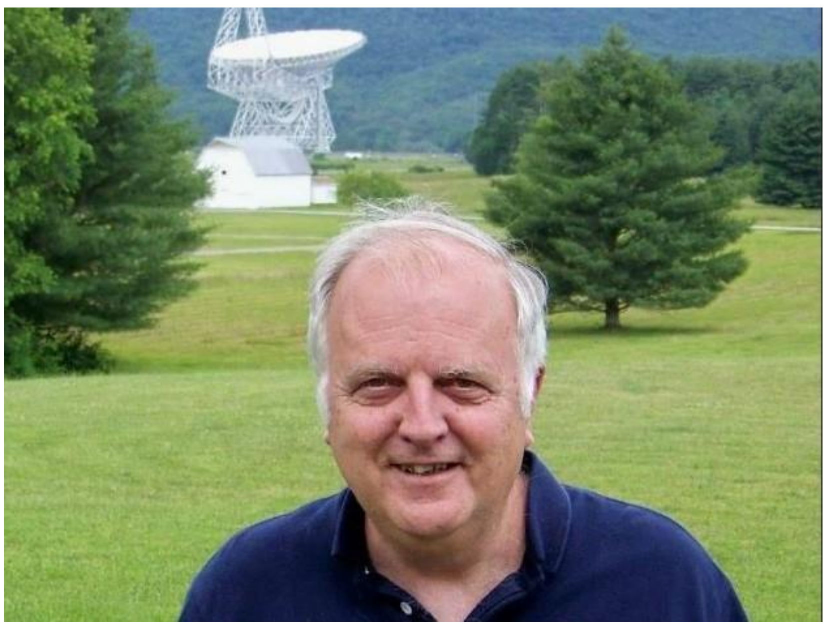
RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers
July – August 2022



Paul Oxley

August 2, 1942 — April 5, 2022

and the RASDR Program

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It is the mission of the Society of Amateur Radio Astronomers (SARA) to: Facilitate the flow of information pertinent to the field of Radio Astronomy among our members; Promote members to mentor newcomers to our hobby and share the excitement of radio astronomy with other interested persons and organizations; Promote individual and multi station observing programs; Encourage programs that enhance the technical abilities of our members to monitor cosmic radio signals, as well as to share and analyze such signals; Encourage educational programs within SARA and educational outreach initiatives. Founded in 1981, the Society of Amateur Radio Astronomers, Inc. is a membership supported, non-profit [501(c) (3)], educational and scientific corporation.

Cover Photo: Bruce Randall

Contents

Radio Waves

President's Page

Thank you for your confidence on electing me as SARA's president.

Outgoing president, Dennis Farr, did an outstanding job and has energized the SARA members with doing hydrogen observations with the Scope in a Box radio telescope and many other initiatives

The 2022 Eastern conference was a success! We had a very high level of presentations that provided invaluable information for the new and experienced radio astronomer. Special thanks to Dr. Wolfgang Herrmann for his very insightful keynote address.

The videos of the presentations are available at the SARA YouTube channel at:
https://www.youtube.com/channel/UC-SzptAQZ-20c9CkRb9ZPxw/videos

Your new Vice President, Jay Wilson, is actively working on getting us back to Green Bank next year!

Another valuable resource for SARA members is the Radio Telescope Observation Party (RTOP) and the Drake's Lounge. These ZOOM forums provide a live interactive conversation on technical and observation best practices for your radio astronomy hobby. Watch for an email with the zoom links announcing these events.

Thanks!

Rich

Dr. Richard Russel
President

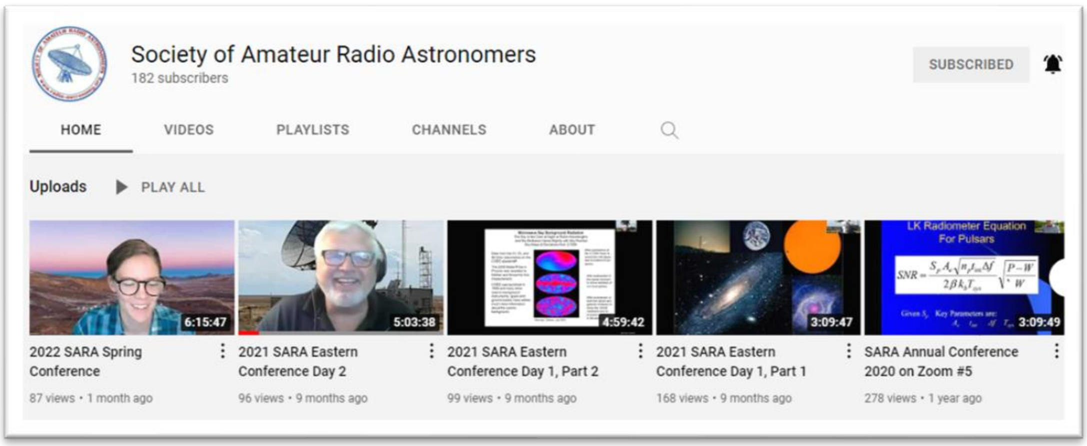
Editor's Notes

We are always looking for basic radio astronomy articles, radio astronomy tutorials, theoretical articles, application and construction articles, news pertinent to radio astronomy, profiles and interviews with amateur and professional radio astronomers, book reviews, puzzles (including word challenges, riddles, and crossword puzzles), anecdotes, expository on "bad astronomy," articles on radio astronomy observations, suggestions for reprint of articles from past journals, book reviews and other publications, and announcements of radio astronomy star parties, meetings, and outreach activities.

Subscribe to the SARA YouTube Channel

SARA has a YouTube channel at: https://www.youtube.com/channel/UC-SzptAQZ-20c9CkRb9ZPxw/videos

We are also looking to add content to the site. Anyone who wants to help produce a series of 5 - minute videos relating to radio astronomy technology or observations please contact me. (drrichrussel@netscape.net)



Observation Reports

We are now accepting 1-2 page observation reports. These reports should include the astronomical objects RA/DEC plus UTC of the observation. Also include the telescope configuration, process used to observe the object and results. Picture of the setup and plots of the observation are a plus to the report.

If you would like to write an article for Radio Astronomy, please follow **the newly updated Author's Guide** on the SARA web site:
http://www.radio-astronomy.org/publicat/RA-JSARA_Author's_Guide.pdf.

Let us know if you have questions; we are glad to assist authors with their articles and papers and will not hesitate to work with you. You may contact your editors any time via email here: edit@radio-astronomy.org.

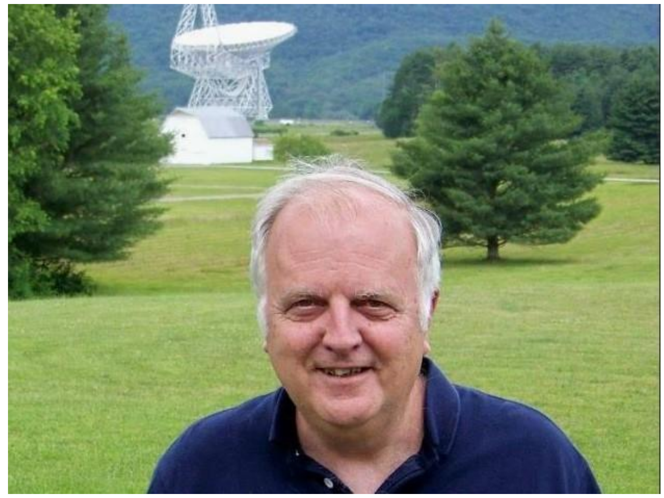
The editor(s) will acknowledge that they have received your submission within two days. If they do not reply, assume they did not receive it and please try again.

Please consider submitting your radio astronomy observations for publication: any object, any wavelength. Strip charts, spectrograms, magnetograms, meteor scatter records, space radar records, photographs; examples of radio frequency interference (RFI) are also welcome.
Guidelines for submitting observations may be found here: http://www.radio-astronomy.org/publicat/RA-JSARA_Observation_Submission_Guide.pdf

Tribute to Paul L. Oxley
August 2, 1942 — April 5, 2022

Bruce Randall, NT4RT   nt4rt@arrl.net

SARA member Paul Oxley passed away on April 5, 2022.   He was 79 years old.



Paul grew up in Iowa City, Iowa and graduated from Iowa City High School in 1960.

Paul enlisted in the U.S. Army Reserve and specialized as a radio operator. Briefly activated during the Cuban Missile Crisis, Paul returned to reside in Iowa City in the early 1960s.

Paul graduated with honors from the Milwaukee School of Engineering with a degree in Electrical Engineering in 1968. Paul also graduated from a master's level program offered through AT&T Bell Labs and Stevens Institute of Technology.

Paul spent his entire 38-year professional career at AT&T. He rose through the ranks and retired as District Manager. At AT&T, he made significant contributions to microwave radio telephony systems.

Because of Paul's microwave engineering background at AT&T, he could and did contribute a lot to SARA. He was one of the resident experts on waveguides and antennas.   The following are SARA contributions by Paul.

SARA Board of Directors, 2010

SARA Vice President, 2011 – 2012, which means he managed the SARA conference at Green Bank. His management skills pulled together good conferences both years.

Conference 2007: Design of a Tunable LO for ELF measurements. This is the design of a receiver local oscillator for 950 to 1450MHz. Low phase and amplitude noise is needed for a solar study. A lot of effort went into very low noise of circuits including power supplies, VCOs and phase lock loop ICs. This was tech support for Rodney Howe's solar research project.

Conference 2008: Observation of the February 20, 2008, lunar eclipse at 12 GHz. These measurements established the thermal origin of the 12 GHz radiation and established that it is not reflected solar emissions.

Conference 2008: Improvements to a Digital Baseband Four Channel Receiver. This paper presents a set of improvements made to his four channel receiver. Isolation between receiver channels and circuit noise reduction were achieved. This seems to be the start of Paul's SDR work that later led to RASDR.

Conference 2009: A multi band feed horn for radio astronomy. This feed works at 1420 MHz, 2800 MHz, and 12 GHz. This feed is used with Paul's 6 ft. diameter dish with an F/D of 0.38. This feed is on a portable radio telescope that was often setup at SARA Conferences. It is in pictures below.

Conference 2010: Interfacing a Pan/Tilt Mount to Planetarium Software. The pan/tilt mounts designed for TV cameras are used to accurately position a small dish antenna to track the pointing of planetarium software. This was used with the 6 ft. dish in photographs below.

Conference 2011: Position Sensors microprocessor controlled antenna mounts. This is a continuation of the 2010 antenna mount control, again used with the 6 ft. dish in photographs below.

2011 is also the start of the RASDR project using the Lime™ LMS6002 receiver chip. Paul was involved with getting the Lime™ chip working properly with the FPGA, high speed microcomputer and the USB interface. The basic RASDR receiver covers 300 to 3800 MHz.

Conference 2012: RASDR Low and intermediate frequency receiver using the Lime™ LMS6002 chip with an up converter. The Lime™ chip will not accommodate inputs below 300 MHz. This up converter translates frequencies below 300 MHz to frequencies within the chip's range.

Conference 2013: RASDR Windows™ interface presented. This interface allows setting all the Lime™ chip setup parameters as needed. Basic radio astronomy features are shown. FFT analysis is available as well as raw data capture.

Conference 2014: RASDR control software and RASDR Viewer presented. This has improved control of Lime™ chip. The viewer function gives much improved ways to view data.

Conference 2015: RASDR viewer update for pulsar use. This involves the issues of exact sample rates, dispersion of signals, and proper alignment of data blocks for folding algorithm.

Conference 2016: RASDR unbound project for RASDR4 using Lime LMS 7002 chip. The LMS7002 chip extends low frequency coverage to 100 KHz without an external up converter. The new chip also has a dual channel receiver.

The RASDR project was Paul's big project, along with the rest of the team. The RASDR is definitely a high-end radio astronomy SDR product. The many low cost SDRs on the market probably kept RASDR from being a great success.

Paul often brought equipment that he had designed and built to the conferences for display. There was always a lot of interest in Paul's equipment. The design was very interesting, and the workmanship was very high quality. He was definitely a skilled craftsman.

I really miss Paul's technical input to SARA list serve. Occasionally he would get in a little friendly disagreement with Jeff Kruth over some details of waveguide theory. It made life interesting as long as Tom Crowley did not have to break it up! Not long before he died, he was still active on the list serve.

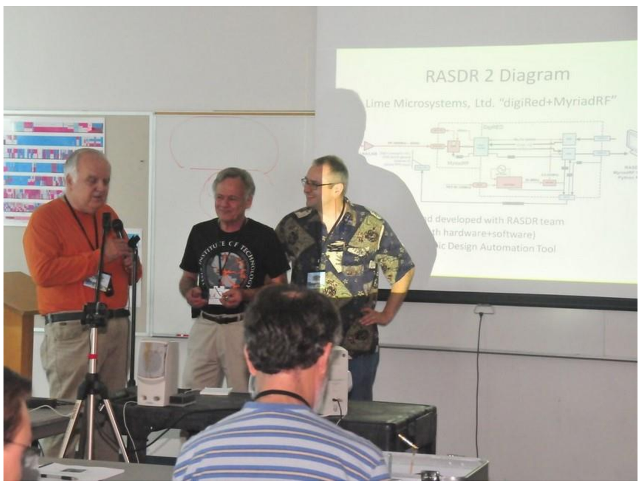
9/10/21 list serve: He shared some insight into grid type dishes and polarization problems.

10/4/21 list serve: He was involved in discussion on dish mountings and drives. Proper brakes are a good idea. He recommended DC motors with PWM controllers to allow very small movements of a dish.

12/14/21 list serve: We had a discussion on waveguide feeds and the high pass filter that is inherent to the design. This seems to be the last discussion where Paul was involved.

Paul will be missed!

Paul's 6 foot dish attended most conferences. Second picture shows a better view of the *PELCO* drive and the electronics enclosure.

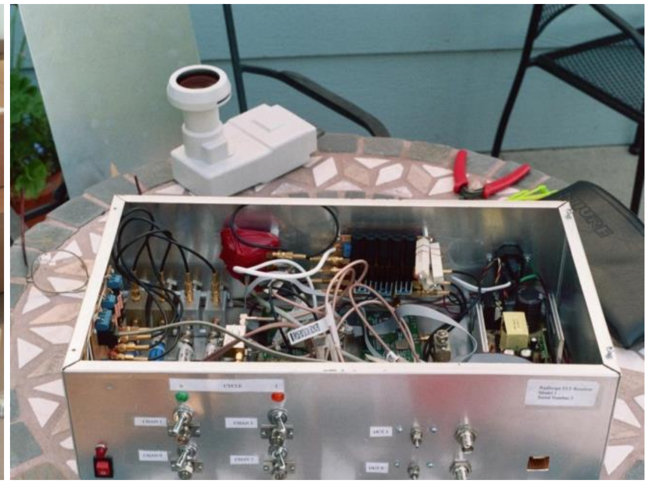


Paul was very involved with RASDR.

Upper Left: Paul, David Fields, and Bogdan Vacaliuc with RASDR diagram.

Upper right: RASDR team get award from SARA president Ken Redcap.

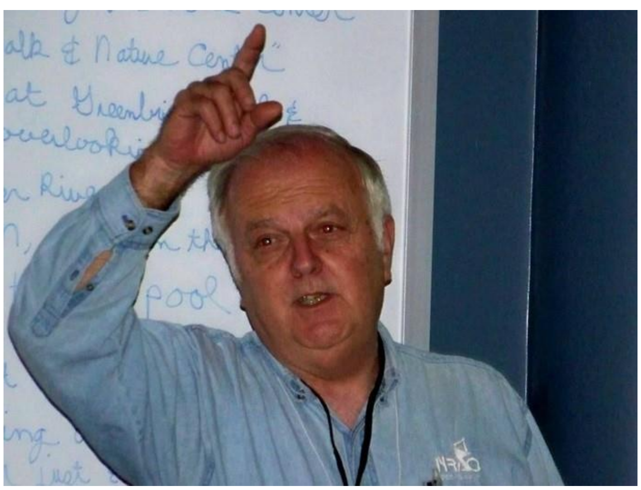
Lower Left: Paul receives a 408 MHz dish feed for RASDR from Bruce Randall



Receiver that Paul designed and built for Rodney Howe's solar research.

With Nick Pugh and unidentified individual

With Jim Brown, Karen Mehlmauer and Hal Braschwitz



Paul in teacher mode

Paul with hard hat on

Paul Oxley's contributions to the RASDR Project
David fields

Paul Oxley was not only an important member of SARA – he was an especially important participant on our RASDR team. RASDR (Radio Astronomy Software Defined Radio) arose from a conversation between Marcus Leach and me, in which Marcus suggested that a SARA team might design and build an affordable receiver (Leach, Trondsan, & Matthews, 2011). This device would be new for us – it would process incoming radio data across a wide range of frequencies and provide derived information most useful to radio astronomers – including as a start, time-averaged radio spectra (in Janskys and noise temperature), S/N, parameter settings and comments… Key concepts were 'affordable' and 'Radio Astronomy', neither of which described receivers found in the marketplace at that time. To best serve the SARA community, it should run in a Windows environment. We viewed this is something that SARA needed, and that would benefit us all.

The project took off when Paul Oxley and Bogdan Vacaliuc (later including Carl Lyster, Tony Bigbee, Stan Kurtz and others) started contributing. We set aside most of the pile of discrete components that I had amassed and with Paul's and Bogdan's hardware and software insights, we embraced the Lime world of enticing but always-changing high-tech receiver chips. (Lime_Microsystems, Home page of Myriadrf) (Lime_Microsystems, LimeSDR Launched on Crowd Supply, 2016)

Figure 1Paul Oxley presenting a perspective on RASDR design at Tamke-Allan Observatory "RASDR conference"in 2016.

Figure 2 Paul demonstrating RASDR2 at Tamke-Allan Observatory in 2016.

Paul much enjoyed Radio Astronomy and was usually ready to setup a demo or test new ideas (as he often did at SARA meetings). He enjoyed the 'raw cutting edge' of the development, which is not the best place for demonstrations, thus our demonstrations often did not go as well as we would have enjoyed. They were more for sharing with other friends.

Fig. 2 shows Paul demonstrating RASDR2 at Tamke-Allan Observatory in 2016. As with most unrehearsed demonstrations, things did not go as planned. The solar noise was not our friend that day. In the world of radio astronomy, one man's signal is another man's noise.

However, as with most of these demonstrations, we learned some things and rekindled our enthusiasm. That was what was nice in working with Paul.

Paul was a great friend and collaborator, often irascible but always contributing. We kept RASDR0 (our evolving suitcase RASDR "football" containing some Lime chips kindly bought by SARA and shown in Fig. 3) moving between Oak Ridge and Atlanta, as we built, tested, and refined. The project stayed behind schedule, but I was delighted that Paul was a contributing member of our team. Progress was slow and we documented our developments in the SARA Journal, both as articles (Fields, et al., June 29-July 2, 2014) (Oxley P. , Fields, Kurtz, & Berl, 2014) and as periodic progress reports.

Figure 3 The RASDR team's RASDR0 "football"

Figure 4 RASDR2, documented, and ready for production.

RASDR1 was our first respectable prototype while RASDR2 (Fig. 4)was our fully-functional, encased, documented, 'ready for production' version with fully-functional software, as presented to SARA and published (RASDRteam, 2022).

However, we had taken too long for development and RASDR2, coupled with Lime Microsystem's continued high prices for aging chip designs, proved too expensive to produce in quantities of perhaps less than 300.

Although we fulfulled our technical goals, the market moved on.

We developed a subsequent design, RASDR4, and produced some kits for cases.

The RASDR project showed Paul's dedication to Radio Astronomy. All our RASDR projects are acknowledgements to his love for linking theory to quality in an actual product. Paul was a great contributor to SARA and to the RASDR project and we will miss him.

Figure 5 RASDR4 case kit

Figure 6 RASDR4 installed in case.

VINTAGE SARA

By Charles Osborne, k4cso@twc.com

Retrospective on SARA Member: Dick Knadle, K2RIW

This month's Vintage SARA column will introduce some of you to a SARA member we lost during the pandemic. I know half the members are not amateur radio operators, but bear with me, Dick Knadle's knowledge is very applicable to our discussions even today.

I became friends with Dick on the air on 432 MHz while I was still in college in 1979. We talked on the 550 mile path from Long Island NY to the W4ATC NC State Amateur radio Club station in Raleigh NC.

He was already a prolific engineer with many awards and front cover pictures in magazines crediting his exploits. The one that caught my attention was the cover of ARRL QST from August 1972 showing Dick hand holding a 12 foot dish of his own design. That was reprinted in the "A Look Back" section of the July 2022 QST on p.92. ARRL gave me permission to reprint that in this column.

The reason it's of current interest relates to all the discussions of how difficult it is becoming to obtain a decent size dish for a reasonable price. I suppose we've gone thru the phases of: disrepair, neglect, yard art, to scrap aluminum for many of the 6-10ft dishes that were so common in yards and on the rooftops of sports bars twenty or thirty years ago. I still see them. But they are more and more bedraggled.

Dick Knadle's build your own dish utilizes a concept which capitalizes on the fact that a piece of 6061-T6 aluminum will take on a parabolic curvature temporarily if pulled from its tip toward the focus. He started with a metal hub with a pipe welded to it to support the feed perpendicular to the center plate. The flat plate was drilled with two holes per rib. And each rib was drilled similarly to be mounted to that plate. The more ribs the stronger the dish. The 12foot dish in the cover shot used 24 ribs of about 3/8" tubing. A second plate was similarly drilled and sandwiched to make the center plate even stronger.

Now this dish does have one or two caveats. It has very little resistance to wind from behind. So if you live in an area with ice, snow, and high winds it may not be for you. I have seen a few that add strings back to the counterweight supports to help counter that and add to its chances of surviving. But that can affect the natural physics at work in making the parabolic curve. In college I built a 6ft one of these for 1296 MHz and it worked very well.

Whatever size tubing you can get for reasonable cost will probably determine your dish size. The tip of each rib is cross drilled for a perimeter wire which helps keep the screen wire surface tight. I used a piece of fiberglass tubing to support the feed and be the connection point for all the strings. Fishing squid line and snap swivels make it all come together easily.

How well does it work? Well, that brings up the next memorable event that got Dick Knadle another front cover on QST. He created a downconverter from a spectrum analyzer which fed a shortwave receiver. The feed was a 2.2 GHz W2IMU dual mode coffee can style feed with LNA hanging on it. Very similar to our present 1420 MHz feeds. Using that arrangement, he was able to pick up the Apollo 16 mission enroute to the Moon. Enough to make any SARA member proud.

Dick attended a SARA meeting at Green Bank, and I remember him telling us that he had to point the dish to the left of the Moon in peaking the signal. It dawned on him that they had to “lead the target” by pointing the spacecraft to where the Moon would be in two days as they left Earth orbit. For any of the Flat Earthers who think we never went to the Moon, and it was all done on a sound stage somewhere, that little unexpected piece of information about leading the target is pretty good proof of the reality of it all.

Dick Knadle designed: noise figure measurement equipment for AIL (Airborne Instruments Lab) during his 30+ years there, a kilowatt 432 MHz amplifier that got him another two QST cover awards, a 19-element 432 MHz yagi, and power combiners for it. He used a 16 yagi array at 100 feet for his 432 MHz experiments. It employed a series of relays which could zoom the array from 24° beamwidth to 6° beamwidth in azimuth and elevation. He formed a company RIW-Products to sell the antennas and combiners. Bruce NT4RT and I still use those antennas forty years later.

There were many other articles, too many to list. For 2010 he was awarded the ARRL Technical Service Award for his many contributions over the years.

Dick was very knowledgeable about many things. I remember making a special subdirectory to save his emails in because they were like mini tutorials on specific subjects when he was fielding questions about things on a microwave list server I’m on. I’ll reprint one email below in total as he describes defocusing an offset dish at 10 GHz to act like a zoom control. The W1GHZ link still works, a great antenna website.

Dick Knadle, K2RIW, an amazing person, and SARA member. He is missed.

-----K2RIW email-----
W1GHZ es The MW Group de K2RIW 9/16/09

Dear Paul,

GOOD WORK -- Your 9/15/09 PDF submittal entitled "Parabolic Dish Focus, Zoom and Tilt" contains some fine work.

<http://www.w1ghz.org/new/Parabolic_Dish_Focus_Zoom_and_Tilt.pdf>

I really like the 3D-colored antenna patterns. I would like to know which program created those simulations, and I wish I could afford it -- Hi.

THE CRITICAL FOCAL DISTANCE -- Your article clearly indicates the importance of using the correct Parabolic Dish Feed Focal Distance -- with a required accuracy of a fraction of a wavelength -- when using a small F/D Reflector.

MY PURPOSE -- I want to supply some information to increase the understanding of a Zoom Control.

A ZOOM CONTROL -- For 5 years I used a 3 step Zoom Control on my 16 Yagi array of RIW-19 Yagis on 432 MHz. That Zoom Control made it about 5 times easier to find people that were at an Unknown Azimuth during a VHF Contest, and it helped me make the top score in the W2 (NY and NJ) area on three occasions while using nothing but 432 MHz. It was the "Most Fun" antenna I have ever owned.

That experience convinced me that the Zoom Control concept needs more favorable acknowledgement, and more employment -- all good cameras have a Zoom Lens. A person can view a picture of my antenna, and the three 3D Zoom Patterns, in the March 2008 issue of "CQ Amateur Radio", page 36. THE OFFSET FED PARABOLA ELEVATION PROBLEM -- On almost all of the available Offset Fed Parabolas, the apex of the "Parent Parabola" is located at the "bottom edge" of the Asymmetric Reflector. Once that fact is known, an amateur can easily determine the Elevation Setting of his Dish by sighting
from behind that lower edge and looking through the Phase Center of the Feed Horn. This assumes the Feed Horn is properly located at the Focus.

"AXIAL" DISPLACEMENT -- If you want to displace the Feed Horn in an Axial Manner on a Prime Fed Parabolic Dish you would merely move the Horn closer or further from the center of the Reflector, because that is the Axis of the antenna.

BUT WHERE IS THE OFFSET AXIS? -- However, on an Offset Fed Parabola, the correct way to do an Axial Feed Displacement is to move the Feed Horn toward a spot that is very close to the Geometric Center of the Asymmetric Reflector, because that is the True Axis of that complete antenna system. If you stood off at a long distance and measured the "Apparent Phase Center" of the Radiation from that antenna, it would be on a line that goes through the Geometric Center of the Asymmetric Reflector

SQUINT -- I know this seem opposite from common sense. The further evidence is that the total antenna will develop "Squint" (a change in Elevation, or an Elevation Error) if you move the Horn in any other way. Figure 12 in the W1GHZ article is displaying the 5.75-degree Squint Error that occurred -- that’s a 1.4 Beamwidth Error for a one wavelength Displacement.

PATTERN DEGRADATION -- When you Displace the Feed Horn toward the Apex of the "Parent" of the Parabolic Reflector (toward the lower edge of the remaining Reflector) you will be creating both an Axial Displacement, and a Transverse Displacement. That will cause the Pattern to break up more rapidly, and the Gain will decrease more rapidly.

THE ZOOM POSSIBILITY -- However, even with the disadvantage of the simultaneous Displacement Error, I believe Figure 14 of your article is displaying the potential advantage of a Zoom Control. Here are the details.

1. A properly fed 18-inch Offset Fed Parabola on 10 GHz will have a -3 dB Beamwidth of about 4 degrees, and a -10 dB beamwidth of about 7 degrees.

2. Figure 14 (with 1 wavelength of Displacement in both an Axial and Transverse manner) shows a beamwidth of 14 degrees, at -12 dB from the Non-displaced Peak Gain. If the Feed had been Displaced only Axially, the 14-degree Beamwidth would probably be at -10 dB (instead of -12 dB), and the Pattern would be very nearly the same in Azimuth and Elevation.

3. That's a doubling of the Azimuth and Elevation Beamwidths at the -10 dB level, a 4:1 increase in the "Area" at -10 dB. That increase your chances by almost a 4:1 ratio of finding that signal, just as long as the signal is 10 dB above your Ultimate Threshold when your Gain is Peaked (no Feed Displacement, no Zoom).

THE ZOOM DISADVANTAGE -- Make no mistake, any operation of a Zoom Control must be accompanied by a Decrease in Gain; it's a tradeoff. If you're spreading your signal over a greater

Angular Area, it has got to get weaker -- that's the Physics of "The Conservation of Energy". Therefore, if the signal of interest is only 1 dB above your Ultimate Threshold (and it has no QSB), then a Zoom Control will give you no benefit. But, in the Real World a weak signal almost always has QSB, and you're really not sure of the Azimuth, the Elevation, the Frequency, and the Time he is transmitting (you're doing a 4 Dimensional Search). That signal is periodically going through brief QSB peaks. If you're not on the right Azimuth, Elevation, and Frequency at the Time he has the key down, you will miss that QSB Peak, and you will not know he is there. The Zoom Control (in this example) can give you a 4:1 increase in the Probability of Intercept.

TOTAL ACCURACY? -- I'll admit that a Zoom Control is not for everybody. You have to have "the faith" that it's going to give you some advantage a certain percentage of the time. If you and the guy you're contacting are using a Rubidium Reference, and you know your frequency (and his) to the nearest 1 Hz; if your Dish is perfectly leveled, and has 0.5 degree of Azimuth Accuracy: you've calculated his exact Azimuth; and if you know the propagation so well that you're sure the signal is not arriving 2.5 degrees above the horizon -- than under those conditions you probably do not need a Zoom Control. I think very few of us have that much accuracy and confidence in all of those areas at the same time.

SIDELOBES -- We should be careful of the way we view the Sidelobes of a Dish Pattern. The Decibel Display can greatly expand the apparent level of those zillions of Sidelobes. If the display was in Volts, they would look much smaller. If they were being displayed in Power (which is the way the antenna really works), you wouldn't see them at all. Until the Sidelobes get up to a level of about -13 dB (or stronger), or cover a zillion square degrees, their Total Integrated Power is usually quite small. Therefore, Dish Efficiency and Gain is mostly due to what is happening in the Main Lobe -- as long as there are no Lossy Resistive Components within the antenna system.

73 es Good Dish DX,
Dick, K2RIW

SARA NOTES

SARA Election Results for 2022-2024

President: Dr. Rich Russel
Vice President: Jay Wilson
Director: Ed Harfmann
Director: Stephen Tzikas
Director at Large: David Westman
Director at Large: Bob Stricklin

Special thanks to outgoing Director at Large, Keith Payea for serving on the board!

SARA Student & Teacher Grant Program

All, SARA has a grant program that is, sad to say very underutilized. We will provide kits or money to students and teachers including college students to help them with a radio telescope project. SARA can supply any of the following kits:

[1] SuperSID
[2] Scope in a Box
[3] IBT (Itty Bitty Telescope)
[4] Radio Jove kit
[5] Inspire
[6] Sky Scan

We can also provide up to five hundred dollars ($500.00 USD) for an approved radio telescope project.

We have on occasion provided more money based on the merits of the project and the SARA Grant Committee approval.

More information on the grant program can be found at the URL below.
SARA Student and Teacher Project Grants | Society of Amateur Radio Astronomers (radio-astronomy.org)

All that is required is the SARA grant request form be filled out and sent in. If it needs more work for approval, we will work with the student to help ensure their success.

Please pass the word that SARA will fund any legitimate radio telescope project anywhere in the world.

If you have a question, contact me at crowleytj at hotmail dot com.

Tom Crowley
SARA Grant Program Administrator

NEW Radio Telescope Observation Party (RTOP)

RTOP is designed to demonstrate how to take observations using various radio telescopes. It will also cover how to record and analyze data.

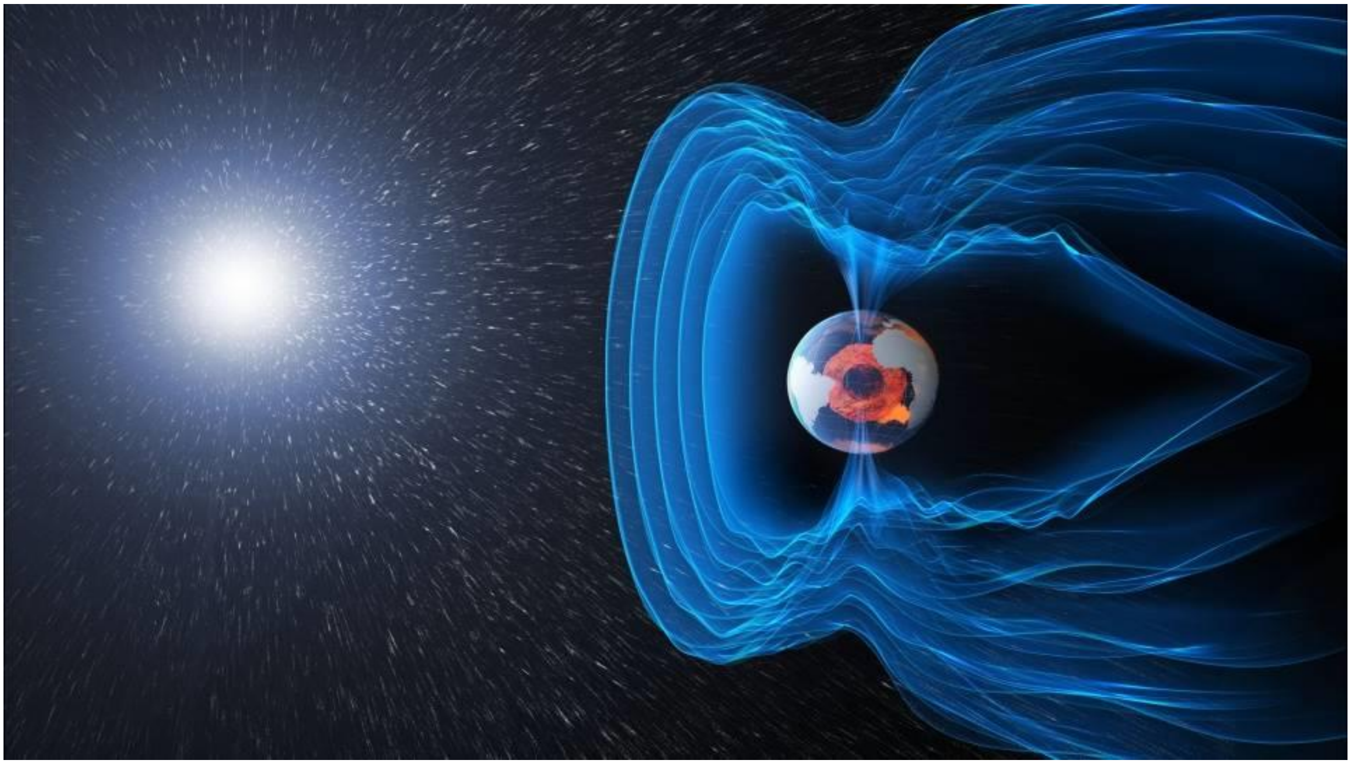
RTOP is every month on the 1st Sunday at 2 pm Eastern time. ZOOM email notifications will be sent to all members.

Drake's Lounge

Join the SARA community as we discuss the latest astronomy and radio astronomy news. The lounge also provides a forum to share and get advice on your radio astronomy projects from very experienced amateur radio astronomers.

Drake's Lounge is every month on the 3rd Sunday at 2 pm Eastern time. ZOOM email notifications will be sent to all members.

News: (July-August 2022)



Universe Today ~ *The Rapid Changes We're Seeing With the Earth's Magnetic Field Don't Mean the Poles are About to Flip. This is Normal*: https://www.universetoday.com/156234/the-rapid-changes-were-seeing-with-the-earths-magnetic-field-dont-mean-the-poles-are-about-to-flip-this-is-normal/

My friends, can your heart stand the shocking facts about graverobbers from outer space?: Phys.org ~ *Did a giant radio telescope in China just discover aliens? Not so FAST...*: https://phys.org/news/2022-06-giant-radio-telescope-china-aliens.html

National Radio Astronomy Observatory ~ *Astronomers Find Evidence for Most Powerful Pulsar in Distant Galaxy*: https://public.nrao.edu/news/powerful-pulsar-in-distant-galaxy/

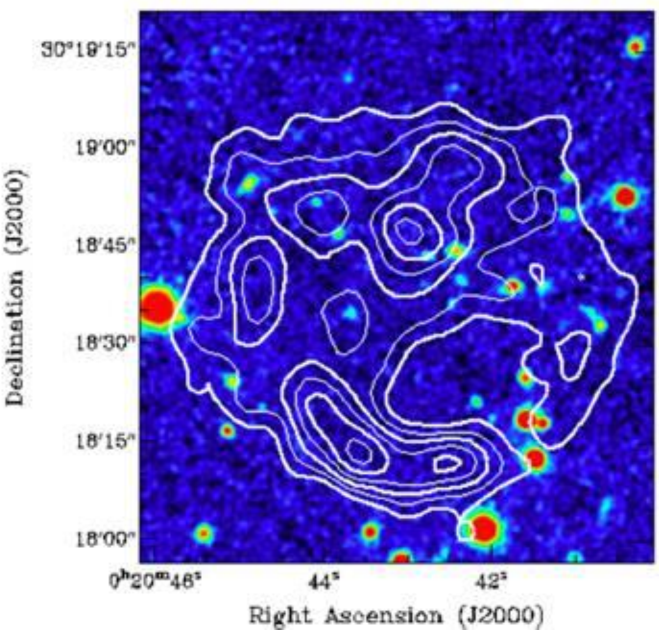
Universe Today ~ *A Rare Repeating Fast Radio Burst Gives Astronomers a Chance to Study These Mysterious Objects*: https://www.universetoday.com/156275/a-rare-repeating-fast-radio-burst-gives-astronomers-a-chance-to-study-these-mysterious-objects/

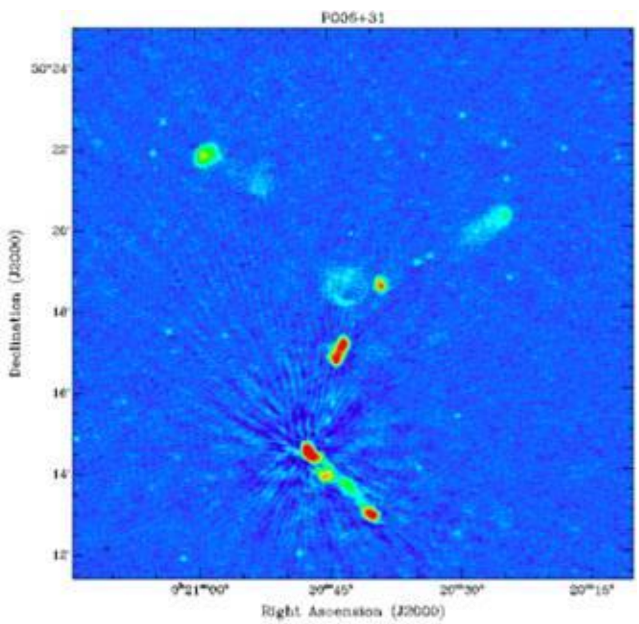
Universe Today ~ *64 Radio Telescopes Come Together to act as a Single Giant Observatory*: https://www.universetoday.com/156406/64-radio-telescopes-come-together-to-act-as-a-single-giant-observatory/

Society of Amateur Radio Astronomers ~ *Video of Green Bank 300 ft Radio Telescope before It Collapsed in November 1988*: https://www.youtube.com/watch?v=WMkdXRf9mF4

National Radio Astronomy Observatory (NRAO) ~ *News*: https://science.nrao.edu/enews/

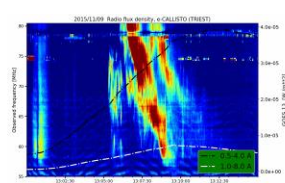
Technical Knowledge & Education: (July-August 2022)





Research Notes of the AAS ~ *Yet Another Odd Radio Circle?*: https://iopscience.iop.org/article/10.3847/2515-5172/ac7044

Community of European Solar Radio Astronomers (CESRA) ~ *Trieste CALLISTO Station Setup and Observations of Solar Radio Bursts*: https://www.astro.gla.ac.uk/users/eduard/cesra/?p=3339



NASA ~ *Fv: The Interactive FITS File Editor* (for Flexible Image Transport System files): https://heasarc.gsfc.nasa.gov/ftools/fv/

arXiv ~ *BURSTT: Bustling Universe Radio Survey Telescope for Taiwan*:
https://arxiv.org/abs/2206.08983

HPWiki ~ *Hewlett Packard / Agilent / Keysight Test Equipment*: https://hpwiki.mcguirescientificservices.com/

Signal Integrity Journal ~ *Practical EMC: Choosing a Real-Time Spectrum Analyzer*:
https://www.signalintegrityjournal.com/blogs/17-practical-emc/post/2668-choosing-a-real-time-spectrum-analyzer

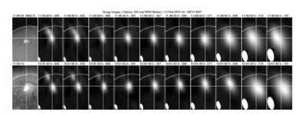
Community of European Solar Radio Astronomers (CESRA) ~ *Solar radio bursts associated with in situ detected energetic electrons in solar cycles 23 and 24*: https://www.astro.gla.ac.uk/users/eduard/cesra/?p=3350

MagPi magazine ~ *GroundBIRD telescope*:
https://magpi.raspberrypi.com/articles/groundbird-telescope

Society of Amateur Radio Astronomers (SARA) ~ *Detecting a Galactic Hydrogen Absorption Cloud using Cassiopeia A as a Broadband Emitter*:
https://www.youtube.com/watch?v=qkBu2RgLZoo

Texas Instruments ~ *An Engineer's Guide to Low EMI in DC/DC Regulators*: https://www.ti.com/power-management/non-isolated-dc-dc-switching-regulators/engineers-guide-low-emi-dcdc-regulators.html

Community of European Solar Radio Astronomers (CESRA) ~ *First detection of metric emission from a solar surge*:
https://www.astro.gla.ac.uk/users/eduard/cesra/?p=3363

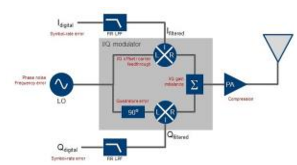


SALSA ~ *SALSA means "Such a lovely small antenna" (or in Swedish: "Sicken Attans Liten Söt Antenn") and refers to our small (2.3m) radio telescopes situated at Onsala Space Observatory in Sweden*: https://liv.oso.chalmers.se/salsa/

Electronic Design ~ *Using a VNA Like a Time-Domain Reflectometer*:
https://www.electronicdesign.com/technologies/test-measurement/article/21247467/megiq-using-a-vna-like-a-timedomain-reflectometer

Rohde & Schwarz ~

- *Application Note - Receiver testing: Noise, interferers and channel simulation*: https://www.rohde-schwarz.com/us/products/test-and-measurement/signal-generators/applnote-receiver-testing-noise-interferers-and-channel-simulation-register_255706.html



- Application Note - Receiver testing: The importance of fading: https://www.rohde-schwarz.com.cn/products/test-and-measurement/signal-generators/applnote-receiver-testing-the-importance-of-fading-register_255705.html

Announcements (July-August 2022)

(Note: Some events may have occurred before being published here but still are shown so readers may view any associated recordings)

The Voyager Mission: 45 Years of Discovery
SHIELD DRIVE Center Webinar Aug. 19th at 2 pm EDT (1800 UTC)

From: Nicholas Gross (gross at bu.edu)

Webinar Registration:
https://bostonu.zoom.us/webinar/register/WN_8sYLwV14R4OOY3NFrzJoLg

Join us for this panel discussion to celebrate the 45th anniversary of the launch of Voyager as well as 20 years of exploration outside of the Heliopause. This panel will reflect on how the past discoveries of Voyager have shaped humanity?s understandings of the outer regions of the Solar System as well as the current and future observations in the Interstellar Medium influenced by the Heliosphere. Panelists will also highlight connections with current missions, such as IBEX and New Horizons, and future missions such as IMAP. The panelists will reflect on the outstanding scientific puzzles that scientists are looking to solve through the future of exploration, and then conclude with a Q and A session.

Panelists include:

- Dr. Nicola Fox - Director, Heliophysics Division, NASA Science Mission Directorate
- Dr. Linda Spilker - senior research scientist and Fellow at NASA?s Jet Propulsion Laboratory and Voyager Deputy Project Scientist
- Prof. Merav Opher - Professor of Astronomy, Boston University. Radcliffe Fellow 2021-2022, Harvard Radcliffe Institute. Director of the NASA SHIELD DRIVE Science Centers.

For more information and to register, go to https://sites.bu.edu/shield-drive/outreach-2/webinars/

Find us on the web at:
Email: shieldoutreach@bu.edu
Website: https://sites.bu.edu/shield-drive/
Facebook: https://www.facebook.com/SHIELDDriveScienceCenter
Twitter: @SHIELD_drive
Join the SHIELD Outreach list serve by sending a message to our email

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THIRD ANNOUNCEMENT: 16TH INTERNATIONAL SYMPOSIUM ON EQUATORIAL AERONOMY (ISEA-16)
during 12 - 16 September 2022 at Kyoto University (in person / virtual hybrid)

The abstract submission deadline is approaching now. Please visit our website for more information.
https://www.rish.kyoto-u.ac.jp/isea16/

The International Symposium on Equatorial Aeronomy (ISEA) is held once in every three to four years. Researchers from the fields of atmosphere, ionosphere and magnetosphere gather together in ISEA to share new findings, discuss the current status, and identify topics for future research. The 16th International Symposium on Equatorial

Aeronomy (ISEA-16) will be held in person during 12 - 16 September 2022 at Kyoto University along with zoom virtual conference.

Please also note the newest information of visa and quarantine requirements if you plan to attend in person.
https://www.mofa.go.jp/p_pd/ipr/page7e_900126.html
https://www.hco.mhlw.go.jp/en/

INTERNATIONAL EARTH ROTATION AND REFERENCE SYSTEMS SERVICE (IERS)
SERVICE INTERNATIONAL DE LA ROTATION TERRESTRE ET DES SYSTEMES DE REFERENCE

SERVICE DE LA ROTATION TERRESTRE DE L'IERS
OBSERVATOIRE DE PARIS
61, Av. de l'Observatoire 75014 PARIS (France)
Tel.: +33 1 40 51 23 35
e-mail: services.iers@obspm.fr
http://hpiers.obspm.fr/eop-pc

Paris, 05 July 2022

Bulletin C 64

To authorities responsible for the measurement and distribution of time

INFORMATION ON UTC - TAI

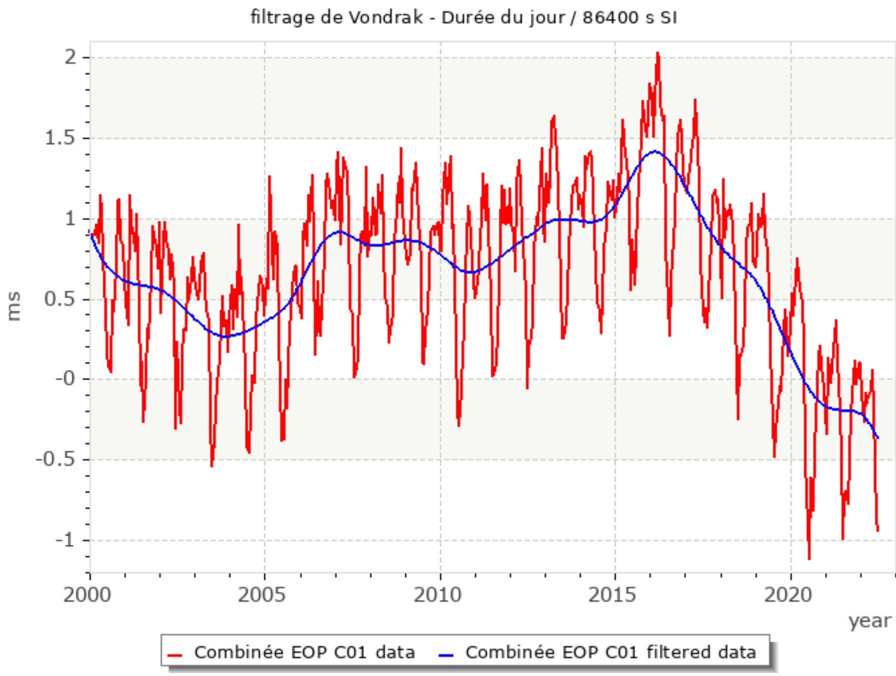
NO leap second will be introduced at the end of December 2022. The difference between Coordinated Universal Time UTC and the International Atomic Time TAI is:

from 2017 January 1, 0h UTC, until further notice: UTC-TAI = -37 s

Leap seconds can be introduced in UTC at the end of the months of December or June, depending on the evolution of UT1-TAI. Bulletin C is mailed every six months, either to announce a time step in UTC, or to confirm that there will be no time step at the next possible date.

Christian BIZOUARD, Director
Earth Orientation Center of IERS
Observatoire de Paris, France

Earth rotation acceleration: the length of day (LOD) since decreases in average by 0.3 ms/year since 2016:



K-Band Science Using the Green Bank Telescope

The Green Bank Observatory (GBO) is hosting a workshop on K-band science, past, present, and future with the Green Bank Telescope (GBT) from September 19-21 in Green Bank, WV.

From ammonia surveys to maser studies, to the astrochemistry of star formation regions and beyond — K-band has enabled a wealth of science in Green Bank! Registration for this workshop will be open on our website until August 15.

We are anticipating an in-person registration fee of USD $550, which will include ground transport to the GBO site from Washington Dulles (if necessary), lodging, and meals. We hope to provide virtual access to all contributed and invited talks, although other aspects of the workshop (i.e. panels and evening lectures) may remain in-person only. The workshop will be held over ~3 days, and the total number of participants will be limited to ~50 people which allows for candid discussions. Talks given will focus on survey results and the dissemination of those data, new results and general reviews. There will be a session dedicated to future instrumentation, both to evaluate community requirements and to explore the potential options for the GBT. There will also be space and time for poster presentations.

Workshop GoalsL

- ✓ Celebrate the success of prior observing campaigns and the K-band Focal Plane Array (KFPA), while encouraging use of the available archival data;
- ✓ Poll the community on the science being done or proposed at K-band to establish if the GBT is able to meet those needs;
- ✓ Seek community input on the future direction of K-band science and instrumentation at Green Bank.

Session Topics:

- ✓ GBT Surveys – RAMPS, GAS, KEYSTONE, etc.
- ✓ Astrochemistry
- ✓ Extragalactic Observations – Masers
- ✓ Other K-Band Projects
- ✓ Data Reduction Pipelines and Archive Data Products
- ✓ Instrumentation – Current and Future

Register Now: https://greenbankobservatory.org/science/meetings-and-workshops/current-future-k-band-workshop/

For more information on the conference, please check out the registration webpage or contact Larry Morgan (SOC chair, lmorgan (at) nrao.edu). We hope to see you in Green Bank soon!

Many thanks

Science Organizing Committee
K-Band Science Using the Green Bank Telescope

The Institute for Space-Earth Environmental Research (ISEE), Nagoya University, will hold "The 5th ISEE Symposium: Toward the Future of Space–Earth Environmental Research" from the 15th to 17th of November 2022 in a hybrid manner.

This symposium aims to discuss the current status and prospect of space–Earth environmental research from an interdisciplinary view. The symposium consists of six topical sessions and panel discussions for the future of space-Earth environmental research. We also accept contributed presentations. Please visit the website for details of this symposium, including the registration.

https://www.isee.nagoya-u.ac.jp/symposium05/

We look forward to your participation.

Kanya Kusano, Director
Institute for Space-Earth Environmental Research (ISEE)
Nagoya University

NRAO Program Designed to Educate Emerging Generation of Scientists Using Amateur Radio

The National Radio Astronomy Observatory program aims to engage BIPOC and LGBTQIA+ students in amateur radio as a gateway to understanding the electromagnetic spectrum.

August 8, 2022—A new National Radio Astronomy Observatory (NRAO) program aims to educate emerging generations about the electromagnetic spectrum through an interactive, substantive experience with amateur radio. Funded by a grant from Amateur Radio Digital Communications (ARDC), the program Exploring the Electromagnetic Spectrum (and Why Amateur Radio Matters) will focus on broadening the excitement of amateur radio among BIPOC and LGBTQIA+ students.

Bringing together the expertise of the National Radio Astronomy Observatory (NRAO), amateur radio enthusiasts, and subject matter experts (SMEs), the two-year program will:

- Introduce two cohorts of students to radio technologies,
- Engage these students in hands-on activities that will deepen their knowledge of astronomy, particularly radio astronomy,
- Support them in attaining their Technician Class and General Class amateur radio licenses, and
- Develop a scalable curriculum to be shared nationwide (and internationally) through Superknova, NRAO's online learning platform.

Students will learn about the very real ways in which the electromagnetic spectrum is a natural resource, every bit as limited and precious as the oceans and forests. They will also learn how amateur radio is an essential part of our national emergency infrastructure, and a critical resource in times of climate change and pandemics. The program is expected to start January 2023, initially serving 10 students. According to Dr. Tony Beasley, Director of the NRAO, "Amateur radio continues to be incredibly important to the nation and global communications, and NRAO is excited to be working with ARDC to bring a new generation and diverse communities to the field."

About the National Radio Astronomy Observatory: The National Radio Astronomy Observatory (NRAO) is a facility of the National Science Foundation (NSF), operated under cooperative agreement by Associated Universities, Inc. Furthering NSF's mission to advance the progress of science, the NRAO enables research into the Universe at radio wavelengths and provides world-class telescopes, instrumentation, and expertise to the scientific community. NRAO's mission includes a commitment to broader, equitable, inclusive participation in science and engineering, training the next generation of scientists and engineers, and promoting astronomy to foster a more scientifically literate society. NRAO operates three research facilities: the Atacama Large Millimeter/submillimeter Array (ALMA), the Karl G. Jansky Very Large Array (VLA), and the Very Long Baseline Array (VLBA), which are available for use by scientists from around the globe, regardless of institutional or national affiliation. NRAO welcomes applicants who bring diverse and innovative dimensions to the Observatory and to the field of radio astronomy. For more information about NRAO, go to https://public.nrao.edu .

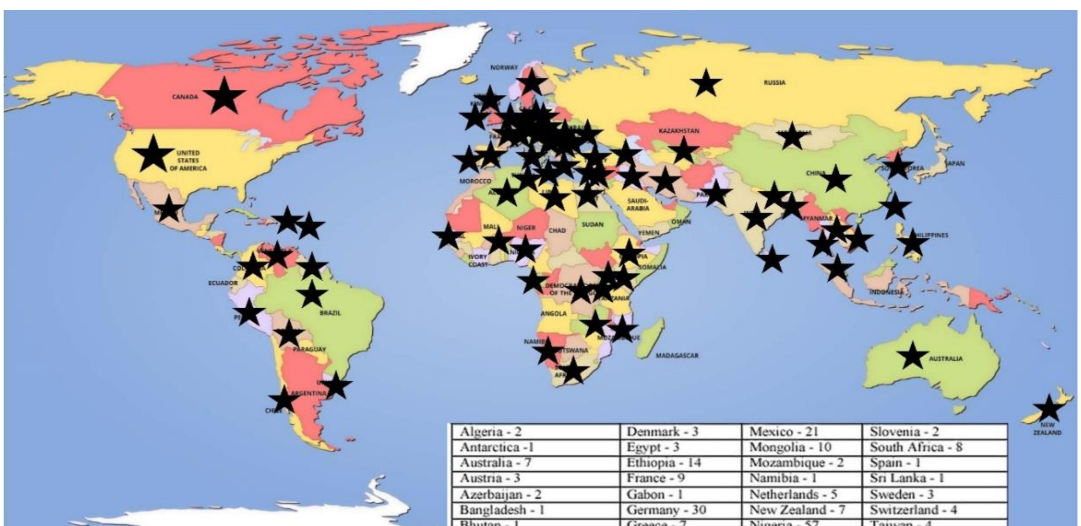
About ARDC: Amateur Radio Digital Communications (ARDC) is a California-based foundation with roots in amateur radio and the technology of internet communication. The organization got its start by managing the AMPRNet address space, which is reserved for licensed amateur radio operators worldwide. Additionally, ARDC makes grants to projects and organizations that follow amateur radio's practice and tradition of technical experimentation in both amateur radio and digital communication science. Such experimentation has led to advances that benefit the general public, including the mobile phone and wireless internet technology. ARDC envisions a world where all such technology is available through open-source hardware and software, and where anyone has the ability to innovate upon it. To learn more about ARDC, please visit https://www.ampr.org
.

For more information, contact: Lyndele von Schill, Director of Diversity & Inclusion, NRAO, lvonschi@nrao.edu
Dan Romanchik, KB6NU, ARDC Communications Manager, 858.477.9903, dan@ardc.net

SuperSID

Collaboration of Society of Amateur Radio Astronomers and Stanford Solar Center

- Stanford provides data hosting, database programming, and maintains the SuperSID website
- Society of Amateur Radio Astronomers (SARA) sells the SuperSID monitors for 48 USD to amateur radio astronomers and the funds are then used to support free distribution to students all over the world (image below as of Fall 2017)
-
- Jonathan Pettingale at SARA is responsible for building and shipping the SuperSID monitor kits: SuperSID@radio-astronomy.org
- SuperSID kits may be ordered through the SARA SuperSID webpage: http://radio-astronomy.org/node/210
- Questions about the SuperSID project may be directed to Steve Berl at Stanford: steveberl@gmail.com
- Jaap Akkerhuis at Stanford is responsible for the SuperSID software and SARA has provided financial support for his efforts
- SuperSID website hosted by Stanford: http://solar-center.stanford.edu/SID/sidmonitor/
- SuperSID database: http://sid.stanford.edu/database-browser/
- The data is searchable by time, station, date, and multiple plots may be placed on the same graph for comparison.



Algeria - 2	Denmark - 3	Mexico - 21	Slovenia - 2
Antarctica -1	Egypt - 3	Mongolia - 10	South Africa - 8
Australia - 7	Ethiopia - 14	Mozambique - 2	Spain - 1
Austria - 3	France - 9	Namibia - 1	Sri Lanka - 1
Azerbaijan - 2	Gabon - 1	Netherlands - 5	Sweden - 3
Bangladesh - 1	Germany - 30	New Zealand - 7	Switzerland - 4
Bhutan - 1	Greece - 7	Nigeria - 57	Taiwan - 4
Bolivia - 1	Guyana - 1	Pakistan - 4	Thailand - 5
Bosnia-Herzegovina - 2	Hungary - 1	Peru - 10	Tunisia - 9
Brazil - 11	India - 33	Philippines - 3	Turkey - 2
British Virgin Islands - 1	Indonesia - 2	Poland - 2	Uganda - 5
Bulgaria - 2	Iran - 4	Portugal - 3	UK - 32
Burkino Faso - 1	Iraq - 1	Rep of Congo - 3	Uruguay - 9
Canada - 33	Ireland - 9	Romania - 4	US Virgin Islands - 2
Chile - 1	Italy - 42	Russia - 3	USA - 491
China - 38	Kenya - 23	Rwanda - 1	Uzbekistan - 2
Columbia - 9	Korea (South) - 2	S Africa - 4	Venezuela - 2
Croatia - 7	Lebanon - 11	Senegal - 1	Vietnam - 1
Cypress - 1	Libya - 1	Serbia - 1	Zambia - 2
Czech Republic - 1	Malaysia - 19	Singapore - 3	
D Rep of Congo - 4	Malta - 1	Slovak Repub - 2	

SID Monitor Distribution
1078 instruments
82 countries
7 continents

-

For official use only
Monitor assigned: ___________
Site name: _________________
Country: ___________________

SuperSID Space Weather Monitor

Request Form

	Your information here		
Name of site/school *(if an institution)*:			
Choose a site name: *(3-6 characters) No Spaces*			
Primary contact person:			
Email:			
Phone(s):			
Primary Address:	Name School or Business Street Street City State/Province Country Postal Code		
Shipping address, if different:	Name School or Business Street Street City State/Province Country Postal Code		
Shipping phone number:			
Latitude & longitude of site:	Latitude: ______________________________ Longitude: _____________________________		

I understand that neither Stanford nor the Society of Amateur Radio Astronomers is responsible for accidents or injuries related to monitor use. I will assure that a surge protector and other lightning protection devices are installed if necessary.

Signature: ____ **Date: ______________________________**

I will need:

What	*Cost*	*How many?*
SuperSID distribution USB Power	$48 (assembled)	
USB Sound card 96 kHz sample rate *(or provide this yourself)*	$40 *(optional)*	
Antenna wire (120 meters) *(or you can provide this yourself)*	$23 *(optional)* with connectors *attached and tested*	
RG 58 Coax Cable (9 meters) *(or provide this yourself)*	$14 *(optional)* with connectors *attached and tested*	
Shipping	US $12 Canada & Mexico $40 all other $60	
	TOTAL	$

____ **I have included a $_____________ check** (payable to SARA)

____ **I will make payment thru** www.paypal.com to treas@radio-astronomy.org

or

____ If you are a Minority-serving institution, in a Developing or economically deprived nation, and/or you are using the monitor with students for educational purposes, you may qualify for obtaining a monitor at reduced or no cost. Check here if you wish to apply for this designation. Then tell us how you want to use the SuperSID monitor. Include type of site, number of students involved, whether public or private school, grade levels, etc. and describe your program. The goal of the SuperSID project is to provide as many students with systems as possible. If you are able to pay for a system, even if you qualify for a free one, please do so and help support our goal.

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____

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For more details on the Space Weather Monitor project, see: **http://sid.stanford.edu**

To set up a SuperSID monitor you will need:

1 Access to power and an antenna location that is relatively free of electric interference (could be indoors or out)

2 A **PC**** with the following minimal specifications:

   a. A sound card that can record (sample) up to 96 kHz, or a USB port to connect such a sound card (for North and South America)
      i. All other countries can use AC97 sound card with 48 kHz record (sample) rate. Most computers made after 1997 will have AC97.
   b. Windows 2000 or more recent operating system
   c. 1 GHz Processer with 128 mb RAM
   d. Ethernet connection & internet browser (desirable, but not required)
   e. Standard keyboard, mouse, monitor, etc.

3 An inexpensive antenna that you build yourself. You'll need about 120 meters (400 feet) of **insulated** wire. Solid wire is easier to wind than stranded. Magnet wire will work but be more fragile. You can use anything from #18 to #26 size wire. The antenna frame can be made of wood, PVC pipe, or similar materials. We'll provide instructions. You can purchase the wire from us or obtain your own.

4 RG58 coax cable with a BNC connector at one end to run from the antenna to the SuperSID receiver. 9 meters is recommended, but the length will depend on where you place the antenna. You can purchase the coax from us or obtain your own.

5 Surge protector and other protection against a lightning strike

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Return this form to: SuperSID@radio-astronomy.org
or mail to: SARA
Brian O'Rourke, SARA Treasurer
337 Meadow Ridge Rd,
Troy, VA 22974-3256

Announcing Radio JOVE 2.0

The Radio JOVE Team

Radio JOVE students and amateur scientists from around the world observe and analyze natural radio emissions of Jupiter, the Sun, and our galaxy using their own easy to construct radio telescopes.

Our Project announces Radio JOVE 2.0, where participants assemble a 16-24 MHz radio spectrograph to observe solar, Jupiter, Galactic, and Earth-based natural radio emissions and share their observations with fellow participants.

In the Beginning

Radio JOVE started as a NASA sponsored educational outreach project in 1999. We developed a radio telescope kit suitable for receiving signals from Jupiter, the Sun, the Galaxy, and Earth-based radio emissions. The original kit comprised a radio receiver (RJ1.1) and a dual dipole antenna for 20.1 MHz. An important goal was to teach electronic principles including how to build, solder, and assemble the radio receiver and antenna.

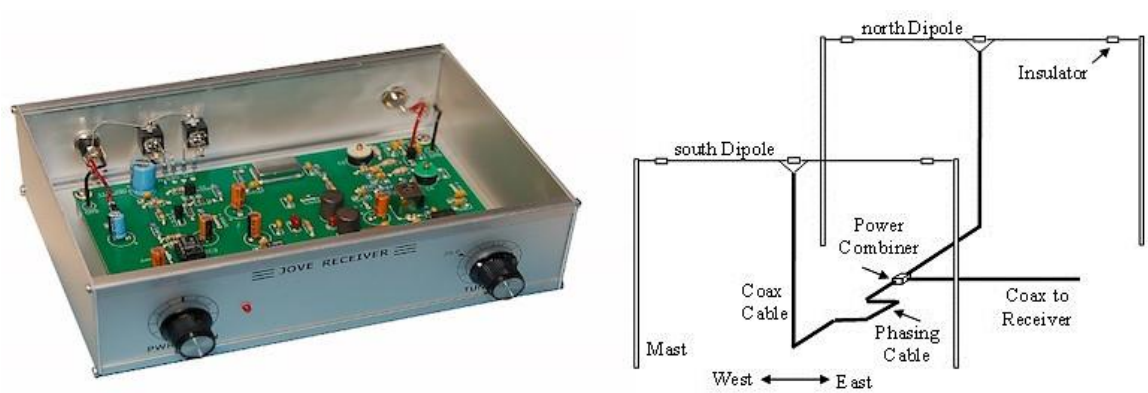

Figure 1. A Radio JOVE RJ1.1 receiver and a schematic of the dual-dipole antenna.

In addition to the hardware, three software packages were developed. These were Radio Jupiter Pro (Jupiter emission prediction program), Radio-SkyPipe (strip chart program) and Radio Sky Spectrograph (control and display of radio spectrograph data).

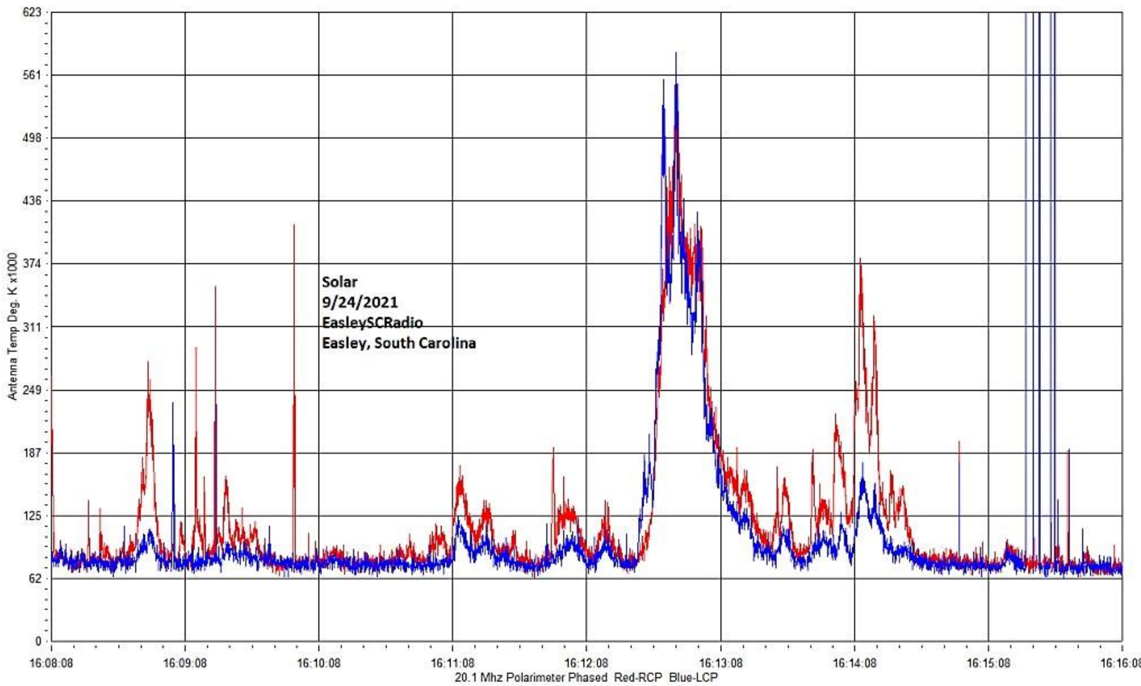

Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver. John Cox, SC.

The Growth of Radio JOVE

As of Autumn 2021, over 2,500 kits have been sold at cost to schools and individuals around the world. Thousands of data submissions from observers have been made to the Radio JOVE data archive.

The Radio JOVE web site has always provided a wealth of information describing observation methods and various educational materials intended to teach radio astronomy techniques and scientific methods. Biannual newsletters are produced and several telephone help sessions are held each year.

A sub-group of experienced observers known as the Spectrograph Users Group (SUG) evolved from the core JOVE group. These observers developed data collection and analysis techniques using more advanced equipment and techniques. SUG members have contributed to articles published in peer-reviewed scientific journals. This group remains active under the Radio JOVE listserv at https://groups.io/g/radio-jove/.

Moving Forward with New Technology

In the past, Radio JOVE provided the hands-on experience of building a radio kit. We have many RJ1.1 receivers in operation successfully contributing scientifically valuable data. It has, however, become increasingly difficult to obtain parts for the RJ1.1 receiver kits and we therefore decided to replace the RJ1.1 receiver with a new SDR-based design for the receiver portion of our radio telescope kits. While we continue to support the hardware and software for the original RJ1.1 receivers, the only kits now available for purchase from Radio JOVE contain this newly designed system.

In recent years, new technologies have made software defined radios (SDRs) ever more affordable. These radios can operate on a single frequency like the original JOVE receiver but can also generate spectrograms which depict radio activity as a function of both time and frequency. Such displays offer new insights into our studies of the Sun, Jupiter, the Galaxy, and both natural and artificial Earth-based radio emissions.

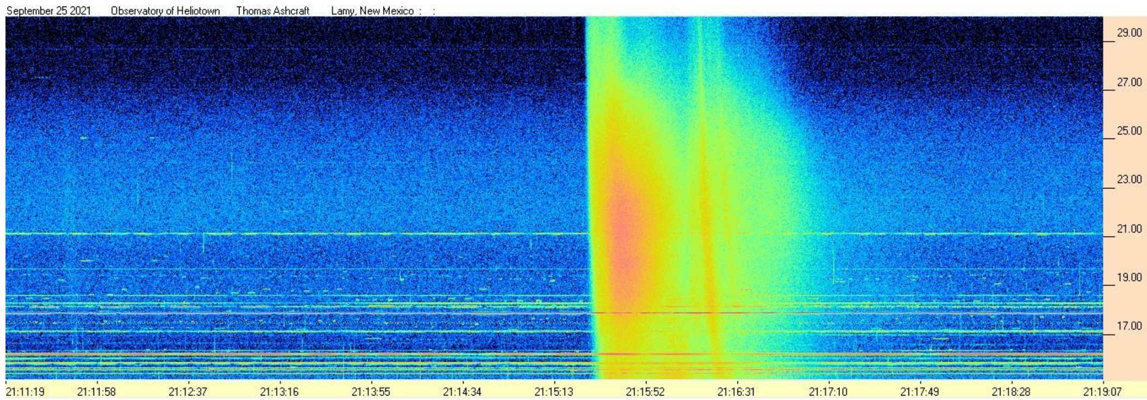

Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

Radio JOVE continues to sell radio telescope packages including an antenna, receiver, and software; however, the receiver is now a commercially built SDR.

Figure 4. The JOVE team has had considerable success with the SDRPlay RSP1A unit and will provide support for using this instrument for our radio astronomy program. Not all SDR types can be supported, but it is our intent to provide support for some other SDRs as they become available during this period of rapid SDR development.

It continues to be our goal to introduce new observers to the scientific method and help them experience the thrill of receiving cosmic radio signals. Through a series of educational training modules and observing and analysis projects we aim to guide new observers to levels where they can contribute to Citizen Science projects.

We continue to support our large user base that uses JOVE RJ1.1 receivers – both in terms of technical support for the receivers but also with new and exciting observing projects for both RJ1.1 and SDR users.

We welcome both new and experienced observers to the JOVE 2.0 program as we share the excitement of receiving, studying, and understanding radio signals from our corner of the galaxy.

Please see the Radio JOVE web site at https://radiojove.gsfc.nasa.gov for more information.

RADIO JOVE 2.0 RADIO TELESCOPE KIT ORDER FORM

Order Online using PayPal™

* * * Please allow 2 to 3 weeks for delivery. * * *

IMPORTANT: Before you order the Jove receiver kit and/or the antenna kit, we suggest that you read the on-line manuals. You will need to provide additional materials and tools to complete the antenna. The cost of additional materials for the antenna support structure (masts, etc.) may be in the range of US$75 to US$100. Also note that the optimal antenna height can be up to 20ft, depending upon your latitude.

Item # RJK2u – Complete 2.0 Kit: Receiver + Unbuilt Antenna Kit + Software This kit includes an SDRplay RSP1A, USB Cable, SMA/BNC cable, F-adapter, unbuilt Antenna Kit (RJA), printed assembly manuals, and Radio-Sky Spectrograph (RSS) software. Note: Kit does not include antenna support structure. **Price: $215 + Shipping (See reverse for shipping)**	**Item # RJK2p** – Complete 2.0 Kit: Receiver + Professionally Built Antenna Kit + Software This kit includes an SDRplay RSP1A, USB Cable, SMA/BNC cable, F-adapter, Professionally Built Antenna Kit (RJA2), printed assembly manuals, and Radio-Sky Spectrograph (RSS) software. Note: Kit does not include antenna support structure. **Price: $384 + Shipping (See reverse for shipping)**
Item # RJA – Unbuilt Antenna Kit The RJA Radio JOVE Antenna Kit includes a printed construction manual, stranded copper easy-to-solder antenna wire, ceramic insulators, RG-59 easy-to-solder coax cable, screw-on Fconnectors, and a power combiner. Note: Kit does not include antenna support structure. Assembly requires a soldering gun and other tools. **Price: $90 + Shipping (See reverse for shipping)**	**Item # RJA2** – Professionally Built Antenna Kit The RJA2 Radio JOVE Antenna Kit includes a printed installation manual, two professionally assembled dipole antennas constructed of #14 Copperweld wire with Budwig center insulators and center support rope attachment points, high quality RG-6 coax with pre-installed commercial grade connectors, and a power combiner. Note: Kit does not include antenna support structure. **Price: $249 + Shipping (See reverse for shipping)**
Item # LTJ2 – Listening to Jupiter, 2nd Ed. by R. S. Flagg PDF download of Richard Flagg's book "Listening to Jupiter, 2nd Ed., 2005". The file is downloaded from a secure website. **Price: $10 + $0 shipping (PDF file download)**	**Item # RJR2** – Radio JOVE 2.0 Receiver-Only Kit This kit includes one SDRplay RSP1A SDR receiver, USB Cable, SMA/BNC cable, and F-adapter, printed assembly manuals, and Radio-Sky Spectrograph (RSS) software. **Price: $135 + Shipping (See reverse for shipping)**

RADIO JOVE 2.0 RADIO TELESCOPE KIT ORDER FORM (continued)

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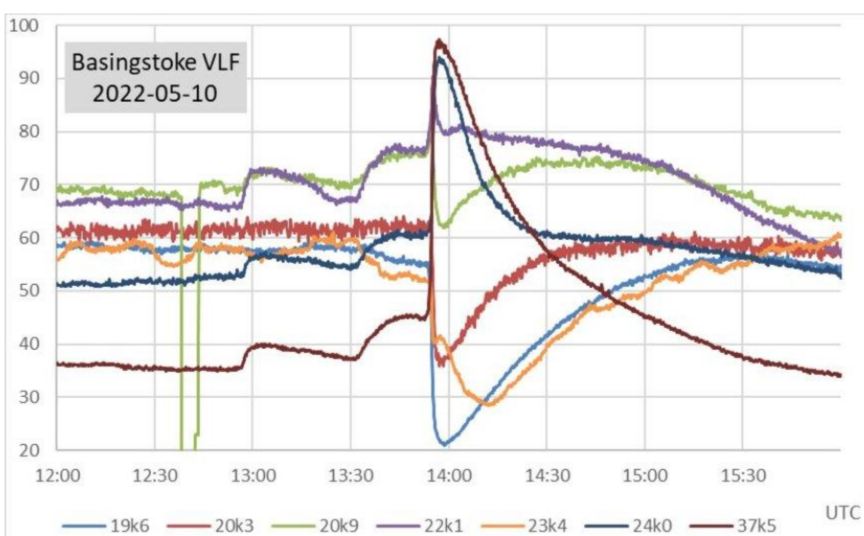
John Cook's VLF Report

BAA Radio Astronomy Section, Director: Paul Hearn

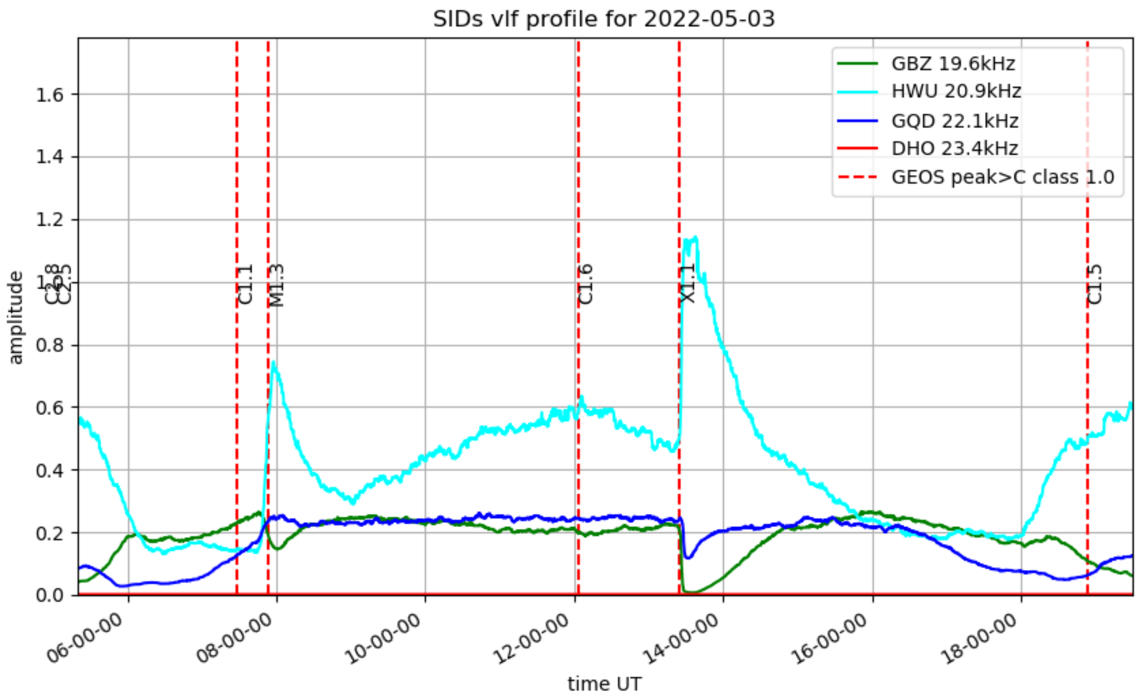
RADIO SKY NEWS **2022 MAY**

VLF SID OBSERVATIONS

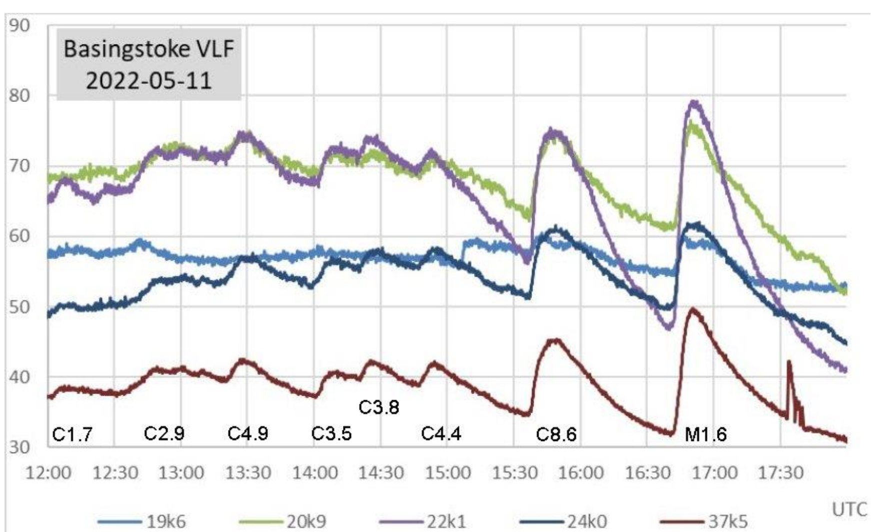
Flare activity in May has exceeded that in April, with 148 events listed in the timing table. There have been plenty of more energetic flares, with two of X-class recorded. Many of these events have been multiple-peaked, making analysis rather tricky. I have included the X-ray magnitudes where they are shown in the SWPC listings. The background X-ray flux has also been fairly high at times, making SIDs from some of the C-class flares hard to detect in the VLF recordings. There were two X-class flares well timed for us to record, both produced by active region AR13006. The second of these, on the 10th, was fairly complex to analyse. This recording by Paul Hyde shows the SIDs:



The main peak is clear at about 13:58UT, but is preceded by two smaller peaks, the second merging into the main peak. This matches well with the satellite X-ray plots that show a plateau at about the C5 level from 13:30, the X1.5 flare superimposed on top and decaying slowly afterwards.

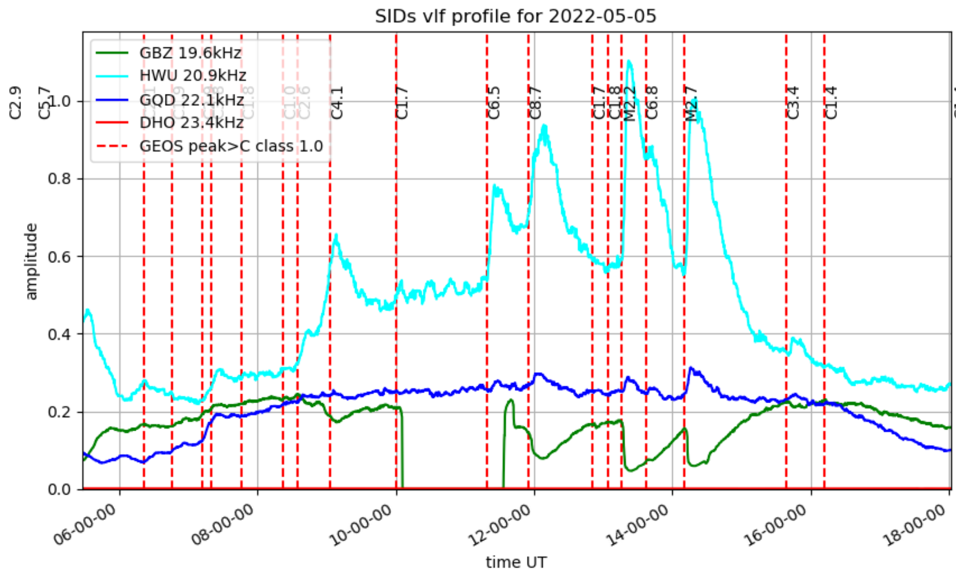


This recording by Mark Prescott shows the X1.1 flare on the 3rd. All of our SID timings show a peak around 13:30UT, in agreement with the charts of X-ray data found on the internet. The SWPC bulletin lists the flare as peaking at 13:08, ending at 13:13, which is rather a puzzle.

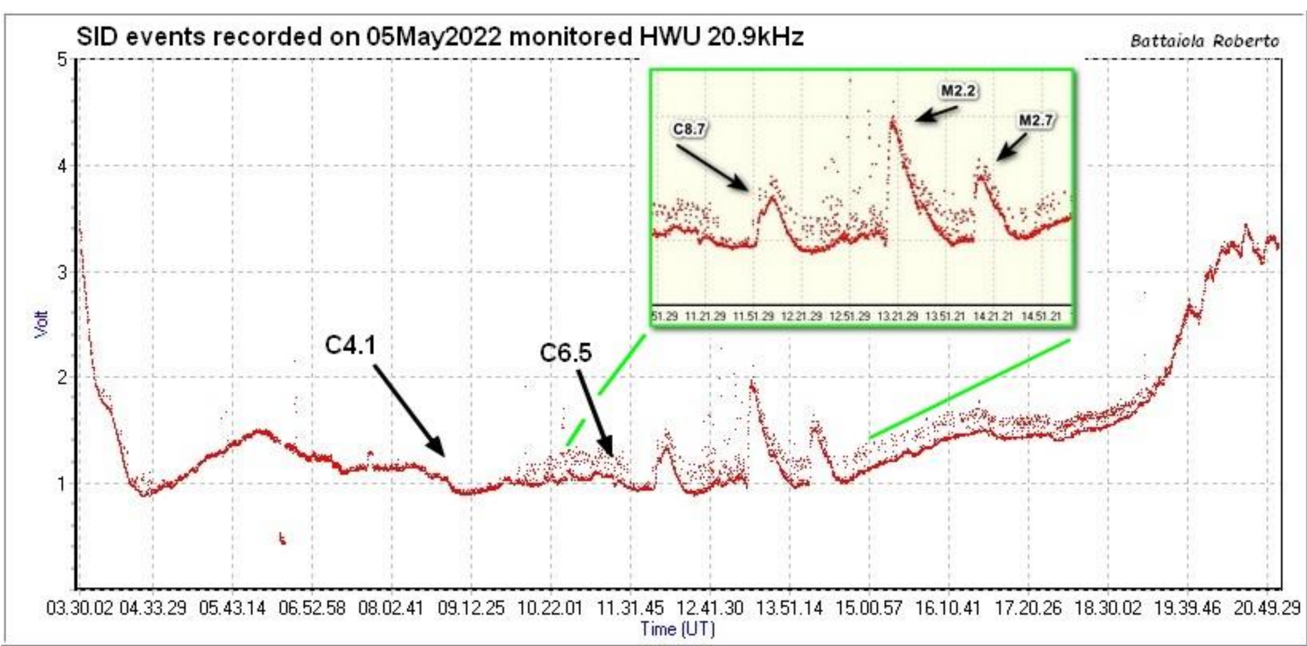


This chart by Paul Hyde shows some of the 14 SIDs recorded on the 11th, with a nearly continuous stream of C-class flares. The final M2.2 flare at 18:45UT is not shown, but this was unusual in having a flat peak lasting for about an hour.

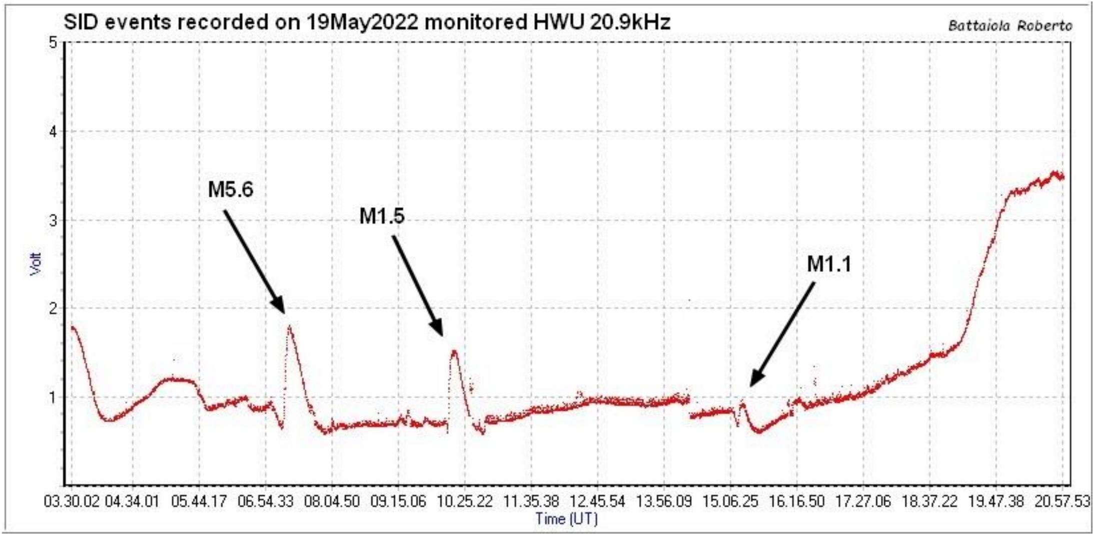
May 5th was also very busy with flares, shown here in the recording by Mark Prescott:



23.4kHz was off-air at the time, as it was for several days. 19.6kHz also shows a large break from about 10UT. 20.9kHz shows the best SIDs, although the smaller flares have been lost under the larger ones. Roberto Battaiola also recorded 20.9kHz, although with a fairly noisy signal:

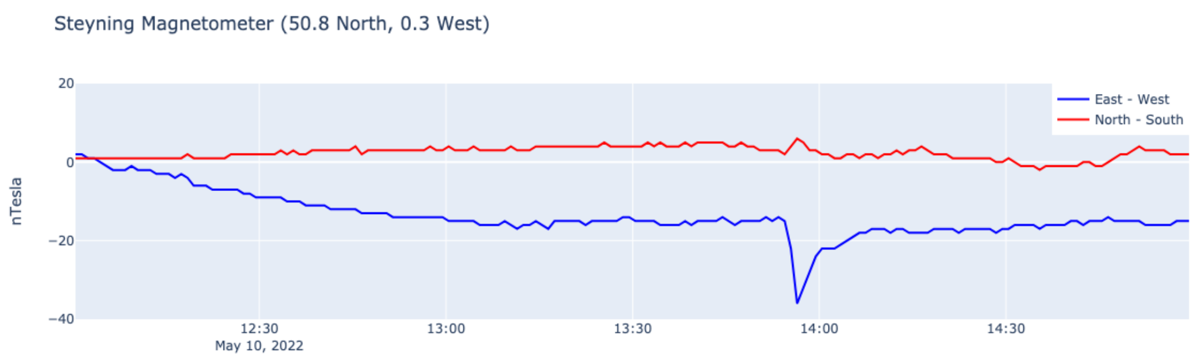


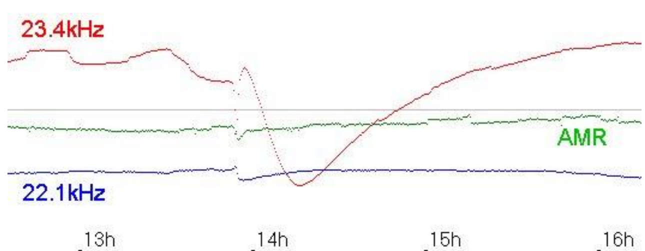
Solar activity dropped towards the end of May, the background X-ray flux falling back to B-levels. There were still a few stronger flares though, and Roberto Battaiola recorded the three M-class flares on the 19th, shown on the next page. The four SIDs shown in the timing tables between the M1.5 and M1.1 flares are listed in the SWPC bulletin, but without magnitude data.



MAGNETIC OBSERVATIONS

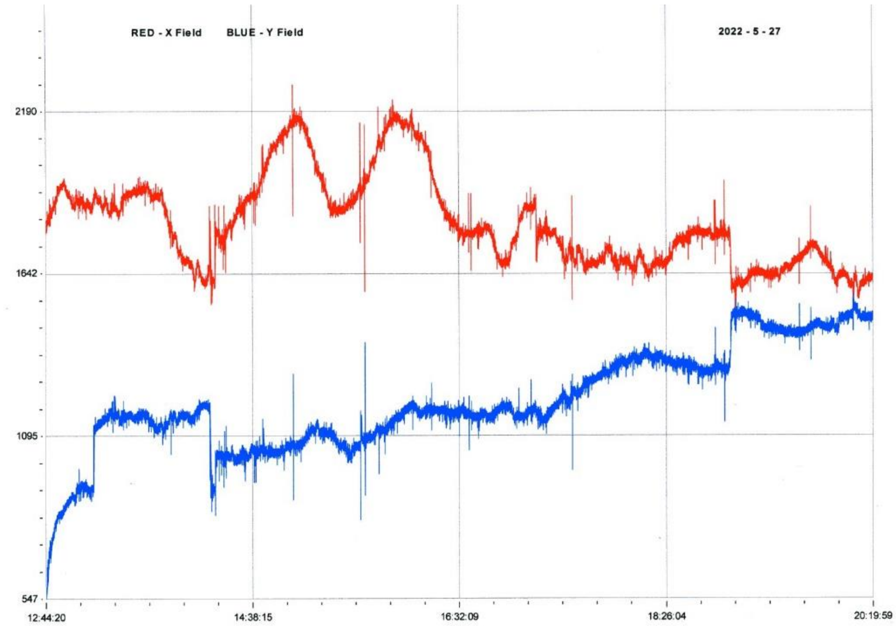
Magnetic activity in May was fairly mild, despite the large number of flares. Most of the disturbances were from enhancements in the solar wind. The X1.5 flare on the 10th did however produce a magnetic SFE, very clearly shown in the recording by Nick Quinn:

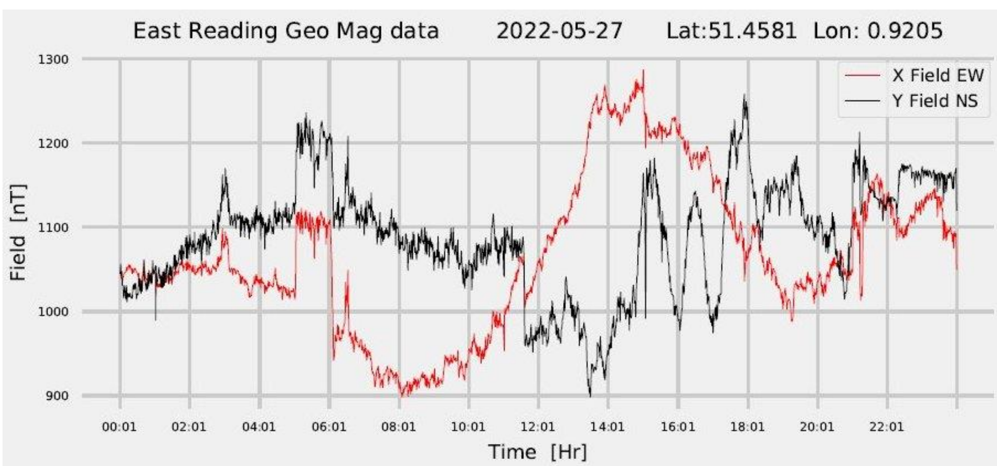


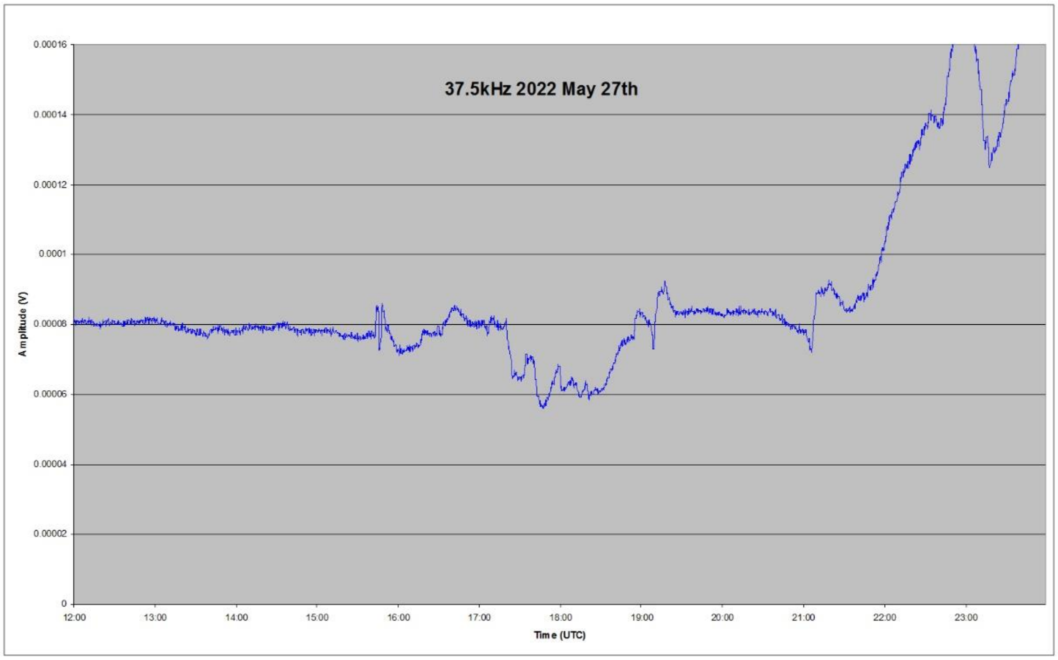


I have included the VLF signals on my own recording, showing the exact timing match of the flare with the SFE. The X1.1 flare on the 3rd did not produce an SFE. Neither flare produced Earth-directed CMEs.

Mark Edwards reported non-flare related disturbances to the 37.5kHz signal on the 27th and 31st. Magnetic conditions were fairly quiet on both occasions, although the 27th did show a mild disturbance. This did not show on any of our single-axis sensor magnetometers but does show on the dual-axis recordings by Nick Quinn, Paul Hearn and Colin Clements. Colin's recording is shown on the next page, followed by Paul's and Mark's 37.5kHz:





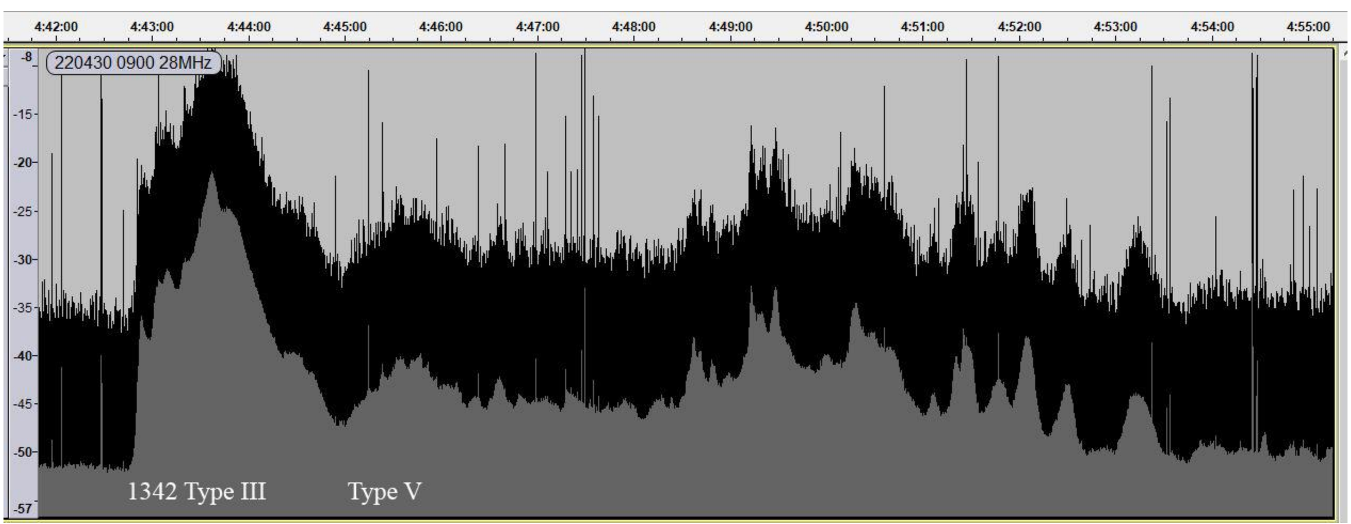


All of the other magnetic activity shown on the Bartels diagram was very mild.

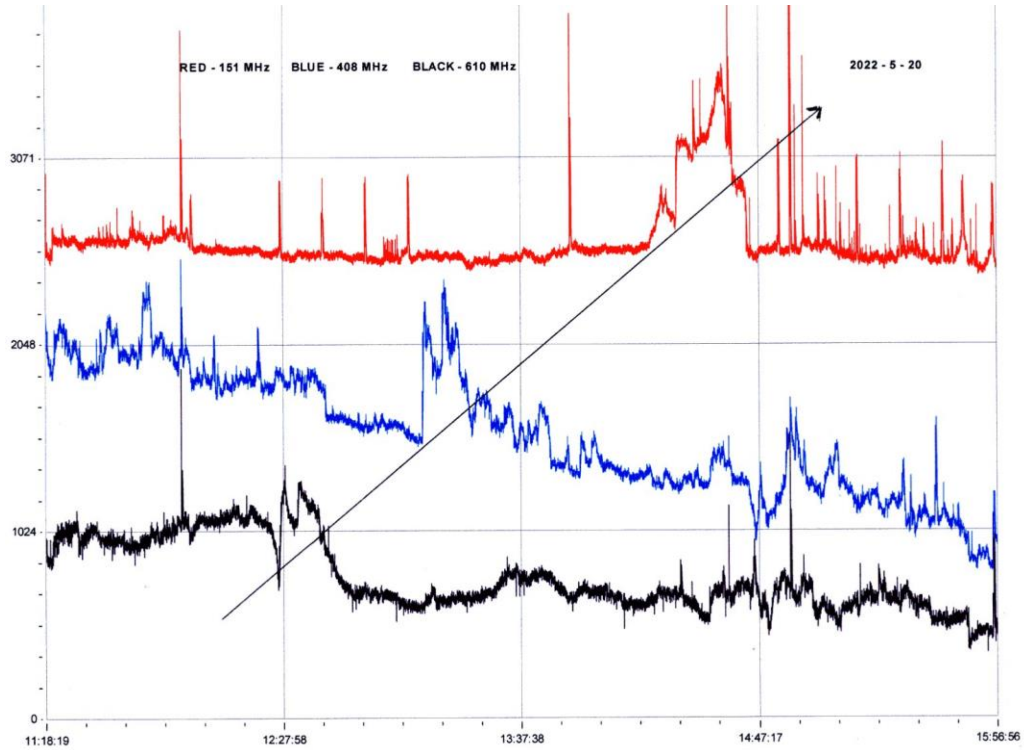
Magnetic observations received from Roger Blackwell, Colin Clements, Paul Hearn, Callum Potter, Nick Quinn and John cook.

SOLAR EMISSIONS

First, an apology for an error in last month's report. The wrong 28MHz recording for the April 30th X1.1 flare by Colin Briden was accidentally included. This is the correct version:

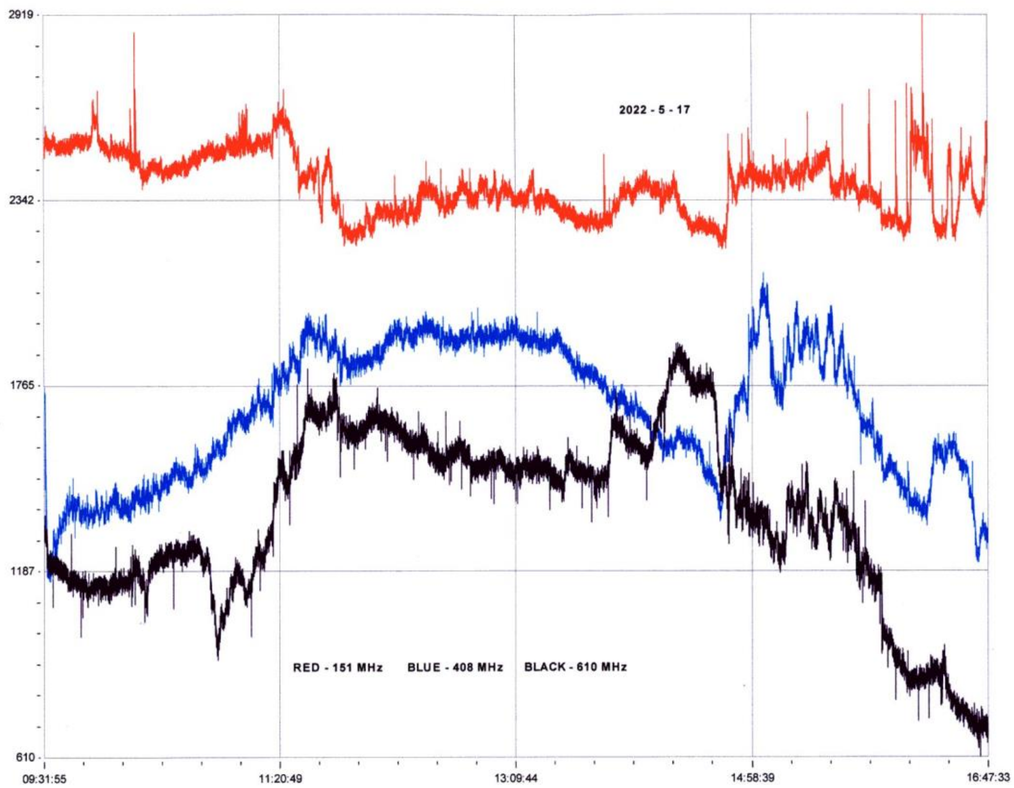


This shows much more activity appropraite for an X1.1 flare compared to the one included last time.



This chart by Colin Clements shows a feature that we have not previously recorded. The arrow shows a noise burst falling in frequency over time, known as a Slow Drift Continuum burst. Colin has done some research on this, and links it to the M3.0 flare at 07:55, produced by AR13014. This was a very complex sunspot group, the largest recorded so far in solar cycle 25.

Many of the larger flares did not seem to produce much in the way of VHF signals, but Colin did record effects from the series of smaller flares on the 17th.



A rise at 610MHz (black) and 408MHz (blue) starts around the time of the C3.0 flare, along with a small rise at 151MHz (red). 151MHz then seems to fall away again, almost the inverse of the 610MHz pattern. 610MHz and 408MHz fall in intensity again before the late afternoon C4.6 flare.

The M2.4 flare at 13:30 on the 16th produced a strong burst at 151MHz, with weaker bursts at 408MHz and 610MHz. The C3.1 flare on the 1st also produced small bursts at all three frequencies.

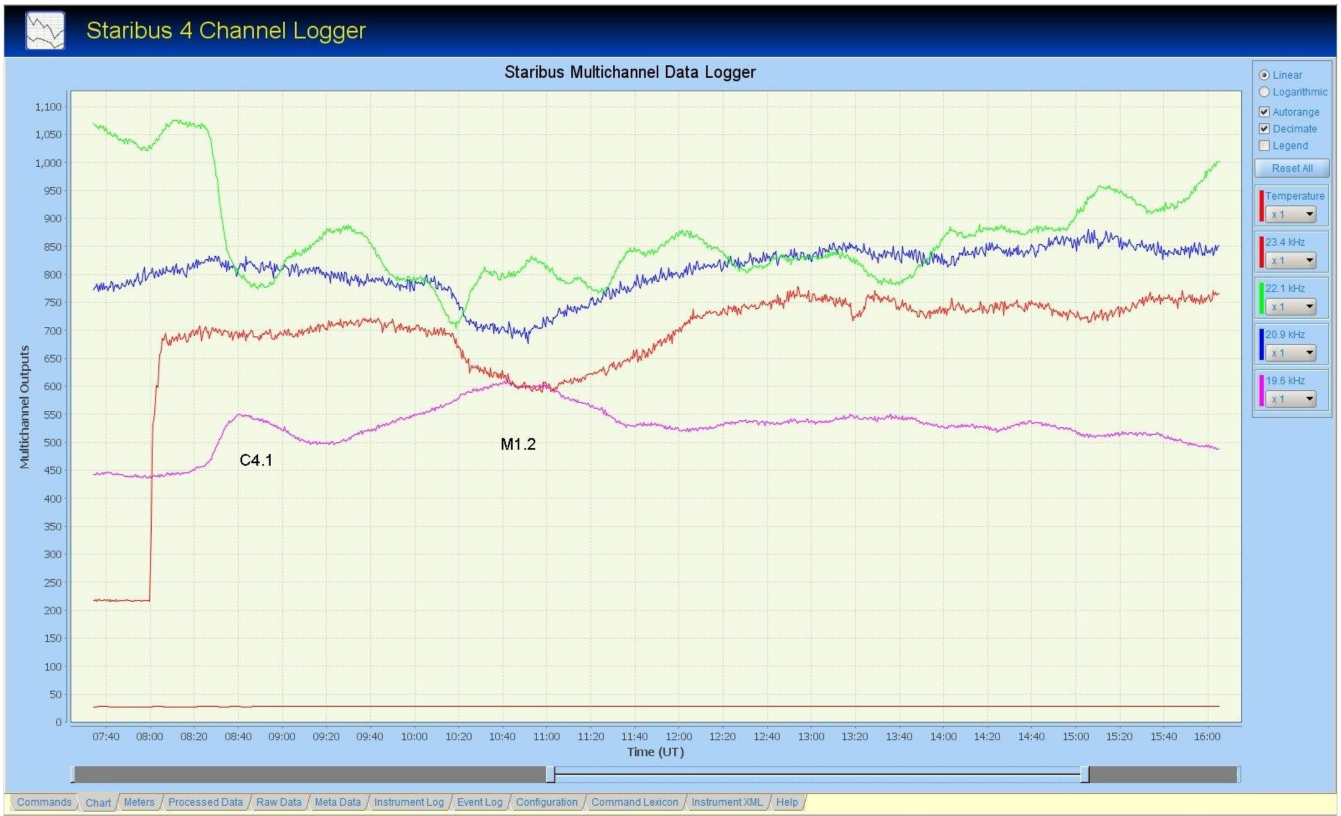
METEOR OBSERVATIONS

No meteor observations were reported in May. We do however now have a new beacon signal available in the UK for observers. GB3MBA is operating at 50.408MHz from Sherwood observatory, and has been organised by Brian Coleman, G4NNS. It is backed by both the RSGB and BAA. Further details can be found at ukmeteorbeacon.org/home. Our thanks go to Brian for organising this project.

RADIO SKY NEWS **2022 JUNE**

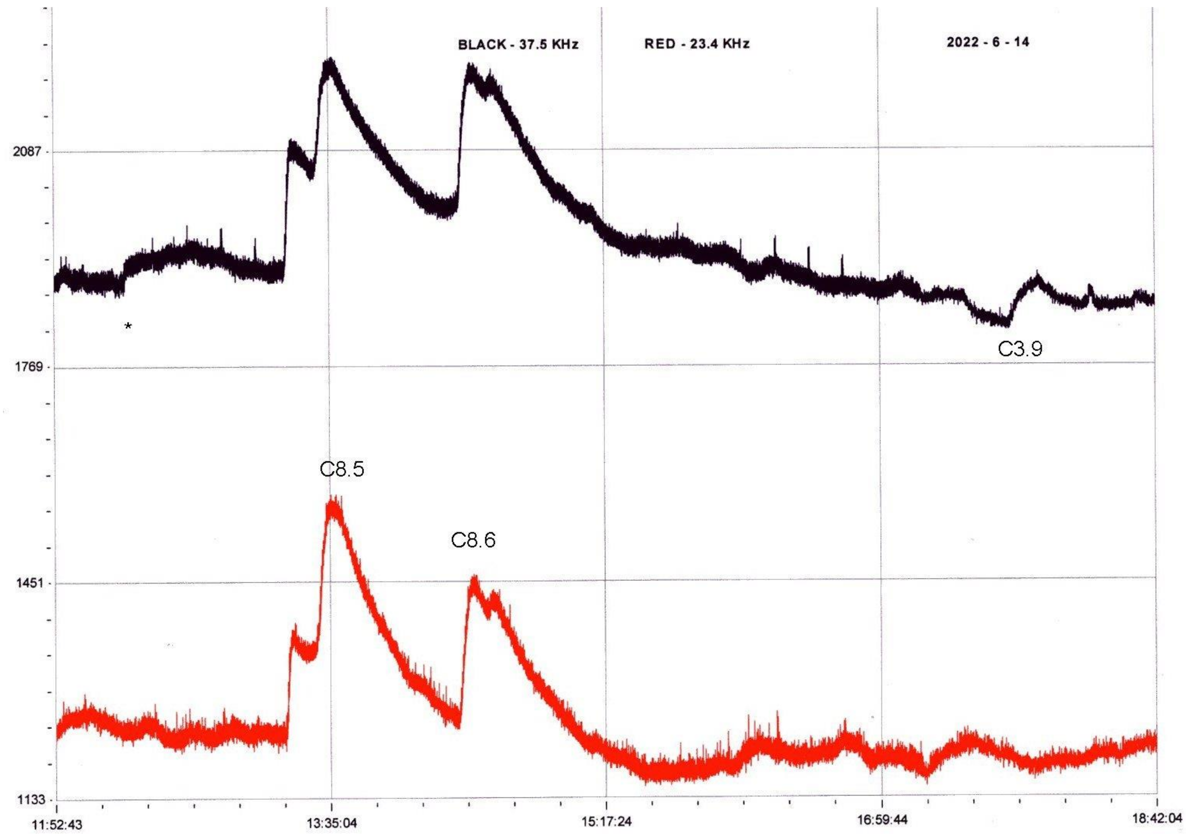
VLF SID OBSERVATIONS

Sunspot counts in June remained high, but flares were generally much weaker than in May. The background X-ray flux also remained high, so the majority of smaller C-class flares were not recorded as SIDs. There are just two M-class flares listed in the SWPC bulletins; an M3.4 peaking at 04:07UT on the 13th was too early for us record, but we did get some recordings of the M1.2 flare on the 10th. This was quite a slow event, and so the VLF effect was not very SID-like. This recording By Steve Parkinson shows the result:

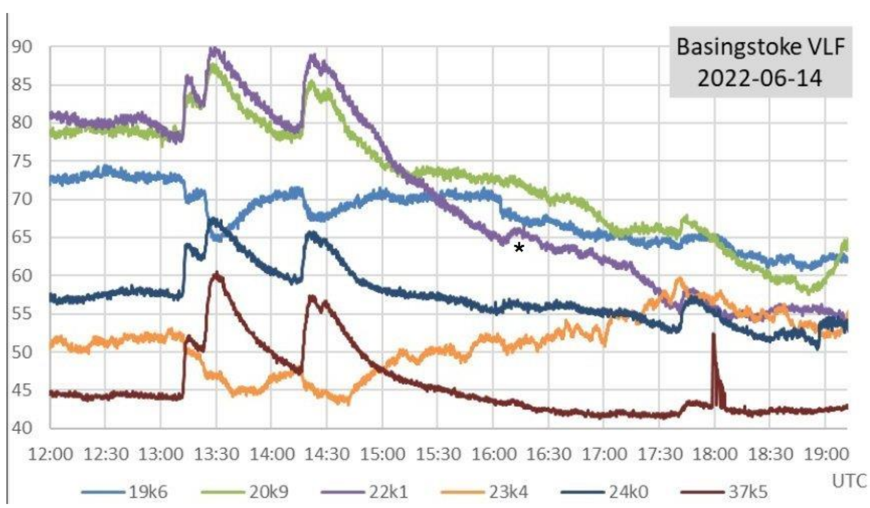


The pink trace is 19.6kHz, showing the M1.2 and C4.1 flares. Red is 23.4kHz, blue 20.9kHz and Green 22.1kHz. The timings are very tricky to determine, the tables showing a peak-time variation from 10:41to 11:02. The GOES X-ray flux is listed as start: 10:11, peak: 10:54, end: 11:14. Looking at the X-ray data, the flux still appears to be above C3 level at 12:00.

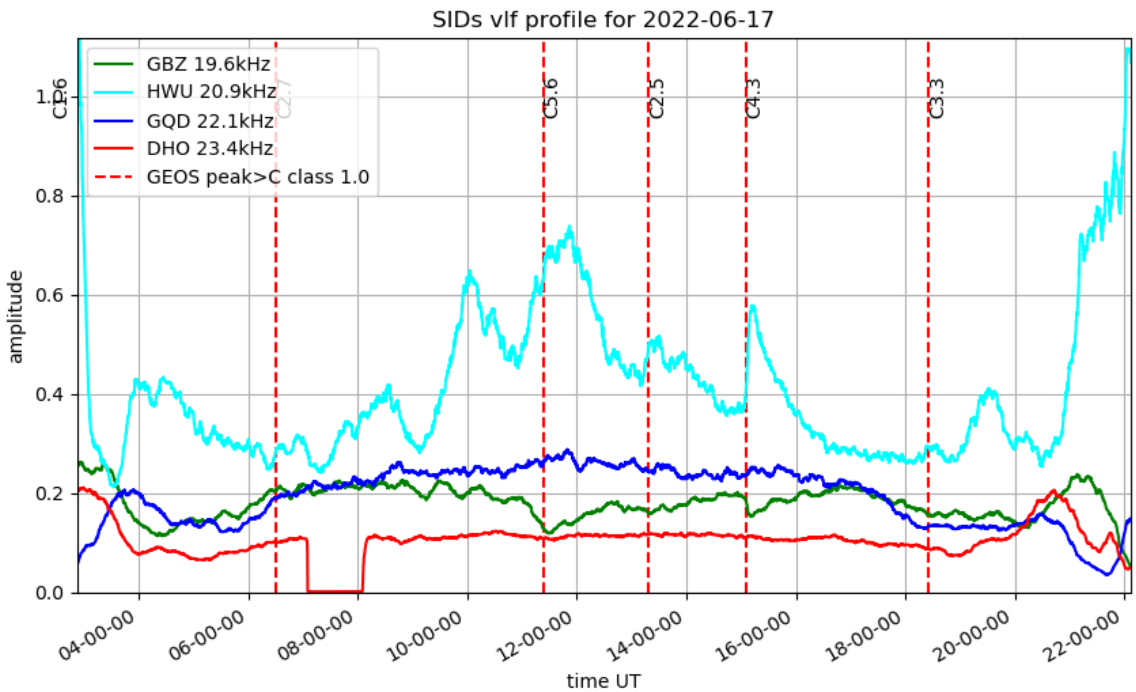
June 14th was very busy with flares, shown here by Colin Clements:



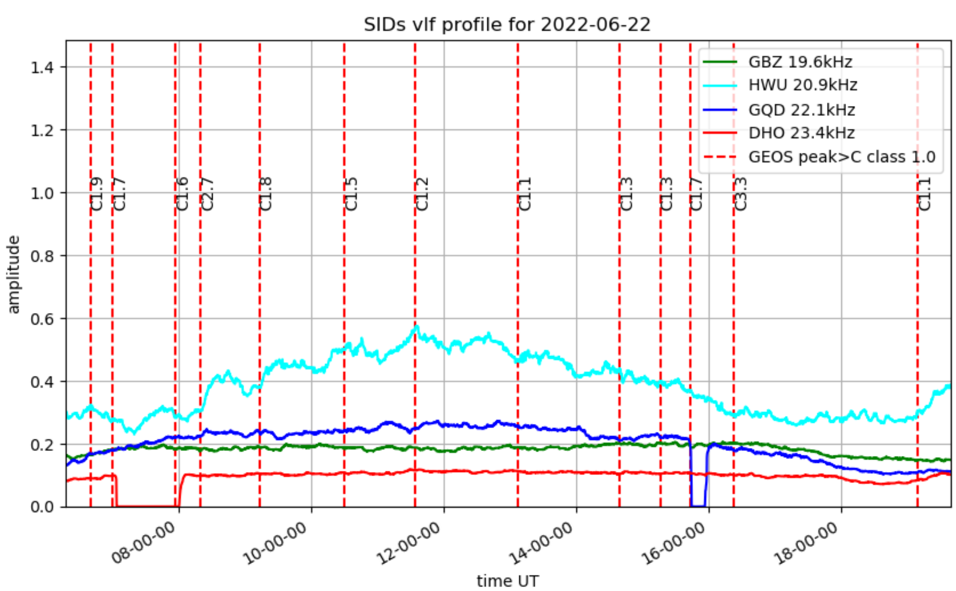
Both the C8.5 and C8.6 flares were double peaked, shown clearly at 23.4kHz and 37.5kHz. The 37.5kHz signal from Grindavik (top trace) also show evidence of the smaller unlisted flare at 12:38UT, indicated on the chart with a '*'.



This recording by Paul Hyde shows very similar SIDs, but also shows a small C1.3 flare at 16:13UT, again marked '*'. It is most clear in the 22.1kHz signal. The C3.9 flare at 17:50 is also visible on several of the signals.



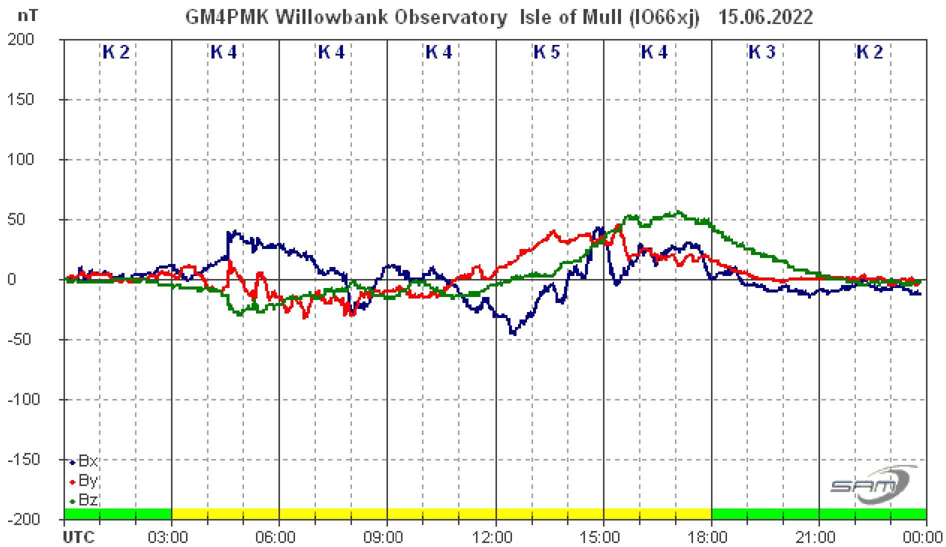
The 17th was also quite busy, shown here by Mark Prescott. 20.9kHz shows SIDs for most of the flares listed, while 23.4kHz has remained unaffected. There is also evidence of some non-solar noise on the 20.9kHz signal, with a strong rise in amplitude at 10:00 that has no X-ray counterpart. Mark's recording from the 22nd also shows some very noisy signals:



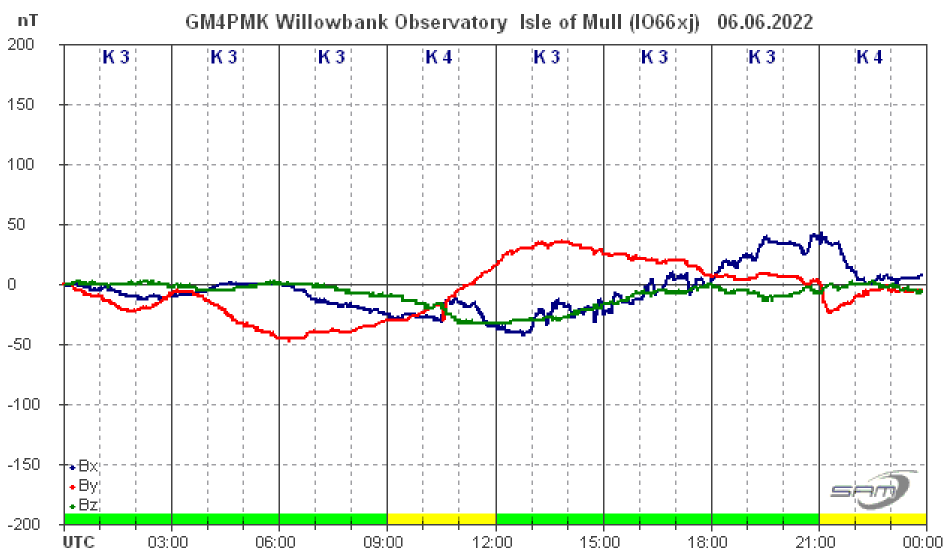
As noted at the start of this report, the high background X-ray flux made it tricky to record the smaller C-class flares. 20.9kHz here shows the problem well, with a very noisy signal and plenty of hidden flares. 23.4kHz has also remained flat throughout the day.

MAGNETIC OBSERVATIONS

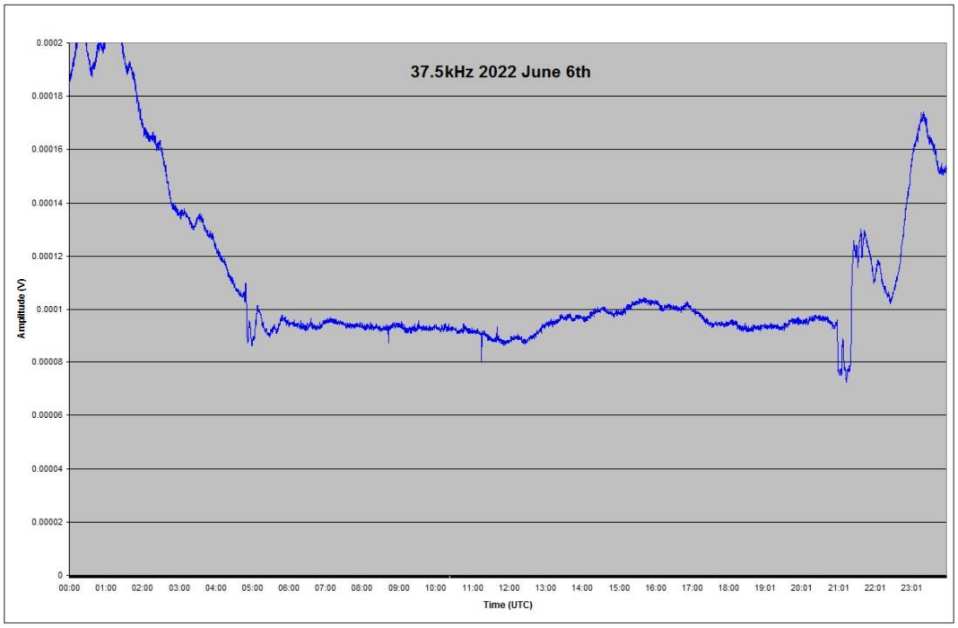
Most of the magnetic activity in June seems to have been from high speed winds, with only two CMEs that had Earth-directed components. The M3.4 flare early in the morning of the 13th did produce a CME, with fairly mild magnetic disturbances recorded on the 15th. Roger Blackwell's recording shows the disturbance during the day, along with what appears to be the arrival shock just after 04:30UT:



This was a very mild CME with only +/-50nT disturbance in the afternoon. It faded out in the evening and had very little effect into the following morning. A filament eruption on the 2nd also produced a CME that was geo-effective, arriving on the 6th.

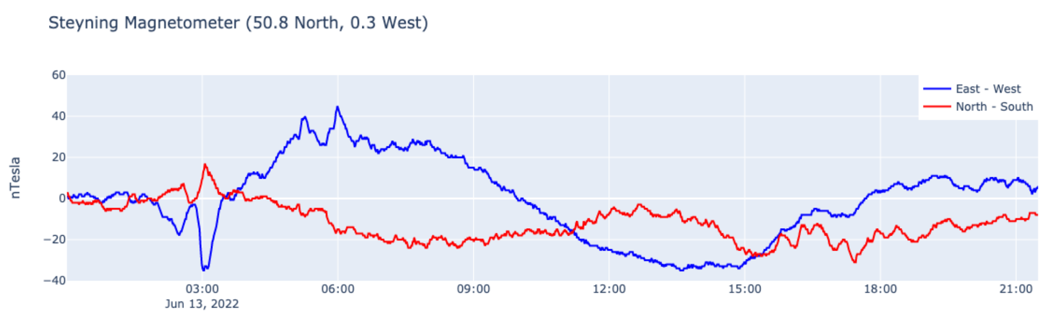


Roger Blackwell's recording shows that it had even less effect than the CME on the 15th. The sudden pulse in the Bx signal (blue) could mark its arrival at 10:30, the disturbance again fading out in the evening and with no disturbance in the morning of the 7th. The M1.2 flare recorded on the 10th does not appear to have produced a CME.

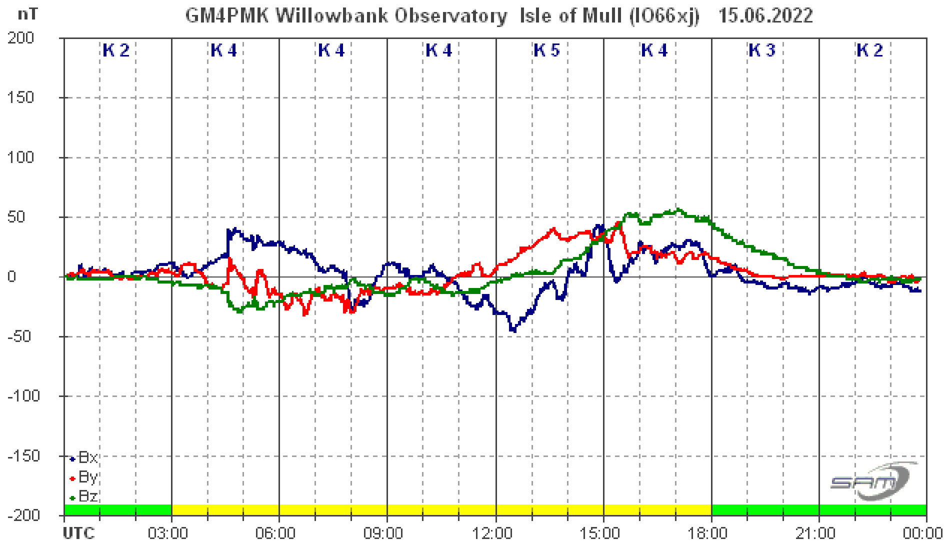


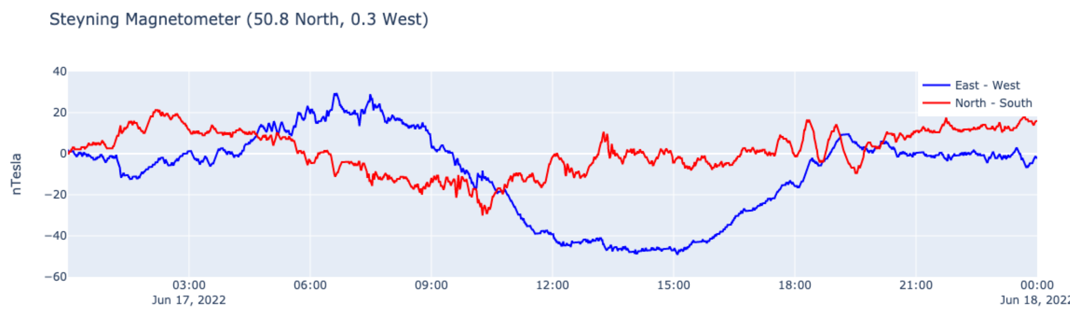
The CME could also be partly responsible for this disturbance to the 37.5kHz signal, recorded on June 6th by Mark Edwards. The early morning transient at 04:50 is well before the magnetic shock arrival but does match magnetic disturbances recorded in other parts of the world. The pulse just before sunset at 21:00 is much larger and matches the more widely recorded magnetic disturbances.

The remainder of the magnetic activity was from high-speed solar winds, this recording by Nick Quinn shows a fairly strong change in wind speed around 3AM on the 13th:

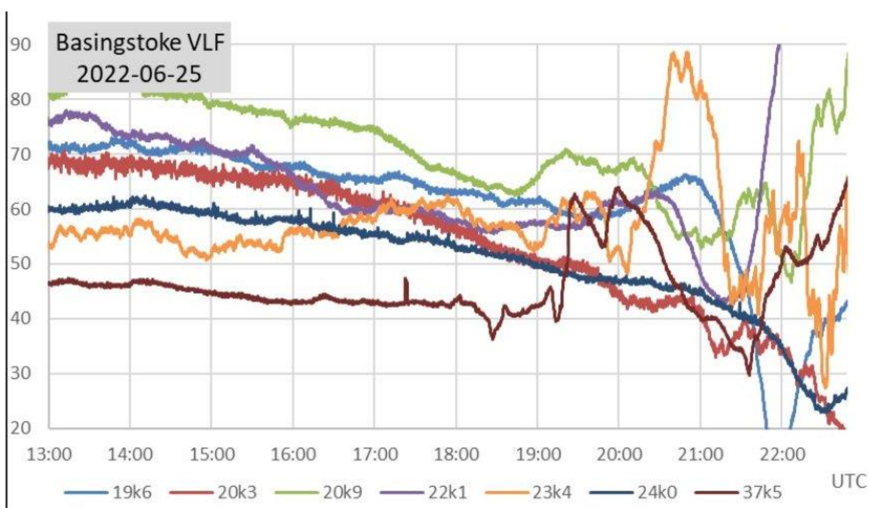


The initial transient is timed to match the M3.4 flare, but as this had very slow rise and fall times, it is unlikely to be an SFE. The following disturbance is rather mild at about +/- 40nT, but it did last for several days. The recording from the 15th is by Roger Blackwell, and the 17th by Nick Quinn:

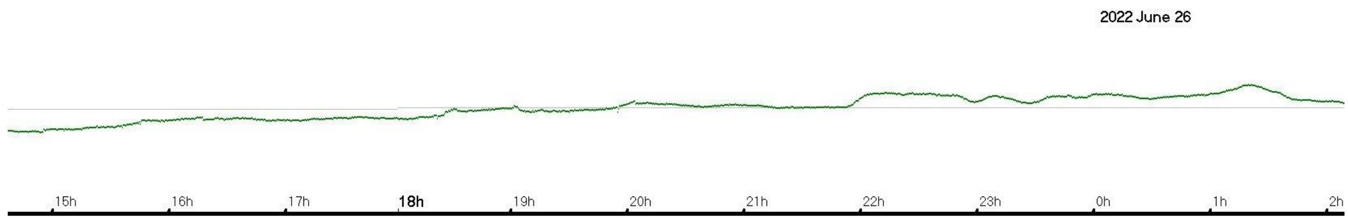




There will be some variation in intensity at these different locations, the isle of Mull and Steyning near the south coast, but +/- 50nT seems to be the maximum disturbance recorded.



This recording from Paul Hyde shows the VLF signals on the 25th. The European signals are all moving into the sunset by 19:00, the longer trans-Atlantic path at 24kHz stable for a few hours longer. Most notable is the disturbance in the 37.5kHz signal after 18:30 and leading into its local sunset. This appears to be due to the magnetic disturbance from the high speed solar wind, shown in my own recording:



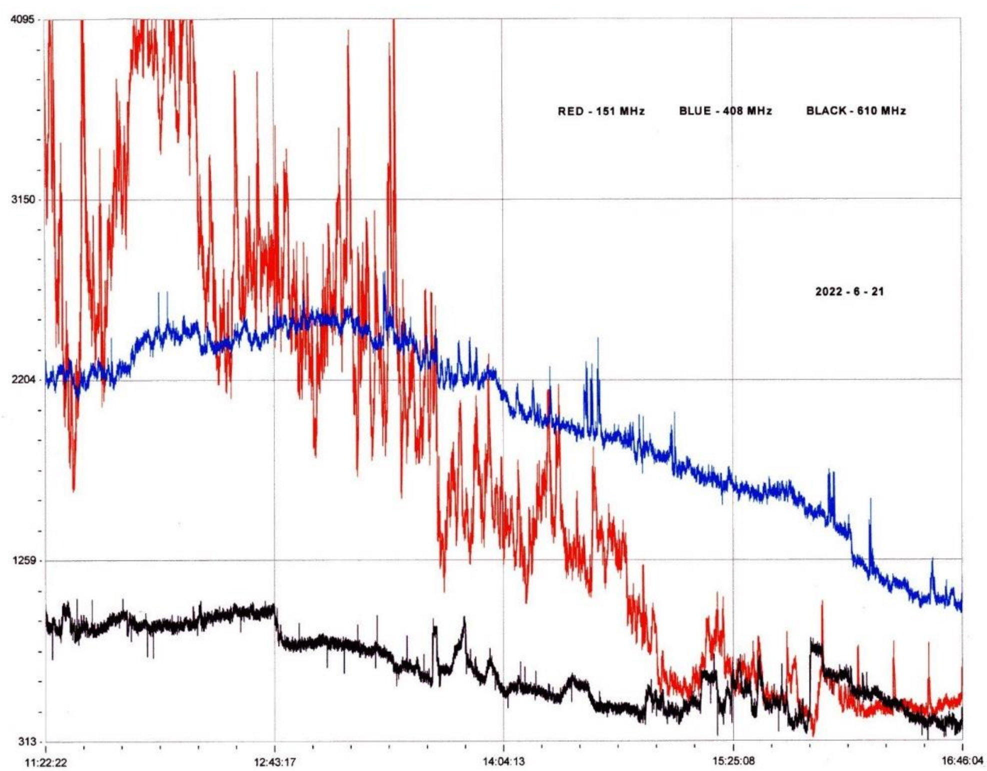
Luckily free from any local interference, a small disturbance can be seen from about 18:30 and lasting into the following morning. My single axis sensor tends to show smaller deviations compared to 2- and 3-axis sensors, with Colin Clements' and Roger Blackwell's recordings showing a stronger disturbance.

Magnetic observations received from Roger Blackwell, Colin Clements, Nick Quinn and John Cook.

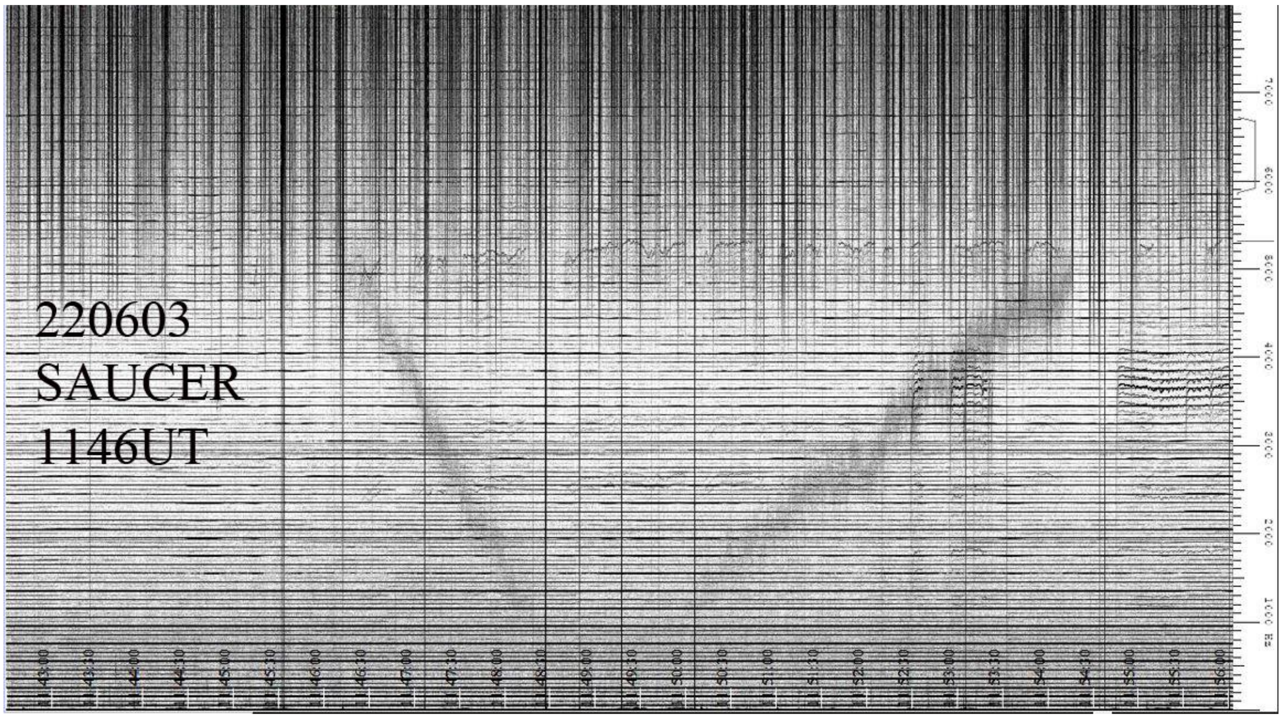
SOLAR EMISSIONS

Colin Clements did not record any significant VHF emissions following the M1.2 flare on the 10th, but did see some strong emissions from the flares on the 17th:

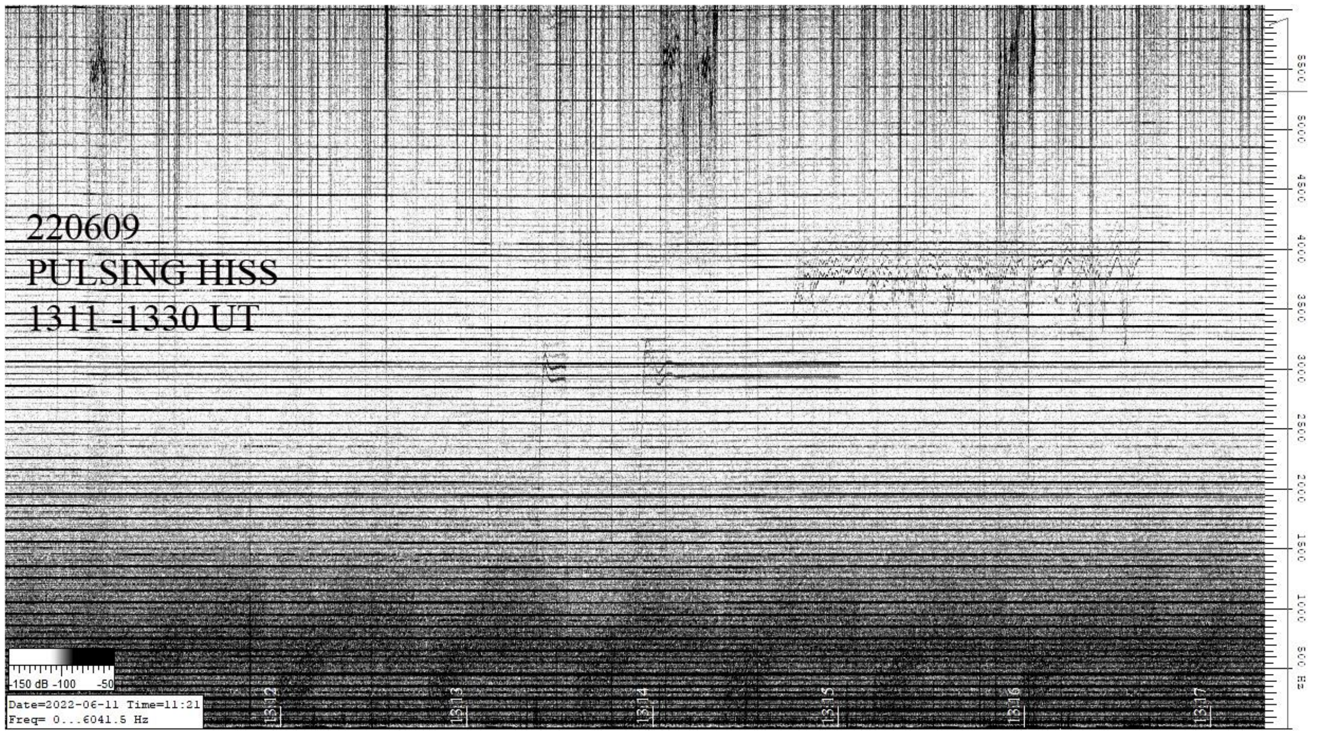
The 610MHz signal (black) shows a very strong signal during the first four flares. 408MHz (blue) is also quite strong, with a delayed signal at 151Mhz (red).



Colin's recording from the 21st is unusual, showing a very strong signal at 151MHz, with very little on the others. It does not match with our flare timings in the afternoon so may well be some interference, although it has not been seen before. Colin Briden has been recording again at VLF, seeing the usual chirps and hooks previously reported. In June he also recorded some less usual effects that are apparently associated with Aurora.



The time and frequency markings are unfortunately not very clear in the picture. Frequency runs vertically, 0Hz at the bottom and 8kHz at the top. Time runs horizontally. A darker V-shaped pattern (known as a saucer) can be seen across the centre, lasting from 11:46 to 11:54 on the 3rd, over 500Hz to 5kHz.

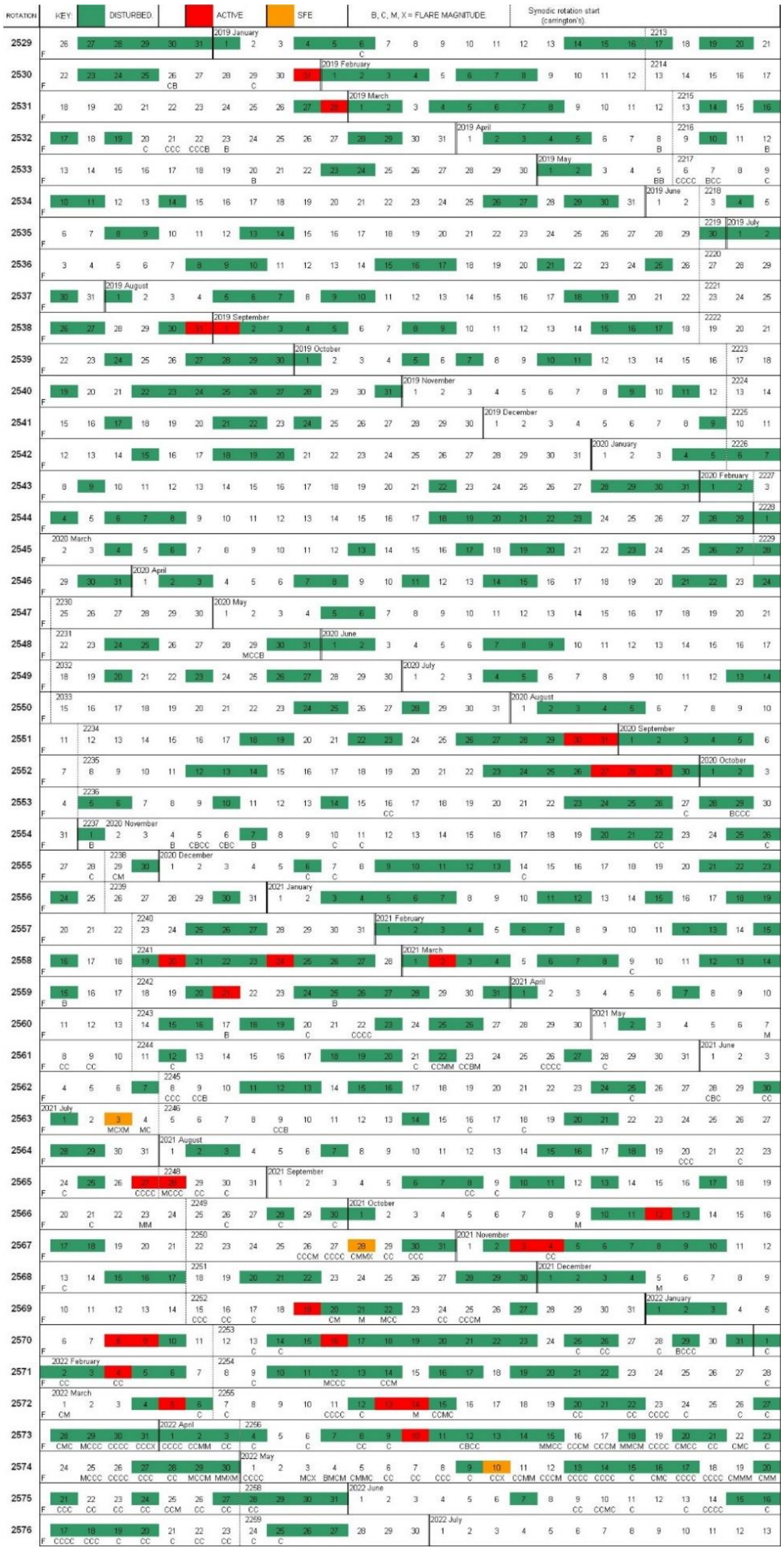


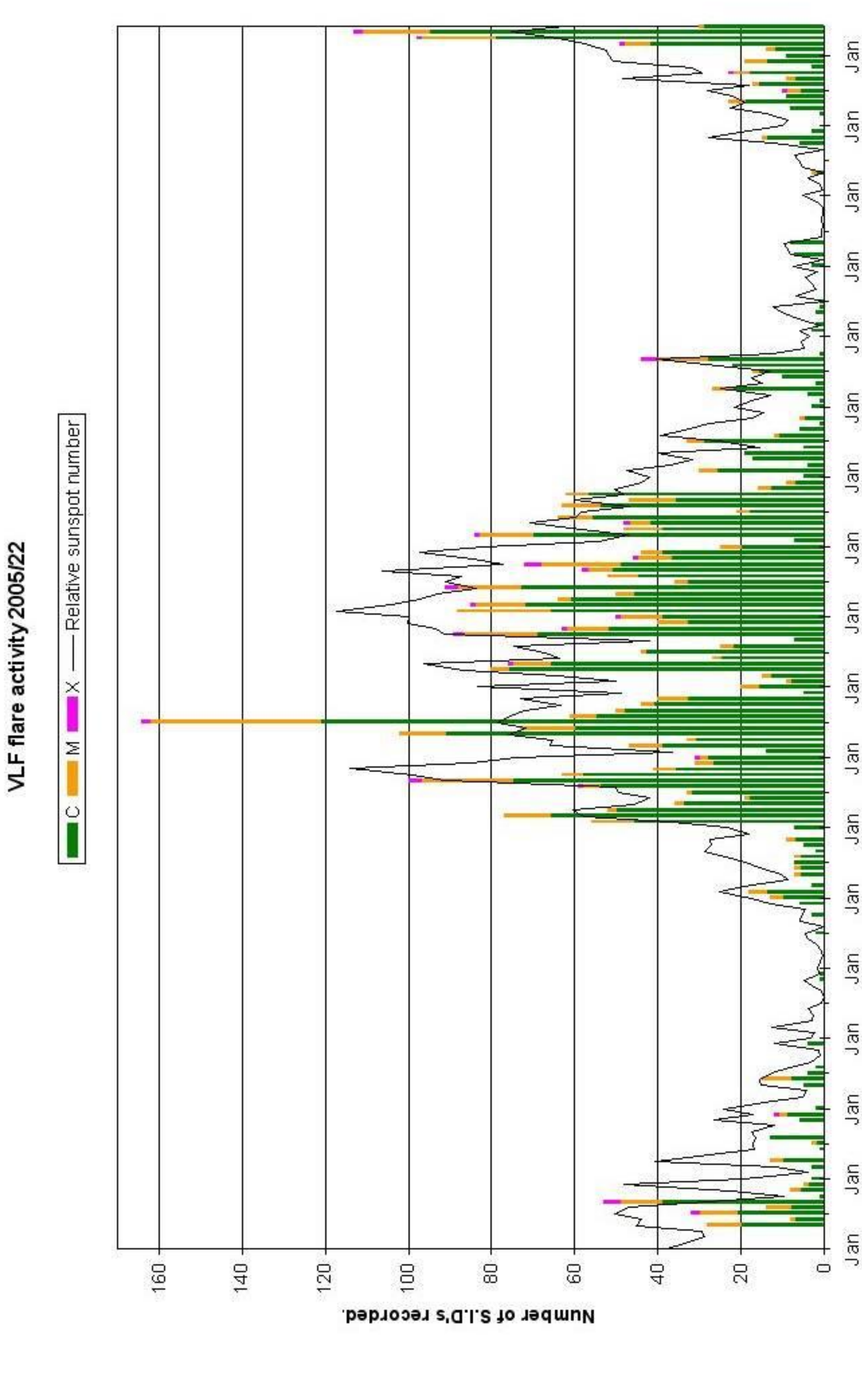
This recording covers 0Hz to 6kHz, and shows a pulsing hiss between 500Hz and 1.5kHz. The period is about 50 seconds. This was seen for about 30 minutes on the 9th. There is evidence of extra noise at higher frequencies on both recordings. This was observed to be from a neighbour's lawn mower, and trains arriving and leaving a nearby railway station.

DAY	Xray class	Observers	John Cook (23.4kHz/*22.1kHz*)				Roberto Battaiola				Paul Hyde (22.1kHz/*24kHz*)				Mark Edwards (24.0/*19.6*/**37.5kHz**)				Colin Clements (37.5kHz)			
			Tuned radio frequency receiver, 0.58m frame aerial.				Modified AAVSO receiver.				Spectrum Lab / PC 1.5m frame aerial.				Spectrum Lab / PC 2m loop aerial.				Tuned Radio Frequency receivers, 0.76m screened loop aerial.			
DAY			START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)	
9	C1.7	1													08:59	09:06	09:15	1-				
9	C1.9	2									10:08	10:21	10:53	2	10:14	10:27	10:59	2				
10	C3.7	2													*05:39*	*05:53*	*06:11*	*1+*				
10	C4.1	7	08:25	08:41	09:16	2+					08:23	08:42	09:36	2+	08:30	08:40	09:26	2+	08:32	08:50	09:39	2+
10	**M1.2**	7	10:15	10:45	12:01	3					10:14	10:42	12:00	3	10:16	10:54	12:10	3	09:39	11:02	12:07	3+
10	C2.3	2									14:24	14:35	14:47	1	14:29	14:36	15:11	2				
11	C1.2	1													14:11	14:10	14:17	1-				
13	C8.5	1													21:23	21:26	21:29	1-				
14	?	5									09:59	10:09	10:32	2	10:01	10:12	10:37	2	10:03	10:14	10:51	2+
14	?	1																				
14	?	1													**12:32**	**12:39**	**13:00**	**1+**				
14	?	6	13:13	13:15	?	-					13:10	13:17	?	-	13:13	13:16	?	-	13:19	13:21	13:28	1-
14	C8.5	8	13:24	13:30	?	-					13:23	13:31	14:11	2+	13:22	13:29	?	-	13:28	13:35	14:22	2+
14	C8.6	8	14:17	14:20	15:28	2+					14:16	14:24	?	-	14:17	14:23	14:59	2	14:22	14:28	15:31	2+
14	?	2									14:27	14:30	15:08	2	*14:28*	*14:29*	*15:19*	*2+*				
14	C1.3	1									16:06	16:13	16:28	1								
14	C3.9	3									17:41	17:47	18:30	2+	17:42	17:50	18:15	2				
16	C4.5	8	13:43	13:44	14:14	1+					13:41	13:46	14:32	2+	13:42	13:46	14:07	1	13:48	13:51	14:04	1-
17	C5.6	6	10:59	11:21	12:13	2+									10:58	11:29	?	-	10:36	11:29	11:36	2+
17	?	2													11:43	11:50	12:18	2	11:48	11:53	12:40	2+
17	C2.5	2									13:06	13:16	13:36	1+	13:10	13:26	13:57	2+				
17	C4.3	8	15:01	15:06	15:21	1					14:58	15:07	16:04	2+	15:02	15:11	15:34	1+	15:05	15:11	15:30	1
17	C3.3	1													18:25	18:27	18:46	1				
18	C1.8	2													11:38	11:46	12:11	2				
18	?	1													*11:53*	*11:57*	*12:06*	*1-*				
18	C1.8	1													13:30	13:35	13:57	1+				
18	C1.4	1													17:41	17:48	17:57	1-				
19	C4.0	1													20:00	20:09	20:36	2				
20	C5.7	2													06:17	06:20	06:25	1-				
20	?	1													14:54	14:58	15:08	1-				
20	?	3									15:19	15:31	16:01	2	15:24	15:34	16:04	2				
20	C4.5	3									16:06	16:14	16:40	2	16:08	16:13	16:27	1				
21	C5.6	6									16:12	16:27	17:32	2+	16:17	16:27	17:08	2+	16:15	16:32	17:26	2+
22	C2.7	2									08:17	08:26	08:51	2	08:18	08:23	08:43	1				
22	C3.3	1													**16:23**	**16:25**	**16:47**	**1**				
23	C4.0	1																				
23	C3.6	1													20:07	20:29	20:49	2				
24	C1.5	5	08:55	09:00	09:15	1					08:54	09:06	09:37	2	08:56	09:06	09:37	2	08:58	09:10	09:40	2
25	C1.2	1													14:01	14:03	14:16	1-				

DAY	Xray class		Steve Parkinson (Various)				Andrew Thomas (20.9/*22.1*/**19.6kHz**)				Phil Rourke (23.4kHz)				Mark Prescott (20.9kHz)				Christopher Bailey			
			Tuned radio frequency receiver, frame aerials.				Tuned radio frequency receiver, 0.6m frame aerial.				Spectrum Lab, 0.6m frame aerial.								Spectrum Lab			
DAY			START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)		START	PEAK	END (UT)	
9	C1.7																					
9	C1.9																					
10	C3.7						*05:40*	*05:46*	*06:00*	*1*												
10	C4.1		08:26	08:44	09:24	2+	08:26	08:43	09:29	2+					08:28	08:54	09:21	2+				
10	**M1.2**		10:15	10:54	12:10	3	09:35	10:41	12:30	3+					09:51	10:50	11:55	3				
10	C2.3																					
11	C1.2																					
13	C8.5																					
14	?						09:41	10:08	10:38	2+					09:55	10:16	10:45	2+				
14	?														11:31	11:44	11:52	1				
14	?																					
14	?		13:12	13:16	?	-	13:12	13:16	13:22	1-												
14	C8.5		13:24	13:30	?	-	13:22	13:31	14:17	2+					13:14	13:35	14:10	2+	13:10	13:30	13:44	2
14	C8.6		14:17	14:22	15:15	2+	14:17	14:21	15:57	3					14:16	14:25	14:49	2	14:00	14:22	14:50	2+
14	?																					
14	C1.3																					
14	C3.9						*17:40*	*17:46*	*18:03*	*1*												
16	C4.5		13:42	13:47	14:15	2	13:43	13:47	14:18	2					13:43	13:51	14:21	2	13:42	13:45	14:15	2
17	C5.6						10:56	11:24	12:32	3					10:59	11:53	12:35	3	10:45	11:25	12:12	3
17	?																					
17	C2.5																					
17	C4.3		15:00	15:08	15:34	2	15:01	15:07	16:02	2+					15:03	15:14	16:25	2+	15:00	15:05	15:25	1
17	C3.3																					
18	C1.8														11:43	11:56	12:11	1+				
18	?																					
18	C1.8																					
18	C1.4																					
19	C4.0																					
20	C5.7						*06:05*	*06:21*	*06:44*	*2*												
20	?																					
20	?														15:24	15:33	15:50	1+				
20	C4.5														16:09	16:16	16:31	1				
21	C5.6		16:15	16:24	16:42	1+	16:18	16:22	16:46	1+					16:17	16:29	16:54	2				
22	C2.7																					
22	C3.3																					
23	C4.0						09:38	11:26	12:08	3+												
23	C3.6																					
24	C1.5						08:54	09:11	09:45	2+												
25	C1.2																					

BARTELS CHART




VLF flare activity 2005/22
C
M
X
Relative sunspot number
Number of S.I.D's recorded.
0
20
40
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80
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Jan 2020
Jan 2021
Jan 2022

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Radio Astronomy Section

BAA RA Section Autumn programme 2022

Sep. 2nd.	**Dr Helen Russell**	***x-ray astronomy***
19:30 BST (18:30 UTC)	School of Physics & Astronomy Nottingham University	‘An X-ray view of the Universe
Oct. 7rd.	**Dr Samuel Lander**	***All about Magnetar’s***
19:30 BST (18:30 UTC)	Theoretical astrophysicist. Univ. East Angela. The main focus of research is neutron stars: the collapsed remnants of a normal star's core following a supernova.	A magnetar is a type of neutron star with a particularly strong magnetic field. This field powers a range of outburst activity, from X-ray and gamma-ray bursts and flares, to the recently discovered fast radio bursts. This talk will survey the observations and give a picture of how a magnetar releases all this energy.
Nov. 4st.	**Prof. John Richer**	***‘On ALMA’***
19:30 GMT (18:30 UTC)	The Cavendish Laboratory Cambridge Univ. John Richer is an astrophysicist with expertise in the field of star formation, with a particular in interest in radio and submillimetre observations of young stars and protostellar systems.	Atacama Large Millimetre/submillimetre Array ALMA is a submillimetre interferometer at the Chajnantor site in the Atacama Desert at 5100 metres above sea level. The principle research areas are millimetre and submillimetre imaging and spectroscopic observations of star-forming regions in our own Galaxy, in nearby galaxies, and in the very distant universe. These observations provide an unobscured view of the cold universe.

Dec. 2st.	**Dr. Emma Chapman**	**Christmas Lecture**
19:30 GMT (18:30 UTC)	Guest star: JWST	***'Exploring the Dark Ages of the Universe by Radio'***
	Royal Society Dorothy Hodgkin fellow based at the University of Nottingham.	The first stars ever! 400 million years after the big bang. This era has never been observed and constitutes over a billion-year gap in our knowledge.

If you have any suggestions for the winter 2023 term do let me know.
Our meetings are open to all. Once you are registered on the RA Section email list the Zoom link will be sent out to you before the meeting. If you are not on the email list, please request registration from Paul Hearn (paul@hearn.org.uk).
All recordings will be posted on our BAA YouTube channel. https://www.youtube.com/user/britishastronomical/playlists

Novel Narrow Band Cylindrical Feedhorn Assembly for High RF Environments

Steven Black[1] and Gary Krohe[2]

[1]Washburn University Physics Department, Topeka, KS
[2]KTWU Public Television Washburn University, Topeka, KS

1. Abstract

A cylindrical feedhorn assembly was designed and constructed for use in a high RF environment. This high RF is due to two nearby cell towers. These transmit in cell bands both above and below the desired receive frequency of 1420 MHz. The assembly consists of the feedhorn, antenna probe, line stretcher, cylindrical band pass cavity filter, and LNA from Kuhne. The design process, construction, and results are presented.

2. Introduction

The offending cell towers are approximately 265 m from the antenna at an azimuth of 150 °, as shown in Figure 1.

Figure 5: Cell Towers Producing LNA Overload

The cell bands being broadcast from the towers lie both below and above the 1420 MHz frequency of interest and produce overload in the LNA, even when within the side lobes of the antenna. The feedhorn was designed to reject those frequencies below 1420 MHz. Then a band pass filter was designed to reject those frequencies both above and below the desired frequency, and finally the proper electrical connection was made between the feedhorn and band pass filter.

3. Feed horn design, construction, and tuning

The cutoff frequency (λ_c) of the TE_{11} mode in a cylindrical waveguide is a function of the inside diameter of the cylinder. The cutoff frequency is the frequency below which an electromagnetic wave will not propagate. The cutoff frequency increases as the diameter decreases. The length of the cylinder is typically chosen to be ¾ guide wavelength (λ_g), with this increasing as the diameter decreases.

In order to keep the cutoff frequency reasonably close to the desired frequency without the cylinder becoming too long, an inside diameter of 5.1 inch was selected. This makes the λ_c a bit over 1300 MHz. Gary produced the design and suggested that tuning screws placed 180° from the RF probe would allow one to tune the cavity. The probe was mounted on a slider (Figure 2a) so that its distance from the end plate could be adjusted, which is nominally ¼ λ_g. The probe was cut to ½ free space wavelength (λ). The feedhorn constructed by Tim Morrissey of [1] West Tek Inc. is shown in Figure 2b, with the choke ring attached. The tube was constructed from 5.5 inch aluminum tube with the inner diameter bored to 5.1 ± 0.002 inch.

Figure 2a: Probe Slider

Figure 6b: Feedhorn with Choke Ring, Line Stretcher, Band Pass Filter, and Kuhne LNA

The feed was tuned with an [2] xaVNA, which is no longer available, by adjusting the position of the probe for minimum S_{11} and then adjusting the tuning screws by starting with the one nominally opposite the probe and working outward in an alternating fashion. The final adjustment was carried out so that the impedance was as close as possible to 50 + j 0 ohm at the desired frequency of 1420 MHz. The VNA output for the tuned feed is shown in Figure 3, Figure 4, and Figure 5.

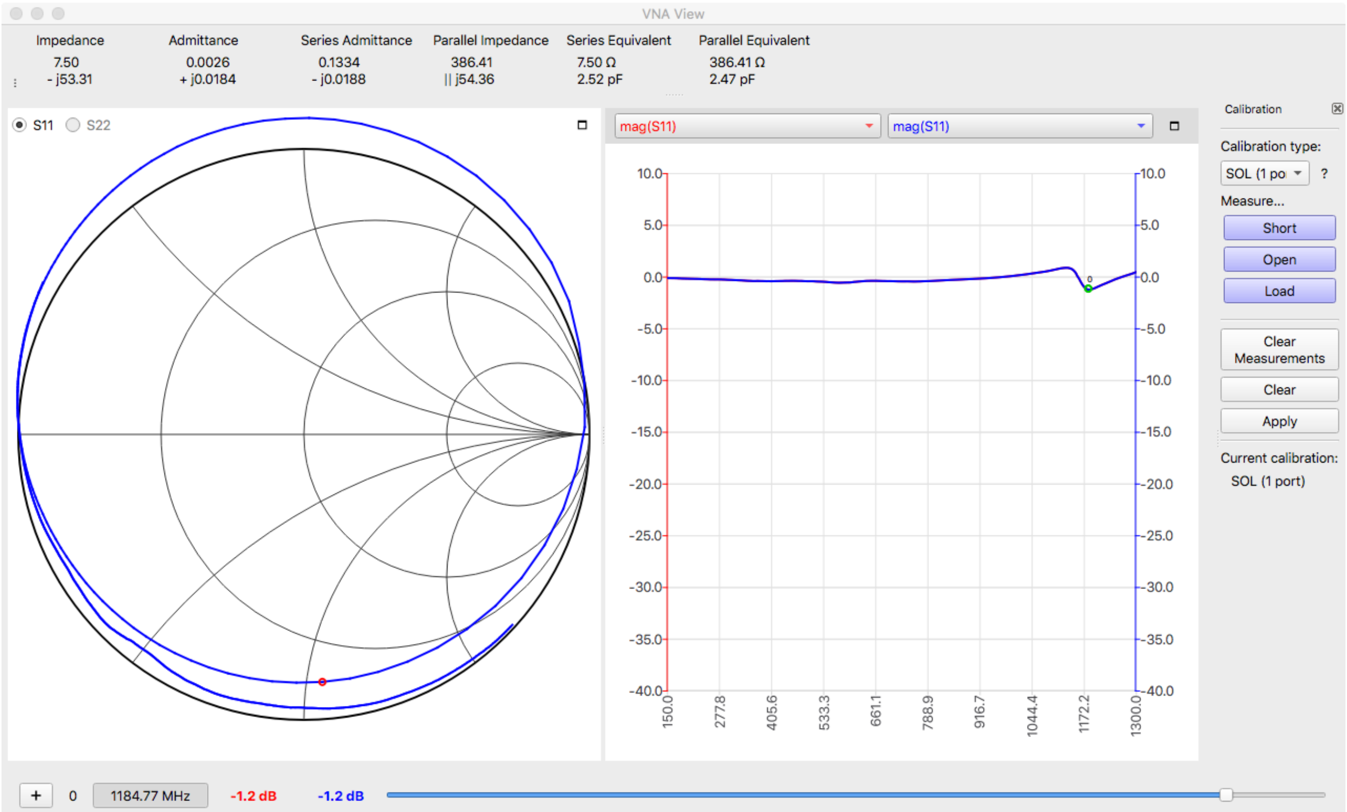


Figure 3: S_{11} from 250 to 1300 MHz

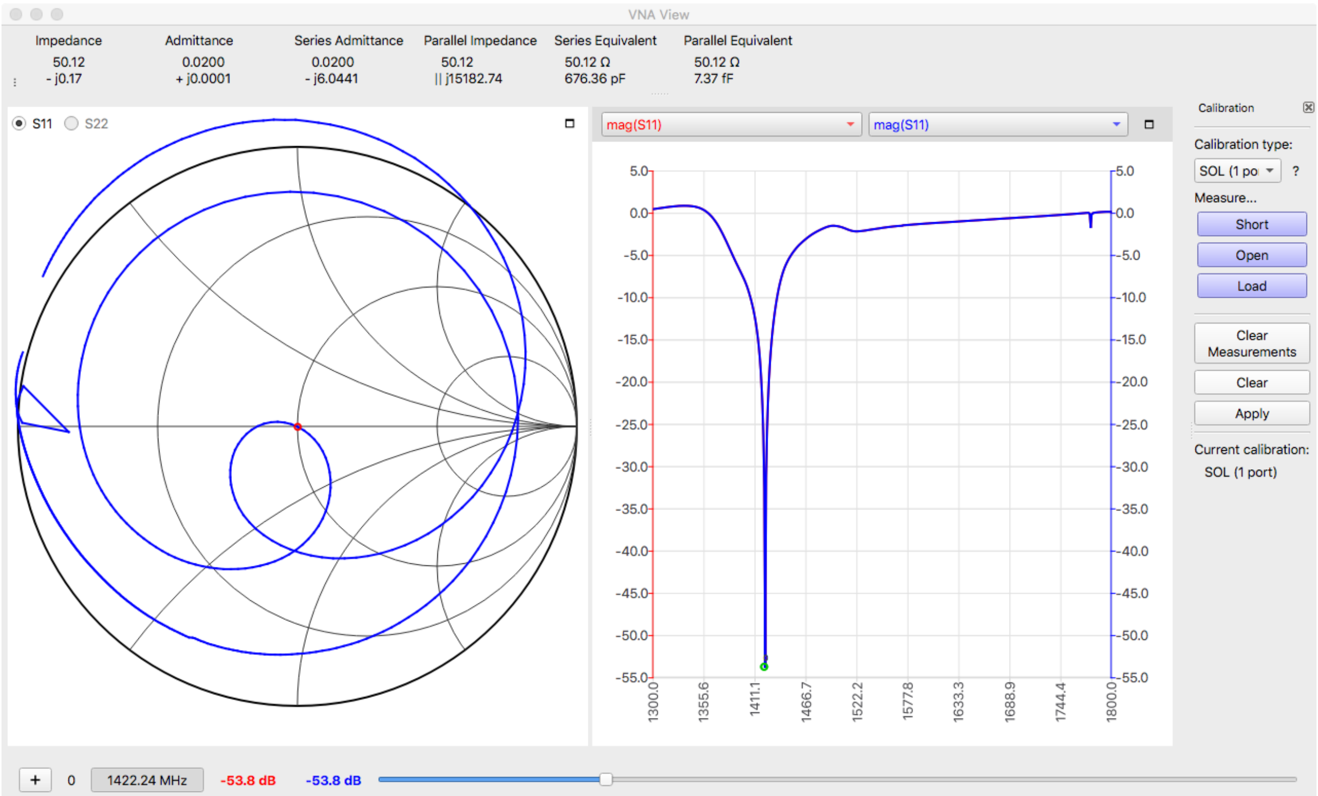


Figure 4: S_{11} from 1300 to 1800 MHz

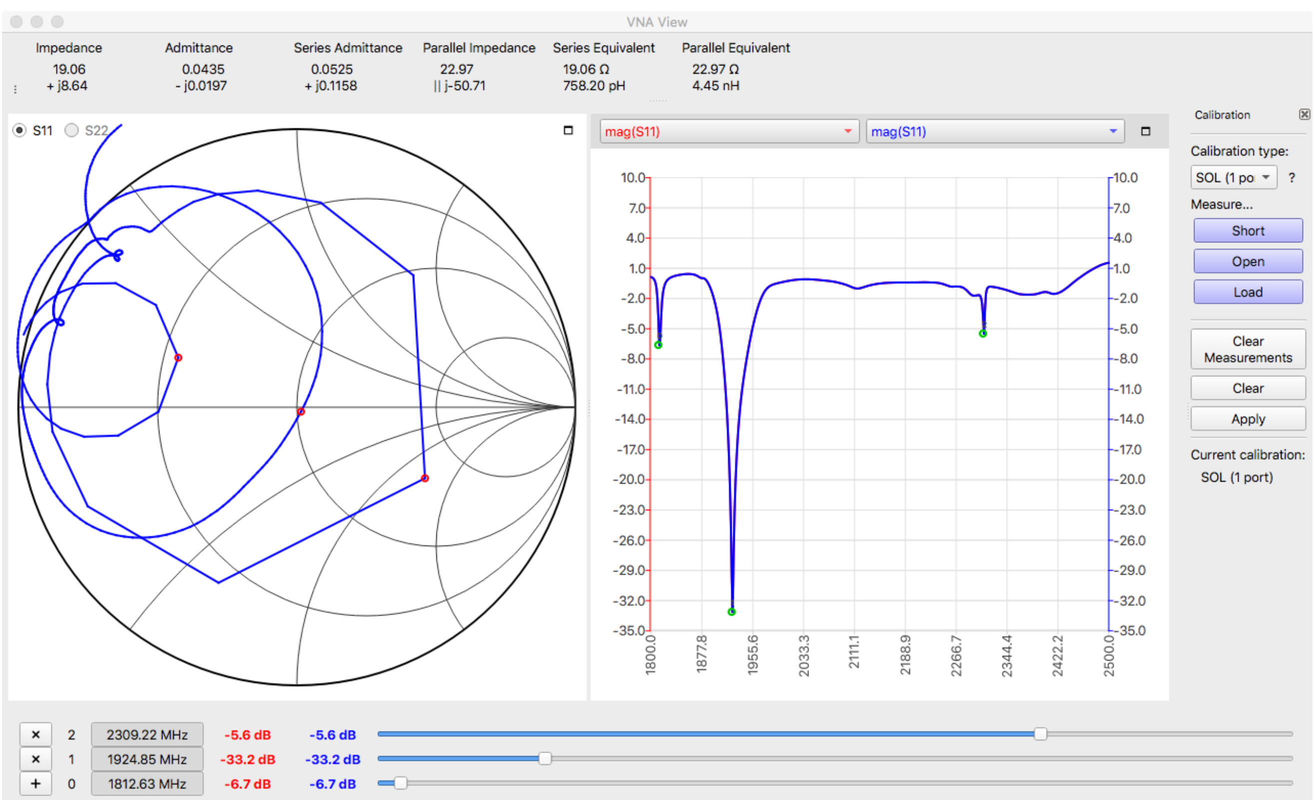


Figure 5: S_{11} from 1800 to 2500 MHz

As can be seen in Figure 3, the 5.1 inch inside diameter for the feed was successful in eliminating any response below 1300 MHz. The slight response in S_{11} at 1185 MHz shows an impedance that is nearly all imaginary, and thus is a near field phenomenon.

The response from 1300 to 1800 MHz (Figure 4) is excellent with the narrow band response at approximately 1420 MHz and deep S_{11}. The tuning procedure is tedious and requires considerable patience and time to complete. The imaginary part of the impendence is particularly sensitive to tuning screw adjustments when approaching a value of zero.

Unfortunately, the results between 1800 and 2500 MHz (Figure 5) are disappointing, especially the apparent excellent response at approximately 1925 MHz. The tuning screw nearest the probe is approximately the proper length to be responsive to this frequency. It is postulated that the probe couples to this tuning screw. Since a VNA measure the S_{11} by transmitting a signal and measuring the reflected response, the tuning screw coupling to the probe will lead to reduced reflection and a dip of the S_{11} value. The tuning screw is at ground, and it's thought that such a frequency will be shorted and not propagate in the waveguide. Not being certain that this is true, we decided that the best path would be to place a bandpass filter between the probe and the LNA.

4. Cavity filter design, construction, and tuning

A small, narrow band, tunable bandpass filter is desirable for this application. Such a filter was designed using [3] Online Filter Design, with the disc on the center rod excluded. The filter was built entirely of copper, except for the steel tuning bolt, by [1] West Tek. We tried a copper bolt which does not work. Apparently, a ferromagnetic material must be used, since the coupling between the input and output is via the magnetic field.

The filter was tuned with the VNA to a center frequency of approximately 1420 MHz (Figure 6). Note the low loss of 0.2 dB at the center frequency. Figure 7 shows the filter mounted.

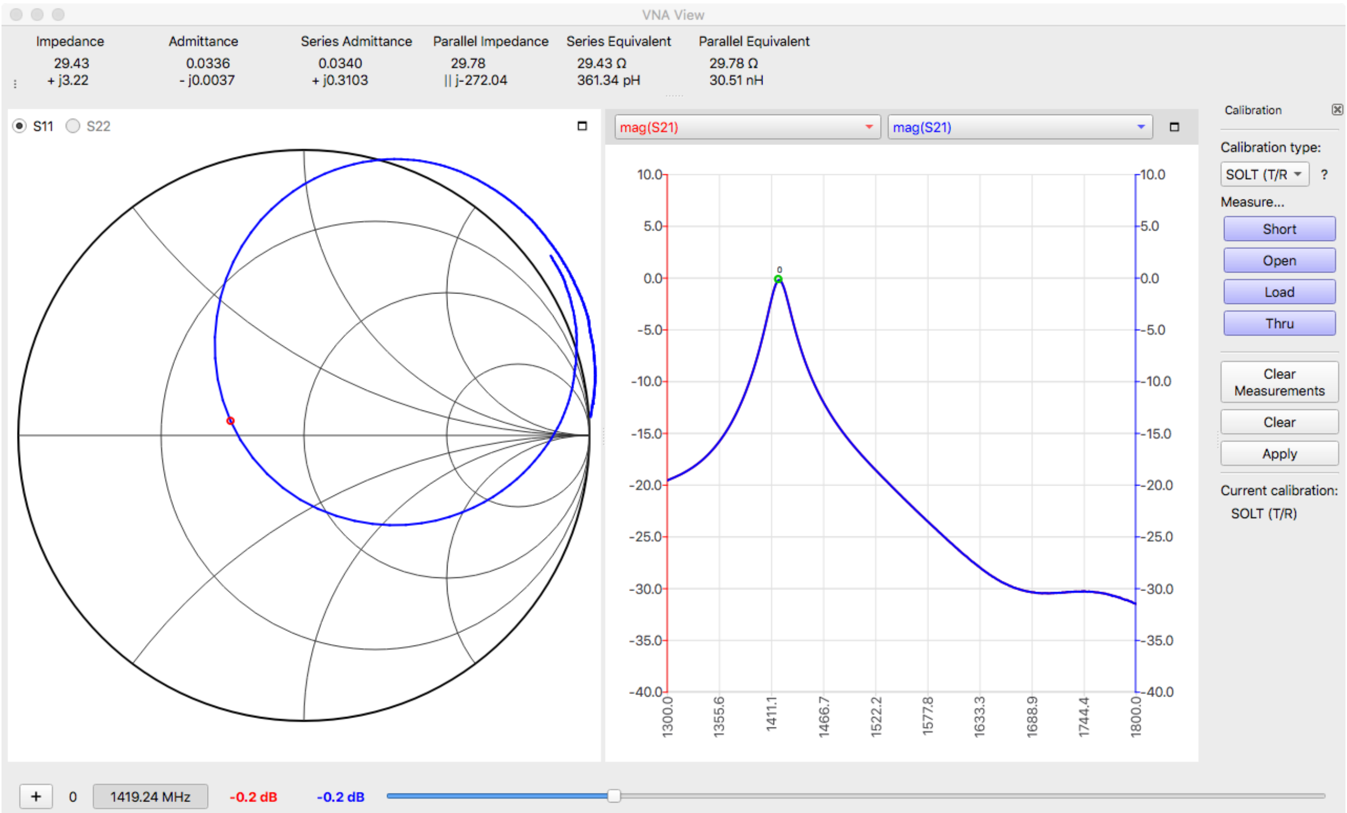


Figure 6: S_{21} for Cylindrical Bandpass Filter

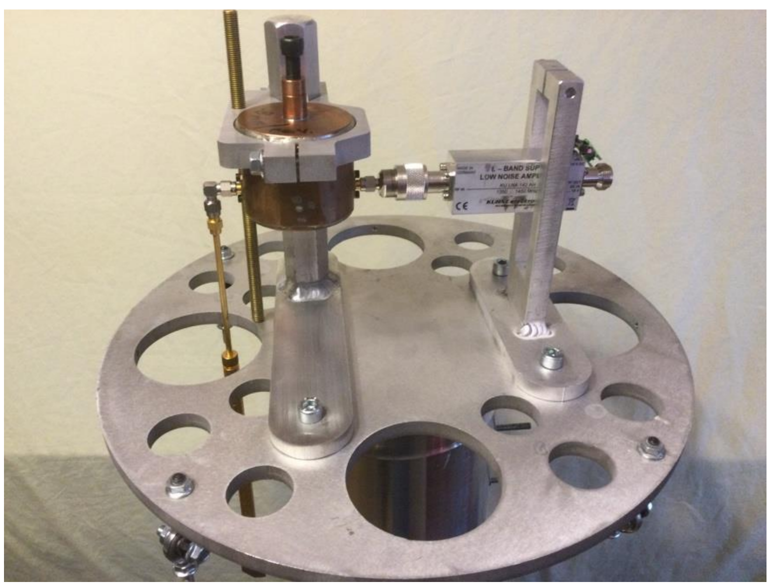


Figure 7: Highlighting the Filter (Copper Colored Device)

The last step in the process was to mount the filter connected to the probe via the line stretcher, which is discussed in the next section.

5. Final Tuning of the Assembly with the Filter Attached

From a book entitled [4] The Cavity Duplexer it was learned that the electrical length of the connection between two cavities is critical for producing the correct phase of the signal between the pair. To quote from the book:

"Here is the concept in a simplified nutshell. We need to make the electrical pathway from one cavity to the next "disappear." In other words, we must "tune" the length of the line until the two cavities think there is no line between them."

To further elaborate, the author states:

"To accomplish this perhaps-seemingly difficult feat, we employ a very basic fact about transmission lines, including coax. That is, ½ wavelength of transmission line does not change the impedance of what it is connected to it on one end, at the other end. This is of course ½ wavelength electrically, not physically. The velocity factor of the line must be factored in."

We deemed the most practical way to accomplish this was to use a line stretcher between the probe and the filter. The mount for the filter was designed so that the filter could be clamped around its circumference and slide toward or away from the probe.

The VNA was once again used to monitor the S_{11} while the length of the line stretcher was changed by moving the filter. The length chosen was the one which produced the minimum S_{11} at approximately 1420 MHz. The final result for S_{11} as a function of frequency from 250 to 1300 MHz (Figure 8), from 1300 to 1800 MHz (Figure 9), and from 1800 to 2500 MHz (Figure 10).

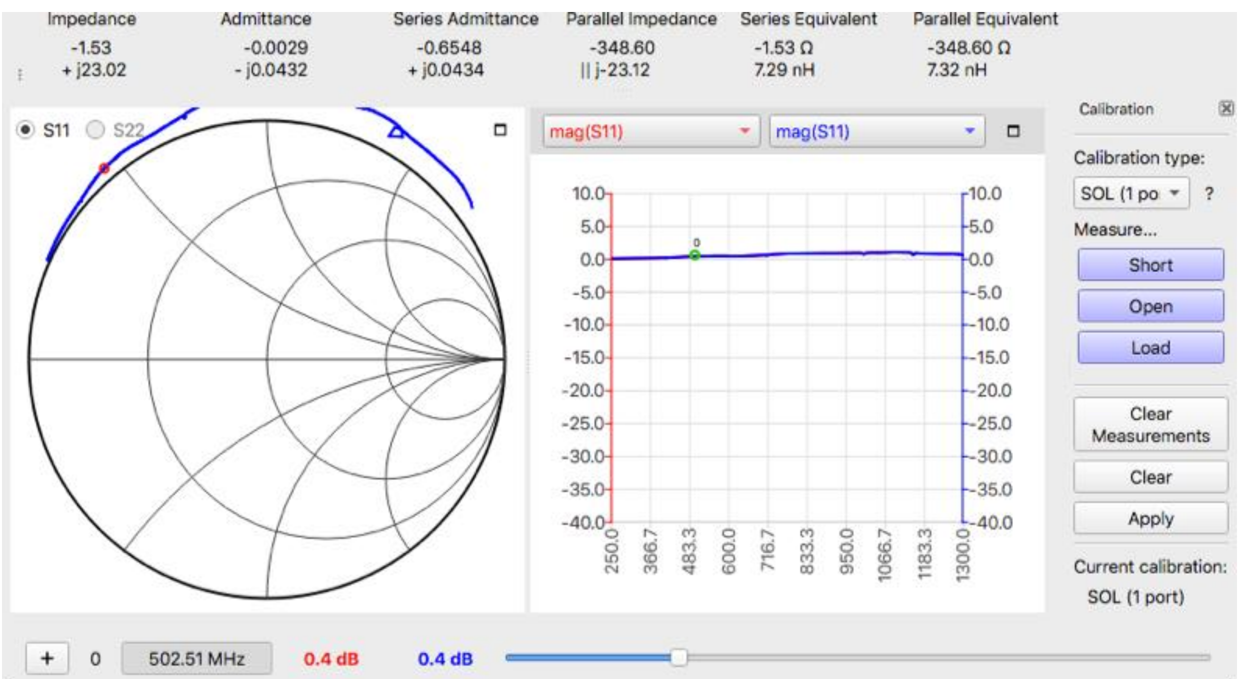


Figure 8: Feed and filter S_{11} from *250 to 1300 MHz*

The S_{11} from 250 to 1300 MHZ is quite good with the value being near zero over the entire span. We're not sure why the value is slightly positive as the VNA was calibrated before each measurement. The calibrators are inexpensive ones made from SMA connectors, which were provided with the instrument.

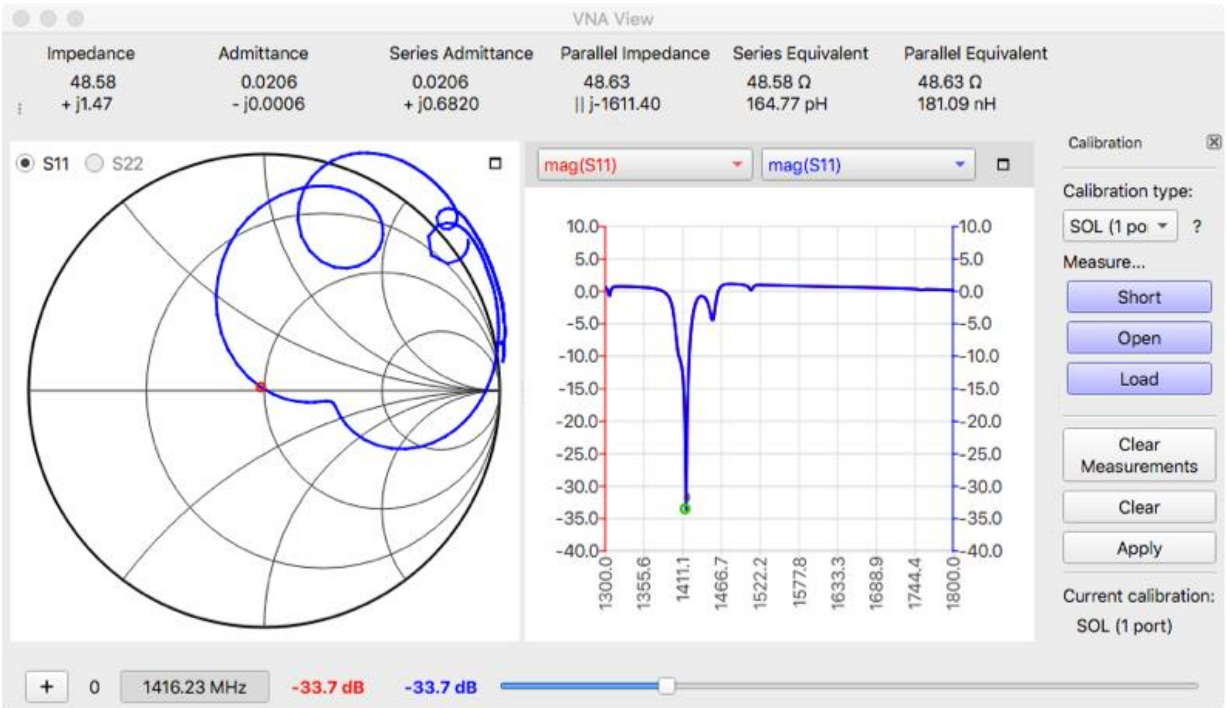


Figure 9: Feed and Filter S_{11} from 1300 to 1800 MHz

The S_{11} is still quite good at a frequency that is slightly below 1420 MHz and still narrow band. The real part of the impendence is quite close to the desired 50 ohm and the imaginary part is still reasonably close to zero.

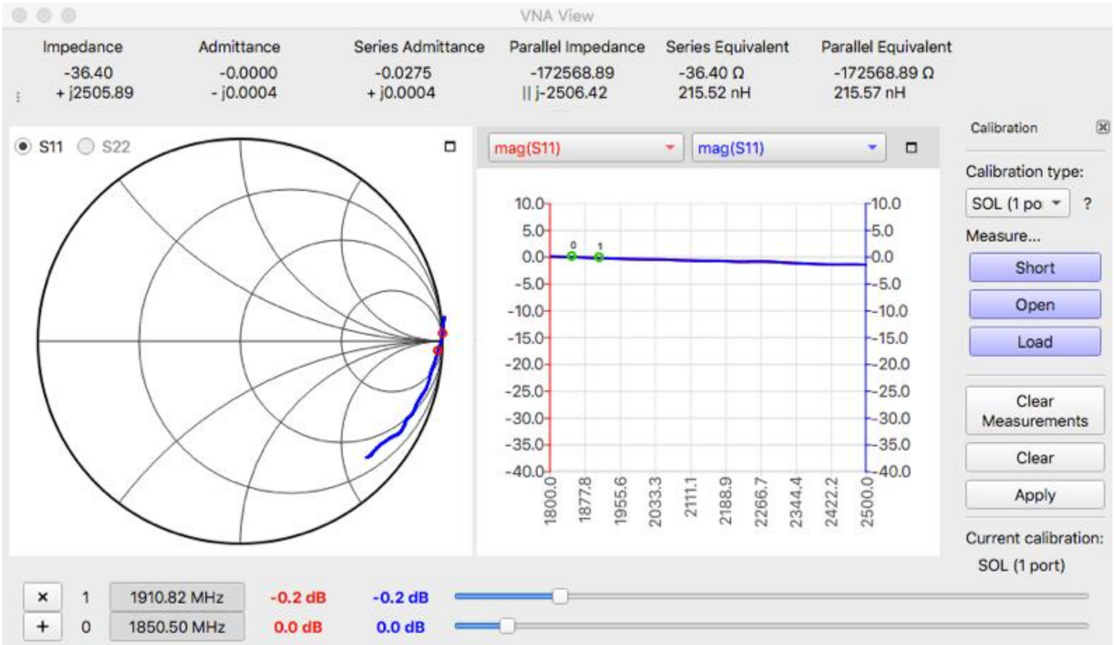


Figure 10: Feed and filter S_{11} from 1800 to 2500 MHz

The filter solved the feed response problem from 1800 to 2500 MHz, with the S_{11} near zero over the entire frequency range.

6. Example Measurement Results of the Target G210 in the Milky Way Galaxy and Conclusions

Figure 11 is a screen shot of the uncalibrated data acquired using [5] GNU Radio as the measurement software. The measurement position is such that the antenna side lobes do not see the cell towers.

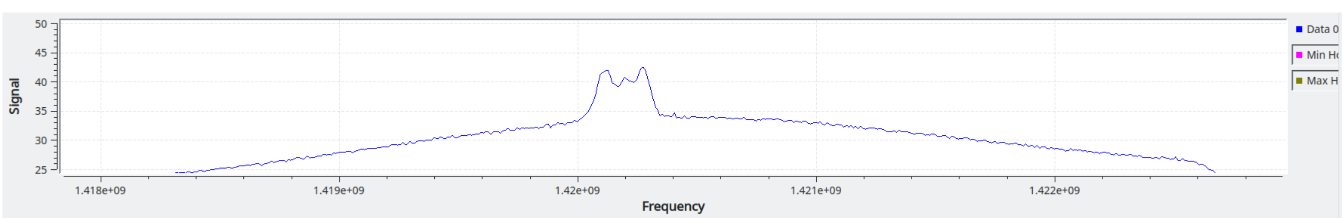


Figure 11: G210 at an Azimuth of 241° and an Elevation of 35°

The results are excellent with a strong signal and a clean baseline.

Unfortunately, when acquiring data at a position where the cell towers are in the side lobes of the antenna, some LNA overload is still present (Figure 12). Although, this is a significant improvement compared to the previous feedhorn.

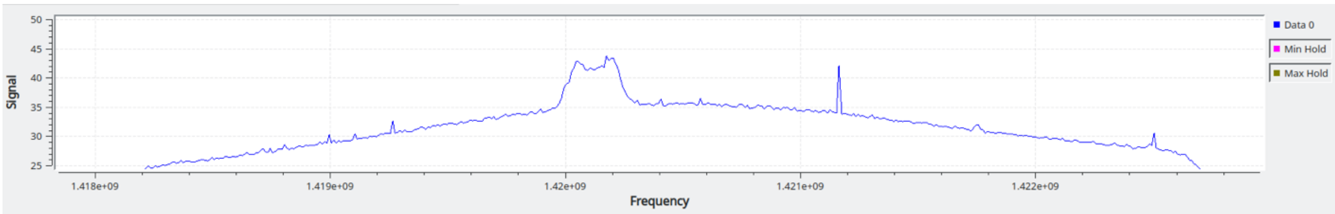


Figure 12: G210 at an Azimuth of 192.5° and an Elevation of 53.5°

So, the next project is to shield the side lobes of the antenna by installing an absorbing rim shield on the dish. It is believed that this will eliminate the overload on all positions outside the main beam of the antenna.

References:

[1] West Tek Inc., westtek@cjnetworks.com
[2] xaVNA, https://www.kickstarter.com/projects/1759352588/xavna-a-full-featured-low-cost-two-port-vna
[3] Online Filter Design, https://www.changpuak.ch/electronics/Coaxial_Tank_VHF_Filter_Designer.php
[4] The Cavity Duplexer, https://w6nbc.com/articles/duplexer.pdf
[5] GNU Radio, https://www.gnuradio.org/

Acknowledgements:

The radio telescope was made possible by a Major Research Grant from Washburn University and a location provided by KTWU Washburn University Public Television.

About the Authors:

Dr. Steven Black received his PhD in Physics from Oklahoma State University. He subsequently spent 34 years as a faculty member in the Department of Physics and Astronomy at Washburn University. He was Chair of the Department for the last 14 years before his retirement. He became involved in radio astronomy when a student wanted to build a radio telescope.

Mr. Krohe received a B.A. in communication Arts, double emphasis in Broadcasting and Journalism from Washburn University in 1976. He obtained an additional 39 hours in Electrical Engineering from Kansas State University. Mr. Krohe has been a member of the Society of Broadcast Engineers since 1980. Mr. Krohe is a lifetime certified Professional Broadcast Engineer in both radio and television from SBE. Mr. Krohe has been either a Chief Engineer, Director of Engineering, or Consultant to some full power television station/group since 1982. He has spent the last eight years as Director of Engineering and Technology for KTWU, PBS owned by Washburn University.

Refurbishing an SRT

Part 3: Installation and Commissioning

Wolfgang Herrmann

1. Introduction

This is the third part of our report on the refurbishment of a Small Radio Telescope (SRT) which we received from "Dr. Karl Remeis-Sternwarte" of the University of Nürnberg-Erlangen. In this part we report how the instrument was installed and taken into operation.

2. Site selection

The western side of a garage building was selected as the site for our 2.3-m dish. A mast could be attached to the garage wall. From the roof of the building, easy access is possible to the drive, the dish, the LNA and the feed which facilitates maintenance. The distance to our 3-m dish is approximately 59 meter, see fig. 1. This will be the baseline when used jointly with the 3-m dish as an interferometer. Unfortunately, this baseline is not exactly in east-west direction, which complicates the evaluation. However, there was no reasonable alternative to this location.

Fig 1: *Sites of the 2.3-m and 3-m dish*

Setup

2.1. Overview

Fig. 2 below shows the overall setup. There are three major components: The dish with drive unit, feed horn and low noise amplifiers (LNA); an outdoor cabinet with the electronics for the drive, RF amplifiers and filters and; indoor installations with the backends and connections to the network.

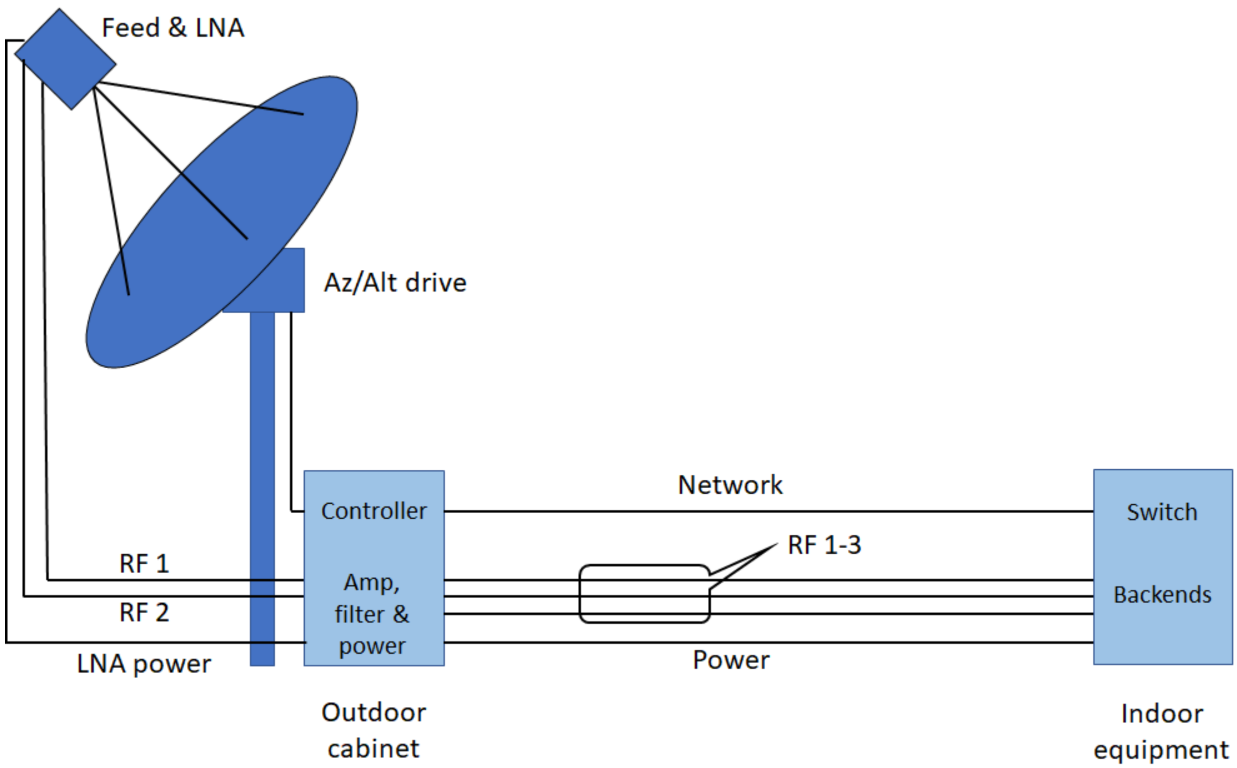


Fig 2: *Overview diagram*

The connections between the LNAs and the outdoor cabinet are done via two Aircell 7 coaxial cables and a power supply cable. The drive unit is connected via a cable for the motors and control signals. A further cable is used for the inclination sensor.

From the outdoor cabinet there are three Ecoflex 10 coaxial cables running into the operations building. The attenuation of these cables is 7.1 dB at 1420 MHz. Two of the cables are used for the two polarizations, one cable is a spare. On the same cable path there is also the power supply cable and a network cable. The length of the cable path is 34 meters.

2.2. Outdoor installation

Fig. 3 below shows the outdoor setup. A pole has been embedded in concrete in the ground and a fixture for the pole has been mounted on the wall of the garage building. The drive unit is mounted on top of the pole. The control electronics is inside an outdoor cabinet which is mounted on the wall.

Fig 3: *Outdoor setup*

The wall mounted cabinet shown in fig. 4 is water and dust protected (IP65). It contains the power supplies and the telescope control as described in part 2 of this series of articles. The lower part is reserved for those RF-components which are not directly attached to the feed horn. There is plenty of room to accommodate various components in a flexible manner. Depending on the observation tasks, different setups can be implemented. In the fig. 4, a setup with two amplifier/filter units (Noolec SAWbird+ H1) [1] are shown. These serve as 2nd stage amplifiers.

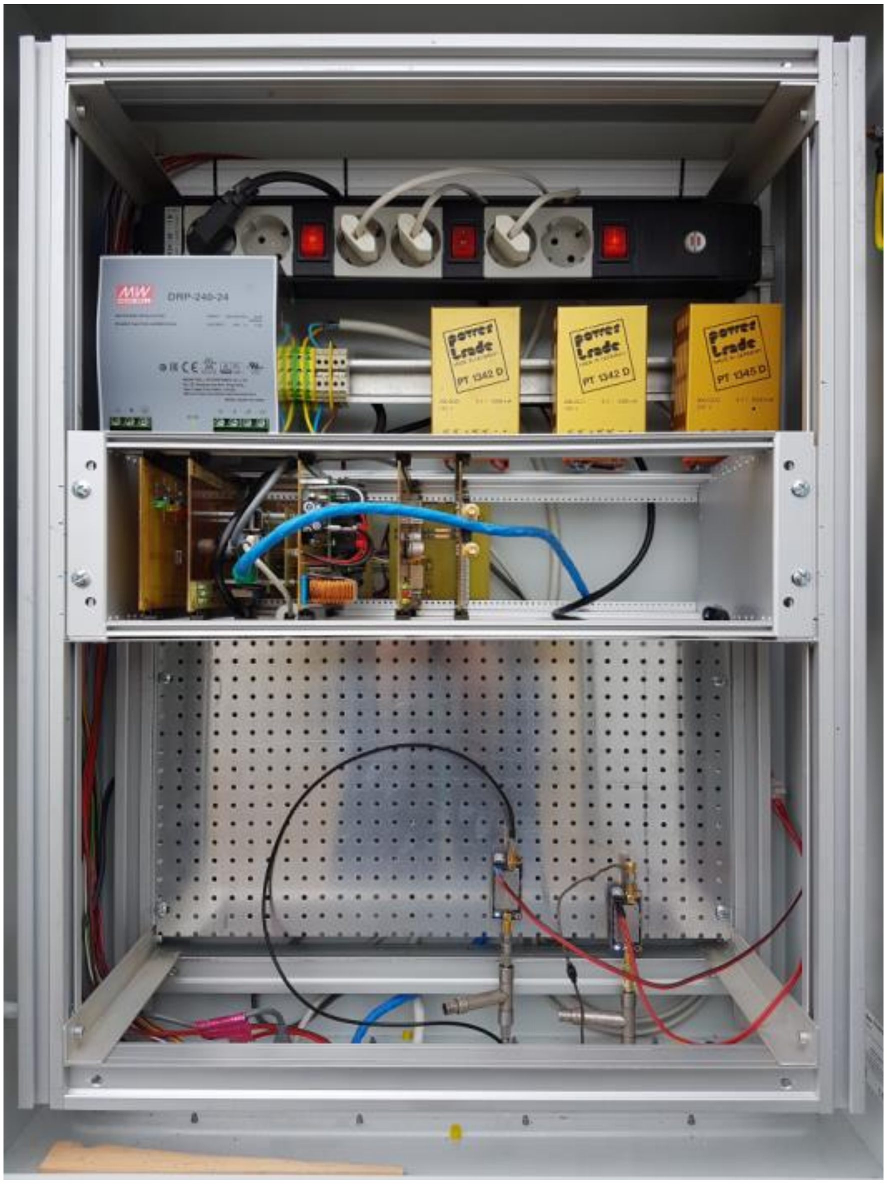


Fig 4: *Setup of outdoor cabinet*

Another example configuration is shown in fig. 5 where one of the polarizations is configured for 1612 MHz operation. Two amplifiers and a cavity filter are used there, and the other polarization is for 1400 MHz operation as shown above.

Fig 5: *Different RF configuration for 1612 MHz*

All cables are fed into the wall cabinet from below, see fig. 6. From left to right: Connection for the drive unit, a USB port (front), cable for the elevation sensor (back), cable for LNA-power (front), network connection (rear, blue), 230V AC, three coax cable for the connection to the building (rear), two coax cables to the LNAs at the feedhorn (front).

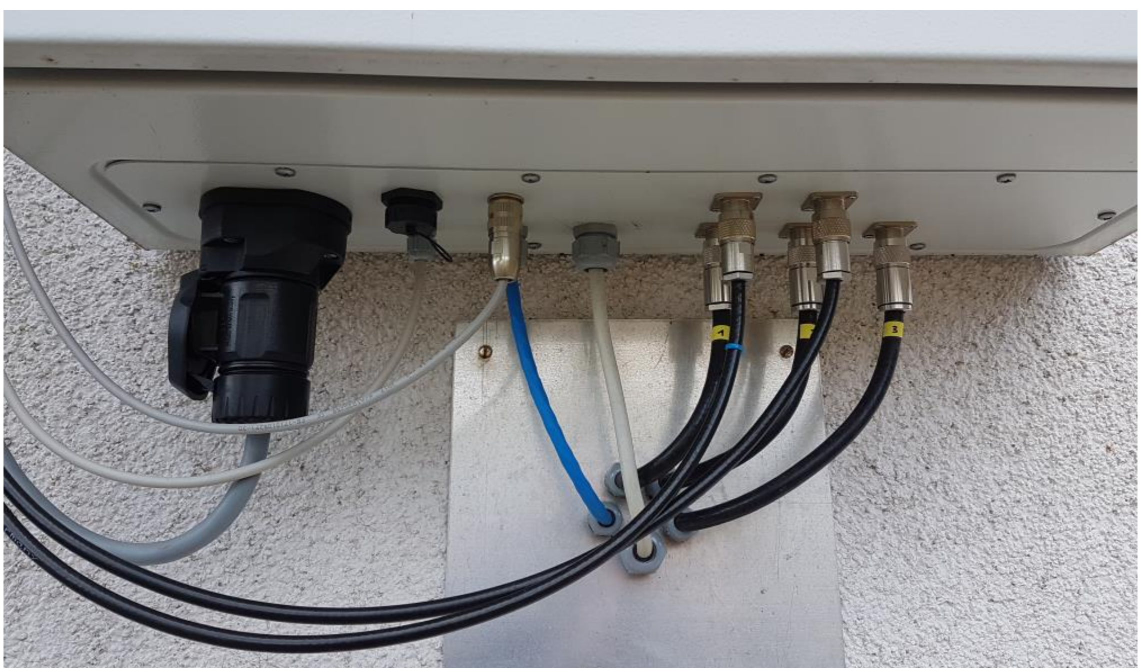


Fig 6: *Cabling*

2.3. Indoor installation

The equipment inside the building for the 2.3-m dish is inside a rack which is shared with various other equipment for our 10-m and 3-m dishes as shown in fig. 7.

Fig 7: *Electronics rack*

The coaxial cables coming from the outdoor cabinet are terminated there. Also, the network connection is terminated on a network switch. The RF-signal can be connected to whatever backend is required. Typically, we will use a software defined radio for that purpose, with the computer running software for either spectral observations or continuum recording.

3. Commissioning

3.1. Azimuth and Elevation setup

As a first step, the Azimuth and Elevation offsets were determined using the sun. For this purpose, the control system was commanded to set the telescope towards the direction of the sun. Offsets were then added in the control software so that the shadow of the feedhorn was exactly centered on the dish. It was then verified that the maximum signal was also received when the shadow was centered so that any squinting of the feed could be excluded.

It can be expected that the vertical axis of the mounting pole may not be perfectly vertical. This will lead to a variation of the elevation with azimuth. Due to the design chosen where the elevation is determined by an inclination sensor this is compensated automatically. In order to verify this, a 360° azimuth scan was performed with the elevation control loop activated and de-activated. This demonstrates that the control loop is working as expected. Indeed, there is a small tilt of the mounting pole of about 1°.

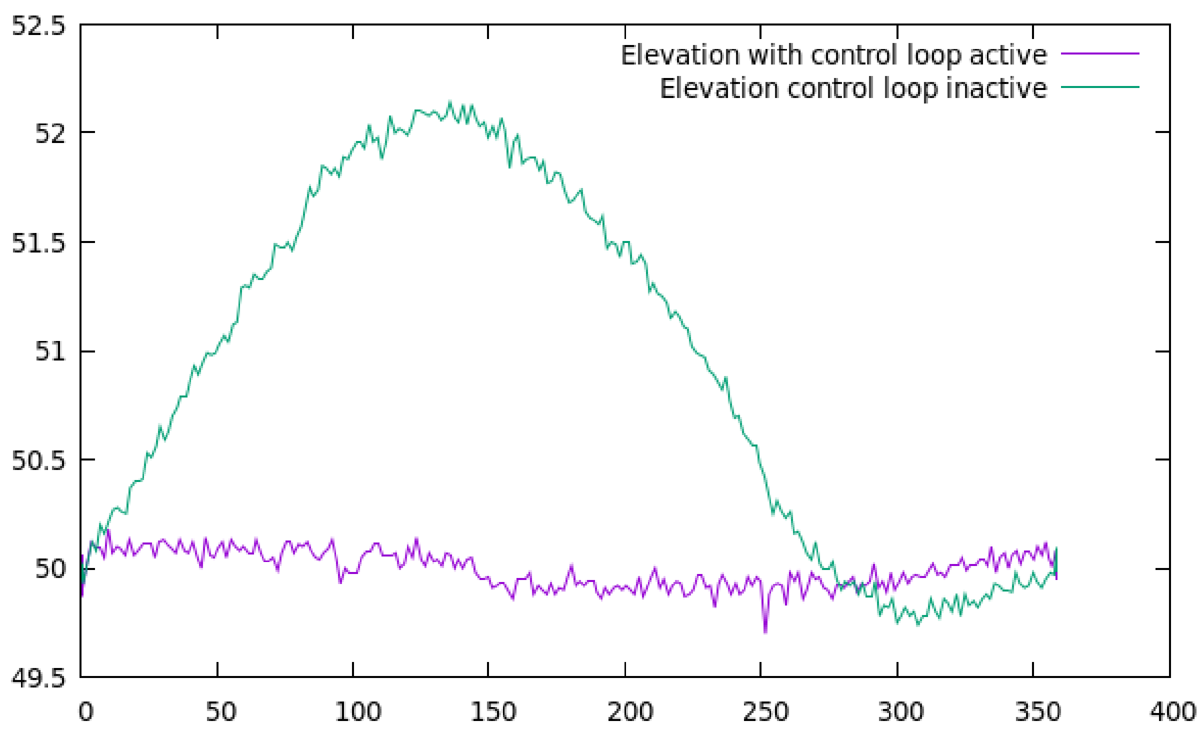
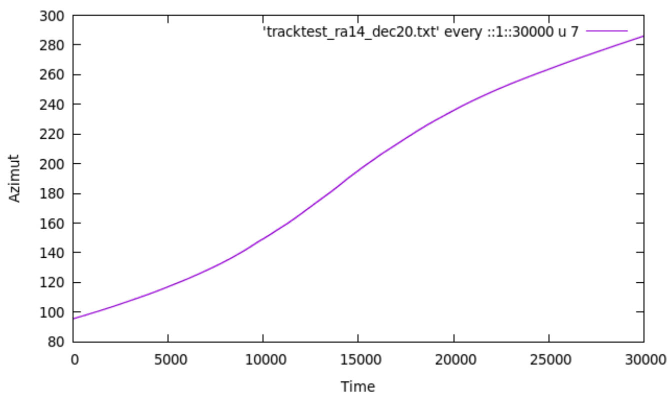


Fig 8: *Elevation control loop test;*
horizontal axis: azimuth in degrees, vertical axis: elevation in degrees

A further test was to monitor the sun shadow during a day from sunrise to sunset to verify that the shadow remains centred on the dish throughout the day. This was the case so no further corrections were required.

3.2. Tracking test

In order to confirm tracking and control loop stability, sky locations were tracked and the positioning was recorded. One example of such a test is shown below. Here the position RA 14 hrs, Dec 20° was tracked over about 10 hours with 30,000 test points taken. During this time, the location culminated in the south. While tracking the sky location the azimuth and elevation varied as shown in fig. 9.



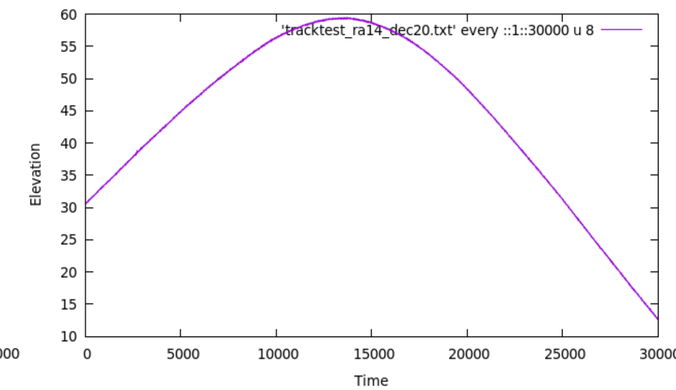


***Fig. 9**: Azimuth vs. time   Elevation vs. time*

During the tracking period, the actual position in equatorial coordinates was constantly recorded, see fig. 10 and 11.

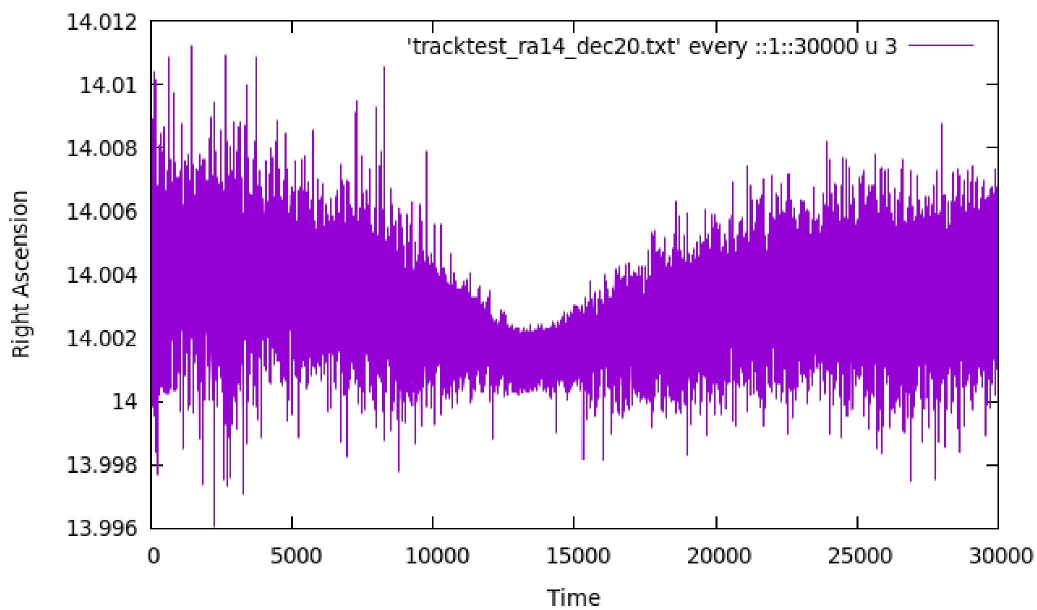


***Fig. 10:** Actual right ascension vs. time, target right ascension is 14 hrs*

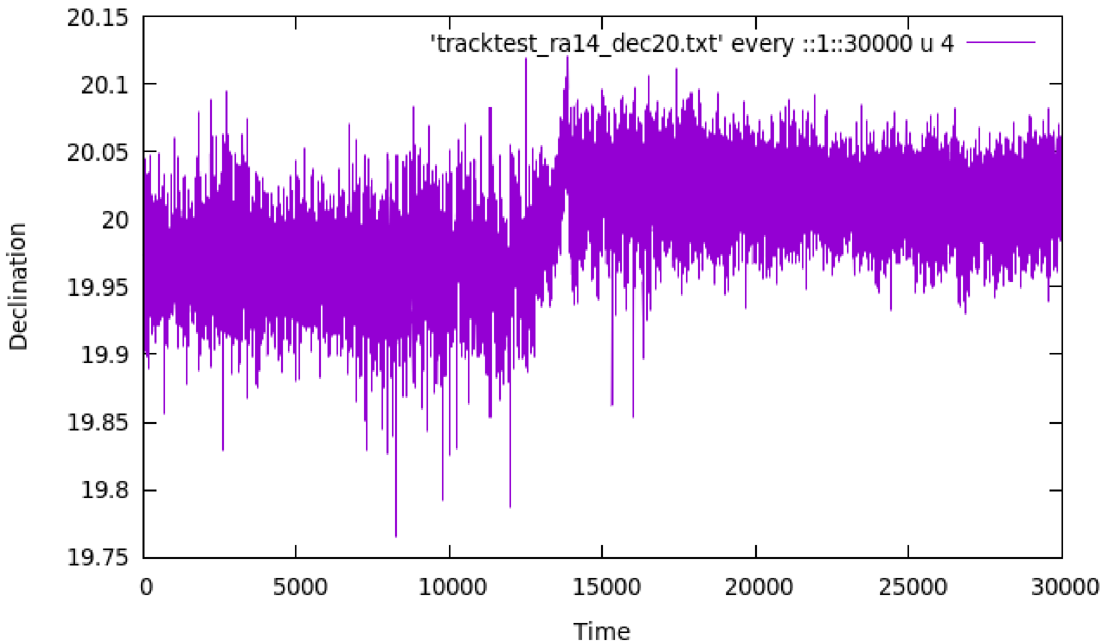


Fig. 11: *Actual declination vs. time, target declination is 20°*

As can be seen from the plots, the sky position was well maintained. The error has been much less than the beam width all the time. In particular there are not short term deviations indicating a good operation of the control system. It has to be noted, though, that the angular encoder for azimuth is not directly attached to the axis of motion. Therefore, some gear slack will come on top as an additional error. However, the goal to have a pointing accuracy to less than a tenth of the beam width has been achieved.

4. First light

After all commissioning tests were completed, it was time for fist light.
As "First Light" we took a spectrum of the hydrogen emission from the IAU calibration location "S7" at galactic longitude 132° and galactic latitude -1° [1].

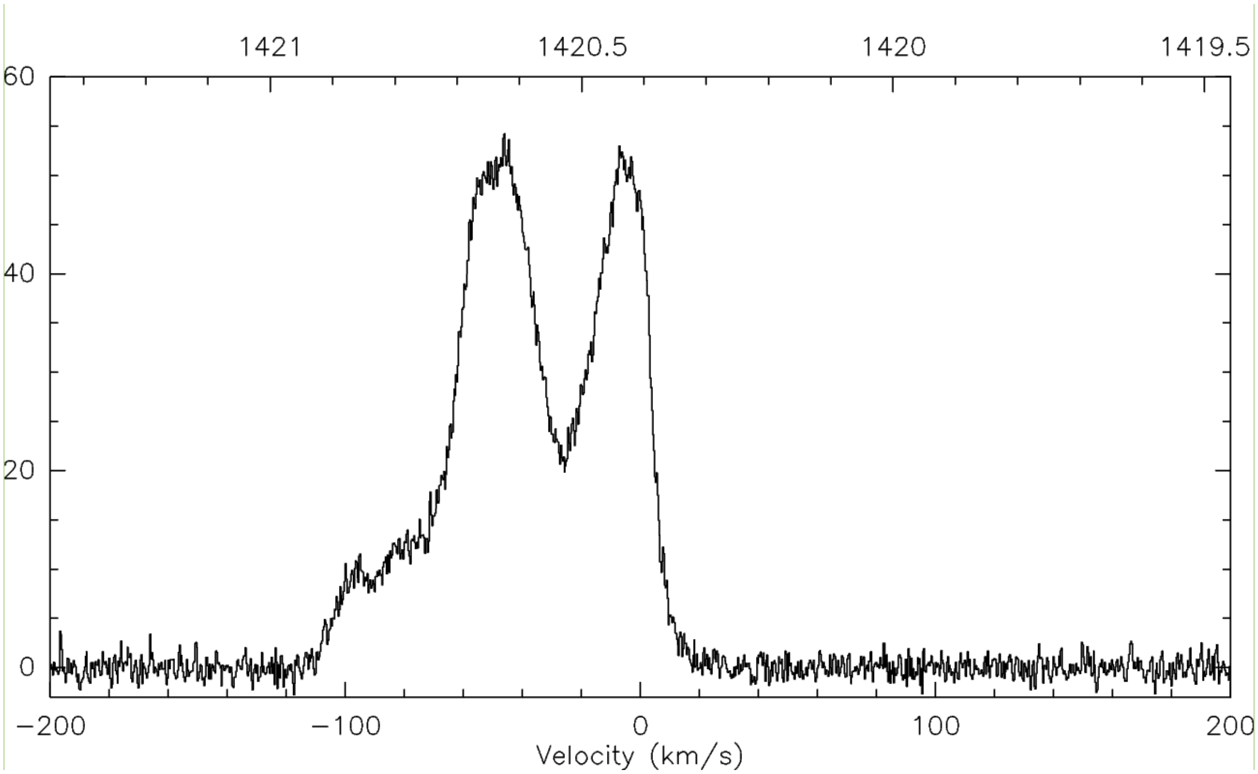


Fig 12: *Hydrogen spectrum at S7;*

Lower horizontal axis: Velocity (LSR-corrected), upper horizontal axis: Frequency in MHz; vertical axis: brightness temperature in K

This recording was taken on the 30th of November 2020. It concluded an effort which began on Nov. 18th, 2019 when we picked up the telescope elements in Bamberg. So it took one year to refurbish the telescope, to design the new elements and to do the commissioning work. The telescope was then ready for full characterization and observations. This will be the subject of the next article in this series.

Reference:

[1] W. Kalberla et.al., Brightness Temperature Calibration for 21-cm Line Observations, Astron. Astrophys. 106, 190-196 (1982)

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VLF signal directions and SID direction transients measured with sidmon3

Nathan Towne

Abstract

Sudden Ionospheric Disturbances (SIDs) affect electron densities in the ionosphere, which in turn affect terrestrial radio propagation at lower frequencies where the waves are confined to the Earth/ionosphere waveguide. This affects particularly signal intensities, an effect utilized by the Stanford SID receiver, SuperSID, and others, to detect ionospheric changes brought on by X-ray bursts from the sun. The code sidmon3 was recently developed to, in addition to detecting intensity transients, measure signal direction transients associated with SIDs. Since then, several months of SID data have been taken with direction data showing that the precision of the direction data can be below 0.1 degree with a strong transmitter and one-minute integration times. These data in fact show measurable direction transients associated with stronger SIDs, a definite approximately linear relation between the SID direction and intensity transients specific to each transmitter/receiver pair, and interesting distributions revealed by direction/intensity histograms with completely different day and night distributions. These results suggest that, while information about the ionospheric paths between transmitters and receivers may be available from the histograms, limited information about SIDs is provided by the direction transients. This paper is a summary of these results.

Introduction

I developed the first version of sidmon in 2017. As with other SID monitoring VLF receivers, it records transmitter intensities for the purpose of detecting intensity transients indicative of ionospheric disturbances affecting VLF radio propagation in the Earth-ionosphere waveguide. As you know, these propagation transients often result from X-ray bursts from solar flares and corona mass ejections from the sun. So sidmon does what other SID monitoring receivers do, such as the original Stanford receiver [SID monitor] and SuperSID [SuperSID]. sidmon has an exceptional line-intensity detection algorithm able to exclude narrow (spurious) lines in spectra from intensity measurements, and a veto feature for detecting and excluding short-duration transients. In spite of these features, I don't regard sidmon as clearly better than those other receivers.

But early in 2022 I developed in sidmon the additional capability to measure the direction from which VLF signals originate. This is done using a second loop antenna orthogonal to the first, both with vertical orientation, and using the simultaneous-sampling capability of dual-ADC sound cards. Because the signal from each loop is modulated by the direction cosine between the vector normal to the loop and the direction of the RF wave's magnetic field, and with the two antennas at 90 degrees relative orientation, the direction of the signal can be determined from the two intensities and the x/y cross correlation, although with a 180-degree ambiguity. Each of these measurements employs the intensity-detection algorithm mentioned earlier. This is basically how it works, and detection of SID direction transients is the benefit of this new capability. It has worked remarkably well in that precisions of measured directions can be below 0.1 degree with a strong source, such as NML from my location, one-minute integrations, and a low-EMI environment. Further information on how this new version of sidmon, sidmon3, works is available from the documentation [sidmon3, doc].

In the next section there is a discussion of the direction transients detected by sidmon3, scatter plots of the intensity/direction pairs of SIDs measured by sidmon3, and simple patterns present in these plots. In the following section there is a discussion of day and night distributions in intensity/direction space as revealed by sidmon3. This section is no longer about SID detections and SID monitoring, but simply illustrates the nature of the data provided by sidmon3 as it relates to signal fluctuations. Finally, there is a summary section.

Note that there is minimal interpretation of these data in terms of ionospheric or solar physics as I am not competent to contribute in these areas.

SID transients

Figure 1 is an example of an intensity/direction graph from March 31. The blue trace is uncalibrated intensity, while the red trace is direction relative to the beam-formed antenna pointing for that transmitter (explained in the sidmon3 documentation [sidmon3]). The SID at 18:30 UT is caused by an M9.8 x-ray burst, nearly X level. While small on the vertical scale, the direction transient has high signal-to-noise ratio as shown in the inset.

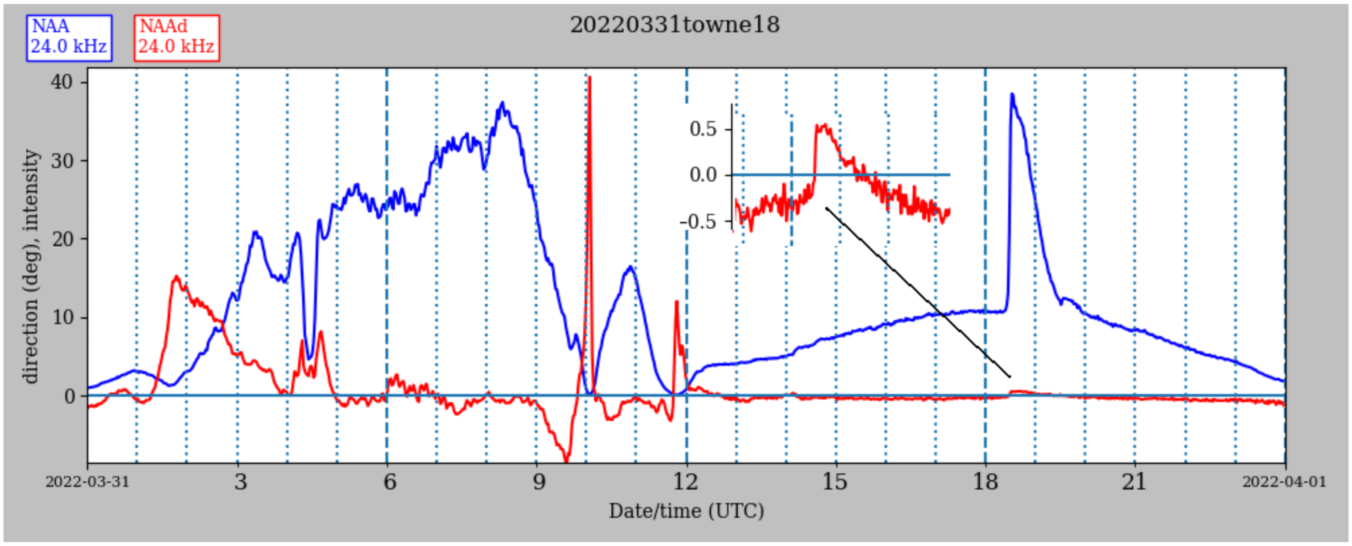

Figure 1: Example graph of transmitter intensity and direction also containing a SID.

Figure 2 shows SIDs on an NLK signal. Here the intensity transients are negative, while the direction transients are positive and rather more prominent that in the NAA example. From left to right, the intensities of the three x-ray bursts starting at 18:00 UT are C6.2, M1.5, and M4.4.

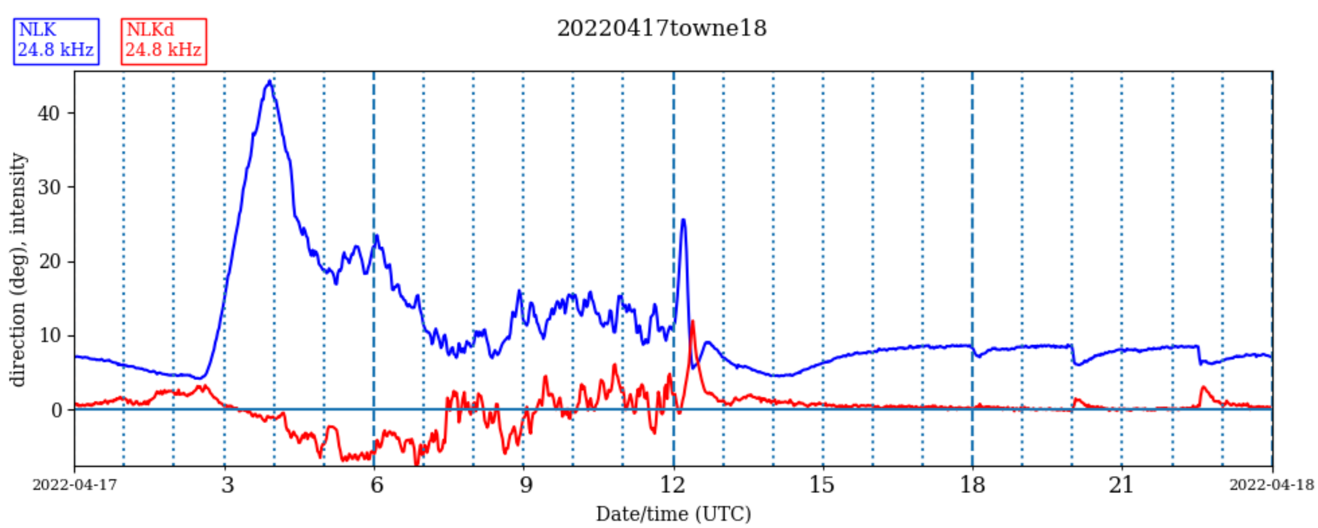

Figure 2: NLK intensity and direction plot containing a series of SIDs.

For a given transmitter, the signs of both intensity and direction transients are generally consistent among the events. For modest-intensity x-ray bursts, the transients appear as a fast rise representing some kind of excitation of the ionosphere by an x-ray burst, followed by an approximately exponential relaxation of the excitation after the burst finishes. The intensities of these transients are readily measured using the start-peak-end procedure used for SID reporting. But there are some exceptions. One is at low burst intensities where noise can dominate. The other is at very high (X-level) burst intensities where the excitation/relaxation behavior fails. An example is in Figure 3 of a SID driven by an X1.3 burst that shows a rather more complicated transient profile where the intensity shows a false negative start, a positive pulse, and negative overshoot. The full-resolution data show that the glitch just after 18:00 is when the transmitter was switched off for about 20 seconds.

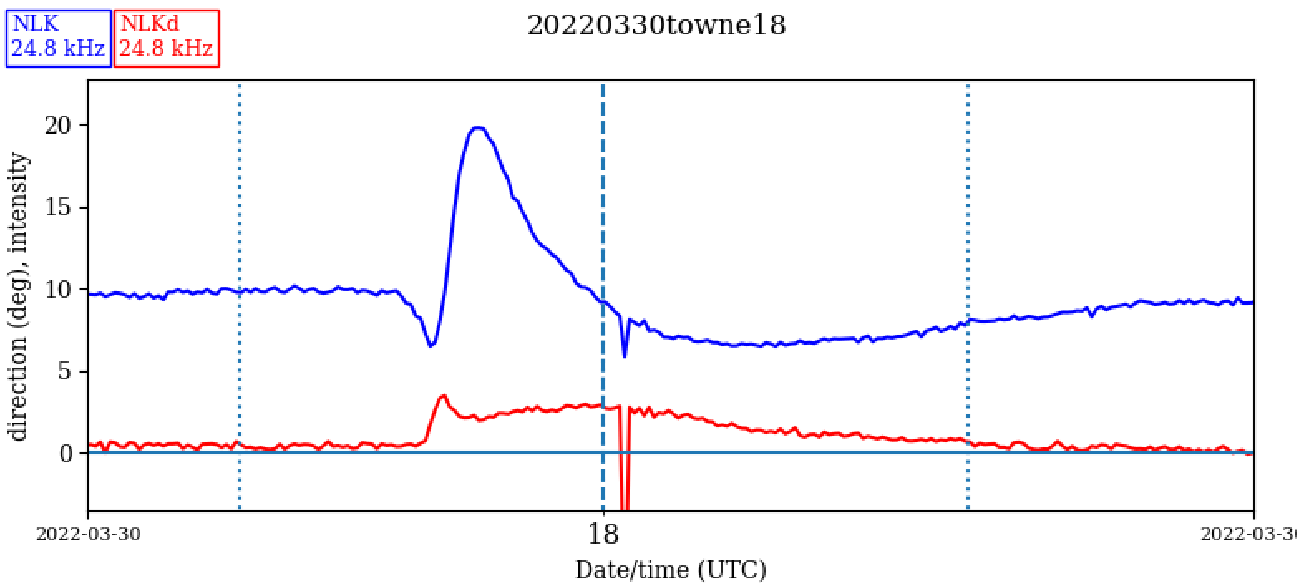

Figure 3: Example of an intense SID with anomalous transient profile.

Compare with the previous figure of an NLK-observed SID where the signs of the intensity and direction excursions have opposite signs. These cases do not allow an unambiguous intensity measurement via the start/peak/end methodology used in SID reporting. These odd profiles are familiar to SID observers.

As you may know, SIDs often appear prominently in dynamic spectra at upper HF frequencies such as in Figures 4 and 5.

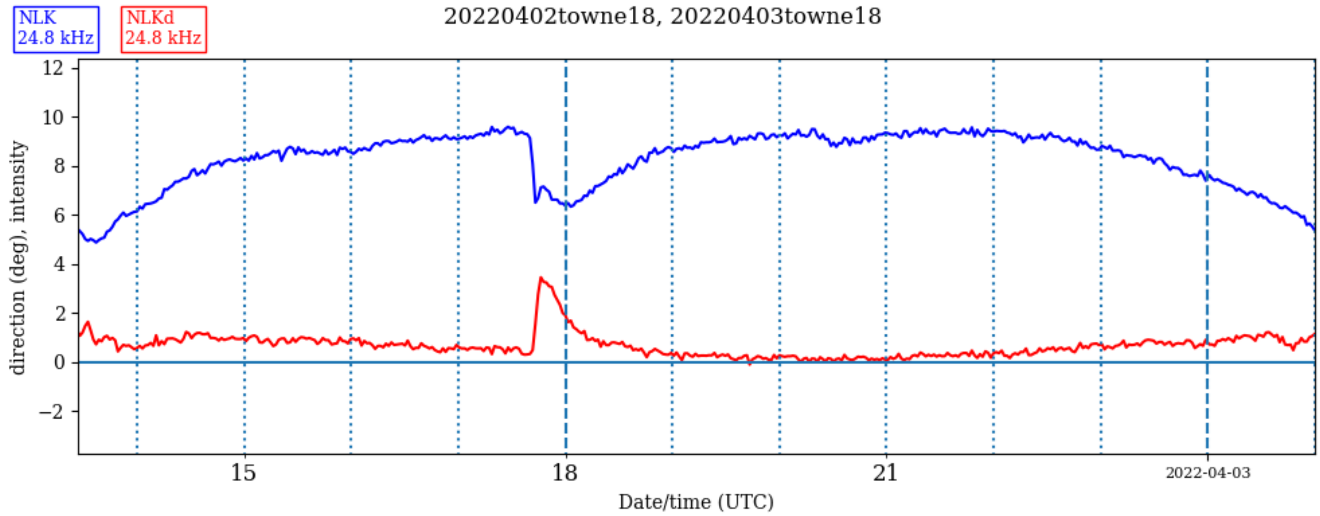

Figure 4: A strong SID driven by an M4.3 x-ray burst.

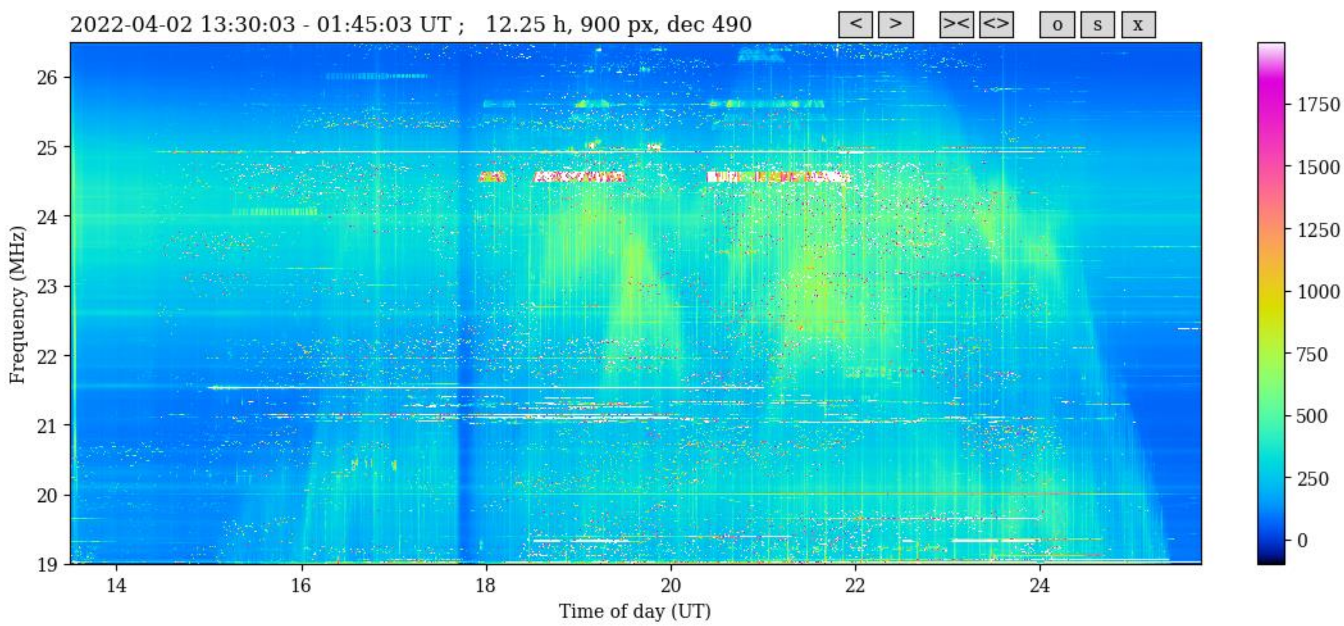

Figure 5: Impact of a SID on a dynamic spectrum at HF frequencies.

This SID is driven by an M4.3 burst. Spectrograph Users Group [SUG] members have on occasion contributed dynamic spectra showing transients at HF frequencies. Even at this modest x-ray-burst intensity, there is evidence in the shape of the intensity transient of failure of the excitation/relaxation behavior present in lower-intensity SIDs.

Aggregated intensities of SID intensity/direction transients show interesting patterns in scatter plots. Data for the scatter plots shown in the following graphs were extracted from SID plots in the same manner as is done for SIDS reporting - by marking the start, peak, and end of each SID transient with intensities extracted from the mark heights. Data points were extracted for all SIDs with measurable direction transients. So a data point consists of an intensity-transient intensity and a direction-transient intensity. Each can be positive or negative. Each point has the intensity transient as the x coordinate, and the direction transient as the y coordinate. The intensity coordinate is in fractional units, i.e., 1 unit means the transient has magnitude equal to the quiescent intensity. The y coordinate is the direction-transient intensity in degrees. The points also have the SID x-ray intensity as reported by the SWPC [SWPC] events reports coded into the points by color, C (blue) to X (red). The result is shown in the graphs of Figure 6. These graphs represent nearly six months of SID data.

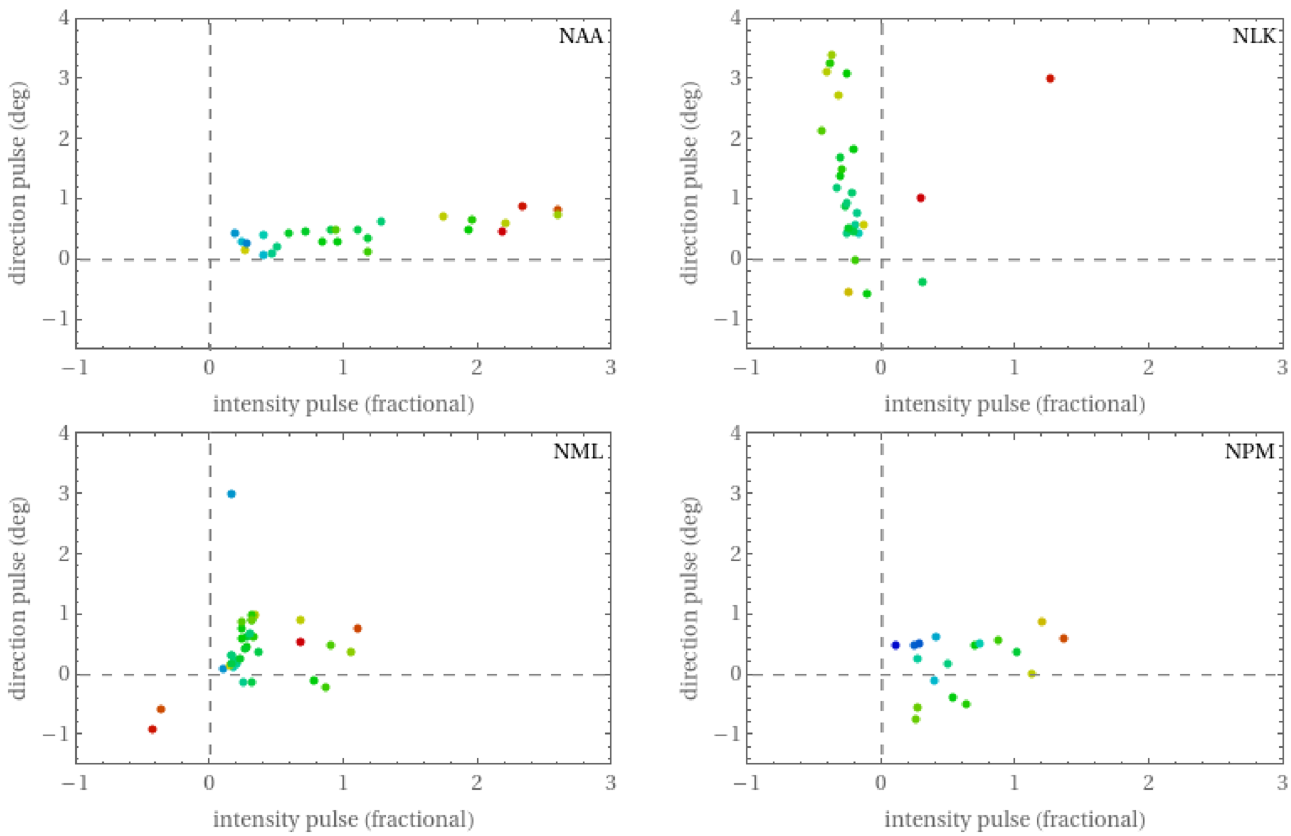

Figure 6: Scatter plot of SID events. The x axis is the fractional intensity of the intensity transient. The y axis is the direction transient in degrees.

I had expected that SID direction transients would have both signs, but evidently this is not the case. These graphs show instead that direction transients are as a rule positive, although here are outliers, including those driven by the X-level bursts discussed earlier (red points).

The graphs for NAA and NLK show particularly clear direction/intensity relations. In the case of NAA, the intensity transients are positive and there is a clear positive relation between intensity and direction transients. The NLK case is the opposite. Intensity transients are as a rule negative and there is a negative slope in the direction/intensity relation. These observations suggest a couple of things. First, because the data show that the direction transients are to a large degree determined by the intensity transient, a direction transient does not contain additional information about the SID itself beyond that which is revealed by the intensity transient. Second, that the sign of direction transients may be determined, or at least strongly influenced, by the details of the path between the source and receiver. In other words, the intensity/direction relation says something about daytime ionospheric physics as sampled by the transmitter-to-receiver paths. Not being knowledgeable about ionospheric physics, I cannot develop this idea further.

The graphs for NPM and NML do not show the clear trends seen in the NAA and NLK graphs - particularly NPM. In the NML case, there is a core set of points with intensity less than 0.4 and direction less than 1 degree that might be interpreted as a intensity/direction relation, but there are several outliers besides the red X-level ones.

Day and Night non-SID behavior

Putting aside SIDs in this section, data taken from VLF receivers for SID detection in general have information on terrestrial signal propagation. SID observers are accustomed to seeing, for example, the slow variation of transmitter intensities during daylight hours, and the erratic variations during nighttime. Directions also show these same behaviors: erratic fluctuations over several degrees at night, and almost constant direction during the day. An interesting thing to plot is the two-dimensional distribution of intensity and direction in the 2-d intensity/direction plane. Because these day and night behaviors are so different, I will show monthly data for the two cases separately. The histograms for March 2022 in the daytime hours are shown in Figure 7.

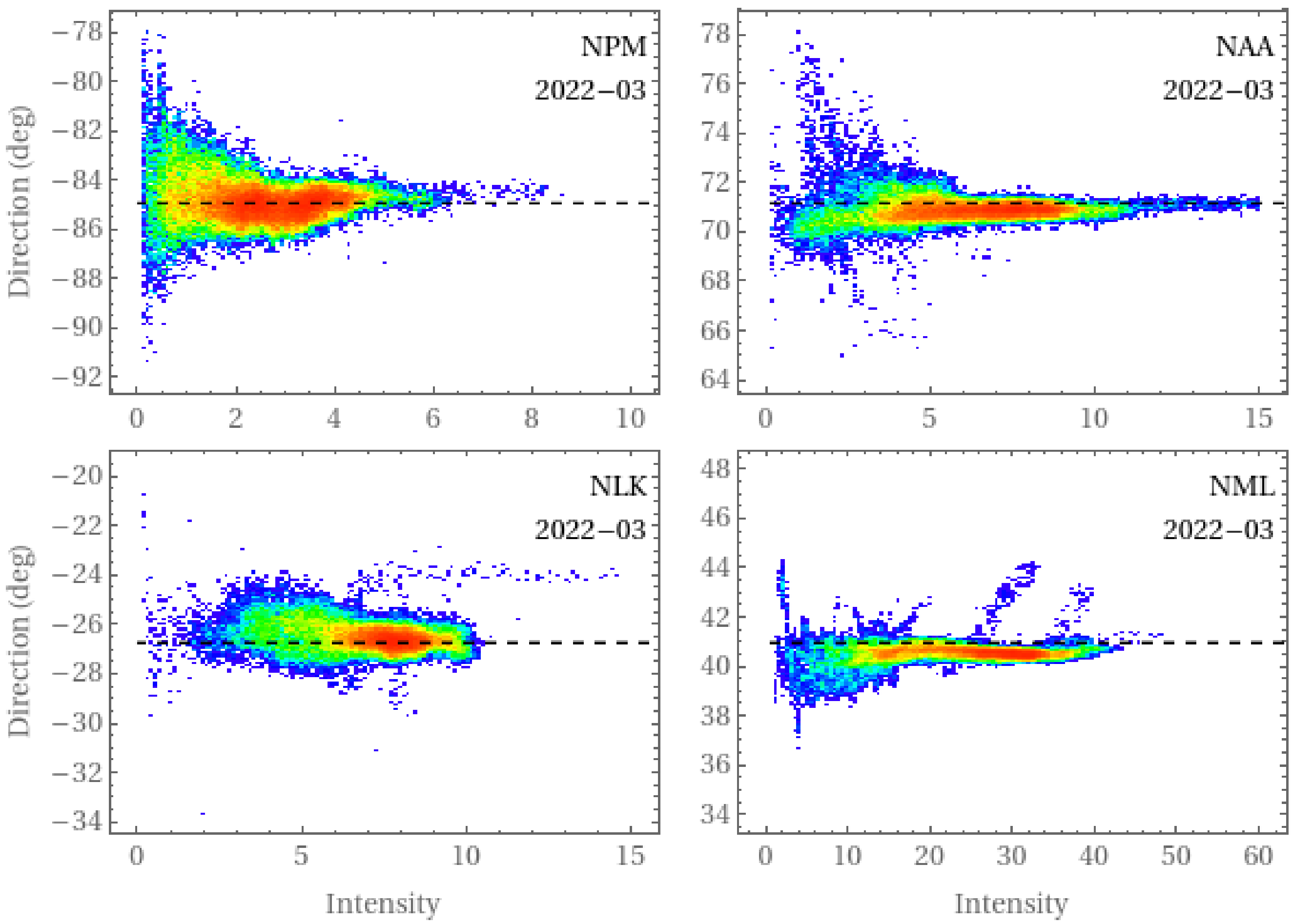

Figure 7: Two-dimensional histograms of transmitter intensity and received direction during the day-time hours during March of 2022. The x axis is uncalibrated received transmitter intensity. The y axis is the received direction in degrees with a span of 14 degrees. The individual plots are annotated with the transmitter and month. The dashed lines are the nominal pointings of synthesized beams.

Here the direction (vertical) span is 14 degrees and directions are relative to north with positive being clockwise (looking down). The color is from blue (zero bin count) to red (greatest bin count), where the scale is nonlinear, so that red regions do not show how sharply peaked the frequency is at their greatest.

During the day the directions stay near zero, with outliers near the start and end of the dataset. The finite (vertical) width is due to two contributions: the day-to-day variation of the direction, and sample-to-sample variation due to receiver noise. In the case of NML with its greater intensity, the receiver noise is below a tenth of a degree, which is reflected in its quite narrow direction distribution. This observation also suggests that day-to-day variation of the direction is rather small. The other transmitters signals are weaker, making receiver noise greater in those cases and direction distributions wider.

The night-time behavior of intensities and directions is quite different, where there are fluctuations reflecting the "turbulent nature of the nighttime ionosphere" [Gross, 2018]. Direction fluctuations span tens of degrees and intensity fluctuations are similarly large. March distributions are shown in the following graphs.

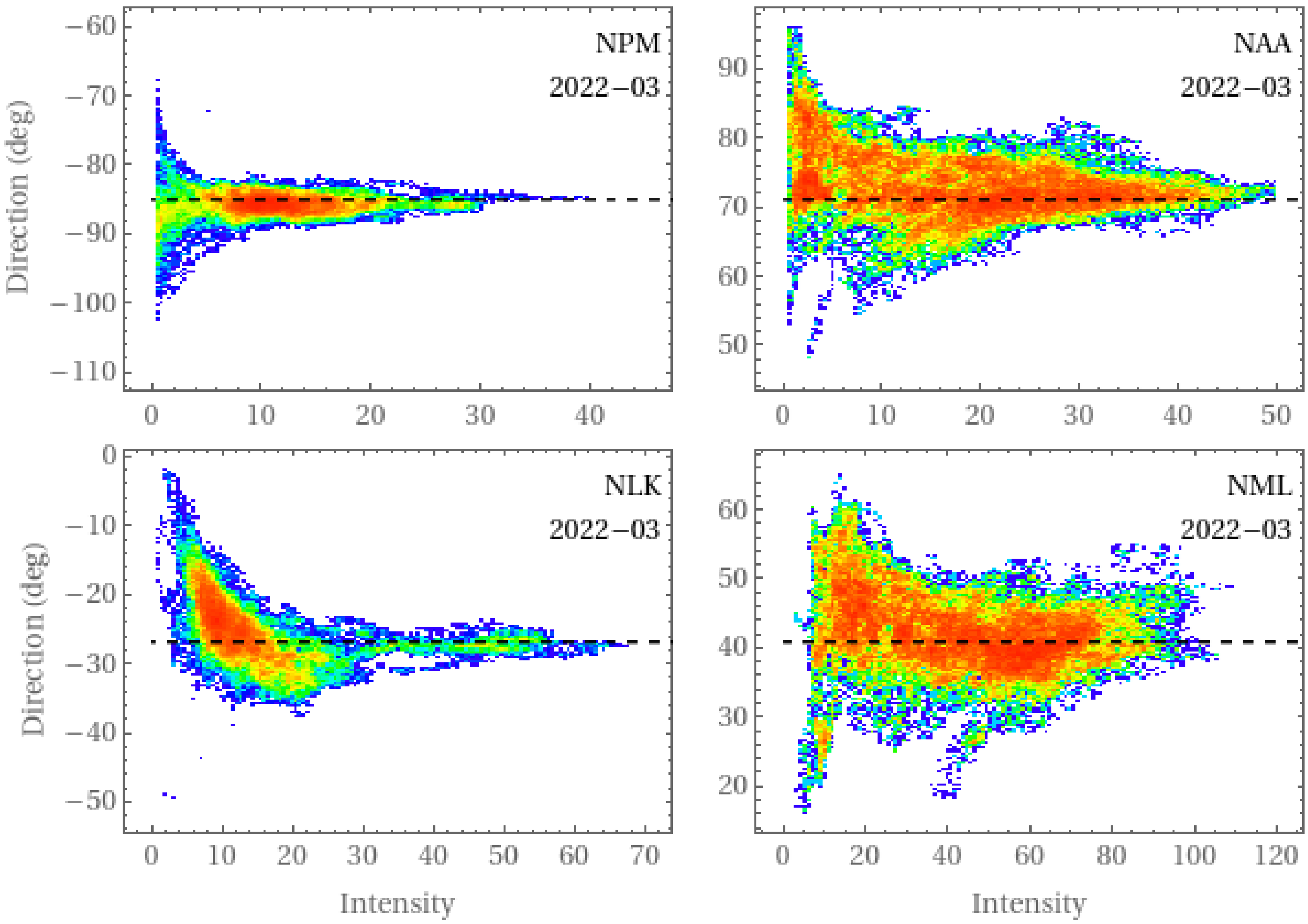

Figure 8: Two-dimensional histogram of transmitter intensity and received direction during the night-time hours during March of 2022. The x axis is uncalibrated received transmitter intensity. The y axis is the received direction in degrees with a span of 50 degrees. The individual plots are annotated with the transmitter and month. The dashed lines are the nominal pointing of synthesized beam.

In these graphs, the direction span is 50 degrees. The same color function as was used to graph day-time data was used.

The transmitters with negative bearings (left two above) have narrower direction distributions than transmitters with positive bearing. This effect persists throughout the nearly six months of data taken by sidmon3. Further data might reveal seasonal trends.

Histograms for other months (February through July 2022) are available online at links that start with "http://towne56.ownmail.net/sidmon/graphs/" and finish with "2022nnDay.png" for day-time histograms, where "nn" is the two-digit month. The links for the nigh-time histograms finish with "2022nnNight.png". For example, April's day and night graphs have the links:

http://towne56.ownmail.net/sidmon/graphs/202204Day.png
http://towne56.ownmail.net/sidmon/graphs/202204Night.png

There are also GIF files that animate all six months:

http://towne56.ownmail.net/sidmon/graphs/2022Day.gif
http://towne56.ownmail.net/sidmon/graphs/2022Night.gif

Summary

simdon3 [sidmon3; sidmon3, doc] has shown that VLF receivers can implement measurement of source directions using dual-channel sound cards accurately and in a simple manner. Directions measured by one such receiver has precision below 0.1 degree under some conditions, sufficient to detect direction transients of SIDs of modest intensity. Aggregated SID detections did not, however, suggest that direction transients contribute useful information about detected SIDs, and further data of longer durations and more source/receiver pairs could firm this tentative conclusion. But directions taken with intensities do reveal behaviors in direction/intensity histograms, and further data could fill out seasonal behaviors, possibly contributing interesting ionospheric physics.

Although SID monitoring may not benefit from measurement of direction transients, the use of dual orthogonal antennas and synthesized beams does benefit SID monitoring in that the receiver can synthetically point the antenna towards each transmitter, getting the maximum sensitivity of the receiver for each transmitter even though the antennas are fixed. This is a feature that should be considered for other SID VLF receivers employing sound cards.

Synthesized beams is a powerful tool, but it should be noted that it is not consistent with the practice of orienting a single antenna so as to best null local RFI [Harfmann, 7/8/2022]. So dual antennas and beam pointing is not useful in some high-EMI environments.

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[SUG], Spectrograph Users Group, http://www.radiojove.org/SUG/.
[SWPC], Space Weather Prediction Center, site: https://www.swpc.noaa.gov/; events reports: ftp://ftp.swpc.noaa.gov/pub/indices/events/.
[Harfmann, 7/8/2022], Antenna orientation for EMI nulling, 7/8/2022 SARA-list email.
[SuperSID], https://www.radio-astronomy.org/node/210, https://github.com/sberl/supersid, https://groups.io/g/supersid
[SID monitor], http://solar-center.stanford.edu/SID/sidmonitor/

About the author

Nathan Towne has a Masters degree in Physics from the University of Chicago and a long career in RF and beam physics for particle accelerators. He became interested in astronomy as a child and built small optical telescopes off and on over the years. In 2010 he more intensively pursued telescope optics and interferometry, telescope control, and image processing. Now retired, he develops receivers and studies phenomena seen in dynamic spectra at HF frequencies. You can contact the author at towne56@ownmail.net.

Observations of the water maser sources W49 and W51

Eduard Mol

Water masers are a type of radio sources which emit an amplified spectral line of water at 22.235 GHz. They are commonly found in star forming regions and in the gas envelopes of evolved stars [1]. Water masers are among the brightest sources in the sky at microwave frequencies: the flux densities of the strongest water masers often exceed 10000 Jy. Water masers are also highly variable, with spectral components often changing in flux density and velocity over timescales of weeks to years [2]. One of the most exciting aspects of water masers is their flaring behaviour: occasionally, a spectral component in a water maser may become several times stronger and fade away again over the course of a few months or even weeks [3, 4]. The variability and flaring behaviour of water masers makes them interesting targets for long-term observing programs.

I have been interested in water masers ever since I first read about them. However, despite the high flux densities it is still very difficult to observe water masers due to the high frequency. A high-quality solid dish is needed and pointing has to be very accurate. For this project, a solid 1.1 metre offset dish was mounted on a HEQ5 telescope mount for accurate pointing and tracking.

Figure 7: 1- metre offset dish on HEQ5 mount

A norsat 9000LDF LNB was used to receive at 22.2 GHz. It has an LO frequency of 20250 MHz, so the water line is converted down to 22235-20250=1985 MHz. This is outside the tuning range of my airspy mini SDR, so a NeSDR XTR is used instead, which has an extended frequency range up to 2300 MHz. Because the LNB came without a feed, a rectangular horn feed was made from a sheet of brass foil. It was designed using the HDL-ANT program by W1GHZ [5]; the length of the horn is 25mm, the dimensions of the opening are 24X20mm.

Cold sky/ ground noise of this setup was 2.9 dB at 22.2 GHz. When pointing the dish at the Sun a 6.5 dB noise increase was measured, while pointing at the Moon resulted in a 0.5 dB noise increase.

The local oscillator of the Norsat LNB was not very stable. To solve this issue, a stable reference signal was recorded along with the observations, so that it could be used to correct for the frequency drift and offset afterwards. For generating the reference signal, a Leo Bodnar GPSDO was used. The output of this GPSDO is not a very "clean" signal, it has lots of harmonics at higher frequency. This was actually desirable for my project: when a crude homemade 13.5mm dipole antenna was attached to the output and the GPSDO output frequency was set to

794.107143 MHz, the weak 28th harmonic at 22235 MHz could be detected. To prevent this setup from generating lots of RFI at lower frequencies, a small circular waveguide was built from a piece of 1cm copper tube. The inner diameter is 8mm, so the cut-off frequency should be around 11 GHz. In order to make this small antenna more directional, a conical horn section with an opening of 35mm was added.

Figure 8: reference signal source

For recording spectra, SDR# with the IF average plugin was used. Spectra were recorded every few minutes. Off-target spectra for bandpass correction were recorded before and after the on-target spectra, and sometimes on- and off-target spectra were recorded alternately to compensate for the effect of temperature changes.
In total, four sources were successfully observed: W49, W51, W3 and Orion KL. All four sources are associated with major star forming complexes. W49 and W51 were relatively strong and easier to detect, while the other two sources were much weaker and more difficult to detect. It was therefore decided to focus on W49 and W51 for more long-term observations.

W49
W49 is a massive star-forming complex at a distance of 11.4±1.2 kiloparsec (approximately 37000 light-years) [6]. It is often the most powerful water maser source, with flux densities ranging from 6000 to 80000 Jansky reported in the maser database MaserDB [7]. Shown below are the results of the observations carried out roughly every month since February 2022. Integration times were typically 20- 30 minutes. Since the reference signal was only installed in May, the first three spectra had an uncertain frequency. The LSR velocity scale for these spectra has been established by aligning the peaks in the spectra with those in the later spectra (which did have an exact frequency scale). Note that the vertical scale has not been calibrated to antenna temperature or flux density. Some of the intensity changes could therefore be attributed to variations in amplifier gain, atmospheric moisture or pointing inaccuracies. However, these effects are expected to change the apparent intensity of all peaks in the spectrum equally. In the spectra shown below, some of the peaks vary independently of each other, while other peaks are more stable. Such results could only be explained by the intrinsic variability of the source.

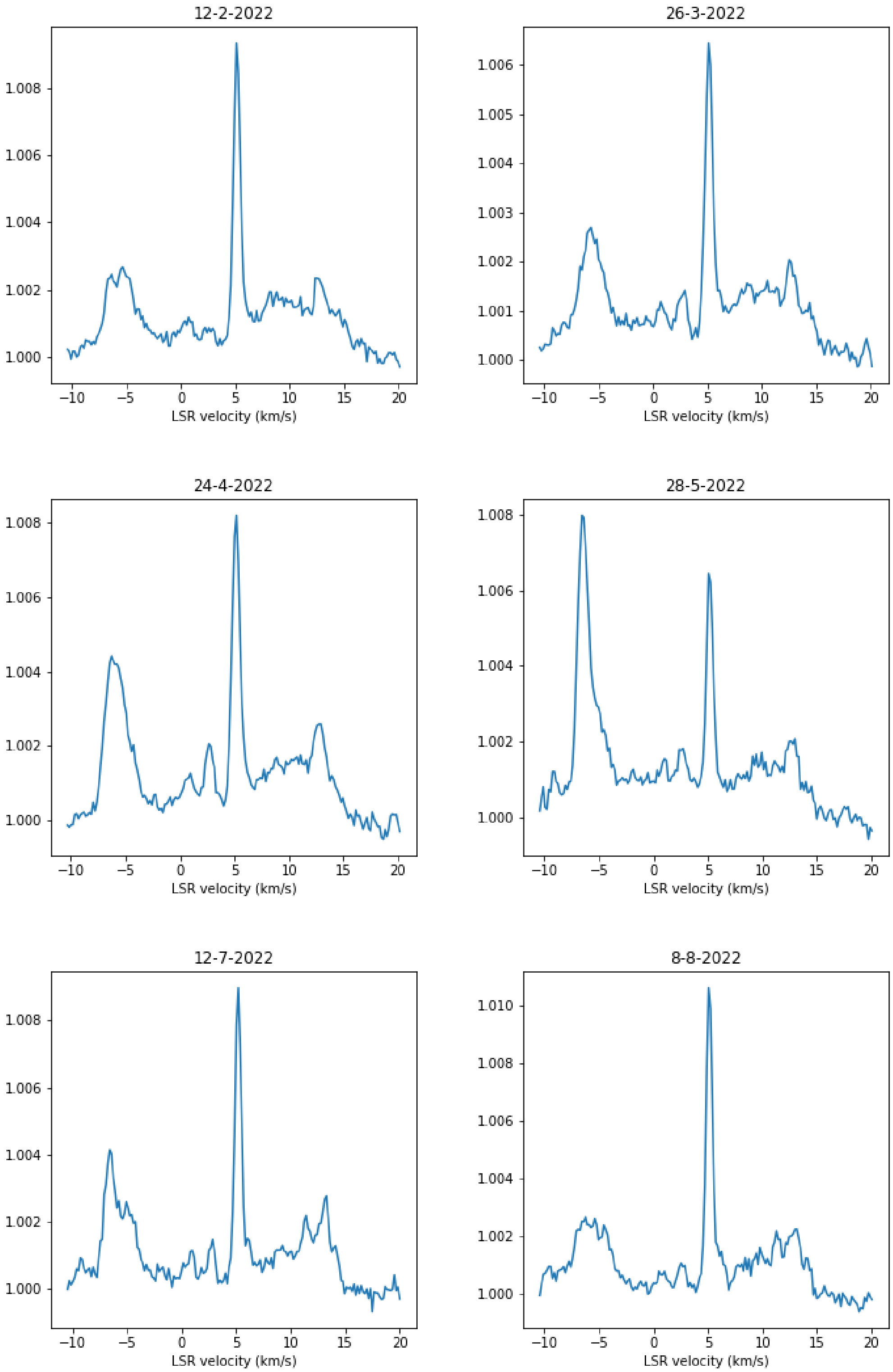

Figure 9: spectra of the W49 water maser from the period February- August 2022

Another way to show the changes in the spectrum is by plotting a heatmap. Most features in the spectrum, including the strong peak at 5 km/s, seem to be relatively stable. The feature at -6 km/s flared around May 28, but was mostly gone at August 8. A fainter feature emerged at -9 km/s at the same time when the -6 km/s flared. A new feature also appeared at 11 km/s since July 12.

In addition to the monthly spectra, a 12 MHz wide spectrum was made on August 6 by combining six 2.5 MHz wide spectra taken at 2 MHz intervals, with an integration time of 10 minutes per spectrum. Most of the emission falls within the -10 - +15 km/s range, which is covered by the spectra recorded earlier. However, several weaker peaks are present at high velocities, such as the peaks at -42 km/s and +58 km/s.

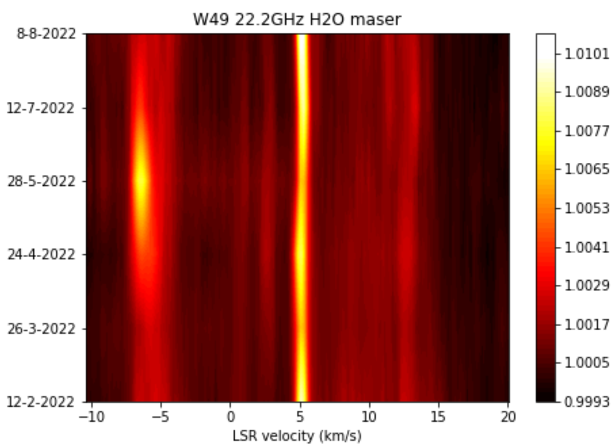

Figure 10: heatmap plot of all the spectra of W49

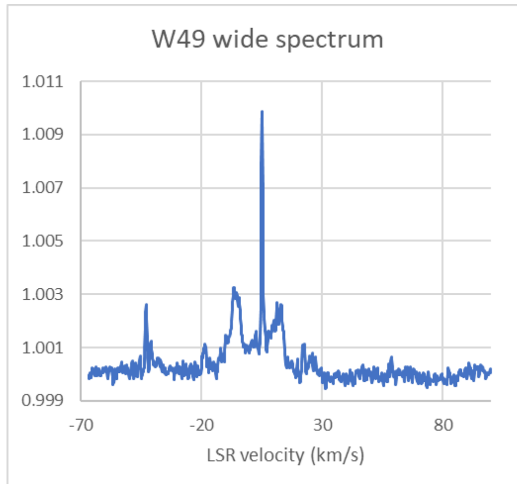

Figure 11: 12 MHz wide spectrum of W49

W51

W51 is another large star forming complex at a distance of 5.4±0.3 KPc, or approximately 18000 light-years [8]. The W51 water maser is normally weaker than W49: flux densities ranging from 400 to 7000 Jansky are reported on MaserDB [7]. However, when I detected W51 for the first time in February 2022 it appeared to be stronger than W49. A flaring event in W51, reaching 26200 Jansky, was reported on the Astronomers' Telegram in October 2021 [9]. It is possible that the flare was still ongoing in February, or that a new flare had emerged by that time. The intensity of the maser had decreased by a factor of >10 in April. In the period April- August, there was only minor variation observed, but this low- amplitude variation could also be attributed to variable observing conditions (temperature and moisture).

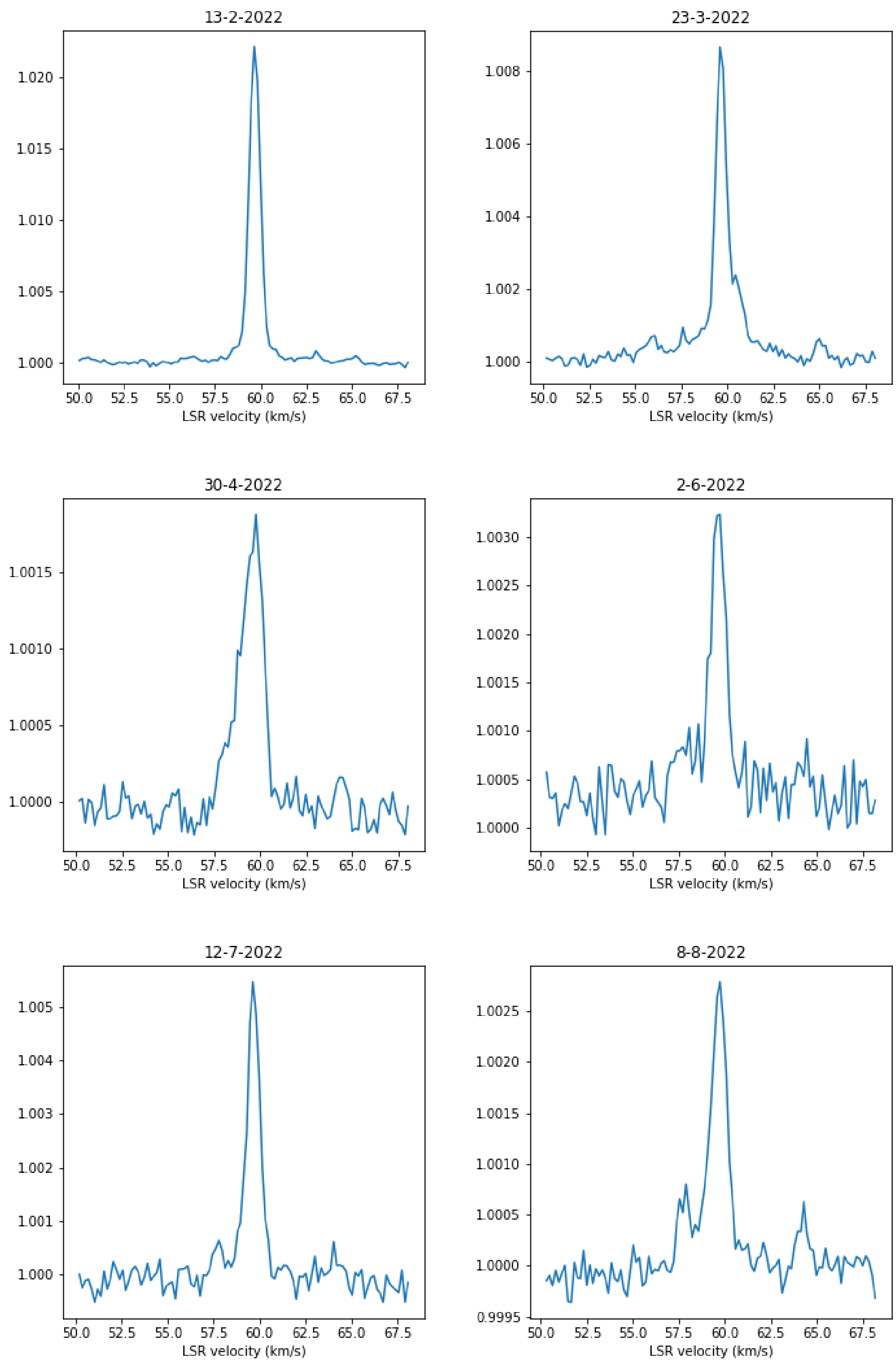

Figure 12: spectra of the W51 water maser from the period February- August 2022

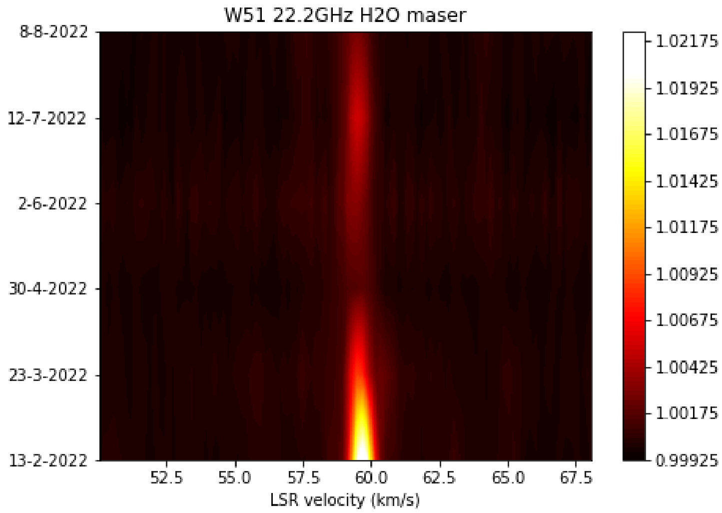

Figure 13: heatmap plot of all the spectra of W51

Conclusion

This project has demonstrated that it is possible to detect the strongest water masers with a dish as small as 1 metre and off-the-shelve equipment. Furthermore, by doing monthly observations of two masers, their variability has been successfully observed. Despite the technical challenges and limitations, the observation of water masers with small dishes presents new and interesting opportunities for radio astronomy enthusiasts.

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Observation Reports

Special Note:

These observation reports are from SARA members and have not been verified by peer review.

These observations are included in the journal to allow for discussion on improving the SARA member's observation system.

Some observations may be **false positives**, therefore the SARA staff requests that recommendations to improve the observation be addressed directly to the author.

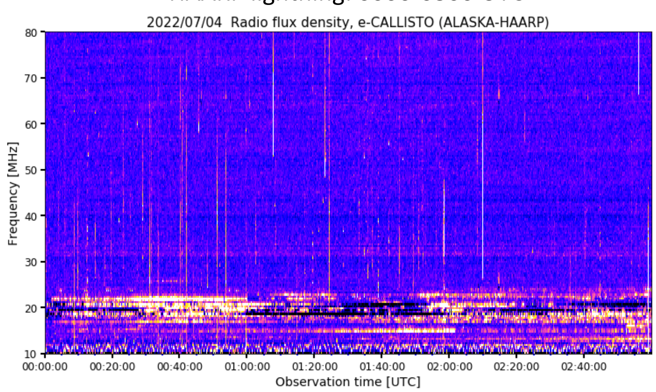
Nature's 4th of July Fireworks Observed in Alaska

Whitham D. Reeve

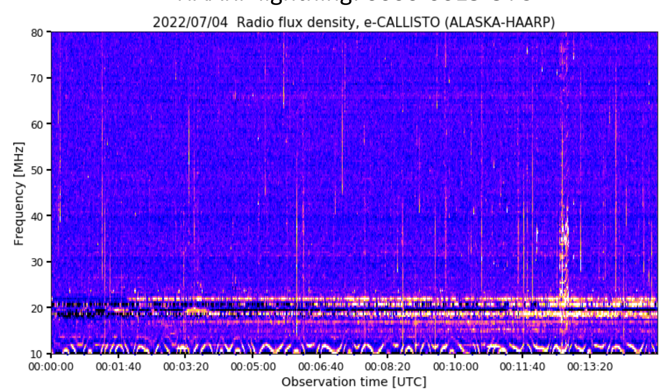
Nature celebrated the USA's greatest holiday, Independence Day – July 4th, with plenty of electromagnetic fireworks. The Sun produced numerous flares and radio bursts. The collision of a coronal mass ejection with Earth disturbed its magnetic field, producing aurora radio reflections. Terrestrial lightning produced broadband radio emissions. These were observed at three locations in Alaska – Anchorage Radio Observatory, Cohoe Radio Observatory and HAARP Radio Observatory – and discussed below. See Instrumentation section for information on the site locations and a brief description of the instrumentation and Resources section for internet links to explanations of the phenomena.

Thunderstorms developed during the local afternoon above the broad plain on which the HAARP Radio Observatory is located. The images below show the associated lightning activity as bright vertical lines over the frequency span of 10 to 80 MHz on two time scales. The left image spans the 3-h period from 0000 to 0300 UTC and the right image spans the 15-min period from 0000 to 0015. Note that the spectra appear very similar at both time scales. The bright horizontal lines below about 22 MHz are terrestrial HF transmissions.

HAARP lightning: 0000-0300 UTC

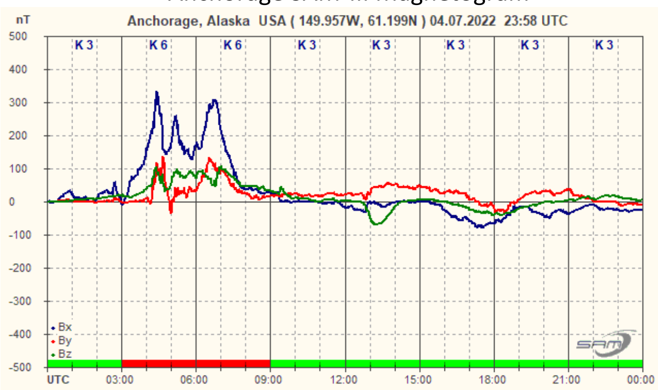


HAARP lightning: 0000-0015 UTC

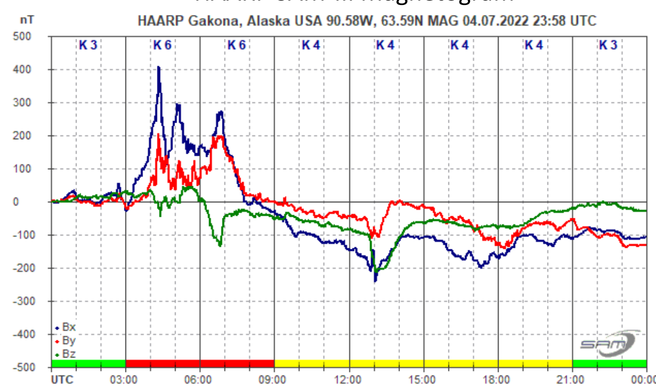


The two 24-h magnetograms below show geomagnetic activity observed at Anchorage Radio Observatory and HAARP Radio Observatory. The disturbances are quite pronounced in the 0300 to 0600 and 0600 to 0900 UTC synoptic periods. These were caused by merging of Earth's magnetic field with the solar magnetic field embedded in a coronal mass ejection from 29 June, altering the currents in the auroral electrojet and the magnetic field measured on the ground. The magnetograms show broad similarities but subtle differences.

Anchorage SAM-III Magnetogram



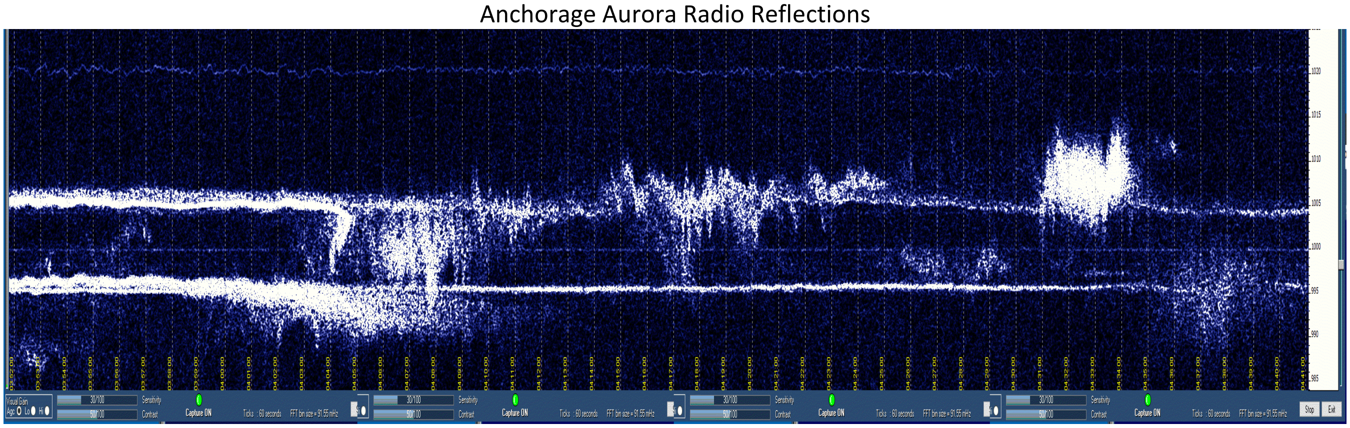
HAARP SAM-III Magnetogram



The separation in geomagnetic latitudes of the two observatories can explain some of the differences seen in the plots. The geomagnetic coordinates are 61.72° N, 94.41° W for Anchorage and 63.95° N, 90.58° W for HAARP, a difference of about 2° in latitude. The magnetometer at HAARP was installed only a few days before the measurements and the buried sensors were still acclimating to the underground temperatures over the holiday and showed some temperature related drift.

The narrowband spectrogram image below shows HF aurora radio reflections received at Anchorage Radio Observatory. The vertical frequency scale spans 40 Hz, and the horizontal time scale is the 50-min period between about 0350 and 0440 UTC. The 1-minute time stamps are seen as faint vertical yellow lines. The lower and upper traces correspond to demodulated WWVH carriers on 15 and 20 MHz, respectively, propagated to and reflected by enhanced electron density regions associated with aurora estimated to be 500 to 1000 km north of Anchorage. The reflections are related to the geomagnetic disturbances previously described. Four Argo spectrogram images were stitched together and then stretched vertically to visually enhance the reflections.

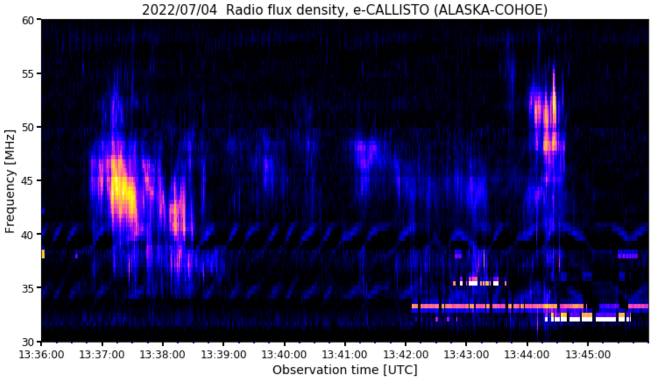
Anchorage Aurora Radio Reflections



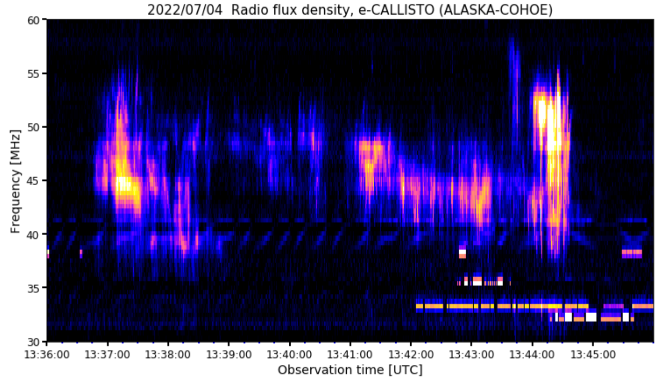
The spectra below from 30 to 60 MHz appear as *curtains of fire* and were obtained by the Callisto spectrometer instrumentation at Cohoe Radio Observatory and HARRP Radio Observatory in left- and right-hand circular polarizations (LHCP and RHCP, respectively). The spectra span the 10-min period from 1336 to 1346 UTC and show continuum radio emissions (possibly Type IV flare continuum) from the Sun. Space Weather Prediction Center reported a C5.1 x-ray flare and a Type II slow radio sweep during this time period but the sweep is not obvious in the spectra. The spectral structures are slightly different between the two observatories as are the polarizations.

The bright horizontal lines below 36 MHz late in the Cohoe Radio Observatory spectra are radio frequency interference of unknown origin.

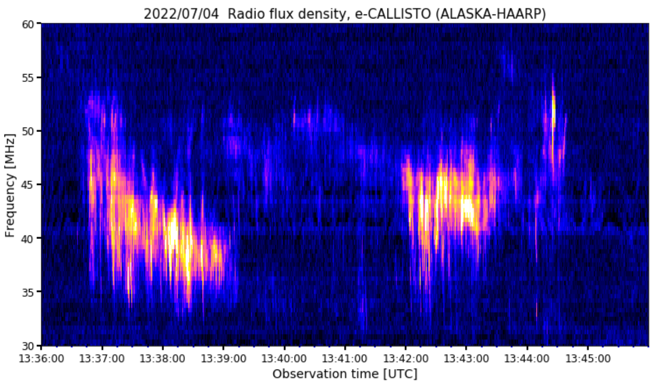
Cohoe Solar Radio LHCP



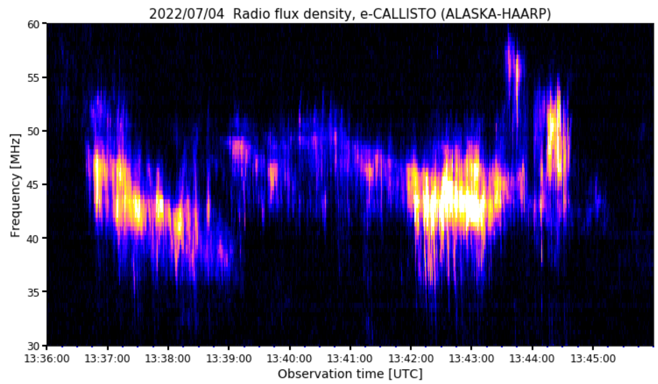
Cohoe Solar Radio RHCP



HAARP Solar Radio LHCP



HAARP Solar Radio RHCP



LWA Antenna at HAARP Radio Observatory on 1 July 2022, just before the holiday. The HRO equipment is collocated on the science pad with the Modular UHF Incoherent Radar (MUIR). Image © 2022 W. Reeve.

Instrumentation:

- Anchorage Radio Observatory, Anchorage, Alaska: 61° 11' 57.62" N, 149° 57' 23.49" W, 22 m AMSL
  - 8-element log periodic dipole array connected through a multicoupler to Icom R-8600 wideband receivers (LSB mode and carrier frequency offset) with audio outputs connected through an analog audio mixer to a PC soundcard, Argo software
  - SAM-III 3-Axis Magnetometer, SAM_VIEW software;
- Cohoe Radio Observatory, Cohoe, Alaska: 60° 22' 5.04" N, 151° 18' 55.74" W, 22 M AMSL
  - LWA Antenna connected through a quadrature coupler and RF power splitters to a dual up-converter and two Callisto instruments, Callisto software;
- HAARP Radio Observatory, Gakona, Alaska: 62° 23' 20.93"N, 145° 8' 15.51" W, 562 AMSL
  - LWA Antenna (shown above) connected through a quadrature coupler and RF power splitters to a dual up-converter and two Callisto instruments, Callisto software
  - SAM-III 3-Axis Magnetometer, SAM_VIEW software.

Resources:

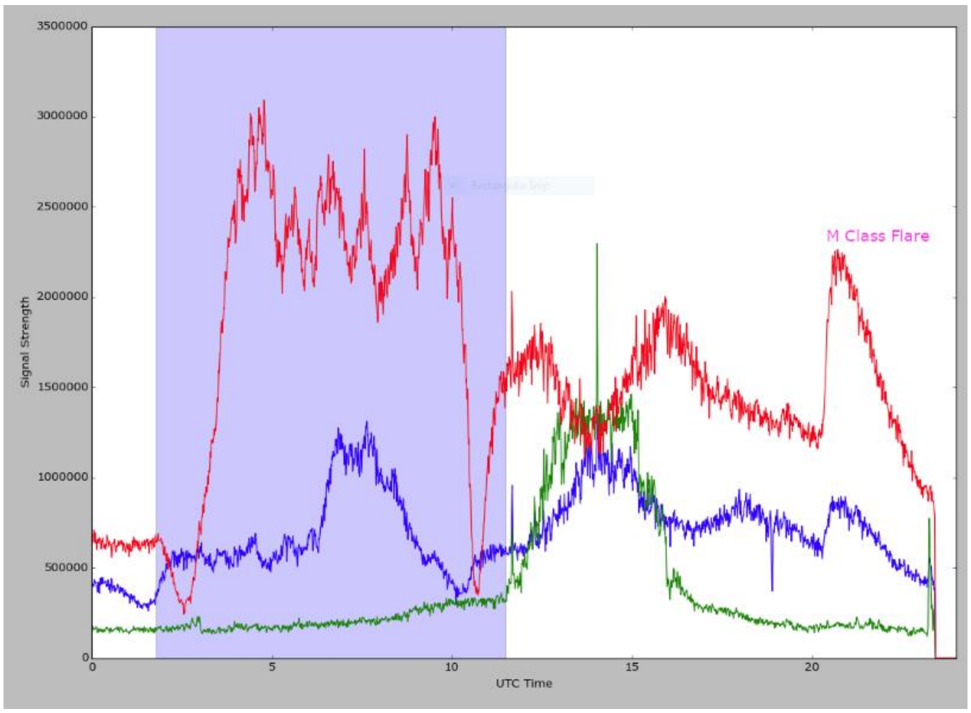
- Aurora radio reflections: HF Aurora Radio Reflections Observed at Anchorage, Alaska USA: https://reeve.com/Documents/Articles%20Papers/Reeve_AuroraRadioObsrv.pdf
- Geomagnetism Tutorial: https://reeve.com/Documents/SAM/GeomagnetismTutorial.pdf
- Solar radio burst types: https://reeve.com/Solar/Solar.htm
- Space Weather Prediction Center: https://www.swpc.noaa.gov/
- Type II Slow Sweep Radio Bursts: https://www.reeve.com/Documents/CALLISTO/Reeve_TypeII-Burst.pdf

Acknowledgements:

Callisto FITS files, credit: FHNW Brugg/Windisch and IRSOL Locarno, Switzerland, {Callisto}

First M-Flare observation from a new Super-SID
Richard Marsden

Earlier this summer, I installed a new Super-SID device in Wichita Falls, Texas. Attached is my first SID observation from 8th July 2022. This was confirmed as an M-Class Flare by the GOES X-Ray Flux Satellites (https://www.swpc.noaa.gov/products/goes-x-ray-flux).



The flare is clearest on red (NAA; Cutler ME transmitter), but also appears on blue (NLK; Jim Creek WA). Interestingly it does not appear on green (NML; La Maure ND) which is almost due north from the receiver. NAA also shows a good day/night transition signal.

I am still working to mitigate noise and to understand the various other peaks I see. I have replaced noisy fluorescent shop lights, and a very noisy dimmer switch in the house. I am in the process of constructing an ARRL RFI Sniffer (2022 ARRL Handbook, v6 27.51).

The SID receiver is constructed using PVC pipe to produce an approximately square loop 1.3m on a side. Data acquisition is a resurrected (>10yr old) PC with Windows 10 and the SuperSID software. The above recording was made with the antenna in my workshop approximately 1m from the PC. After detecting interference from the LCD monitor I have since moved it outside:

It has only been at this new location for about a week. I am undecided if it is any better and the extra run of RG58 cable gives me concern. Currently anchored with trampoline anchors and stones, I will probably raise it up above the ground by about 1ft. The wall a/c unit does not appear to produce any interference.

Membership

Journal Archives & Other Promotions

The rich and diverse legacy of member contributed content is available in the SARA Journal Archives. Table of contents for journals is available online at radio-astronomy.org/store.

The entire set of The Journal of The Society of Amateur Radio Astronomers is available on USB drive. It goes from the beginning of 1981 to the end of 2017 (over 6000 pages of SARA history!) Or you can choose one of the following USB drive's or DVD:* (Prices are US dollars and include postage.)

†All SARA journals and conference proceedings are available through the previous calendar year.

Prices, US dollars, including postage

Members	
Each USB drive	$15.00
USB drive + 1-year membership extension	$30.00
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Each USB drive	$25.00
USB drive + 1-year membership	$30.00
Non-USA members	
Each USB drive	$20.00 (airmail)
USB drive+ 1-year members extension	$35.00

*Already a member and want any or all these USB drives or DVD's? Buy any one for $15.00 or get any three for $35.00.

SARA Store (radio-astronomy.org/store.)

SARA offers the above USB drives, DVDs, printed Proceedings and Proceedings on USB drive and other items at the SARA Store: http://www.radio-astronomy.org/e-store. Proceeds from sales go to support the student grant program. Members receive an additional 10% discount on orders over $50 US. Payments can be made by sending payment by PayPal to treas@radio-astronomy.org or by mailing a check or money order to SARA, c/o Brian O'Rourke, 337 Meadow Ridge Rd, Troy, VA 22974-3256

SARA Online Discussion Group

SARA members participate in the online forum at http://groups.google.com/group/sara-list. This is an invaluable resource for any amateur radio astronomer.

SARA Conferences

SARA organizes multiple conferences each year. Participants give talks, share ideas, attend seminars, and get hands-on experience. For more information, visit http://www.radio-astronomy.org/meetings.

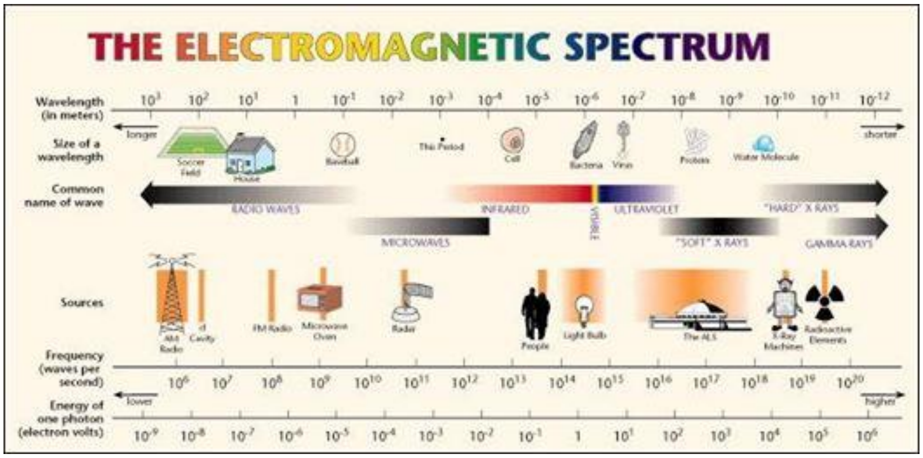
Facebook

Like SARA on Facebook
http://www.facebook.com/pages/Society-of-Amateur-Radio-Astronomers/128085007262843

Twitter
Follow SARA on Twitter@RadioAstronomy1

What is Radio Astronomy?

This link is for a booklet explaining the basics of radio astronomy.
http://www.radio-astronomy.org/pdf/sara-beginner-booklet.pdf



Administrative

Officers, directors, and additional SARA contacts

The Society of Amateur Radio Astronomers is an all-volunteer organization. The best way to reach people on this page is by email with SARA in the subject line SARA Officers.

President: Dr. Rich Russel, AC0UB, https://www.radio-astronomy.org/contact/President
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Past President: Dennis Farr, tbd@radio-astronomy.org
Founder Emeritus and Director: Jeffrey M. Lichtman, KI4GIY, jeff@radioastronomysupplies.com

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David Westman	2024	david.westman@engineeringretirees.org

Other SARA Contacts

All Officers	http://www.radio-astronomy.org/contact-sara

All Directors and Officers	http://www.radio-astronomy.org/contact/All-Directors-and-Officers	
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Webmaster	Ciprian (Chip) Sufitchi, N2YO	webmaster@radio-astronomy.org

Resources

Great Projects to Get Started in Radio Astronomy

Radio Observing Program

The Astronomical League (AL) is starting a radio astronomy observing program. If you observe one category, you get a Bronze certificate. Silver pin is two categories with one being personally built. Gold pin level is at least four categories. (Silver and Gold level require AL membership which many clubs have membership. For the bronze level, you need not be a member of AL.)

Categories include
1) SID
2) Sun (aka IBT)
3) Jupiter (aka Radio Jove)
4) Meteor back-scatter
5) Galactic radio sources

This program is a collaboration between NRAO and AL. Steve Boerner is the Lead Coordinator and a SARA member.

For more information:
Steve Boerner
2017 Lake Clay Drive
Chesterfield, MO 63017
Email: sboerner@charter.net
Phone: 636-537-2495
http://www.astroleague.org/programs/radio-astronomy-observing-program

Radio Jove

The Radio Jove Project monitors the storms of Jupiter, solar activity and the galactic background. The radio telescope can be purchased as a kit or you can order it assembled. They have a terrific user group you can join.
http://radiojove.gsfc.nasa.gov/

INSPIRE Program

The INSPIRE program uses build-it-yourself radio telescope kits to measure and record VLF emissions such as tweeks, whistlers, sferics, and chorus along with man-made emissions. This is a very portable unit that can be easily transported to remote sites for observations.
http://theinspireproject.org/default.asp?contentID=27

SARA/Stanford SuperSID

Stanford Solar Center and the Society of Amateur Radio Astronomers have teamed up to produce and distribute the SuperSID (Sudden Ionospheric Disturbance) monitor. The monitor utilizes a simple pre-amp to magnify the VLF radio signals which are then fed into a high definition sound card. This design allows the user to monitor and record multiple frequencies simultaneously. The unit uses a compact 1-meter loop antenna that can be used indoors or outside. This is an ideal project for the radio astronomer that has limited space. To request a unit, send an e-mail to supersid@radio-astronomy.org

Radio Astronomy Online Resources

AJ4CO Observatory – Radio Astronomy Website: http://www.aj4co.org/	A New Radio Telescope for Mexico - ORION 2021 01 20. Dr. Stan Kurtz https://www.youtube.com/watch?v=Q9aBWr1aBVc
Radio Astronomy calculators https://www.aj4co.org/Calculators/Calculators.html	National Radio Astronomy Observatory http://www.nrao.edu
Introduction to Amateur Radio Astronomy (presentation) http://www.aj4co.org/Publications/Intro%20to%20Amateur%20Radio%20Astronomy,%20Typinski%20(AAC,%202016)%20v2.pdf	NRAO Essential Radio Astronomy Course http://www.cv.nrao.edu/course/astr534/ERA.shtml
RF Associates Richard Flagg, rf@hawaii.rr.com 1721-1 Young Street, Honolulu, HI 96826	Exotic Ions and Molecules in Interstellar Space -- ORION 2020 10 21. Dr. Bob Compton https://www.youtube.com/watch?v=r6cKhp23SUo&t=5s
RFSpace, Inc. http://www.rfspace.com	The Radio JOVE Project & NASA Citizen Science – ORION 2020.6.17. Dr. Chuck Higgins https://www.youtube.com/watch?v=s6eWAxJywp8&t=5s
CALLISTO Receiver & e-CALLISTO http://www.reeve.com/Solar/e-CALLISTO/e-callisto.htm	UK Radio Astronomy Association http://www.ukraa.com/
Deep Space Exploration Society http://DSES.science	CALLISTO software and data archive: www.e-callisto.org
Deep Space Object Astrophotography Part 1 -- ORION 2021 02 17. George Sradnov https://www.youtube.com/watch?v=Pm_Rs17KIyQ	Radio Jove Spectrograph Users Group http://www.radiojove.org/SUG/
European Radio Astronomy Club http://www.eracnet.org	Radio Sky Publishing http://radiosky.com
British Astronomical Association – Radio Astronomy Group http://www.britastro.org/baa/	The Arecibo Radio Telescope; It's History, Collapse, and Future - ORION 2020.12.16. Dr. Stan Kurtz, Dr. David Fields https://www.youtube.com/watch?v=rBZlPOLNX9E
Forum and Discussion Group http://groups.google.com/group/sara-list	Shirleys Bay Radio Astronomy Consortium marcus@propulsionpolymers.com
GNU Radio https://www.gnuradio.org/	SARA Twitter feed https://twitter.com/RadioAstronomy1
SETI League http://www.setileague.org	SARA Web Site http://radio-astronomy.org
NRAO Essential Radio Astronomy Course http://www.cv.nrao.edu/course/astr534/ERA.shtml	SARA Facebook page https://www.facebook.com/pages/Society-of-Amateur-Radio-Astronomers/128085007262843
NASA Radio JOVE Project http://radiojove.gsfc.nasa.gov Archive: http://radiojove.org/archive.html https://groups.io/g/radio-jove	Simple Aurora Monitor: Magnetometer http://www.reeve.com/SAMDescription.htm
National Radio Astronomy Observatory http://www.nrao.edu	Stanford Solar Center http://solar-center.stanford.edu/SID/

For Sale, Trade and Wanted

At the SARA online store: radio-astronomy.org/store.

SARA Polo Shirts

New SARA shirts have arrived.

We now have a good selection of X, XX, and XXX shirts available in all colors including white!

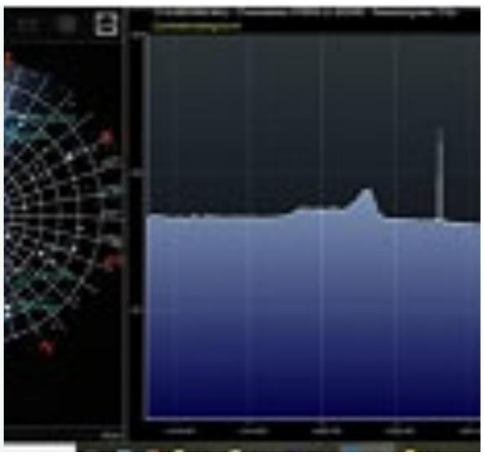
Shirts are $20 at the conference and $25 shipped.

Contact the treasurer at treas@radio-astronomy.org for availability and shipping.

Scope in a Box $295

radio-astronomy.org/store.

Kit of parts and software to build a working Radio Telescope to detect Hydrogen Line emissions. Available to USA addresses only at this time.



SuperSID Complete Kit ($112-$160 depending on options)
radio-astronomy.org/store.

SARA Publication, Journals and Conference Proceedings (various prices)
radio-astronomy.org/store.

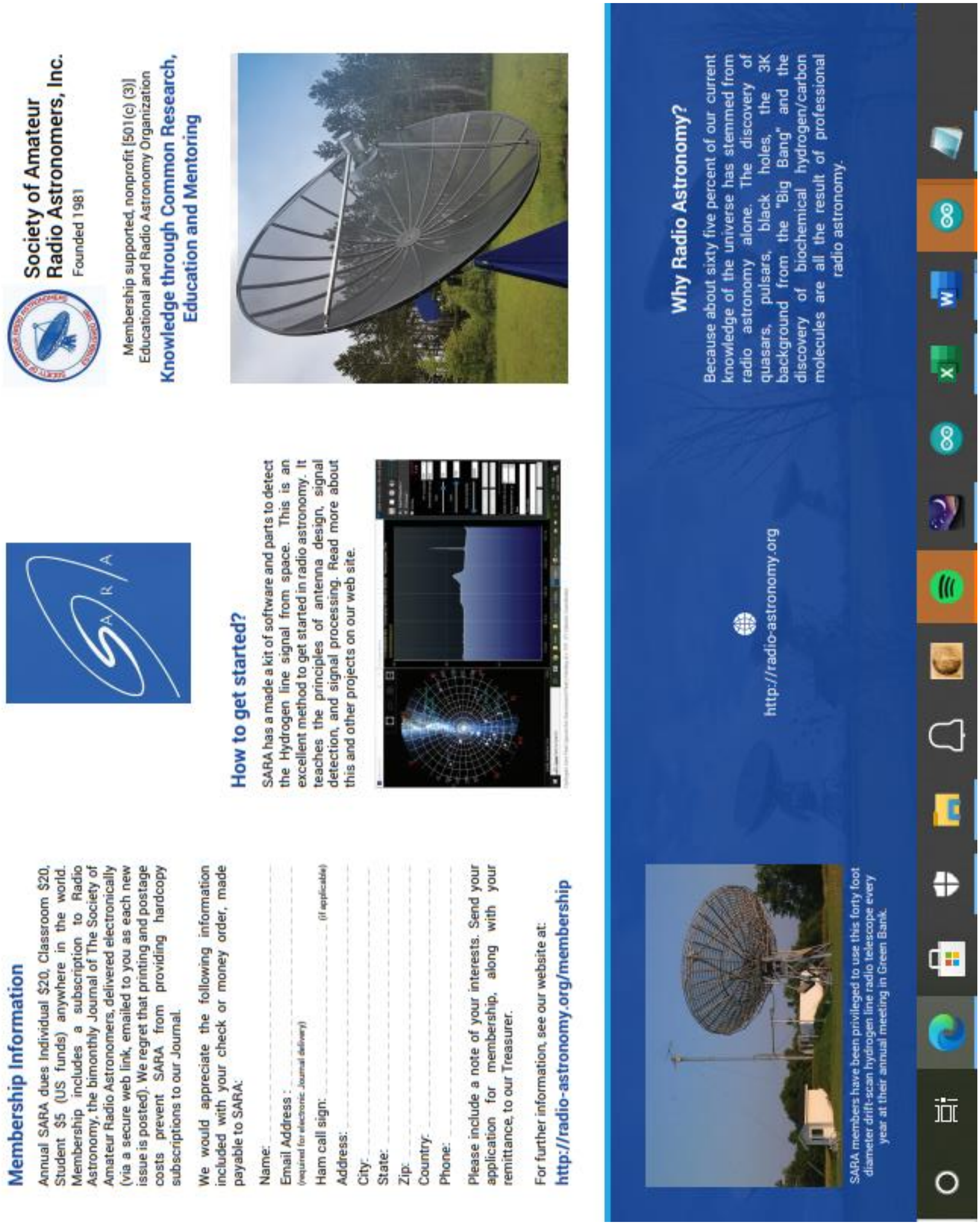
SARA Journal USB Drive ($15-$35 depending on shipping option)
radio-astronomy.org/store.

The USB drive covers the society journal "Radio Astronomy" from the founding of the organization in 1981 thru 2020. Articles cover a wide range of topics including: cosmic radiation, pulsars, quasars, meteor detection, solar observing, Jupiter, Radio Jove, gamma ray bursts, the Itty Bitty Telescope (IBT), dark matter, black holes, the Jansky antenna, methanol masers, mapping at 408 MHz and more. This CD contains all of the above and more with over 4800 pages of articles on radio astronomy. Also included is a copy of Grote Reber's handwritten, 34 page document "Carriage and Mirror Detail" of his historic antenna now on display at the National Radio Astronomy Observatory (NRAO) in Greenbank, WV. You also get an electronic copy of the 109 page "Basics of Radio Astronomy" from JPL Goldstone-Apple Valley Radio Telescope. Also included is the NRAO 40-foot radio telescope "Operators Manual", which by the way, you get to operate if you attend the Eastern SARA conference in July.

SARA Advertisements

There is no charge to place an ad in Radio Astronomy; but you must be a current SARA member. Ads must be pertinent to radio astronomy and are subject to the editor's approval and alteration for brevity. Please send your "For Sale," "Trade," or "Wanted" ads to edit@radio-astronomy.org. Please include email and/or telephone contact information. Please keep your ad text to a reasonable length. Ads run for one bimonthly issue unless you request otherwise.

SARA Brochure



Membership Information

Annual SARA dues Individual $20, Classroom $20, Student $5 (US funds) anywhere in the world. Membership includes a subscription to Radio Astronomy, the bimonthly Journal of The Society of Amateur Radio Astronomers, delivered electronically (via a secure web link, emailed to you as each new issue is posted). We regret that printing and postage costs prevent SARA from providing hardcopy subscriptions to our Journal.

We would appreciate the following information included with your check or money order, made payable to SARA:

Name: ____________________

Email Address : ____________________
(required for electronic Journal delivery)

Ham call sign: ____________________ (if applicable)

Address: ____________________

City: ____________________

State: ____________________

Zip: ____________________

Country: ____________________

Phone: ____________________

Please include a note of your interests. Send your application for membership, along with your remittance, to our Treasurer.

For further information, see our website at:
http://radio-astronomy.org/membership

How to get started?

SARA has a made a kit of software and parts to detect the Hydrogen line signal from space. This is an excellent method to get started in radio astronomy. It teaches the principles of antenna design, signal detection, and signal processing. Read more about this and other projects on our web site.

Society of Amateur Radio Astronomers, Inc.
Founded 1981

Membership supported, nonprofit [501(c) (3)]
Educational and Radio Astronomy Organization

Knowledge through Common Research, Education and Mentoring

SARA members have been privileged to use this forty foot diameter drift-scan hydrogen line radio telescope every year at their annual meeting in Green Bank.

http://radio-astronomy.org

Why Radio Astronomy?

Because about sixty five percent of our current knowledge of the universe has stemmed from radio astronomy alone. The discovery of quasars, pulsars, black holes, the 3K background from the "Big Bang" and the discovery of biochemical hydrogen/carbon molecules are all the result of professional radio astronomy.

The Society of Amateur Radio Astronomers

SARA was founded in 1981, with the purpose of educating those interested in pursuing amateur radio astronomy.

The society is open to all, wishing to participate with others, worldwide.

SARA members have many interests, some are as follows:

SARA Areas of Study and Research:

- Solar Radio Astronomy
- Galactic Radio Astronomy
- Meteor Detection
- Jupiter
- SETI
- Gamma Ray/High Energy Pulse
- Detection
- Antennas
- Design of Hardware / Software

The members of the society offer a friendly mentor atmosphere. All questions and inquiries are answered in a constructive manner. No question is silly!

SARA offers its members an electronic bi-monthly journal entitled Radio Astronomy. Within the journal, members report on their research and observations. In addition, members receive updates on the professional radio astronomy community and, society news.

Once a year SARA meets for a three-day conference at the Green Bank Observatory in Green Bank West Va.

There is also a spring conference held at various cities in the Western USA. Previous meeting have been at the VLA in Socorro, NM and at Stanford University.

How do I get started?

Just as a long journey begins with the first step, the project you elect must start with a clear idea of your objectives. Do you wish to study the sun? Jupiter? Make meteor counts? Do you wish to engage in imaging radio astronomy? What you decide will not only determine the type of equipment you will need, but also the local radio spectrum.

How do amateurs do radio astronomy?

Radio astronomy by amateurs is conducted using antennas of various shapes and sizes, from smaller parabolic dishes to simple wire antennas. These antennas are connected to receivers and most of these receivers are software defined radios these days. Data from the receivers are collected by computers, and the received signals will be displayed as charts, graphs or maybe even sky maps. As diverse as the observed objects, so is are the instruments and tools used. SARA members will always be supportive to find good solutions for what one wishes to observe.

Is amateur radio astronomy instrumentation expensive?

Technical information freely circulated in our monthly journal helps amateurs to obtain good low noise equipment from off the shelf assemblies, or to build their own units. The actual cash investment in radio astronomy equipment need not exceed that of any other hobby.

What are amateurs actually looking for in the received data?

The aim of the radio amateur is to find something new and unusual. Just as an amateur optical observer hopes to notice a supernova or a new comet, so does an amateur radio observer hope to notice a new radio source, or one whose radiation has changed appreciably.

The Reber Telescope at NRAO. Constructed by Grote Reber in 1937 in his back yard in Wheaton, Illinois

SARA Members discussing the IBT (Itty Bitty Telescope)