Multi-element lowband vertical arrays – approaches for small and other lots

Dayton Hamvention Antenna Forum

May 16, 2008

Ray Sokola K9RS **Ted Rappaport N9NB**

The K9RS odyssey

How did this all start?

- K9RS moved to Pennsylvania in 2005
- Ray searched for 50 acres – but no go
- Ray decided to settle for 4 acres
- But the lot is unusual: 155 feet wide by about 1200 feet deep


739 Minsi Trail, Perkasie, PA 18944
N
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Google
Pointer 40°23'05.81" N 75°14'05.52" W elev 419 ft Streaming 100%
Eye alt 1416 ft

Actually it started quite a while ago…

…when K9RS first started using verticals in the Caribbean in‘86

Or even before that ….

Ham Radio Magazine May 1985

By Ted S. Rappaport, N9NB, Box 283, Electrical Engineering, Purdue University, West Lafayette, Indiana 47907

160-meter transmission line antenna

If height or space is a problem, try this

with the coaxial cable or ladder line that fee
antenna — something that "carries power
antenna," and not something that should, its
ate RF. Of course, it is undesirable to have ou

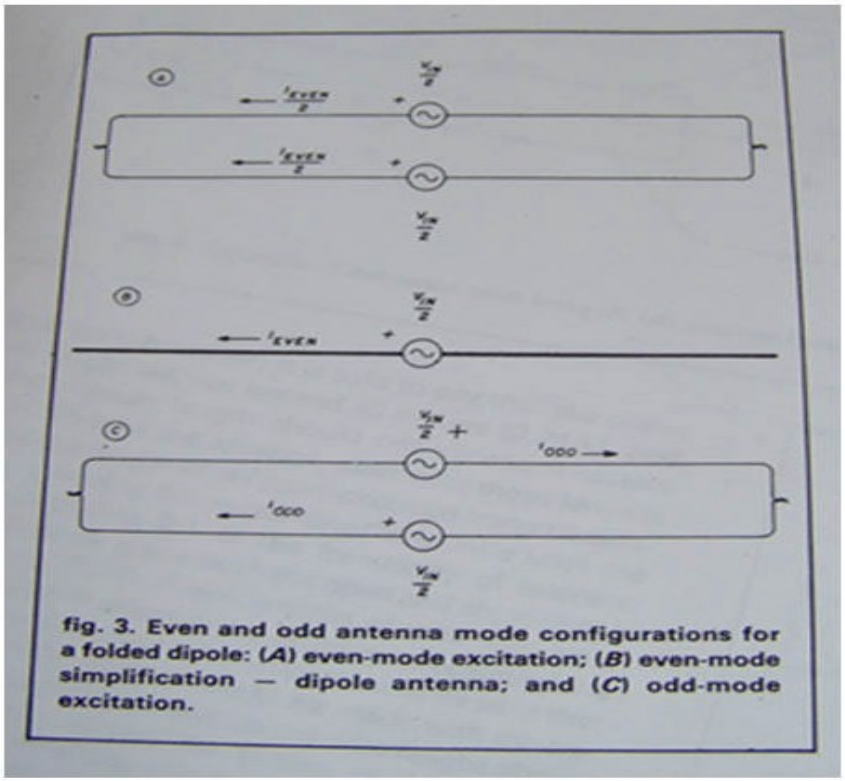


fig. 3. Even and odd antenna mode configurations for a folded dipole: (*A*) even-mode excitation; (*B*) even-mode simplification — dipole antenna; and (*C*) odd-mode excitation.

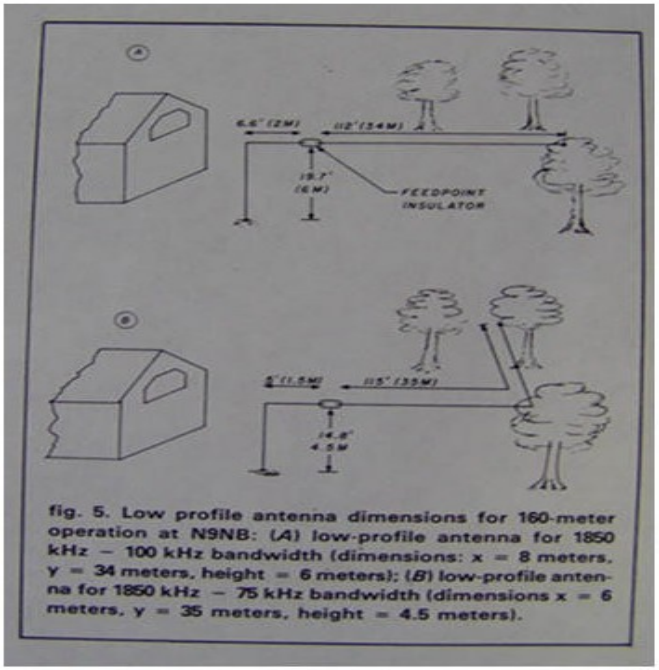


fig. 5. Low profile antenna dimensions for 160-meter operation at N9NB: (*A*) low-profile antenna for 1850 kHz — 100 kHz bandwidth (dimensions: x = 8 meters, y = 34 meters, height = 6 meters); (*B*) low-profile antenna for 1850 kHz — 75 kHz bandwidth (dimensions x = 6 meters, y = 35 meters, height = 4.5 meters).

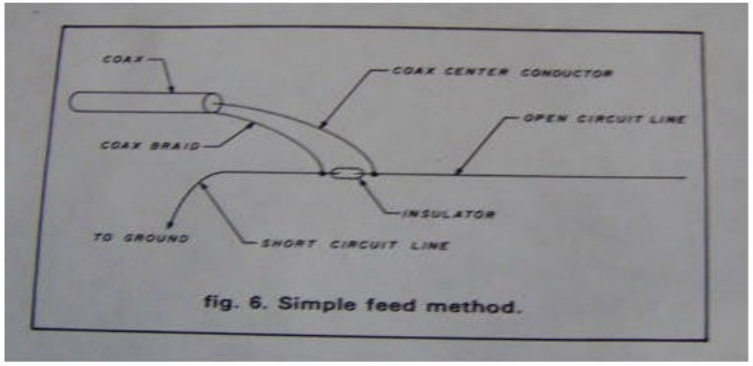


fig. 6. Simple feed method.

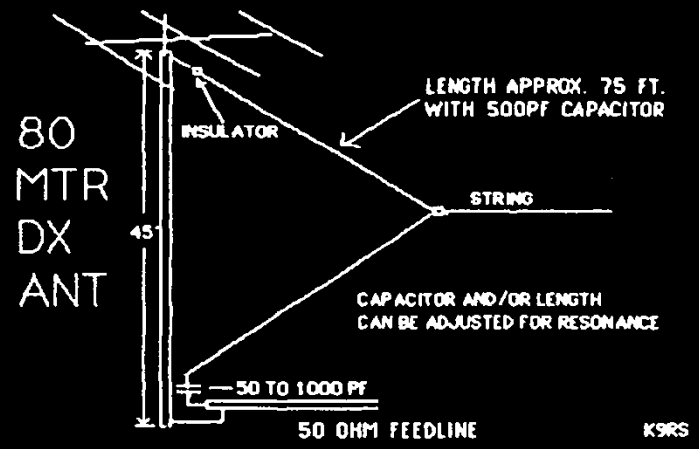
Nov/Dec 1985 NCJ

K9RS 80 meter antenna
first used on a 34 ft tower
110 countries in 4 months

Before packet!

80M DX ANTENNA
by Ray Sheffield K9RS

This 80M DX antenna in various forms has worked well at K9RS. Originally the tower was only 35 feet tall but even then the antenna worked well enough to work 110 countries in four months. The capacitance value and wire length can be jockeyed to resonance - increasing either decreases frequency and vica-versa. Try to use about 300 to 400 pF for best match to 50 ohm line. Even small fixed silver mica capacitors have been used successfully but transmit type "doorknobs" are preferrable, or use a variable for easy tuning and also to change from phone to CW. Also, use as many radials as possible - I like to lay them down just before it snows.



VP5K 40 meter 2 element vertical


VP5K
K9RS and AG9A
with 2 element 40M antenna
Global
VQ-TBF
EXIT

40M Feed point

2 Ground bars

Top
- **antenna**
- **Coax center**

Bottom
- **Radials**
- **Coax shield**

2 Element 40 M vertical array

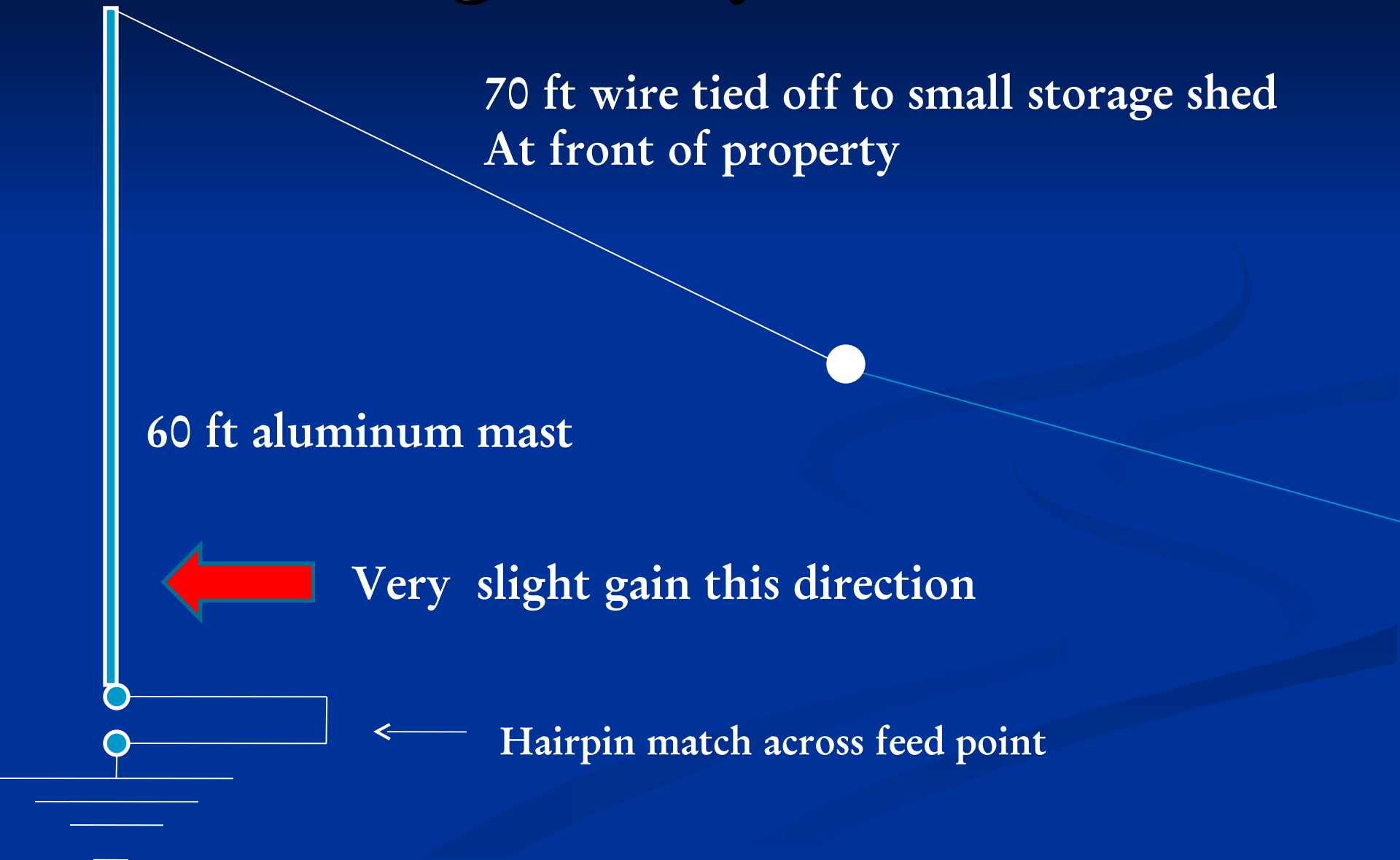
- K9RS used in 1986 at ZF2KE

  Still holds record

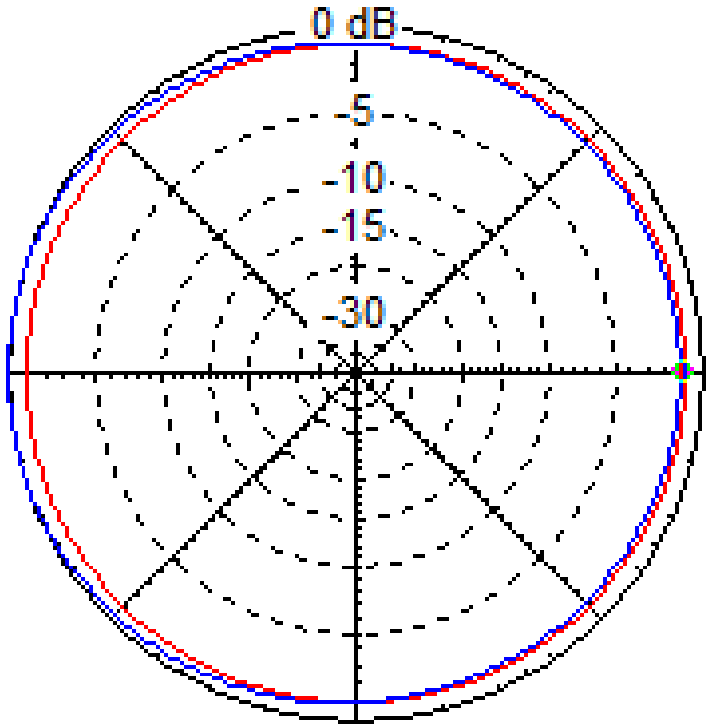
  M/S ARRL CW 1990 5.98M
- Most recently used at VP5
  - VP5K 2004 ARRL CW Multi-op 2nd
  - VP5B 2005 ARRL SSB Multi-op 1st


VP5B the last operation
March 2005
WELCOME
TO NORTH CAICOS
K4ISV
K9RS K4CN

VP5B legendary 160 antenna



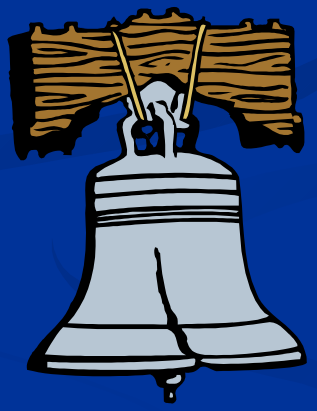
Full size 160 VP5B antenna



Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	23.0 deg.	Gain	1.43 dBi
Outer Ring	2.36 dBi		0.0 dBmax

Slice Max Gain	1.43 dBi @ Az Angle = 0.0 deg.
Front/Side	0.0 dB
Beamwidth	?
Sidelobe Gain	< -100 dBi
Front/Sidelobe	> 100 dB

Now back to Pennsylvania




K9RS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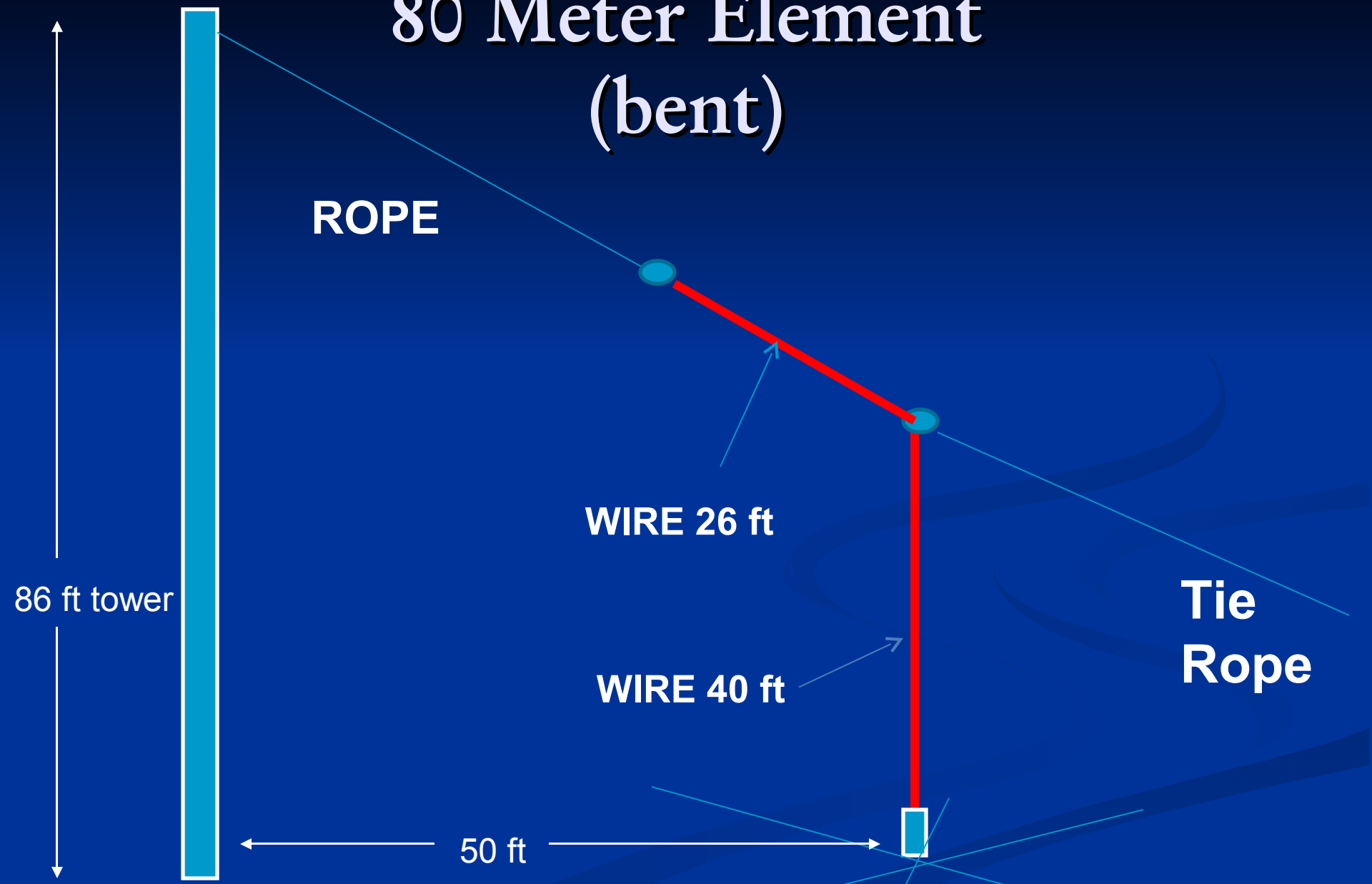
Pointer 40°23'05.81" N 75°14'05.52" W elev 419 ft Streaming 100%
Eye alt 1416 ft

Bent vertical elements

Why use them?

- Convenient with short tower or mast
- Exploit your tower for use in an array
- Surprising results – not intuitive!

80 Meter Element (bent)



4x4 POST & ANCHOR KIT

#APK00000

4x4 POST & ANCHOR KIT

#APK00000

MADE TO SIMPLIFY INSTALLATION OF THESE POPULAR MAILBOX & POST PRODUCTS:

- THE GENTRY™ & CLASSIC 1™ by SOLAR GROUP, INC.
- MAILMASTER™ SERIES by STEP 2®
- OTHER SIMILAR MAILBOX & POST KITS THAT REQUIRE A 4x4 POST FOR INSTALLATION

* MAILMASTER™ is a trademark of The Step 2 Company®. The Step 2 Company® is not affiliated with this product.

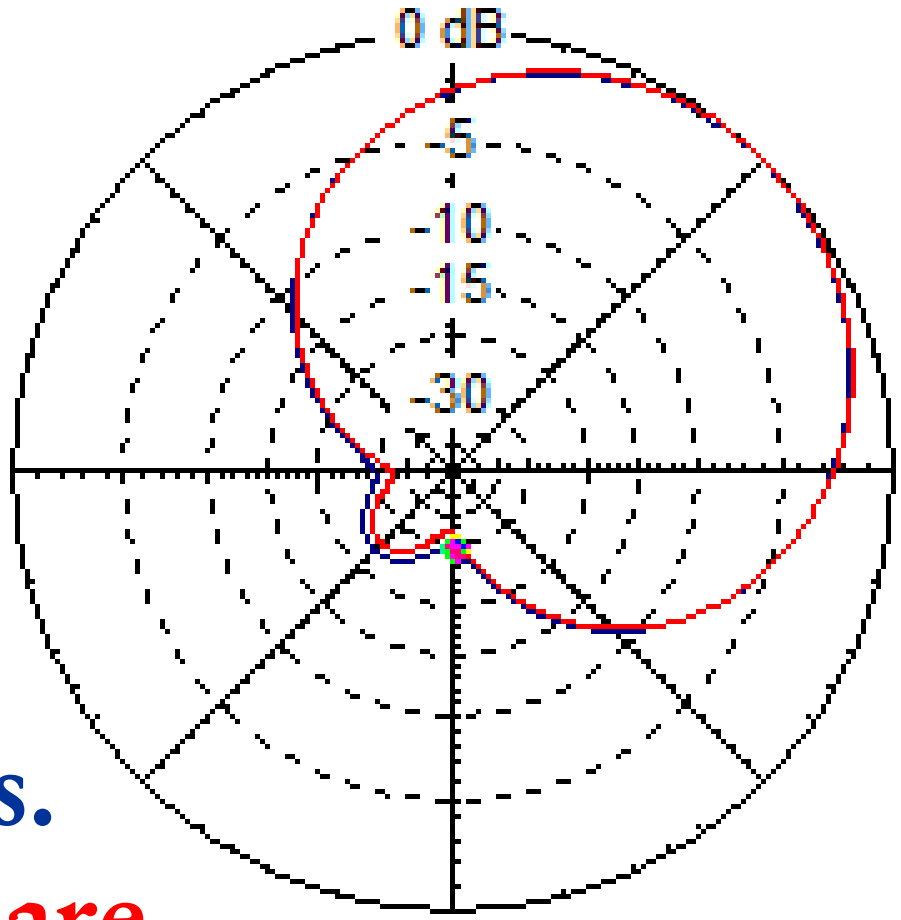
Bent 4 square

What is it?

A wire 4 square hung from a relatively short tower with the extra length bent in towards tower

80 meter bent 4 square

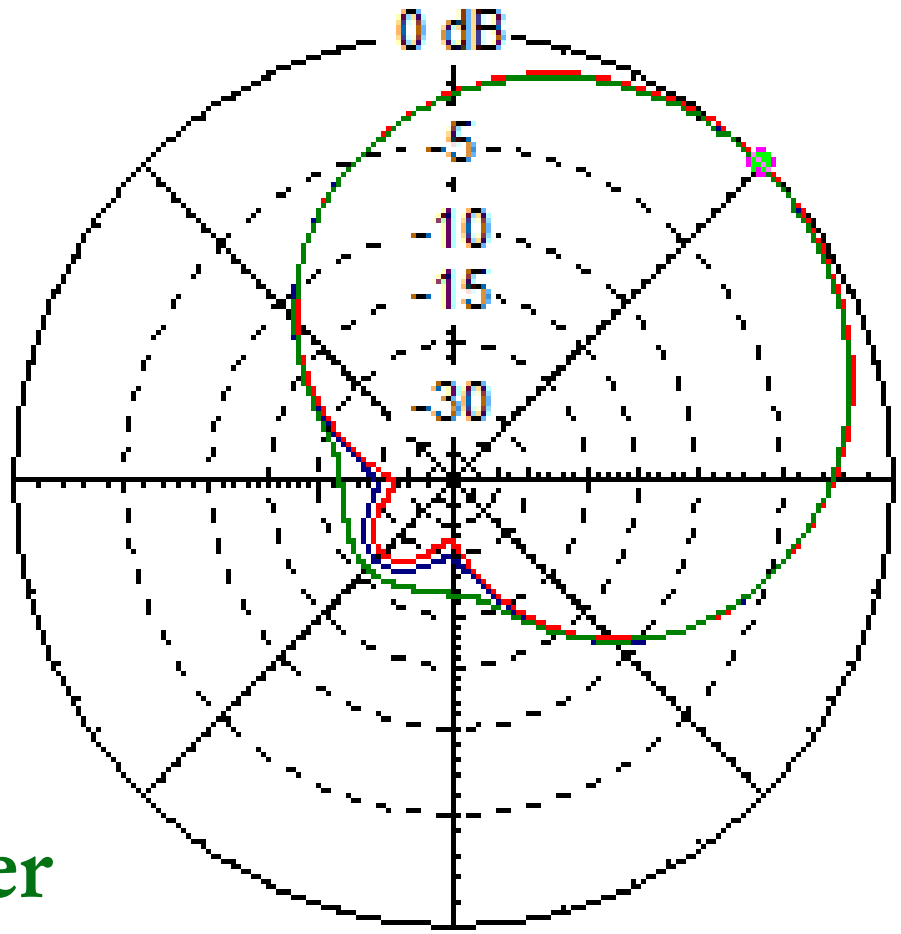
- 40 ft vertical, the rest slopes towards tower
- Comtek box
- Each element fed with 75 Ohm RG-6 cable
- #14 Flexweave wire
- Each element started with 15 radials
- 3/16 inch Dacron rope



Outside ring
6dBi

Full size vs.
Bent 4 square

Bent Verticals – very little difference !
No tower modeled here

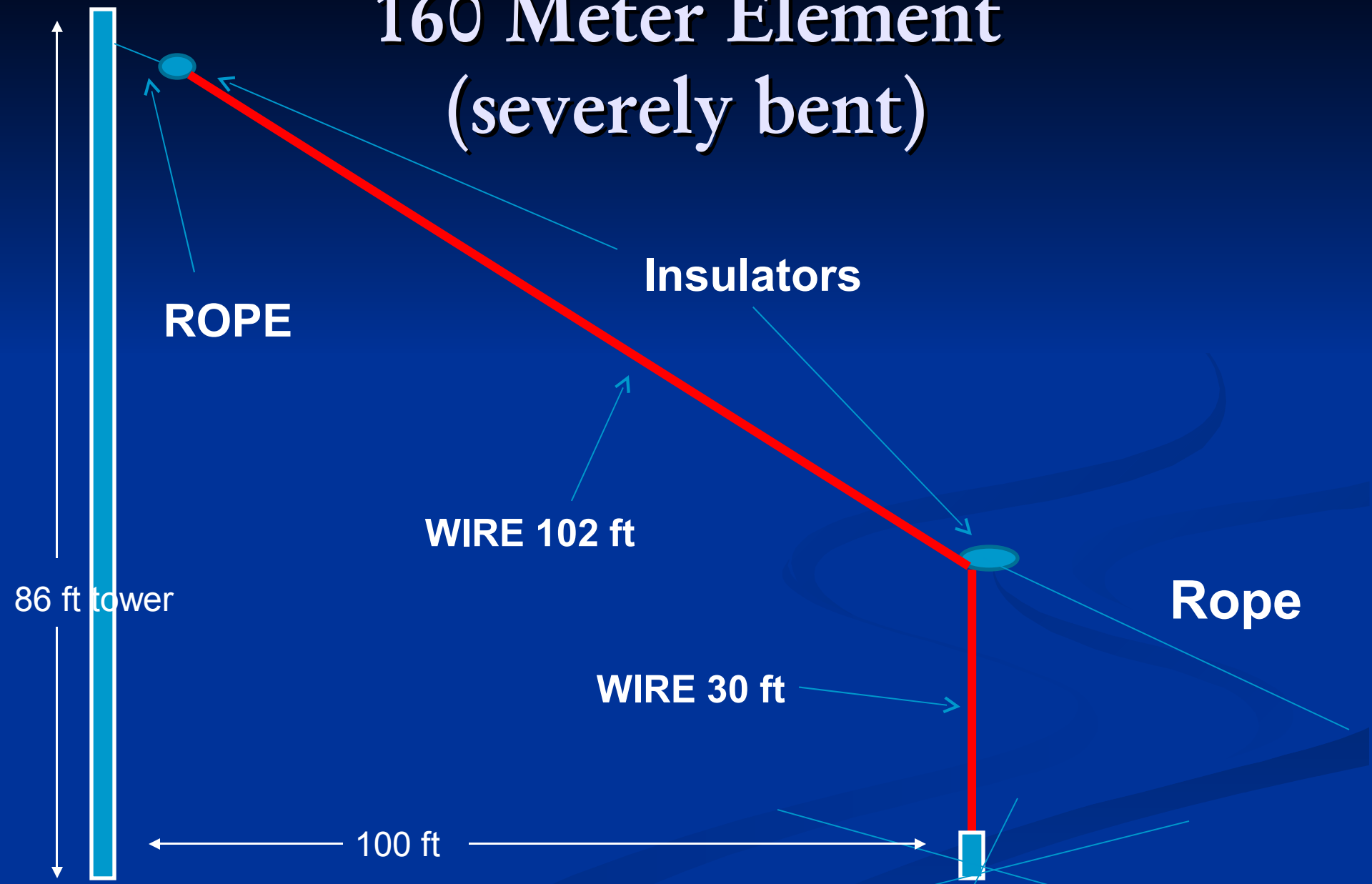


Outside ring
6 dBi

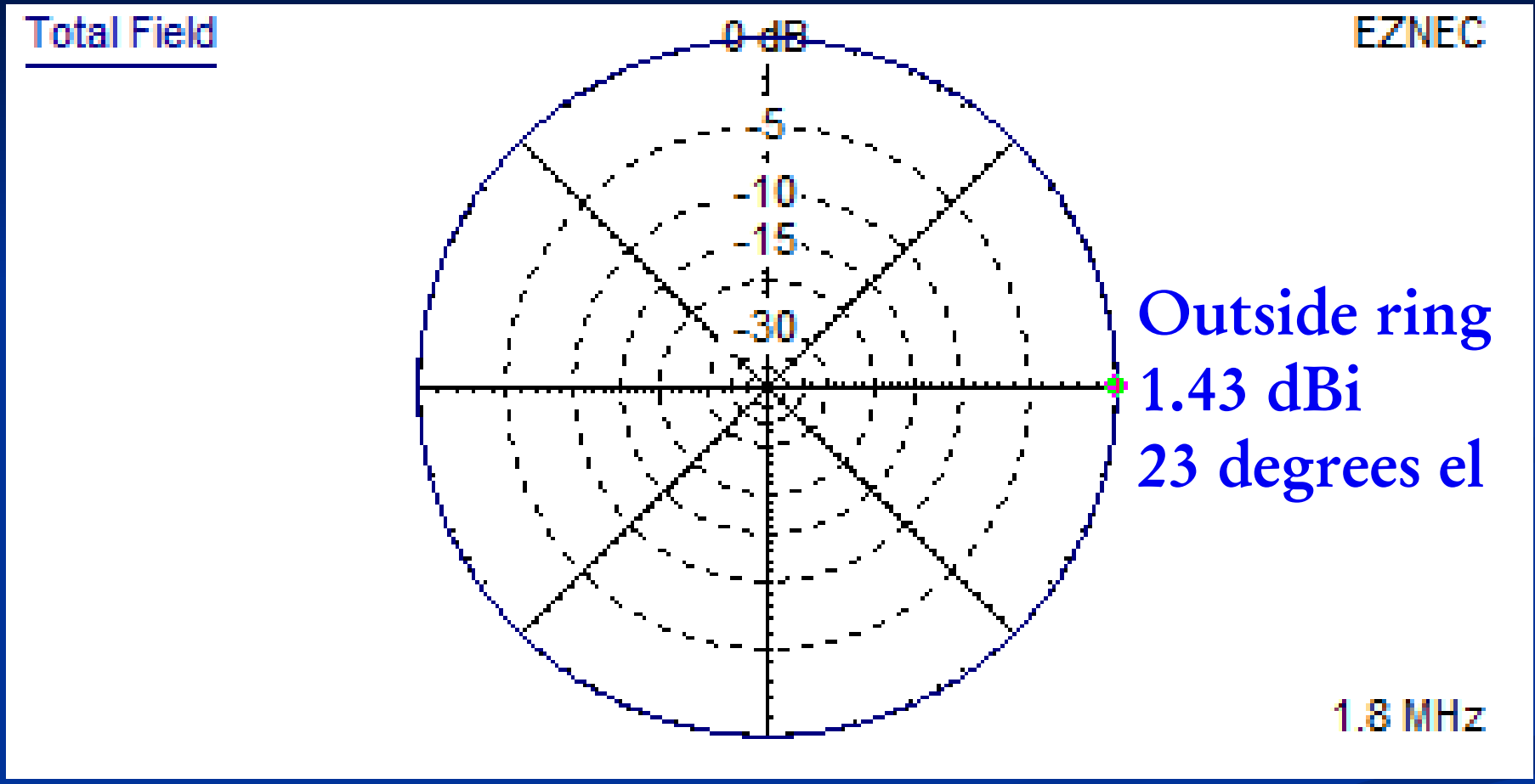
Full Size
Bent
Bent w tower

Minimal difference between (a) full size 4 square (b) bent 4 square and (c) bent 4 square with 146 ft equivalent height tower

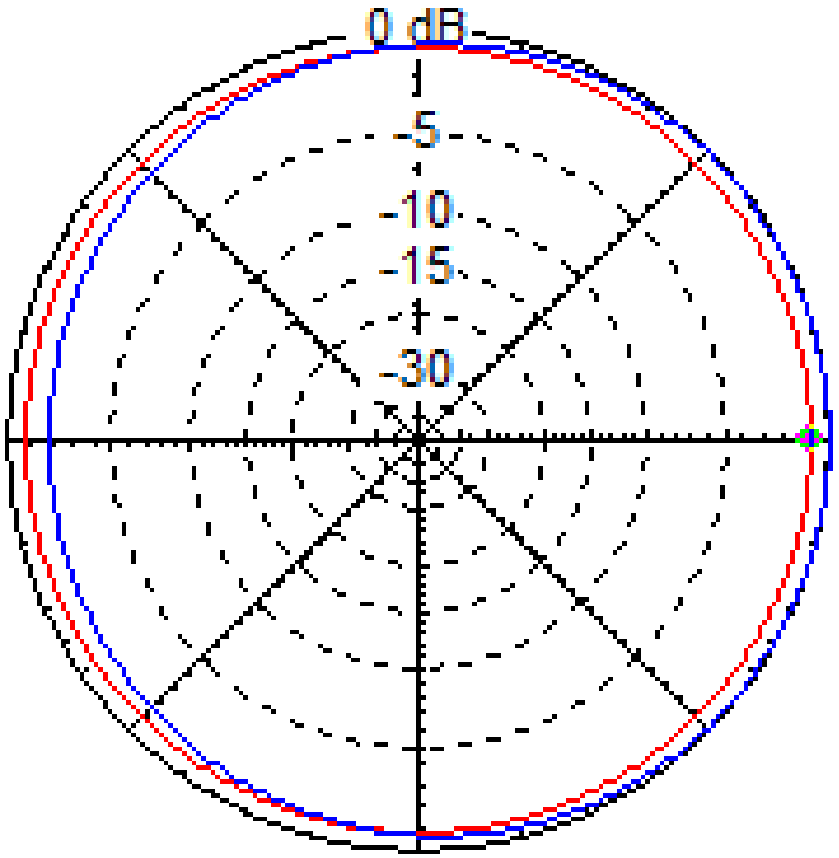
160 Meter Element (severely bent)



Full size element 160



Modeled with MININEC real ground



Full size vert

Severely bent

160m full size vertical vs. 'severely bent' vertical

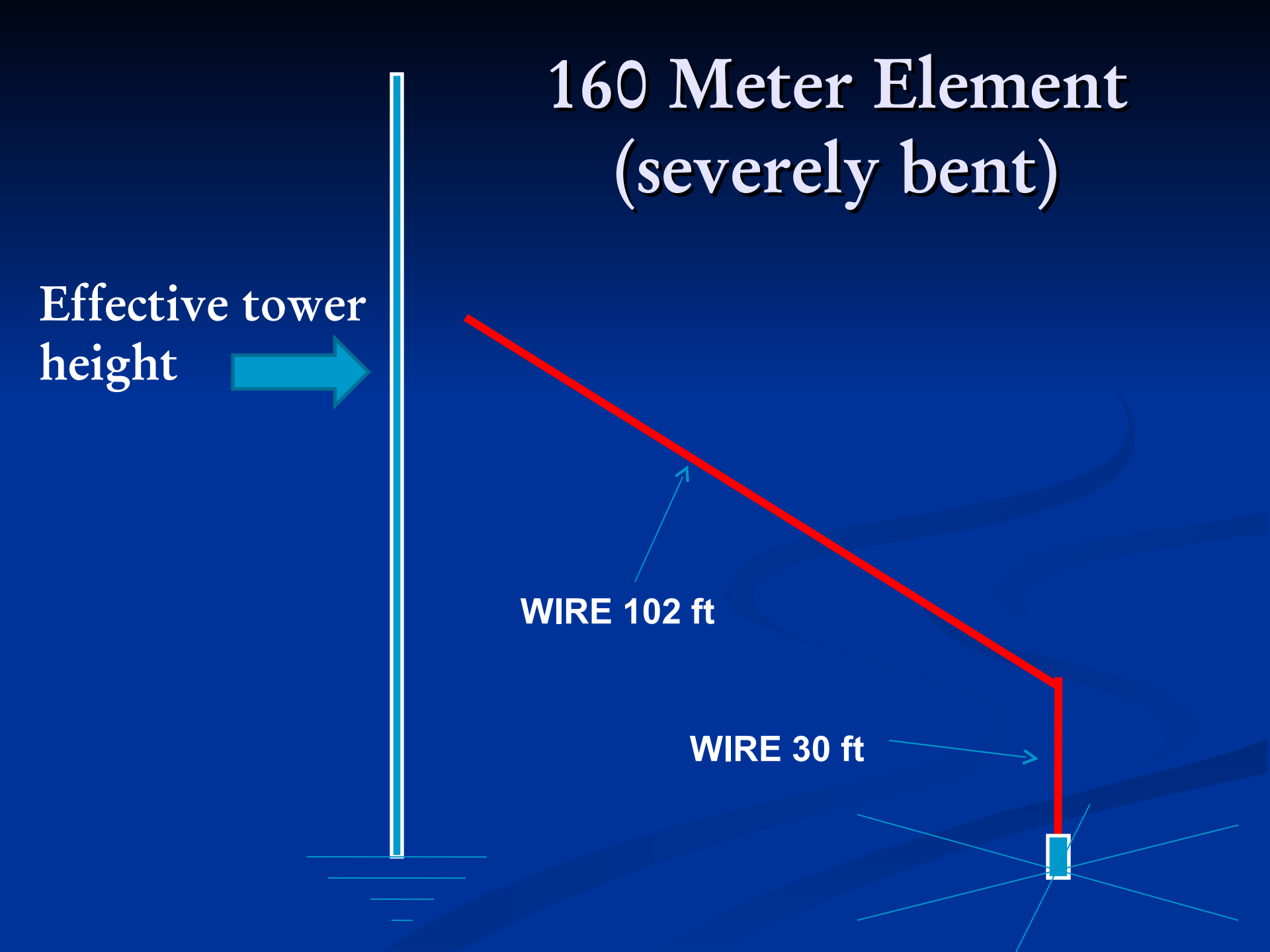
- The full size qtr. wave has 1.43 dBi
- The 'severely bent' has 2.2 dBi max. away from sloping wire and 1.8 db front to back

Put up and phased 2 severely bent elements, diametrically opposed from the tower ...

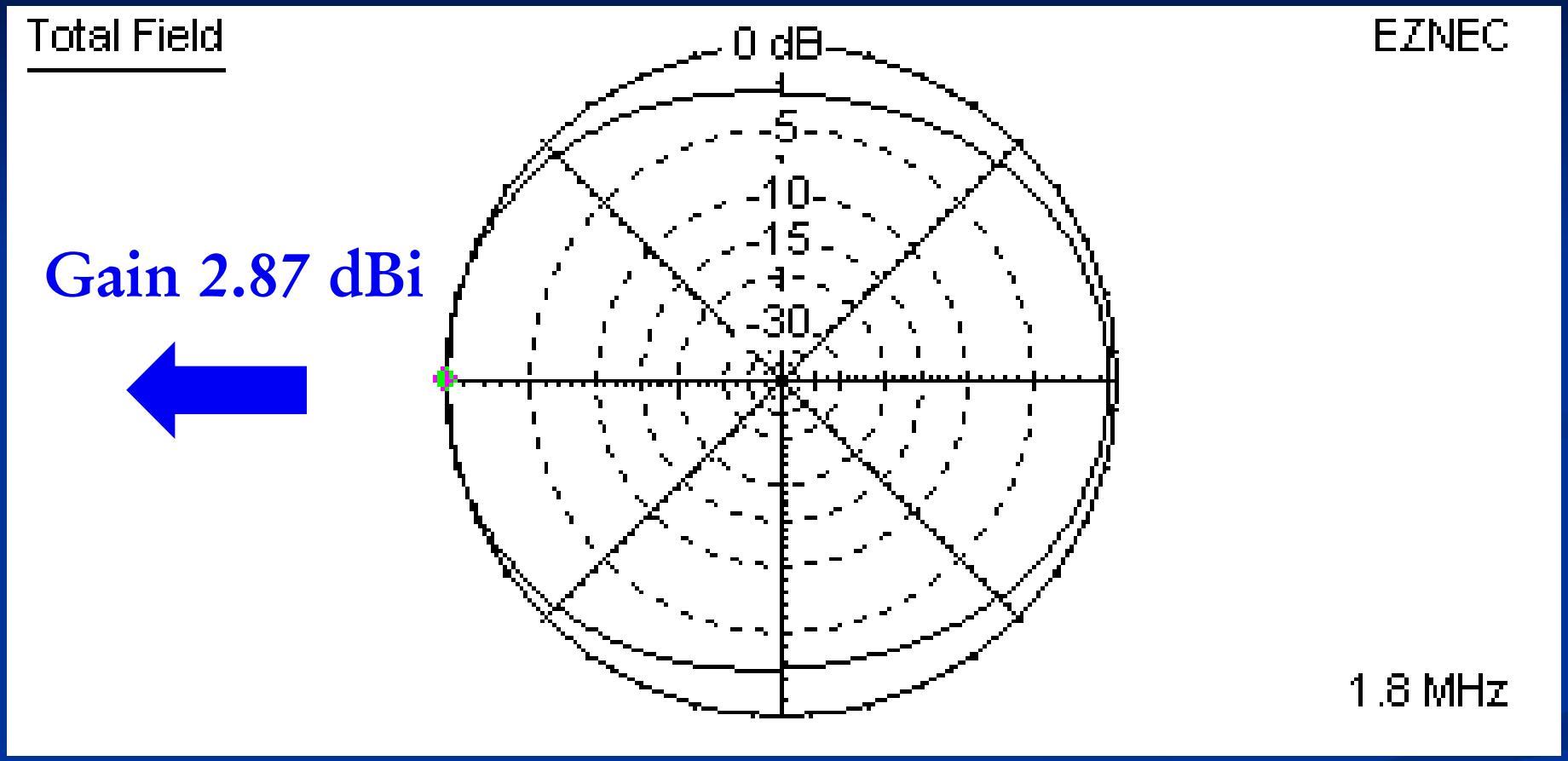
But....a single element seemed to work better than the 2 element phased array

EZNEC modeling reveals why!

160 Meter Element (severely bent)



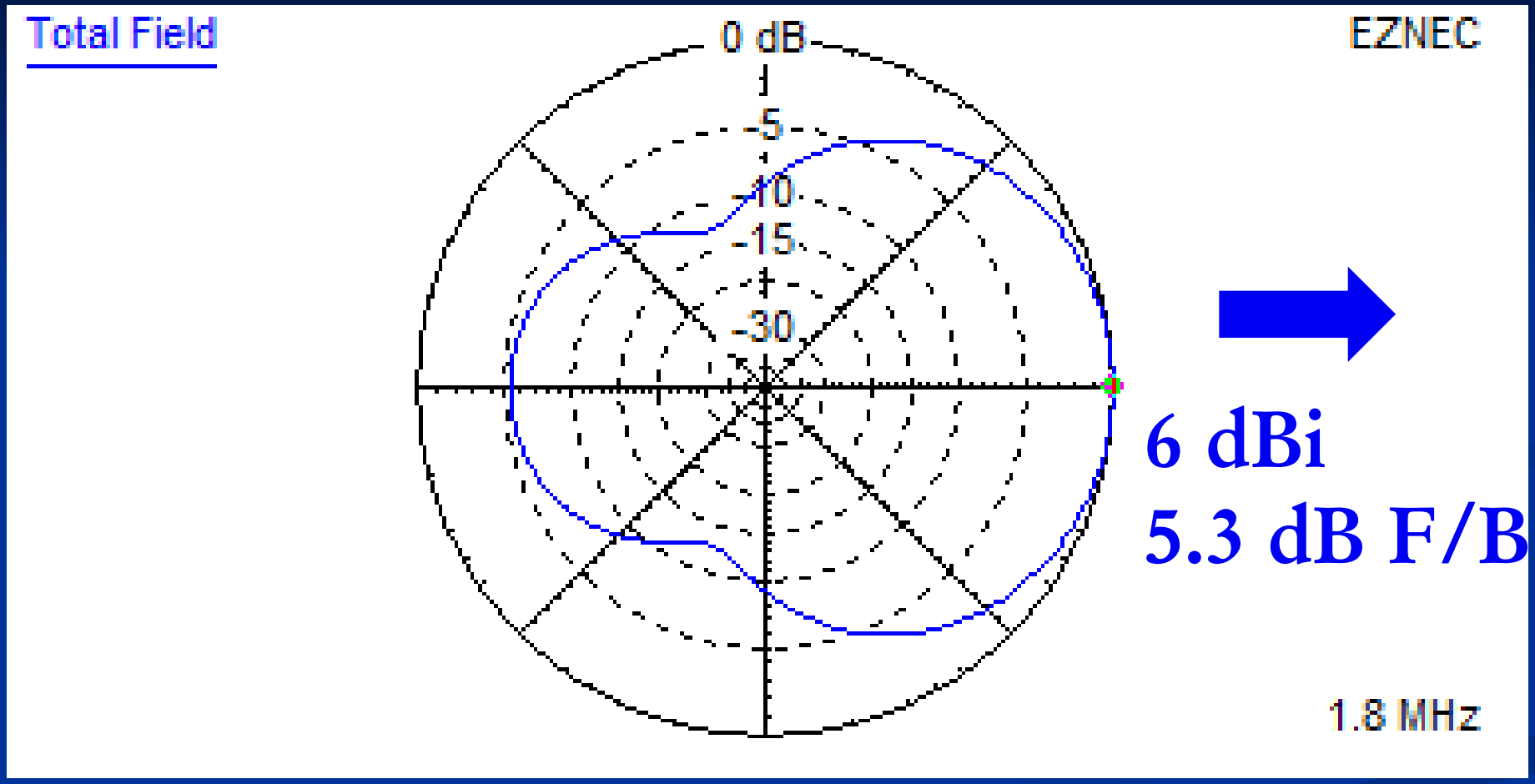
Single severely bent element 160



Gain 2.87 dBi

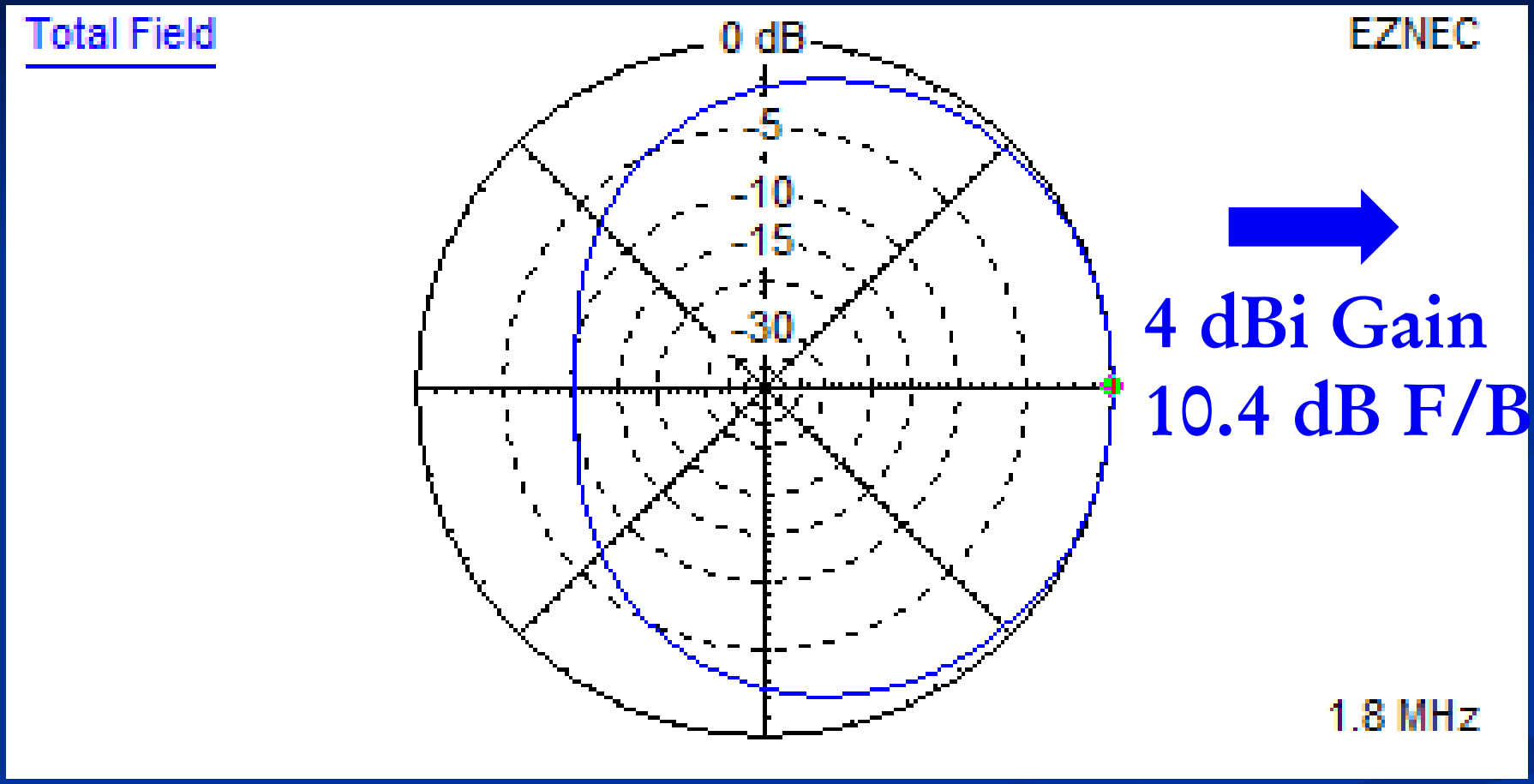
Modeled with 120 ft effective height tower
Geometry is 160m 'severely bent' vertical

Single bent element becomes 4!



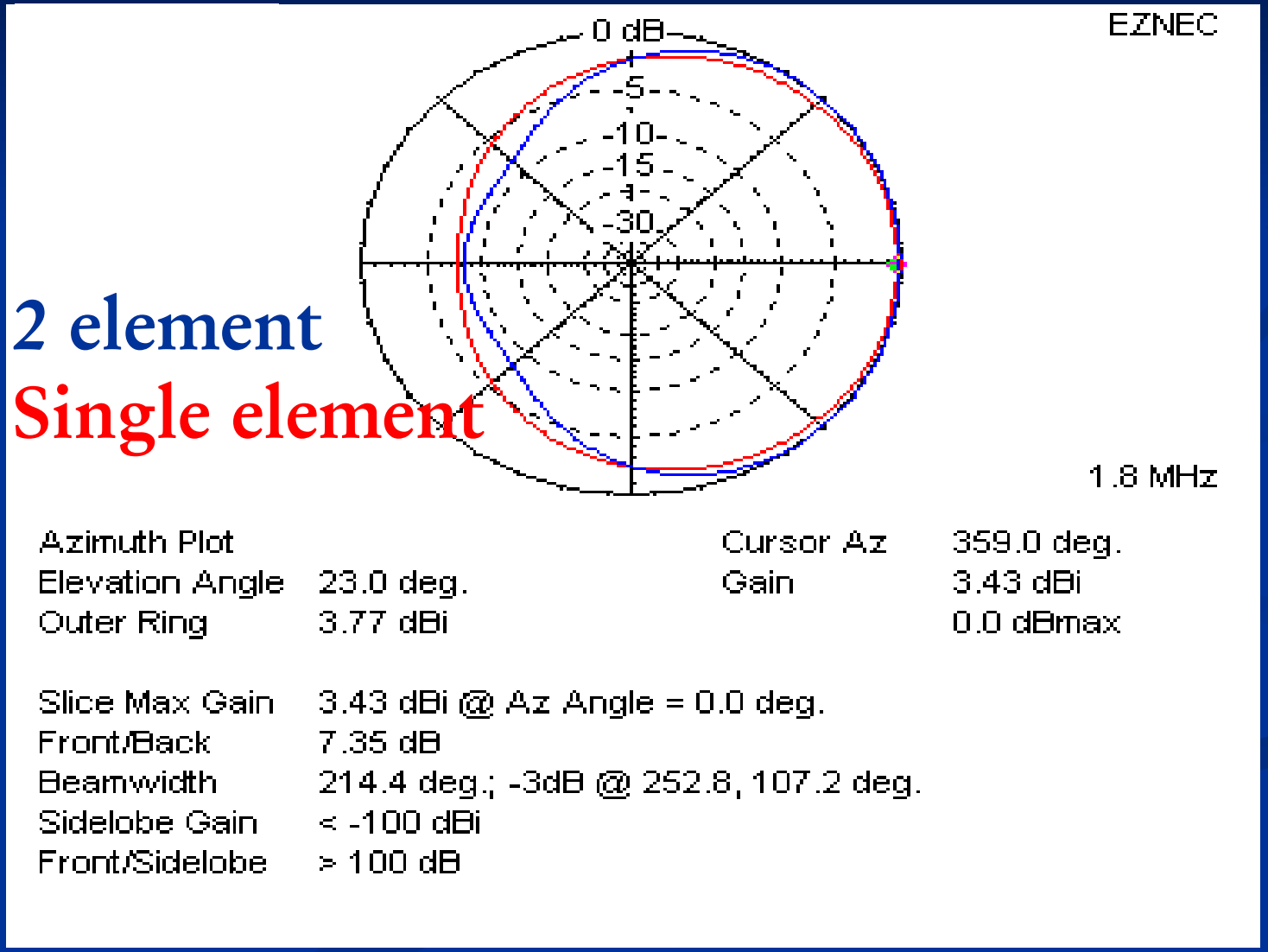
Modeled with 130 ft effective height tower

Severely bent element acts like 2 ele!

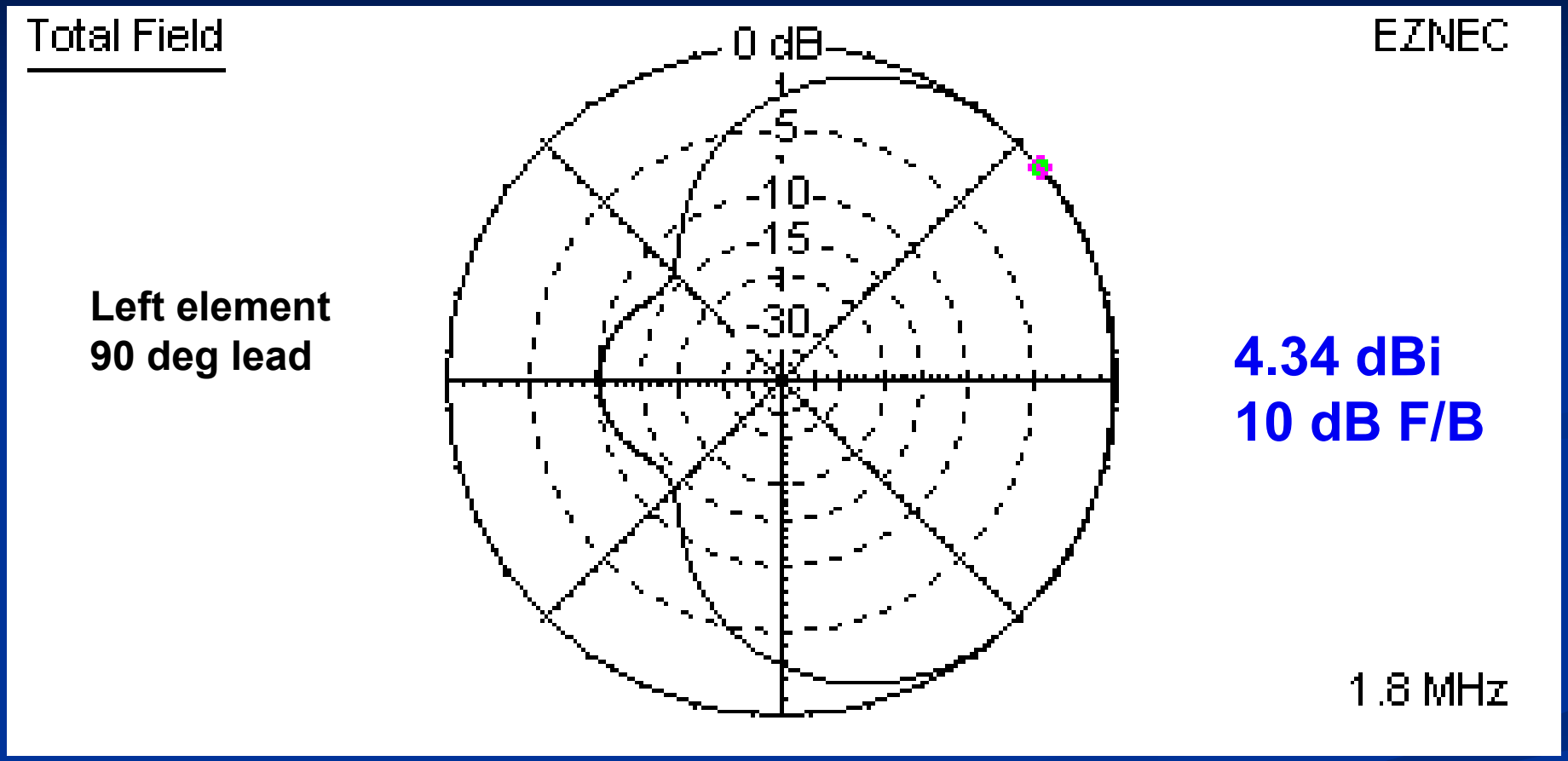


Modeled with 140 ft effective height tower

Single element w/146 ft effective tower = 2 phased ele!
Using 2 severely bent elements doesn't improve anything!
I found this out the hard way!

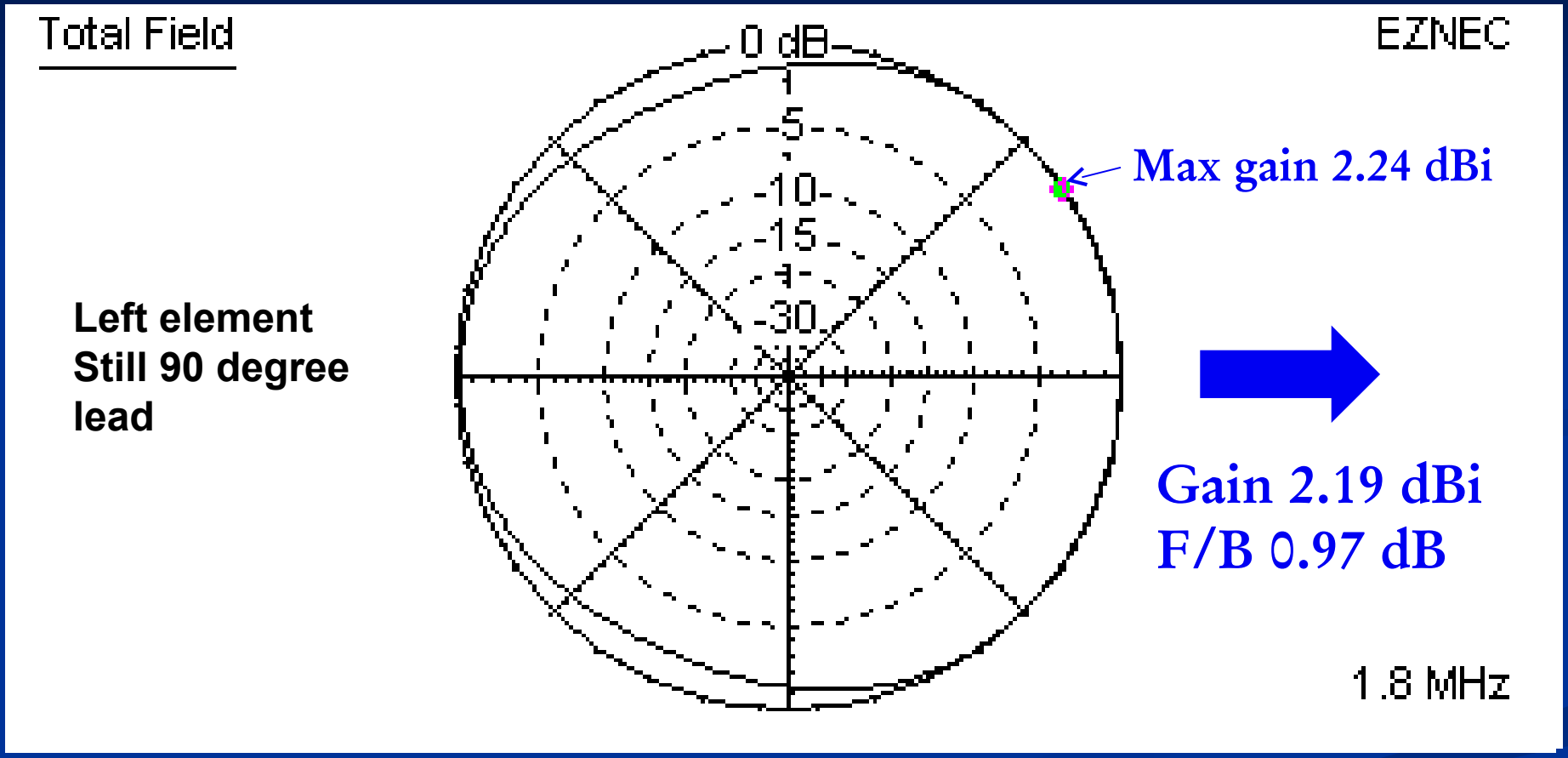


two phased severely bent 160m ele



Modeled with No tower in between

Two severely bent phased elements perform only like a single element



Modeled With 135 ft effective height tower

A BIG DIFFERENCE – THE TOWER HURTS PERFORMANCE!

Tower effective height calculation
(electrical resonant length in EZNEC)

Structure	Effective height
86 ft Rohn 45 and 14 ft 2 inch mast	95.5 ft
Add 40 meter boom	109 ft
Add top C31XR boom	123 ft
Add 6 meter beam	126 ft
Add bottom C31XR, etc	130 ft
Add 40M & C31XR driven elements	146 ft

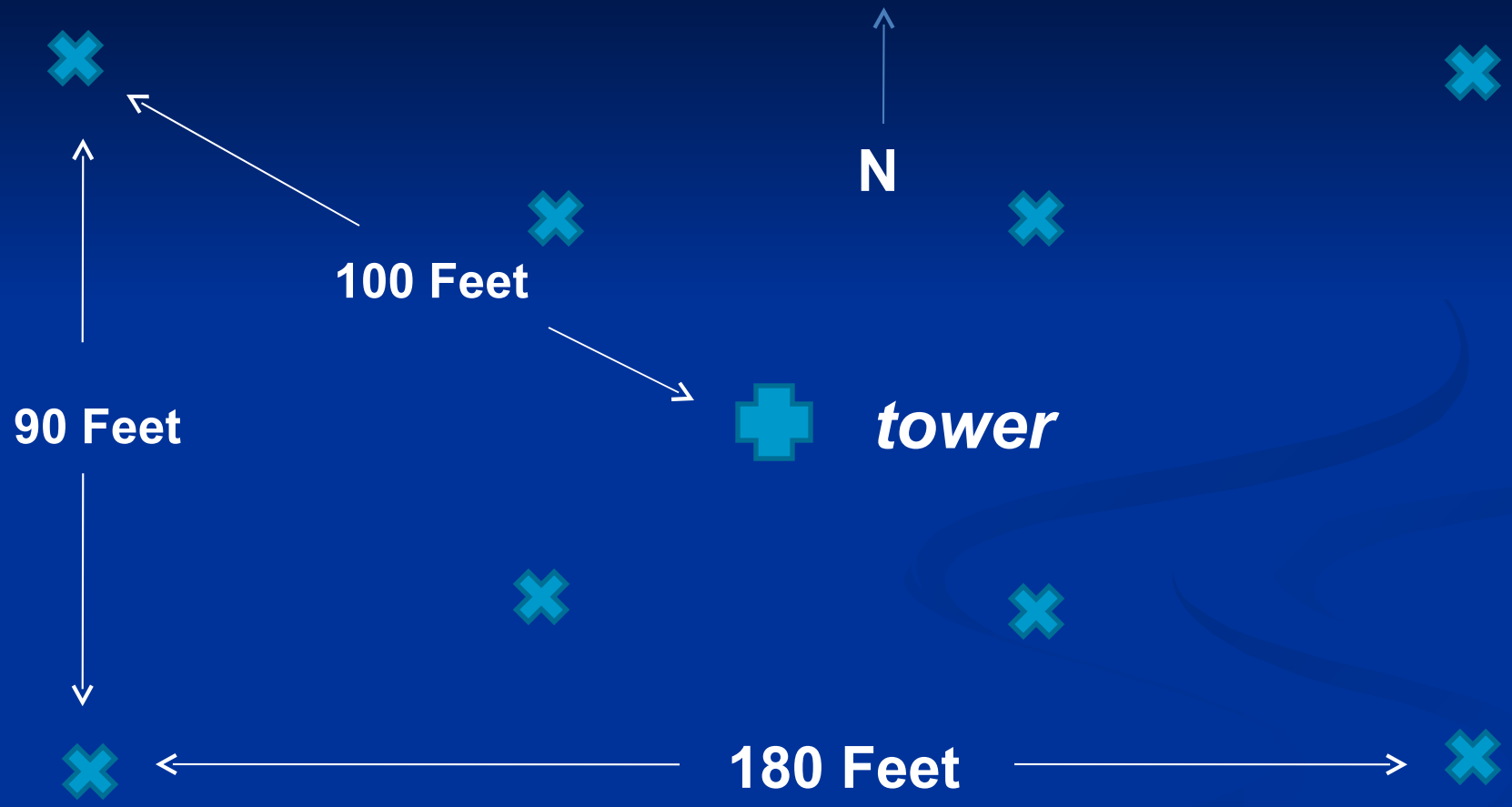
After trying 2 elements with poor performance as compared to the single severely sloped vertical:

tried 3 elements, and various combinations

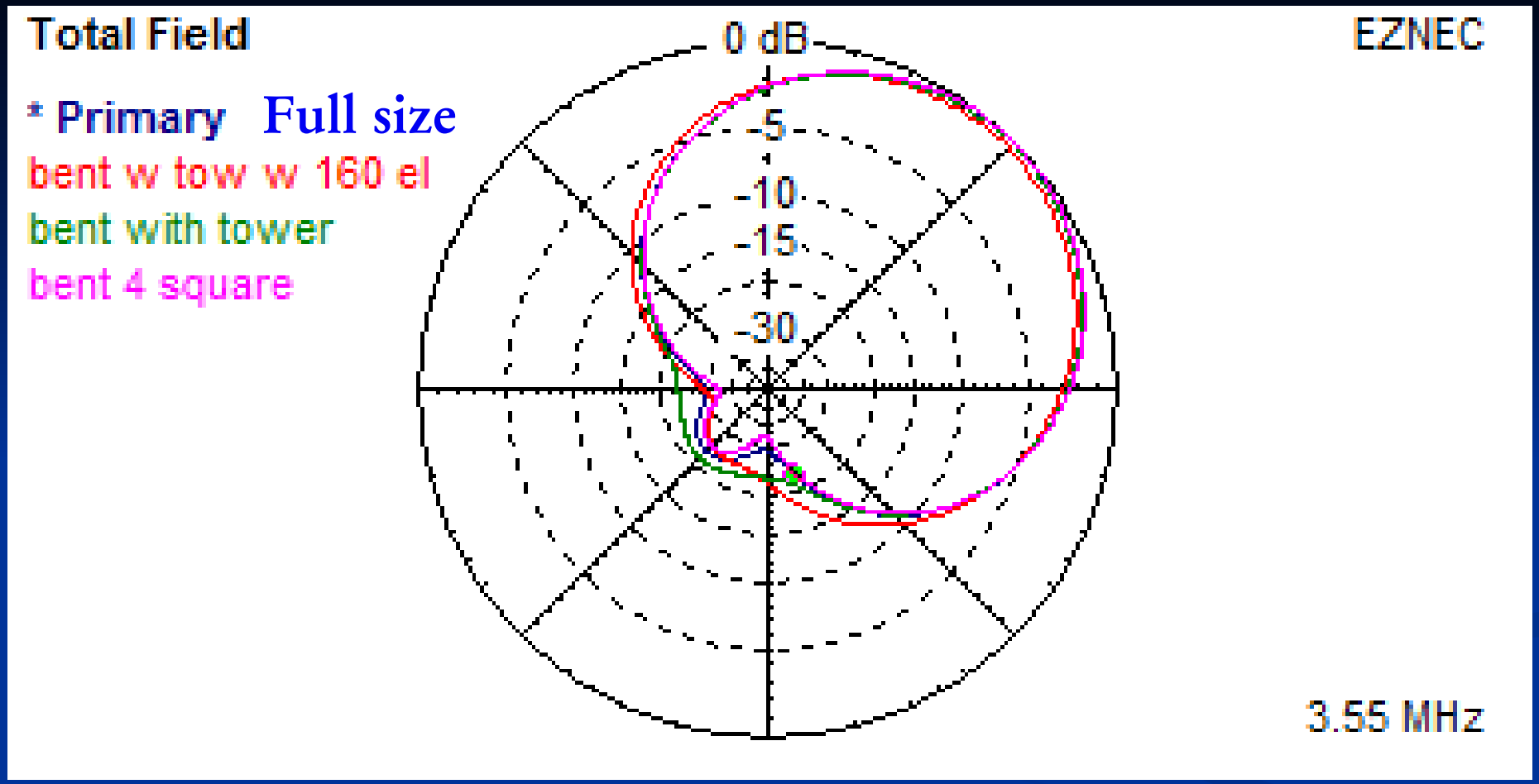
None seemed to work as well as a single severely bent element

Based on success with 80 M 4 Square, he added a 4th element

A “4 square” doesn’t have to be square



K9RS 160 meter 4 “square” layout
and 80 meter 4 square layout



In this 80m model:

Full size 80 Meter 4 square 6.0dBi

Bent with tower and 160 el 5.67dBi

Effect of tower, bending, and one 160 element in front is minimal

160 meter ‘severely bent’ 4 square

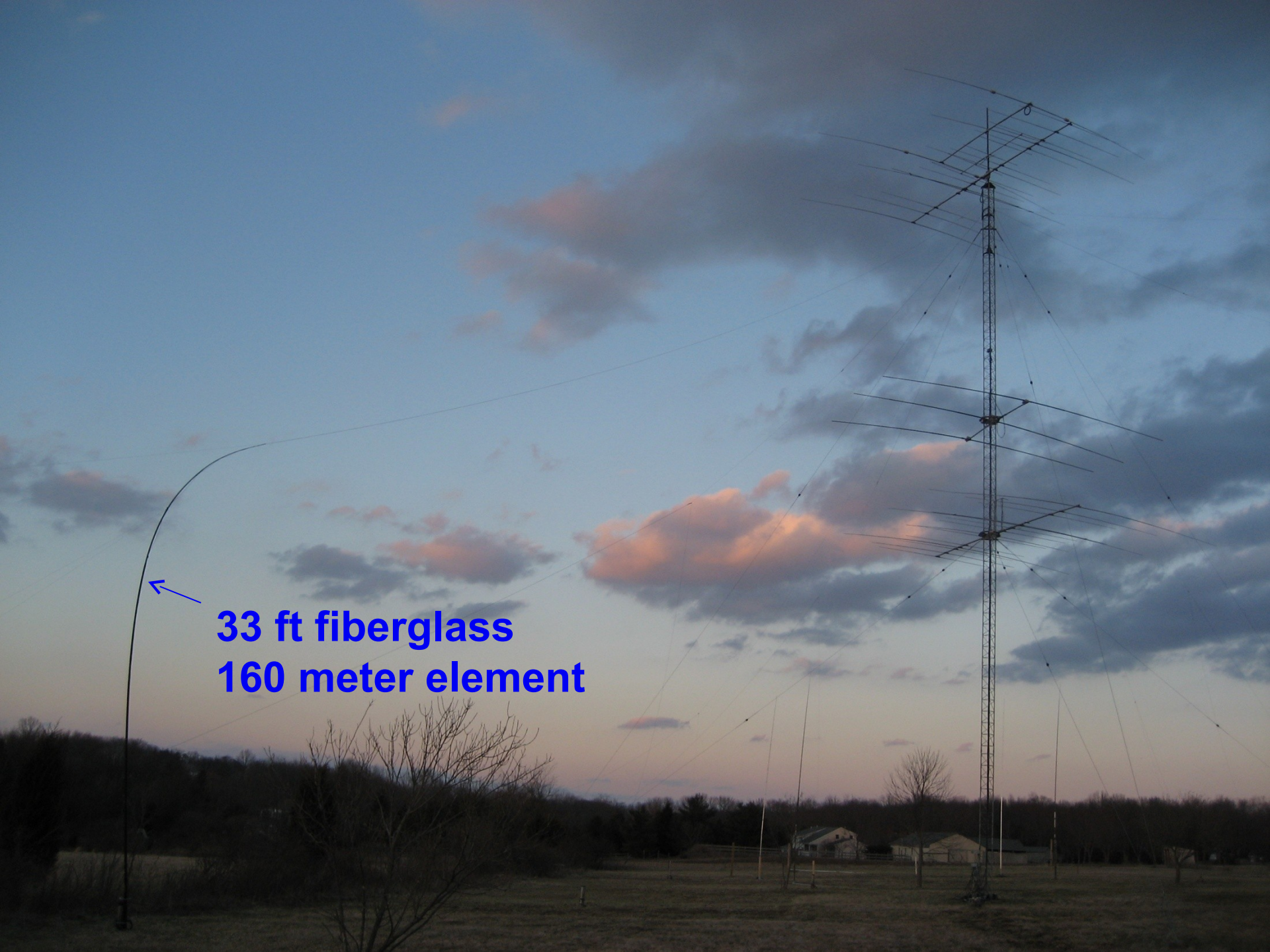
- 30 ft vertical, the rest slopes towards tower
- Comtek box
- #14 Flex-Weave wire
- 3/16 inch Dacron rope
- Each element started with 15 radials
- Each element fed with 50 Ohm RG-8

Note this important point:

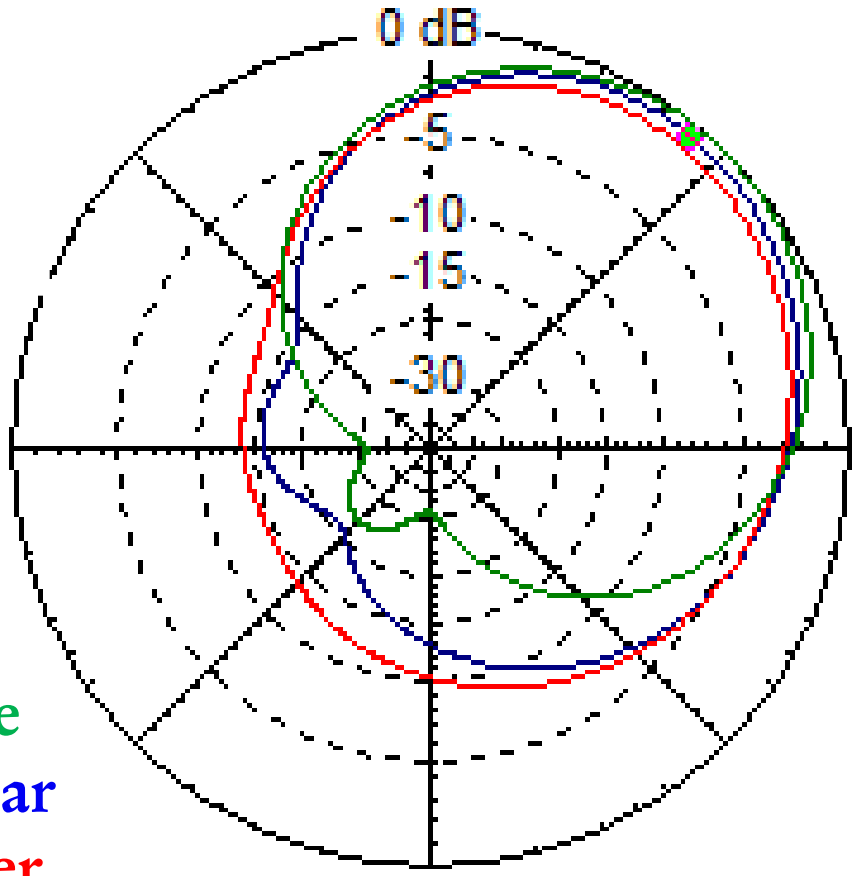
Feed ‘severely bent’ Verticals with RG8 when using a Comtek box

The severely bent verticals reduce feed point impedance to about 20 Ohms at resonance

When used with a Comtek box this is easily accommodated by using 50 Ohm cable instead of 75 Ohm for the quarter wave lines


33 ft fiberglass
160 meter element

160 Meter 4 “square” Comparison
Considering shape and tower interaction



Outer ring
6.88 dBi

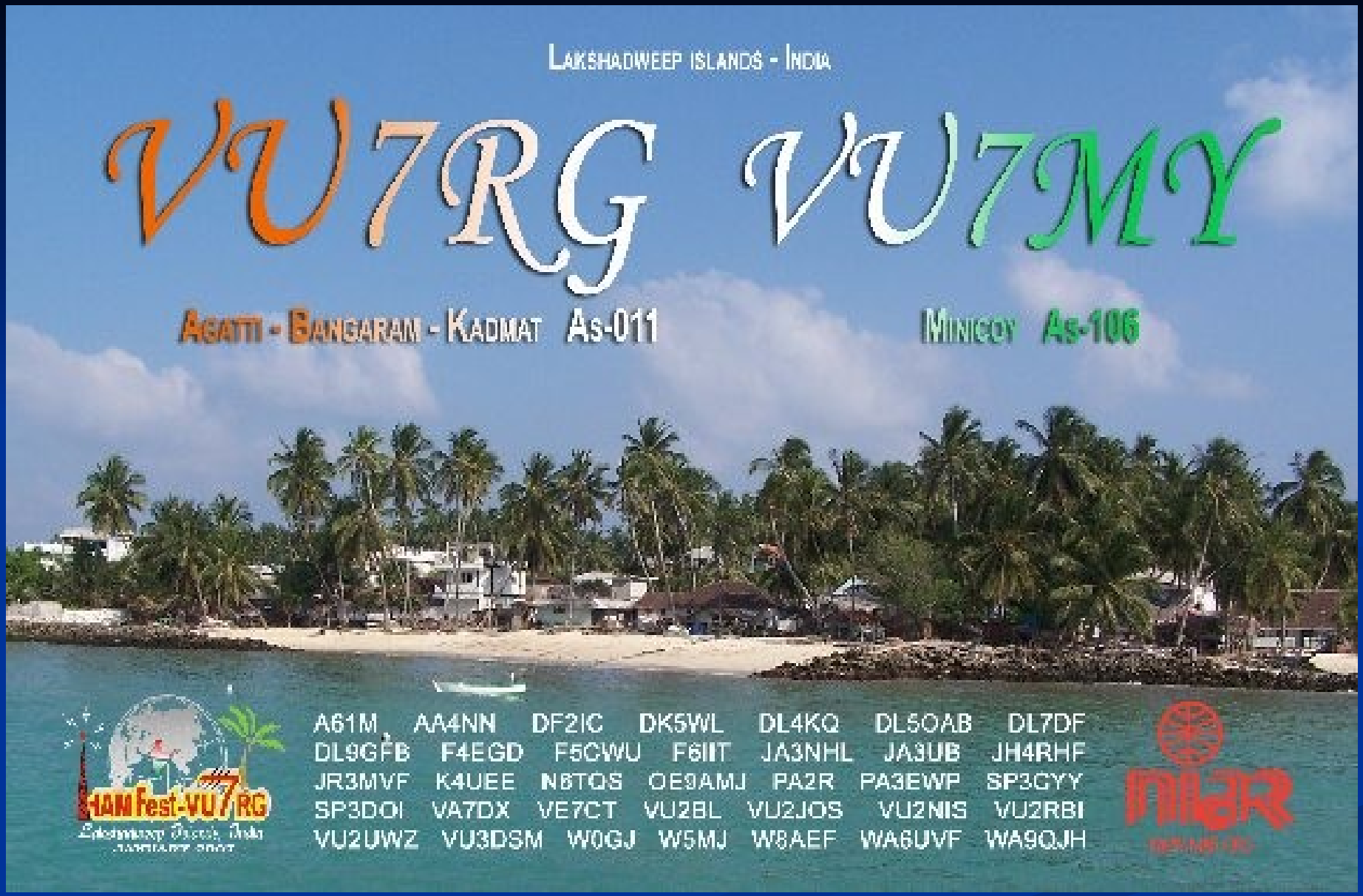
K9RS 5.82 dBi

Full size square
Bent rectangular
Bent with tower

Modeled with K9RS 146 ft effective height tower

160 M 4- “square” cost

Anchor kits and ground	
Bar strips	$100
Wire and cable	$250
Dacron Rope	$50
Comtek 4 ACB-160	$420



First QSO VU7RG Jan 19 , 2007 just after finishing

Priceless


N3DXX Adding radials

This is the way to bury radials !

Results – this stuff works! K9RS on a narrow lot

- 1st in N. America M/S WAE 2007
- 1st N. America M/S CQWW SSB 2007
- 2nd M/S IARU 2007
- 2nd ARRL DX SSB M/S 2008
- 5th ARRL DX CW M/S 2008
- 145 countries 160M, 207 on 80M

So what does this mean for you?

If you can do anything you want

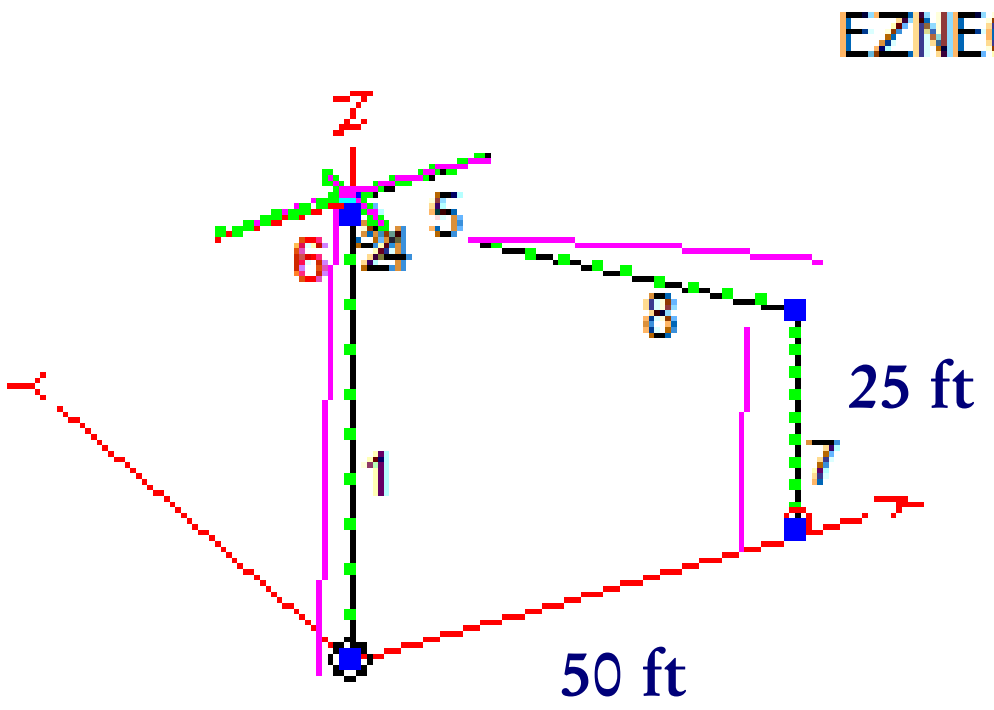
This might not be useful

But…

- If you don't have as tall a tower
- If you don't have as much space

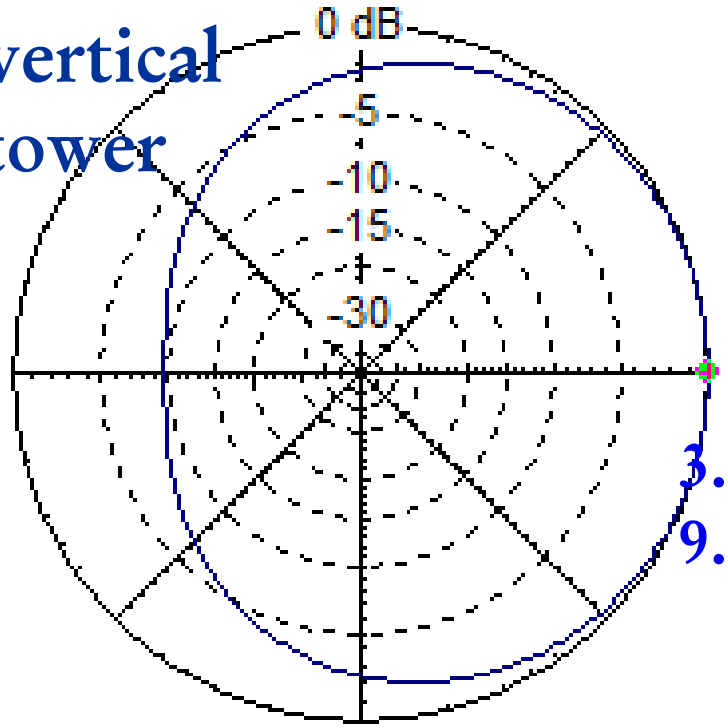
Lets look at a shorter tower

- 50 ft tower
- 2 ft mast
- C3S tribander
- single bent vertical element



- Model of 80 meter severely 'bent' vertical off a 50 ft tower
- Use EZNEC to model tower and 'severely bent' vertical

Bent 80 M vertical
With 50 ft tower

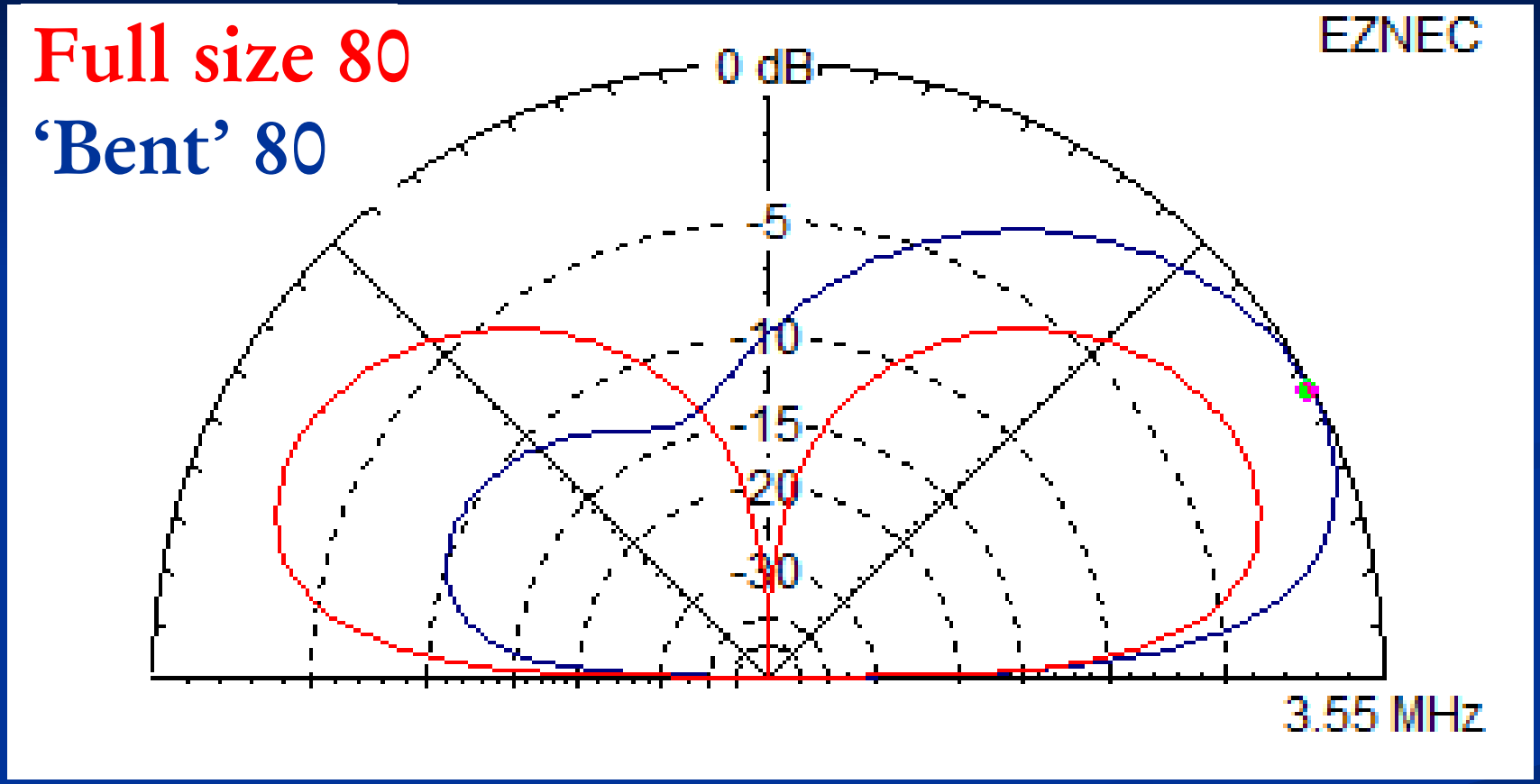


3.27 dBi
9.78 dB F/B

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	28.0 deg.	Gain	3.27 dBi
Outer Ring	3.27 dBi		0.0 dBmax

Slice Max Gain	3.27 dBi @ Az Angle = 0.0 deg.
Front/Back	9.78 dB
Beamwidth	197.1 deg.; -3dB @ 261.4, 98.5 deg.
Sidelobe Gain	< -100 dBi
Front/Sidelobe	> 100 dB

Bent element & tower vs. full size vertical



1.8 dB gain over qtr. wave vertical
9.8 dB front to back

IMAGINE: Put a Bent 4 square on a much shorter tower

- Easy to install: 40 meter 4 square with a single 20 ft support on tiny lot
- Easy to install: 80m and 40m bent 4 squares with 40 ft tower support
- Apartment/condo dwellers: 20 meter 4 square on a 10 to 20 ft support
- Use drain spouts or flagpoles for

Ideas and Future work

- Find optimal dimensions and base placements for bent verticals and different eff. tower heights
- model and use tower-mounted parallel wires and other techniques to lower/heighten effective tower heights
- Explore horizontal and vertical patterns using various geometries for single element, 4 square

Thank You

And special thanks to:

W2GD, W2RQ, WE3C, N3BB, N3DXX, AA5B, W5JAW, K9DX, K9HMB, N9NC, CTDXCC

And of course Tim K3LR