RF Propagation Research

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Summary of Presentation

- Introduction
- GRC Propagation History: 1990-2002
- Recent Experimental Results
- Future Work

RF Propagation Research

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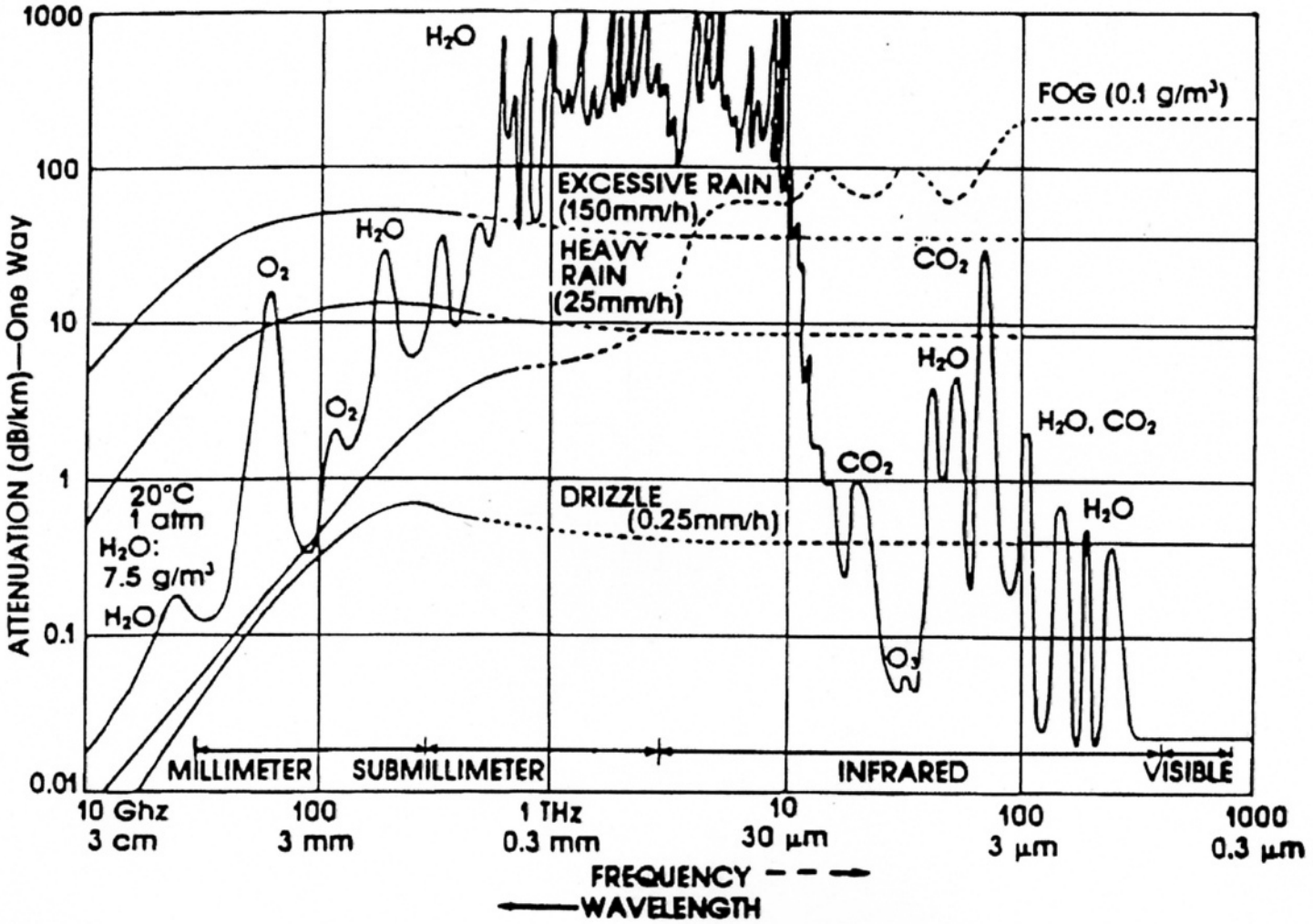
Attenuation of Millimeter Waves by Fog, Rain, and Atmospheric Gases



Major Results and Accomplishments

Link Availability

- GEO CW beacon link experiments performed at 20 and 27.5GHz
- Thirty five station years (1992-1996)
- Seven sites dry to sub-tropical rain region
- Elevation angles from 10 deg to 60 degrees

Rain Attenuation Modeling and Prediction

- Best model relative to the ACTS data developed
- International Telecommunication Union Radiocommunication (ITU-R) Accepted
- Still, Model predictions has a 20% error (in dB) in all rain zones

Scintillation Effects

- Effect characterized over dry to semi-tropical rain regions
- Lowest elevation angle was 10 degrees
- Thirty five station years

Wet Surface Effects

- Effect characterized in a sub-tropical region
- Wet antenna model was developed (< 2% error)
- One station year (1998)

Rain and Ice Depolarization

- Effect characterized over a dry to sub-tropical region
- Thirty five station years

What issues are still unresolved?

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Link Availability	- No beacon data is available above 27.5 GHz - ACTS data did not investigate tropical rain zone (worse case)
Rain Attenuation Modeling and Prediction	- Model prediction at 20- 27.5 GHz developed by the ACTS propagation campaign has a 20% error even at the dry rain zone (best case) - No validated models above 27.5 GHz
Scintillation Effects	- No data available for frequencies above 27.5 GHz
Wet Surface Effects	- No data available for frequencies above 27.5 GHz
Wet Radome Effects	- No data available for frequencies above 27.5 GHz
Rain and Ice Depolarization	- No data available for frequencies above 27.5 GHz
Spatial de-correlation	- No data available at 20–41 GHz
Frequency de-correlation	- No data available at 20-41 GHz

Tropical Data Collection 20.7 GHz

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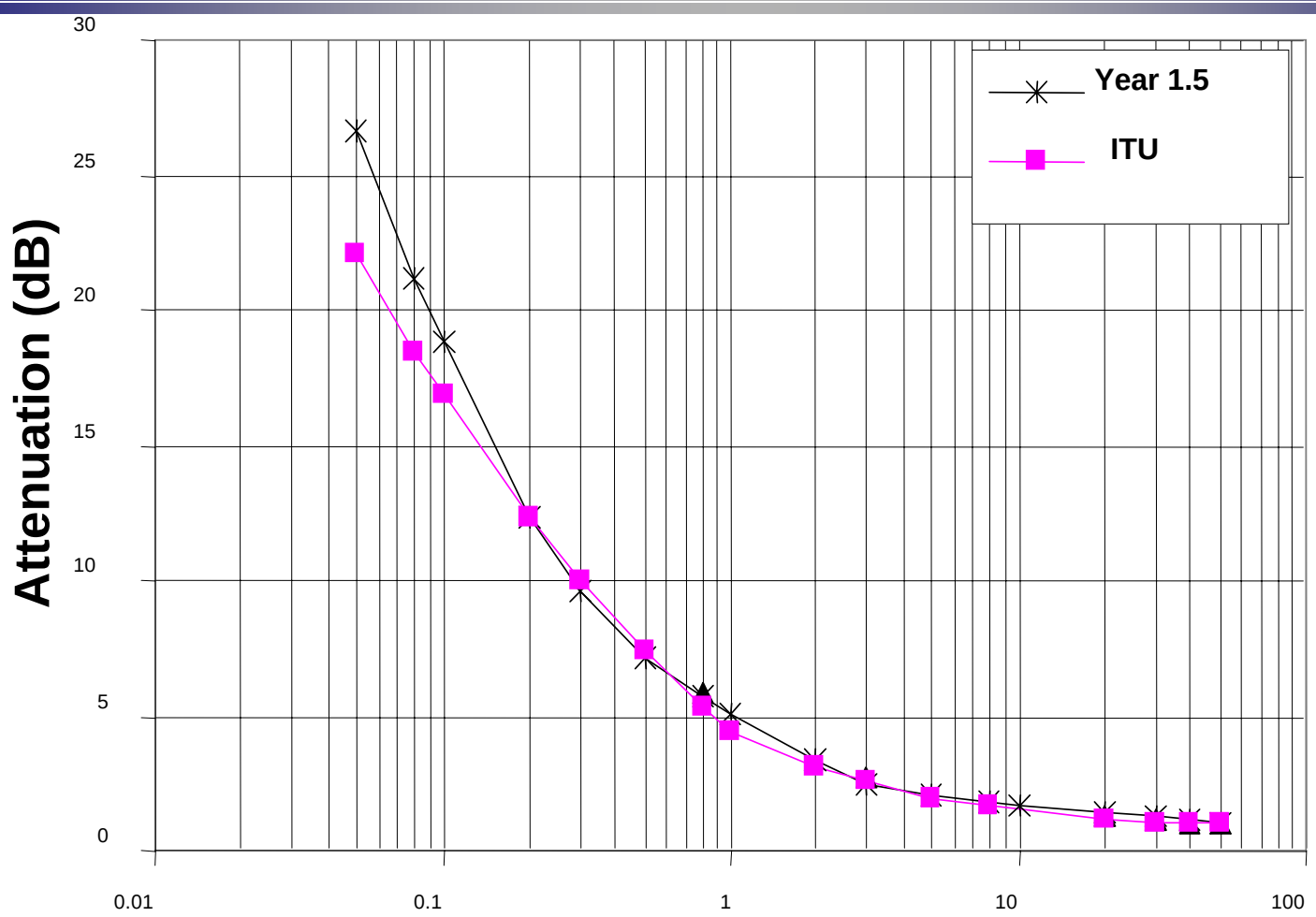
Humacao, Puerto Rico

Outdoor Unit 1.2 m

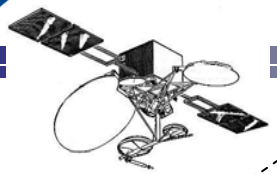
Indoor Unit

Tropical Data Analysis - Results 1.5 Years



Note – Prediction error > 20 %

Spatial De-Correlation Experiment



ANIK F2 (111.1 Deg.)

20.2 GHz

Water Vapor Distribution

Data Collected-

1- 20 Hz – 1 Hz : I,Q Co-Polarization

2- 20 Hz – 1 Hz: I,Q Cross-Polarization

3- 1 Hz Radiometer Voltage

4- 1 Hz :Surface Temperature, Barometric Temperature, Relative Humidity

5- Tipping Bucket

Rb GPS Discipline Oscillator

DAC

A/D

1 pps

10MHz

5m- 500 m

A/D

DAC

1 pps

10MHz

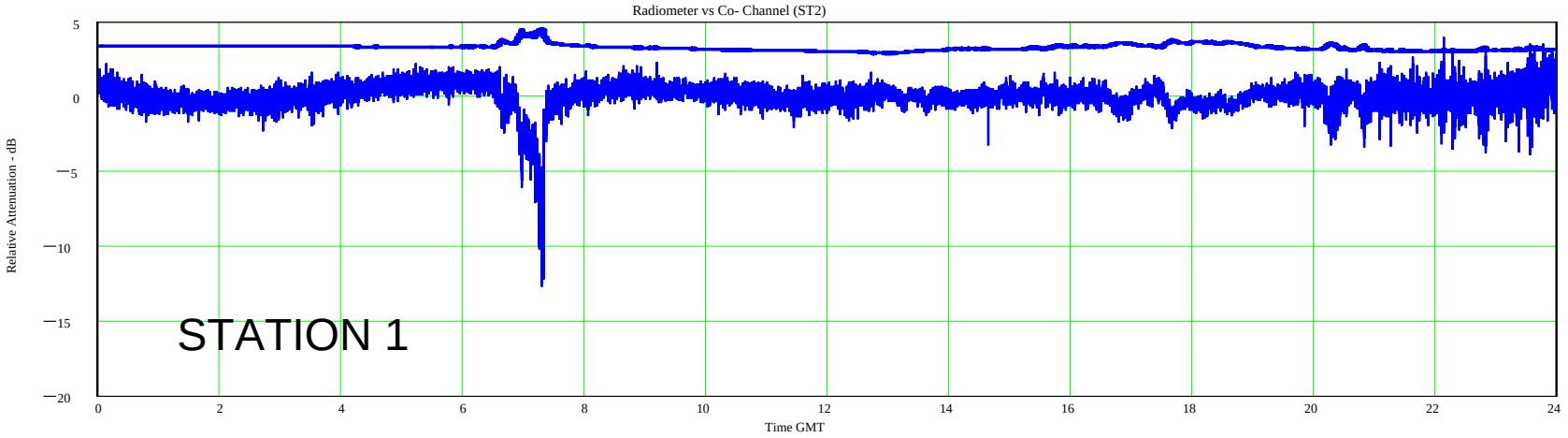
Rb GPS Discipline Oscillator

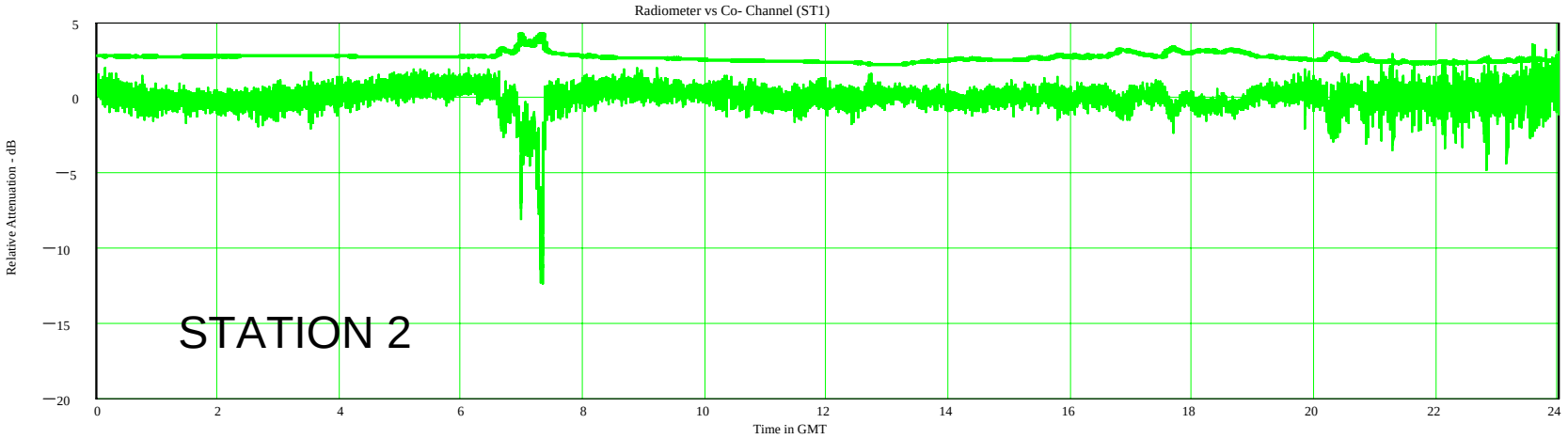
Amplitude Decorrelation at 20.7 GHz

Baseline 5 m

Baseline 500 m

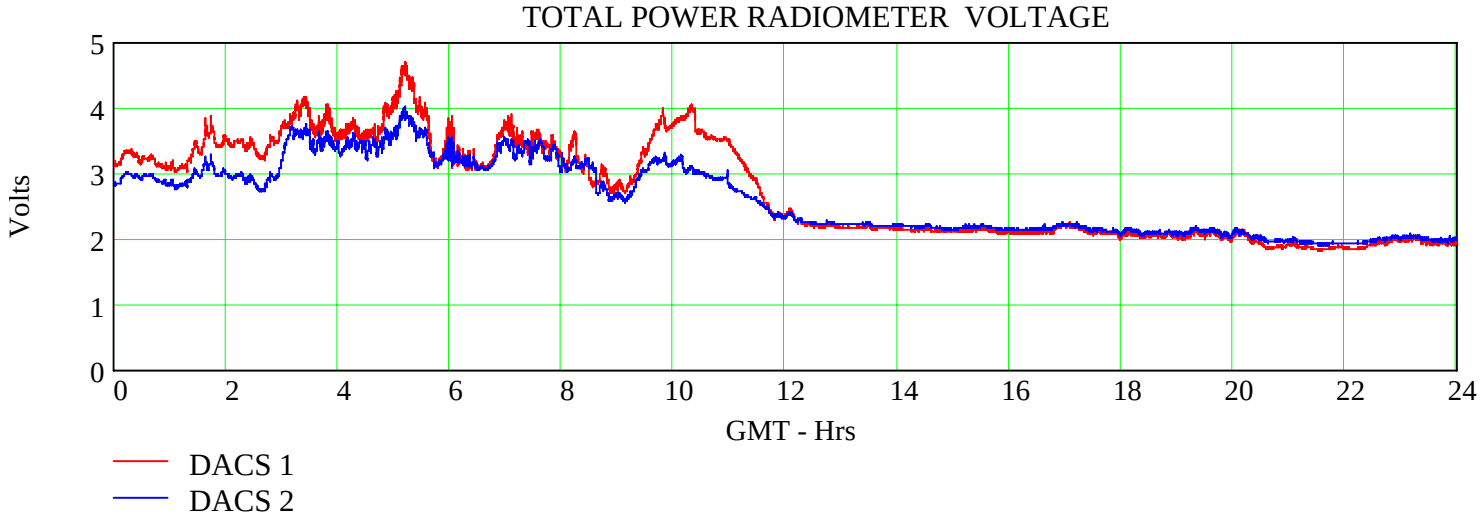
Amplitude Decorrelation - Results
Baseline 5 m

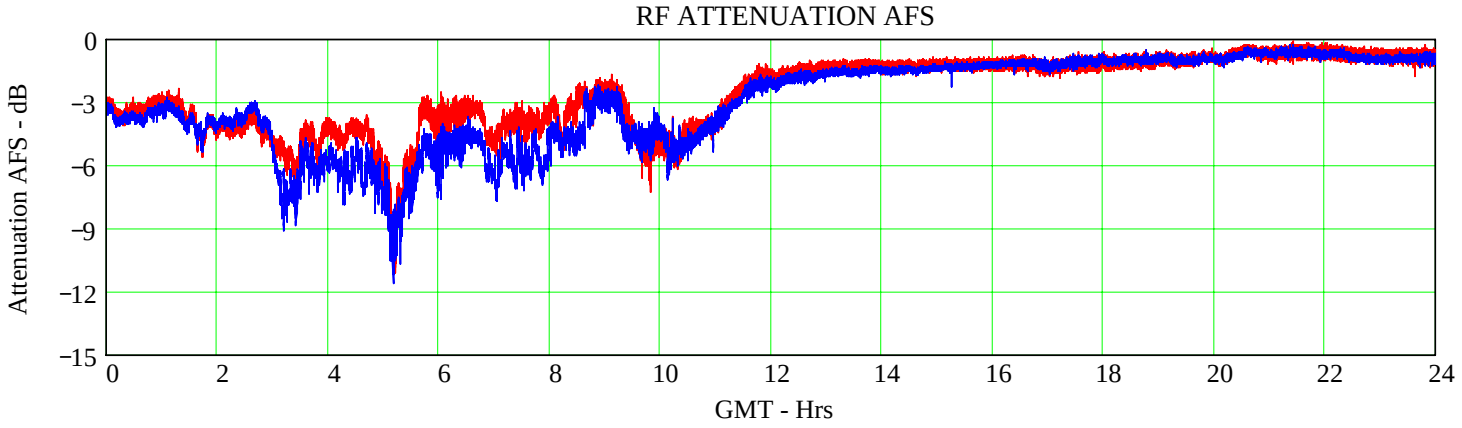




Site: Cleveland, Ohio
Event : November 20, 2005
Rain : 0.1 in (< 40 mm/hr)

Amplitude Decorrelation - Results
Baseline 500 m





Site: Cleveland, Ohio
Event : January 18, 2006
Rain : 0.28 in (< 40 mm/hr)

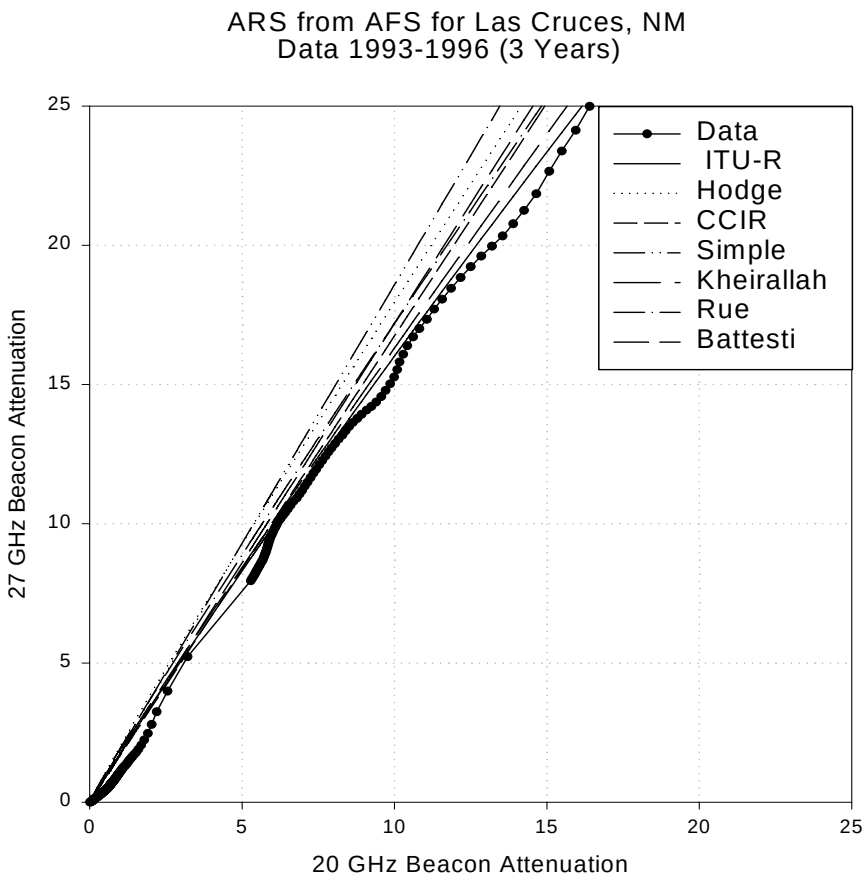
FUTURE WORK -Amplitude and Phase Decorrelation at 20.7 GHz (FY07)

Measurements Site

1.2 m Outdoor Equipment

2 x 1.2 m Interferometer – Baseline 5m, 500m and 1.5 Km

Amplitude Scaling 20 and 27 GHz (Well Documented)



No RF sources are available for direct measurements at near-earth (26 GHz) or DSN frequencies (32 – 38 GHz) for long term observations. Extrapolation techniques will be required to predict performance at these frequencies from observations made at K-band.