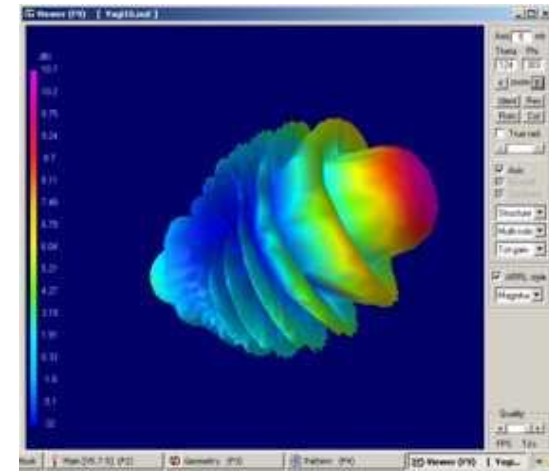


# VE3KL Presentation

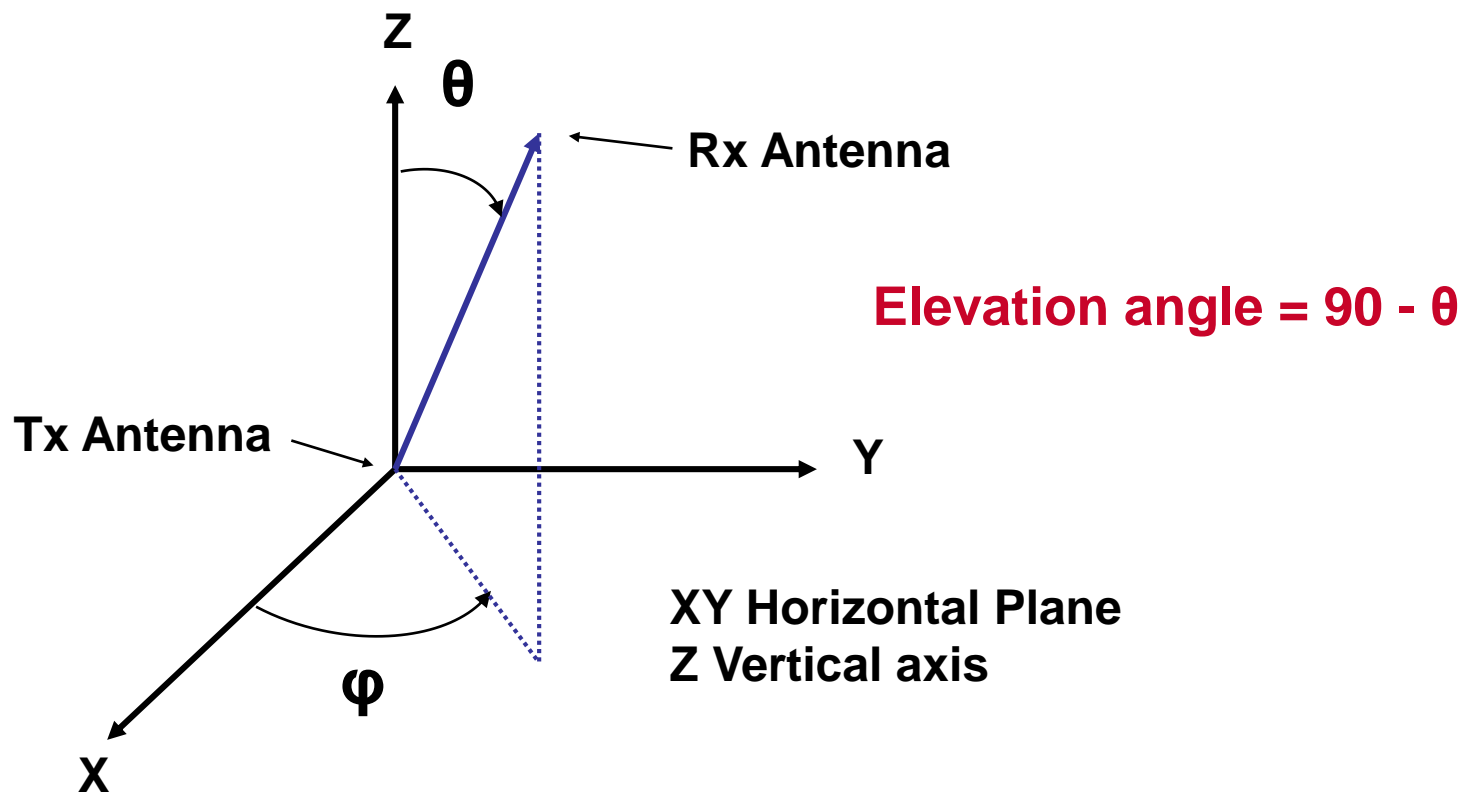
## 4NEC2

### Antenna Simulator by Arie Voors

- Based on the NEC2/4 Fortran Kernel
- Uses the classic Method of Moments
- Models radiating wires, loads, ground, sources.....more
- Four Editors with extensive Math capabilities
- Smith Charts
- Optimizer
- *Extremely powerful graphics capabilities*
- Free, users forum, updated frequently



# Spherical Coordinate System



$\phi$  is the horizontal **azimuth** angle  
 $\theta$  is the angle measured from vertical

# Method of Moments

- A discrete numerical method
- Divide wires into many segments...25 per wavelength
- Apply Coulomb's Law and match boundary conditions
- Solve large matrices
- EE Students usually solve the 3D Capacitor Problem

## 3D Capacitor Example

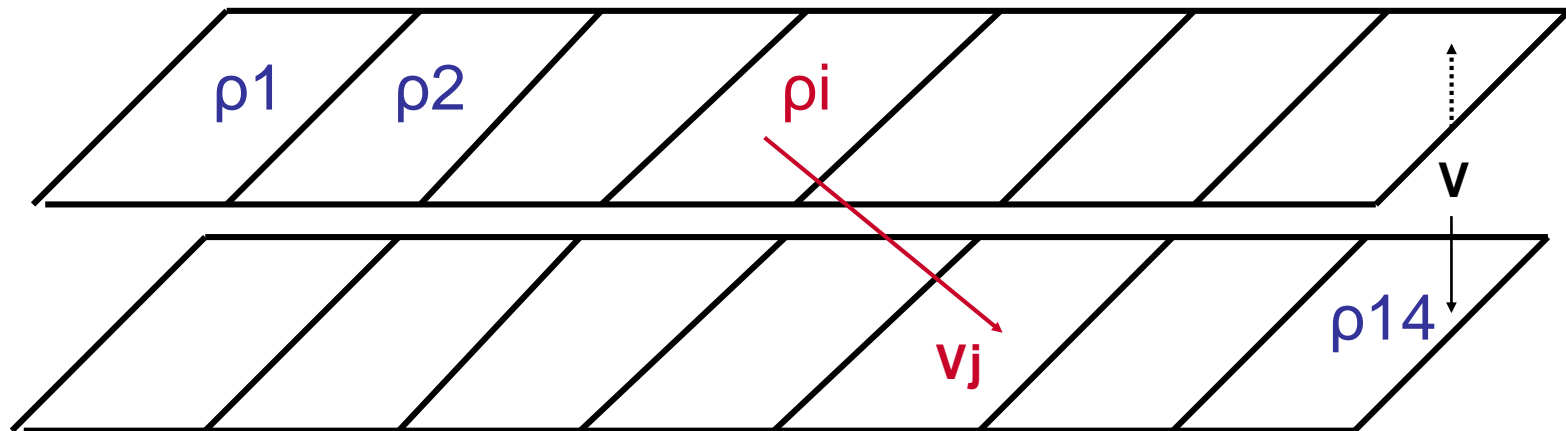
Divide plates into 14 segments

Assume each plate has a point charge,  $p_i$ ...not equal

Apply a voltage  $V$  across the plates

Write Coulombs Law for each charge > 14 by 14 Matrix

Solve for charge by matrix inversion

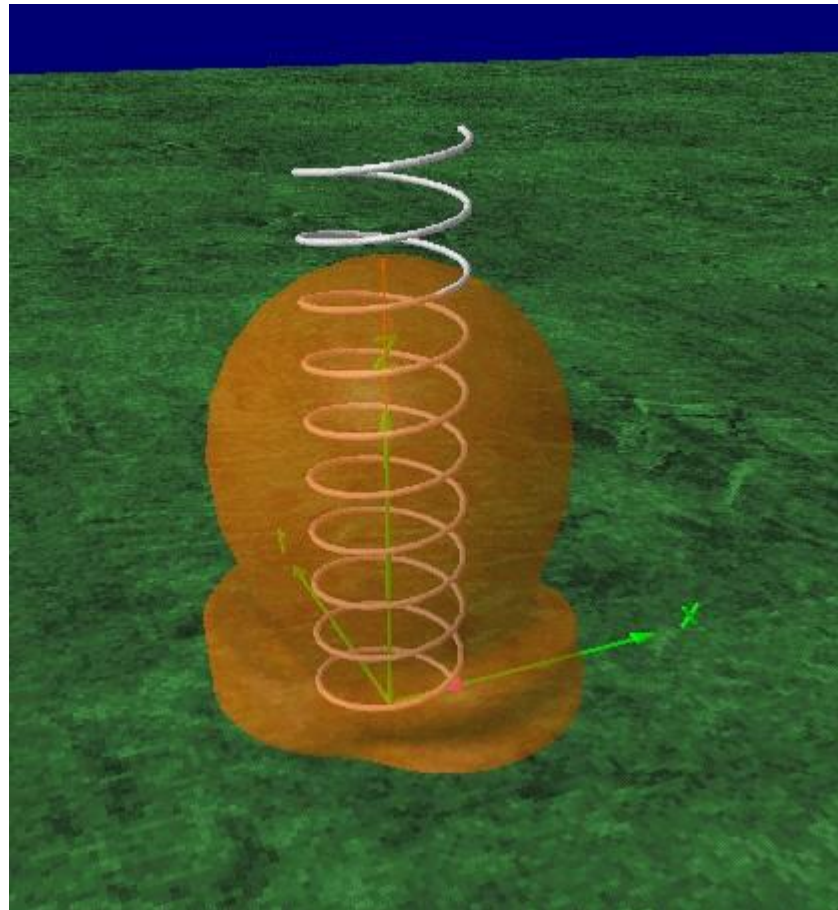


**$\rho_1 > \rho_2$  .. Charge piles up at edges**

# 4NEC2

## Super Graphics

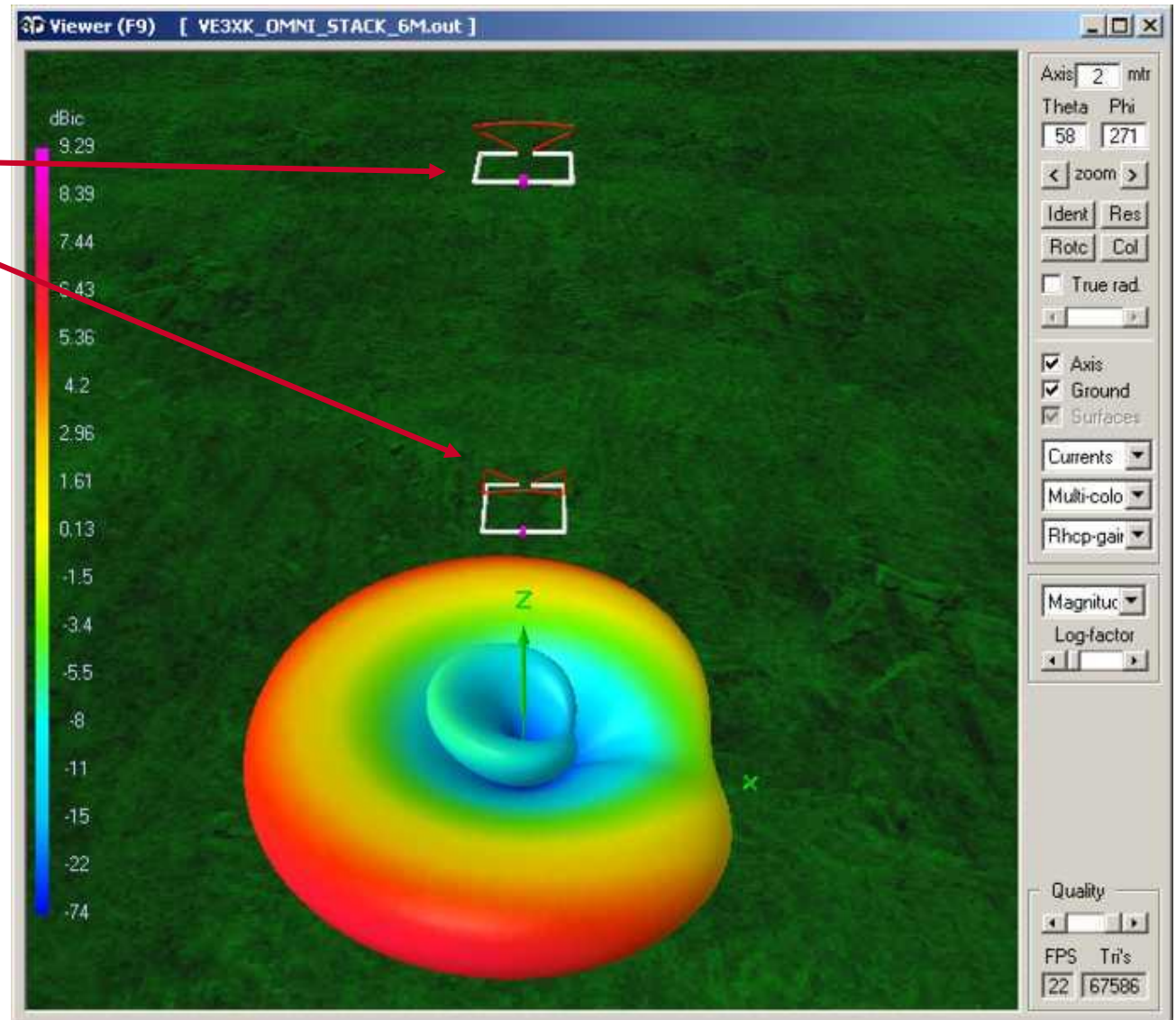
**Helix Antenna  
Vertically Oriented**



# 3D VE3XK 50 MHz Stack

50 MHz OMNI  
Source Side  
Along X Axis

Right Hand Circular  
Polarization  
Shown

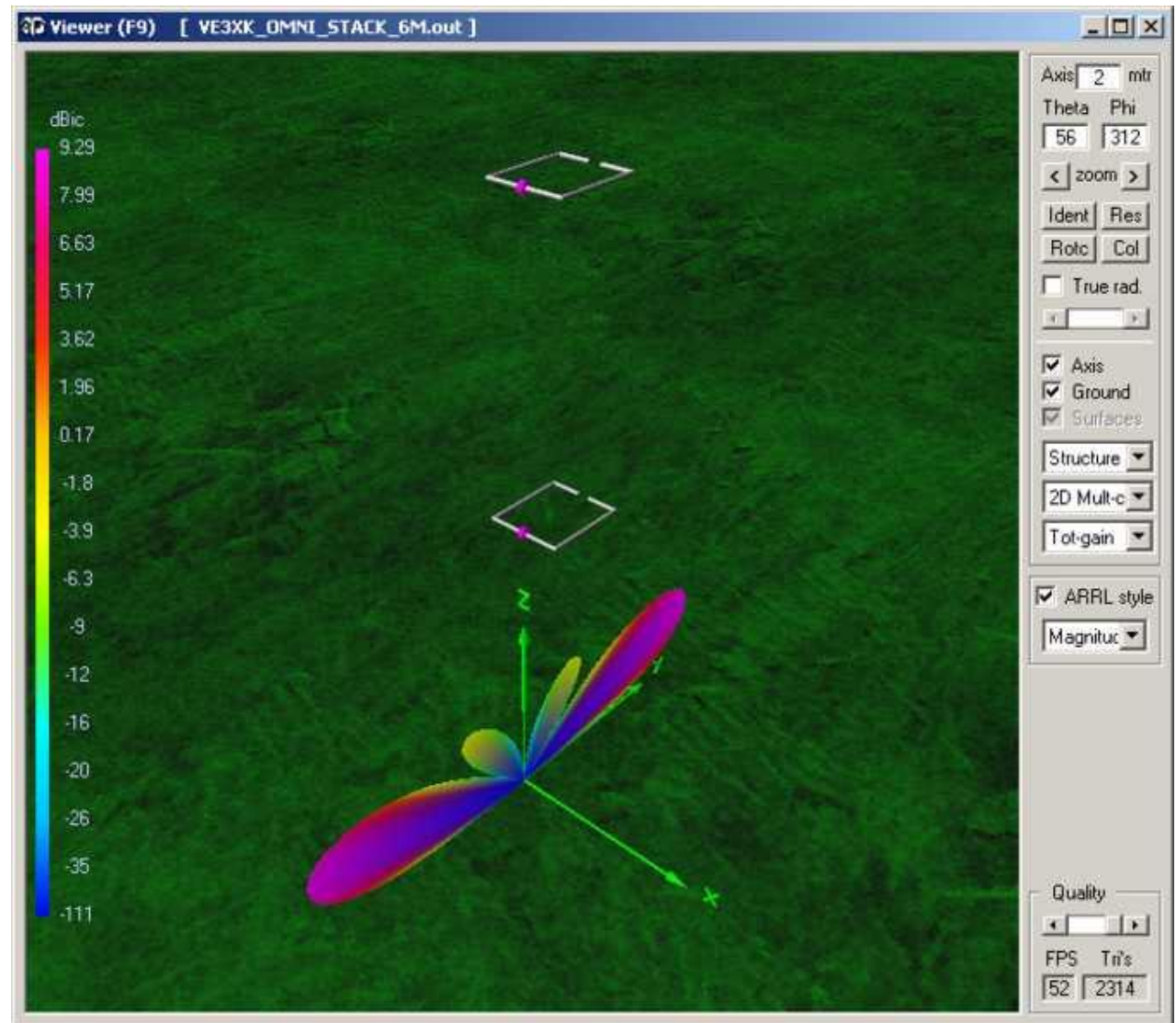




## 2D VE3XK 50 MHz Stack

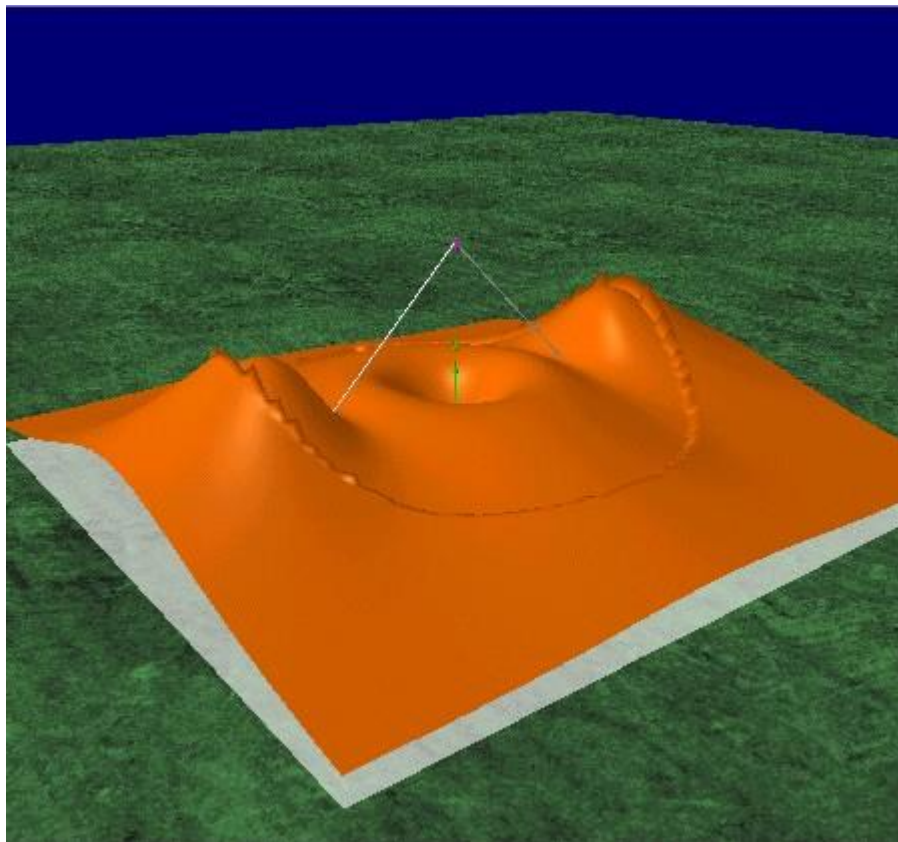
**50 MHz OMNI  
Source Side  
Along X Axis**

**Total Gain  
Shown**



# 4NEC2

## 3D Near Field

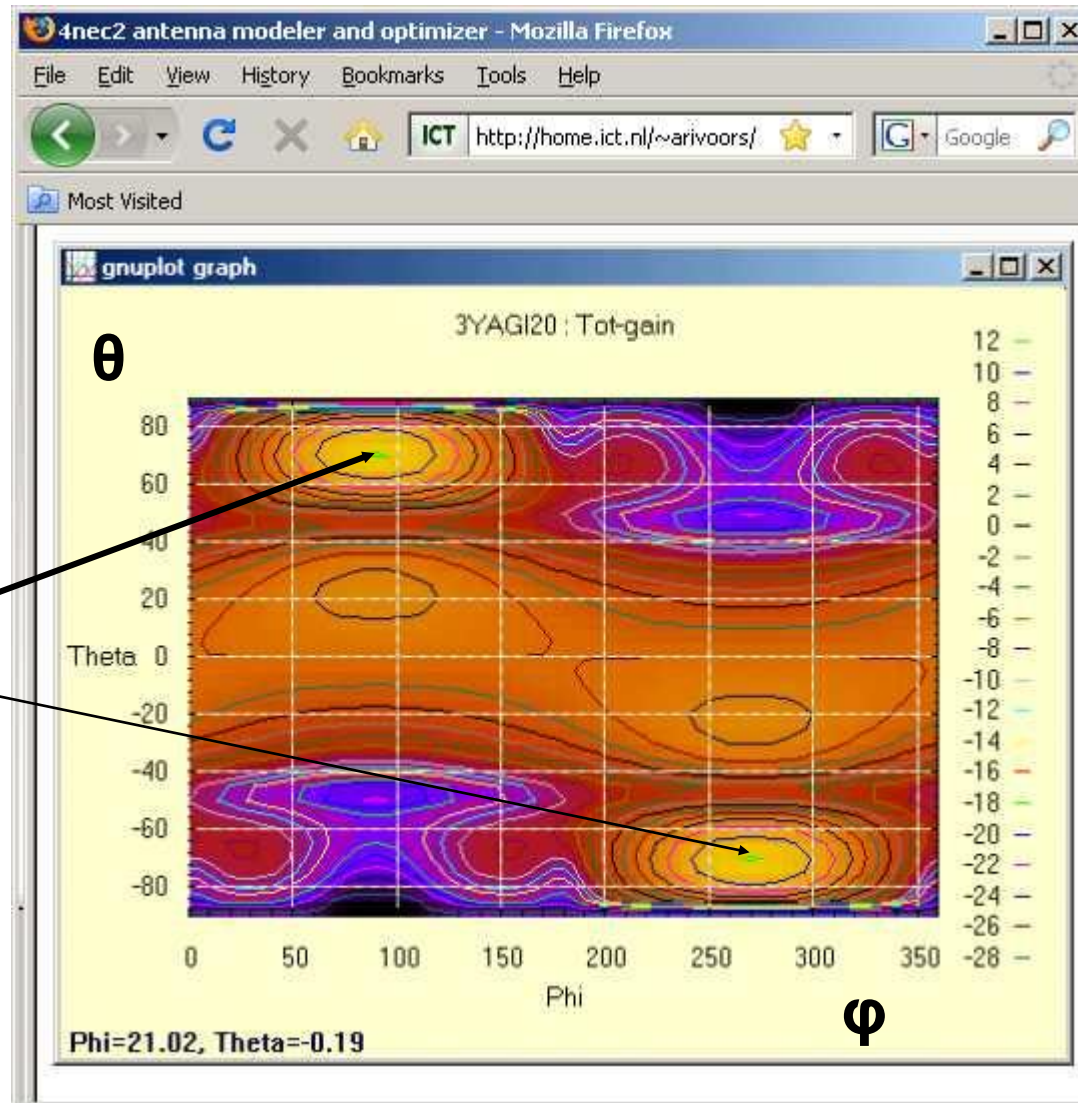




# 4NEC2

## Advanced Far Field Map

High Gain

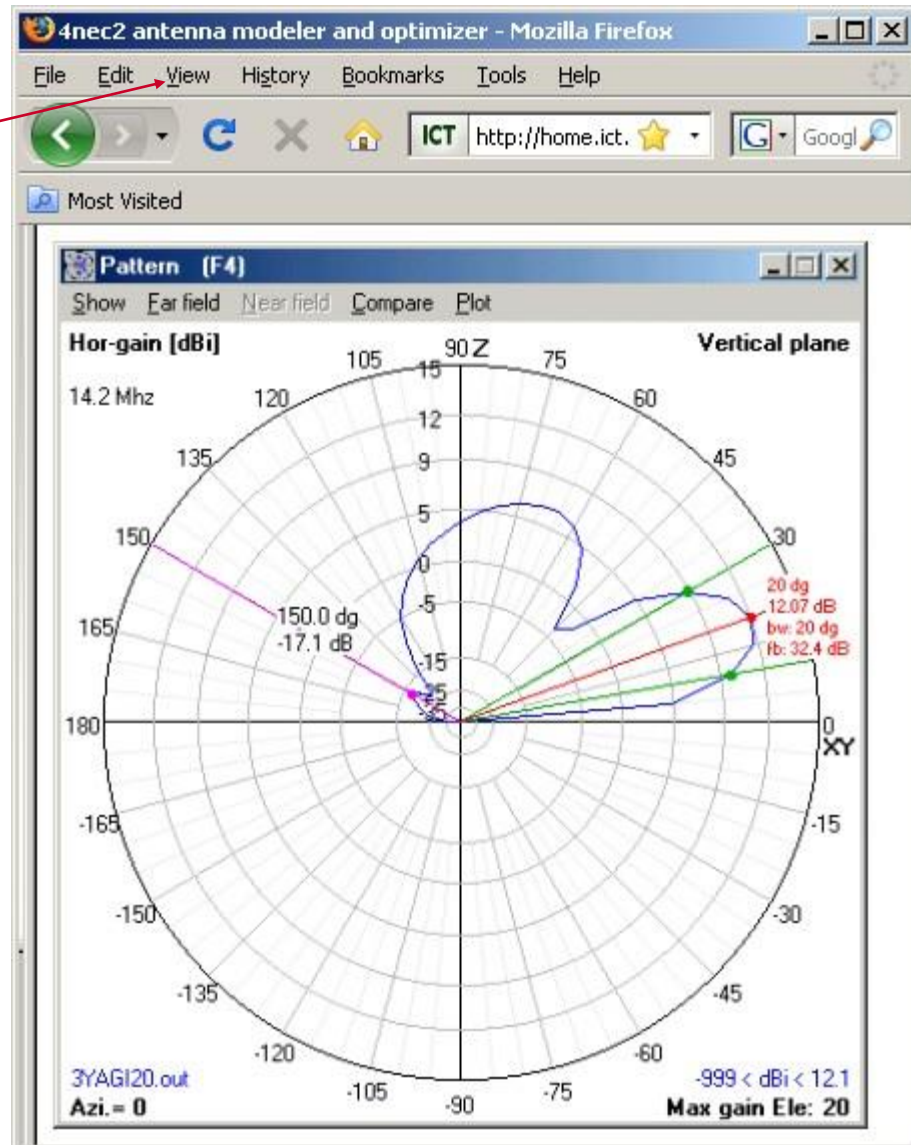


# 4NEC2

## Far Field Traditional Plot

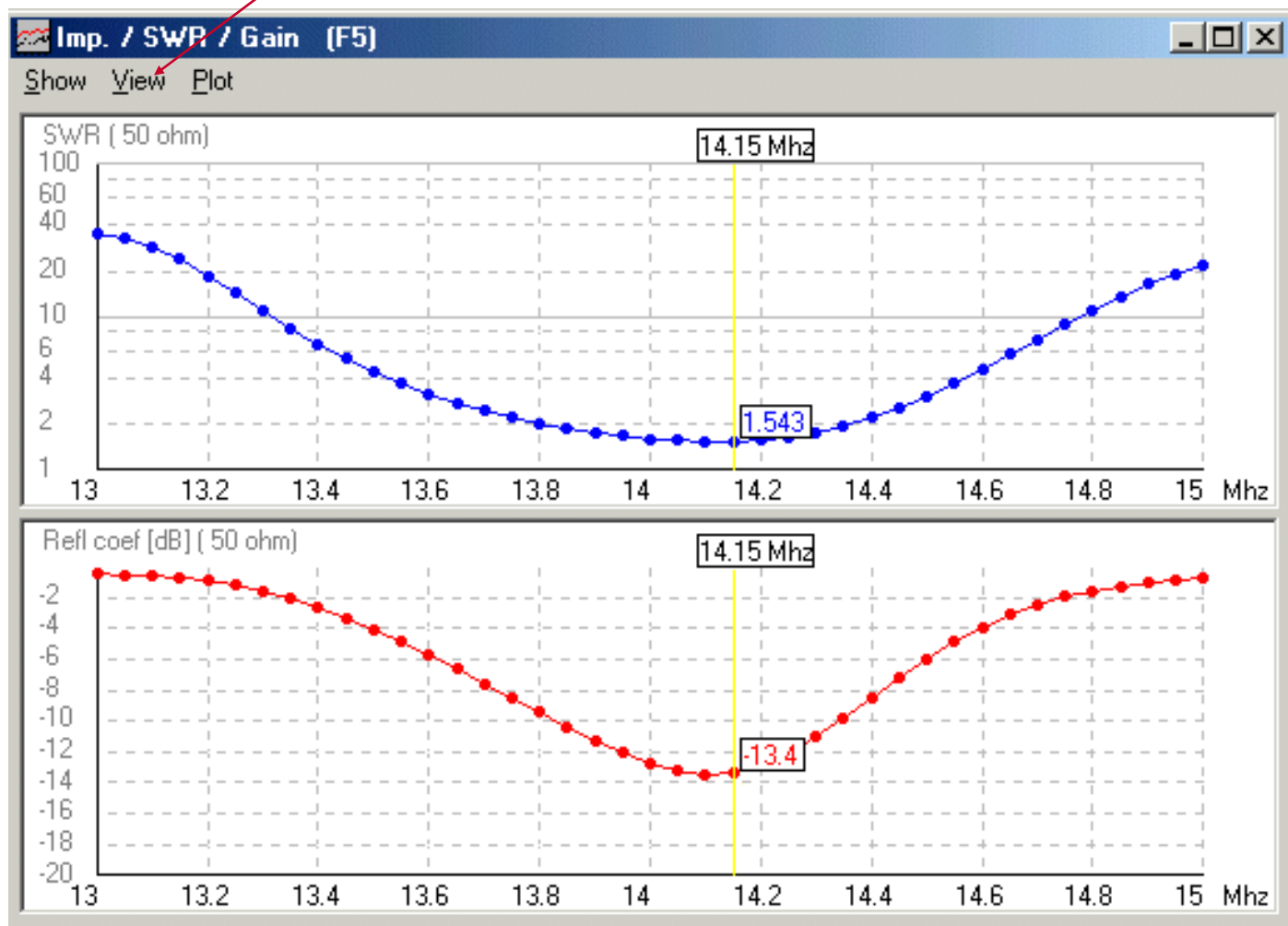
### Several Views

- Vertical, Horizontal, Total
- Circular Polarization  
RHC, LHC, Total

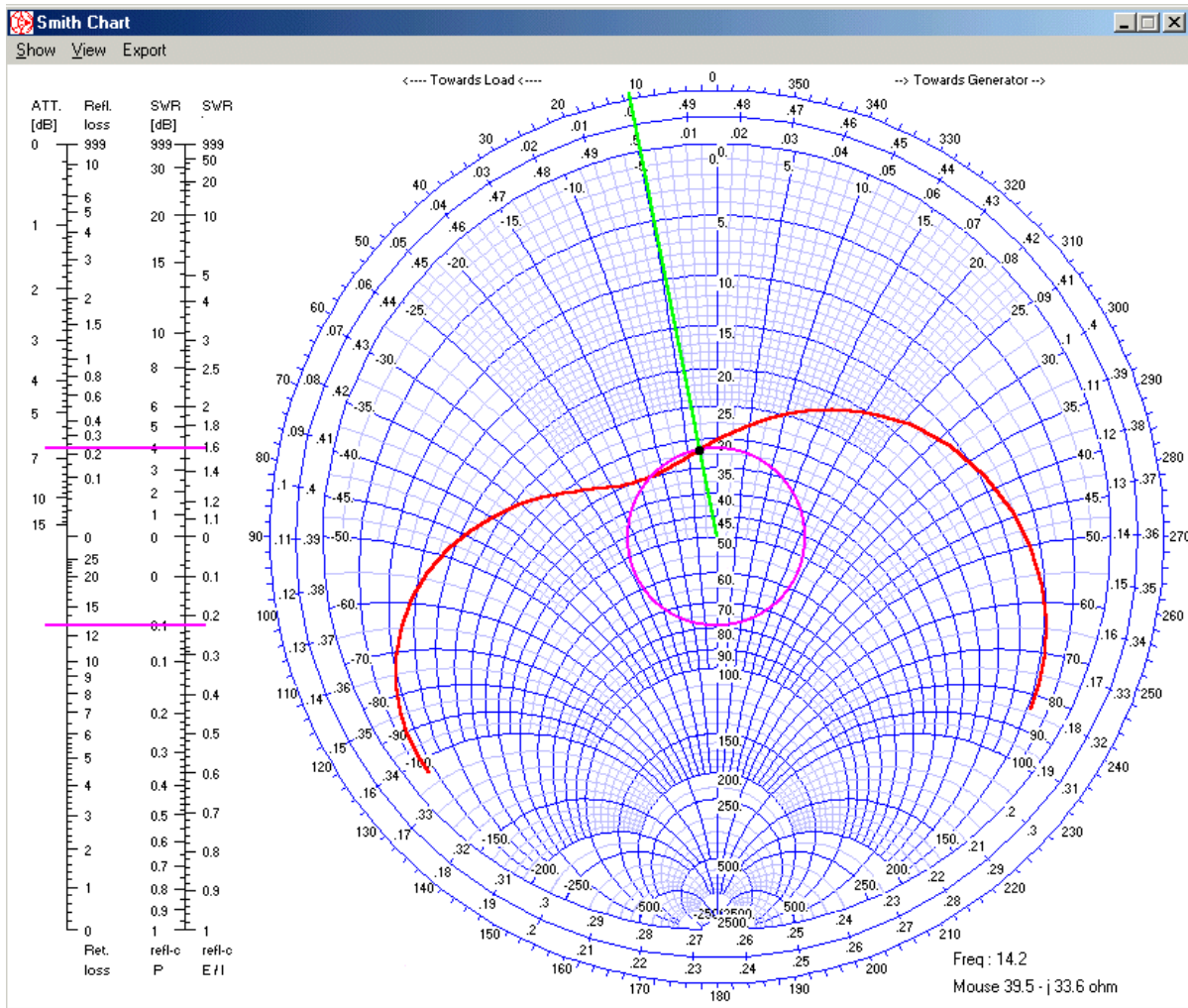


# 4NEC2

## Several Views of Frequency Response



# 4NEC2 Smith Chart



# Matching

**f1 RLC Matching (F10)**

Z-src (rig)  J  Z-load (antenna)  J

Freq  Mhz

Min netw-Q

**L-network**  $q'$

Low-pass		High-pass	
<input type="text" value="343 nH"/>	$X_s$ <input type="text" value="231 nH"/>	<input type="text" value="231 nH"/>	$X_p$ <input type="text" value="65.1 nH"/>
<input type="text" value="156 pF"/>			

**Pi-network**  $Q$

Low-pass		High-pass	
<input type="text" value="157 pF"/>	$X_{p1}$ <input type="text" value="64.4 nH"/>	<input type="text" value="64.4 nH"/>	$X_s$ <input type="text" value="29.8 pF"/>
<input type="text" value="340 nH"/>	$X_s$ <input type="text" value="29.8 pF"/>	<input type="text" value="29.8 pF"/>	$X_{p2}$ <input type="text" value="144 nH"/>
<input type="text" value="0.3 pF"/>	$X_{p2}$ <input type="text" value="144 nH"/>		

**T-network**  $Q$

Low-pass		High-pass	
<input type="text" value="20.9 nH"/>	$X_{s1}$ <input type="text" value="485 pF"/>	<input type="text" value="485 pF"/>	$X_p$ <input type="text" value="62.2 nH"/>
<input type="text" value="163 pF"/>	$X_p$ <input type="text" value="62.2 nH"/>	<input type="text" value="62.2 nH"/>	$X_{s2}$ <input type="text" value="231 nH"/>
<input type="text" value="343 nH"/>	$X_{s2}$ <input type="text" value="231 nH"/>		

**Stub match**

Q-coil   
Q-cap.

**Select network**

**Use Network**

**Exit**

**NT parameters**

Y11   
Y12   
Y22

# 4NEC2..The Big Gun (Optimization)

## Optimize (Tune) a 2 metre dipole to 6 metres

Adjust reactance to zero

Optimizer: Ready...

Settings

Function: Optimize Option: Default

Variables: length=2.8097, wiredia=25.5, height=2

Selected: length

Weighting factors (FOM) in %:

SWR	Gain	F/B	F/R	R-in	X-in	Eff.
0	0	0	0	0	100	0

Surf-wave at distance = 1 Km

Theta: 180, 0

Phi: 0, 180

Resolution: 5 deg.

d-Theta: 0, 0

d-Phi: 0, 0

Tot-gain: [dropdown]

Freq-sweep: [checkbox]

Frequency: 50

Resume Update NEC-file Exit

Variable Sensivity:

Run:	length
5-1	1
6-1	-1
7-1	-1
8-1	-1
9-1	-1
10-1	-1
11-1	1
12-1	1
13-1	1
14-1	1
15-1	-1
16-1	1

Calculated results:

Show Log Plot result

Run:	SWR	Gain	F/B	F/R	R-in	X-in	Eff.	Res. %	Step %
14-1	1.4375	0	0	0	71.873	0.1234	100	3.e-3	0.08
14-2	1.4375	0	0	0	71.873	0.1234	100	3.e-3	0.08
14-3	1.4413	0	0	0	72.054	0.7099	100	-6.e-3	0.08
15-1	1.4456	0	0	0	72.235	1.2972	100	-6.e-3	0.08
15-2	1.4403	0	0	0	72.008	0.5633	100	1.e-3	0.02
15-3	1.4394	0	0	0	71.963	0.4163	100	1.e-3	0.02
15-4	1.4384	0	0	0	71.918	0.2696	100	1.e-3	0.02
15-5	1.4375	0	0	0	71.873	0.123	100	1.e-3	0.02
15-6	1.4365	0	0	0	71.827	-0.024	100	1.e-3	0.02
15-7	1.4357	0	0	0	71.782	-0.17	100	1.e-3	0.02
16-1	1.4365	0	0	0	71.827	-0.024	100	1.e-3	0.02
16-2	1.4359	0	0	0	71.794	-0.154	100	4.e-4	5.e-3

Variable Values:

Run:	length
14-1	2.8107
14-2	2.8107
14-3	2.813
15-1	2.8152
15-2	2.8124
15-3	2.8119
15-4	2.8113
15-5	2.8107
15-6	2.8102
15-7	2.8096
16-1	2.8102
16-2	2.8097

Vary Length

Results

L = 2.8 metres  
Xin = -0.13 Ohms



# Optimization Issues

- An extremely complex and active field of study
- Local minimum vs. global minimum .. Optimizer gets trapped
- Poorly defined problem by the user .. Optimizer loops forever
- Type of Objective function
  - minimum .. for science and math people
  - good enough .. for engineers
  - constrained values .. for engineers
- Can be difficult for beginners
- Example: An optimizer might set the antenna length **to infinity!**

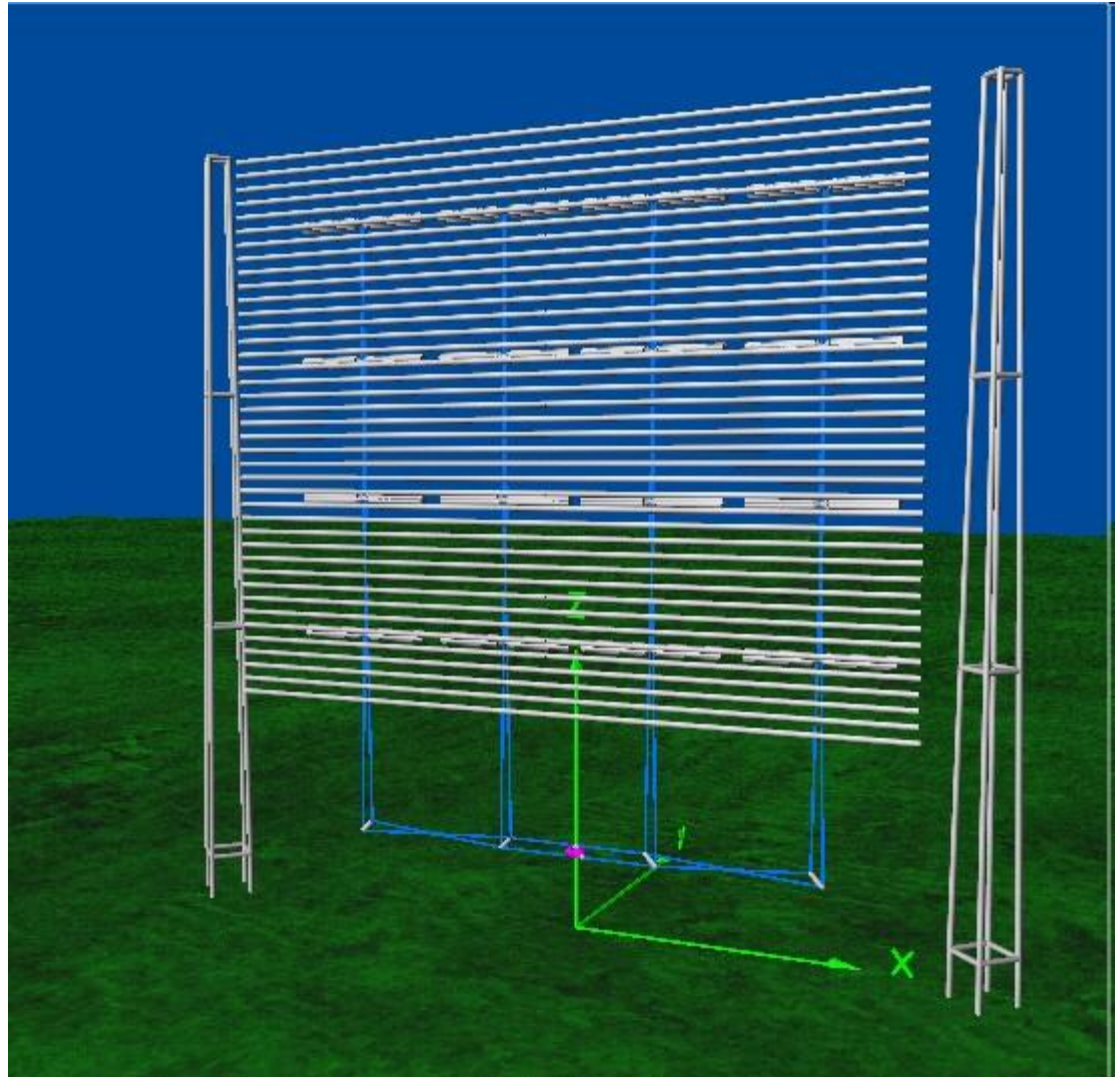
# Using the Editors

Define the wires  
and axis

Define the  
Voltage Sources

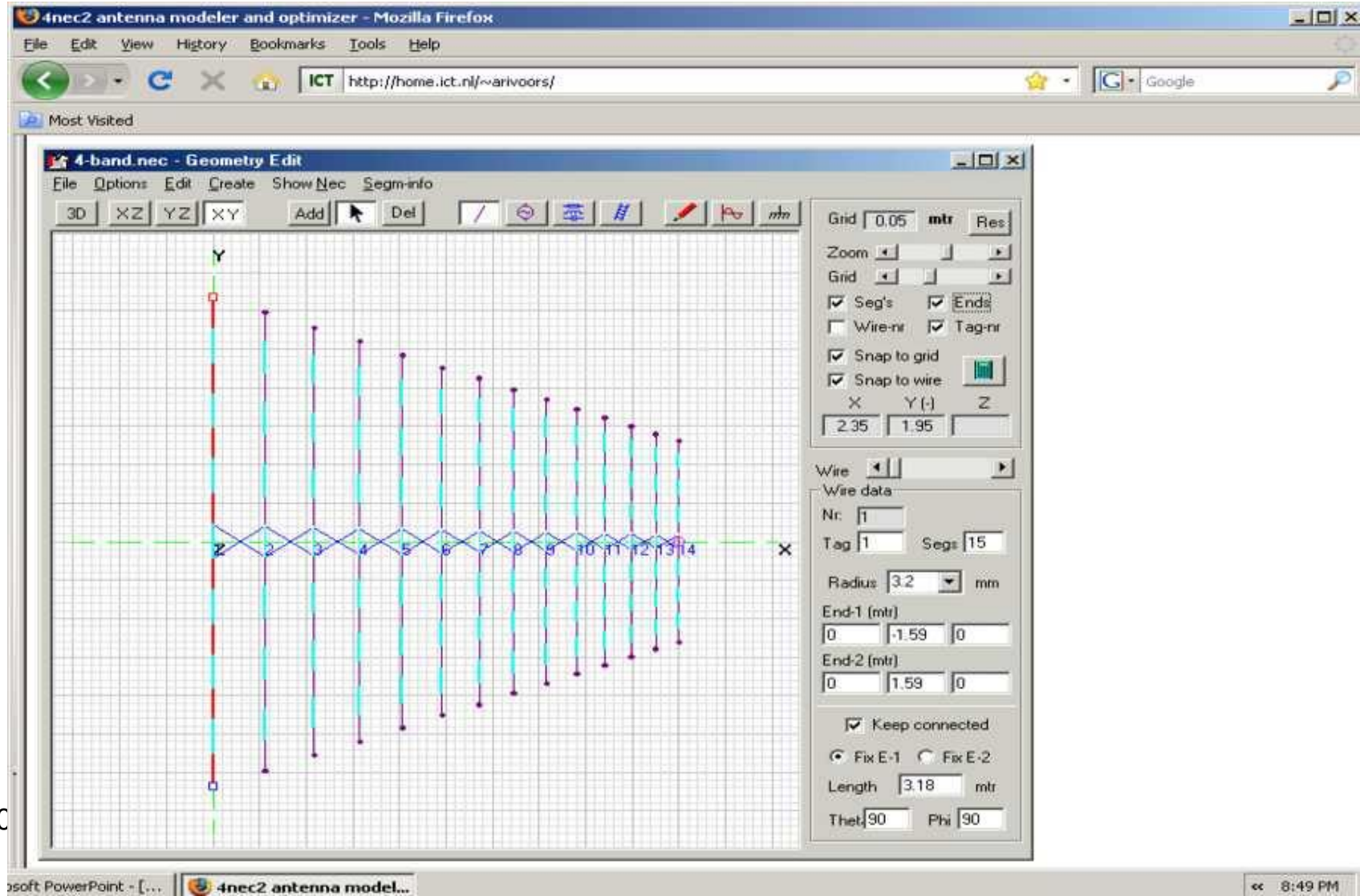
Define the Ground  
Type if any

Define R,L,C,  
Transmission Line  
components



# 4NEC2

## Graphical Editor for Beginners



1/28/20

# 4NEC2 NEC Editor to Describe the Antenna

4nec2 antenna modeler and optimizer - Mozilla Firefox

File Edit View History Bookmarks Tools Help

ICT <http://home.ict.nl/~arivoors/> Google

Most Visited

36INV.NEC - NEC-Edit (file changed)

File Edit

**Wire geometry**

Card	Tag	segs	X1	Y1	Z1	X2	Y2	Z2	wire-rad
GW	3	nrseg	0.3	0	hgh	X	0	hgh-z	#12

Comnt Save Ins Del

CM Inverted V for 80 Mtr.  
 CE  
 SY hgh=20 ' Height  
 SY len = 19.72197 ' Wire length  
 SY ang=110 ' Angle between wires  
 SY Z=len\*cos(ang/2) X=len\*sin(ang/2) ' Get delta-Z and -X distances  
 SY nrseg=25 ' To do nr-segs evaluation...

Card	Tag	segs	X1	Y1	Z1	X2	Y2	Z2	wire-rad
GW	1	nrseg	X	0	hgh-Z	-0.3	0	hgh	#12 ' radius for #12 wire
GW	2	3	-0.3	0	hgh	0.3	0	hgh	#12
GW	3	nrseg	0.3	0	hgh	X	0	hgh-z	#12

GE

Card	Tag	segs	X1	Y1	Z1	X2	Y2	Z2	wire-rad
GN	2	0	0	0	14	.006			' Sommerfeld ground
EX	0	2	2	0	1	0			' Default voltage source
FR	0	1	0	0	3.680				' Design frequency

RP, 0, 91, 1, 0, 90.0, 90.0, -1.0, 1.0

EN ' End of file

**Note the use of Math Functions**

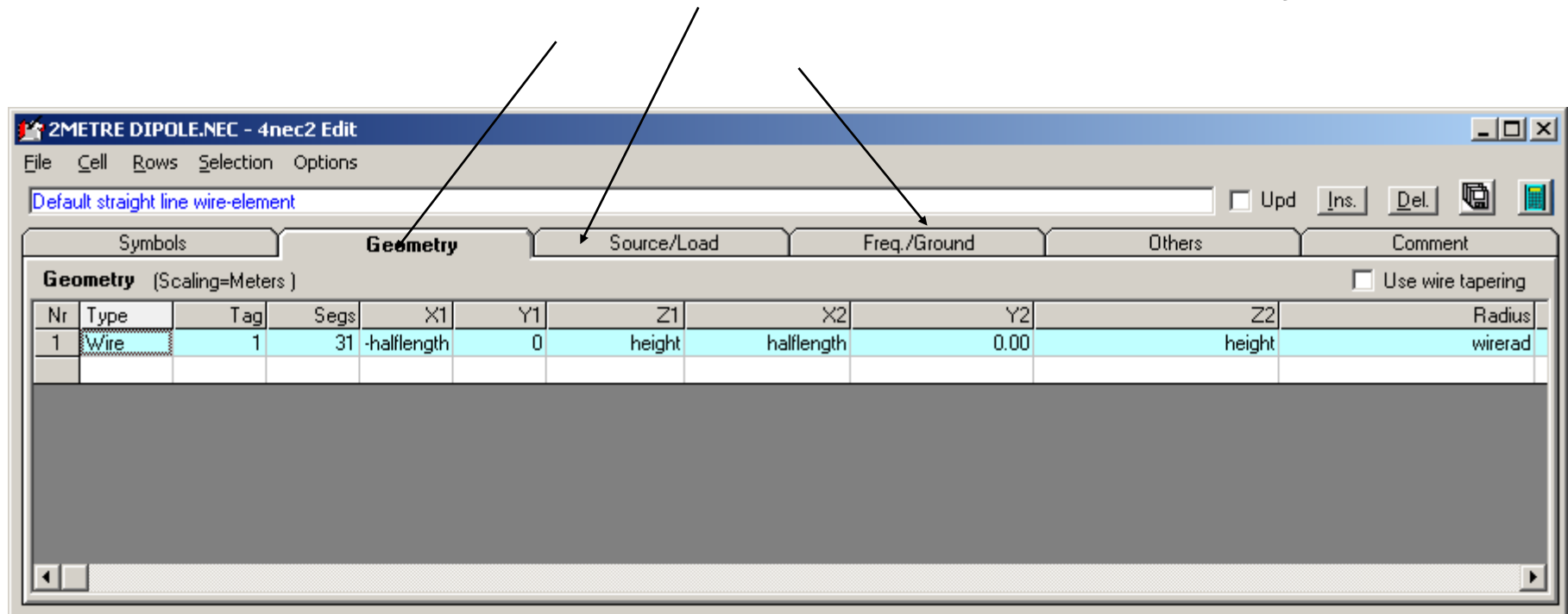
# Simple Text Editor

## Best for Computer Defined Antennas

```
'VE3XK OMNI 6 metres..stack
SY height=3      'height in metres
SY Freq=50.0     'freq in MHz
SY B=0.3556      'metres
SY C=0.8128      'metres
SY D=0.29845     'metres
SY rad=3.17e-3   'metres
SY spacingWave=0.5 'spacing in
wavelengths
SY spacing=spacingWave*300/freq
'spacing in metres
GW      1      21      -B      0
height  B      0.00  heigh
height+spacing rad
GW      8      21      B      C
height+spacing B-D      C
```

# A New Windows Menu Type Editor

Menu Bar on top allows user to define files rapidly

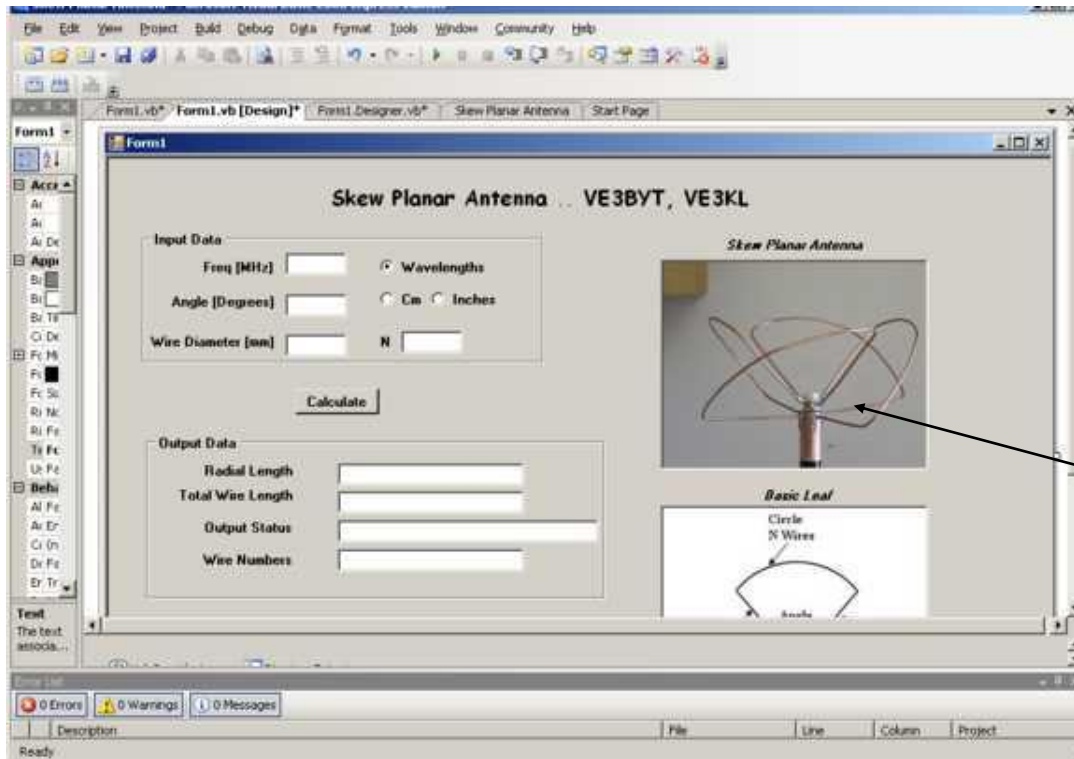


Geometry Menu Open in this example



# Editing Big Antennas..500 Segments Complex Geometry

- Use VB.Net or C#.net to drive the editors.



4NEC2 Text  
Editor

VB.net Program  
Skew Planar Antenna

# Examples “Simple” 2m Dipole Free Space

$-L/2$

$L/2$

X Axis

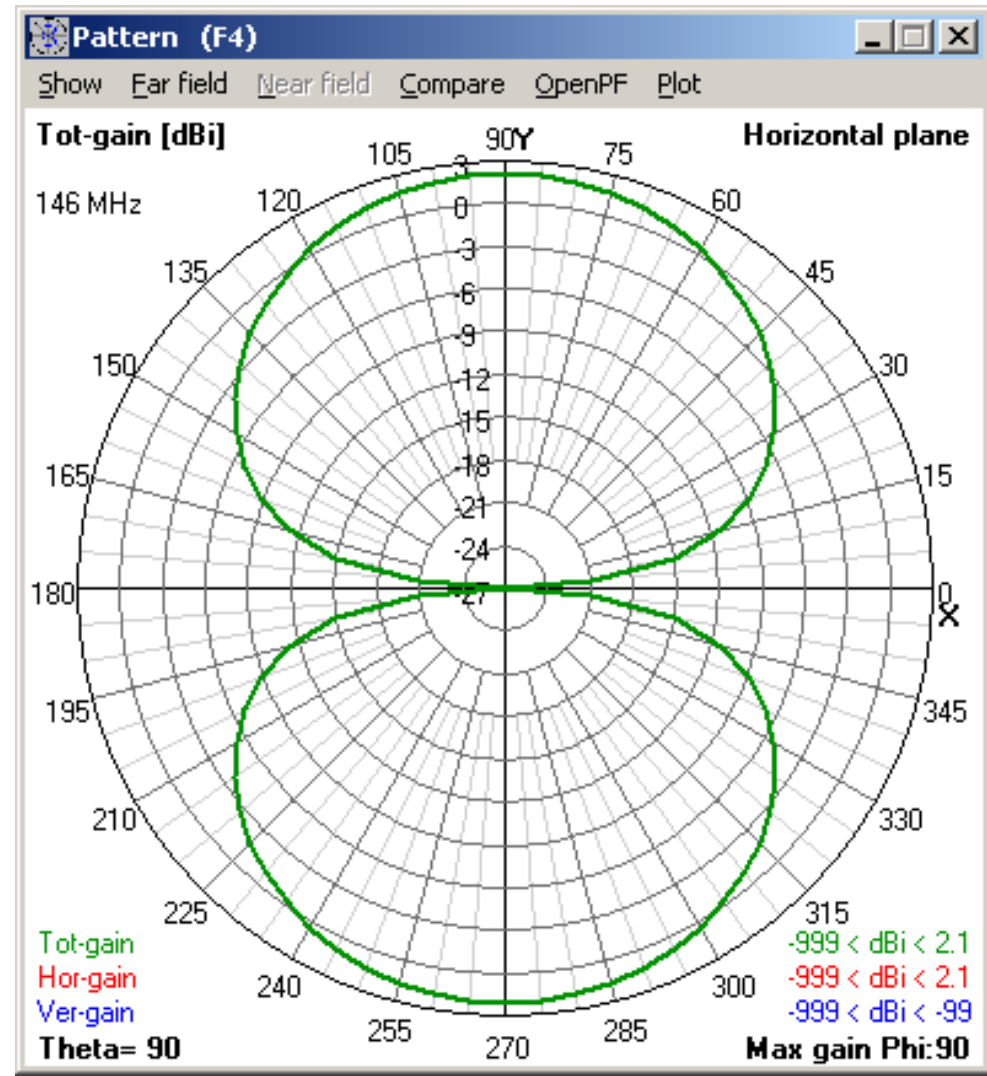
Horizontal Plane

Theta = 90 degrees

Horizontally Polarized

No Vertical Component

(No surprises Here!)



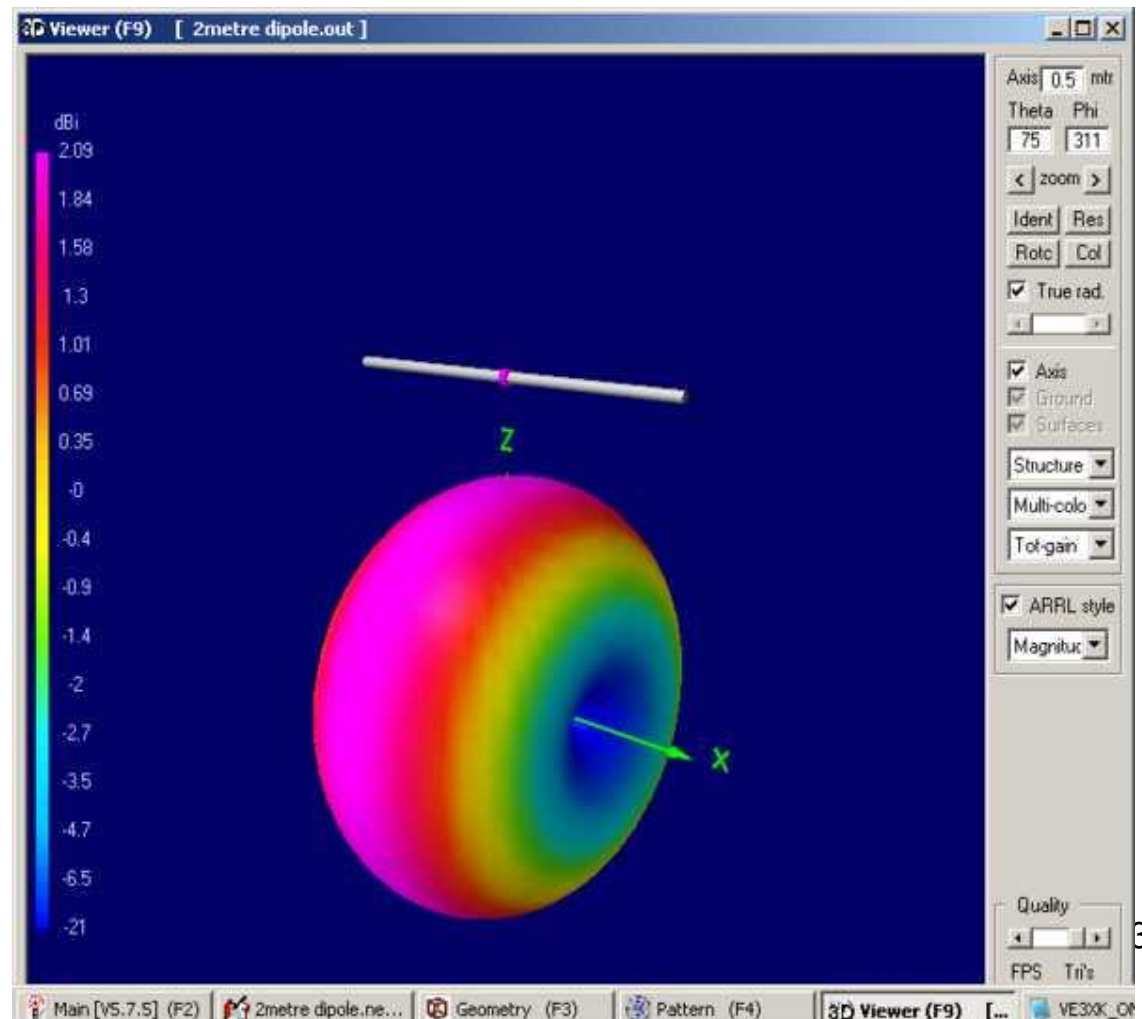
# Examples “Simple” 2m Dipole Free Space

$-L/2$

$L/2$

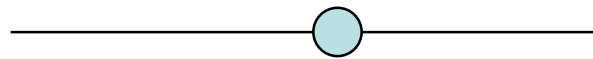
X Axis

Horizontal Plane  
Theta = 90 degrees  
Horizontally Polarized  
No Vertical Component  
  
(No surprises Here!)



1/28/2017

## X Axis



**Pattern (F4)**

Show Ear field Near field Compare OpenPF Plot

**Tot-gain [dBi]**

146 MHz

Horizontal plane

90Y

0 X

Theta= 45

Max gain Phi: 90

Tot-gain  
Hor-gain  
Ver-gain

-1.8 < dBi < 2.1  
-999 < dBi < 2.1  
-999 < dBi < -1.8

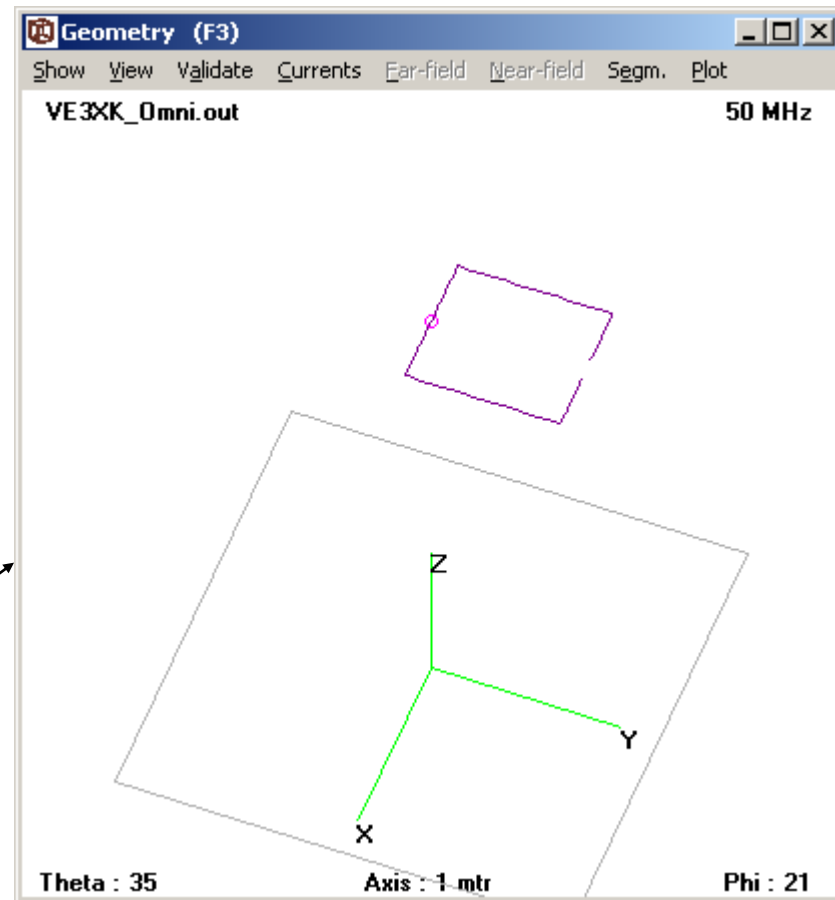
3  
0  
-3  
-6  
-9  
-12  
-15  
-18  
-21  
-24  
-27

105 90 75 60 45 30 15 0 345 330 315 300 285 270 255 240 225 210 195 180 165 150 135 120

# 50 MHz Horizontal OMNI

**Geometry**  
**Source side on X axis**  
**Horizontally Mounted**

**Geometry Window**



# 50 MHz Horizontal OMNI Pattern

Horizontal Plane  
Showing Circular Polarization  
Blue RHCP  
RED LHCP  
Green Total

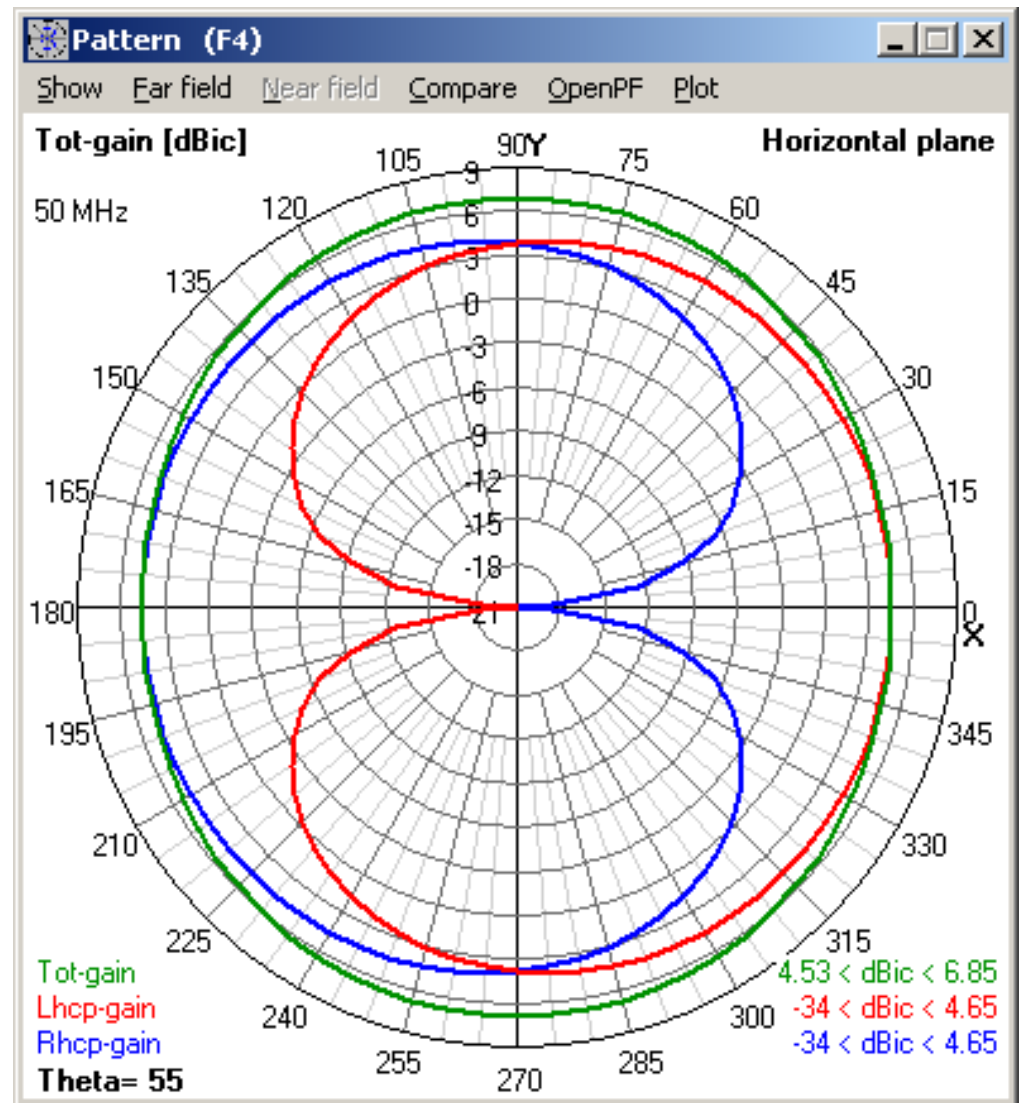
Nearly Omni Directional

Circular Polarization on X axis

Linear Polarization on Y axis

Note the Red/Blue Cardioids

$\theta = 55$  Degrees



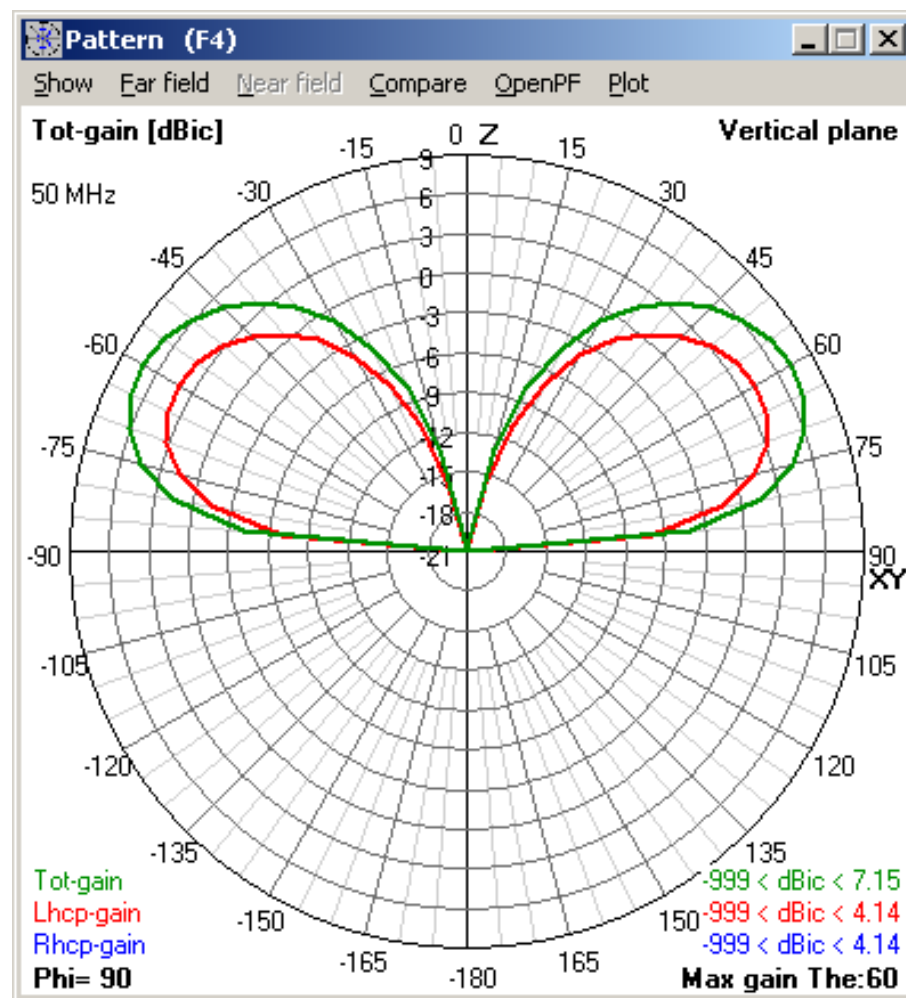


# 50 MHz Vertical OMNI Pattern

## Height = 3 metres

Vertical Plane  
Linearly Polarized  
Takeoff angle 30 deg  
Max Gain = 7.15 dBi

$\theta = 90$  Degrees

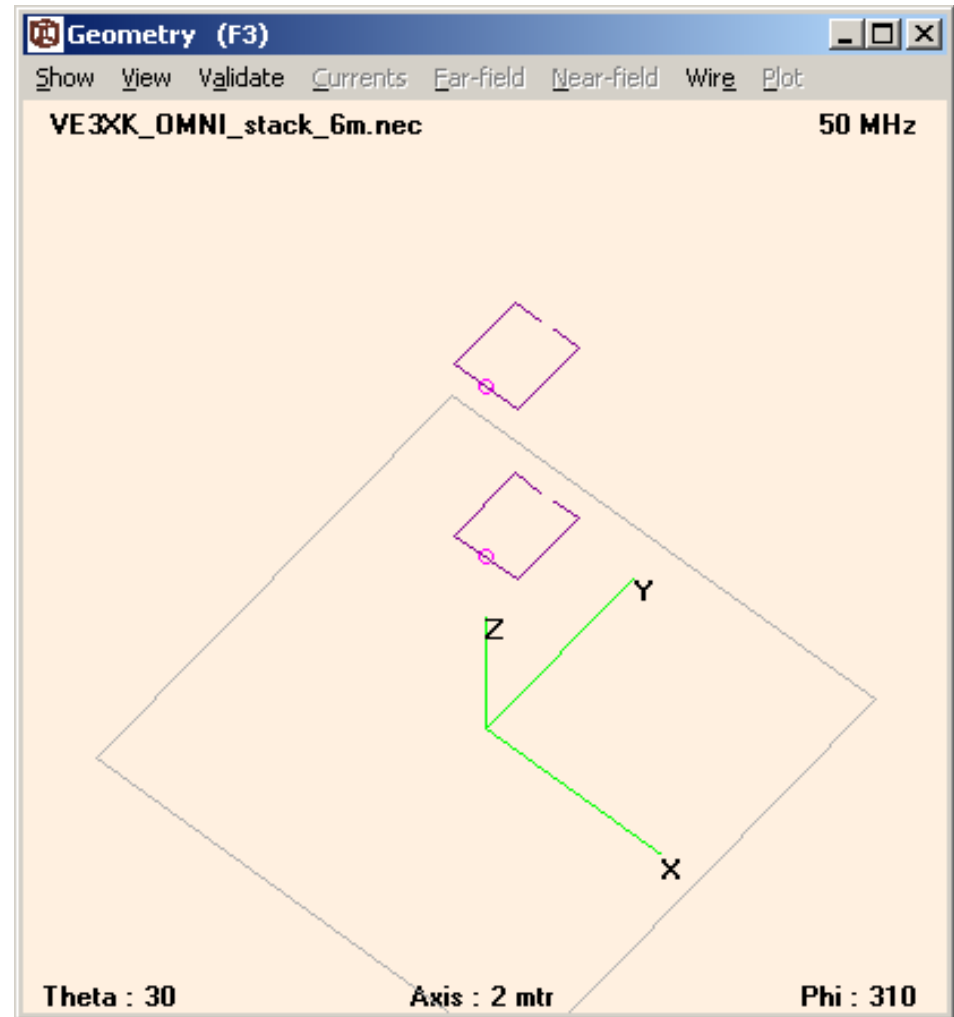


# 50 MHz OMNI Stack

**Same Orientation as Single Element**

**Height = 3 metres**

**Spacing = 0.5 wavelengths**



# 50 MHz OMNI Stack Vertical Plane

**Same Orientation as Single Element**

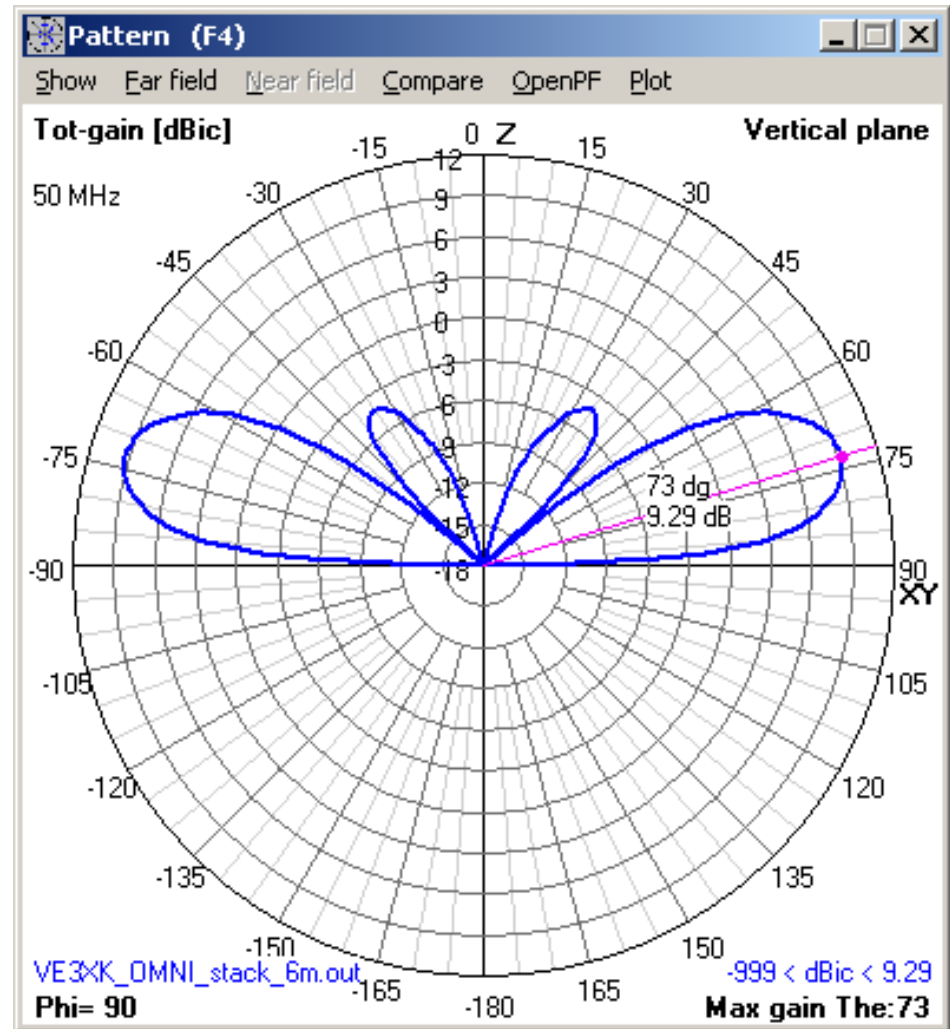
**Height = 3 metres**

**Spacing = 0.5 wavelengths**

**Gain Increased to 9.29 dBi**

**Take off angle now 15 degrees**

**Some high angle side lobes.**



# 50 MHz OMNI Stack Horizontal Plane

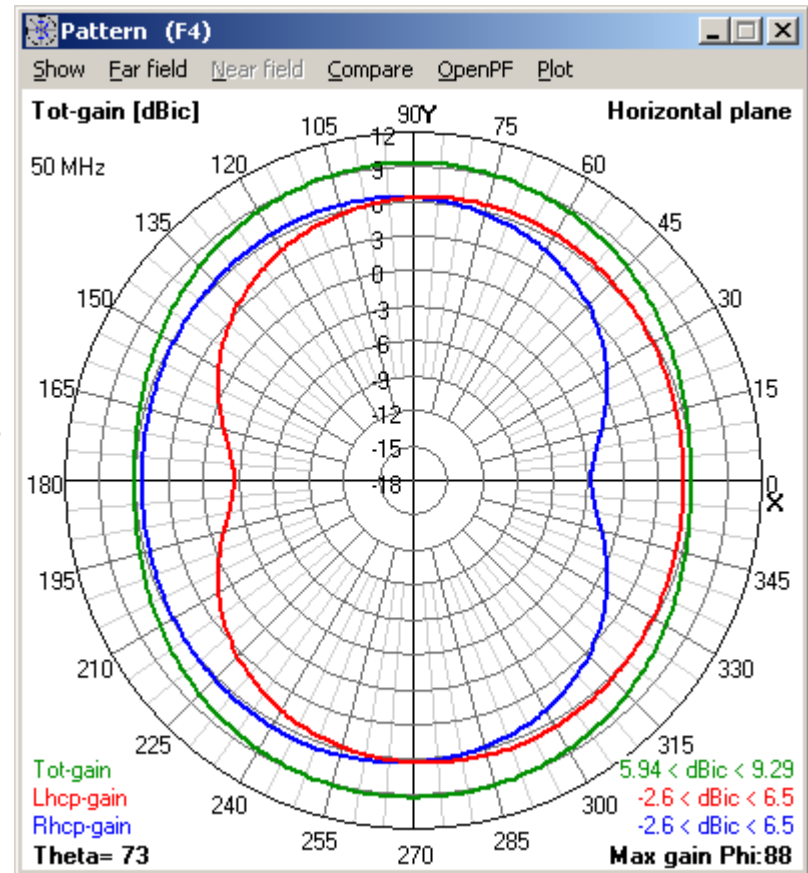
**Same Orientation as Single Element**

**Height = 3 metres**

**Spacing = 0.5 wavelengths**

**Circularly Polarized along the X axis**

**$\Theta = 73$  degrees**



# Summary

- **Uses NEC2 or NEC4 Engine**
- **Contains an Optimizer**
- **Outstanding Graphics capability**
- **Uses four different editors**
- **Many features not covered in this talk**



**Fundamental Wave Reflection Talk Available**

**73 Dave VE3KL**