Antenna Myths and Magic

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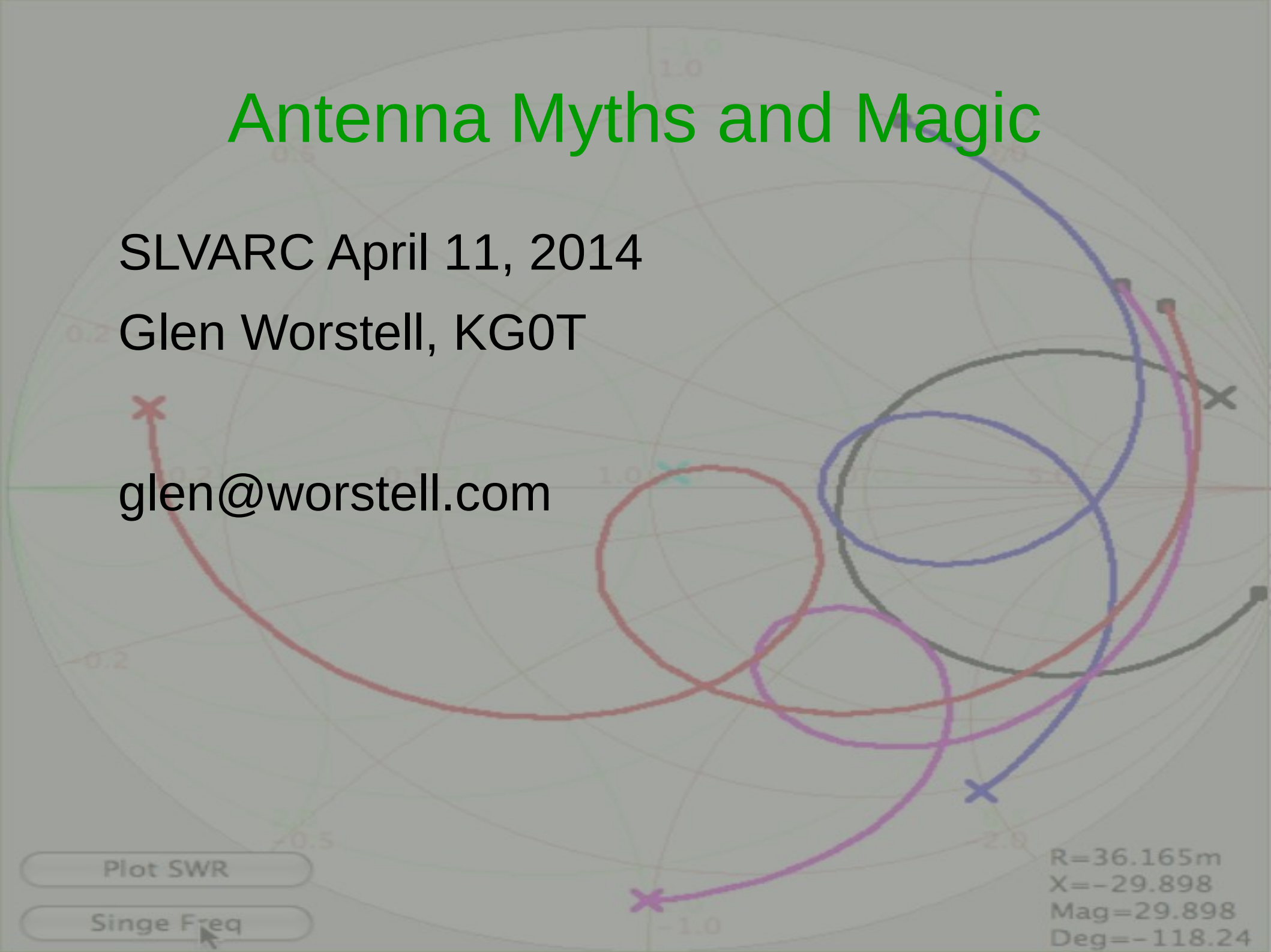
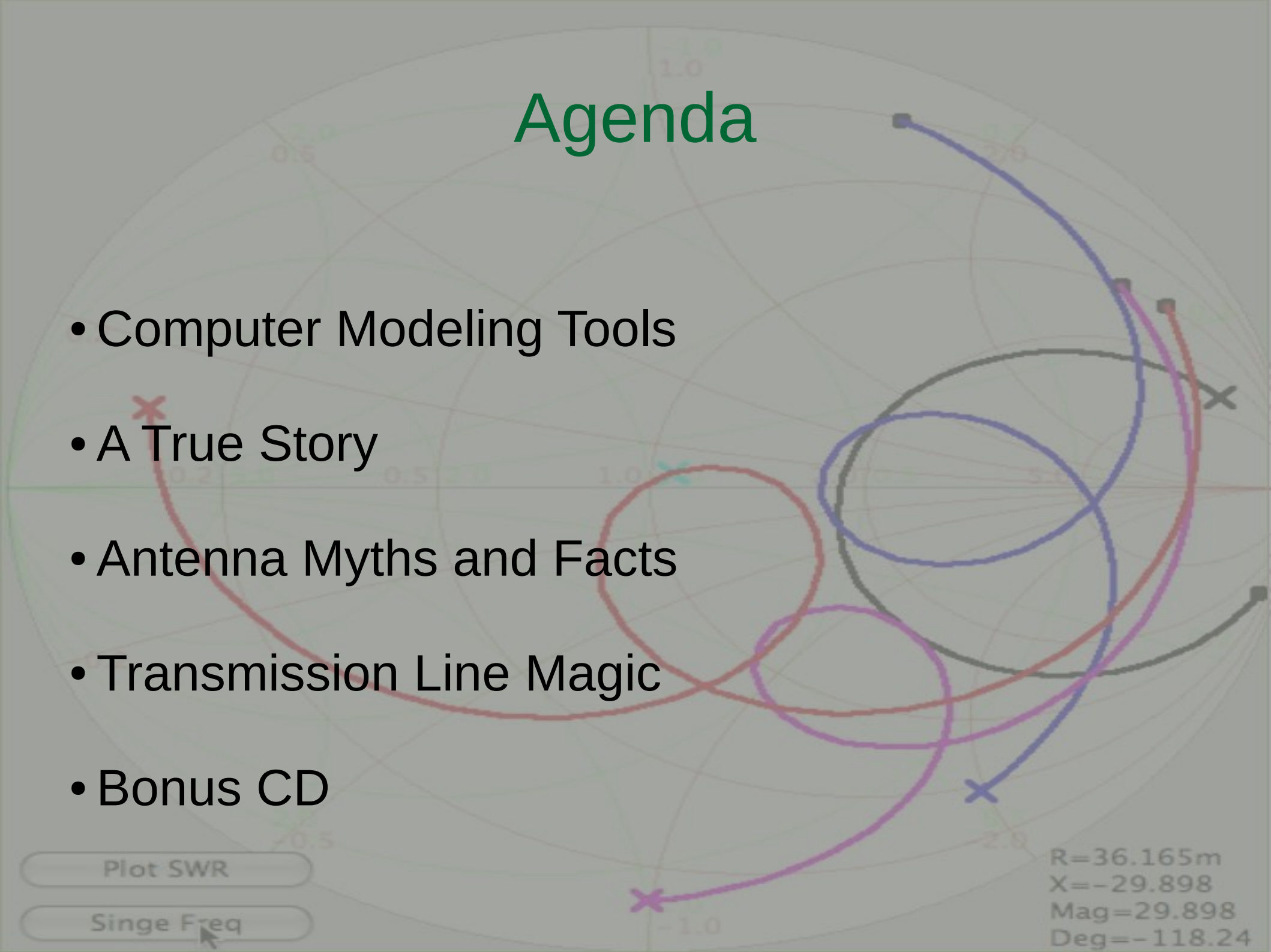


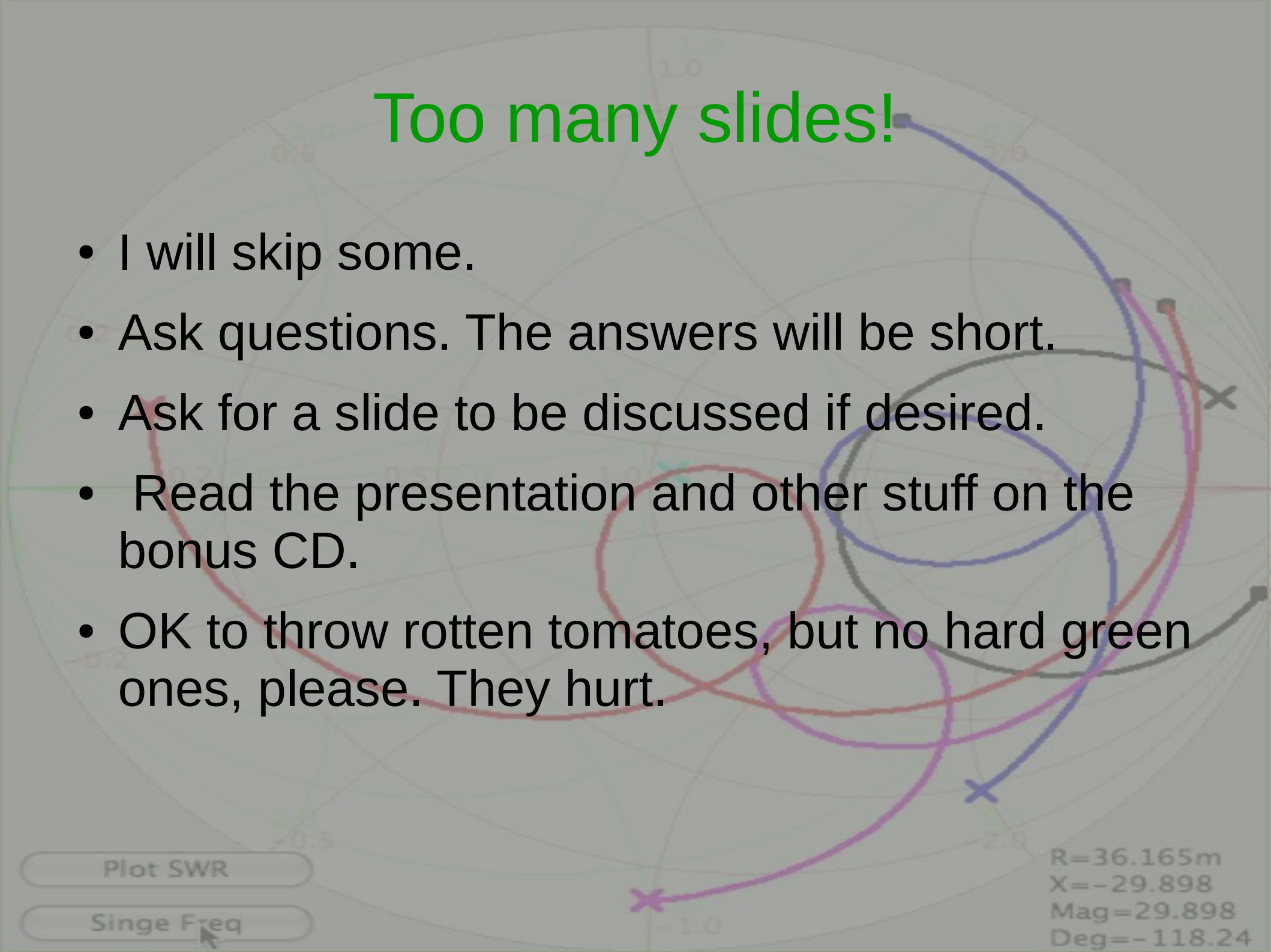
Agenda

- Computer Modeling Tools
- A True Story
- Antenna Myths and Facts
- Transmission Line Magic
- Bonus CD



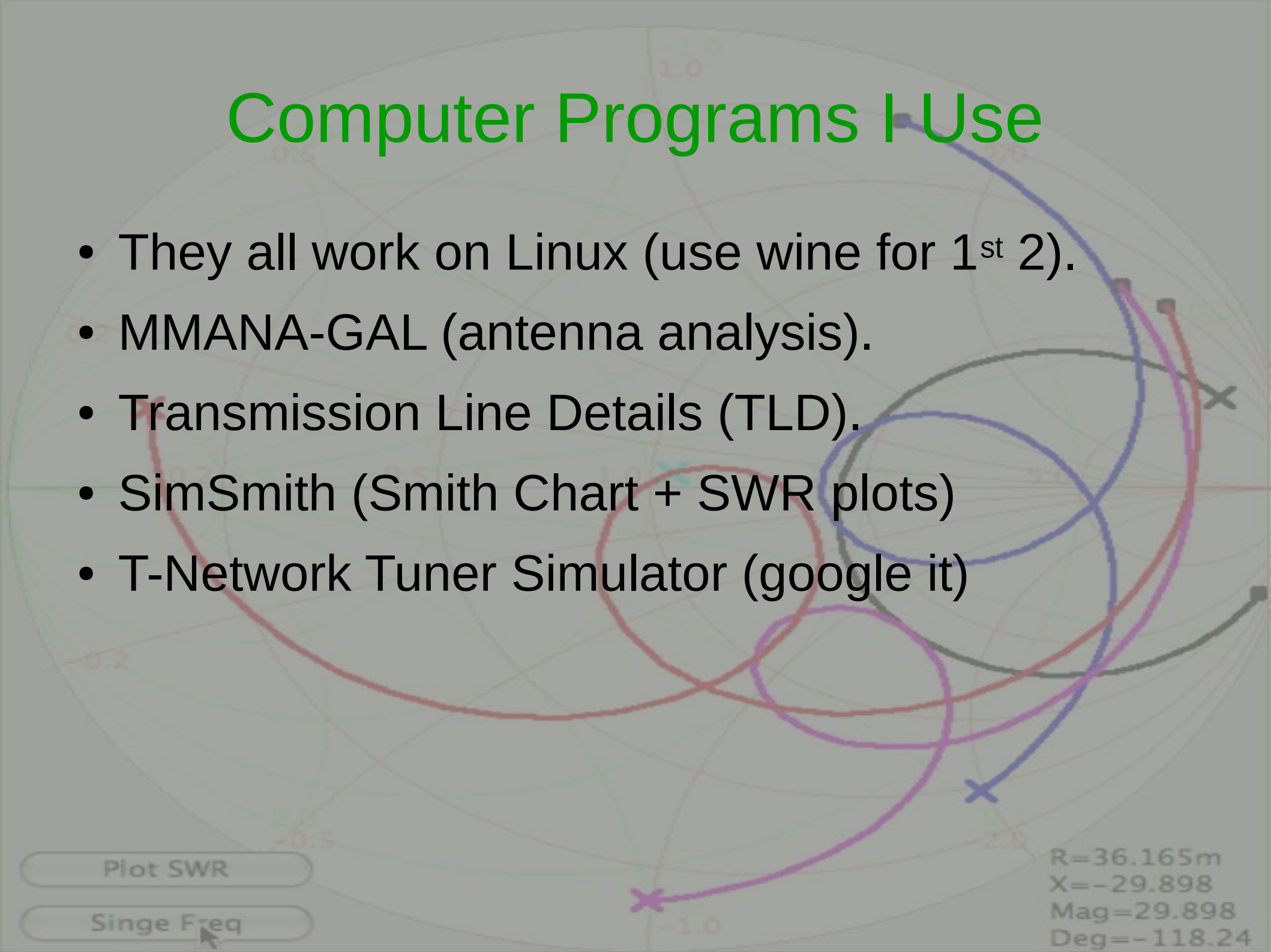
Too many slides!

- I will skip some.
- Ask questions. The answers will be short.
- Ask for a slide to be discussed if desired.
- Read the presentation and other stuff on the bonus CD.
- OK to throw rotten tomatoes, but no hard green ones, please. They hurt.



Computer Programs I Use

- They all work on Linux (use wine for 1st 2).
- MMANA-GAL (antenna analysis).
- Transmission Line Details (TLD).
- SimSmith (Smith Chart + SWR plots)
- T-Network Tuner Simulator (google it)



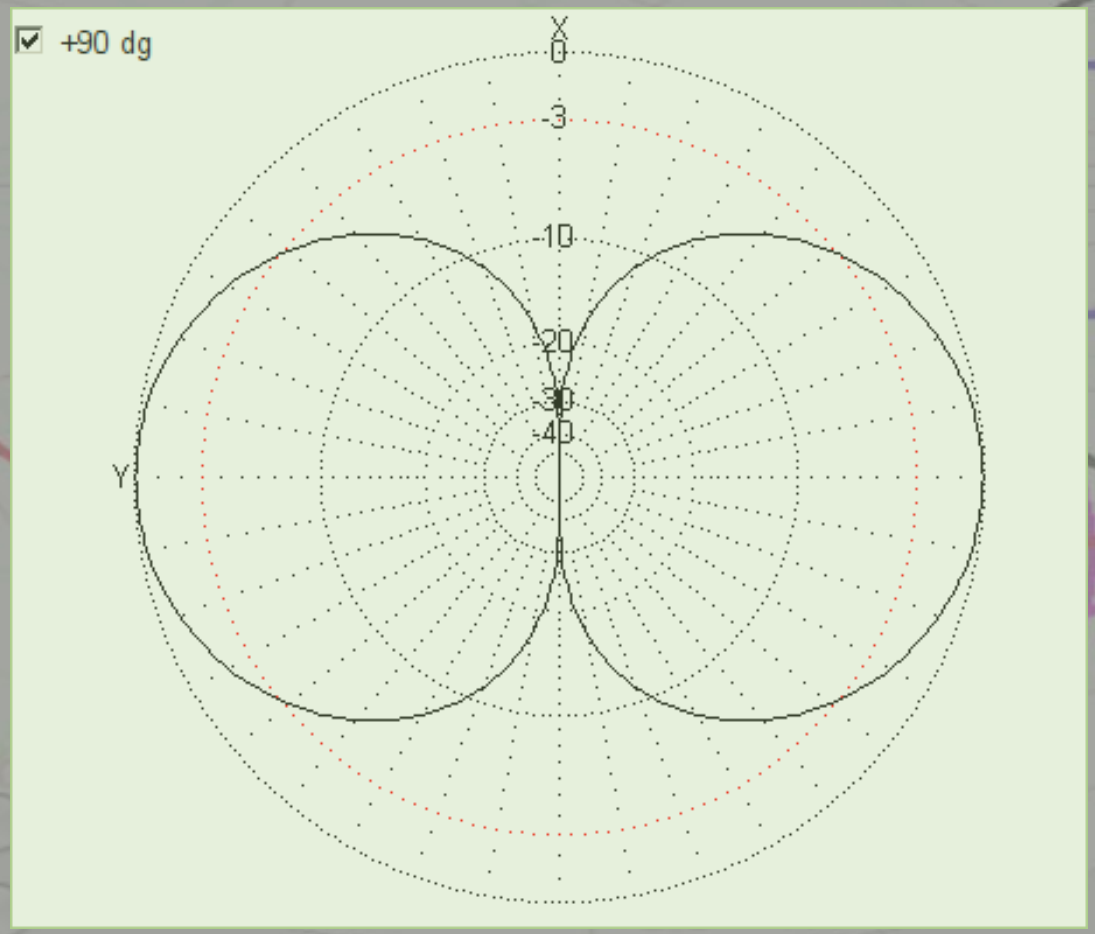
True Story-This would have been nice...

This is what I had

- Free from someone's junk box
- I restored it and made it work
- AM, dual 813 final
- Dual 811 plate modulation
- Young kids like Rich
  - never heard of AM or 813
- Ask Tom, who knows about AM and tubes

A little knowledge …

Dipole pattern:



Plot SWR

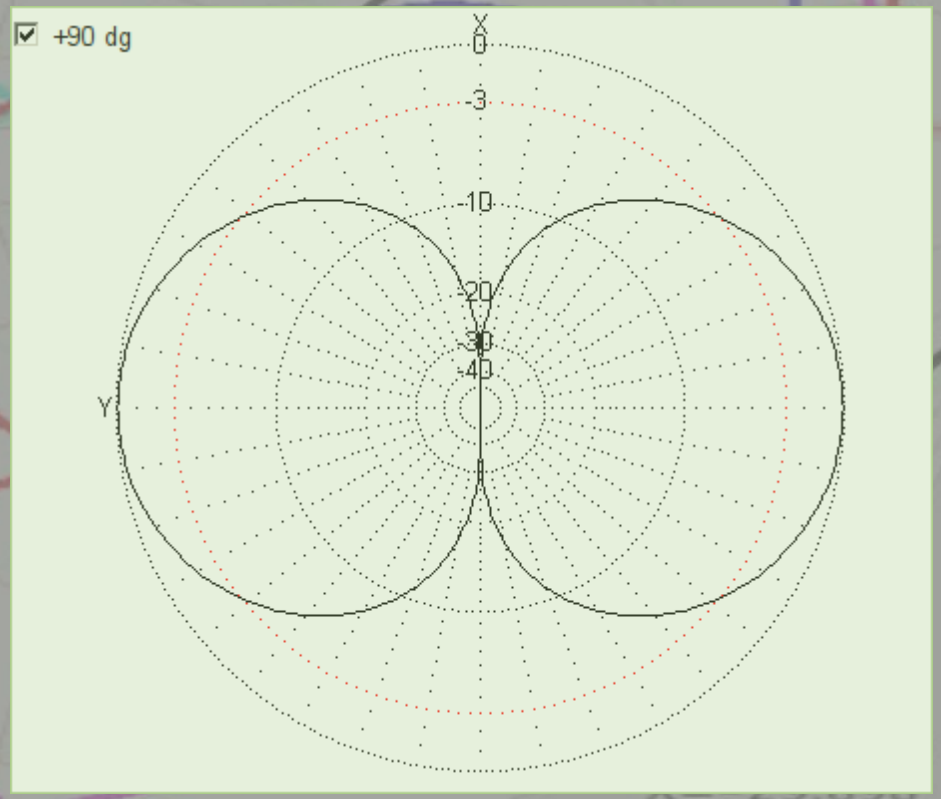
Singe Freq

R=36.165m
X=-29.898
Mag=29.898
Deg=-118.24

I built an armstrong rotatable diople

- Strongest signal broadside to antenna wire
- Weak signal off end
- Tested, QSO with Net Control station in L.A.
  - Using 813 xmtr, 50 miles.
- Very disappointing result
  - NO DIFFERENCE!

  Why not?
- MYTH!!!



Plot SWR

Singe Freq

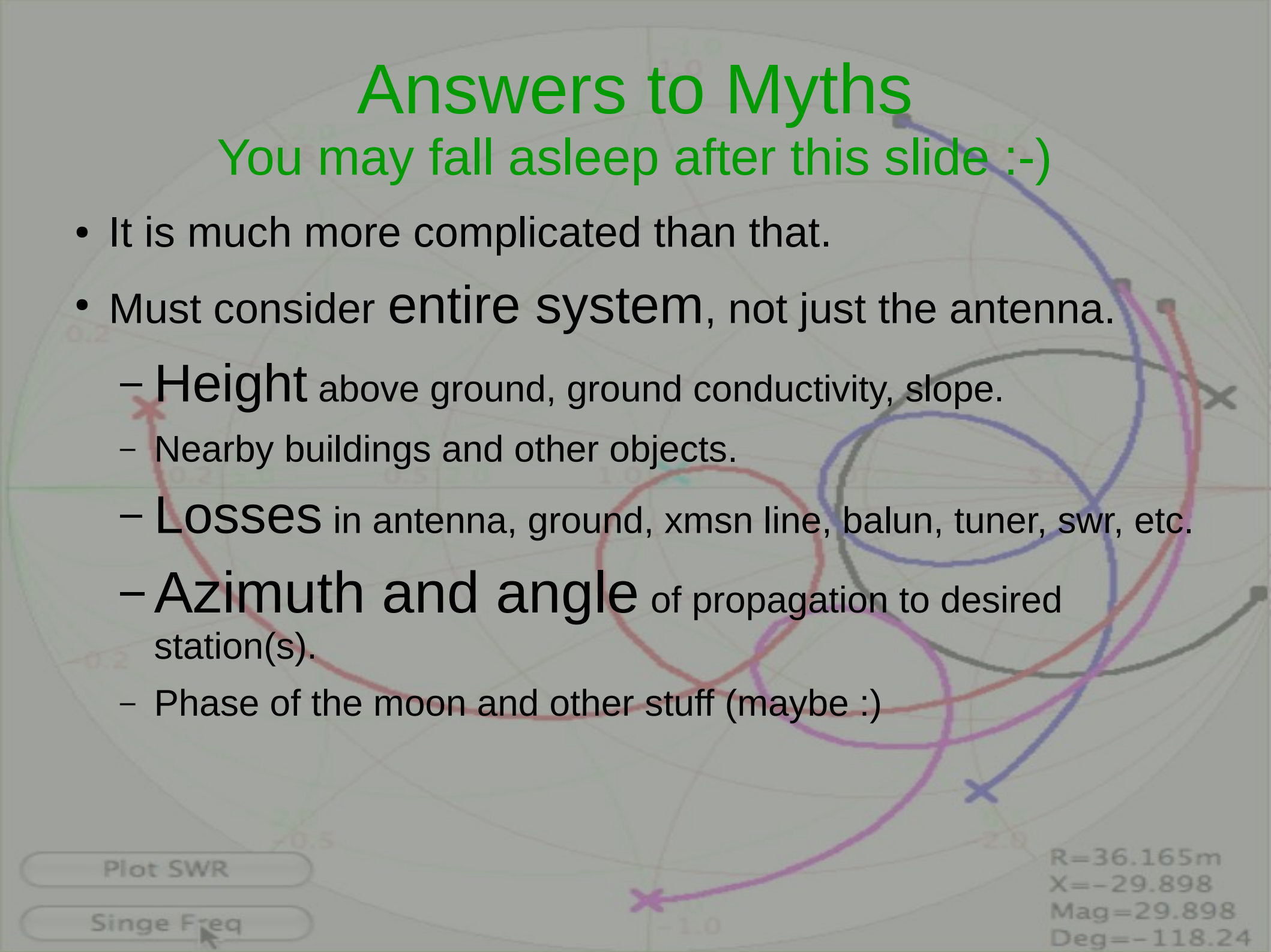
Mag=29.898

Deg=-118.24

Answers to Myths

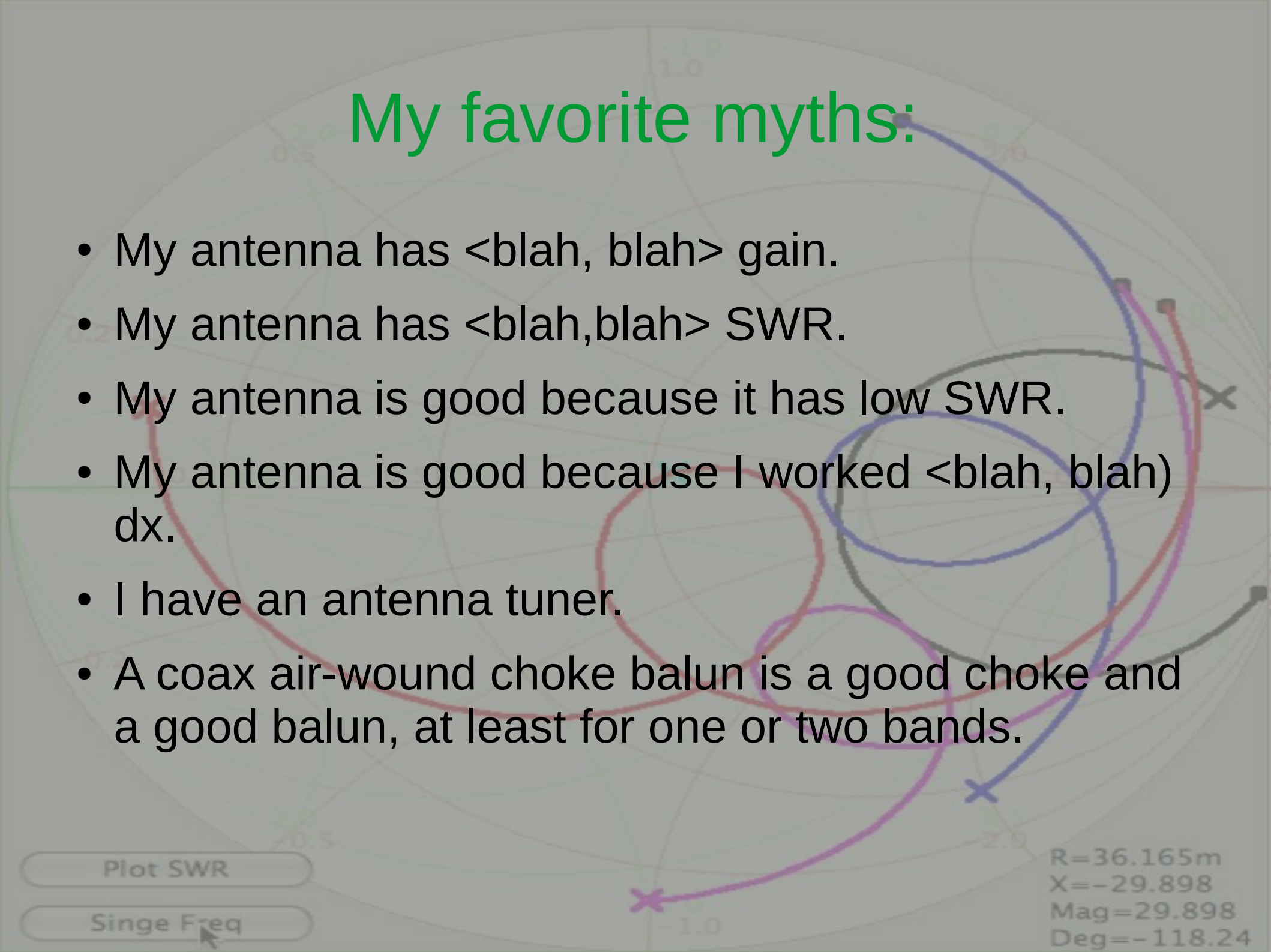
You may fall asleep after this slide :-)

- It is much more complicated than that.
- Must consider entire system, not just the antenna.
  - Height above ground, ground conductivity, slope.
  - Nearby buildings and other objects.
  - Losses in antenna, ground, xmsn line, balun, tuner, swr, etc.
  - Azimuth and angle of propagation to desired station(s).
  - Phase of the moon and other stuff (maybe :)



My favorite myths:

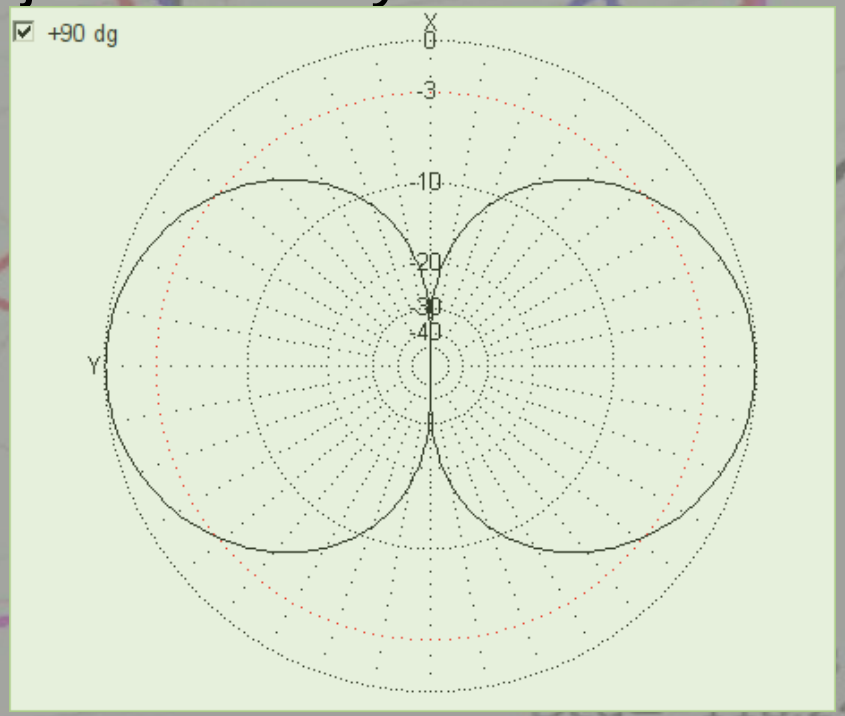
- My antenna has <blah, blah> gain.
- My antenna has <blah,blah> SWR.
- My antenna is good because it has low SWR.
- My antenna is good because I worked <blah, blah) dx.
- I have an antenna tuner.
- A coax air-wound choke balun is a good choke and a good balun, at least for one or two bands.



MYTH: My antenna has <blah, blah> db gain.

Facts:

- Antennas have only loss (but they have directivity).
- db is a Ratio – dbi and dbd are common.
- dbd is often bogus (what dipole)?
- dbi “gain” is bogus because it could just as easily be loss!
- Dipole has large loss
  in some directions, maybe.
- “gain” means “loss”
  at other azimuth.

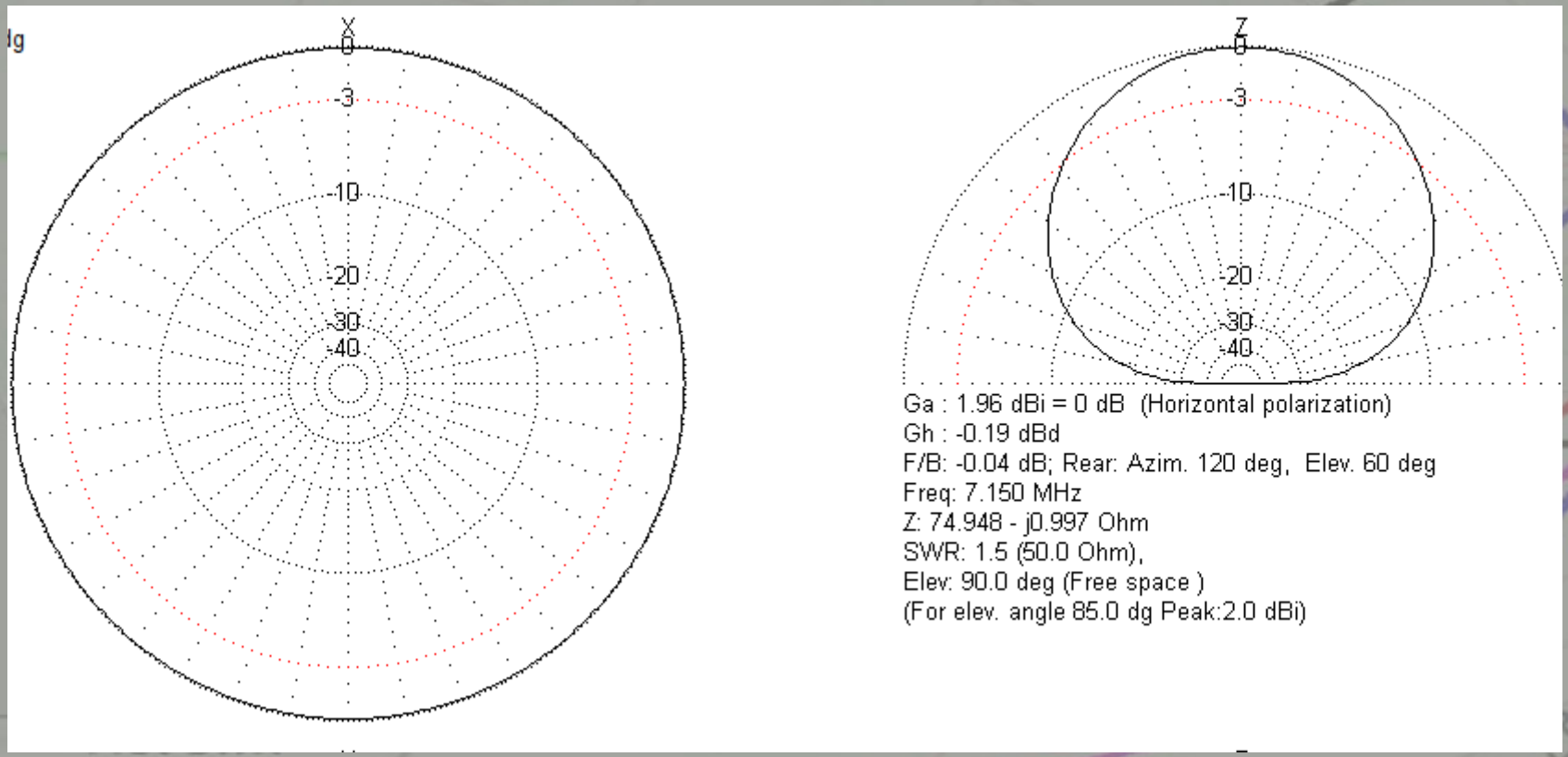


Plot SWR

Singe Freq

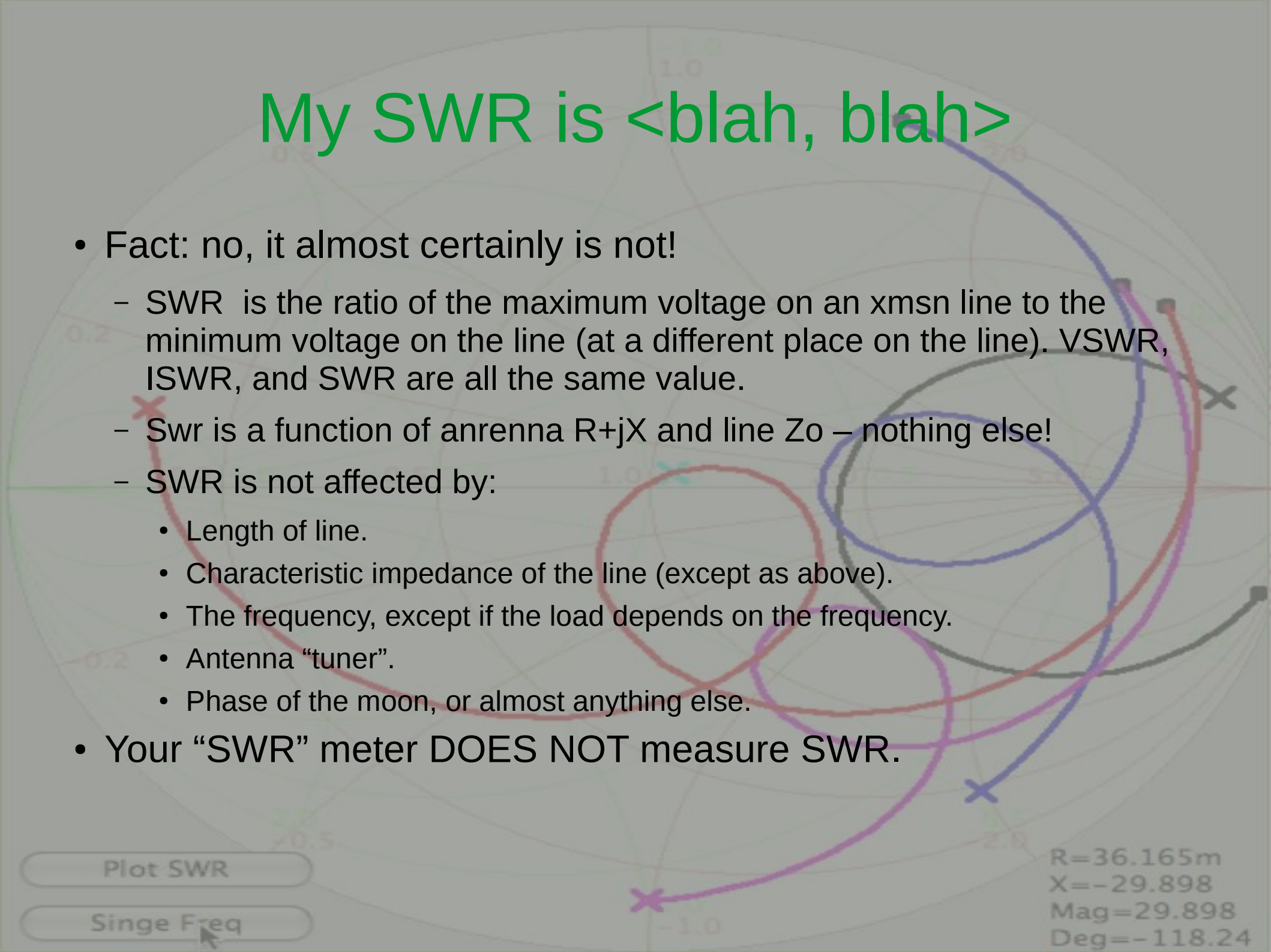
Why my armstrong dipole had no directivity:

- Best azimuth angle is high for local contacts.
- No directivity at high angle (85 degrees).



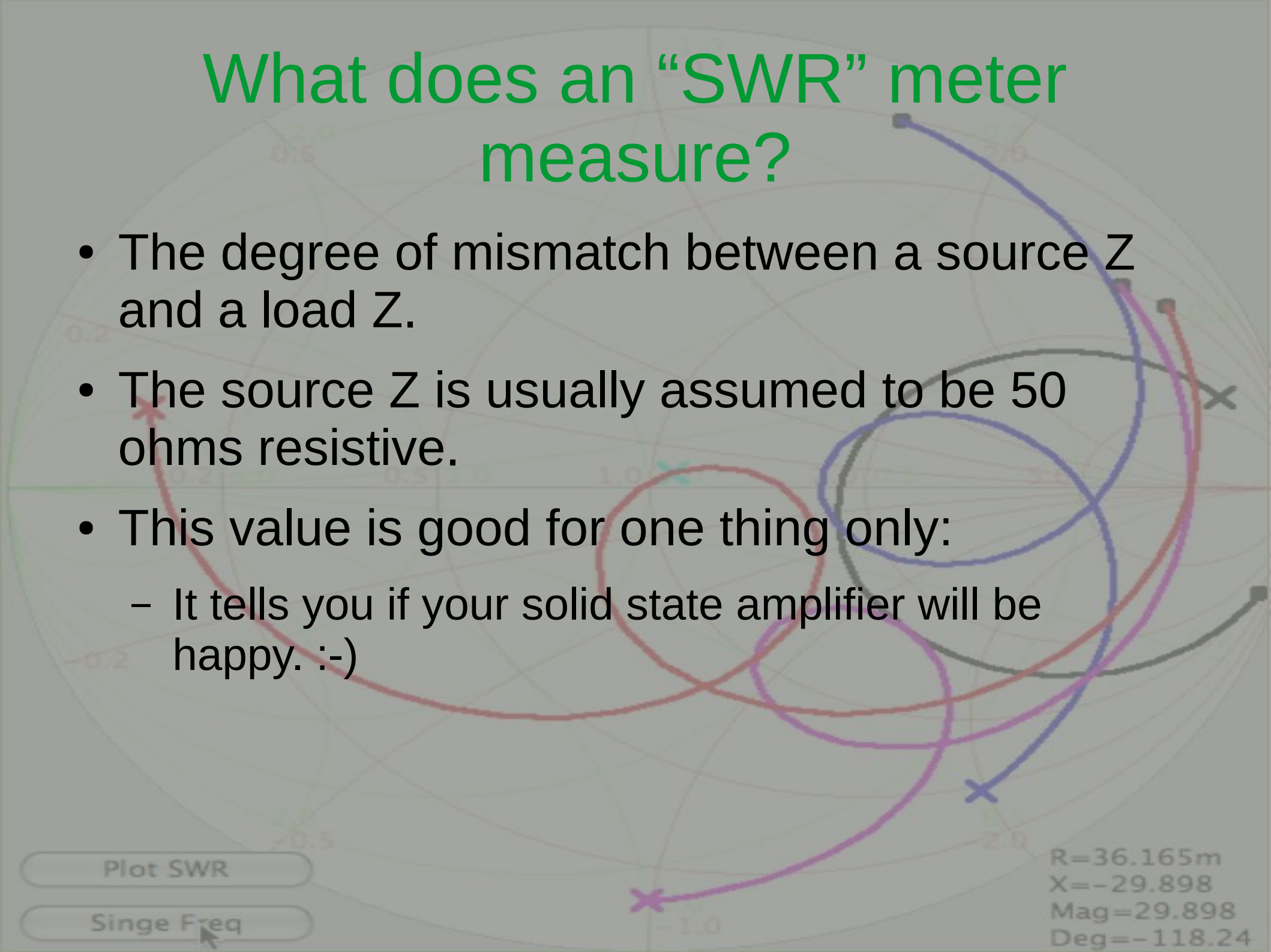
My SWR is <blah, blah>

- Fact: no, it almost certainly is not!
  - SWR is the ratio of the maximum voltage on an xmsn line to the minimum voltage on the line (at a different place on the line). VSWR, ISWR, and SWR are all the same value.
  - Swr is a function of anrenna R+jX and line Zo – nothing else!
  - SWR is not affected by:
    - Length of line.
    - Characteristic impedance of the line (except as above).
    - The frequency, except if the load depends on the frequency.
    - Antenna “tuner”.
    - Phase of the moon, or almost anything else.
- Your “SWR” meter DOES NOT measure SWR.



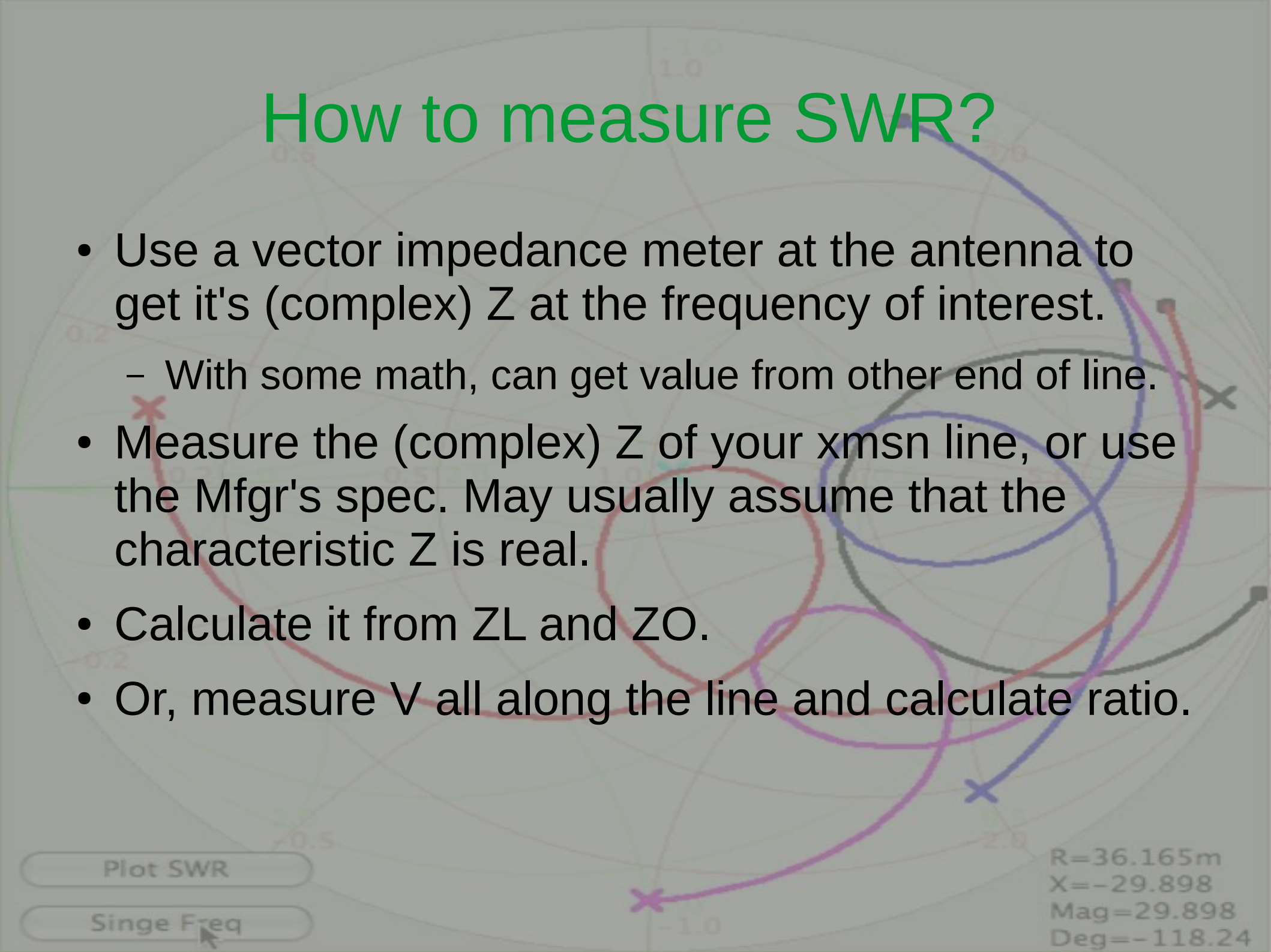
What does an “SWR” meter measure?

- The degree of mismatch between a source Z and a load Z.
- The source Z is usually assumed to be 50 ohms resistive.
- This value is good for one thing only:
  - It tells you if your solid state amplifier will be happy. :-)



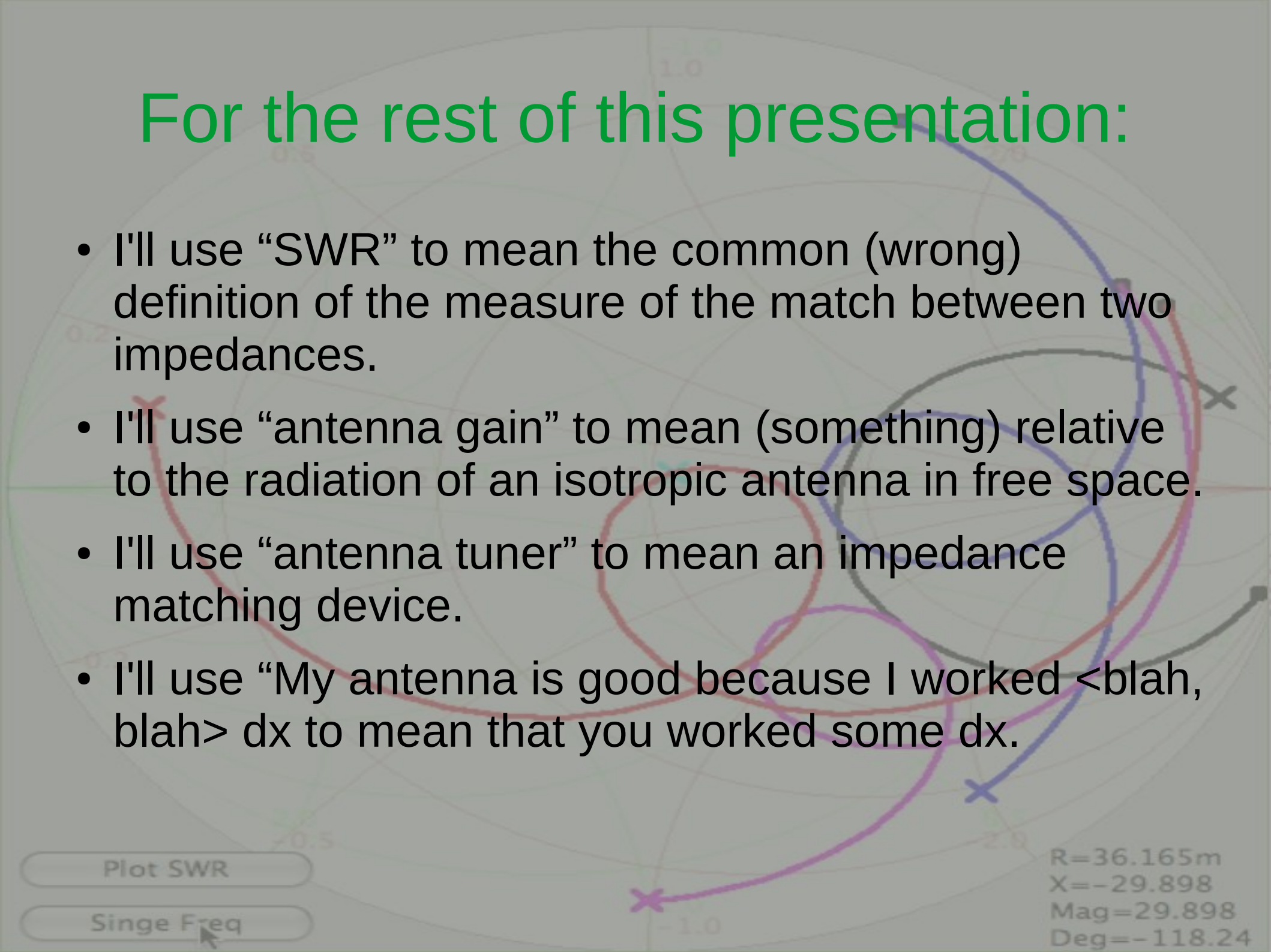
How to measure SWR?

- Use a vector impedance meter at the antenna to get it's (complex) Z at the frequency of interest.
  - With some math, can get value from other end of line.
- Measure the (complex) Z of your xmsn line, or use the Mfgr's spec. May usually assume that the characteristic Z is real.
- Calculate it from ZL and ZO.
- Or, measure V all along the line and calculate ratio.



For the rest of this presentation:

- I'll use “SWR” to mean the common (wrong) definition of the measure of the match between two impedances.
- I'll use “antenna gain” to mean (something) relative to the radiation of an isotropic antenna in free space.
- I'll use “antenna tuner” to mean an impedance matching device.
- I'll use “My antenna is good because I worked <blah, blah> dx to mean that you worked some dx.



Myth: Low SWR means good antenna.

- SWR (Standing Wave RATIO) is relative to some (complex) impedance.
  - Antenna, transmission line, input to xmsn line; usually relative to 50 ohms resistive.
  - Often SWR meters are relative to 50 ohms resistive.
- 50 ohm dummy load has good broadband SWR relative to modern xmtr output Z.
- Long lossy xmsn line may give low SWR at xmtr.
- Must treat as SYSTEM.

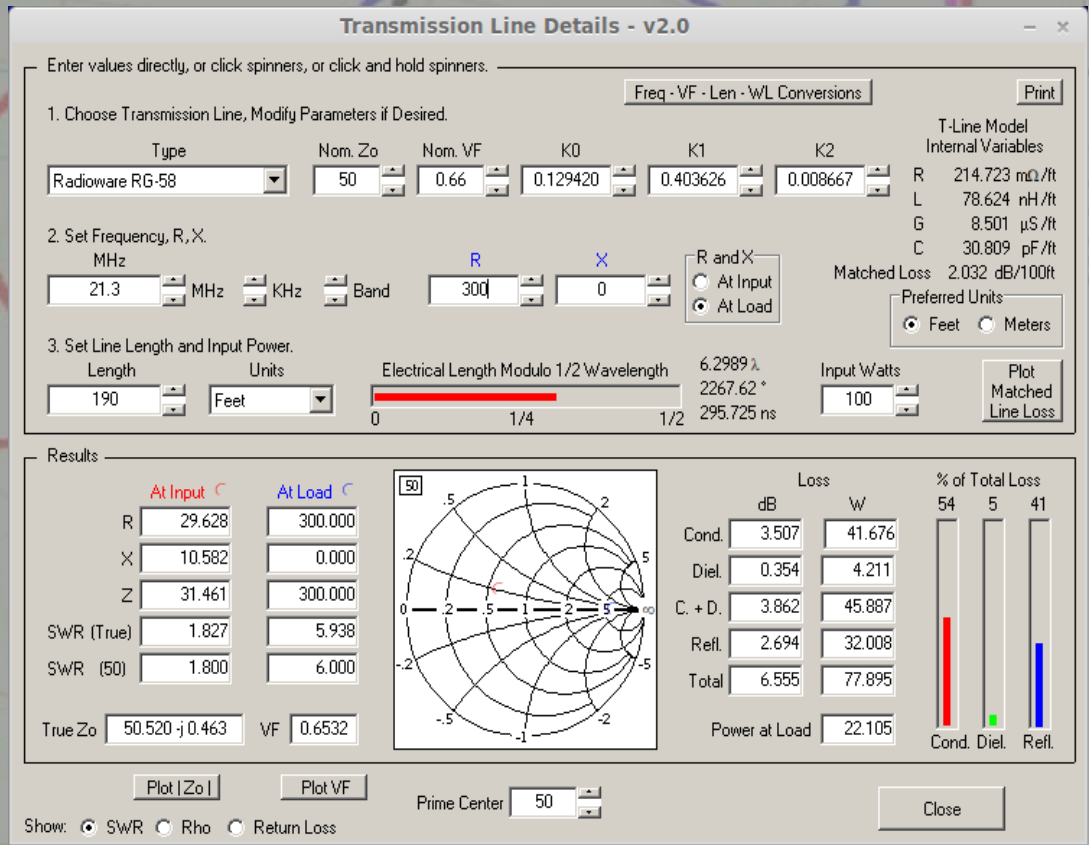
Folded dipole, 21.3 MHz.

50 0hm xmsn line.

SWR at antenna 6:1

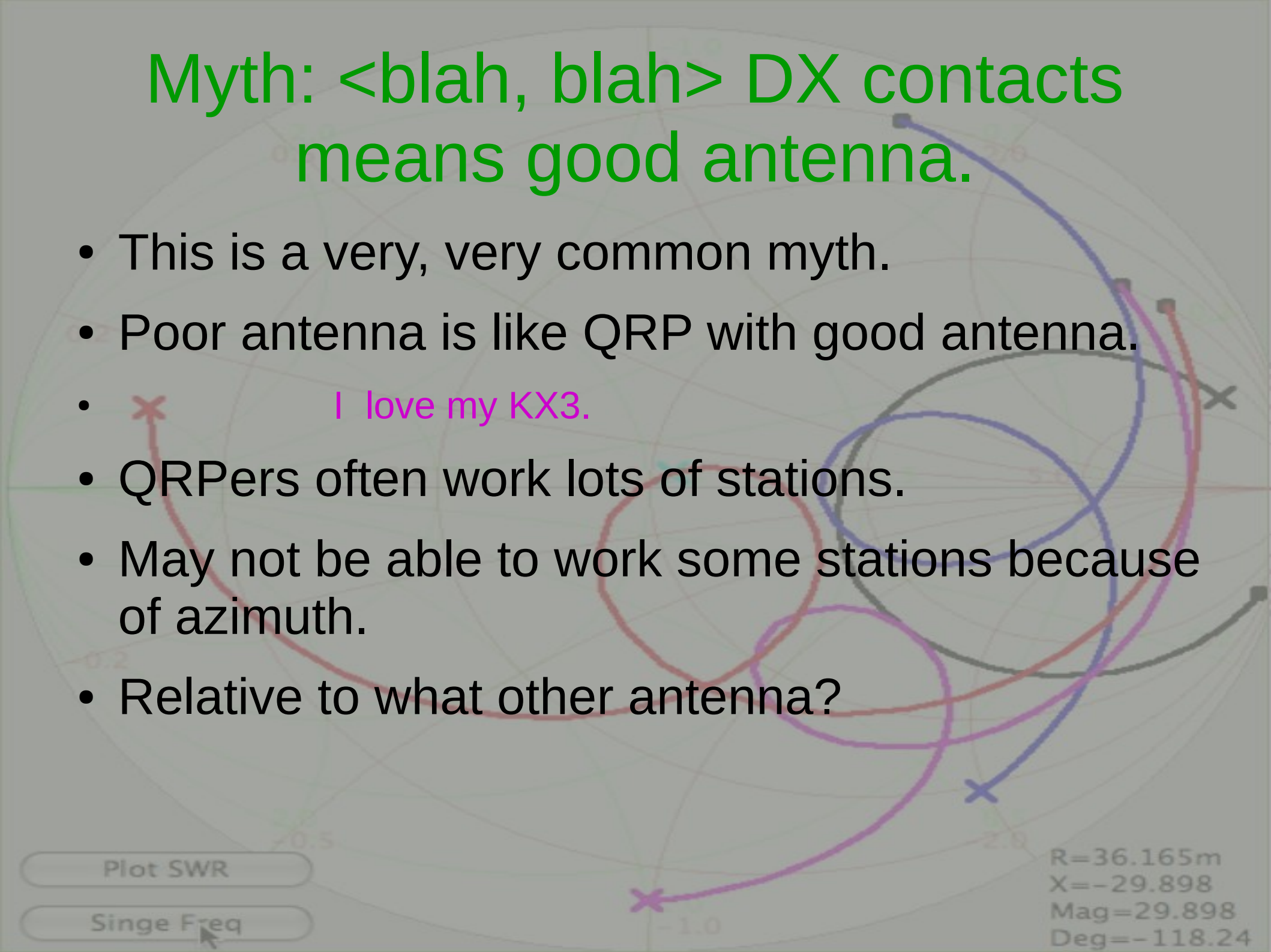
SWR at xmtr depends on line length.

TLD ->



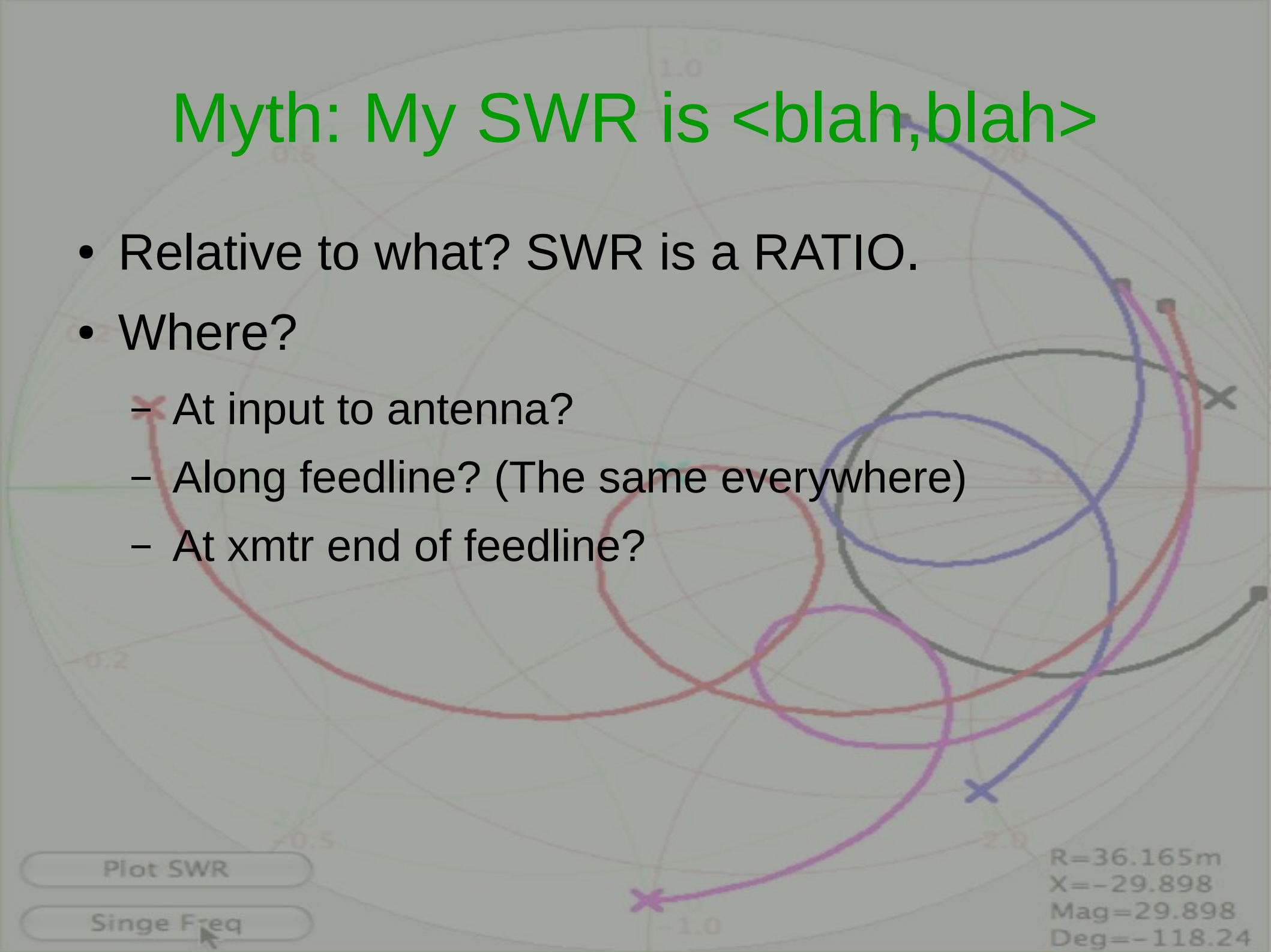
Myth: <blah, blah> DX contacts means good antenna.

- This is a very, very common myth.
- Poor antenna is like QRP with good antenna.
- I love my KX3.
- QRPers often work lots of stations.
- May not be able to work some stations because of azimuth.
- Relative to what other antenna?



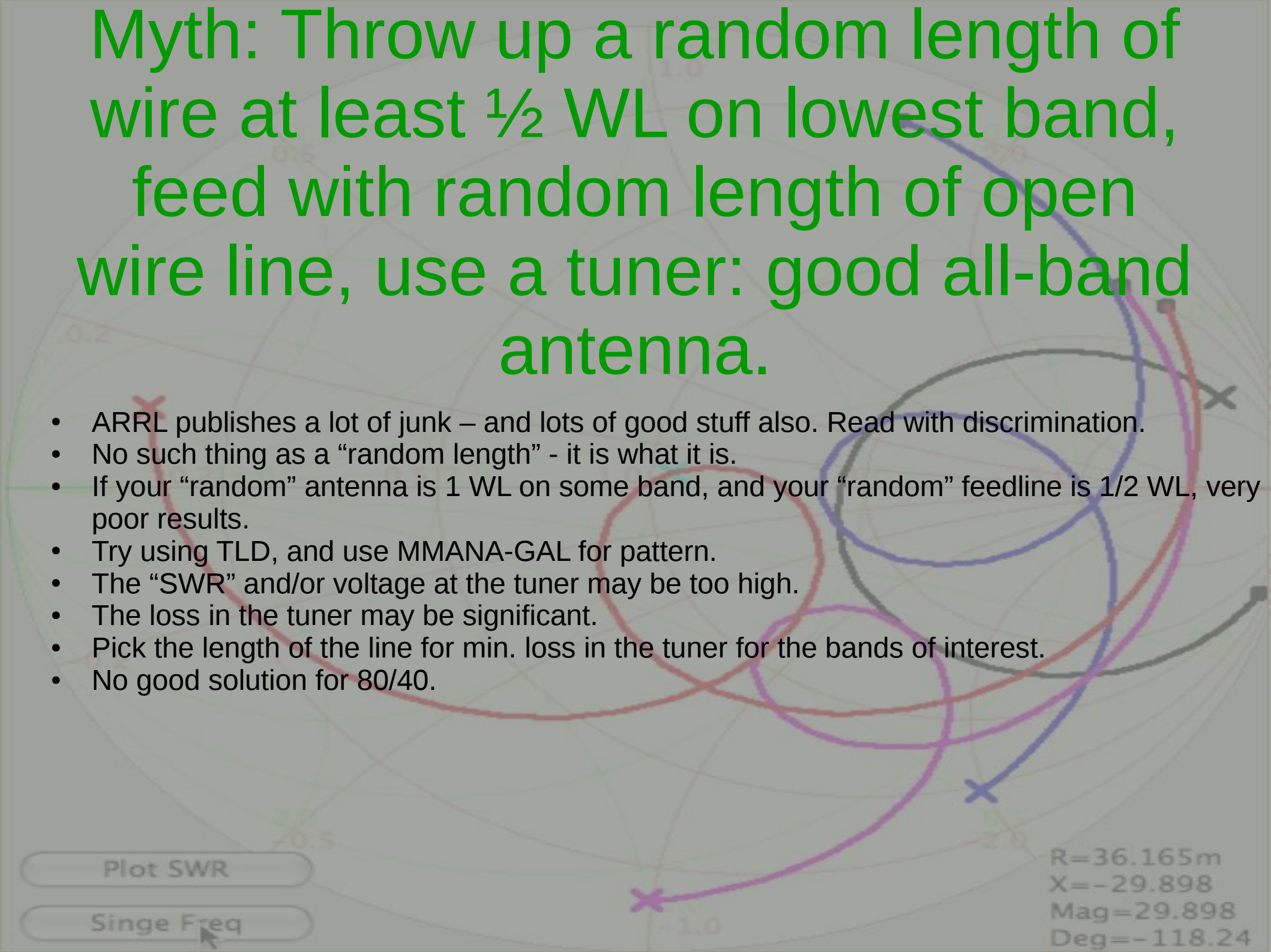
Myth: My SWR is <blah,blah>

- Relative to what? SWR is a RATIO.
- Where?
  - At input to antenna?
  - Along feedline? (The same everywhere)
  - At xmtr end of feedline?



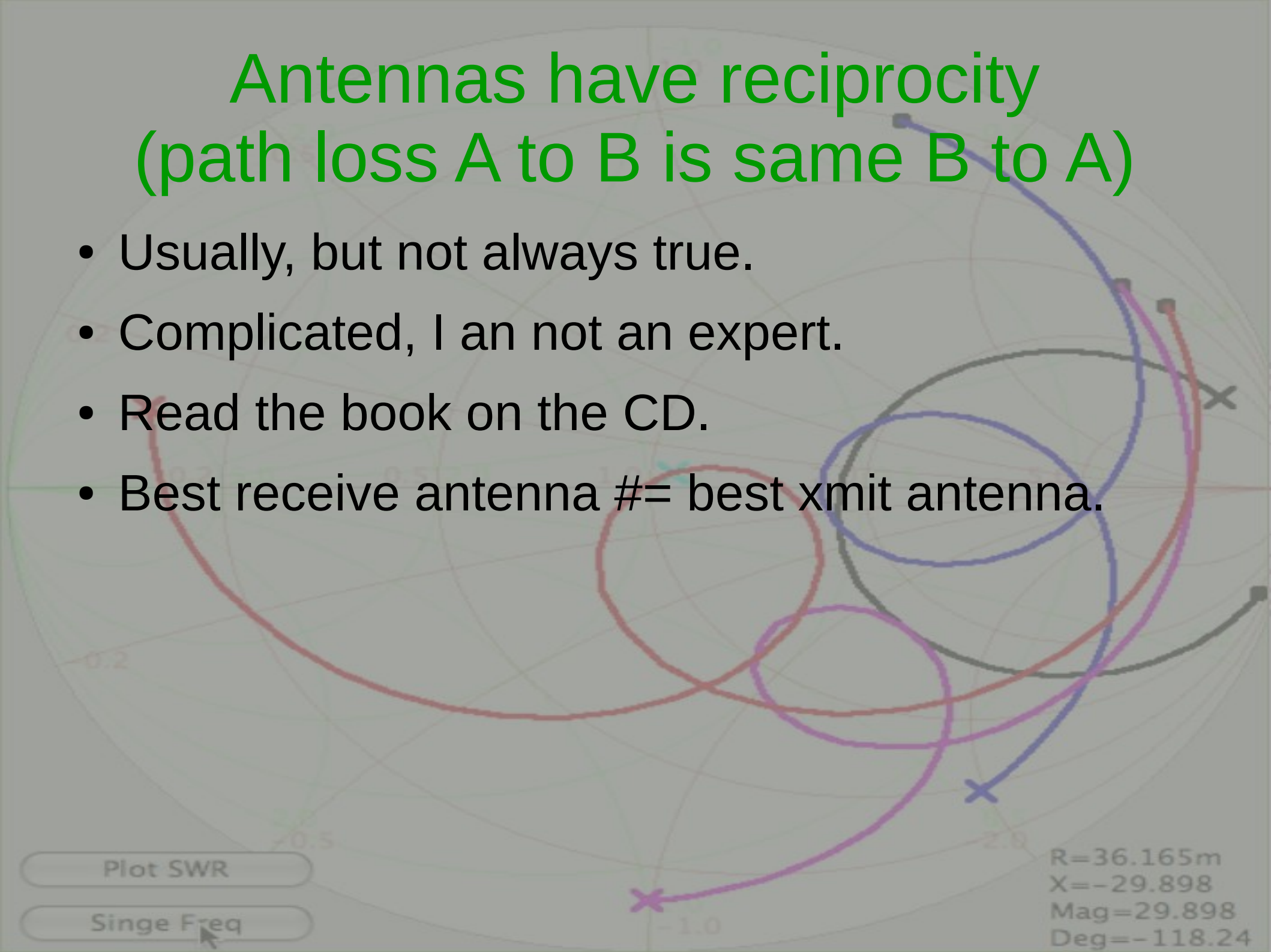
Myth: Throw up a random length of wire at least ½ WL on lowest band, feed with random length of open wire line, use a tuner: good all-band antenna.

- ARRL publishes a lot of junk – and lots of good stuff also. Read with discrimination.
- No such thing as a “random length” - it is what it is.
- If your “random” antenna is 1 WL on some band, and your “random” feedline is 1/2 WL, very poor results.
- Try using TLD, and use MMANA-GAL for pattern.
- The “SWR” and/or voltage at the tuner may be too high.
- The loss in the tuner may be significant.
- Pick the length of the line for min. loss in the tuner for the bands of interest.
- No good solution for 80/40.



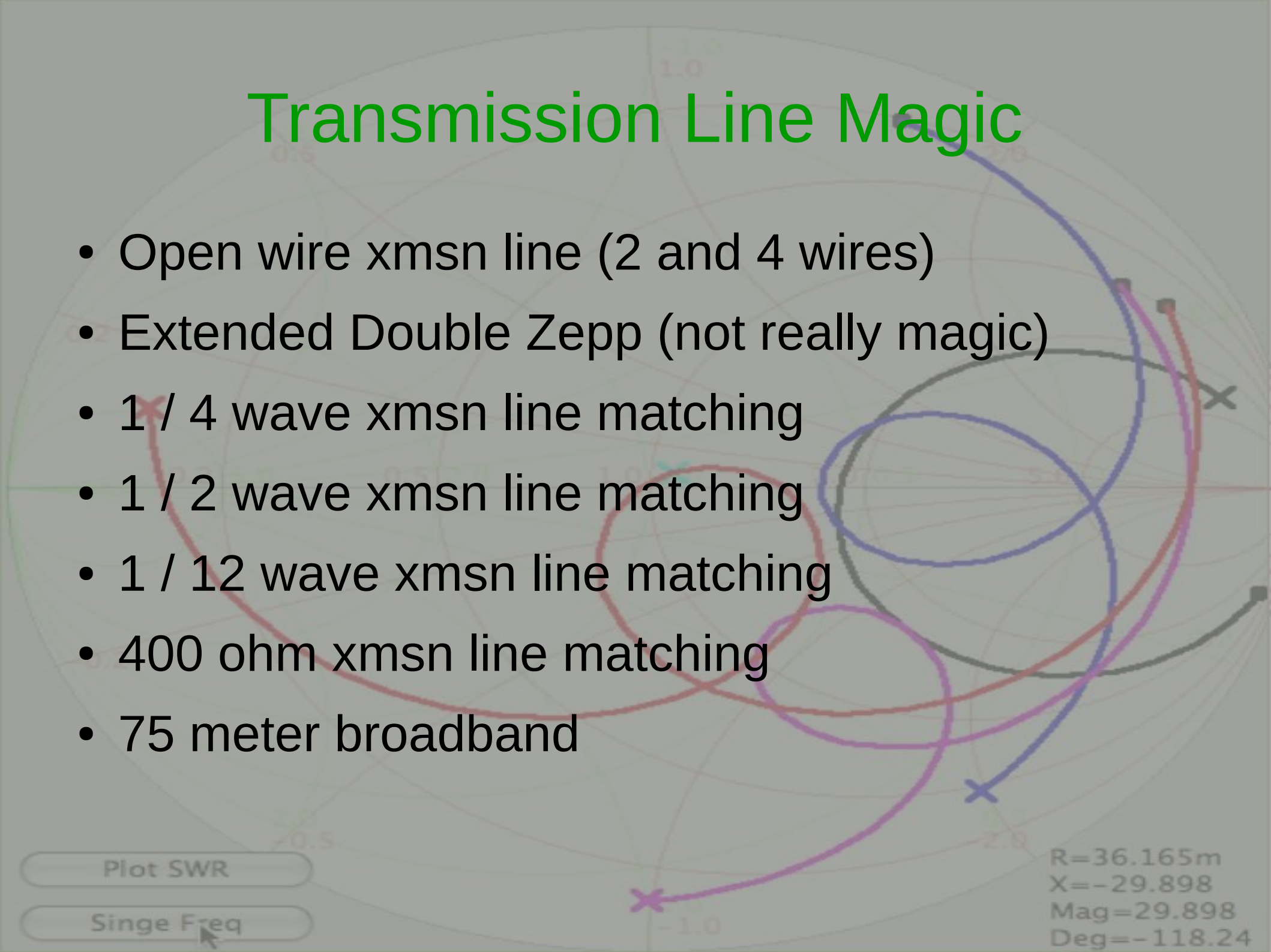
Antennas have reciprocity (path loss A to B is same B to A)

- Usually, but not always true.
- Complicated, I an not an expert.
- Read the book on the CD.
- Best receive antenna #= best xmit antenna.



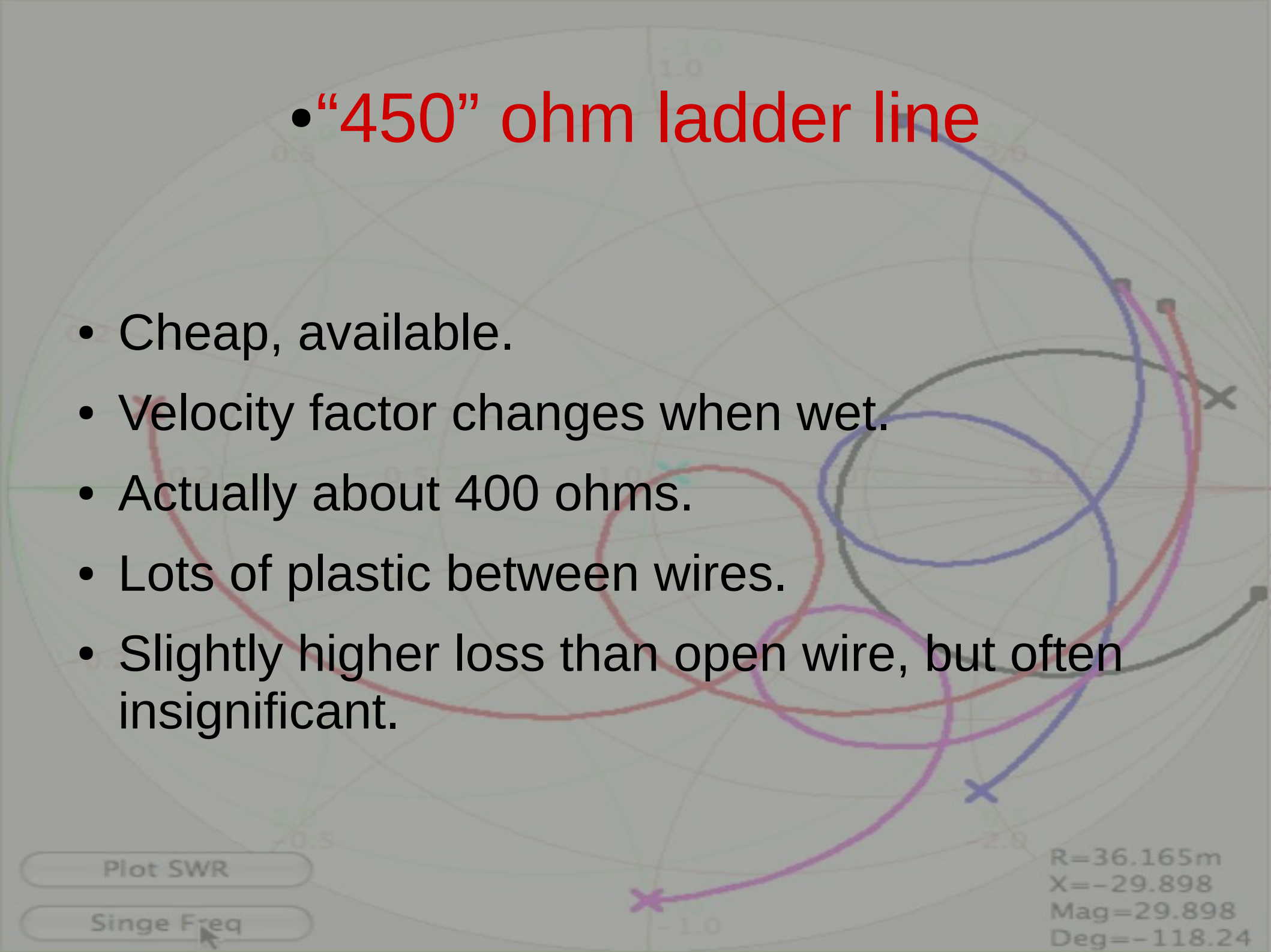
Transmission Line Magic

- Open wire xmsn line (2 and 4 wires)
- Extended Double Zepp (not really magic)
- 1 / 4 wave xmsn line matching
- 1 / 2 wave xmsn line matching
- 1 / 12 wave xmsn line matching
- 400 ohm xmsn line matching
- 75 meter broadband



•“450” ohm ladder line

- Cheap, available.
- Velocity factor changes when wet.
- Actually about 400 ohms.
- Lots of plastic between wires.
- Slightly higher loss than open wire, but often insignificant.



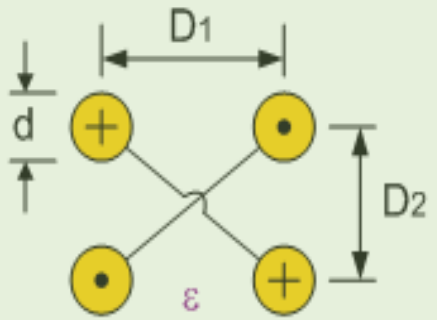
4-wire open wire line

- 4-wire has advantages:
  - Lower loss. Z0 = 83.7*log((2D/d)*1.414))
  - Lower noise and radiation.
  - Lower Zo (sometimes useful).

Balanced 4-Wire Array

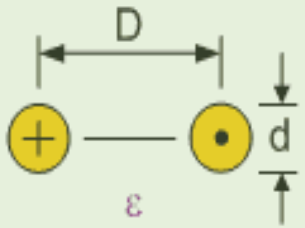
For $d << D_1, D_2$

$$Z_0 = (138/\varepsilon^{1/2}) \log_{10}\{(2D_2/d)[1+(D_2/D_1)^2]^{-1/2}\}$$



Two Conductors in Open Air

$$Z_0 = 276 \log_{10}(2D/d)$$

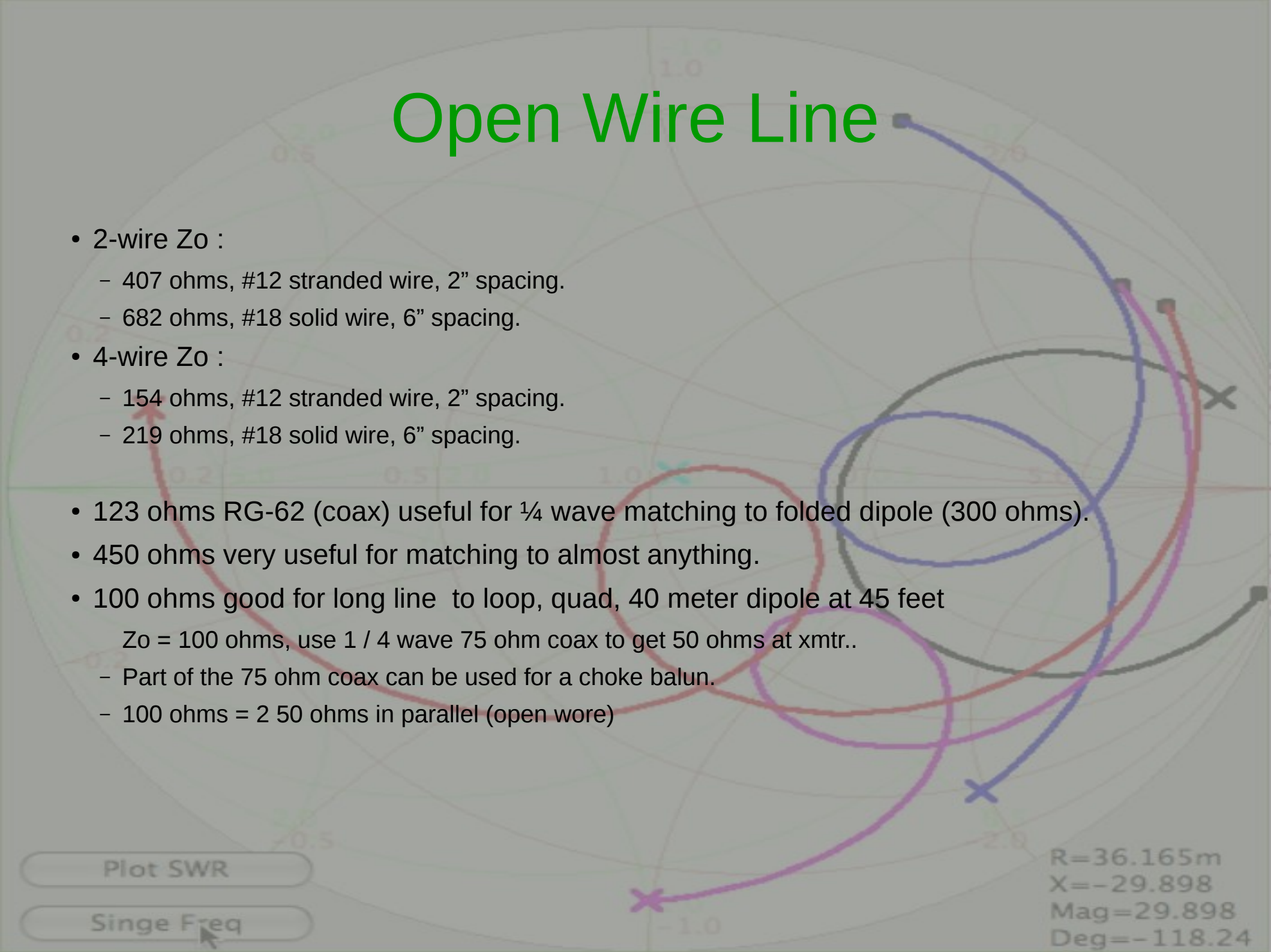


Open Wire Line

- 2-wire Zo :
  - 407 ohms, #12 stranded wire, 2” spacing.
  - 682 ohms, #18 solid wire, 6” spacing.
- 4-wire Zo :
  - 154 ohms, #12 stranded wire, 2” spacing.
  - 219 ohms, #18 solid wire, 6” spacing.

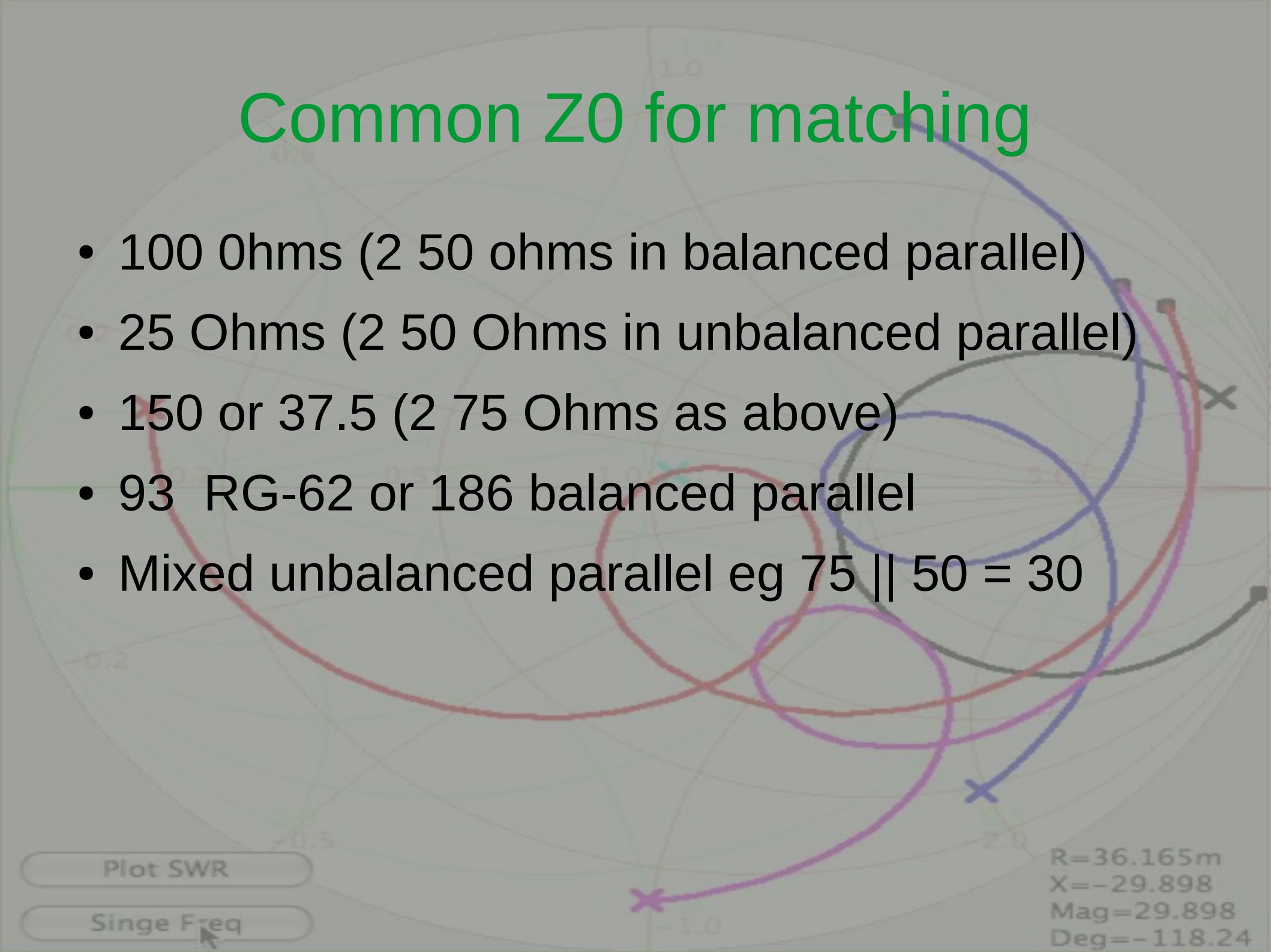
- 123 ohms RG-62 (coax) useful for ¼ wave matching to folded dipole (300 ohms).
- 450 ohms very useful for matching to almost anything.
- 100 ohms good for long line to loop, quad, 40 meter dipole at 45 feet

  Zo = 100 ohms, use 1 / 4 wave 75 ohm coax to get 50 ohms at xmtr..
  - Part of the 75 ohm coax can be used for a choke balun.
  - 100 ohms = 2 50 ohms in parallel (open wore)



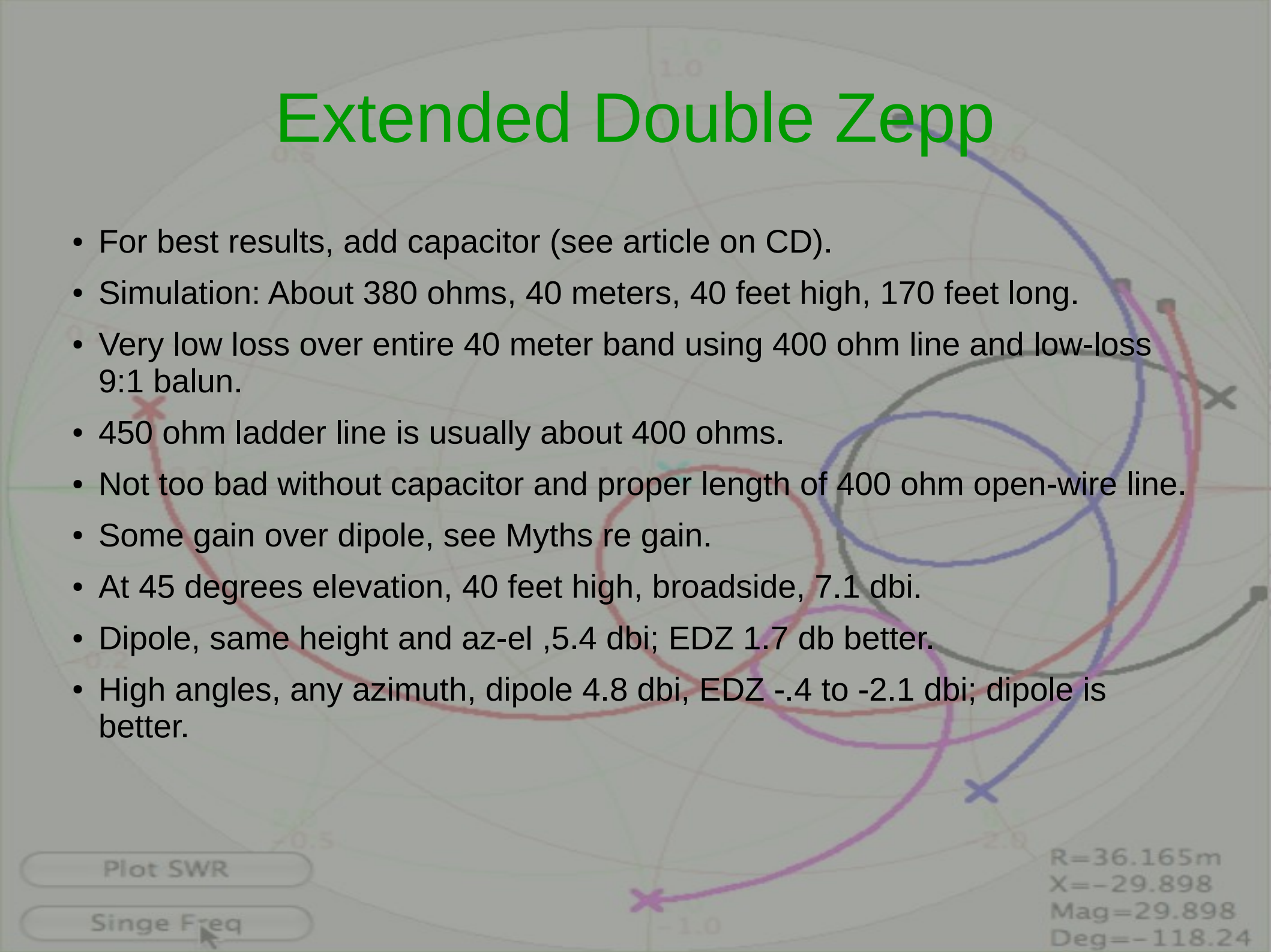
Common Z0 for matching

- 100 0hms (2 50 ohms in balanced parallel)
- 25 Ohms (2 50 Ohms in unbalanced parallel)
- 150 or 37.5 (2 75 Ohms as above)
- 93 RG-62 or 186 balanced parallel
- Mixed unbalanced parallel eg 75 || 50 = 30



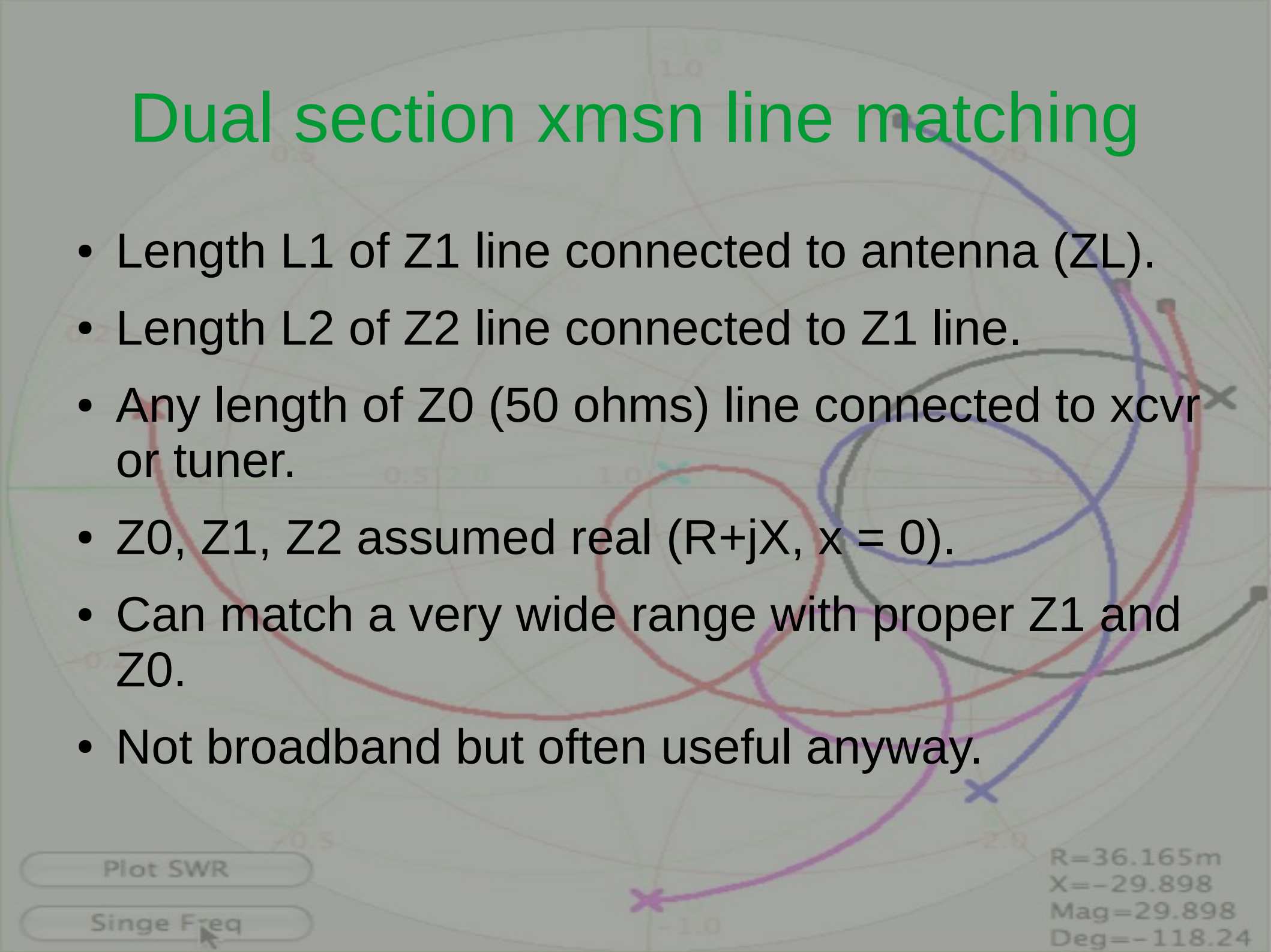
Extended Double Zepp

- For best results, add capacitor (see article on CD).
- Simulation: About 380 ohms, 40 meters, 40 feet high, 170 feet long.
- Very low loss over entire 40 meter band using 400 ohm line and low-loss 9:1 balun.
- 450 ohm ladder line is usually about 400 ohms.
- Not too bad without capacitor and proper length of 400 ohm open-wire line.
- Some gain over dipole, see Myths re gain.
- At 45 degrees elevation, 40 feet high, broadside, 7.1 dbi.
- Dipole, same height and az-el ,5.4 dbi; EDZ 1.7 db better.
- High angles, any azimuth, dipole 4.8 dbi, EDZ -.4 to -2.1 dbi; dipole is better.



Dual section xmsn line matching

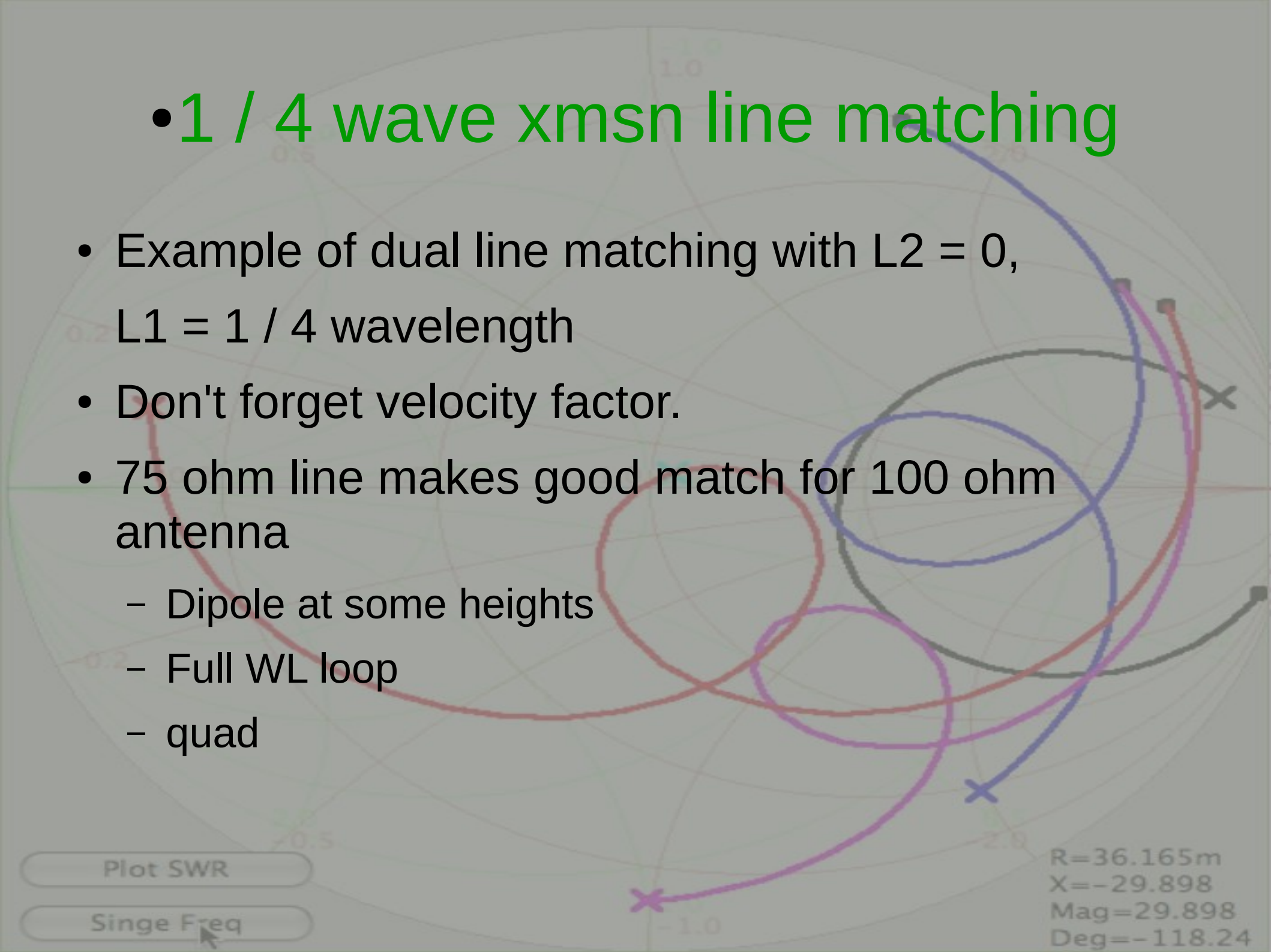
- Length L1 of Z1 line connected to antenna (ZL).
- Length L2 of Z2 line connected to Z1 line.
- Any length of Z0 (50 ohms) line connected to xcvr or tuner.
- Z0, Z1, Z2 assumed real (R+jX, x = 0).
- Can match a very wide range with proper Z1 and Z0.
- Not broadband but often useful anyway.



•1 / 4 wave xmsn line matching

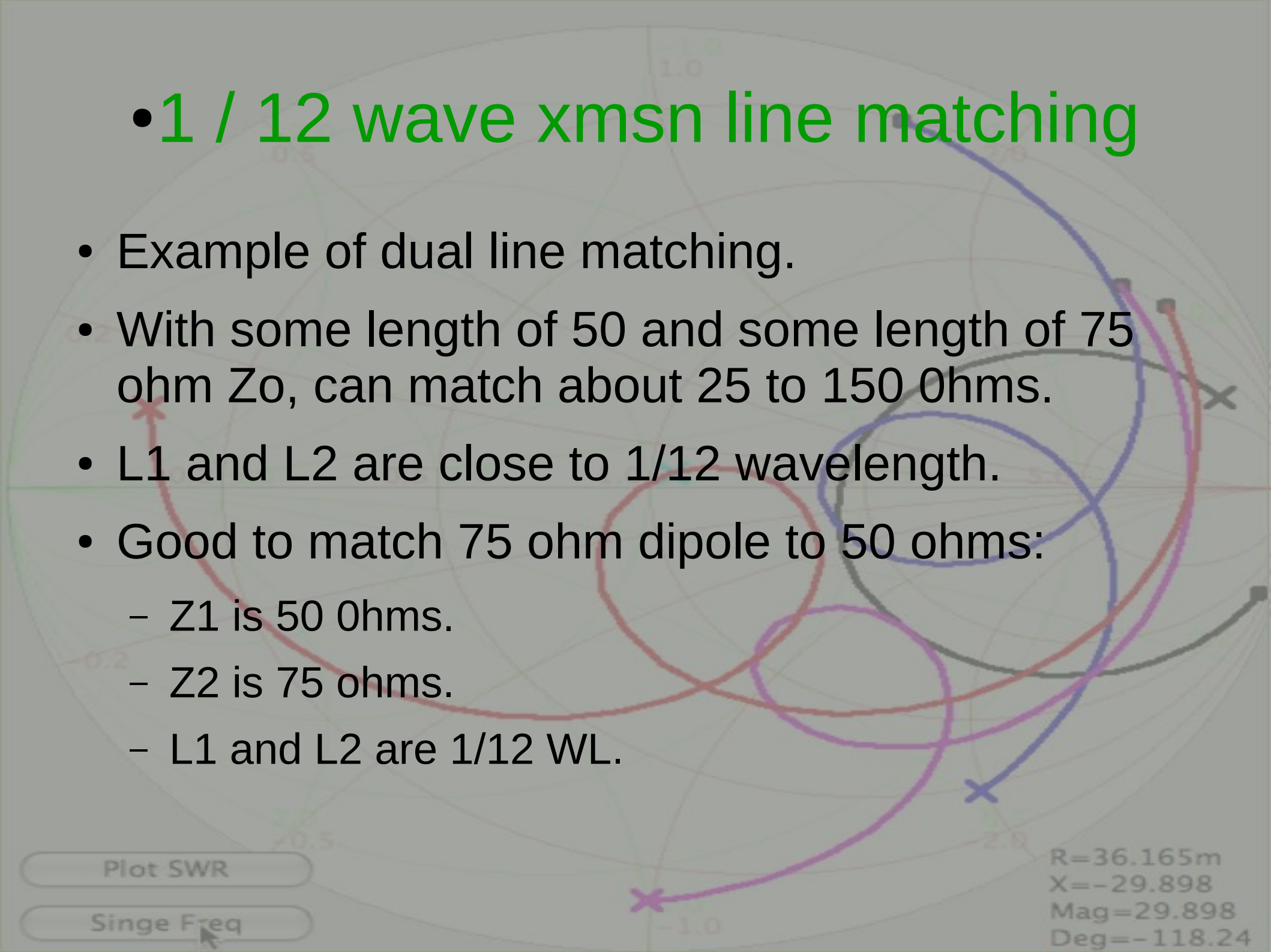
- Example of dual line matching with L2 = 0,

  L1 = 1 / 4 wavelength
- Don't forget velocity factor.
- 75 ohm line makes good match for 100 ohm antenna
  - Dipole at some heights
  - Full WL loop
  - quad



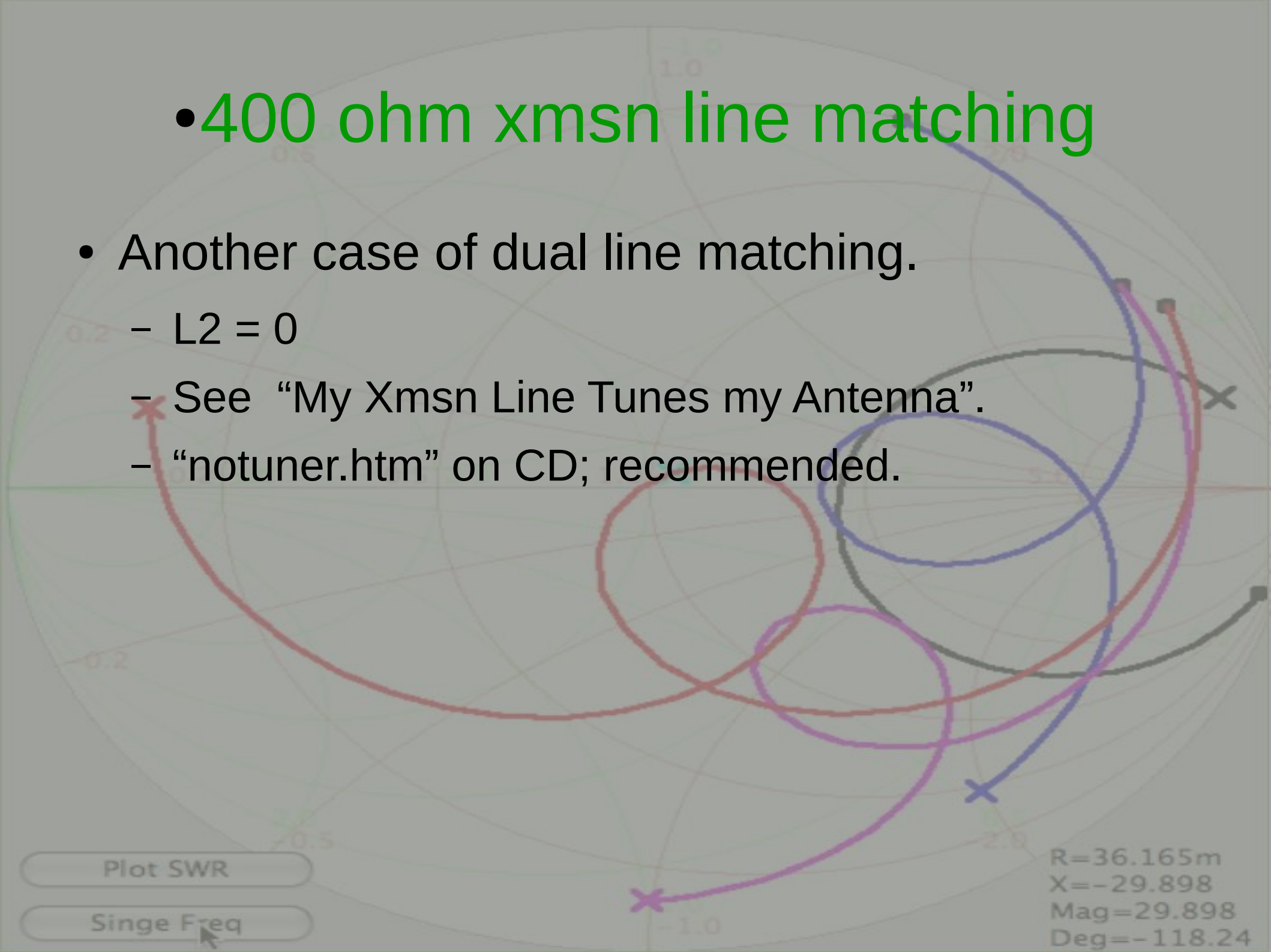
•1 / 12 wave xmsn line matching

- Example of dual line matching.
- With some length of 50 and some length of 75 ohm Zo, can match about 25 to 150 0hms.
- L1 and L2 are close to 1/12 wavelength.
- Good to match 75 ohm dipole to 50 ohms:
  - Z1 is 50 0hms.
  - Z2 is 75 ohms.
  - L1 and L2 are 1/12 WL.



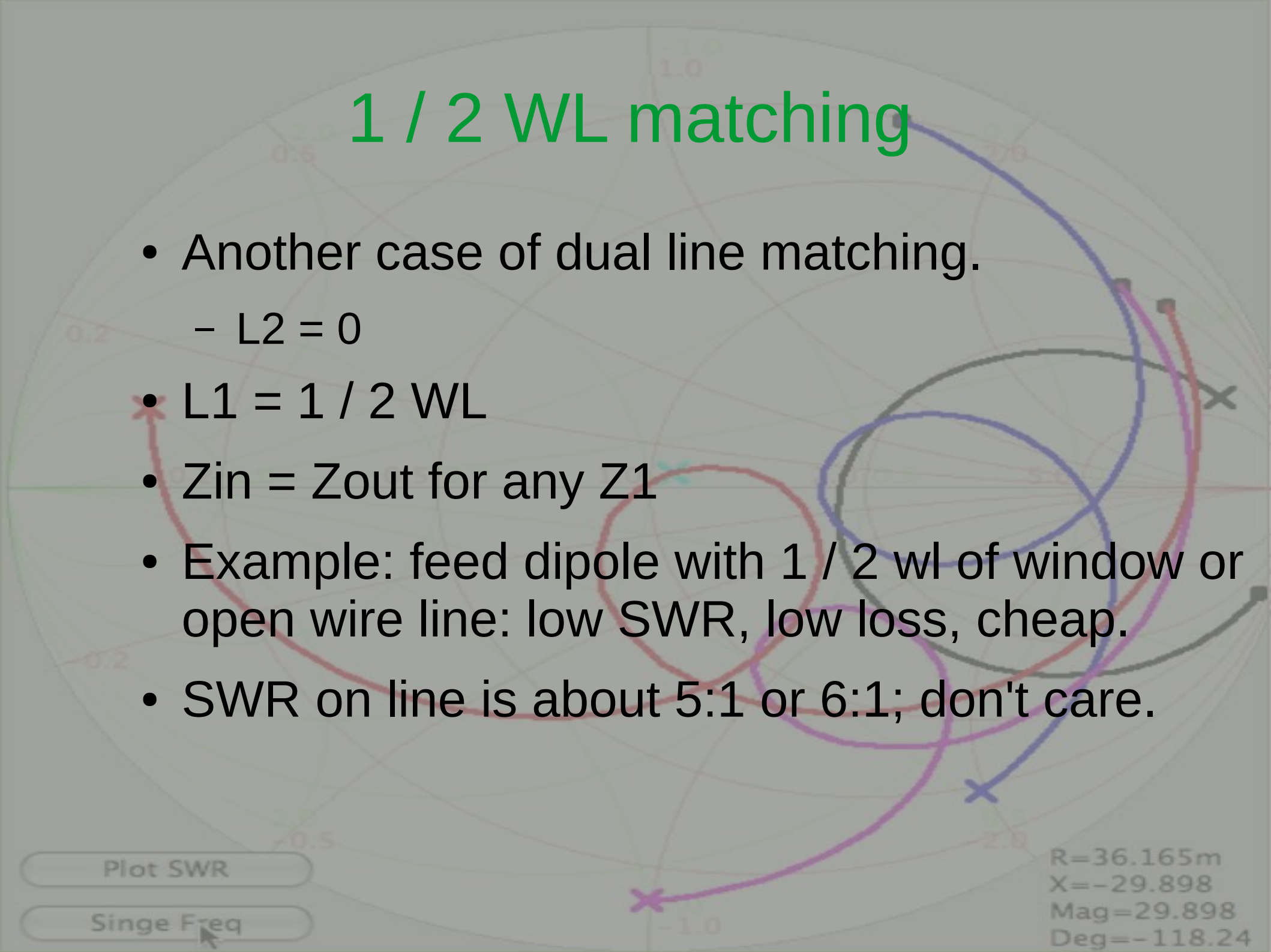
•400 ohm xmsn line matching

- Another case of dual line matching.
  - L2 = 0
  - See “My Xmsn Line Tunes my Antenna”.
  - “notuner.htm” on CD; recommended.



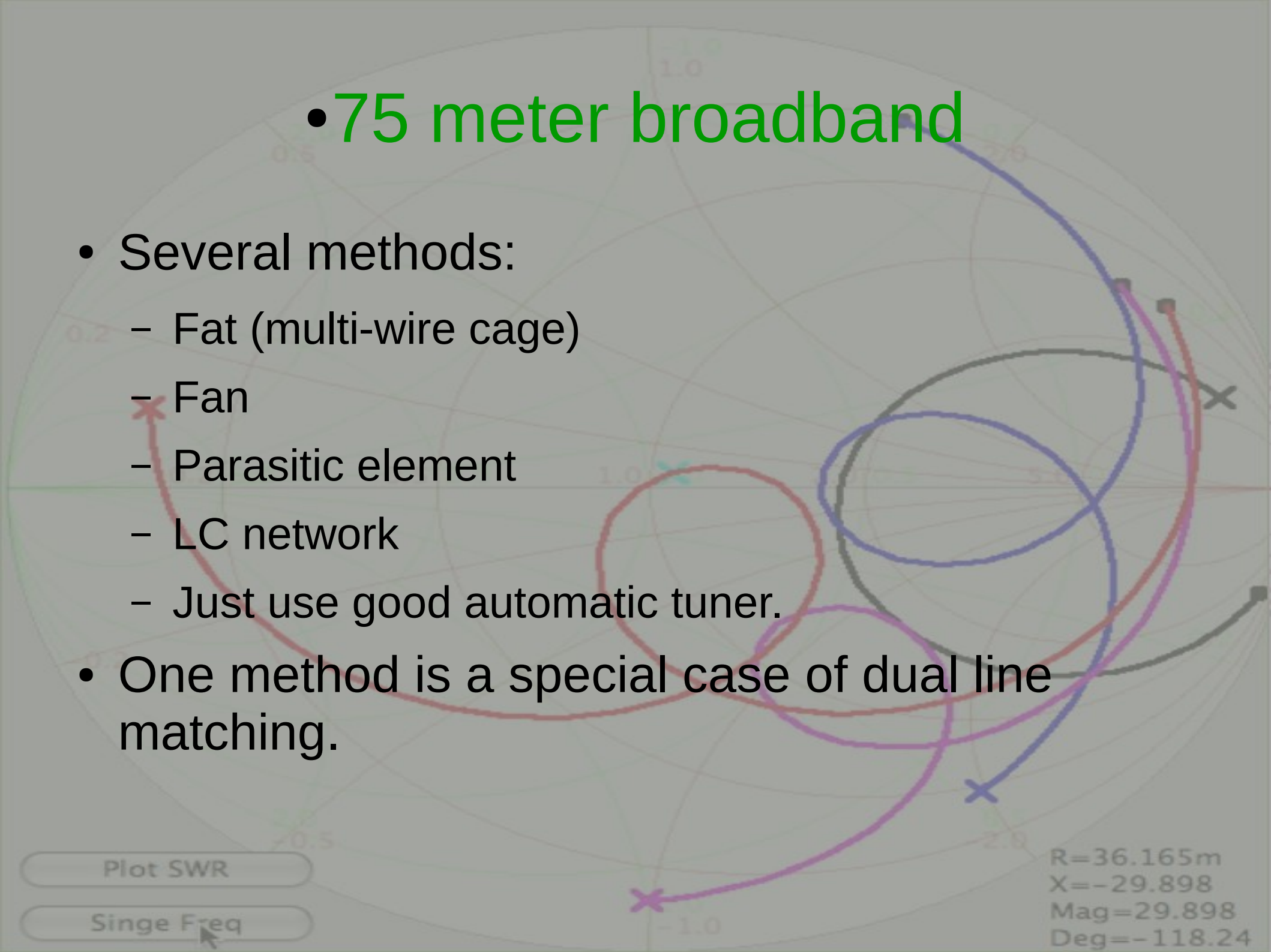
1 / 2 WL matching

- Another case of dual line matching.
  - L2 = 0
- L1 = 1 / 2 WL
- Zin = Zout for any Z1
- Example: feed dipole with 1 / 2 wl of window or open wire line: low SWR, low loss, cheap.
- SWR on line is about 5:1 or 6:1; don't care.



•75 meter broadband

- Several methods:
  - Fat (multi-wire cage)
  - Fan
  - Parasitic element
  - LC network
  - Just use good automatic tuner.
- One method is a special case of dual line matching.



Conclusion: how to put up a good antenna.

- What is azimuth and angle of path to stations you want?
- Select an antenna to fit space and $.
- Model it to see if it has the desired azimuth and angle.
- Put it up and measure Zo.
- Use appropriate xmsn line, balun, and matching network for the measured Zo.
- A dipole is often a good, easy, cheap antenna.
- BEST: compare it to another (real, not modeled) antenna.