Site Survey May 2025

2 June, 2025

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Introduction

A potential partner has offered to lease a piece of land for the Winona Radio Observatory to use. It is about 3 acres, located just south of I-90 between Wilson and Witoka, MN (See Fig 1). We went to the site on 29 May 2025 to assess the feasibility. We were concerned with RF interference (especially given the proximity to the interstate), terrain, power and internet access, and accessibility for regular site visits, building instruments, and electronics shelters.

Figure 1

Equipment

Our RF measurements were performed using two antennas: a folding [biconical low-frequency antenna]() from A.H. systems (20 – 330 MHz), and a [discone antenna]() from

SIGNALPLUS purchased on Amazon (25 – 3000 MHz). The latter is a relatively cheap antenna that Beardsley picked up at the last minute to cover higher frequencies. Although it probably has low sensitivity, these frequencies are outside our primary science regime. One at a time, the antennas were mounted on a tripod borrowed from geoscience.

Data collection was done with a Rohde and Schwarz Spectrum Rider FPH handheld spectrum analyzer (SA). While prepping for the trip we discovered the SA does not have the preamplifier enabled. Beardsley is in communication with R&S to fix this for future excursions. The SA also only goes up to 2 GHz, which is plenty good for any 21cm astronomy, although we may want to look into expanding to S-band (2-4 GHz) in the future for other science cases or communication downlinks. This can be done with a software license from R&S. We considered using an SDR (ADALM-Pluto or HackRF One) to cover the S-band, but given our quick timeline to get out into the field, and the work required to set up a frequency scanning observation, and the limited bandwidth (20 MHz), we opted not to do it this time.

Pack list

- Spectrum rider FPH Model .02
    - SD card with USB adaptor
- Antennas
    - Biconical
        - Two cones
        - Mast
        - N-type cable
    - Discone
        - Mast with cable and adaptors
        - Bag with all the spokes, clamp hardware, 10mm wrench
- Mounts
    - Tripod
    - Clamps (attached to discone mast, separate ones for biconical)
- GPS Coordinates – Phone
- RF explorer
- Notebook
- Carrying box
- Printed out procedure, packing list, maps
- Sundries
    - Bug repellent

- Sunscreen
- Water
- Snacks
- Duct tape
- Tarp
- Clipboard/binder

Setup

Site and initial Observations

Driving to the site, we noticed a couple radio towers nearby, although none were actually visible from the site location. A couple of us noticed our cell phones were getting a couple bars of 4G on the site.

The site is a field with prairie vegetation. Grasses and such were, for the most part, no higher than a couple of feet, and easy to navigate through. There is a path that runs along the west and north sides, presumably for driving trucks and/or ATVs. There is a less pronounced path that splits the site down the middle North-South. There is an overall North to South slope of about 8-10 degrees, but otherwise, it is relatively flat. There is a steep drop-off leading to two ponds on the south side. We likely would not use land south of the red line shown in Fig 1.

Setting up Equipment

1. The site and initial observations (e.g. slope, terrain, power location, etc)
    a. Two radio towers were noticed on the drive there, but they were not visible at the site.
    b. Power is located at southeast corner of site
    c. Power lines went across the northeast side of the site following the road
    d. Overall, the site had some uneven ground and appeared to be at a slight angle (estimated 8-10 degrees). The site area north of the red line in figure 1 was determined to be the most suitable for setting up equipment.
2. How to setup antennas
    a. Biconical
        i. To set up the biconical antenna, we started by attaching clamps to the tripod, and the pole of the antenna to the clamps according to figure 2.

ii. Next, we screwed in the 2 antennas to the sides of the antenna pole at the top and attached the cable to the bottom of the pole according to figure 3.
iii. Lastly, we attached the cable to the spectrum analyzer, and the antenna was ready.

Figure 2

Figure 3

b. Discone
    i. To set up the discone antenna we started by attaching the antenna pole to the tripod pole using two “u” shaped rods with threads and four of each: 10mm nuts, washers, and spring lock washers. (Figure 4)
    ii. Next, we attached the pole on the top by screwing it in place, and the downward facing poles by adjusting the set screws.
    iii. Lastly, we attached the horizontal poles by screwing them in place, and tightening the black covers near the base, and attaching the cable to the spectrum analyzer.

Figure 4

Procedure & Measurements Made

Table of Measurements and File Numbers		
Site	Data (data###.csv)	Antenna
1	001-003	Biconical - Parallel
1	004-006	Biconical - Perpendicular
2	007-009	Biconical - Parallel
2	010-012	Biconical - Perpendicular
3	013-015	Biconical - Parallel
3	016-018	Biconical - Perpendicular
1	019-021	Discone –With Phone
1	022-024	Discone – Without Phone
2	025-027	Discone – Without Phone
3	028-030	Discone – Without Phone

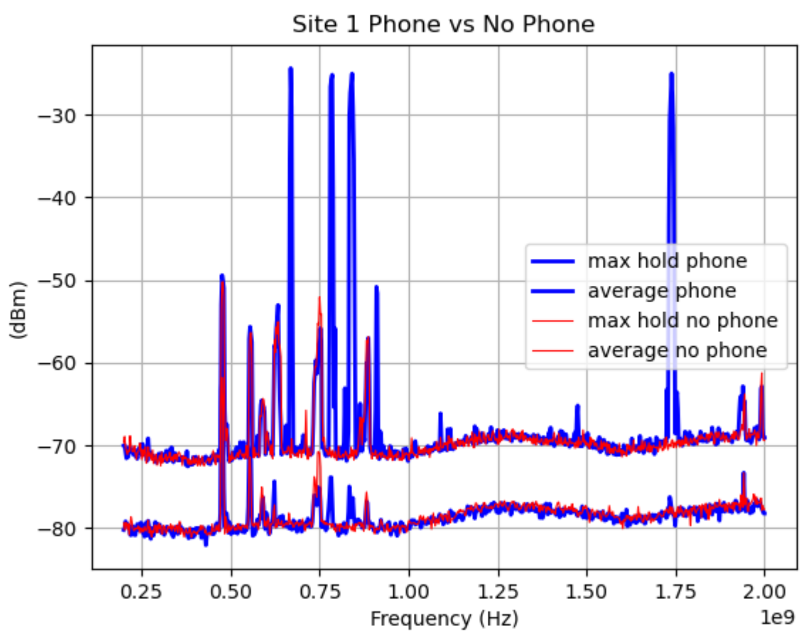
Procedure

1. We tested Radio interference at 3 different sites (Figure 1)
3. We went to each location twice, with a different antenna each time
4. For both antennas we gathered data using the traces max hold, average, and clear (or no trace) on the spectrum analyzer

5. On our first stop at each location (going in order of site 1, 2, 3), we used the biconical antenna to gather data on a frequency range of 20-330MHz.
    a. Because of the shape of the biconical antenna we gathered two sets of data (rotating the antenna 90 degrees between the two sets) at each location to ensure that we were detecting interference in all directions
6. On our second stop at each location (going in order again) we used the discone antenna, to gather data on a frequency range of 25-3000MHz
    a. For our first test (at site 1) with the discone antenna we tested if using phones affected our data.
    b. We determined that rotation of the discone antenna was not necessary as it has a different shape than the biconical antenna
7. The Day before we conducted a “test run” on campus to practice using the antennas, and to get a baseline for data in town to compare to our out-of-town site.

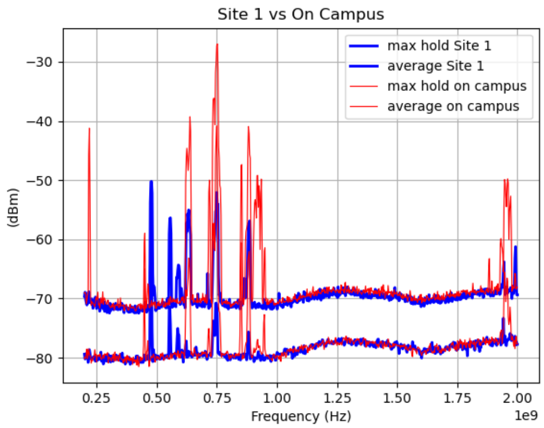
Data/Analysis

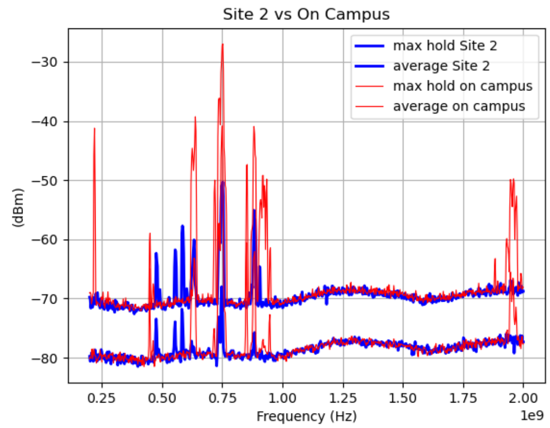
Phones On/Off

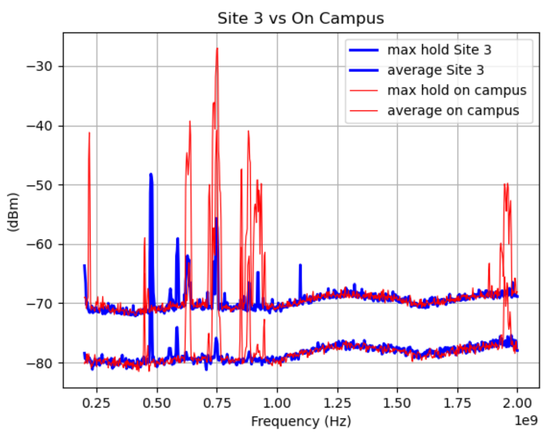


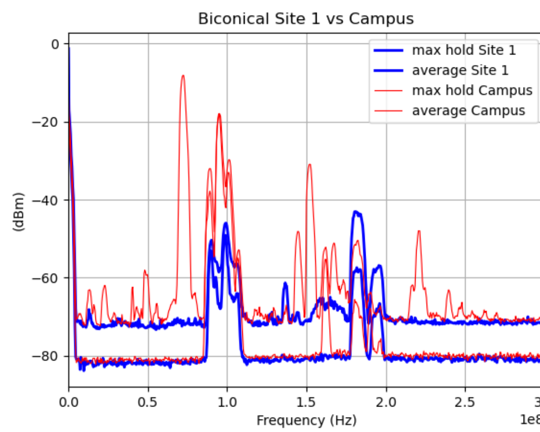
There were multiple peaks that showed significantly higher levels of interference when phones were being used (four peaks between 0.6-0.9 GHz and one peak around 1.75 GHz). The interference that occurred when there was no phone use was also visible during phone use at the same frequencies and similar levels.

Comparing Campus versus Site



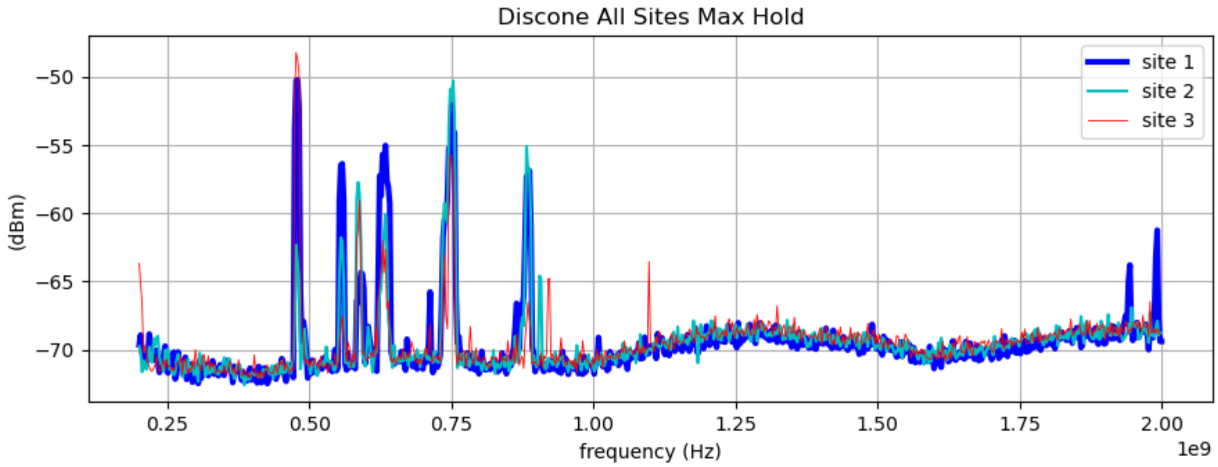


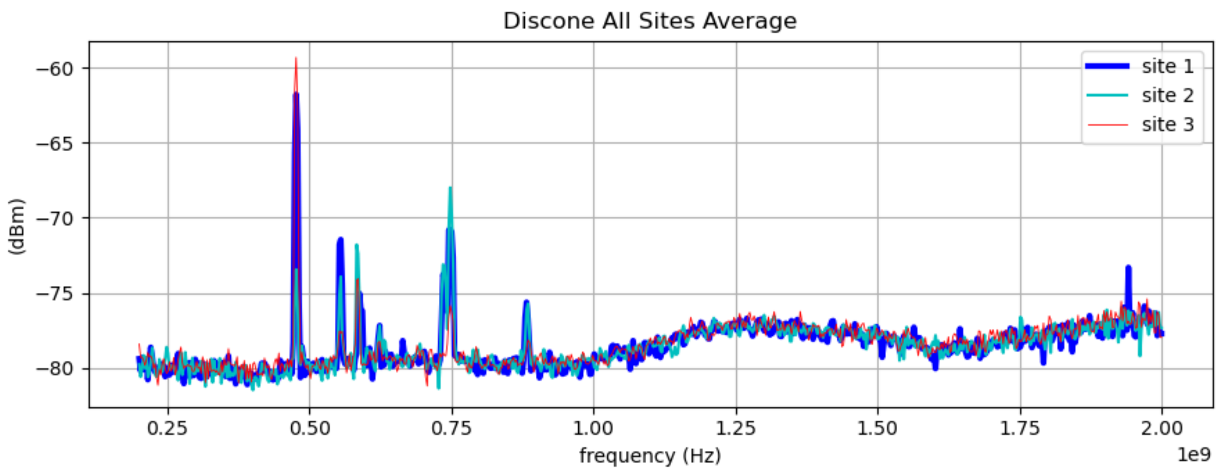




As one would expect, there was less interference at sites 1, 2, and 3 than on campus. However, for the discone antenna measurements on site, there is interference at frequencies of 0.45-0.6 GHz that is not seen on the Winona campus. For the biconical antenna, site 1's measurements also show less interference than what was seen on campus.

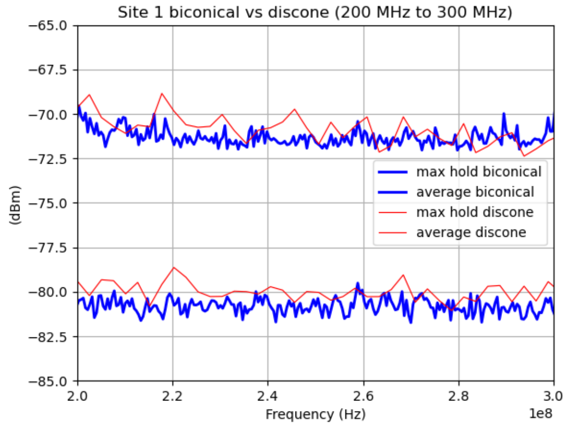
Site 1 versus Site 2 versus Site 3

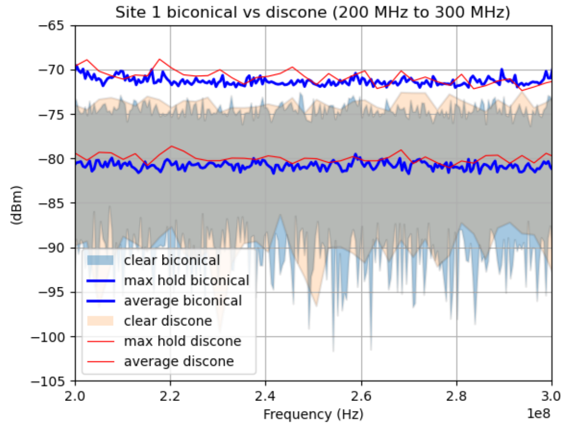




Site 3 has the largest peak (500 MHz). It is difficult to say which site has the least amount of interference on average. However, site 1 does appear to have more peaks during the max hold, which may be attributed to the fact that site 1 is closest to the interstate.

Low Frequency (bicone) versus High Frequency (discone)





The overlapping range of measurements for the biconical antenna and the discone antenna is 200-300 MHz. The biconical antenna will give more precise measurements because it is measuring a much smaller range of frequencies. While the measurements show a similar level of interference, the measurements for the discone antenna appear to have slightly elevated levels of interference at frequencies 215-250 MHz. The solid filled area of the clear trace measurements shows that the biconical antenna (blue) tends to have a lower minimum while the discone antenna (orange) has a greater maximum.

Power and Internet

Power is run to the site (actually just south of it to the edge of the farmland in the southeast corner of Fig 1).

HBC does not have fiber or RF coax at this location. They do have an Air service, which operates at 5820 MHz, with a channel width of 20 MHz. This would be a dish that would communicate with a tower. They say the tower is located northwest of our site: “other side of I-90 and following 43 north.” So it seems reasonable to try to set up an electronics shelter in the north corner and mount the dish on the side facing the interstate.

WSU already uses HBC, so our best bet is to go through our people and have them reach out to the business sales at HBC to get pricing. This is outside the scope of this memo – for now, there’s a feasible solution.

Conclusions

In conclusion it was determine that:

1. Phone use should not occur while measurements are being taken
2. The site has less interference than campus, but some interference seen only at the site may be caused by the proximity to the interstate
3. Sites 2 and 3 experience less random spike of interference than site 1 due to being farther away from the interstate
4. The antenna being used for measurements would depend on the range of frequencies being measured. For the overlapping range (200-300 MHz), the biconical antenna would be the better option.
5. The site and initial observations (e.g. slope, terrain, power location, etc)
    - Two radio towers were noticed on the drive there, but they were not visible at the site.
    - Power is located at southeast corner of site
    - Power lines went across the north side of the site following the road
    - Overall, the site had some uneven ground and appeared to be at a slight angle (estimated 8-10 degrees). The site area north of the red line in figure 1 was determined to be the most suitable for setting up equipment.
6. Power and internet
    - HBC does not have fiber or RF coax at this location. They do have an Air service, which operates at 5820 MHz, with a channel width of 20 MHz.

Ideas for next trip

- Better tripod, streamline assembly/disassembly
    - The antennas were mounted on a tripod with a pole that had an adjustable height; however, the legs were not adjustable, making leveling the equipment not possible. Adding a level and a compass to a new tripod would assist in consistent set up. A slightly taller tripod and a tripod for each antenna may be more convenient in the future.
    - Looking into a different way to mount the biconical antenna may also be beneficial.
- Obtaining a 10 mm wrench
    - Part of the set up for the discone antenna involves tightening 10 mm nuts.
- Bigger box (Beardsley has some, just buried deep in a closet)
- Review measurements

- We may want to average longer than 10 points. This will result in lower noise level, which may bring out smaller interference features. We should revisit this once the preamplifier is enabled.
- Do a zoom on LWA band (~10 to ~115 MHz). Although we are covering this with our current data, the SA is limited to 711 channels per trace (at least as far as I can tell so far). So setting the range to this specific band will give us more precise channelization.
- Zoom on BAO band (~300 to 1420 MHz). Same argument as LWA band.
- Spectrograms? We may want to save waterfall plots showing frequency spectrum over some amount of time to get a feel for the nature of the interference that we see. We should look into whether the SA can export these to csv.