

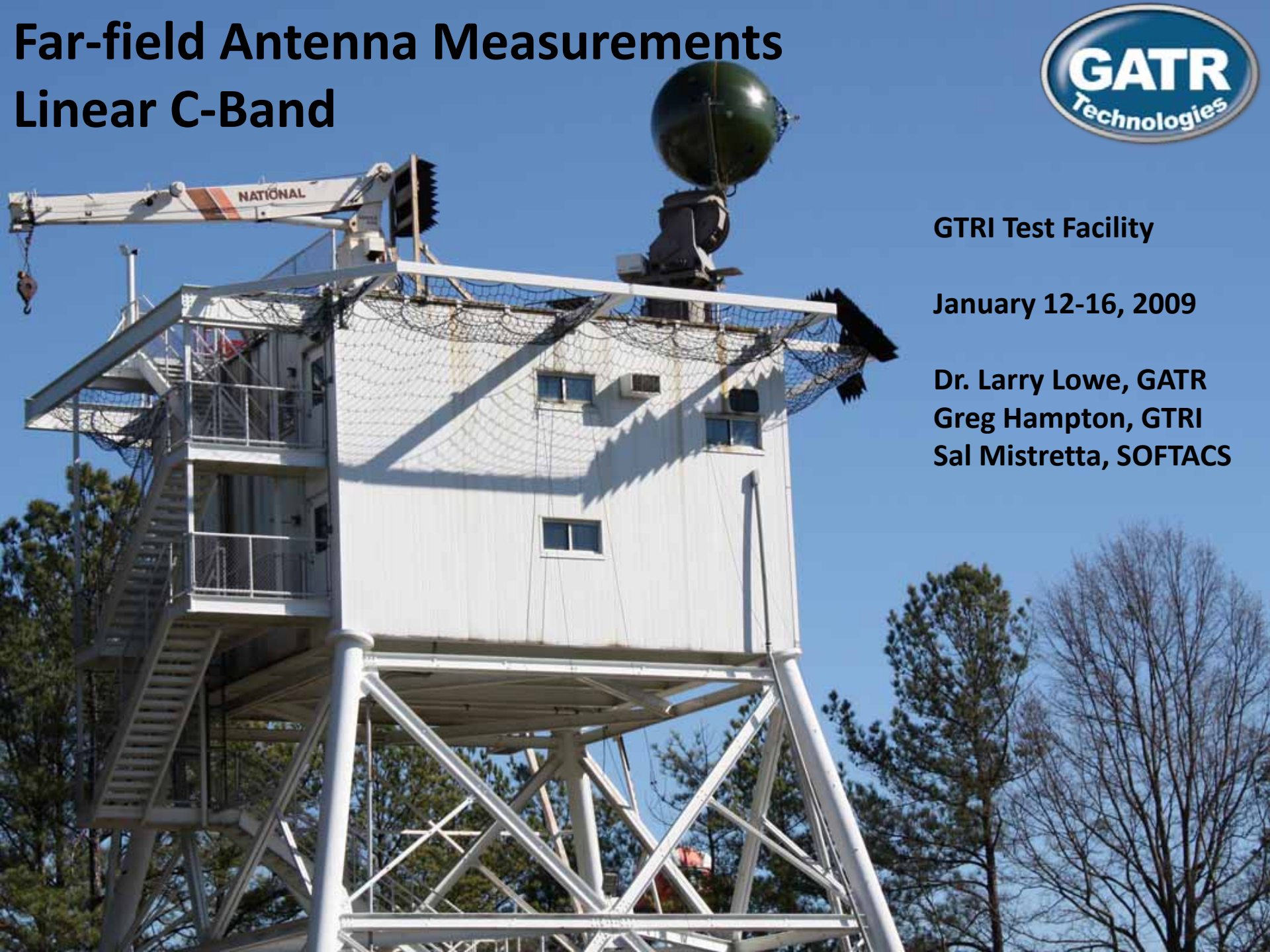
Far-field Antenna Measurements Linear C-Band



GTRI Test Facility

January 12-16, 2009

**Dr. Larry Lowe, GATR
Greg Hampton, GTRI
Sal Mistretta, SOFTACS**



C-band Test Objectives

1. **1/13/2009 – Arrive and Set up 2.4-14 Antenna for C-band testing**
 - GATR arrived at GTRI at 8:30AM and was ready for testing at 9:30AM.
 - Seavey OSA-46 Linear feed used as feed horn.
 - Weather conditions were ideal – Winds calm.
2. **1/13/2009 – Optimize C-band feed horn position for peak gain**
 - Optimum feed position found by moving the feed horn normal to the aperture plane in $\lambda/10$ increments until peak gain and best focus found. The Az and El patterns were measured across +/- 5 deg to capture peak gain and first-null focus.
 - Full set of patterns collected in the transmit band before weather.
3. **1/14/2009 - Measure full set of FCC patterns in transmit and receive bands.**
 - A full set of patterns were collected in the transmit and receive frequency band at a second feed position.



C-band Far-field Antenna Pattern Requirements

FCC 25.209 Antenna performance standards

(a) The gain of any antenna to be employed in transmission from an earth station in the fixed-satellite service shall lie below the envelope defined by:

(1) In the plane of the geostationary satellite orbit as it appears at the particular earth station location.

$$G(\theta) = 29 - 25 \cdot \log_{10}(\theta) \text{ (dBi)}, \text{ for } 1^\circ \leq \theta \leq 7^\circ$$

$$G(\theta) = +8 \text{ (dBi)}, \text{ for } 7^\circ < \theta \leq 9.2^\circ$$

$$G(\theta) = 32 - 25 \cdot \log_{10}(\theta) \text{ (dBi)}, \text{ for } 9.2^\circ \leq \theta \leq 48^\circ$$

$$G(\theta) = -10 \text{ (dBi)}, \text{ for } 48^\circ < \theta \leq 180^\circ$$

(2) In all other directions, or in the plane of the horizon including any out-of-plane potential terrestrial interference paths:

$$G(\theta) = 32 - 25 \cdot \log_{10}(\theta) \text{ (dBi)}, \text{ for } 1^\circ \leq \theta \leq 48^\circ$$

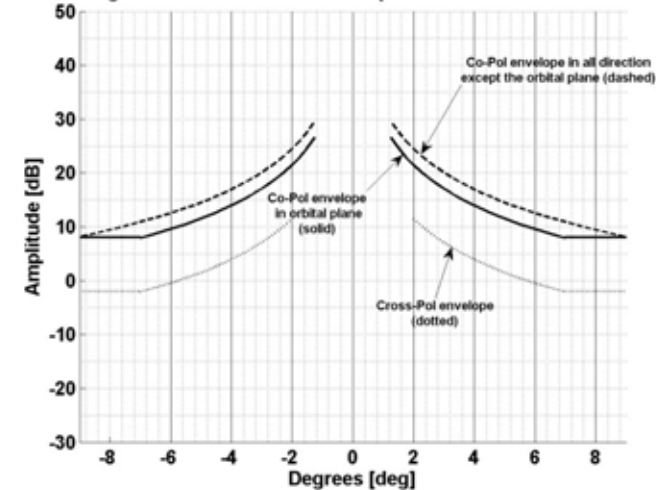
$$G(\theta) = -10 \text{ (dBi)}, \text{ for } 48^\circ < \theta \leq 180^\circ$$

(b) The off-axis cross-polarization gain of any antenna to be employed in transmission from an earth station to a space station in domestic fixed satellite service shall be defined by:

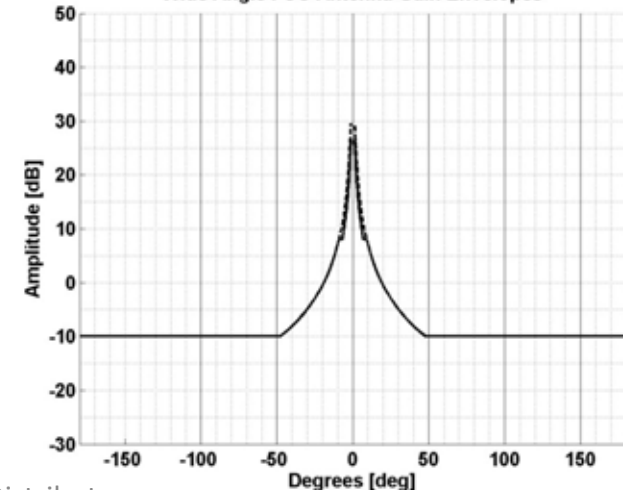
$$G(\theta) = 19 - 25 \cdot \log_{10}(\theta) \text{ (dBi)}, \text{ for } 1^\circ \leq \theta \leq 7^\circ$$

$$G(\theta) = -2 \text{ (dBi)}, \text{ for } 7^\circ < \theta \leq 9.2^\circ$$

Narrow Angle FCC Antenna Gain Envelopes For Co and Cross-Polarization



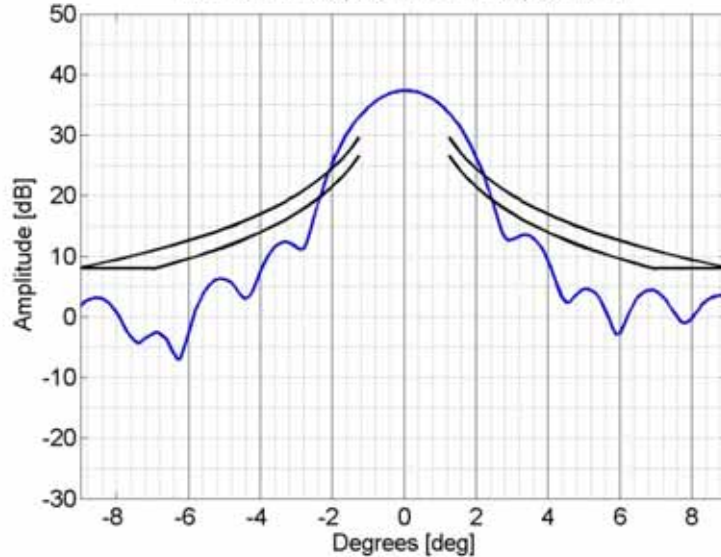
Wide Angle FCC Antenna Gain Envelopes



3.625 GHz Narrow Angle Azimuth Patterns

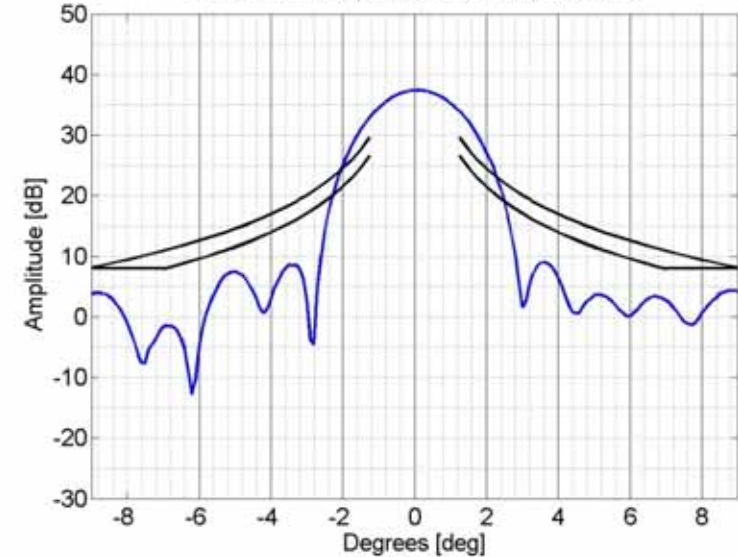
14 January 2009

2.4-14: Far Field, Azimuth HH-Pol, 3.95 GHz



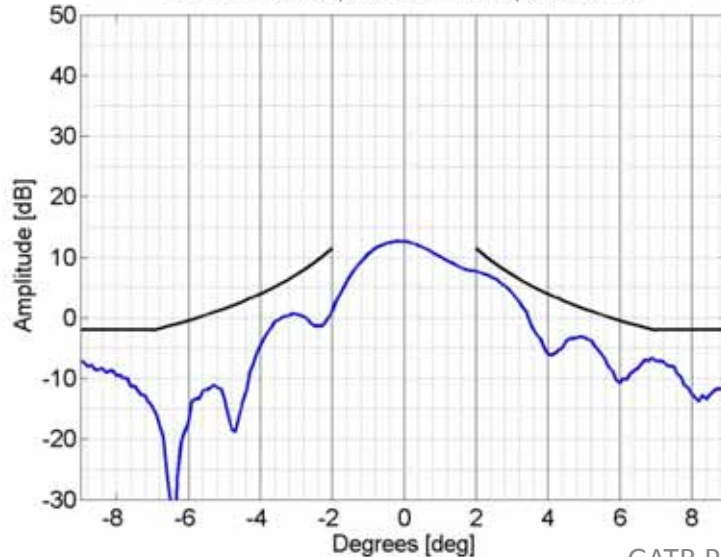
14 January 2009

2.4-14: Far Field, Azimuth VV-Pol, 3.95 GHz



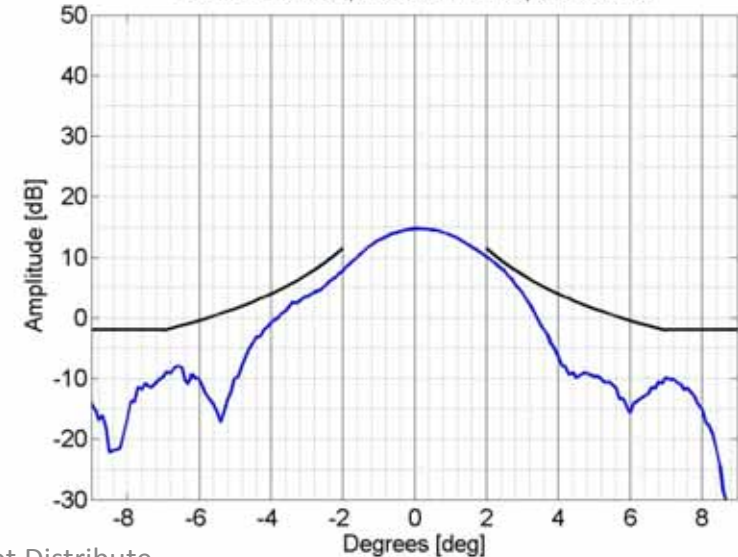
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2.4-14: Far Field, Azimuth HV-Pol, 3.625 GHz



14 January 2009

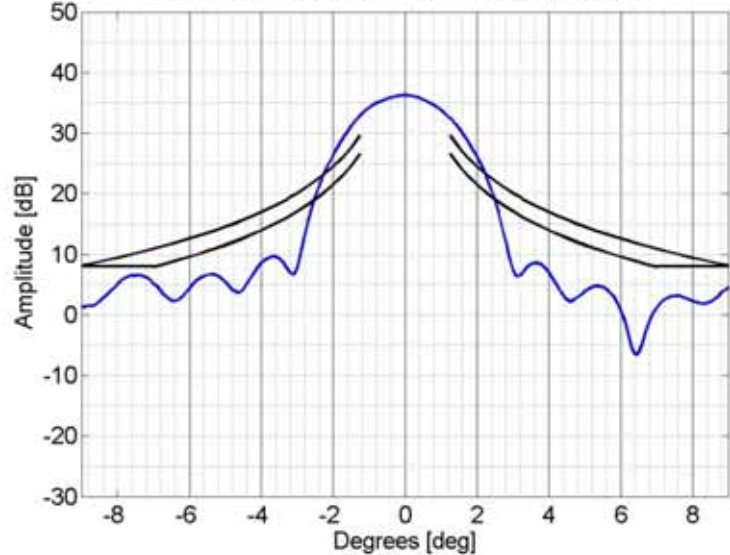
2.4-14: Far Field, Azimuth VH-Pol, 3.625 GHz



3.625 GHz Narrow Angle Elevation Patterns

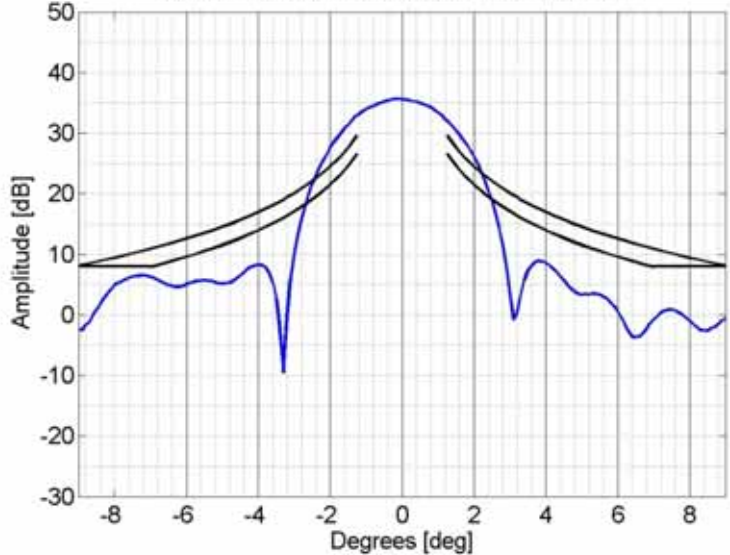
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2.4-14: Far Field, Elevation HH-Pol, 3.625 GHz



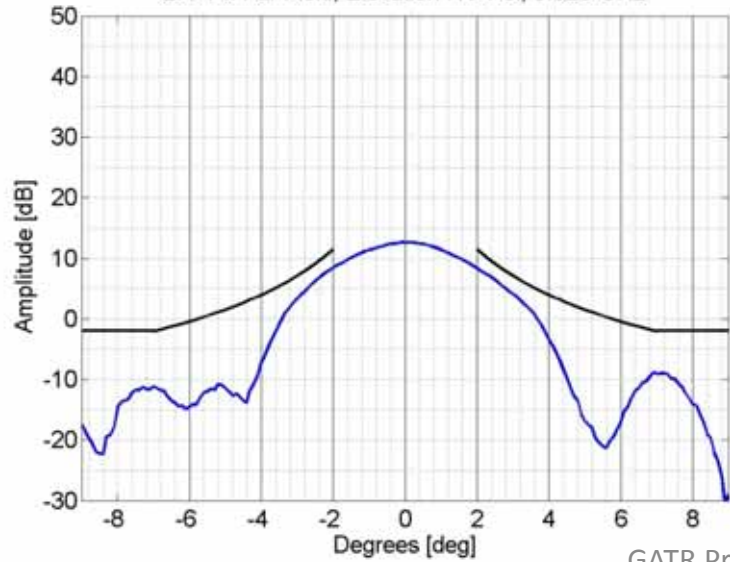
14 January 2009

2.4-14: Far Field, Elevation VV-Pol, 3.625 GHz



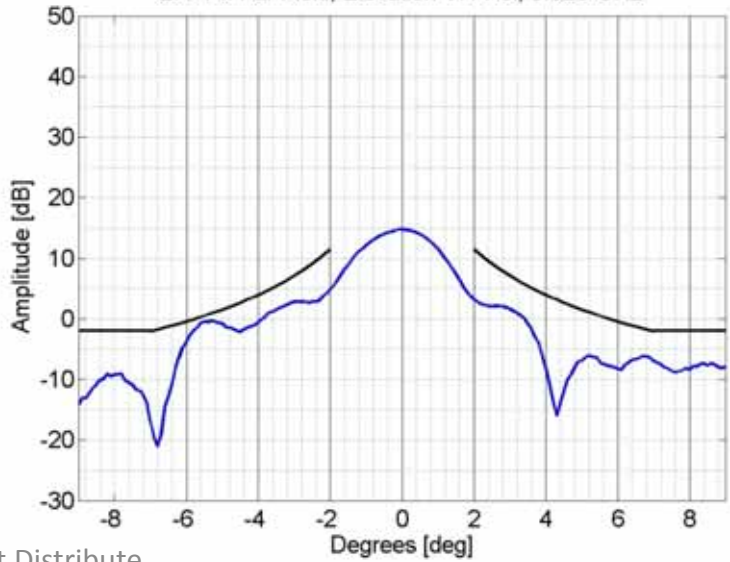
14 January 2009

2.4-14: Far Field, Elevation HV-Pol, 3.625 GHz



14 January 2009

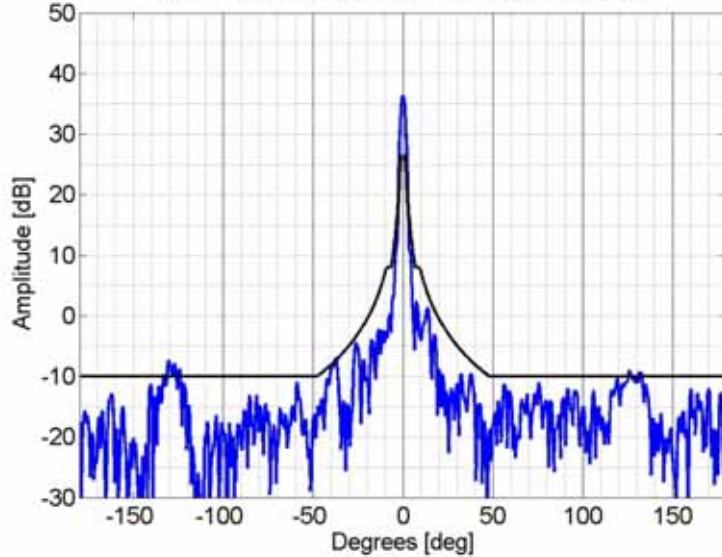
2.4-14: Far Field, Elevation VH-Pol, 3.625 GHz



3.625 GHz Wide Angle Patterns

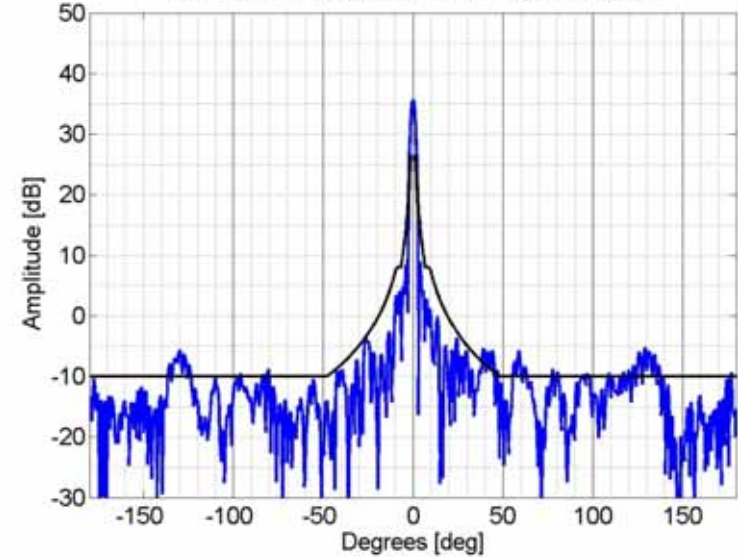
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2.4-14: Far Field, Azimuth HH-Pol, 3.625 GHz



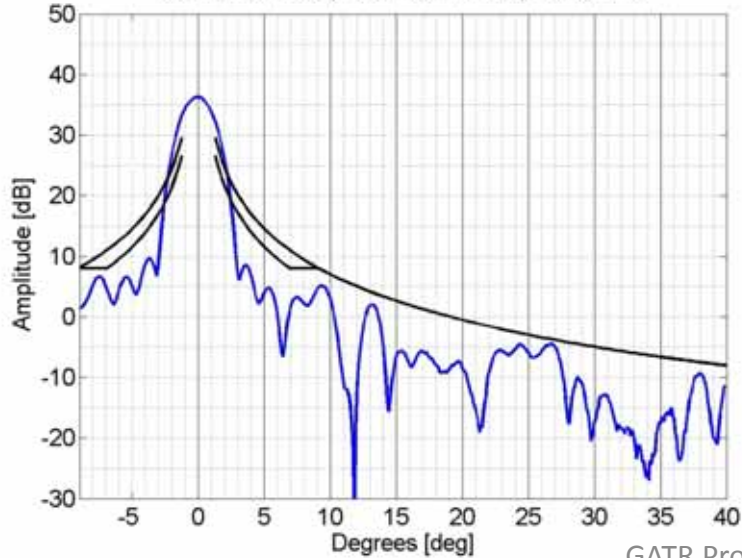
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2.4-14: Far Field, Azimuth VV-Pol, 3.625 GHz



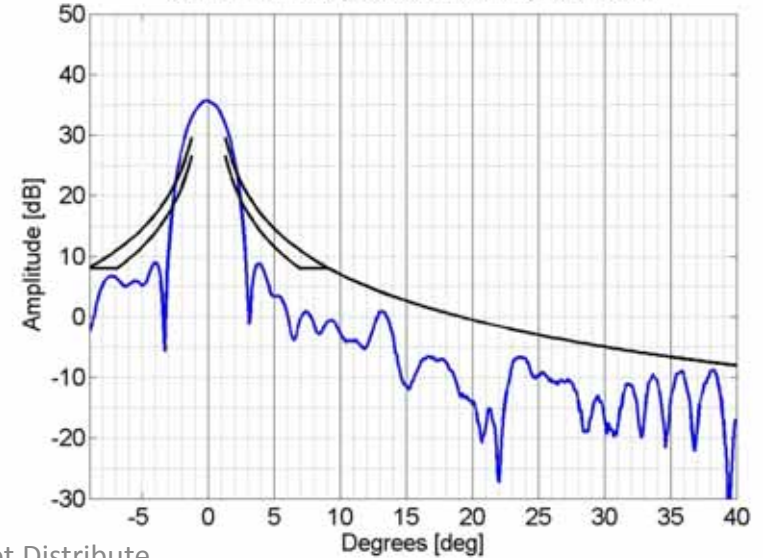
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2.4-14: Far Field, Elevation HH-Pol, 3.625 GHz



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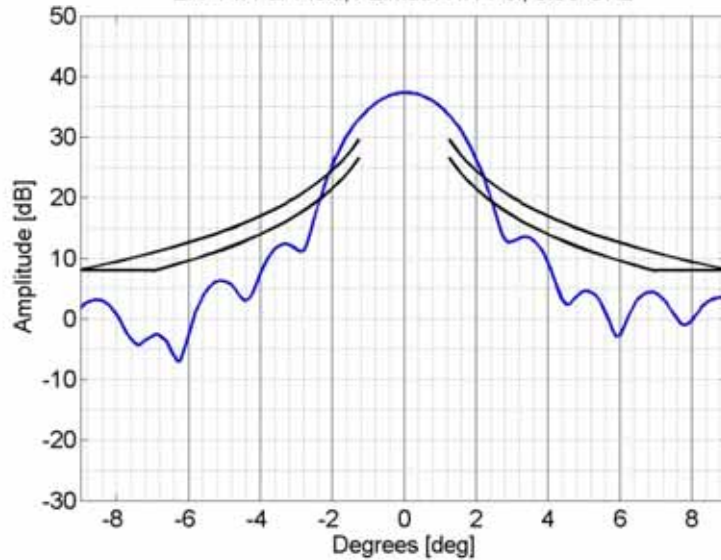
2.4-14: Far Field, Elevation VV-Pol, 3.625 GHz



3.95 GHz Narrow Angle Azimuth Patterns

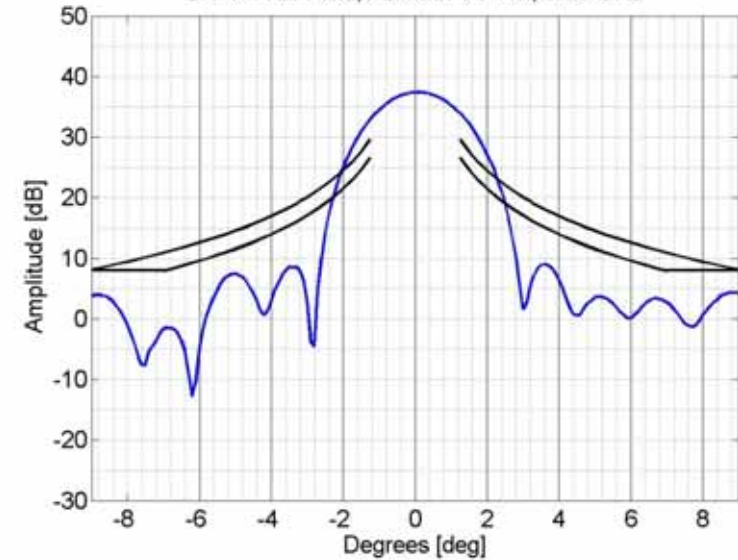
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2.4-14: Far Field, Azimuth HH-Pol, 3.95 GHz



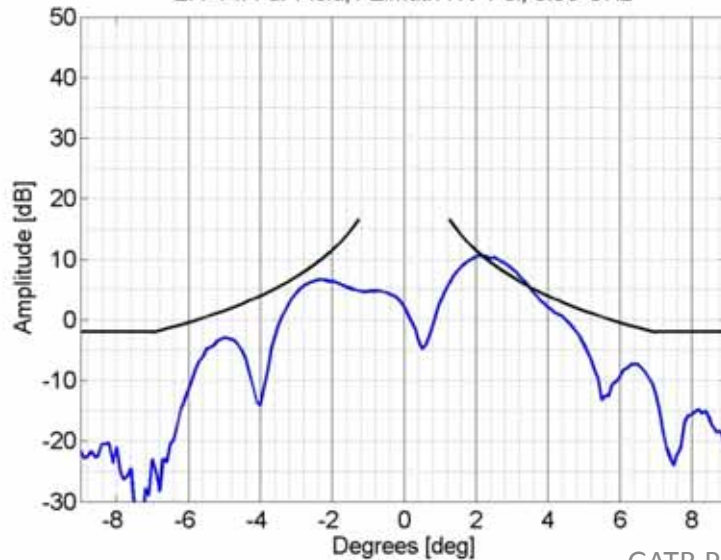
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2.4-14: Far Field, Azimuth VV-Pol, 3.95 GHz



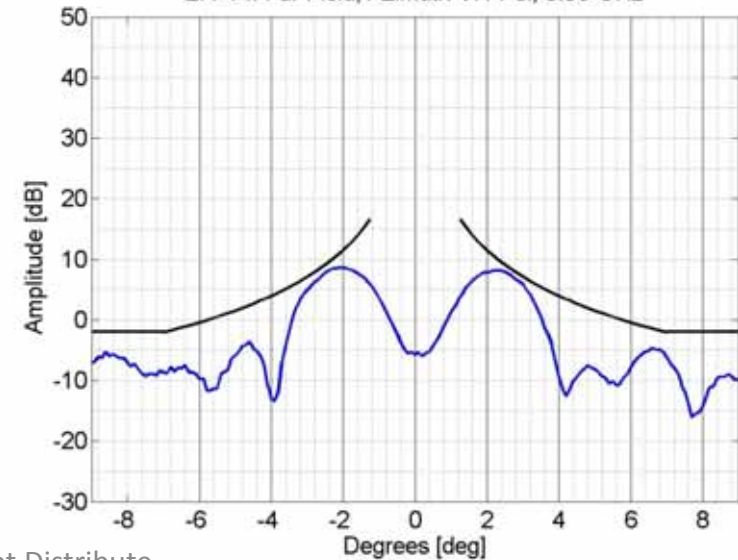
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2.4-14: Far Field, Azimuth HV-Pol, 3.95 GHz



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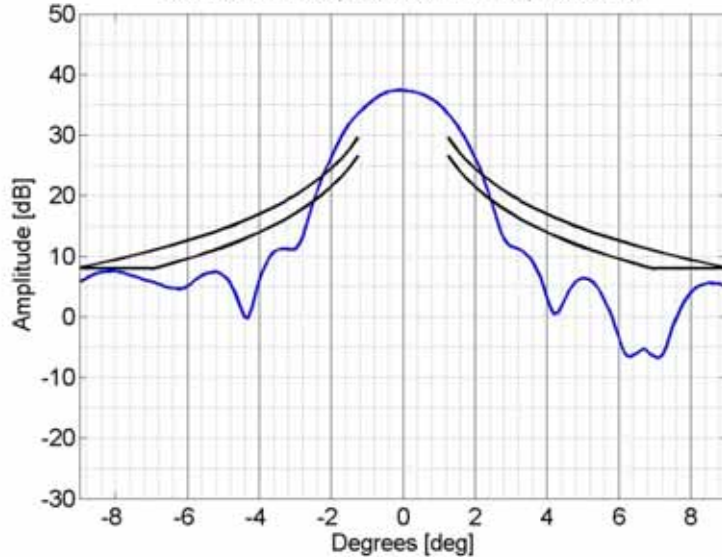
2.4-14: Far Field, Azimuth VH-Pol, 3.95 GHz



3.95 GHz Narrow Angle Elevation Patterns

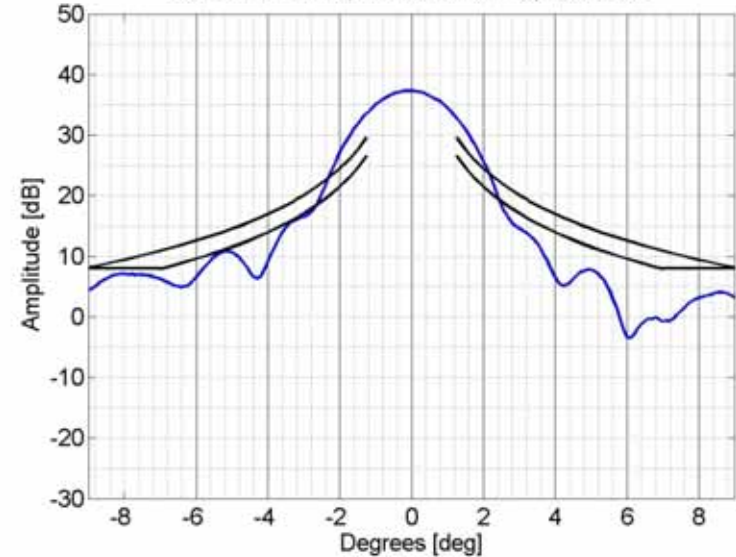
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2.4-14: Far Field, Elevation HH-Pol, 3.95 GHz



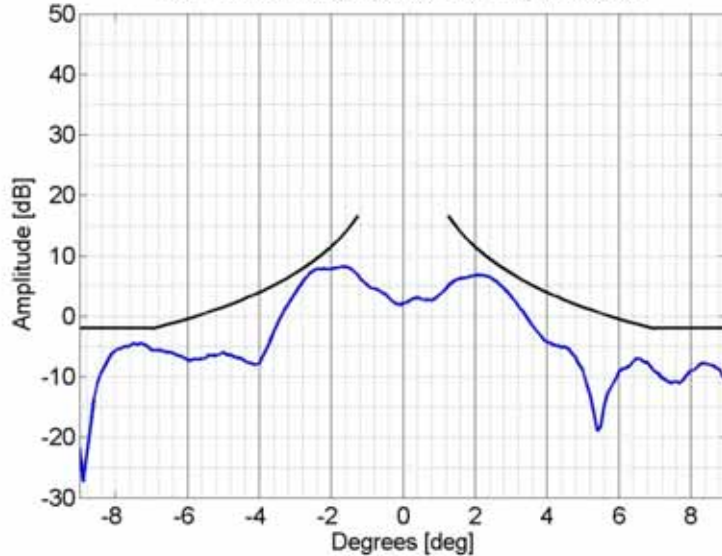
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2.4-14: Far Field, Elevation VV-Pol, 3.95 GHz



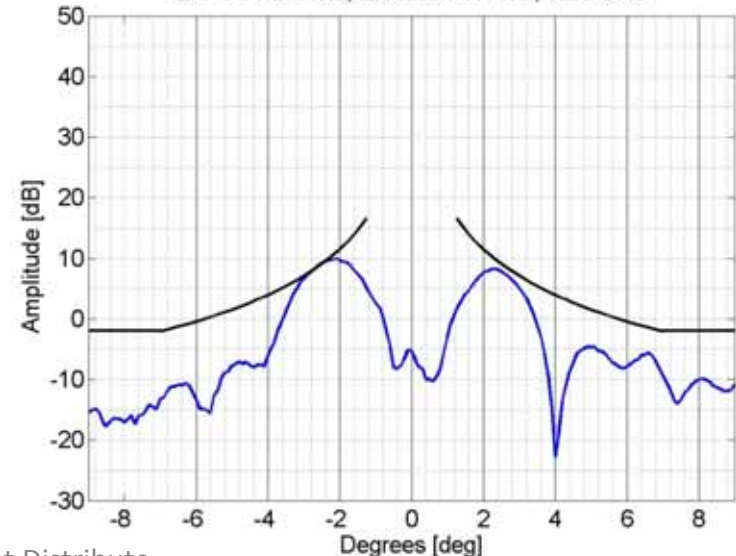
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2.4-14: Far Field, Elevation HV-Pol, 3.95 GHz



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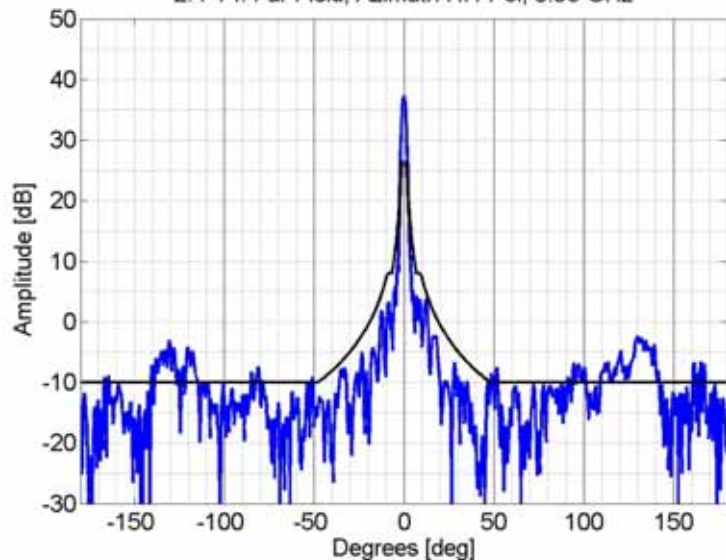
2.4-14: Far Field, Elevation VH-Pol, 3.95 GHz



3.95 GHz Wide Angle Patterns

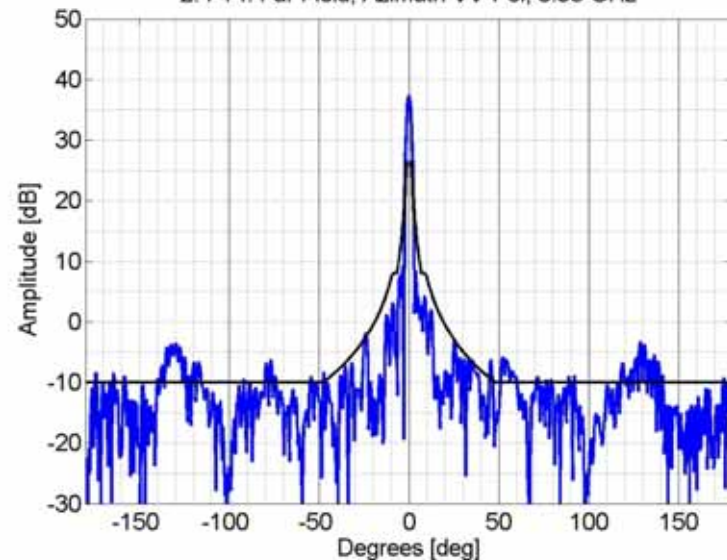
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2.4-14: Far Field, Azimuth HH-Pol, 3.95 GHz



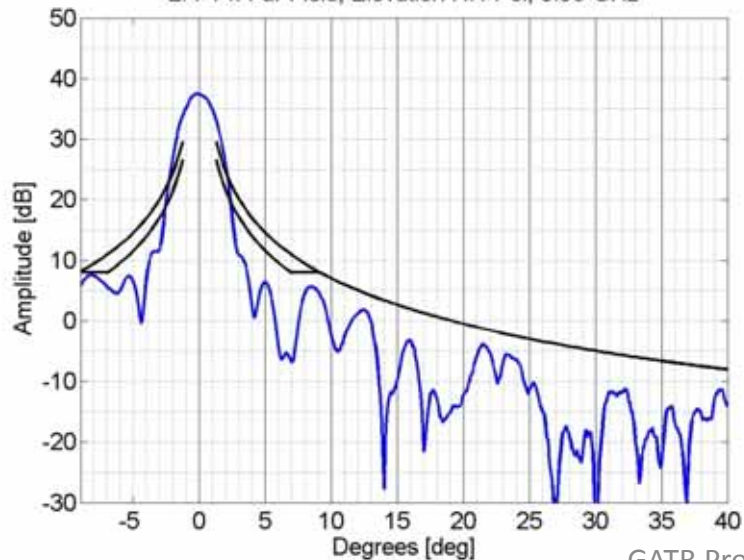
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2.4-14: Far Field, Azimuth VV-Pol, 3.95 GHz



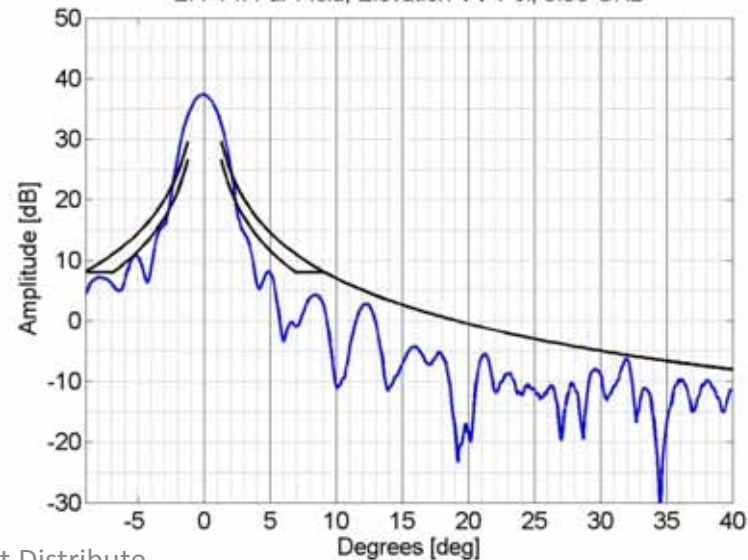
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2.4-14: Far Field, Elevation HH-Pol, 3.95 GHz



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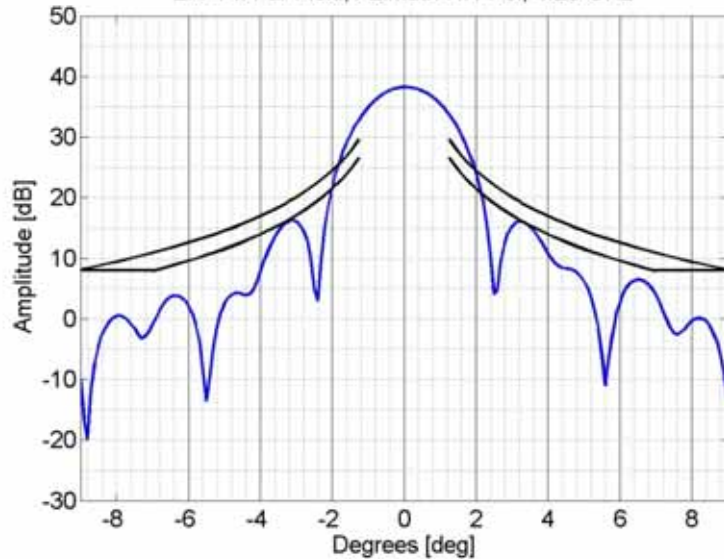
2.4-14: Far Field, Elevation VV-Pol, 3.95 GHz



4.20 GHz Narrow Angle Azimuth Patterns

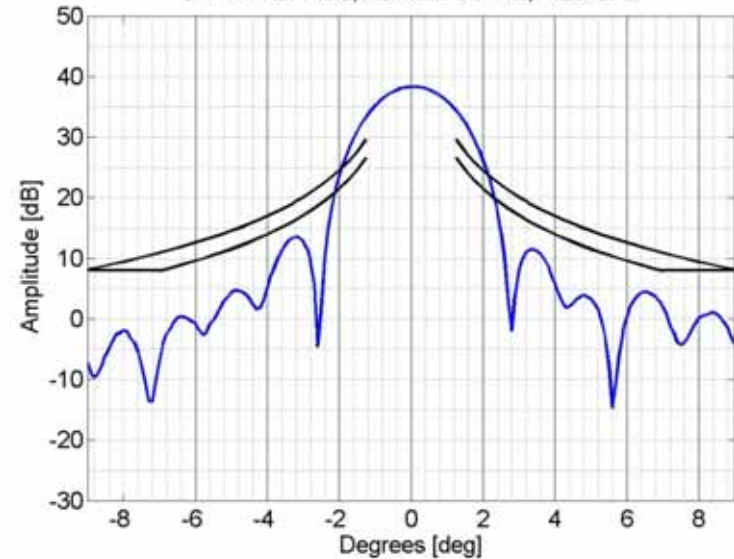
14 January 2009

2.4-14: Far Field, Azimuth HH-Pol, 4.20 GHz



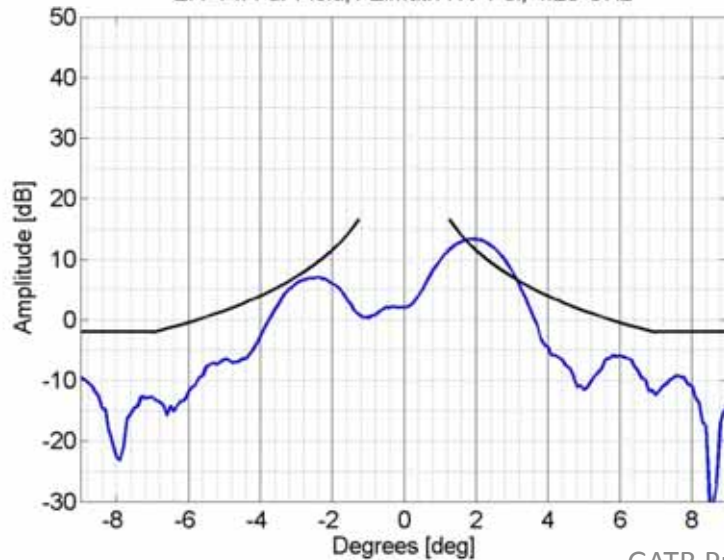
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2.4-14: Far Field, Azimuth VV-Pol, 4.20 GHz



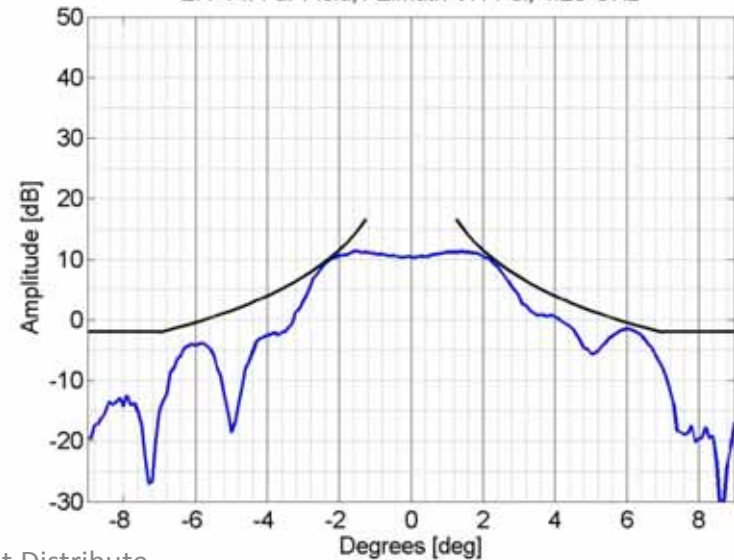
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2.4-14: Far Field, Azimuth HV-Pol, 4.20 GHz



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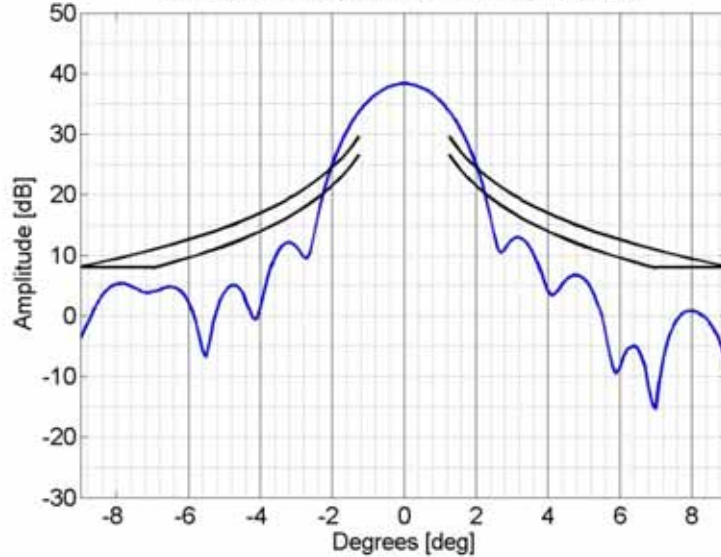
2.4-14: Far Field, Azimuth VH-Pol, 4.20 GHz



4.20 GHz Narrow Angle Elevation Patterns

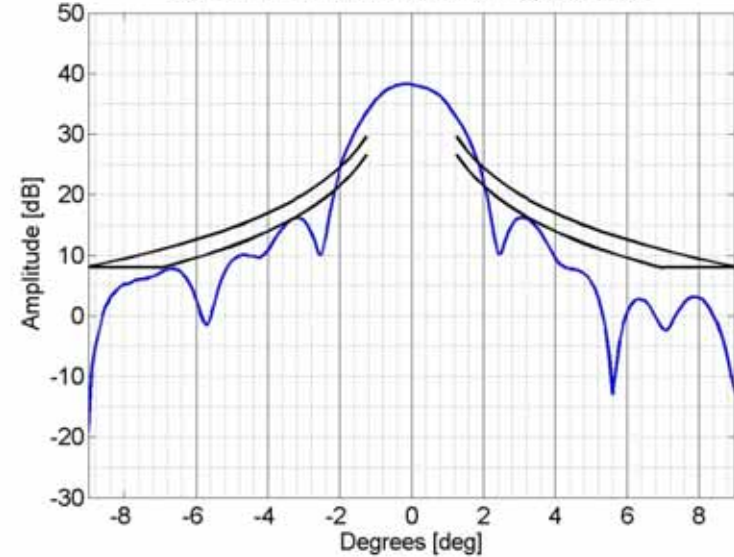
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2.4-14: Far Field, Elevation HH-Pol, 4.20 GHz



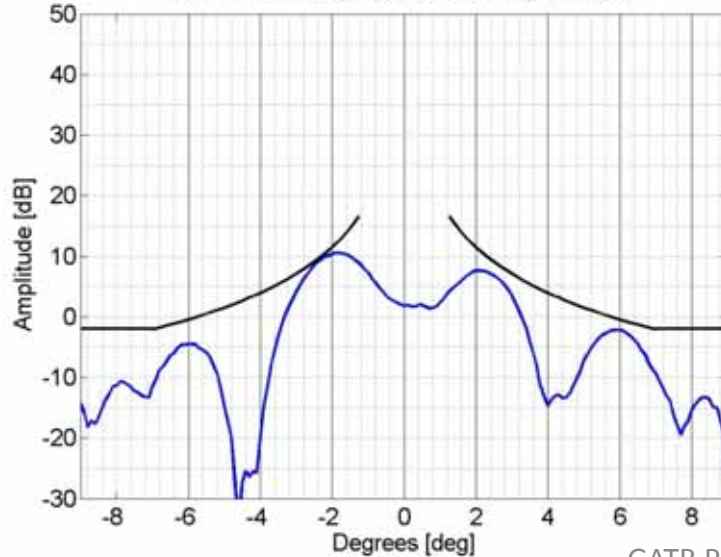
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2.4-14: Far Field, Elevation VV-Pol, 4.20 GHz



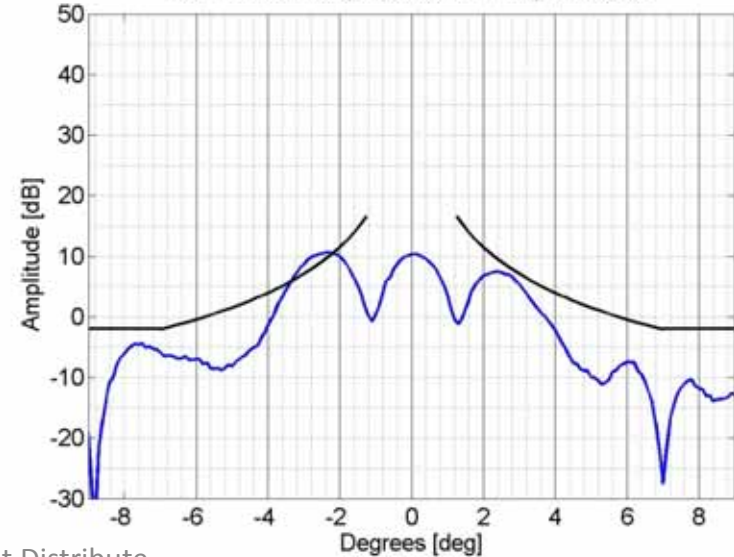
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2.4-14: Far Field, Elevation HV-Pol, 4.20 GHz



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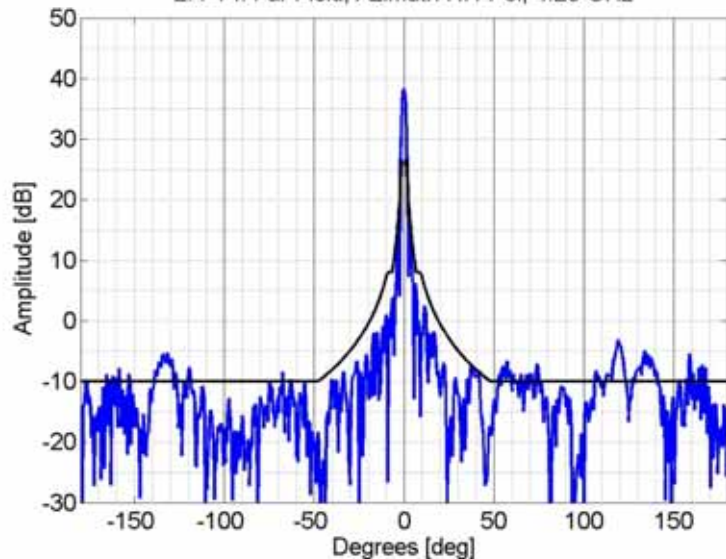
2.4-14: Far Field, Elevation VH-Pol, 4.20 GHz



4.20 GHz Wide Angle Patterns

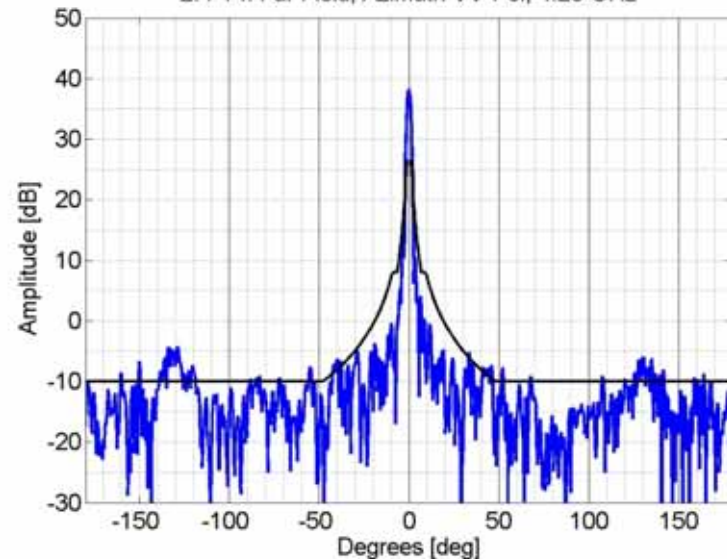
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2.4-14: Far Field, Azimuth HH-Pol, 4.20 GHz



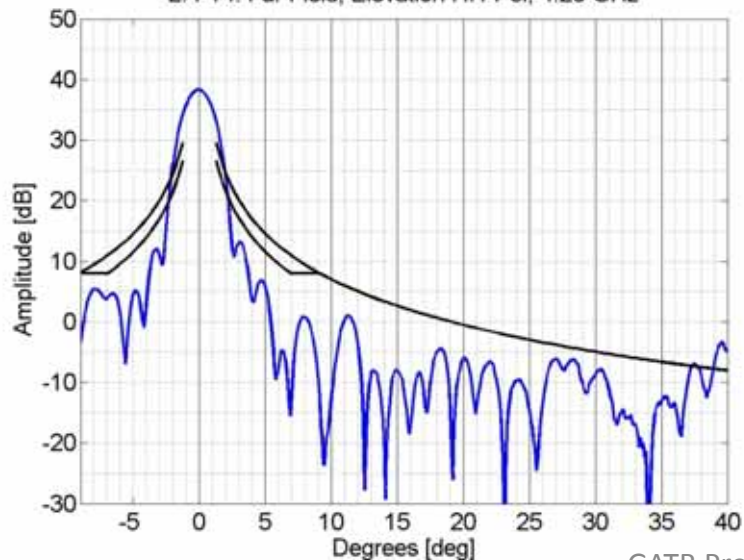
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2.4-14: Far Field, Azimuth VV-Pol, 4.20 GHz



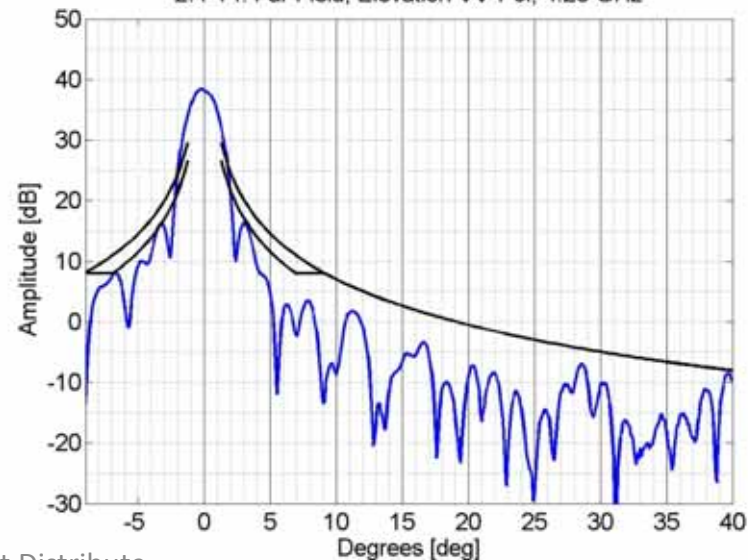
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2.4-14: Far Field, Elevation HH-Pol, 4.20 GHz



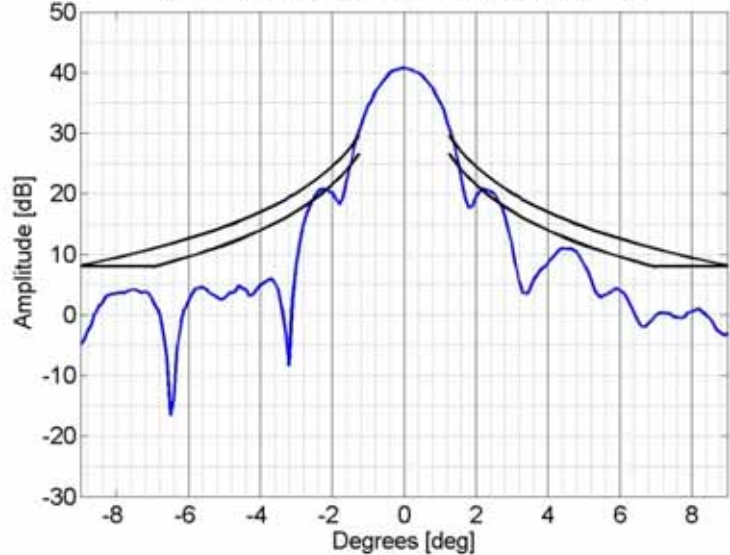
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2.4-14: Far Field, Elevation VV-Pol, 4.20 GHz

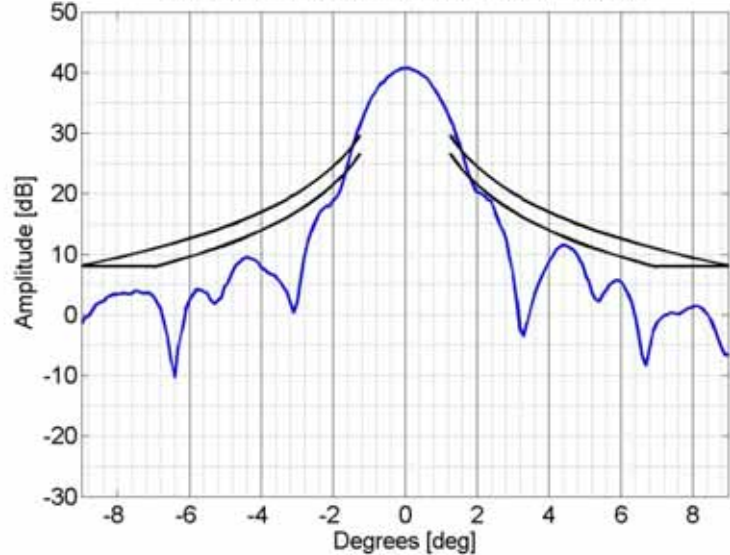


5.925 GHz Narrow Angle Azimuth Patterns

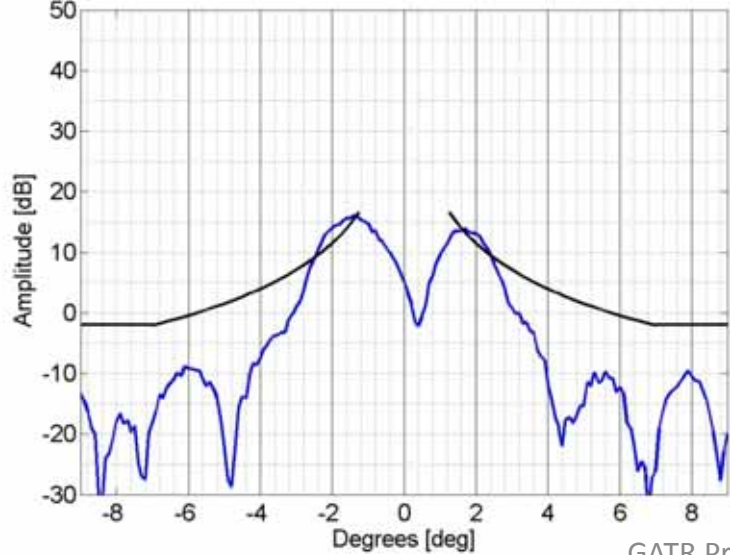
14 January 2009
2.4-14: Far Field, Azimuth HH-Pol, 5.925 GHz



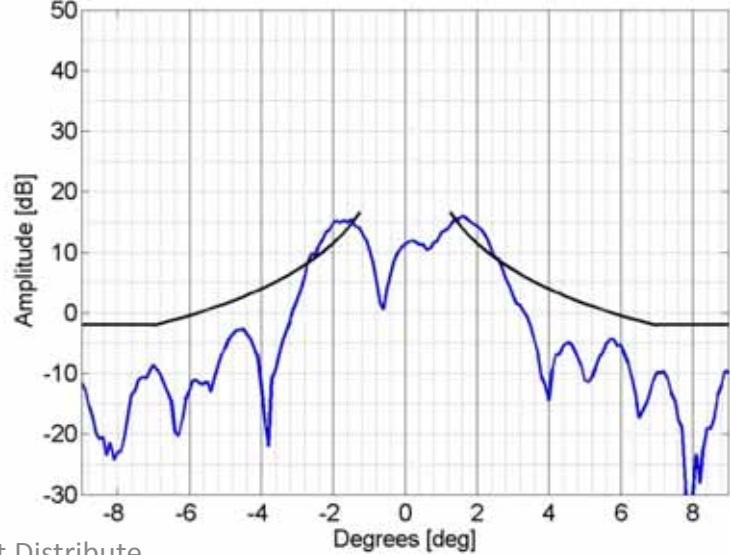
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2.4-14: Far Field, Azimuth VV-Pol, 5.925 GHz



14 January 2009
2.4-14: Far Field, Azimuth HV-Pol, 5.925 GHz



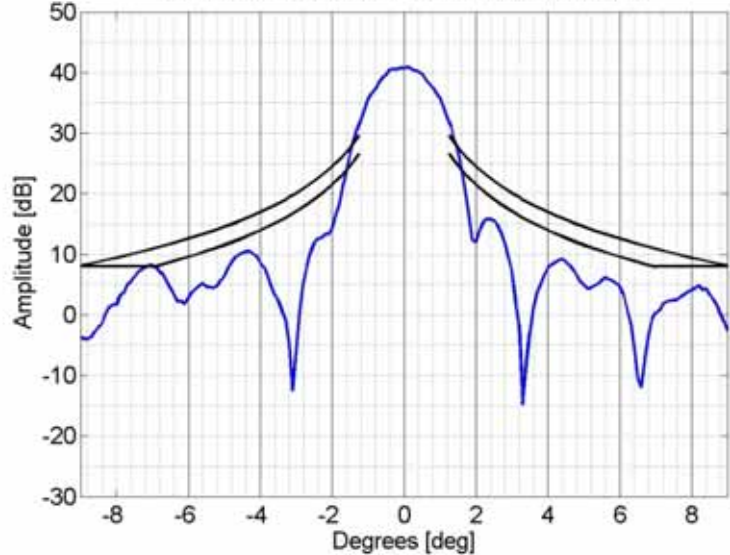
14 January 2009
2.4-14: Far Field, Azimuth VH-Pol, 5.925 GHz



5.925 GHz Narrow Angle Elevation Patterns

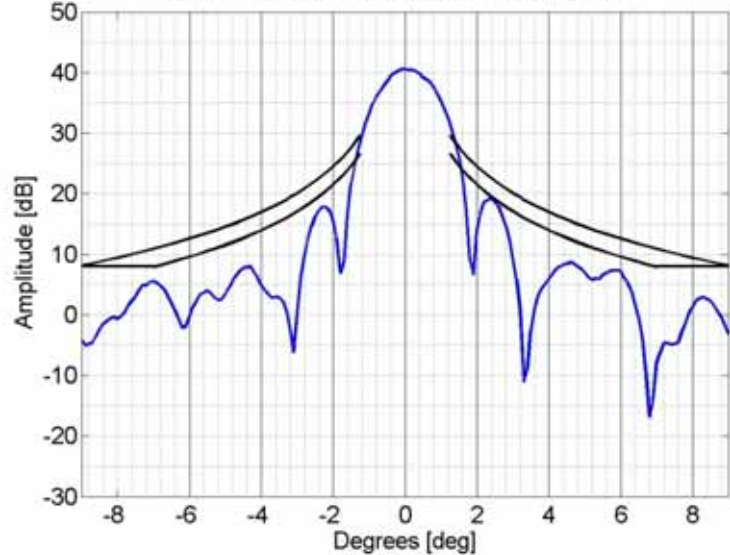
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2.4-14: Far Field, Elevation HH-Pol, 5.925 GHz



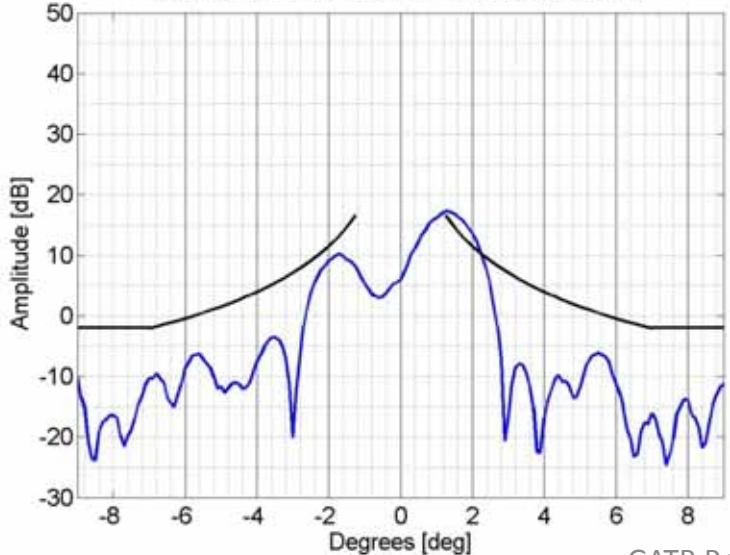
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2.4-14: Far Field, Elevation VV-Pol, 5.925 GHz



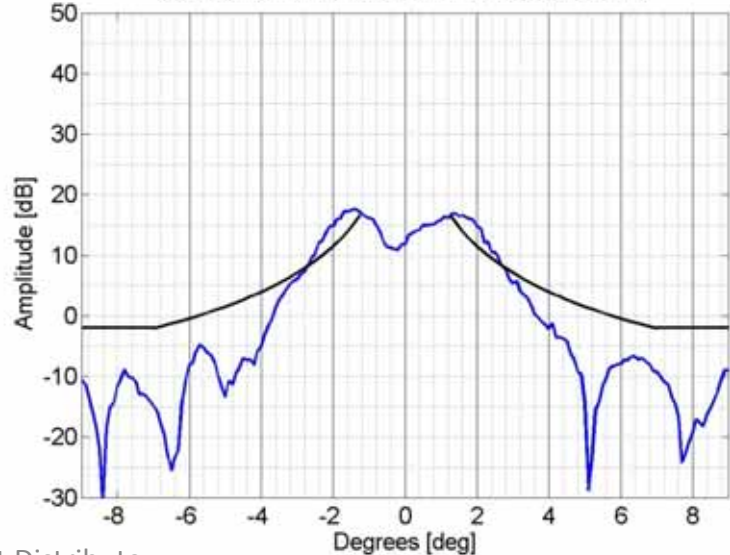
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2.4-14: Far Field, Elevation HV-Pol, 5.925 GHz



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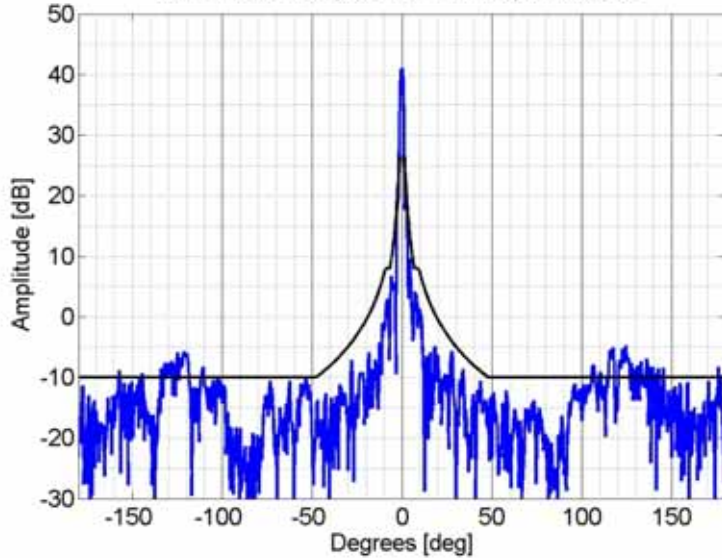
2.4-14: Far Field, Elevation VH-Pol, 5.925 GHz



5.925 GHz Wide Angle Patterns

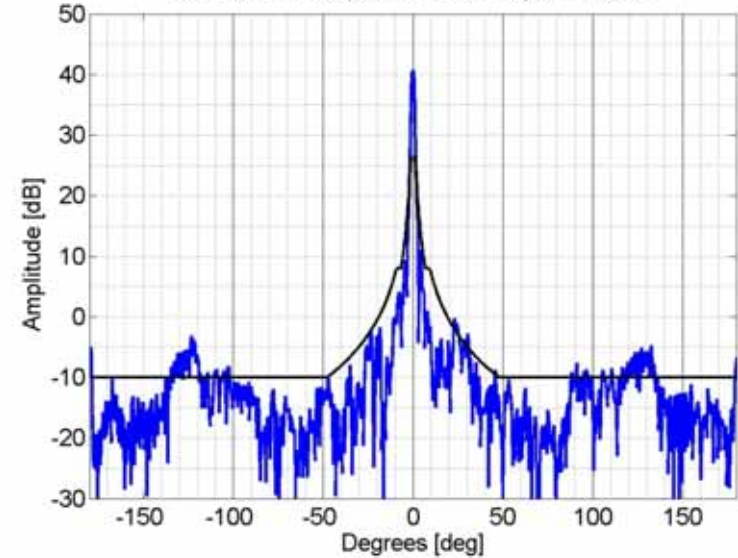
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2.4-14: Far Field, Azimuth HH-Pol, 5.925 GHz



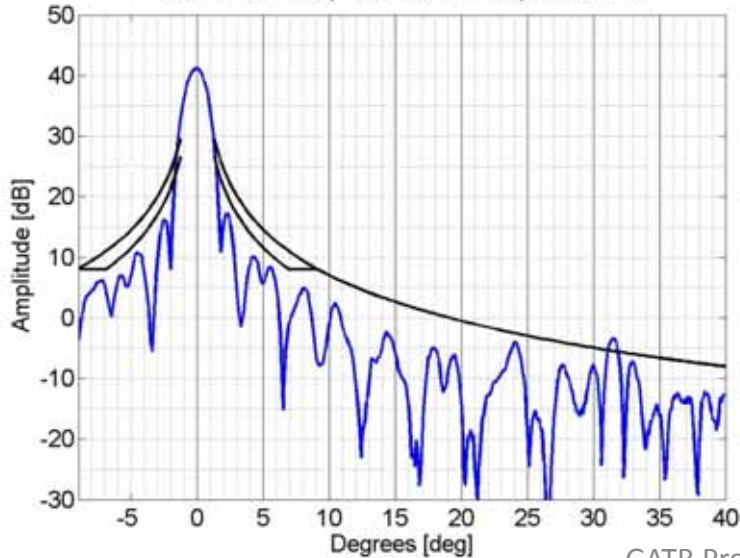
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2.4-14: Far Field, Azimuth VV-Pol, 5.925 GHz



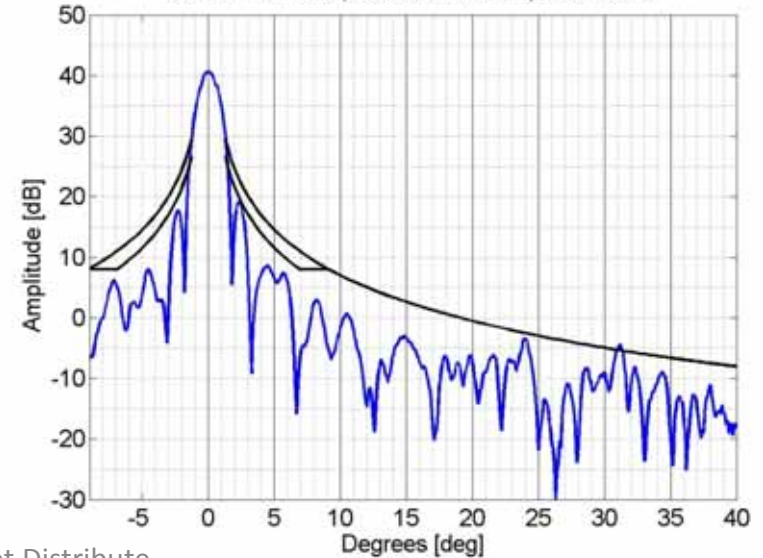
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2.4-14: Far Field, Elevation HH-Pol, 5.925 GHz



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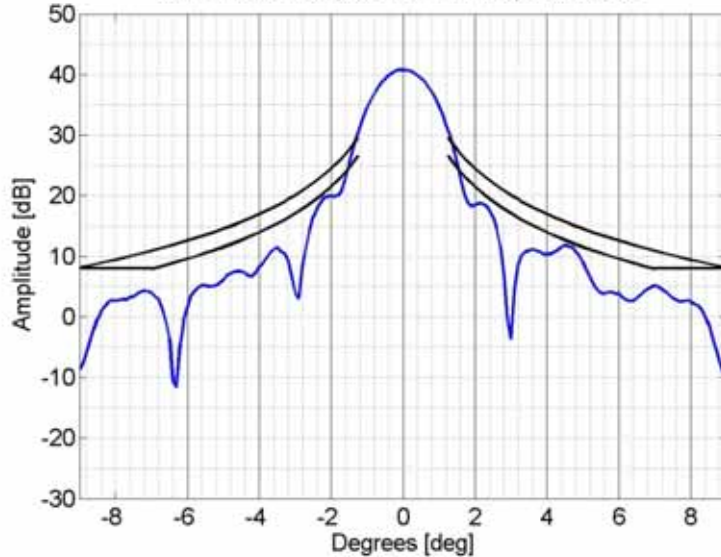
2.4-14: Far Field, Elevation VV-Pol, 5.925 GHz



6.175 GHz Narrow Angle Azimuth Patterns

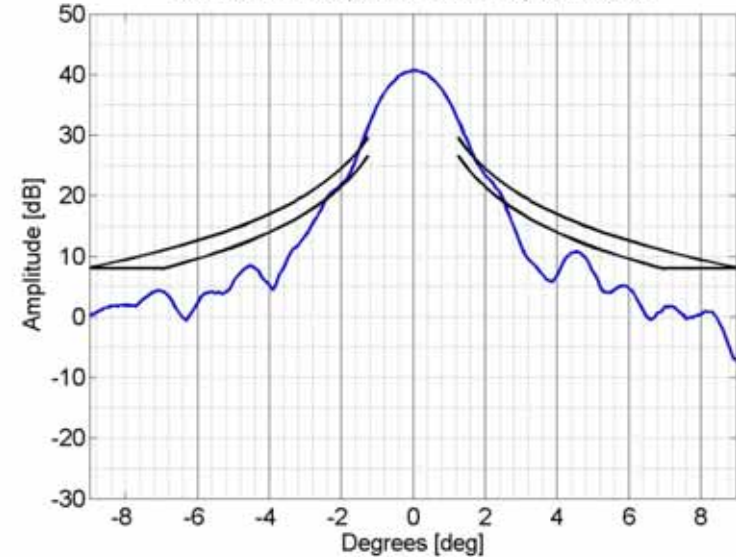
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2.4-14: Far Field, Azimuth HH-Pol, 6.175 GHz



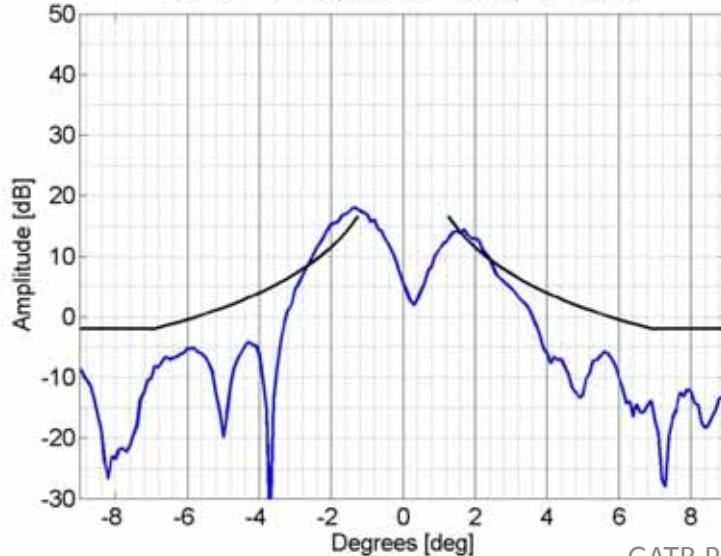
14 January 2009

2.4-14: Far Field, Azimuth VV-Pol, 6.175 GHz



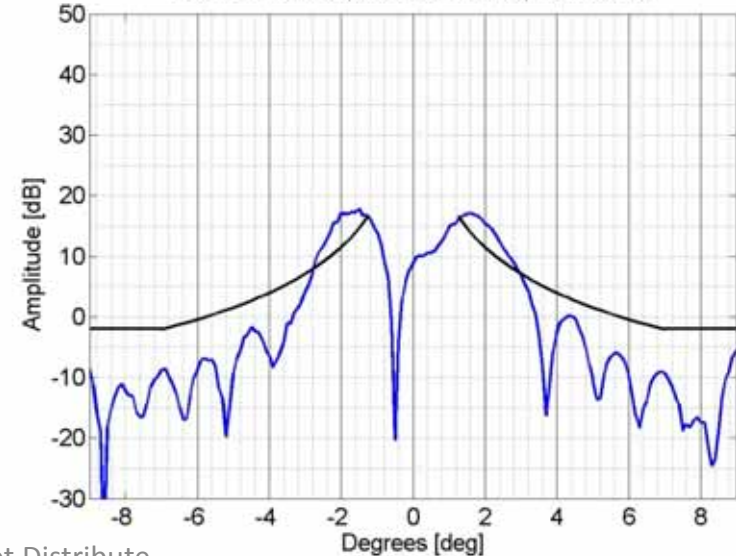
14 January 2009

2.4-14: Far Field, Azimuth HV-Pol, 6.175 GHz



14 January 2009

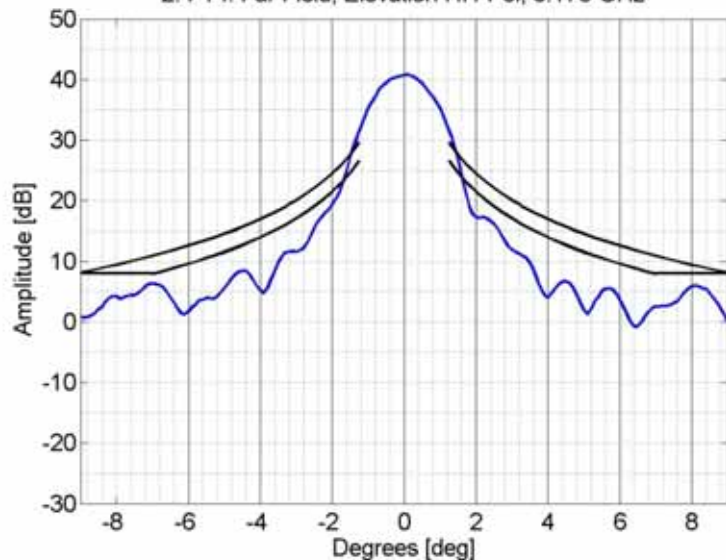
2.4-14: Far Field, Azimuth VH-Pol, 6.175 GHz



6.175 GHz Narrow Angle Elevation Patterns

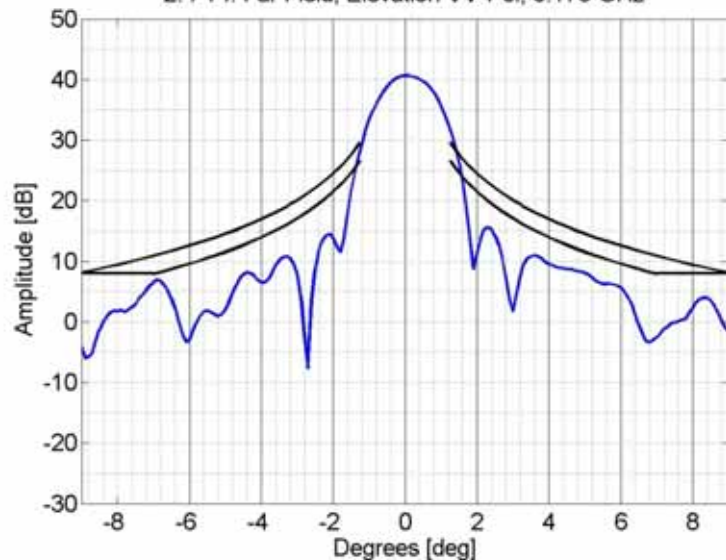
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2.4-14: Far Field, Elevation HH-Pol, 6.175 GHz



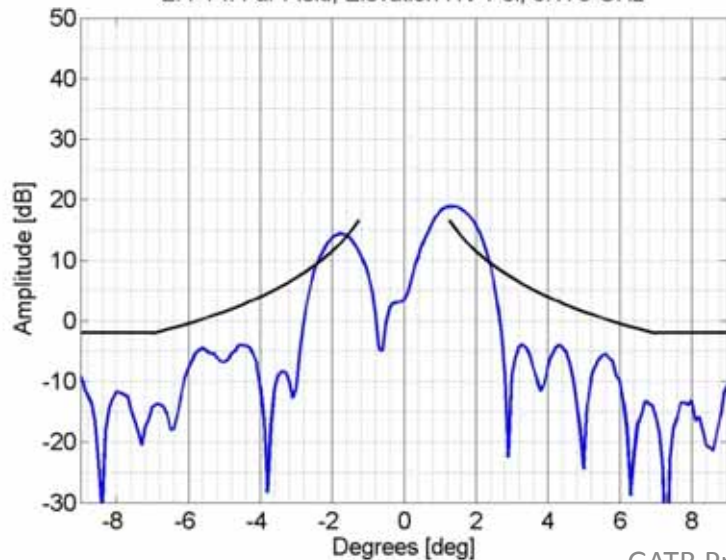
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2.4-14: Far Field, Elevation VV-Pol, 6.175 GHz



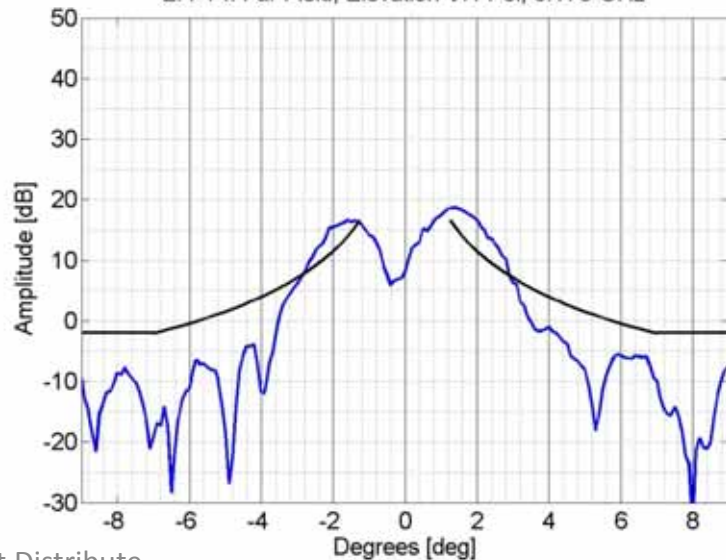
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2.4-14: Far Field, Elevation HV-Pol, 6.175 GHz



14 January 2009

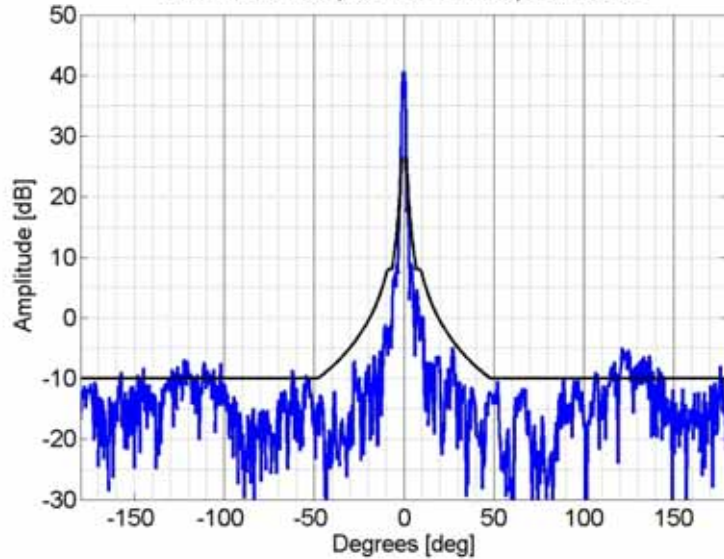
2.4-14: Far Field, Elevation VH-Pol, 6.175 GHz



6.175 GHz Wide Angle Patterns

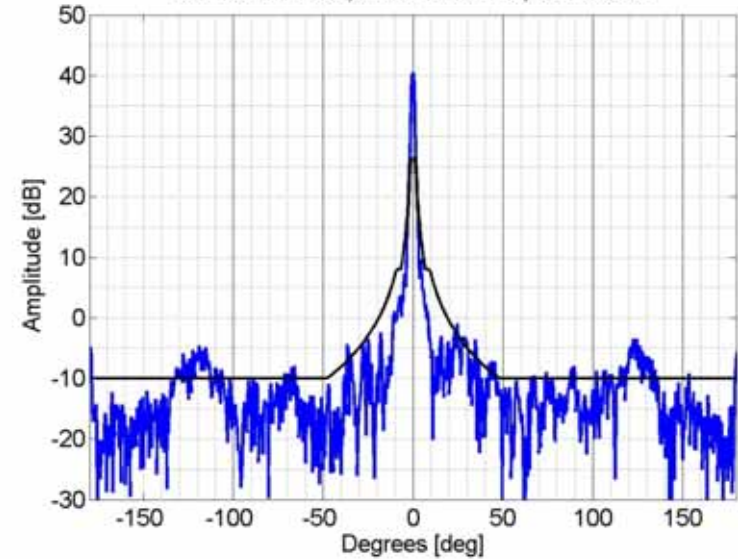
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2.4-14: Far Field, Azimuth HH-Pol, 6.175 GHz



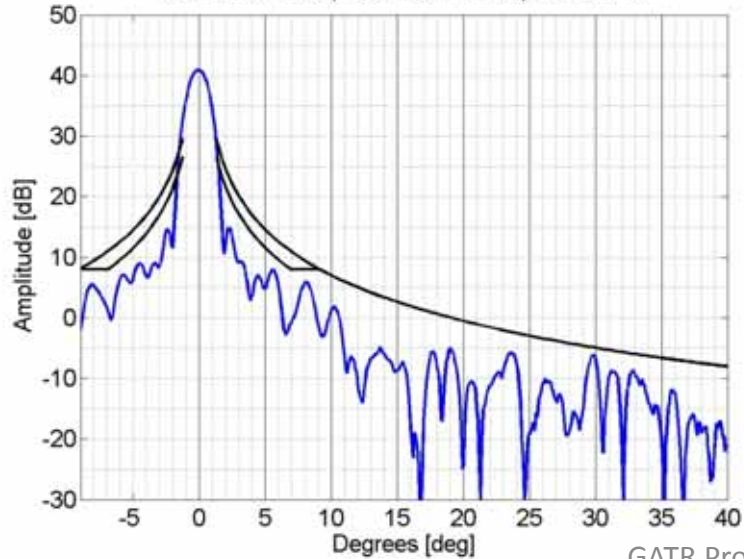
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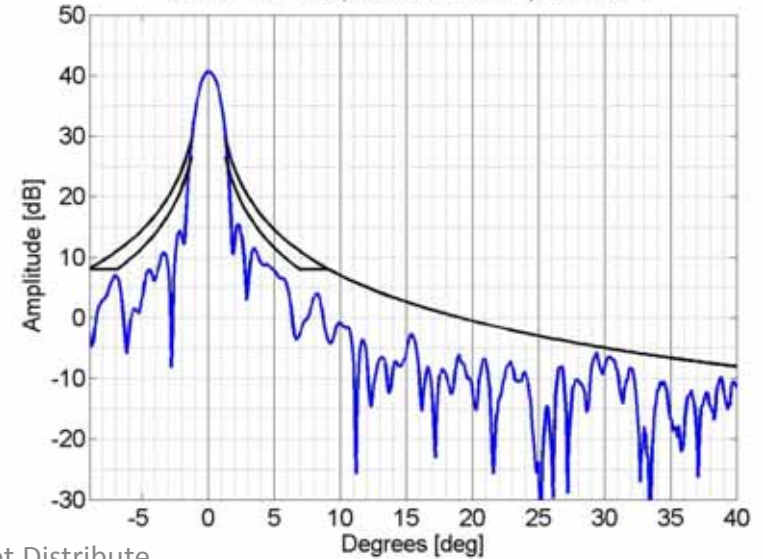
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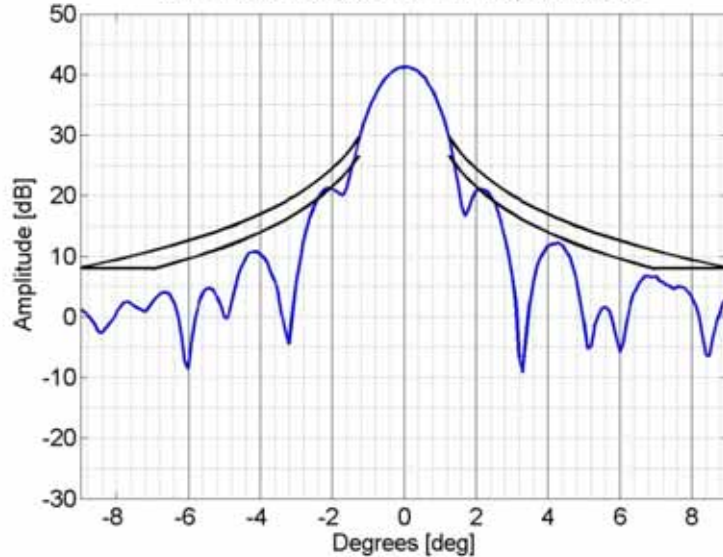
2.4-14: Far Field, Elevation VV-Pol, 6.175 GHz



6.425 GHz Narrow Angle Azimuth Patterns

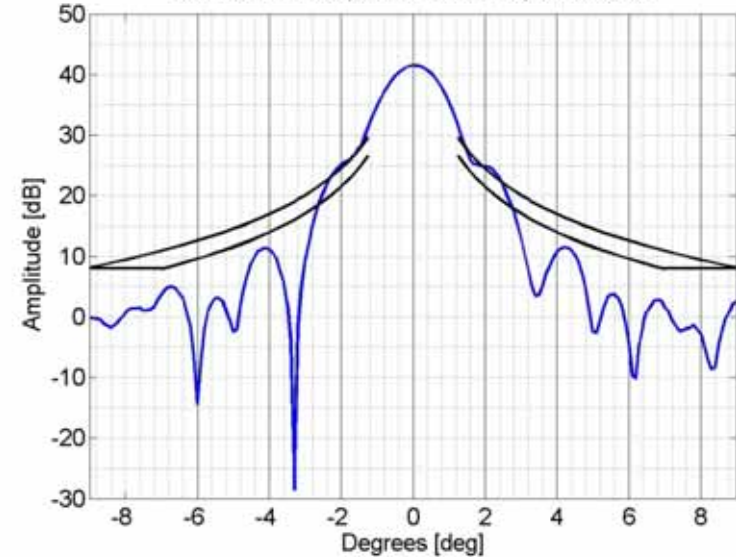
14 January 2009

2.4-14: Far Field, Azimuth HH-Pol, 6.425 GHz



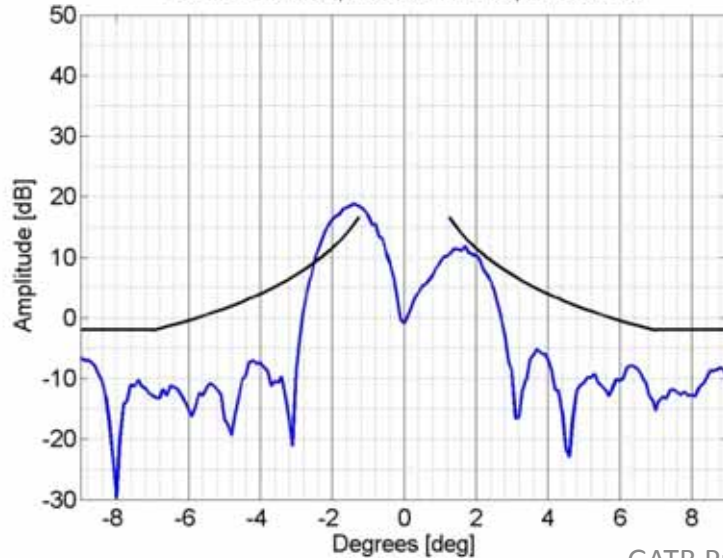
14 January 2009

2.4-14: Far Field, Azimuth VV-Pol, 6.425 GHz



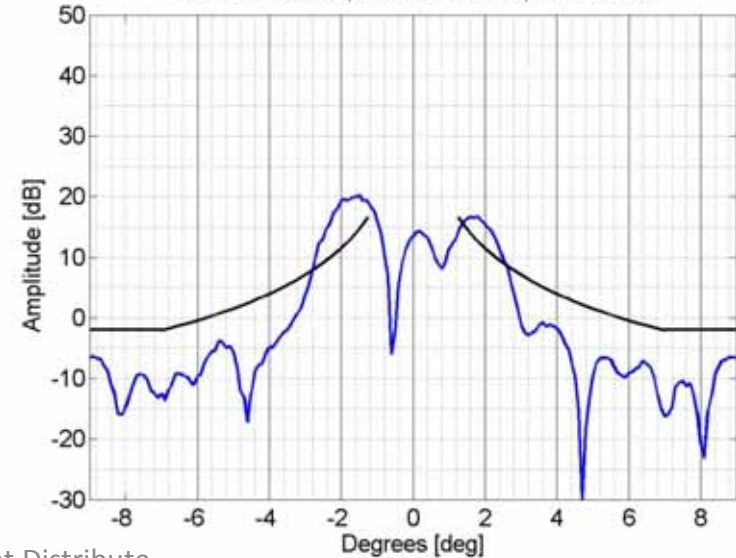
14 January 2009

2.4-14: Far Field, Azimuth HV-Pol, 6.425 GHz



14 January 2009

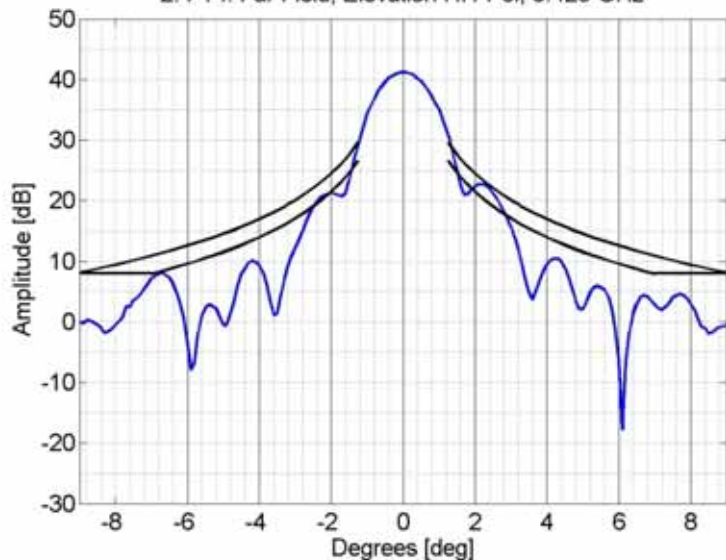
2.4-14: Far Field, Azimuth VH-Pol, 6.425 GHz



6.425 GHz Narrow Angle Elevation Patterns

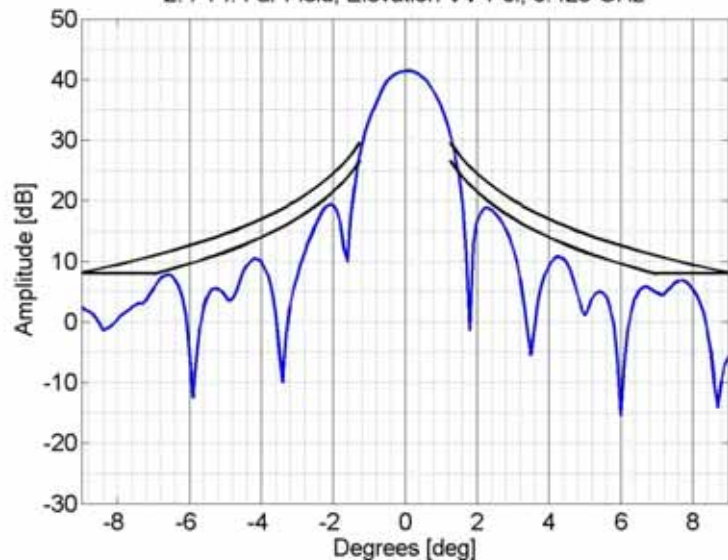
14 January 2009

2.4-14: Far Field, Elevation HH-Pol, 6.425 GHz



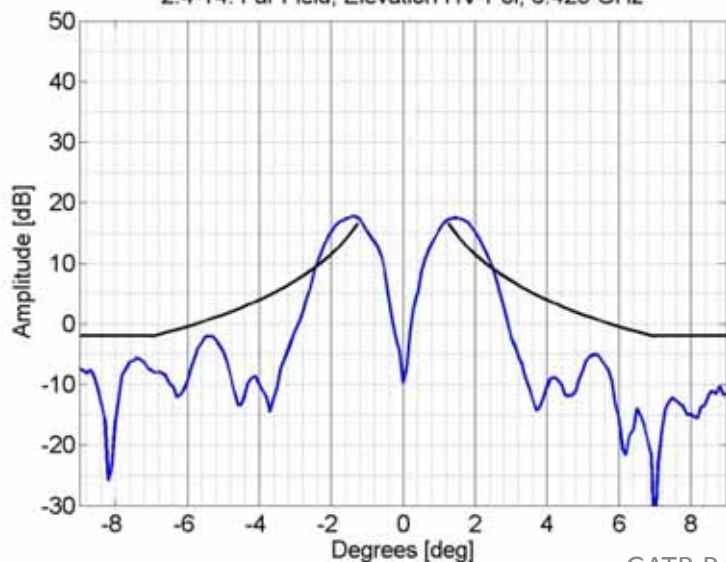
14 January 2009

2.4-14: Far Field, Elevation VV-Pol, 6.425 GHz



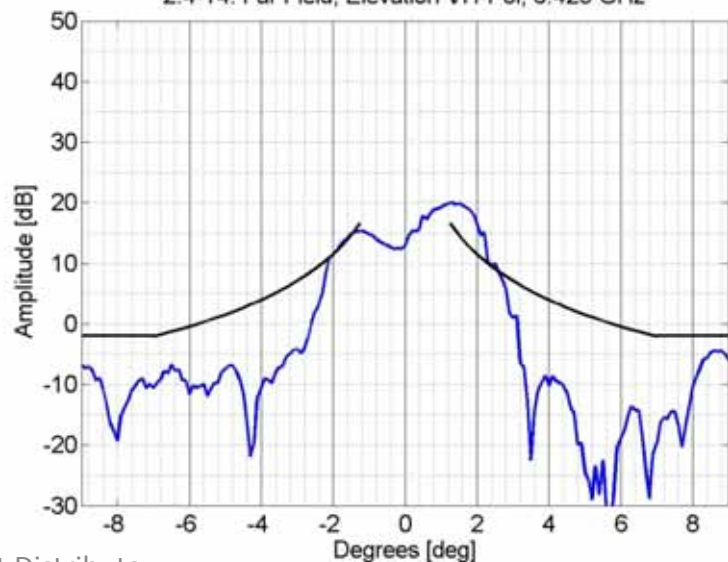
14 January 2009

2.4-14: Far Field, Elevation HV-Pol, 6.425 GHz



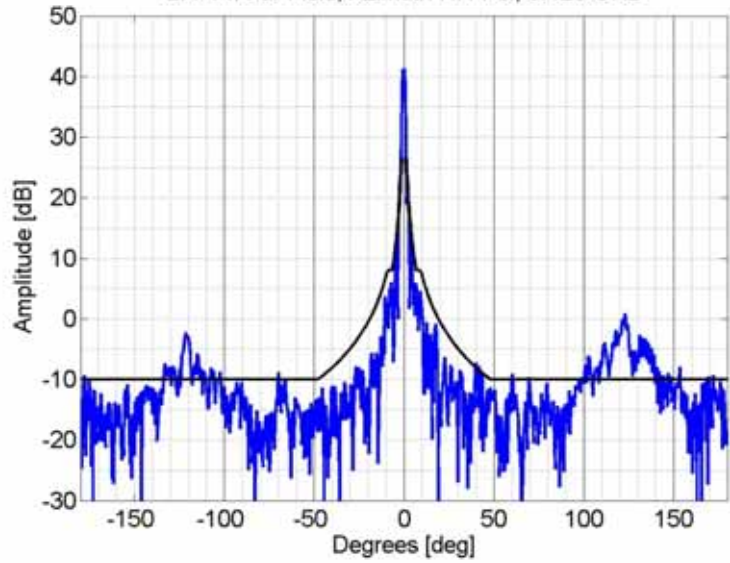
14 January 2009

2.4-14: Far Field, Elevation VH-Pol, 6.425 GHz

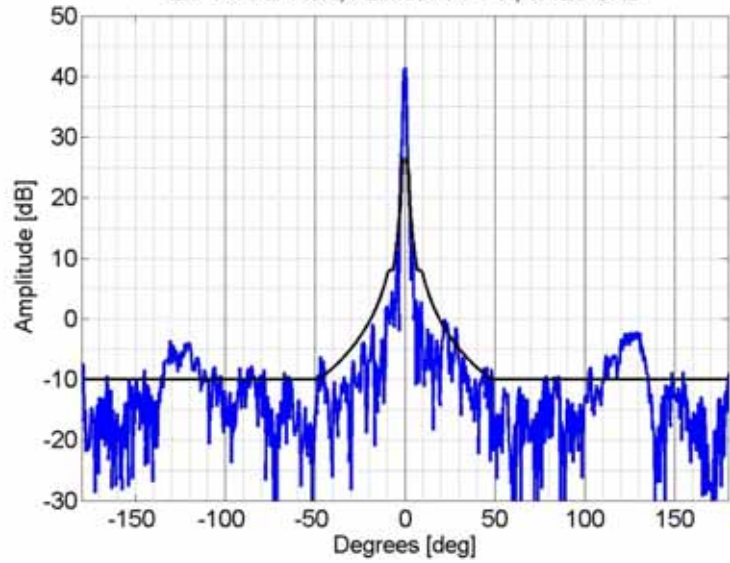


6.425 GHz Wide Angle Patterns

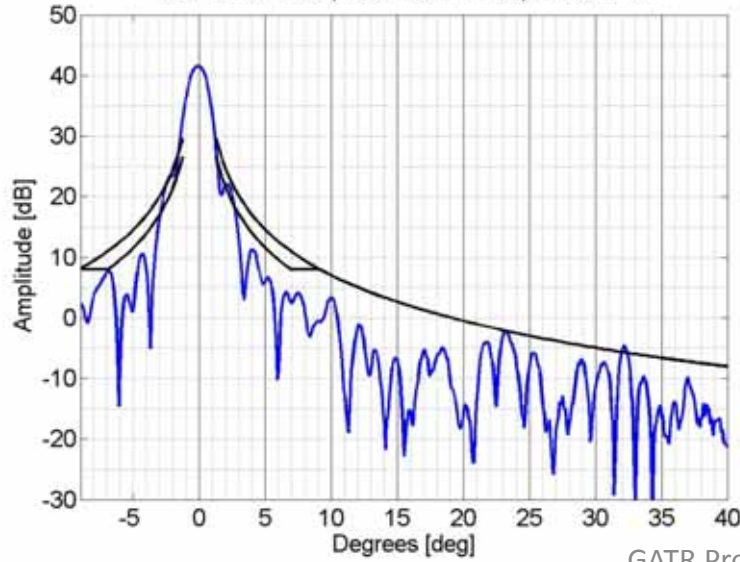
14 January 2009
2.4-14: Far Field, Azimuth HH-Pol, 6.425 GHz



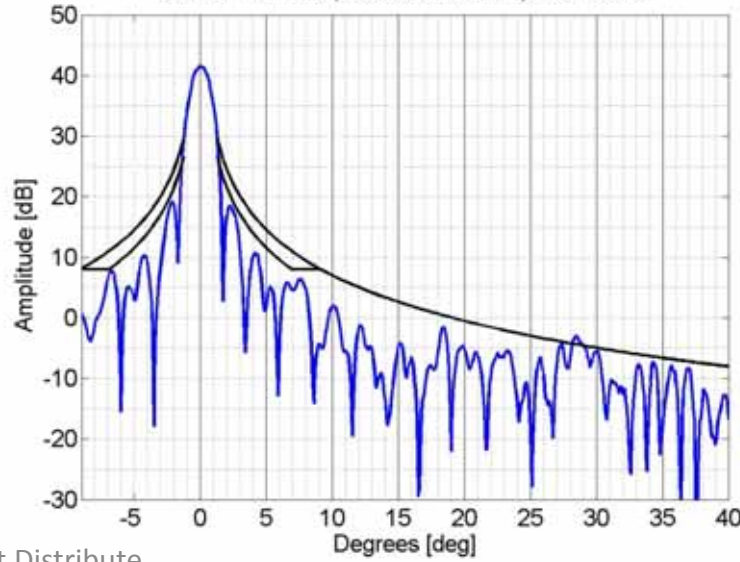
14 January 2009
2.4-14: Far Field, Azimuth VV-Pol, 6.425 GHz



14 January 2009
2.4-14: Far Field, Elevation HH-Pol, 6.425 GHz



14 January 2009
2.4-14: Far Field, Elevation VV-Pol, 6.425 GHz



C-band Measurement Conclusions

- The GATR 2.4-14 antenna was characterized at C-band on the GTRI far-field range.
- The feed horn tested was the Seavey OSA-46 (Linearly Polarized, C-band).
- The patterns collected in the receive band (3.625 – 4.20 GHz) all meet the FCC gain envelope.
- The patterns collected in the transmit band (5.925 – 6.425 GHz) meet the FCC gain envelope with a few exceptions. Specifically, the vertically polarized Co-pol patterns lose focus at 6.175 and 6.425 GHz resulting in the first side-lobe merging with the main lobe with no definite first-null. Even these patterns are not grossly over the FCC gain envelope.
- The phase pattern of the Seavey feed horn in the transmit band is too narrow for the GATR 2.4m aperture. This feed horn works well with the GATR 2.4m antenna, but it will take a different feed horn that is optimized to the GATR to fully meet the FCC gain envelope with no exceptions.