Testing Foil Outside CHART Horn

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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

- Set the outer horn on the ground with the long edge down (probe should be vertical) and attach the signal chain(amp-filter-amp)
- Attach the coax cable to the signal chain and the radio
- Connect the radio to the raspberry pi
- Connect the monitor, keyboard, and power source to the raspberry pi
- Turn on the portable charger
- Turn on the raspberry pi
- Open terminal

Using commit 7d3428ed9169fdf10271cb456de8af61d0e791a1 of CHART repo (quicklook branch, which is basically the main branch but with a quicklook notebook added)

Location

We will go to Farmer's Community Park near Stockton to get relatively clean data.

Tests to be performed

All tests are to be performed with each horn.

- In the lab, collect data with the RF explorer transmitting at 1423 MHz and -29.2 dBm
- In the field, transmitter on in 30 feet front of horn.
- In the field, transmitter on to the right side of horn.
- In the field, transmitter off.

Data Collection Procedure

- Start the transmitter at 1423MHz, -29.2 dBm and place it 30 feet in front of the horn
- Check amp battery voltage (should be >8V, if not, replace). Turn on amps.
- Run these commands, note the time, take a picture
    - `cd ~/CHART/daq`

    - `python freq_and_time_scan.py --freq_i=1390 --freq_f=1450 --int_time=0.5 --nint=20 --data_dir='home/winona/CHART/daq/ivanhoeStocktonFront'`
- Wait for the program to finish and move the transmitter 30 feet to the right side of the horn
- Check amp battery
- Run this command, note the time, take a picture
    - `python freq_and_time_scan.py –freq_i=1390 –freq_f=1450 --int_time=0.5 –nint=20 -- data_dir=’home/winona/CHART/daq/ivanhoeStocktonSide’`
- Wait for the program to finish and turn off the transmitter
- Check amp battery
- Run this command, note the time, take a picture
    - `python freq_and_time_scan.py –freq_i=1390 –freq_f=1450 --int_time=0.5 –nint=20 – data_dir=’home/winona/CHART/daq/ivanhoeStocktonOff’`
- Now switch the horns and use the John horn
- Check amp battery
- Turn on the transmitter to 1423MHz 30 feet in front of the horn
- Run this command, note the time, take a picture
    - `python freq_and_time_scan.py –freq_i=1390 –freq_f=1450 --int_time=0.5 –nint=20 – data_dir=’home/winona/CHART/daq/johnStocktonFront’`
- Wait for the program to finish and move the transmitter 30 feet to the right side of the horn
- Check amp battery
- Run this command, note the time, take a picture
    - `python freq_and_time_scan.py –freq_i=1390 –freq_f=1450 --int_time=0.5 –nint=20 – data_dir=’home/winona/CHART/daq/johnStocktonSide’`
- Wait for the program to finish and turn of the transmitter
- Check amp battery
- Run this command, note the time, take a picture
    - `python freq_and_time_scan.py –freq_i=1390 –freq_f=1450 --int_time=0.5 –nint=20 – data_dir=’home/winona/CHART/daq/johnStocktonOff’`
- Once this program is done running you can pack up
- Check amp battery

Packing List

- RF Explorer transmitter
- 2 CHART horns
- 2 amps, minicircuits 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 8)
- Notebook & pen
- Multimeter
- Extra aluminum foil & foil tape
- Duct tape
- Tape measure
- Water
- Phone

Observing Notes

Experiments were carried out June 10, 2022.
We found an open baseball field at Farmer's Community Park to observe. We set up at the gray marker below.

We placed the horns on the ground facing South, and the transmitter 30 feet away, also on the ground.

Here the transmitter is on the side, circled in red.

Trial 1 – Ivanhoe Front:
- Time: 14:09
- Battery voltage: 9.73 V

Trial 2 – Ivanhoe Front pt.2:
- Time: 14:25
- Battery voltage: 9.13 V

Trial 3 – Ivanhoe Side:
- Time: 14:38
- Battery voltage: 8.90 V

Trial 4 – Ivanhoe Off:
- Time: 14:52
- Battery voltage: 9.71

Trial 5 – John Front:
- Time: 15:07
- Battery voltage: 8.89 V*

Trial 6 – John Side:
- Time: 15:22

Battery voltage: 8.87

Trial 7 – John Off:

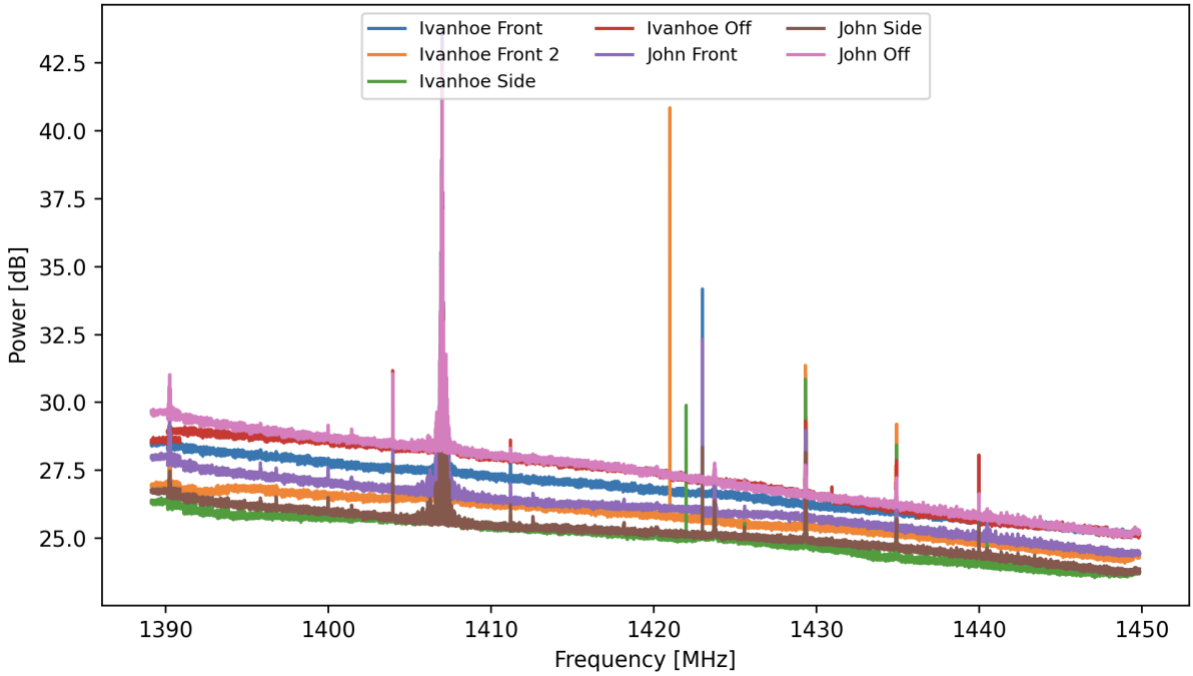
Time: 15:37

Battery voltage: 9.73

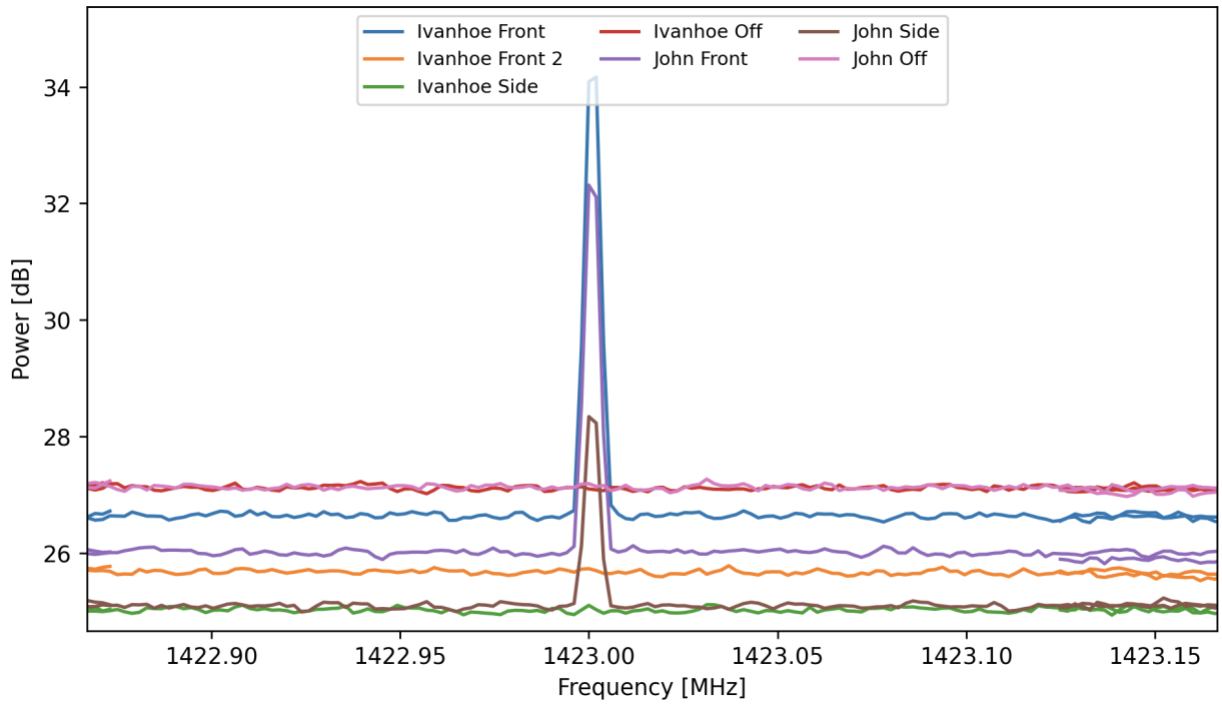
Note the battery drained very quickly, which drastically affects the amplifier gain, which can be seen in the spectra in the Results section. Luckily, we ended up with roughly the same voltage for similar runs between the two horns (e.g. Ivanhoe Side has similar voltage to John Side).

Results

Full spectra:

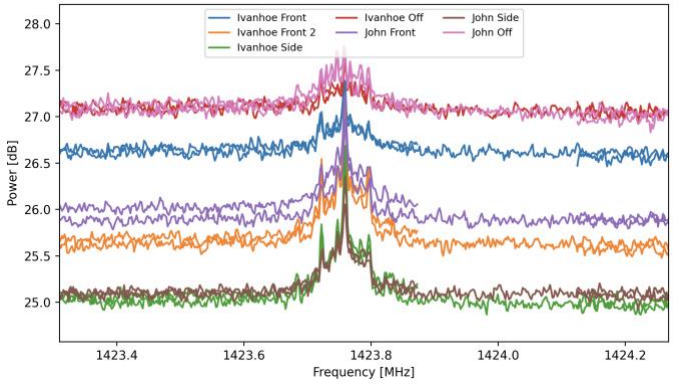


Generally, things look good and consistent. Runs with similar battery level seem to have similar noise floors. However, when we zoom into the 1423MHz line, we see Ivanhoe Front 2 and Ivanhoe Side do not see the line at all.

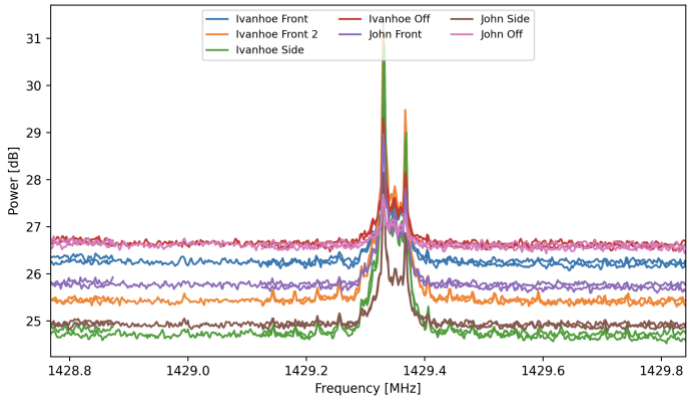


This probably means that the transmitter was off for some reason. Beardsley is certain he checked it before and after the observations, so he suspects there might have been an auto-shutoff going on.

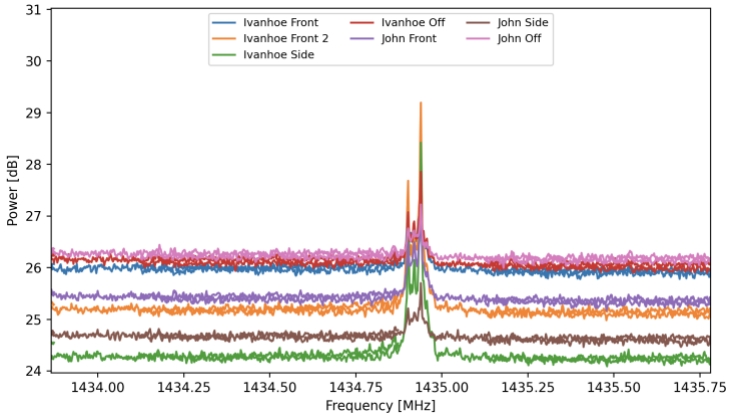
We can zoom in on some other lines that all runs see.
A)



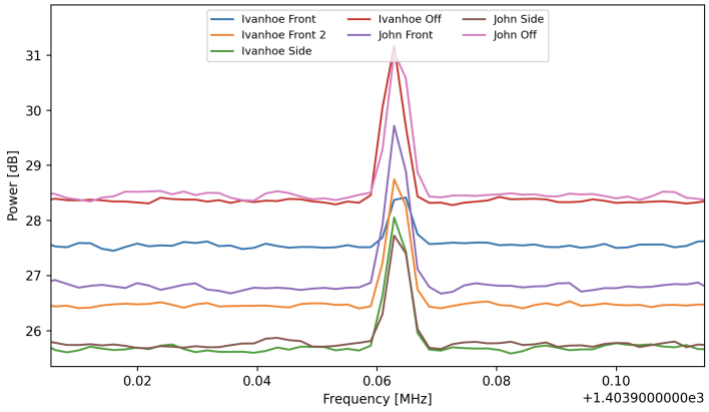
B)



C)



D)



Unfortunately, these (and several others checked) also show up in the lab test, so we cannot be certain they are external – they could be self-interference or internal to our electronics. We could run some data with a load and no horn to see if the lines go away.

The only thing remaining to check is the peak-to-noise level for Ivanhoe Front vs John Front.

Ivanhoe Front Peak	34.1 dB
Ivanhoe Front Noise (near the peak)	26.7 dB
John Front Peak	32.3 dB
John Front Noise (near the peak)	26.1 dB

By this rough estimate, Ivanhoe showed a gain ~1dB higher than John (7.4 vs 6.2). But this is very rough, especially because it looks like the true peak of the spectrum was between frequency channels, and we are using the center channel, which is prone to error.

Beardsley trying to recreate transmitter shutoff

I tried to observe the transmitter auto-shutoff in the lab by it up and observing with the horn. I watched the data on the gnu radio GUI for 30minutes, but it never did shut off. Now I suspect either 1) I was mistaken, and didn't actually check that the transmitter was on in the field, or 2) it may have overheated in the sun and shut off. I was fairly certain I checked that it was on, and I even remember seeing the "POWER ON" message while the backlight was off, which I thought was weird. Either way, we need more data.

Conclusions

- The forward sensitivities of the two horns appear within ~1dB of each other (Ivanhoe being a little higher).
- The 9V battery powering the amplifiers drains very quickly. This needs to be accounted for in future experiments, and potentially find alternative power solution.
- We may have seen the transmitter automatically shut down for an unknown reason, or we simply misread and didn't have it on for a couple runs.
- More testing is necessary, improvements to be made:
    - Place the transmitting frequency away from center channel (i.e. not an integer number of MHz with our current observing parameters)
    - Check data after each run.
    - Now that we have a wide-band look at the park's RF environment, future tests could hone in around just the transmitter frequency.