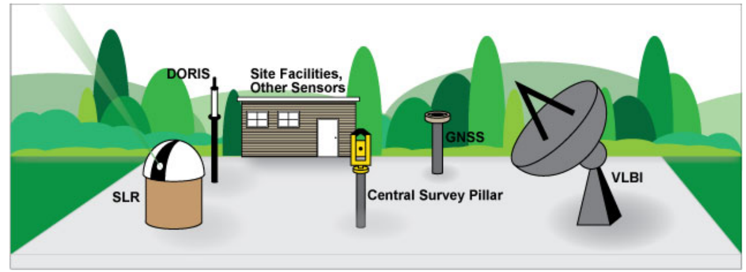
SGP Visit from CNES and NASA HQ

DORIS ***Radio Frequency Interference (RFI) Study***



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April 5, 2012

RF Compatibility Methodology

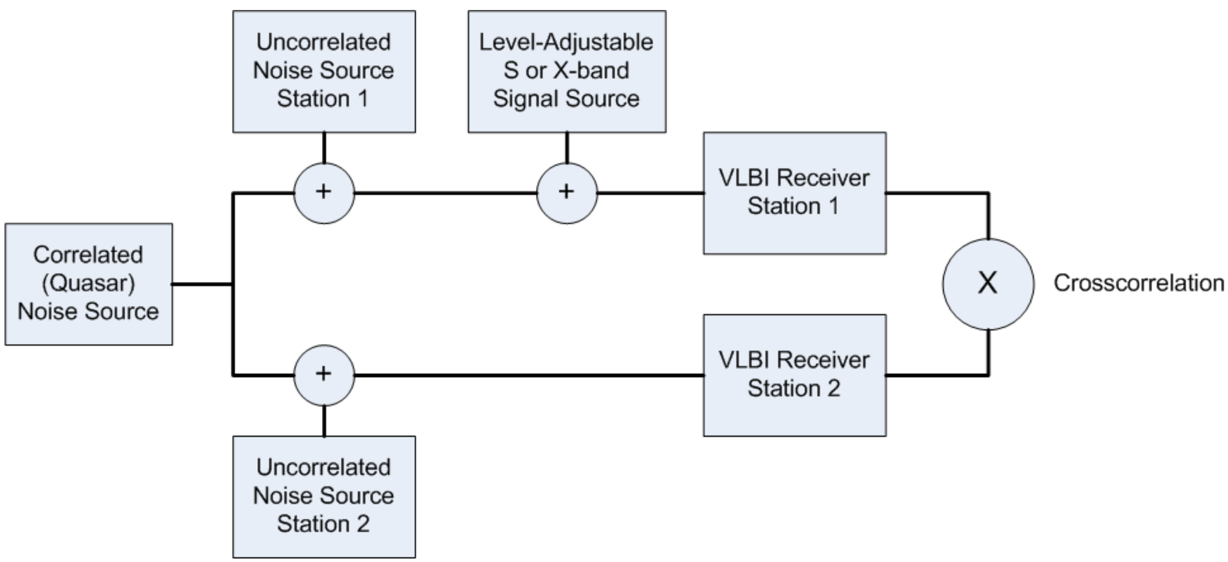
- Broadband VLBI receiver saturation model verification
- Measurement of transmitter radiation properties
- Field testing of 12m sidelobe envelope
- Barrier design considerations and field testing

RF Compatibility Methodology

Receiver Saturation Model Verification

- Preliminary tolerable levels based on a textbook non-linear model and rough estimates of the LNA saturation behavior
  - See AGU2010 poster at: ftp://web.haystack.mit.edu/pub/cjb/AGUPoster2010.pdf

- Actual tolerable levels will be verified in controlled laboratory experiment



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

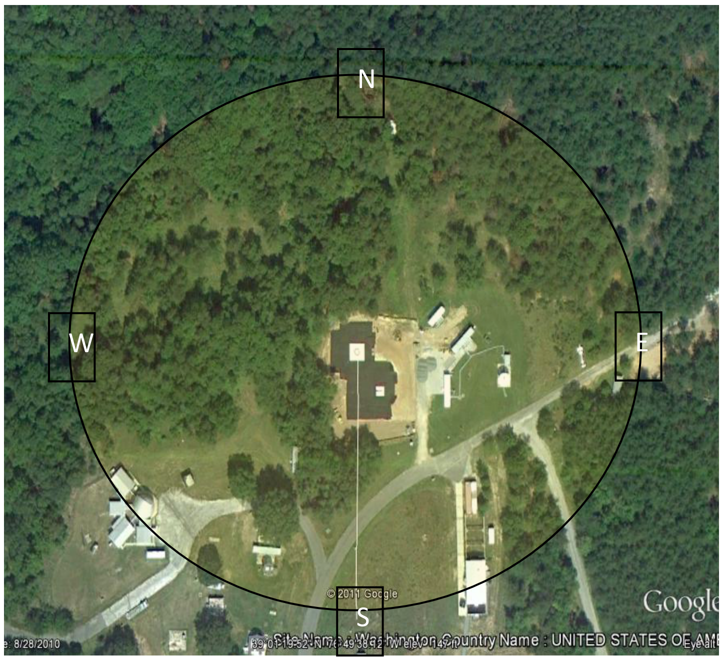
RF Compatibility Methodology

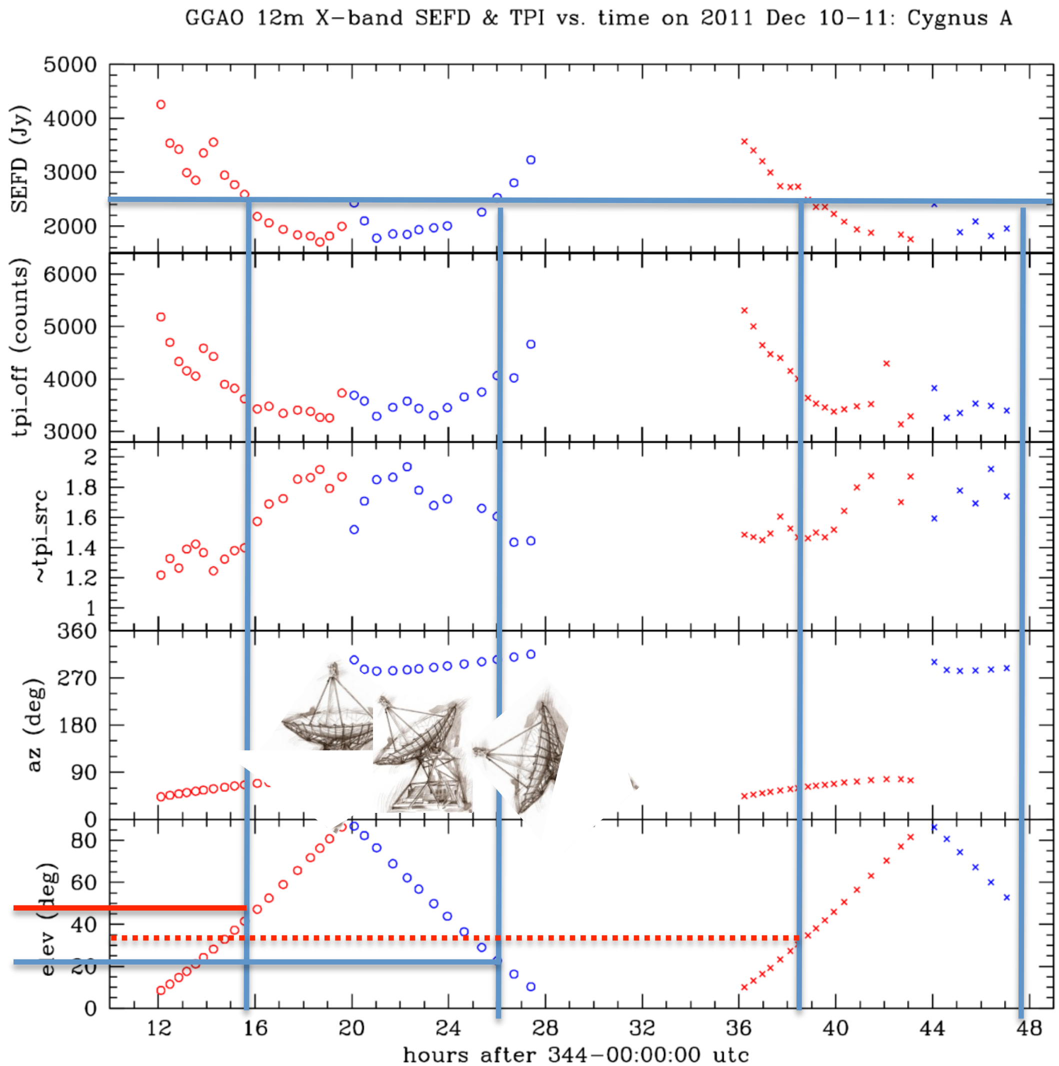
Field testing of 12m sidelobe envelope

- Initial estimates of RF limits assumed a ITU-R SA.509 standard sidelobe envelope for large reflector antennas
  - See AGU2010 poster at: ftp://web.haystack.mit.edu/pub/cjb/AGUPoster2010.pdf
- Must verify that this model is valid for the GGAO 12m antenna at S and X-band
  - This can be accomplished without a portable DORIS beacon
- Standard gain horns and S/X-band COTs signal generators can be used to construct test beacons
- Test beacons are simpler in design, provide more flexibility in field testing, and will not interfere will normal IDS/SLR operations

Source Cygnus @ Az = 0-90 deg, 270-360 deg, i.e North

- 2500 Janskys reference point
- RFI Threshold 40 degrees in elevation, N→NE, then near Zenith → NW → N 20 in elevation



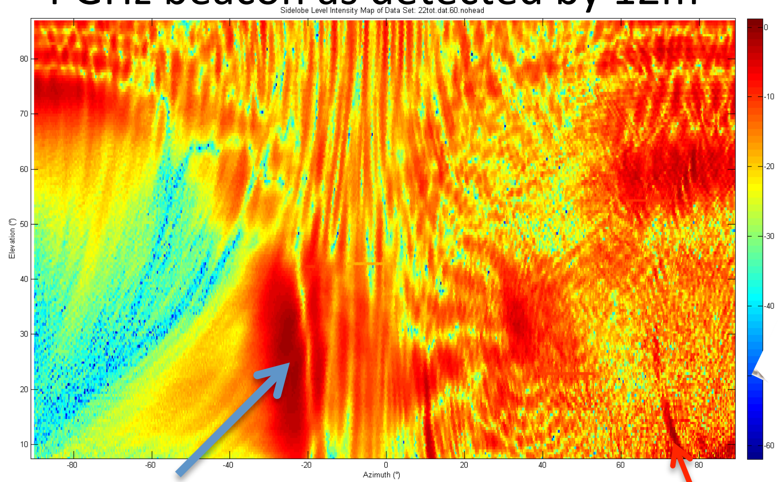


- Effects on Total Power Integrator (TPI) readings both on and off source also plotted

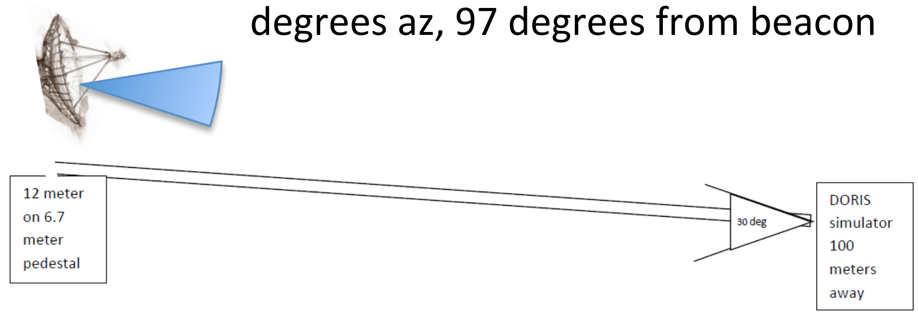
100 meter radius around 12 meter antenna @ GGAO

12 meter pattern Simulator @100-200 meters

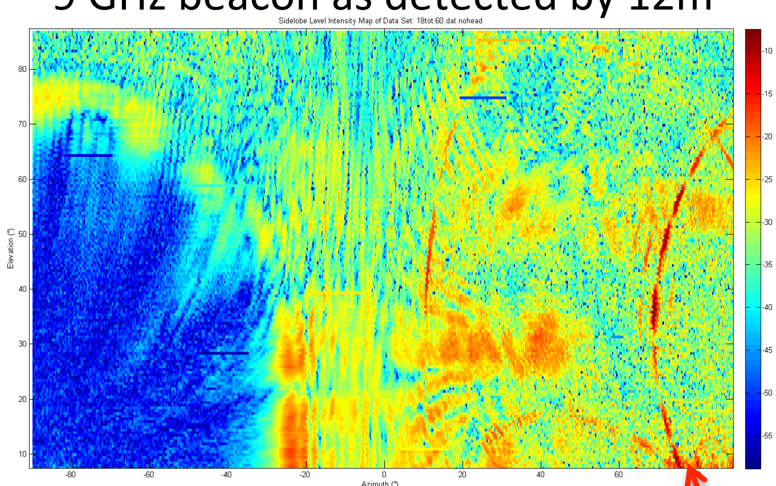
- 4 GHz beacon as detected by 12m

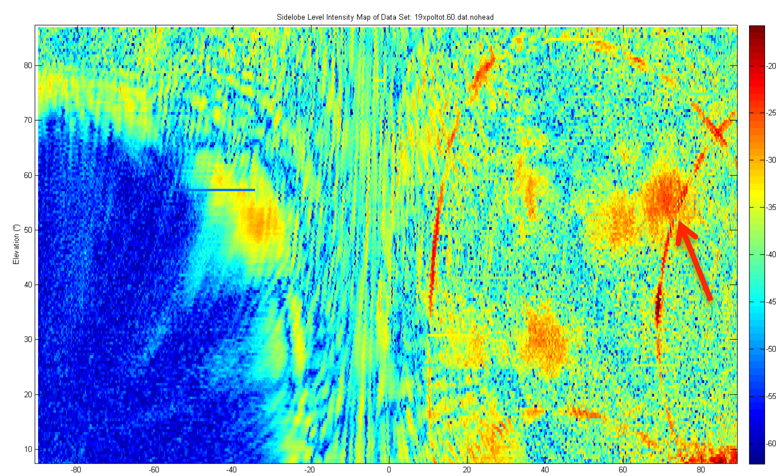


- 12 meter scans to 7 degree minimum in elevation, beacon placed ~4 degrees below horizon
- Beacon @ 72 degree in azimuth detected in all 3 cases
- Large sidelobe at low els and -25 degrees az, 97 degrees from beacon



- 9 GHz beacon as detected by 12m





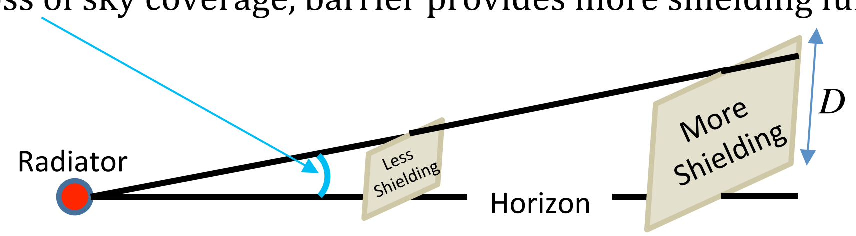
- 9 GHz beacon as detected by 12m X-pol

RF Compatibility Methodology

Barrier Design Considerations

- Only reflective-type barriers considered so far
  - Electromagnetics analysis method: Uniform Theory of Diffraction (UTD)
  - Conceptual design of SLR radar and DORIS barriers are underway

- For given loss of sky coverage, barrier provides more shielding further from the transmitting source



- Restricting size of the barriers in initial simulations such that the 12m antenna is in the far-field of barrier

$$R_{ff} = \frac{2fD^2}{c}$$

- The following are VLBI shielding requirements needed to permit tolerable VLBI signal-to-noise degradation when pointing within 5° of SLR or DORIS at 100m separation:
  - 26 dB DORIS
  - 37 dB SLR when radar pointing no less than 10° elevation
  - Both specifications assume the ITU-R SA.509 sidelobe envelope is valid model for the 12m and radar antennas

RF Compatibility Methodology

Barrier Design Considerations

- DORIS multipath requirement also weighs into the DORIS barrier design
  - Currently assuming that barrier multipath should introduce no more than ±1dB perturbation in DORIS-expected power levels above 10° elevation mask

- It is likely that both VLBI and DORIS will need to sacrifice sky coverage to meet the requirements of the respective techniques
  - It should be possible to achieve this compromise in a sky-coverage-equitable way
  - With a barrier, the sky loss is expected to be no more than 15° toward each technique

RF Compatibility Methodology

Barrier Field Testing

- Testing VLBI compatibility is not very time intensive (1-2 days)
- Testing DORIS compatibility requires ~30 days of observation to detect multipath interference that may be introduced by a barrier
- Proposed course of action:
  - Confirm barrier designs meet VLBI expectations using test beacon and then mobile DORIS beacon to minimize conflicts with DORIS operations
  - If DORIS barrier design meets VLBI expectations, then embark on the 30 day DORIS observing campaign
- Before field testing of SLR radar barriers, minimum elevation angle (max power) must be established to develop barrier design.