Microwavers use Real Antennas

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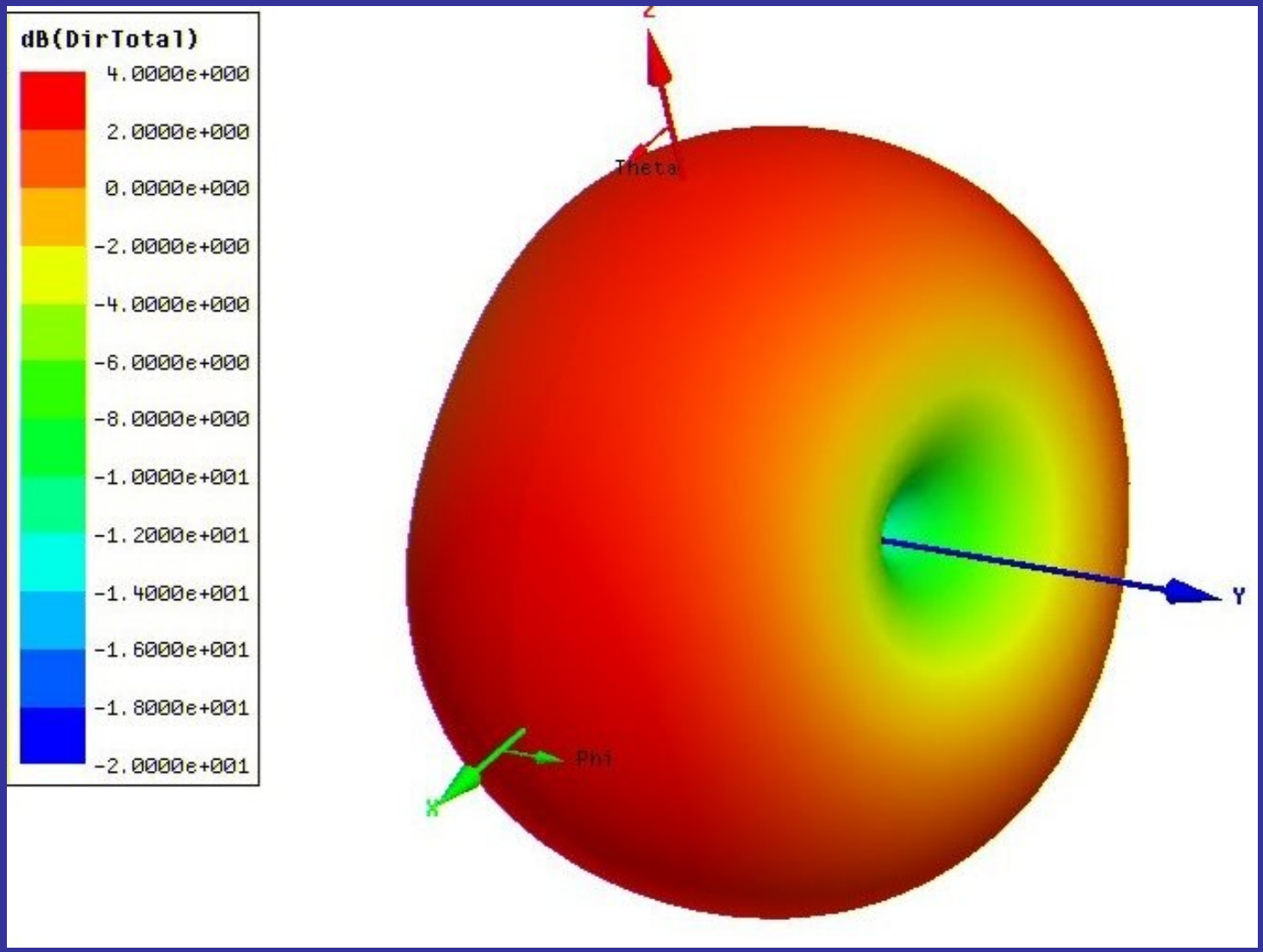
Microwave Antennas

- Good antennas are essential for all communications, but especially for microwave frequencies

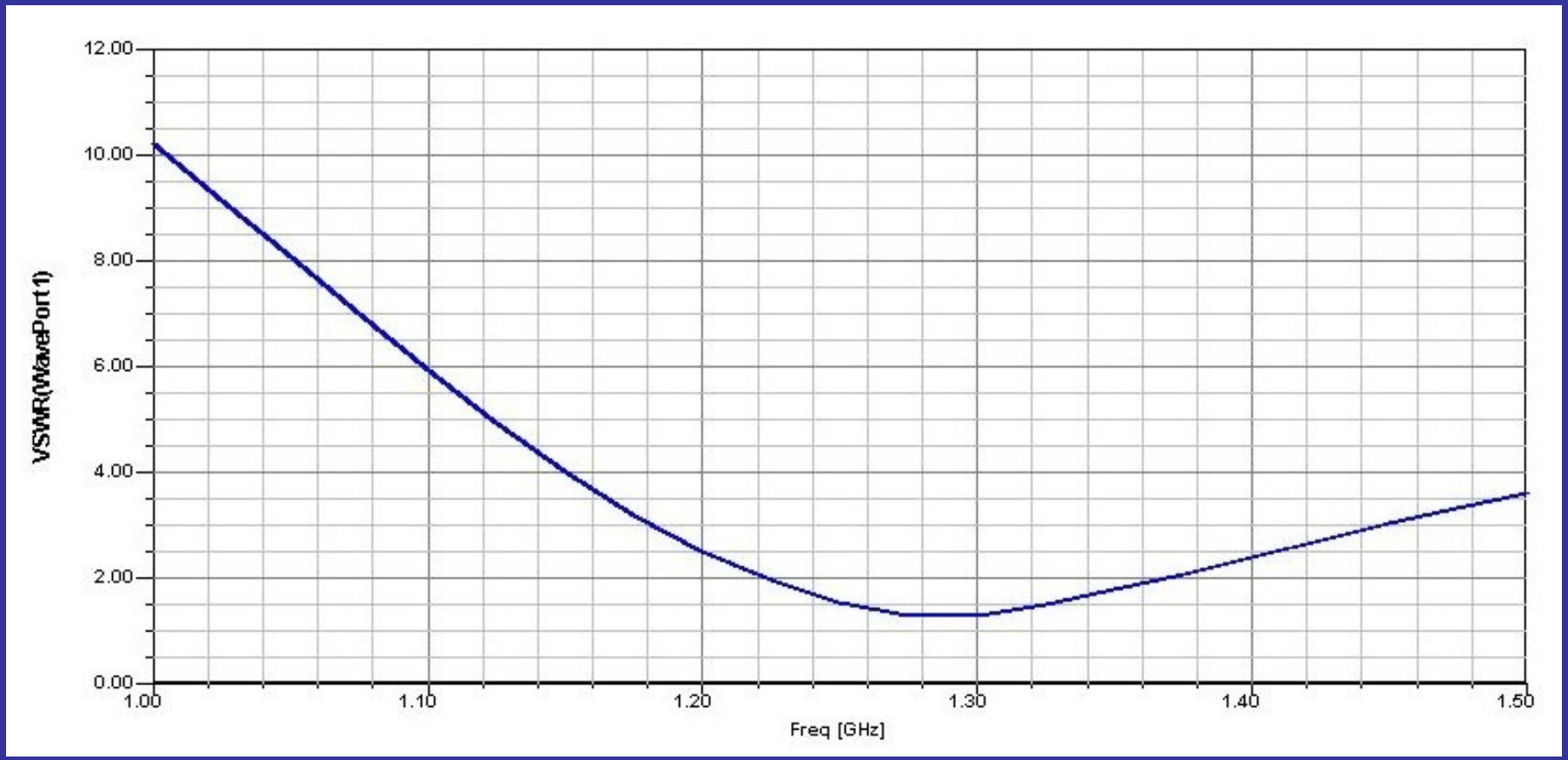
Antennas

- **Microwave**
  - High Gain
  - Large –
    - many λ
- **HF**
  - Low Gain
  - Small
    - ½ λ
    - Dipole
    - vertical

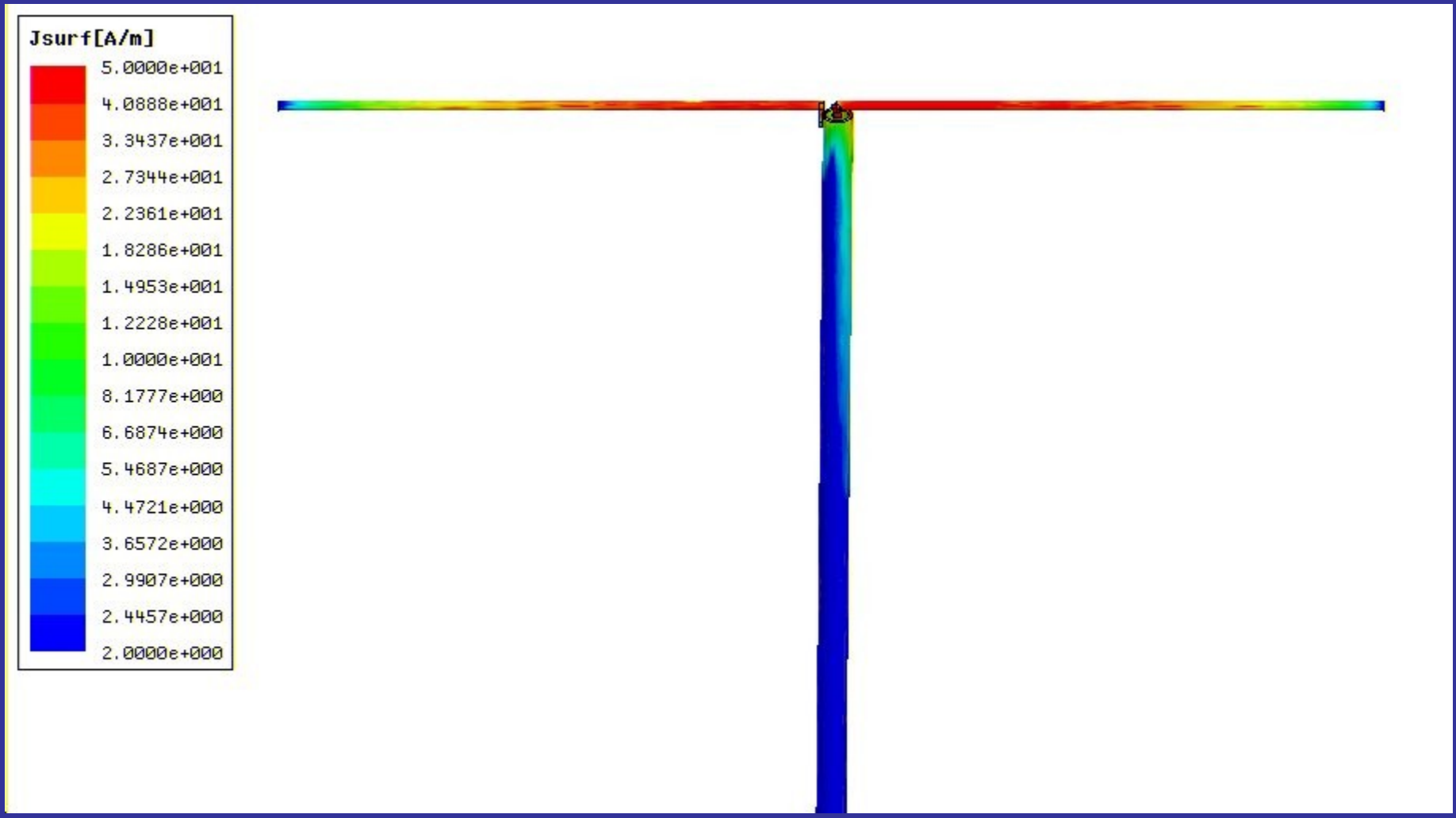
Half-wave Dipole



Half-wave dipole - VSWR



Half-wave dipole - currents



Gain?

- From Mt. Wachusett, my 10 GHz signal was 74 dB above noise to WA1MBA (S9+)
- My antenna gain = 33 dBi
- His antenna gain = 34 dBi
- Total antenna gain = 67 dB
- With dipoles, only 7 dB above noise
  - (weak CW)

What is antenna gain?

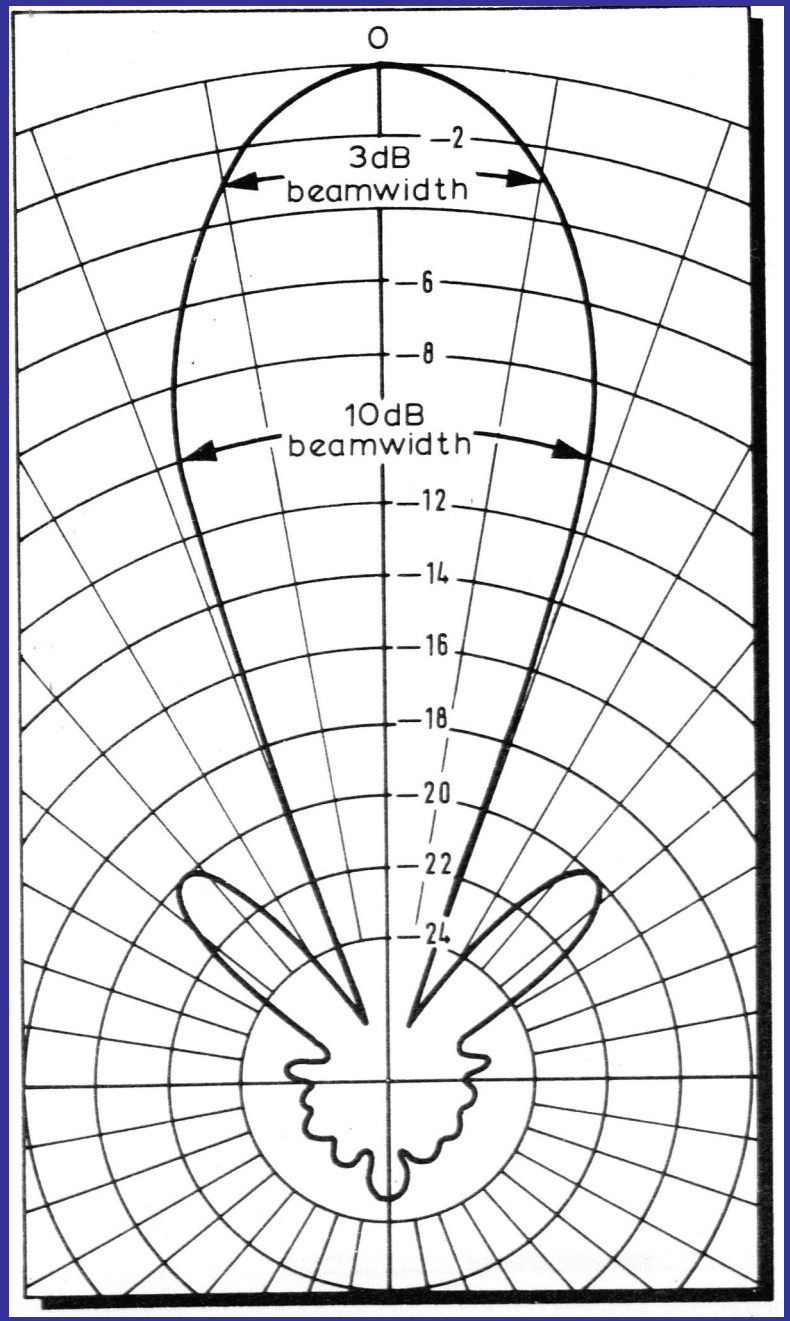
- Antenna gain is directing energy in desired direction
- Same total energy radiated
- More in one direction means less in another
  - Must point antenna at other station
- Higher gain = narrower beam

What does gain do for us?

- More signal (in desired direction)

  = *more distance*

- DX = rare, unusual, difficult contacts
- **More fun!**



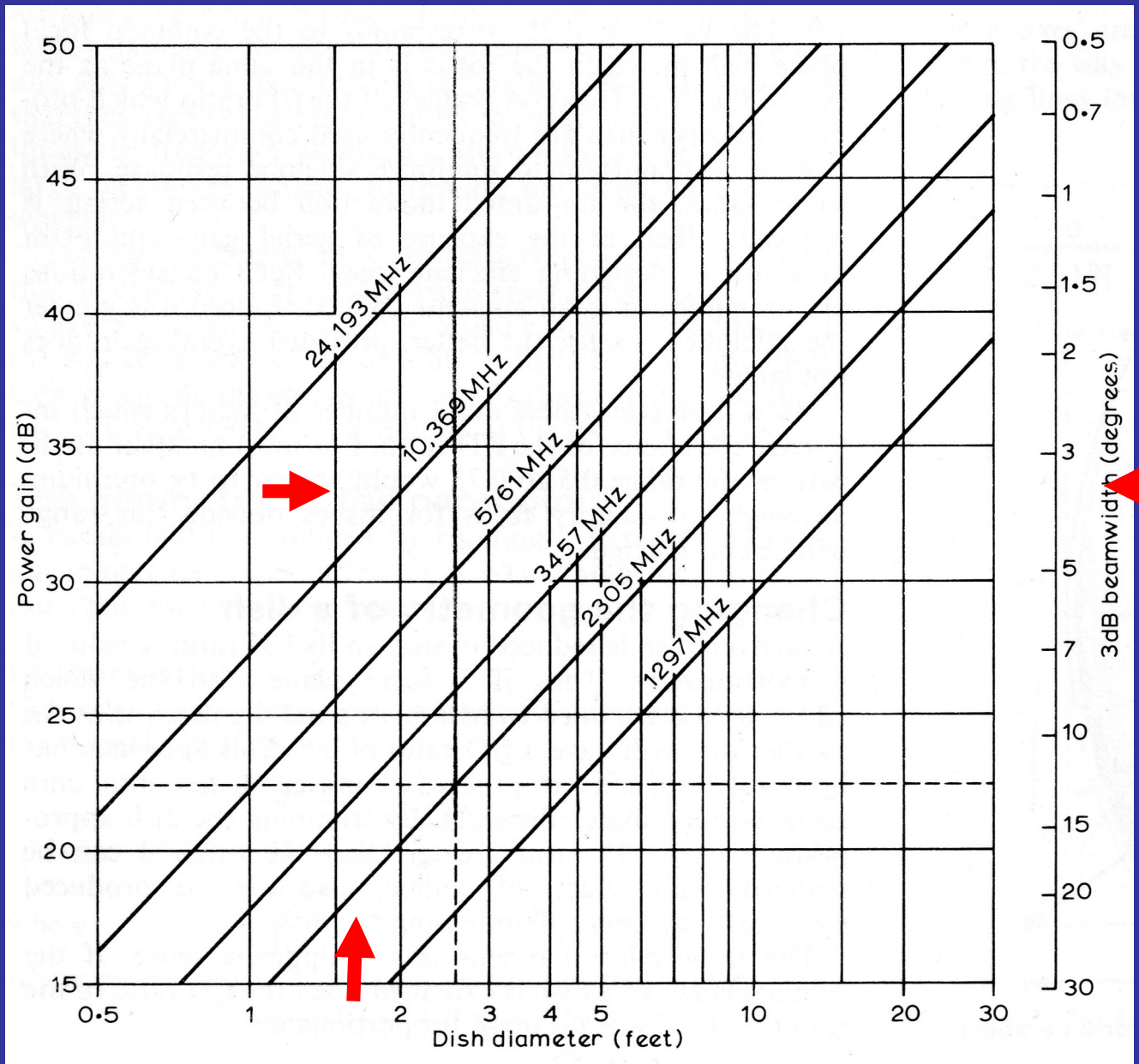
Radiation pattern of an antenna

The "Beamwidth" normally refers to the width at the ½ power points (3 dB)

Gain in dBi

- dB over an isotropic antenna
- = theoretical antenna which radiates uniformly in all directions
- Dipole has 2.14 dBi gain
- Rubber ducky does not have gain
- Different than advertising dB!

Antenna characteristics at microwave frequencies



How do we get gain?

- Make antenna bigger!
- Gain is proportional to **Aperture** area
- **Aperture** is "capture area" -- electrical size

$$Gain = 10\log\left(\eta\frac{4\pi}{\lambda^2}\mathrm{A}\right) \quad \mathrm{dBi}$$

What's a dB worth?

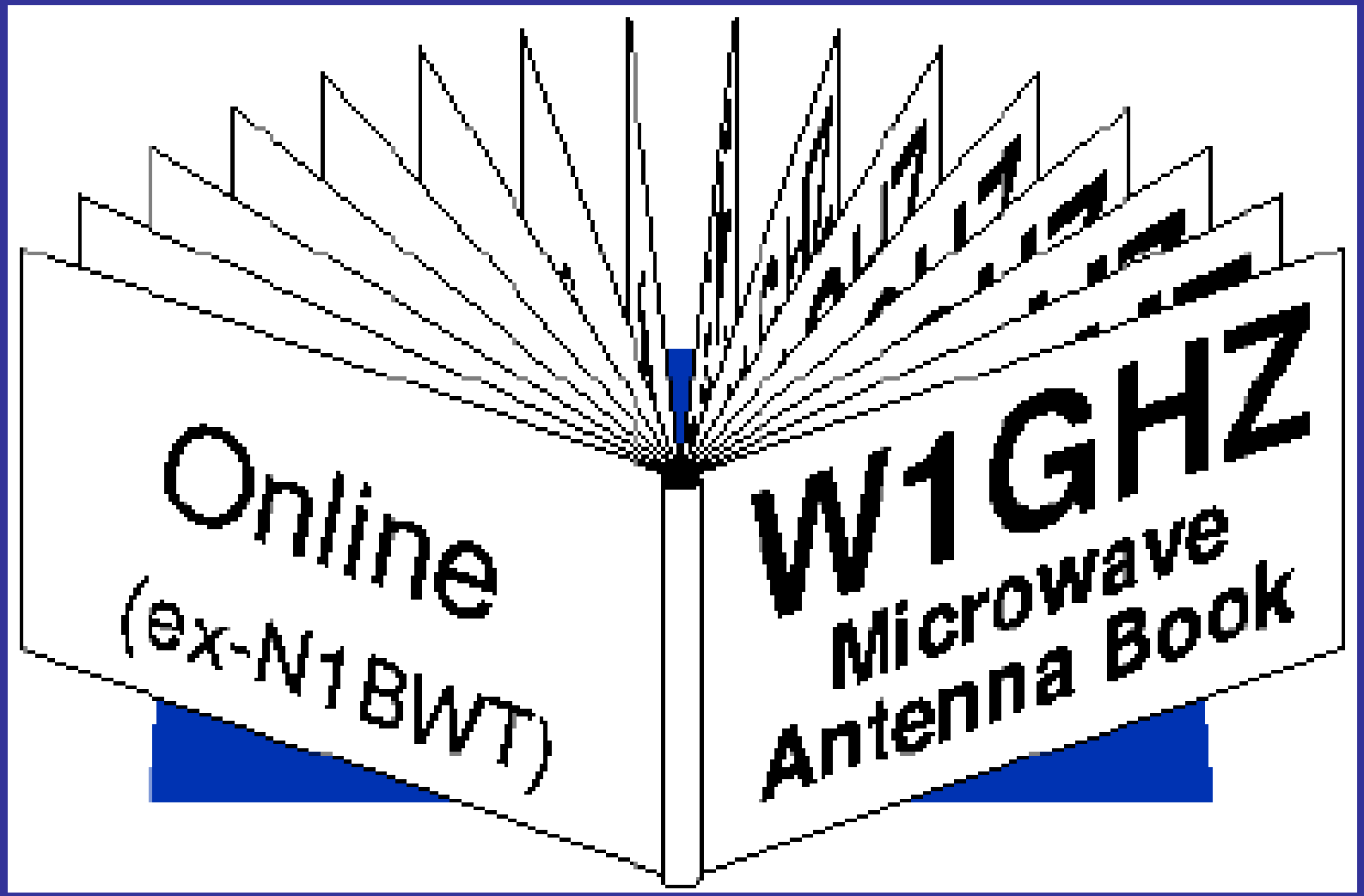
- Inverse-square law:
  Doubling distance loses 6 dB

- Every dB increases range!
- CW has more range

Size matters!

Antenna Performance =

Gain x efficiency



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W1GHZ Microwave Antenna Book *Online*

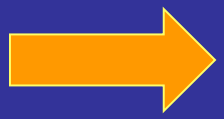
- Describe microwave antennas
- Visual – pictures for enhanced understanding
- Explanations, not just cookbook
- Computer for complex math
  - *Programs and spreadsheets*

FREE

Common Microwave Antennas

- Horn -- 10 to 25 dB gain
- Lens -- 15 to 30 dB gain
- Dish -- 20 dB gain and up
- Offset dish -- 20 dB gain and up
- Helix -- 8 to 15 dB gain
- Slot -- 0 to 20 dB gain (omnidirectional)
- Loop Yagi – 10 to 20 dB gain

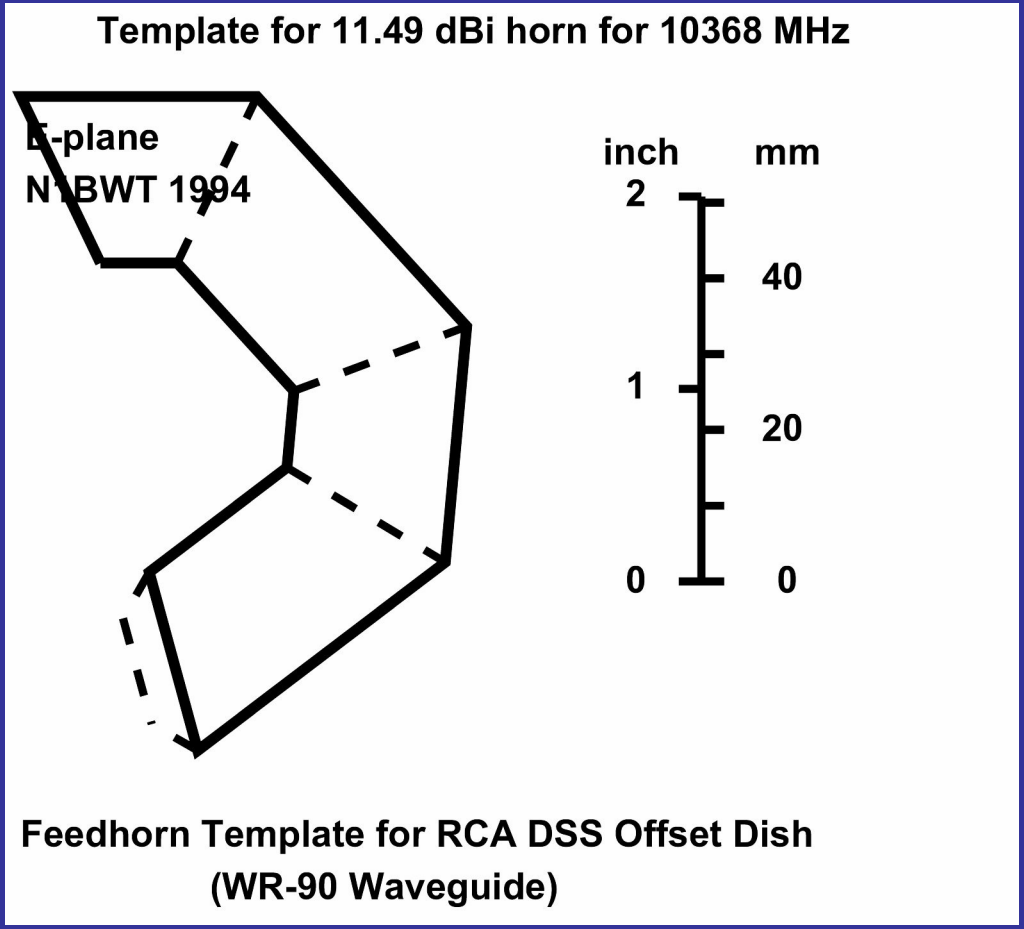
Horn Antennas

- Funnel – round or rectangular
- Easy to build, always works
- Gain  Aperture size
- Wide flare reduces gain, so large horns are very long
- High Gain = lots of metal
- Good for moderate gain (15-20 dBi)

Horn Antennas

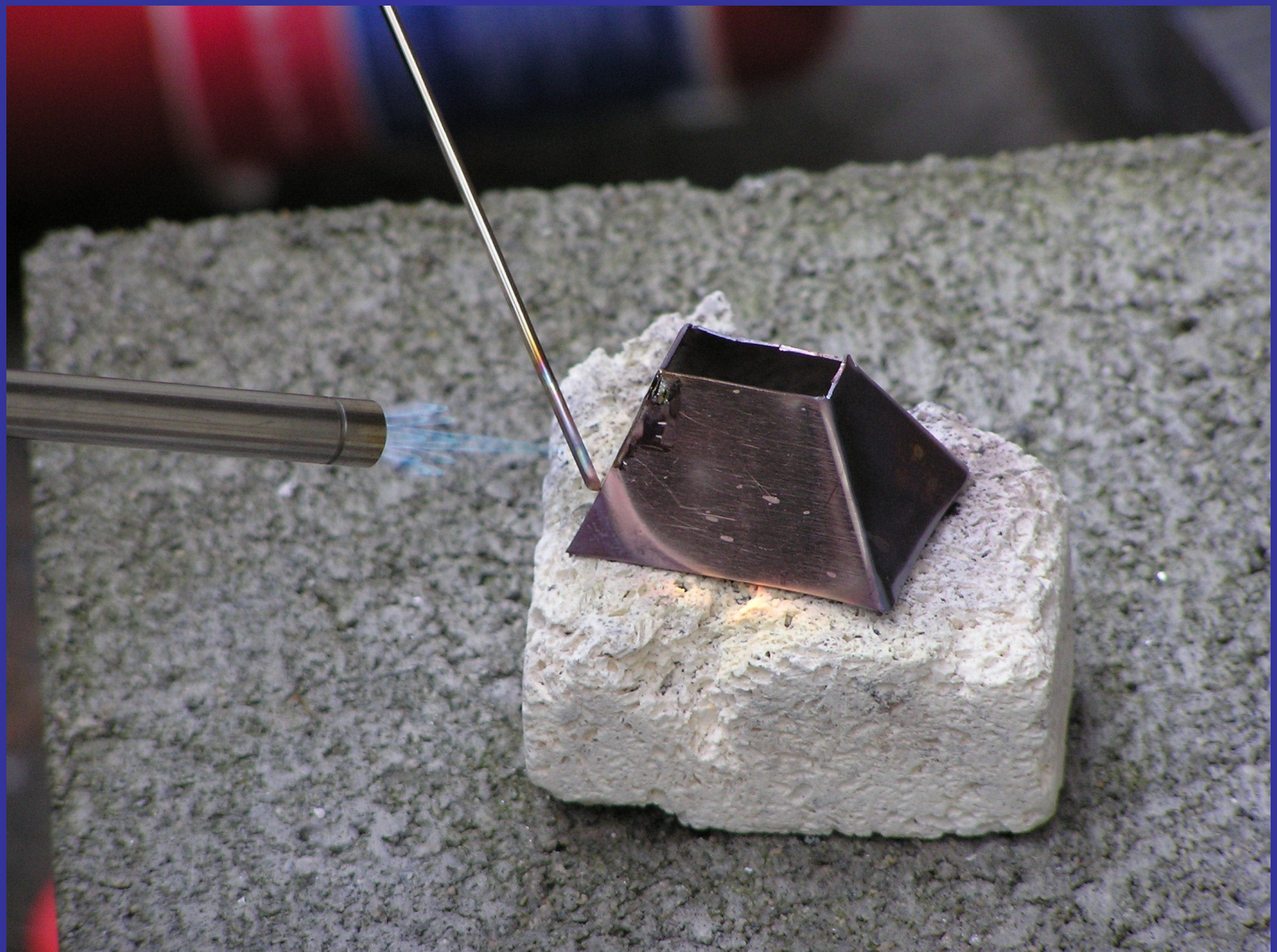
Rectangular Horns

Rectangular Horn Template

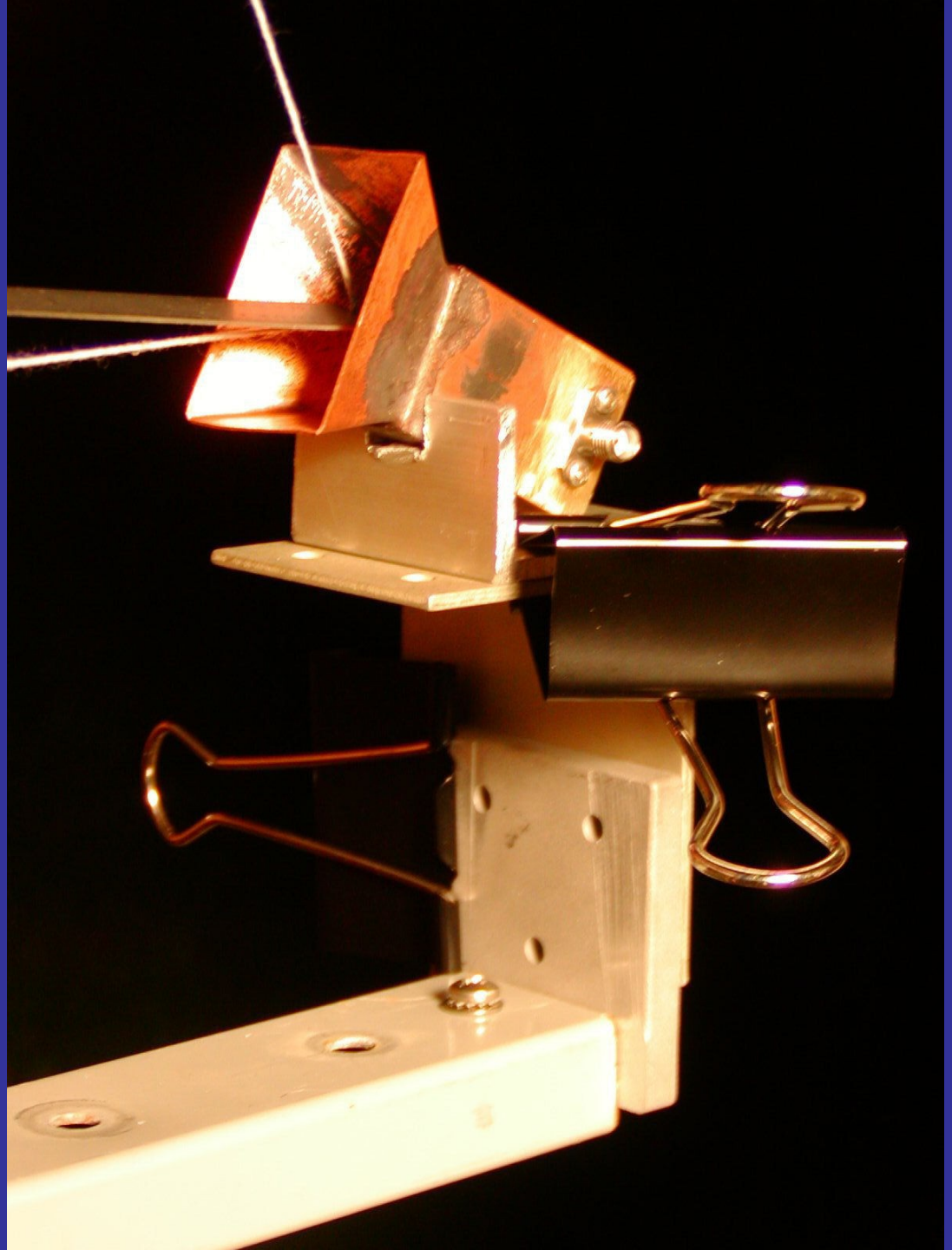


Cut it out, bend it up

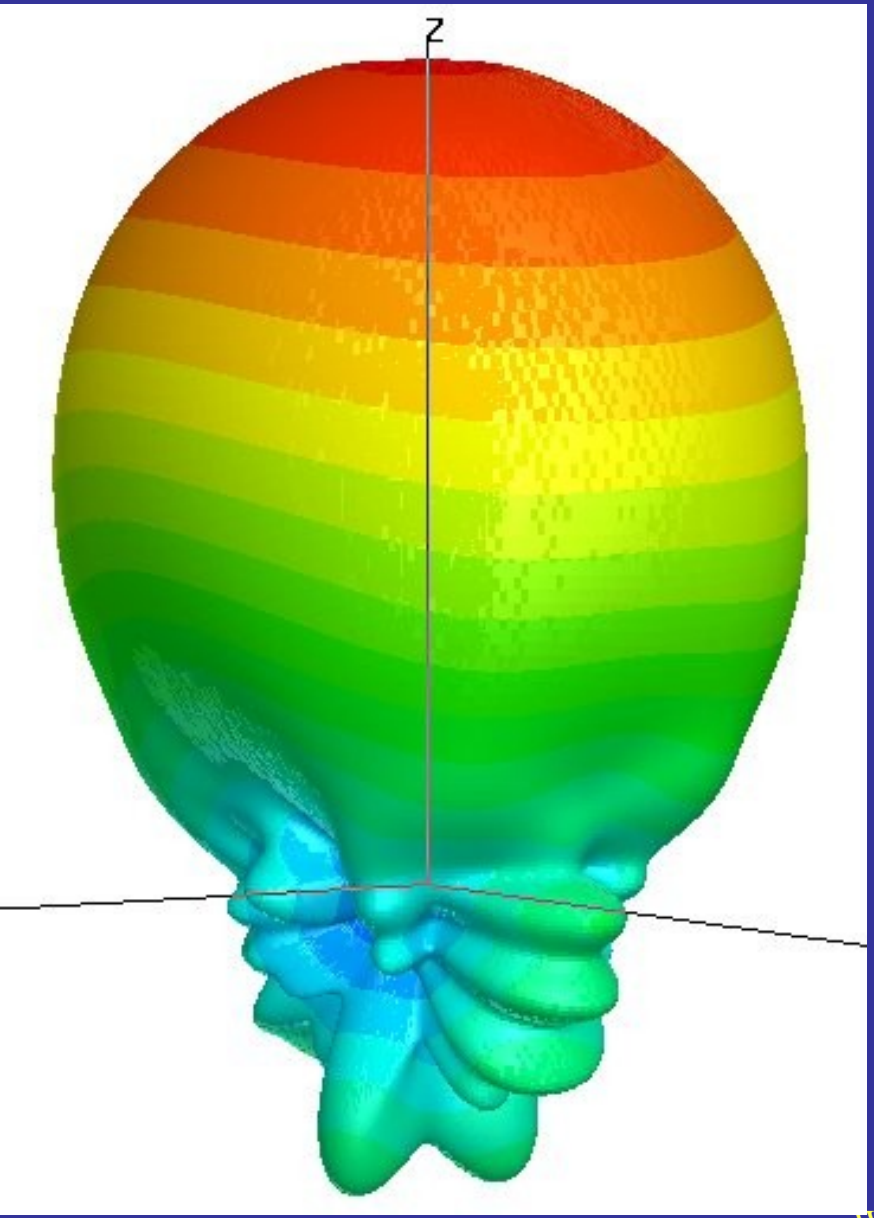
Solder it up



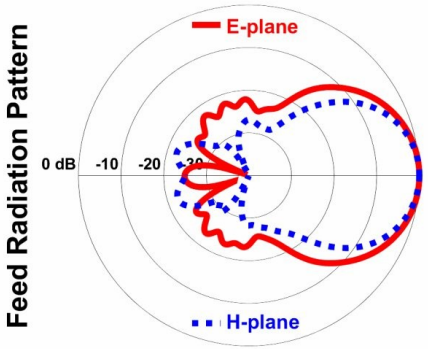
Get it right at the Phase Center of the Dish

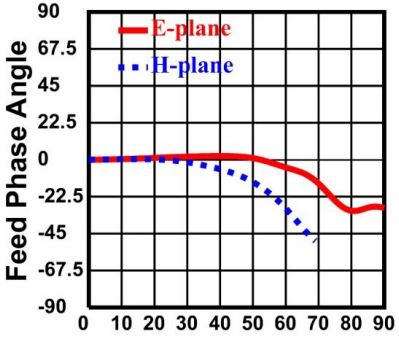


DSS rect. horn

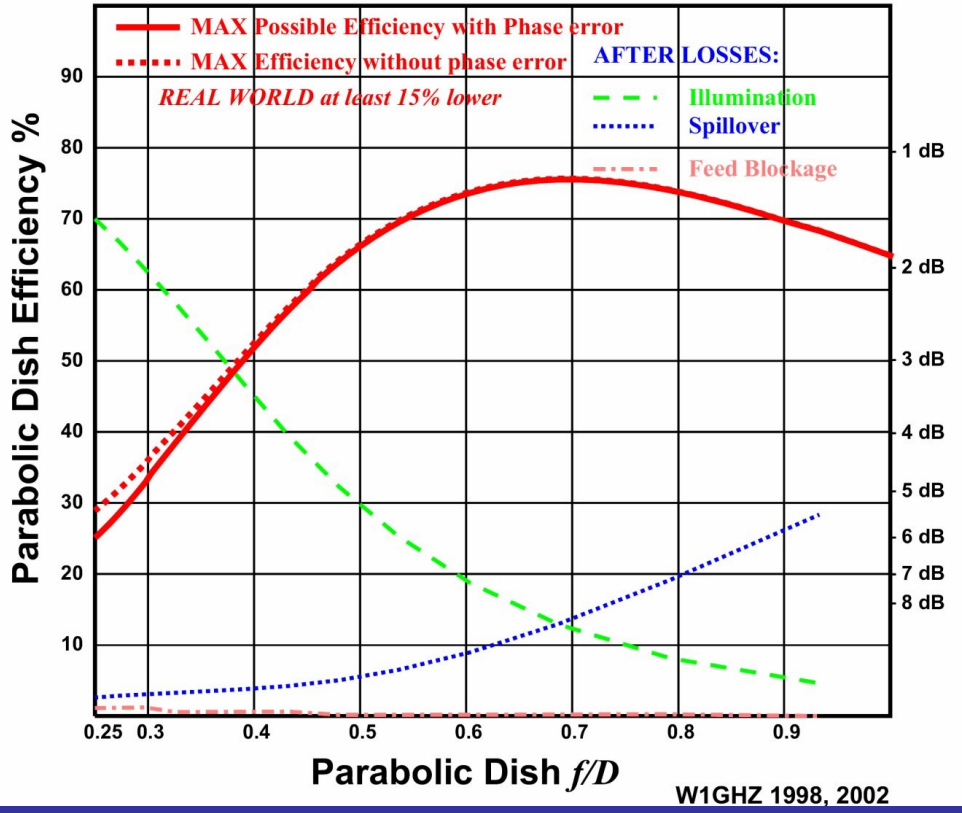


WR-90 rectangular feedhorn for DSS dish, by HFSS





Dish diameter = 15.8 λ Feed diameter = 0.5 λ



Conical Horn

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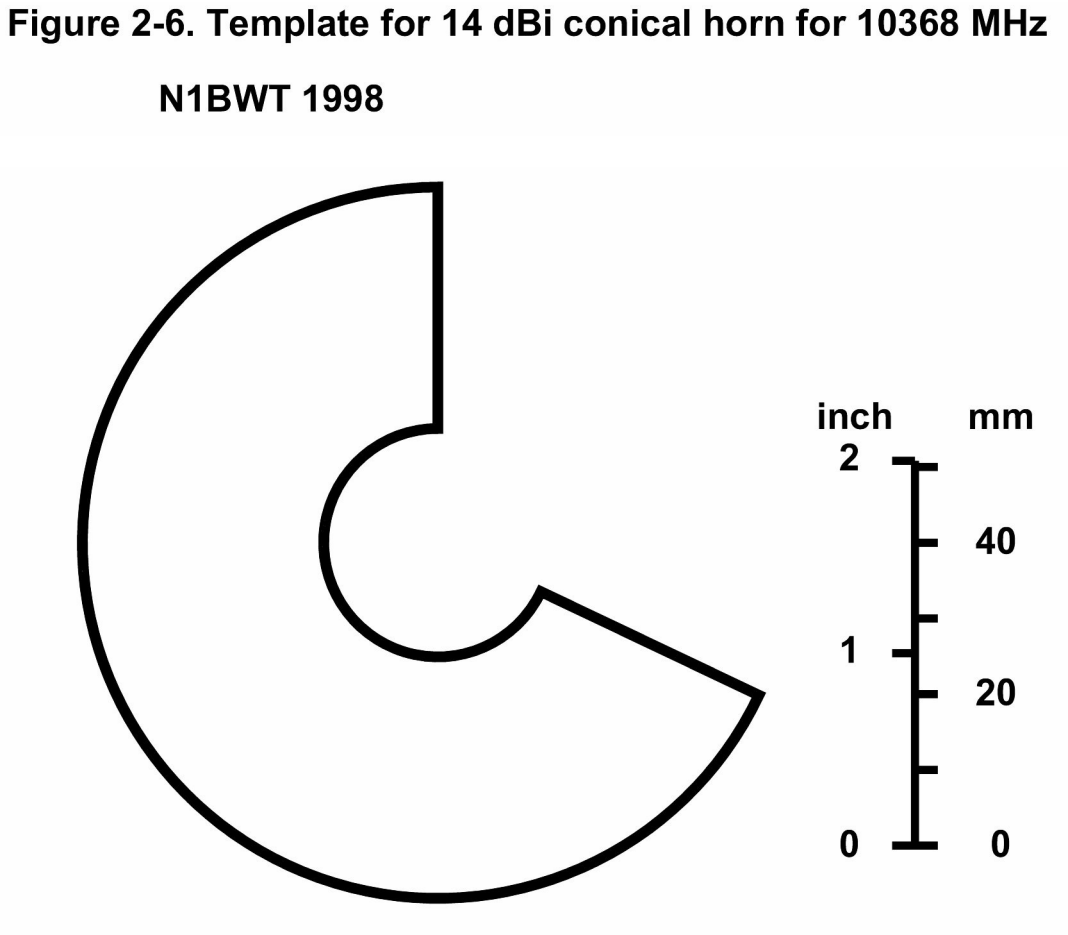
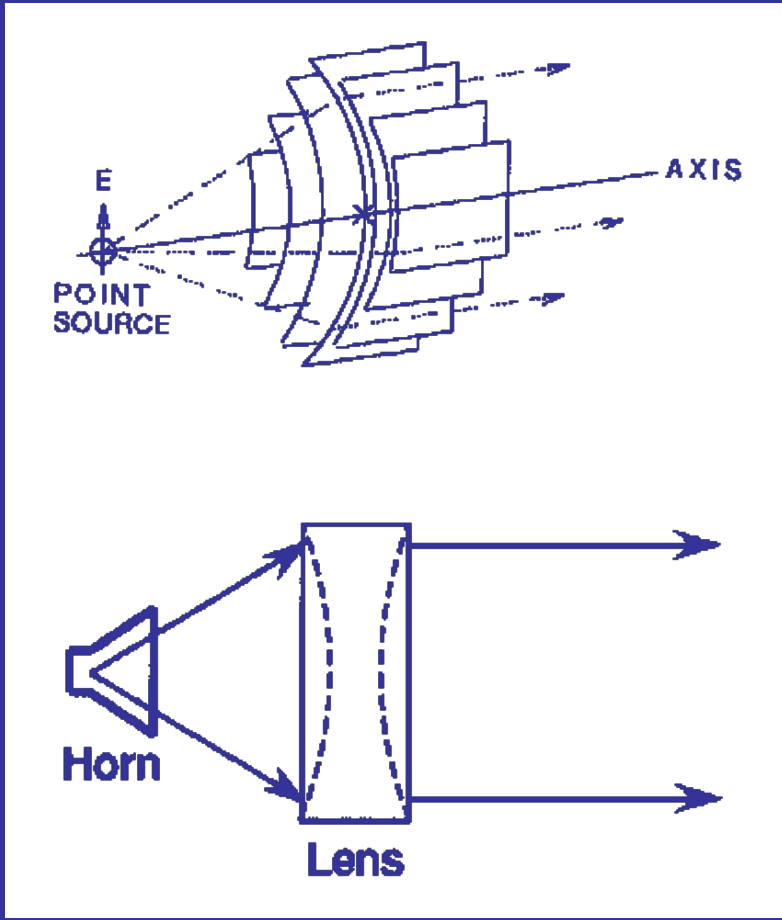
Conical Horn Template



Lens Antenna

- Lens focuses energy into tighter beam
- Lens can be dielectric (plastic, wax) or artificial dielectric (metal strips)
- Gain  Aperture size
- Lens in front of horn can be very long

Metal-Plate Lens Antenna



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Lens amplifies Horn

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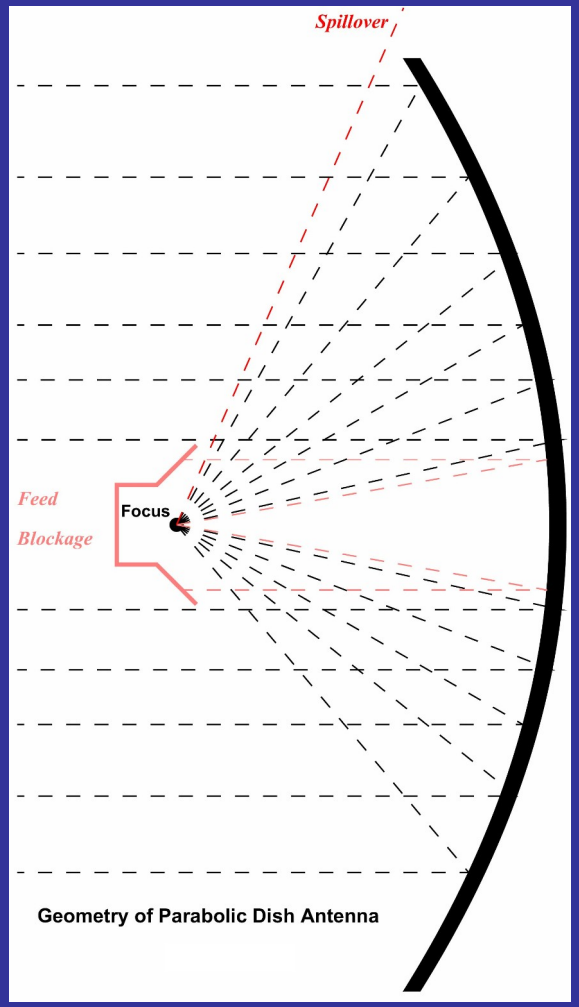
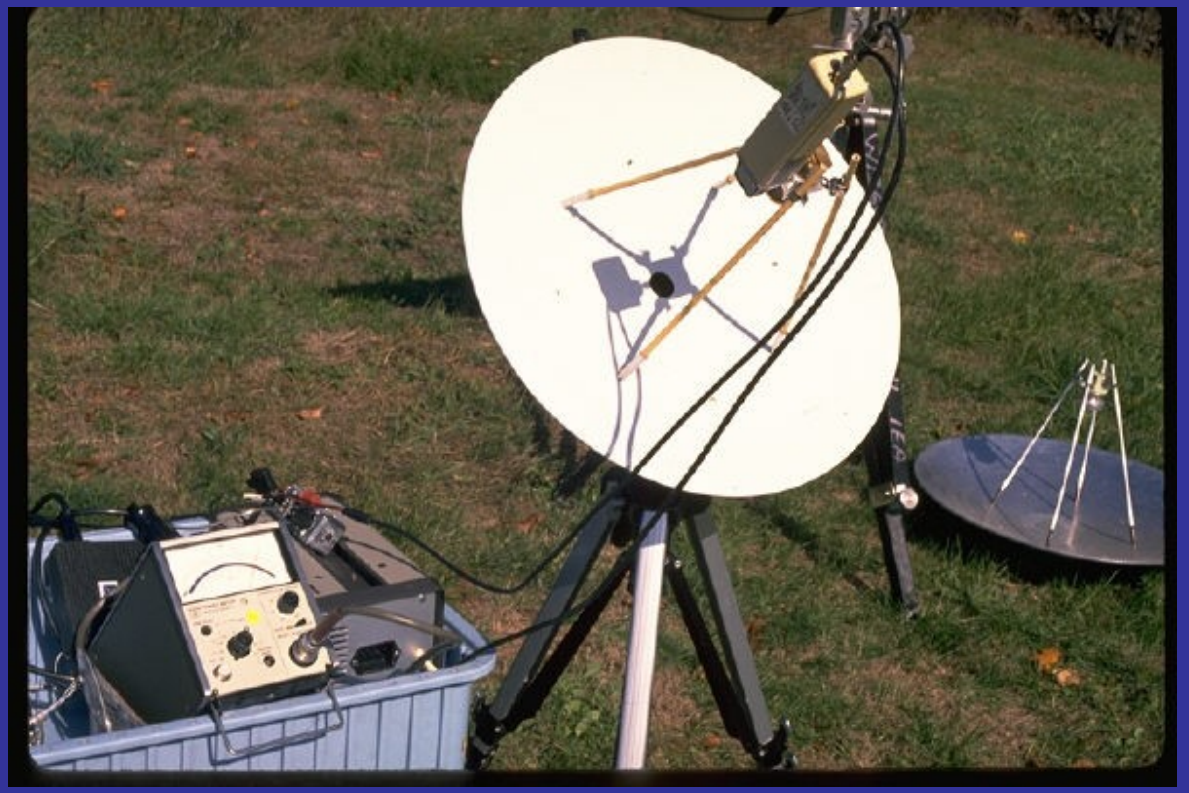
Parabolic Dish Antenna

- Parabolic shape = Reflecting Lens
- Feed at focus – shadow
- Larger works better: > 10λ diameter for good efficiency
- High gain: > 30 dBi

Parabolic Dish Antenna





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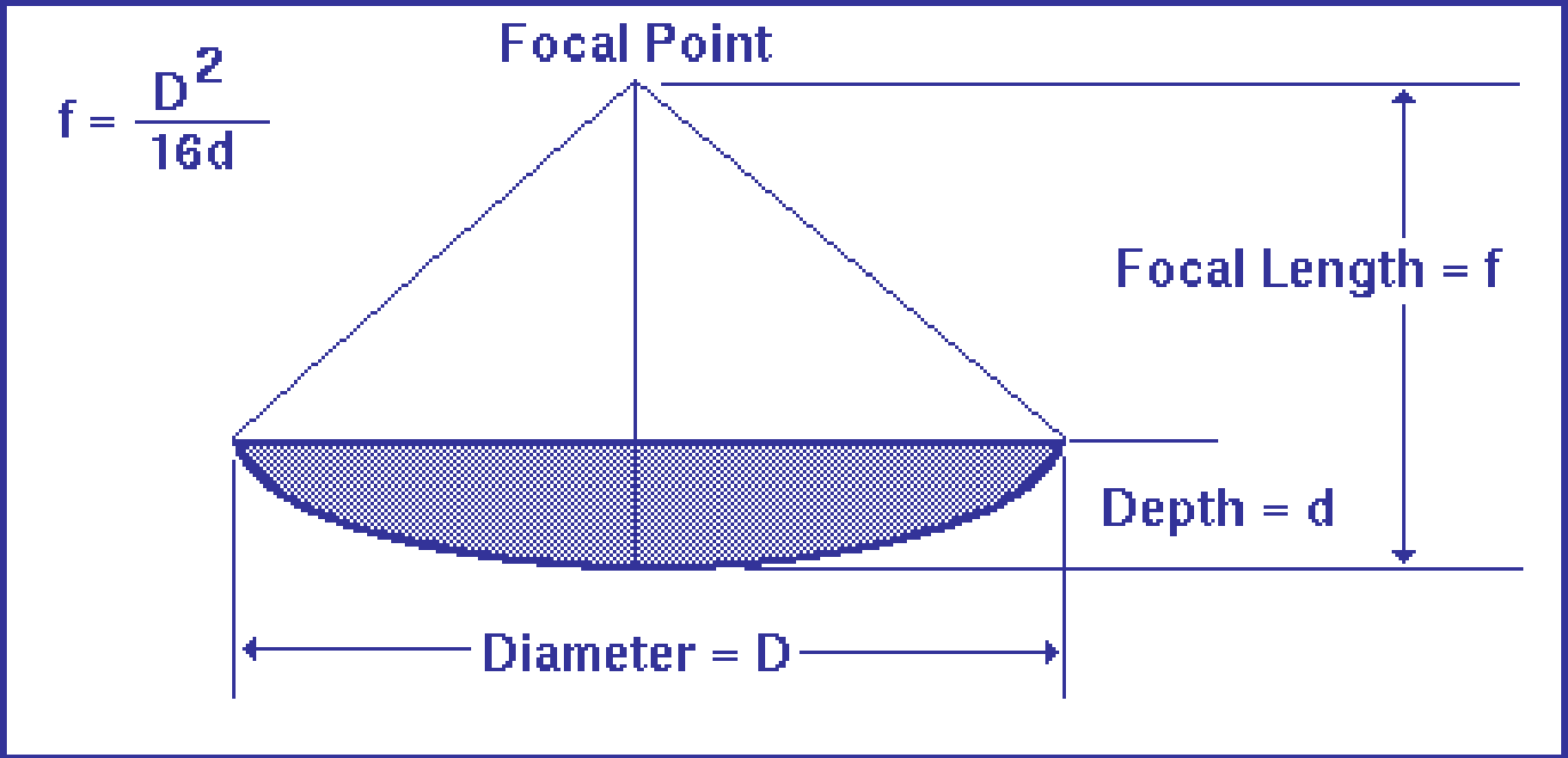
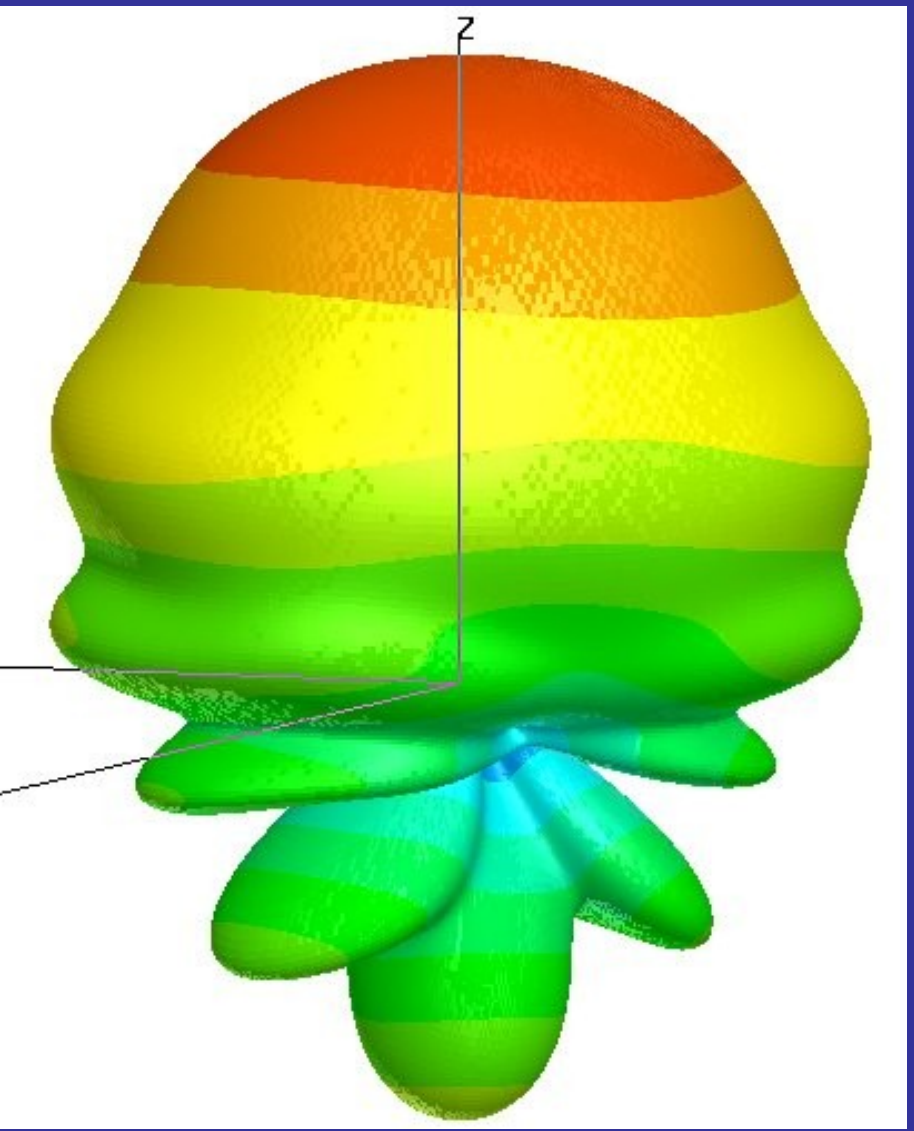
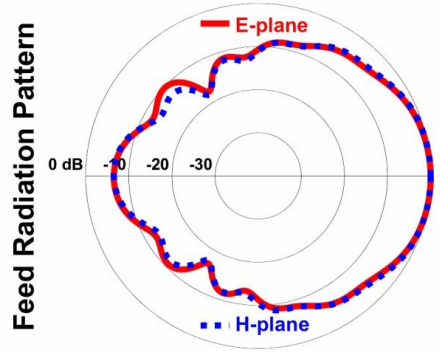
Dish Geometry

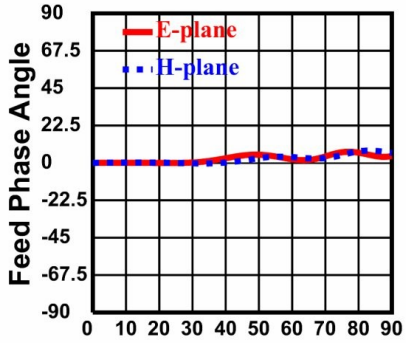


Coffee can feed

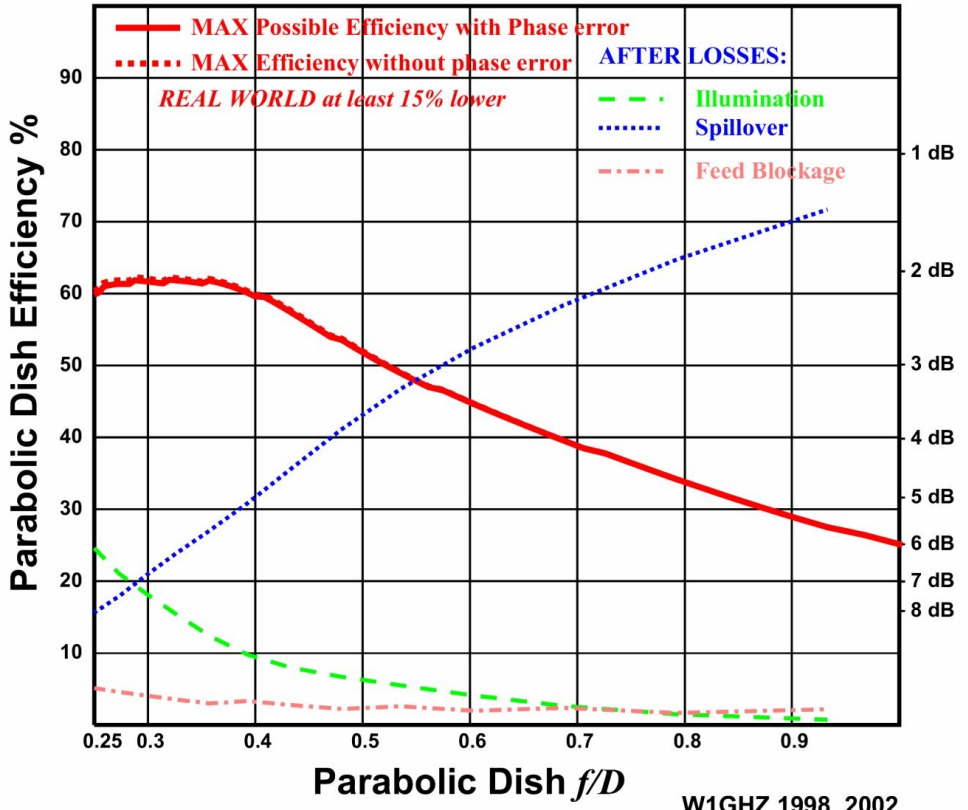


Coffee can feed 0.6l dia, waveguide source, by HFSS





Dish diameter = 10 λ Feed diameter = 1 λ



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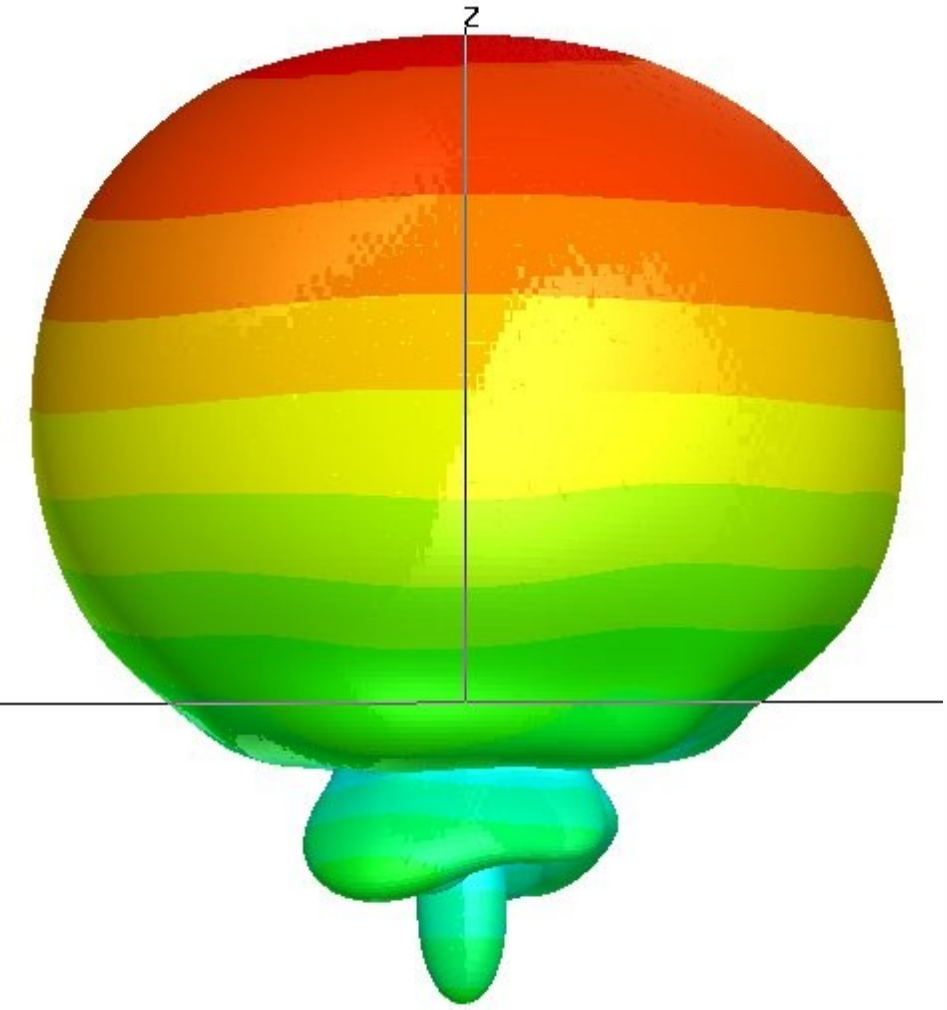
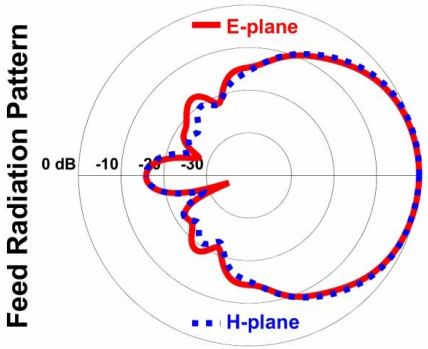
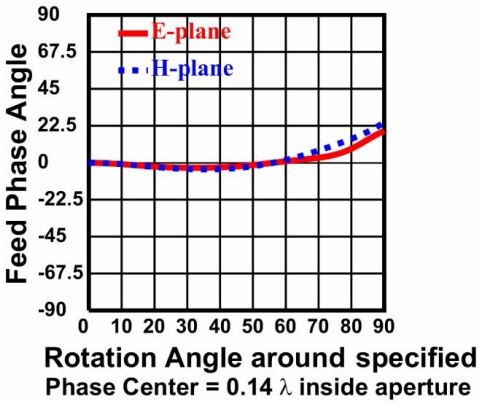
VE4MA feed

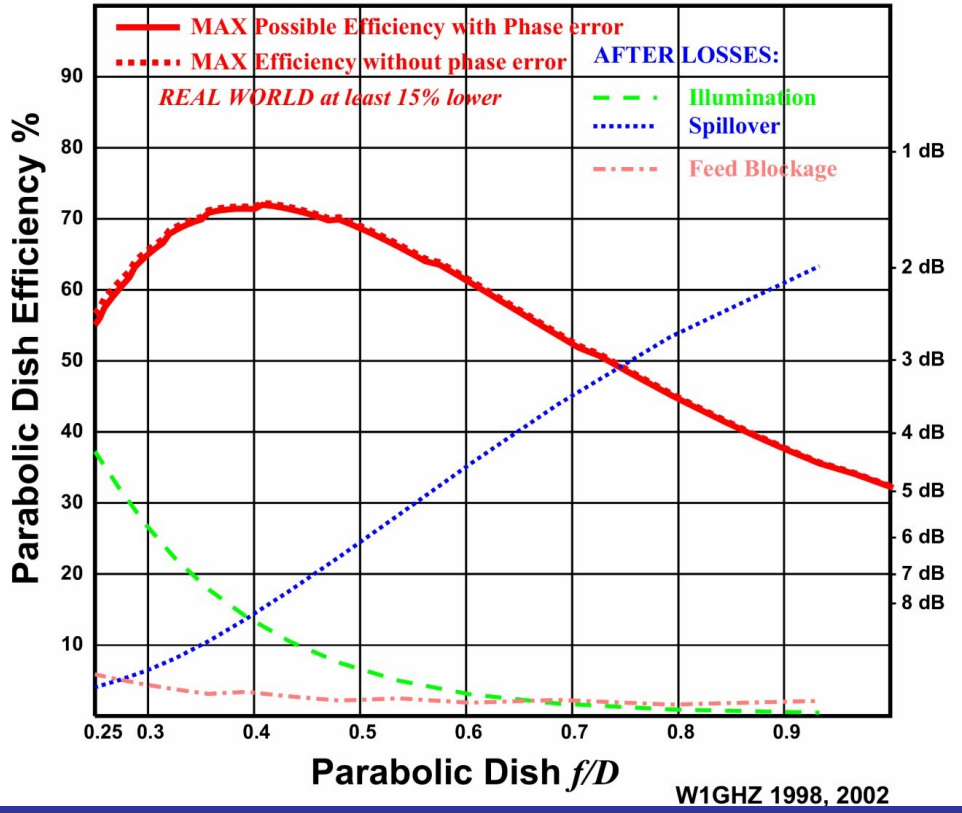


VE4MA 10 GHz feed, choke flush, wg excitation,by HFSS

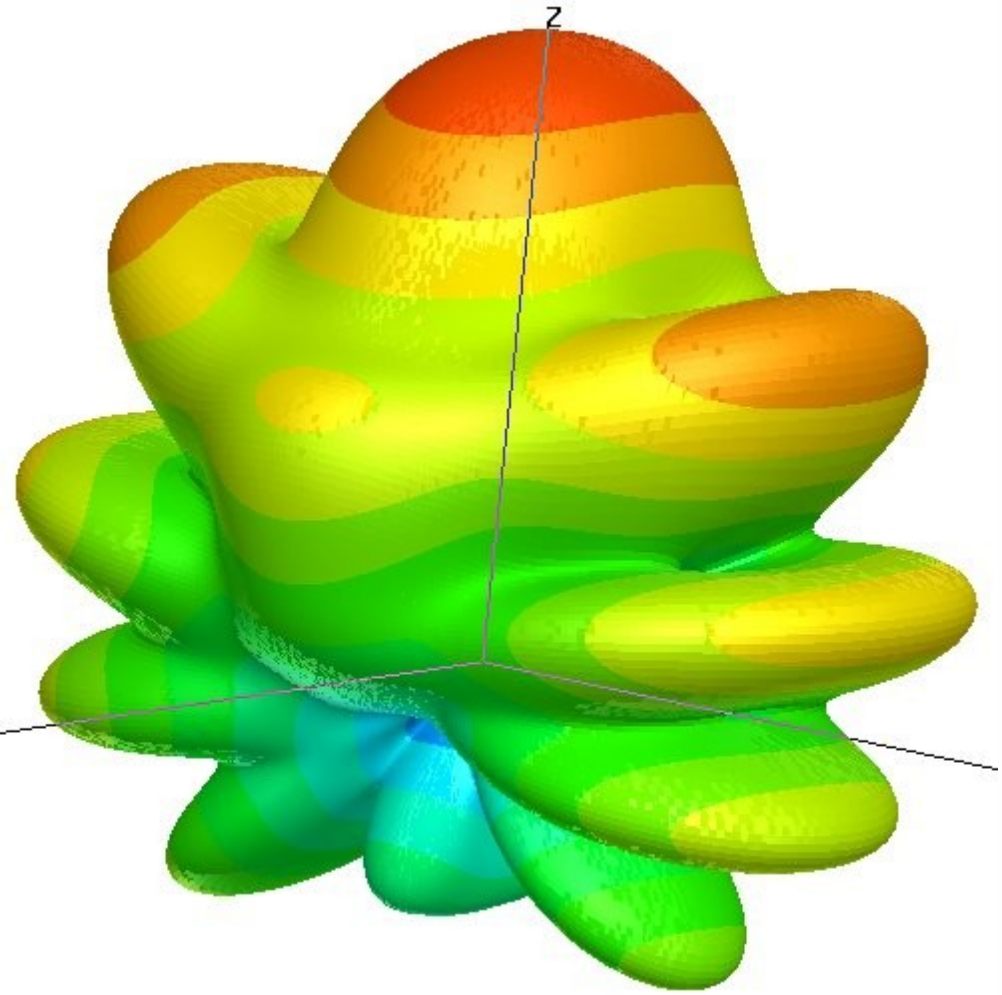


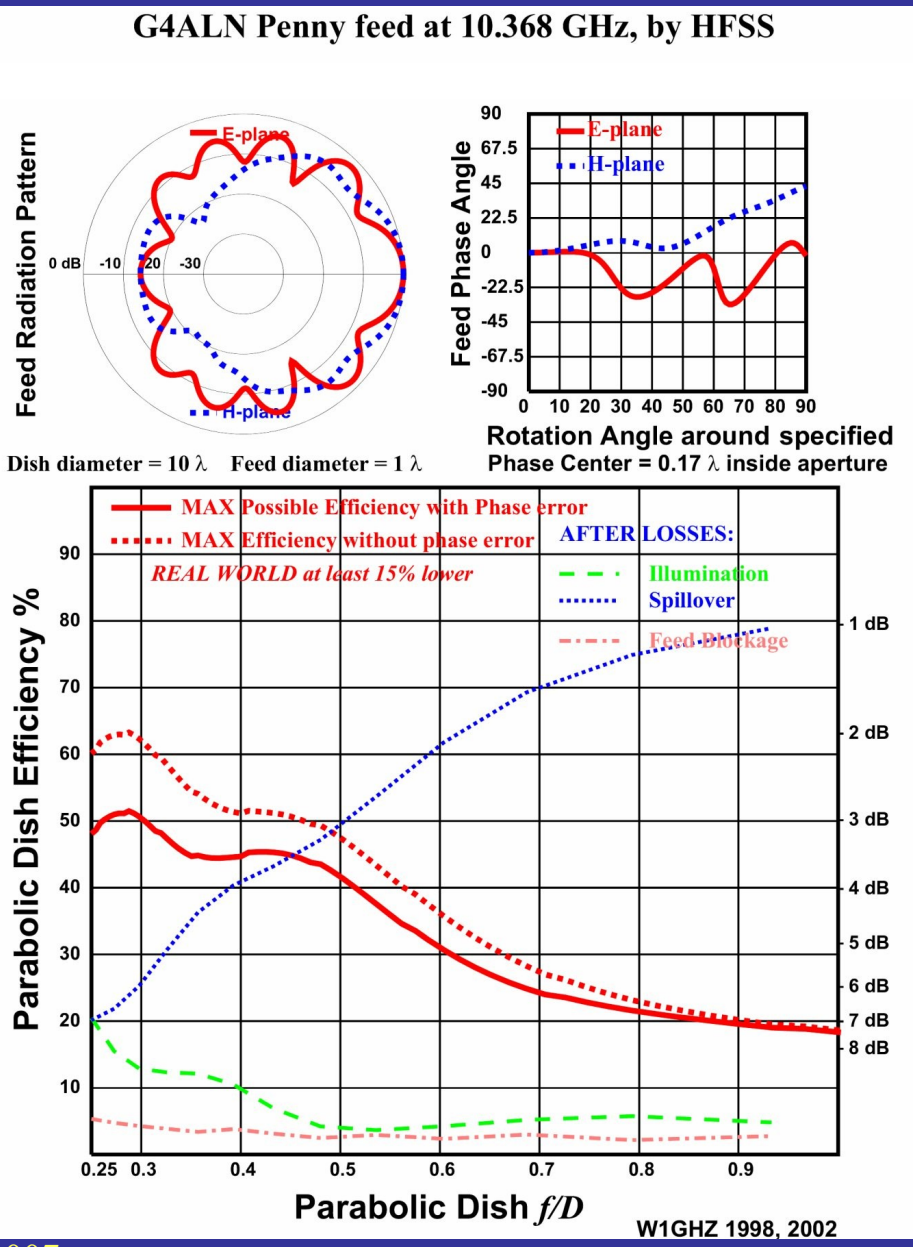


Dish diameter = 10 λ Feed diameter = 1 λ



Penny Feed

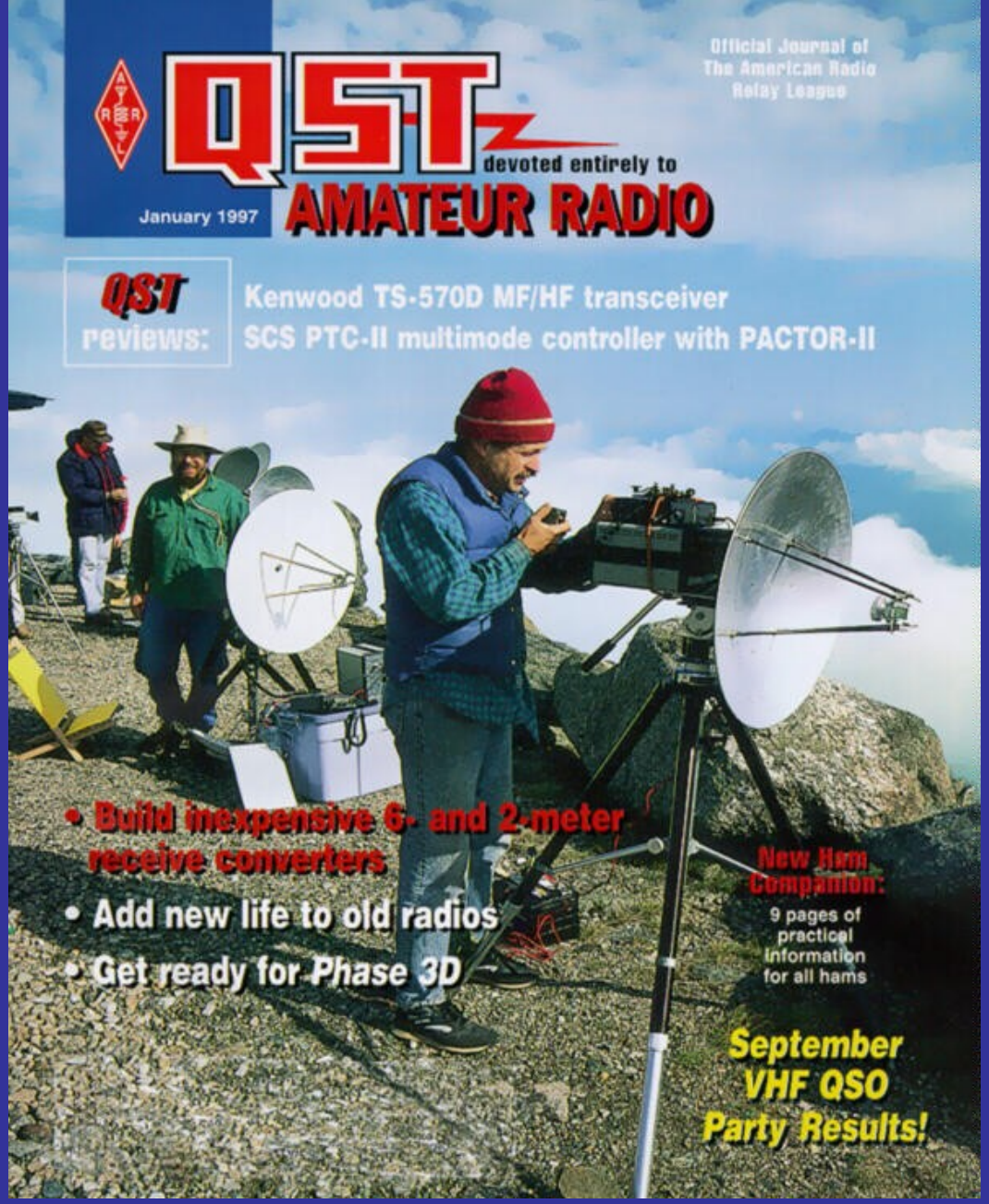

Z


G4ALN Penny feed at 10.368 GHz, by HFSS
Feed Radiation Pattern
E-plane
H-plane
0 dB
-10
-20
-30
Feed Phase Angle
90
67.5
45
22.5
0
-22.5
-45
-67.5
-90
0 10 20 30 40 50 60 70 80 90
Rotation Angle around specified
Phase Center = 0.17 λ inside aperture
Dish diameter = 10 λ
Feed diameter = 1 λ
MAX Possible Efficiency with Phase error
MAX Efficiency without phase error
REAL WORLD at least 15% lower
AFTER LOSSES:
Illumination
Spillover
Feed Blockage
Parabolic Dish Efficiency %
90
80
70
60
50
40
30
20
10
1 dB
2 dB
3 dB
4 dB
5 dB
6 dB
7 dB
8 dB
0.25 0.3 0.4 0.5 0.6 0.7 0.8 0.9
Parabolic Dish f/D
W1GHZ 1998, 2002

Small dishes for Rover

Small Dishes for Rovers

This is Mt. Washington



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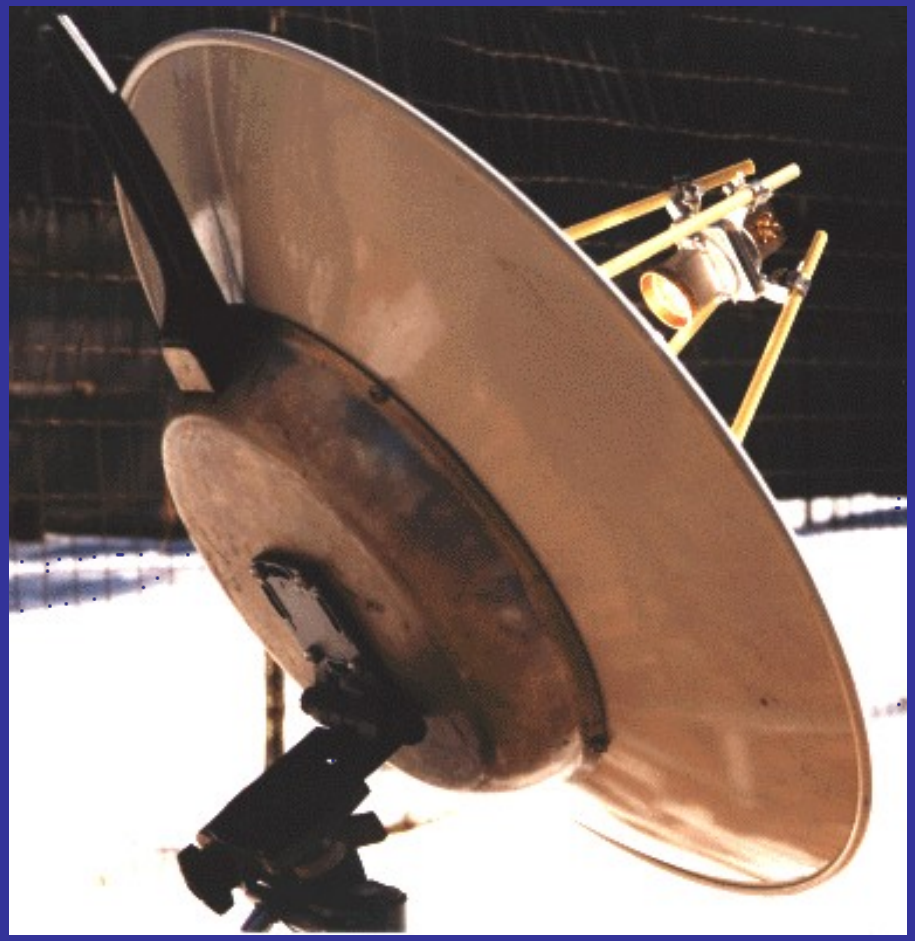
Mt. Washington - normal!

Small dish



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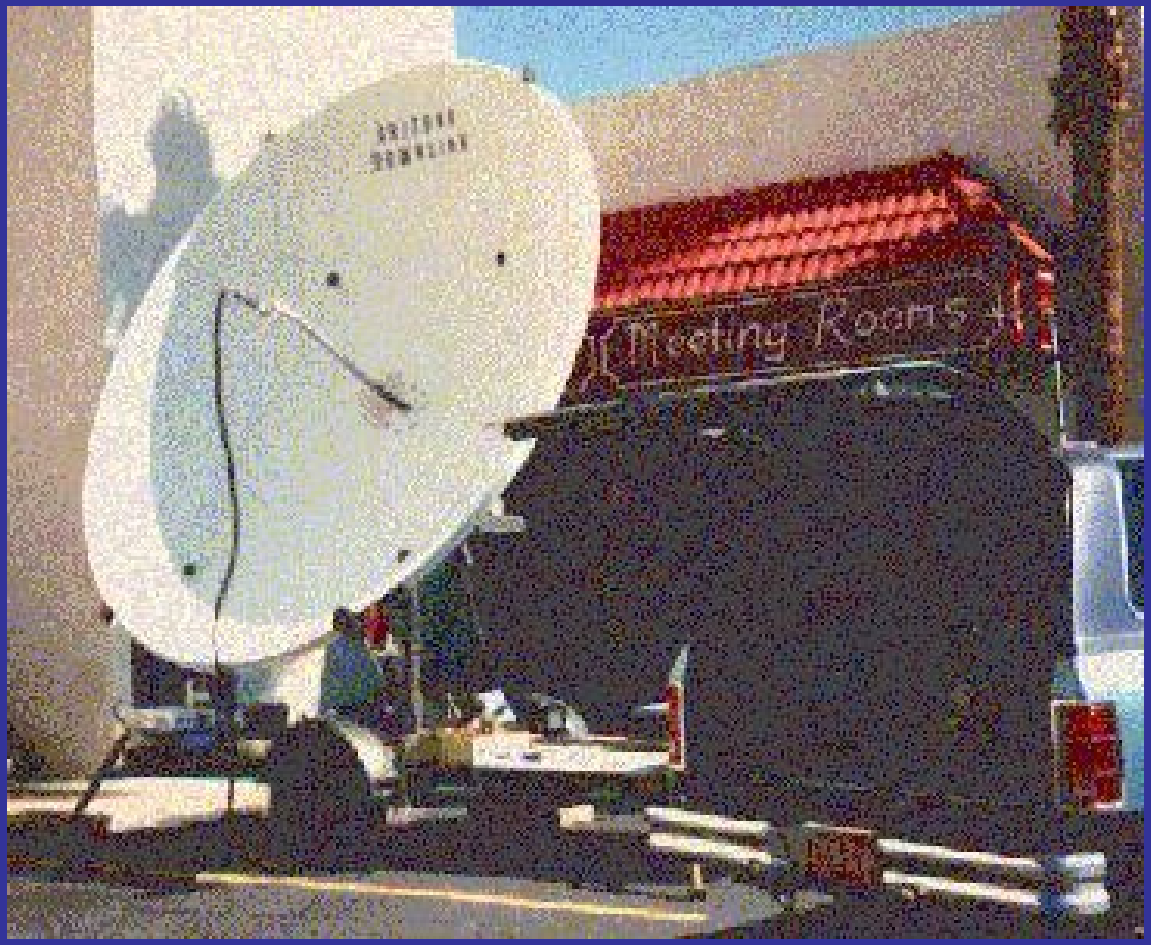
Large Dish for EME



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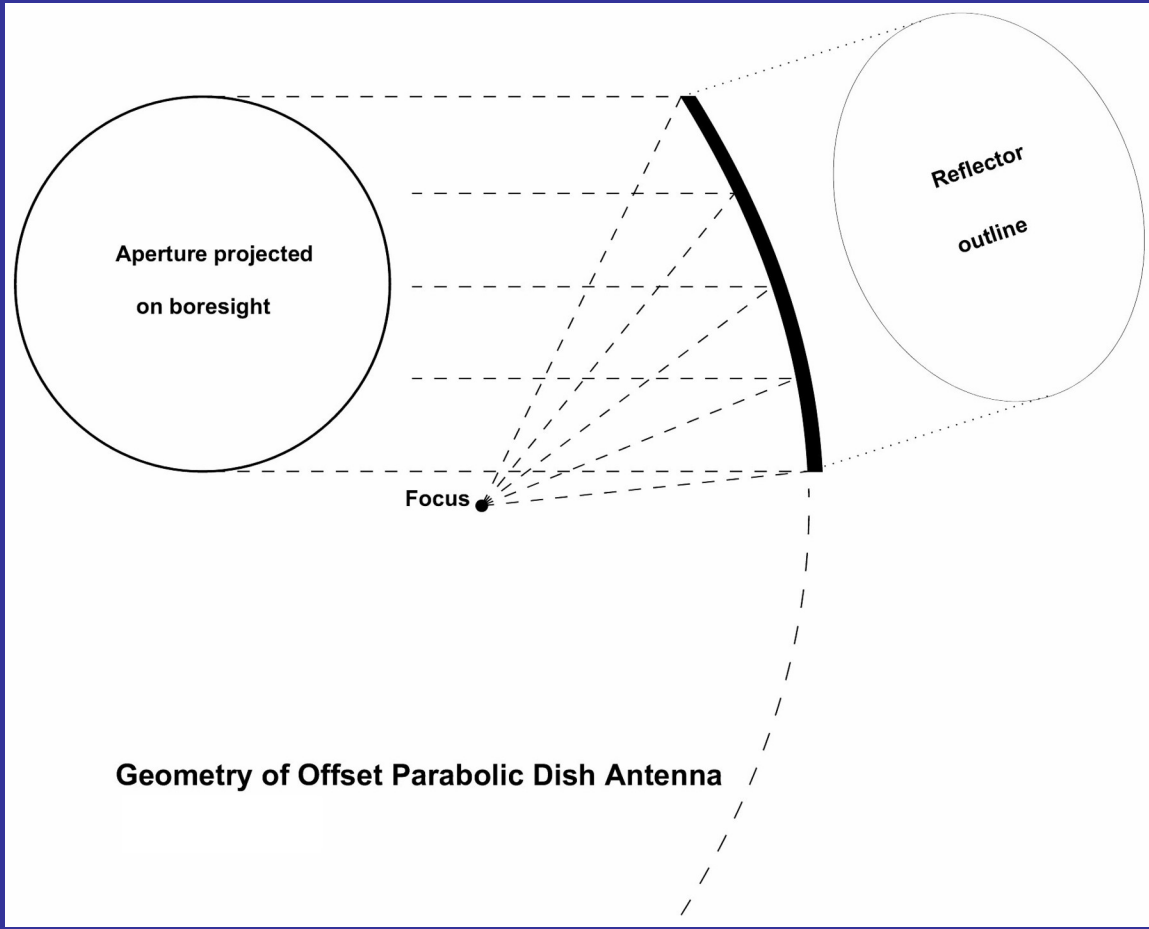
REALLY big dish

Offset Dish

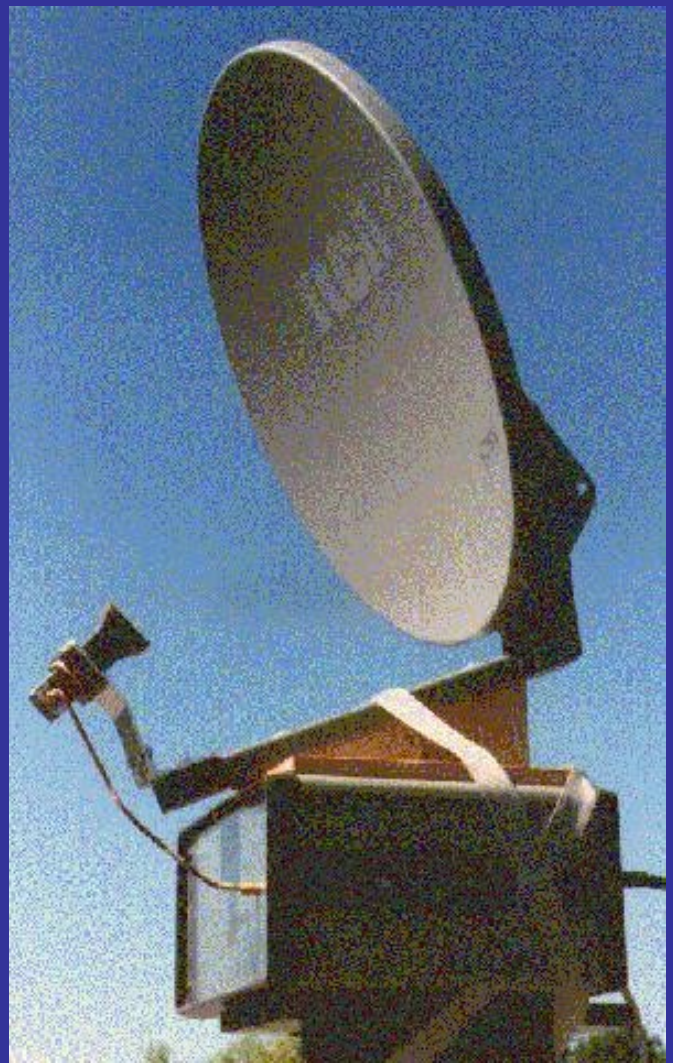
- DSS dish
- Dish is section of full parabola
- No shadow from feed
- DSS dish works great at 10 GHz

Offset Dish


Aperture projected
on boresight
Reflector
outline
Focus
Geometry of Offset Parabolic Dish Antenna

DSS offset dish

Feedhorn



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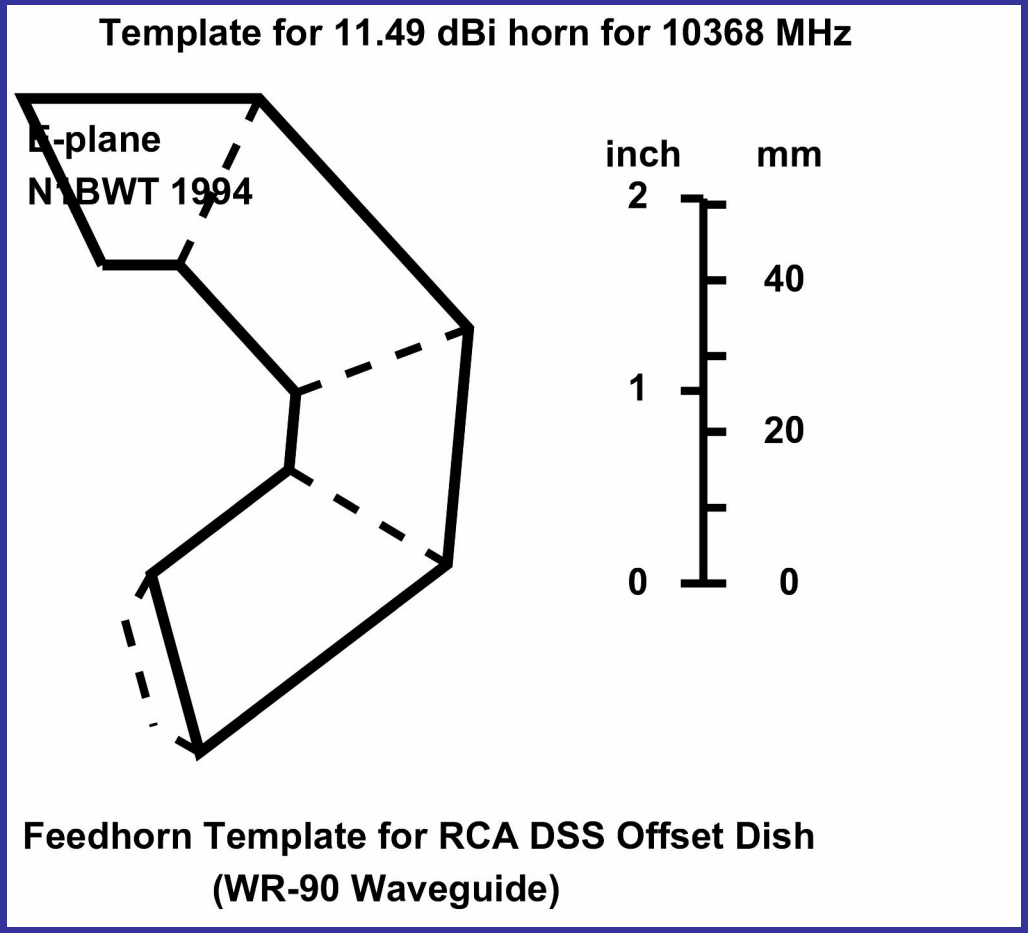
Template for DSS Feedhorn



Aligning the feedhorn

Primestar offset dish

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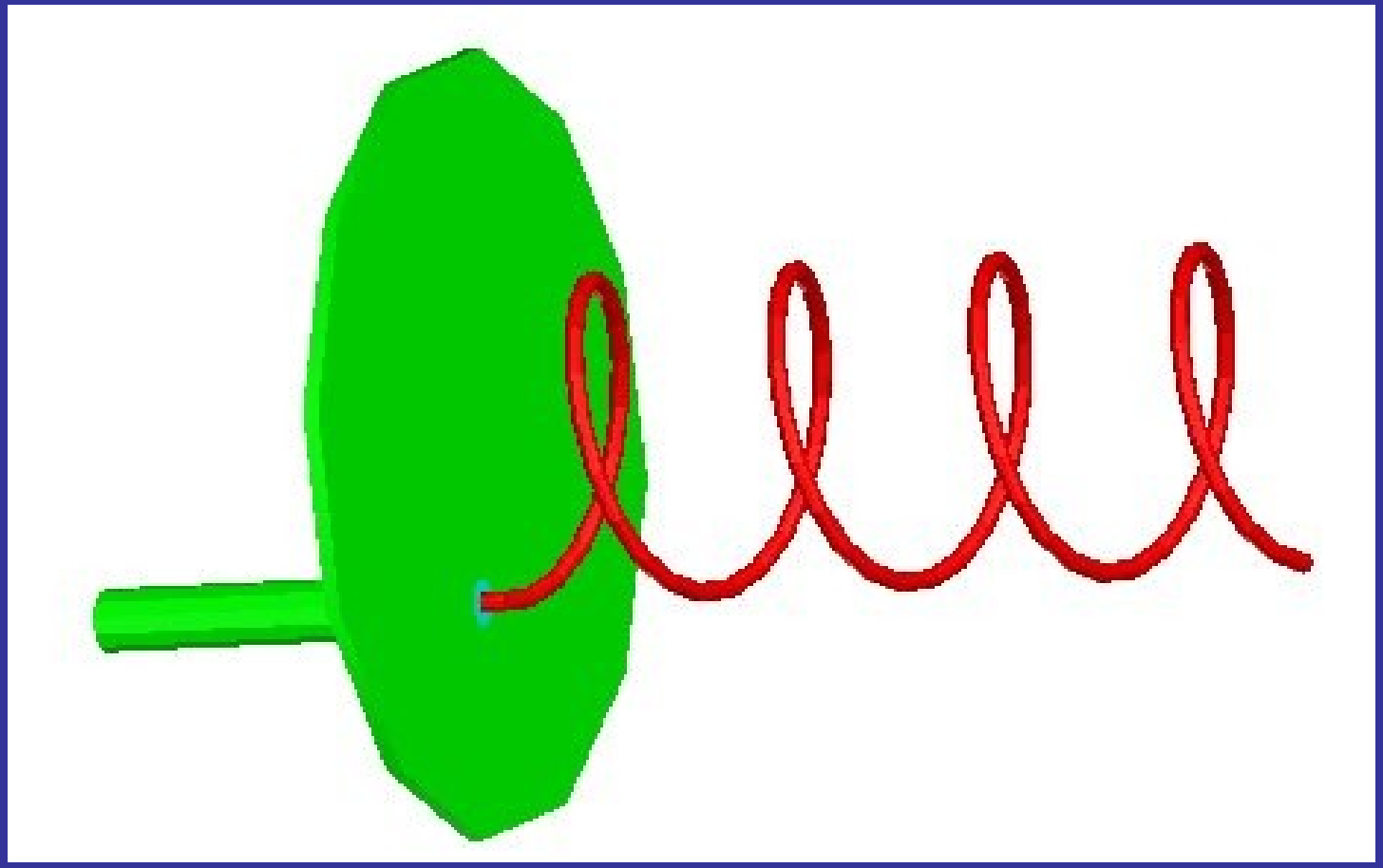
Helical Antenna

- Corkscrew – circumference ~ 1λ
- Circular polarization
- Amateur satellites use circular polarization
- Long helix – moderate gain
- Short helix – feed for dish

Helical Antenna



Helix - Easy to build

Helical Dish Feed

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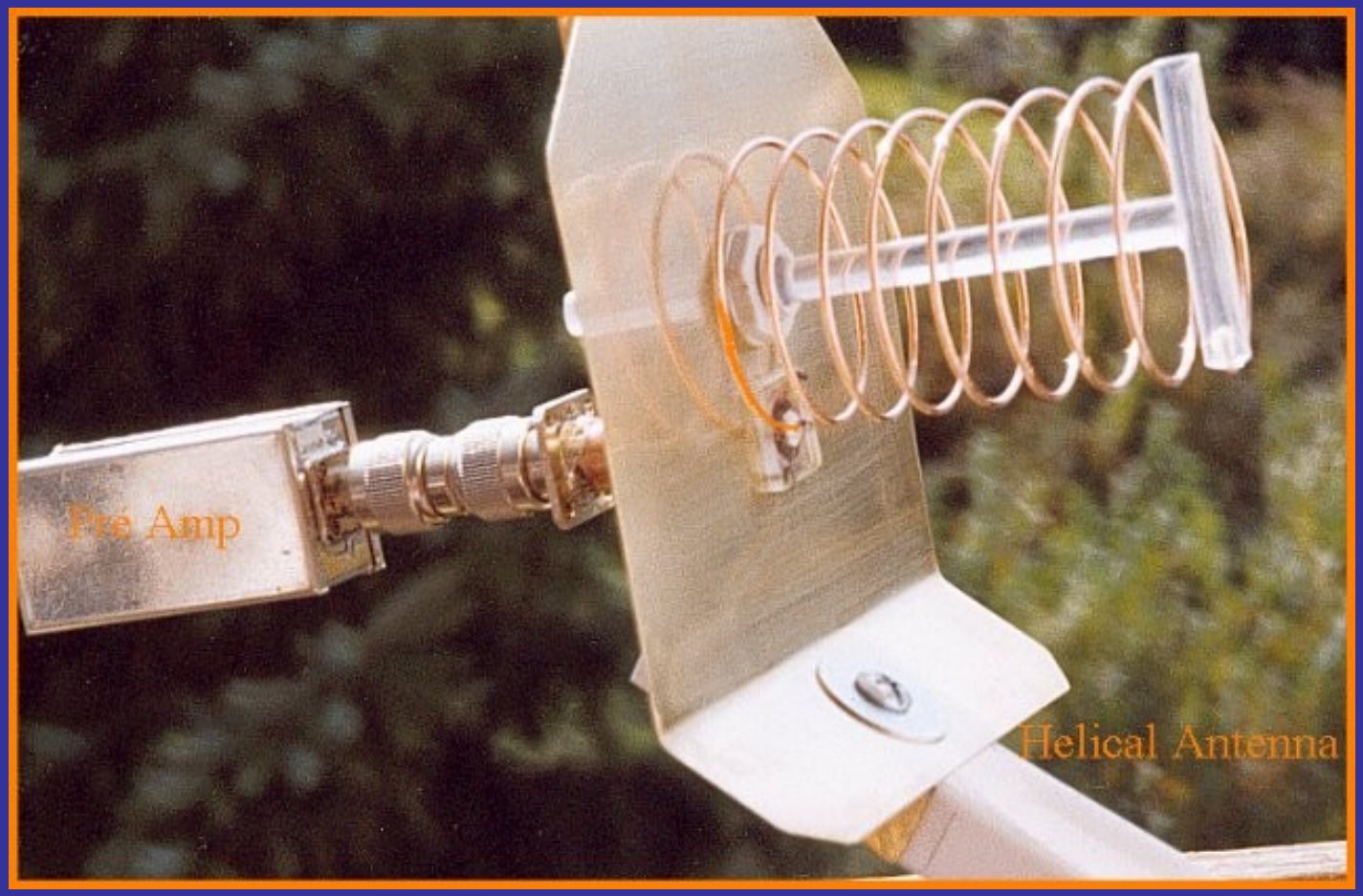
Mode-S Helical Feed



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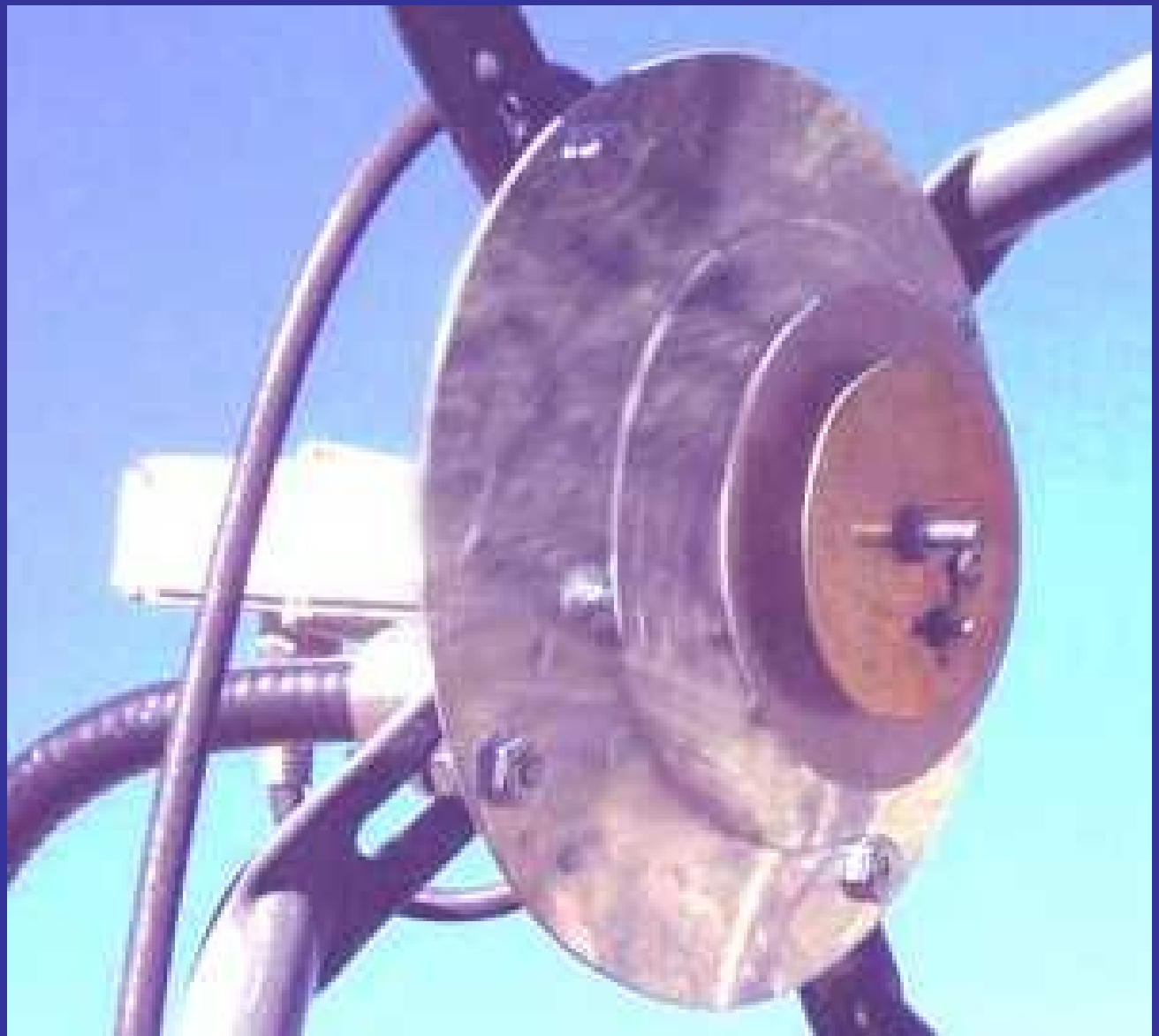
Loop Yagi

Patch Antenna

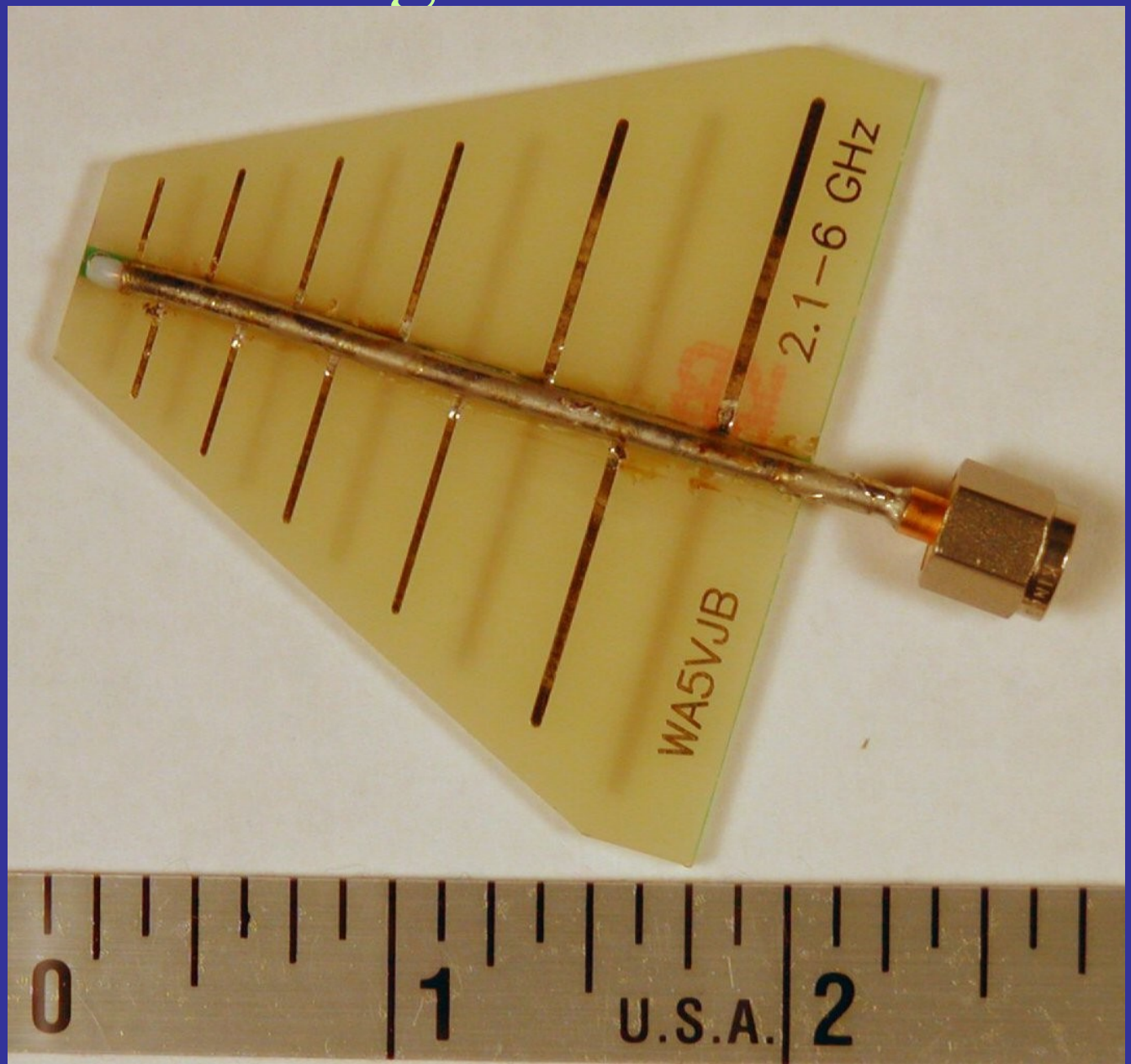


Mode-S

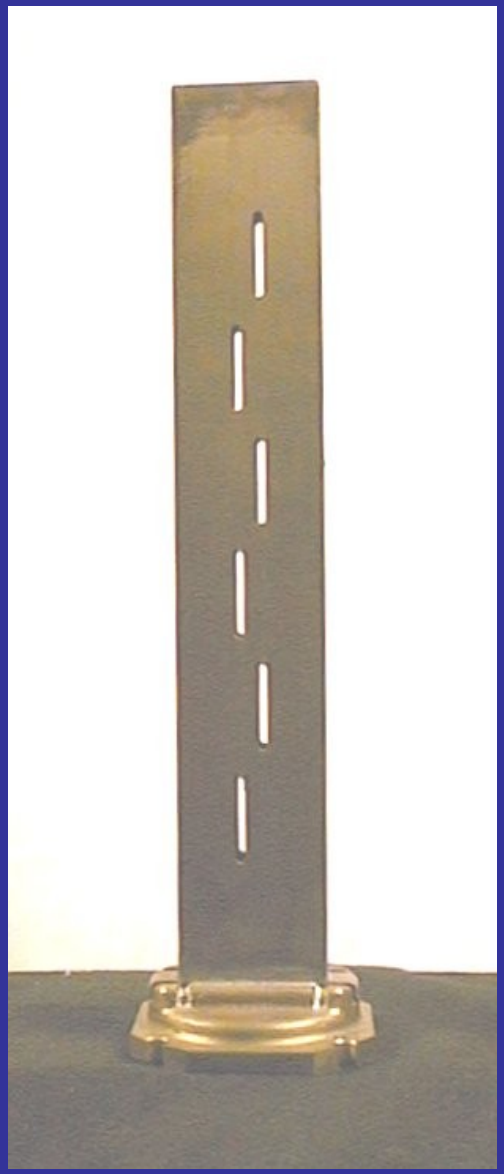
Dish

Feed

LPA – Log Periodic Antenna

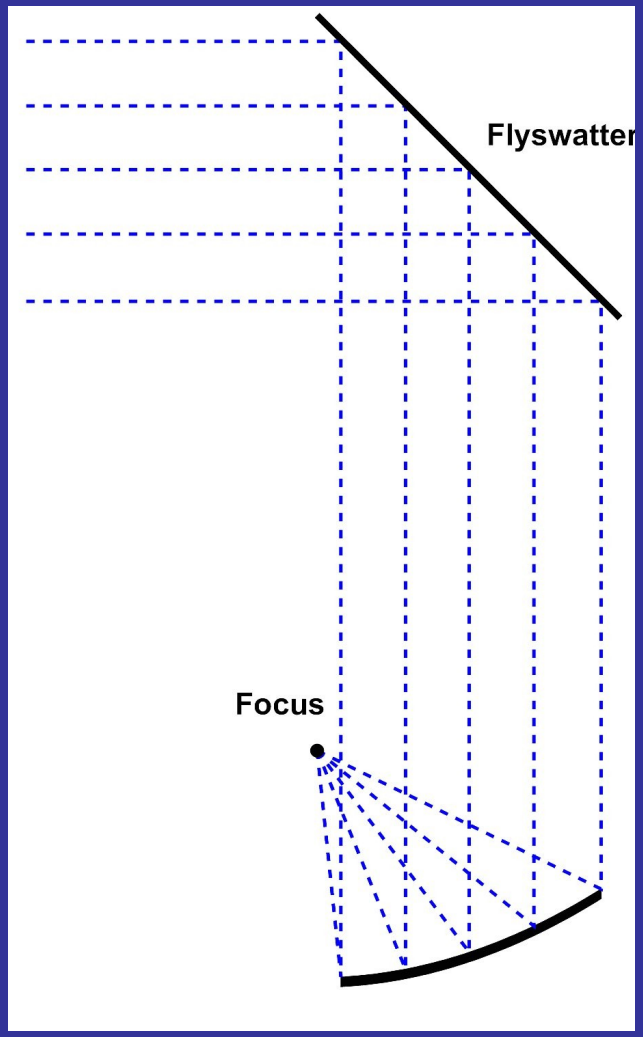


Waveguide Slot Antenna



Omnidirectional - good for beacon

Periscope Antenna



Rotatable reflector

over

Fixed dish

W1GHZ Periscope Antenna

Figure 8-16

So, what's the best antenna?

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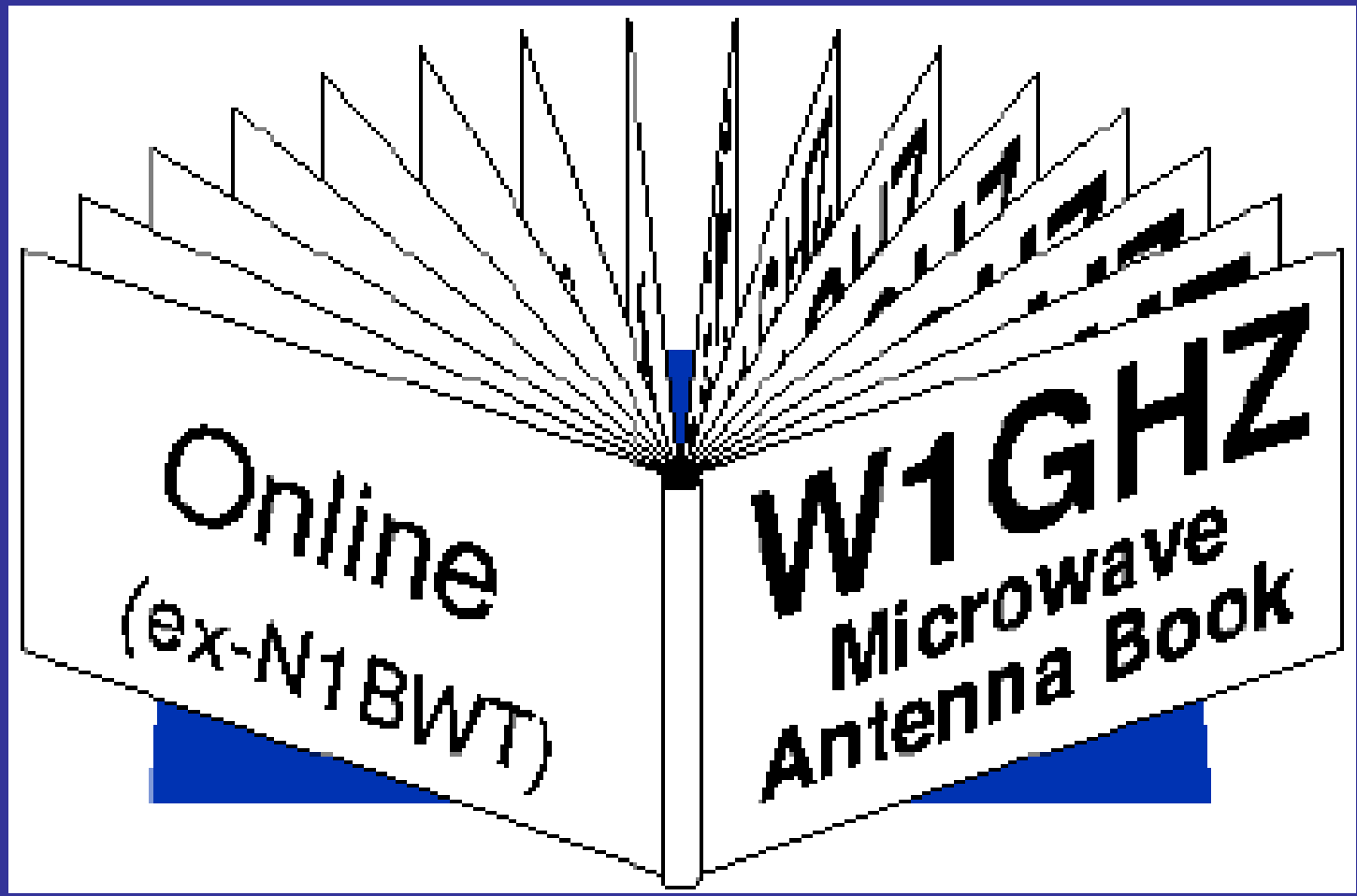
For more information



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8/11/2004