Using Free Software to Improve Your Station

K0NA

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Introduction

- A look at the following software packages and how they were used for practical projects at K0NA
  - 4NEC2   Free on the web
  - Yagi for Windows   ARRL
  - Transmission Lines for Windows   ARRL
  - High Frequency Terrain Assessment   ARRL
- This will not be a tutorial on how to use the software packages

Projects

- An inverted Vee vs. a shunt fed tower on 80 meters
- Elevated radials (guy wires) on a shunt fed tower
- Multiband vertical dipole on 40 and 30
- Optimized 4 element yagi
- Where to put a new tower to resolve a zoning issue
- A new low band antenna that meets the zoning requirements
- What to do about poor performance on 10 M

Using Software to Model Systems

- Software does not have to be 100% accurate
  - It just needs to accurately track the changes
  - Moderate your interpretation of the results by considering conditions such as ground, terrain, trees, and buildings
- Look for changes
- You may find enough small changes to make a big change
  - A .5 DB change is not noticeable.
  - Find enough .5 DB changes and it could make a big difference

Define What You Want Your Station to Do

- A station designed for net operation on 80 M is quite different that one for DX

- I enjoy chasing DX and casual contesting

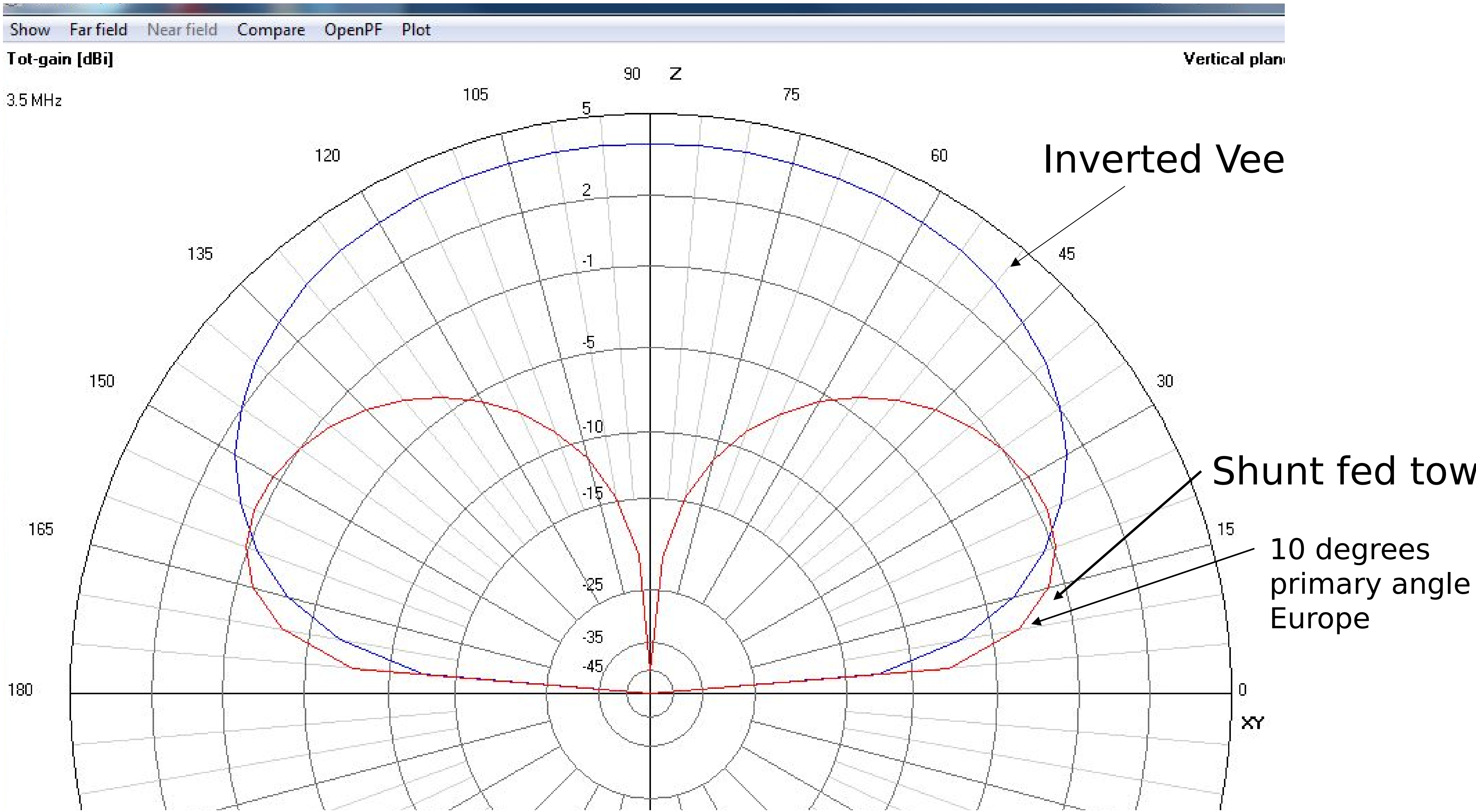
  - That is what this presentation will focus on

An Inverted Vee vs a Shunt Fed Tower

- An inverted V was hung from a 70 foot tower to talk to a friend in Casper Wy on 80 M

- The 70 foot tower with a triband beam was fed with a sloping wire at 40 feet and L network to use the tower as a vertical.

- Both worked well but how did they compare for working DX?
  - 4NEC2 to the rescue



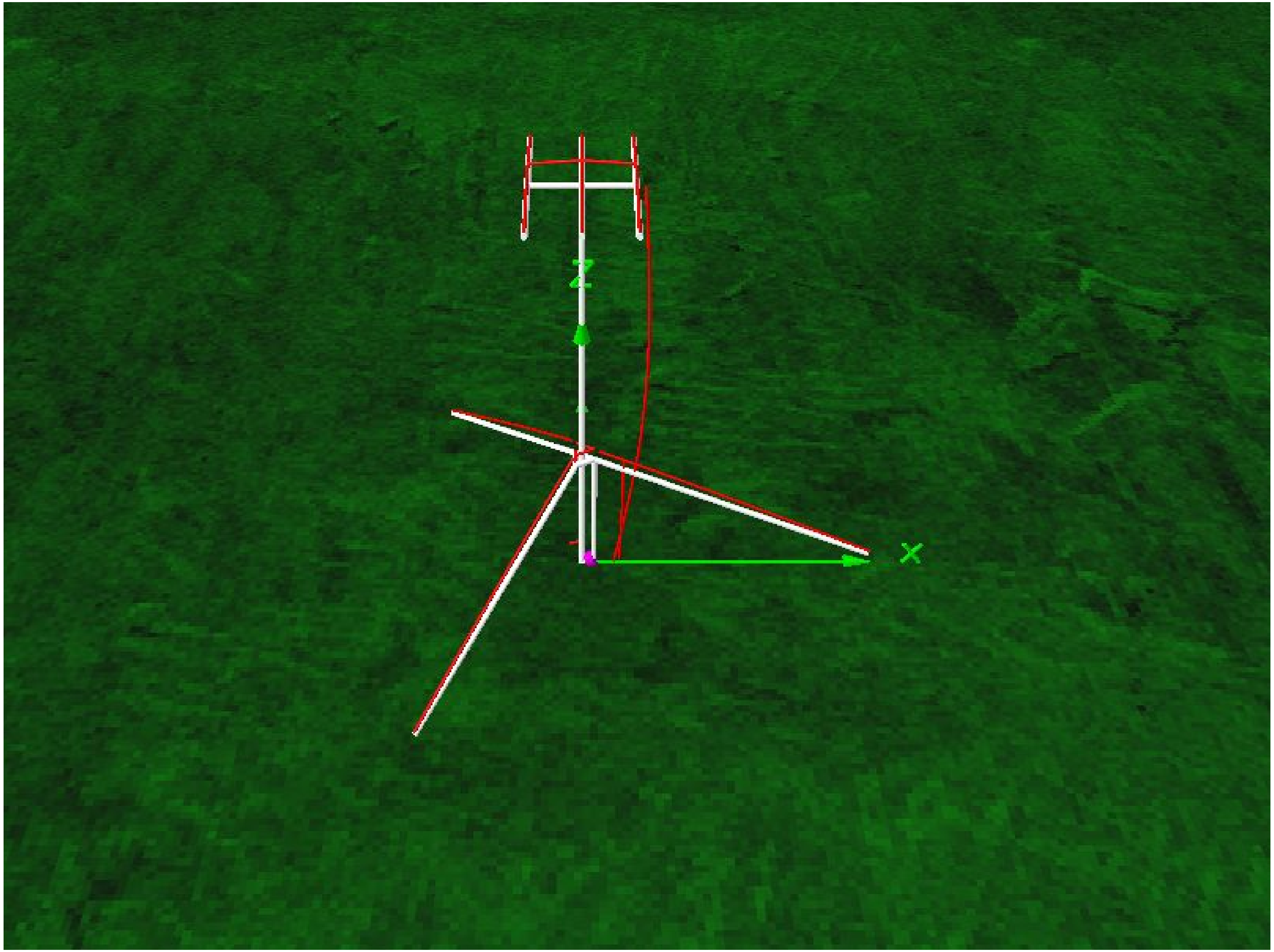
Show
Far field
Near field
Compare
OpenPF
Plot
Tot-gain [dBi]
Vertical plan
3.5 MHz
Inverted Vee
Shunt fed tow
10 degrees
primary angle
Europe

Test Results:

- Generally the tower was better for DX except for the Caribbean and South America
  - The vertical tower is more prone to ground conditions than the Vee
  - I have a hill to the south that distorts patterns from the tower more than the Vee
  - The slope to the north is about 10 degrees down that enhances the pattern on the tower
- Typically state side signals were down 2 S units on the tower
  - State side signals come in at a higher angle and are attenuated by the tower
  - This is in general a good thing in that local QRM is a serious problem on 80
- There were many times the opposite was true
  - One can never have too many antennas!

Using the Guy Wires as Elevated Radials

- The ground system was marginal
- Could I use a set of guy wires as an elevated radial system?
  - They say a set of 4 elevated radials is a great system
  - A true elevated system would be impossible because of the terrain, driveway and deer
- 4NEC2 to check it out



Structure showing the currents

Note the low current on the non resonate guy wires

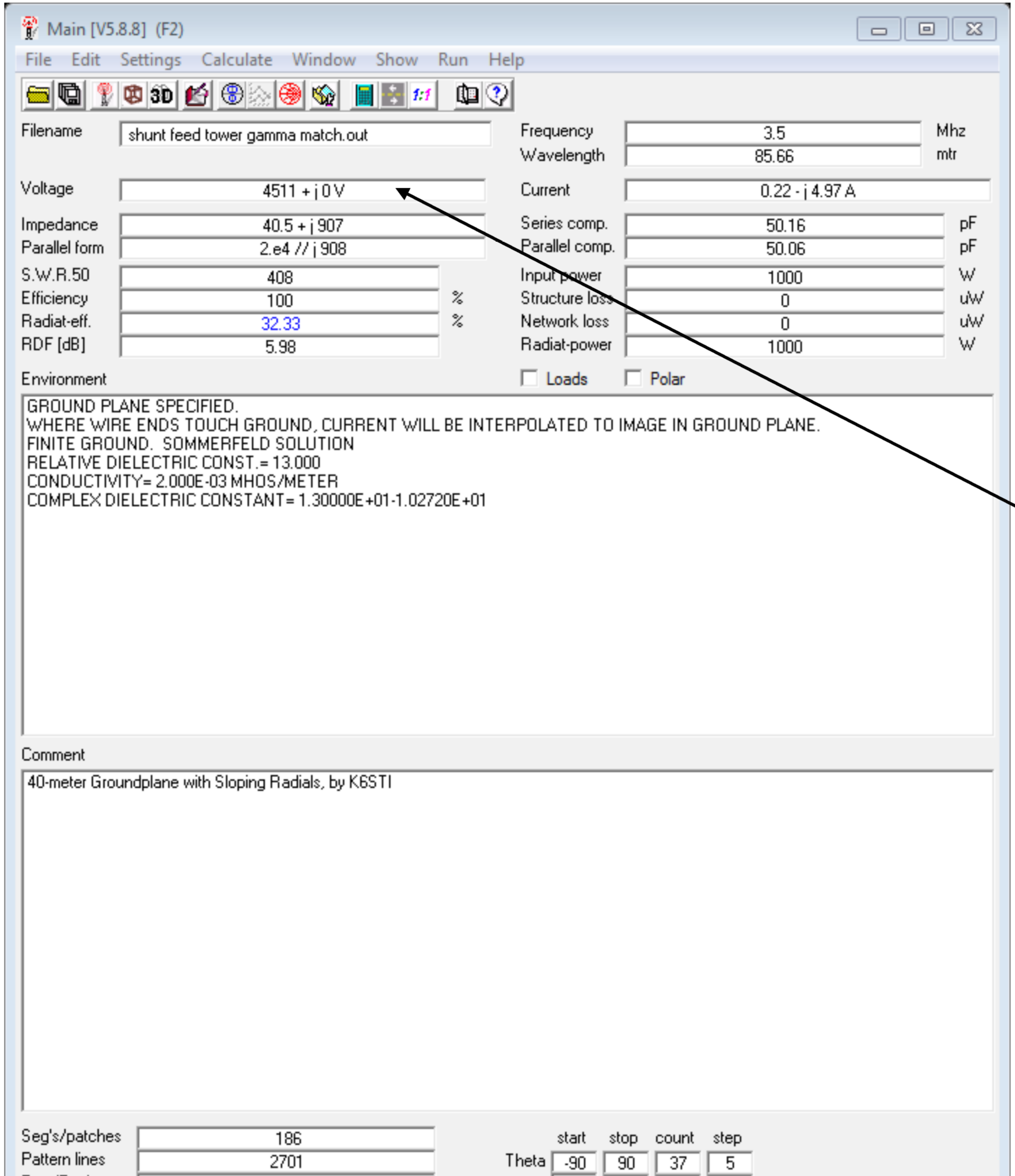
Results

- There was little current on the non-resonate guy wires
  - The tower still had high current at the base requiring a ground system
- The system was hard to match
- No gain was seen
- The concept was abandoned
  - It may have been possible to add wire to the guys to resonate them but it was never tried

Using a Gamma Match to Feed the Tower on 80 M

- The hap-hazard feed system was not a real good way to feed the tower
  - It was difficult to match
  - Used a lot of inductance (losses)
  - Had a narrow band width
- A Gamma Match was designed on 4NEC2 and implemented
  - The 4NEC calculations were close
  - The band width improved
  - A UHF connector was used to bring the capacitor out of a box at the base of the tower
- When a 1,000 watts was applied, the connector was burned off!
  - WHY???

4NEC2 output for the gamma matc



Note the voltage at the feed p

4 Element 20 M Yagi

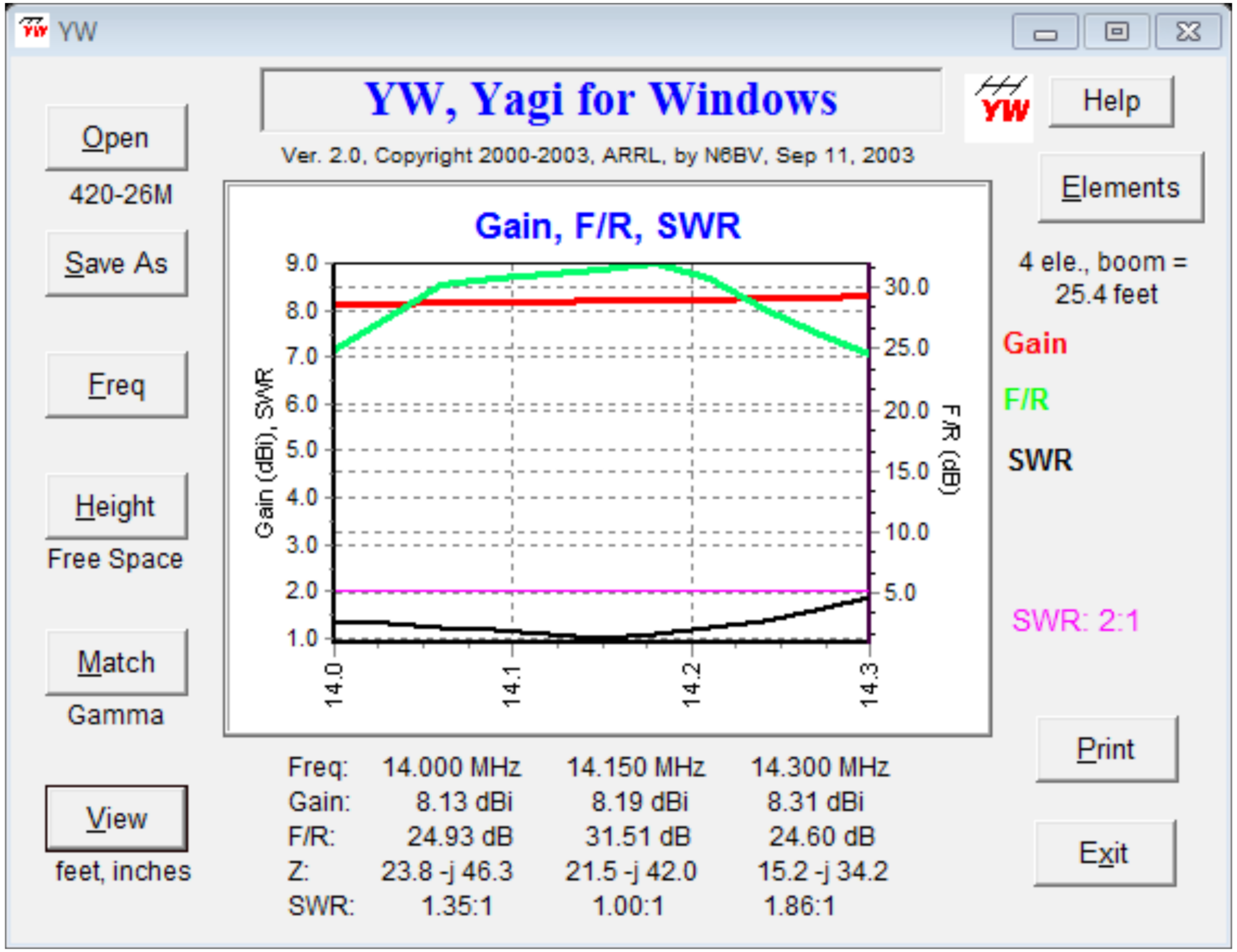
- The triband beam seemed to have marginal performance on 15 and 10
- A decision was made to try a modification of the ARRL optimized 4 element yagi
- Because of a noise problem, gain and band width were compromised for improved front to back ratios
- Yagi for windows from the ARRL was used to design the antenna

The circumference of the boom to element plate divided by pi

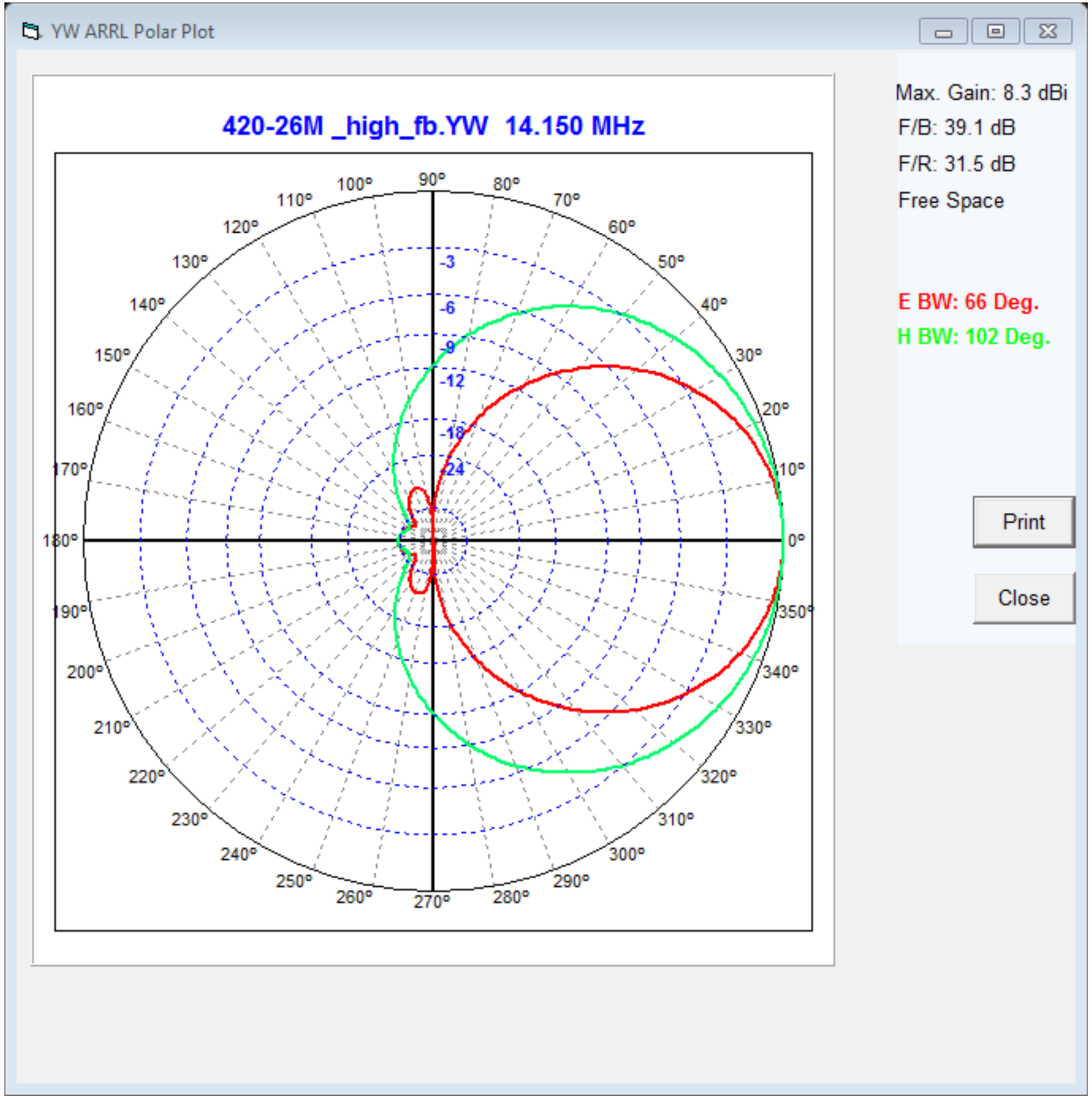
420-26M _high_fb.YW, Element Taper and Boom Spacing

Inches	Spacin	Dia 1	Dia 2	Dia 3	Dia 4	Dia 5	Dia 6	Dia 7	Dia 8	Dia 9
Diameter		3.8	1.0	0.75	0.5					
Reflector	0.0	4.0	66.0	70.0	78.5					
Diameter		3.5	1.0	0.75	0.5					
Driver	71.625	4.0	66.0	70.0	63.5					
Dir 1	131.25	4.0	66.0	70.0	64.0					
Dir 2	04.375	4.0	66.0	70.0	45.0					

Cancel OK



YW
YW, Yagi for Windows
Ver. 2.0, Copyright 2000-2003, ARRL, by N6BV, Sep 11, 2003
Help
Open
420-26M
Save As
Freq
Height
Free Space
Match
Gamma
View
feet, inches
Elements
4 ele., boom = 25.4 feet
Gain
F/R
SWR
SWR: 2:1
Print
Exit
Gain, F/R, SWR
Gain (dBi), SWR
F/R (dB)
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
30.0
25.0
20.0
15.0
10.0
5.0
14.0
14.1
14.2
14.3
Freq: 14.000 MHz 14.150 MHz 14.300 MHz
Gain: 8.13 dBi 8.19 dBi 8.31 dBi
F/R: 24.93 dB 31.51 dB 24.60 dB
Z: 23.8 -j 46.3 21.5 -j 42.0 15.2 -j 34.2
SWR: 1.35:1 1.00:1 1.86:1



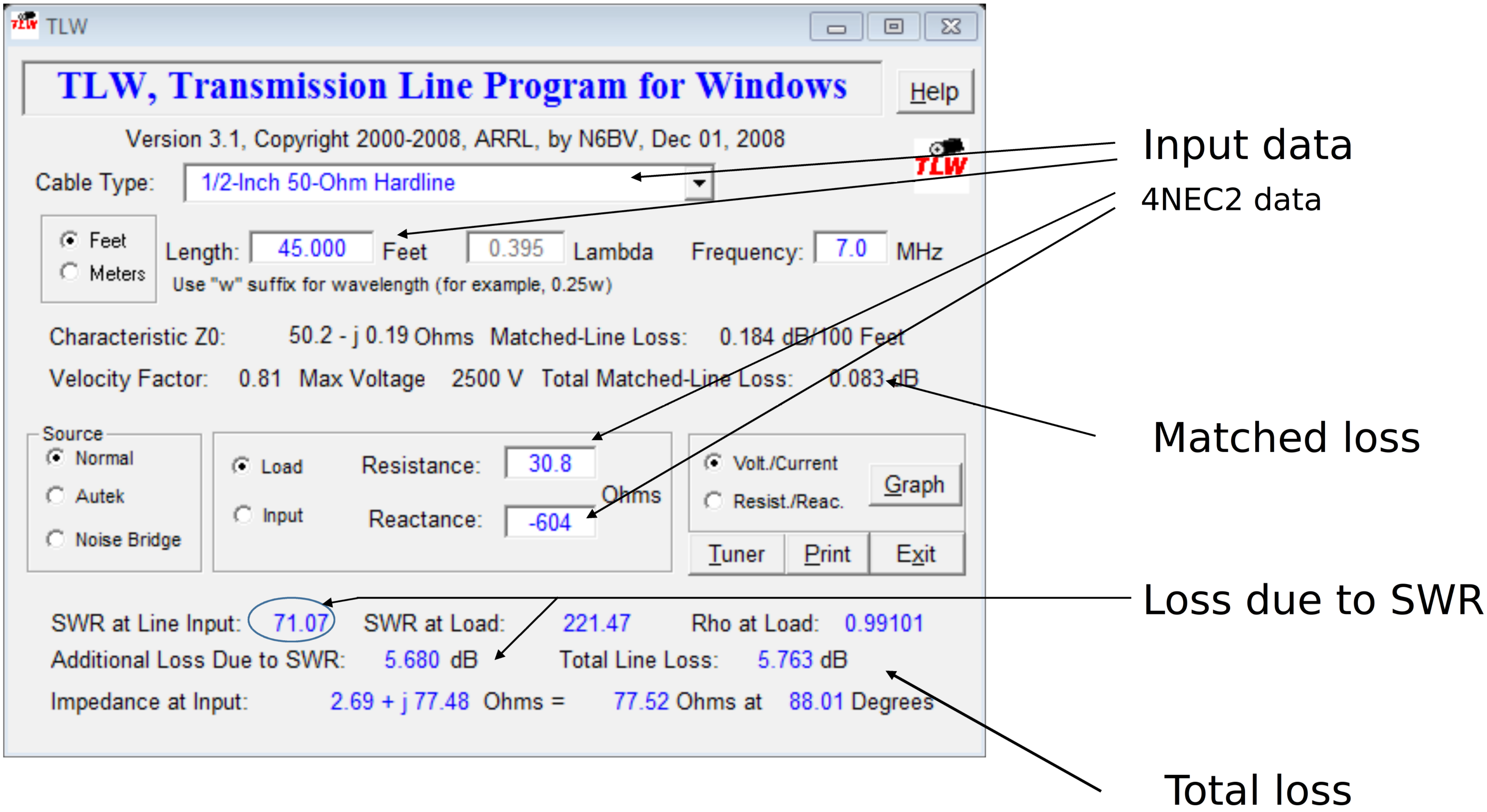
Typical measured numbe
were 30DB !

Results

- The front to back ratio was excellent as predicted
- The Gamma match dimensions were as predicted
- The resonant frequency was a little high (50 KHz)
- Later the antenna was removed to install a 3 element Steppir
    - The Steppir then had to be removed because of a zoning problem
    - When the 4 element yagi was reinstalled it was redesigned for more gain, band width and lower front to back ratios

A Multiband Antenna for 40, 30, 17, and 15

- The plan was to use a vertical 30M vertical dipole on the other bands with a tuner at the base of the tower
- Feed line would be low loss ½ inch hard line
- The patterns looked promising
- The 40M feed point impedance was calculated in 4NEC2 and put into Transmission Line for Windows (ARRL) to see what the loss would be due to a high swr


TLW
TLW, Transmission Line Program for Windows
Help
Version 3.1, Copyright 2000-2008, ARRL, by N6BV, Dec 01, 2008
Cable Type: 1/2-Inch 50-Ohm Hardline
Feet
Meters
Length: 45.000 Feet 0.395 Lambda Frequency: 7.0 MHz
Use "w" suffix for wavelength (for example, 0.25w)
Characteristic Z0: 50.2 - j 0.19 Ohms Matched-Line Loss: 0.184 dB/100 Feet
Velocity Factor: 0.81 Max Voltage 2500 V Total Matched-Line Loss: 0.083 dB
Source
Normal
Autek
Noise Bridge
Load
Input
Resistance: 30.8
Reactance: -604
Ohms
Volt./Current
Resist./Reac.
Graph
Tuner
Print
Exit
SWR at Line Input: 71.07 SWR at Load: 221.47 Rho at Load: 0.99101
Additional Loss Due to SWR: 5.680 dB Total Line Loss: 5.763 dB
Impedance at Input: 2.69 + j 77.48 Ohms = 77.52 Ohms at 88.01 Degrees
Input data
4NEC2 data
Matched loss
Loss due to SWR
Total loss

Results

- With a nearly 6 DB loss it was not a practical antenna
- A 46 foot rotatable dipole was in operation at the same time the vertical dipole was in operation
- The dipole at 70 feet almost always out performed the vertical dipole by several S units on 30 M

The idea was abandoned for a Steppir DB18E !

Problem: Zoning Violation

- A Steppir antenna was put on the tower as a multiband solution
  - Shortly after installing the new antenna a notice of violation was received from Jefferson County
  - I had 30 days to remove the antenna or receive a $100/day fine
  - Since I had pictures that proved the existence of the tower and yagi before 2004, the old yagi could be reinstalled
- The tower had been in place for 30+ years but since it was modified it had to meet all current regulations
  - That would be difficult

Possible Solutions

- Live with the existing 4 element yagi
  - I really enjoyed the Steppir the short time it was up
- Remove 2 sections of tower to get under 50 feet and move 1 set of guy wires
  - What would it do to my signal?
  - How would I maintain the antenna in the future?
- Put up a new 50 foot tower
  - Where?
- Put up a 75 foot crank up tower
  - Would it be worth the money?
  - The county only allows the tower to be fully extended for 12 hours a day

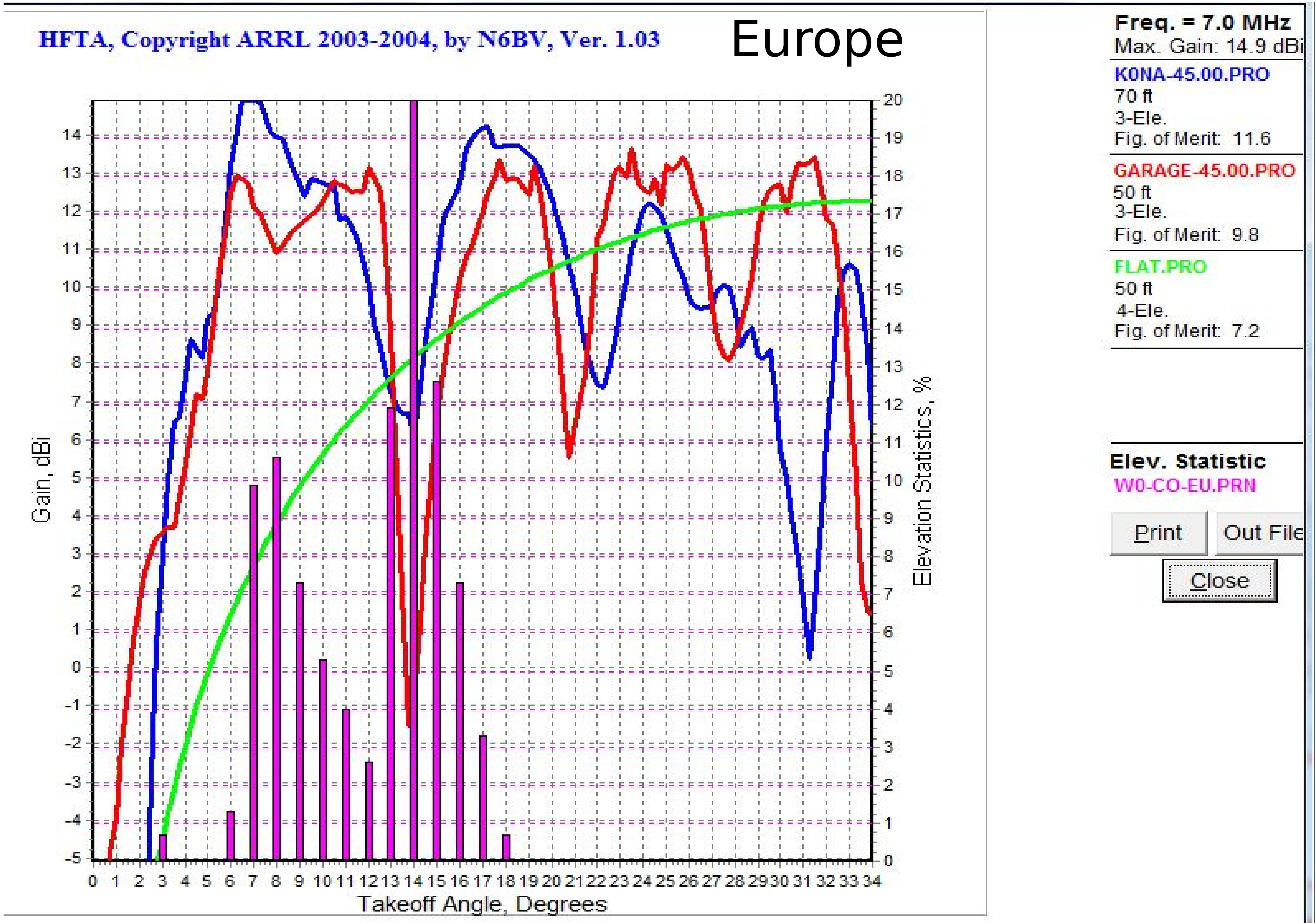
The Key Question: “How Would It Affect My Signal”

- High Frequency Terrain Assesement by N6BV was to answer the following questions (ARRL)
  - How would a change in height affect my signal?
  - Is one spot better than another?
  - How would my signal compare to a similar antenna on flat ground at 50 feet?
- The antennas sits about 300 feet above the valley floor so the pattern is quite complex
  - This is shown in the next slide looking to the north east toward Europe
  - High Frequency Terrain Assessment for answers !

View to the North East

Possible tower locatio

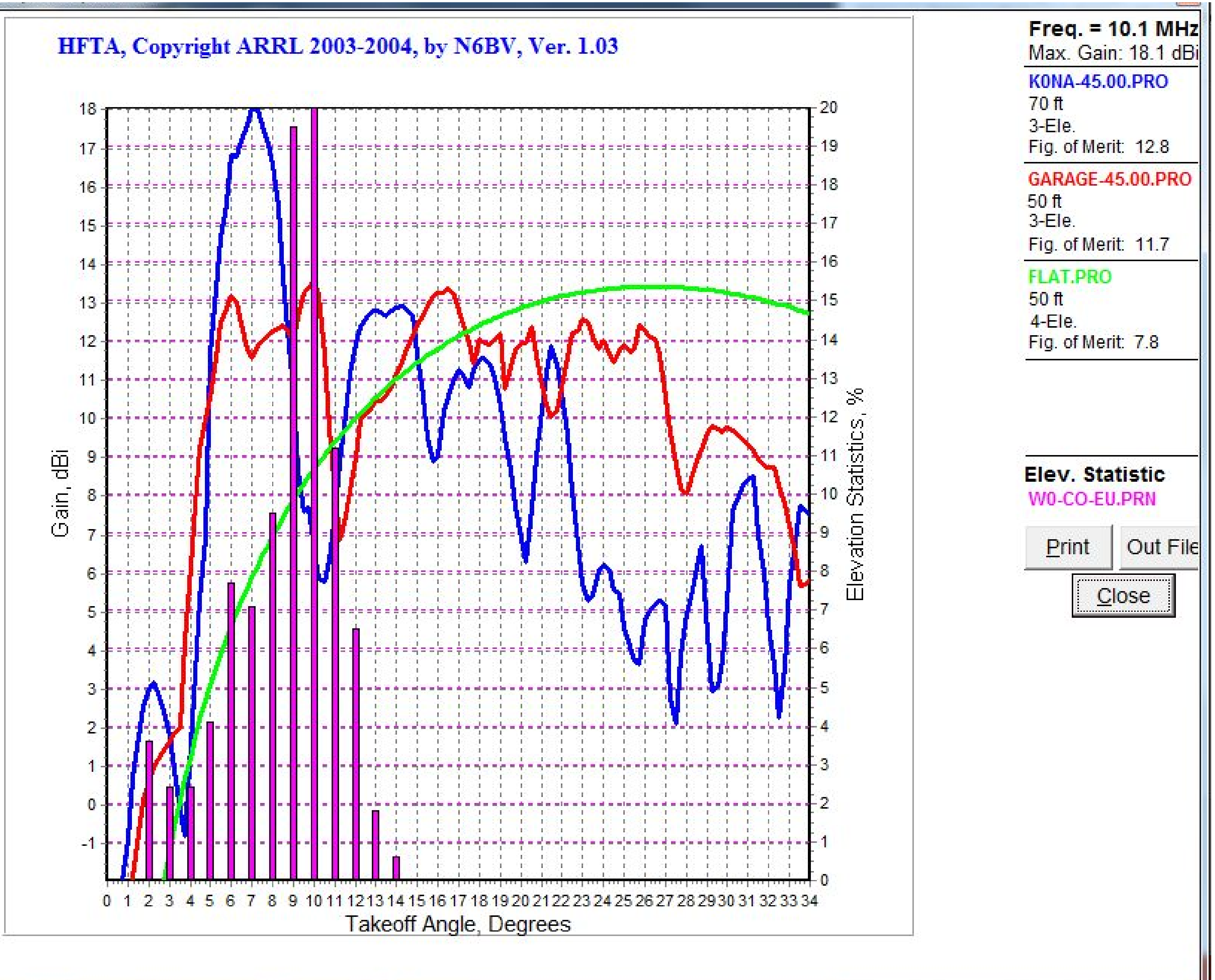
40 Meters to Europe

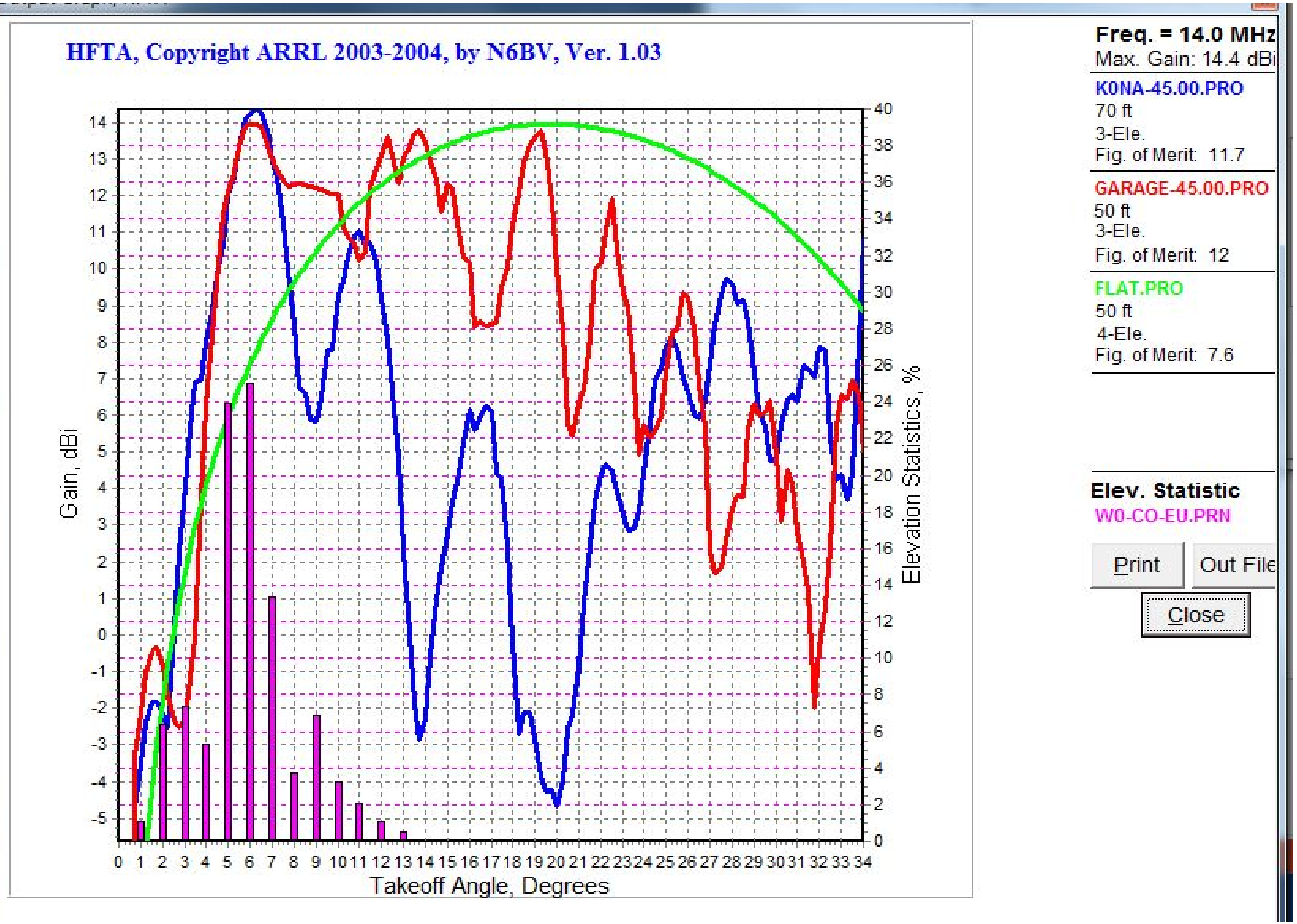


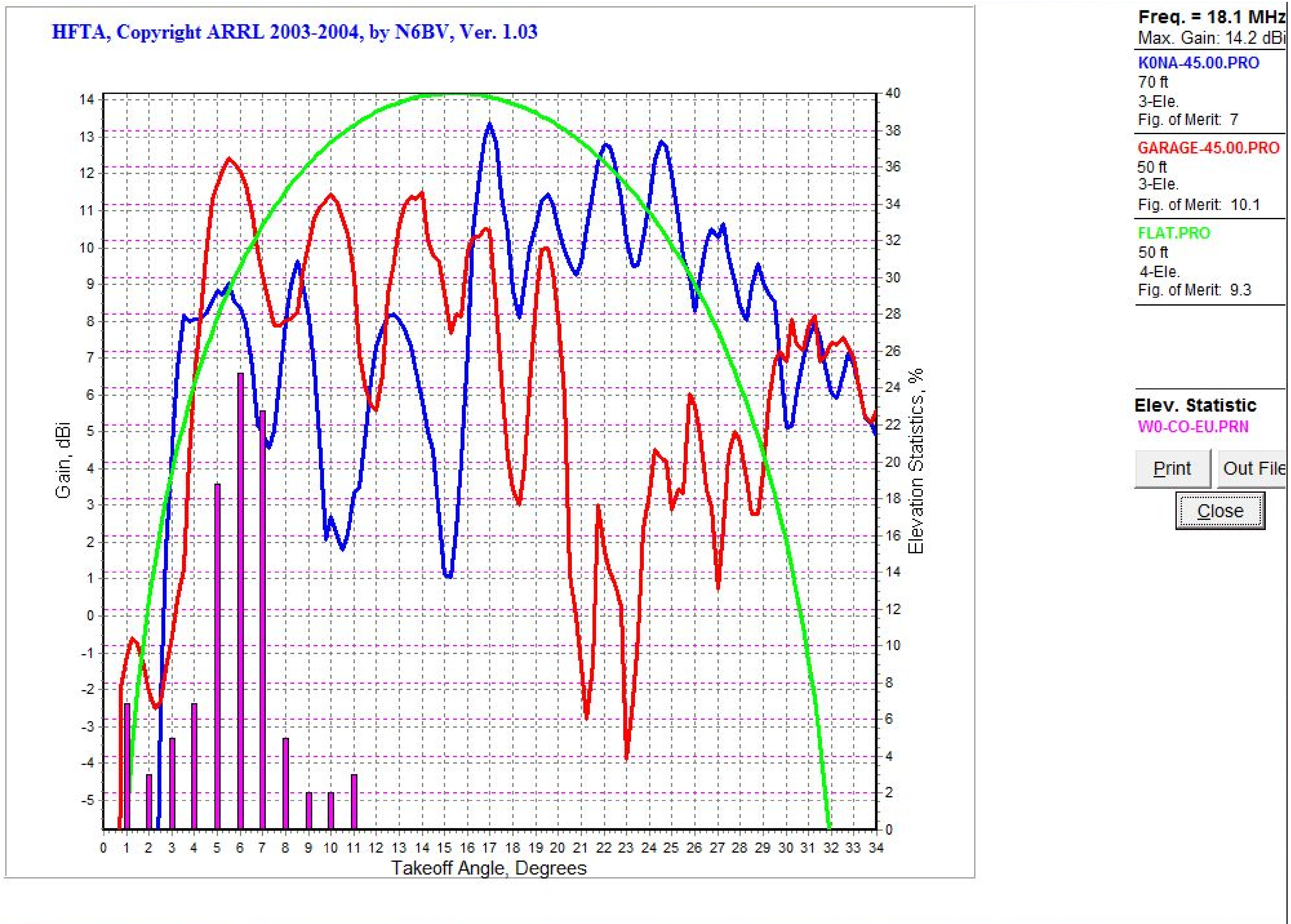
Existing antenna and tower

A preferred location at 50 feet

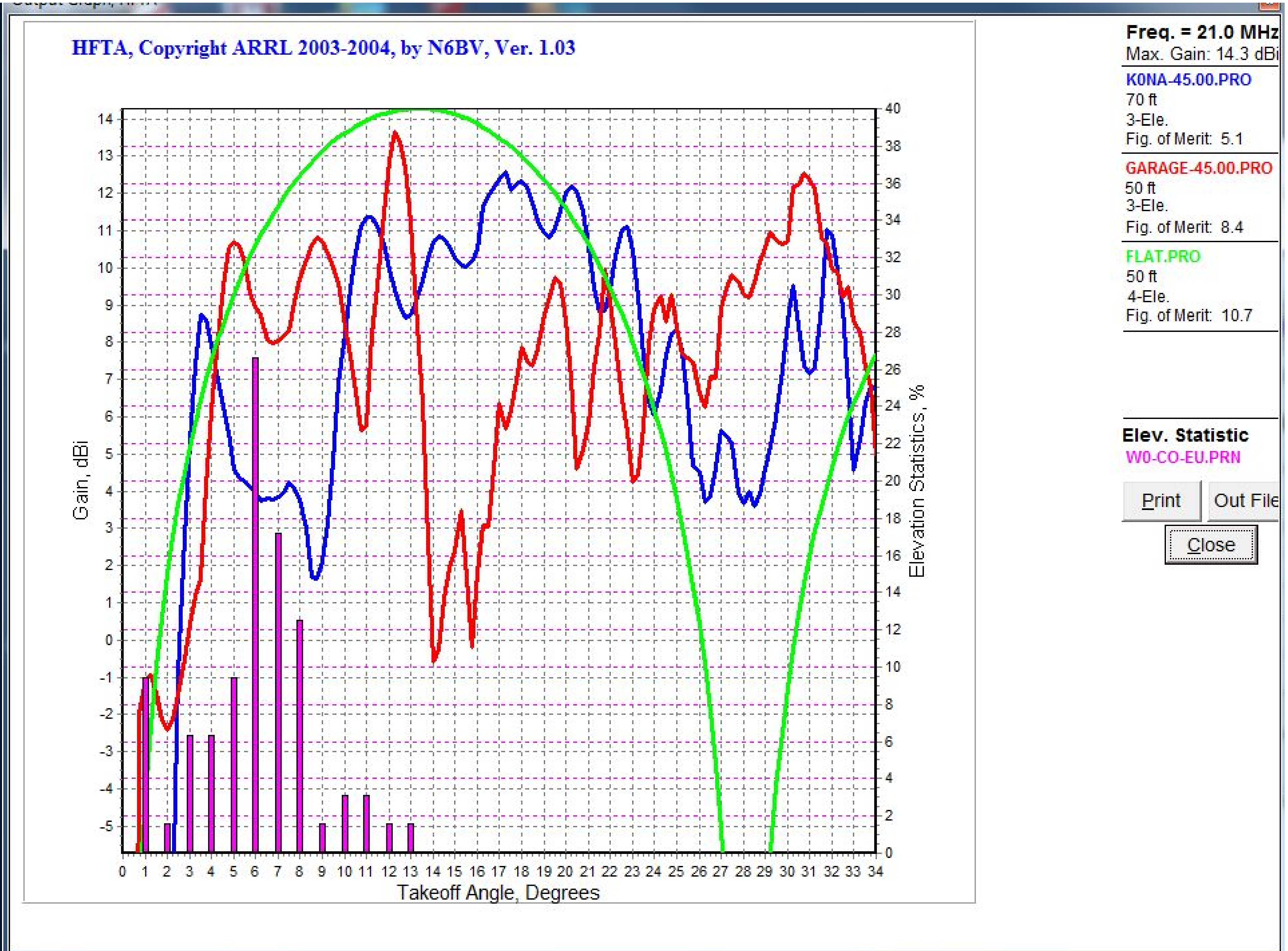
An antenna at 50 feet over flat ground


HFTA, Copyright ARRL 2003-2004, by N6BV, Ver. 1.03
Gain, dBi
Elevation Statistics, %
Takeoff Angle, Degrees
Freq. = 10.1 MHz
Max. Gain: 18.1 dBi
K0NA-45.00.PRO
70 ft
3-Ele.
Fig. of Merit: 12.8
GARAGE-45.00.PRO
50 ft
3-Ele.
Fig. of Merit: 11.7
FLAT.PRO
50 ft
4-Ele.
Fig. of Merit: 7.8
Elev. Statistic
W0-CO-EU.PRN
Print
Out File
Close

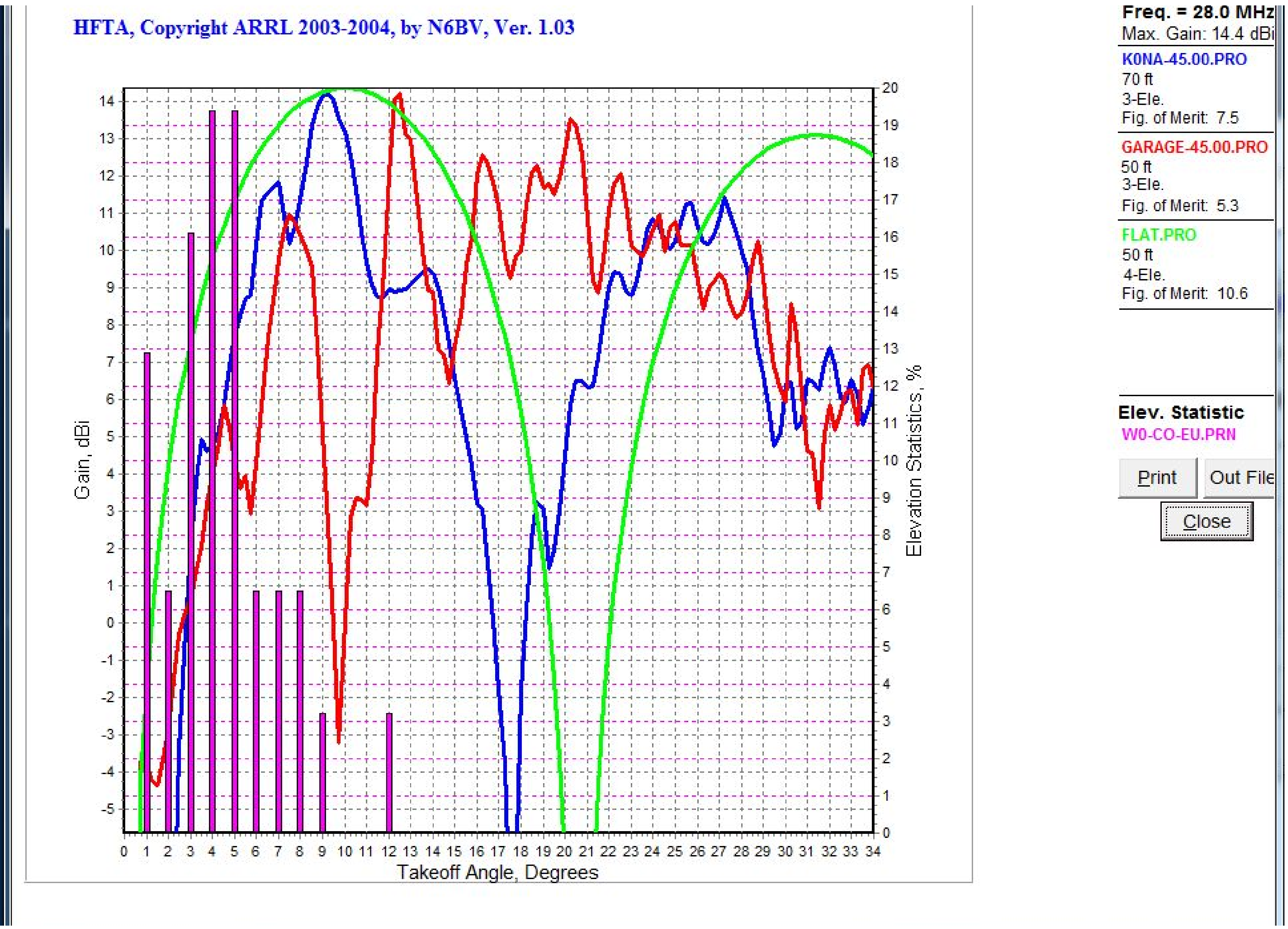

HFTA, Copyright ARRL 2003-2004, by N6BV, Ver. 1.03
Gain, dBi
Elevation Statistics, %
Takeoff Angle, Degrees
Freq. = 14.0 MHz
Max. Gain: 14.4 dBi
K0NA-45.00.PRO
70 ft
3-Ele.
Fig. of Merit: 11.7
GARAGE-45.00.PRO
50 ft
3-Ele.
Fig. of Merit: 12
FLAT.PRO
50 ft
4-Ele.
Fig. of Merit: 7.6
Elev. Statistic
W0-CO-EU.PRN
Print
Out File
Close



HFTA, Copyright ARRL 2003-2004, by N6BV, Ver. 1.03
Gain, dBi
Elevation Statistics, %
Takeoff Angle, Degrees
Freq. = 18.1 MHz
Max. Gain: 14.2 dBi
K0NA-45.00.PRO
70 ft
3-Ele.
Fig. of Merit: 7
GARAGE-45.00.PRO
50 ft
3-Ele.
Fig. of Merit: 10.1
FLAT.PRO
50 ft
4-Ele.
Fig. of Merit: 9.3
Elev. Statistic
W0-CO-EU.PRN
Print
Out File
Close



HFTA, Copyright ARRL 2003-2004, by N6BV, Ver. 1.03
Gain, dBi
Elevation Statistics, %
Takeoff Angle, Degrees
Freq. = 21.0 MHz
Max. Gain: 14.3 dBi
K0NA-45.00.PRO
70 ft
3-Ele.
Fig. of Merit: 5.1
GARAGE-45.00.PRO
50 ft
3-Ele.
Fig. of Merit: 8.4
FLAT.PRO
50 ft
4-Ele.
Fig. of Merit: 10.7
Elev. Statistic
W0-CO-EU.PRN
Print
Out File
Close



HFTA, Copyright ARRL 2003-2004, by N6BV, Ver. 1.03
Gain, dBi
Elevation Statistics, %
Takeoff Angle, Degrees
Freq. = 28.0 MHz
Max. Gain: 14.4 dBi
K0NA-45.00.PRO
70 ft
3-Ele.
Fig. of Merit: 7.5
GARAGE-45.00.PRO
50 ft
3-Ele.
Fig. of Merit: 5.3
FLAT.PRO
50 ft
4-Ele.
Fig. of Merit: 10.6
Elev. Statistic
W0-CO-EU.PRN
Print
Out File
Close

Comparing Locations

Band	70 ft old to 50ft new	50 ft new to 50 ft flat
40	-1.8 DB	+2.6 DB
30	-1.1	+3.9
20	+0.3	+2.6
17	+3.1	+2.7
15	+3.3	-2.3
10	-2.2	-5.3

Conclusions on Resolving the Zoning Problem

- Moving the antenna next to the garage is a reasonable solution
- Maximum loss on 40 is 1.8 DB which would be made up by eliminating 200 foot of coax
- Nothing can be done about the null on 40 for the peak openings
- Performance on the higher bands is improved in the new location
- The new location still gives a significant advantage on the low bands over a 50 foot antenna on flat ground
- Ease of maintenance far out weights any loss in performance

The New 50 Foot Tower

80 Meters

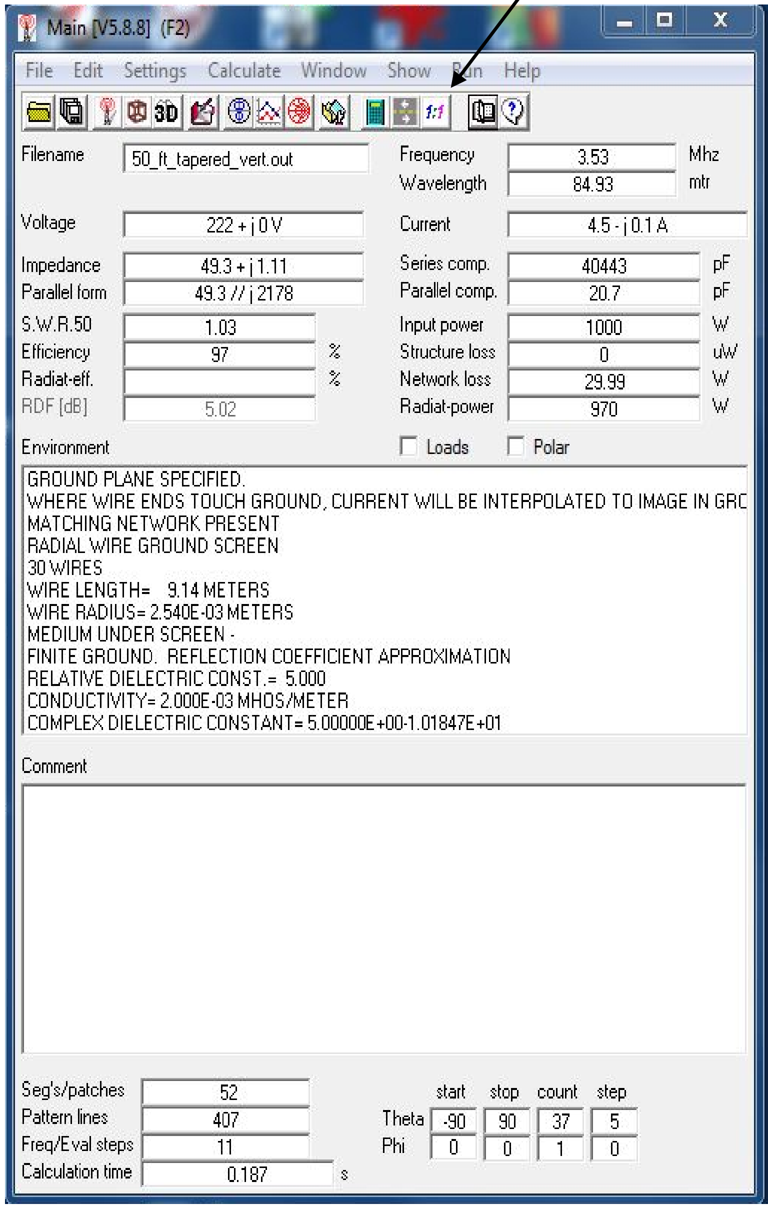
- In place of the tower a 50 foot self supporting pole was permitted at the same time to be used on 80
  - Under the old tower a ground system of 30 30 foot + radials were buried to improve the shunt fed tower's performance
  - It would not be possible to put a adequate ground system under the new tower
  - 50 foot was as high as I could go with out applying for a zoning variance
  - The plan was to place a 50 foot pole in the location of the old tower
- To check the performance and matching requirements 4NEC2 was run

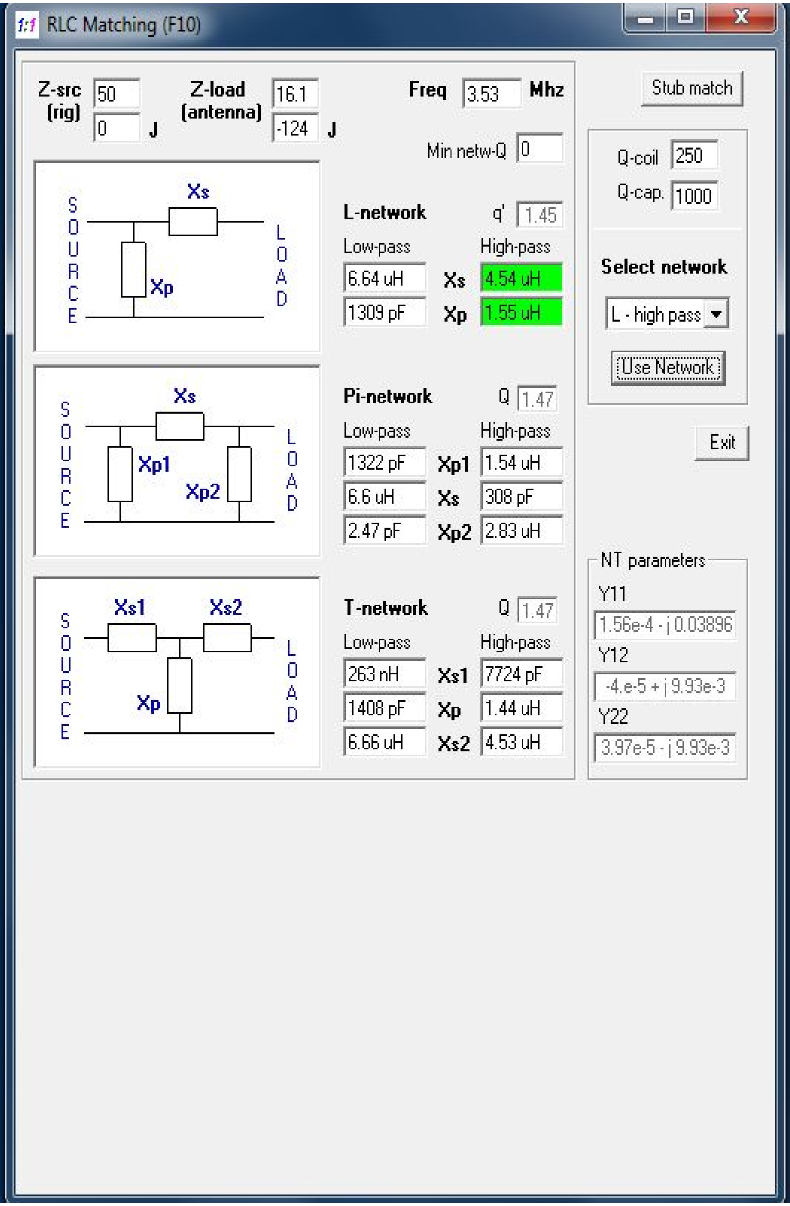
Matching a 50 ft Vertical

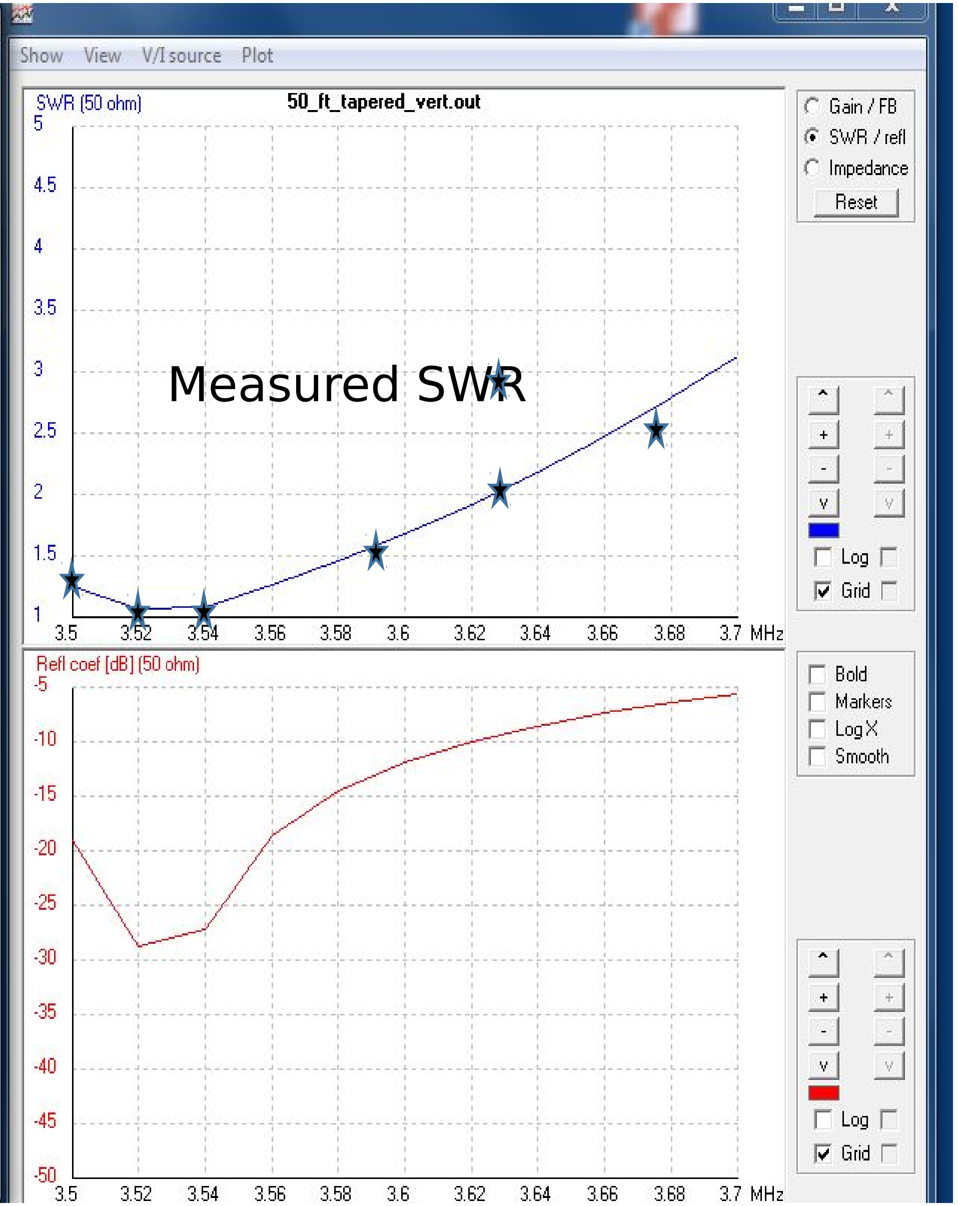
Click

Matching possibilities

SWR curve

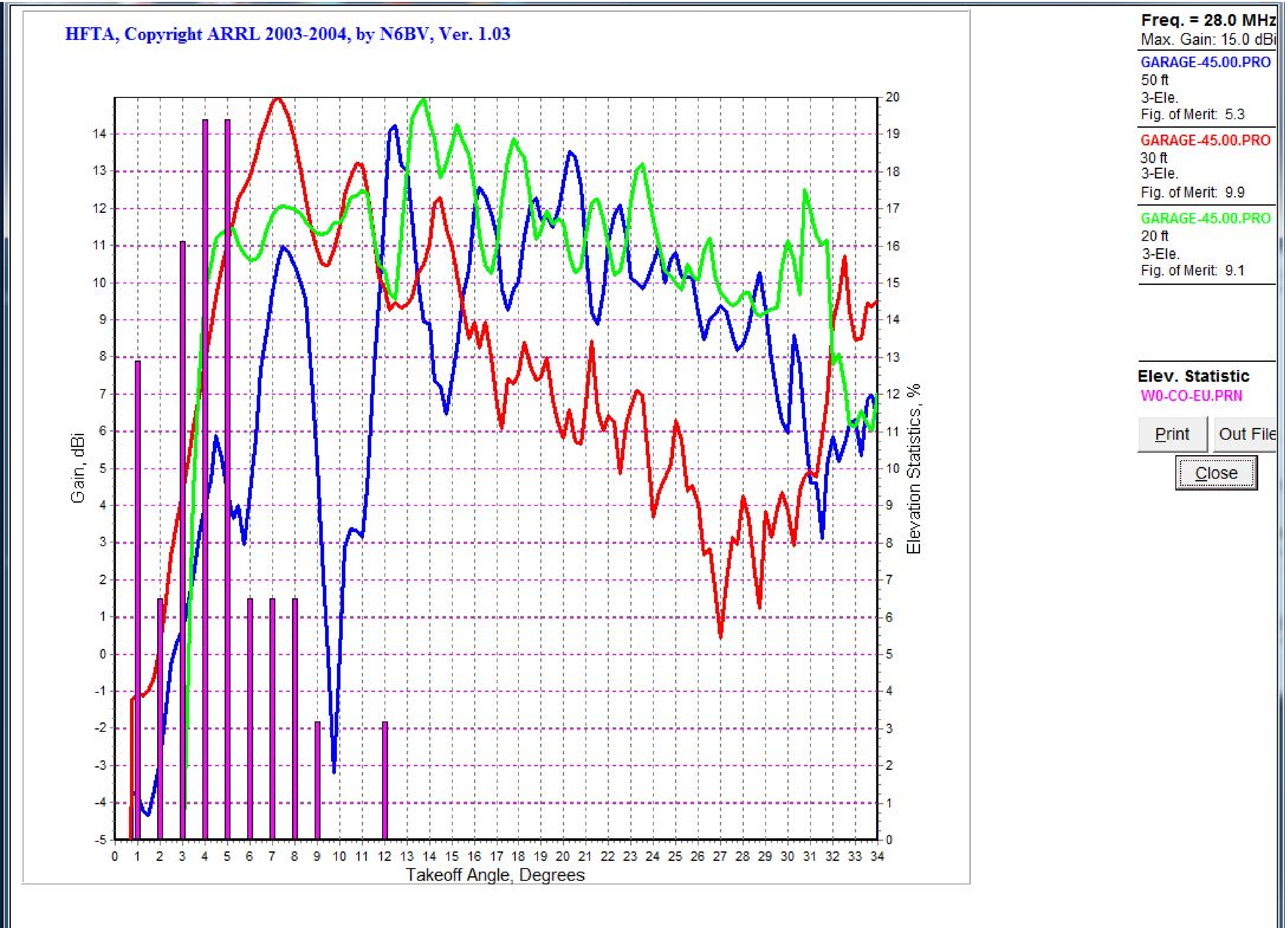






10 Meter Poor Performance

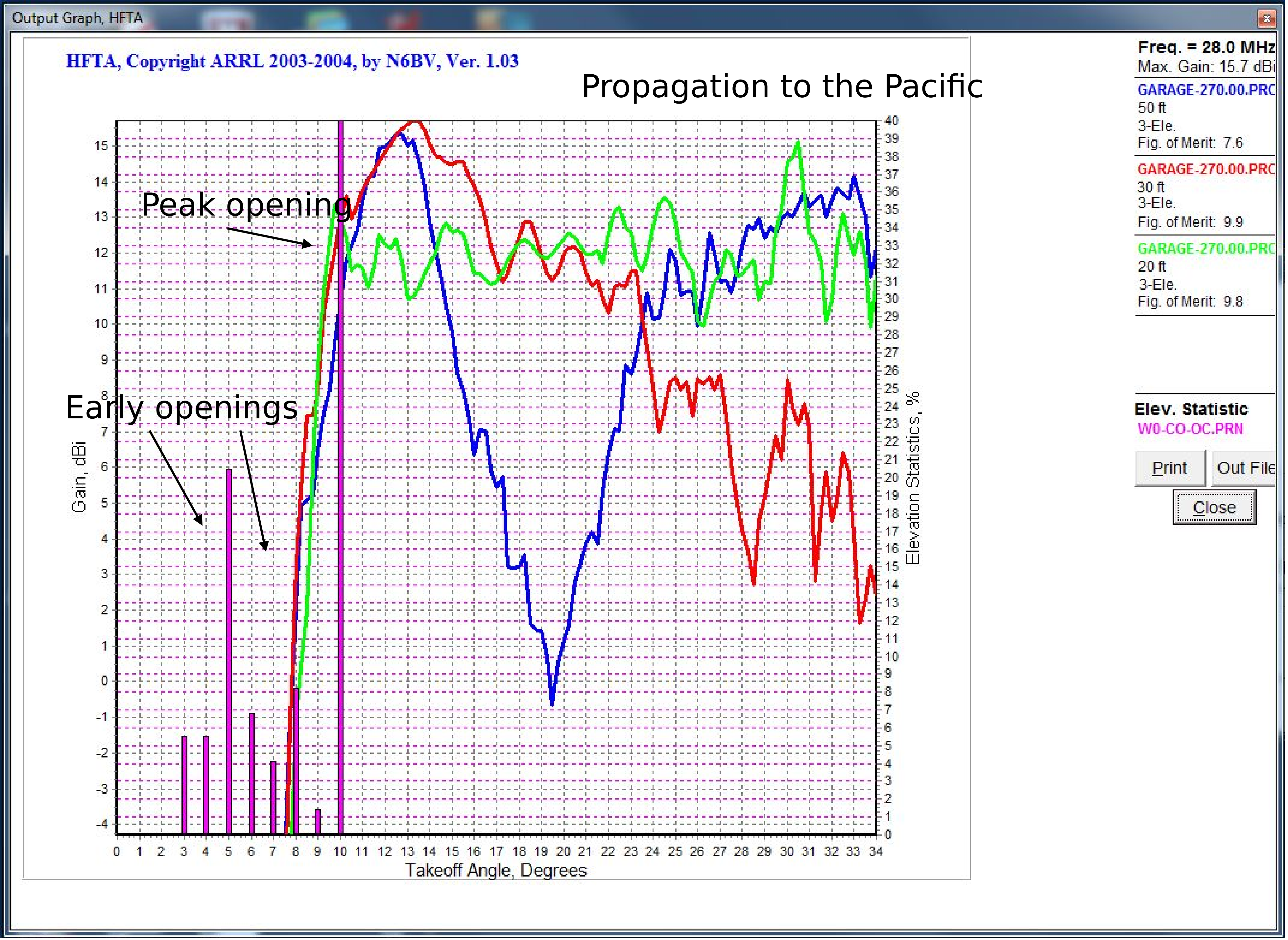
- 10 and 15 were always marginal
  - I only reached 2 countries on 10
  - 5 band DXCC was probably only a dream
- There were great conditions leading up to CQ World Wide SSB contest
  - On Thursday before the contest I was able to work some Asian stations
  - The CQWW contest would be a good way to up my country count
- Was there anything I could do to up improve my 10 M performance?
  - The antenna was probably too high
  - What would be a better height?



+ 4.6 DB gain by droppi
the antenna to 30 feet

Results:

- 30 feet looked like a good height
- By Sunday afternoon:
  - Countries worked = 105
  - Zones worked = 33
  - Worked all continents including Antarctica
- The conditions were great
- Lowering the antenna probably helped
  - How much is up to debate
- Difficulty in reaching into the Pacific with the early openings
  - The early opening signals were very weak even with the big stations
  - At the peak of the opening signals were extremely strong
  - Why?


Output Graph, HFTA
HFTA, Copyright ARRL 2003-2004, by N6BV, Ver. 1.03
Propagation to the Pacific
Peak opening
Early openings
Gain, dBi
Elevation Statistics, %
Takeoff Angle, Degrees
Freq. = 28.0 MHz
Max. Gain: 15.7 dBi
GARAGE-270.00.PRC
50 ft
3-Ele.
Fig. of Merit: 7.6
GARAGE-270.00.PRC
30 ft
3-Ele.
Fig. of Merit: 9.9
GARAGE-270.00.PRC
20 ft
3-Ele.
Fig. of Merit: 9.8
Elev. Statistic
W0-CO-OC.PRN
Print
Out File
Close

Conclusions

- There are very powerful software packages available for free
  - 4NEC2
  - Transmission Line for Windows
  - Yagi for Windows
  - High Frequency Terrain Assesment
- Using these packages can greatly enhance your knowledge and avoid costly mistakes
  - From all my experience they are very accurate
- The goal of this presentation was to show how these packages could be used to solve real problems
  - Most have good tutorials

?