

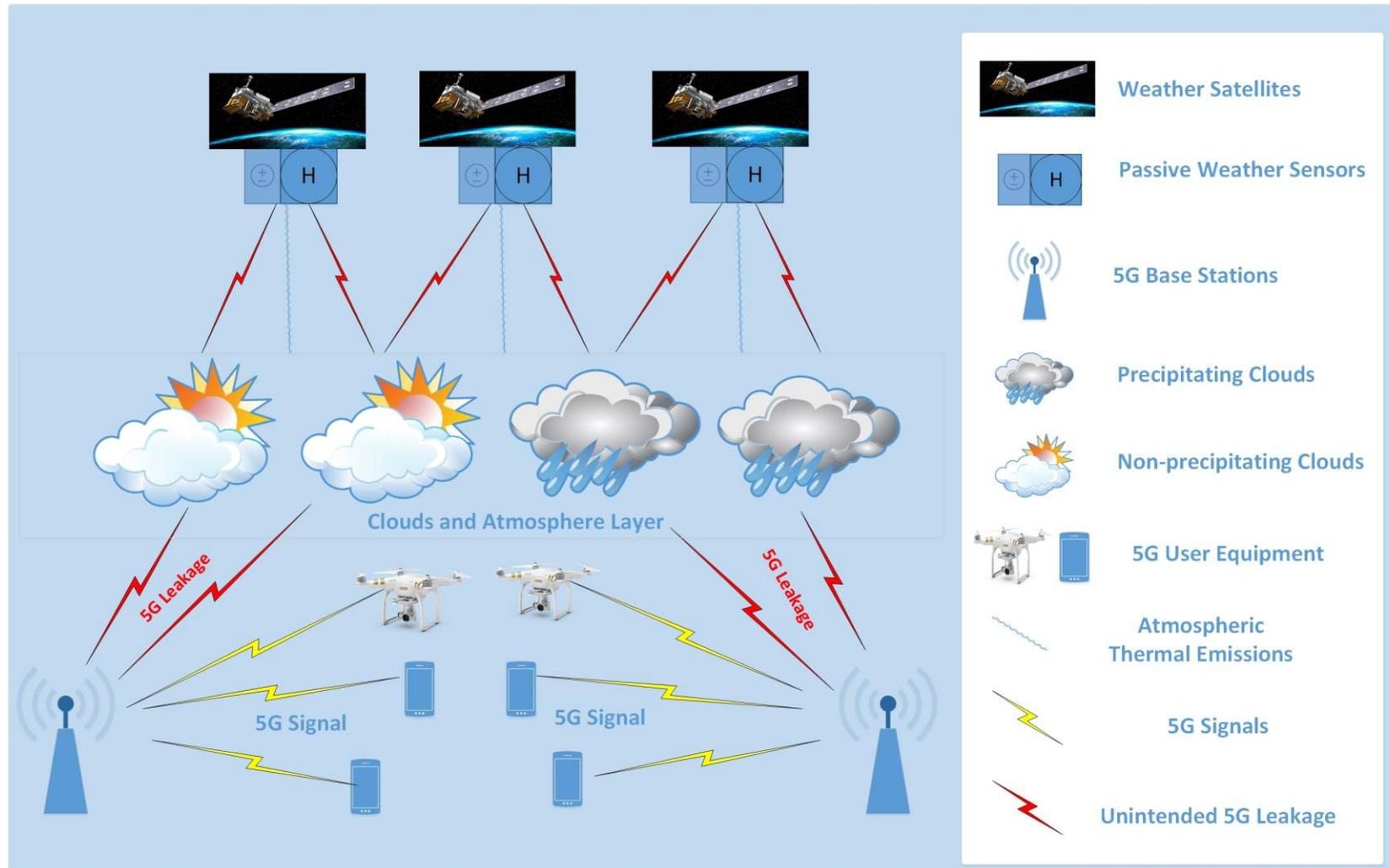
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CHARACTERIZING 5G LEAKAGE ON PASSIVE WEATHER SENSING SPECTRUM BANDS

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5G uses millimeter wave frequencies (>20 GHz) potentially causing interference with weather sensing at 23.8 GHz

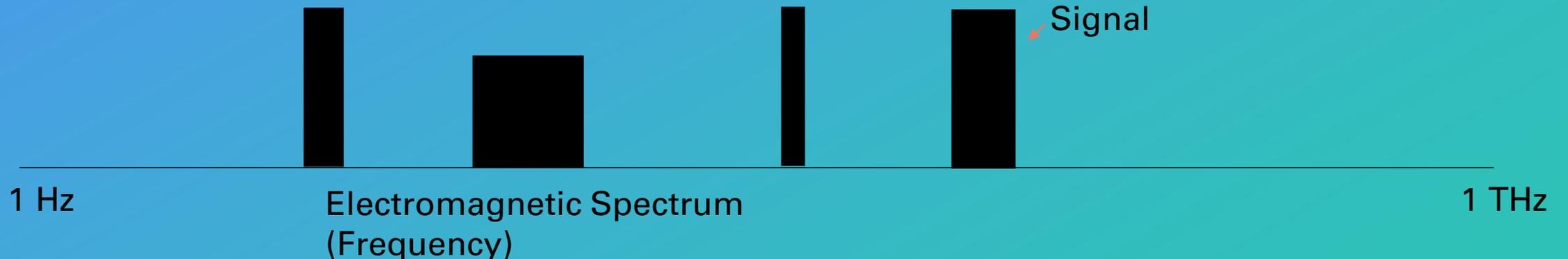
OBJECTIVE:

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 - The goal of the experiment is to determine the amount of unwanted leakage generated by 5G signals in mmWave frequencies and quantify their potential
 - impact on weather sensing.



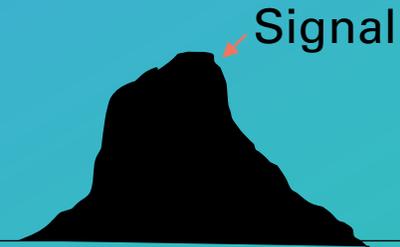
BACKGROUND:

- + Signals have an intended range of frequencies which they ideally would be sent over.
- Each user/operator is assigned certain channels (e.g. portion of spectrum) which they can transmit over by the FCC.
 - Ideal signal should be a rectangle between two frequencies forming a **bandwidth**, fully utilizing allocated FCC spectrum.



BACKGROUND:

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 - Real signals do not look like rectangles however due to various equipment imperfections and environment.
 - Bandwidth of the assigned channel varies based on target rate and is typically larger at higher frequencies (such as mmWave for 5G).

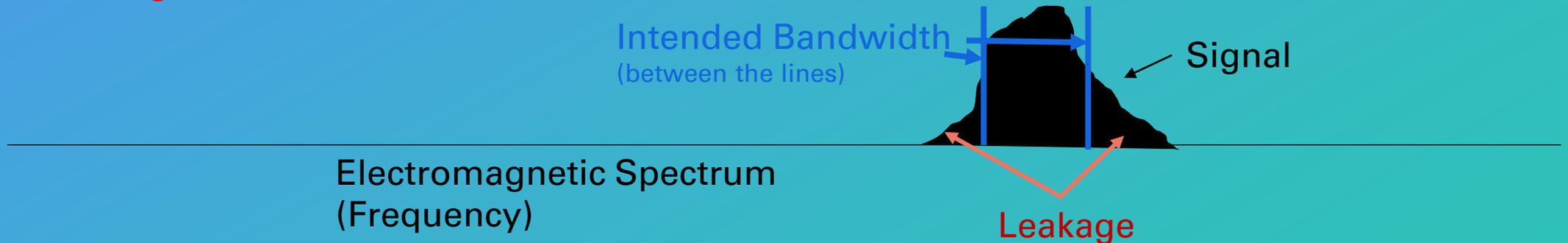


Electromagnetic Spectrum
(Frequency)

BACKGROUND:

Real emissions typically leak outside of the intended bandwidth range.

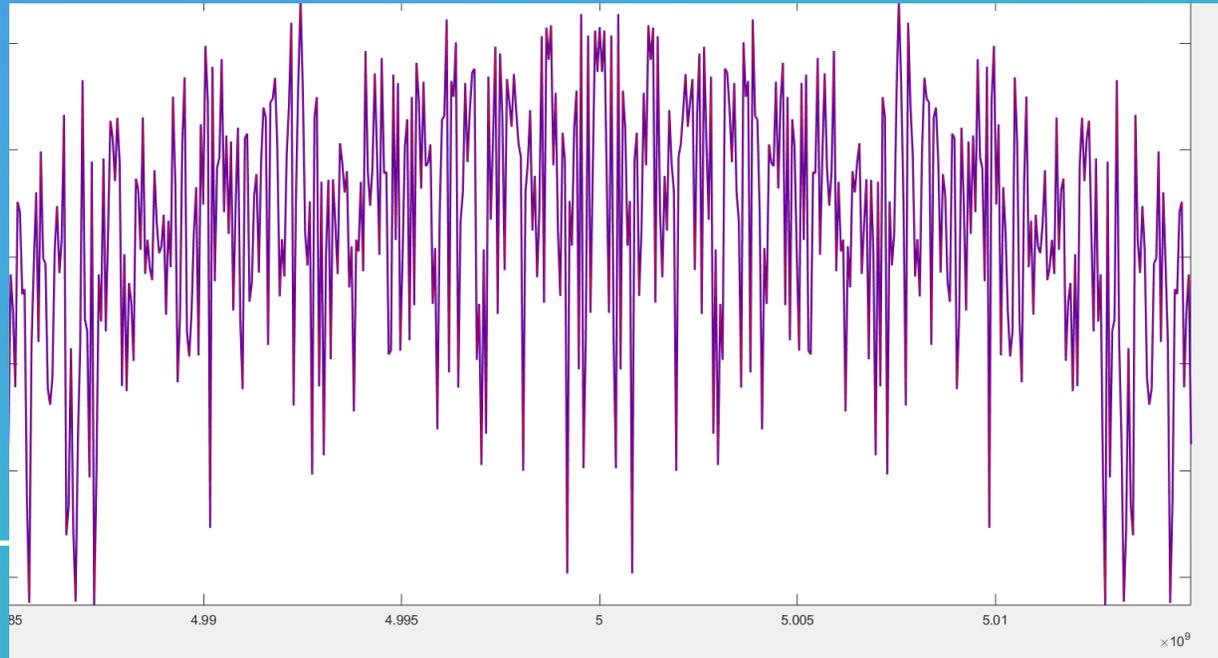
- + In this study: -3dB points are used as a measure of the assigned/intended bandwidth
- Noise floor: the base low-level radio frequency emission when signal is not present
- Signal outside the intended bandwidth that is above the **noise floor** is labeled as **leakage**.



BACKGROUND:

One of the main issues in the study would be to find a value for the noise floor.

There are constant, low-level signals throughout the Electromagnetic Spectrum, so finding an exact level to call the "noise floor" can be tricky.



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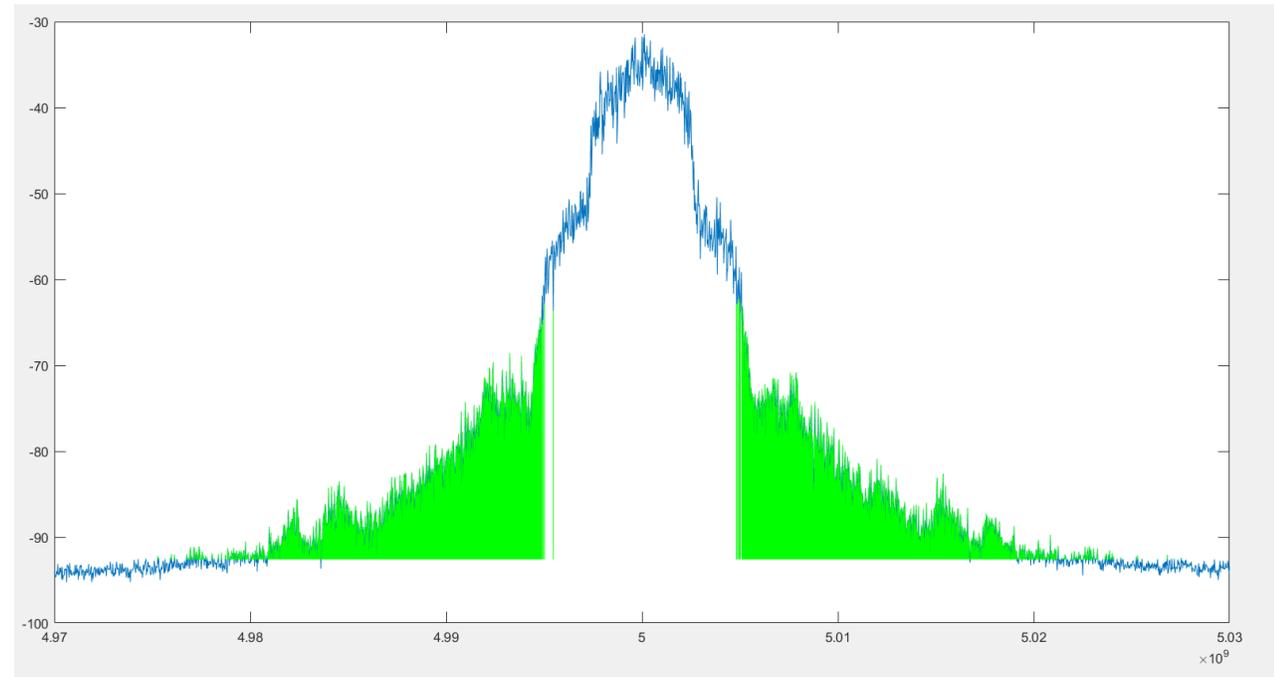
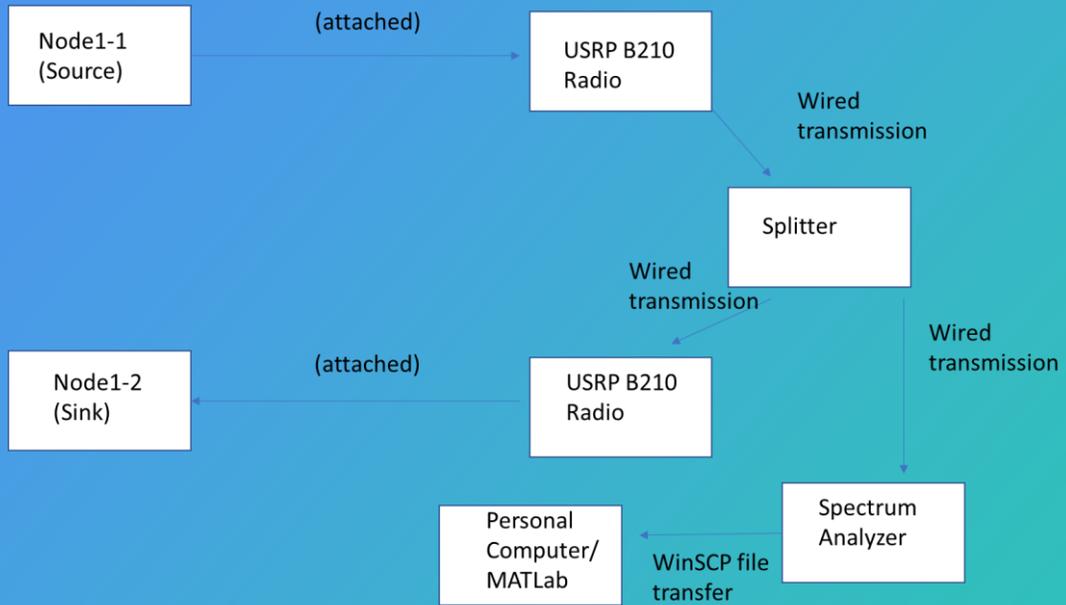
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Experiment 1

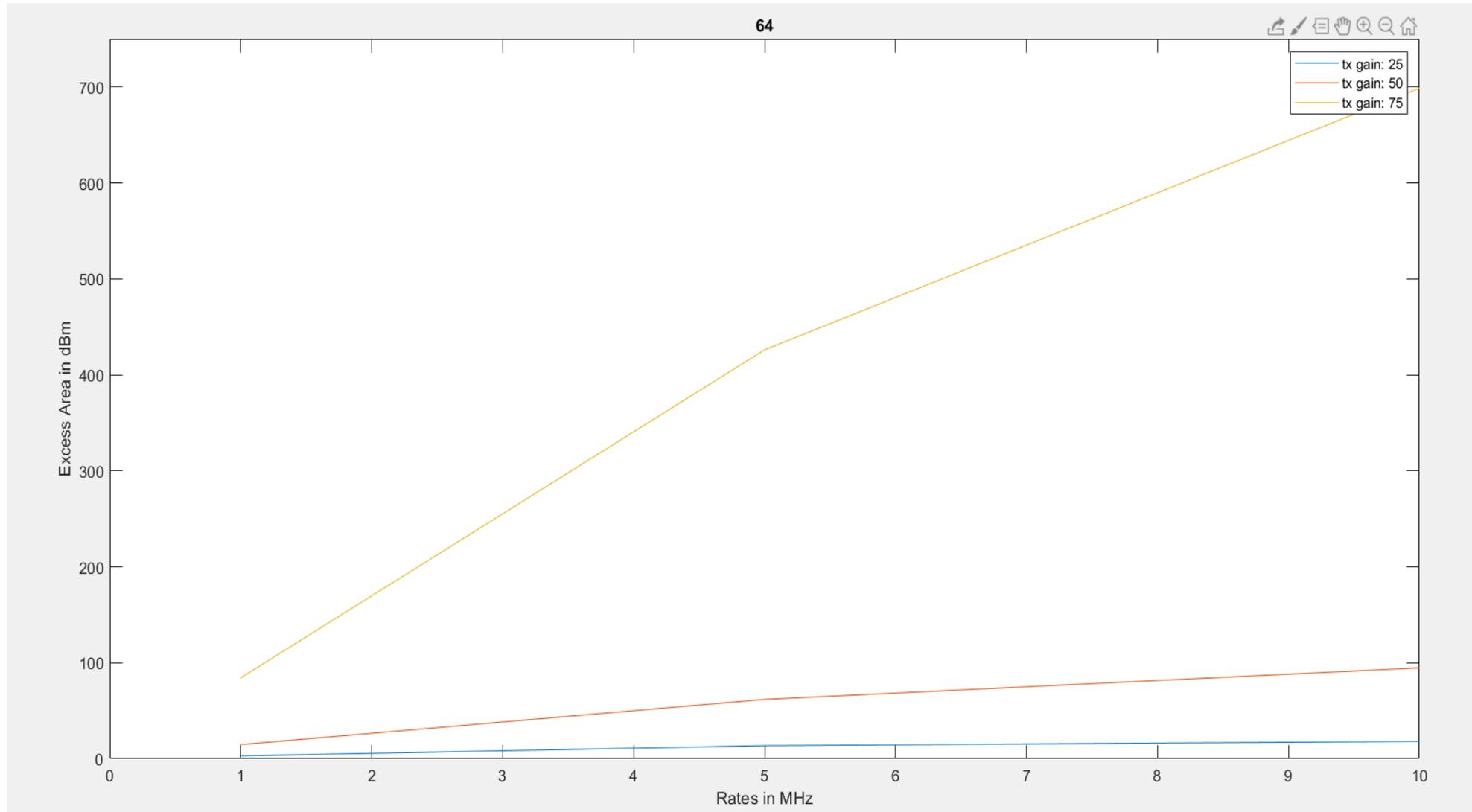
- Experiment involved sending a signal centered at 5 GHz and varying the bandwidth (also known as sampling rate) along with other factors such as tx gain and measuring the ratio of leakage and noise (outside of the -3dB signal bandwidth region).

EXPERIMENT 1



Experiment 1

- Increasing bandwidth increases leakage
- Higher frequencies (like 5G) require more bandwidth (100-400 MHz at mmWave frequencies)
- Relative flatness of the noise floor and the waveform due to the wired transmission in the setup



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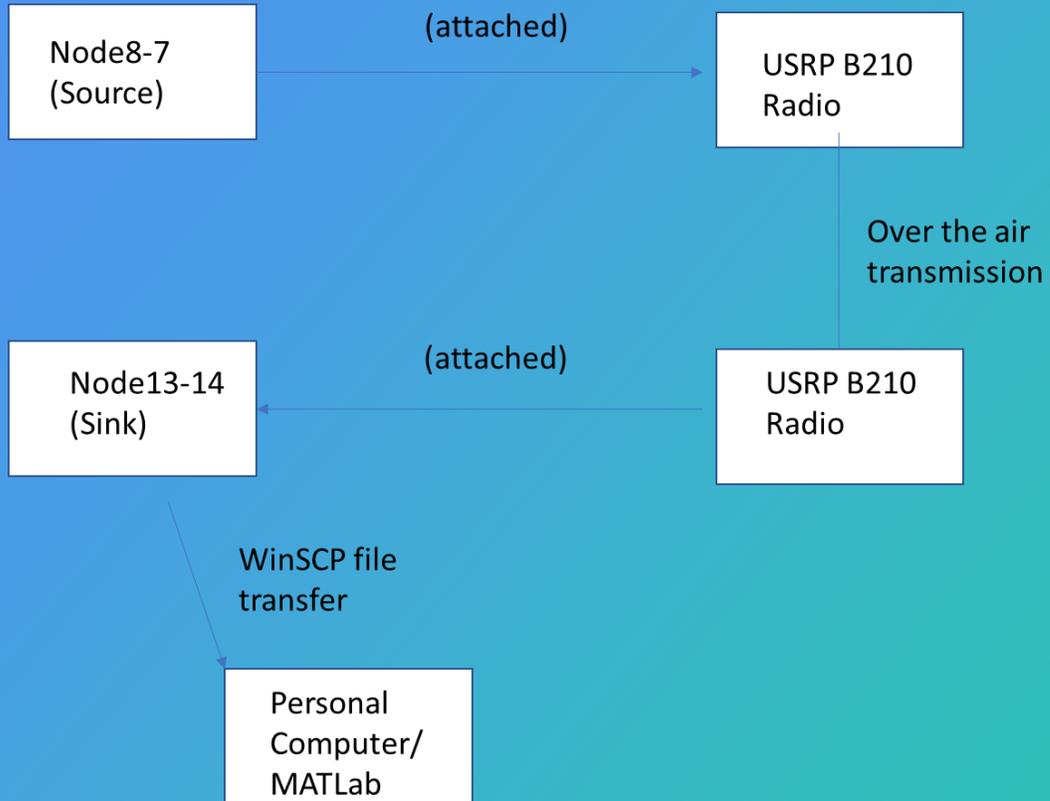
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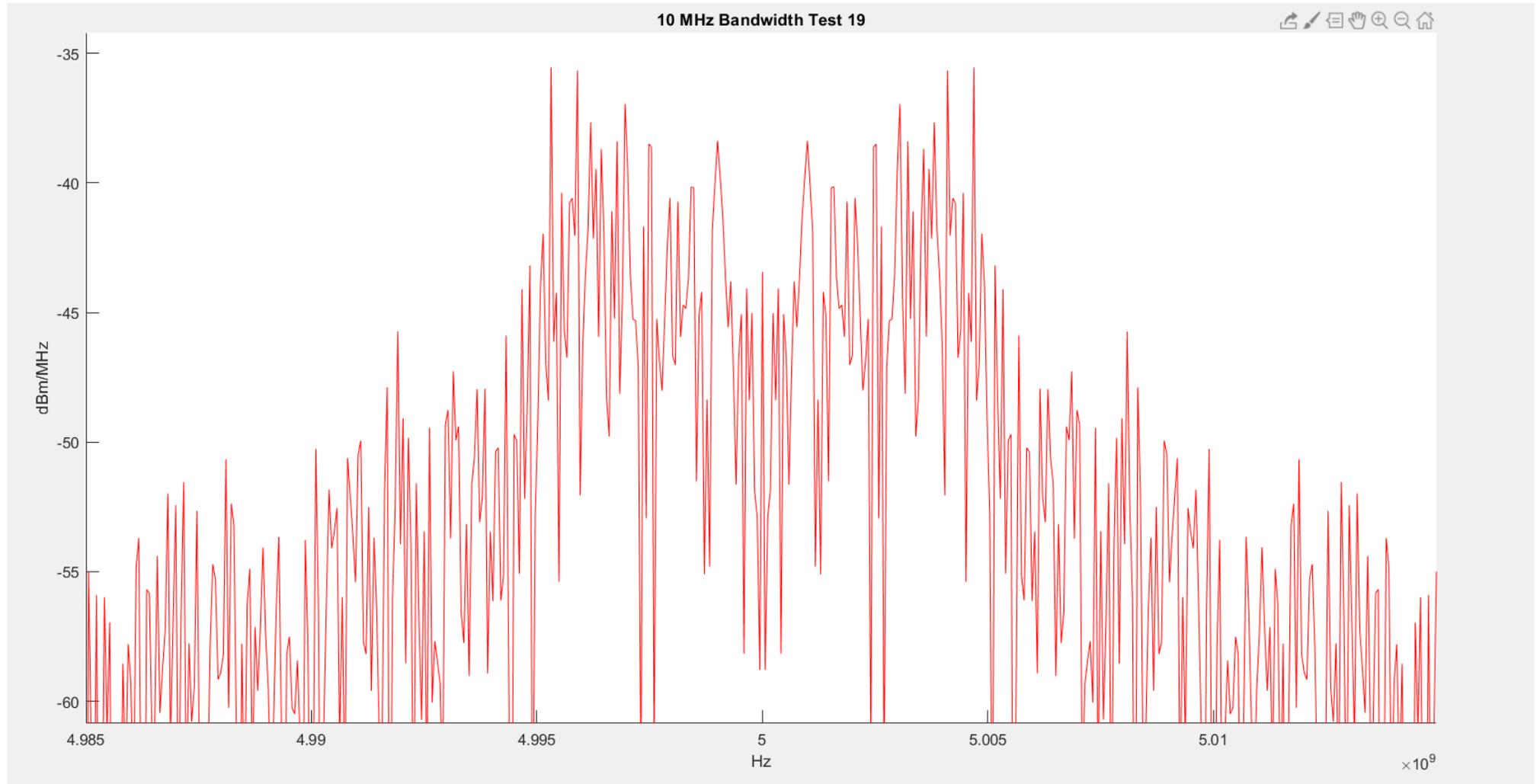
Experiment 2

- The second experiment used a receiver radio to receive the wave as opposed to a spectrum analyzer and transmitted the signal over the air as opposed to over wire (also at 5GHz).
- Another way the Experiment 2 differed was the way it identified the level of the noise floor from finding the mean level of signal from 16 waveforms without any transmitting signal.
- Previously, the noise floor was just calculated from the first and last 4% of a waveform capture.

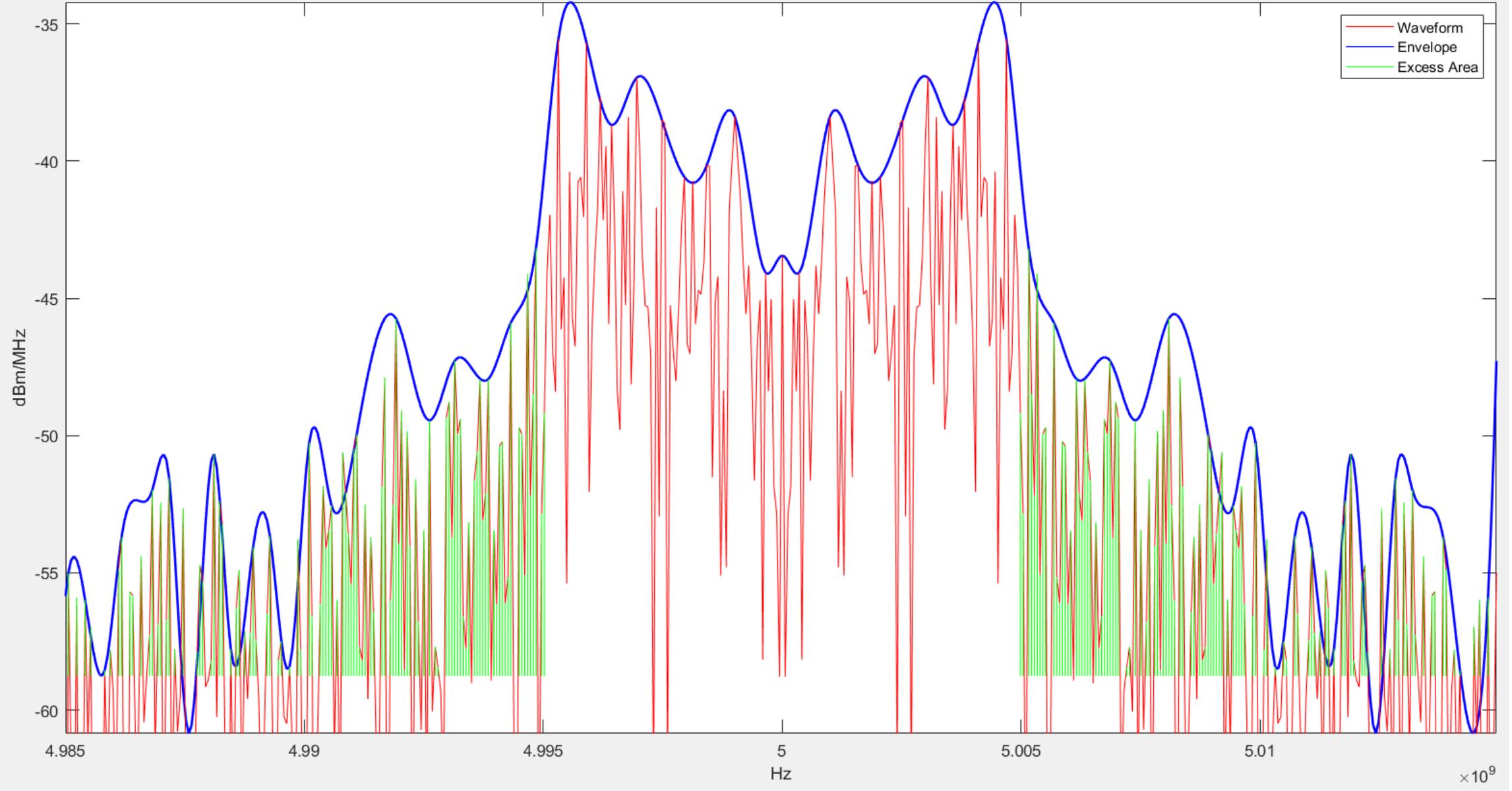
EXPERIMENT 2



Much noisier over-the-air experiment

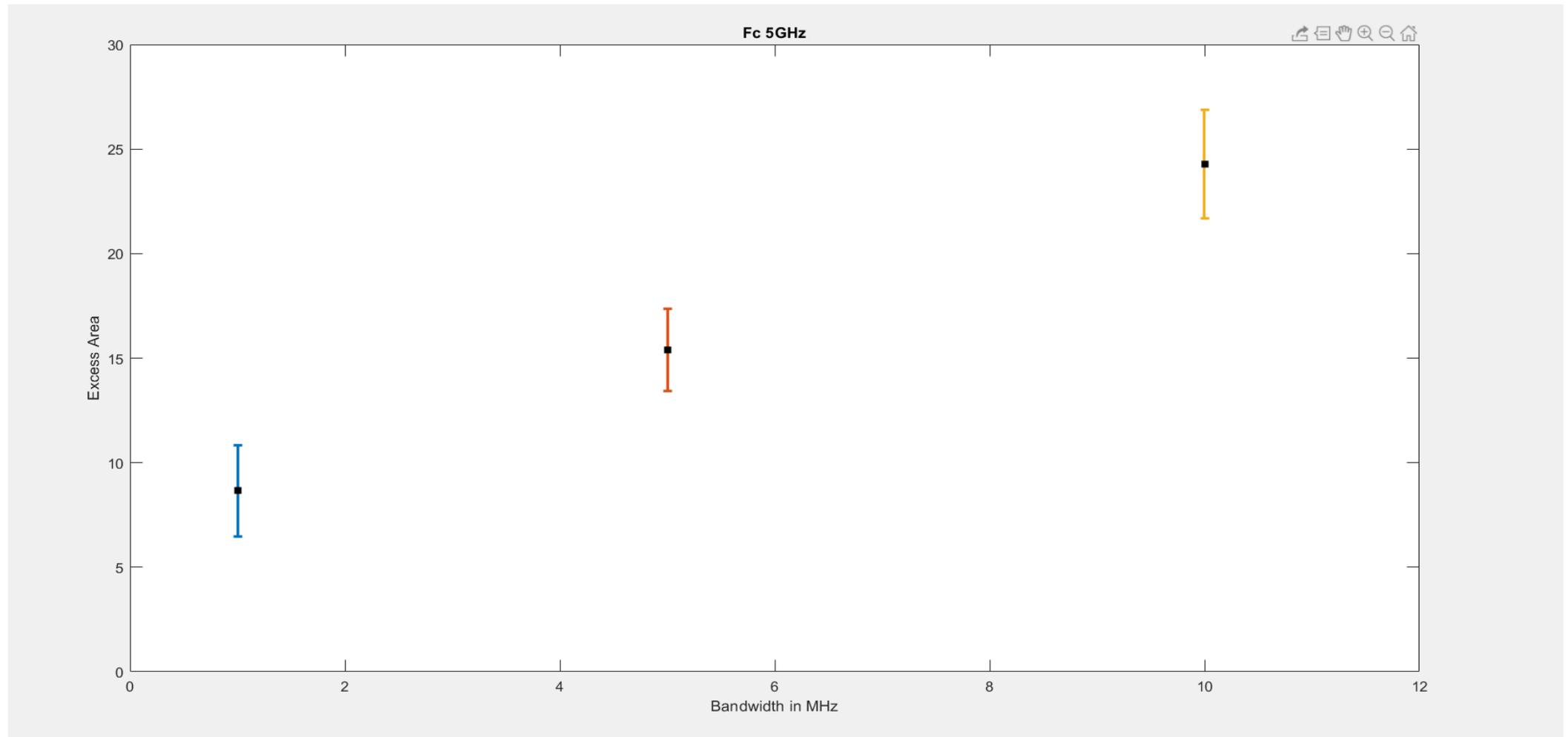


10 MHz Bandwidth Test 19



Experiment 2

- Same trend observed over-the-air (higher bandwidth results in higher leakage)
- Much larger variance in measurements due to actual propagation environment



+ CURRENT STEPS

Focusing measuring leakage with signals centered at 26-28GHz and much larger bandwidths (50-100 MHz).

Talk to weather researchers to determine sensitivity of their equipment (i.e., how much leakage can they tolerate)

Extrapolate how close to 23.8GHz can 5G mmWave transmissions be allowed.

For more details about the process for analyzing waveforms in Experiments 1 and 2, please see the associated papers on the project website.

<https://www.orbit-lab.org/wiki/MillimeterWaveProjectWinlab2021>



THANK YOU

