Long-Lasting Tree Antennas

Initial Development and Challenges

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Motivation: Longevity of Space Missions

Voyager 1

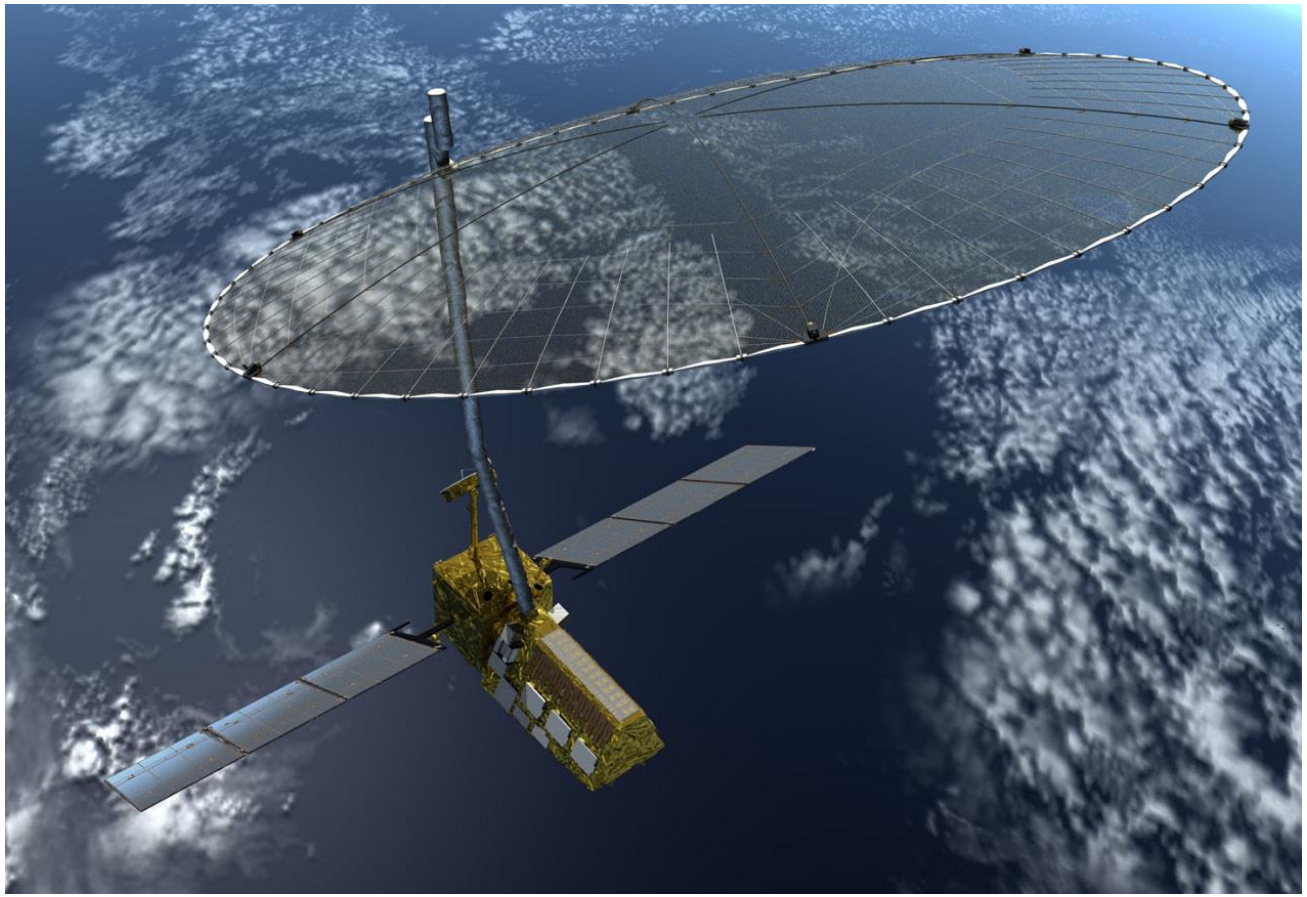
Credit: NASA

Proxima Centauri b

Credit: ESO/M. Kornmesser

Goal: Talk to CubeSat in LEO for 200 Years

NISAR



Credit: NASA

Smaller Goal:
Receive UHF/L-band signals from CubeSats

Literature Review

FIG. 1

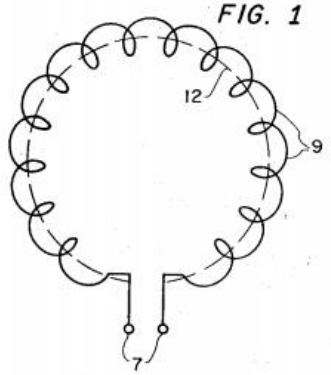


FIG. 2

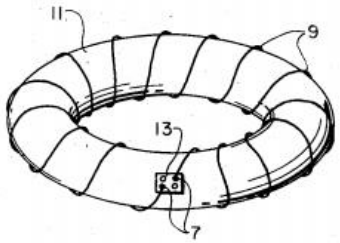
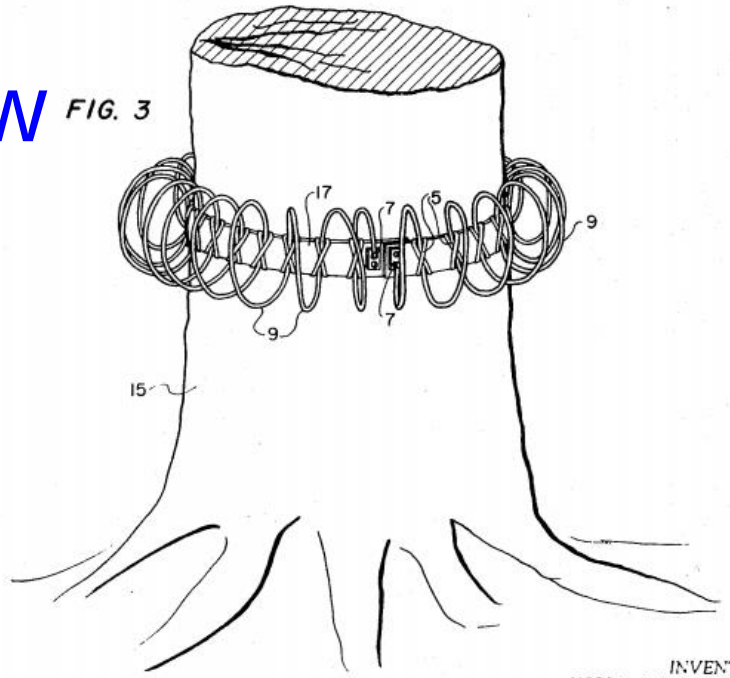


FIG. 3



INVENTORS,
MORRIS ACKER, KURT IKRATH
& WILHELM A. SCHNEIDER
BY: Gordon W. Kerr,
Harry M. Saragovitz,
Edward J. Kelly &
Herbert Berl
ATTORNEYS

[1]

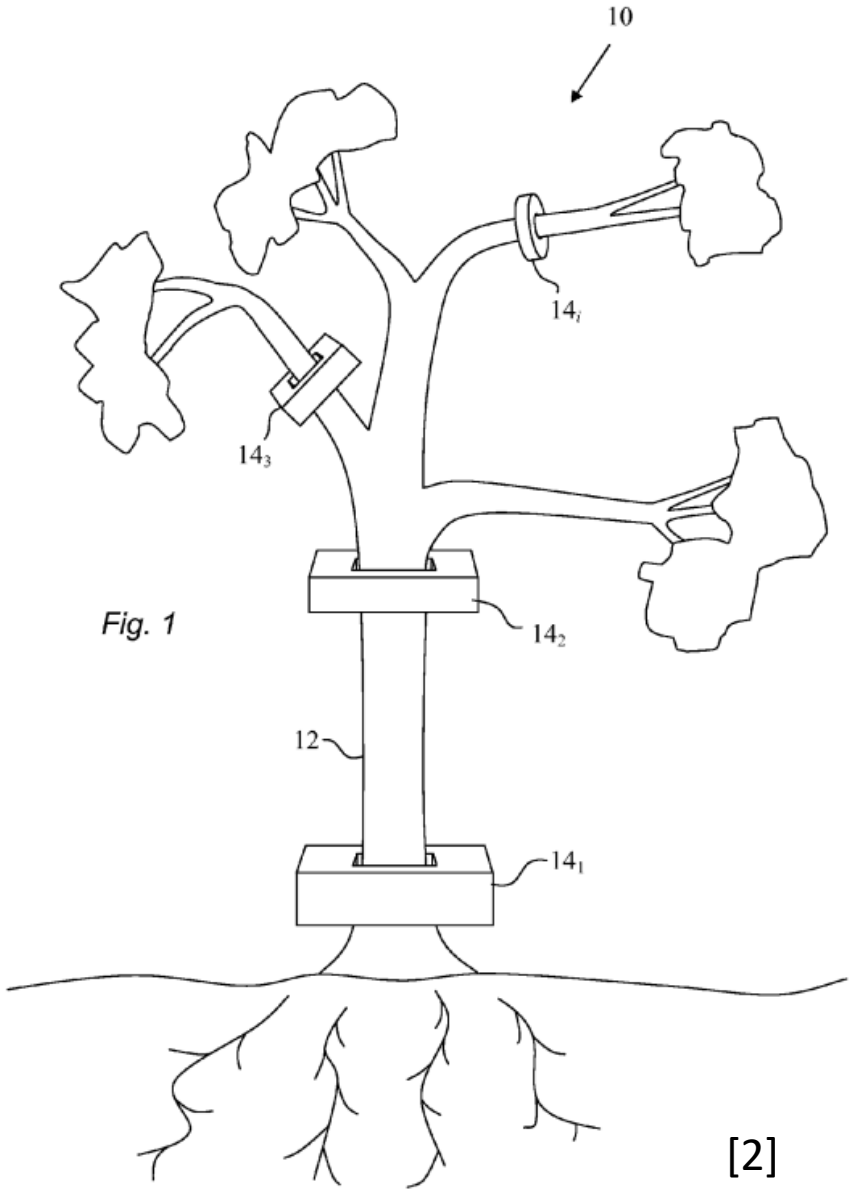
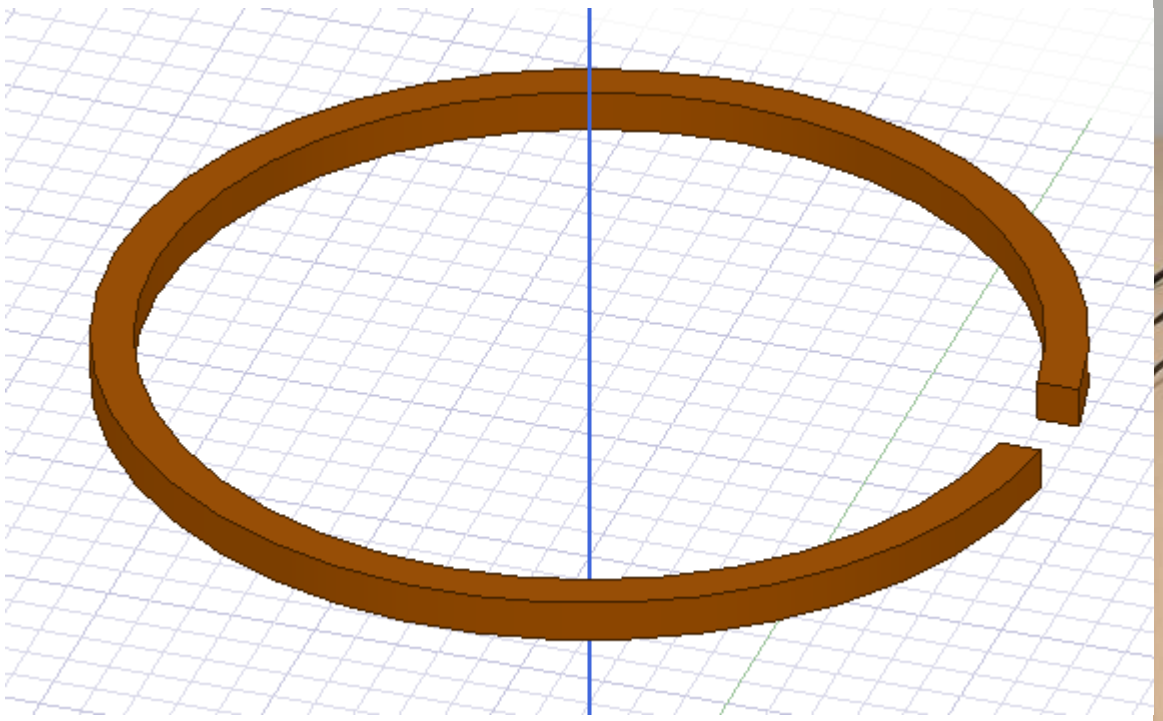


Fig. 1

[2]

Our Design: A Loop Antenna



Design Consideration Regarding Trees

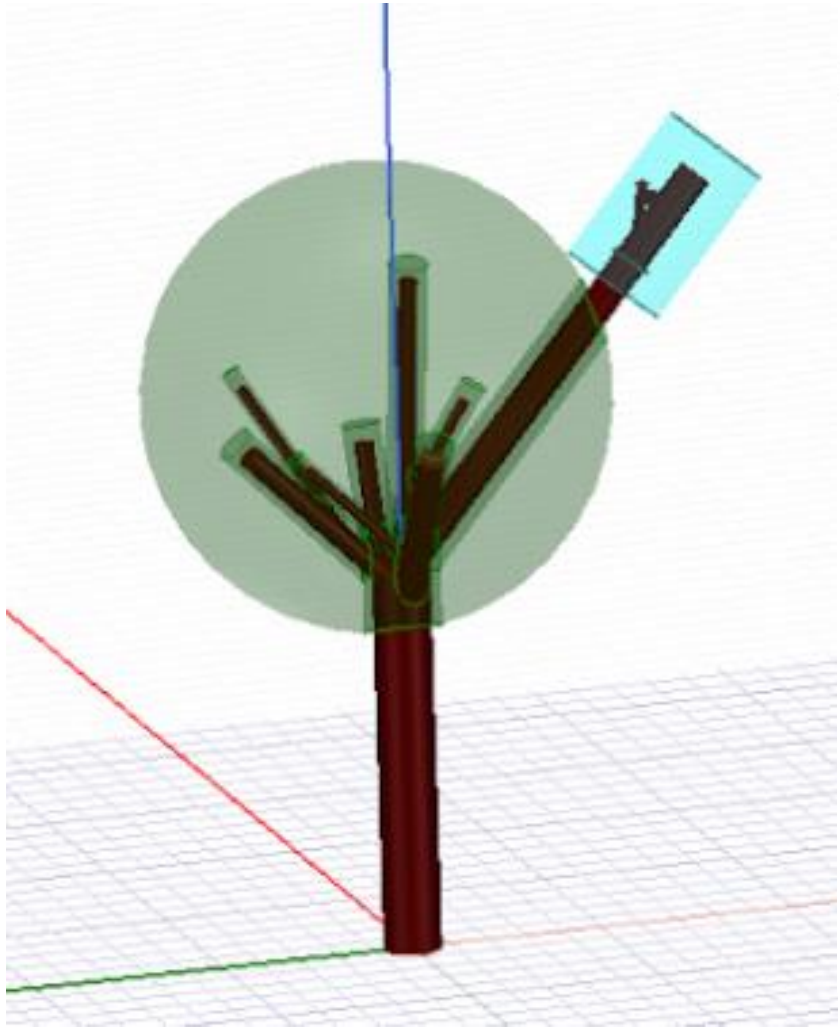
1. Dielectric constant of the tree
2. Modeling the tree
3. Attenuation from the leaves
4. Radius of the tree trunk/branches
5. How tight the antenna fits with the tree

Dielectric Constant of the Tree

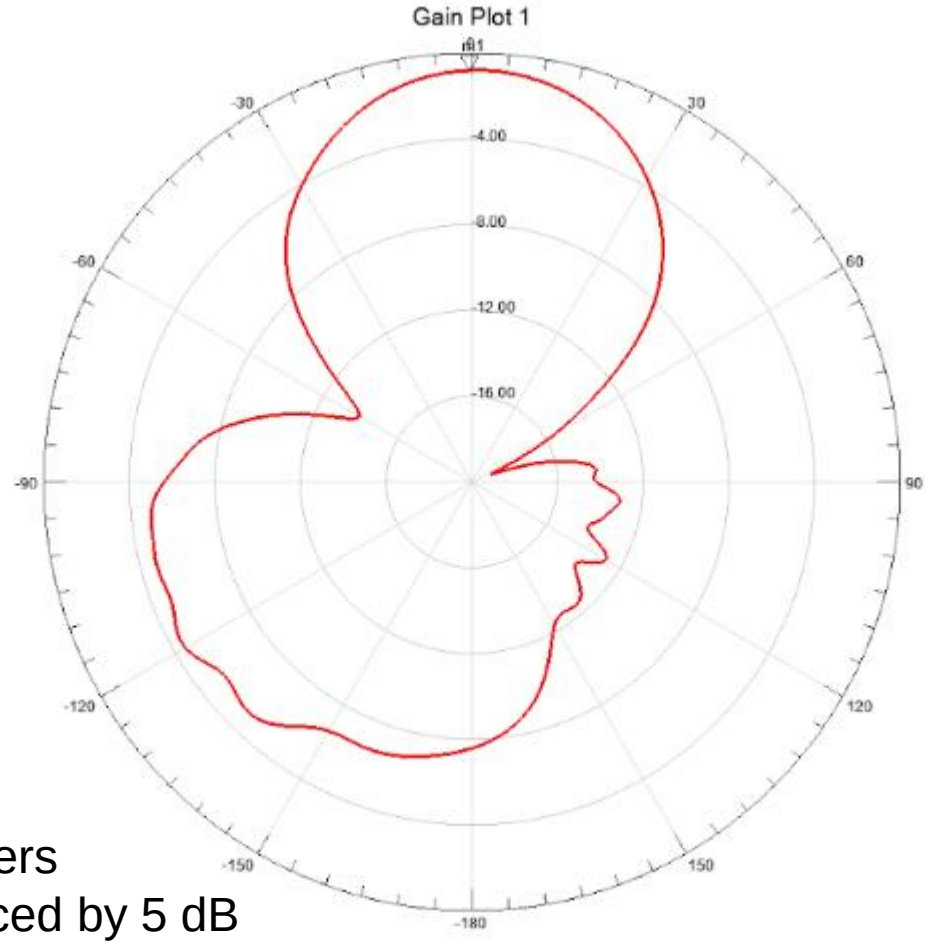
[3]

Parameter	Value
Real Permittivity	4.4
Imaginary Permittivity	0.54
Real Permeability	1
Imaginary Permeability	0
Dielectric Loss Tangent	0.122

Simulation of the Trees / Attenuation From the Leaves

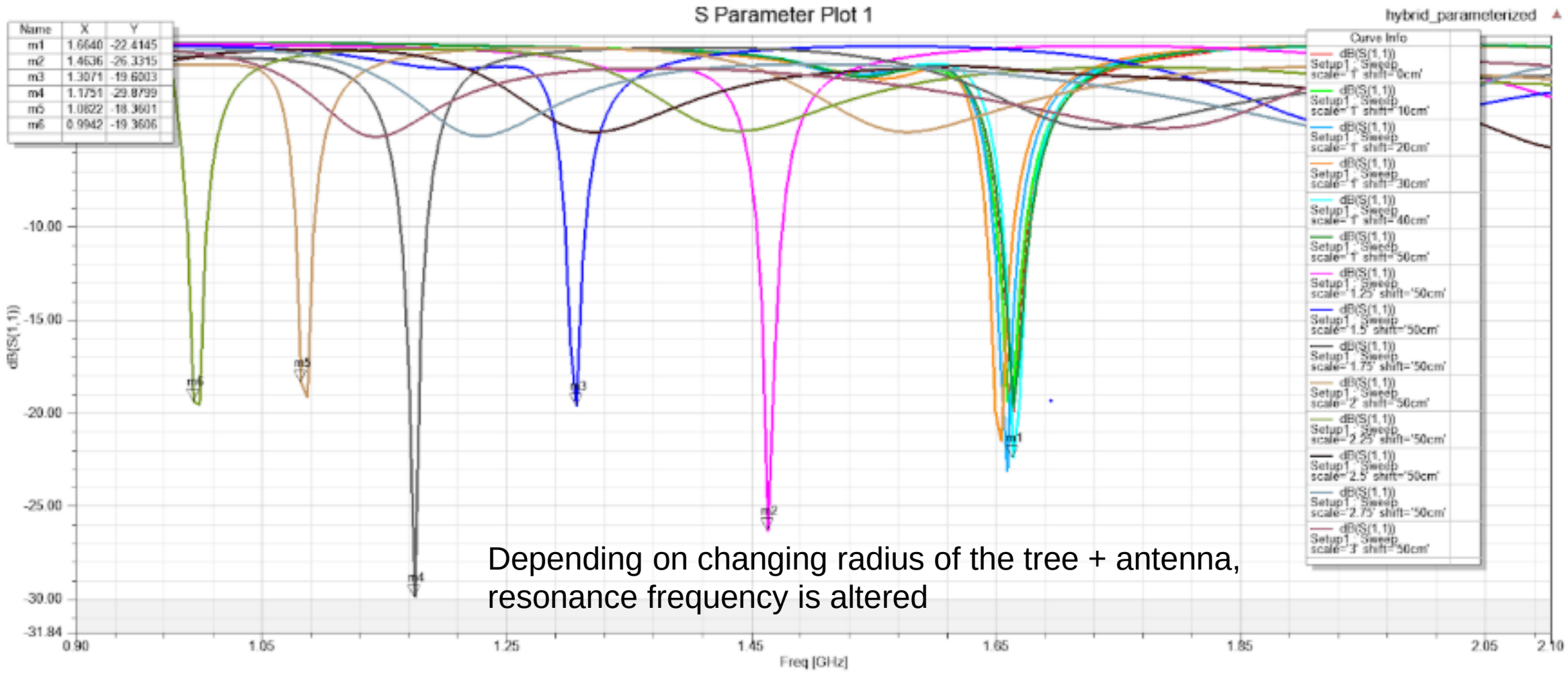


Name	Theta	Ang	Mag
m1	0.0000	0.0000	-0.8112



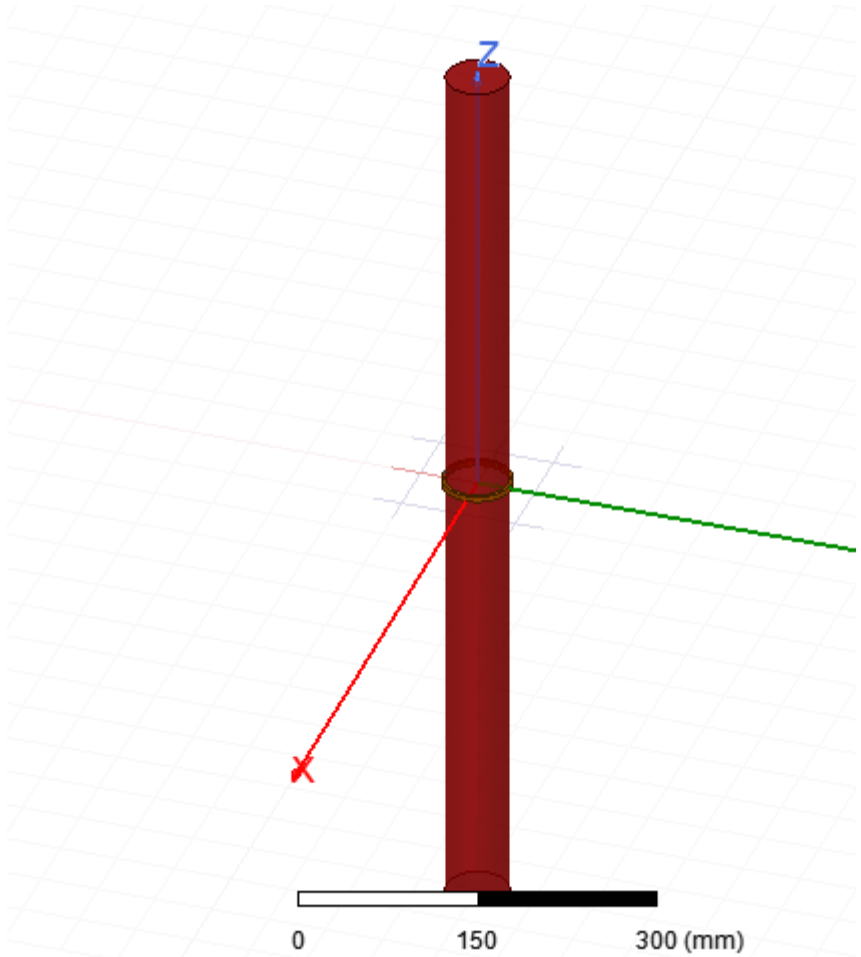
Gain pattern alters
Peak gain reduced by 5 dB
Even when the branch sits outside the leaves

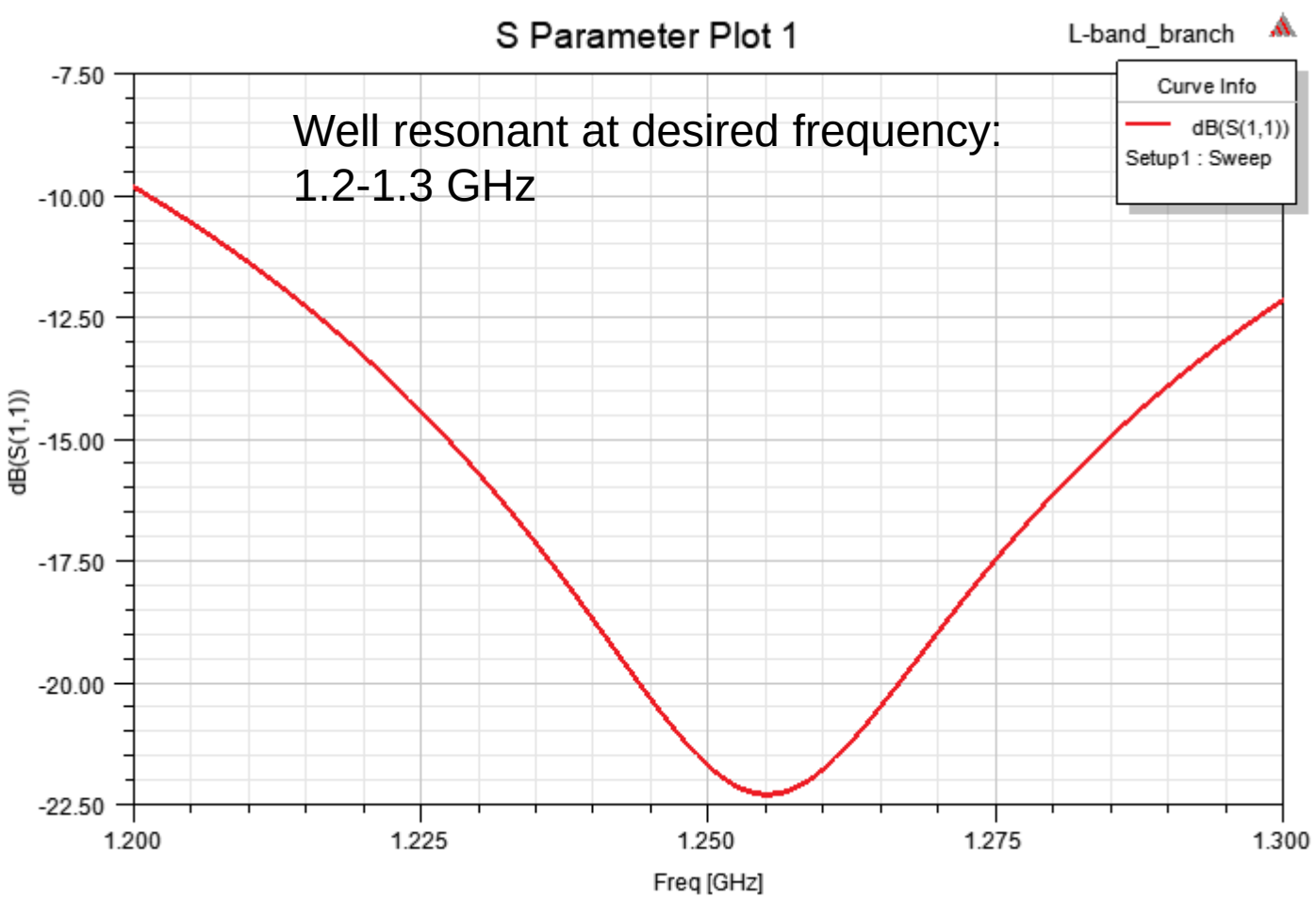
Radius of the Branches/Antennas



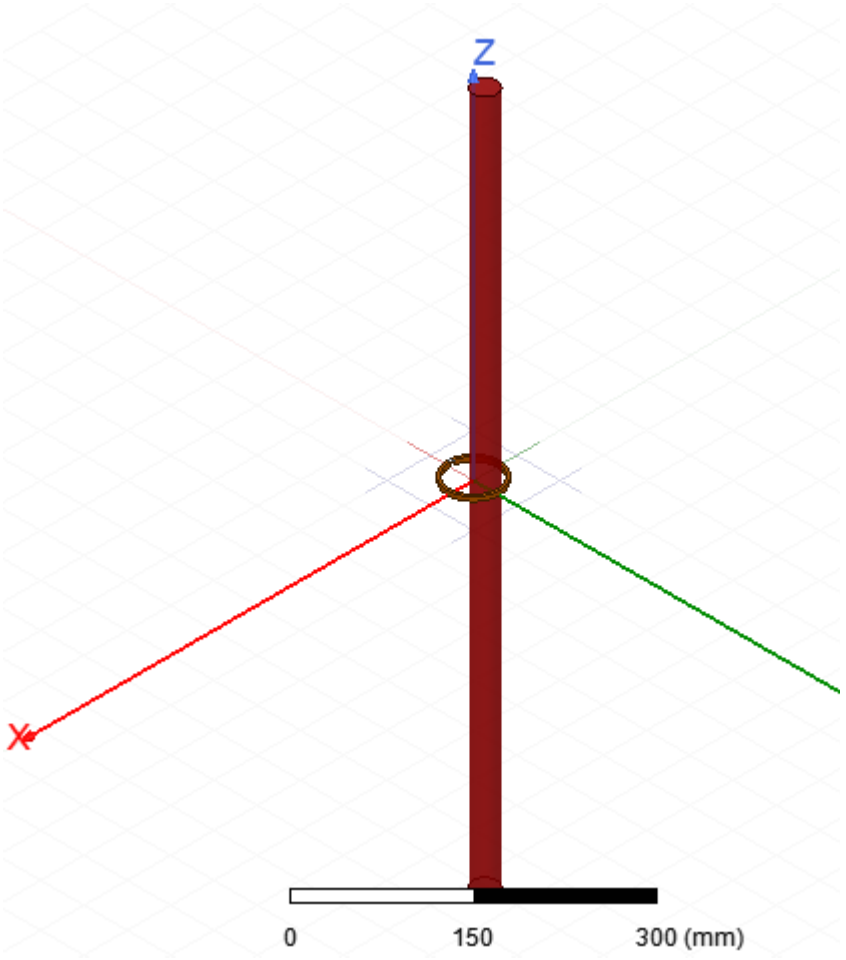
Depending on changing radius of the tree + antenna, resonance frequency is altered

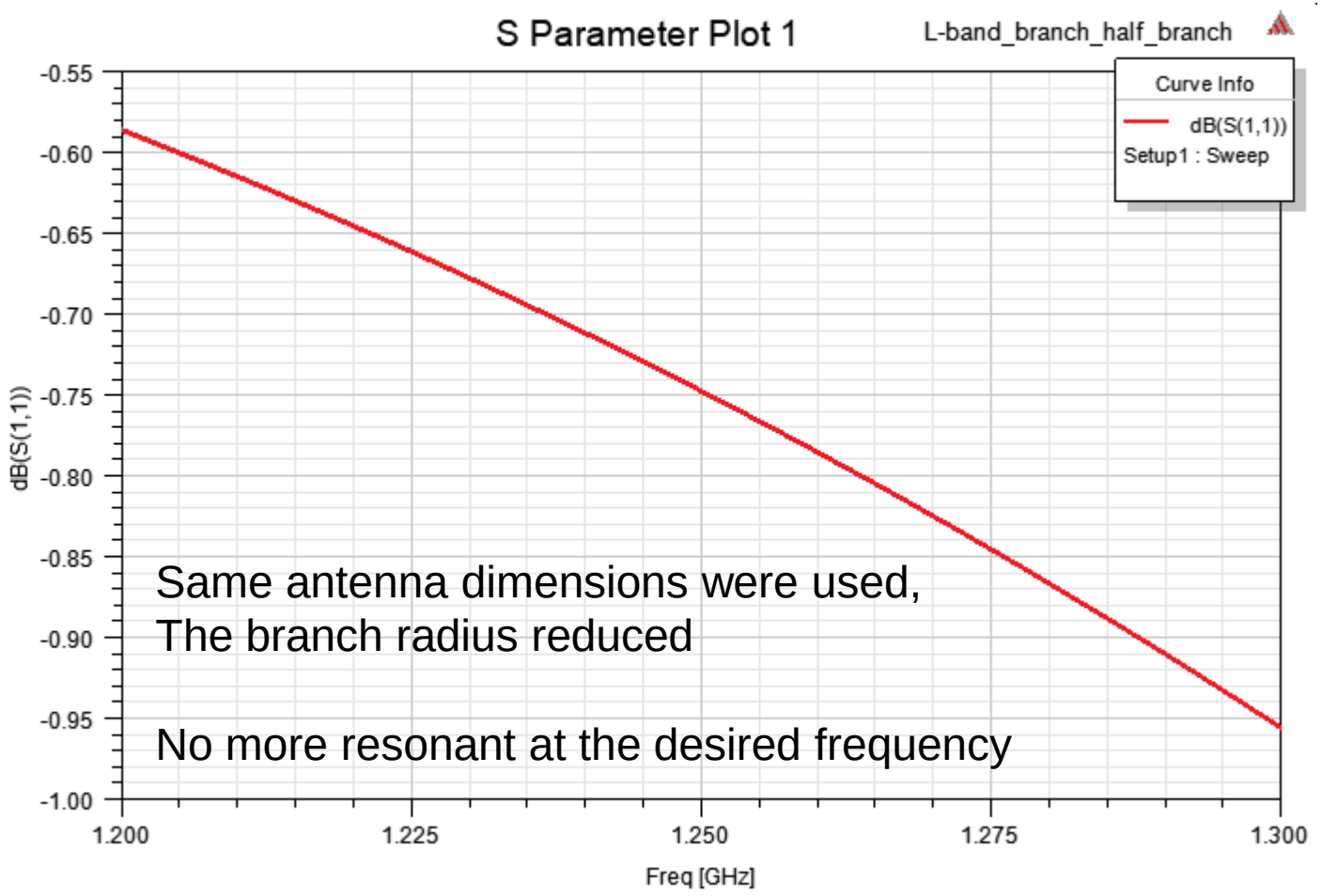
Antenna Tightness to the Tree: Tight



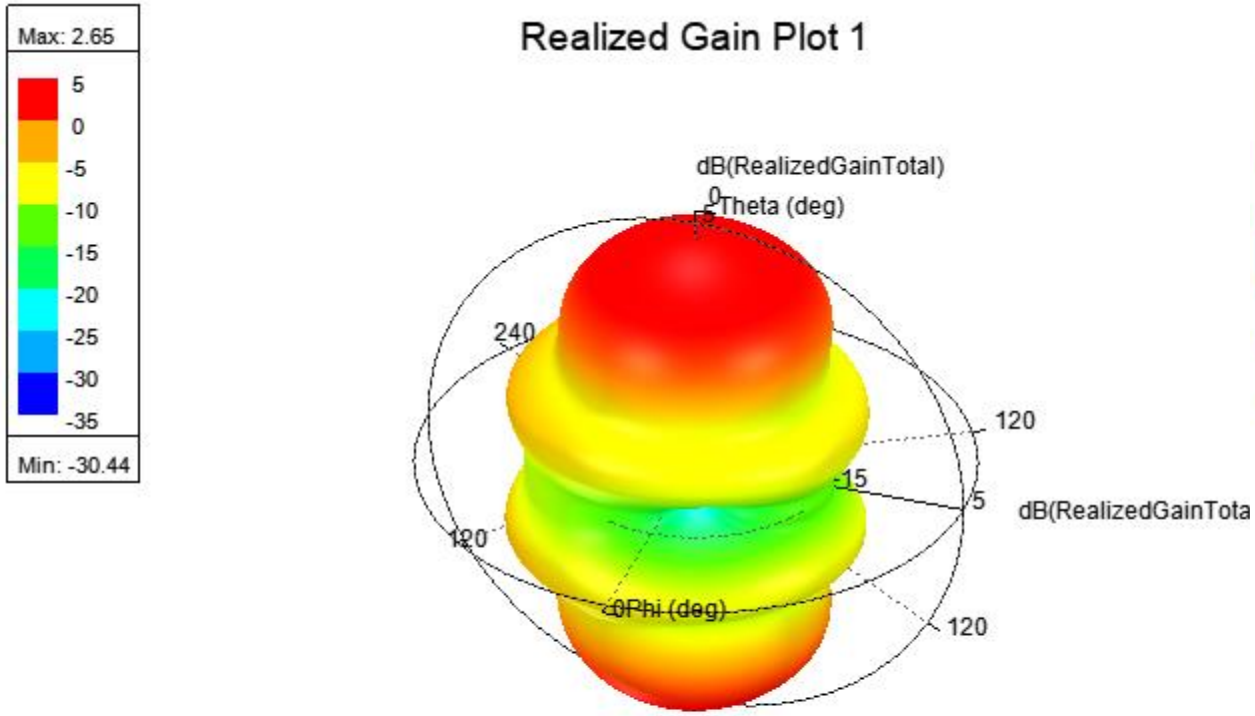


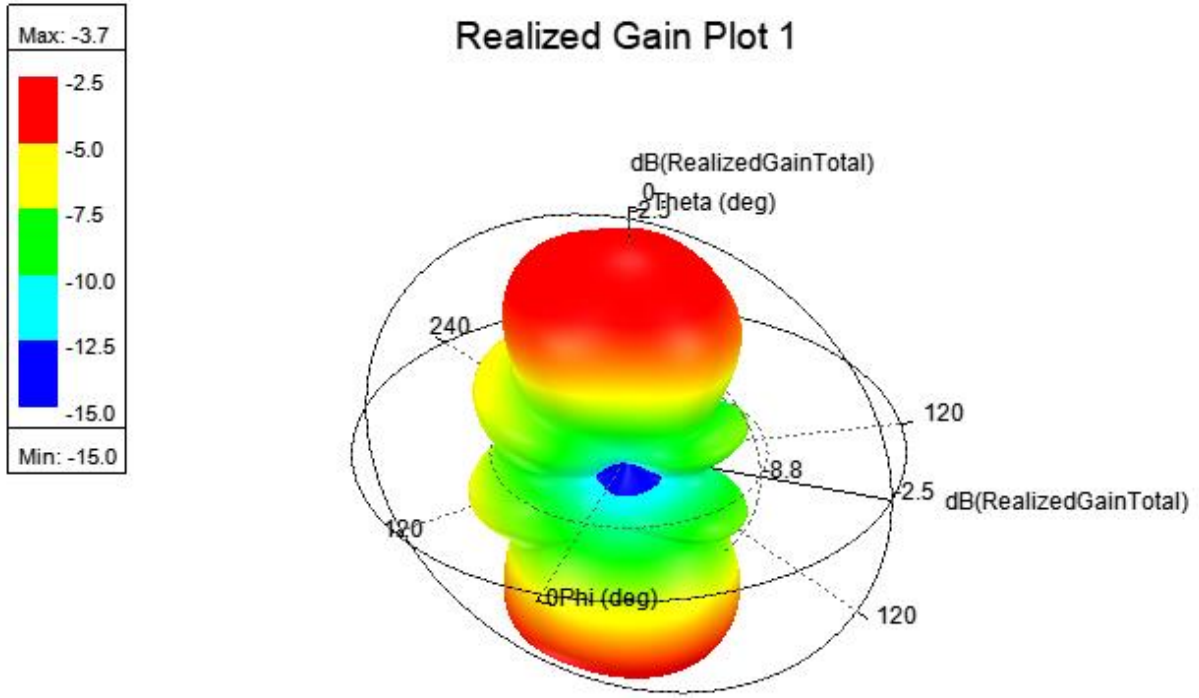
Antenna Tightness to the Tree: Loose





Antenna Tightness to the Tree: Tight vs. Loose





Peak gain reduced by 7 dB

Tree Selection is the Most Difficult Part

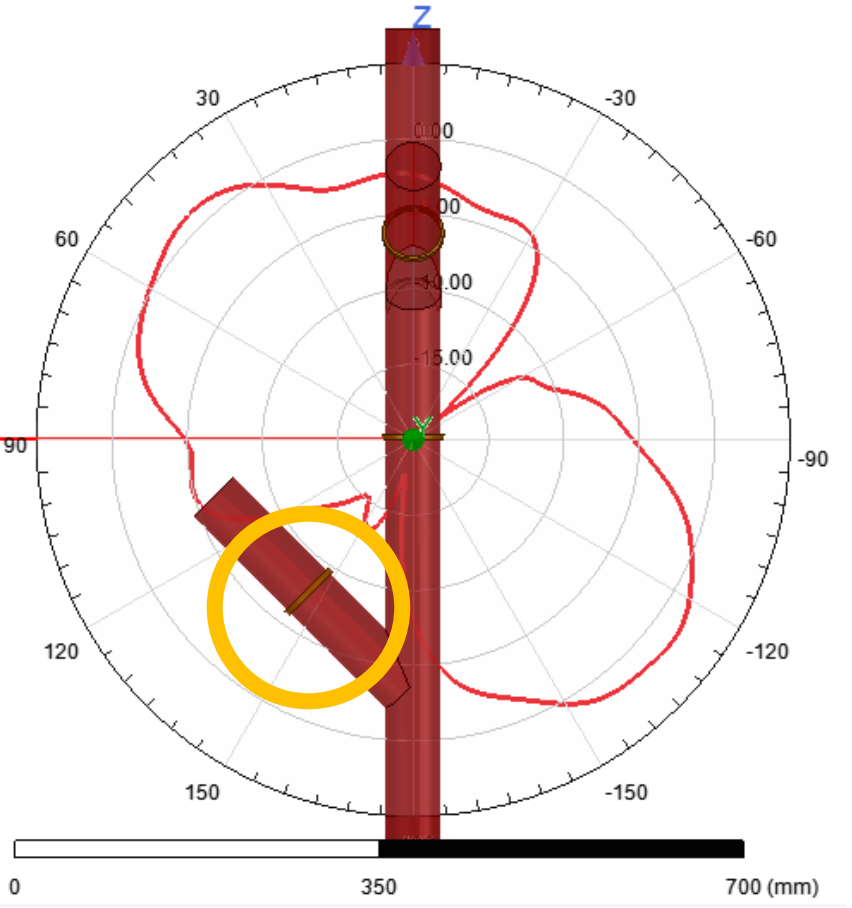
Everything has to match perfectly

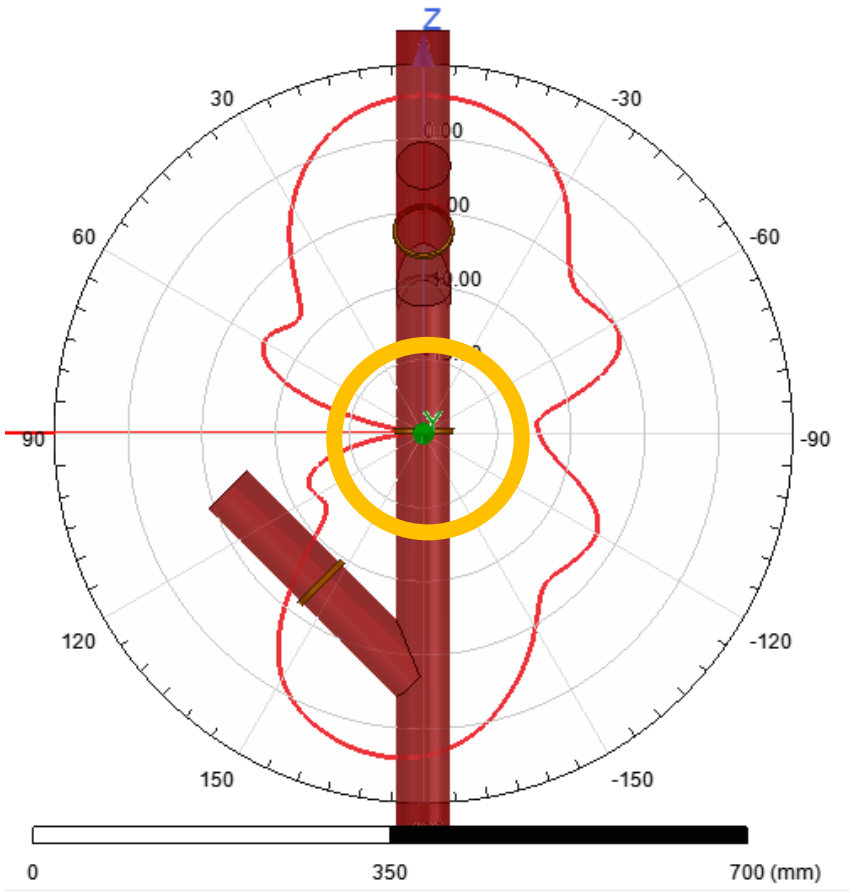
- The tree has to be simulated as accurately as possible
- Best to operate the antenna without the leaves
- Perfect branch must be selected at the desired frequency range
- Antenna must adaptively fit to the branch

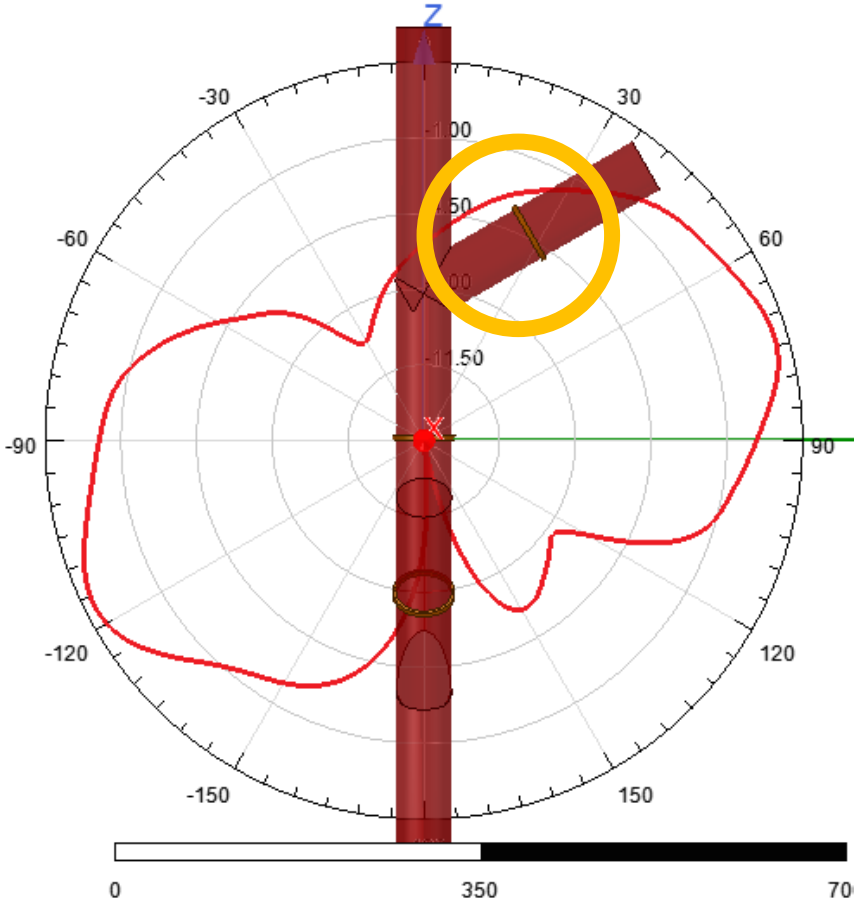
Other Research Directions Regarding Trees

Beamwidth of the station may be limited with one antenna only

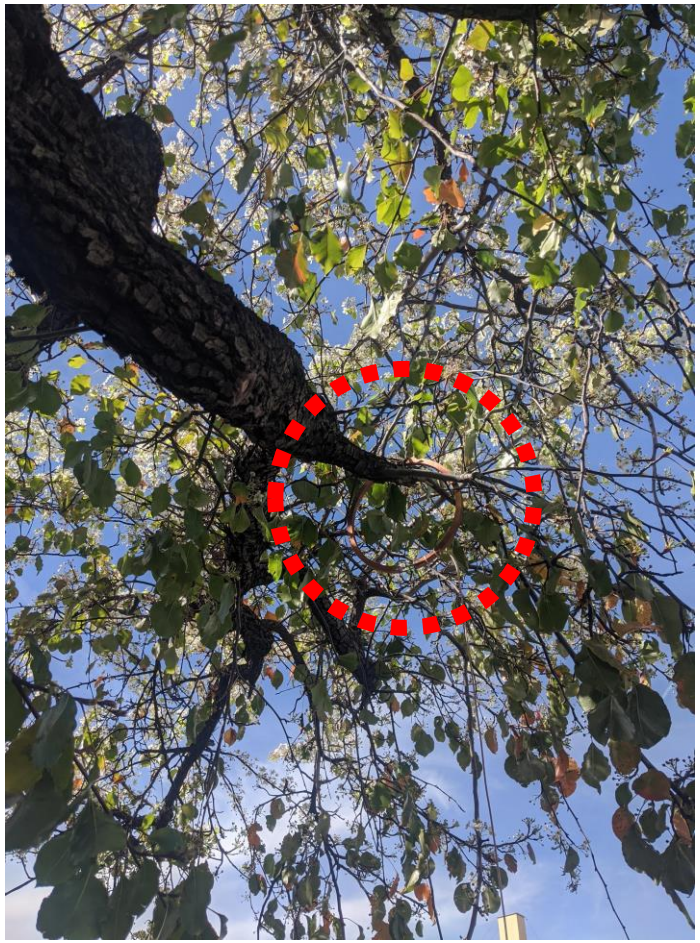
- Create a switched array with many antennas during a satellite pass

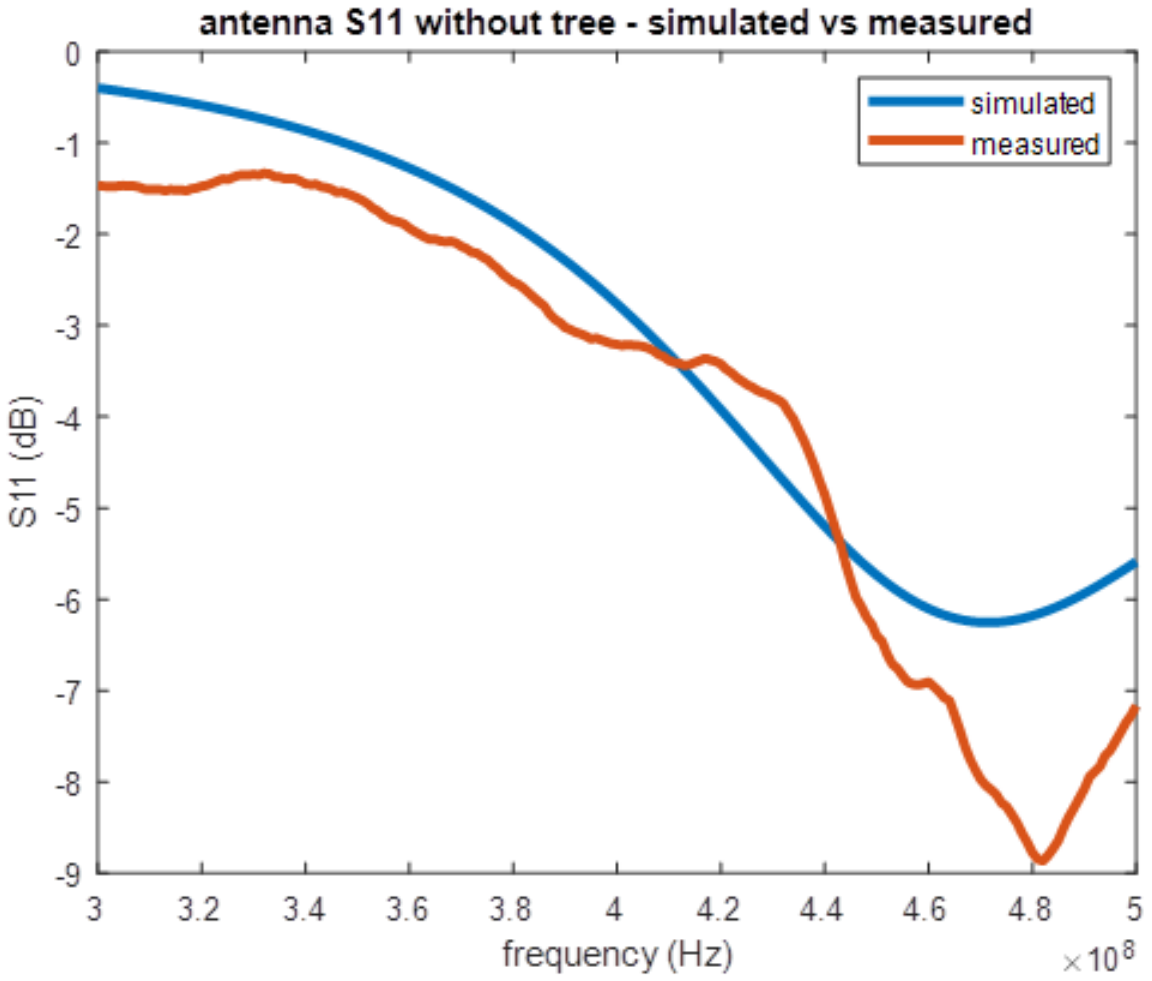




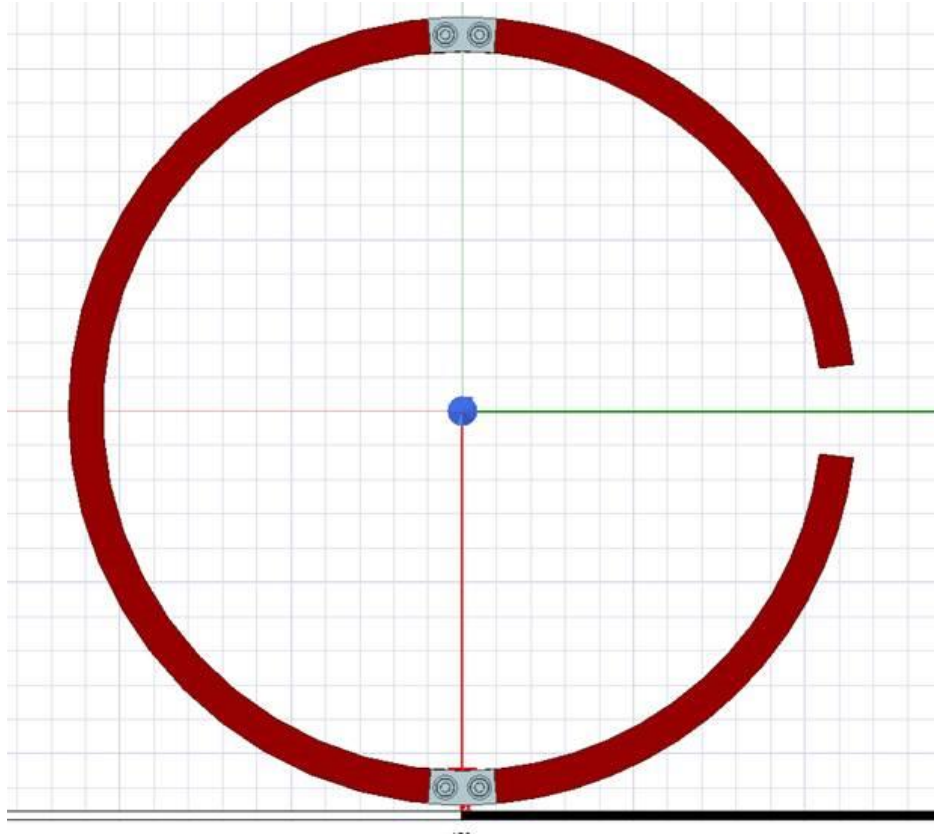


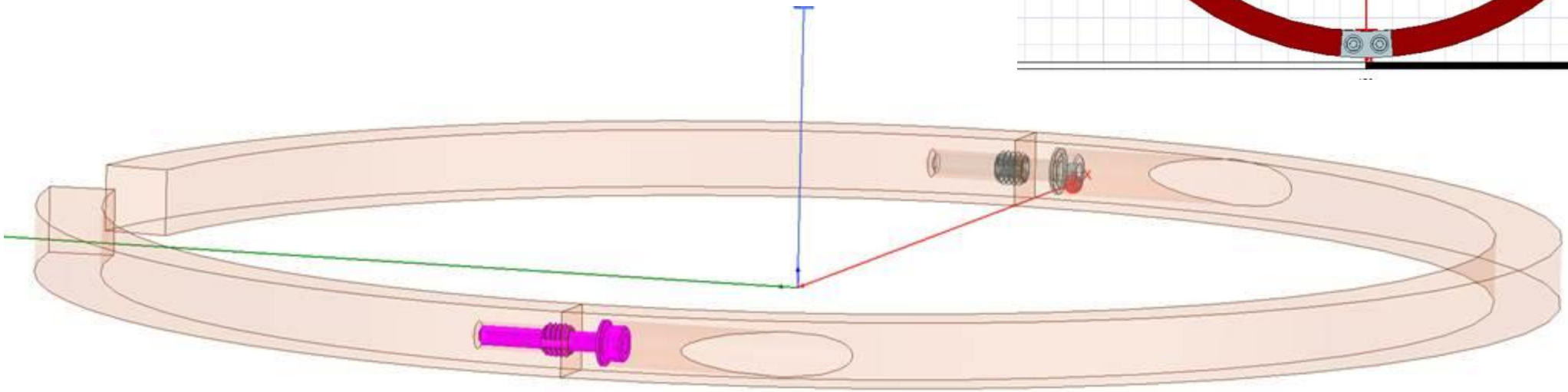
UHF Antenna Prototype





Structural Development





Acknowledgements

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Soldering: Tuyen Long
Administrative: Nerissa Laserna

References

[1] US Secretary of the Navy, "Helical coil coupled to a live tree to provide a radiating antenna", US3646562A, 2019.
[2] J. Rockway and D. Tam, "Multi-band tree antenna", US8094083B1, 2008.
[3] I. Baho, “Tree of Life: Designing and Simulating the Antenna Tree”, Internal Report, 2019.