Comparison of HF Channel Variation Models

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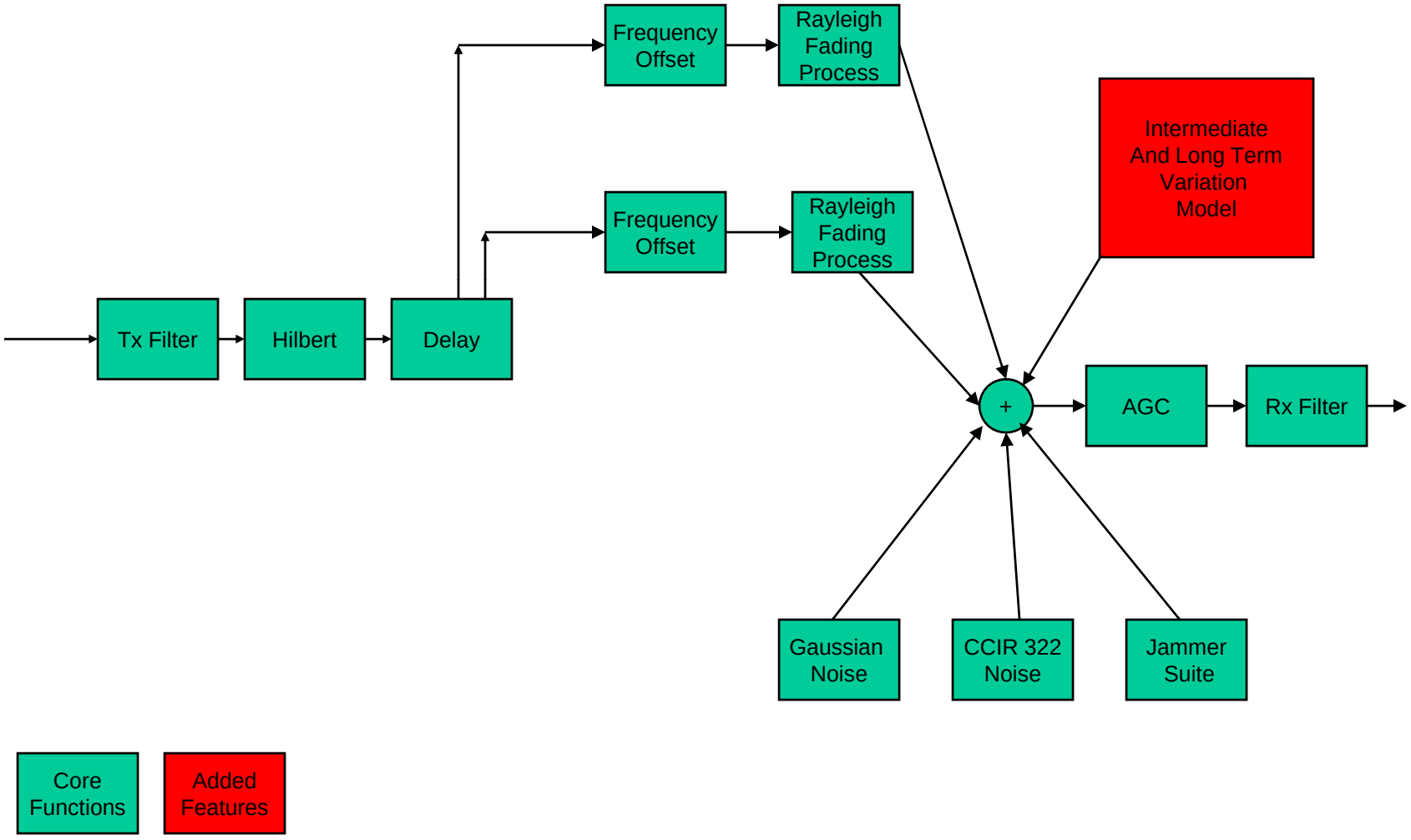
Background 1

- Harris utilizes a HF Channel simulator for system development and characterization
- Previously presented guidelines on how to achieve repeatable testin
- Simulator is standard Watterson Model with Gaussian shaped Rayleigh fading process
- Recent Harris projects have:
  - measured longer term SNR variation on HF Channels
  - modeled these variations
  - modified the channel simulator to implement these variation models
  - utilized new simulator for system testing.
- Work has been reported at HFIA, Nordic HF, MILCOM 2007

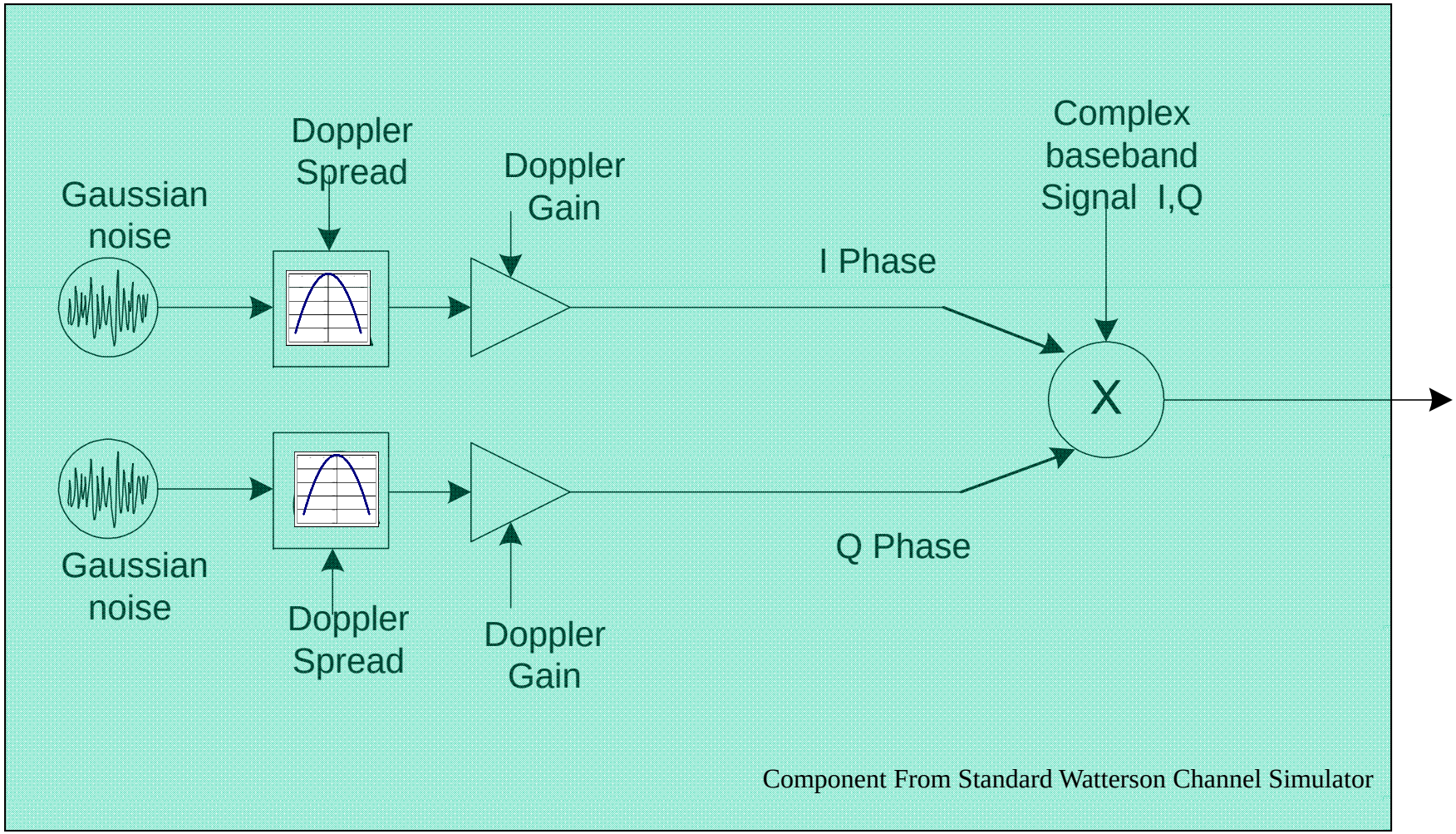
Background 2

- The goal of this presentation
  - Review SNR variation Models
  - Examine SNR variation vs time
  - Examine “spectrum” of SNR
  - Examine HF modem performance under different variation models

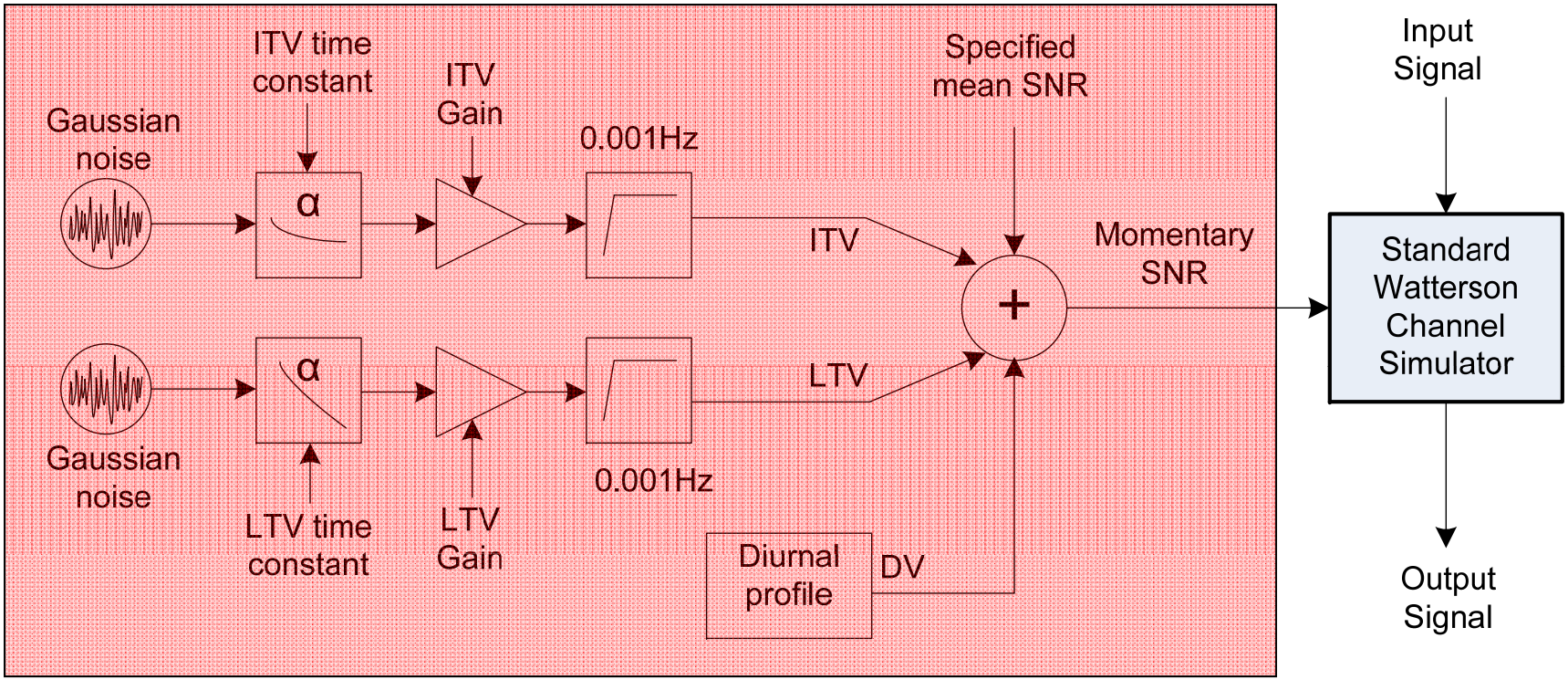
Simulator Block Diagram



Rayleigh Fading Model

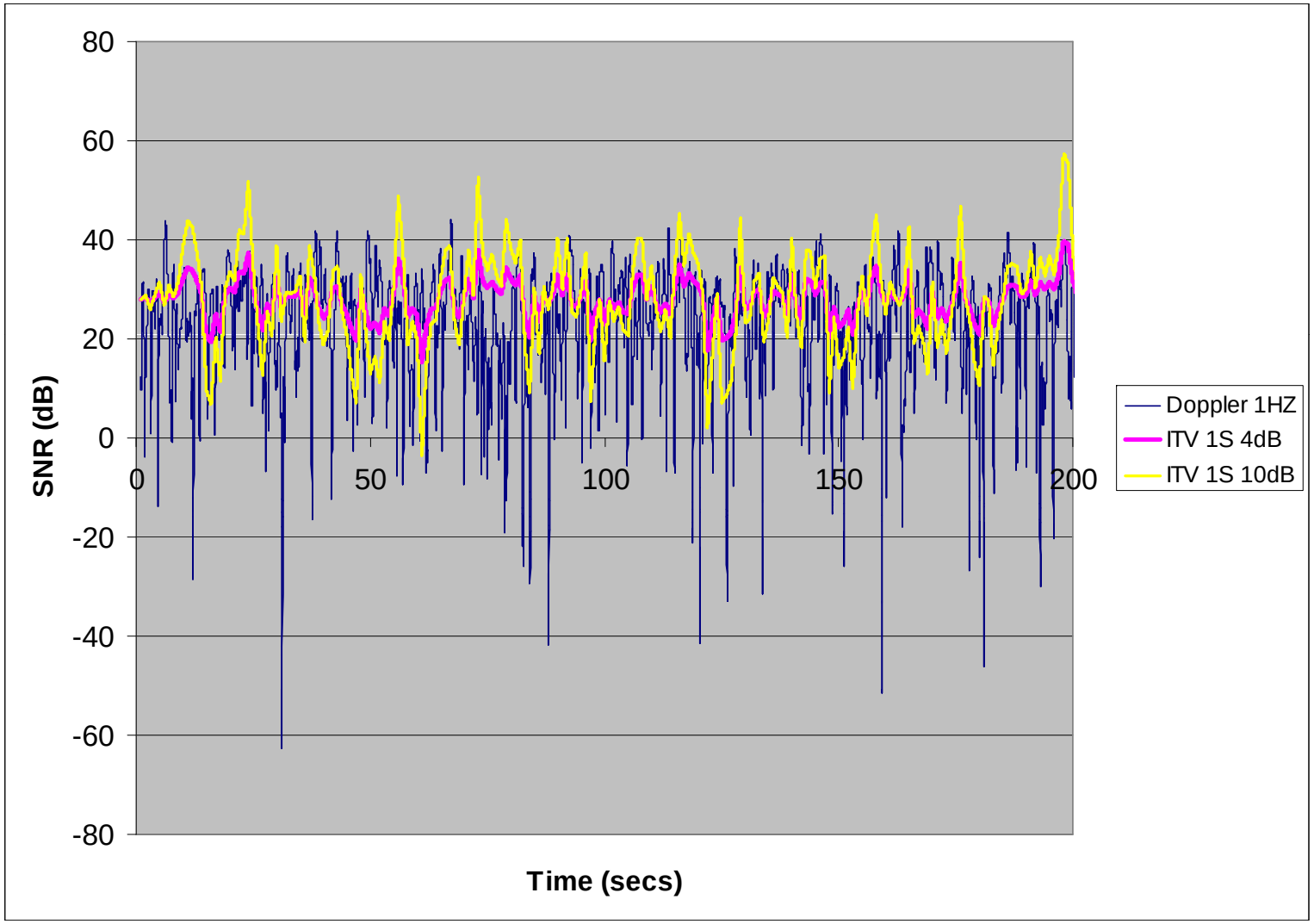


ITV LTV Variation Model



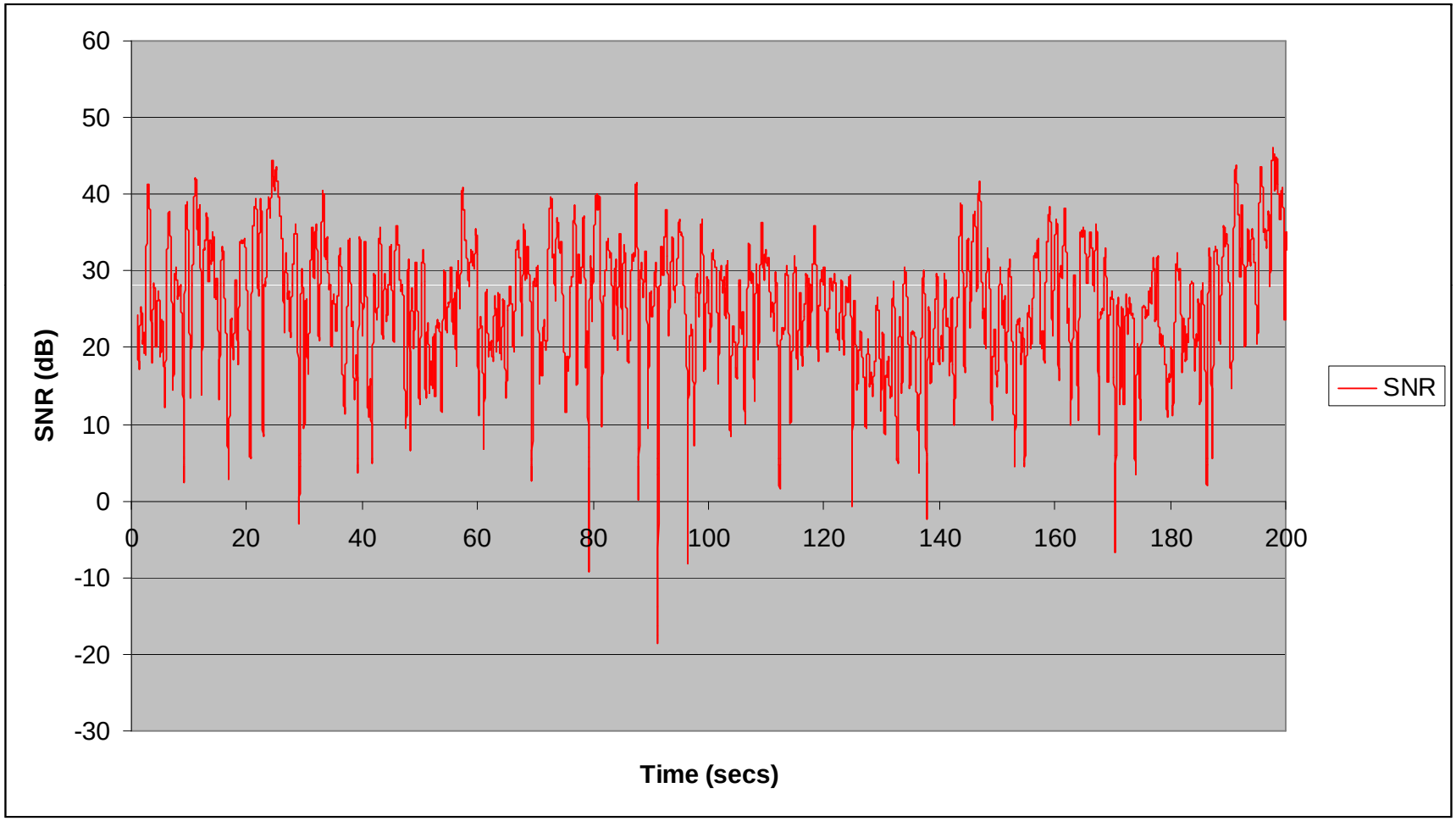
- Mean SNR input to Watterson-model simulator is replaced with a momentary SNR parameter reflecting channel quality variation
- Independent generator structures are used to generate Intermediate-Term (ITV) and Long-Term (LTV) random processes
- 'Alpha filter' produces noise with exponential autocorrelation
- High-pass filter eliminates variation in the frequency range attributed to diurnal and longer-term processes
- Diurnal profile could be based on measurements or VOACAP/ICEPAC predictions (as in 'Walnut Street')

Comparison of SNR Profiles



Composite SNR Profile

2 path Fading (2ms-1Hz), ITV(3.89dB-5.2s) LTV(3.493dB-180s)



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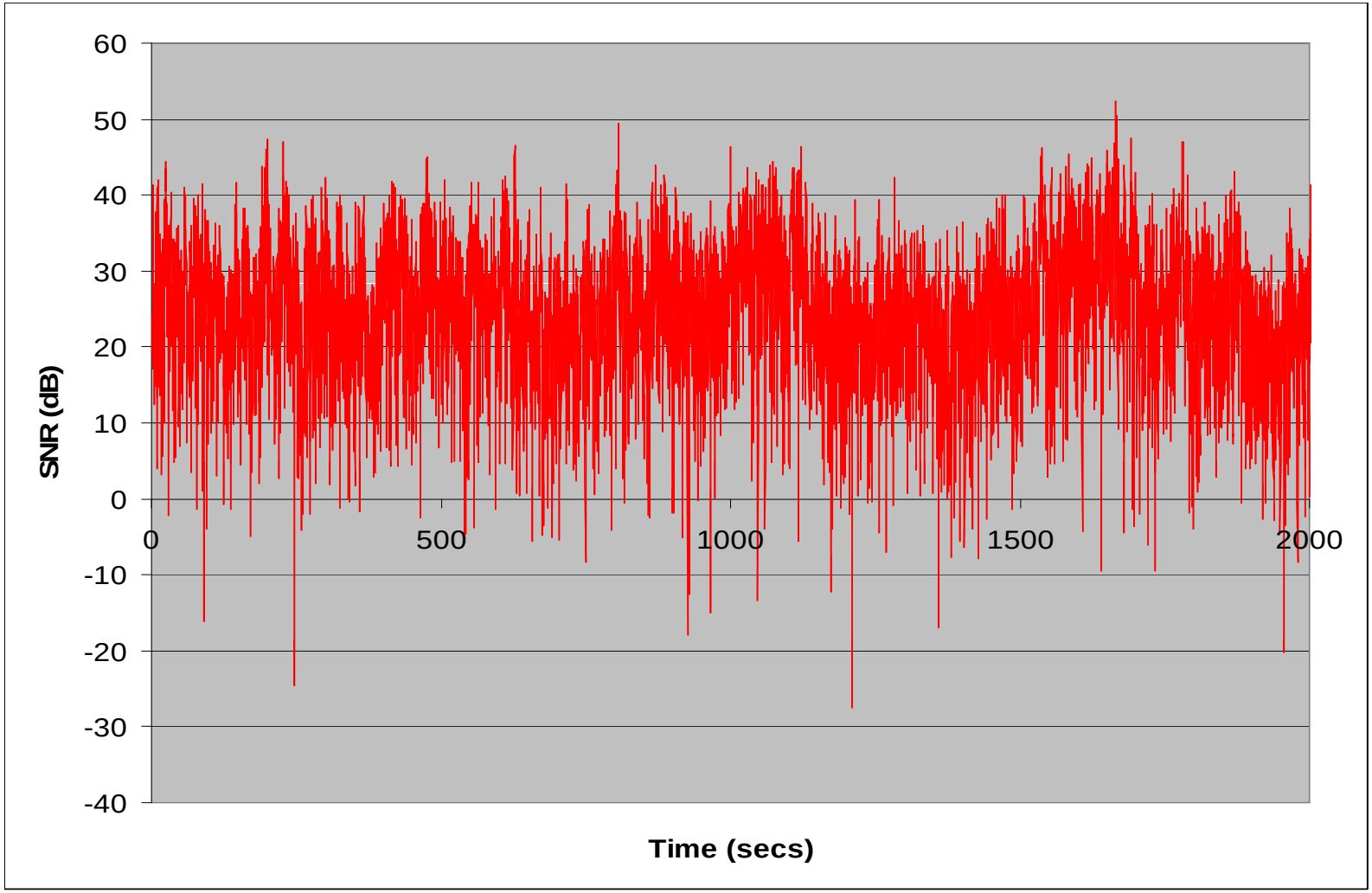
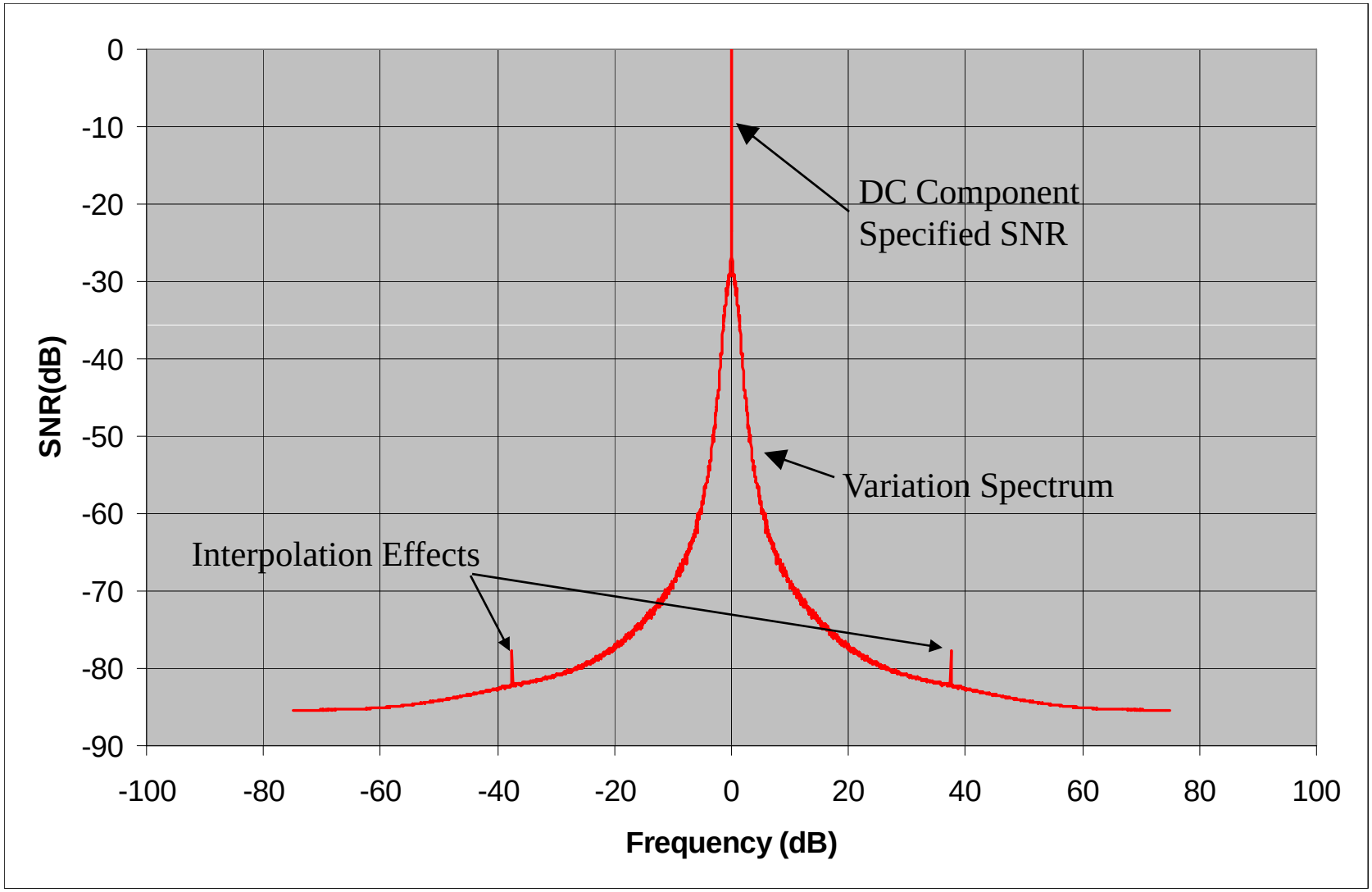
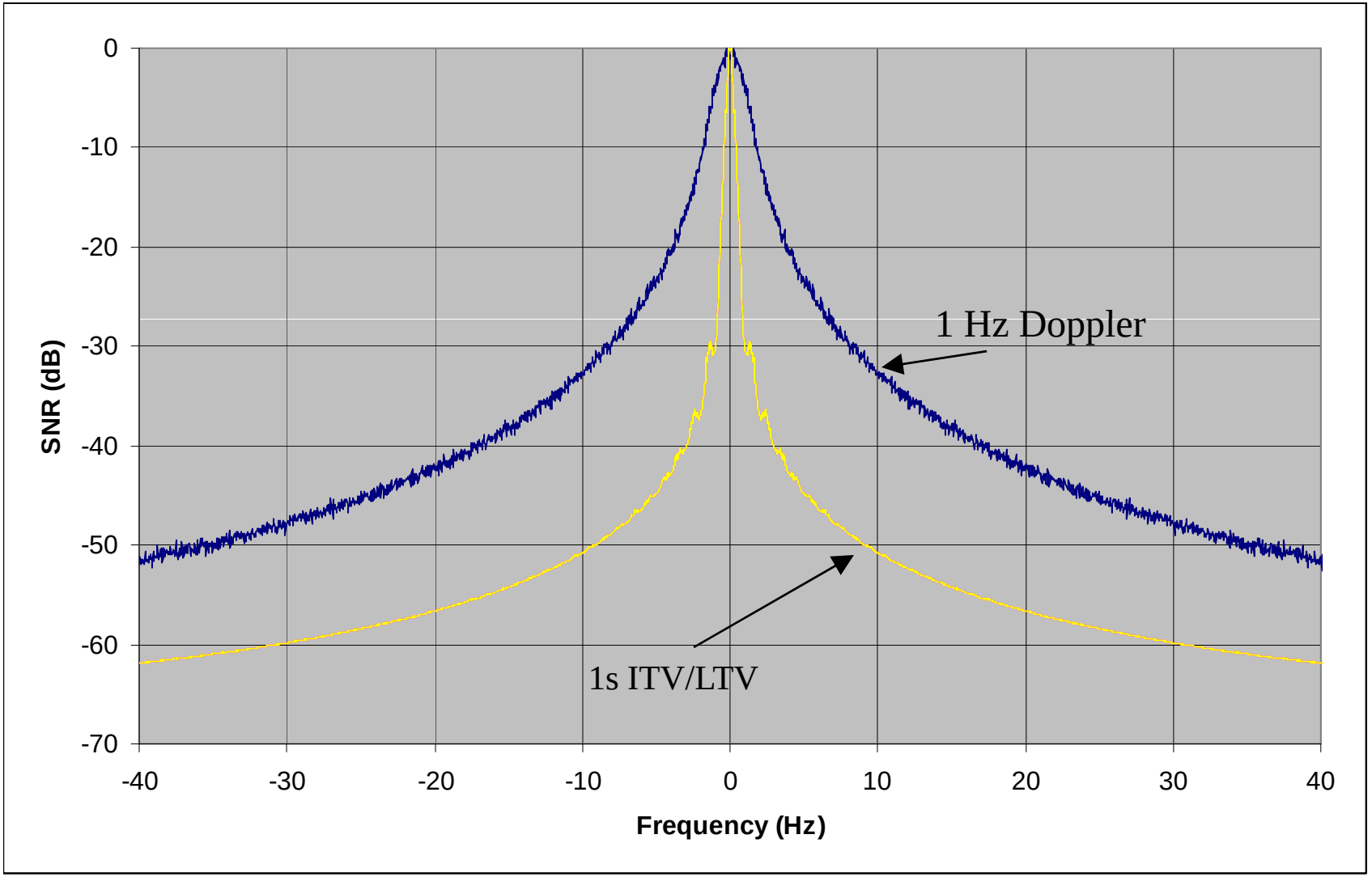


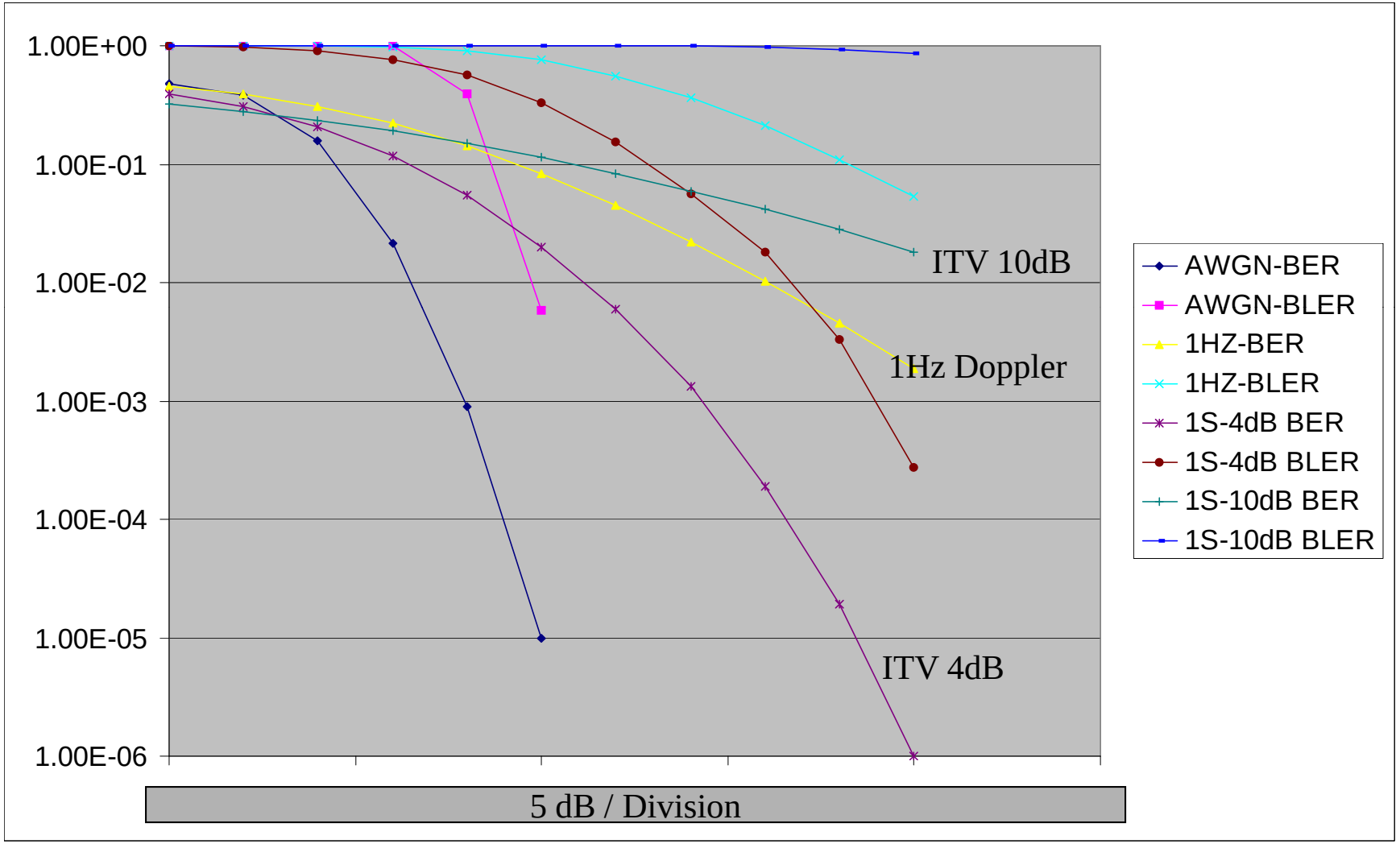
SNR Spectrum - Composite



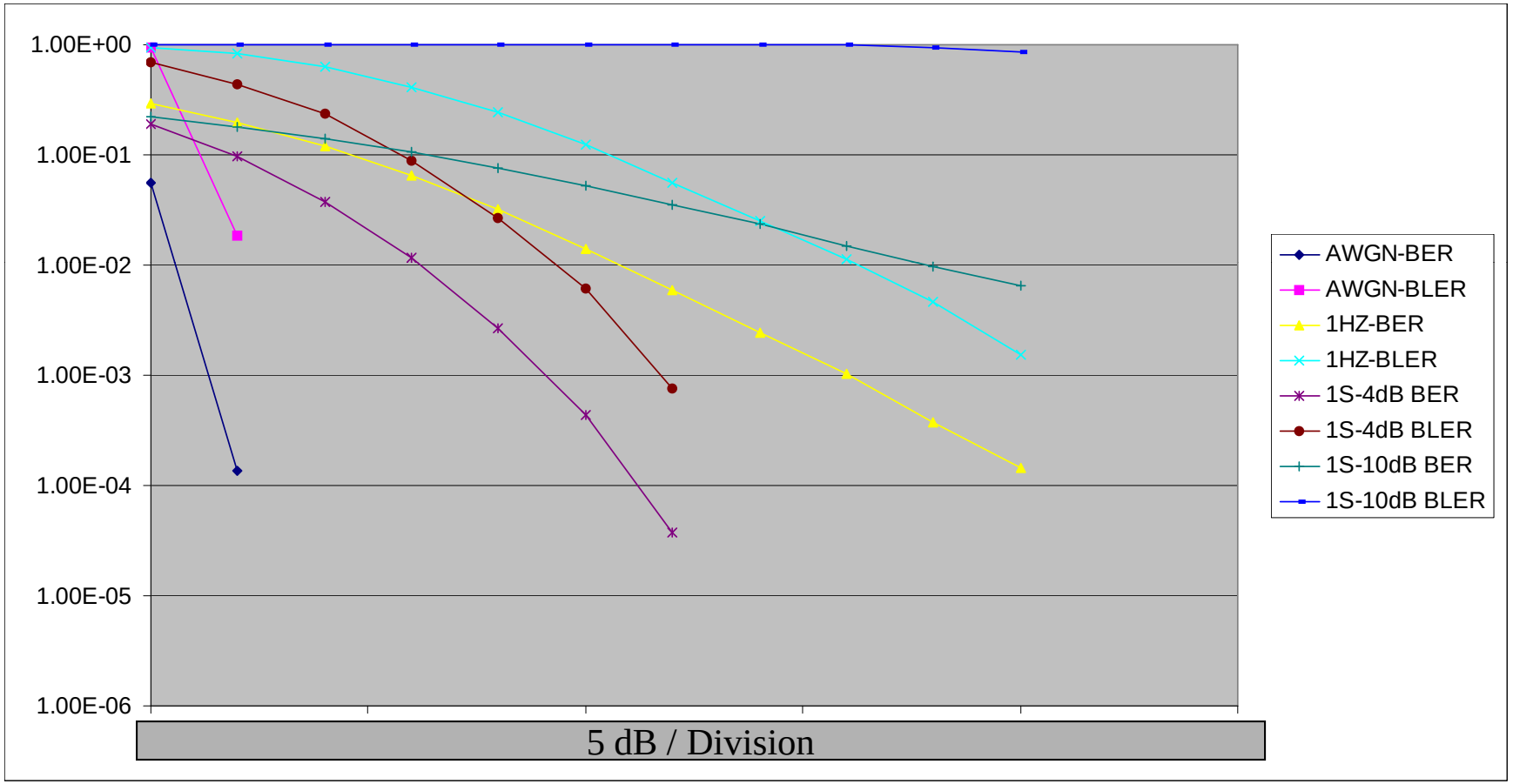
SNR Spectrum



MIL-STD 188-110B 2400BPS



MIL-STD 188-110B 600BPS



Observations

- Rayleigh Fading variation is faster with deeper nulls
- Intermediate variation is noticeably slower. 4dB has less total variation, 10dB similar variation (max-min)
- Spectrum plots of these SNR variation processes confirm that the Rayleigh Model is higher bandwidth than the intermediate variation, which has a much narrower bandwidth.

Observations

- Data collected for MIL-STD-188-110A, 2400bps and 600 bps. Both Short interleaver.
  - Block size set to 1 second (2400 and 600 bits)
  - Bit error rate (BER) and Block Error rate (BLER) both 5 - 8 dB better with the 4dB intermediate term variation model than with single path Rayleigh Fading.
  - Bit error rate (BER) and Block Error rate (BLER) both significantly worse with the 10dB intermediate term variation model than with single path Rayleigh Fading.

Summary

- The Fading processes of the well known Watterson HF channel model and that of the new variation models differ in implementation and results.
- A Rayleigh fading process with 1 Hz Doppler spread has a significantly wider bandwidth than the intermediate term variation model with a 1 second time constant
- Modem performance is in general better with the intermediate variation than with the faster Rayleigh variation as long as the degree of variation is within the range of the modem waveform. If the Gain of this process is increased there will be SNR swings to lower SNRs which are outside of the range of acceptable modem performance for the given bit rate necessitating a modulation / data rate change.
- Both Models should be used in conjunction to measure performance of adaptive HF systems, especially those such as DLP which may access the channel over time period of 10s of seconds or minutes

References

- Furman and Nieto, “Understanding HF Channel Simulator Requirements in Order to reduce HF Modem Performance Measurement Variability”, Nordic HF 01 Conference, August 2001, Faro, Sweden
- Arcoraci, “Channel Quality Variation and its Impact on Data Link Protocol Performance “, HFIA Meeting, July 2007, Rome, Italy
- Batts, Furman, Koski, “Empirically characterizing channel quality variation on HF ionospheric channels ”, *Nordic HF 07 Conference, August 2007, Faro, Sweden*
- Batts, Furman, Koski, “Channel Quality Variation as a Design Consideration for Wireless Data Link Protocols”, IEEE Military Communications Conference MILCOM 2007, October 29-31 2007, Orlando, Florida, USA.