

# WSPRsonde Installation at WWV/WWVB

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## Abstract

The 19th meeting of the WWV/H Scientific Modulation Working Group was held on May 28, 2024. The topic of discussion centered on WSPR with Rob Robinett, AI6VN, giving a presentation on his software, WSPRdaemon, and the potential for the WSPR network to contribute to HamSCI efforts. After discussion, it was decided that installation of a WSPRsonde transmitter manufactured by Turn Island Systems and Paul Elliott, WB6CXC, would be pursued at both WWV and WWVB transmitter sites. Dave Swartz, W0DAS, conducted the initial installation at WWV/B over the summer and fall months of 2024 with extensive help from the NIST WWV/B staff, and details will be discussed. Early analysis of the WSPR data was very encouraging, with the 1-watt signal sharing very similar Doppler shifts with its 10,000-watt counterpart, as reported from a station at >1500km. Installation of similar equipment at WWVB is in the works.

## A Short History

The 2019 100<sup>th</sup> Anniversary of WWV opened several opportunities for the amateur radio community, specifically HamSCI, to work with NIST staff in aiding ongoing HamSCI ionospheric research. During the 2019 WW0WWV Special Event Station, the Festival of Frequency Measurement, coordinated by Case Western Reserve University, demonstrated the validity of crowd-sourced data. A talk by Dr. Phil Erickson, W1PJE, during the official anniversary ceremony outlined the science potential of the HamSCI efforts that utilize both the time and frequency of WWV broadcasts exclusively.

The 100<sup>th</sup> Anniversary of WWV also started a now 6-year successful working relationship between the WWV/WWVB station staff, the NIST Time and Frequency Division, the local WWV ARC members, and numerous members of the broader HamSCI community.

Starting in March 2021, the WWV/H Scientific Modulation Group began meeting, and by November 2021 a modulation test signal was created and broadcast on WWV at minute 8 and WWVB minute 48 of each hour. The test signal continues today after almost 3 ½ years.

Since inception, the WWV/H Scientific Modulation Working Group has met 22 times. It is currently pursuing several updates to the test modulation including the use of Costas Arrays and Coherent CW, as well as deployment of WSPRsonde transmitters and more.

## RX-888, KA9Q - Radio, and WSPRdaemon

Phil Karn, KA9Q, introduced the RX-888 and his SDR KA9Q package at the 15<sup>th</sup> meeting of the Working Group on August 8, 2023. KA9Q Radio is well-suited for multi-frequency reception of WWV and CHU and is now being deployed in the WSPR network along with the RX-888 SDR and WSPRdaemon, the combination gaining a following.

In January 2024 Rob Robinett, AI6VN, shipped an RX-888 and a Think Center PC w/ KA9Q and WSPRdaemon to Colorado. Dave Swartz, W0DAS, installed it along with the suite of Grape receivers - Grape 1 legacy, Grape 1.2 DRF, Grape 2 - at the Greyhawk Farm and Greenhouse located due east of the WWV antennas 6.5 km, almost line-of-sight.

3 of the receivers are the ground wave/control for the Grape experiments, and the RX-888 receives all WWV and CHU frequencies, as well as WSPR decoding utilizing WSPRdaemon and KA9Q - radio. The RX-888 is on a 30m vertical ¼ wave antenna while the Grapes are on a 30m horizontal dipole.

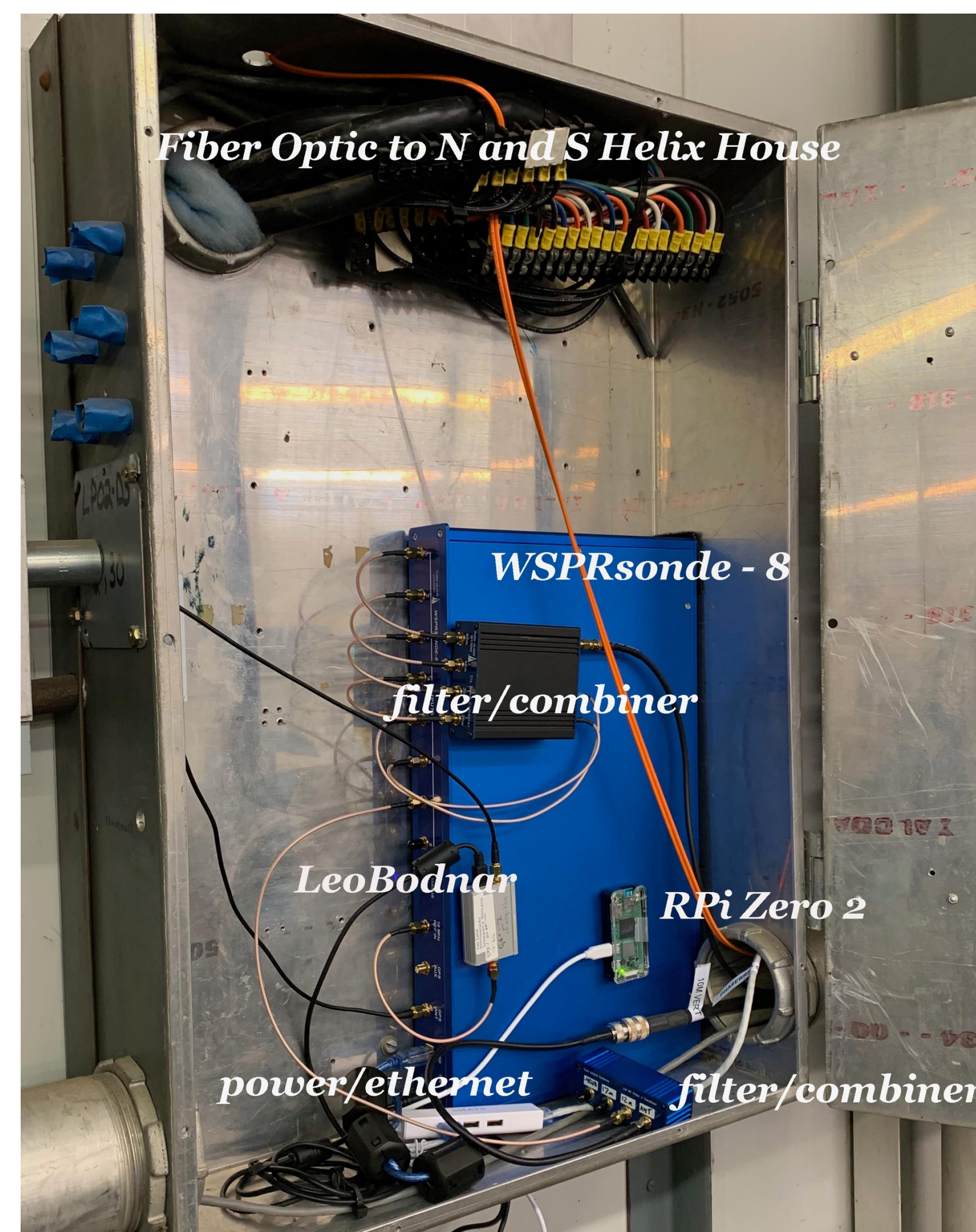
A major thread of the March 2024 HamSCI meeting revolved around the new software/hardware combination. Rob Robinett and Paul Elliott gave a talk on the WSPRdaemon Grape reporting network during the first session. Saturday morning started with Phil Karn and the KA9Q-Radio SDR Package. Both sparked discussions heard throughout the weekend.

Much of the May 28, 2024, 19<sup>th</sup> WWV/H Scientific Modulation Working Group meeting was devoted to discussion of the WSPRdaemon software and the potential of a WSPRsonde transmission from WWV and WWVB. The initial science goal is to confirm that a 1-Watt WSPR transmissions could also be used to observe similar Doppler shifts to the 10 kW WWV transmissions.

## WSPRsonde installation

In mid-June 2024, Rob Robinett and Paul Elliott shipped the necessary equipment for an install at WWV: A WSPRsonde-8 transmitter, 6-channel filter/combiner, A Leo Bodnar Mini GPSDO, a My Antennas EFHW-LP 80-10 antenna, and a Raspberry Pi ZERO 2.

Dave Swartz provided a SpiderBeam 12m pole, guy belt, polyphaser, 2 - 100' RG-8U, 2 - 3' RG-8x, various guy-wires, a powerstrip, pulleys, waterproofing, 5V power supplies, and a homebrew ¼-wave 12m vertical antenna.

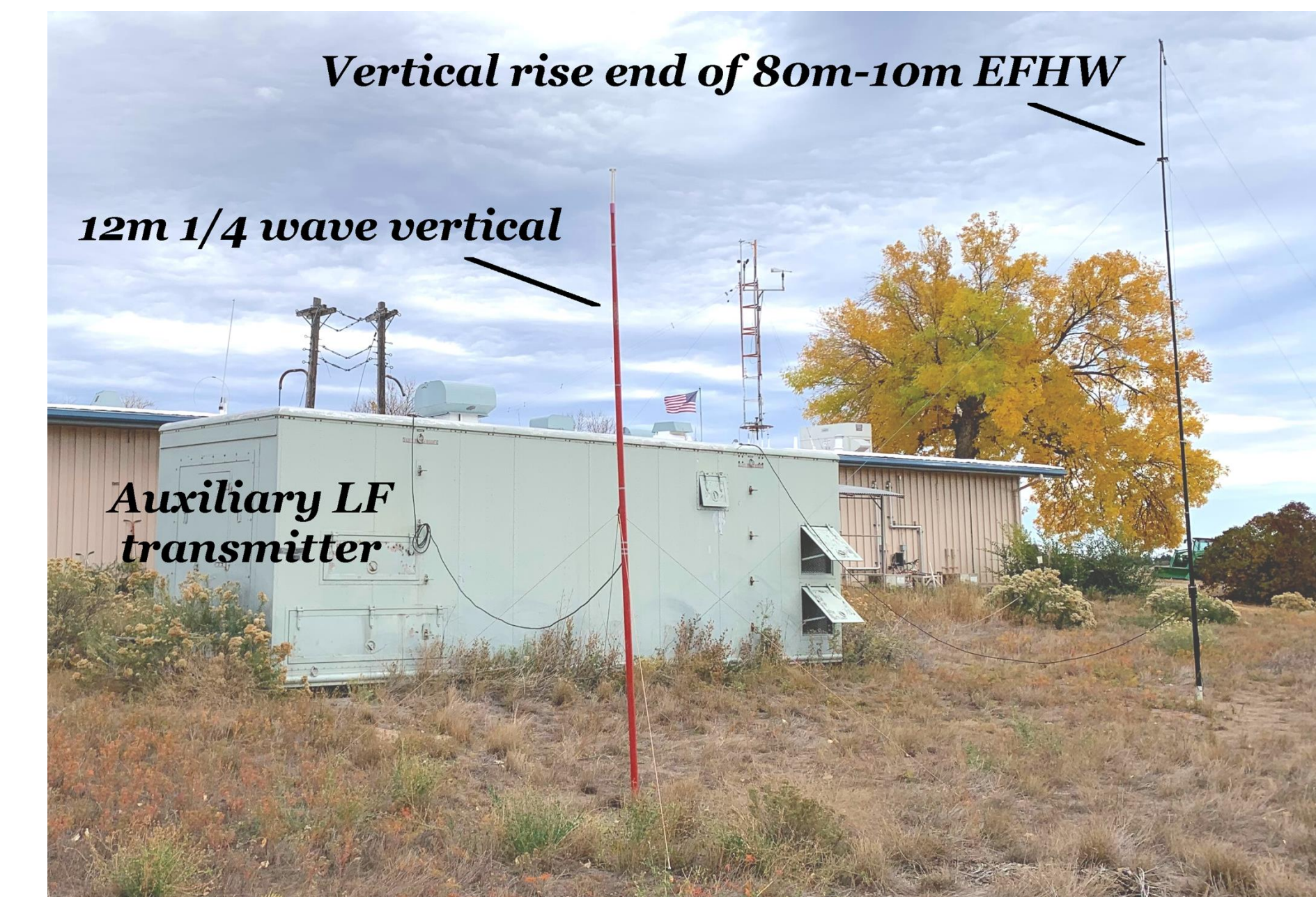


In early July 2024, Dave met with the WWV station staff to discuss placement of a WSPRsonde transmitter. The installation basic requirements included a power source, some equipment protection, easy access to a view of the sky for GPS antennas, access to the exterior for antennas, and placement of an antenna. It was recommended that the transmitter not be located at WWV proper, so attention was turned to WWVB. A first location option was abandoned because it was too close to the WWVB North Array. The second option station staff recommended was placement of the WSPRsonde in an empty cabinet in the control room for WWVB. The space met all the installation requirements.

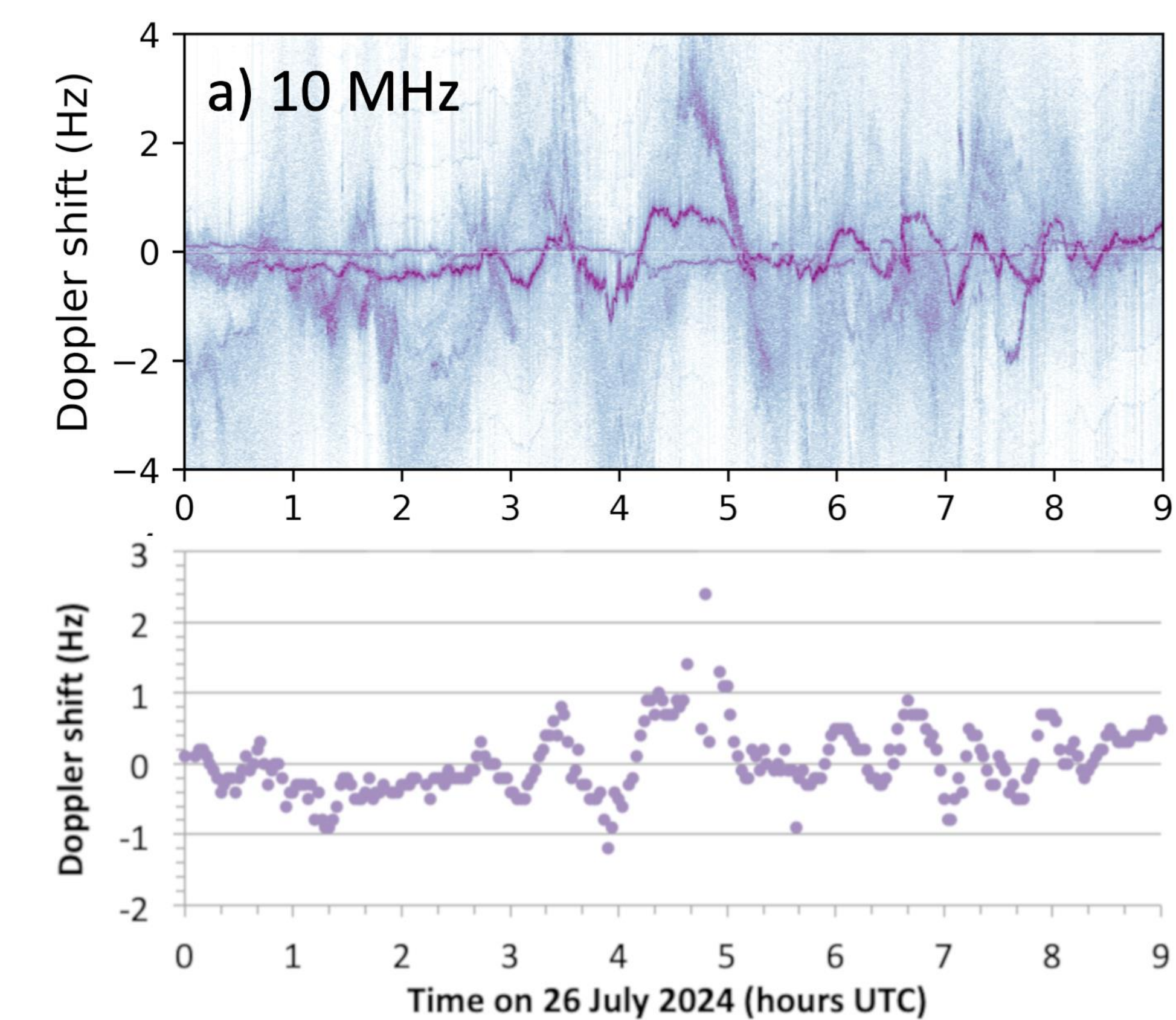
The space is a 2' x 3' aluminum shielded cabinet just behind the dummy load for WWVB and the antenna switching matrix. There is plenty of room for the WSPRsonde equipment. The space is shared with the fiber optic control-line feed to the North and South Helix Houses. Access to outside was easy through abandoned cable conduit in adjacent cabinets. The equipment is held in place by a lot of Velcro.

The end-feed antenna installation took place on July 16 utilizing two poles originally carrying the feedlines to the WWVB South and North Arrays. The north pole was abandoned after tuning issues and replaced with a SpiderBeam 12m pole about a week later. The south pole still suspends one end. A ¼ - wave 12m vertical was added in September 2024.

Antenna feed lines ended up being 100ft using RG-8U for lower loss. The end-feed half-wave also has a PolyPhaser in-line for lightning protection. All coax had to be suspended off the ground because of field mice. The coax exits the building and stays high across an auxiliary WWVB transmitter and then is held about 2-4 feet above ground until it reaches the antenna masts.



The WSPRsonde went on the air July 17, 2024 on 6 bands: 80m, 40m, 30m, 20m, 15m, and 10m. Results were analyzed within days and proved the WSPRsonde Doppler shifts aligned with those observed for WWV. 12m was added October 28, 2024.



Gwyn Griffith, G3ZIL, produced several graphs from WSPR data and Grapes during the first weeks of operation. Gwyn notes WSJT-X only records one frequency for the Doppler shift, same as the Grape 1 using fldigi, while the Grape DRF spectrograms show rich detail of co-propagating multipath, side and forward scatter, high and low rays, etc. The upper image is an RX-888 spectrogram of WWV above a WSJT-X recording of WW0WWV 10.14 MHz, both observed by N8GA.

## Acknowledgements

Special thanks to Rob Robinett, AI6VN, and Paul Elliott, WB6CXC, for the WSPRsonde equipment loan. The staff at WWV is incredible: Matt Deutch, Bill Yates, Glenn Nelson, Jim Spicer, and Kyle Kniegge. Jim Spicer has taken a keen interest and is our caretaker-on-site for the WSPRsonde and reports any issues he encounters. Thanks to Gwyn Griffith, G3ZIL, for his interpretation and graphs of the first WW0WWV WSPR broadcasts. John Delaney and Greyhawk Farm and Greenhouse hosts the Grapes and an RX-888 and provides Internet access for all 4 instruments. An anonymous amateur radio researcher is currently working at WWVB and is permitting the project to use his Internet access to control the WSPRsonde remotely.