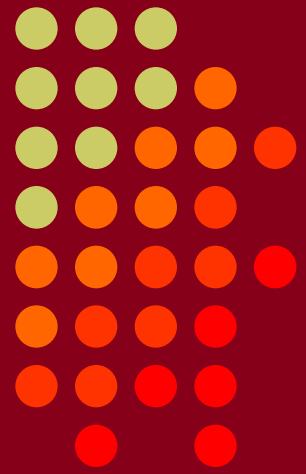
Improving Your 160 and 80 Meter Antennas for the Declining Solar Cycle

- Vertical polarization on 160 meters
- Horizontal polarization on 80 meters
- Small receiving antennas
- High performance receiving antennas



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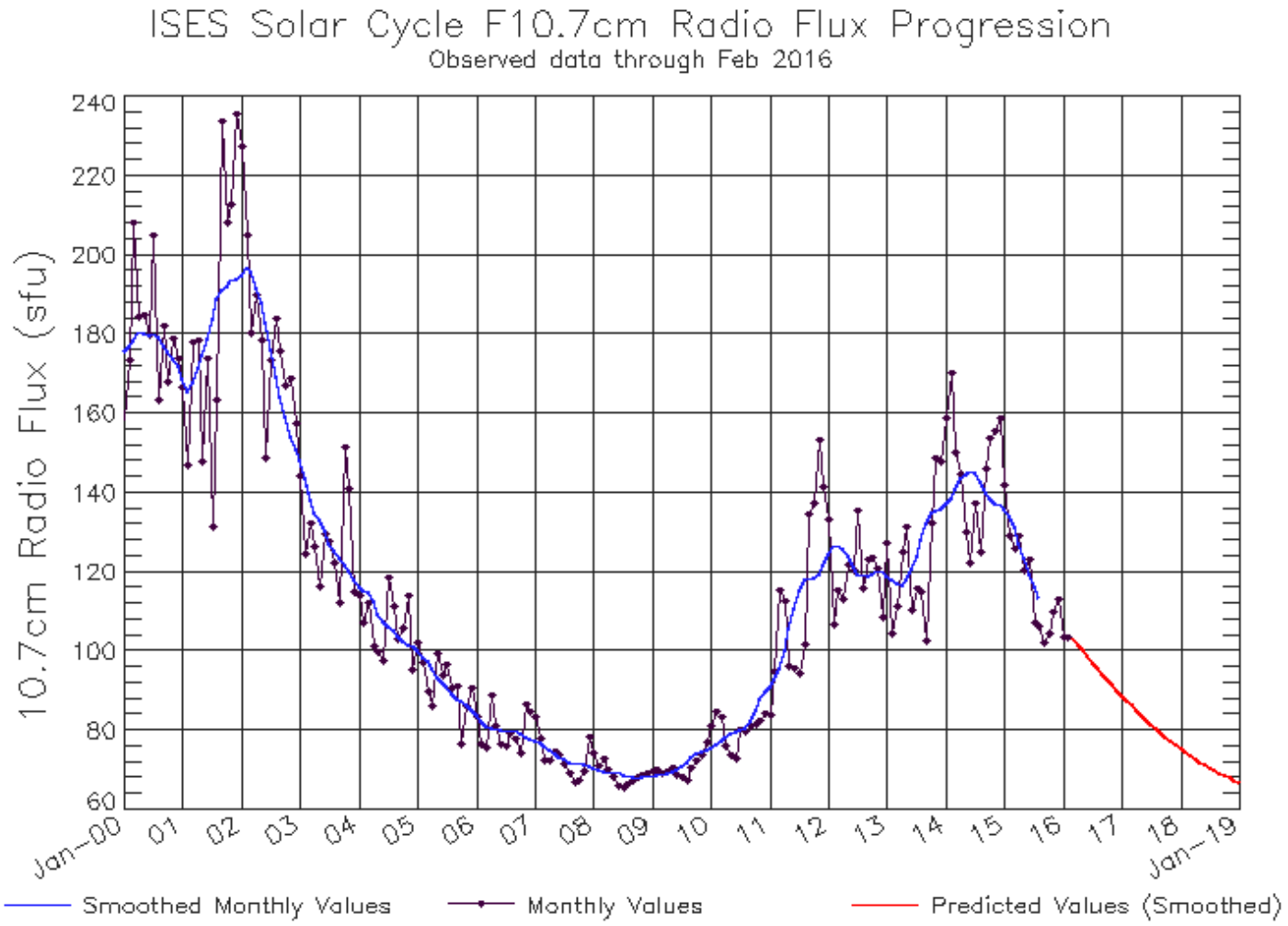
Dayton 2016

Two More Years of Declining Solar Flux

Followed by Three+ Years of Solar Minimum



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What About Solar Cycle 25 ??

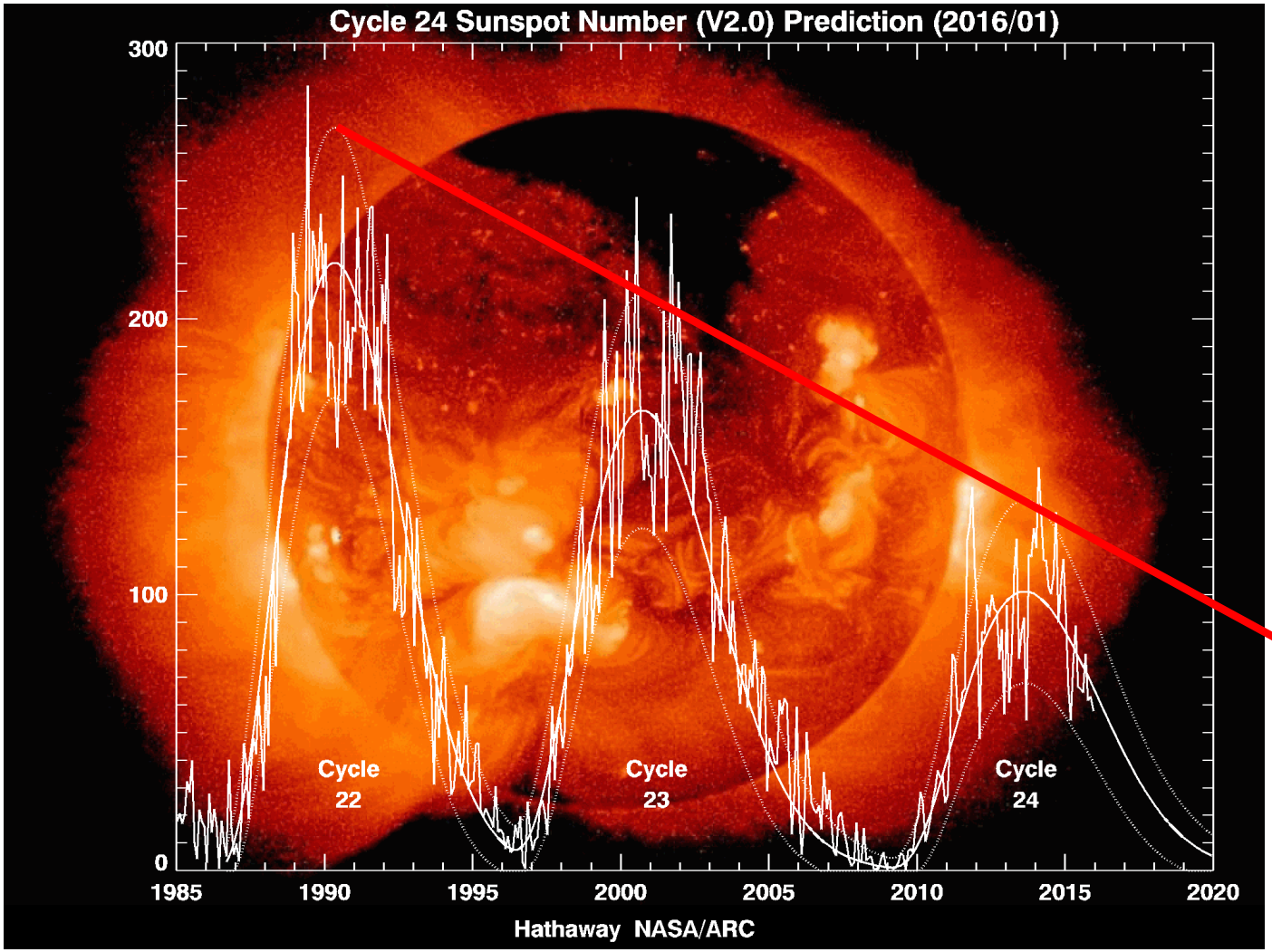
Precursors of a *possibly* weak Solar Cycle 25

- Unusually weak solar polar magnetic field strengths
  - field strengths should reach their peak between 2018 and 2020
    - www.solen.info/solar/polarfields/polarfields.jpg
- 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

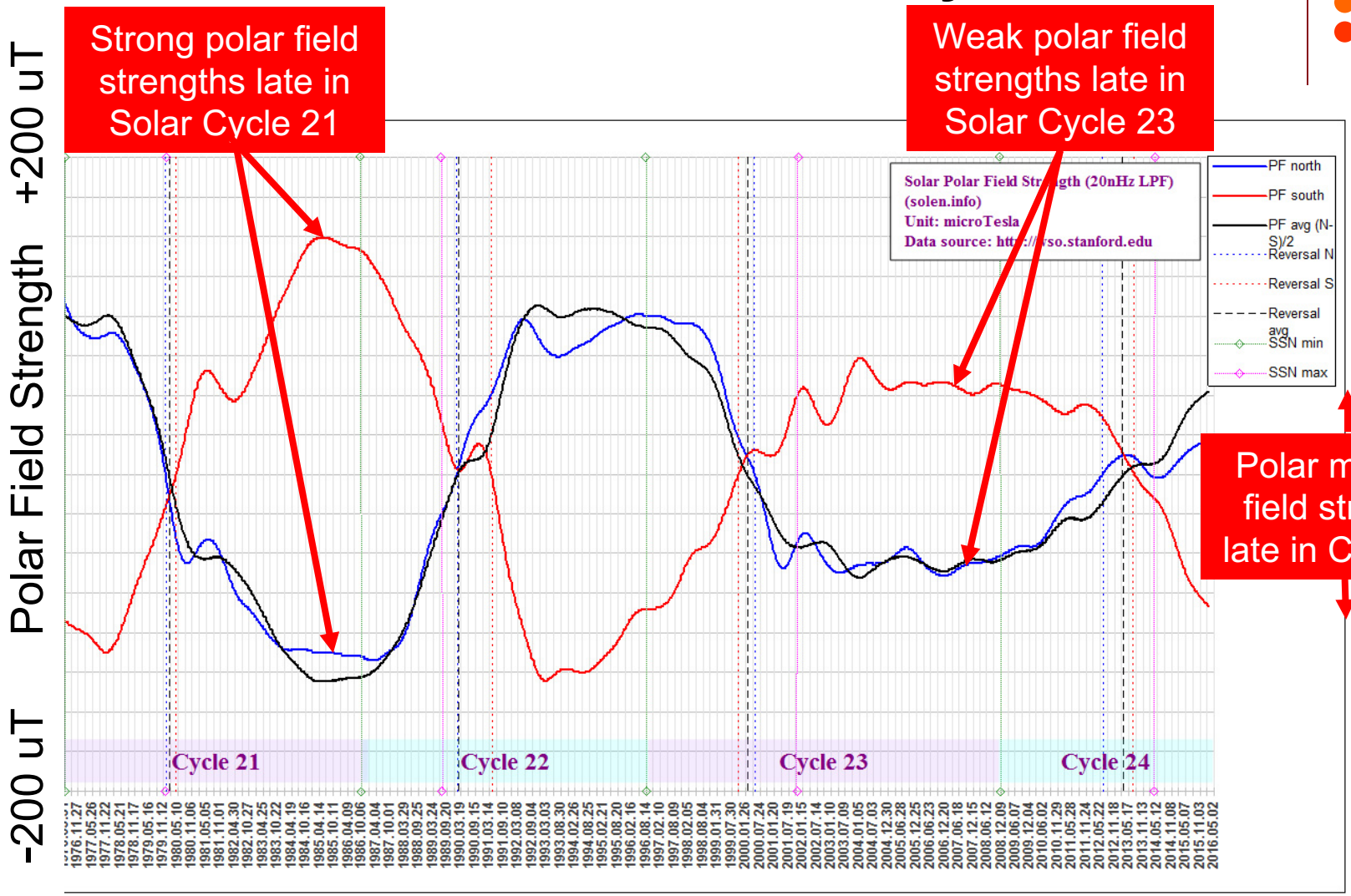
Suggests a Weak Solar Cycle 25



solarscience.msfc.nasa.gov/images/Cycle22Cycle23Cycle24big.gif

The Sun's Polar Magnetic Field Strength

A Reliable Precursor of Solar Cycle 25



www.solen.info/solar/polarfields/polar.html

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Vertical Polarization for 160 Meters

almost always provides better DX performance than any horizontally polarized antenna

- Vertical, inverted-L, T, and umbrella transmitting antennas *almost always* outperform horizontally polarized antennas at distances beyond 1500 miles

- Nearby tall towers and antennas can significantly degrade the performance of vertical antennas
  - antenna pattern degradation
  - losses

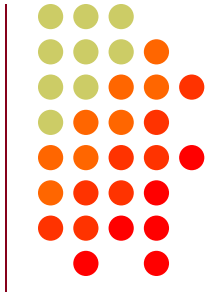
- Efficient radial systems are essential to achieving the full performance potential of vertical transmitting antennas

Horizontal Polarization for 80 Meters

easily provides 6 dB of "free" ground gain

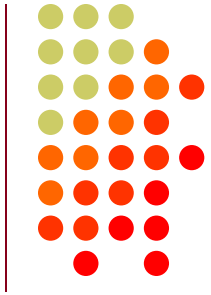
- Horizontal dipole or inverted-V dipole 50-70 feet high
  - superb Sweepstakes and Field Day antenna
  - a good DX antenna for distances up to about 5000 miles
- Horizontal dipole or inverted-V dipole at 70 feet or higher
  - outperforms a single 65 foot vertical installed over all but the most conductive soils such as a salt marsh
- Use a vertically polarized 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 30-60 radials
  - or a corner fed delta loop or inverted-U
- **Four-square vertical array**
  - with at least sixty 70 foot shallow buried radials per vertical
  - very competitive with high horizontally polarized arrays

High Performance Transmitting Antennas for 160 Meter DX



- A 125 foot vertical: the gold standard 160 meter 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
  - Install at least 30-60 shallow buried 125 foot radials
    - or at least two (preferably four or more) elevated 125 foot radials
      - but only if 30-60 shallow buried 125 foot radials are not possible
    - or a K2AV folded counterpoise (a counterpoise 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
- Vertically polarized corner fed delta loop

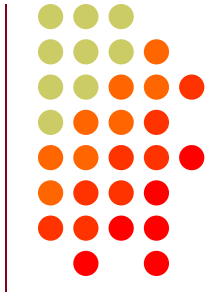
High Performance Transmitting Antennas for 80 Meter DX



- Horizontal dipole at least 70 feet high
  - higher is better
- 65 foot vertical
  - install at least 30-60 shallow buried 65 foot radials
    - or at least two (but preferably four or more) elevated 65 foot radials
      - only if buried radials are impossible
  - 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 30-60 shallow buried 65 foot radials
    - or elevated radials
    - or a reduced size counterpoise
- Or a vertically polarized corner fed delta loop

4-Square Vertical Array

an excellent high performance alternative to a very high 80 meter horizontal antenna

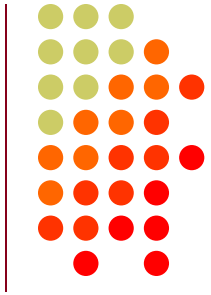


- A four square vertical array is very competitive with high horizontally polarized Yagis and quads
  - its also an excellent receiving antenna
- install at least 70 feet from all other towers
  - much more than 70 feet will significantly improve its performance
- at least 30-60 shallow buried 70 foot radials under each vertical

Comtek 4-Square Controller

www.dxengineering.com/search/brand/comtek

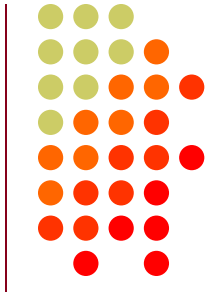
Why Receiving Antennas?



- Much better performance than most transmitting antennas
  - much lower cost
  - greatly reduced footprint
  - greatly reduced height (7 to 25 feet)
  - good directivity on as little as 650 to 2500 square feet
  - excellent directivity on less than an ¼ acre
  - superb directivity on less than 3/4 acre
  - greatly reduced mutual coupling between individual verticals
  - greatly reduced need for high efficiency matching and radial systems
- A large array performs equivalent to a 5 element Yagi!
- Combining two antennas with a variable phase controller
  - steerable nulls
  - optimizes the front-to-back ratio of phased arrays of Beverages and verticals
- Diversity reception with dual phase locked receivers

All receiving antennas dimension are for 160 meters - simply scale them to 80 meters

Receiving Directivity Factor (RDF)



- A proven measure of receiving antenna performance
  - forward gain at the desired azimuth and elevation angle compared to average gain over the entire hemisphere
- 4 dB: very small diameter “magnetic” loop
- 5 dB: single vertical antenna (short vertical or a 1/4 wavelength vertical)
- 4 - 6 dB: 250 - 400 foot Beverage
- 4 - 6 dB: 225 foot Beverage on Ground (BOG)
- 6 - 9 dB: small loop arrays (flag, pennant, EWE, K9AY, Shared Apex Loop Array)
- 9 dB: two element or triangle array of short verticals (80-120 foot spacing)
- 10 dB: 500 - 600 foot Beverage
- 11 dB: two or three close spaced 500 - 600 foot Beverages staggered 65 feet
- **12 dB: 4-square array of short verticals only 80 feet on a side (3/16 acre)**
- 13.5 dB: four short verticals switchable in two directions (1/2 acre)
- 13.5 dB: steerable 8-circle array of short verticals (3/4 acre)
- 14 dB broadside/end-fire 800 foot Beverages (8 acres)

Re-radiation from nearby antennas, towers and power lines can degrade your actual RDF **especially high RDF arrays**

Popular Receiving Antennas

- Small loops 4-12 dB RDF 80 to165 degree beamwidth
  - eight foot diameter “magnetic” loop
  - fixed unidirectional terminated loop (e.g., flag, pennant, EWE, K9AY)
  - electrically steerable compact array of loops (e.g., K9AY, Shared Apex Loop Array)
  - mechanically rotatable unidirectional terminated loop (e.g., rotatable flag)
- Beverages 4-14 dB RDF 35 to 90+ degree beamwidth
  - Beverage on ground (BOG)
  - single wire Beverage
  - two wire bi-directional Beverage or BOG
  - arrays of two or three close spaced staggered Beverages or BOGs
- Arrays of short verticals 9-14 dB RDF 50 to 135 degree beamwidth
  - active high impedance 20 foot verticals
    - requires a high input impedance amplifier at the base of each vertical
  - passive low impedance 25 foot verticals – **simple to troubleshoot and very reliable**
    - requires eight 70 foot or sixteen 35 foot radials at the base of each vertical
      - stabilizes feed point impedance in all weather and decouples the coax shield
    - four 25 foot umbrella wires
      - reduces the required height to 25 feet and increases the array bandwidth

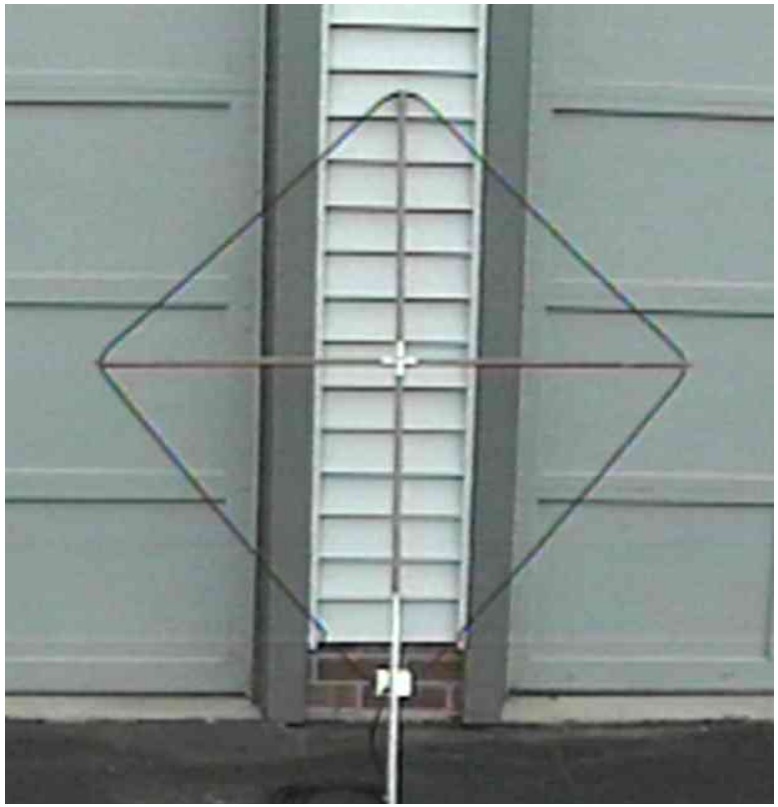
Small Diameter Loop Antenna

The "Magnetic" Loop

- Excellent for nulling a single nearby RFI source
  - but a poor low angle DX receiving antenna
  - RFI must be vertically polarized and received at a low angle via ground wave
- Excellent for very accurately locating RFI sources
- Bi-directional figure-8 pattern 150 degree 3 dB beamwidth
  - omni-directional for skywave propagated signals
- Very deep nulls (2 degrees wide) off both ends of the loop
  - mechanically rotate the loop until the single local RFI source is nulled
  - no useful nulls for skywave propagated signals
- Small loop antennas produce very low signal levels
  - requires a high gain, low noise preamplifier
- Decouple stray pickup from all attached cables
  - install chokes on the coaxial feed line shield and the DC power cable
  - bury cables about 12 inches deep for optimum null depth
- Avoid re-radiated signals from nearby antennas and power lines
  - locate the antenna as far as possible from other antennas and power lines

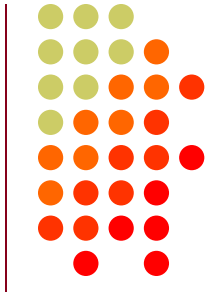
Small Diameter Loop Antenna

inexpensive and very easy to build and use
8 foot diameter (4 foot diameter on 80 meters)
Very deep, narrow beam width nulls for local RFI suppression
bidirectional 150 degree 3 dB beam width
4 dB RDF



www.seedsolutions.com/gregordy/Amateur%20Radio/Experimentation/160loop.htm

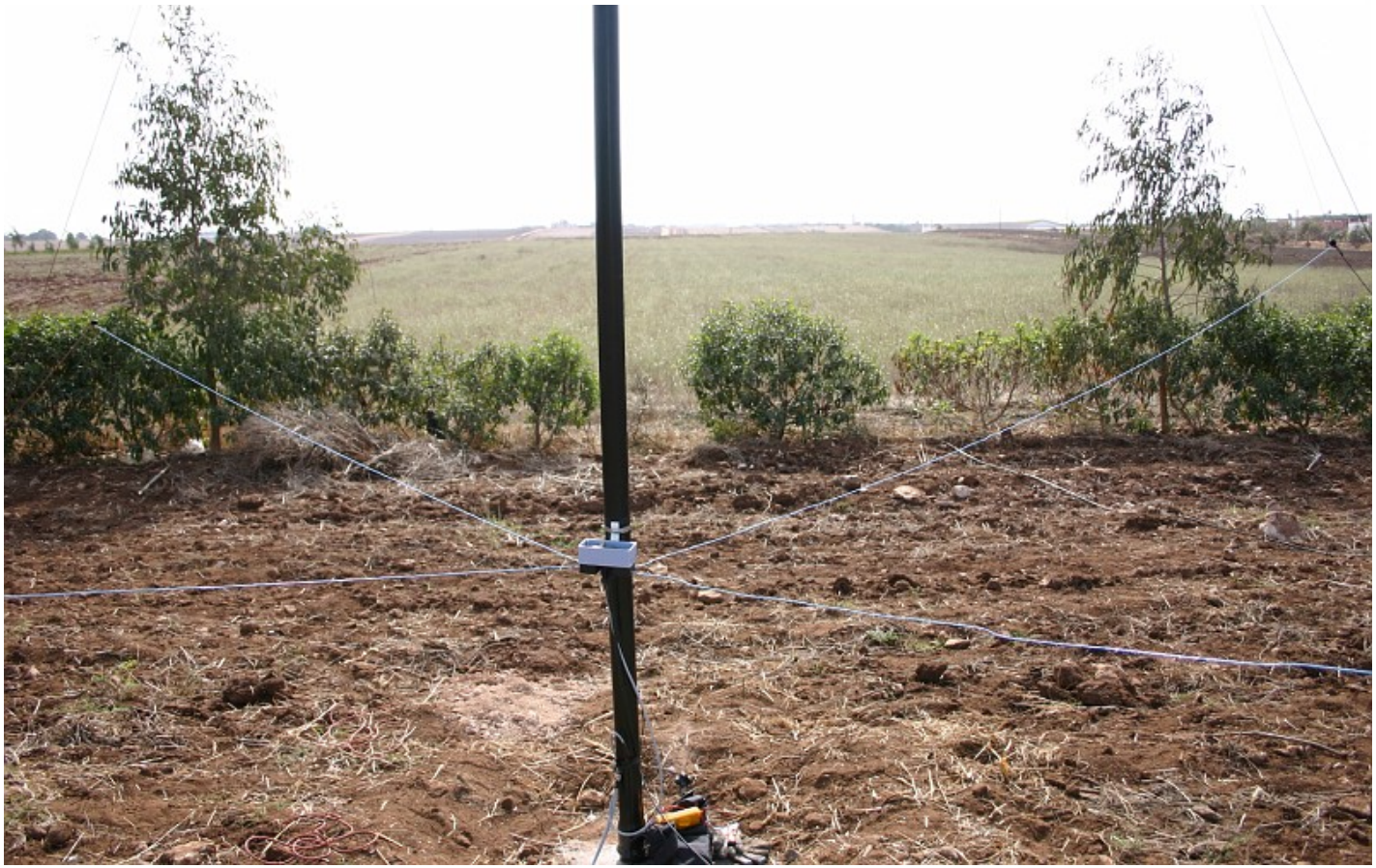
Electrically Steerable Loop Arrays



- Two K9AY loops
  - switchable in four directions
  - footprint is only 25x25 feet and 25 feet tall
  - 120 degree 3 dB beam width
  - 7 dB RDF
- Shared Apex Loop Array
  - switchable in eight directions
  - footprint is only 50x50 feet and 25 feet tall
  - 75 degree 3 dB beam width
  - 8 dB RDF
- Loops produce very low signal levels
  - a high gain, low noise figure preamplifier must be used
  - requires very careful attention to eliminating all unwanted signal coupling
    - decouple the coaxial feed line shield, control cable and DC power cable
    - bury cables about 12 inches deep for best unwanted signal rejection
- Avoid re-radiated signals from nearby antennas, towers and power lines
  - locate the antenna as far as possible from antennas, towers and power lines

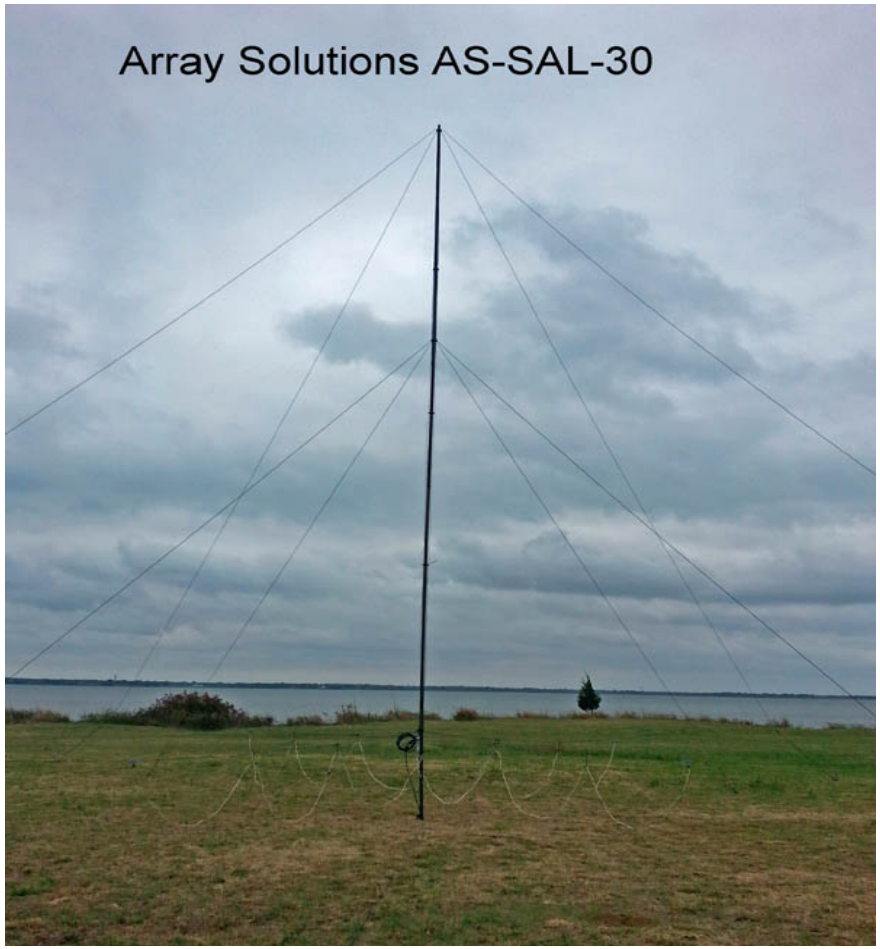
Two K9AY Loops

very small 25x25 foot square x 25 feet high footprint
switchable in four directions
120 degree 3 dB beam width
7 dB RDF in only 625 square feet



Shared Apex Loop Array

50x50 foot square x 25 feet high footprint
switchable in eight directions
75 degree 3 dB beam width
8 dB RDF in only 2500 square feet



www.arraysolutions.com/Products/sal_array.htm

Single Wire Beverage

The simplest and most reliable high performance receiving antenna

250 - 400 feet long	4 - 6 dB RDF	100 degree beam width
500 - 700 feet long	10 -11 dB RDF	70 degree beam width
800 - 900 feet long	12 dB RDF	60 degree beam width

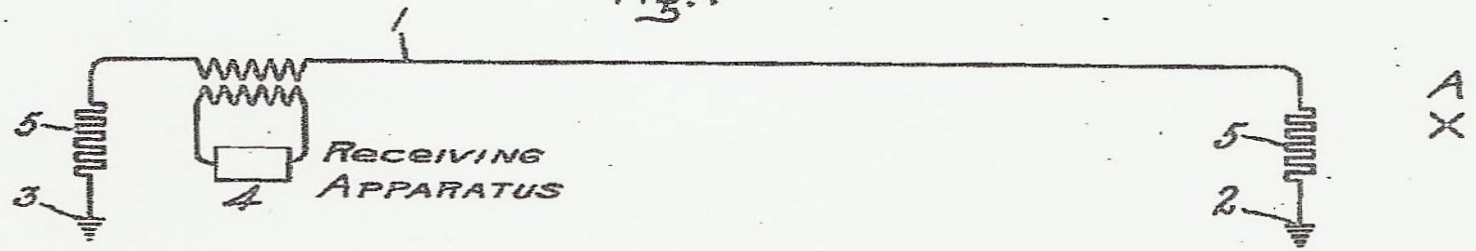
H. H. BEVERAGE.

RADIORECEIVING SYSTEM.

APPLICATION FILED APR. 10, 1920.

1,381,089. Patented June 7, 1921.

Fig. 1



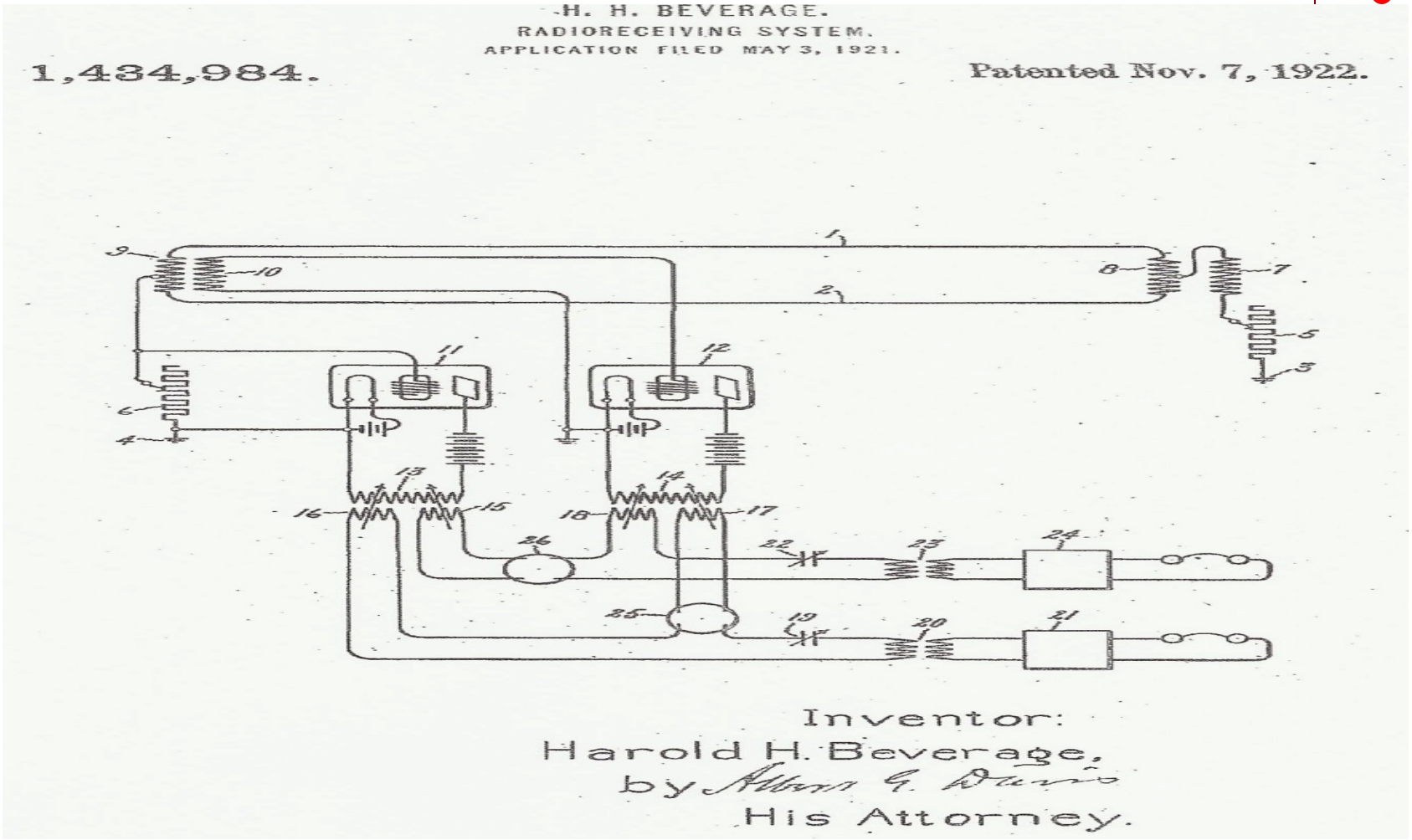
Inventor:
Harold H. Beverage,
by Albert G. Davis
His Attorney.

Beverage on (or near) Ground

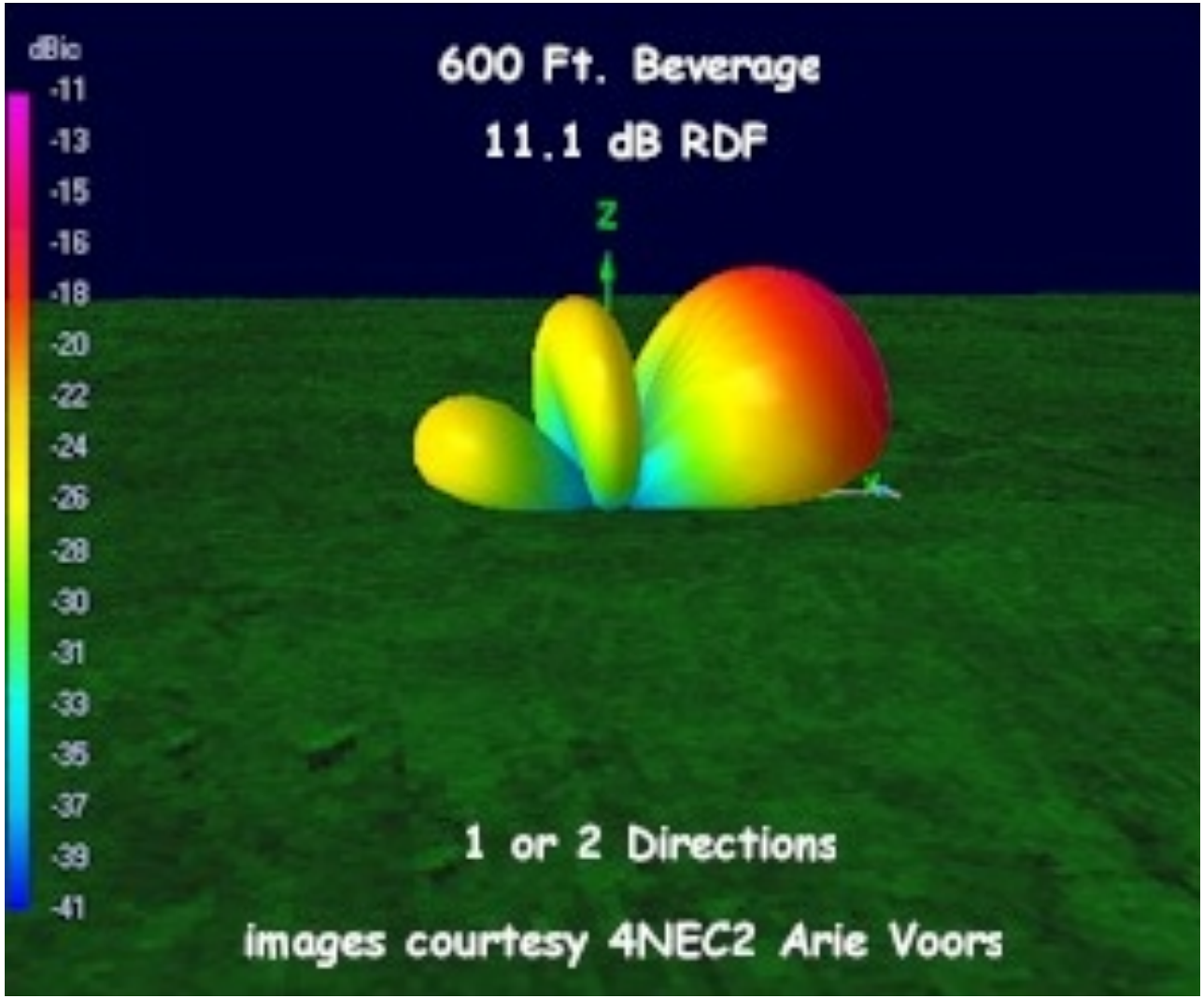
a good choice when stealth is important
only 200-250 feet long for 160 meters
longer lengths degrade performance
70 - 100 degree 3 dB beam width
6 - 8 dB RDF with only 200 feet of length

Two Wire Bidirectional Beverage

Switchable in two directions with one feed line
deep steerable rear null if both feed lines feed a variable phase combiner



Radiation Pattern of a 600 Foot Beverage



Close Spaced Staggered Beverage Arrays

two or three close spaced, staggered Beverages or BOGs
enhanced front-to-back ratio compared to a single Beverage or BOG
the deep rear null can be steered by a variable phase combiner
11 dB RDF with two or three close spaced 500-600 foot Beverages

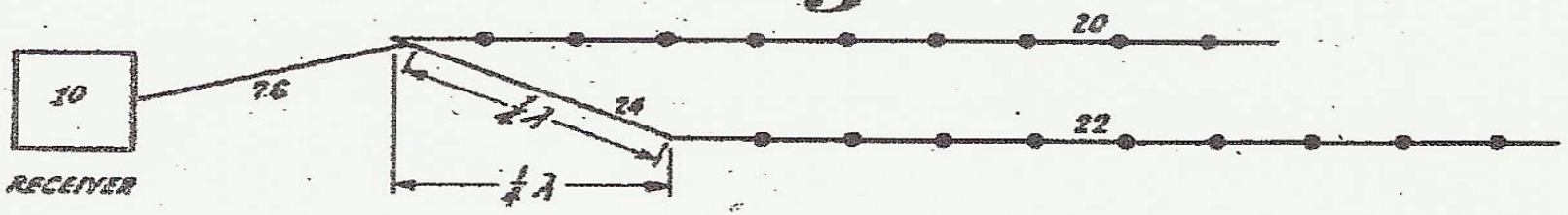
11 dB RDF on one acre

Sept. 1, 1931. H. O. PETERSON 1,821,402

ANTENNA

Filed Nov. 8, 1927 2 Sheets-Sheet 2

Fig. 7



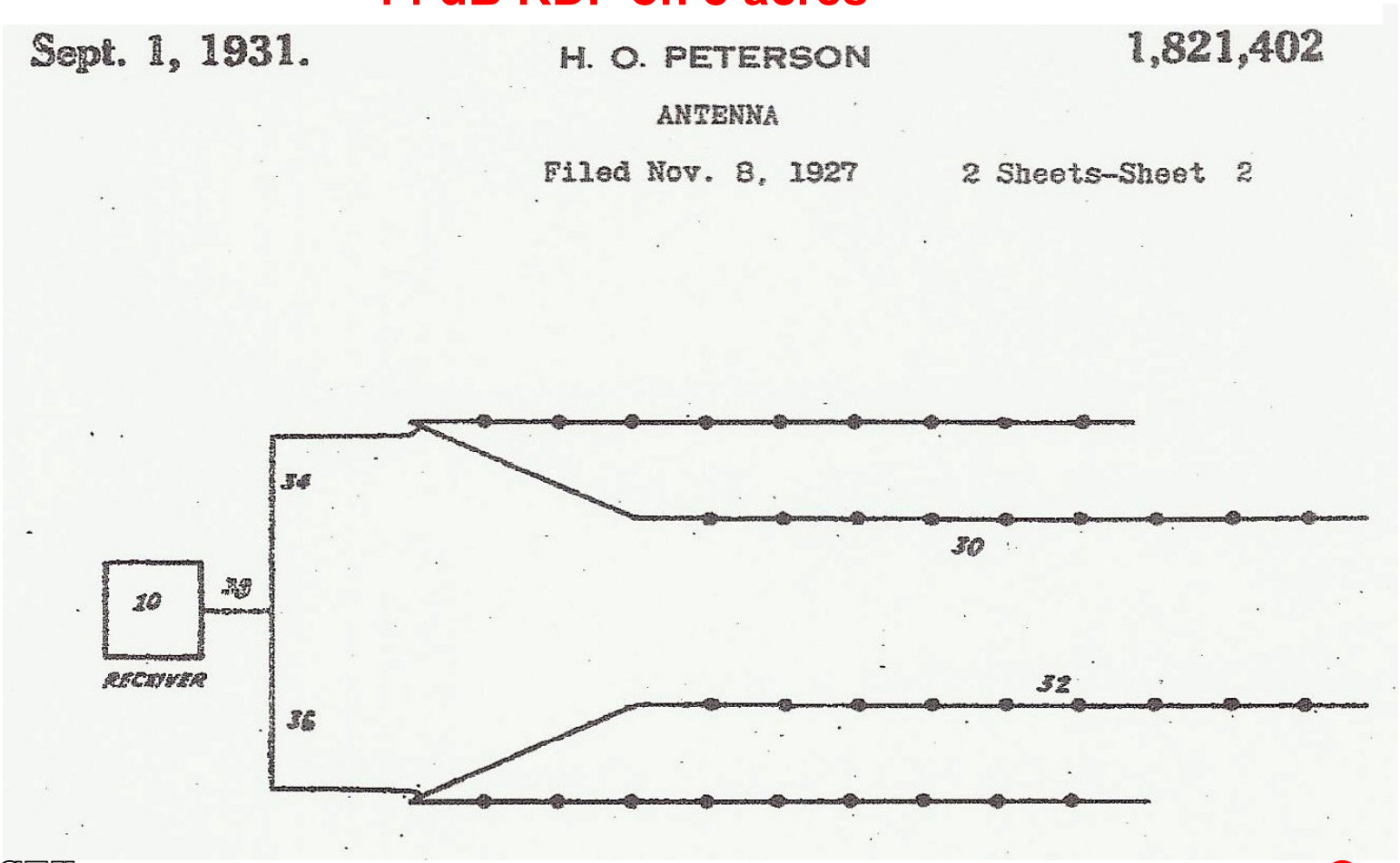
http://ncjweb.com/features/sepoct11feat.pdf

Broadside Pair of Staggered Beverages

800-900 foot Beverages, 330 foot broad side spacing

45 degree 3 dB beamwidth

14 dB RDF on 8 acres

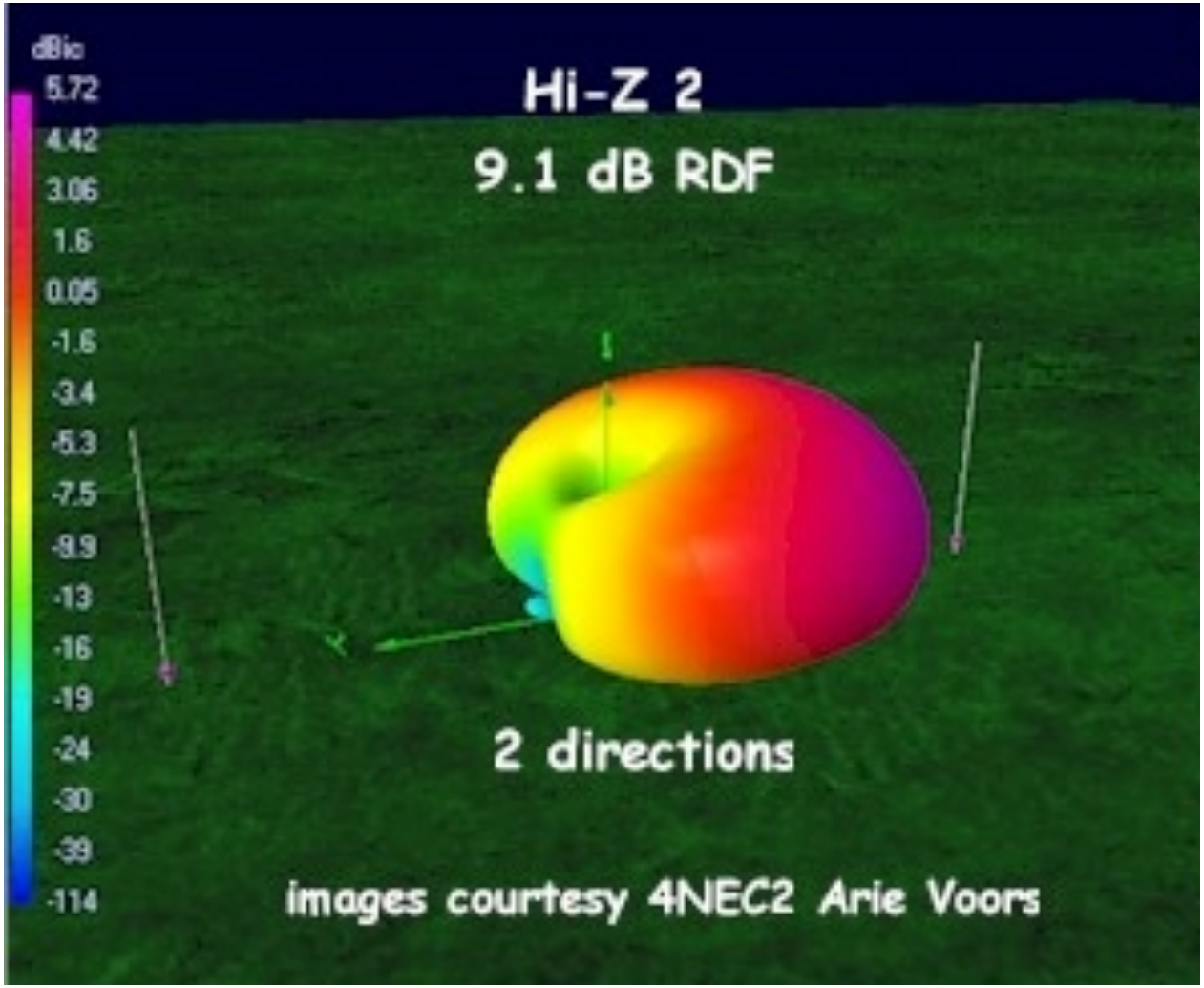


Phased High Impedance Verticals

Two or More 20 Foot Verticals

- No radials
- No umbrella wires
- Dual band operation with compromise 65 foot element spacing
- 80 foot element spacing for improved 160 meter performance
  - closer spacing is possible by using a variable phase combiner
- High input impedance amplifier at the feed point of each vertical
  - stray capacitance to nearby trees and other objects, at the feed point of each vertical and at the input to each amplifier must be as low as possible
- Switchable in multiple directions
- Verticals must not be installed within ten feet of nearby objects
  - Avoid nearby trees or any conductive or partially conductive structure
- Avoid re-radiated signals from nearby antennas and power lines
  - locate the antenna as far as possible from antennas, towers and power lines

Radiation Pattern of a Two Element Array of 20 Foot Verticals

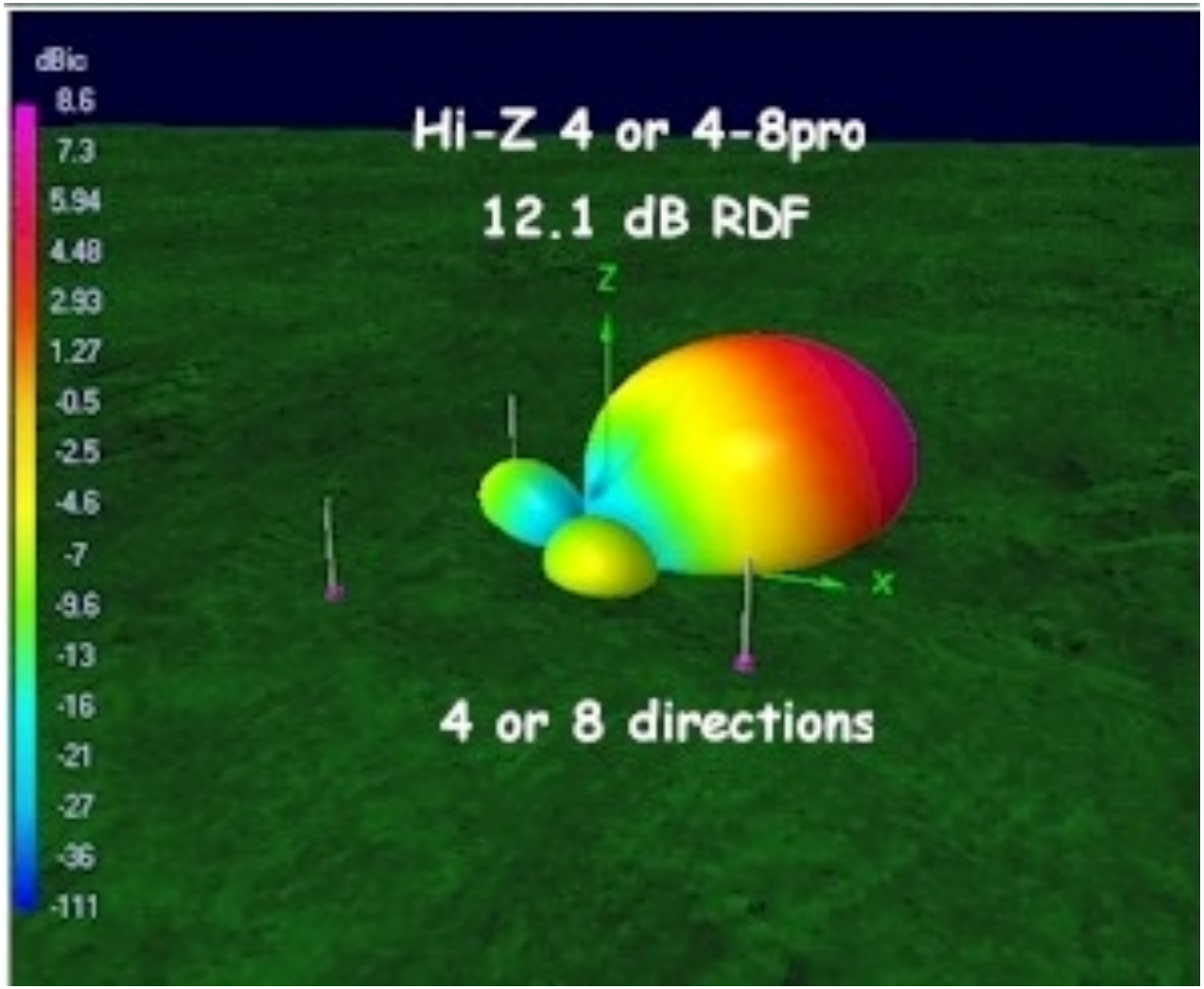


Electrically Steerable 4-Square Vertical Array

four high impedance 20 foot verticals
no radials and no umbrella wires
80x80 foot square x 20 foot high footprint
high input impedance amplifier at the base of each vertical
switchable in four directions
100 degree 3 dB beam width
12 dB RDF on less than ¼ acre

www.dxengineering.com/parts/hiz-4-lv2-80

Radiation Pattern of a 4-Square Array of 20 Foot Verticals

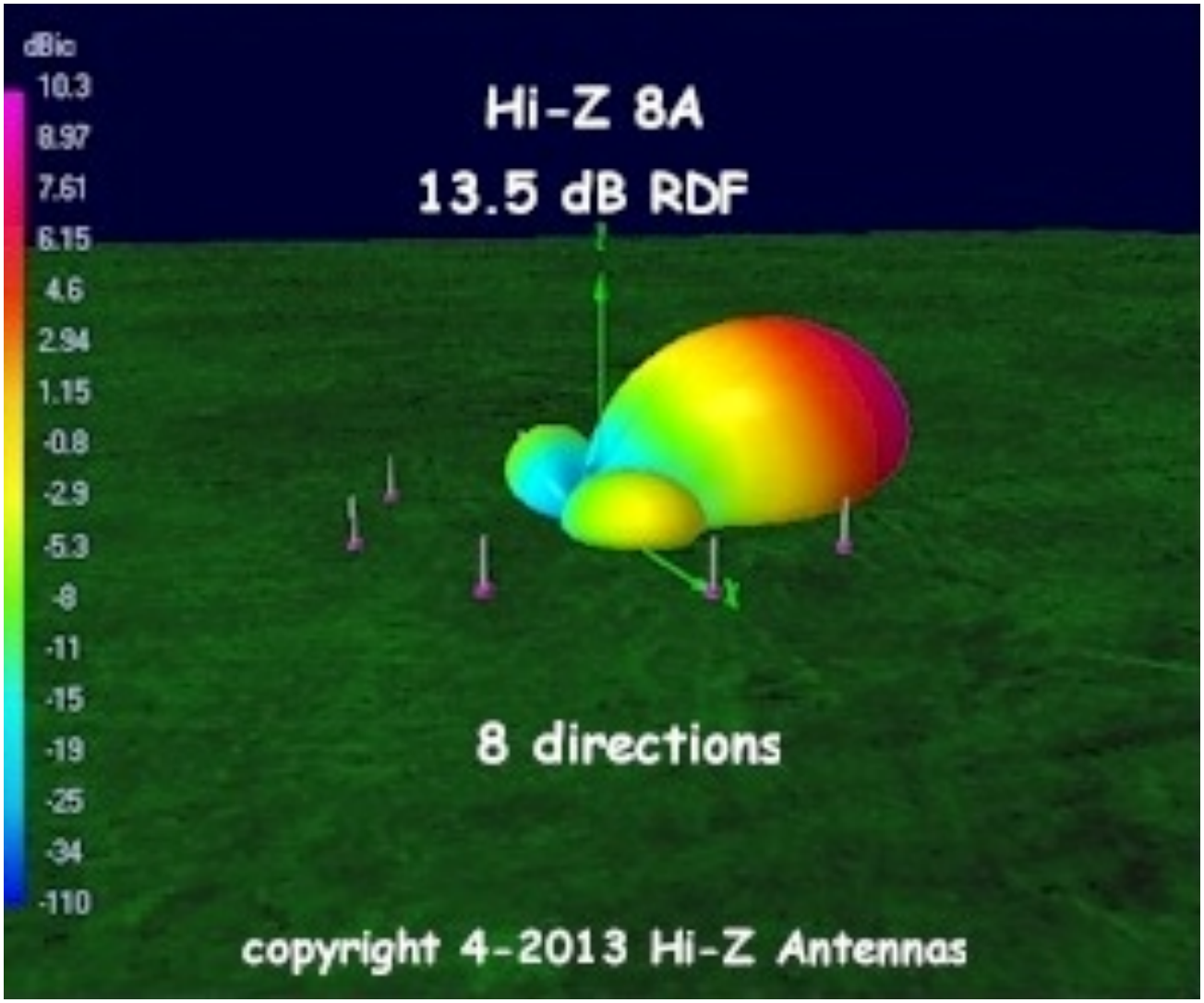


Electrically Steerable 8-Circle Vertical Array

eight high impedance 20 foot verticals
no radials and no umbrella wires
requires a high input impedance amplifier at the base of each vertical
200 foot diameter array with 106 degree phasing
switchable in eight directions
50 degree 3 dB beam width, the performance of a 5 element Yagi

13.5 dB RDF on ¾ acre

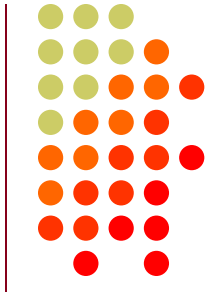
Radiation Pattern of a 200 Foot Diameter 8-Circle Array



Eight phased verticals with 106 degree phasing

Phased Low Impedance Verticals

Two or More 25 Foot Umbrella Verticals



- Short radials are required at the base of each vertical
  - eight 70 foot radials, sixteen 35 foot radials or chicken wire
  - randomly laid on the ground or shallow buried, symmetry is not important
- Four 25 foot umbrella wires attached to the top of each vertical
  - reduces antenna height and improves array bandwidth
  - if necessary, use 35 foot verticals with no umbrella wires
- As little a 65 foot element spacing
  - its difficult to achieve stable, repeatable performance with smaller spacing
- Amplifiers not needed at the base of each vertical – higher reliability
- Switchable in multiple directions
- Very easy and low cost to homebrew your own antenna
  - large diameter arrays are very tolerant of moderate amplitude and phase errors
- Low impedance verticals are tolerant of nearby trees and buildings
- Avoid re-radiated signals from nearby towers, antennas and power lines
  - locate the antenna as far as possible from other antennas and power lines

Electrically Steerable 4-Square Vertical Array

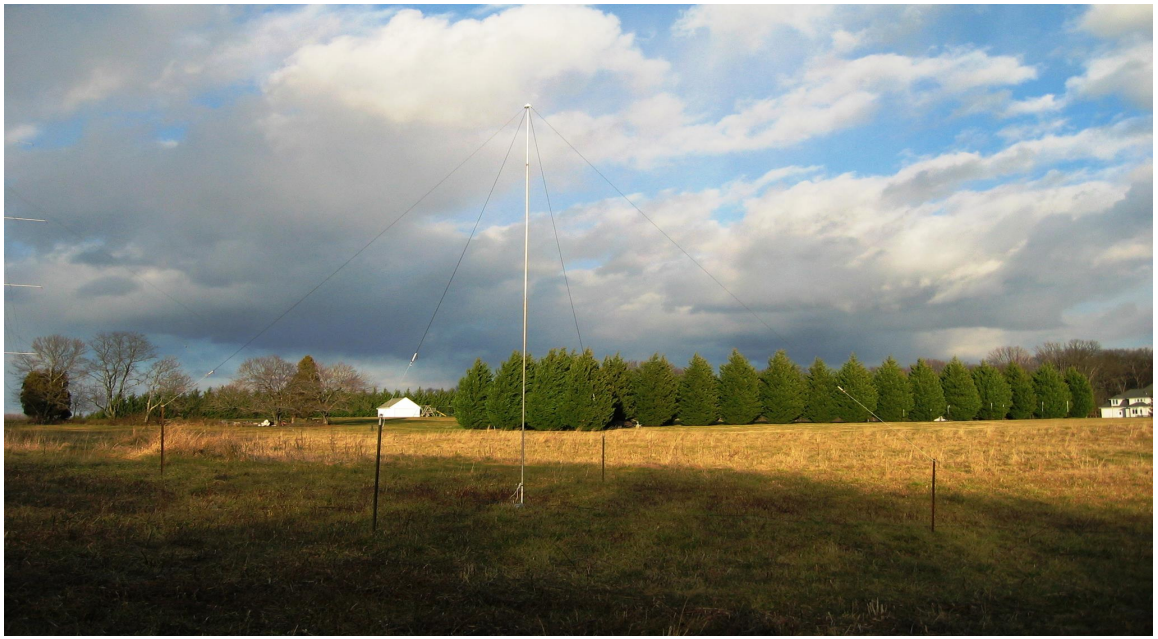
four low impedance 25 foot umbrella verticals
four 25 foot umbrella wires attached to the top of each vertical
eight 70 foot or sixteen 35 foot radials per vertical
65x65 foot square footprint plus additional space for radials
switchable in four directions
easy and inexpensive to build
100 degree 3 dB beamwidth
12 dB RDF on ¼ acre

www.iv3prk.it/user/image/site2-rxant.prk_4-square_1.pdf

Electrically Steerable 8-Circle Vertical Array

eight low impedance 25 foot umbrella verticals
four 25 foot umbrella wires per vertical
eight 70 foot or sixteen 35 foot radials per vertical
350 foot diameter with 1/4 wavelength spacing plus space for radials
or only 200 foot diameter with a 106 degree Hi-Z phasing controller
switchable in eight directions
Very easy and inexpensive to build
50 degree 3 dB beam width, the performance of a 5 element Yagi

13.5 dB RDF on one acre



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construction details: http://www.w5zn.org

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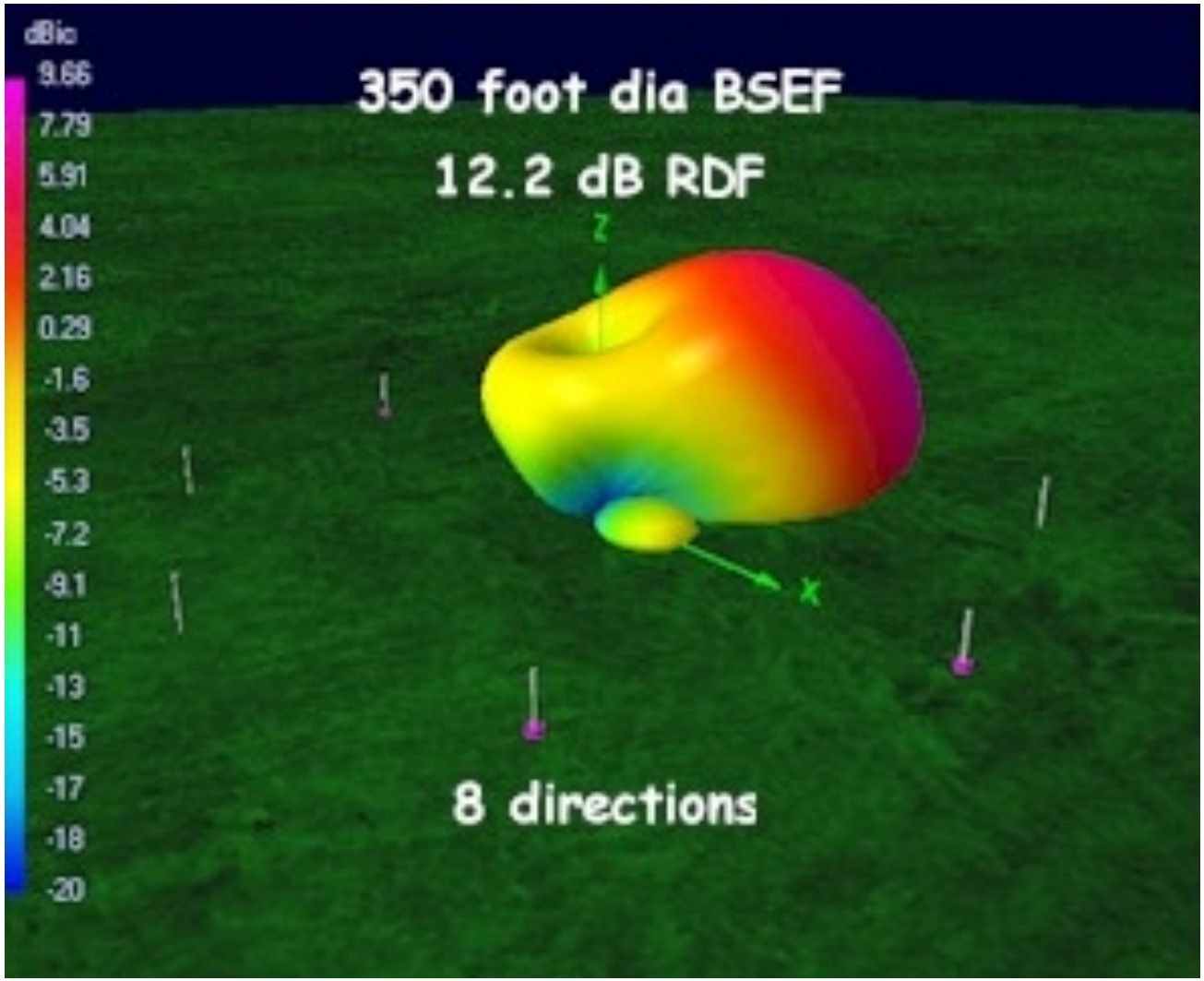
Radiation Pattern of a 350 Foot Diameter 8-Circle Array



Four phased elements with 115 degree phasing

Receive Antenna Variable Phasing Controller

DX Engineering NCC-1

Combines the inputs from two antennas

- creates a directional pattern with deep steerable nulls
- optimizes the performance of phased Beverages and phased verticals
- very well engineered and exceptionally easy to use

Phase Synchronous Diversity Reception

two widely spaced antennas (500 to1000+ feet) feeding
two identical high performance phase locked receivers

Elecraft K3S transceiver with KRX3 sub-receiver