Memo: 14 *Small Aperture Antennae for Introductory 21cm telescopes.*

To: Interested parties

Cc: Open Source Radio Telescopes

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Subject: *Small Aperture Antennae for Introductory 21cm telescopes.*

This memorandum explores antenna options for small-aperture antenna that might reasonably be used in introductory 21cm experiments by the amateur observer.

Introduction

The amateur radio astronomy observer is often faced with the question "what type of antenna should I use for initial experiments". There are a considerable variety of paths one might follow in this regard, and we try to explore a few of them.

Some observers now use a "para-grid" type antenna that is available primarily for use in terrestrial point-to-point WiFi links at 2.4GHz, but also have been marketed for use with GOES and Iridium L-band satellites. We wanted to understand how well these antennae worked at 21cm and explore other viable options.

Experimental Set Up

The experimental set-up was designed to, as much as possible, allow for "apples to apples" comparison of the various antenna options.

The receiver chain consisted of a *SawBird H1 LNA*[1] 3m of RG6Q coaxial cable, feeding an *AirSpy Mini SDR*[2]. The SDR was connected to a laptop computer running Ubuntu 21.04 with Gnu Radio 3.8.0.2. There were two 17m USB2.0 extension cables, made by MonoPrice connecting the SDR to the laptop, allowing the SDR to be fairly close to the antenna+LNA, while not being so close as to produce objectionable RFI.

1 https://www.nooelec.com/store/sdr/sdr-addons/sawbird/sawbird-h1.html
2 https://airspy.com/airspy-mini/

The set-up is shown below with one of the test antennae attached.

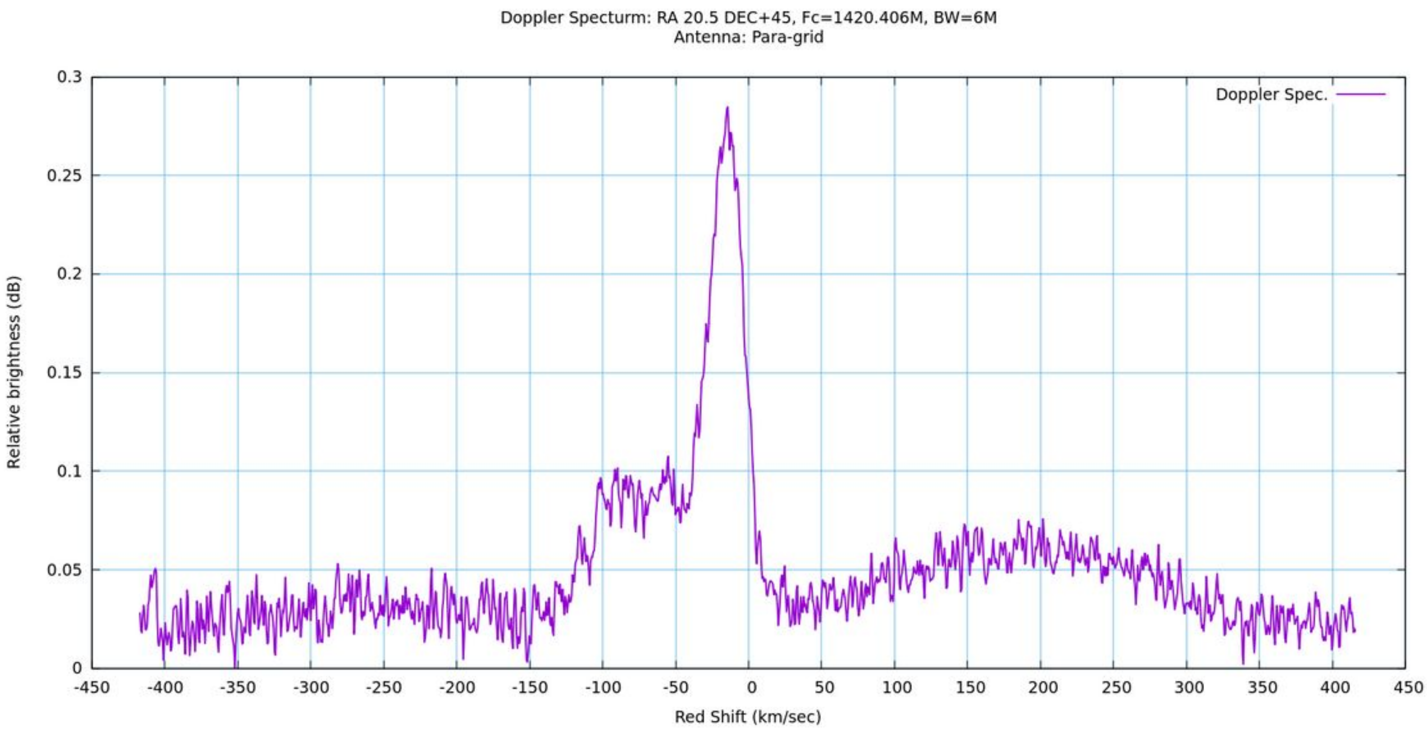
All the test antenna were oriented such that they were pointing at the local Zenith, and measurements of the H1 response were taken during a 10-minute interval around 20:30 LMST. In our location, that would be the region around *Deneb*, which has a relatively bright area of neutral hydrogen surrounding it.

30 x 60cm Para-Grid

We purchased a 30 x 60cm para-grid antenna[3] while it was being offered at 50% reduced prices on Amazon.

The assumption was made initially that the tuning of the feed dipole on the as-manufactured para-grid antenna would be unacceptable, so a small extension was soldered to the feed dipole on either side, to bring it into what we thought would be resonance.

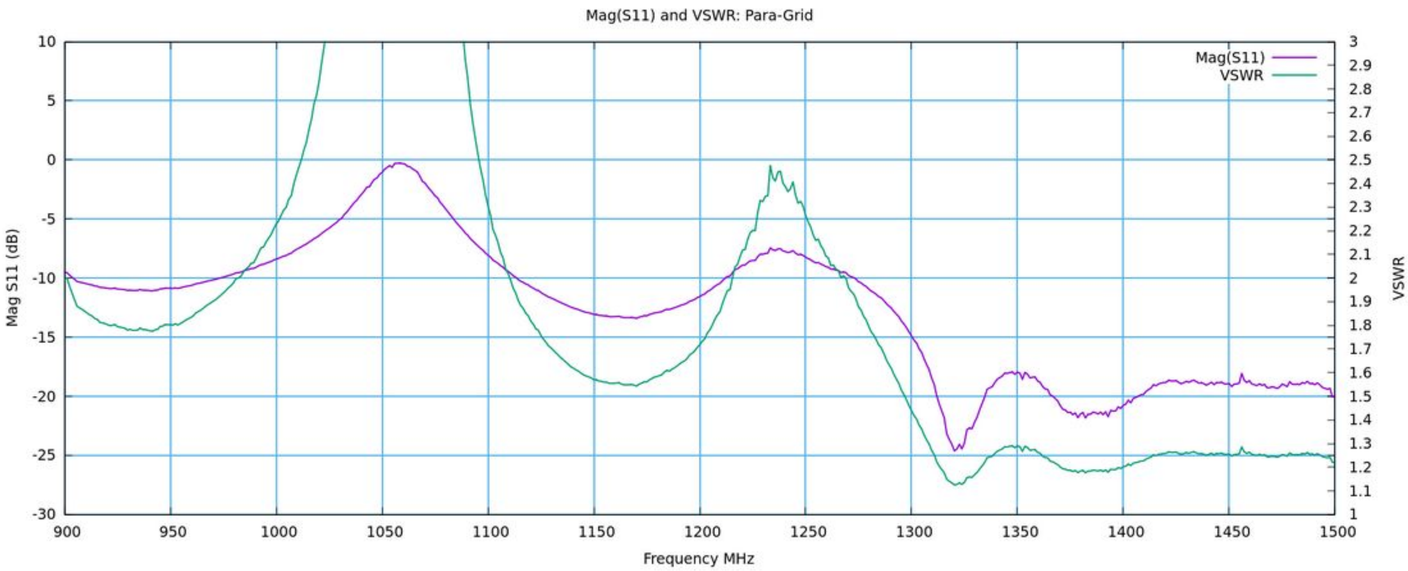
The initial results had a much-poorer SNR than was expected:



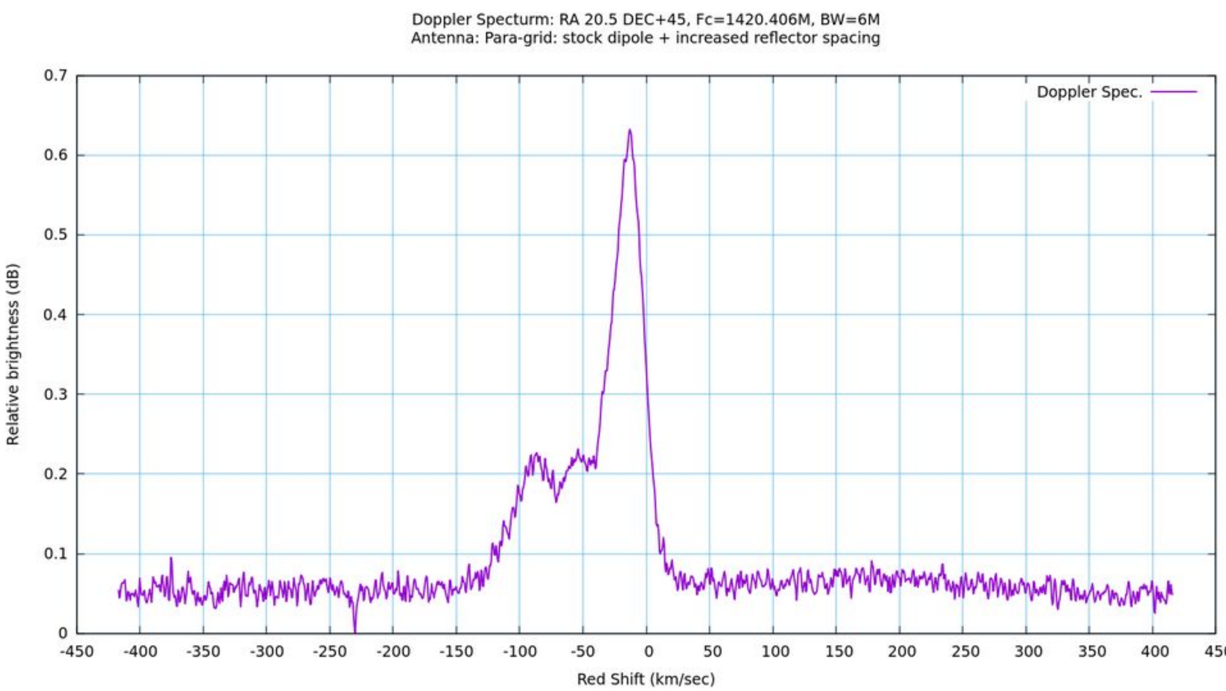
This was certainly adequate for an initial observation, but theoretically (given the effective aperture of this 30cm x 60cm parabola) the response should have been better.

We opted to remove the “tuning” tabs that had been added to the feed dipole, and measure the resulting VSWR, shown below.

3 A Turmode WAG24213



The VSWR shown by the "as manufactured" feed dipole at 21cm wavelength is actually quite acceptable at 1.3:1. This suggested that another "sky test" should be performed with the feed restored to "as manufactured" condition.



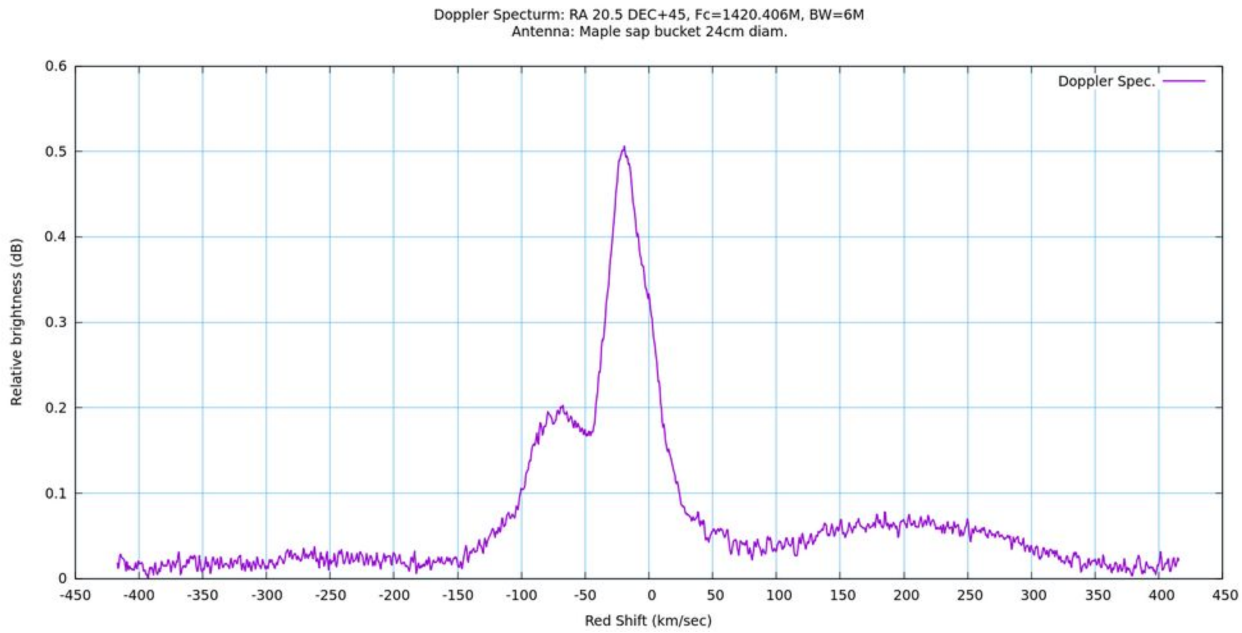
The resulting SNR was much improved and the signal peak was almost 0.4dB higher, which put it much closer to what one would expect given the apeture.

A Maple-Sap Bucket

Various experimenters have used “odd” horn-like antennae for initial experiments with the 21cm line. Since this author lives in an area known for its maple-syrup production (Lanark County, in Eastern Ontario, Canada), it made sense to seek out an old aluminum maple-sap bucket and turn it into an impromptu horn antenna and evaluate its performance. A suitable bucket was secured from an antiques dealer for CAD$6.00, and a feed-probe and type-N connector were fitted at a height from the bottom of the bucket of approximately 8.8cm.

The antenna performed more-than adequately given the very low cost, and *ad-hoc* nature of its construction.

Show below is the H1 response.



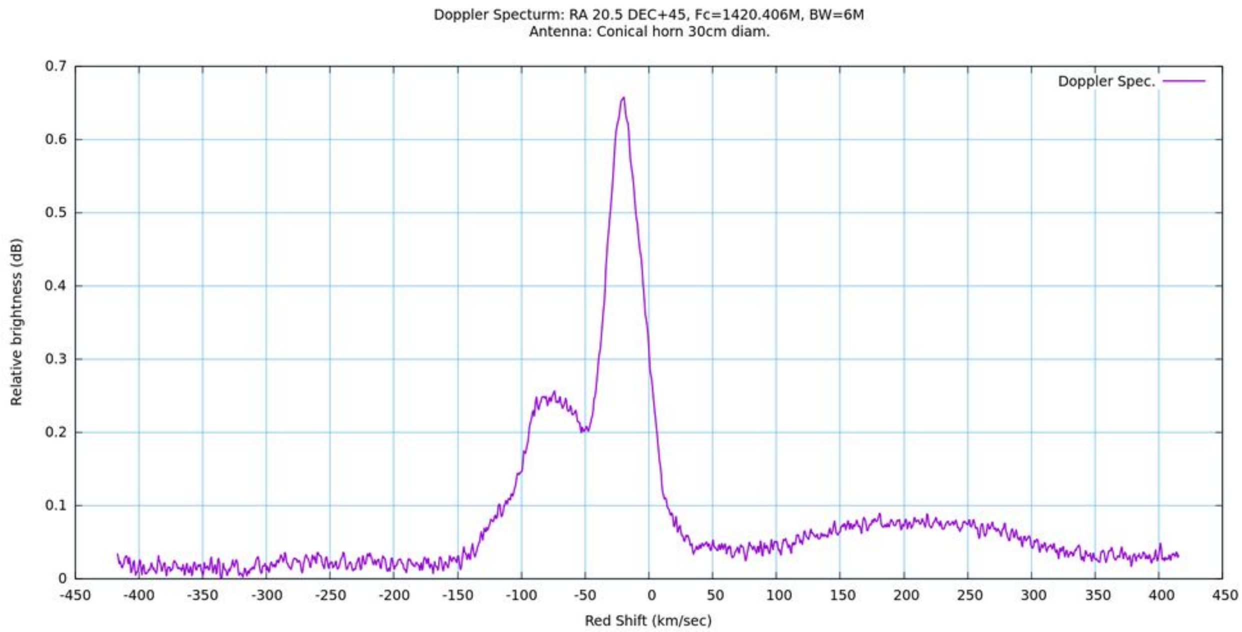
This is considerably better than the initial tests with the more expensive para-grid antenna.

A Larger Bucket

We fitted a larger (galvanized) bucket to an existing horn antenna with a 24cm aperture, bringing the aperture out to slightly more than 30cm.


The CAD$9.00 bucket was modified by cutting out the bottom and fitting it to the existing somewhat-smaller circular-horn antenna.

Results were good, as shown below.

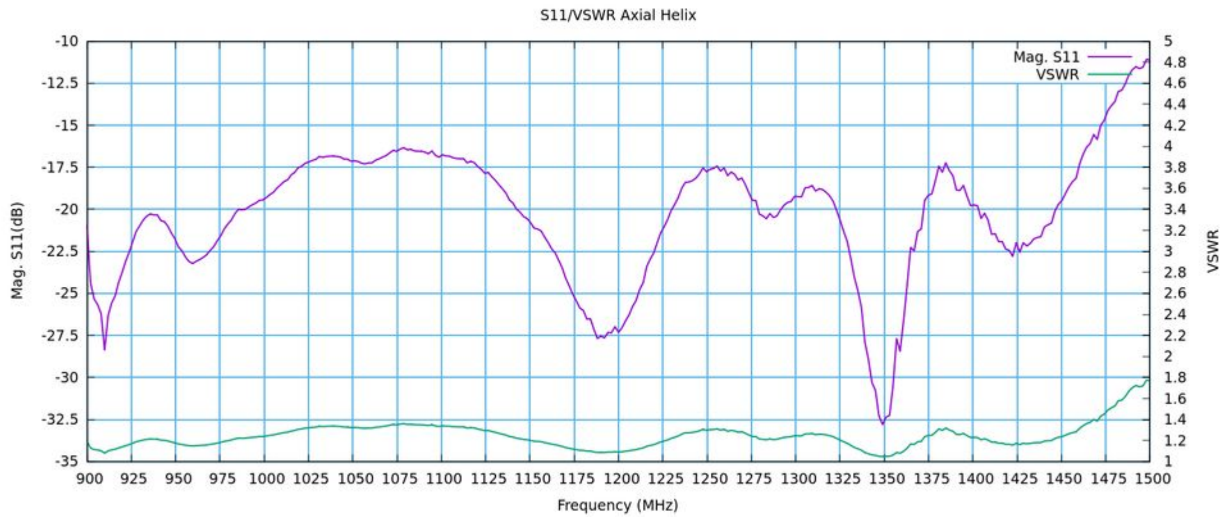


The result is very similar to the 30cm x 60cm para-grid in terms of both peak H1 response and overall SNR.

A 6-turn Axial Mode Helix

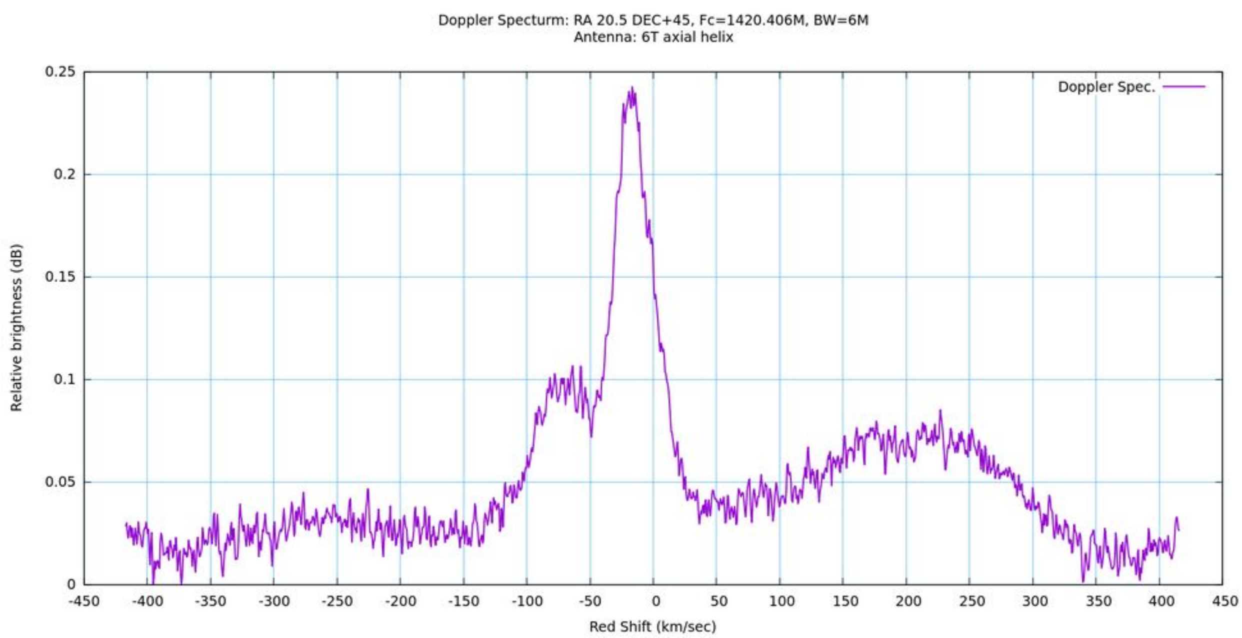
We constructed a 6-turn axial-mode helix antenna, using 14ga copper wire and a wooden dowel for support. A small piece of copper sheet acts as a matching section to bring the impedance closer to 50+j0 ohms.

We measured the VSWR of the helix antenna, since they tend to be somewhat difficult to match.



The VSWR at 1420MHz is approximately 1.16:1, as shown above.

The sky performance, however, was quite poor, as shown below.



The SNR is poor, and the peak sky response is a paltry 0.25dB above the noise.

The assumption is that the axial-mode helix is notorious for having substantial low-angle side-lobes, and given the Zenith orientation in all of the tests, a lot of that side-lobe energy would have been from the 300K surroundings.

Discussion

It is clear that nearly ANY antenna with 8-12dB of forward gain will work adequately for initial experiments with the hydrogen line at 21cm. A para-grid antenna performs well, but it should be noted is considerably more expensive than any of the *ad hoc* choices presented here. In balance with that is the fact that the other choices do require some amount of DIY skill, which may be missing in the novice observer.

It is clear that small *ad-hoc* horn-type antenna perform exceptionally well considering their modest aperture. This is not unexpected, since horn antennae **in general** have excellent side-lobe and back-lobe behavior, and it is clear that behavior can be relied upon even in “unconventional” horn antenna designs.

Other Potential Horn-type Antennae

The results suggest that **many** off-the-shelf metallic objects might be pressed into service as an unconventional horn-type antenna. Anything that is “cone like” (even vaguely so, as witness the maple sap bucket) and has a diameter near the bottom that is perhaps 6-8” (15cm-19cm), and has a gentle slope out to a larger diameter of 25-30cm.

There are, for example, galvanized steel floral buckets of the “French Style” that would likely work quite well. See, for example:

https://www.wholesaleflowersandsupplies.com/galvanized-metal-french-flower-buckets-and-pails-c-24-tall.html

There are also a variety of off-the-shelf galvanized parts for forced-air heating and cooling that can be pressed into service as part of a horn antenna system.