Radio Frequency Signal Leakage in Mutilated Micro-Coaxial Cable

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ABSTRACT

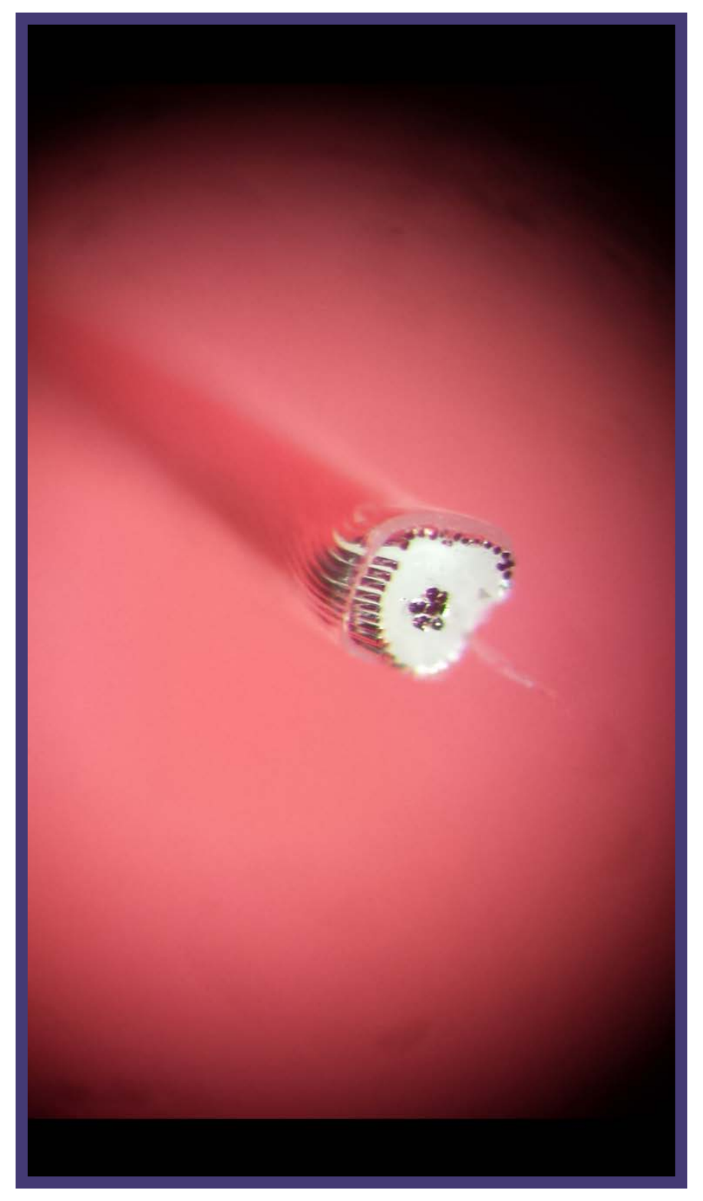
The aim of this project is to determine the resonance frequencies of varying wiring system, to optimize various transmission lines, and to have those corresponding numbers for future modeling and reference. We measured the radio frequency of our systems, and then subjected the systems under mechanical stresses similar to those in a real experiment. Qualitatively, degradation in signal quality matched expectations. We provide real world quantitative results to start improving experiments right away.

INTRODUCTION

At the National High Magnetic Field Laboratory, we study physical phenomena of materials by subjecting them to varying conditions, such as low temperature and high pressure, and then into a magnet to alter the properties. Along the probe are wires that connect the sample to the equipment used to excite the sample. The sample is affected by these conditions and a magnetic field, and these changes are transmitted along these wires.

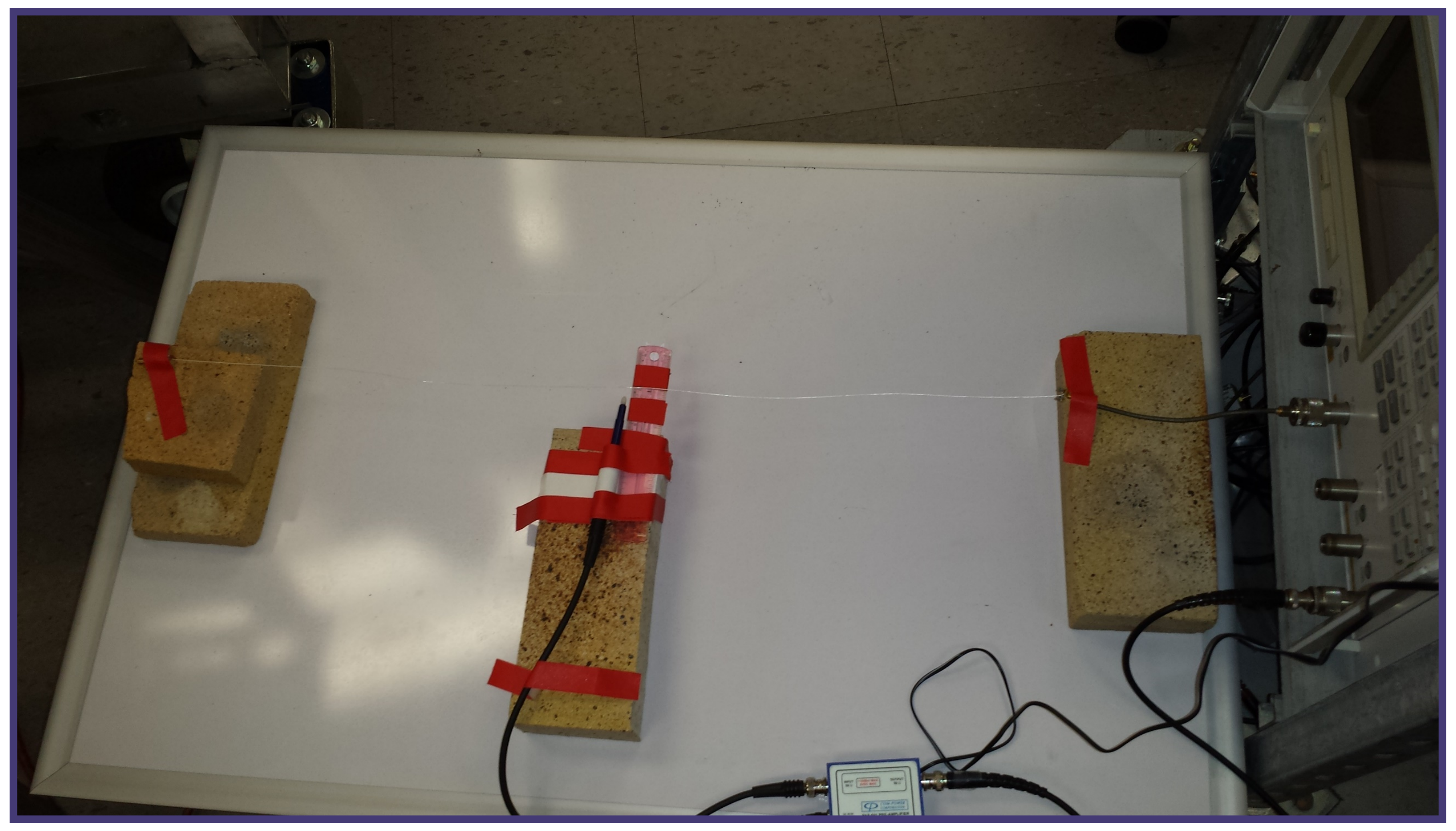
EXPLANATION

As voltage is transmitted through the wires, an electric field is created around them and goes into the environment. Interactions with the environment can affect the sample, and potentially create unwanted resonances. Ultimately, these resonances interfere with our data collection, and make our results inaccurate. By testing different wire schemes, we can minimize the deleterious effects of this resonant frequency, creating a better signal-to-noise ratio in our data sets.



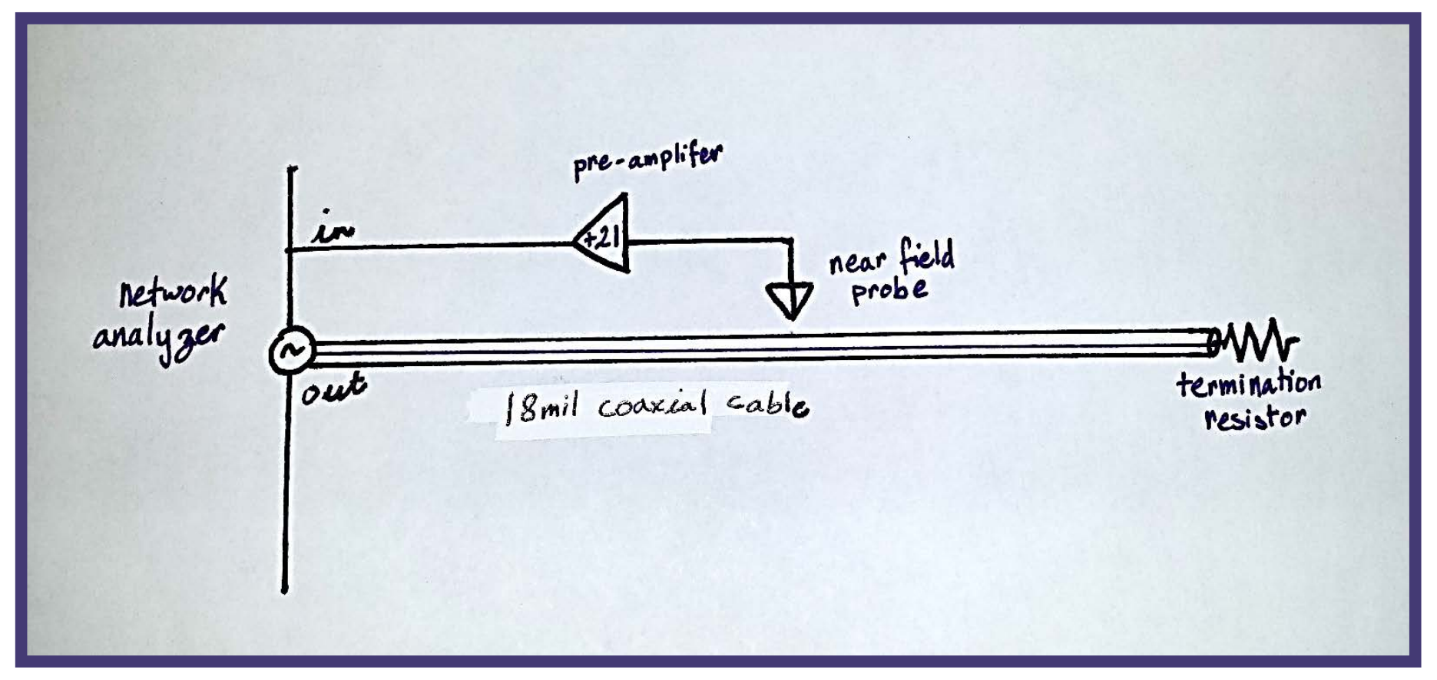
A microscope image of the cross-section of 18 mil flexible coaxial cable, commonly used for data collection.

EXPERIMENT AND SET-UP



We developed a setup that suspended the cable from any object that might reflect the electric field back and interfere with our data collection. To suspend it, we used nonmagnetic, insulating objects.

Once assembled, we made a reference system of semi-rigid coax and plugged it into a network analyzer to supply power running through the cable, and then attached a 50 Ω termination resistor to the other end so that we wouldn't be measuring the signal bouncing back towards the power source. We positioned our near-field antenna probe at the center of the cable to decrease the amount of E-field we would be getting from the soldered connector joints. We measured the power loss in dB for frequencies between 100 khz to 1.8 GHz. We then graphed the power loss over frequency to compare this reference system for the various wire schemes that we tested later.



A circuit diagram of our setup.

We focused on 18 mil flexible coaxial cable (W.L. Gore), manipulated in different ways to simulate the stress it would be under if used for a probe. As our benchmark, we measured one line of Gore that hadn't been subjected to mechanical stress.

We then made a tiny hole in the outer plastic insulation of the Gore and snipped a few ground wires, similar to what would happen if the wire was badly kinked. We steadily made the hole bigger, measuring along the way, until all of the ground wires were snipped away, and measured the final result.

ACKNOWLEDGEMENTS

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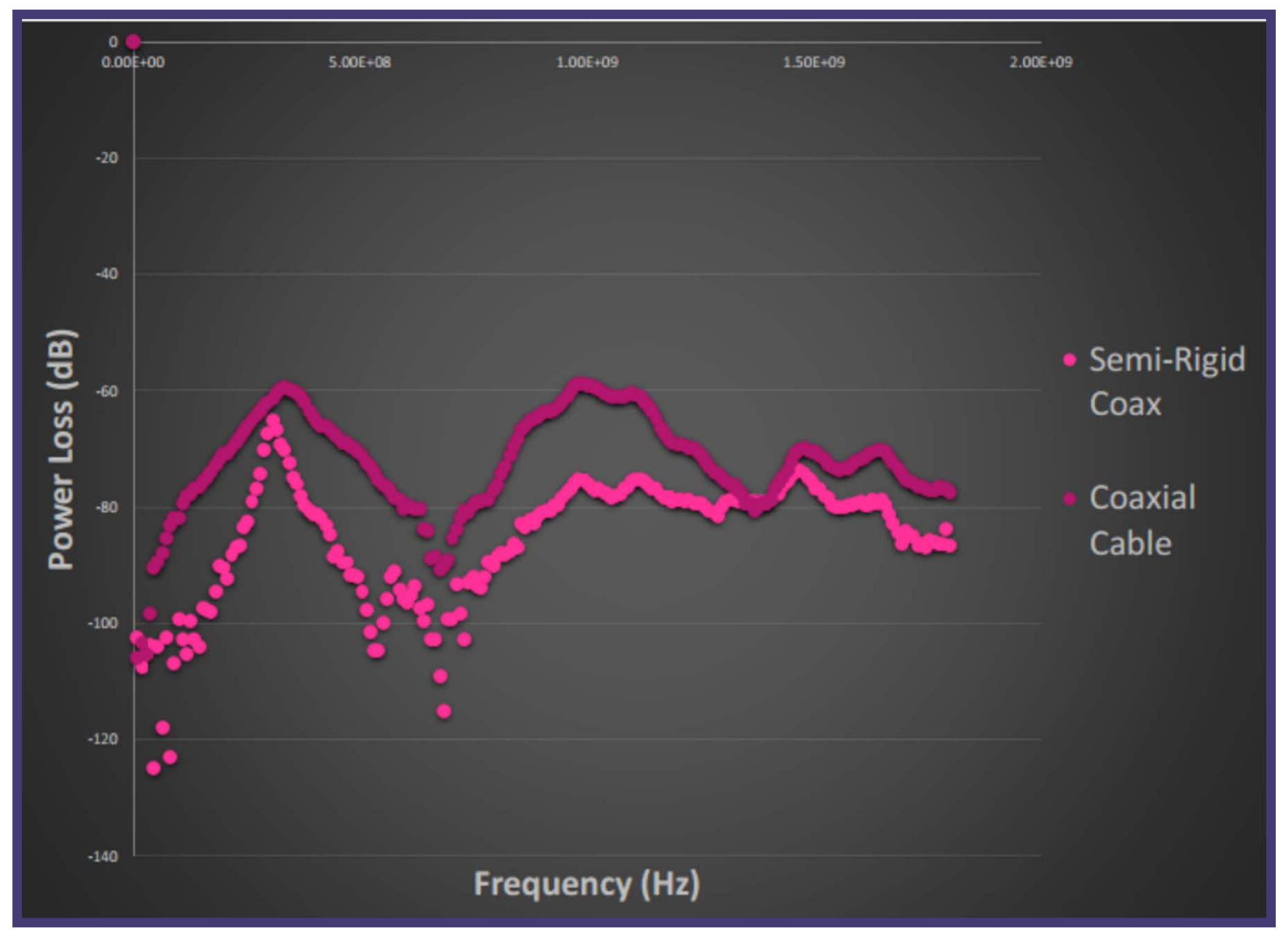
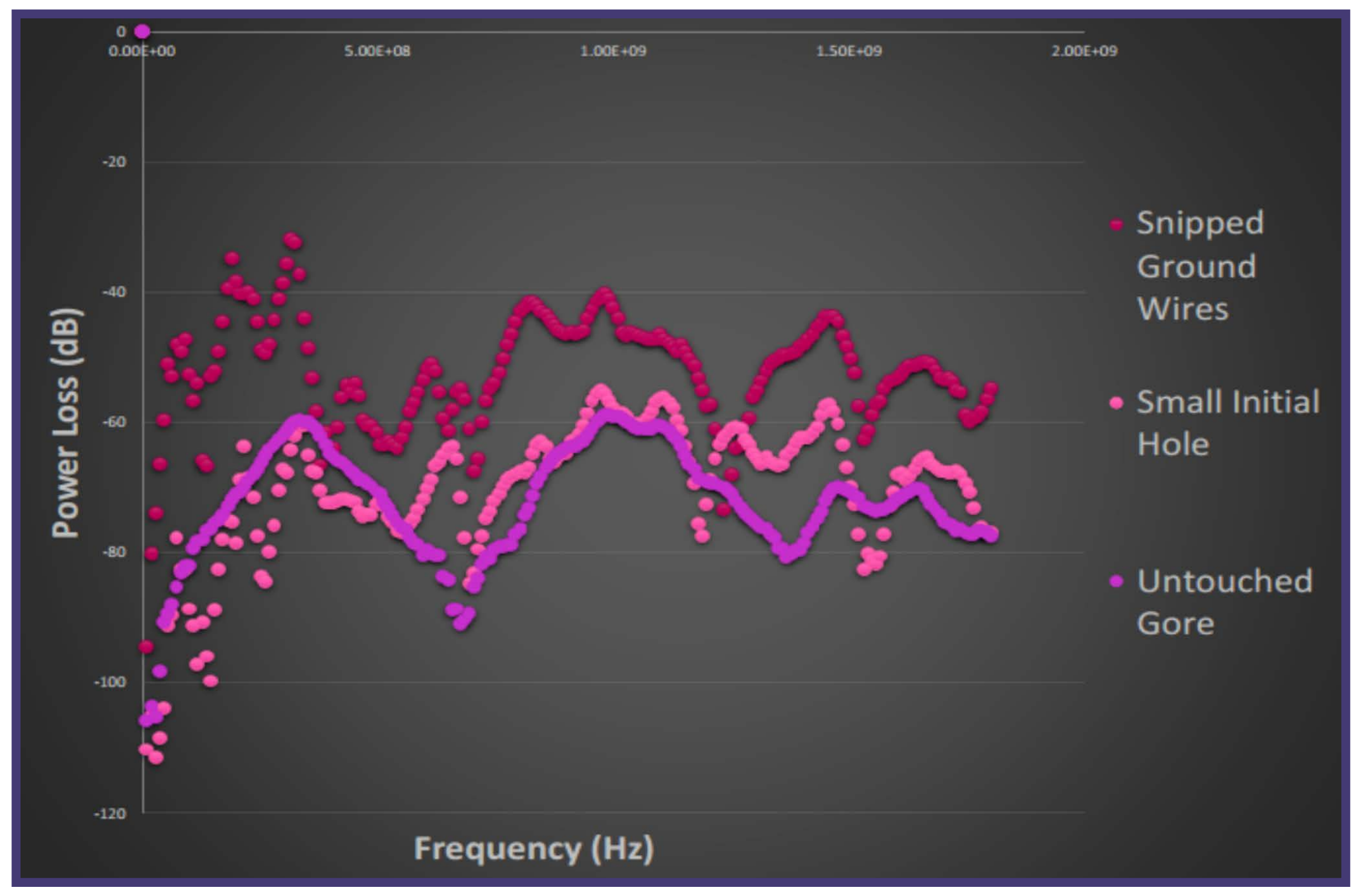
RESULTS

We graphed the ideal Gore coax with the semi-rigid coax, to see how much of a difference the semi-rigid's insulation affected the resonance frequency coming off the cable, and if it is really worth the extra effort to rewire some probes in semi-rigid as opposed to Gore. The results vary across frequencies, and match our qualitative expectation. Semi-rigid gives off less power into the environment than Gore, at some frequencies as great as an almost 20 dB difference, while at others it's as little as 5 dB or less.



The decibel (dB) is used as a logarithmic unit to convey multiplication and division in terms of additions and subtraction. When something is -60 dB, it translates to 0.000001. The more negative the decibel, the smaller the actual number.

For the "kinked" Gore coax, we plotted the ideal Gore against the Gore with the initial hole, and Gore with the snipped ground.



As predicted, the untouched Gore had the least amount of power loss, but the Gore with the first tiny hole was close in performance. As the hole got bigger, the power loss increased, indicating the worse the kink, the more likely the data is going to be inaccurate. While this is intuitive, we now have quantitative data to support it, and can determine which problems should be addressed when building probes, and which can be ignored for certain experiments.

In the future, we should repeat the experiment using more wire schemes, more complex setups to see where the lost power is going, and more kinds of physical stress to better simulate a wider variety of scientific experiments.