RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers
September – October 2022

Dr. Frank Drake

and new SARA member, Dr. Mary Lou West,

at the AAS meeting in Chicago in 1999.

Dr. Richard A. Russel
SARA President and Editor

Whitham D. Reeve
Contributing Editor

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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: Dr. Mary Lou West

Contents

Radio Waves

President's Page

I want to recognize Dr. Frank Drake for his work on SETI and radio astronomy in general. He has been an inspiration to the SARA members who have visited Drake's Lounge at the Green Bank Observatory and touched the plaque with the Drake Equation on it. He is also the inspiration for the SARA monthly "Drake's Lounge" forum which has allowed monthly, face – to – face, worldwide communications between members.

We are starting a new ZOOM forum called: "Drake's Lounge – Australia". This will be on November 26, 9AM, Melbourne time and monthly thereafter. Australia has a significant amateur radio astronomy community who like what we are doing and would like to get involved with us. Special thanks to Paul Butler for coordinating this!

The SARA Journal index has been added to the SARA web page. This will allow you to do a keyword or author search for topics from over 1400 articles, videos, and newsletters over 40 years!

New content has been added to the SARA YouTube channel. This includes tutorials and radio astronomy observations. The videos of the presentations are available at the SARA YouTube channel at:
https://www.youtube.com/channel/UC-SzptAQZ-20c9CkRb9ZPxw/videos

Thanks!

Rich

Dr. Richard Russel
President

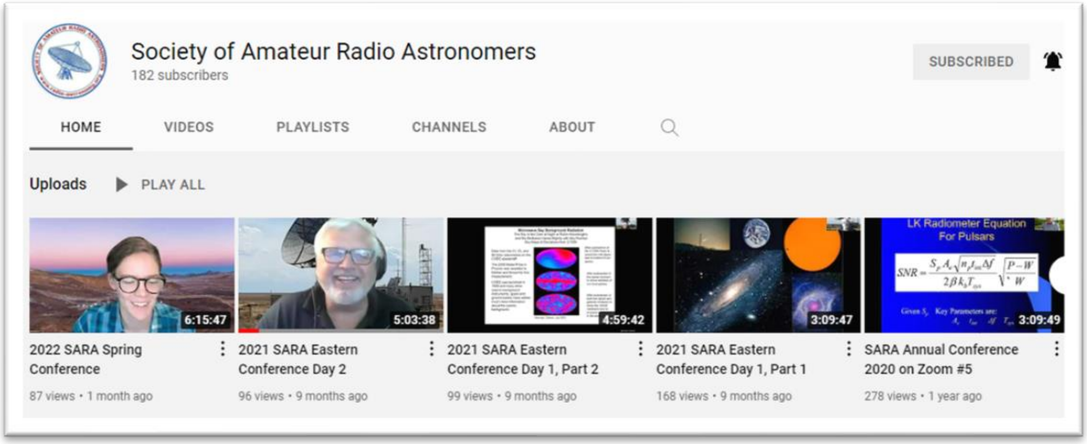
Editor's Notes

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

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 Drake's Lounge Australia

This new zoom forum is geared to the Melbourne, Australia time zone (UTC+10) in order to improve coordination with our Australia, New Zealand, and Japanese members. The first meeting is on November 26, 9AM Melbourne time (2000 UTC Nov 25). A zoom announcement will be sent out to all SARA members before the meeting.

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 (1800 UTC). 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 (1800 UTC). ZOOM email notifications will be sent to all members.

News: (**September-October** 2022)

Society of Amateur Radio Astronomy Educational and Conference videos: https://www.youtube.com/channel/UC-SzptAQZ-20c9CkRb9ZPxw/videos

History of Geo- and Space Sciences ~ *History of Kakioka Magnetic Observatory*: https://hgss.copernicus.org/articles/13/147/2022/

Arecibo Observatory ~ *Newsletters*: http://www.naic.edu/ao/newsletters

Universe Today ~ *Rare “Red Sprites” Seen From ESO’s La Silla Observatory in Chile*: https://www.universetoday.com/157271/rare-red-sprites-seen-from-esos-la-silla-observatory-in-chile/

ArXiv ~ *How to Deploy a 10-km Interferometric Radio Telescope on the Moon with Just Four Tethered Robots*: https://arxiv.org/abs/2209.02216

Radio Jove Conference videos on Youtube: https://www.youtube.com/playlist?list=PLCEbOD5_znsnOZDTc2UubJhJuEgrtO_jN

The Radio JOVE Project 2.0

Chuck Higgins, Middle Tennessee State University

Chuck Higgins, Shing Fung, James Thieman, Leonard Garcia, James Gass, Richard Flagg, Jim Sky, Larry Dodd, David Typinski, Francisco Reyes, James Brown, Thomas Ashcraft, Wes Greenman, S. Blair, and John Cox

Citizen Scientists

Radio JOVE uses hands-on radio astronomy to help people learn and do science.

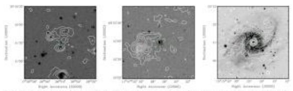
- Radio Astronomy Introduction

Physics Today ~ *New telescopes seek the cosmic dark ages*: https://physicstoday.scitation.org/doi/full/10.1063/PT.3.5079

CGTN ~ *China starts building world's largest steerable telescope*: https://news.cgtn.com/news/2022-09-25/China-starts-building-world-s-largest-steerable-telescope-1dBOtcmfY9W/index.html

British Astronomical Association ~ *UK Radio Meteor Beacon, BAA Journal – Volume 132 Number 05 – October 2022*: https://britastro.org/journal/baa-journal-volume-132-number-05-october-2022

Research Notes of the AAS ~ *LOFAR Search for Radio Emission from Galaxies Hosting Tidal Disruption Events*: https://iopscience.iop.org/article/10.3847/2515-5172/ac9313

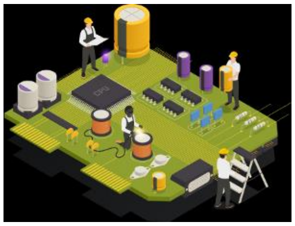


Technical Knowledge & Education: (September-October 2022)

Learn EMC ~ *Electromagnetic Compatibility Resources*: https://learnemc.com/emc-resources

EDN ~ *Ceramic capacitors: How far can you trust them?*: https://www.edn.com/ceramic-capacitors-how-far-can-you-trust-them/

Atacama Large Millimeter/submillimeter Array ~ *ALMA Primer, how the issue of weighting arises, various weighting schemes, and when/why you might choose to use them*: https://www.youtube.com/channel/UCwTfiIlYuUQr4sRc5iSJaRg



PartLocator ~ *Locate and buy Hard-to-Find, Obsolete and Long Lead Time electronic components*: http://www.partlocator.com/Default.aspx

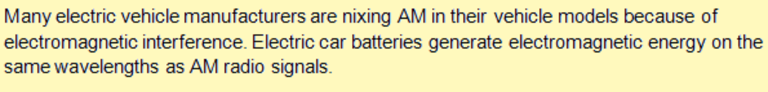
Community of European Solar Radio Astronomers (CESRA) ~ *Narrowband Spikes Observed During the 13 June 2012 Flare in the 800 – 2000 MHz Range*: https://www.astro.gla.ac.uk/users/eduard/cesra/?p=3378

Microwave Journal ~ *New Trends in EMC Testing*: https://www.microwavejournal.com/articles/38641-new-trends-in-emc-testing

WHAT GREEK LETTERS MEAN IN EQUATIONS

π	THIS MATH IS EITHER VERY SIMPLE OR IMPOSSIBLE.
Δ	SOMETHING HAS CHANGED.
δ	SOMETHING HAS CHANGED AND IT'S A MATHEMATICIAN'S FAULT.
θ	CIRCLES!
ϕ	*ORBS*
ϵ	NOT IMPORTANT, DON'T WORRY ABOUT IT.
υ, ν	IS THAT A V OR A U? OR...OH NO, IT'S ONE OF *THOSE*.
μ	THIS MATH IS COOL BUT IT'S NOT ABOUT ANYTHING THAT YOU WILL EVER SEE OR TOUCH, SO WHATEVER.
Σ	THANK YOU FOR PURCHASING *ADDITION PRO*®!
Π	...AND THE *MULTIPLICATION*® EXPANSION PACK!
ζ	THIS MATH WILL ONLY LEAD TO MORE MATH.
β	THERE ARE JUST TOO MANY COEFFICIENTS.
α	OH BOY, NOW *THIS* IS MATH ABOUT SOMETHING REAL. THIS IS MATH THAT COULD *KILL* SOMEONE.
Ω	OOOH, *SOME* MATHEMATICIAN THINKS THEIR FUNCTION IS COOL AND IMPORTANT.
ω	A LOT OF WORK WENT INTO THESE EQUATIONS AND YOU ARE GOING TO DIE HERE AMONG THEM.
σ	SOME POOR SOUL IS TRYING TO APPLY THIS MATH TO REAL LIFE AND IT'S NOT WORKING.
ξ	EITHER THIS IS TERRIFYING MATHEMATICS OR THERE WAS A HAIR ON THE SCANNED PAGE.
γ	*ZOOM* PEW PEW PEW [SPACE NOISES] *ZOOOOM!*
ρ	UNFORTUNATELY, THE TEST VEHICLE SUFFERED AN UNEXPECTED WING SEPARATION EVENT.
Ξ	GREETINGS! WE HOPE TO LEARN A GREAT DEAL BY EXCHANGING KNOWLEDGE WITH YOUR EARTH MATHEMATICIANS.
ψ	YOU HAVE ENTERED THE DOMAIN OF KING TRITON, RULER OF THE WAVES.

Mini-Circuits ~ *Every Block Covered: Noise and Signal-to-Noise Ratio (SNR) in a Simple Microwave Front-End*: https://blog.minicircuits.com/noise-and-signal-to-noise-ratio-snr-in-a-simple-microwave-front-end/



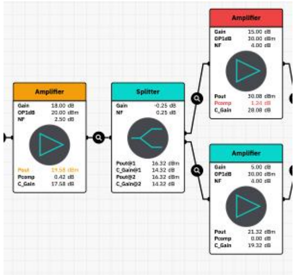
Many electric vehicle manufacturers are nixing AM in their vehicle models because of electromagnetic interference. Electric car batteries generate electromagnetic energy on the same wavelengths as AM radio signals.

EDN ~ *A new EMI threat?*: https://www.edn.com/a-new-emi-threat/

Jameco ~ *How to Read an Oscilloscope*:

https://www.jameco.com/Jameco/Blog/how-to-read-an-oscilloscope.html

Source (left): https://xkcd.com/2586/



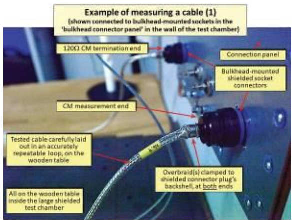
RFGraph ~ *The new way to visualize your RF cascaded analysis*: https://rfgraph.com/

EEWeb ~ *Digital Electronics Course — Part 1: Binary Logic and Signals*: https://www.eeweb.com/digital-electronics-course-part-1-binary-logic-and-signals/

Microwaves & RF ~ Using a VNA Like a Time-Domain Reflectometer: https://www.mwrf.com/print/content/21247456

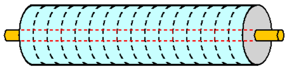
In Compliance ~ *Getting the Best EMC from Shielded Cables Up to 2.8 GHz:*

- Part 1: https://digital.incompliancemag.com/issue/september-2022/
- Part 2: https://digital.incompliancemag.com/issue/october-2022/



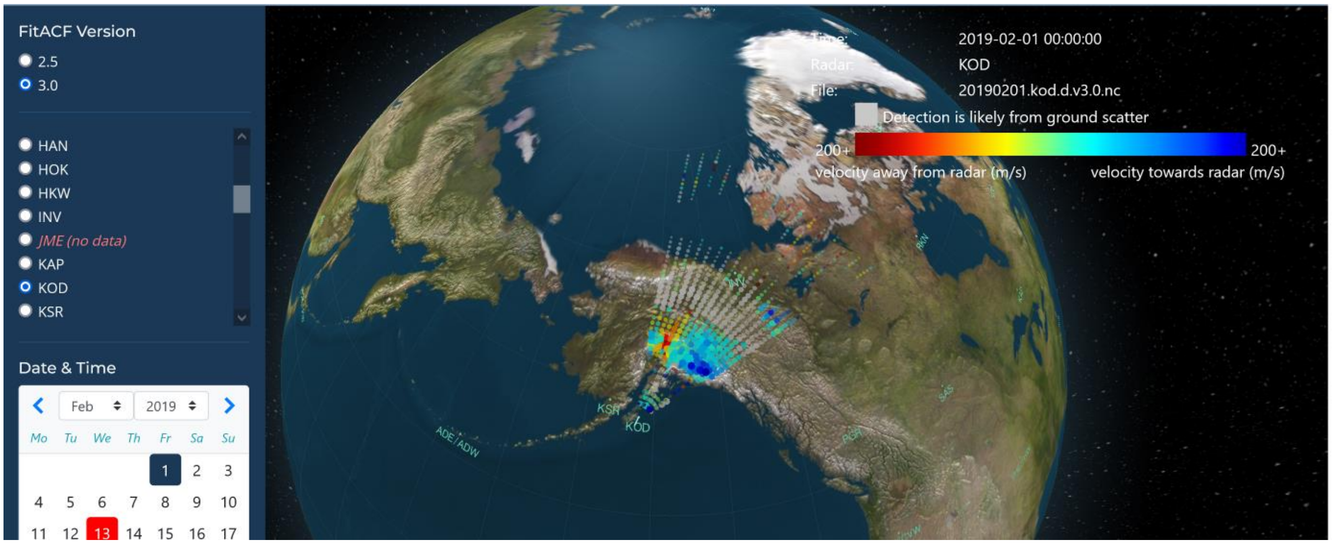
CUI Inc. ~ *EMI Filter Components: what they are and how they work*: https://www.cui.com/blog/emi-filter-components-what-they-are-and-how-they-work

EDN ~ *Coaxial Z—breaking down the impedance of a coaxial transmission line*: https://www.edn.com/coaxial-z-breaking-down-the-impedance-of-a-coaxial-transmission-line/



Let a length of line be taken as one foot and divided into 2400 sectors, each sector of 0.005 inch.

Announcements (September-October 2022



FitACF Version
○ 2.5
● 3.0

○ HAN
○ HOK
○ HKW
○ INV
○ JME (no data)
○ KAP
● KOD
○ KSR

Date & Time
Feb 2019

Time: 2019-02-01 00:00:00
Radar: KOD
File: 20190201.kod.d.v3.0.nc
Detection is likely from ground scatter

New SuperDARN Data and Web Visualization Tools Available

The APL SuperDARN page has been updated with new data visualization and download tools: https://superdarn.jhuapl.edu . The files now available for download provide geolocated line-of-sight velocity data in netCDF format. The availability is shown here: https://superdarn.jhuapl.edu/inventory . The netCDF files are stored on Zenodo, but can be downloaded via our page here: https://superdarn.jhuapl.edu/download . All these files are based on the publicly released set of rawACF data: https://www.frdr-dfdr.ca/repo/collection/superdarn

As always, users should consult with the relevant SuperDARN radar PI(s) prior to submission of work intended for publication.

Alex Chartier, Wallops SuperDARN P.I.
Space Exploration Sector: Geospace and Earth Sciences
Johns Hopkins University Applied Physics Laboratory
Laurel, MD 20723
Office Phone: 240-592-5861
https://superdarn.jhuapl.edu

ALMA at 10 years: Past, Present, and Future

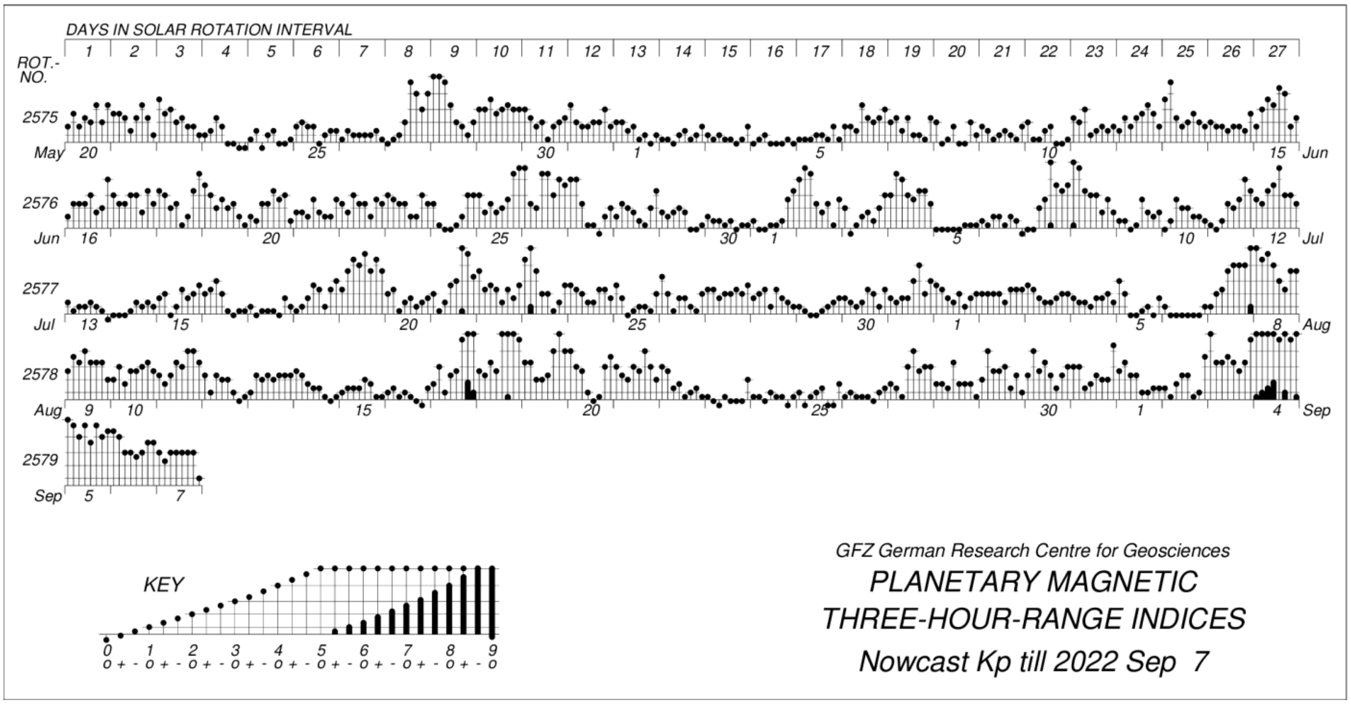
To commemorate its first decade of science operations, the ALMA partnership is organizing a conference that will take a look back at the observatory accomplishments, highlight its latest results and look forward to future technical developments.

The first decade of ALMA has led to many exciting discoveries, and has resulted in over 2800 publications and counting. As ALMA starts on its second decade of operations, it is implementing an ambitious development roadmap that will ultimately quadruple the system bandwidth and vastly improve ALMA's observing efficiency for both continuum and spectral line science.

The conference will include invited talks, contributed talks, and poster presentations. The conference will have a hybrid format to allow participants to choose to attend in-person or remotely on a virtual platform. Talks and posters are welcome in all fields of astronomy: from cosmology and galaxies in the distant Universe to nearby galaxies and the Galactic Center, interstellar medium, and star formation in our galaxy, as well as astrochemistry, circumstellar disks, exoplanets, Solar System, stellar evolution, and the Sun.

The conference will be held in Puerto Varas, Chile on 4-8 December 2023. More information on the conference will be posted on the conference webpage as it becomes available. Registration for the conference will open in early 2023: https://www.almaobservatory.org/en/alma-at-10-years-past-present-and-future/

Crystal Brogan, On Behalf of the ALMA Integrated Science Team



The geomagnetic Kp index has a new home on:
https://kp.gfz-potsdam.de/en/

You can download Kp, derived products, and the new Hpo (half-hourly Hp30, hourly Hp60 index) via web service, API, https, and FTPAlso, you can interactively produce and download plots and you can register for the Kp index user's newsletter. The existing data streams at GFZ will remain active.

Dear SCOSTEP colleagues

We will hold a symposium in memory of the late Prof. Yohsuke Kamide on November 14, 2022. The symposium will be held in memory of the late Prof. Kamide, who passed away on December 9, 2021.

Prof. Kamide graduated from the Graduate School of Science at the University of Tokyo in 1972. After completing his graduate studies at the Graduate School of Science, the University of Tokyo in 1972, he worked at the University of Alaska and the University of Colorado. After returning to Japan in 1977, he became a professor at Kyoto Sangyo University and Nagoya University and also served as the director of the Solar-Terrestrial Environmental Laboratory at Nagoya University. He has also served as editor-in-chief of AGU's Journal of Geophysical Research and as the founder of AOGS. He has also made great efforts in outreach activities.

The symposium is planned to provide an opportunity to look back on Prof. Kamide's achievements, remember him together, and pass him on to the next generation. We are planning to have invited speakers and messages from people who are closely related to Prof. Kamide.

Date： November 14, 2022
Place： Noyori Conference Hall, Nagoya University, and Internet via Zoom
Deadline for Registration and Message to Prof. Kamide: November 6, 2022
Homepage and registration: https://www.isee.nagoya-u.ac.jp/kamide_symp/
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Kanya Kusano / 草野完也, Director & Professor
Institute for Space–Earth Environmental Research (ISEE), Nagoya University
Furo-cho, Chikusa-ku, Nagoya, Japan 464-8601
kusano at nagoya-u.jp
http://www.isee.nagoya-u.ac.jp/~kusano/

The SKA-France Day 2022 will take place on November 10 at the premises of ENS Paris.

It is now possible to register to participate in this day, which will allow us to take stock of the recent major progress of the SKA project at national and international level, as well as to discuss future developments of the French contribution to the construction and scientific exploitation of the SKA Observatory. Registrations are open until October 21 at the following website: https://ska-france-2022.sciencesconf.org . Follow the instructions by selecting "Registration" on the left column. If you do not have it yet, you will be asked to create an account on the sciencesconf.org website. The event will be organized face-to-face. For any further information, contact Chiara Ferrari - Director of SKA-France

LWA
Long Wavelength Array

The Long Wavelength Array
Catching big waves with small blades

Cycle 11 Call for Proposals: LWA Radio Observatory

We invite applications for observing time with the LWA Radio Observatory. The complete call for proposals including the required cover page can be found at http://lwa.unm.edu. At this time proposers can request observations with LWA1, LWA-SV, or an interferometry mode between the two.

LWA1 currently offers up to three independently-steerable wide-band beams. Each beam supports two independent tunings over the LWA1 frequency range from 10 to 88 MHz with a FWHM ranging from 15 to 2 degrees. Each tuning can cover up to 20 MHz bandwidth. Two all-dipole modes are also available; a transient buffer narrow (TBN), and a transient buffer wide (TBW).

LWA-SV offers up to two beams with 2 tunings of 20 MHz each. The two tunings are dependent between the beams, and thus need to be at the same frequency. In addition, two all-dipole modes are available; a transient buffer narrow (TBN) and a transient buffer frequency domain (TBF).

For the interferometer mode two beams are used at both LWA1 and LWA-SV, one-beam for calibration and the other beam for the target source. The correlation produces a fan-beam on the sky with a phase center that is affected by the ionosphere. The bandwidth available is 2 tunings of 20 MHz each. For details about the observing setup and data reduction see the online tutorial at: http://www.phys.unm.edu/~lwa/singleB_tutorial.pdf

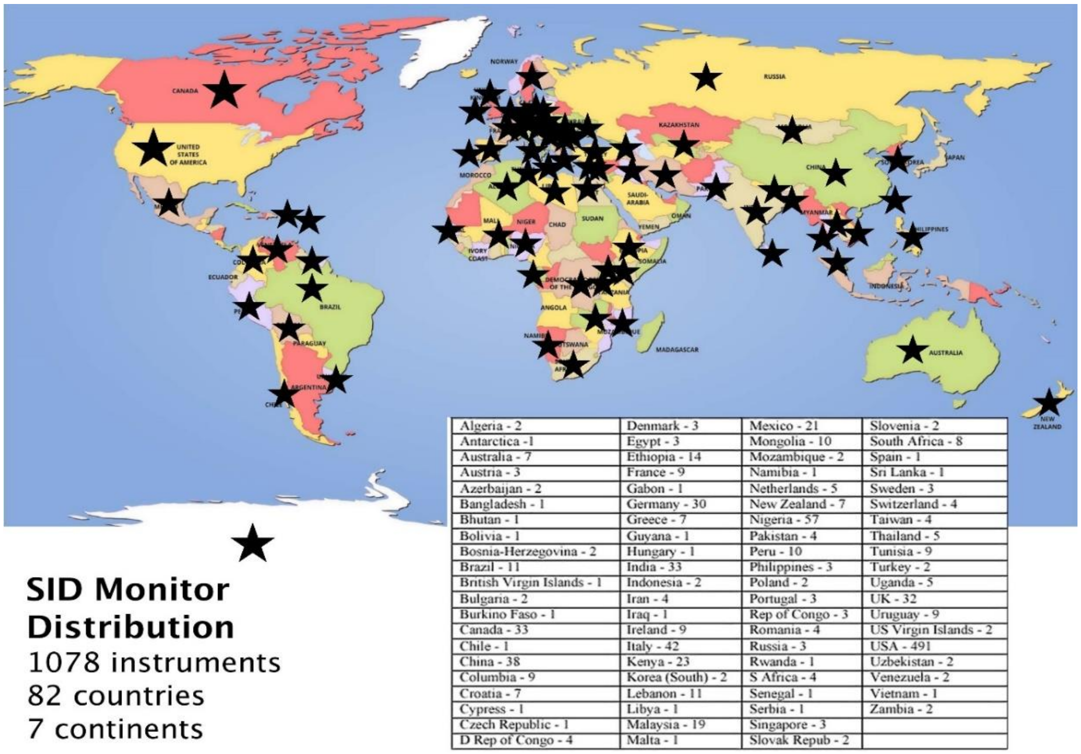
The deadline for application is 11:59 pm MDT on November 1, 2022 and covers observations expected to occur in the 2023 calendar year. The complete call for proposals including the required and updated cover page can be found at http://lwa.unm.edu. Support for operations and continuing development of the LWA is provided by the National Science Foundation under grant AST-1835400 of the MSIP program, and the Air Force Research Laboratory. We invite proposals from all communities wishing to use this instrument.

More information about the capabilities of the LWA1 can be found on the LWA web pages: http://www.phys.unm.edu/~lwa/status.html . An introduction to using the LWA1 is also available at: http://www.ece.vt.edu/swe/lwa1/ . For questions regarding this call for proposals, please email lwa@unm.edu . Access the LWAUSERS-L Home Page and Archives: https://list.unm.edu/cgi-bin/wa?A0=LWAUSERS-L

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.



SID Monitor Distribution
1078 instruments
82 countries
7 continents

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	

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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____

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

---

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.

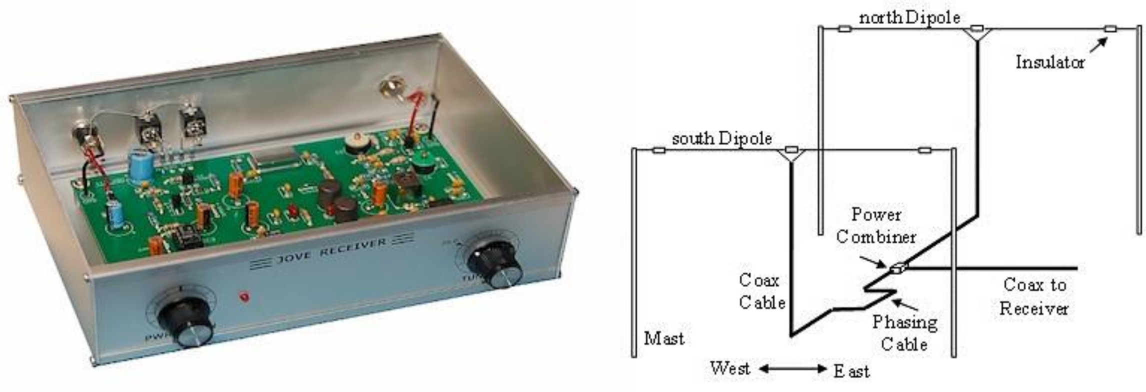


Figure 1. A Radio JOVE RJ1.1 receiver and a schematic of the dual-dipole antenna.

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).

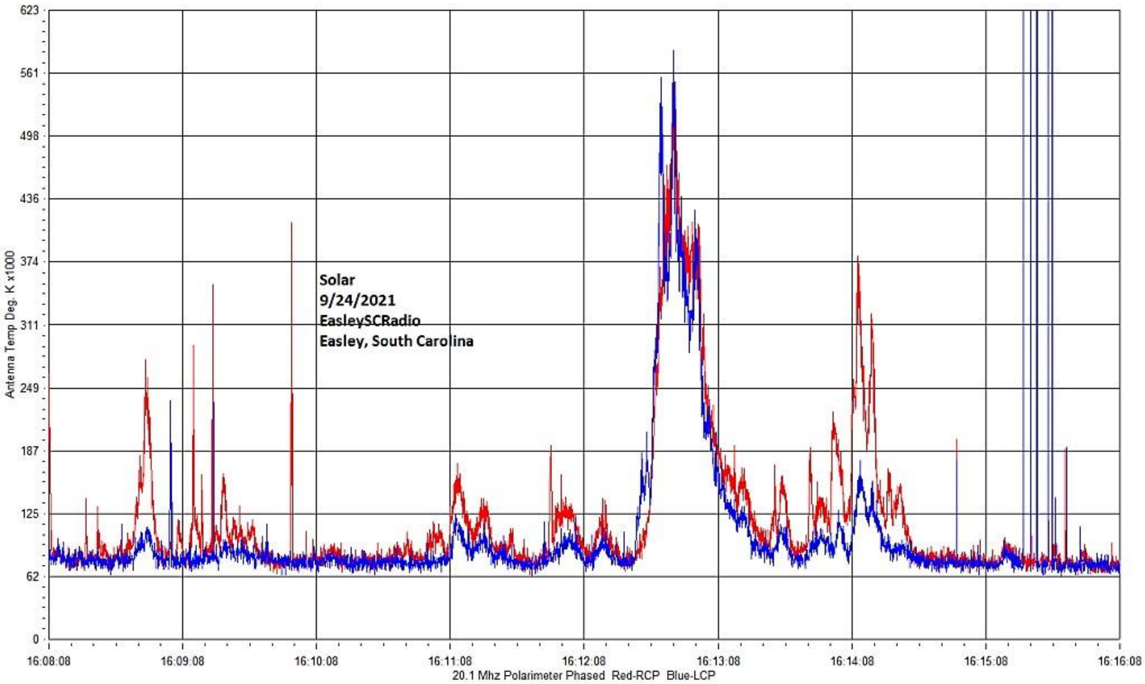


Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver. John Cox, SC.

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.

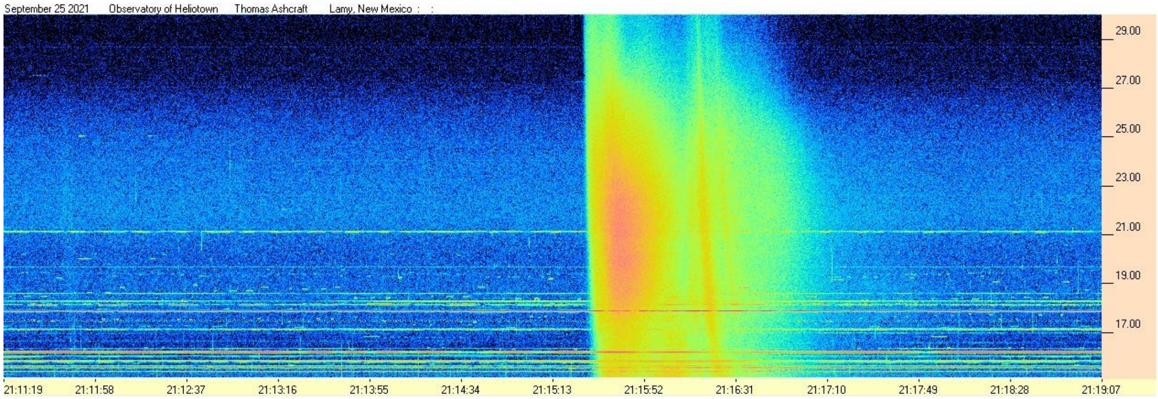


Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

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)

Order Online at https://radiojove.net/kit/order_form.html OR
Complete this form and mail with payment

Payment may be made by Credit Card via PayPal™, U.S. Check, U.S. Money Order, International Money Order in U.S. funds drawn on a U.S. bank, or Western Union Money Transfer made payable to **The Radio JOVE Project**. No bank-to-bank wire transfers are accepted. Purchase Orders are accepted from U.S. Institutions.

Send to: The Radio JOVE Project
1301 East Main St
MTSU Box 412
Murfreesboro, TN 37132, USA
email: chiggins@mtsu.edu
FEIN: 20-5239863

Item	Description	Quantity	Item Price	Shipping (see below)	Subtotal
RJK2u	Complete Radio JOVE 2.0 Kit Receiver + unbuilt Antenna		$215		
RJK2p	Complete Radio JOVE 2.0 Kit Receiver + Professionally Built Antenna		$384		
RJA2	Professionally Built Antenna-Only Kit		$249		
RJA	Unbuilt Antenna-Only Kit		$90		
RJR2	Receiver-Only Kit		$135		
LTJ2	Listening to Jupiter, 2nd Ed., by R.S. Flagg (PDF download)		$10	$0	
				Total:	

Shipping Fees for Radio JOVE: We ship all packages using USPS Priority Mail flat rate boxes.
U.S.A.: $17.00
Canada: $57.00
All Other International Shipping: $85.00

Ship to: (Please print clearly)

Name: ____

Address: ____

City, State, Postal Code: ____

Province, Country: ____

Email: ____

Visit the Radio JOVE web site and fill out the team application form at https://radiojove.net/sign_up_form.php even if you are just an interested individual so that you can receive important information about kit updates, online services, and activities within the project as they occur!

BAA
Founded in 1890

The British Astronomical Association
A company limited by guarantee
Registered Charity No. 210769
Burlington House, Piccadilly, London, W1J 0DU
Telephone: 020 7734 4145
Fax No.: 020 7439 4629
Email: office@britastro.org
Website: www.britastro.org

Please send all reports and observations to John Cook: jacook@jacook.plus.com

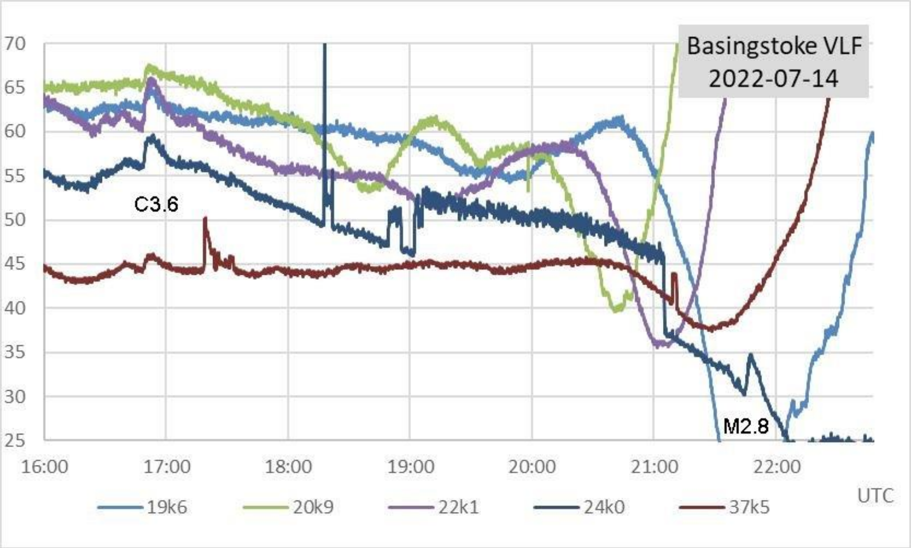
John Cook's VLF Report

BAA Radio Astronomy Section, Director: Paul Hearn

RADIO SKY NEWS **2022 JULY**

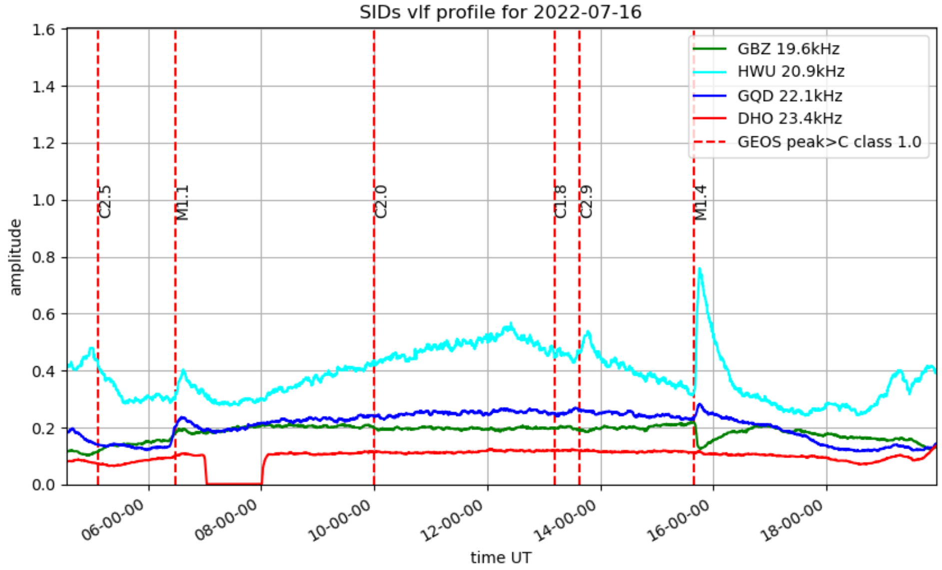
VLF SID OBSERVATIONS

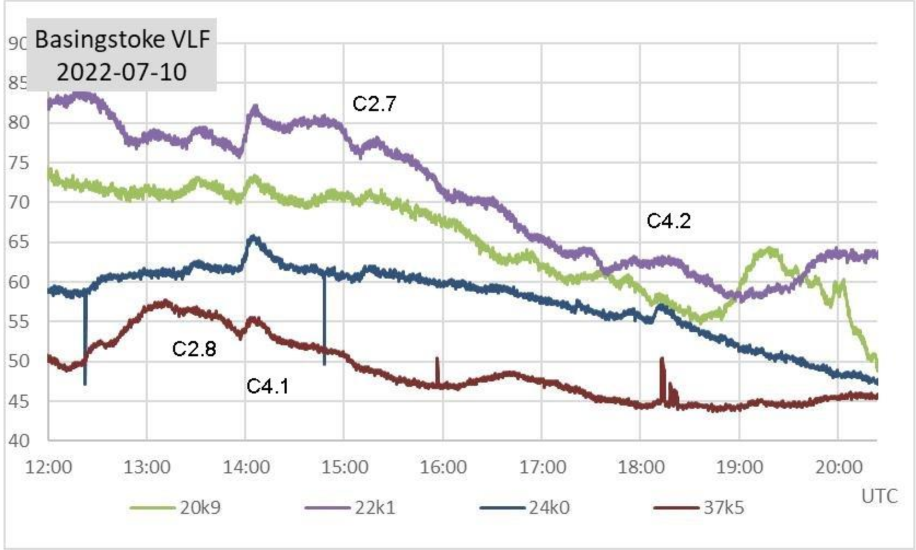
After the lower activity recorded in June activity increased again in July, although not back to the levels seen in May. There were six M-class flares recorded, the strongest being the M2.8 recorded late on the 14th. This was also the strongest event recorded in the SWPC X-ray data.



This recording by Paul Hyde shows a clear SID on the 24kHz signal, while the others have passed their local sunset times. The earlier C3.6 flare is also visible, preceded by two smaller peaks that seem to have been part of the same flare. The sharp spike at 17:20 on the 37.5kHz signal does not seem to have a magnetic origin, so may be local interference. 24kHz also shows some transmitter effects between 18:00 and 21:00UT.

There were two M-flares on the 16th, along with several smaller C-flares. The M1.4 flare was well timed in the afternoon, while the M1.1 was much earlier in the morning. Both show well in the recording by Mark Prescott on the next page, the M1.1 giving a smaller SID squeezed between sunrise and the 23.4kHz signal break. 23.4kHz does not show much disturbance from any of these flares.

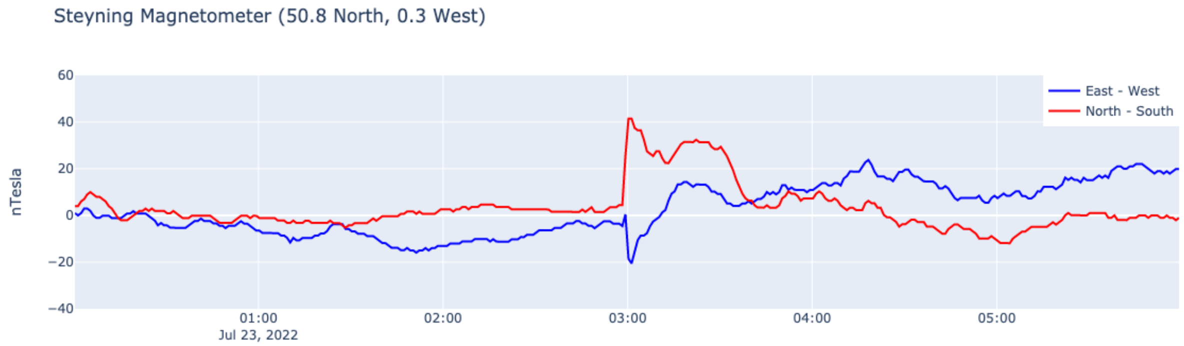




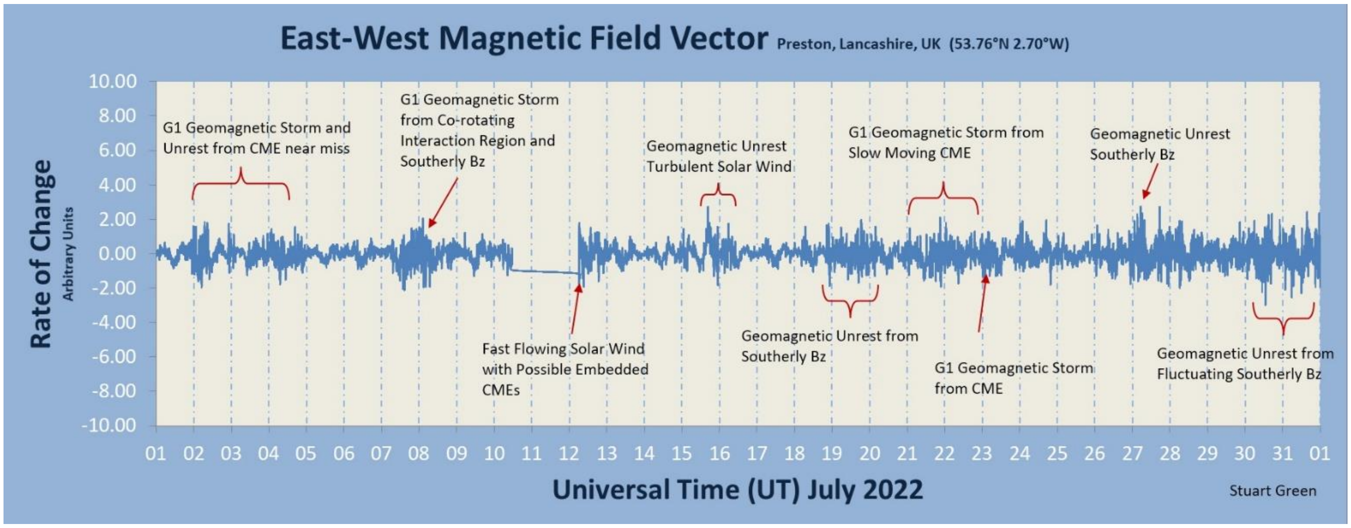
Paul Hyde's recording from the 10th shows some of the smaller flares. The higher background X-ray flux has resulted in rather small SIDs that are not always easy to spot. Under quieter conditions they would be much clearer.

MAGNETIC OBSERVATIONS

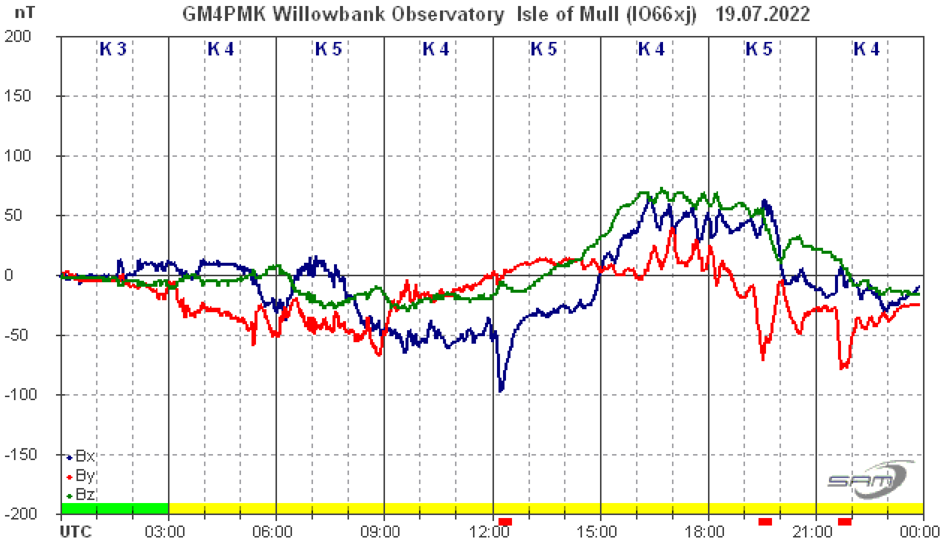
The strong flaring activity produced several weak CMEs, but mostly not directed towards Earth. There was also some high speed wind disturbance from small coronal holes, particularly at the start of the month. The most clearly recorded CME impact arrived at 03:00UT on the 23rd. Satellite data shows the CME on the 21st, although it does not seem to be related to a flare that we have recorded. The CME arrival shows well in the recording by Nick Quinn:



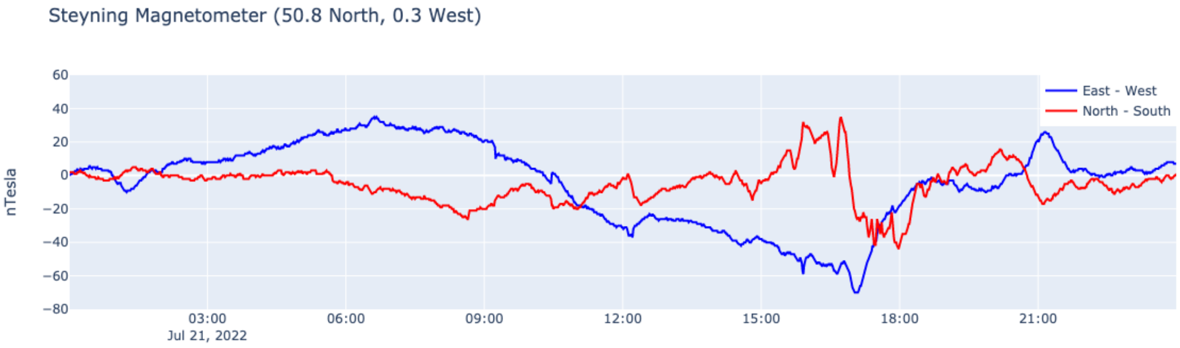
The following magnetic disturbance was very mild, and faded out during the morning. Stuart Green has again provided his monthly summary of magnetic activity:



A very mild disturbance at the start of the month was from a CME near-miss, and was followed by a mild coronal hole wind stream. A turbulent solar wind caused some disturbance on the 19th, shown here by Roger Blackwell:

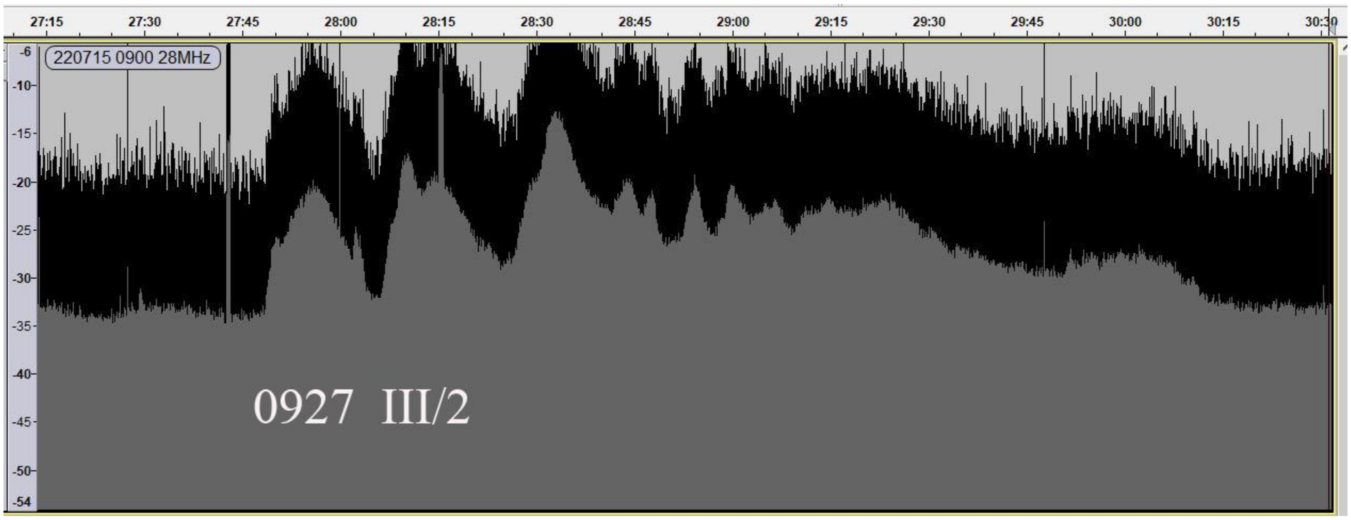


A CME of unknown origin produced a more active period in the afternoon of the 21st, recorded by Nick Quinn:



A very mild disturbance continued through the 22nd, merging with the CME impact on the 23rd. Magnetic observations received from Roger Blackwell, Colin Clements, Stuart Green, Nick Quinn and John Cook.

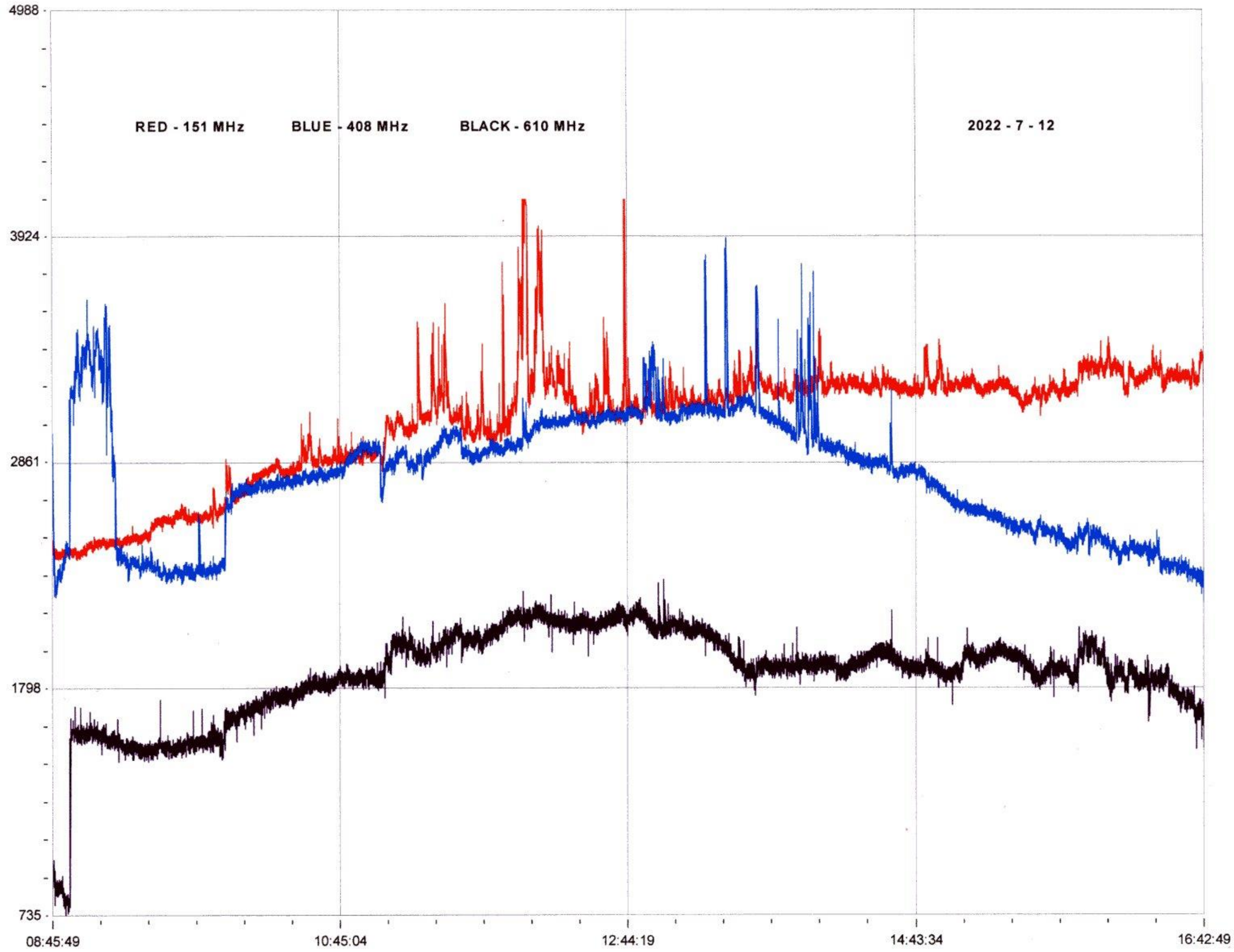
SOLAR EMISSIONS



Colin Briden recorded this type III/2 28MHz emission starting at 09:27UT on the 15th. It has three distinct peaks, followed by a number of smaller peaks over a period of about 2 minutes 30 seconds. This is not related to any of the flares that we have recorded, although the X-ray data does show a very tiny unclassified flare peaking at 09:30. Colin Clements did not report any VHF effects at this time.

Colin Clements also reported VHF/UHF emissions from some of the smaller flares in July. His recording from the 12th, on the next page, shows a significant noise burst on 151MHz (red) around the time of the C2.5 and C4.0 flares, and a noise burst on 408MHz (blue) matching the C7.5 flare. 610MHz (black) does not show any effects from these flares.

Colin Briden reports a large number of discrete emissions during July, with 64 events recorded over six and a half hours on the 12th. Colin notes that the Kp index was at 4..5 during this time.

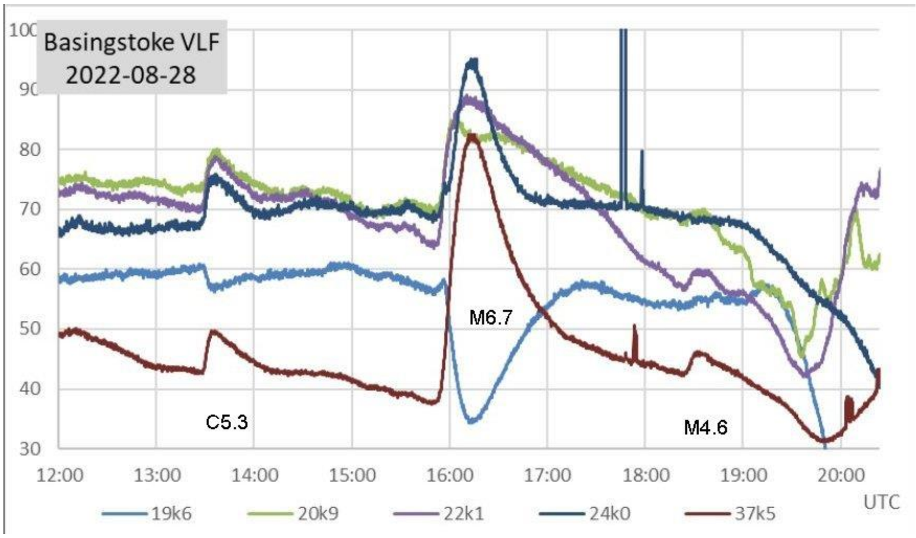


The Perseid meteor shower was active during August, so please do send in any activity reports that you have collected. The series of on-line meetings continues through the autumn, so please do check the Radio Astronomy pages of the BAA web site for full details. Paul Hearn sends out joining details prior to each event, so do let him know if you would like to be added to the mailing list.

RADIO SKY NEWS 2022 AUGUST

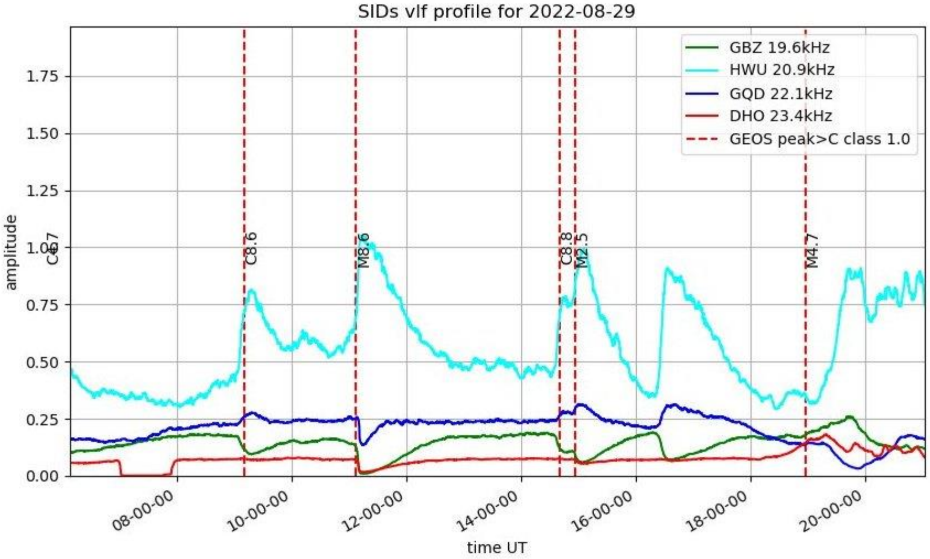
VLF SID OBSERVATIONS

Activity predictions for solar cycle 25 suggested that it would be weaker than cycle 24. Our activity chart shows that the first two years of the new cycle were actually much stronger than in cycle 24. We have recorded 23 M-class flares in August, the highest count since 2012 July when we had 41. Most of the stronger activity was in the second half of the month, much of it produced by active region AR13088, an unusual group in that its magnetic orientation was north-south compared to the normal east-west.

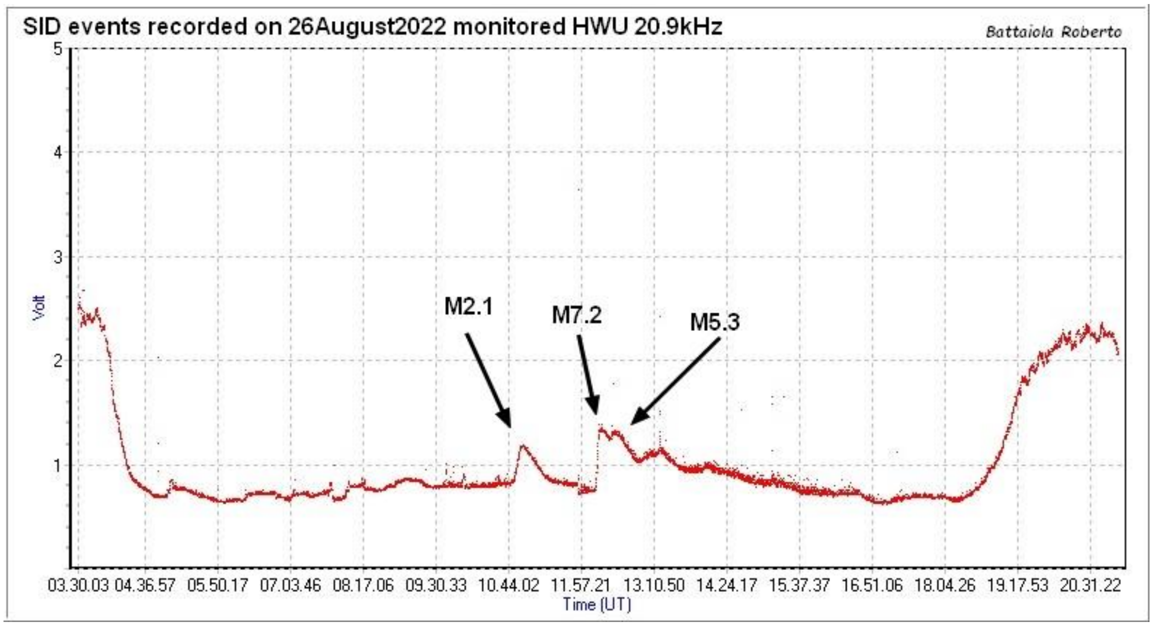


This recording by Paul Hyde shows the activity from AR13088 during the afternoon of the 28th. The M6.7 flare has produced a very strong SID at all frequencies, with just a hint of a spike-and-wave SID at 20.9kHz. 19.6kHz shows inverted SIDs for all three of the flares. The M4.6 appears to be much weaker, probably due to its timing just before the sunset dip in signal strength.

Mark Prescott recorded more AR13088 activity on the 29th, shown on the next page:

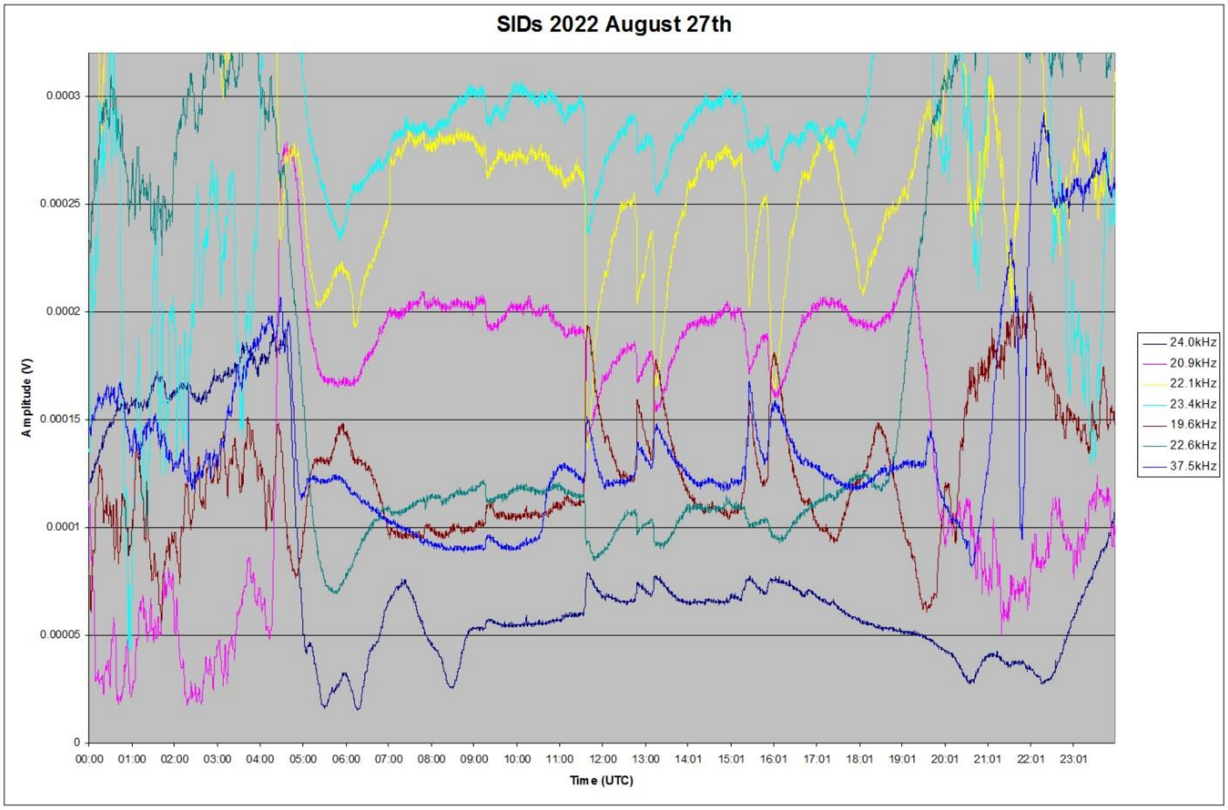


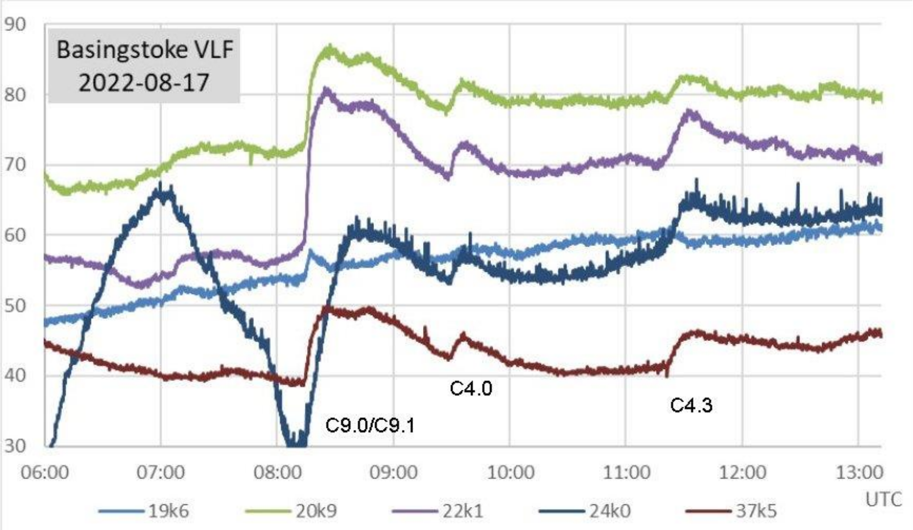
The C8.8 / M2.5 combination appears to be from a multi-peaked flare, but the SWPC tables do not include a source for the C8.8 peak. The strong peak at 16:35 is not listed by the SWPC, but does appear to be from an M-class flare.



AR13089 was also very active over this period, with three M-class flares on the 26th shown here by Roberto Battaiola. The M7.2 and M5.3 flares are listed separately, but have produced overlapping SIDs. The satellite data shows a total of 13 M-class flares over the four days from the 26th. It also shows that their activity continued as they rotated onto the far side of the sun.

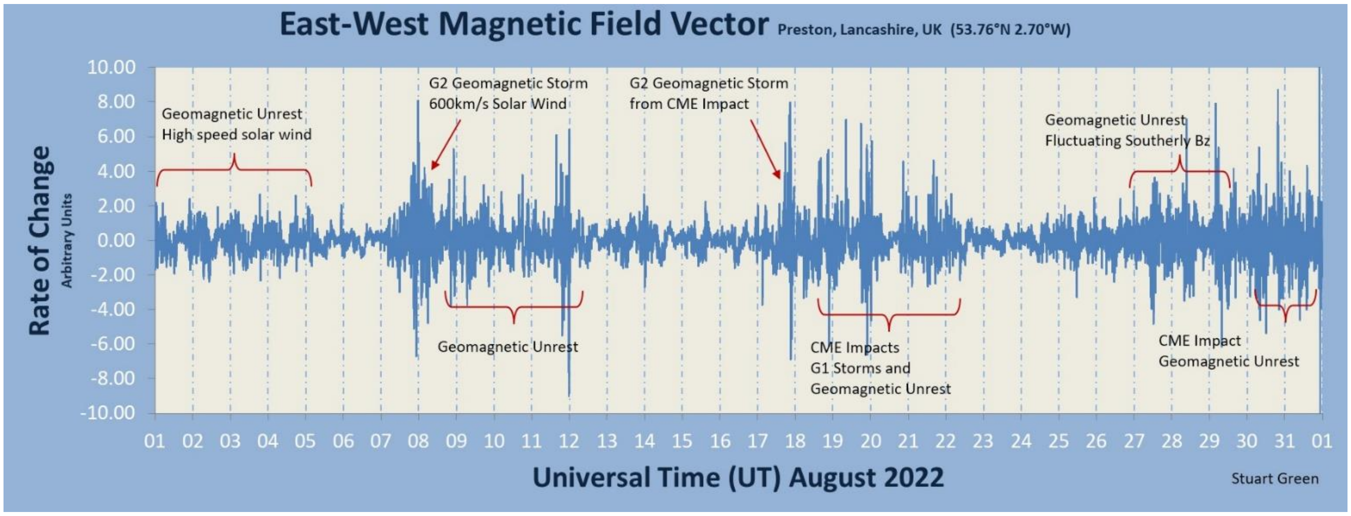
The chart from Mark Edwards on the 27th shows just how chaotic these flares have been when seen at multiple frequencies, and gives an indication of the difficulty in analysing our observations:





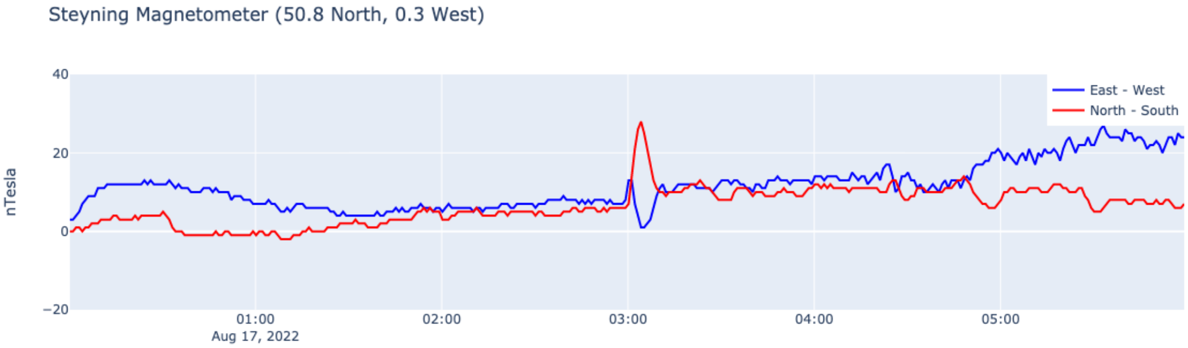
Paul Hyde's recording from the 17th shows a pair of simultaneous flares, C9.0 and C9.1 as listed in the SWPC data. They are shown with identical timings, both from AR13078, appearing here as a double peaked SID. The SWPC listing for the 15th includes a flare of magnitude M0.9, a very odd number for a logarithmic scale. It was rather late in the day, producing only a minor SID.

MAGNETIC OBSERVATIONS

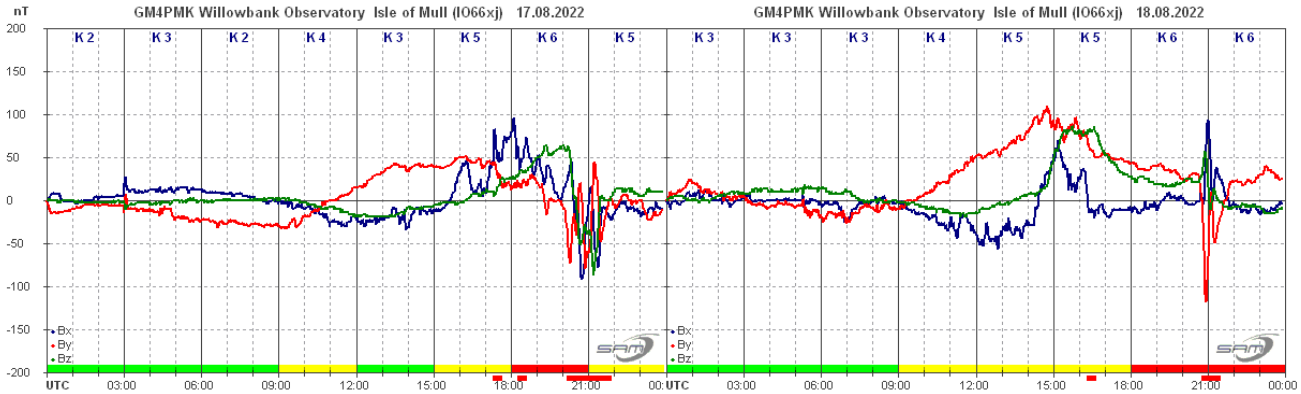


Stuart Green's summary chart of the month's activity shows three distinct periods of very strong activity. With the number of M-class flares recorded it is not surprising that there were a number of CMEs, although many were not geo-effective. There were also several filament eruptions as well as some coronal hole high speed winds to start the month.

Satellite images show a filament eruption at 12:48UT on the 14th, producing a CME. Its arrival time was predicted for the 17th. Nick Quinn recorded the magnetic impact shortly after 03UT on the morning of the 17th:

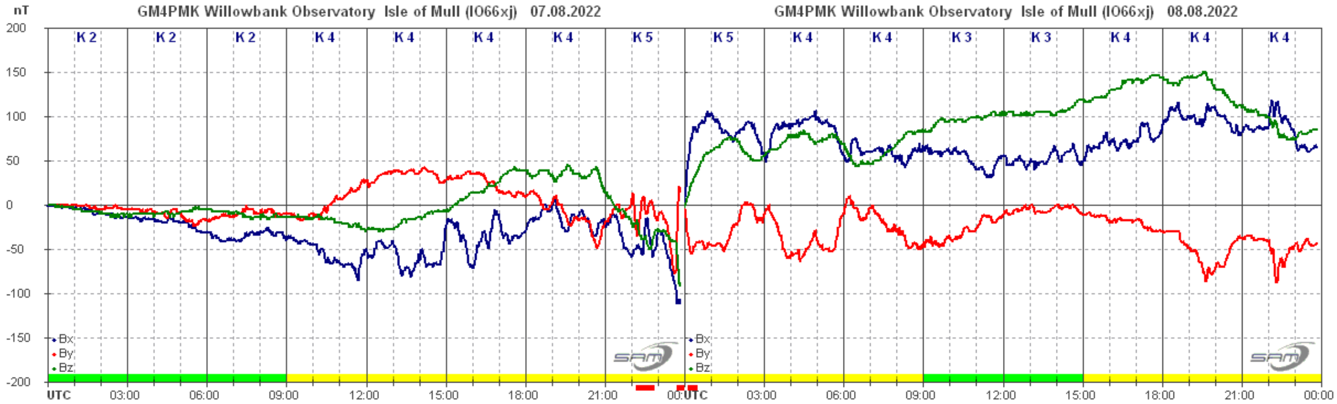


The filament eruption did not produce a flare that we recorded, although the SWPC data does include a number of small flares on the 14th.



Roger Blackwell's recording shows the strong increase in magnetic activity in the evening of the 17th, with some very rapid oscillations in the field around 21:00. A similar disturbance continued through the 18th.

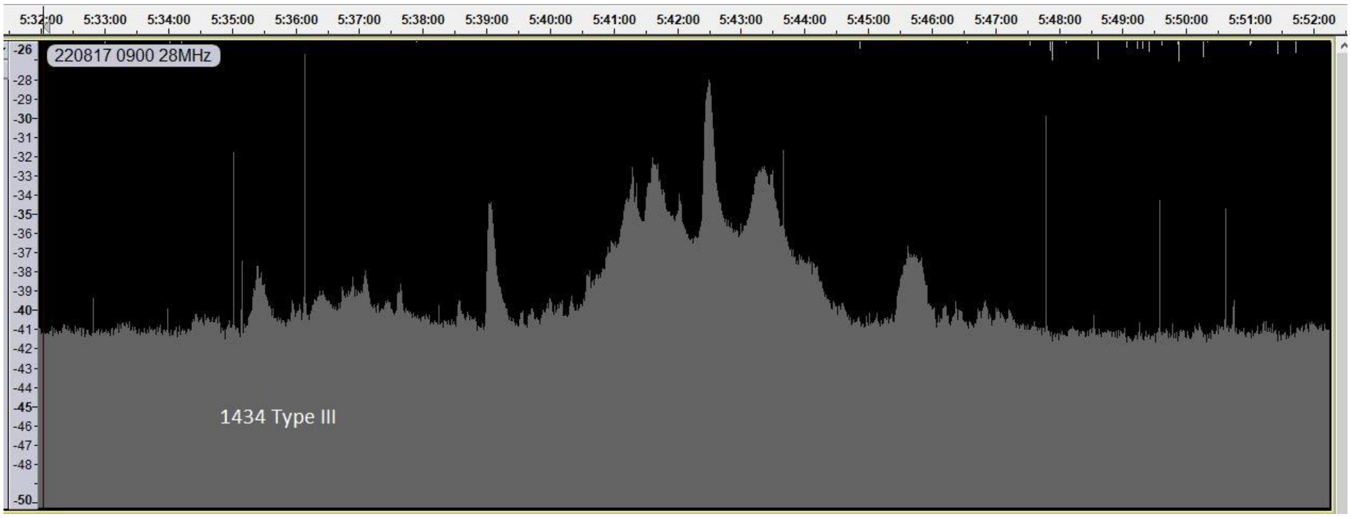
The sharp spike at 21:00 may well be from another CME impact, although I have not been able to determine a source. There were a number of CMEs active over this period. A similar spike was reported by Nick Quinn and John Cook.



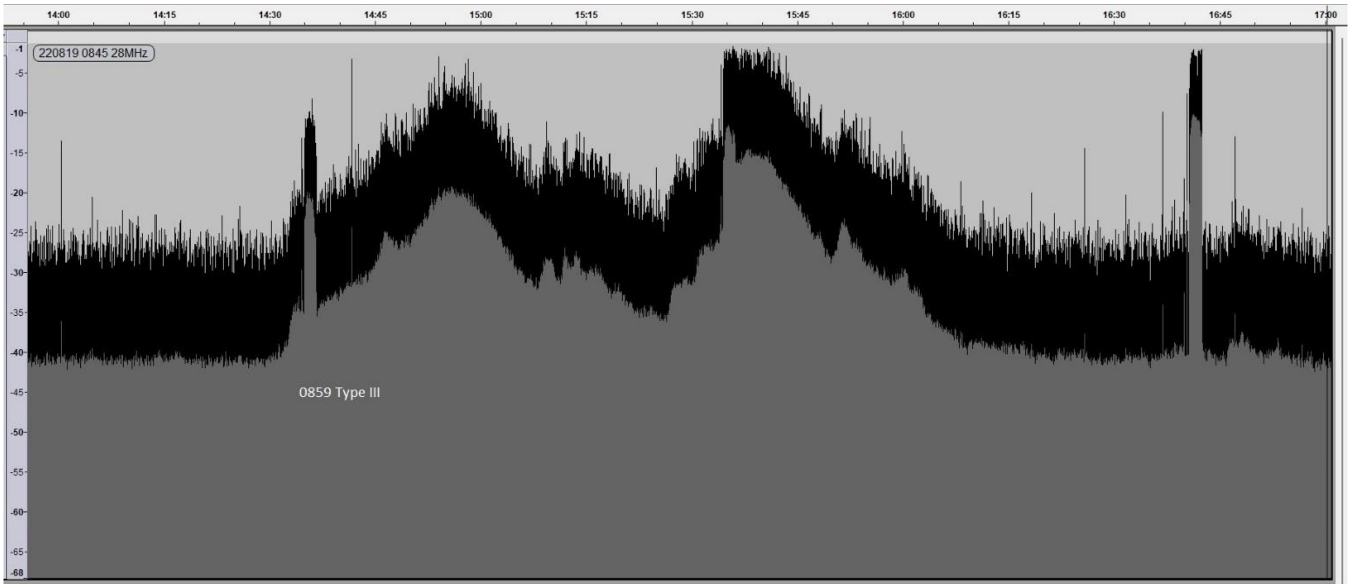
Roger Blackwell's recording from the 7th and 8th shows the magnetic disturbance from a coronal hole high speed wind. This started in the morning of the 7th, becoming more active after 21:00. The sensor is reset at midnight, which has rather distorted the offset of the Bx and Bz components. The general disturbance can still be seen through the rest of the day.

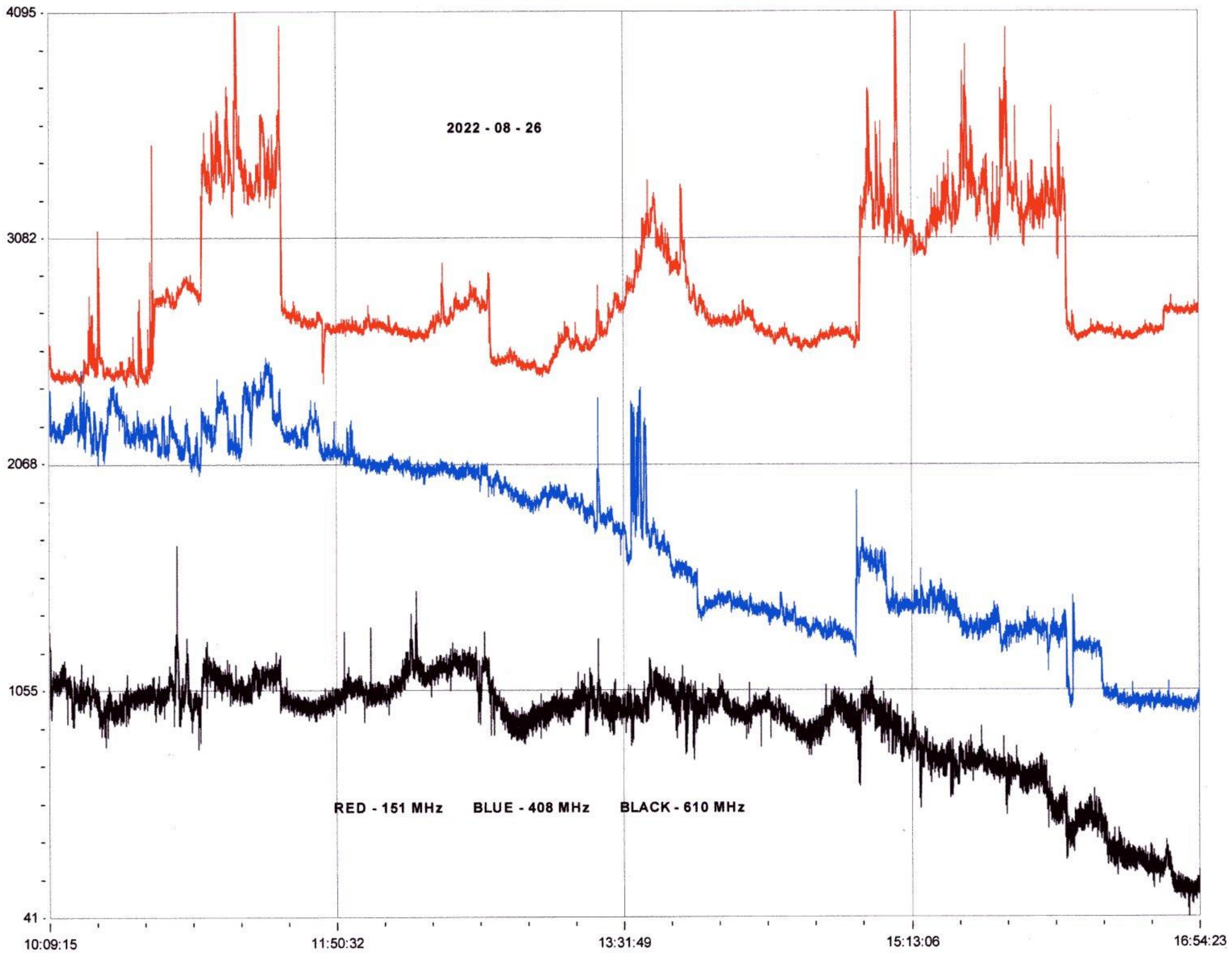
Magnetic observations received from Roger Blackwell, Colin Clements, Stuart Green, Nick Quinn and John Cook.

SOLAR EMISSIONS

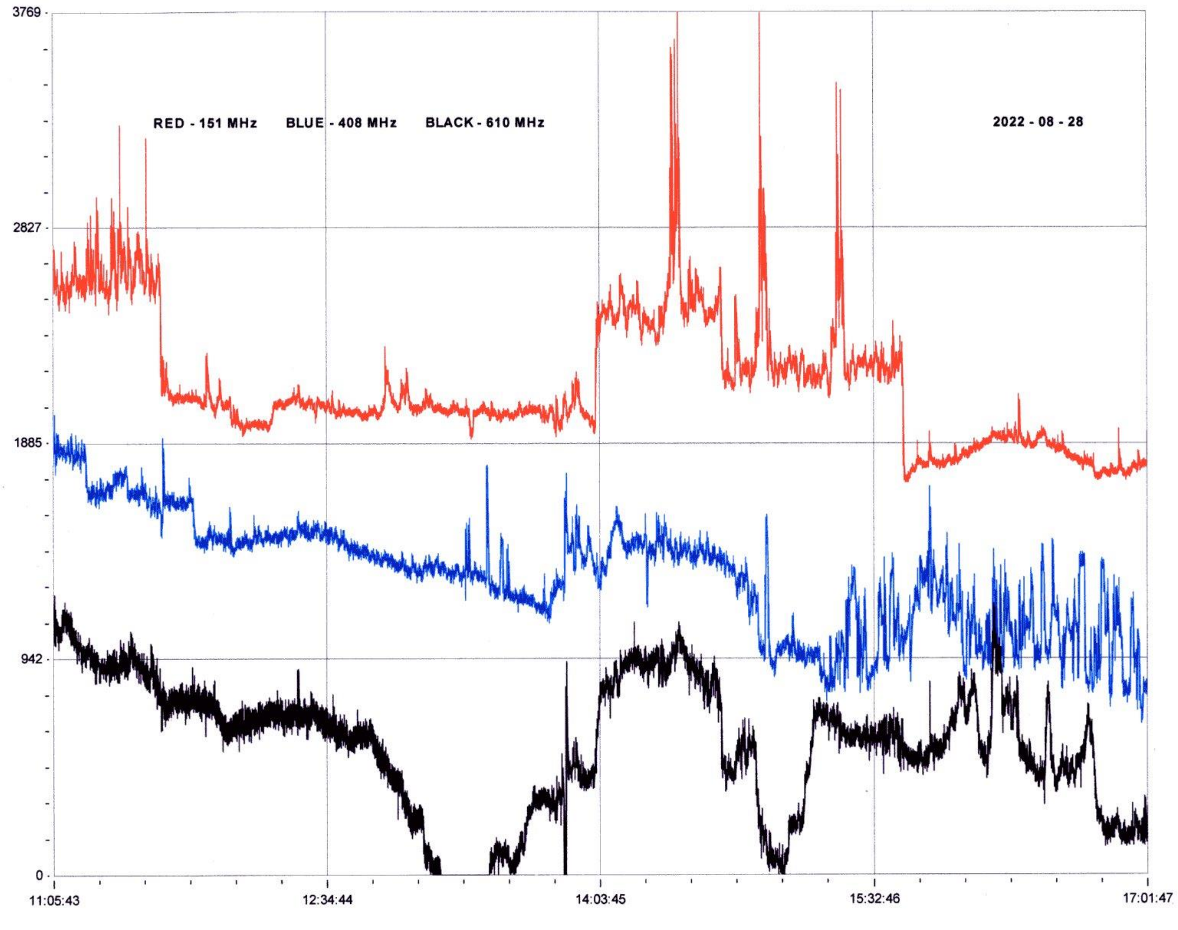


Colin Briden has recorded 28MHz radio bursts with two of the flares that we have recorded. The first, shown above, is a type III burst at 14:34UT on the 17th, matching the start time of our SID recordings of the M1 flare. The chart shows about 20 minutes, the burst lasting about 10 minutes. The second chart, on the next page, shows a much shorter type III burst at 08:59 on the 19th. This matches with the timing of our SID recordings from the C1.9 flare. Despite being a weaker flare, the burst appears to be stronger, but Colin does note that this may be due to different levels of noise floor in the recordings.



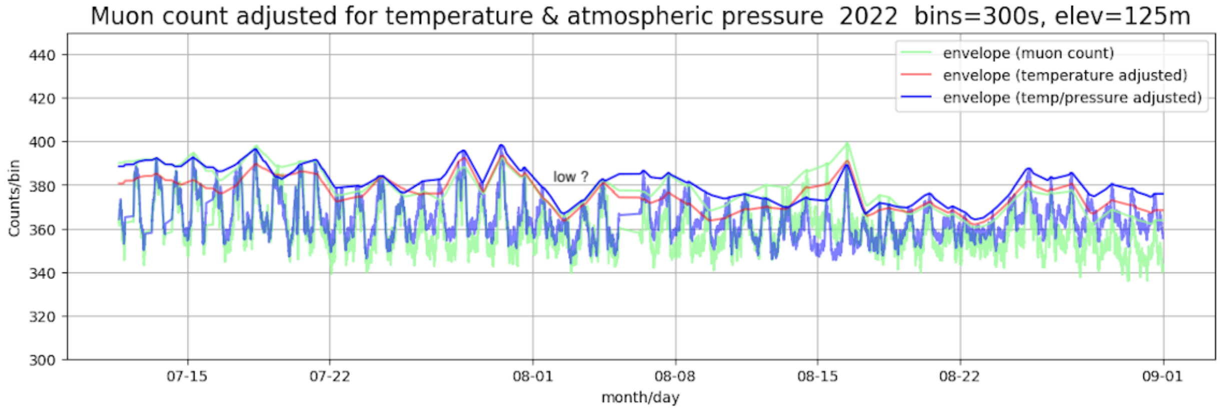


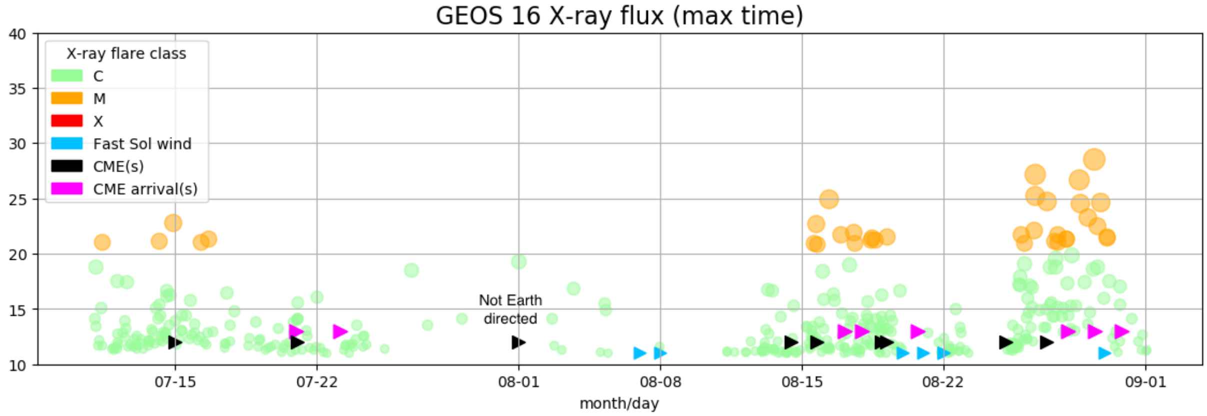
Colin Clements did not see any VHF/UHF emissions matching these events but did record some strong emissions later in the month. This recording from the 26th shows strong 151MHz bursts during the sequence of three M-class flares. 408MHz also has some smaller noise bursts, but very little was recorded at 610MHz. A more complex pattern of emissions was recorded on the 28th, matching some of the multiple peaks seen around the C5.3 flare. The larger M6.7 flare did not produce any emissions.



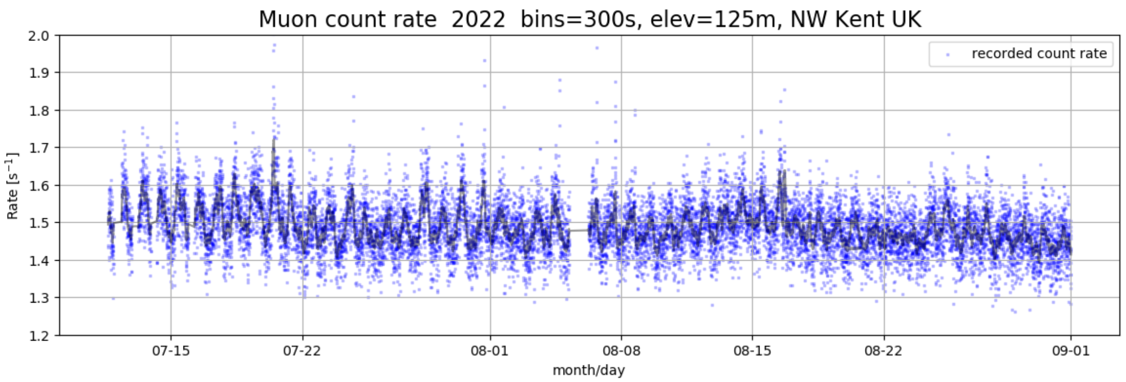
3769
2827
1885
942
0
RED - 151 MHz
BLUE - 408 MHz
BLACK - 610 MHz
2022 - 08 - 28
11:05:43
12:34:44
14:03:45
15:32:46
17:01:47

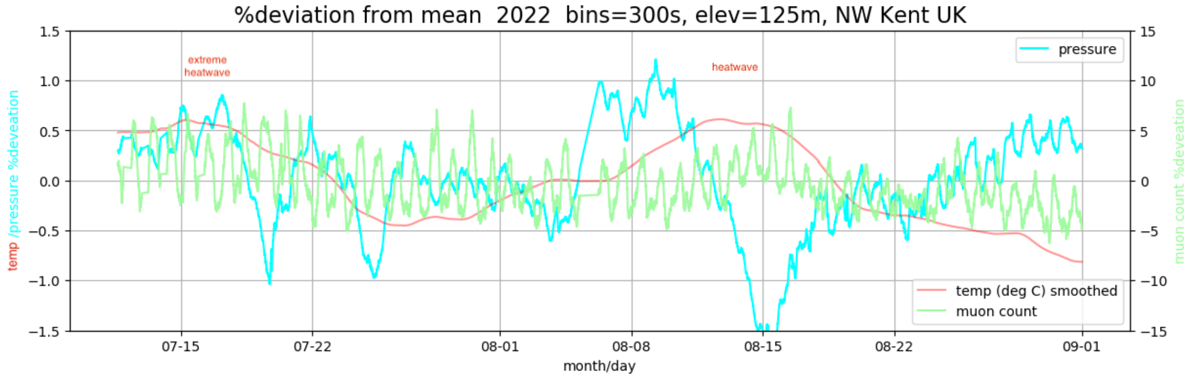
MUONS



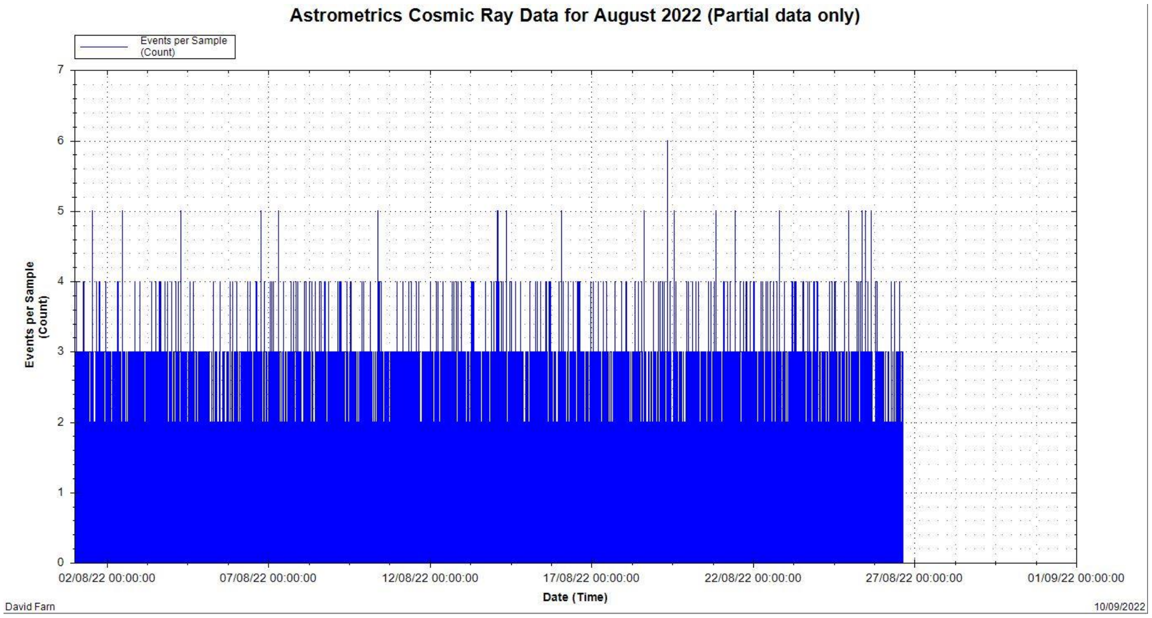


Mark Prescott has been experimenting with a UKRAA muon detector and has been able to make some interesting measurements. This recording covers the period from mid-July to the end of August, showing counts recorded in 300 second bins, adjusted for local atmospheric pressure and temperature in the top panel. The lower panel identifies the major flares and CMEs over this period. These adjustments were made on the basis of similar adjustments in professional data.



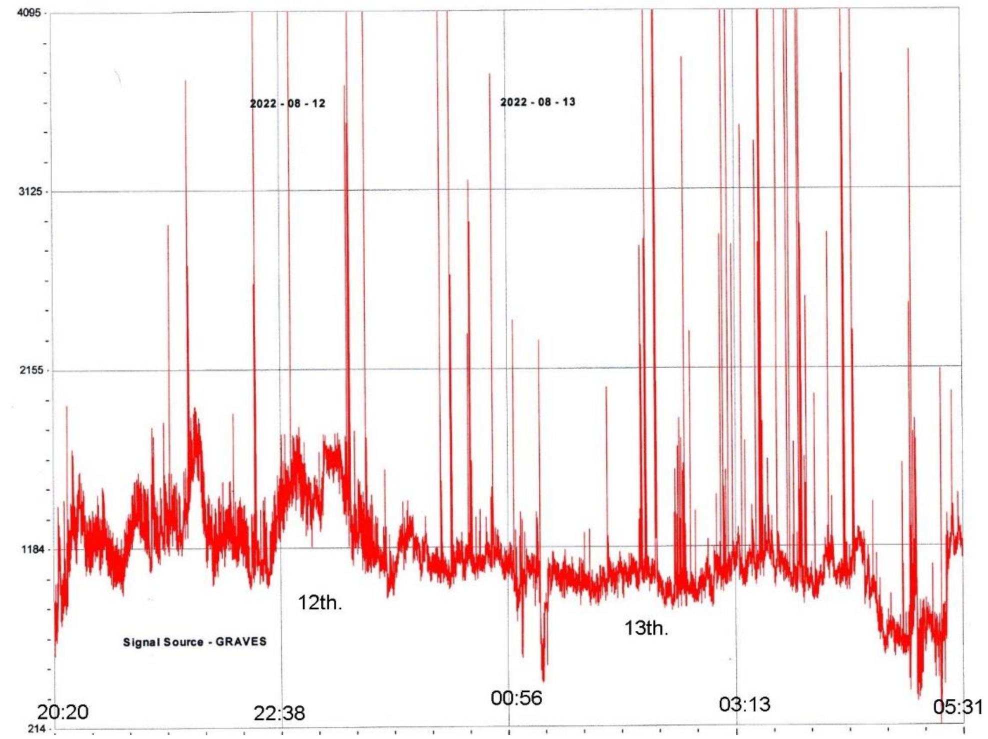


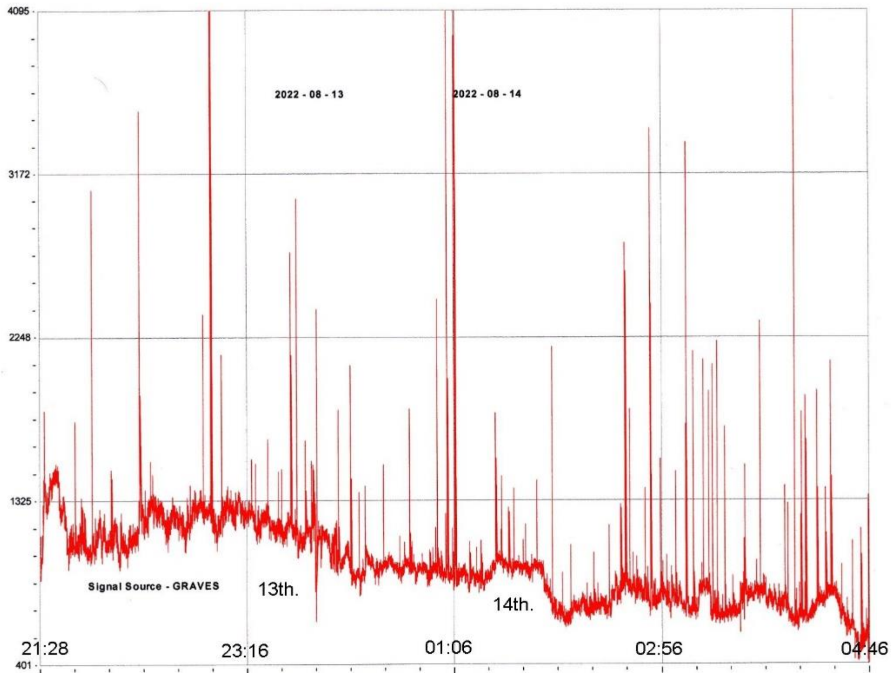
This shows the raw data in the upper panel, with deviation from the mean value in the lower panel. Mark has also added the temperature data in red, noting in particular the strong heatwaves experienced over the summer.



David Farn has also provided his detection results for August. David uses 10 second bins for averaging, giving a background count of about 12 events per minute. No major events were noted, making comparisons difficult.

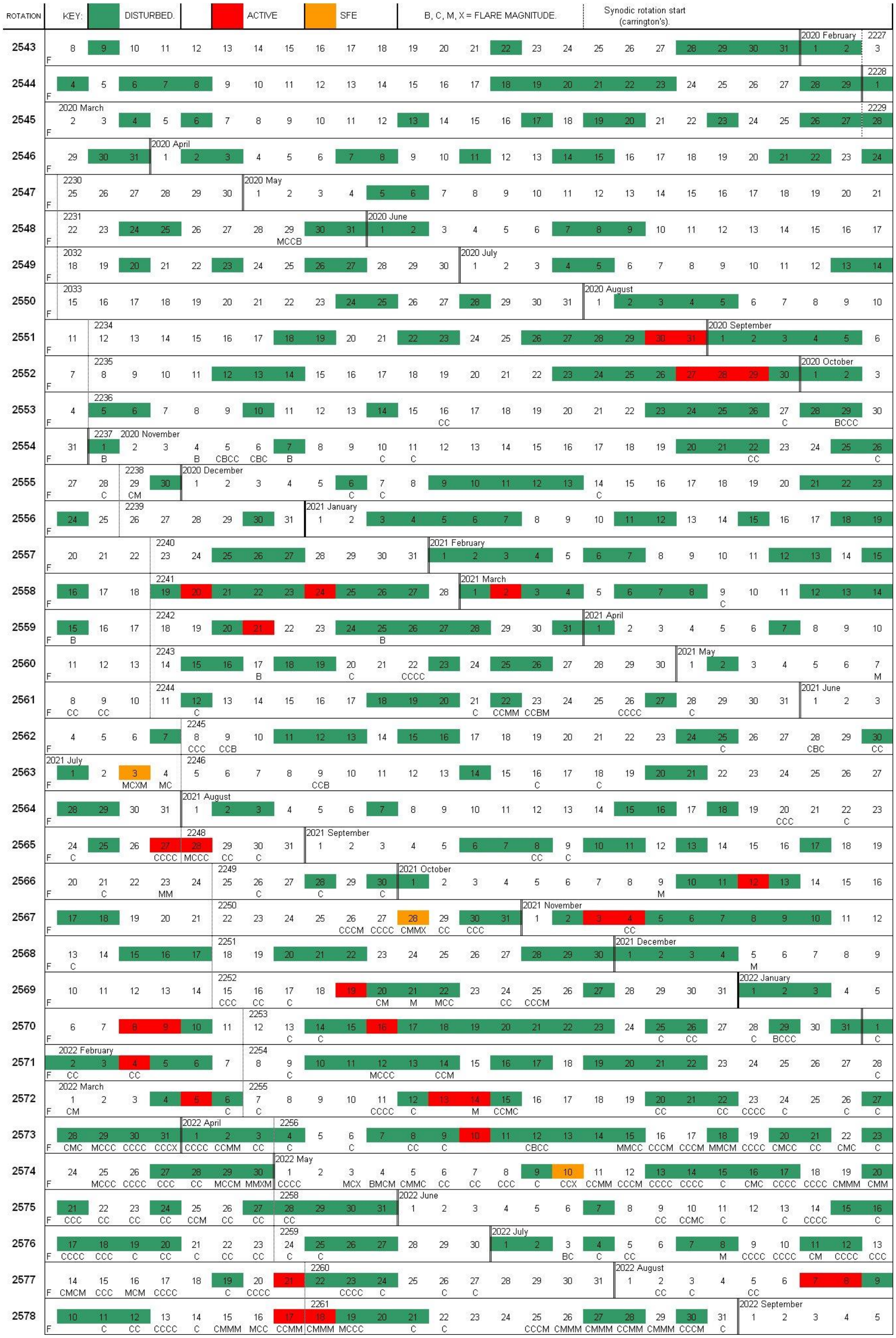
METEORS





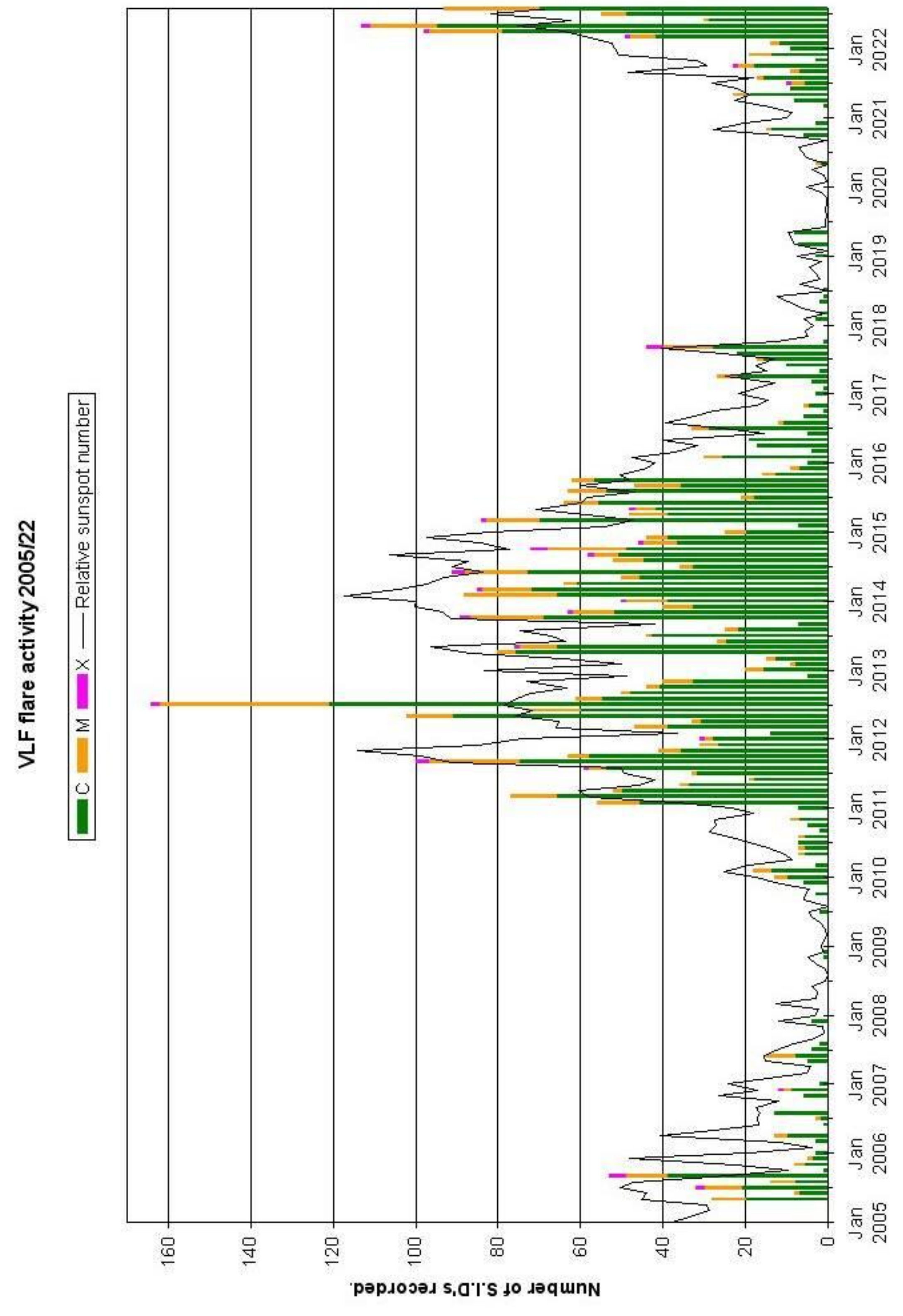
Colin Clements made recordings of the Perseid meteor shower using the GRAVES radio signal. The charts show echoes detected from 20:20UT on the 12th to 04:46 on the 14th. A peak in activity is clear in the early hours of the 13th, as predicted in the BAA handbook. A smaller activity peak is also shown early on the 14th. A much smaller peak was also recorded in the early hours of the 15th. A few detections were recorded on the 12th.

BARTELS CHART



ROTATION | KEY: 🟩 DISTURBED. | 🟥 ACTIVE | 🟧 SFE | B, C, M, X = FLARE MAGNITUDE. | Synodic rotation start (carrington's).

ROTATION																											
2543 F	8	🟩 9	10	11	12	13	14	15	16	17	18	19	20	21	🟩 22	23	24	25	26	27	🟩 28	🟩 29	🟩 30	🟩 31	2020 February 🟩 1	🟩 2	2227 3
2544 F	🟩 4	5	🟩 6	🟩 7	🟩 8	9	10	11	12	13	14	15	16	17	🟩 18	🟩 19	🟩 20	🟩 21	🟩 22	🟩 23	24	25	26	27	🟩 28	🟩 29	2228 🟩 1
2545 F	2020 March 2	3	🟩 4	5	🟩 6	7	8	9	10	11	12	🟩 13	14	15	16	🟩 17	18	🟩 19	🟩 20	21	22	🟩 23	24	25	🟩 26	🟩 27	2229 🟩 28
2546 F	29	🟩 30	🟩 31	2020 April 1	🟩 2	🟩 3	4	5	6	🟩 7	🟩 8	9	10	🟩 11	12	13	🟩 14	🟩 15	16	17	18	19	20	🟩 21	🟩 22	23	🟩 24
2547 F	2230 25	26	27	28	29	30	2020 May 1	2	3	4	🟩 5	🟩 6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2548 F	2231 22	23	🟩 24	🟩 25	26	27	28	29 MCCB	🟩 30	🟩 31	2020 June 🟩 1	🟩 2	3	4	5	6	🟩 7	🟩 8	🟩 9	10	11	12	13	14	15	16	17
2549 F	2032 18	19	🟩 20	21	22	🟩 23	24	25	🟩 26	🟩 27	28	29	30	2020 July 1	2	3	🟩 4	🟩 5	6	7	8	9	10	11	12	🟩 13	🟩 14
2550 F	2033 15	16	17	18	19	20	21	22	23	🟩 24	🟩 25	26	27	🟩 28	29	30	31	2020 August 1	🟩 2	🟩 3	🟩 4	🟩 5	6	7	8	9	10
2551 F	11	2234 12	13	14	15	16	17	🟩 18	🟩 19	20	21	🟩 22	🟩 23	24	25	🟩 26	🟩 27	🟩 28	🟩 29	🟥 30	🟥 31	2020 September 🟩 1	🟩 2	🟩 3	🟩 4	🟩 5	6
2552 F	7	2235 8	9	10	11	🟩 12	🟩 13	🟩 14	15	16	17	18	19	20	21	22	🟩 23	🟩 24	🟩 25	🟩 26	🟥 27	🟥 28	🟥 29	🟩 30	2020 October 🟩 1	🟩 2	3
2553 F	4	2236 🟩 5	🟩 6	7	8	9	🟩 10	11	12	13	🟩 14	15	16 CC	17	18	19	20	21	22	🟩 23	🟩 24	🟩 25	🟩 26	27 C	🟩 28	🟩 29 BCCC	30
2554 F	31	2237 🟩 1 B	2020 November 2	3	4 B	5 CBCC	6 CBC	🟩 7 B	8	9	10 C	11 C	12	13	14	15	16	17	18	19	🟩 20	🟩 21	🟩 22 CC	23	24	🟩 25	🟩 26 C
2555 F	27	28 C	2238 29 CM	🟩 30	2020 December 1	2	3	4	5	🟩 6 C	7 C	8	🟩 9	🟩 10	🟩 11	🟩 12	🟩 13	14 C	15	16	17	18	19	20	🟩 21	🟩 22	🟩 23
2556 F	🟩 24	25	2239 26	27	28	29	🟩 30	31	2021 January 1	2	🟩 3	🟩 4	🟩 5	🟩 6	🟩 7	8	9	10	🟩 11	🟩 12	13	14	🟩 15	16	17	🟩 18	🟩 19
2557 F	20	21	22	2240 23	24	🟩 25	🟩 26	🟩 27	28	29	30	31	2021 February 🟩 1	🟩 2	🟩 3	🟩 4	5	🟩 6	🟩 7	8	9	10	11	🟩 12	🟩 13	14	🟩 15
2558 F	🟩 16	17	18	2241 🟩 19	🟥 20	🟩 21	🟩 22	🟩 23	🟥 24	🟩 25	🟩 26	🟩 27	28	2021 March 🟩 1	🟥 2	🟩 3	🟩 4	5	🟩 6	🟩 7	🟩 8	9 C	10	11	🟩 12	🟩 13	🟩 14
2559 F	🟩 15 B	16	17	2242 18	19	🟩 20	🟥 21	22	23	🟩 24	🟩 25 B	🟩 26	🟩 27	🟩 28	29	30	🟩 31	2021 April 🟩 1	2	3	4	5	6	🟩 7	8	9	10
2560 F	11	12	13	2243 14	🟩 15	🟩 16	17 B	🟩 18	🟩 19	20 C	21	22 CCCC	🟩 23	24	🟩 25	🟩 26	27	28	29	30	2021 May 1	🟩 2	3	4	5	6	7 M
2561 F	8 CC	9 CC	10	2244 11	🟩 12 C	13	14	15	16	17	🟩 18	🟩 19	🟩 20	21 C	🟩 22 CCMM	23 CCBM	24	25	26 CCCC	🟩 27	28 C	29	30	31	2021 June 1	2	3
2562 F	4	5	6	🟩 7	2245 8 CCC	9 CCB	10	🟩 11	🟩 12	🟩 13	14	🟩 15	🟩 16	17	18	19	20	21	22	23	🟩 24	🟩 25 C	26	27	28 CBC	29	🟩 30 CC
2563 F	2021 July 🟩 1	2	🟧 3 MCXM	4 MC	2246 5	6	7	8	9 CCB	10	11	12	13	🟩 14	15	16 C	17	18 C	19	🟩 20	🟩 21	22	23	24	25	26	27
2564 F	🟩 28	🟩 29	30	31	2021 August 1	🟩 2	🟩 3	4	5	6	🟩 7	8	9	10	11	12	13	14	🟩 15	🟩 16	17	🟩 18	19	20 CCC	21	22 C	23
2565 F	24 C	🟩 25	26	🟥 27 CCCC	2248 🟥 28 MCCC	29 CC	30 C	31	2021 September 1	2	3	4	5	🟩 6	🟩 7	🟩 8 CC	9 C	🟩 10	🟩 11	12	🟩 13	14	15	16	🟩 17	18	19
2566 F	20	21 C	22	23 MM	24	2249 25	26 C	27	🟩 28 C	29	🟩 30 C	2021 October 🟩 1	2	3	4	5	6	7	8	9 M	🟩 10	🟩 11	🟥 12	🟩 13	14	15	16
2567 F	🟩 17	🟩 18	19	20	21	2250 22	23	24	25	26 CCCM	27 CCCC	🟧 28 CMMX	29 CC	🟩 30 CCC	🟩 31	2021 November 1	🟩 2	🟥 3	🟥 4 CC	🟩 5	🟩 6	🟩 7	🟩 8	🟩 9	🟩 10	11	12
2568 F	13 C	14	🟩 15	🟩 16	🟩 17	2251 18	19	🟩 20	🟩 21	🟩 22	23	24	25	26	27	🟩 28	🟩 29	🟩 30	2021 December 🟩 1	🟩 2	🟩 3	🟩 4	5 M	6	7	8	9
2569 F	10	11	12	13	14	2252 15 CCC	16 CC	17 C	18	🟥 19	🟩 20 CM	🟩 21 M	🟩 22 MCC	23	24 CC	25 CCCM	26	🟩 27	28	29	30	31	2022 January 🟩 1	🟩 2	🟩 3	4	5
2570 F	6	7	🟥 8	🟥 9	🟩 10	11	2253 12	13 C	🟩 14 C	🟩 15	🟥 16	🟩 17	🟩 18	🟩 19	🟩 20	🟩 21	🟩 22	🟩 23	24	🟩 25 C	🟩 26 CC	27	28 C	🟩 29 BCCC	30	🟩 31	🟩 1 C
2571 F	2022 February 🟩 2 CC	🟩 3	🟥 4 CC	🟩 5	🟩 6	7	2254 8	9 C	🟩 10	🟩 11	🟩 12 MCCC	🟩 13	🟩 14 CCM	15	🟩 16	🟩 17	18	🟩 19	🟩 20	🟩 21	🟩 22	23	24	25	26	27	28 C
2572 F	2022 March 1 CM	2	3	🟩 4	🟥 5	🟩 6 C	2255 7 C	8	9	10	11 CCCC	🟩 12 C	🟥 13	🟥 14 M	🟩 15 CCMC	16	17	18	19	🟩 20 CC	🟩 21	🟩 22 CC	23 CCCC	24 C	25	26 C	🟩 27 C
2573 F	🟩 28 CMC	🟩 29 MCCC	🟩 30 CCCC	🟩 31 CCCX	2022 April 🟩 1 CCCC	🟩 2 CCMM	🟩 3 CC	2256 🟩 4 C	5	6 C	🟩 7	🟩 8 CC	🟩 9 C	🟥 10	🟩 11	🟩 12 CBCC	🟩 13	🟩 14	🟩 15 MMCC	16 CCCM	17 CCCM	🟩 18 MMCM	19 CCCC	🟩 20 CMCC	🟩 21 CC	22 CMC	🟩 23 C
2574 F	24	25 MCCC	26 CCCC	🟩 27 CCC	🟩 28 CC	🟩 29 MCCM	🟩 30 MMXM	2022 May 1 CCCC	2	3 MCX	4 BMCM	5 CMMC	6 CC	7 CC	8 CCC	🟩 9 C	🟧 10 CCX	11 CCMM	12 CCCM	🟩 13 CCCC	🟩 14 CCCC	🟩 15 C	🟩 16 CMC	🟩 17 CCCC	18 CCCC	19 CMMM	🟩 20 CMM
2575 F	🟩 21 CCC	22 CC	23 CC	🟩 24 CC	25 CCM	26 CC	🟩 27 CC	2258 🟩 28 CC	🟩 29	🟩 30	🟩 31	2022 June 1	2	3	4	5	6	🟩 7	8	9 CC	10 CCMC	11 C	12	13 C	14 CCCC	🟩 15	🟩 16 C
2576 F	🟩 17 CCCC	🟩 18 CCC	🟩 19 C	🟩 20 CC	21 C	22 CC	23 CC	2259 24 C	🟩 25 C	🟩 26	🟩 27	28	29	30	2022 July 🟩 1	🟩 2	3 BC	🟩 4 C	5 CC	6	🟩 7	🟩 8 M	9 CCCC	10 CCCC	🟩 11 CM	🟩 12 CCCC	13 CCC
2577 F	14 CMCM	15 CCC	16 MCM	17 CCCC	18	🟩 19 C	20 CCCC	🟥 21	2260 🟩 22	🟩 23 CCCC	🟩 24 C	25	26 C	27 C	28	29	30	31	2022 August 1	2 CC	3 C	4	5 CC	6	🟥 7	🟥 8	🟩 9
2578 F	🟩 10	🟩 11 C	🟩 12 CC	13 CCCC	14 C	15 CMMM	16 MCC	🟥 17 CCCM	2261 🟥 18 CMMM	🟩 19 MCCC	🟩 20	🟩 21 C	22 C	23	24	25 CCCM	26 CMMM	🟩 27 CMMM	🟩 28 CCMM	29 CMMM	🟩 30 CCCM	31 C	2022 September 1	2	3	4	5


VLF flare activity 2005/22
C
M
X
Relative sunspot number
Number of S.I.D's recorded.
0
20
40
60
80
100
120
140
160
Jan 2005
Jan 2006
Jan 2007
Jan 2008
Jan 2009
Jan 2010
Jan 2011
Jan 2012
Jan 2013
Jan 2014
Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Jan 2021
Jan 2022

British Astronomical Association
Supporting amateur astronomers since 1890
Radio Astronomy Section

BAA RA Section Autumn **programme 2022**

Nov. 4st.	**Prof. John Richer**	***'On ALMA'***
19:30 GMT (18:30 UTC)	The Cavendish Laboratory Cambridge Univ.	Atacama Large Millimetre/submillimetre Array
	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.	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

Refurbishing an SRT

Part 4: Characterization and Observation Examples

Wolfgang Herrmann

1. Introduction

This is the fourth and final 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 on the instrument characteristics and show some observation examples.

2. Instrument characteristics

After first light was achieved, the telescope was fully characterized. The procedure to determine the different telescope parameters is along the lines of what we have described for our 3-m dish in a previous SARA journal [1].

2.1. Beam Width

The beam width has been measured by recording a transit scan of the sun. Since the diameter of the sun at radio wavelengths is substantially smaller than the expected beam width, it can be considered as a good approximation of a point source. Figure 1 shows the plot of the intensity over time:

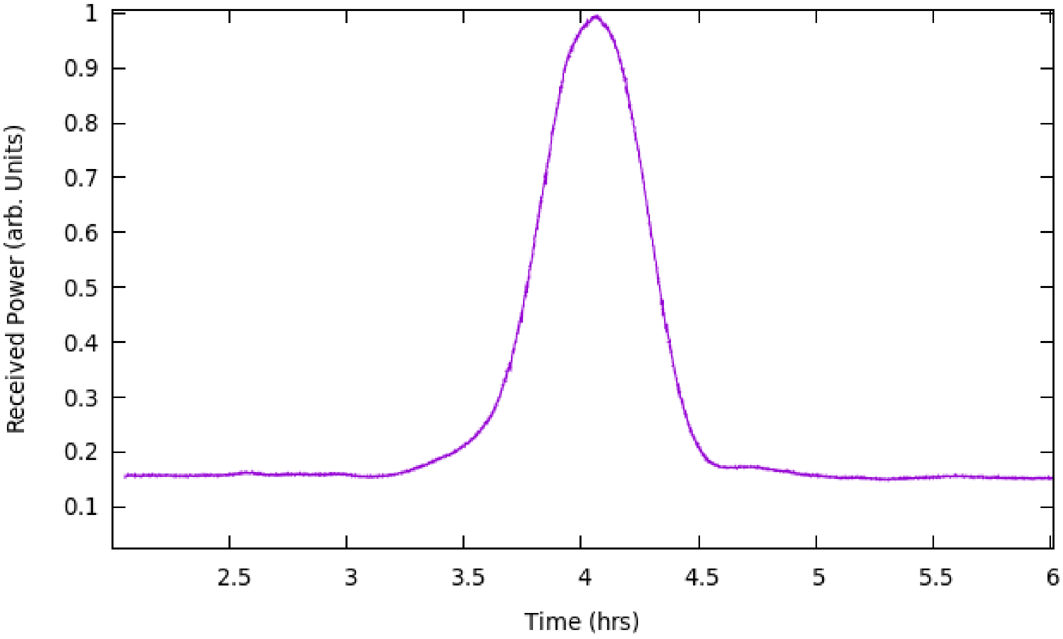


Fig 1: *Transit scan of the sun*

From this transit, the FWHM beam width can be determined to be 7°. The theoretical limit is given by the equation:

$$\mathrm{W} = \arcsin\left(1.22\,\frac{\lambda}{D}\right) \tag{1}$$

For a 2.3-m dish at 21 cm wavelength this is 6.4°, so the beam is a bit wider than this limit. This is expected as the feedhorn is not illuminating the dish by 100%.

2.2. System Temperature

At 21 cm wavelength, it is convenient to determine the system temperature with the help of the "S7" calibration location in the sky. This method is based on the radiometer equation:

$$\sigma_{rms} = \frac{T_{sys}}{\sqrt{\Delta\nu \cdot t}} \tag{2}$$

Rearranging this equation gives:

$$T_{sys} = \sigma_{rms}\sqrt{\Delta\nu \cdot t} \tag{3}$$

σ_{rms} is the rms noise of the signal, $\Delta\nu$ the measurement bandwidth (per spectral channel) and t the measurement time. If the rms noise can be determined as an absolute temperature, the system temperature can be calculated. This requires an intensity calibration of the telescope which can be done by observing "S7".

S7 is a location in the sky where the brightness temperature of the hydrogen line is known with high precision [2]. It is located at galactic longitude 131°, galactic latitude -1°. The specific characteristic of this location is that the hydrogen distribution varies only very little over a larger region. This allows to calibrate telescopes with various beam widths. However, this is no longer quite true for larger beam widths. For a small telescope with a diameter of 2.3 meter and, as in our case, 7° beam width, the exact spectrum needs to be calculated from the original survey data. This can conveniently be done by using the tool on the website of the Argelander Institute of the University of Bonn [3]. Using this tool, one can determine that the peak brightness temperature of the spectrum is 51 K for our beam width.

The spectrum of S7 was recorded with 20 sec integration time and 1465 kHz resolution as shown in fig. 2

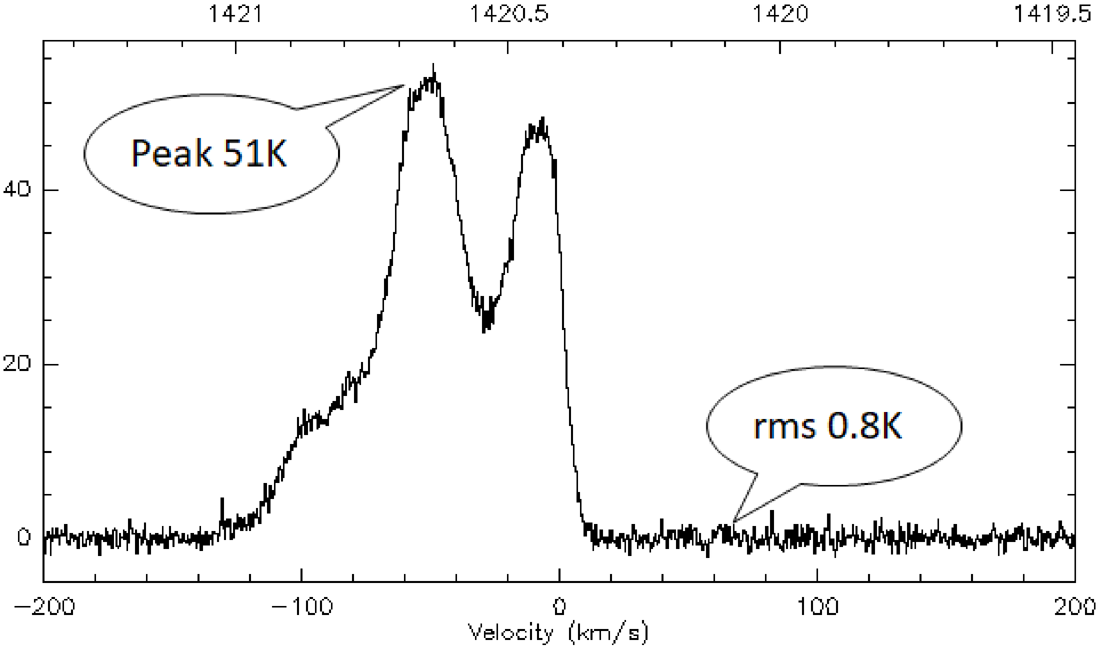


***Fig 2:** Spectrum of S7*

The spectrum was scaled so that the peak corresponds to 51K, the rms value then is 0.8K. Entering the values into eq. (2) then gives a system temperature of 137K.

At our location, S7 is circumpolar. The elevation of this source varies during 24 hours and therefore, the system temperature can be determined over a larger elevation range. The same elevation occurs both to the east and to the west of the culmination in the north. Therefore, it can be seen if the system temperature differs in these directions, possibly due to different surroundings. The results of this effort are shown in fig. 3.

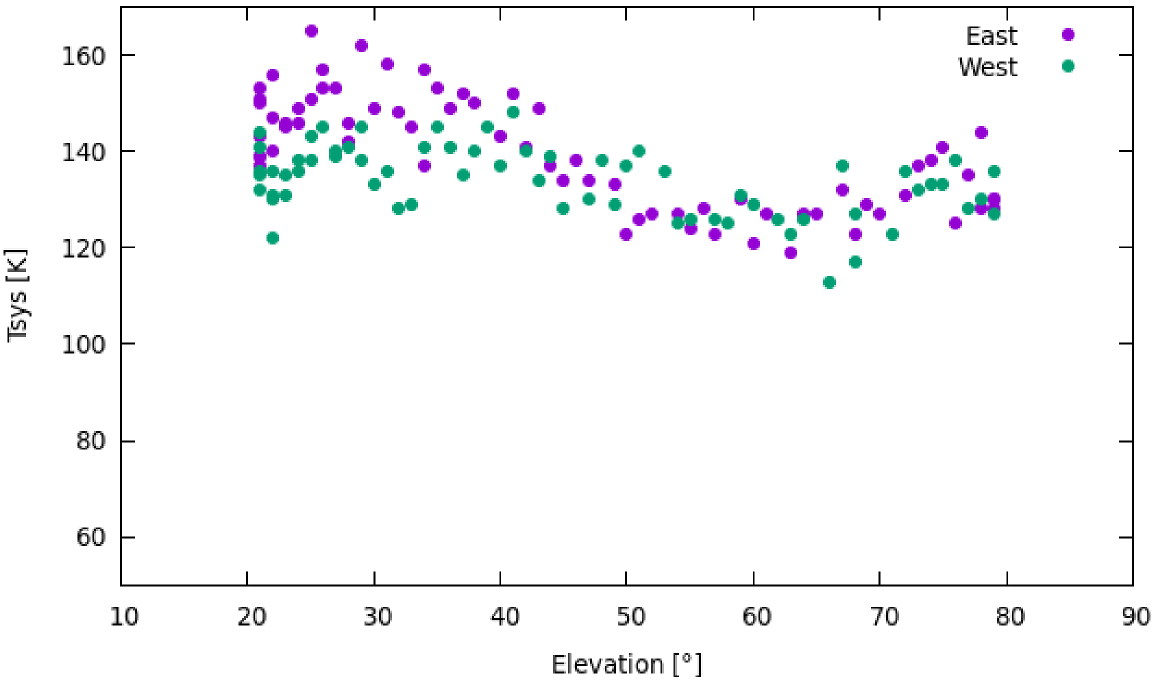


Fig 3: *System temperature at various elevations*

As one can see, the system temperature is highest at low elevations due to thermal pickup from the ground. This effect seems to be slightly different towards East and West, likely due to different terrain features. For the purpose of sensitivity calculations, we have adopted a T_{sys} of 132 K as a "standard value".

2.3. Forward Gain

"Forward Gain" is an expression used in different circumstances and, hence, with different definitions. In radio astronomy it describes the raise in antenna temperature in response to a signal received from an astronomical object with a certain flux. This is measured in K/Jy.

In order to determine the forward gain three power measurements are taken:

- The power received when pointing at the celestial pole ("dark" position with approximately 10 K brightness temperature), P_{cold}.
- The power received when the feed horn is covered with an absorber, P_{hot}. As an alternative, one can also direct the telescope towards trees or bushes, which also represent a fairly good absorber. This procedure has been used here.
- The power received when pointing at the sun, F_{sun}.

One needs to record the ambient temperature T_a and the solar flux F_{sun} at the time of the measurement. The current solar flux can be obtained from the Learmoth observatory [4]

The forward gain of the telescope is given by

$$G = \frac{T_a - T_{cold}}{P_{hot} - P_{cold}} \cdot \frac{P_{sun} - P_{cold}}{F_{sun}} \qquad (4)$$

The good news here is that since power appears both in the numerator and the denominator, no absolute measurements are needed. One can use uncalibrated power readings.

The measurement was taken by directing the telescope at the sun, then at bushes and then at the northern celestial pole. The recording of this experiment is shown below in fig. 4.

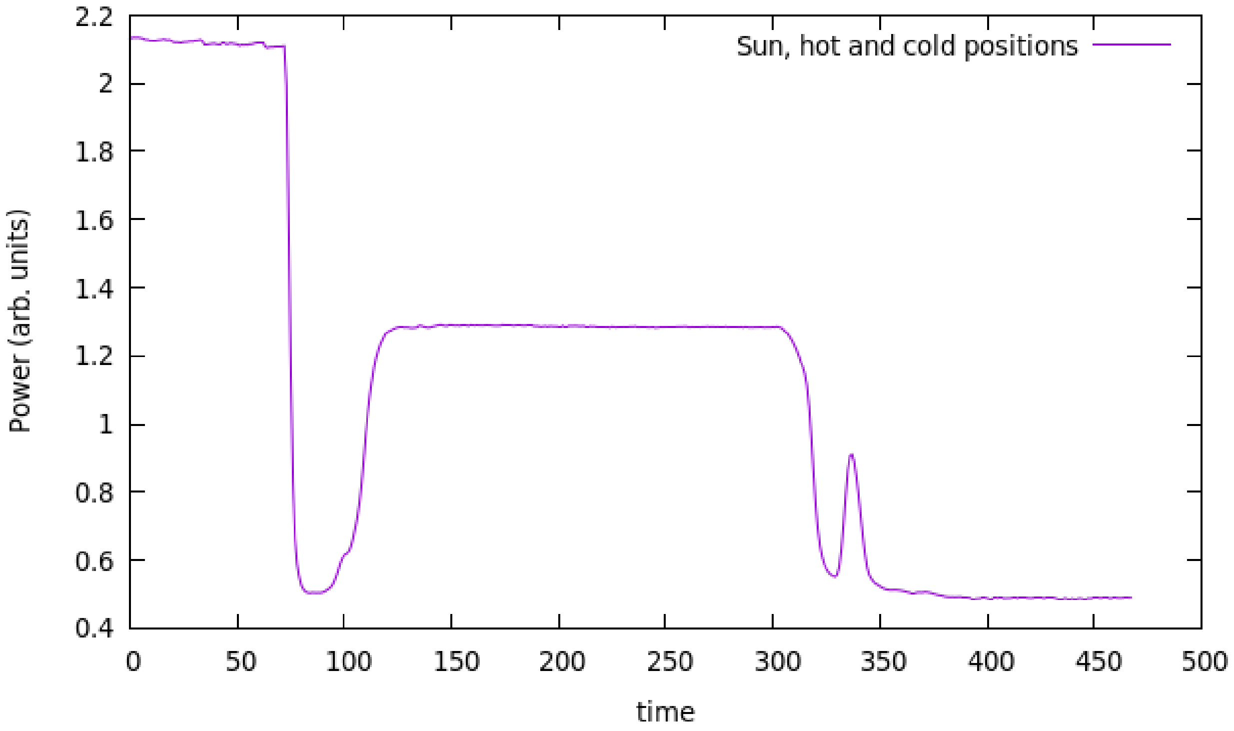


Fig 4: *Power at Sun, hot and cold positions*

During the first 70 seconds, the telescope was directed at the sun, then it transited to the "hot" position remaining there from 125 to 300 seconds of the recording, and then it moved to the celestial pole. The peak at around 335 seconds is due to a building which came partially in the line of sight during the movement towards the pole. The results of this measurement were:

P_{hot}	1.29 (arb. units)
P_{cold}	0.487 (arb. units)
P_{sun}	2.12 (arb. units)

Temperatures and solar flux used were:

T_a	287 K (as per our weather station on site)
T_{cold}	10 K (approximate brightness temperature at the celestial pole)
F_{sun}	70 SFU = 700,000 Jy (as per Learmonth observatory)

Entering these values into eq. (4) gives a forward gain of 0.0008 K/Jy.

One can also use these measured values to determine the system temperature via the Y-Factor method. This gives a T_{sys} of 158 K, similar to what has been determined via using the S7 calibration source.

2.4. System Equivalent Flux Density

The system equivalent flux density (SEFD) is defined as the flux density of an astronomical object which gives the same antenna temperature (signal from the antenna) as the system temperature. This SEFD is a measure of the sensitivity of the telescope:

$$\mathrm{SEFD} = \frac{T_{sys}}{G} \qquad (5)$$

With the system temperature as determined above (standard value) and the measured gain, this gives a SEFD of 165,000 Jy.

2.5. Aperture Efficiency

The aperture efficiency is the relation between the energy received by the telescope divided by the energy incident on the aperture (the area of the telescope). The sun can be used as a strong source of known flux density, so the total energy incident on the dish is known. The increase in antenna temperature can be calibrated by observing the S7 calibration area. Therefore, the rise in antenna temperature can be determined when directing the telescope towards the sun.

The aperture efficiency can then be calculated as:

$$\eta = \frac{2kT_a}{A \cdot F} \qquad (6)$$

Where k is the Boltzmann constant, T_a the increase in antenna temperature, A the area of the telescope and F the flux density of the source (sun in this case).

This has been measured by directing the telescope at the celestial pole as cold position and at the sun. The difference then is T_a. In this case, it needs to be calibrated in K, so an additional measurement was taken at the S7 position to get a calibration factor. Even though it is not necessary for this experiment, the “hot” position (bushes and trees) was measured as well. For determining the calibration factor with S7, the measurements need to be spectrally resolved. Therefore, measurements were taken with a spectrometer. The result is shown in fig. 5 below. The black curve is the cold position, the red curve the S7 spectrum, the green curve is the hot position and the blue curve is the sun. The narrow spikes in the spectrum are RFI and the center line intrinsic to the SDR.

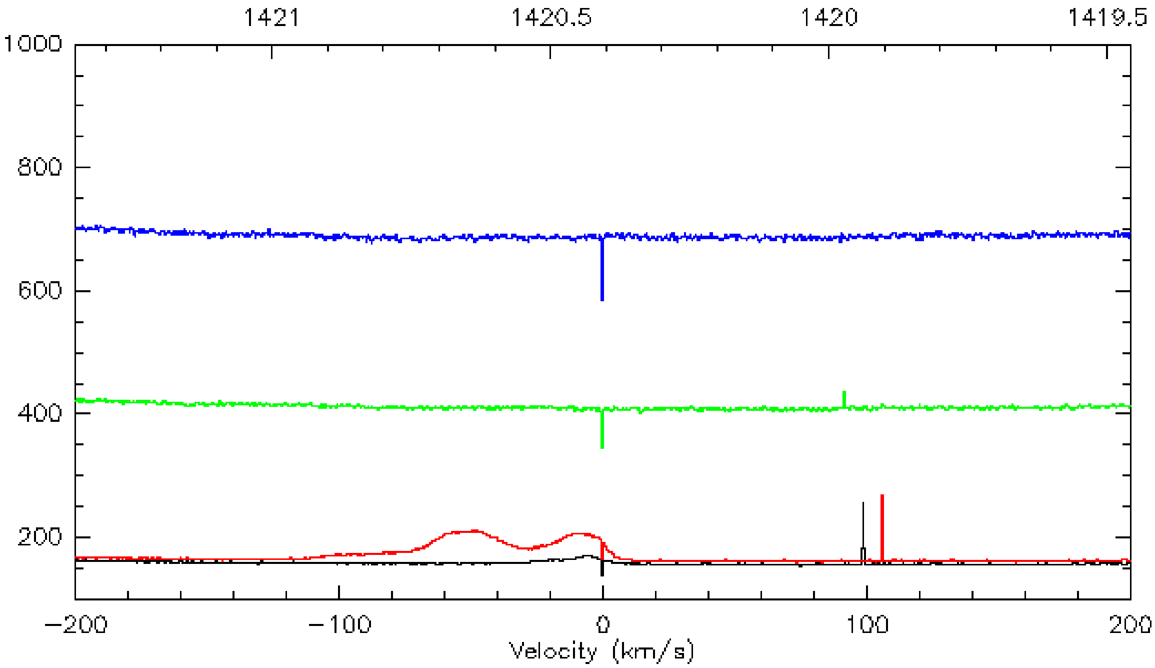


Fig 5: *Calibrated spectrum at cold, S7, hot and sun positions*
Vertical scale is in K, calibrated by S7 (red curve)

The increase in antenna temperature was 530 K when directing the telescope towards the sun.

The parameters for calculating the aperture efficiencies are:

A	4.15 m^2
F	70 SFU = 700,000 Jy
k	$1.38064852 \times 10^{-23}$ m^2 kg s^{-2} K^{-1}
T_a	530 K

From this, the aperture efficiency was determined to be 50%. This is a reasonable value, considering that the feedhorn is quite an exotic design.

2.6. Summary of characteristics

In summary, the main characteristics were determined as follows:

Beam Width	**7°**
SEFD	**165,000 Jy**
System temperature	**132 K**
Gain	**0.0008 K / Jy**
Aperture Efficiency	**50%**

The performance of the telescope can be considered as reasonable, but not outstanding. There is room for improvement by replacing the feed horn with a Kumar type feed horn, and possibly by using better LNAs. Improvements of system temperature and aperture efficiency can be expected by such measures. But nevertheless, the main intended purpose of the instrument is served.

3. Observation Examples

3.1. Galactic Hydrogen

Smaller dishes like this 2.3-m dish are very well suited to observe the emission of Hydrogen in our galaxy. A nice experiment is to take the spectrum in the galactic plane at various galactic longitude. If this is done in small increments in longitude, one can generate a contour plot showing the brightness temperature at these longitudes and the different velocities as shown below in fig. 6. The velocities are referenced to the local standard of rest [5].

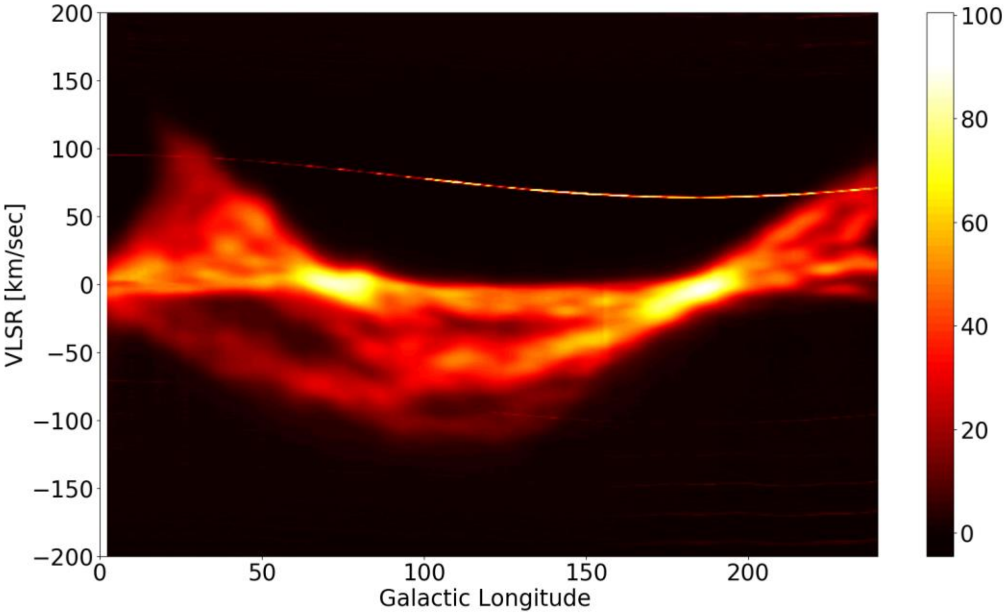


Fig 6: *Scan of the galactic plane (galactic latitude 0°)*
Colour scale is in K antenna temperature

The narrow line which is present in a large part of the plot is caused by an interferer, it has no astronomical origin. It appears as a curved line, as it is a fixed frequency interferer. Applying the local standard of rest velocity correction, it becomes a line representing different velocities, hence the curvature.

3.2. Continuum source: Transit scan of the Cygnus complex

Some of the stronger continuum sources (supernova remnants, star forming regions, radio galaxies) can be observed with smaller telescopes. One of the prominent examples is the Cygnus complex which will be used as an example here. For a small telescope like this 2.3-m dish with its limited resolution, the Cygnus complex is the combination of Cygnus A and Cygnus X which remain unresolved. In fig. 7 a transit scan is shown where the telescope remains stationary and the received power is recorded as the source passes through the beam.

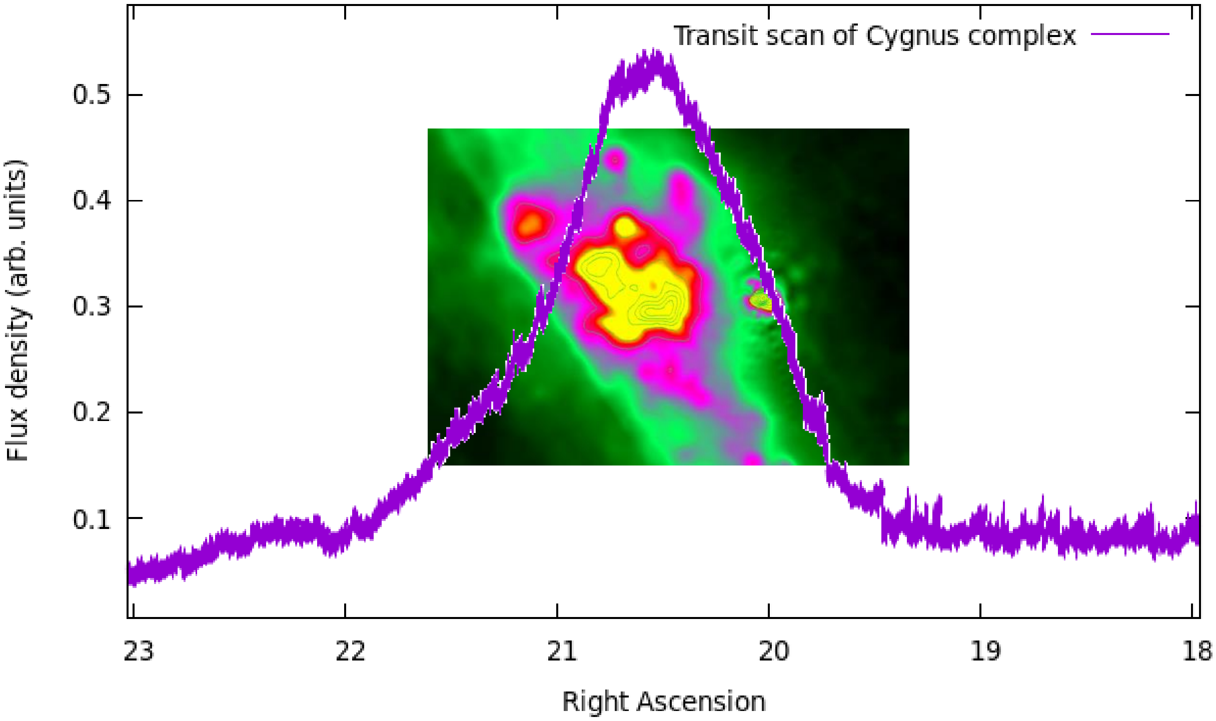


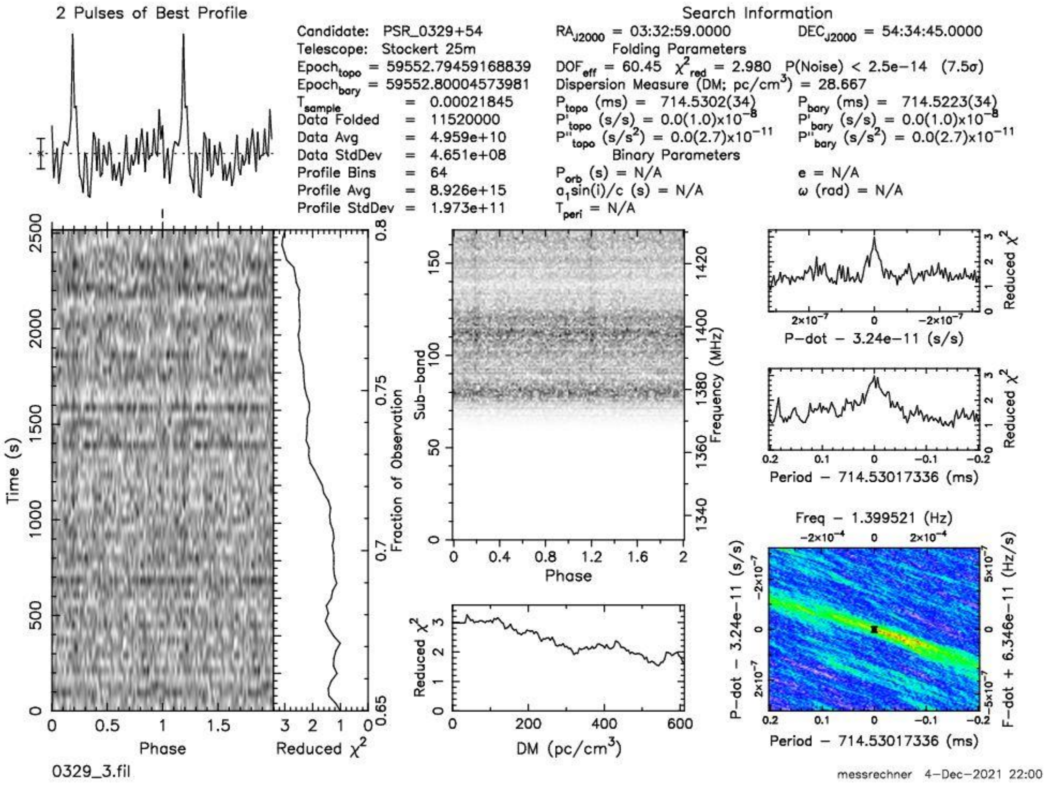
***Fig 7:** Transit scan of the Cygnus complex (Cygnus A and Cygnus X unresolved in the scan) shown with a background map of the area*

In the background of the recording a contour map of the area is shown. This contour map has been prepared by downloading data from the survey tool of the Max-Planck Institute for Radio Astronomy [6] and subsequent processing of the FITS file. The data is based on the 1420-MHz All Sky survey by P. Reich and W. Reich [7],[8].

The radio galaxy Cygnus A is at RA=19.99 hrs, and the cloud Cygnus X is at 21.5 hrs. Cygnus X is extended and this makes it the dominant source in this plot, even though it is not as bright as Cygnus A.

3.3. Pulsars

The pulsar observation has already been reported as an "observation report" in the December 2021 issue of the SARA journal [9]. Details about this observation can be found there. Here we just show again the Presto plot of the successful observation.



```
2 Pulses of Best Profile                                   Search Information
Candidate:  PSR_0329+54          RAJ2000 = 03:32:59.0000           DECJ2000 = 54:34:45.0000
Telescope:  Stockert 25m                   Folding Parameters
Epochtopo = 59552.79459168839    DOFeff = 60.45  χ2red = 2.980  P(Noise) < 2.5e−14  (7.5σ)
Epochbary = 59552.80004573981    Dispersion Measure (DM; pc/cm3) = 28.667
Tsample        =  0.00021845     Ptopo (ms) =  714.5302(34)         Pbary (ms) =  714.5223(34)
Data Folded    =  11520000       P'topo (s/s) = 0.0(1.0)x10−8       P'bary (s/s) = 0.0(1.0)x10−8
Data Avg       =  4.959e+10      P''topo (s/s2) = 0.0(2.7)x10−11    P''bary (s/s2) = 0.0(2.7)x10−11
Data StdDev    =  4.651e+08                Binary Parameters
Profile Bins   =  64             Porb (s) = N/A                     e = N/A
Profile Avg    =  8.926e+15      a1sin(i)/c (s) = N/A               ω (rad) = N/A
Profile StdDev =  1.973e+11      Tperi = N/A
```

Fig 8: *Presto plot of the observation of pulsar B0329+54*

4. Interferometer trials

As mentioned the first part of this series of articles, one of the purposes of setting up this dish was to conduct interferometer experiments with this dish and our 3-m dish. First trials were made with a setup where the two RF signals were correlated using a dual channel software defined radio. The radio used was a Lime SDR [10]. The software for correlation was kindly provided by Marcus Leech [11]. This software is based on GNU radio and provides the complex conjugate of the two I/Q signals coming from the two receiving chains. Fig. 9 shows an overview of the setup.

A transit scan of the Cygnus region was performed. The result is shown in fig. 10., displaying interference fringes. If compared to the total power transit scan shown in fig. 7 one can note that the maximum of the signal in this case is at 19.9 hours of right ascension rather than at 20.5 hours. The preliminary explanation for this effect is that the Cygnus X complex is too wide to produce fringes at this fairly large baseline of 56 meters. Only the signal from the compact source Cygnus A remains. Further investigation is required to confirm this.

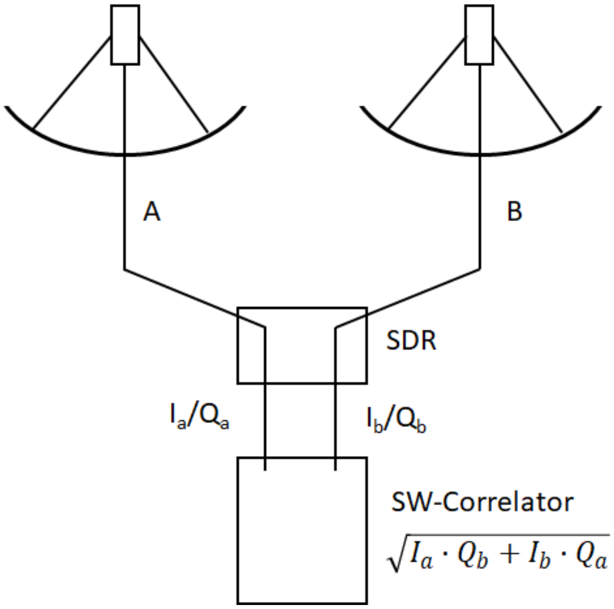


***Fig 9:** Interferometry setup with a software correlator*

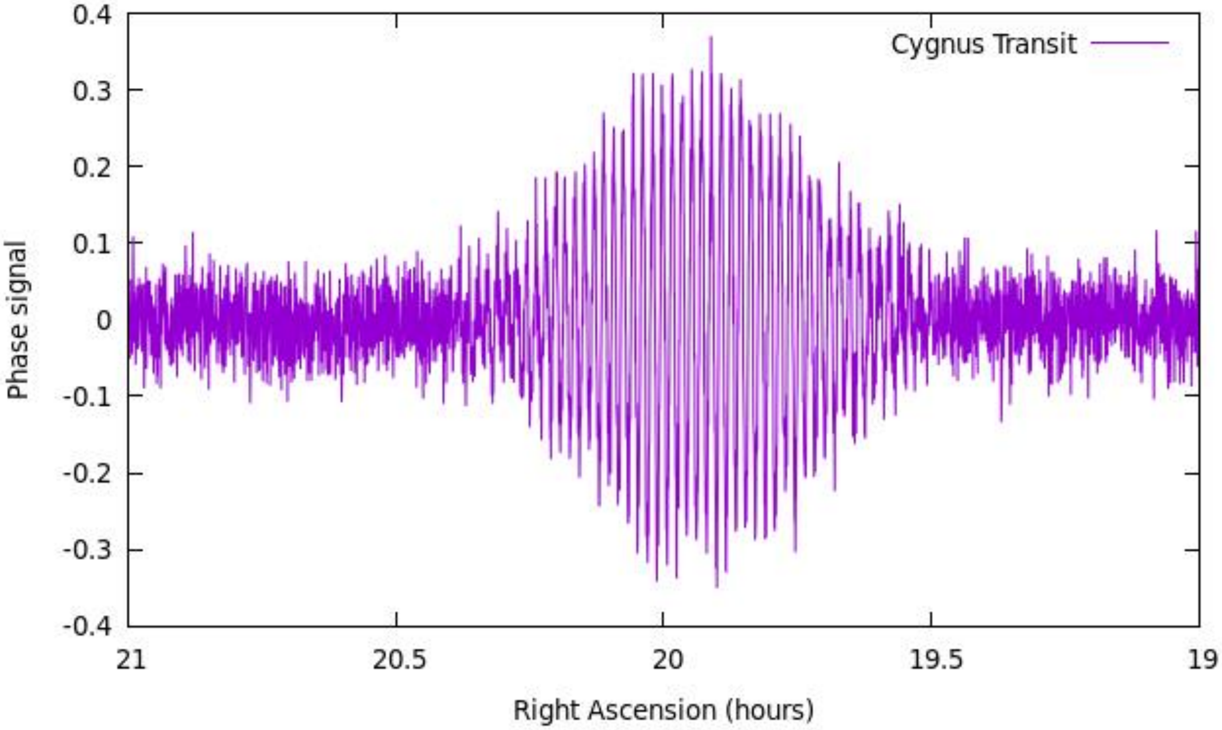


***Fig 10:** Fringes from the transit of the Cygnus complex*

Another example is a transit scan of CAS A as shown in fig. 11:

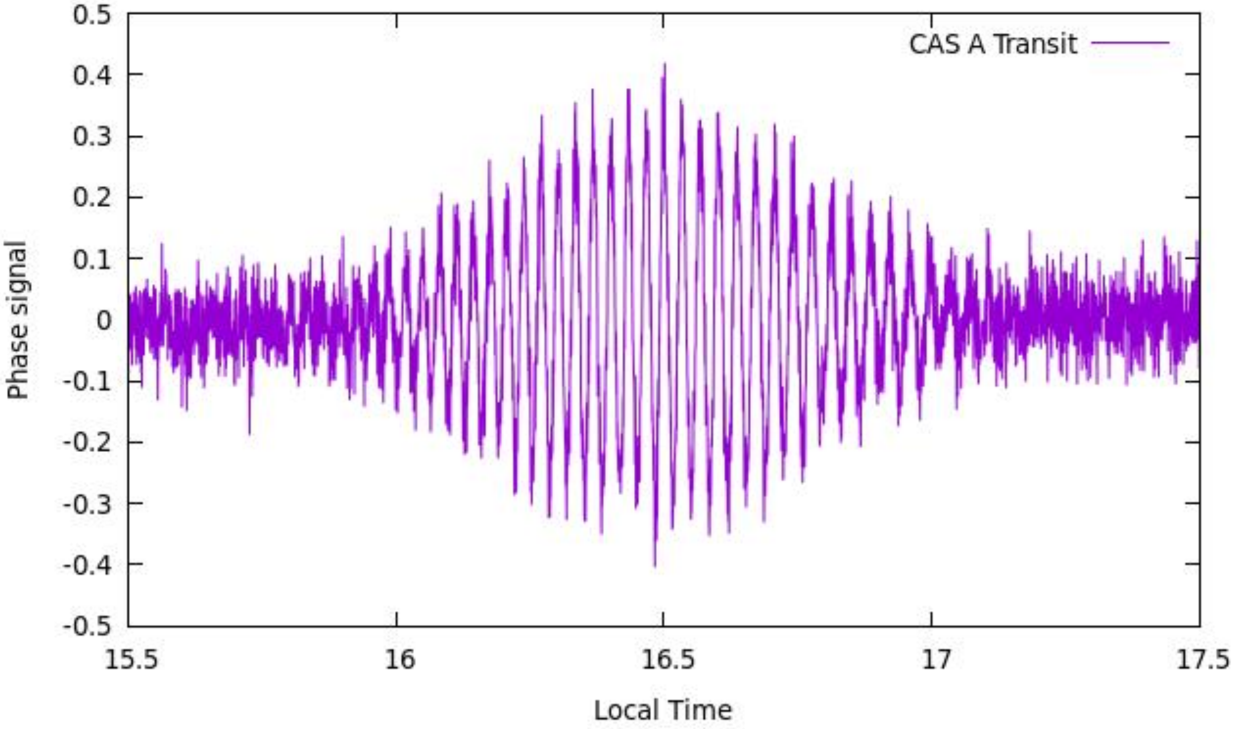


Fig 11: *Fringes from the transit of CAS A*

The interferometer recordings were intended as a proof of concept to demonstrate the basic functionality of our two dishes as an interferometer. More detailed studies will be conducted in the future.

5. Summary and conclusion

When the project was started, it was not clear from the beginning how much effort would be involved. However, based on the previous experience with building small telescopes we were confident that it would be a manageable task. In particular, using essentially the same hardware and software components as for the other dishes allowed to minimize design efforts. One of the new developments was the home-made angular encoder solution for the azimuth. This was required as there was not enough space to accommodate a commercial device.

The mechanics of the telescope turned out to be very rigid. This in particular makes it very worthwhile to refurbish old SRT as cost effective, rigid Az/El drives are hard to come by these days. Therefore, we would highly recommend to other groups to refurbish such SRTs if they get a chance to get one.

6. The refurbishment team

Refurbishing a small radio telescope is much fun. As usual, the fun was shared between quite a few people from the Astropeiler team. In alphabetical order:

Thomas Buchsteiner: Coordination of all hardware build and installation tasks
Bert Engelskirchen: Elevation drive refurbishment and upgrade
Walter Grommes: Outdoor cable installation, electrical power
Manfred Härtel: Network integration
Wolfgang Herrmann: System integration, backends, software and astronomical measurements
Marcus Keseberg: Installation of rotor unit
Clemens Kluithan: Mechanics
Hans-Peter Löge: Controller hardware
Karl-Josef Mauel: Concrete foundation, mounting pole hardware
Kevin Schmitz: Network integration
Gerhard Stramm: Cavity filter, azimuth drive bearing upgrade

References:

[1] W. Herrmann, The 3-Meter Dish at the "Astropeiler Stockert" Part 2: Characterization and Observations, SARA Journal March-April 2020, 57
[2] P.W.M. Kalberla et. al., Brightness Temperature Calibration for 21-cm Line Observations, Astron. Astrophys. 106, 190-196 (1982)
[3] https://www.astro.uni-bonn.de/hisurvey/euhou/LABprofile/
[4] https://www.sws.bom.gov.au/Solar/3/4/2
[5] W. Herrmann, On the local standard of rest, SARA Journal July-August 2021, 73
[6] https://www3.mpifr-bonn.mpg.de/survey.html
[7] W. Reich, A radio continuum survey of the northern sky at 1420 MHz I
Astronomy and Astrophysics Supplement Series, vol. 48, 219-297. (1982)
[8] P. Reich, and W. Reich, A radio continuum survey of the northern sky at 1420 MHz II
Astronomy and Astrophysics Supplement Series, vol. 63, no. 2, 205-288 (1986).
[9] W. Herrmann, Pulsar Observation with a 2.3-m Dish, SARA Journal November-December 2021, 51
[10] https://limemicro.com/products/boards/limesdr/
[11] Marcus Leech, CCERA, private communication

About the Author: Dr. Wolfgang Herrmann is the president of the "Astropeiler Stockert e.V.", the organization which operates the observatory.
He received his PhD in Physics from the University of Bonn. He has spent most of his professional career in the telecommunication industry. At retirement age, he now enjoys learning as much as possible about radio astronomy, doing observations and improving the instruments at Astropeiler.

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Solar Radio & Geomagnetic Activity Observed in Alaska During August 2022

Whitham D. Reeve

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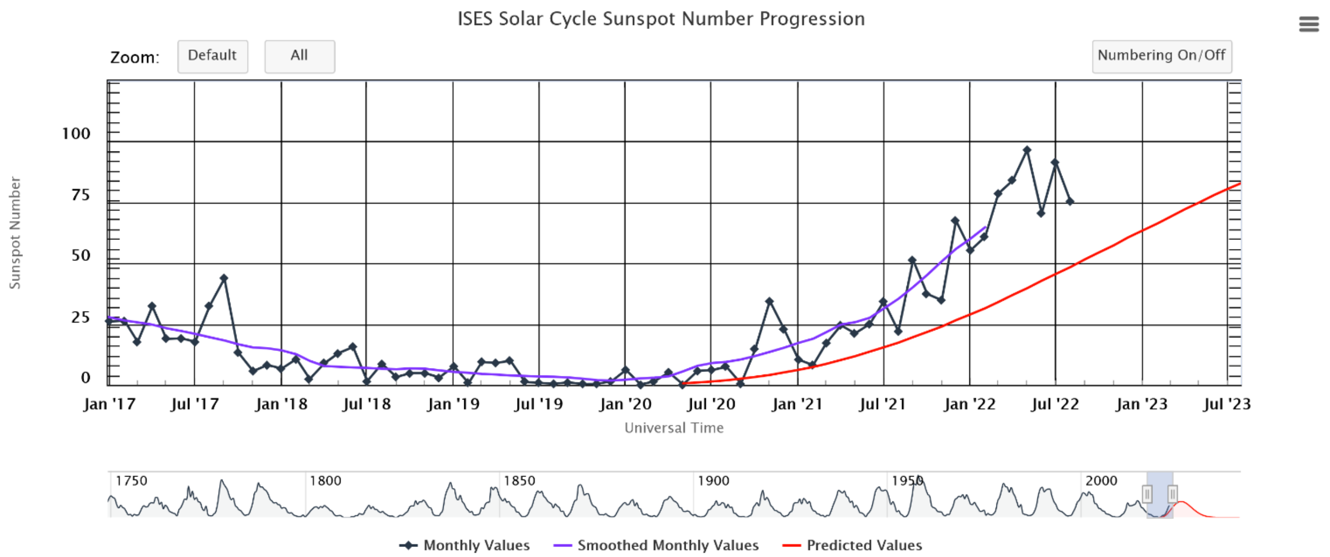
1. Introduction

The month of August 2022 was quite active as recorded by radio and magnetic sensors at the three Alaska observatories: Anchorage Radio Observatory, HAARP Radio Observatory near Gakona and Cohoe Radio Observatory. The observations included solar radio emissions, meteor trail and aurora radio reflections, sudden frequency deviations and sudden ionospheric disturbances, geomagnetic disturbances and ultralow frequency waves (ULF Waves).

The Sun produced thirty M-class x-ray flares but, surprisingly, no X-class flares (table 1), several coronal mass ejections, almost endless geoeffective coronal hole high-speed streams (CHHSS) and accompanying corotating interaction regions (CIR). Most of the strong solar activity took place in the second half of the month. The observations discussed below are a fraction of the total interesting events during August. They span frequencies from mHz to tens of MHz but are not continuous in frequency coverage.

In August 2022, the most active Sunspots and all M-class flares originated from solar Active Regions 3078 and 3088. The activity occurred as Solar Sunspot Cycle 25 ramped up from its beginning in December 2019 (figure 1). It is well known that solar radio emissions and geomagnetic activity increase with the number of sunspots, so the months ahead may prove to be even more active than August.



Space Weather Prediction Center

Figure 1 ~ End of Solar Sunspot Cycle 24 and the beginning of Cycle 25 for reference. The lower scale and trace shows the sunspot cycles since 1750; the shaded area on the lower-right shows the range of the upper trace. Image source: [SWPC]

Solar flares often result in radio emissions that are received directly by ground stations on Earth. The high-energy radiation from flares can affect Earth's ionosphere and, thus, terrestrial radio propagation. The radiation effects can be in the form of radio blackouts and sudden frequency deviations (SFD) in the HF band and sudden ionospheric disturbances (SID) in the LF and VLF bands. Some strong flares produce coronal mass ejections (CME), which in turn can cause Type II slow sweep and Type IV continuum radio emissions from the solar corona and geomagnetic disturbances, the latter delayed by the travel time of the CME from the Sun to Earth. Types of solar radio emissions and their spectral and temporal characteristics are described in detail at {ReeveSolar}.

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2. Solar Radio Emissions 5-85 MHz

The first solar radio bursts presented in this section were received on 15 August at HAARP Radio Observatory (figure 2). These Type III sweeps and Type V continuum were received about 2 hours after local sunrise.

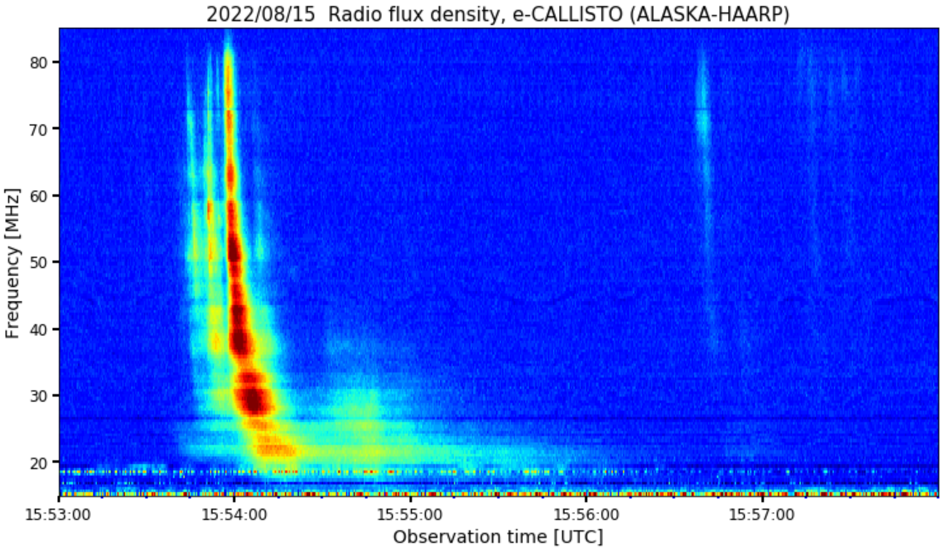

Figure 2 ~ Spectrogram from HAARP shows Type III fast sweep radio bursts received at 1554 on 15 August, which covered the 15-85 MHz frequency range. The sweeps were immediately followed by a Type V continuum between 17 and 39 MHz. Additional weak Type III radio sweeps are seen toward the end of this record. The broken horizontal lines below 20 MHz are terrestrial HF transmissions.

Earth's ionosphere usually is opaque to celestial radio emissions below about 15 MHz, but the actual blocking frequency can occasionally reach as low as 5 MHz. Two of the three Callisto installations in Alaska are set to observe down to 5 MHz as part of a long-term study of the ionosphere's blocking frequency at high latitudes. A consequence of operating at the lower frequency is the ever-present terrestrial HF traffic, a form of unavoidable interference. The traffic is seen as solid or broken horizontal lines on the spectrograms.

The HAARP science facility is multiuse with many diagnostic instruments and other types of instrumentation including a local ionosonde (DigiSonde) and a sweeping transmitter on the TCI-540 HF antenna. This antenna has a low elevation angle and is used for ocean scatter experiments. These systems result in slanted lines below 25 MHz on the HAARP spectrograms. There is very little interference from HF transmissions at Cohoe Radio Observatory.

Additional solar radio emissions were received at HAARP on 19 August (figure 3). The form of this spectra does not conveniently fit any specific radio burst Type and probably is an overlay of more than one burst type or bursts from more than one solar region received at the same time.

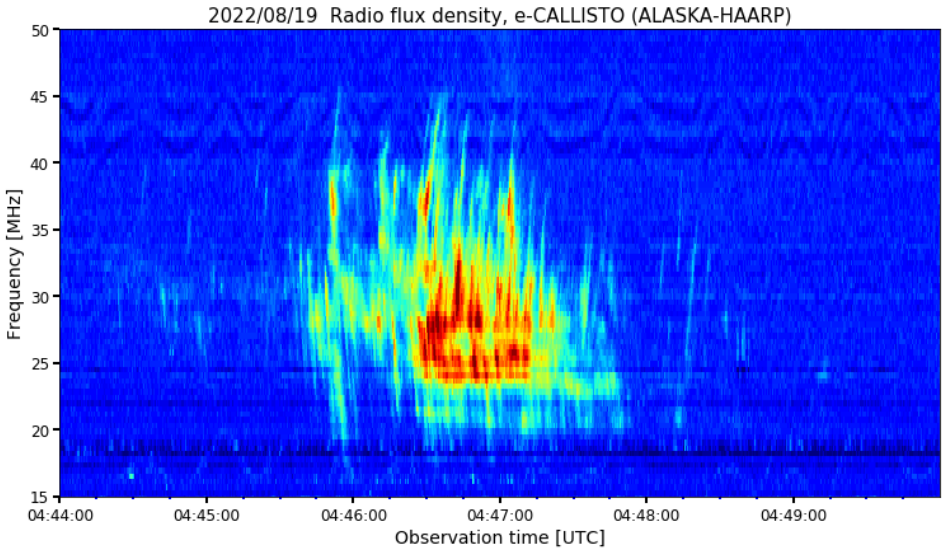

Figure 3 ~ A spectrogram from HAARP on 19 August shows radio emissions associated with an M1.6 x-ray flare that began at 0414, peaked at 0444 and ended 0518. Type II, III, IV and VI sweeps were reported with this flare by Space Weather Prediction Center, but the type shown on this spectrogram is unknown. It could be a combination of Type II and IV or III. Some of the spectra appears to sweep from low to high frequencies, opposite of normal.

Type IV broadband continuum emissions take on several forms, one of which is called Stationary Type IV Broadband Continuum with Fine Structure. It is related to flares and proton emission. Such a radio continuum resulted from an M4.8 x-ray flare and was received at both HAARP and Cohoe on 27 August (figure 4 and 5). Broadband continuum emissions usually are very weak when received on Earth and the associated spectrograms often show background noise or other system-related spectral defects resulting from the spectrum image processing.

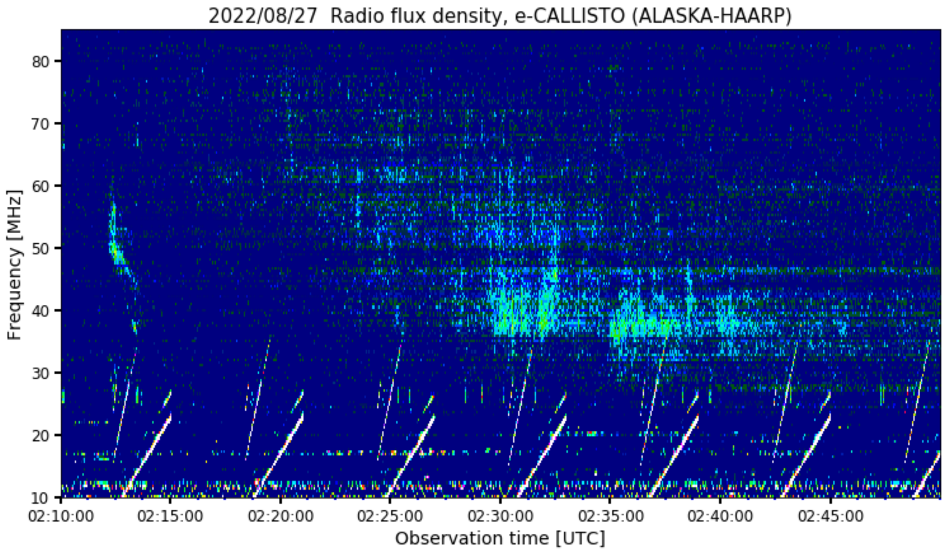

Figure 4 ~ A Type IV broadband continuum was received at HAARP on 27 August. It was associated with an M4.8 x-ray flare that began at 0152, peaked at 0240 and ended 0305. The continuum was very weak so the background was enhanced, which resulted in some horizontal banding in the spectra. The slanted lines are local HF transmissions.

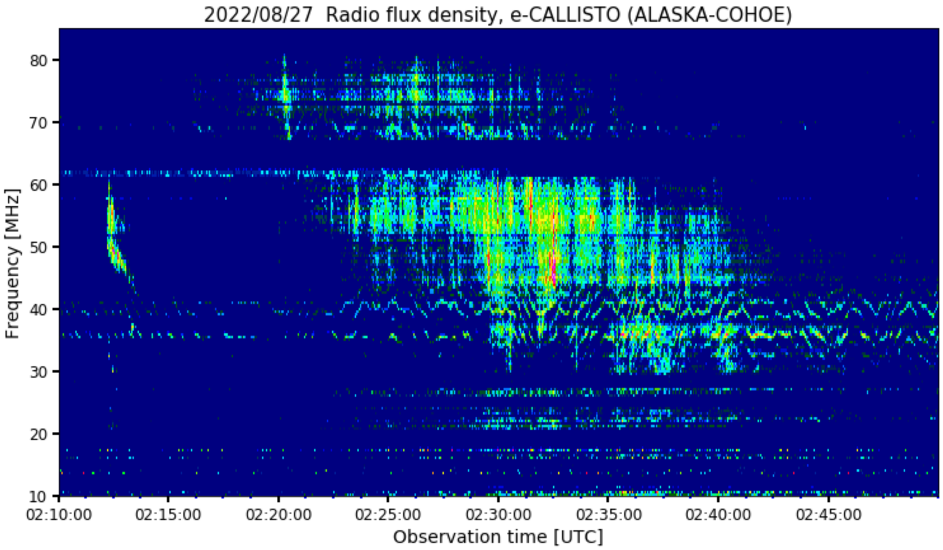

Figure 5 ~ This spectrogram from Cohoe was processed using the same frequency and time settings as the HAARP spectrogram above. The Cohoe spectrogram shows a dropout centered on 65 MHz due to FM broadcast band intermodulation interference. The spectrogram also shows wavey lines between 36 and 40 MHz that may be self-generated interference from system power supplies.

A short-lived continuum with Type II slow radio sweep and other spectral oddities was received at HAARP on 29 August about 2.5 hours after sunrise (figure 6).

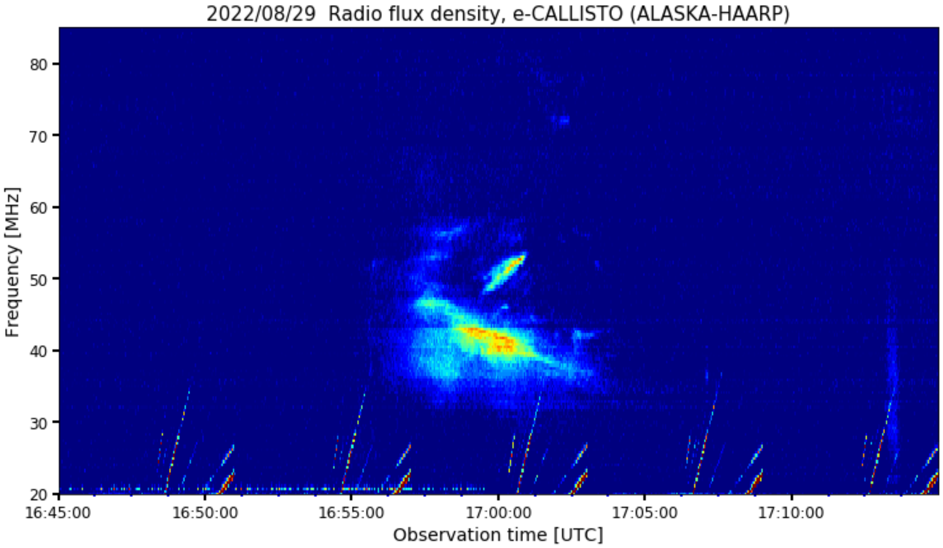

Figure 6 ~ Solar radio burst received at HAARP on 29 August had weak spectral components to at least 85 MHz (the upper limit of the up-converter used with the Callisto instrument). A weak Type III radio sweep appears near the end of this record. The slanted lines are local HF transmissions.

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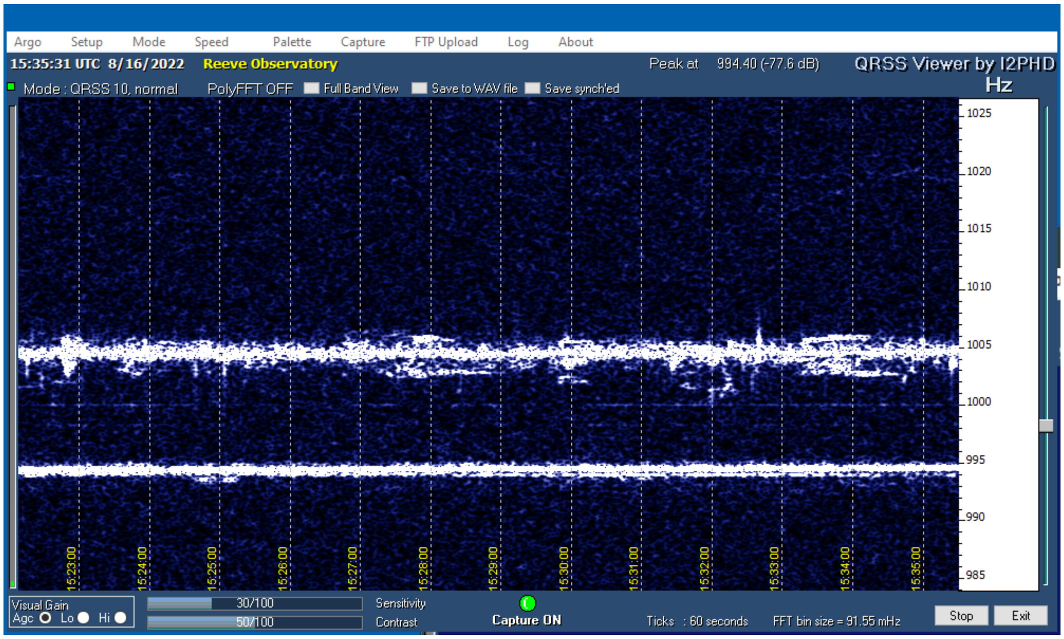
3. Meteor Trail Reflections at 20 MHz

The narrowband Argo spectrogram below (figure 7), dated 16 August, is from Anchorage Radio Observatory and shows meteor trail reflections at 20 MHz from WWV (Colorado) or WWVH (Hawaii). The time frame of the plot corresponds to the Perseids meteor shower, which was active between about 14 and 24 August, but the meteors recorded may very well be random. A basic requirement of receiving meteor trail reflections at Anchorage while using the WWV or WWVH transmitters (both around 4000 km away), is that a multimode propagation path must exist from the distant transmitters to the location of the meteor trail at approximately 100 km altitude and from that location to the receiver. Experience has shown that a path from the transmitter to the receiver (not reflected) must also exist at the time. The actual location of the reflection region is unknown. Receiving meteor trail reflections at HF is fully described at {ReeveMeteor}.

For display on an Argo plot, the 20 MHz carrier has been demodulated using LSB mode. The receiver was tuned to 20.001 005 MHz, so the carrier corresponds to the 1005 Hz trace on the plot. The trace at 995 Hz is the demodulated WWV or WWVH carrier at 15 MHz. In this case, the receiver was tuned to 15.000 995 MHz, but no meteor trail reflections are seen on it.



15:35:31 UTC 8/16/2022 Reeve Observatory

Peak at 994.40 (-77.6 dB)

Mode : QRSS 10, normal

PolyFFT OFF

☐ Full Band View ☐ Save to WAV file ☐ Save synch'ed

Sensitivity 30/100

Contrast 50/100

Ticks : 60 seconds

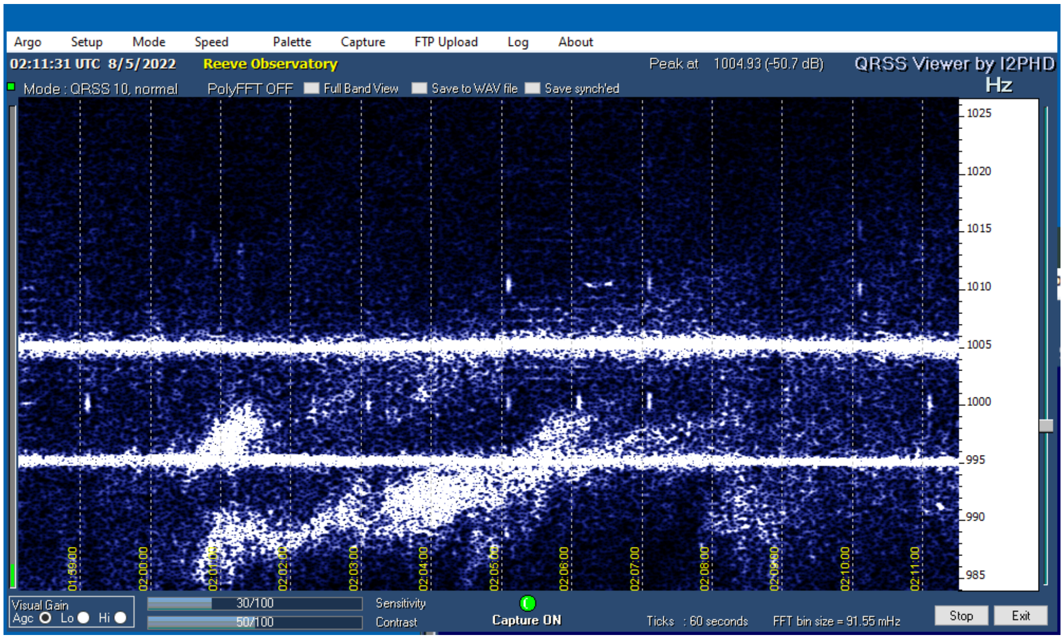
FFT bin size = 91.55 mHz

Figure 7 ~ This Argo plot from 16 August shows several short duration (vertical ticks) and a few long duration (horizontal striated lines) meteor trail reflections. The carrier at 20 MHz is represented by the jagged horizontal line at 1005 Hz. The line at 995 Hz represents a carrier at 15 MHz but it shows no reflections.

4. Aurora Radio Reflections at 15 and 20 MHz

The geomagnetic disturbances during August led to aurora activity north of Anchorage Radio Observatory and the reception of radio reflections at 15 and 20 MHz, examples of which are shown (figure 8). The receiver and antenna setup for receiving aurora radio reflections is the same as for meteor trail reflections; however, in this case the transmitter is believed to be WWVH exclusively because of its favorable north-south alignment with Anchorage Radio Observatory.

The presumed aurora reflection regions are believed to be around 500 to 1000 km north of Anchorage, which requires a multimode propagation path from Hawaii to the aurora reflection region at 100 to 120 km altitude and from there back to Anchorage. The received reflections take on many spectral forms, but all include rapid or high Doppler frequency shifts and signal level enhancements. Also, all aurora radio reflections are associated with geomagnetic disturbances, particularly rapid decreases or increases in the magnetic field flux density measured by the Anchorage SAM-III magnetometer. A detailed discussion of aurora radio reflections can be found at {ReeveAurora}.



02:11:31 UTC 8/5/2022 **Reeve Observatory**

Peak at 1004.93 (-50.7 dB)

Mode : QRSS 10, normal

PolyFFT OFF ☐ Full Band View ☐ Save to WAV file ☐ Save synch'ed

30/100 Sensitivity

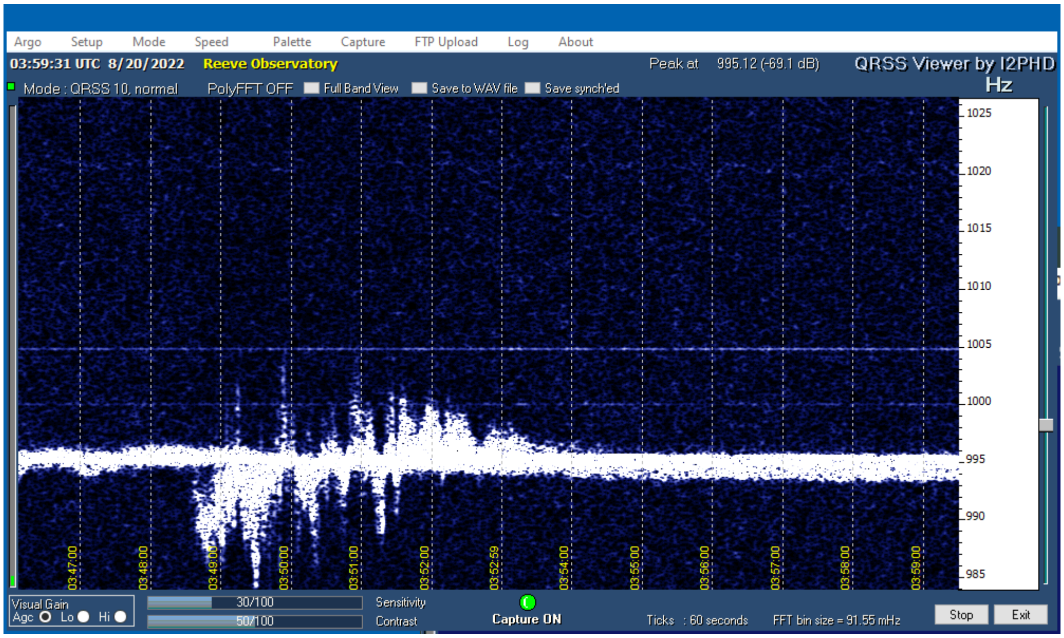
50/100 Contrast

Capture ON

Ticks : 60 seconds

FFT bin size = 91.55 mHz

Figure 8.a ~ Aurora radio reflections on 5 August at around 6:00 pm local time (0200 UTC). These reflections are the diffused type with a slanted, blob-like structure. These appear to be at both 15 and 20 MHz (995 and 1005 Hz, respectively, on the right frequency scale). The short, vertical ticks are processing artifacts of the WWVH minute time marks.



03:59:31 UTC 8/20/2022 **Reeve Observatory**

Peak at 995.12 (-69.1 dB)

Mode : QRSS 10, normal

PolyFFT OFF ☐ Full Band View ☐ Save to WAV file ☐ Save synch'ed

30/100 Sensitivity

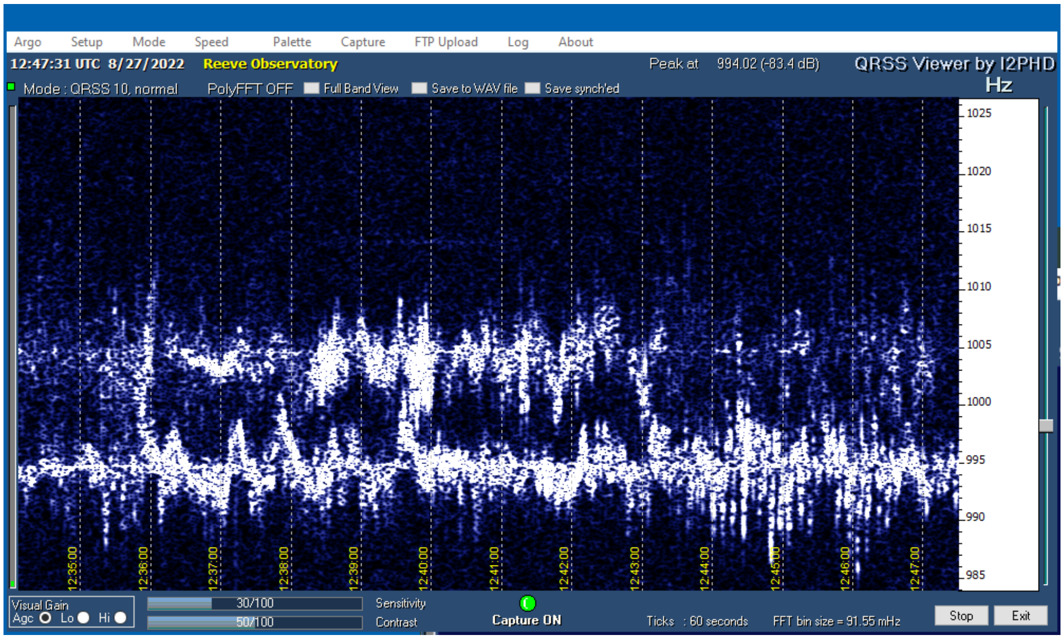
50/100 Contrast

Capture ON

Ticks : 60 seconds

FFT bin size = 91.55 mHz

Figure 8.b ~ Aurora radio reflections on 20 August around 8:00 pm on 15 MHz only (995 Hz on frequency scale). No signal is received at 20 MHz (1005 Hz on frequency scale). The Doppler frequency shift is at least –10 Hz to +6 Hz.



12:47:31 UTC 8/27/2022 Reeve Observatory

Peak at 994.02 (-83.4 dB)

Mode : QRSS 10, normal

PolyFFT OFF ☐ Full Band View ☐ Save to WAV file ☐ Save synch'ed

Sensitivity 30/100

Contrast 50/100

Ticks : 60 seconds

FFT bin size = 91.55 mHz

Figure 8.c ~ Early morning aurora radio reflections on 27 August at both 15 MHz (995 Hz on frequency scale) and 20 MHz (1005 Hz on frequency scale). The local time is around 4:40 am (1240 UTC).

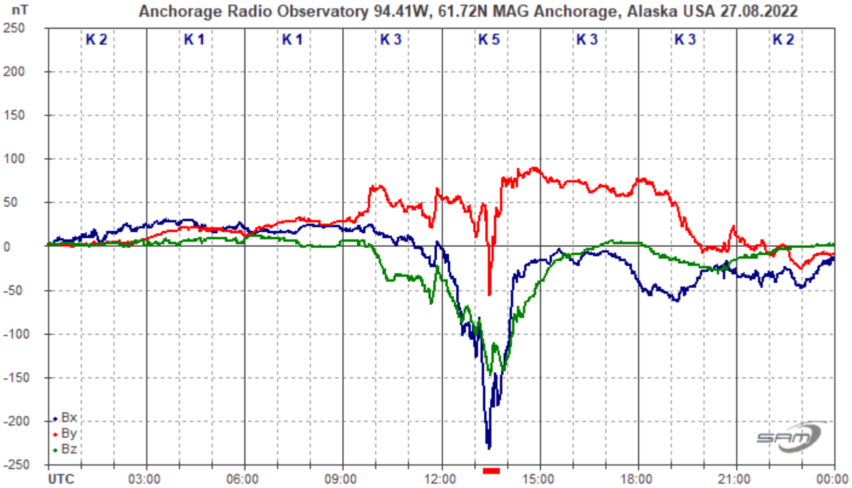


Figure 8.c.1 ~ Geomagnetic activity between 1235 and 1247 corresponds to the aurora radio reflections seen in the previous image. The magnetic bay between 1200 and 1400 is a strong indicator of aurora and their associated magnetic field-aligned enhanced electron density regions where the reflections take place.

---

5. Sudden Frequency Deviation on 15 and 20 MHz

Sudden frequency deviations, SFD are direct evidence of solar flare radiation affecting Earth's ionosphere by rapidly moving the ionosphere's reflection region (modeled as a slab of electrons), thus altering the propagating signal's wave number and frequency. Two SFDs are shown here on 15 and 16 August (figure 9 and 10, respectively). The radio system setup for observing sudden frequency deviations is identical to that used for meteor trail and aurora radio reflections discussed above. Sudden frequency deviations at HF are fully described at {ReeveSFD}.

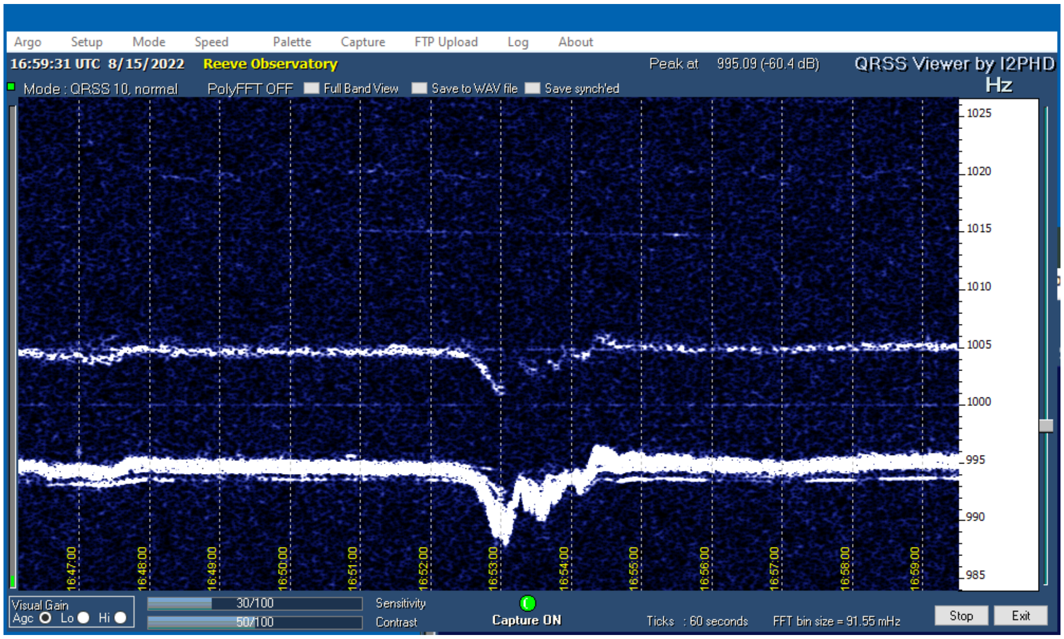


Figure 9 ~ Sudden frequency deviations on 15 and 20 MHz at 1653 UTC on 15 August caused by an M2.7 x-ray flare. Note the small precursor deviation at the beginning of the plot. The transmitted carrier, receiver and displayed frequencies are as described for meteor trail and aurora radio reflections discussed above.

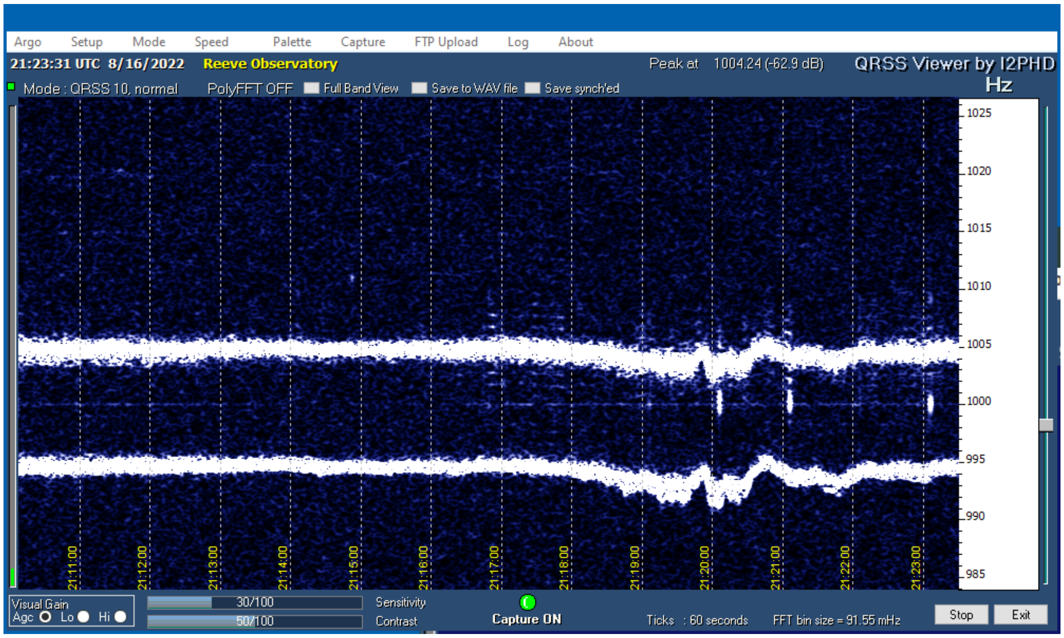


Figure 10 ~ Sudden frequency deviation on 16 August caused by an M1.8 x-ray flare at both 15 and 20 MHz. This SFD started about 2118 with full effects at 2120 UTC. The vertical ticks just below the upper trace are processing artifacts.

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6. VLF and LF Sudden Ionospheric Disturbances

Sudden ionospheric disturbances (SID) are like sudden frequency deviations in that solar flare radiation affects the ionosphere in such a way that radio propagation also is affected. In the case of SIDs, it is the transmissions from high power, low frequency transmitters used for submarine communications that are being continuously monitored. In most cases, signal propagation is enhanced so that the received signal level increases during the flare.

During August 2022, Cohoe Radio Observatory had two VLF/LF receiver/loop antenna systems in operation. One recorded the received signal level from station NPM in Hawaii on 21.4 kHz (figure 11) and the other recorded the signal levels from station WWVB in Colorado on 60 kHz (figure 12). NPM is almost due-south of Cohoe with an overwater path length of about 4400 km, while WWVB is almost due-east of Cohoe with an overland path length of about 3800 km.

Both systems occasionally experience severe interference believed to be from nearby powerlines. The interference was more severe at 60 kHz and, along with weaker received signal levels, the plot for WWVB is very ragged.

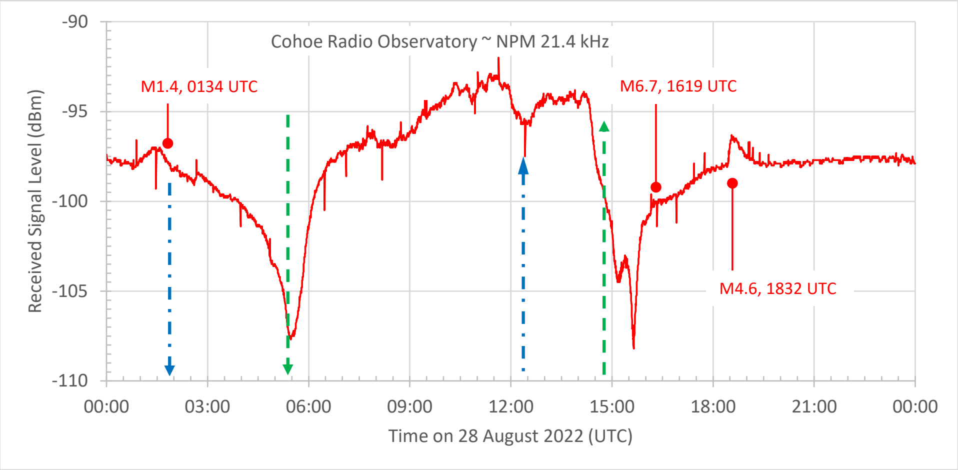

Figure 11 ~ Plot of NPM received signal level for 28 August at Cohoe Radio Observatory. Three M-class x-ray flares occurred during the daylight hours at Cohoe and each left a small imprint on the received signal level. Sunset and sunrise effects are most apparent at the Cohoe end. Sunset and sunrise times are shown by down and up arrows for Cohoe (green dashed) and WWVB (blue dotted-dashed).

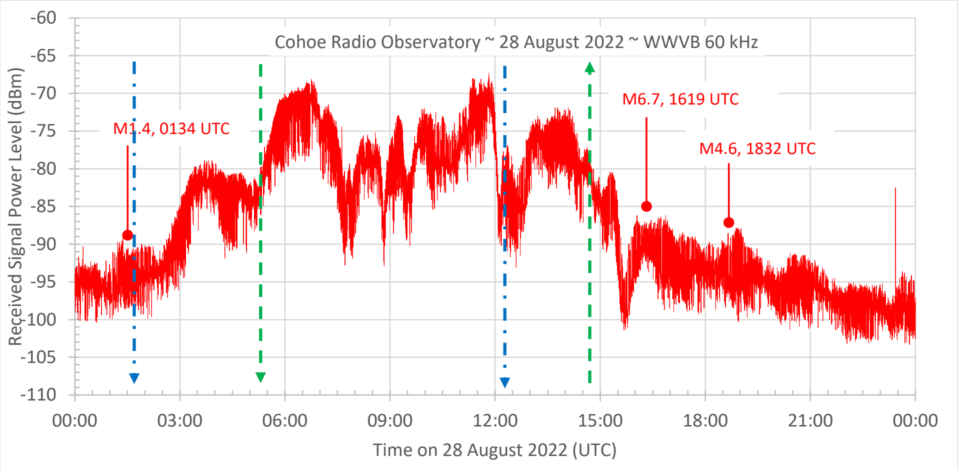

Figure 12 ~ Received signal level on 28 August from WWVB at 60 kHz. The Cohoe sunrise and sunset shown in green dashed lines and WWVB shown in blue dotted-dashed lines. The sunset and sunrise at both WWVB and Cohoe affected the signal received at Cohoe.

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7. Geomagnetic disturbances and ULF Waves

Geomagnetic disturbances result from many phenomena in the solar wind, such as coronal hole high-speed streams, coronal mass ejections and merging of Earth's magnetic field with the interplanetary magnetic field (IMF). These disturbances are seen on magnetograms, which were produced by the SAM_VIEW software and the SAM-III magnetometer at Anchorage Radio Observatory. A consequence of many disturbances in the solar wind is the production of ULF Waves in the Earth's magnetospheric cavity. ULF Waves are electromagnetic with frequencies that range from a few Hz to a few mHz. The magnetic component is detected by ground magnetometers and appear on magnetograms as rapid pulsations with quasi-sinusoidal waveforms. A geomagnetism tutorial may be found at {Geomag}. ULF Waves will be covered in detail in a future paper and SARA conference presentation.

In all the magnetograms in this section, the magnetometer X-axis is oriented north-south, the Y-axis is oriented east-west and the Z-axis is vertical.

On 8 August, geomagnetic disturbances from coronal hole high-speed streams led to storm conditions and erratic magnetic field variations throughout the day (figure 13).

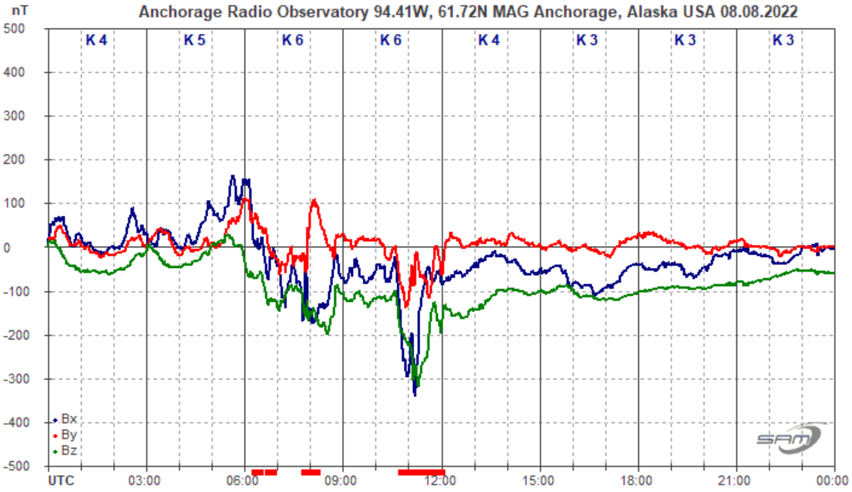

Figure 13 ~ On 8 August, geomagnetic disturbances from coronal hole high-speed streams led to storm conditions with K-index K5 or higher in the 0300-0600, 0600-0900 and 0900-1200 synoptic periods. Earth's magnetic field showed erratic deviations during these periods but quieted down after 1200.

A geomagnetic sudden impulse was observed 17 August at 0303 UTC (figure 14.a). A geomagnetic storm often follows soon after a sudden impulse but, in this case, the storm actually occurred 33 hours later. ULF Waves, which appear as rapid pulsations on a magnetogram, can be seen during at least two periods. The ULF Waves appear quite weak on the 2-day magnetograms because of the relatively high vertical scale needed to display the overall magnetic deviations. Individual magnetograms and a selected plot with smaller vertical scales show more detail (figure 14.b, 14.c and 14.d).

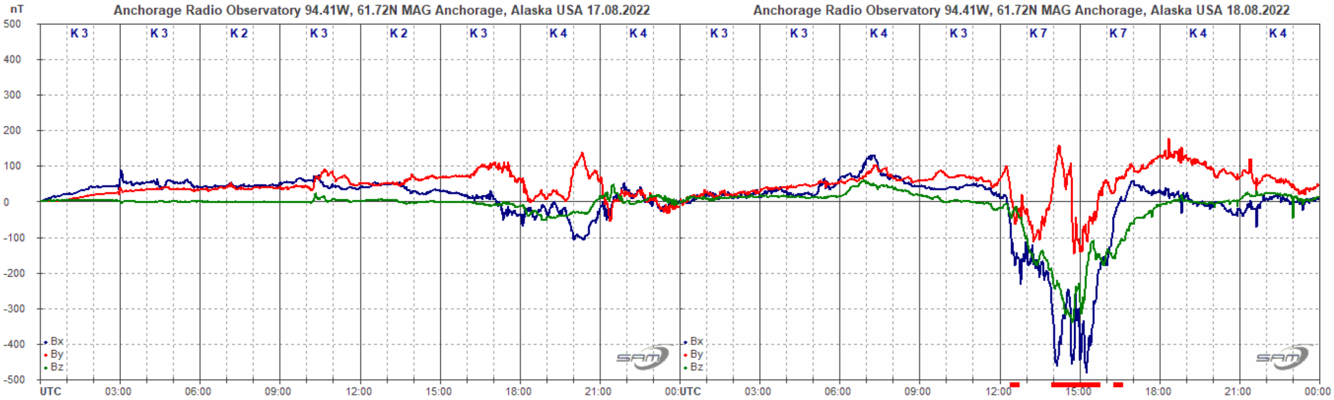

Figure 14.a ~ Two 24 hour magnetograms spliced together to show the sequence of events for 17 and 18 August after a sudden impulse at 0303 UTC on 17 August. The sudden impulse resulted from a coronal mass ejection a few days before. There were relatively mild follow-on geomagnetic disturbances about 14 hours later at 1700 through 2300. ULF Waves also were generated about the same time and appear between 1600 and 1800 and between 2100 and 2400 on 17 August, continuing until about 0400 the next day. Storm conditions were reach on 18 August during the 1200-1500 and 1500-1800 synoptic periods during which ULF waves also were observed.

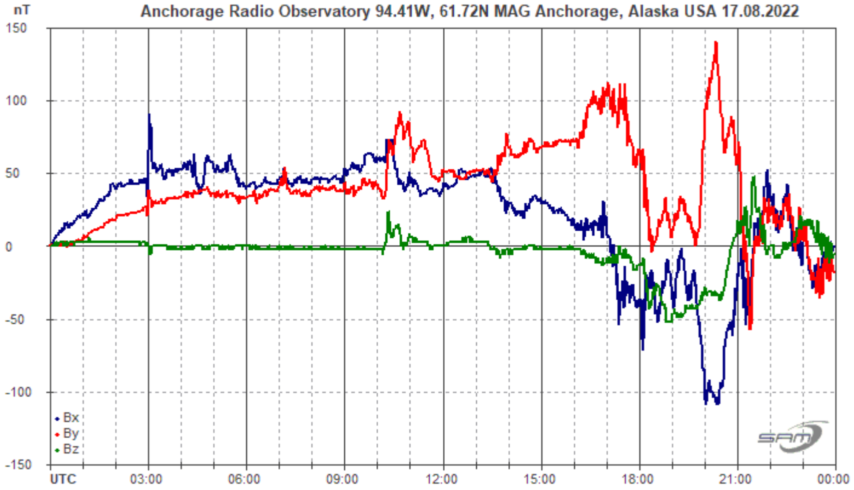

Figure 14.b ~ Magnetogram for 17 August more clearly shows the sudden impulse at 0303 and ULF Waves between approximately 1630 and 1800 and between 2100 and 2400, the latter spilling into the next day as shown below.

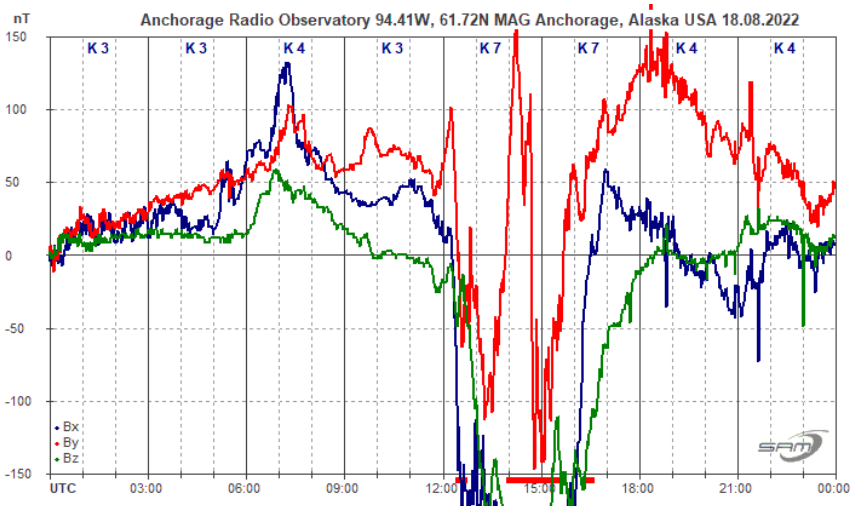

Figure 14.c ~ Magnetogram for 18 August at a fixed scale to show ULF Waves at the beginning of the UTC day from 0000 to about 0500. ULF Waves also are visible between approximately 1700 and 2400 in both the X- and Y-axes.

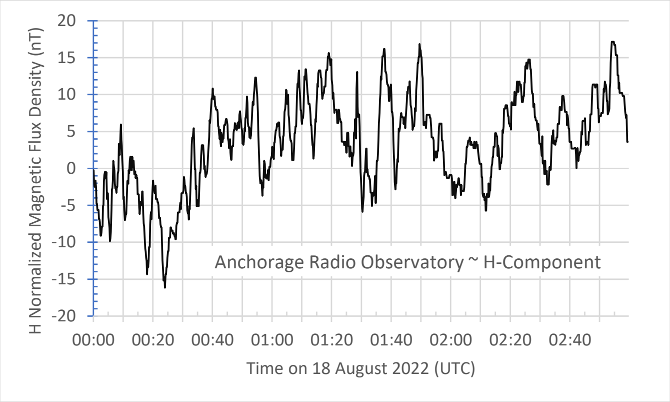

Figure 14.d ~ Normalized plot showing ULF Waves from 0000 to 0300 on 18 August. This plot shows the horizontal, or H, component, which is the vector sum of the X- and Y-axis magnetic flux density from the previous magnetogram. There are 51 cycles in this 3 hour time span, giving an average period of 212 s and an equivalent frequency of 4.7 mHz.

The Bartels Diagram provides a visual summary of geomagnetic activity in terms of a 27 day solar rotation with 3 hour resolution. Bartels Diagrams for the time period 1 August through 4 September 2022 are shown (figure 15).

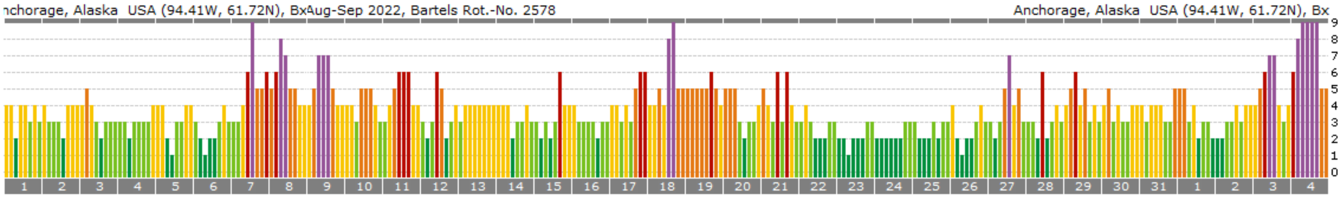

Figure 15 ~ Bartels Diagram for rotations 2577 and 2578 stitched together to show relatively high geomagnetic activity on 7-8 August as well as 27 days later on 3-4 September. The enhanced activity of 18 August coincides with the storm conditions previously described. This plot was produced by SAM_STAT software using the SAM-III data.

Table 1 ~ M-Class Flares during August 2022. Solar transit is within 20 min of 2200 UTC at all observatories. Shading indicates flares that occurred after sunset. Source: Space Weather Prediction Center weekly reports {Weekly}

Flare class	Date (UTC)	Max Time (UTC)	Active region	Daylight	Sunrise/sunset
M1.0	15 Aug	1436	3078	After sunrise	1409/0601
M2.7	15 Aug	1654	3078	After sunrise	
M0.9	15 Aug	1733	3078	After sunrise	
M1.1	15 Aug	2153	3078	Transit	
M5.0	16 Aug	0758	3078	After sunset	1412/0558
M1.8	16 Aug	2121	3078	Transit	
M2.0	17 Aug	1345	3078	Before sunrise	
M1.0	17 Aug	1452	3078	After sunrise	
M1.3	18 Aug	1009	3078	Before sunrise	1417/0552
M1.5	18 Aug	1055	3078	Before sunrise	
M1.3	18 Aug	1413	3078	Before sunrise	
M1.6	19 Aug	0444	3078	Before sunset	1419/0549
M1.8	25 Aug	1951	3078	After sunrise	1435/0530
M1.0	25 Aug	2327	3078	After transit	
M2.1	26 Aug	1055	3078	Before sunrise	1437/0527
M7.2	26 Aug	1214	3078	Before sunrise	
M5.3	26 Aug	1231	3078	Before sunrise	
M4.8	27 Aug	0240	3078	Before sunset	1440/0524

M1.2	27 Aug	1138	3078	Before sunrise	
M1.1	27 Aug	1525	3078	After sunrise	
M1.8	27 Aug	1558	3078	After sunrise	
M1.4	28 Aug	0134	3078	Before sunset	1442/0521
M6.7	28 Aug	1619	3078	After sunrise	
M4.6	28 Aug	1832	3078	After sunrise	
M3.3	29 Aug	0338	3088	Before sunset	1445/0518
M8.6	29 Aug	1108	3088	Before sunrise	
M2.5	29 Aug	1456	3088	After sunrise	
M4.7	29 Aug	1857	3088	After sunrise	
M1.5	30 Aug	0213	3088	Before sunset	1447/0515
M2.1	30 Aug	1929	3088	After sunrise	

8. Instrumentation

A map shows the locations and geographic and geomagnetic coordinates of Anchorage Radio Observatory (ARO), Cohoe Radio Observatory (CRO) and HAARP Radio Observatory (HRO) (figure 16).

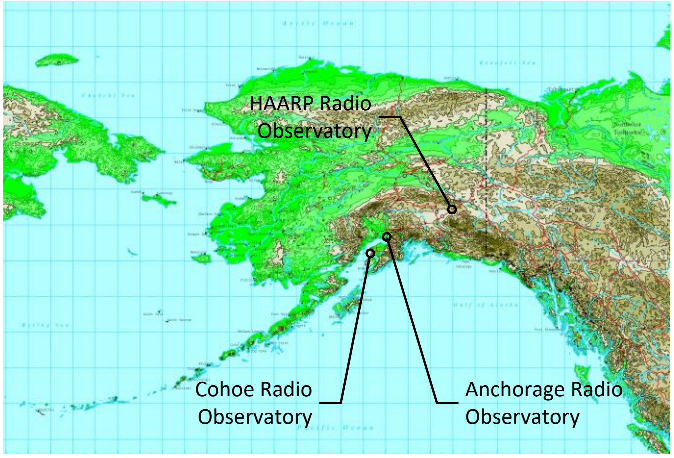

Figure 16 ~ Locations of the three observatories:

ARO: 22 m AMSL elevation
61° 11' 57.70" N, 149° 57' 23.62" W geographic
61.72° N, 94.41° W geomagnetic (2022)
CRO: 22 m AMSL elevation
60° 22' 5.34" N, 151° 18' 55.74" W geographic
60.71° N, 95.15° W geomagnetic (2022)
HRO: 562 m AMSL elevation
62° 23' 21.00" N, 145° 8' 15.18" W geographic
63.62° N, 90.61° W geomagnetic (2022)

Underlying map source: USGS

The instrumentation at each of the three observatories is described in terms of block diagrams (figure 17, 18 and 19). Shown here mostly are the systems and subsystems used to produce the above-described plots. Each observatory has additional antennas, receivers and instruments not shown; for example, seismometers, weather stations and infrasound detectors. The spectra displayed in sections 2 and 3 were produced by identical installations of Callisto instruments and an LWA Antenna at Cohoe Radio Observatory and HAARP Radio Observatory. These systems supply data during daylight hours to the e-CALLISTO Solar Radio Spectrometer Network {e-CALLISTO}.

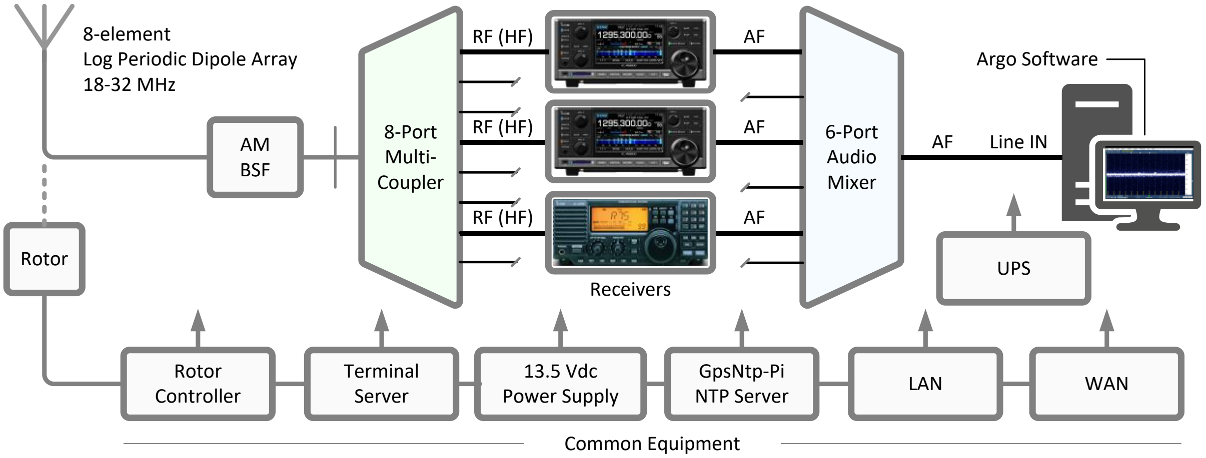

Figure 17.a ~ Anchorage Radio Observatory block diagram. Only the receiver and antenna systems used for this article are shown. The infrastructure along the bottom is shared by the various receiver and antenna systems and instruments.

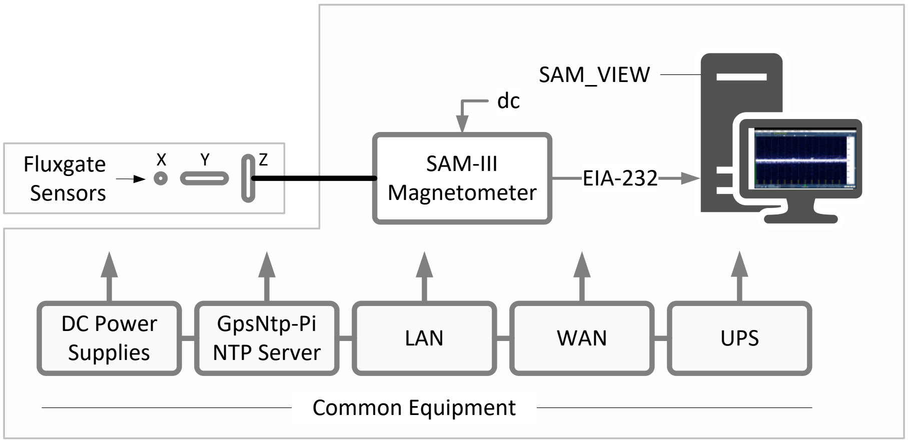

Figure 17.b ~ SAM-III magnetometer at Anchorage Radio Observatory. The SAM_VIEW software collects serial data from the SAM-III Controller at a 1/10 Hz rate. The three magnetic sensors are buried about 1 m below the ground surface to reduce the effects of daily temperature variations on sensor operation.

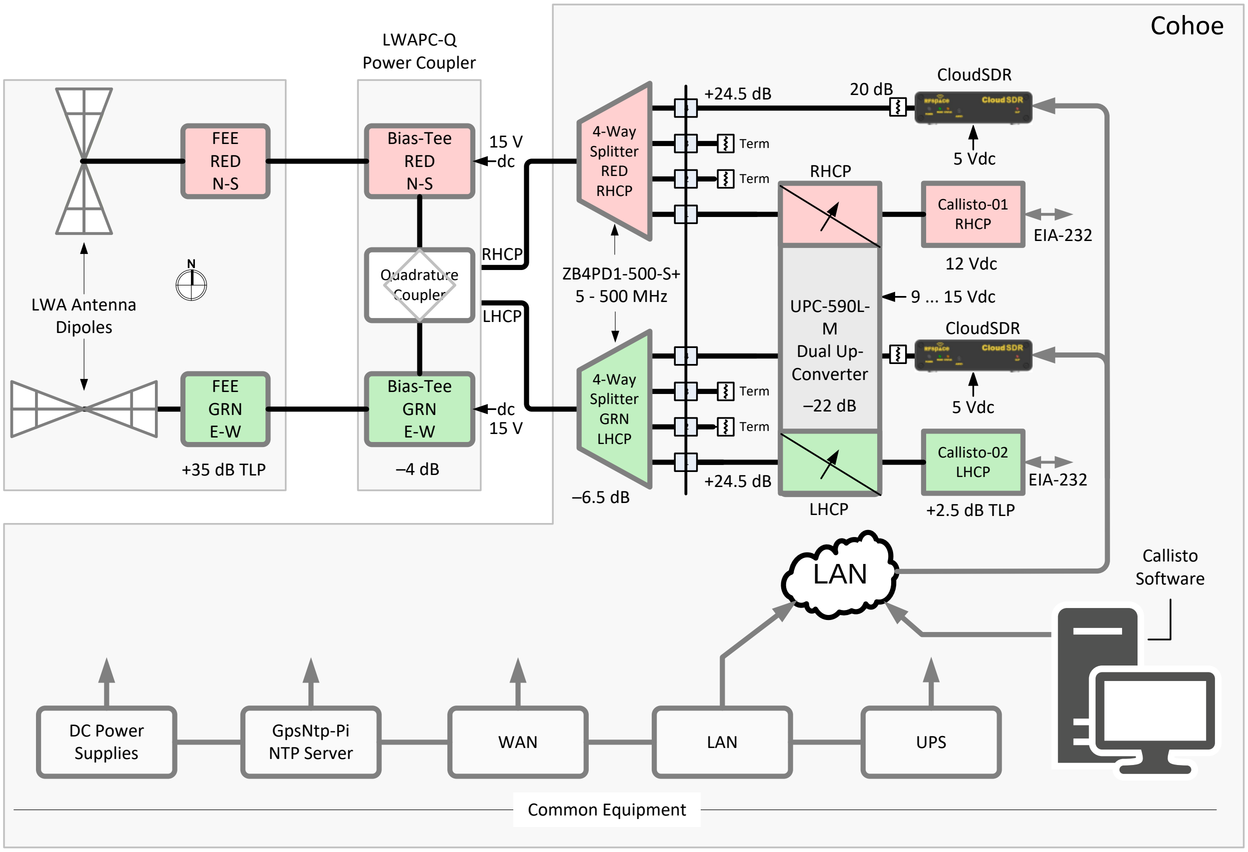

Figure 18.a ~ Cohoe Radio Observatory block diagram. The infrastructure along the bottom is shared by the various receiver and antenna systems and instruments.

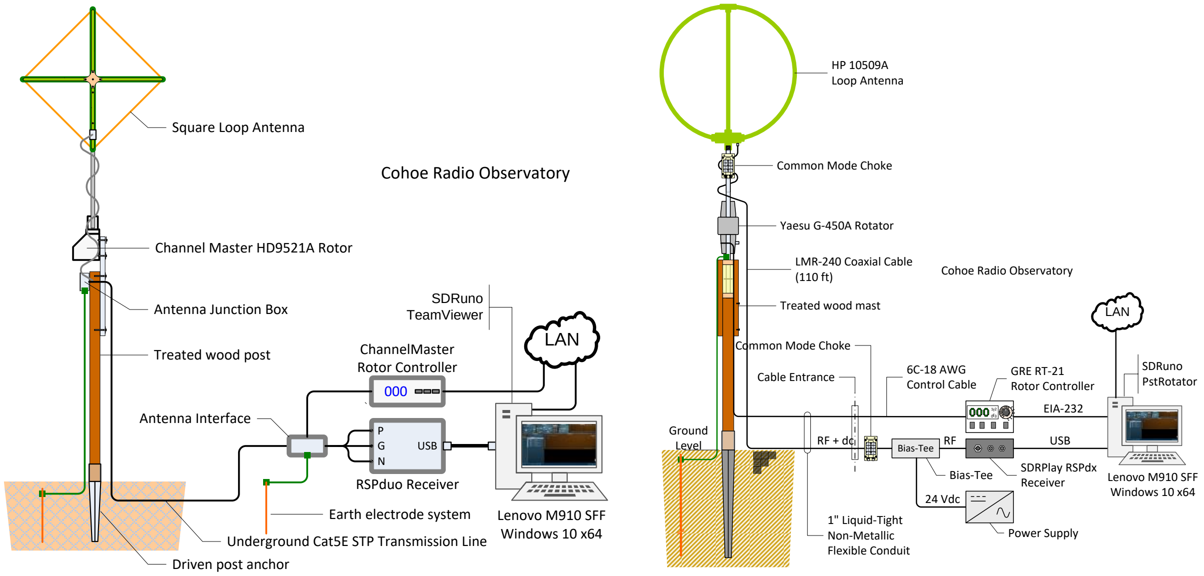

Figure 18.b ~ Two loop antennas and associated software defined radio (SDR) receivers are used at Cohoe Radio Observatory. This caption only briefly describes the setups; the loop antennas and receivers are more fully described at {ReeveLF}. Left: One loop is a shop-built square loop antenna with 1.2 m diagonal on a modified Channel Master rotator for web control. This

antenna is connected to an SDRPlay RSPduo receiver through the balanced interface and CAT5E cable. The receiver was tuned to 21.4 kHz during August 2022. Right: The other loop is a 1.1 m diameter refurbished HP circular active loop with an antenna-mounted, shop-built preamplifier. The antenna is mounted on a Yaesu G450-A rotator controlled by a Green Heron Engineering RT-21 controller with web control through the PstRotatorAz software application. This antenna is connected through a shop-built Loop Power Coupler and two common mode chokes to an SDRPlay RSPdx SDR receiver, which was tuned to 60 kHz during August 2022.

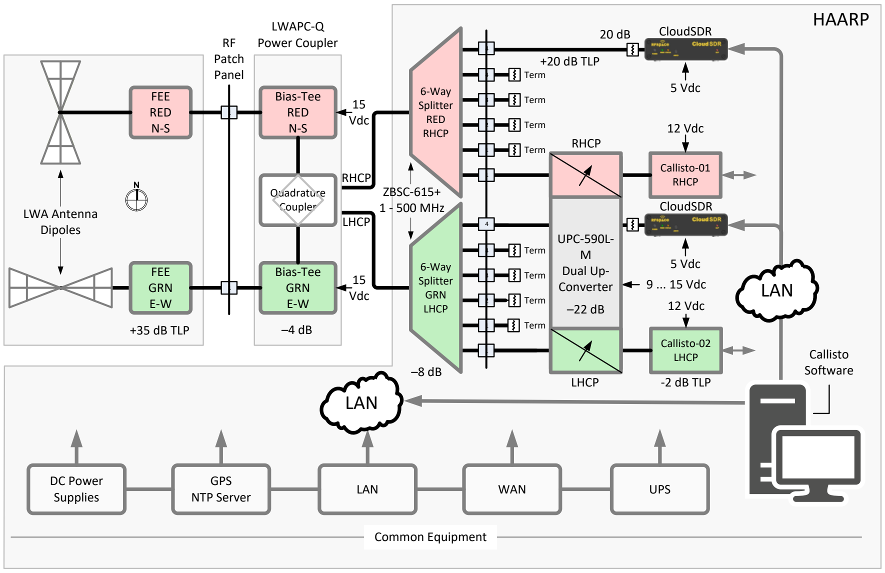

Figure 19 ~ HAARP Radio Observatory block diagram is almost identical to Cohoe. The Callisto instruments were the primary devices used during August. The SDR receivers shown in addition to the Callisto instruments are used to support HAARP experiments and radio propagation studies.

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9. References & Further Reading

{Callisto}	http://soleil.i4ds.ch/solarradio/callistoQuicklooks/
{e-CALLISTO}	https://e-callisto.org/
{Geomag}	https://reeve.com/Documents/SAM/GeomagnetismTutorial.pdf
{ReeveAurora}	https://reeve.com/Documents/Articles%20Papers/Reeve_AuroraRadioObsrv.pdf
{ReeveLF}	https://reeve.com/Documents/Articles%20Papers/Reeve_SquareLoopAntenna1.2m.pdf and https://reeve.com/Documents/Articles%20Papers/Reeve_HP10509A_SSUpdate.pdf and https://reeve.com/Documents/Articles%20Papers/Reeve_VLF-LF-RFChoke.pdf and https://reeve.com/Documents/Articles%20Papers/Reeve_LoopPwrCplr.pdf
{ReeveMeteor}	https://reeve.com/Documents/Articles%20Papers/Reeve_MeteorRadioObsrv.pdf
{ReeveSolar}	https://reeve.com/Solar/Solar.htm
{ReeveSFD}	https://reeve.com/Documents/Articles%20Papers/Propagation%20Anomalies/Reeve_SuddenFreqDevConcepts_P1.pdf and https://reeve.com/Documents/Articles%20Papers/Propagation%20Anomalies/Reeve_SuddenFreqDevMeas_P2.pdf
{SWPC}	https://www.swpc.noaa.gov/products/solar-cycle-progression
{Weekly}	ftp.swpc.noaa.gov/pub/warehouse/2022/WeeklyPDF

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

Methanol maser lines 12 GHz observations

by Dimitry Fedorov UA3AVR

The frequency of this molecular line from indoor laboratory tests is 12178.597(4) MHz [1]. The line is associated with rotational transition $J_k=2_0 \rightarrow 3_{-1}$, E type of CH_3OH molecule. The maser line 12 GHz is usually related to II class, i.e. a radiating cloud is excited and pumped by the infrared radiation from a nearby object, may be located aside without clear collisional excitations; there are rather stable masers as like as with a significant variability [2]. This is one of strongest lines in the interstellar media (ISM) and seems convenient to observe by amateur means with availability of the Sat equipment. In other hand, RFI interferences at nearby frequencies are present also.

The receiver setup

The receiver should be designed with a good frequency stability to observe maser lines. My setup consists of indoor and outdoor parts. The outdoor part is shown at *FIg. 1*.

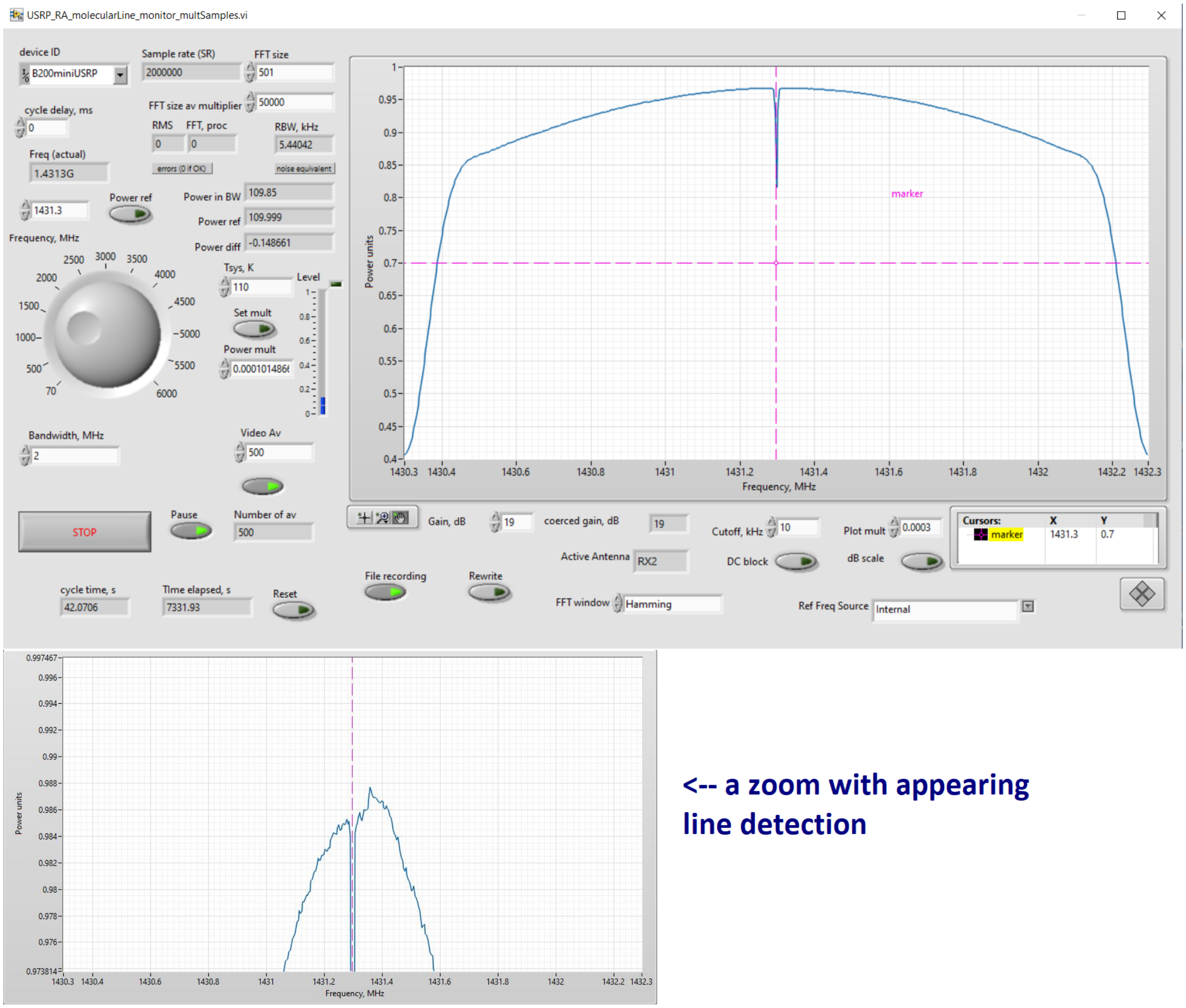
-+

FIg. 1. Outdoor observation setup, dish D=1.8 m, automatic Az-El tracking. Location near Moscow (N56.146254, E37.496530).

I have removed inner DRO oscillator in old Sat LNB and applied an external LO (YIG based PLL with oven controlled reference, OCXO). The LO frequency 10750 MHz, therefore IF frequency is about 1430 MHz. The IF signal is amplified additionally before coax 20 m connecting the indoor and outdoor parts (in order to compensate the coax losses). LNB is equipped by a circular polarizer.

Dish size D=1.8 m, the system temperature T_{sys} is contributed by the LNB Noise Figure, the dish spillover, back- and side-lobes of the feed and was estimated about 110 K.

The indoor part receives the IF signal, - SDR module USRP B200mini is applied. SDR is driven by specially written LabVIEW software. This software performs receiving of SDR IQ-samples, IF power calculations, digital signal processing (DSP) including the Fast Fourier Transform (FFT) and running on-fly average of the spectrum (point-to-point, no intermediate data are stored during measurements). A result of running average is plotted on the software screen. The amplitude/frequency response of B200mini in nominal bandwidth is far from flat significantly (as I guess due to antialiasing filters and DC suppressing means), see the screen form receiver software at *FIg. 2*.



USRP_RA_molecularLine_monitor_multSamples.vi

device ID: B200miniUSRP
Sample rate (SR): 2000000
FFT size: 501
cycle delay, ms: 0
FFT size av multiplier: 50000
RMS: 0
FFT, proc: 0
RBW, kHz: 5.44042
Freq (actual): 1.4313G
Frequency, MHz: 1431.3
Power in BW: 109.85
Power ref: 109.999
Power diff: -0.148661
Tsys, K: 110
Power mult: 0.0001014866
Bandwidth, MHz: 2
Video Av: 500
Number of av: 500
cycle time, s: 42.0706
Time elapsed, s: 7331.93
Gain, dB: 19
coerced gain, dB: 19
Cutoff, kHz: 10
Plot mult: 0.0003
Active Antenna: RX2
FFT window: Hamming
Ref Freq Source: Internal

Cursors:	X	Y
marker	1431.3	0.7

<-- a zoom with appearing line detection

FIg. 2. The receiver screen for all receiving bandwidth: top – a common view, bottom – a zoomed part where a maser line appears slowly.

The receiver parameters are collected in Table 1. The FFT size was chosen as a tradeoff between processing speed and acceptable spectrum resolution. The velocity (VLSR) resolution about 0.15 km/s allows successful detections of lines with widths as narrow as 1 km/s. The resolution is defined by the noise RBW of the receiver; it may differ from the nominal RBW=BW*(FFT size)$^{-1}$ while using window filters in the Digital Signal Processing. Approximating values for T_{sys} and dish sensitivity are needed to get estimations of the lines level (for additional identification besides the peak velocity and the line width).

Table 1. Receiver parametrs.

Dish size, m	Dish sensitivity, mK/Jy (approximate)	System temperature, T_{sys} (approximate)	Receiver bandwidth, BW, MHz	FFT size, points	Receiver resolution bandwidth, RBW, kHz	Noise RBW, kHz (Hamming window before FFT)	VLSR resolution, km/s (approximate)
1.8	0.46	110 K	2.0	501	4.0	5.44	0.15

Measurements and post processing

Measurements were made using automatic azimuth-elevation tracking of the dish. Spectrum data are averaged on-fly by the receiver software during tracking.

A form of uneven amplitude/frequency response of the receiver can be extracted from background data collected with the same number of spectrum averages (integration time) and directing the antenna to supposedly empty sky. For the background measurements, the antenna beam was directed approximately at the middle between start and final positions of the beam in maser line measurements. The background data in power units were subtracted from the maser line data in post processing procedures. Final fine corrections (for slight slants, adjusting zero levels for plots in flux units) were made by hands. Sharp peaks on the lines plot could be smoothed applying a 25 pts cubic spline fit.

There was an atmospheric absorption at 12 GHz taken into account. Atmospheric gases contribute in the system temperature T_{sys} and attenuates the flux of observed source. For a clear weather the gaseous attenuation could be calculated relatively easy, see the methods and tools in [3]. The problem is a clear weather happens not too often, - clouds usually present, and their attenuation is less predictable. To take into account the atmosphere I used approximate estimations up to 0.1-0.3 dB for clear weather and light clouds, up to 1 dB for visually dense clouds. The atmosphere contributes also to T_{sys}, but the atmospheric part in T_{sys} is not too large and it seems do not exceed the uncertainty of T_{sys} =110 K; anyhow, 110 K was used to get the level estimations. The attenuation correction was applied to lines only, for ranges of their widths.

For VLSR calculations, I used codes from the page [4].

The results

The results of my observations in August-September 2022 are presented here:

1. W3(OH) observations, 2022-08-26, *FIg. 3*. Integration time do not exceed 2 hours. Atmospheric losses up to 0.3 dB, the spline smoothing was applied. The peak level and velocity, the line width are close to expected. The line is rather strong, expected peak level was about 800 Jy [2].

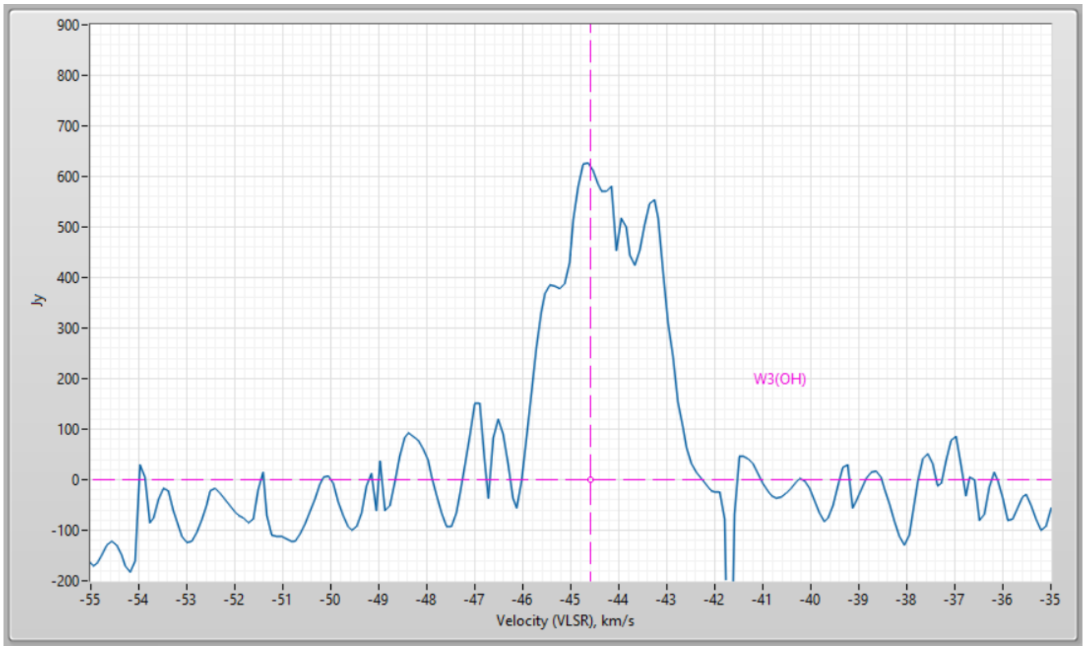


FIg. 3. W3(OH) maser line, observations 2022-08-26.*2. The same, but without spline smoothing,* FIg. 4*.*

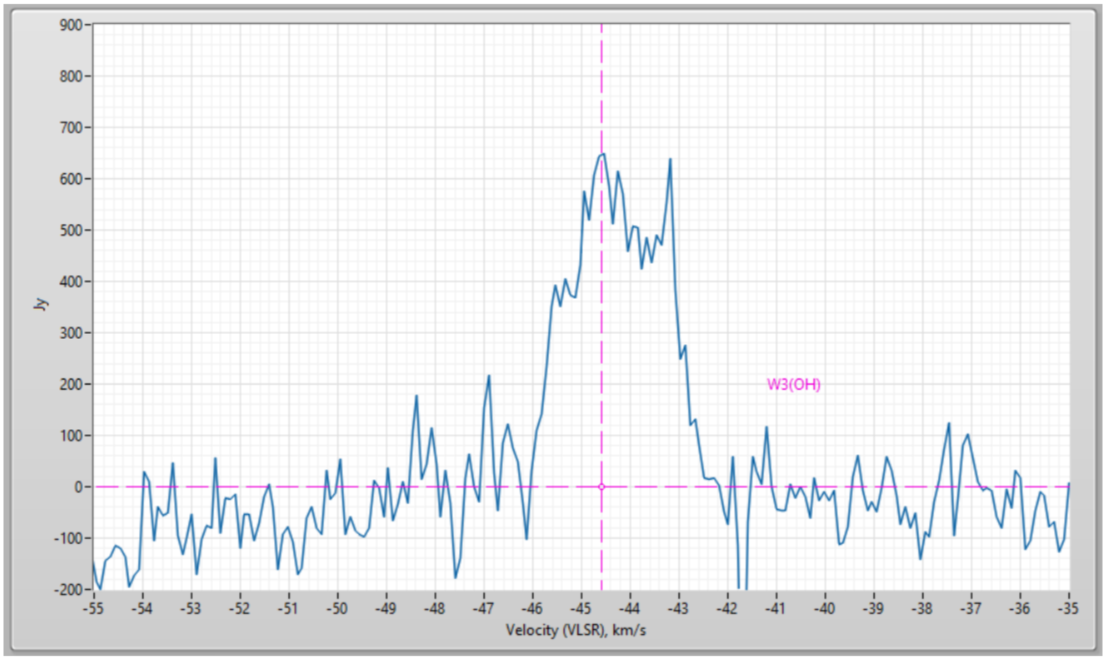
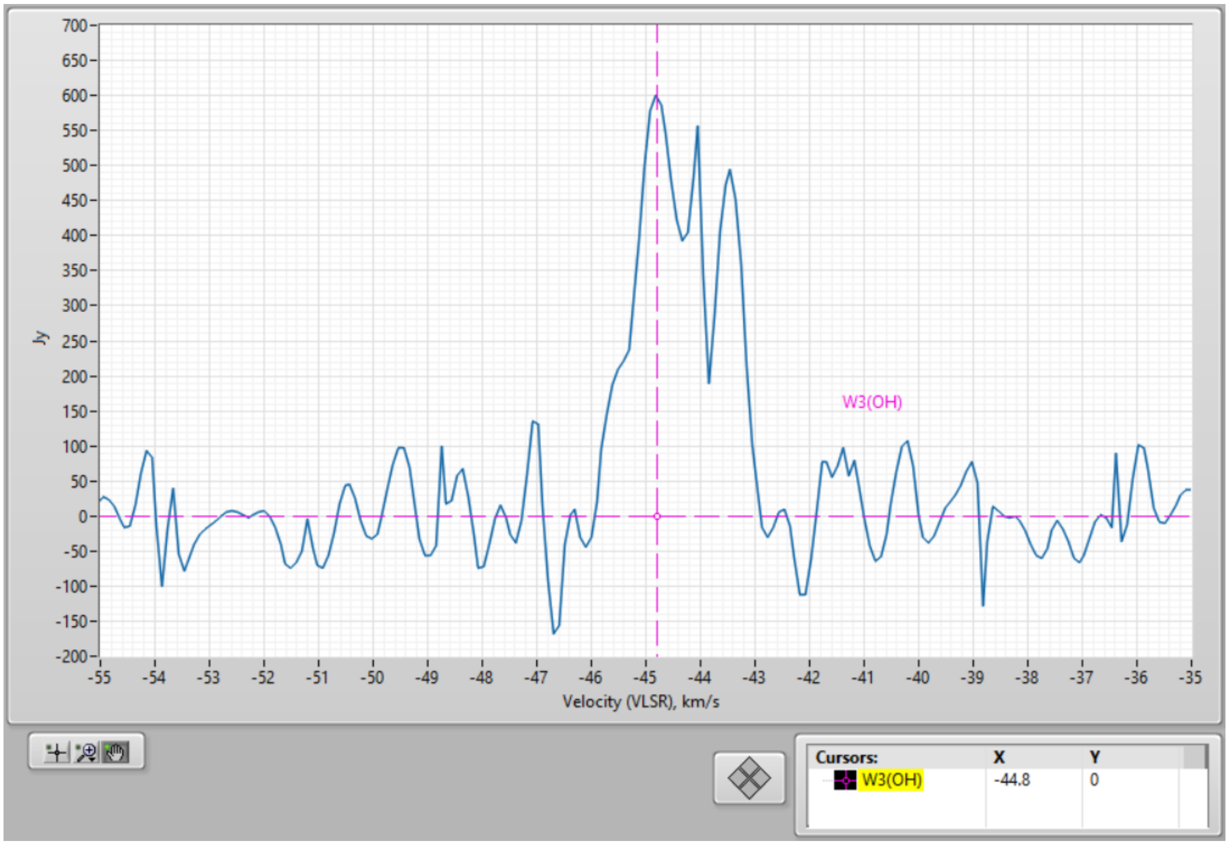


FIg. 4. W3(OH) line, 2022-08-26 without spline smoothing.

3. W3(OH) measurements were repeated 2022-09-18, *FIg. 5*. The density of clouds were rising from the beginning of measurements with almost clear sky. The observations were made with rather low elevations of the dish, mainly less 30 deg, atmospheric losses up to 1 dB. Integration time is about 1.5 hours. Spline smoothing is applied.



Cursors:	X	Y
W3(OH)	-44.8	0

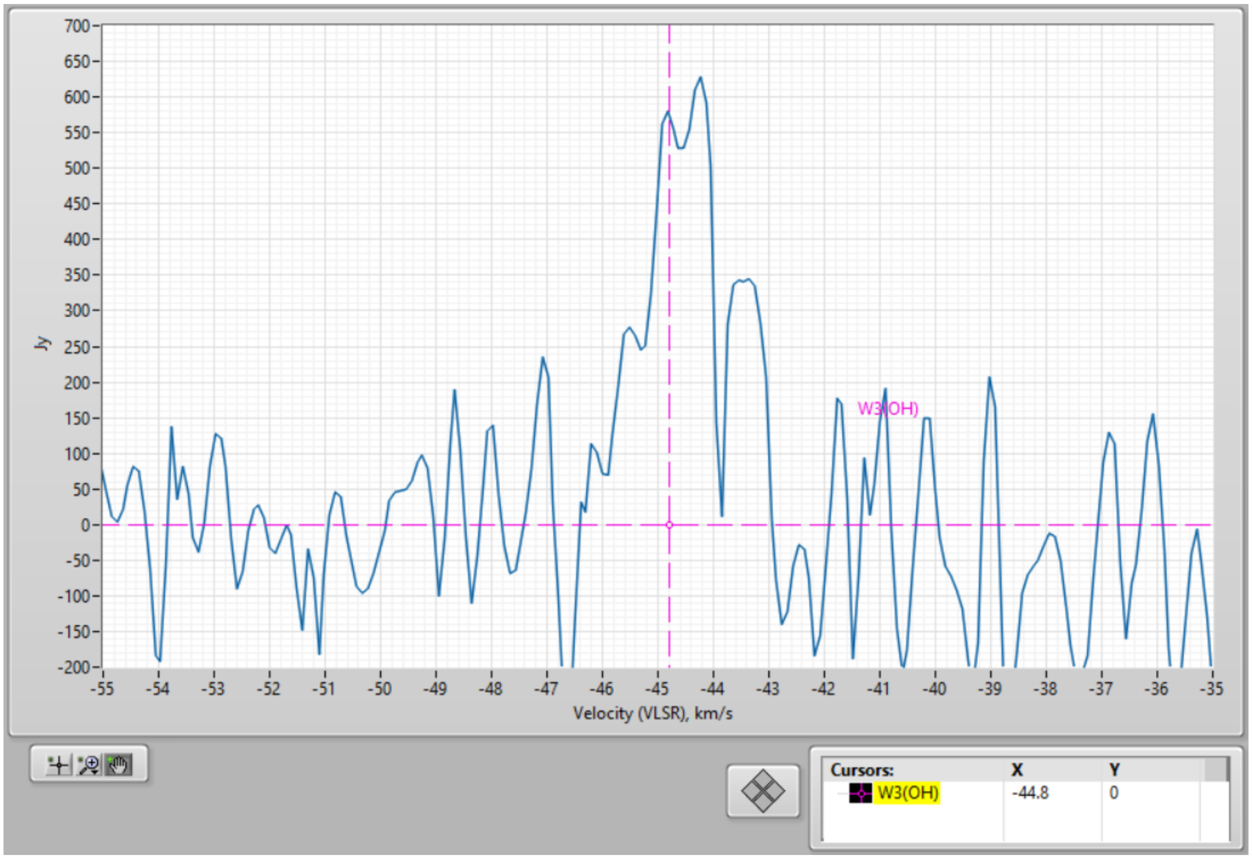
FIg. 5. W3(OH) observations 2022-09-18, integration time 1.5 hours.

4. The same observations, but the integration time is about 40 min, *FIg. 6*. The atmospheric correction was taken less, - the data collected with less dense clouds in the beginning part of measurements.

Cursors:	X	Y
W3(OH)	-44.8	0

FIg. 6. W3(OH) observations 2022-09-18, integration time 40 min, spline smoothing. Atmospheric correction is 0.3 dB.

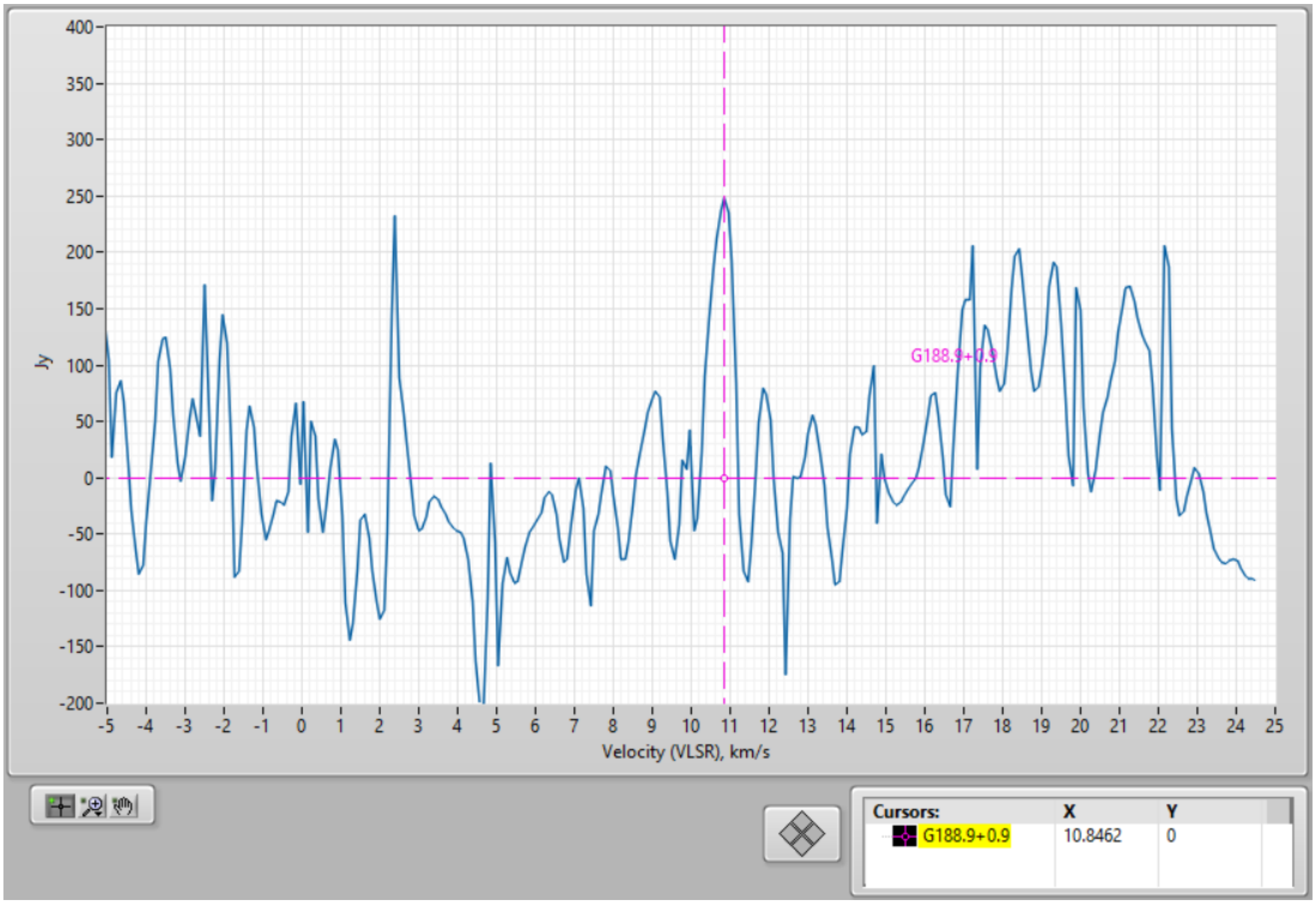
5. Also the same observation, but integration time was reduced more, to 20 min, *FIg. 7*. The line is still seen well! This 20 min the sky was almost clear. Atmosphere gives the correction 0.2 dB; rare clouds occurred and could interfere in the antenna beam.



Cursors:	X	Y
W3(OH)	-44.8	0

FIg. 7. W3(OH) observations 2022-09-18, integration time 20 min, spline smoothing. Atmospheric correction is 0.2 dB, almost clear sky during the measurements.

6. The methanol line 12 GHz from G188.94+0.89 object. This line is significantly weaker in comparison with W3(OH) line. Expected peak level is about 200 Jy [2]. Observation date 2022-09-11, overcast weather, atmospheric attenuation was estimated up to 0.3 dB. Integration time was about 1.5 hours. The result is shown at FIg. 8, spline smooth was applied. The peak position and line width are close to expected, the level of observed line is not far from expected too. The spike near 2 km/s is a possible RFI.



Cursors:	X	Y
G188.9+0.9	10.8462	0

FIg. 8. G188.94+0.89 maser line 12 GHz, 2022-09-11, spline smooth.

7. Observations of G188.94+0.89 line was repeated 2022-10-08, see FIg. 9, the spline smooth was applied. The weather was not too good, rather dense clouds were present form the beginning of observation time, atmospheric losses up to 1 dB. Integration time was about 1.5 hours. The peak velocity, line width and the line level were repeated too.

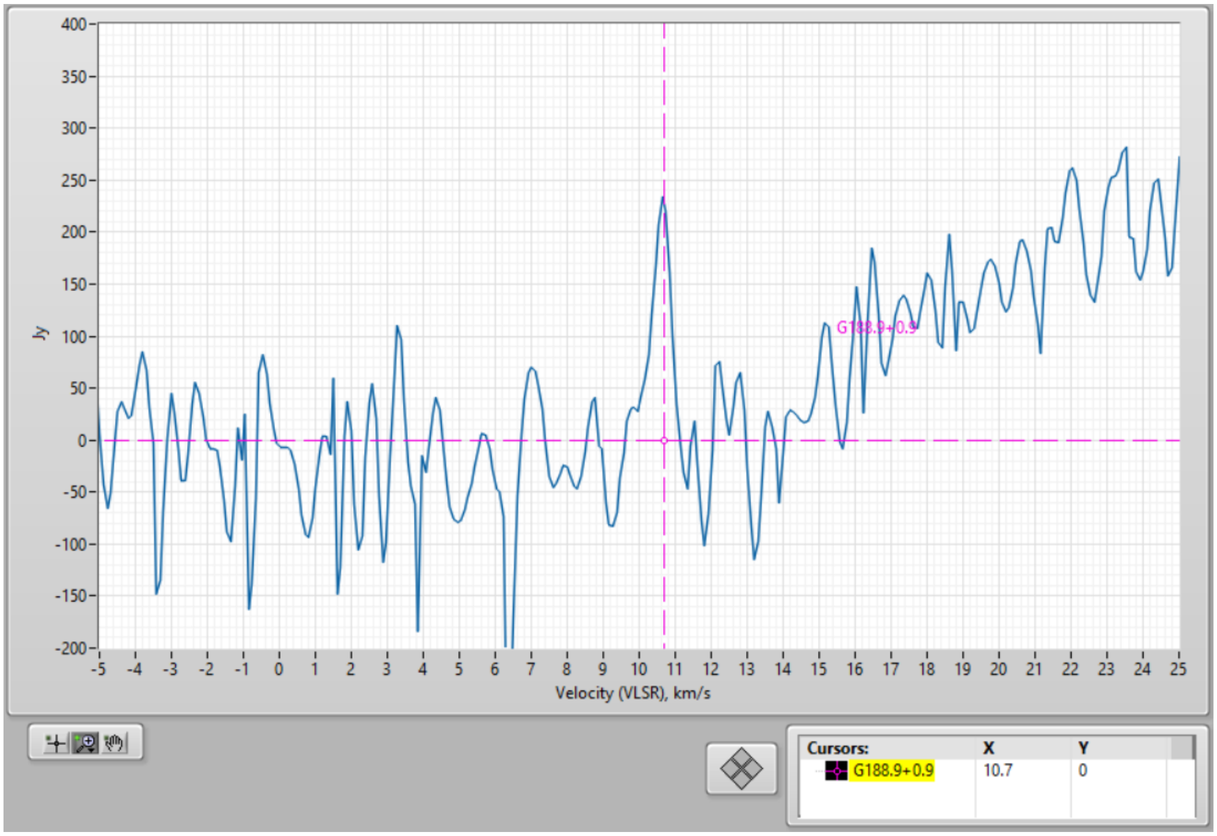


FIg. 9. G188.94+0.89 maser line 12 GHz, 2022-10-08, spline smooth.

8. There were attempts to detect 12 GHz lines from NGC7538 (observation date 2022-09-04) and Cepheus A (observation date 2022-09-18) taking data from [2] as guidelines. Integration time was about 1.5 hours. No detections were observed yet. NGS7538 was reported with a peak flux about 90 Jy in 2017 [5]; the long-term variability of these masers may be more significant than noted in [2].

Concluding notes

Maser lines identification by their level and width could be useful while RFI are present nearby the observation frequencies. Atmospheric gases at 12 GHz affect observations noticeably; weather conditions should be considered as significant factor. During the integration time, the antenna elevation changes and the atmospheric losses depend on the elevation. It limits a possible measurement time, and, therefore, integration time in addition to other factors worsening the detection sensitivity.

Acknowledgments

To Eduard Mol for attention to the work and references to maser databases with more fresh data.

References

[1] H.S.P. Müller, K.M. Menten and H. Mäder, Accurate rest frequencies of methanol maser and dark cloud lines, A&A **428**, 1019-1026 (2004), arXiv:astro-ph/0408094
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[3] ITU, P.676: Attenuation by atmospheric gases and related effects, https://www.itu.int/rec/R-REC-P.676; ITU, P.372: Radio noise, https://www.itu.int/rec/R-REC-P.372; calculator by Joachim Köppen DF3GJ, https://portia.astrophysik.uni-kiel.de/~koeppen/JS/AtmosAtten.html
[4] HawkRAO VLSR Calculator (modifications by F4KLO/N5CNB), RadioTélescope de la Villette, http://f4klo.ampr.org/vlsrKLO.php
[5] See NGS7538 in VisieR under coordinate name G111.542+0.776, https://vizier.cds.unistra.fr/viz-bin/VizieR?-source=J/ApJS/258/19

About the author

Dimitry Fedorov was first licensed as radio amateur since 1982, as UA3AVR since 1983. In 1990 graduated as MS in electronics in Moscow Power Engineering University. Now works as research and development engineer in wireless industry, LTE/5G NR, RF and microwave modules development. Previous scientific experience in nuclear and particle physics, worked in Moscow State University, Institute of Nuclear Physics and Universität Tübingen, Institut für Theoretische Physik, see profile blog at https://www.researchgate.net/profile/Dimitry-Fedorov-2. Radio Astronomy hobby since 2012, mainly in applications for weak signals reception. You can contact the author at ua3avr@yandex.ru.

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Prices, US dollars, including postage

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Each USB drive	$15.00
USB drive + 1-year membership extension	$30.00
Non-members	
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

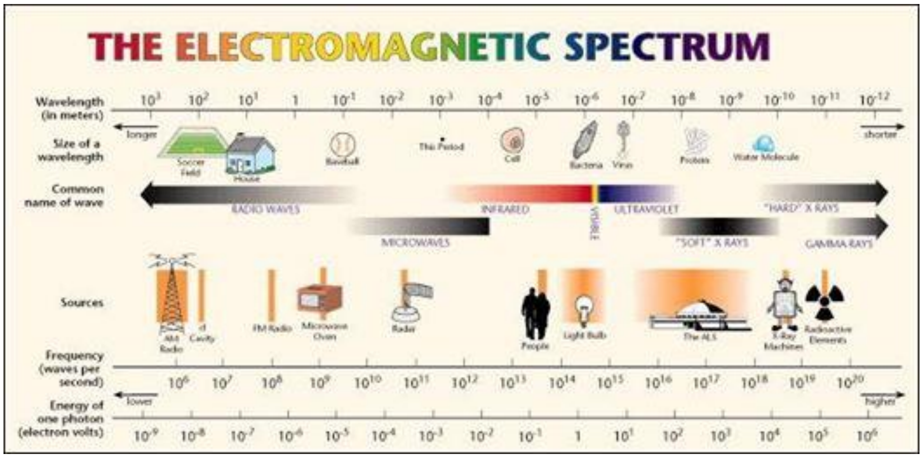
Like SARA on Facebook
http://www.facebook.com/pages/Society-of-Amateur-Radio-Astronomers/128085007262843

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
Vice President: Jay Wilson, https://www.radio-astronomy.org/contact/Vicepresident
Secretary: Bruce Randall, NT4RT, https://www.radio-astronomy.org/contact/Secretary
Treasurer: Brian O'Rourke, K4UL, https://www.radio-astronomy.org/contact/Treasurer
Past President: Dennis Farr, tbd@radio-astronomy.org
Founder Emeritus and Director: Jeffrey M. Lichtman, KI4GIY, jeff@radioastronomysupplies.com

Board of Directors

Name	Term expires	Email
Ed Harfmann	2024	edharfmann@comcast.net
Dr. Wolfgang Herrmann	2023	messbetrieb@astropeiler.de
Tom Jacobs	2023	tdj0@bellsouth.net
Charles Osborne	2023	k4cso@twc.com
Bob Stricklin	2024	bstrick@n5brg.com
Steve Tzikas	2024	Tzikas@alum.rpi.edu
Jon Wallace	2023	wallacefj@comcast.net
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	
Eastern Conference Coordinator	http://www.radio-astronomy.org/contact/Annual-Meeting	
All Radio Astronomy Editors	http://www.radio-astronomy.org/contact/Newsletter-Editor	
Radio Astronomy Editor	Dr. Richard A. Russel	drrichrussel@netscape.net
Contributing Editor	Whitham D. Reeve	whitreeve@gmail.com
Educational Outreach	http://www.radio-astronomy.org/contact/Educational-Outreach	
Grant Committee	Tom Crowley	grants@radio-astronomy.org
Membership Chair	http://www.radio-astronomy.org/contact/Membership-Chair	
Technical Queries (David Westman)	http://www.radio-astronomy.org/contact/Technical-Queries	
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

SARA YouTube Videos: https://www.youtube.com/channel/UC-SzptAQZ-20c9CkRb9ZPxw/videos	
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_Rs17KlyQ	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

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.

Radio-Astro-Machine, zzblac@gmail.com
Elevation rotation adapter plate for Scope in a Box and custom machining. For further information visit https://radio-astro-machine.wixsite.com/my-site or send an email.

Typinski Radio Astronomy, Inc., info@typinski.com
Antenna systems and feed line components for HF radio astronomy

Jeff Kruth, WA3ZKR, kmec@aol.com
RF components from HF to MMW, various types including mixers, RF switches, amplifiers, oscillators, coaxial components, waveguide components, etc. I have a very large collection of stuff and the facilities to test and provide data. Please email with your needs and I will see if I have something for you. Have fun!

Stuart and Lorraine Rumley, sales@valontechnology.com
The Valon Technology 2100 Downconverter, when combined with our 5009 frequency synthesizer module, provides a high-performance, compact receiver downconverter system. Applications include hydrogen line studies at 1420MHz and radio astronomy in the protected 30MHz segment of the 21 cm band. For more information visit http://www.valontechnology.com/2100downconverter.html or send an email.

Radio2Space, filippo.bradaschia@primalucelab.com
SPIDER radio telescopes and turn-key-systems designed specifically for education.
https://www.radio2space.com
We developed our SPIDER radio telescopes as turn-key-system just to avoid the problem you perfectly highlighted in your website: "Purchasing a radio telescope isn't like buying an optical telescope. They are harder to find, and usually require assembly and software troubleshooting. In some cases, a radio telescope must be built from components." Our SPIDER radio telescopes are not designed for amateurs that prefer to build a radio telescope but to schools, universities, museums, and other science institutes that needs for a complete and ready-to-use system, just like the optical telescopes they can normally buy!

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)