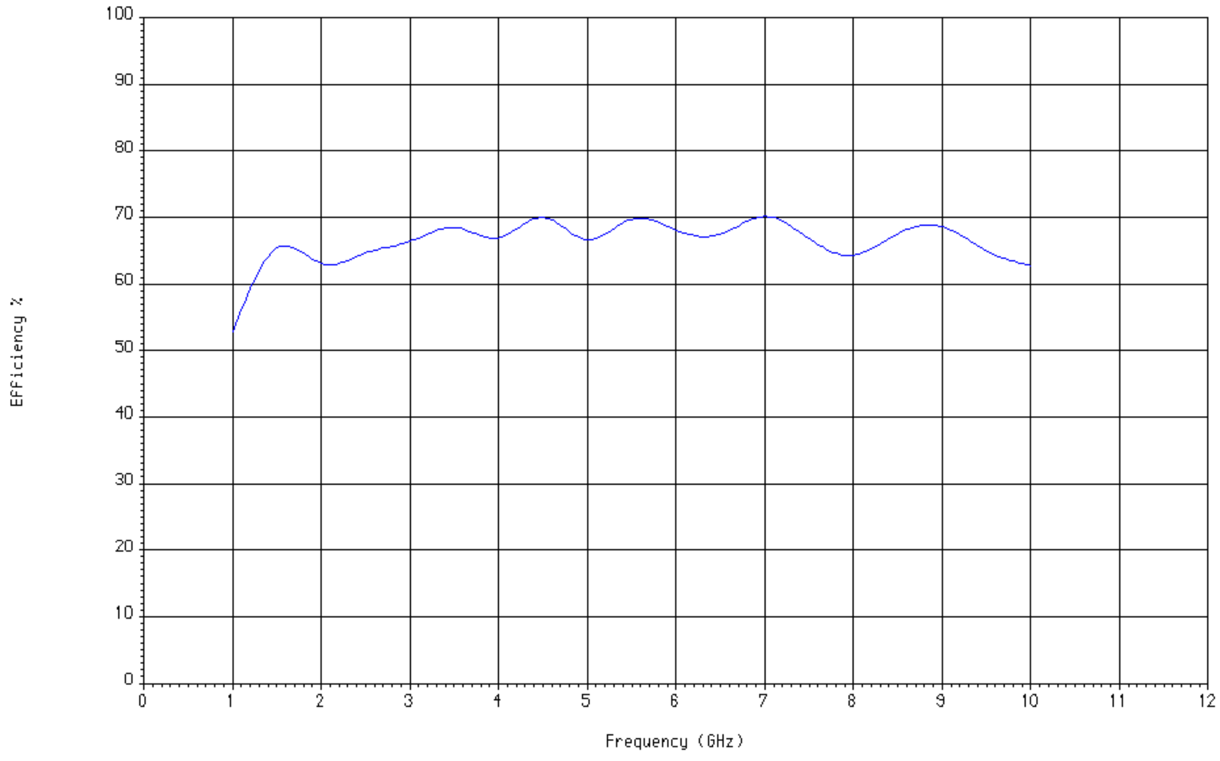


Figure 1.28 Efficiency of the QSC-i as a function of frequency

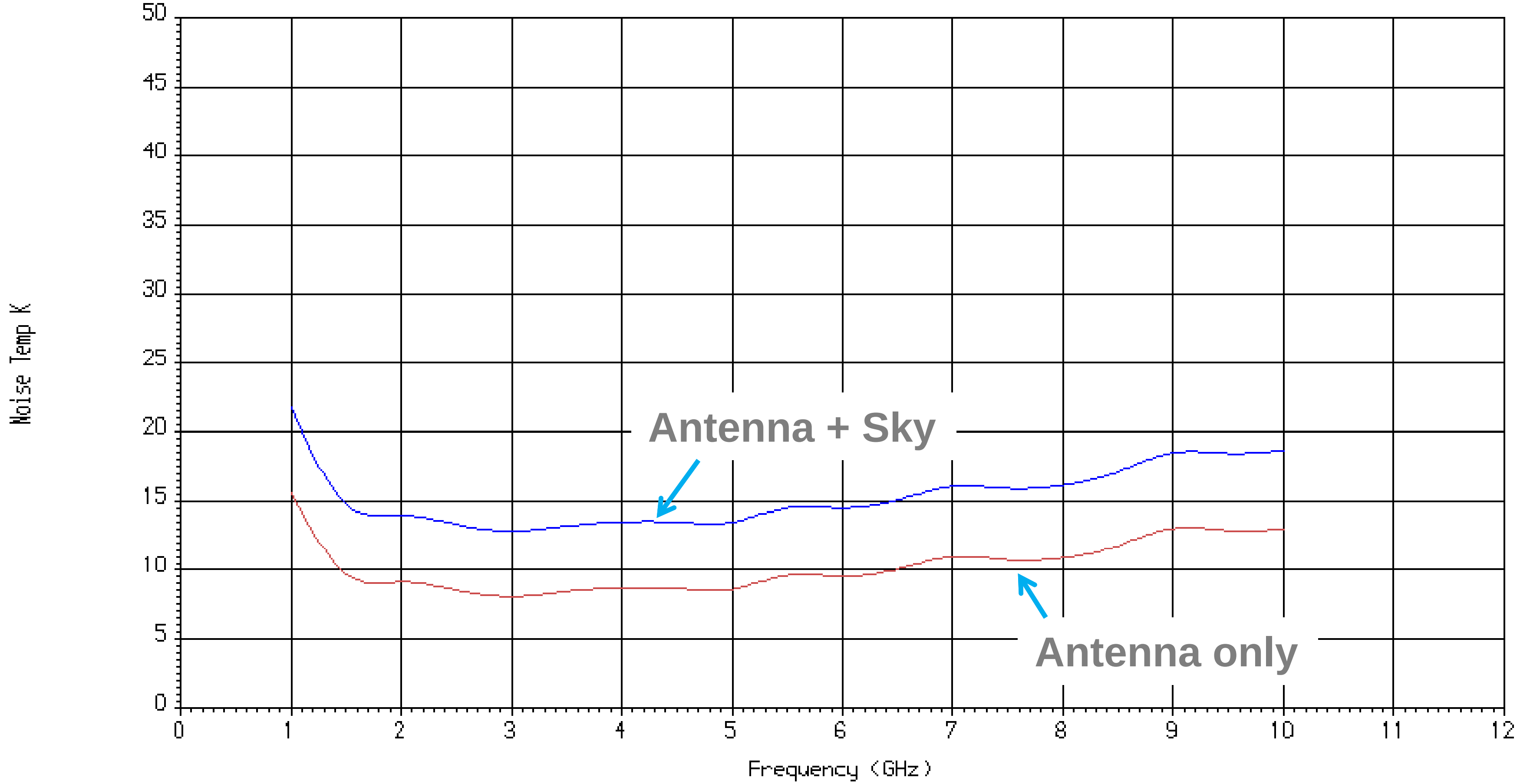


Figure 1.29 Noise Temperature of the QSC-i as a function of frequency

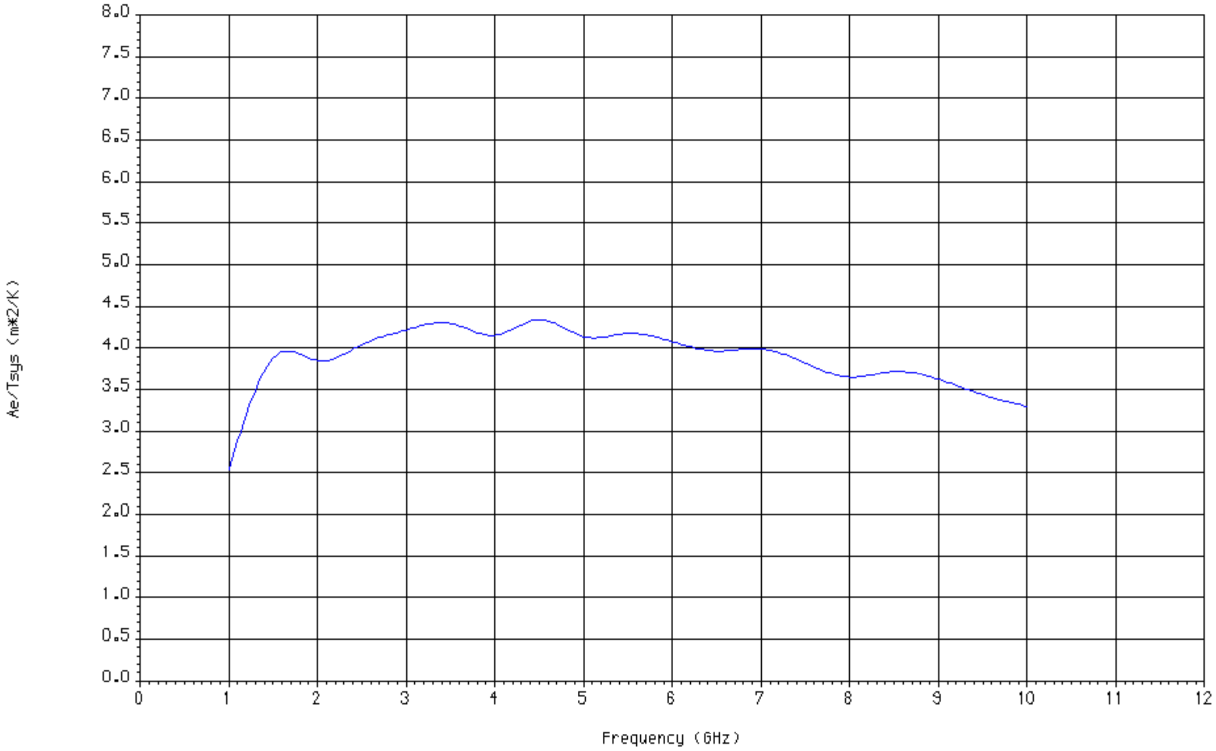


Figure 1.30 Ae/Tsys of the QSC-i as a function of frequency

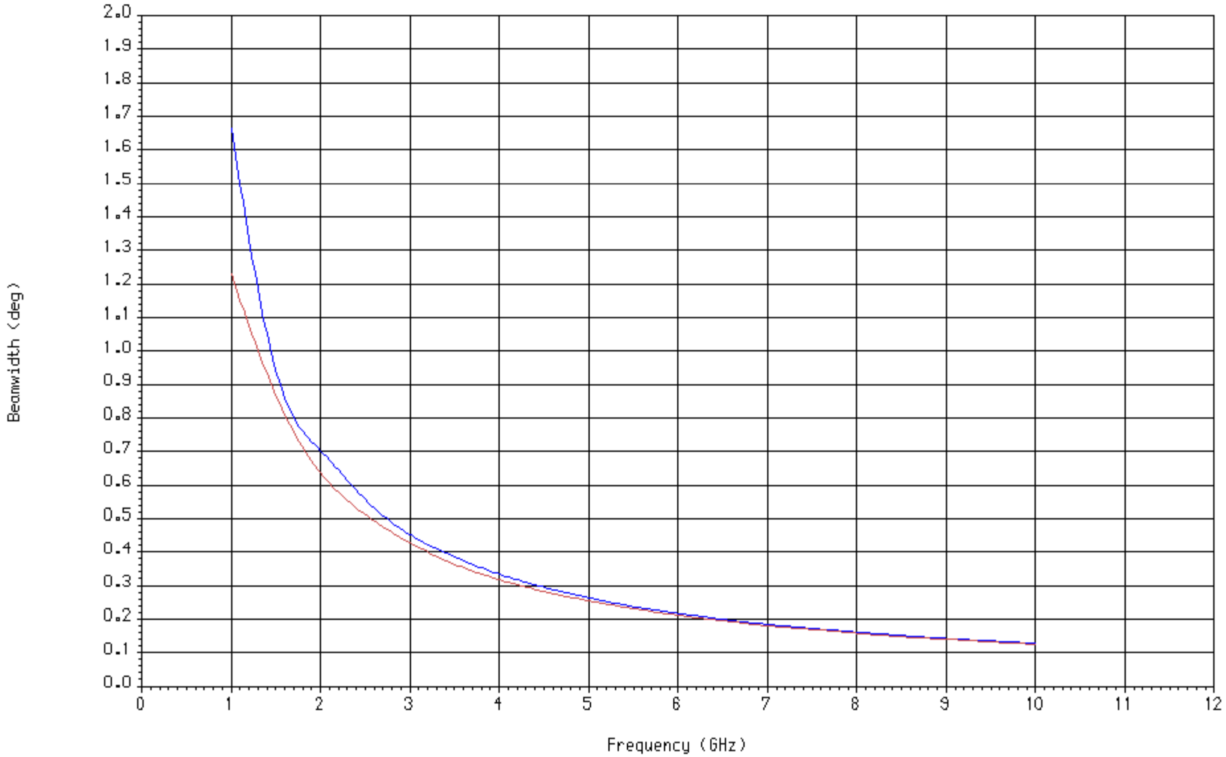


Figure 1.32 E- and H-plane beamwidths of the QSC-i as a function of frequency

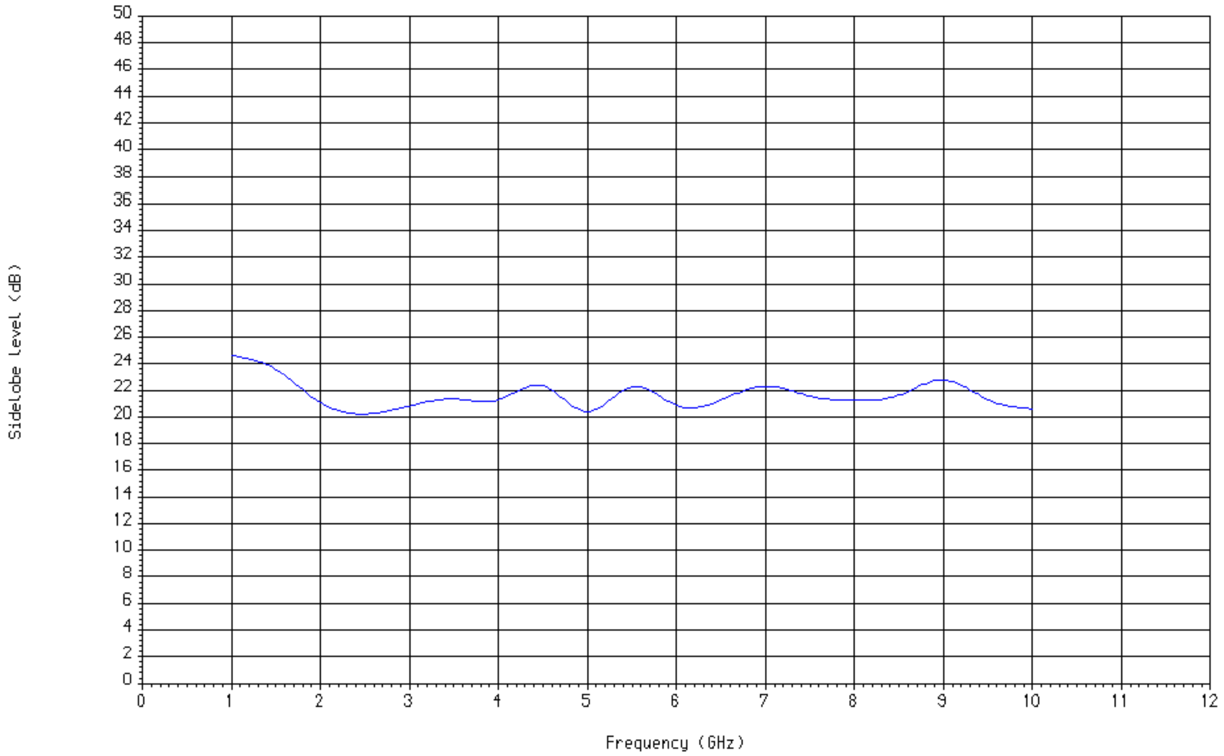


Figure 1.33 Sidelobe level of the QSC-i as a function of frequency

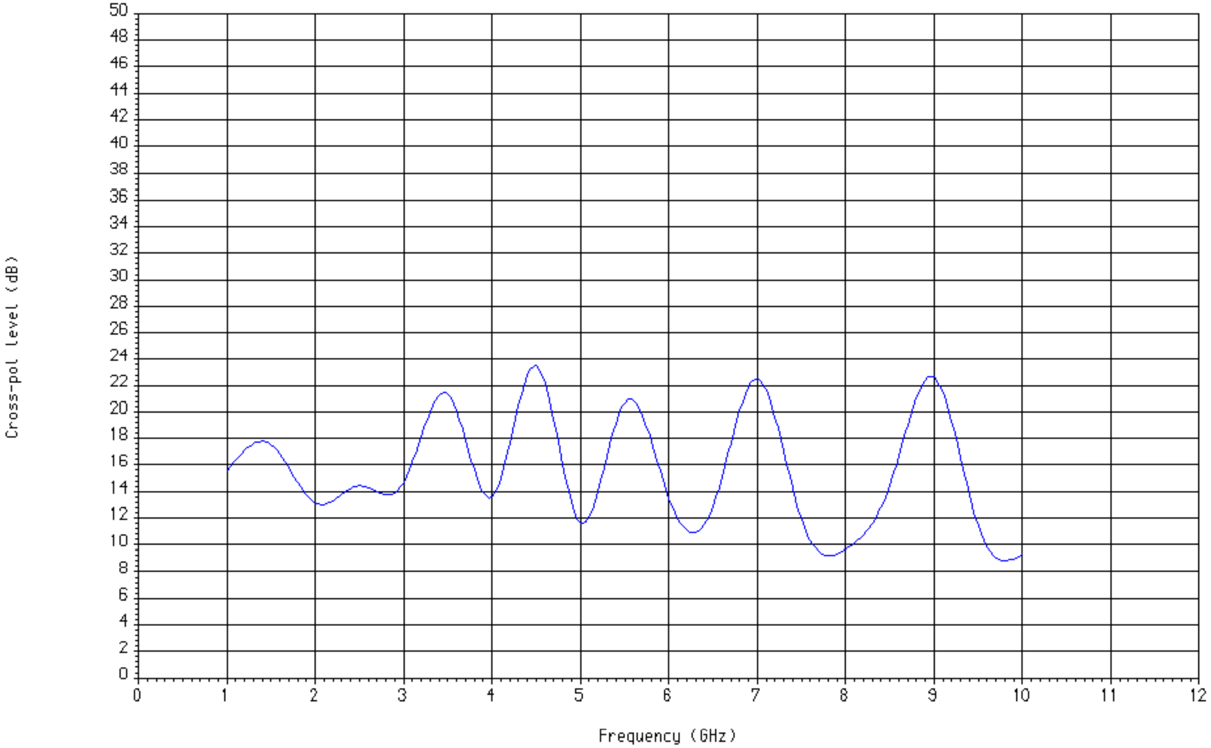
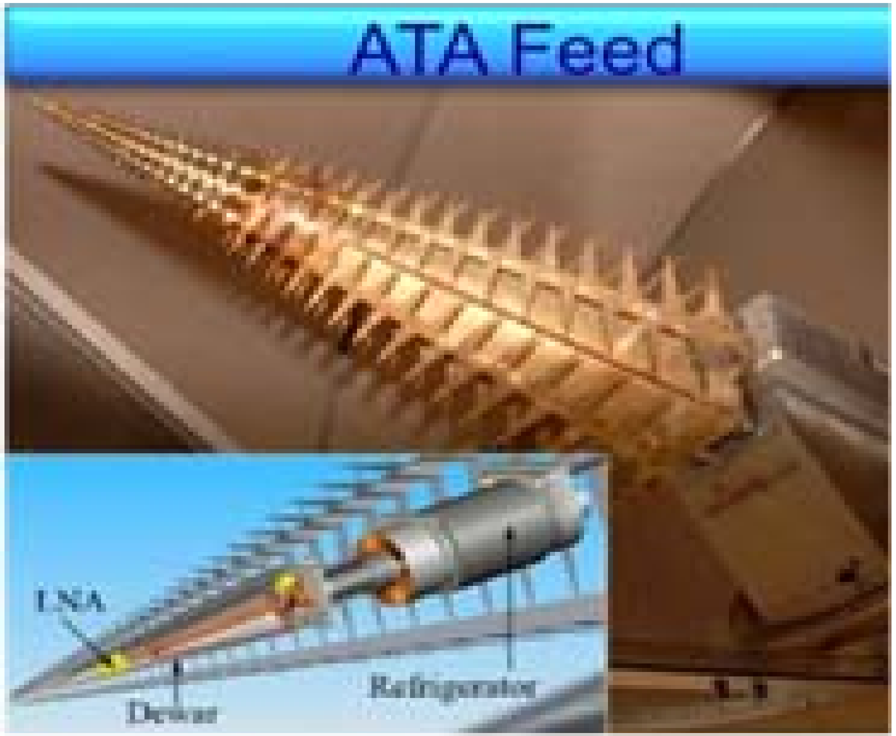


Figure 1.34 Peak Cross polarization of the QSC-i as a function of frequency


ATA Feed
LNA
Dewar
Refrigerator

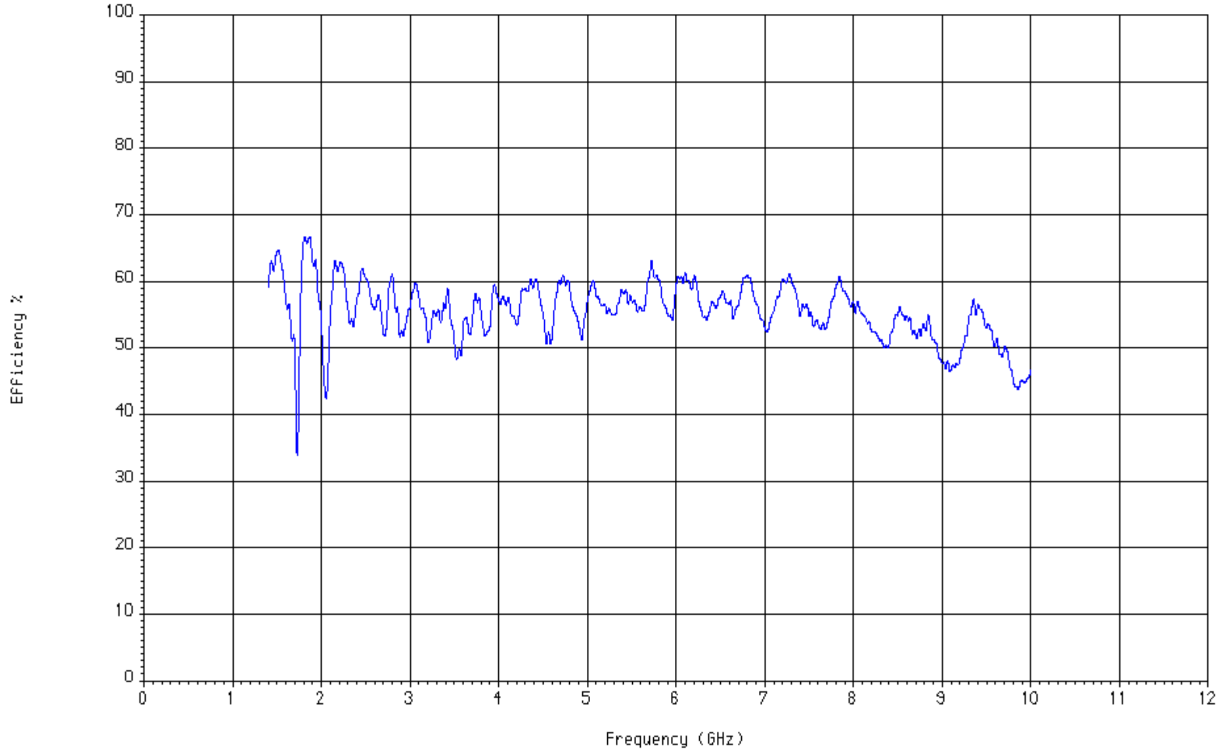


Figure 1.36 Efficiency of the ATA feed as a function of frequency

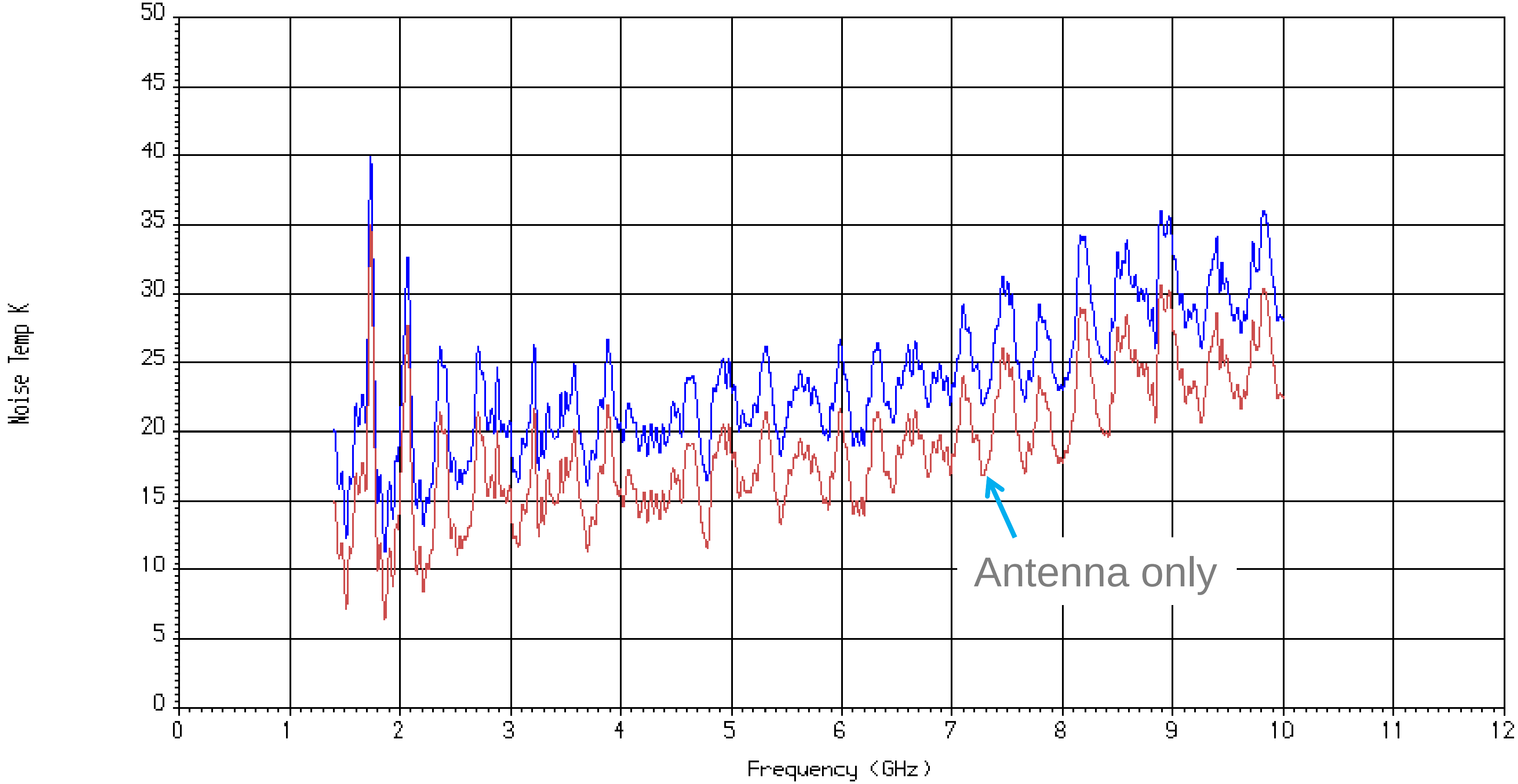


Figure 1.37 Noise Temperature of the ATA feed as a function of frequency

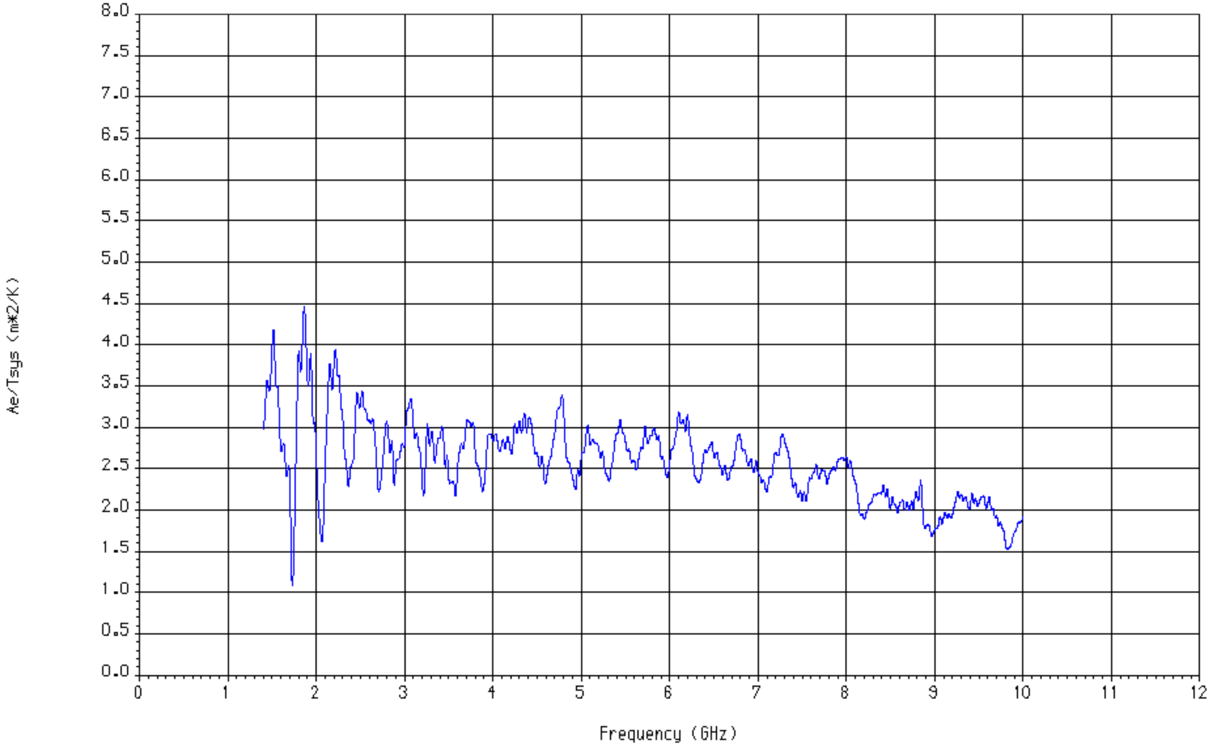


Figure 1.38 Ae/Tsys of the ATA feed as a function of frequency

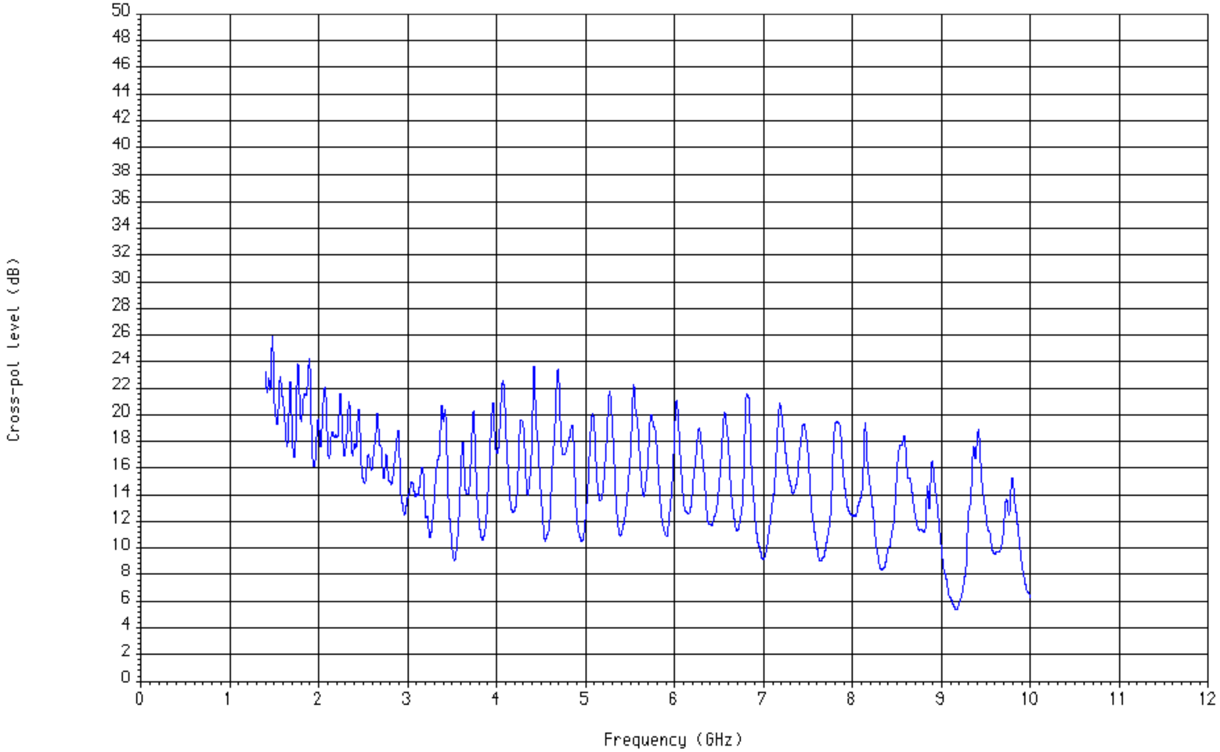
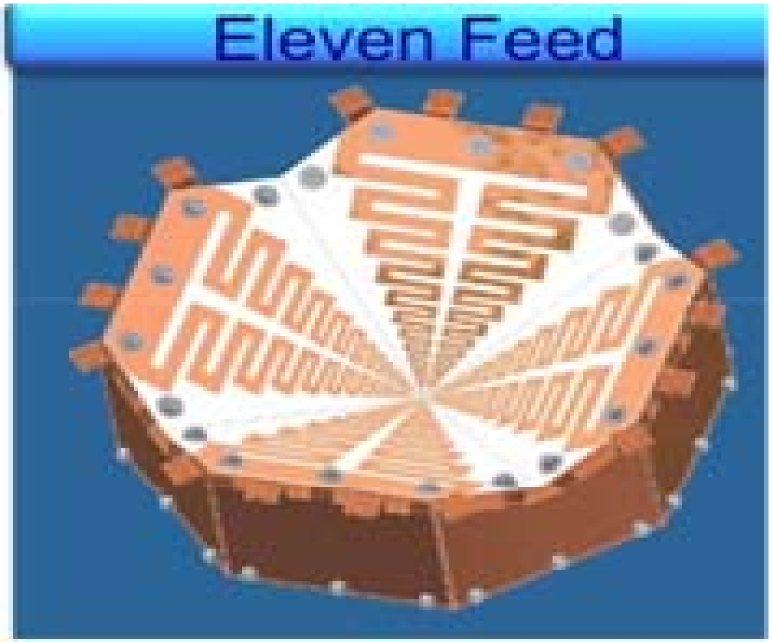


Figure 1.42 Peak Cross polarization of the ATA feed as a function of frequency


Eleven Feed

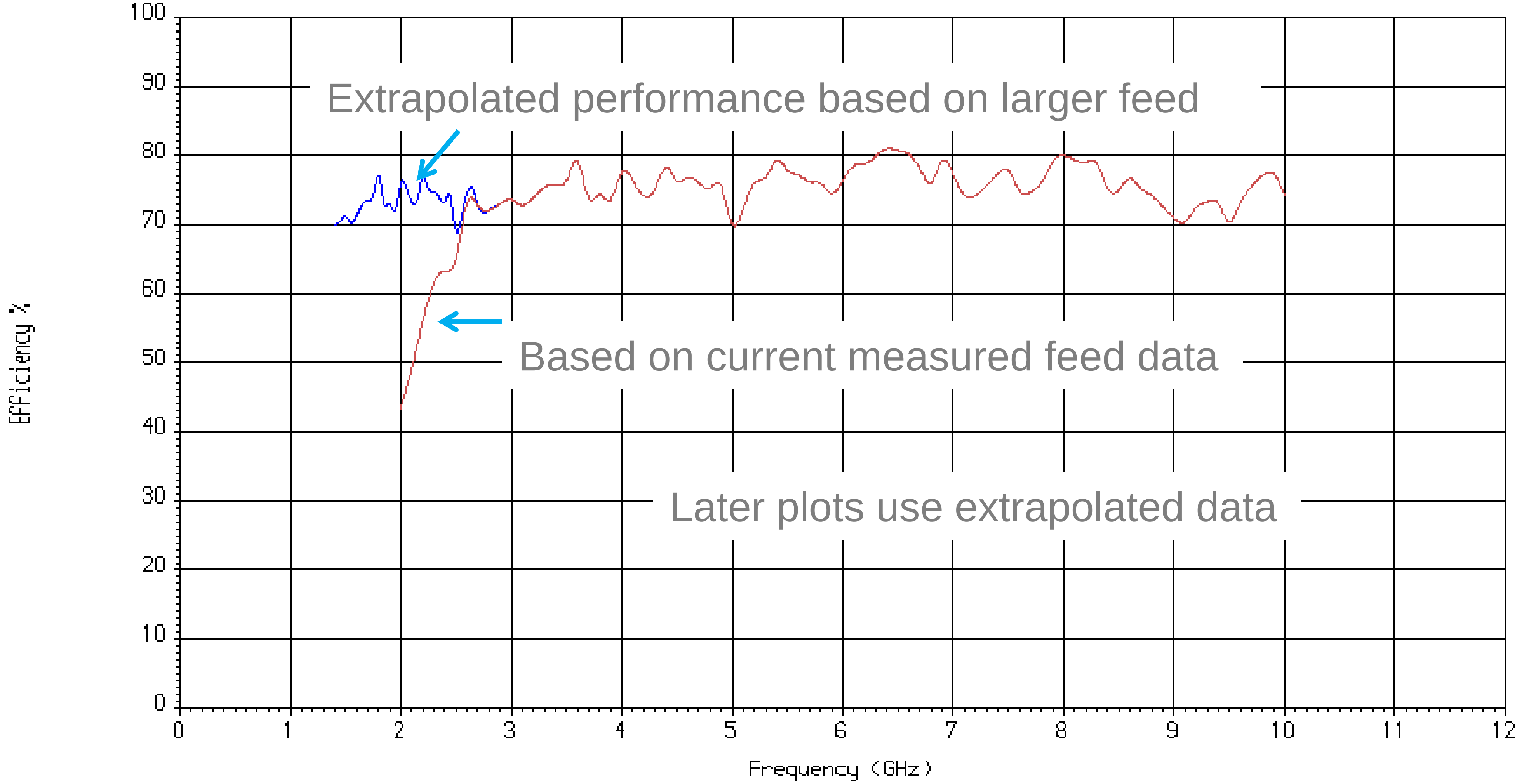


Figure 1.44 Efficiency of the Eleven feed as a function of frequency

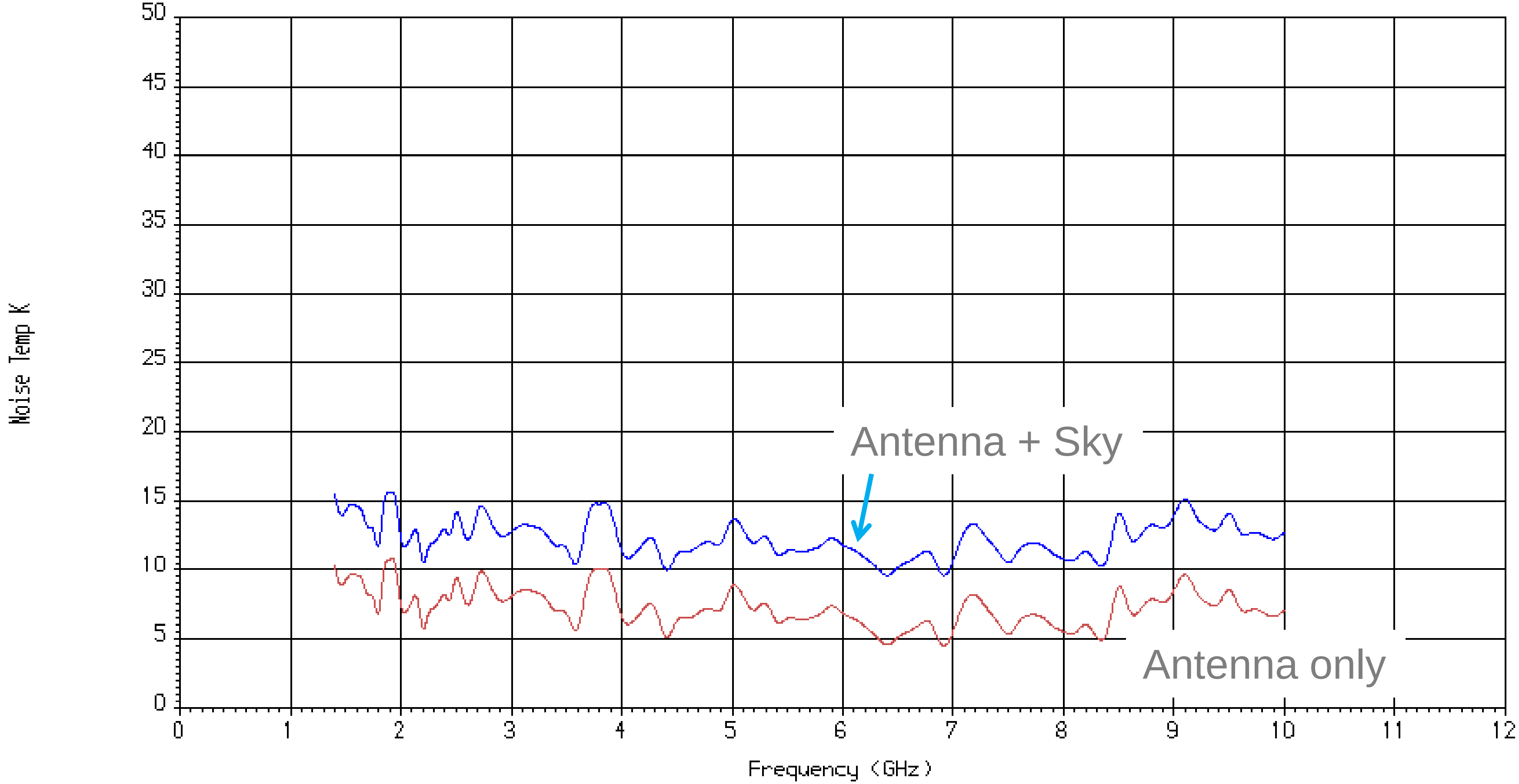


Figure 1.45 Noise Temperature of the Eleven feed as a function of frequency

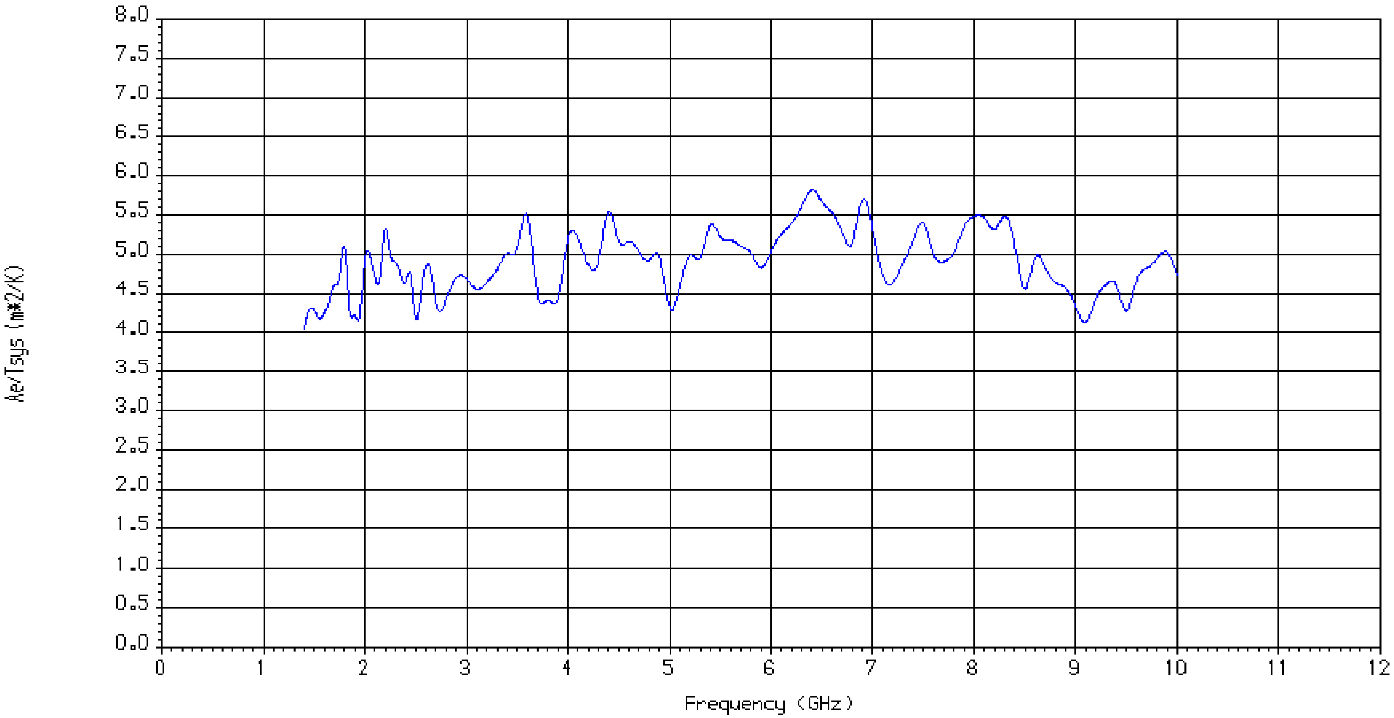


Figure 1.46 Ae/Tsys of the Eleven feed as a function of frequency

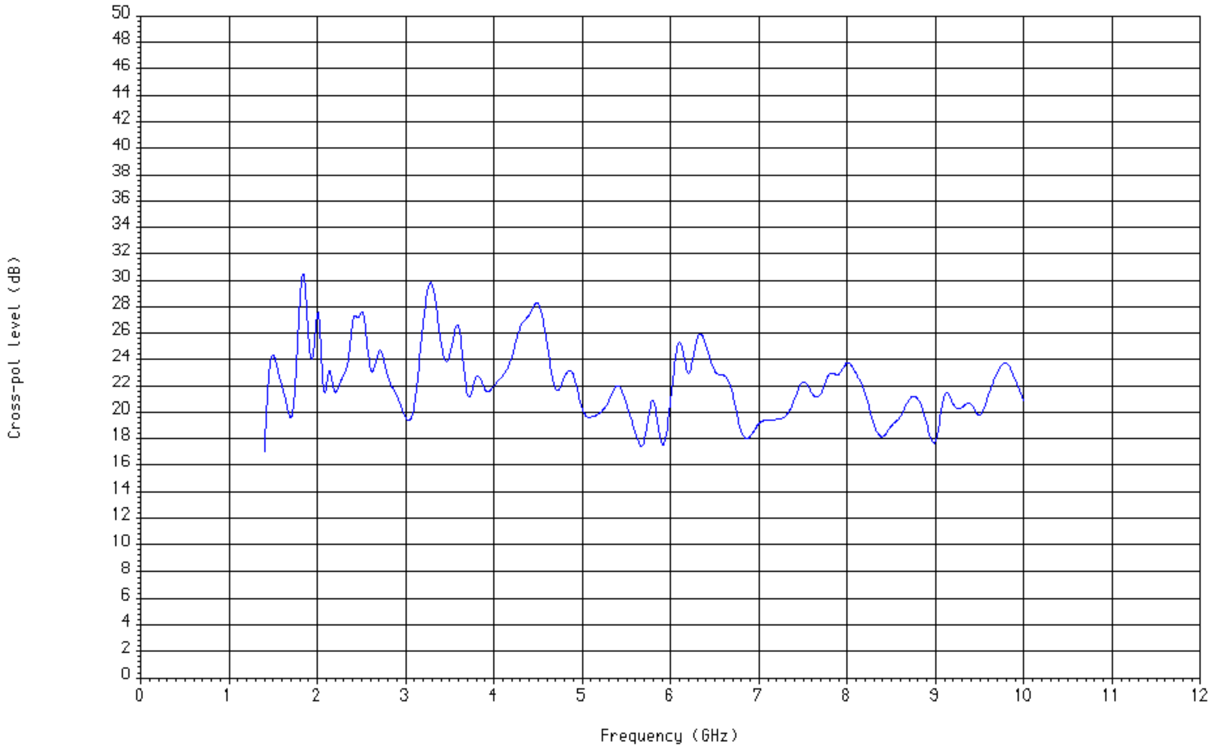
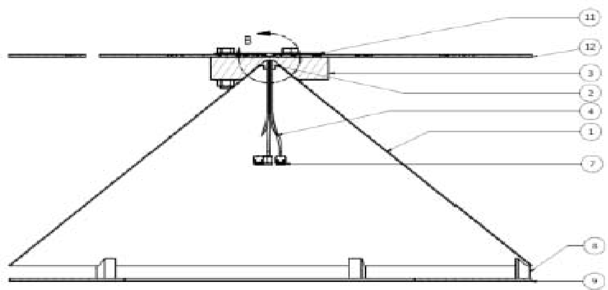


Figure 1.50 Peak Cross-polarization of the Eleven feed as a function of frequency

Log Periodic Log Spiral

(a)



(b)

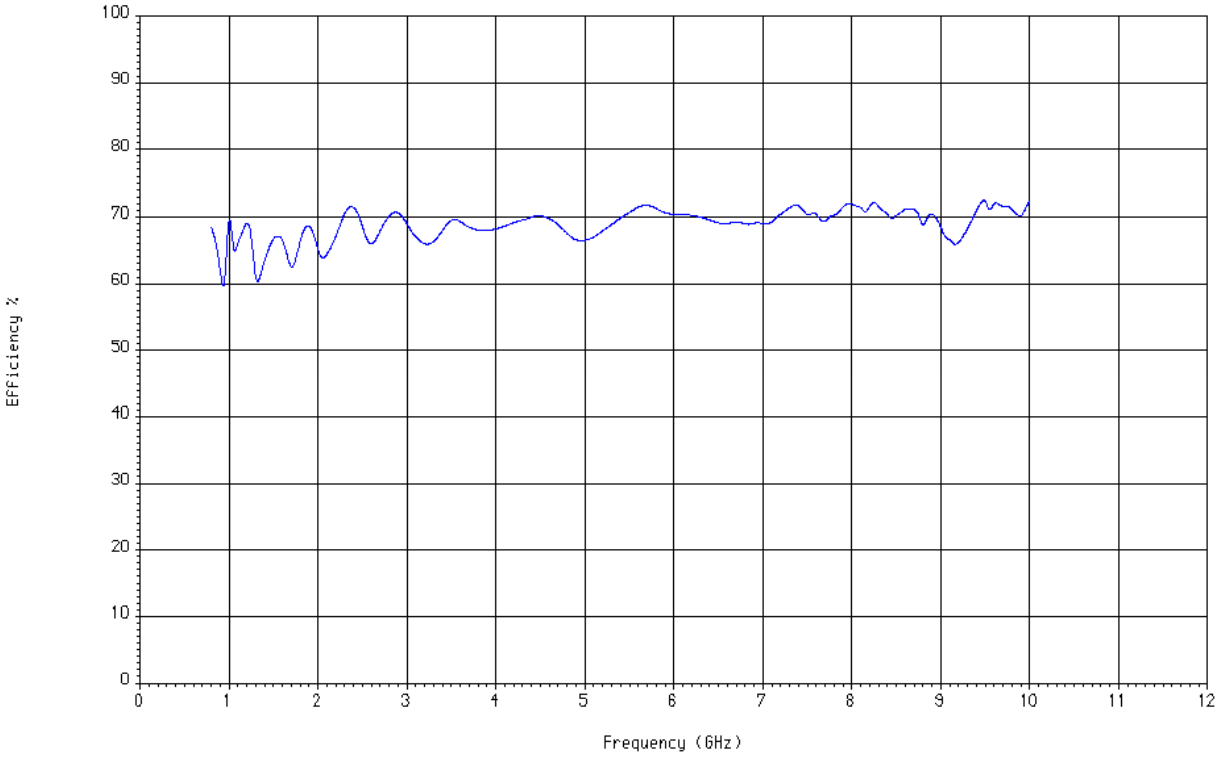


Figure 1.52 Efficiency of the log spiral antenna

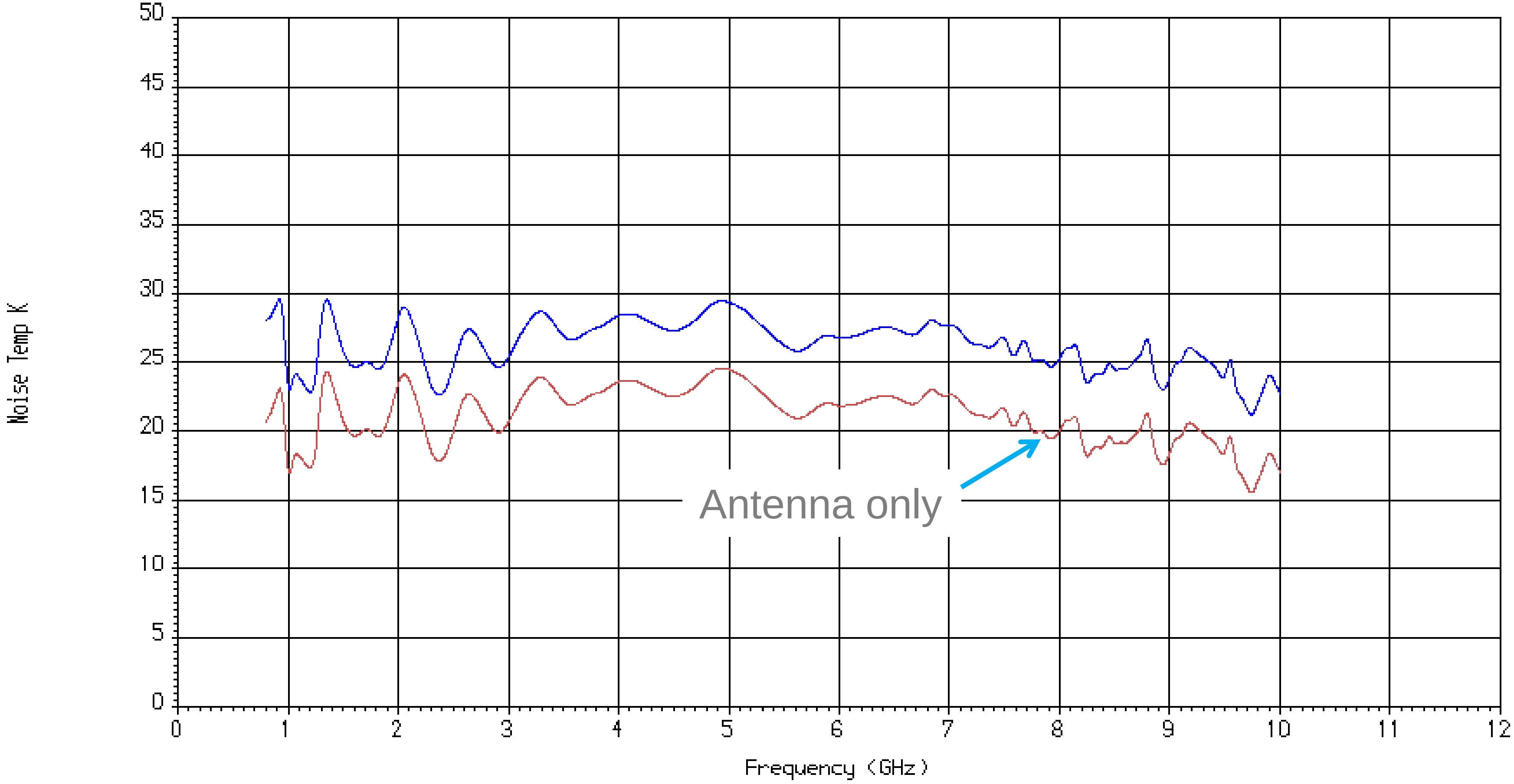


Figure 1.53 Noise Temperature of the log spiral antenna

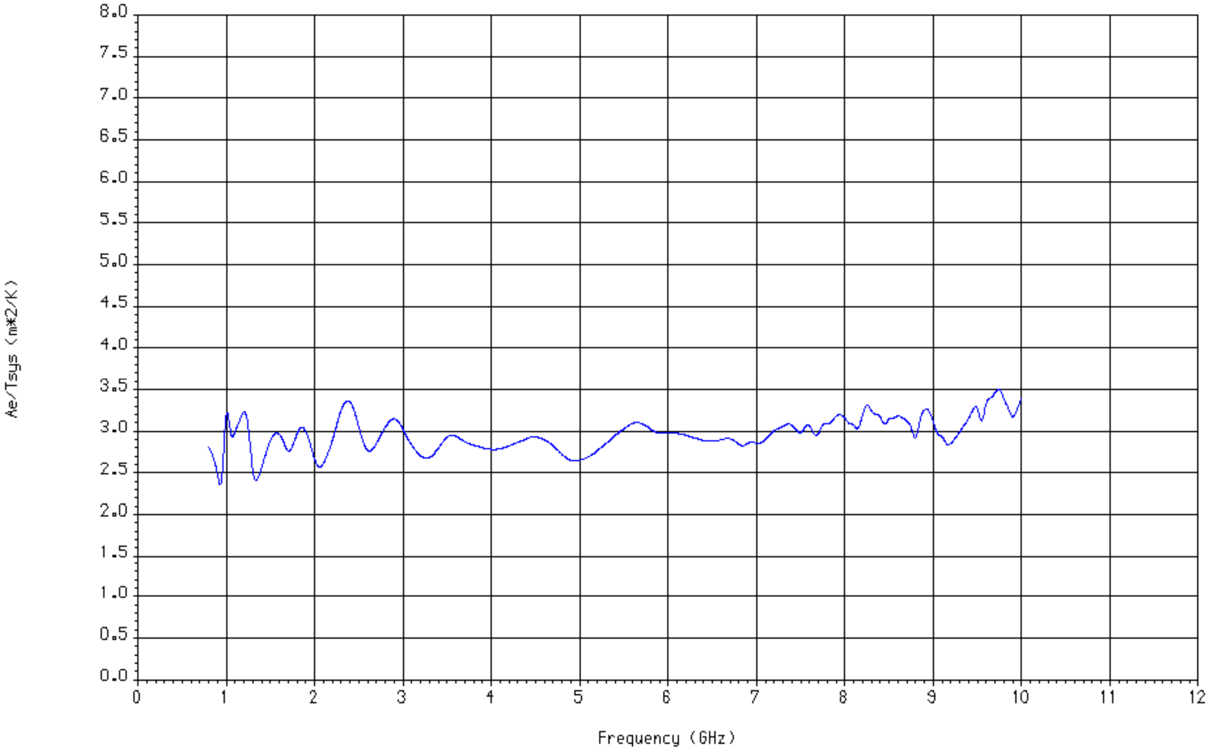


Figure 1.54 Ae/Tsys of the log spiral antenna as a function of frequency

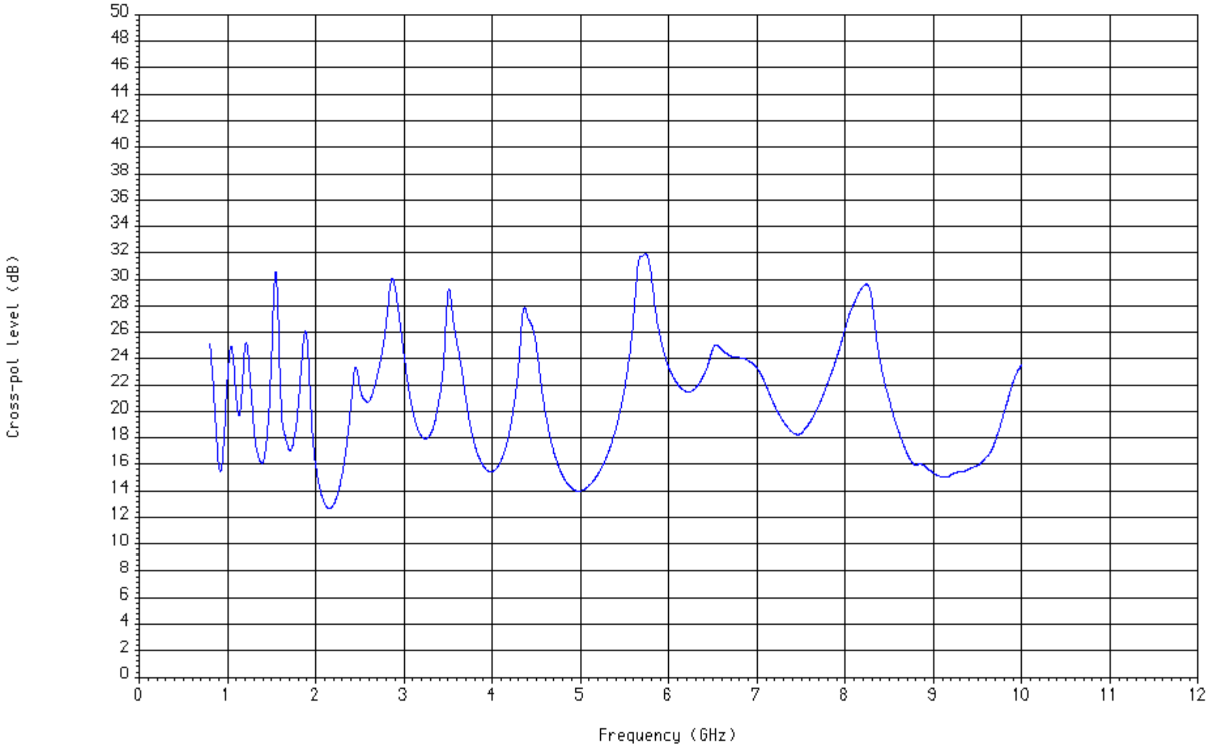


Figure 1.59 Peak cross polarization level of the log spiral antenna

DVA-1 Optics, Summary

- High Aeff / Tsys
- Very low RFI susceptability
- Selected first sidelobe magnitude
- Low cross polarization

- Actual performance depends on the feed
- Corrugated horns approach the ideal performance
- Wide band feeds have lower performance