

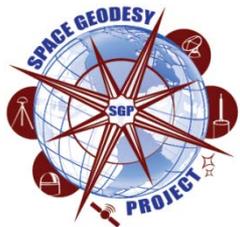
Space Geodesy Project (SGP) Colocation considerations and Radio Frequency Interference (RFI) Mitigation Techniques

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Space Geodesy Project (SGP)

- Modeling the GGAO environment and VLBI2010 susceptibility before & after the trees came down
- Measuring the DORIS Beacon, and the NGS LR radars in South , radar masks & DORIS path loss provide mitigation
- Measuring 12m side lobes with a standard gain horn simulator $\geq 100\text{m}$ away
- Mitigate RFI with masks, filtering, and shielding

RF Compatibility Methodology

Measurement of Transmitter Radiation Properties

MOBLAS 7 Summary

Location	Expected Power (+/- 2 dB)	Measured Power			
		No Obstruction	Radome	Railings	Radome-Railings
Loc #2	-4.1 dBm	-4.9 dBm	-7.0		-0.7
GODE W	-1.0 dBm	-0.8 dBm	-5.9	8.1	2.4

NGSLR Summary

Location	Expected Power (+/- 2 dB)	Measured Power	
		No Obstruction	Radome
Loc #2	-3.0 dBm	-3.6 dBm	-0.7

DORIS Summary

Location	Expected Power	Measured Power
DORIS Pad	-1.3 dBm	-1 dBm
Observatory Pad	-29.5 dBm	-27.6 dBm

- DORIS and SLR radar power levels were measured using S and X-band standard gain horn antennas
- SLR Radar Power Level Measurement Memo:

http://www.haystack.mit.edu/geo/vlbi_td/BBDev/o37.pdf



High pass filter in current configuration of GGAO VLBI front end



- New configuration will adapt gain and filtering to low end of the band

- Prior to use of pre amp filter
- Isolated S-band harmonic distortion generation to a stage between the LNA and the fiber



12 Meter side lobe characterization at GGAO

antenna gain vs. angle between 12-m boresight and transmitter. The data have been binned by angle into 40 bins equispaced in $\log(\text{angle})$.

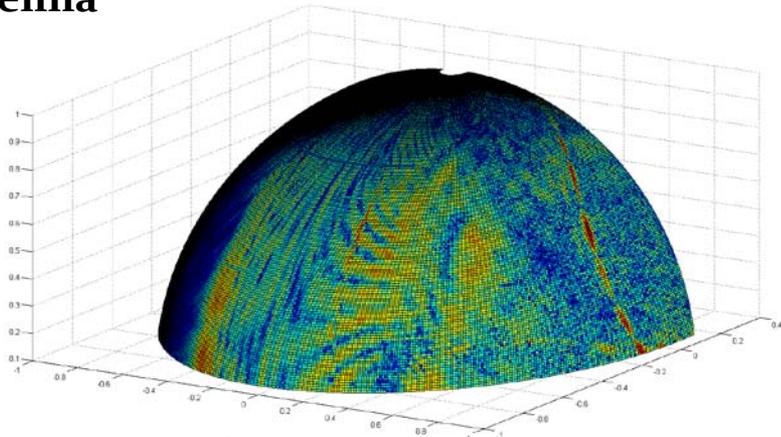
The 4 "curves" are

red 100th percentile in each bin (i.e., max gain)

green 90th percentile

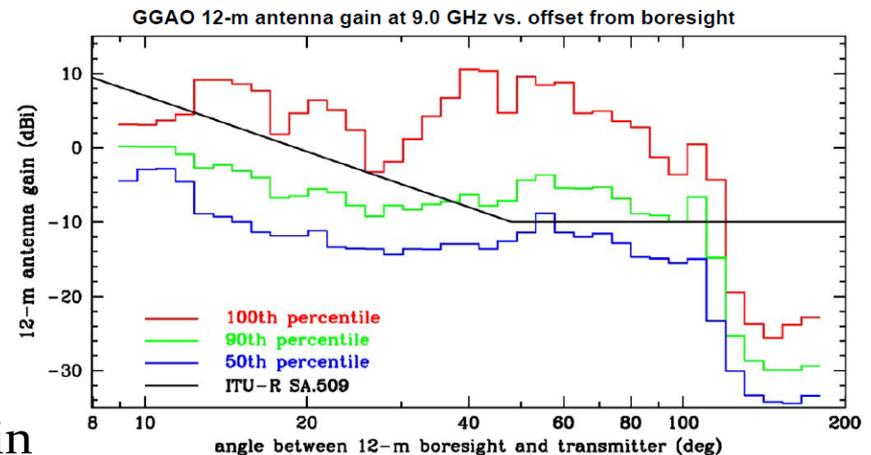
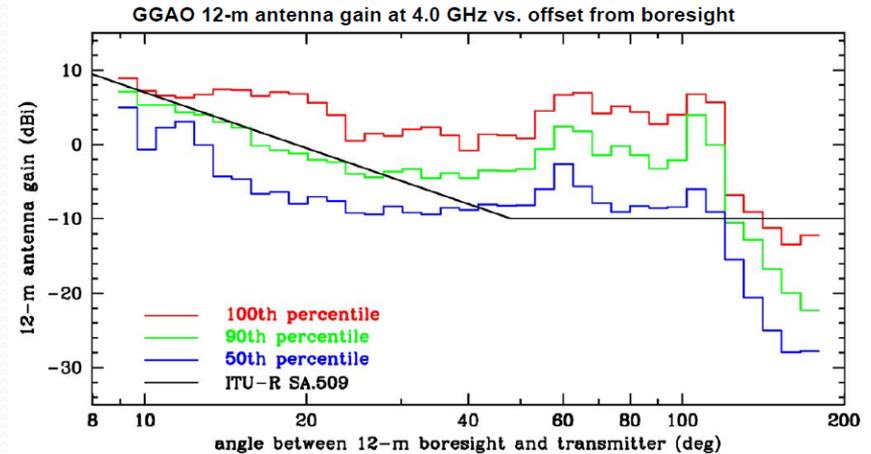
blue 50th percentile (i.e., median gain)

black ITU-R SA.509 standard for the 90th percentile of the far-field gain of a large antenna

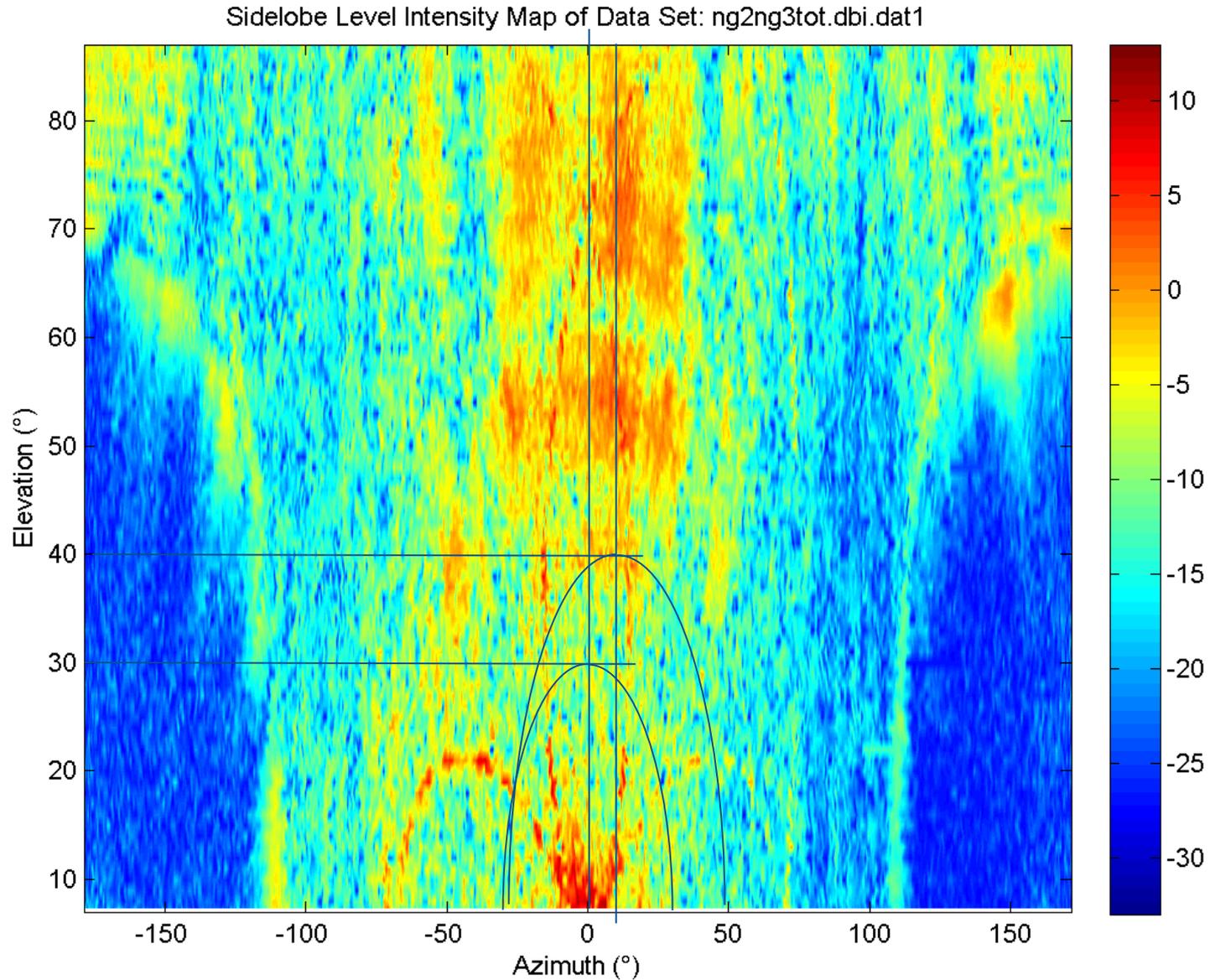


12 m Sidelobe views it peripherally in the North

Beacon in the East



Sidelobe Measurement of 12 meter antenna - with beacon deployed near NGSLR LHRS phase center



Comparison to ANSI sidelobe envelope

ng2ng3tot.dbi.dat1: 9 GHz, V/V, NGSLR site

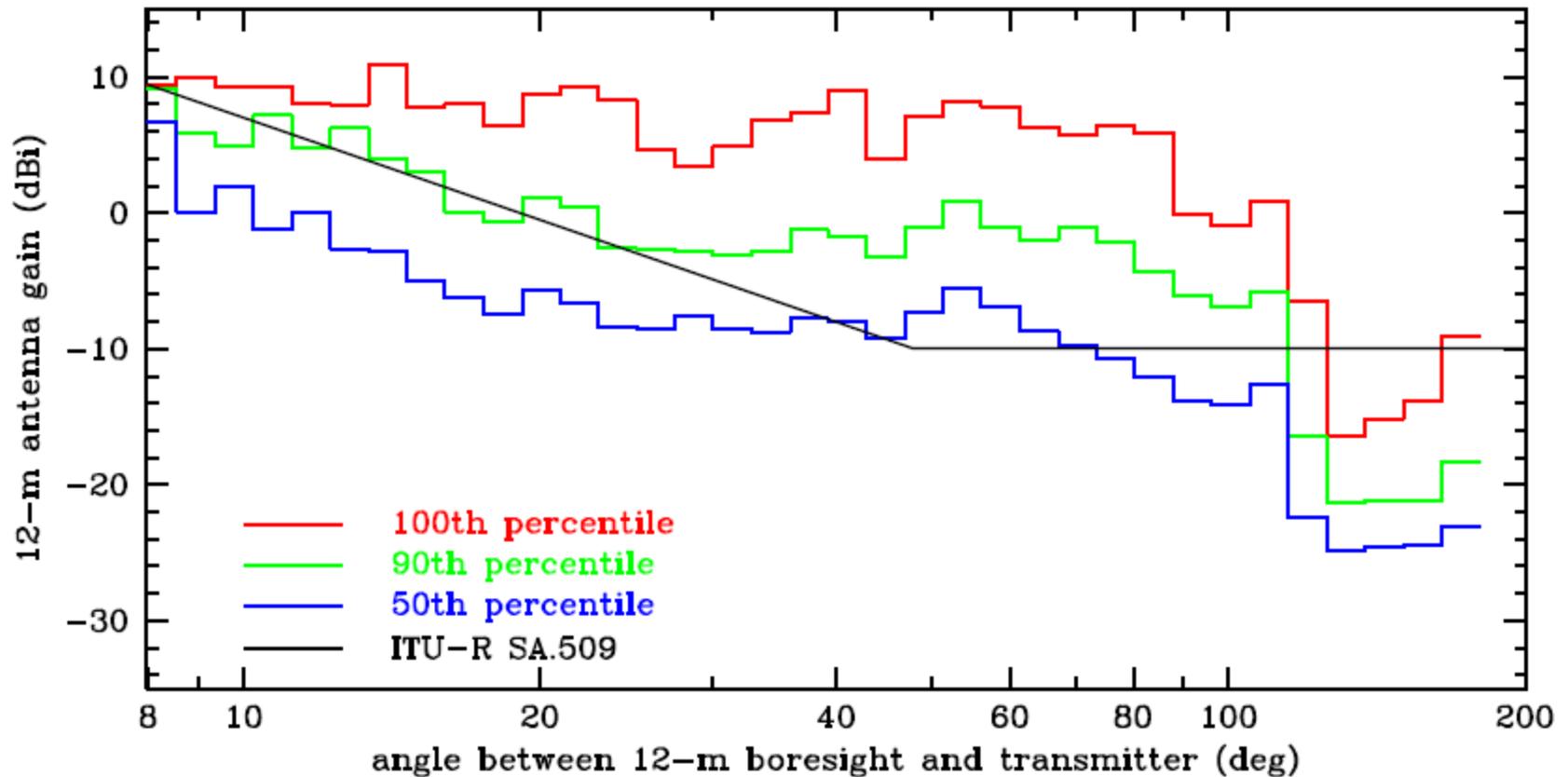
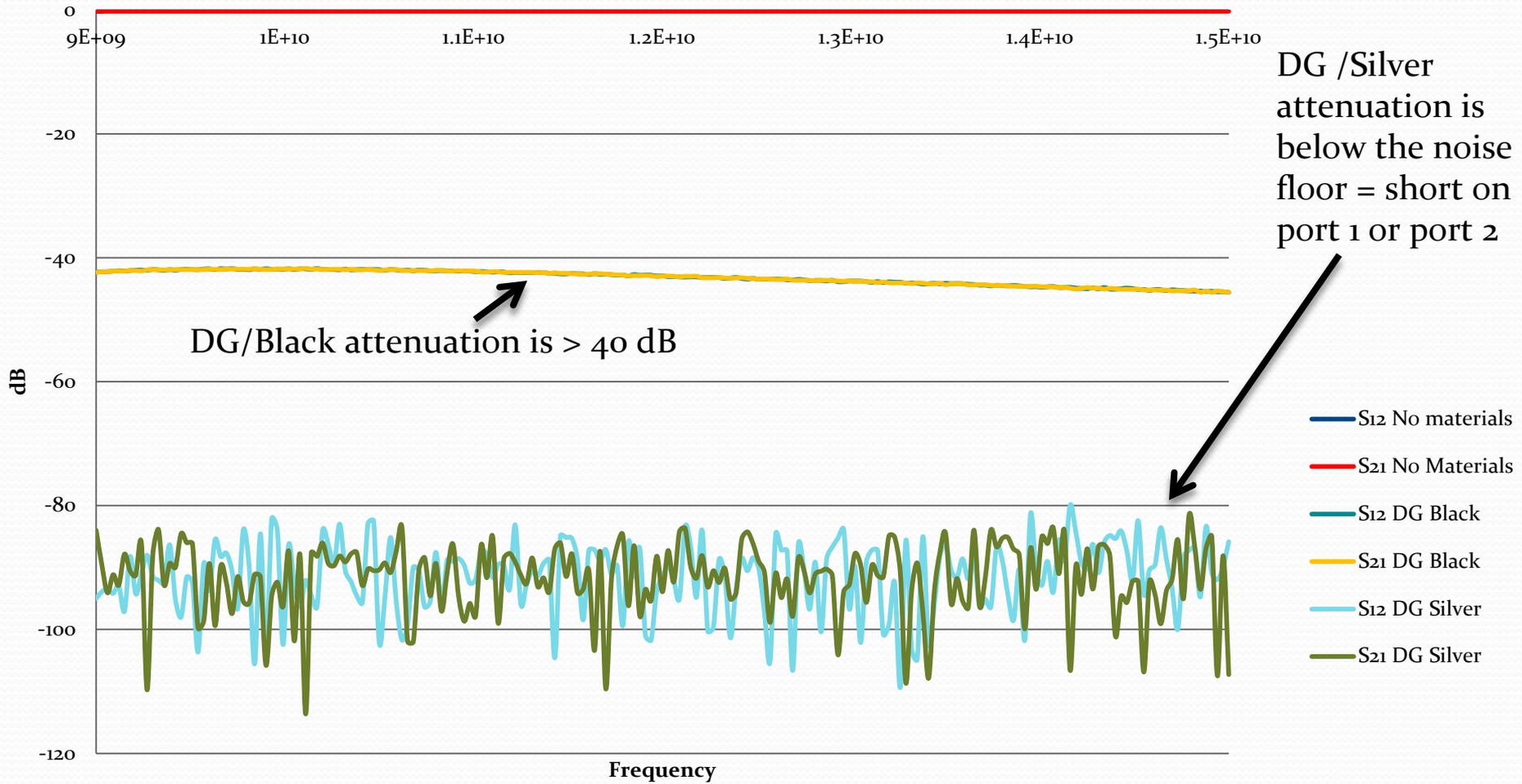


Figure 1: ITU-5009 antenna sidelobe envelope model incorporated in numerical RFI-compatibility studies.

Absorber/reflector Material Evaluation: X-band

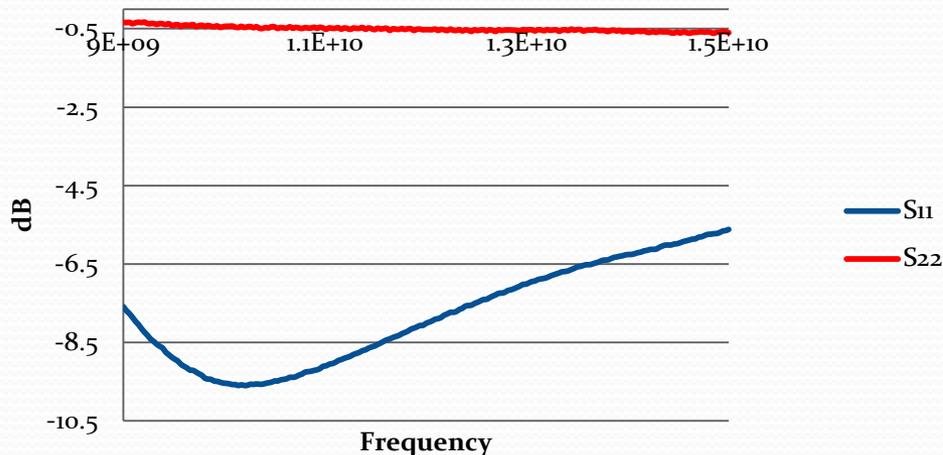
Transfer Coefficients (Absorber/reflector Combinations)



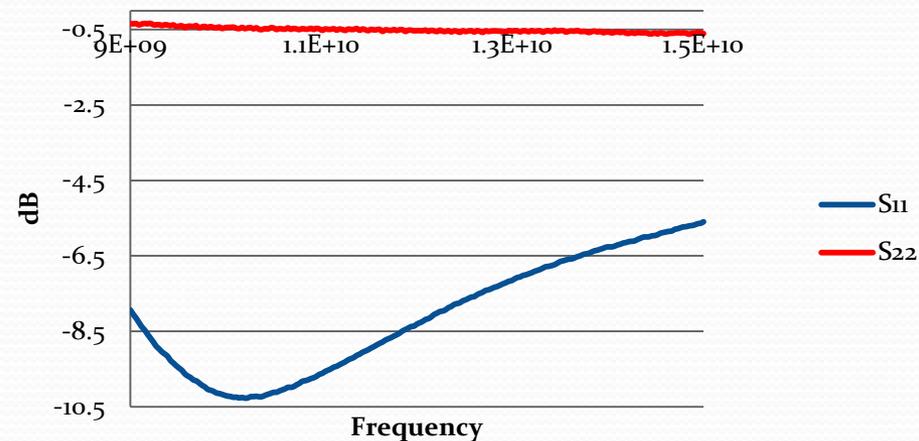
S11 & S22 Comparison of thin Reflector materials

- S11 & S22 Comparison of AL100 (Silver) and Laminated MW Absorber (Black):
 - P1: Absorber (EC SF-9.5)
 - P2: Reflector

Amplitude-Dark Gray absorber
Black Reflector

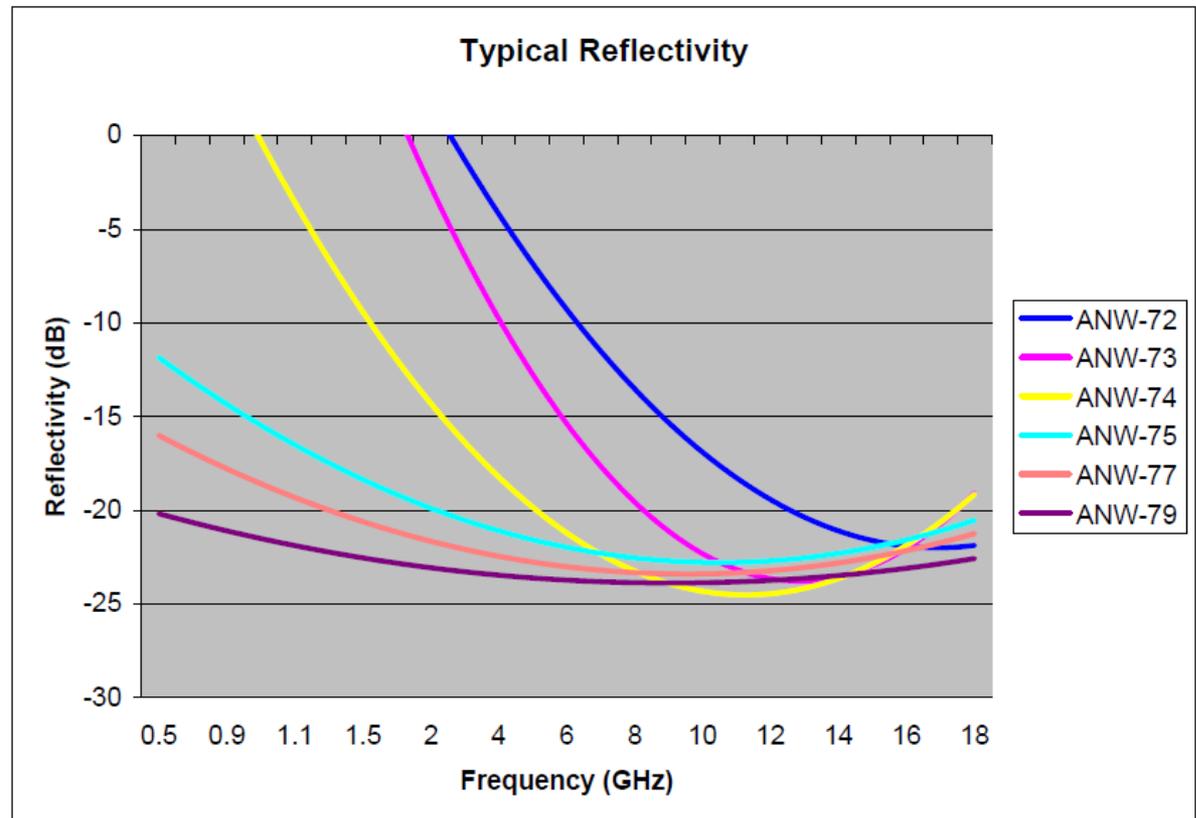


Amplitude- Dark Gray absorber
Silver Reflector



ANW-75 absorber material characteristics

- ANW-75
 - Reflectivity range (>20 dB) >2.4 GHz
 - Thickness: 2.9 cm
 - Weight: 0.80 kg/piece
 - Density: 0.07 g/cm³



Configuration for Radar Shield experiments

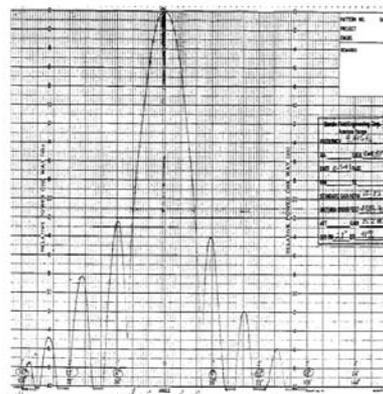
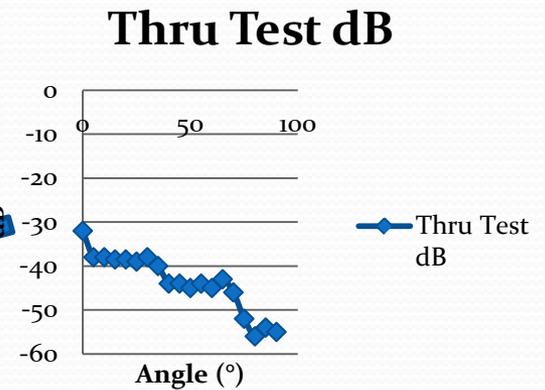
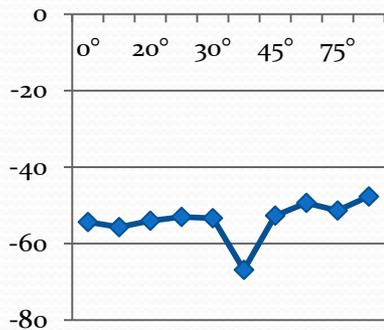


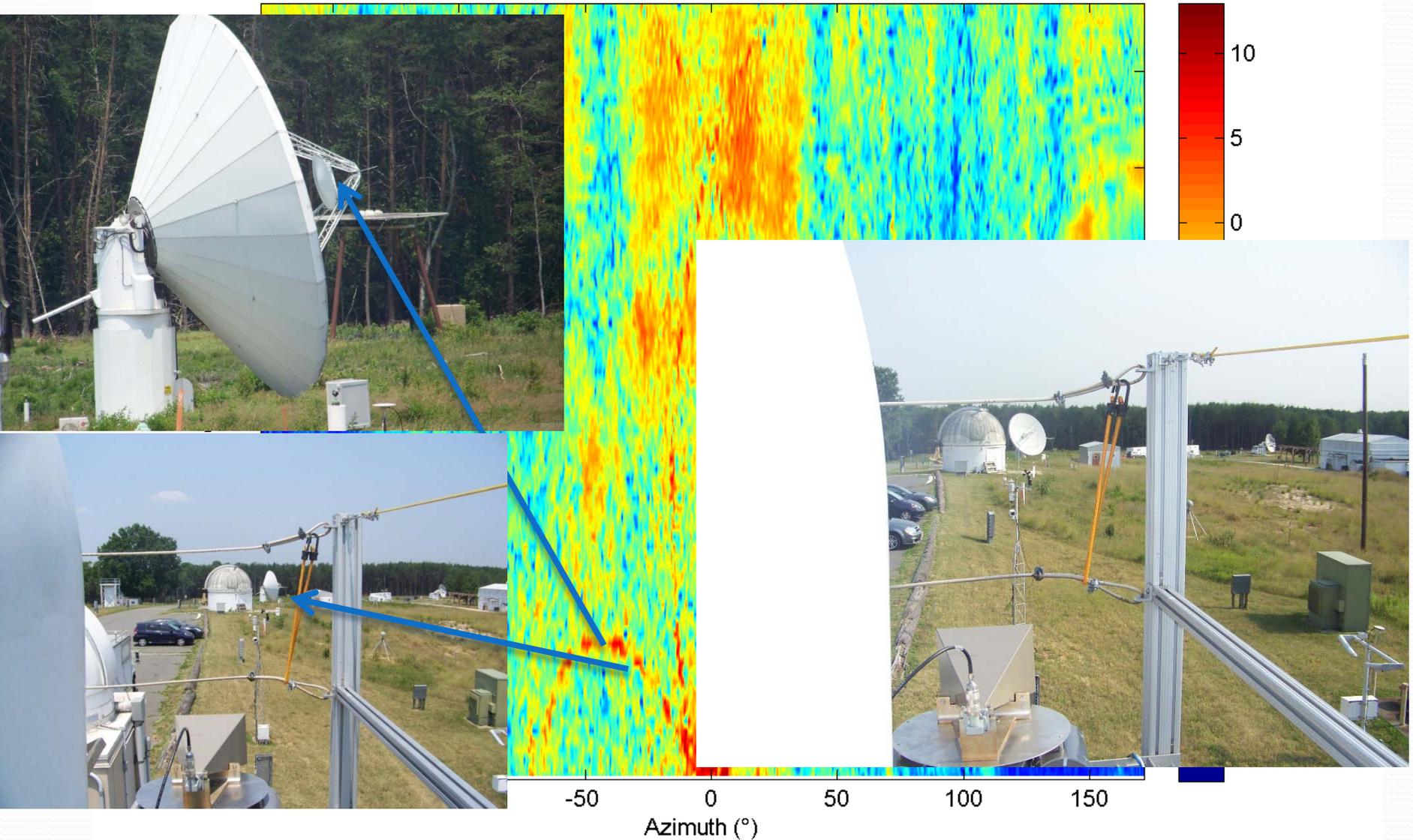
Figure 16. Antenna E-Plane Pattern



- From preliminary ground tests the best combination of attenuation and back reflection is at 35°

Sidelobe Measurement of 12 meter antenna - with beacon deployed near NGSLR LHRS phase center

Sidelobe Level Intensity Map of Data Set: ng2ng3tot.dbi.dat1

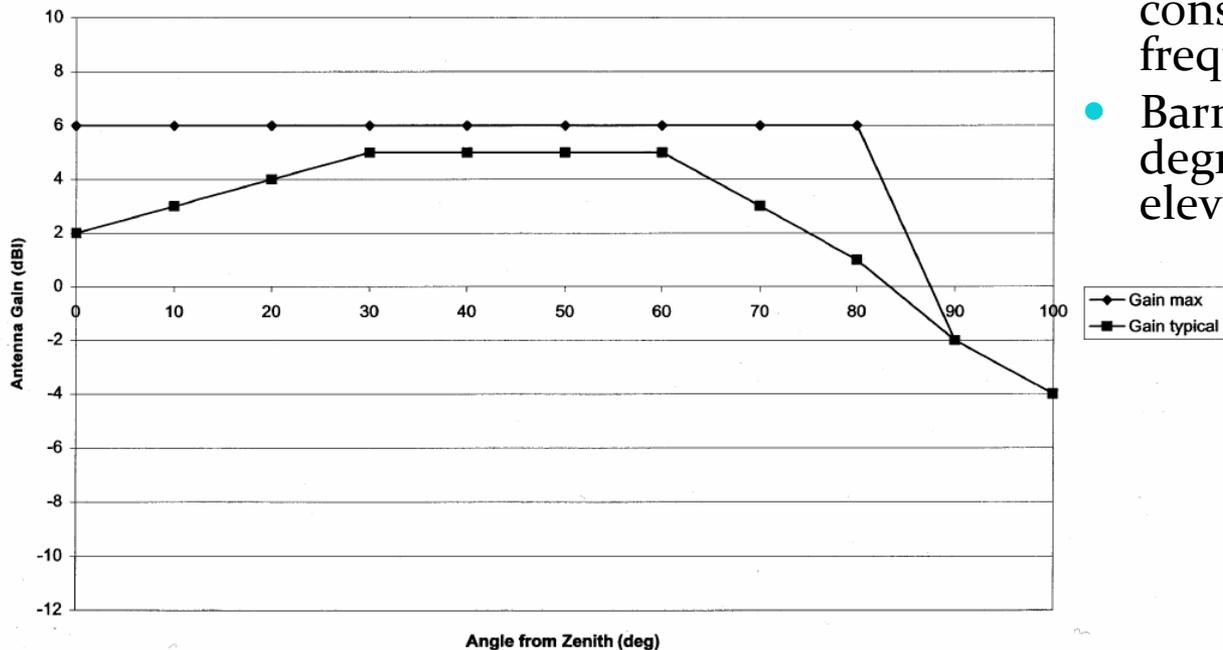


Radar absorber/reflector barrier design and test – Mob7 radar platform



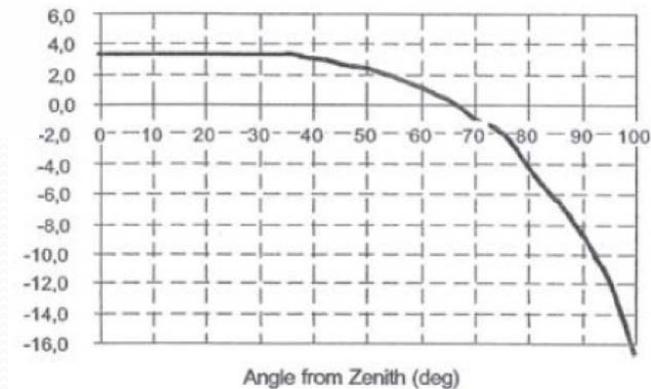
DORIS beacon characteristics

Antenna Gain - 2GHz Channel



- DORIS barrier must be considered for two frequencies
- Barriers modeled for 6 degrees in azimuth and elevation

Antenna Gain - 400 MHz Channel



S-Band (DORIS frequency) shielding effectiveness

• <http://www.feko.info/>

- Physical Optics and Uniform Theory of Diffraction

• at 5m, the linear dimension of the square barrier was

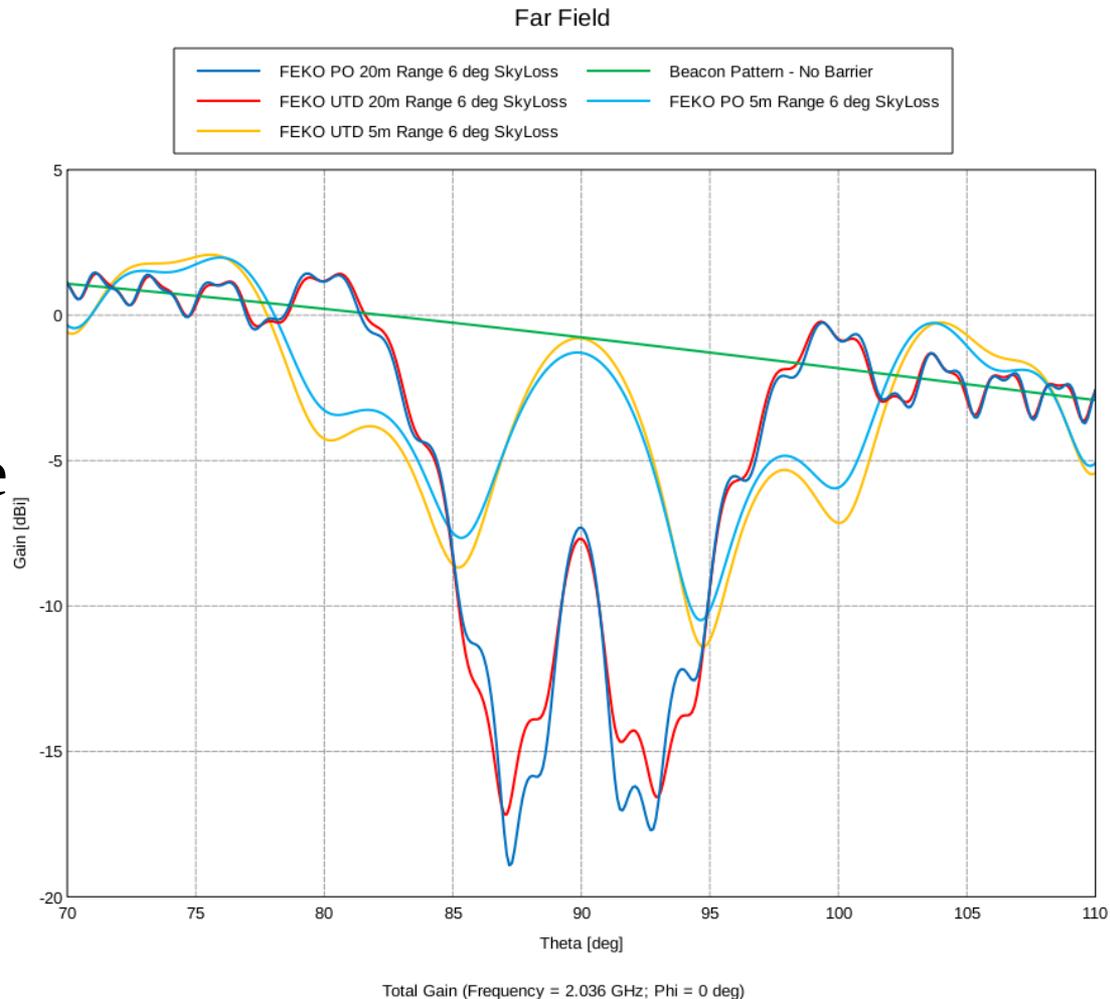
$$2 * 5 * \tan(6\text{deg})$$

- 1 meter

• 20m the square barrier was

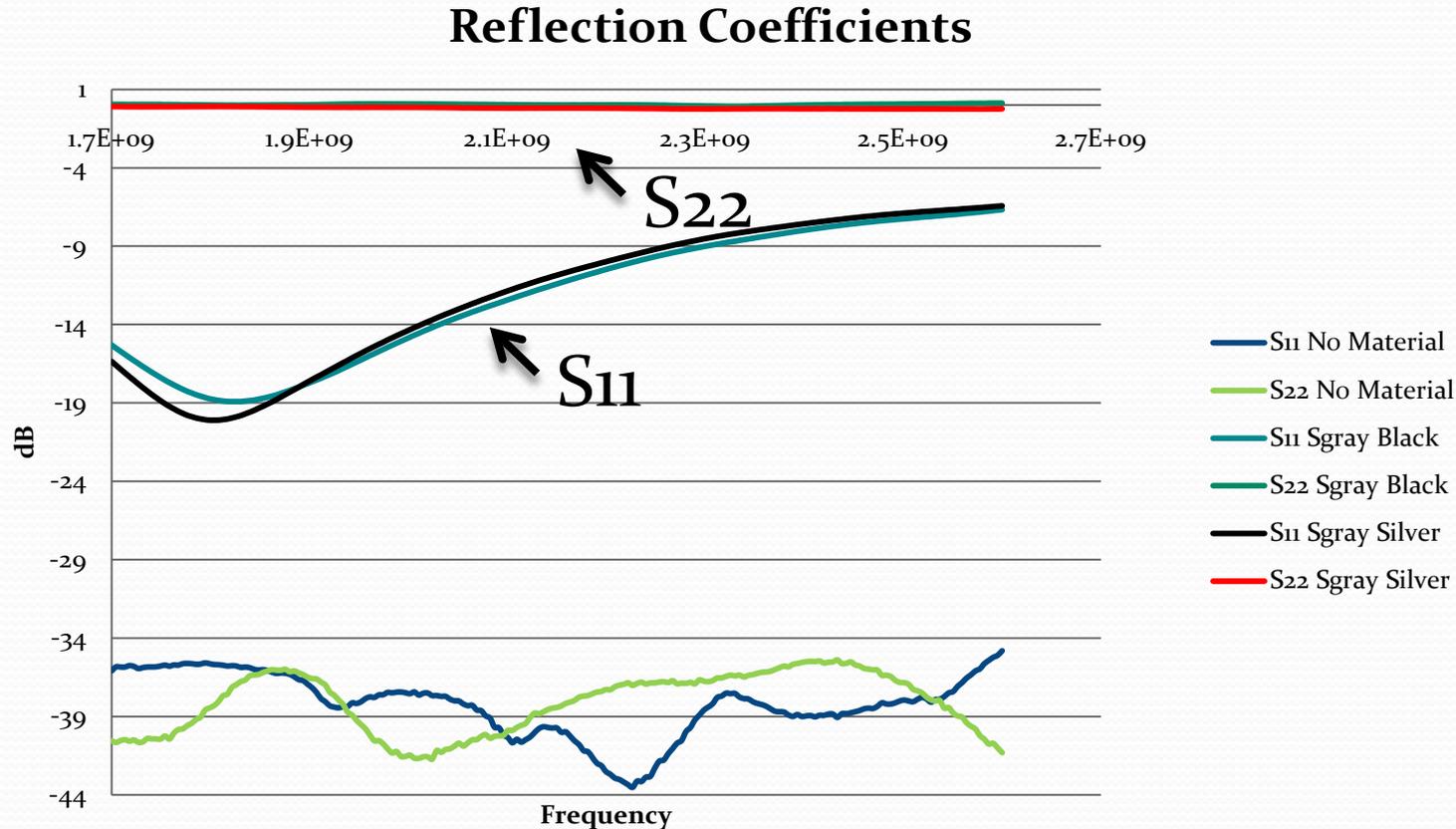
$$2 * 20 * \tan(6\text{deg}).$$

- 4 meters



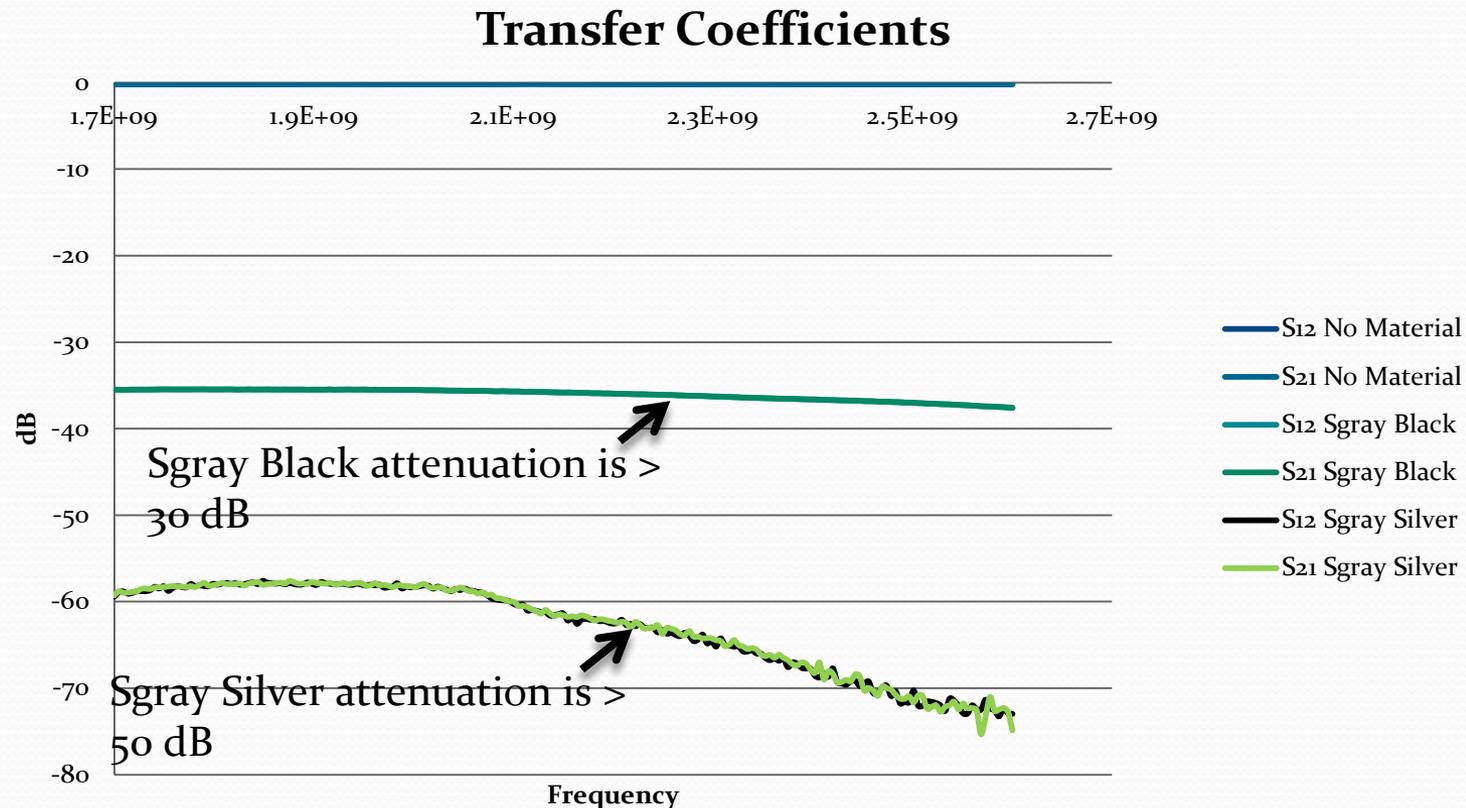
Material Analysis: S-band

- Eccosorb SF-2.0
- Thicker material wedged between waveguide launchers
- 4" x 4" sample



Material Evaluation: S-band

- Eccosorb SF-2.0
- Thicker material wedged between waveguide launchers
- 4" X 4" sample



Tradeoffs to RFI Mitigation Techniques

Technique	Current Implementation	Current results/limitations	Next steps
Masking	MOBLAS 7/ 20 ⁰ NGSLR / 30 ⁰ VLBI/ 40 ⁰ and 30 ⁰	May 16 th geodetic test lost targets due to mask	Masks will be removed when absorber/reflector go up
Filtering	3.9 GHz highpass filter immediately preceding the fiber transmitter	Broadband system cannot form baselines with legacy S-band channels	Combination of high pass filter and isolation w/ tailored dynamic range . Notch at 9.41 GHz under consideration
Shielding	Radars are blocked by GGAO buildings	Radar platform guard rail occupies space. Metal guardrails re- resonate	Deliberate shielding must control back reflection
Absorbing	No absorber currently deployed		Cover guard rails
Shielding/ Absorbing		Further experiments necessary. 35 degree above horizontal experiment – must be all - weather	