Testing Foil Outside CHART Horn

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6/17/2022

Last year, Nahum built two CHART horns. For the first, he followed the existing tutorials which has the aluminum foil on the inside of the horn – let's call this **Inner Horn (Ivanhoe)**. He found that assembly to be difficult and proposed to first assemble the cardboard, then wrap the whole thing in foil. Then he wrapped the horn again using plastic wrap to protect the foil. Let's call this **Outer Horn (John)**.

Our goal is to test the two horns to make sure we have not lost sensitivity and that the beam shape is roughly the same.

Setup

- Make sure phones and/or smart watches are on airplane mode and have their Bluetooth turned off
- Set the horn on the ground with the long edge down (probe should be vertical) and attach the signal chain(amp-filter-amp) to the probe
- Attach the coax cable to the signal chain and the radio
- Connect the RTL-SDR to the raspberry pi using the coax cable
- Connect the monitor, keyboard, and power source to the raspberry pi
- Measure 30 feet away from the wide end of the horn and place rocks at regular intervals along the half circle to be used as markers when you walk
- Turn on the portable charger
- Turn on the raspberry pi
- Open terminal
- Use commit 7d3428ed9169fdf10271cb456de8af61d0e791a1 of CHART repo (quicklook branch, which is basically the main branch but with a quicklook notebook added) to use jupyter notebook to look at the data
- Open a separate terminal to run the program commands

Location

Farmer's Community Park near Stockton because it does not have a large amount of non-related signals

Tests to be performed

All tests are to be performed with each horn.

- In the lab, collect data with the RF explorer transmitting at 1419.2 MHz and -29.2 dBm
- In the field, walk the transmitter in a half circle in a 30 foot radius from the front of the horn

Data Collection Procedure

- Start the transmitter at 1419.2MHz, -29.2 dBm and stand and hold it 32 inches above the ground 30 feet away from the horn on the left side
- Check amp battery voltage (should be >8V, if not, replace)
- Turn on amps
- Run these commands, note the time, wait a couple of seconds before starting the transmitter, and take a video of the person walking
    - `cd ~/CHART/daq`
    - `python freq_and_time_scan.py --freq_i=1419 --freq_f=1419.2 --int_time=0.5 --nint=100 --data_dir='home/winona/CHART/daq/ivStockCircle1'`
- After the walk is finished, turn off the transmitter and amp
- Check the data to make sure it is correct
- Check amp battery and replace if need be
- Stand 30 feet away from the horn on the left side again and hold the transmitter 32in. above the ground
- Run this command, note the time, wait 10 seconds before starting the transmitter, and take a video of the person walking around the rock markers
    - `python freq_and_time_scan.py –freq_i=1419–freq_f=1419.2 --int_time=0.5 –nint=100 ––data_dir=’home/winona/CHART/daq/ivStockCircle2’`
- After the walk is finished, turn off the transmitter and amp
- Check the data to make sure it is correct
- Check amp battery and replace with a new one
- Now switch the horns and use the John horn
- Check the amp battery again
- Turn on the transmitter to 1419.2MHz 30 feet from the horn and 32 in. above the ground starting on the left side
- Run this command, note the time, wait 10 seconds before starting the transmitter, and take a video of the person walking around the rock markers
    - `python freq_and_time_scan.py –freq_i=1419 –freq_f=1419.2 --int_time=0.5 –nint=100 –data_dir=’home/winona/CHART/daq/johnStockCircle1’`
- After the walk is finished, turn off the transmitter and amp
- Check the data to make sure it is correct
- Check amp battery and replace if need be
- Run this command, note the time, wait 10 seconds before starting the transmitter, and take a video of the person walking around the rock markers
    - `python freq_and_time_scan.py –freq_i=1419 –freq_f=1419.2 --int_time=0.5 –nint=100 –data_dir=’home/winona/CHART/daq/johnStockCircle2’`
- After the walk is finished, turn off the transmitter and amp
- Check the data to make sure it is correct
- Check the amp battery and pack up

Packing List

- RF Explorer transmitter
- 2 CHART horns (Ivanhoe and John)
- 2 amps, Mini-Circuits filter, 9V battery assembly
- SMA cable
- RTL-SDR
- Raspberry Pi
- Monitor, HDMI cable, USB to micro-USB cable for monitor power
- Keyboard/mouse
- 10 Ah portable charger, including USB to USB-C cable (to power the pi)
- 9V batteries & extras (bringing 5)
- Notebook & pen
- Multimeter
- Extra aluminum foil & foil tape
- Duct tape
- Tape measure
- Water
- Phone

Observing Notes

The experiments were carried out on June 17, 2022 at the gray marker on the picture below
We set up at the same empty baseball field as our initial tests on June 10, 2022

We set both horns facing south with the SMA connector facing up and connected the amps, filter, and battery chain to the horn and the raspberry pi.

This shows the beginning of each trial in which Lindsey would start 30 feet away on the left side of the horn.

With the use of rock markers to designate the correct distance from the horn, all Lindsey had to do was hold the transmitter steady for the duration of the walk.

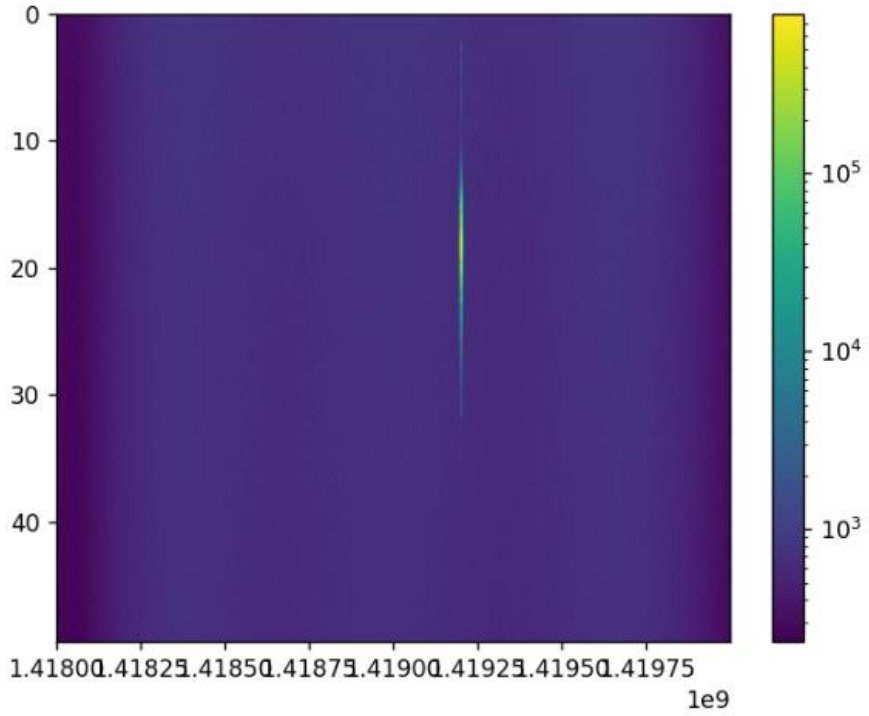
	Time	Initial Battery Voltage	Final Battery Voltage
Ivanhoe Trial 1	13:35	9.61 V	9.46 V
Ivanhoe Trial 2	14:00	9.46 V	9.38 V
John Trial 1	14:09	9.61 V	9.51 V
John Trial 2	14:14	9.51 V	9.42 V

*Note: we switched batteries between horns to try to get similar voltages

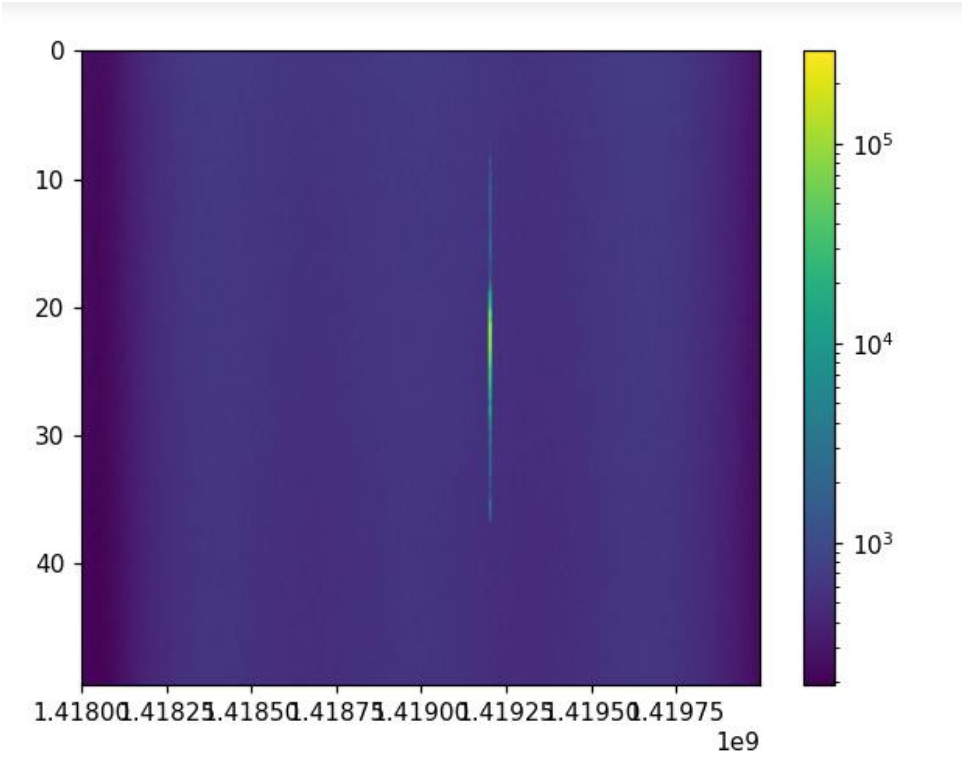
Results

The images below display a Time (y-axis) vs Frequency (x-axis) graph which has an overlay of intensity in color. Because we only displayed the same frequency, the line should go straight up. The time on the y-axis can help determine how strong the signal was at a certain time interval.

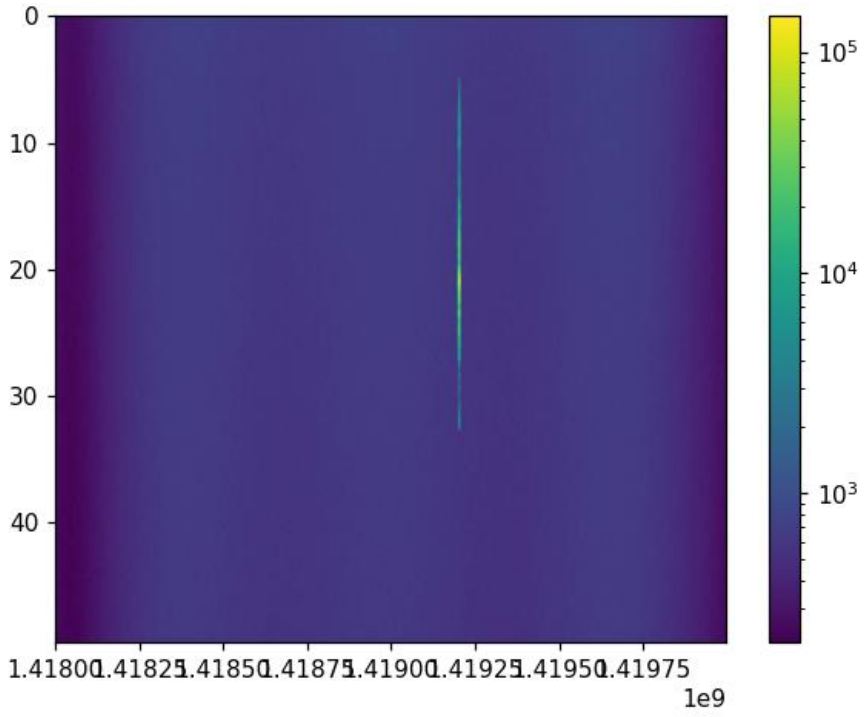
Ivanhoe Trial 1



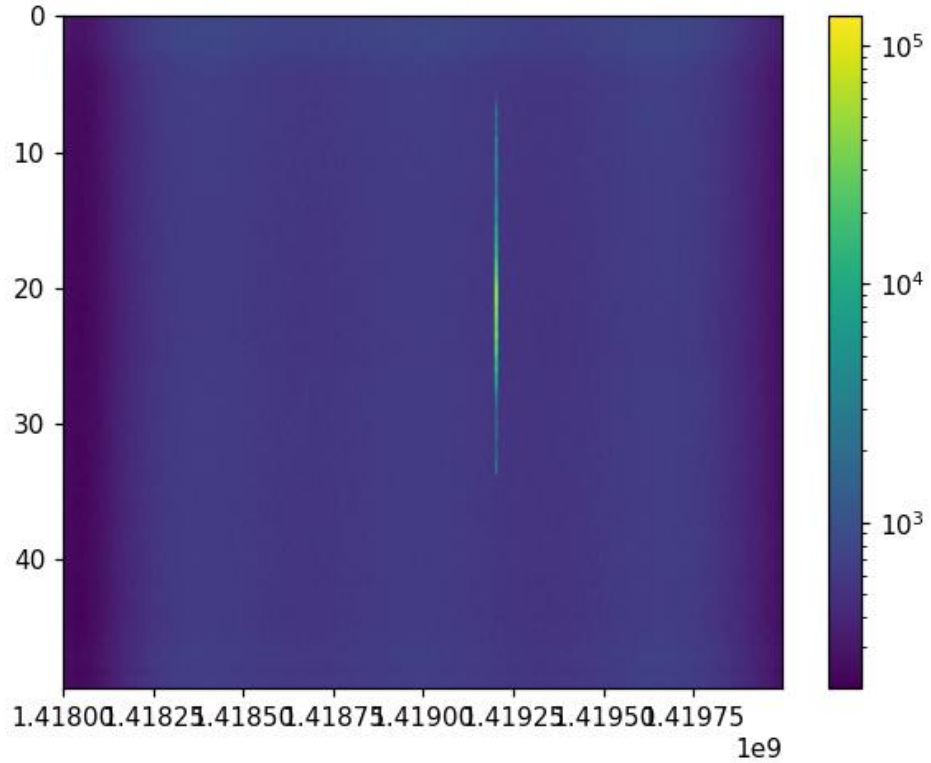
Ivanhoe Trial 2



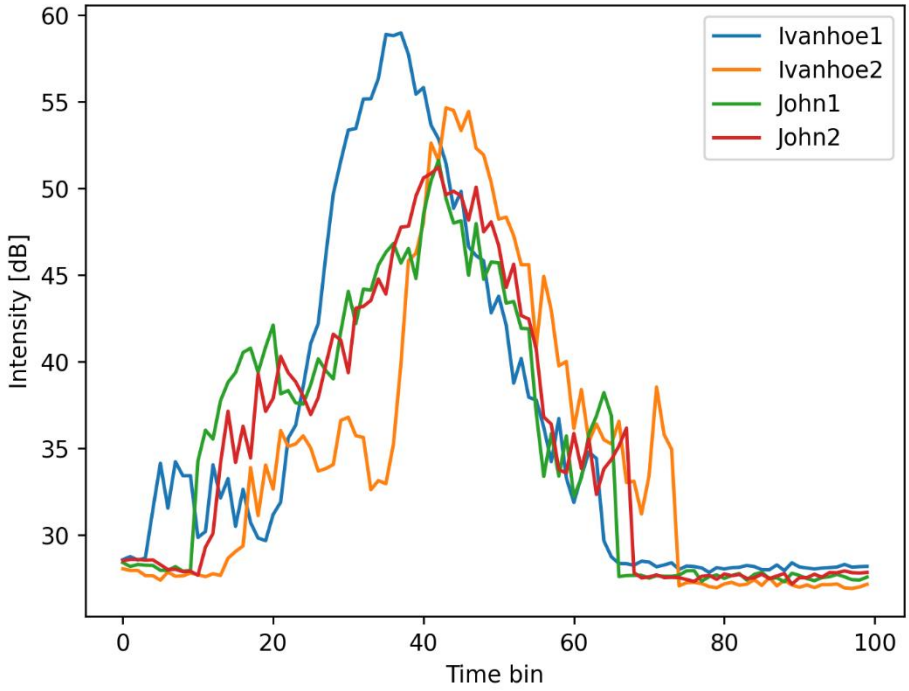
John Trial 1


0
10
20
30
40
1.41800
1.41825
1.41850
1.41875
1.41900
1.41925
1.41950
1.41975
1e9
10^5
10^4
10^3

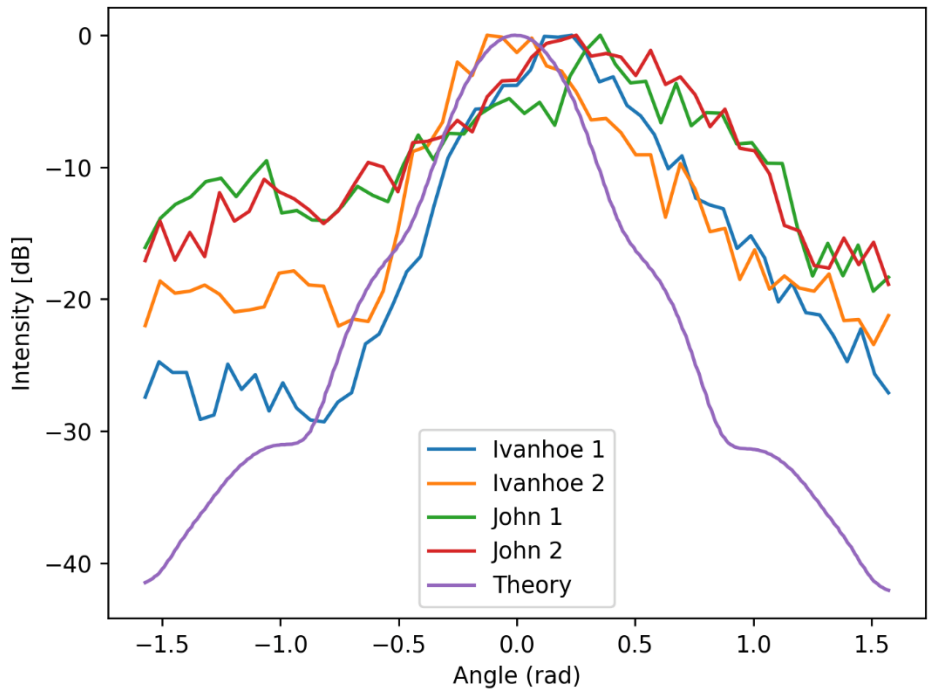
John Trial 2


0
10
20
30
40
1.41800
1.41825
1.41850
1.41875
1.41900
1.41925
1.41950
1.41975
1e9
10^5
10^4
10^3

Raw data time curves for the frequency channel where the transmitter was:



Using the videos and the obvious turn on/off of the transmitter, we were able to translate time bin into Lindsey Location. In the figure below we also normalized to 0 dB at center and added a theory curve from Mru's simulations.



Conclusions

We believe that Ivanhoe is a better candidate than John for future testing based on the data we collected. Looking at the Time vs Intensity graph, we can see that Ivanhoe has a greater intensity than John in general. From the Angle vs Intensity graph, we can conclude that Ivanhoe is still at a higher intensity based on how low in intensity each side gets.

Although Ivanhoe is thought to be a better solution for looking at radio signals, more testing can be done to fully prove that it is the case. Ivanhoe 1 and Ivanhoe 2 seem to have more major differences in intensity than any Ivanhoe and John test. There is also an unknown reason to why the left side of the Angle vs Intensity graph levels off. Because of this major difference and confusion in data, more testing can be done to prove that one is a better candidate than the other.