RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers
May - June 2025

SARA 2025 Eastern Conference

Contents

Dr. Richard A. Russel
SARA President and Editor

Bogdan Vacaliuc
Contributing Editor

Radio Astronomy is published bimonthly as the official journal of the Society of Amateur Radio Astronomers. Duplication of uncopyrighted material for educational purposes is permitted but credit shall be given to SARA and to the specific author. Copyrighted materials may not be copied without written permission from the copyright owner.

Radio Astronomy is available for download only by SARA members from the SARA web site and may not be posted anywhere else.

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:
SARA

President's Page.....2
Editor's Notes.....3
"All Wheels Stop" – Wrapping Up the 2025 SARA and Radio JOVE Eastern Conference – Marcus Fisher.....4
SARA NOTES.....9
SARA Eastern Conference Photos.....9
British Astronomical Association – Radio Astronomy Section Programs.....16
SuperSID.....18
Announcing Radio JOVE 2.0.....21
John Cook's VLF Report.....26
Featured Articles.....48
Accessing e-CALLISTO Data - Christian Monstein & Whitham D. Reeve.....48
Observations of OH/IR stars in several molecular lines - *Dimitry Fedorov*.....57
Observation report: nearby galaxies at 21 cm part II – Eduard Mol.....63
Periodic Ionospheric Absorption Events on Cinco de Mayo - Whitham D. Reeve.....72
H1 Observations of the LEO Triplet Using the Green Bank 20 Meter Skynet Dish – Jason Burnfield.....77
Journal Archives and Other Promotions.....79
What is Radio Astronomy?.....80
Administrative.....81
Officers, directors, and additional SARA contacts.....81
Resources.....82
Great Projects to Get Started in Radio Astronomy.....82
Radio Astronomy Online Resources.....84
SARA Brochure.....88

President's Page

Congratulations!
Marcus Fisher, Jay Wilson, Tom Jacobs and Chip Csufitchi

Thanks also to the outstanding authors and presenters who provided high quality content to the conference.

The presentations are posted on the SARA YouTube channel:

https://www.youtube.com/playlist?list=PLCEbOD5_znsnpdYF0d5Tq1RR21WGBx8Rr

Congratulations to the newly elected officers and board members!

Secretary: Brian O'Rourke
Board Members:
  Ted Cline
  Ed Harfmann
  Dr Wolfgang Hermann
  Bruce Randall

Thank you to all of the SARA members who accepted the nominations but didn't get elected. This is the first year in a long time that we had very competitive elections! I will work with everyone who wants to contribute to running SARA. We have a lot of work for everyone.

Get your SARA Eastern Conference shirts, mugs, etc… at the SARA Gift store. Note - expect at least 3 weeks for delivery, so order soon!
2025 Eastern Conference – Society of Amateur Radio Astronomers Gift Shop

Editor's Notes

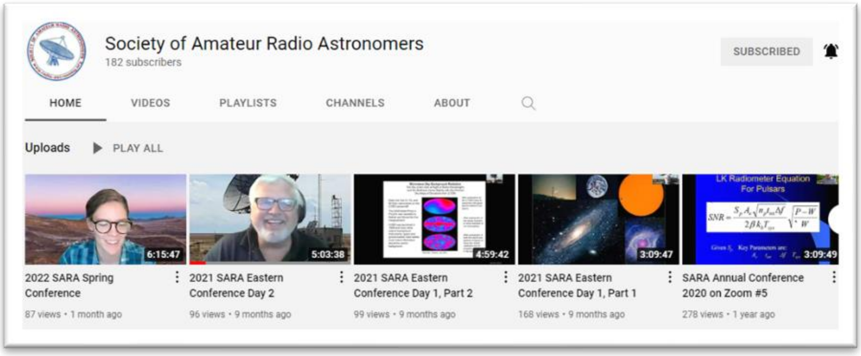
We are always looking for basic radio astronomy articles, radio astronomy tutorials, theoretical articles, application and construction articles, news pertinent to radio astronomy, profiles and interviews with amateur and professional radio astronomers, book reviews, puzzles (including word challenges, riddles, and crossword puzzles), anecdotes, expository on "bad astronomy," articles on radio astronomy observations, suggestions for reprint of articles from past journals 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/@radio-astronomy

Don't forget to LIKE the videos! It helps with the YouTube distribution algorithm.

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 object's 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.

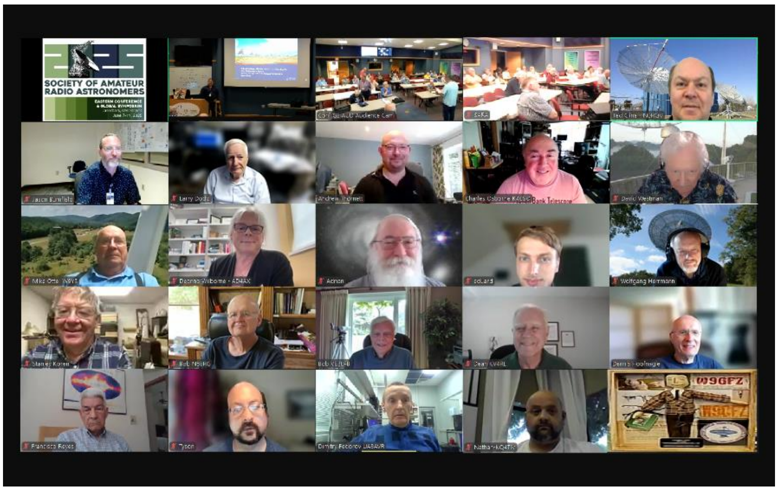
If you would like to write an article for Radio Astronomy, please follow **the newly updated Author's Guide** on the SARA web site:
http://www.radio-astronomy.org/publicat/RA-JSARA_Author's__Guide.pdf.

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

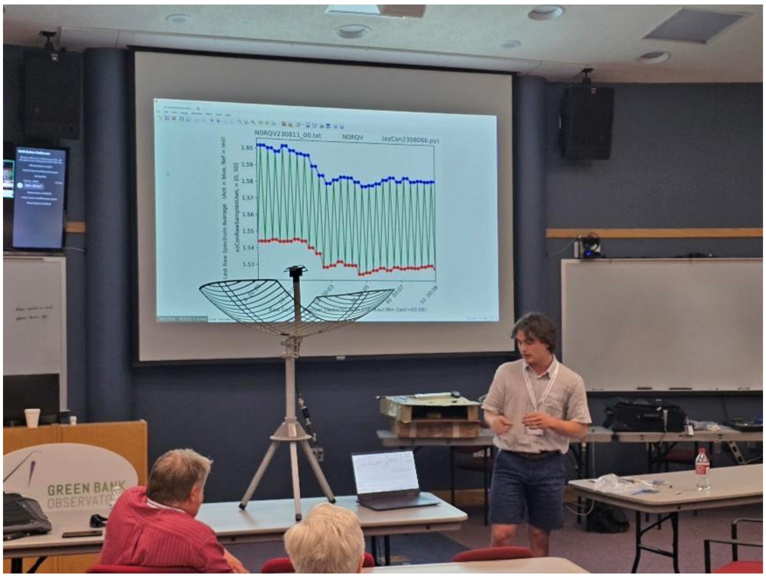
“All Wheels Stop” – Wrapping Up the 2025 SARA and Radio JOVE Eastern Conference



In astronautical terms, "All wheels stop" signals the official conclusion of a mission. I borrow that phrase to mark the successful end of our 2025 Eastern Conference — a remarkable joint gathering between the Society of Amateur Radio Astronomers (SARA) and the Radio JOVE Project.

Held at the iconic Green Bank Observatory (GBO), this year's conference was both informative and inspiring. The collaboration with the Radio JOVE community brought a fresh and dynamic energy to the event, and I am hopeful this marks the beginning of many such joint ventures.

Our program launched Saturday with Dave Lacko offering an engaging introduction to radio astronomy, followed by hands-on sessions using Scope-In-A-Box to observe the 21-centimeter hydrogen line. These practical experiences helped bridge theory and application for participants at all levels.



Evenings at Drake’s Lounge became a cherished tradition — not only for enjoying films but for deep, informal conversations that enriched our learning. Various radio telescope setups, including meteor scatter arrays, Radio JOVE receivers, and the Scope-In-A-Box system, provided ample opportunities for nighttime observing.

On Sunday, the conference continued with a diverse lineup of presentations. Ed Harfmann, Stephen Tzikas, and Skip Crilly delivered excellent talks on topics ranging from the basics of radio astronomy to the use of SkyNet, GBO's 20-meter telescope, and the historic 40-foot dish.

Monday and Tuesday featured a wide-ranging agenda covering observational projects using the 20-meter dish, insights into amateur observatories, updates on the latest Radio JOVE instrumentation, and technical discussions on inductors, small-dish setups, and more. A complete collection of conference proceedings will soon be published to document the breadth and depth of our sessions.

We were honored to host three distinguished guest speakers during the conference: Dr. Emmanuel Fonseca, Anoj Khadka, and Dr. Tony Remijan, Interim Director of the Green Bank Observatory. Their contributions elevated our discussions and connected our amateur pursuits with cutting-edge professional research.

To cap off the event, GBO staff member Sophie Saint Georges guided us through two exceptional facility tours, including the 140-foot telescope and the telescope control center — a fitting finale to an already unforgettable conference.

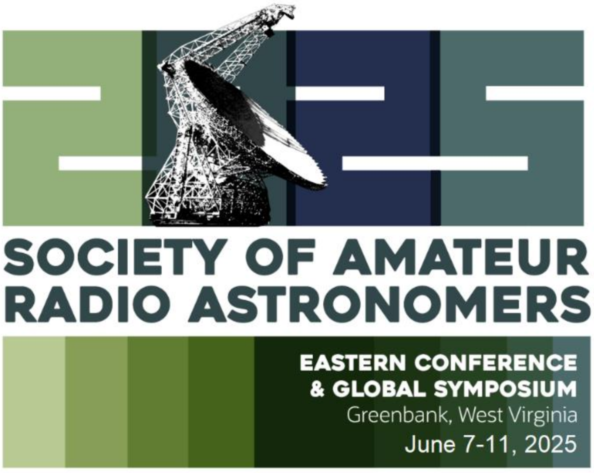

A heartfelt thank you goes to Jay Wilson, Tom Jacobs, and Chip Sufitchi for their steadfast support throughout the year and during the conference itself. Special thanks to Ted Cline for managing the online portion with excellence. And finally, sincere gratitude to the entire conference committee and the Green Bank staff — your dedication made this event possible.

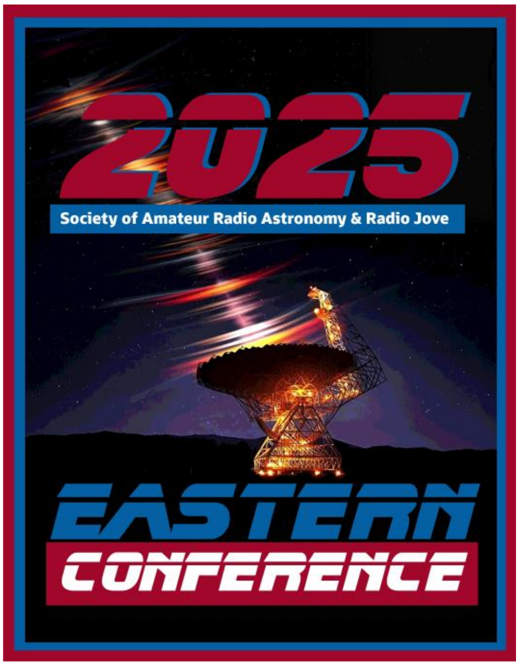
In 2026, block your calendars for the second week in June and start thinking about topics to discuss!

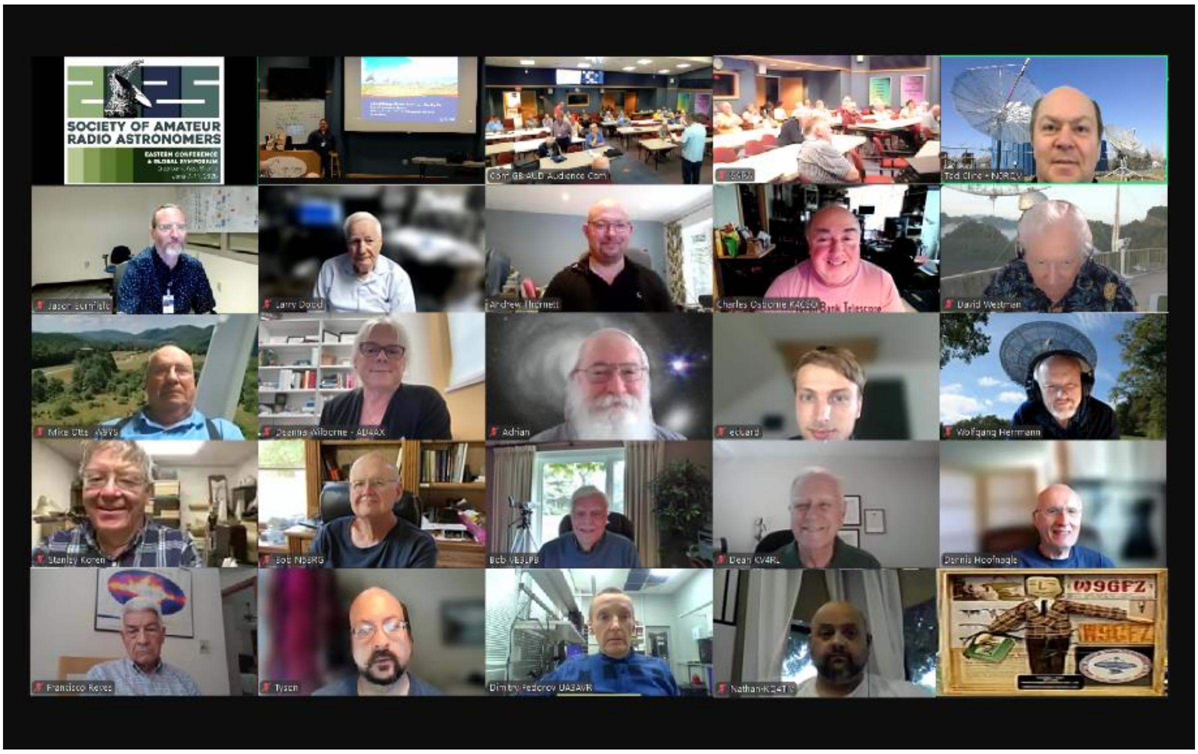
Conference proceedings will be published soon. Thanks again for participating! Comments and/or suggestions please reach out to me, and I look forward to seeing everyone next year!

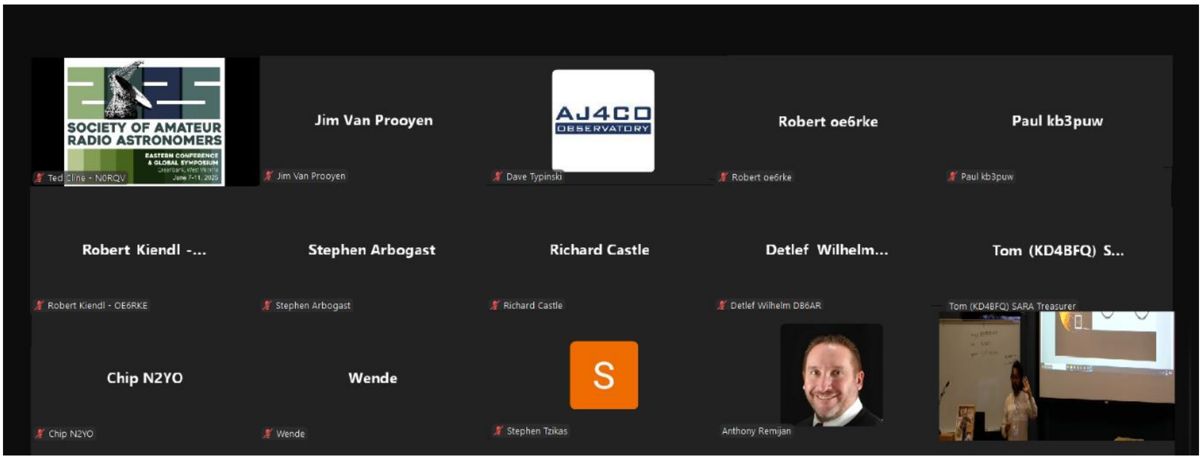
Marcus Fisher
Vice President, Society of Amateur Radio Astronomers (SARA)
vicepresident@radio-astronomy.org

SARA Eastern Conference Photos

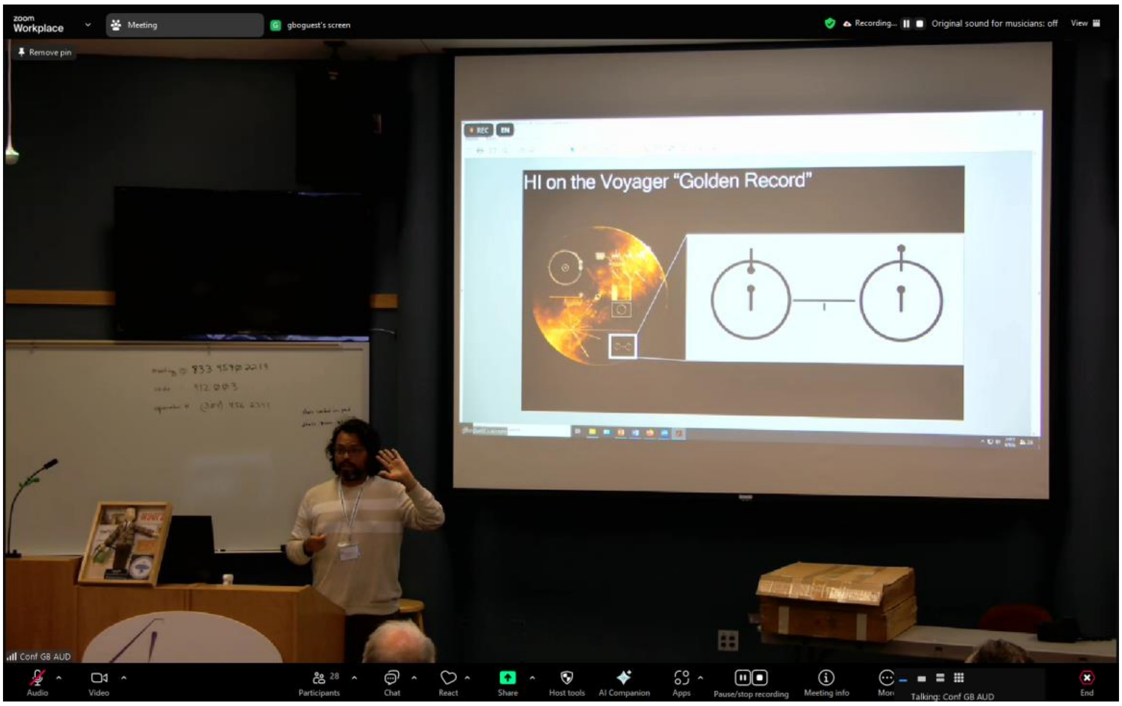


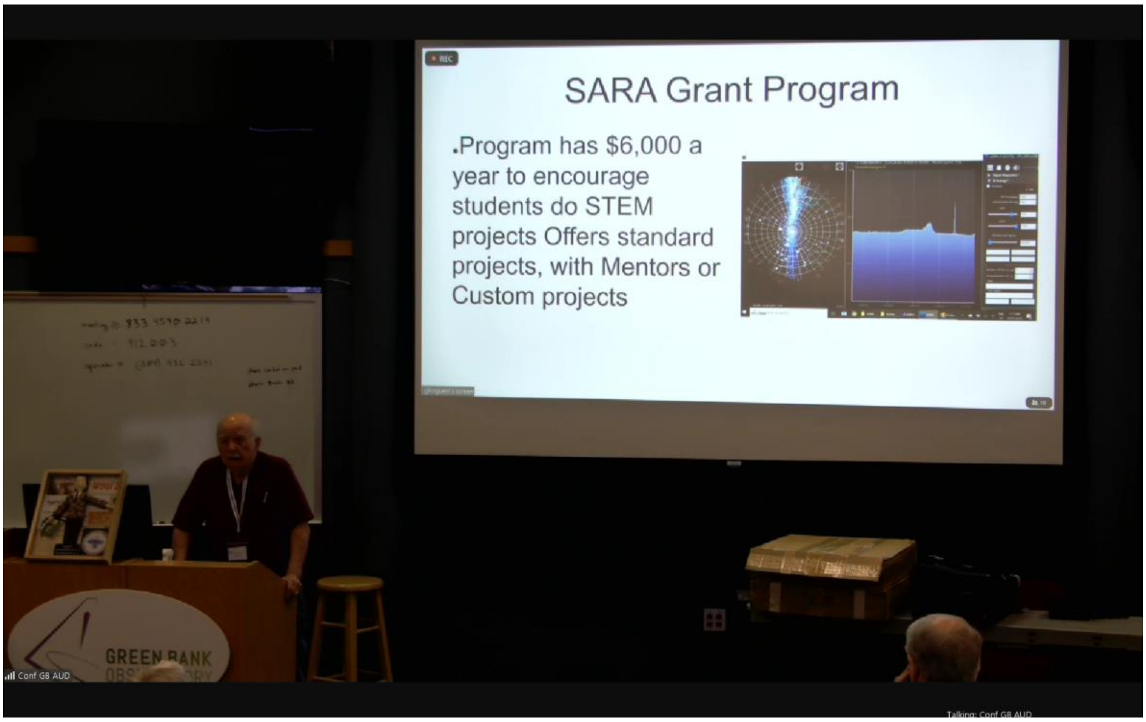


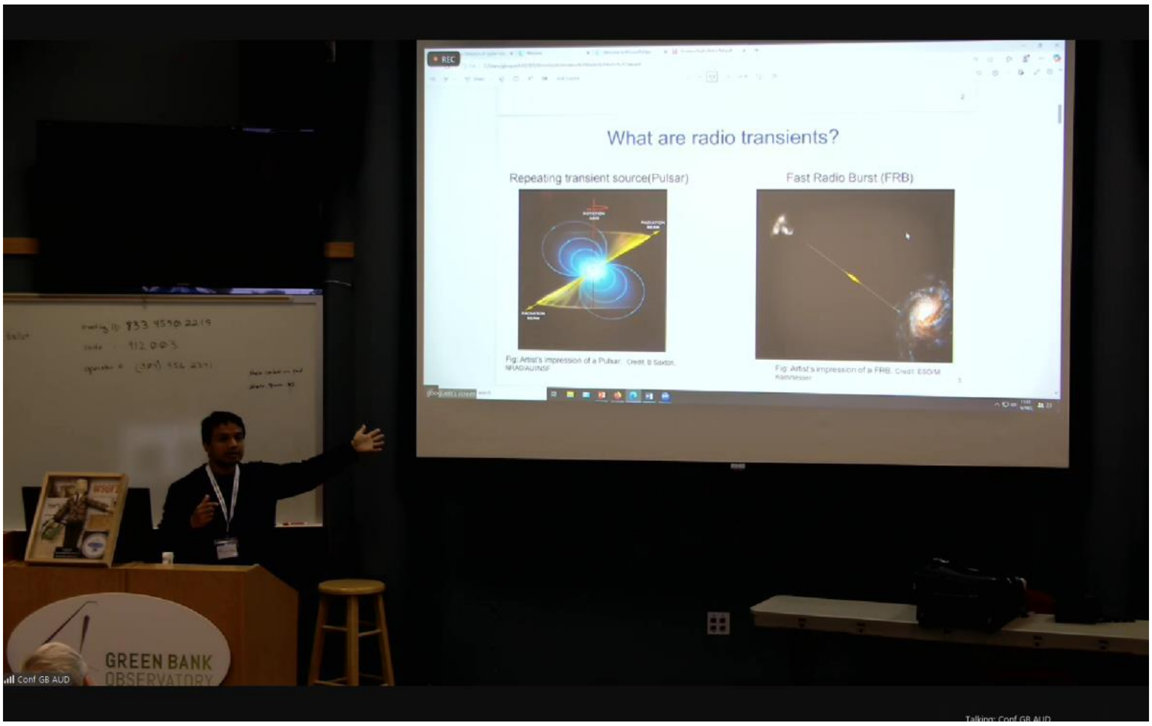

SOCIETY OF AMATEUR RADIO ASTRONOMERS
Ted Cline - N0RQV
David Westman
Adrian
Wolfgang Herrmann
Stanley Koren
Dennis Hoofnagle
Francisco Reyes
Tyson
W9GFZ


SOCIETY OF AMATEUR RADIO ASTRONOMERS
Ted Cline - N0RQV
Jim Van Prooyen
AJ4CO OBSERVATORY
Dave Typinski
Robert oe6rke
Paul kb3puw
Robert Kiendl -...
Robert Kiendl - OE6RKE
Stephen Arbogast
Richard Castle
Detlef Wilhelm...
Detlef Wilhelm DB6AR
Tom (KD4BFQ) S...
Tom (KD4BFQ) SARA Treasurer
Chip N2YO
Wende
S
Stephen Tzikas
Anthony Remijan

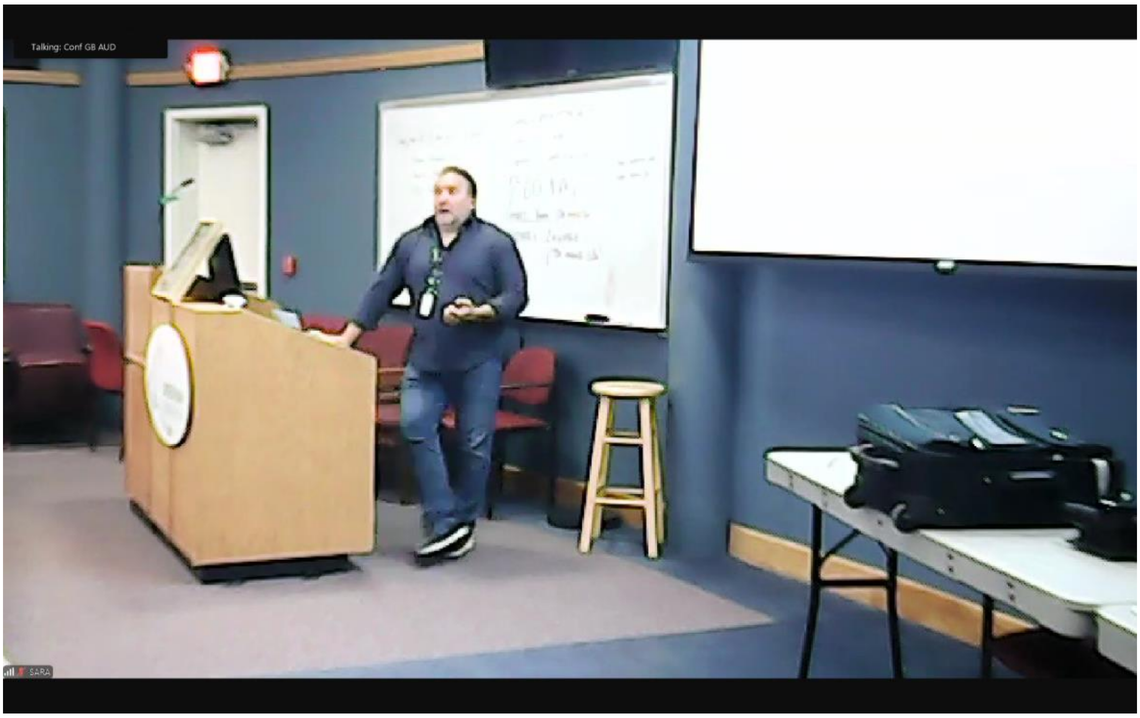

EXIT
WE MAKE TIME TRAVEL LOOK EASY
THE UNIVERSE IS WHISPERING TO US
Conf GB AUD Audience Cam
Talking: Conf GB AUD


zoom Workplace
Meeting
gboguest's screen
Recording...
Original sound for musicians: off
View
Remove pin
HI on the Voyager "Golden Record"
Conf GB AUD
Audio
Video
Participants
Chat
React
Share
Host tools
AI Companion
Apps
Pause/stop recording
Meeting info
Talking: Conf GB AUD
End


SARA Grant Program
.Program has $6,000 a year to encourage students do STEM projects Offers standard projects, with Mentors or Custom projects
GREEN BANK
Conf GB AUD


What are radio transients?
Repeating transient source(Pulsar)
Fast Radio Burst (FRB)
GREEN BANK
OBSERVATORY
Conf GB AUD


A Brief History of Astrochemistry – Hunting for New Molecules in Space
Anthony Remijan – Interim Director, Green Bank Observatory
7:00 PM
GREEN BANK OBSERVATORY
Conf GB AUD


Talking: Conf GB AUD

The BYTE

A new section is being added to the bimonthly SARA journal focused on system software applicable for amateur radio astronomy (RA).

Society of Amateur Radio Astronomers (SARA) **2025 SARA Eastern Conference**	

2025 *EU Conference on Amateur Radio Astronomy* (EUCARA25)

We are pleased to announce the date of the 2025 *EU Conference on Amateur Radio Astronomy* (EUCARA25) - Friday September 5th - Sunday 7th.

This will be held at the Visitor Center on the Harwell Campus. Further details will be published soon on our website – www.**eucara.org** .

We are honored that **Professor Jocelyn Bell Burnell** will be our keynote speaker.

When registration is open, we will let you know via the forums.

SARA Student & Teacher Grant Program

All, SARA has a grant program that is, sad to say, very underutilized. We will provide kits or money for 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 to be filled out and sent in. If it needs more work for approval, we will work with the students 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@hotmail.com .
Tom Crowley - SARA Grant Program Administrator

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 meetings are scheduled for the 4th Friday of every month, 9 AM Melbourne time. 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.

British Astronomical Association
Supporting amateur astronomers since 1890
Radio Astronomy Section


Director: Paul Hearn

The Radio Astronomy Section aspires to encourage and support the construction of radio telescopes by amateurs, their use for observing programmes, and the development of a deeper understanding of the science underlying what is being observed. Programmes can be aimed at any radio astronomical phenomenon, at any radio frequency. This encouragement will be through the operation of continuing group programmes, and through building communication and information exchange between individuals and groups pursuing their own projects. The main purpose of the Group is to act as a reservoir and clearing house for information on radio telescope design, construction and debugging, and how to use these instruments effectively. This will include the discussion of observing techniques and data analysis. Members should be able to exchange ideas, give advice and help each other. Establishing a pool of design information and software suitable for use in observing and data processing is a priority.

BAA Radio Astronomy Section Seminar programme.

These seminars are on Zoom, if you are not on the BAA RA Section email list please contact Paul Hearn – Section Director – paul@hearn.org.uk

Friday 4th July 19:30 BST (18:30 UTC) The detection of ultra-high-energy cosmic rays and neutrinos through their radio signals
Dr Katharine Mulrey Associate professor - Astrophysics (Radboud University, the Netherlands)

Cosmic rays have been observed for over a century, and yet the sources of the highest energy particles still remain a mystery. We can detect these cosmic rays, and the associated high energy neutrinos, through the particle cascades they initiate when they interact in the atmosphere or the earth. In this talk, I will present an overview of modern efforts to measure these cascades using the radio signals they generate, in particular, using radio telescopes like LOFAR and the SKA.

European Conference on Amateur Radio Astronomy - EUCARA25
EuCARA Sept. 5th - 7th. Registration will close July 31st

The conference for the amateur Radio Astronomer - Registration is now open.

Visit https://eucara.org/   Note: on site hotel accommodation is limited, book early to avoid disappointment

Join the RA conversation
Join the muon conversation
Join the UK Beacon conversation
Society of American Radio Astronomers
UK Radio Astronomy Association (UKRAA)
BAA RA YouTube channel

Paul Hearn
BAA Radio Astronomy Section Director
UKRAA Trustee
British Astronomical Association ¦¦
https://britastro.org/section_front/24
https://www.youtube.com/user/britishastronomical/playlists

SuperSID

Collaboration of Society of Amateur Radio Astronomers and Stanford Solar Center

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

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

SID Monitor Distribution
1078 instruments
82 countries
7 continents

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

SuperSID Space Weather Monitor

Request Form

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

I understand that neither Stanford nor the Society of Amateur Radio Astronomers is responsible for accidents or injuries related to monitoring use. I will ensure 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.
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 Treasurer
c/o Thomas Jacobs
P. O. Box 4245
Wilmington, NC 28406.

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.

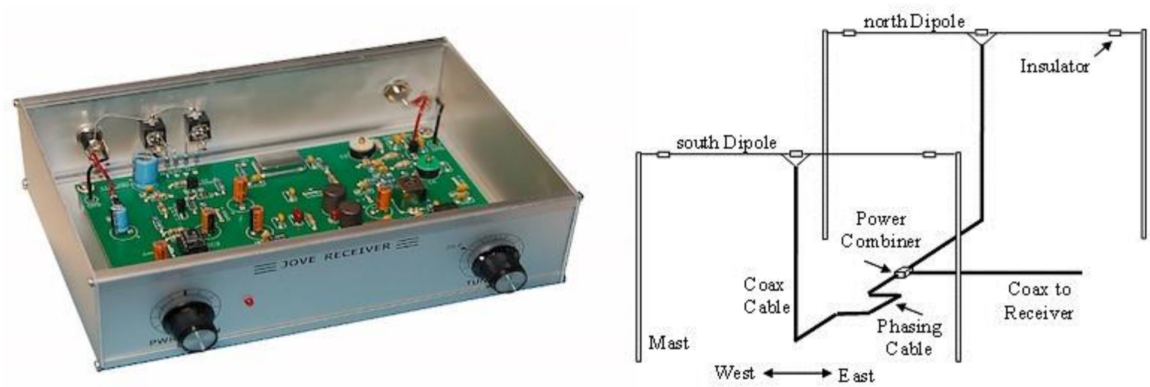


Figure 1. A Radio JOVE RJ1.1 receiver and a schematic of the dual-dipole antenna.

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).

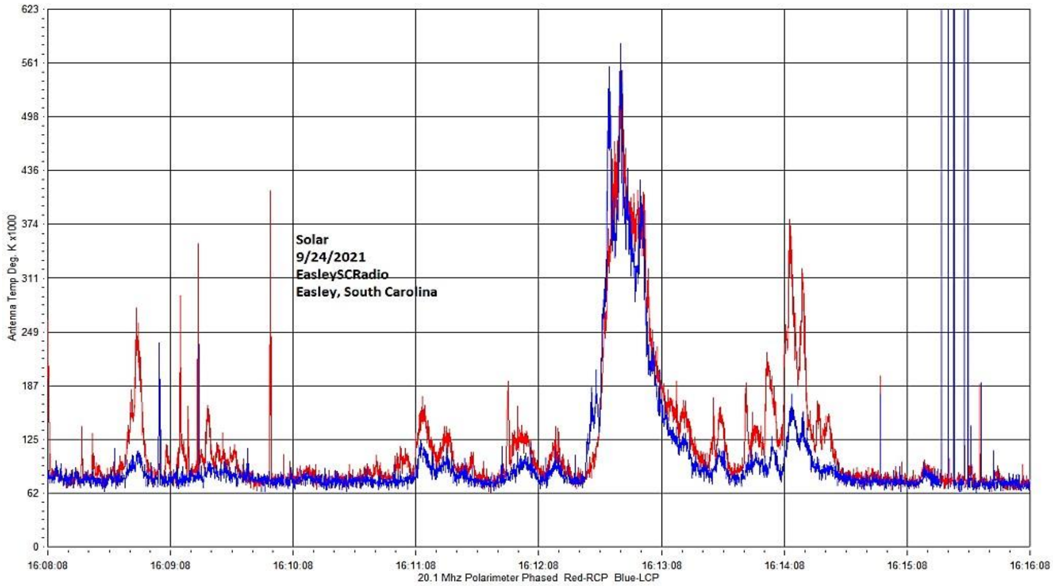


Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver. John Cox, SC.

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.

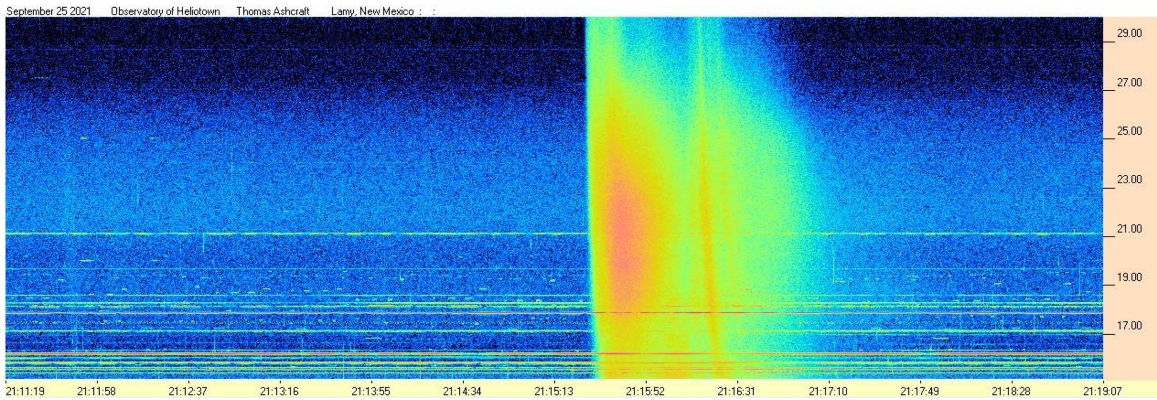


Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time, and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

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 F connectors, 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!

The British Astronomical Association
A company limited by guarantee
Registered Charity No. 210769
Founded in 1890
PO Box 702, Tonbridge, TN9-9TX 020-7734 4145
www.britastro.org

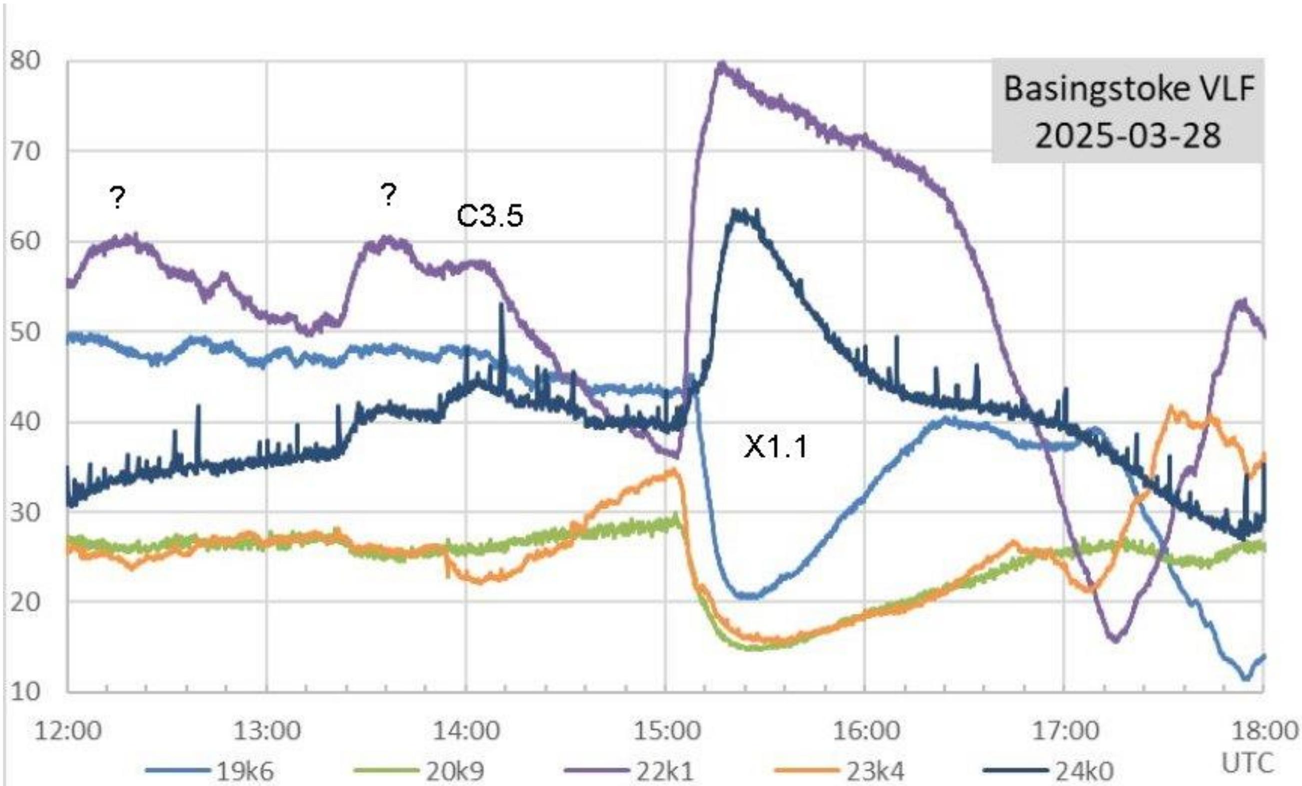
Please send questions, reports, and observations to John Cook: jacook@jacook.plus.com

BAA Radio Astronomy Section, Director: Paul Hearn

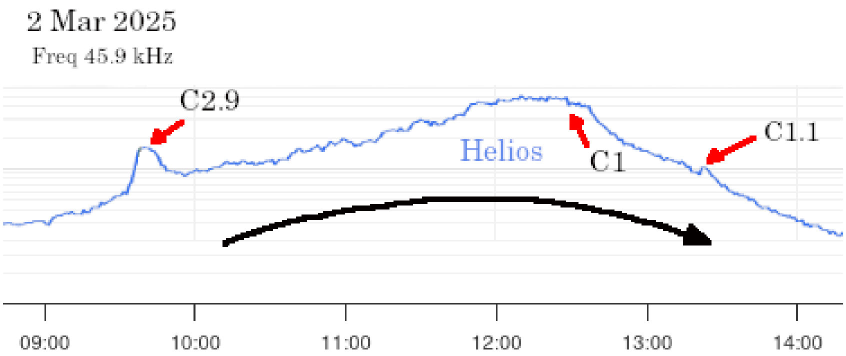
RADIO SKY NEWS **2025 MARCH**

VLF SID OBSERVATIONS

Solar flaring activity in March has been generally weaker than in February. We recorded a total of 83 SIDs compared with 80 in February, although only 9 were of M-class. In February there were 23 M-class SIDs recorded. There was a single X-flare shown in the satellite X-ray data, well timed at 15:30UT on the 28th. Most of the SIDs recorded between the 1st and 20th were from C-class flares, flaring strength increasing after that. Paul Hyde's recording from the 28th shows the X-flare:

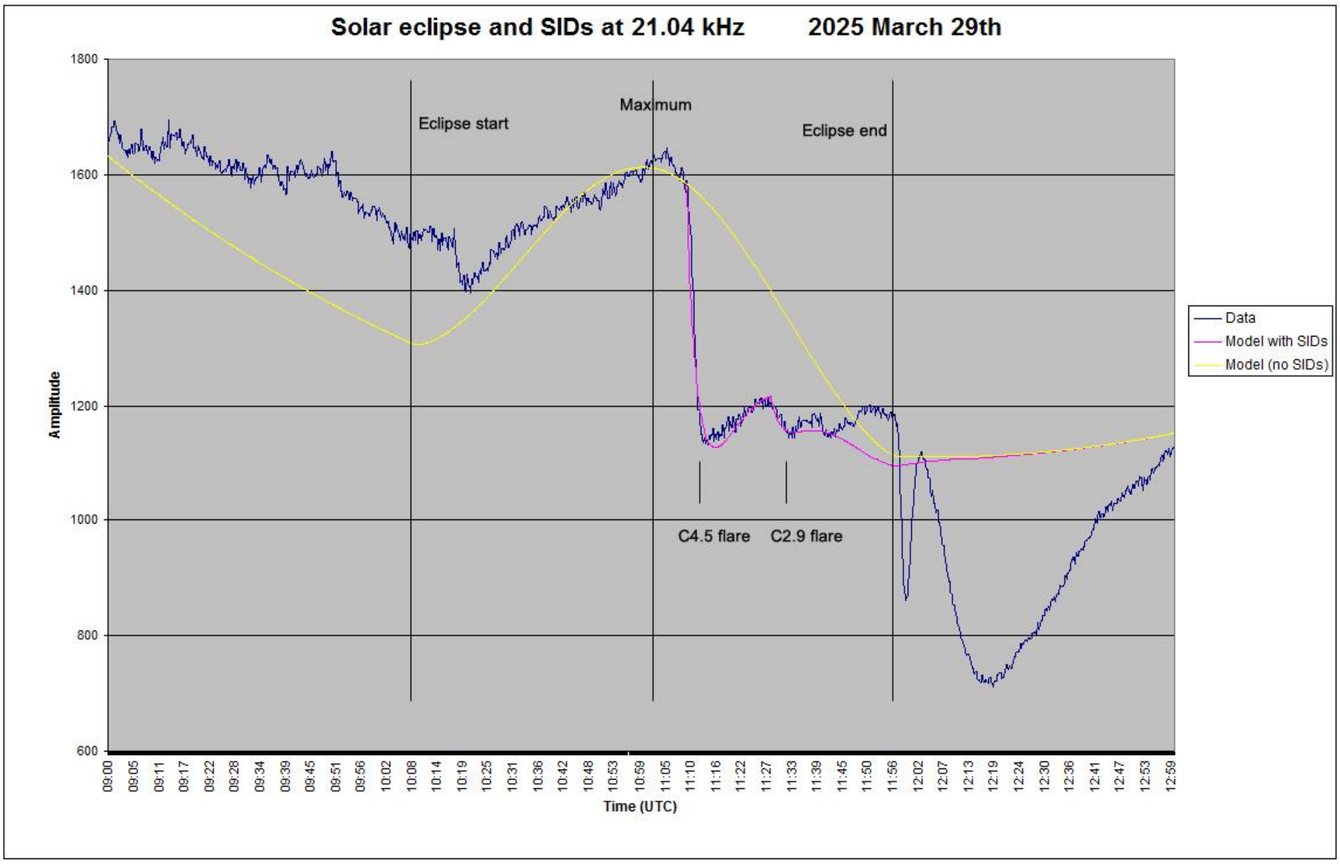


The 24kHz and 19.6kHz signals show a nice pair of mirror-SIDs, while the other signals seem to show much longer decay times, influenced perhaps by the sunset. The C3.5 flare has produced quite a weak SID, while the unlisted events both show stronger SIDs. The one at 13:40UT was widely recorded, although the earlier one just had a single observation.

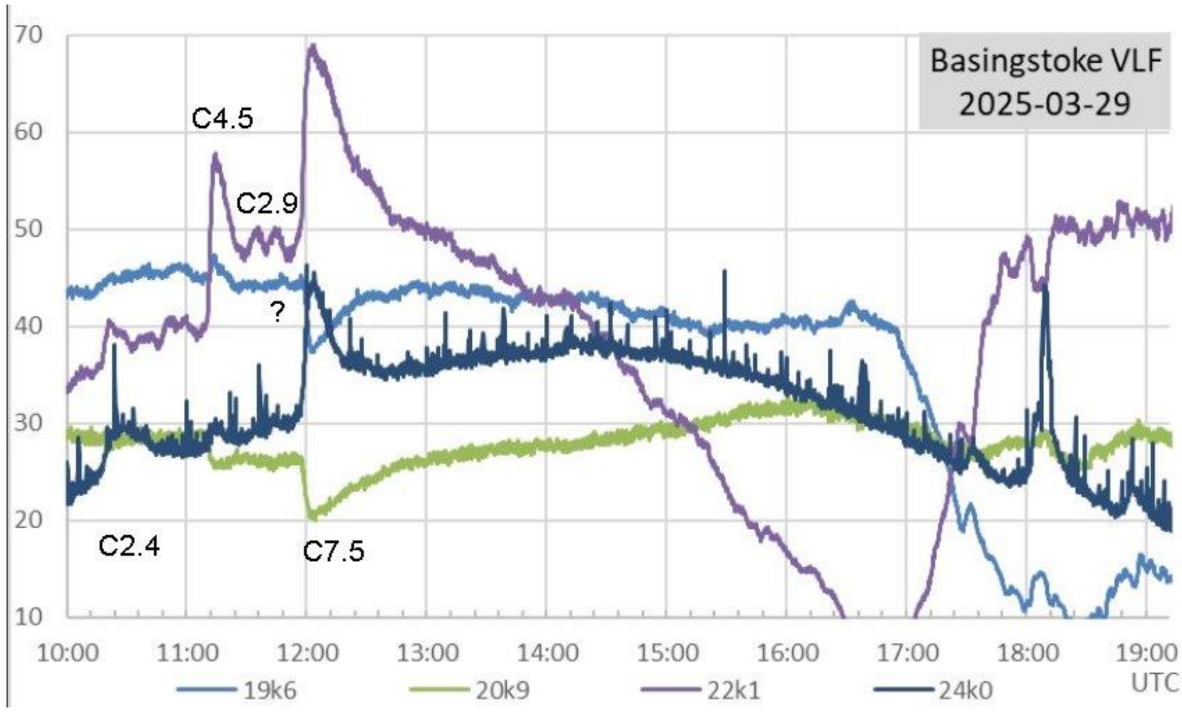


Thomas Mazzi in Italy recorded some of the weakest flares seen for a long time. The one marked C1 is not listed in the satellite data, but the other two are listed. We had two other observations of the C2.9 flare, while the C1.1 was missed.

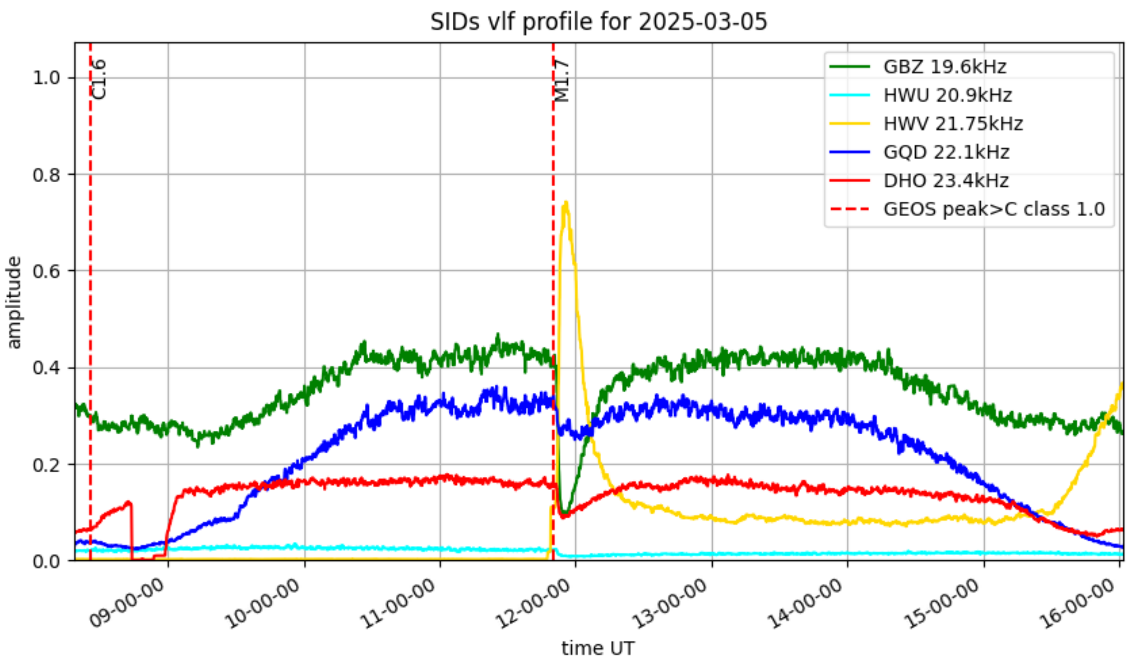
On Saturday 29th March we had some mixed weather here in the UK for observing the partial solar eclipse. It was about 40% maximum and well seen visually. Looking at the radio data however showed that there were flares going off at the same time, rather confusing our VLF recordings. Mark Edwards has used his modelling method to show the effect both with and without the SIDs present. It required a few modifications to the model used for the last partial eclipse in order to get it to work. The C7.5 flare started after the eclipse had ended but is included in the chart.



Our recordings of the 2015 March partial eclipse showed an increase in some signals, with a drop in others. Most showed a double peak, but that partial eclipse had a much larger phase compared to this one. There were no SIDs present!

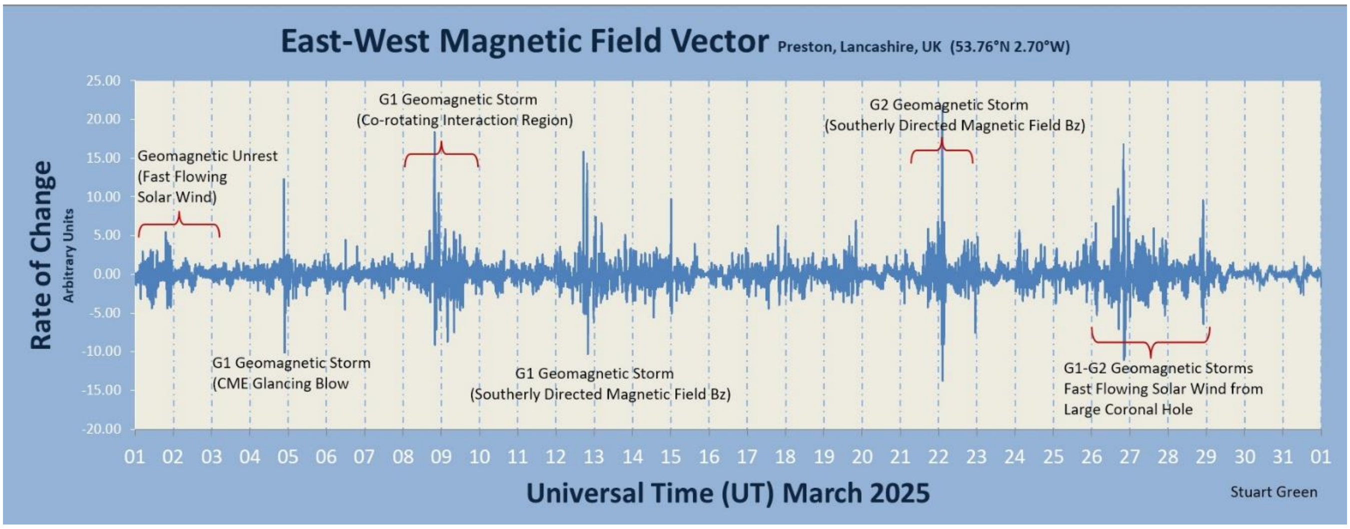


This recording from Paul Hyde shows very little effect from the eclipse, the SIDs dominating the picture on all four signals. 22.1kHz shows the C2.9 and unlisted flares best.

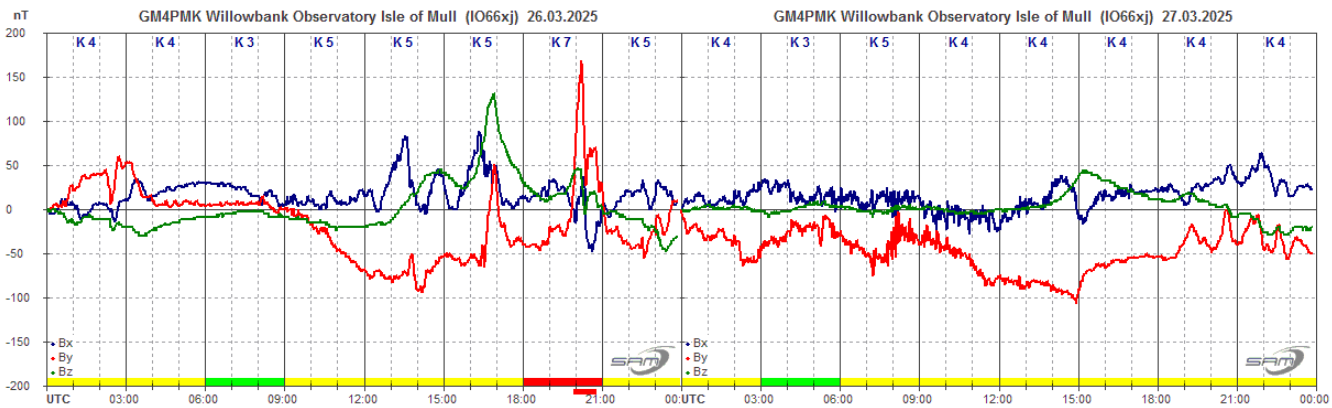


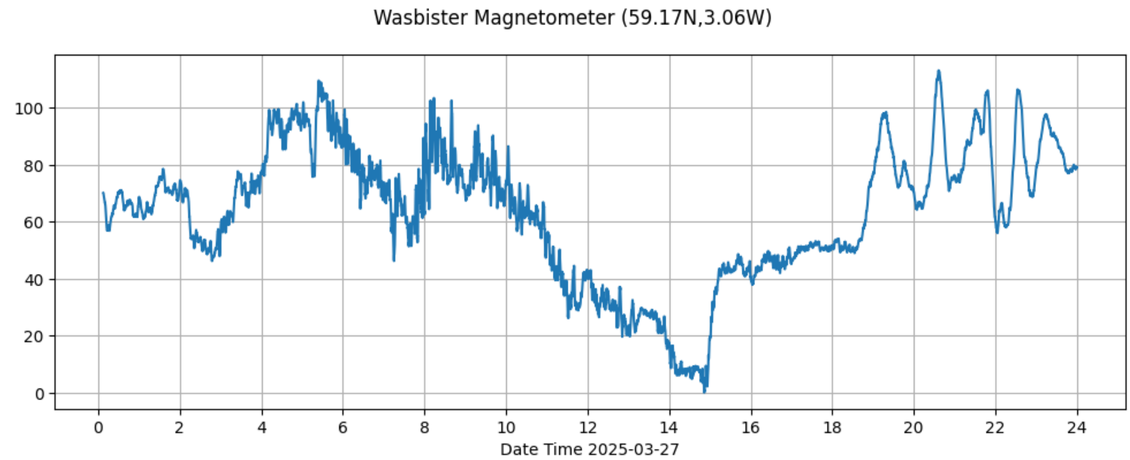
Activity at the start of March was much lower, and generally weaker. We did however catch the M1.7 flare peaking just before midday on the 5th, shown in Mark Prescott's recording. 20.9kHz appears to be off all day, although there is a tiny drop in signal level matching the start of the flare. All the other signals show clear SIDs, 21.75kHz being particularly strong, although it also appears to have been off before the flare. 19.6kHz, 22.1kHz and 23.4kHz all show an excellent diurnal curve between sunrise and sunset, not often seen during the periods of higher solar activity.

MAGNETIC OBSERVATIONS

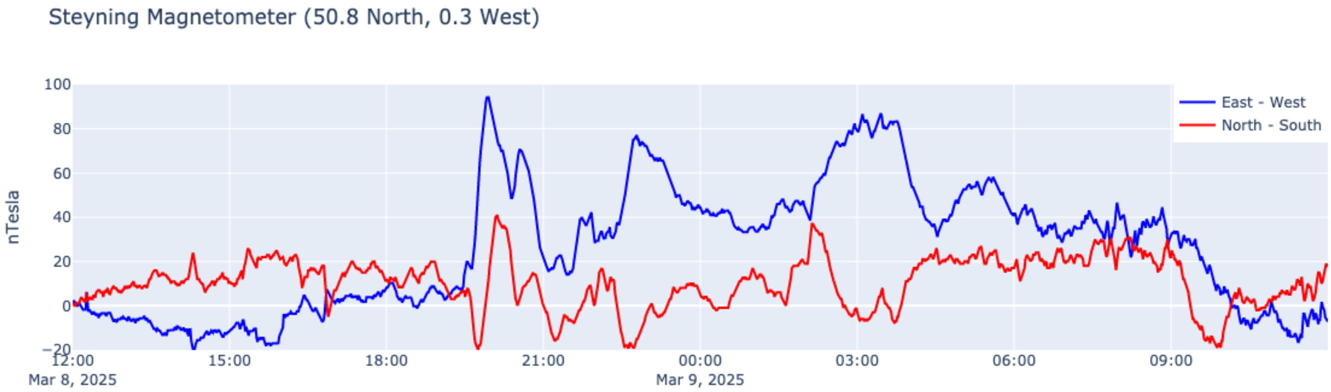


Stuart Green's chart of magnetic activity in March shows plenty of disturbances, mostly from fast solar winds. Coronal holes are starting to become more common with the lower level of flaring, Roger Blackwell's recording from the 26th and 27th showing a very turbulent period:

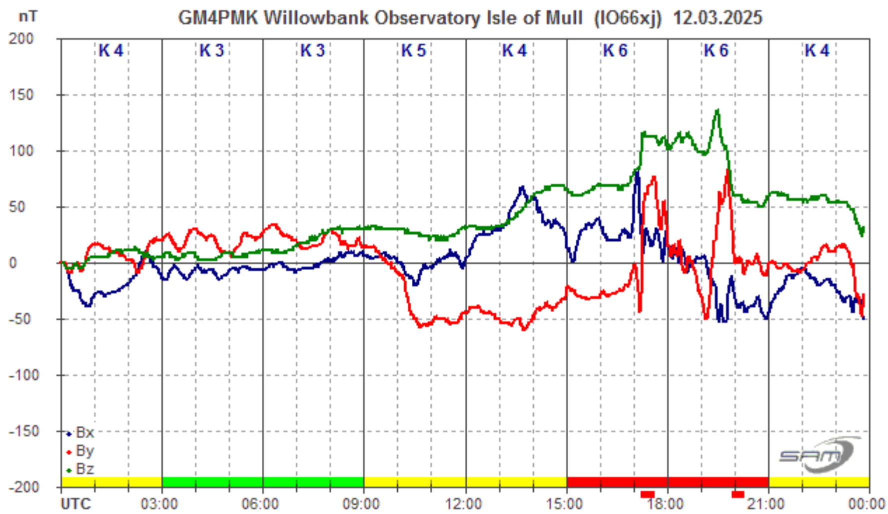




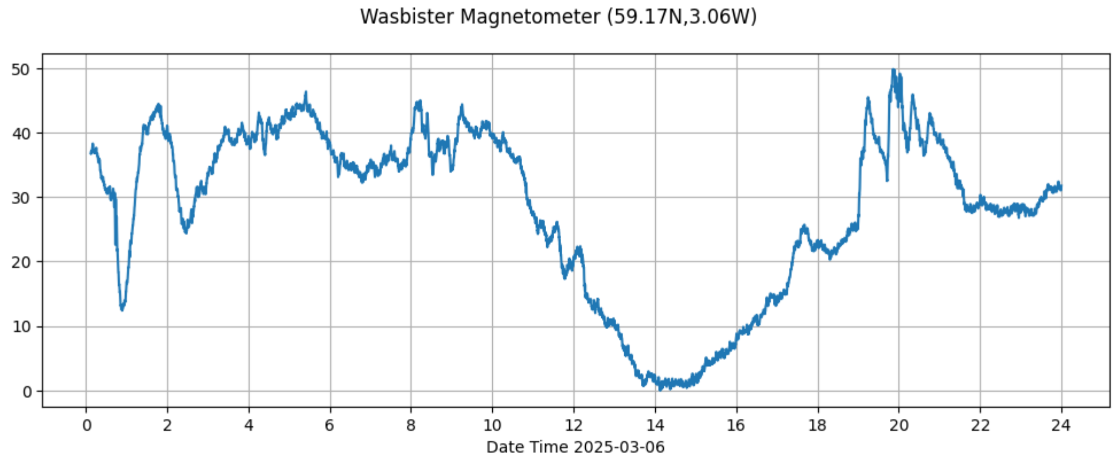
Callum Potter's recording on the 27th shows the very rapid variations in field strength during the morning.



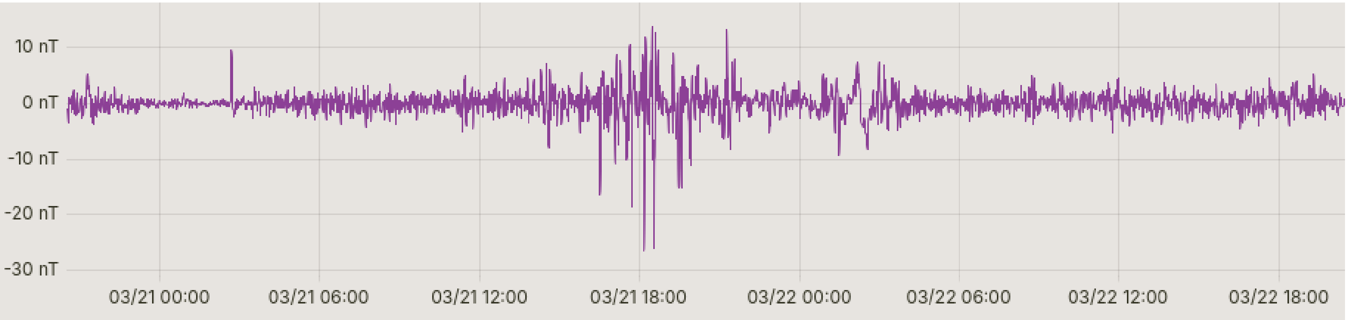
Nick Quinn's recording from the 8th / 9th also shows solar wind turbulence, this time from a co-rotating interaction region (CIR), where magnetic polarities rapidly change. There is also a high-speed wind present, although it faded out later the 9th. Activity increased again on the 12th, a strong disturbance in the evening shown in Roger Blackwell's recording. This continued over the next few days, but not quite as strong.



The STCE bulletin reports a CME impact late on the 5th, although none of our recordings show the impact. Callum Potter recorded a fairly mild disturbance on the 6th, possibly related to the CME. This was much weaker on the 7th, fading out after that.



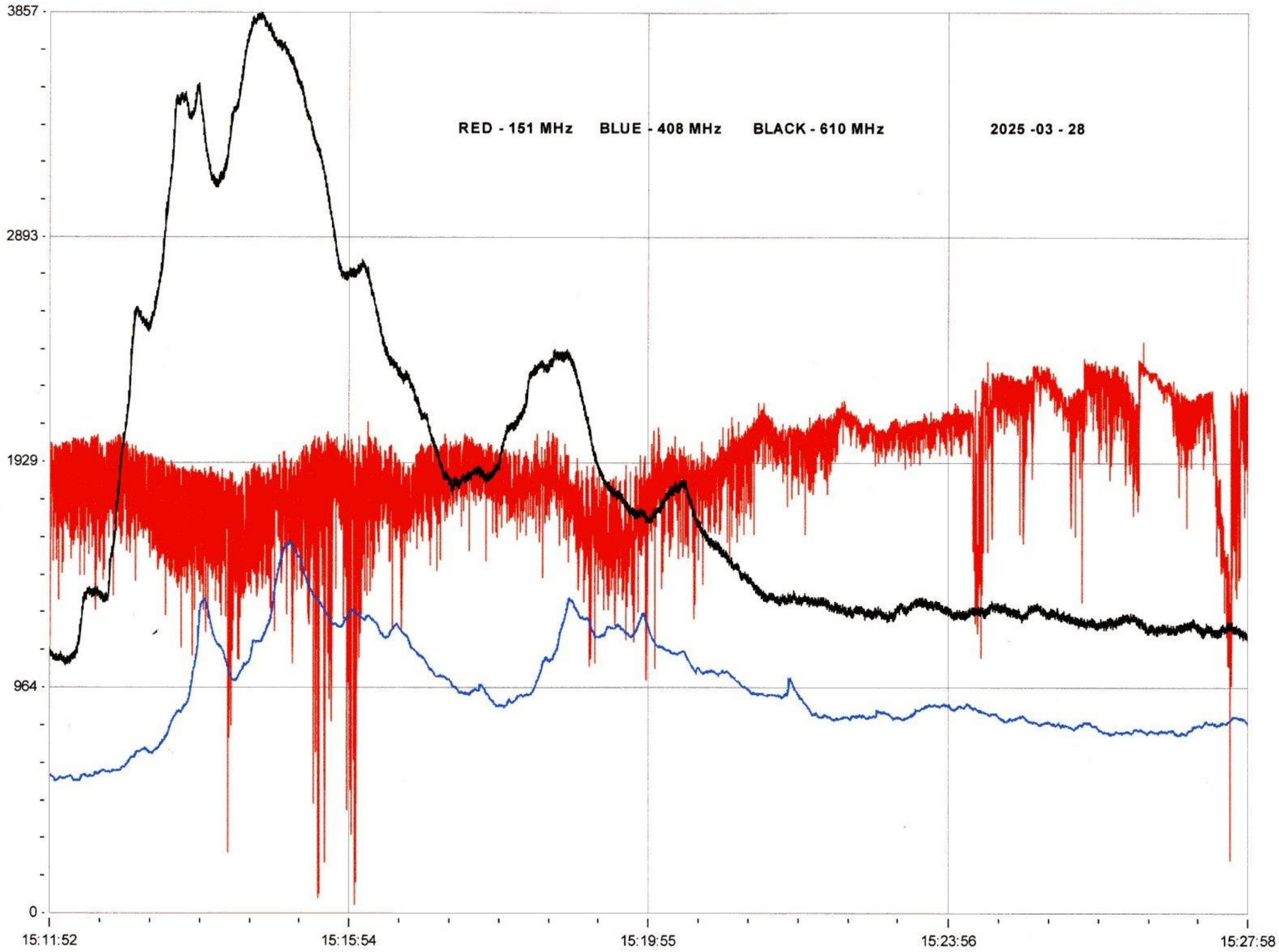
The STCE bulletin does list a CME from the X1.1 flare on the 28th, but our recordings show little evidence other than mild activity at the end of the month. There was also a CME on the 22nd with a short period of activity recorded by Thomas Mazzi:



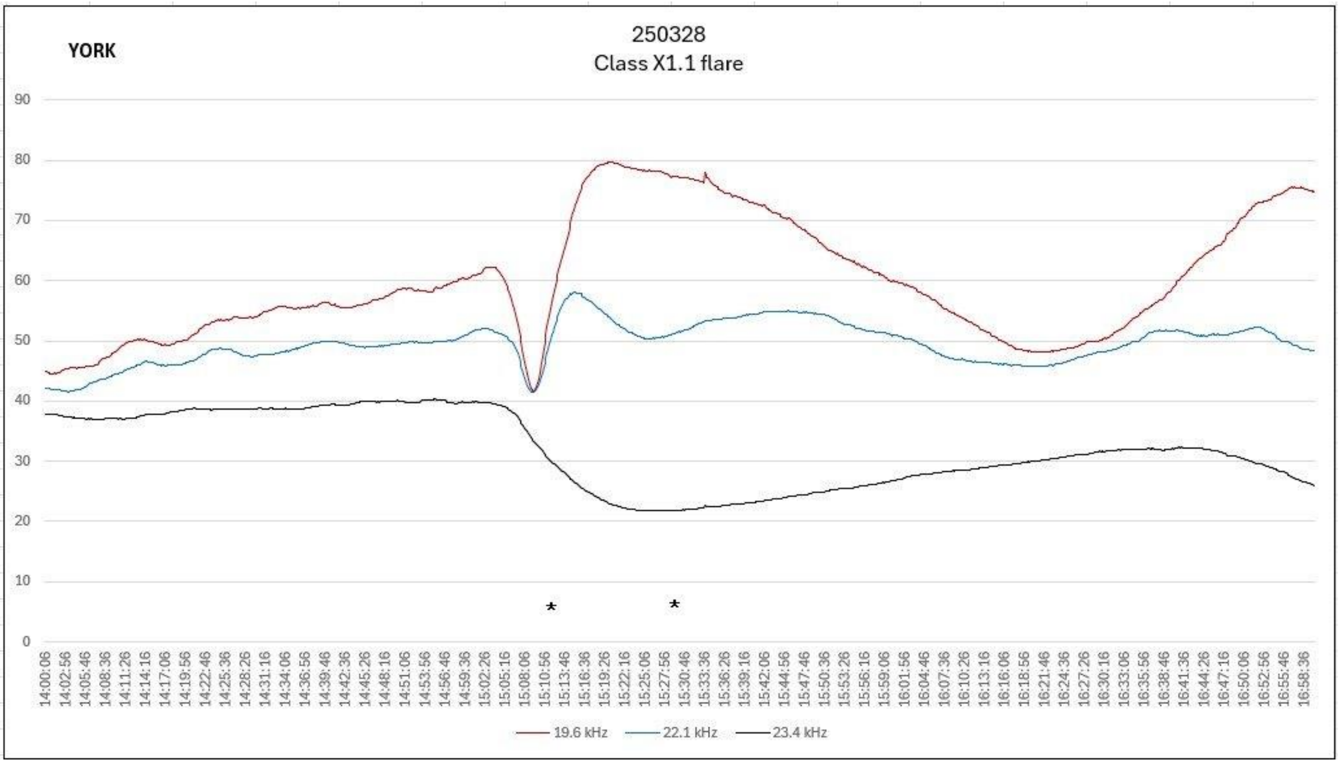
Activity starts mid-afternoon on the 21st with a quiet period over midnight and further activity early morning on the 22nd.

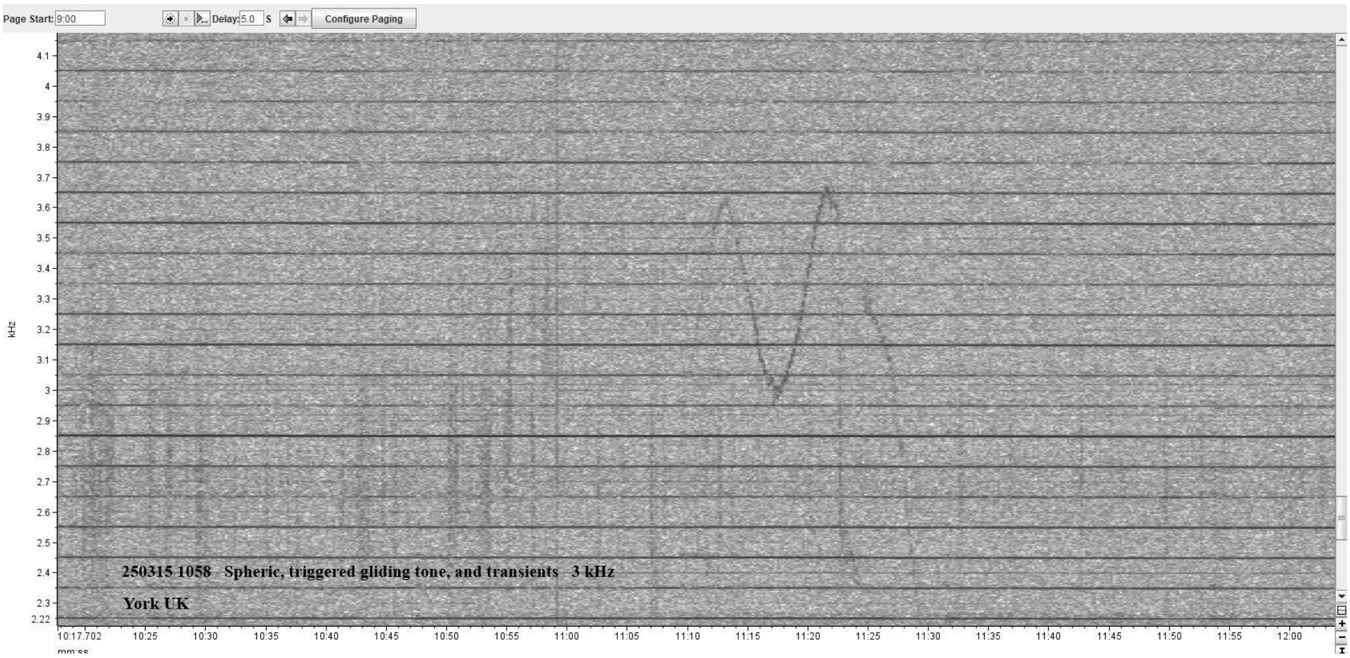
Magnetic observations received from Roger Blackwell, Stuart Green, Thomas Mazzi, Callum Potter, Nick Quinn, and John Cook.

SOLAR EMISSIONS



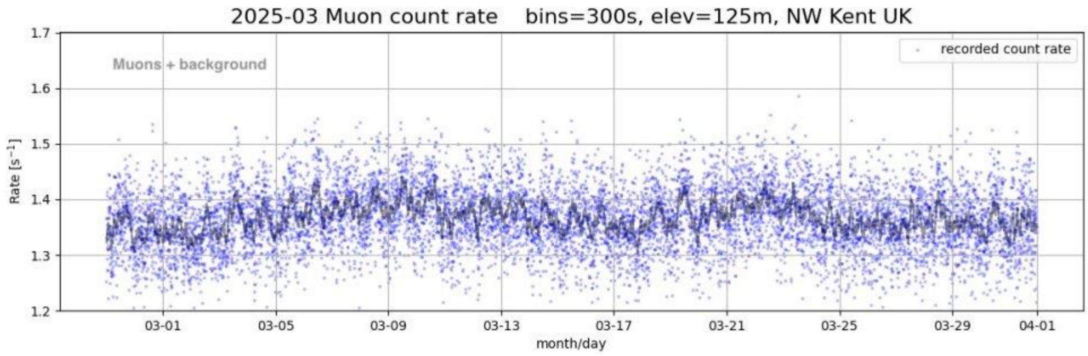
Significant VHF / UHF emissions were recorded by Colin Clements from the X1.1 flare. 408MHz and 610MHz both show a very clean rise in signal level, peaks shifted barely a minute apart. 151MHz shows more noise, but the pattern is very similar with just a small delay. Colin Briden provided an expanded VLF recording showing 19.6kHz, 22.1kHz and 23.4kHz. I have added '*' marks to show where the VHF / UHF chart starts and ends. This also shows the short delay between the X-ray output and the RF output.

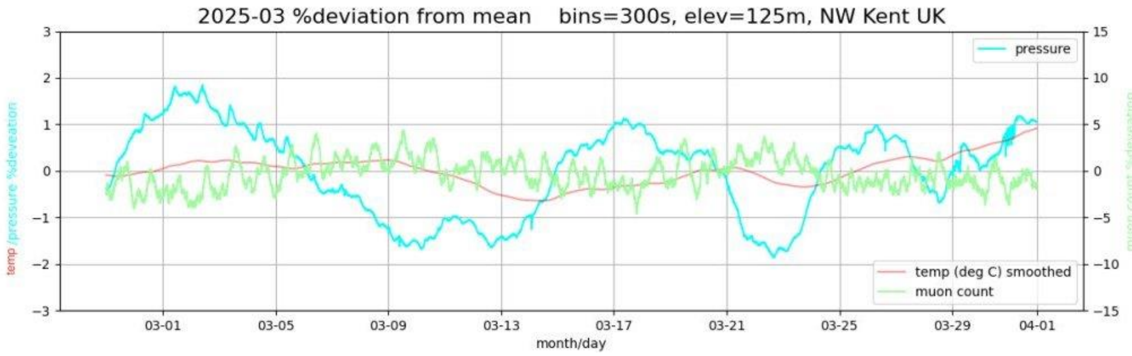


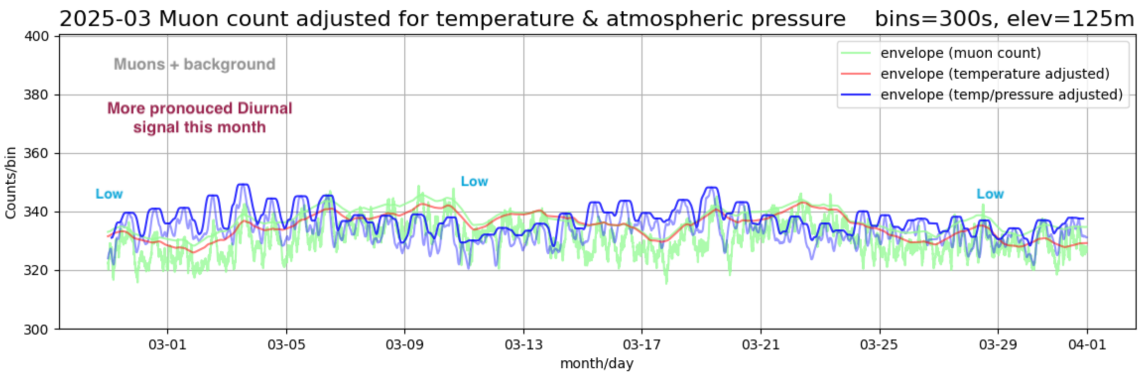


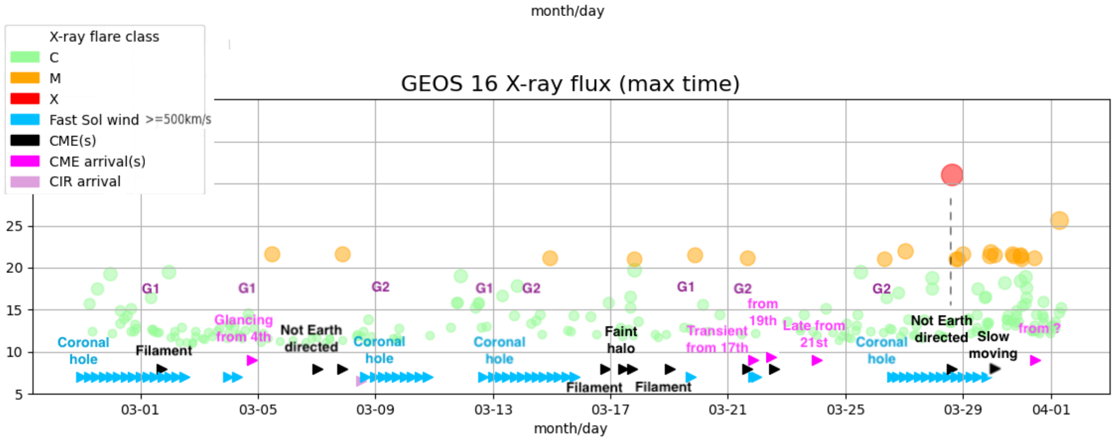
Colin Briden also recorded spherics at 3kHz on the 15th. His chart runs from 11:17 to 12:00, showing transients and a gliding tone. The vertical axis covers 2.3kHz to 4kHz. I have enhanced the contrast a little to make them a little easier to see.

MUONS

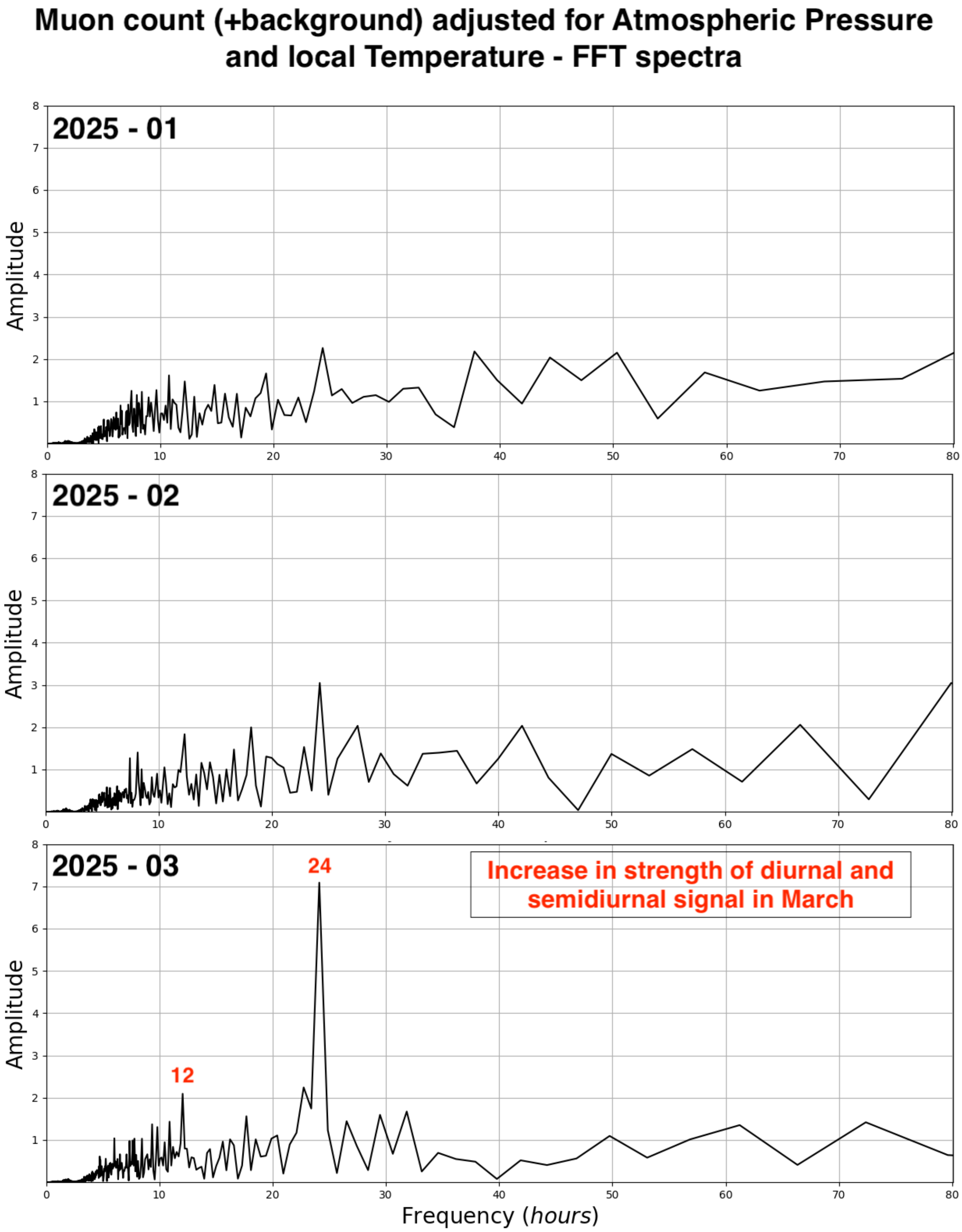








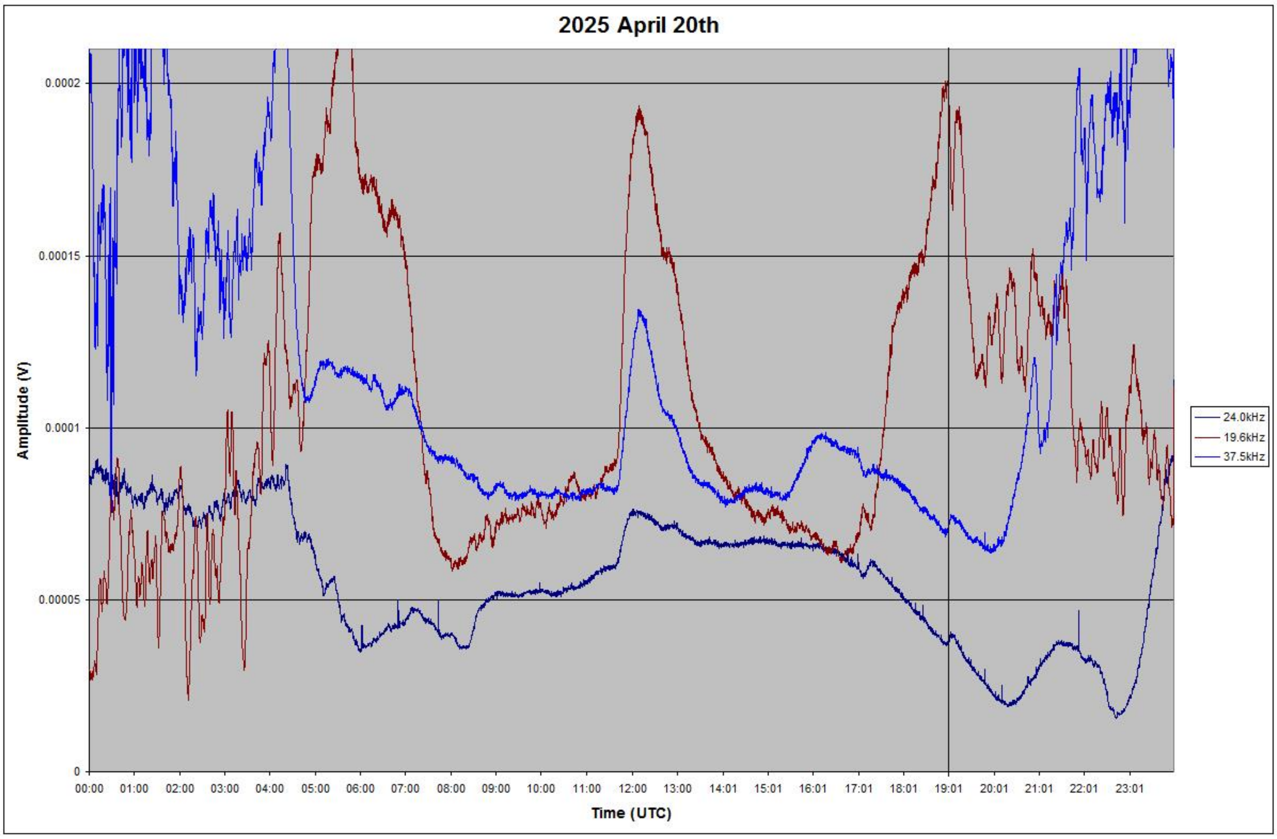
The raw muon data in the top chart from Mark Prescott shows a very slow variation through the month, reflecting the weaker flaring activity. Mark has also noticed a more pronounced diurnal variation, illustrated in his FFT analysis of data recorded over January to March on the next page:



The top two charts from January and February both show peaks at 12 hour and 24-hour intervals, but the peaks in March are considerably stronger. The peaks at longer intervals are far more random.

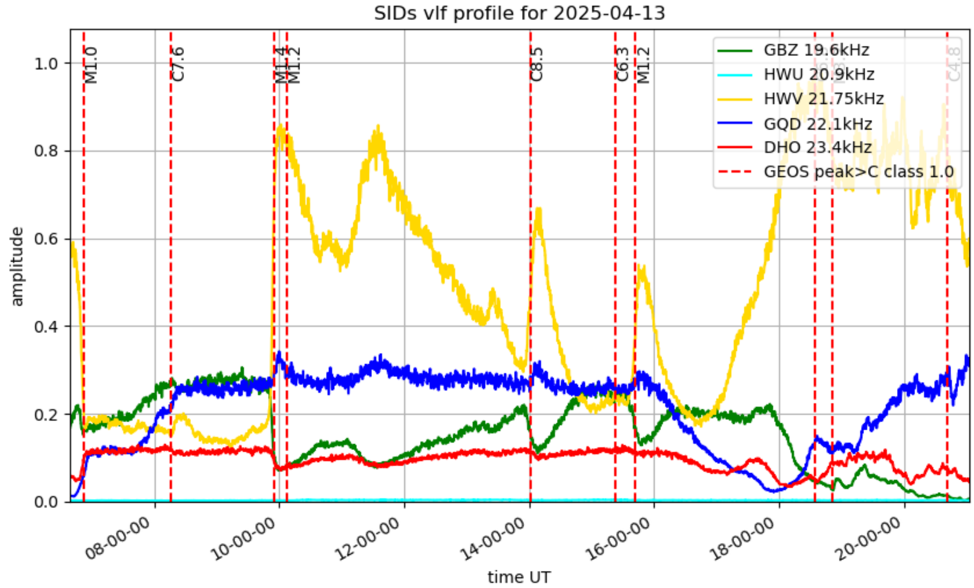
VLF SID OBSERVATIONS

Solar flaring activity increased slightly in April, with 88 SIDs recorded. The flare strength was however much greater, 27% being M-class compared with 11% in March. There were no X-class flares shown in the SWPC satellite data. We often record a few unlisted SIDs, but three observers noted an unusual SID at 19:00UT on the 20th.

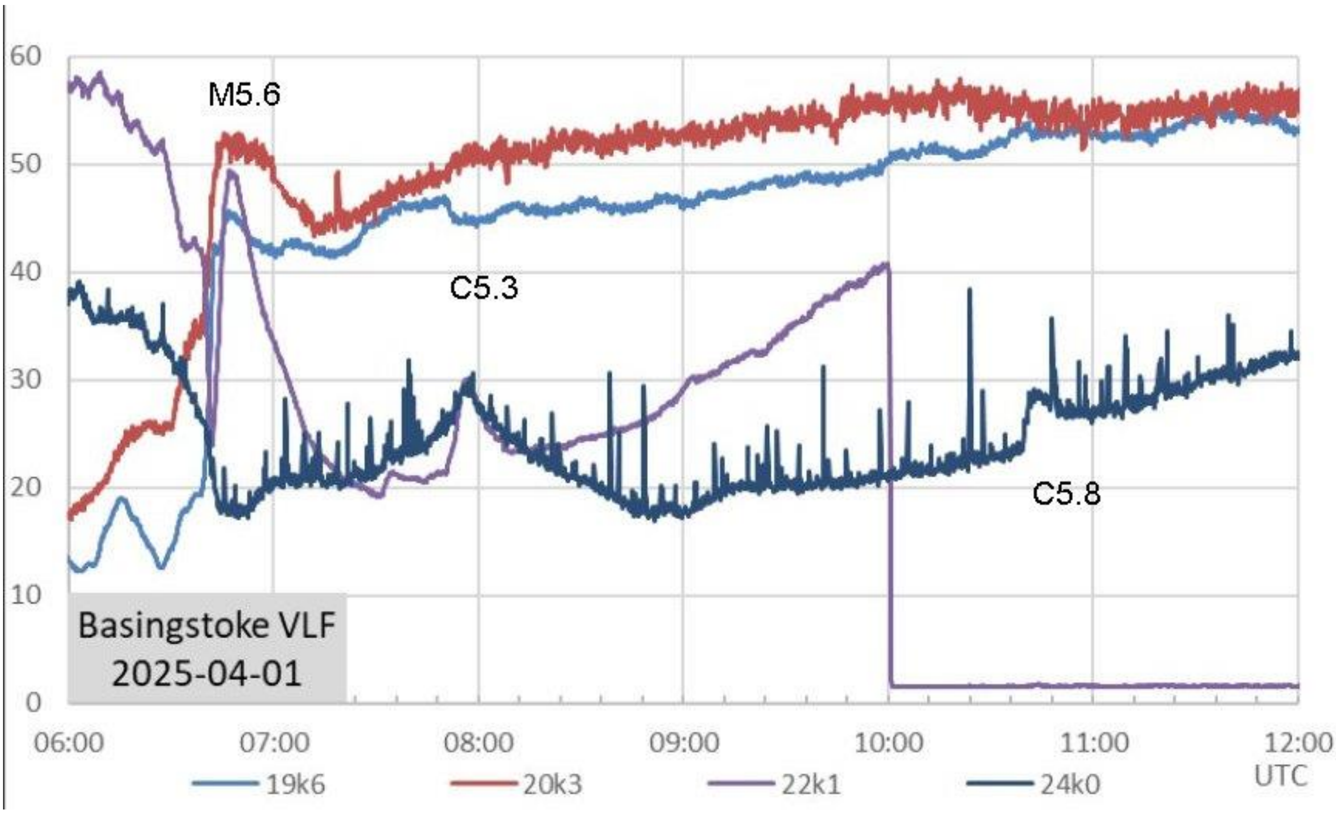


Mark Edwards has added a vertical black line onto his chart to show the alignment of all three signals peaking at 19:07UT. The source is unknown as it does not show in any of the X-ray lists. The strong M1.0 flare at midday also shows well on all the signals, as does the smaller C4.3 flare at 17:18.

There was also a series of unlisted flares on the 13th, although these did have a solar origin. Mark Prescott's recording shows a strong SID at 11:32UT:

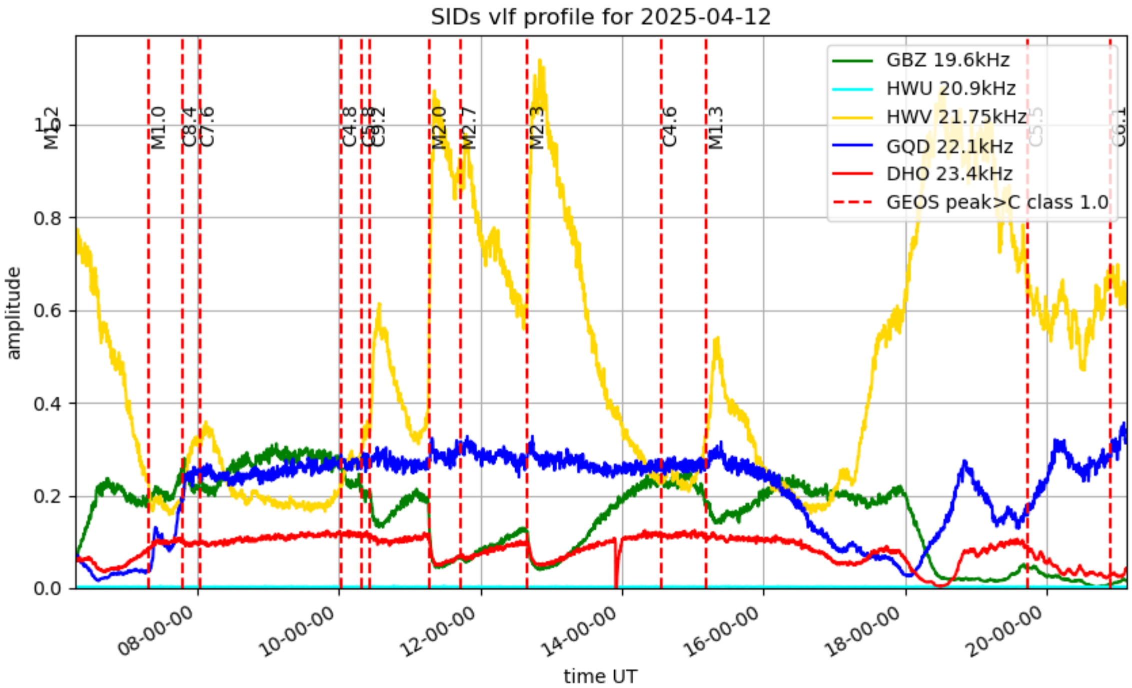


Comparing with the other SIDs shown, it could easily be a large C-class or small M-class flare. Smaller SIDs can also be seen either side on the 21.75kHz signal, with less clear effect at 19.6kHz.

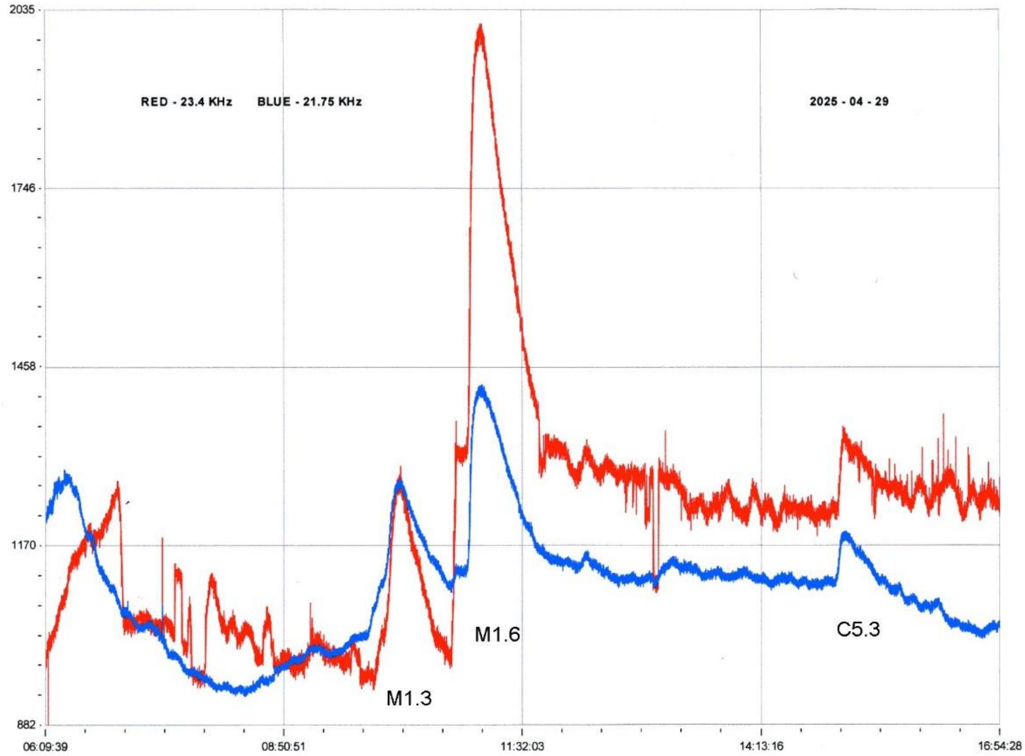


The strongest flare in April was the M5.6, peaking at 06:47UT on the 1st. Paul Hyde's recording shows a strong response on most of the signals, although it was rather early for the 24kHz Trans-Atlantic signal. The small dip shown is mostly from the sunrise at its reflection point. The two C-flares do show at 24kHz, although the C5.3 at 08:00 has produced an unusual shape. The later C5.8 is more typical. Following this burst of activity at the start of the month, we recorded mostly much weaker flares over the next week, and then the 8th showed no flaring at all.

Activity increased again on the 12th, shown in this recording by Mark Prescott:

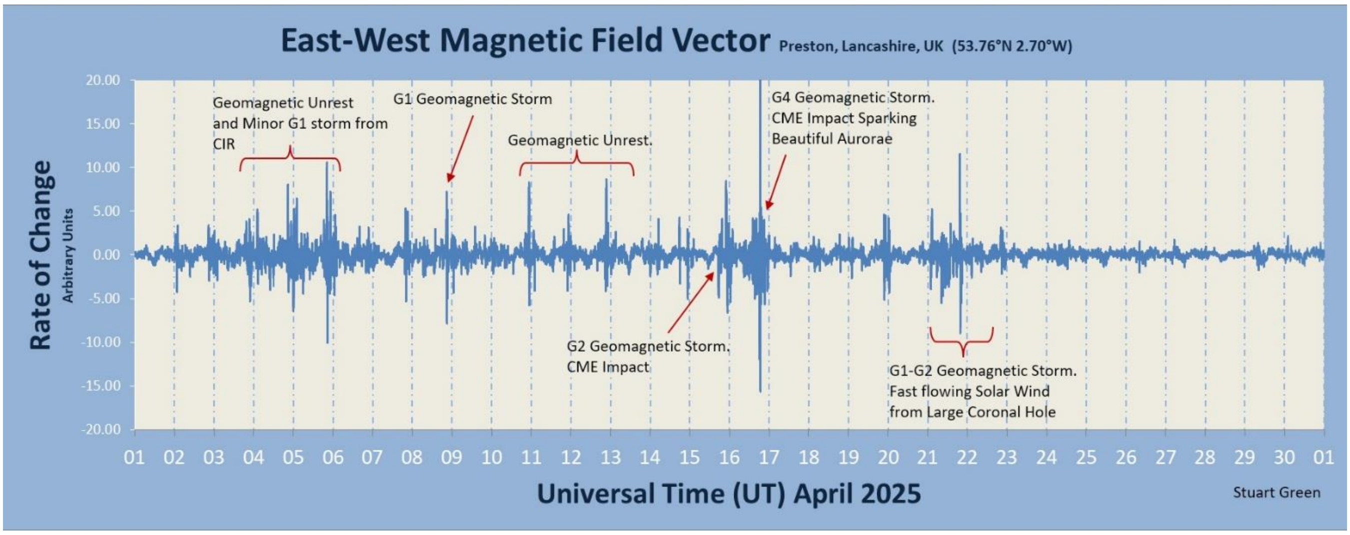


Three strong M-flares have produced overlapping SIDs around midday, with a small unclassified flare clearly seen at 12:05UT on the 21.75kHz signal. The 23.4kHz signal shows a very sharp drop-out just before 14:00, an effect that seems to occur frequently on this signal. Mark Edwards noticed that from 12 to 16UT the 24kHz signal precisely matched the GOES short wavelength X-ray data, something not often seen.

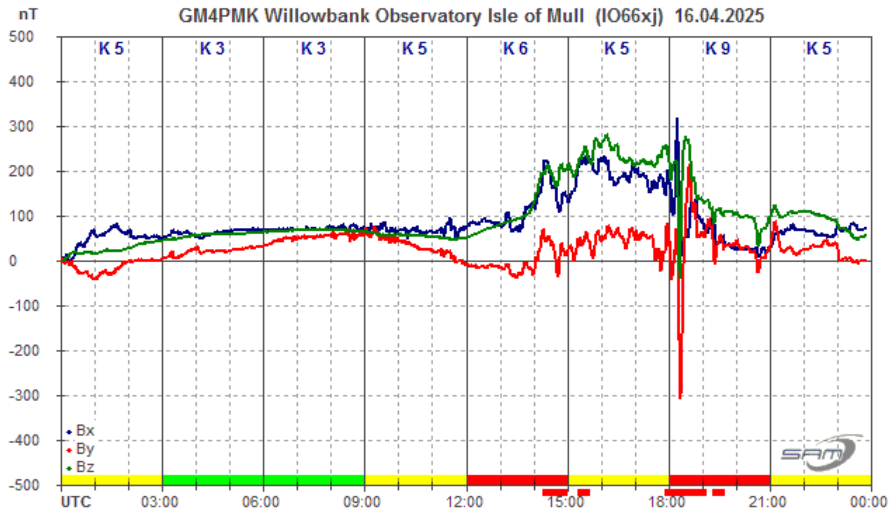


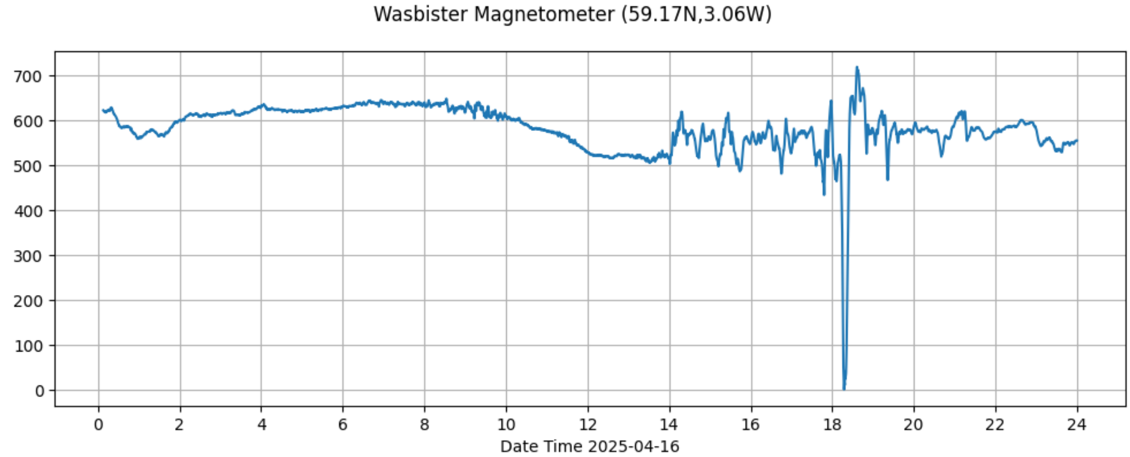
This recording from Colin Clements shows another burst of stronger flaring on the 29th. The SID from the M1.6 flare shows an unusual rise on both signals, an effect not seen on other recordings, and so may be from local interference.

MAGNETIC OBSERVATIONS



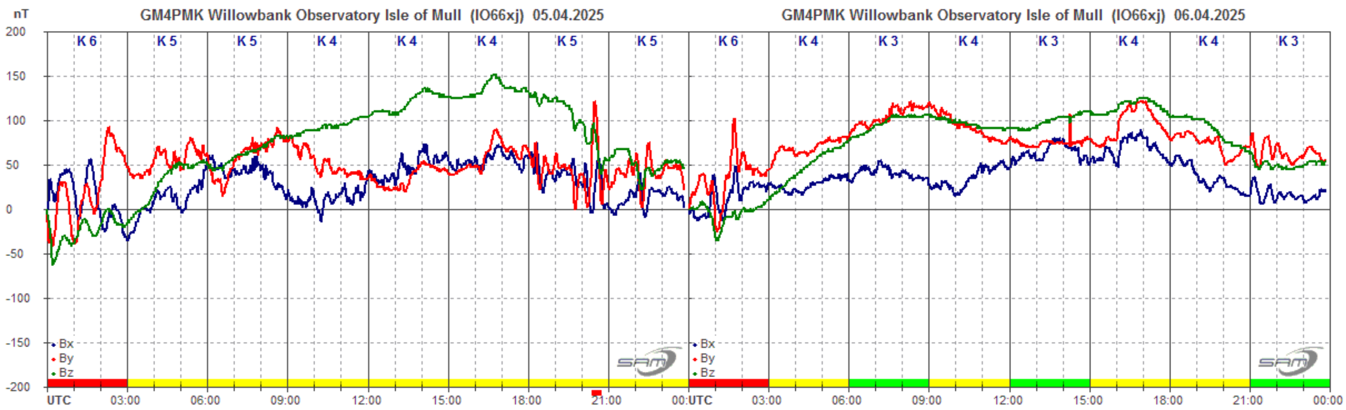
Stuart Green's chart of the month's magnetic activity shows plenty of disturbance during most of April, with a very flat period in the last week.



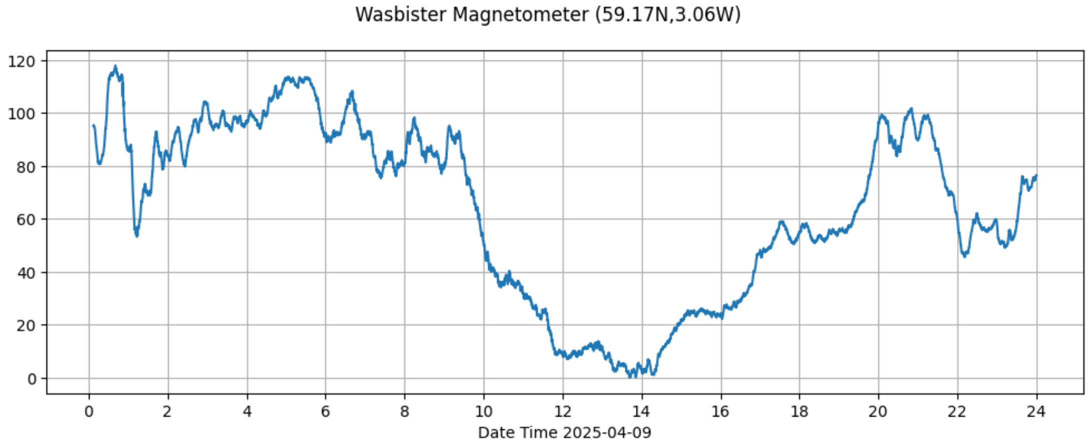


Recordings by Roger Blackwell and Callum Potter on the 16th both show a strong spike at about 18:15UT, with a magnitude of about 500nT. Callum Potter's shows a more distinct impulse at 14:00, marking the start of the disturbance. There was a series of filament eruptions on the 12th and 13th with CMEs shown in the satellite data. This disturbance appears to be related to these CMEs, as they were the only ones Earth-directed at this time. The disturbance was quite strong, Stuart Green indicating that aurora were seen.

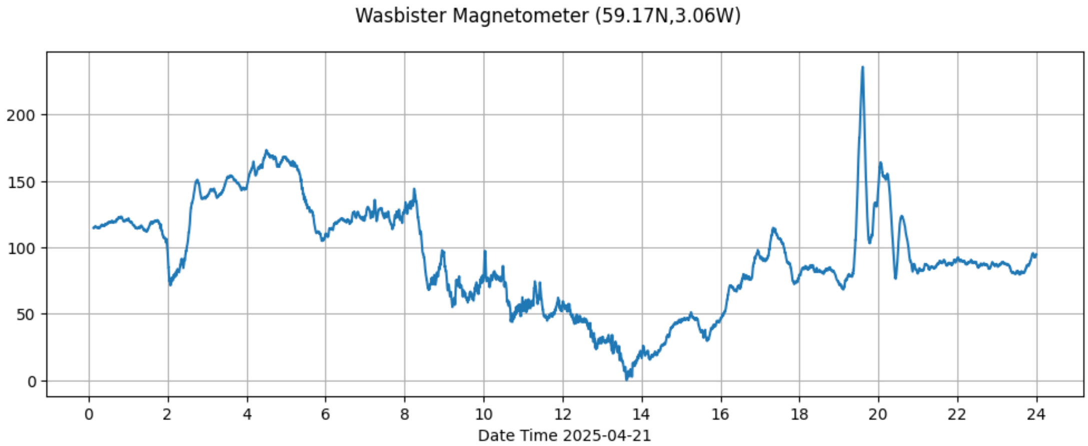
There were disturbances through most of the month, the first three weeks being the most active. Roger Blackwell's recording over the 5th and 6th shows some of this:



The 9th was also quite active, shown in Callum Potter's recording:



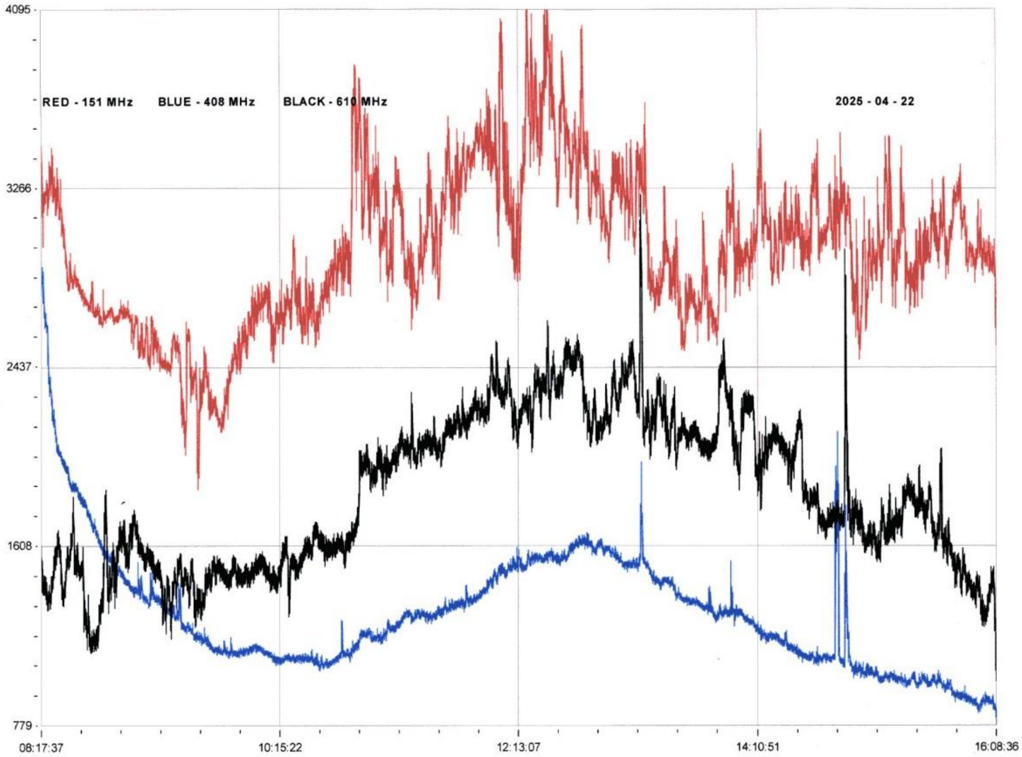
A final active period was recorded on the 21st from a coronal hole high speed wind. Coronal holes usually appear mostly during periods of lower solar activity, perhaps indicating that solar cycle 25 is now on the decline.



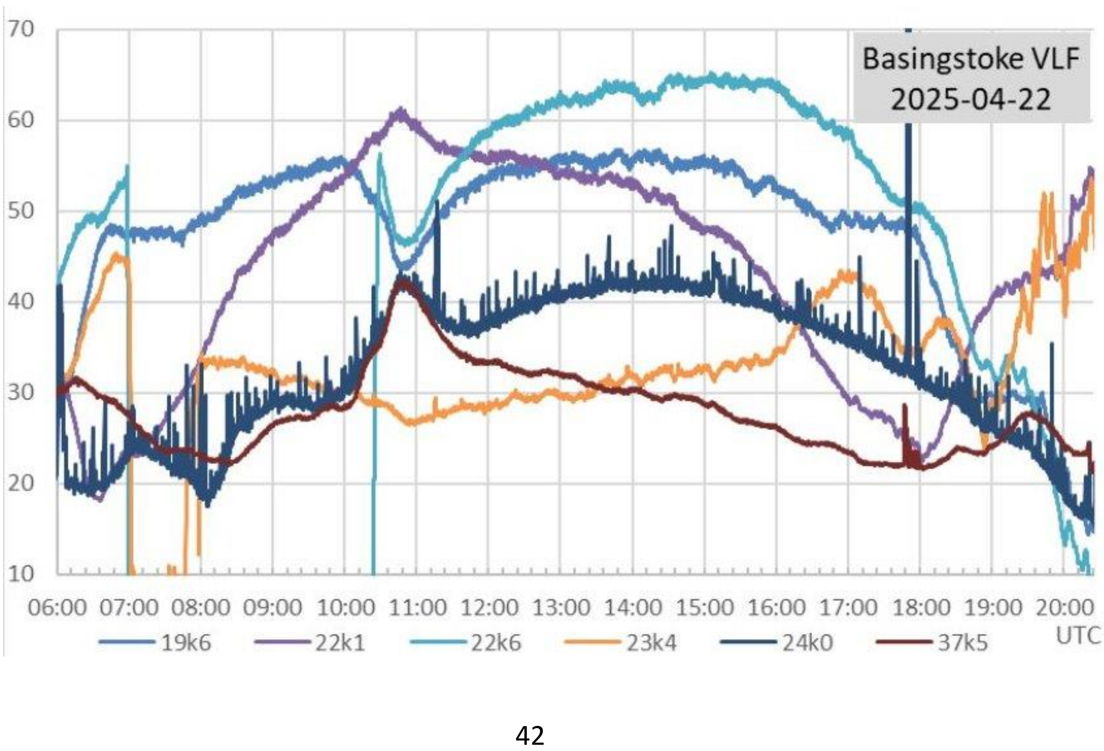
Magnetic observations received from Roger Blackwell, Stuart Green, Callum Potter, and John Cook.

SOLAR EMISSIONS

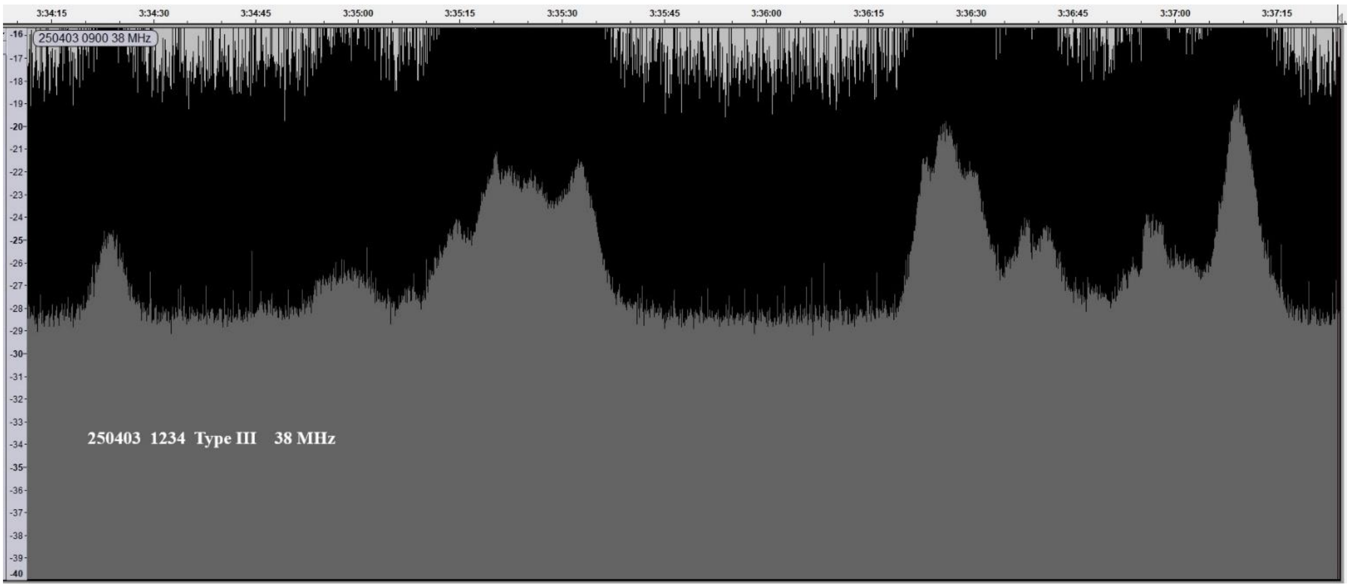
The M1.3 flare on the 22nd was widely observed as a SID, with a peak timing at 10:45UT. Colin Clements also recorded significant VHF / UHF noise over an extended period around this peak, shown in his recording:

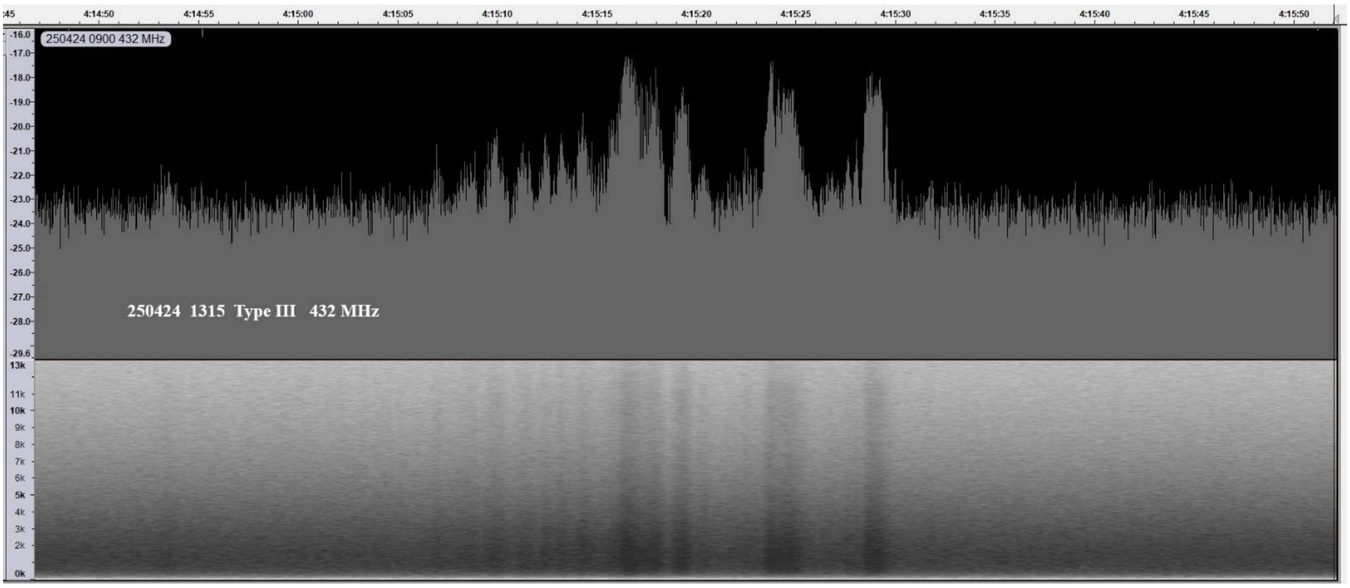


This timing does not match the X-ray peak of 08:29UT in the SWPC satellite listing. Paul Hyde's VLF recording shows an unusual SID shape on the 22.1kHz signal:



It is not at all clear whether this is related. Most of the other signals have a rather symmetrical shape around the peak, while 23.4kHz appears to show a double minimum within a long dip. There are just a few unclassified events in the X-ray data following its entry at 08:29. Colin also recorded smaller noise associated with the C3.2 and C4.9 flares on the 14th.

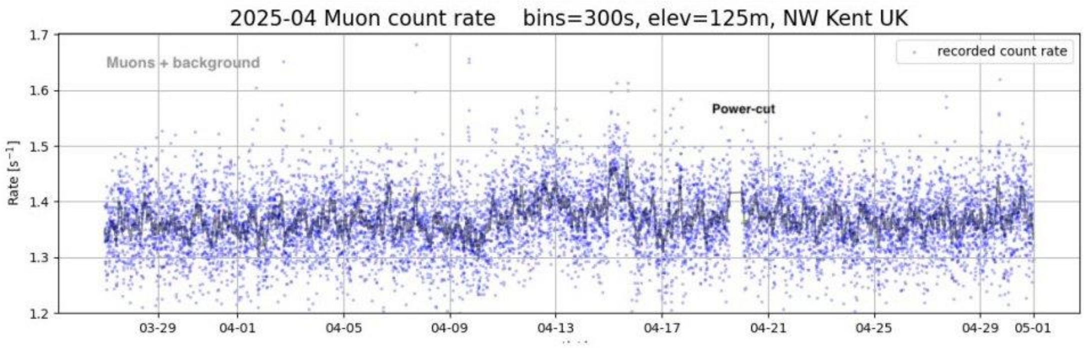


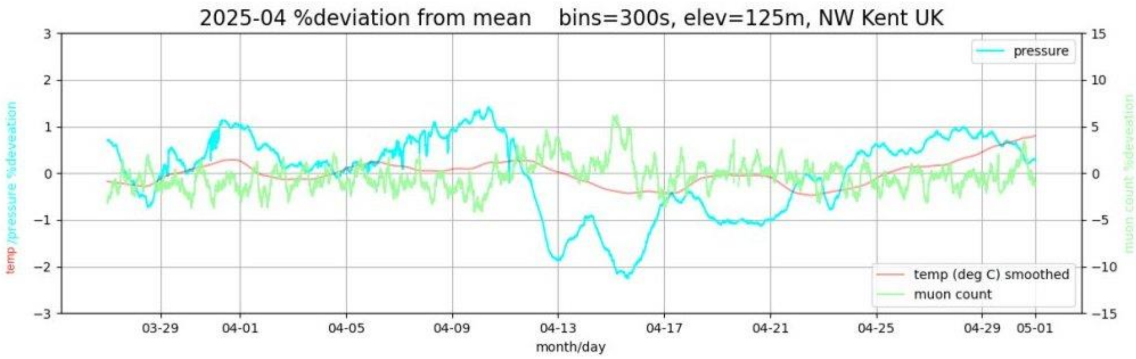


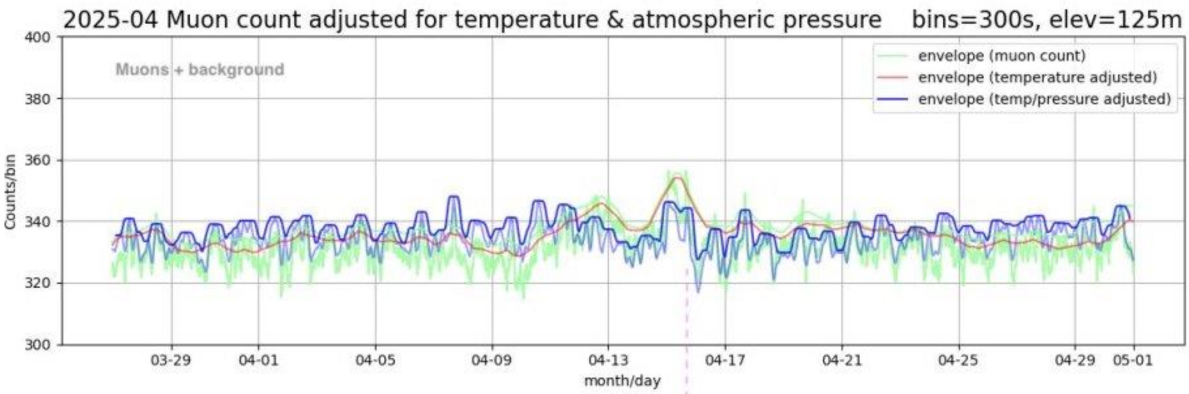
Colin Briden made a 38MHz recording of a type III noise burst at 12:34 on the 3rd, shown in the top recording. The chart runs for 3.5 minutes, the noise peaks being 6 to 8dB above the noise floor. The second recording starts at 13:15UT on the 24th, and was made at 432MHz, at the lower end of the amateur 70cm band. It also shows a type III noise burst, but this recording only lasts for about 45 seconds. It also has an amplitude of about 6 to 8dB. The lower part of the chart covers a bandwidth of 13kHz. Neither of these match with events that we have recorded as SIDs.

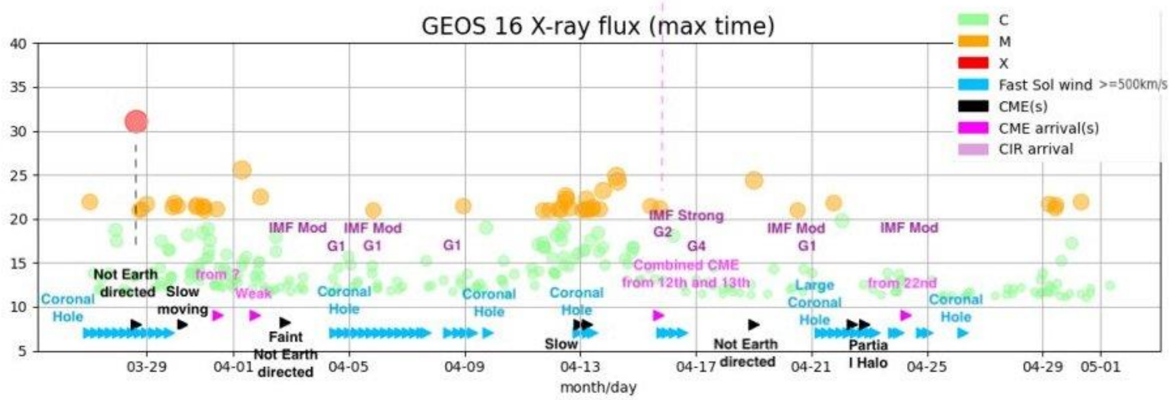
MUONS

Mark Prescott's muon recordings show a fairly flat count for most of April, with a noticeable increase from the 10th to 17th. There was a large drop in atmospheric pressure over this period, along with an increase in the solar flaring on the 11th to 13th. The temperature / pressure corrected chart shows a small increase in muon flux from the 10th to 13th and on the 15th, followed by a distinct drop on the 16th matching the CME impacts. The corrected chart then shows a flat count for the rest of the month. There is a small gap during a power cut on the 20th.

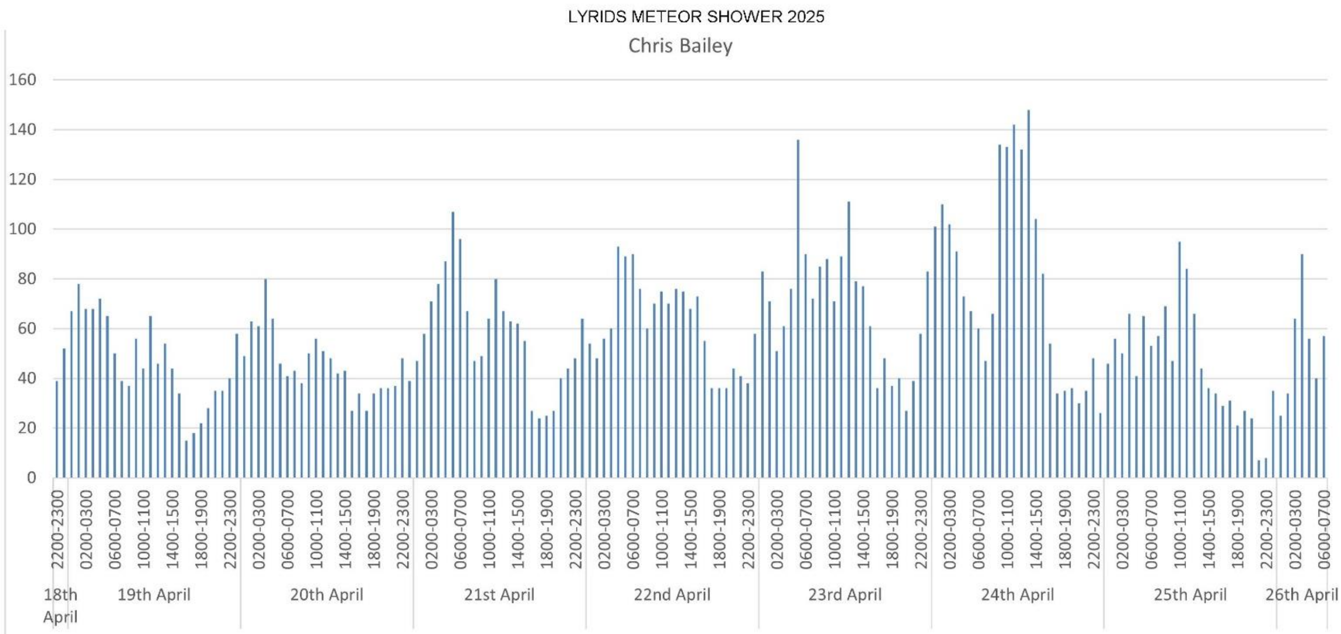




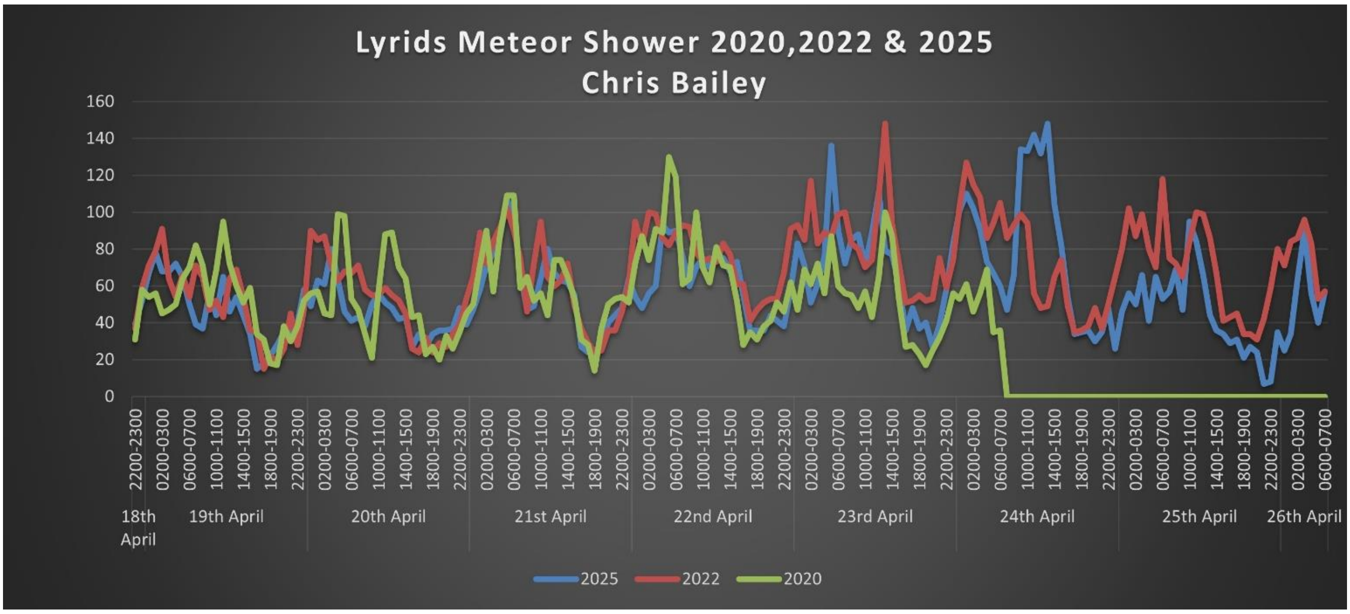




METEORS

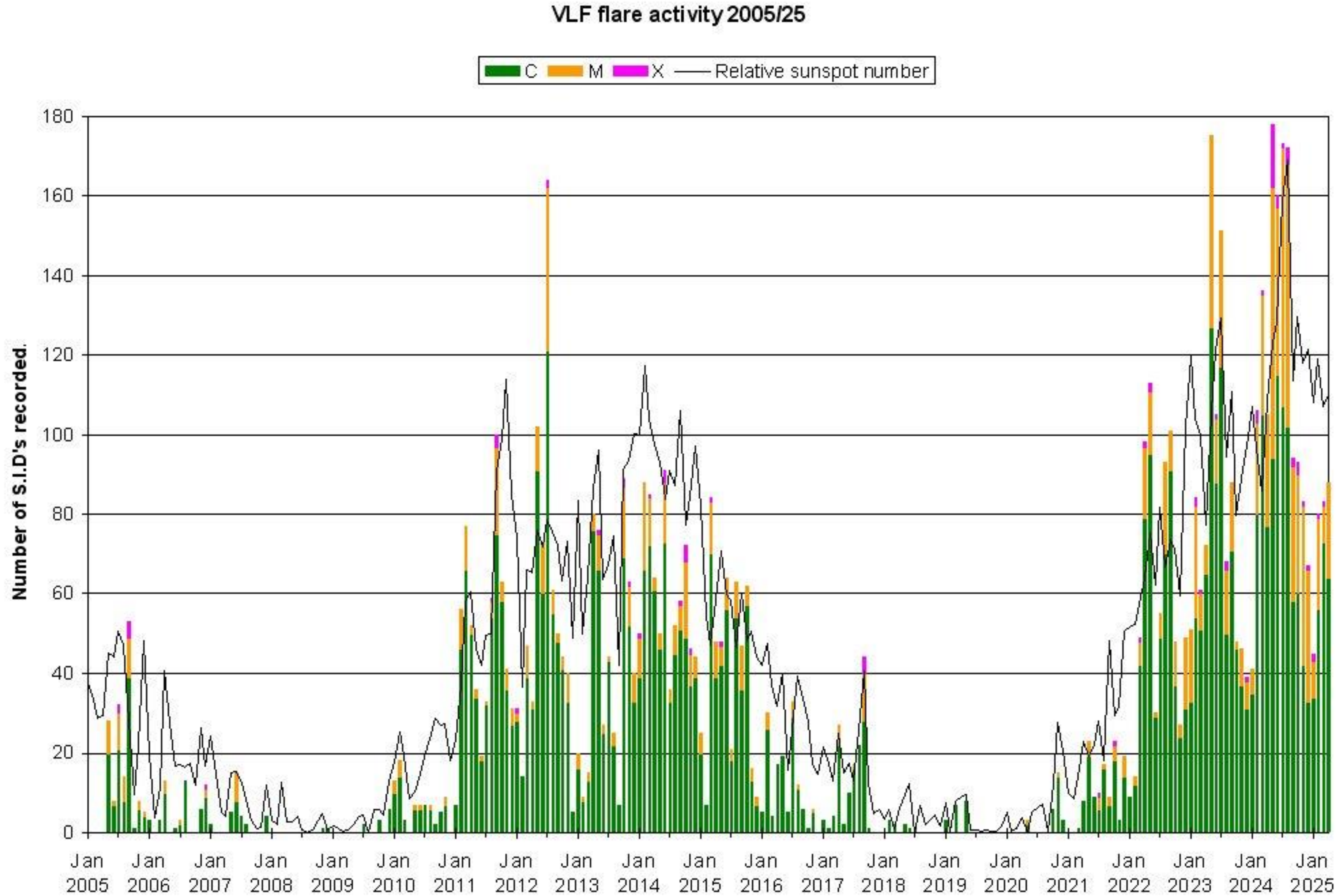


Chris Bailey monitored the April Lyrid meteors using the GRAVES signal. His recording shows slowly increasing counts from the 18th reaching a peak on the 23rd and 24th. There seems to be two activity peaks on each day, the first in the early morning followed by the second in the early afternoon. This may be due to the geometry of the activity and the signal source.



Comparing activity in 2020, 2022 and 2025 shows similar rates, although the 2020 data stops on the 24th. The 2020 peak also seems to be a day earlier, on the 22nd compared to the 23rd in 2022. 2022 shows less of the morning / afternoon split in activity compared to 2020 and 2025.

BARTELS CHART


VLF flare activity 2005/25
C
M
X
Relative sunspot number
Number of S.I.D's recorded.
180
160
140
120
100
80
60
40
20
0
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
Jan 2023
Jan 2024
Jan 2025

Accessing e-CALLISTO Data

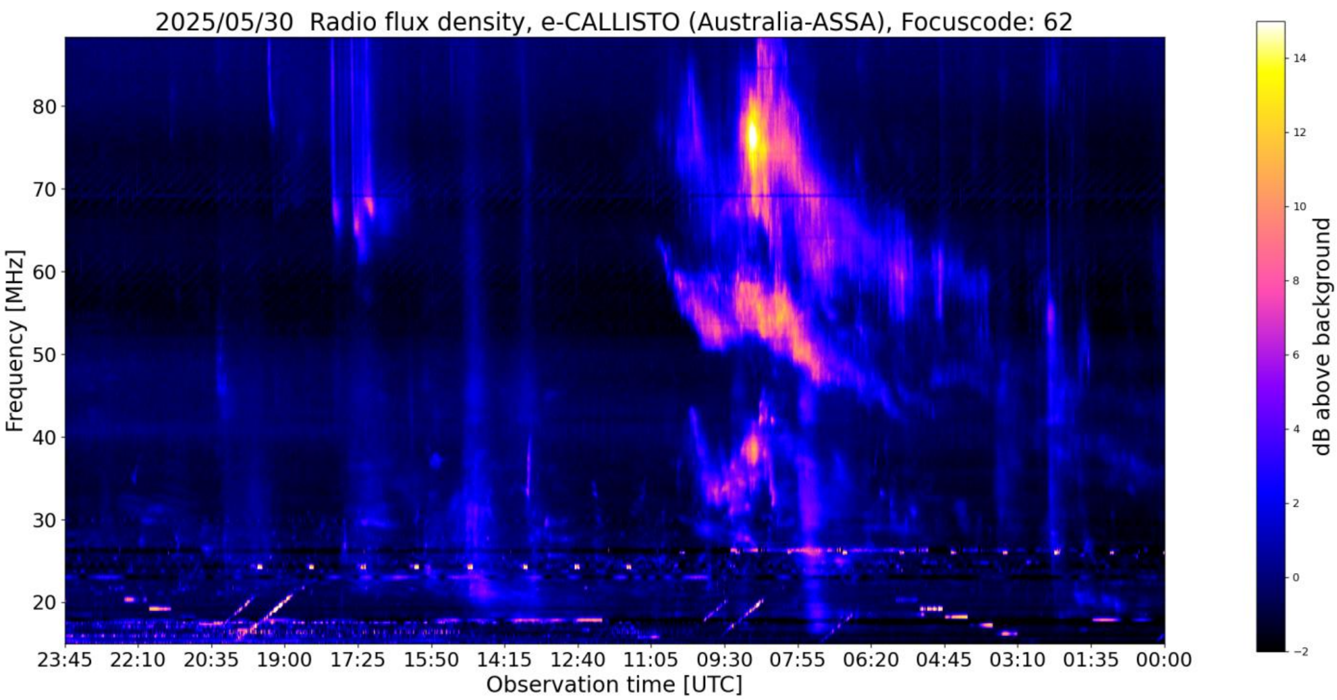
Christian Monstein & Whitham D. Reeve

Introduction

The e-CALLISTO Solar Radio Spectrometer Network (eCallisto} has produced and archived data for many years. The raw spectrometer data consist of FITS (Flexible Image Transport System) files and are hosted by Fachhochschule Nordwestschweiz (FHNW) Brugg/Windisch, and the affiliation of the principal investigator (PI) is at Istituto Ricerche Solari Aldo e Cele Daccò (IRSOL) Locarno, Switzerland. This article briefly describes additional websites that have been developed that allow browsing and searching the data in different ways.

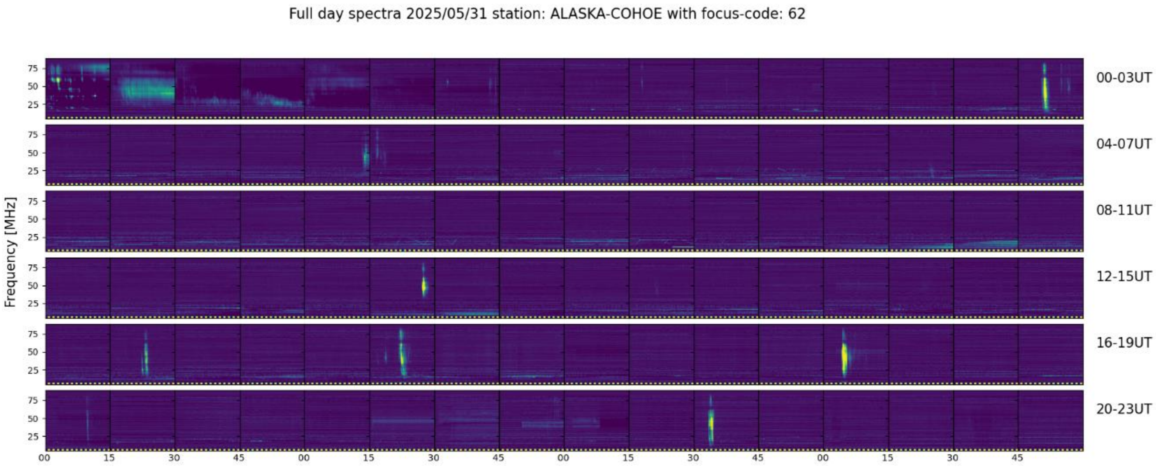
Websites & Internet Access

Destination of FITS files sent by File Transfer Protocol (FTP) from individual e-CALLISTO stations as well as observations of historic spectrometers such as IKARUS, PHOENIX, PHOENIX-2, PHOENIX-3, PHOENIX-4, AOS, and Argos. This is the FITS file source for all users of e-CALLISTO data: https://soleil.i4ds.ch/solarradio/callistoQuicklooks/



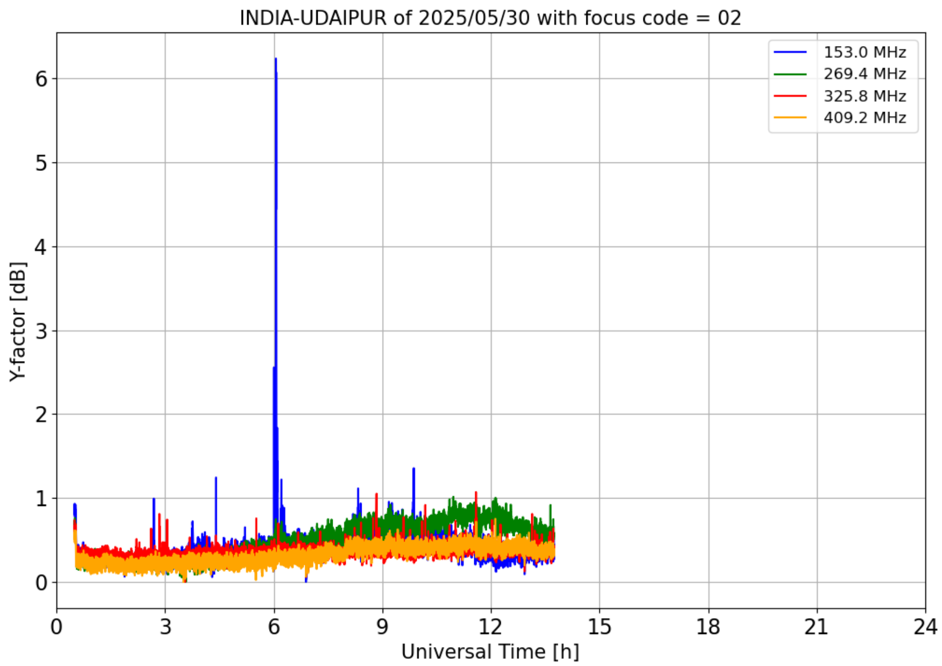
Example QuickLook depicting a recent event, observed by ASSA at Sunnydale in Australia. Several type III burst and a type II burst with fundamental and harmonic radiation, both with split band allowing to derive velocity of the corresponding CME and magnetic field strength at the shock-wave.

QuickViews hosted by FHNW. The folder name was created in the 1990s and nobody was thinking that the project would survive 2009. As of this writing, the project has been operational for 19 years. QuckViews, as the name indicates, are meant to provide a brief impression. Vertical stripes indicate a solar radio burst. The type of the burst cannot be seen here. For higher resolution and larger images, one needs to zoom in with a Python-script or by JavaViewer: https://soleil.i4ds.ch/solarradio/data/1998-2009_quickviews/



Example QuickViews for an Alaskan station. Each bar shows 4 hours in 15 minute increments.

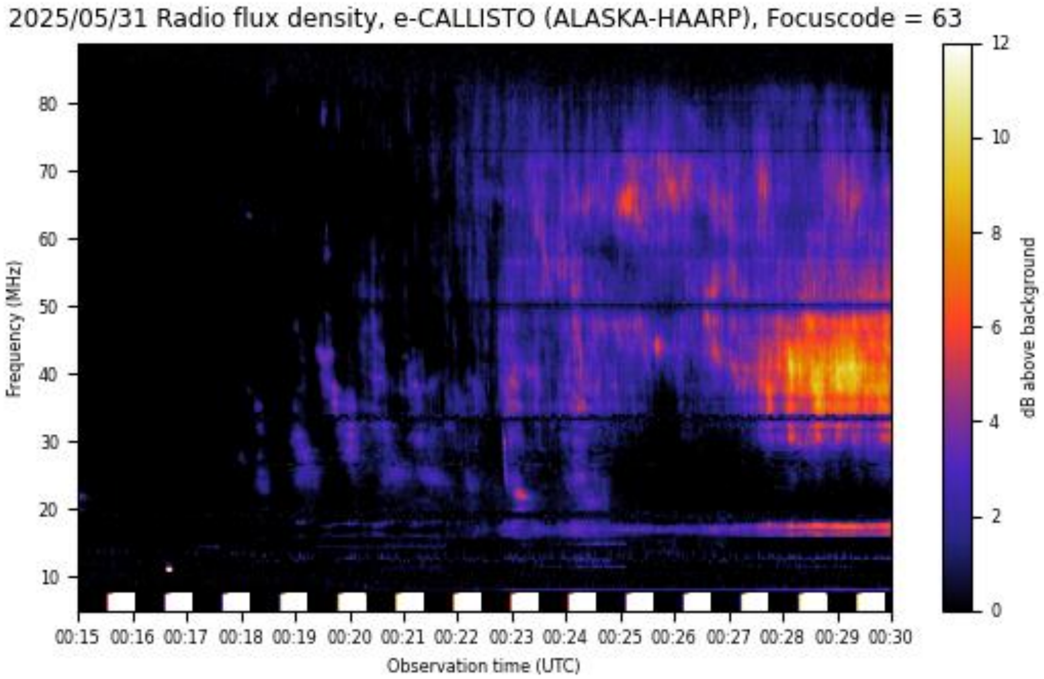
Light curves hosted by FHNW. The data from each station are processed after midnight (UT). Frequencies are plotted that are protected by authorization of the International Telecommunications Union (ITU) for space weather passive instruments. All Callisto instruments are now registered at ITU as MetAids (meteorological service): https://soleil.i4ds.ch/solarradio/data/Lightcurves/



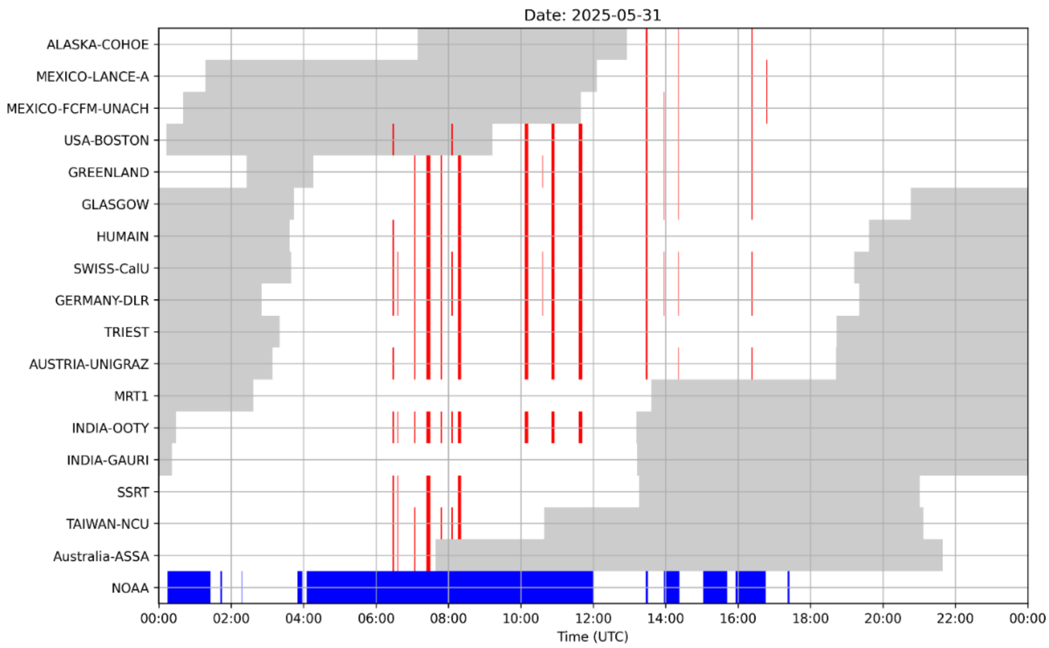
Example Light curves from Udaipur Solar Observatory (USO). Four individual frequencies are plotted with different colors as shown in the upper-right corner. The small curved trend is due to the Milky Way while the peak around 6 UT is from a type III solar radio burst. The plot shows data for the sunlit collection times and is blank at other times.

---

e-CALLISTO Data hosted by Universidad de Alcalá. Universidad de Alcalá mirrors all data at FHNW, and new data are copied every day from Switzerland to Spain. A few stations are also able and willing to directly upload data to Spain using SFTP (Secure FTP). This website uses artificial intelligence (AI) to automatically detect radio bursts and to generate a burst-list here: https://astrodoncel.uah.es/dashboard/burst.php . An example spectra and plot of burst detection are shown below: https://astrodoncel.uah.es/dashboard/index.php

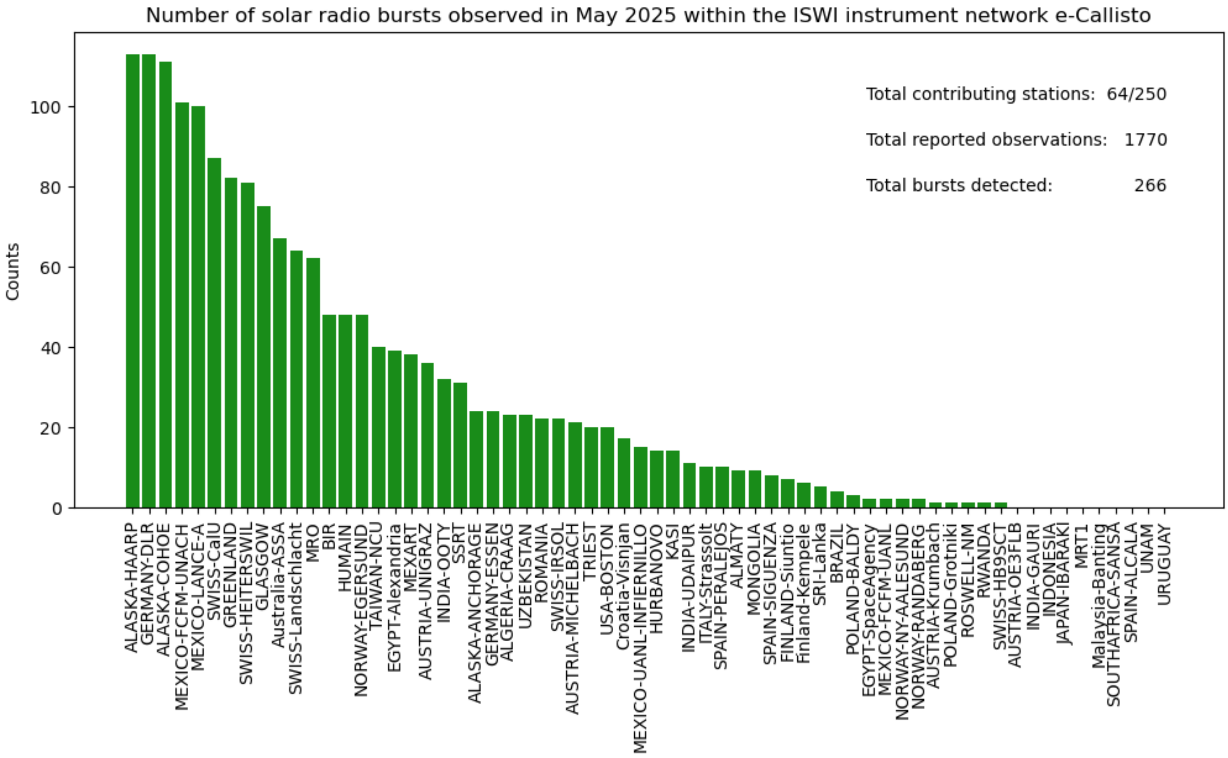


Example QuickView from the Spanish University showing a type IV solar radio burst at low frequency.



Example of so-called X-match showing which station observed a burst at a certain time. The gray shadowed areas show when the sun is below the horizon at every station. The AI process detects an event as a burst when at least 3 stations ‘see’ the same event. Otherwise it is assumed to be local radio frequency interference (RFI).

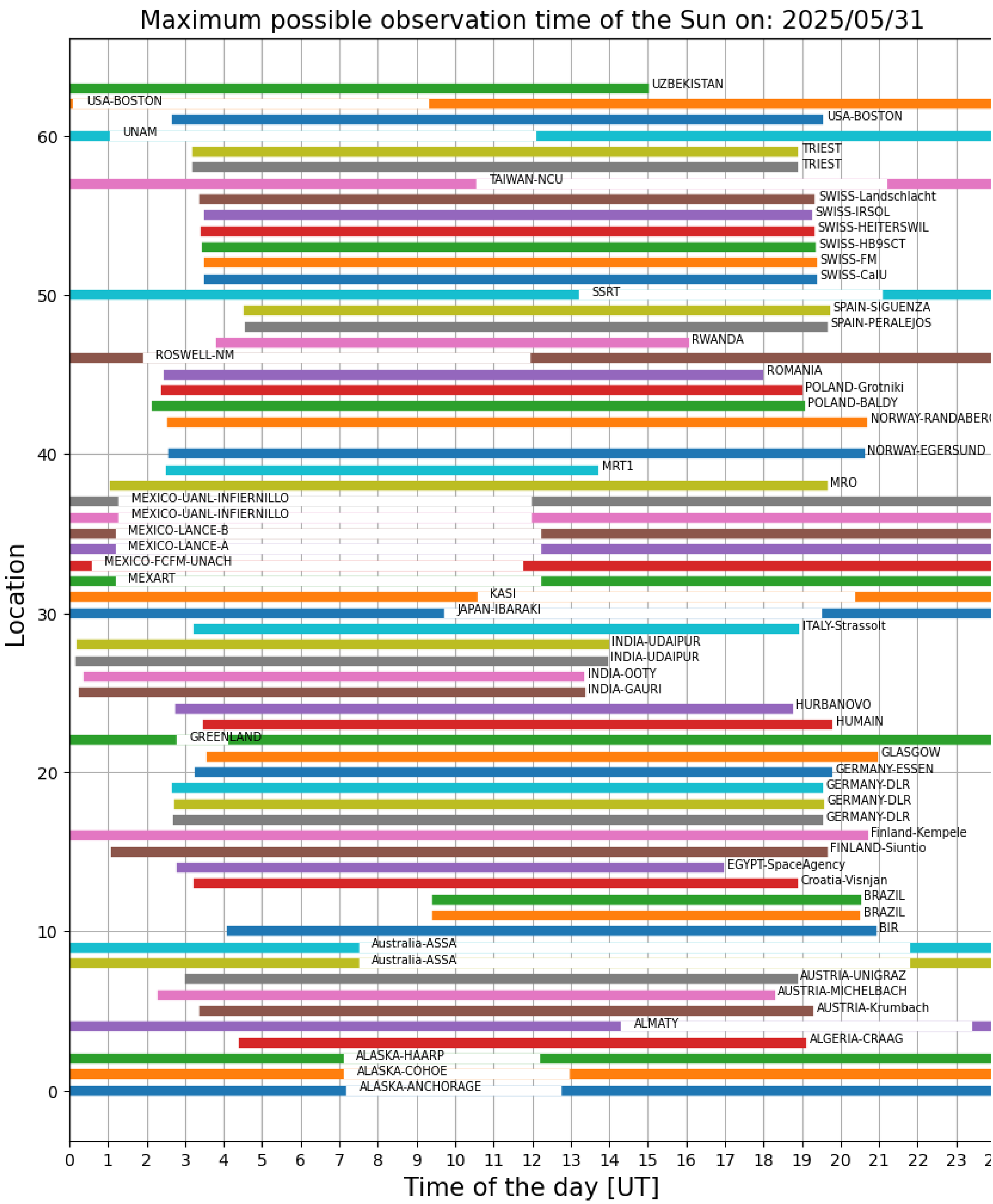
Burst statistics, burst counts per station



Example Burst-Statistics (above). From X-match data shown previously, a new burst-list is generated every month and can be found here: https://soleil.i4ds.ch/solarradio/data/BurstLists/2010-yyyy_Monstein/ . We can see that the number of bursts per station varies quite a lot due to different aspects of each radio-telescope. Main aspects to detect many bursts are: High directivity antenna, ideally tracking the sun, a low noise amplifier (LNA) and a location with low man-made interference. Thus, many stations shown in this plot have room for improvements. The 64 active stations out of 250 distributed stations indicate other issues such as: No electrical power, no internet, lightning strikes, water penetration, political situation and even loss of motivation to operate the telescope.

Observation timing

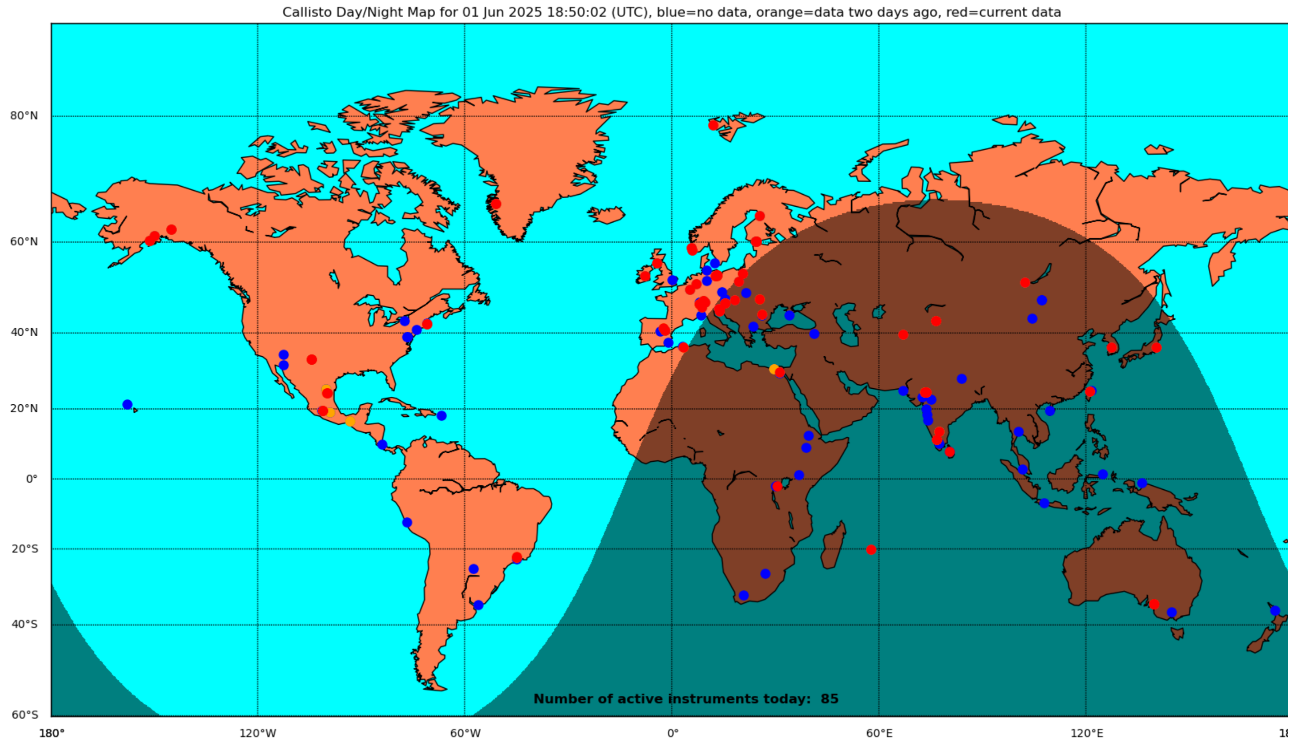
Many processes are executed many times per day on the central LINUX-server at FHNW. Among all the plots above, an observation table-plot also is generated once a day as shown below. The table-plot indicates which station was active the day before and the start-time and stop-time of the observation. Observations of CALLISTO frequency agile spectrometer are automatically scheduled every day based on longitude, latitude and elevation of the surrounding horizon. The table-plot also demonstrates that we reached the goal to observe the Sun 24/7 throughout the year.



Example observation times per station (above). Every night this plot is generated from data uploaded by the host and based on longitude and latitude stored in the header-information of the FITS files. This plot shows which station sees the Sun with respect to universal time. It also proves that we can observe the Sun 24/7 throughout the year as there are many overlaps between stations in different countries. One of the main goals of the project was to observe the Sun all the time with no gaps.

Active stations worldwide

Our planet is very well covered with CALLISTO instruments. Nevertheless, it would be nice to get more active instruments in the Pacific region as well as in the South America area where we have 4 instruments but at this time only Brazil is providing data to the network.



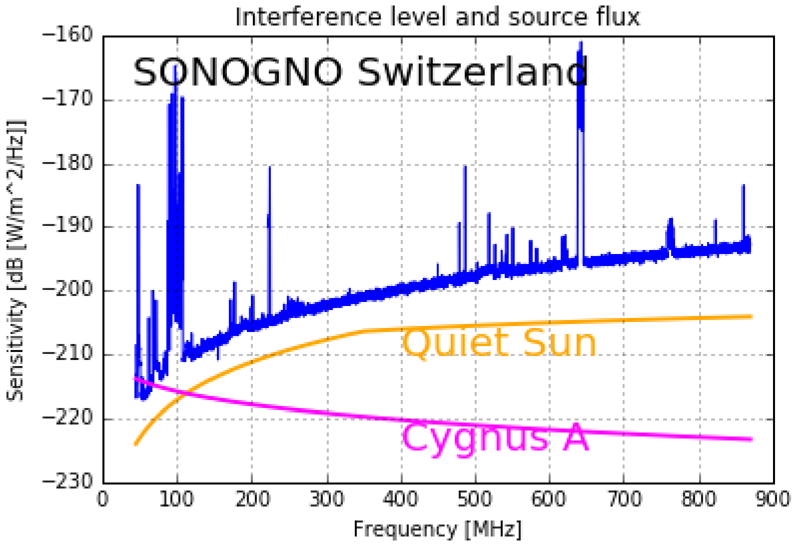
Example of world map plot (above). This plot is automatically generated every 15 minutes and updated on the main website https://e-callisto.org/ considering those stations which uploaded FITS files to the central server. Active stations are in red while orange dots tell us that this station was active two days before but not today. The many blue dots indicate all those stations (the majority) which have not supplied data for many different reasons. The bright blueish part shows the area where the sun can be observed at the time the plot is produced, here June 1st 2025 at 18:50 UTC.

Spectral overviews per country

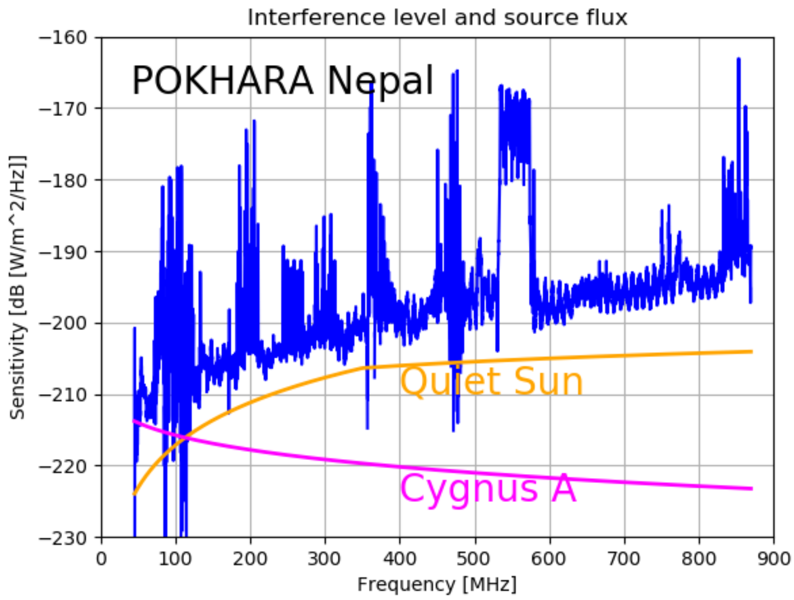
Prior to any instrument deployment we usually perform a so-called spectral overview as a basis to decide which frequencies can be observed with low interference. Often such measurements are performed at different geographical locations to find the best place in terms of RFI. A set of worldwide observations can be found here: https://e-callisto.org/OVS/Spectral-Overview.html .

Unfortunately, the spectral overview is a momentary observation of what is actually a dynamic situation. The level of RFI generally increases with time due to many new radio services popping up with higher priority than radio-astronomy. In the plots below, we can see that the blue plot (signal from antenna) is about 6 dB … 10 dB above the quiet Sun. This means that the stations in the current network can detect only the active Sun and not the quiet Sun. If someone needs to detect the quiet Sun then their corresponding antenna requires a higher gain in the order of more than 20 dB.

There are only two instruments that currently can observe and measure the quiet Sun in X-band (~10 GHz). One instrument is at NASA, and it is used for observation of solar eclipses. The other is located at MeteoSwiss in Locarno Monti Switzerland, and it is used to measure the quiet solar flux to cross-calibrate weather radar receivers. Observations for MeteoSwiss may be found at: https://meteoswiss.github.io/callisto/



A 'good' example of a spectral overview, taken in a hidden valley in Switzerland. We can detect a few FM-transmitters which can be notched out by a notch-filter and one digital video broadcast terrestrial transmitter (DVB-T) which is outside of the standard observation plan 45 MHz – 450 MHz. Unfortunately, this location was hard to access, and there is neither electrical power nor internet access. Thus, this location was skipped as a permanent site although almost perfect for radio astronomy.

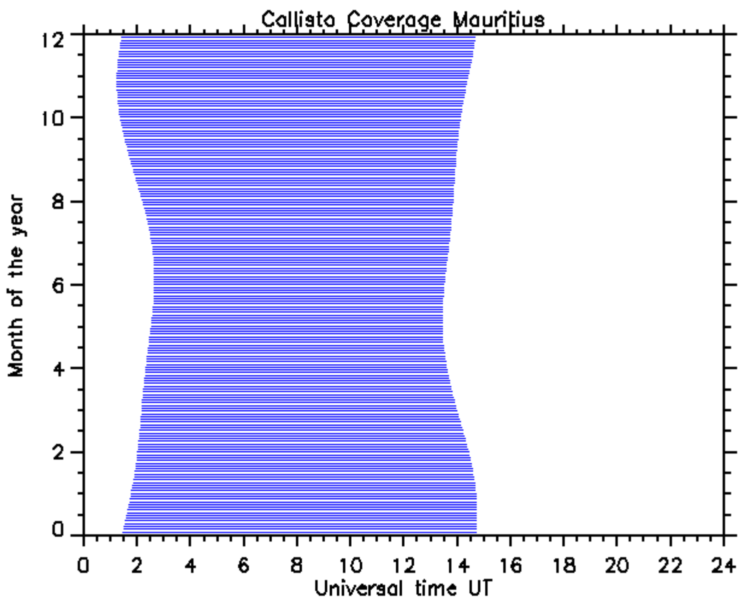


This observation was performed at the Tribhuvan University in Pokhara, Nepal. Beside FM broadcast radio channels, we see digital audio broadcast terrestrial (DAB-T) as well as digital video broadcast terrestrial transmitter (DVB-T). Even worse is a lot of man-made noise from nearby badly shielded electronics. Thus, this location is a bad example for a radio telescope because there is too much RFI.

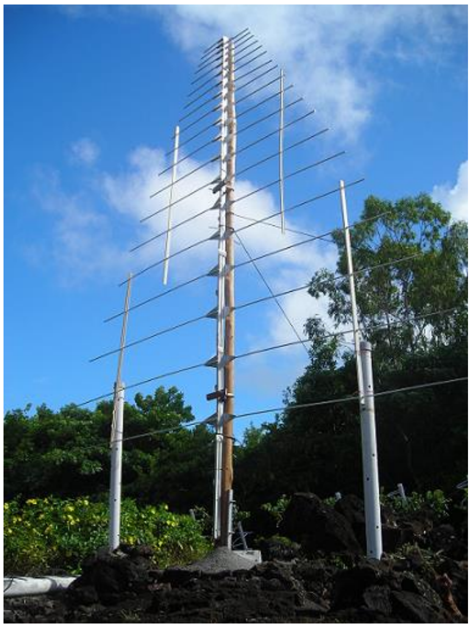
Antennas and instrument coverage

To show any potential host which type of antenna can be used for solar radio burst observations, we prepared a website with a few (not all) examples. Many different types of antennas can be used, including commercial and self-manufactured ones based on simple aluminum profiles from the local shop. We see stations with log periodic dipole array (LPDA), a few use a biconical (BICON) antenna and others the LWA Antenna. A very few even make use of parabolic dishes. The majority of the stations use the LPDA, both commercial and self-manufactured, because they are relatively cheap and simple to install. Several examples (not all) can be found on this website here: https://e-callisto.org/coverage/coverage.html

Ideally, the antenna is mounted on a tracking system to track the Sun from sunrise to sunset to ensure full sensitivity throughout the observation the day. As this is often a funding issue, most of the sites near the equator erect the antenna just vertically with no directional control. Some stations that are more than 20° away in latitude from the equator often erect their antennas such that the main beam points to the meridian transit of the Sun.



Example observation time of the sun during the course of time at Poste de Flacq in Mauritius. About 11 hours in winter and roughly 16 hours in summer.



Self-manufactured LPDA, mounted on an old/dry Eucalyptus tree. Long dipoles were supported by plastic tubes from sanitary shop.

Additional e-Callisto related websites

e-CALLISTO Facebook:
https://www.facebook.com/groups/788389237975335
Here, interesting and 'nice' radio-events are posted for discussion. Also, problems regarding RFI or instrumental artefacts are presented and discussed.

ESA Space Weather Service Network. Registration required:
https://swe.ssa.esa.int/ecallisto-federated
Access to all Callisto data but, background subtraction is not perfect and axis labels are sometimes crowded. Needs some updates.

NASA has a link on their Virtual Wave Observatory. Link Callisto in ground-based Passive Data:
https://vwo.nasa.gov/VWO-DataResources.php
Offers a direct link to https://www.e-callisto.org/

Astronomical Society of South Australia (ASSA) maintains a nice website:
https://www.radioastronomysa.au/
Amateur site with lot of examples, hardware ideas and photos as well as nice videos from the active sun (evolution of radio bursts).

USO Udaipur Solar Observatory;
https://www.prl.res.in/%7Eecallisto
Instrument pictures and a real-time light-curve from their own instrument.

Royal Observatory of Belgium ROB at station HUMAIN:
https://www.sidc.be/humain/home
Several archives about bursts and spectra as well as real-time spectra.

National Autonomous University of Mexico. Copy of e-callisto.org (not up-to-date):
http://e-callisto.unam.mx/
Acts as a backup of e-callisto.org with access to data. Real-time plots are not updated (yet).

TRIEST, Italy Callisto observatory:
http://montebaldo.oats.inaf.it/callisto.php
Alex Marassi INAF: The server suffered an important disk failure.
Unfortunately, I had only an old backup of the system, so a lot of work has been necessary to update it.
Montebello is currently up and running but still not reachable from outside.
I hope to put it online again ASAP. Sorry for the inconvenience.

Discussion

The ISWI space weather network e-Callisto has demonstrated for almost 20 years that one can produce scientific useful data even with low cost instruments. Originally the network was intended to support developing countries such that they can participate in 'western' science. In the mean-time many 'western' universities installed and operated one or more CALLSTO spectrometer to monitor solar activity at radio wavelengths for 24/7 time periods. During the years many scientific papers have been published. The network is still growing with about 2…3 instruments per year. Some redundancy in geographical distribution is useful as the quality and intensity of RFI (man-made) is increasing almost exponentially. The large number of instruments allows the scientist to select those observations which suffer less from RFI. It even allows to combine observations from different sites to increase sensitivity and at the same process to reduce noise and RFI. If the amount of RFI is growing like now, we will not be able to operate ground-based instruments at some point in the future. Thus, e-Callisto is also kind of RFI-monitor and can help to mitigate self-produced interference.

References

{eCallisto} https://e-callisto.org/
Monstein, C., New Quickviews Show Daily Spectrograms for e-CALLISTO, 2017
Reeve, W., Viewing Callisto Spectrograms ~ Quick Start Guide

International Space Weather Initiative (ISWI). https://doi.org/10.48322/pmwd-mk15

ISWI Instrument Data Management Plan for Callisto, describing the majority of data products.

Acknowledgement from co-author Whitham D. Reeve

Credit for the development of e-CALLISTO as a highly respected worldwide solar radio spectrometer network is singularly due to Christian Monstein's efforts over the years. Co-author Reeve is grateful for being allowed by his friend and colleague to actively participate and contribute to the network.

Observations of OH/IR stars in several molecular lines

by Dimitry Fedorov UA3AVR

Common and introductory notes

This report about observation OH/IR stars in hydroxyl OH lines with 20 m Green Bank telescope in Skynet Network, see the telescope dish in Figure 1 and resources with Skynet user info in [1,2]. There are four OH lines what can be seen with L-band receiver installed on this telescope now - 1612, 1665, 1667, 1720 MHz. The 1665 and 1667 MHz lines are often called the "main" lines, since they are more common in maser observations (especially in star-forming regions); the other two lines are called "satellite" lines. In special case of OH/IR stars the situation is reversed: the line 1612 MHz dominates, but other lines also can be seen from some OH/IR stars with weaker levels. Main motivation of this work is hunting for survived "main" lines of OH/IR stars.

Figure 1. Green Bank 20 m telescope dish.

OH/IR stars are in the latest stages of their evolution; they are shedding their shells of gas and dust. These stars are well observed in infrared and radio frequencies. The dense dust absorbs the visible light, but some of them are optically seen too. They are classified as red giants on Asymptotic Giant Branch of Hertzsprung–Russell diagram (AGB stars) with moderate star mass <8-10 $M_{\odot}$. More massive stars or red super-giants evolve outside the Asymptotic Giant Branch, but have similar properties, and they are considered here as OH/IR stars. They are noticeably variable (pulsating), and this is well seen in the infrared band and molecular radio lines. Pulsation periods are ranged from hundreds of days up to thousands of days.

Circumstellar OH masers are pumped usually by the infrared radiation from the hot dust, mainly in transitions 34.6 and 53.3 μm of the hydroxyl molecule [3] with subsequent cascading downward. Collisional processes, which favor the 1665/1667 MHz inversion in star forming regions, play a minor role in OH/IR stars [4]. The dense dust envelope provides conditions for molecular emission with the maser amplification, but much depends on specific mass-loss rate $\dot{m}$. Higher mass-loss rates provide better conditions for 1612 MHz OH line domination (type II OH/IR stars); the lower mass-loss rates give a chance to "main" 1665/1667 MHz lines (type I OH/IR stars) and potentially make such stars optically seen with identification as Mira variables [5].

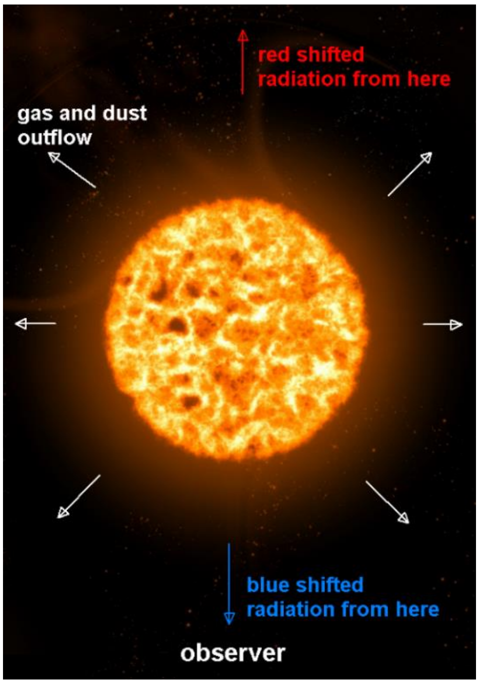


Figure 2. Radiating shells in front of a red giant star and behind it.

The emission line 1612 MHz from OH/IR stars usually exhibits a characteristic double-peaked spectral profile. Two peaks appear because of the radiation comes from different parts of the pumped molecular clouds: in front of the star and behind it [6, 7], see Figure 2. The radiating cloud behind the star moves from the observer leading to a red shift of the spectral line due to the Doppler effect; the radiating cloud in front of the star moves toward the observer making a blue shift of the line.

The line 1720 MHz is not seen from OH/IR stars [5]. For more info about OH lines and pumping schemes see [3,4,6,7] and [8], ch. 15.6.4. This report is based on single observations, but because of significant variability the repeating observations are interesting to view the stars in their dynamics. Present L-band receiver of the telescope provides an output in two linear polarizations only, not circular.

Calibration of the instrument. Receiver tunings and observation parameters.

Calibration of the instrument is needed to compare results with other observers and for variability tracking. The goal of calibration is the System Equivalent Flux Density (SEFD) of the instrument for obtaining results in flux density units [9]. SEFD is defined as a flux density that gives the same antenna temperature $\mathbf{T_a}$ as the System Temperature $\mathbf{T_{sys}}$. It is usually measured in Jy and can be calculated from known the System Temperature and the telescope Forward Gain (dish sensitivity) Γ

$$\mathrm{SEFD} = \frac{T_{sys}}{\Gamma}, \qquad \Gamma = \eta_A \frac{\pi D^2}{8\,k}, \tag{1}$$

where **k** – the Boltzmann constant ≈ 1.38 · 10^{-23} J/K, **D** – the parabolic reflector diameter, η_A – the Aperture Efficiency (=0.6 for 20 m Green Bank telescope with L-band receiver). The Forward Gain Γ is usually measured in K/Jy and gives to know what antenna temperature $\mathbf{T_a}$ would be induced by received radiation with known flux density. For more details about Γ see [8], eq. (7.25) and text comments there. For 20 m Green Bank dish the Forward Gain Γ = 0.068 K/Jy.

Thus, the System Temperature $\mathbf{T_{sys}}$ becomes now a subject of calibration procedures. They are based on observations of calibration sources Cygnus A, Cassiopeia A, and the Moon made by SARA Skynet users (Curt Kinghorn, Stephen Tzikas, Charles Dean Covey III and me) in 2021-2025, see Table 1. All types of performed observations in Table 1 allow to extract the Y-factor **Y** as a ratio of receiver outputs when the antenna beam looks immediately into the source and a bit aside. Table 1 also gives details about the calibration sources including calibration flux densities $\mathbf{F_{cal}}$, type of observations, obtained Y-factors and results for $\mathbf{T_{sys}}$ in two linear polarizations provided by present L-band receiver. The calibration flux density of Cassiopeia A was taken for the year of observations according known pattern of fading.

Table 1. Calibration sources, Y-factors and results for T_{sys}.

Observation date (with reference to NRAO archive)	Calibration source	Type of observations (Path type)	Frequency of calibration	Calibration flux density, $\mathbf{F_{cal}}$	Y-factor, **Y**, X, Y pol	Resulting $\mathbf{T_{sys}}$, X, Y pol
2025-05-21	Cyg A	on-off	1665 MHz	1367 Jy	2.67, 2.59	56, 59 K
2025-05-08	The Moon	on-off	1612 MHz	Extended src.	1.47, 1.48	133, 131 K
2024-05-14*	Cas A	Raster map	1406 MHz	1391 Jy	3.92, 3.95	32.1, 31.8 K
2022-01-27**	Cyg A	Raster map	1600 MHz***	1439 Jy	2.64, 2.59	60, 62 K
2021-09-26****	Cyg A	Raster map	1400 MHz	1707 Jy	3.46, 3.33	47, 50 K
2021-09-23****	Cyg A	Daisy map	1400 MHz	1707 Jy	3.93, 3.74	40, 43 K

*Observation by Curt Kinghorn; **Observation by Stephen Tzikas; ***Wide band in low resolution mode, filter 1300-1800 MHz; **** Observation by Charles Dean Covey III.

The System Temperature $\mathbf{T_{sys}}$ for point-like sources (Cyg A, Cas A) is given by formula

$$T_{sys} = \frac{F_{cal}\,\Gamma}{Y-1}. \tag{2}$$

For extended source (the Moon) $\mathbf{T_{sys}}$ was obtained by formula (3) from [10],

$$T_{sys} = \eta_B \frac{f_{BEAM}\,T_{moon}}{(Y-1)}, \tag{3}$$

where η_B – the Main Beam Efficiency, $\eta_B \approx \eta_A/0.75$ derived for Gaussian beams in [11], f_{BEAM} – the Beam Filling Factor, $f_{BEAM} = 1 - 2^{-\delta^2_{moon}/\delta^2_{HPBW}}$ (see [10, 12] or [8], ch. 8.2.3), δ_{moon} = 0.49° in the day of measurements, δ_{HBPW} = 0.63° for 20 m Green Bank dish. The Moon temperature T_{moon} was taken = 230 K, considered not dependent on the lunation phase, and distributed uniformly over the disk. As expected, formula (3) gives overestimated values for $\mathbf{T_{sys}}$ because of it do not take into account the Galactic Noise and CMB.

One more estimate of the System Temperature was obtained by summation of supposed Receiver Noise Temperature $\mathbf{T_{rcvr}} \approx$ 20 K and dish Spillover Temperature $\mathbf{T_{spill}}$ (as a measure of how much noise the dish is collected from ambient objects including the ground),

$$T_{sys} = T_{rcvr} + T_{spill}, \qquad T_{spill} \approx \frac{1}{2}\,(1 - \eta_B)\,T_{amb}, \tag{4}$$

where $\mathbf{T_{amb}} \approx$ 295 K – the temperature in the Green Bank location (presents the Noise Temperature of ambient objects). Calculations by (4) give $\mathbf{T_{sys}} \approx$ 50 K.

Thus, the Moon $\mathbf{T_{sys}}$ values are considered as overestimations; the pair of $\mathbf{T_{sys}}$ = 60 K (X pol), $\mathbf{T_{sys}}$ = 62 K (Y pol) was selected for further work. Corresponding SEFD values by (1) are 880 Jy and 910 Jy; they are used to calculate outputs in two linear polarizations. Resulting maser levels in observations were obtained by averaging these two outputs. Possible variations of SEFD with the telescope pointing were considered small.

The L-band receiver is tuned in High Resolution Data Acquisition Mode with 16384 channels, Path Type of the telescope was set as "Track" with Duration 100 s. The Integration Time parameter was set 5 s, but this parameter does not define an actual integration time for maser spectra (it is related to the time domain presentation of observation results in Skynet). The integration time for spectra is defined by Duration parameter in the "Track" Path Type. Some info about telescope tuning could be found in second reference from [1].

Minimal Detectable Peak Flux density was calculated by Radiometer Equation adapted for spectral lines [9]

$$F_{peak} = \frac{\mathrm{K\ SEFD}}{\sqrt{\Delta t\ \mathrm{RBW}}}, \tag{5}$$

where $\mathbf{K} \approx 3$ – the peak factor of the background noise, $\mathbf{\Delta t}$ – the integration time, RBW – the Resolution Bandwidth of the receiver. If a maser line reaches $\mathbf{F_{peak}}$ from (5), its level would be about the background noise peaks. Averaging the data of two polarizations reduces $\mathbf{F_{peak}}$ by factor $1/\sqrt{2}$. Parameters of the telescope and observations are collected in Table 2.

Table 2. Parameters of the telescope and observations

Dish diameter	**D**	20 m
Aperture Efficiency	η_A	0.6*
Main Beam Efficiency (calculated from $\eta_B \approx \eta_A/0.75$ [11])	η_B	0.8
System Temperature	$\mathbf{T_{sys}}$	60 K (X pol), 62 K (Y pol)
Forward Gain (dish sensitivity)	$\mathbf{\Gamma}$	0.068 K/Jy
System Equivalent Flux Density (=$\mathbf{T_{sys}}$ /$\mathbf{\Gamma}$)	SEFD	880 Jy (Xpol), 910 Jy (Y pol)
Resolution Bandwidth	RBW	0.95 kHz
Resolution in velocities		< 0.2 km/s
Integration Time	Δt	100 s
Minimal Detectable Peak Flux Density (max level of background noise peaks)	$\mathbf{F_{peak}}$	< 6.4 Jy (after averaging data of two polarizations)

*Supposed value. ChatGPT replies the same to question about Aperture Efficiency of 20 m Green Bank dish with L-band receiver.

VY CMa and IRAS17411-3154 spectra observed in OH.

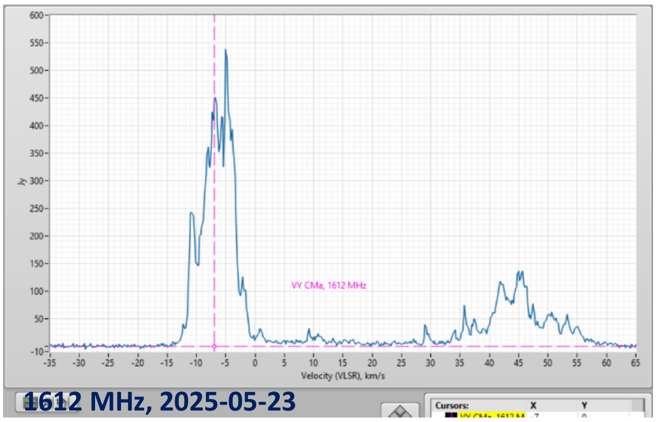


Figure 3. VY CMa in 1612 OH line. Observation 2025-05-23, 20m Green Bank telescope.

VY Canis Majoris (VY CMa) is a red super-giant with present mass estimation about 15 M⊙ [13] and high mass-loss rate 2.8 × 10^{-4} M⊙/year [14]. The order of luminosity is ~ 4 × 10^{5} L⊙ according data in [14], Table 6. Despite the dense circumstellar dust, the star is seen in the optical band. VY CMa radiates at 1612 MHz expectedly with double peak profile of the spectrum, see Figure 3, although the peak levels are noticeably different.

The "main" lines 1665/1667 MHz are weaker and do not follow the regular pattern of 1612 MHz line, see Figure 4.

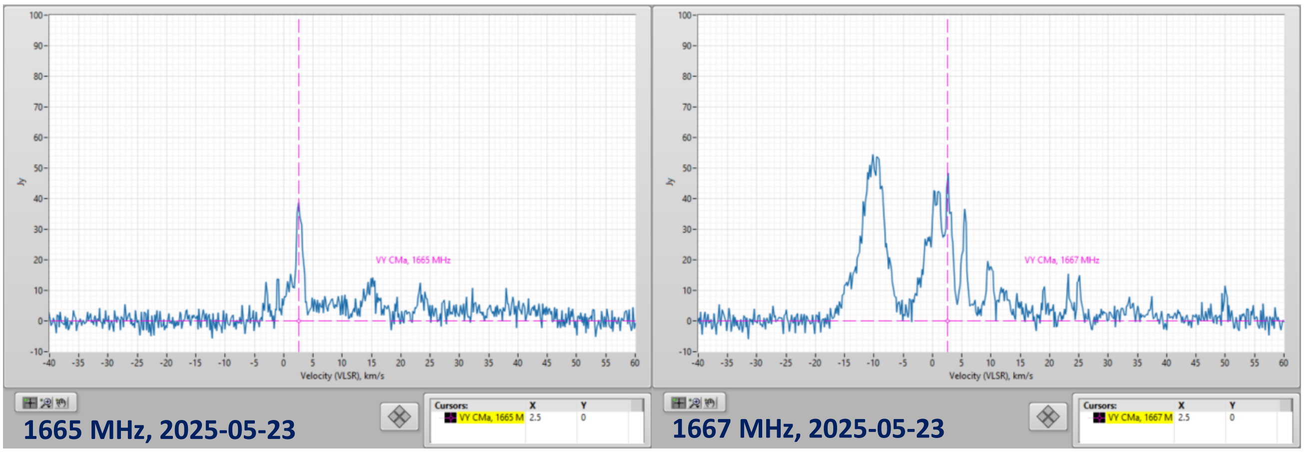


Figure 4. VY CMa in "main" OH lines 1665/1667 MHz. Observation 2025-05-23, 20m Green Bank telescope.

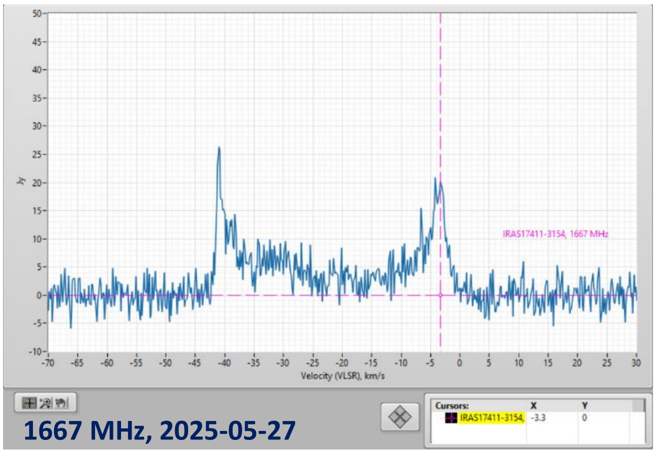


Figure 5. IIRAS17411-3154 in "main" OH line 1667 MHz, observation 2025-05-27, 20m Green Bank telescope.

OH/IR star IRAS17411-3154 (also known as AFGL 5379) has lower mass-loss rate 2.8 × 10^{-5} M⊙/year and classified as AGB star [14]. It is also less massive and luminous, the order of luminosity is ~3 × 10^{4} L⊙ according to data in [14], Table 6; this star is typically not seen in the optical band.

In contrast to VY CMa, the star demonstrates double peak pattern in the 1667 MHz line like in 1612 MHz, see Figure 5.

Unfortunately, I have not obtained yet the spectrum of IRAS17411-3154 in the 1612 MHz line from observations, as I suppose, due to RFI issues; Skynet excessively shifts initially specified receiver band up or down, so, the frequencies about 1612 MHz turn out aside of actual band. Samples of 1612 MHz and 1667 MHz spectra from [5] are shown at Figure 6.

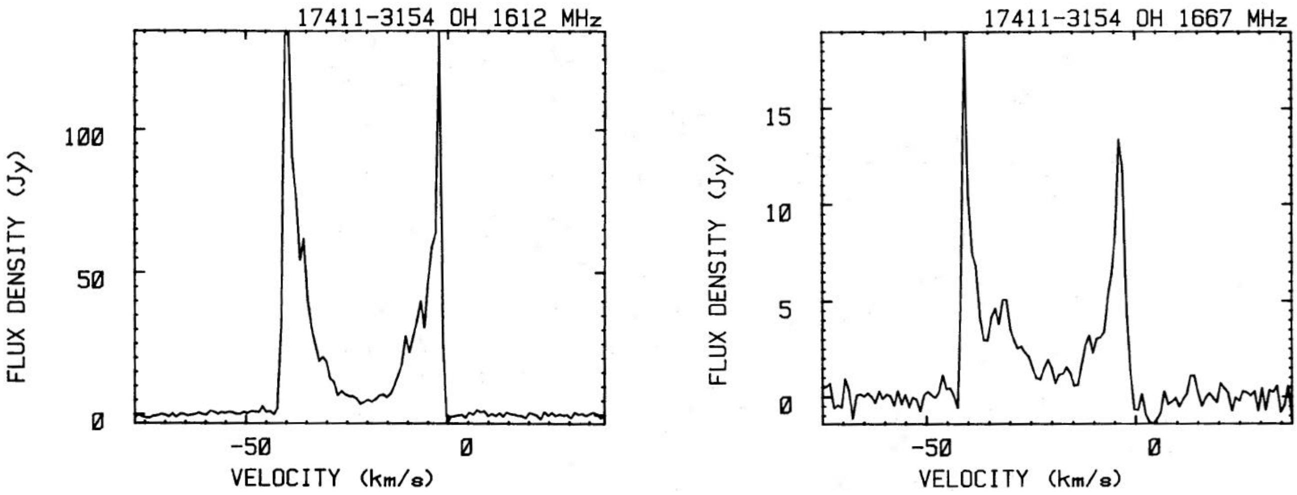


Figure 6. A sample of 1612 MHz and 1667 MHz spectra of IRAS17411-3154 from [5].

Discussion and concluding notes

Two OH/IR stars with detected "main" lines have been observed so far: the massive red supergiant VY Canis Majoris (VY CMa), which has a high luminosity, and the less luminous AGB star IRAS 17411-3154. Their mass-loss rates differ by an order of magnitude, at 2.8×10^{-4} and 2.8×10^{-5} $M_\odot$/year, respectively. Both stars exhibit emission in the "main" OH lines: VY CMa in both the 1665 and 1667 MHz transitions, while IRAS17411-3154 is detected only at 1667 MHz.

The spectral structure of VY CMa in the "main" lines does not replicate the double-peaked profile seen in its 1612 MHz line. This suggests that the pumping regions for the 1665/1667 MHz and 1612 MHz transitions are located differently within the circumstellar OH envelope of VY CMa. In contrast, the 1667 MHz "main" line of IRAS 17411-3154 retains similar spectral profile as its 1612 MHz line, indicating that the corresponding transitions are likely pumped in the same regions of the OH envelope.

This difference in OH lines excitation between the two stars is presumably linked to their differing mass-loss rates and, consequently, to variations in the dust content of their circumstellar envelopes. However, these stars differ noticeably in their masses, radii and luminosities. The ratio of mass-loss rate to the square of the stellar radius $\dot{m}/R_*^2$ can serve as an indicator of circumstellar envelope density. Using stellar radii of 1679 $R_\odot$ for VY CMa and 830 $R_\odot$ for IRAS17411-3154 (from [14], Table 6), the derived values are:

• 9.9×10^{-11} $M_\odot$/(year × $R_\odot^2$) for VY CMa
• 4.1×10^{-11} $M_\odot$/(year × $R_\odot^2$) for IRAS17411-3154

A denser circumstellar envelope implies a higher dust density. VY CMa, with its denser envelope and high luminosity, provides more favorable conditions for infrared pumping of the 1612 MHz transition. While some localized regions of "main" lines excitation persist, they do not coincide with the zones where the 1612 MHz line exhibits inversion.

Acknowledgments

To Stephen Tzikas for maintaining Skynet services for SARA members.

References

[1] Skynet Network resource, https://skynet.unc.edu/; *Observing Advice for the NRAO Skynet 20-meter telescope*, https://www.gb.nrao.edu/20m/obsadvice.html;
[2] Stephen Tzikas, Maser observation program (pptx file from SARA site), Analytical Section Meeting: Demo, Masers, & W3 Radio Mapping, SARA Eastern Conference 2021.

[3] Thai-Q-Tung et al., *Excitation of far-infrared lines of OH and maser pumping efficiency in circumstellar envelopes*, A&A 331, pp 317–327 (1998).
[4] M.D. Gray, *Pumping of OH Main-Line Masers in Star-Forming Regions*, arXiv:astro-ph/0611709 (2006).
[5] M.J. Gaylard, M. E. West, P.A. Whitelock and R.J. Cohen, *The identification of bright OH/IR stars and their mimics*, MNRAS 236, pp 247-261 (1989).
[6] Wolfgang Herrmann, *The "Astropeiler Stockert Story", Part 5: Spectral Observations Hydroxyl (OH) Masers and Absorption*, 2016/2017.
[7] Eduard Mol, Tammo Jan Dijkema, and Thomas Telkamp, *Observation report: OH masers observed with the Dwingeloo telescope*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers (SARA journal), March – April 2024, p 100.
[8] T.L. Wilson, K. Rohlfs, S. Hüttemeister, *Tools of Radio Astronomy*, 6th ed, Springer, 2013.
[9] D. Fedorov UA3AVR, *Notes on building a maser receiver*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers (SARA journal), March – April 2024, p 71; D. Fedorov UA3AVR, *Low Signal-to-Noise observations of masers*, Proceedings of Annual Eastern Conference and Global Symposium on Amateur Radio Astronomy, Green Bank, West Virginia, August 4-7, 2024, p 232; D. Fedorov UA3AVR, *The 6.7 GHz maser telescope parameters by solar measurements*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers (SARA journal), March – April 2025, p 77.
[10] D. Fedorov UA3AVR, *System temperature T_{sys} by measurements the Moon radiation*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers (SARA journal), January – February 2024, p 62.
[11] D. Fedorov UA3AVR, *Solar Flux and Temperature at Millimetre Wavelengths*, DUBUS 3/2016, p 41; http://dx.doi.org/10.13140/RG.2.1.1656.9361.
[12] Joachim Köppen DF3GJ, *A Closer Look at Filling Factors*, DUBUS 4/2021, v 50, p 15.
[13] L. Decin et al., *Probing the mass-loss history of AGB and red supergiant stars from CO rotational line profiles, I. Theoretical model – Mass-loss history unravelled in VY CMa*, A&A 456, pp 549–563 (2006).
[14] E. De Beck et al., *Probing the mass-loss history of AGB and red supergiant stars from CO rotational line profiles*, *II. CO line survey of evolved stars: derivation of mass-loss rate formulae*, A&A 523, A18 (2010).

About the author

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

Observation report: nearby galaxies at 21 cm part II

Eduard Mol

Introduction

In an earlier article in the January- February 2025 SARA journal I described the results of an observation programme on the galaxies M31 and M33 at 21 cm with my 3 metre dish. In this article, the possible detections of two additional galaxies (IC342 and M101) are presented, as well as additional results on M33 and the Cygnus A/ Cygnus X complex.

List of galaxies

In order to see which galaxies beyond M31 and M33 may be detectable with my 3 metre dish I compiled a short list of galaxies with HI flux densities greater than 10 Jansky from the galaxy neutral hydrogen surveys by Rots (1980) and Dean and Davies (1975) [2, 3]. Some quick back-of-the-envelope calculations using the radiometer equation (assuming a reasonable Tsys of 120 K, 1 hour of accumulated integration time, and a bandwidth of 40 KHz) demonstrates that the weaker galaxies M83 and IC10 are likely out of reach. M31, M33 and also IC342 should all be detectable with an SNR well above 5. For IC1613 and M101, 1 hour of integration is clearly insufficient to reach an SNR>5, but with more integration time these galaxies may just be detectable. However, this is not taking into account additional problems such as RFI and bandpass stability at these extremely low signal levels…

Galaxy	S peak (Jy) [2, 3]	Tant (K)	Signal/noise (1 hour int.)
M31	120	0.3	30
M33	70	0.17	17
IC 342	35	0.09	8.5
IC 1613	16	0.039	3.9
M101	16	0.039	3.9
M83	10	0.025	2.5
IC 10	10	0.025	2.5

Table 3: Neutral hydrogen properties of selected nearby galaxies and expected SNR with 1 hour integration with the 3 metre dish.

Methods

The 3 metre dish

For this project a homemade 3 metre f/0.5 dish was used. The dish has a plywood construction with an aluminium mesh reflector. It is not permanently set up in the backyard but consists of four segments which can be assembled around a central hub and stored in a shed when not in use. The system temperature is about 110- 120 K, as estimated following the "SNR method" described in [4].


Figure 7: the modular 3 metre dish.

In summary, the electronics chain of the 3 metre dish setup consists of the following components:

- 1420 MHz W2IMU type feed
- G8FEK L-band LNA (noise figure 0.5 dB)
- 1420 MHz interdigital filter (built after the design of T. Saje and M. Vidmar)
- 16 dB amplifier (to overcome cable losses)
- Airspy mini SDR receiver

The SDR is cooled using an old PC fan to avoid gain drifting due to heating.

Data collection and processing

Since the 3 metre dish has no tracking capability all data collection was done in driftscan mode. The data collection and processing procedures are described in an earlier articles on the observations of M31 and M33 by Jason Burnfield and by me in the March- April 2024 and the January- February 2025 SARA journal [1, 5]. Briefly, an integrated spectrum is saved every minute using SDR# with the IFaverage plugin. Two blocks of off-target “pre- transit” and “post-transit” spectra are averaged and divided from the averaged “on- target” spectrum for bandpass correction. The frequency axis is converted to LSR velocity, using an Astropy script developed by T. J. Dijkema [6] to obtain the LSR correction factor for the location and time of the observation. Results from multiple transits are then averaged together to improve the signal-to-noise ratio (SNR). Finally, residual slope (if present) is removed by fitting and subtracting a trendline through the background, and the resolution is reduced by averaging adjacent FFT bins to improve the SNR even further. Finally, the vertical scale of the spectrum is converted to brightness temperature in order to allow a comparison with LAB survey simulations. Methods for simulating galaxy transits using LAB survey data are described in my earlier article on M31 and M33 [1] and were also presented during the 2025 Western Conference by Jason Burnfield and me.

Results and discussion

Messier 33 revisited

An additional series of driftscans on M33 was done from February 12 to February 19, this time the dish was pointed 1 degree higher in elevation as it was suspected that the pointing was slightly off during the previous series of observations. This turned out to be correct: the brightness temperature almost exactly matches the simulated LAB profile. Also, the redshifted peak seems to have been detected this time.

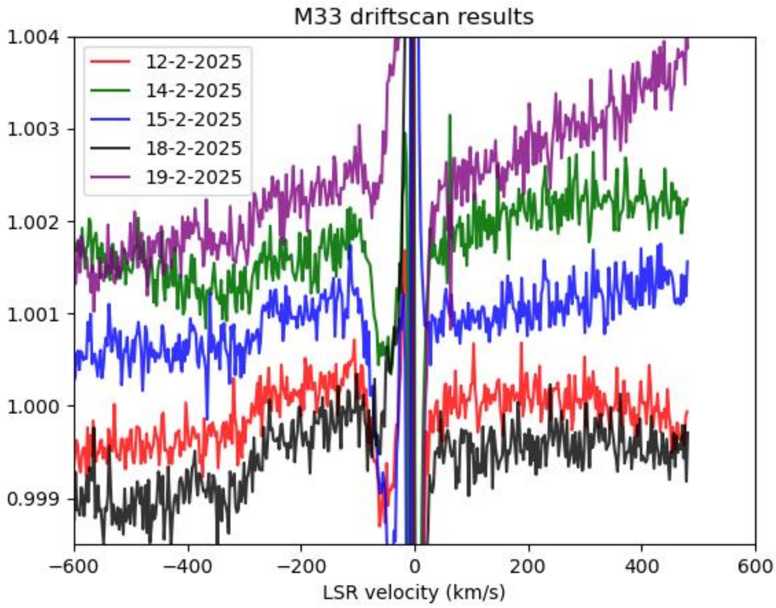


Figure 8: results from the driftscans of M33 from February 12- 19, 2025

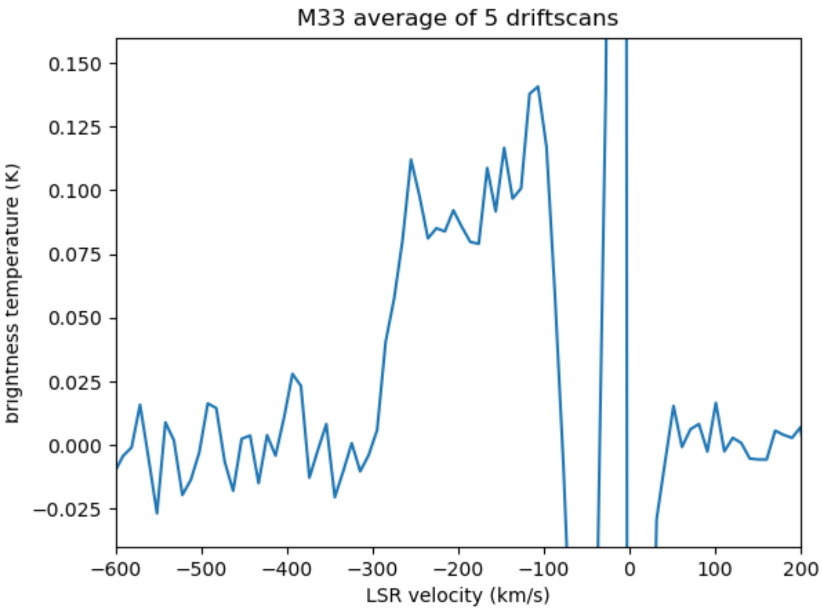


Figure 9: Final result of the February 12- 19 M33 driftscan survey. The background was detrended with a second order polynomial. Resolution: 46.9 KHz, total integration time: 100 minutes.

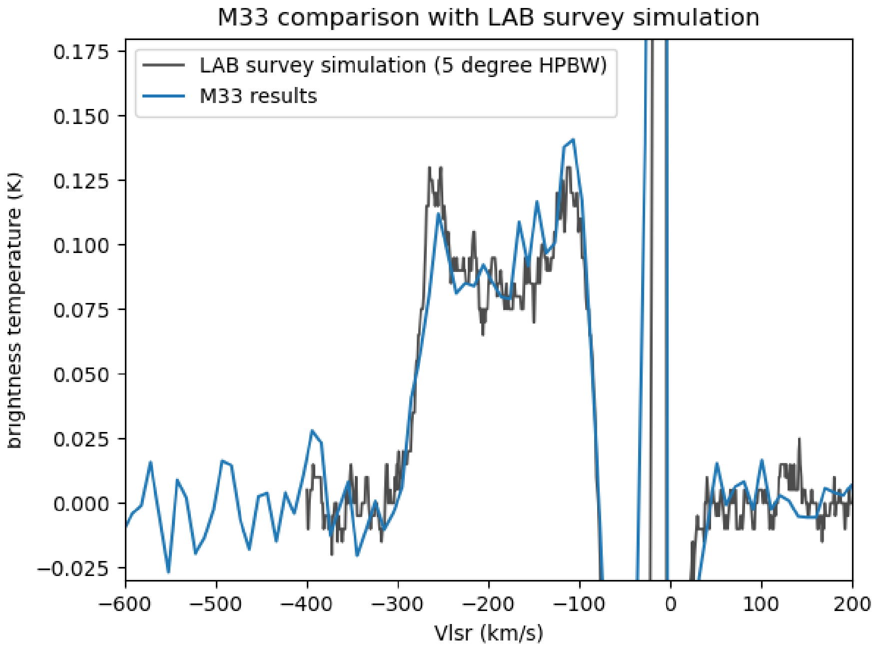


Figure 10: Comparison with LAB survey data

IC 342

Located at a distance of roughly 11 million light years, IC342 is substantially further away than M31 and M33 and is not a member of the Local Group [8]. According to the survey by Rots (1980) it's HI flux density is 35 Jansky, about half that of M33. Given the SNR of the M33 observation, detection of IC342 with a 3 metre dish should be in the realm of possibilities. The high northern declination of the galaxy at +68˚ also allows for about 40 minutes of on-target recording for each transit. However, due to the small redshift of IC342 the spectrum has significant overlap with the local galactic hydrogen signal. Only the redshifted part of the spectrum at ~50-150 km/s can be detected [2].

Driftscans of IC 342 were collected from February 12 until February 20. Unfortunately, I have more RFI towards the north at my location. The RFI was overall stronger during the off-target recordings, resulting in a large number of negative spikes in the spectrum. There was also a prominent residual slope after averaging the results from all the driftscans. The slope was removed by fitting and subtracting a trendline through the background between 150- 380 km/s.

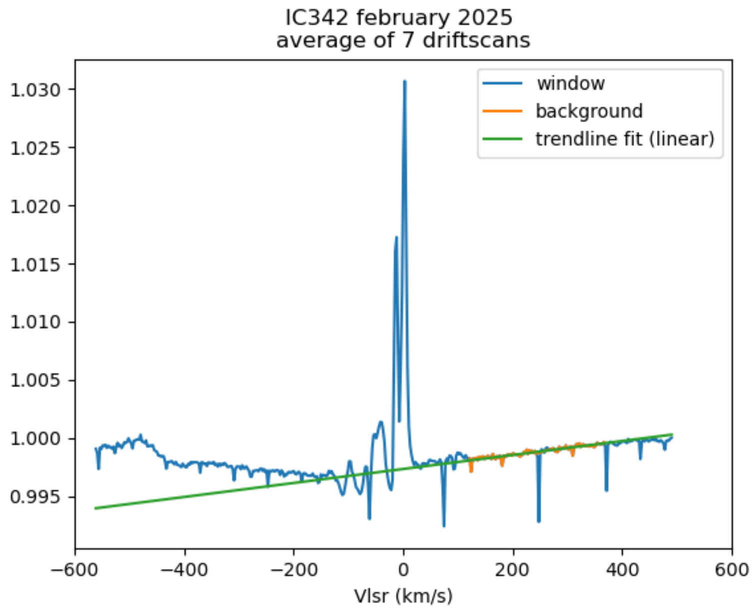


Figure 11: trendline fitting through background

After detrending, the negative RFI spikes were removed by removing all the values below a threshold of -0.0004

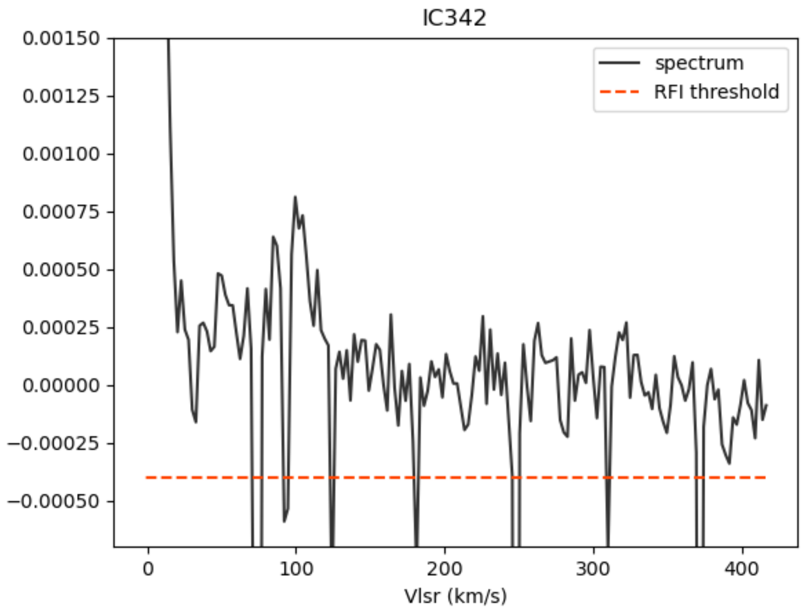


Figure 12: removal of RFI artifacts

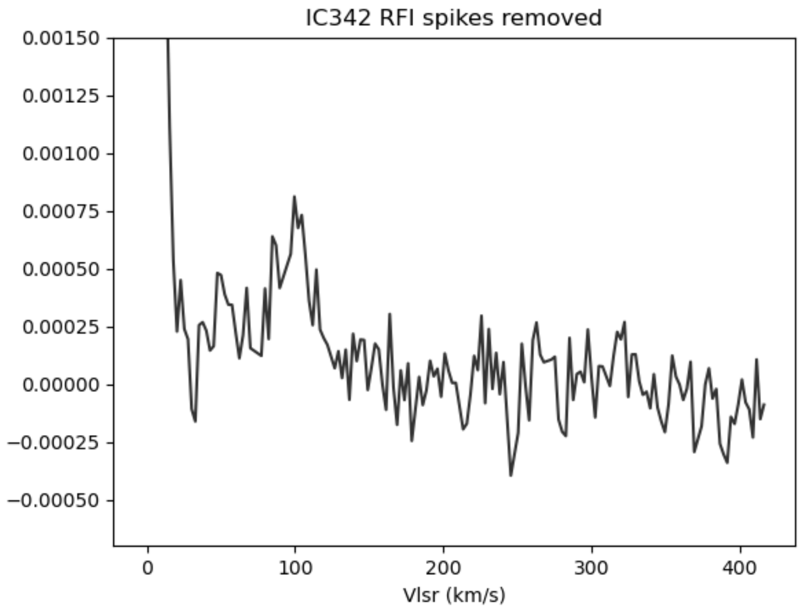


Figure 13: spectrum after removing channels affected by RFI

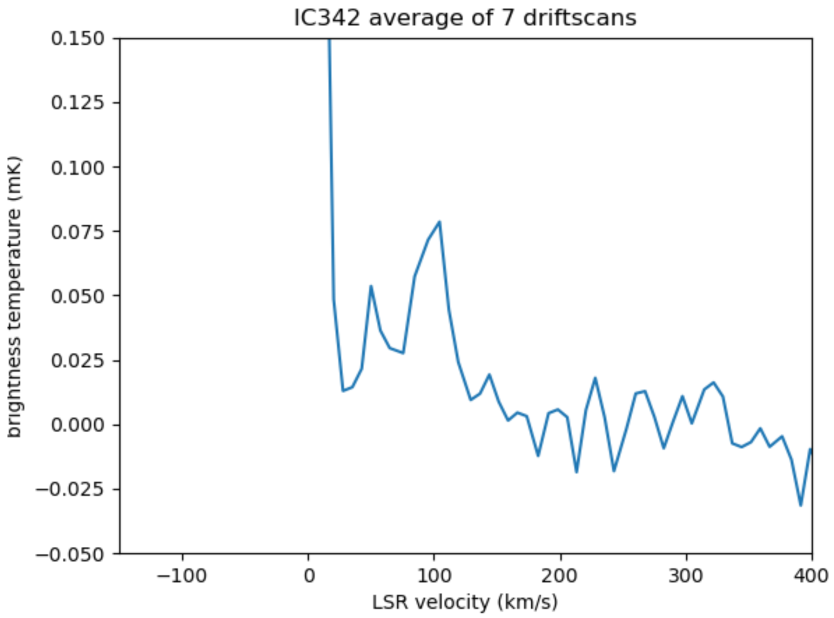


Figure 14: final result of the IC342 driftscan survey (resolution: 35.2 KHz, total integration time: 280 minutes)

This result matches the LAB survey simulation almost perfectly, even though the SNR is fairly low.

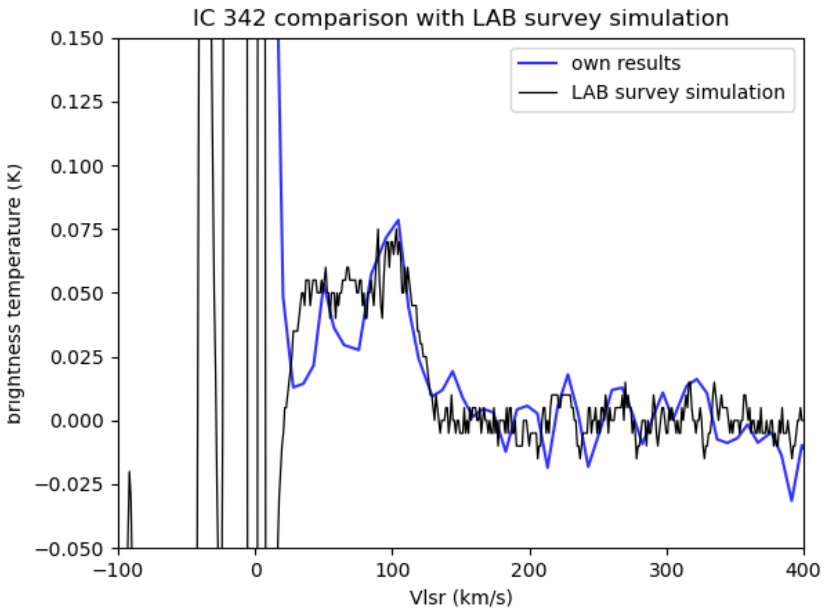


Figure 15: Comparison of IC 342 data to LAB survey simulation

Messier 101

Messier 101, also known as the pinwheel galaxy, is a massive spiral galaxy located at a distance of 21 million light years, almost 10 times further than M31 [10]. This places M101 well outside of the local group. At a flux density of 16 Jansky, the observation of this galaxy was really pushing the detection limits of my system. A total of 8 driftscans on M101 were recorded overnight between February 10- 20, yielding 30 minutes of on-target recordings per transit. Luckily there was little RFI or background drift. At least the blueshifted peak at 300 km/s seems to be detected and matches with the LAB survey simulation. The weaker redshifted peak is not detected, but this is not a surprise.

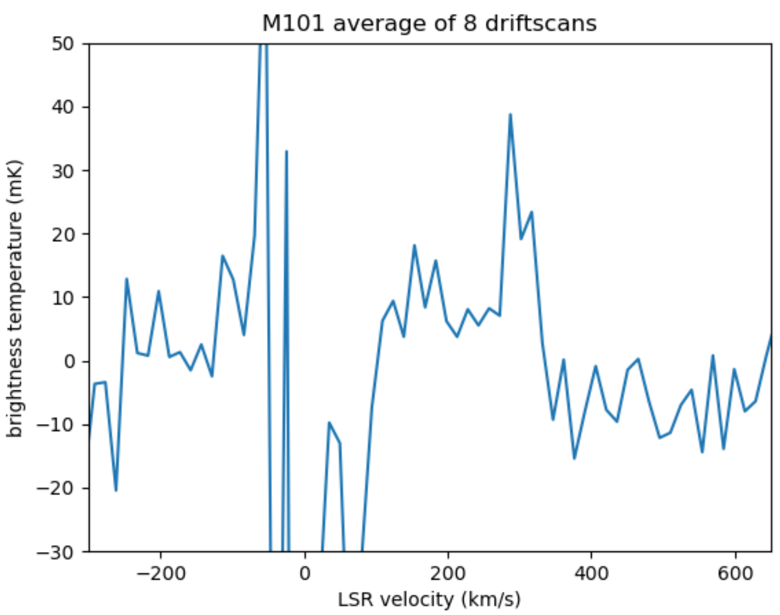


Figure 16: Final result of the M101 driftscan survey. Spectral resolution: 70.3 KHz, total integration time: 240 minutes.

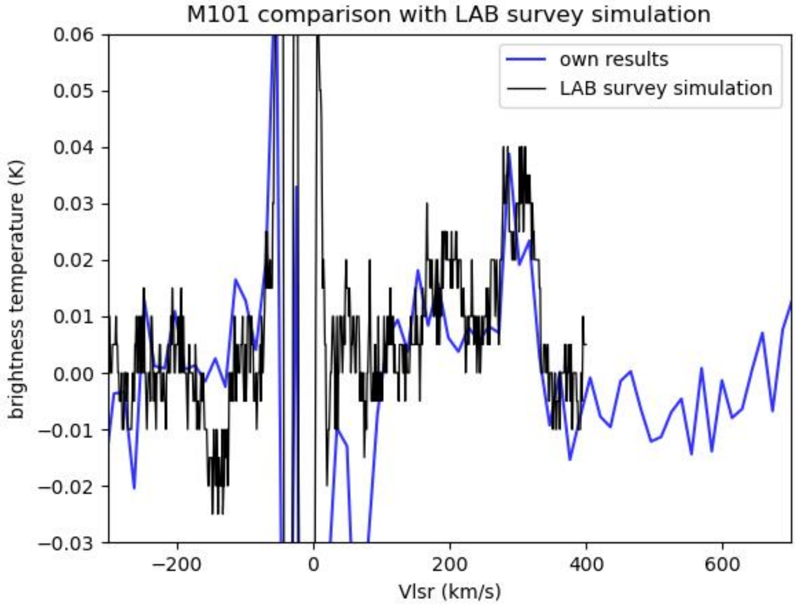


Figure 17: Comparison of M101 results to LAB survey simulation

Bonus result: continuum radiation from Cygnus A and Cygnus X.

During the processing of the driftscan data of M31 from December 2024 I noticed a rise in the background of the spectra a few hours before the transit of M31. This rise, between RA ~19:40 and 21:20, can be attributed to the strong continuum sources Cygnus A and Cygnus X, which are roughly at the same declination as M31. Cygnus X is a large complex of star forming regions in the Galactic plane, in fact it consists of multiple radio sources but due to the 5 degree wide beam of the 3 metre dish we see an integrated signal. Cygnus A is a radio galaxy at a distance of 750 million light years. Because it is only a few degrees from the Cygnus X complex, these sources cannot be separated with a 3 metre dish at 1420 MHz. Thus, the presence of Cygnus A as a separate source is only revealed by a slight bump in the curve at a RA of 20:00. This effect was also noted by the Astropeiler group when doing continuum drift scans of the Cygnus A/ X region with their 3 metre instrument [4].

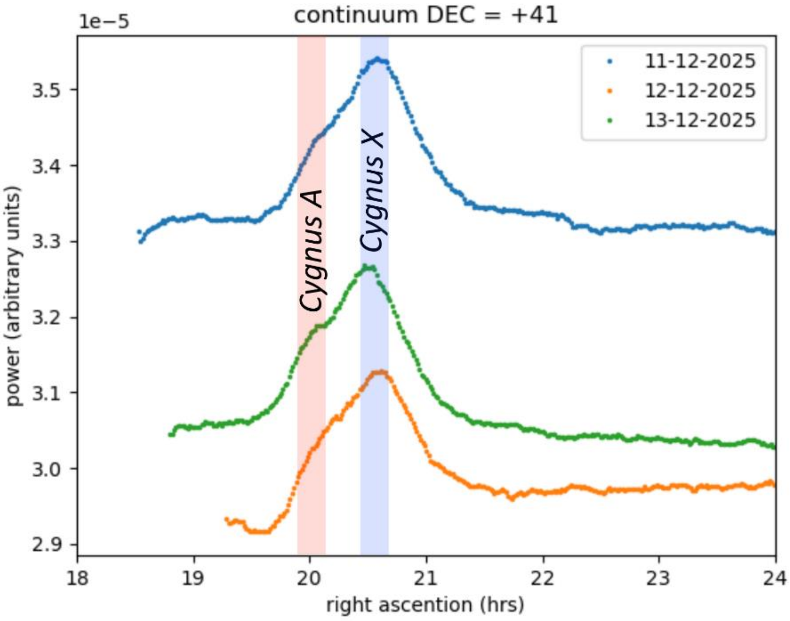


Figure 18: Continuüm traces of the driftscans from December 11- 13 2024. The continuüm signal was extracted by averaging the spectral channels outside the hydrogen line (1421.5- 1424 MHz).

References:

"Observation report: M31 and M33 at 21 cm", Eduard Mol, SARA journal January- February 2025, p. 122-130.
Rots, A. H. (1980). A neutral hydrogen mapping survey of large galaxies. I-Observations. Astronomy and Astrophysics Supplement Series, vol. 41, Aug. 1980, p. 189-209., 41, 189-209.
https://adsabs.harvard.edu/full/1980A&AS...41..189R
Dean, J. F., & Davies, R. D. (1975). The integrated neutral hydrogen properties of nearby galaxies. Monthly Notices of the Royal Astronomical Society, 170(3), 503-518.
"The 3 metre dish at the "Astropeiler Stockert", part 2: characterization and observations", Wolfgang Herrmann. (https://astropeiler.de/wp-content/uploads/2017/12/Part2_The_3-Meter_Dish_Astropeiler_Stockert_Characterisation_and_Observations.pdf)
"Hydrogen line driftscan detection of M31 and M33 with a portable 2.64 meter dish", Jason Burnfield, SARA journal March- April 2024 p. 88- 96.
https://gitlab.camras.nl/dijkema/HPIB/blob/185d241ad9bd7507ed90c9fa91fe0a63009d3eee/vlsr.py
https://www.astro.uni-bonn.de/hisurvey/euhou/LABprofile/index.php
https://en.wikipedia.org/wiki/IC_342
https://en.wikipedia.org/wiki/Pinwheel_Galaxy

Periodic Ionospheric Absorption Events on Cinco de Mayo

Whitham D. Reeve

Introduction: Ionospheric absorption has three primary causes: Solar Flares; Solar Energetic Particle (SEP) Precipitation; and Auroral Particle Precipitation. Auroral Particle Precipitation and geomagnetic disturbances often are observed together. Many geomagnetic disturbances induce auroral substorms and substorms can occur quasi-periodically during a night. However, the literature does not mention that ionospheric absorption events related to Auroral Particle Precipitation may have a periodic nature as well.

On 5 May 2025, the day of the annual Mexican-American celebration known as *Cinco de Mayo*, such an event was observed at the HAARP facility near Gakona, Alaska (figure 1) and is discussed in this article. The observations were with a Riometer and Magnetometer. The Riometer records the Galactic background radiation with respect to a reference noise source and indicates absorption at 30.3 and 38.2 MHz. Any decrease in the cosmic noise received at these frequencies is attributed to absorption in the ionosphere's D-region. The SAM-III Magnetometer is about 2.3 km away and records the characteristics of the geomagnetic field and associated disturbances.

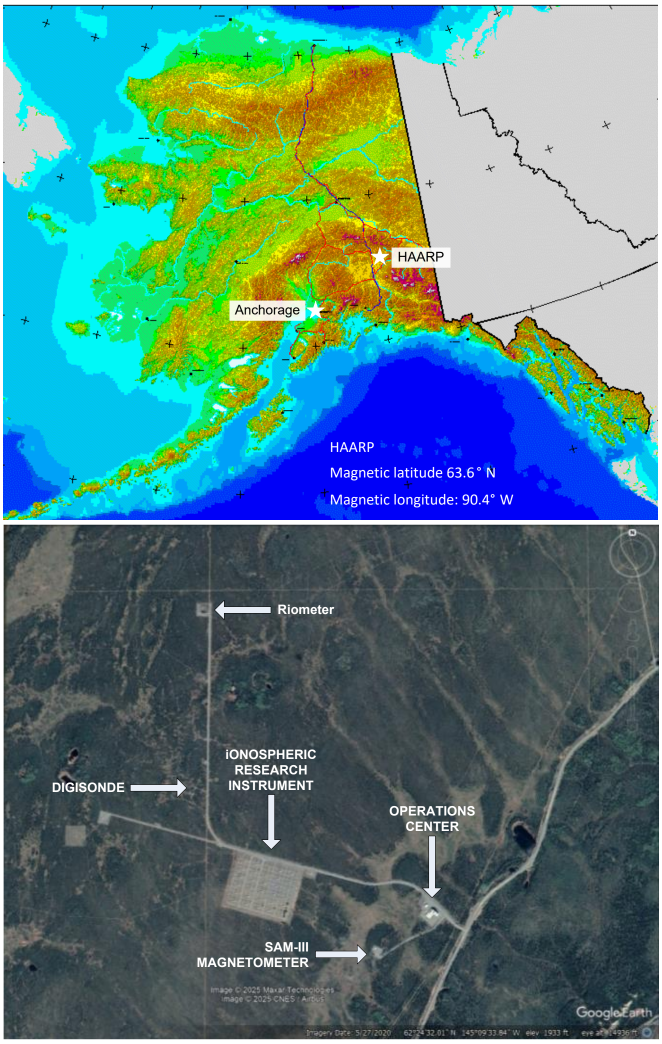


Figure 1 ~ Left: Alaska map showing the proximity of the HAARP facility to Alaska's largest city Anchorage about 300 km to the southwest and the Canadian border about 200 km to the east. Right: Zoomed image equivalent to an altitude of 29 000 ft (9 000 km) showing the HAARP science facilities. North is up.

Auroral Particle Precipitation: When the solar wind speed is elevated for long time periods (at least an hour or two), the energy loading in the magnetosphere and its subsequent release can occur quasi-periodically. This is particularly the case when the Interplanetary Magnetic Field (IMF) embedded in the solar wind has a southward component (figure 2) and is able to merge with Earth's northward magnetic field. Merging allows energetic electrons in the solar wind to enter the magnetosphere on the dayside (figure 3). Some of these electrons precipitate into the lower regions of the ionosphere at higher latitudes and some are carried by the open magnetic field lines to the magnetotail where they add energy to the magnetotail plasma.

It is thought that the energy loading reaches a tipping point and is released during reconnection of the open magnetic field lines in the magnetotail. The reconnection causes an outflow of electrons, some of which are convected back toward Earth along now-closed magnetic field lines. Their electron energy is increased along the way and they then precipitate into the D- and E-regions, producing aurora and related phenomena. This is called *Auroral Particle Precipitation*. The process repeats two or three times during the night at a given location and manifests as periodic structures seen in magnetograms with periods ranging from about 0.5 to 3.5 hours.

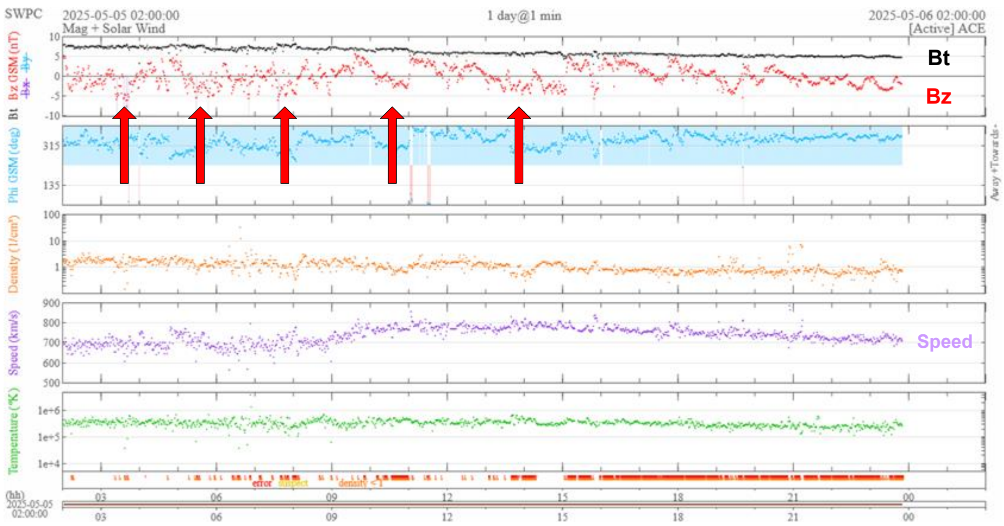


Figure 2 ~ Advanced Composition Explorer (ACE) spacecraft data for 5 May 2025. ACE is located 1.5 million km from Earth on the Earth-Sun line. The red trace (Bz) in the upper plot shows the IMF component aligned with Earth's magnetic dipole axis. Negative (southward) values, marked by the red arrows, enable merging of the IMF and Earth's field and the opening of the magnetosphere through which energetic particles from the solar wind can enter. The solar wind speed, shown by the purple trace in a lower plot, is above 700 km s^{-1} and considerably elevated compared to quiet conditions. Image source: NOAA

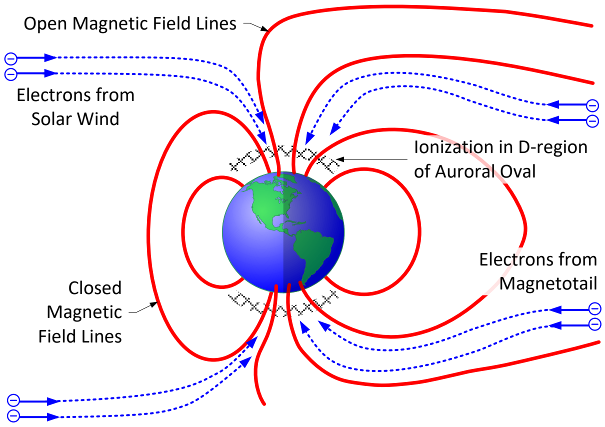


Figure 3 ~ The IMF and Earth's magnetic field can merge if the IMF has a southward component (aligned with but opposite Earth's dipole field). The merging event opens some previously closed field lines on the dayside allowing energetic electrons in the solar wind to enter the magnetosphere. These can precipitate into the D-region ionosphere and some can work their way to the magnetotail. The open field lines eventually reconnect in the magnetotail causing the convection of energetic electrons toward Earth where they precipitate to the D-region. The merging-reconnection events typically occur two to three times in a quasi-periodic manner.

<u>Observations</u>: When the energetic electrons precipitate to the lower ionosphere and collide with neutral atmospheric particles, they have enough energy to ionize the neutral particles and increase the electron density. The freed electrons are excited by the Galactic background radiation, but their higher density increases the collision rate with neutral particles causing the excited electrons to lose energy and the Galactic background radiation to be absorbed (figure 4).

The Riometer plot shows absorption events as dips in the trace, which indicate a reduction in the received Galactic background radiation. In this case, the dips are aligned with magnetic features that occur roughly every 3 hours. This Riometer plot does not include a Quiet Day Curve, which is used for comparing with quiet day conditions, so the data are qualitative rather than quantitative. Nevertheless, the apparent absorption is on the order of a couple dB, which would translate to much higher values and a complete radio blackout at frequencies in the lower HF band. The absorption events shown here have up to 3-hour duration.

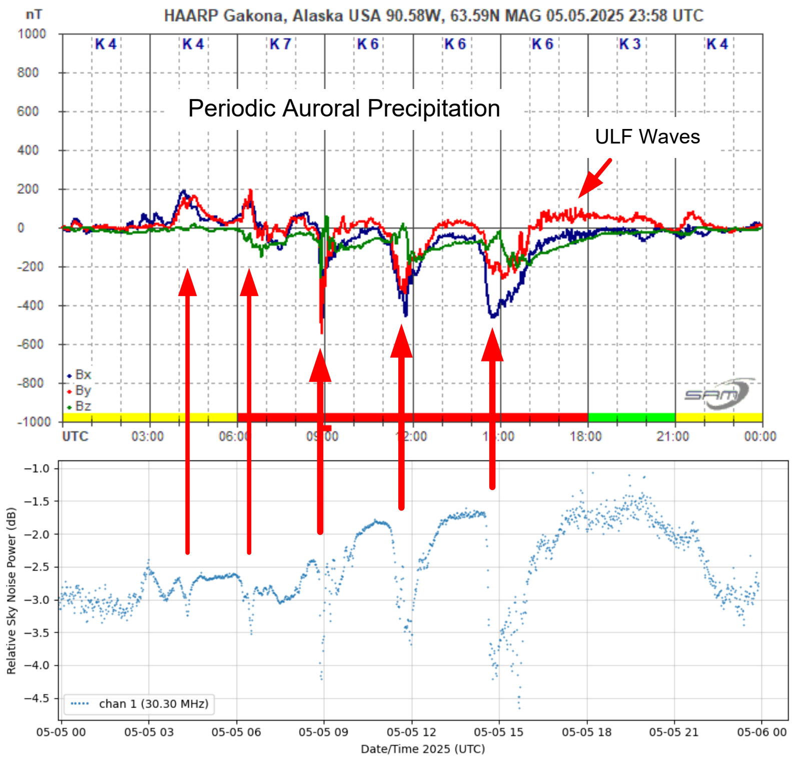


Figure 4 ~ Overlay of the SAM-III magnetogram (upper plot) with the Riometer plot for 30.3 MHz. The red arrows mark the time correspondence of absorption events in the lower plot with magnetic activity in the upper plot. The first two are inverse magnetic bays that normally do not affect particle precipitation and absorption but in these two cases there are slight absorption increases (dips). The following three events are textbook magnetic bays in which the local magnetic field decreased substantially, indicating enhanced Auroral Electrojets from Auroral Particle Precipitation. The apparent absorption is around 1 to 3 dB at low VHF frequencies. A period of ULF Waves occurred in the latter part of the UTC day and is marked on the magnetogram. ULF Waves are low amplitude oscillations in the magnetic field that have periods on the order of a couple hundred ms to 10 min. Bottom image: Courtesy of UAF-GI

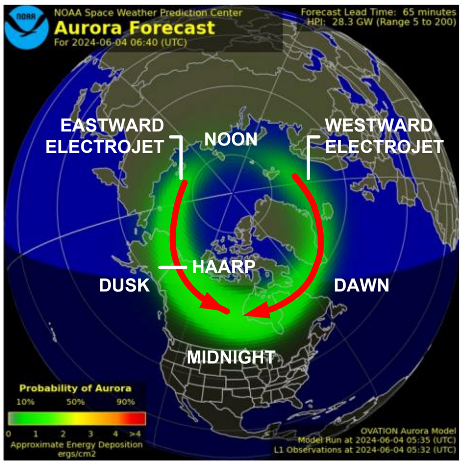


Figure 5 ~ The Auroral Oval, shown in green, in this Auroral Forecast image has been expanded toward the equator during a magnetic disturbance. The red arrows have been added to indicate the eastward and westward Auroral Electrojets. The Sun is directly up, and Alaska is in the Dusk sector with the eastward electrojet flowing overhead. Image source: NOAA

The increased electron density also increases the conductivity of the lower ionosphere and enhances the *Auroral Electrojet*. The Auroral Electrojet is a huge current system in the *Auroral Oval* (figure 5) that, during quiet magnetic conditions, flows horizontally about 100 km above the ground at around 67° latitude. When the Auroral Oval expands toward the equator, the electrojet is enhanced and moves along with it. The HAARP facility is located at 63° north magnetic latitude, and disturbed conditions can expand the electrojet so that it flows directly overhead or even south of HAARP. The electrojet produces its own magnetic field because of the current flow, and this field can add to or subtract from Earth’s internal dipole field as seen in the magnetogram.

In the observations discussed here, the periodicity started around 0400 UTC (1800 local solar time) when HAARP was on the Dusk side of Earth. Over the next several hours, a series of auroral substorms appeared to take place. The Auroral Electrojet was initially eastward and the magnetic field generated by the current flow slightly enhanced the magnetic field through a couple cycles. As the night progressed, the measured magnetic disturbances changed polarity with the first peak at about 0900 UTC (2300 local solar time) as HAARP moved through the solar Midnight sector. At this point, Earth and HAARP rotated into a region where the overhead electrojet was flowing westward (the auroral oval and electrojet are fixed in space as Earth rotates below). Due to the energy loading and release previously described, the electrojet periodically reduced the local magnetic field at the same time as the ionospheric absorption increased. The oscillations continued to 1500 UTC (0500 local solar time) as HAARP moved into the Dawn sector and they then ended shortly thereafter.

The Auroral Electrojets are a global high-latitude current system, and their characteristics are described by an *auroral electrojet activity index*. The index actually consists of four individual indices: AU, AL, AE and AO, which take into account global magnetic activity and are produced by measuring the horizontal (H) component of Earth’s magnetic field. It is interesting to compare the global AE indices to the local measurements (figure 6).

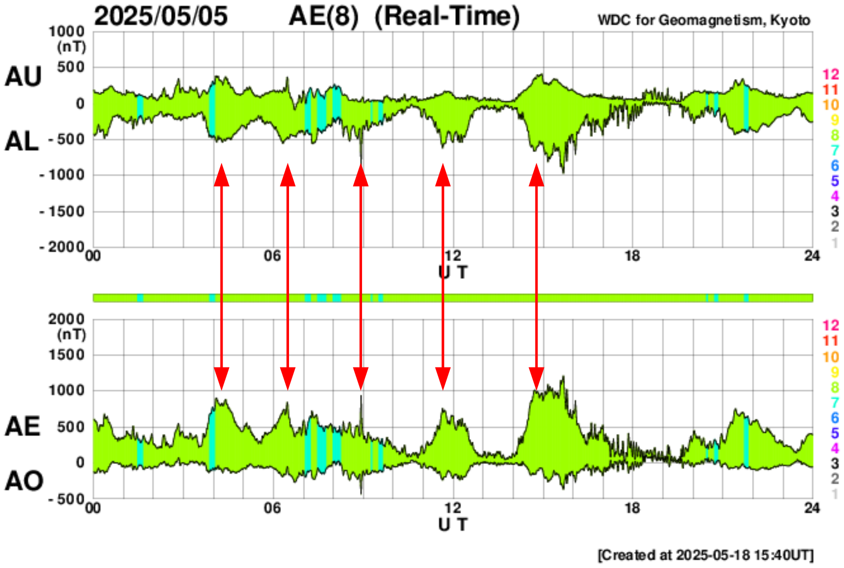


Figure 6 ~ Auroral Electrojet Indices for 5 May 2025. See text below for definition. Red arrows have been added that correspond to the times of the arrows drawn in Figure 4. The correspondence with electrojet activity is remarkable but not surprising. The plots shown here are based on global measurements, and it is clear that the periodic nature of the Cinco de Mayo event was not confined to the vicinity of the HAARP facility; however, the absorption elsewhere is unknown. Image source: World Data Center for Geomagnetism, Kyoto

The Auroral Electrojet indices are produced from data at high latitude stations (in this case, 8 stations, see color chart on right side of plots). The AU and AL indices indicate the strongest current intensity of the eastward and westward auroral electrojets, respectively, at any given time (these are a composite of all stations). AE and AO are derived from AU and AL. AE is the difference between AU and AL or (AU – AL), and AO is the average of AU and AL or [(AU+AL)/2] at any given time. AE indicates the total range of deviation from quiet day values at an instant of time around the Auroral Oval, so it represents the overall or peak-to-peak activity of the electrojets. AE is always positive. AO provides a measure of the current and may be positive or negative.

H1 Observations of the Leo Triplet Using the Green Bank 20 Meter Skynet Dish

By Jason Burnfield

14 June 2025

Observation Settings

- L-Band
- High Resolution
- 10 seconds “ON”
- 10 seconds “OFF”
- 10 repetitions for a total of 100 seconds each.

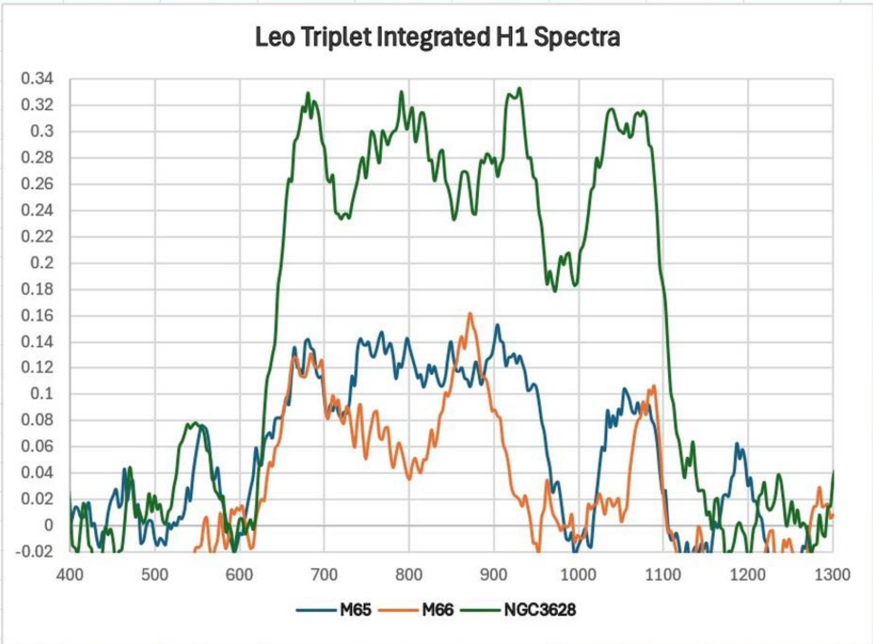
This method of “on target” and “off target” data collection allows the empty sky near the galaxy in question to be used for a calibration reference which also removes almost all of the interference from the local Milky Way hydrogen signal because it is nearly the same for on and off target data sets so cancels out. In the case of the Leo Triplet the Milky Way is not a problem anyway because they are all redshifted several hundred km/s.

The vertical scale is Power in Kelvin.

The horizontal scale is radial velocity in km/s.

M65, M66 and NGC3628 are all receding from us so the velocities are positive.

You can see that the spectrum of NGC3628 is much wider since it is edge-on.

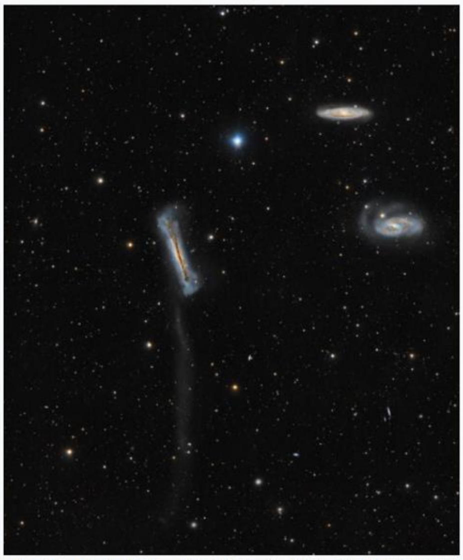


The **Leo Triplet** (also known as the **M66 Group**) is a small group of galaxies about 35 million light-years away[5] in the constellation Leo. This galaxy group consists of the spiral galaxies M65, M66, and NGC 3628.

Members of the Leo Triplet

Name	Type[6]	R.A. (J2000)[6]	Dec. (J2000)[6]	Redshift (km/s)[6]	Apparent Magnitude
M65	SAB(rs)a	$11^h 18^m 56.0^s$	+13° 05′ 32″	807 ± 3	9.3[7]
M66	SAB(s)b	$11^h 20^m 15.0^s$	+12° 59′ 30″	727 ± 3	8.9[8]
NGC 3628	SAb pec	$11^h 20^m 17.0^s$	+13° 35′ 23″	843 ± 1	9.5[9]

Leo Triplet



The **Leo Triplet**, with M65 (right top), M66 (right bottom) and NGC 3628 (left). North is to the left.

References

1. https://en.wikipedia.org/wiki/Leo_Triplet

Journal Archives and Other Promotions

The rich and diverse legacy of member contributed content is available in the SARA Journal Archives. Table of contents for journals is available online at: SARA-Journal-Master-Index.xlsx (live.com)

The entire set of The Journal of The Society of Amateur Radio Astronomers is available by online download. It goes from the beginning of 1981 to the present (over 6000 pages of SARA history!)

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

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

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.

What is Radio Astronomy?

Radio Astronomy is just what the name implies…. Astronomy observed at radio wavelengths instead of optical. But why do radio astronomy? Radio astronomy has expanded the knowledge of the universe about as much since its discovery in 1932 as optical has since humans first looked up at the sky. (The sky in the different frequencies or colors of radio are as different and varied as all of the flowers on Earth. Each frequency has its own information about what is happening in the universe.) This knowledge has been gained by both professional astronomers as well as amateurs, with amateurs contributing to this day.

Do I need a big dish and expensive equipment?
No. Complete beginner projects are available at the SARA store at very reasonable prices. You can monitor the Sun's effects upon our planet with SuperSID. This information is gathered for Stanford for research into our ionosphere and radio signal propagation. Another project is the detection the hydrogen line just like Dr. Ewen had done in 1951 for a fraction of the cost using the Scope in a Box kit.

That said, radio astronomy is like optical astronomy in that you can spend as much as you want to. Many amateurs push the lower boundaries of cost by using very low-cost receivers and low-noise low-cost amplifiers that were not available even a few years ago. (See the Scope in a Box kit in the store for examples of both.)

Is everything 'plug and play' and boring?
The kits mentioned above are a starting point which are mostly plug-and-play… that gets you started. After you have mastered the basics, where you go from there depends upon your interests. Monitoring pulsars is done by amateurs. (One even noticed a pulsar glitch before the professionals!) These amateurs are pushing the boundaries of what can be done. Papers are being published and discussions had about pulsar detection as well detection of a MASER with a 50-inch dish. Techniques on new detection methods are posted in the SARA forum and elsewhere. You are free to build your own equipment to receive the signals as well as software to collect and analyze the data.

What is SETI?
SETI is the Search for Extra-Terrestrial Intelligence. Some amateurs scan the sky and search for signals that might be from aliens. To date no one has received a definitive alien signal (professional or amateur), but the search continues. The search has resulted not just in better receiving equipment but also wide and lively discussions about how aliens might communicate and how they might be trying to contact us. Some of these techniques have interesting ideas for our own communication techniques here on Earth!

What should I do to get started?
You should start with reading our Introduction to Radio Astronomy and joining our online SARA Forum. Look at the SARA store to get a project to get your feet wet without much expense and minimal risk. We will work with you so you can succeed.

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: Marcus Fisher, https://www.radio-astronomy.org/contact/Vicepresident
Secretary: Brian O'Rourke, https://www.radio-astronomy.org/contact/Secretary
Treasurer: Tom Jacobs, https://www.radio-astronomy.org/contact/Treasurer
Past President: Dennis Farr
Founder Emeritus and Director: Jeffrey M. Lichtman, KI4GIY, jeff@radioastronomysupplies.com

Board of Directors

Name	**Term expires**	**Email**
Ted Cline	2027	TedClineGit@gmail.com
Dennis Farr	2026	dennisfarr@verizon.net
Ed Harfmann	2027	edharfmann@comcast.net
Dr. Wolfgang Herrmann	2027	messbetrieb@astropeiler.de
Don Latham	2026	djl@montana.com
Bruce Randall	2027	brandall@comporium.net
Steve Tzikas	2026	Tzikas@alum.rpi.edu
Jay Wilson	2026	jwilson@radio-astronomy.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@radio-astronomy.org
Contributing Editor	Bogdan Vacaliuc	bvaculiuc@iee.org
Educational Co-Chairs	Ken Redcap, Tom Hagen: 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/@radio-astronomy	Pisgah Astronomical Research Institute: www.pari.edu
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.net/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	Simple Aurora Monitor: Magnetometer http://www.reeve.com/SAMDescription.htm
NASA Radio JOVE Project http://radiojove.gsfc.nasa.gov Archive: http://radiojove.net/archive.html https://groups.io/g/radio-jove	Stanford Solar Center http://solar-center.stanford.edu/SID/
Green Bank Observatory https://greenbankobservatory.org/ .	https://www.csiro.au/ There's a wealth of info on this site of the Australian National Science Agency. It's much more than just radio astronomy. Looking under "Research" opens a real family tree of interesting pages of things they are involved with.

Found an interesting Grote Reber link: https://www.utas.edu.au/groterebermuseum Their gallery is interesting, but sure wish they had some captions to indicate who and what some of it is about. I can guess, knowing some of

Grote's stories, but others might need more info. Several pictures show the University of Tasmania 26m dish that was once one of the NASA worldwide Satellite Tracking and Data Network (STDN) dishes like the ones at the Pisgah Astronomical Research Institute (www.pari.edu). PARI's dishes were the first qualification units for that network.

For Sale, Trade and Wanted

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

New on-demand store for SARA SWAG! https://saragifts.org/

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

radio-astronomy.org/store.

SARA Publication, Journals and Conference Proceedings (various prices)

radio-astronomy.org/store.

SARA Journal Online Download

radio-astronomy.org/store.

The Journal archive covers the society journal "Radio Astronomy" from the founding of the organization in 1981 through the present. 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.

New! SARA On-Demand Store: https://saragifts.org

These are the current items – more to come in the future!

(Note: No returns or refunds possible because of the on-demand production approach)












My gma
is a radio
astronomer

Ask me
about my
antennas

2025
EASTERN
CONFERENCE

My gpa
is a radio
astronomer

Ask me
about my
antennas

I'M A RADIO
ASTRONOMER...
BECAUSE
ALIENS
WON'T TEXT
ME BACK.

2025
EASTERN
CONFERENCE

Radio
JOVE

2025
Society of Amateur Radio Astronomers & Radio Jove
EASTERN
CONFERENCE
Green Bank Observatory, WV

2025
EASTERN
CONFERENCE

2025
EASTERN
CONFERENCE

2025
EASTERN
CONFERENCE

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: ____________________

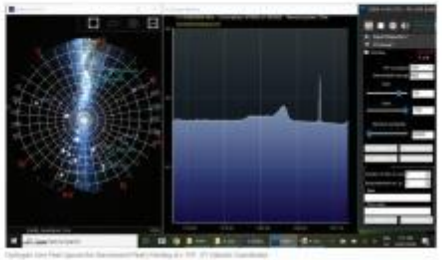
Phone: ____________________

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)