

Deterministic Ray-Launching Tool for THz Propagation Modeling

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The advent of sixth generation (6G) wireless networks aims to deliver unprecedented data rates, ultra-low latency, and enhanced connectivity by utilizing the Terahertz (THz) spectrum (0.3–10 THz), which can support data throughput exceeding 100 Gb/s. However, THz waves exhibit significant challenges, including high path loss, scattering, atmospheric absorption, and surface interactions, requiring a precise understanding of signal behavior. Traditional statistical models often fail to capture the complexities of the THz channel, particularly in intricate environments. Additionally, performing empirical measurements in the THz spectrum is a daunting task due to the specialized equipment requirements, high costs, and variability in material properties, leading to limited and inconsistent datasets. The need for modeling site-specific environments and ensuring repeatability adds further complexity. Thus, there is a critical need for an alternative approach that enables accurate modeling with minimal reliance on empirical measurements.

To address these challenges, we introduce a deterministic ray-launching (RL) tool for THz propagation modeling. The tool includes a library of electromagnetic material properties, obtained from measurements of common building materials and uses geometric and electromagnetic principles of RL technique to accurately simulate THz signal propagation, accounting for scattering and atmospheric effects. The proposed tool has been validated against a channel measurement campaign conducted in a conference room at the 300 GHz frequency band (A. Schultze, F. Undi, M. Peter, W. Keusgen, and T. Eichler, “Angle-Resolved THz Channel Measurements at 300 GHz in a Conference Room Environment,” in 2021 XXXIVth General Assembly and Scientific Symposium of the International Union of Radio Science (URSI GASS), Rome, Italy: IEEE, Aug. 2021). A total of eight receiver positions were measured, and the collected raw data were further processed to derive channel parameters such as path loss (PL), root mean square (RMS) delay spread (DS), and RMS angular spread (AS).

The channel parameters simulated using the RL tool were cross-correlated with measurements taken at all eight positions, with comparisons illustrated in Fig. 1. The results indicate a strong agreement between the simulations and measurements across all three parameters. This proposed RL tool confirms its reliability for investigating THz frequency scenarios through simulation. It will allow researchers and engineers to accurately predict THz signal behavior in both indoor and outdoor environments, eliminating the logistical and financial challenges associated with measurement campaigns.

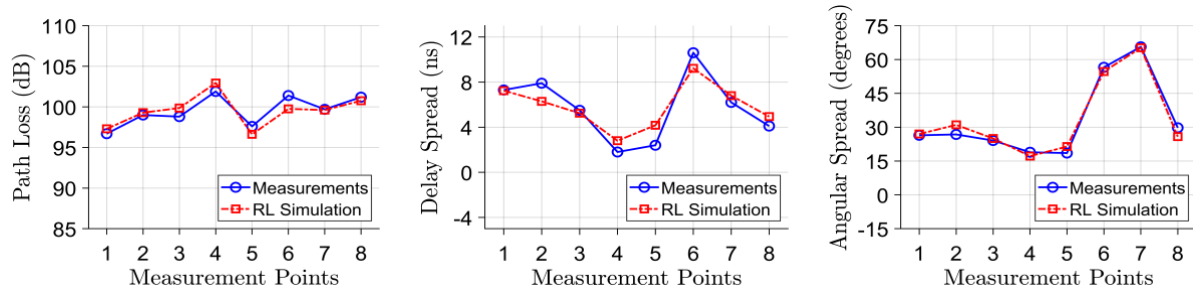


Fig. 1. Simulation and measurements comparison for PL (left), RMS DS (middle), and RMS AS (right).