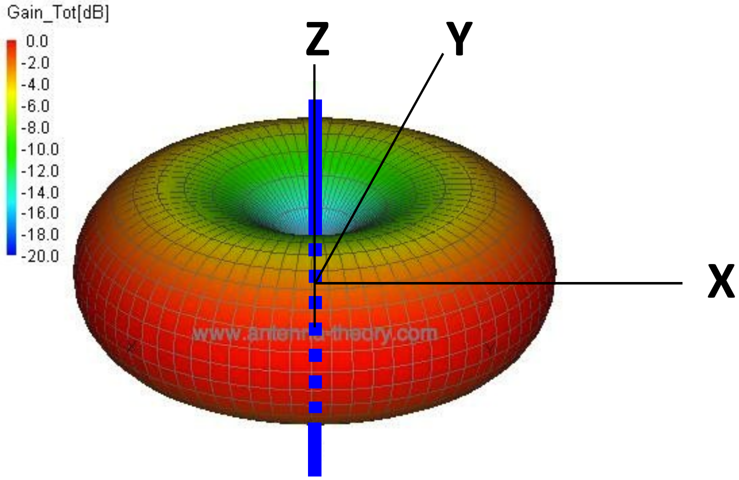
Using EZNEC To Compare Antennas Part 4

Bill Leonard N0CU

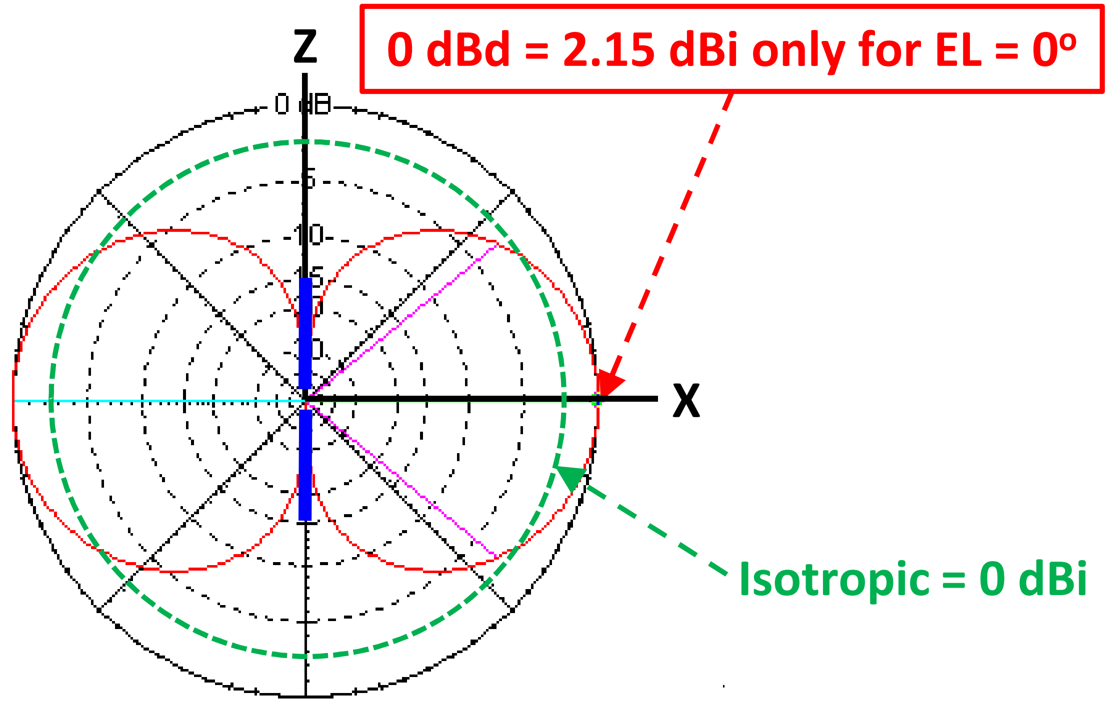
Topics

- Dipole in Free Space
- What is dBd
- Reflections from real ground
- Horizontal dipole at different heights over different grounds
- Vertical dipole at different heights over different grounds
- Full wave loops over real ground

Dipole in ***Free Space***

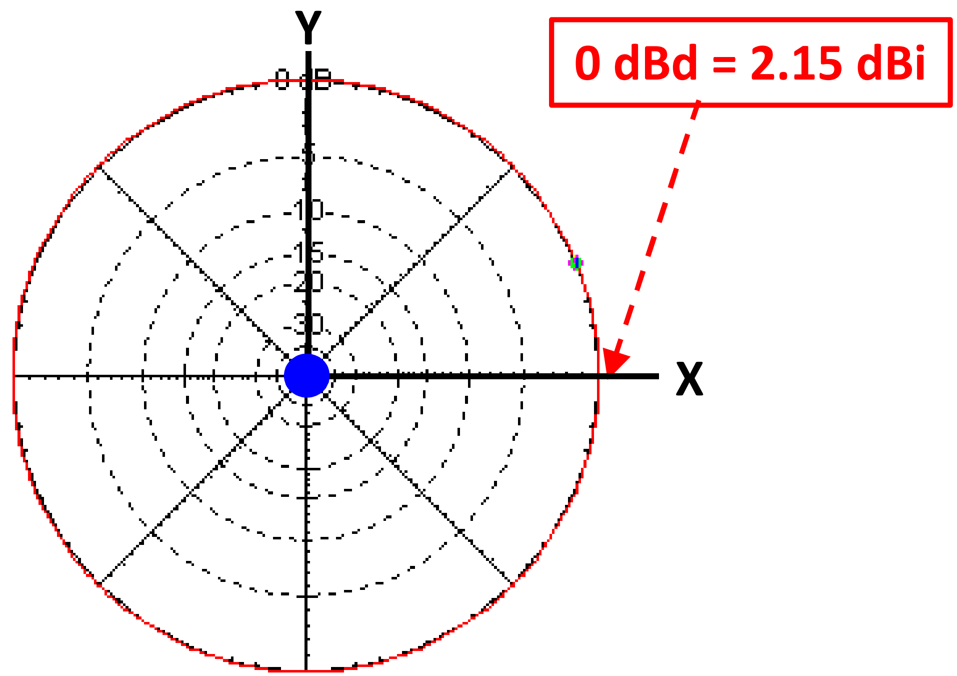


ELEVATION



F_o:	14.15 MHz
Gain:	2.15 dBi
EL Angle:	n/a°
EL BW:	n/a°
AZ BW:	78.2°
R:	72.1 Ω
SWR:	1.44
Length (#12):	33.719 ft

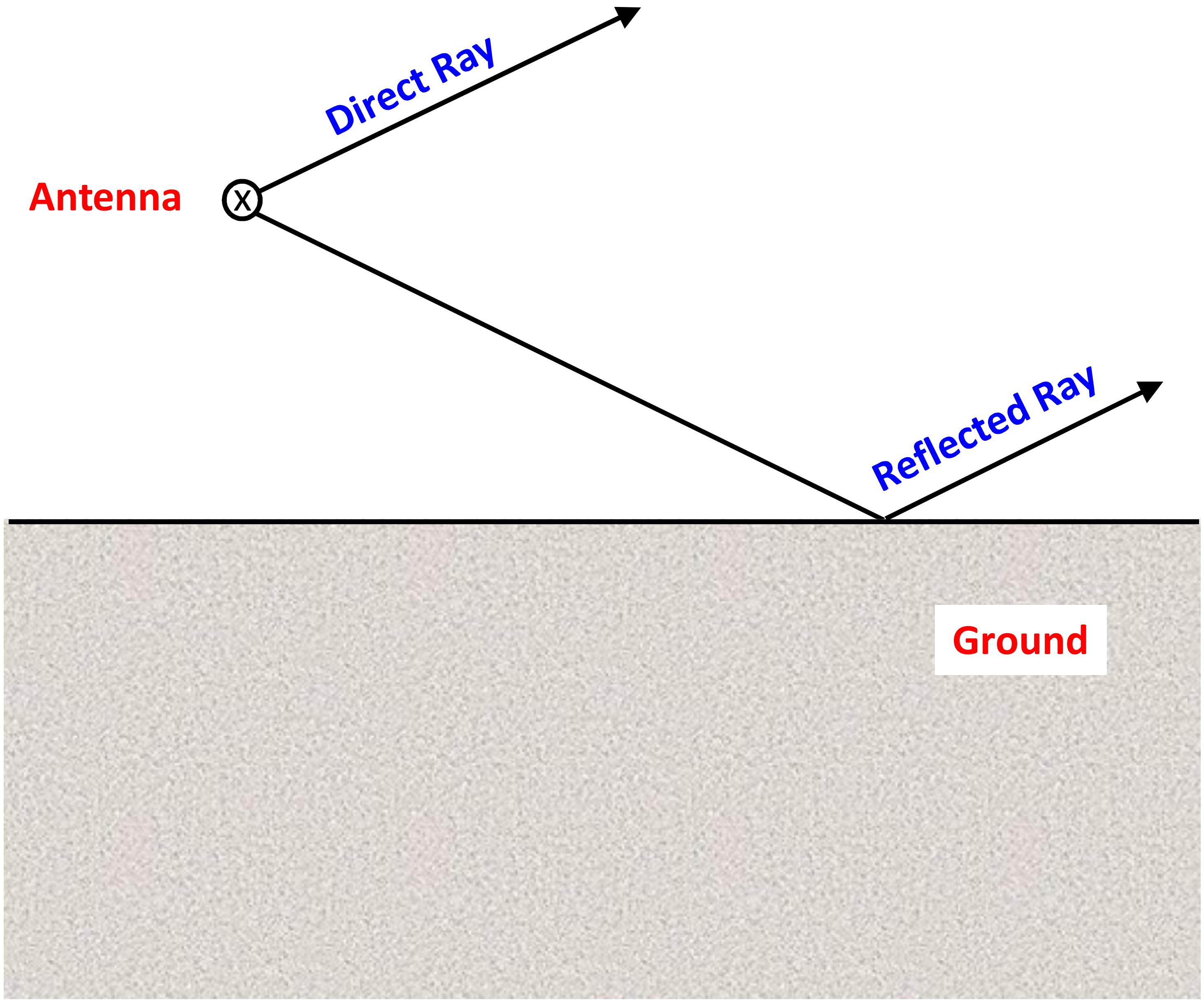
AZIMUTH



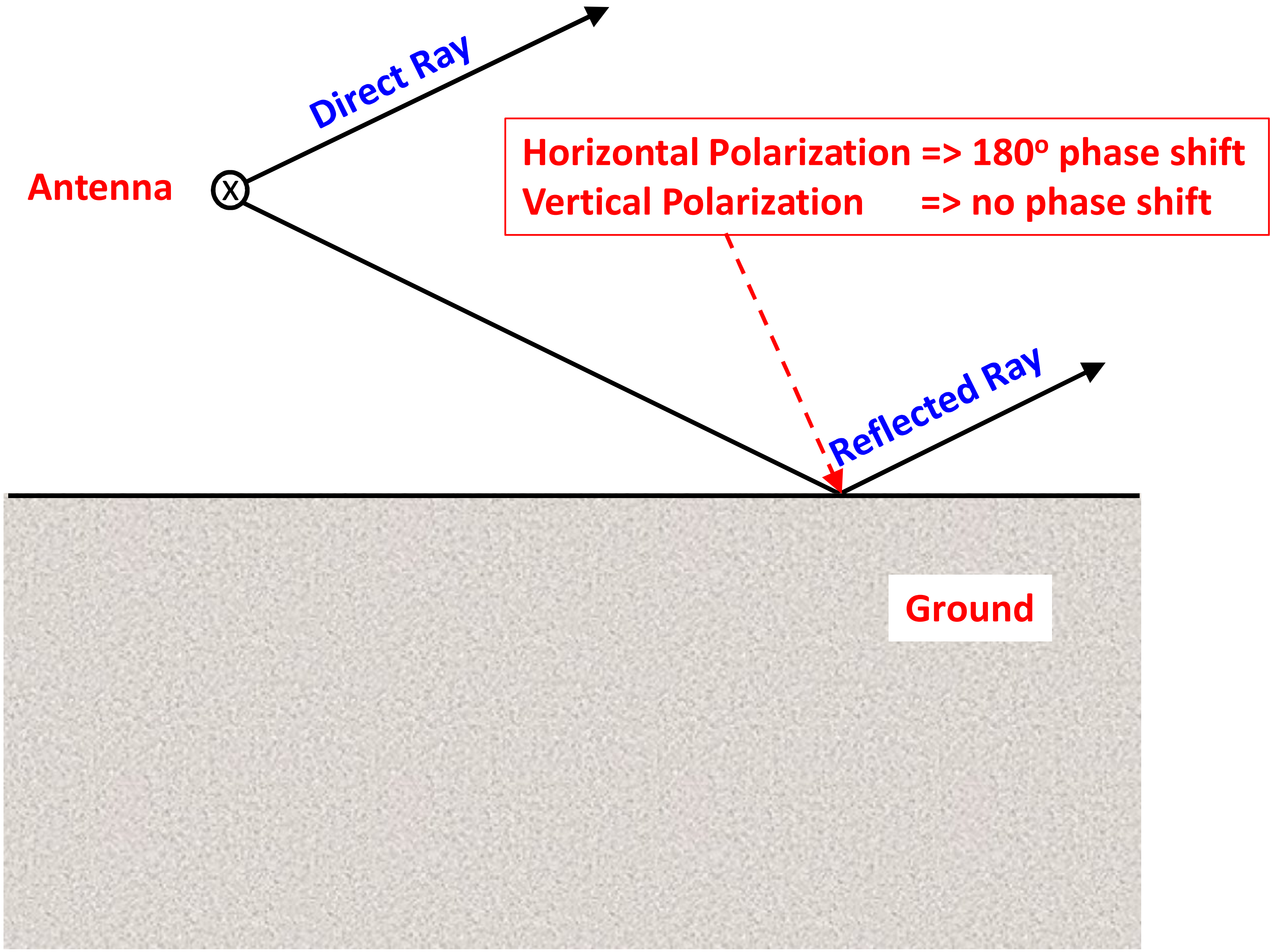
Real Dipoles

- **For any Dipole above any *__real ground__*,** the pattern, gain and impedance can vary with:
  - Height above ground
  - Electrical properties of the ground
  - Polarization
  - Construction:
    - Size of element
    - Material used for element
    - Mounting hardware and technique
    - Type and size of insulators

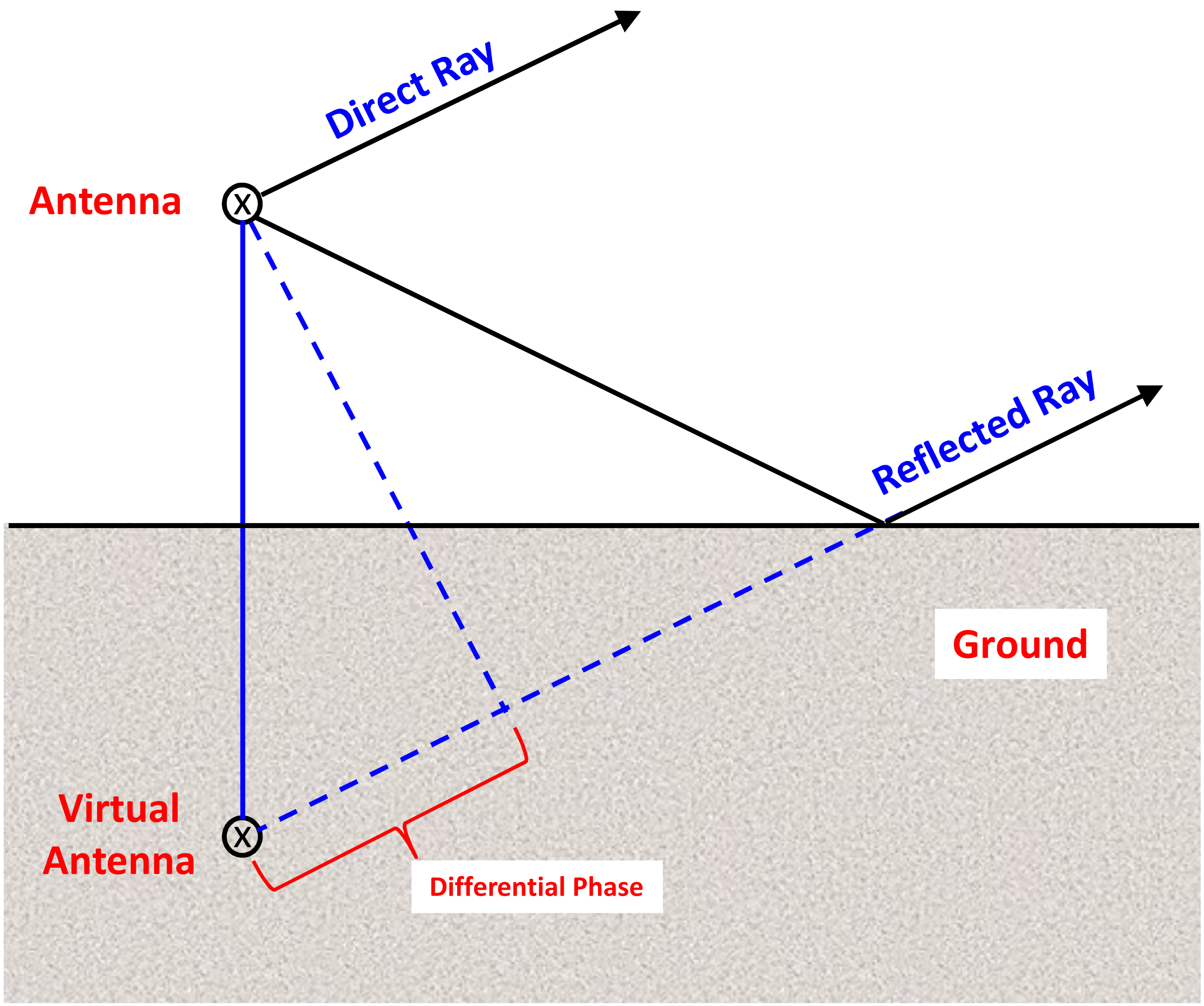
Reflections From Real Ground (Ray Tracing)



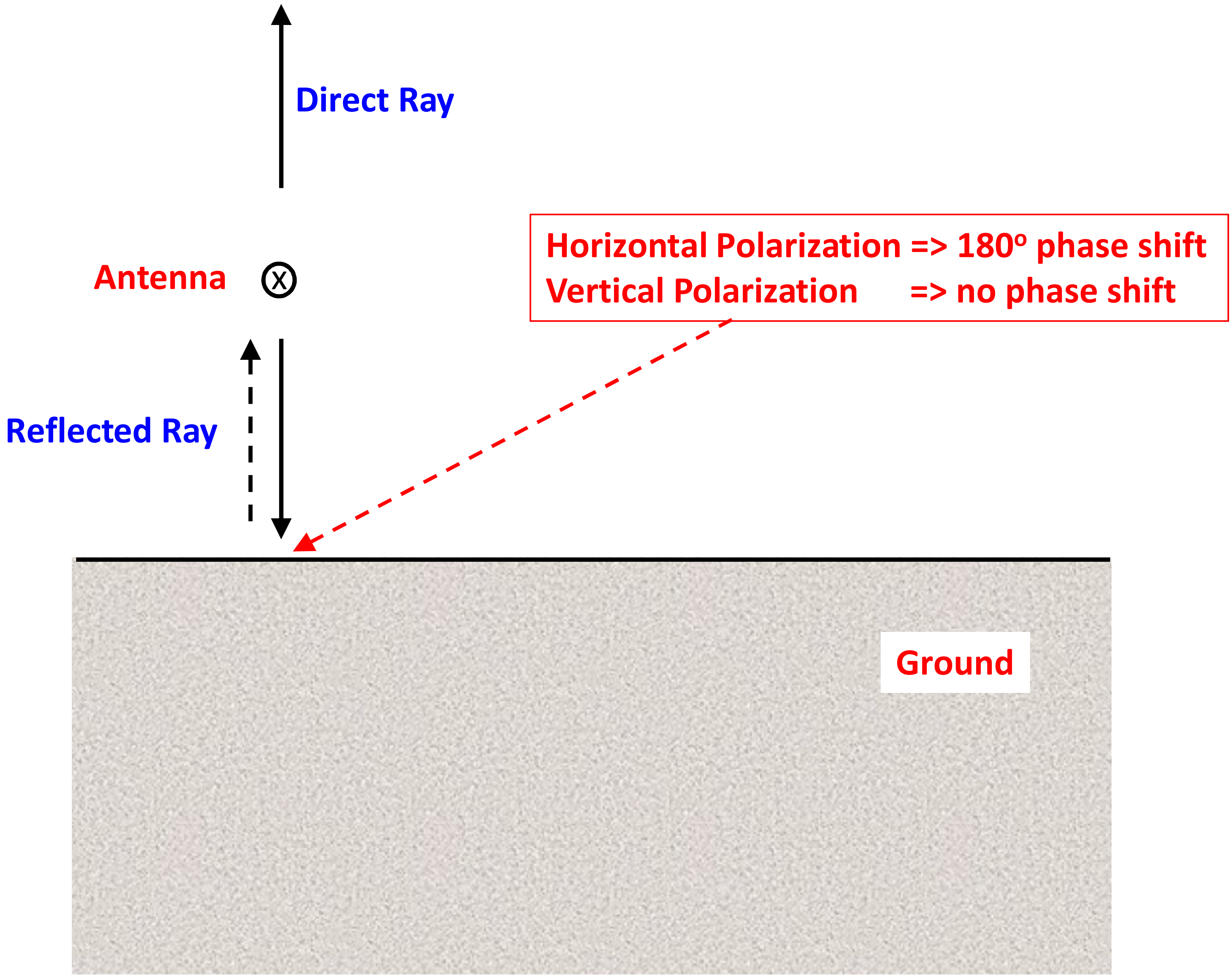
Reflections From Real Ground (Ray Tracing)



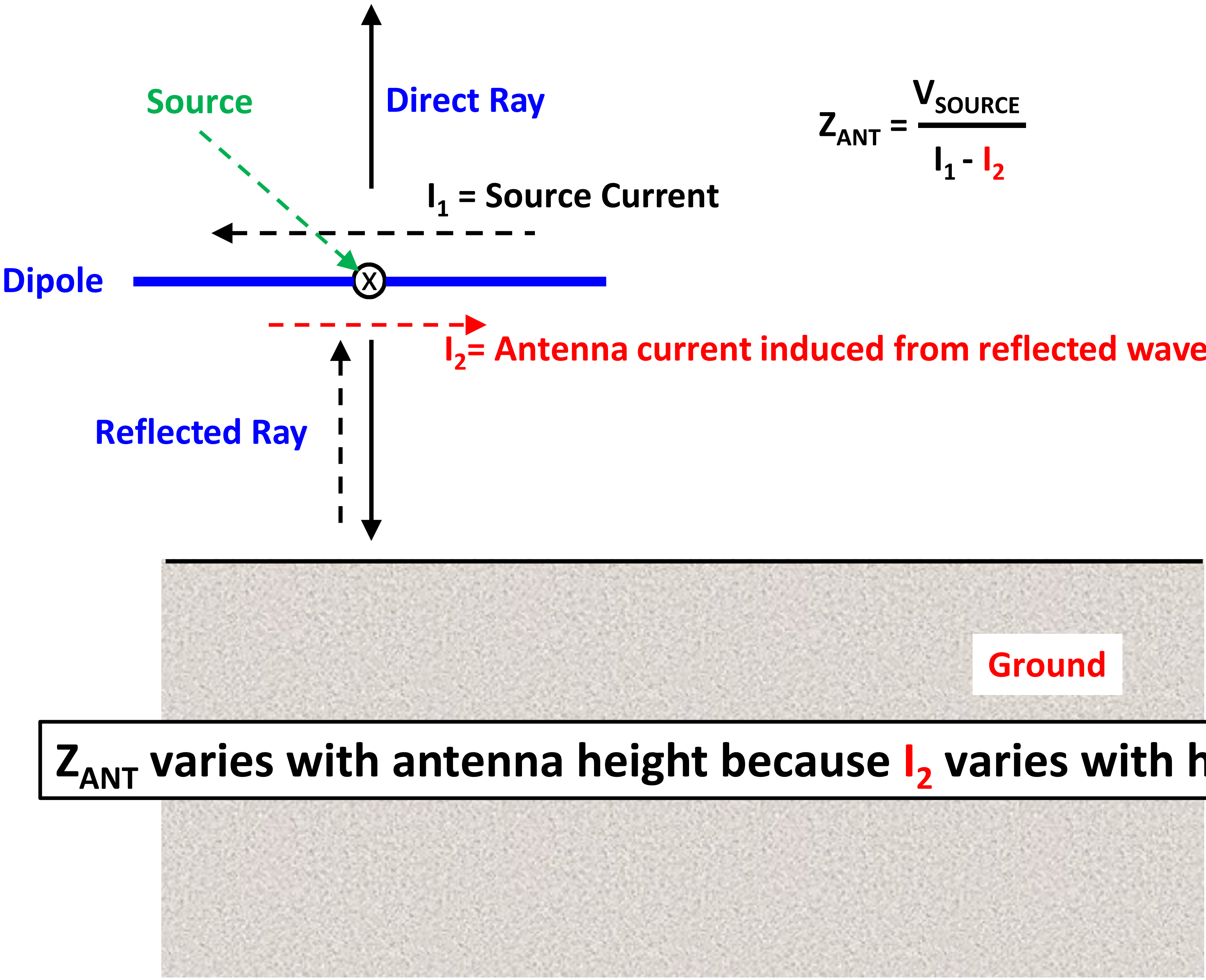
Reflections From Real Ground (Ray Tracing)



Reflections From Real Ground (Ray Tracing)



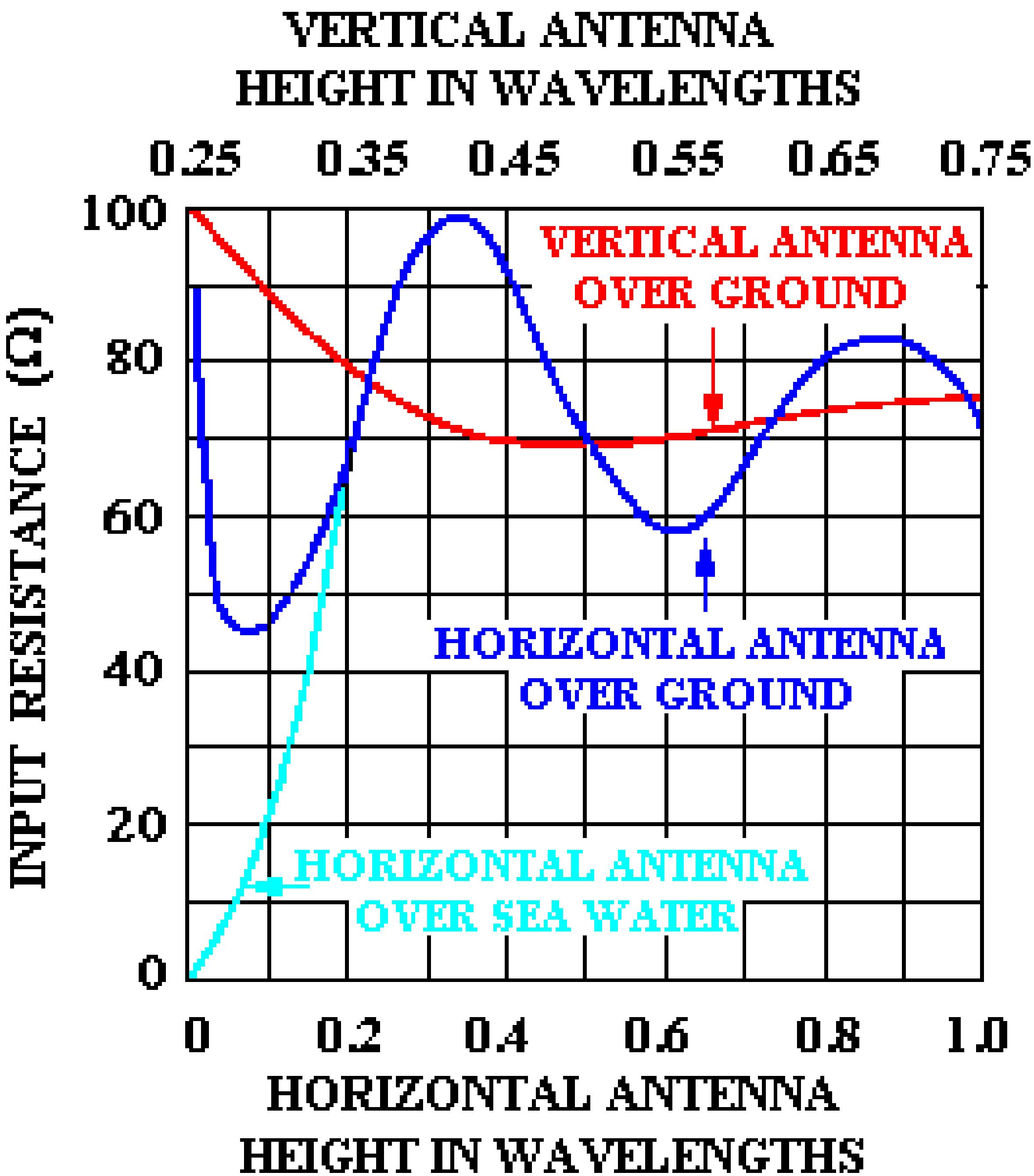
Reflections From Real Ground (Impedance)



$$Z_{ANT} = \frac{V_{SOURCE}}{I_1 - I_2}$$

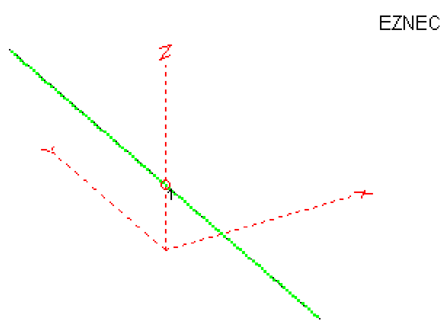
Z_{ANT} varies with antenna height because I_2 varies with height

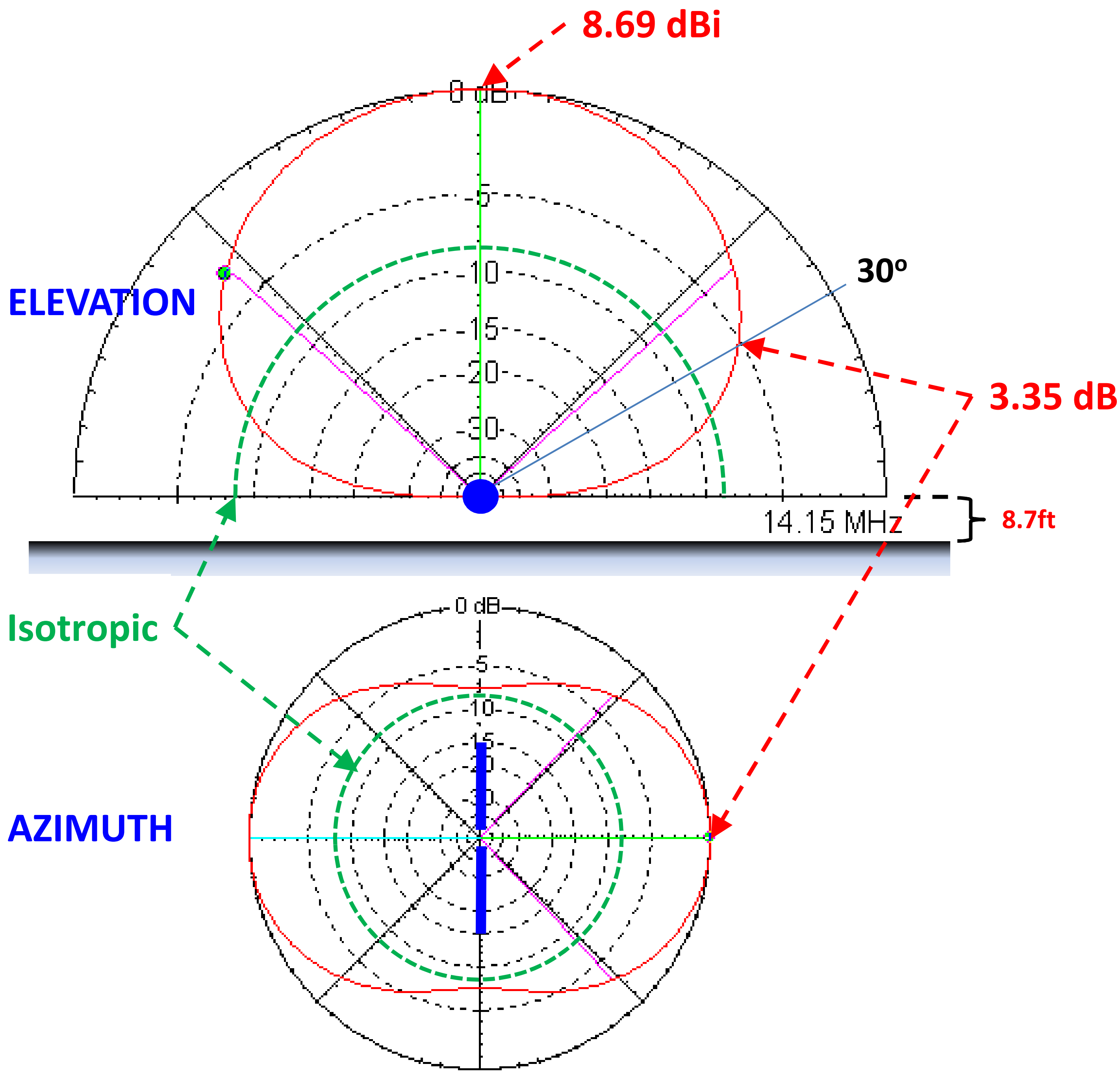
Reflections From Real Ground (Impedance)



Horizontal Dipole 1/8λ Above Perfect Ground

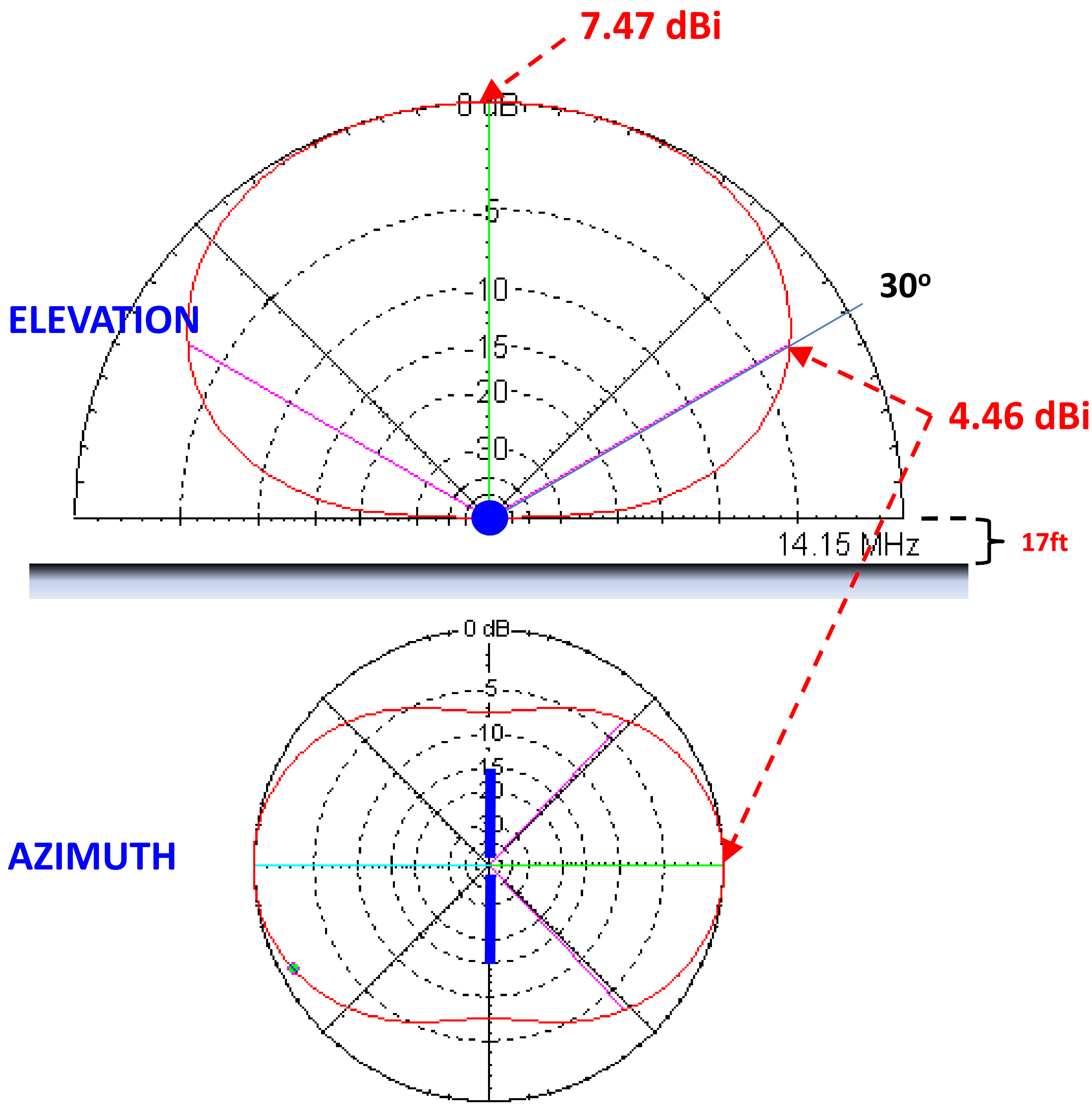
F_o:	14.15 MHz
Gain:	8.69 dBi
EL Angle:	90°
EL BW:	96.2°
AZ BW:	99.4°
R:	**30.7 Ω**
SWR:	1.63
Length (#12):	33.055 ft





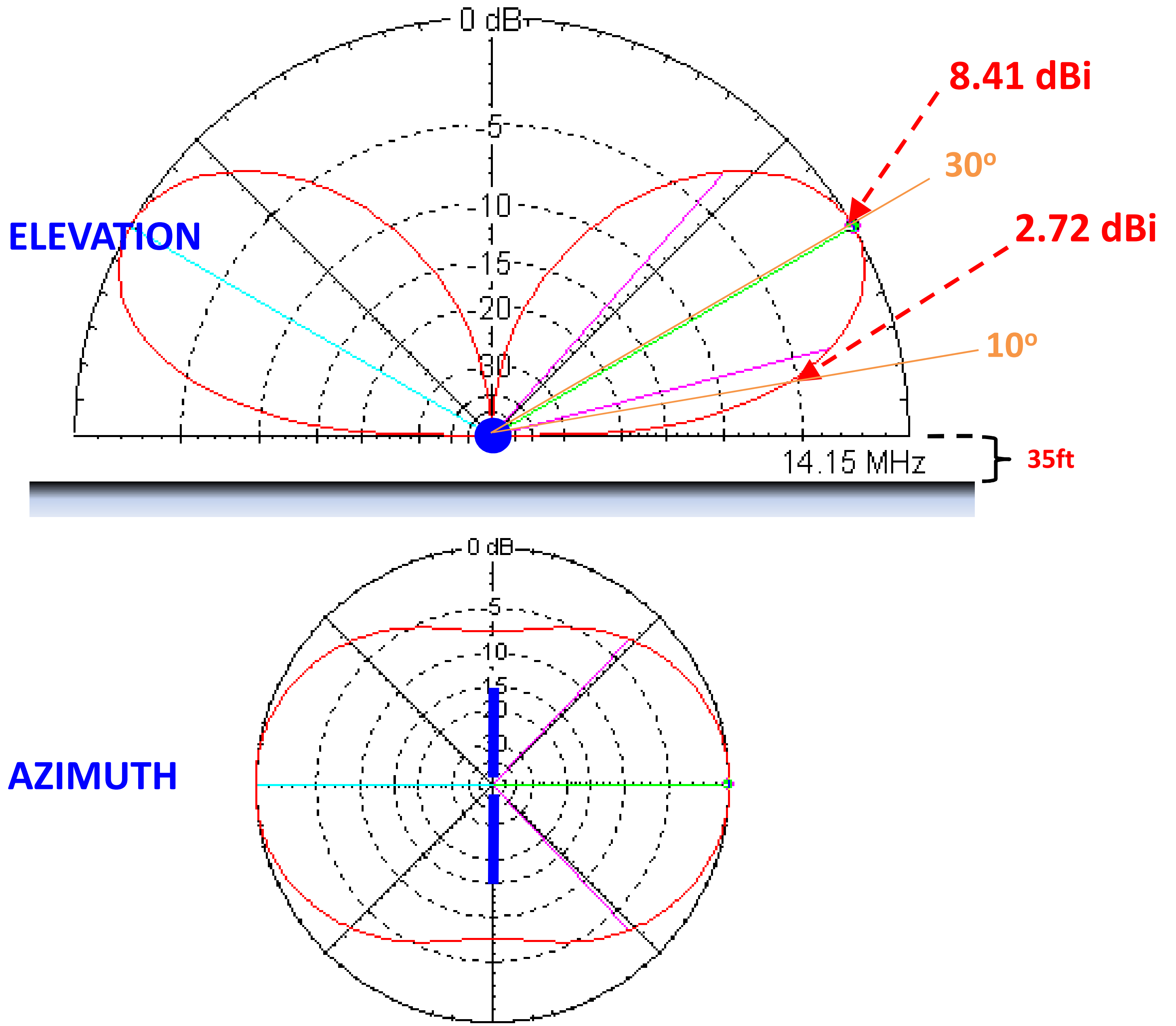
Horizontal Dipole 1/4λ Above Perfect Ground

F_o:	14.15 MHz
Gain:	7.47 dBi
EL Angle:	90º
EL BW:	120º
AZ BW:	93.8º
R:	**81.7 Ω**
SWR:	1.63
Length (#12):	33.089 ft



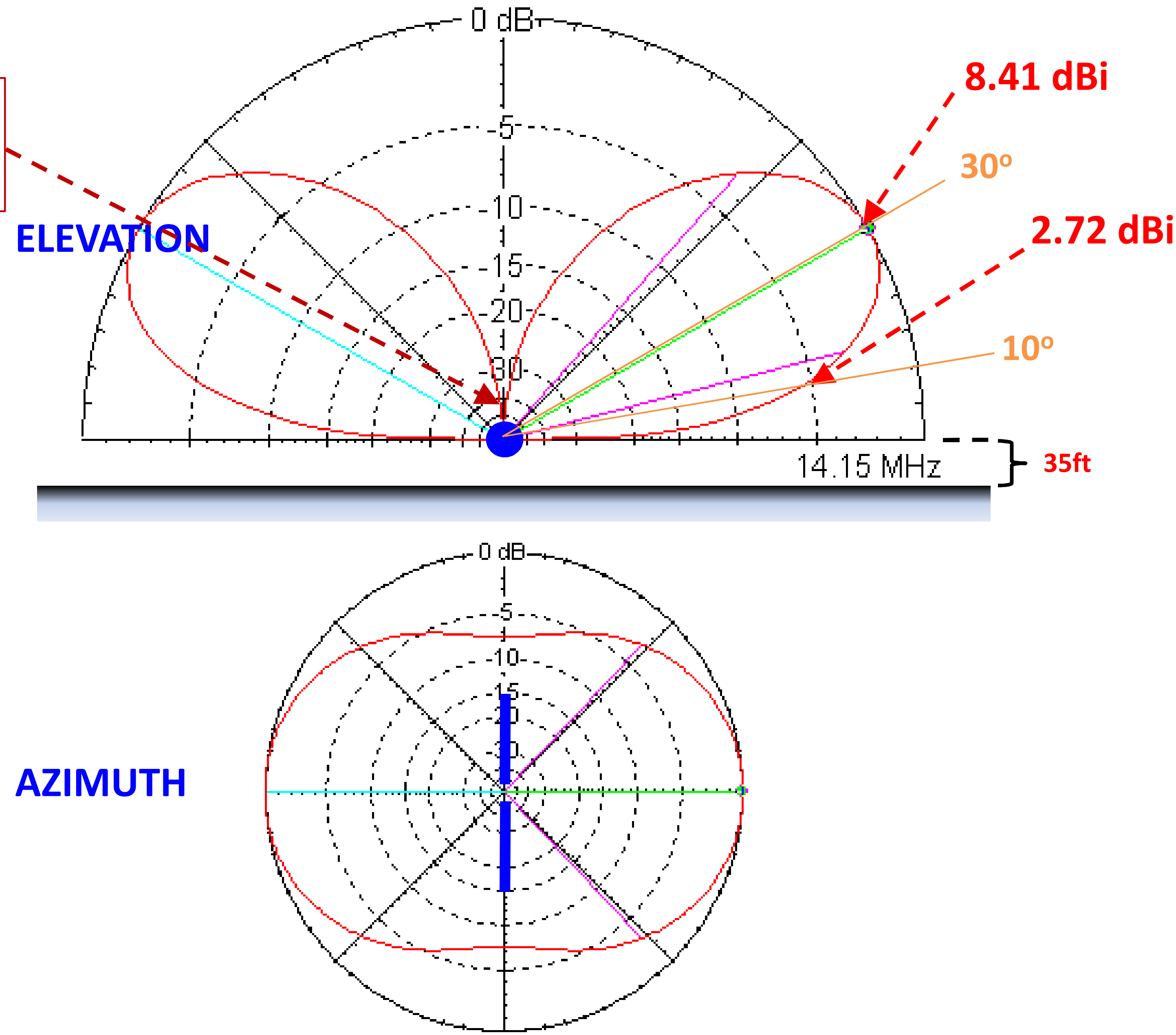
Horizontal Dipole 1/2λ Above Perfect Ground

F_o:	14.15 MHz
Gain:	8.41 dBi
EL Angle:	30.0º
EL BW:	34.1º
AZ BW:	93.4º
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft



Horizontal Dipole 1/2λ Above Perfect Ground

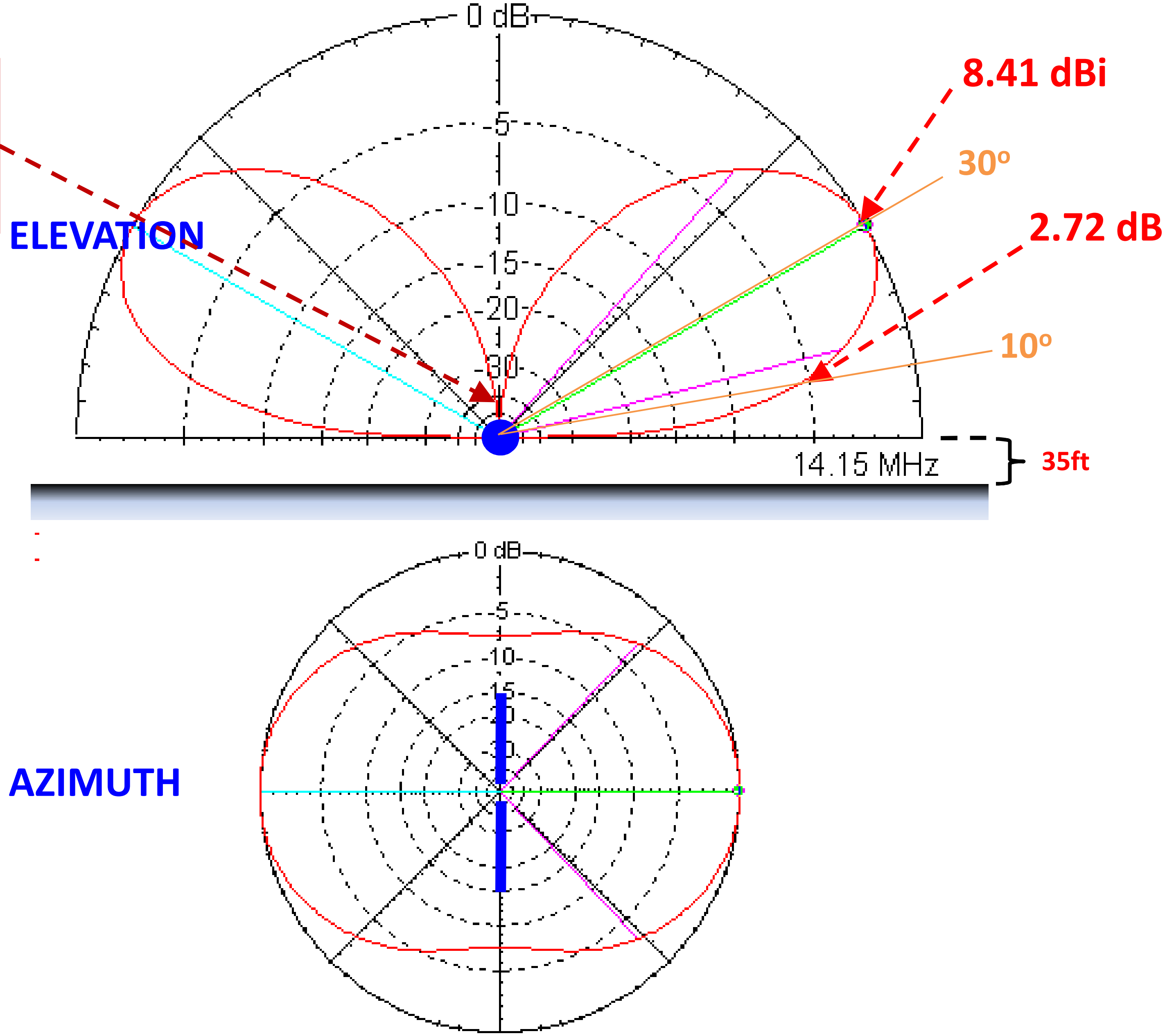
F_o:	14.15 MHz
Gain:	8.41 dBi
EL Angle:	30.0º
EL BW:	34.1º
AZ BW:	93.4º
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft



Horizontal Dipole 1/2λ Above Perfect Ground

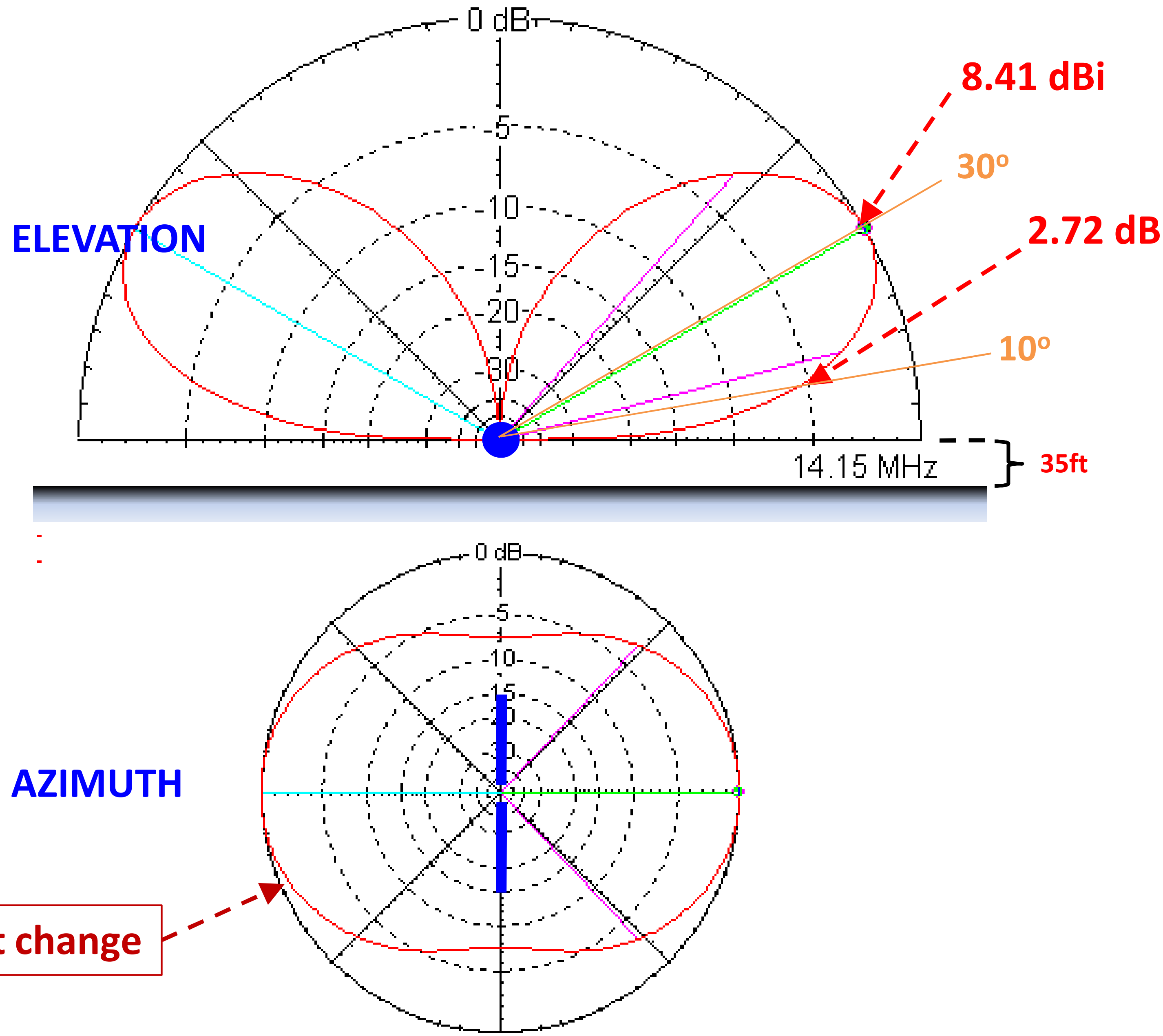
180° phase reversal of reflected signal causes null at 90° elevation

F_o:	14.15 MHz
Gain:	8.41 dBi
EL Angle:	30.0°
EL BW:	34.1°
AZ BW:	93.4°
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft



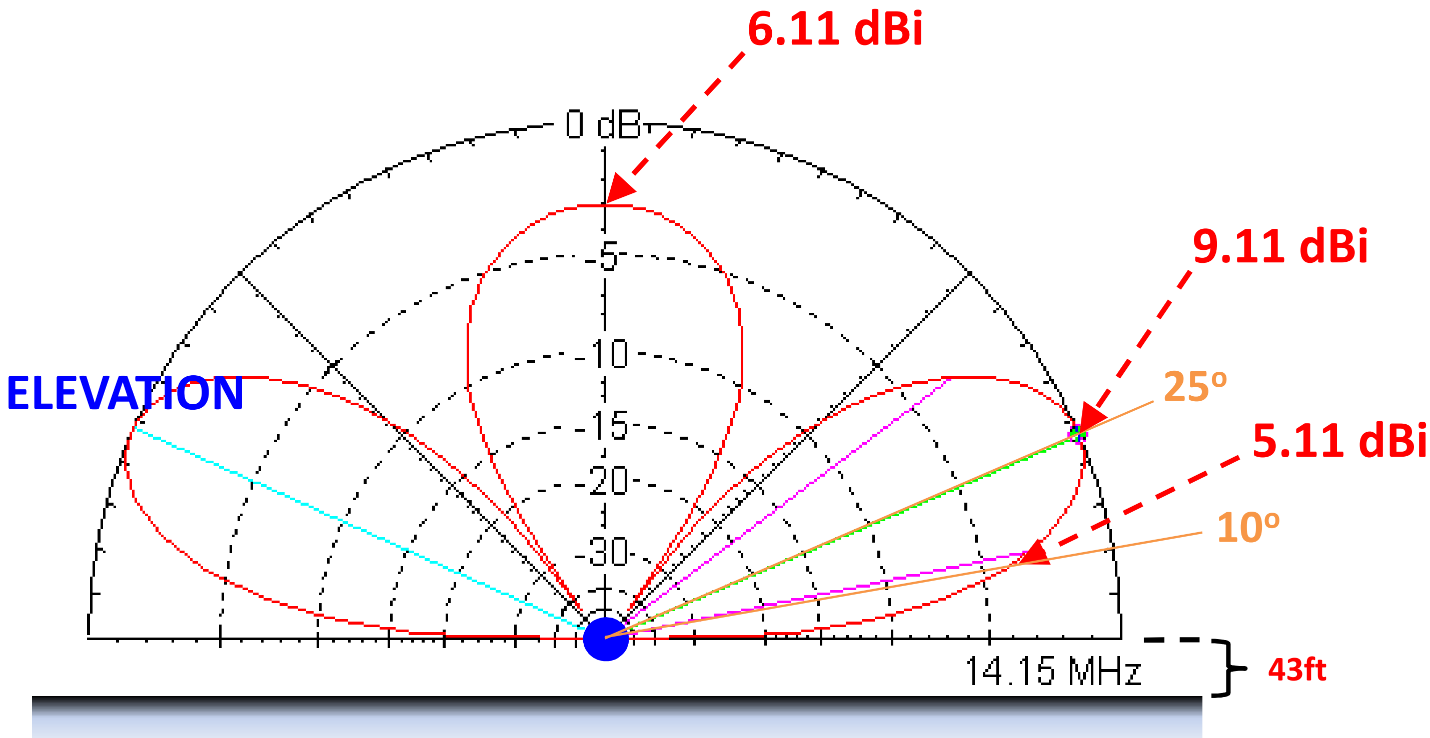
Horizontal Dipole 1/2λ Above Perfect Ground

F_o:	14.15 MHz
Gain:	8.41 dBi
EL Angle:	30.0º
EL BW:	34.1º
AZ BW:	93.4º
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft



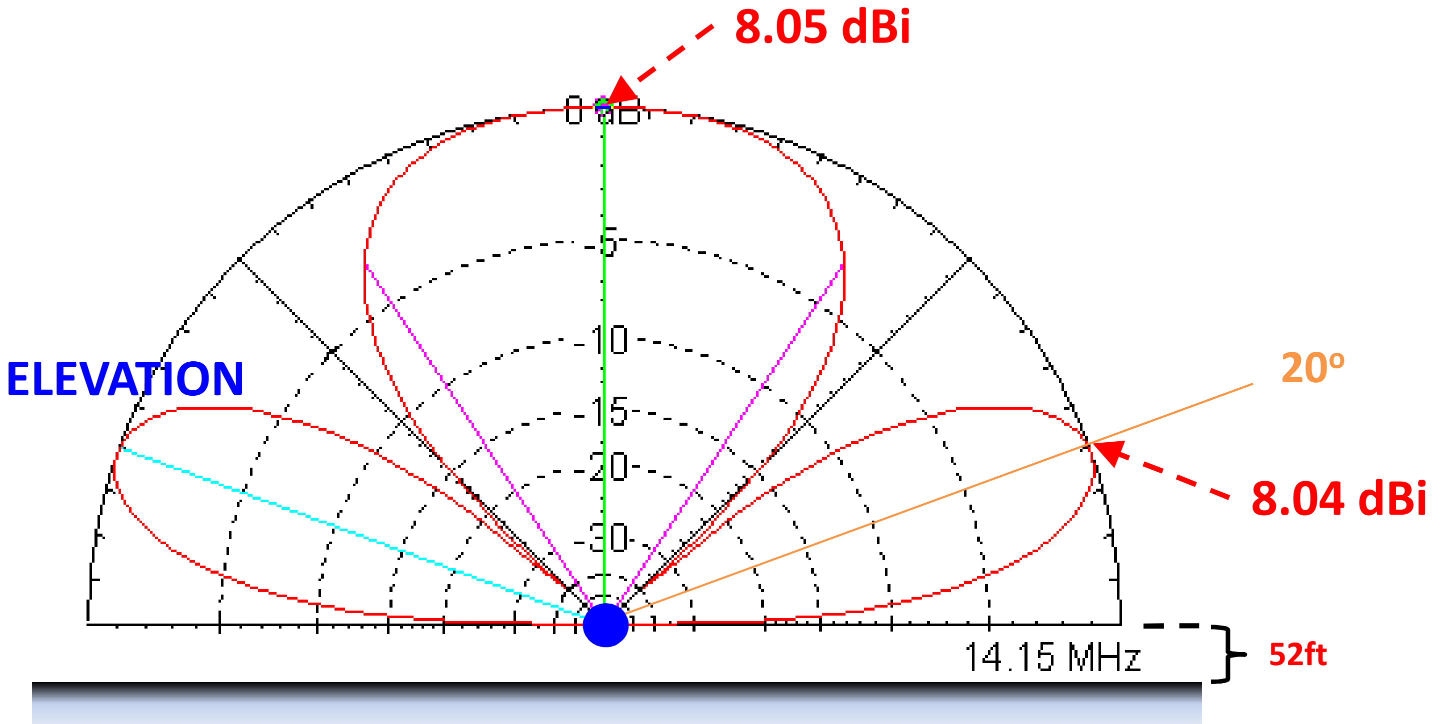
Azimuth patterns don't change

Horizontal Dipole 5/8λ Above Perfect Ground



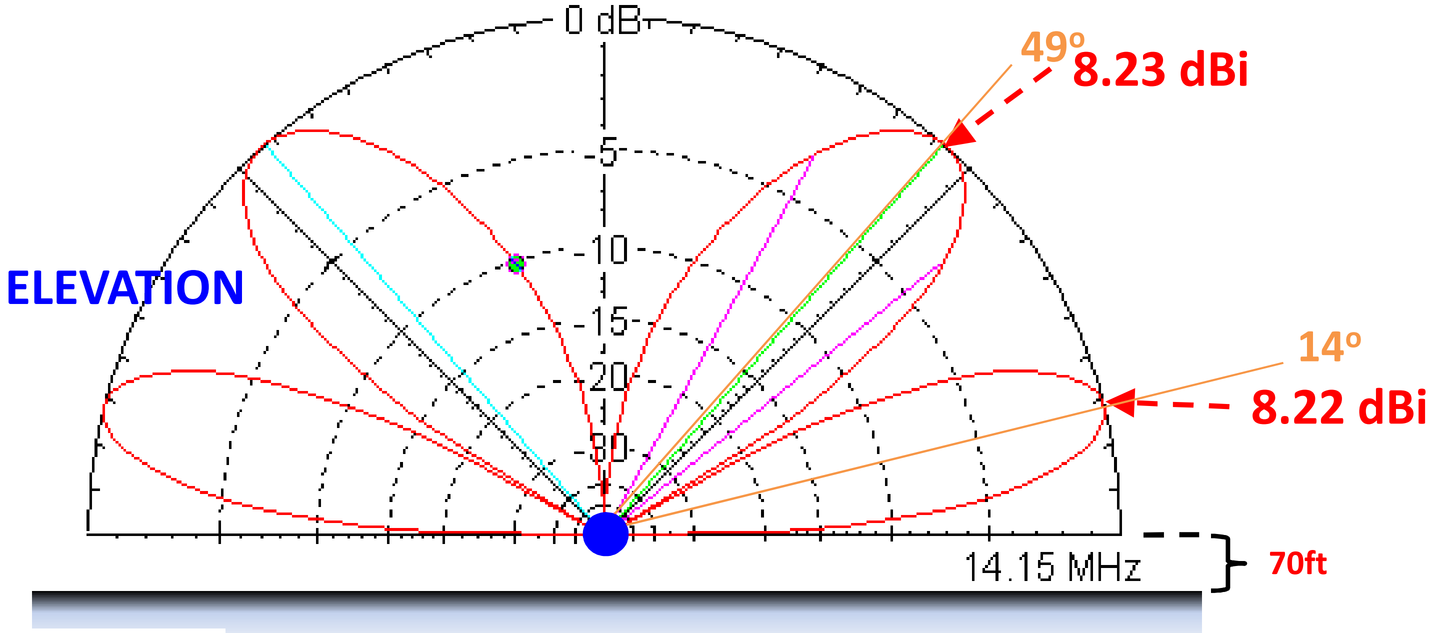
F_o:	14.15 MHz
Gain:	9.12,6.11 dBi
EL Angle:	25,90º
EL BW:	-º
AZ BW:	93.6º
R:	57.5 Ω
SWR:	1.15
Length (#12):	33.640 ft

Horizontal Dipole 3/4λ Above Perfect Ground



F_o:	14.15 MHz
Gain:	8.05 dBi
EL Angle:	20º & 90º
EL BW:	-º
AZ BW:	93.6º
R:	72.9 Ω
SWR:	1.46
Length (#12):	33.450 ft

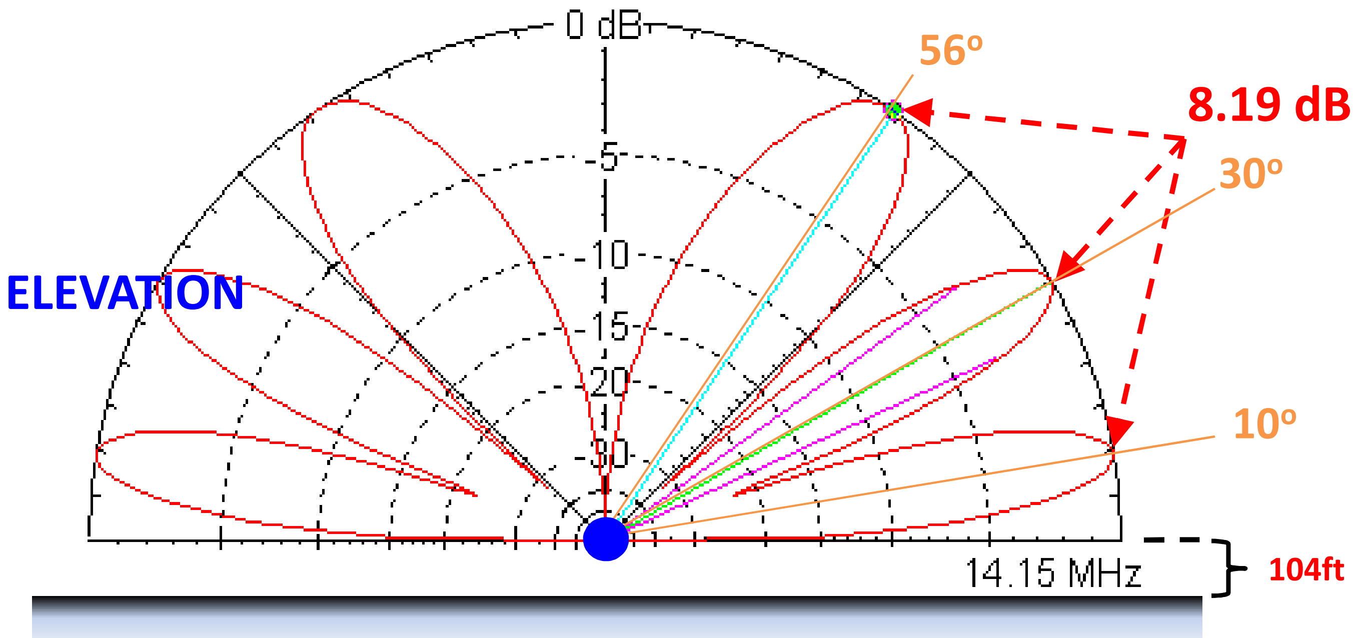
Horizontal Dipole 1λ Above Perfect Ground



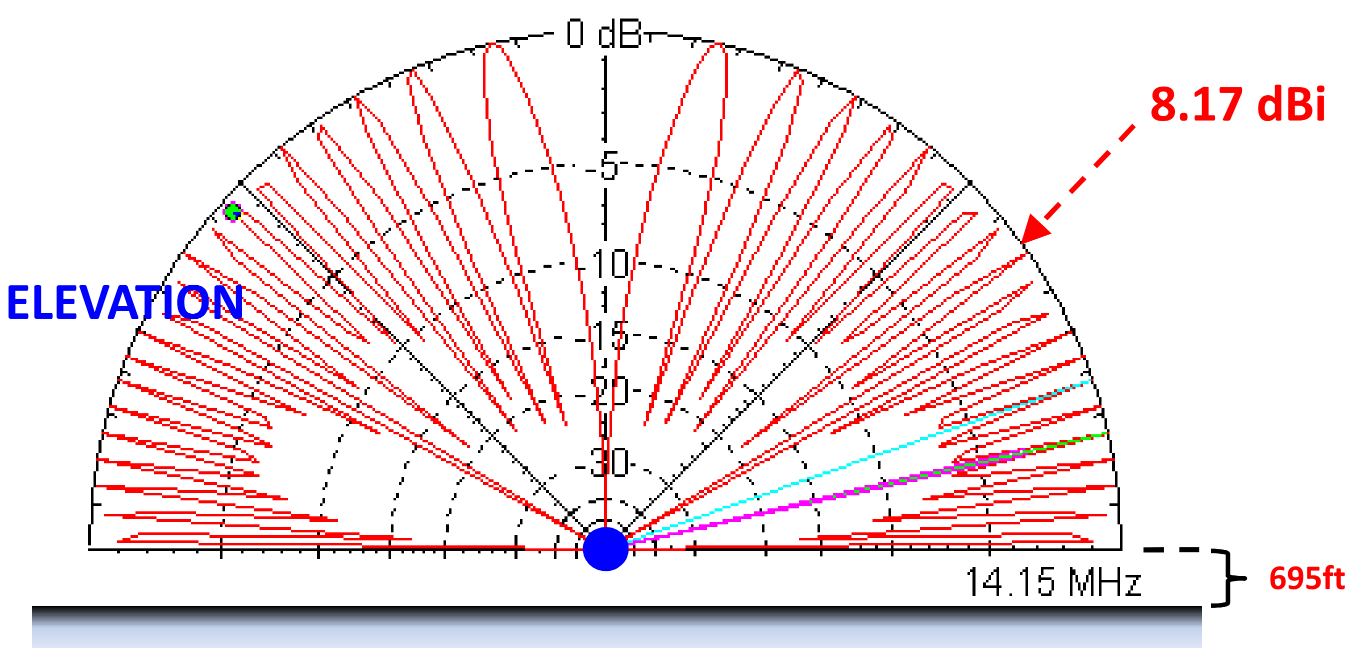
F_o:	14.15 MHz
Gain:	8.23 dBi
EL Angle:	14° & 49°
EL BW:	-°
AZ BW:	93.4°
R:	71.7 Ω
SWR:	1.43
Length (#12):	33.930 ft

Horizontal Dipole 1.5λ Above Perfect Ground

F_o:	14.15 MHz
Gain:	8.19 dBi
EL Angle:	10,30,56°
EL BW:	-°
AZ BW:	93.6°
R:	72.1 Ω
SWR:	1.44
Length (#12):	33.865 ft



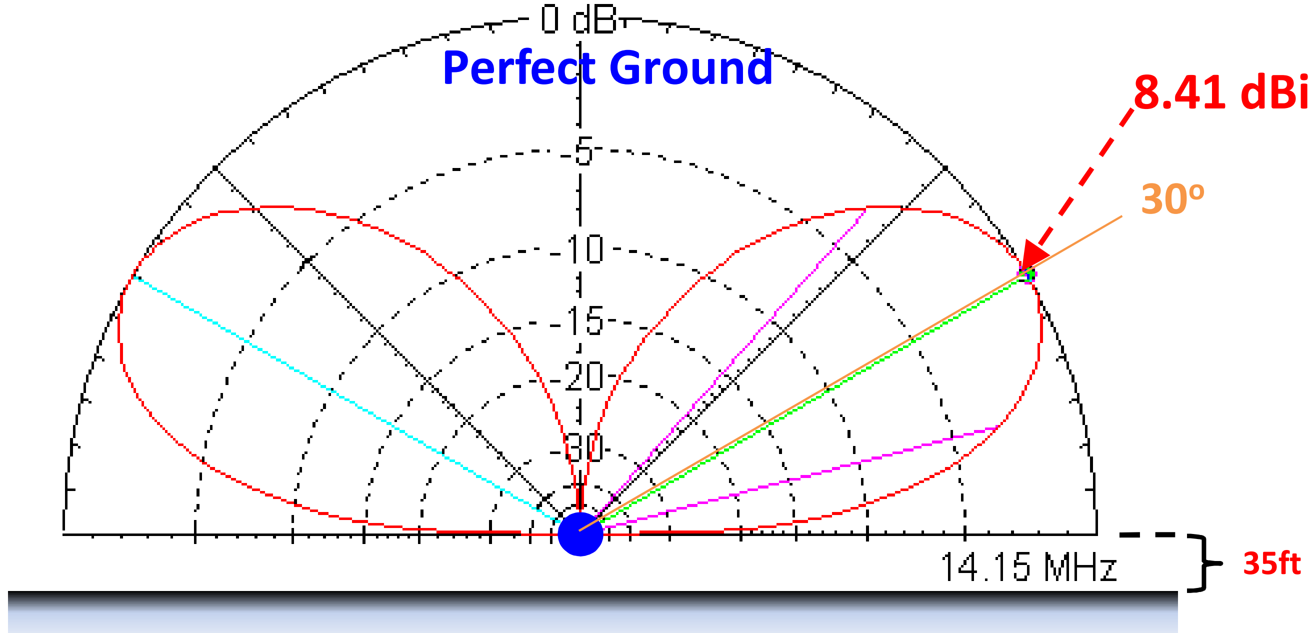
Horizontal Dipole 10λ Above Perfect Ground



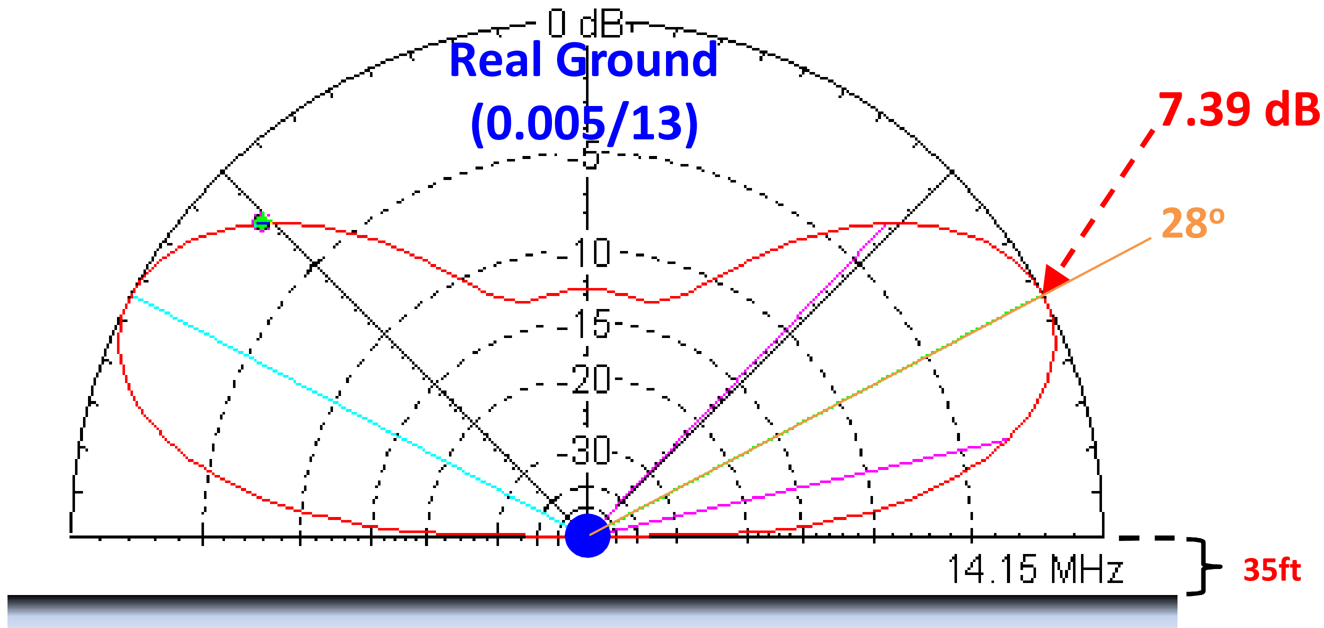
F_o:	14.15 MHz
Gain:	8.17 dBi
EL Angle:	-º
EL BW:	-º
AZ BW:	-º
R:	72.1 Ω
SWR:	1.44
Length (#12):	33.740 ft

Horizontal Dipole: Real vs Perfect Ground (1/2λ)

F_o:	14.15 MHz
Gain:	8.41 dBi
EL Angle:	30.0º
EL BW:	34.1º
AZ BW:	93.4º
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft

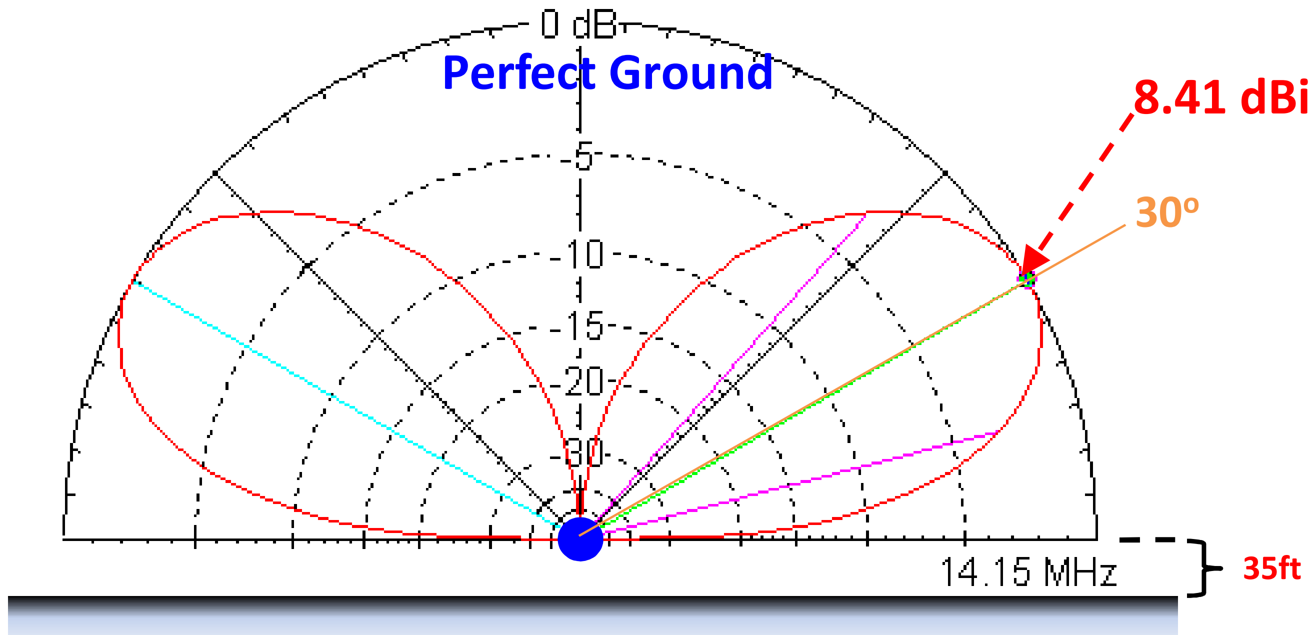


F_o:	14.15 MHz
Gain:	7.39 dBi
EL Angle:	28.0º
EL BW:	33.1º
AZ BW:	87.2º
R:	68.3 Ω
SWR:	1.51
Length (#12):	34.125 ft

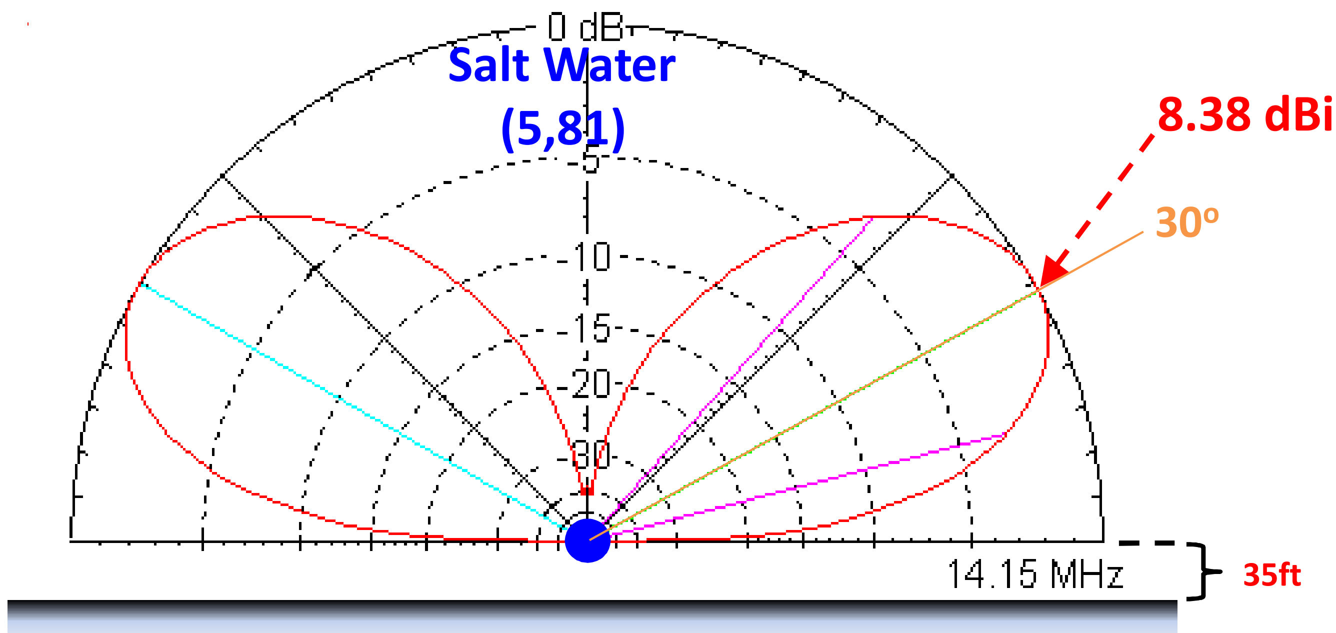


Horizontal Dipole: Real vs Salt Water Ground (1/2λ)

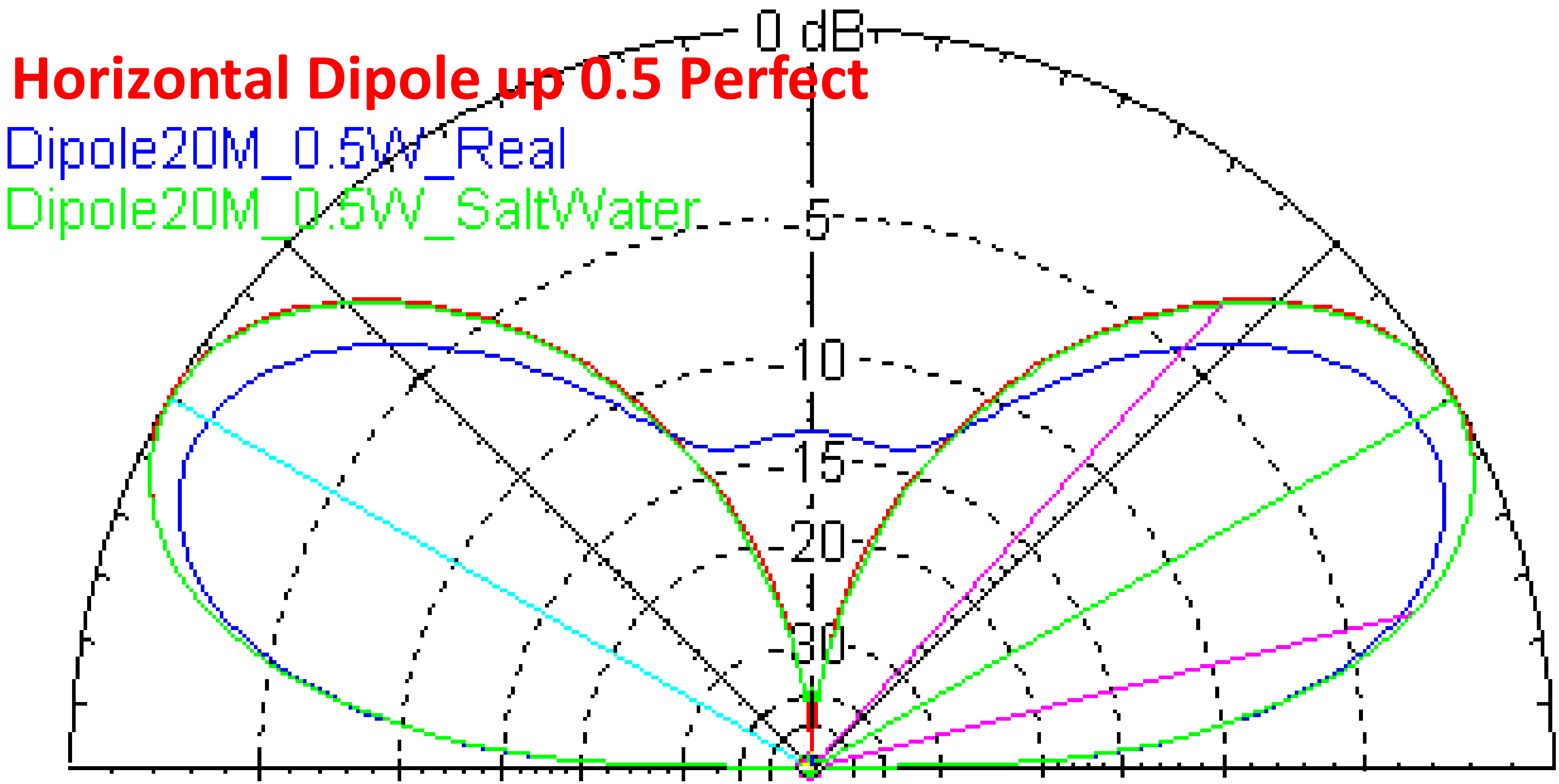
F_o:	14.15 MHz
Gain:	8.41 dBi
EL Angle:	30.0°
EL BW:	34.1°
AZ BW:	93.4°
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft



F_o:	14.15 MHz
Gain:	8.38 dBi
EL Angle:	29.0°
EL BW:	33.9°
AZ BW:	92.6°
R:	69.5 Ω
SWR:	1.39
Length (#12):	34.125 ft



Horizontal Dipoles 1/2λ Above Ground

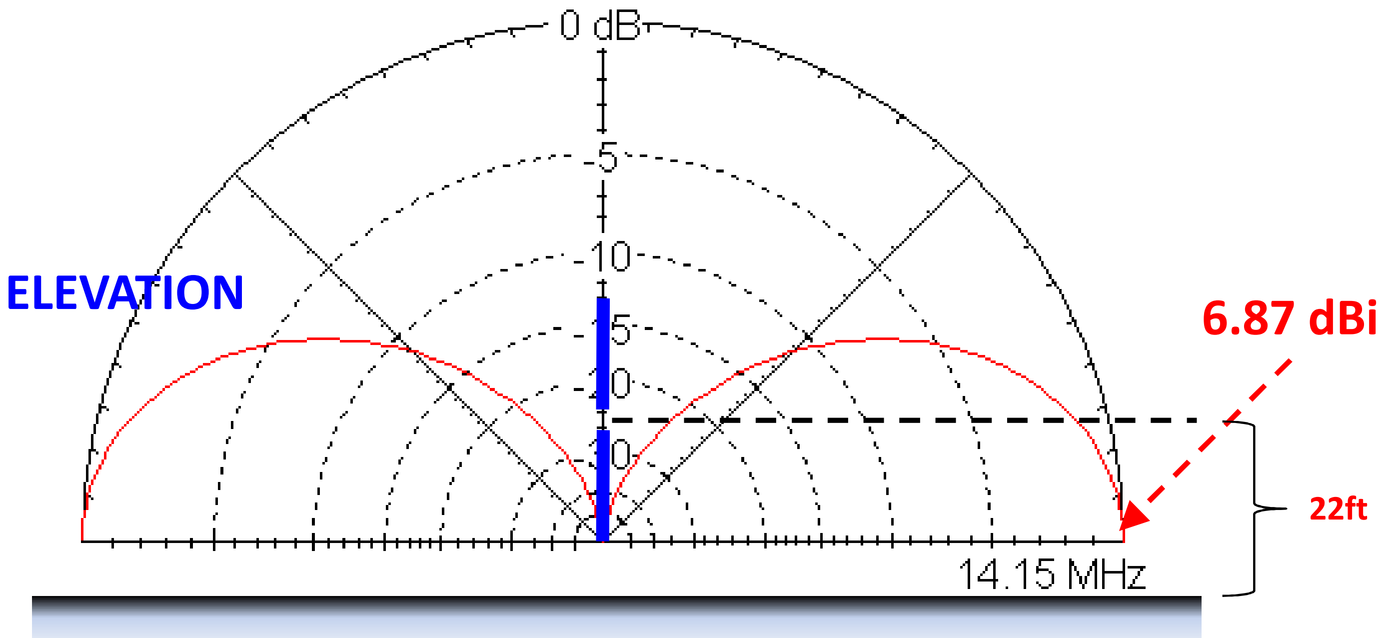


Horizontally Polarized Antennas Above Ground

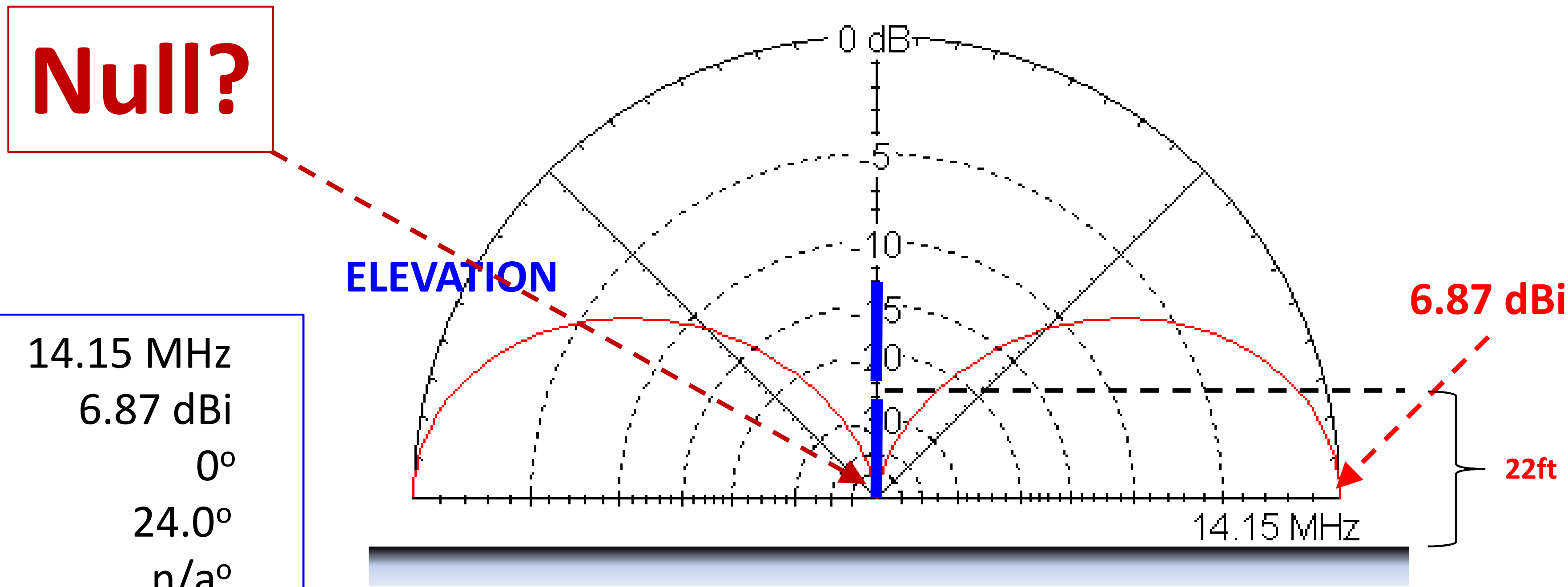
- **Real (lossy) ground results in:**
  - **Lobe splitting**
    - **More lobes as height increases**
    - ***Significant* variation in takeoff angle with height**
      - **Lower takeoff angle requires increased height**
  - **Slight reduction in gain**
    - **Gain peak never at EL=0°**
  - **Slight reduction in takeoff angle**
  - **Very deep nulls become very shallow nulls**
  - **Z_{ANT} varies greatly with height for heights < 0.5λ**
  - **Azimuth pattern remains constant as height is changed**

Vertical Dipole 1/4λ + 1 ft Above Perfect Ground

F_o:	14.15 MHz
Gain:	6.87 dBi
EL Angle:	0°
EL BW:	24.0°
AZ BW:	n/a°
R:	**97.0 Ω**
SWR:	1.94
Length (#12):	33.520 ft



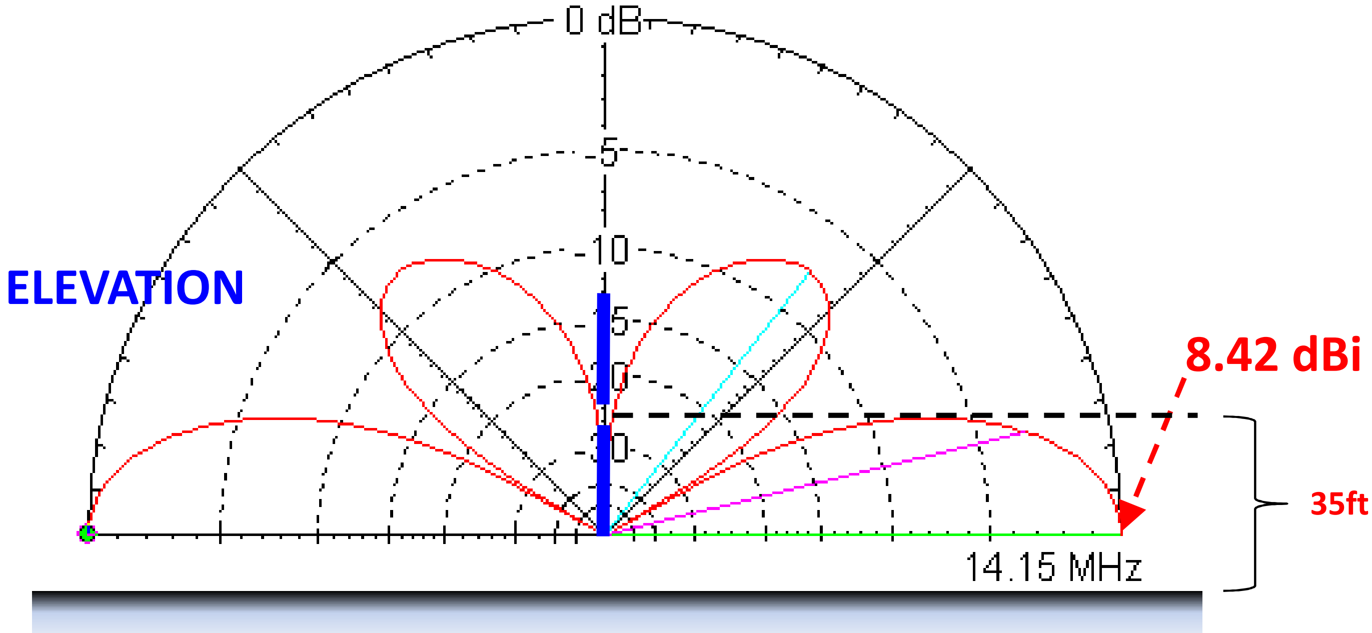
Vertical Dipole 1/4λ + 1 ft Above Perfect Ground



F_o:	14.15 MHz
Gain:	6.87 dBi
EL Angle:	0º
EL BW:	24.0º
AZ BW:	n/aº
R:	97.0 Ω
SWR:	1.94
Length (#12):	33.520 ft

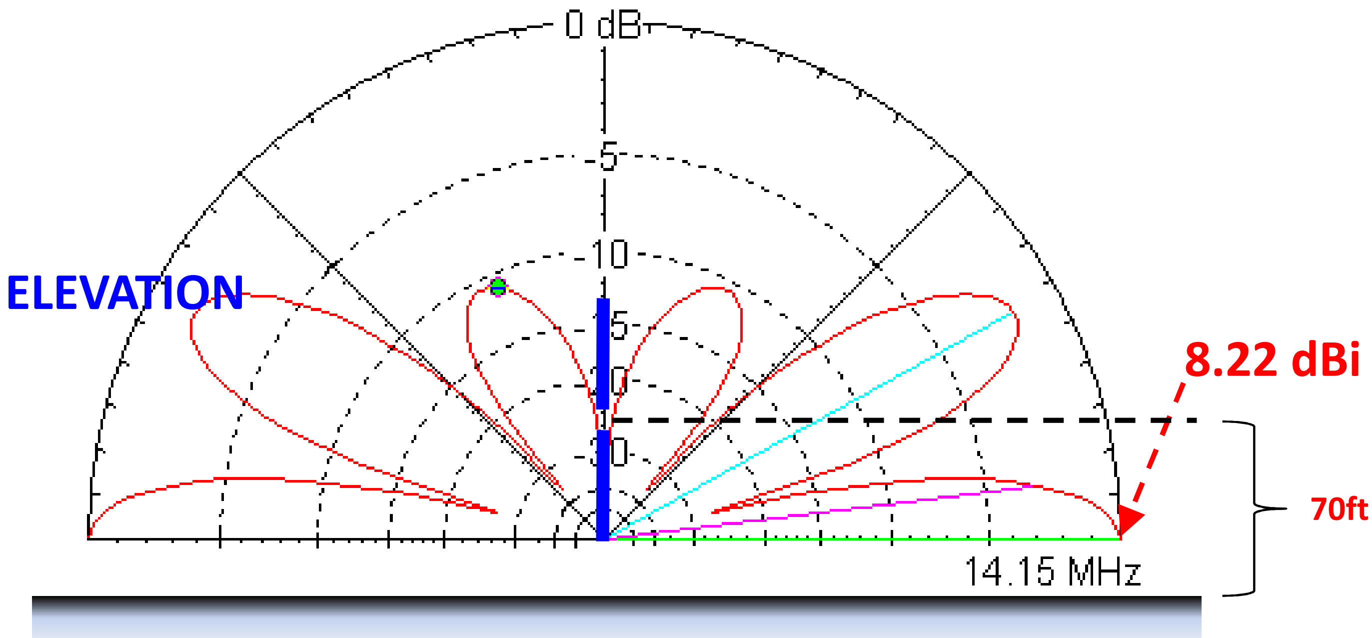
Vertical Dipole 1/2λ Above Perfect Ground

F_o:	14.15 MHz
Gain:	8.42 dBi
EL Angle:	0º
EL BW:	14.0º
AZ BW:	n/aº
R:	68.0 Ω
SWR:	1.36
Length (#12):	33.730 ft



Vertical Dipole 1λ Above Perfect Ground

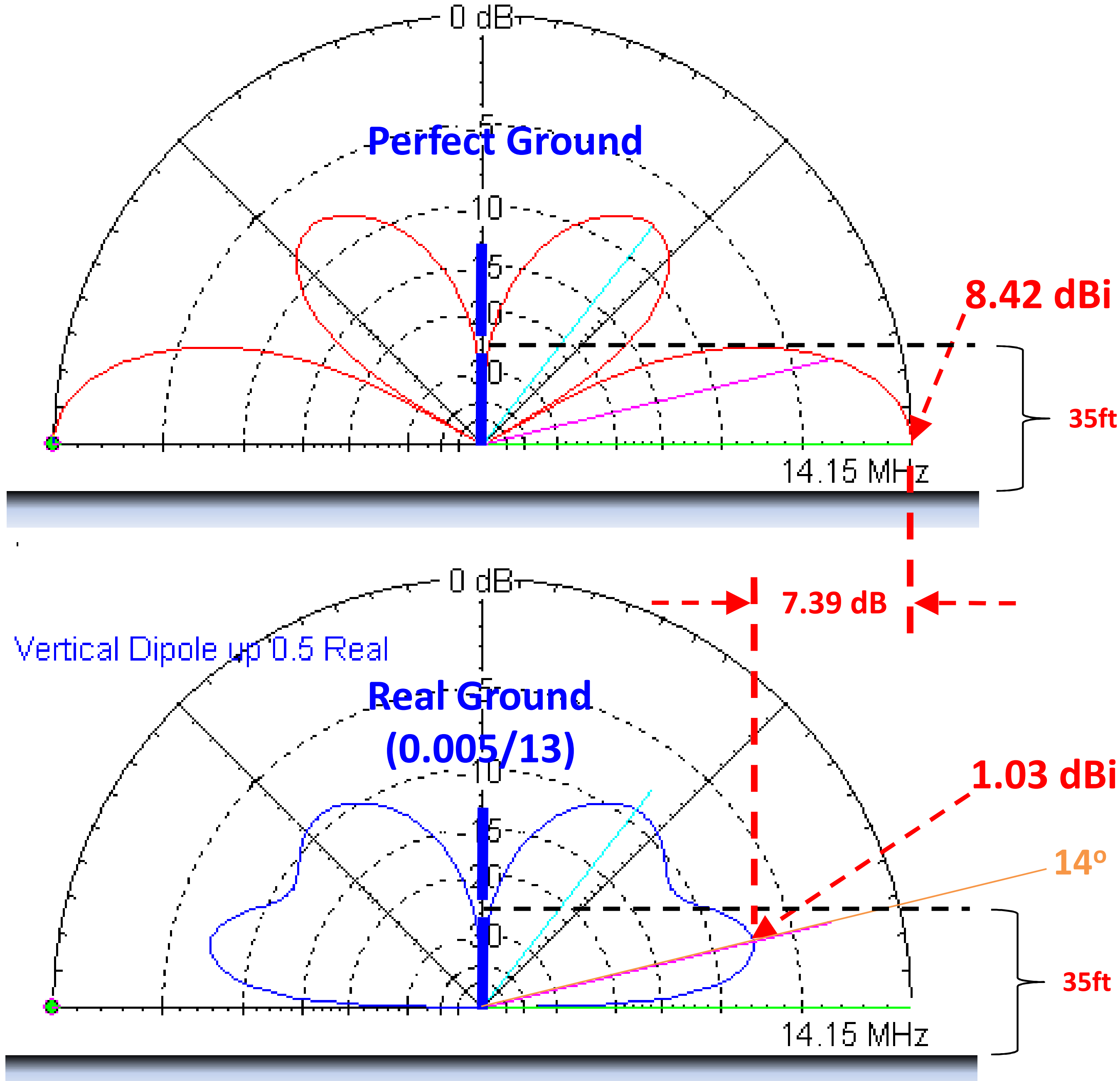
F_o:	14.15 MHz
Gain:	8.22 dBi
EL Angle:	0??º
EL BW:	7.1º
AZ BW:	n/aº
R:	71.1 Ω
SWR:	1.42
Length (#12):	33.730 ft



Vertical Dipole 1/2λ Above Real Ground

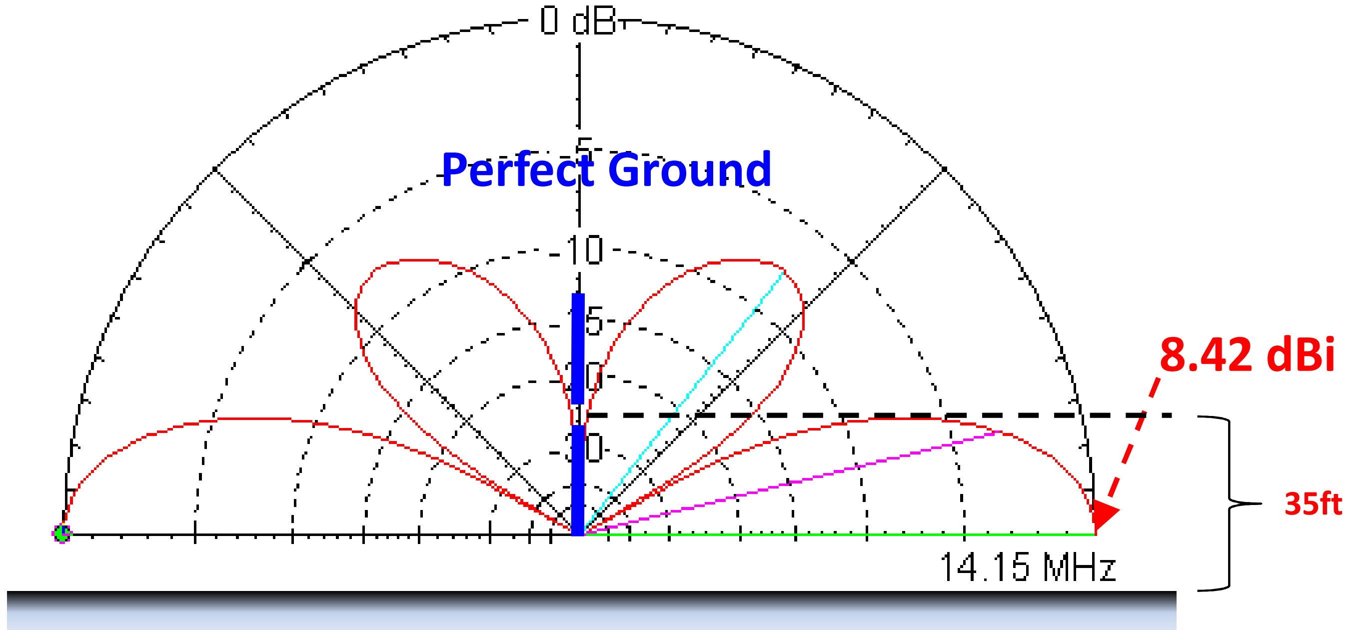
F_o:	14.15 MHz
Gain:	8.42 dBi
EL Angle:	0°
EL BW:	14.0°
AZ BW:	n/a°
R:	68.0 Ω
SWR:	1.36
Length (#12):	33.730 ft

F_o:	14.15 MHz
Gain:	1.03 dBi
EL Angle:	14°
EL BW	n/a°
AZ BW:	n/a°
R:	68.0 Ω
SWR:	1.36
Length (#12):	33.730 ft

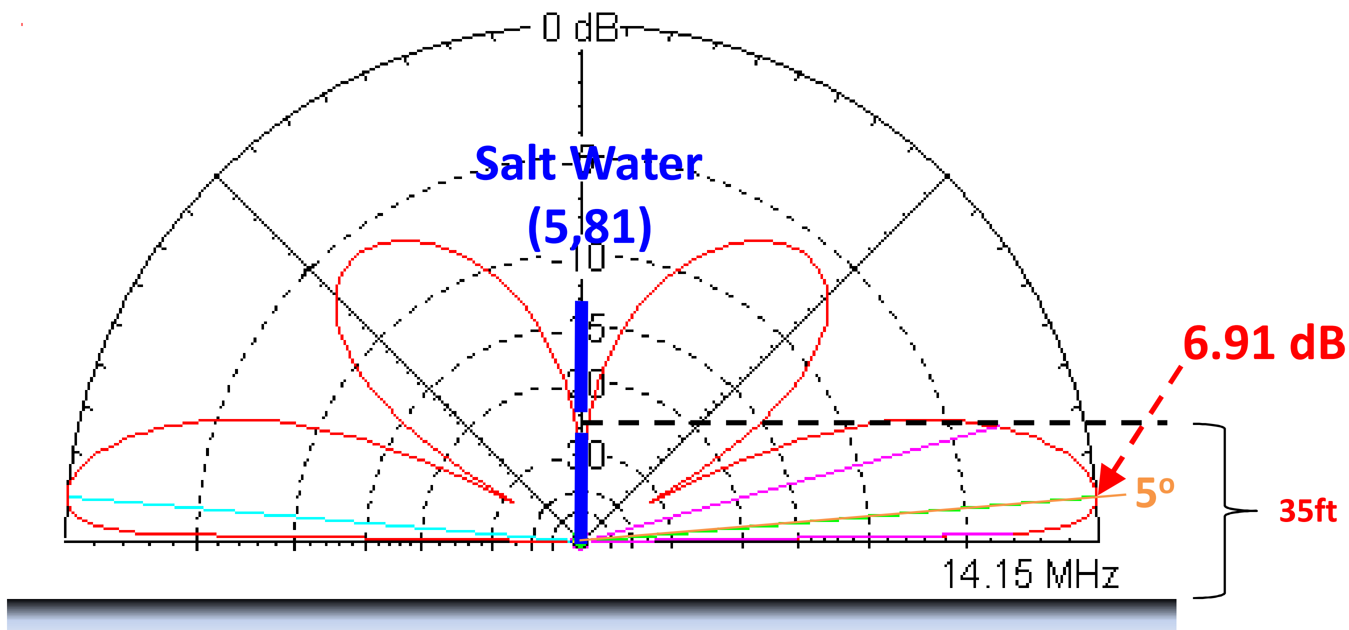


Vertical Dipole 1/2λ Above Salt Water

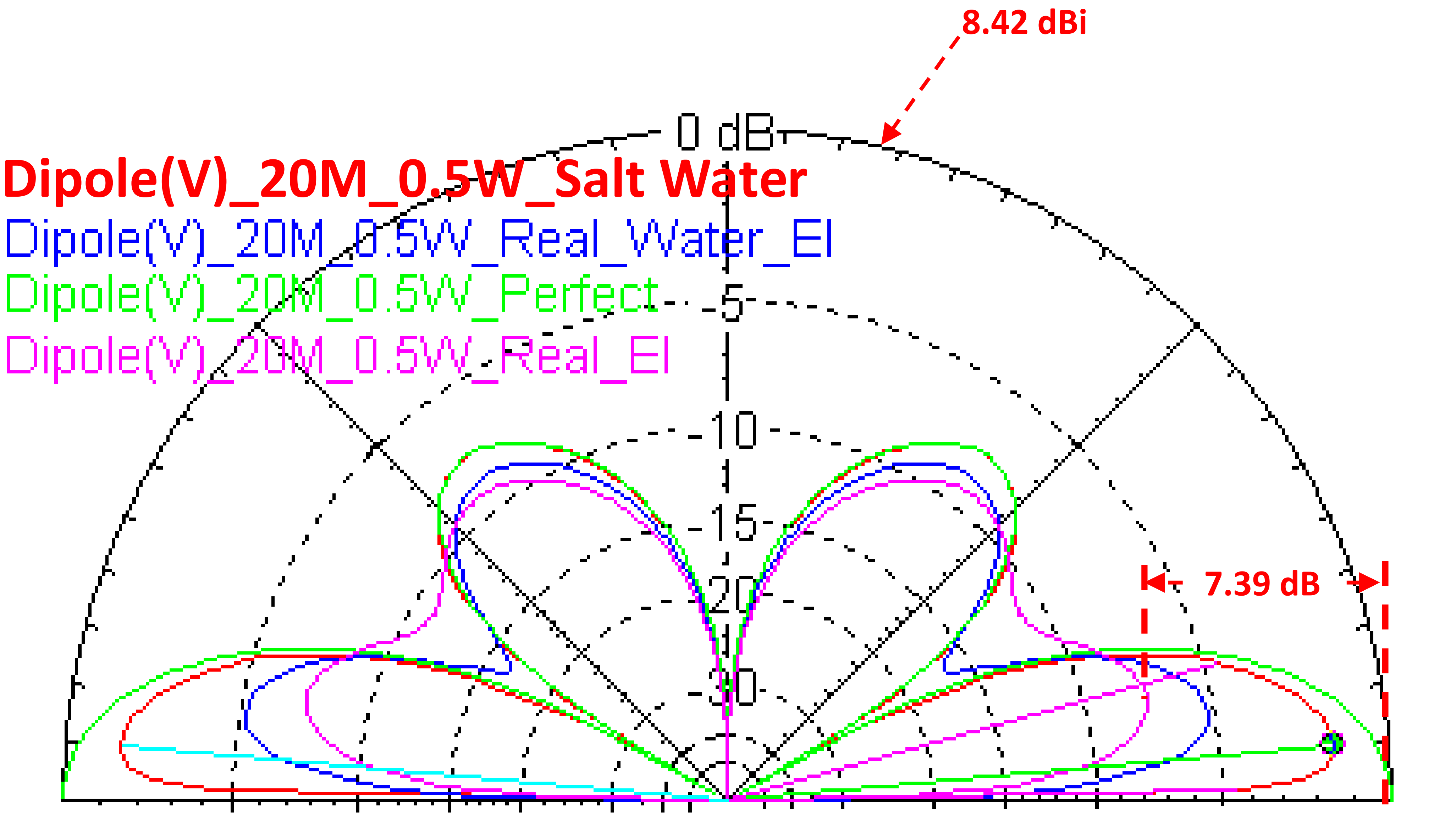
F_o:	14.15 MHz
Gain:	8.42 dBi
EL Angle:	0°
EL BW:	14.0°
AZ BW:	n/a°
R:	68.0 Ω
SWR:	1.36
Length (#12):	33.730 ft



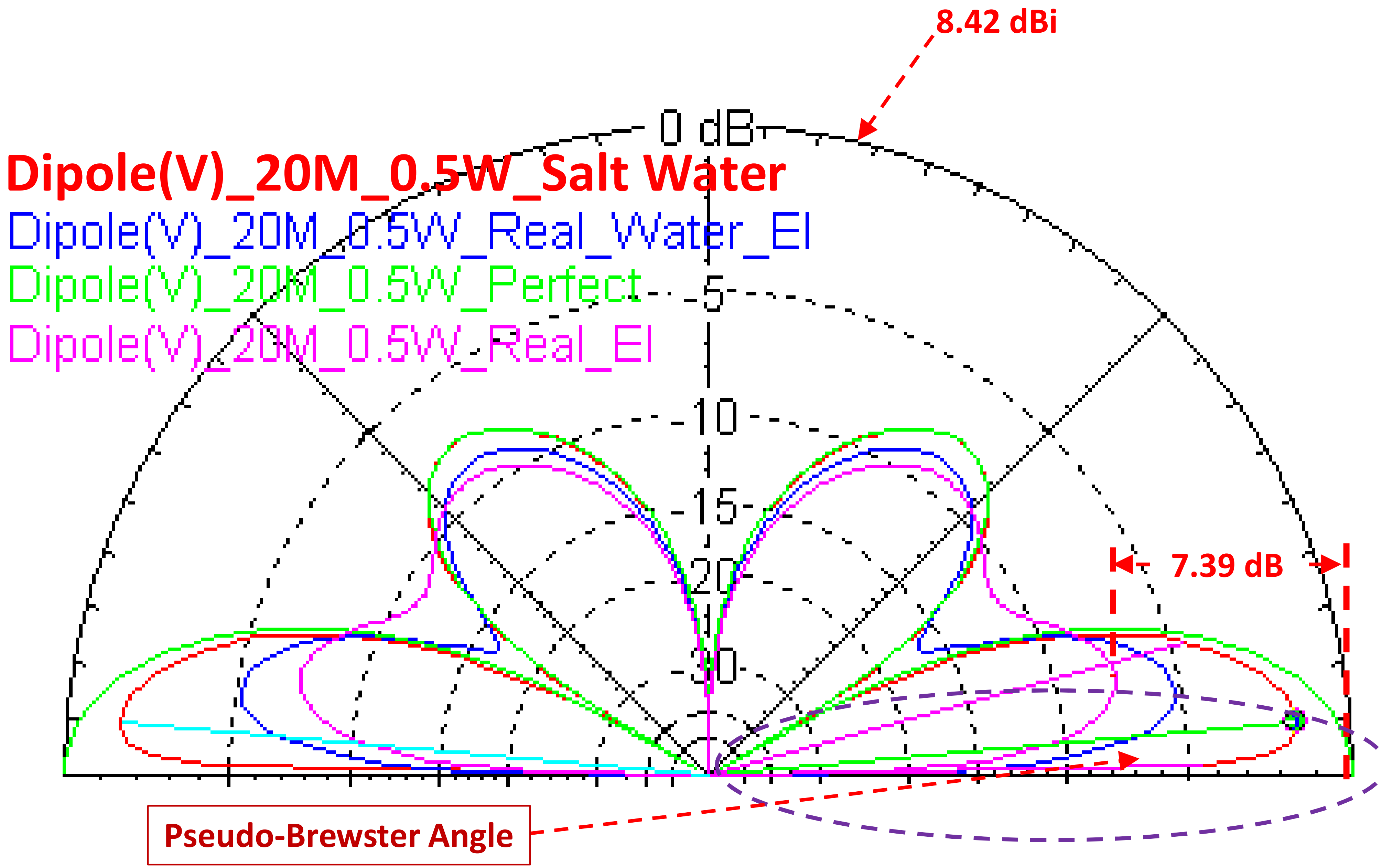
F_o:	14.15 MHz
Gain:	6.91 dBi
EL Angle:	5°
EL BW	14.4°
AZ BW:	n/a°
R:	68.0 Ω
SWR:	1.36
Length (#12):	33.730 ft



Vertical Dipole 1/2λ Above Ground



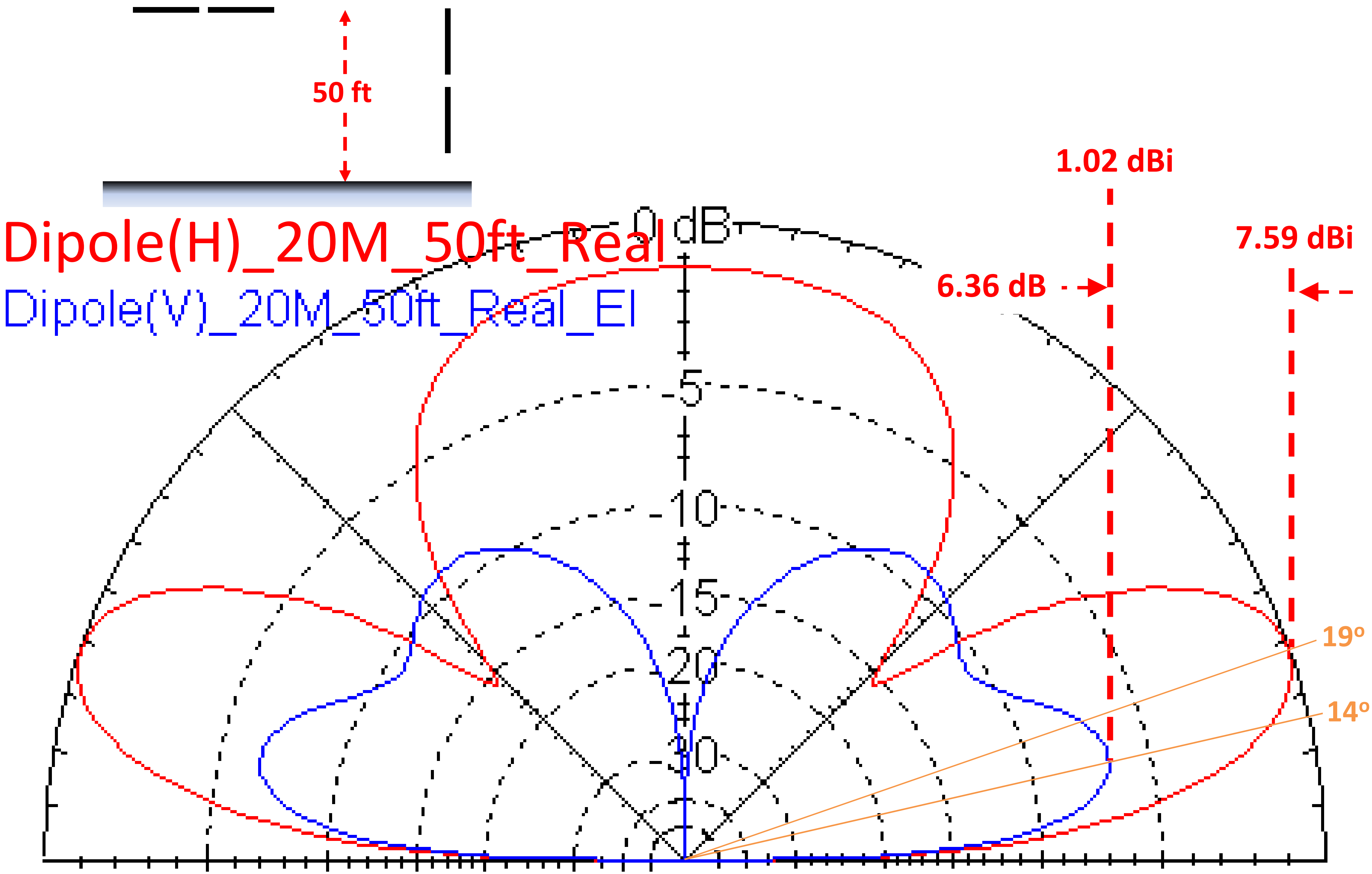
Vertical Dipole 1/2λ Above Ground



Vertically Polarized Antennas Above Ground

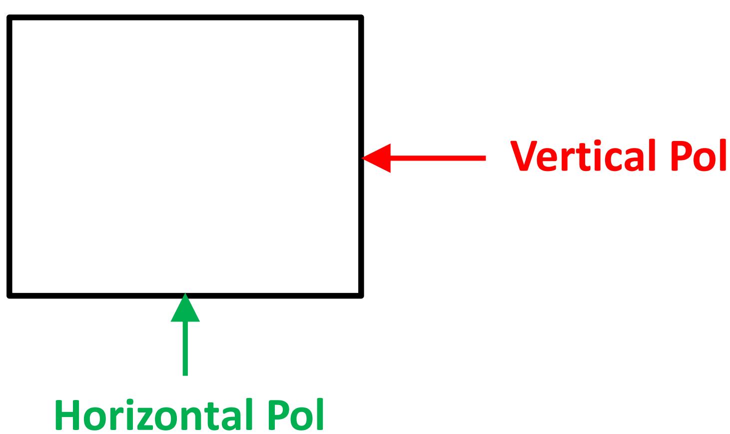
- **Real (lossy) ground results in:**
  - **Lobe splitting**
    - **More lobes as height increases**
    - **Peak gain (main lobe) usually near horizon (EL< 20^o)**
    - **Increasing height may *not* increase peak gain**
  - ***Significant* reduction in gain**
    - **Gain peak never at EL= 0^o with real grounds**
  - **Very deep nulls become very shallow nulls**
    - **Always a null at EL= 90^o**
  - **Z_{ANT} varies modestly with height**
  - **Takeoff angle increases with increasing ground loss**
    - **Pseudo Brewster anlge kills very low angle gain (except for near perfect ground)**
      - **Can *negate low takeoff angle advantage* over horizontal polarization**

Vertical vs Horizontal Dipole at 50 ft Max Above Real Ground

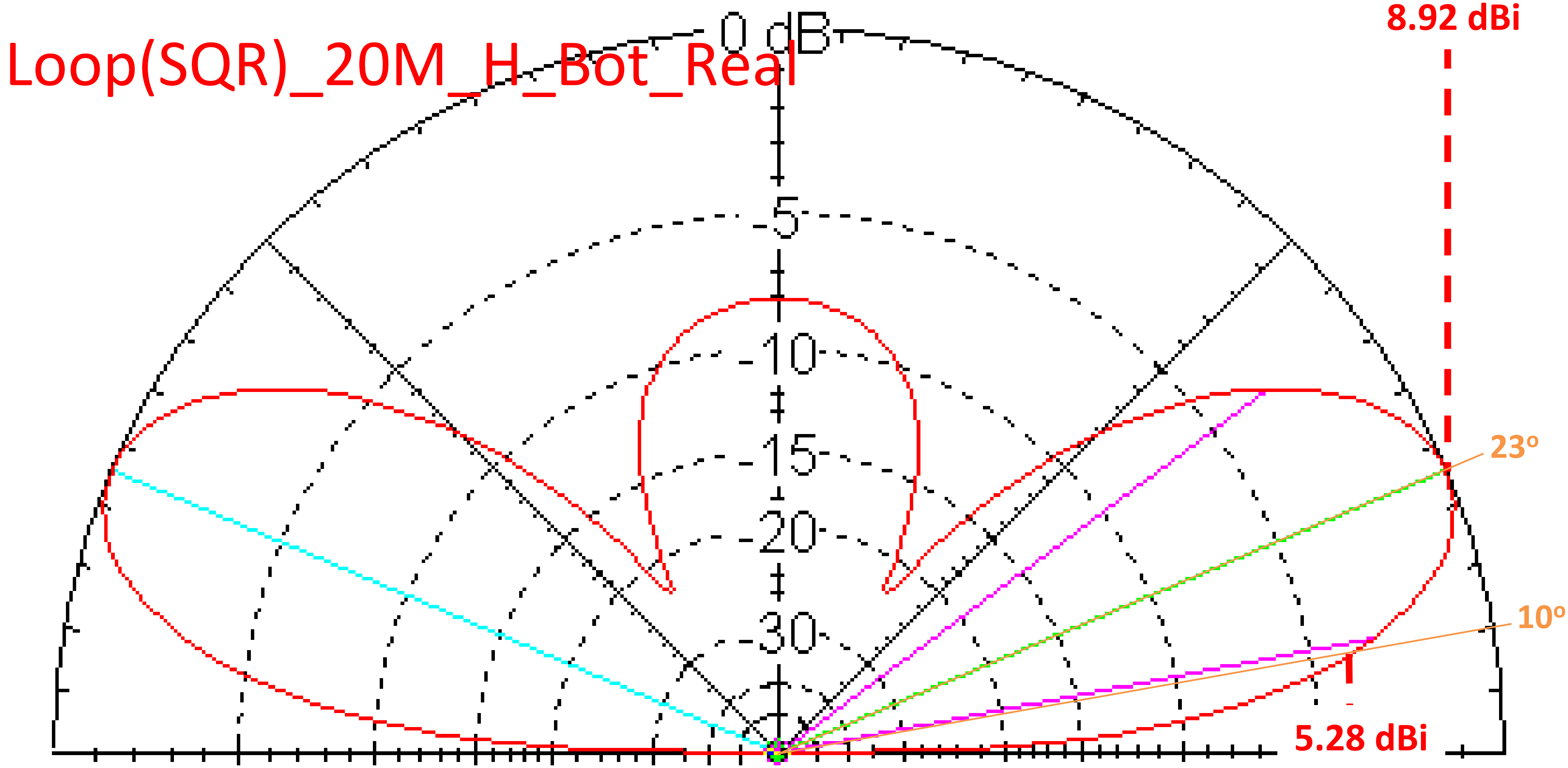


Loop Antenna Comparisons (Free Space)

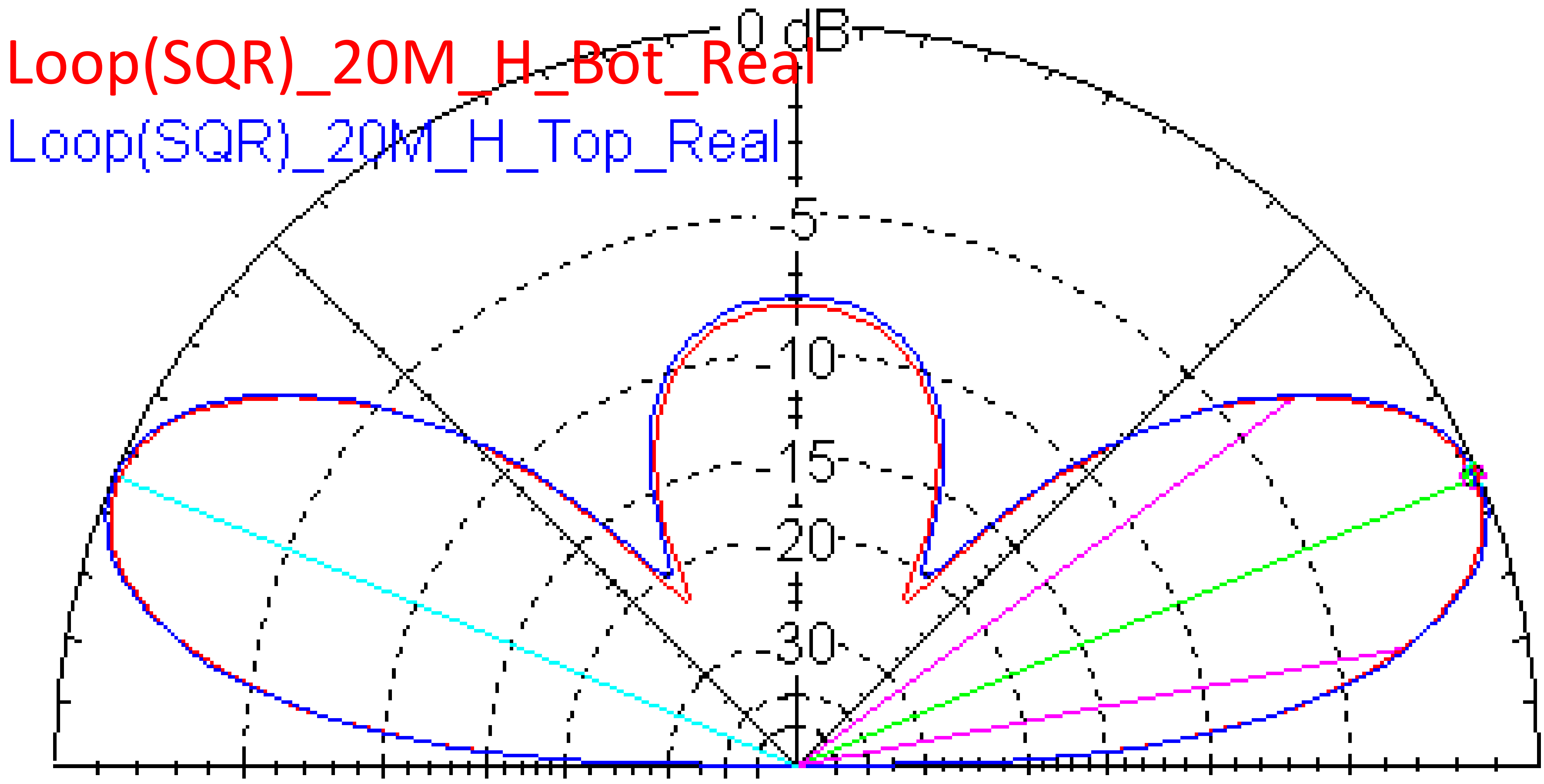
Antenna	Total Length	Gain Over Isotropic	Gain Over Dipole	Radiation Resistance
	Feet	dBi	dBd	Ohms
Dipole	λ/2	2.15	0.00	73
Delta Loop	1λ	2.9	0.75	120
Square Loop	1λ	3.3	1.19	125
Diamond Loop	1λ	3.3	1.19	125
Circular Loop	1λ	3.5	1.34	133



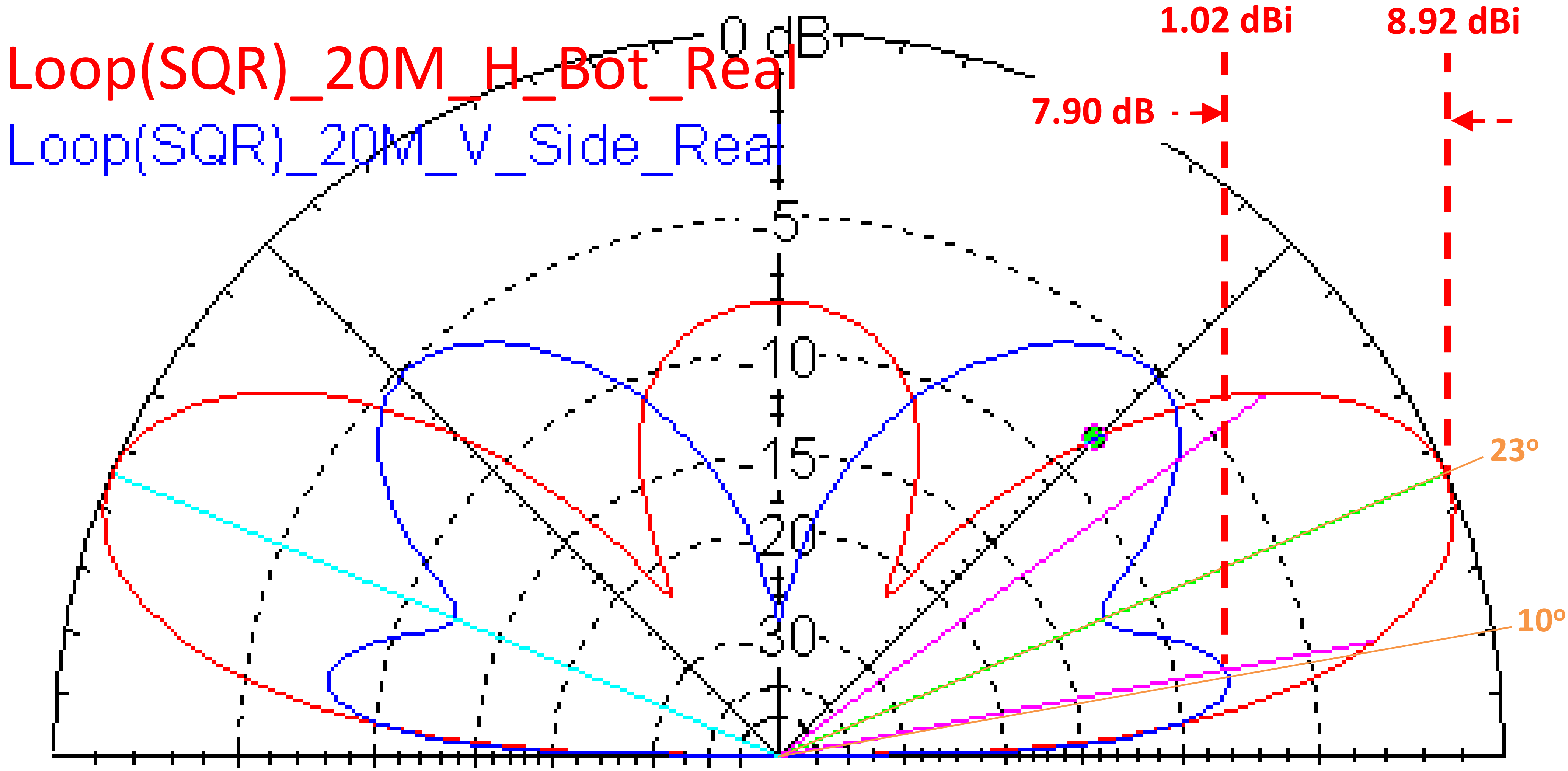
Full Wave Loop at 50 ft Max Above Real Ground



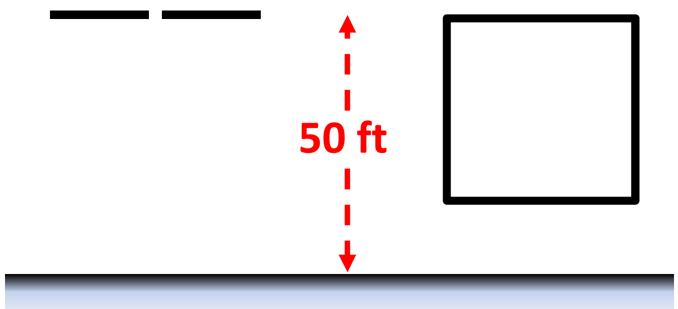
Full Wave Loop at 50 ft Max Above Real Ground

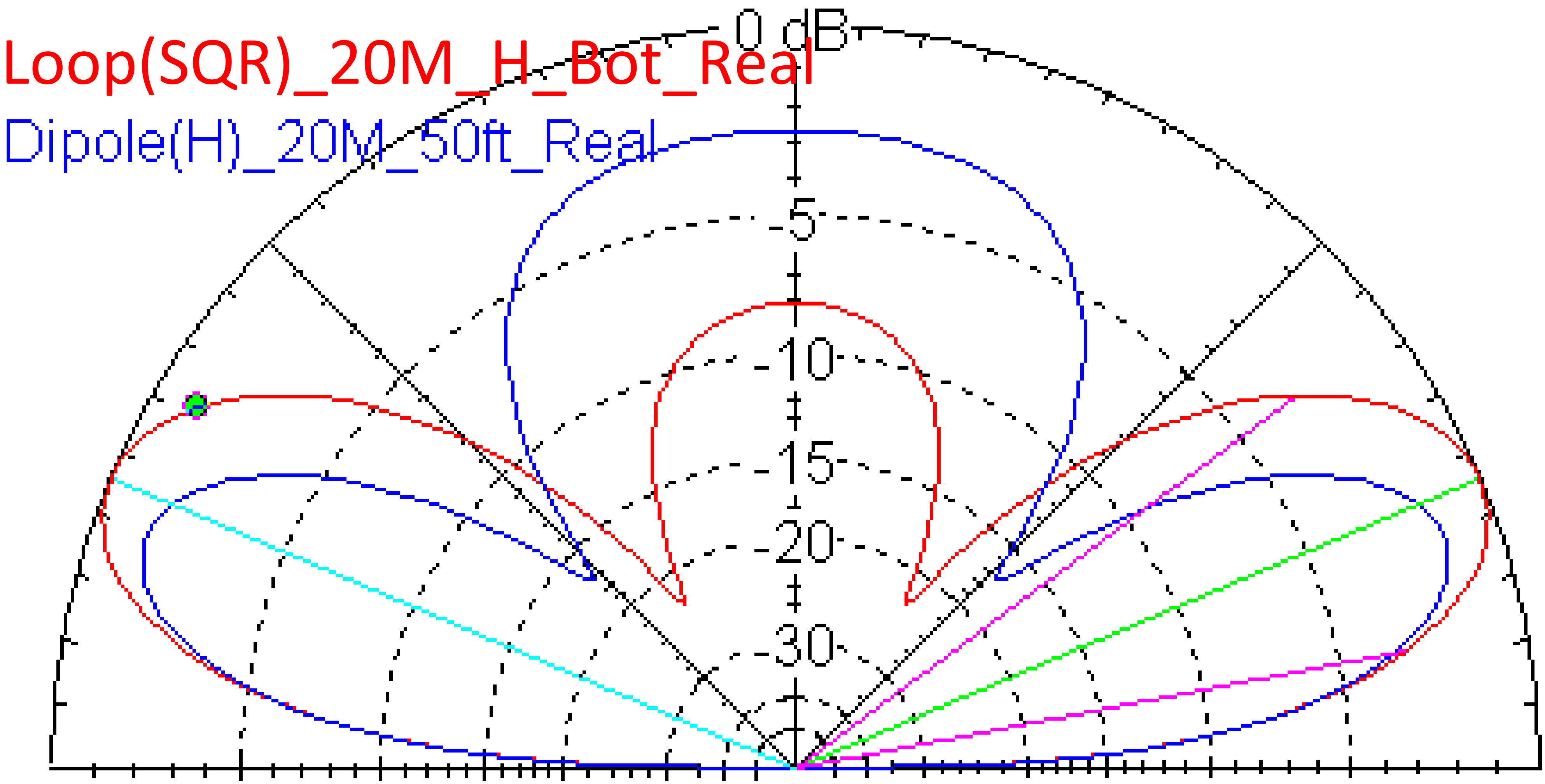


Full Wave Loop at 50 ft Max Above Real Ground



Dipole & Full Wave Loop at 50 ft Max Above Real Ground





Dipole & Full Wave Loop at 50 ft Max Above Real Ground