ANALYSIS OF THE ACTS-VANCOUVER PATH PROPAGATION DATA

1st December, 1993 — 30th November, 1995

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Outline

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2. Data Description
3. Attenuation Due to Wetting of Antenna Surfaces
4. Observed (Total) Attenuation Statistics
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1. SITE DESCRIPTION

Location

University of British Columbia, Vancouver, Canada
49°] 5’ N latitude
123° 15’ W longitude

Elevation

164.6 metres above mean sea level

Antenna Orientation

Elevation angle: 29,4°
Azimuth: 150° clockwise from true north

Climate

ITU-R rain climatic zone D
Between rain zones B 1 and C in Crane’s classification

2. DATA DESCRIPTION

The data described here cover a two-year period, 1st December, 1993 to 30th November, 1995. The anal ysis is done for two sets of valid data:

(a) observed or total attenuation data, which include all at mospheric effects plus the additional attenuation resulting from wet antenna surfaces during rain events, and

(b) adjusted attenuation data: the same data as in (a) minus estimated values of attenuation due to wetting of antenna surfaces.

In both cases, average and worst month CDFS, fade-duration statistics and fade-slope statistics for the 20 and 27 GHz beacons are presented.

30 ATTENUATION DUE TO WETTING OF ANTENNA SURFACES

The detailed analysis will be presented in a proposed paper for the Special Issue of the Proceedings of IEEE. The main points are summarized here.

(i) The surfaces involved are those of the parabolic dish and the membrane covering the feed horn.

(ii) The theoretical analysis is relatively simple, as it assumes a uniform layer of water on the surfaces. This assumption, however, is far from being representative of a real situation, and the corresponding results can only serve as a guideline, Figs. 1 to 3.

(iii) Since the effect of wetting depends on many factors (e.g., elevation angle, type and condition of surface, rain rate, drop-size distribution, wind speed and direction, temperature, humidity, etc.), some experimental input was, therefore, considered necessary.

(iv) Experiments were conducted on clear days using a variety of nozzles pointing upwards and producing showers of different intensity and drop size, which fell on the antenna structure.

(v) The resulting attenuation time series depicts certain characteristics (e.g., Fig 4). The average attenuation did not, however, exceed about 3 dB for the 20 GHz signal and 4 dB for the 27 GHz signal.

(vi) Proposed models for incorporating this phenomenon in the analysis were used to separate out the effect of surface wetting, and obtain the adjusted attenuation values due to atmospheric factors only.

4. OBSERVED (TOTAL) ATTENUATION STATISTICS

The data considered in this section are those directly derived from the observations, without adjustment for the effect of antenna wetting. Only examples of the statistics are shown here.

4.1 Cumulative Distribution Functions (CDFs)

Fig. 5 shows the two-year average for the 20 GHz and 27 GHz signals. The results of frequency scaling between the two frequencies, as described in ITU-R rev. rec. 618-1, are also shown in this figure. Fig. 6 depicts the worst-month statistics.

4.2 Fade-duration Statistics

These are shown in Figs. 7 and 8 for the average month in the two-year period for various thresholds and a block-averaging period that includes 11 samples at one second intervals for the 20 GHz and 27 GHz signals, respectively. The corresponding statistics for the worst month are shown in Figs. 9 and 10.

4.3 Fade-slope Statistics

The fade slopes are calculated by the method proposed by the European Space Agency. The statistics are shown in Figs 11 and 12 for the average month in the two-year period, for the same thresholds and block-averaging period as in 4.2. The corresponding worst-month statistics are shown in Figs. 13 and 14.

5. ADJUSTED ATTENUATION STATISTICS

These are the statistics derived by taking into consideration the effect of antenna-surface wetting. They are shown in Figs. 15 to 24, in the same order as in Section 4.

6. SOME COMPARISONS

This section presents the statistics shown in sections 4 and 5 in a manner which will demonstrate the effects of adjustment due to antenna-surface wetting and average versus worst-month statistics.

6.1 Cumulative Distribution Functions (CDFs)

Figs. 25 and 26 compare unadjusted and adjusted CDFS for the two-year average and for the worst month, respectively. The unadjusted two-year average-month and worst-month CDFS are compared in Fig. 27 while the same comparison for adjusted values is presented in Fig. 28.

6.2 Fade-duration Statistics

The unadjusted and adjusted statistics for the 3 dB threshold and 11-sample block-average for the average month are compared in Fig. 29 for the 20 GHz signal. The same comparison for worst-month statistics is shown in Fig. 30. Fig. 31 presents the comparison between unadjusted average-month and worst-month statistics for the same threshold and block averaging period for 27 GHz. The same comparison for adjusted statistics is shown in Fig. 32.

6.3 Fade-slope Statistics

Similar comparisons showing the effects of antenna-surface wetting on fade-slope statistics are presented in Figs. 33 through 36. The same threshold and block-averaging period is used as for the fade-duration statistics.

7. CONCLUDING REMARKS

7.1 Scope of- the analysis

The statistics presented are for the period 1st December, 1993 to 30th November, 1995. These include average and worst-month statistics pertaining to the CDFs, fade duration and fade slopes.

7.2 Effect of moisture on the antenna surfaces

Statistics, similar to those in 7.1, are also presented, where the effect of antenna-surface wetting during rain events is taken into consideration in an approximate manner. It is shown that moisture clinging to antenna surfaces can significantly affect propagation-data statistics. It must be emphasized however, that this effect depends on antenna type and conditions at the receiving site.

(i) The ITU-R frequency-scaling model appears to apply more closely to the adjusted values rather than the unadjusted.

(ii) For fade duration, the number of events for any particular duration is almost an order of magnitude lower using the adjusted results than for the unadjusted.

(iii) The fade-slope statistics show a similar trend as for fade duration.

7.3 New designs for Ka-band antennas

There appears to be a need for developing Ka-band antennas which do not suffer from the effect of moisture on their surfaces. This is particularly important for systems with low facie margin. The development of such antennas is not only possible but also feasible.

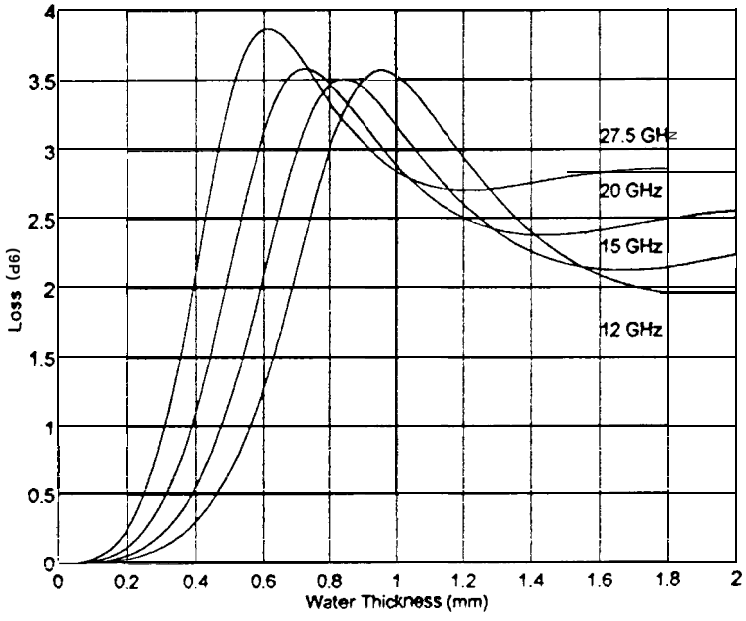

Fig 1 Reflection Loss from Dish

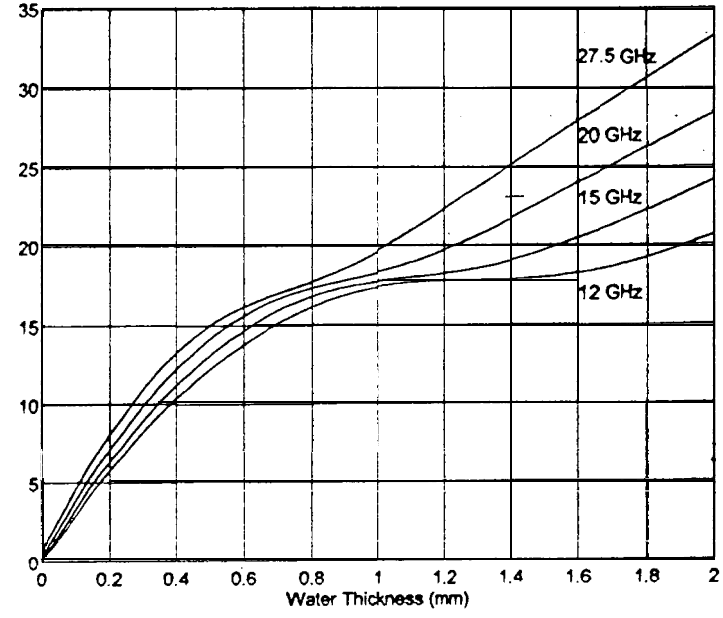

Fig. 2: Total Loss through Membrane

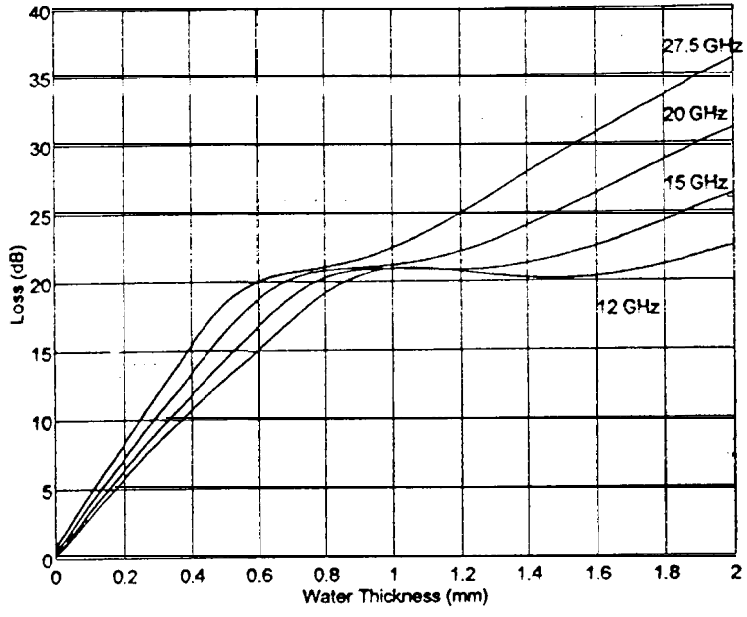

Fig. 3: Total Loss due to Water on Both Dish and Membrane

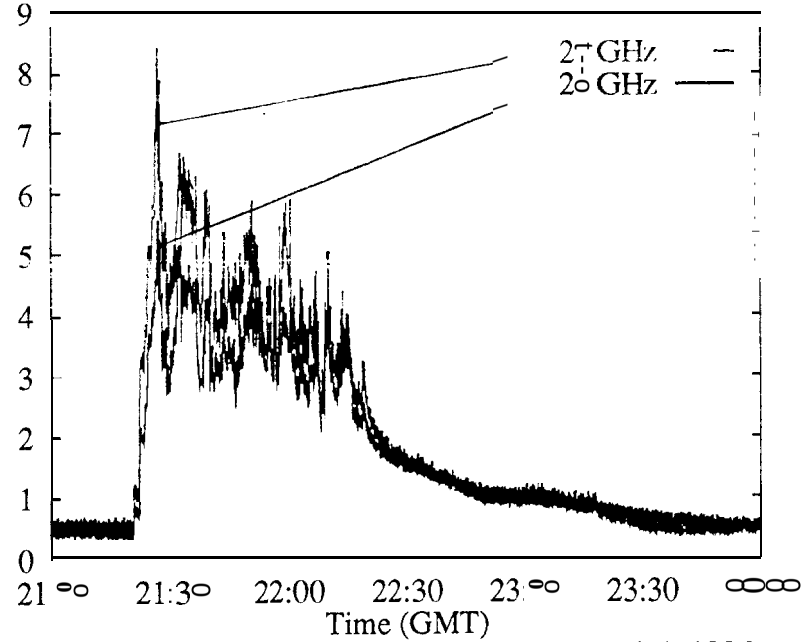

Fig. 4: Antenna Wetting Experiment on March 1 1996

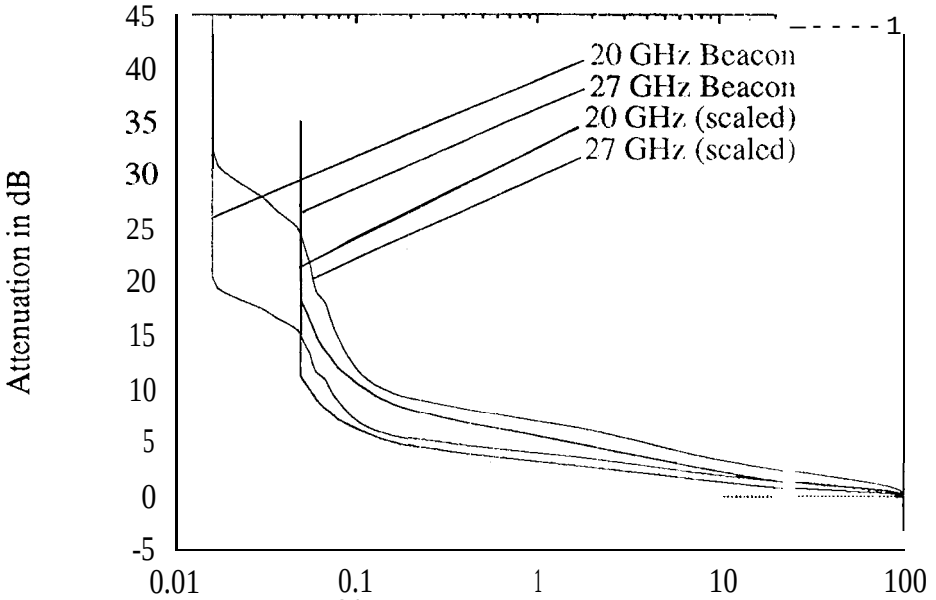

Fig. 5:9312-9511 Unadjusted CDFs

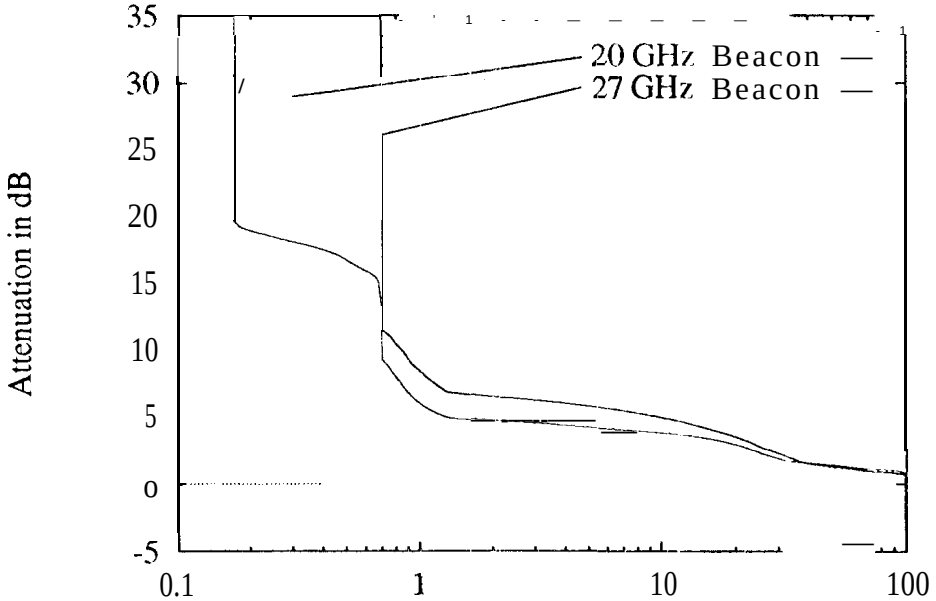

Fig. 6:9312-9511 Worst-Month Unadjusted CDFS

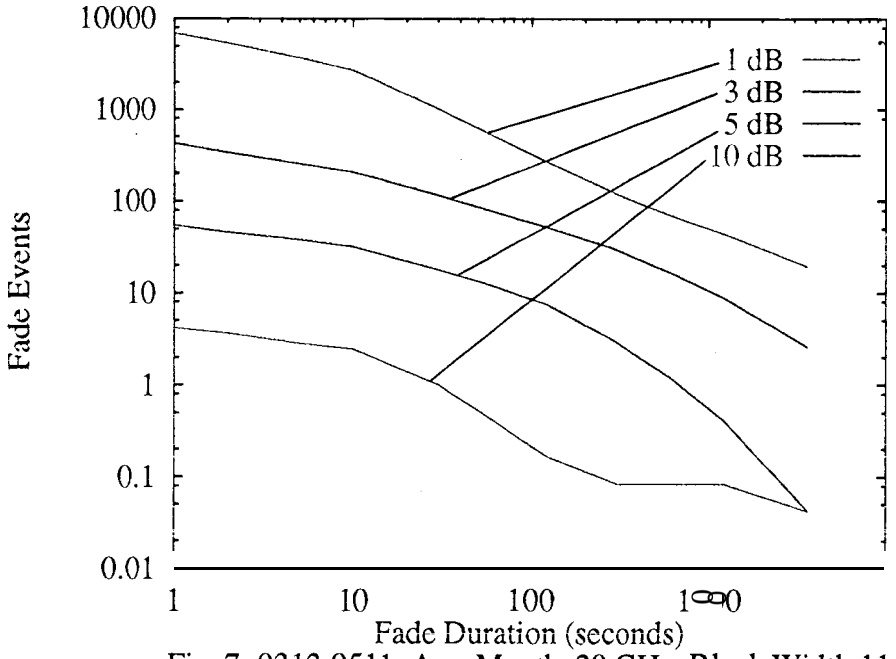

Fig. 7: 9312-9511, Avg-Month, 20 GHz, Block Width 11

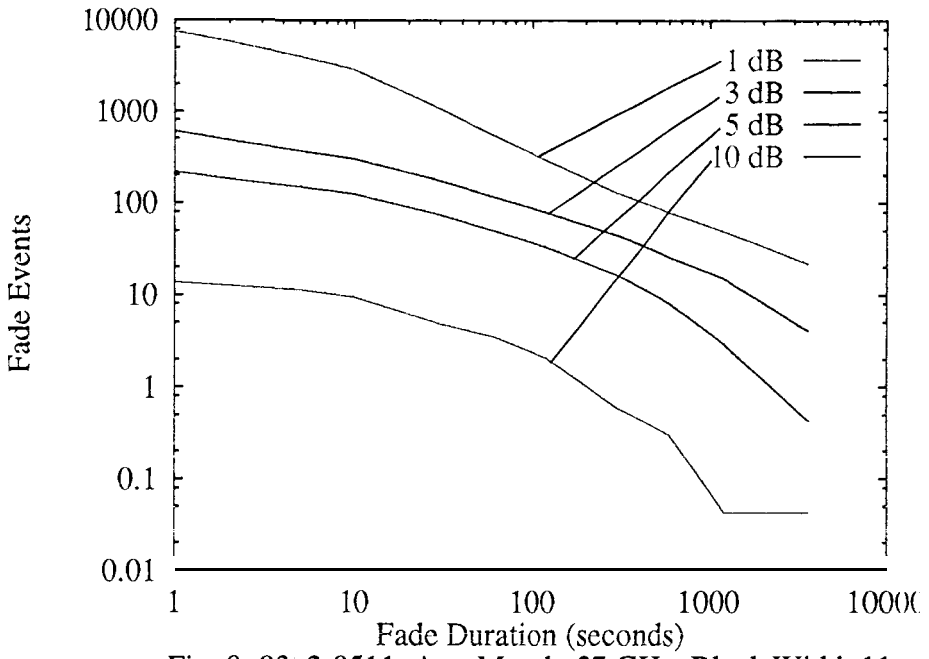

Fig. 8: 93 2-9511, Avg-Month, 27 GHz, Block Width 11

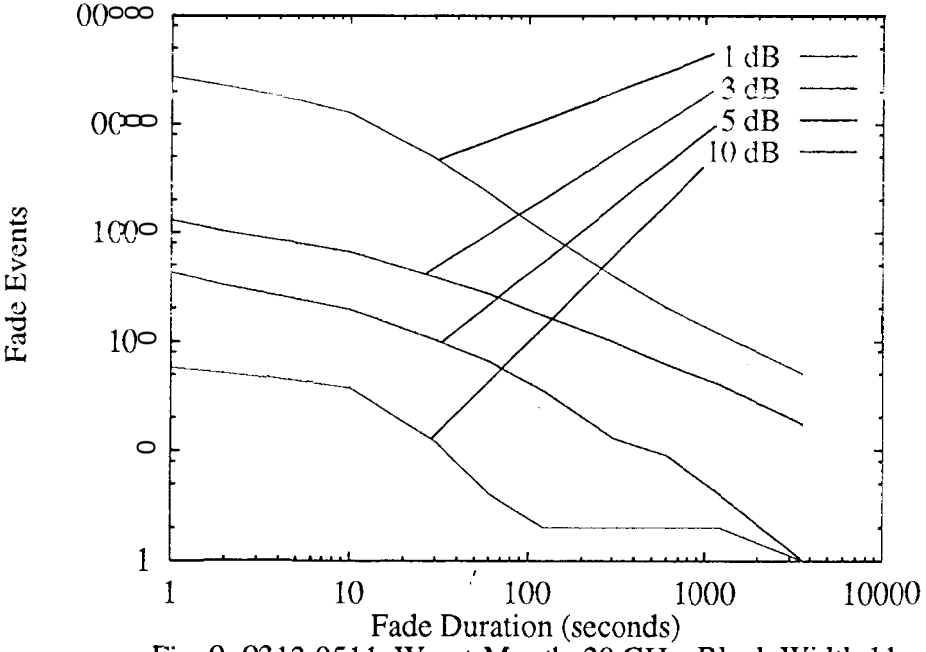

Fig. 9: 9312-9511, Worst-Month, 20 GHz, Block Width 11

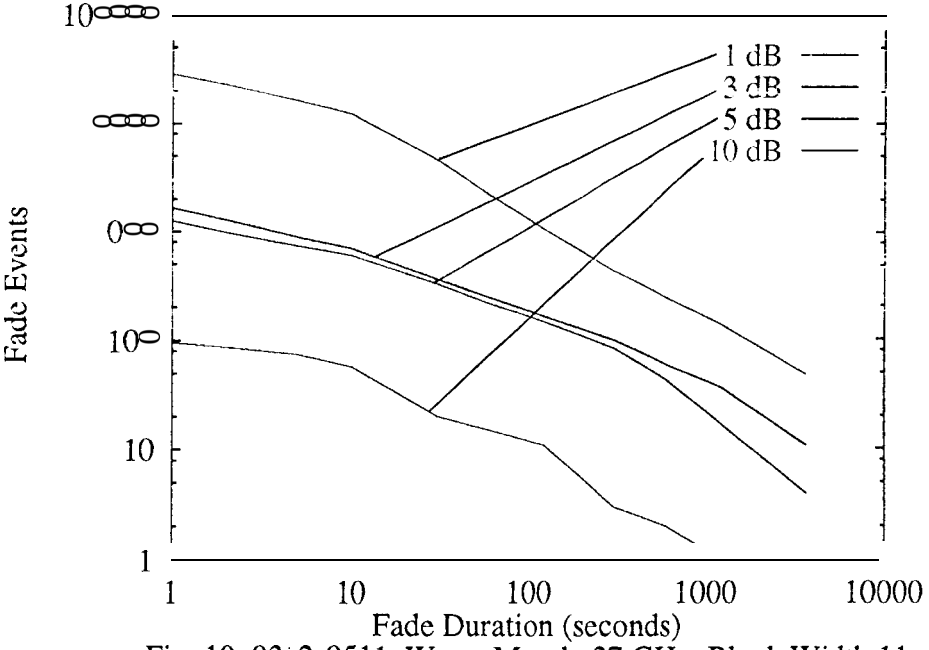

Fig. 10: 93 2-9511, Worst-Month, 27 GHz, Block Width 11

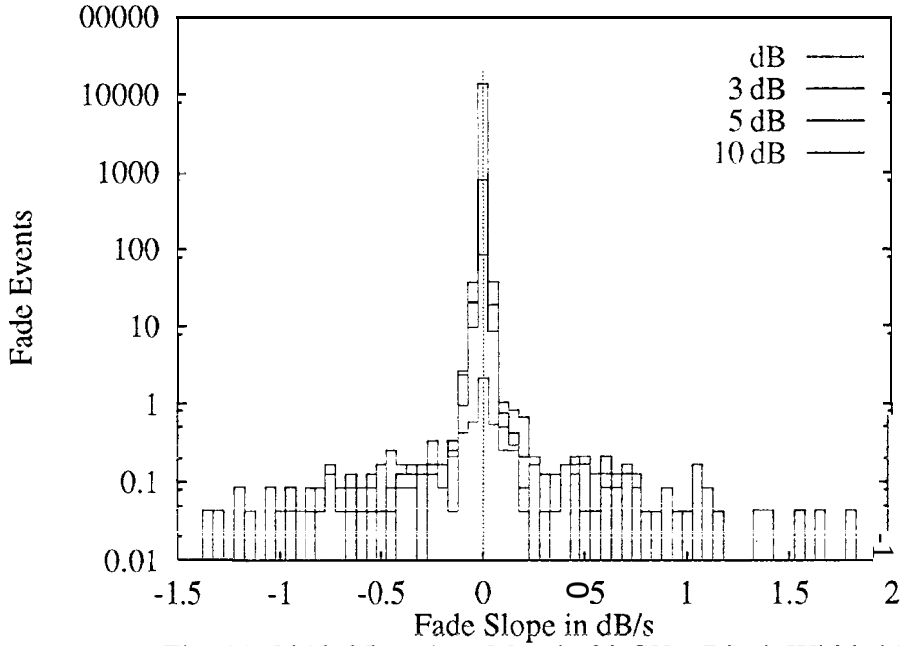

Fig. 11: 9312-95 , Avg-Month, 20 GHz, Block Width 11

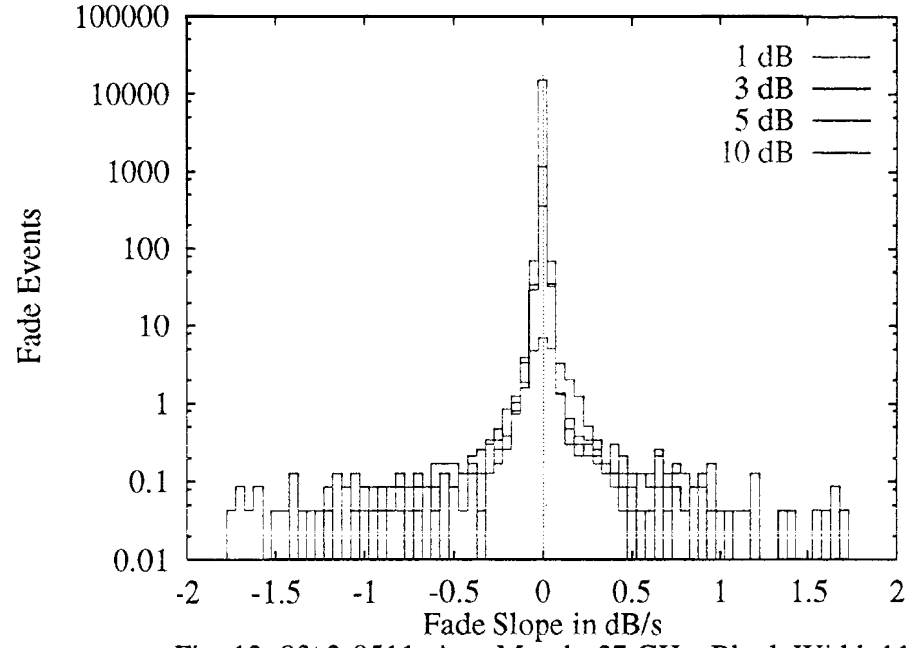

Fig. 12: 93 2-9511, Avg-Month, 27 GHz, Block Width 11

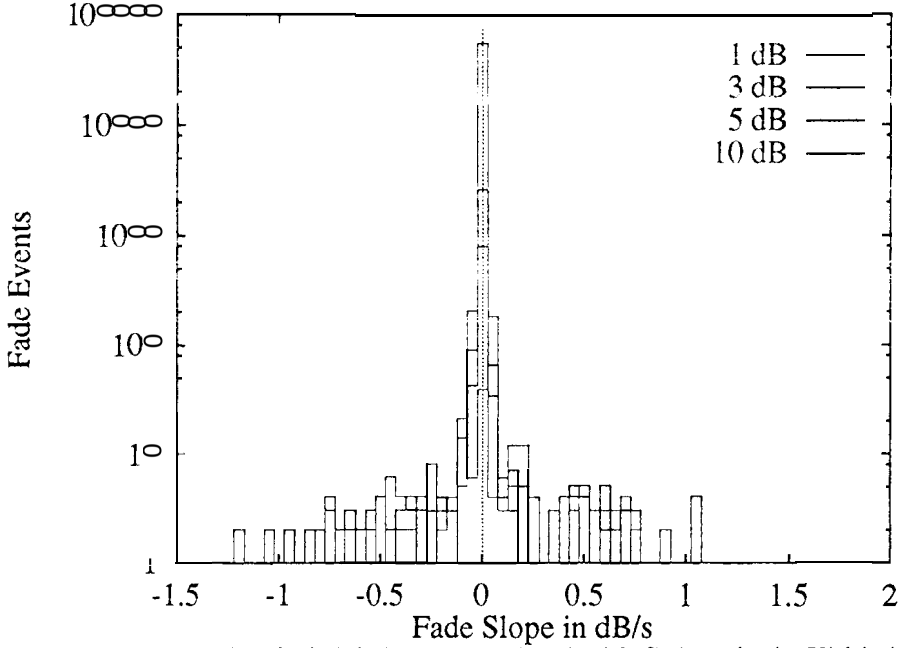

Fig. 13: 9312-9511, Worst-Month, 20 GHz, Block Width 11

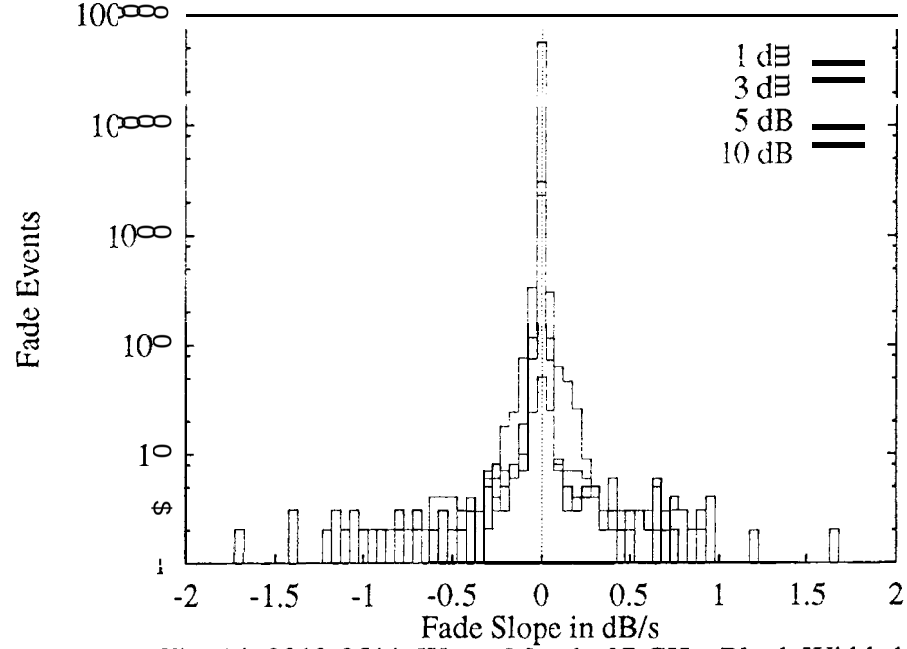

Fig. 14: 9312-9511, Worst-Month, 27 GHz, Block Width 1

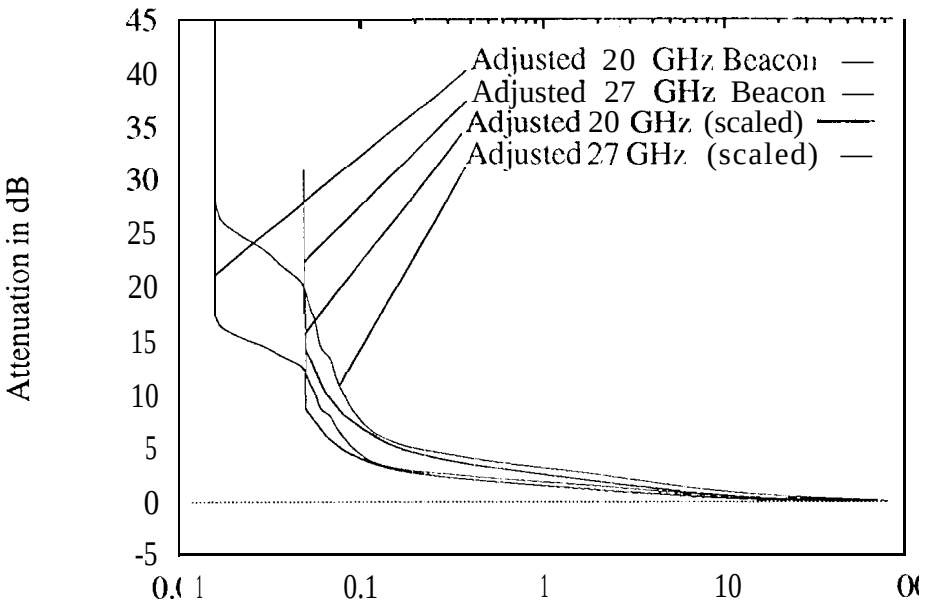

Fig. 15:9312-9511 Adjusted CDFs

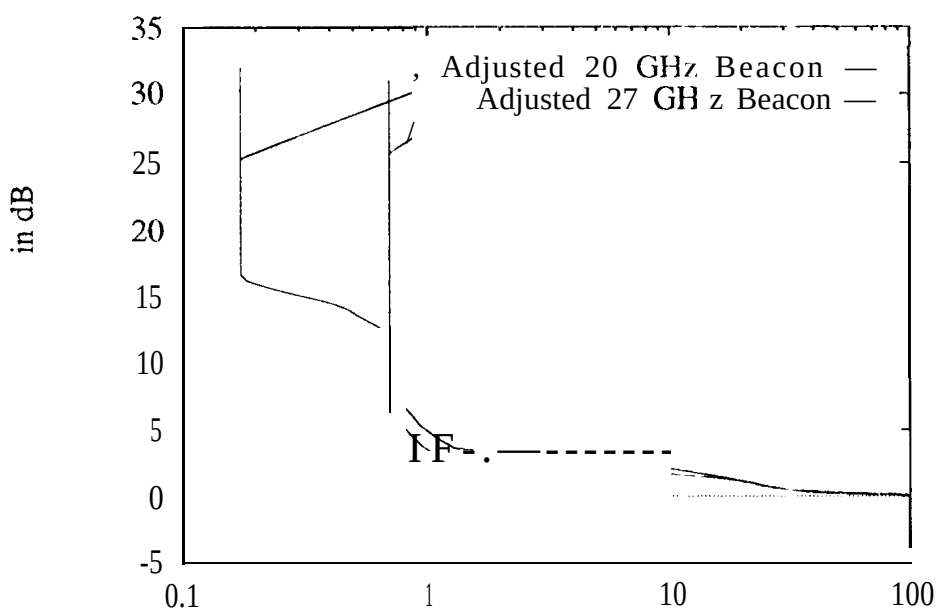

Fig. 16:9312-9511 Worst-Month Adjusted CDFS

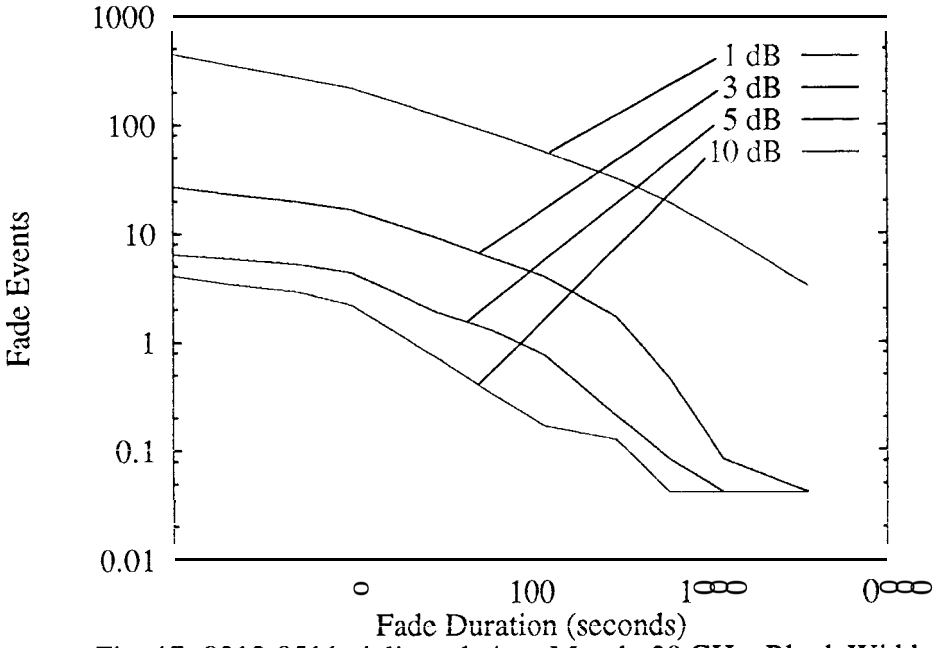

Fig. 17: 9312-9511, Adjusted, Avg-Month, 20 GHz, Block Width 11

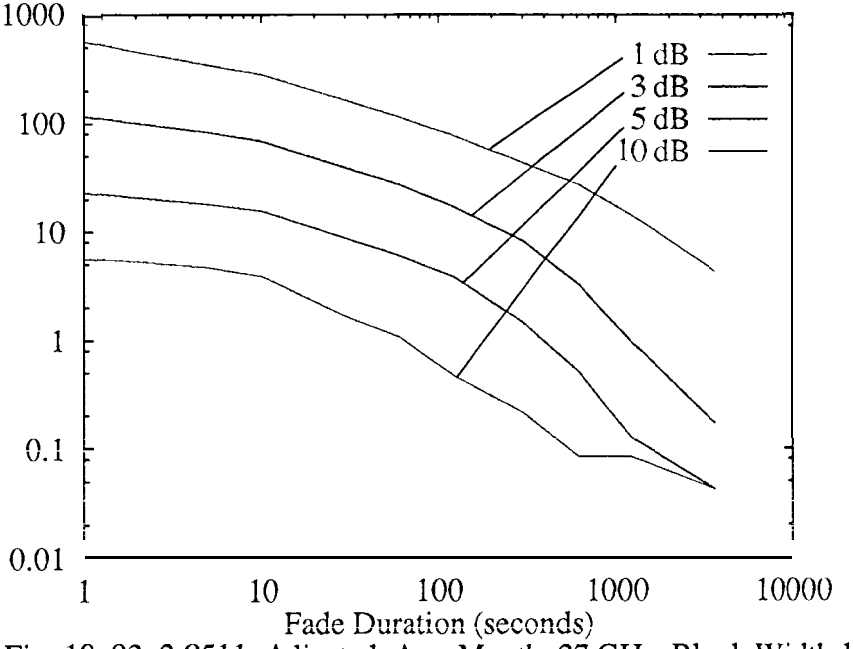

Fig. 18: 93 2-9511, Adjusted, Avg-Month, 27 GHz Block Width 11

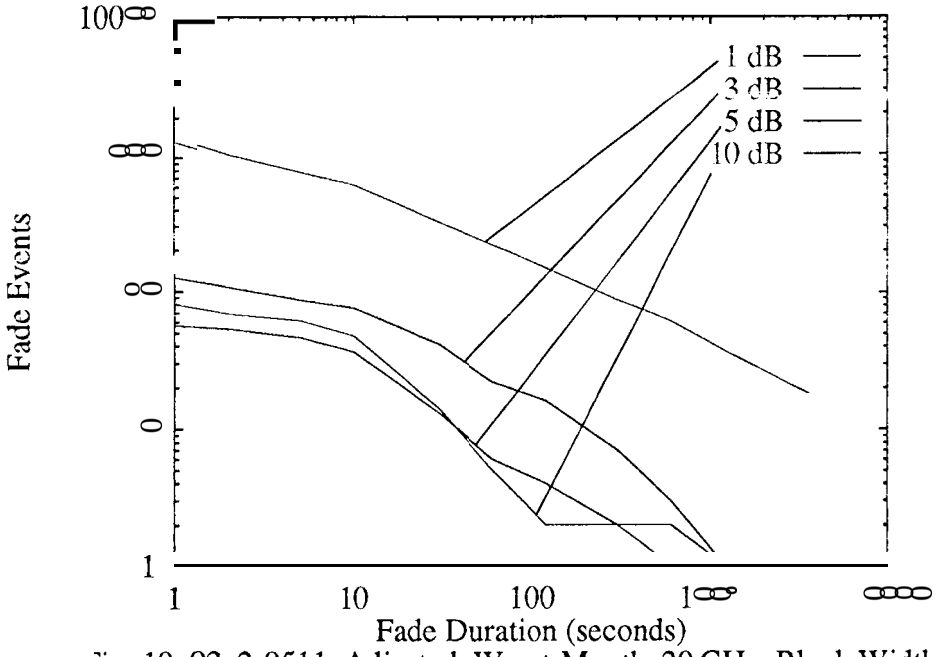

Fig. 19: 93 2-9511, Adjusted, Worst-Month, 20 GHz, Block Width 11

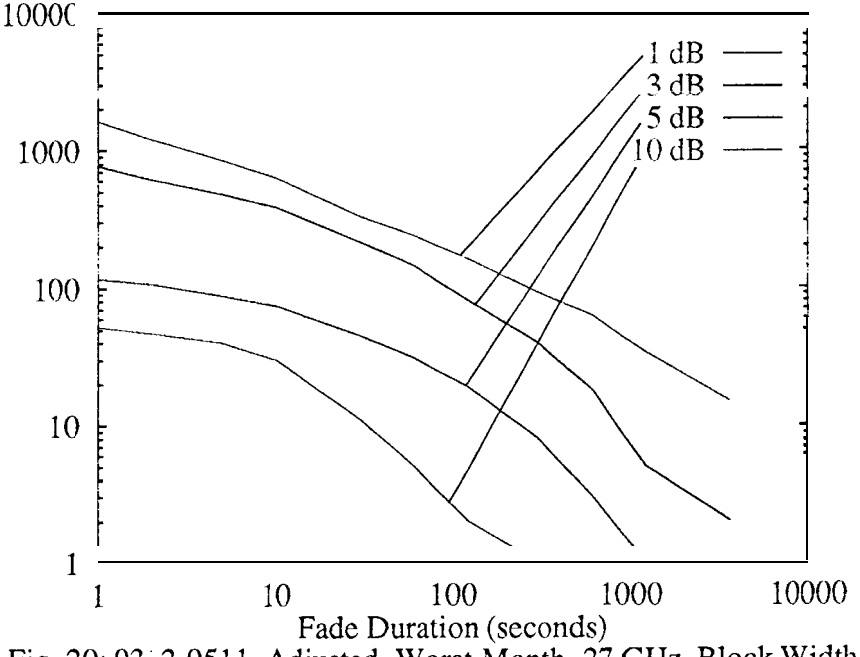

Fig. 20: 93 2-9511, Adjusted, Worst-Month, 27 GHz, Block Width

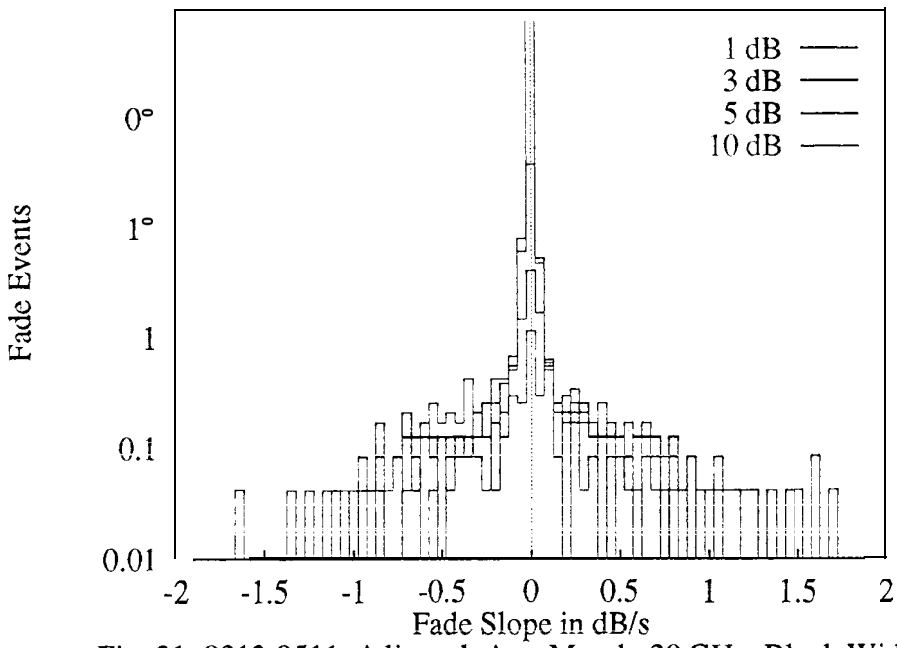

Fig. 21: 9312-9511, Adjusted, Avg-Month, 20 GHz, Block Width 11

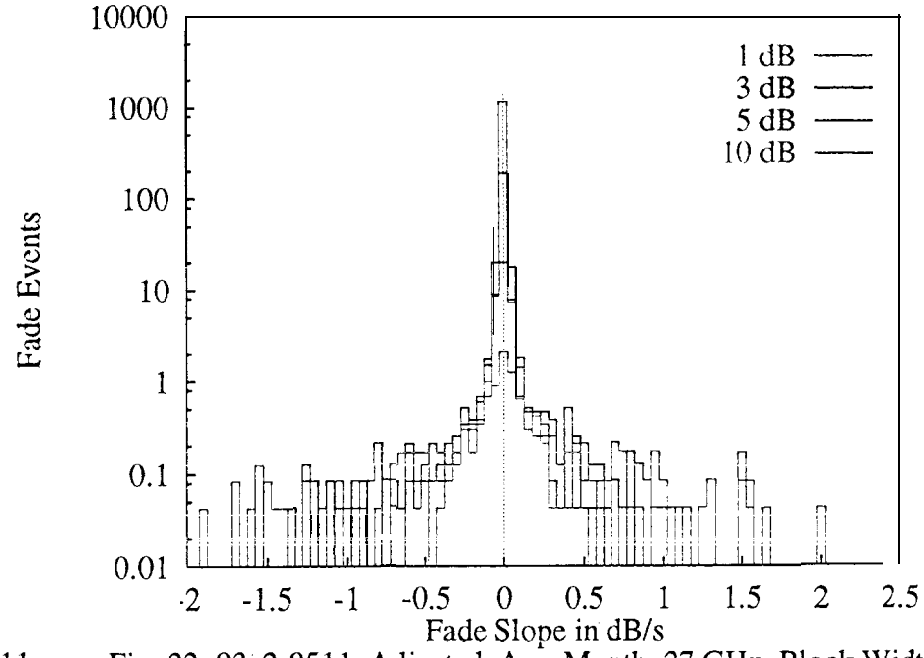

Fig. 22: 93 2-9511, Adjusted, Avg-Month, 27 GHz, Block Width 11

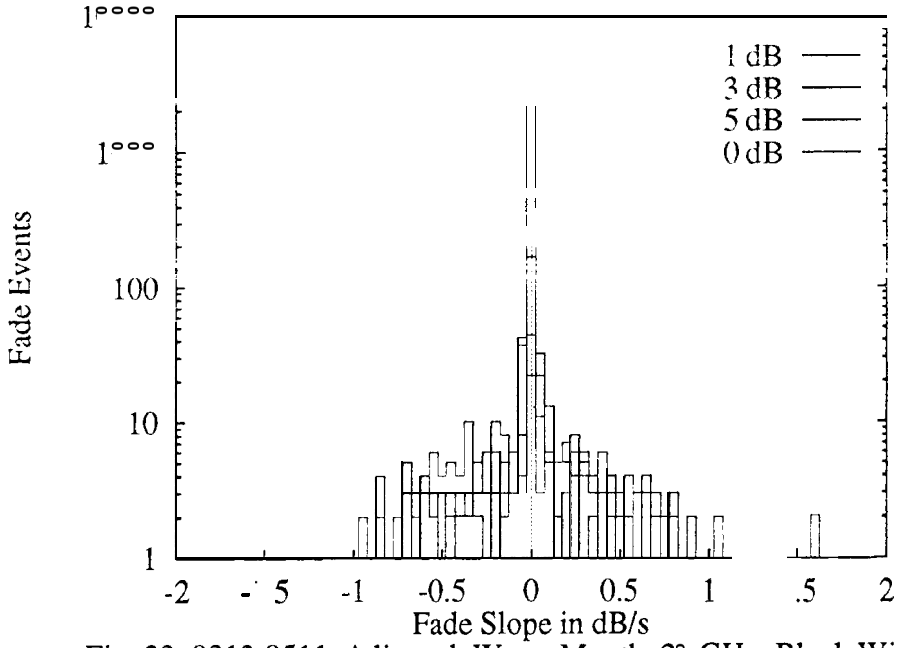

Fig. 23: 9312-9511, Adjusted, Worst-Month, 2° GHz, Block Width 11

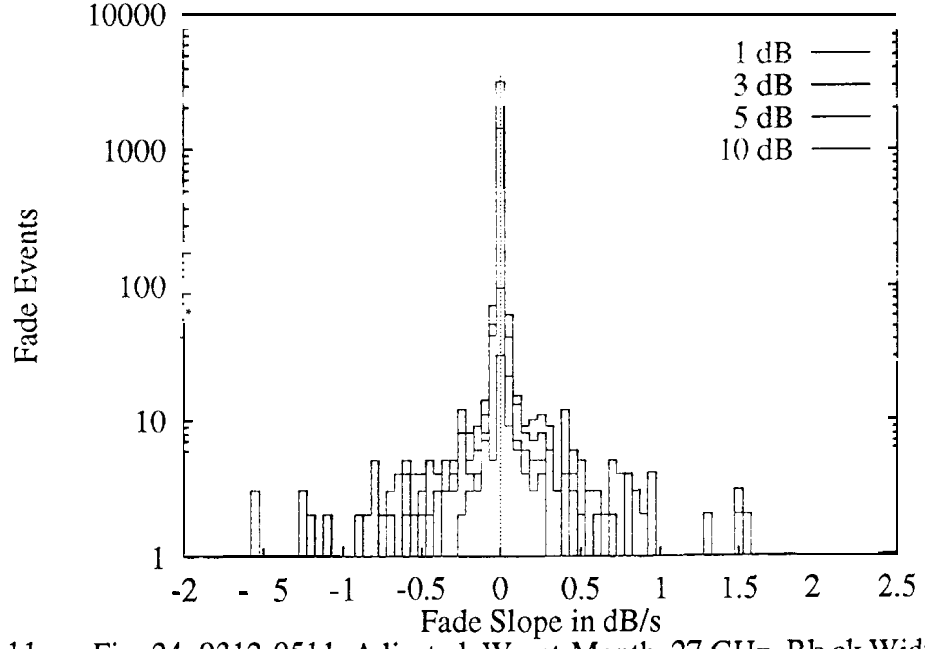

Fig. 24: 9312-9511, Adjusted, Worst-Month, 27 GHz, Block Width 11

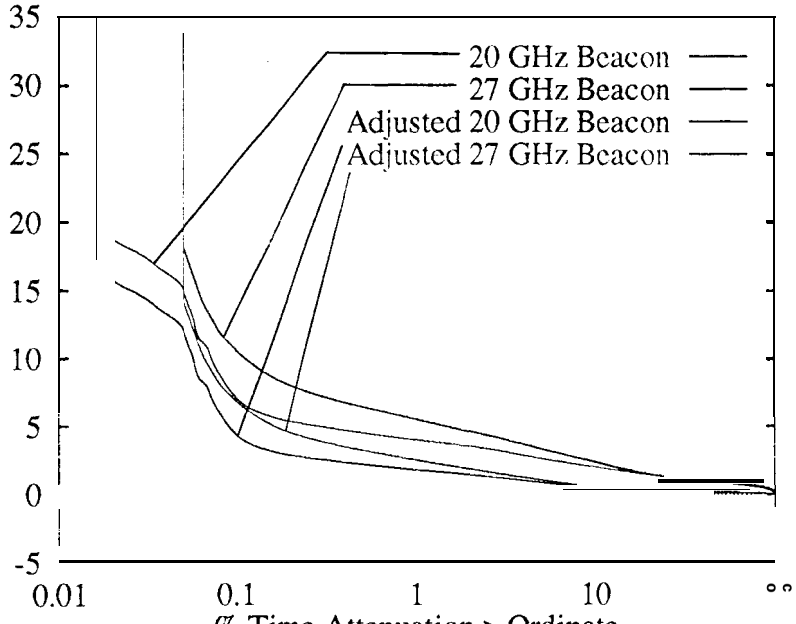

Fig. 25: 9312-9511 CDFs

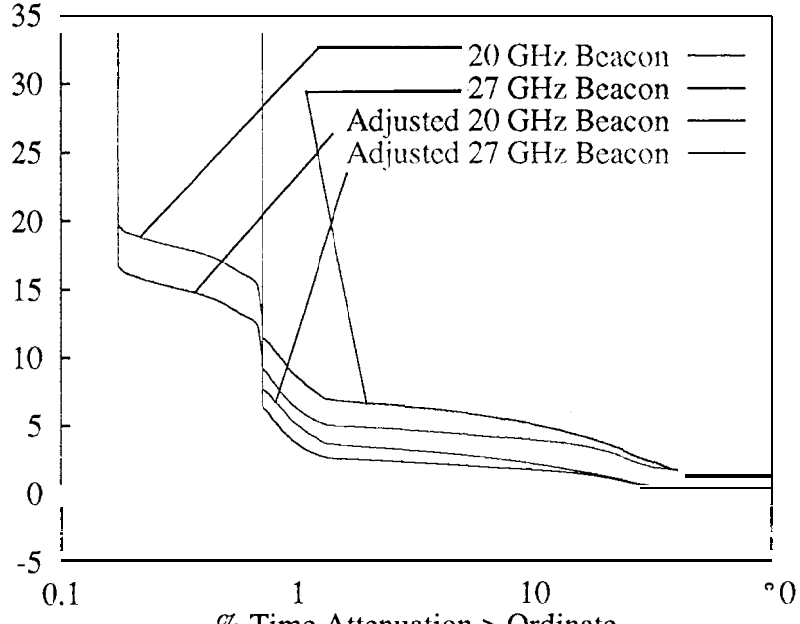

Fig. 26: 9312-9511 Worst-Month CDFs

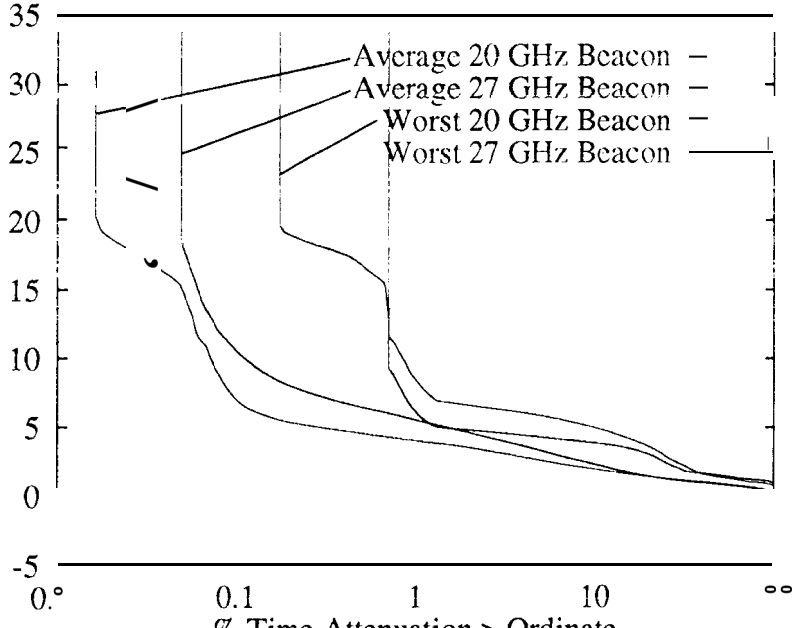

Fig. 27: 9312-9511 Unadjusted CDFs

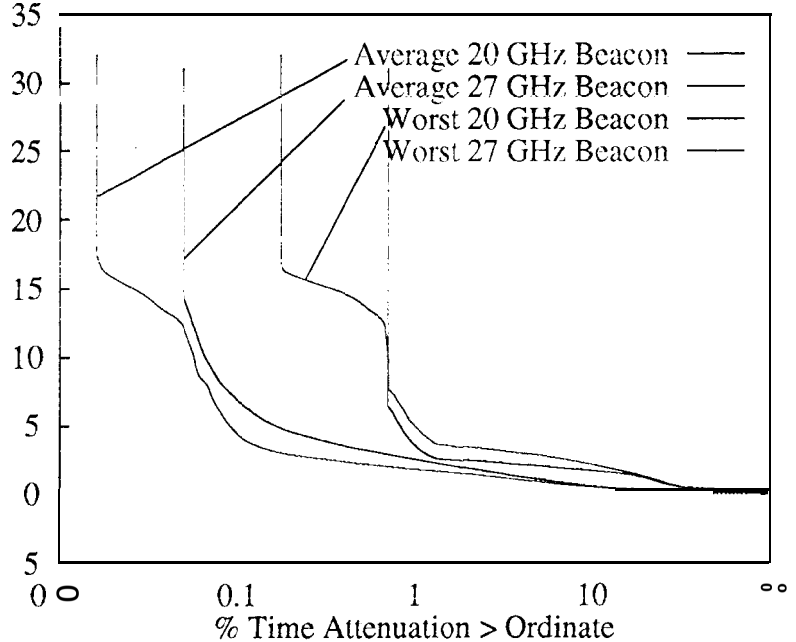

Fig. 28: 9312-9511 Adjusted CDFs

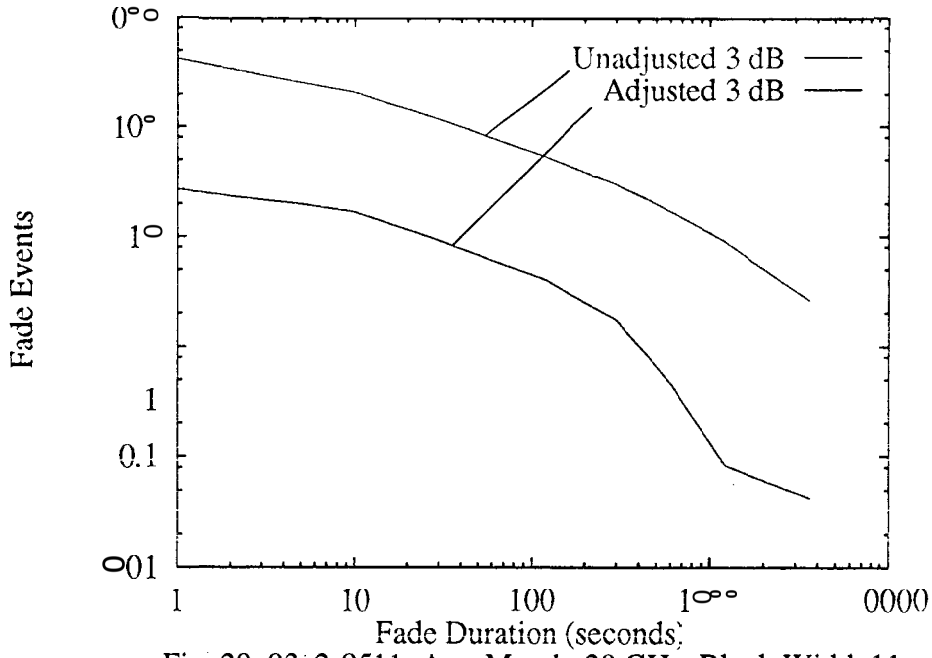

Fig. 29: 93 2-9511, Avg-Month, 20 GHz, Block Width 11

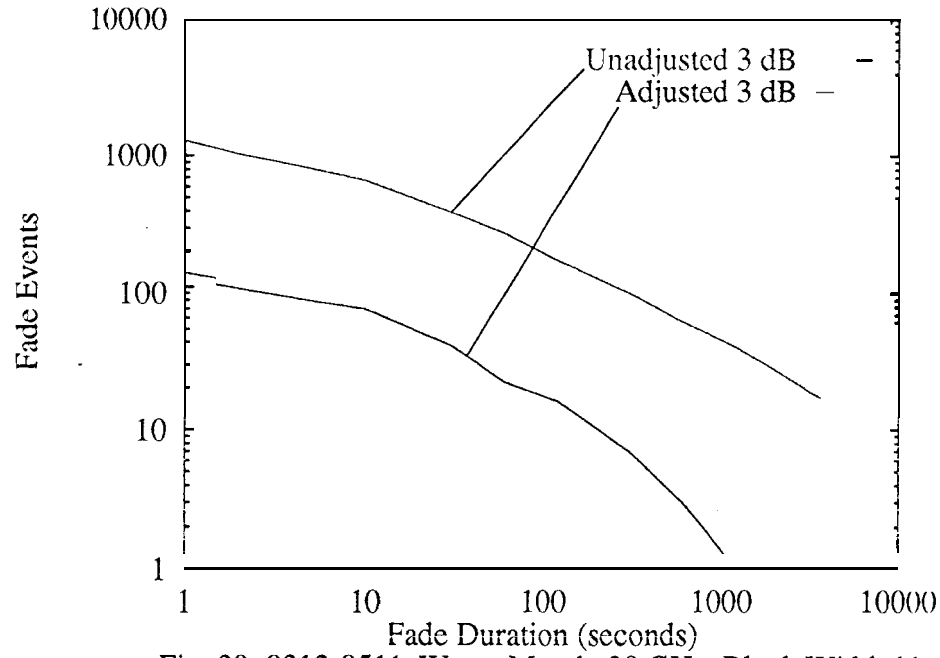

Fig. 30: 9312-9511, Worst-Month, 20 GHz, Block Width 11

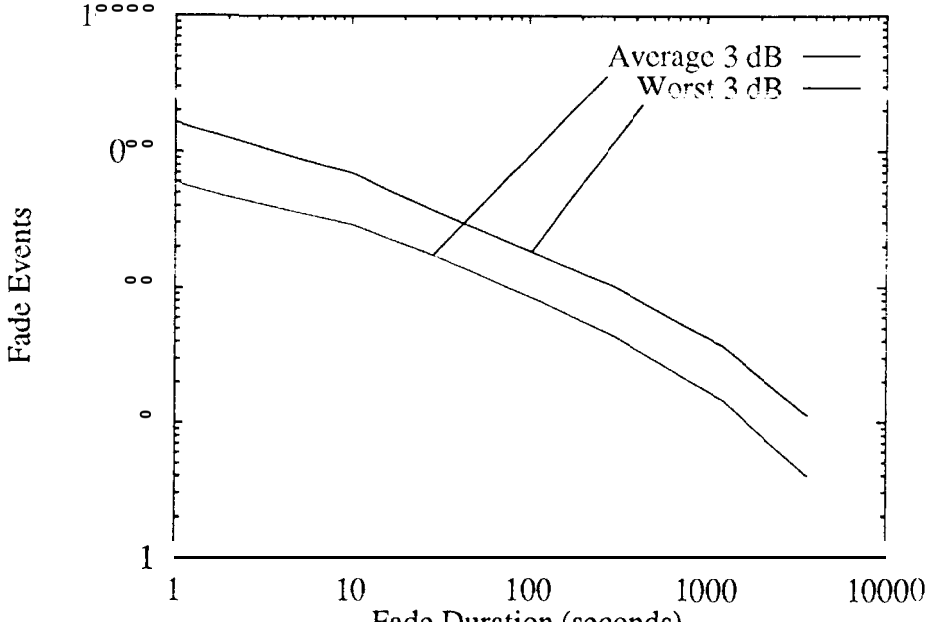

Fig. 31: 9312-9511, Unadjusted, 27 GHz, Block Width 11

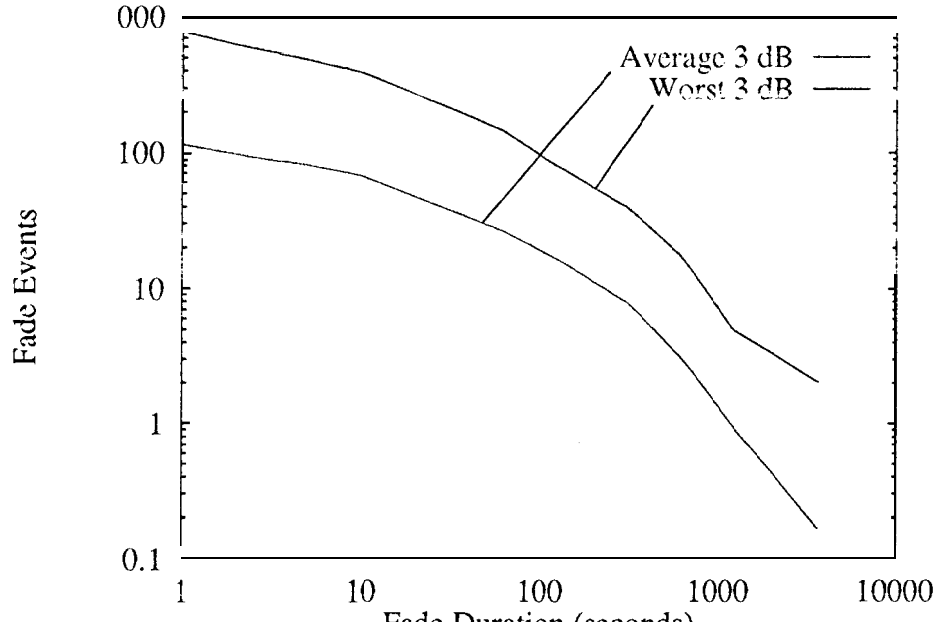

Fig. 32: 93 2-9511, Adjusted, 27 GHz, Block Width 11

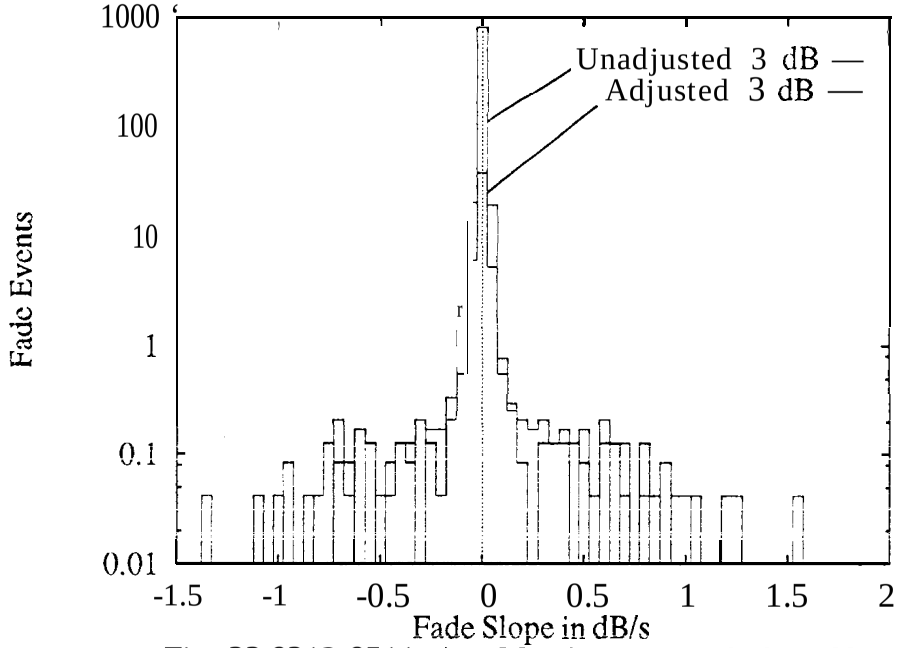

Fig. 33:9312-9511, Avg-Month, 20 GHz, Block Width 11

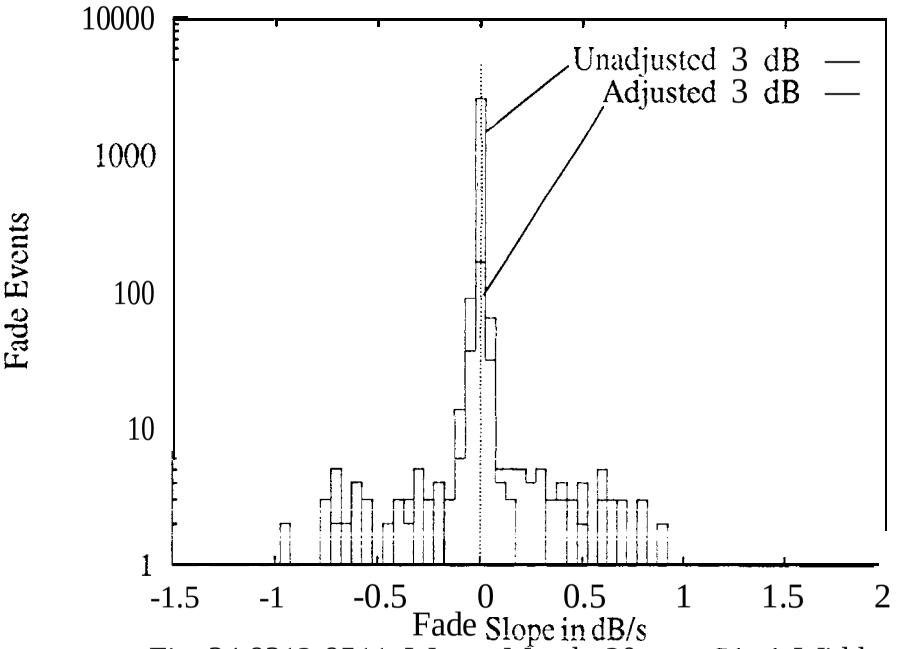

Fig. 34:9312-9511, Worst-.Month, 20 GHz, Block Width 11

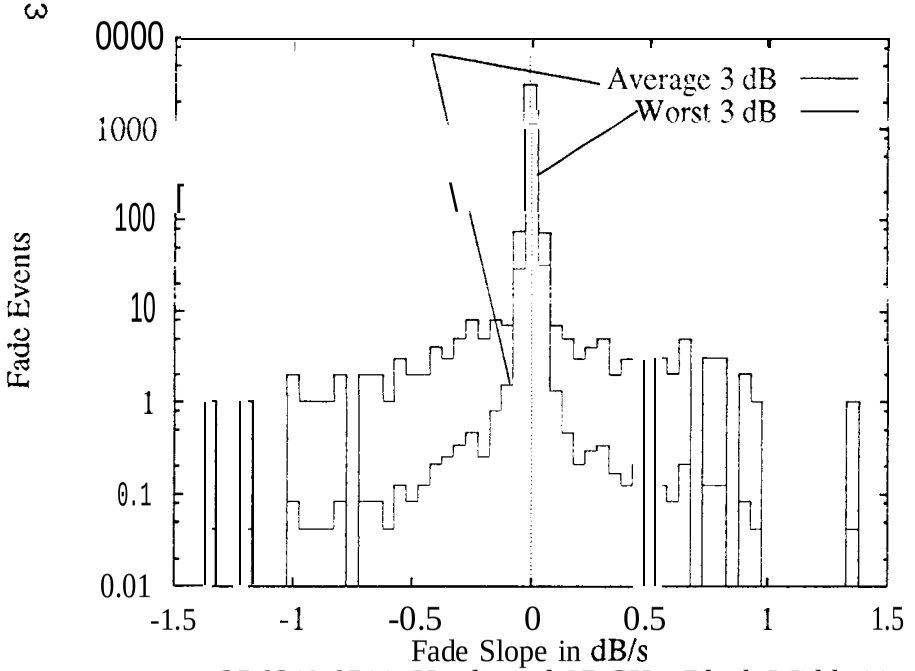

Fig. 35:9312-9511, Unadjusted 27 GHz, Block Width 11

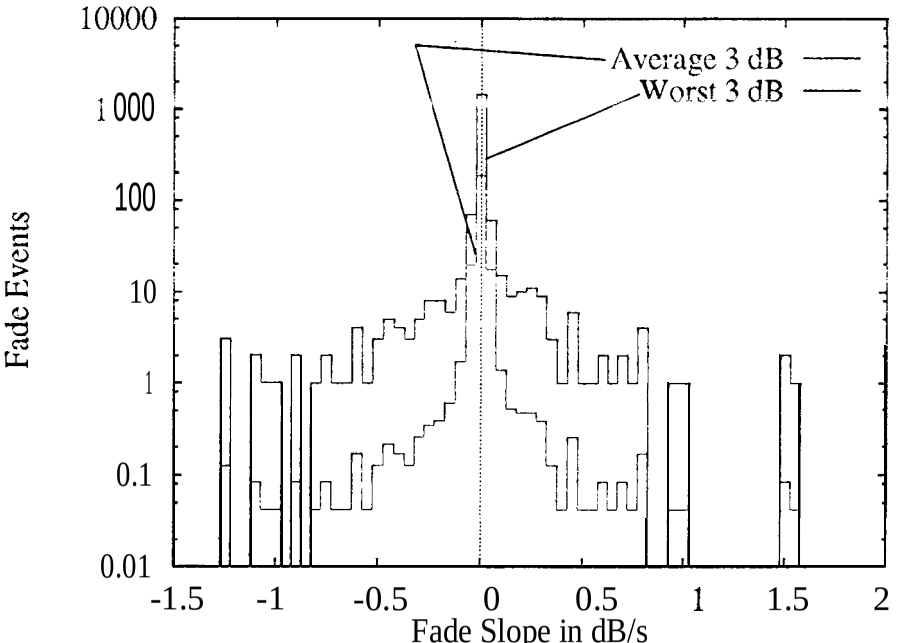

Fig. 36:9312-9511, Adjusted 27 GHz, Block Width 11