# 8 Vertical Array

for

# Low Band Receiving

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Team W5ZN
Zilla Contest Group

*"The design of antennas is a rich field for investigation and innovation. Even after over a hundred years of work in the field we can still gain new insights and create ideas with immediate practical applications."*
Rudy Severns, N6LF

# The Grim Noise Reaper Is NOT Your Friend

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# Beverage Antennas

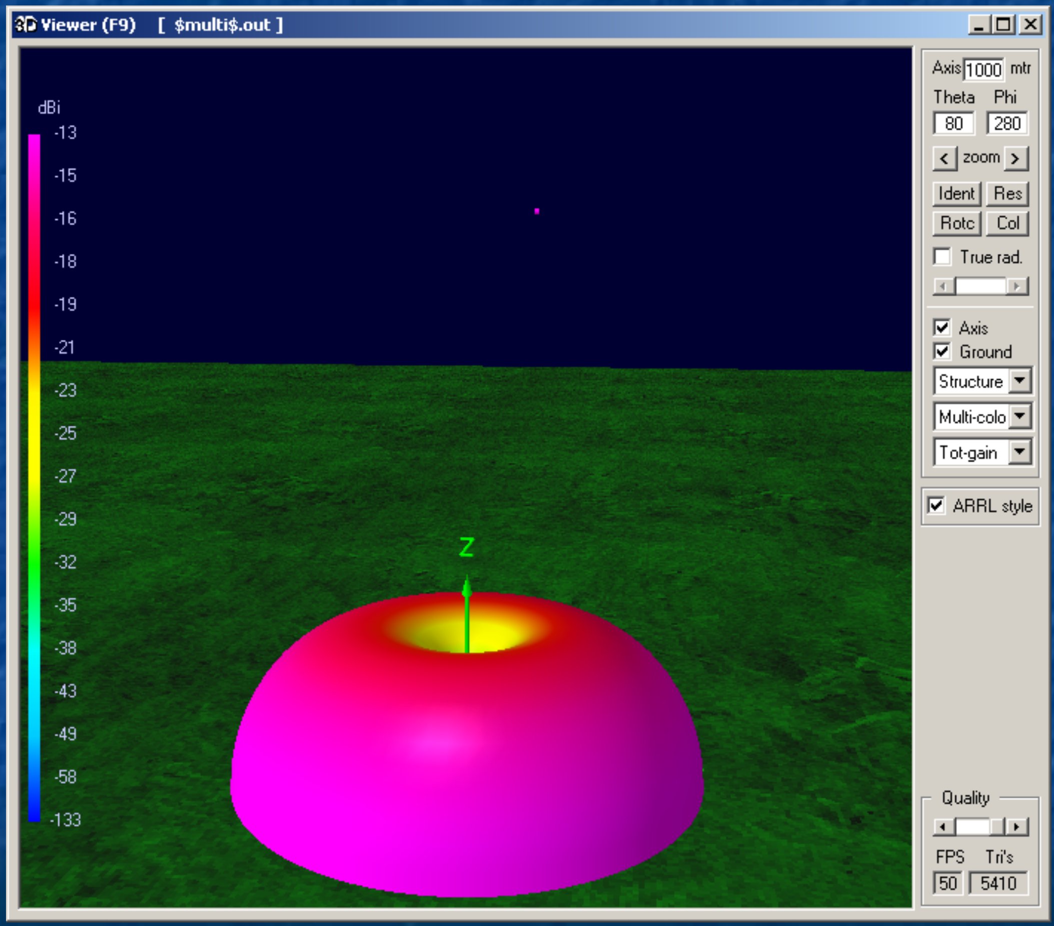
## The bad side

- Can be a nuisance to wild animals
- Require lots of maintenance
- Take up considerable space

# The Search for Improvement

- N4HY recommended End Fire / Broadside Array
- Concept works with Beverages, vertical arrays, etc.
- We decided to use the short vertical, so the array is centered on this element

# Phasing Principle

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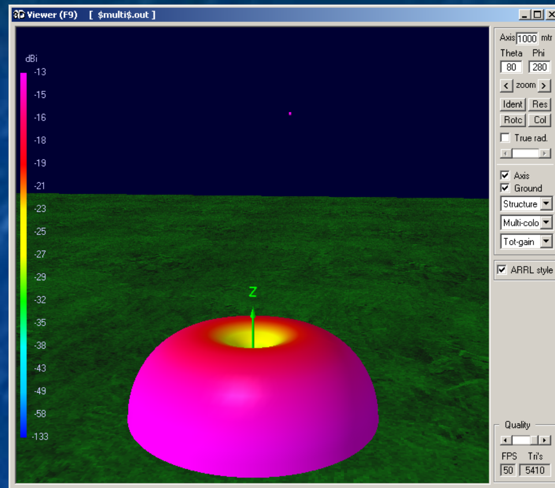
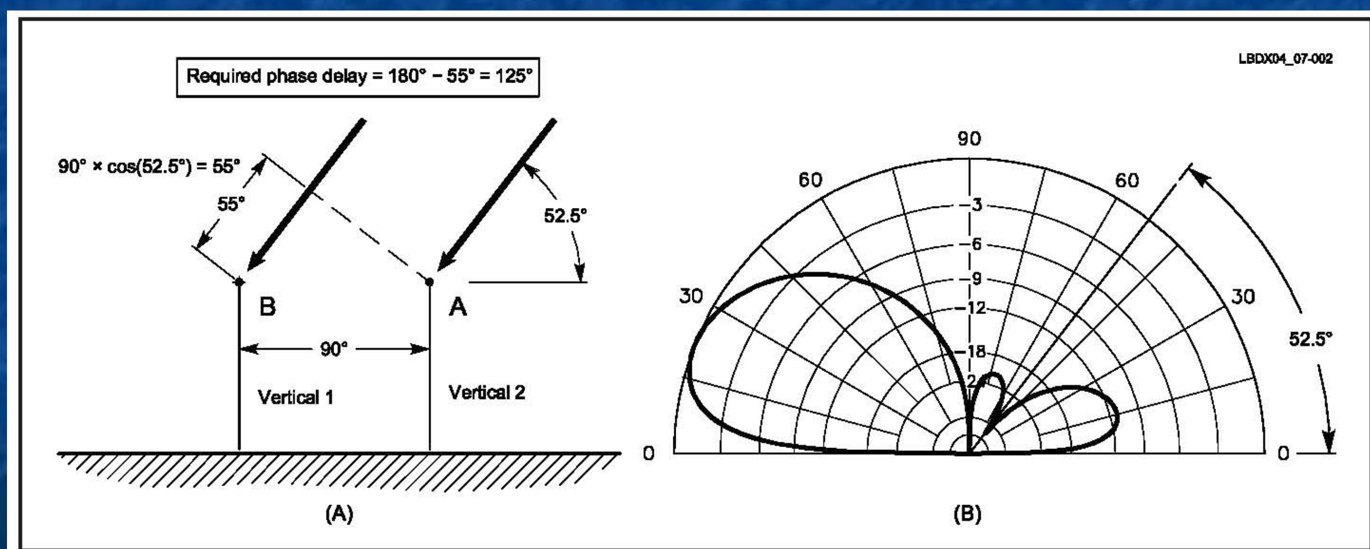
# End-fire Principle

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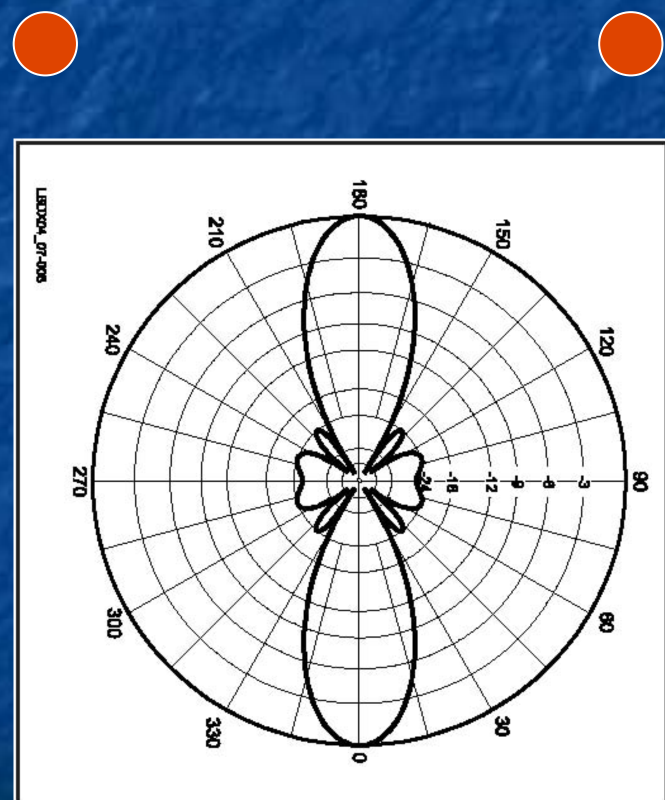
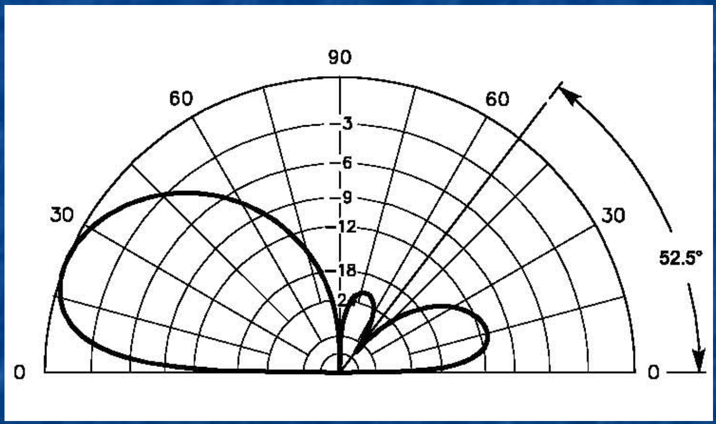
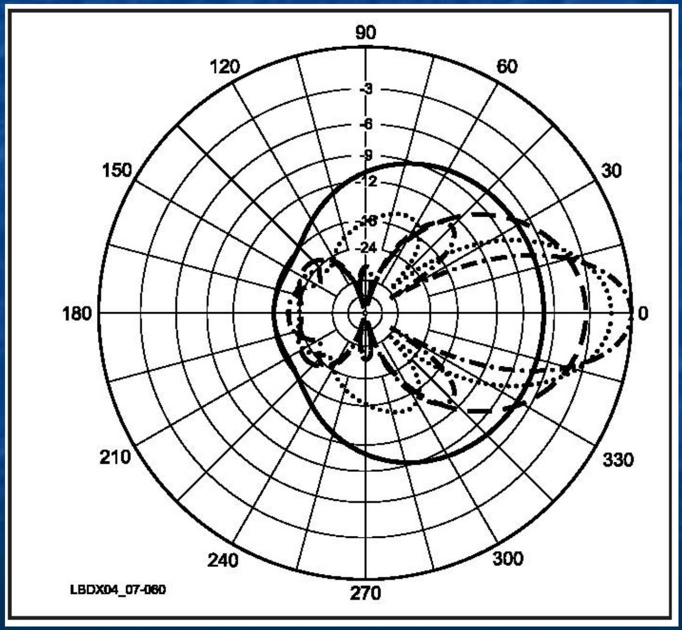
# Broadside Principle



# Broadside/End-fire Principle

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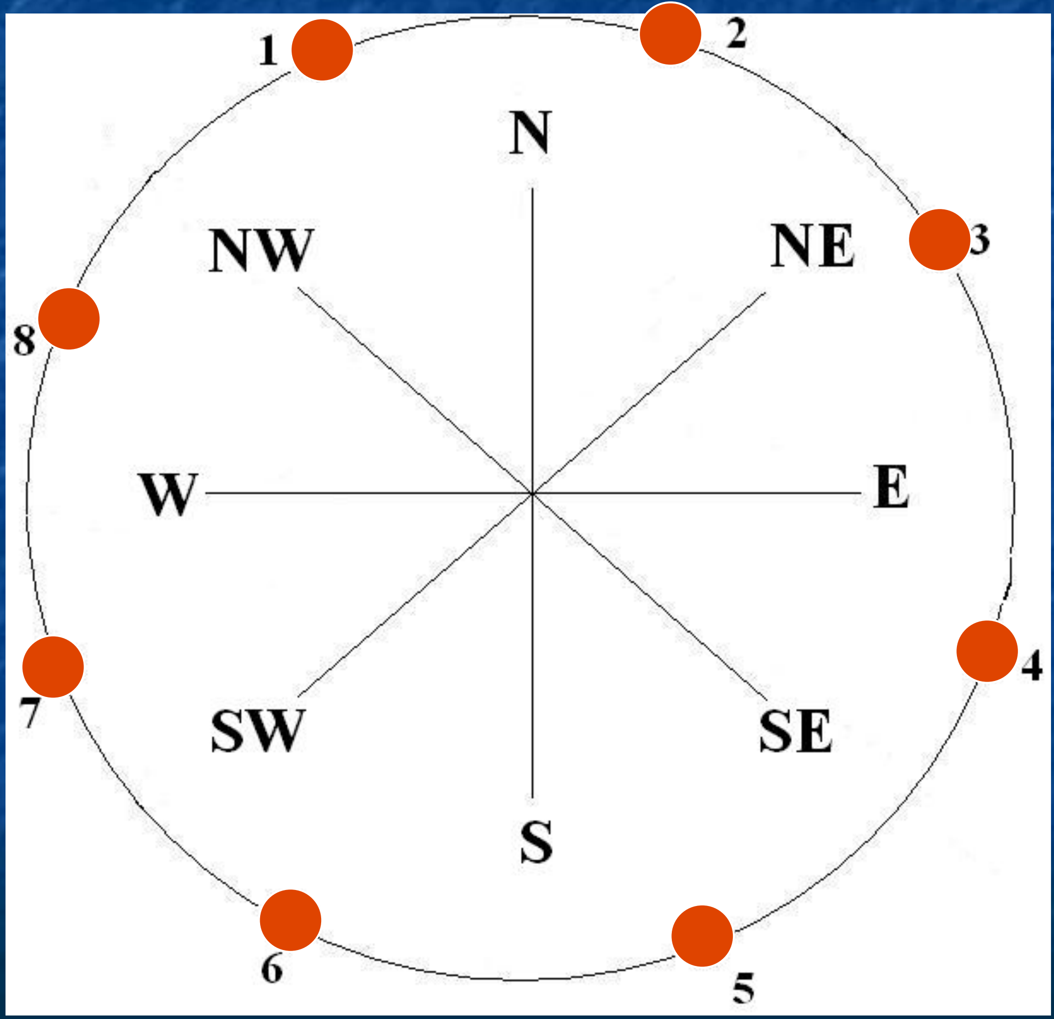
# Expanding to a 8 Direction Steerable Array

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# Design

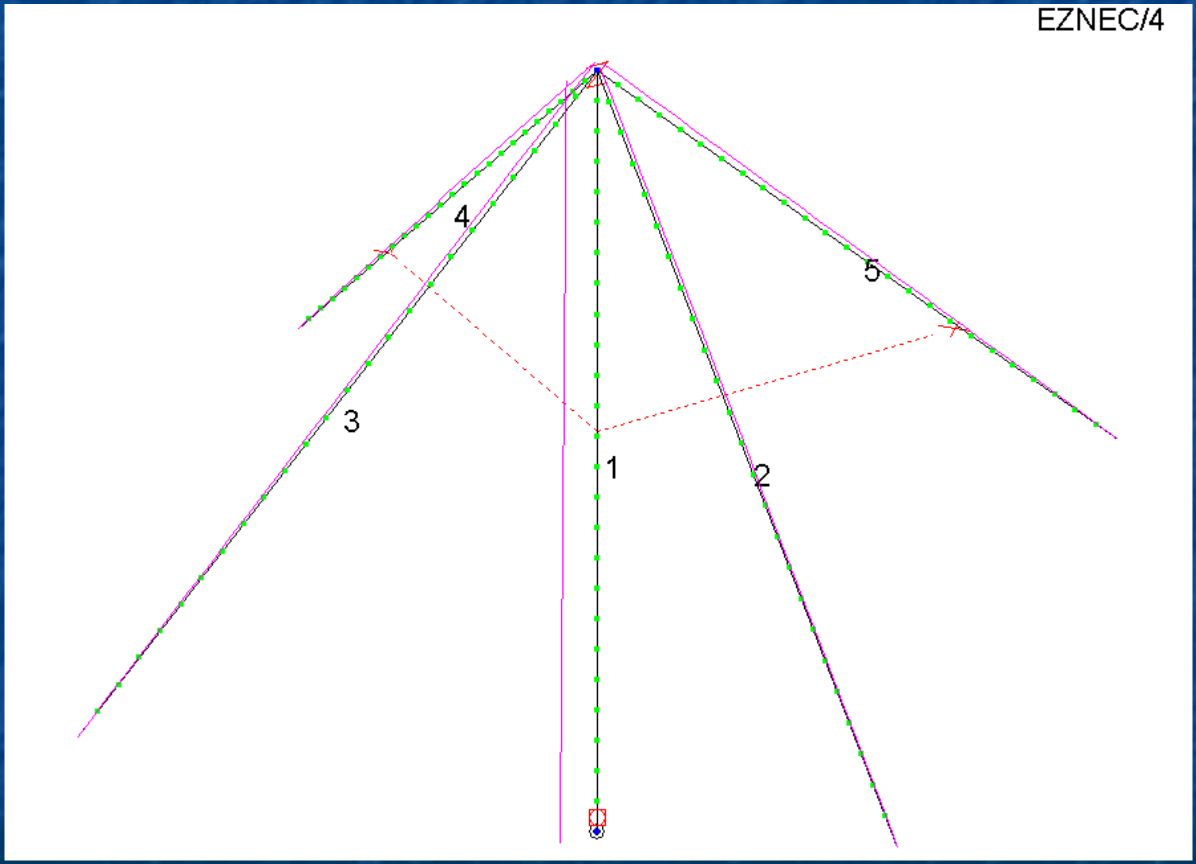
- This is a receiving array - it is unsuitable for transmit applications
  - Impedance matching with a low wattage resistor
  - Lower the Q and broaden the response of the antenna at good SWR
  - Comes at the expense of gain, but gain is not the primary objective with a low band receiving antenna design and its insertion loss is not harmful

# Design

- We did our own modeling using EZNEC/4 Professional
- For 160 and 80 meters, the dimensions of the vertical and top hat wires are all 25 feet in length, with the top-hat wires also acting as guys, 25 feet from the base of the vertical.
- This allows the top-hat to serve as both capacitive top-loading and provide very good high angle rejection as well.

# Design

## Individual Elements



# Design

## Individual Elements

- The element is self resonant at 75 meters.
  - Will need to bring the resonant frequency down with a small inductor.
    - For 160 meters, our design indicated the load inductor to be 30 μH with enough resistance to give a low SWR at 1.85 MHz.
    - For 80 meters, the design indicates a 2 μH inductor will be required with the addition of enough resistance to give a low VSWR from 3.5-3.8 MHz.

# Design
## Individual Elements

- Why 75 Ω feed point impedance?
  - The availability of inexpensive readily available coax (cable TV installation) for feedline.
  - The higher resistance is used to broaden the VSWR by lowering the Q.
  - Lowering the VSWR allows the front end of the receiver to see the proper load

# Design
## Individual Elements

- The mounting is not critical and no special fixtures are needed to insulate the vertical element and top hat wires from the ground.

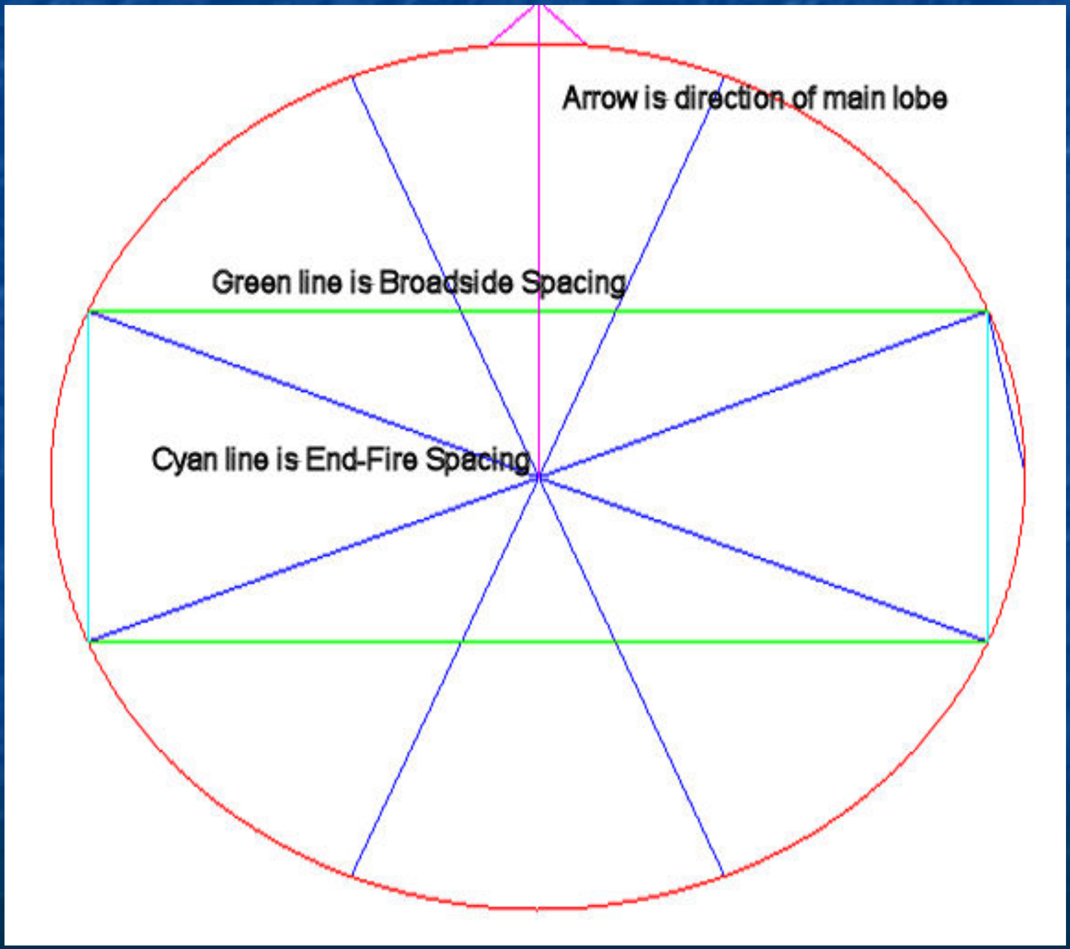
# Design

## Array

| Band – Meters | Broadside Spacing - λ | Circle Diameter |
|---|---|---|
| 160 | 0.55 λ (90.1 Meters/296 ft) | 320 feet |
| 160 | 0.65 λ (106.5 Meters/350 ft) | 378 feet |
| 80 | 0.55 λ (46.5 Meters/152.5 ft) | 165 feet |
| 80 | 0.65 λ (55.0 Meters/180 ft) | 194 feet |

# Design

## Array

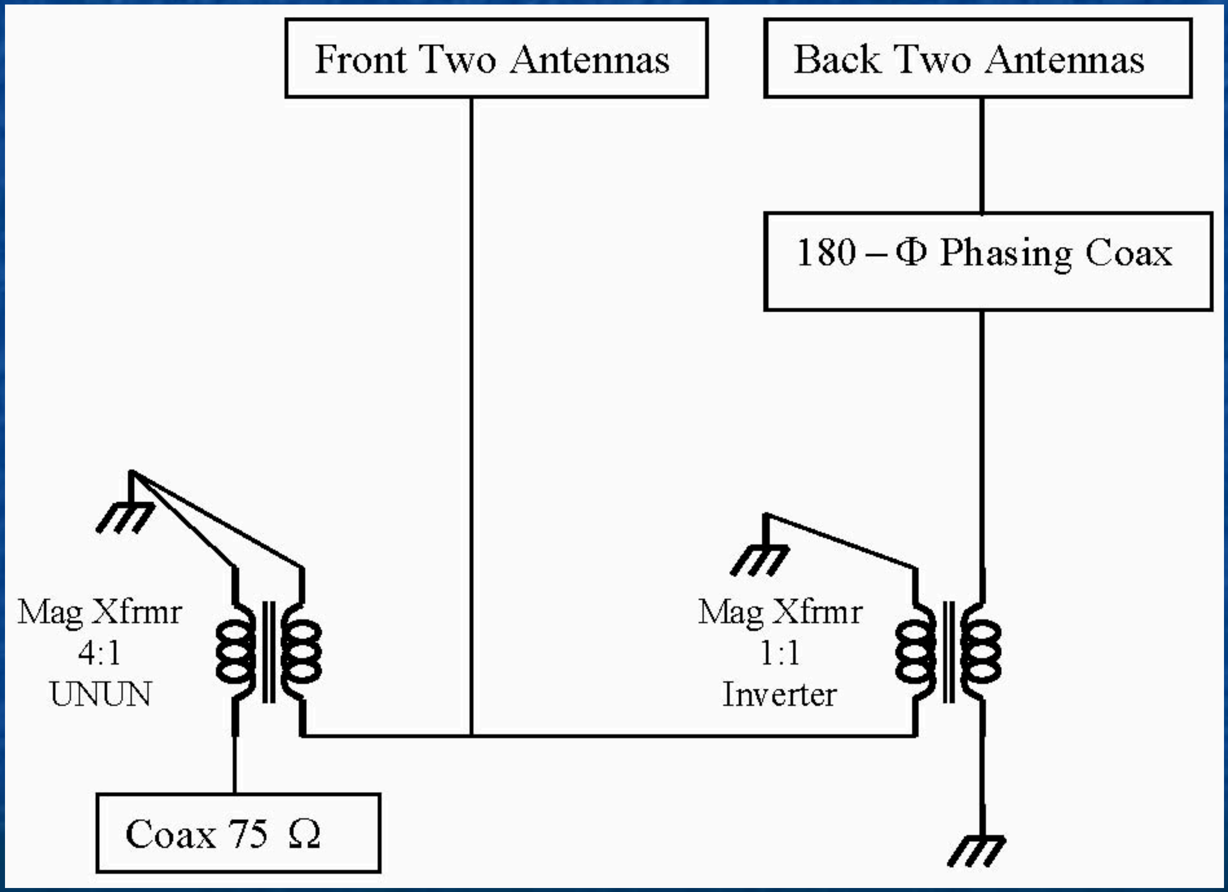


# Design
## Array

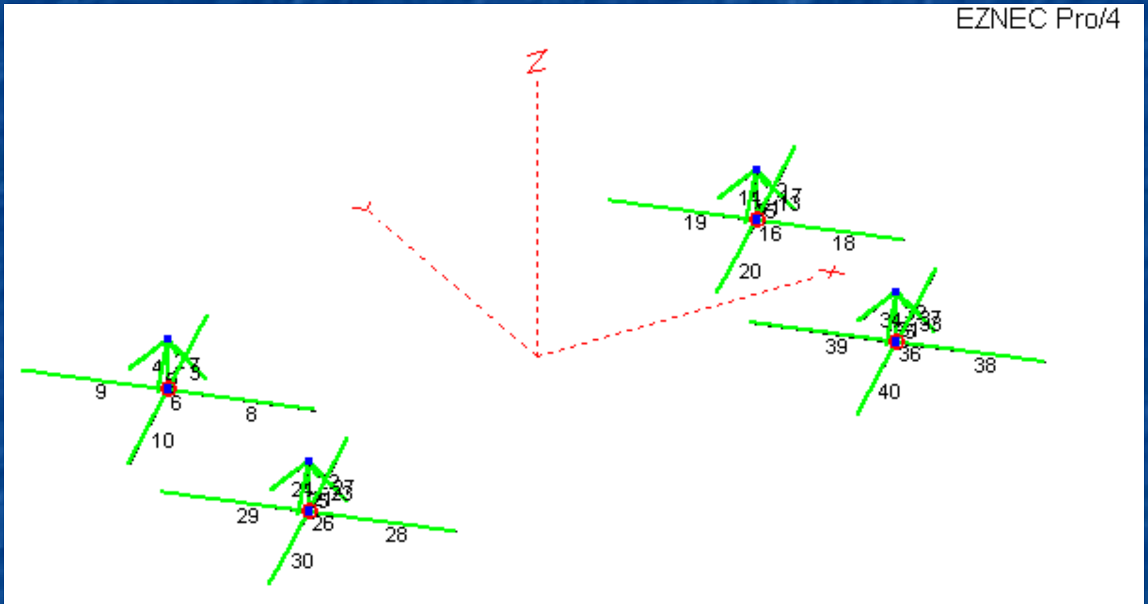
- Feeding this array is relatively easy. The materials required are:
  - One - 4:1 UNUN transformer
  - One - 1:1 Inverter transformer
  - Nine - DPDT relays & and four diodes.
  - 75Ω Coaxial Phasing Line
    - Two pieces of 75Ω coax connected in parallel to form a 37.5 Ω phase line. The length will be discussed later as there are trade offs to consider.

# Design

## Array



# Modeling an End-Fire / Broadside Array of Short Verticals

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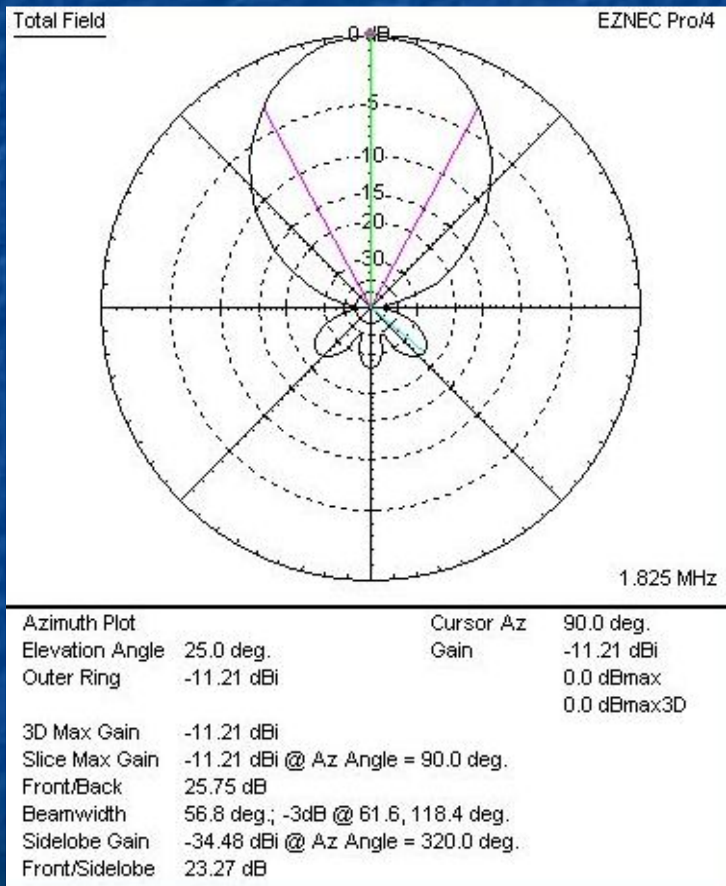
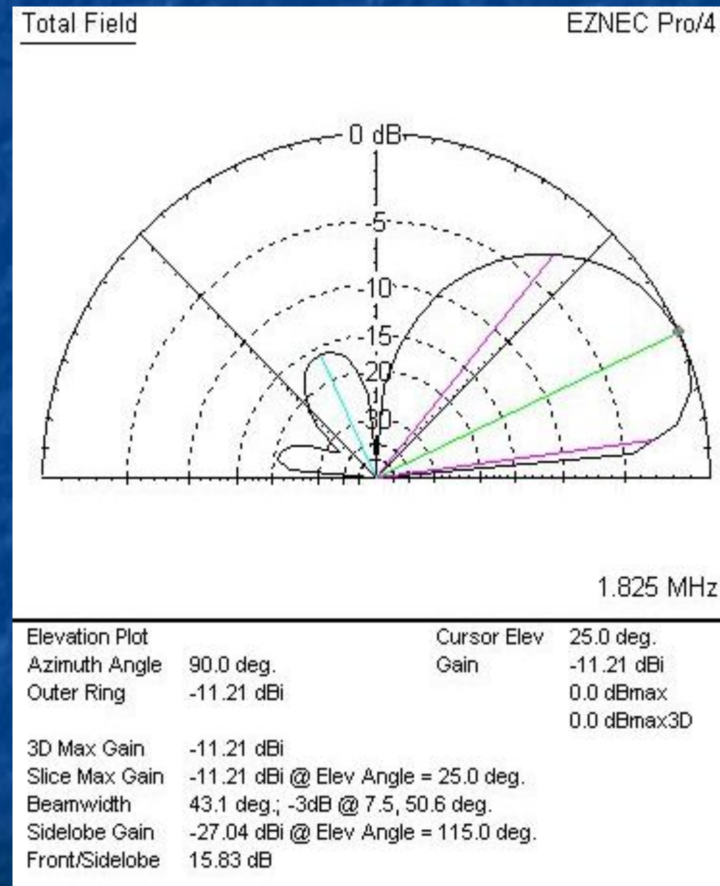
# Design

## Array

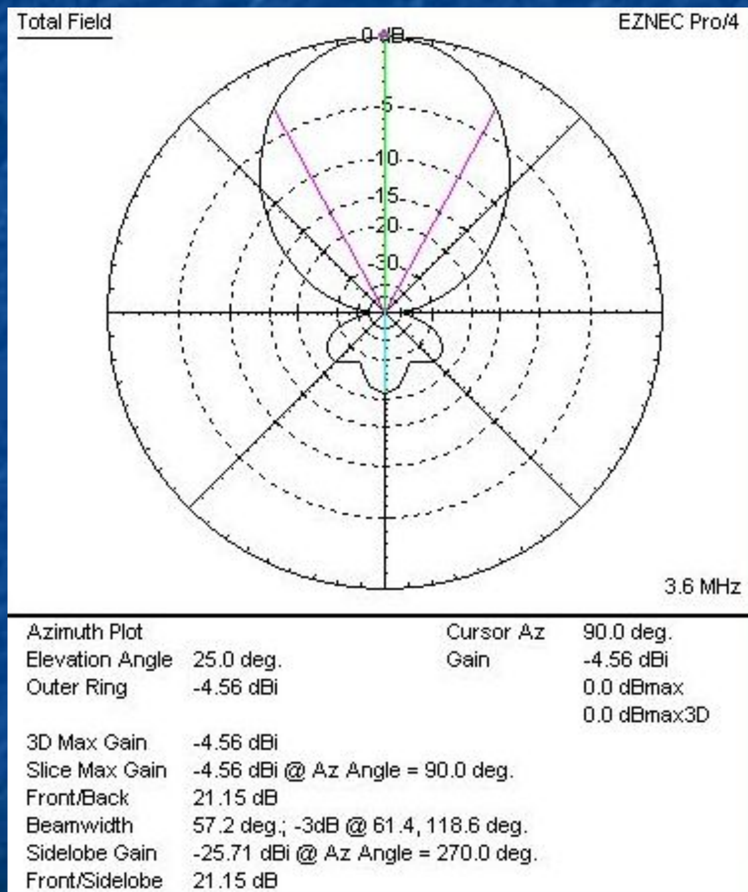


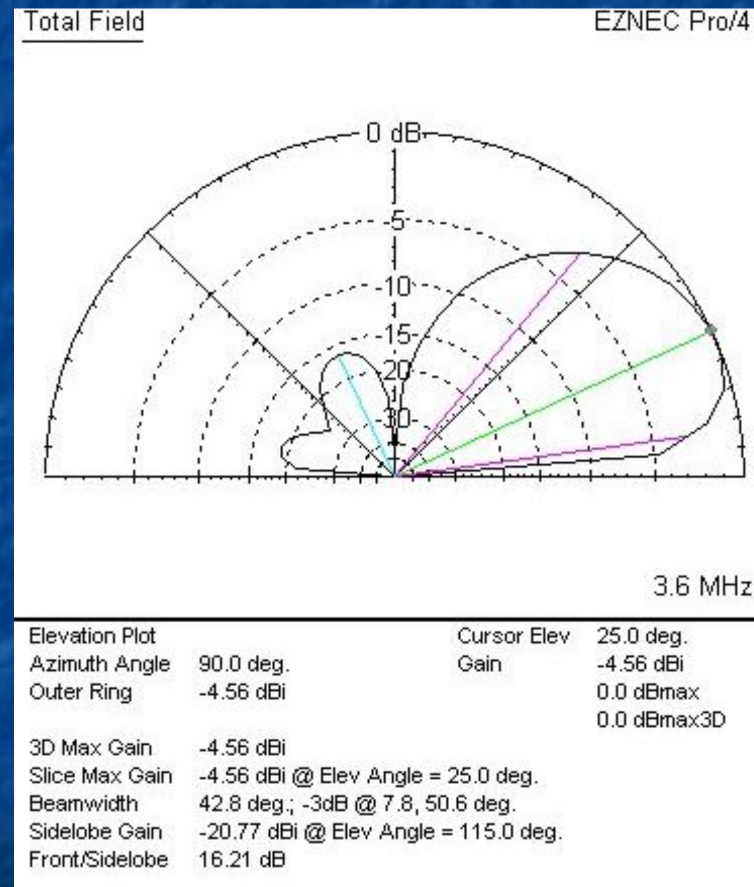




**160 Meters**

# Design

## Array




**80 Meters**

# Construction

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# Completed Vertical Based on Model

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# Actual Measurements Agree with Model

| Vertical | Self Resonance | Feedpoint Impedance | 160 Meter Feedpoint Resistance (no matching) |
|---|---|---|---|
| 1 | 3.90 MHz | 20 *j*0Ω | 18 *j*321Ω |
| 2 | 3.85 MHz | 19 *j*0Ω | 16 *j*321Ω |
| 3 | 3.90 MHz | 22 *j*0Ω | 16 *j*321Ω |
| 4 | 3.92 MHz | 21 *j*0Ω | 18 *j*328Ω |
| 5 | 3.92 MHz | 18 *j*0Ω | 18 *j*328Ω |
| 6 | 3.90 MHz | 18 *j*0Ω | 18 *j*328Ω |
| 7 | 3.90 MHz | 18 *j*0Ω | 18 *j*321Ω |
| 8 | 3.90 MHz | 22 *j*0Ω | 16 *j*315Ω |

# Actual Measurements of Tuned Array on 160 Meters

| Vert | 1.800 | 1.830 | 1.860 | 1.890 | *j*0 Bandwidth | Ind | Res | Total Ind & Res |
|---|---|---|---|---|---|---|---|---|
| 1 | 74 *j*13Ω | 75 *j*0Ω | 75 *j*0Ω | 76 *j*16Ω | 1.815 - 1.862 | 28 uH | 56Ω | 28.4 uH 56.5Ω |
| 2 | 75 *j*10Ω | 75 *j*0Ω | 76 *j*0 Ω | 77 *j*19Ω | 1.815 - 1.860 | 27.5 uH | 55Ω | 28.6 uH 54Ω |
| 3 | 76 *j*15Ω | 76 *j*0Ω | 76 *j*0Ω | 76 *j*9Ω | 1.817 - 1.868 | 28 uH | 54Ω | 28.6 uH 54.5Ω |
| 4 | 76 *j*15Ω | 75 *j*0Ω | 75 *j*0Ω | 76 *j*15Ω | 1.820 - 1.874 | 28 uH | 53Ω | 28.3 uH 54Ω |
| 5 | 76 *j*17Ω | 75 *j*0Ω | 75 *j*0Ω | 76 *j*12Ω | 1.824 - 1.878 | 27.5 uH | 53Ω | 28.0 uH 54Ω |
| 6 | 74 *j*11Ω | 74 *j*0Ω | 75 *j*0Ω | 76 *j*20Ω | 1.814 - 1.863 | 28 uH | 55Ω | 28.5 uH 56Ω |
| 7 | 75 *j*15Ω | 74 *j*0Ω | 75 *j*0Ω | 75 *j*17Ω | 1.818 - 1.868 | 28 uH | 53Ω | 28.5 uH 54Ω |
| 8 | 73 *j*16Ω | 73 *j*0Ω | 74 *j*0Ω | 74 *j*16Ω | 1.815 - 1.862 | 27.2 uH | 56Ω | 27.7 uH 56.5Ω |

# Evaluation

If I put up a low noise receive antenna, I will begin to magically hear DX stations that never existed before!

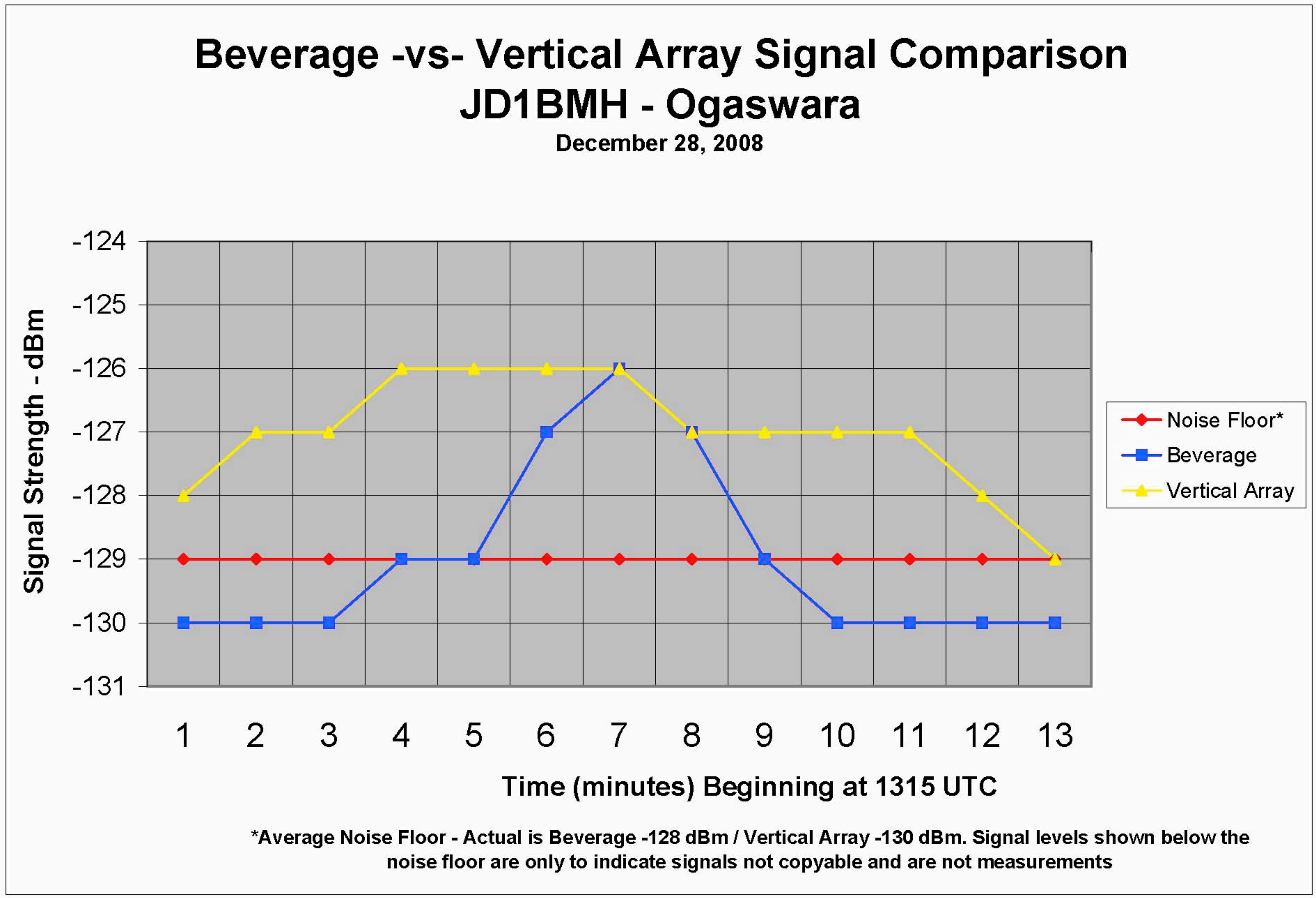
# BALONEY!!!

Fully understand the expectations of your antenna.

Propagation Characteristics are a MAJOR factor in determining whether you will hear a signal or not

# Noise Floor Measurements

| Direction | 8 Circle Vertical Array Noise Floor | Beverage Noise Floor | K9AY Loop | Shunt Fed 135' HF Tower 160 Meter Xmit | ½ λ Inverted Vee |
|---|---|---|---|---|---|
| N | -129 dBm | -125 dBm | N/A | -100 dBm[2] | -105 dBm[2] |
| NE | -125 dBm | -120 dBm | -132 dBm[1] | -100 dBm[2] | -105 dBm[2] |
| E | -125 dBm | -124 dBm | N/A | -100 dBm[2] | -105 dBm[2] |
| SE | -126 dBm | -123 dBm | -130 dBm[1] | -100 dBm[2] | -105 dBm[2] |
| S | -126 dBm | -120 dBm | N/A | -100 dBm[2] | -105 dBm[2] |
| SW | -125 dBm | -120 dBm | -132 dBm[1] | -100 dBm[2] | -105 dBm[2] |
| W | -126 dBm | -125 dBm | N/A | -100 dBm[2] | -105 dBm[2] |
| NW | -130 dBm | -128 dBm | -132 dBm[1] | -100 dBm[2] | -105 dBm[2] |

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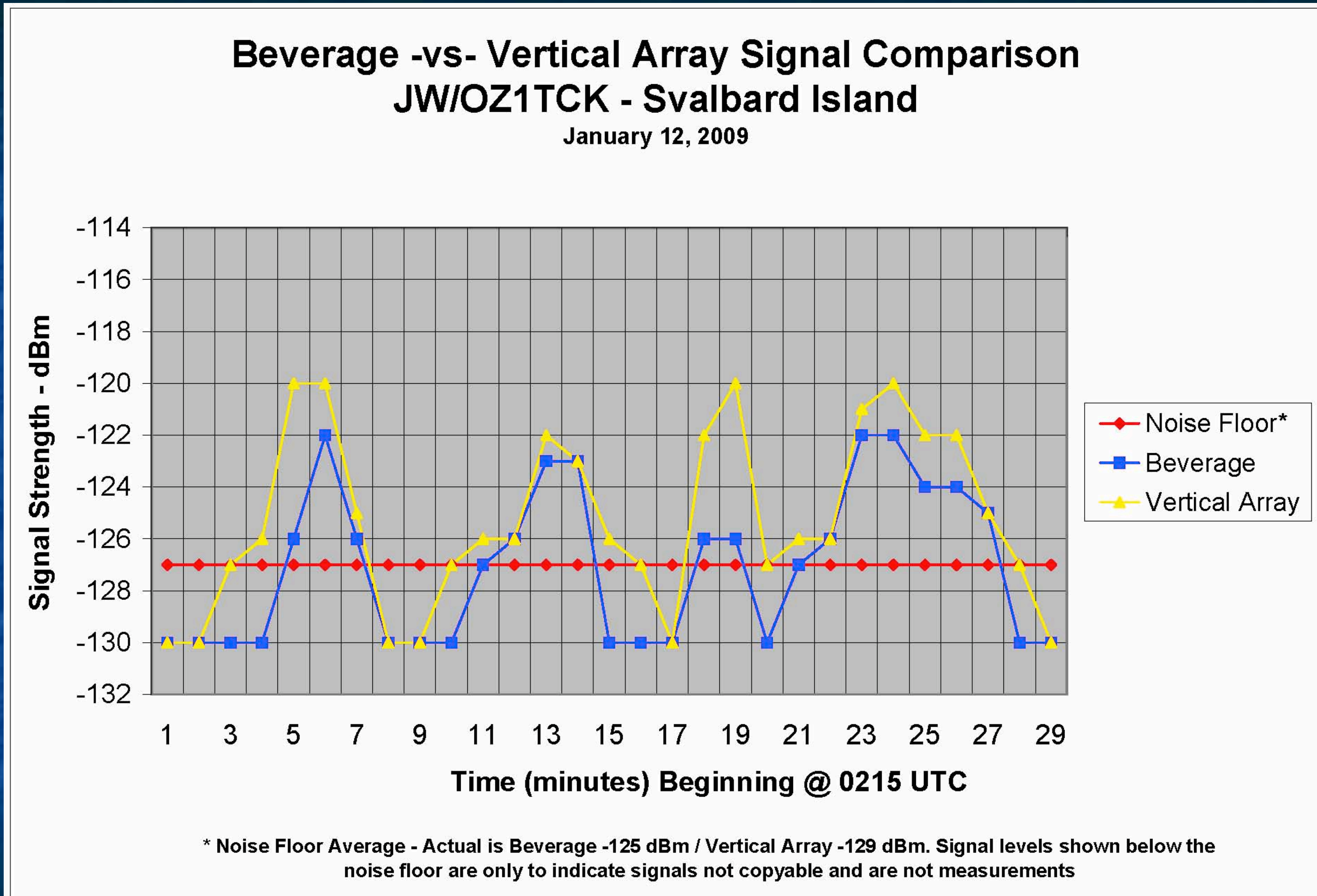


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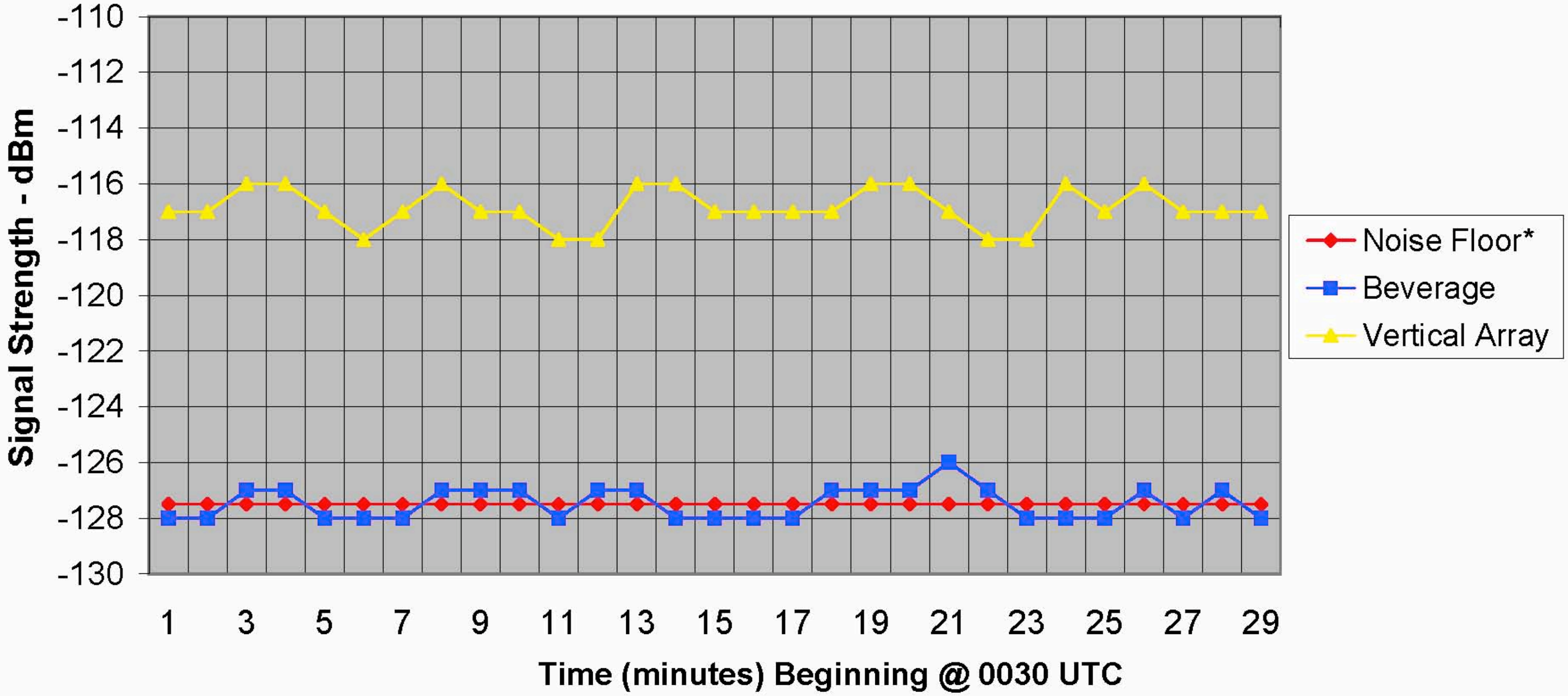
# Beverage -vs- Vertical Array Signal Comparison
## EY8MM - Tajikistan
**January 23, 2009**




*Noise Floor Average - Actual is Beverage -125 dBm / Vertical Array -130 dBm. Signal levels shown below the noise floor are only to indicate signals not copyable and are not measurements

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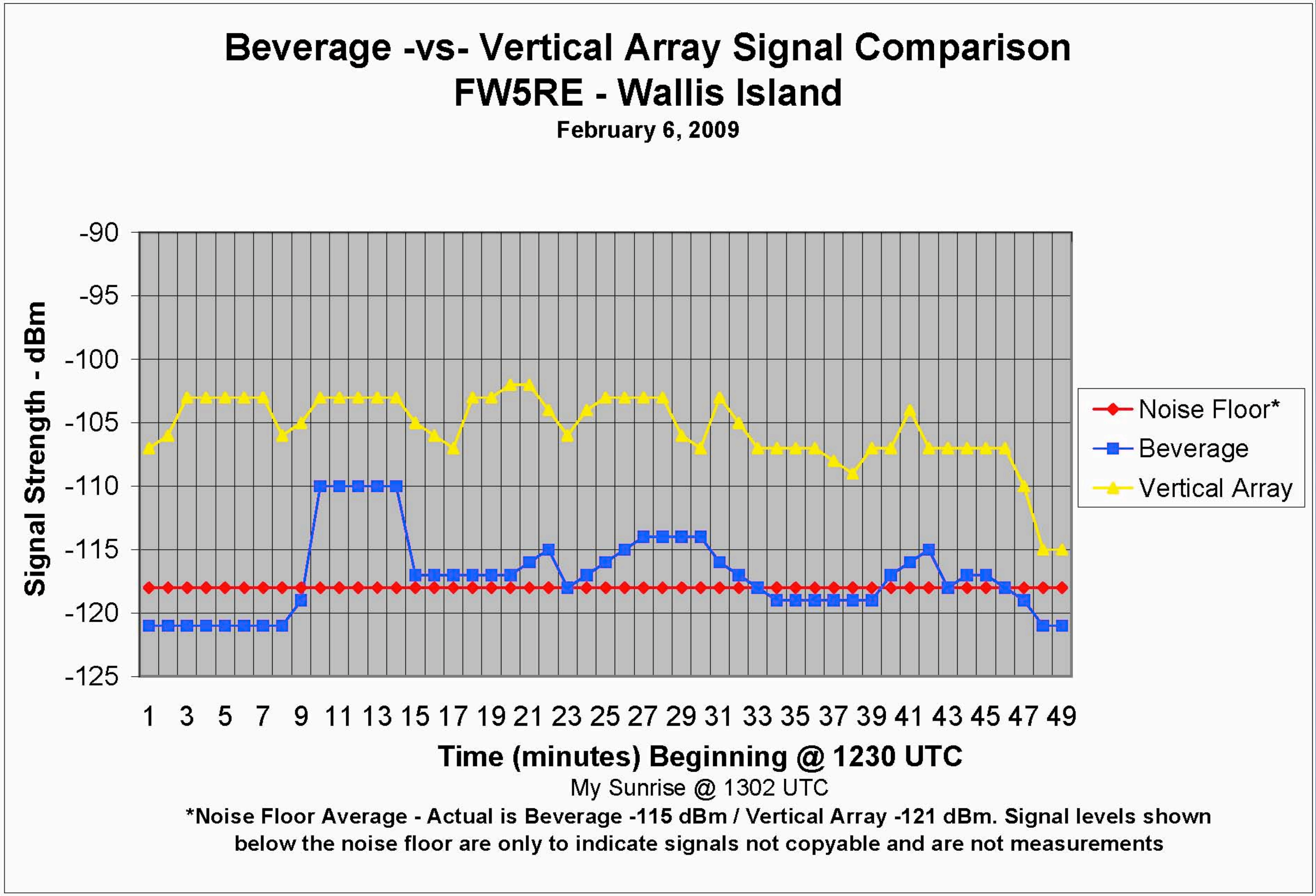


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# Construction

## 80 Meter Results

- Only one known to have been built & evaluated.
- Dimensions of elements are same as 160 Meter version, but spacing & circle are much smaller.

# Construction

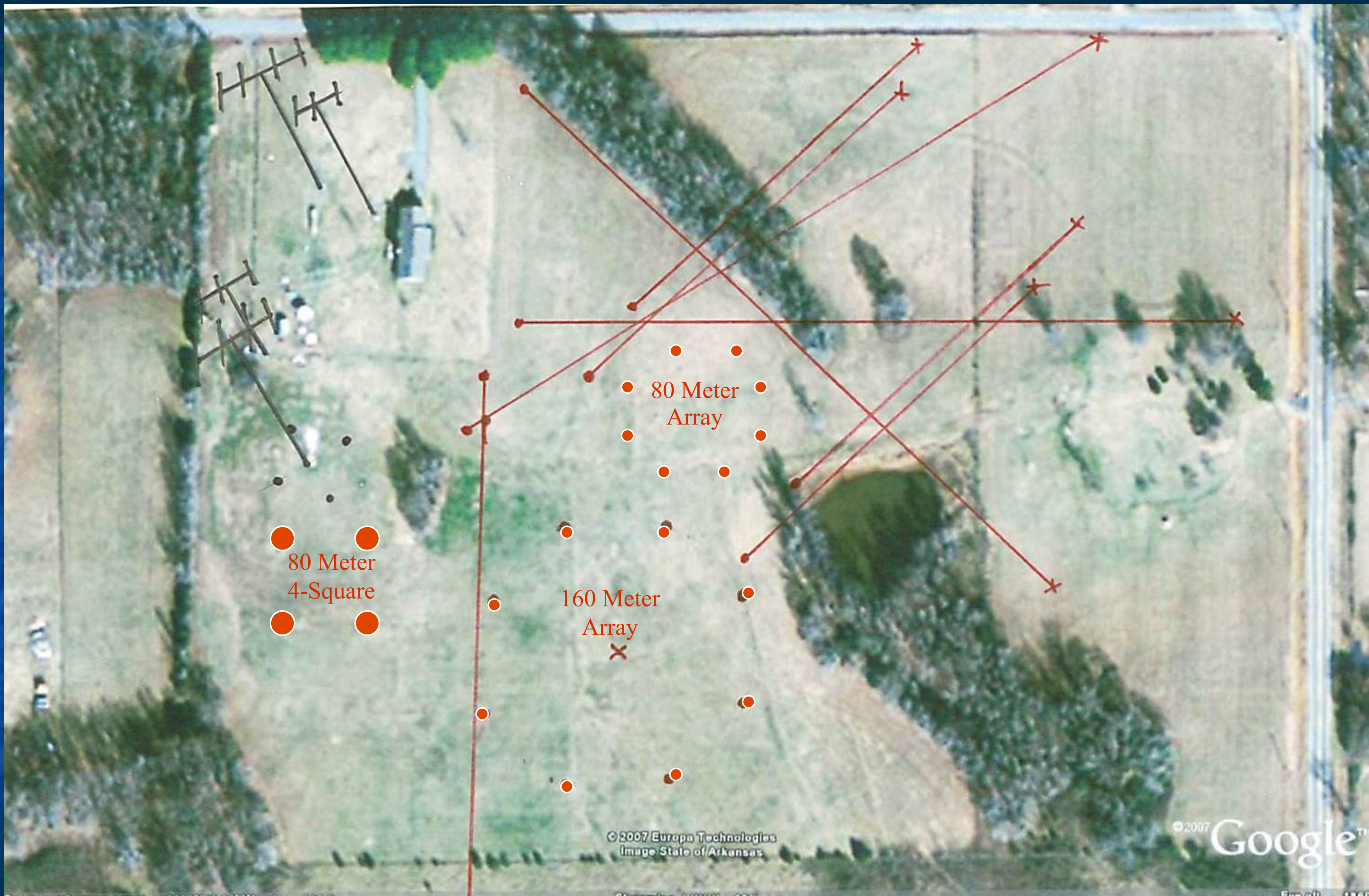
## 80 Meter Results

- Radial layout more critical
  - Started with ¼ λ, went to 1/8 λ
- Matching values are more critical
  - Smaller component value change makes larger resonant freq change

# Evaluation

## 80 Meter Results

- Noise floor equivalent to Beverages
- Able to hear weaker stations not copyable on Beverages
  - 5X1NH, R1ANF, 9U1VO
  - ARRL DX Contest
    - XU7ACY 40 minutes after Sunrise
    - Able to go one level deeper for QRP EU stations

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# Necessary Equipment


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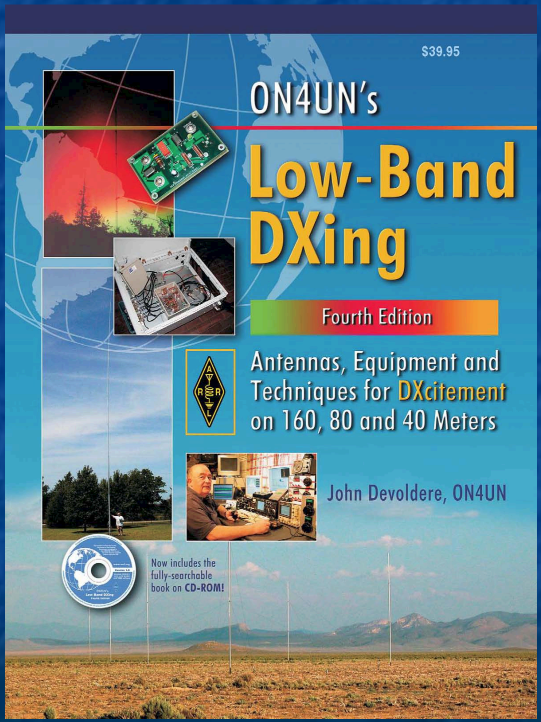
# Design, Construction & Evaluation of the 8 Circle Vertical Array

Joel Harrison, W5ZN and Bob McGwier, N4HY

- Download a copy at www.w5zn.org
- QEX Article in March/April Issue

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