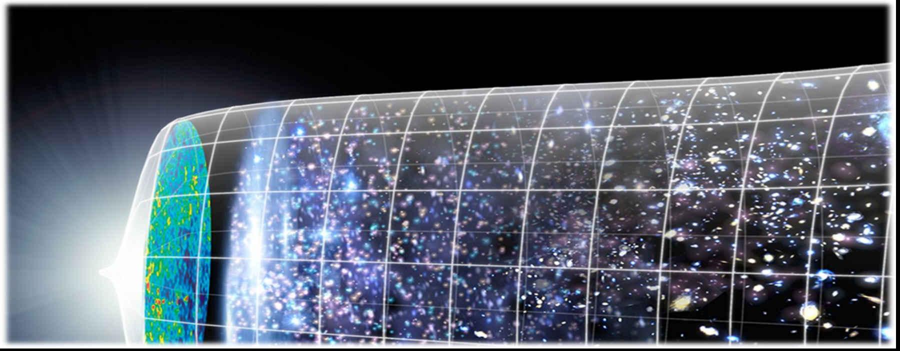

Modeling Planar Dipoles on Lunar Regolith for a Radio Array on the Lunar Far-side.

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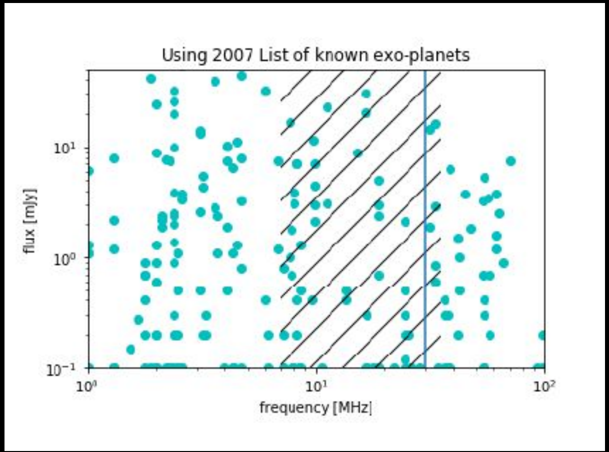
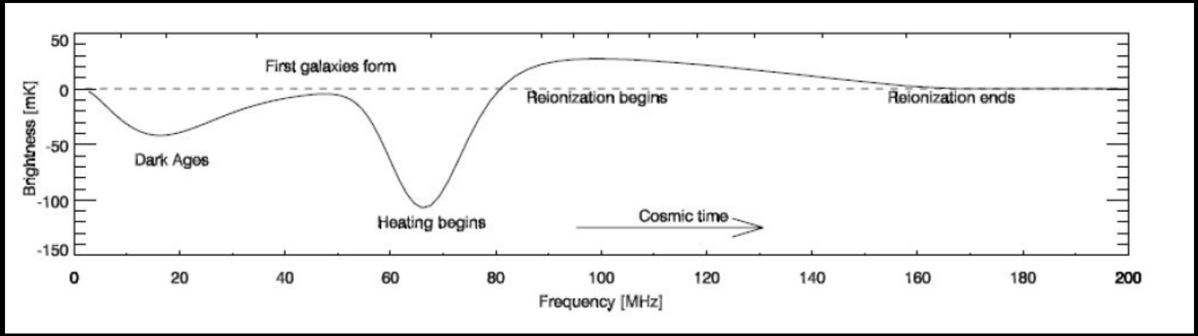
Introduction

Main science goals of FARSIDE:

1) Detection of exoplanet radio emission

2) Probing fundamental physics and cosmology



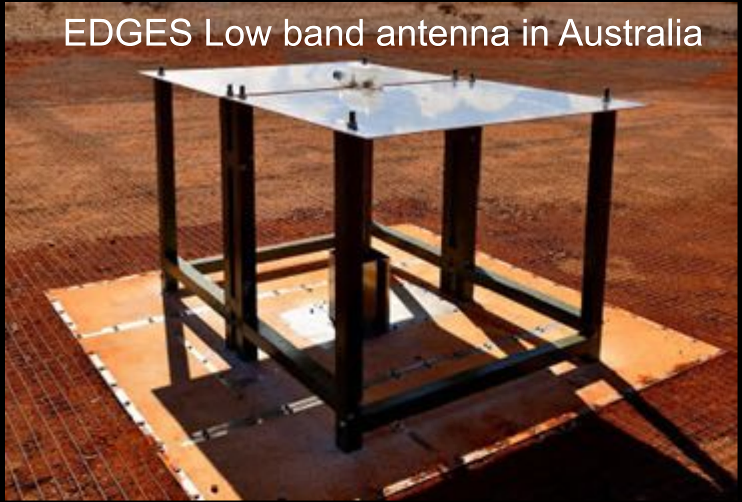


Existing Earth based antennas have to be redesigned:

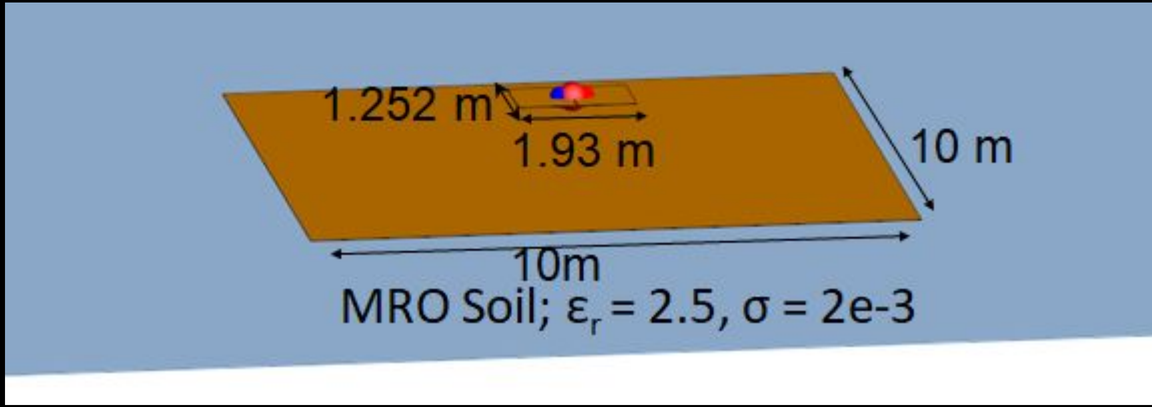
- Increase sensitivity < 30 MHz
- Optimize for the regolith properties
- Lunar environment survival and deployment

Antenna Analysis with EDGES

Start off: well-known antenna - The EDGES blade.
Our Tools: The modeling is accurate - Shown that the simple and well-studied EDGES beam matches observations.

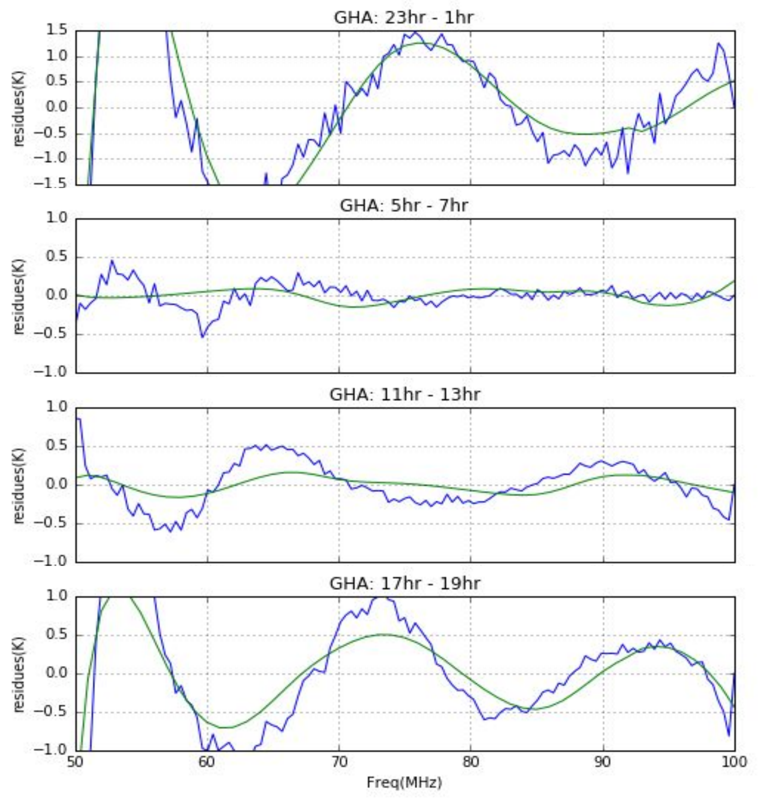


FEKO model of the Blade antenna



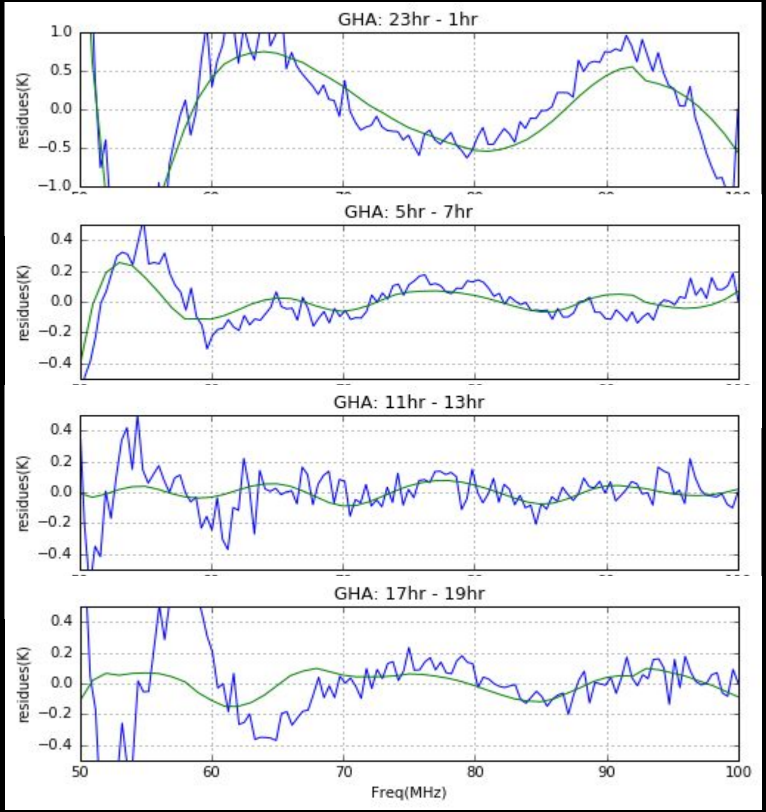
How well we know the EDGES Beam?

Old ground plane beam

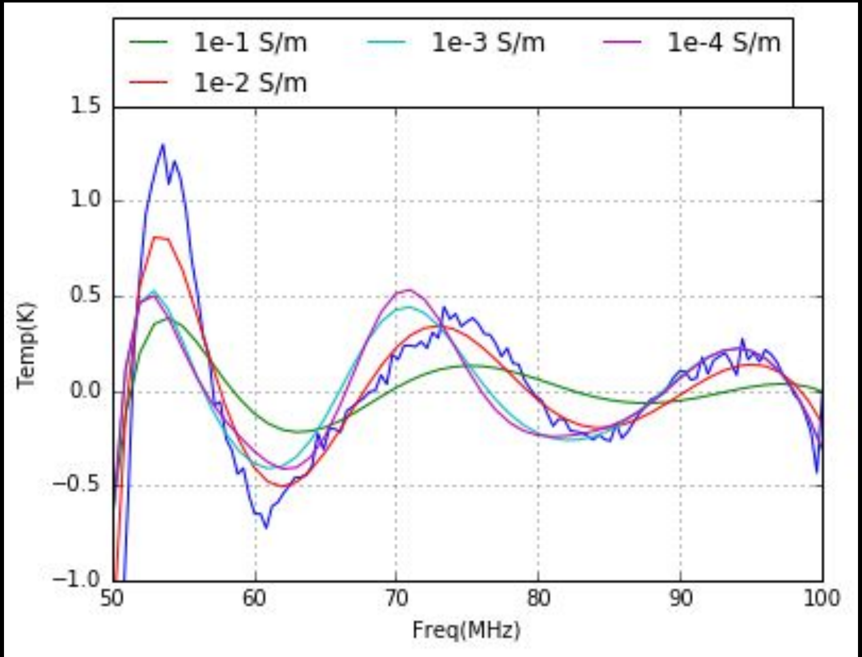


Green - Simulation
Blue - Data

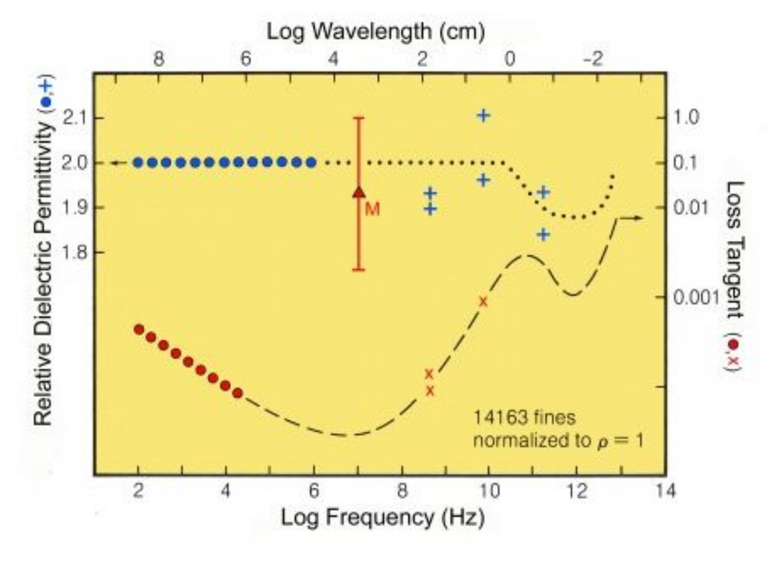
New ground plane beam



Lunar Environment: Soil Characteristics



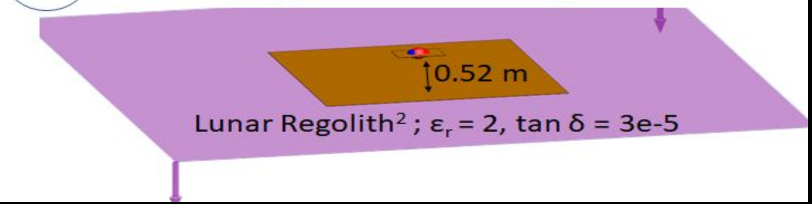
Changes in soil conductivity changes the beam chromaticity therefore changes the structure in the residues



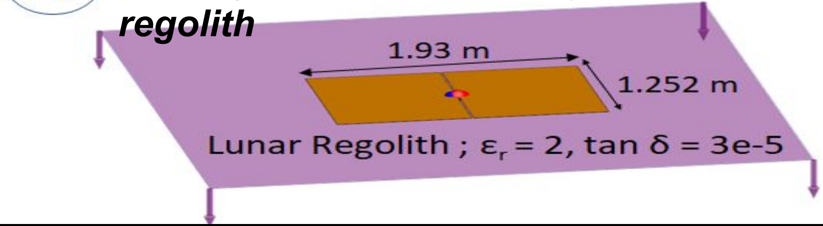
Ref: Lunar and Planetary Institute

Simulation configurations

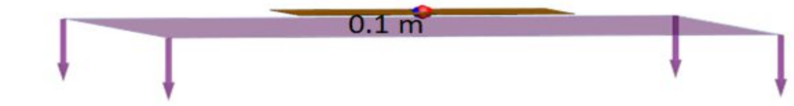
2.) *Soil changed to Lunar regolith*



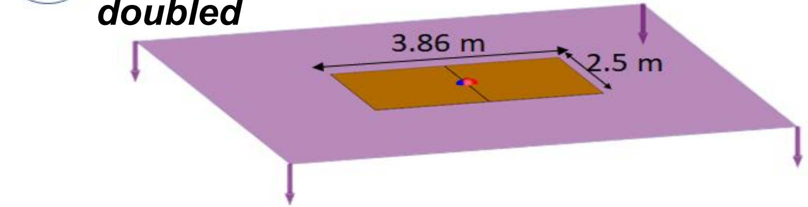
3.) *Placing the blades directly on the regolith*



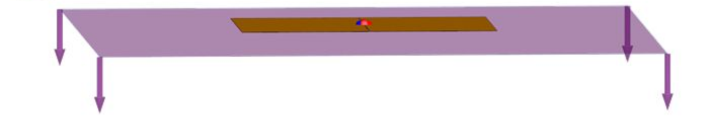
4.) *Placing the blades 10cm above the regolith*



5.) *Same as config 3 but the blade size doubled*



6.) *Same as config 4. but the blade size is doubled*

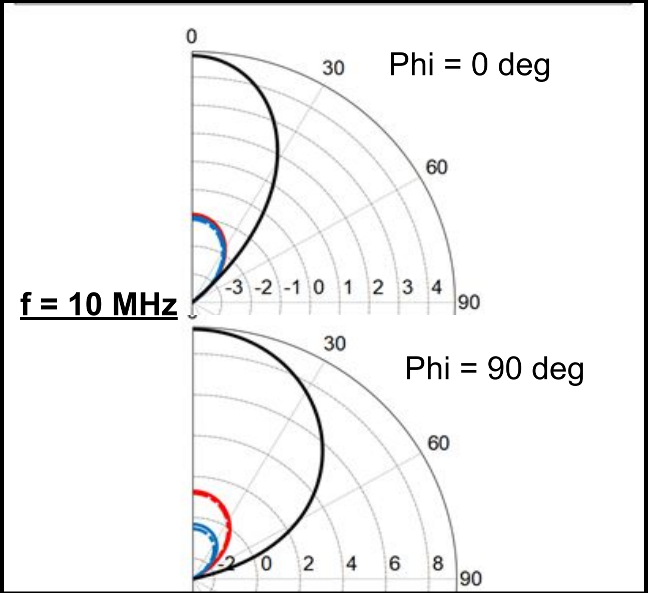


Do we need a ground plane?

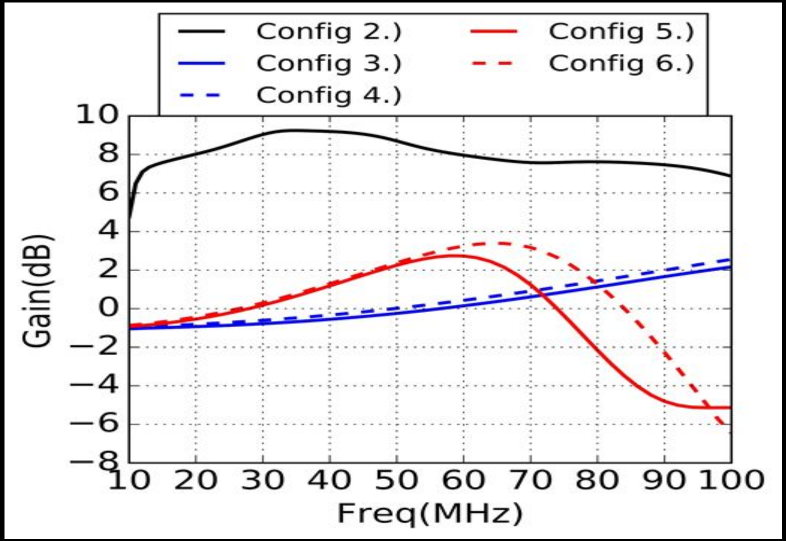
We will answer the question based on 3 characteristics of the antenna:

- Gain & Beam patterns
- Reflection / S11
- Power to the receiver

Beam patterns & Gain



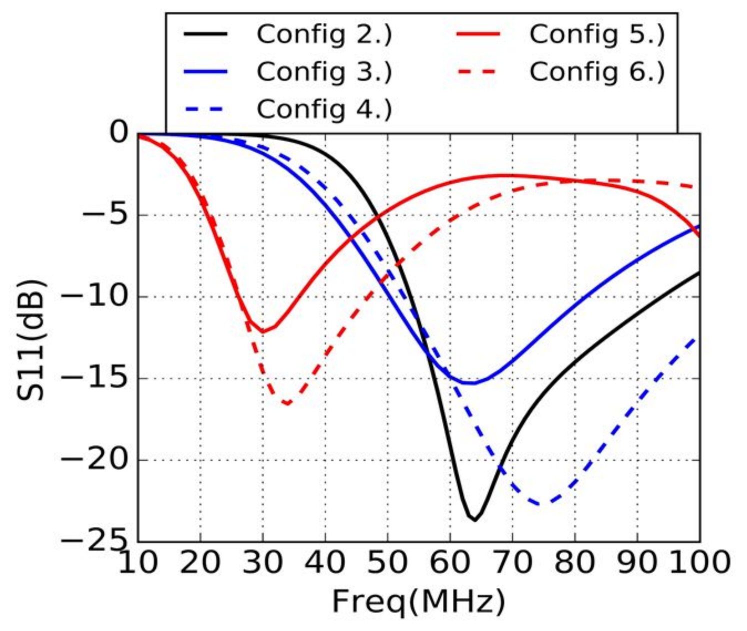
2. EDGES on regolith
3. Blade on Gnd
4. Blade 10 cm above
5. Blade (x2) on Gnd
6. Blade (x2) 10cm up



- The antenna beam is well-behaved and retains the smoothly changing beam pattern in angle & frequency characteristic of a dipole-based antenna, even without a ground plane.
- The gain reduces by ~ 85% without a ground plane. So the maximum is toward the nadir.
- The blade size is doubled to successfully improve the gain in the desired range.

Reflection co-effecients

2. EDGES on regolith
3. Blade on Gnd
4. Blade 10 cm above
5. Blade (x2) on Gnd
6. Blade (x2) 10 cm above



S11 referenced to 50 ohms.

- At low Frequencies, the S11 improves for the no ground plane cases compared to Config 2.)
- Simulations with the antenna blades 10cm above the regolith have a larger band-width where S11 < -10dB. (solid curves vs dashed curves)
- The cases of increased blade size result in better match at lower frequencies; 10-45 MHz (red curves Vs blue curves)

Power to the receiver

Using the Gain & S11 (w.r.t 50 ohm),
we calculate how much power reaches the receiver for each of the 6 configurations.

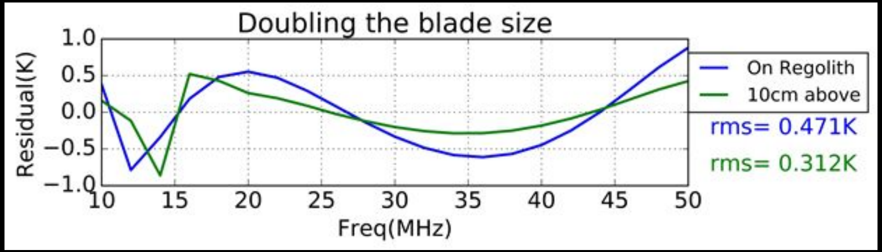
Total Noise power ~ 250 K

Configs	dT_{ant} due to sky @ 10 MHz [K]	dT_{ant} due to sky @ 40 MHz [K]
EDGES at MRO	214.5	1290
EDGES on regolith	112.5	1123
Blade on Gnd	49.4	559
Blade 10 cm above	97.1	629
Blade (x2) on Gnd	1651	1030
Blade (x2) 10 cm above	1423	1188

- The 2x scaled versions of the antenna are needed to achieve a SNR >1 at 10 MHz.

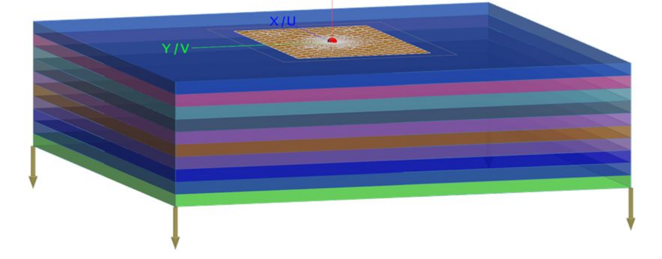
Beam Chromaticity Analysis

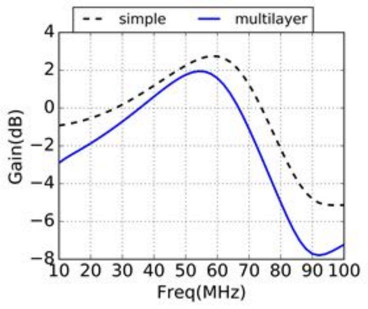
Generated simulated spectra by convolving the beam with Haslam sky map

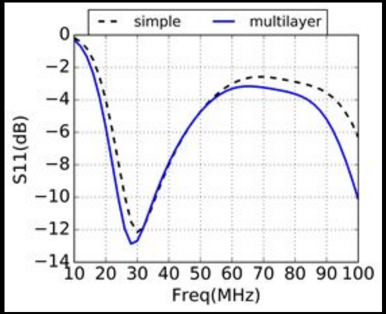


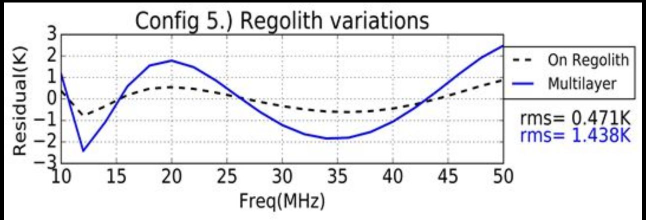
- The simulations with the original blade size (configs 3&4) produce the lowest spectral structure.
- The model with the ground plane has the largest spectral variations.
- Raising the blades from the regolith surface reduces the chromaticity slightly.

Varying the regolith properties









- The gain reduces.
- The antenna efficiency decreases
- The chromaticity increases

Configs.	dT_{ant} from sky @ 10 MHz [K]	dT_{ant} from sky @ 40 MHz [K]
Simple	1651	1030
Multilayer	1381	862.3

Summary

- No need to include a ground plane.
- The blade size needs to be twice the size of EDGES low-band antenna to achieve sky-noise dominated performance at 10 MHz.

<u>What's Next?</u>

- Will model the current FARSIDE antenna design (Dual Polarized Dipoles)
- Will use High impedance reference in calculation and characterization
- Simulations of detailed frequency dependent Regolith properties
- Analysis of simulated spectra was done assuming Antenna was placed on Earth
- Building a prototype to make validation measurements.

<u>Tasks Proposed</u>

- Correlator Schemes
- Sensitivity analysis for the two science cases