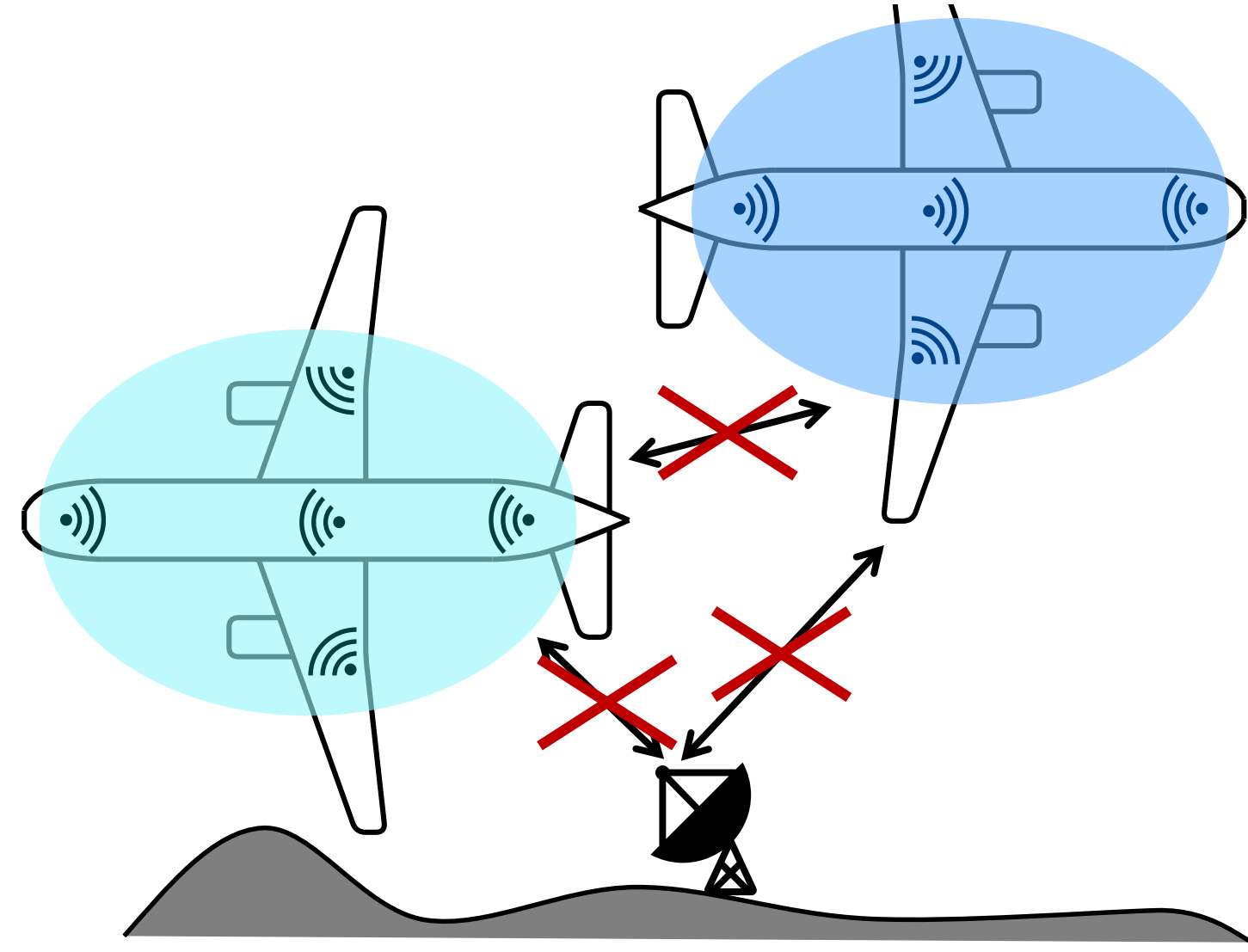
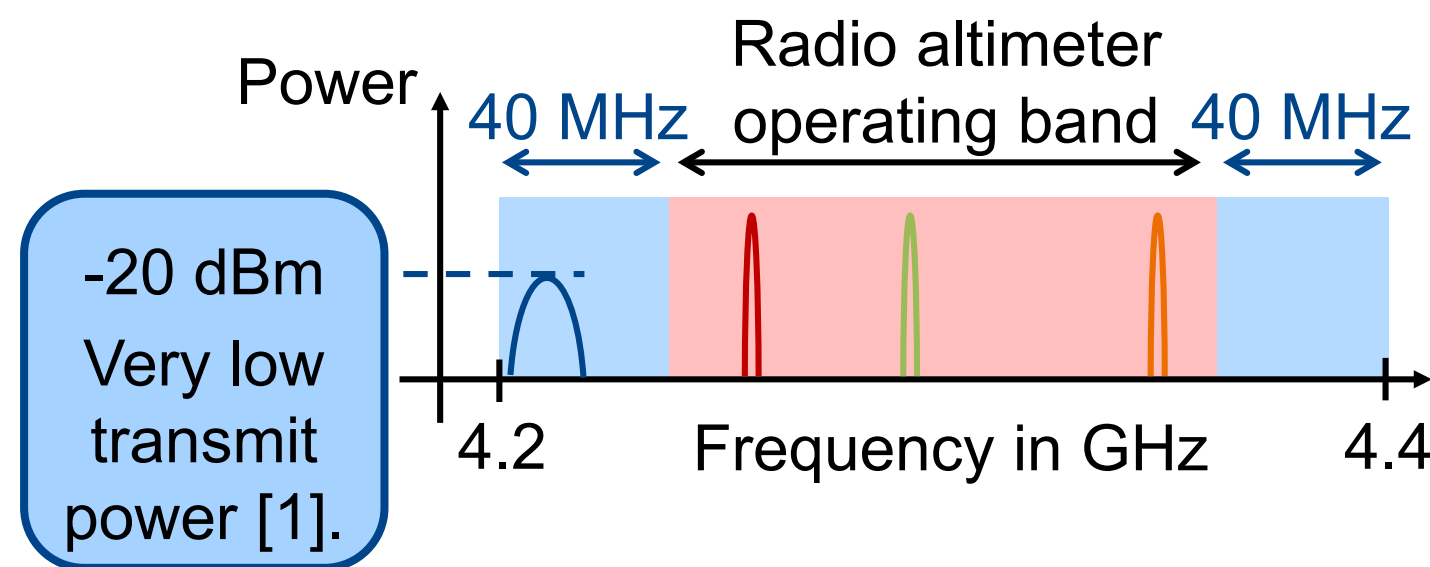


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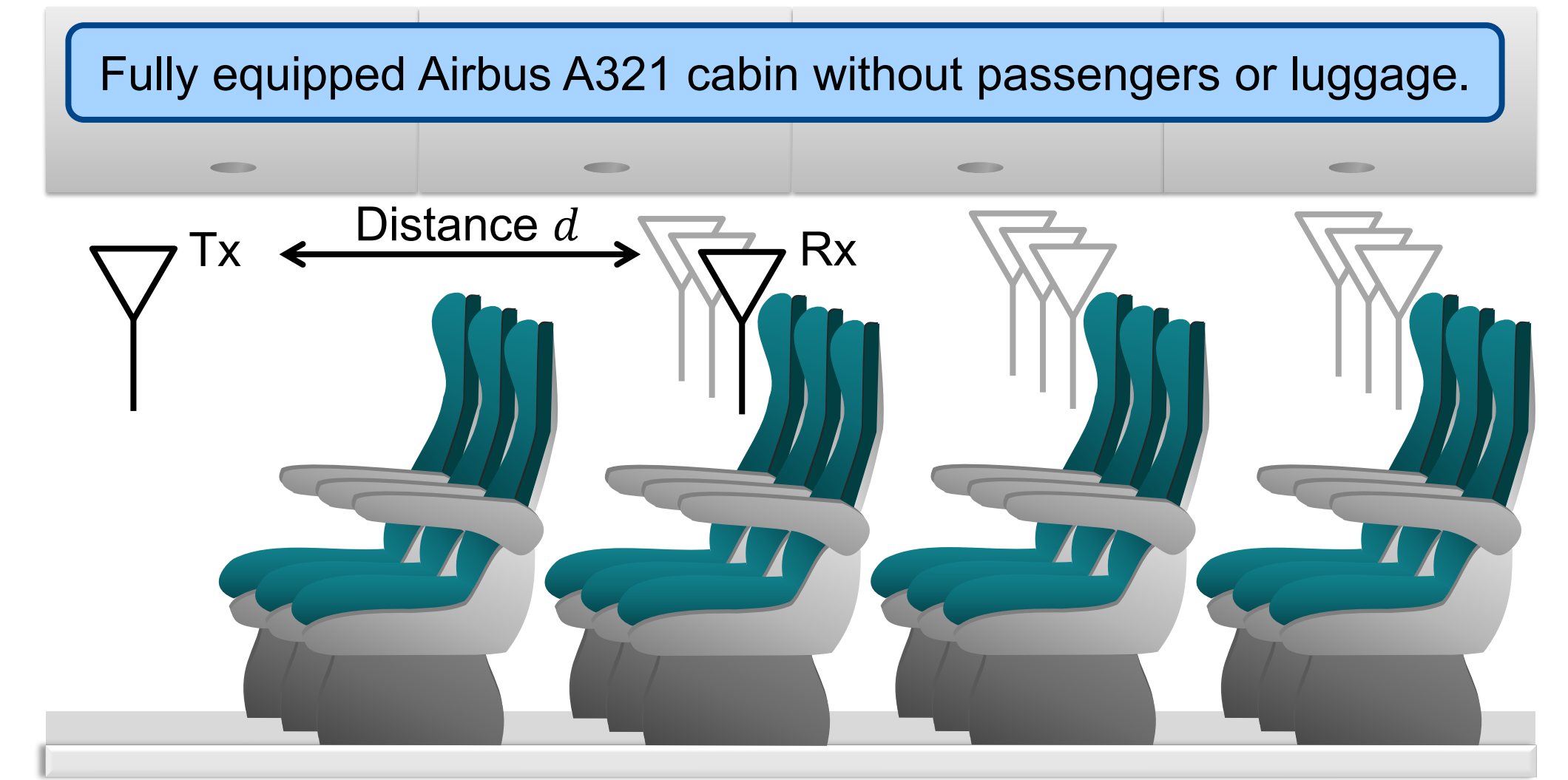
Wireless Avionics Intra-Communications (WAIC)



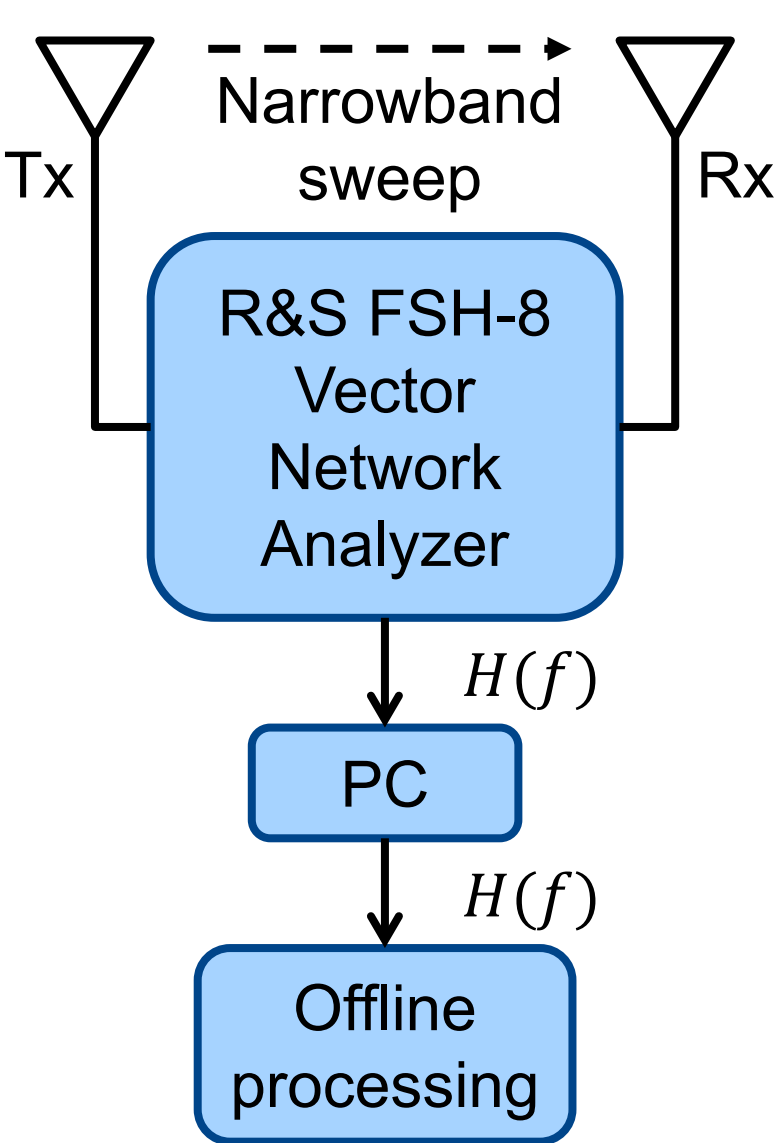
Intra-aircraft applications related to **safety** and **regularity** of flight.



Measurement Environment



Small-Scale Modeling

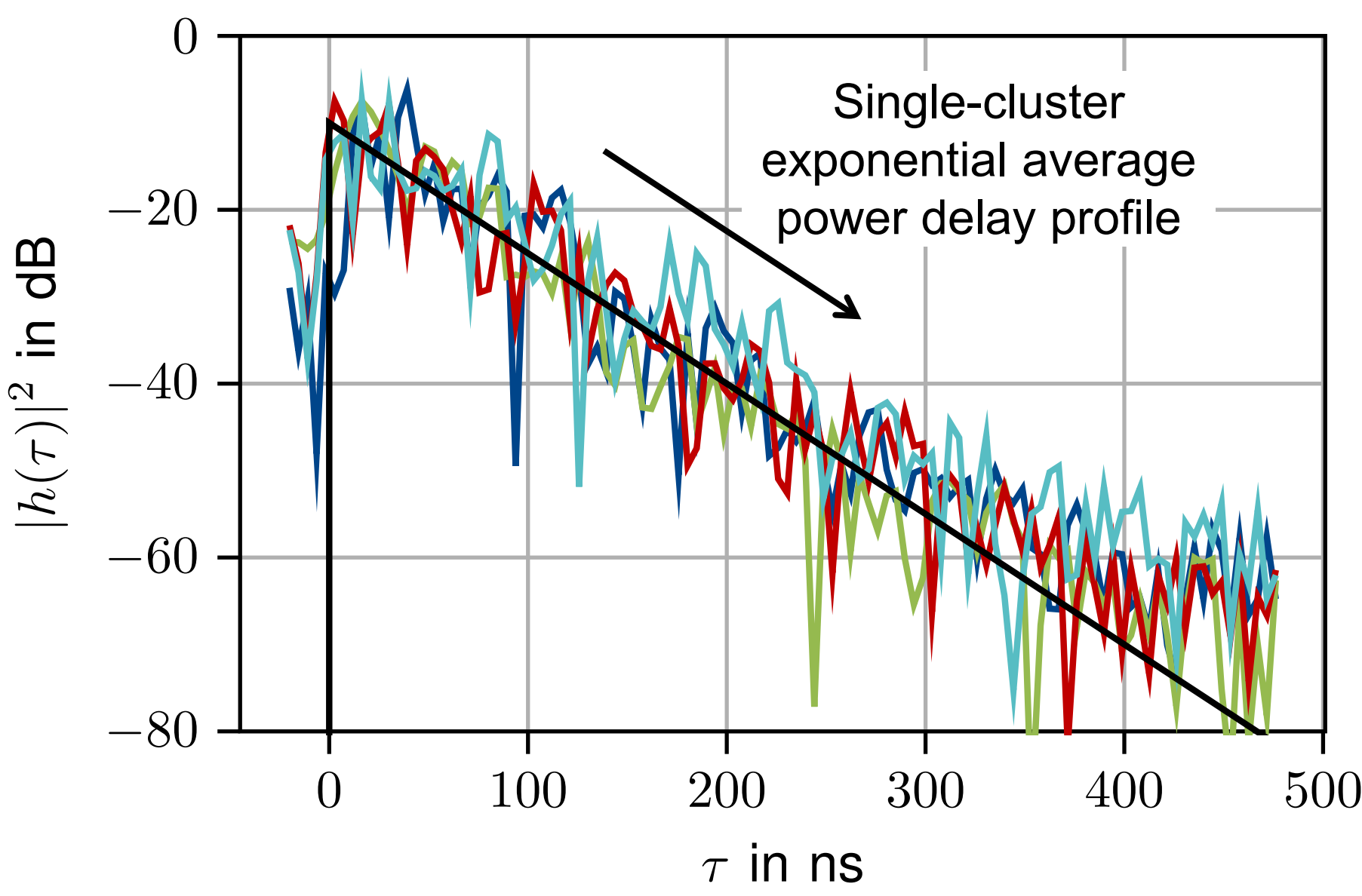


Channel Impulse Response

$$h(\tau) = \sum_{k=0}^{\infty} a_k \delta(\tau - \tau_k)$$

Average Power Delay Profile

$$E\{|h(\tau)|^2\} = \frac{1}{\gamma} e^{-\frac{\tau}{\gamma}}$$



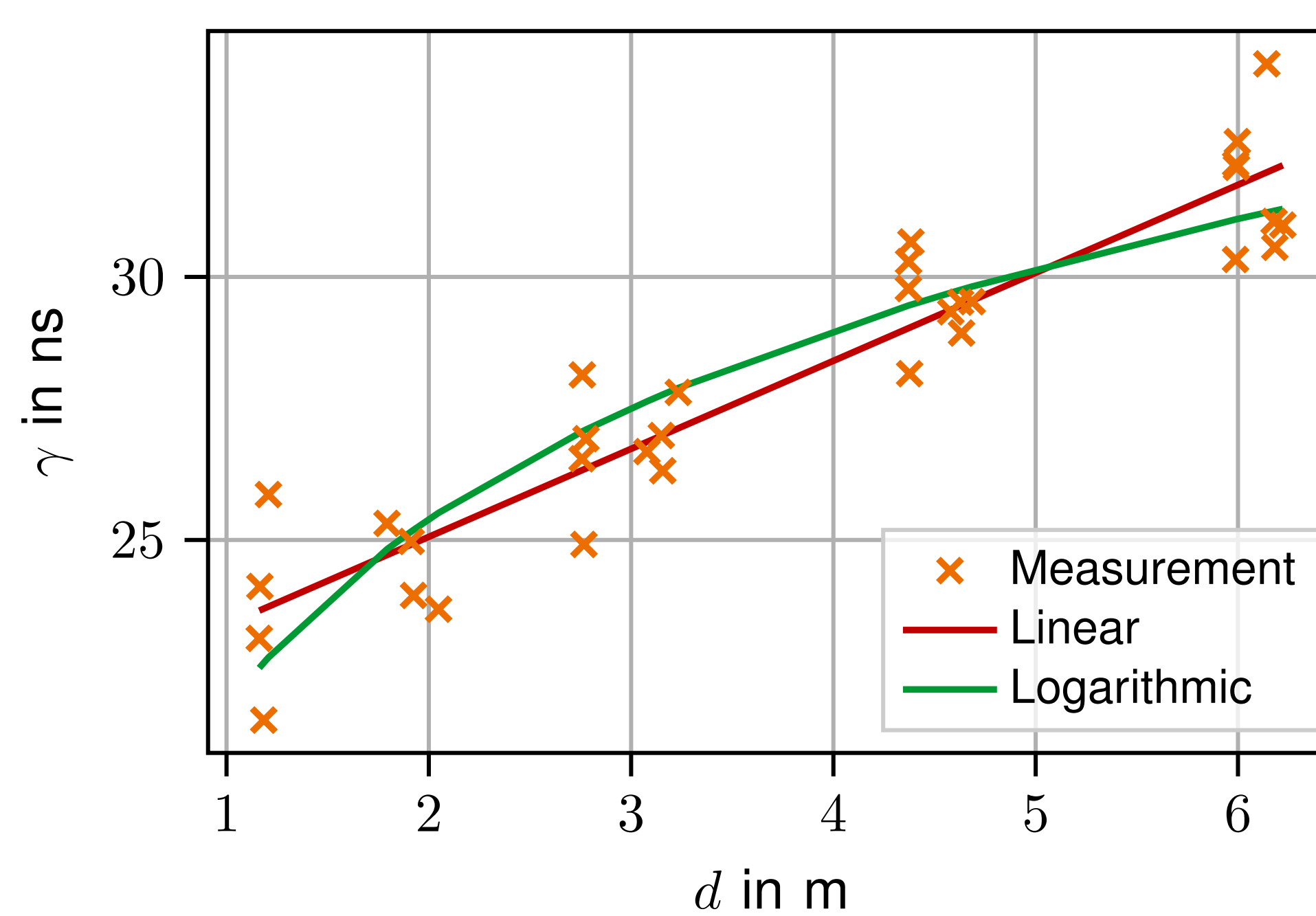
Error term: $X_\gamma \sim \mathcal{N}(0, \sigma_\gamma^2)$

Linear Time Constant

$$\gamma = \gamma_0 + \frac{m_\gamma d}{1 \text{ m}} + X_\gamma$$

Logarithmic Time Constant

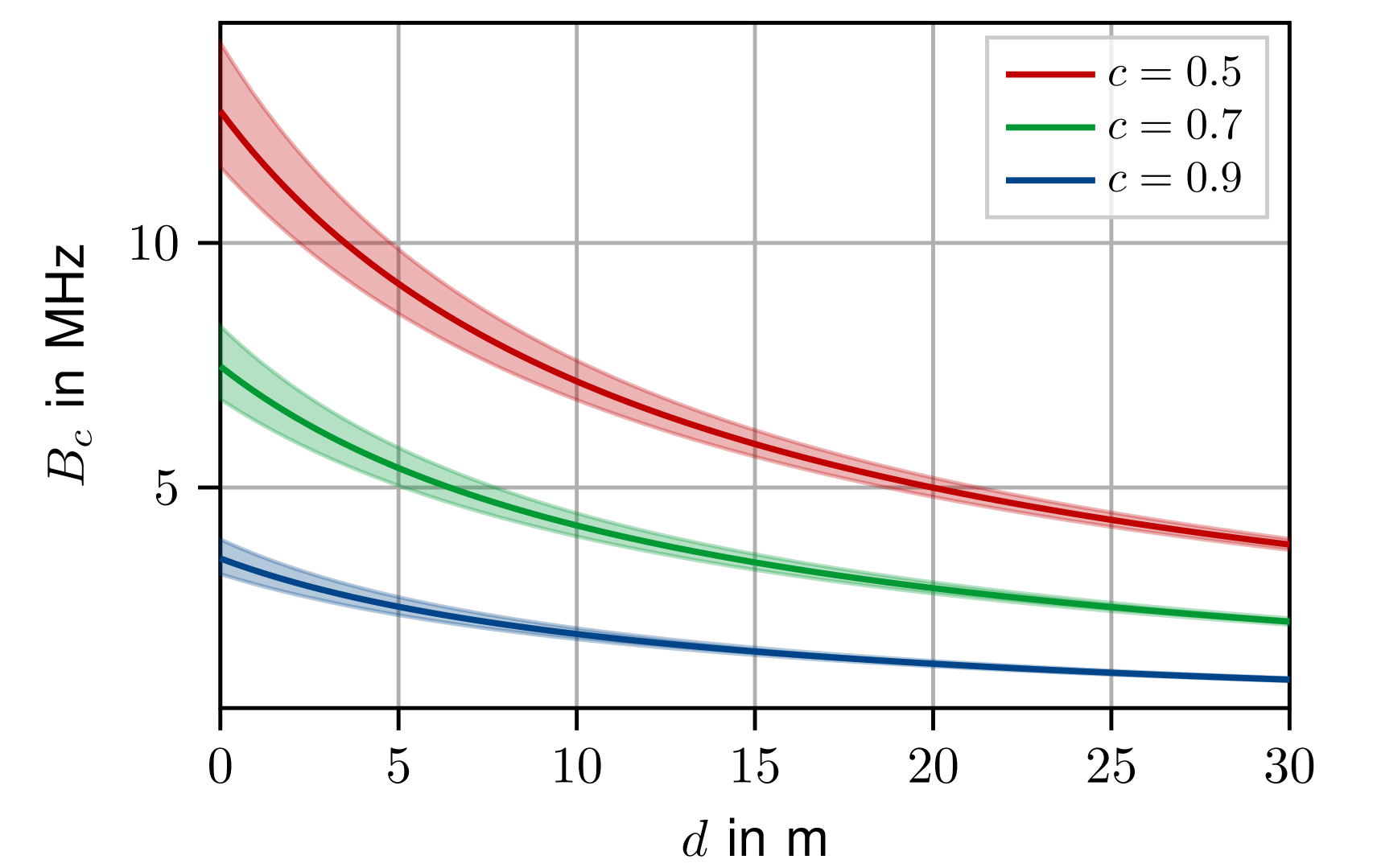
$$\gamma = \gamma_0 + 10m_\gamma \log_{10}\left(\frac{d}{1 \text{ m}}\right) + X_\gamma$$



Model	γ_0 in ns	m_γ in ns	σ_γ in ns
Linear	21.714	1.673	1.077
Logarithmic	21.788	1.197	1.207
Linear [2]	14.74	2.28	5.66
Linear [3]	16.68	3.26	9.40
Logarithmic [3]	12.7	1.10	0.648
Logarithmic [3]	16.02	1.54	1.22

Coherence Bandwidth with Correlation Threshold c

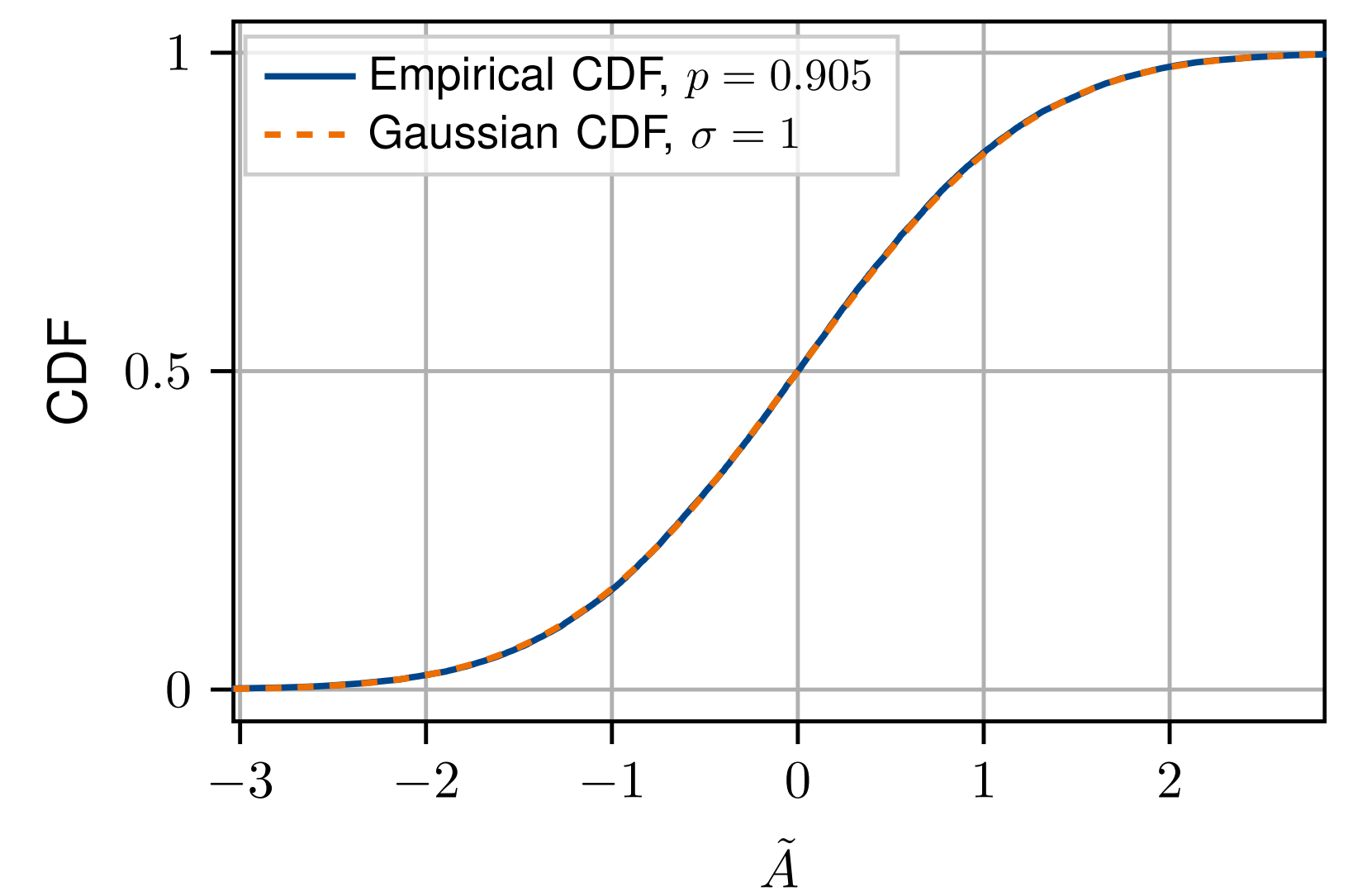
$$B_c = (2\pi\gamma)^{-1} \sqrt{c^{-2} - 1}$$



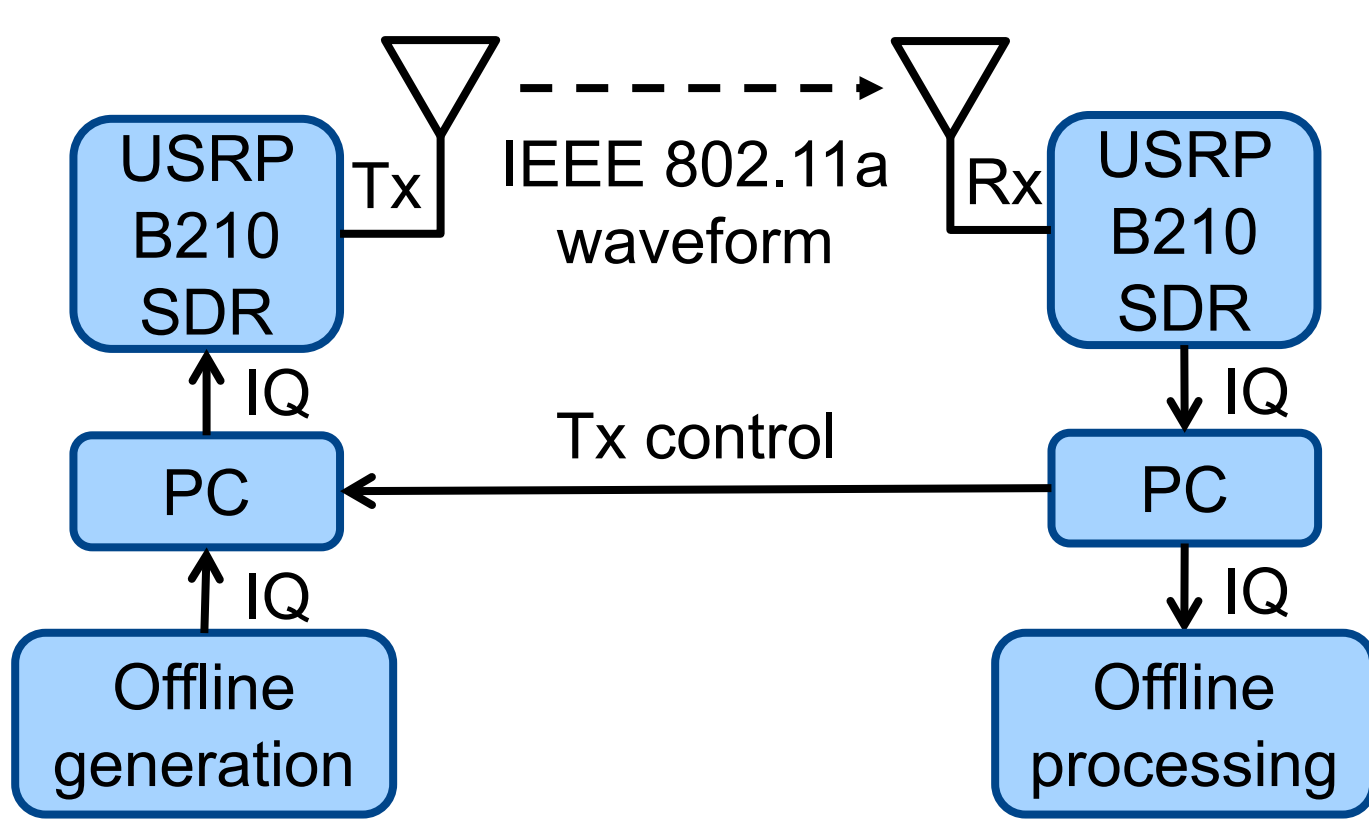
Normalized Fading Coefficients

$$\tilde{a}_k = \frac{a_k}{\sqrt{\frac{1}{2} E\{|a_k|^2\}}}$$

All $\text{Re}\{\tilde{a}_k\}$ and $\text{Im}\{\tilde{a}_k\}$ are realizations of \tilde{A} .
→ $\tilde{A} \sim \mathcal{N}(0,1)$ → **Rayleigh fading**



Large-Scale Modeling



Linear Path Loss

$$L(d) = X_L - L_0 - 10n_0 \log_{10}\left(\frac{d}{1 \text{ m}}\right) \text{ dB}$$

Quadratic Path Loss

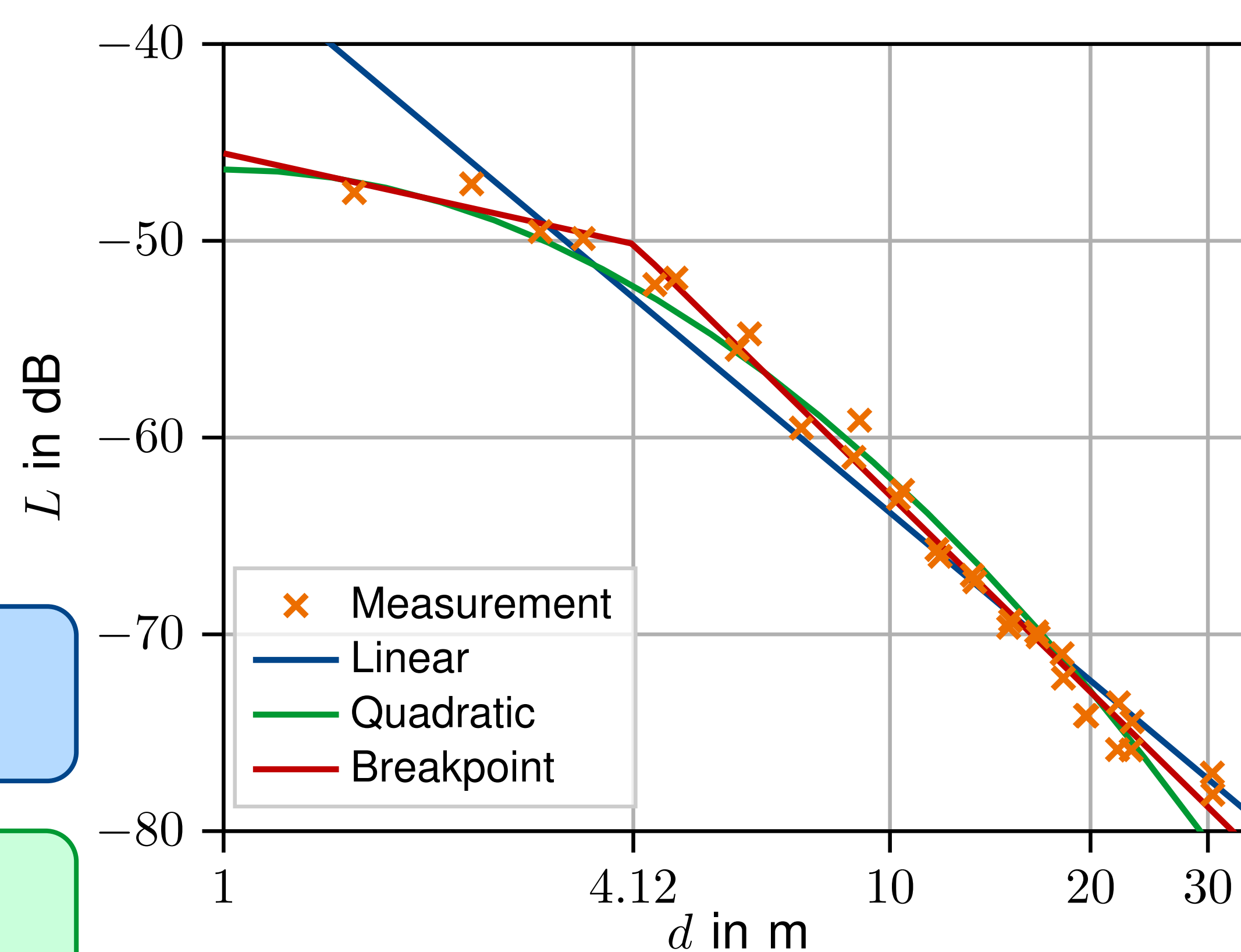
$$L(d) = X_L - L_0 - 10n_0 \left[\log_{10}\left(\frac{d}{1 \text{ m}}\right) \right]^2 \text{ dB}$$

Breakpoint Path Loss

$$L(d) = X_L + \begin{cases} -L_0 - 10n_0 \log_{10}\left(\frac{d}{1 \text{ m}}\right) \text{ dB}, & d \leq d_B \\ -L_1 - 10n_1 \log_{10}\left(\frac{d}{1 \text{ m}}\right) \text{ dB}, & d > d_B \end{cases}$$

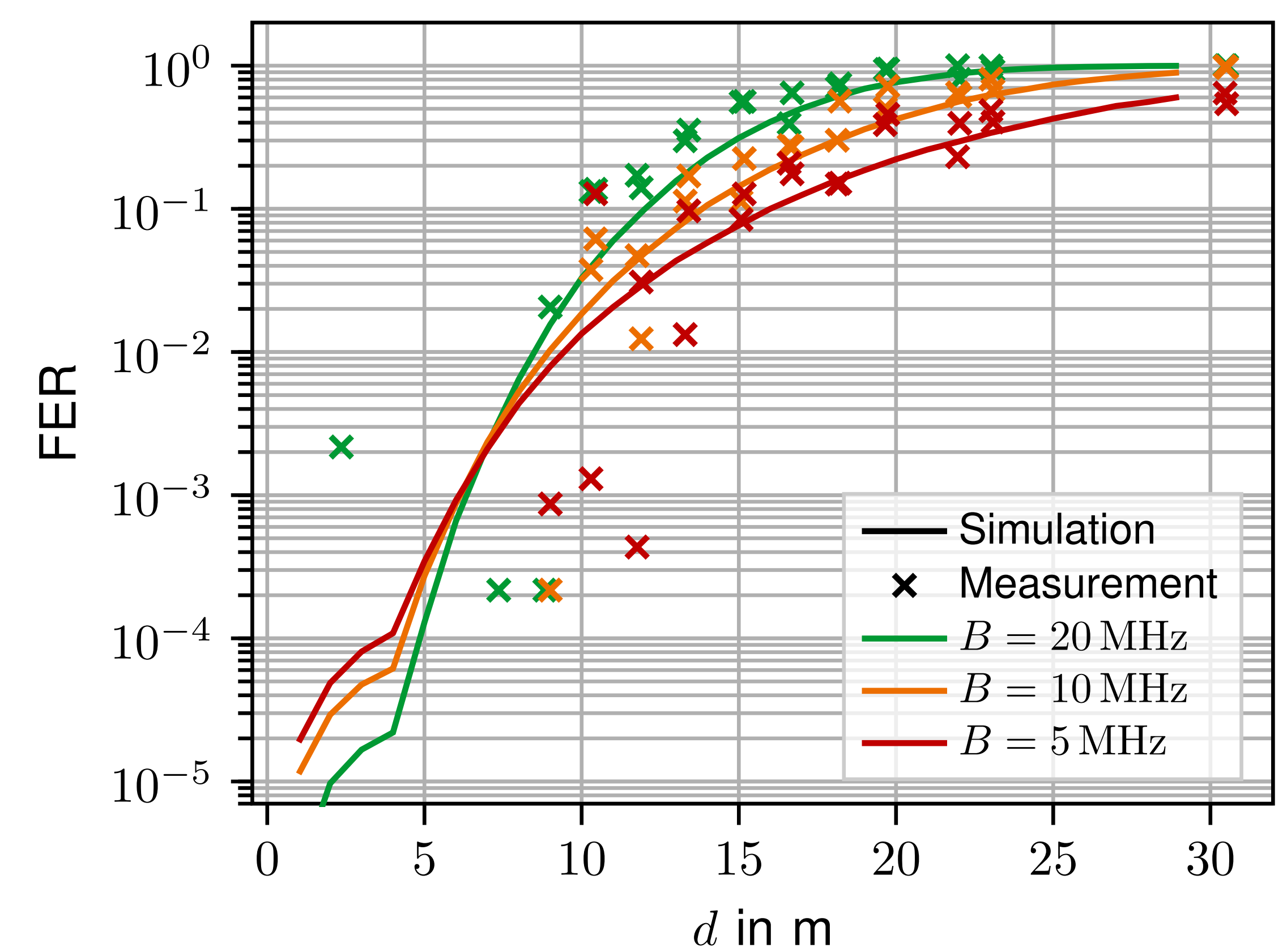
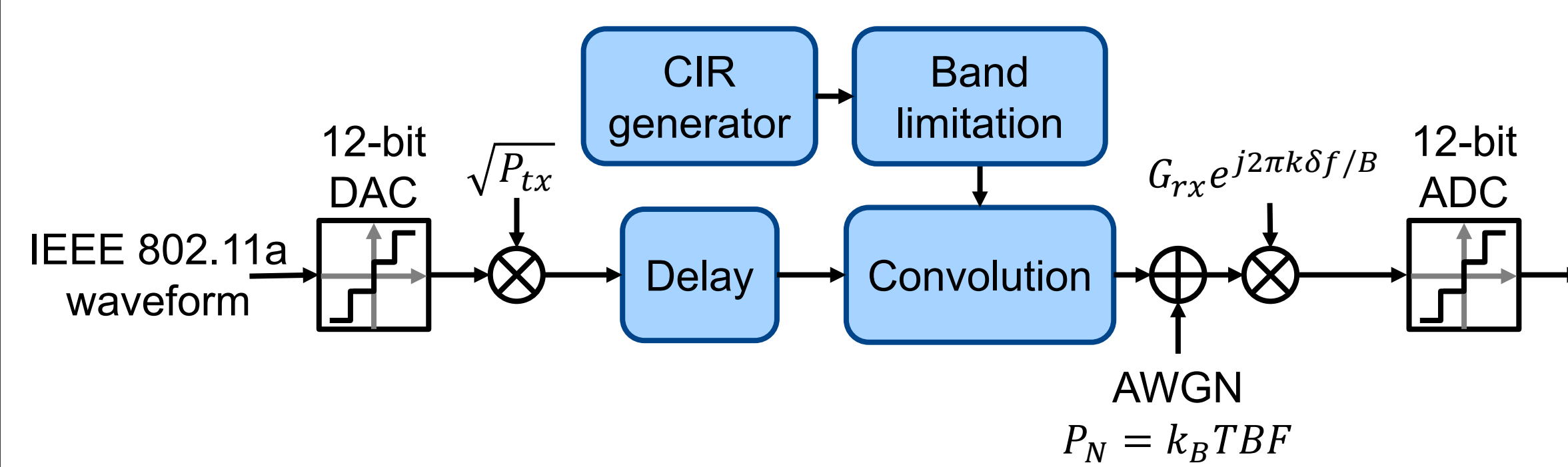
$$L_1 = L_0 + 10(n_0 - n_1) \log_{10}\left(\frac{d_B}{1 \text{ m}}\right) \text{ dB}$$

Shadowing: $X_L \sim \mathcal{N}(0, \sigma_L^2)$



Model	L_0 in dB	n_0	n_1	d_B in m	σ_L in dB
Linear	35.44	2.83	-	-	1.84
Quadratic	47.37	1.56	-	-	1.34
Breakpoint	45.55	0.75	3.32	4.12	0.93
Breakpoint [2]	40.45	-0.08	2.27	2.84	1.76
Breakpoint [3]	46.72	1.51	3.19	7.24	2.74

Experimental Model Validation



Noise figure 9 dB, temperature 25°C, $\delta f = 10$ kHz, $P_{tx} = -20$ dBm, $G_{rx} = 76$ dB, BPSK, conv. code rate $\frac{1}{2}$

Conclusions

We presented the results of a measurement campaign, characterizing the propagation environment inside an Airbus A321 cabin in the WAIC frequency band. A segment-wise path loss model was parameterized. Additionally, small-scale fading was modeled by an exponential average power delay profile with a linearly increasing distance-dependent time constant and Rayleigh fading. The channel model was successfully verified by comparing experimentally measured FER to simulated FER using the channel model. The FER measurements are based on IEEE 802.11a in the WAIC band with -20 dBm transmit power.

References

- [1] ICAO, „Proposed Amendment to the Internat. SARPS, Aeronautical Telecom., Annex 10, Vol. V, Aeronautical Radio Frequency Spectrum Utilization to the Convention on Internat. Civil Aviation, 2023
- [2] M. Bachhuber, „Analysis and Modeling of Radio Propagation in Passenger Cabins of big sized Aircrafts“, 2011
- [3] S. Chiu, J. Chuang and D. G. Michelson, „Characterization of UWB Channel Impulse Responses Within the Passenger Cabin of a Boeing 737-200 Aircraft“, 2010