# Antenna Simulation and Design for Underground Localization Systems


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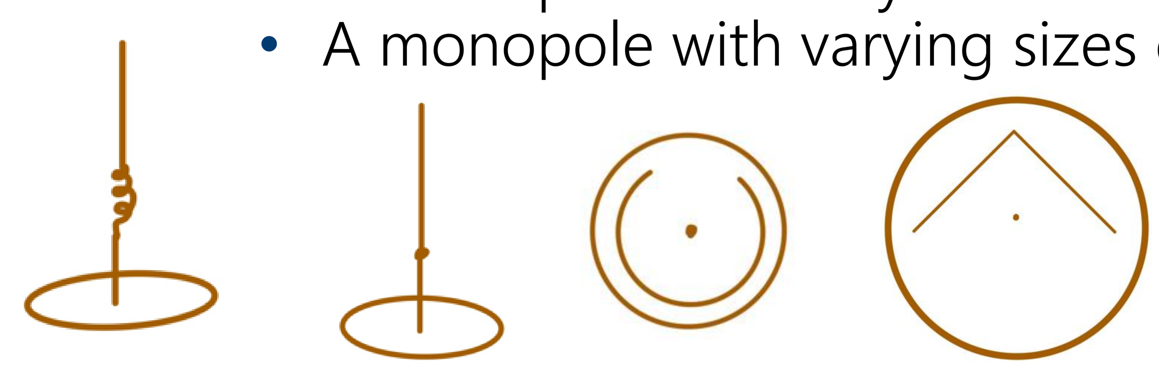
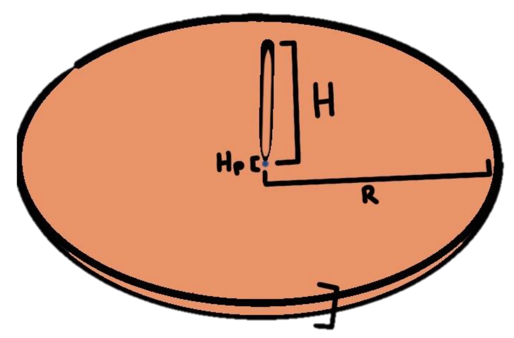
## Introduction

- Underground localization in mining situations is very important for worker safety, and methods like GPS do not work as GPS cannot penetrate through the ground
- A system was designed using RFID tags hung on the walls of the mine, a wearable antenna, and a receiver antenna & processor
- Our goal was to refine this design, and my portion was to design a 915 MHz monopole antenna with a highly directional pattern
- We went through several iterations (see below) using HFSS and CEMS
  - Dipole with and without a tuning inductor
  - A monopole with a cylindrical reflector
  - A monopole with varying sizes of corner reflector



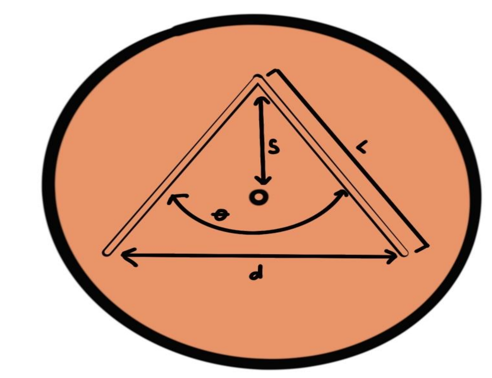



## Simulation Results

- We looked at three main parameters: $S_{11}$ , Realized Gain, and main beam width
- We optimized several parameters of our final design, including reflector height (H), angle (Θ), and distance of the monopole from from reflector apex (S)

Change in Realized Gain due to Reflector Height — HFSSDesign1 ANSYS

| | Freq [MHz] | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefHeight='75' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefHeight='100' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefHeight='125' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefHeight='150' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefHeight='175' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefHeight='200' |
|---|---|---|---|---|---|---|---|
| 1 | 915.000000 | 3.896190 | 5.804766 | 6.643691 | 7.223980 | 7.440351 | 7.245019 |

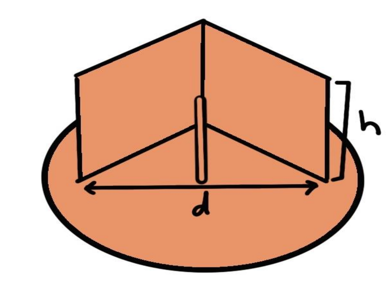



Peak Realized Gain due to Reflector Angle — HFSSDesign1 Ansys 2022 R2 STUDENT

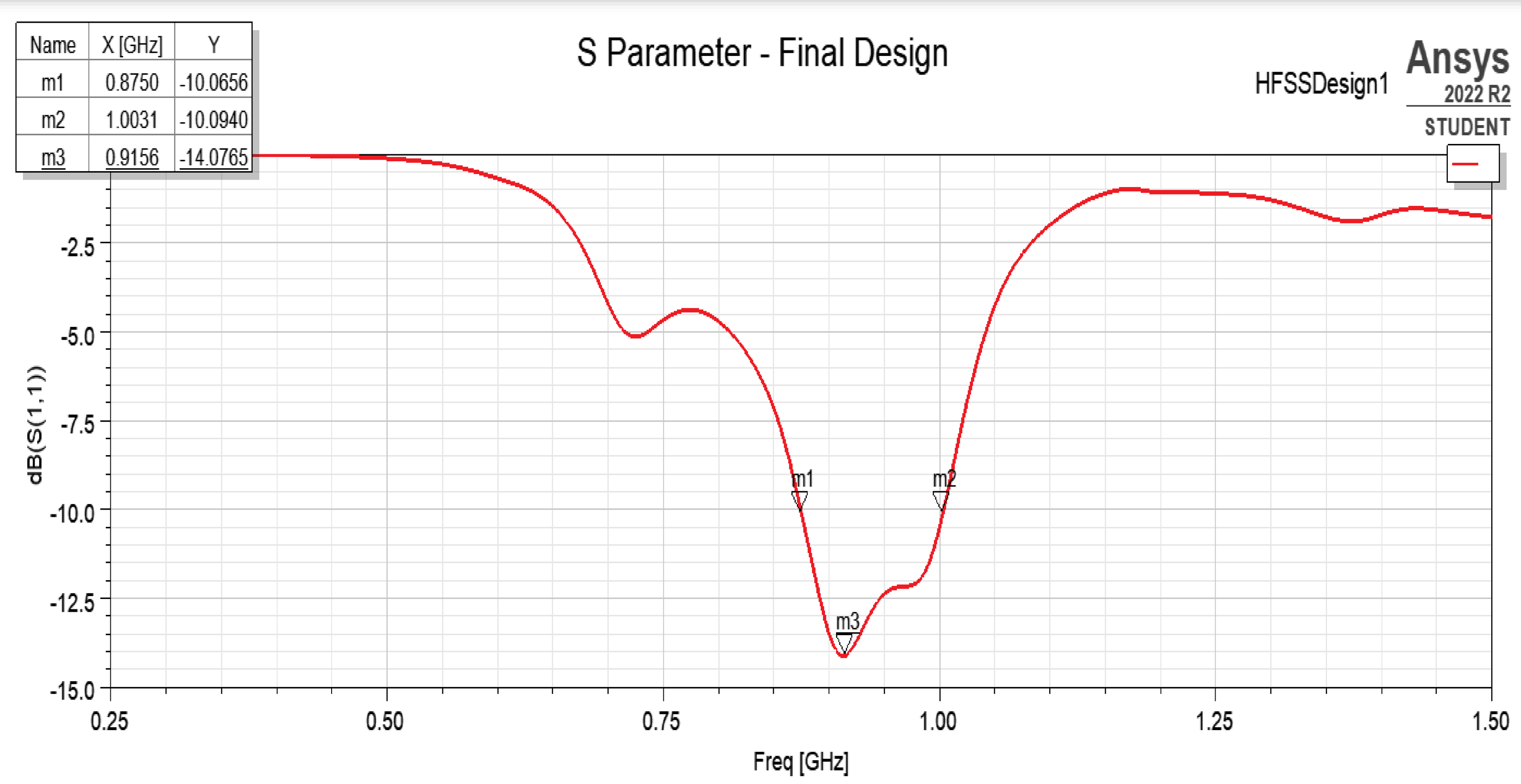
| | Freq [MHz] | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefAngle='30deg' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefAngle='45deg' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefAngle='60deg' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefAngle='75deg' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefAngle='90deg' |
|---|---|---|---|---|---|---|
| 1 | 915.000000 | 5.789242 | 3.661746 | 5.111106 | 5.312790 | 7.362257 |

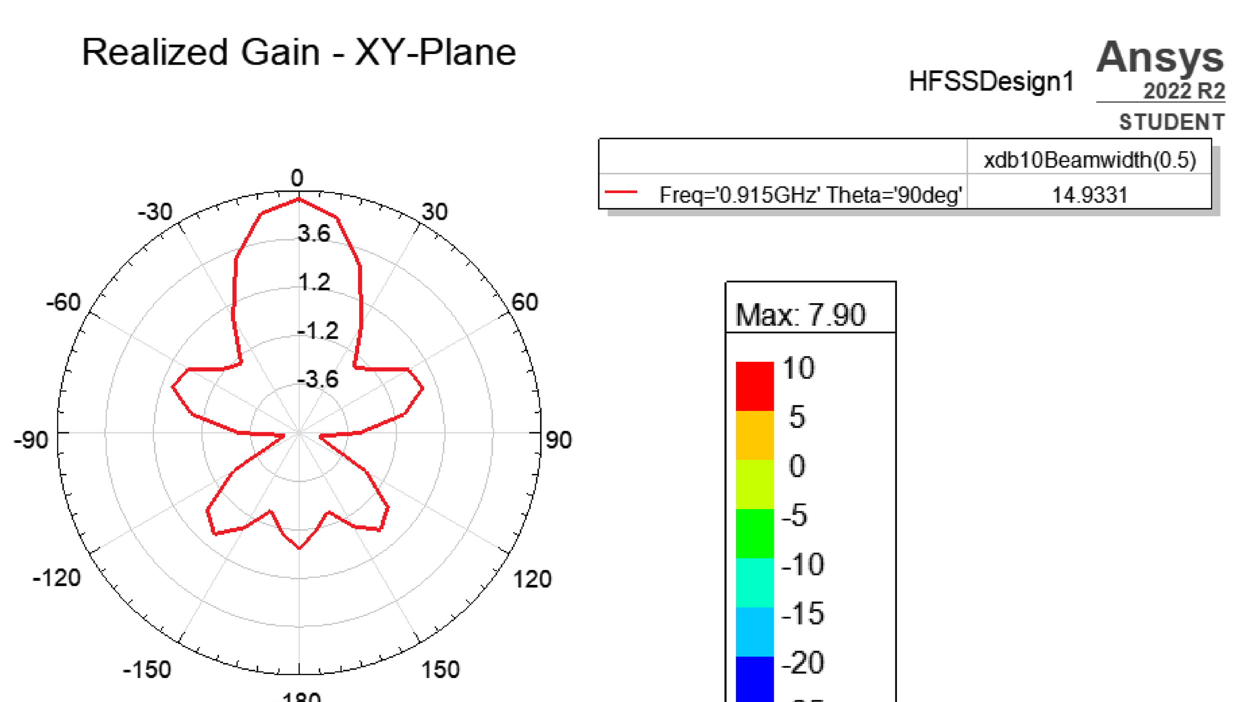
Peak Realized Gain - S (mm) — HFSSDesign1 Ansys 2022 R2 STUDENT

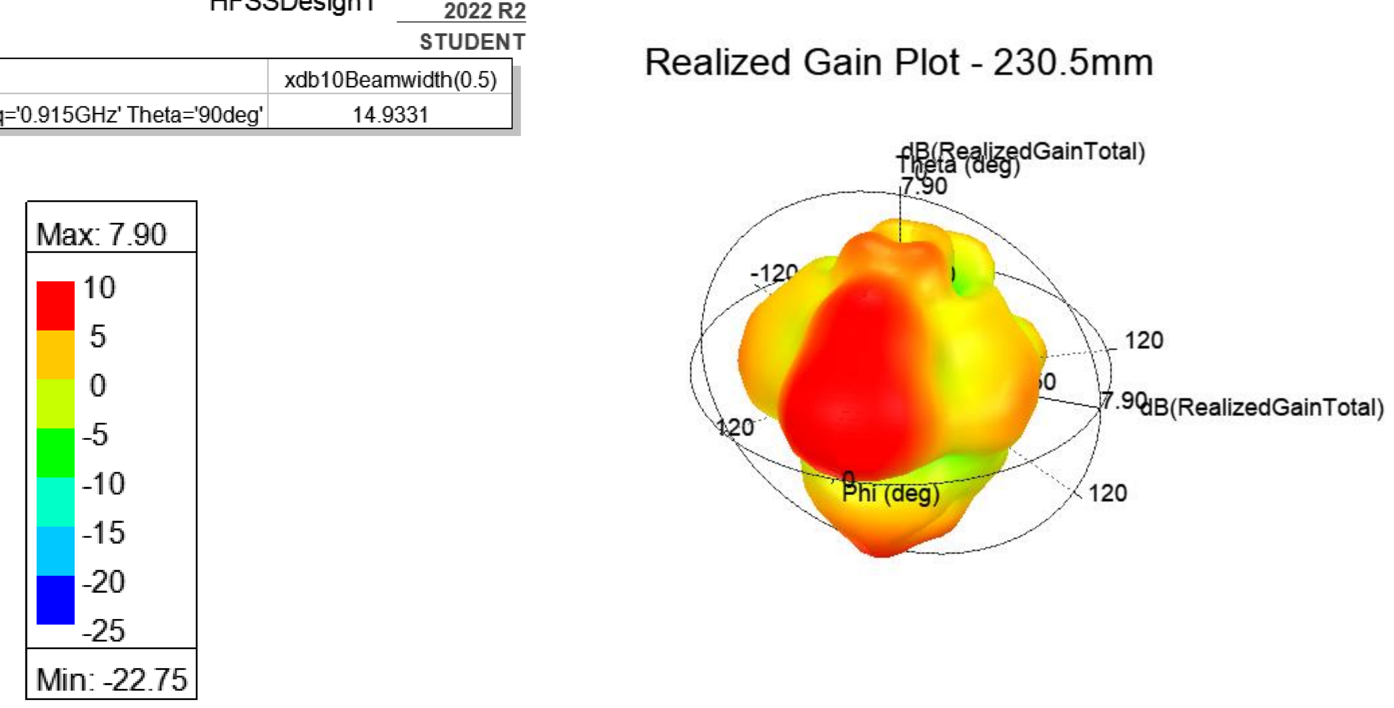
| | Freq [MHz] | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefDistmm='-60mm' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefDistmm='-30mm' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefDistmm='0mm' | dB(PeakRealizedGain) Setup1 : LastAdaptive $RefDistmm='30mm' |
|---|---|---|---|---|---|
| 1 | 915.000000 | 6.655944 | 8.342908 | 7.362257 | 6.275271 |




## Optimized Design & Results




## Conclusion

- We found that a monopole with a corner reflector generated the most ideal results:
  - Resonance
    - 875 MHz – 1 GHz
    - $S_{11}$ at 915 MHz – 14dB
  - Maximum Realized Gain
    - 7.9 dB
  - Beam Width in XY Plane
    - 14.93 Degrees

## Future Work

- Future work for this project involves optimizing the design to have a significantly smaller footprint.
- Fabrication of the antenna and measurement in the anechoic chamber
- Integration of the antenna with the other components of the localization system.

## Acknowledgements


- The Authors would like to thank Robert Jones for his help with running the simulations.


## References


[1] R. D. Jones, J. E. Diener, Y. Chen, A. Z. Elsherbeni and J. Brune, "Underground Localization System using a Combination of RFID and IMU Technologies," *2021 International Applied Computational Electromagnetics Society Symposium (ACES)*, Hamilton, ON, Canada, 2021, pp. 1-4.

[2] V. Demir and A. Elsherbeni, "Computational Electromagnetics Simulator (CEMS)," software package version 4, veysdemir@gmail.com, August 2020.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