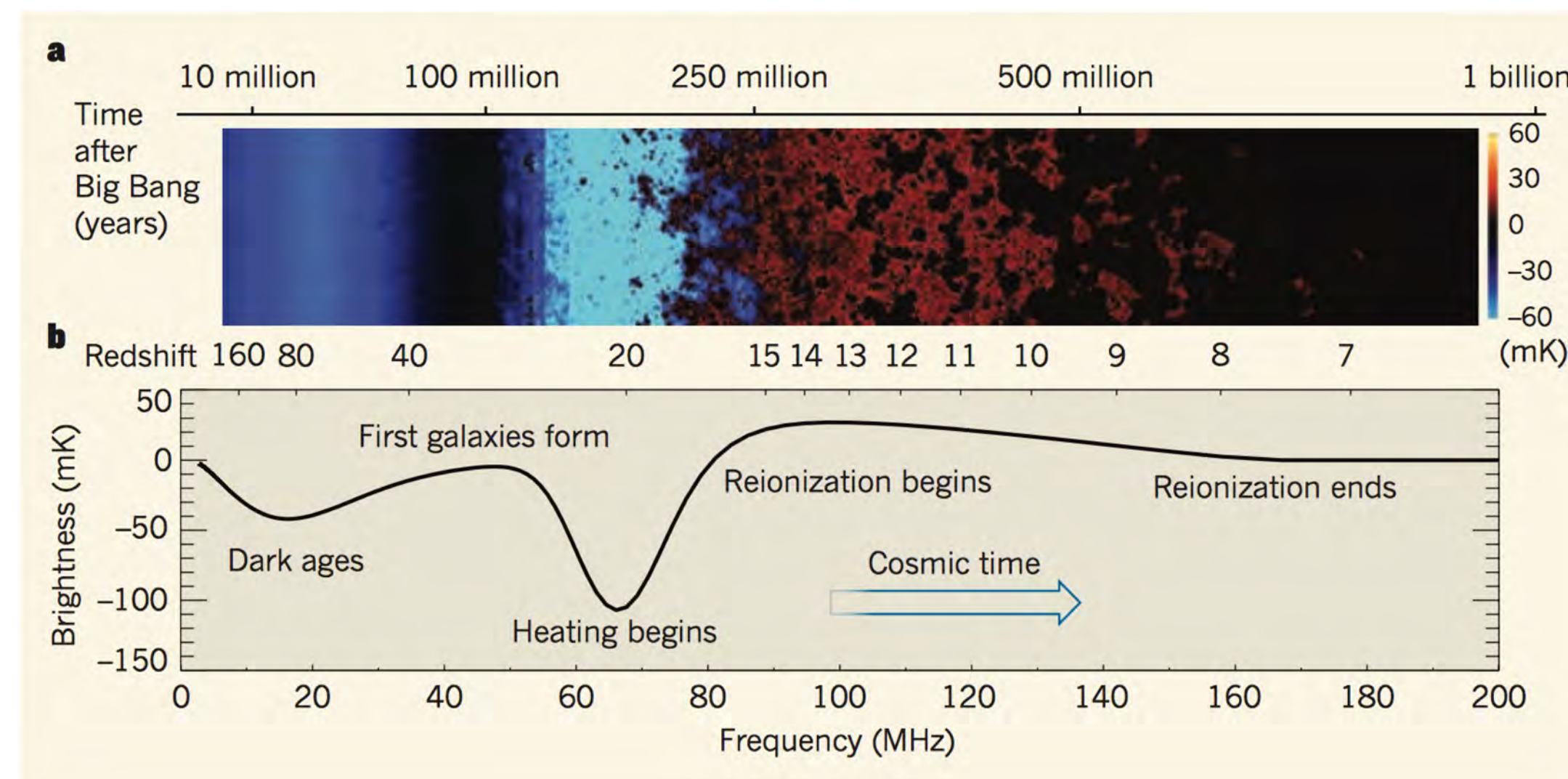


## Theory

When the universe was starting out and the first stars began to form, the first stars were enclosed by intergalactic medium (IGM). Intergalactic medium mainly consists of neutral hydrogen gas. The study of intergalactic medium allows us to study the early universe, which is not completely understood. By measuring the sharp feature in the neutral hydrogen gas' spectrum at a frequency of 1420 MHz or at 21-cm. At this wavelength, the signal has an intensity that is proportional to the brightness temperature of the hydrogen gas producing a signal. When the intensity of the signal at 21-cm is measured at a variety of frequencies, a redshifted signal is procured and this allows us to see the brightness temperature profile over time. By observing the evolution of brightness temperature vs. redshift, information about the first stars is able to be gathered because they cause changes in the intergalactic medium. In certain theoretical models of star formation, a decrease in brightness temperature is predicted at a temperature of 10 mK to 200 mK at a redshift of around 20. Below is a figure that depicts a theoretical model (ref: Pritchard & Loeb, Nature, Dec 2010).



## Importance of Ground Plane & Radials

- A ground plane is a conducting surface that is large compared to the wavelength and it is connected to the transmitter's ground wire and serves as a reflecting surface for radio waves.
- A ground plane must have good conductivity because it dissipates power from the transmitter.
- Radials are used in order to further dissipate the power of the transmitter and are buried in the earth to facilitate with that.

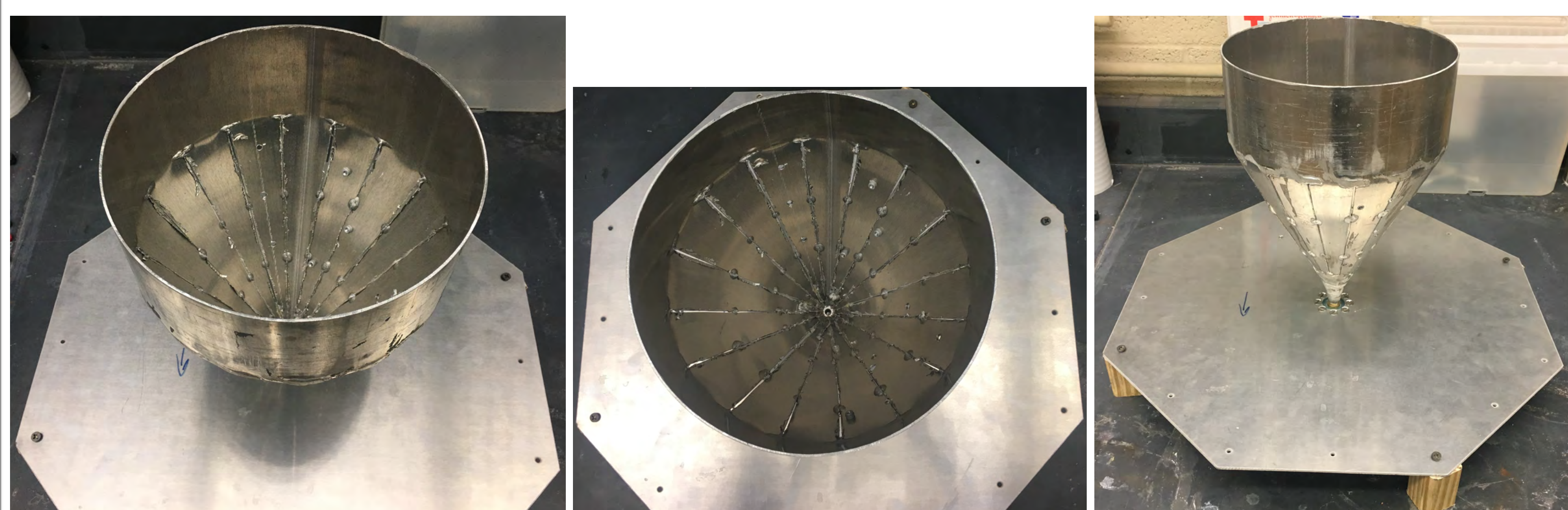
## Ground Plane Properties

- Relative Permittivity: a material's ratio of absolute permittivity (measure of resistance when forming an electric field in a particular medium) relative to permittivity of vacuum of a material.
- Dielectric Loss Tangent: a dielectric material's inherent dissipation of electromagnetic energy (heat).

|                       | $\epsilon_r$ | $\tan \delta$ |
|-----------------------|--------------|---------------|
| Perfect Ground        | 1            | 0             |
| Marshy (Moist) Ground | 25           | .1            |

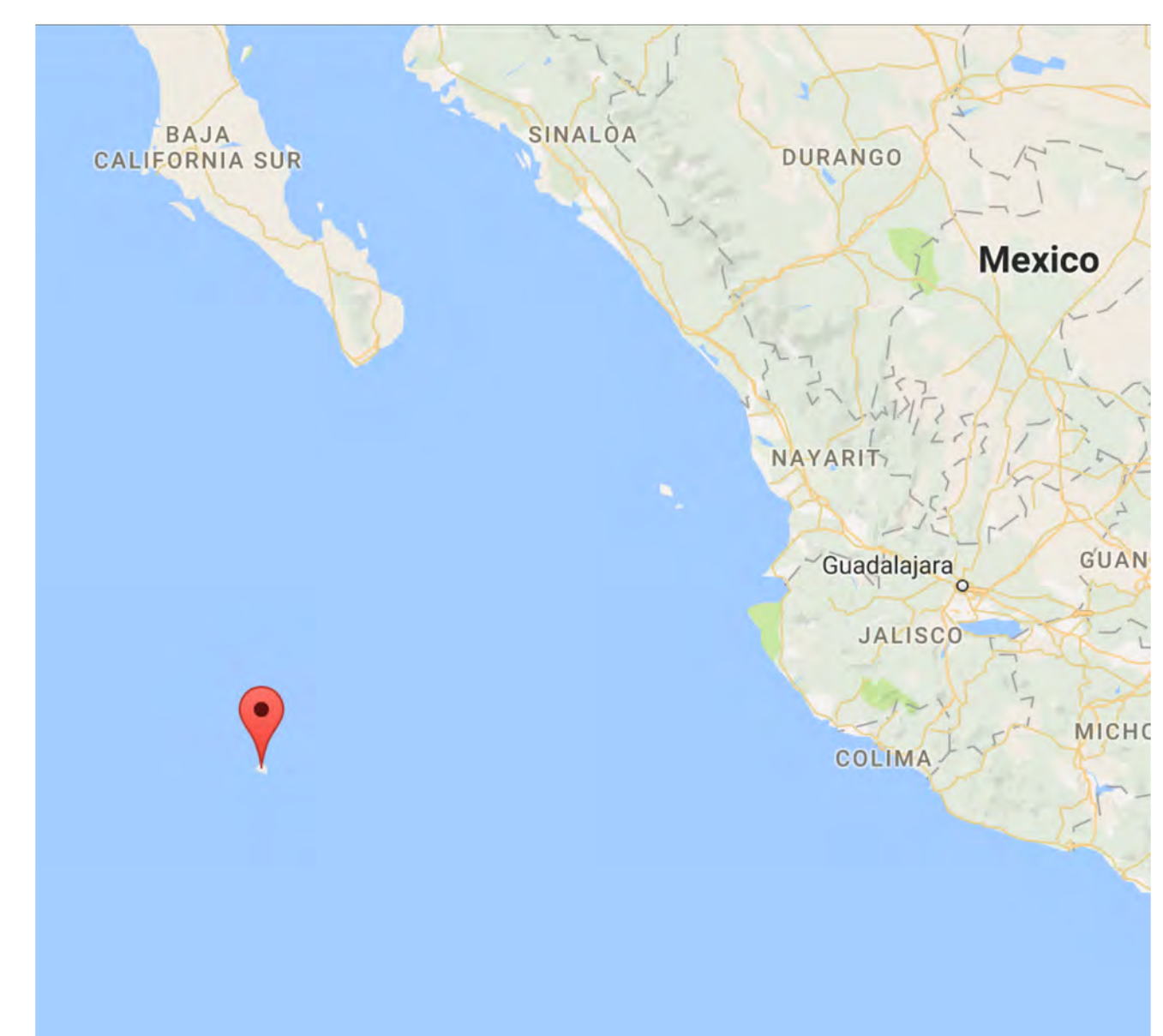
## Short Vertical Antenna

- Metal plate in the shape of an octagon 0.9525 cm off the ground.
- Antenna is connected 1.2 cm above the metal plate.
- Antenna has a total height of 27.94 cm.



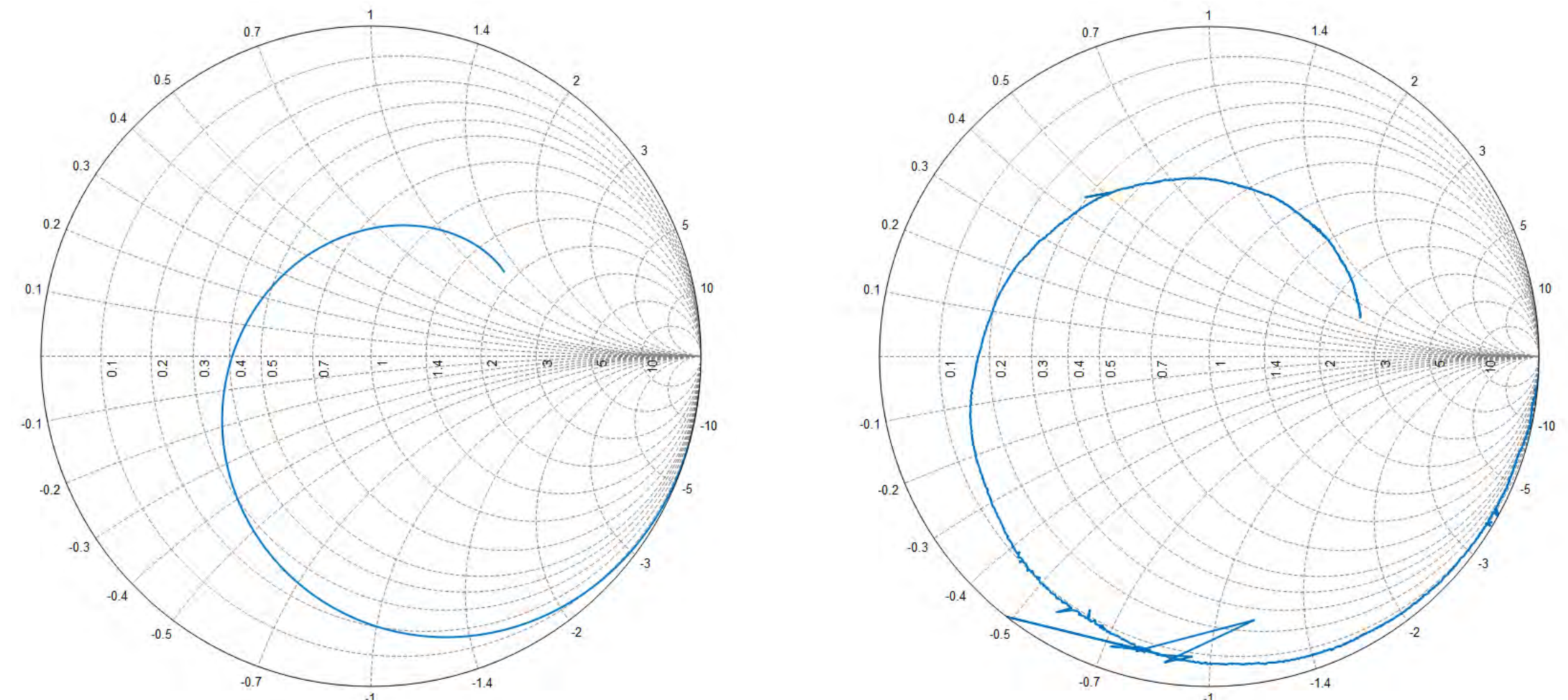
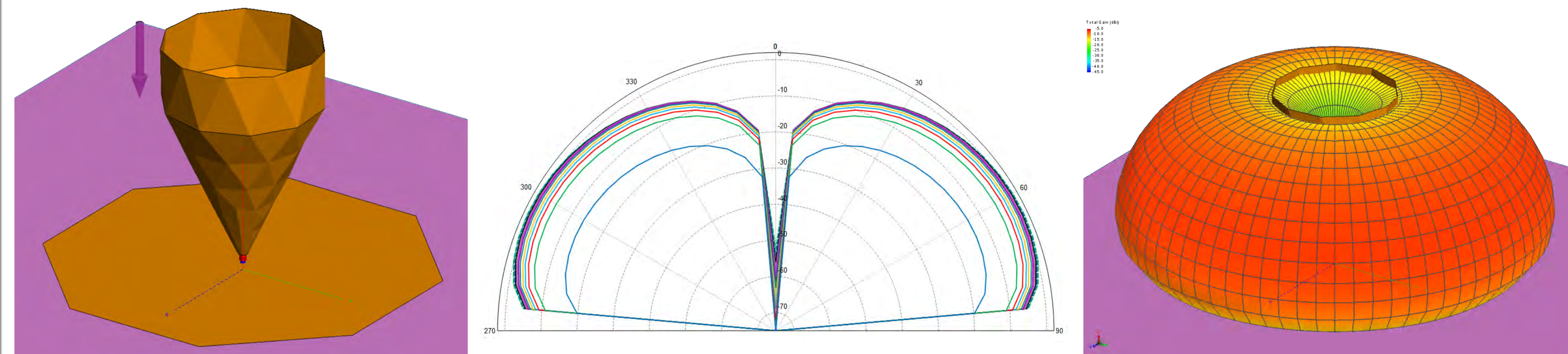
## Experiment Site

- In this frequency range (40 MHz – 250 MHz), there is a lot of radio frequency interference (RFI) from FM radio stations that transmit frequencies at this range.
- Experiments used on this antenna will be conducted at radio-quiet locations such as Isla Socorro, which is around 600 km off the Mexican coast.



## Simulated Antenna

- Short vertical antenna simulated on top of a marshy ground plane.



Measured Results

- Short vertical antenna with 16, 1889.76 cm radials simulated on top of a marshy ground plane.

