

Radio Frequency Interference on the SGP and Worldwide

Tom Clark, Scott Galbraith, Jeremy
Hill, and Larry Hilliard

July 18th, 2012

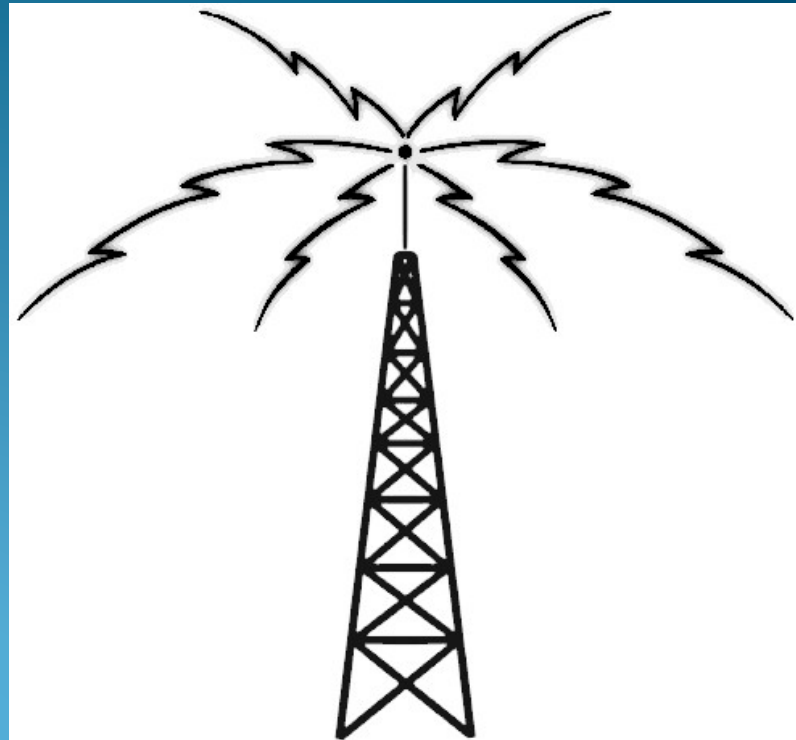
July 18th, SGP Intern Lunch time speaker Agenda

- Scott Galbraith – Spectrum Management at GSFC
- Larry – RFI on Space Geodesy Project introduction
 - ↪ Jeremy – Solving the RFI Problems at GGAO
- Larry - RFI experienced in Space borne Radiometers
- Tom – RFI on VLBI 2010 and legacy systems

Solving the RFI Problems at GGAO

Mentor: Larry Hilliard

Mentee: Jeremy Hill



Introduction

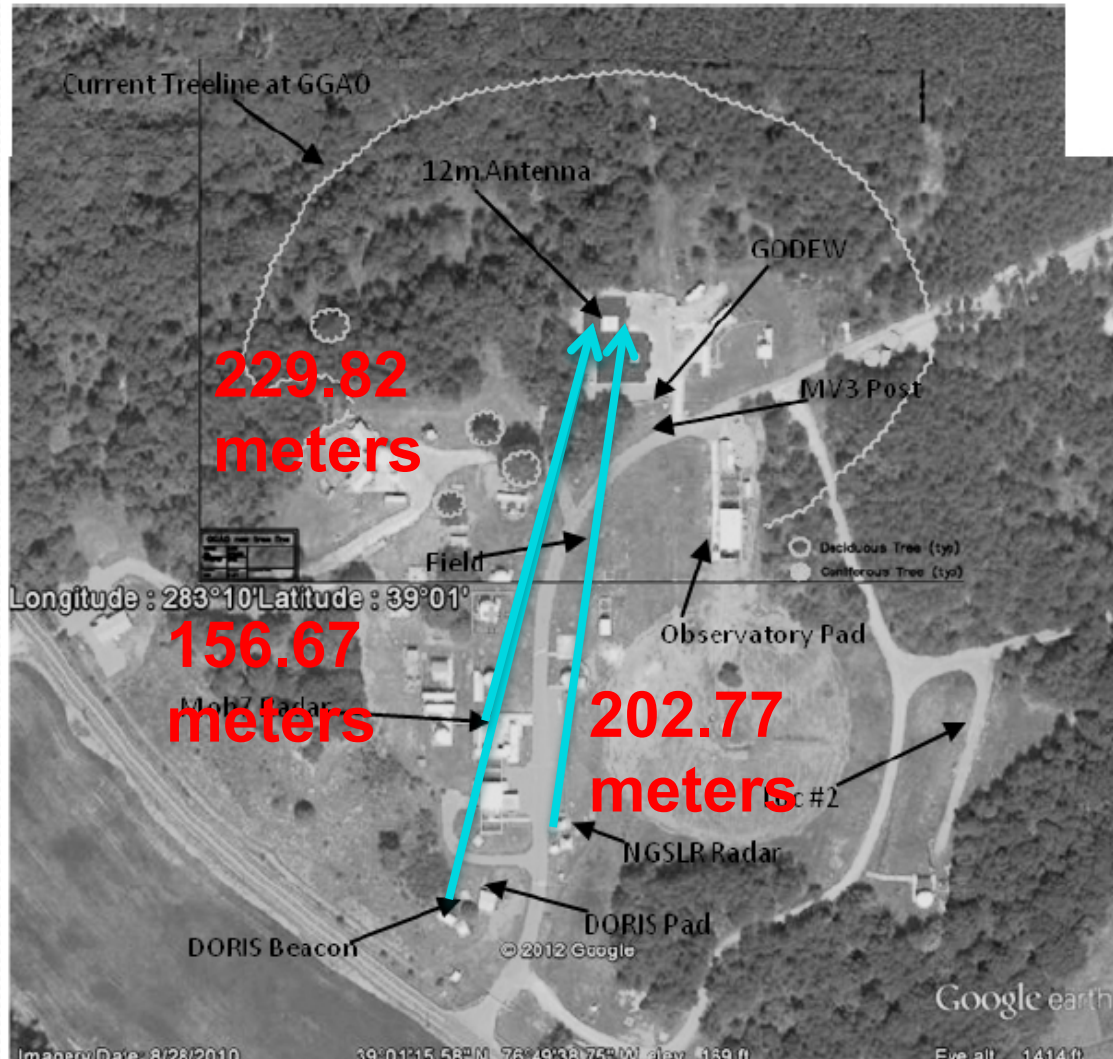
RFI – Radio Frequency Interference

The VLBI2010 (12m) picks up on various frequencies within the range of 2 to 14 GHz

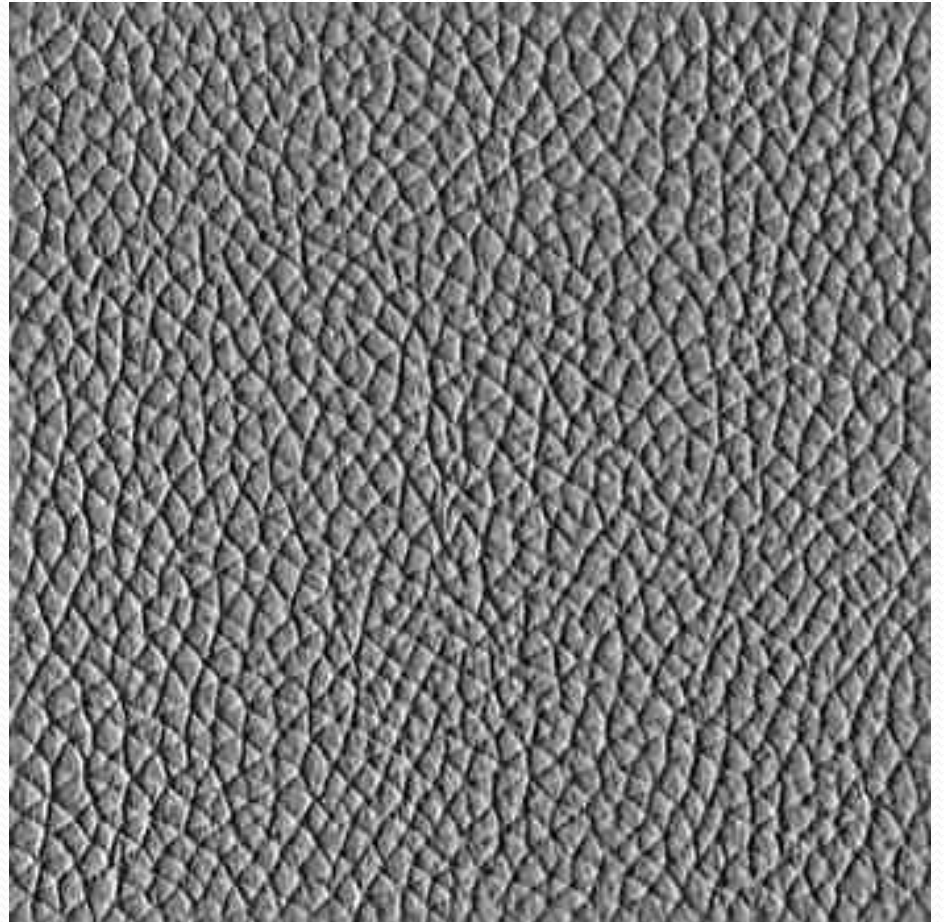
This is a problem:

- DORIS beacon (2.036 GHz)
- NGSLR radar (9.41 GHz)
- MOB7 radar (9.41 GHz)

Introduction: GGAO



Material Selection



Material Selection: Eccosorb SF-9.5

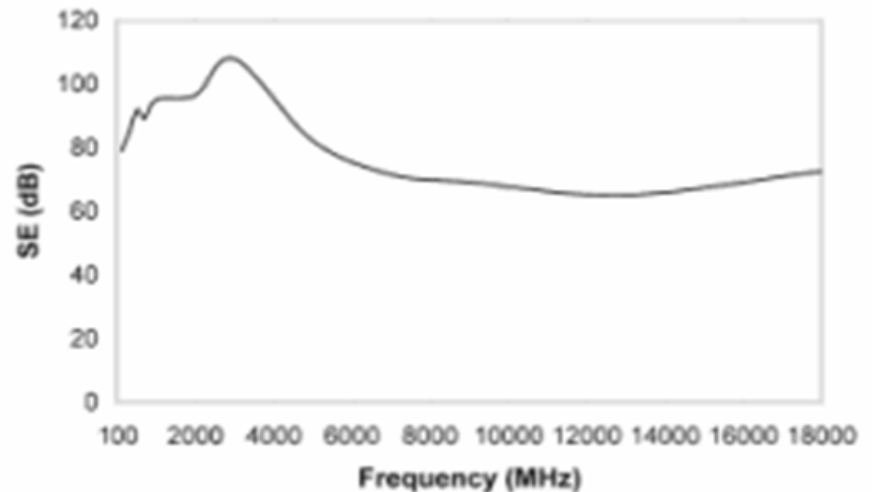
- Service Temperature: -65°F to 325°F
- Frequency range: 1-18GHz
- Performance degrades as incidence angle increases.
 - -16dB has been demonstrated at incident angles out to 45°
- Reflectivity of -20 dB or less of the normal incident microwave energy.
 - This is slightly less for frequencies less than 2.5 GHz
- (Referred to as “Dark Gray” in tests)

Material Selection: Eccosorb DSF-9.5

- Service Temperature: -65°F to 329°F
- Frequency range: 3-17GHz
- Performance degrades as incidence angle increases.
 - -16dB has been demonstrated at incident angles out to 45°
- Reflectivity of -20 dB or less of the normal incident microwave energy.
- (Referred to as “Gray” in tests)

Material Selection: AL100 reflector

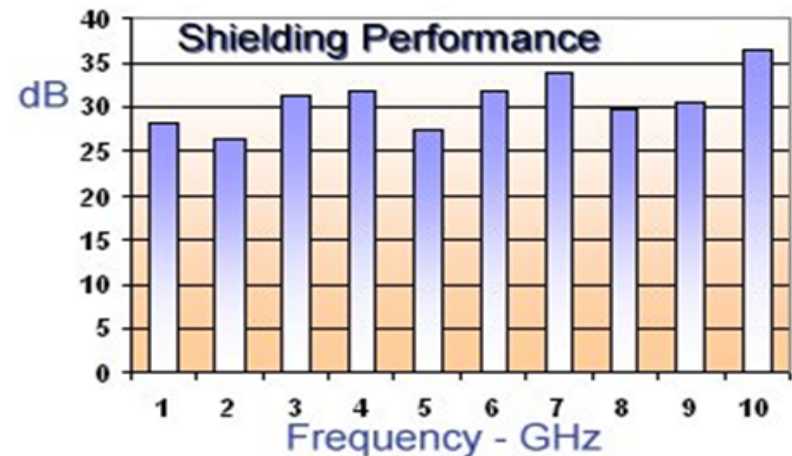
- Apply to surface to achieve ~60 dB from 100 MHz to 18 GHz
 - Conductive on one side
- Tolerates 32-122°F
- (Referred to as “Silver” in tests)
- Distributor:
 - LessEMF



Material Selection:

Laminated MW Absorber

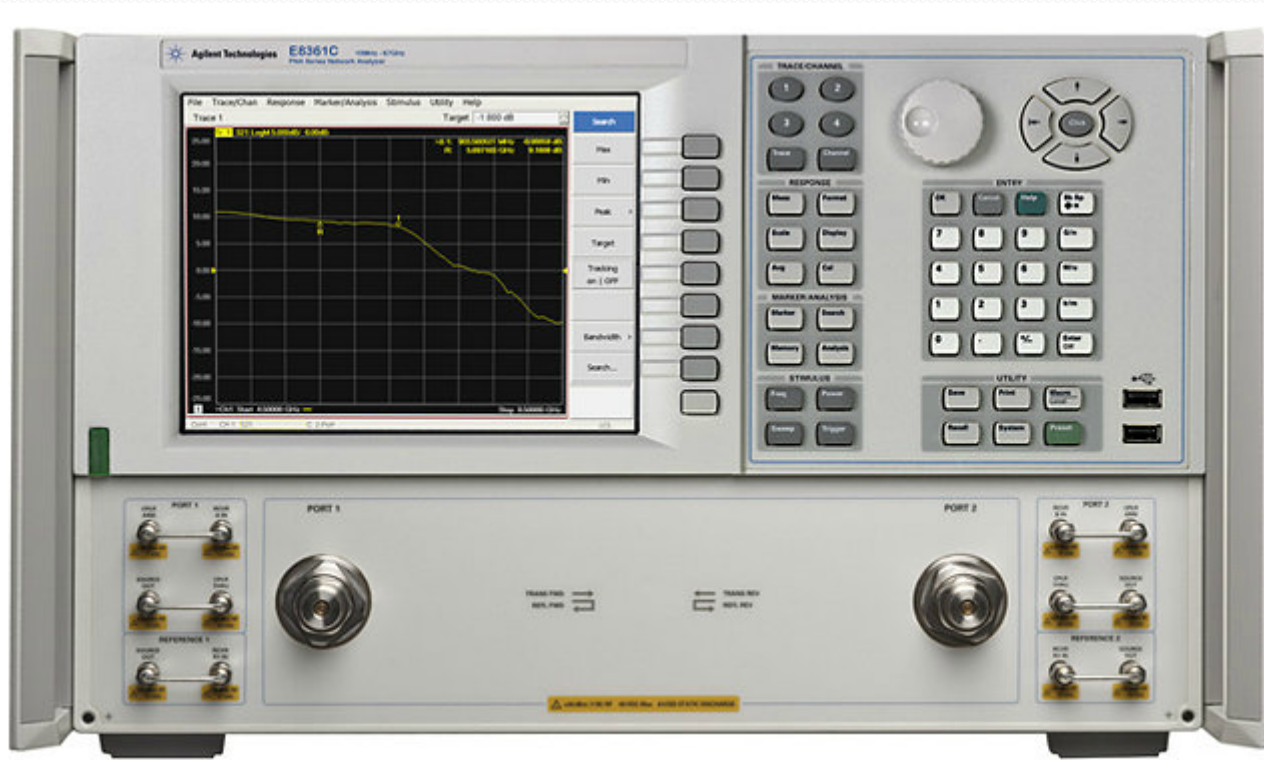
- Carbon Base Material (without plastic laminate)
- Offers protection for frequencies up to, and over, 10GHz
- Specs:
 - Resistivity: ~3 Ohms per square
 - Non-conductive surface
- (Referred to as “Black” in tests)
- Distributor:
 - LessEMF



Material Selection: Eccosorb SF-2.0

- Frequency range: 1-18GHz
- Performance degrades as incidence angle increases.
 - -16dB has been demonstrated at incident angles out to 45°
- Reflectivity of -20 dB or less of the normal incident microwave energy.
- (Referred to as “Sgray” in tests)

Network Analyzer



Network Analyzer

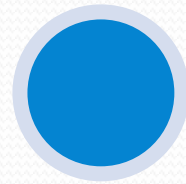


Specs:

Frequency
range from 10
MHz to 40
GHz

110 dB of
dynamic range

- <.006 dB of trace
noise



Measures:

S-parameters

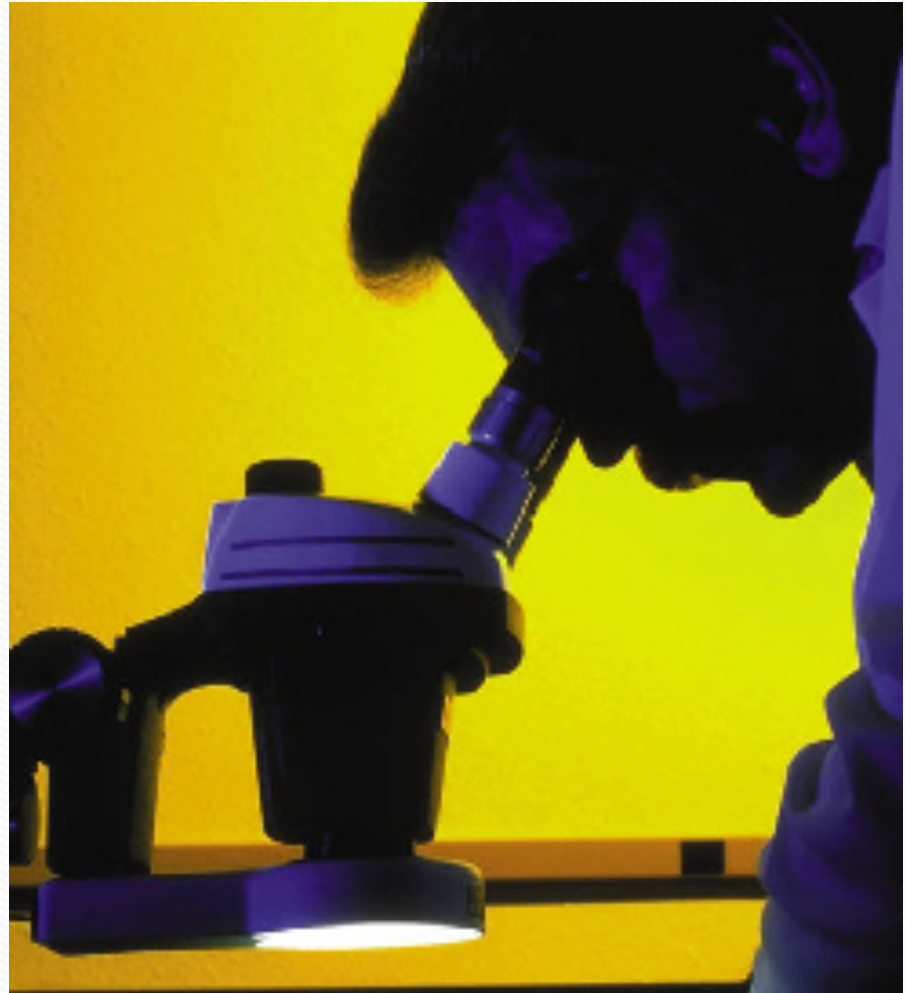
Insertion loss

Gain

Noise figures

And much
more...

Material Analysis



Material Analysis: X-band

Best Attenuation
to date for X-
band:

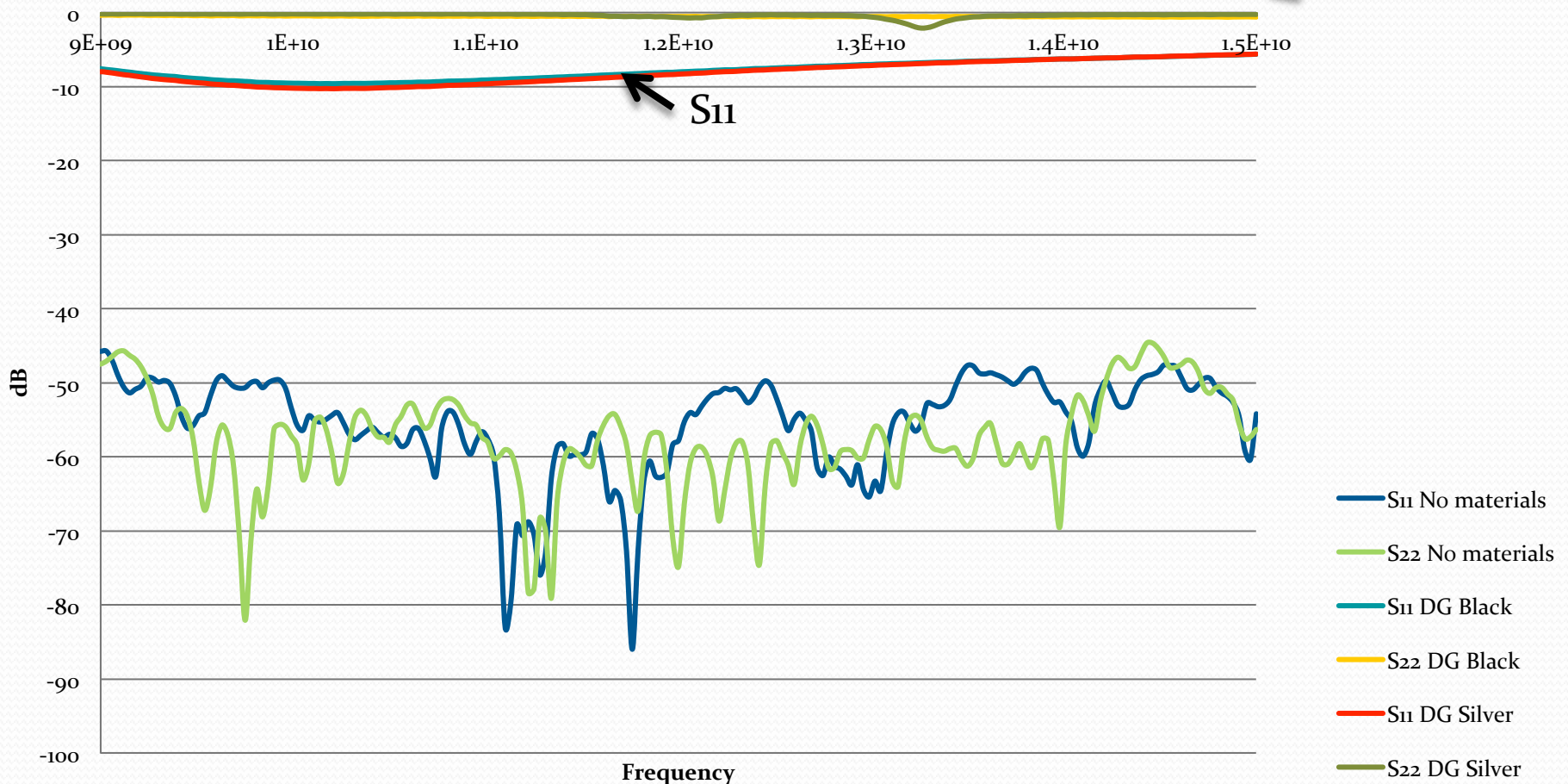
- Combined Absorber and Reflector:
 - Eccosorb SF - 9.5 and AL100 reflector wall shield
 - Eccosorb DSF - 9.5 and AL100 reflector wall shield

Material Analysis: X-band

Material between

$P_1 \rightarrow$: Absorber: reflector: $P_2 \rightarrow$

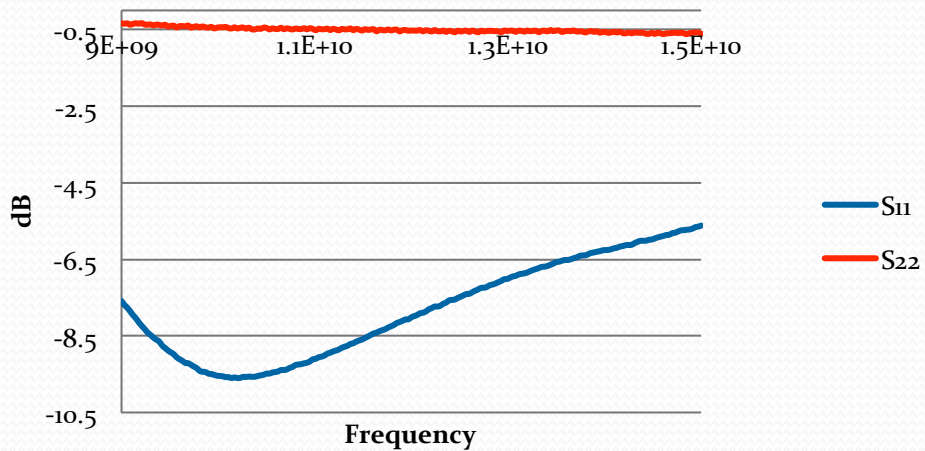
Reflection Coefficients (Dark Gray Combinations) \leftarrow S22



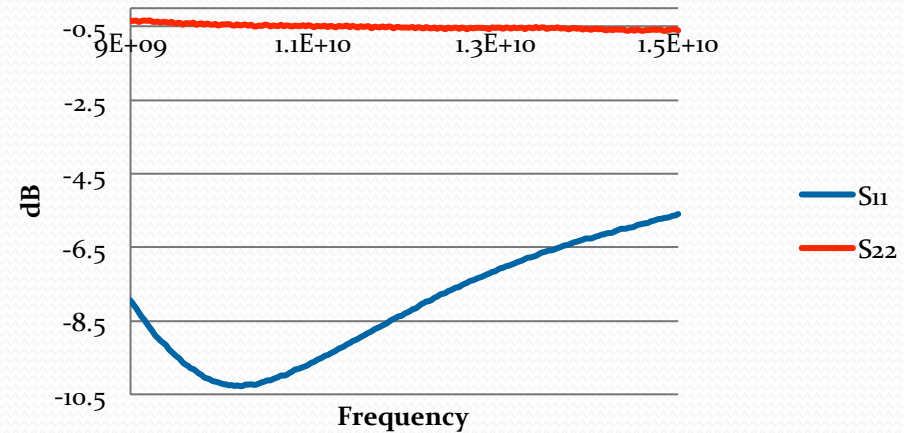
S11 & S22 Comparison of Silver and Black

- 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**

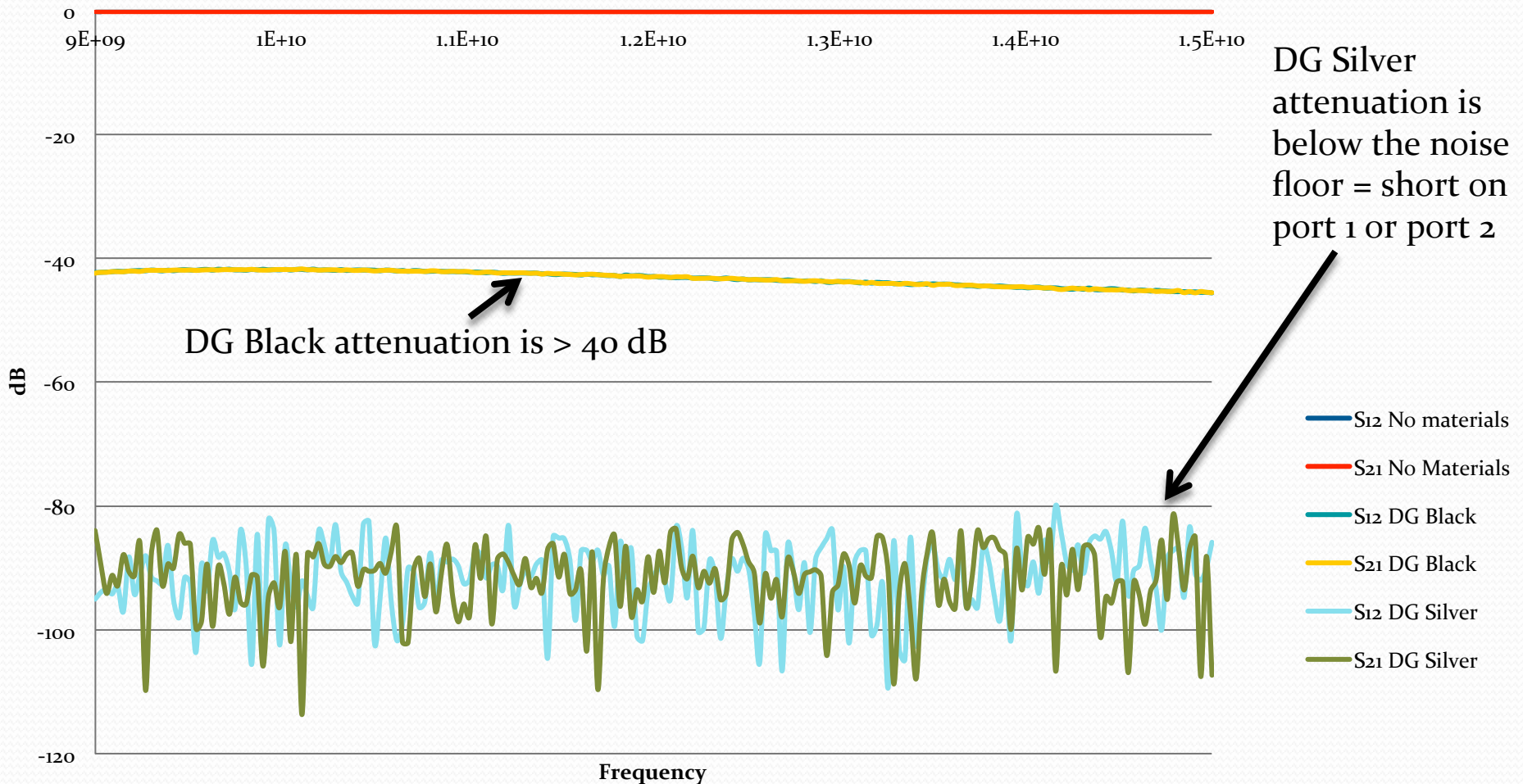


**Amplitude- Dark Gray absorber
Silver Reflector**



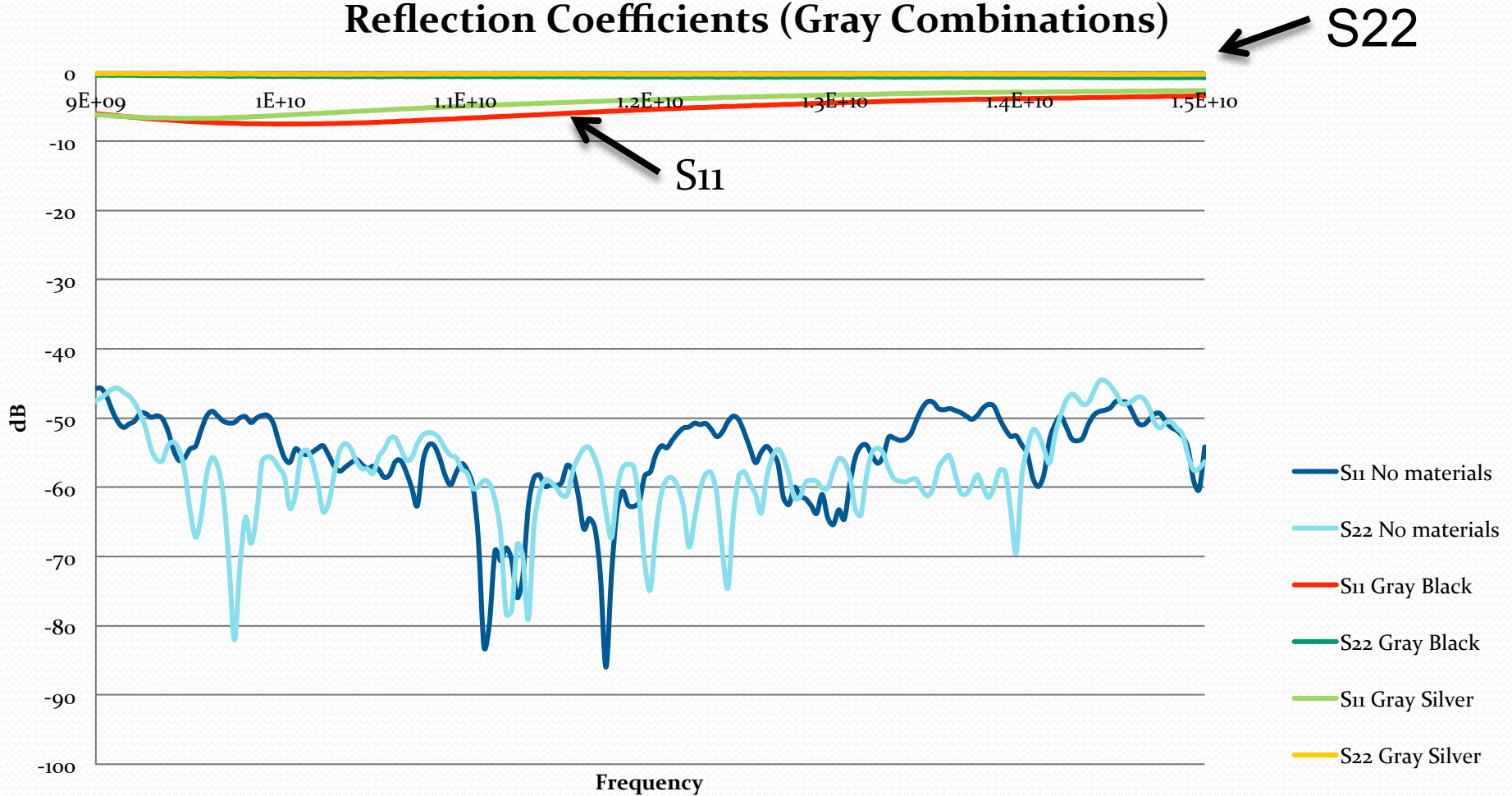
Material Analysis: X-band

Transfer Coefficients (Dark Gray Combinations)



Material Analysis: X-band

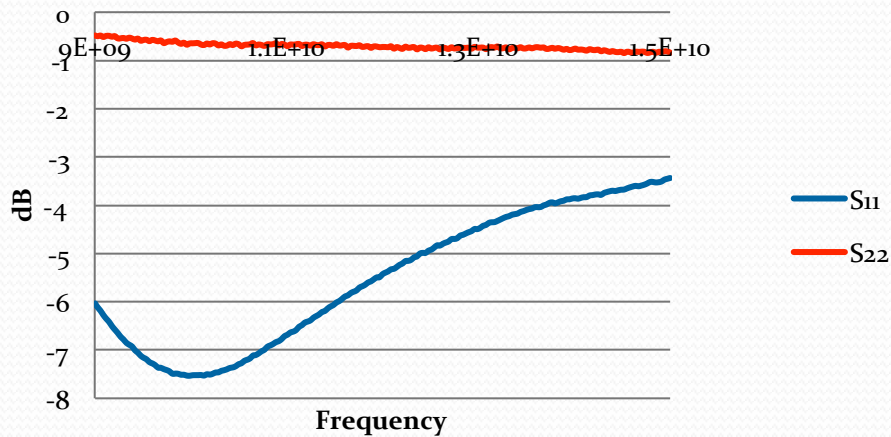
Reflection Coefficients (Gray Combinations)



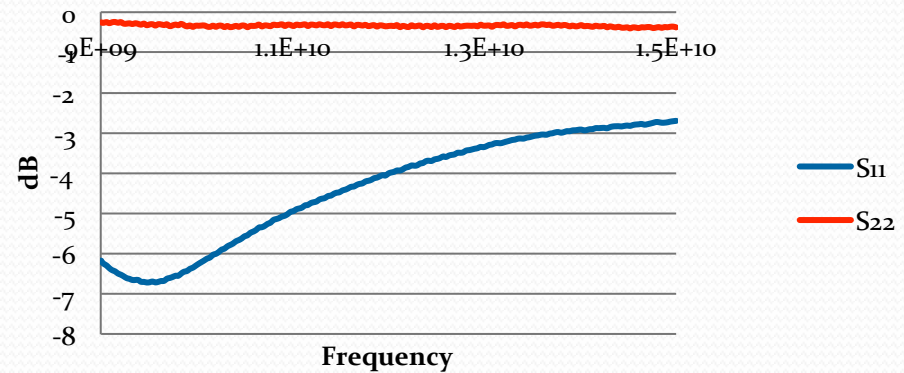
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 - P1: Absorber (EC DSF-9.5)
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Amplitude- Gray Absorber Black Reflector

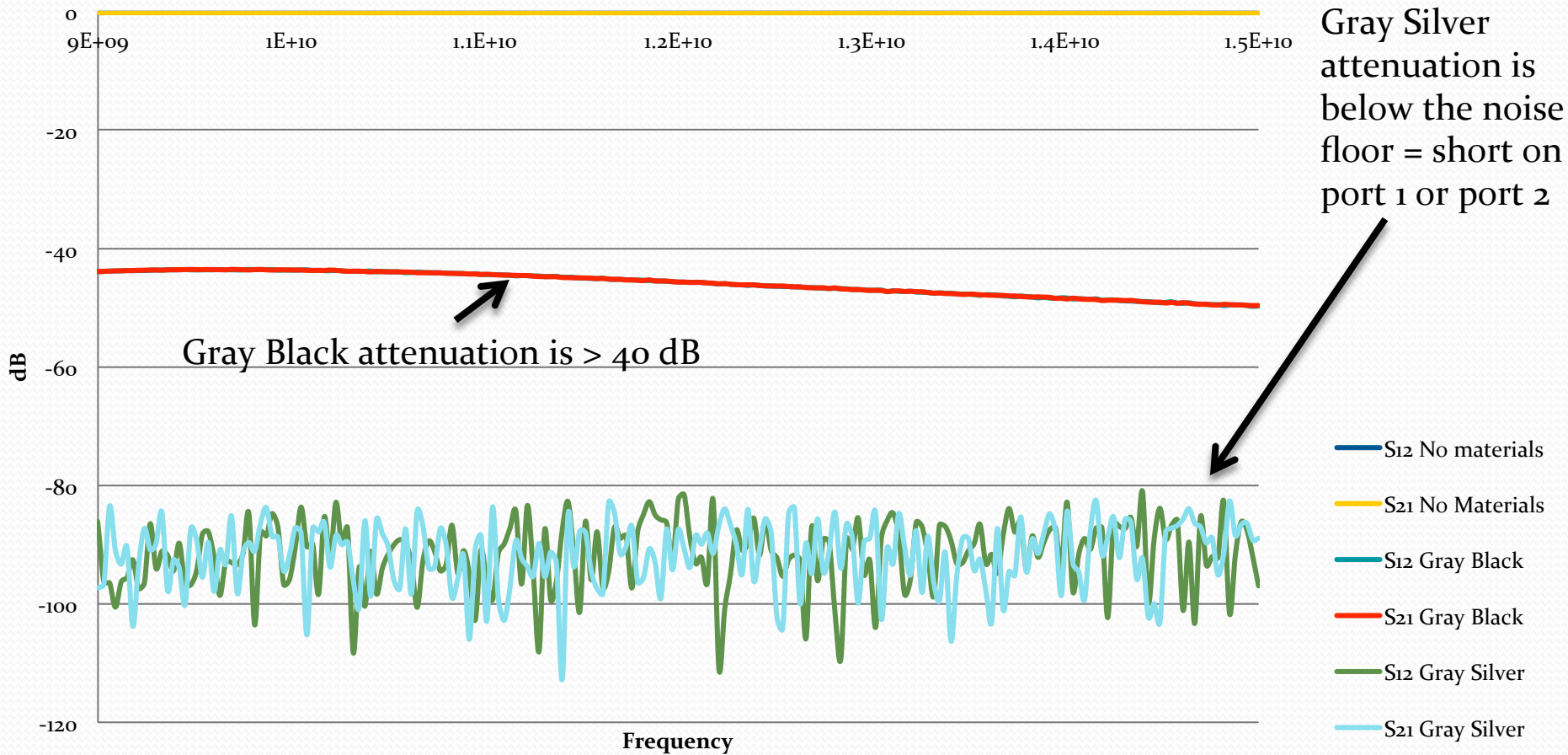


Amplitude - Gray Absorber Silver Reflector



Material Analysis: X-band

Transfer Coefficients (Gray Combinations)



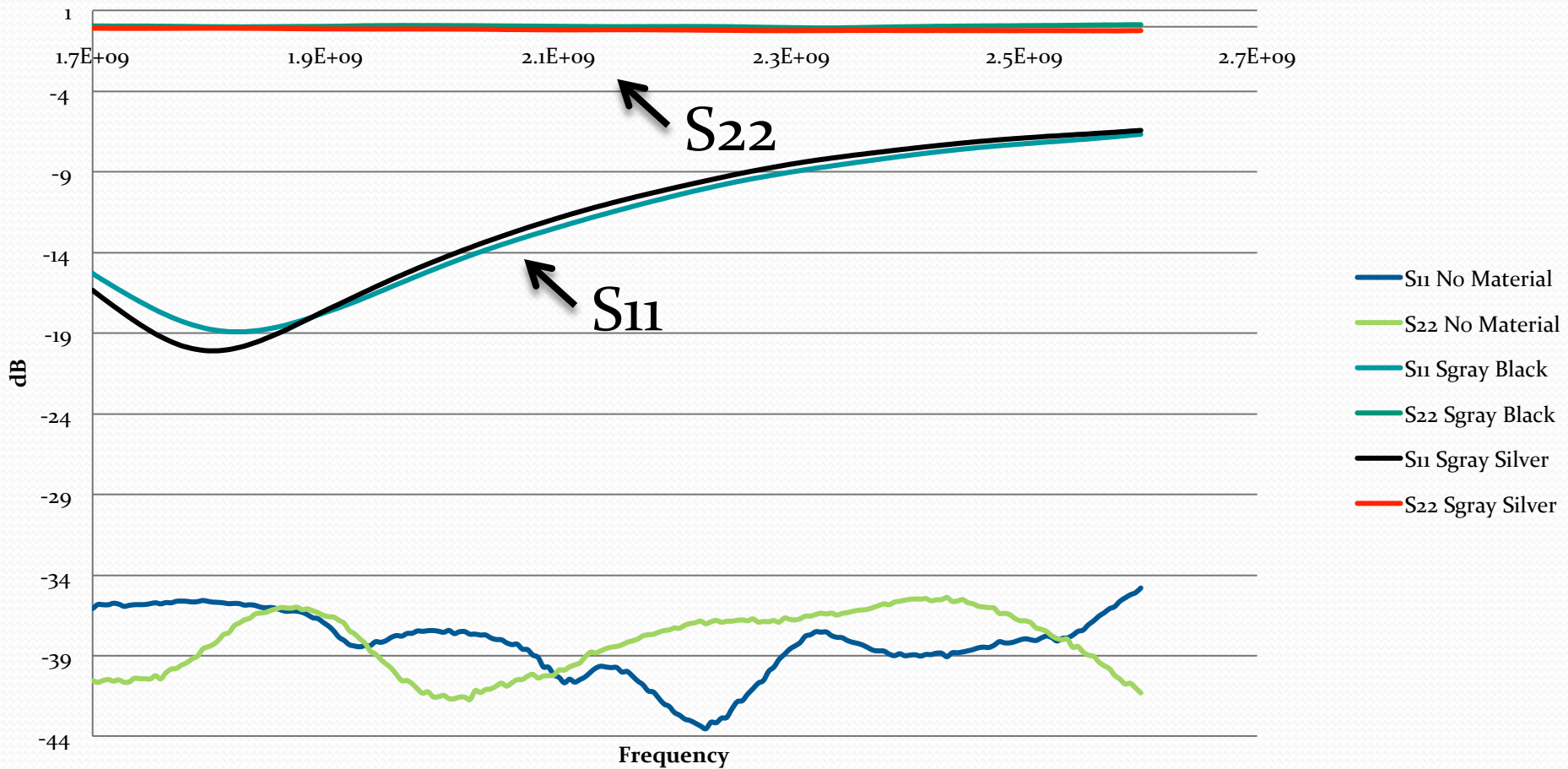
Material Analysis: S-band

Best Attenuation
to date for S-
band:

- Combined Absorber and Reflector:
- Eccosorb SF – 2.0 and AL100 reflector wall shield

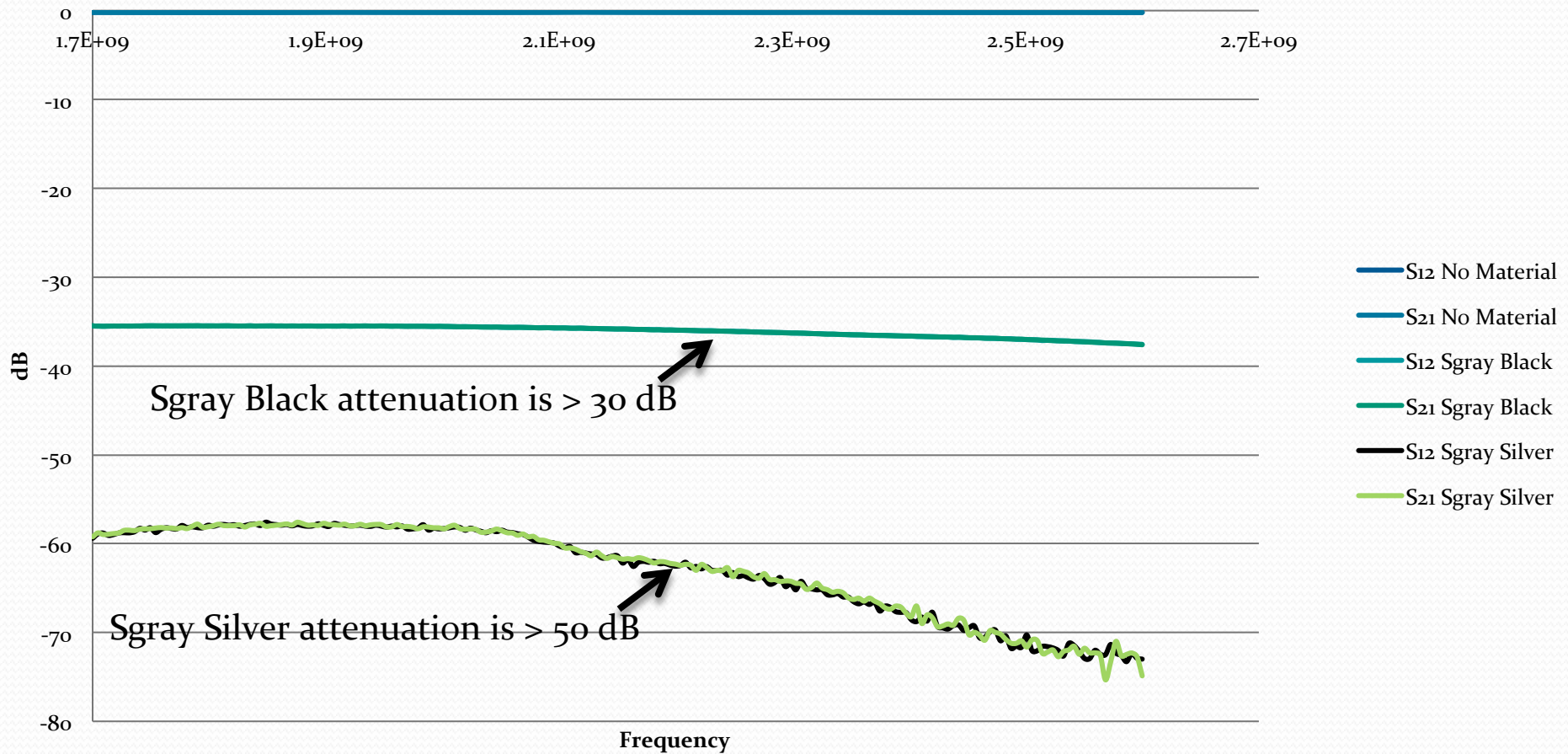
Material Analysis: S-band

Reflection Coefficients



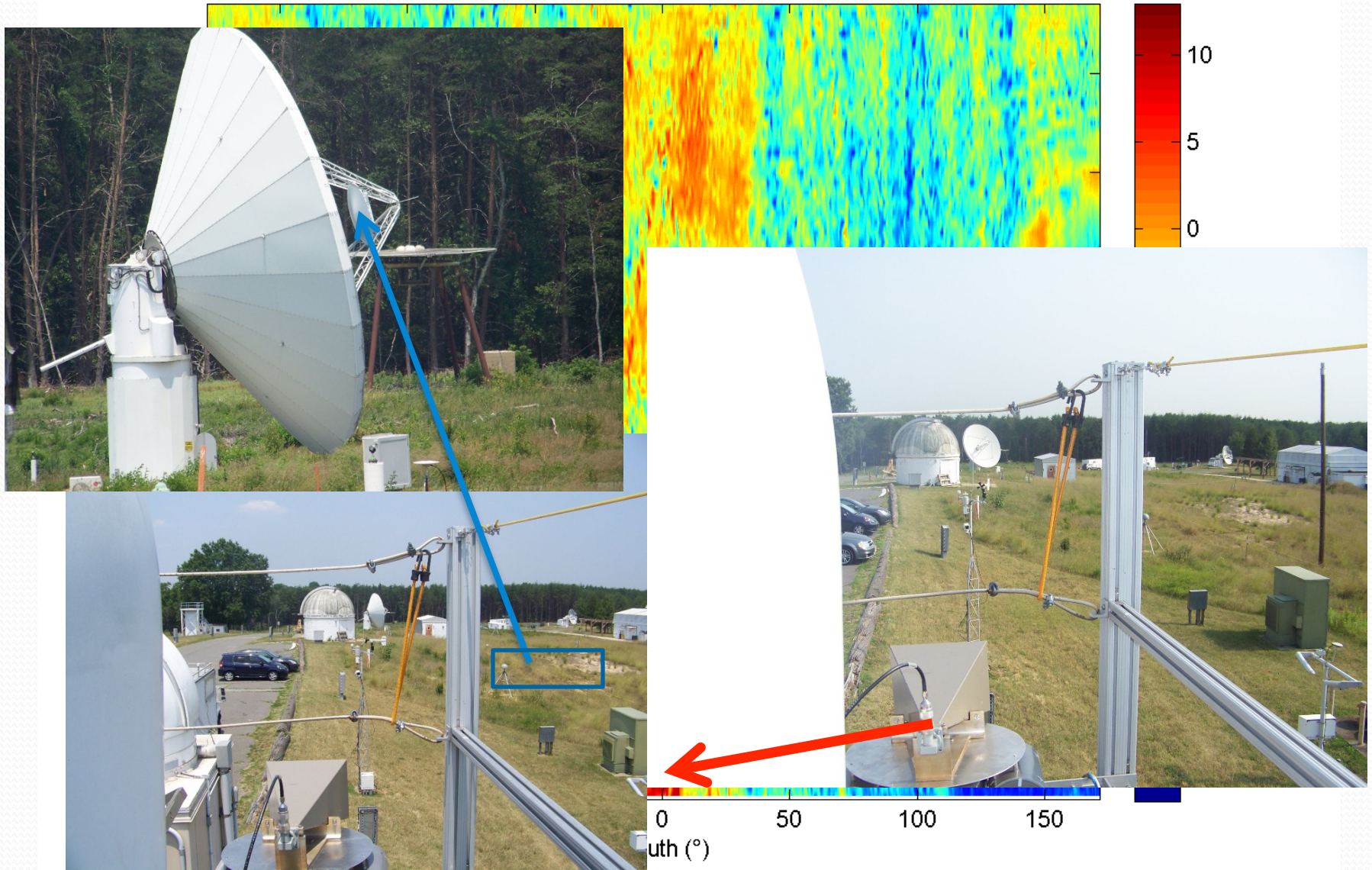
Material Analysis: S-band

Transfer Coefficients



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

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



Far-Field Region

- On the far side of the antenna
- Radiation pattern does not change shape as a function of distance
- This region is dominated by radiated fields
- The far-field distance is given by:
 - $d_{\text{farfield}} > 2D^2 / \lambda$

Far-Field Region

- Far-field for DORIS:

- $d_{\text{farfield}} > 2 * (12)^2 / 3 * 10^8 / 2.036 * 10^9 = 1.95 \text{ km}$

- Far-field for NGSLR radar:

- $d_{\text{farfield}} > 2 * (12)^2 / 3 * 10^8 / 9.41 * 10^9 = 9 \text{ km}$

10/29/2010
1993 2010

Horn at IOA of 12m
Nail 100 Nail 101

Country Name : UNITED STATES OF AMERICA Longitude : 283°10' Latitude : 39°01'

SCS Lake

© 2012 Google

Google earth

Imagery Date: 8/28/2010 1993

39°00'38.09" N 76°50'05.54" W elev 127 ft

Eye alt 9328 ft

Future Plans



Future Plans

Test material reflection with a standard gain horn

Deploy beacon to the top of the MOB 7

Repeat beacon test with an S-band horn

Questions?

