The Yagi Antenna

And other interesting tid-bits…

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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 construction, etc.
- **Key point:** Antennas are reciprocal devices – they behave the same while transmitting as they do while receiving (this include antenna patterns)
- Designed using a variety of theory and computational tools
  - NEC (free)
  - EZ NEC ($89)
  - PCAAD ($450)
  - Ansoft HFSS ($$$$$)
  - CST Microwave Studio ($$$$$)
- 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.
- Lengths and diameters of elements, plus their spacing determine antenna behavior.
- Driven element size and diameter has little effect on forward gain, but significant effect on input impedance and backward gain.
- Reflector spacing and size has little effect on forward gain, but significant effect on backward gain as well as input impedance.
- Directors, the most critical part of a Yagi design, control front and backward impedance and input impedance.

The Yagi Uda antenna

- Typical driven element: less than $\lambda/2$.
- Typical director length: 0.4-0.45λ, but not necessarily same length or diameter.
- Typical separation between directors: 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. However, adding 2-3 reflectors in parallel will improve the bandwidth over which a certain front-to-back ratio is maintained.
- Significant performance is added with the addition of more directors.
- Input impedance is usually small; strongly influenced by reflector-driven element spacing. Gamma matches and folded dipoles are used to match Yagis 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

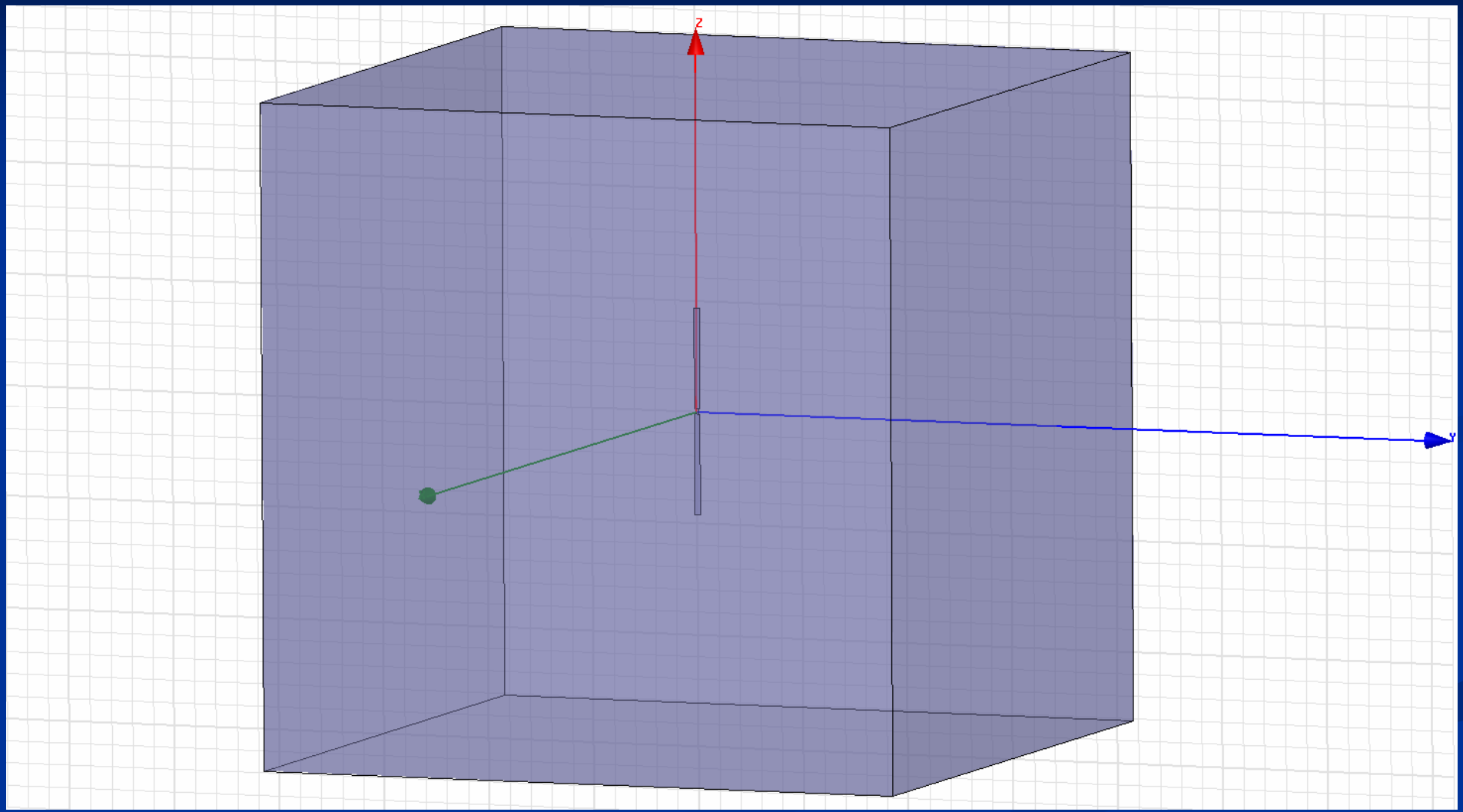
12 elements: 14.5-dBi gain

15 elements: 15.5-dBi gain

18 elements: 16.5-dBi gain

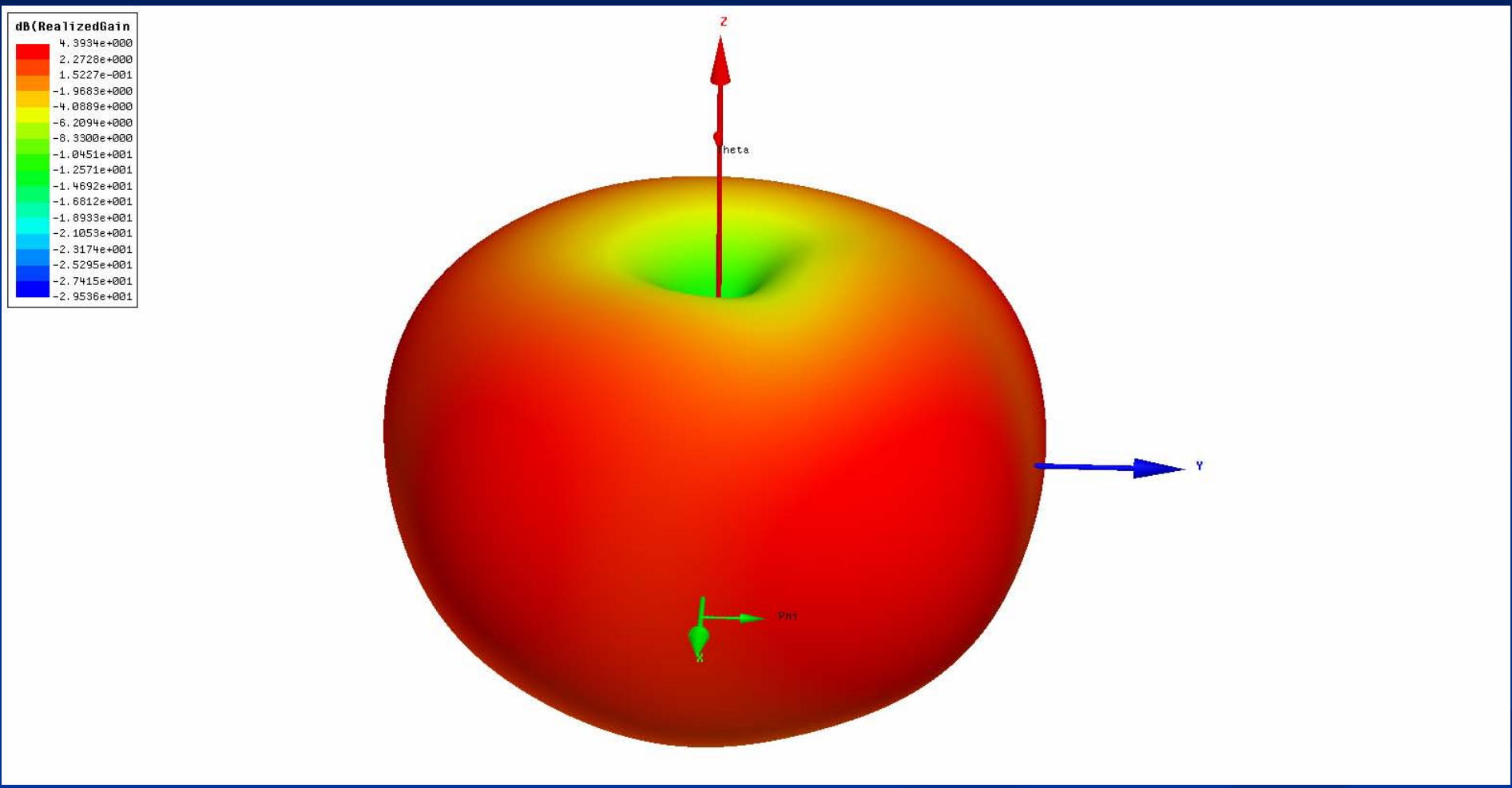
Source: Antenna Engineering Handbook (Johnson)

Driven element only



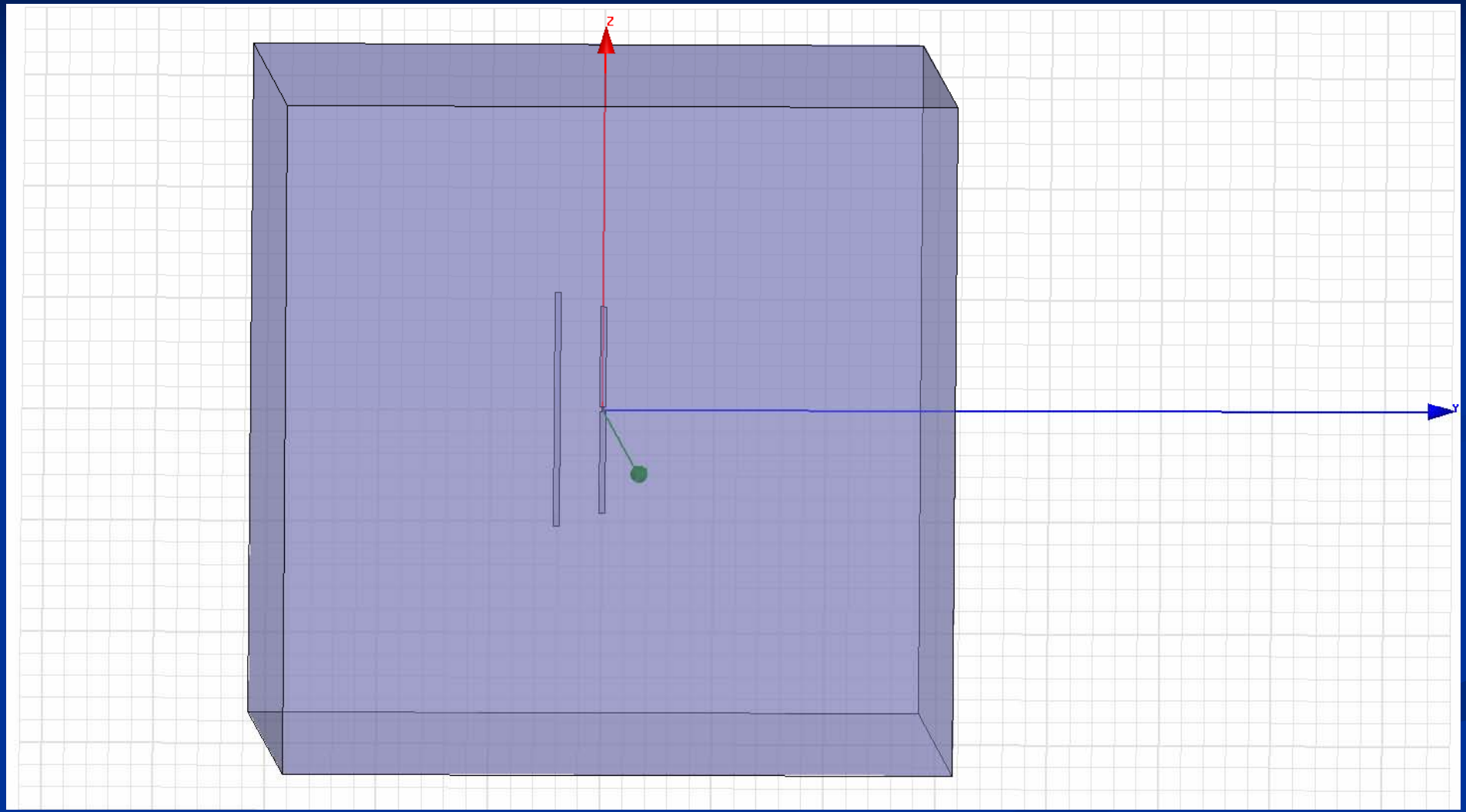
Driven element inside of an air box

Driven element only



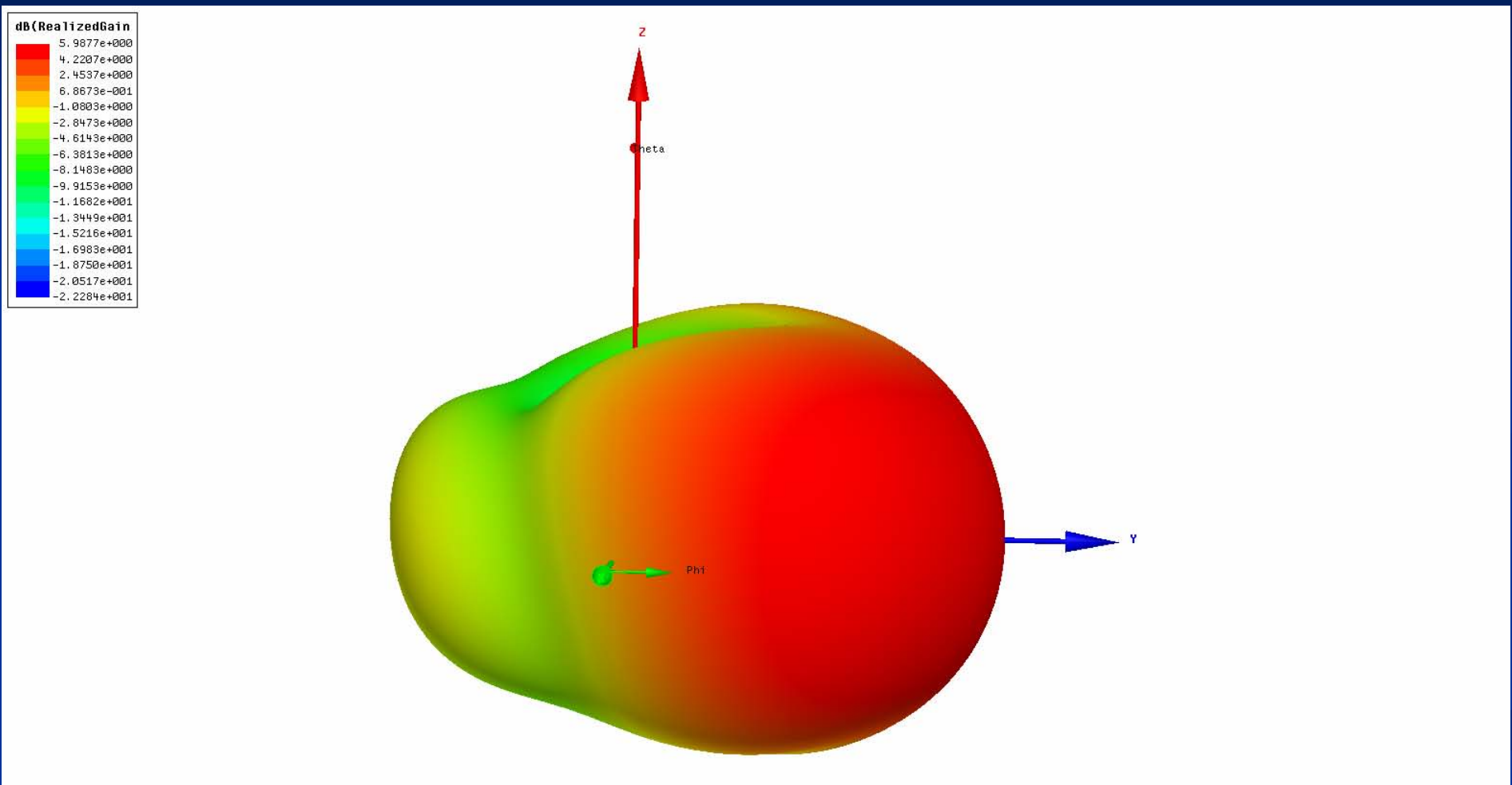
Total gain (horizontal plus vertical polarizations)

Driven element plus reflector



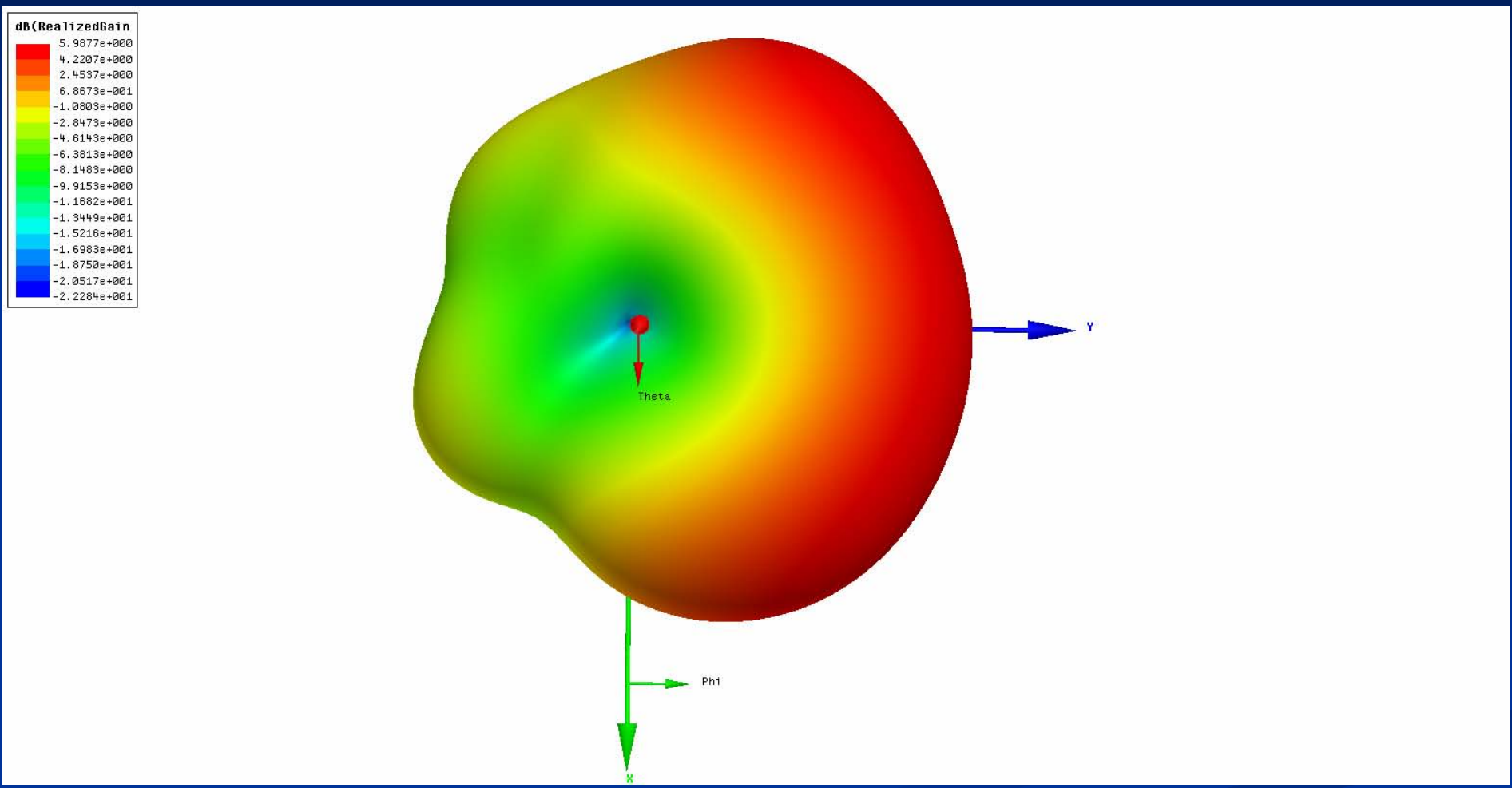
Driven element plus reflector inside of an air box

Driven element plus reflector



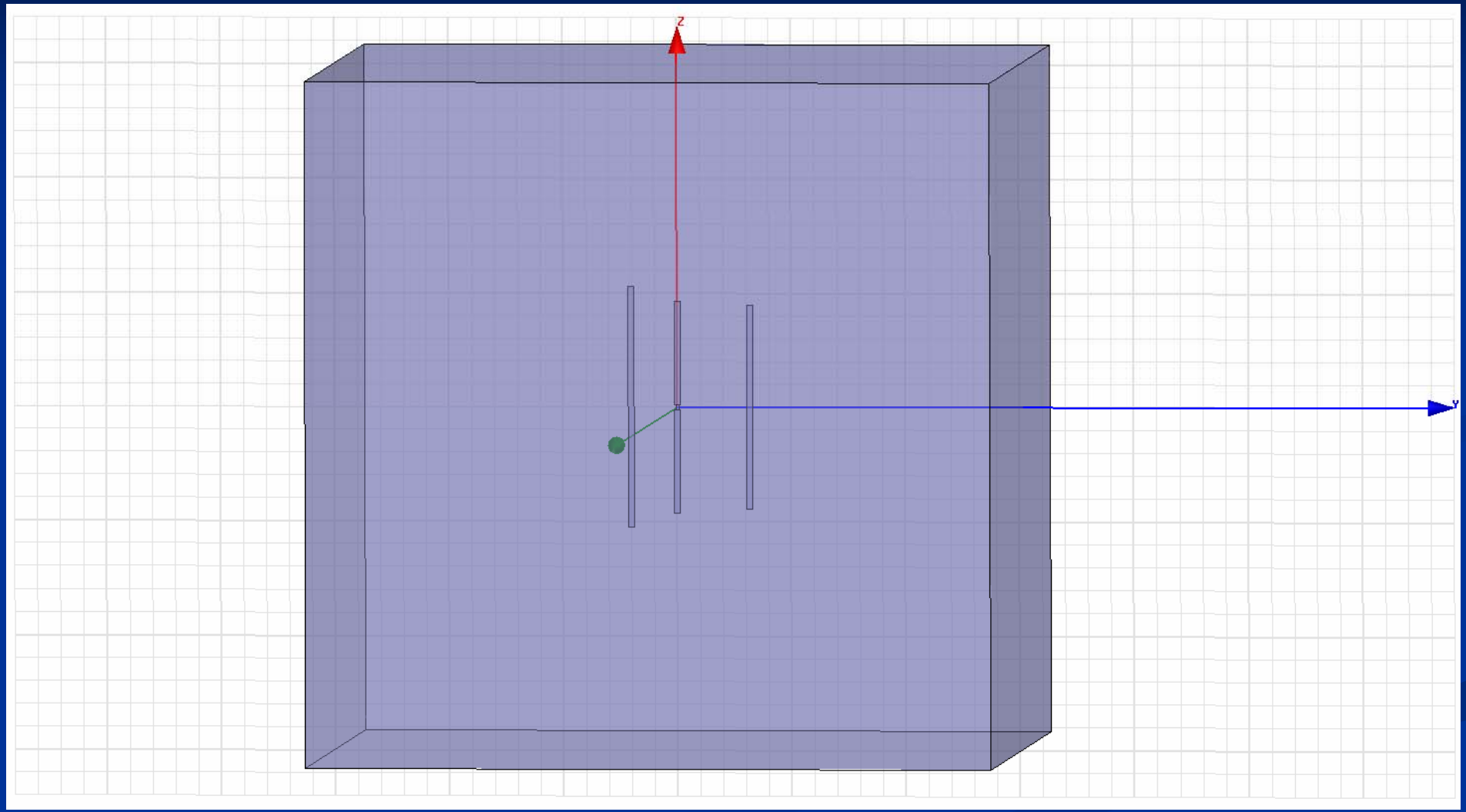
Total gain (horizontal plus vertical polarizations; elevation view)

Driven element plus reflector



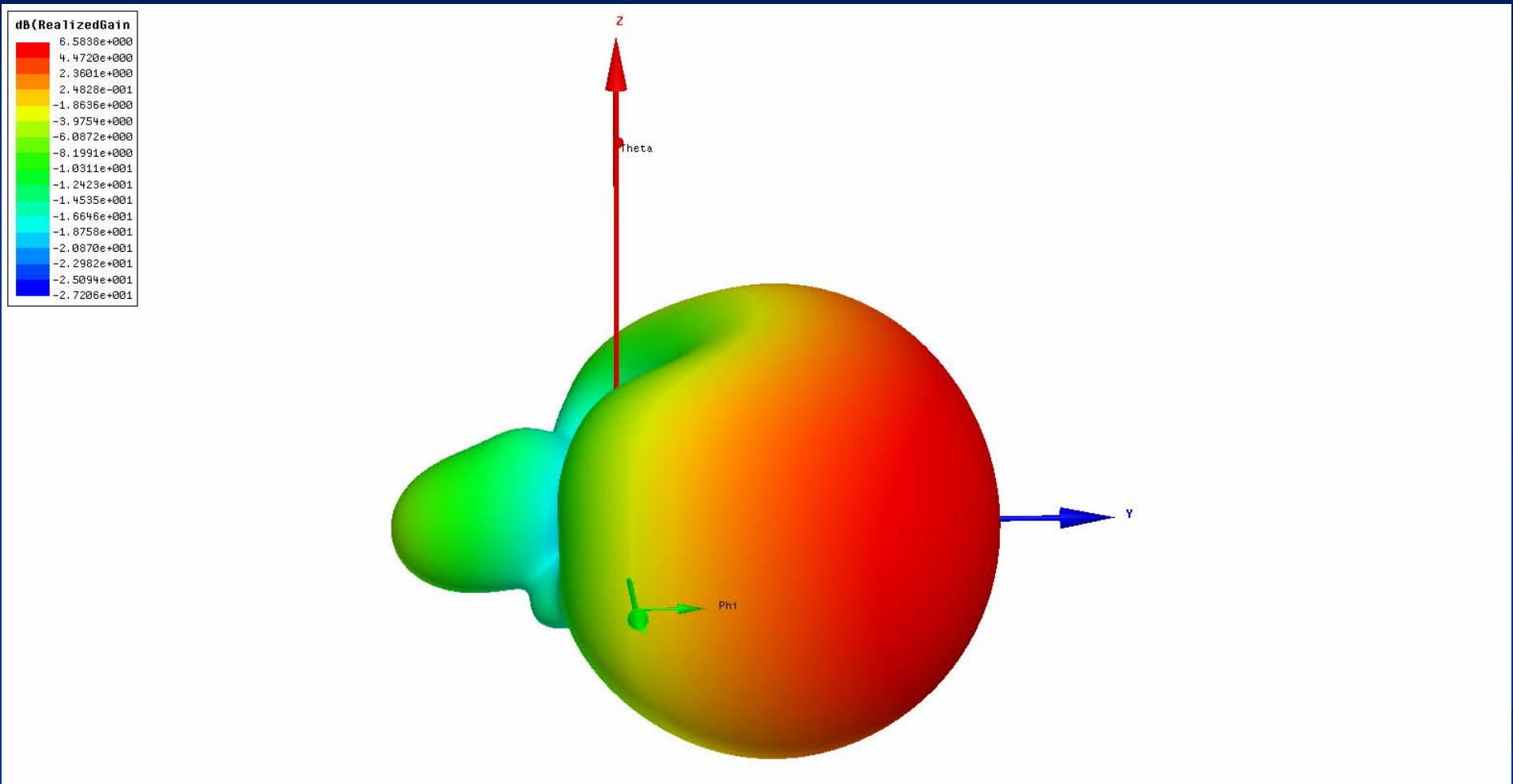
Total gain (horizontal plus vertical polarizations; azimuth view)

Driven element, reflector & director



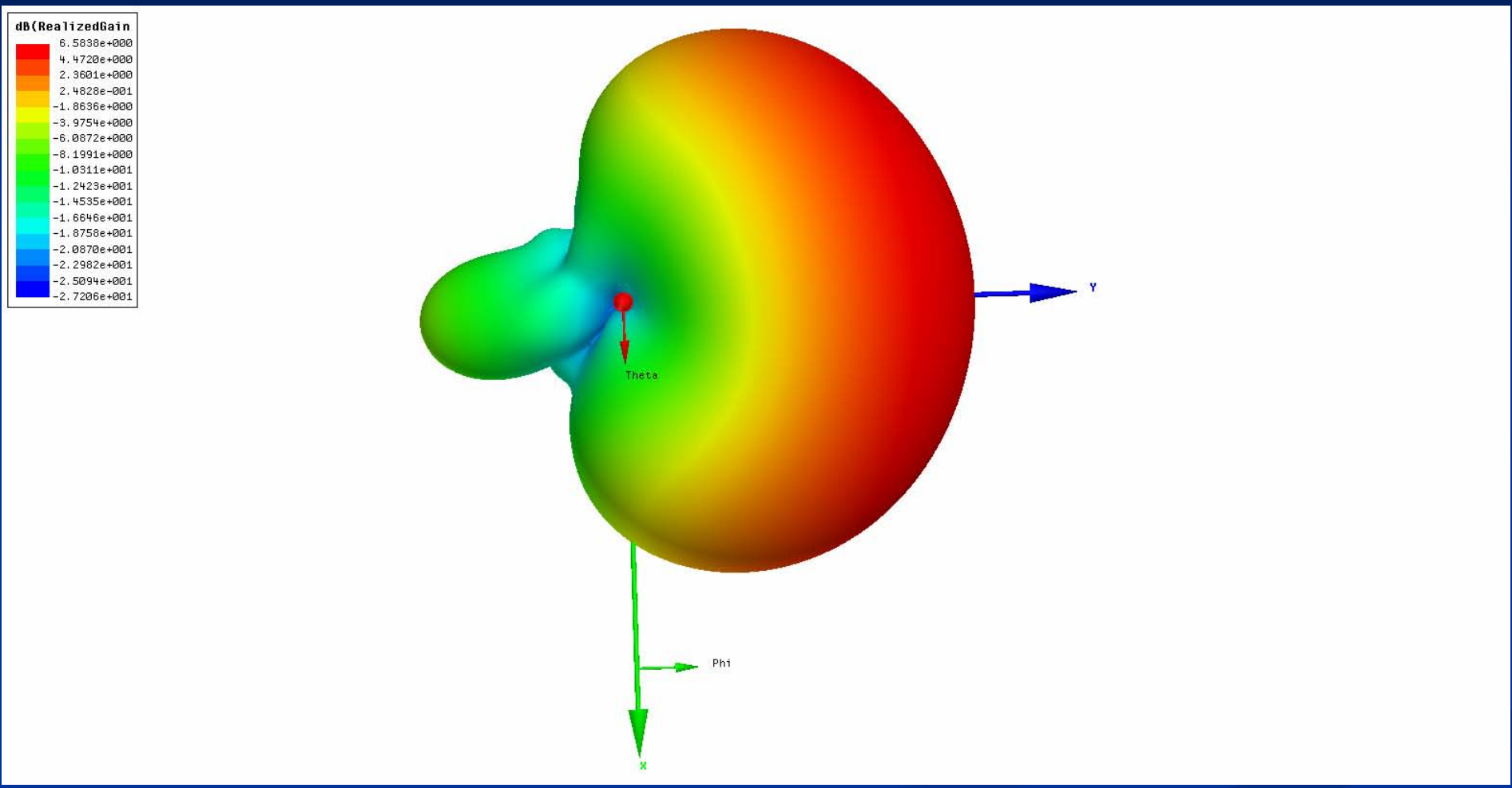
Driven element, reflector & director inside of an air box

Driven element, reflector & director



Total gain (horizontal plus vertical polarizations; elevation view)

Driven element, reflector & director



Total gain (horizontal plus vertical polarizations; azimuth view)

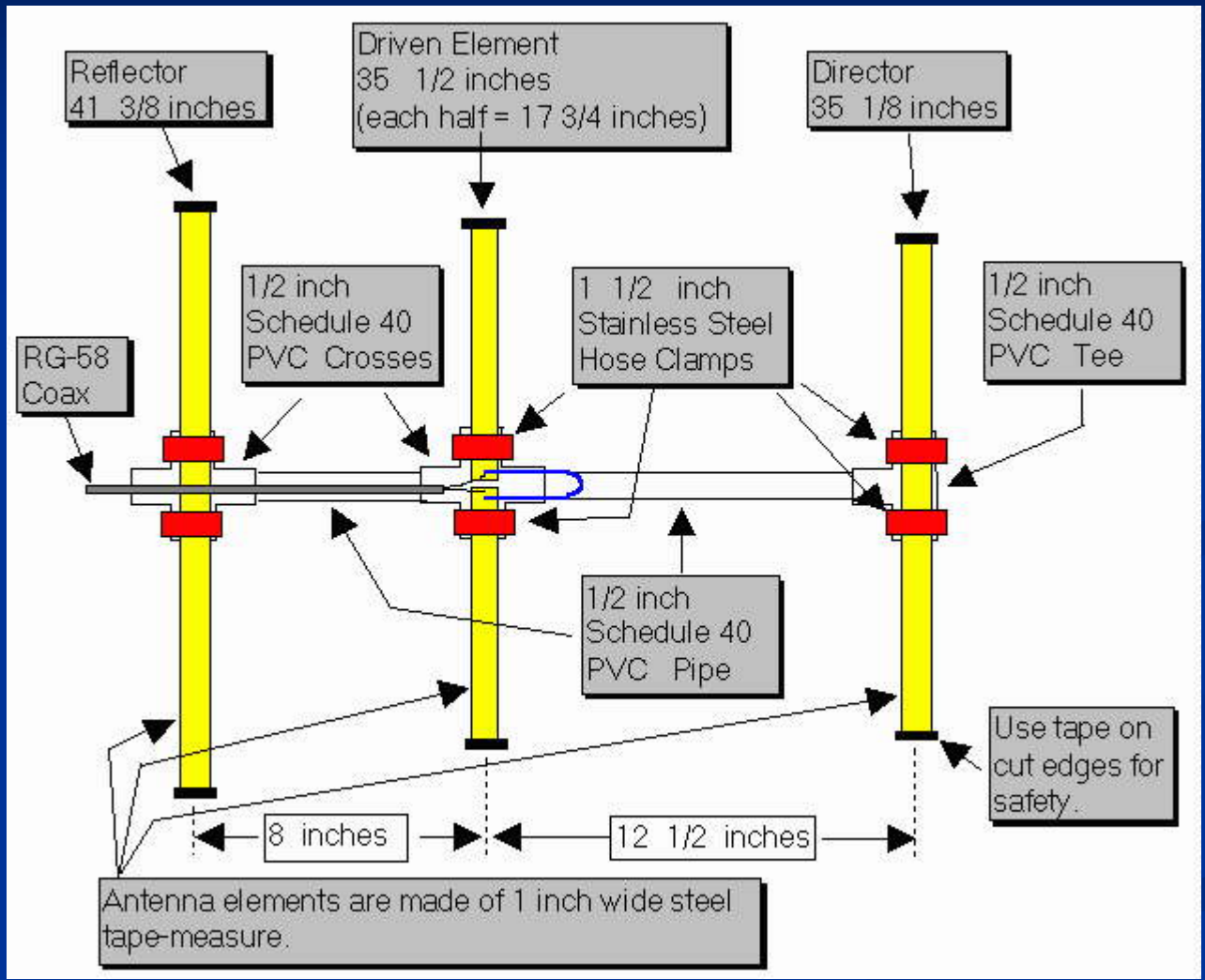
The Tape Measure Yagi…

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

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

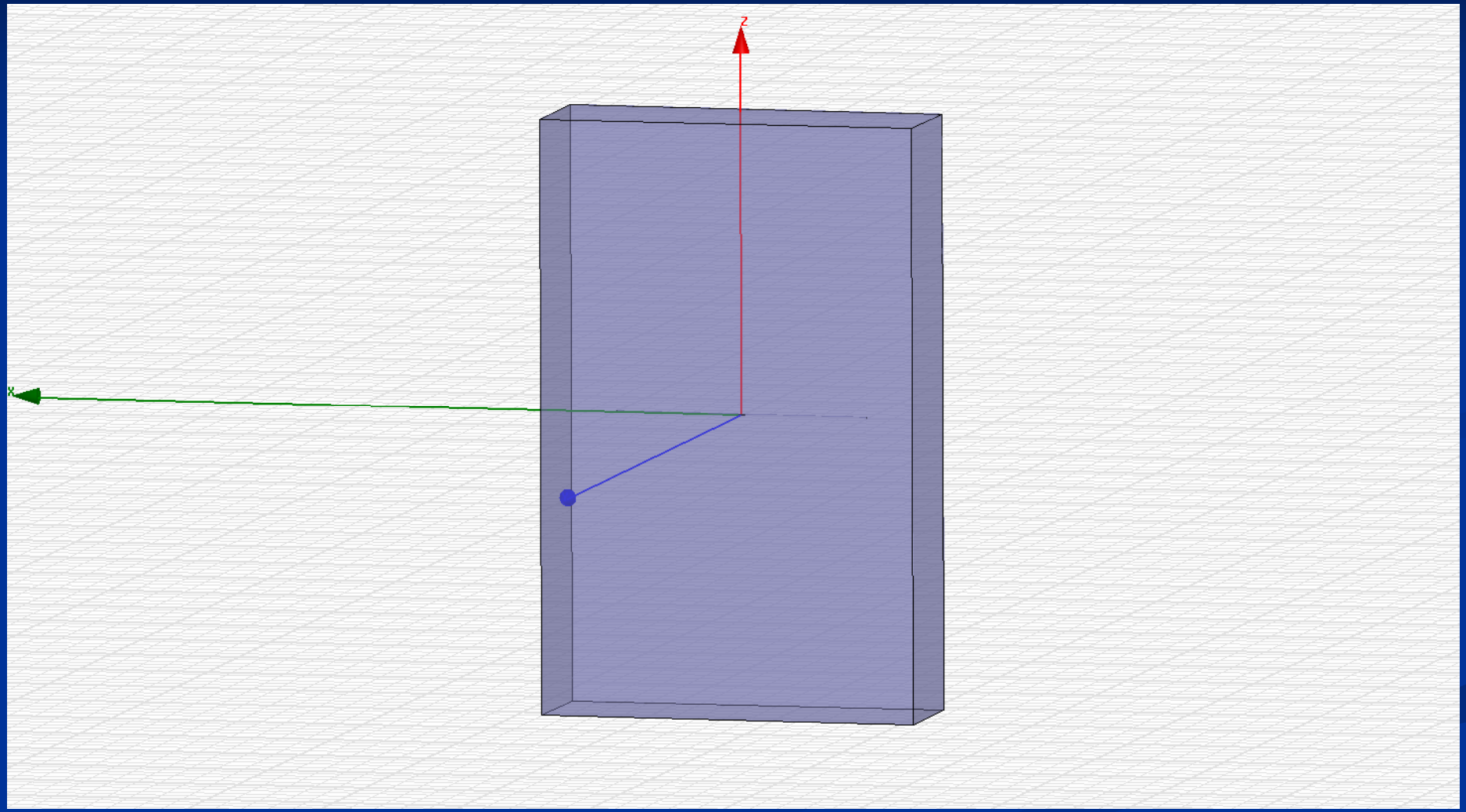
The Tape Measure Yagi



A quick look at Dipoles and NVIS

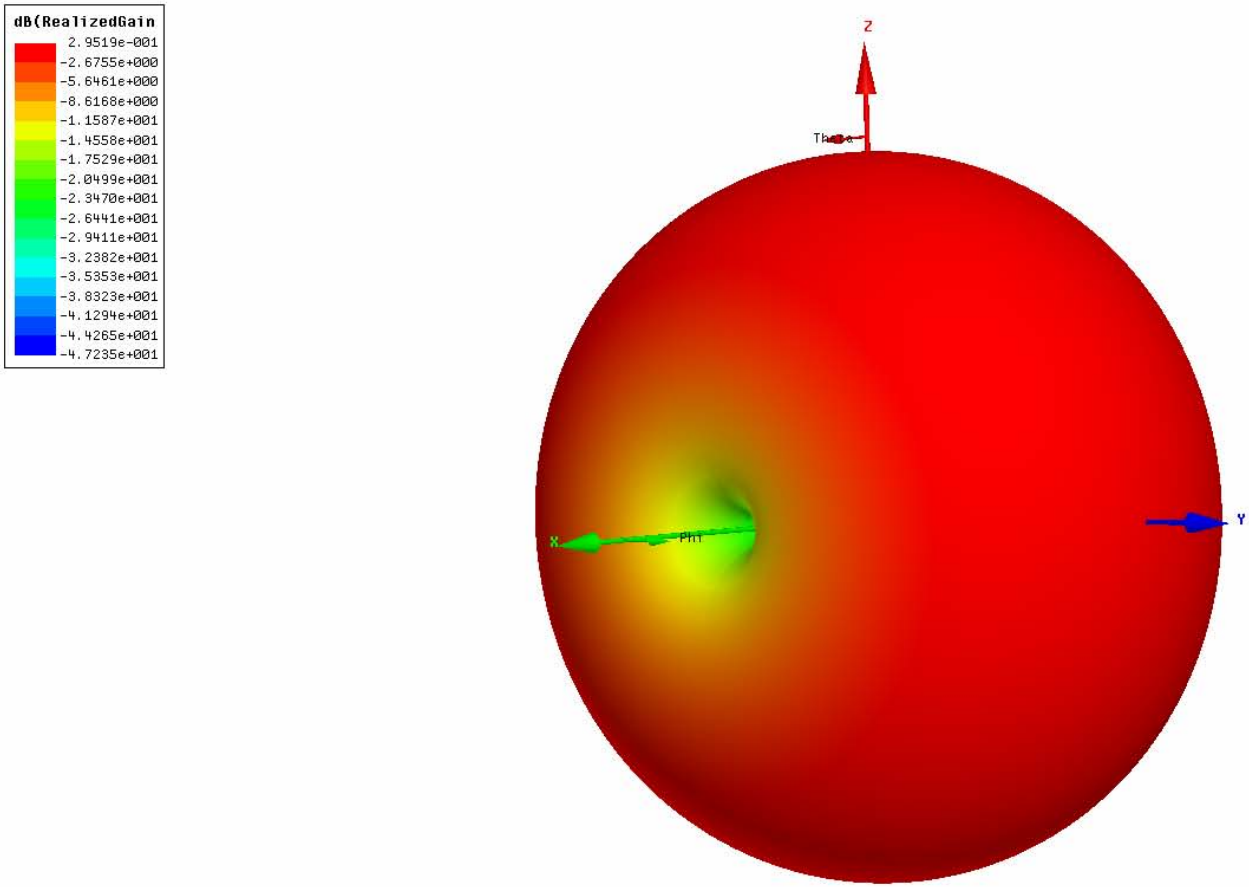
An excellent presentation on what Near Vertical Incident Skywave (NVIS) is all about:
http://www.arrl.org/FandES/ead/materials/NVIS.ppt

Dipole (suspended in air)



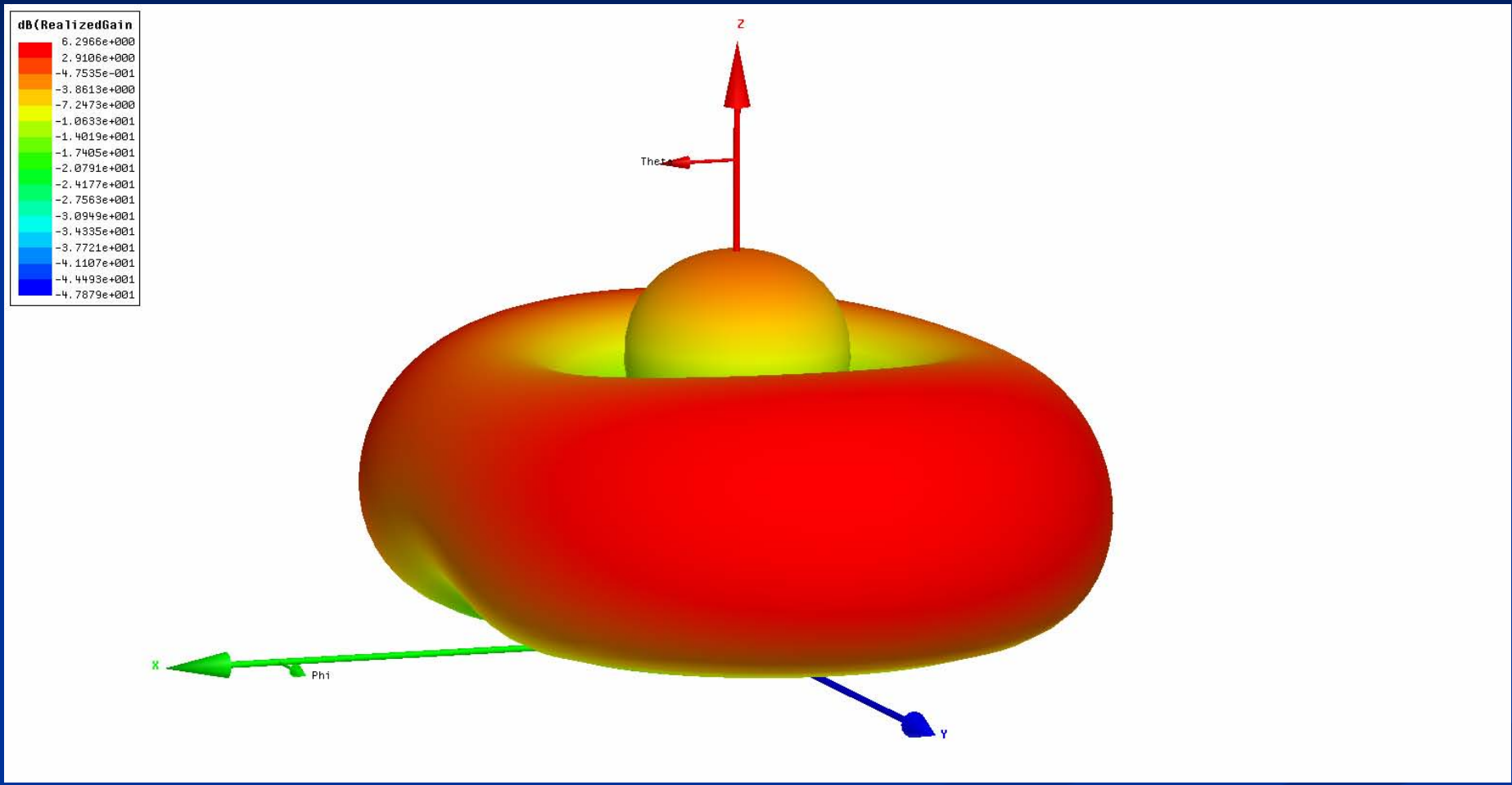
Suspended dipole inside of an air box, no ground plane

Dipole (suspended in air)



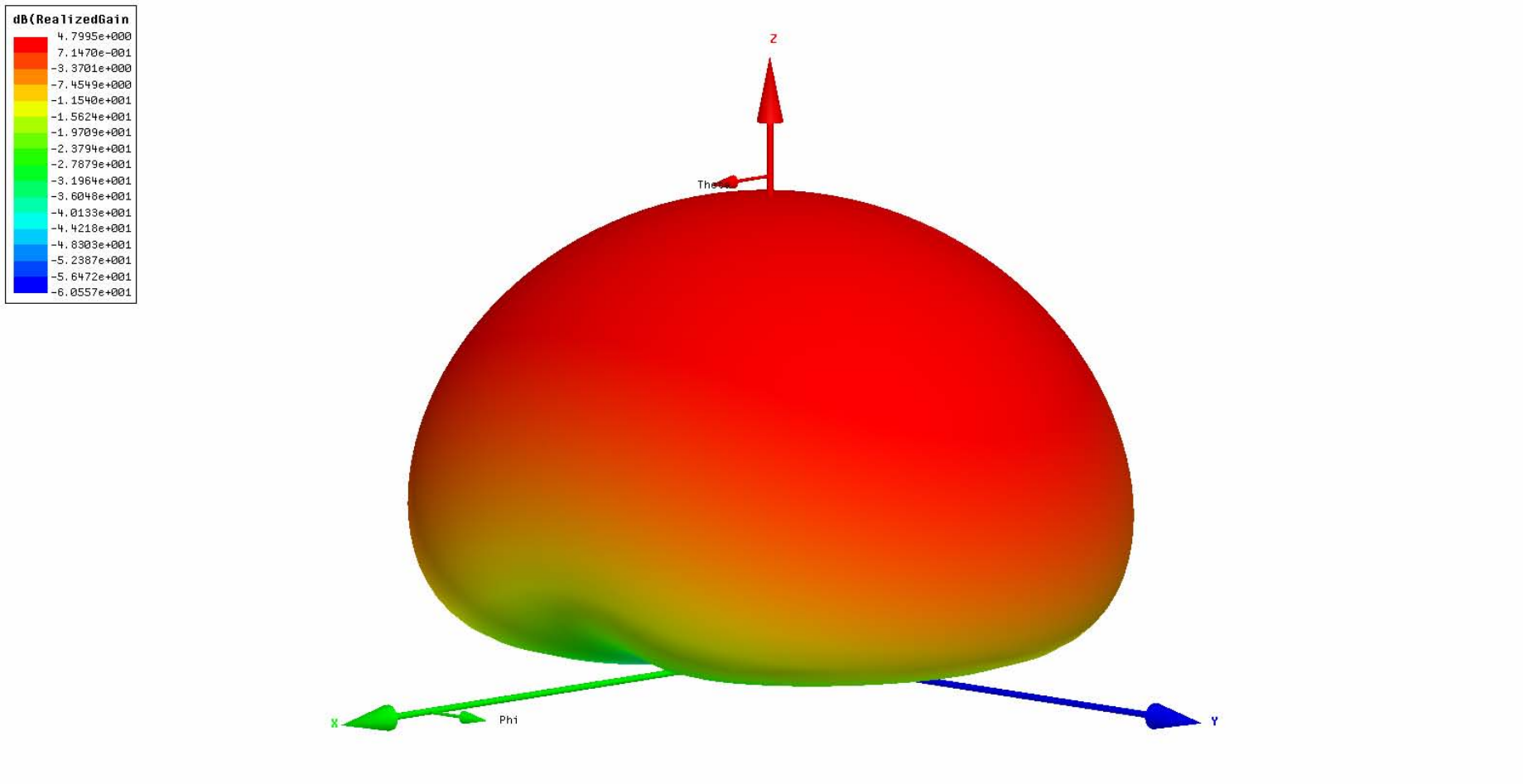
Suspended in air; no ground effects.
Total gain (horizontal plus vertical polarizations)

Dipole (1λ above ground)



Dipole modeled over infinite, perfect ground. Total gain (horizontal plus vertical polarizations) shown above. Note that most of radiation is low angle; close to horizon. This is a non-NVIS case.

Same Dipole (NVIS, **0.1**λ above ground)



Dipole modeled over infinite, perfect ground. Total gain (horizontal plus vertical polarizations) shown above. Note that antenna is now radiating mostly 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
  - EZ NEC: http://www.eznec.com