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

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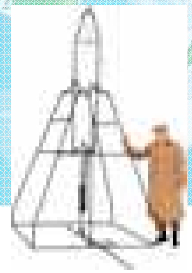


SPACE GEODESY PROJECT SGP

International Laser Ranging Service

IDS

HAYSTACK OBSERVATORY

www.nrc-cnrc.gc.ca

Canada

NASA

Space Geodesy Project (SGP)

- Modeling the GGAO environment and VLBI2010 susceptibility before & after the trees came down
- Measuring the DORIS Beacon, and the NGSLR radars in South , radar masks & DORIS path loss provide mitigation
- Measuring 12m side lobes with a standard gain horn simulator ≥100m 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
GODEW	-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/037.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

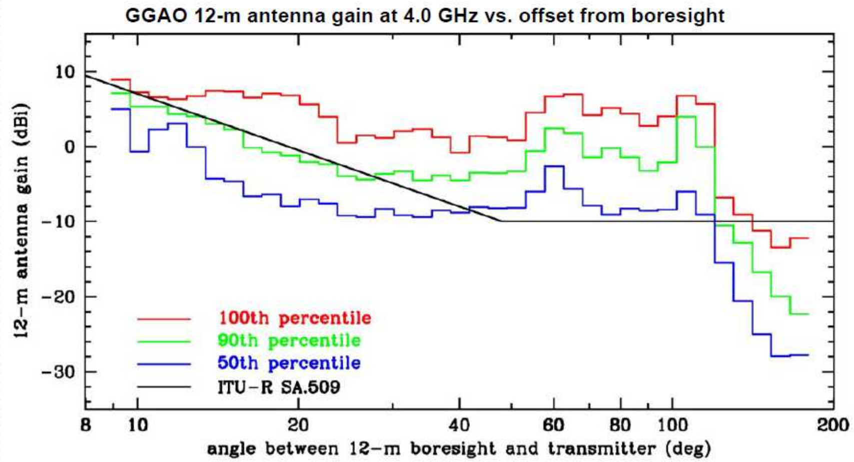
antenna gain vs. angle between 12-m boresight and transmitter. The data have been binned by angle into 40 bins equispaced in log(angle). The 4 "curves" are

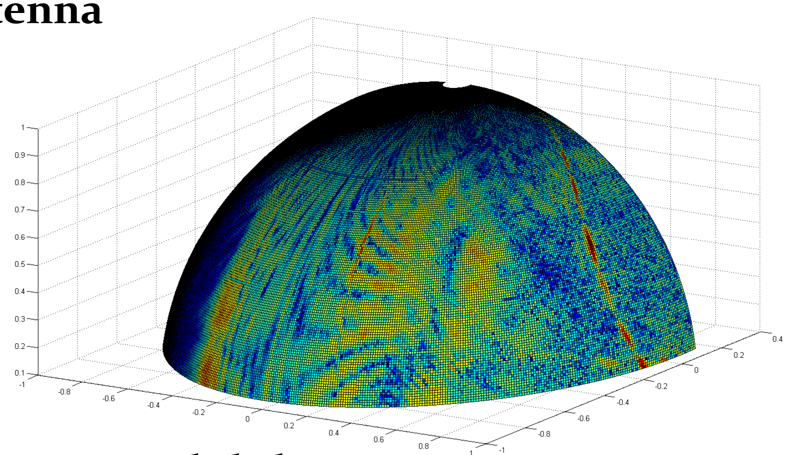
red 100th percentile in each bin (i.e., max gain)

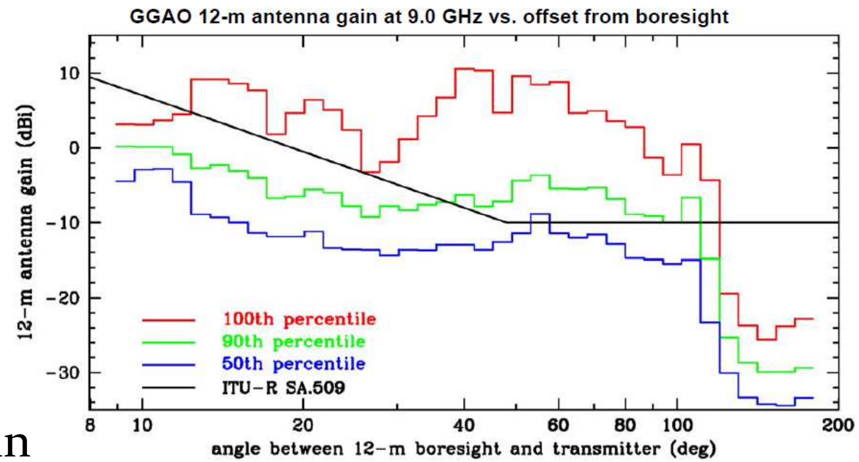
green 90th percentile

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



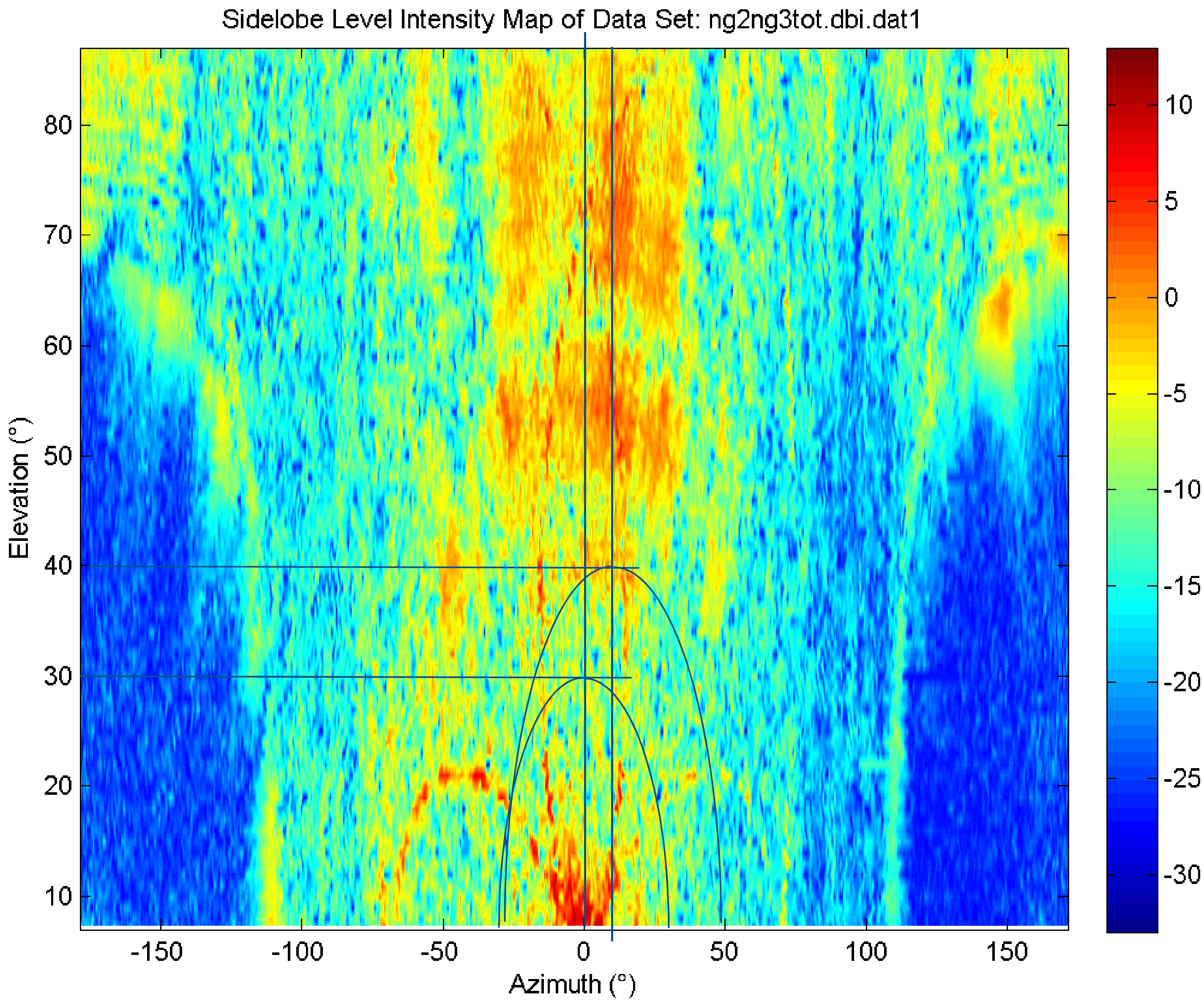




12 m Sidelobe views it peripherally in the North

Beacon in the East

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



Comparison to ANSI sidelobe envelope

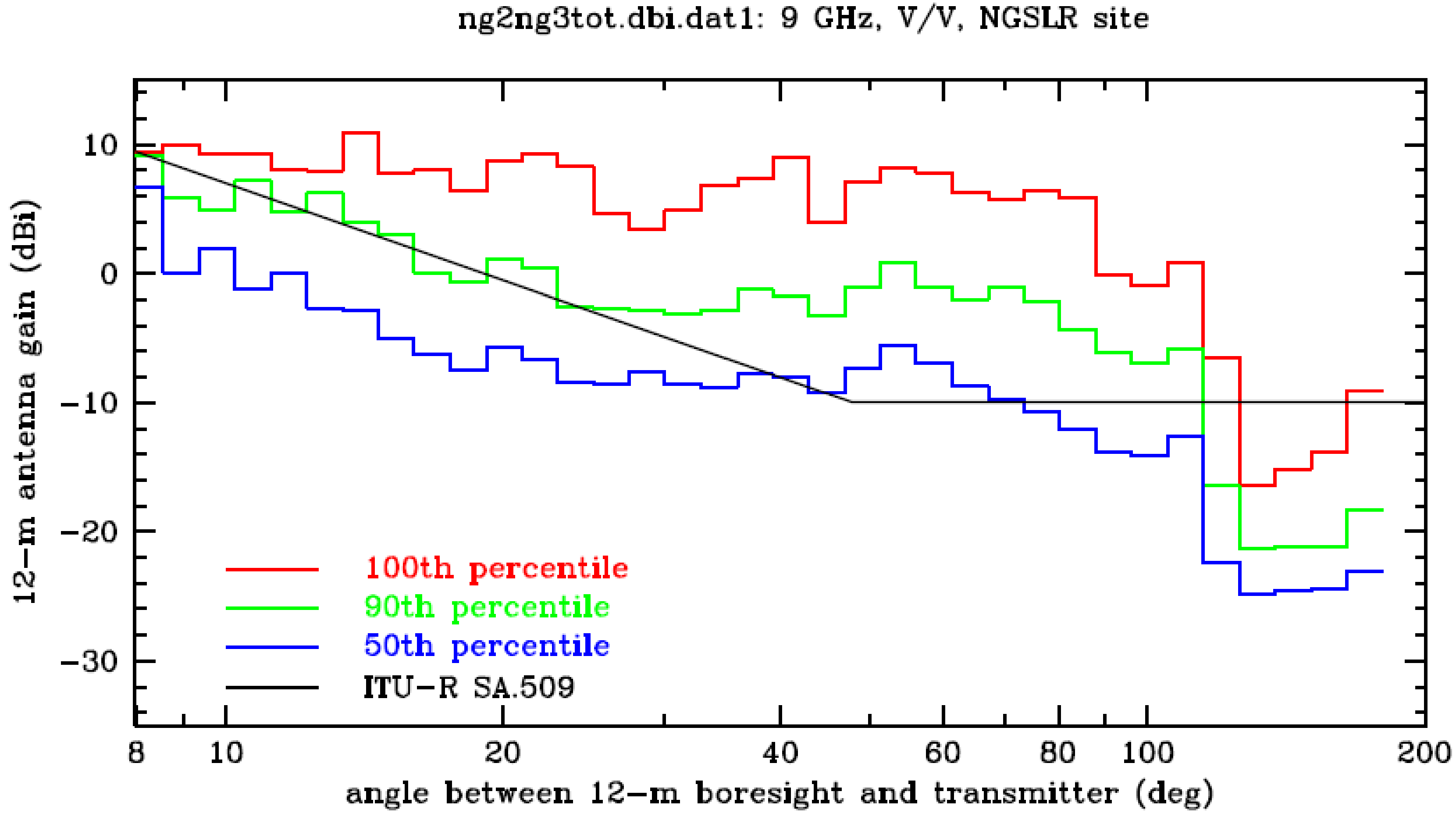
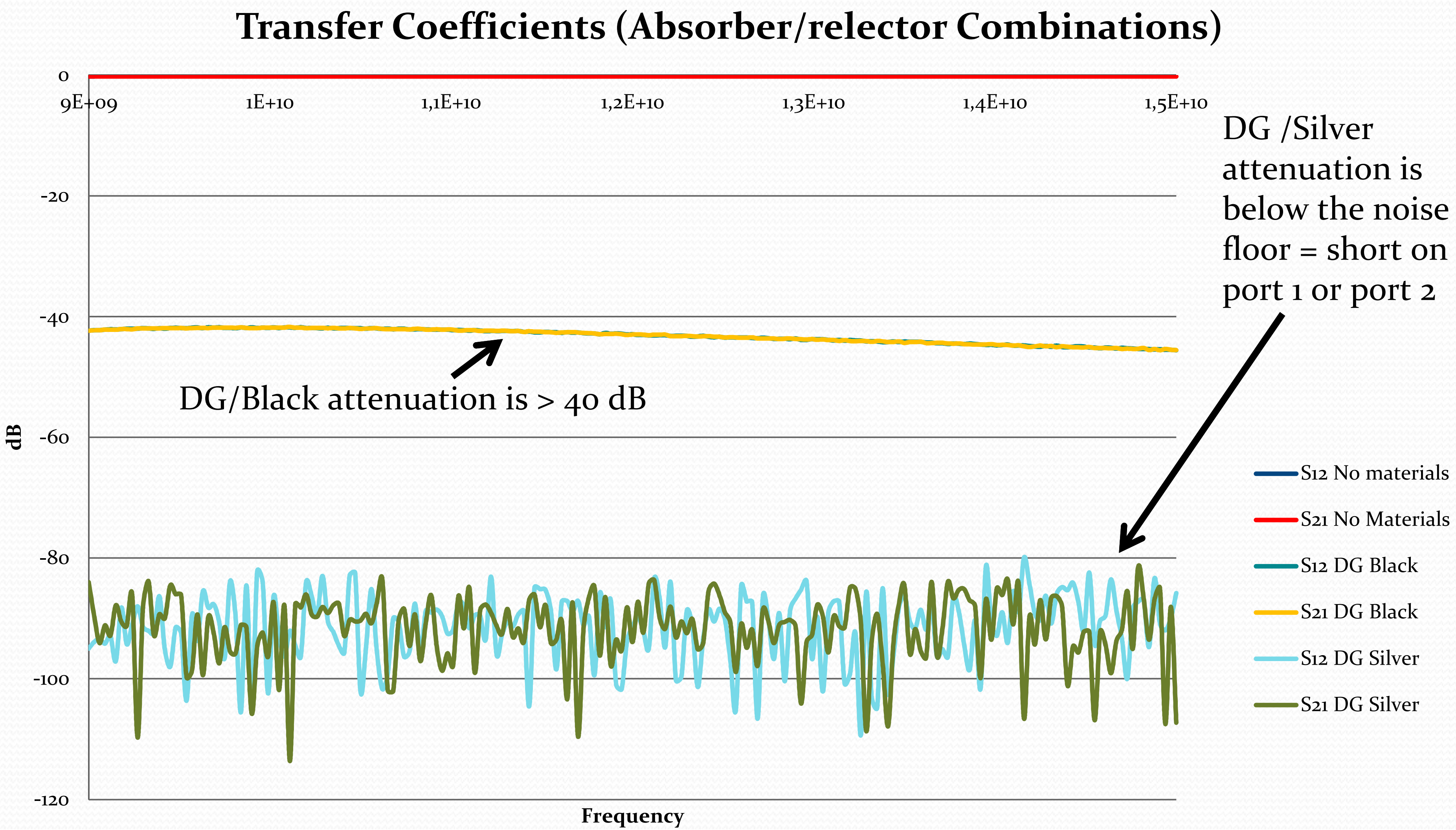


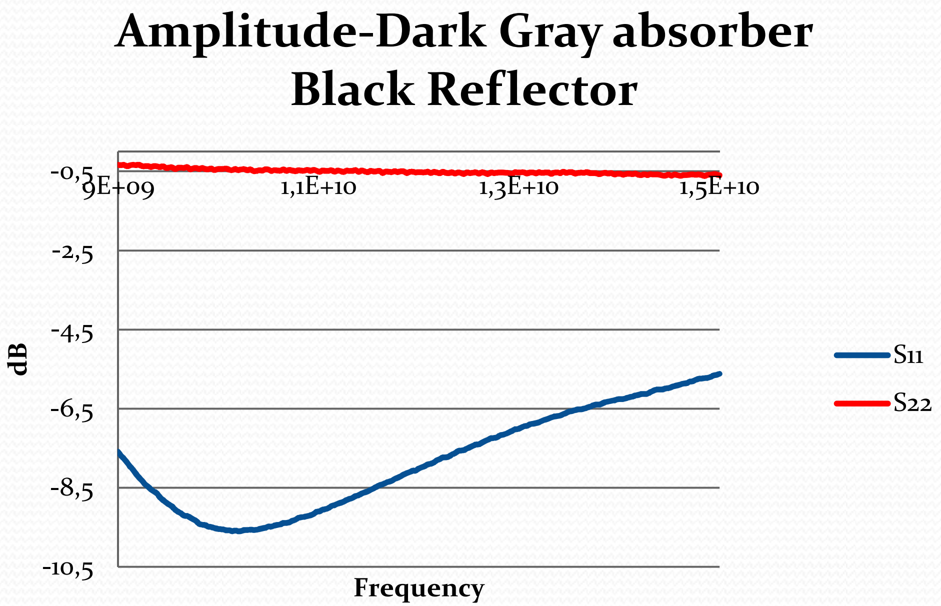
Figure 1: ITU-5009 antenna sidelobe envelope model incorporated in numerical RFI-compatibility studies.

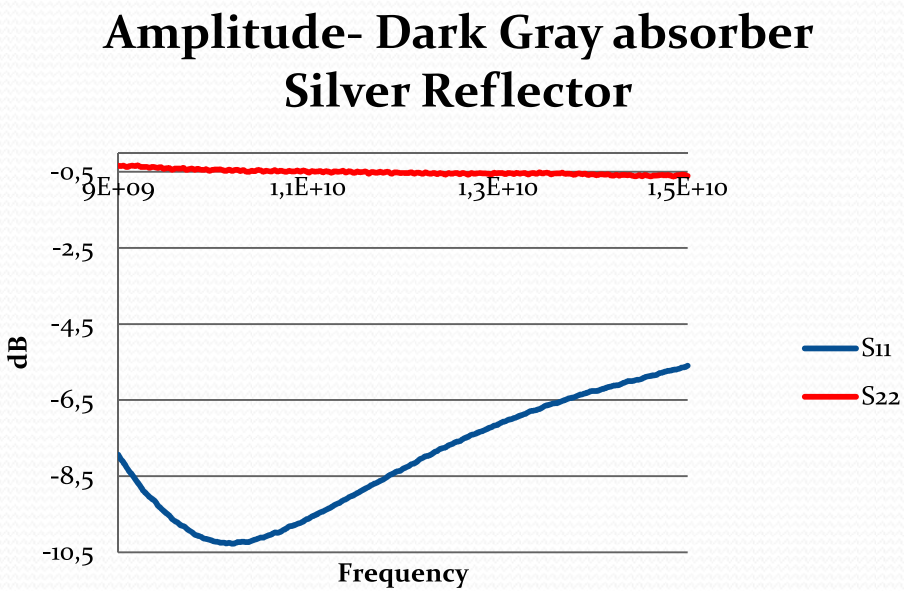
Absorber/reflector Material Evaluation: X-band



S11 & S22 Comparison of thin Reflector materials

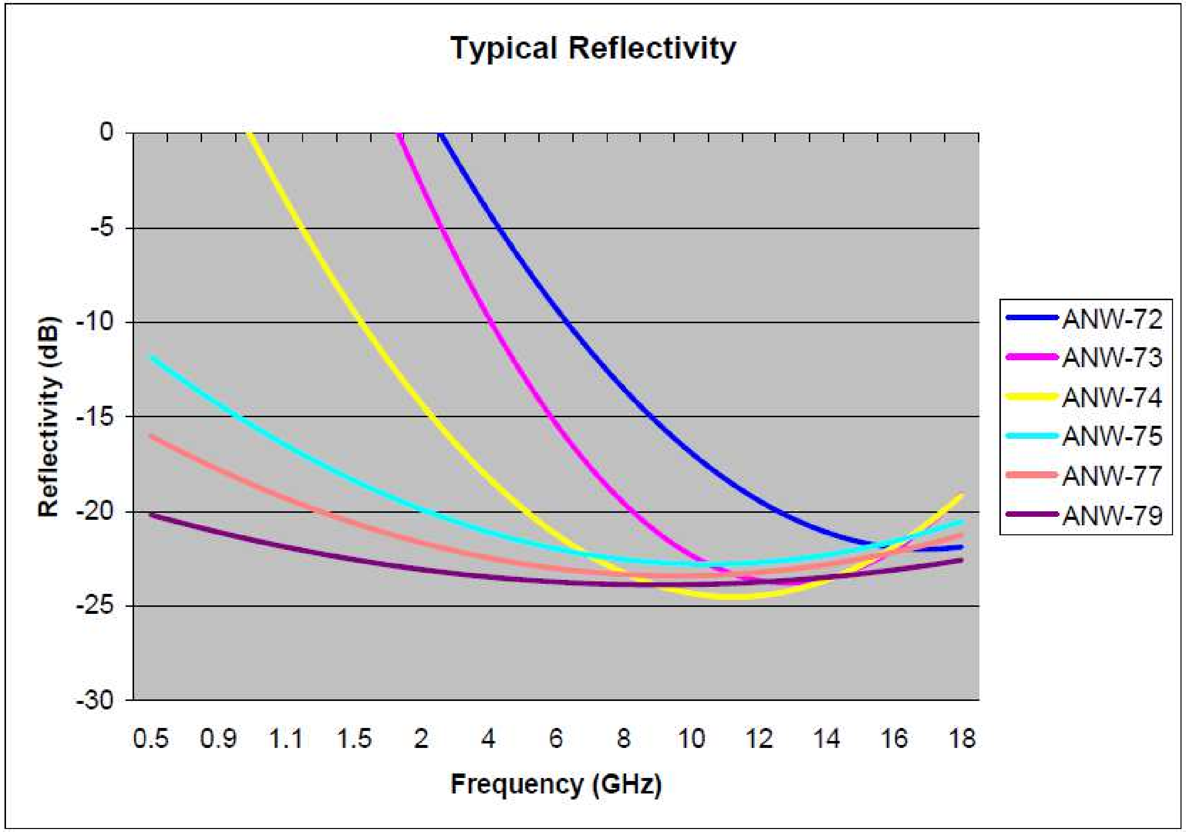
- S11 & S22 Comparison of AL100 (Silver) and Laminated MW Absorber (Black):
  - P1: Absorber (EC SF-9.5)
  - P2: Reflector



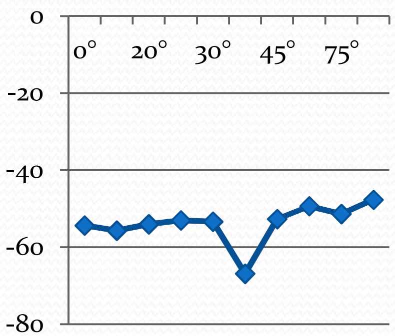


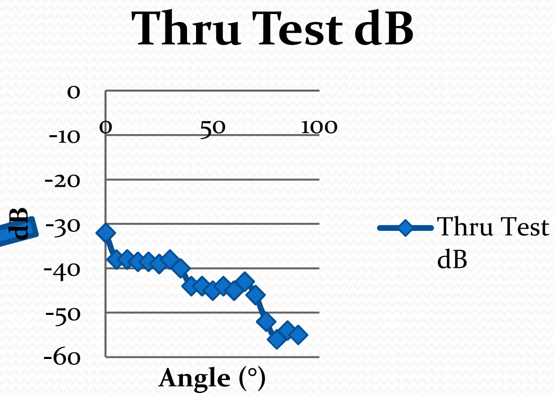
ANW-75 absorber material characteristics

- **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





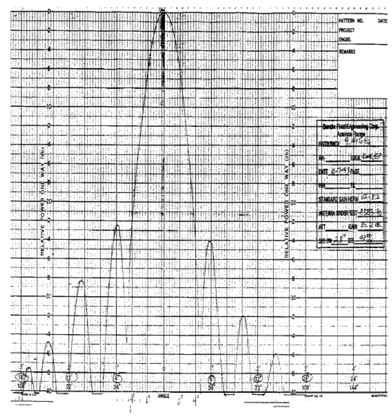
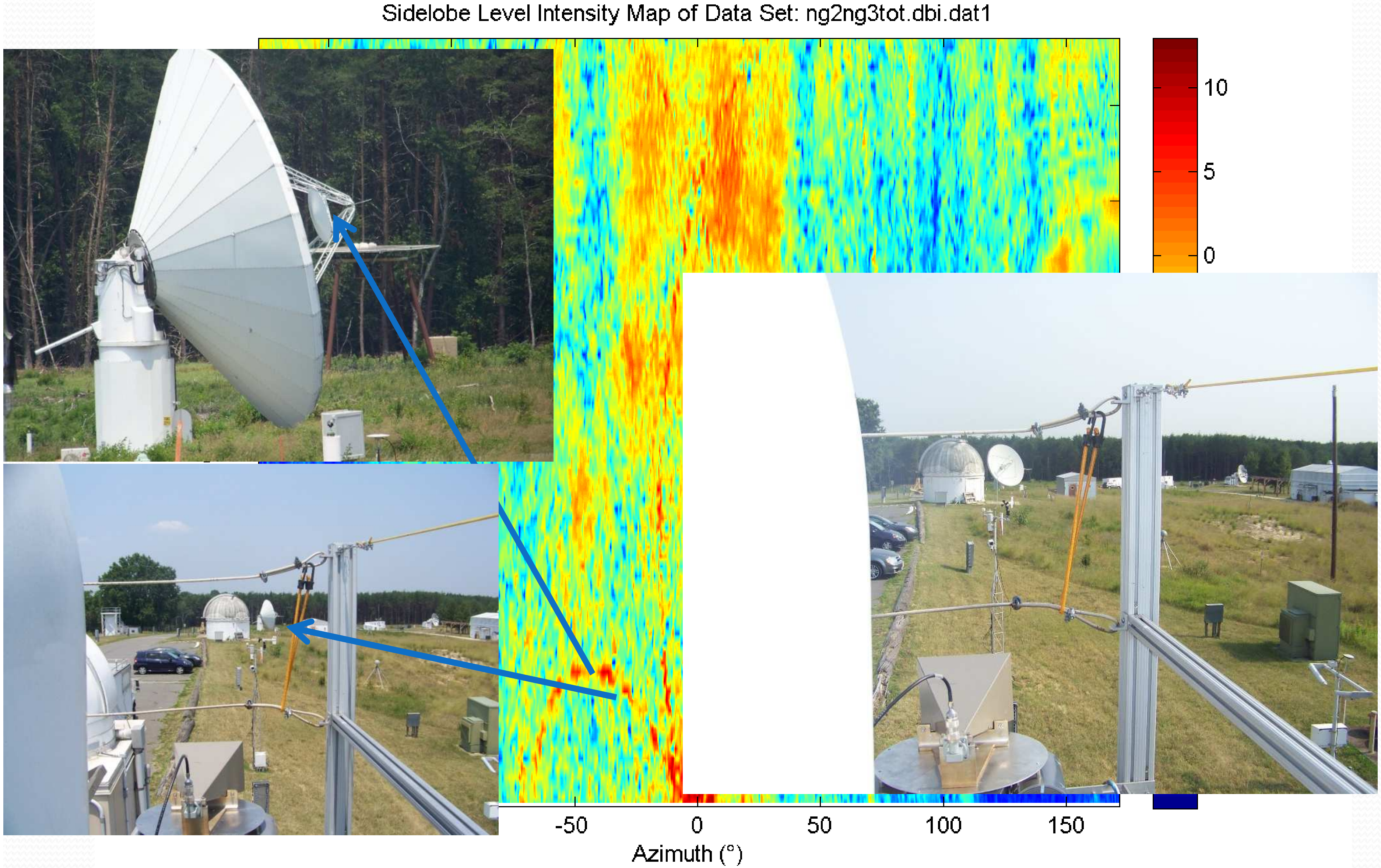


Figure 16. Antenna E-Plane Pattern

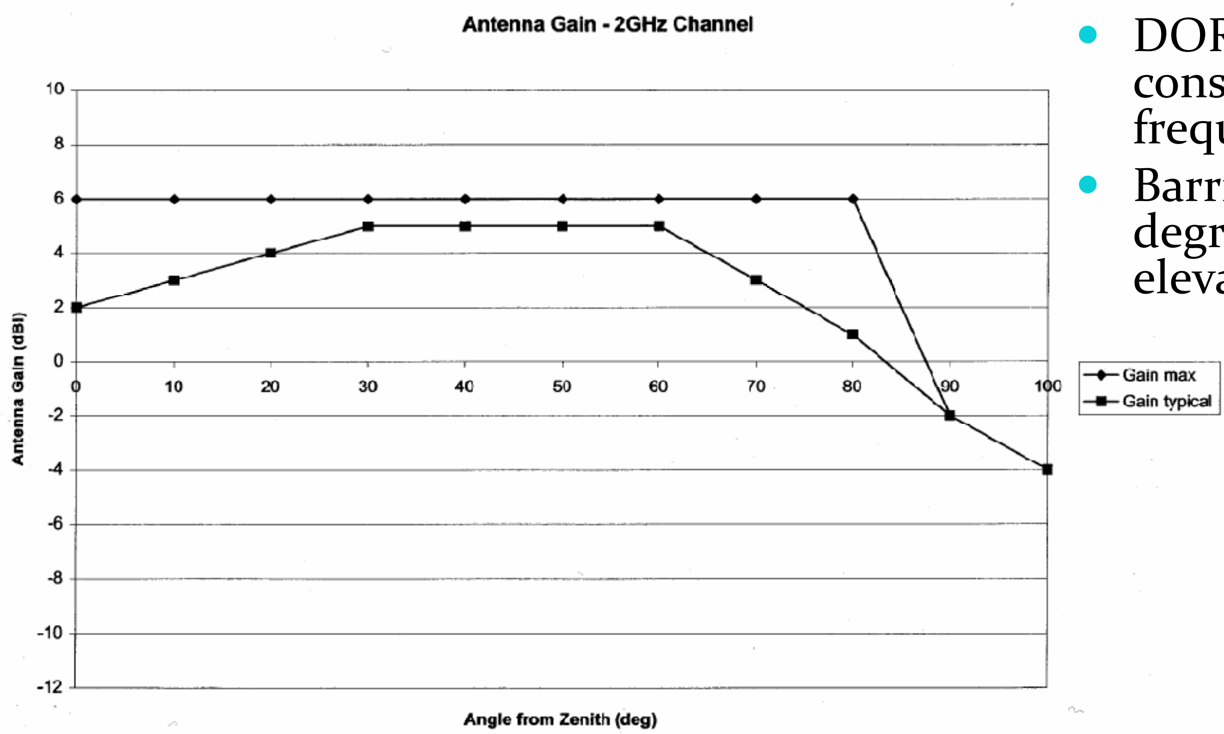
- From preliminary ground tests the best combination of attenuation and back reflection is at 35^0

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

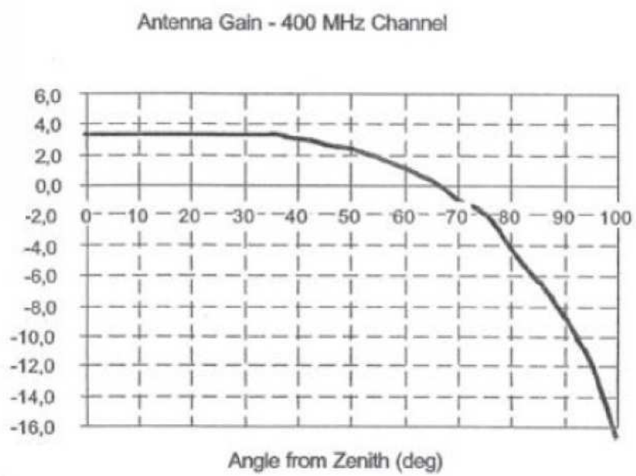


Radar absorber/reflector barrier design and test – Mob7 radar platform

DORIS beacon characteristics

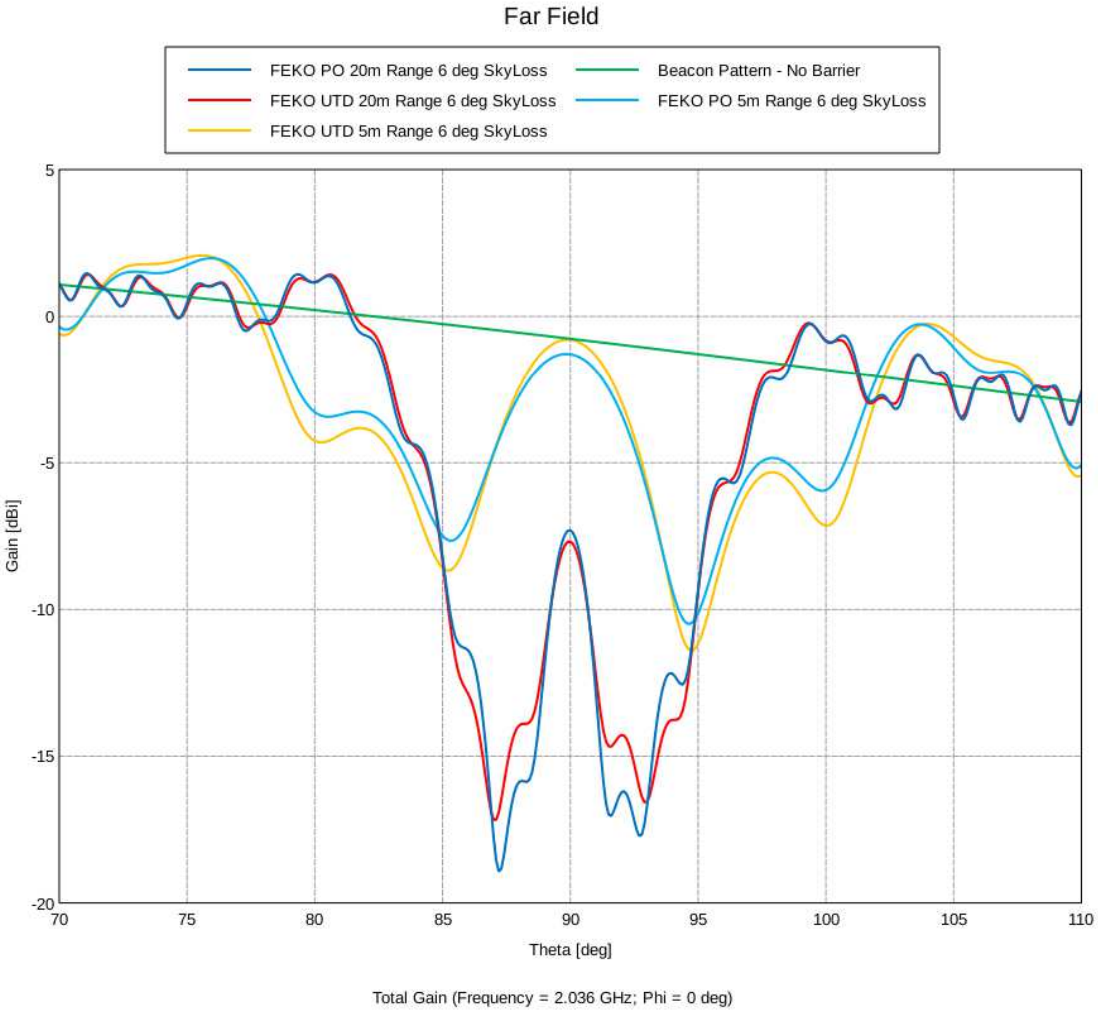


- DORIS barrier must be considered for two frequencies
- Barriers modeled for 6 degrees in azimuth and elevation



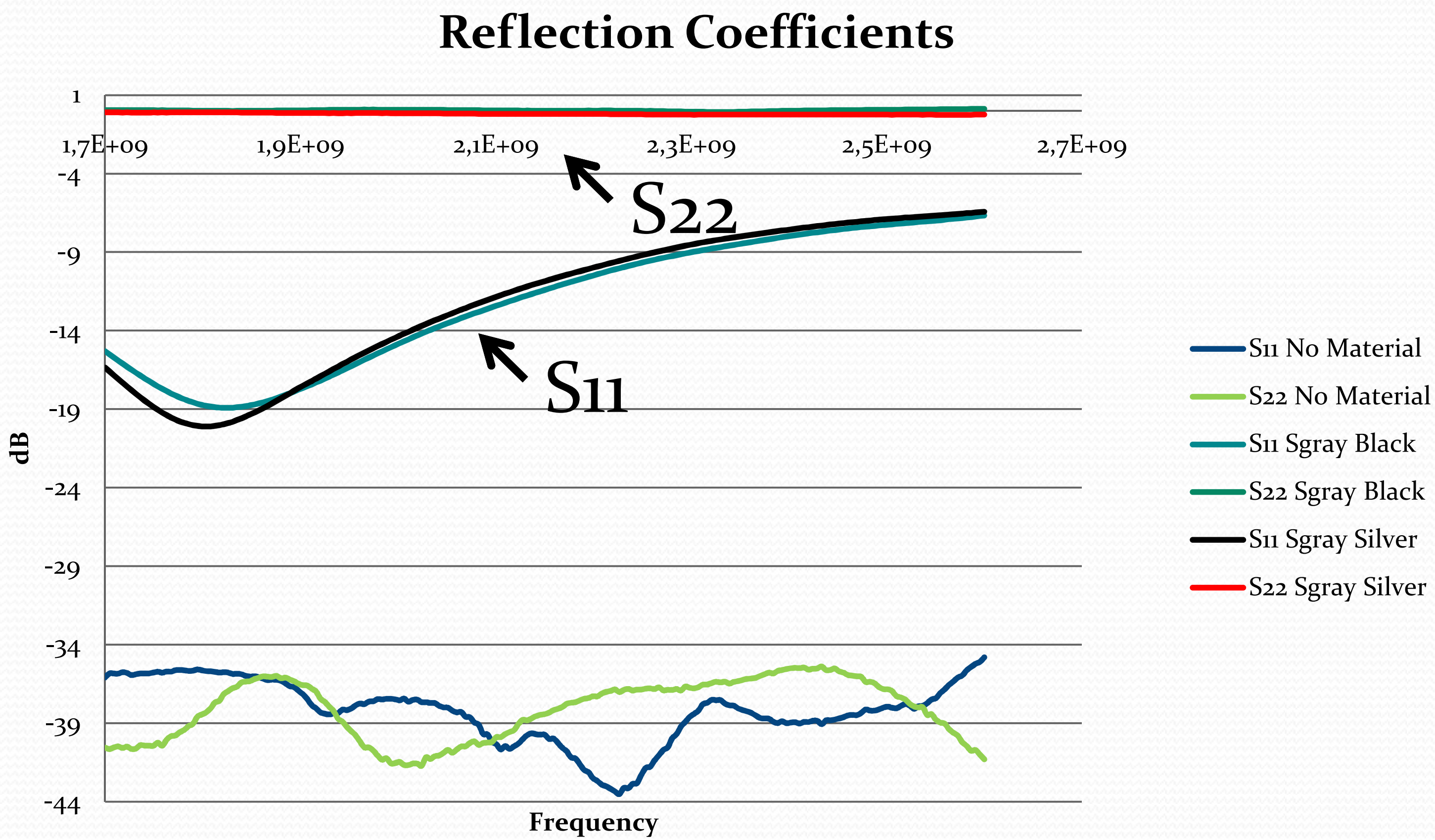
S-Band (DORIS frequency) shielding effectiveness

- http://www.feko.info/
  - Physical Optics and Uniform Theory of Diffraction
- at 5m, the linear dimension of the square barrier was 2*5*tan(6deg)
  - 1 meter
- 20m the square barrier was 2*20*tan(6deg).
  - 4 meters



Material Analysis: S-band

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



Material Evaluation: S-band

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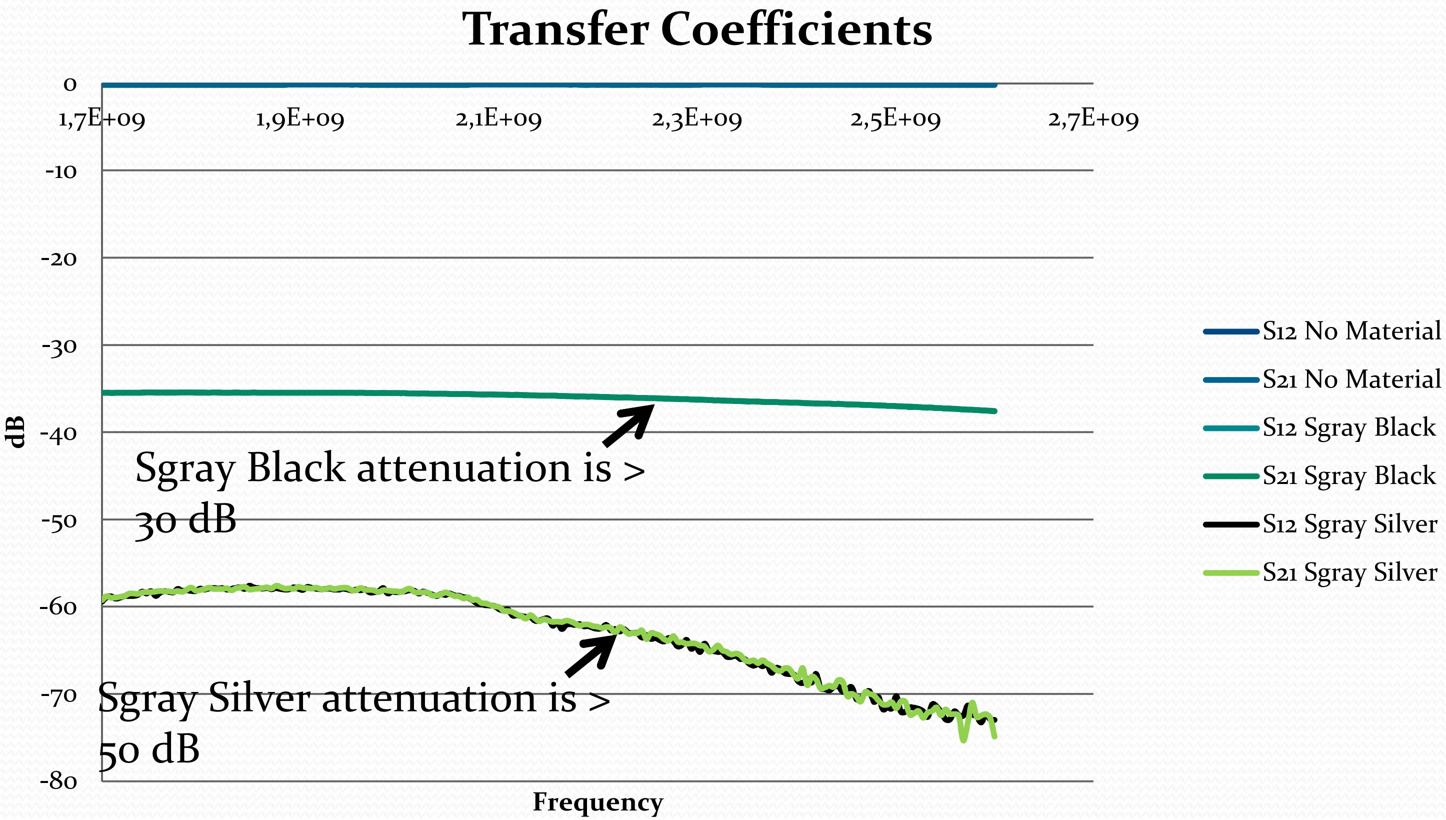

Tradeoffs to RFI Mitigation Techniques

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	