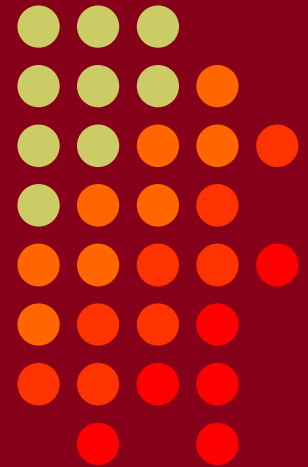
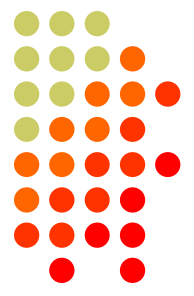


# How to Improve Your Transmitting Antennas as Solar Cycle 25 Approaches Solar Maximum in about 2024

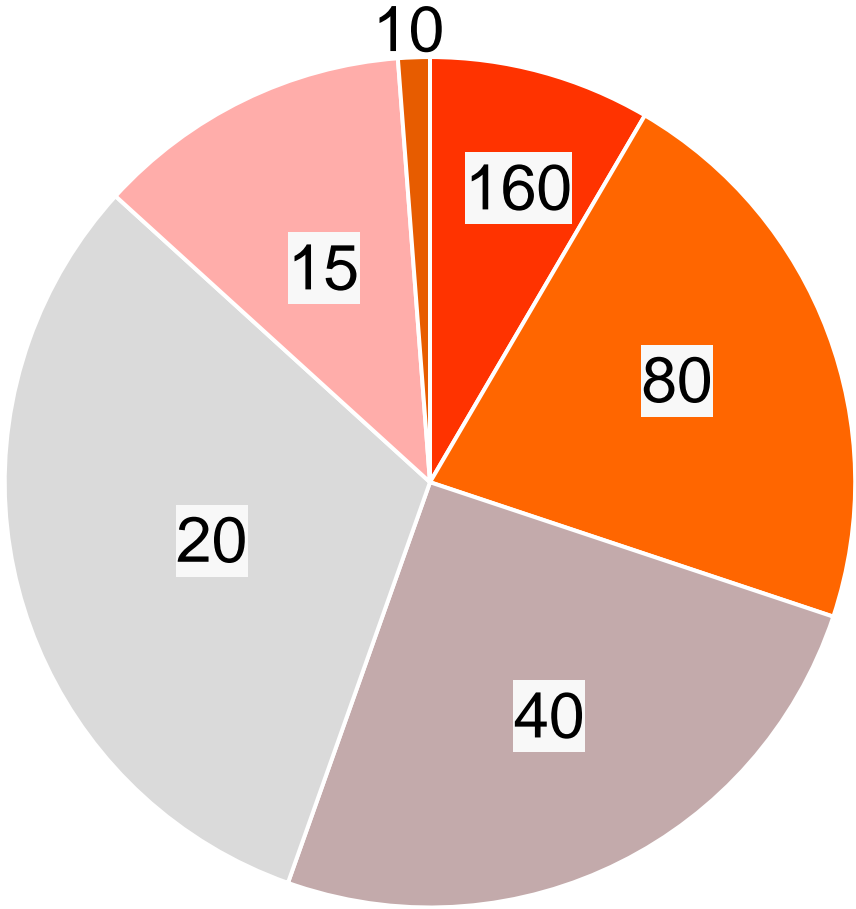
- What's important during the next two years?
- Vertically polarized 160 meter antennas
- Horizontally polarized 80 to 10 meter antennas
- Single Yagi stations
- Stacked Yagis
- Multi-tower stations
- When good antennas go bad...



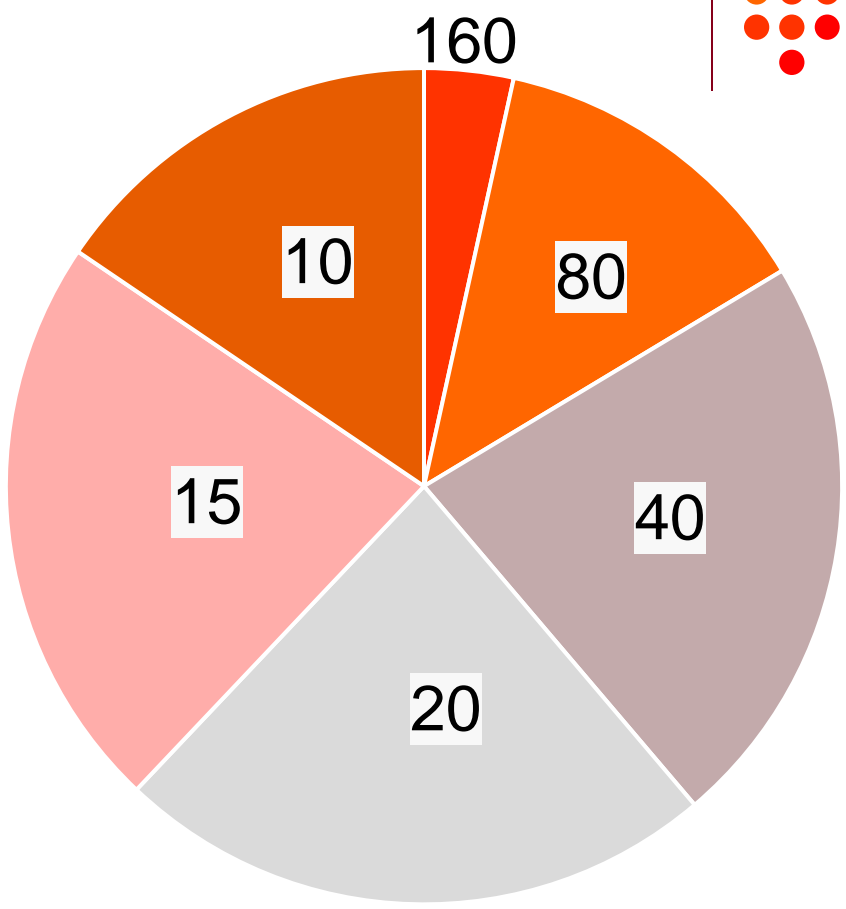
# Percentage of CW DX Contest QSOs Per Band



Near Solar Minimum



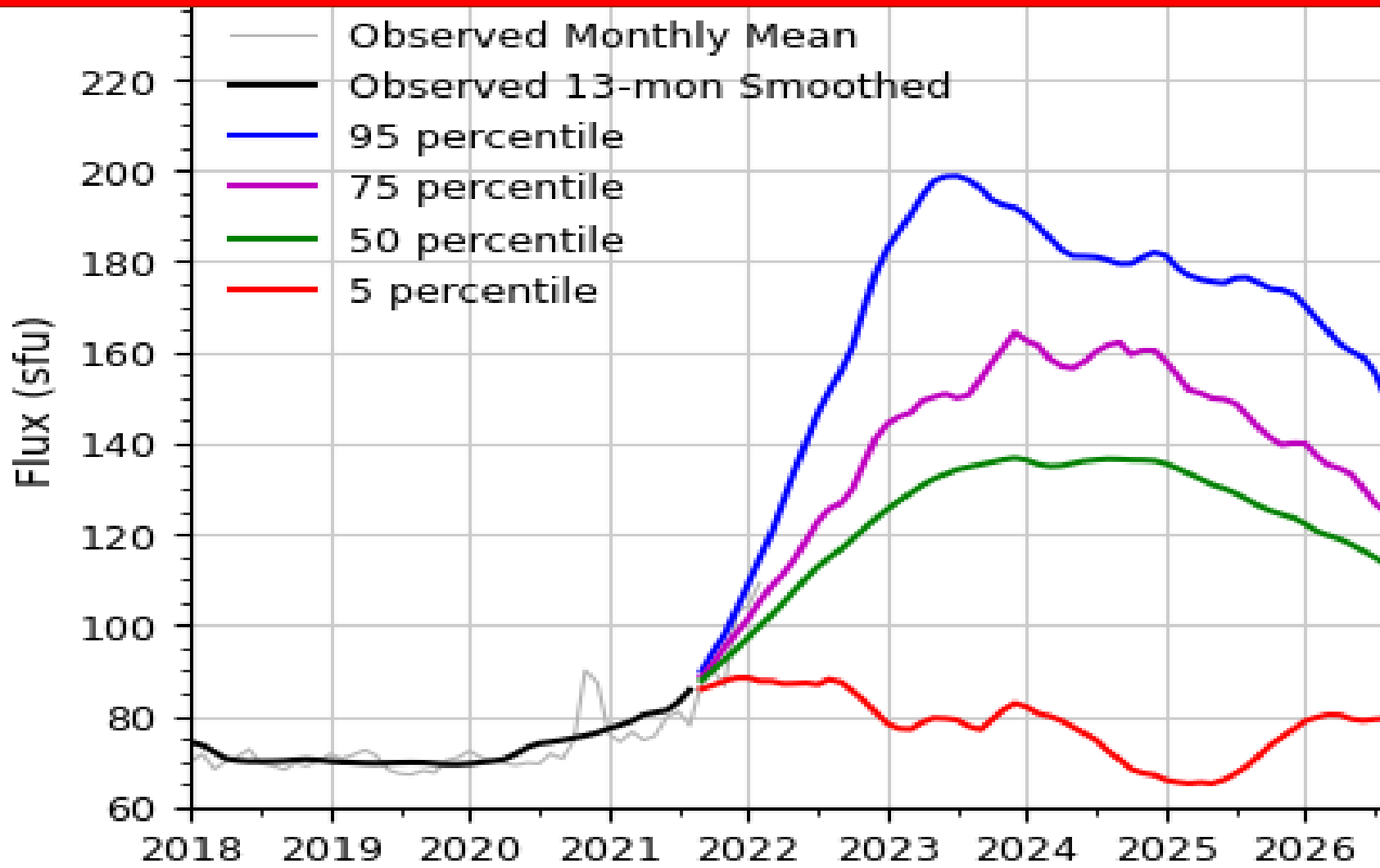
Near Solar Maximum



10 and 15 meters are much more important within a few years of solar maximum  
160 and 80 are somewhat less important within a few years of solar maximum

# Solar Cycle 25 Solar Flux Index Forecast

## NASA Marshall Space Flight Center – 10 Mar 2022

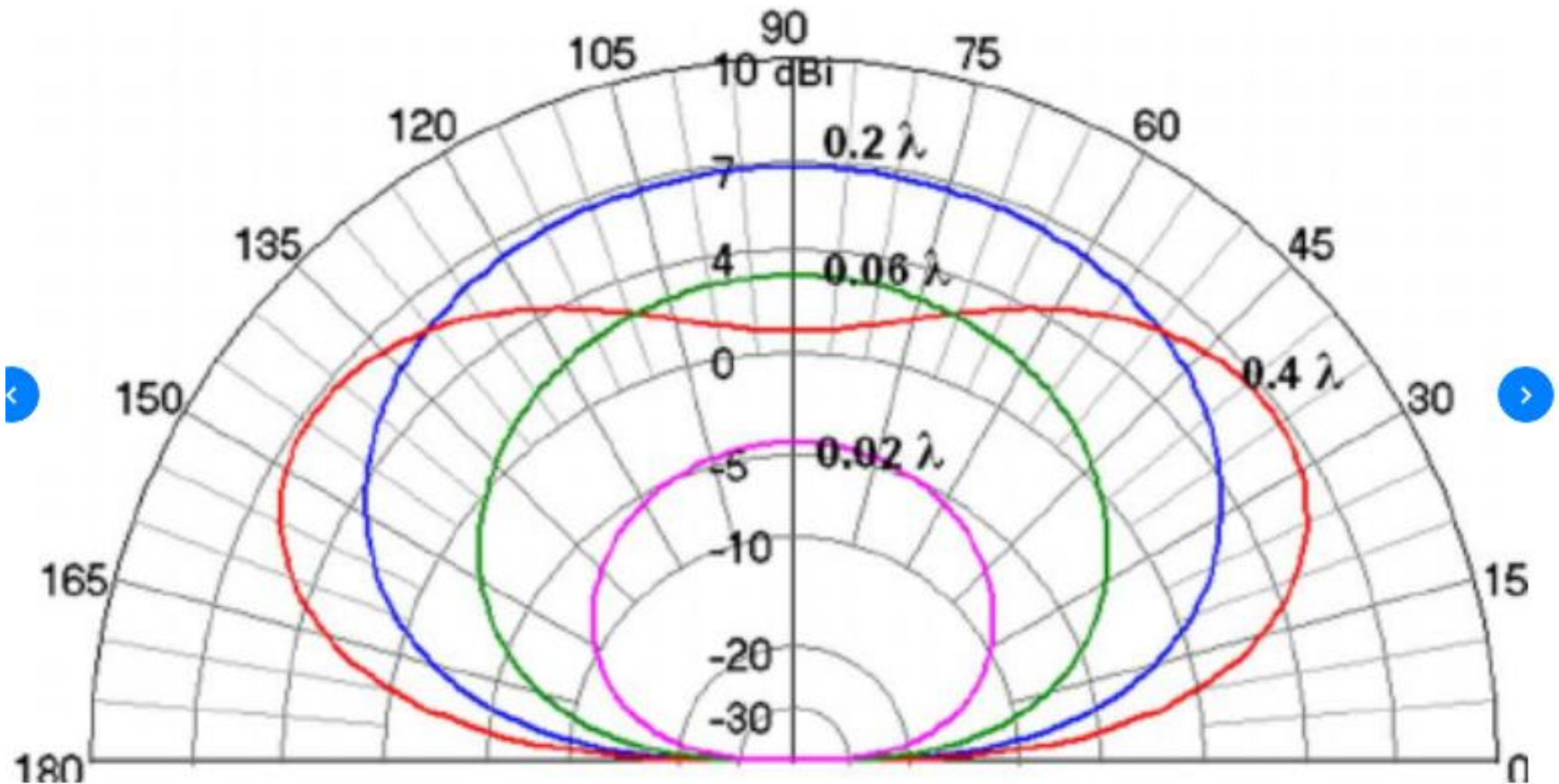


# Transmitting Antenna Elevation Angles as Solar Cycle 25 Approaches Solar Maximum



- **10 meters** - early morning through sunset world wide DX band
  - most DX propagation is at low elevation angles **5 to 10 degrees**
  - marginal DX paths require very low elevation angles **well below 5 degrees**
- **15 meters** - sunrise to early evening worldwide DX band
  - most DX propagation is at low and mid elevation angles **5 to 15 degrees**
  - marginal DX paths require very low elevation angles **well below 5 degrees**
- **20 meters** - 24 hour very crowded competitive worldwide DX band
  - DX propagation covers low, mid and high elevation angles **5 to 20 degrees**
  - marginal DX paths require low elevation angles **below 5 degrees**
- **40 meters** - evening and night very crowded competitive DX band
  - requires a broad range of elevation angles **10 to 25 degrees**
  - marginal DX paths require low elevation angles **below 10 degrees**
- **80 meters** - less reliable and weaker DX signals than recent years
  - use very efficient antennas covering a broad range of angles **10 to 25 degrees**
- **160 meters** - less reliable and weaker DX signals than recent years
  - **vertical antennas** *almost always* provide much better DX performance

# 6 dB of Ground Gain for Horizontally Polarized Antennas At Least 0.2 Wavelengths High



Its very difficult to achieve 6 dB of  
ground gain with vertical polarization

# 6 dB of “Free” Ground Gain



- Horizontally polarized dipoles, Yagis or quads
  - easily provide 6 dB of very important ground gain over almost any soil
  - *must be installed at an appropriate height*
  - terrain must be reasonably smooth and free of large obstructions
  - *but nearby antennas can destroy ground gain, antenna gain and directivity*
- Some vertically polarized antennas achieve nearly 6 dB of ground gain
  - *but only over highly conductive soil such as a salt marsh*
- Competitive DX contest stations require high horizontally polarized 40 through 10 meter antennas during very low solar activity
- Stacked Yagis provide additional gain by suppressing unwanted high angle radiation and redistributing the power into low angles
  - *if installed at proper heights and spacings to obtain significant stacking gain*
  - a Stackmatch allows selection of the optimum elevation angle

# Vertical Polarization for 160 Meters



- Vertical, inverted-L, T, and umbrella antennas
  - *almost always* provide much better DX performance than horizontally polarized antennas at distances beyond 1500 miles
- Nearby tall towers and antennas can significantly degrade the gain and directivity of vertical antennas
  - antenna pattern degradation
  - increased ground losses
- Efficient radial systems are essential to achieving the full performance potential of vertical transmitting antennas

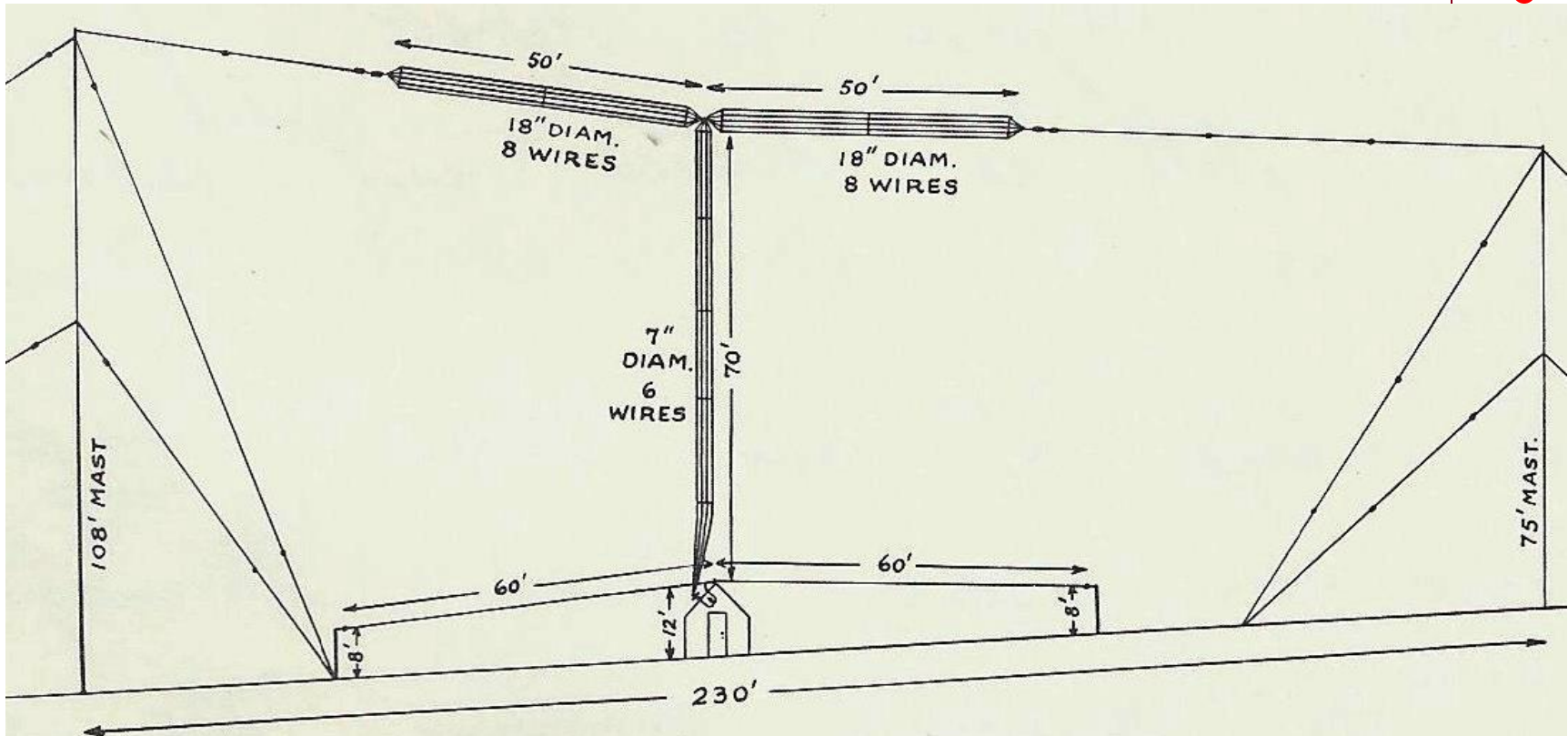
# High Performance Transmitting Antennas for 160 Meter DX



- 125 foot vertical: the gold standard 160 meter DX antenna
  - *well spaced from all nearby tall towers and antennas*
    - at least 140 ft from towers over 80 feet tall supporting large HF Yagis
    - optimum performance with spacing much greater than 140 feet
  - at least 30 to 60 shallow buried 125 foot radials
    - or at least two (preferably four or more) elevated 125 foot radials
      - but only if 30 to 60 shallow buried 125 foot radials are not possible
    - a K2AV folded counterpoise is a good alternative for small lots
- Inverted-L, T and umbrella antennas are good alternatives
  - 50 feet or higher (as short as 35 feet with reduced performance)
  - supported by a tower, mast or trees
- or a corner fed delta loop or corner fed inverted-U antenna



# Cage T-Vertical Used by 1BCG at about 1500 kHz during the 1921 Transatlantic Tests



By far the strongest North American signal heard in Europe during the 1921 Transatlantic Tests

# Horizontal Polarization for 80 Meters

## easily provides 6 dB of ground gain



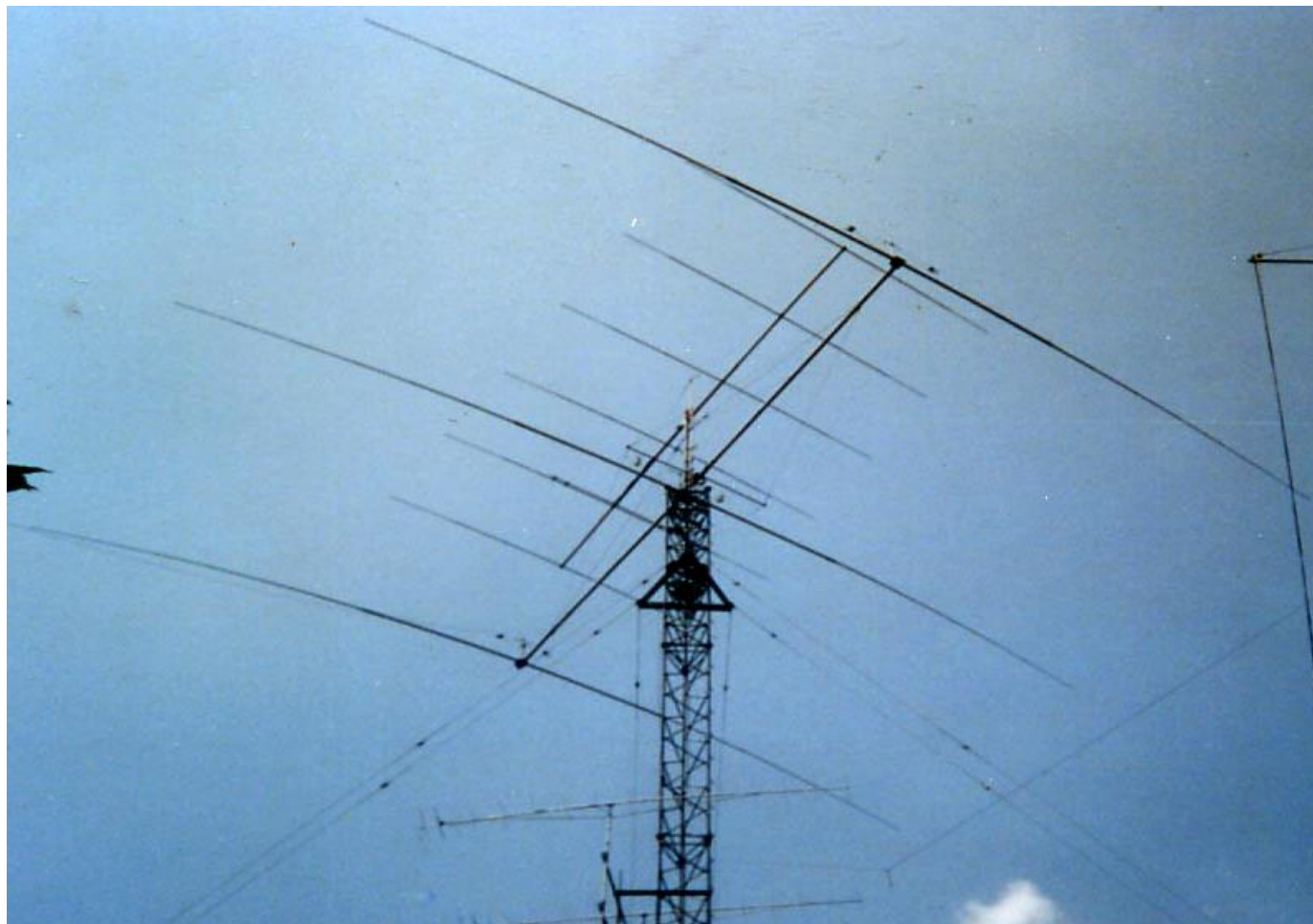
- Horizontal dipole or inverted-V dipole about 50 feet high
  - superb antenna for domestic contests: Sweepstakes and Field Day
  - a good DX antenna for distances up to about 5000 miles
- Horizontal dipole or inverted-V dipole at least 70 feet high
  - outperforms a single 65 foot vertical installed over all but the most conductive soils such as a salt marsh
- Use a vertical antenna if you cannot install a dipole or inverted-V dipole at least 70 feet high
  - 65 foot vertical, inverted-L, T or umbrella with at least thirty 65 foot radials
  - or a corner fed delta loop or a corner fed inverted-U
  - ***vertical are very susceptible to degradation by nearby towers***
- Four-square vertical array
  - very competitive with high horizontally polarized antennas
  - at least sixty 65 foot shallow buried radials for each vertical

# High Performance Transmitting Antennas for 80 Meter DX



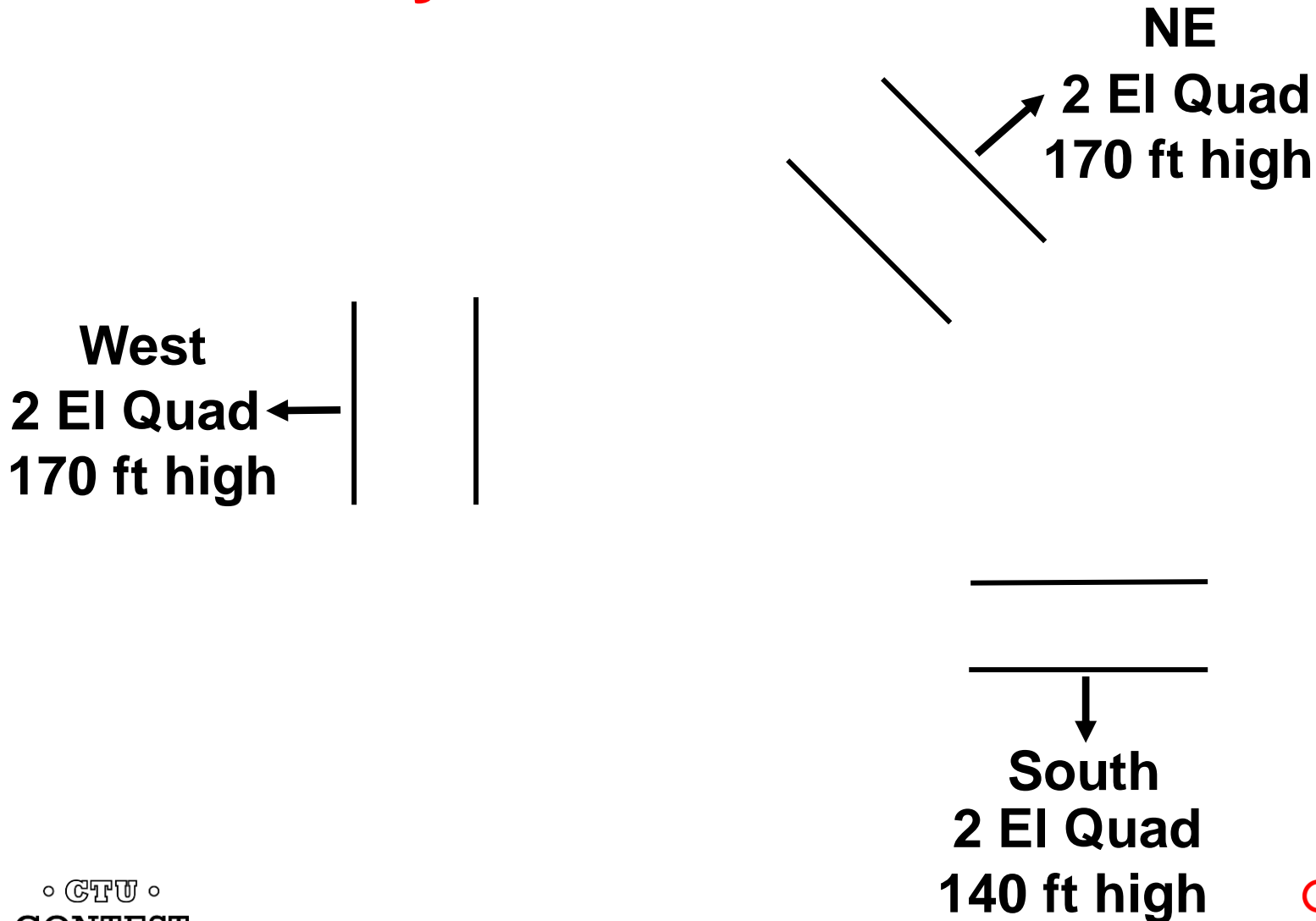
- Horizontal dipole at least 70 to 100 feet high
  - higher is better
- 65 foot vertical
  - install at least 30 to 60 shallow buried 65 foot radials
    - or at least two (preferably four or more) elevated 65 foot radials
      - only if shallow buried radials are not possible
  - ***verticals are very susceptible to degradation by nearby tall towers***
    - at least 70 feet from towers over 40 feet tall supporting a Yagi antenna
    - optimum performance with much more than 70 foot spacing
- Inverted-L, T and umbrella verticals are good alternatives
  - as little as 25 feet tall -- supported by a tower or trees
  - install at least 30 to 60 shallow buried 65 foot radials
    - or elevated radials
    - or a K2AV reduced size counterpoise for a small lot
  - or a vertically polarized corner fed delta loop or corner fed inverted-U

# K3ZO Installed his 3 Element 80 Meter Yagi at 140 Feet in 1984



K3ZO's horizontally polarized 3 element Yagi  
changed my thinking about 80 meter antennas for DX

# 80 Meter Transmitting Antenna Layout at W3LPL



# 80 Meter 4-Square Vertical Array

very competitive high performance alternative  
to a high 80 meter horizontal antenna



- A four square vertical array is very competitive with high horizontally polarized Yagis and quads
- *Install at least 70 feet from all towers*
  - much more than 70 foot spacing will significantly improve its performance
- Use at least 60 shallow buried 65 foot radials under each vertical
- A 4-square is also an excellent receiving antenna

# Comtek 4-Square Controller





# High Performance 40M Antennas



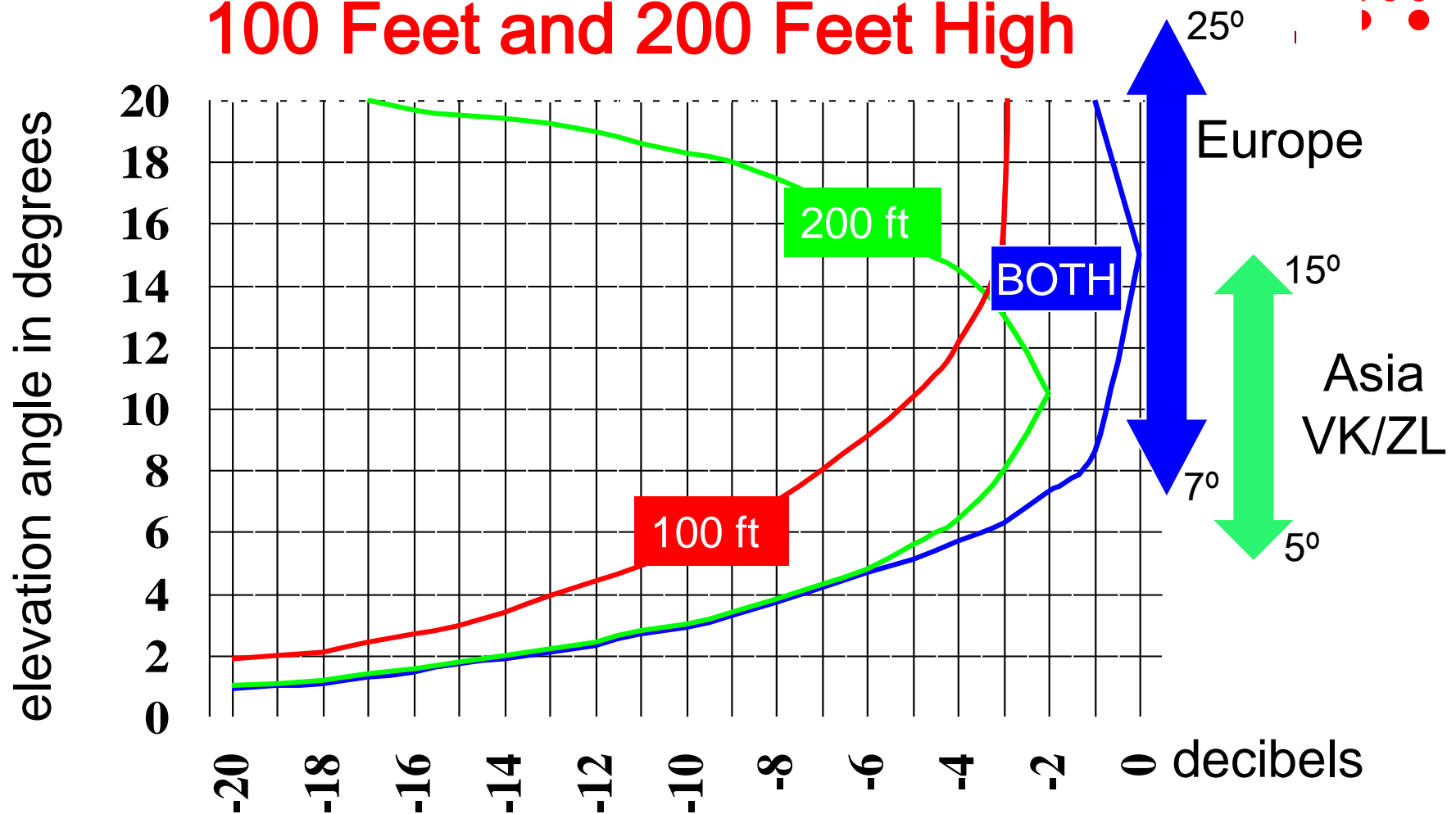
- Horizontal dipole at least 70 feet high
  - 13 to 45 degree elevation pattern at -3 dB points
  - otherwise use a vertical or a four-square vertical array with 30 to 60 radials
- Higher gain: 2 element “shorty 40” Yagi at 70 to 100 feet high
  - 10 to 30 degree elevation pattern at -3 dB points
  - significant improvement over a simple horizontal dipole for DX
  - a Cushcraft XM-240 at 100 feet high is very cost effective
  - a Moxon Yagi is an excellent broad bandwidth low VSWR alternative
- Highest gain: full size 3 or 4 element monoband Yagis
  - single Yagi at least 140 feet high
  - two stacked Yagis on a 200 foot tower and a Stackmatch
    - *selectable* 6 to 30 degree elevation beam patterns at -3 dB points
  - this antenna is often too high for Caribbean and northern South America
  - but don’t underestimate the high cost and complexity of a full size 40M Yagi!



# Stacked 3 Element 40 Meter Yagis

## 48 Foot Booms

### 100 Feet and 200 Feet High



# First Known 40 Meter Rotatable Yagi 2 Element Full Size Yagi at 60 Feet Constructed by W9LM in 1950



# Cushcraft XM-240

## 2 Element 40 Meter Yagi

The most popular “Shorty Forty” Yagi



# 40 Meter Moxon

VSWR less than 1.4:1 from 7.0 to 7.3 MHz  
22 foot boom and 48 foot elements



Two stacked Moxons on a 140 foot tower are fully competitive  
with a much more expensive full size 3 or 4 element Yagi





# Telrex (near) Full Size 3 Element Yagi Revolutionized 40 meter Dxing in 1955



**TELREX 40 METER "MONARCH" ARRAYS**  
Optimum spaced for optimum results  
Worlds finest, most potent, 2 and 3 element 40 Meter Arrays.

Telrex 40 Meter "Balun" fed "Monarch" Arrays are professionally engineered, custom machined then precision tuned, matched and calibrated for easy, fool-proof assembly, at your site, to our specifications, --- when mounted in the clear a minimum of 64 ft. above ground.

Telrex 40 Meter Arrays employ state of the art materials including glass Melamine insulation, heavy wall taper swaged reinforced thru the boom dural elements, and extra heavy-wall sectional and specially reinforced aluminum boom, with boom struts\* and turnbuckles, stainless steel electrical hardware and an exclusive custom designed heavy-duty cadmium plated steel tiltable gusset plate mounting.

	40M214	40M329	40M346
<b>ELECTRICAL</b>			
Number of Elements	2	3	3
Gain reference 1/2 wave dipole	5.6 dbd	8.3 dbd	9.0 dbd
F/B Ratio	17 db	30 db	30 db
V/S/W/R at Resonant Point	1.2/1	1.2/1	1.2/1
Impedance Bandwidth (2/1 VSWR)	4%	4%	4%
Maximum Power Input	4 KWP	4 KWP	4 KWP
Nominal Input Impedance	52 ohm	52 ohm	52 ohm
Beamwidth to 1/2 Power Point	66°	62°	59°
<b>MECHANICAL</b>			
Alum. Boom: length and diameter	3.5,3"x14'	3.5,3"x29'	3.5,3"x46'
Longest Element Length (approx.)	64'	64'	64'
Turning Radius (approx.)	34'	35'	40'
Wind Surface Area (approx.)	8.0 sq. ft.	12.6 sq. ft.	13.8 sq. ft.
Wind Load at 100 mph (approx.)	252 lbs.	406 lbs.	490 lbs.
Net Weight (approx.)	60 lbs.	110 lbs.	177 lbs.
Approx. Shipping Weight	90 lbs.	130 lbs.	222 lbs.

**Figure 1.** Center section of a 40M346 revealing the intricate design and workmanship which comes only with pride. Pride in knowing it is the most durable, and best performing antenna of its kind.

**Figure 2.** Melamine insulated (for high tensile strength) end element section captivated by a reinforced boom.

**Typical Radiation Pattern**

1/2 Power Beamwidth 66°

**Typical S/W/R Curve**

Frequency in MHZ

**Telrex 40M346 installed at the Telrex "Sky-top" Lab Site.**

Please Note: The Telrex Model 40M214 does not require boom struts.

W0MLY W1FZ K2DGT K2GL K2LWR WA2SFP(W2PV) W8FGX W8VSK W9EWC

# W3KRQ's Homebrew Full Size 3 Element 40 Meter Yagi in 1959



Contesters and DXers built many 3 element 40M Yagis  
W3GRF W3KRQ W3MSK (W3AU) W8JIN and many others

# Stacked 40 Meter 4 Element OWA Yagis at K9CT



# 40 Meter 4-Square Vertical Array



- A 4-square vertical array is good alternative to a Yagi
  - if you cannot install a “shorty 40” Yagi at least 70 feet high
- Install at least 60 shallow buried 35 foot radials under each vertical
- *Install at least 40 feet from all towers*
  - more than 40 foot spacing will significantly improve its performance
- A 4-square is also an excellent 40 meter receiving antenna



# High Performance 20M Antennas

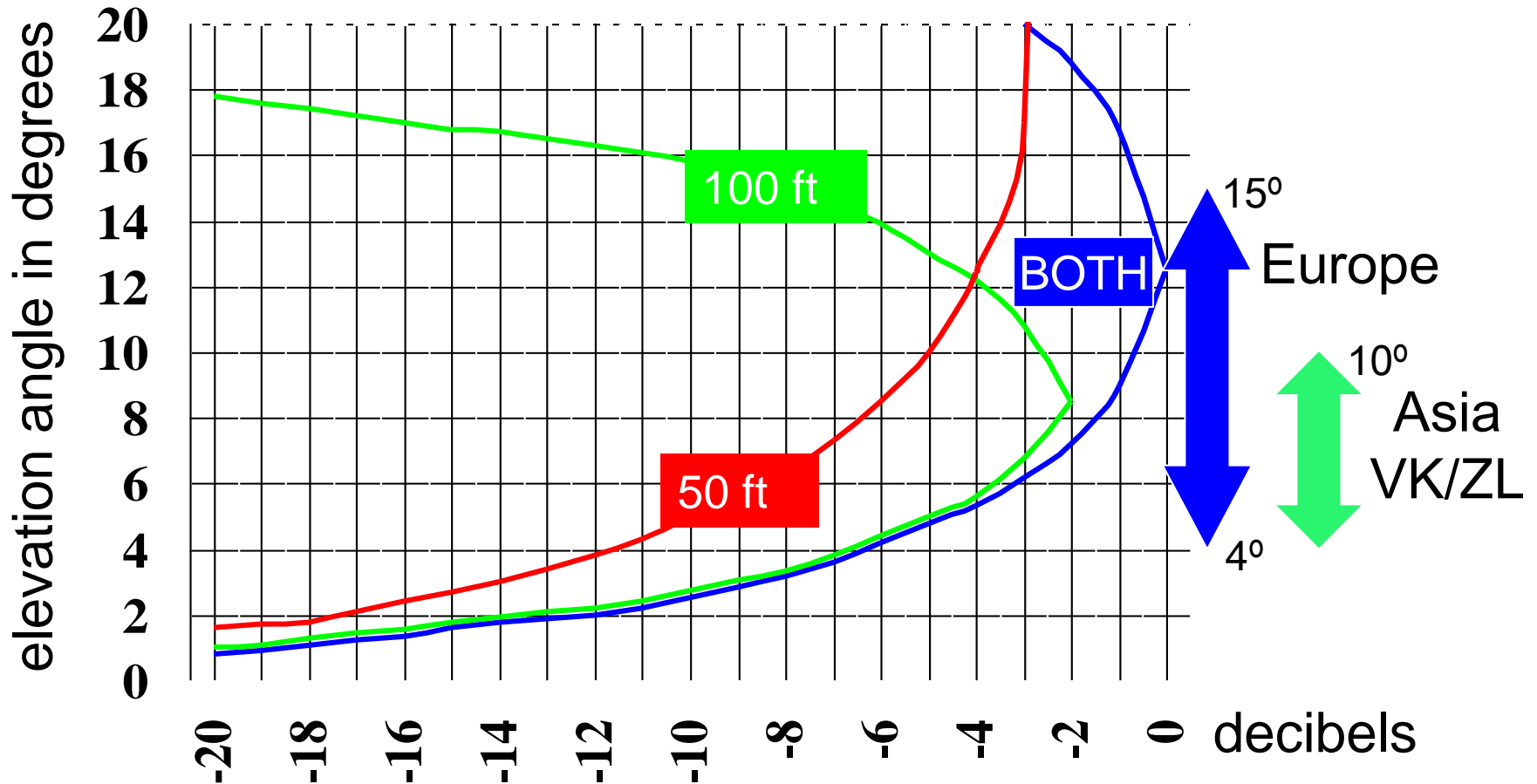


- A horizontal Yagi or quad is always the best choice
  - if you can install your antenna at least 35 feet high
  - 13 to 45 degree elevation beam pattern at -3 dB points
- Moderate gain: small tri-band Yagi, hex-beam, Moxon or quad
  - a small Yagi at least 50 to 70 feet high will produce good DX results
  - 10 to 30 degree elevation beam pattern at -3 dB points
- High gain: full size tri-band Yagi, small monoband Yagi or quad
  - at least 70 to 100 feet high
  - 7 to 20 degree elevation beam pattern at -3 dB points
- Highest gain: stacked large 20 meter monoband Yagis
  - 100 to 140 foot tower with two stacked Yagis and a Stackmatch
  - 170 to 200 foot tower with three stacked Yagis and a Stackmatch
    - *selectable* 3 to 25 degree elevation beam patterns at -3 dB points
  - stack switching ( a “Stackmatch”) provides high payoff at low cost

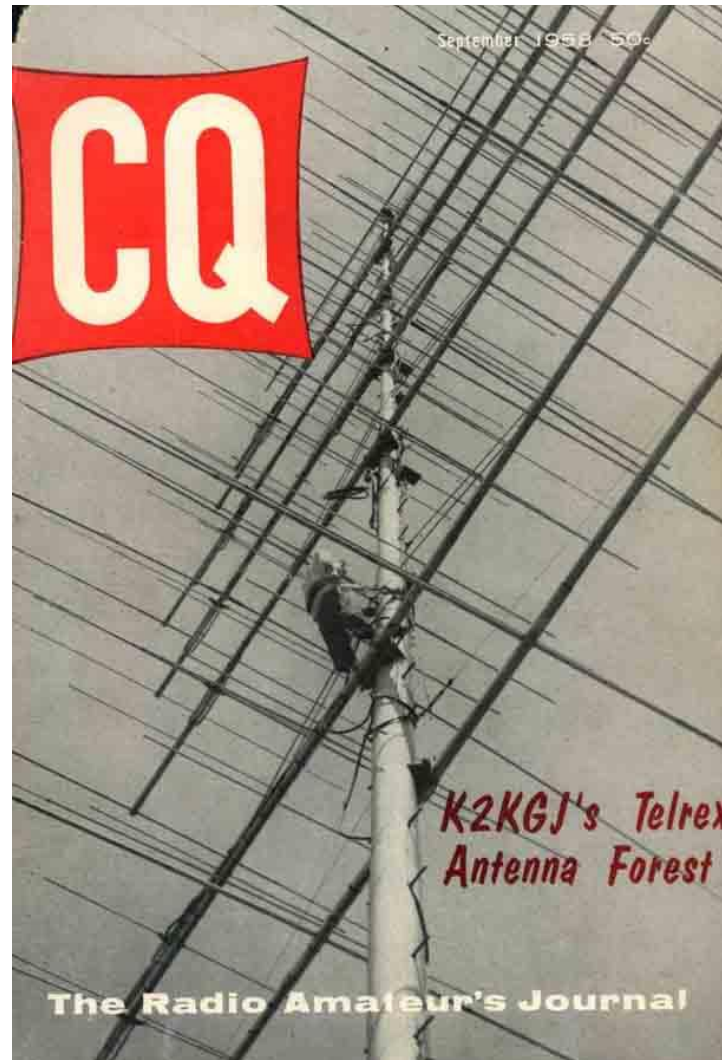
# Stacked 5 Element 20 Meter Yagis

## 48 Foot Booms

### 50 and 100 Feet High



# Telrex 20, 15 and 10 meter stacked Yagis revolutionized competitive HF antennas in 1955



# Array Solutions Stack Match



**The Stackmatch revolutionized the performance and flexibility of stacked Yagi antennas**

# High Performance 15M Antennas

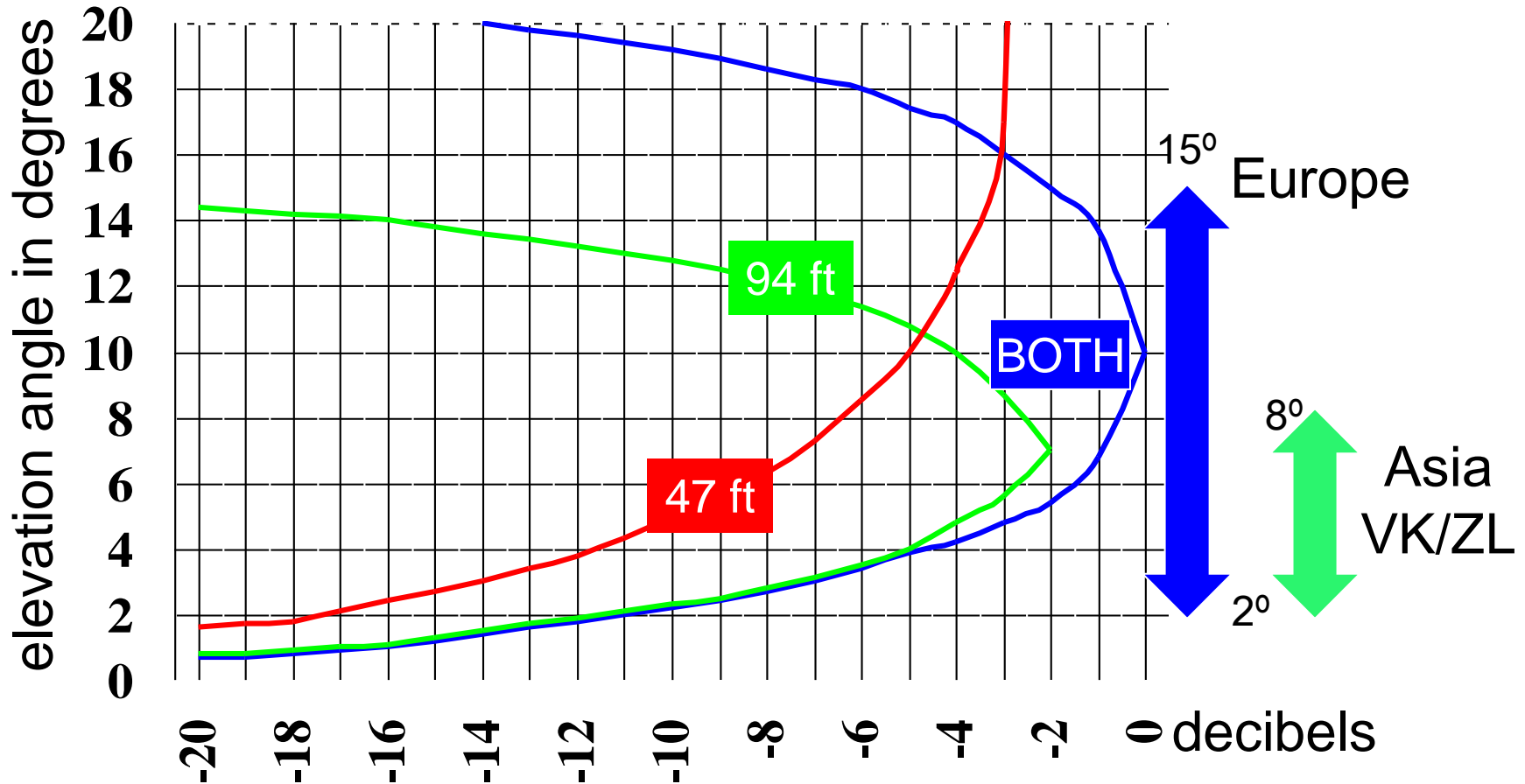


- A horizontal Yagi or quad is always the best choice
  - if you can install your antenna at least 25 feet high
  - 13 to 45 degree elevation beam pattern at -3 dB points
- Moderate gain: small tri-bander Yagi, hex-beam, Moxon or quad
  - a small Yagi at least 50 to 70 feet high will produce good DX results
  - 7 to 20 degree elevation beam pattern at -3 dB points
- High gain: full size tri-band Yagi, small monoband Yagi or quad
  - at least 70 to 100 feet high
  - 5 to 15 degree elevation beam pattern at -3 dB points
- Highest gain: stacked large 15 meter monoband Yagis
  - at least a 90 foot tower with two stacked Yagis and a Stackmatch
  - at least a 120 to 140 foot tower with three stacked Yagis and a Stackmatch
    - *selectable* 5 to 25 degree elevation beam patterns at -3 dB points
  - stack switching ( a “Stackmatch”) provides high payoff at low cost

# Stacked 6 Element 15 Meter Yagis

## 48 Foot Booms

### 47 and 94 Feet High



# High Performance 10M Antennas



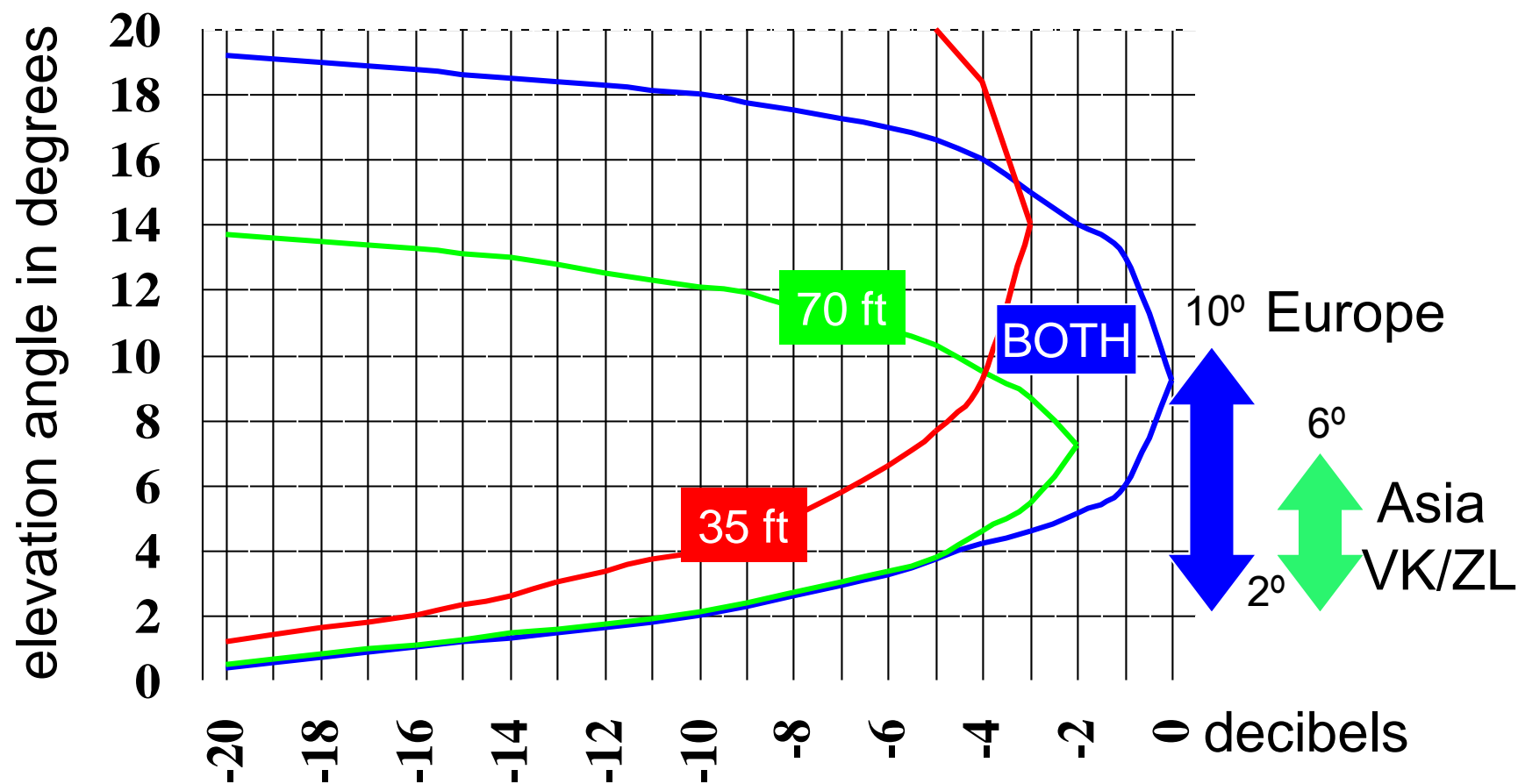
- A horizontal Yagi or quad is always the best choice
  - if you can install your antenna at 20 feet high or higher
  - 13 to 45 degree elevation beam pattern at -3 dB points
- Moderate gain: small tri-bander Yagi, hex-beam, Moxon or quad
  - a small Yagi at least 35 to 50 feet high will produce good DX results
  - 7 to 20 degree elevation beam pattern at -3 dB points
- High gain: full size tri-band Yagi, small monoband Yagi or quad
  - at least 50 to 70 feet high
  - 5 to 15 degree elevation beam pattern at -3 dB points
- Highest gain: stacked large 10 meter monoband Yagis
  - at least a 70 foot tower with two stacked Yagis and a Stackmatch
  - at least a 90 to 100 foot tower with three stacked Yagis and a Stackmatch
    - *selectable* 4 to 20 degree elevation beam patterns at -3 dB points
  - stack switching ( a “Stackmatch”) provides high payoff at low cost



# Stacked 6 Element 10 Meter Yagis

## 36 Foot Booms

### 35 and 70 Feet High





# Competitive One Tower Antenna Systems



- 50-70 foot tower and a small rotator (e.g., HyGain Ham-IV)
  - small tri-band Yagi, Hex-beam or quad
  - 40 and 80 meter dipoles and 160 meter inverted-L
- 70-90 foot tower and a medium rotator (e.g. HyGain T2X)
  - Cushcraft XM-240 two element 40 meter Yagi
  - large tri-band Yagi such as the DX Engineering Skyhawk
  - 80 meter dipole and 160 meter inverted-L
- 100-140+ foot tower and a large rotator (e.g., M2 Orion)
  - Cushcraft XM-240 two element 40 meter Yagi
  - monoband Yagis such as the Hy-Gain LJ series on ring rotators
  - 80 meter dipole and 160 meter inverted-L

# Multi-Tower Antenna Systems

Designing a multi-tower station with acceptable degradation is an antenna modelling challenge

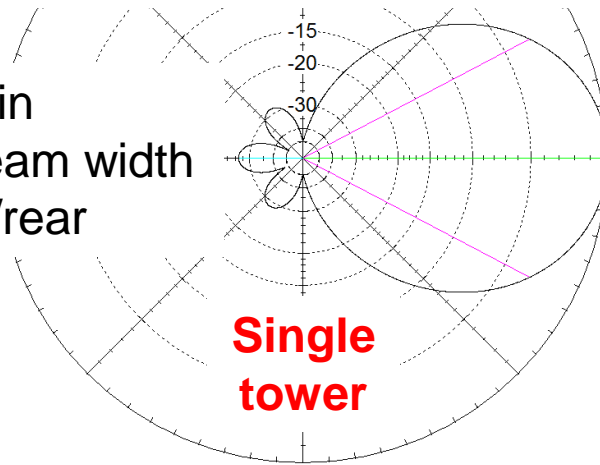


- Placement of Yagis and the relative location of the towers to minimize degradation is critical to achieving high performance
  - in most cases multiple Triband Yagis and multiple Yagis for the same band should be installed on only one tower
  - placing Yagis covering the same band *on multiple towers* requires detailed antenna modelling
- An excellent design for two towers with minor degradation:
  - tower one: 40 meter Yagi and 10 meter stacked Yagis
  - tower two: 20 and 15 meter stacked Yagis
- An excellent design for three towers with minimal degradation:
  - tower one: 40 meter Yagi and 10 meter stacked Yagis
  - tower two: 20 meter stacked Yagis
  - tower three: 15 meter stacked Yagis

# 20 Meter 6 Element Stacked Yagi Array Pointing Through an Identical Array

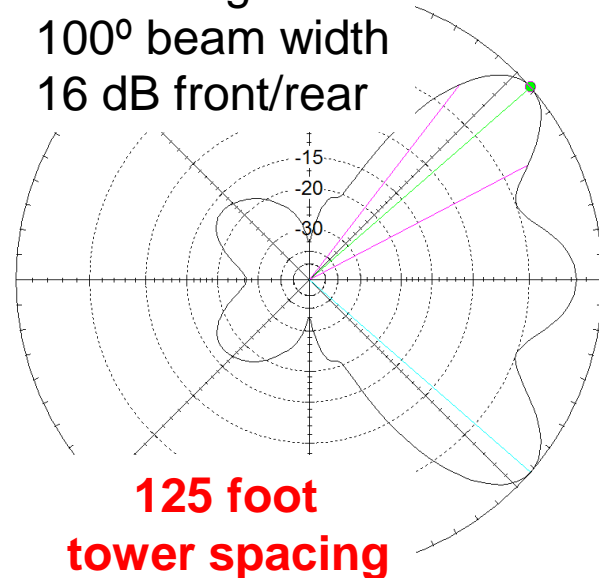


17.8 dBi gain  
55° 3 dB beam width  
27 dB front/rear



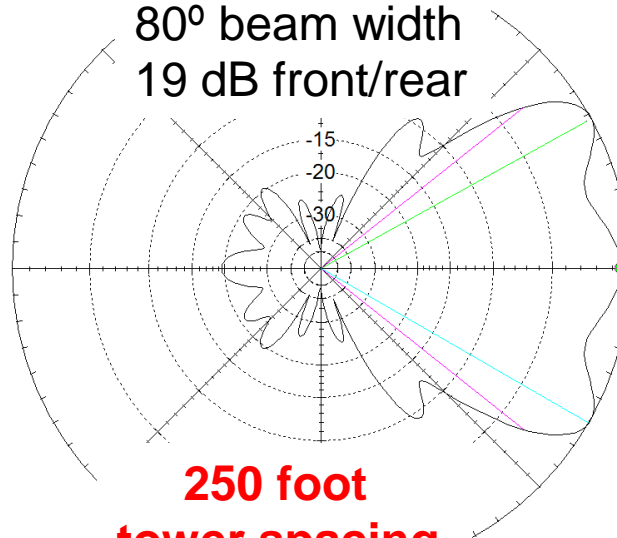
**Single  
tower**

14.3 dBi gain  
100° beam width  
16 dB front/rear



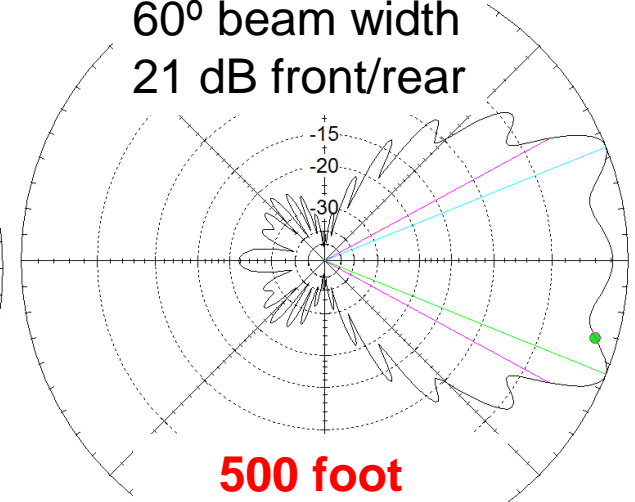
**125 foot  
tower spacing**

15.7 dBi gain  
80° beam width  
19 dB front/rear



**250 foot  
tower spacing**

16.5 dBi gain  
60° beam width  
21 dB front/rear



**500 foot  
tower spacing**

# When Good Antennas Go Bad...

## antenna system design issues



- Yagi director installed very close to the tower face
  - spacing *less than one tower diameter* shortens effective director length
- 80 meter dipole installed too close to a 40 meter Yagi
  - improper coaxial cable length makes an 80 meter dipole operate like two 40 meter dipoles tightly coupled to the 40 meter Yagi
- 10 and 15 meter Yagis installed too close to each other
  - use 10 foot minimum spacing unless you model their interactions
- 15 meter Yagi pointed through -- or mounted too close to -- a full size 40 meter Yagi
- Conductive guy wires degrading Yagi antenna performance
- 160 and 80 meter vertical antenna performance degradation caused by installing them too close to towers
- Multiple **Triband Yagis** or multiple Yagis for the same band installed on two or more towers without detailed modelling

# When Good Antennas Go Bad...

## common coaxial cable issues



- Improperly installed connectors
- PL-259 connectors not gently wrench tightened ¼ turn
- Obsolete N connectors with floating pins
  - if you must use N connectors... use only captive pin connectors
- Connectors not adequately protected from water and moisture
  - connectors on towers should be mounted horizontally not vertically
- Coax not securely fastened to the tower
- Coax not electrically bonded to the top and bottom of the tower
- Inadequate waterproofing of the coax connection to the antenna
- Coaxial cable shield exposed to rain at the antenna connection
- Undetected rodent damage to coaxial cable jackets and more

# Amphenol 83-1SP PL-259 Connector



Shell is labeled exactly:  
**Amphenol 83-1SP**

[newark.com/amphenol-rf/83-1sp/rf-coaxial-uhf-plug-straight-50ohm/dp/59K0534](https://newark.com/amphenol-rf/83-1sp/rf-coaxial-uhf-plug-straight-50ohm/dp/59K0534)

# Waterproof your Connectors!



Cover your connectors with **two 50% overlapped layers** of Scotch 130C self-vulcanizing linerless rubber splicing tape

- stretched to 50% of its original width
- sticky side facing out

[homedepot.com/p/3M-Scotch-3-4-in-x-30-ft-Linerless-Rubber-Splicing-Tape-41717-BX-10/205523418](https://www.homedepot.com/p/3M-Scotch-3-4-in-x-30-ft-Linerless-Rubber-Splicing-Tape-41717-BX-10/205523418)

Cover the Scotch 130C tape with **two 50% overlapped layers** of Scotch Super 33+ vinyl electrical tape

[homedepot.com/p/Scotch-Super-33-3-4-in-x-66-ft-x-0-007-in-Vinyl-Electrical-Tape-Black-6132-BA-10/304653556](https://www.homedepot.com/p/Scotch-Super-33-3-4-in-x-66-ft-x-0-007-in-Vinyl-Electrical-Tape-Black-6132-BA-10/304653556)

◦ CTU ◦

CONTEST  
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ICOM<sup>®</sup>



# Antenna Feedpoint

## Waterproof and Shakeproof Connections





# When Good Antennas Go Bad...

## Performance Evaluation Inspections Preventive Maintenance



- Maintaining competitive antenna performance
  - antenna performance evaluations
  - tower, foundation and guy wire inspections
  - guy wire, guy hardware and ground anchor inspections
  - rotator inspections
  - coaxial cable inspections and performance measurements
  - coaxial connector inspections PL-259s and SO-239s