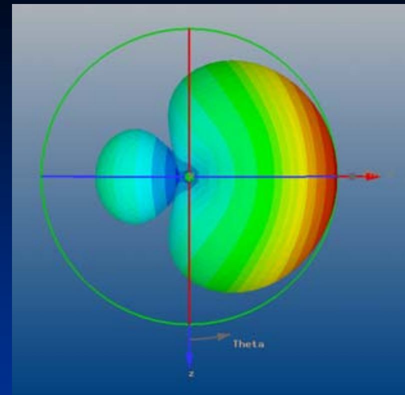
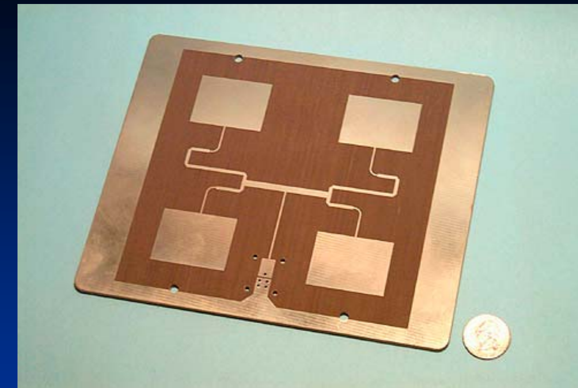
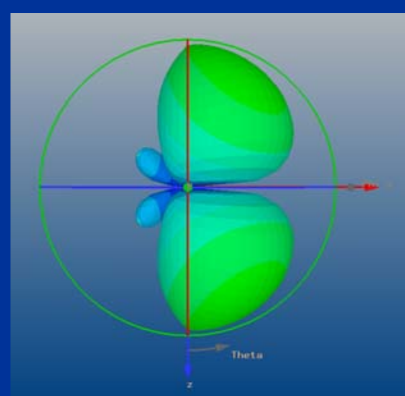


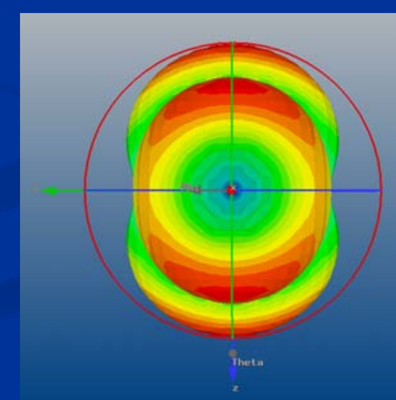


The Yagi, J-Pole and NVIS Dipole

Design and 3D Electromagnetic Simulation

Brian Mileshosky, N5ZGT





Antennas

- The most critical element of any transmitting/receiving system.
- Come in many shapes (linear, helical, aperture, reflective, horns, loops, mixtures of each) and sizes (100+ foot tower down to something less than the size of a stamp).
- Design criteria: gain, bandwidth, physical size, directivity, polarization, feed method, power handling, price, ease of fabrication, etc.
- **Key point:** Antennas are reciprocal devices – they behave the same while transmitting as they do while receiving (including its radiation pattern)
- Designed using a variety of theory and computational tools
  - NEC (free)
  - 4NEC2 (free, and awesome!)
  - EZ NEC ($89)
  - PCAAD ($450)
  - CST Microwave Studio or Ansoft HFSS (>$50,000)
- Other resources:
  - ARRL Antenna Book
  - LB Cebik's website (www.cebik.com)
  - Antenna Engineering Handbook (Johnson) and Antenna Theory (Balanis)
  - Google

The Yagi Uda antenna

- Described and published by S. Uda and H. Yagi in the 1920s
- Did not receive full acclaim in the United States until 1928.
- Driven element is excited directly via feedline, all other elements excited parasitically.
- Element lengths/diameters and element spacing determine antenna behavior.
- Typical driven element: less than $\lambda/2$.
- Typical director length: 0.4-0.45λ
  - If multiple directors are use, they are not necessarily the same length or diameter.
  - Typical separation between directors is 0.3-0.4λ, but not necessarily equally spaced.
- Typical separation between driven element and reflector: 0.25λ.
- Little performance is added with the addition of more than one reflector.
- Significant performance is added with the addition of more directors.
- Input impedance is usually small; Gamma matches often used to match to 50Ω.

The Yagi Uda antenna

Typical data for Yagi-Uda antennas:

3 elements: 7-dBi gain

4 elements: 9-dBi gain

6 elements: 10.5-dBi gain

8 elements: 12.5-dBi gain

12 elements: 14.5-dBi gain

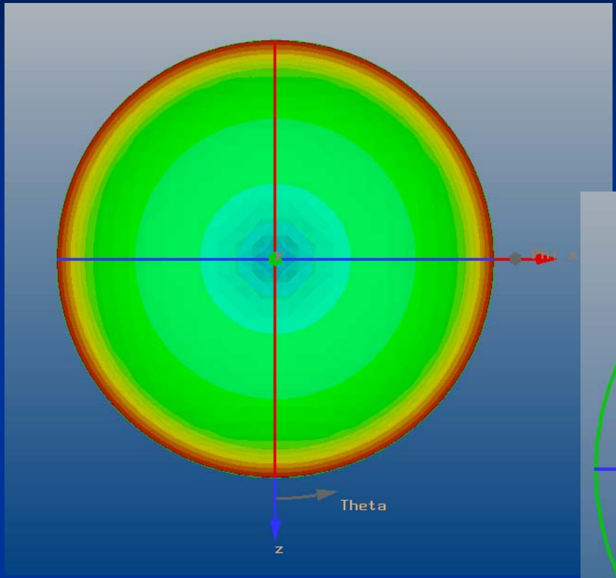
15 elements: 15.5-dBi gain

18 elements: 16.5-dBi gain

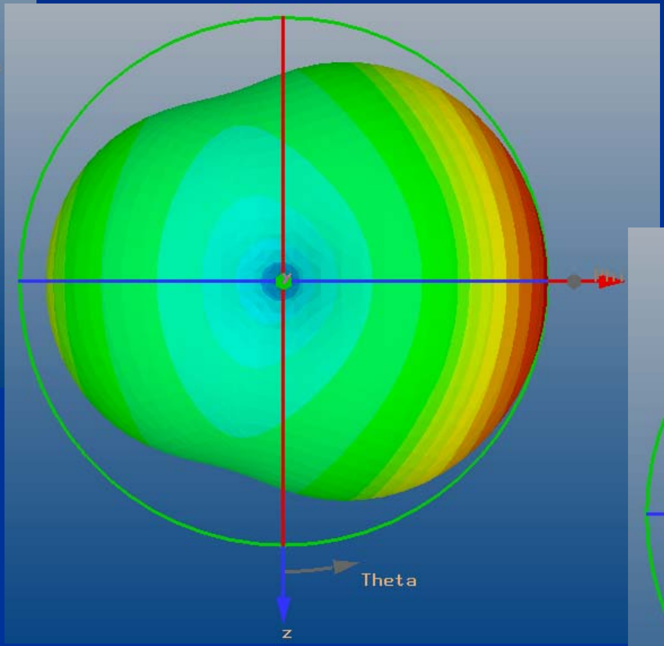
Source: Antenna Engineering Handbook (Johnson)

Note: 0 dBi = 2.14 dBd

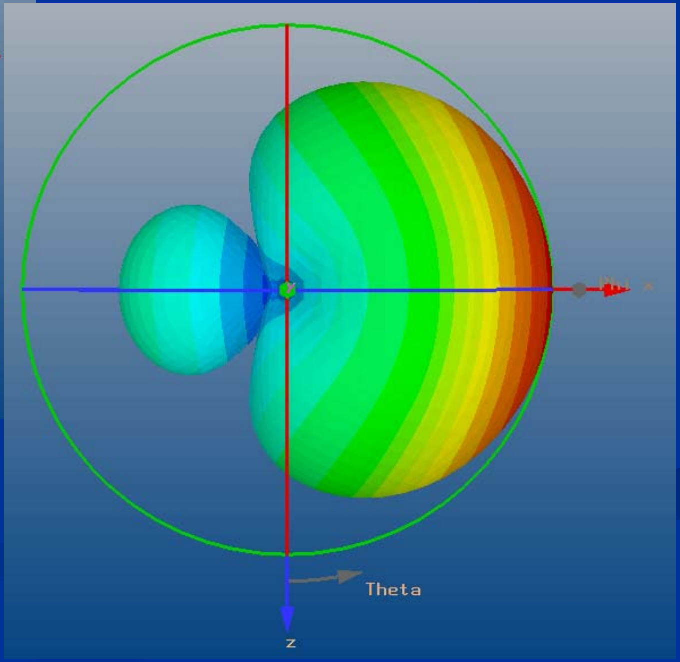
Yagi performance, element by element



Driven element only
Gain: 1.98 dBi



Driven element and director
Gain: 5.7 dBi



Driven element, director and reflector
Gain: 7.74 dBi

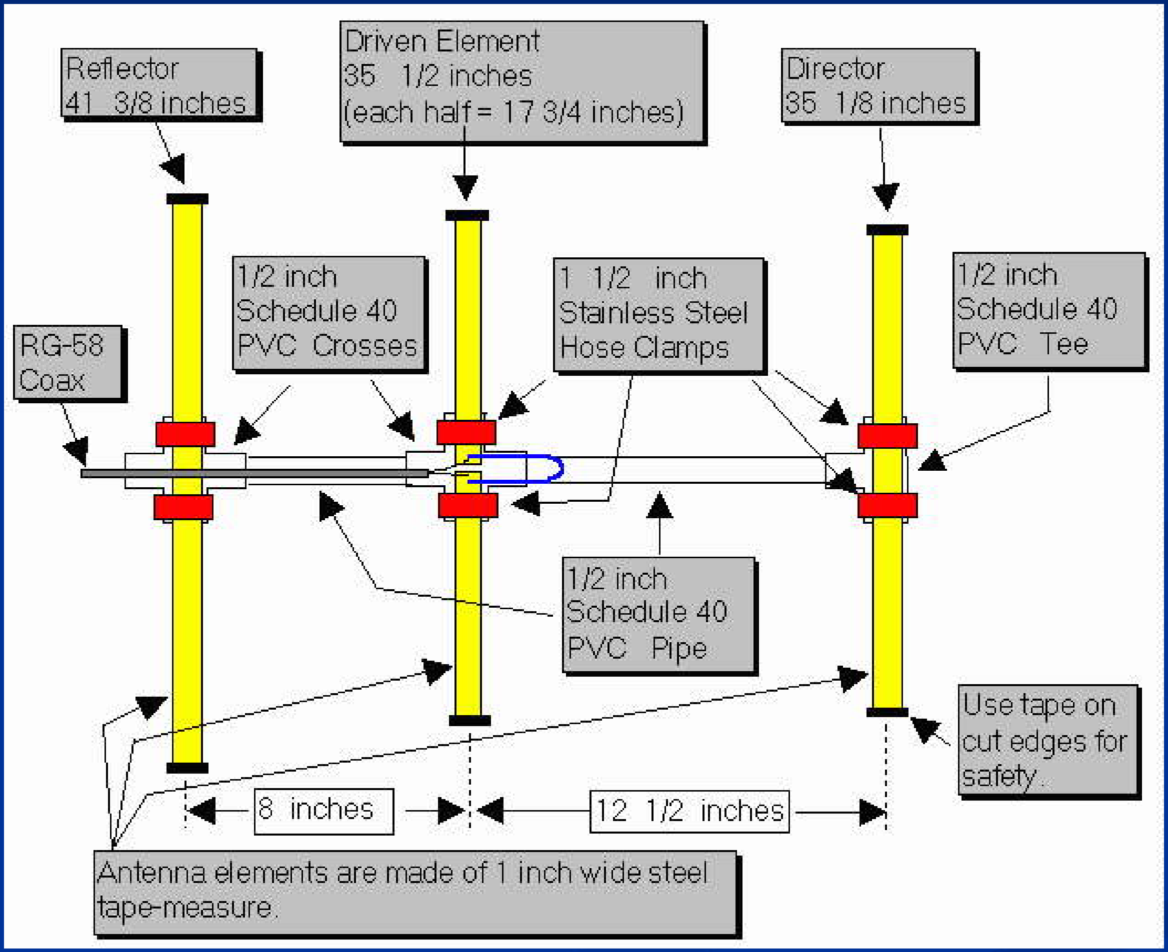
The Tape Measure Yagi…

The Tape Measure Yagi

- Easily built from PVC, tape measure material, hose clamps and a short piece of coax.
- Total cost, on average: < $15 if you have some parts around garage now.
- Can achieve up to 7-dBi of gain from this antenna – perfect for use in the field, or from home. Excellent antenna for radio direction finding on 2 meters. Just as excellent for reaching distant stations or repeater while in the field for ARES.
- Not intended for permanent installation – elements will collapse briefly when blown by a gust of wind.
- Not intended for high power use – you will be in the near-field of this antenna when transmitting. Use common sense and be safe!
- Plans and description provided by Joe Leggio WB2HOL at: http://home.att.net/~jleggio/projects/rdf/tape_bm.htm

- **Tip**: Use silver solder since tape measure material is stainless steel!
- **Tip**: Don't use RG-58…way too clumsy. Use RG-174 with BNC or SMA installed.
- **Tip**: Round off element edges to prevent cuts, or fold over piece of electrical tape, or dip in liquid rubber.

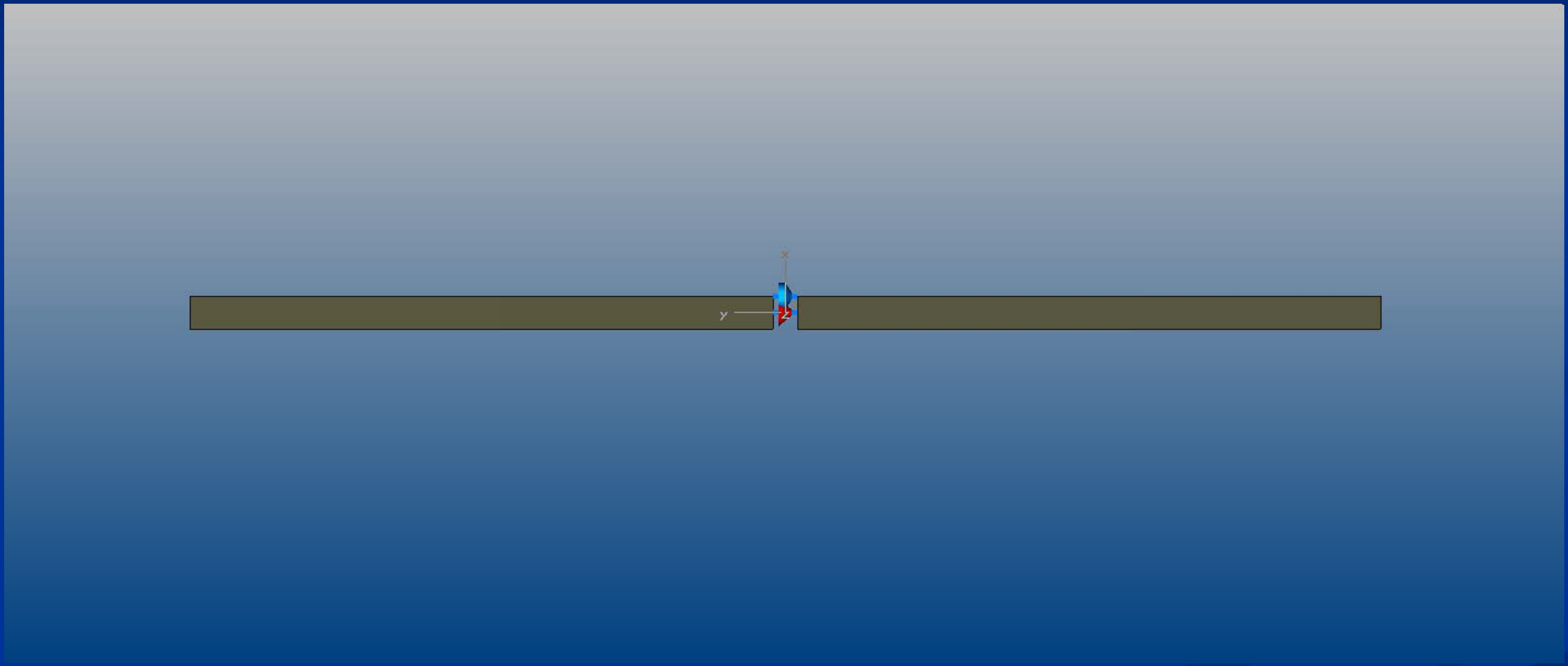
The Tape Measure Yagi



A quick look at Dipoles and NVIS

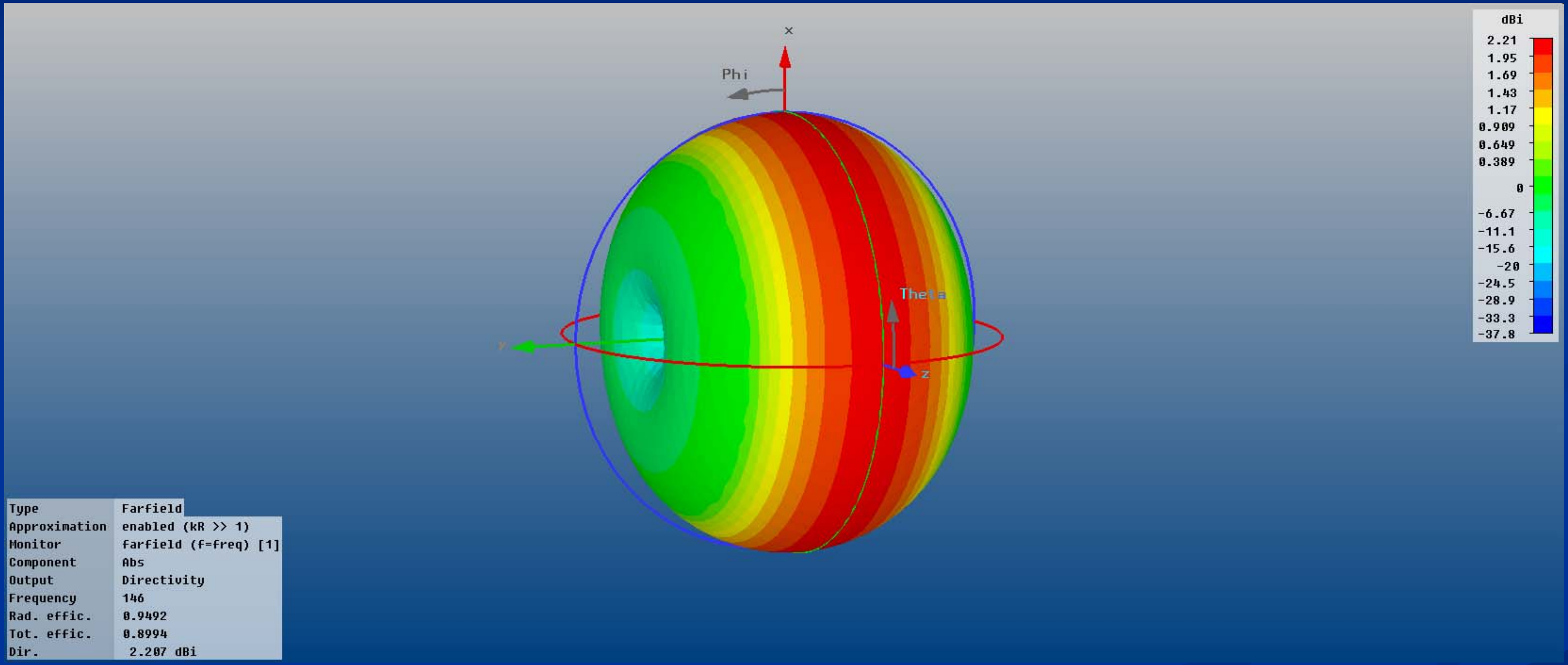
An excellent presentation on what Near Vertical Incident Skywave (NVIS) is all about:
http://www.arrl.org/FandES/ead/materials/NVIS.ppt

Dipole (suspended in air)



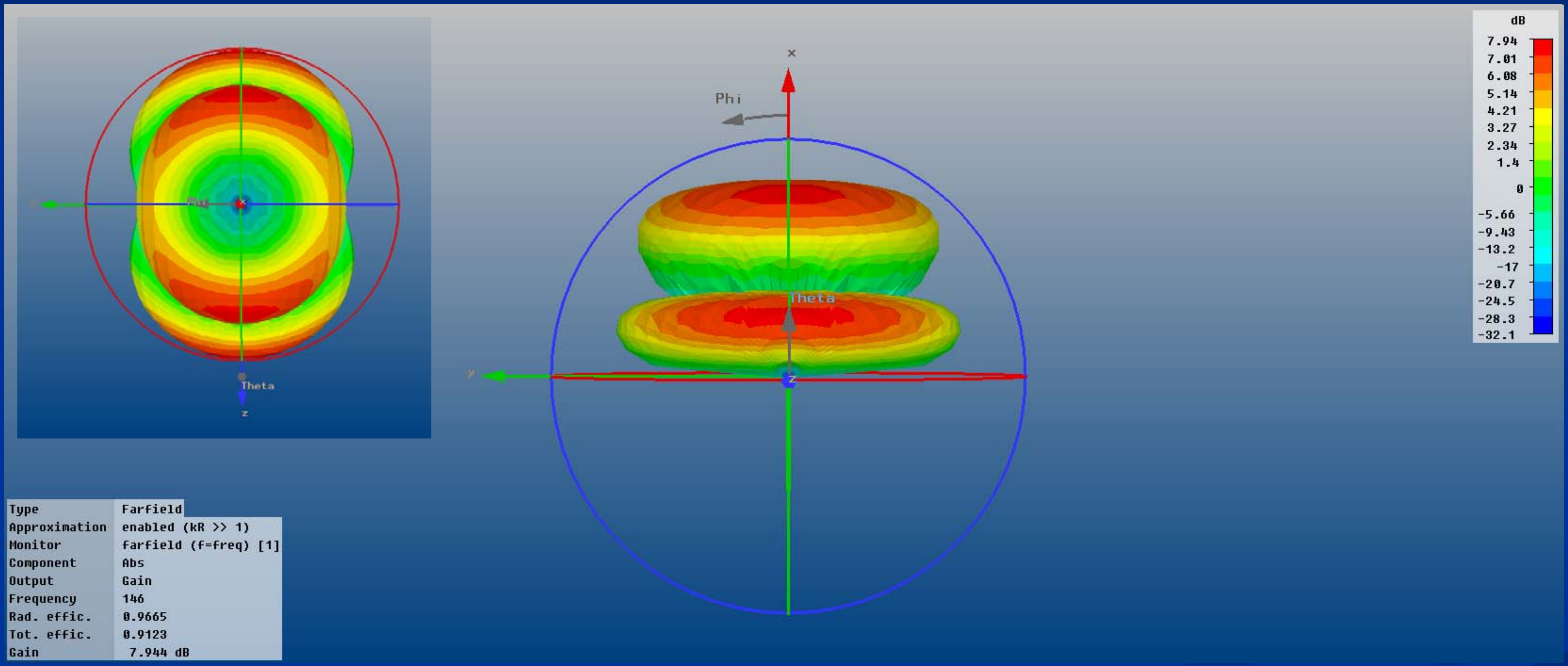
Dipole, no ground plane

Dipole (suspended in air)



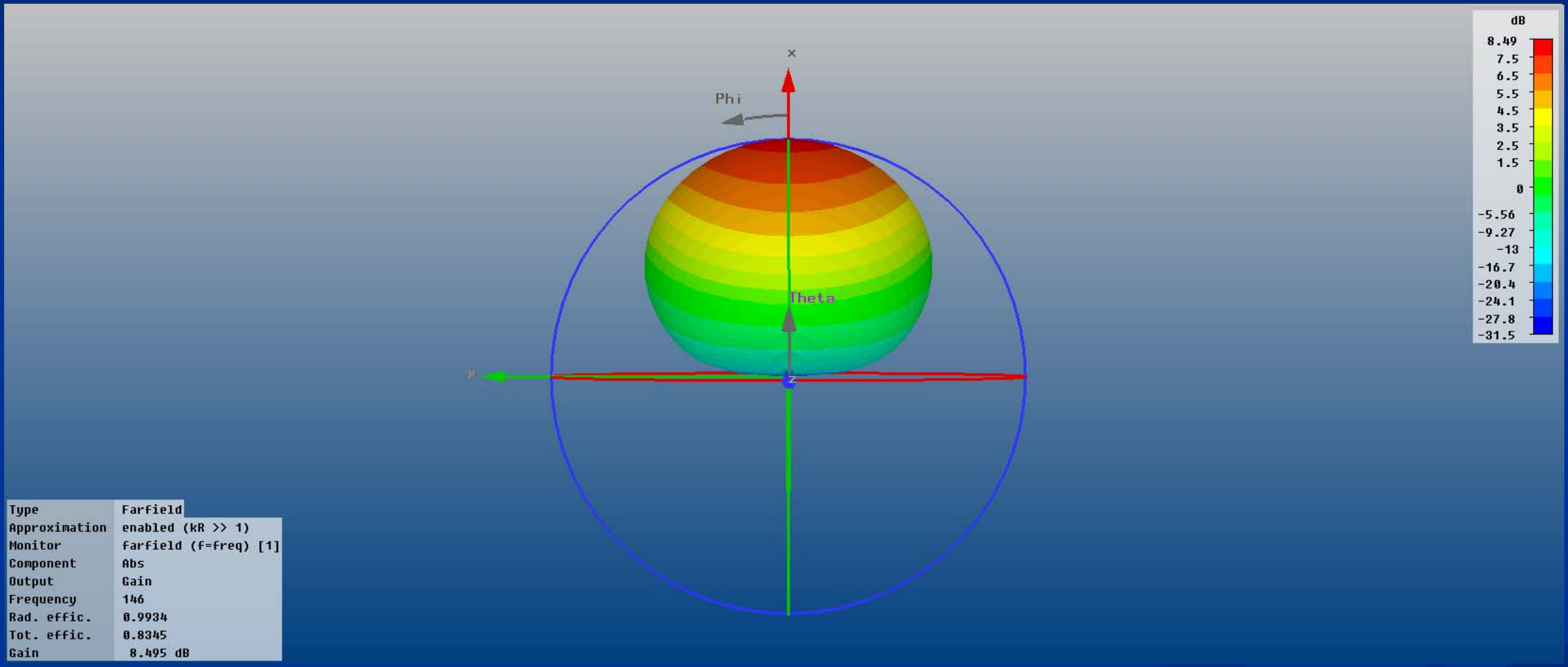
Suspended in air; no ground effects
Absolute gain (horizontal + vertical polarization)

Dipole (Non-NVIS, 1λ above ground)



Dipole modeled over perfect, infinite ground. Absolute gain (horizontal + vertical polarizations) shown above. Note that most of radiation is taking off at a low angle. This is a non-NVIS case.

Dipole (NVIS, 0.1λ above ground)



Dipole modeled over perfect, infinite ground. Absolute gain (horizontal + vertical polarizations) shown above. Note that antenna is now radiating almost entirely upward – crucial for NVIS operation!

Selected web resources

- **Yagis:**
  - P.P. Viezbicke, “Yagi Antenna Design, ” December 1968: http://tf.nist.gov/timefreq/general/pdf/451.pdf
- **J-Poles:**
  - Compilation of articles: http://www.arrl.org/tis/info/JPole-V.html
- **NVIS:**
  - Excellent Powerpoint presentation with links to websites: http://www.arrl.org/FandES/ead/materials/NVIS.ppt
- **Antenna design & software:**
  - L.B. Cebik W4RNL: http://www.cebik.com
  - ARRL Technical Information Service: http://www.arrl.org/tis/tismenu.html
  - NEC: http://www.nec2.org
  - 4NEC2: http://home.ict.nl/~arivoors
  - EZ NEC: http://www.eznec.com