Taking Measurements With Smaller CHART Horns

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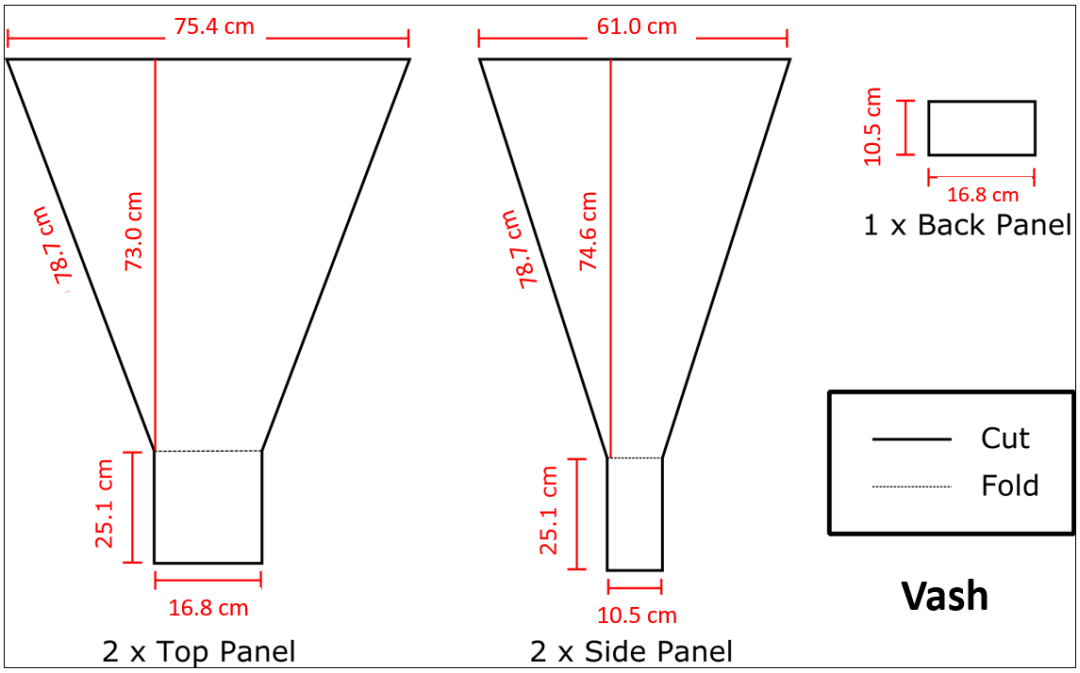
Goal

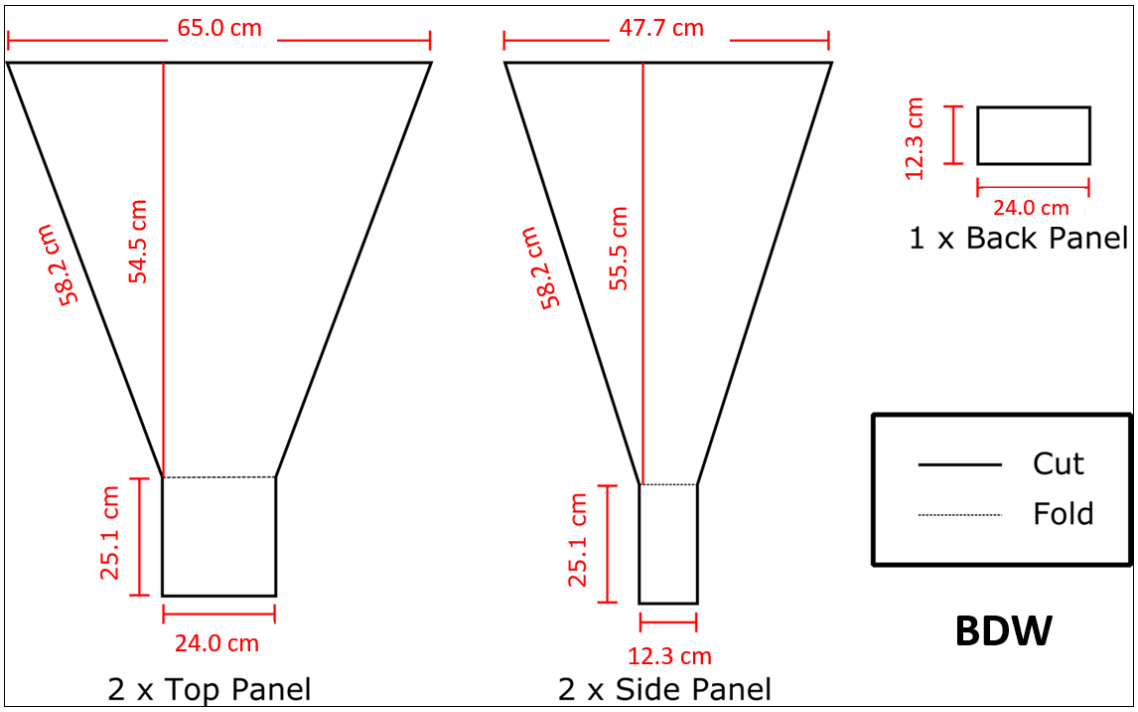
Measure the sky with smaller horns and do the same measurements as we did with the regular horn (nicknamed DJ) to compare results.

Horn Construction

- For both mini horns, the length of the copper probe is the same as the larger horn.
- Vash
  - This smaller horn was constructed using the dimensions outlined in LightWork Memo 29 and DSPIRA Horn Assembly. It is essentially a scaled-down version of the regular-sized horn. Cutout dimensions shown in figure below.
  - Notes on certain measurements:
    - The length between the end of the waveguide and the opening of the horn differs between the two references. The numbers 73.0 cm and 74.6 cm used for this horn came from the DSPIRA assembly.
    - Neither reference had a measurement for the length of the waveguide, so the measurement from the regular-sized CHART horn was used (25.1 cm). This also matches the Baby CHART built at ASU.
    - The hole for the probe was drilled 6.75 cm from the closed end of the waveguide.



- BDW
    - This version was made by reducing the area of the open end of the regular-sized CHART horn by a factor of 2. The waveguide containing the probe remains the same as the larger version.



Packing List

- 2 tarps
- Improvised horn support[1]
- Printed out procedure
- Horns (Vash and BDW)
- Nooelec amp + filter
- RTL-SDR
- SMA cable
- Pi + Mouse
- Monitor + HDMI cable
- Battery + 2 cables (for monitor and pi)
- RF explorer
- Tape, aluminum tape, foil
- Table
- Notebook, pen
- Phone for measuring alt/az.
- Yoyos

[1] We have been experimenting with easily constructed structures to hold the horns at different angles. Nothing worth writing up just yet.

Setting up for Observation

For more info on how we found the galactic coordinates for the reference targets, visit the memo from 6/22. The procedure is the same as that memo unless stated otherwise. We set up the horn that was not in the process of scanning in order to view the targets in roughly the same position and reduce down time. We started with BDW for no reason other than that its smaller size would fit in Ahlea's car because she had to leave early. The following is the projected timeline of events for data collection with the actual times and coordinates listed in the next section:

Planned Timeline:

- Arrive: 7 or 7:15 on Monday 26 June
- 7:30 - Caph, BDW
    - Az, Alt = 345:43, 74°
- 7:45 - Caph, Vash
    - Az, Alt = 339.5°, 73:16
- 8:00 - Caldwell 20, BDW
    - Az, Alt = 293.5°, 46°
- 8:15 - Caldwell 20, Vash
    - Az, Alt = 295°, 43:40
- 8:30 - Sun, BDW
    - Az, Alt = 85.5°, 30°
- 8:45 - Sun, Vash
    - Az, Alt = 88°, 33°

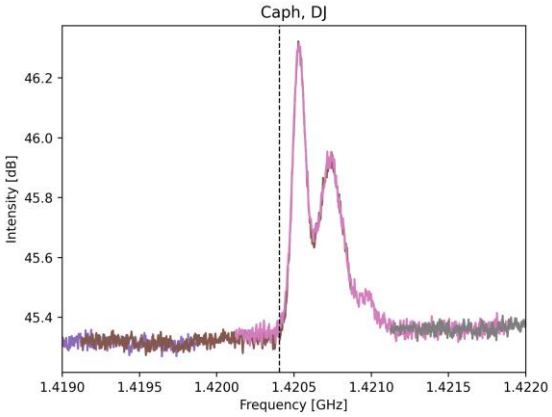
Actual times and coordinates

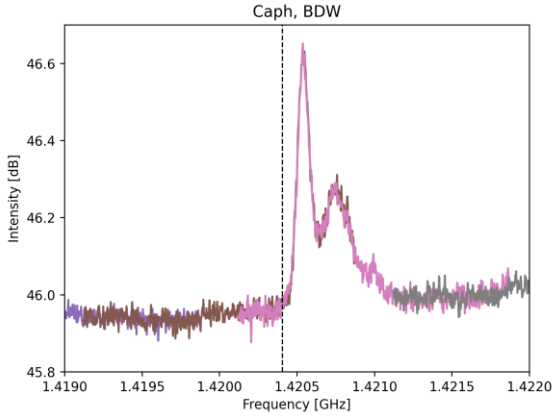
*Note that the trial numbers are not sequential because of a mix-up with the raspberry pi
**The weather conditions on this day were just windy enough to require some stabilization from us on occasion.

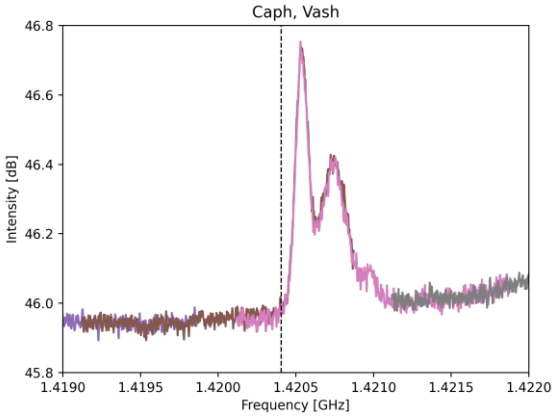
- 7:30 - Caph, BDW
    - Az, Alt = 345:43, 74°
    - Filename: `abeardsley_Winona_2023.06.26_1_7:30_am`
- 7:45 - Caph, Vash
    - Az, Alt = 342°, 73:16
    - Filename: `abeardsley_Winona_2023.06.26_2_7:45_am`
- 8:00 - Caldwell 20, BDW
    - Az, Alt = 293°, 46°
    - Filename: `abeardsley_Winona_2023.06.26_3_8:00_am`
- 8:17 - Caldwell 20, Vash
    - Az, Alt = 295°, 44°
    - Filename: `abeardsley_Winona_2023.06.26_5_8:17_am`

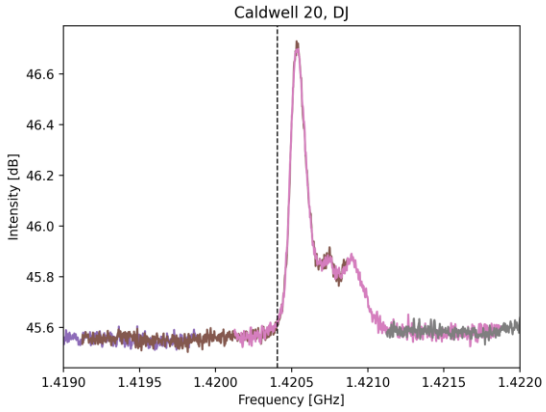
- 8:30 - Sun, BDW
    - Az, Alt = 85°, 30°
    - Filename: `abeardsley_Winona_2023.06.26_6_8:30_am`
- 8:45 - Sun, Vash
    - Az, Alt = 88°, 33°
    - Filename: `abeardsley_Winona_2023.06.26_8_8:45_am`

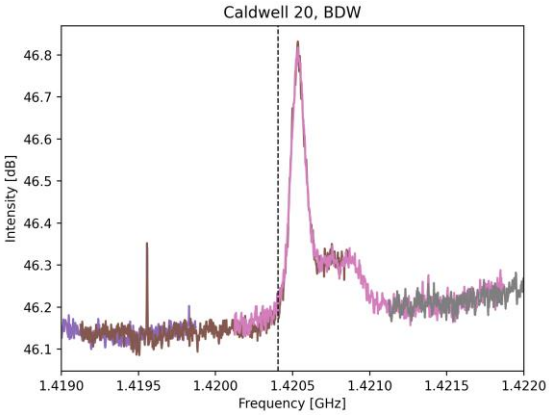
Quick Look

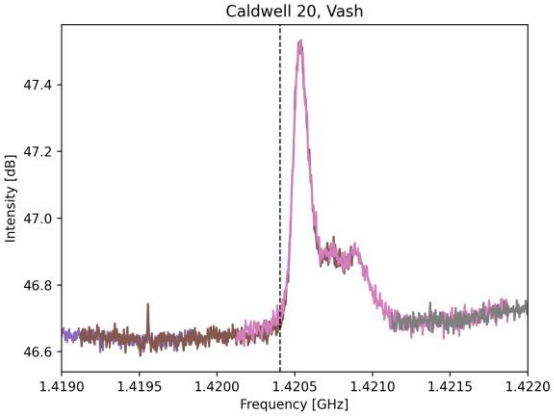


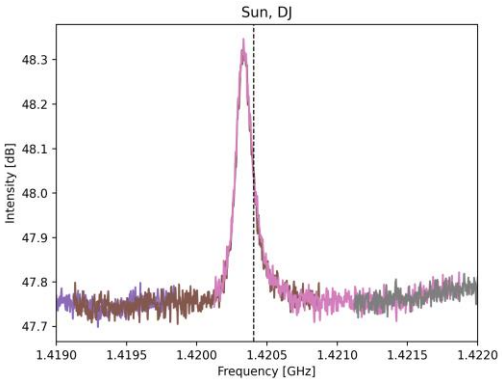


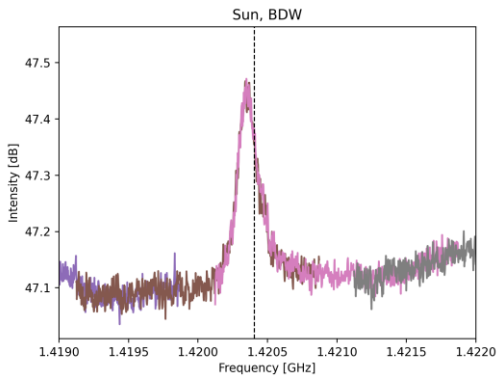


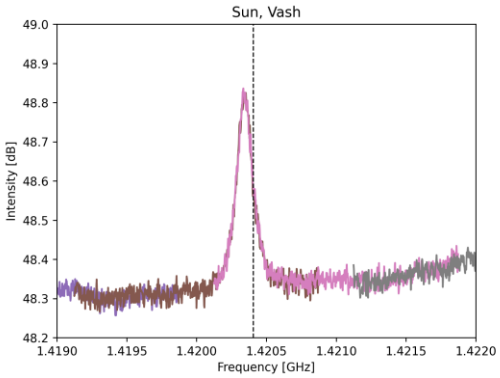

Caldwell 20, DJ
Intensity [dB]
Frequency [GHz]


Caldwell 20, BDW
Intensity [dB]
Frequency [GHz]


Caldwell 20, Vash
Intensity [dB]
Frequency [GHz]


Sun, DJ
Intensity [dB]
Frequency [GHz]

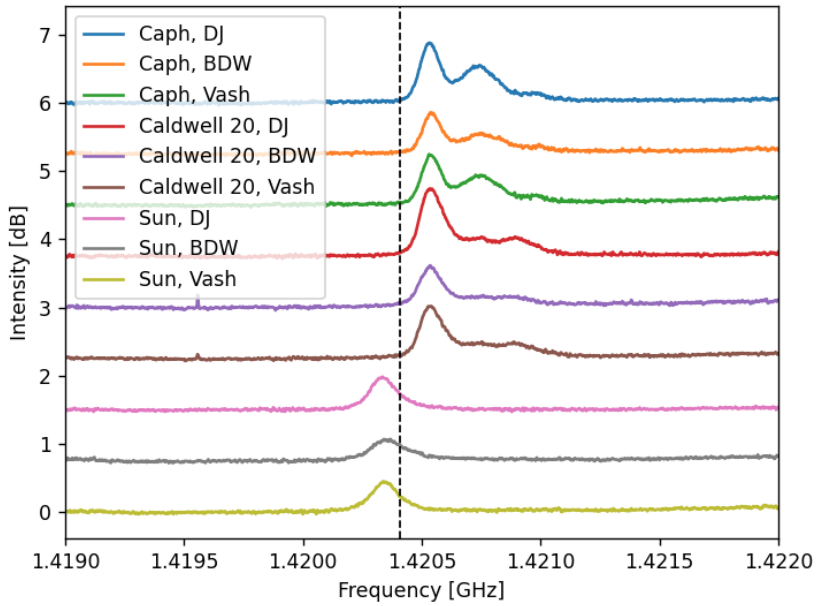

Sun, BDW
Intensity [dB]
Frequency [GHz]


Sun, Vash
Intensity [dB]
Frequency [GHz]

Analysis

Our analysis notebook can be found on the radiolab.winona.edu server at:
`~abeardsley/notebooks/Winona_26.6.2023.ipynb`

Stacked spectra:

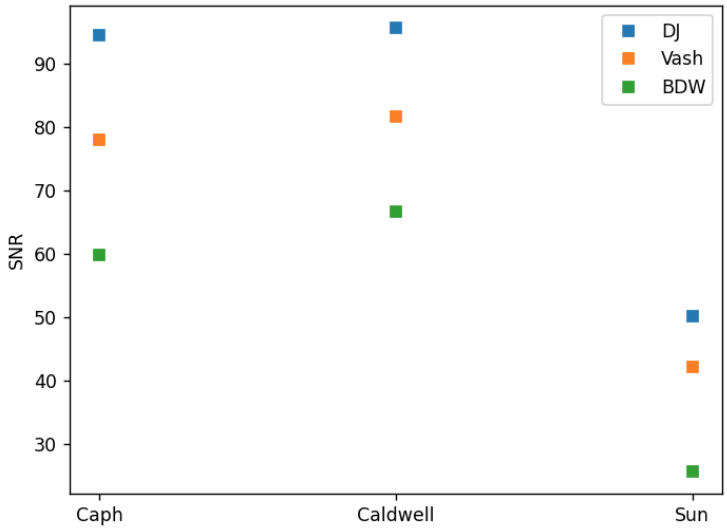


All three horns made convincing detections for all three targets. We compare the quality of the detections with a simple signal-to-noise ratio (SNR). The noise is calculated for each spectrum by measuring the median absolute deviation (MAD) in the noise region, and taking the peak of the spectrum as the "signal." These measurements are done in linear units (i.e. not dB).

SNR values:
Caph, DJ: 94.56738730160562
Caph, BDW: 59.90233470003832
Caph, Vash: 78.09967634881426
Caldwell 20, DJ: 95.75119860102146
Caldwell 20, BDW: 66.60909075305858
Caldwell 20, Vash: 81.77767951265632
Sun, DJ: 50.175394985325084
Sun, BDW: 25.582870542189614
Sun, Vash: 42.200396290691785

Noise values:
Caph, DJ: 81.09444074268784
Caph, BDW: 99.21481831014277
Caph, Vash: 94.75476353791579
Caldwell 20, DJ: 96.92596188710347
Caldwell 20, BDW: 94.50997711027483

Caldwell 20, Vash: 110.15169300149994
Sun, DJ: 140.92427133305566
Sun, BDW: 154.53054981580976
Sun, Vash: 175.20357206563364



DJ is consistently the highest quality detection, while Vash loses about 16% sensitivity and BDW loses about 39%.

Conclusion

While the normal-sized CHART horn is shown to be the best in terms of sensitivity, BDW and Vash are still viable options if one's cardboard budget and/or vehicle space are in short supply. We suspect that the field of view will change with the smaller horns, so our future plan is to measure that and write up those findings as well. When deciding what size horn to build, one should consider their experimental goals and how they will be affected by sensitivity and field of view.