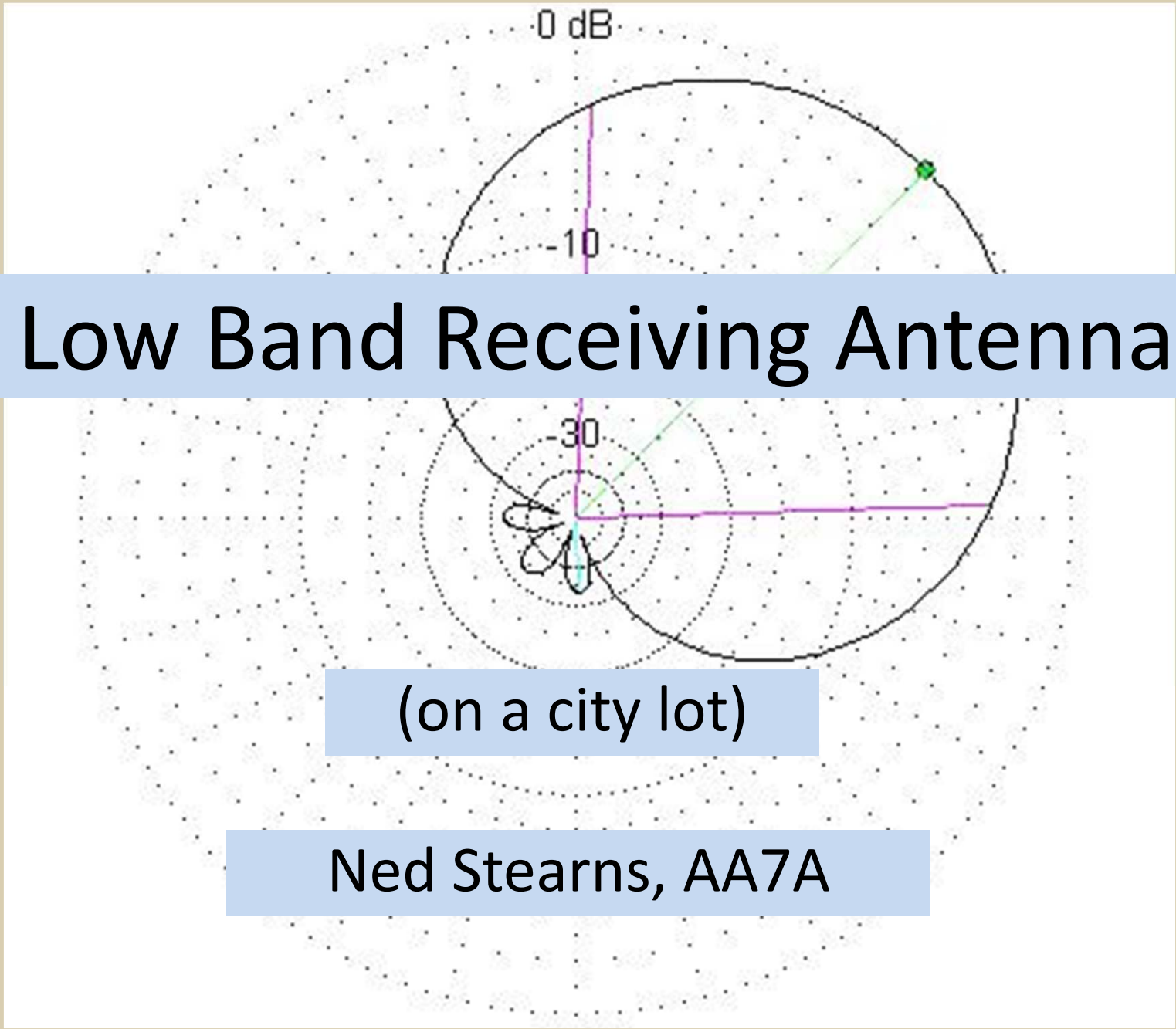


Low Band Receiving Antennas

(on a city lot)

Ned Stearns, AA7A

How do you know you need a Receive Antenna?

- Scenario #1 – Many DX stations hear you much better than you hear them
- Scenario #2 – When your DXer neighbor hears a lot of stations that you do not hear
- Scenario #3 – When you want to increase the likelihood of a successful DX QSO

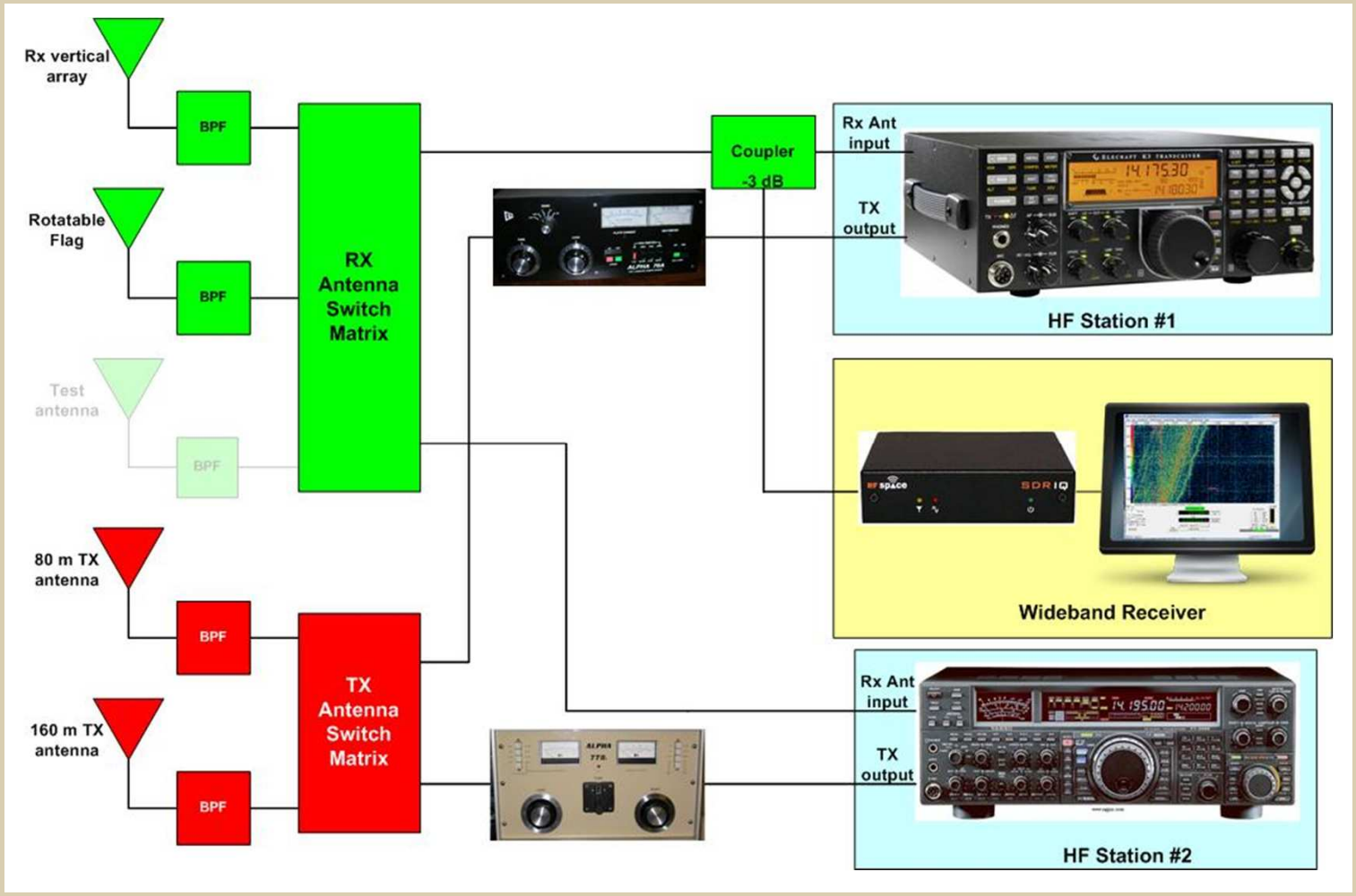
What is Noise?

- Noise, (noun, *'nöiz'*): *an unwanted signal or a disturbance (as static or a variation of voltage) in an electronic device or instrument (as radio or television)*
- Noise types:
  - *Thermal*; not usually an issue on LF
  - *Shot noise*; unless you are using a 6AU6 in your LF receiver preamp, not an issue
  - *Flicker noise*; Maybe an issue on 137 KHz but not any of the higher amateur bands
  - *Atmospheric noise*; Major factor on LF
  - *Undesirable signals*; Major factor on LF

Method to study Noise

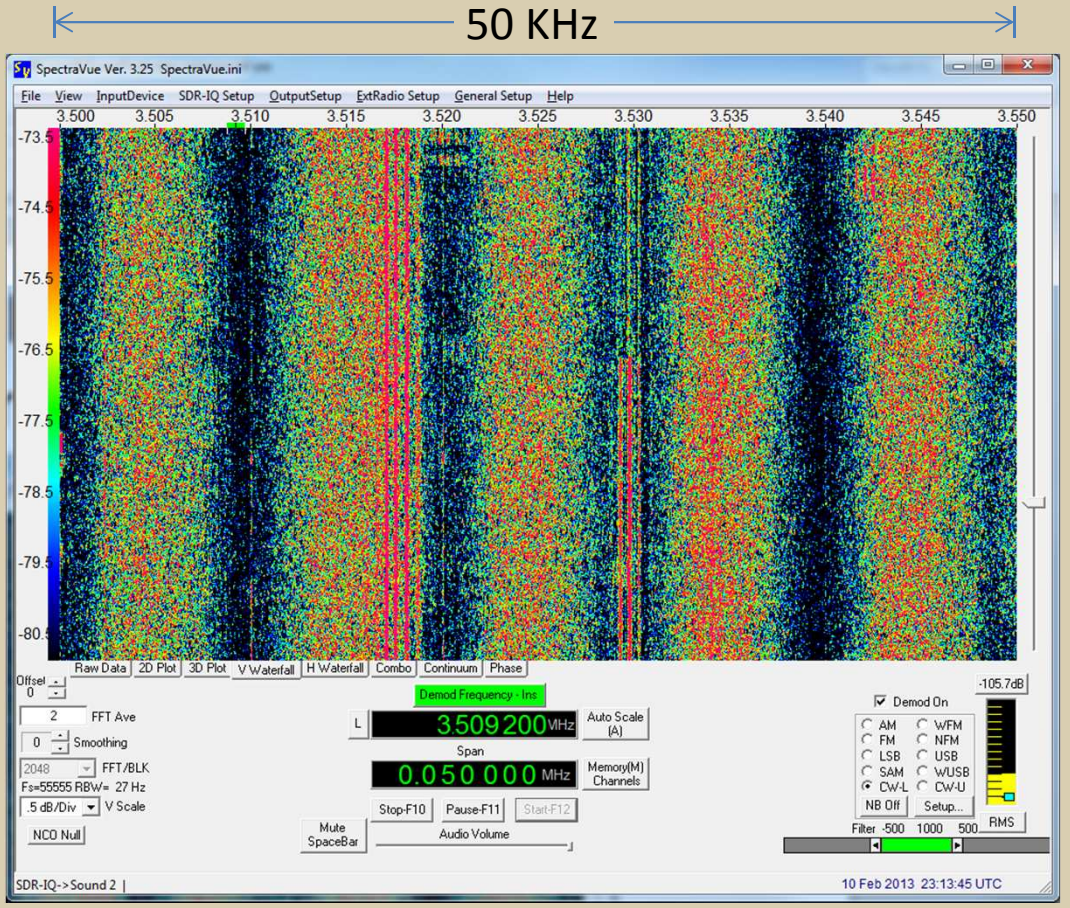
- Ham radio communications use narrowband channels
  - CW: 700 Hz
  - SSB: 3.1 KHz
  - AM: 6 KHz
- Most noise sources are due to transients and occupy bandwidths much wider than ham communication channels
- It is usually more meaningful to look at noise in wider bandwidths

Method to study Noise – AA7A LF System



What is Noise? – Undesirable Signals

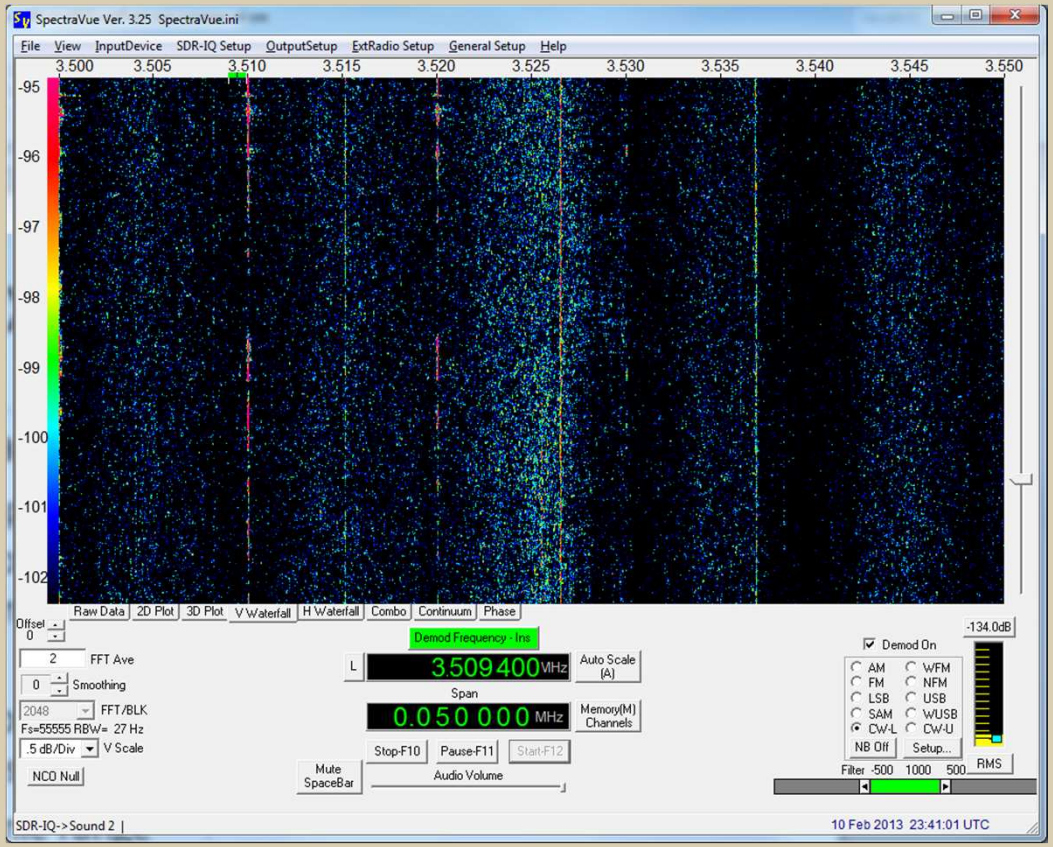
- Noise characteristics
  - Noise power in noise “hole” -105.7 dBm
  - Noise peaks 8 db higher 5 KHz away
  - Likely a plasma TX somewhere nearby
- Other discrete spectral artifacts



Spectrum of 80 meter CW DX band on 80 meter TX vertical array (South)

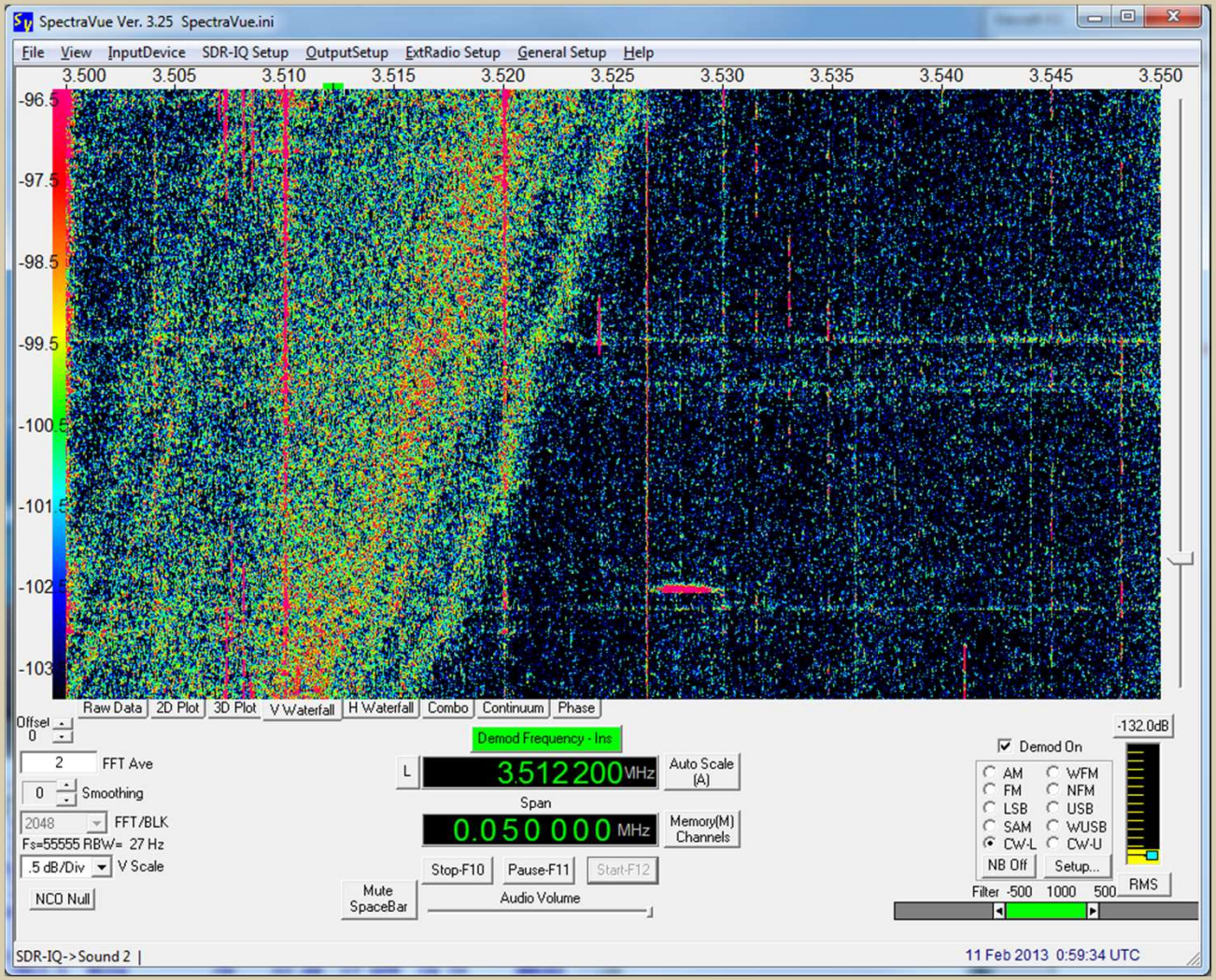
What is Noise? - Undesirable Signals

- Noise characteristics
  - Noise power in noise “hole” -134 dBm
  - Noise peaks 1 db higher 5 KHz away
  - Less coupling to local plasma TV
- Other discrete spectral artifacts much weaker



Spectrum of 80 meter CW DX band on 80 RX antenna array (SE)

What is Noise? – Undesirable Signals



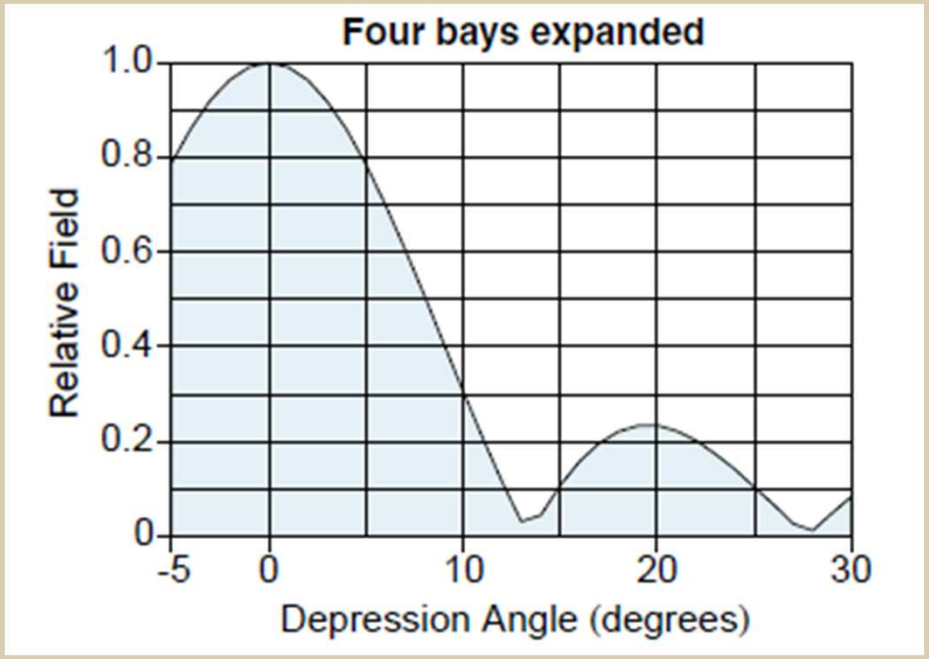
RX Antennas – Do any good?

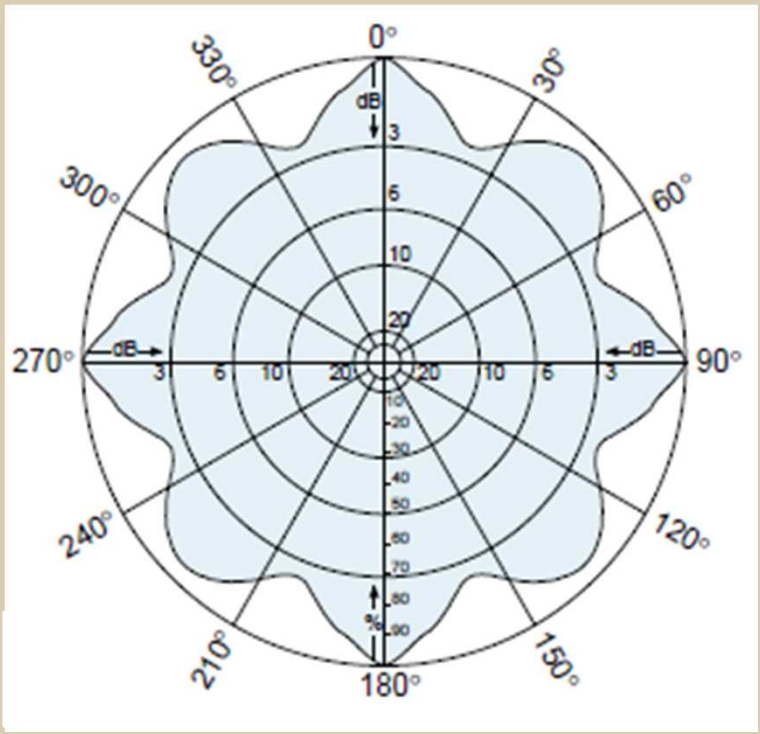
- It’s all about the Signal-to-Noise ratio
  - Not antenna gain
  - Not about your S-meter reading
- Pattern is the most important attribute
  - HA5TI’s six meter party story

HG50MHZ Story…In their words

- 15 August 2011, HA television stations stop TX'ing on CH 1 (covering six meters)
- HA Hams celebrate with a special event where they start 6m activity using high power and CH 1 Transmitter Antenna signing HG50MHZ

Antenna pattern is good for TX'ing, but…





They had to use an antenna with a better pattern

- “we were struggling with understanding weak signals covered by high noise”
- “we erected a five element **DK7ZB Yagi**” and started working stations
- “It is very likely that we wouldn’t have copied most of them with the broadcast antenna.”

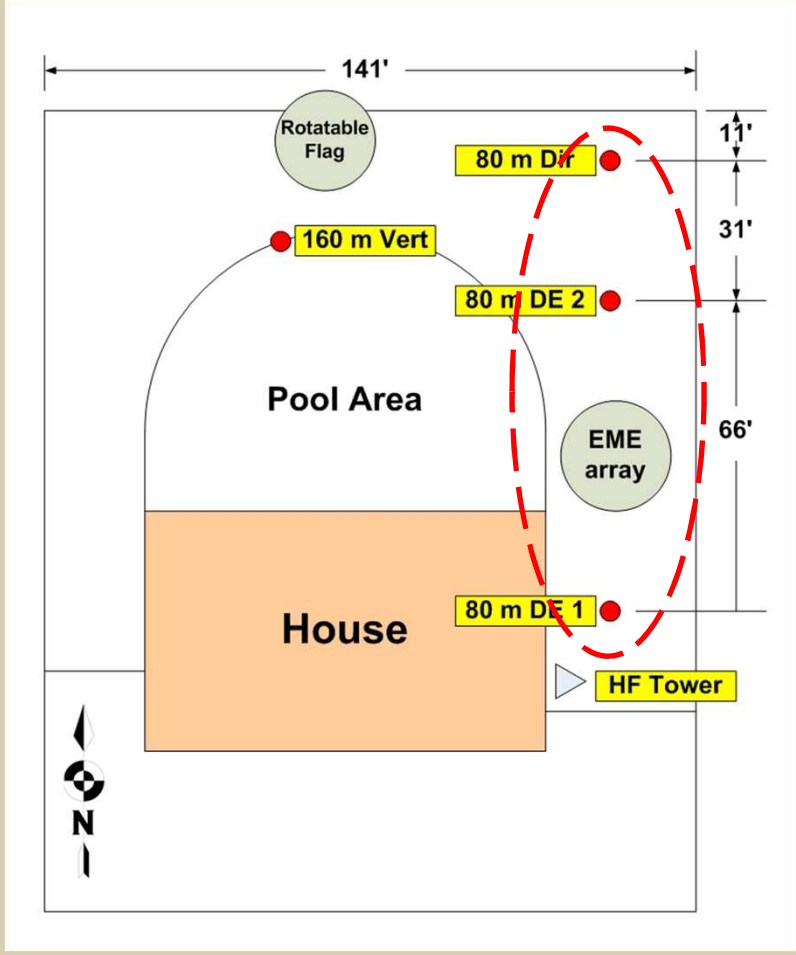
General strategies to improve receiving capabilities on LF bands

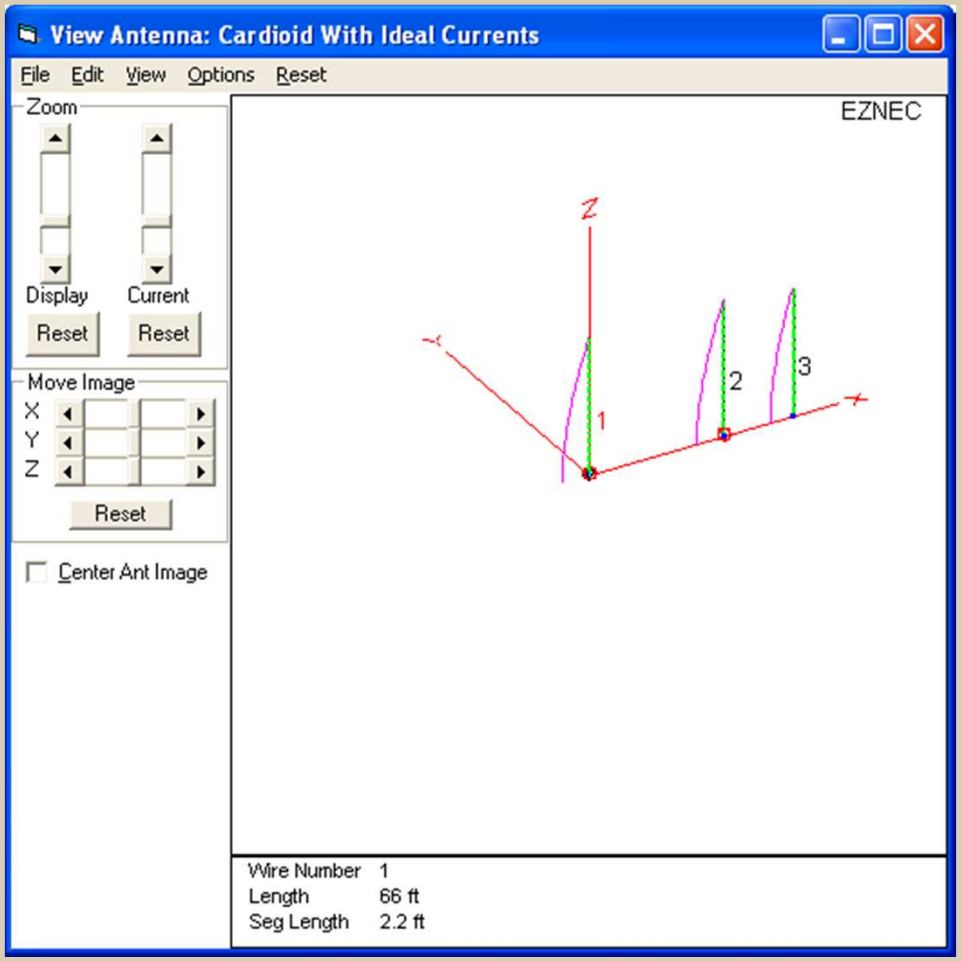
- Use antenna null feature to reduce interference from point radiating sources
- Use antenna pattern to reduce effects of lightning crashes from storm systems in the sub-tropics
- Use an antenna with a different elevation pattern (lower or higher launch angle then TX antenna)
- Use an antenna which provides spatial diversity when used in tandem with TX antenna

Starting point for RX antenna studies

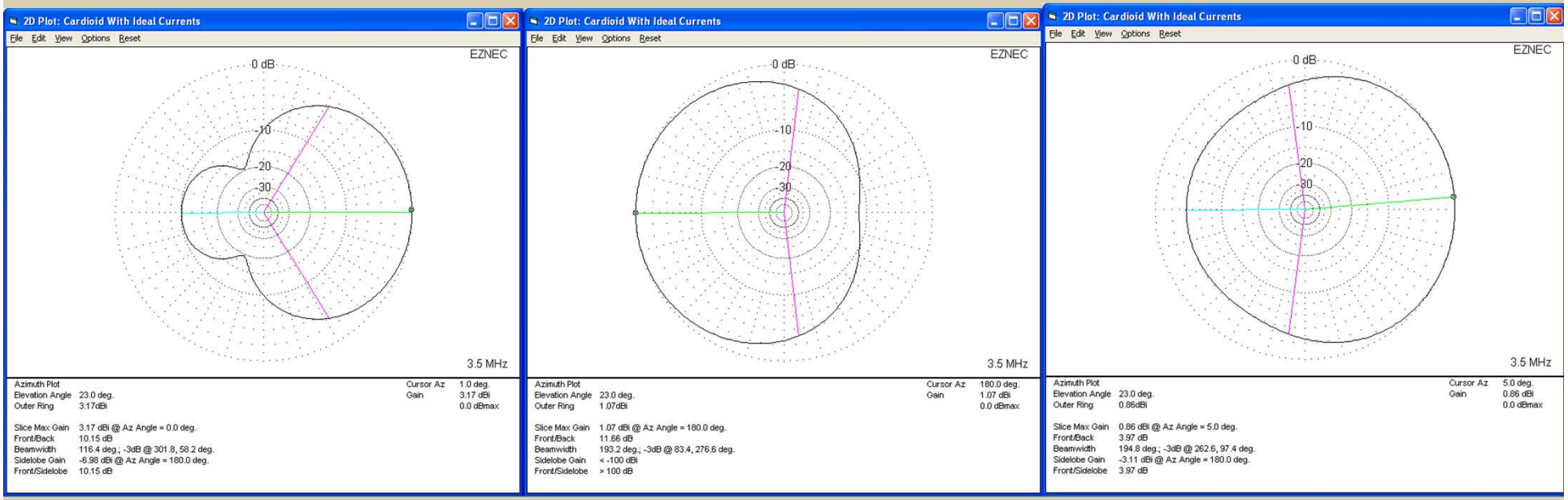
- AA7A developed 3-element vertical array to chase the last 50 needed on 80 m
- Rotatable flag antenna with custom dual band preamp used as RX antenna
- Success was limited by ability to receive
- Was there more that could be done without moving closer to DX?

Starting Point – AA7A 80 m TX Antenna





3-element azimuth pattern



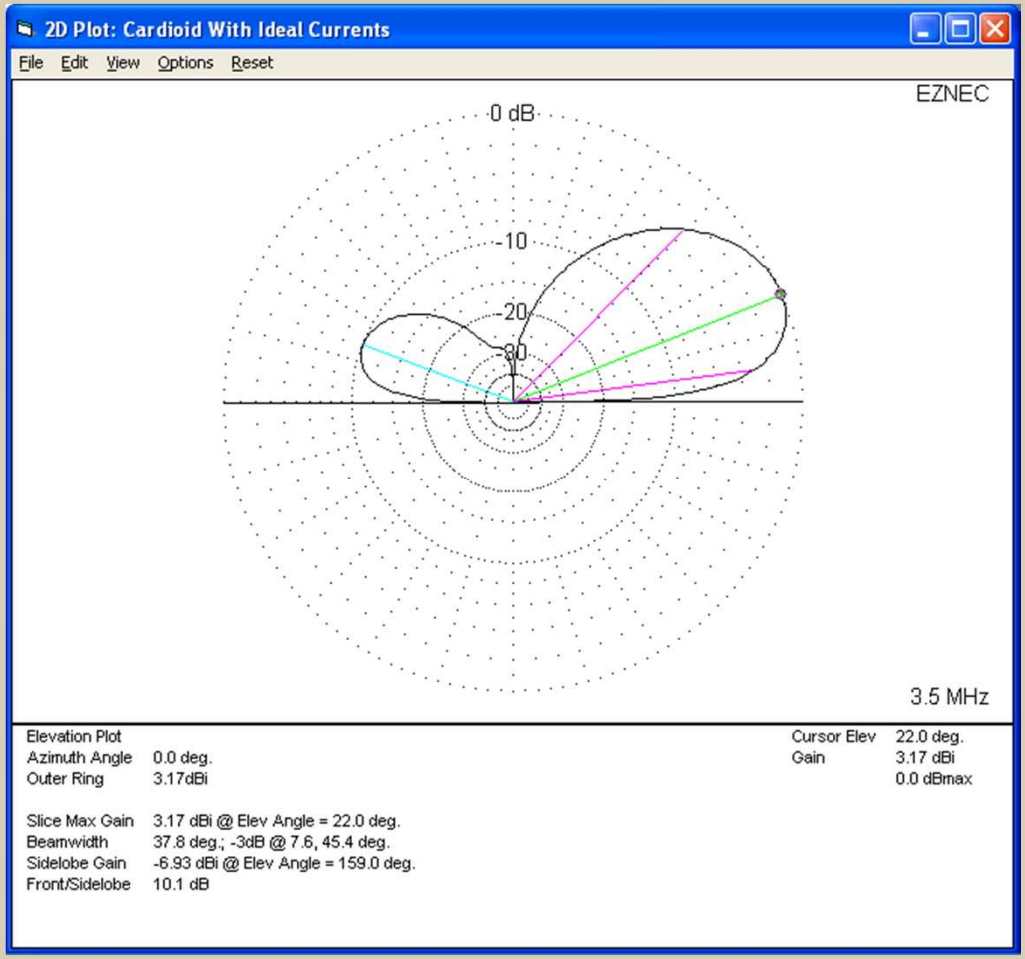
End-fire North

End-fire South

Broadside

Adding Director Increases Gain by 1.4 dB

3-element elevation pattern (end fire North)



Adding Director Lowers Elevation of Main Lobe by 3 degrees

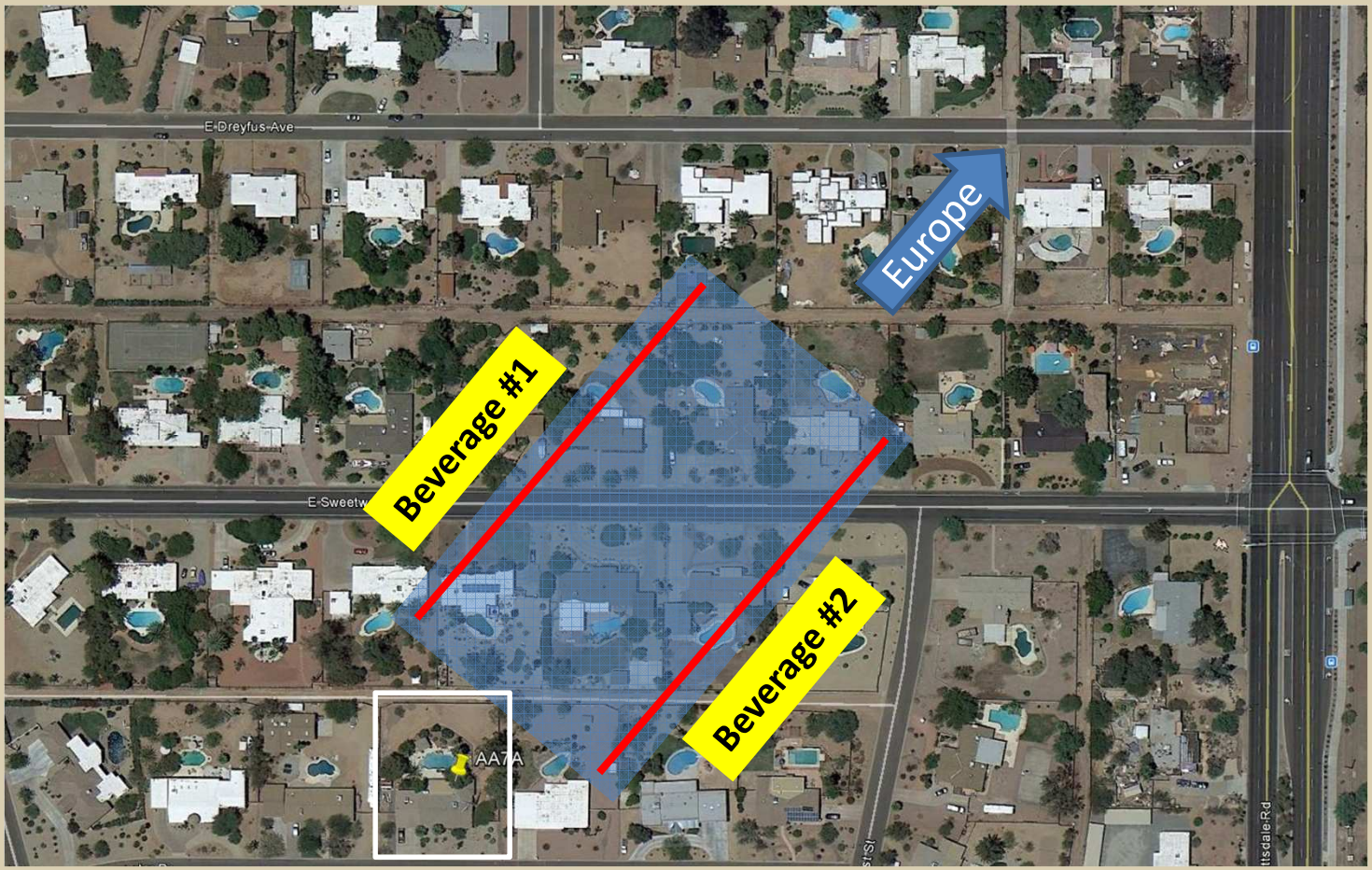
RX Antenna Performance vs Space

(data from W8JI's RX Antenna web pages)

Antenna Type	RDF (dB)	20-degree forward gain (dBi)	Space required*
1/2λ Beverage	4.52	-20.28	2
Vertical Omni, 60 1/4λ radials	5.05	1.9	1
(Ewe Flag) Pennant	7.39	-36.16	1
K9AY	7.7	-26.23	1
1/2λ end-fire Beverages	7.94	-20.5	2
1λ Beverage	8.64	-14.31	4
two verts optimum phasing 1/8 λ spacing	9.14	-22.46	1
two 1λ Beverages Echelon 1/8 λ stagger	10.21	-15.45	4
Small 4-square 1/4 λ per side (optimum phase)	10.70	-15.79	2
1-1/2 λ Beverage	10.84	-10.88	6
Small 4-square 1/8λ per side (opt. phase)	10.97	-30.28	1+
Single 1.75λ Beverage	11.16	-6.50	7
2 Broadside 1.75λ Beverages .2λ spacing	11.36	-3.51	8
2 Broadside 1.75λ Beverages .4λ spacing	11.91	-3.50	8
.625λ x .125λ spaced BS/EF vertical array	12.5	-19.5	4
2 Broadside 1.75λ Beverages 5/8λ spacing	12.98	-3.50	9
2 Broadside 1.75λ Beverages .75λ spacing	13.48	-3.49	10

*** Number of AA7A-sized property lots needed to fit antenna**

How big are these RX antennas? – 2 X 1.75λ Beverages spaced 0.75λ apart



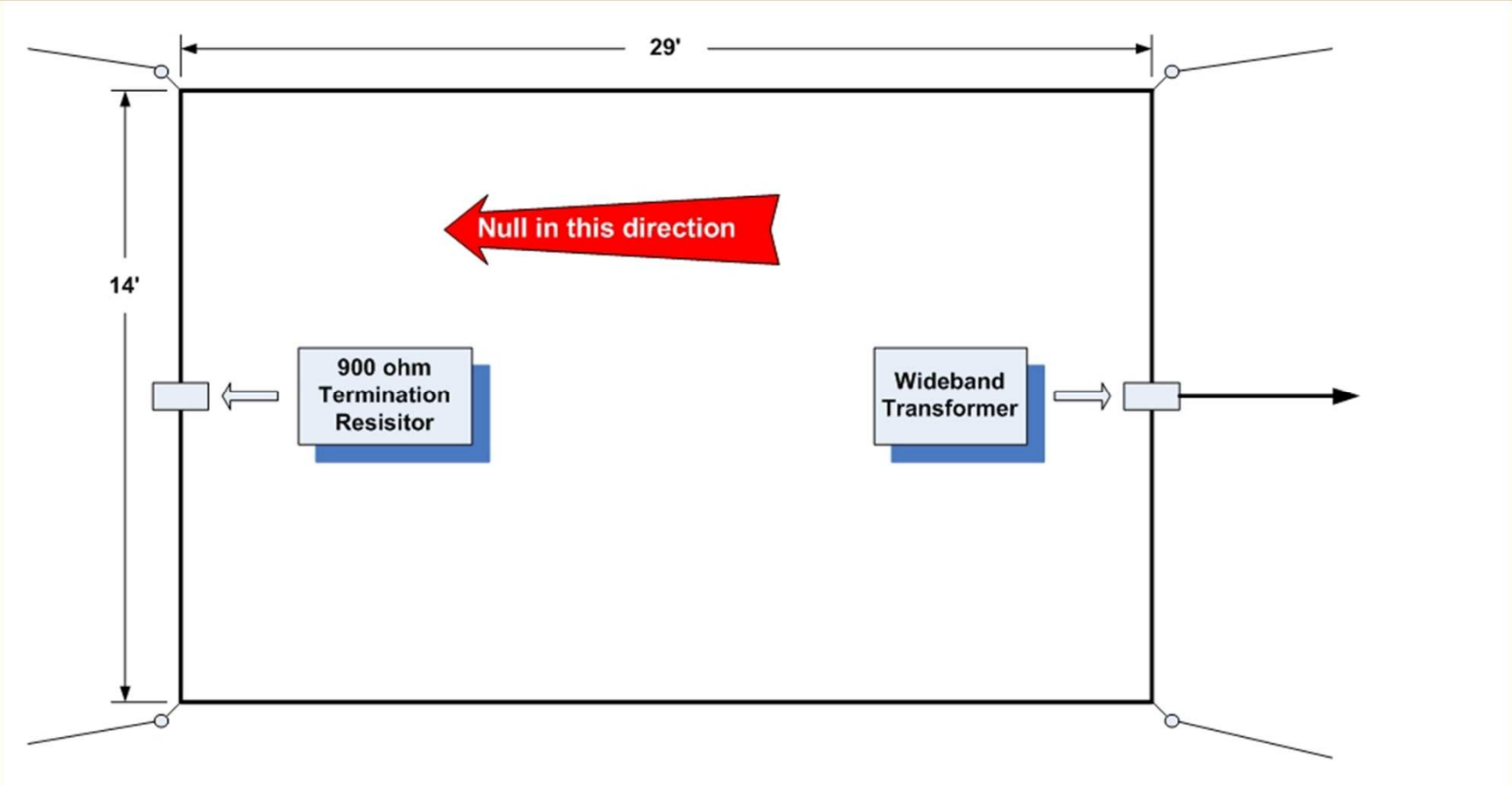
80 meter RX antenna will touch over 10 other 1 acre lots

Viable* LF RX Antenna Options

- Single λ/4 vertical – tried it already
- Flag antenna – tried it; some success with reducing point noise sources

*** Those that fit in AA7A's backyard**

Flag Antenna Concept



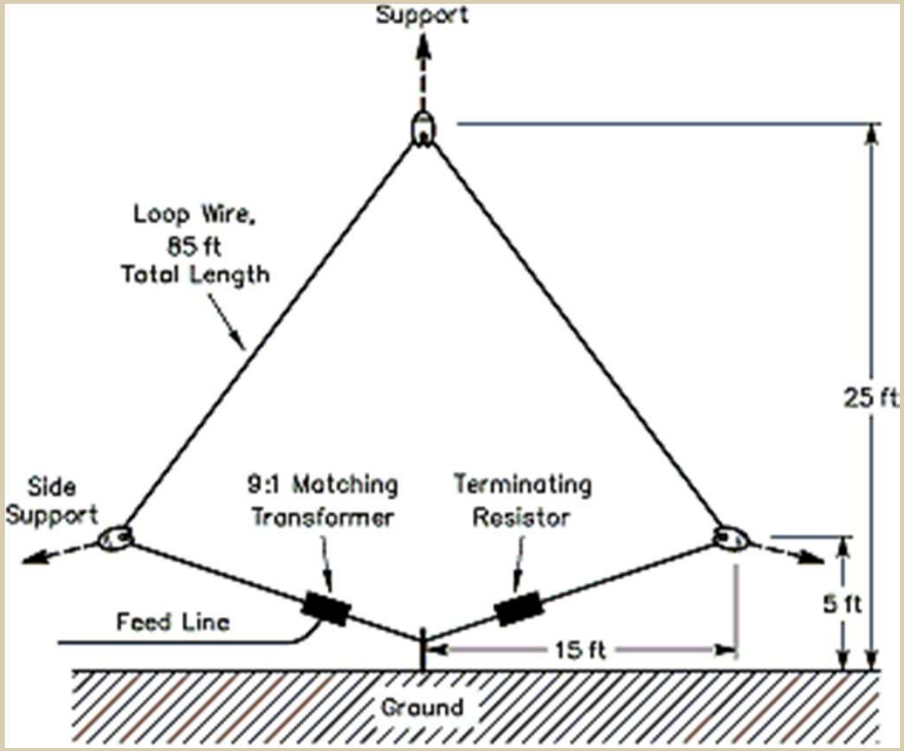
AA7A Rotatable Flag Antenna

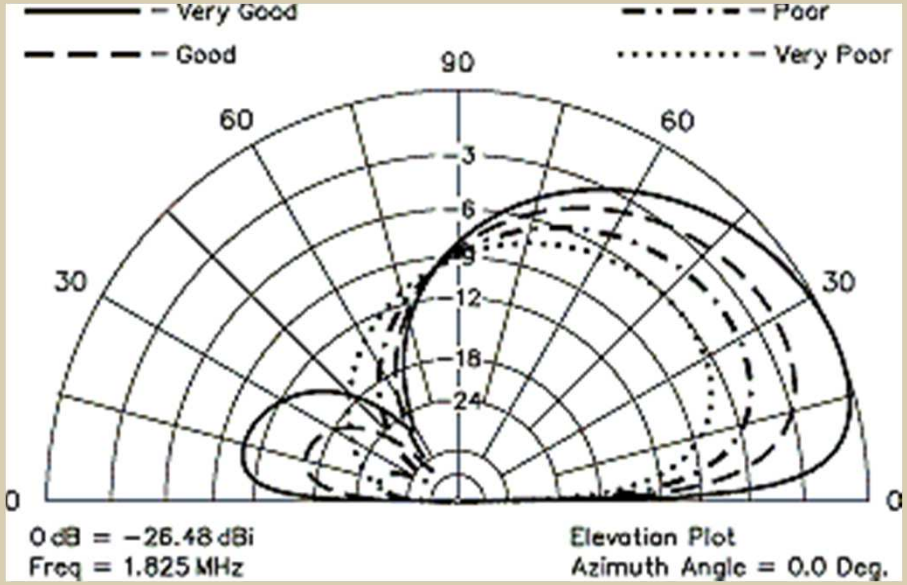
Viable* LF RX Antenna Options

- Single λ/4 vertical – tried it already
- Flag antenna – tried it; some success with reducing point noise sources
- K9AY – untried; performance claims seem to be all over the map

*** Those that fit in AA7A's backyard**

K9AY Loop





Gain & elevation patterns significantly affected by ground conductivity values

Viable* LF RX Antenna Options

- Single λ/4 vertical – tried it already
- Flag antenna – tried it; some success with reducing point noise sources
- K9AY – untried; performance claims seem to be all over the map
- Two λ/4 verticals – tried; limited pointing options
- Small 4-square of verticals – untried; might be too large, unless…

*** Those that fit in AA7A's backyard**

RX Antenna Performance vs Space (data from W8JI's web pages)

Antenna Type	RDF (dB)	20-degree forward gain (dBi)	Space required*
1/2λ Beverage	4.52	-20.	2
Vertical Omni, 60 1/4λ radials	5.05	1.	1
(Ewe Flag) Pennant	7.39	-36.	1
K9AY	7.7	-26.23	1
1/2λ end-fire Beverages		-20.5	2
1λ Beverage		-14.31	4
two verts optimum phasing 1/8 λ spacing		-22.46	1
two 1λ Beverages Echelon 1/8 λ stagger	10.21	-15.45	4
Small 4-square 1/4 λ per side (optimum phase)	10.70	-15.79	2
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2 Broadside 1.75λ Beverages 5/8λ spacing	12.98	-3.50	9
2 Broadside 1.75λ Beverages .75λ spacing	13.48	-3.49	10

Higher gain could eliminate need for a preamp

Is there a configuration that will fit???

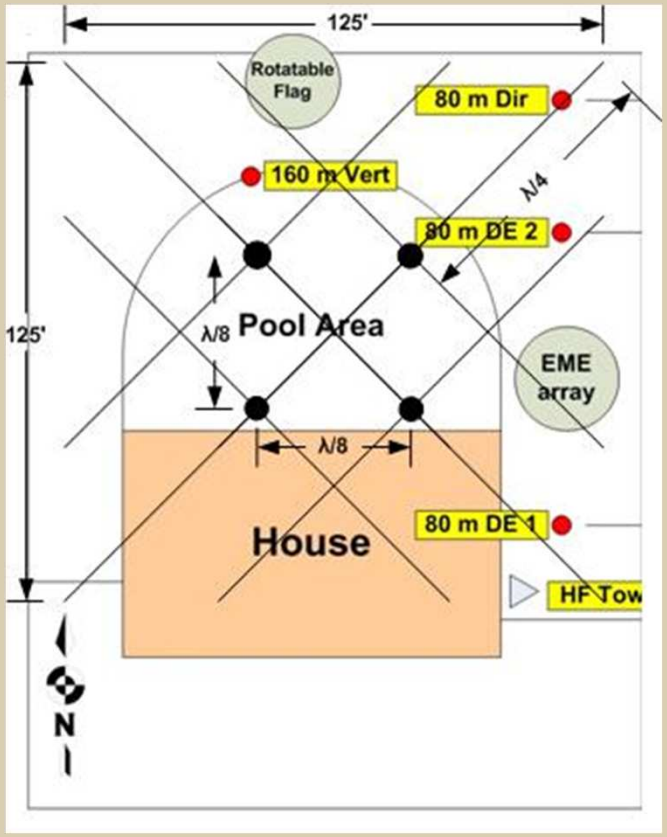
*** Number of AA7A-sized property lots needed to fit antenna**

AA7A's RX Antenna Project - small lot/high performance, single band rx antenna

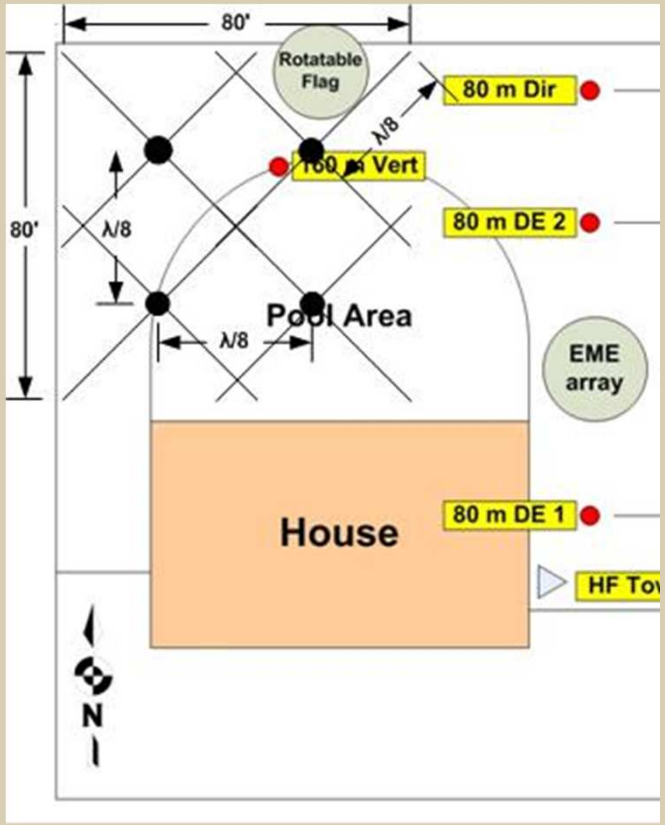
- Clean pattern that is steerable in 4 directions
  - 4-square array
- No preamplifiers to permit SO2R contest operation
  - Not electrically "too short"
- Fit in generally unusable part of AA7A back lot
- Above the urban clutter/layer of RF absorption
- Self-supporting (no guys)

4-Square sizing – Layout options

Array of λ/4 verticals



Array of "shortened" verticals

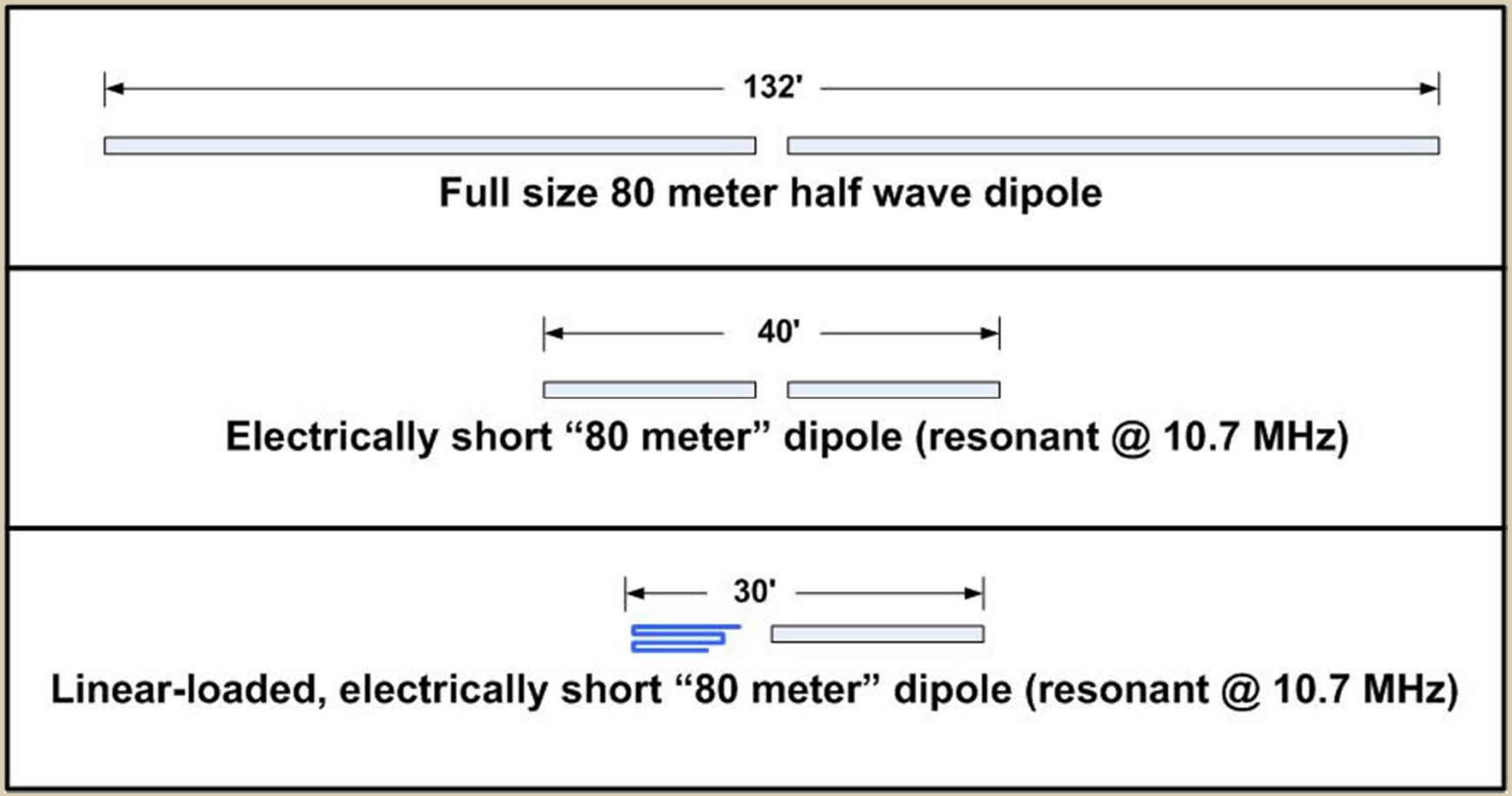


Traditional 4-square option takes up more room than desirable

Electrically Small Dipole Antennas

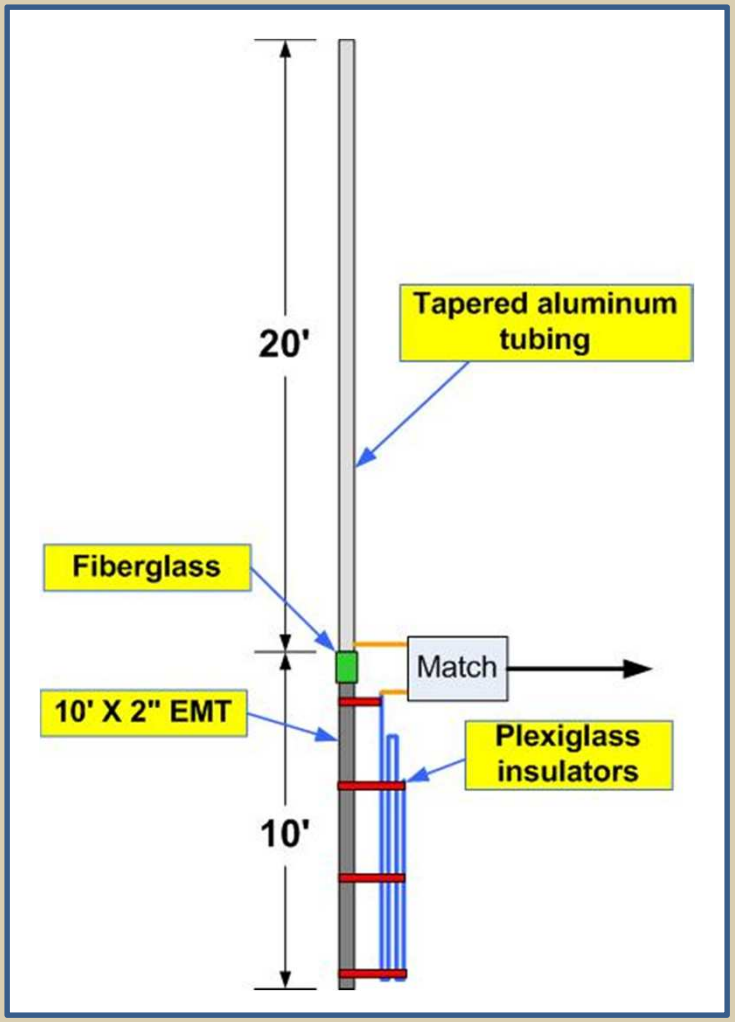
- New concept: **electrically short, vertical dipole** as the antenna element in a 4-square array
- Dipole elements cancel horizontal component which results in less pattern uncertainty
- Gain is simply related to the physical dimensions of the dipole
- Increasing the electrical length by linear loading reduces impedance mismatch losses
- 30’ tall elements require no guy wires

Short dipole receiving element

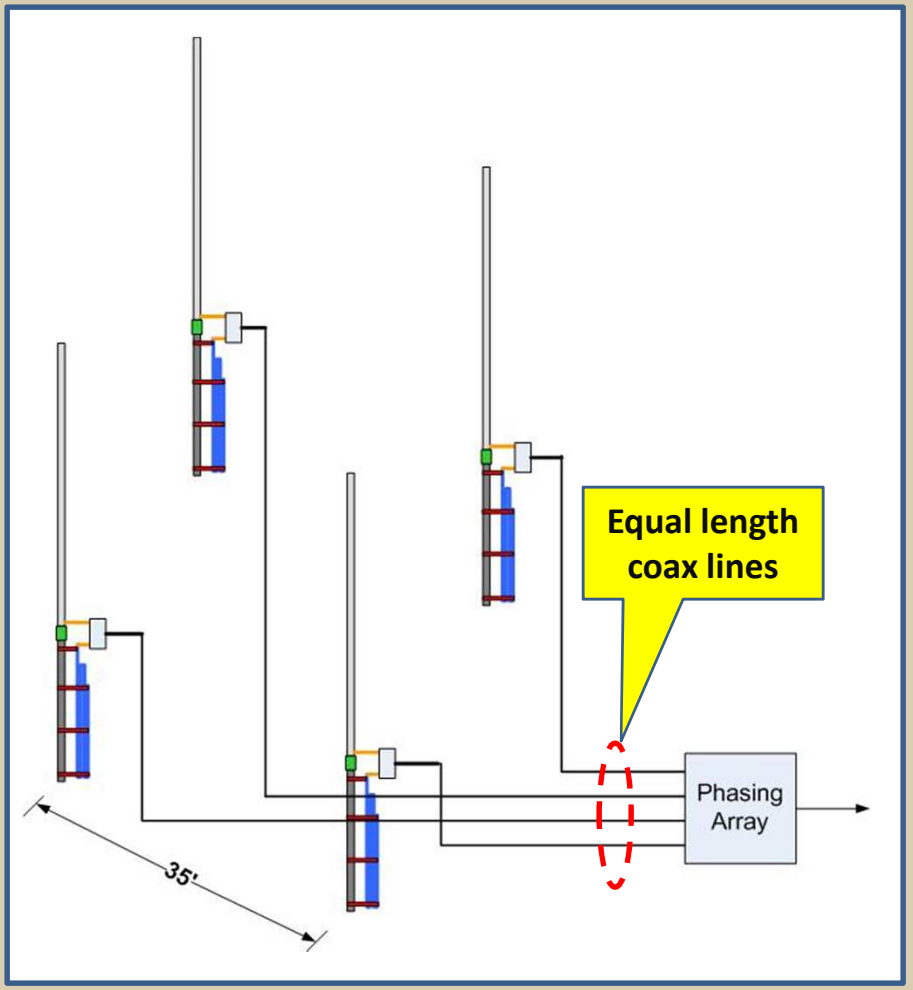


Loaded element should be only 16 dB less gain than full size element (~10 dB higher than Hi-Z array elements)

AA7A Vertical Dipole RX Array



Vertical Dipole Element

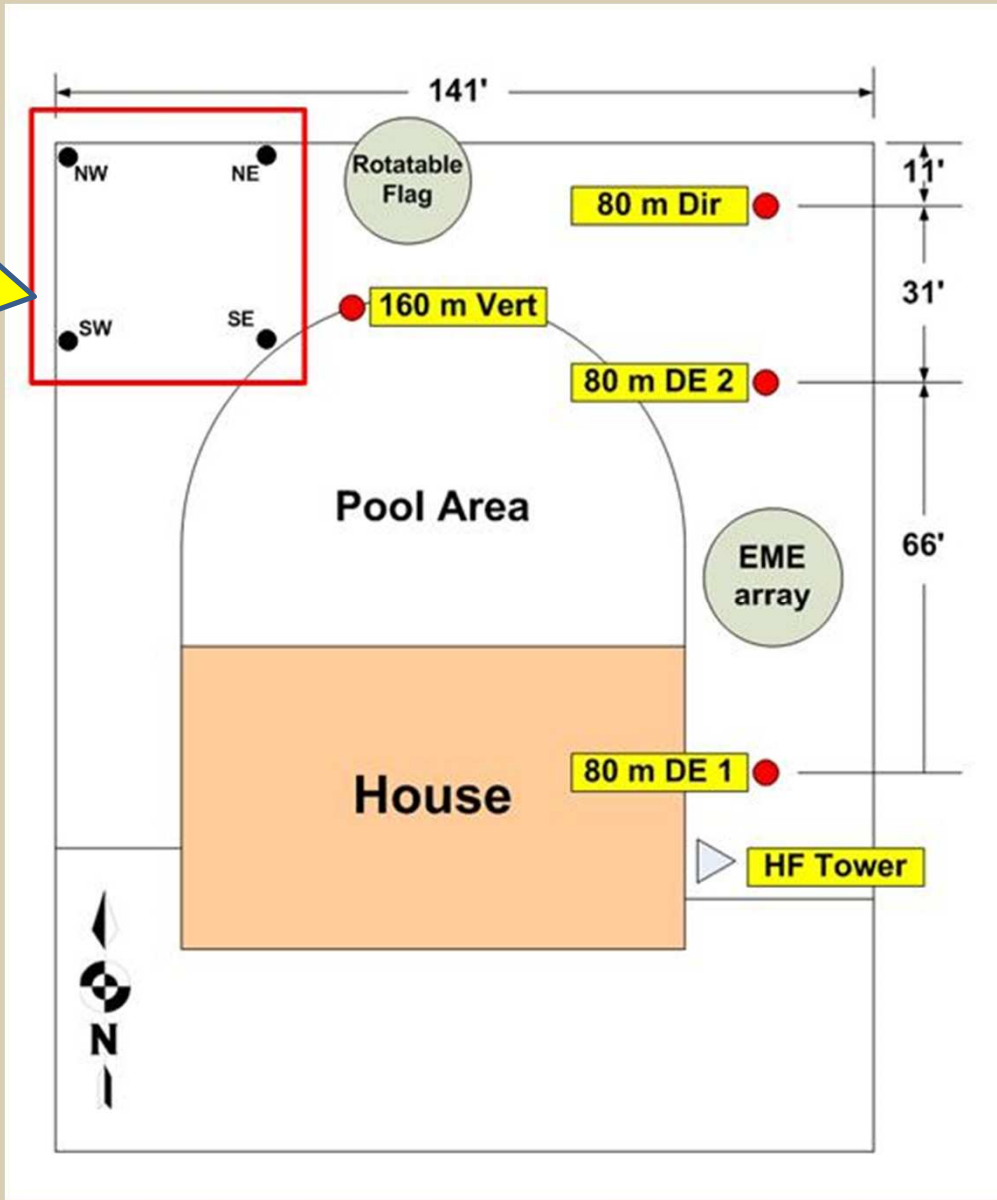


Vertical Dipole Array

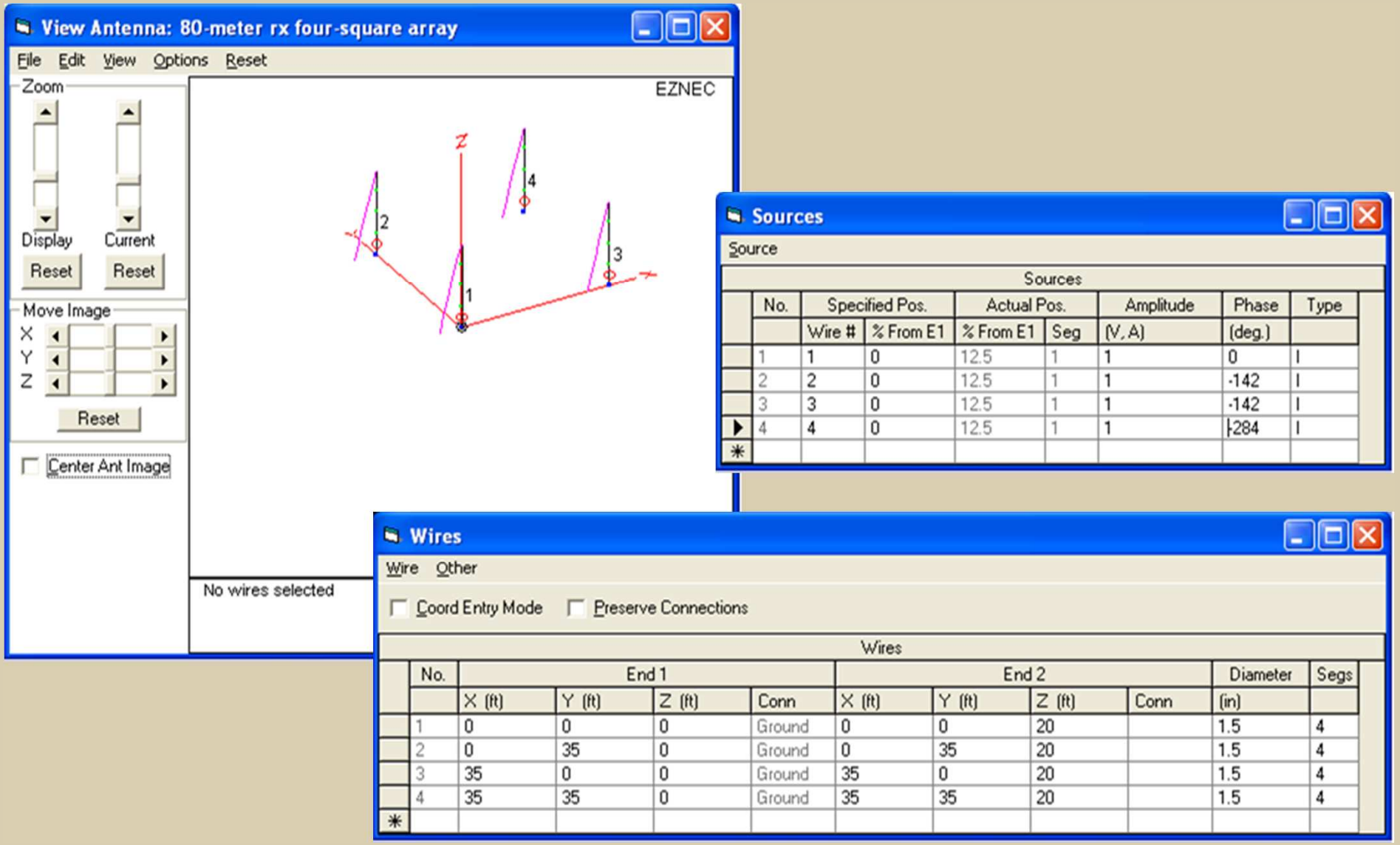
It Fits! – Will it work?

Array dimension constrained by available space

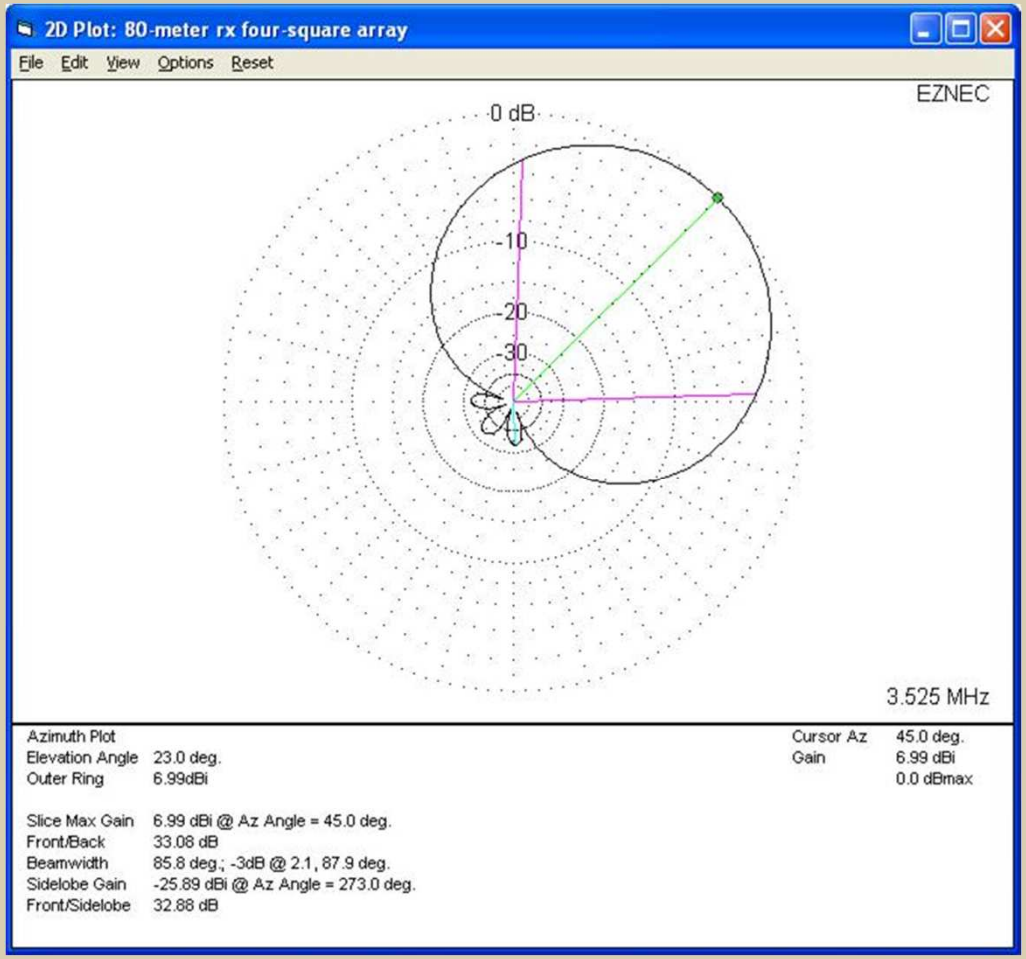
Optimum phasing determined from modeling



EZNEC Modeling Results



Pattern using optimum phasing

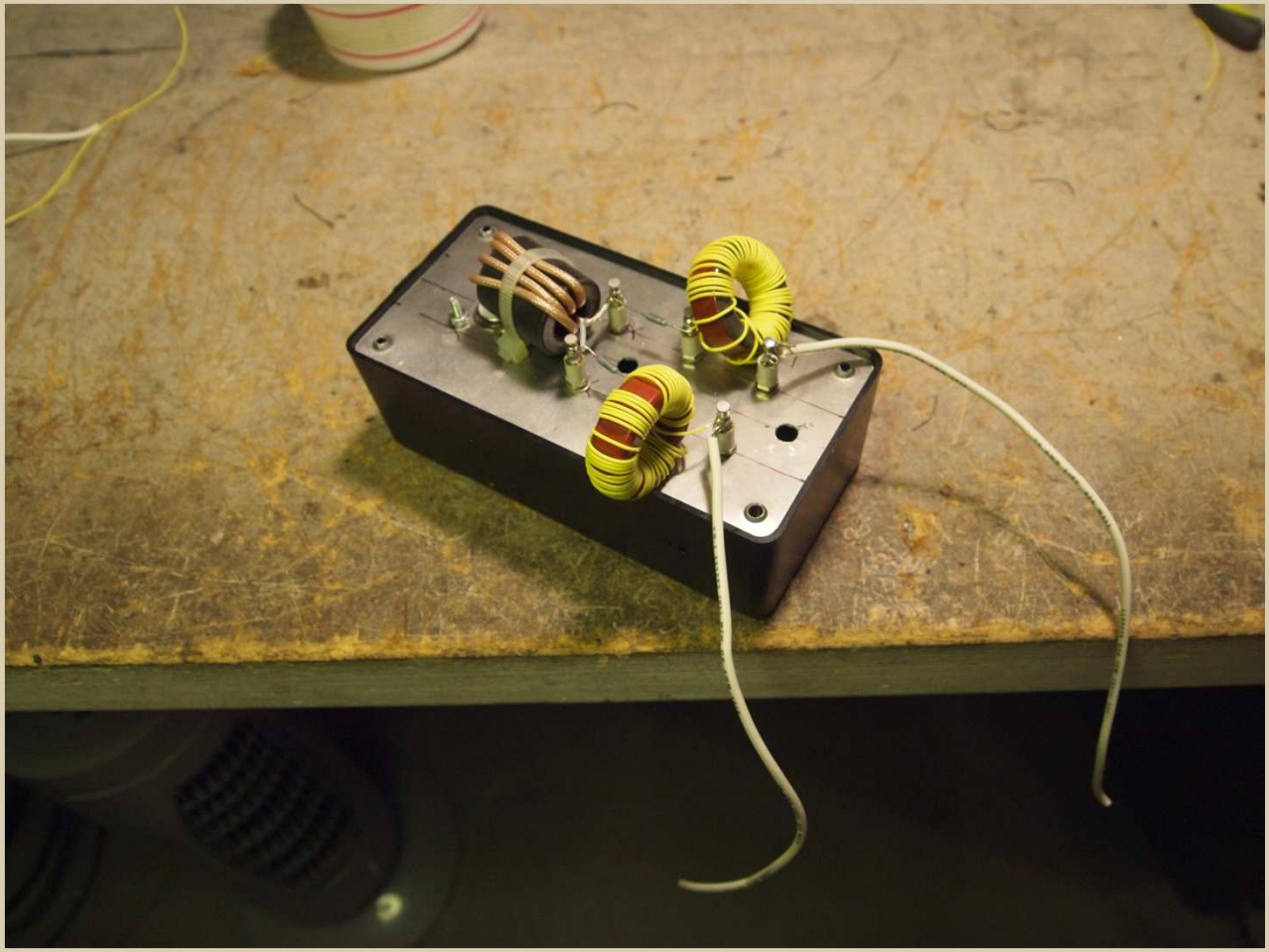


Dipole Construction

Matching Process

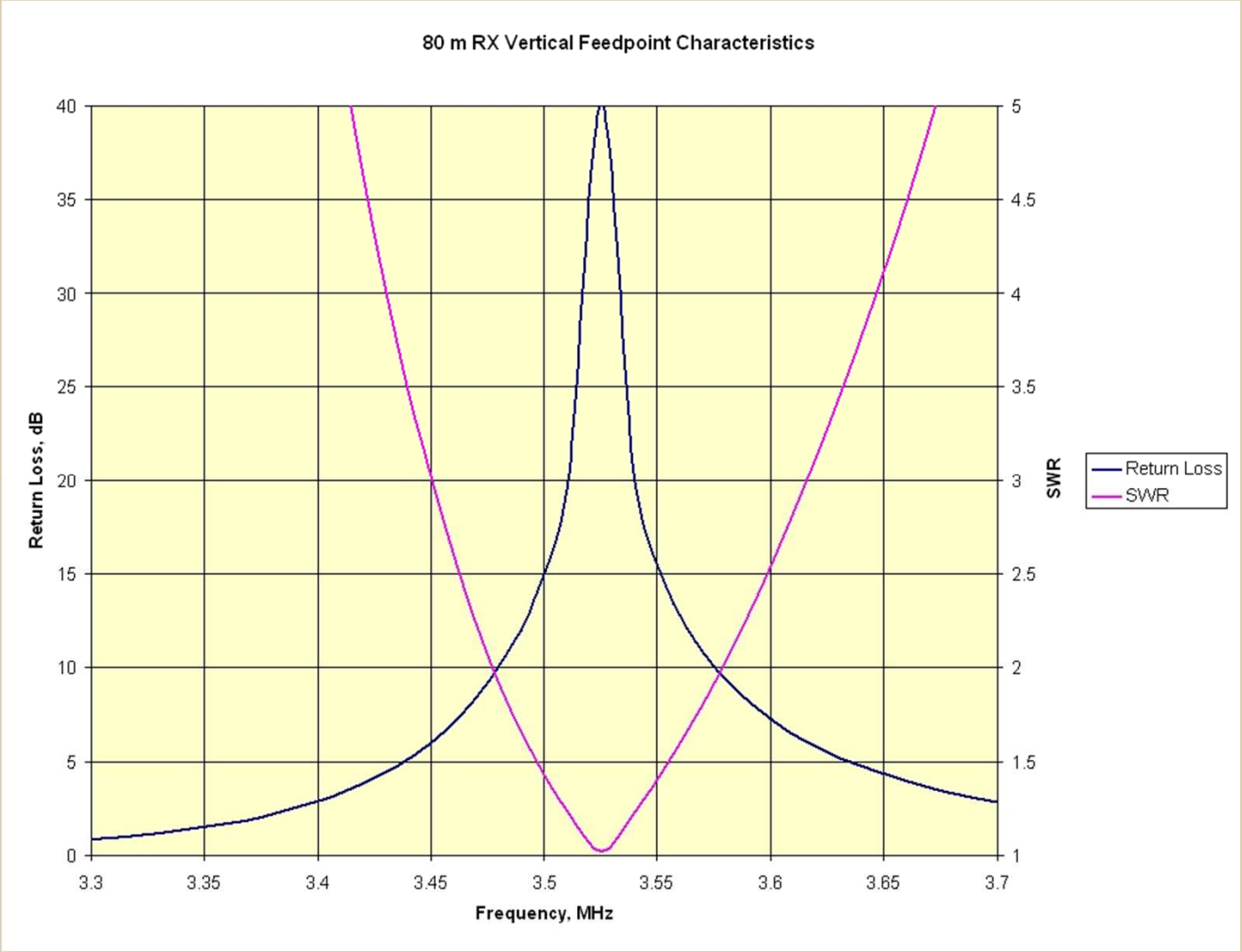
1. Tuned linear loaded half of dipole for resonance at 10.7 MHz
2. Measured impedance of dipole at 3.525 MHz
3. Calculated inductor value to cancel capacitive reactance on each side of dipole balanced feed
4. Inserted resistors in series of each side of balanced feed to obtain 50 ohm match (only 3 dB loss)
5. Installed choke balun on coax lead to isolate feedline from the dipole

Matching Network for 80 CW

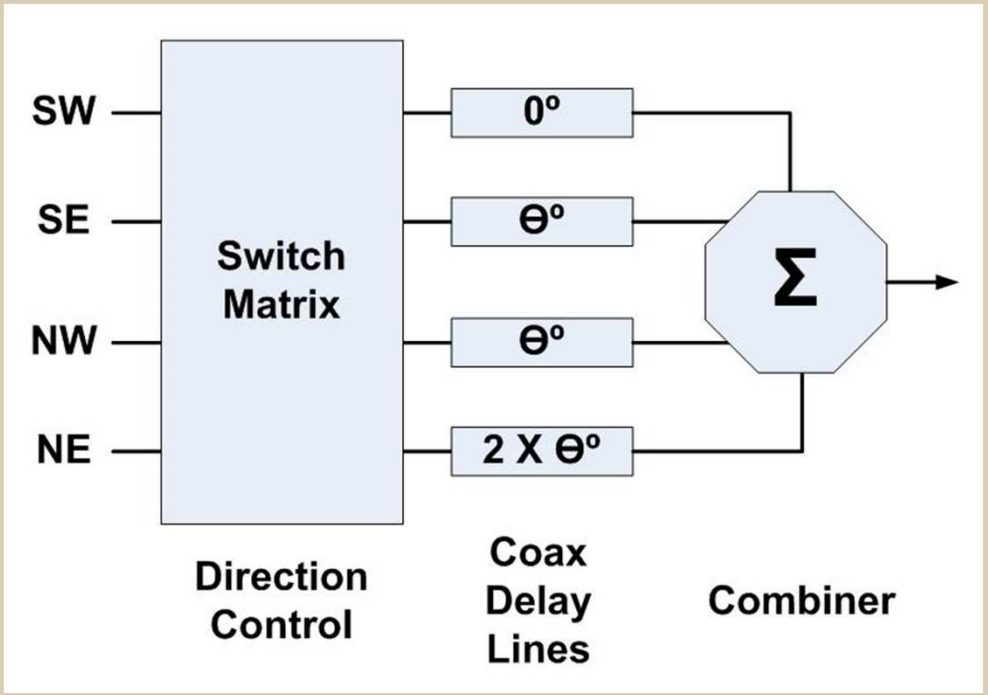


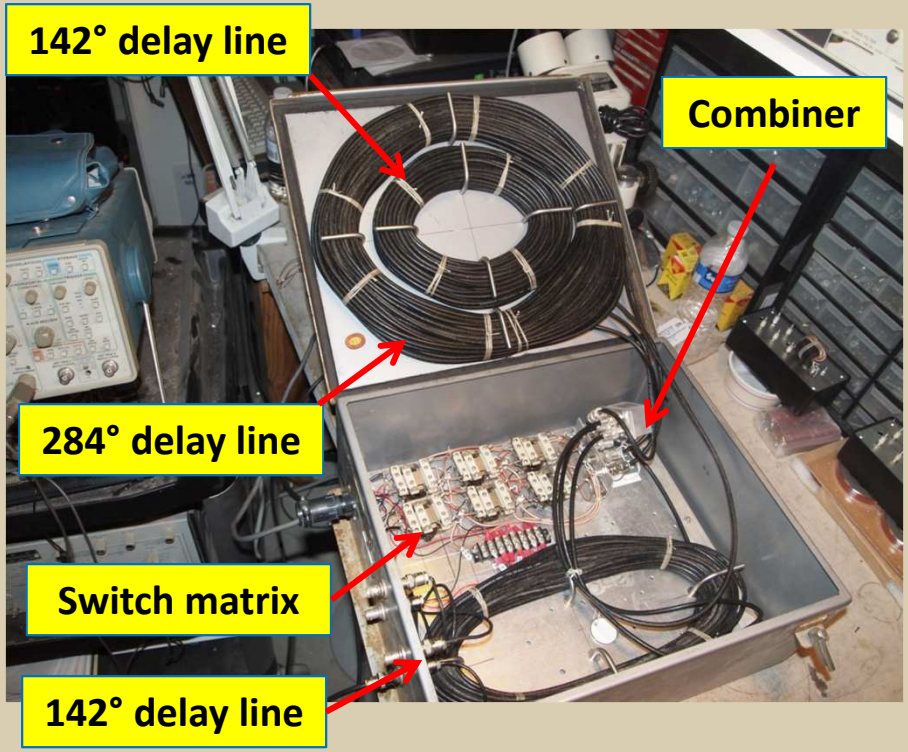
Element Matching Results

(Not bad for an Amateur)



Phasing Unit Description





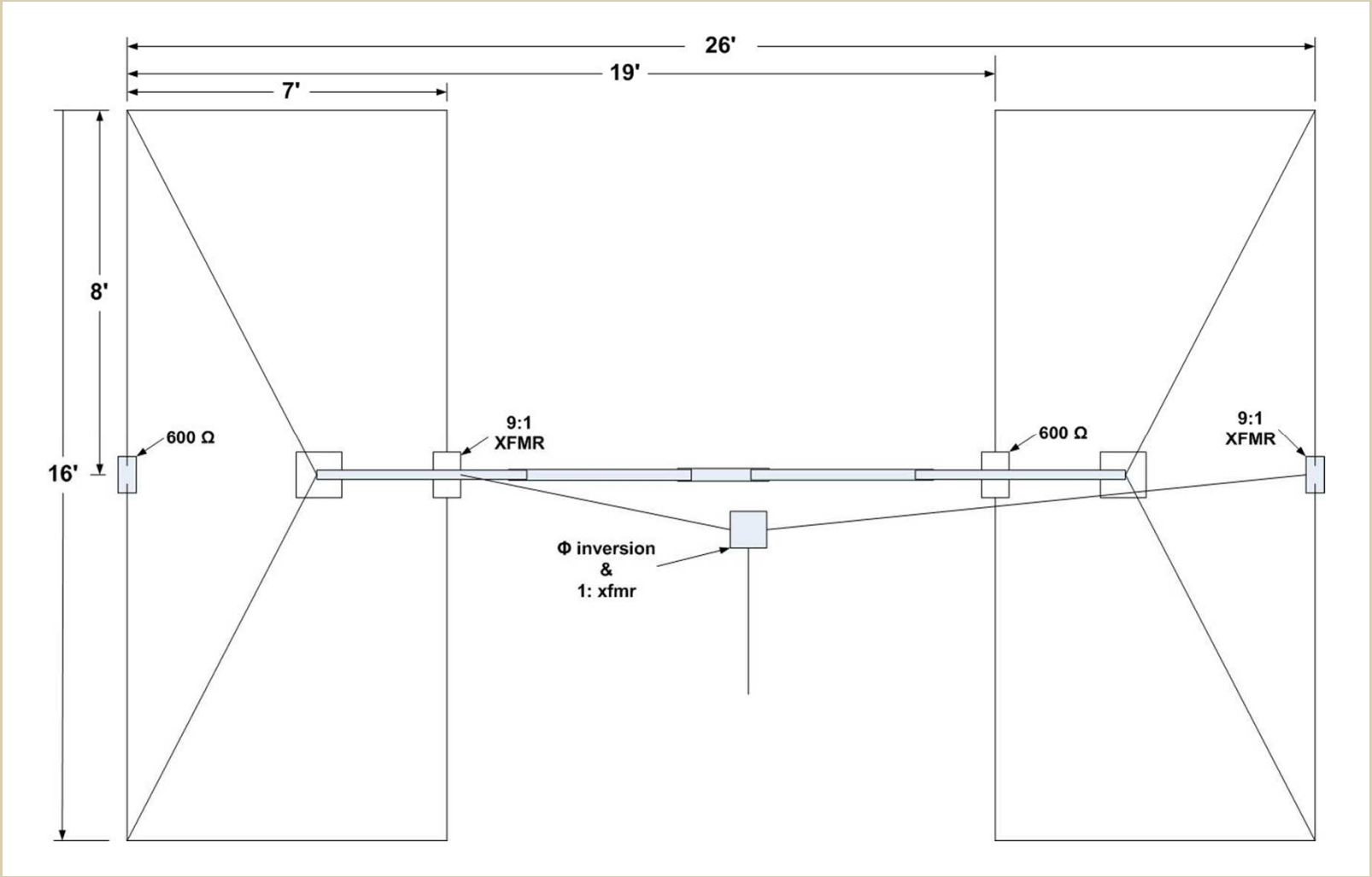
Does it work?

- Hell yes!
  - 32 dB front-to-back measured
  - Gain roughly 15 dB lower than 3 element full sized TX array
  - No preamp required!
- Hear anything?
  - Good results through 1st LF season (albeit a bad year)
  - Roughly 3 to 4 dB rx improvement over large TX array
  - More direction options for checking odd paths
  - Can dodge many of my local Plasma TV noise sources
  - Outstanding diversity receive antenna

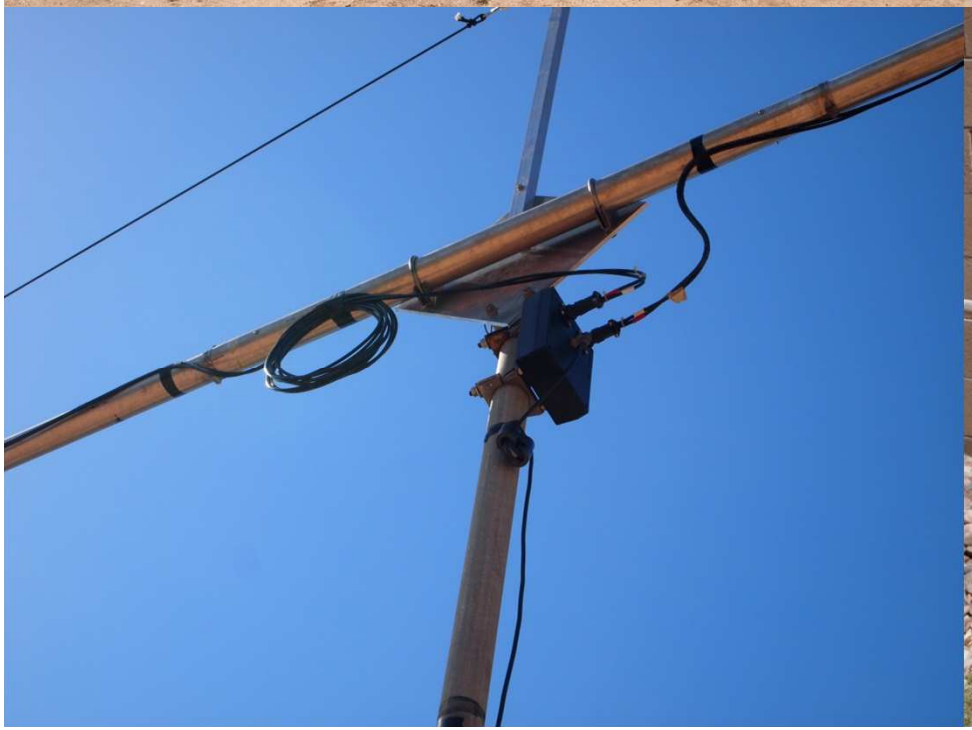
What's Next?

- Add 160 meter capability
  - Add 2nd matching network for short dipole
  - Add incremental delay elements for optimized pattern
- Non-square array pattern layout design
- Waller Flag – invented by Doug Waller, NX4D

Waller Flag Design

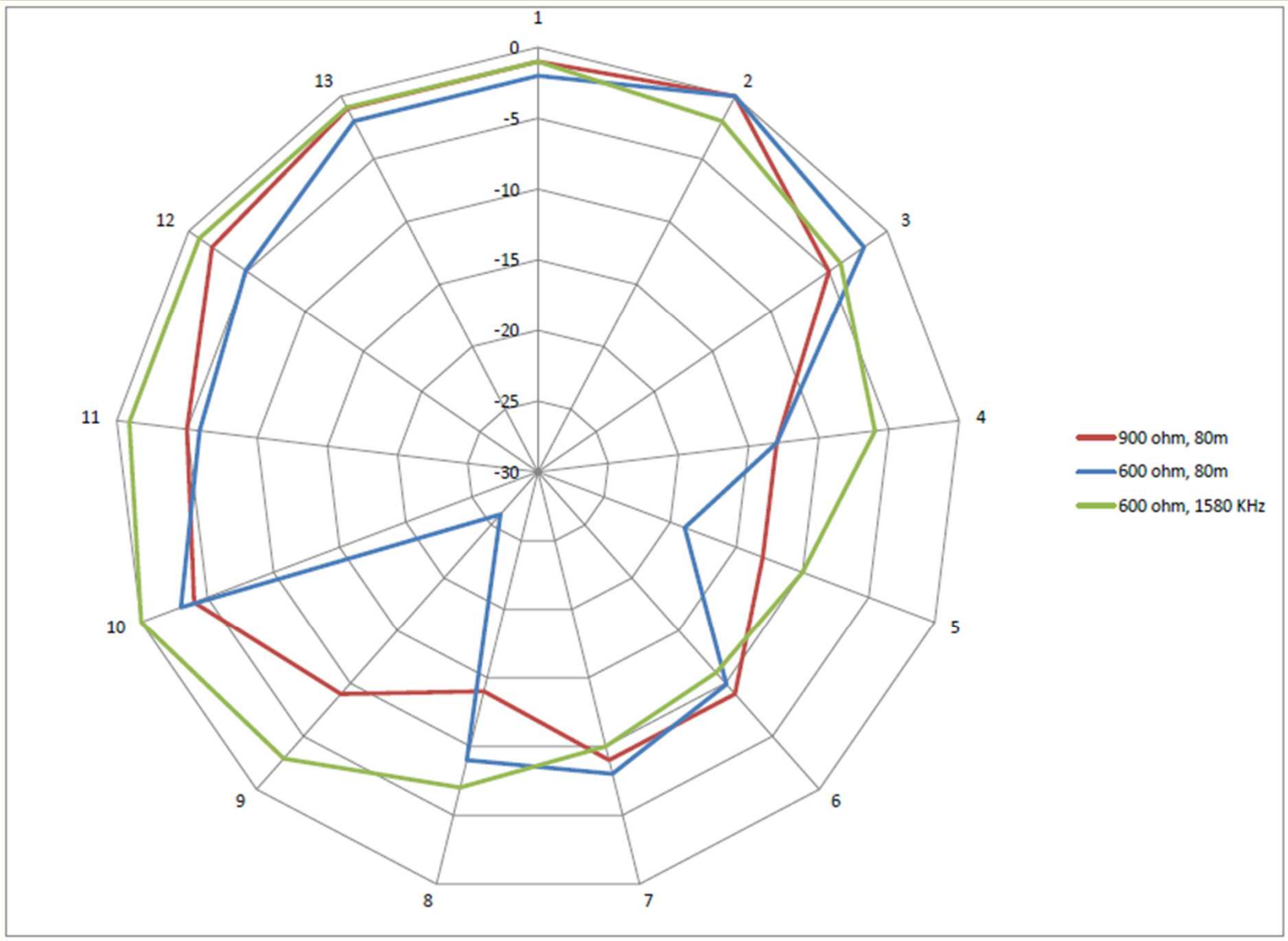


AA7A version of the Waller Flag




STRETCHED LOT 623525
AMS 4027 KAISER

Measured pattern



Stop complaining
and
get to work

Bonus Slides

Topics

- Do I really need a receive antenna?
- What is Noise?
- Why do some antennas work better on receive?
- AA7A LF system as performance baseline
- RX antenna options and space requirements?
- Thoughts on antenna modeling?
- Proposed new RX antenna concept for city lots
- Results to date and future plans

LF Antennas have Special Concerns

- LF antennas are large and have significant capture of AM broadcast signals
- IM products can easily be generated in any metal joint
  - AA7A 80 m RX antenna has several BC stations at 0 dBm (1 milliwatt)
  - Good passive IM practices can keep mixing products -150 dBc or more (20 dB below rx noise floor)
  - One bad metal contact or preamp non-linearity can easily result in a spectrum full of inter-modulation (IM) noise
- Most relay contacts in LF antennas require burnishing every few months to eliminate pesky spectral artifacts

AA7A Experience on Antenna Modeling

- Antenna modeling is a tool
  - All models are wrong
  - Some models are useful
- Why do models not work?
  - Force currents of one polarization into conductors
  - Do not account for random polarization of inbound signals in real antennas
- AA7A's DF antenna development story