The Future:
Ultra Wide Band Feeds
and
Focal Plane Arrays

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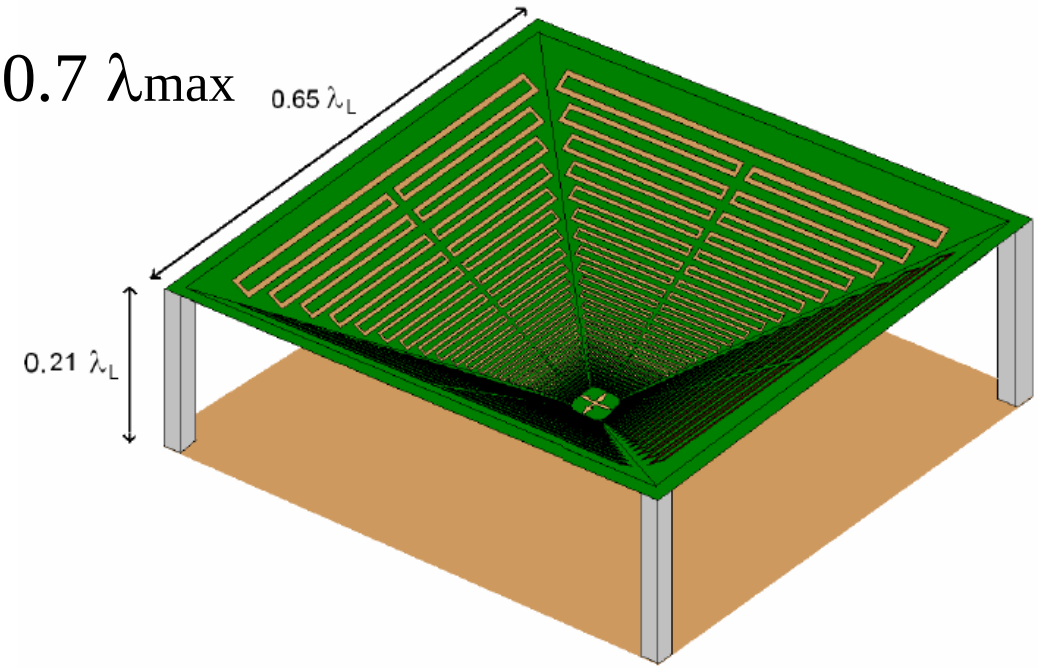
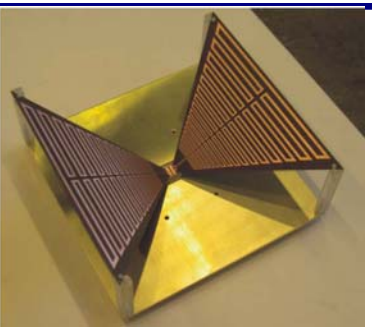
Overview

- Chalmers Feed
- Characterization of Chalmers Feed at Arecibo
- Focal Plane Arrays for Arecibo
- Conclusions

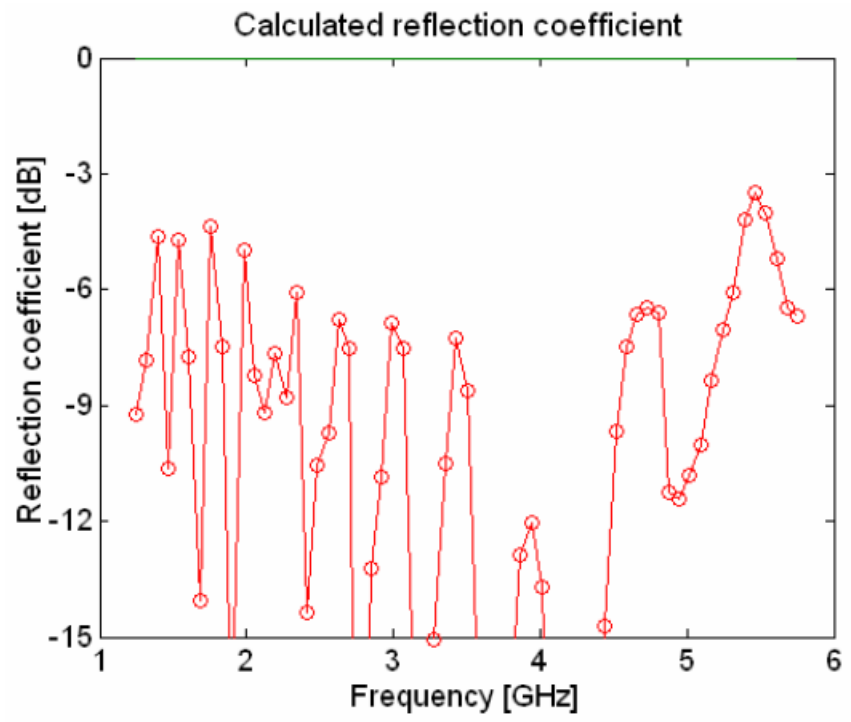
Chalmers' Feed

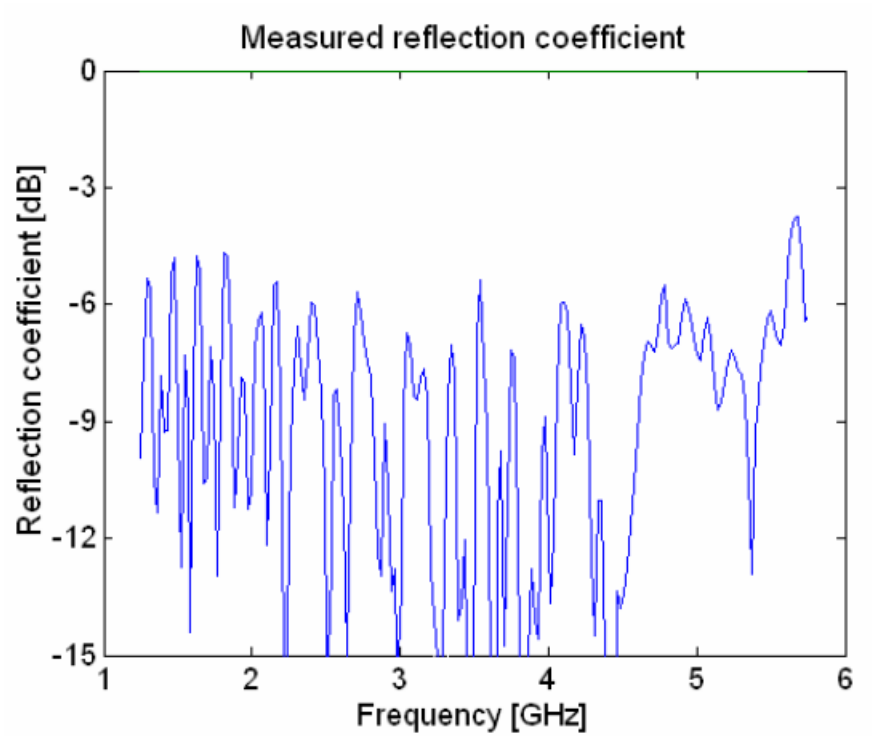
- Developed by Rikard Olsson and Per-Simon Kildal for the US-SKA
- Bandwidth 1:10
- Small Size ~ 0.5 to 0.7 λ_{max}
- Phase Center independent of Frequency



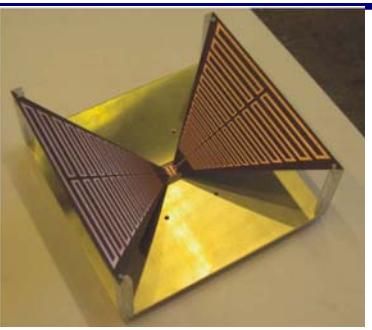


Chalmers' Feed
Input Matching Characteristics

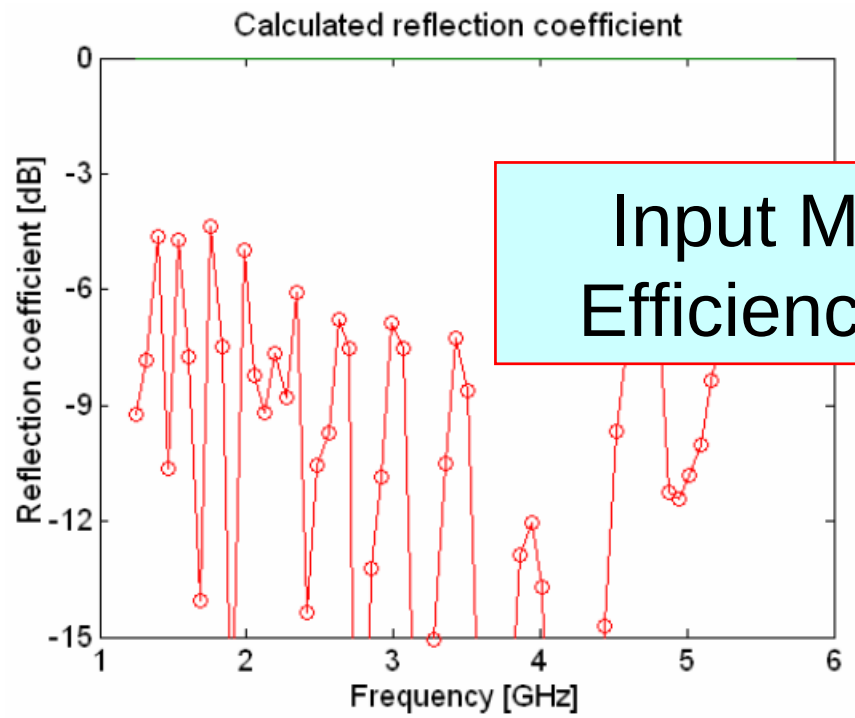


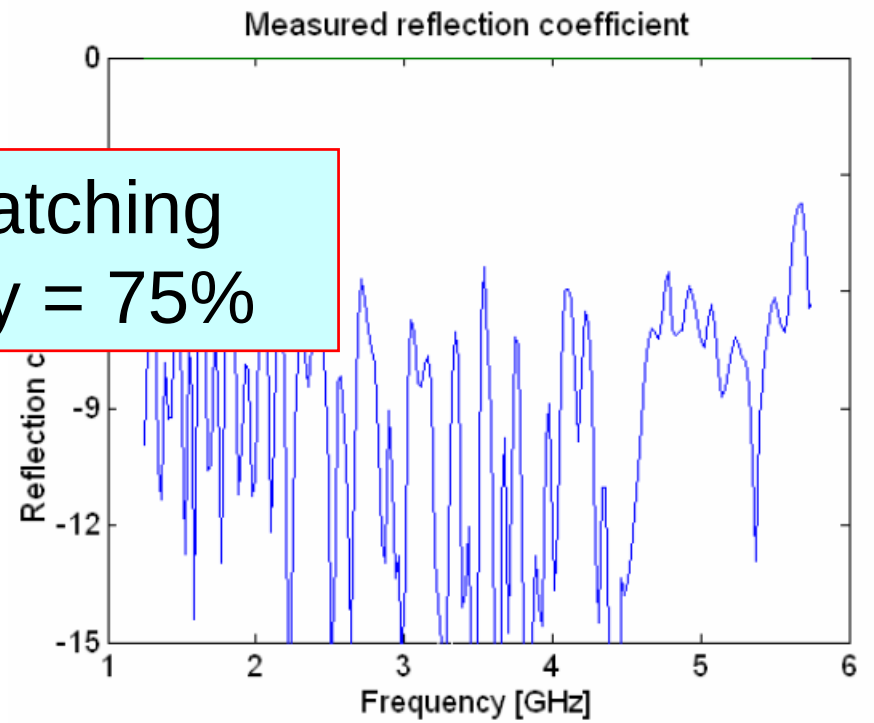


From: R. Olson and P.S. Kildal, "A Novel Low-Profile Log-Periodic Ultra Wideband Feed for the Dual-Reflector Antenna of US-SKA". *IEEE Antennas and Propagation International Symposium, 2004*



Chalmers' Feed
Input Matching Characteristics





Input Matching Efficiency = 75%

From: R. Olson and P.S. Kildal, "A Novel Low-Profile Log-Periodic Ultra Wideband Feed for the Dual-Reflector Antenna of US-SKA". *IEEE Antennas and Propagation International Symposium, 2004*

Evaluation of Chalmers Feed for Arecibo

From 1.5 to 12.0 GHz

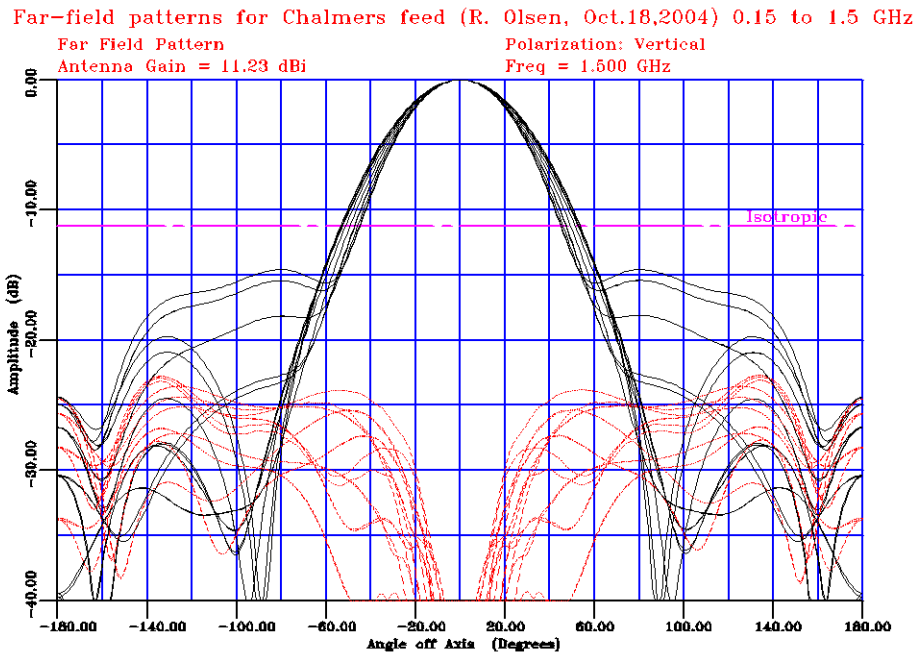
Evaluation of Chalmers Feed for Arecibo

- Spherical Wave Expansion (SWE) of Chalmers feed data patterns from 150 MHz to 1.2 GHz
- Scaled SWE by a factor of 10: yielding 1.5 to 12.0 GHz
- Radiation Patterns:

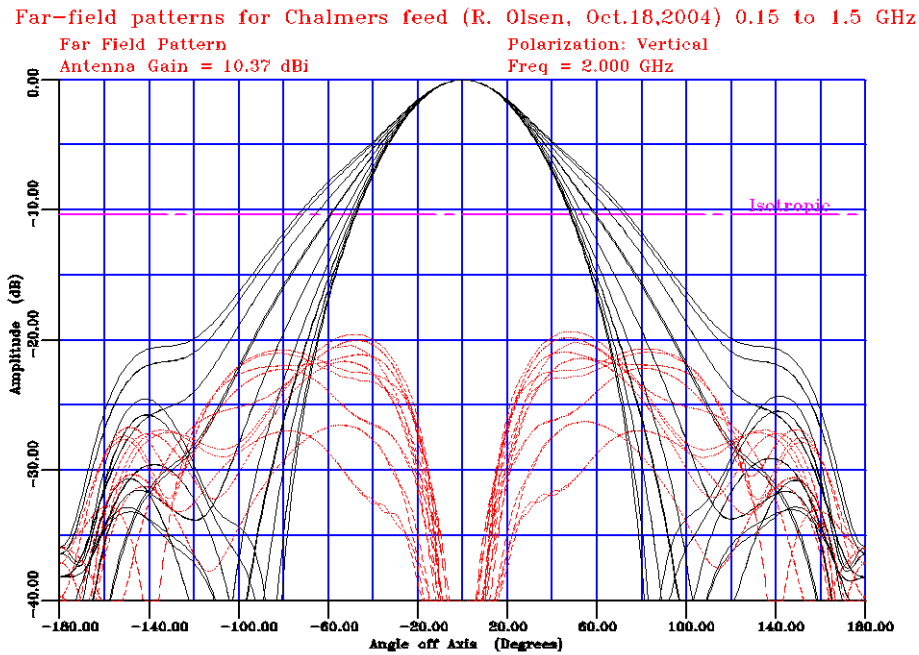
Chalmers Feed Radiation Patterns 0

Frequency Scaled x10 for Arecibo Analysis

1.5 GHz



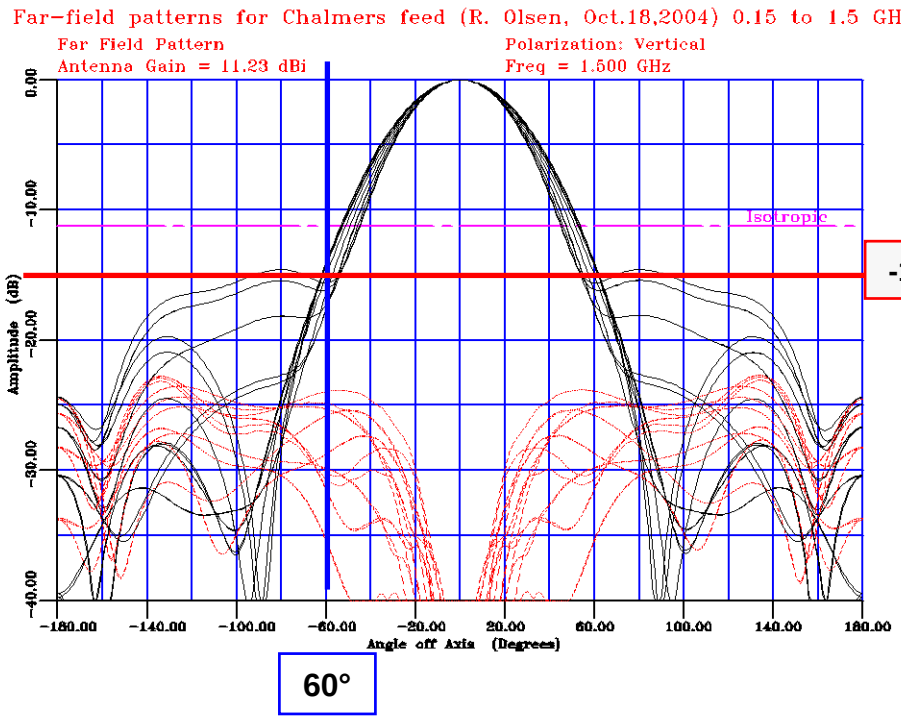
2.0 GHz



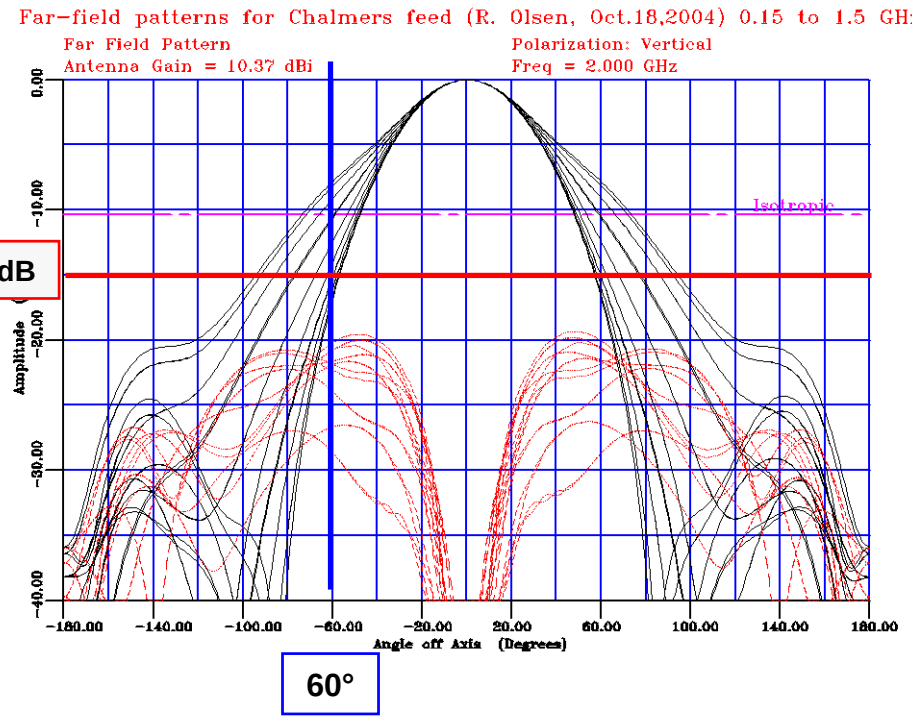
Chalmers Feed Radiation Patterns 1

Frequency Scaled x10 for Arecibo Analysis

1.5 GHz



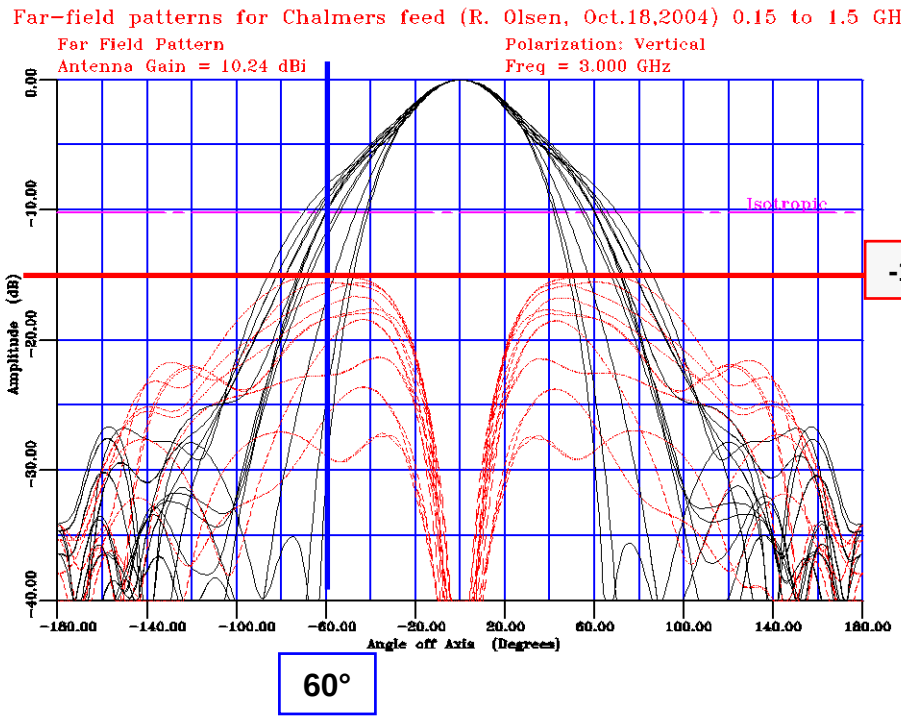
2.0 GHz



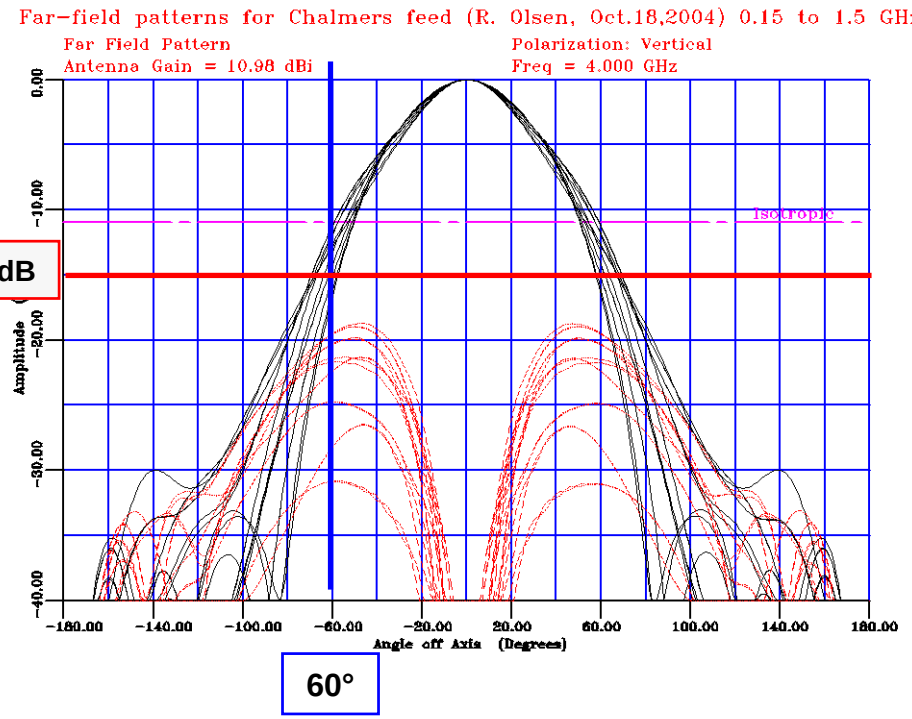
Chalmers Feed Radiation Patterns 2

Frequency Scaled x10 for Arecibo Analysis

3.0 GHz



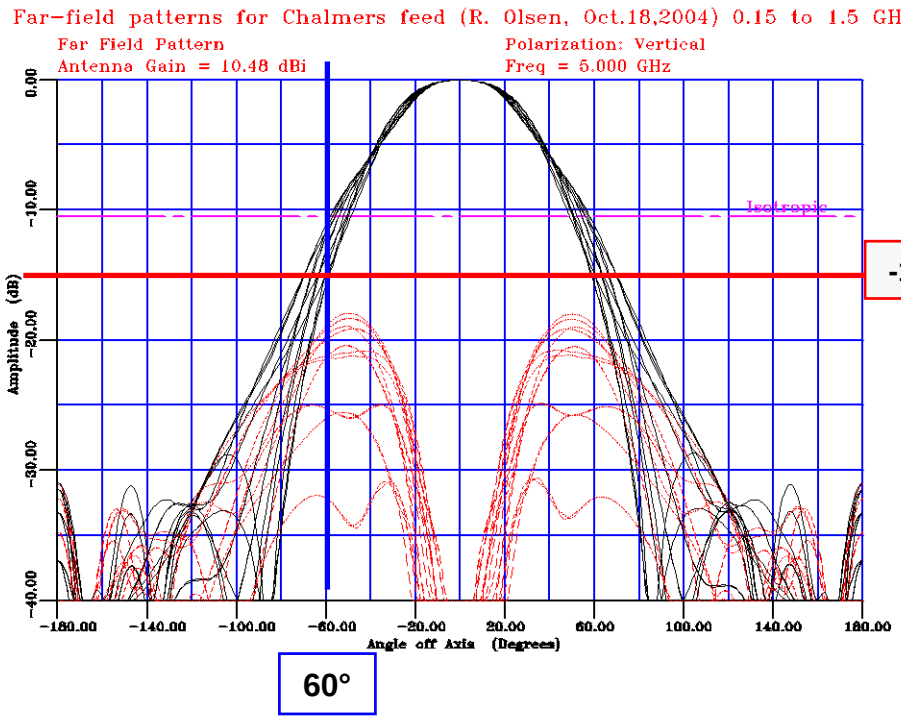
4.0 GHz



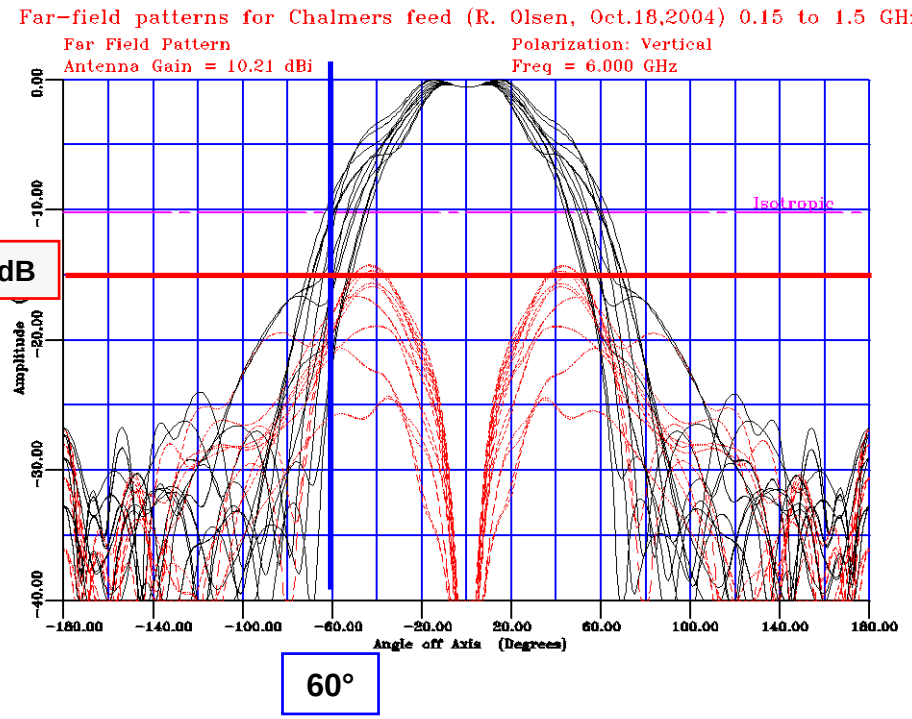
Chalmers Feed Radiation Patterns 3

Frequency Scaled x10 for Arecibo Analysis

5.0 GHz



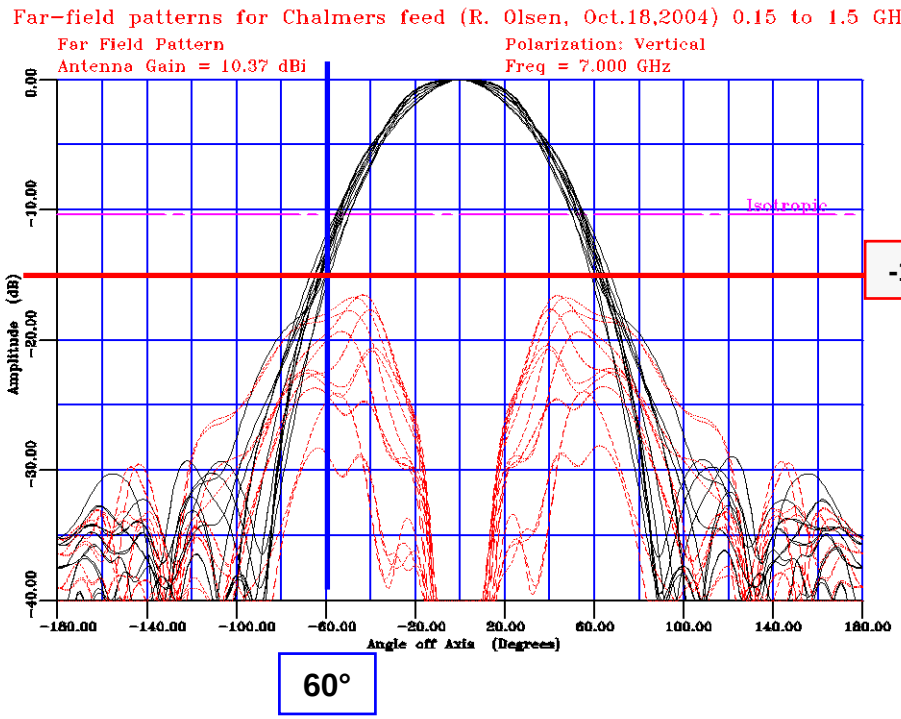
6.0 GHz



Chalmers Feed Radiation Patterns 4

Frequency Scaled x10 for Arecibo Analysis

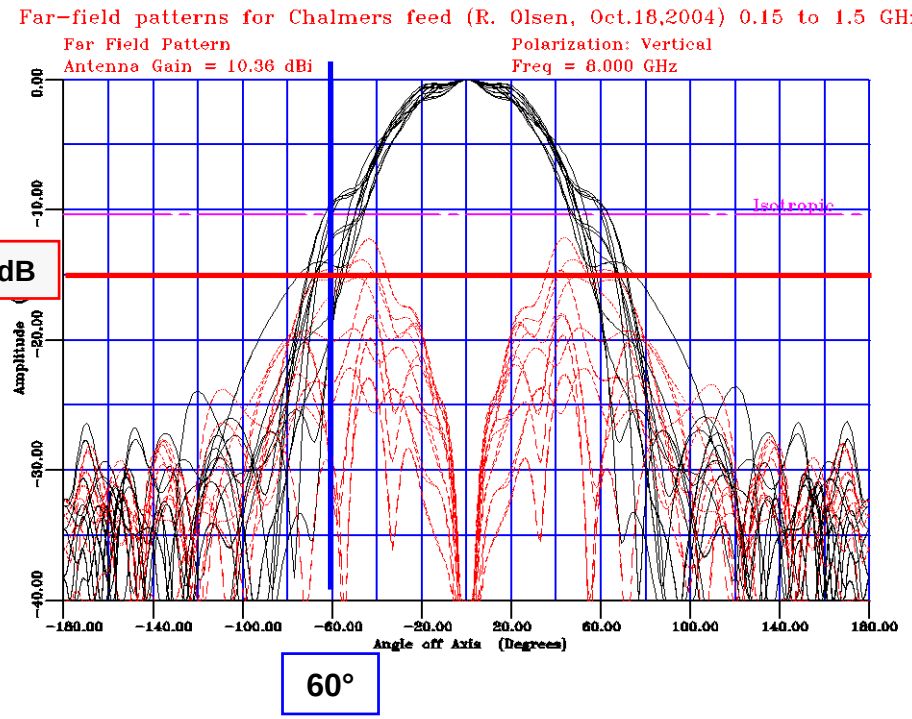
7.0 GHz



-15dB

60°

8.0 GHz

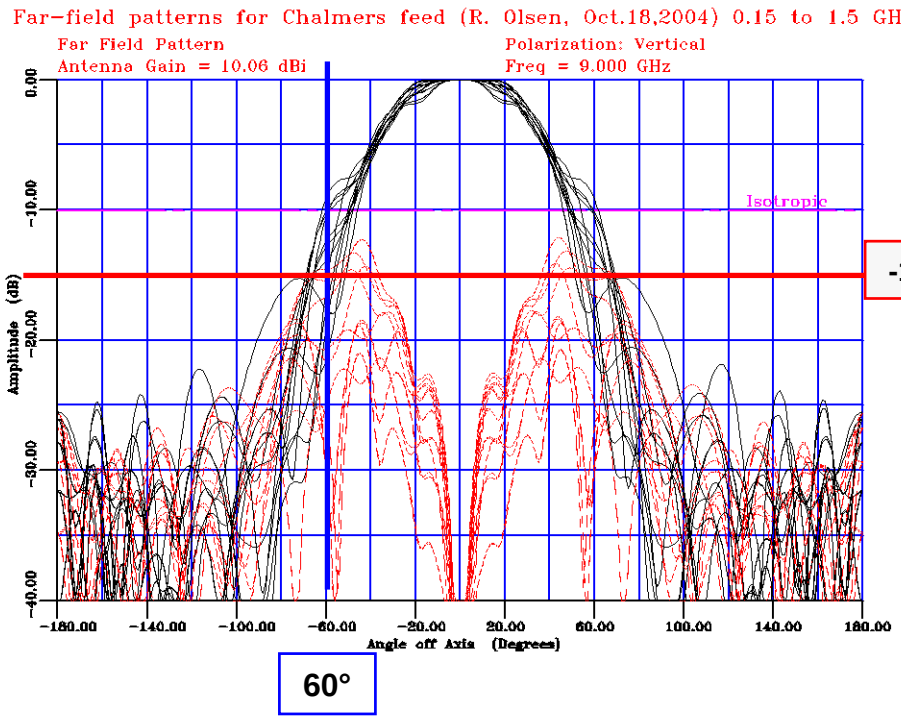


60°

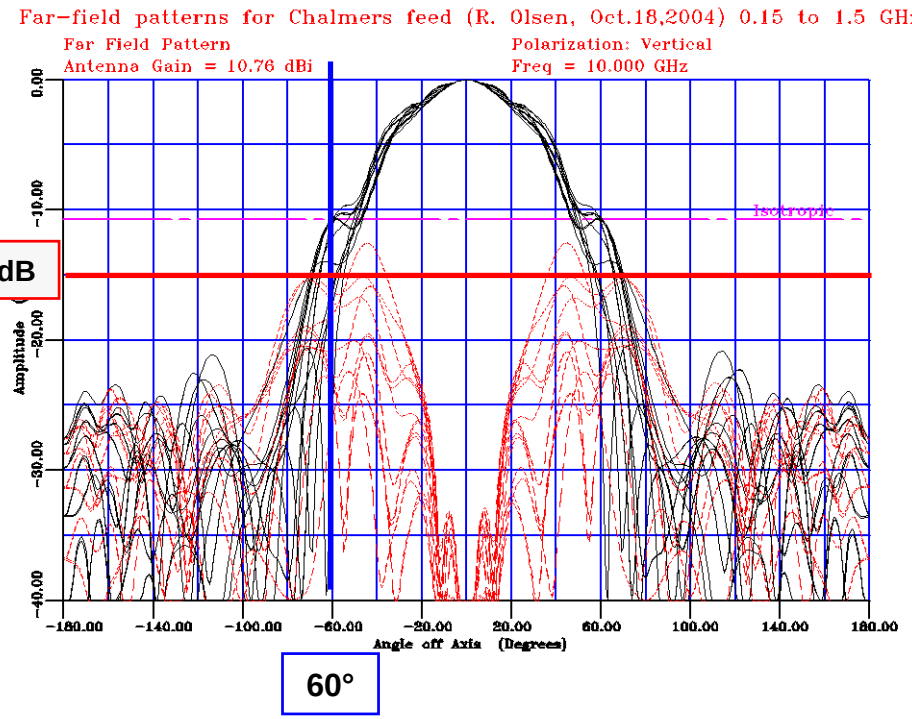
Chalmers Feed Radiation Patterns 5

Frequency Scaled x10 for Arecibo Analysis

9.0 GHz



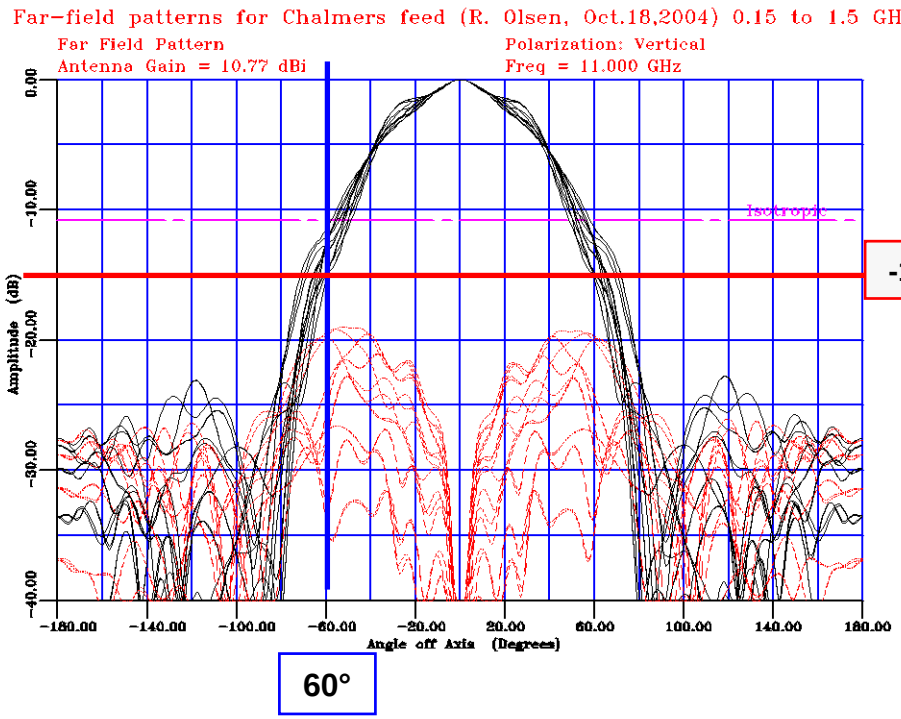
10.0 GHz



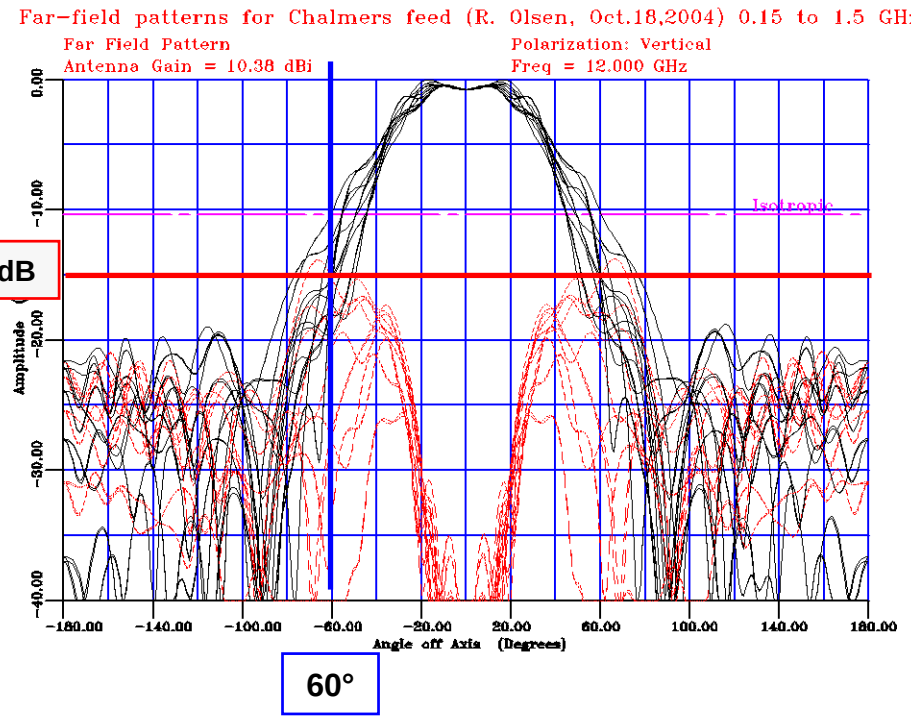
Chalmers Feed Radiation Patterns 6

Frequency Scaled x10 for Arecibo Analysis

11.0 GHz



12.0 GHz

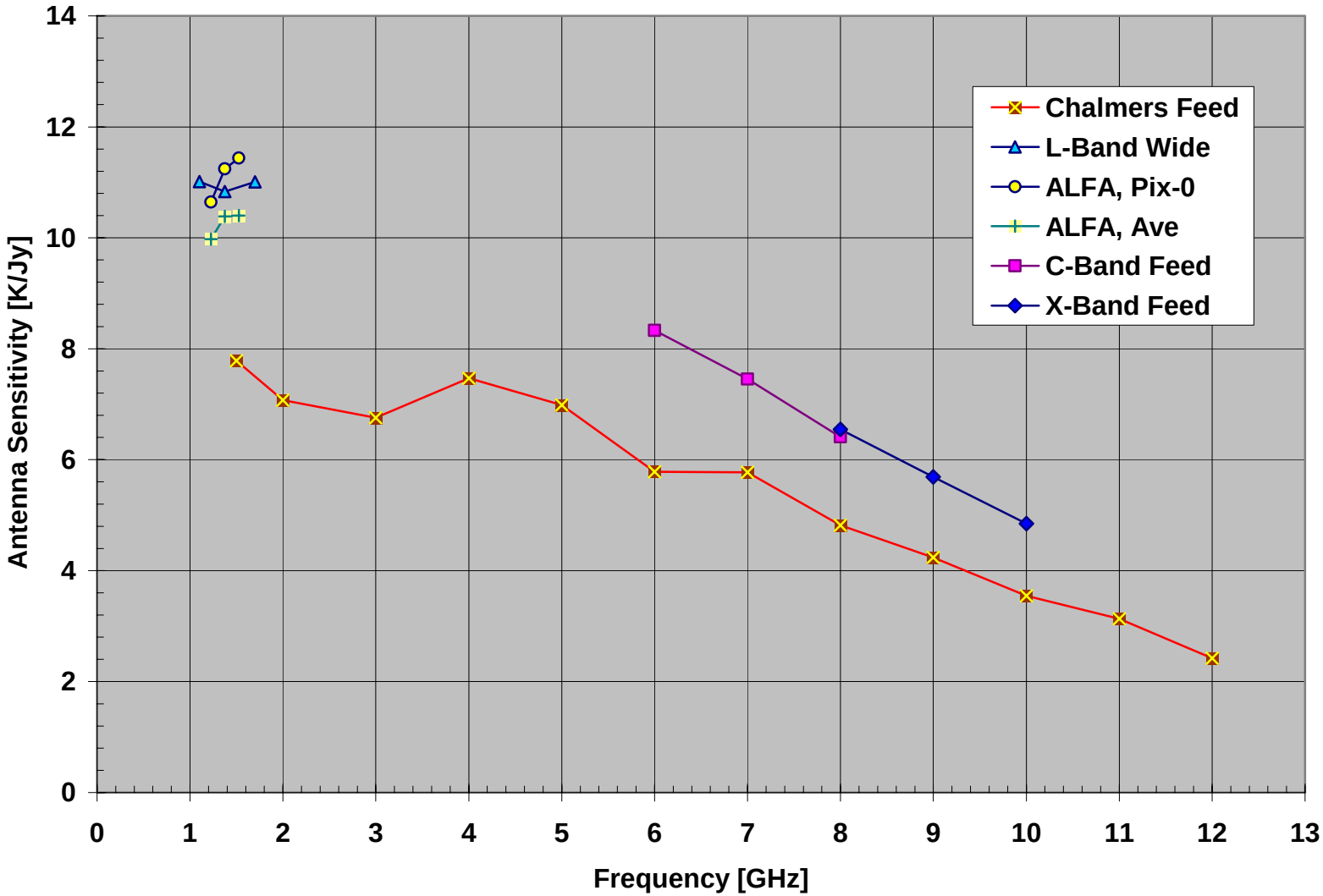


Calculated Arecibo Antenna Performance with Chalmers Feed

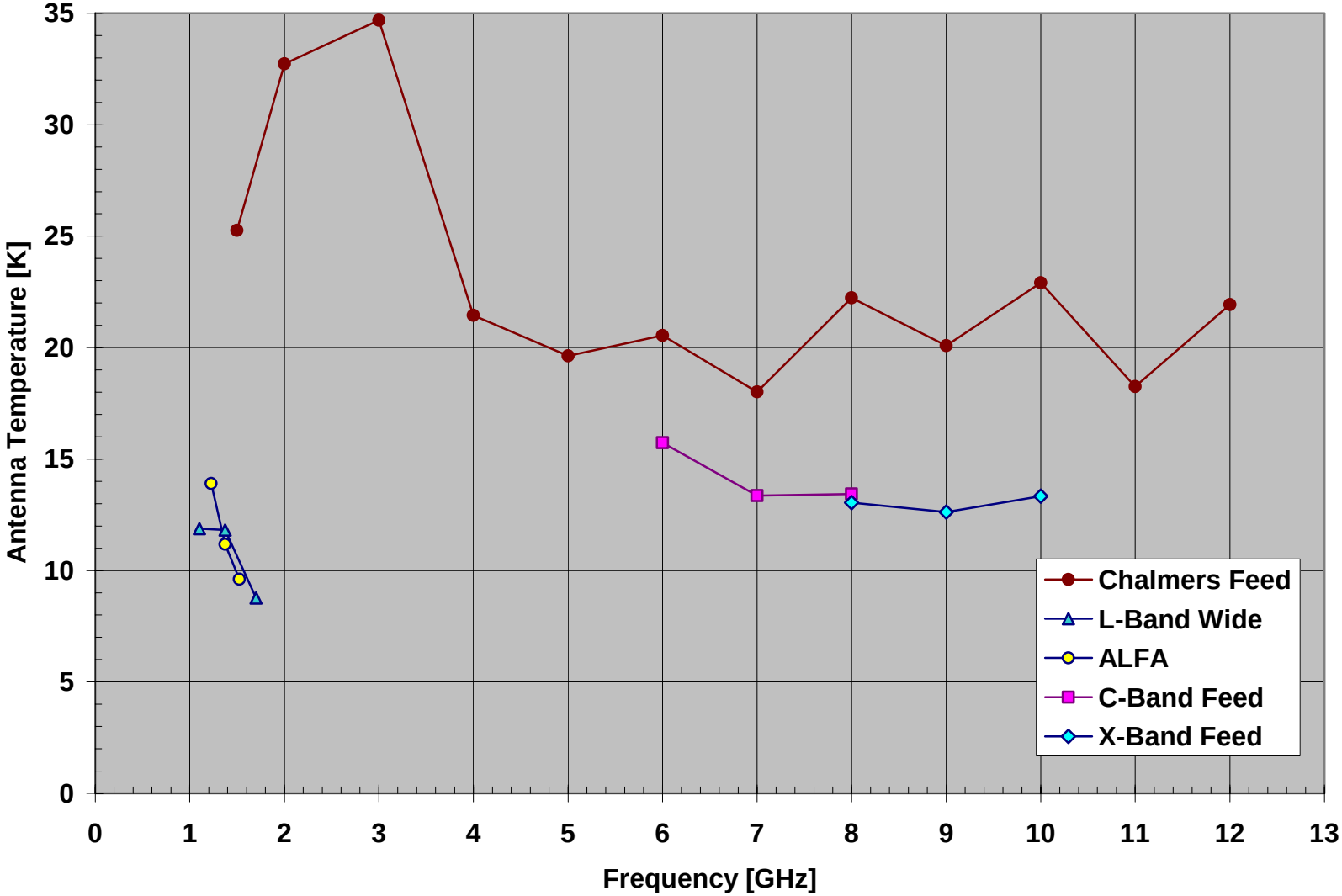
Calculated Antenna Performance

- Antenna Sensitivity
- Antenna Noise Temperature
- System Noise Temperature

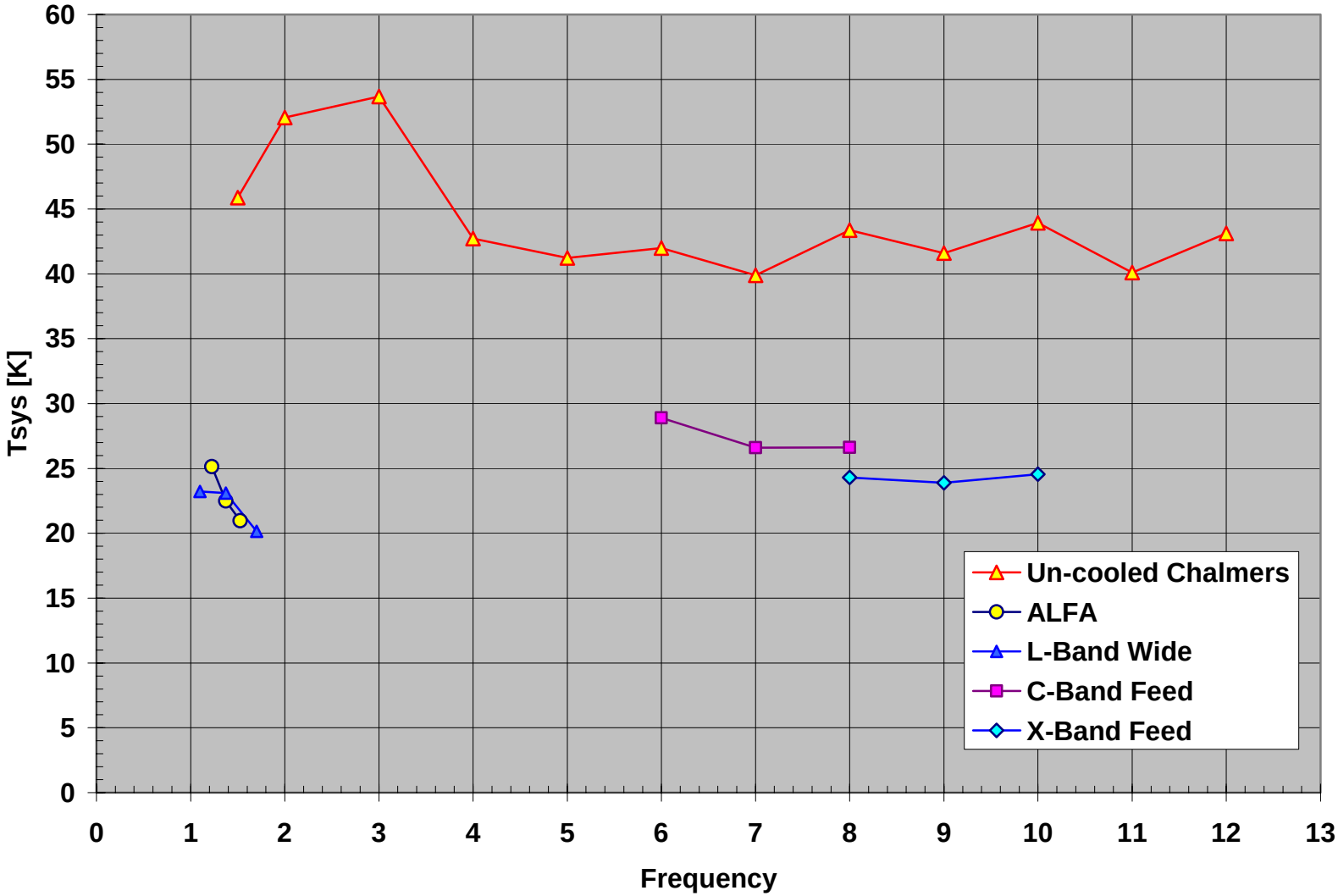
Calculated Antenna Sensitivity



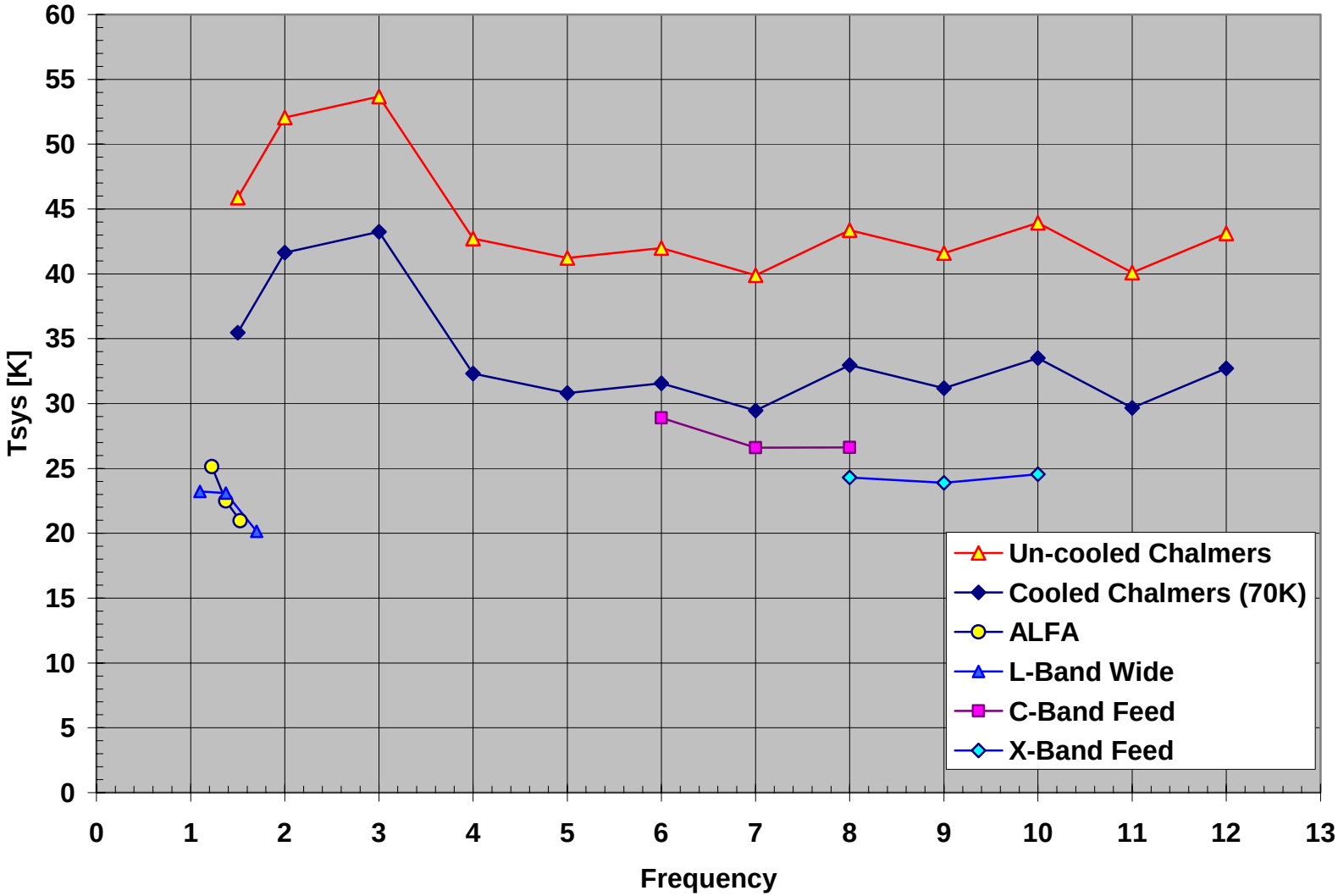
Calculated Antenna Noise Temperature



Calculated System Temperature I



Calculated System Temperature II



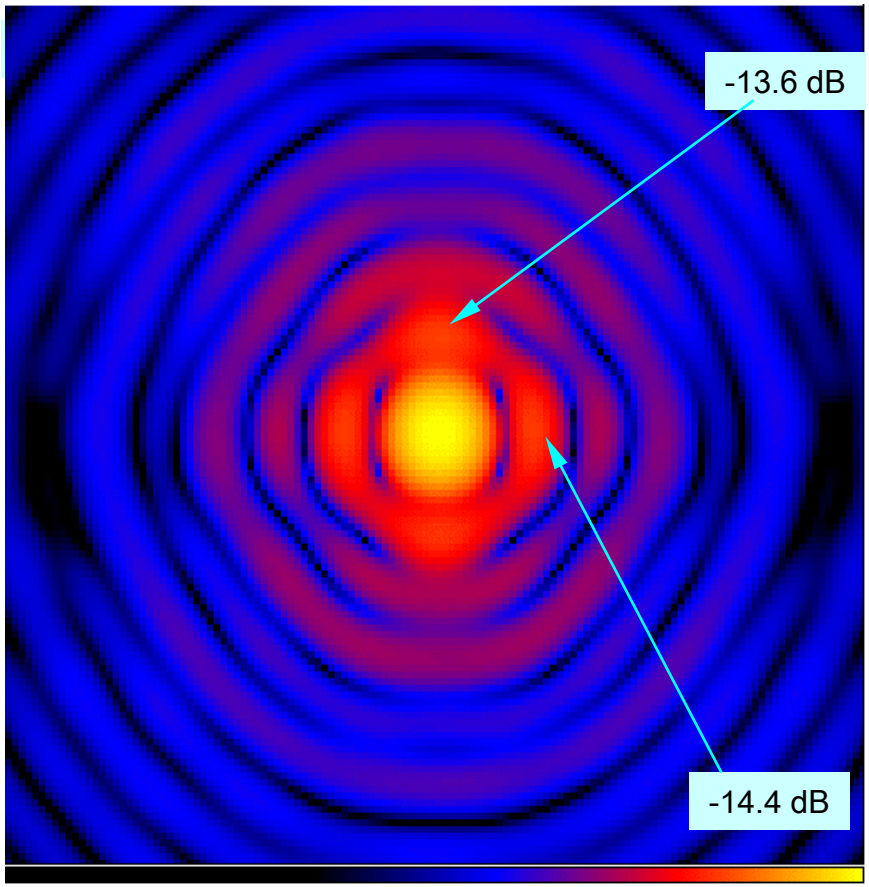
Calculated Antenna Performance

- Antenna Sensitivity
- Antenna Noise Temperature
- System Noise Temperature
- **Beam radiation Patterns**
- Cross-Polarization Levels

Arecibo Antenna Beam Pattern with Chalmers Feed

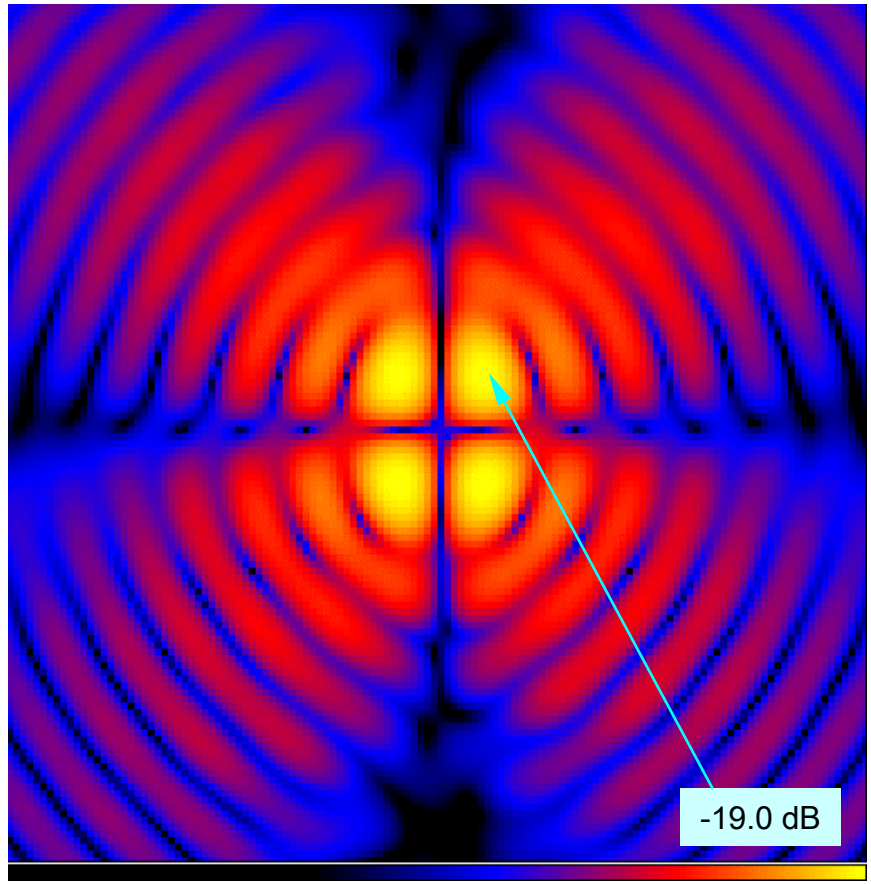
Freq= 3.0 GHz

11'x11'



Co-Polar Beam Pattern

11'x11'

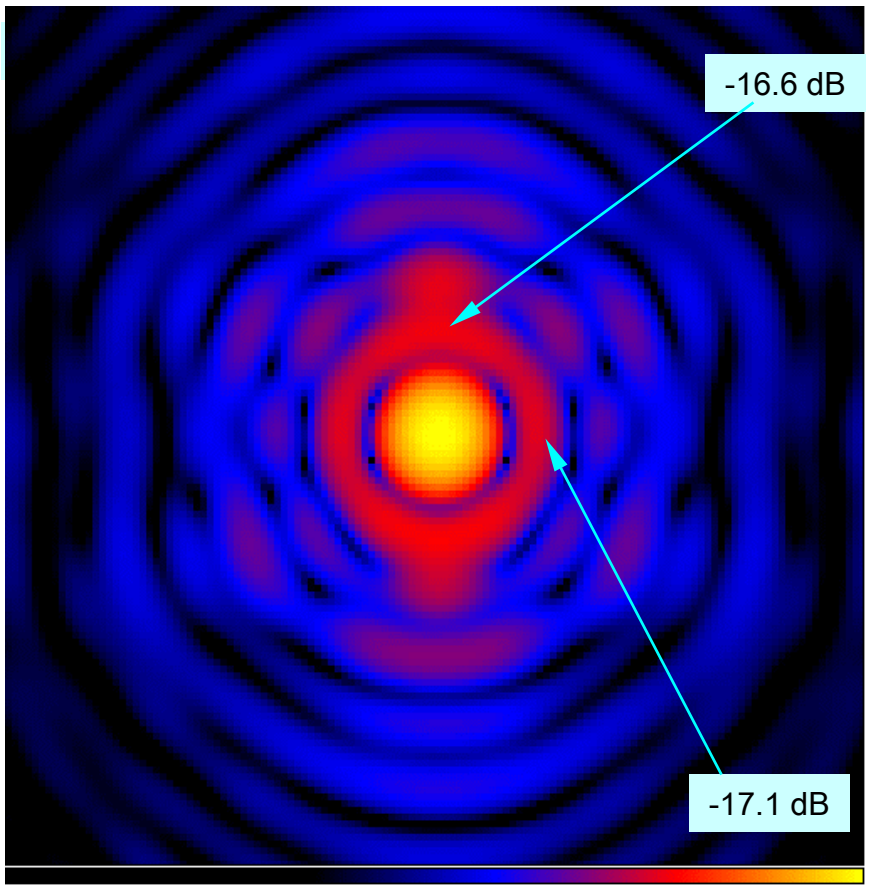


X-Polar Beam Pattern

Arecibo Antenna Beam Pattern with Chalmers Feed

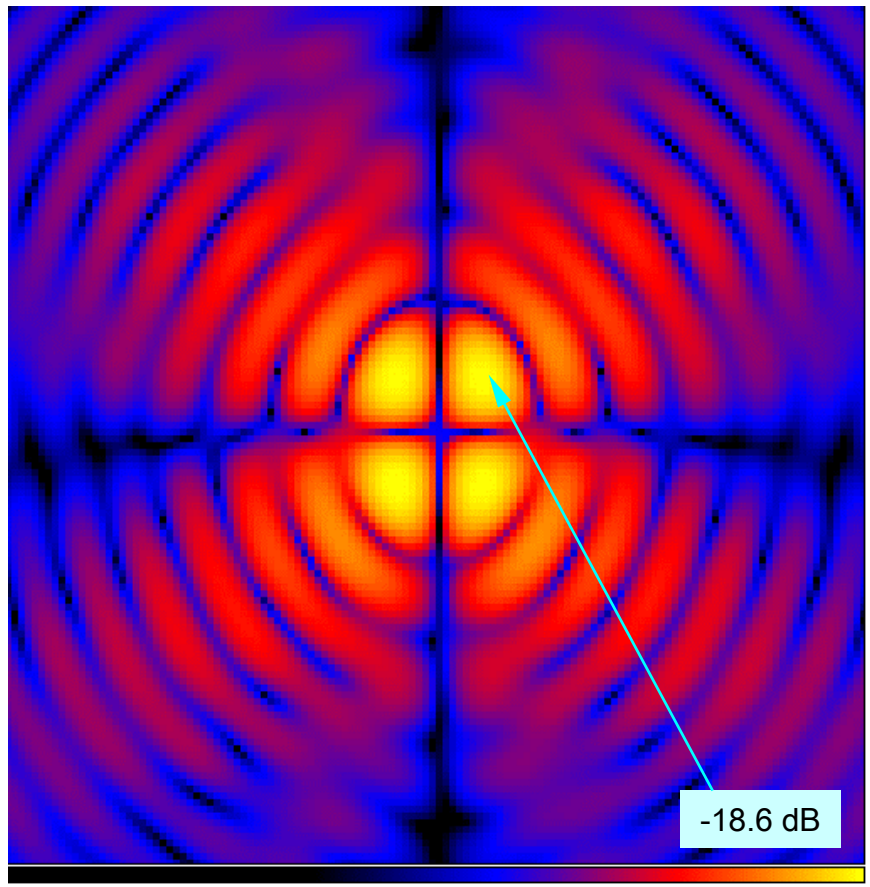
Freq= 6.0 GHz

5.5' x 5.5'



Co-Polar Beam Pattern

5.5' x 5.5'

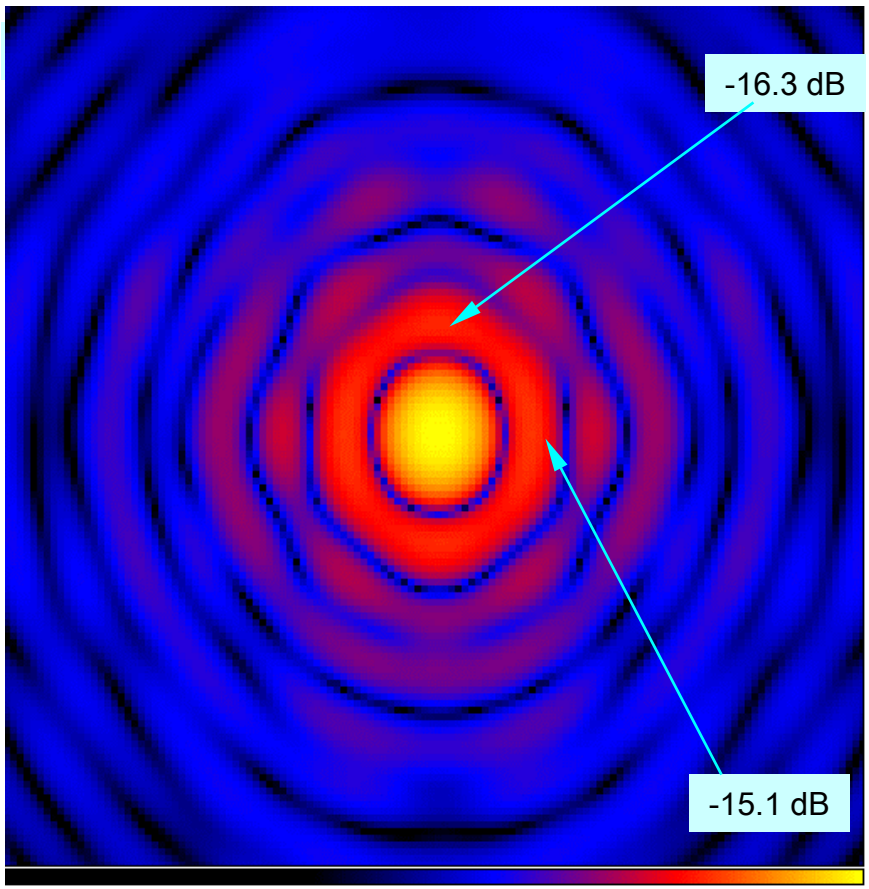


X-Polar Beam Pattern

Arecibo Antenna Beam Pattern with Chalmers Feed

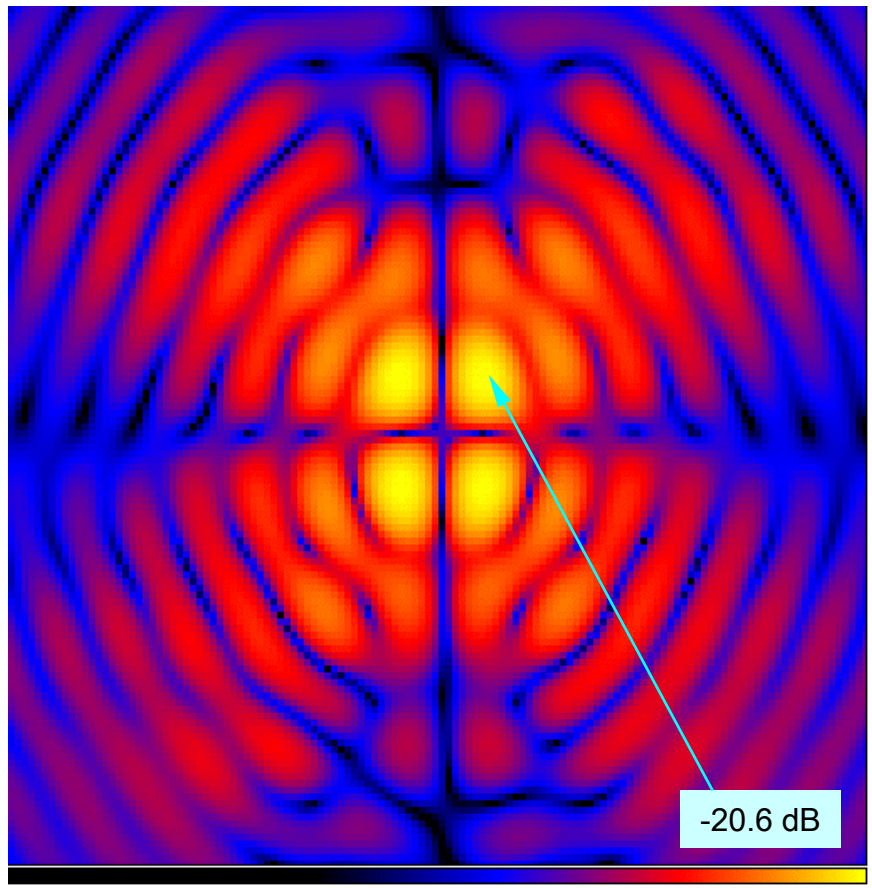
Freq= 9.0 GHz

3.7' x 3.7'



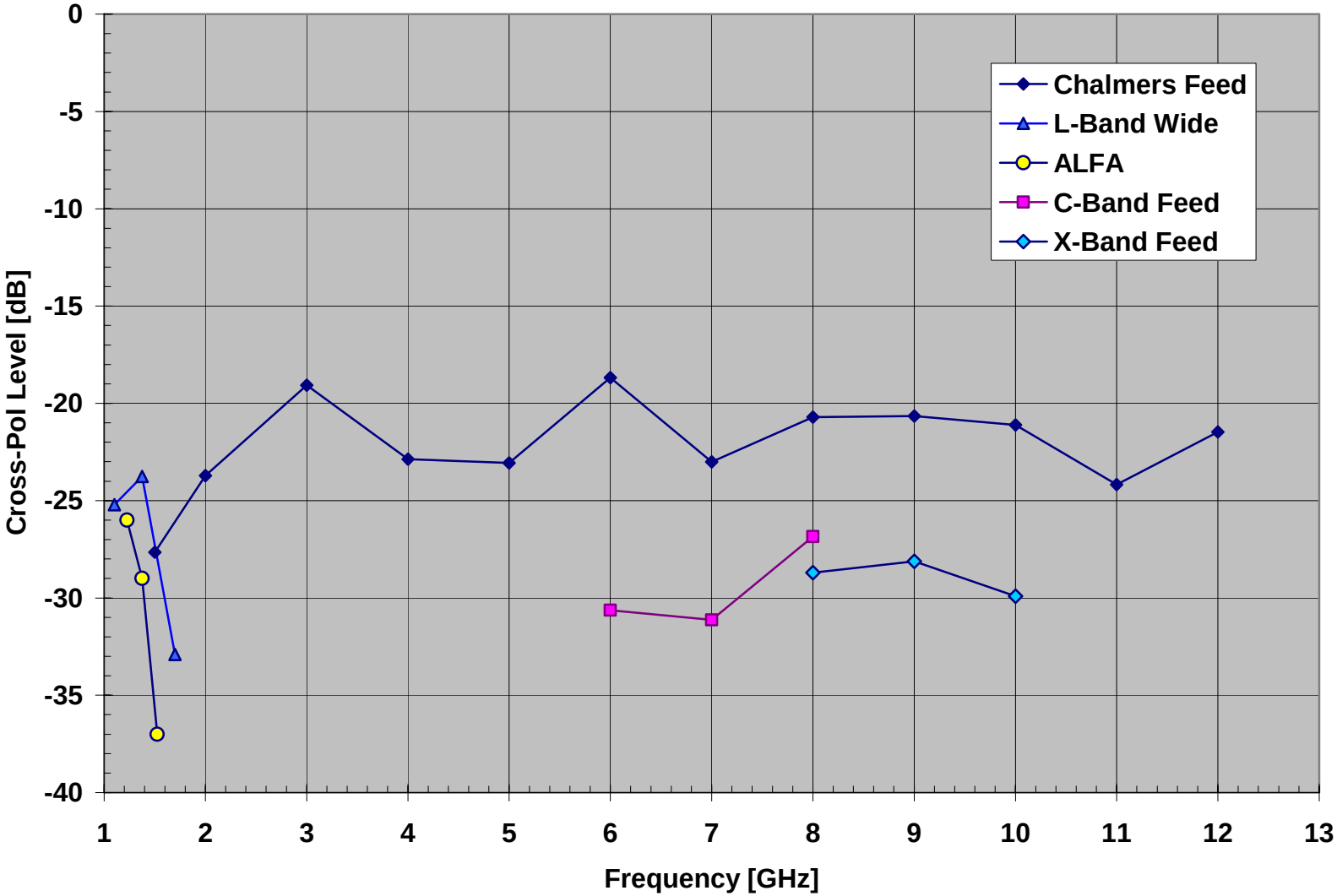
Co-Polar Beam Pattern

3.7' x 3.7'



X-Polar Beam Pattern

Cross-Polarization Level



Conclusions: Chalmers' Feed

- Great Bandwidth, and compact size
- Antenna Sensitivity less than current systems
- Antenna Cross-Pol level better that –19 dB, compared with –25 dB
- Large Spillover yields Higher Antenna Noise Temperature.
- Moderate High Tsys. By cooling the feed to 70K, Tsys reduces from 43K to 33K

Focal Plane Arrays for Arecibo

Enabling Feed Technologies

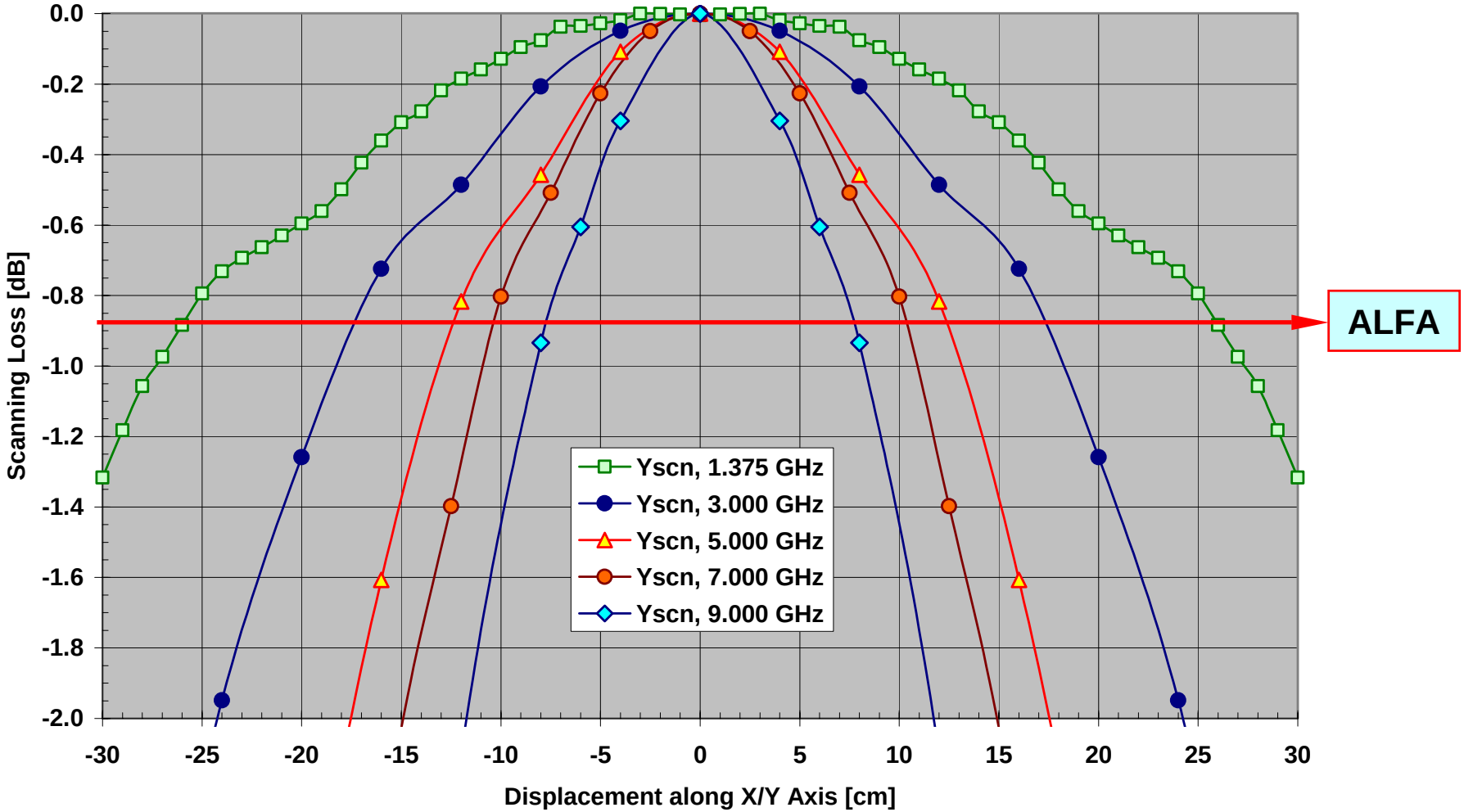
Feed Technology	Band width Current	Band width Feasible	Input Matching [dB]	Noise Perform.	Imaging Config.
Corrugated Feed Horns	1.55:1	2:1	-25.0	**GOOD**	Single/Array
Quad-Ridge Feed Horn	2:1	3:1	-20.0	**GOOD**	Single/Array
ATA Feed	20:1	-----	-15.0	**FAIR**	Single/Array?
Chalmers Feed	10:1	-----	-6.0	**POOR**	Single/Array?
Vivaldi Feed	3:1	5:1	-15.0	**FAIR**	Phase Array

Possible Focal Plane Arrays Configurations for Arecibo

- TE11 mode Focal Plane Arrays
- Chalmers/Ingerson Feed based Focal Plane Arrays
- Vivaldi Focal Phased Arrays
- Others: Quad-Ridge …

Arecibo Gregorian Optics

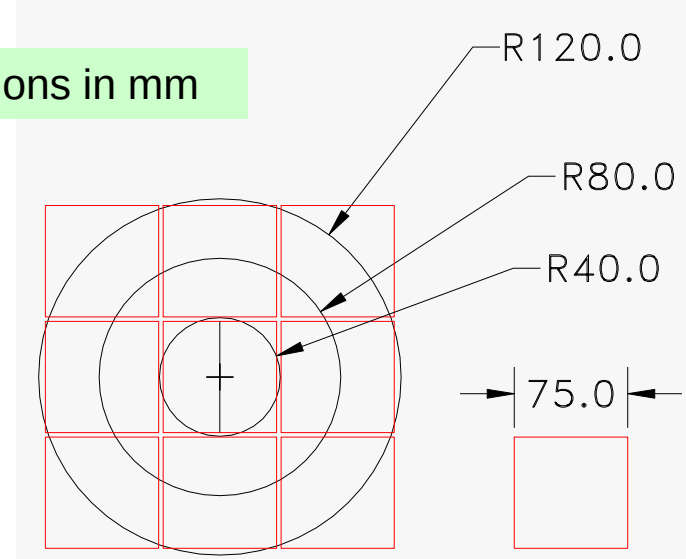
Scanning Losses and Field of View



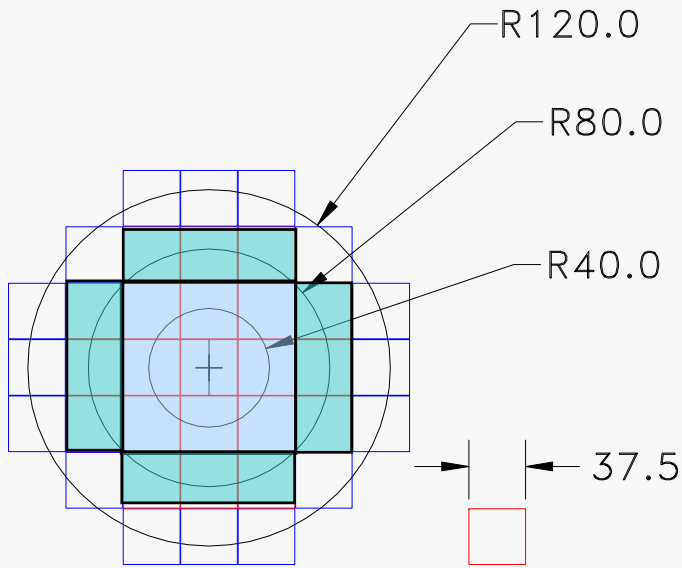
Chalmers/Ingerson Feed based Focal Plane Arrays

- Element Separation 0.5 to 0.7λ_{max}
- Max. Scanning loss across the band: 1.0 dB

Dimensions in mm



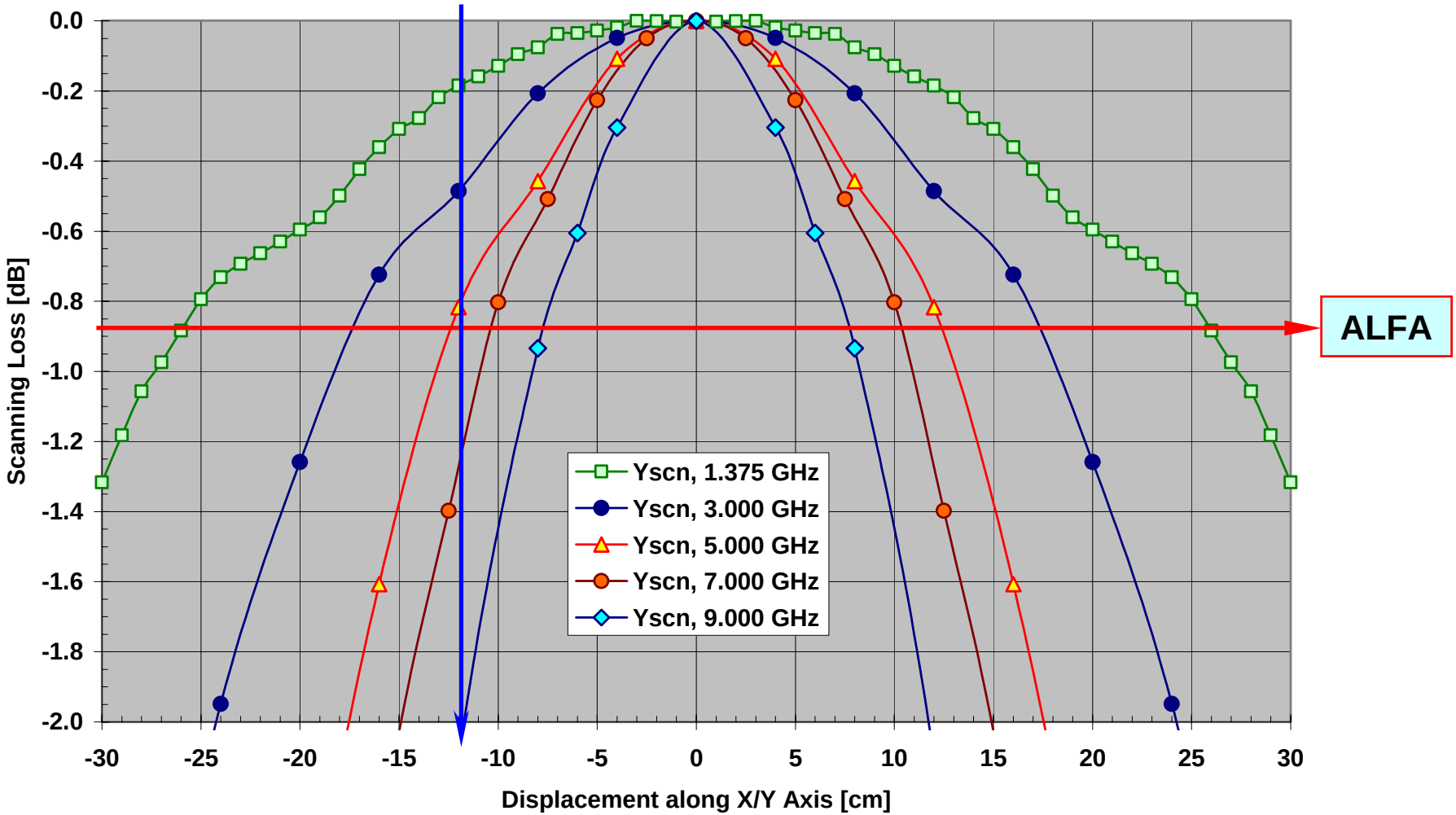
CHALMERS FP ARRAY
2 To 7 GHz
9 elements



CHALMERS FP ARRAY
4 To 8 GHz
21 to 37 elements

Arecibo Gregorian Optics

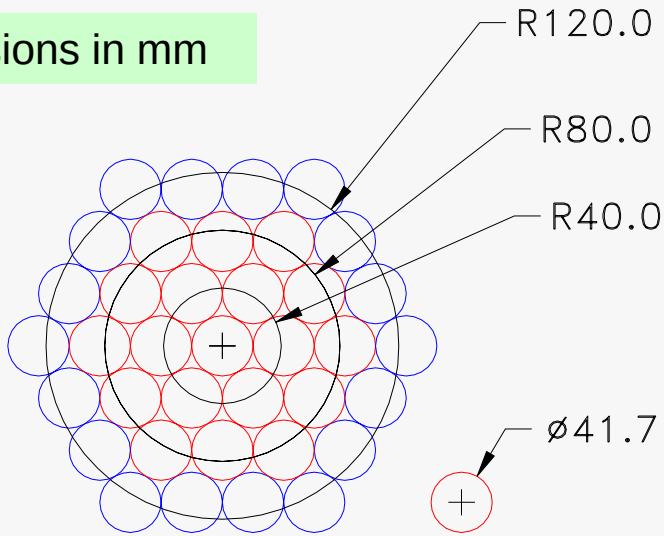
Scanning Losses and Field of View



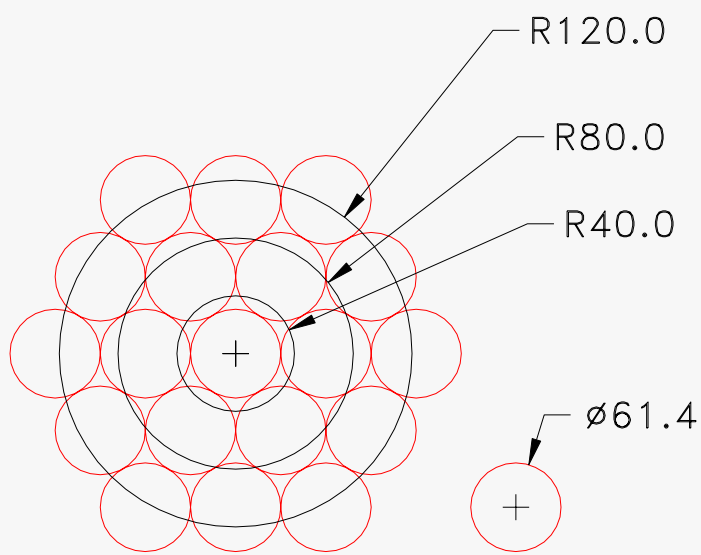
TE11 Mode Horns based Focal Plane Arrays

- Element Separation 1.19λ
- Max. Scanning loss across the band: 1.0 dB

Dimensions in mm



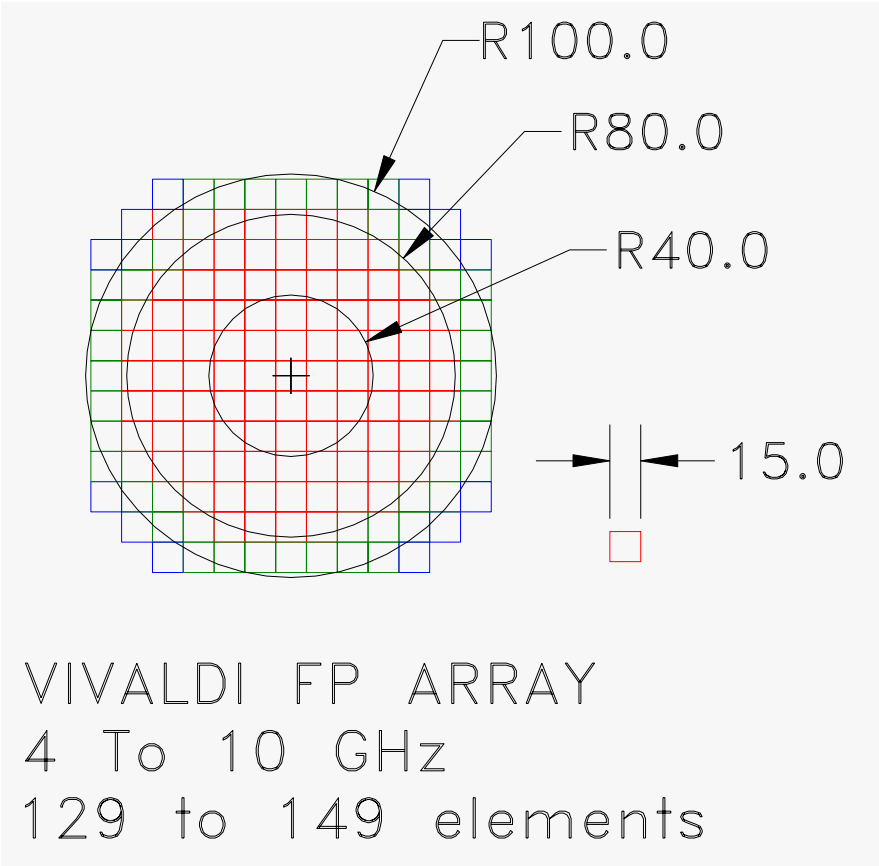
TE11 Feed ARRAY
8 to 10 GHz
19 to 37 elements



TE11 Feed ARRAY
6 to 8 GHz
7 to 19 elements

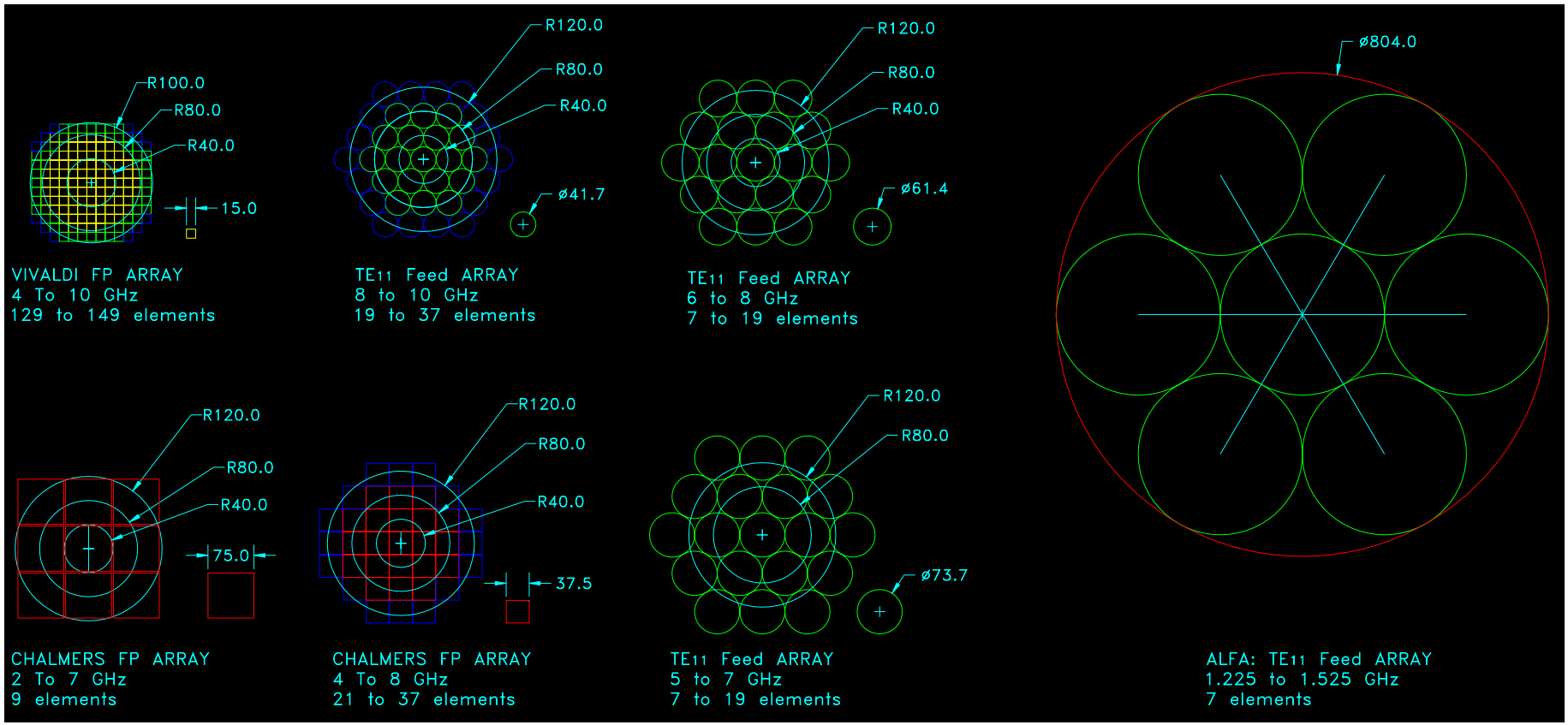
Vivaldi Feed Based Focal Phased Arrays

- Element Separation 0.5λ_{min}



Dimensions in mm

Focal Plane Arrays Possibilities…



Conclusions Cont…

- Bandwidth of Focal Plane Array at Arecibo is determined by the scanning Losses in the FOV
- Un-cooled Chalmers Feeds are better suited for single pixel applications than for Focal Plane Array applications due to poor input matching and cooling requirements to reduce Tsys.
- Vivaldi type Phased Arrays could be located in away from the Gregorian Focal Plane…
- A 19 element X-Band TE11 mode focal plane array is feasible…

End