RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers
September – October 2025

Eduard Mol's Outreach at the Herzberg Telescope Meeting, Germany

Dr. Richard A. Russel
SARA President and Editor

Bogdan Vacaliuc
Contributing Editor

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

Cover Photo:
Eduard Mol

Contents

President's Page

Start thinking about presentations and attendance at the 2026 Western Conference at Owen's Valley in March 2026.

Ken Redcap (former 6 year SARA president) has volunteered to organize the event this year.

Details to follow as we finalize the schedule.

Use of the artificial intelligence applications has been widely discussed at the Drake's Lounge sessions. I have personally used them extensively in designing my phased array project. (Windows CoPilot). ChatGPT has been used by many of the members.

Remember that these AI tools give great information **but can be wrong**. Take the information provided as a suggestion, then verify it.

Membership renewals for 2026 are being sent out. Since there are only the treasurer and myself who process these, it would help if everyone could renew before the end of December.

Thanks!

Rich

Dr. Richard Russel
SARA President

Editor's Notes

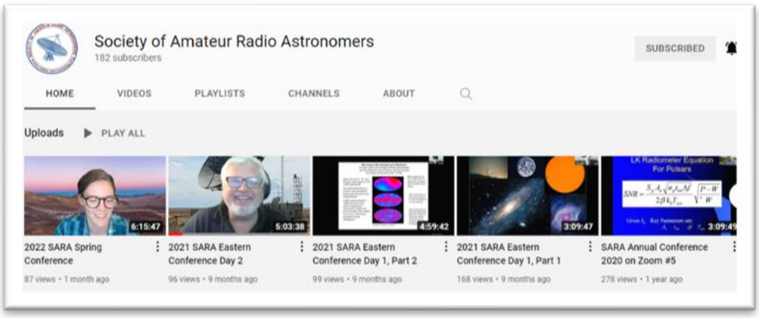
We are always looking for basic radio astronomy articles, radio astronomy tutorials, theoretical articles, application and construction articles, news pertinent to radio astronomy, profiles and interviews with amateur and professional radio astronomers, book reviews, puzzles (including word challenges,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

VINTAGE SARA BY CHARLES OSBORNE

VINTAGE SARA

BY CHARLES OSBORNE, SARA HISTORIAN

Shanni Prutchi - Then and Now

While moving picture albums around on my PC I happened to see a picture from twenty years ago of a 5th grader giving a Hydrogen Line Observing presentation at the 2005 Green Bank SARA Conference.

Giving a presentation to our group of “gray beards” has got to be pretty intimidating for a 5th grader. Usually this is a sign that the student is not your average student. I began to think to myself “I wonder what she’s doing today twenty years later?” And her name was just unusual enough to thin down the inevitable thousands of hits in a Google Search. Then it occurred to me, why not try LinkedIn? Bingo, there she is. She even mentions radio astronomy on her LinkedIn entry.

Paul Shuch N6TX, SARA VP at the time, doing Shanni’s introduction at the 2005 SARA Conference.


Shanni Prutchi and her dad, SARA member David Prutchi N2QG, in the audience awaiting her turn to present.

When I tried to contact her, Shanni responded: “What a pleasant surprise to be reminded of SARA, it feels like ages ago (which to be fair, 20 years is 2/3 of my life experience).”

Today Shanni is a Strategic Advisory Services Consultant at CrowdStrike. She’s a Cybersecurity consultant, experienced in application security, threat modeling, secure architecture and design, and incident response. I am passionate about documentation, museums, needle art, and reading. Past research includes radio astronomy, quantum physics, and smart contracts. Always looking to learn something new and to share it with others.

Well said. And definitely an interesting then and now life story.

Here’s a more recent picture with her dad David Prutchi at the Huntsville Space and Rocket Center.

And today she says she's staying busy planning her wedding. It was a bit serendipitous that I found the picture and did the search when I did. If she changes her name in marriage that would have made it much less likely that I would have found her and might not have connected the dots.

On a bit more somber note A SARA friend from the 1990's and 2000's Gary Anderson W4IVF passed away in his sleep on 9/21/2025. Gary worked for various radio/TV stations on Poor Mtn near Roanoke VA, Harris Aerospace, JPL, and NRAO.

Gary worked at NRAO Green Bank for 15 years and was often involved in SARA Conference tours of the labs, anechoic chamber, and antenna range test setups. I would often see Gary at the Shelby Hamfest each year. 2025 was his 50th year attending that Hamfest. I'm one year older than Gary and have been camping out at that hamfest almost as long. At the Shelby Hamfest this Labor Day weekend he showed me a new camera he planned to mount on his Dobsonian optical telescope. As is often the case, "we thought we had more time. "

Gary had left NRAO in 2012 to help his sister care for their mother in her final years at the home he grew up in in Stuart Virginia.

Gary's funeral was well attended and had a definite ham radio retrospective feel with one ham even having recorded "W4IVF SK" in morse code to end the service with. Even the officiating minister was a ham. The visitation included slide shows and videos of various contests and Field Days and Microwave outings with Gary doing 10 GHz two ways many decades ago.

Gary even did the hymns for his own service without planning it. He had restored many old 1940's family choir recordings including "Amazing Grace" which was played at the service.
https://www.moodyfuneralservices.com/obituaries/gary-anderson#

Gary Anderson inspecting a 24 GHz dish at the Shelby Hamfest.

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)

2026 SARA & Radio Jove Eastern Conference
August 1 (Sat) – August 5 (Wed) 2026
Green Bank Observatory (GBO) West Virginia (WV)

Block your calendars and start thinking about next year's travels. The 2026 Eastern Conference has been set to occur the first week in August 2026 back in Green Bank WV!

- 2026 SARA and Radio Jove Eastern Conference
- August 1 (Sat) – August 5 (Wed) 2026
- Green Bank Observatory (GBO) West Virginia (WV)

We will be following a similar format as years past. For example:

- Saturday (8/1): Guided tours of public exhibits, Dave Lacko and Jay Wilson discussion on "What is Radio Astronomy Anyhow?", hands on workshop assembling Scope in a Box and eZRA software
- Sunday (8/2): hands on workshop for 40' telescope and 20-meter telescopes, with attendees able to plan and make observations
- Monday – Tuesday: Technical discussions
- Wednesday (8/5): Guest Speaker and technical tours of GBO
- Evenings: Drake lounge discussions, flea market, and observations using Scope in a Box, Radio Jove, Super SID, 40', 20 meter telescopes

Any comments and/or suggestions please reach out to the committee chair Marcus Fisher (vicepresident@radio-astronomy.org)

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] Radio Jove kit
[4] Inspire
[5] 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 3rd October 19:30 BST (18:30 UTC)
Solar Energetic Particles, Solar Eruptions, Space Weather

We welcome the BAA Solar Section to this joint meeting.

Dr Timo Laitinen University of Central Lancashire

Timo has been a post-doctoral research associate at the Jeremiah Horrocks Institute (JHI) in UCLan since 2010 and is a member of the JHI's solar physics research group. Previously, he worked as a University Lecturer in Turku, Finland, and he has worked as a post-doctoral researcher in Finland and Germany. He works on the modelling of energetic particle transport in the heliosphere, has experience in energetic particle observations, and is involved in space-borne missions.

Join Zoom Meeting
https://us02web.zoom.us/j/86239932018?pwd=9mByt4aFbME56dtQTz8jFozByQe6Nq.1

Meeting ID: 862 3993 2018
Passcode: 809192

Friday November 7th 19:30 (19:30 UTC)
Dr Katharine Mulrey Associate professor - Astrophysics (Radboud University, the Netherlands)
The detection of ultra-high-energy cosmic rays and neutrinos through their radio signals

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.

Friday December 5th 19:30 (19:30 UTC)
Diane Swan
Exploring the radio emission of Core Collapse Supernova SN2017eaw, and glimpse at the eMERLIN array.

On the 15th of May 2017, a new supernova in the galaxy NGC6946, (the Fireworks Galaxy), was reported from visual observation by Peter Wiggins, and at a distance of approximately

5.5Mpc, this is in our cosmic back yard. Consequently, this supernova has been well observed at frequencies across the EM spectrum, but unusually we have detailed radio observation in the ranges, L, C, X U and K. Interpretation of the radio data, provides a range of information about the progenitor, its behaviour in the final years prior to the explosion, and the physical processes linked to the radio emission.
Dian will explore: The nature of Core Collapse Supernovae, Progenitor behaviour and its influence on radio emission, Why is it unusual to have radio observation at all!

Friday 23rd Jan. 2026 19:30 GMT (19:30 UTC)
An evening at Dwingeloo - Live observations.
Tammo Jan Dijkema and Thomas Telkamp

With the historic Dwingeloo 25m radio telescope, we can observe many interesting sources: pulsars, OH masers, continuum sources, galactic and extragalactic neutral hydrogen to name a few. We will present from the cabin of the Dwingeloo telescope.

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

e paul@hearn.org.uk
a RG6 1BU UK
t +44 (0)7967 388 578

SuperSID

SuperSID
Collaboration of Society of Amateur Radio Astronomers and Stanford Solar Center

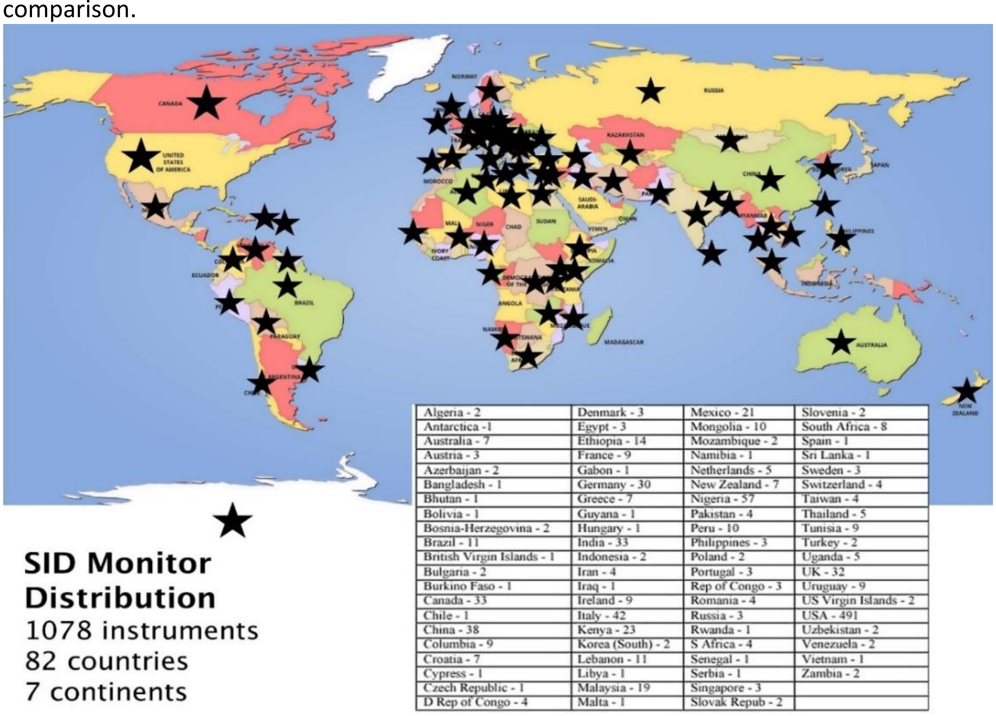
- Stanford provides data hosting, database programming, and maintains the SuperSID website
- Society of Amateur Radio Astronomers (SARA) sells the SuperSID monitors for 48 USD to amateur radio astronomers and the funds are then used to support free distribution to students all over the world (image below 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	

-

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

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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.

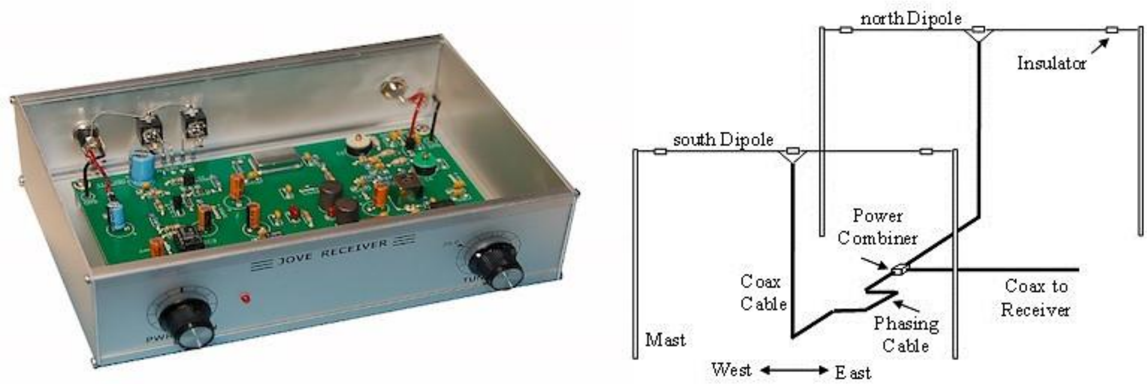

Figure 1. A Radio JOVE RJ1.1 receiver and a schematic of the dual-dipole antenna.

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).

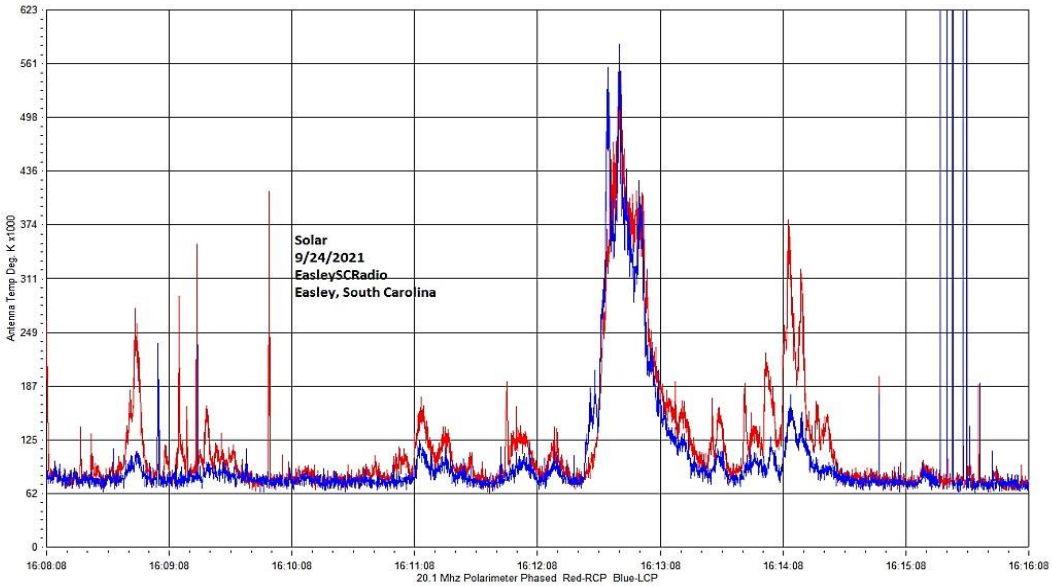

Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver. John Cox, SC.

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.

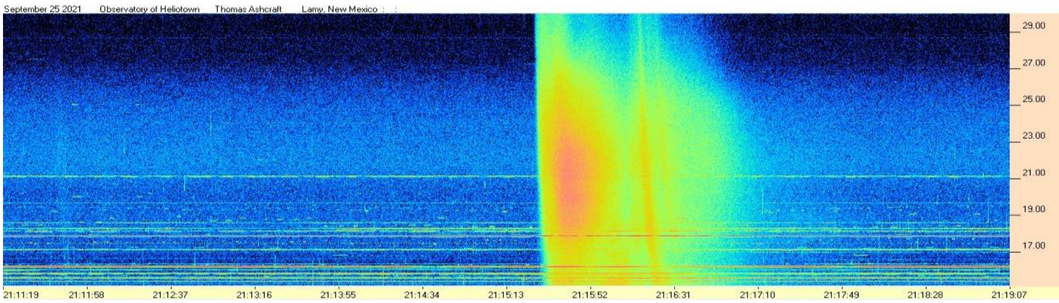

Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time, and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

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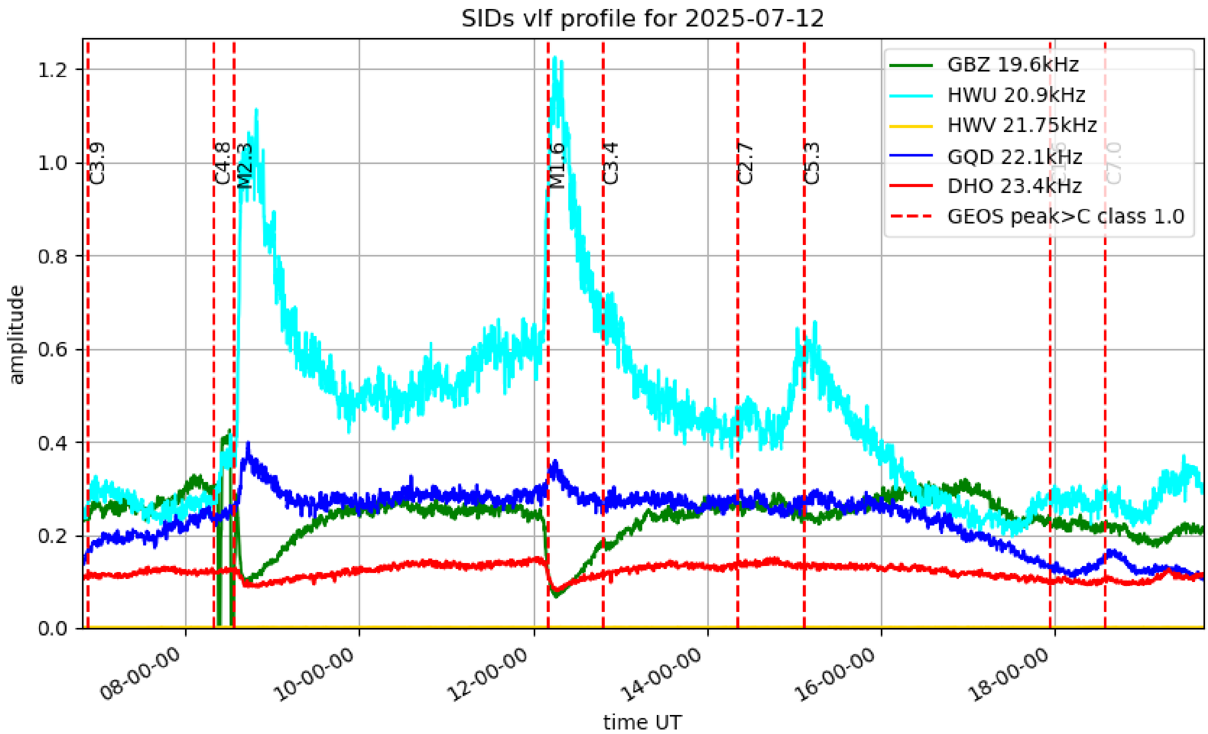
Please send questions, reports, and observations to John Cook: jacook@jacook.plus.com

BAA Radio Astronomy Section, Director: Paul Hearn

RADIO SKY NEWS **2025 JULY**

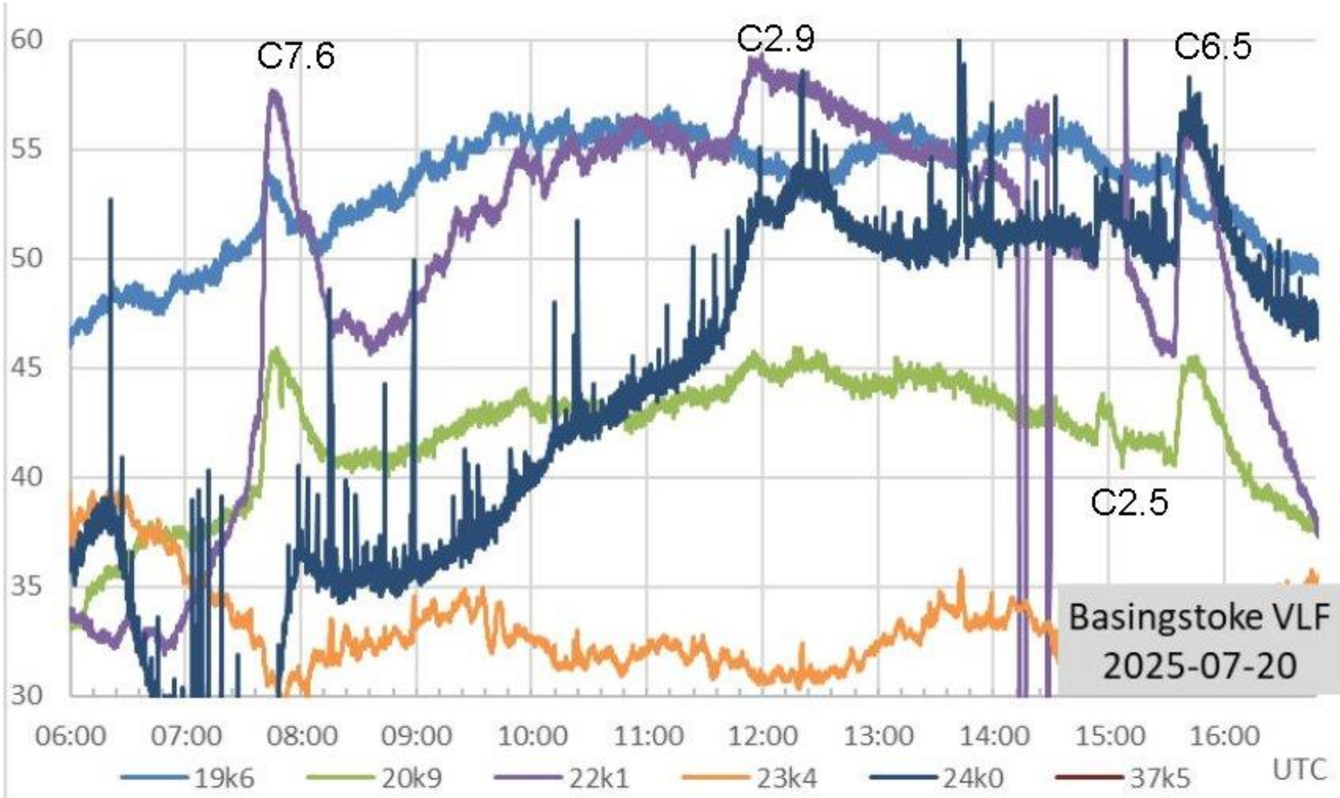
VLF SID OBSERVATIONS

Solar activity in July has again fallen, with only 35 flares recorded as SIDs. There were just two M-class flares recorded. The SWPC satellite list shows that there were no X-class flares. The activity chart shows that this is the lowest number of SIDs recorded since 2022 June.

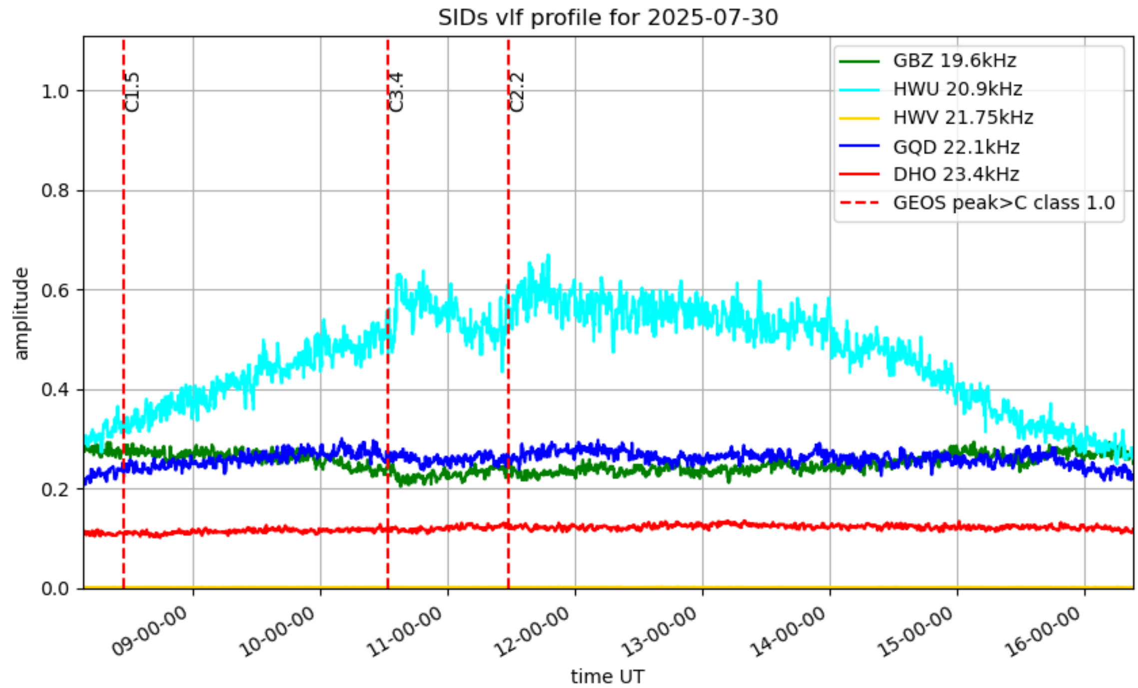


This recording by Mark Prescott shows the pair of M-flares on the 12th along with some of the smaller C-flares. 22.1kHz shows both of the M-flares and also shows a small response from the C7.0 flare at 18:36. 19.6kHz has inverted SIDs for the M-flares. 23.4kHz has a much weaker response to all of the activity. 20.9kHz from France has a very strong response to the stronger flares but also shows a small SID for the C2.7 flare at 14:24UT. Most of the activity that we recorded was from C-flares, the

SWPC satellite lists including plenty of weaker events that we missed. We last recorded SIDs from B-class flares in 2022.

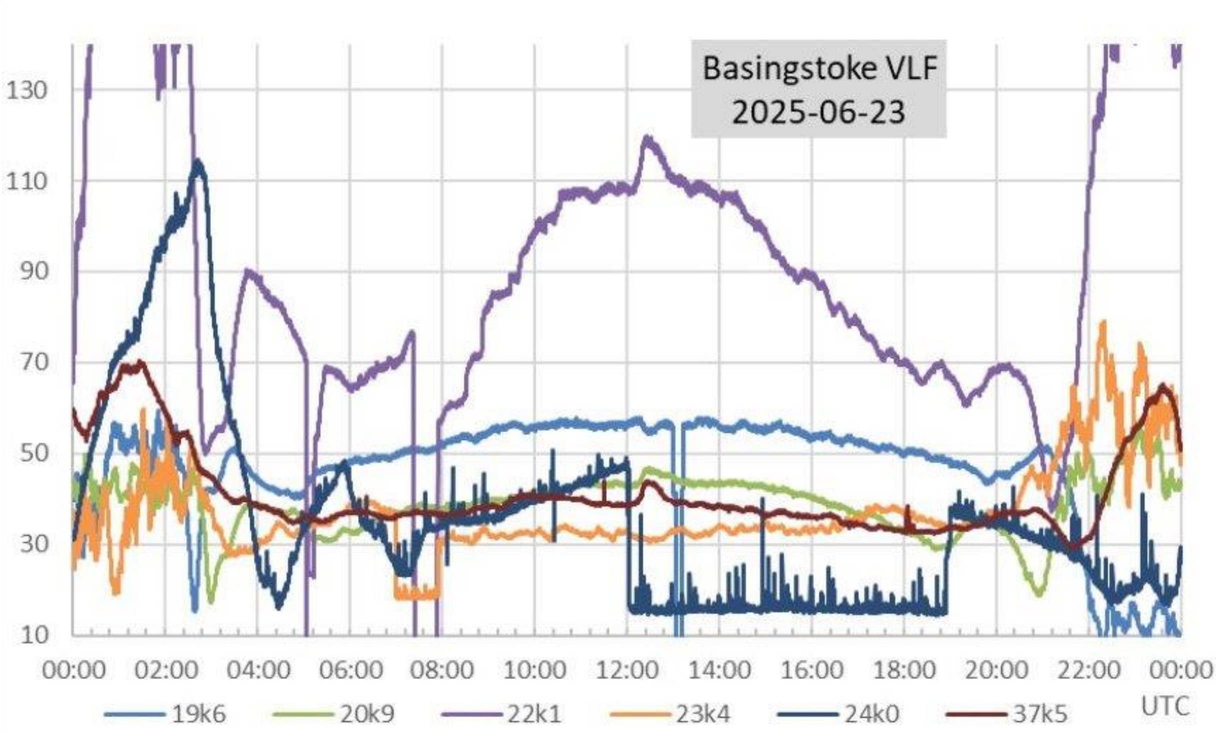


Paul Hyde's recording from the 20th shows more of the C-class activity. 19.6kHz and 22.1kHz again show the best SIDs from the weaker flares, 24kHz and 20.9kHz catching the later C6.5 flare. 23.4kHz remains very noisy and unresponsive to any of the activity.



Activity was quite low in the last week of July, Mark Prescott's chart from the 30th showing SIDs from C3.4 and C2.2 flares at 20.9kHz

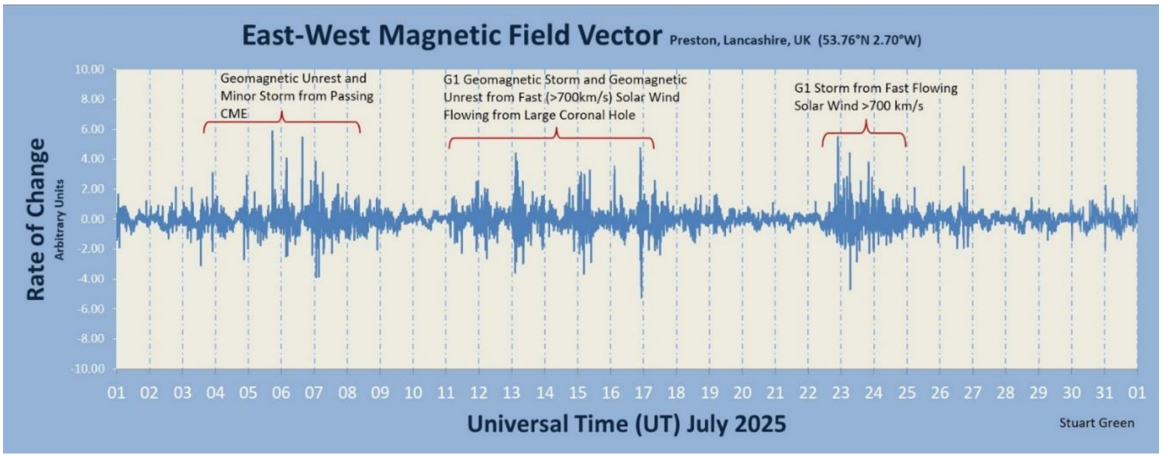
In the June report I included a recording from Mark Prescott showing an unusual diurnal curve at 22.1kHz. Paul Hyde has responded with his own recording, showing exactly the same effect:



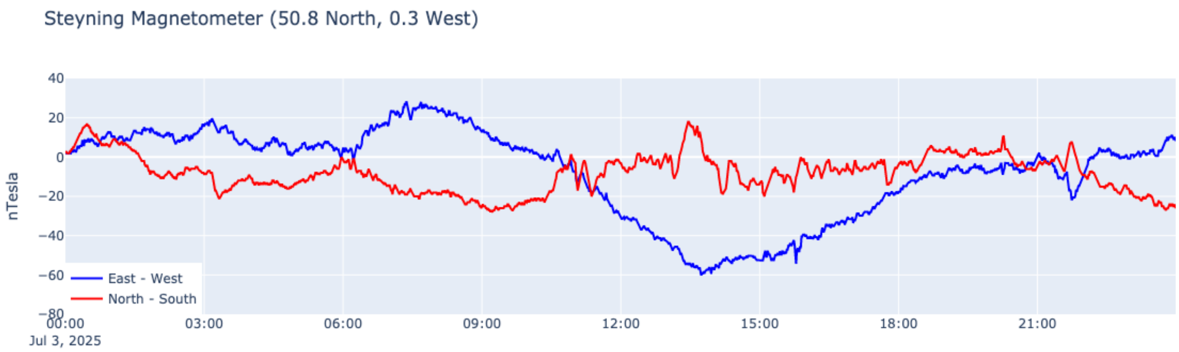
Checking back on my own recordings, it looks like the signal level increased overnight into the early hours of June 23rd. The signal level then remained high through the rest of the 23rd and into the

24th. There was a short break in the signal around 07:30 on the 24th, after which the signal level was back to normal.

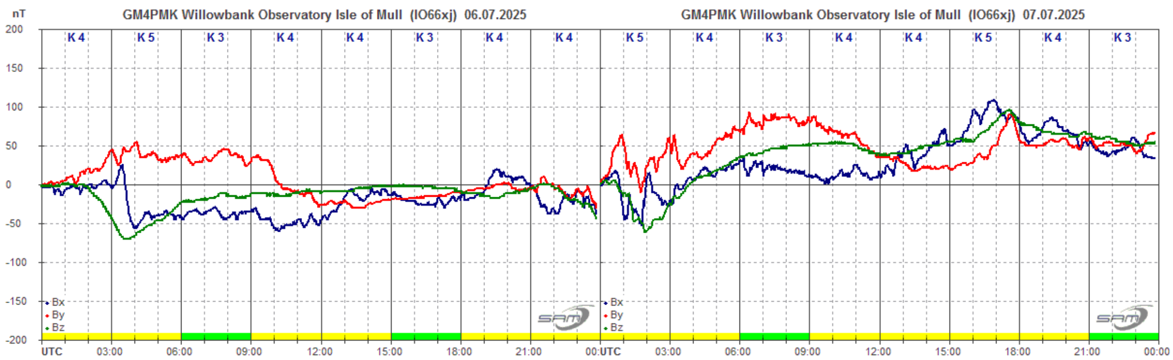
MAGNETIC OBSERVATIONS

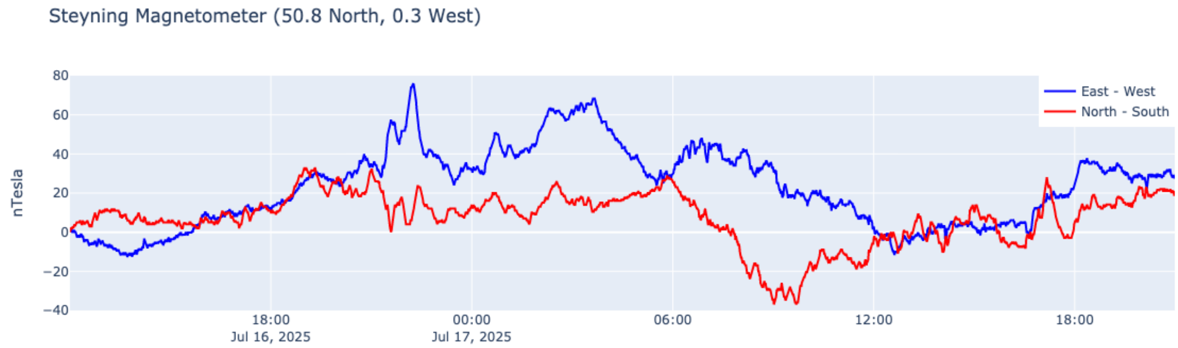


The monthly summary of magnetic activity from Stuart Green shows three periods of disturbance. These were mostly from coronal hole high speed winds, with a glancing CME adding to the effect at the start of the month. There were a number of CMEs detected in satellite images, but they were not Earth-directed.

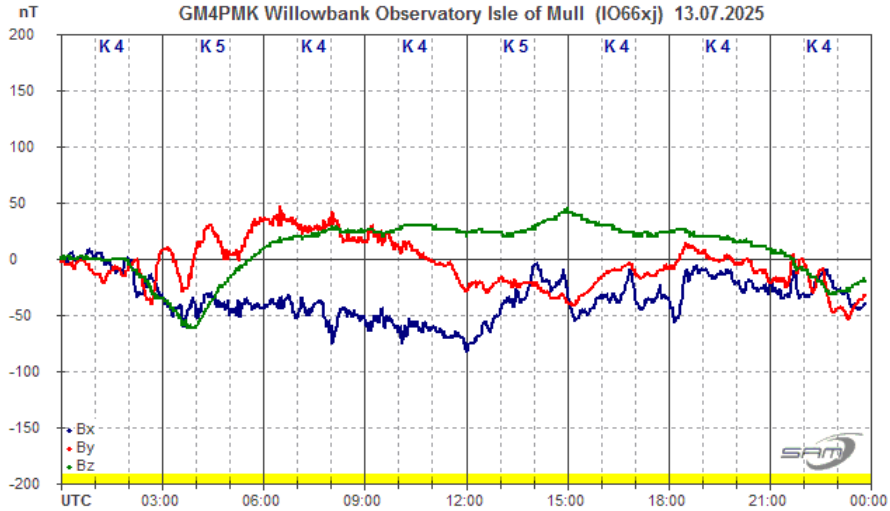


Nick Quinn's recording from the 3rd shows a possible impact from the CME at about 10:45UT, followed by some rapid turbulence. The solar wind speed increased over the next few days, with some stronger activity on the 6th and 7th shown in Roger Blackwell's recording:



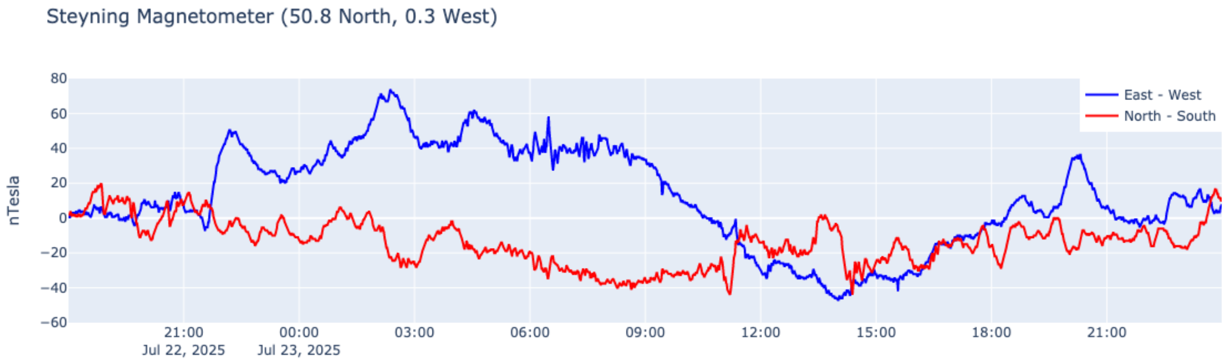


A much larger coronal hole started to cross the solar meridian by mid-month, with some stronger disturbance recorded on the 16th and 17th by Nick Quinn.



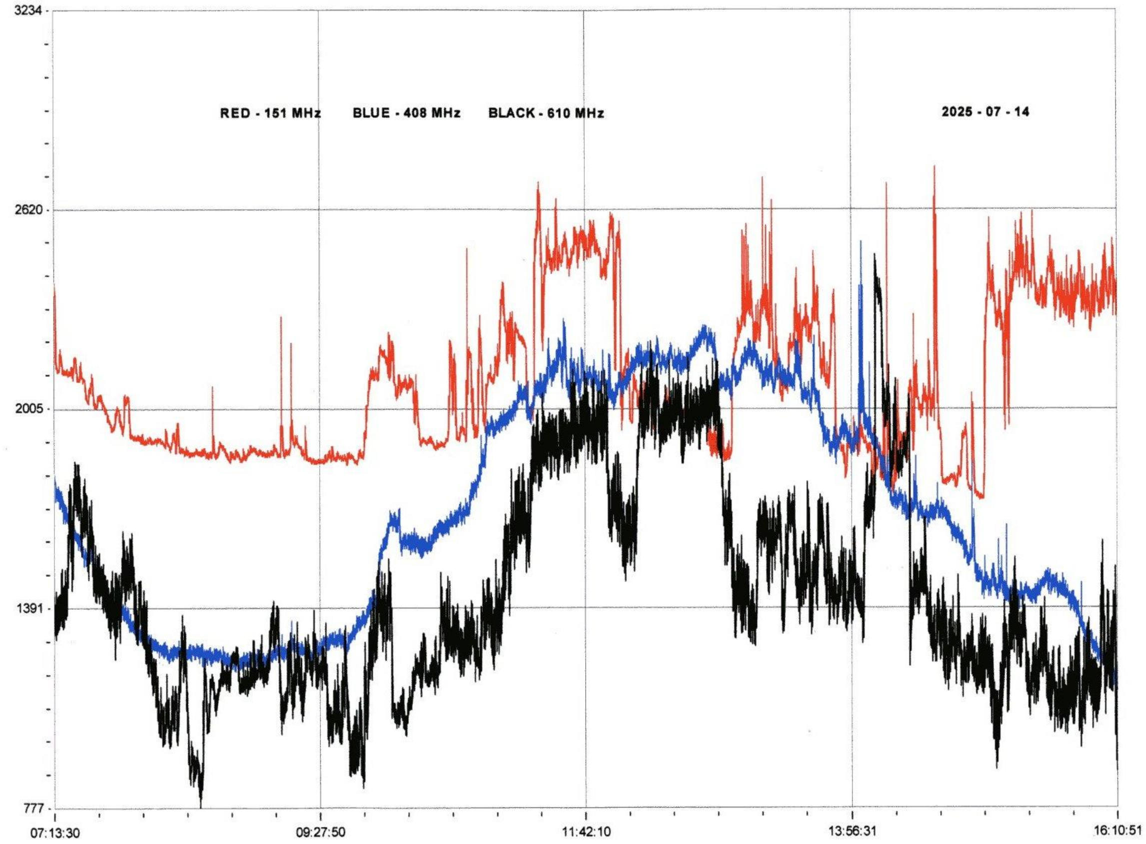
A much more rapid turbulence was recorded on the 13th by Roger Blackwell. It is interesting that the Bz component (green trace) does not show the turbulence.

More coronal holes were seen later in the month, with another strong disturbance recorded by Nick Quinn on the 22nd and 23rd.



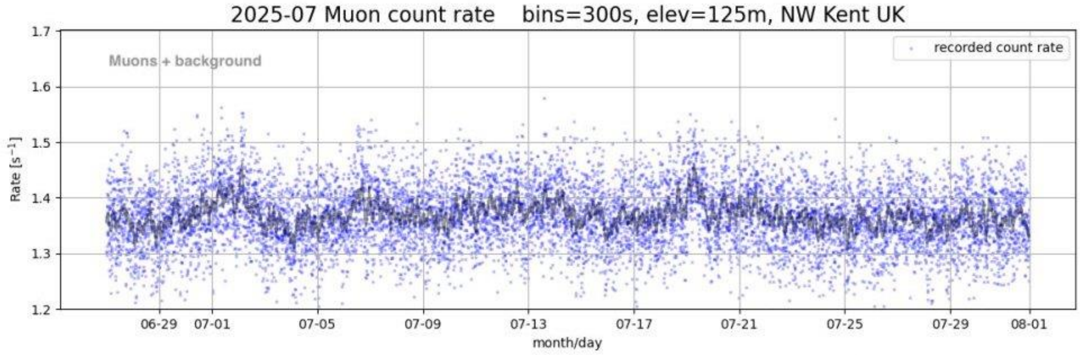
Magnetic observations received from Roger Blackwell, Stuart Green, Nick Quinn, and John Cook.

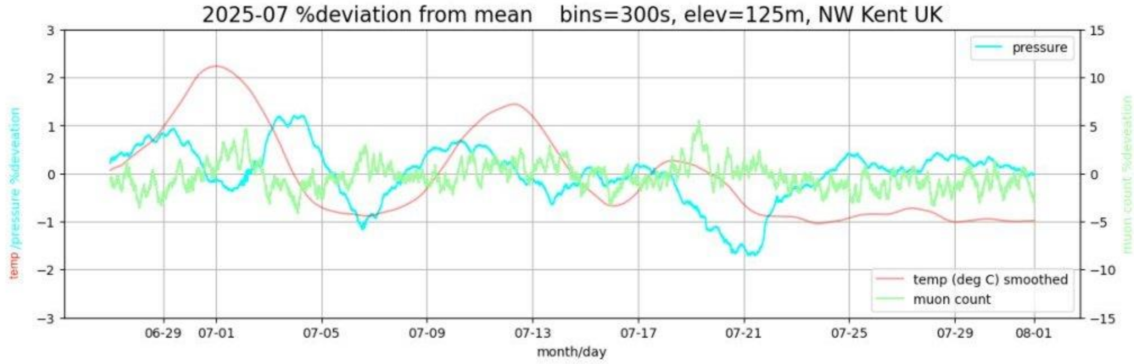
SOLAR EMISSIONS

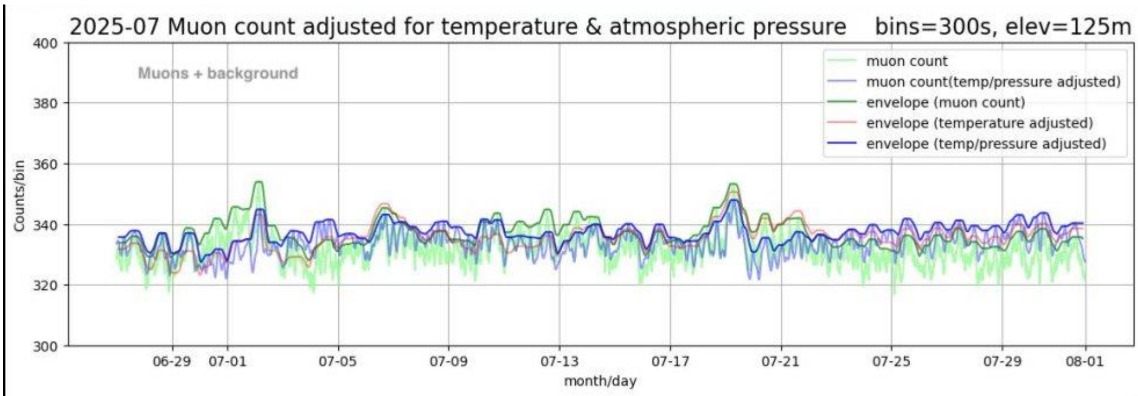


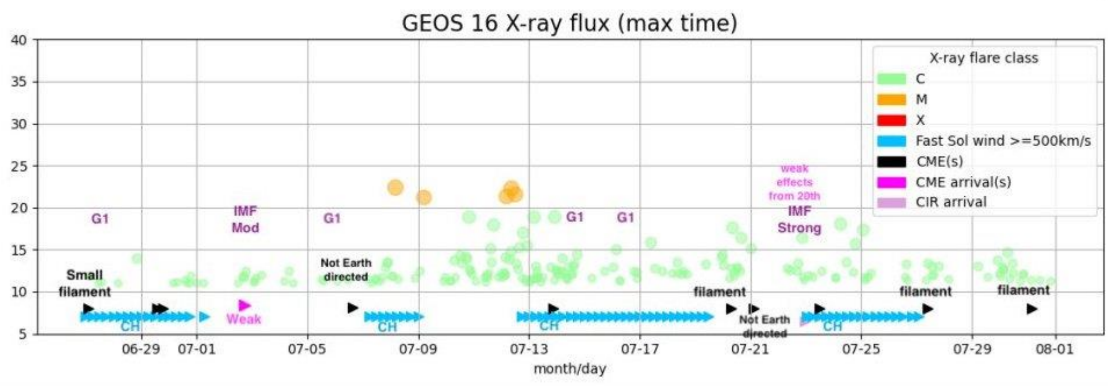
Colin Clements recorded some strong VHF/UHF solar emissions on the 14th. Our SID recordings show a C2.9 flare peaking around 09:40UT, with no further activity until 16:00. The SWPC does include a radio emission warning at 10:45, which matches with the timing of Colin's chart. All three frequencies are active, 408MHz showing a smooth rise and fall through the day, while 151MHz remains active to the end of the recording. Colin also recorded emissions on the 17th, possibly related to the C5.9 flare.

MUONS

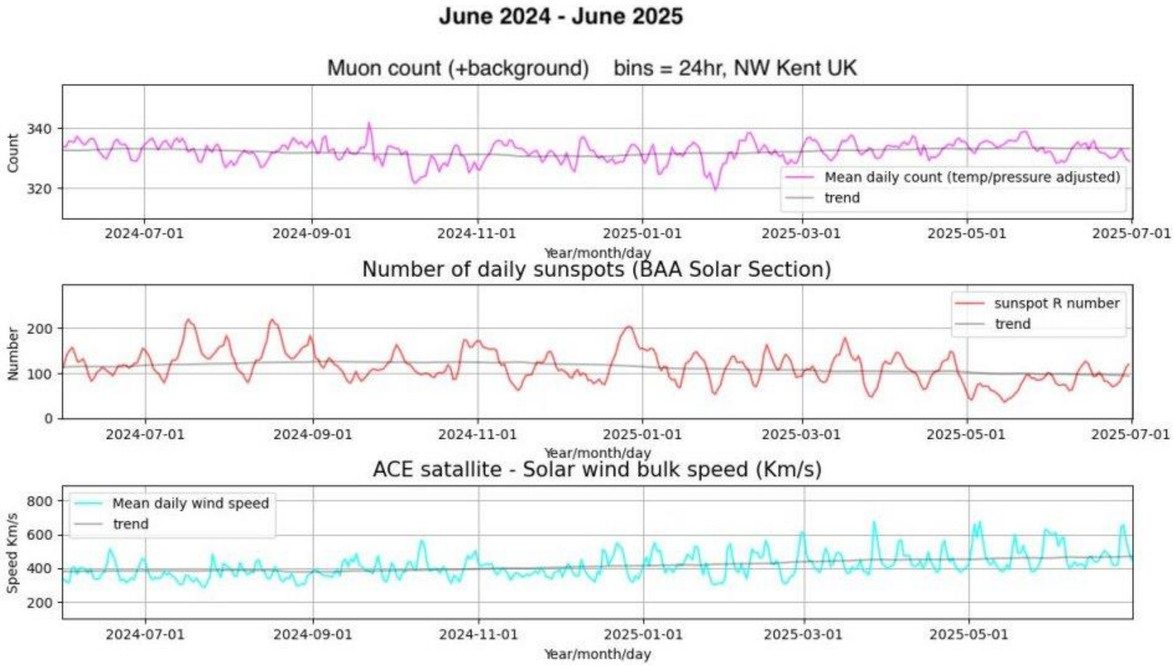

2025-07 Muon count rate bins=300s, elev=125m, NW Kent UK
Muons + background
recorded count rate
Rate [s^-1]
month/day


2025-07 %deviation from mean bins=300s, elev=125m, NW Kent UK
pressure
temp (deg C) smoothed
muon count
temp/pressure %deveation
muon count %deveation
month/day


2025-07 Muon count adjusted for temperature & atmospheric pressure bins=300s, elev=125m
Muons + background
muon count
muon count(temp/pressure adjusted)
envelope (muon count)
envelope (temperature adjusted)
envelope (temp/pressure adjusted)
Counts/bin
month/day


GEOS 16 X-ray flux (max time)
X-ray flare class
C
M
X
Fast Sol wind >=500km/s
CME(s)
CME arrival(s)
CIR arrival
G1
IMF Mod
G1
G1
G1
weak effects from 20th
IMF Strong
Small filament
Weak
Not Earth directed
CH
CH
CH
CH
filament
Not Earth directed
filament
filament
month/day

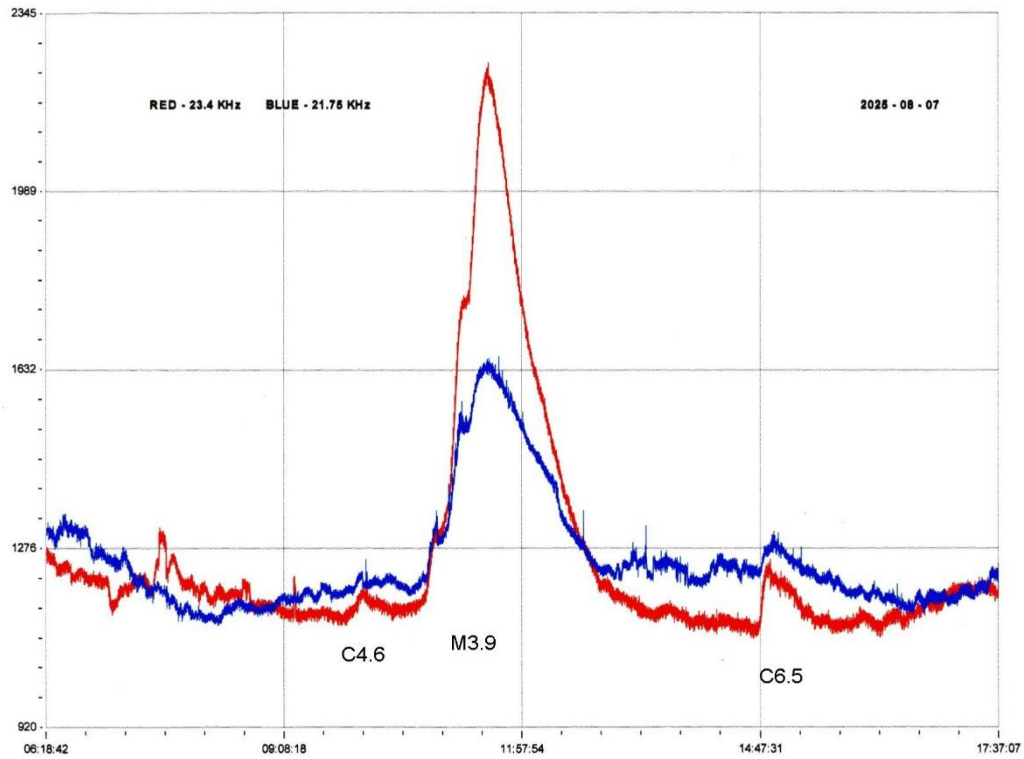
The Muon flux charts from Mark Prescott show two distinct peaks, the first matching the CME impact on the 3rd. The count drops after the impact, rising again after the solar wind speed returns to normal. The second peak is between the second and third periods of increased solar wind speed on the 19th-20th. The muon count falls again as the coronal hole becomes active. There is a general trend of increasing muon flux through the month, as the solar activity slows down.



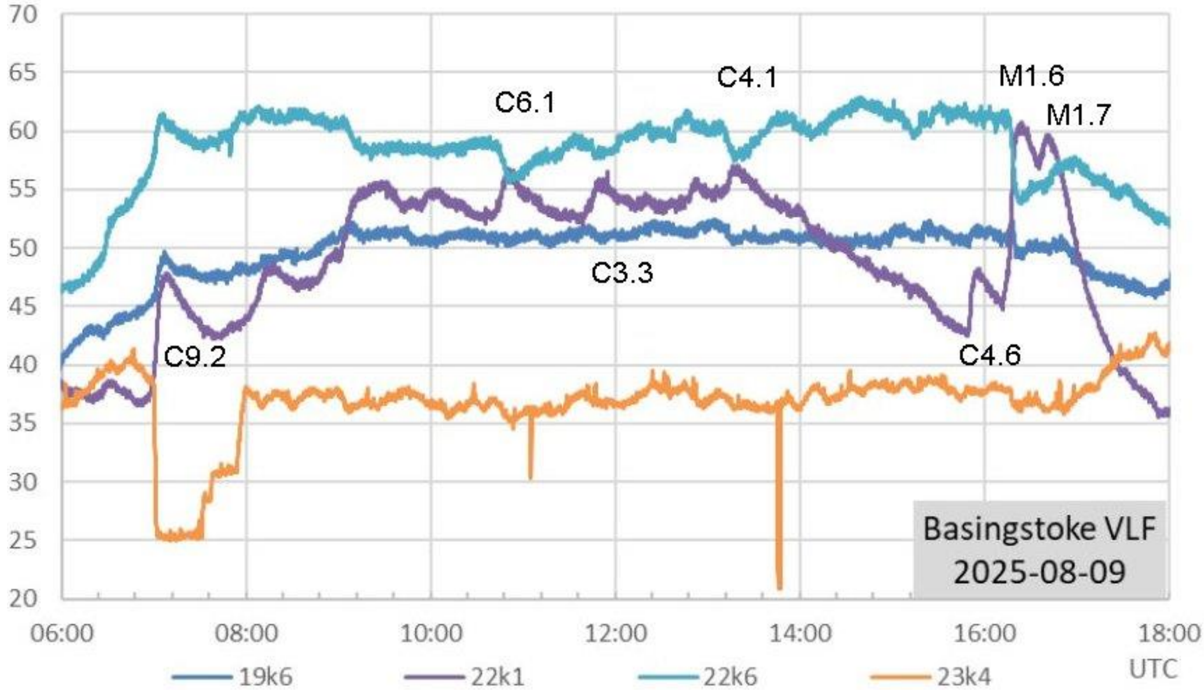
Mark has also provided a comparison of Muon counts and Solar activity over the last 12 months. The Muon counts were lower during the last few months of 2024, rising again this year. The last couple of months have remained fairly flat. The Muon counts are generally lower this year compared to those recorded in 2022 as the current solar cycle activity started to rise. Overall, there seems to be an anti-correlation between sunspot numbers and muon counts. The lower panel is the solar wind speed measured by the ACE satellite and shows much greater variation this year as sunspot numbers fall and coronal holes become more active.

VLF SID OBSERVATIONS

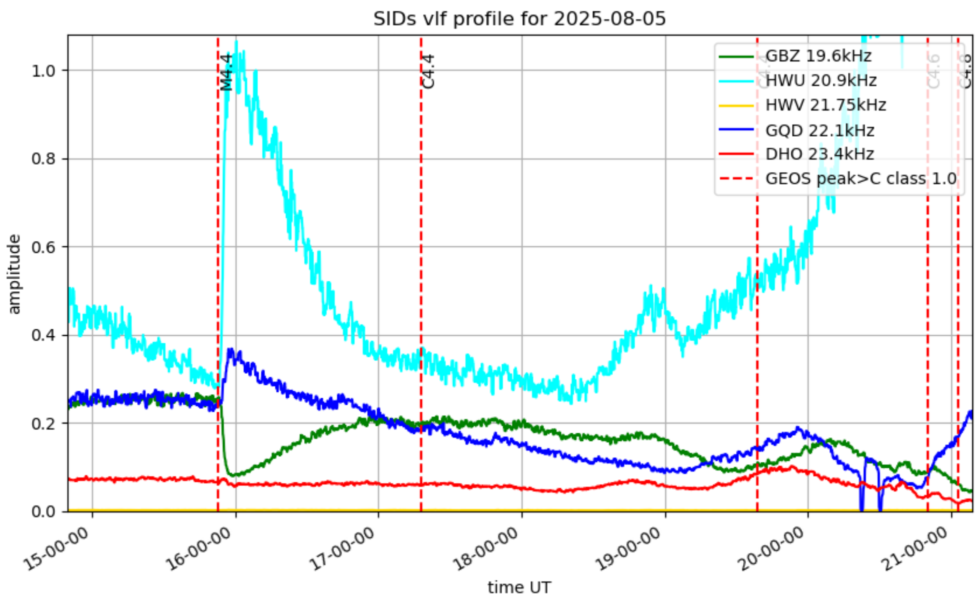
Solar activity in August increased after falling in June and July. We recorded 66 flares as SIDs in August compared with 50 in June and 35 in July. The flare strength also increased, with 18 M-class recorded. The satellite X-ray data does not show any X-class flares in August. August's flaring activity shows a large gap from the 16th to 22nd when no SIDs were recorded. The satellite data for this period includes mostly very small C-class flares, with a few M-flares during our night-time. The Bartels chart shows a similar reduction in activity In July and June, matching the solar rotation. Solar section data also shows a drop in sunspot counts during these periods.



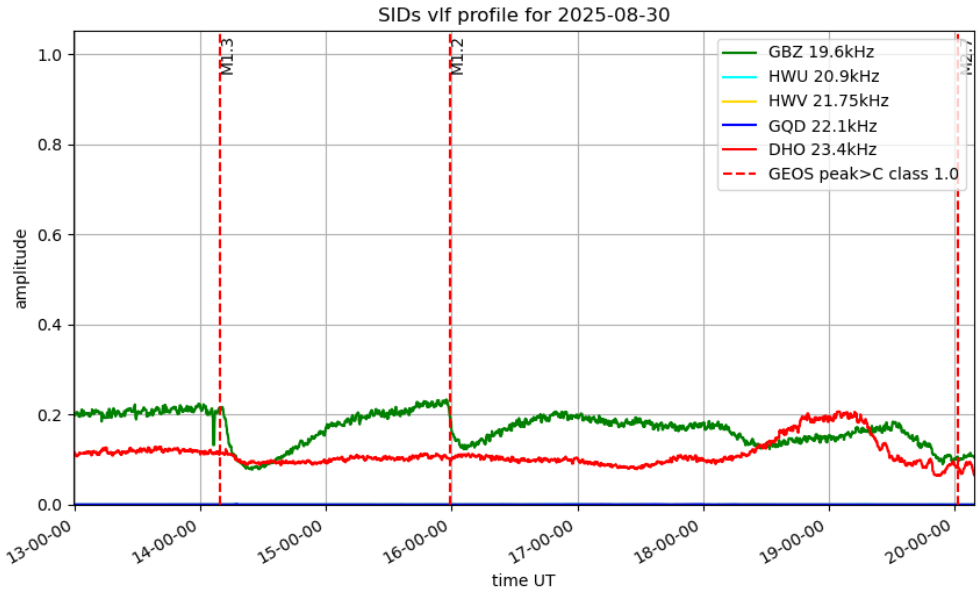
Colin Clements' recording from the 7th shows one of the stronger flares, at M3.9. Both signals show two minor peaks during the rising phase of the flare, a feature also shown in my own recording. The satellite data shows that there were two nearly simultaneous flares from the same active region. Colin's chart also shows the two smaller flares clearly at 23.4kHz.



August 9th was another busy day for flares, including another multiple peaked event seen near the end of Paul Hyde's recording. The M1.6 and M1.7 flares peaked about 20 minutes apart, following the weaker C4.6 flare about 20 minutes earlier. All of the flares shown were from the same active region. 22.1kHz and 22.6kHz show clear mirror SIDs, while 23.4kHz has remained unresponsive. 19.6kHz only shows a very weak response to the stronger flares, which is rather unusual for this signal.

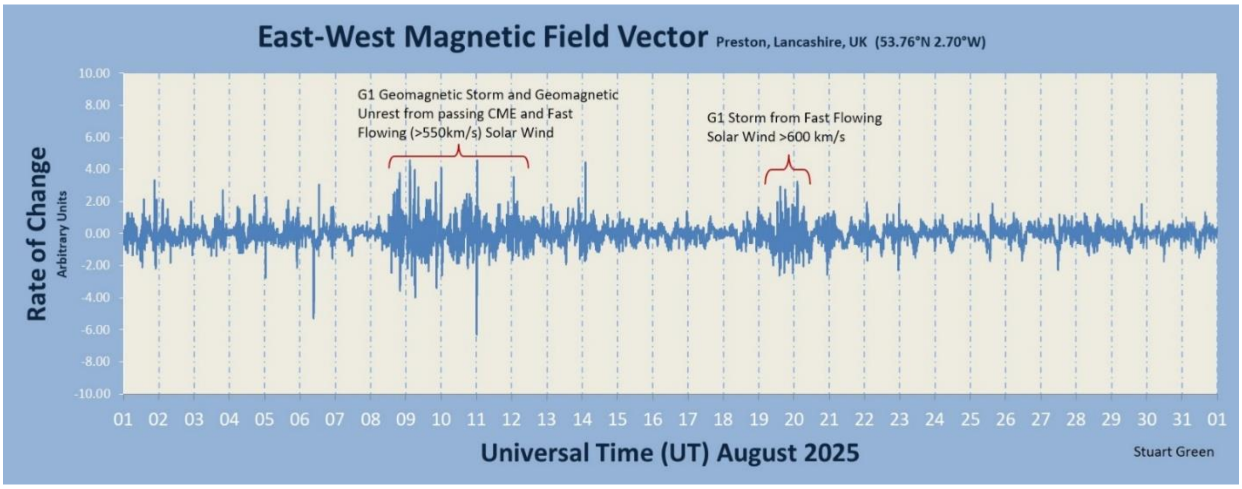


Mark Prescott recorded a strong SID from the M4.4 flare on the 5th. This was quite late in the afternoon, but the longer summer day length allowed it to show before the sunset effects started. 19.6kHz and 22.1kHz show their usual mirror SIDs. The C4.4 flare is not very clear but has left a small trace. 23.4kHz is again unresponsive.

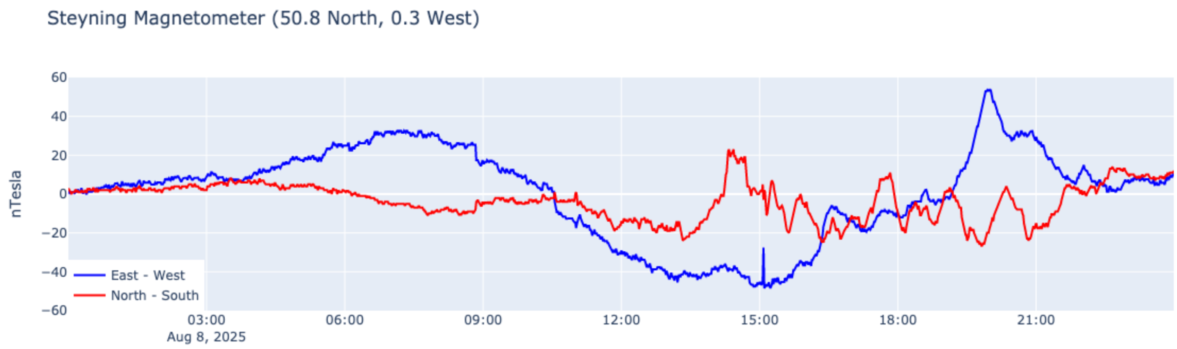


Activity picked up again in the last week of August, with another pair of M-flares on the 30th. These were far enough apart to produce individual SIDs, recorded by Mark Prescott at 19.6kHz. 22.1kHz went off-air on the 18th, remaining off for the rest of the month.

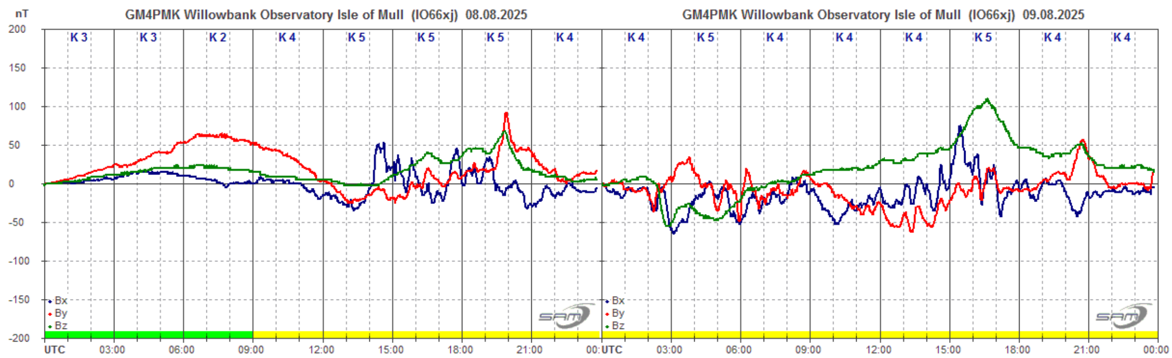
MAGNETIC OBSERVATIONS



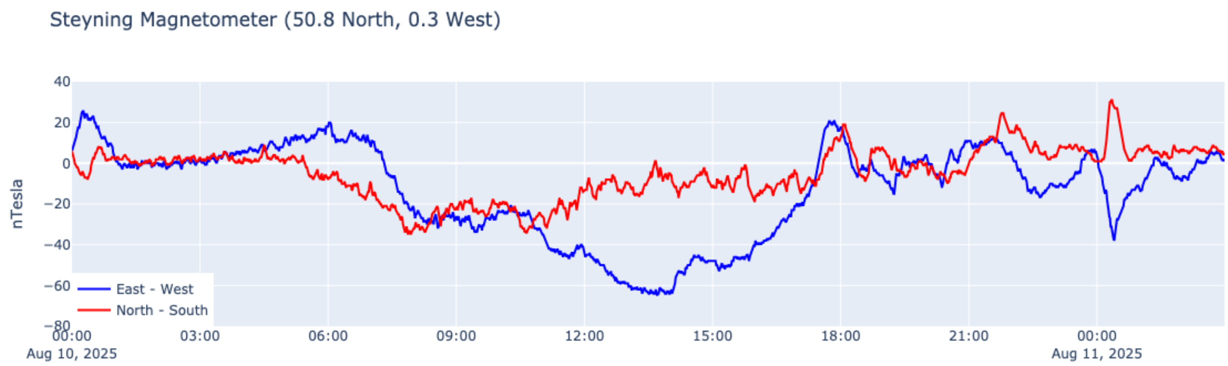
The summary of magnetic activity from Stuart Green shows just two periods of significant disturbance. The first of these started in the afternoon of the 8th, shown in the recording from Nick Quinn:

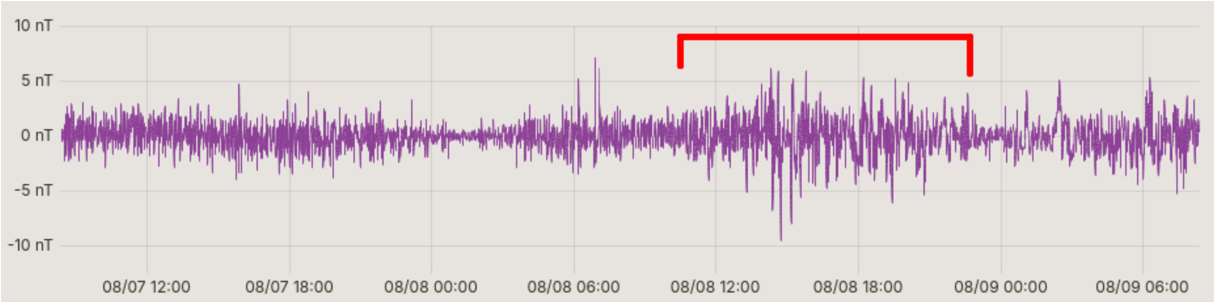


This activity appears to be a combination of a strong coronal hole solar wind and a CME. There is a noticeable spike in the East – West (blue) trace just after 15:00UT that initially looks like some local interference. However, there does seem to be a similar feature in the recording from Roger Blackwell:



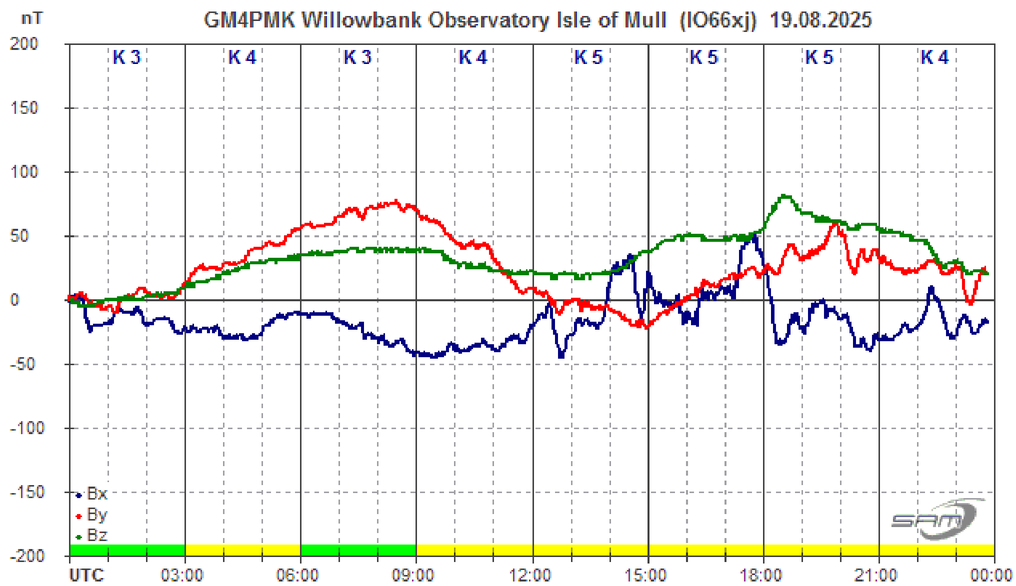
The vertical scale of this chart covers about twice the range, and so the spike does look much smaller. It is easiest to see in the Bx (blue) trace. It may be related to a CME impact, but it is not clear. Activity continued overnight, increasing again in the late afternoon of the 9th. Disturbance continued on the 10th, although much weaker, shown in Nick Quinn's recording:

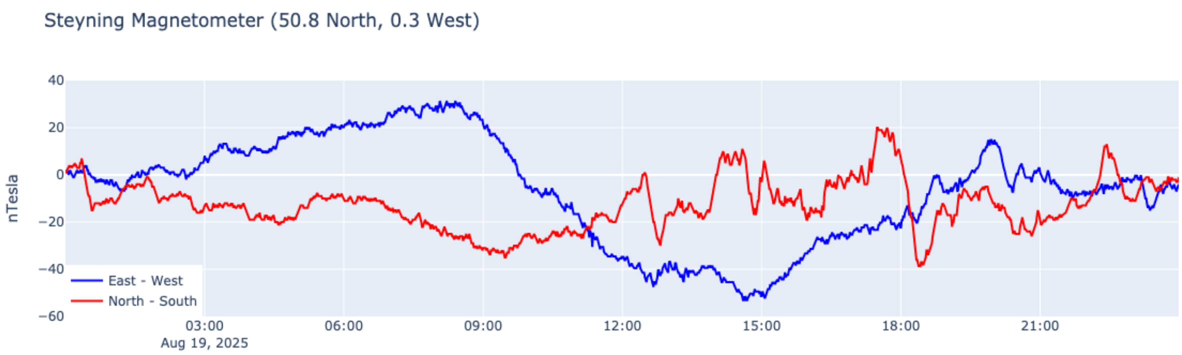




Thomas Mazzi also made a recording of activity on the 8th and 9th, although it appears much weaker from his location in Italy.

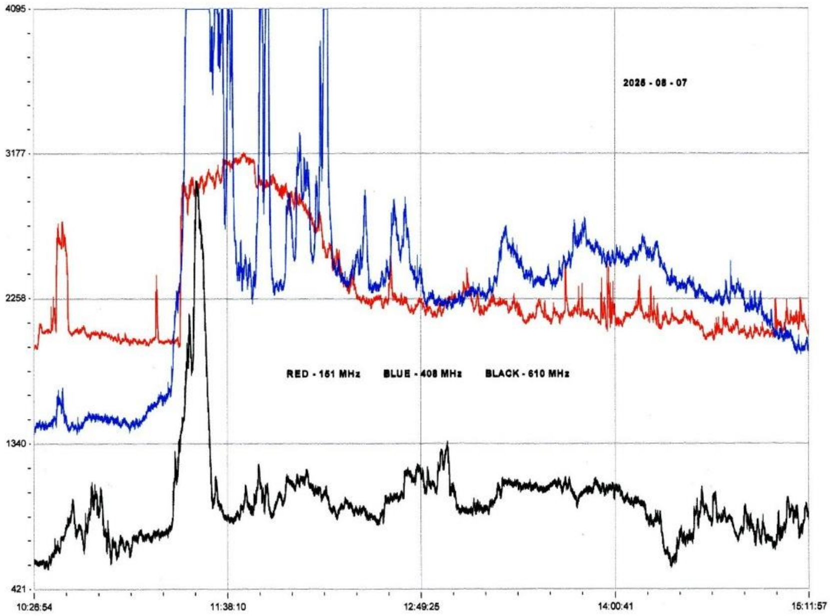
Further periods of activity were recorded on the 11th to 14th, mostly fairly weak as the solar wind speed decayed. The solar wind speed increased again on the 19th with a small disturbance over the next few days. The recordings from Roger Blackwell and Nick Quinn show very similar activity, although a little weaker at Nick's location near the south coast.



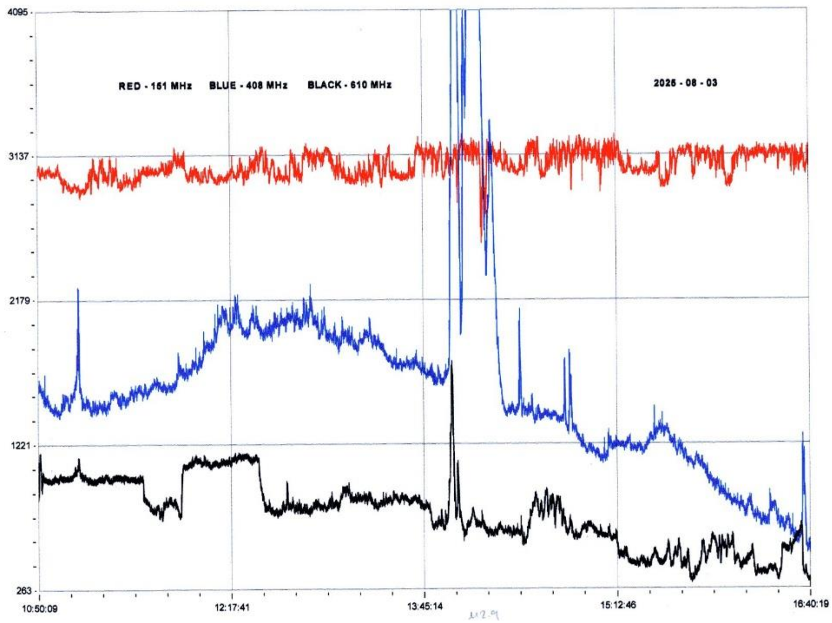


Magnetic observations received from Roger Blackwell, Stuart Green, Thomas Mazzi, Nick Quinn, and John Cook.

SOLAR EMISSIONS

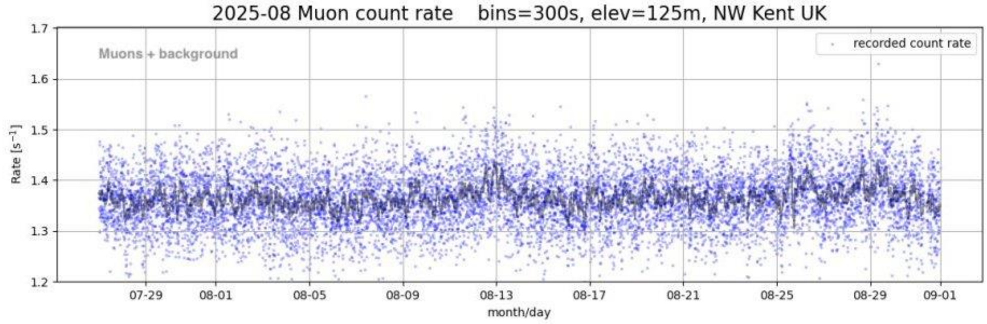


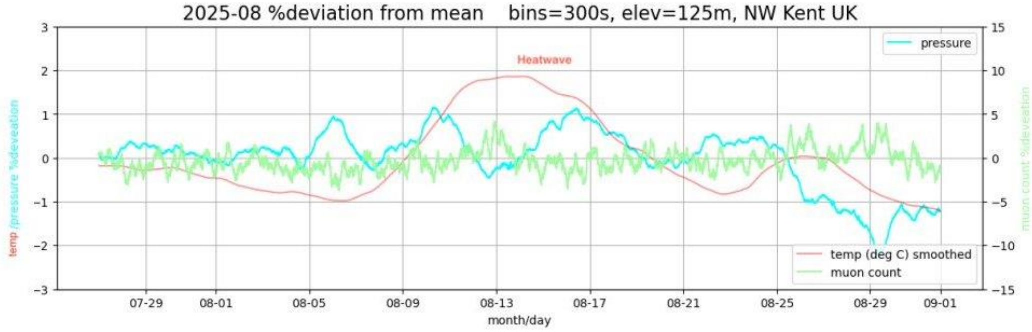
Colin Clements' VHF/UHF recording from the 7th shows very strong 408MHz and 151MHz emissions matching the M3.9 flare on the 7th. The 408MHz signal (blue) has gone off-scale with several peaks lasting about 90 minutes in total. 151MHz (red) has a more gentle signal, its peak being about 15 minutes after the flare's peak. 610MHz (black) shows a short sharp spike right at the start of the flare. All three frequencies appear to start at the same time.

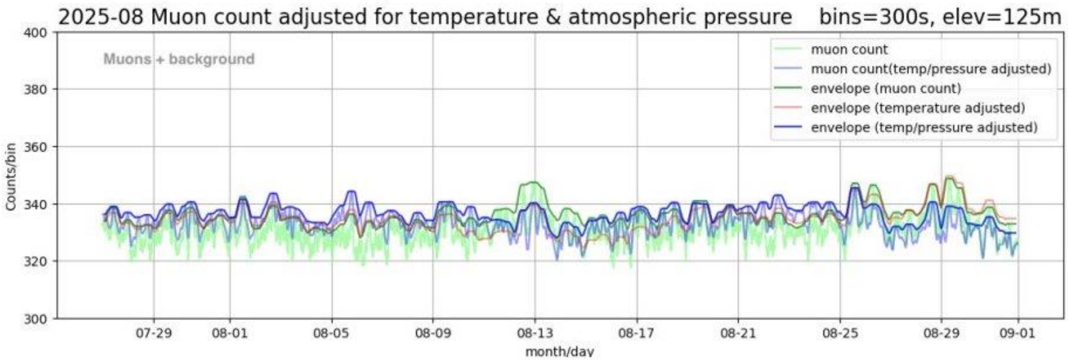


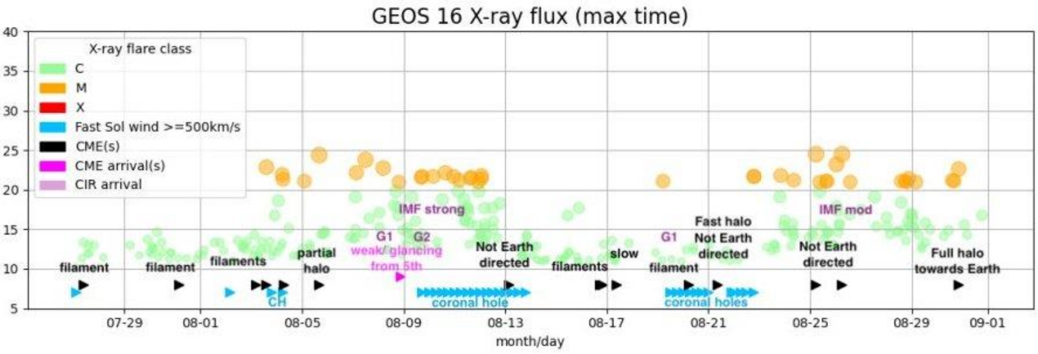
Colin's recording from the 3rd shows another very strong emission at 408MHz from the M2.9 flare at about 14:00UT. There is a very short 610MHz spike at the start of the flare, but 151MHz seems to show a small drop in signal level, probably not related to the flare. Colin also recorded emissions from the M4.4 flare on the 5th.

MUONS



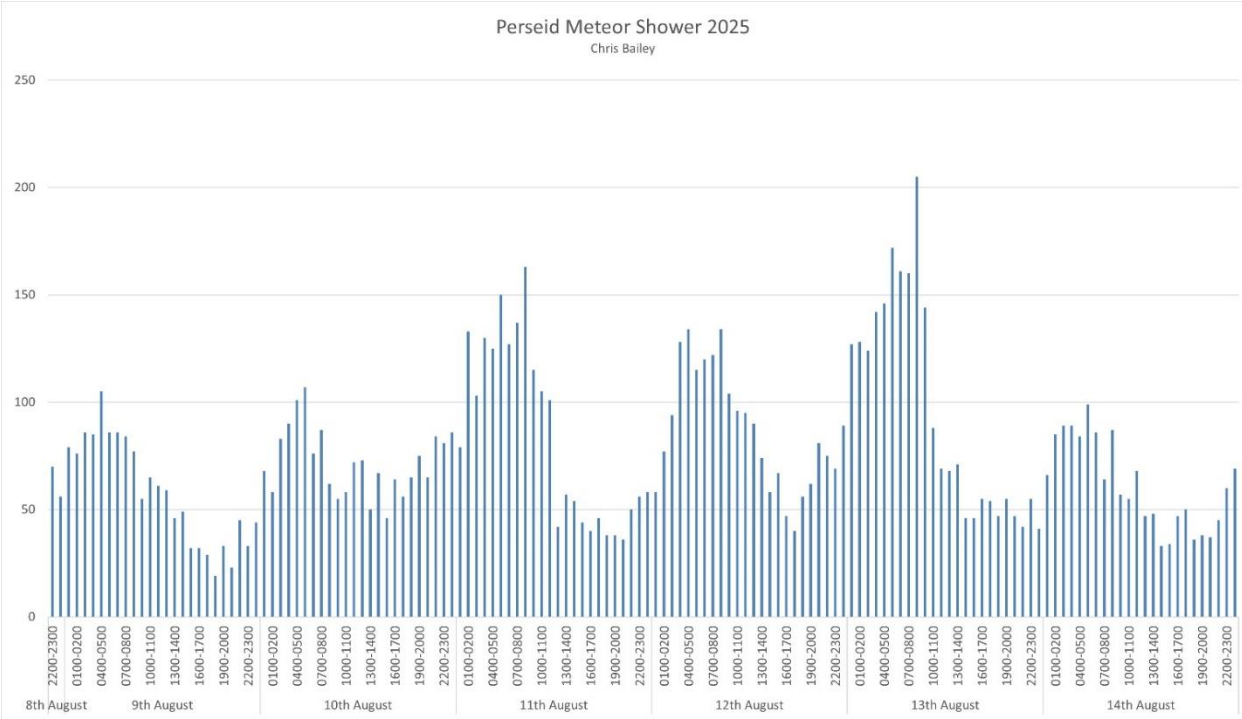




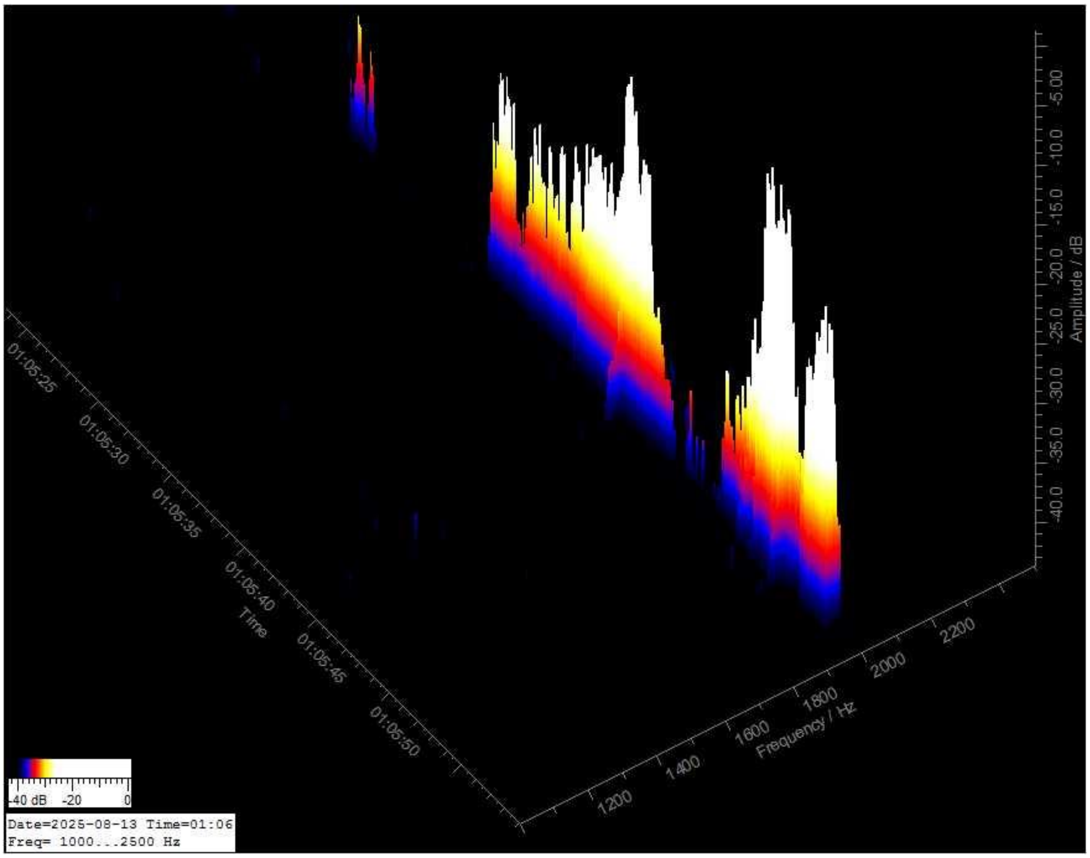


Mark Prescott has provided the usual charts of Muon activity in August, mostly fairly quiet. The weak CME on the 8th has not had any impact on the muon flux, while the faster solar wind between the 9th and 12th has produced a very small drop in the flux. Solar activity was very low from the 13th, with a steady rise in muon flux up to the 23rd when activity picked up again. The change in behaviour after the 25th may be due to the increasing flare strength, but there may also be a link to the very low atmospheric pressure over this period.

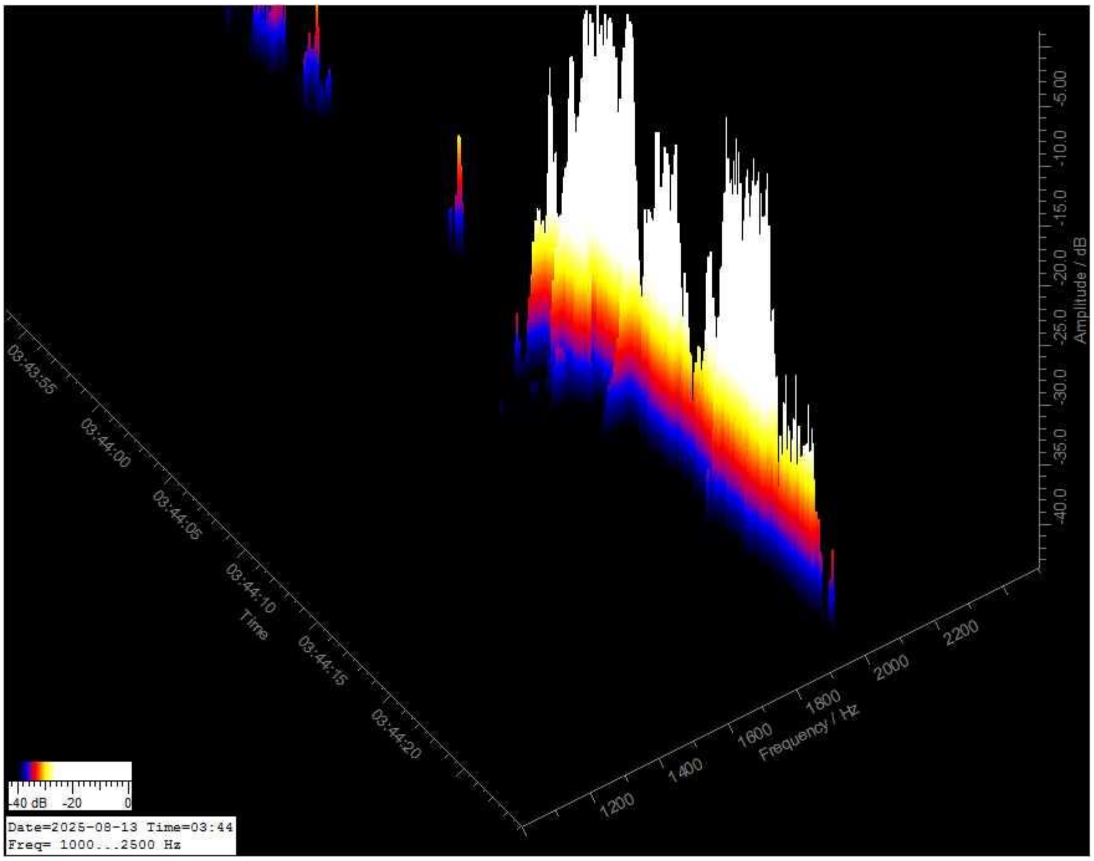
PERSEIDS



Chris Bailey made Perseid observations from the 8th to the 14th, using the GRAVES radio source. Each day shows the expected dip in counts in the afternoon and early evening, with peaks around 04 to 08UT. The peak in activity seems to be around 08UT on the 13th, with strong activity also on the 11th and 12th.



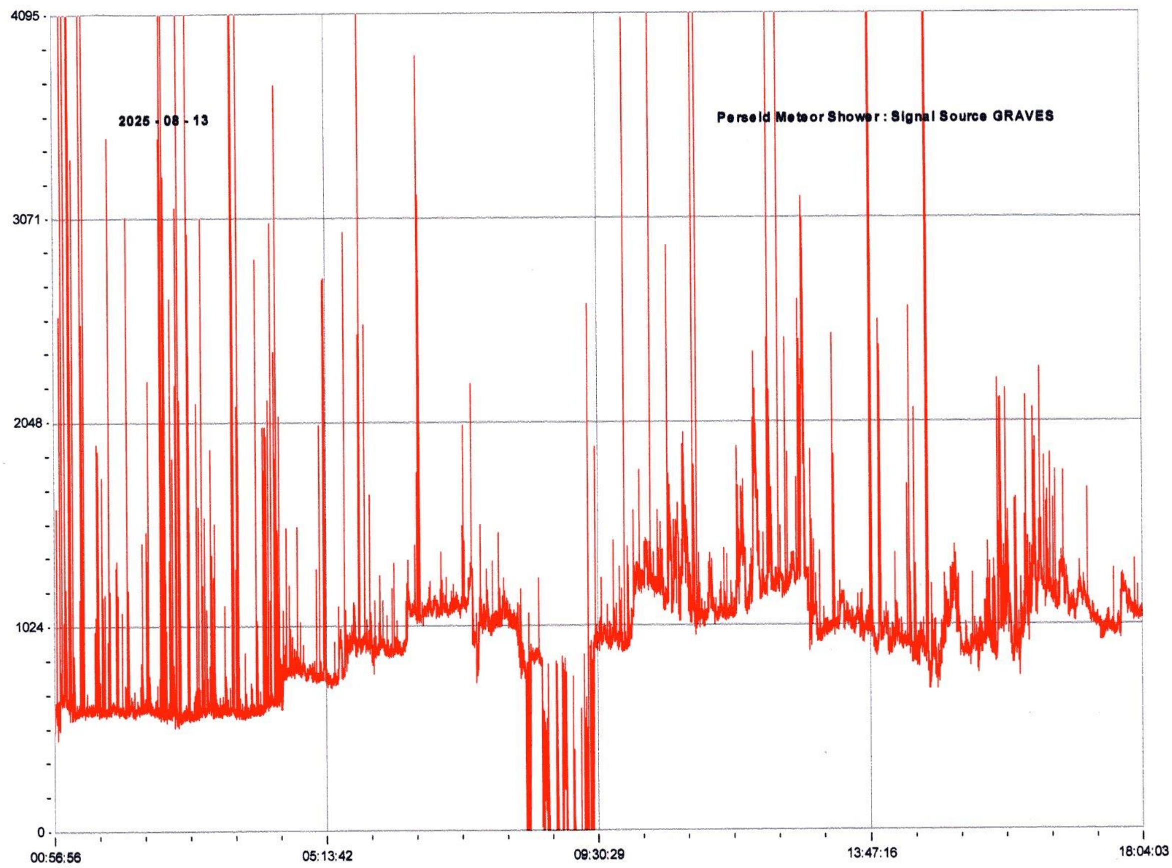
Amplitude / dB
-5.00
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
01:05:25
01:05:30
01:05:35
01:05:40
01:05:45
01:05:50
Time
1200
1400
1600
1800
2000
2200
Frequency / Hz
-40 dB -20 0
Date=2025-08-13 Time=01:06
Freq= 1000...2500 Hz



Amplitude / dB
-5.00
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
03:43:55
03:44:00
03:44:05
03:44:10
03:44:15
03:44:20
Time
1200
1400
1600
1800
2000
2200
Frequency / Hz
-40 dB -20 0
Date=2025-08-13 Time=03:44
Freq= 1000...2500 Hz

Chris has also included some sample echoes from his recordings. The first one is timed at 01:06 on the 13th and appears to last about 20 seconds. The second image is at 03:44 on the 13th, lasting nearer 40 seconds with the earlier echoes at the upper left of the chart. Chris noted that the later echoes were generally stronger than the earlier ones.

Colin Clements also made Perseid recordings, this chart showing activity from 01 to 18UT on the 13th:



Colin also used the GRAVES radio source, but in a different direction compared with Chris Bailey. The highest activity is again seen in the morning, with lower counts in the afternoon. The dip in the centre of the chart is probably due to a temporary loss of the GRAVES signal.

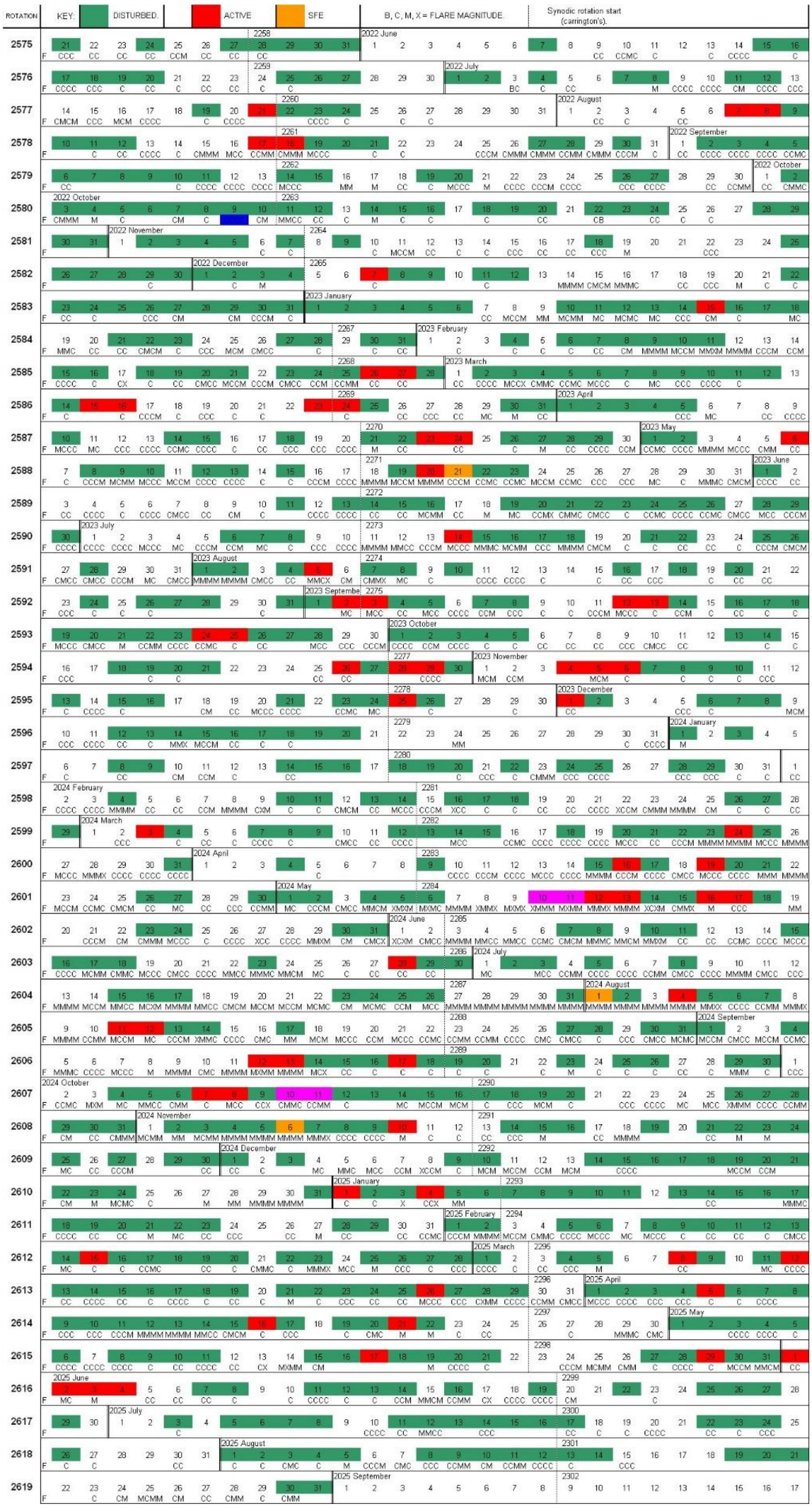
EUCARA

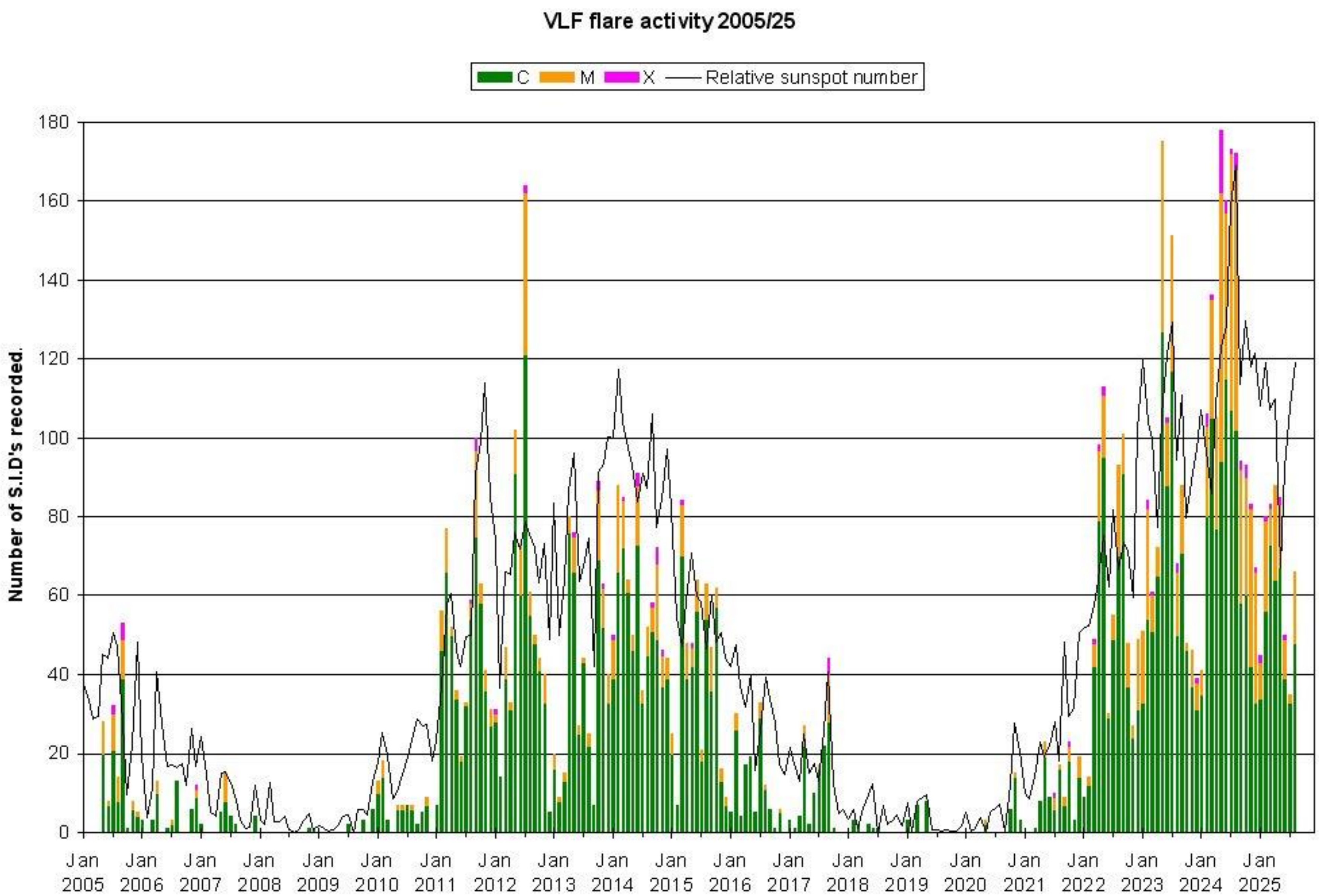
EUCARA held its first UK meeting at the Rutherford Appleton Laboratory near Oxford. In the past, meetings have been either in Germany or the Netherlands, so it was an excellent opportunity for the Radio Astronomy community to meet in the UK. The group photograph was taken on the Saturday, quite a struggle to get everyone in the frame! Our speakers included amateurs as well as professionals, with Prof. Jocelyn Bell Burnell giving a very interesting talk on her work with pulsar detection. Peter East followed this with a talk on amateur pulsar detection. Other subjects included Meteor scatter, Radar, cosmic radiation, the SKA and Hydrogen line detection. We were also treated to visits to some of the RAL facilities.

Various items of observing equipment were on display, with guidance on how to use them and make observations. There were also display boards including observing results and an interesting history of Ruby Payne-Scott, the world's first female Radio Astronomer. Thanks go to Paul Hearn and Andrew Thomas for their hard work in putting this all together, along with those who helped to make the meeting run smoothly. The group picture is by John Thain.

Several new names have been added to the distribution list for Radio Sky News, so if you have any observations then please do send them in.

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

Callisto Data Time-Stamping

Whitham D. Reeve and Christian Monstein

Introduction

The goal of the e-CALLISTO solar radio spectrometer network is to provide the best data possible. That goal is not achievable unless the data timestamps are accurate. In particular, when computational methods, such as Artificial Intelligence (AI), are used to identify and classify radio bursts, it is imperative that the timestamps be very accurate so that the data from different stations can be cross-correlated. For best accuracy, the PC that gathers the data at each station must be synchronized to Coordinated Universal Time (UTC) using the Network Time Protocol (NTP), and the Callisto instrument must use an external clock source. This article describes the application of external clock sources to Callisto instruments so that the quality of e-CALLISTO data is as high as possible.

Callisto Data Timing

The Callisto instrument in conjunction with its operating software (callisto.exe) produces Flexible Image Transport System (FITS) files that include metadata as well as the frequency, amplitude and time of the observations. The length of the FITS files can be any practical value but a typical setting is 900 seconds (15 minutes). In addition, Callistos typically are setup to produce four observations each second, giving a total of 3600 observations in each 15 minute FITS file. Each observation is time-stamped as it is transferred to the PC over the Callisto's serial data link at 115 200 b s^{-1}.

PC timing: As mentioned above, the PC that collects the Callisto data must be synchronized to UTC using NTP. The synchronization interval for most Windows PCs has been found to be 15 minutes to 2 hours with the shorter interval required for laptops and PCs in an unstable temperature environment. If the PC real-time clock is not synchronized often enough, the real-time clock drifts and the timestamp error accumulates. NTP setup on a Windows PC is beyond the scope of this article, but readers may refer to {Reeve15.1} and {Reeve15.2} for NTP installation and application details.

Even with the above considerations, the time uncertainty can be on the order of ±60 ms in older PCs but somewhat lower at ±20 to ±50 ms in newer PCs. Also, the time-stamps used by the callisto.exe software are determined several times per second, but the Windows operating system can introduce delays and other effects, resulting in an error that approaches ±1 s.

The rate at which the data is transferred from the Callisto to the PC is determined by the Callisto clock. The clock may operate *asynchronously* or *synchronously* according to the [`clocksource`] parameter setting in the Callisto configuration file (callisto.cfg).

Asynchronous operation: When operated asynchronously, the [`clocksource`] parameter is set to 1 and the Callisto processor's 11.0592 MHz quartz crystal determines the transfer rate. The frequency is scaled internally by the processor to perfectly meet standard baud-rates for purposes of serial data transfer. The crystals used in manufactured Callistos usually have a ±30 ppm frequency tolerance and ±50 ppm frequency stability over a temperature range of –10 to +70 °C. Thus, the crystal frequency can vary by 80 ppm from its specified value of 11.0592 MHz. For example, if the crystal frequency is low by 80 ppm (80 Hz), a nominal 15 minute FITS file is actually filled with 3600 observations in 900.3 seconds.

Synchronous operation: For practical purposes, synchronous operation eliminates the potential timing errors inherent to the asynchronous operation described above. An external 1 MHz, 5 V TTL-compatible clock source is connected to the Callisto, and the [`clocksource`] parameter is set to 2. Synchronous operation typically uses a GNSS-disciplined oscillator (called GPSDO in this article). The accuracy is usually in the range 0.1 to 1 ppb, at least 80 000 times better than the quartz oscillator in the instrument. The external clock is connected to a processor input port where it is used to synchronously output the FITS data over the serial link to the PC.

External 1 MHz clock sources

Two GNSS-disciplined oscillators that may be used as an external clock source for the Callisto are: Mini Precision GPS Reference Clock (Mini-GPS) and LBE-1420 GPSDO Locked Clock Source (LBE-1420), both from Leo Bodnar Electronics {LBE}. The latter is the most current model (see also the Discussion section).

In the Callisto application, the oscillators are connected through the external clock connector (figure 1) to a high impedance load in the instrument. The load is equivalent to an infinite resistance in parallel with a 10 pF capacitor. The output amplitude of both units is 3.3 V-pk under these conditions (figure 2).

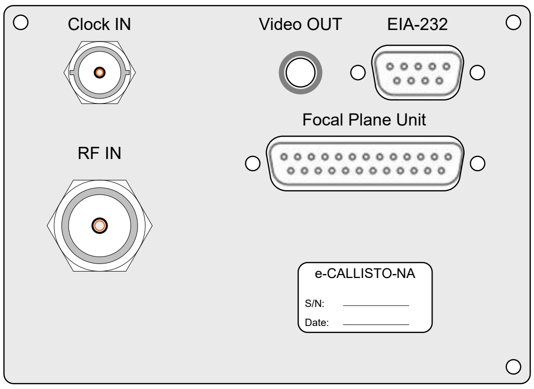


Figure 1 ~ Callisto front panel for instruments manufactured in USA. Units from Switzerland are very similar. The Clock IN connector at the upper-left is used to connect a 1 MHz external clock source.

The Callisto 1 MHz clock input uses a TTL CMOS buffer (IC8, 74HC244), which requires a nominal 0 to 5.0 V input signal. The basic specifications for CMOS technology require the high input state voltage to be ≥ 3.5 V and low input state voltage to be ≤ 1.5 V. However, the datasheet for the 74HC244 used in the Callisto indicates that the minimum voltage for a high input state is 3.15 V and the low input state is a maximum of 1.35 V. The two external clock sources easily meet the low state requirement, but the high state voltage is 3.3 V-pk, which falls between the two voltage levels. Although no reliability problems were encountered during testing, the setup has a low operating margin (see Discussion section).

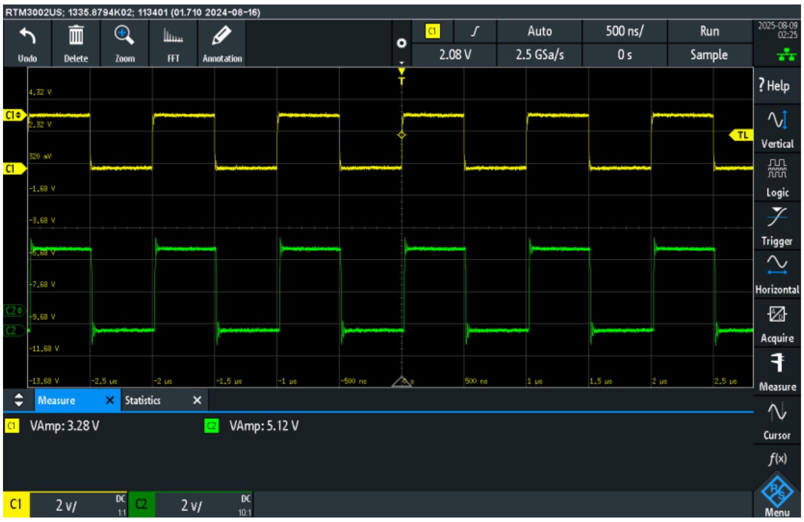


Figure 2 ~ Input (yellow) and output (green) voltage waveforms for the clock buffer IC8. The input waveform is from the LBE-1420 and its amplitude is 3.28 V; the buffer input waveform and voltage from the Mini-GPS is identical. The output voltage from the buffer is TTL level at 5.12 V.

Application

The 1 MHz clock connection requires a single coaxial cable (figure 3). Because of the low operating margin of the GPSDO outputs (discussed above), the cable that connects the GPSDO output to the Callisto clock input must be high quality and short length.

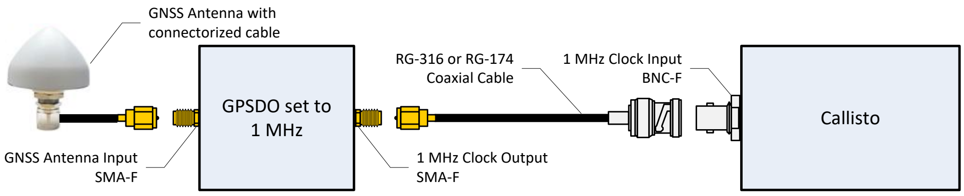


Figure 3 ~ RF connections for 1 MHz external clock source.

The Mini-GPS and LBE-1420 are supplied with an antenna that has an integral connectorized cable. The antennas are active types with relatively high gain, so the cable length can be extended if necessary. Online resources should be used to find information on the best GNSS antenna location and placement.

Both of the clock sources described above are powered by 5 Vdc and have a load current about 250 mA. A mini-USB-A connector is used on the Mini-GPS and a USB-C connector is used on the LBE-1420. A switchmode power supply should be avoided because of its inherently high noise and the possibility for electromagnetic interference (EMI). Instead, a 5 V linear power supply that is capable of delivering at least 250 mA should be used. The clock sources are configured through their USB interfaces with the software tools available from the manufacturer (figure 4). The GPSDOs may be disconnected from the PC after setup and then connected to a 5 V power supply for normal operation.

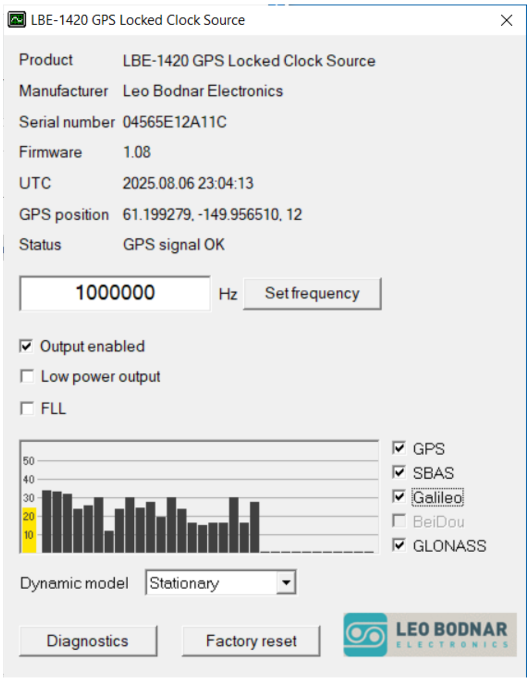
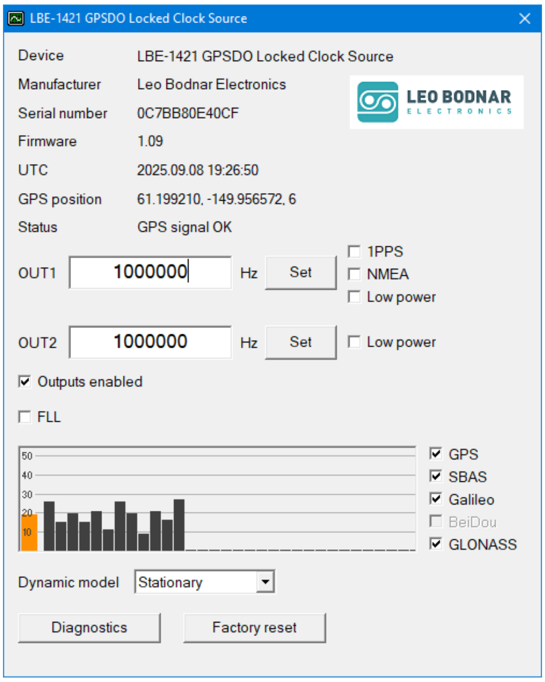


Figure 4 ~ Left: Mini-GPS setup software. The frequency must be set to 1 MHz (1 000 000 Hz), and the *Output drive strength* should be set to *32ma* and the *Enable output* box should be checked. Do not enable the *Timecode* setting. Right: LBE-1420 setup software. The *Output enabled* box for the LBE-1420 should be checked. After setup, the units may be disconnected from the Windows PC and then connected to a 5 V power supply for normal operation.

For stations that use two Callistos in a dual polarization system, two external clock sources are required, one for each instrument. It is not recommended that a single Mini-GPS or LBE-1420 be connected through a splitter to two Callistos because the voltage level probably will be reduced below the Callisto input buffer threshold and it will not properly detect the signal. An alternative is to use two Mini-GPS or two LBE-1420, but a better alternative is to use a single LBE-1421 (figure 5). The LBE-1421 has two outputs, both programmable for 1 MHz output, but its load current is higher, 300 mA at

5 Vdc. A single LBE-1421 is less expensive than two Mini-GPS or two LBE-1420. The setup of the LBE-1421 uses the downloadable Windows Configuration Software tool. The output waveforms on the two channels are identical except that channel 2 lags channel 1 by 21 ns (figure 6).

Figure 5 ~ Below: Leo Bodnar LBE-1421 dual output channel GPSDO. Image source: Leo Bodnar Electronics.



Left: LBE-1421 Configuration Software user interface. After setup, the LBE-1421 is disconnected from the PC and connected to its power supply.

Figure 6 ~ LBE-1421 output waveforms for channel 1 (yellow trace) and 2 (green trace). Note there is a phase delay in channel 2 of 21 ns compared to channel 1.

A typical e-CALLISTO station is setup to operate in the Automatic mode, in which case the Callisto is controlled by the scheduler.cfg file. If an external clock source is connected to the instrument, but the [clocksource] parameter in the callisto.cfg file is set to 1, the external clock signal is ignored and FITS data files are produced asynchronously as described above and according to the schedule.

On the other hand, if the [clocksource] parameter is set to 2 but no external clock source is connected or is lost, no FITS data files are produced, and callisto.exe displays various errors such as *Auto stop due to data loss* and *Check RS232 connection* (figure 5). The callisto.exe application will automatically recover when the external clock source is reconnected and will continue according to the schedule. The [clocksource] parameter usually may be changed on-the-fly but some Windows operating systems do not support this, so it is good practice to restart the callisto.exe application whenever the callisto.cfg file is changed.

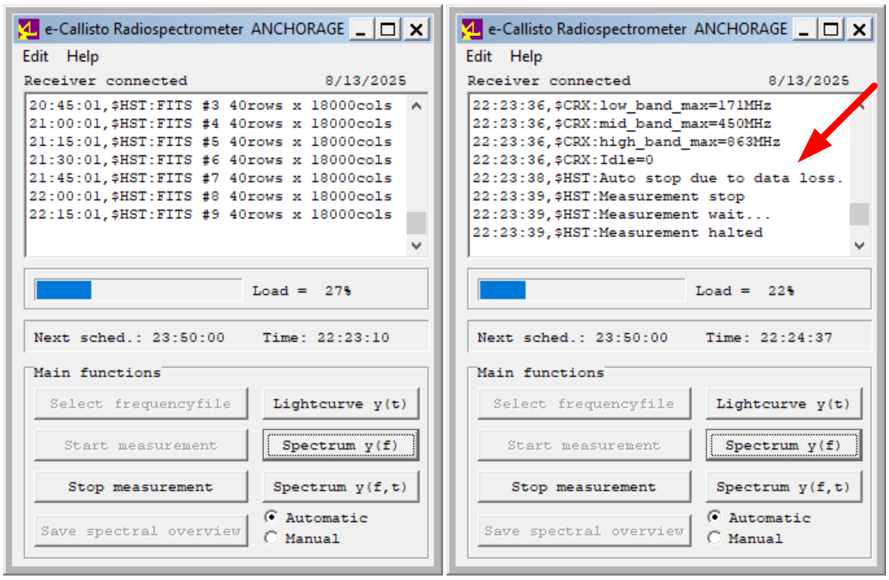
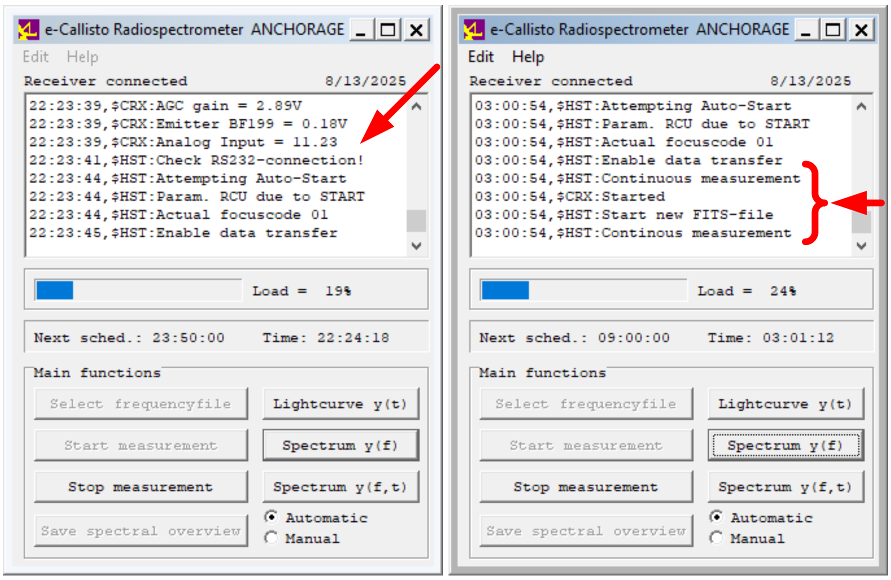


Figure 5.a ~ Left: Callisto.exe operating normally and collecting data with the external clock source connected. Right: Callisto.exe error (red arrow) when the external clock source was lost or disconnected.



igure 5.b ~ Left: Another Callisto.exe error (red arrow) that is shown when the external clock source was lost or disconnected. Right: Attempted Auto-Start was successful (red bracket) after the external clock source was reconnected and data collection back to normal.

Discussion

- The external clock input on the Callisto is through a 100 ohm resistor to the TTL buffer IC8 (figure 6). The resistor isolates noise that might be produced by the external clock connection, and its application is described in a Non-Conformance Report from 2011 (NCR20110617, https://e-callisto.org/Hardware/ncr/NCR20110617.pdf). All current production Callistos have the resistor installed.

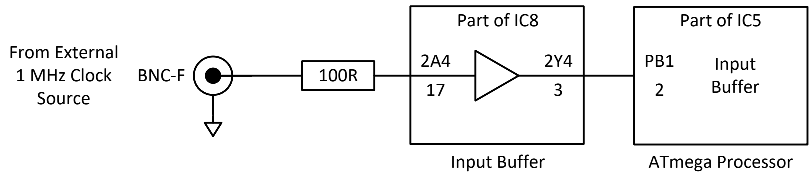


Figure 6 ~ Callisto clock source circuit schematic.

- If the external clock sources described above prove to be unreliable in a specific installation, it may be necessary to hand-select (trial-and-error) a different buffer integrated circuit (IC8) to find one with a low enough input voltage threshold. Of course, a GPSDO with a 5 V TTL output would not require any special considerations. Alternatively, a level-shifter could be used between the Mini-GPS or LBE-1420 and the Callisto to change the high state output from 3.3 V to 5.0 V. If noise induced into the coaxial cable from an external interference source is suspected of causing unreliable operation, clamp-type ferrite beads may be placed on the cable to reduce the common mode noise.
- The Leo Bodnar Electronics GPSDO units described above are the only commercial units known to the authors that are able to provide a programmable GNSS-disciplined 1 MHz output. There are many similar commercial GPSDOs that provide a fixed 10 MHz output, some with 3.3 V CMOS and some with 5.0 V TTL outputs. These units may be used with divider circuit that provides ÷10 ratio.

References

{LBE} Leo Bodnar Electronics: https://www.leobodnar.com/shop/

{Reeve15.1} Reeve, W., Network Time Protocol and Meinberg NTP Time Server Monitor ~ Installation Guide, 2015: https://www.reeve.com/Documents/Articles%20Papers/Reeve_NTP-MeinMon_Install.pdf

{Reeve15.2} Reeve, W., Meinberg NTP Time Server Monitor Guide, 2015: https://www.reeve.com/Documents/Articles%20Papers/Reeve_MeinbergMonGuide.pdf

One Possible Model for HI Clouds in the Milky Way Galaxy

by Preston Ozmar

Introduction

The purpose of this paper is to model a neutral hydrogen cloud in a certain region of the Milky Way galaxy studied by Dr. Felix J. Lockman and his colleagues at the Green Bank Observatory in West Virginia. The data used for the model are the median values in Table I of a paper written by Dr. Lockman [3]. Therefore, the model represents a median cloud, not a specific cloud. Of course, there are numerous ways to model the HI clouds. This paper presents only one possibility.

Neutral hydrogen galactic clouds are called HI clouds, where H represents hydrogen and the Roman numeral I is pronounced "one."

One reason that HI clouds are convenient to study is that they generate a spectral line in the microwave band at a wavelength of 21.106 cm. [1]

For simplicity, a sphere was chosen as a model for the cloud. The goal was to determine the amount of spectral radiation from the surface of the cloud facing the Earth. It is unlikely that the cloud is actually spherical.

Generation of the 21.106 cm Hydrogen Line

Rather than delving deeply into quantum mechanics, the results presented by Dr. Mark Van Raamsdonk in a three-part lecture on YouTube for his students at the University of British Columbia in 2020 will be used. [2] Neutral hydrogen clouds in the ISM are cold, so the atoms are in their ground state. Neutral hydrogen atoms have four ground-state spin vectors. The four state vectors can be represented by arrows representing the spin of the proton and the electron. The spins in the four states are:

↑↑ (up up)
↑↓ (up down)
↓↑ (down up)
↓↓ (down down)

Figure 1 (above) shows the up up state.

There is one case where the total spin is zero (lower state). It is ↑↓ - ↓↑. This case is called a singlet. The other three cases each result in a total spin of one (higher state). They are ↑↑, ↑↓ + ↓↑, and ↓↓. This is called a triplet.

Therefore, three-quarters of the atoms can be expected to be in the high state, and one-quarter in the low state. When the spin changes from high to low, energy is released. Please note that we are talking about quantum spin, not physical spin. Quantum spin is an intrinsic property of the particles. The amount of energy released is,

E = 5.87433 X 10^{-6} eV, where eV is electron volts, 1 eV = 1.602177 X 10^{-19} Joules [7] CRC 96TH ED

The energy is released as a photon. The frequency of the photon is $f = \frac{E}{h}$. In this paper, f is used for frequency instead of the Greek letter nu. This avoids confusion between 'nu' and the lowercase' v'. (Planck constant) h = 6.626070 × 10^{-34} J s or Joule seconds

So, where f_0 is the neutral hydrogen (HI) spin-flip spectral line rest frequency in Hertz (Hz):

$$f_0 = \frac{E}{h} = \left(\frac{\left(5.87433X10^{-6}\right)\left(1.602177X10^{-19}\right)}{6.626070X10^{-34}} \right)\left(eV\right)\left(\frac{Joules}{eV}\right)\left(\frac{1}{Joule}\right)\left(\frac{1}{\sec onds}\right) = 1.420405752X10^{9}\,Hz$$

Equation (1.1)

The following data are from portions of Lockman's Table 1. [3]

Table 1

Property	Median
V_{LSR}	+118 km per second – velocity referenced to the Local Standard of Rest.
Z (pc)	-940 pc (parsecs) where z is the distance from the galactic plane. A parsec equals 3.086×10^{16} meters.
T_L (K)	1.0, where T_L(K) is the peak line intensity in Kelvin.
Δv (km s^{-1})	12.2 where delta v is the spectral line width in km per second. It is the measured FWHM (Full Width at Half Maximum).
N_{HI} ($\times 10^{19}$ cm^{-2})	2, where N_{HI} is the column density toward the cloud center.
Diameter (pc)	24, Lockman calculated an equivalent diameter of the HI clouds by finding the "square root of the product of the diameters in longitude and latitude." [3]
$\langle n \rangle \left(cm^{-1} \right)$	0.25, The median of the average volume density.
$M_{HI} \left(M_{\odot} \right)$	50, So, the median mass of the 38 clouds was 50 times that of the Sun or $50 \times 1.9884 \times 10^{33}$ grams. [7]
r	7.6 kpc (kiloparsecs). Distance of the cloud from the Sun from the second page of the same paper by Lockman. [3]

Find the number of neutral hydrogen atoms contained in a median HI cloud.

$$N_{cloud} = \frac{(50)(\text{mass of the sun in grams})}{(\text{grams in a mole of H})}(\text{atoms per mole which is Avogadro's number}) = \text{atoms in the cloud}$$

$$N_{cloud} = \frac{(50)(1.9884 \times 10^{33})\left(6.022 \times 10^{23}\right)}{1.008} = 5.93956 \times 10^{58}\, atoms$$

Equation (1.2)

The Spectral Line

Choose a Gaussian normal distribution of frequencies (f) for the spectral line. Breipohl, page 85, describes the normal distribution as an integral. [4] He substitutes into the integral to get it in the form of a standard normal random variable whose solutions can be found in the normal distribution tables, "where F_{SN} is the distribution function of the normal random variable." [4] The upper limit is

$F_{SN}\left(\frac{(a_2-\mu)}{\sigma}\right)$ and $F_{SN}\left(\frac{(a_1-\mu)}{\sigma}\right)$ is the lower limit. The peak of the curve, called the mean, is named μ. The spread of the curve (standard deviation) is described by σ. The objective is to find the probability that the region between the limits will occur. So, in this case, you look in the tables and find the result of $F_{SN}(upper)-F_{SN}(lower)$. If either is a negative number, make it positive and use 1-F_{SN} instead of F_{SN}. Both F_{SN} and (1- F_{SN}) are listed in the math tables. An example will provide more clarification. For the tables, see reference [5] or similar.

Briepohl shows the integral as, $\int_{\left(\frac{a_1-\mu}{\sigma}\right)}^{\left(\frac{a_2-\mu}{\sigma}\right)} \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx = F_{SN}\left(\frac{a_2-\mu}{\sigma}\right) - F_{SN}\left(\frac{a_1-\mu}{\sigma}\right)$ Equation (1.3)

Using the median data from Lockman referenced above:

Δv = 12.2 km s^{-1} FWHM

To center the spectral line at the median, divide it into two velocities, -6.1 km s^{-1} and +6.1km s^{-1} or $\pm\frac{FWHM}{2}$.

v is velocity and f is frequency.

Convert the velocities to frequencies.

$$f_1 = f_0\left(1-\frac{v}{c}\right) = (1420405752)\left(1-\frac{6100}{299792458}\right) = 1420376850 \text{ Hz} \qquad \text{Equation (1.4)}$$

$$f_2 = f_0\left(1+\frac{v}{c}\right) = 1420434654 \text{ Hz}$$

From Microsoft Copilot: $\sigma = \frac{FWHM}{2.35482}$

$$\sigma = \frac{FWHM}{2.35482} = \frac{(f2-f1)}{2.35482} = \frac{(1420434654-1420376850)}{2.35482} = 24547 \qquad \text{Equation (1.5)}$$

$$\mu = f_0 = 1420405752 \text{ Hz}$$

Determine the Spectral Intensity Emitted from the Cloud

In order to determine the spectral intensity emitted from the cloud, the optical depth should be found. The optical depth determines whether a cloud is thick or thin. For a thin cloud, the generated photons and those coming from behind the cloud pass through to the other side. For a thick cloud, neither passes through the cloud. The emitted photons come from a slab on the outside of the cloud, determined by the optical depth.

The optical depth determines the depth that f_0 will penetrate the cloud. At deeper depths, the cloud will appear opaque when viewed externally.

Optical Depth

Equation (1.16) on page 12 of [Wilson] defines the optical depth. [6]

$\tau_f = \int_{s_0}^{s} \kappa_f(s)ds$ where τ_f is the optical depth with respect to frequency. S is distance and κ_f is the absorption coefficient with respect to frequency and is affected by distance. Equation (1.6)

Find the Absorption Coefficient

$$\kappa_f = \frac{c^2}{(8\pi)} \frac{1}{f_0^2} \frac{g_2}{g_1} n_1 A_{21} \left[1 - e^{-\left(\frac{hf_0}{kT}\right)}\right] \varphi(f)$$ Equation (1.7)

Equation (3.17) from Reference [6].

κ_f is the absorption coefficient.

c is the speed of light, 299792458 meters per second.

f_0 is the rest frequency of HI, 1420405752 Hz.

$\frac{g_2}{g_1}$ is the ratio of atoms with a spin of 1 to those with a spin of 0. In this case 3.

n_1 is one-fourth of the number of HI atoms per cubic meter.

$$V_{cloud} = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi\left(12 \times 3.086 \times 10^{16}\right)^3 = 2.12725 \times 10^{53} m^3$$ Equation (1.8)

Where V_{cloud} is the volume of the HI cloud.

The radius of 12 parsecs was converted to meters during the calculation.

$$n_1 = \frac{1}{4}\frac{N_{cloud}}{V_{cloud}} = 0.25\frac{(5.93956 \times 10^{58})}{(2.12725 \times 10^{53})} = 69{,}803 \frac{atoms}{m^3}$$ (average) Equation (1.9)

A_{21} is the Einstein emission coefficient, 2.85 x 10^{-15} per second.

h is Planck's constant, 6.62607015 x 10^{-34} Joule seconds. See reference [8].

k is Boltzmann's constant, 1.380649 x 10^{-23} Joules per degree Kelvin. See reference [8].

T is the temperature in Kelvin.

$\varphi(f)$ is the distribution of the spectral line with frequency. In this case, a normal distribution was chosen.

$$\varphi(f) = F_{SN}\left(\frac{f_2 - \mu}{\sigma}\right) - F_{SN}\left(\frac{f_1 - \mu}{\sigma}\right) = F_{SN}\left(\frac{1420434654 - 1420405752}{24547}\right) - F_{SN}\left(\frac{1420376850 - 1420405752}{24547}\right)$$
$$= F_{SN}(1.177) - F_{SN}(-1.177) \approx F_{SN}(1.18) - \left[1 - F_{SN}(1.18)\right] = 0.8810 - 0.1190 = 0.762$$

So,

$$\kappa_f = \frac{\left(2.99792458\times10^{8}\right)^{2}}{(8\pi)}\frac{1}{\left(1.420405752\times10^{9}\right)^{2}}(3)(69{,}803)\left(2.85\times10^{-15}\right)\bullet$$

$$\left[1-e^{-\left(\frac{\left(6.6260715\times10^{-34}\right)\left(1.420405752\times10^{9}\right)}{\left(1.380649\times10^{-23}\right)(1)}\right)}\right](0.762)=$$

$$\frac{\left(2.99792458\times10^{8}\right)^{2}}{8\pi}\frac{1}{\left(1.420405752\times10^{9}\right)^{2}}(3)(69825)\left(2.85\times10^{-15}\right)(0.065897)(0.762)=5.31342\times10^{-14}m^{-1}s^{-1}$$

Equation (1.10)

Find the Optical Depth

Equation (1.16) on page 12 of [Wilson] [6]

$\tau_f(s)=\int_{s_0}^{s}\kappa_f(s)ds$ where τ_f is the optical depth with respect to frequency, S is the distance, and κ_f is the absorption coefficient with respect to frequency.

The next step is to determine $\varphi(s)$.

A Model for the Distribution of Atoms in the Cloud

There are likely several models that can be used to describe the distribution of HI atoms in the cloud. One model that would not be accurate is a linear model where the number of HI atoms per meter remains constant throughout the cloud. The cloud would then be flat and have edges perpendicular to the surface. This is unlikely for a large gas cloud due to gravity and cloud spin. So, a model is needed where the number of atoms approaches zero at the edge of the cloud. One such model is a normal distribution.

The diameter of the cloud is 24 parsecs (pc). So, let $\mu=12$. Let $\sigma=6$.

Using the equation from Breipohl again [4],

$$\varphi(s)=\int_{\frac{(s_1-\mu)}{\sigma}}^{\frac{(s_2-\mu)}{\sigma}}\frac{1}{\sqrt{2\pi}}e^{-\frac{x^2}{2}}dx=F_{SN}\left(\frac{s_2-\mu}{\sigma}\right)-F_{SN}\left(\frac{s_1-\mu}{\sigma}\right)$$

Now, $\tau_f(s)=\kappa_f\int_{s_1}^{s_2}\varphi(s)ds$ Equation (1.11)

$\varphi(s)$ is an integral that is within an integral. Perform the outside integration first and then $\tau_f(s)=\kappa_f\varphi(s)s$ where s is distance. Evaluate $\varphi(s)$ using the tables in reference [5].

Further Define the Optical Depth

Proceeding into the cloud from the edge, a signal would decrease according to $e^{-\tau_f(s)}$. A good place to define an optical depth of interest might be when a signal from outside drops to ten percent of its original value. Then,

$$e^{-\tau_f(s)} = 0.1 \qquad \text{Equation (1.12)}$$

Taking the natural logarithm of both sides of the equation, we have:

$$-\tau_f(s) = -2.30259$$

$$2.30259 = \kappa_f s\varphi(s)$$

Then, Equation (1.13)

$$s\varphi(s) = \frac{2.30259}{5.31342\times10^{-14}} = 4.33354\times10^{13}$$

One way to solve this equation for the value of s is by trial and error, with or without writing a computer program. The solution, found through trial and error, is that the optical depth is 0.385 parsecs. Use this value for s and check the value of $s\varphi(s)$.

$$\varphi(s) = F_{SN}\left(\frac{0.385-12}{6}\right) - F_{SN}\left(\frac{0-12}{6}\right) = F_{SN}(-1.936) - F_{SN}(-2) = \left(1-F_{SN}(1.936)\right) - \left(1-F_{SN}(2)\right) =$$

$$0.0265 - 0.0228 = 0.0037$$

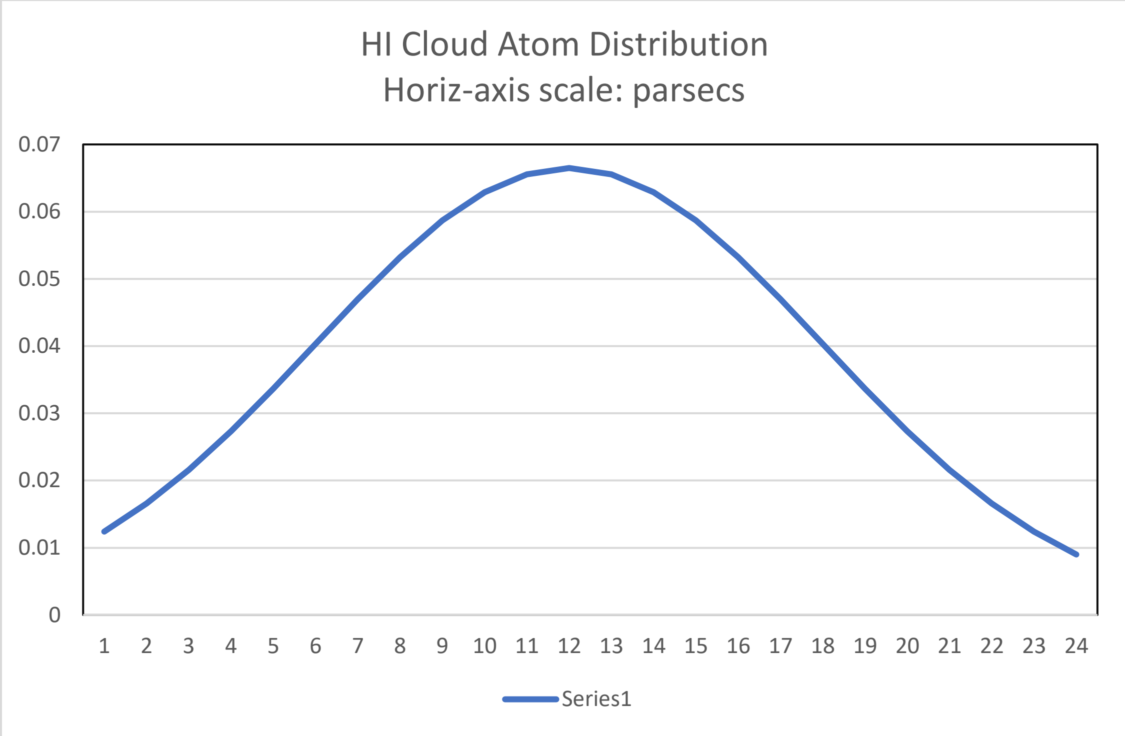
$$\tau_f(s) = \kappa_f s\varphi(s) = \left(5.31342\times10^{-14}\right)(0.385)\left(3.085678\times10^{16}\right)(.0037) = 2.33554$$

Above are equations (1.14) and (1.15).
Note that parsecs were converted to meters during the calculation. One parsec = 3.085678 x 10^{16} meters.

So, $e^{-2.33554} = 0.096758$ and the goal was 0.1. The goal was missed by approximately 3.2%.

An optical depth of 0.385 pc will be used.

The distribution curve for $\varphi(s)$ is shown in Figure 2 and is from an Excel spreadsheet.



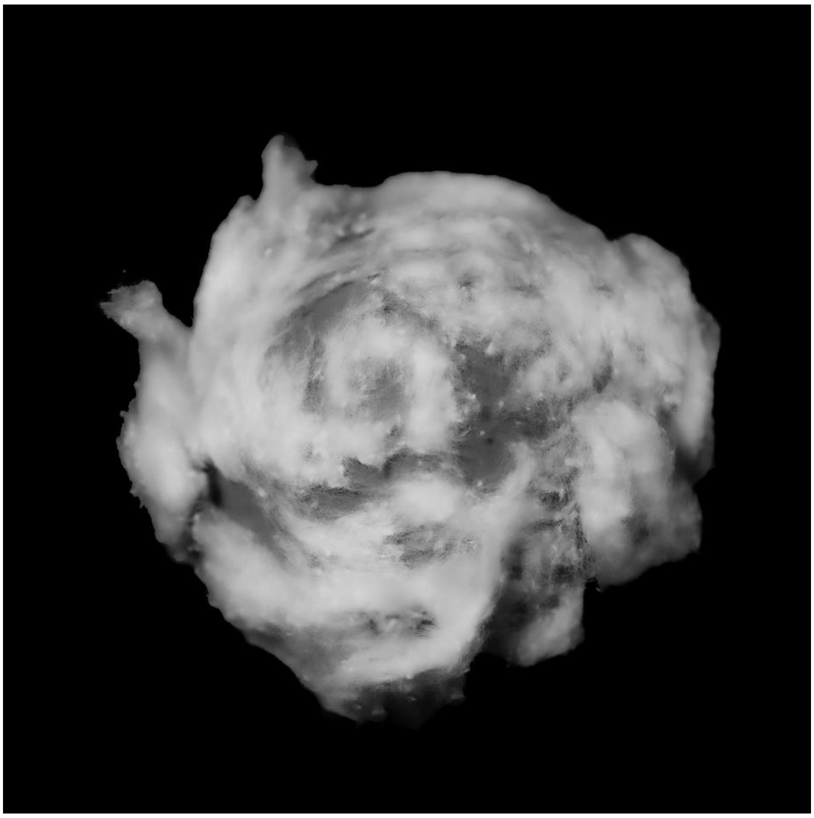


Figure 3 – Artistic impression of an HI cloud by PBO

Calculate the Number of Photons Leaving the Cloud

Consider the cloud to be made up of two spheres, one inside the other. The inner sphere would have a radius of 12 parsecs minus the optical depth. It could be considered to be dark. Photons would not be passing through or emitted from this inner sphere to the outside. The emitted photons would come from a hemispherical slab of optical depth, as only one side of the sphere would be visible from Earth. A hemisphere is an approximation.

So, the volume considered to be radiating photons would be the volume of the entire hemisphere minus the volume of the dark (smaller) hemisphere.

$$V_{hemi} = 0.5 \times V_{sphere} = \frac{2}{3}\pi r^3$$

$$V_{slab} = V_{hemi-l\arg e} - V_{hemi-small}$$

$$= \frac{2}{3}\pi\left(12\times 3.085678\times 10^{16}\right)^3 - \frac{2}{3}\pi\left(\left(12-0.385\right)3.085678\times 10^{16}\right)^3 = 9.909\times 10^{51} m^3$$

where V_{slab} is the hemispherical volume with a thickness that is equal to the optical depth. Above are equations (1.16) and (1.17).

Since photons will be leaving both sides of the slab and only one side will be toward the Earth, a factor of 0.5 is included in the following equation.

$$Photons = V_{slab} \times n_{avg} \times \varphi(s) \times \frac{n_2}{n_{tot}} \times A_{21} \times 0.5 \qquad \text{Equation (1.18)}$$

$$n_{avg} = \frac{N_{cloud}}{V_{cloud}} = \frac{5.93956\times 10^{58}}{2.12725\times 10^{53}} = 279,213\frac{atoms}{m^3} \qquad \text{Equation (1.19)}$$

$\varphi(s) = 0.0037$ and is the normal distribution coefficient for the optical depth.

$\frac{n_2}{n_{tot}} = 0.75$ represents the fraction of atoms that have spin = 1.

A_{21} is Einstein's emissivity constant.

$$Photons = \left(9.909\times 10^{51}\right)\left(279213\right)\left(0.0037\right)\left(0.75\right)\left(2.85\times 10^{-15}\right)\left(0.5\right) = 1.09407\times 10^{40}\ \sec^{-1}$$

Find Photons Per Square Meter for the Surface of the Hemisphere

$A_{hemi} = \frac{\pi}{2}D^2$ where D is the diameter of the sphere. Equation (1.20)

D = 24 pc

$$A_{hemi} = \frac{\pi}{2}\left(\left(24\right)\left(3.085678\times 10^{16}\right)\right)^2 = 8.61477\times 10^{35} m^2$$

$$\frac{Photons}{m^2 s} = \frac{photons}{A_{hemi}} = \frac{2.26064\times 10^{40}}{8.61477\times 10^{35}} = 26,241 \qquad \text{Equation (1.21)}$$

So, there are 26,241 photons per second exiting each square meter of the surface of the cloud hemisphere.

Find Watts Per Square Meter Passing Through the Surface of the Hemisphere

$E=\left(5.87433\times10^{-6}eV\right)\left(1.602177\times10^{-19}\,\frac{joules}{eV}\right)=9.4117\times10^{-25}\,joules$ is the energy per photon.

Equation (1.22) is above.

$I_f=\left(\frac{photons}{m^2 s}\right)(E)=(12,700)\left(9.41171\times10^{-25}\right)=1.19529\times10^{-20}$ joules per second or watts.

I_f is the specific intensity.

Find the Expected Power Reaching the Earth

From [Wilson] pages 7-9. [6]

$s_f=\pi I_f\,\frac{R^2}{r^2}$ where s_f is the total flux density received on Earth, neglecting losses in the ISM (interstellar medium), the solar system medium, the magnetosphere, and the atmosphere. I_f is the brightness or specific intensity. R is the radius of the cloud, and r is the distance from the Sun to the cloud.

$$s_f=\pi\left(1.19529\times10^{-20}\right)\left(\frac{(12)}{(7600)^2}^{\,2}\right)=9.36178\times10^{-26}\,\frac{watts}{m^2 Hz}$$

A Jy (jansky) is defined as 10^{-26}watts per square meter per Hertz.

So, a flux of approximately 9 Jy (janskys) is expected to be received on Earth, neglecting transit losses.

Conclusion

This paper used median data from a paper by Dr. Felix J. Lockman [3] to design a possible model for an HI cloud. The model included the choice of a spherically shaped cloud and normal distributions for the spectral line and the atoms in the cloud.

Future improvements could include a more arbitrary cloud shape and use a more accurate distribution for the atoms in the cloud. Future papers could explore the loss and distortion in the interstellar medium (ISM), the solar system medium, the magnetosphere, and the Earth's atmosphere.

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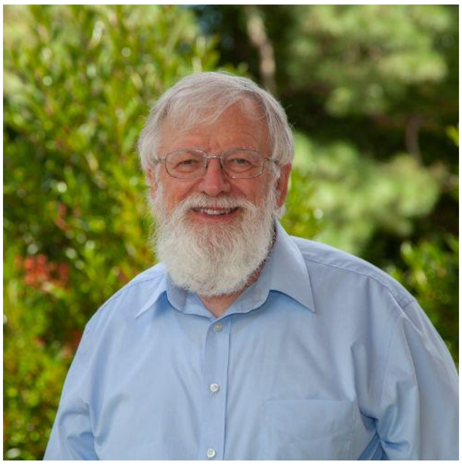
Preston Ozmar



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Radio astronomy outreach at the
Herzberg Telescope Meeting (HTT) in Germany

Eduard Mol

Introduction

Within the amateur astronomy community, radio astronomy remains a niche subject. Go to a star party and you will encounter many visual observers and astrophotographers, but rarely anyone has a radio telescope. This year I decided to bring a small horn antenna for hydrogen line observations to the Herzberger Teleskoptreffen (Herzberg telescope meeting) in Brandenburg, Germany. This is one of the more well-attended star parties in Germany with several hundred visitors every year, but still I was the only one doing radio astronomy there. The demo was overall very well received: many visitors were surprised as to what was possible in radio astronomy using low-cost equipment, and a few people were even interested in building a hydrogen line telescope themselves after seeing the demo.

The antenna

The idea of bringing a small antenna for outreach came up after meeting Dr. Asayama Shinichiro from the SKA observatory at the EUCARA conference. Besides his activities as a professional astronomer Dr. Shinichiro also does a lot of outreach, for example at schools. During EUCARA he demonstrated one of the antennas he had made, which was built from a large can, aluminium foil, and balloons.

Figure 1: left: Dr. Shinichiro's hydrogen line demo at EUCARA. Right: transportable horn antenna built for hydrogen line demonstrations at the HTT 2025 star party.

My antenna had to be compact, I was travelling to the star party by train so it had to fit in a suitcase with all of my camping and visual astronomy gear. For the "cantenna" part forming the base of the horn I used an old milk pan with an opening and depth of 16 cm. This is not the ideal shape for 1420 MHz, but close enough. For the monopole probe I soldered a 5cm long and 3mm thick piece of copper wire to a BNC endpoint and placed it 8.3 cm from the bottom of the milk pan. The horn part was made from thick paper which I had bought for covering the floor when painting my bedroom. This was covered with aluminium foil. The horn has a 45cm opening and can be folded up for transport. A Nooelec SAWbird HI barebones was used as a preamplifier. An airspy mini SDR was used because of its relatively flat bandpass response, which makes it easier to show the hydrogen line without the need for bandpass correction. For displaying and saving hydrogen line spectra SDR# with the IF average plugin was used.

Hydrogen line demos at the HTT

Figure 2: horn antenna set up at the HTT star party.

Two different radio astronomy demos were performed during the HTT. In the first and easiest demo the antenna was pointed at different parts of the sky to show visitors how the shape and intensity of the hydrogen line varies. Visitors could see that the hydrogen line was stronger towards the Milky Way and weaker in other directions. The milky way around Cygnus and Cassiopeia was also an interesting target: the hydrogen line in this direction has two or three distinct components with different blueshift, corresponding to different arms of our galaxy.

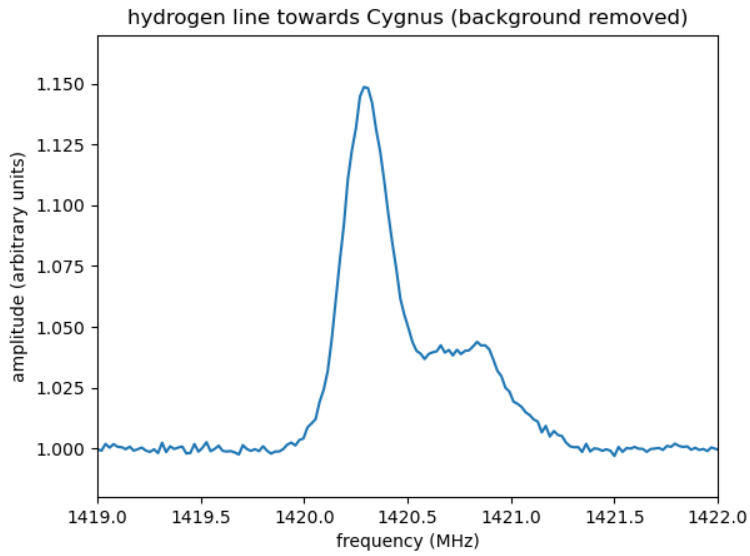

Figure 3: hydrogen line spectrum towards the milky way in Cygnus (galactic longitude ~70- 90 degrees). Besides the strong feature near the rest frequency at 1420.405 MHz, two weaker and more blueshifted features corresponding to more distant spiral arms of our galaxy are visible as well.

The second demo was mapping the intensity of the hydrogen line in the sky. Normally this would be done via a series of driftscans, but that would be too time-consuming for a four-day event. Instead, I improvised a method for quick raster scanning, using the rocker box of my 6" Dobsonian telescope for moving the antenna. The antenna was rotated at 30-degree steps at different elevations to cover the entire sky. The 30-degree steps were marked on the altitude bearing of the rocker box and the antenna was pointed at the starting position towards the north at 10 degrees elevation. Then the IFaverage recording was started, saving a spectrum every 10 seconds (I had timed beforehand how many samples IFaverage processes per second). The antenna was moved in 30 degree steps in azimuth every 10 seconds synchronous with the IFaverage recording, using the stopwatch function on my smartwatch for timing. After a full 360 degree rotation the antenna would be moved back to the north, pointed 20 degrees higher and a new recording would be started. This process would be repeated until the zenith was reached. It took some practice to get it right but after a few attempts I could map the entire sky this way in about 10- 15 minutes.

For drawing the maps, a custom Python script was improvised during the star party (after all, you have to keep yourself busy during the daytime somehow…). In short, a 3rd order polynomial was fitted through the background of each spectrum outside the hydrogen line and subtracted to get rid of the SDR bandpass response. Then, the maximum value inside the frequency window of the hydrogen line (1420- 1421 MHz) of each spectrum was found and displayed in a heatmap on an altitude- azimuth grid using the matplotlib contourf function. As a final step the map could be transformed to polar coordinates using GIMP to display what the sky would actually look like if you could see radio waves. I was surprised that the milky way was still clearly recognizable as a bright band across the sky, despite an angular resolution of 30 degrees!

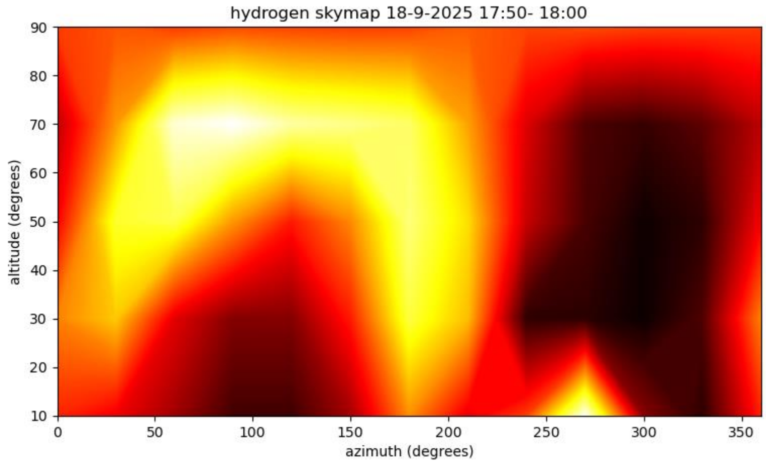

Figure 4: Map showing the peak intensity of the hydrogen line in horizon coördinates (cylindrical projection). The bright arc is the Milky Way.

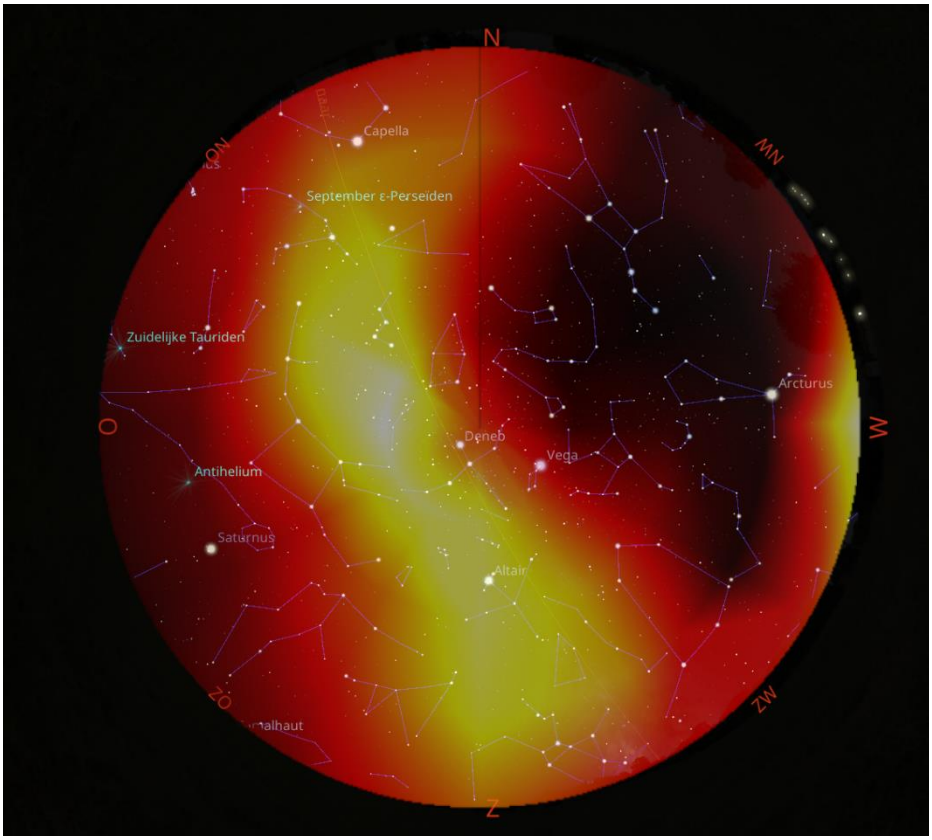

Figure 5: same as fig. 4 but converted to polar coordinates and with a Stellarium screenshot as background. Note how the bright band of hydrogen emission closely matches the Milky Way. The bright spot at the western horizon is RFI from the laptop.

As an extra experiment three different maps were made for different frequency windows (1420.3, 1420.4 and 1420.5 MHz). These maps were layered on top of one another in GIMP and colour-coded red, green and blue to display the Doppler shift.

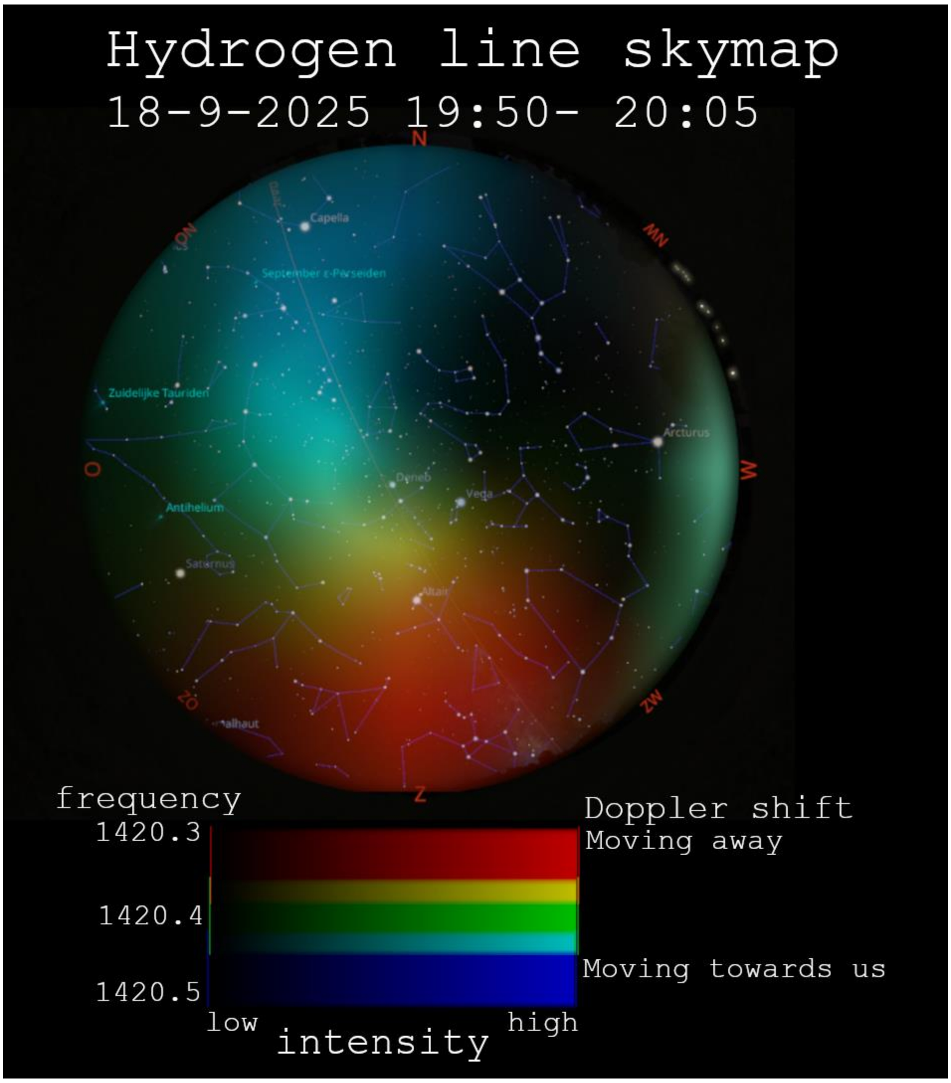

Figure 6: map showing both the intensity and doppler shift of the hydrogen line.

Overall, the demos were very well received. Many visitors were surprised with what was possible using only simple equipment. Some were familiar with the hydrogen line but for many this was a first introduction. I have also been contacted by two visitors who are now interested in getting started with hydrogen line observing as well. For some people it was initially difficult to understand what was shown on the graph, after all radio astronomy is much more abstract than visual observing or astrophotography. However, displaying the data on a sky map definitely helped to visualise it and make it more accessible.

Hydrogen Line Doppler Mapping of the Leo Triplet Using the 20m Skynet Dish at Green Bank Observatory

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Dr Andrew Thornett, M6THO, Lichfield Radio Observatory, Lichfield, UK *www.astronomy.me.uk*

Green Bank 20m Skynet Radio Telescope

The 20 m telescope(1) was built by RSI and delivered to Green Bank in 1994 as part of the US Naval Observatory's Earth Orientation (geodetic VLBI) program. It operated from 1995 until 2000, when USNO funding was cut, and the facility was repurposed for testing and education (Green Bank Observatory 20m, accessed 2025). In 2012, the dish was refurbished and integrated into the Skynet Robotic Telescope Network, becoming the first radio element of the UNC Chapel Hill operated network. The dish is 20m diameter, with F/D ratio: 0.43. The receivers are cryogenically cooled (≈15 K) HEMT systems covering roughly 1.3–1.8 GHz (L band) and 8–10 GHz (X band) (gb.nrao.edu).
The 20m's performance allows for system temperatures ~31 K (L band), ~46 K (X band); a surface accuracy ~0.8 mm RMS; slew rate ~2°/sec; aperture efficiency ~58–61% for L band; and a pointing accuracy ~34″ RMS (https://www.gb.nrao.edu/20m/).

Skynet's network (2) includes ~20 optical telescopes globally plus this single radio telescope at Green Bank, enabling automated, remote observations by professional astronomers and students worldwide. Professional science includes pulsar timing, fast radio burst (FRB) searches, supernova remnant flux monitoring, and blazar variability campaigns (https://www.danreichart.com/radio). Educational and student use ranges from timing and spectroscopy to mapping neutral hydrogen (HI), OH lines, and continuum studies—Skynet has been used by thousands of students annually (https://www.danreichart.com/radio).

Dedicated solely for educational use, SARA members (Society of Amateur Radio Astronomers)(3) have engaged with the 20 m telescope, especially via guidance documents and workshops (Society of Amateur Radio Astronomers. https://radio-astronomy.org/) In the SARA email list, amateur radio observers have shared real results.

All SARA members can access the telescope to make observations using SARA's account. There are also pre-taken observations open to all amateurs, whether or not they are members of SARA or have an account at Green Bank Observatory.

Observing the Galaxies in the Leo Triplet

The current paper describes the results of our study of the galaxies in the Leo Triplet namely M65, M66, and NGC3628. According to a professional HI mapping of this group published in 2022 by Gang Wu et. al. (4) there is a prominent plume extending out from NGC3628 which extends about 2.5 times the length of the galaxy itself. Our goal was to see if we could resolve the individual galaxies and this plume using the 20 Meter Telescope. Given that the 20 Meter Telescope has a half-power beamwidth of 0.74 degrees in L-band, we believe that it should just barely resolve the major features of this galaxy group.

Methodology

Observation Settings used on the 20m Skynet Dish for these observations:

- L-Band
- High Resolution
- Centre Frequency set to 1420.4 MHz
- 10 seconds "ON"
- 10 seconds "OFF"
- 10 repetitions for a total of 100 seconds on source for each point
- 3 degrees Az and El offset for "OFF"

Mapping Plan

Each point in the map was given an index number or name according to the chart below. These where the names used in the analysis spreadsheet to identify each point on the map.

Leo Triplet Plan

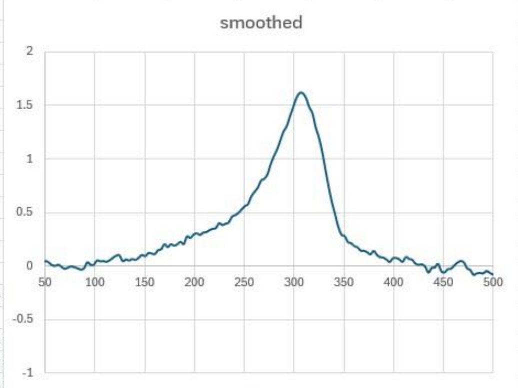
	11h24m	11h23m	11h22m	11h21m	11h20m	11h19m	11h18m	11h17m	11h16m
14deg20m									
14deg5m		19			25	26			
13deg50m	16	20	21	22	23	24	27		
13deg35m	1	2	3	4	n3628	5	28		
13deg20m		17	18	6	7	8	9		
13deg5m				15	m66	m65	10		
12deg50m				14	13	12	11		
12deg35m									
12deg20m									
12deg5m									

Analysing the Data:

Our method involved capturing individual spectra in the same way we do other galaxies and analyzing the data in Excel. We used an Excel spreadsheet designed by one of the authors (Jason Burnfield) to standardize analysis and speed up the process of analysing data from multiple galaxies. If the spectrum had a clear "winning" peak, the value of the velocity at that peak is chosen for that point on the map. If there was no clear "winning" peak or if the spectrum was more or less flat, the average velocity was calculated using the average of the products of amplitudes and velocities over the spectrum divided by the average amplitude. We then coloured cells in the velocity map using conditional formatting with a 3-colour scale (red, yellow, blue) representing 90th percentile, 50th percentile, and 10th percentile of all velocities in the map. Cells in the amplitude map were coloured with a 3-colour scale (white, yellow, black) representing 90th percentile, 50th percentile, and 10th percentile of all amplitudes in the map.

An example of processing within Excel during this study (below):

	A	B	C	D	E	F	G	H	I	J	K	L	M
49	# POWER_XLYR=[1.23, 1.19]												
50	# VELDEF=RADI-OBS												
51	# VELOCITY=0.000												
52	# NPOL=2												
53	# POLMODE=Linear												
54	# POLTYPE=XXYY												
55	# WARNING=None												
56	# NOISECAL=HI												
57	# PRECAL=5												
58	# POSTCAL=5												
59	# CRYOTEMP=16												
60	# BOXTEMP=26												
61	# TSYS=XX1:146.14, YY1:149.82												
62	# TSYS=XX2:145.98, YY2:150.12							pk ampl	pk vel				
63	# TCAL=XX1:9.17, YY1:10.07							1.618325	309				
64	# TCAL=XX2:9.17, YY2:10.07							avg ampl	avg vel				
65	# Calibrated spectra							0.466212	281.2195				
66	#							m	-0.0022				
67	#							b	2.85				
68	#Freq1(MH	XX1	YY1 F	req2(MHz)	XX2	YY2	obs vs cal	V(km/s)	smoothed	avg (XX1,YY1)	fit	corrected	prod
69	1427.444	92.7217	85.89	1427.444	92.6248	86.0631	1.065	-103.937	-0.618348	2.33095	3.07866	-0.747712	64.26928
70	1427.429	93.2004	86.2893	1427.429	93.103	86.4632	1.18155	-100.716	-0.588741	2.5657	3.07158	-0.505876	59.29579
71	1427.414	93.995	86.5098	1427.414	93.8967	86.6841	1.20595	-97.4954	-0.593944	2.0657	3.06449	-0.99879	57.90675
72	1427.399	94.275	86.9029	1427.399	94.1765	87.078	1.00235	-94.2744	-0.585025	2.66895	3.0574	-0.388454	55.15288
73	1427.383	94.9579	87.4953	1427.383	94.8586	87.6715	1.268	-91.0555	-0.555086	2.33845	3.05032	-0.711872	50.54365
74	1427.368	95.5171	87.8621	1427.368	95.4173	88.0391	1.07625	-87.8344	-0.519783	2.68585	3.04324	-0.357386	45.65482
75	1427.353	95.9348	88.2615	1427.353	95.8345	88.4394	1.09855	-84.6132	-0.484474	2.62505	3.03615	-0.411099	40.99292
76	1427.337	96.4285	88.7459	1427.337	96.3277	88.9247	1.12225	-81.392	-0.453897	2.3987	3.02906	-0.630362	36.94361
77	1427.322	96.7688	89.2747	1427.322	96.6677	89.4546	0.98125	-78.1707	-0.328471	2.5083	3.02198	-0.513675	25.67676
78	1427.307	97.7834	89.6412	1427.307	97.6811	89.8218	1.1424	-74.9493	-0.245803	2.72925	3.01489	-0.285638	18.42272



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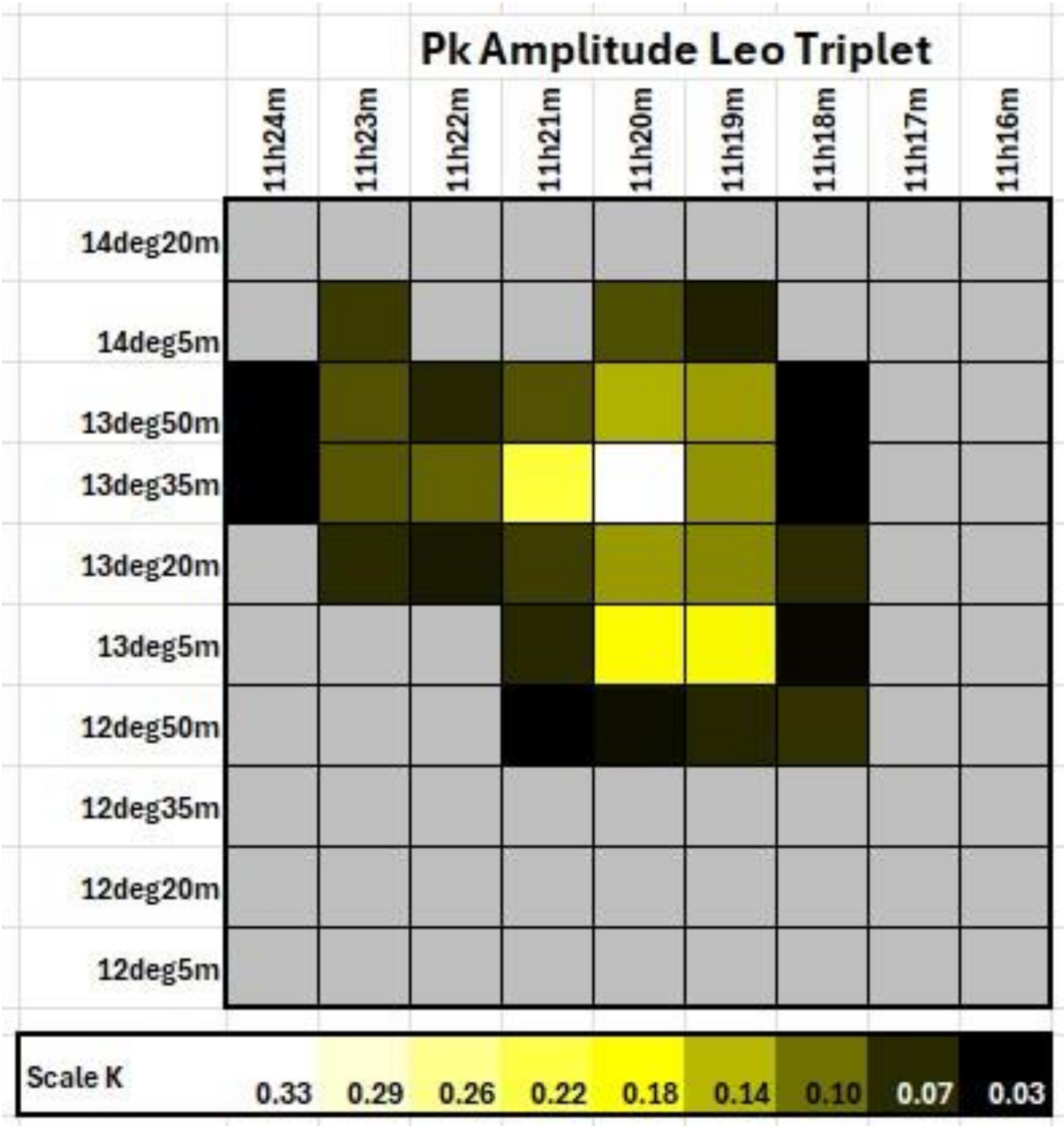
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11h22m
11h21m
11h20m
11h19m
11h18m
11h17m
11h16m
14deg20m
14deg5m
13deg50m
13deg35m
13deg20m
13deg5m
12deg50m
12deg35m
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Scale K
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0.26
0.22
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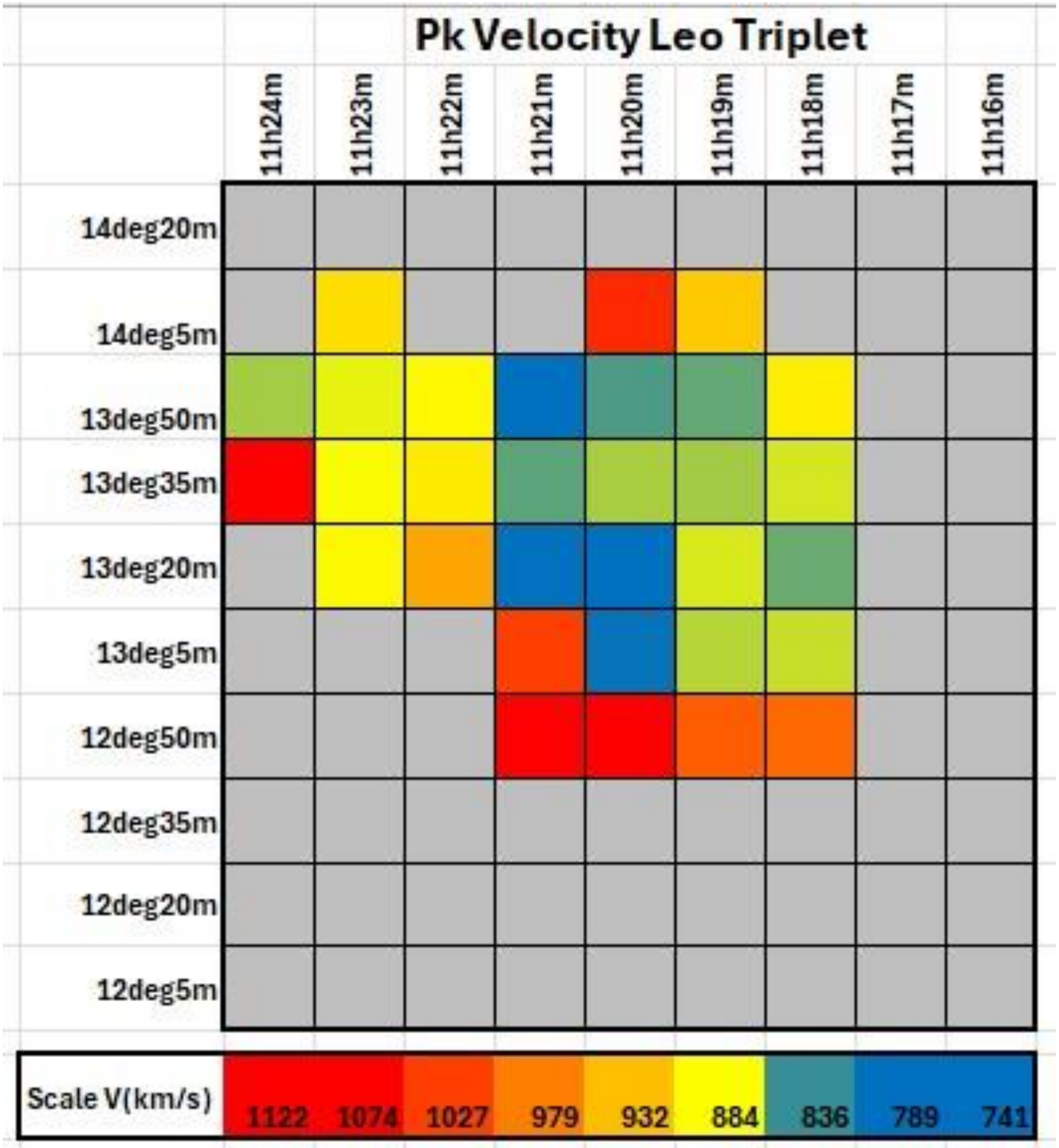
0.10
0.07
0.03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11h22m
11h21m
11h20m
11h19m
11h18m
11h17m
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14deg20m
14deg5m
13deg50m
13deg35m
13deg20m
13deg5m
12deg50m
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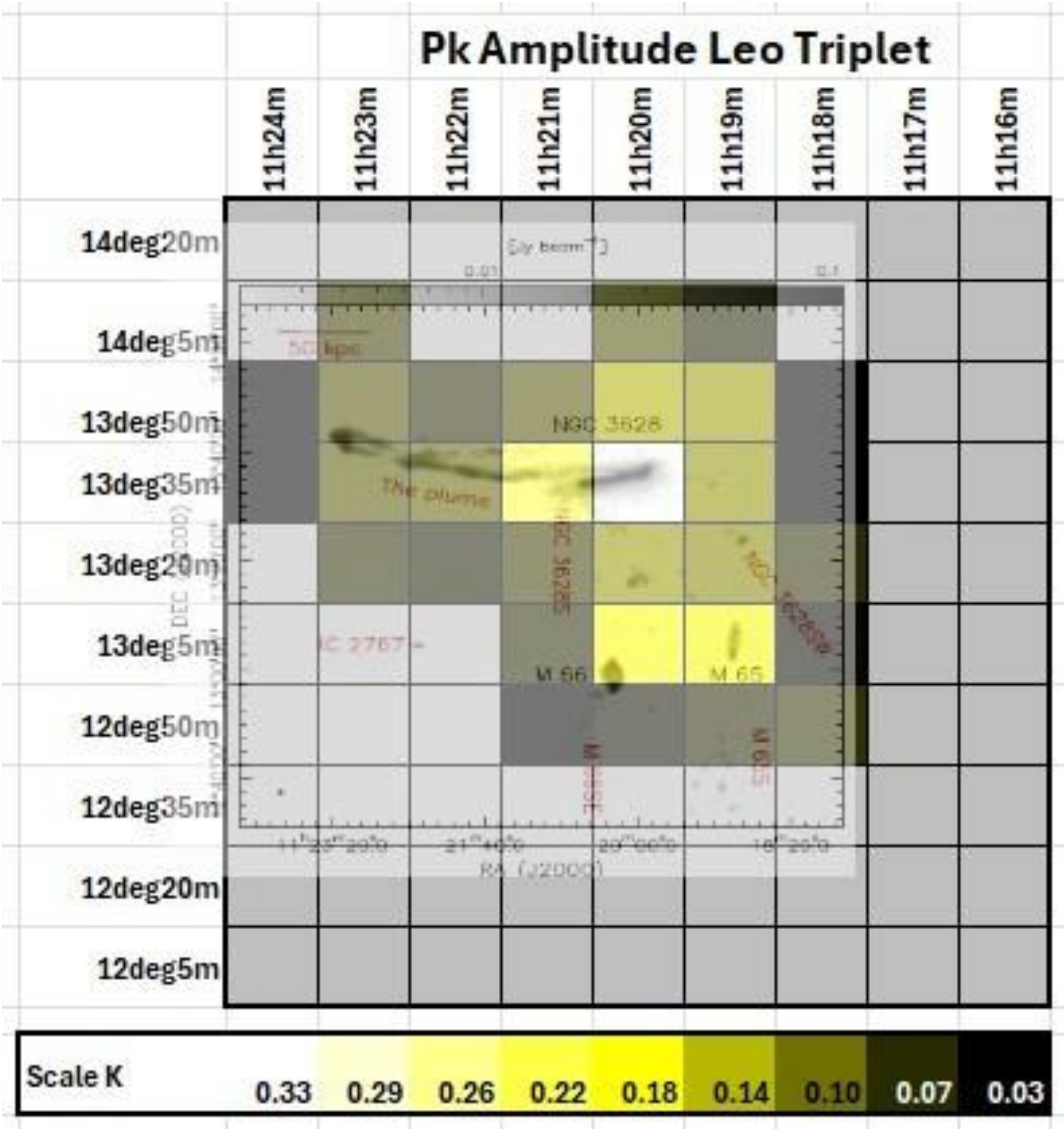
884
836
789
741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14deg20m
14deg5m
13deg50m
13deg35m
13deg20m
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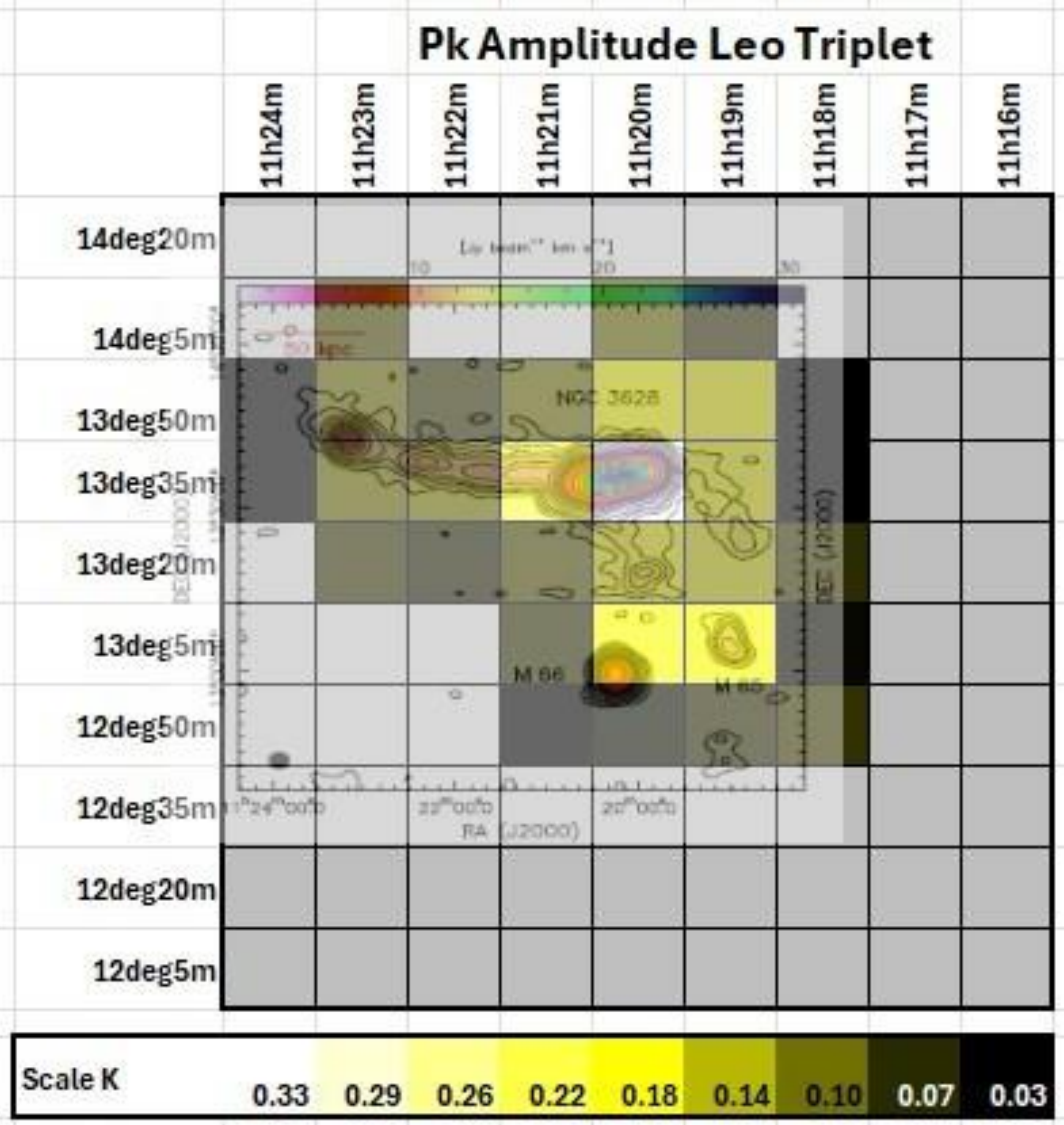
12deg50m
12deg35m
12deg20m
12deg5m
NGC 3628
The plume
M 66
M 65
RA (J2000)
Scale K
0.33
0.29
0.26
0.22
0.18
0.14
0.10
0.07
0.03


Pk Amplitude Leo Triplet
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14deg5m
13deg50m
13deg35m
13deg20m
13deg5m
12deg50m
12deg35m
12deg20m
12deg5m
NGC 3628
M 66
M 65
RA (J2000)
DEC (J2000)
Scale K
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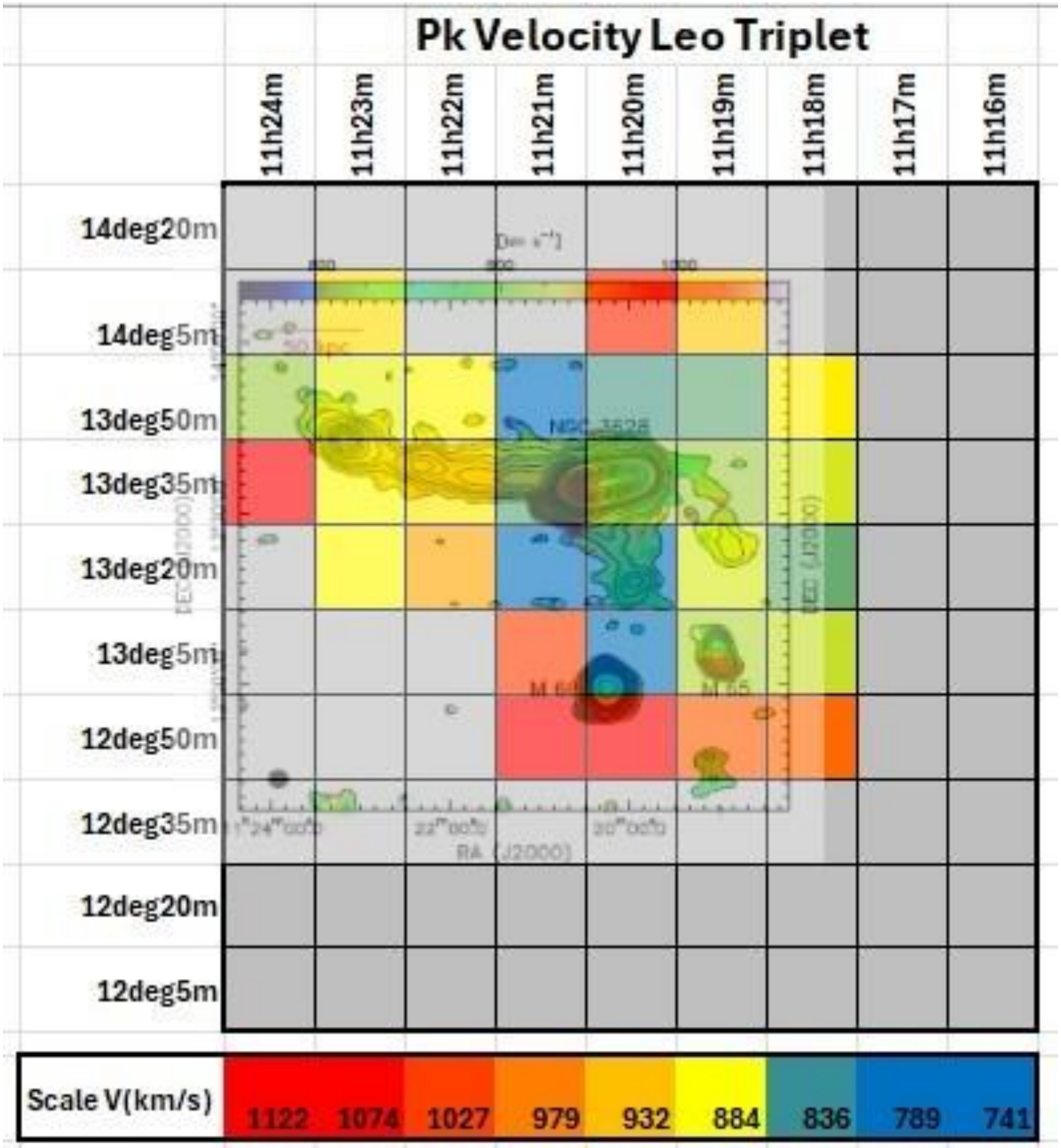
0.14
0.10
0.07
0.03



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https://doi.org/10.1051/0004-6361/202141565

Two Meter Umbrella Antenna for Mosaic 1.42GHz Mapping

by Paul Gochin (KB3PUW)

Abstract

The goal of this study was to design and construct an antenna suitable for targeted studies of 1.42GHz astronomical signal sources. The desired characteristics included being light weight for mounting on an astronomy tripod, inexpensive, quick to fabricate and convenient to store. This report describes the design and shows both lab performance and an actual mosaic study centered on Cygnus A.

Methods

The design for this antenna was based on the Alex Pettit umbrella design [1]. Most of the parts are readily available from web commercial sources. The umbrella utilized was a Westcott 4633 7-Feet Silver Parabolic Photo Umbrella. The back was covered with Military Grade Faraday Cloth (it was too difficult to work on front side and the Pettit study showed that the umbrella silver was transparent at 1.42GHz). The umbrella was held with ¾" thin wall steel tubing Special end caps were constructed to tension hold 4 tines of the umbrella The center back of the umbrella had a ½" short screw which was fit into a ¼" hole in an angle iron L-bracket (see Figure 1). A counterweight was added for balance (see figure 2). The structure is affixed to a Vixen astronomy mount plate compatible with many telescope tripod mounts. The antenna in disassembled form is shown in Figure 2.

The center axis of the antenna was designed to align with an optical guide scope which is used with plate-solving go-to software (Sharpcap Pro) to accurately position the antenna on a target. The antennas and a guide scope were alternately mounted on a Celestron AVX computer controlled tripod. A laptop computer was used to control the AVX.

Data was collected using SDR#/IFAverage software. Mosaic data analysis was done with custom software (Radio Astronomy Interactive Study Environment: RAISE). Comparative data was also obtained from the Survey Database [3] using the same mosaic targeting coordinates as the experimental data.

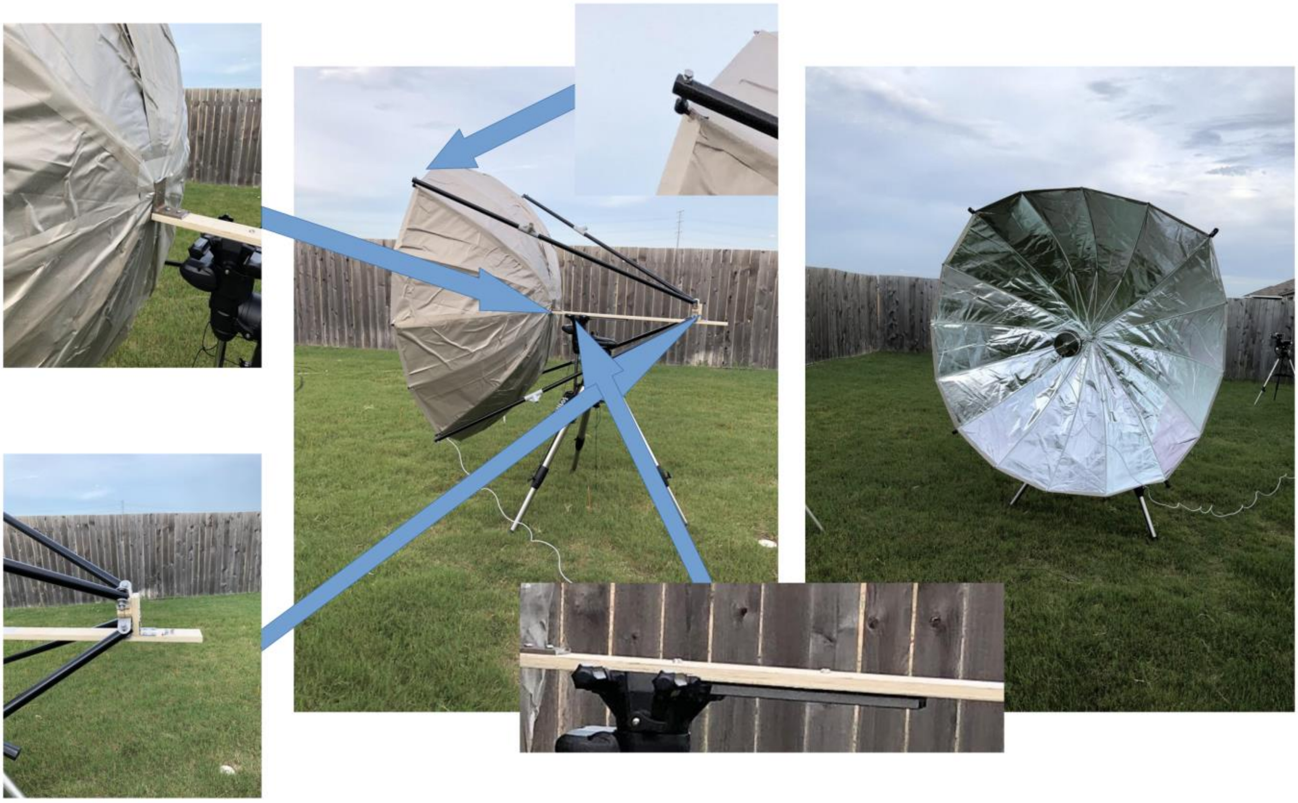


Figure 1
Photographs of the antenna mounted on a tripod including enlargements of the critical mount points. Also shown is the mounting of the “pie pan” loop antenna (the small disk in the center of the umbrella in the rightmost photo)

Figure 2
Photo showing the antenna disassembled for storage.

A combination of 2 tripods were used to hold the umbrella in position while tension fitting the steel tubes to the umbrella tines (see Figure 3). The antenna is transferred to the main tripod for data collection after using the guide camera and plate-solving Go-To functionality to position the mount on the target center area.

Figure 3
Photograph of the antenna on the assembly rig. The right tripod holds the umbrella in structure. The tripod to the left holds the umbrella in place to allow a single person to attach the steel tubes to the umbrella tines.

The detector was constructed from a 6” diameter 2” deep pie plate in accordance with the Pettit design [1].

The theoretical characteristics of the umbrella antenna are [2]:

with the numbers you gave (diameter $D = 84$ in = **2.1336 m**, depth 22 in → focal length $f \approx 20.06$ in = **0.5095 m**), we can estimate the antenna performance at **1.42 GHz** (λ ≈ **0.2113 m**).

Geometry (from your measurements)

- Diameter $D = 2.1336\ \mathrm{m}$
- Physical aperture area $A = \pi(D/2)^2 \approx \mathbf{3.575\ m^2}$
- Focal length $f \approx \mathbf{0.5095\ m}$ → $F/D \approx \mathbf{0.239}$ (very "fast")
- Wavelength $\lambda \approx \mathbf{0.2113\ m}$

Effective aperture & gain (estimates for different aperture efficiencies η)

Effective area $A_e = \eta A$. Gain $G = \dfrac{4\pi A_e}{\lambda^2}$.

(Results rounded to sensible precision.)

η (aperture efficiency)	A_e (m²)	Gain (linear)	Gain (dBi)
0.30 (pessimistic)	1.073 m²	302	**24.8 dBi**
0.50 (typical/realistic)	1.788 m²	503	**27.0 dBi**
0.60 (optimistic)	2.145 m²	604	**27.8 dBi**

Beamwidth (approximate)

- Half-power beamwidth (HPBW) ≈ $70\lambda/D$ ≈ **6.9°**.

The theoretical prediction for the umbrella was a focal point at 20 inches from the umbrella vertex. This was confirmed by sliding the loop detector towards and away from the vertex while measuring the signal amplitude using SDR#/IFAverage. The VNA was used as a signal source for these measures.

Results

Experiment 1

Several lab experiments were done to assess the performance of the antenna system. The first was using a Nano Vector Network Analyzer (VNA). Figure 4 shows the detector dish with the antenna loop. The VNA shows the SWR to be about 1.5:1 which is quite adequate for signal reception (the VNA was set to a range of 1.37 to 1.47 GHz). This pan-loop design worked well for mechanical assembly on the umbrella post.

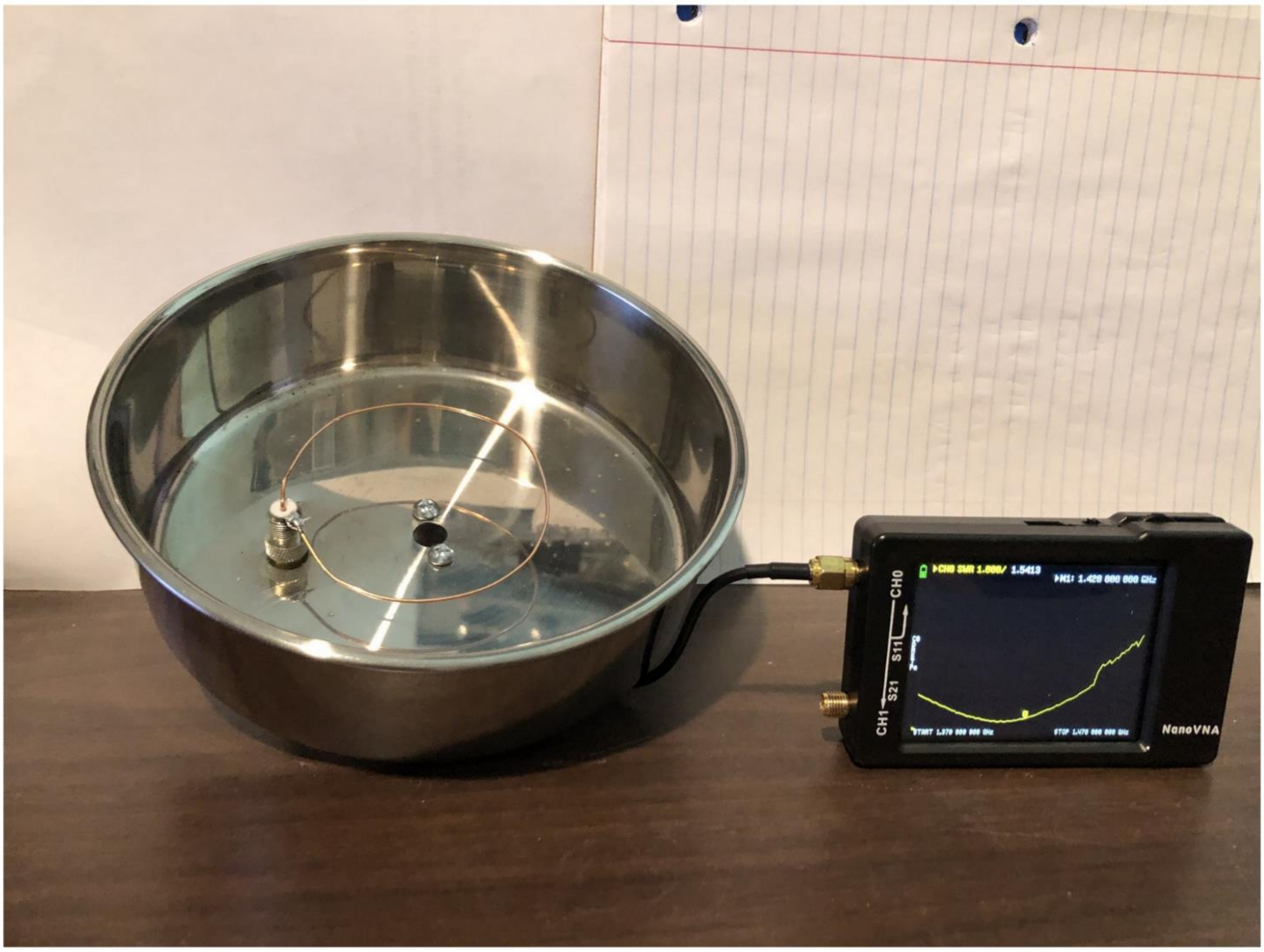


Figure 4
"Pie plate" loop detector SWR being measured with a Nano VNA.

Experiment 2

An experiment was performed to give a rough estimate of the performance of the antenna before attempting to acquire astronomical data. A simulated 1.42GHz signal was produced using a NanoVNA with a 10 CM vertical antenna. The VNA was set to a range of 2MHz centered on 1.420405 GHz. The signal source was moved to 16 positions around the antennas at a distance of about 2 meters. The signal source elevation was set to match the antenna center. SDR#/IFAverage was used for data collection. IFAverage background was set using a 50 ohm load. The same IFAverage parameters were used for all data collection (10 seconds of averaging). A NESDR SMArt v2 (which supplies LNA power) was used as the Software Defined Radio (SDR). A Nooelec SAWbird+ H1 was used as the Low Noise Amplifier (LNA). The test procedure is diagrammed in Figure 5.

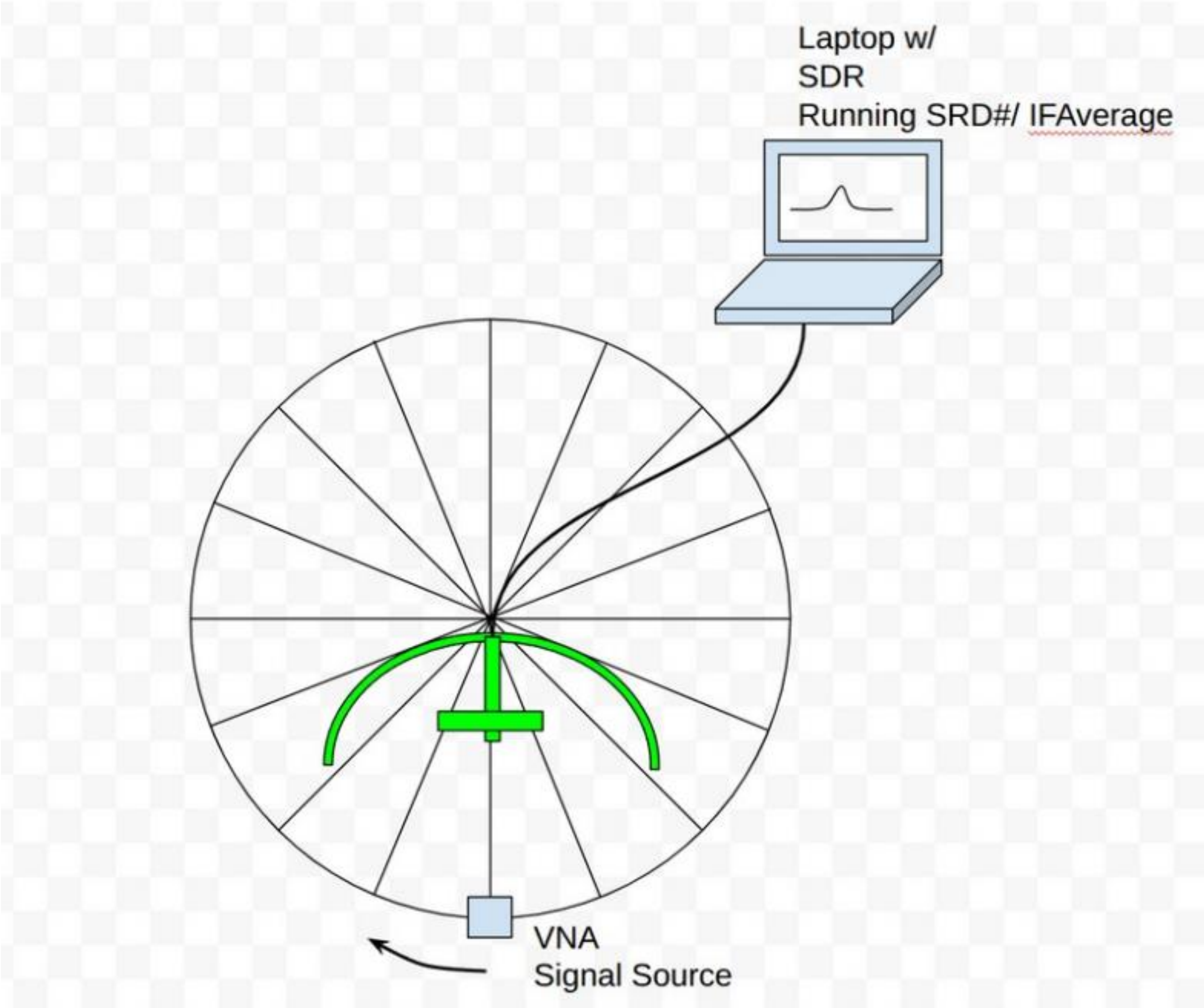


Figure 5

This figure shows the positions the VNA was moved to in gathering the 16 position data

The performance of the umbrella antenna was calibrated against the performance of the Nooelec Satellite Mesh Antenna for Inmarsat, Iridium, & Hydrogen Line Applications (20dBi Parabolic Antenna w/ 1.4GHz Center Frequency). Sample data was collected in the same manner for both the Nooelec and Umbrella antennas.

The experimental setup is shown in Figure 6.

Figure 6
This figure shows the Nooelec mesh antenna mounted on a a tripod. The umbrella was similarly positioned for its measurements. The second tripod held the Nano VNA. The second tripod was moved around to 16 positions. Moving the VNA instead of the antenna reduced variability in results caused by environmental RFI.

Data was collected for both antennas. The largest peak from the VNA was used as the measurement points. Figure 7 shows the raw data plots from IFAverage. Note: a 50ohm load was used as the background for IFAverage.

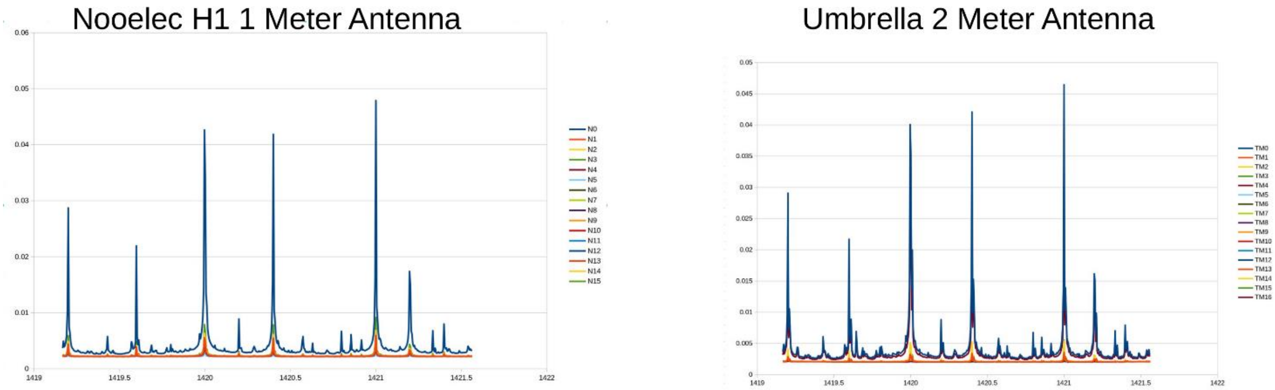


Figure 7

Plots made from the 16 positions of data collection for each antenna. The multiple spikes are due to the frequency scanning of the VNA. The largest peak, which was at 1421 MHz, was used for comparative measurements.

The results from the 2 antennas, plus a limited measure of the Loop detector, are shown in Figure 8. The results are in dB amplitude relative to the maximum value of the Nooelec antenna.

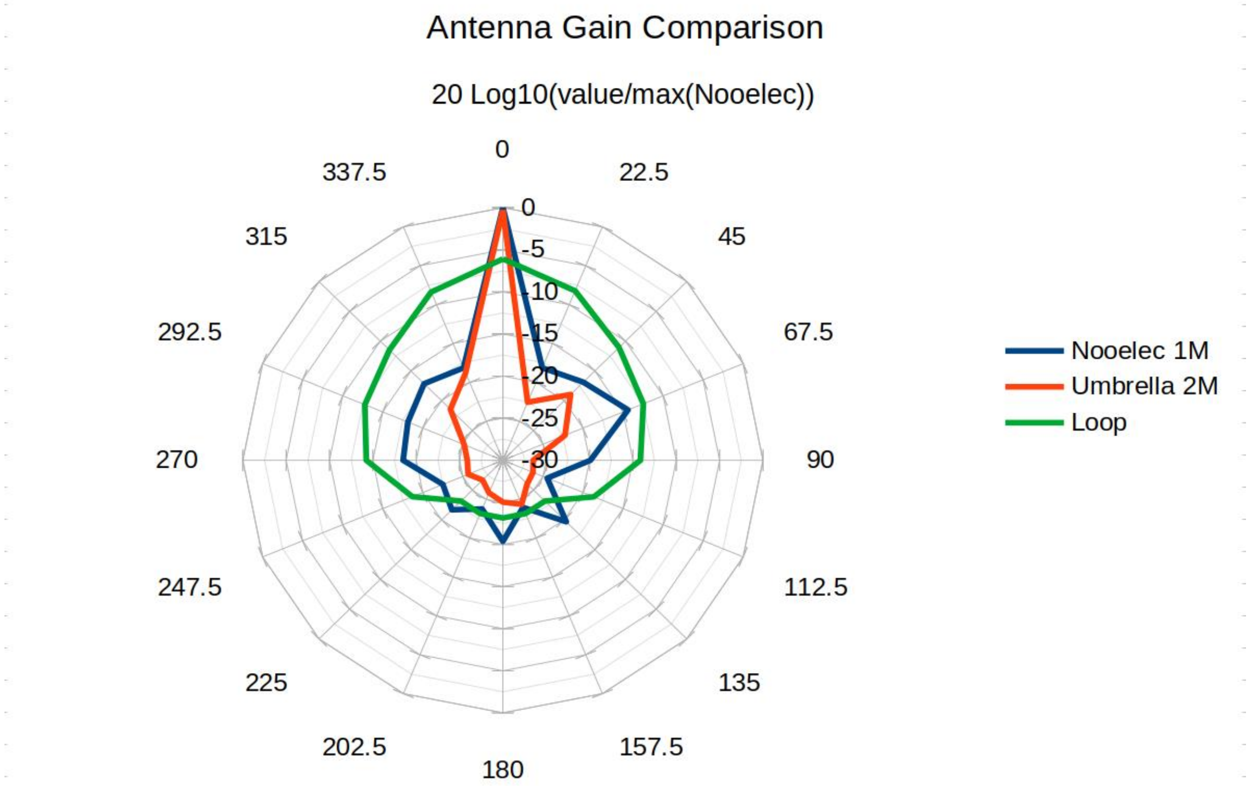


Figure 8
Antenna comparison plot. Note: The VNA test source had a vertical antenna matching the polarization of the Nooelec dipole whereas the Loop antenna is circular. This probably gave an amplitude advantage to the Nooelec. The Loop was only tested at 6 angles (0, 45, 90. 180, 270, 315).

The maximum gain (with the source at the front of the antennas) was about the same for the Nooelec and Umbrella. The side lobe and back attenuation were better for the Umbrella than the Nooelec. The loop detector alone showed lower gain than either antenna. The loop alone had poorer back to front and side lobe suppression than the antennas.

Experiment 3

Astronomical experiments were conducted using both the Nooelec 1 meter and the Umbrella 2 meter antennas. Figure 9 shows the software/hardware architecture used for all the astronomical experiments. The mount was centered on Cygnus A using the guide scope and camera fed into Sharpcap PRO which performed precise GO-TO functionality using plate solving (note: these antennas are not sensitive enough to detect extra-galactic signals - all results are likely from galactic hydrogen). The guide camera was removed and replaced by an antenna for each experiment after precision optical centering. IFAverage was used to collect the data. ASCOM Alpaca together with custom written software controlled the positioning of the mount to sample a 7 by 7 matrix at a resolution of about 3 degrees.

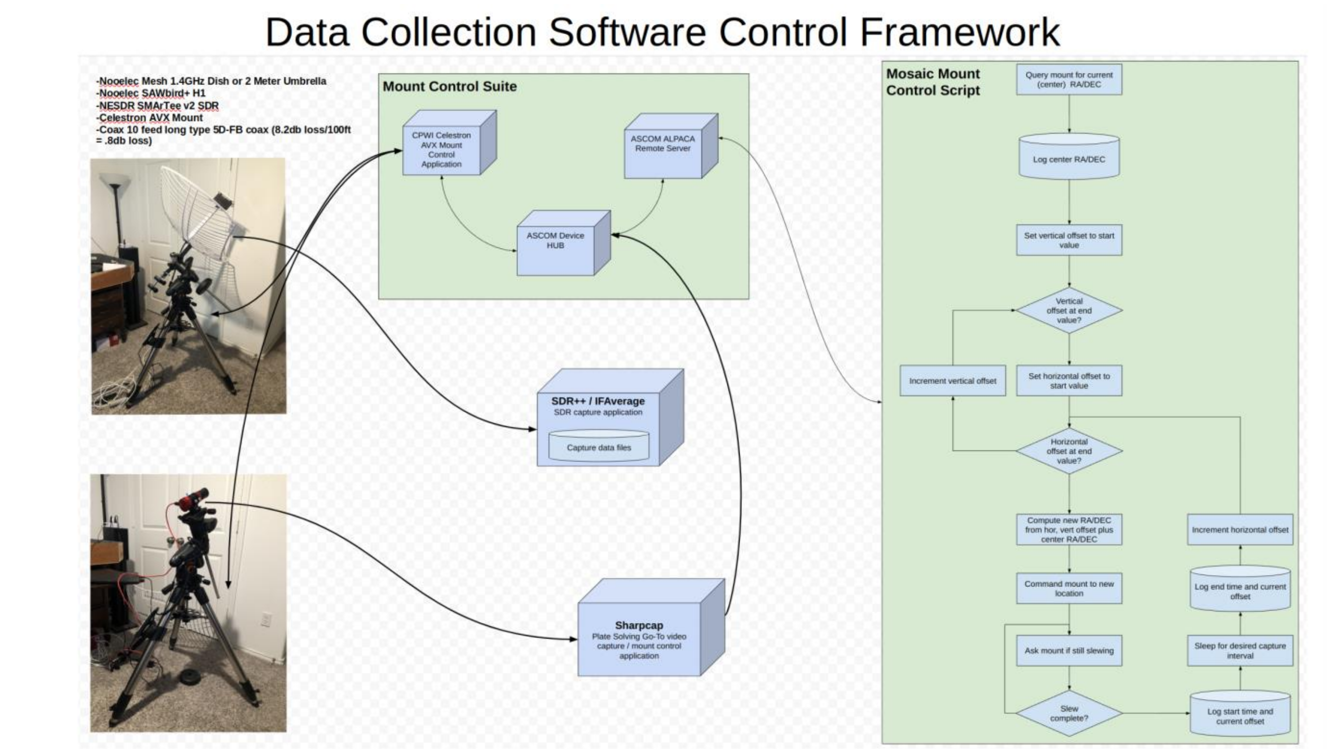


Figure 9

The results of data collection with the Nooelec 1 meter antenna are shown in Figure 10. The plot on the left is actual data from the Nooelec 1 meter antenna. The plot on the right is from a survey database of results collected with large antennas [4]. This database allows simulation of the results that would be obtained from smaller antennas, in this case simulating a 15 degree aperture. The overall results are very similar confirming proper targeting. Note that the plot on the left is about 500 channels covering 2.4MHz whereas the plot on the right is about 700 channels covering 4.5MHz. The spectra within a plot are the same scale. The spectra between plots are not. Each spectra for the collected data were the average of 6 samples gathered for 10 seconds each (1 minute total).

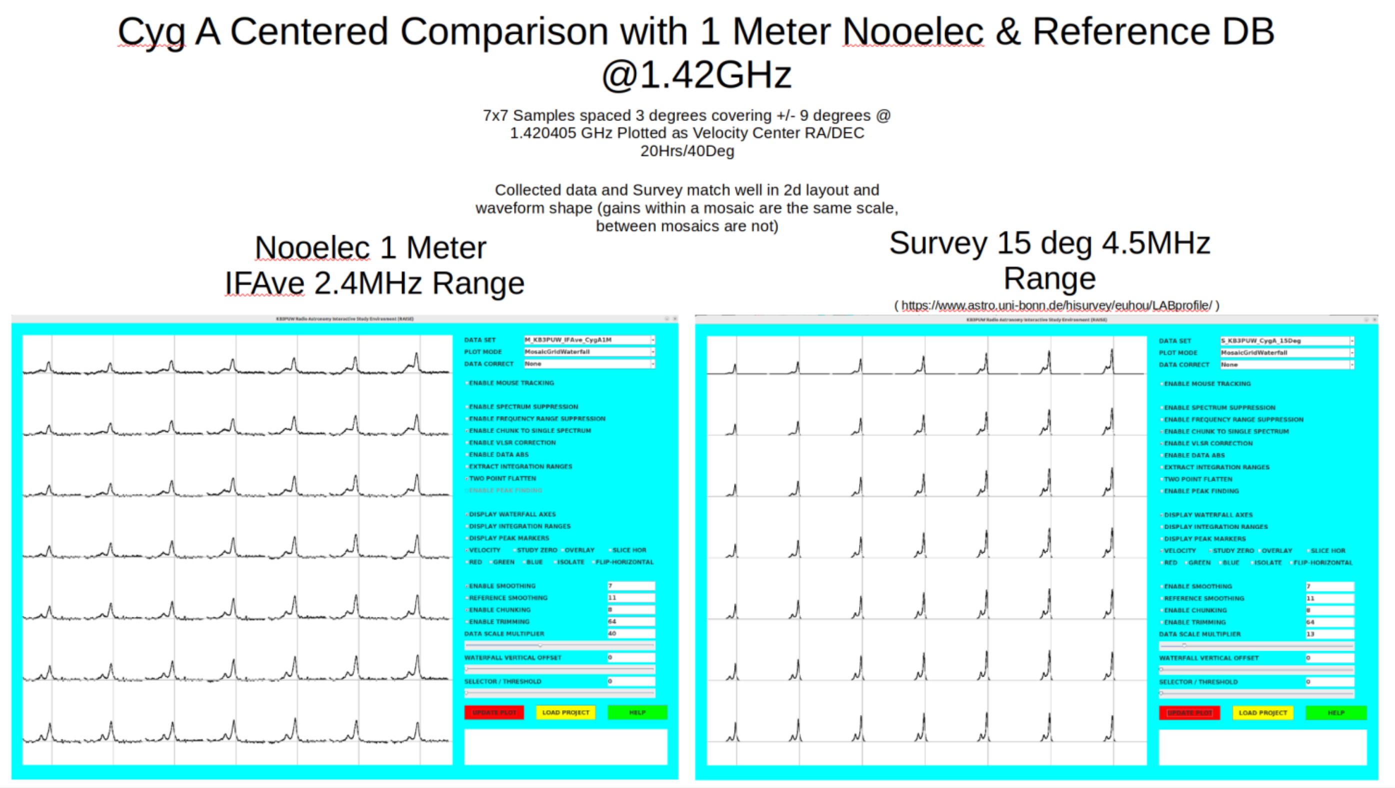


Figure 10

Figure 11 shows the data collection session for the 2 meter umbrella antenna. The photo on the right was taken of the antenna setup during the data collection session. The photo on the left shows like data from IFAverage for 1 sample of 10 seconds.

2 Meter Umbrella Test Session Photos

Photo of live display of IFAverage 10 second integration capture using the umbrella antenna (background set with a 50 ohm load)

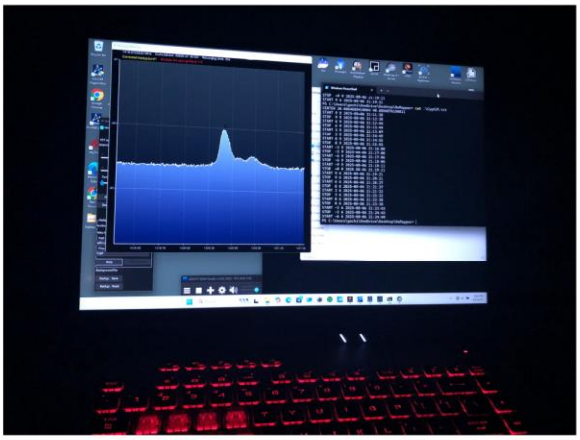


Figure 11

A number of other aspects of the experiment's conditions are worth mentioning. The umbrella structure is relatively fragile compared to most rigid frame antennas. For this reason, it was advisable to check the weather forecast for projected wind conditions. In addition, a local weather station was used to monitor wind speed. Winds were up to 8 miles an hour during the experiment and had no significant impact on the antenna. In addition, the ambient temperature was monitored. At the location and time of the experiment the ambient temperature was in the range of 90 degrees F (see Figure 12). Even in a room with an ambient temperature of 72 degrees the Nooelec SDR reaches 100 degrees F. A peltier cooler was used on the SDR to reduce and stabilize the SDR temperature. Another consideration is that in order to use optical techniques for targeting it is necessary to perform measurements at night. This has the further advantage that there is no spectral baseline variation due to the Sun.

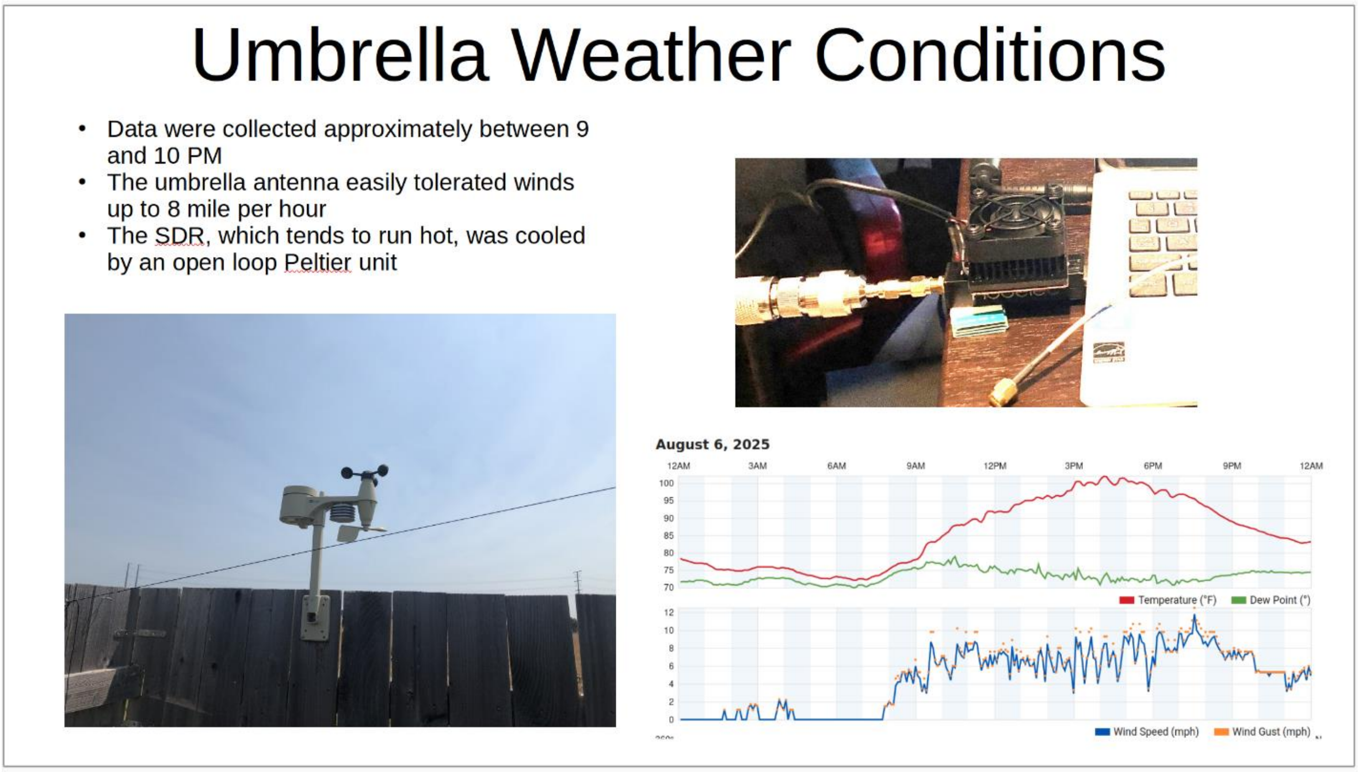


Figure 12

Figure 13 shows mosaic results for the 2 meter umbrella antenna. The plot on the left is the actual data and, on the right, the simulated data for a 5 degree aperture. The simulation here is also covering a different bandwidth and scaling, but the results are overall quite similar.

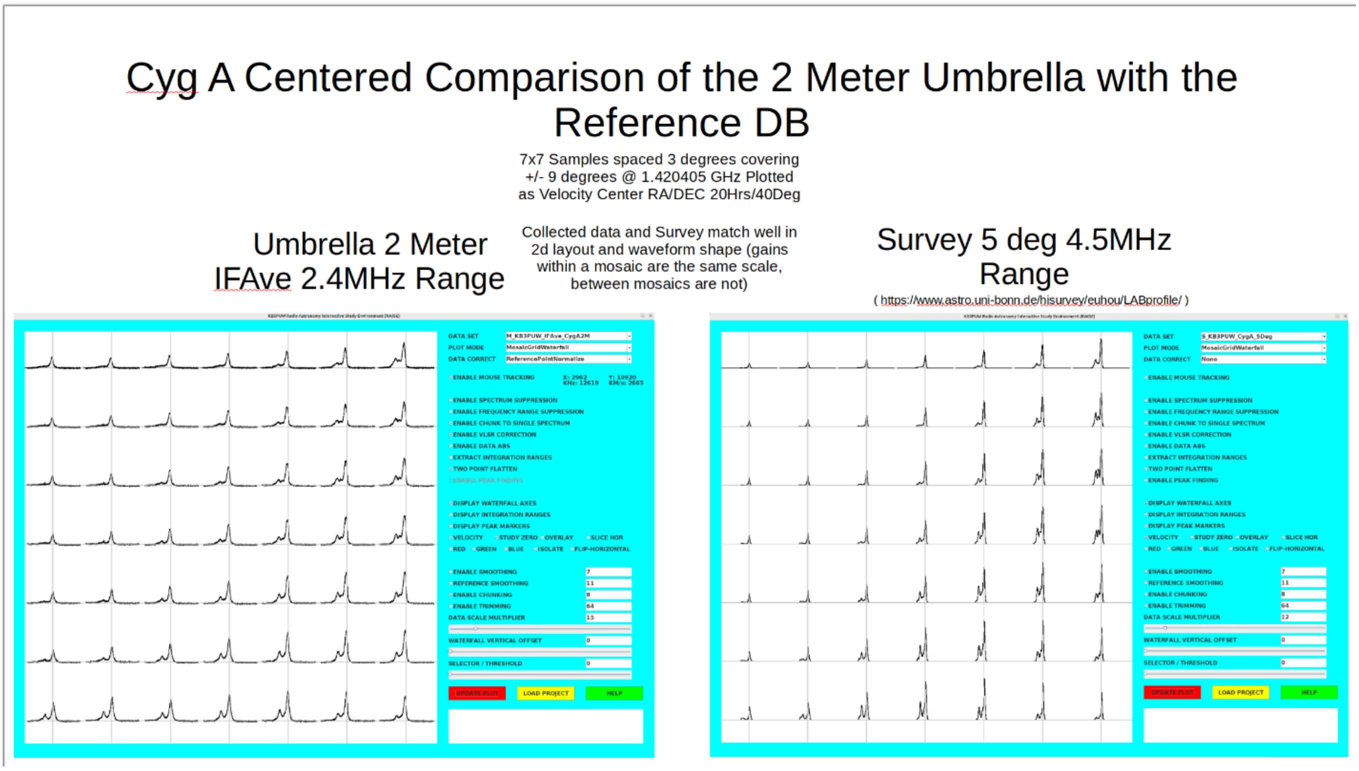


Figure 13

The ultimate goal of the study was to develop an antenna that outperforms the 1 meter Nooelec. Figure 14 shows a comparison of the 2 meter umbrella with the 1 meter Nooelec under identical conditions: same sample coordinates, same electronics, same software, same sampling time spans and the same scaling. The results indicate the 2 meter antenna showed a signal strength of about 4 times greater amplitude as well as signal-to-noise and with a corresponding improvement in spectral detail.

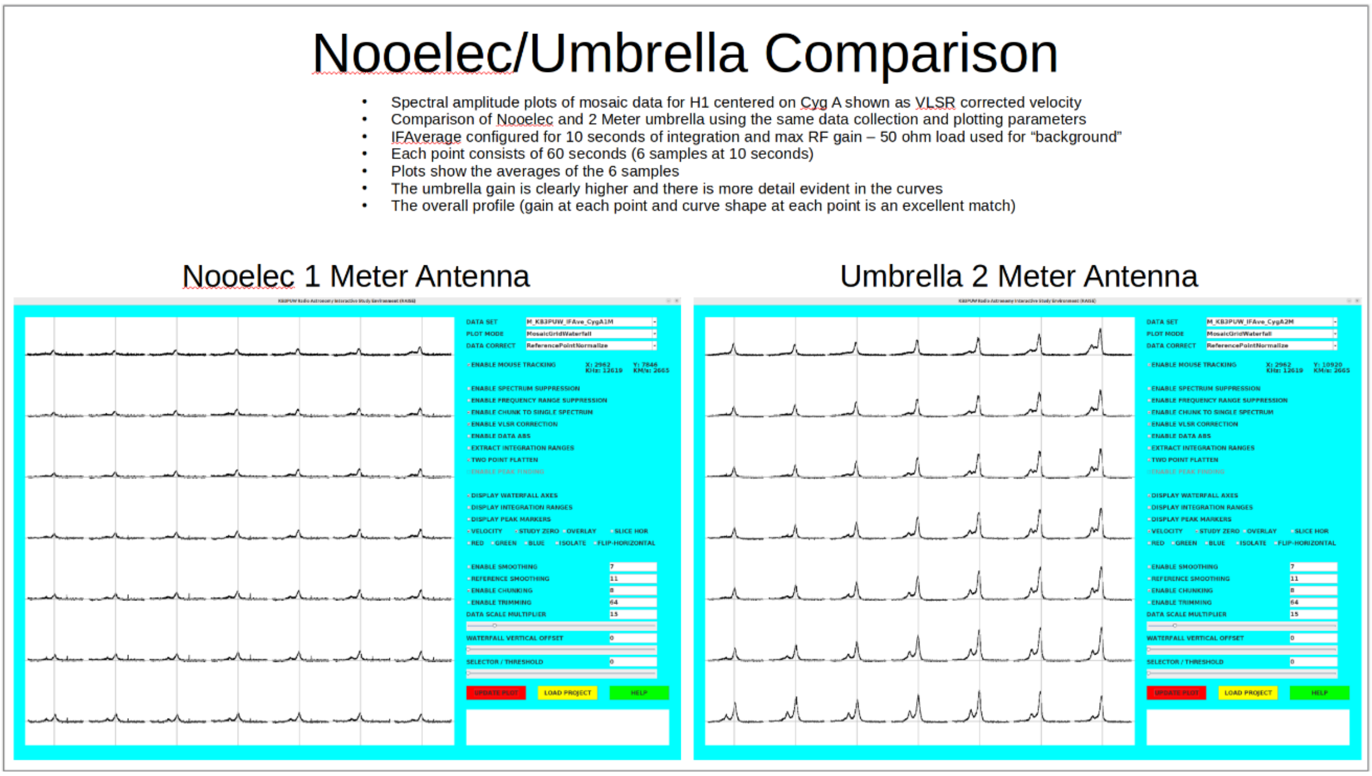


Figure 14

Figure 15 gives a rough impression of the difference in aperture of the 2 antennas in the form of 3D heatmap plots of the data from figure 13. The 2 meter antenna shows less spread as would be expected from a larger diameter antenna.

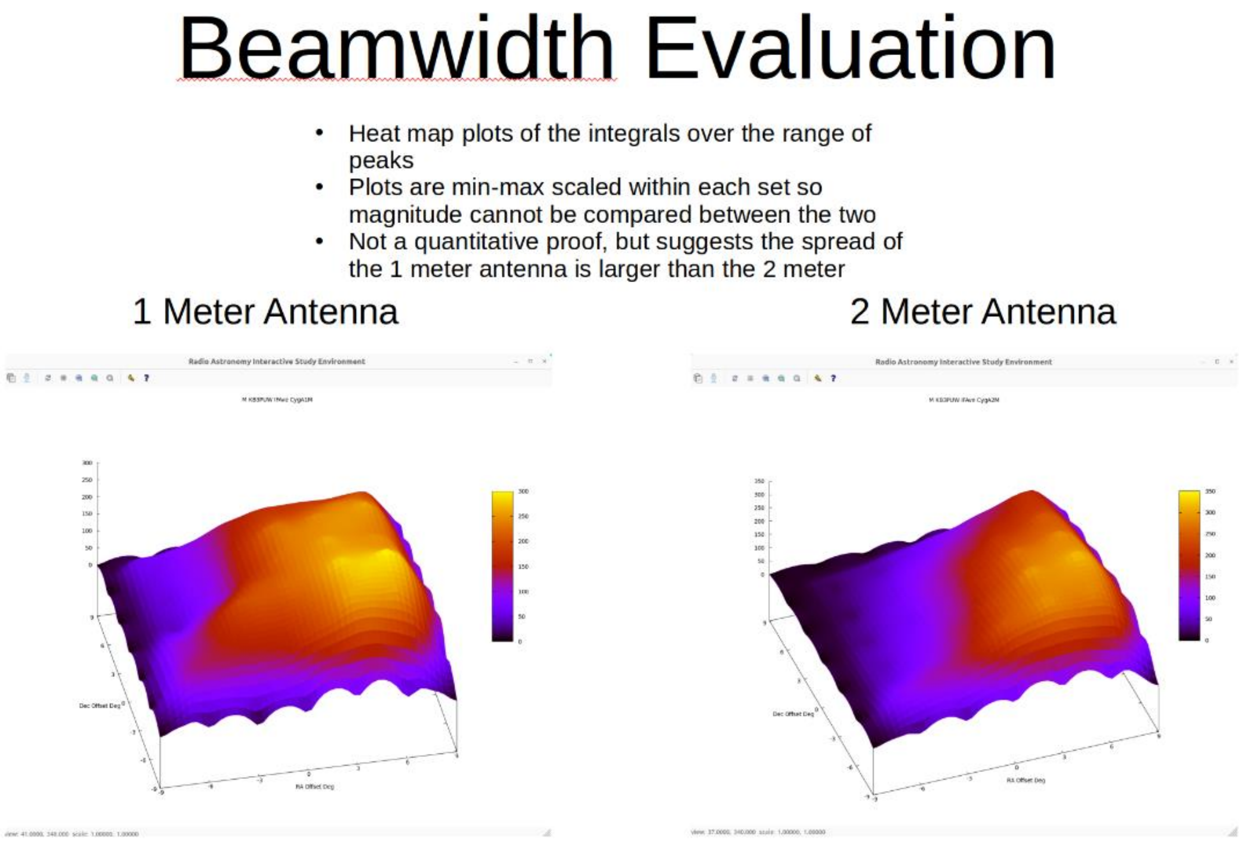


Figure 15

Comparative analysis and calibration were attempted with both antennas (see Figure 16). An attempt was made to measure the T_{sys} of each antenna. A portion of the non-H1 part of the spectra was compared to the spectra when pointing at the ground. Using 10K for the cold sky and 290K for the ground the T_{sys} came out to be about 80K for the 2 meter antenna. The results for the 1 meter antenna were less convincing with a result of 919K. An attempt was also made to be able to compare the current results with previous work [4].

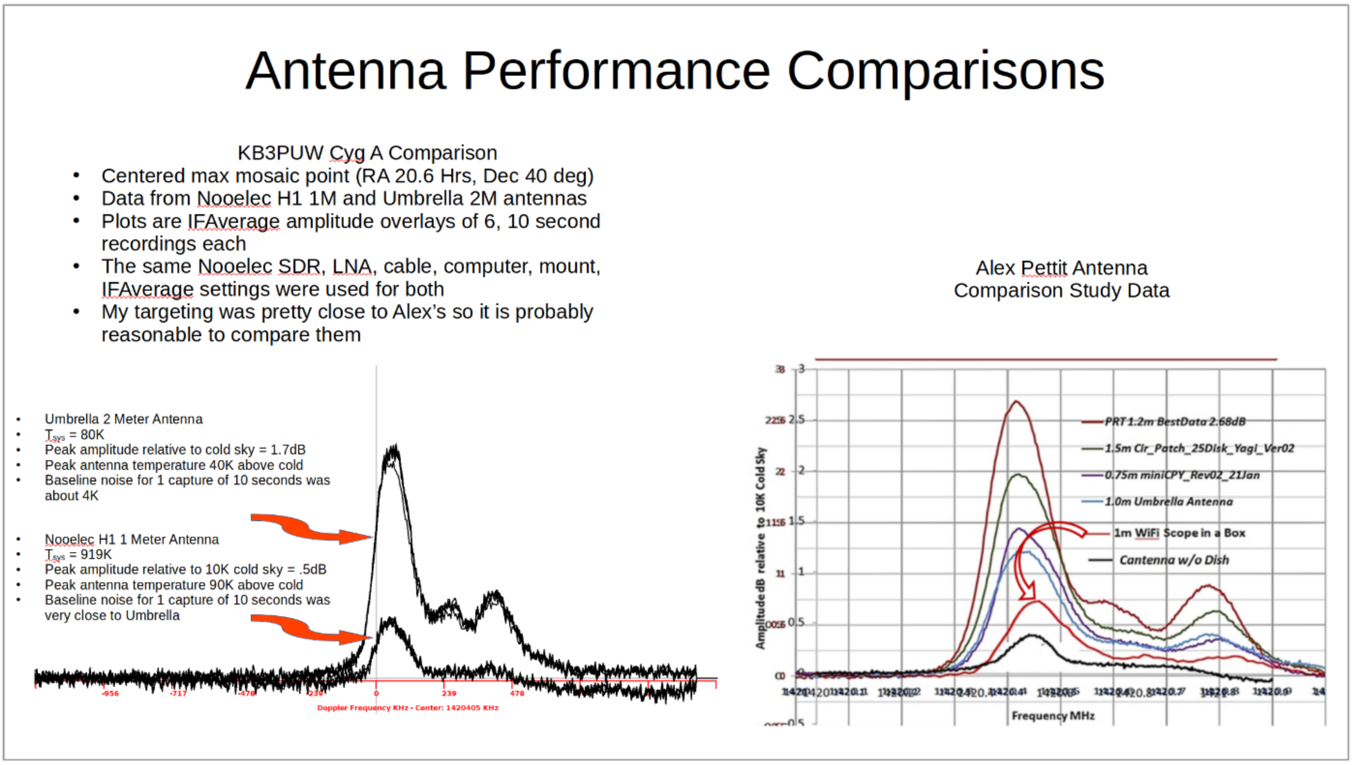


Figure 16

One final analysis step was performed plotting the heatmap for the 2 meter antenna on galactic maps shown in figure 17. Two versions of background were used. One from Ted Cline the other from Alex Pettit. Both sets of results agree well.

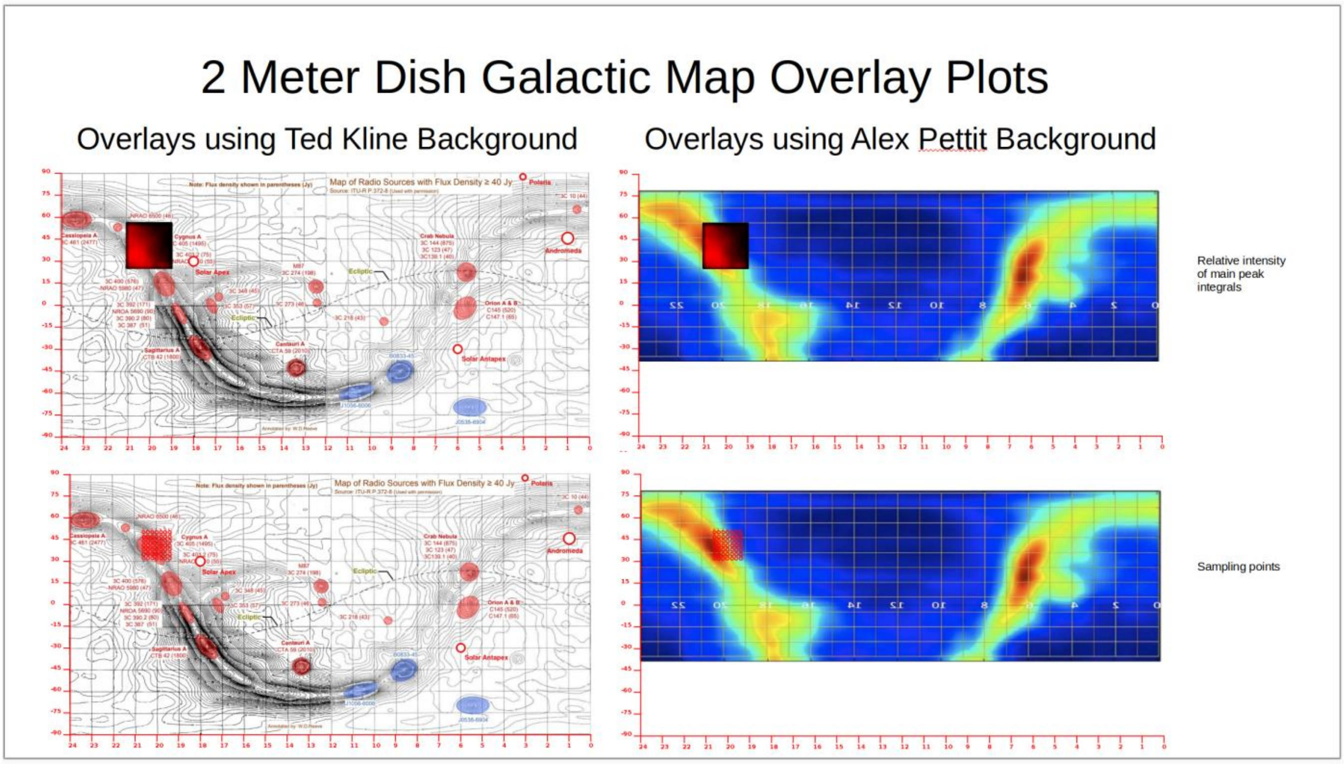


Figure 17

Conclusions

The results of these experiments indicate that the umbrella design was quite successful for the intended purpose. The performance of the umbrella far exceeded the 1 meter Nooelec. The umbrella is light, relatively inexpensive, can be fabricated within a few days and can be disassembled for storage. The increased performance should make it possible to detect more difficult to measure entities such as fast hydrogen.

The umbrella implementation presented herein is a modified version of the Pettit design, using a photography umbrella, Faraday cloth and a “pie pan” loop detector. In addition, a novel structure was created leveraging steel tubing, the tines of the umbrella and a Vixen plate. It is important to note that this antenna is intended for use with a pointing system for short durations under monitored conditions. The structure is not suitable for long term unattended drift studies.

References

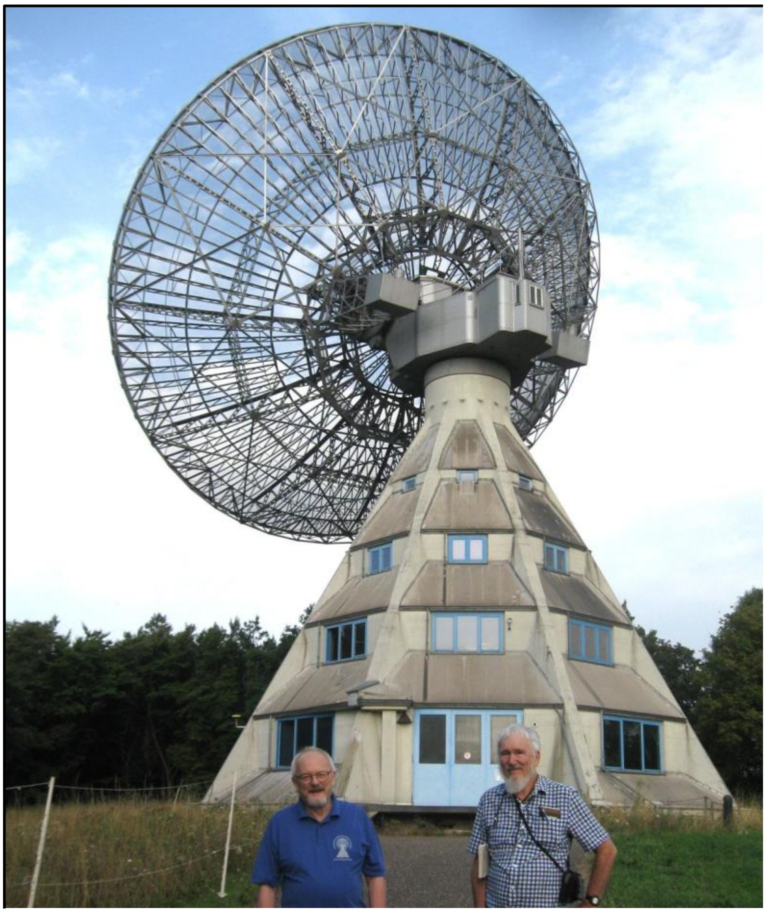
[1] Alex Pettit umbrella design https://www.youtube.com/watch?v=ymclkNnCeCc

[2] ChatGPT

[3] EU-HOU Connecting classrooms to the Milky Way
AIfA Hi Survey Server: https://www.astro.uni-bonn.de/hisurvey/euhou/LABprofile

[4] Alex Pettit antenna comparison study

Welcome to Skynet, Skynet 20m: Education and Science Collaboration.
https://www.gb.nrao.edu/20m/



Visit to Astropeiler Observatory

Bruce Randall, NT4RT
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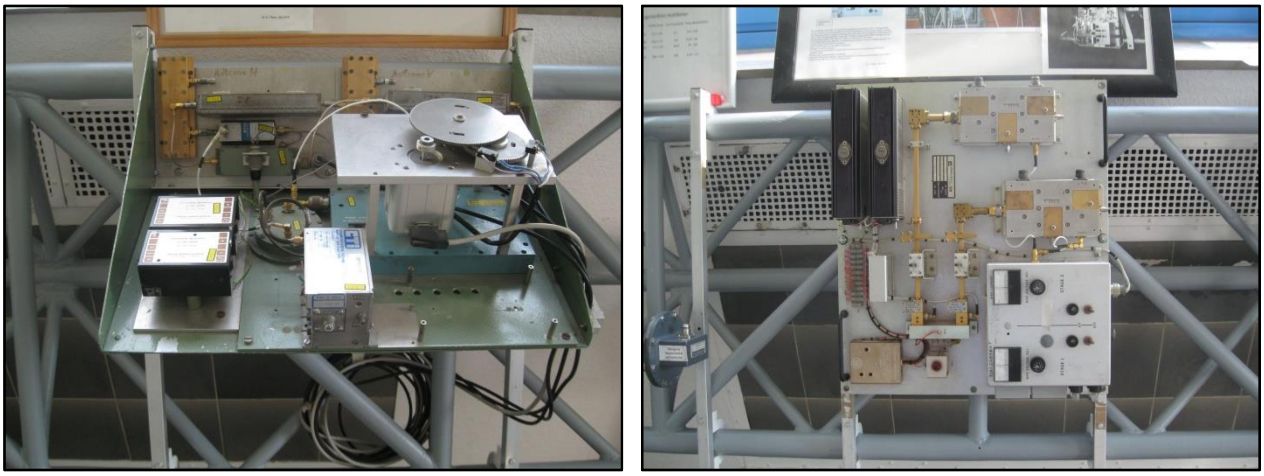
In August of 2025, I visited my son in the US Army, stationed in Germany.

Dr. Wolfgang Herman (on left in picture) was kind enough to arrange a visit to the observatory for me while I was in Germany. [1]

Note that this observatory is on a hill top instead of a valley, as is more normally done for radio telescopes. As initially built, this dish was shared with military radar research. The high location was needed by the military.

Education as well as research is important to the facility.



Above is some of the demonstration equipment in the display area. This facility is a museum and historical site as well as a modern research facility.

This beautifully built model of the 25 meter antenna was made by a high school student. The Commodore PET computer in the next photo is not in use. In is an antique from the 1980's.

On the left is a receiving equipment rack. The signal is down-converted to a range of 100 to 200 MHz at the feed. Somewhere in there is an Ettus B210 SDR receiver which processes up to 56 MHz of bandwidth from the down-converted range. Many receivers on site use the Ettus B210.

On the right is the time and frequency standard rack. A rubidium reference with an output of 10 MHz supplies the entire site. A GPS frequency standard is cross checked against the rubidium reference. The phase noise of the Rubidium standard is much lower than the GPS. The GPS compensates for long term drift. The long term stability of the GPS is better because the system is corrected often. FRBs and Pulsars need very good timing and frequency accuracy.

Azimuth drive hardware is on left. Note the very large gray gear at the left edge. From memory, it is 25cm wide or so. The green housing has a gear train and the drive gear. The gray housing has the motor and speed reduction gears. The size of drive hardware goes up very rapidly with increasing dish area. Proper lubrication and maintenance is essential to keep this in operation. There are multiple levels of safety interlock devices to assure against disaster in the event of a control system failure.

The elevation drive is on the right. Only part of it is visible. Again, note the substantial size of the hardware.

This drive system can move the dish up to 0.5° per second on either azimuth or elevation. The pointing accuracy is 0.05°. The system can be stopped, or track almost anything across the sky.

The 3 phase 380 VAC motor in the center turns two 440 VDC generators to supply the large motors that move the dish. The elevation is on the left and the azimuth on the right.

On the left, the dish feed and the support structure is viewed through the dish surface. The substantial structure allows a large amount of equipment to be installed at the feed.

On the right is a closer view of the Chaparral type dish feed**.** It is usable from 1100 to 1700 MHz. A symmetrical crossed dipole in the back of the wave guide allows the wider bandwidth without undesired waveguide modes.

With the 10K noise temperature LNA from Sandy Weinreb [2], the system temperature is 35K. This performance is obtained without cryogenic cooling.

The amplified signal from the feed is down-converted to 100 to 200 MHz range at the feed, and then goes down a cable to the receiver rack.

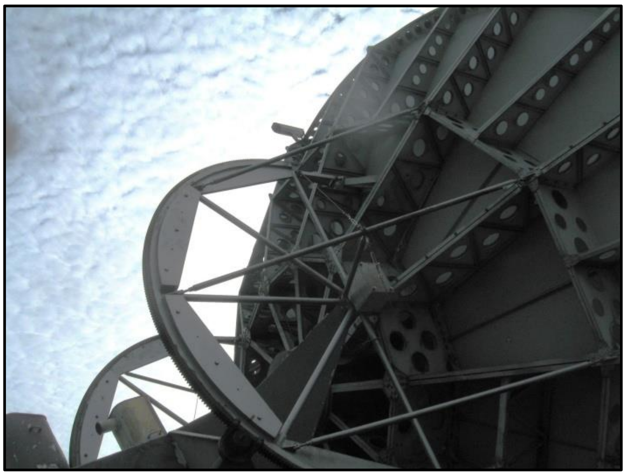
There is some interference to the 25 meter dish from 1450 MHz cell service in the area. General RFI problems are significant. FRB research is assisted by AI. One day of data on a small piece of sky may have 6000 bursts of some sort. AI sorts out a lot of RFI, reducing the manual search to typically 200 areas of interest to examine. Out of that there may be one FRB if they are lucky.

The view from the maintenance area of the dish is impressive. You can see for many kilometers in any direction.

This 1.2 meter antenna has a 1.42 GHz hydrogen line receiver. The trailer is taken to a school, university or other event, and quickly set up to do observations
.

Thomas Buchsteiner told me about the instrument and how it is set up. Drive electronics for dish position and the receiver with a computer are in the enclosures below the dish.

This is the 3 meter telescope. Thomas is explaining the electronics for the motor controls and the receiver. The receiver preamp is mounted directly on the feed. The instrument's main focus is on measurements of the 21cm line of hydrogen in our galaxy. There is enough resolution to see galactic structure.

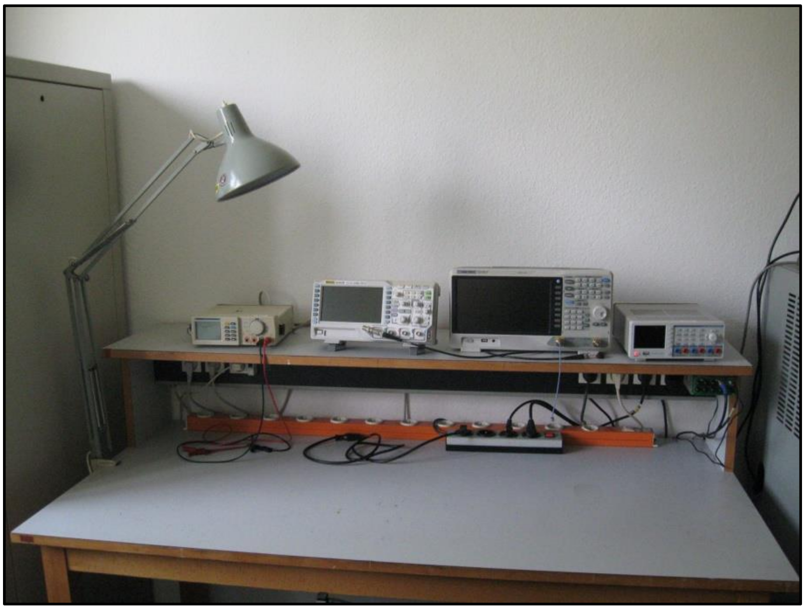


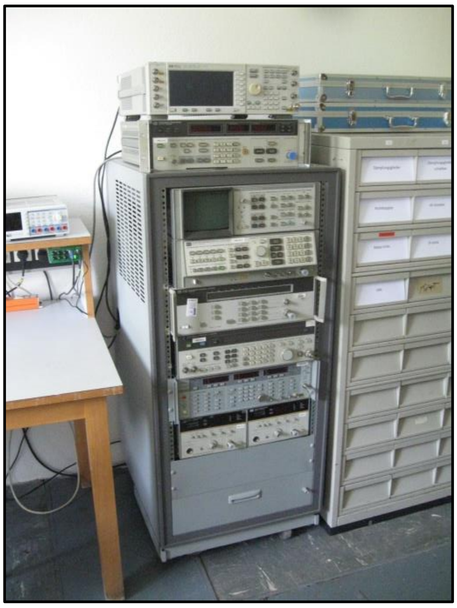

This is this 10 meter dish antenna on site.
The facility's second-largest telescope has an equatorial mount and is designed for the Ku-band and Ka-band reception. Astronomical masers for water and methanol are observed in these frequency ranges.

This dish is large in terms of wavelengths, (330 λ at 10 GHz) so that a Cassegrain feed works well.

Antenna gain at 10 GHz: 58 dB, 55% efficiency
-3dB beamwidth at 10 GHz: 0.21 degree
-10dB beamwidth at 10 GHz: 0.38 degree

The instrument can also be converted for amateur radio in the 10 GHz range, which is then used for so-called "Earth-Moon-Earth operation."





This is the test bench for the equipment building, testing and repair. There is modern test equipment from Rhode & Schwarz, HP, Agilent and others in the rack next to the bench. Second from the top of the stack is an HP 8970A Noise Figure Meter. This not the newest model, but still a very respectable instrument.

This rack full of vintage test equipment is a network analyzer. It still sees occasional use. It is also a historic artifact.

The labs have a real mix of current and advanced test equipment, and a few relics from the past that still serve a useful function. The historical aspect is also important.

Above images of QSL card and amateur radio antennas are from DL0EF biography at https://www.qrz.com/db/DL0EF

There is a ham radio station associated with the observatory. The large dish in the foreground is used for 10 GHz amateur radio EME "Moon Bounce" communications. The club call sign is DL0EF. Their grid square locator is JO30IN. The club has a normal amateur station for HF operation and 144 MHz and 432 MHz operation also.

Note that the 25 meter dish has no transmission capability and has not been used for ham radio operation. The 25 meter dish has been used as a receiving site for some planetary radar experiments.

Astropeiler observatory has been used by the University in Bonn for Bachelor and Masters degree theses. Wolfgang has been an advisor on many of these projects.

Membership in Astropeiler is 36 Euros per year. SARA members are invited to join.
Wolfgang's background is interesting. His PHD is in Physics. He has been involved with research for fiber optics, telecom, cell phone networks, Wi-Fi and cell service on airlines. He solved the Doppler shift problems due to the speed of airliners. He has not taught at the university, but has often been an advisor on student research.

After the deluxe tour of the observatory, we had a pleasant lunch with Wolfgang and my family. My family with restless grandchildren (ages 2, 5, and 7) would not have survived the observatory. Wolfgang's other interests include foraging for wild mushrooms. He assured me that that he does not eat any mushrooms he is not absolutely sure are safe.

References:
[1] https://www.astropeiler.de/en/instrumente/

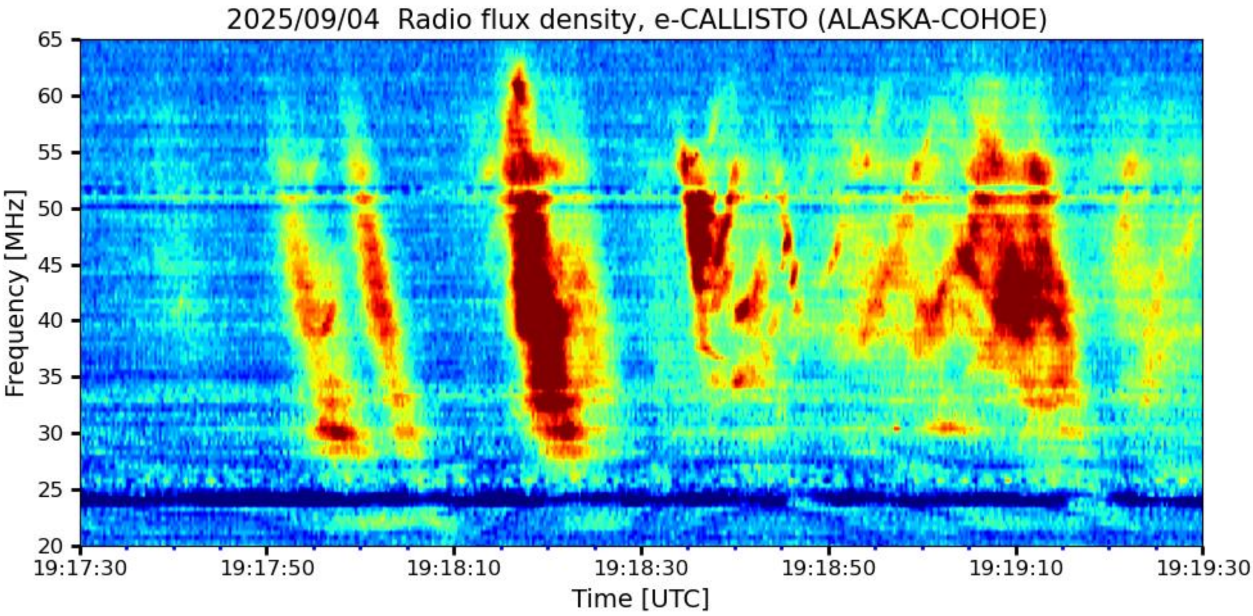
[2] Join the Organization: https://www.astropeiler.de/en/mitwirken-und-unterstuetzen/
And: https://astropeiler.de/wp-content/uploads/2014/11/Beitrittsformular_04_2020.pdf

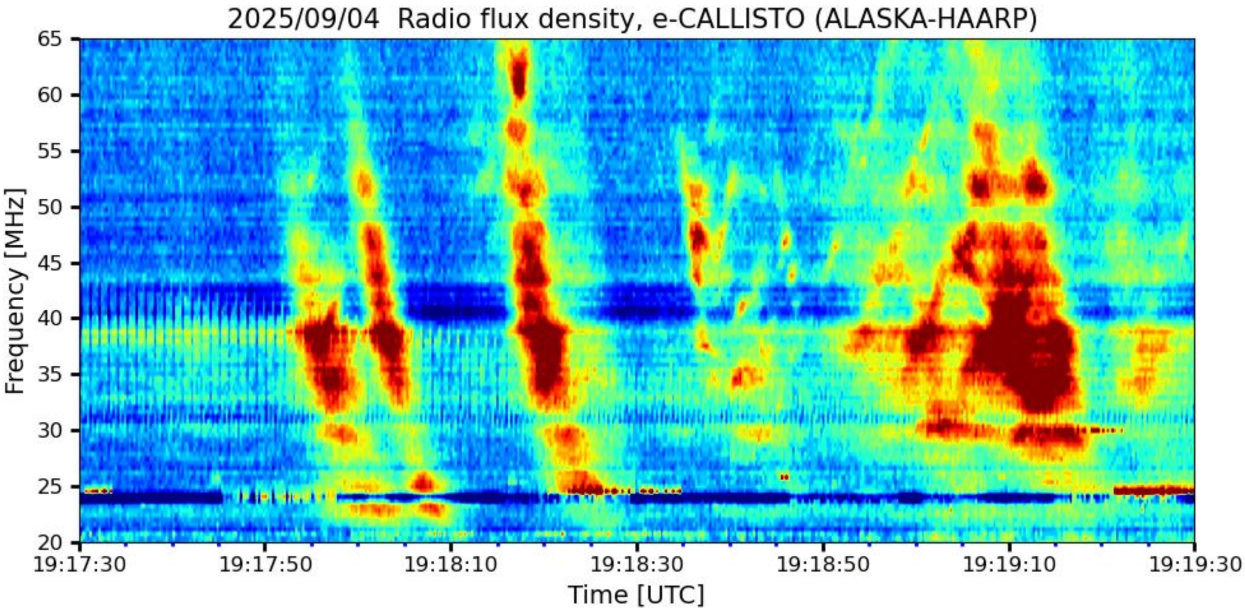
[3, Sander Weinreb LNA https://authors.library.caltech.edu/records/1ee9x-eb110

Solar Radio Observations on 4 September 2025

Christian Monstein & Whitham D. Reeve

Solar Cycle 25 has produced plenty of activity at its peak including a wide variety of radio bursts and emissions. Although many solar radio bursts can be easily categorized, such as the Type II and III radio sweeps, the spectral characteristics of some are more complicated. An episode of radio emissions on 4 September that fall into an unknown category is discussed here. See spectra images below.





The images cover the frequency range from 20 to 65 MHz and time period from 1917:30 to 1919:30, or 2 minutes around mid-day at the Cohoe and HAARP stations in Alaska. The two stations are separated by 400 km and have latitudes of 60.37° N and 62.38° N, respectively. Both are considered high latitude stations and part of the e-CALLISTO Solar Radio Spectrometer Network {e-CALLISTO}.

Several Type III fast radio sweeps are identifiable in the images. These quickly sweep from high to low frequencies and are the most common Type III bursts. At about 1918:40 there are indications of some reverse sweeps. These could be reverse Type III or they could be parts of one or more U-bursts in which the spectra first sweeps from high to low frequencies and then reverses to sweep from low to high frequencies (see References). It is not known if these are from separate regions on the Sun and simply overlap in time or if they are all from the same region. Space Weather Prediction Center {SWPC} identified the activity during a broader time period from 1844 to 1937 as Type VI radio sweeps but provides no other details. A Type VI is a *Series of Type III bursts over a period of 10 minutes or more, with no period longer than 30 minutes without activity* {Solar}.

References:

{e-CALLISTO} e-CALLISTO Solar Radio Spectrometer Network: https://e-callisto.org/

{RM17} Reeve, W., Monstein, C., Inverted U-Burst Observed on 21 August 2017: https://www.reeve.com/Documents/Articles%20Papers/ReeveMonstein_U-Burst.pdf

{Robinson} Robinson, P., Benz, A. Bidirectional Type III Solar Radio Bursts. Solar Physics 194, 345–369 (2000). https://doi.org/10.1023/A:1005203515701

{Solar} Solar Radio Emissions at HF and VHF/UHF: https://reeve.com/Solar/Solar.htm

{SWPC} Space Weather Prediction Center, Events Report: ftp://ftp.swpc.noaa.gov/pub/indices/events/

Red giant star IRAS17004-4119 in OH lines

by Dimitry Fedorov UA3AVR

This observation report continues the work started in the article [1] on observations of evolved red giant stars in several hydroxyl OH lines of the L-band. These stars are also very bright in the infrared due to the hot dust envelope around them, so they are often called OH/IR stars. Observations were made with 20 m Green Bank telescope in Skynet [2], see the telescope dish in Figure 1.

Figure 1. Green Bank 20 m telescope dish.

The dominant 1612 MHz line with a double peak spectrum is a distinctive feature of the hydroxyl radiation from OH/IR stars. Weaker 1665 and 1667 MHz lines are sometimes observed in their spectra, but much depends on specific mass loss rate $\dot{m}$ or, speaking commonly, how collisional excitations and de-excitations are effective in the circumstellar molecular envelope [1,3].

As reported in 1990s [4,5] OH/IR star IRAS17004-4119 (OH 344.93+0.01) also has 1667 MHz emission with the double peak spectrum up to 9-10 Jy, see Figure 2. The star has strong 1612 MHz emission with expected spectrum shape; the low velocity peak is up to 120 Jy.

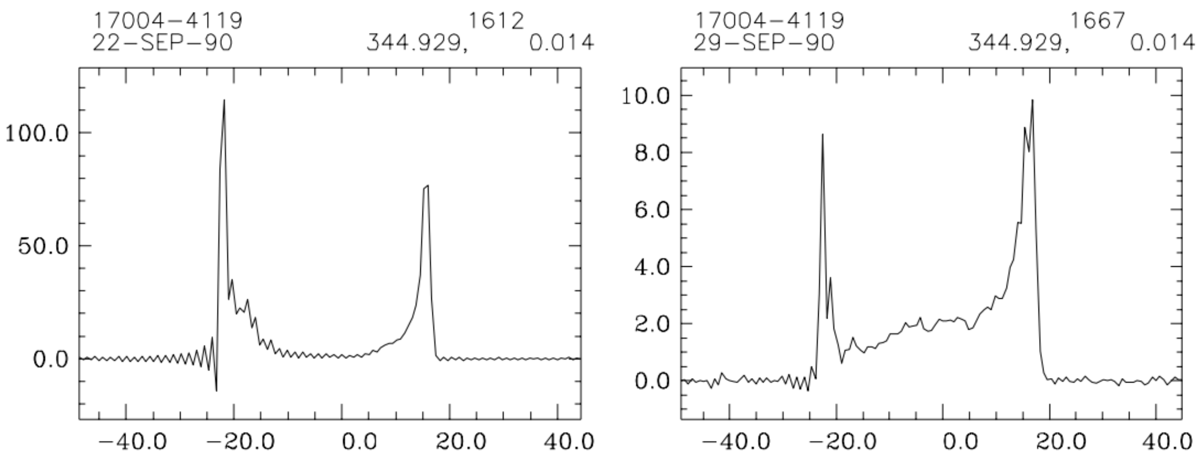


Figure 2. IRAS17004-4119 double peak spectra in 1612 and 1667 MHz OH lines [5].

The star is evolving now on the Asymptotic Giant Branch (AGB) of the Hertzsprung–Russell diagram; its estimated progenitor mass > 4 M⊙. The density indicator $\dot{m}/R_*^2$ of the circumstellar envelope [1], estimated from the typical mass loss rate $\dot{m}$ for AGB stars and presumably small stellar radius R_* , turns out remarkably high for IRAS17004-4119, >10^{-10} M⊙/(year × $R_\odot^2$). No emission from this star at 1665 MHz has been reported [4,5].

The 1612 MHz spectrum with expected peak values up to 120 Jy was obtained from observations recently, see Figure 3. However, despite expectations, no even a trace of 1667 MHz emission has been discovered in the observation data - 1667 MHz, 2025-10-01.

Telescope and observations parameters are collected in Table 1. Minimal Detectable Peak Flux Density at 1667 MHz is ≈3 Jy with 400 s of tracking (integration) time; so, the detection of 1667 MHz emission with levels up to 9-10 Jy could be expected.

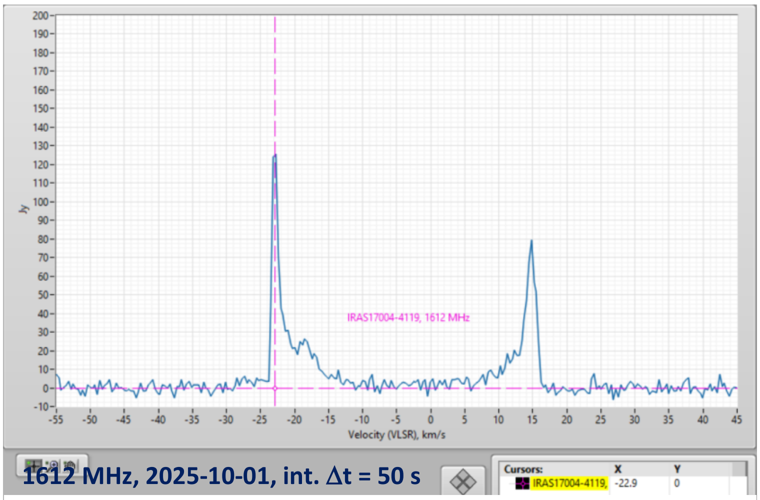


Figure 3. IRAS17004-4119 spectrum in 1612 MHz OH line observed with Green Bank 20 m telescope (Skynet) 2025-10-01, tracking (averaging time) 50 s, high resolution mode, 8192 channels, average of 2 linear polarizations, observation data - 1612 MHz, 2025-10-01.

Table 1. Parameters of the telescope (adopted from [1]) and parameters of present observations

Dish diameter	**D**	20 m
Aperture Efficiency	η_A	0.6
System Temperature	$\mathbf{T_{sys}}$	60 K (X pol), 62 K (Y pol)
Forward Gain (dish sensitivity)	Γ	0.068 K/Jy
System Equivalent Flux Density (= $\mathbf{T_{sys}}$ / Γ)	SEFD	880 Jy (Xpol), 910 Jy (Y pol)
Resolution Bandwidth	RBW	1.9 kHz
Resolution in velocities		< 0.4 km/s
Integration Time	Δt	50 s (1612 MHz), 400 s (1667 MHz)
Minimal Detectable Peak Flux Density (max level of background noise peaks)	$\mathbf{F_{peak}}$	<6.5 Jy (1612 MHz, after averaging data of two linear polarizations), ≈3 Jy (1667 MHz)

References

[1] D. Fedorov UA3AVR, *Observations of OH/IR stars in several molecular lines*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers (SARA journal), May – June 2025, p 57.

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

[3] M.D. Gray, *Pumping of OH Main-Line Masers in Star-Forming Regions*, arXiv:astro-ph/0611709 (2006).

[4] J. L. Caswell, *Positions of hydroxyl masers at 1665 and 1667 MHz*, MNRAS, 297, pp 215–235 (1998).

[5] P. te Lintel Hekkert and J.M. Chapman, *A search for OH maser emission from post-asymptotic giant branch stars*, A&A Suppl. Ser. 119, 459-481 (1996).

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 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.

Non-visibility of polarisation in initial data collected from two orthogonal monopoles in wave guide on the LRO-H2 Hydrogen Line (1420.405 MHz) radio telescope at Lichfield Radio Astronomy Observatory.

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Lichfield Radio Astronomy Observatory, UK.
https://www.astronomy.me.uk
E-mail: andrew@thornett.net

Introduction.

In recent months, there has been discussion of possible benefits from adding a second monopole at 90 degrees to the first one within the cantenna waveguide on the LRO-H2 150cm parabolic dish at Lichfield Radio Astronomy Observatory, in terms of possible improvements in signal to noise ratio and the possible advantages of detecting polarisation in two orthogonal directions.

The current study focuses on exploring whether a difference in signal was seen in the two orthogonal polarisations from data collected at the same elevation and azimuth over the first few weeks using this new system, 28 September 2025 – 8 October 2025.

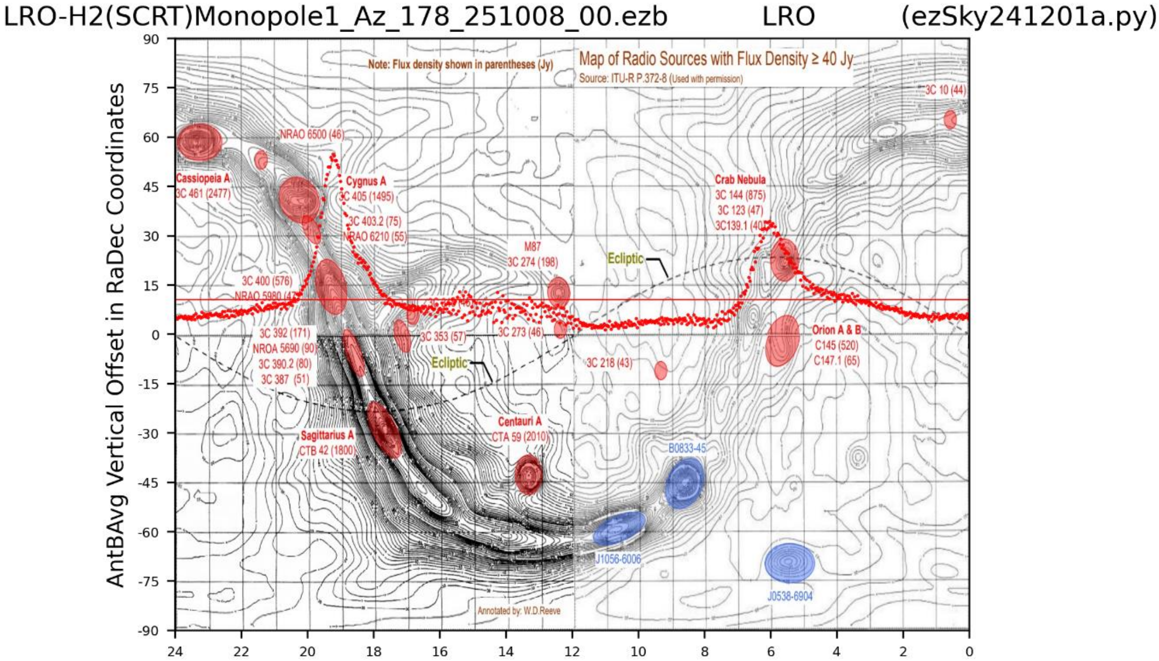
Methodology:

This cantenna waveguide on this telescope is tuned to 1420 MHz for hydrogen line galactic mapping and the second monopole was placed at 90 degrees to the first, with the same length, and similar distance from the bottom of the can.

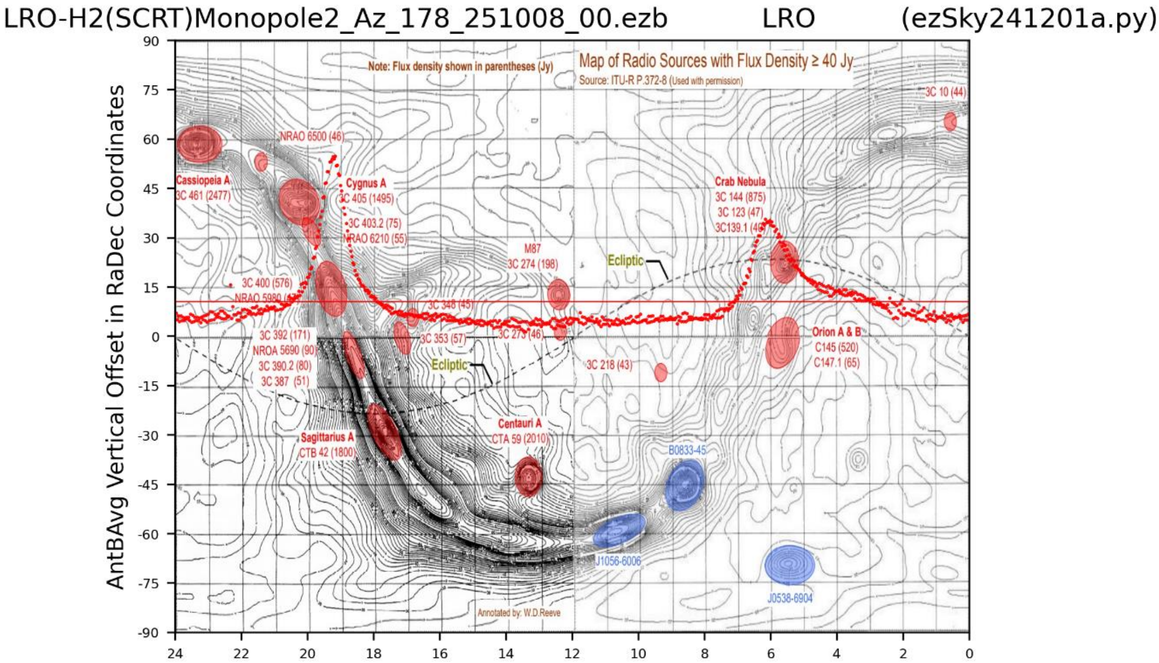
Data was collected with two completely independent systems, one for each monopole, consisting of SAWBird H1+ low noise amplifier and filter close to the monopole, similar lengths of coaxial cable, RTL-SDR V4 software-defined radio, and MiniPC running Easy Radio Astronomy's ezCol data collection software. Analysis was conducted the full suite of Easy Radio Astronomy processing scripts to provide comparison between signals from the two probes.

Results:

Monopole 1:



Monopole 2:



Conclusion:

Hydrogen line signal was detected by both monopoles, but no significant difference was detected between the two orthogonal directions, suggesting that Milky Way transmission at the scale detected by this antenna is not polarised in a preferred direction.

Observation Report : Crab Pulsar (B0531+21) from DSES

Dan Layne (AD0CY), Ray Uberecken (AA0L), Bill Miller (KC0FHN), Rick Hambly (K0GD)
Deep Space Exploration Society (DSES)

DSES members recently completed several site upgrades for the 60' dish at Haswell, Colorado. This includes a new control room, new feed line, new receiver, and improved grounding and bonding in the new building. These improvements have significantly enhanced our ability to detect weak signals. Figure 1 is a picture of the DSES facility. This report presents results from recent observations of the Crab pulsar.

Figure 1: DSES 60' Dish and New Control Building

The Crab pulsar emits three kinds of pulses, all of which DSES detected on August 26, 2025. This pulsar emits a main pulse with a period of 33 msec and a mean flux density of 550 milliJansky at 400 MHz. A smaller interpulse trails the main pulse by 4/10 of the period (~140°). Additionally, the Crab randomly emits "giant pulses," which are single, narrow pulses that can exceed the mean flux density by factors of 10 or more. Giant pulses are known to be emitted at both the main pulse and interpulse phases of the pulsar's rotation. All three pulse types are generated by the extreme magnetic fields on the neutron star's surface, exceeding 10^{12} Gauss.

The Crab pulse profile exhibits both dispersive delay and pulse broadening at lower frequencies (such as 408 MHz). Dispersive delay is corrected by applying the known dispersion measure (DM), which corrects the phase traces. The additional pulse broadening is due to multi-path scattering from the interstellar medium (ISM) and from the expanding supernova plasma shell that the radio signals transit. The broadening of the pulse at 400 MHz may be verified by comparing with other amateur sites (e.g., K5SO, OE5JFL), the EPN Database of Pulsar Profiles (Jodrell Bank), or from the literature (e.g., "Scattering features and variability of the Crab pulsar," L.N. Driessne, et.al., Monthly Notices of the Royal Astronomical Society 483, 2019).

<u>Main pulse and interpulse</u>

The Presto prepfold plot is shown in Figure 2 for a 4 hour collection with the 408 MHz antenna. Both the main pulse and the interpulse were detected. The data collection had very little RFI, and it was masked out (rfifind).

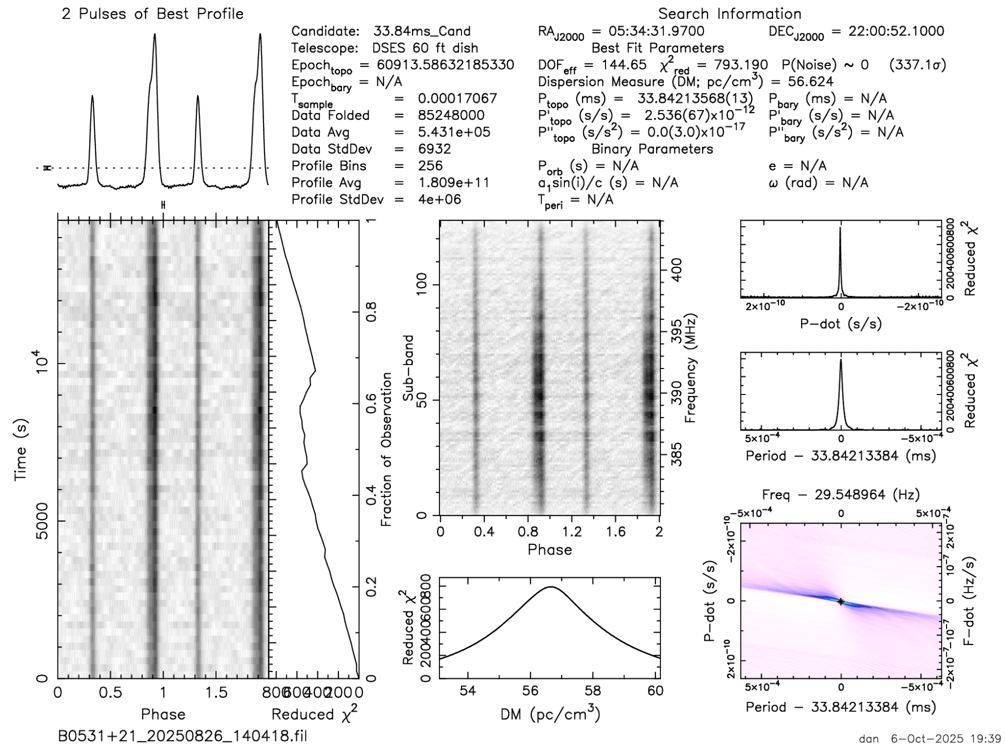


Figure 2: Prepfold plot for 4 hour collection centered at 392 MHz.

Collection parameters are listed in the Table 1 below.

B0531+21 "Crab" Parameters	Values
Date & Time (UTC)	20250826, 140418
Source distance; Flux density	2.0 kpc = 6,520 light years; S400 = 550 mJy
Source period; Dispersion measure	P = 0.334 sec; DM = 56.7
Source RA, DEC (J0534+2200)	05h 34m 31.9s ; +22° 00' 52.1''
Observers	Ray, Rick, Bill M., Dan
Telescope	DSES 60 ft. dish (18.3 m) Haswell, CO
Dish pointing and tracking	System1 (Glen, Lewis, Phil)
Antenna	408 MHz dual dipole, +30 dB LNA, 90 MHz filter
Polarization; Beamwidth (HPBW)	Linear; 2.7°
Receiver	B210+GPS, BW = 24 MHz. Freq = 392 MHz, Gain = 48
Computer	System76 desktop, 16 core, Pop!_OS (Ubuntu 22.04)
Planning software	I0NAA Murmur, Stellarium, ATNF pulsar catalog
Data collection & processing software	GnuRadio 3.10, Python 3.10, PRESTO 4.0
Run time; # channels, width	14,400 seconds (4 hours); 256, 0.094 MHz

Table 1: Crab pulsar data collection parameters.

Giant pulses

The time of occurrence for detected giant pulses is shown in the Single Pulse plot in Figure 3. Peak Signal to Noise Ratio (SNR) is used to verify that each giant pulse has the same dispersion measure (DM) as the pulsar. If the peak SNR for a single pulse occurs at the same DM as the pulsar, then it originates from the same place. On the other hand, if DM is zero, then local RFI caused the pulse. The top middle plot shows the number of pulses peaks as a function of DM, and the top right plot shows that SNR peaks at the correct DM. The bottom plot indicates the times when single pulses were detected. This diagram plots candidate pulses with SNR > 50. There are many more below 50.

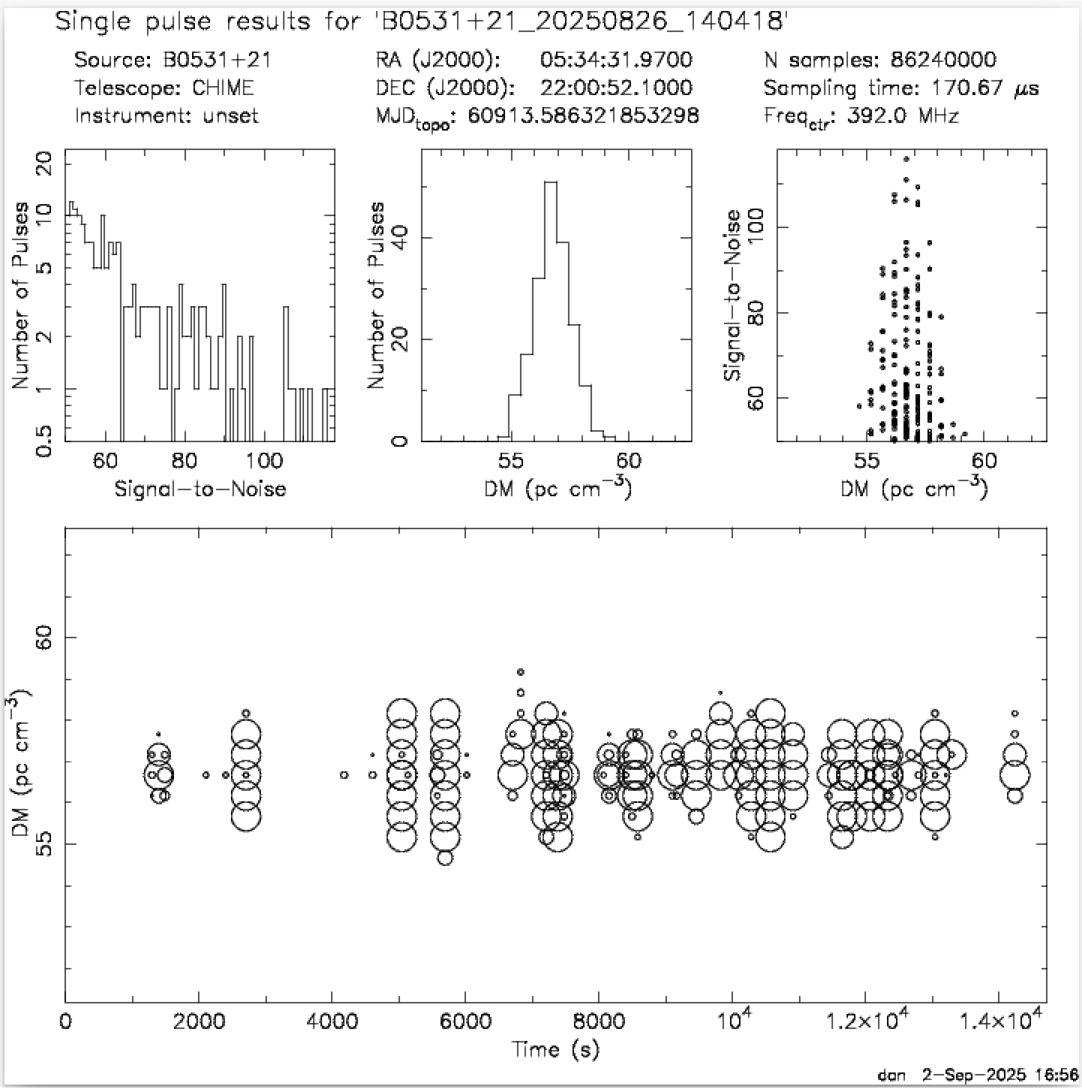


Figure 3: Single pulse results for SNR > 50.

The time series plot (exploredat) in Figure 4 shows the distribution of giant pulses in the 4 hour collection.

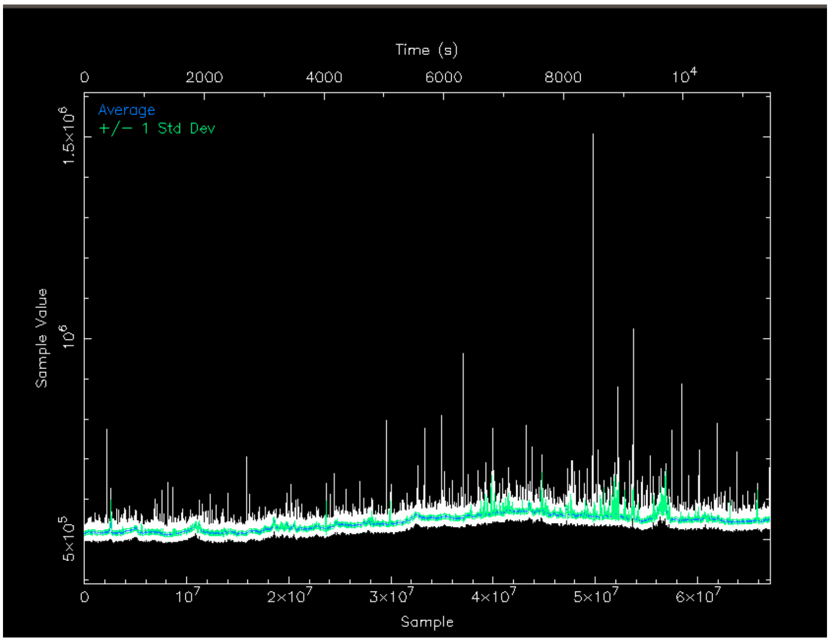


Figure 4: Distribution of giant pulses in the 4-hour data collection.

Using the indicated time from the SinglePulse plot, we can zoom in at 8,506 seconds to see a giant, narrow pulse (Figure 5). In the absence of calibration scans, giant pulse amplitudes are represented as SNR. In this case, the giant pulse has SNR more than 10 times greater than the average pulse.

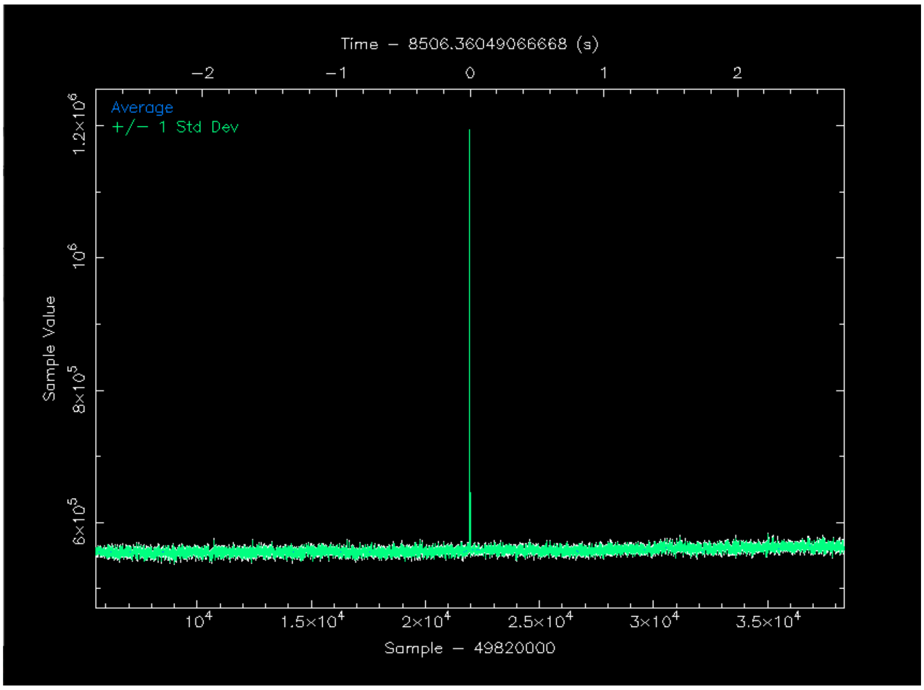


Figure 5: Single giant pulse at 8,506 seconds.

Lunar eclipse observations at 43 GHz

by Dimitry Fedorov UA3AVR

This observation report is about monitoring the lunar eclipse 2029-09-07 with 43 GHz telescope Figure 1. It was the first light of this telescope. The eclipse could be visually seen in Moscow thanks to clear weather.

Figure 1. 43 GHz telescope on the equatorial mount, 55°33'53.9"N 37°28'33.7"E.

The telescope is equipped by 0.6 m offset dish. Supposed aperture efficiency is η_A = 0.5; receiver noise figure is NF=1.8 dB. The system temperature T_{sys} is significantly dependent on the current weather and altitude due to high atmospheric losses at 43 GHz and can be in the range of 300-400 K. Corresponding System Equivalent flux density is in the range $5x10^6$ - $7x10^6$ Jy. The atmosphere attenuation and noise for T_{sys} estimations were calculated according to the ITU recommendations [1] for current weather leaving the gaseous absorption as a main contributor for clear sky.

The dish is positioned by the equatorial mount. The mount was initially designed for astrophotographers and modified for bearing the dish. The mount alignment was performed iteratively until correct tracking of the Sun within at least 1-2 hours. Initial alignment step was in adjusting the elevation in the parking position when astrophotographers are usually looking for the Polaris star in the finder. This elevation has to be equal to the latitude in the observation site.

The receiver has two stages of frequency down-conversion. The first stage with the image suppression in IQ scheme applies ADMV1014 chip with 90° hybrid coupler at the output and without filters 43 GHz at the input. The Chinese evaluation board with LMX2595 synthesizer works in the first LO. Second stage uses an old MMDS down-converter with final IF frequency about 605 MHz. Input LNA was designed by Sergey Zhutyaev RW3BP for 47 GHz amateur band (with die chip CGY2122XUH), but it works well at 43 GHz too. The down-converter has satisfactory frequency stability of LO in 1st and 2nd stages for spectral observations with resolution about 150 kHz (about 1 km/s at 43 GHz in velocity units). The Sun and Moon tracking can be done simply with wideband power meter at the downconverter output.

Figure 2. The Moon tracking during eclipse 2025-09-07, Moscow 55°33'54.3"N 37°28'37.0"E

The Moon eclipse was observed 2025-09-07 from the dimmest Full Moon until the eclipse was over with full visible Moon brightness; see the telescope in Moon tracking Figure 2.

The heating of the Moon when it is coming out from the eclipse has been noticed. The ratio of receiver output powers, Y-factor

$$Y_{moon} = \frac{P_{moon}}{P_{Cold\ Sky}}, \tag{1}$$

when the antenna beam is directed to the Moon and a bit outside in azimuth (in the Cold Sky) was measured. The result is in rising of Y-factor from 0.2-0.3 dB in the dimmest phase to 0.5-0.6 dB for the fully shining lunar disk.

References

[1] ITU-R P.676-13, Attenuation by atmospheric gases and related effects, https://www.itu.int/rec/R-REC-P.676; Recommendation ITU-R P.618-14, Propagation data and prediction methods required for the design of Earth-space telecommunication systems, https://www.itu.int/rec/R-REC-P.618.

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 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.

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.

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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
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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
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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

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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.

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

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SARA Brochure

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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

SARA

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)