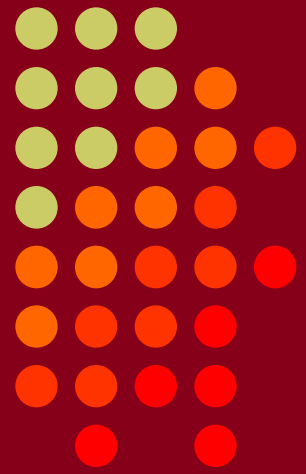
How to Improve your Transmitting Antennas for Very Low Solar Activity

- 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…



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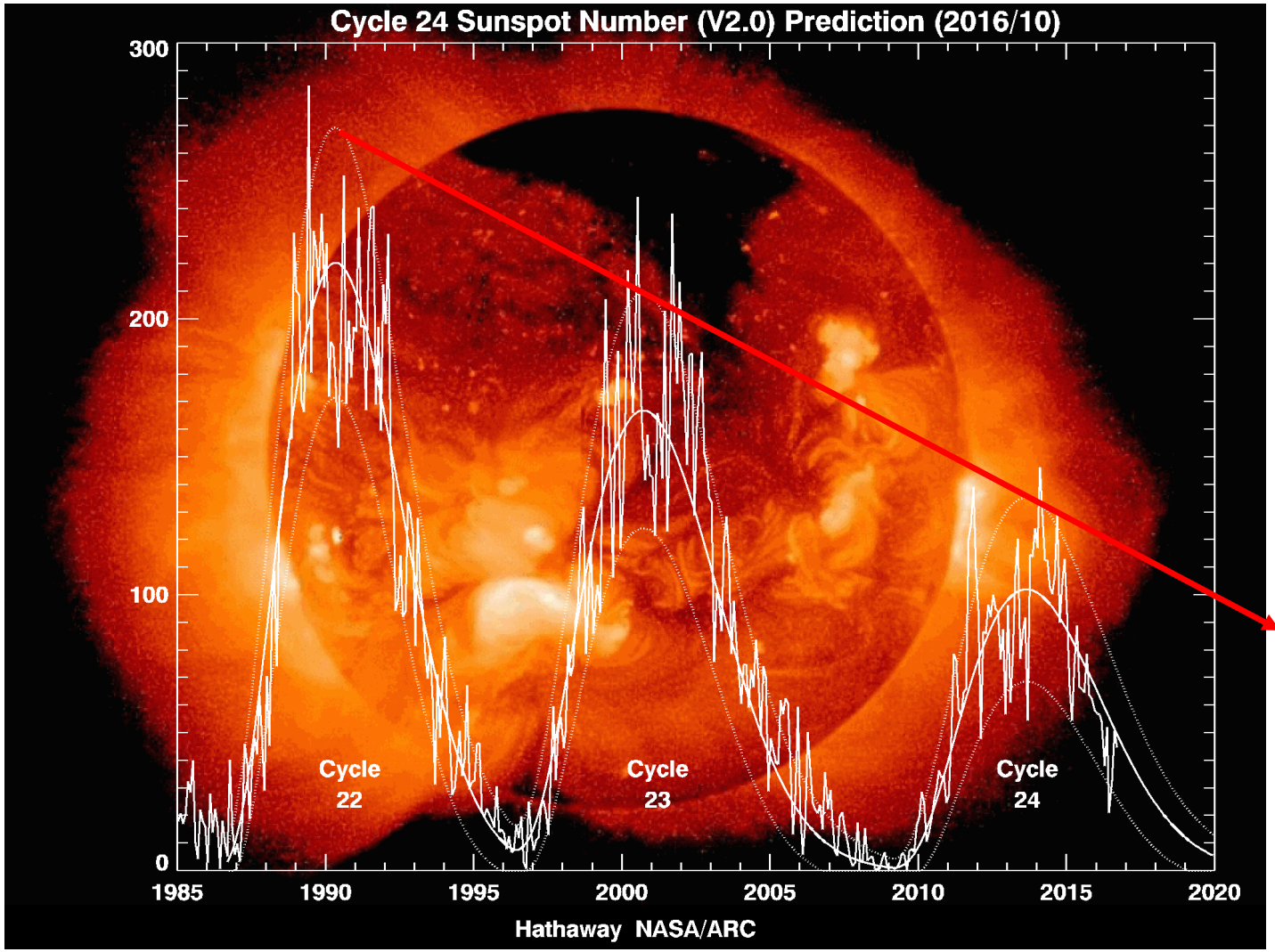
Very Low Solar Activity until 2021

Solar activity starts to slowly increase in 2020



Cycle 25 is likely to be somewhat stronger

Transmitting Antenna Elevation Angles Needed for Very Low Solar Activity

- **10 meters** - almost all DX openings are now to the south
  - almost all DX propagation is at low elevation angles **below 10 degrees**
  - marginal DX paths require very low elevation angles **well below 5 degrees**
- **15 meters** - shorter and weaker openings
  - almost all DX propagation is at low elevation angles **below 10 degrees**
  - marginal DX paths require very low elevation angles **well below 5 degrees**
- **20 meters** - a very crowded, very competitive daytime band
  - almost all DX propagation is at low elevation angles **below 15 degrees**
  - marginal DX paths require very low elevation angles **well below 10 degrees**
- **40 meters** - a very crowded, competitive afternoon and night band
  - almost a 24 hour DX band especially during the November CQWW CW
  - **requires a broad range of elevation angles** **5 to 25 degrees**
- **80 meters** - a very important DX band for the next four years
  - very efficient antennas over a broad range of angles **10 to 30 degrees**
- **160 meters** - an excellent DX band for the next four years
  - **vertical antennas** *almost always* provide much better DX performance

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High horizontally polarized antennas are much more important during very low solar activity

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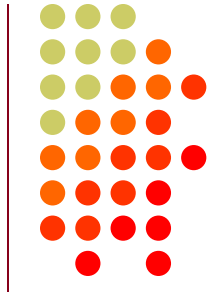
6 dB of "Free" Ground Gain



- 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*
- Vertically polarized antennas can 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

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Horizontal antennas easily achieve 6 dB of ground gain when installed at proper heights

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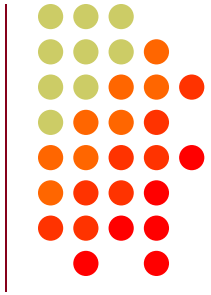
Vertical Polarization for 160 Meters



- 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

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Verticals *almost always* provide better DX performance than horizontal 160M antennas

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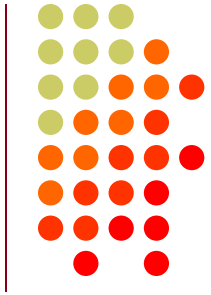
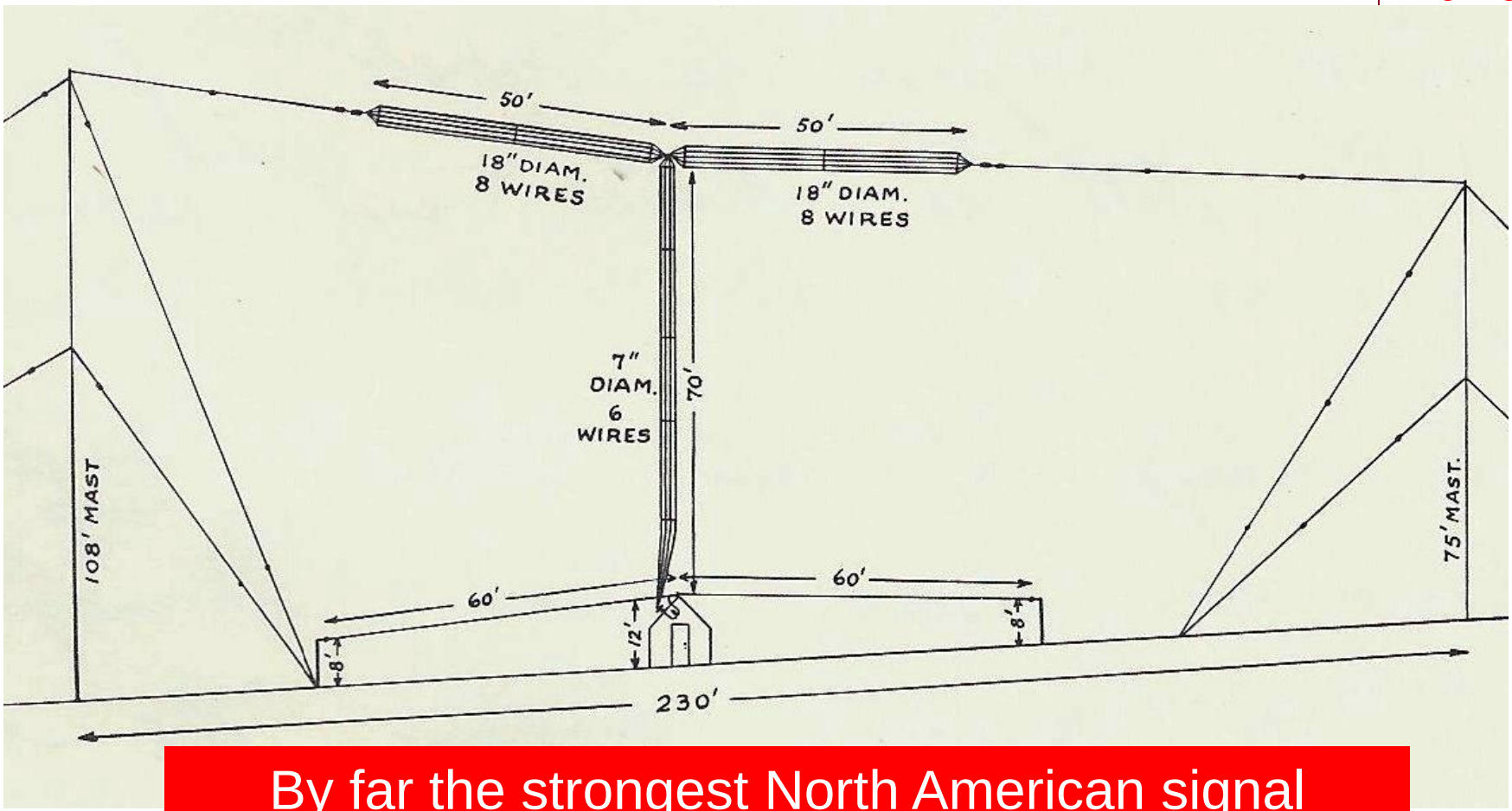
High Performance Transmitting Antennas for 160 Meter DX



- 125 foot vertical: the gold standard 160 meter DX antenna
  - well spaced from all nearby tall towers and antennas
    - at least 140 feet 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 during the Successful 1921 Transatlantic Tests



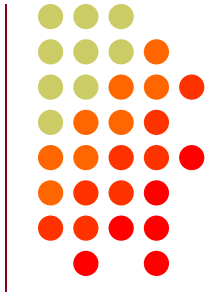
By far the strongest North American signal heard in Europe during the Transatlantic Tests

Horizontal Polarization for 80 Meters

easily provides 6 dB of “free” ground gain

- Horizontal dipole or inverted-V dipole at least 50 feet high
  - superb Sweepstakes and Field Day antenna
  - 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 corner fed inverted-U
  - vertical antennas 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

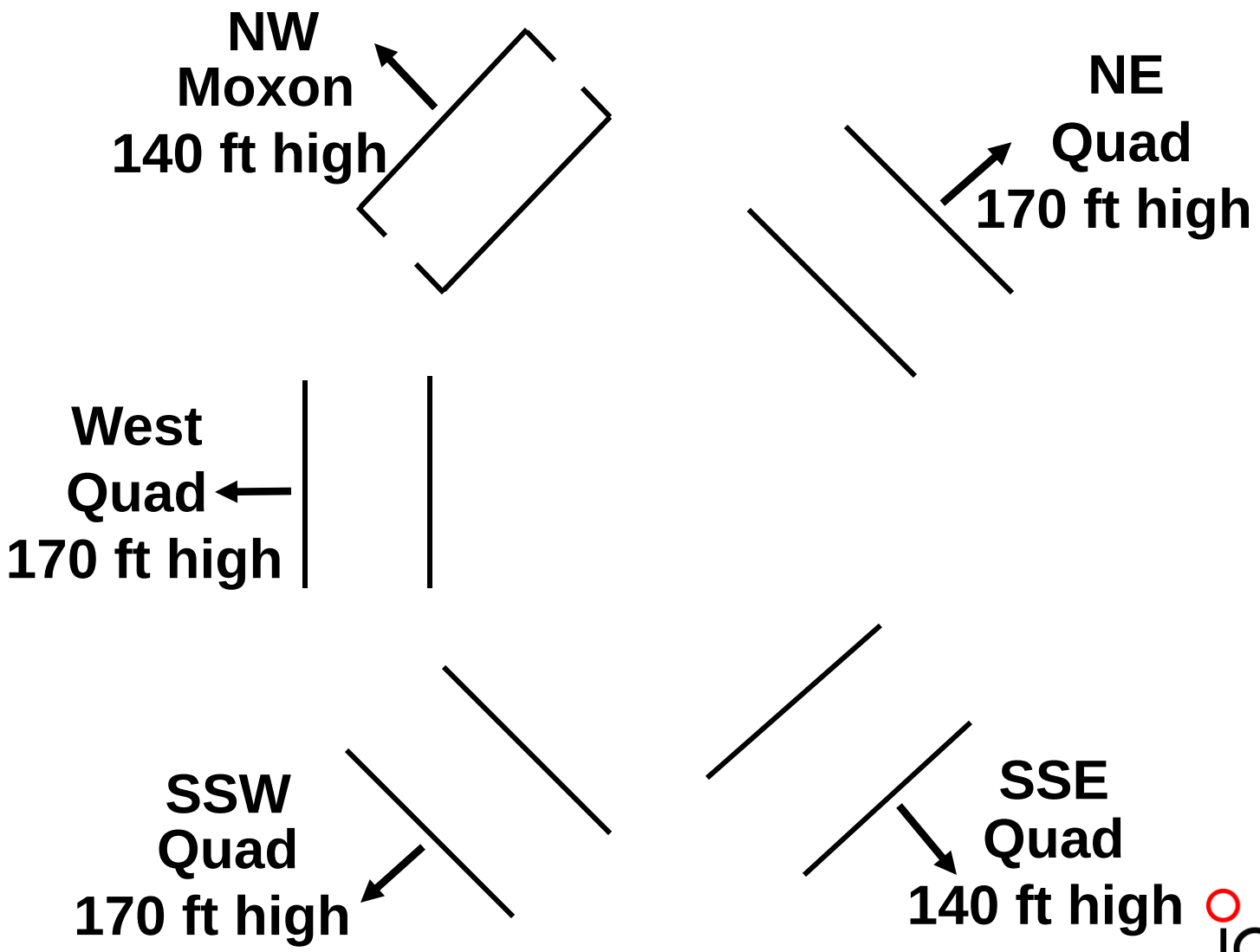


- Horizontal dipole at least 70 to 100 feet high
  - higher is better
- 65 foot vertical
  - install at least 30 to 60 shallow buried 65 foot radials
    - or at least two (preferably four or more) elevated 65 foot radials
      - only if shallow buried radials are not possible
  - verticals are very 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

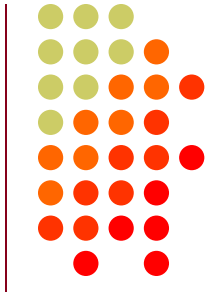
K3ZO's very successful horizontally polarized 3 element Yagi changed my thinking about 80 meter antennas for DX

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

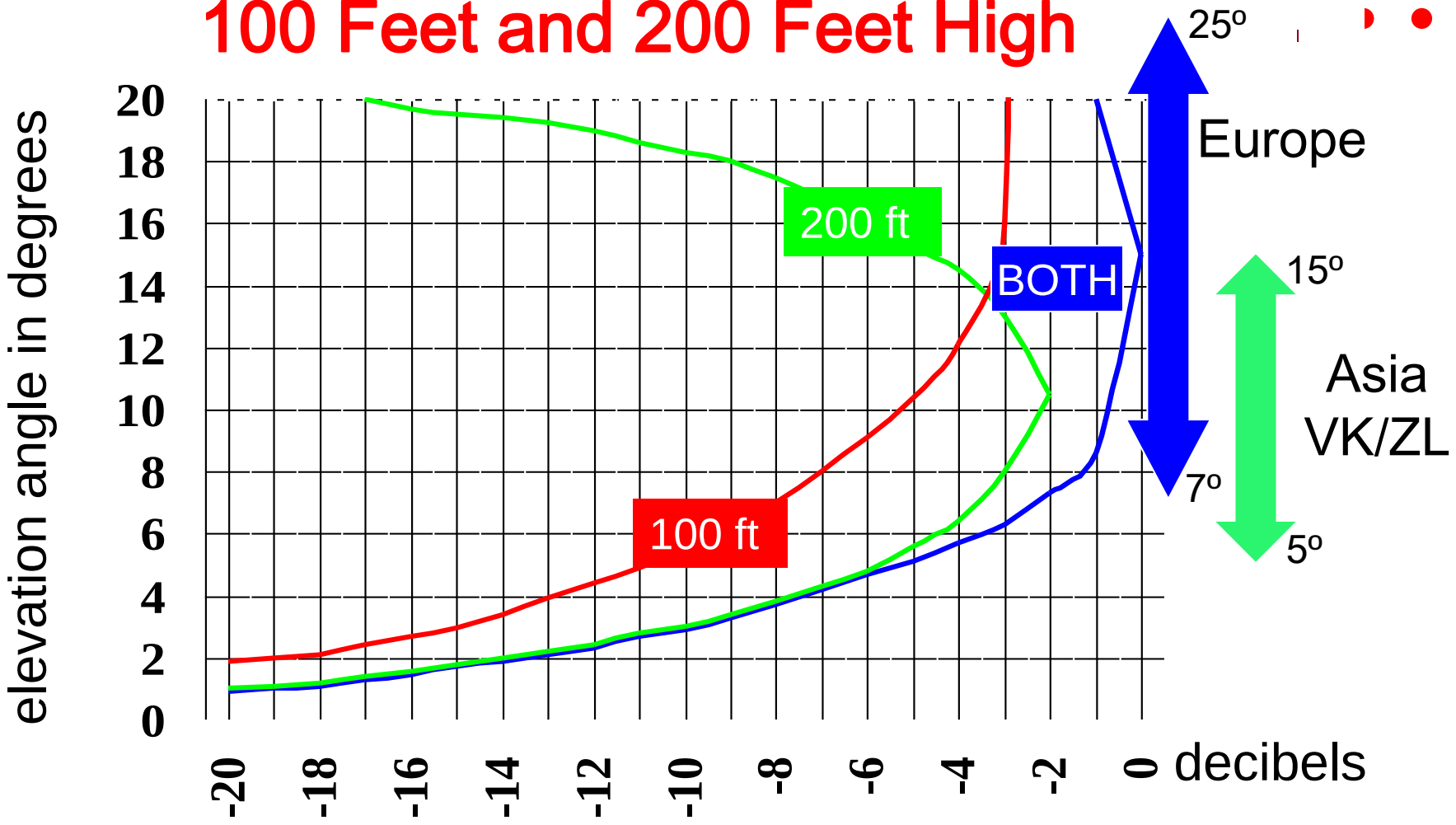
www.dxengineering.com/search/brand/comtek

High Performance 40M Antennas

- Horizontal dipole at least 70 feet high
  - 13 to 45 degree elevation beam 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 beam 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 the effort !

Elevation angles from 5º to 25º are needed

Stacked 3 Element 40 Meter Yagis
48 Foot Booms
100 Feet and 200 Feet High



Elevation angles from 5º to 25º are needed

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

Shortly after testing his new 40 meter Yagi, W9LM removed his 40 meter phased verticals

Cushcraft XM-240
2 Element 40 Meter Yagi

The most popular “Shorty Forty” Yagi

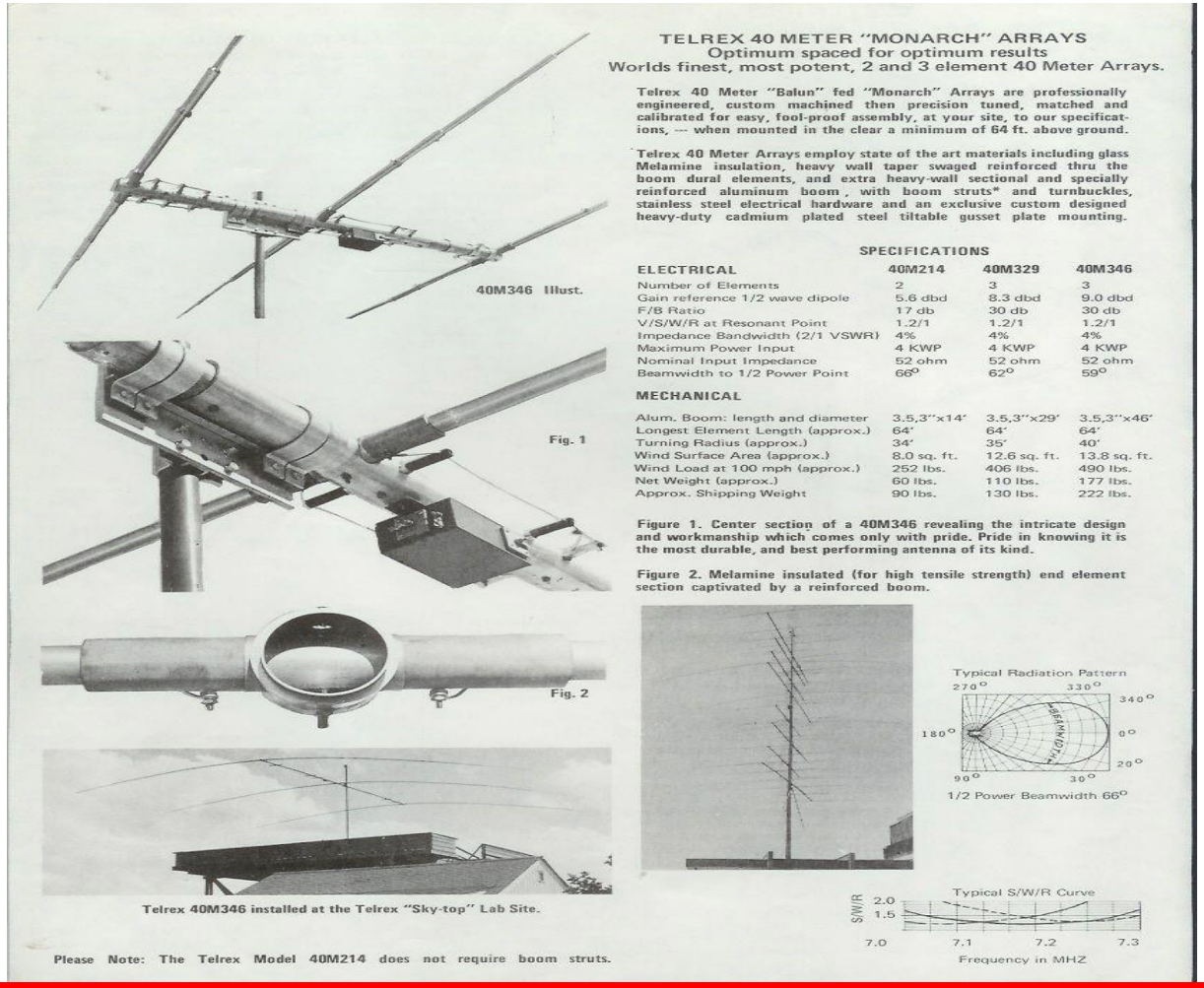
www.cushcraftamateur.com/Product.php?productid=XM-240

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.

40M346 Illust.

Fig. 1

Fig. 2

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

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

SPECIFICATIONS

ELECTRICAL	40M214	40M329	40M346
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°
MECHANICAL			
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
270° 330° 340° 180° 0° 20° 90° 30°
1/2 Power Beamwidth 66°

Typical S/W/R Curve
SWR 2.0 1.5
7.0 7.1 7.2 7.3
Frequency in MHZ

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

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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

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k9ct.us/contest-antennas/40-m

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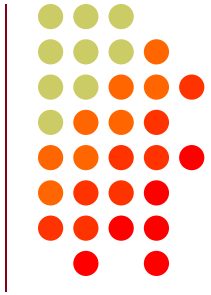
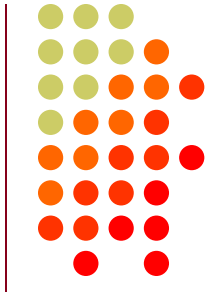
40 Meter 4-Square Vertical Array



- 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 receiving antenna

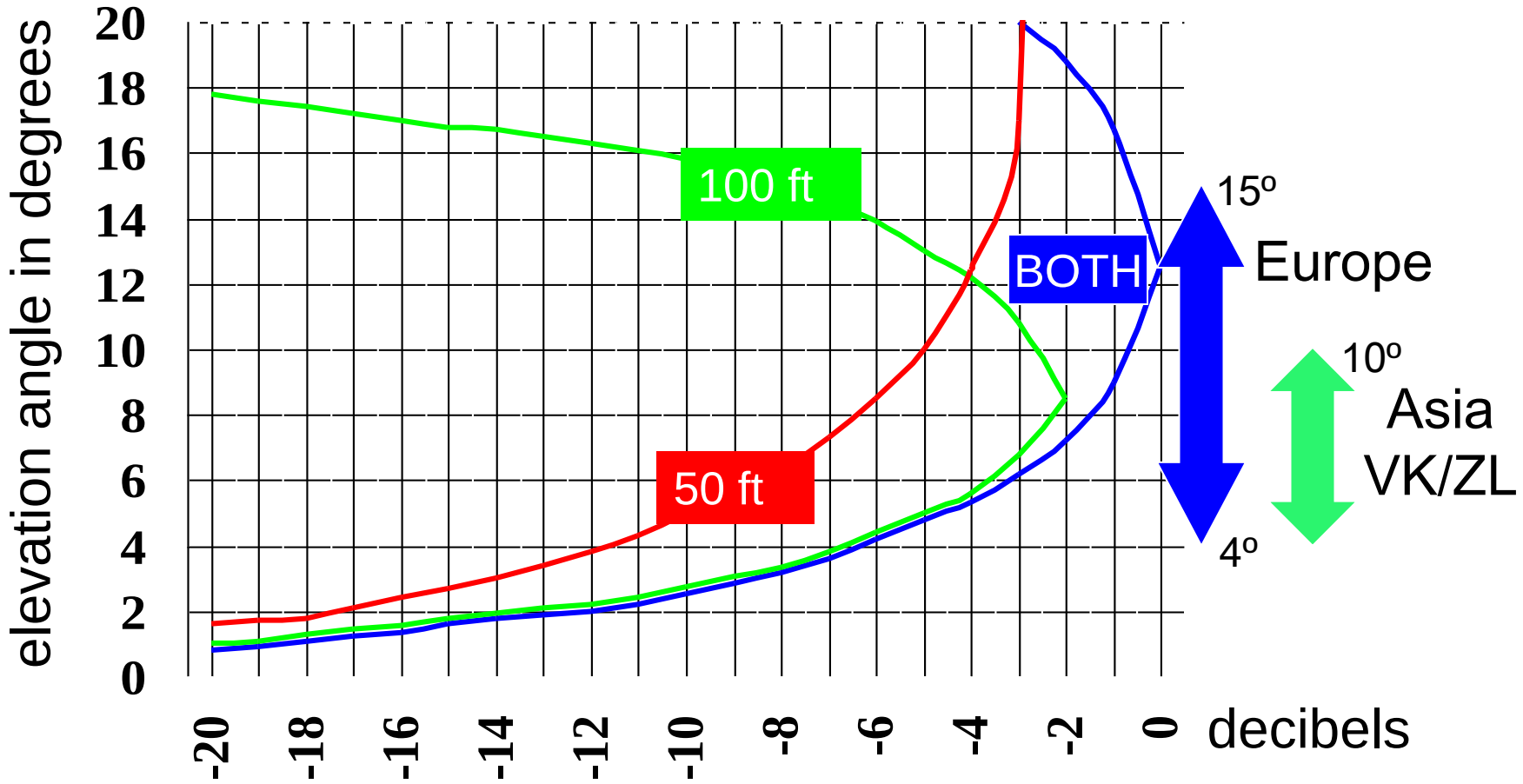
High Performance 20M Antennas



- 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

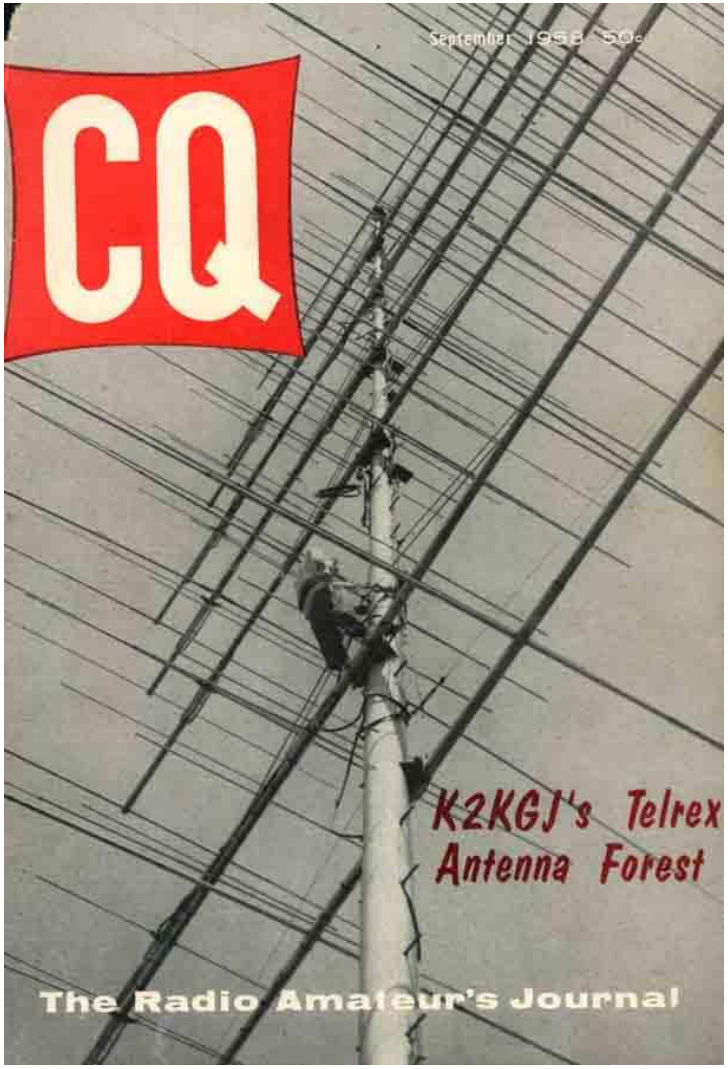
Elevation angles from <5º to 15º are needed

Stacked 5 Element 20 Meter Yagis
48 Foot Booms
50 and 100 Feet High



Elevation angles from <5º to 15º are needed

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

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www.arraysolutions.com/Products/stackmatch.htm

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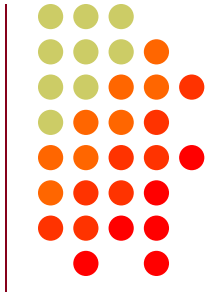
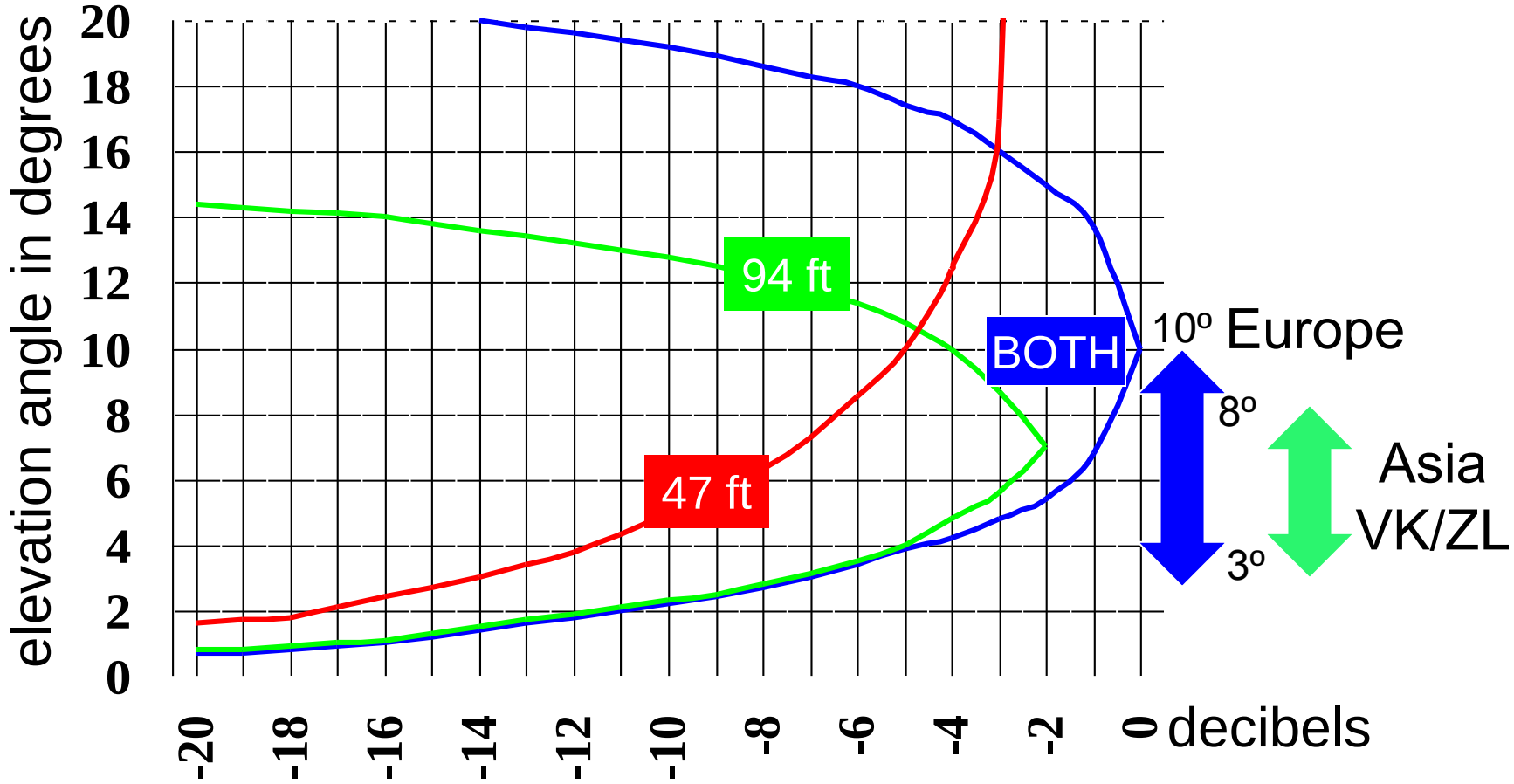
High Performance 15M Antennas



- 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* 4 to 25 degree elevation beam patterns at -3 dB points
  - stack switching (a “Stackmatch”) provides high payoff at low cost

Elevation angles from <5º to 10º are needed

Stacked 6 Element 15 Meter Yagis
48 Foot Booms
47 and 94 Feet High



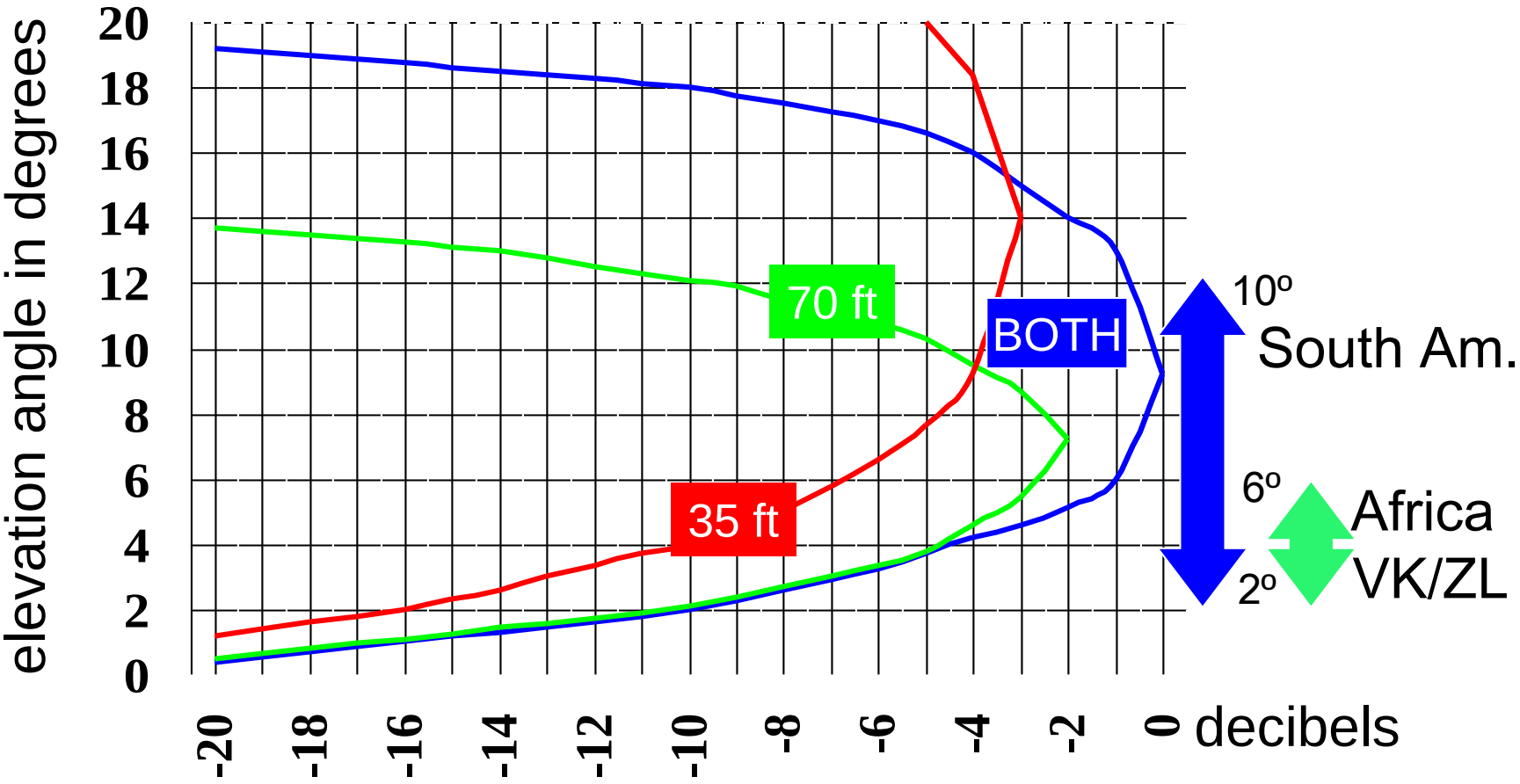
Elevation angles from <5º to 10º are needed

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 25 degree elevation beam patterns at -3 dB points
  - stack switching (a “Stackmatch”) provides high payoff at low cost

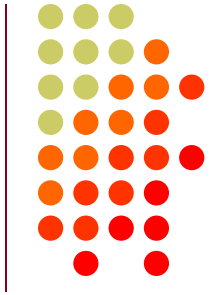
Elevation angles from <5º to 10º are needed

Stacked 6 Element 10 Meter Yagis
36 Foot Booms
35 and 70 Feet High



Elevation angles from <5º to 10º are needed

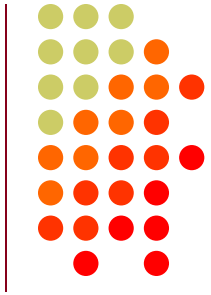
Competitive One Tower Antenna Systems



- 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 or a Moxon
  - 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 or a Moxon
  - monoband Yagis such as the Hy-Gain LJ series on ring rotators
  - 80 meter dipole and 160 meter inverted-L

Multi-Tower Antenna Systems

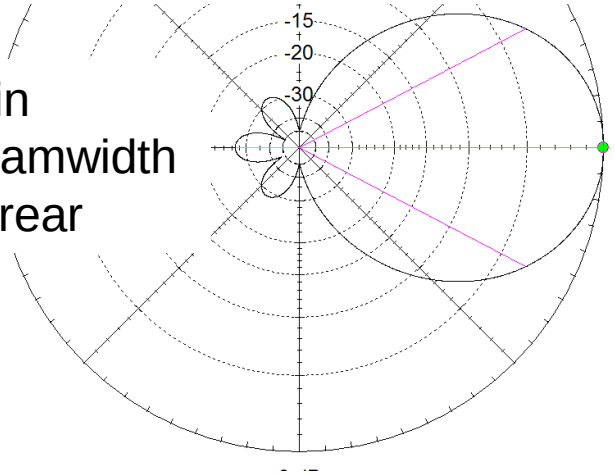
Designing a multi-tower station with acceptable degradation is an antenna modelling challenge



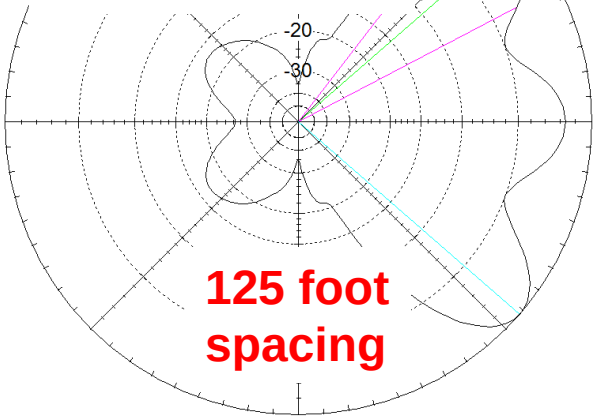
- Placement of Yagis and the relative location of the towers to minimize degradation is critical to achieving high performance
  - in most cases multiple *Triband Yagis* and multiple Yagis for the same band should be installed *on only one tower*
  - placing them *on multiple towers* requires detailed antenna modelling
- An excellent design for two towers with minimal 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

20M 6 Element Stacked Yagi Array Pointing Through an Identical Stack

17.8 dBi gain
55º 3 dB beamwidth
27 dB front/rear

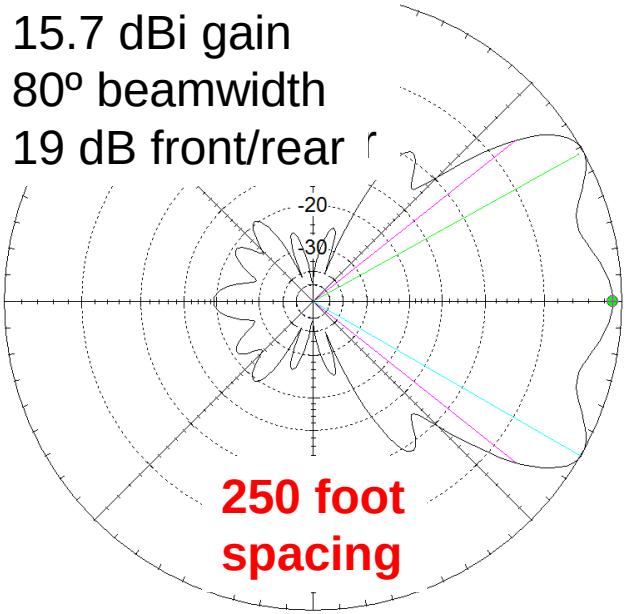


14.3 dBi gain
100º beamwidth
16 dB front/rear



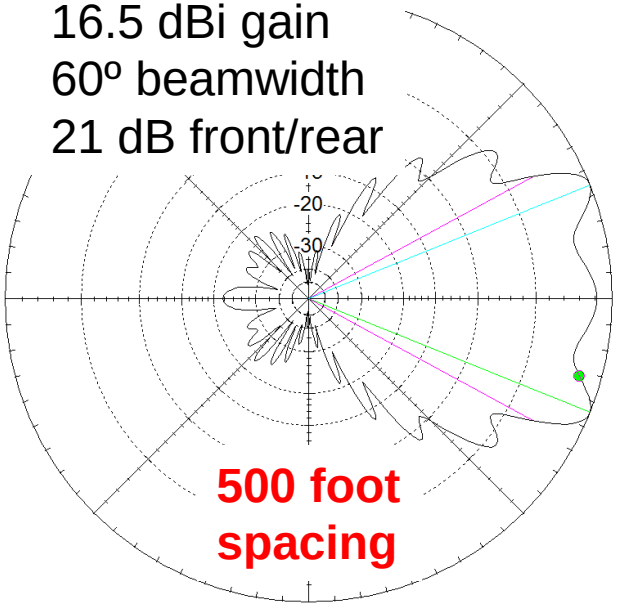
125 foot spacing

15.7 dBi gain
80º beamwidth
19 dB front/rear



250 foot spacing

16.5 dBi gain
60º beamwidth
21 dB front/rear



500 foot spacing

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When Good Antennas Go Bad…

antenna system design issues

- Yagi director installed too close to the tower face
  - spacing less than one tower diameter shortens effective director length
- 80 meter dipole installed 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 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 more than one tower without detailed modelling

When Good Antennas Go Bad…

coaxial cable issues

- Improperly installed connectors
- PL-259 connectors not 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 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

Amphenol 83-1SP
PL-259 Connector

Shell is labeled exactly:
Amphenol 83-1SP

Silver Plated
Center Pin

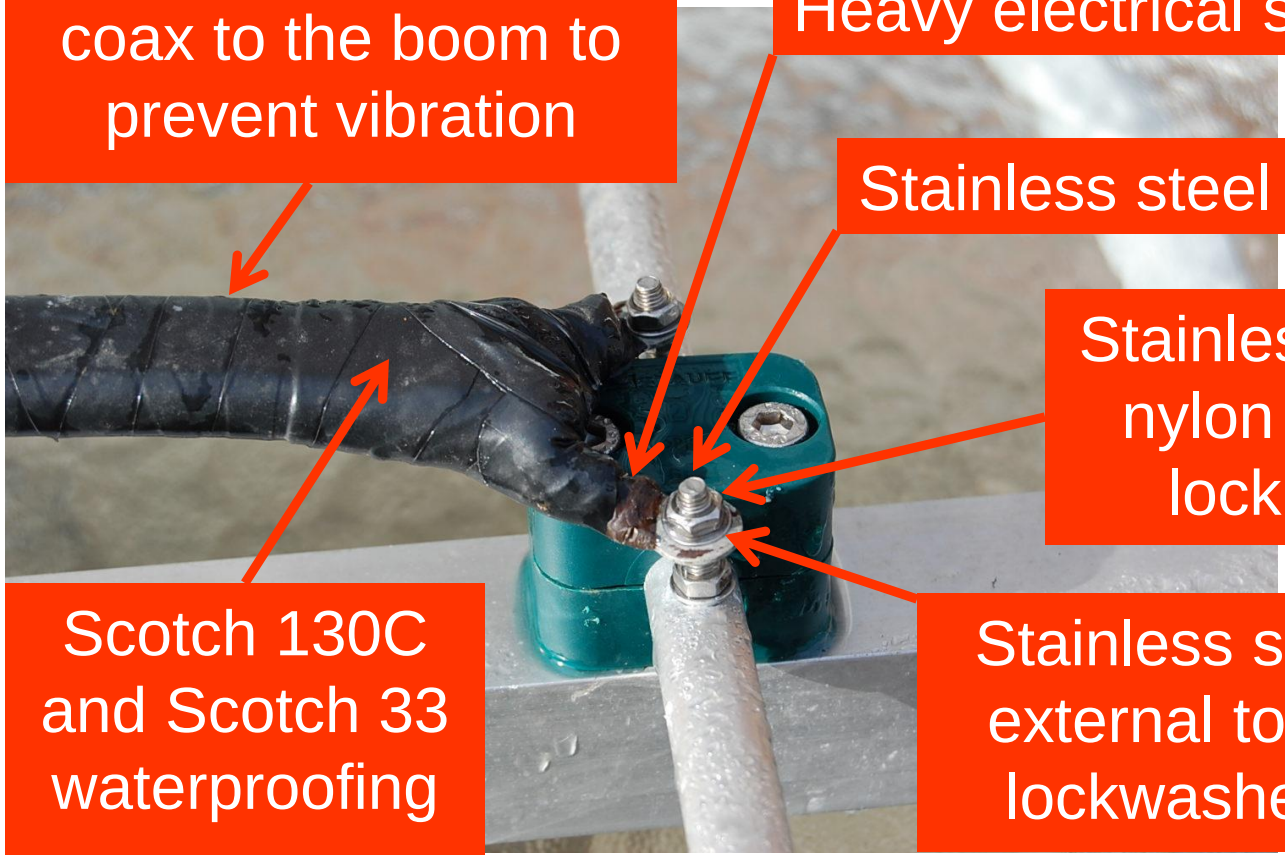
Silver Plated
Body

www.dxengineering.com/parts/aml-83-1sp

This is not a good place to save a few dollars

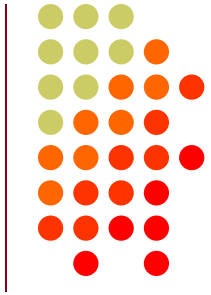
Antenna Feedpoint

Waterproof and Shakeproof Connections



When Good Antennas Go Bad…

Performance Evaluation, Inspections and Preventive Maintenance



- Maintaining competitive antenna performance
  - antenna performance evaluations
  - tower inspections
  - guy wire inspections
  - rotator inspections
  - coaxial cable inspections
  - coaxial connector inspections