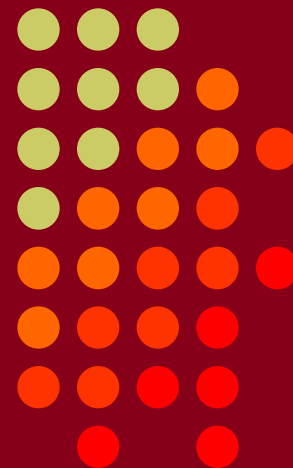


# Improving your 40 through 10 Meter Antennas for the Declining Solar Cycle

- Horizontally polarized antennas
- Single Yagi stations
- Single tower stations
- Stacked Yagis
- Care and feeding of coaxial cables



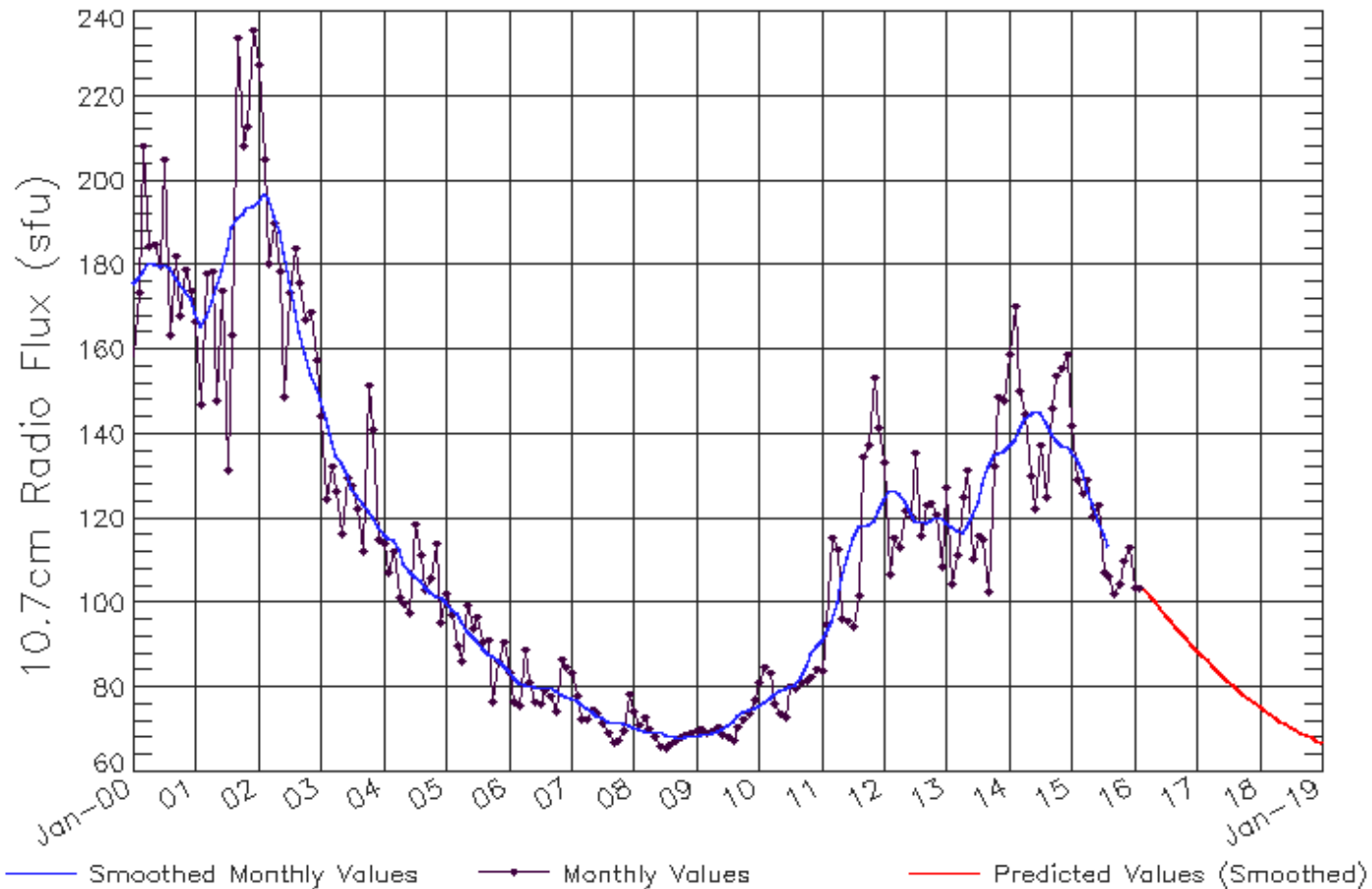
• CTU •  
CONTEST  
UNIVERSITY

ICOM®



# Two More Years of Declining Solar Activity Then Three+ Years of Solar Minimum

ISES Solar Cycle F10.7cm Radio Flux Progression  
Observed data through Feb 2016



CTU Updated 2016 Mar 7

CONTEST  
UNIVERSITY

NOAA/SWPC Boulder, CO USA

ICOM®

# What About Solar Cycle 25 ??

## Precursors of a *possibly* weak Solar Cycle 25

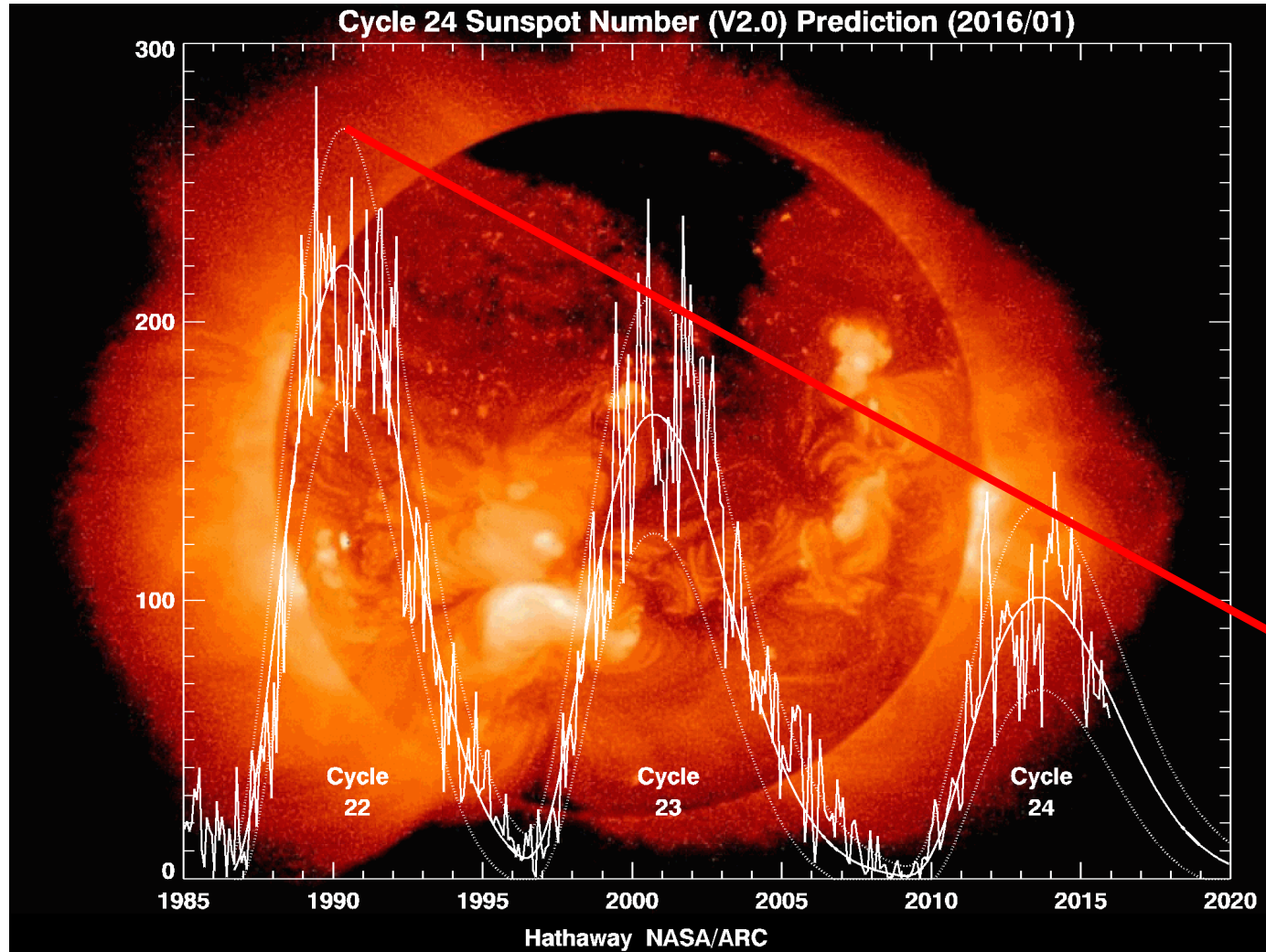


- Unusually weak solar polar magnetic field strengths
  - field strengths should reach their peak between 2018 and 2020
    - [www.solen.info/solar/polarfields/polarfields.jpg](http://www.solen.info/solar/polarfields/polarfields.jpg)
- Unusually large numbers of spotless days
  - possibly starting later this year or next year
- Unusually quiet geomagnetic field from 2018 to 2020+
  - reported by the A-index
- Unusually late appearance of new Solar Cycle 25 sunspots
  - new Solar Cycle 25 sun spots should appear by 2020
- Unusually long solar minimum
  - solar flux in the low 70s persisting after 2020

**Accurate Cycle 25 forecasting is not possible  
until about three years *after* solar minimum**

# Declining Solar Activity Since Cycle 22

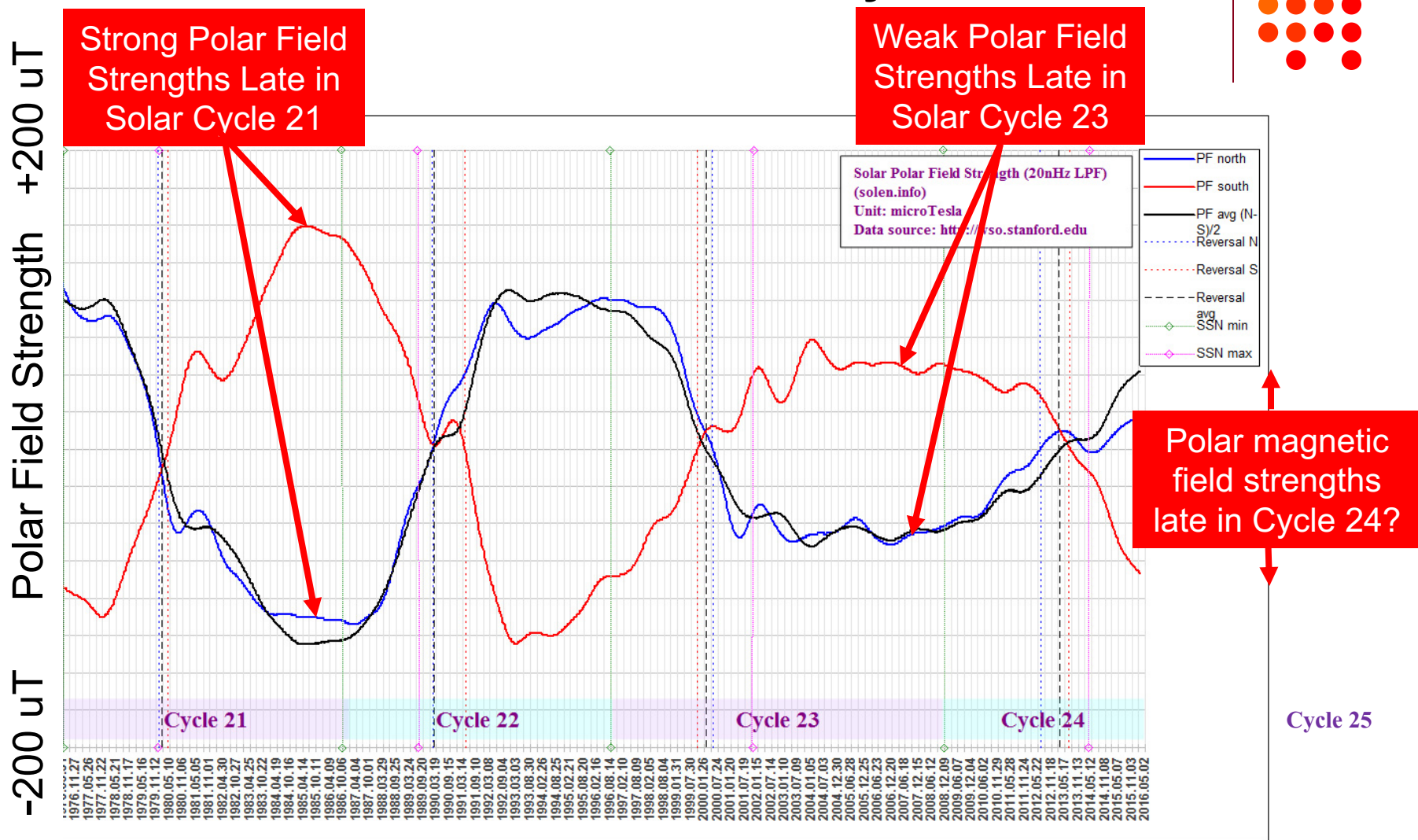
## *Suggests a Weak Solar Cycle 25*



Cycle 25?

# The Sun's Polar Magnetic Field Strength

## A Reliable Precursor of Solar Cycle 25



# 6 dB of “Free” Ground Gain



- A horizontally polarized dipole, Yagi or quad easily provides 6 dB of useful ground gain
  - but only if you install it at an appropriate height
  - vertical antennas can achieve equivalent ground gain only over highly conductive soil such as a salt marsh
- Stacked HF Yagis achieve higher gain mainly by suppressing undesired high angle radiation and redistributing the power into the main low angle beam
  - stacked Yagis must be installed at appropriate heights to achieve the expected results

# High Performance Antennas for 40 Meters



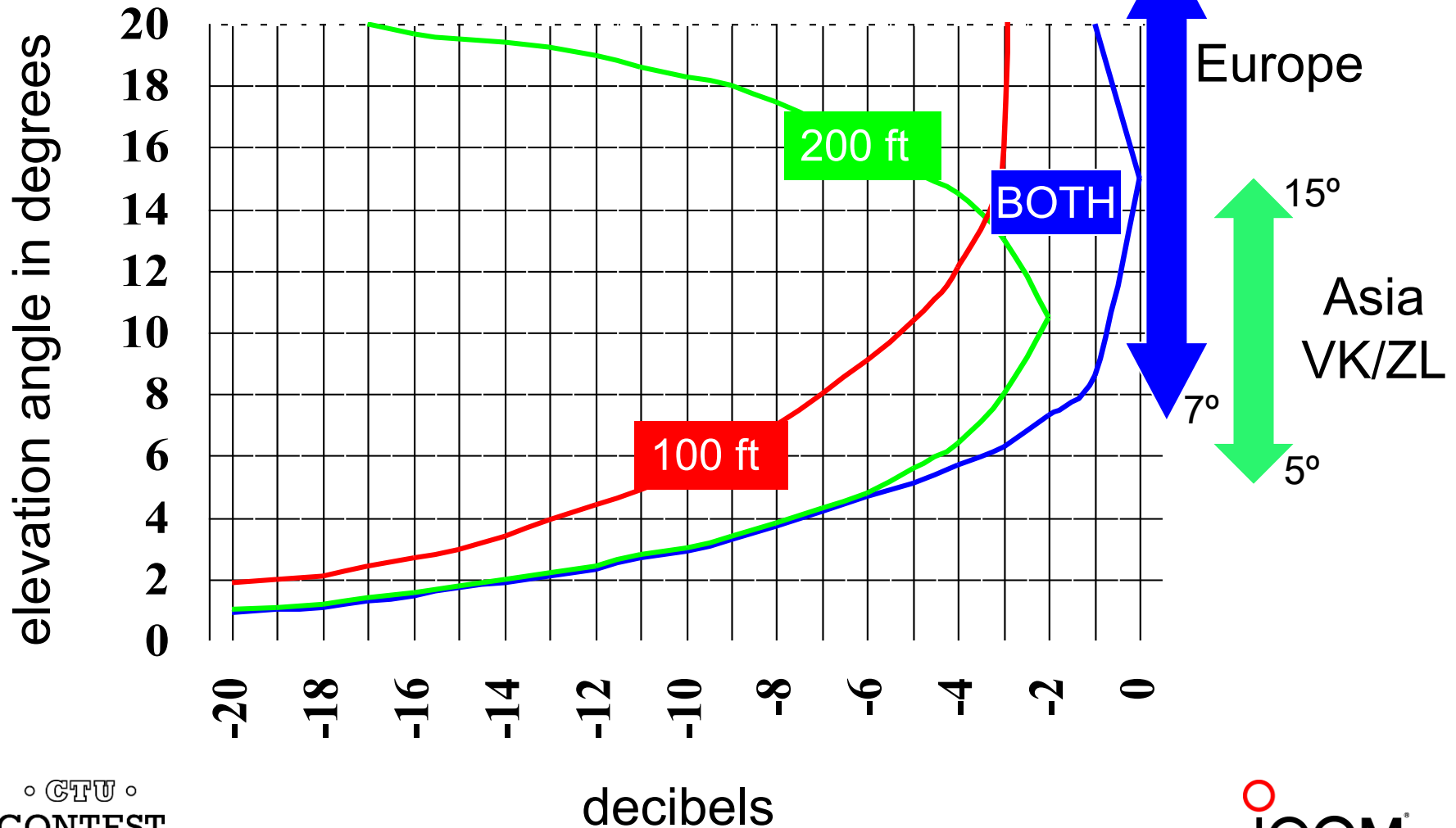
- High horizontal dipole at least 70 feet high for DX contests
  - otherwise use a four-square vertical array with 30-60 radials
  - 40-50 foot high dipole is excellent for Sweepstakes and Field Day
- Higher gain: 2 element Yagi at 70-100 feet high
  - significant improvement over a simple horizontal dipole for DX
  - a Cushcraft XM-240 at 70-100+ feet high is very cost effective
- Highest gain: full size 3 element Yagi at 100-140+ feet high
  - but don't underestimate the high cost and complexity of the effort !
- High performance receiving antennas
  - 200 foot Beverages
  - 4-square and 8-circle arrays of 14 foot verticals



# Stacked 3 Element 40 Meter Yagis

## 48 Foot Booms

### 100 Feet and 200 Feet High





# 4-Square Vertical Array for 40 Meters



- A 4-square vertical array is good alternative to a Yagi if you cannot install it at least 70 feet high
  - install a 4-square at least 40 feet from all towers
    - more spacing will significantly improve its performance
  - at least 30 to 60 slightly buried 35 foot radials under each vertical
- A 4-square is an excellent receiving antenna

# The Comtek 4-Square Controller



# High Performance Antennas for 20 Meters

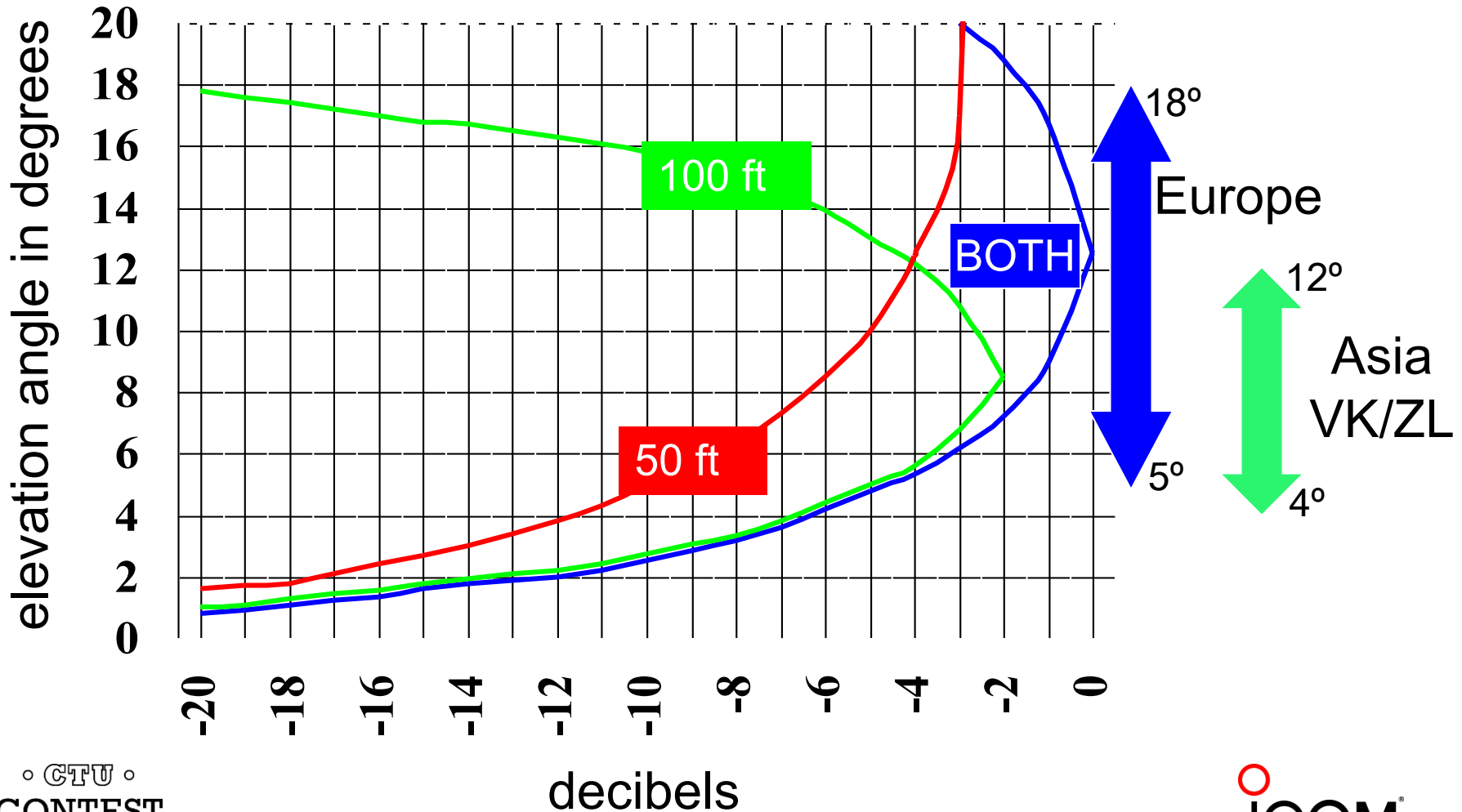
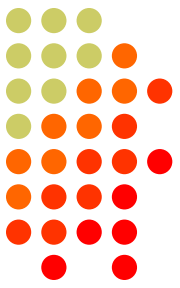


- A horizontal Yagi or quad is always the best choice
  - if you can install your antenna at 35 feet high or higher
  - otherwise use a four-square vertical array with 30-60 radials
- Moderate gain: small tri-band Yagi, hex-beam or quad
  - a small Yagi at 50 to 70 feet high will produce good DX results
  - a small Yagi at 35 to 50 feet high for Sweepstakes and Field Day
- High gain: full size tri-band Yagi, small monoband Yagi or quad at 70 to 100 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 100-140 foot tower (170 to 200 feet high for three stacked Yagis)
  - stack switching ( a “stackmatch”) provides high payoff at low cost

# Stacked 5 Element 20 Meter Yagis

## 48 Foot Booms

### 50 and 100 Feet High



# The Array Solutions Stack Match



# High Performance Antennas for 15 Meters

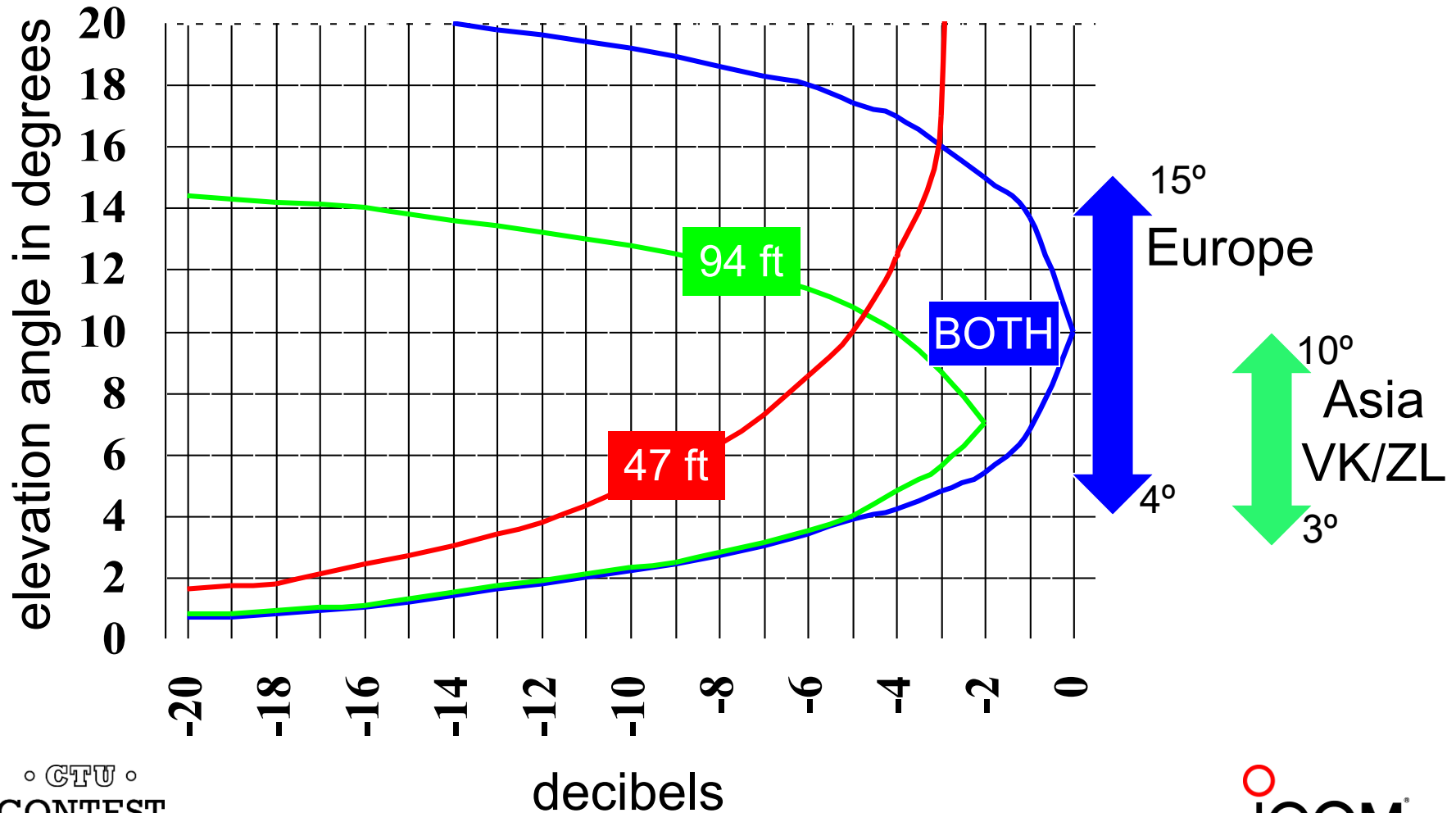


- Horizontal polarization is always the best choice
  - if you can install your antenna 35 feet high or higher
  - otherwise use a four-square vertical array with 30 to 60 radials
- Moderate gain: small tri-bander Yagi, hex-beam or quad
  - a small Yagi at 40 to 50 feet high will produce good DX results
  - a small Yagi at 30 to 50 feet high for Sweepstakes and Field Day
- High gain: a full size tri-band Yagi, small monoband Yagi or quad at 70 to 90 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on an 80-90 foot tower (120-140 feet high for three stacked Yagis)
  - 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 Antennas for 10 Meters

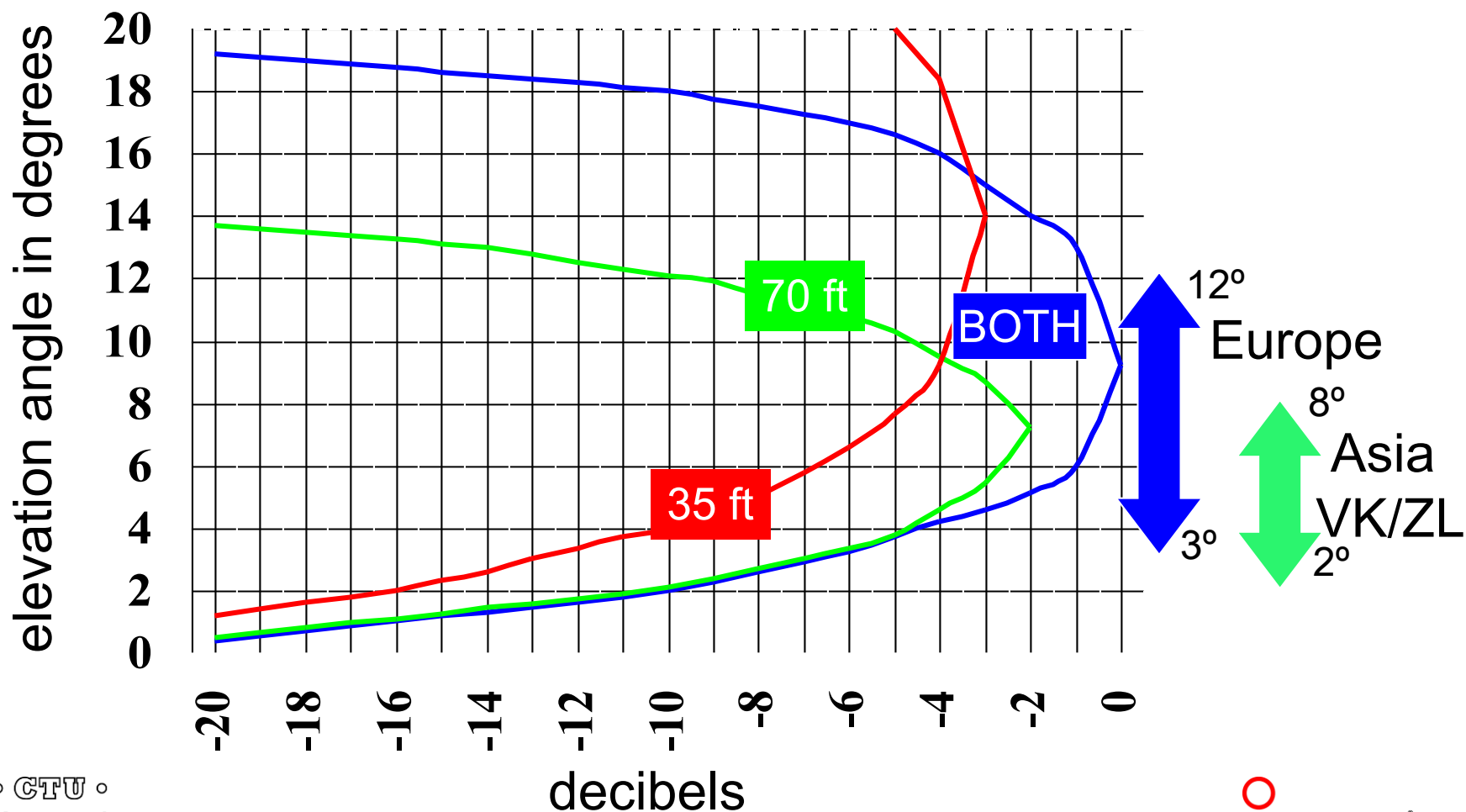


- Horizontal polarization is always your best choice
  - if you can install your antenna only 25 feet high or higher
  - otherwise use a four-square vertical array with 30 to 60 radials
- Moderate gain: small tri-band Yagi, hex-beam or quad
  - a small Yagi 25 to 50 feet high will produce good DX results
  - a small Yagi at 25 to 50 feet high for Sweepstakes and Field Day
- High gain: a full size tri-band Yagi, small monoband Yagi or quad, at 50 to 70 feet high for excellent DX results
- Highest gain: two stacked monoband Yagis on a 60-70 foot tower (90 to 100 feet high for three stacked Yagis)
  - stack switching ( a “stackmatch”) provides high payoff at low cost

# Stacked 6 Element 10 Meter Yagis

## 36 Foot Booms

### 35 and 70 Feet High

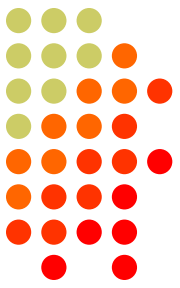


# Competitive One Tower Antenna Systems



- 50-60 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 a 160 meter inverted-L
- 70-80 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 a 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 a 160 meter inverted-L

# Achieving and Maintaining Low Loss Coaxial Cables



- Select appropriate low loss coaxial cables for each antenna
- Protect your investment
  - water entry and condensation are persistent, serious threats to the competitive performance of your station
- Hard-line (e.g., Heliax or 75 ohm CATV) coaxial cables are your best choice for cable runs longer than 100 feet
  - RG-213 and all other flexible jacket coaxial cables are very susceptible to physical jacket damage and water entry
    - a pin hole in the jacket can quickly cause a high loss cable
    - carefully protect your coax cables from physical damage and water entry
- Assure long term performance
  - test and inspect your cables and connectors at least annually

# Coaxial Cable Monetary Considerations



- The selection, installation and maintenance of coaxial cables and connectors should be among your most important investments when building and improving your competitive station
  - is the proper grade of coaxial cable worth your additional cost?
  - is attention to the many details of installation worth your extra effort?
  - is annual inspection to preserve your investment worth your effort?
- Yes
  - if you want trouble-free low loss coax cables for 25 years or longer
- No
  - if you don't mind the high cost and disappointment of catastrophic failure when you least expect it or are least able to repair it



# Coaxial Cable

## Environmental Considerations

- Constant exposure to wind, ice, water, condensation, heat, cold, ultra-violet radiation and lightning strikes
- Flexible jackets of RG-213 and LMR-400 flexible coaxial cables are easily damaged during feedline installation, antenna installation, tower maintenance, wind, ice, UV and lightning
  - **never** use 9913 air dielectric coax or similar “water hose”
  - **never** use foam dielectric flexible coaxial cable outdoors
    - except Davis RF Bury-Flex
- Heliax and jacketed CATV hardline are highly resistant to environmental damage and provide 25 years of service
  - **If no installation errors are made**
  - **if you perform annual inspections to detect problems early**

# UHF Coaxial Cable Connectors



- N and UHF connectors are the most commonly used
  - both have insignificant loss at 50 MHz and below
- High quality silver plated PL-259 connectors provide much more center pin mating force than N connectors
  - eliminates cross-station interference and N connector failures from:
    - unreliable center pin mating force and common pin alignment failures
    - installation errors (e.g., incorrect pin depth, misalignment and pullback)
- Avoid using adapters as much as possible
  - but if necessary use only name-brand silver plated adapters
  - never use nickel plated or “astro-plated” connectors and adapters
  - never use cheap import “no name” adapters and connectors
- Wrench tighten your all of your PL-259 connectors (1/4 turn)



# Amphenol 83-1SP PL-259 Connector



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

[www.dxengineering.com/parts/aml-83-1sp](http://www.dxengineering.com/parts/aml-83-1sp)

# Coaxial Cables

## 83-1SP Connector Installation



[www.k3lr.com/engineering/pl259](http://www.k3lr.com/engineering/pl259)

# Connector Waterproofing



Cover your connectors with two 50% overlapped layers of Scotch 130C stretched to 50% of its original width, **sticky side facing out**

Cover the Scotch 130C with two 50% overlapped layers of Scotch 33+ or Scotch 88

# Antenna Feedpoint

## Waterproof and Shakeproof Connections



# Coaxial Cables Can Make or Break Your Competitive Performance



- How well you select, install, waterproof, inspect and maintain your coaxial cables and connectors can make or break the competitive performance of your contest station
- Cross-station interference in multi-operator and SO2R stations is often caused by
  - failure to properly tighten your PL-259 coaxial connectors
    - wrench tighten ¼ turn
  - inappropriate or failing outdoor coaxial cables or connectors
    - never use type-N connectors below 50 MHz
  - nickel plated, cheap low quality imported connectors and adapters
  - poor connector installation workmanship
  - failure to perform annual inspections and regular maintenance

# Low Loss Coaxial Cables for Single Operator Stations



- Cable loss, proper installation, water proofing and annual inspections are the most important concerns for single operator stations
  - Andrew LDF4-50A 50 ohm Heliax and connectors are commonly available at hamfests and eBay for ~ \$1.00/foot
    - Less than 1 dB of loss on 10 meters for lengths up to 300 feet
  - If you must use flexible coaxial cable on your tower, Davis RF Bury-Flex is an acceptable alternative for single operator stations only, at about the same price.
    - **never** use any other type of foam dielectric flexible coaxial cable
  - Non-flooded coax such as RG-213 and LMR-400 has short service life in the harsh environment on a tower
    - especially on the rotating cable loop above a rotator
    - **never** direct bury RG-213 or LMR-400 or lay it on wet ground

# Low Loss Coaxial Cables for Multi-Op and SO2R Stations



- Andrew LDF4-50A ½ inch Heliax and 3/4 inch CATV cable are ideal choices for lengths up to:
  - 300 feet on 10 meters
  - 400 feet on 20 meters
  - 600 feet on 40 meters
- Eliminate the most common cross-station RFI sources:
  - Heliax avoids RFI caused by dissimilar metals corrosion in aluminum foil and tinned braid shields of Davis RF Bury-Flex cable
  - Avoid signal coupling between single braid shielded RG-213 coaxial cables by not bundling them or running them together in conduits
  - Use the smallest possible number of connectors and adapters
    - use only brand name silver plated UHF connectors and adapters
    - never use nickel plated or cheap no-name connectors and adapters



# Low Loss Coaxial Cables for Multi-tower Stations



- Multi-tower stations often use coax cables longer than 300 ft
- Andrew LDF5-50A 7/8 inch Heliax is an ideal choice for lengths up to:
  - 500 feet on 10 meters
  - 600 feet on 15 meters
  - 700 feet on 20 meters
  - 1000 feet on 40 meters
- Be cautious of the wind load and weight (including ice load) of multiple large diameter coaxial cables fastened to light duty towers such as Rohn 25 and 45

# Coaxial Cable Installation on your Tower



- Wind, ice, water, condensation, heat, cold, ultra-violet radiation and lightning strikes are important concerns
  - If any of these conditions are unusually severe in your environment, implement additional protective measures
- Heliax and CATV hardline must be firmly fastened to the tower at least every five feet to protect them from wind and ice damage
- Flexible coaxial cables (e.g. RG-213) should be firmly attached to the tower at least every two or three feet to protect them from wind and ice damage
- Use electrical tape to protect plastic tie-wraps from ultra-violet radiation

# Coaxial Cable Interface to the Top of your Tower



- Coaxial cables must be bonded (“grounded”) to the top of your tower
  - prevents the coaxial cable jacket from developing pinholes caused by cable-to-tower arcing during lightning strikes
- Connectors must be carefully placed and waterproofed
  - so that water cannot not flow down the outside of your coaxial cables then directly into your connectors

# Coaxial Cable Interface to the Bottom of your Tower



- Tower mounted coaxial cables must be bonded (“grounded”) to your tower base
  - prevents the coaxial cable jacket from developing pinholes caused by cable-to-tower arcing during lightning strikes
- An effective ground system must be connected to your tower base to strip lightning currents from your cables before they flow down the cable shields into your station
  - A *minimum* of three 8-foot galvanized steel ground rods
  - spaced at eight feet from each other and from the tower base
- Connectors must be carefully placed and waterproofed
  - so that water cannot not flow down the outside of the coaxial cables then directly into your connectors

# Buried Coaxial Cables



- Direct Burial
  - use only coaxial cable that is rated for direct burial
    - Andrew Heliax, jacketed CATV cable or Davis RF Bury-Flex
  - PVC jacketed coaxial cable should never be direct buried or laid on wet ground
- Conduit
  - use oversized conduit with plenty of room for cable pulling
  - use sweeps, not sharp right angle connectors
  - use appropriate methods to drain moisture from the conduit
  - prevent water and vermin entry into conduit entrances
  - use only Heliax cables in multi-op and SO2R stations
    - bundled single shielded coax can cause cross-station RFI

# Antenna Rotation Coax



- Your antenna rotation coaxial cable is exposed to the most extreme environmental conditions in your station
- Carefully prevent the coax from rubbing or pulling against the tower or any other objects that could damage it when rotating the antenna or when blown by strong wind
  - rotators with more than 360 degrees of rotation make this extremely difficult to achieve
- Use only new, name brand, high quality RG-213
  - 95% shielded, stranded center conductor, solid dielectric, black UV-resistant jacket
- Replace your coaxial cable when needed
  - whenever you discover abrasion, damage or degradation during your annual inspections
  - replace at least once every ten years

# Single Point Ground at the Cable Entry into your Station



- Your station cable entry interface should establish a single point ground as close as possible to the outside wall of your building
  - a minimum of three 8-foot ground rods near your cable entry
  - spaced at least eight feet from each other in undisturbed soil
- Your single point ground strips lightning currents off of the coaxial cable shields before they enter your station
- Lightning protectors should be installed at your station single point ground
  - **never install lightning protectors at your tower base**



# Coaxial Cables

## Inside your Station



- RG-213 is much more practical than Heliax cable
  - RG-223 and RG-400 are excellent choices for small diameter coax
- Eliminating cable, connector and adapter related cross-station interference in SO2R and multi-operator stations
  - never bundle single shielded coaxial cables such as RG-213
    - avoids cross-cable signal coupling between single shield coaxial cables
    - use double shielded coax if you must bundle your coaxial cables
  - use only PL-259 connectors **and never N connectors** for much better connector reliability and higher center pin contact pressure
    - use only high quality Amphenol 83-1SP silver plated PL-259s
    - use K3LR's excellent PL-259 installation technique
  - avoid nickel plated and cheap low quality imported adapters
    - high quality silver plated adapters are available from DX Engineering

# Annual Coaxial Cable Inspections



- Inspect all indoor and outdoor coaxial cables, connectors and waterproofing for evidence of damage, cuts, cracks, moisture intrusion and improper installation
  - antenna feed point connection (wear and water intrusion)
  - antenna rotation coaxial cable (chaffing and wear)
  - tower top connectors and bonding to tower
  - tower base connectors and bonding to tower
  - all coaxial cable connectors and adapters in your station
  - all SO-239 chassis connectors on your station equipment
- If in doubt, remove the connector for detailed inspection
- Verify that all indoor and outdoor PL-259 connectors are wrench tightened  $\frac{1}{4}$  turn

# Coaxial Cable

## Measurements Inside Your Shack



- Make a record of the following measurements at the ham shack end of every coaxial cable:
  - VSWR across the entire band(s)
  - center conductor to shield resistance
    - typically either a fraction of one ohm or many megohms
  - TDR and/or VNA plots
    - serious station builders should own (and use!) a TDR and a VNA
- **Well before** your next competitive contest, verify that all measurements are unchanged and not erratic
  - any change (better or worse) requires detailed investigation
- Use a digital wattmeter in your station to allow you to quickly detect and diagnose abnormal operation