

Antenna Planning for Small HF Stations (and even larger ones)

Jim Brown K9YC

k9yc@arri.net

<http://k9yc.com/publish.htm>

Don't Bother Taking Notes

- **This Power Point, and a lot more, are at
k9yc.com/publish.htm**

What This Is About

- **This is the third in a series of studies focused on antenna systems for limited space, and/or with limited availability of supports.**
 - **Part One studied the question, “If I Can Put My Multi-band HF Vertical On My Roof, Should I?”**
 - **Part Two studied the strengths and weaknesses of the 43 Ft vertical.**
 - **Both are at k9yc.com/publish.htm**

My Method

- **This work is based entirely on modeling, using W7EL's EZNEC**
 - **All use simple antennas – half wave dipoles, ground planes, 3-el Yagi**
- **A model that accurately and completely describes an antenna system will accurately predict its performance**

The Accuracy of a Model

- **A model must include things that interact with the antenna**
 - **The earth – soil conditions, height**
 - **The feedline, if not isolated by a common mode choke**
 - **Other conductors around the antenna (including other antennas and their feedlines)**

What This Presentation Is About

- **The current work:**
 - **studies how ground quality affects performance of horizontal and vertical antennas**
 - **studies how height affects performance of horizontal dipoles and small Yagi antennas**
 - **compares the performance of ground- and roof-mounted verticals with $\lambda/2$ horizontal dipoles at heights in the range of 33 Ft.**
 - **compares small Yagis at various heights**
 - **Ignores terrain (assumes “flatland”)**
 - **Ignores surround objects**

What This Presentation Is About

- **The current work attempts to help us answer these questions:**
 - **With my available real estate, skyhooks, budget, and operating interests, will I get better performance from a vertical or a horizontal antenna?**
 - **How much is additional height worth in dB?**
 - **Should I spend money on a tower, tree climbers, or a power amp?**

What We've Already Learned

- **Vertical antennas work better at 20-40 ft than they do on the ground**
 - **How much better depends on the quality of your ground**
 - **Improvement is greatest for poorest soil quality**
 - **Sandy and rocky soil are very poor**
 - **City soil conditions are generally worse**
 - **The best soil around here is in the delta**
 - **Most of us have poor to average soil**

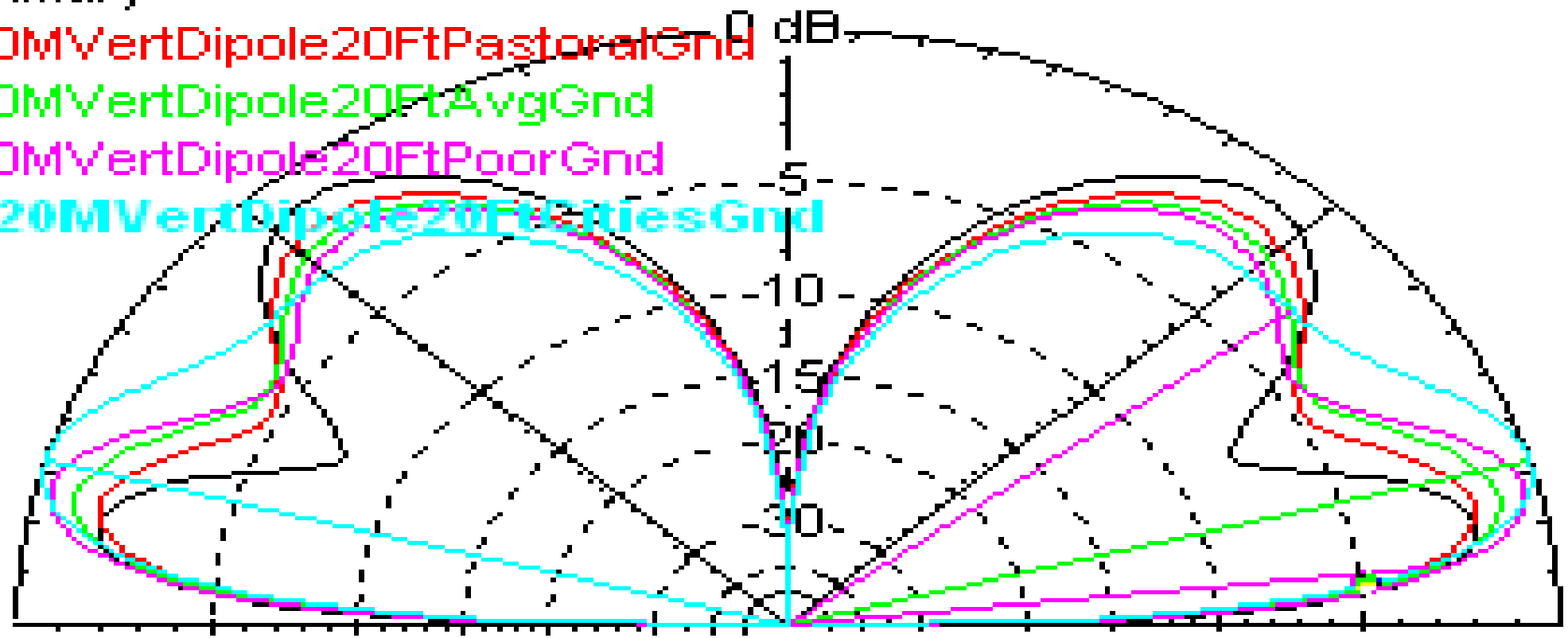
What We've Already Learned

- **Measurements by NOAX and K7LXC show that the most effective verticals are dipoles**
- **Vertical dipoles do not need radials**
- **Ground planes do need radials**
 - **Includes most “trap” designs, Butternut**
 - **Trap designs tend to be less efficient**
 - **On your roof, two resonant radials per band is pretty good, one per band is OK**
 - **On the ground, many radials are needed**

The Effect of Ground Quality

Primary

- 20MVertDipole20FtPastoralGnd
- 20MVertDipole20FtAvgGnd
- 20MVertDipole20FtPoorGnd
- 20MVertDipole20FtCitiesGnd



20M Vertical Dipole, base at 20 Ft

14.2 MHz

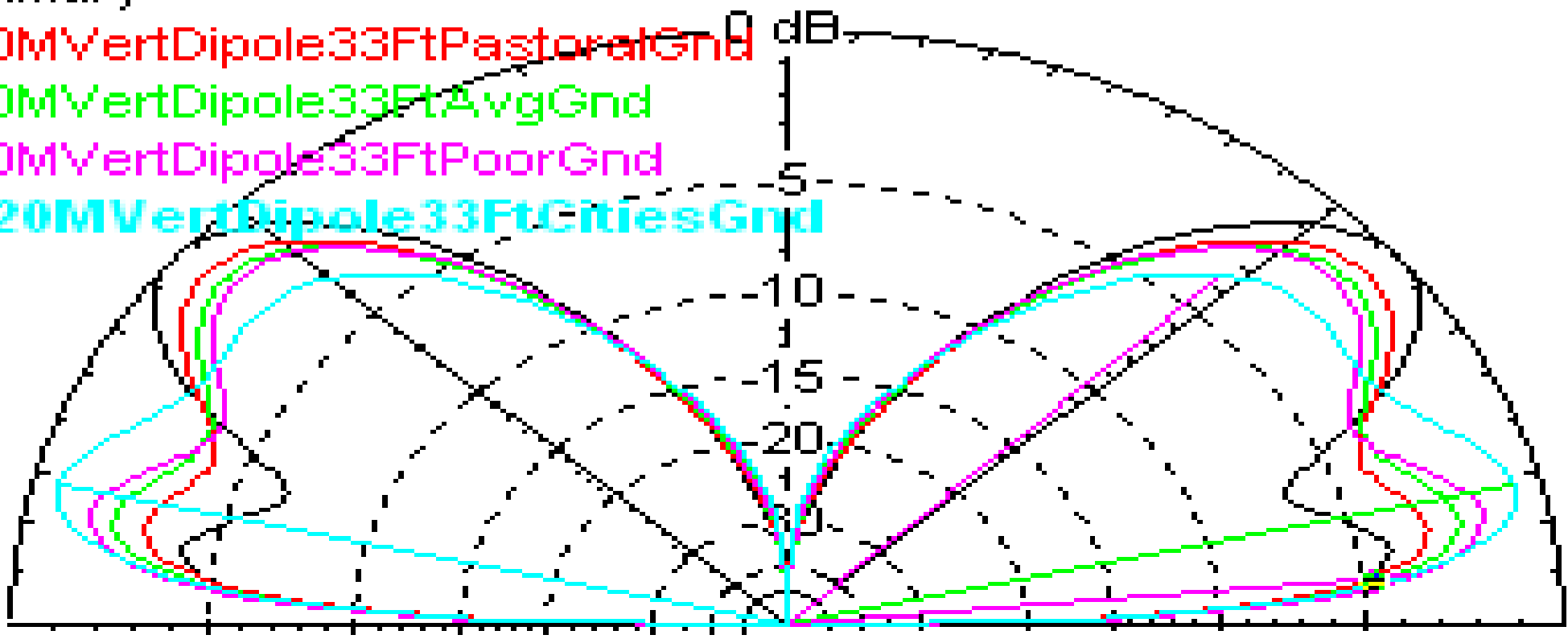
Elevation Plot	Cursor Elev	5.0 deg.
Azimuth Angle	Gain	-2.93 dBi
Outer Ring		-4.85 dBmax
		-1.11 dBPrTrc

Black (Reference) Curve is Very Good Ground

The Effect of Ground Quality

Primary

- 20MVertDipole33FtPastoralGnd
- 20MVertDipole33FtAvgGnd
- 20MVertDipole33FtPoorGnd
- * 20MVertDipole33FtCitiesGnd



20M Vertical Dipole, base at 33 Ft

14.2 MHz

Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-1.32 dBi
Outer Ring	3.35 dBi		-4.04 dBmax
			0.86 dBPrTrc

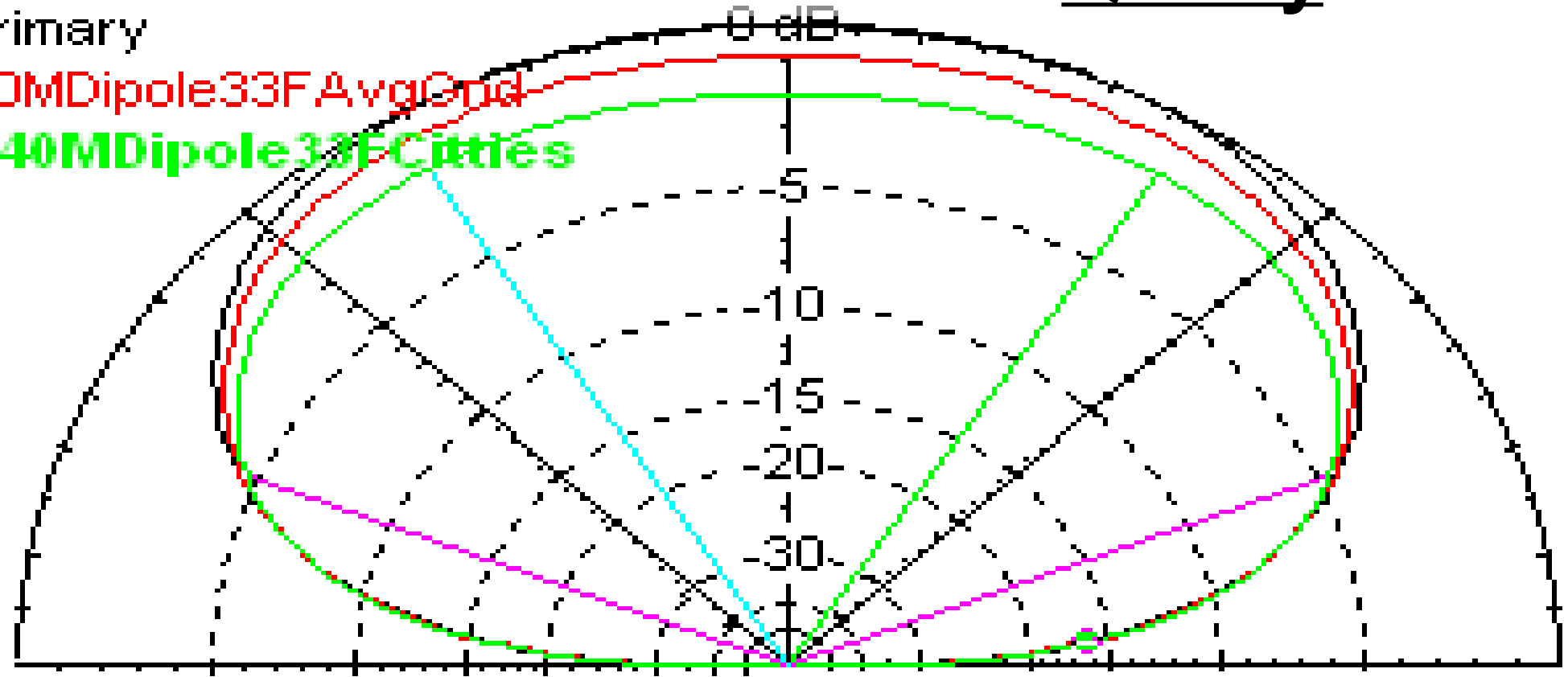
Black (Reference) Curve is Very Good Ground

The Effect of Ground Quality

Primary

40MDipole33F Avg Qd

40MDipole33F Cities



40M Horizontal Dipole, at 33 Ft

7.1 MHz

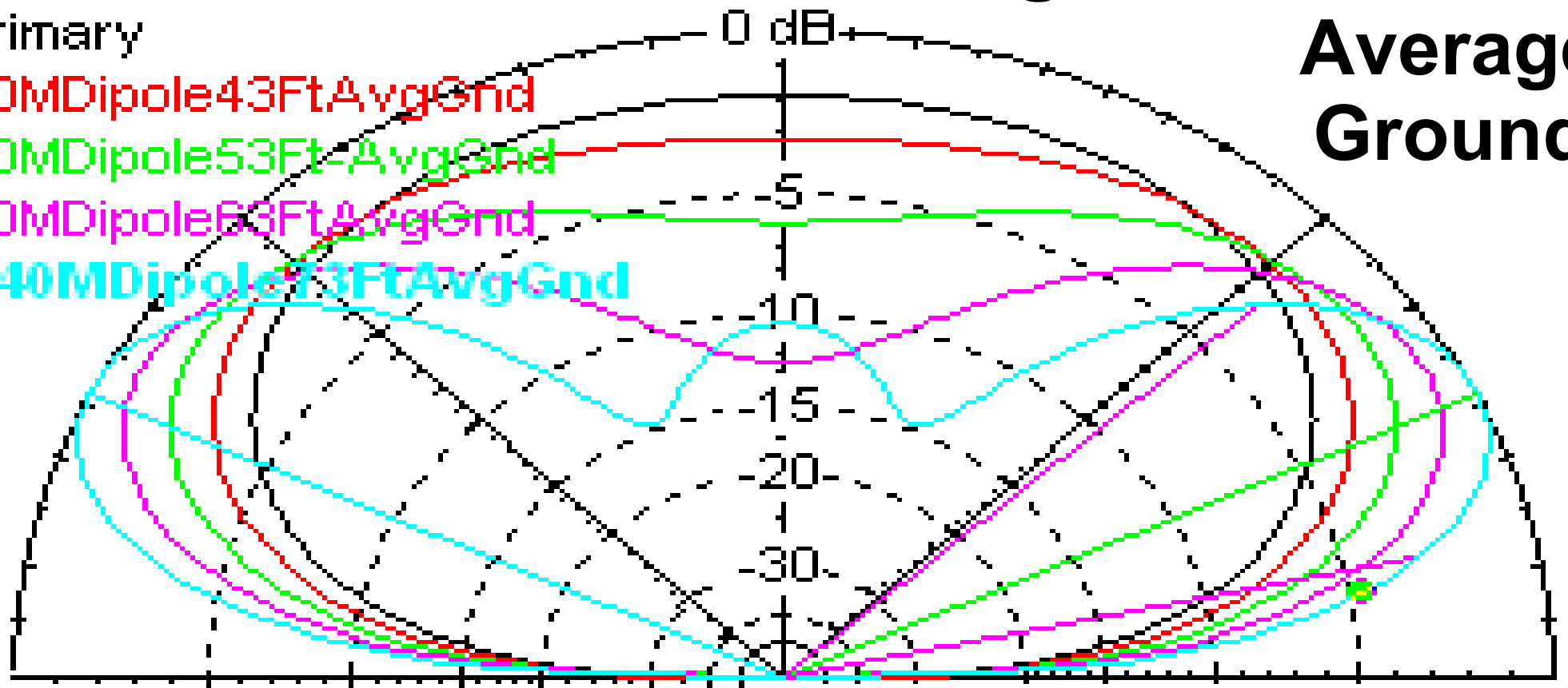
Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-9.23 dBi
Outer Ring	6.82 dBi		-14.26 dBmax
			0.6 dBPrTrc

Black (Reference) Curve is Very Good Ground

Primary

**Average
Ground**

- 40MDipole43FtAvgGnd
- 40MDipole53FtAvgGnd
- 40MDipole63FtAvgGnd
- 40MDipole73FtAvgGnd



40M Horizontal Dipole @ 33 – 73 Ft 7.1 MHz

Elevation Plot	Cursor Elev	10.0 deg.
Azimuth Angle	Gain	3.28 dBi
Outer Ring		-4.56 dBmax
		7.17 dBPrTrc

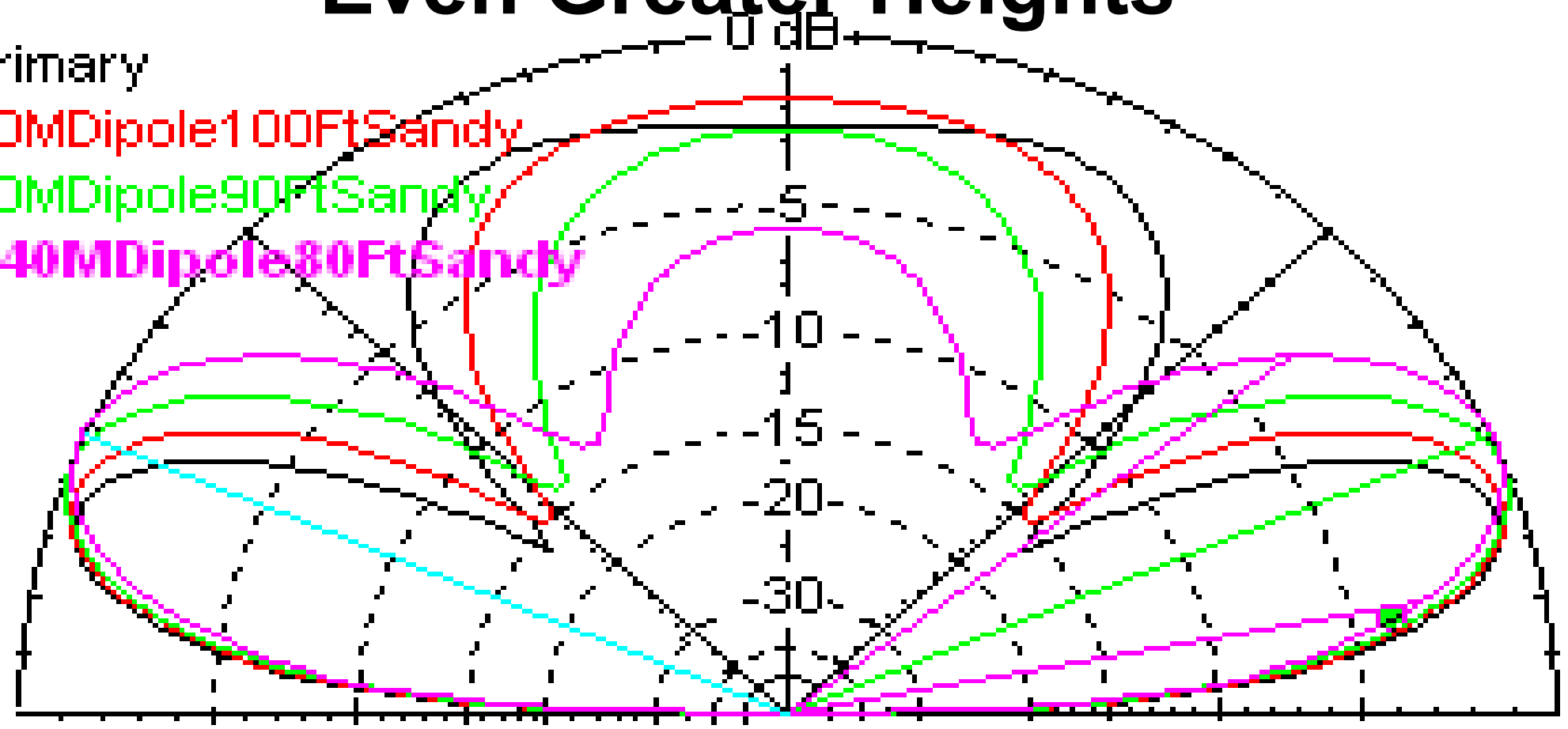
Black (Reference) Curve is 33 Ft

Primary

40MDipole100FtSandy

40MDipole90FtSandy

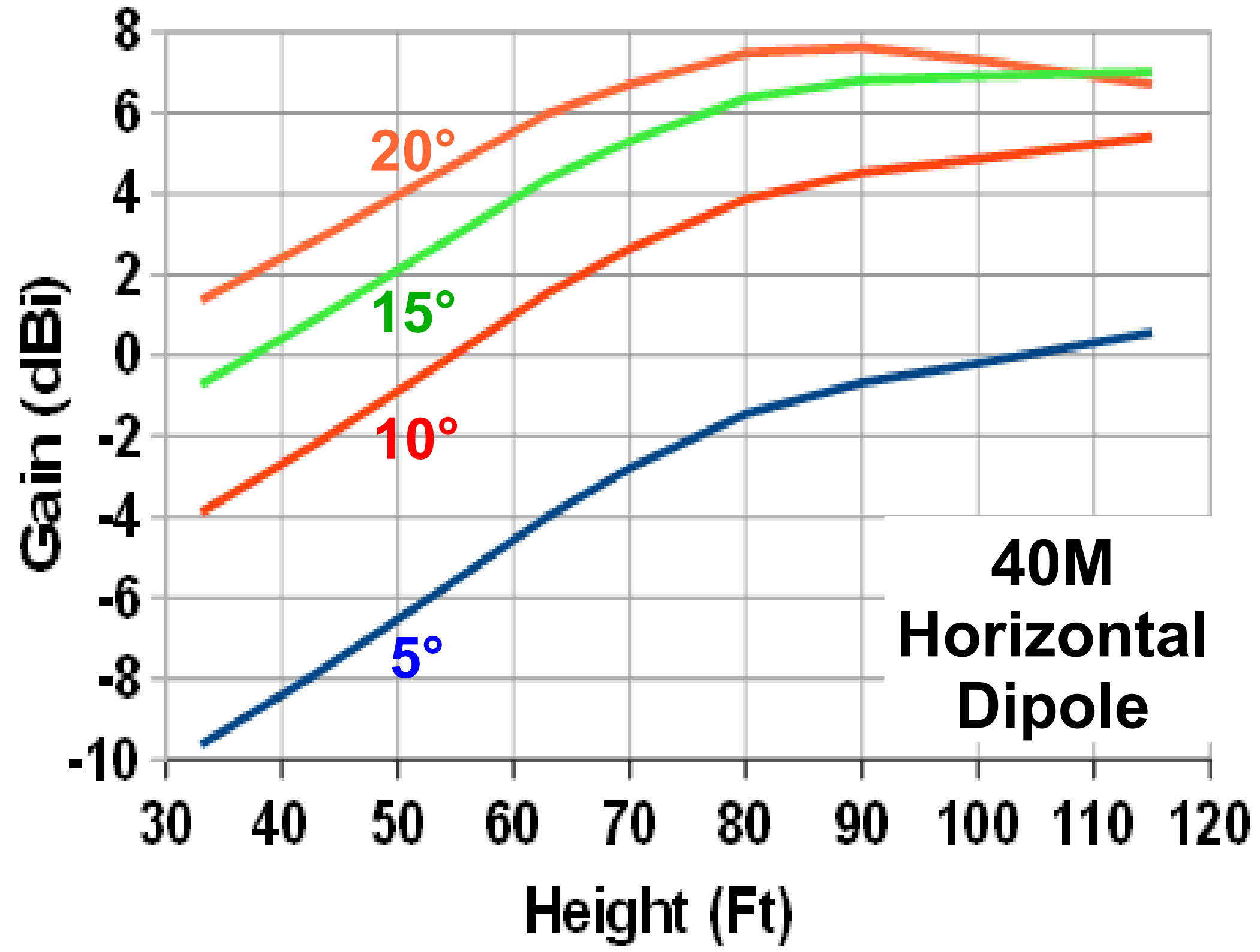
* 40MDipole80FtSandy



40M Horizontal Dipole @ 80 – 110 Ft 7.1 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	3.86 dBi
Outer Ring	7.71 dBi		-3.84 dBmax
			-1.3 dBPrTrc

Black (Reference) Curve is 110 Ft



How Much is Height Worth?

- For a 40M horizontal dipole (or Yagi)
 - 0.9 dB for 5 ft between 30 Ft and 70 Ft below 15°
 - 6 dB for $\lambda/4$ (33 Ft) to $\lambda/2$ (67 Ft)
 - 2.5 dB for $\lambda/2$ (67 Ft) to λ (133 Ft)

How Much is a Tower Worth?

- For a 40M horizontal dipole (or Yagi)
 - 0.9 dB for 5 ft between 30 Ft and 70 Ft below 15°
 - 6 dB for $\lambda/4$ (33 Ft) to $\lambda/2$ (67 Ft)
 - 2.5 dB for $\lambda/2$ (67 Ft) to λ (133 Ft)

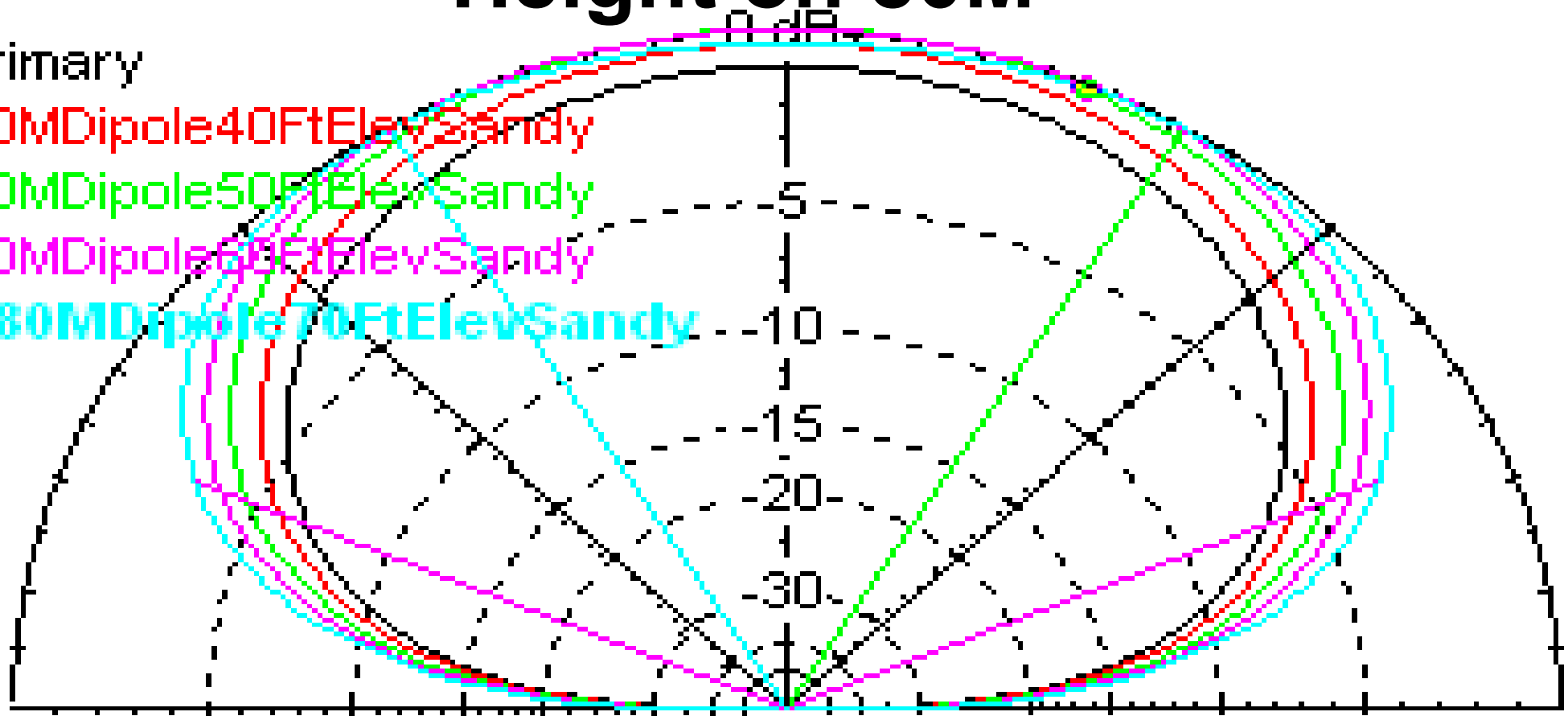
Primary

80MDipole40FtElevSandy

80MDipole50FtElevSandy

80MDipole60FtElevSandy

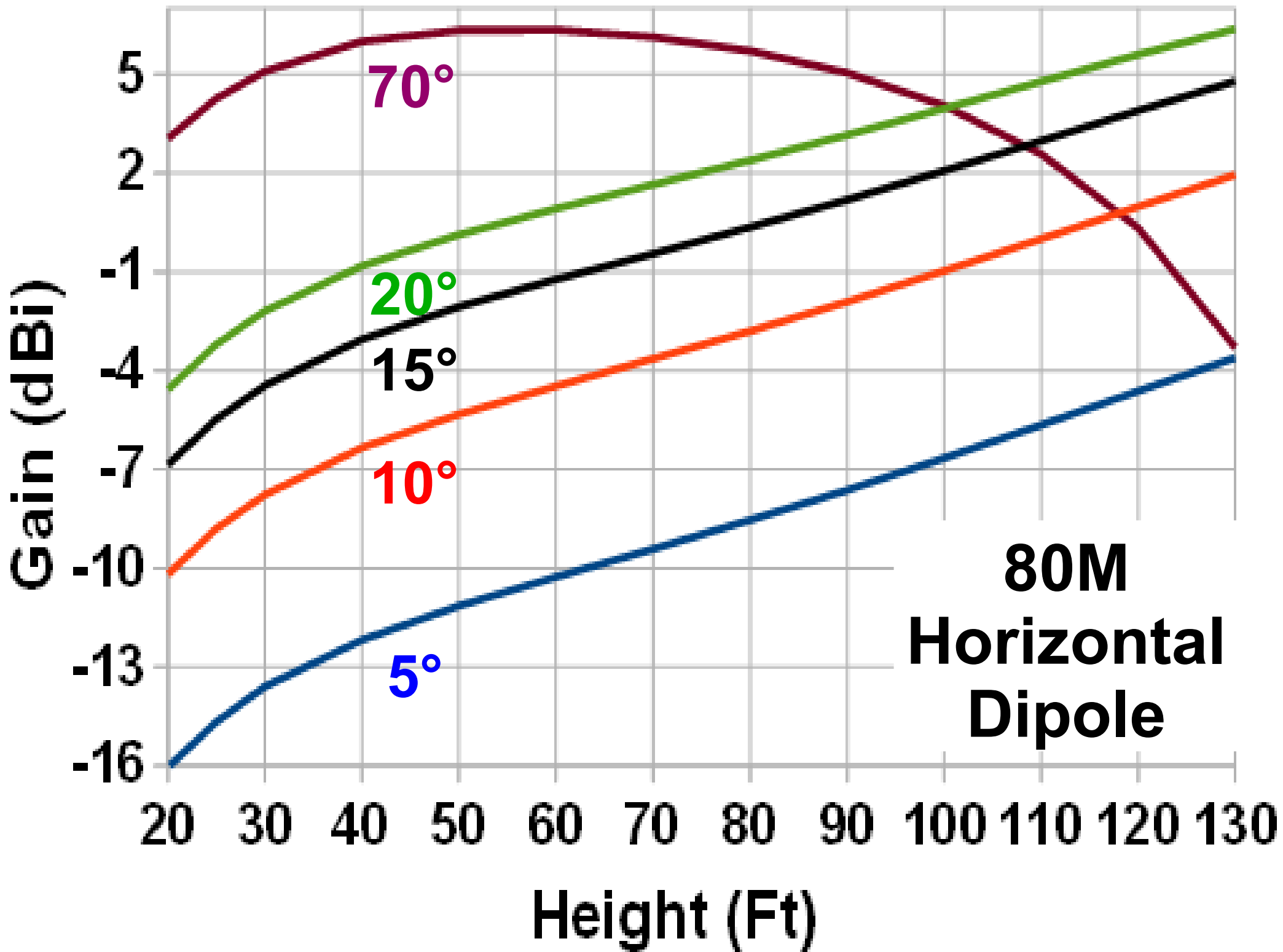
80MDipole70FtElevSandy



80M Horizontal Dipole @ 33 – 70 Ft 3.55 MHz

Elevation Plot		Cursor Elev	67.0 deg.
Azimuth Angle	5.0 deg.	Gain	5.7 dBi
Outer Ring	5.87 dBi		-0.05 dBmax
			1.21 dBPrTrc

Black (Reference) Curve is 33 Ft



**80M
Horizontal
Dipole**

How Much is Height Worth?

- For an 80M horizontal dipole (or Yagi) at 15° and below
 - 0.9 dB for 10 ft between 40 Ft and 130 Ft
 - 3.5 dB for $\lambda/8$ (33 Ft) to $\lambda/4$ (67 Ft)
 - 6 dB for $\lambda/4$ (67 Ft) to $\lambda/2$ (133 Ft)
- On the lower bands, we need less signal to work short distances than long distances
- An antenna cannot be “too high” for 80M

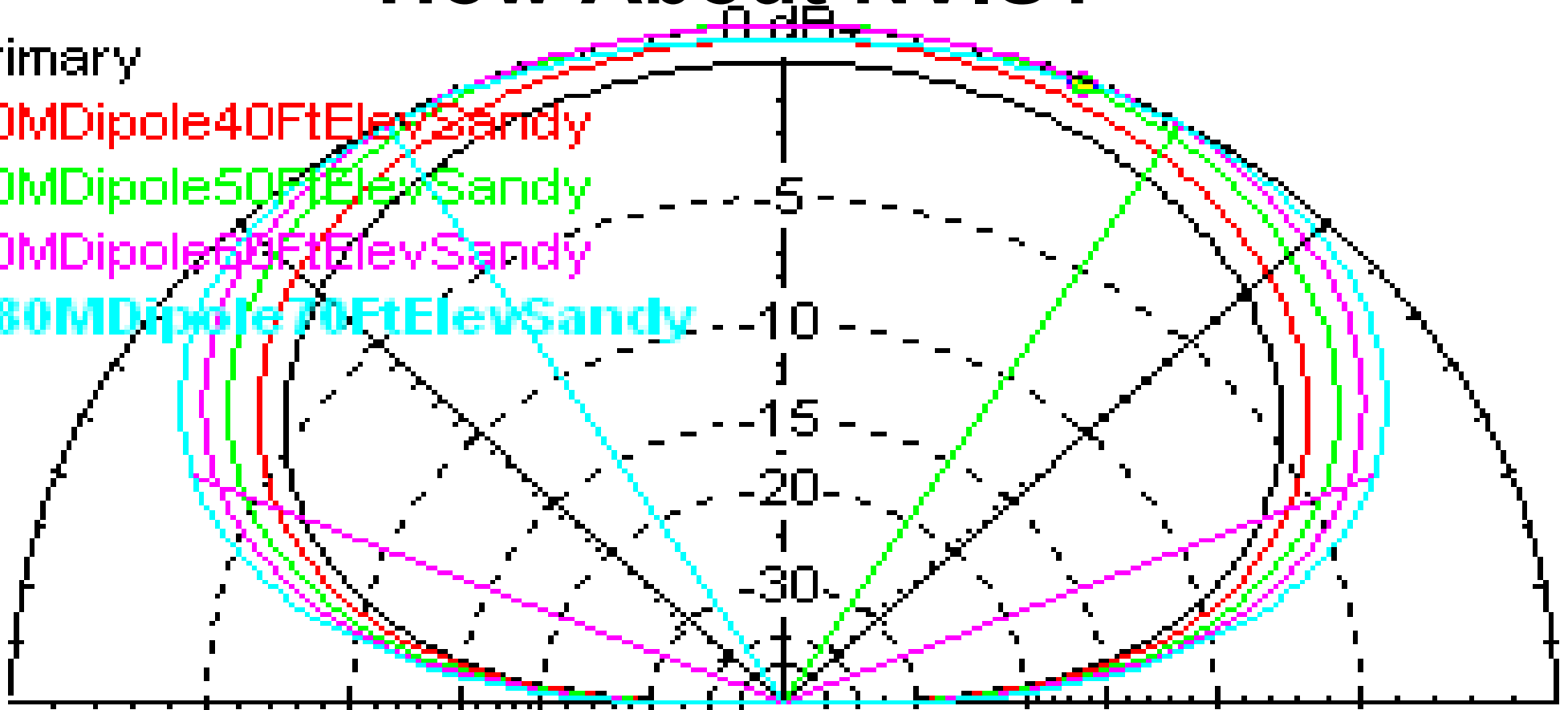
Primary

80MDipole40FtElevSandy

80MDipole50FtElevSandy

80MDipole60FtElevSandy

80MDipole70FtElevSandy



80M Horizontal Dipole @ 33 – 70 Ft 3.55 MHz

Elevation Plot	Cursor Elev	67.0 deg.
Azimuth Angle	Gain	5.7 dBi
Outer Ring	5.87 dBi	-0.05 dBmax
		1.21 dBPrTrc

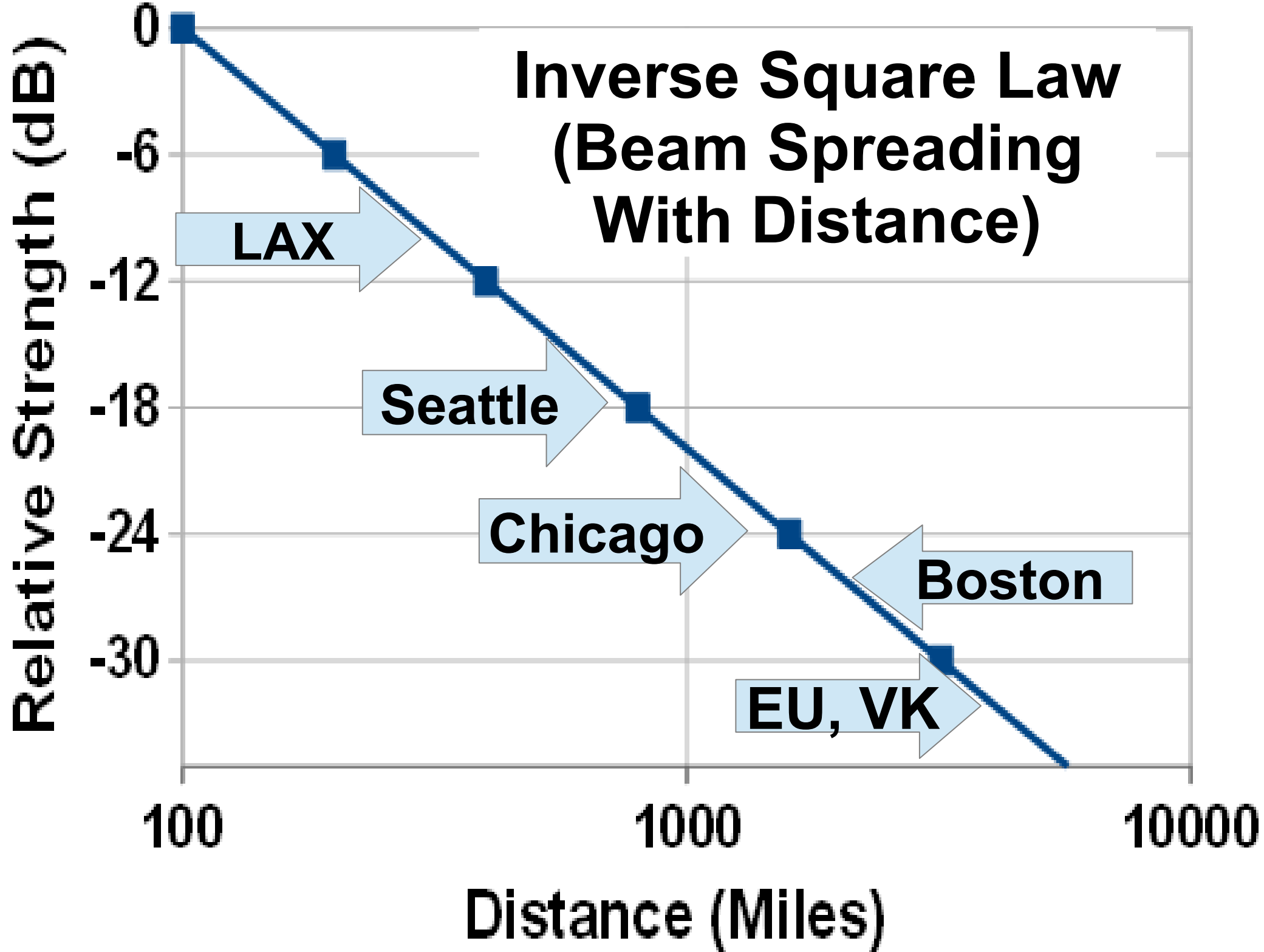
Black (Reference) Curve is 33 Ft

How About NVIS?

- **For a horizontal dipole, $\lambda/4$ high is near optimum**
 - **133 ft on 160M**
 - **67 ft on 80M**
 - **33 ft on 40M**
- **The only reason to rig a horizontal antenna lower than $\lambda/4$ is that's the best you can do**

Can An Antenna Be Too High?

- I want to work locals for nets and during contests. Does a high antenna give away too much high angle performance?**



Inverse Square Law

- **Seattle is 6 dB closer than Chicago, 8 dB closer than Boston**
- **An antenna that favors Chicago (70° azimuth) will work Seattle (5°) as easily as it works Chicago**
- **On the lower bands, we need less signal to work short distances than long distances**

How About NVIS?

- **For a horizontal dipole, $\lambda/4$ high is near optimum**
 - **133 ft on 160M**
 - **67 ft on 80M**
 - **33 ft on 40M**
- **At $\lambda/2$ high, an antenna is -10 dB from $\lambda/4$ high, but Inverse Square Law makes up the difference**
- **The only reason to rig a horizontal antenna lower than $\lambda/4$ is that it's the highest you can get it**

Let's Study Some Modeling Results

First Series

40M Horizontal Dipole @33 Ft (Black curve)

compared to:

40M Ground-mounted quarter wave with 4 Ohm Radial System (Green curve), and

40M Ground Plane @ 33 Ft (Red Curve)

Vertical Pattern, Cursor at 10°

Total Field

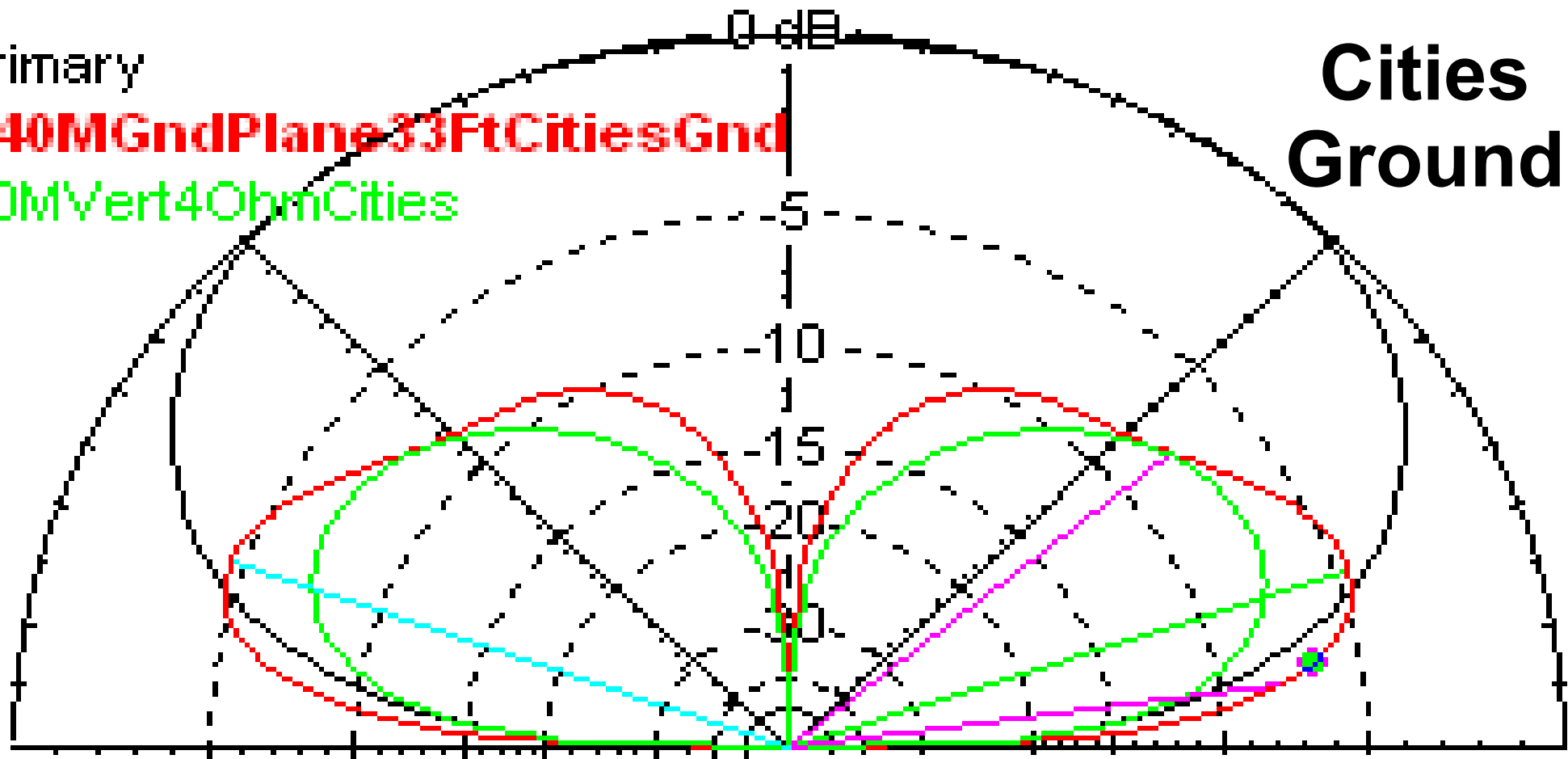
EZNEC Pro/2

Primary

40M Gnd Plane 33 Ft Cities Gnd

40M Vert 4 Ohm Cities

Cities Ground



Black is Horizontal Dipole @ 33 Ft

7.1 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	-1.43 dBi
Outer Ring	5.03 dBi		-1.79 dBmax
			2.23 dBPrTrc

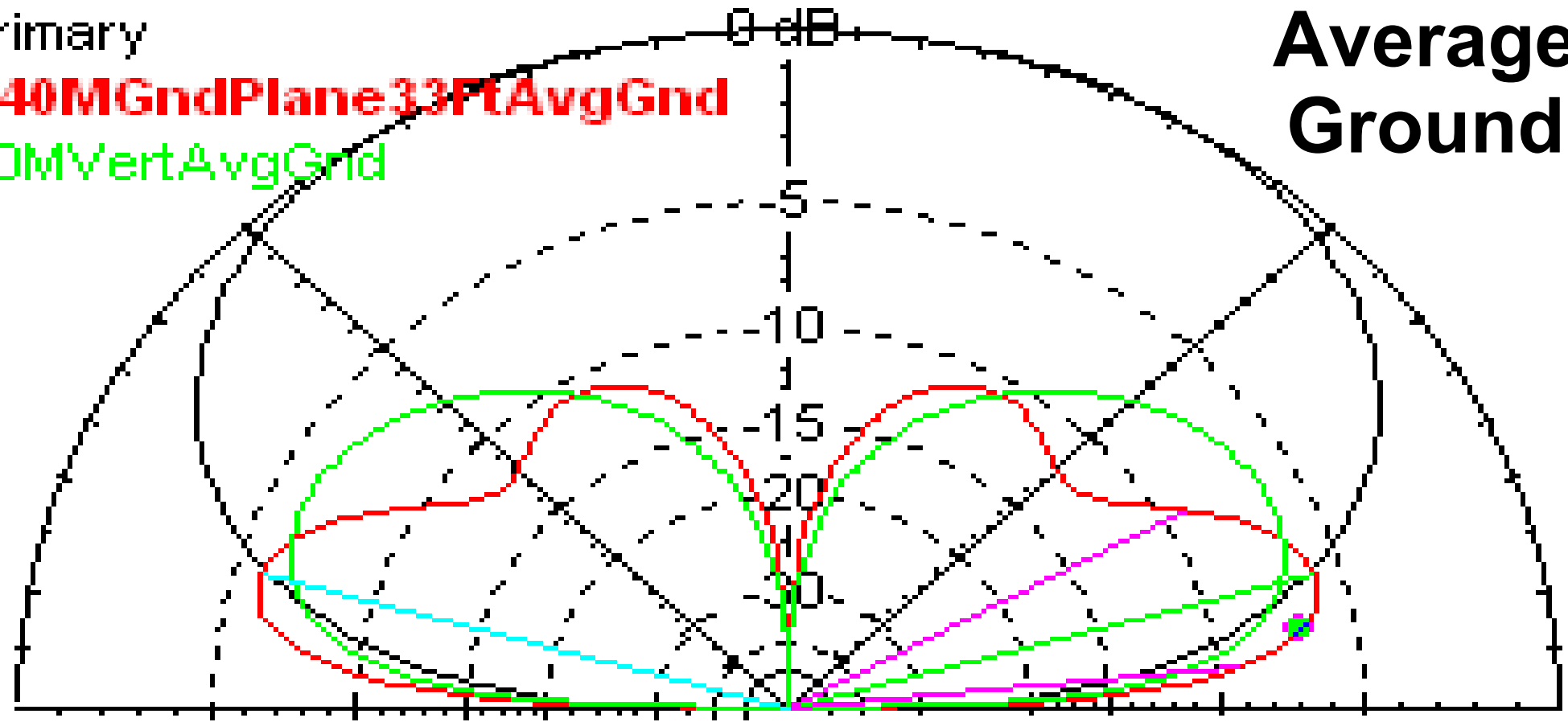
Total Field

EZNEC Pro/2

Primary

40M Gnd Plane 33 Ft Avg Gnd
40M Vert Avg Gnd

Average Ground



Black is Horizontal Dipole @ 33 Ft 7.1 MHz

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	-0.74 dBi
Outer Ring	6.02 dBi		-0.81 dBmax
			3.15 dBPrTrc

Total Field

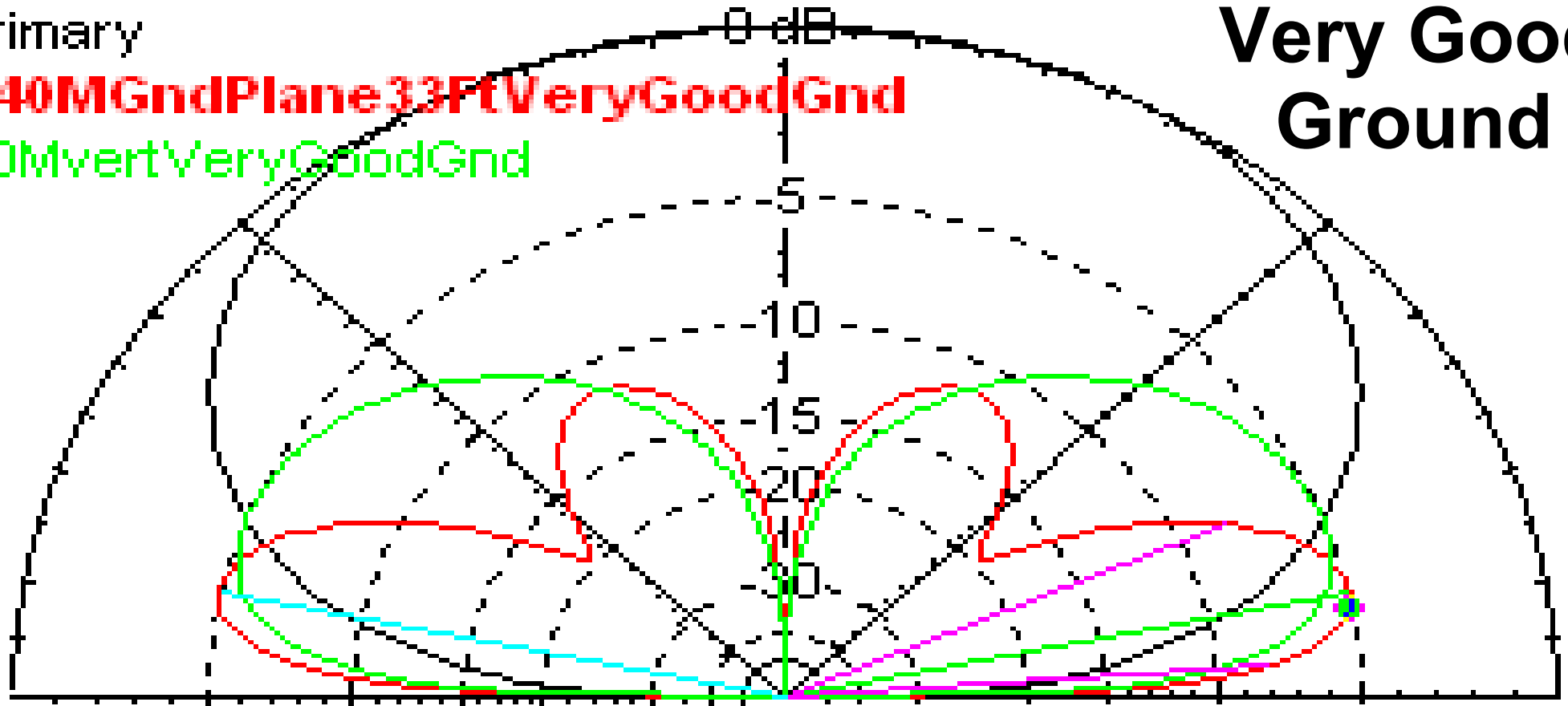
EZNEC Pro/2

Primary

40MGndPlane33FtVeryGoodGnd

40MvertVeryGoodGnd

Very Good Ground



Black is Horizontal Dipole @ 33 Ft

7.1 MHz

Elevation Plot

Azimuth Angle 0.0 deg.

Outer Ring 6.82 dBi

Cursor Elev 10.0 deg.

Gain 1.66 dBi

-0.15 dBmax

5.65 dBPrTrc

First Series – Azimuth Plots

40M Vertical on Ground (Red curve)

40M Ground Plane at 33 Ft (Green curve)

**40M Horizontal Dipole @ 33 Ft
Azimuth Plot @ 10° Elevation**

Total Field

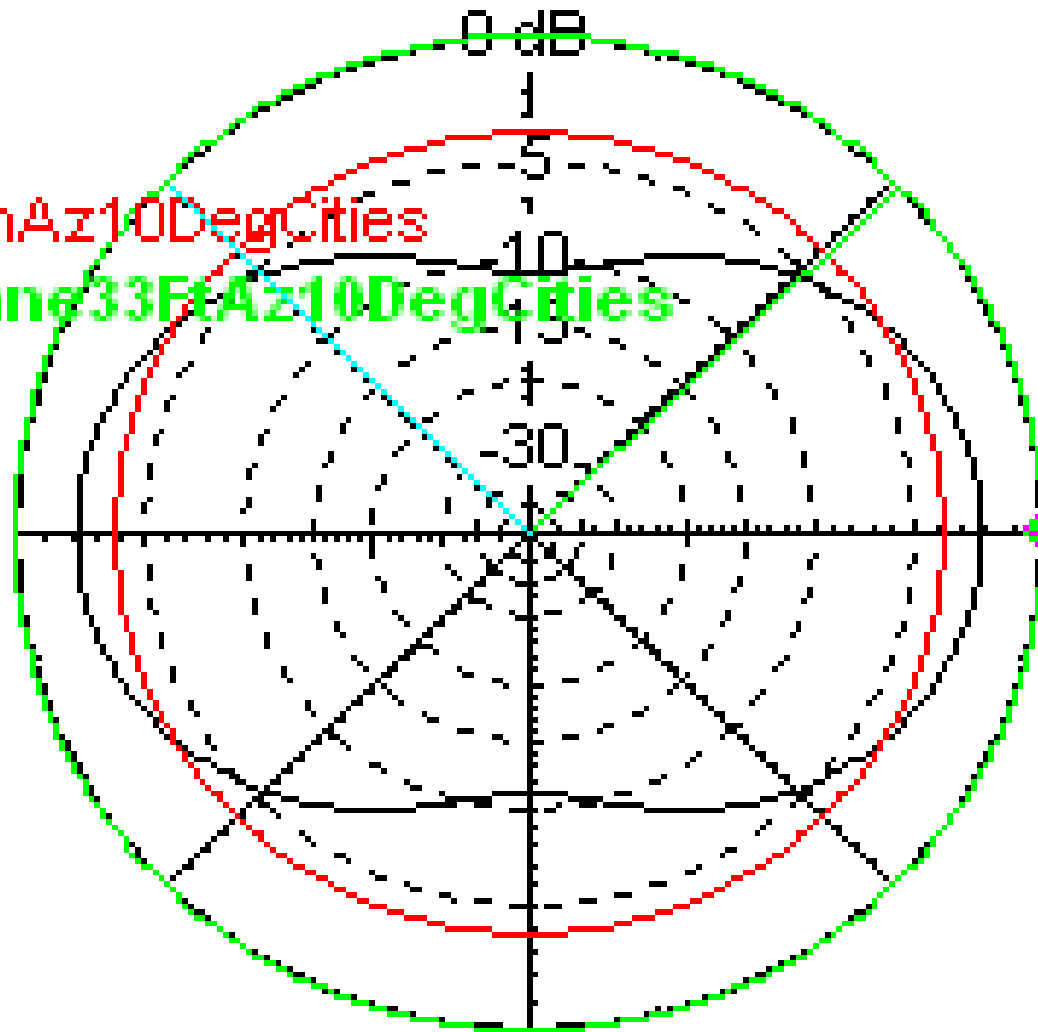
EZNEC Pro/2

Primary

40MVert4OhmAzi10DegCities

* 40MGndPlane33FtAzi10DegCities

Cities Ground



10° Elevation

40M

Azimuth Plot

Cursor Az

0.0 deg.

Elevation Angle 0.0 deg.

Gain

-1.46 dBi

Outer Ring -1.43 dBi

-0.03 dBmax

2.2 dBPrTrc

Black (Reference) Curve is Dipole @ 33 Ft

Total Field

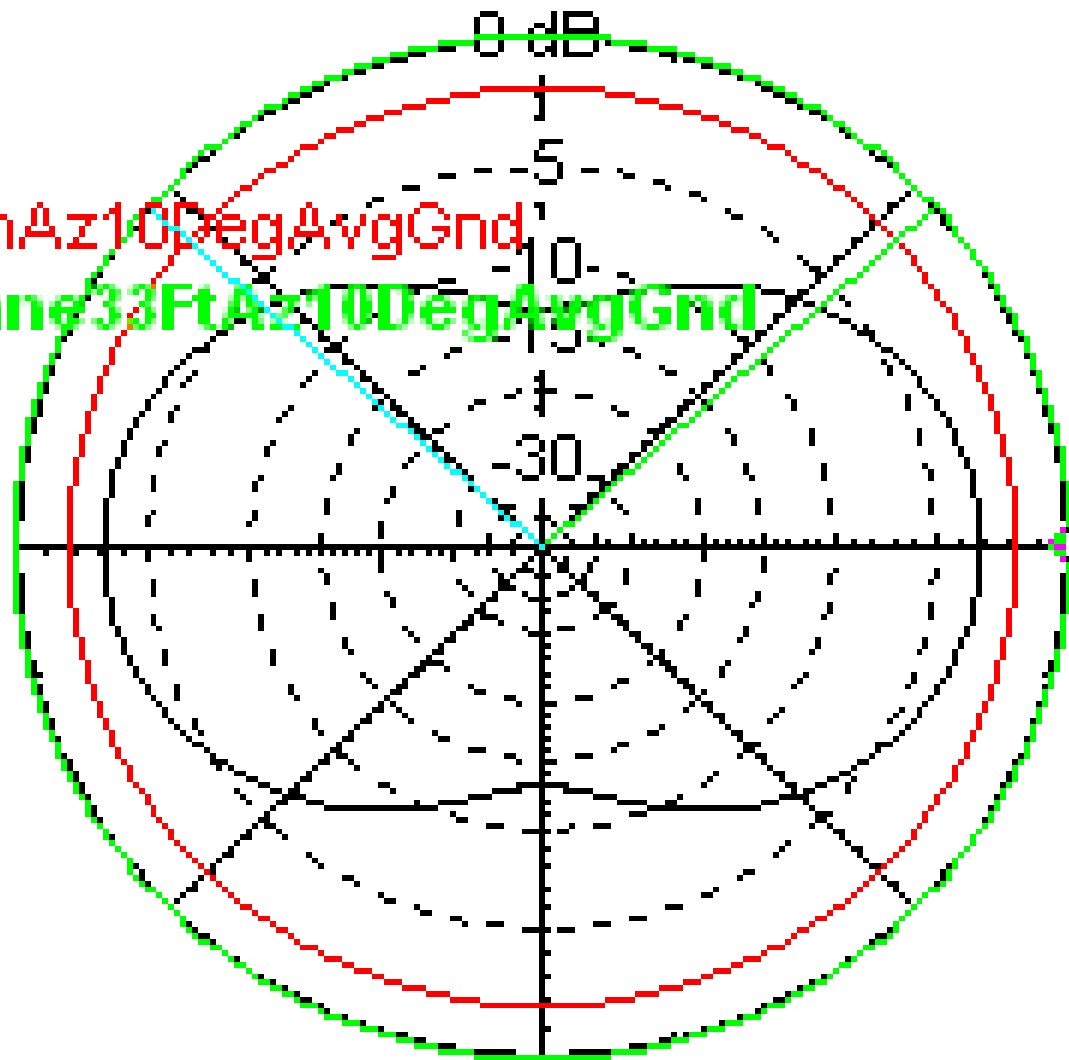
EZNEC Pro/2

Primary

40MVert4OhmAz10DegAvgGnd

40MGndPlane33FtAz10DegAvgGnd

Avg Ground



10° Elevation

40M

Azimuth Plot

Cursor Az

0.0 deg.

Elevation Angle 0.0 deg.

Gain

-0.74 dBi

Outer Ring -0.73 dBi

0.0 dBmax

3.15 dBPrTrc

Black (Reference) Curve is Dipole @ 33 Ft

Total Field

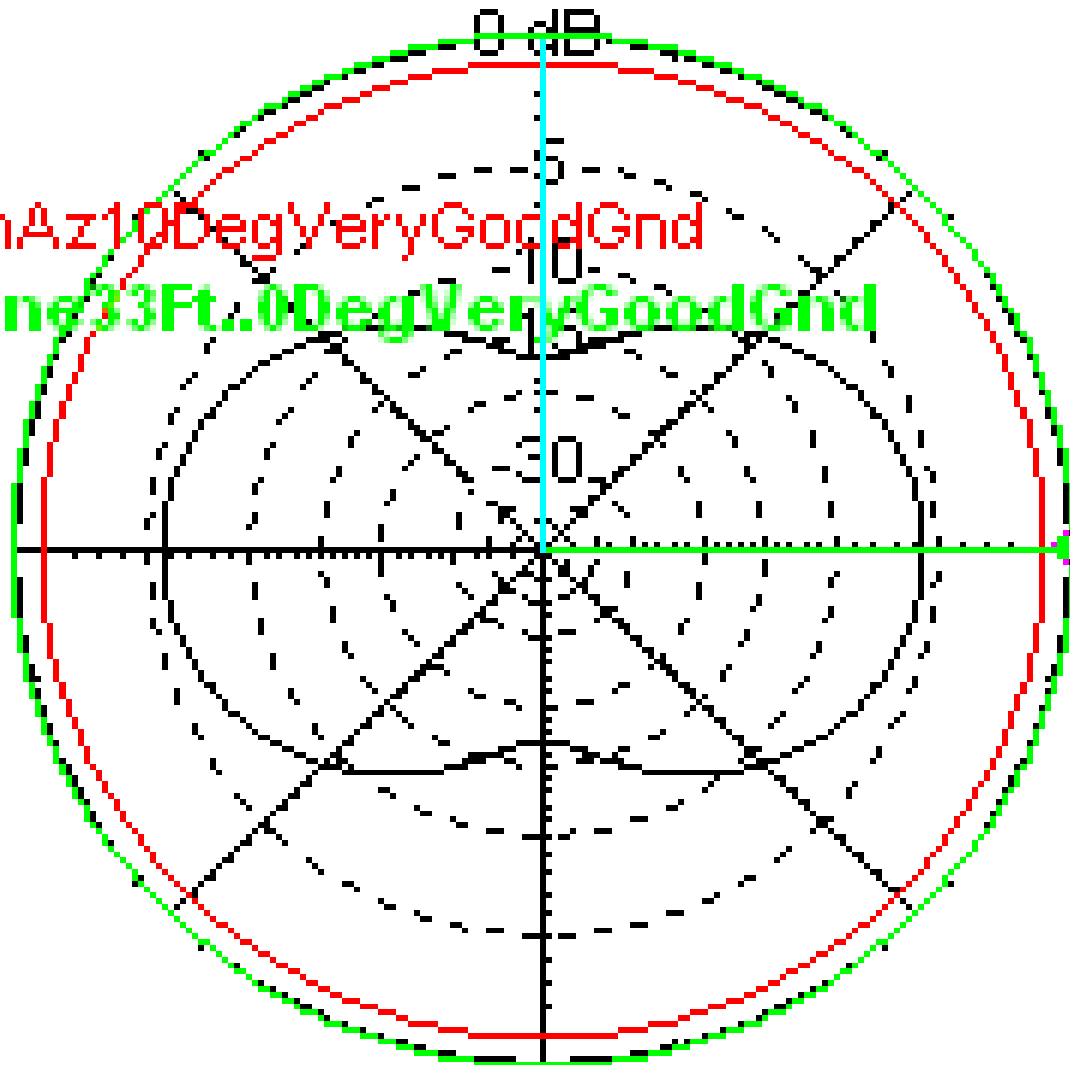
EZNEC Pro/2

Primary

40MVert4OhmAz10DegVeryGoodGnd

40MGndPlane33Ft.0DegVeryGoodGnd

Very Good Ground



10° Elevation

40M

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	1.66 dBi
Outer Ring	1.66 dBi		0.0 dBmax
			5.65 dBPrTrc

Black (Reference) Curve is Dipole @ 33 Ft

Second Series

20M Vertical Dipole at 20 Ft (Red curve)

20M Vertical Dipole at 33 Ft (Green curve)

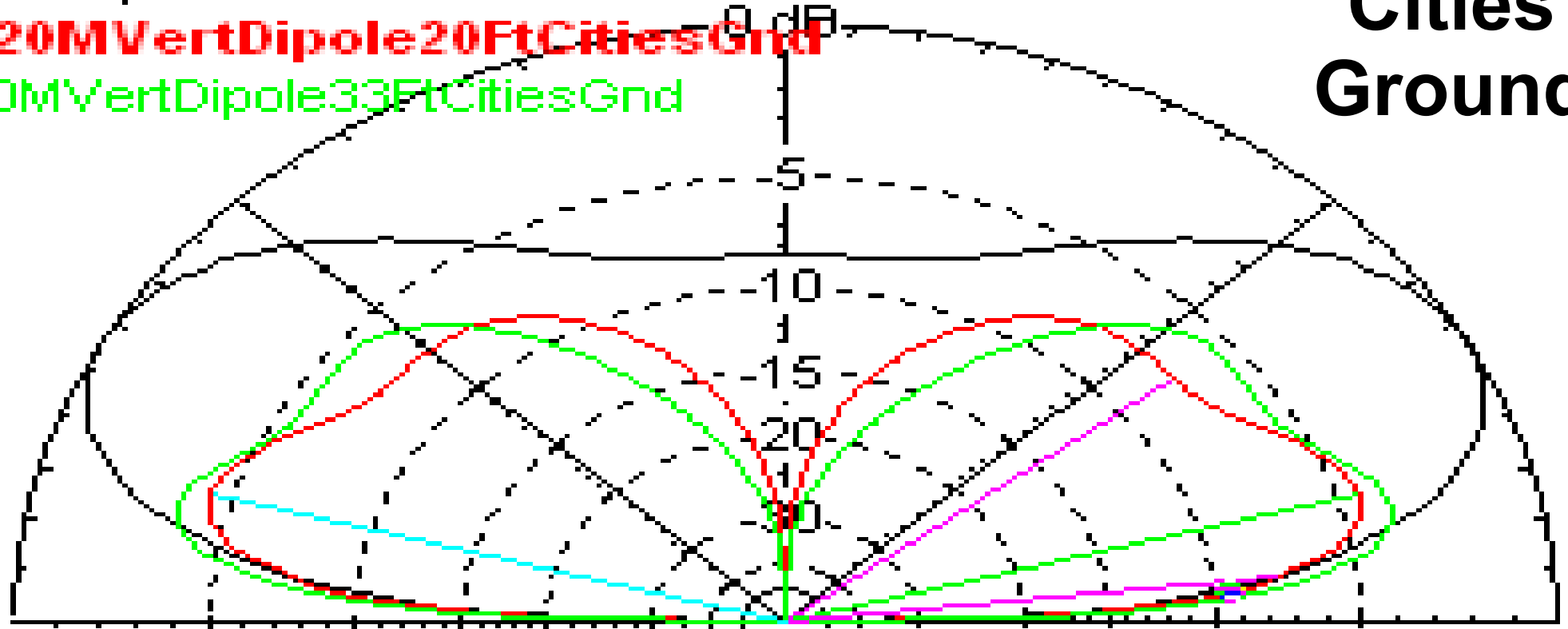
20M Horizontal Dipole @ 33 Ft (Black curve)

Cursor at 5 degrees

Primary

Cities
Ground

* 20MVertDipole20FtCitiesGnd
20MVertDipole33FtCitiesGnd



20M Horizontal Dipole @ 33 Ft 14.1 MHz

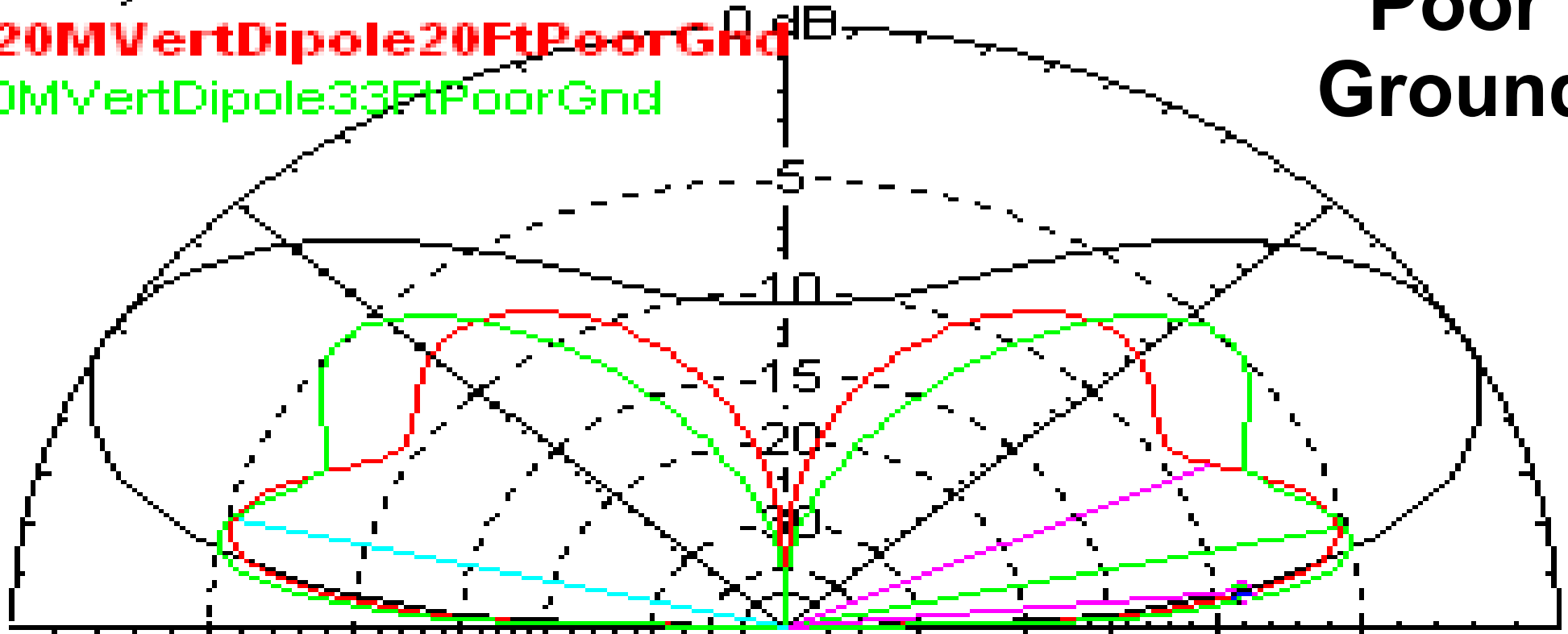
Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-2.93 dBi
Outer Ring	6.37 dBi		-4.85 dBmax
			0.75 dBPrTrc

Poor Ground

Primary

* 20MVertDipole20FtPoorGnd

20MVertDipole33FtPoorGnd



20M Horizontal Dipole @ 33 Ft 14.1 MHz

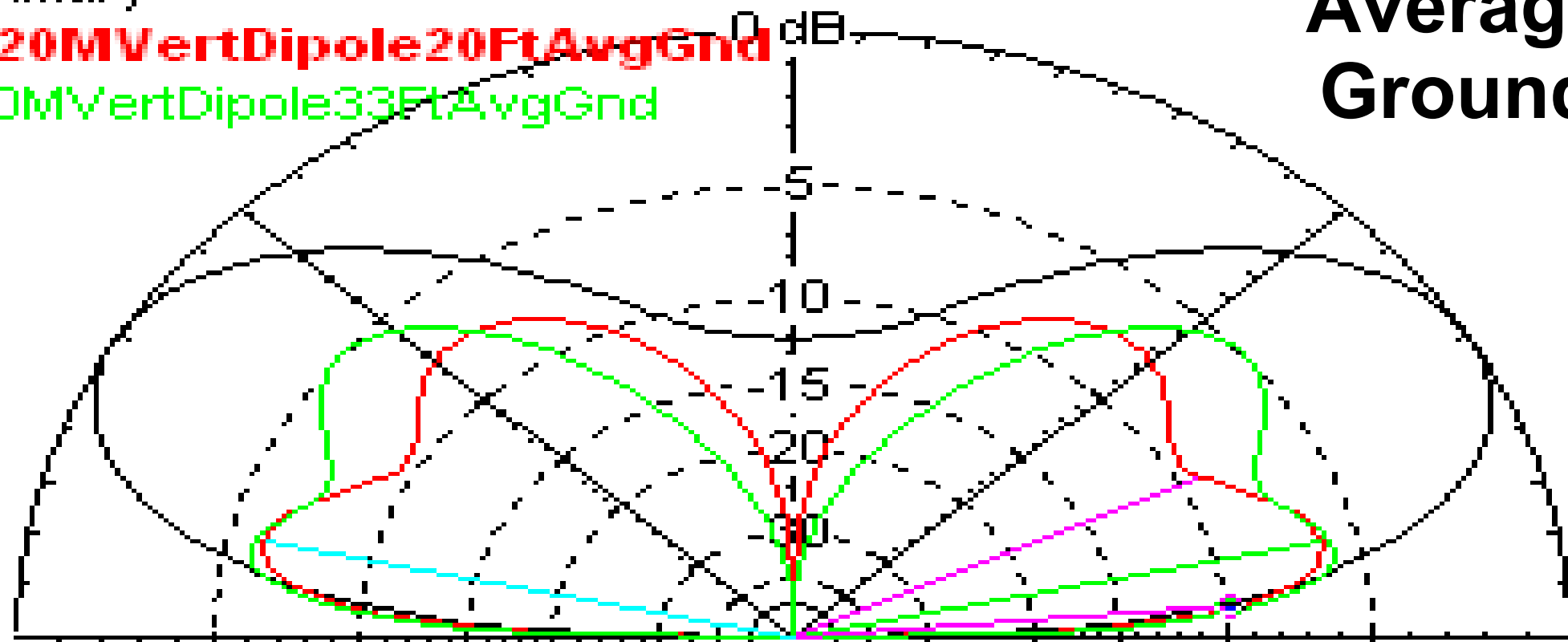
Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-2.03 dBi
Outer Ring	6.86 dBi		-3.58 dBmax
			1.7 dBPrTrc

Total Field

Primary

* 20MVertDipole20FtAvgGnd

20MVertDipole33FtAvgGnd

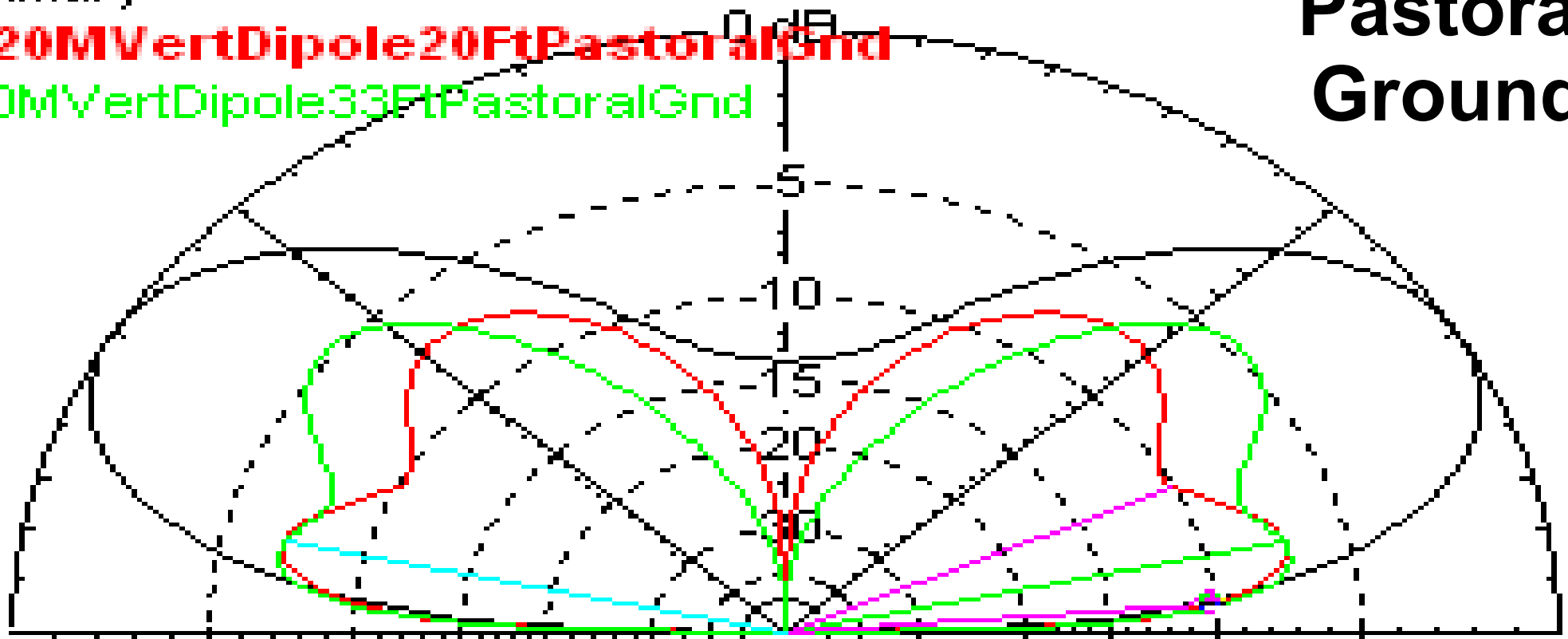
**Average
Ground****20M Horizontal Dipole @ 33 Ft 14.1 MHz**

Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-2.51 dBi
Outer Ring	7.11 dBi		-3.48 dBmax
			1.12 dBPrTrc

Primary

Pastoral Ground

* 20MVertDipole20FtPastoralGnd
20MVertDipole33FtPastoralGnd



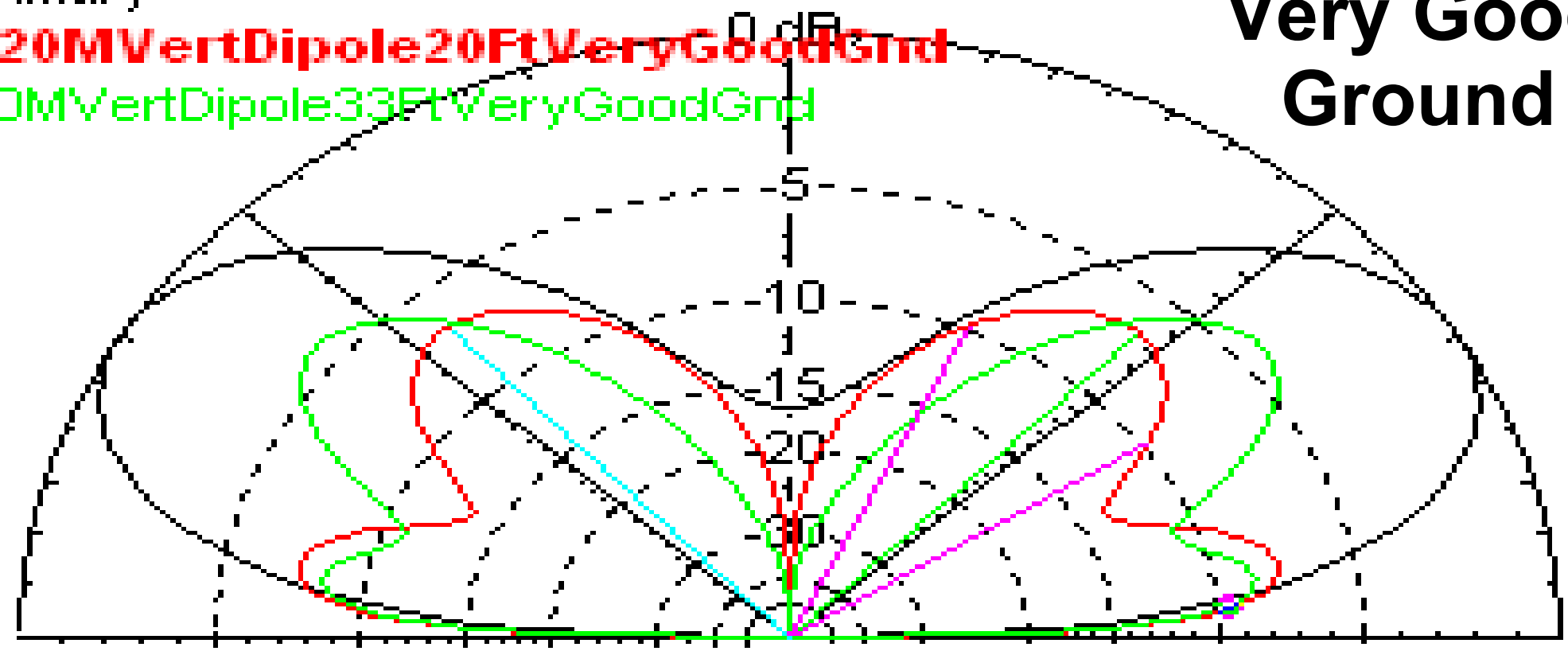
20M Horizontal Dipole @ 33 Ft 14.1 MHz

Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-2.81 dBi
Outer Ring	7.33 dBi		-3.11 dBmax
			0.69 dBPrTrc

Primary

Very Good Ground

* 20MVertDipole20FtVeryGoodGnd
20MVertDipole33FtVeryGoodGnd



20M Horizontal Dipole @ 33 Ft 14.1 MHz

Elevation Plot		Cursor Elev	5.0 deg.
Azimuth Angle	0.0 deg.	Gain	-1.82 dBi
Outer Ring	7.67 dBi		-2.75 dBmax
			1.65 dBPrTrc

Second Series – Azimuth Plot

20M Vertical Dipole at 20 Ft (Red curve)

20M Vertical Dipole at 33 Ft (Green curve)

20M Horizontal Dipole @ 33 Ft (Black curve)

Azimuth Plot @ 5° Elevation

Total Field

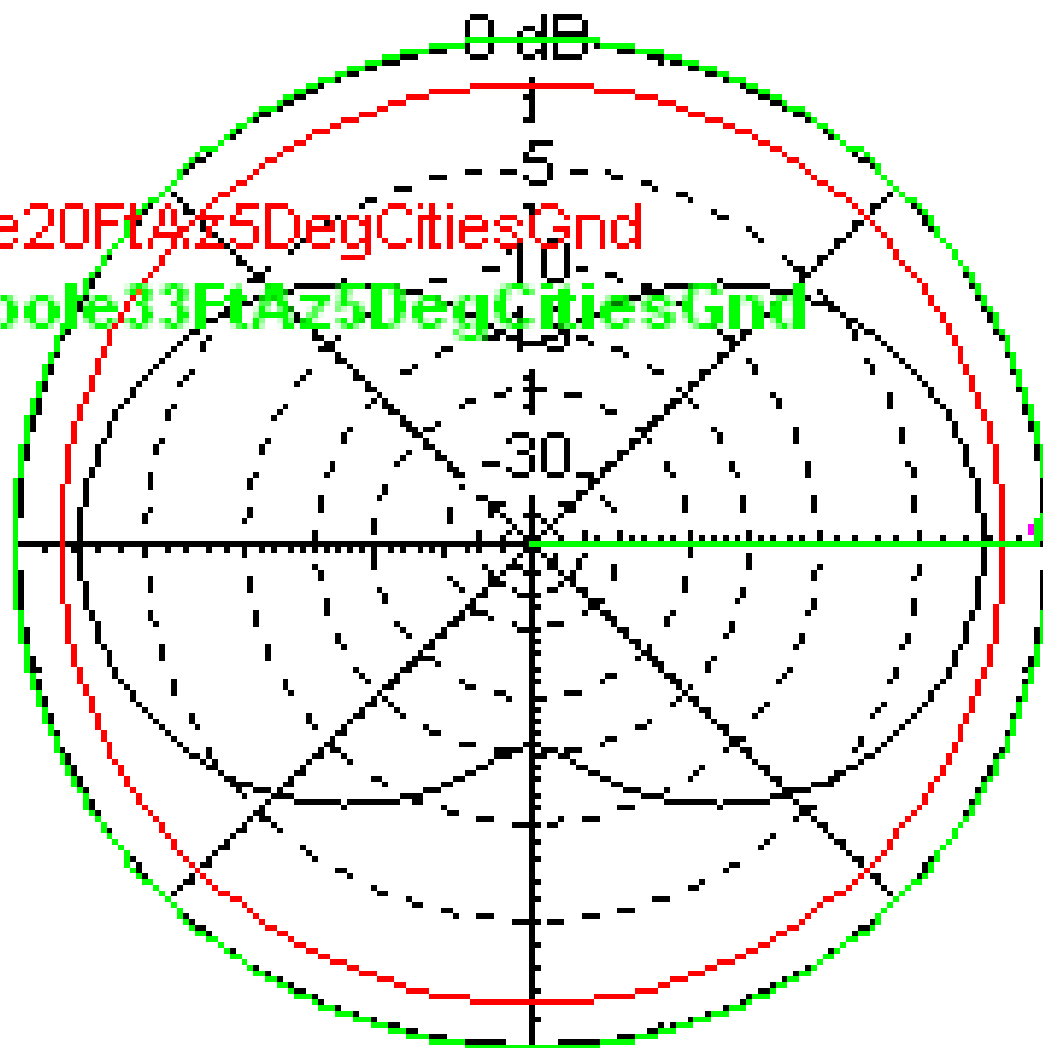
EZNEC Pro/2

Primary

20MVertDipole20FtAz5DegCitiesGnd

20MVertDipole33FtAz5DegCitiesGnd

Cities
Ground



5°
Elevation

20M

Azimuth Plot

Cursor Az

1.0 deg.

Elevation Angle 0.0 deg.

Gain

-1.32 dBi

Outer Ring -1.32 dBi

0.0 dBmax

2.37 dBPrTrc

Black (Reference) Curve is Dipole @ 33 Ft

Total Field

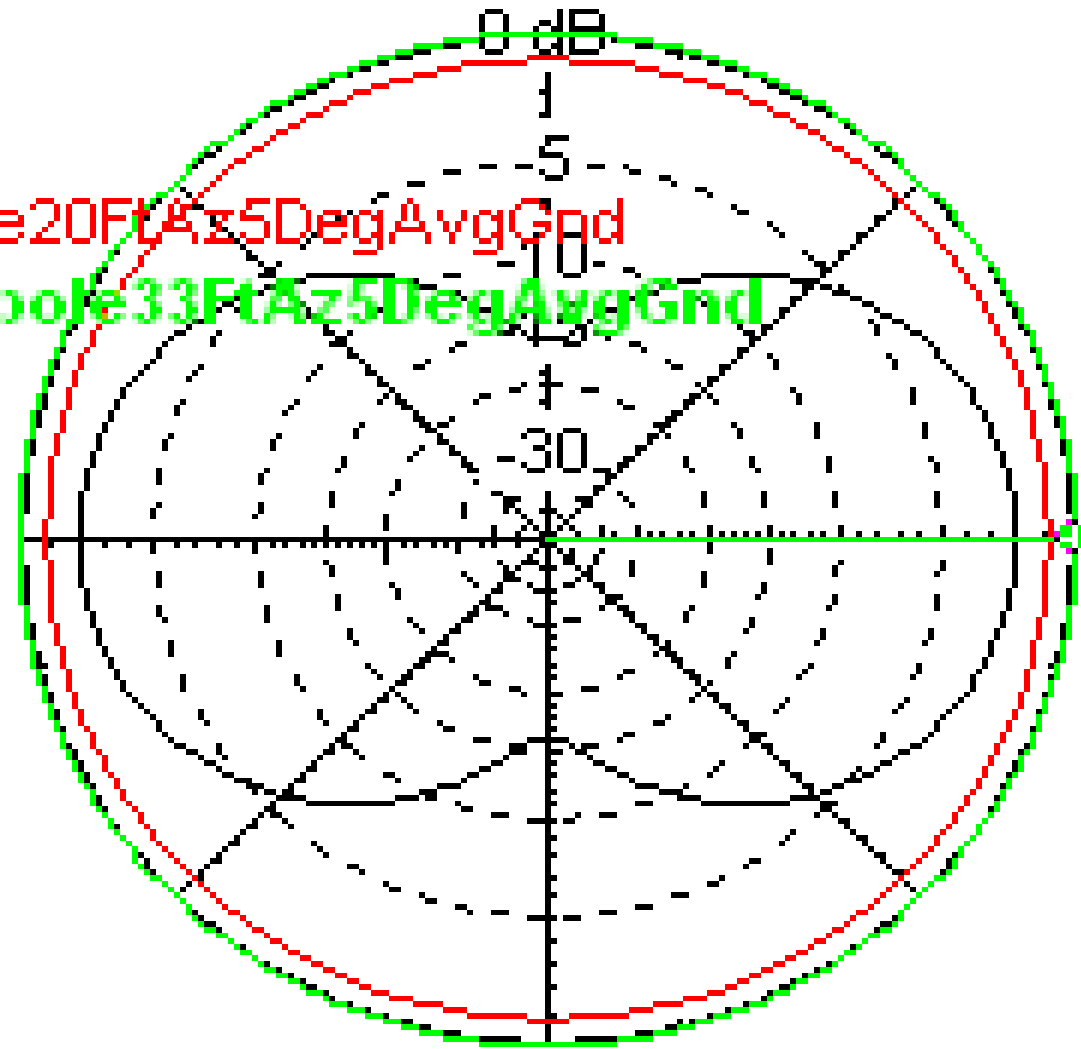
EZNEC Pro/2

Primary

20MVertDipole20FtAz5DegAvgGnd

20MVertDipole33FtAz5DegAvgGnd

Avg Ground



5° Elevation

20M

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	-1.59 dBi
Outer Ring	-1.59 dBi		0.0 dBmax 2.03 dBPrTrc

Black (Reference) Curve is Dipole @ 33 Ft

Total Field

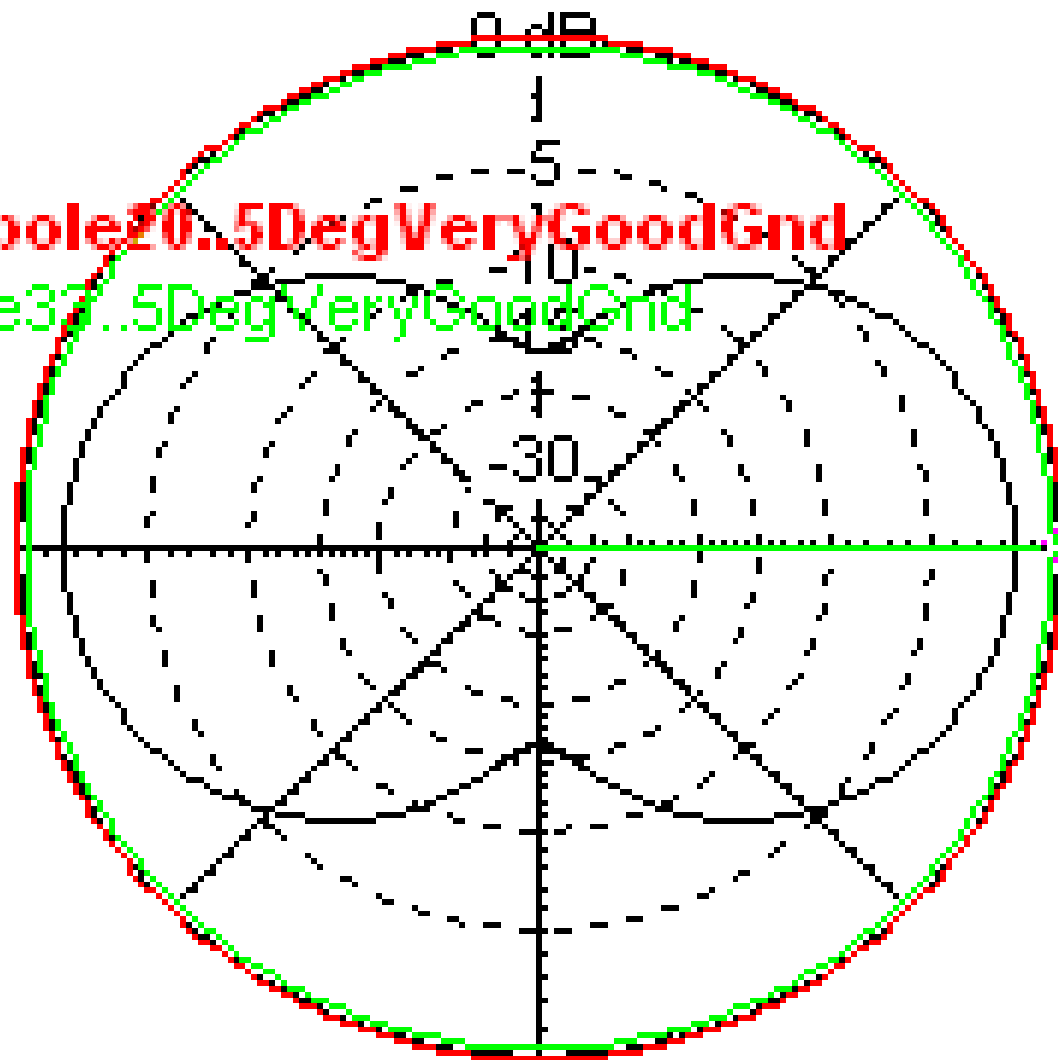
EZNEC Pro/2

Primary

^ 20MVertDipole20.5DegVeryGoodGnd

20MVertDipole33.5DegVeryGoodGnd

Very Good Ground



5° Elevation

20M

Azimuth Plot

Cursor Az

0.0 deg.

Elevation Angle 0.0 deg.

Gain

-1.82 dBi

Outer Ring -1.82 dBi

0.0 dBmax

1.65 dBPrTrc

Black (Reference) Curve is Dipole @ 33 Ft

Third Series

Varying height of 20M 3-el Yagi
@ 33 Ft, 50 Ft, 67 Ft, 84 Ft, 101 Ft
($\lambda/2$, $3\lambda/4$, λ , $5\lambda/4$, $3\lambda/2$)
Azimuth Plot @ 5° Elevation

Total Field

EZNEC Pro/2

Primary

320-50FtAz5deg

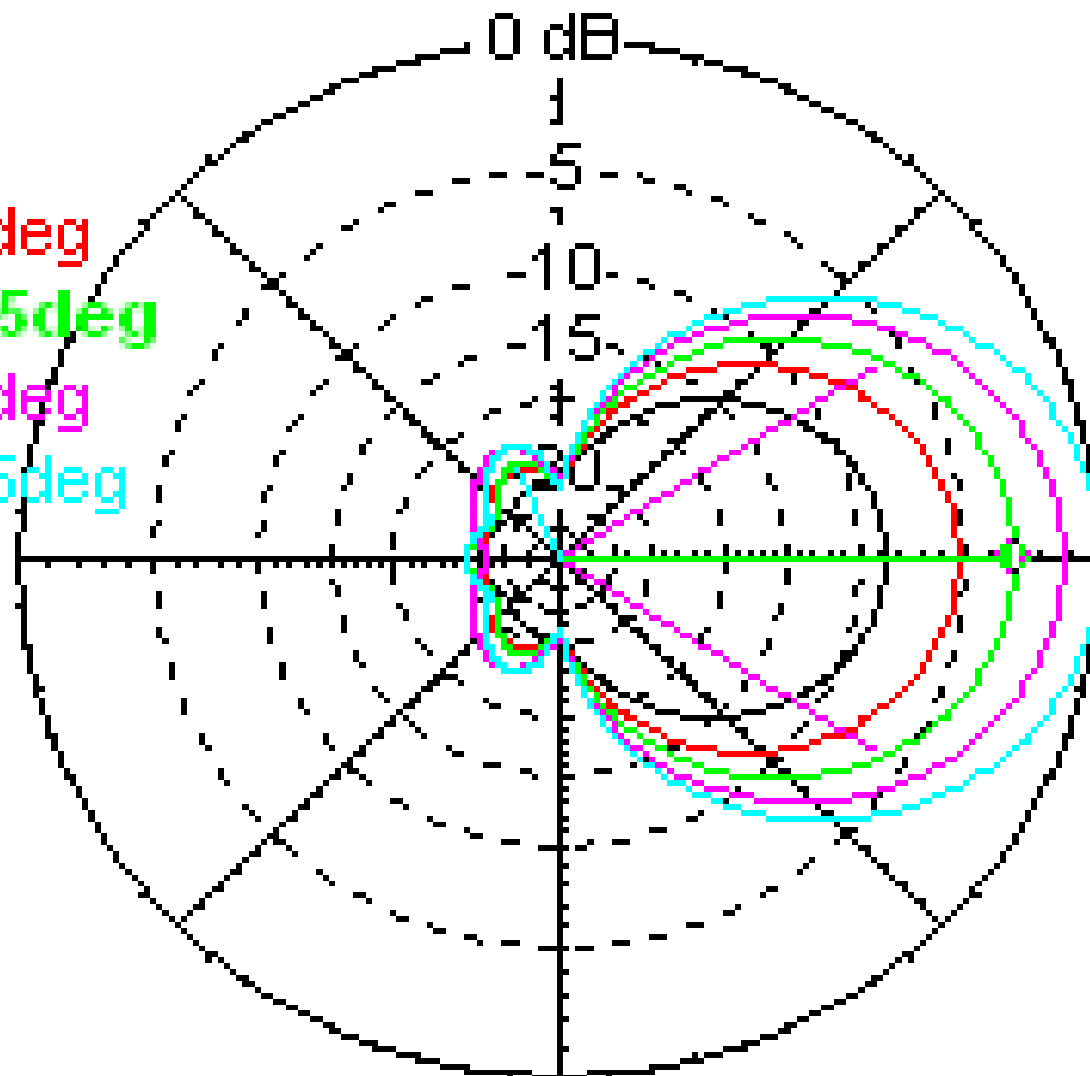
320-67FtAz5deg

320-84FtAz5deg

320-101FtAz5deg

Average Ground

5° Elevation



20M 3-el Yagi

Azimuth Plot

Cursor Az

0.0 deg.

Elevation Angle 0.0 deg.

Gain

7.46 dBi

Outer Ring 10.46 dBi

0.0 dBmax

5.79 dBPrTrc

33 Ft, 50 Ft, 67 Ft, 84 Ft, 101 Ft

Total Field

EZNEC Pro/2

Primary

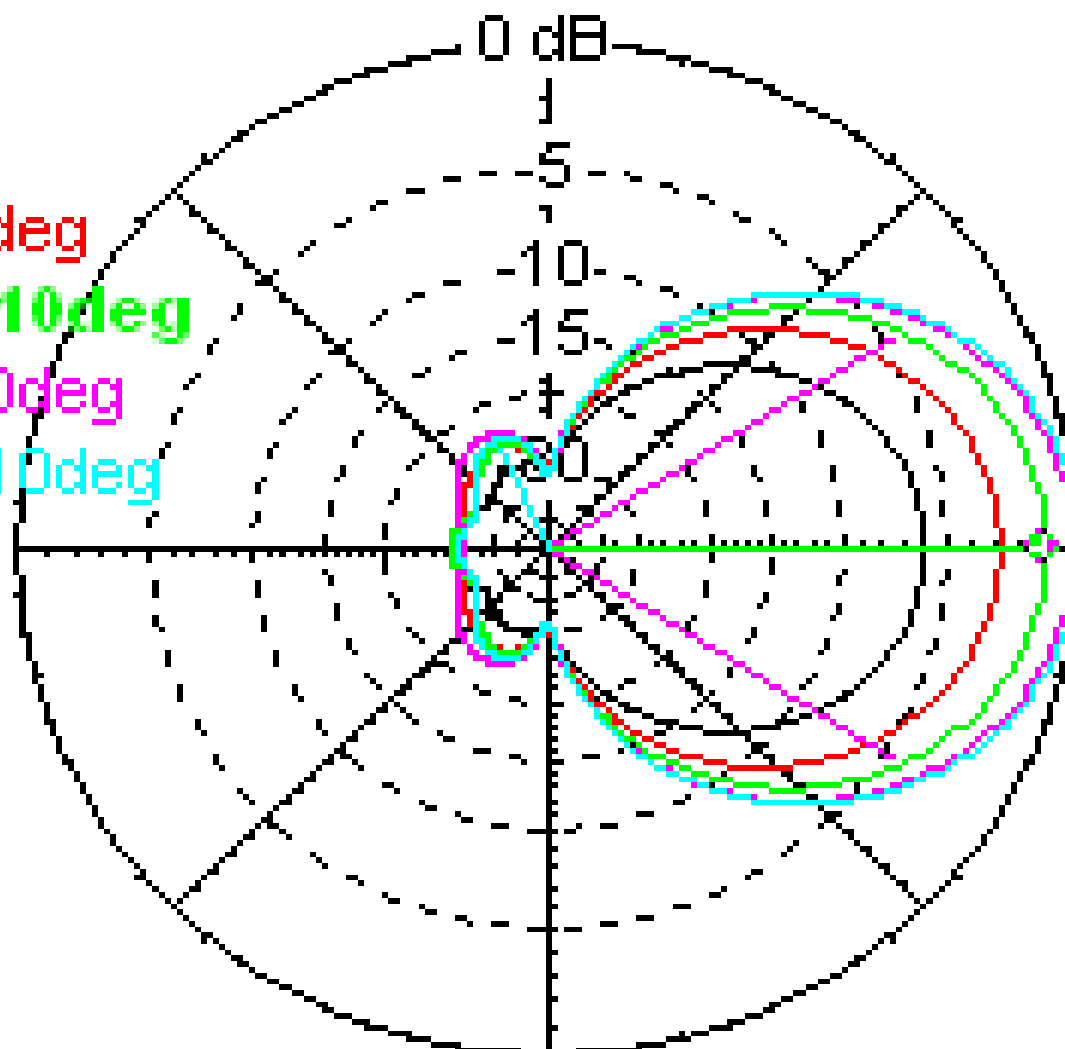
320-50FtAz10deg

^ 320-67FtAz10deg

320-84FtAz10deg

320-101FtAz10deg

Average Ground



10° Elevation

14.2 MHz

Azimuth Plot

Cursor Az

0.0 deg.

Elevation Angle 0.0 deg.

Gain

11.89 dBi

Outer Ring 13.04 dBi

0.0 dBmax

4.8 dBPrTrc

33 Ft, 50 Ft, 67 Ft, 84 Ft, 101 Ft

Total Field

EZNEC Pro/2

Average Ground

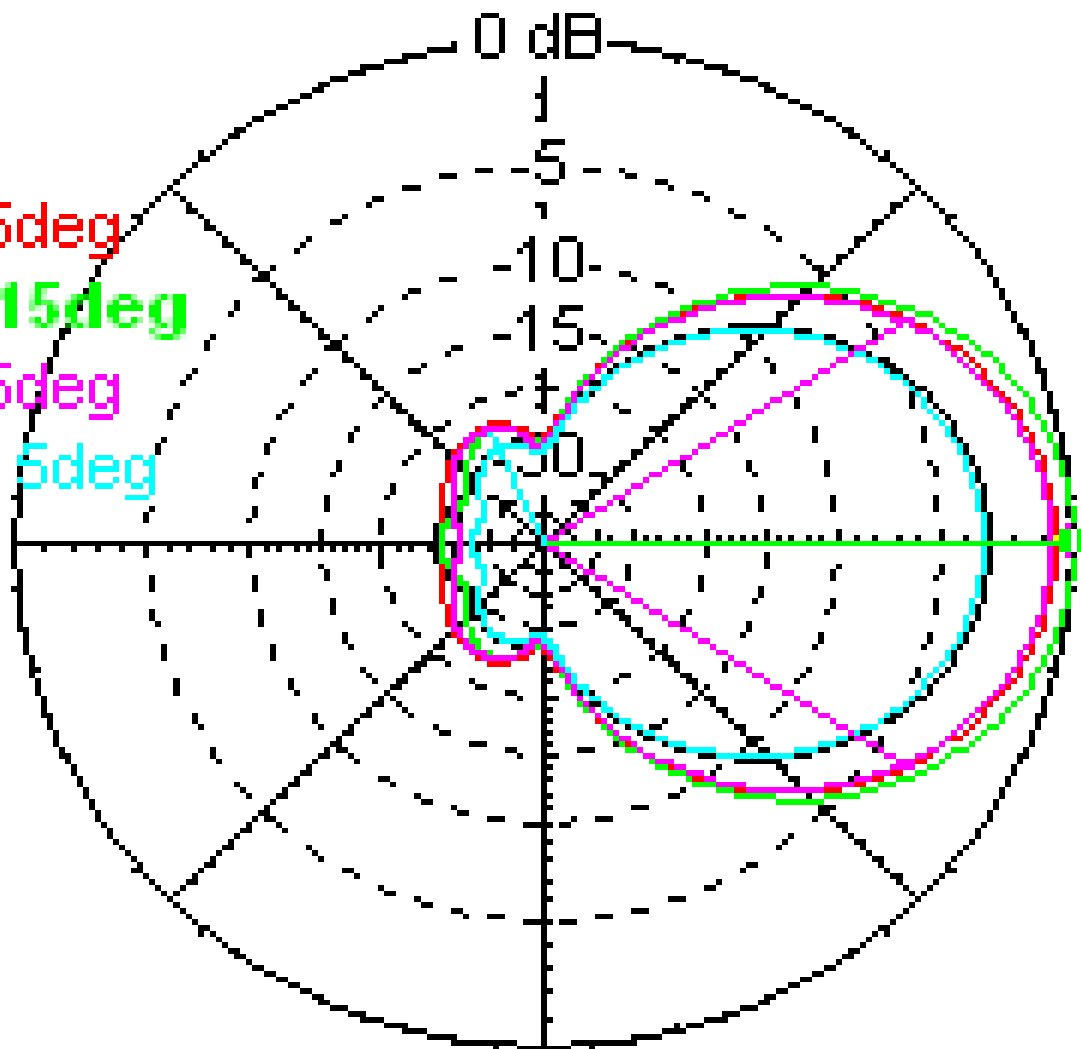
Primary

320-50FtAz15deg

^ 320-67FtAz15deg

320-84FtAz15deg

320-101FtAz15deg

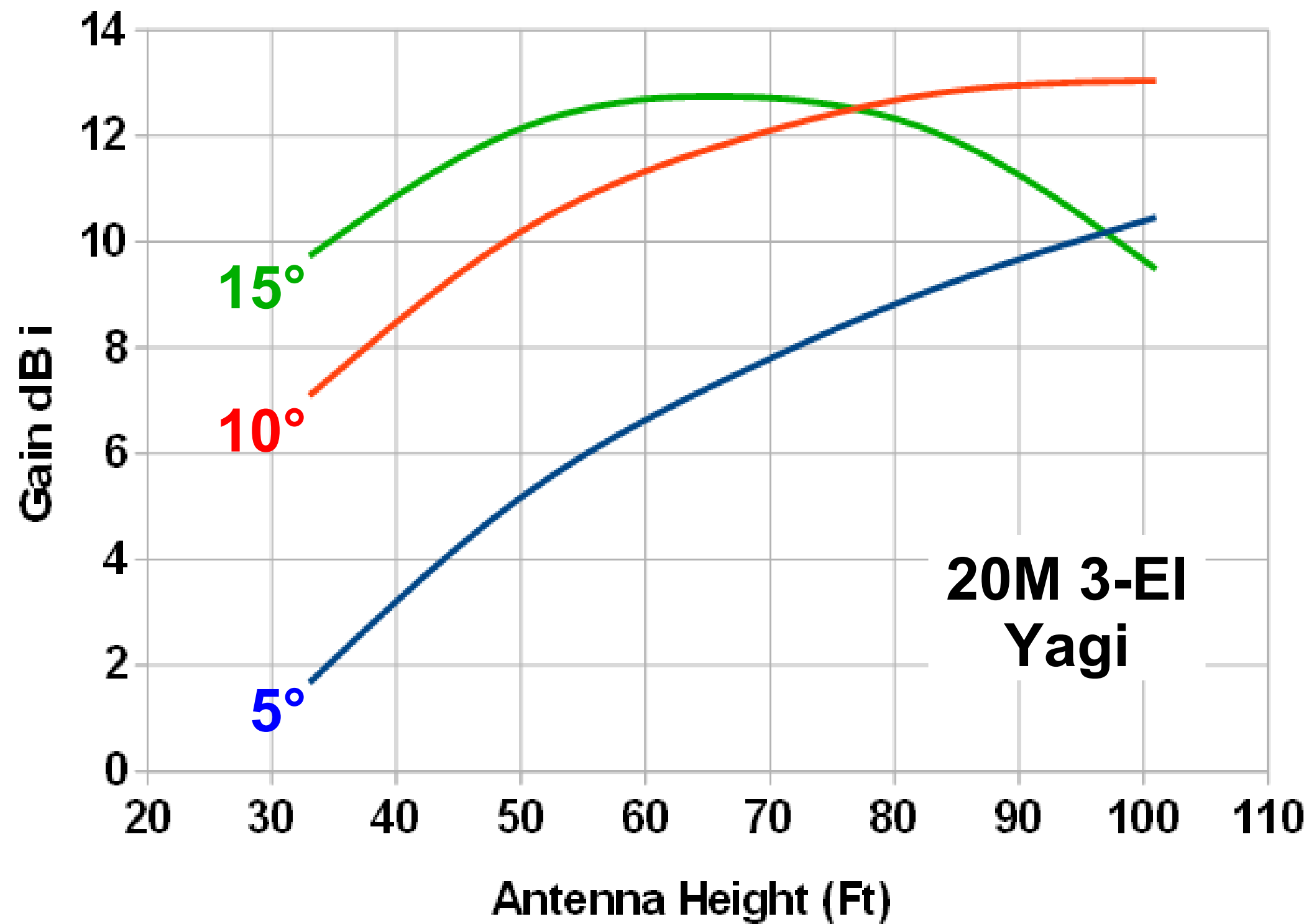


15° Elevation

20M 3-el Yagi

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	12.74 dBi
Outer Ring	12.74 dBi		0.0 dBmax 3.01 dBPrTrc

33 Ft, 50 Ft, 67 Ft, 84 Ft, 101 Ft



How Much is Height Worth on 20M?

- For a 20M Yagi (or horizontal dipole) at low angles
 - 1 dB for 5 ft between 30 Ft and 60 Ft
 - 6 dB for $\lambda/2$ (33 Ft) to λ (67 Ft)
 - 2 dB at 5° for 67 Ft to 100 Ft

Fourth Series

**Height of 20M 3-el Yagi (Black curves)
@ 33 Ft, 50 Ft, 67 Ft ($\lambda/2$, $3\lambda/4$, λ)**

$\lambda/2$ Vertical dipole at 33 Ft (Red curves)

Azimuth Plot @ 5° Elevation

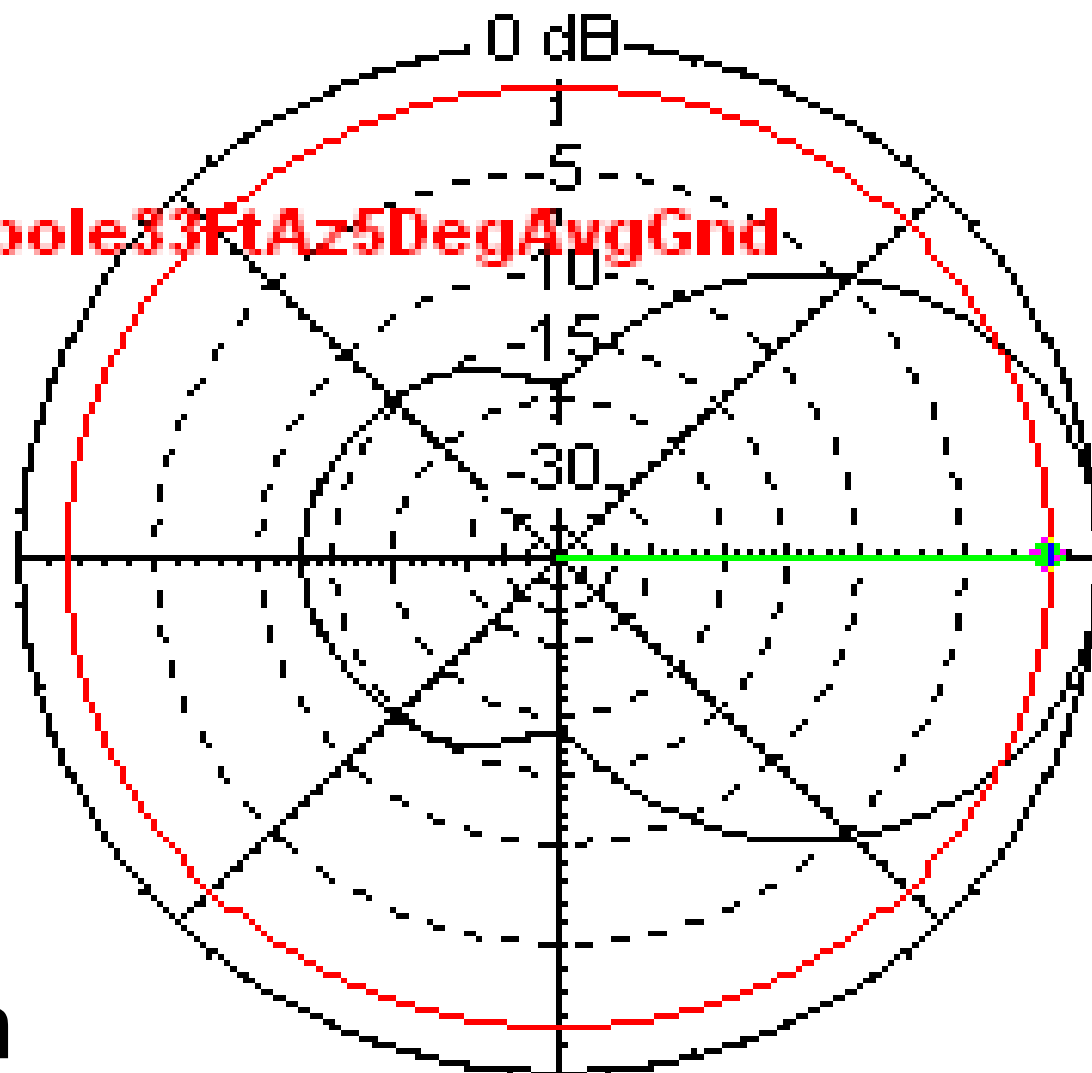
Total Field

EZNEC Pro/2



20M Vert Dipole 33Ft Az 5Deg Avg Gnd

Average Ground



5° Elevation

20M 3-el Yagi, 33Ft

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	-1.59 dBi
Outer Ring	0.06 dBi		0.0 dBmax -1.65 dBPrTrc

Vertical Dipole @ 33 Ft

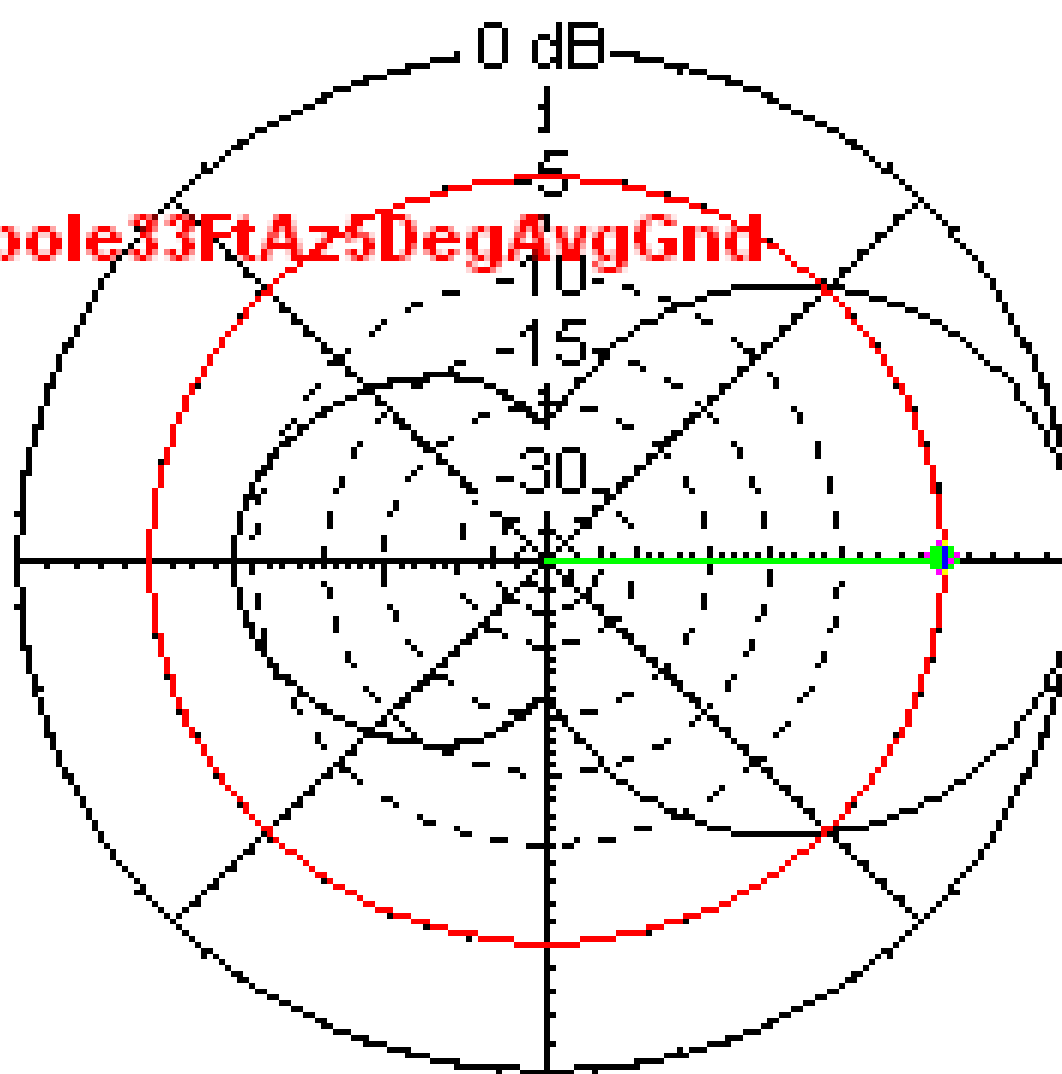
Total Field

EZNEC Pro/2

Primary

^ 20MVertDipole33FtAz5DegAvgGnd

**Average
Ground**



**5°
Elevation**

**20M 3-el
Yagi, 50 Ft**

Azimuth Plot

Cursor Az

0.0 deg.

Elevation Angle 0.0 deg.

Gain

-1.59 dBi

Outer Ring 3.46 dBi

0.0 dBmax

-5.05 dBPrTrc

Vertical Dipole @ 33 Ft

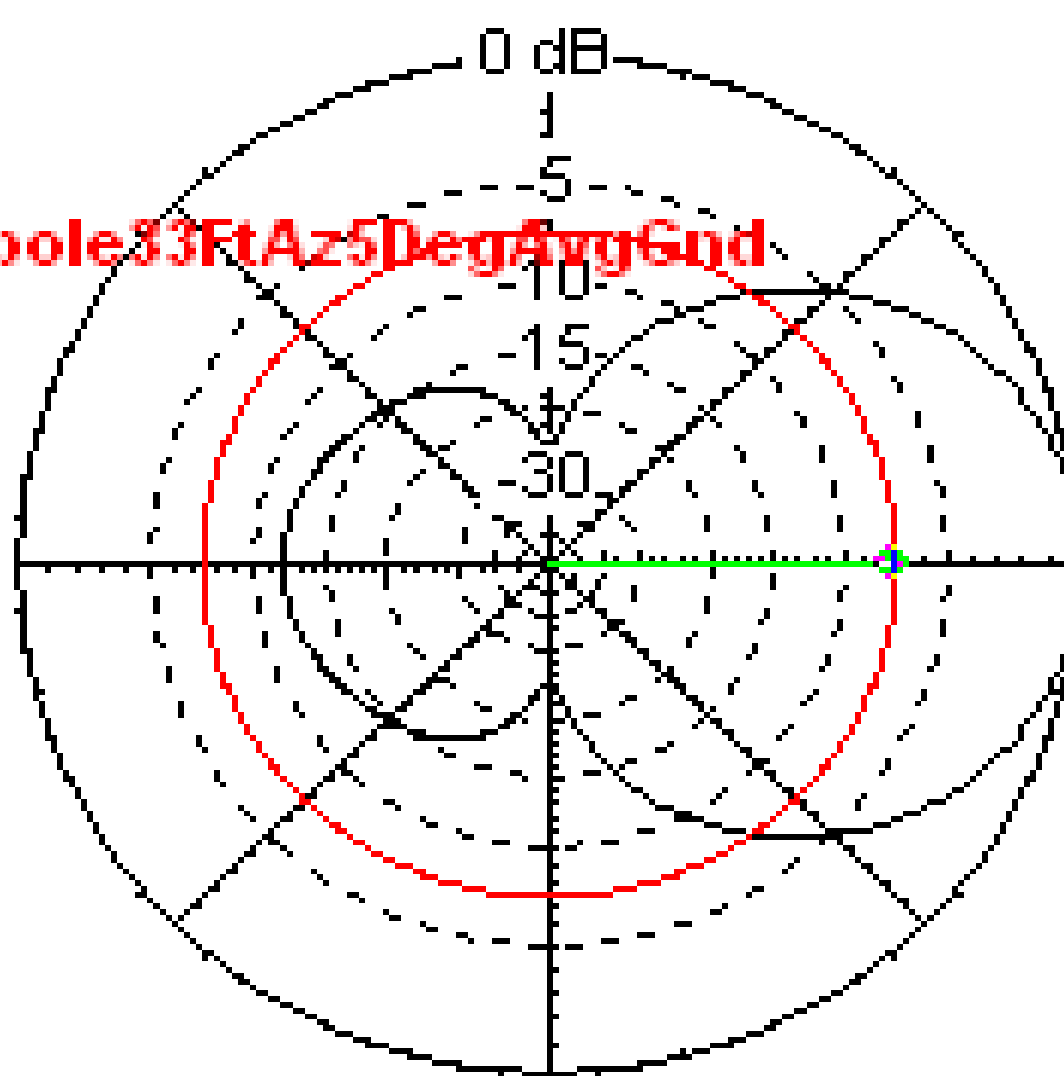
Total Field

EZNEC Pro/2

Primary

**Average
Ground**

*** 20M Vert Dipole 33 Ft Az 5 Deg Ang Gnd**



**5°
Elevation**

**20M 3-el
Yagi, 67 Ft**

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	-1.59 dBi
Outer Ring	5.78 dBi		0.0 dBmax
			-7.38 dBPrTrc

Vertical Dipole @ 33 Ft

Fifth Series

**Height of 20M Dipole
@ 33 Ft, 40 Ft, 50 Ft, 60 Ft**

Average
Ground

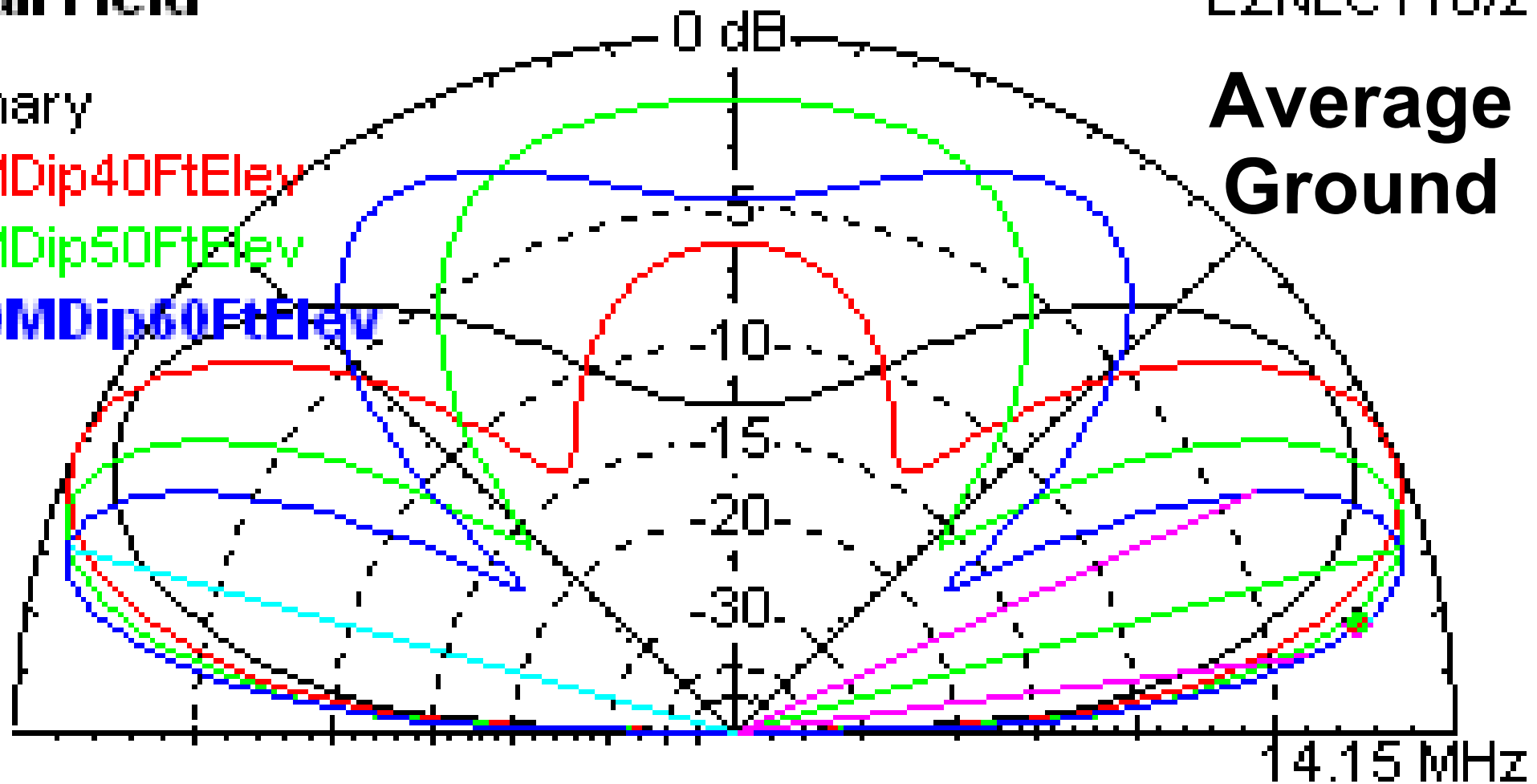
Total Field

Primary

20MDip40FtElev

20MDip50FtElev

20MDip60FtElev



Elevation Plot

Cursor Elev

10.0 deg.

Azimuth Angle

5.0 deg.

Gain

5.58 dBi

Outer Ring

7.78 dBi

-1.54 dBmax

3.74 dBPrTrc

Effect of Height on a Horizontal 20M Dipole

Higher Antennas Have Nulls

- Nulls in vertical pattern begin for height $> \lambda/2$
 - 67 Ft on 40M
 - 33 Ft on 20M
 - 22 Ft on 15M
 - 17 Ft on 10M
- The Null starts high, move down as antenna is raised
- Above λ , a second null develops
- Height does the same thing to a Yagi

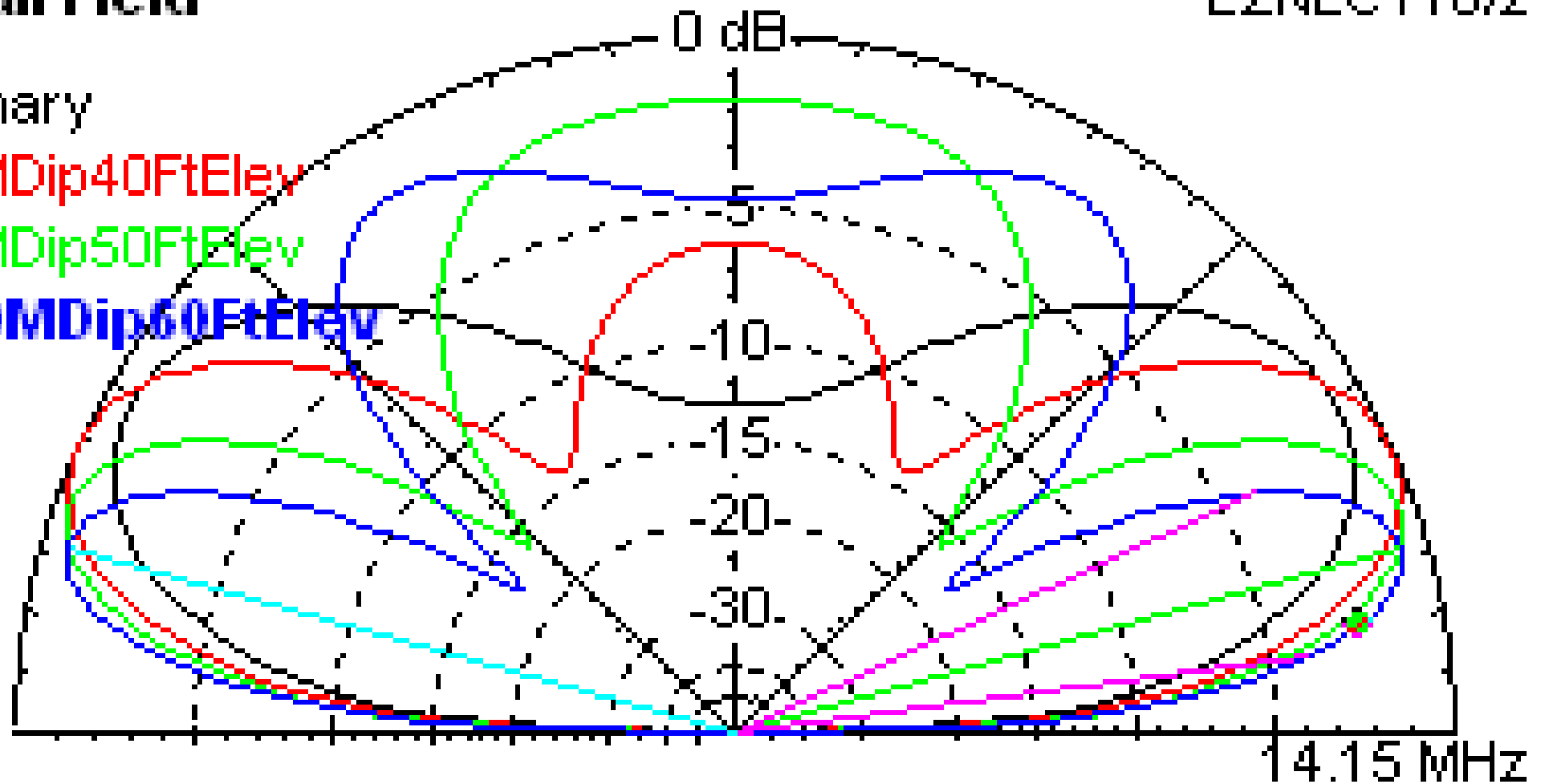
Total Field

Primary

20MDip40FtElev

20MDip50FtElev

20MDip60FtElev



Elevation Plot

Cursor Elev

10.0 deg.

Azimuth Angle

5.0 deg.

Gain

5.58 dBi

Outer Ring

7.78 dBi

-1.54 dBmax

3.74 dBPrTrc

Effect of Height on a Horizontal 20M Dipole

Sixth Series

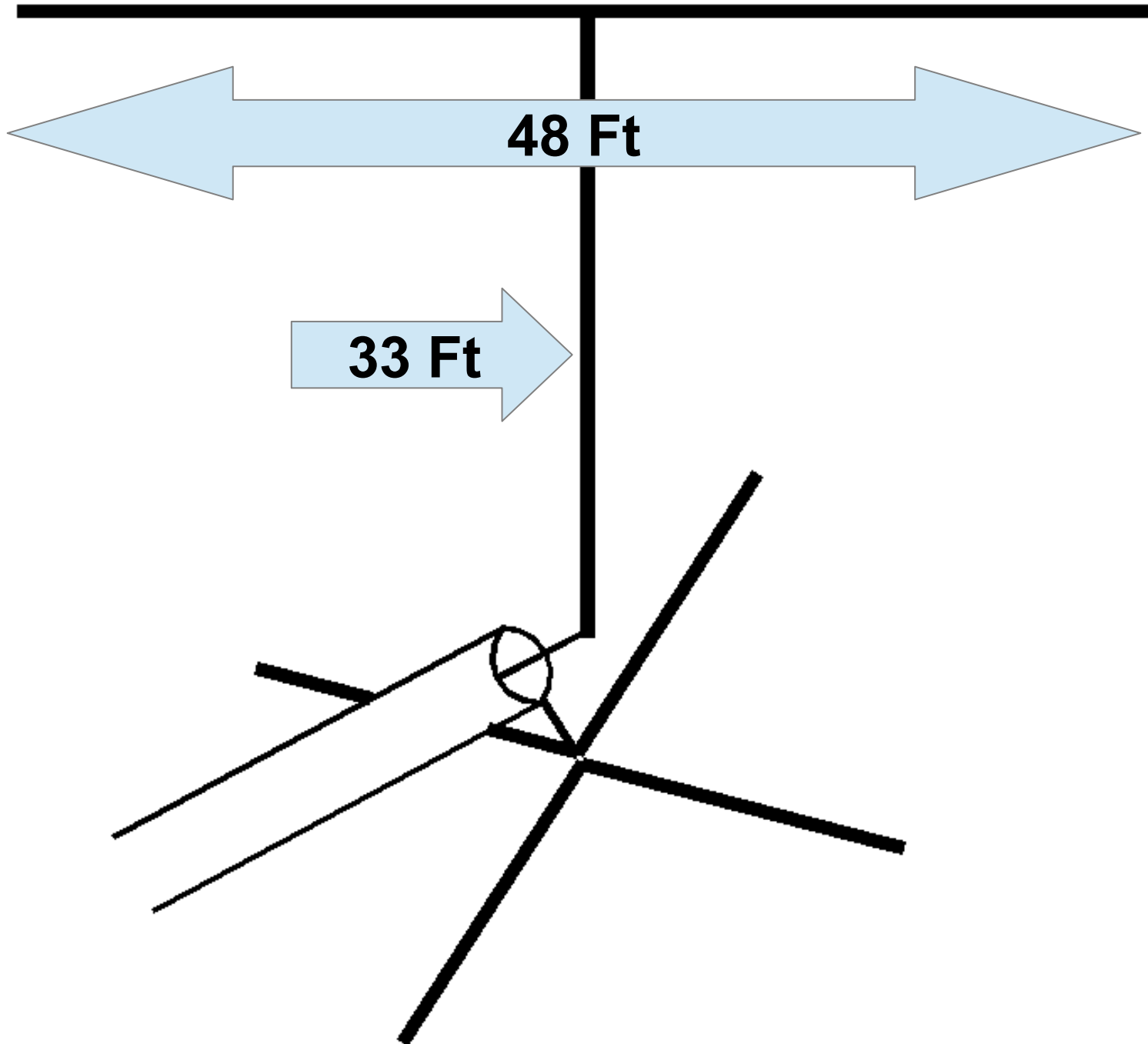
Vertical or Low Dipole for 80M?

80M $\lambda/2$ (133 ft long) Dipole at 33 ft (Black curve)

33 Ft Tall Tee Vertical w/48 Ft Top (Red curve)

Poor to Average Grounds

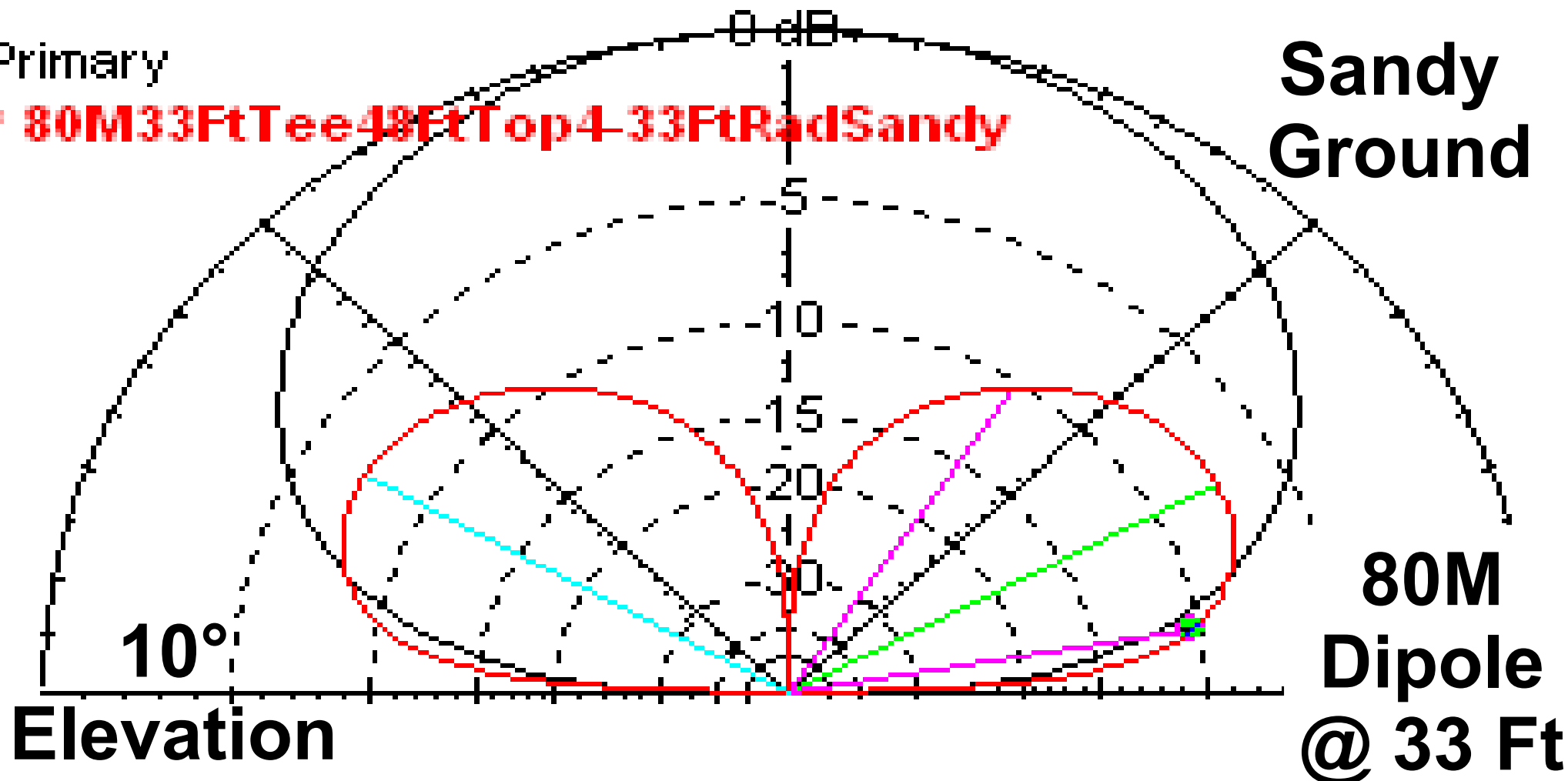
Simple Tee Vertical



Total Field

Primary

^ 80M33FtTee48FtTop4-33FtRadSandy

Sandy
Ground

Elevation Plot

Cursor Elev

10.0 deg.

Azimuth Angle

0.0 deg.

Gain

-5.48 dBi

Outer Ring

4.88 dBi

-3.06 dBmax

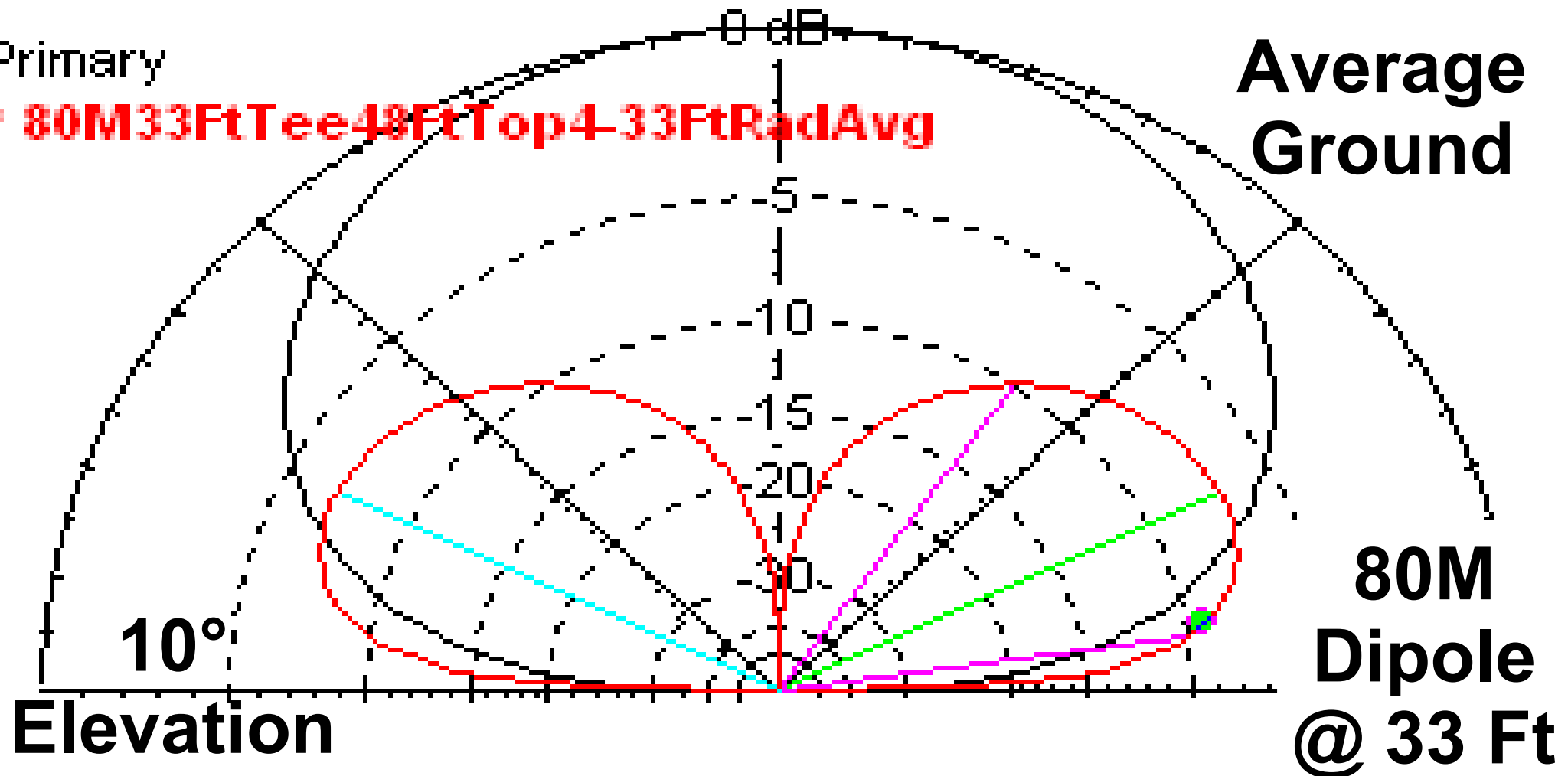
2.08 dBPrTrc

Tee Vertical 33 Ft Tall, 48 Ft Top

Total Field

Primary

^ 80M33FtTee48FtTop4-33FtRadAvg

Average
Ground

Elevation Plot		Cursor Elev	10.0 deg.
Azimuth Angle	0.0 deg.	Gain	-3.48 dBi
Outer Ring	5.78 dBi		-2.33 dBmax
			3.79 dBPrTrc

Tee Vertical 33 Ft Tall, 48 Ft Top

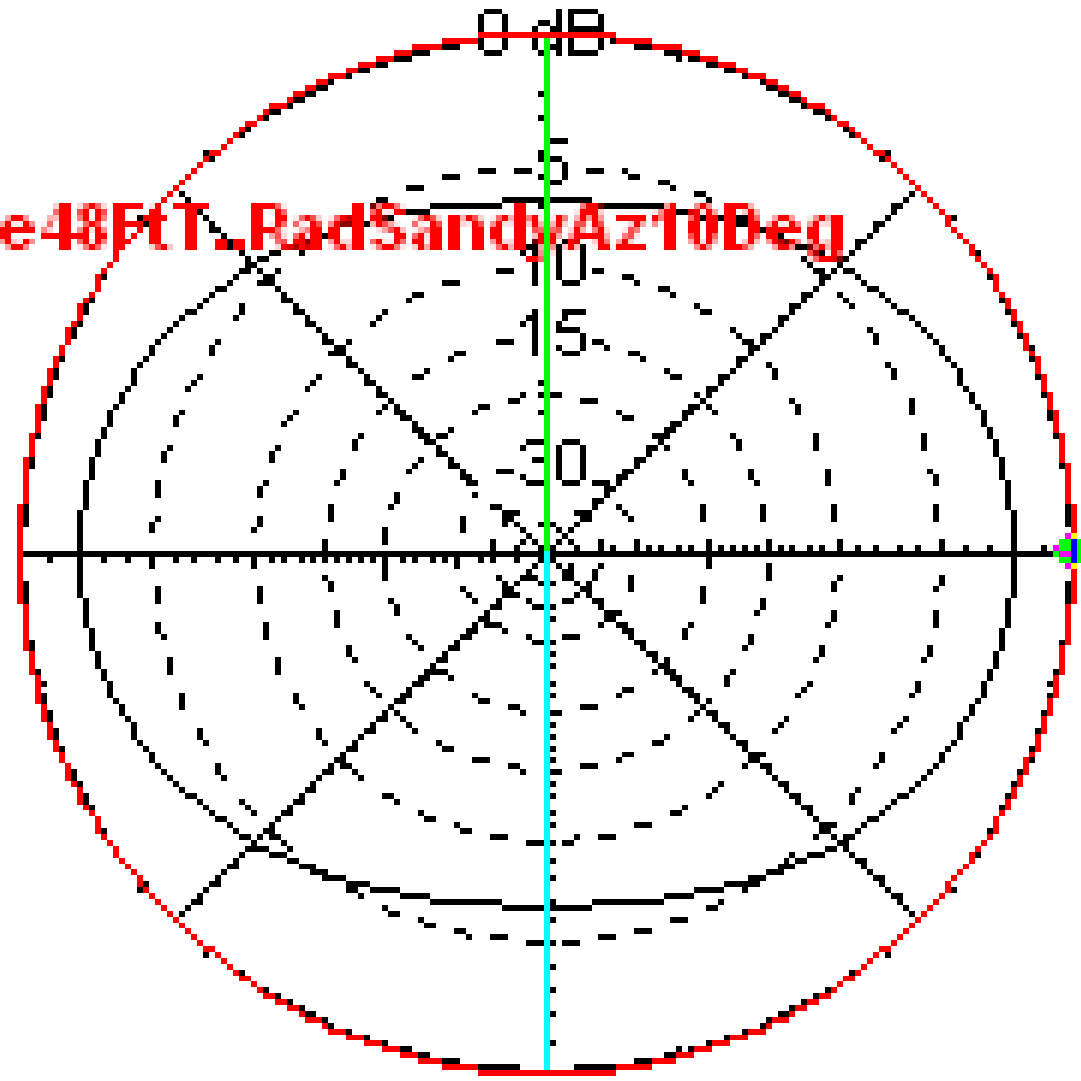
Total Field

EZNEC Pro/2

Primary

80M 33Ft Tee 48Ft Rad Sandy Az 10Deg

Poor Ground



80M Dipole @ 33 Ft

10° Elevation

Azimuth Plot		Cursor Az	0.0 deg.
Elevation Angle	0.0 deg.	Gain	-5.53 dBi
Outer Ring	-5.48 dBi		-0.05 dBmax
			2.04 dBPrTrc

Tee Vertical 33 Ft Tall, 48 Ft Top

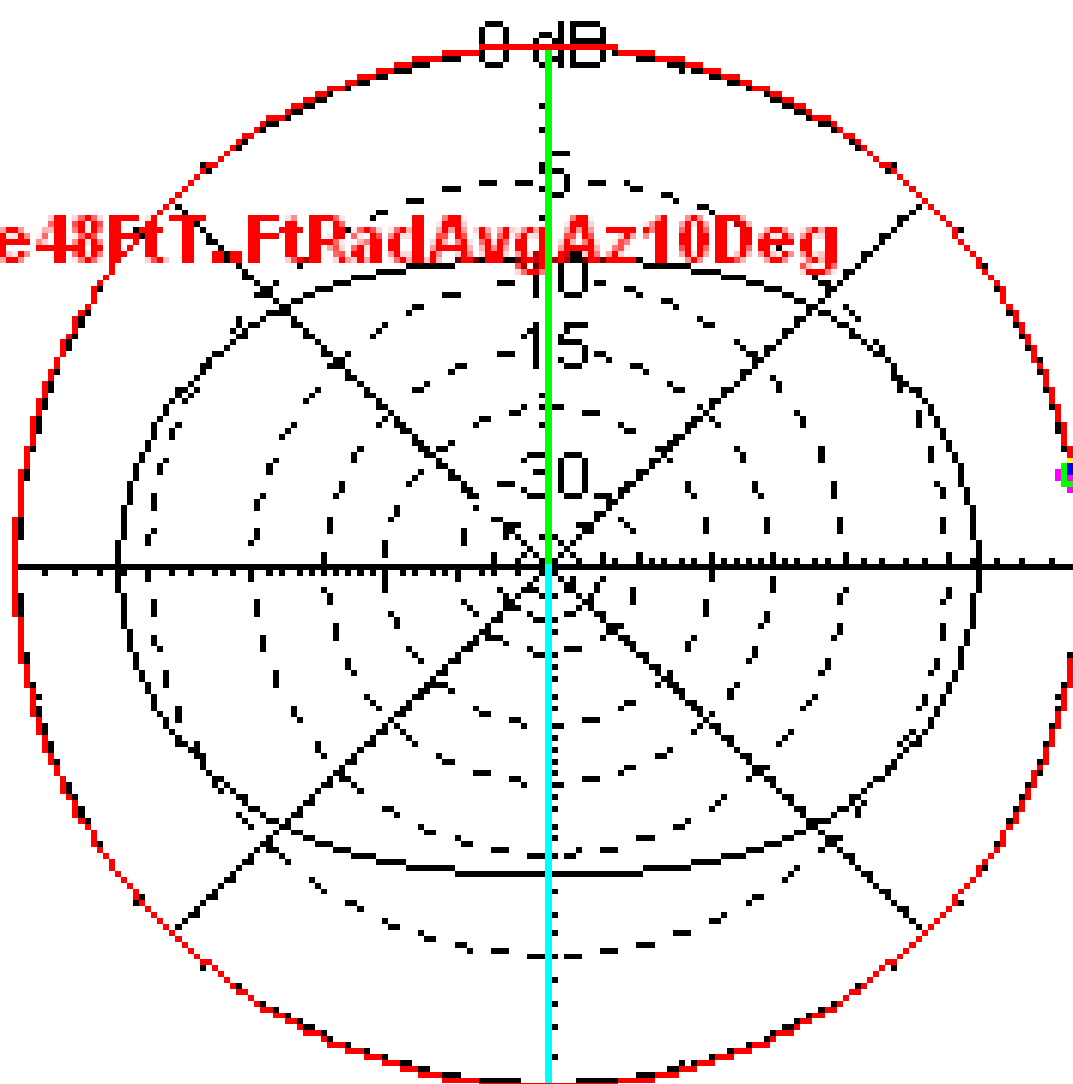
Total Field

EZNEC Pro/2

Primary

80M33FtTee48FtRadAvgAz10Deg

Average Ground



10° Elevation

80M Dipole @ 33 Ft

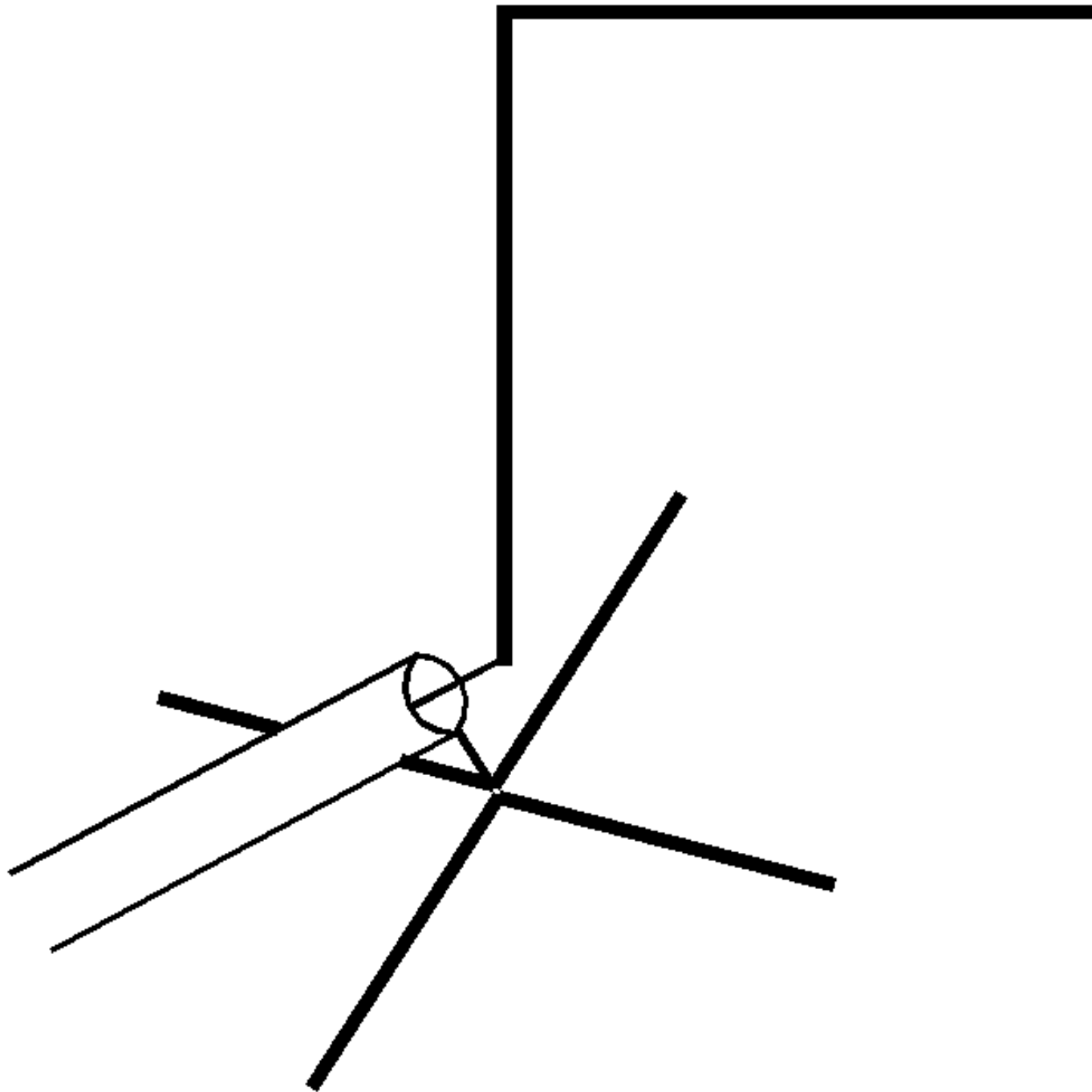
Azimuth Plot		Cursor Az	10.0 deg.
Elevation Angle	0.0 deg.	Gain	-3.54 dBi
Outer Ring	-3.48 dBi		-0.06 dBmax
			3.86 dBPrTrc

Tee Vertical 33 Ft Tall, 48 Ft Top

Conclusions – What We've Learned

- **Higher/taller is nearly always better**
 - **All verticals work better up in the air**
 - **High horizontal antennas work better**
- **Inverted L or Tee vertical with radials beats a low dipole**
 - **40 ft is low for 80M**
 - **125 ft is low for 160M**

Inverted L



How Much is Height Worth?

- **For a 40M horizontal dipole (or Yagi)**
 - **0.9 dB for 5 ft between 30 Ft and 70 Ft below 15°**
 - **6 dB for $\lambda/4$ (33 Ft) to $\lambda/2$ (67 Ft)**
 - **2.5 dB for $\lambda/2$ (67 Ft) to λ (133 Ft)**
- **For a 20M Yagi (or horizontal dipole)**
 - **1 dB for 5 ft between 30 Ft and 60 Ft**
 - **6 dB for $\lambda/2$ (33 Ft) to λ (67 Ft)**
 - **2 dB at 5° for 67 Ft to 100 Ft**

How Much is a Tower Worth?

- For a 40M horizontal dipole (or Yagi)
 - 0.9 dB for 5 ft between 30 Ft and 70 Ft below 15°
 - 6 dB for $\lambda/4$ (33 Ft) to $\lambda/2$ (67 Ft)
 - 2.5 dB for $\lambda/2$ (67 Ft) to λ (133 Ft)
- For a 20M Yagi (or horizontal dipole)
 - 1 dB for 5 ft between 30 Ft and 60 Ft
 - 6 dB for $\lambda/2$ (33 Ft) to λ (67 Ft)
 - 2 dB at 5° for 67 Ft to 100 Ft

How Much is Height Worth?

- For an 80M horizontal dipole (or Yagi) at 15° and below
 - 0.9 dB for 10 ft between 40 Ft and 130 Ft
 - 3.5 dB for $\lambda/8$ (33 Ft) to $\lambda/4$ (67 Ft)
 - 6 dB for $\lambda/4$ (67 Ft) to $\lambda/2$ (133 Ft)
- On the lower bands, we need less signal to work short distances than long distances
- Antennas cannot be “too high” or too tall for 80M or 160M, and few of us can get an antenna too high for 40M

Most Rules Have Exceptions

- **Terrain affects an antenna's vertical pattern**
 - **Use HFTA to study your non-flat QTH**
 - **ARRL Antenna Book CD**
- **Verticals are usually best for all distances on 160M**

Most Rules Have Exceptions

- **Most DX is at low angles – but not always!**
 - **If DX is at high angles, a lower antenna may work better**
- **We may want to work short distances (a few hundred miles) on 80M and 40M**
 - **Verticals don't work well at high angles (which is why verticals are thought of as weak by ragchewers on 75 and 40M)**
 - **Horizontal antennas will work better**

For NVIS

- **For a horizontal dipole, $\lambda/4$ high is near optimum**
 - **133 ft on 160M**
 - **67 ft on 80M**
 - **33 ft on 40M**
- **Horizontal antenna lower than $\lambda/4$ are both cloud-warmers and worm warmers**
- **The only reason to rig a horizontal antenna lower than $\lambda/4$ is that's the highest you can rig it**

Using What We've Learned

- **Study your QTH for a while**
- **Explore all possible skyhooks, their cost**
- **Try to rig dipoles broadside to 70° - 90° Az**
 - **Nulls matter more than peaks**
 - **Nulls should avoid population centers**
- **Avoid crossing over a power line**
- **Be safe – get help from other hams when you need it**

Using What We've Learned

- Don't let the “great” be the enemy of the good
- Use this presentation to help you learn what works best for what you can do
- Put something up and get on the air
- Any antenna that's in the air works better than an antenna that's in your basement!
- Think about ways to do it better
- Use my results to predict the relative results of antennas that you can rig

2-El Yagi 40M or Higher Dipoles?

- **If I had a choice between 2 elements at 70 feet on a tower, or two dipoles at right angles at 120 ft, which gives me the best bang for the buck?**
 - **120 ft is 2dB better on 40M than 70 ft**
 - **40M Yagi is about 3.5 dB better than a dipole at the same height (assuming compact version)**
 - **The Yagi at 70 ft is 1.5dB better than dipoles at 120 ft for same feedline length**

Cost of the Two Options

- **Cost of two high dipoles**
 - About \$1,800 if you have the trees (\$1,400 for climbers, \$400 for antennas, coax, chokes)
- **Cost of Optibeam Moxon on 70 ft tower**
 - About \$7,500 (\$2,500 for antenna, coax, choke, \$2,000 for the tower, \$1,000 for rotor & cable, \$2,000 for climber)
- **Cost of Yagi 1.5dB advantage about \$5,500**
- **Cheaper for what you can do yourself**

References and More Ideas

- On k9yc.com/publish.htm
 - *If I Can Put My HF Vertical on my Roof, Should I?*
 - *Antennas For Limited Space (Power Point)*
 - *Getting On 160M From a Small Lot (and Larger Ones Too)*
- ARRL Antenna Book

Antenna Planning for Small HF Stations (and even larger ones)

Jim Brown K9YC

k9yc@arri.net

<http://k9yc.com/publish.htm>