# Propagation Measurements in the 7 GHz Band Near the VLA Telescope

Sarah Tanveer and Ali Abedi
The University of Wisconsin - Madison, WI, 53706, USA, https://www.cs.wisc.edu/

***Abstract*—The 7.125–8.4 GHz band is a strong candidate for sixth-generation (6G) mobile systems, offering mid-band spectrum with favorable propagation characteristics. Although this band has no protected allocation for radio astronomy, it is among the cleanest spectral regions and is opportunistically used by observatories such as the Very Large Array (VLA). As 6G devices begin to operate in this range, understanding their potential impact on radio astronomy becomes essential.**

**We conducted a field experiment at the VLA by transmitting a CW tone centered at 7.130 GHz with power levels typical of current smartphones. The transmitter, mounted on a vehicle, was driven along a highway near the telescope, while a receiver located at the VLA site recorded the signal. We found that the structure of the VLA introduced unique propagation effects, with some antennas blocking signals to others while reflections enhanced reception at certain positions. These results demonstrate how everyday devices, such as phones or cars passing near the VLA, could affect observations and highlight the importance of characterizing propagation in this band.**

## I. INTRODUCTION

The 7.125–8.4 GHz band has been identified as an important candidate for sixth-generation (6G) wireless systems because it offers mid-band spectrum with the potential to balance wide-area coverage and high capacity [1]. Although there is no protected allocation for radio astronomy in this range, it is nevertheless one of the cleanest and most pristine portions of the spectrum today [2]. The Very Large Array (VLA) and other observatories make opportunistic use of this band for scientific observations precisely because it is relatively free of interference. However, this situation is expected to change as 6G and other wireless technologies begin to occupy the band, raising the potential for harmful interference to radio astronomy.

To investigate these coexistence challenges, we conducted a field experiment in the 7.125–8.4 GHz range at the VLA radio telescope in New Mexico. A custom transmitter was deployed inside a vehicle with an antenna mounted on the roof. The vehicle was driven along a highway near the VLA, transmitting while moving to different locations and distances from the telescope. This setup emulated a realistic scenario where a mobile user device operates in the vicinity of a highly sensitive passive receiver.

Simultaneously, a dedicated receiver was installed near the VLA antennas to capture the transmitted signals. By recording received power as the vehicle transmitted from stationary locations and along the driving route, we measured how signal strength varied with distance, geometry, and motion. These propagation measurements provide insight into interference risk in this mid-band spectrum and support the development of sharing and mitigation strategies that balance emerging wireless systems with ongoing scientific use.

## II. DATA COLLECTION AND PROCESSING

The goal of our measurements was to study how future 6G networks in the 7.125–8.4 GHz band can affect sensitive radio astronomy receivers. To emulate realistic mobile emissions, we began by capturing commercial 5G signals, which we then replayed using our experimental platform. We augmented the replayed waveform with a narrowband beacon consisting of a continuous-wave (CW) tone. The composite signal occupied a 15 MHz bandwidth centered at 7.130 GHz. The total transmit power into the antenna was set to 23 dBm, representative of power levels used by current smartphones. In this paper, we only utilize the CW tone in our analysis.

The transmitter hardware consisted of a USRP B210 connected to an external up-converter to shift the baseband signal into the 7–8 GHz range. The transmit antenna was a 2 dBi magnetic-mount antenna installed on the roof of the vehicle similar to the low-gain and unidirectional antennas used in smartphones. For the receiver, we deployed a similar down-converter chain that shifted the signal into the digitization range of an RFSoC 4×2 software-defined radio. This SDR recorded complex IQ data streams for offline processing.

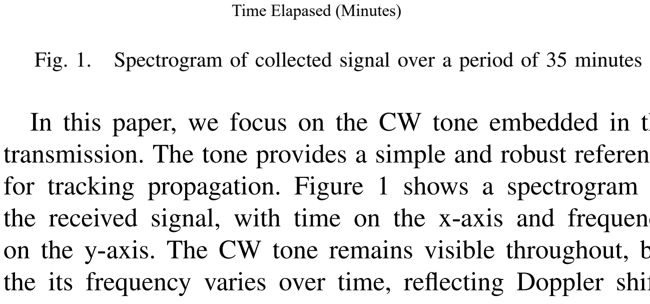

Fig. 1. Spectrogram of collected signal over a period of 35 minutes

In this paper, we focus on the CW tone embedded in the transmission. The tone provides a simple and robust reference for tracking propagation. Figure 1 shows a spectrogram of the received signal, with time on the x-axis and frequency on the y-axis. The CW tone remains visible throughout, but the its frequency varies over time, reflecting Doppler shifts caused by the vehicle traveling at approximately 95 km/h along the highway near the VLA. We analyze the CW tone by estimating its SNR at the receiver during the experiment. In the following section, we present the results of this analysis, highlighting temporal variations in received signal strength and their implications for interference scenarios.

## III. Results and Evaluation

We processed and analyzed the collected data, which was stored in the Digital RF format [3] and originally captured at a sampling rate of 10 MHz. Using GNU Radio, we isolated the CW tone with a low-pass filter and decimated the stream to a sampling rate of 10 kHz. We then measured the SNR of the signal in a mobile scenario, where the receiver was stationary and the transmitter was traveling at approximately 95 km/h along a road. Figure 1 shows that the signal is not stable but exhibits frequency shifts, consistent with Doppler effects from the moving transmitter. The observed signal bandwidth is narrow (-3 kHz to +3 kHz), and at a carrier frequency of 7–8 GHz, a few hundred hertz of Doppler shift is expected (at a relative speed of 95 km/h). The shape of the received tone matches the expected frequency variation due to Doppler, given the relative velocity between the transmitter and receiver.

In Figure 2, a heatmap illustrates the trajectory of the transmitter during the experiment, with longitude on the x-axis and latitude on the y-axis. The locations of the radio telescopes and the receiver are marked on the map using icons. The heatmap shows how the SNR varies as the transmitter moves. In the experiment, we drove from northeast of the VLA towards west for about 15 km from the center of the VLA, made a U-turn, stopped north of the array for five minutes, and then continued back toward the site. The heatmap shows that SNR was lowest when the transmitter was directly north of the VLA, where the antenna structures blocked the receiver. As the vehicle moved further away, the signal improved due to reduced blockage. Upon returning, the strongest signals were recorded when the transmitter was east or south of the array, where line-of-sight paths to the receiver were largely unobstructed.

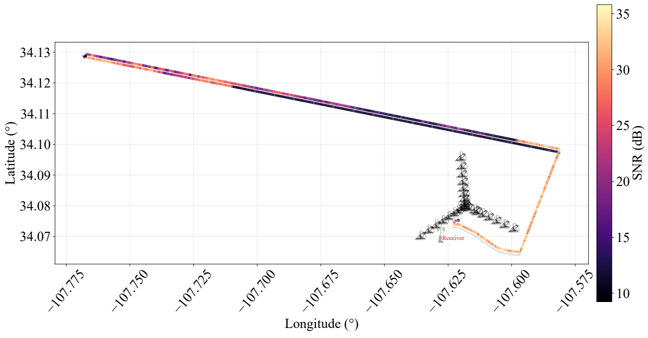

Fig. 2. SNR at the receiver while the transmitter moves near the VLA

Figure 3 shows the SNR as a function of the distance between the transmitter and receiver, expressed in kilometers. The measured SNR versus distance departs significantly from the typical path loss trend, where signal strength decays smoothly with range. In our measurements, SNR values as high as ∼35 dB were observed both at short distances near the VLA (∼1 km) and at longer ranges up to 14 km. At close distances, we believe nearby buildings may have attenuated the signal, reducing levels compared to open-sight conditions. Beyond about 6 km, the SNR exhibits a repeating pattern of peaks and dips that closely follows the geometric layout of the VLA antennas. As the transmitter moves behind an antenna, the received signal drops, and as it passes between antennas, the signal recovers, leading to oscillations in the SNR trace. Interestingly, similar patterns were also visible in data recorded directly on the VLA. These observations highlight that the VLA itself creates a highly complex propagation environment: its large antennas not only block signals for other elements but can also reflect energy in unexpected ways. Thus, even though the array is located on relatively flat terrain with few surrounding structures, the telescope layout introduces intricate interference dynamics that differ substantially from conventional free-space propagation.

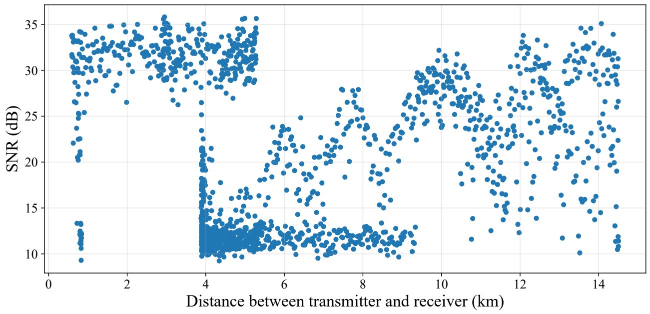

Fig. 3. SNR as a function of the distance between the transmitter and receiver

## IV. Conclusion

We presented propagation measurements of a CW tone transmitted in the 7.125–8.4 GHz band near the VLA. Our results show that signals at smartphone-level power can be detected at distances up to 14–15 km, with SNR values exceeding 30 dB. Unlike the smooth decay expected with distance, the SNR exhibits strong fluctuations due to the VLA antenna layout, where blockage and reflections from the large dishes create complex propagation effects. These findings highlight that even in open terrain, the structure of the VLA itself dominates interference behavior, underscoring the importance of detailed measurement studies for assessing coexistence between future 6G systems and radio astronomy.

## References

[1] International Telecommunication Union (ITU-R). Wrc-27 agenda item: Studies and technical conditions for the use of IMT in 4.4–4.8, 7.125–8.4, and 14.8–15.35 ghz. ITU-R presentation (World Radiocommunication Seminar materials), Dec 2024. Shows 7.125–8.4 GHz under WRC-27 study for IMT identification.

[2] N. R. A. Observatory. X-Band Spectra (8-12 GHz) 2024 May B-config. https://science.nrao.edu/facilities/vla/observing/RFI/may-2024-B-configuration/X-Band_spectra_202405B.

[3] R. Volz, W. C. Rideout, J. Swoboda, J. P. Vierinen, and F. D. Lind. Digital RF. https://github.com/MITHaystack/digital_rf.