N93-26479

THE VIRGINIA TECH OLYMPUS PROPAGATION EXPERIMENT

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Abstract - Virginia Tech has been carrying out a comprehensive set of propagation measurements using the OLYMPUS satellite beacons at 12.5, 20, and 30 GHz since August 1990. Total power radiometers are also included in each terminal, and radiometer data are used both to set the absolute level of the beacon data and to predict path attenuation. This paper presents some results from the experiment set.

1. Introduction

The European Space Agency launched the OLYMPUS satellite in July 1989. In addition to communications experiment packages in Ku- and Ka-bands, OLYMPUS has frequency coherent propagation beacons at 12.5, 19.77 and 29.66 GHz. These beacons are visible from Blacksburg at an elevation angle of 14°. Virginia Tech has four receivers, one at each frequency plus a second portable terminal at 20 and 30 GHz for short-baseline diversity measurements.

The receiving system was constructed to take advantage of the frequency coherent beacons. A frequency locked loop derives frequency tracking information from the 12 GHz receiver which experiences smaller fading than that at 20 and 30 GHz. This permits accurate fade measurements of the relatively frequently occurring deep rain fades (25 dB or more) on 20 and 30 GHz. The 12 GHz derived FLL also permits rapid reacquisition after loss of lock.

Measurements at Virginia Tech began in August 1990. Statistical results are currently being processed. These include; fade, fade rate, and fade duration for rain and scintillation events. Frequency scaling results are especially valuable due to the common elevation angle and location of the receivers. Initial results confirm the somewhat less than frequency squared scaling law. For a diversity separation of 50 m for the two 20 GHz receivers, no improvement during rain fading is experienced, while decorrelation for scintillation events is common.

Data have been recorded continuously since August 1990, with a break during June and July 1991 when the satellite was not on station.

2. The Measurement System

The propagation experiment system at Virginia Tech continuously records the 12.5, 20, and 30 GHz OLYMPUS beacons using receiving antennas 12, 5, and 4 feet in diameter, respectively. A block diagram of the measurement system is shown in Figure 1.

Clouds and scintillation can produce up to 3 dB of attenuation at 30 GHz on a 14° elevation-angle path and may be present for a large percentage of the time. Therefore, it is important in a slant-path propagation experiment to be able to set the clear air reference level accurately. Total power radiometers operate at each beacon frequency in our receiving system to aid in setting this clear air reference level.

The output of the receivers and radiometers are continuously monitored by a PC-based data acquisition system (DAS). Analysis of the propagation data is performed using several 386-class PCs.

3. The Experiment Program

The experiment provides a number of primary and secondary attenuation statistics. Beacon attenuation cumulative distributions referenced both to free space and to clear air are produced. Frequency scaling between frequencies is determined. Secondary statistics such as fade slope, fade duration, and fade interval are also generated. Radiometer predictions of attenuation are also produced.

The Olympus experiment has also been used to study small scale diversity and uplink power control applications. Here it is hoped that on a 20/30 link with rain fading on the uplink at 30 GHz the control of the uplink power level can be based on beacon measurements at 20 or 30 GHz.

4. Results

Attenuation statistics have been derived so far for the months of January, February and March 1991. Figure 2 shows an example of cumulative distributions for the period January through March 1991.

Scintillation events have been analyzed. The spectrum at all frequencies obeys the popular - 8/3 power law. The diversity site (up to 50 m separation) does offer a small improvement for scintillation events, but not for rain events. Some example of statistics for attenuation and fade duration at 20 and 30 GHz are shown in Figs. 2, 3, and 4. An example of the diversity effect in a 20 GHz scintillation event is shown in Fig. 5. The terminal separation was about 50 m.

Figure 1

THE OLYMPUS EXPERIMENT SYSTEM AT VIRGINIA TECH

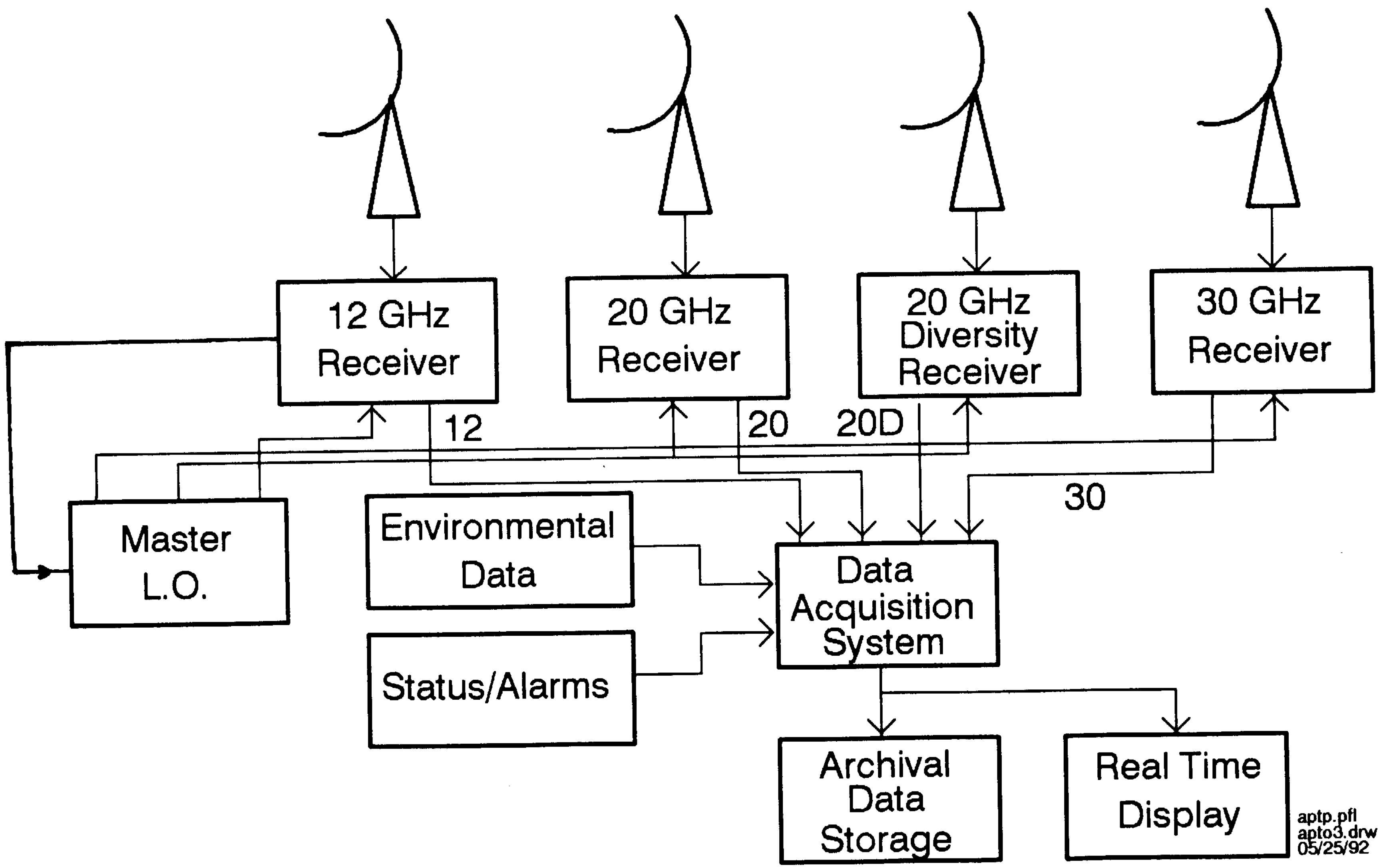
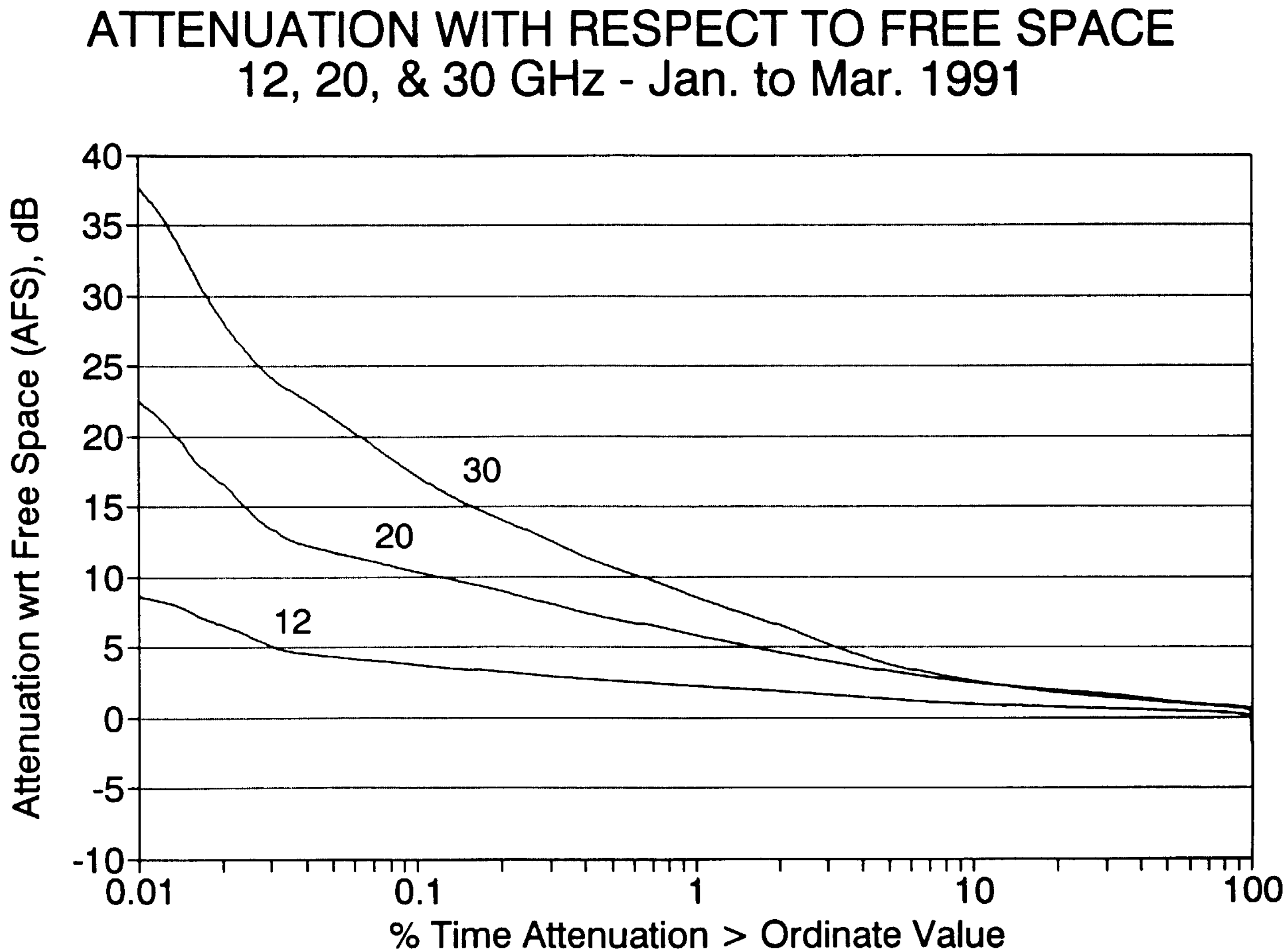


Figure 2a

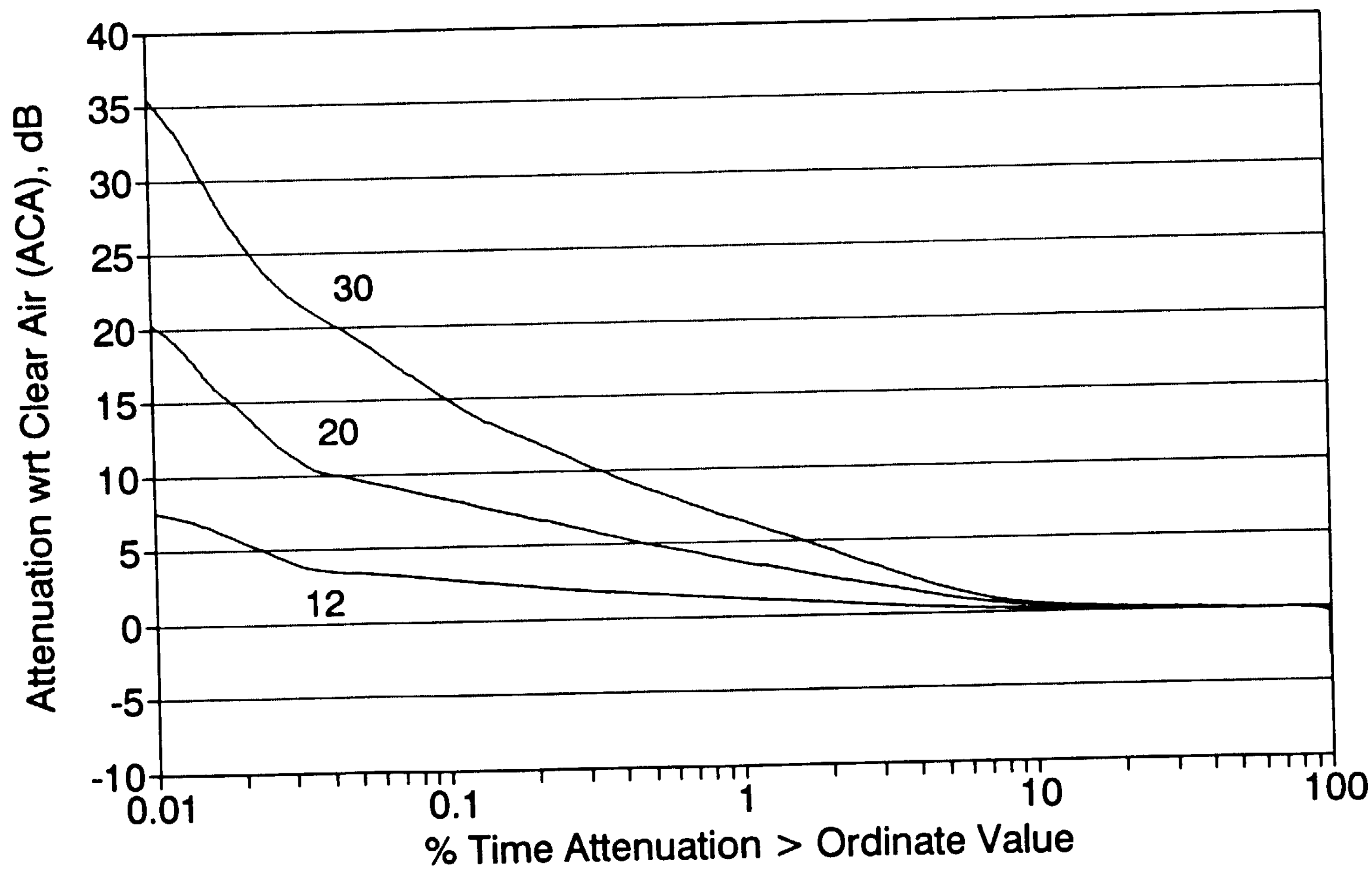


* Common Time Base

05/26/92 - JDL

Figure 2b

ATTENUATION WITH RESPECT TO CLEAR AIR
12, 20, & 30 GHz - Jan. to Mar. 1991



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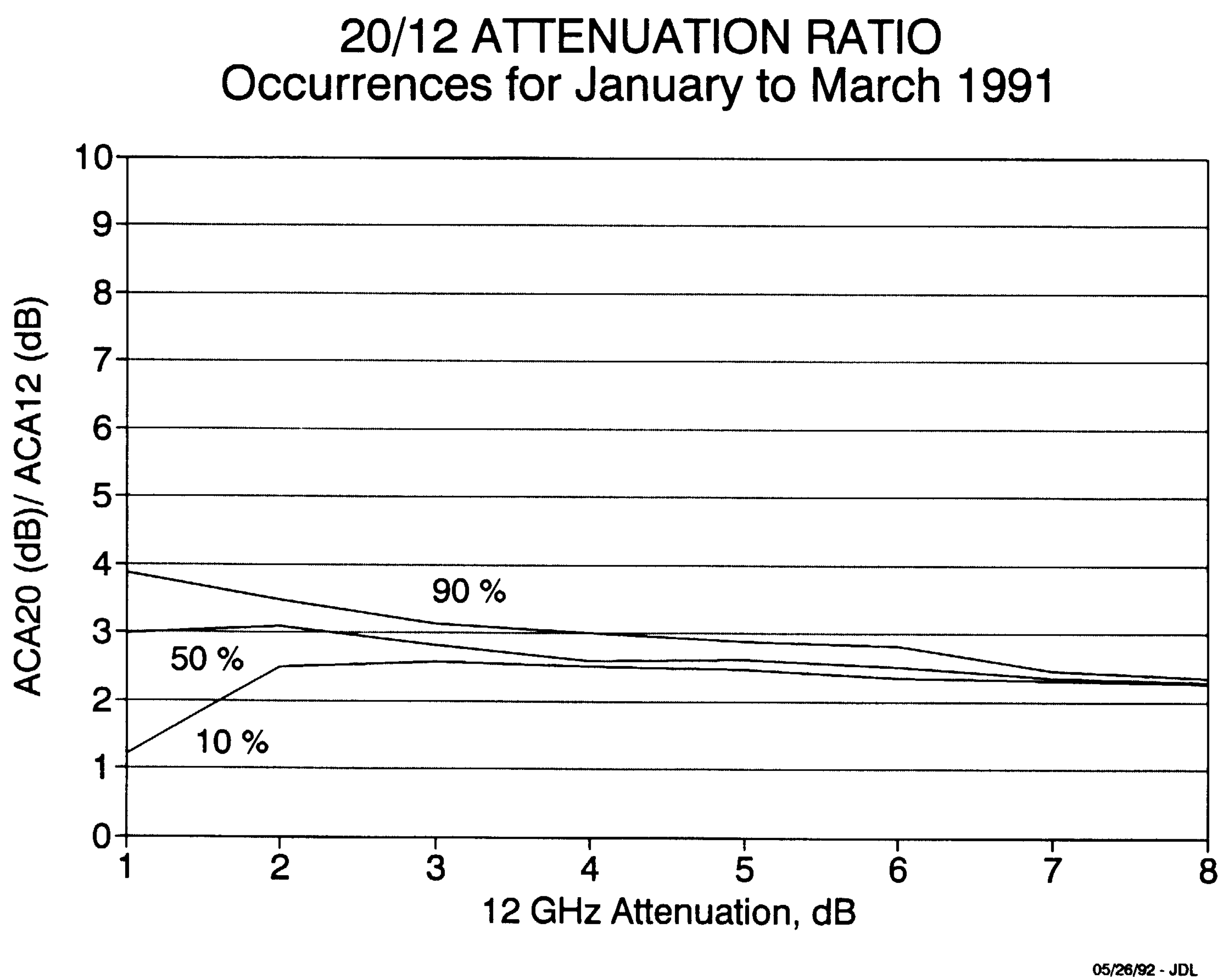
* Common Time Base

Figure 2c



20/12 ATTENUATION RATIO
Occurrences for January to March 1991
ACA20 (dB)/ ACA12 (dB)
10
9
8
7
6
5
4
3
2
1
0
90 %
50 %
10 %
1
2
3
4
5
6
7
8
12 GHz Attenuation, dB
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Figure 3a

FADE DURATION FOR JANUARY 1991
Events Exceeding 10 dB at 20 & 30 GHz

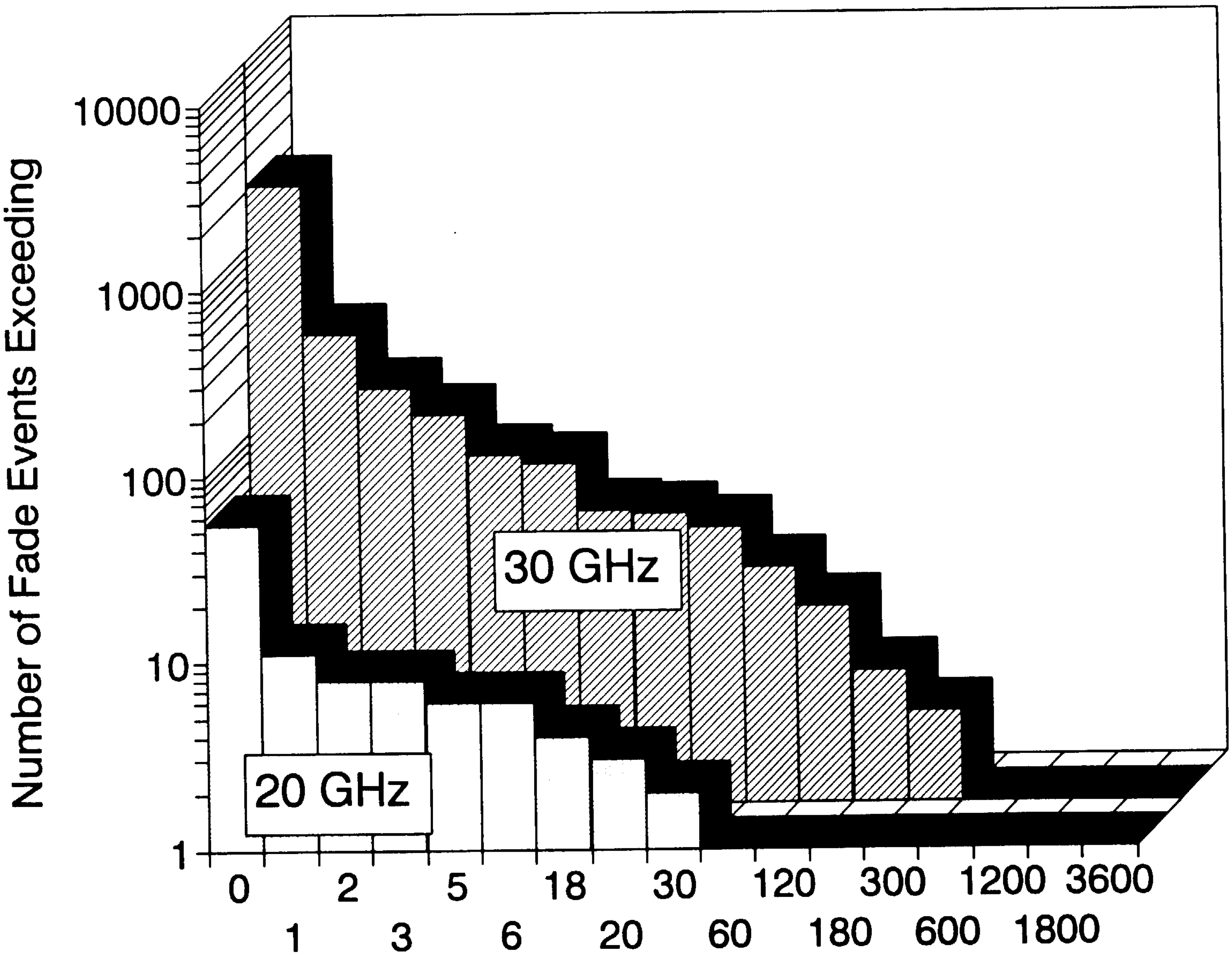

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Figure 3b

FADE DURATION FOR JANUARY 1991
Events Exceeding 5, 10, 20 dB at 30 GHz

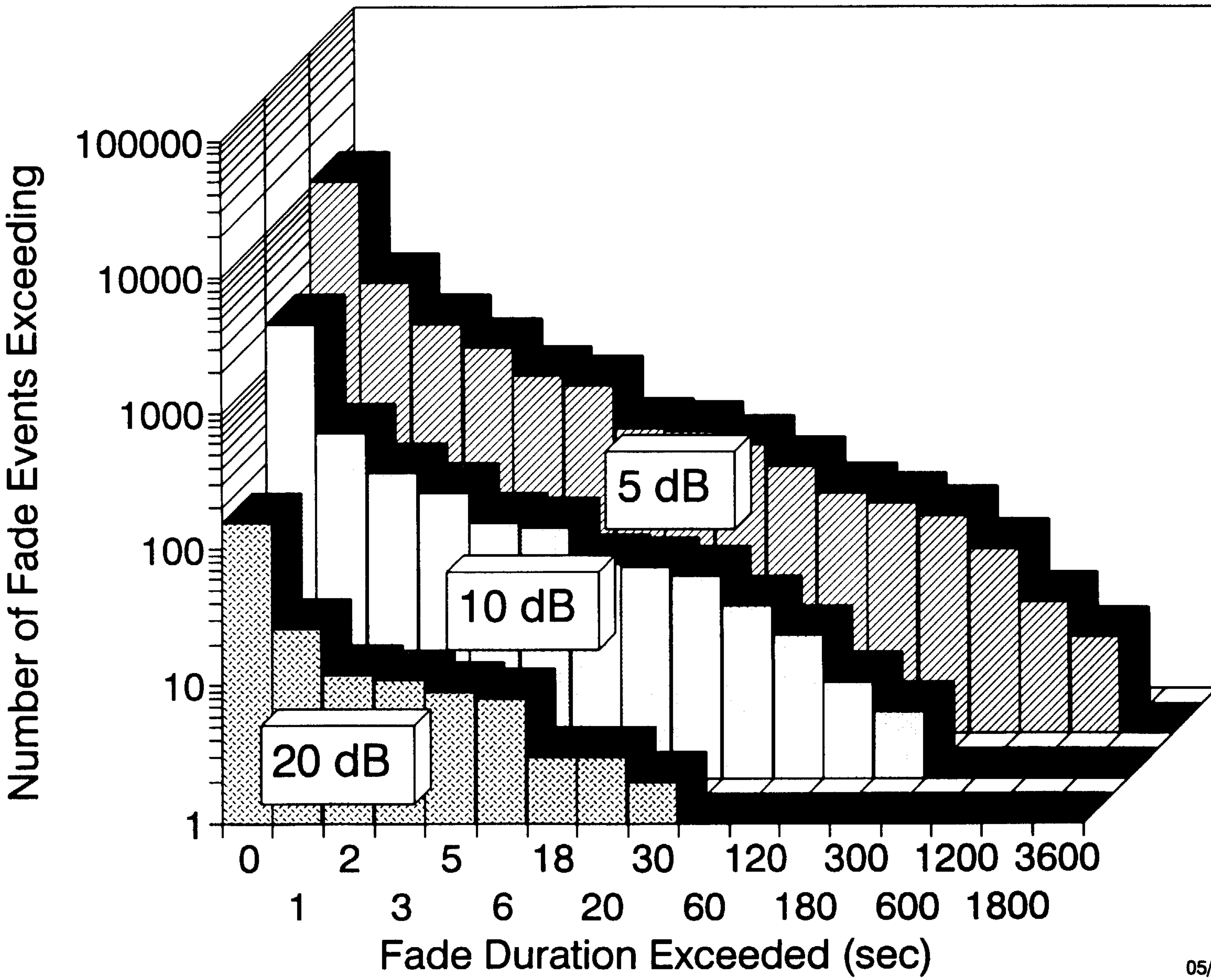

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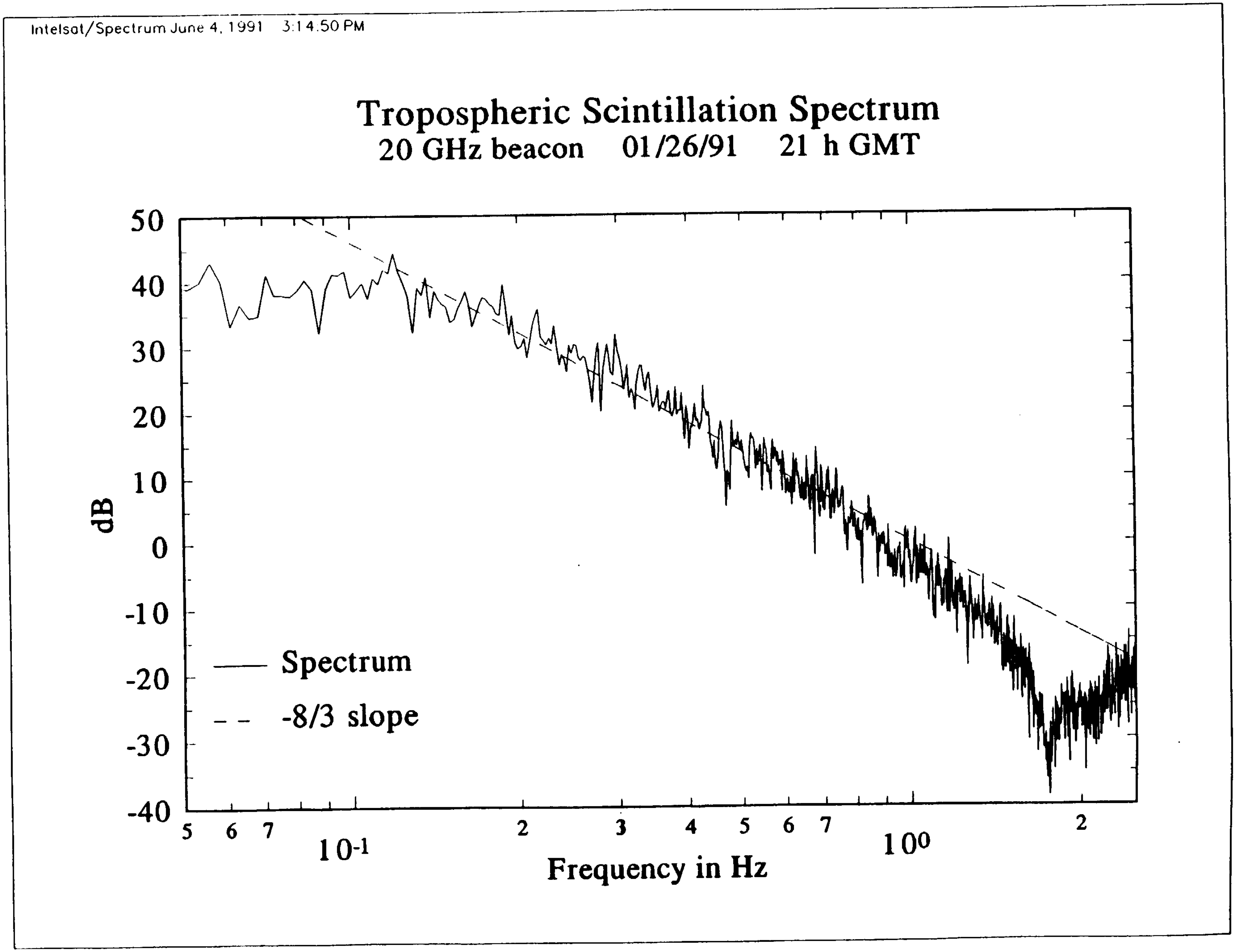
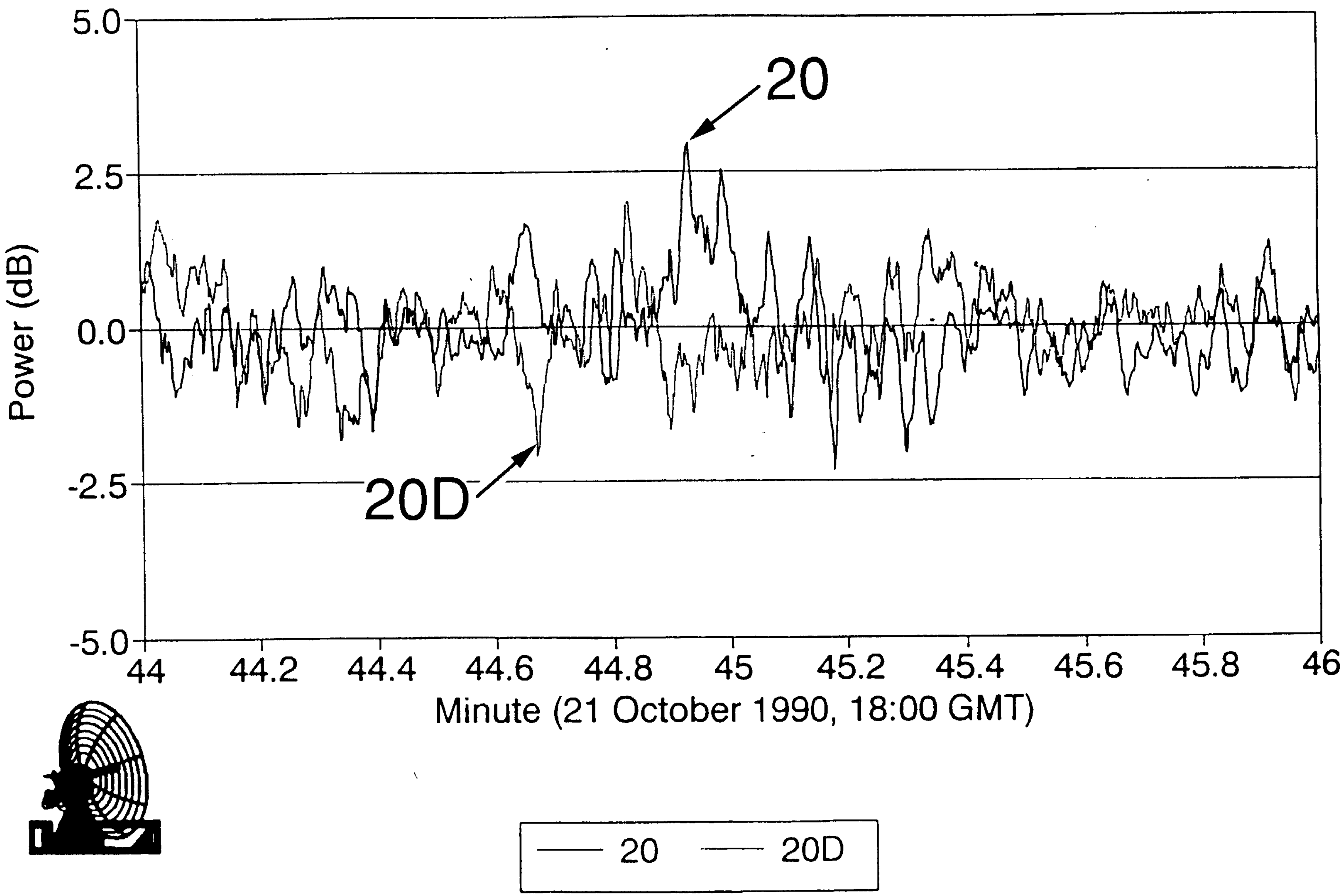
Figure 4



Intelsat/Spectrum June 4, 1991 3:14:50 PM
Tropospheric Scintillation Spectrum
20 GHz beacon 01/26/91 21 h GMT
50
40
30
20
10
0
-10
-20
-30
-40
dB
5 6 7
10-1
2 3 4 5 6 7
100
2
Frequency in Hz
Spectrum
-8/3 slope

Figure 5

DIVERSITY RESULTS



A major use for our data is in uplink power control studies on narrow margin communication links as for Ka-band VSAT application.

5. Conclusions

The Olympus experiment at Virginia Tech has been collecting data for 22 months. The collection of simultaneous data at three frequencies spanning the 12 to 30 GHz region is extremely useful. The 14° path elevation angle is relatively low and data in this region are useful because this is at the lower limit for CONUS coverage with domestic satellites.

Statistics for attenuation relative to clear air and free space are now being assembled, and the first three months in 1991 have been completed. Results are available from the frequency scaling, small scale diversity, and scintillation studies. Numerous events have been observed in which attenuation at 20 and 30 GHz exceeds 30 dB.