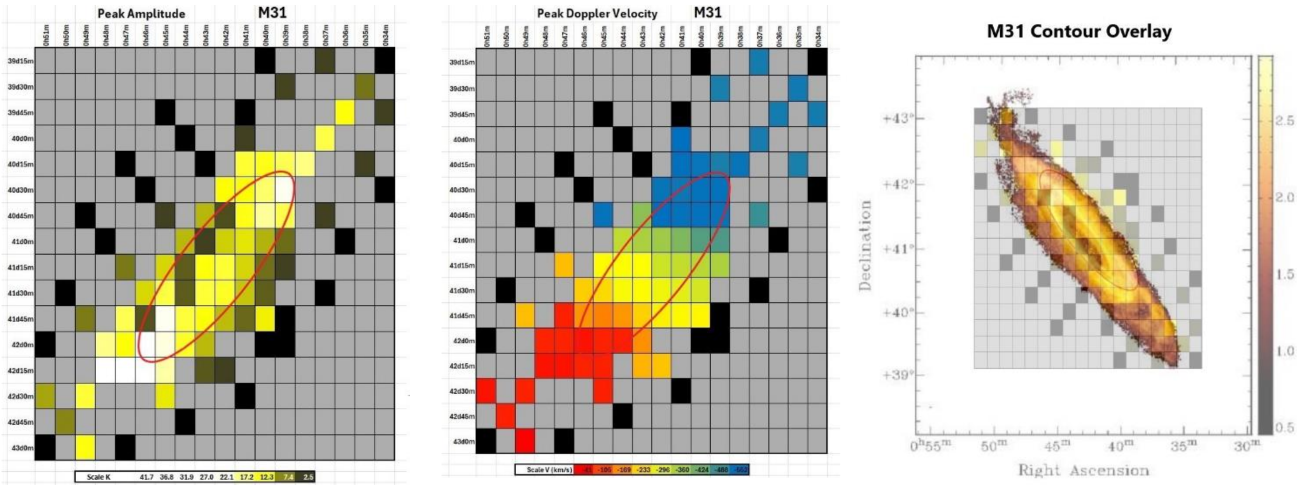
RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers
July - August 2025



Andromeda (M31) Galaxy Detection using the 20 Meter GBO Telescope

Contents

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:
Dr. Andrew Thornett & Jason Burnfield

President's Page

We are having another fantastic year of amateur radio astronomy!

The GBO telescope is getting record usage by SARA members. The current theme is detection of galaxies.

Jonathan Pettingale has built 38 SUPERSIDS this year! SARA provides a tremendous service to the amateur solar observer communities.

Alex Pettit has developed a circular YAGI that has proven effective for H1 measurements. This provides excellent capability for the small antenna user.

Deep Space Exploration Society (DSES) attempted a Venus bounce experiment with Astropeiler Stockert Observatory. This shows that amateur radio research is alive and well!

SARA members have been developing several interferometry systems and even phased array antenna systems

Ted Cline has revolutionized the amateur radio software with eZRA. This has enabled amateurs to readily observe H1 in the galaxy and even observe the Milky Way spiral arms!

Jason Burnfeld has developed the technique of using small antennas to observe galaxies! This technique was also applied to the GBO 20 meter telescope.

Eduard Mol and Dmitry Federov have shown the way in small aperture detection of masers.

Wolfgang Herrmann has been a SARA superstar in providing professional oversight for the amateur radio astronomers! Not to mention that the Astropeiler Stockert Observatory also led the way in detection of FRBs, pulsars, masers, Venus bounce, and H1. Plus, he has mentored a significant number of students in the science, engineering, and art of radio astronomy. ---- Thanks Wolfgang!

I left a lot of people out!

SARA is one of the leading Amateur Radio Astronomy organizations in the world! The Radio Astronomy Journal is one of a small number of journals that deal in radio astronomy. The SARA YouTube channel has been watched over 6000 hours this year alone. We are definitely fulfilling our education outreach!

Thanks!

Rich

Dr. Richard Russel
SARA President

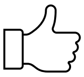
2025 Eastern Conference – Society of Amateur Radio Astronomers Gift Shop

Editor's Notes

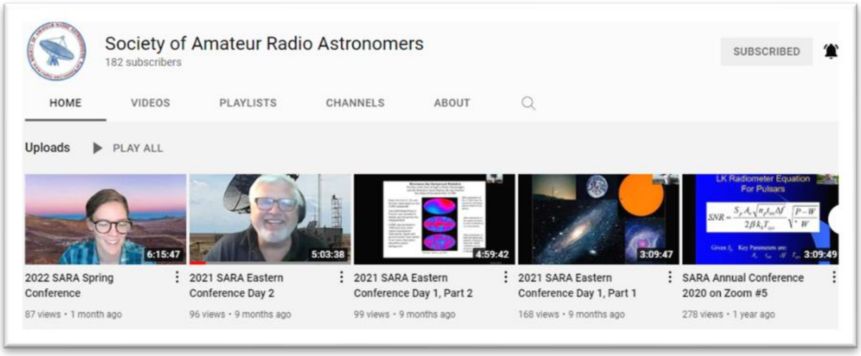
We are always looking for basic radio astronomy articles, radio astronomy tutorials, theoretical articles, application and construction articles, news pertinent to radio astronomy, profiles and interviews with amateur and professional radio astronomers, book reviews, puzzles (including word challenges,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

Subscribe to the SARA YouTube Channel

SARA has a YouTube channel at: https://www.youtube.com/@radio-astronomy

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

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



Observation Reports

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

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

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

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

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

SARA NOTES

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)

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

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

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

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

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

SARA Student & Teacher Grant Program

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

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

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

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

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

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

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

If you have a question, contact me at crowleytj@hotmail.com .
Tom Crowley - SARA Grant Program Administrator

Drake's Lounge Australia

This new zoom forum is geared to the Melbourne, Australia time zone (UTC+10) in order to improve coordination with our Australia, New Zealand, and Japanese members. The meetings are scheduled for the 4th Friday of every month, 9 AM Melbourne time. A zoom announcement will be sent out to all SARA members before the meeting.

Radio Telescope Observation Party (RTOP)

RTOP is designed to demonstrate how to take observations using various radio telescopes. It will also cover how to record and analyze data.
RTOP is every month on the 1st Sunday at 2 pm Eastern time (1800 UTC). ZOOM email notifications will be sent to all members.

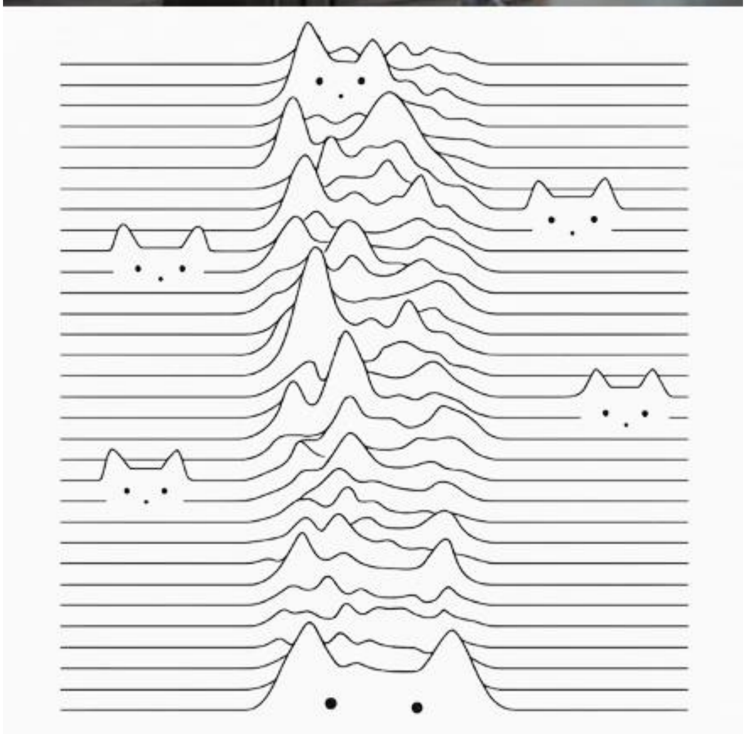
Drake's Lounge

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

Drake's Lounge is every month on the 3rd Sunday at 2 pm Eastern time (1800 UTC). ZOOM email notifications will be sent to all members.

FUN

Dave Typinski
From: davetyp@typnet.net
To: Rich Russel
Tue, Jul 15 at 7:10 PM
What you get when the cat sleeps in your HI dish.
--
Dave



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 October 3rd 19:30 BST (18:30 UTC) **Friday October 3rd 19:30 BST (18:30 UTC)**
This is a joint meeting with the Solar Section

Solar Energetic Particles, Solar Eruptions, Space Weather

Dr Timo Laitinen University of Central Lancashire

Areas of interest and expertise: Solar Energetic Particles, Solar Eruptions, Space Weather
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.

Friday November 7th 19:30
The detection of ultra-high-energy cosmic rays and neutrinos through their radio signals

Dr Katharine Mulrey Associate professor - Astrophysics (Radboud University, the Netherlands)

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

Friday December 5th Confirmed
***Exploring the radio emission of Core Collapse Supernova SN2017eaw* Diane Swan,**

Diane Swan *PhD student University of Central Lancashire*

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.

In this presentation I will briefly discuss:

- The nature of Core Collapse Supernovae
- Progenitor behaviour and its influence on radio emission
- Why is it unusual to have radio observation at all!

Before looking at the observed data from SN2017eaw, (my favourite supernova). If time allows, perhaps a glimpse at the eMERLIN array.

Bio.
I started my working life in the electronics industry but soon migrated to programming the "new fangled" microprocessors, probably because nobody else wanted to. Over the next 40 years I have worked in the IT sector, ending up as an architect on some quite large and complex system. However, many of my earliest memories involve staring at the night sky and asking questions. Finally in 2011, I started on the degree I had always wanted to, a distance learning degree course with the University of Central Lancashire, finally graduating in June 2023. After a short break, (6 months), I was eager to get back to studying and embarked on a PhD by research program, again with the same university. I am now in the second year of my six year part-time distance learning PhD. Still juggling work and academic studies and having a great time!

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

The conference for the amateur Radio Astronomer - Registration is now open.
Visit https://eucara.org/ Note: on site hotel accommodation is limited, book early to avoid disappointment

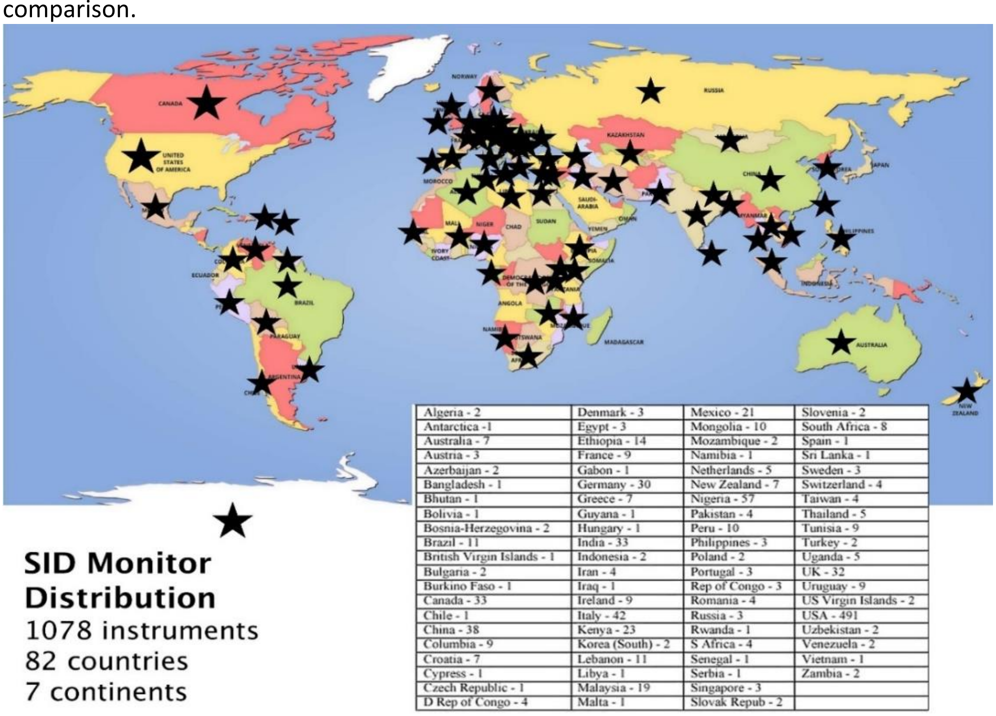
Join the RA conversation

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.

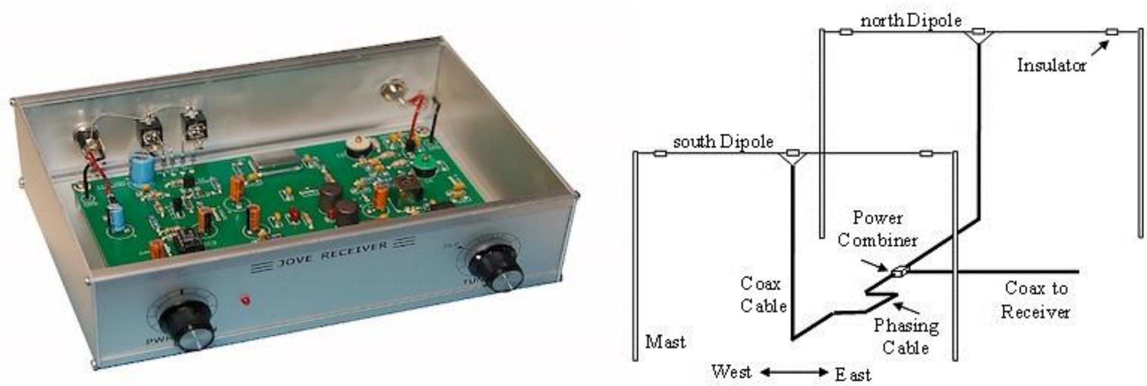

Figure 1. A Radio JOVE RJ1.1 receiver and a schematic of the dual-dipole antenna.

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).

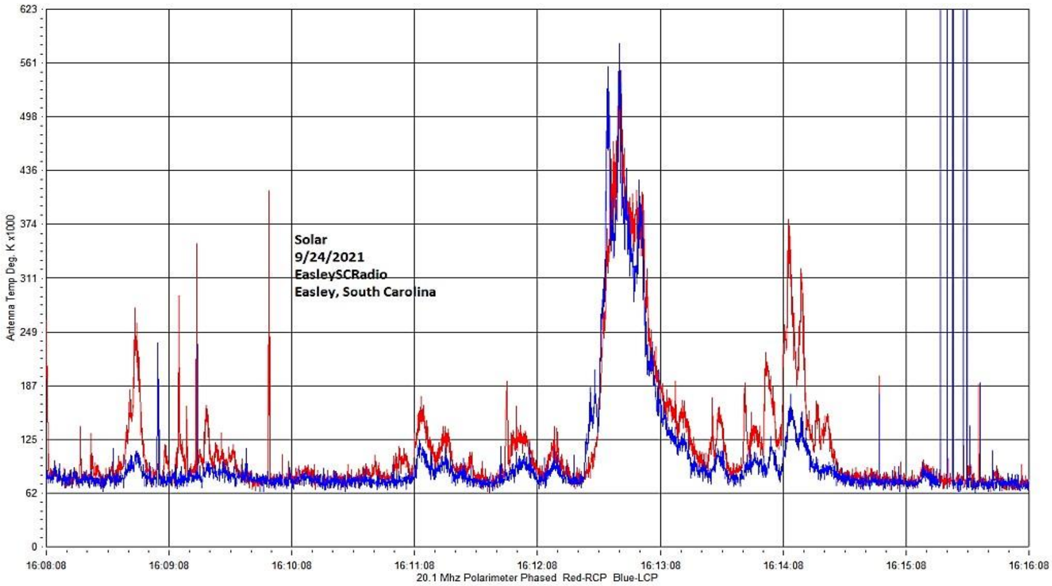

Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver. John Cox, SC.

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.

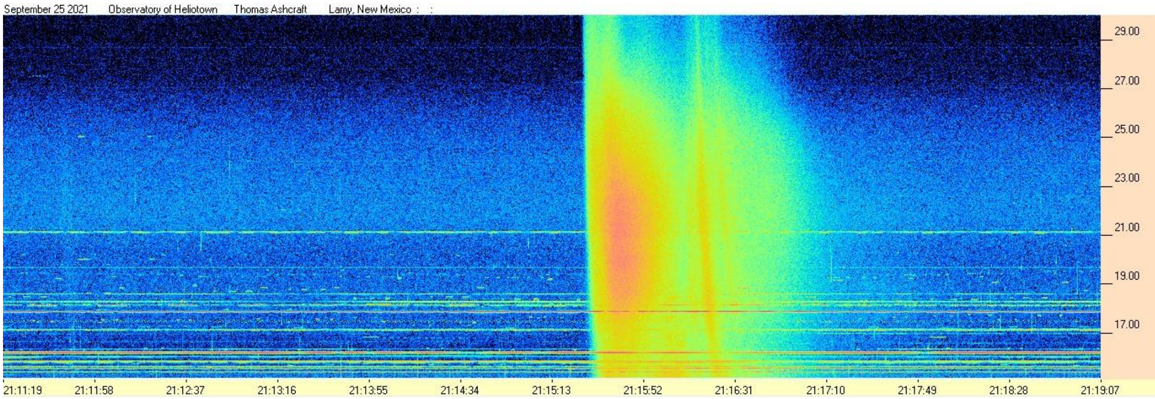

Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time, and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

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		
RJA2	Professionally Built Antenna-Only Kit		$249		
RJA	Unbuilt Antenna-Only Kit		$90		
RJR2	Receiver-Only Kit		$135		
LTJ2	Listening to Jupiter, 2nd Ed., by R.S. Flagg (PDF download)		$10	$0	
				Total:	

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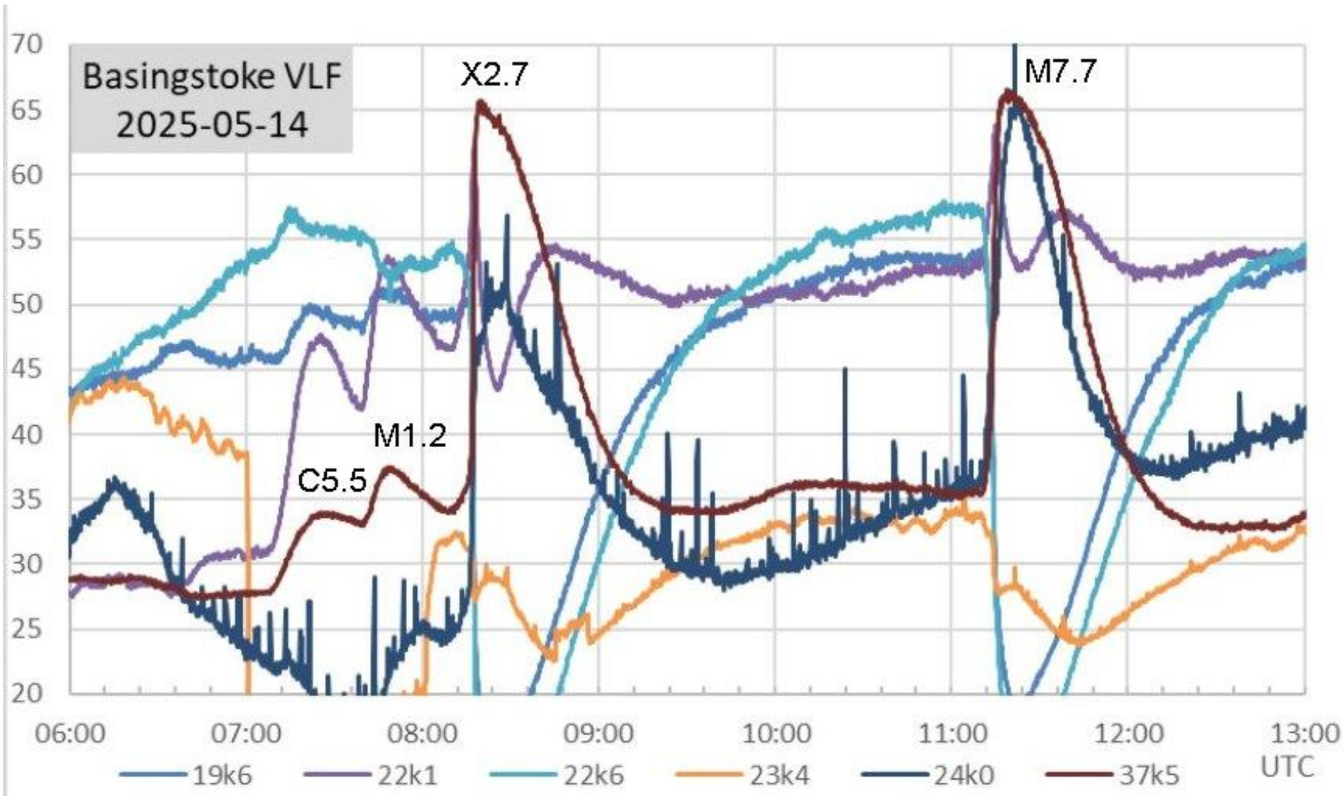
BAA Radio Astronomy Section, Director: Paul Hearn

RADIO SKY NEWS **2025 MAY**

VLF SID OBSERVATIONS

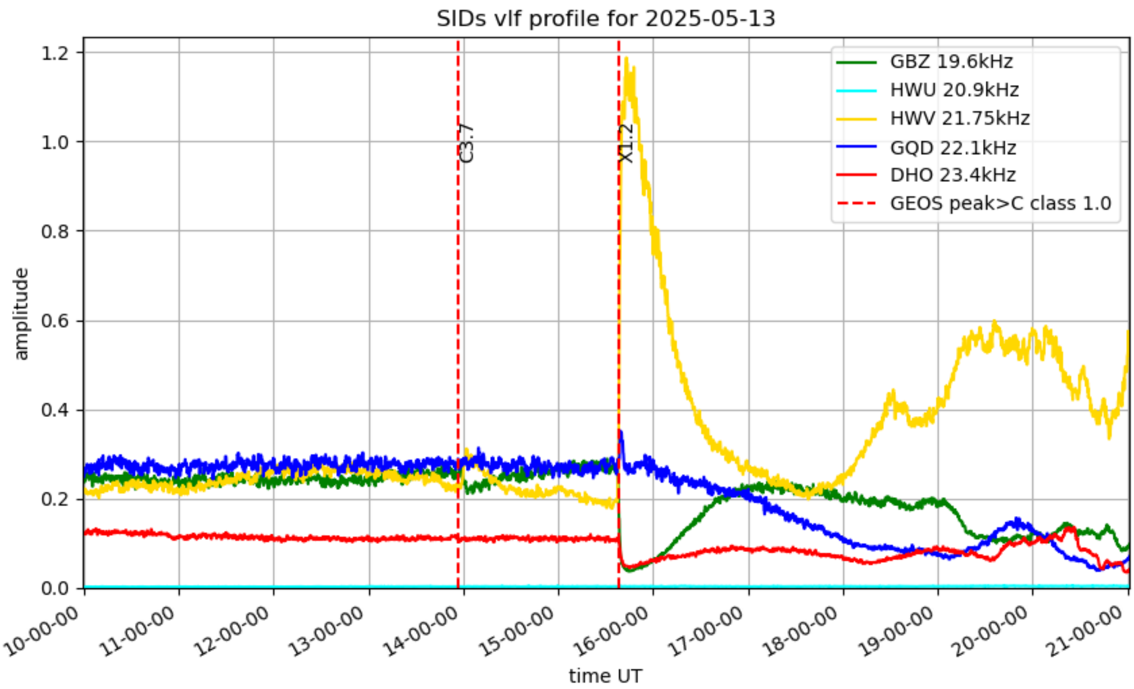
Solar flare activity in May was at a similar level to April, although we did catch two X-class flares. There were also plenty of smaller C2 flares recorded during quieter periods. The SWPC satellite lists include plenty of B-class flares, although we have not seen any as SIDs since 2022.



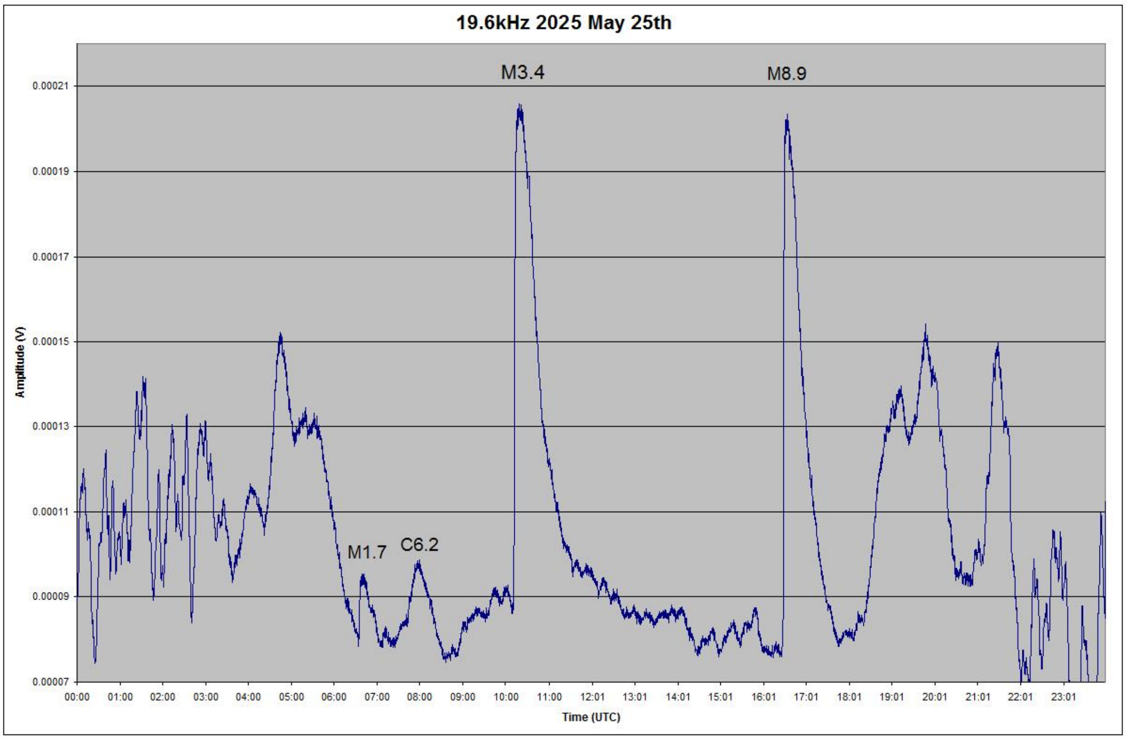
The X2.7 flare on the 14th was quite early in the morning, peaking about 08:30UT, and shows very strongly in Paul Hyde's recording. It is interesting to compare the SID strengths on the various signals. 37.5kHz shows similar SIDs for the

X2.7 and M7.7 flares, while 23.4kHz makes the M7.7 look stronger than the X2.7. The longer day length in May has helped, with 24kHz also showing a strong SID for the X2.7 flare.

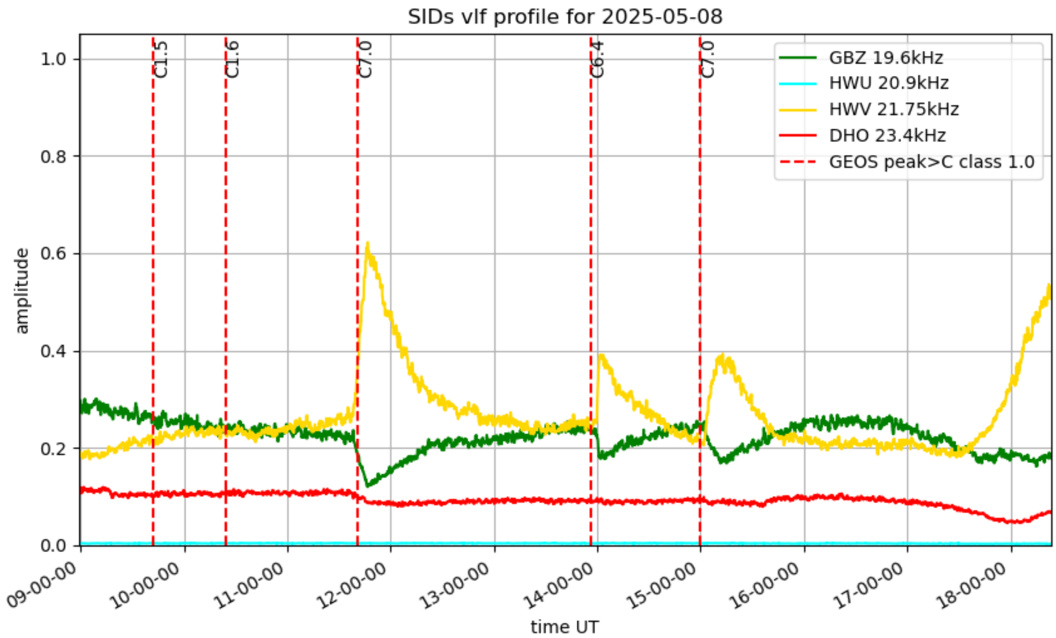
AR14087 was responsible for these flares, along with much of the activity over the following few days. It was not a particularly complex active region, although the primary sunspot was quite large.



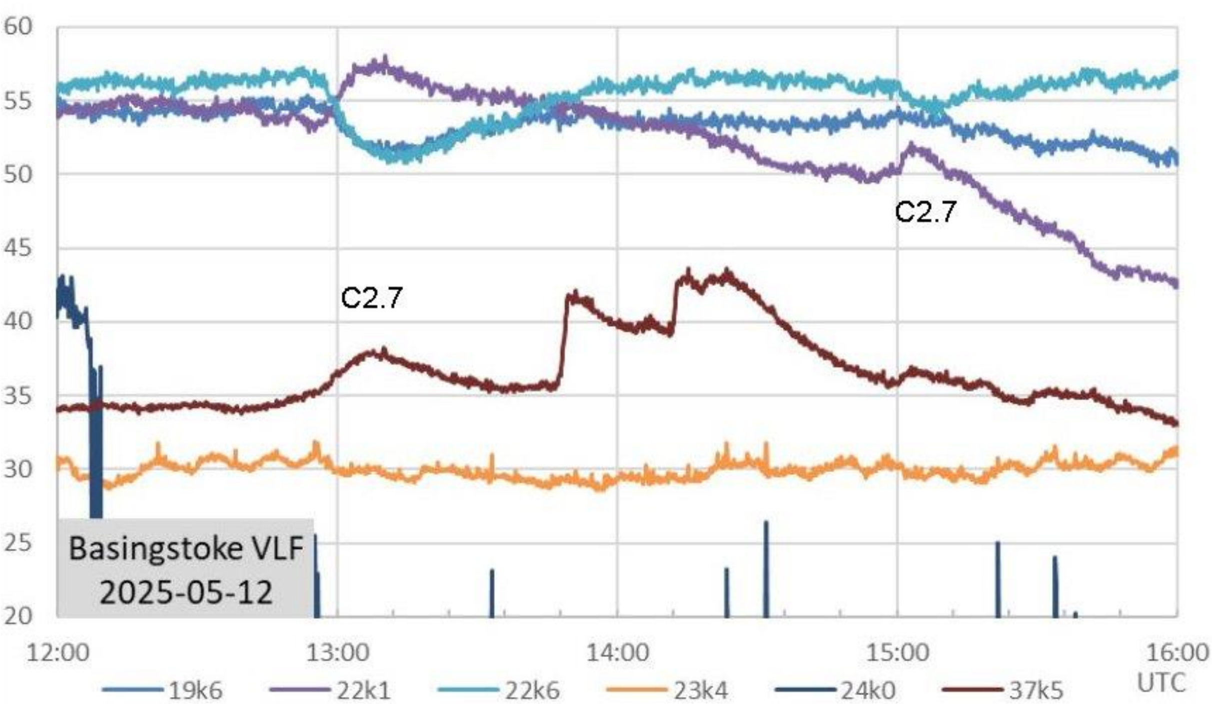
Mark Prescott's recording shows the X1.2 flare in the afternoon of the 13th. 21.75kHz shows a very strong SID, although with a simple 'shark fin' shape. 22.1kHz appears at first to show a very short spike lasting just a few minutes, but it is followed by a very subtle rise up to 16UT before gently falling away again. It is a rather unusual 'spike and wave' SID, where the wave portion is almost flat. The earlier C3.7 flare has produced small SIDs at 21.75kHz and 19.6kHz.



Activity increased again at the end of the month, Mark Edwards' recording showing some strong M-flares on the 25th. The M1.7 was very early at around 07UT, appearing just after the sunrise ends on the 19.6kHz signal. There was another X1.1 flare on the 25th but occurring at 02UT it was far too early for us to record.



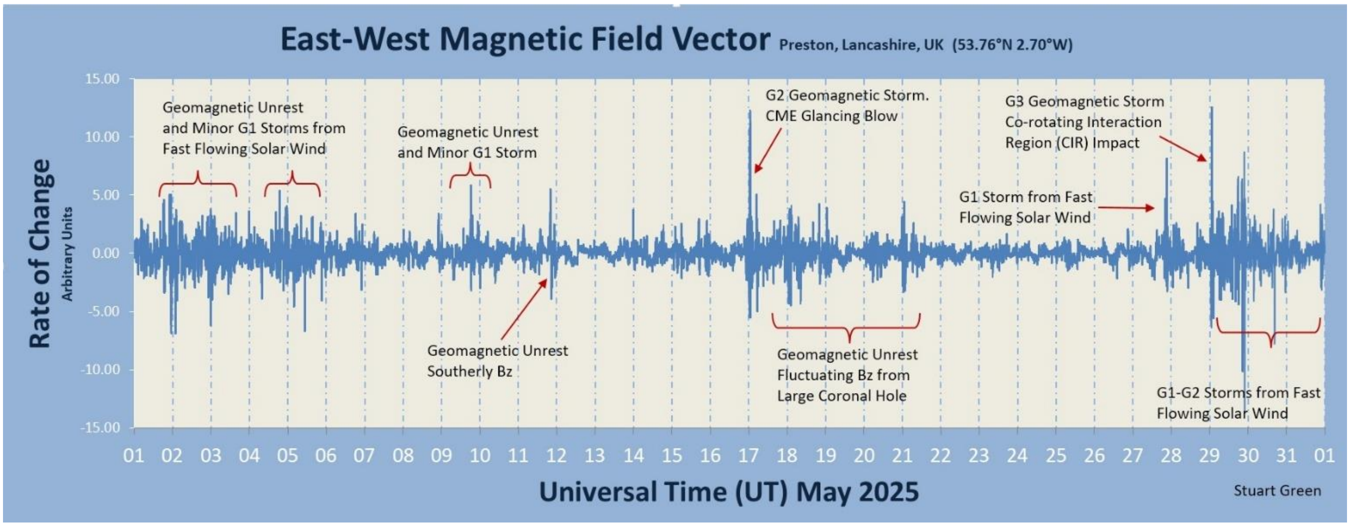
This clean recording by Mark Prescott from the 8th shows a trio of mirror-image SIDs at 21.75kHz and 19.6kHz. 23.4kHz seems to be very unresponsive to these stronger C-class flares.



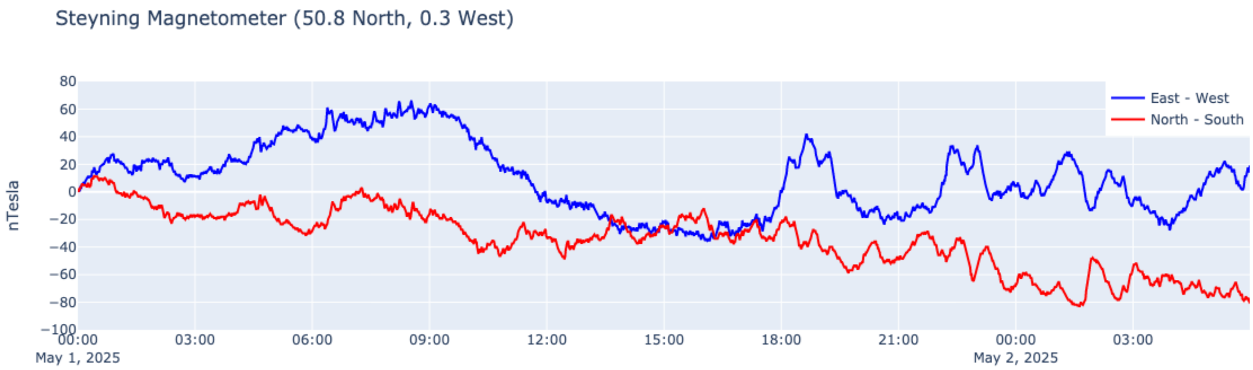
Paul Hyde's recording from the 12th shows a pair of smaller C2.7 flares. 22.1kHz shows both flares very clearly, while 23.4kHz again seems to be unresponsive. 37.5kHz has a very strong double event around 13:45-15:00, with no clear source. There is nothing listed in the satellite data at this time, and no magnetic activity recorded either.

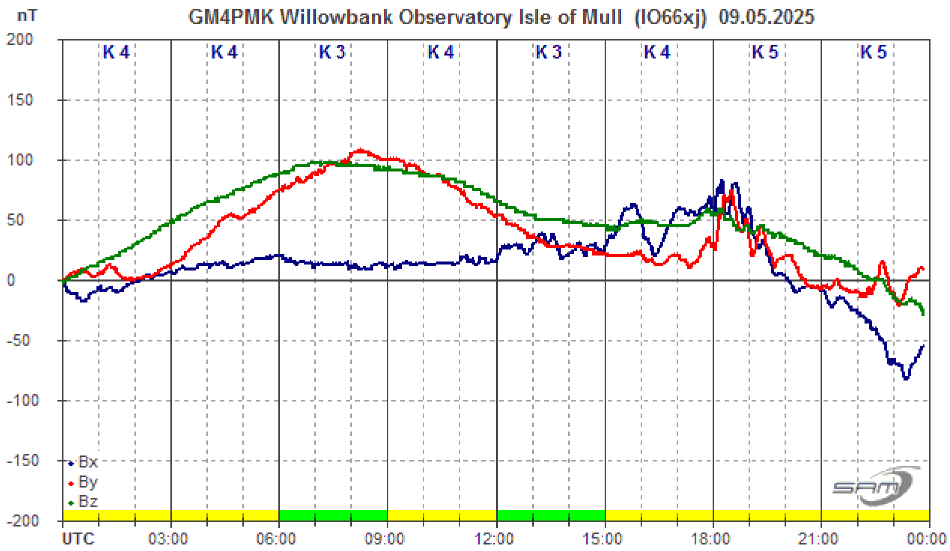
We also recorded some much weaker C-class flares, the weakest being a C1.3 on the 11th. There were C1.4 flares recorded on the 3rd, 4th and 29th; C1.7 flares on the 4th, 6th, and 7th; and a C1.8 on the 28th. These were mostly during periods when the background X-ray flux was at a low level.

MAGNETIC OBSERVATIONS

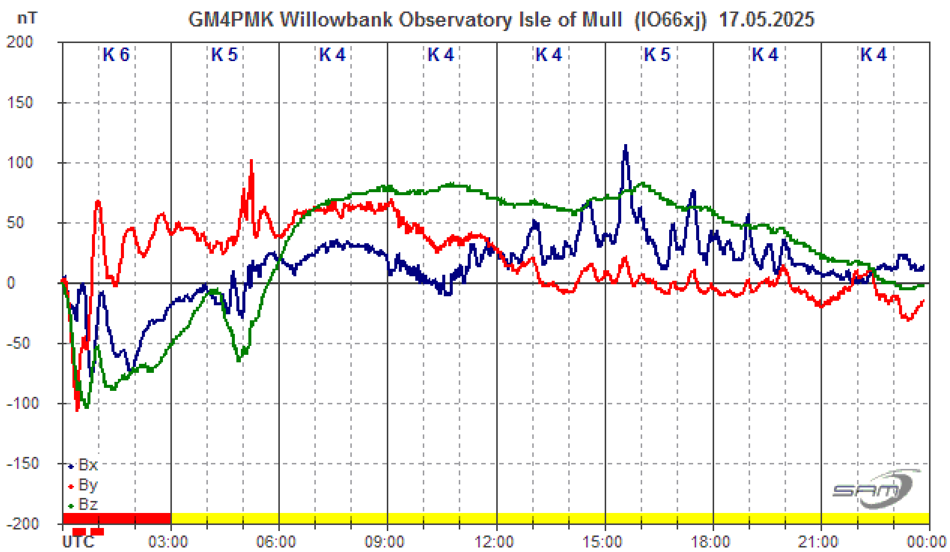


Stuart Green's summary of the month's magnetic activity shows several periods of activity, mostly from solar wind effects. Coronal holes are starting to be more common compared to earlier in the solar cycle, a strong wind from a coronal hole producing some mild disturbance to start the month. Nick Quinn's recording from the 1st showing activity increasing after 18:00UT:

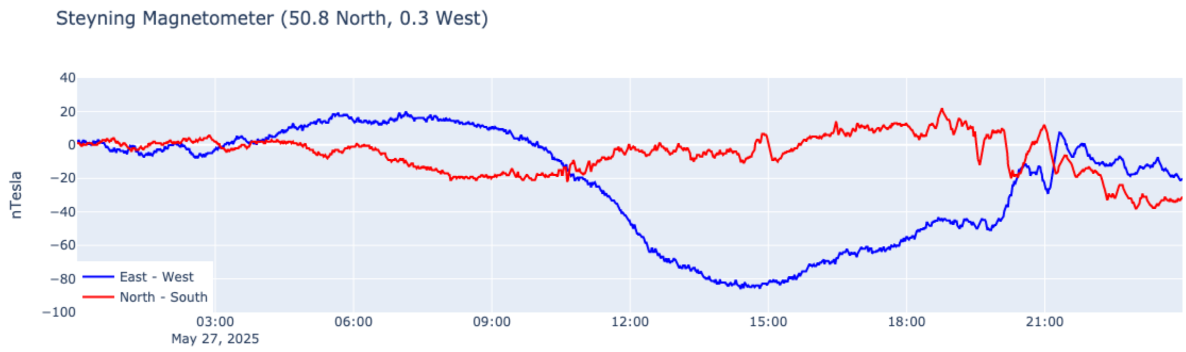


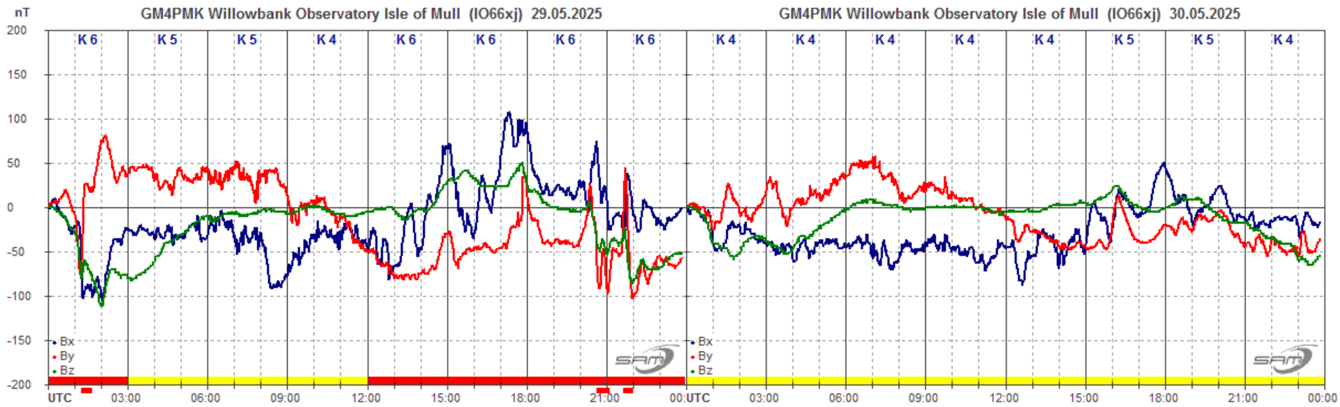


Mild disturbance continued over the next few days, slowly fading, but increased again in the afternoon of the 9th, shown in Roger Blackwell's recording. The STCE bulletin gives the source as a CME, although it is not linked to a specific flare. Coronal hole high speed winds continued to create mild magnetic disturbances over the next few days.



The first really active period started on the 17th, shown in this recording by Roger Blackwell. The STCE bulletin gives a filament eruption on the 12th as the source. This was followed by more coronal hole solar winds producing mild disturbances. Nick Quinn's recording from the 27th is typical of this period:



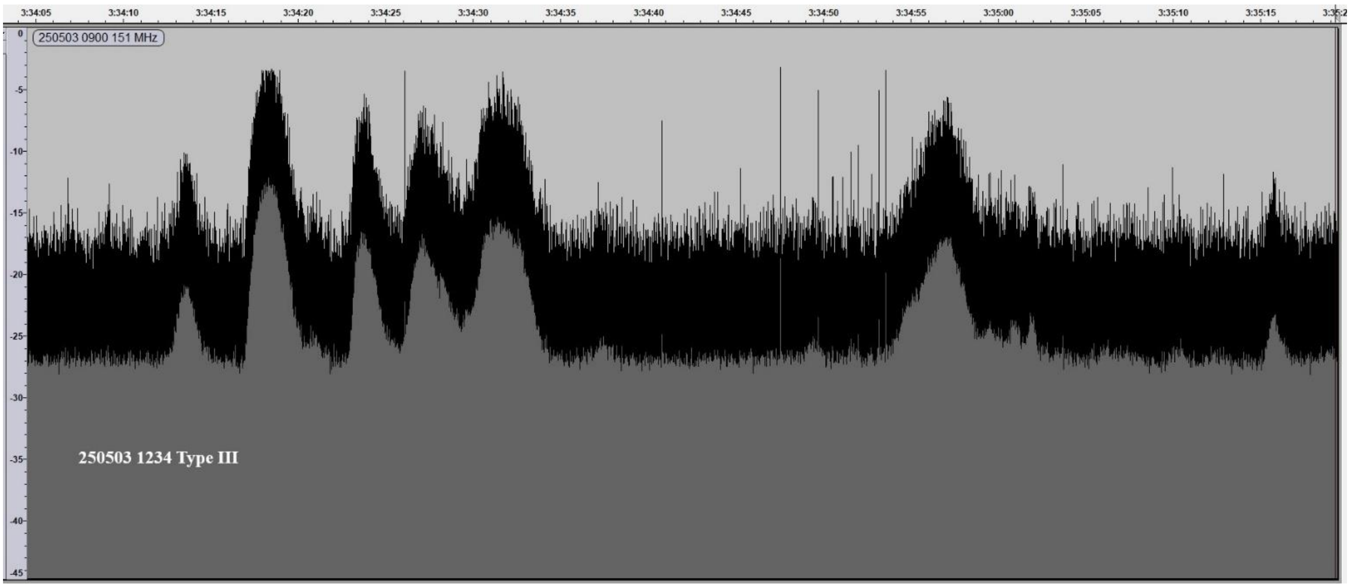


The most active period started early on the 29th, lasting right through to the end of the month. This also seems to be from interacting strong solar winds. Compared with the storms recorded in 2024 May, this was very mild.

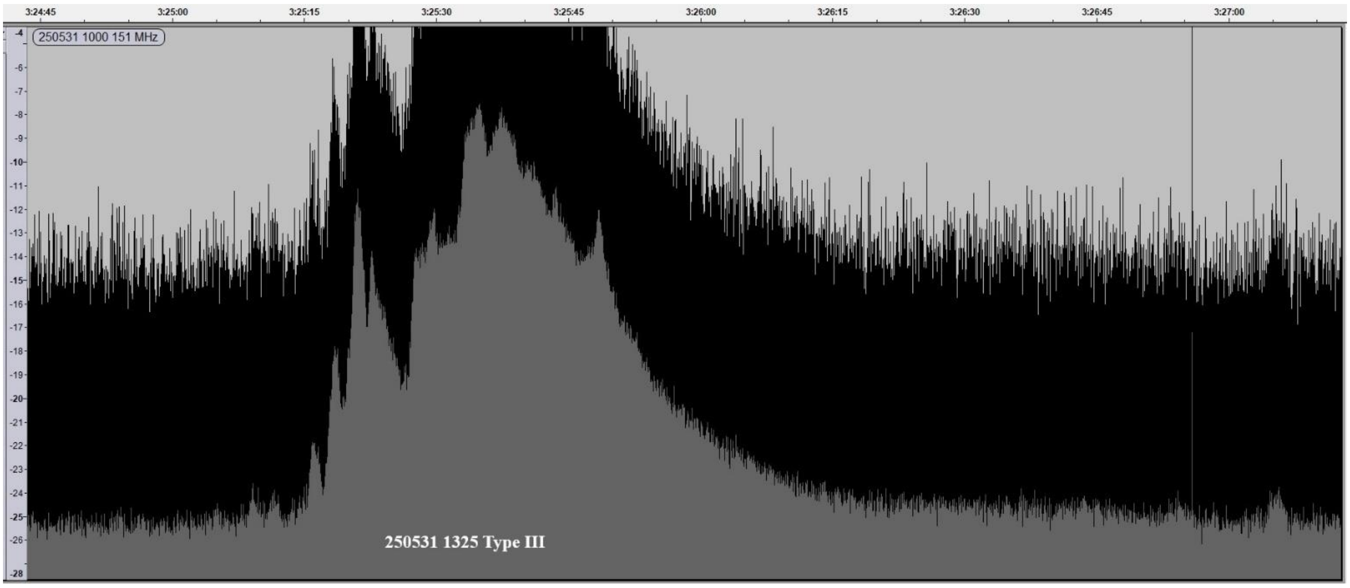
Thomas Mazzi noticed that this magnetic activity was causing disturbances to the GPS signals. This is another way of detecting ionospheric disturbance as the turbulent magnetic field moves its boundaries.

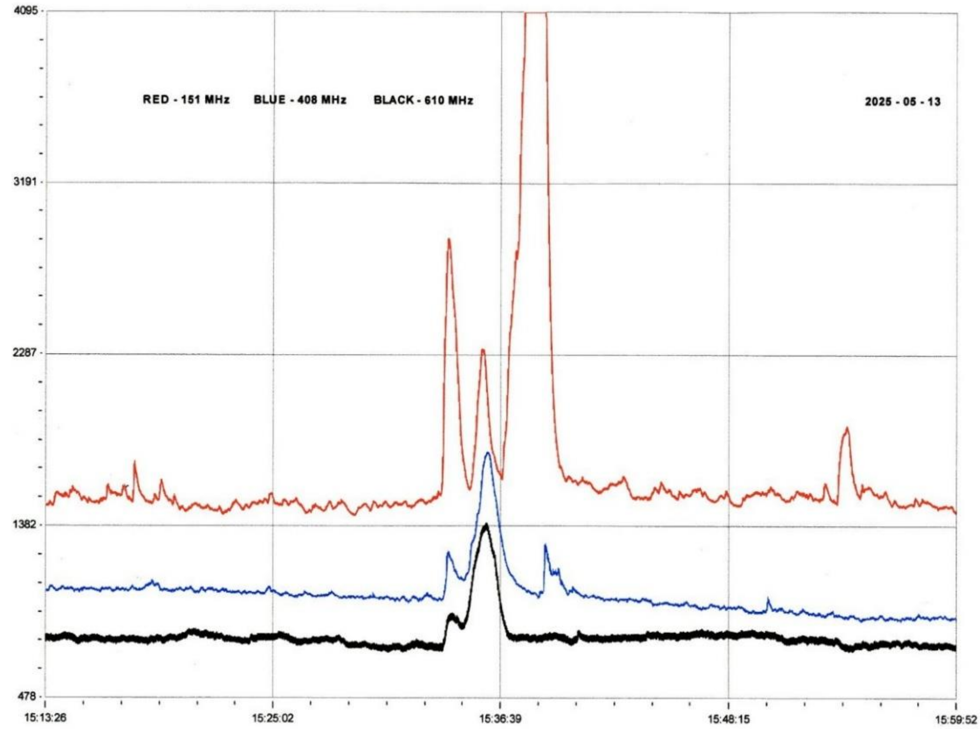
Magnetic observations received from Roger Blackwell, Stuart Green, Thomas Mazzi, Nick Quinn, and John Cook.

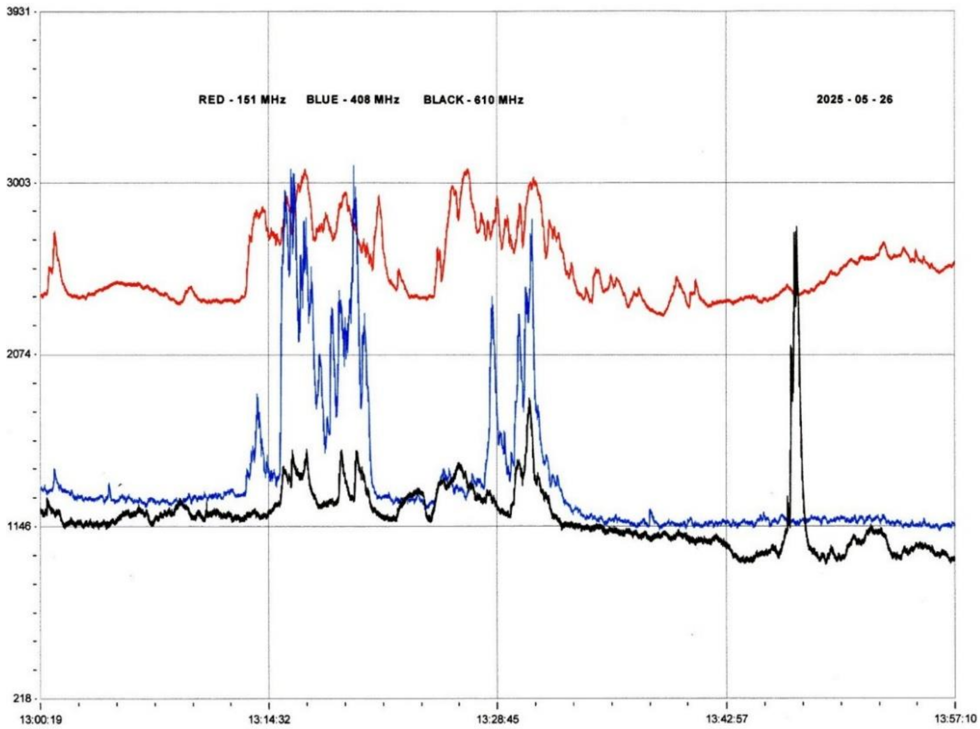
SOLAR EMISSIONS



Colin Briden recorded two type III 151MHz solar emissions. The first started at 12:34UT on the 3rd and matches the timing of a C1.5 flare in the SWPC satellite lists. It is not one that we recorded as a SID. It has an amplitude varying about 15 to 20dB with multiple peaks. The second starts at 13:25 on the 31st, matching the C6.5 flare. It has an amplitude of 18dB and lasts for about two minutes. This has several peaks, but they are all merged into a single event.

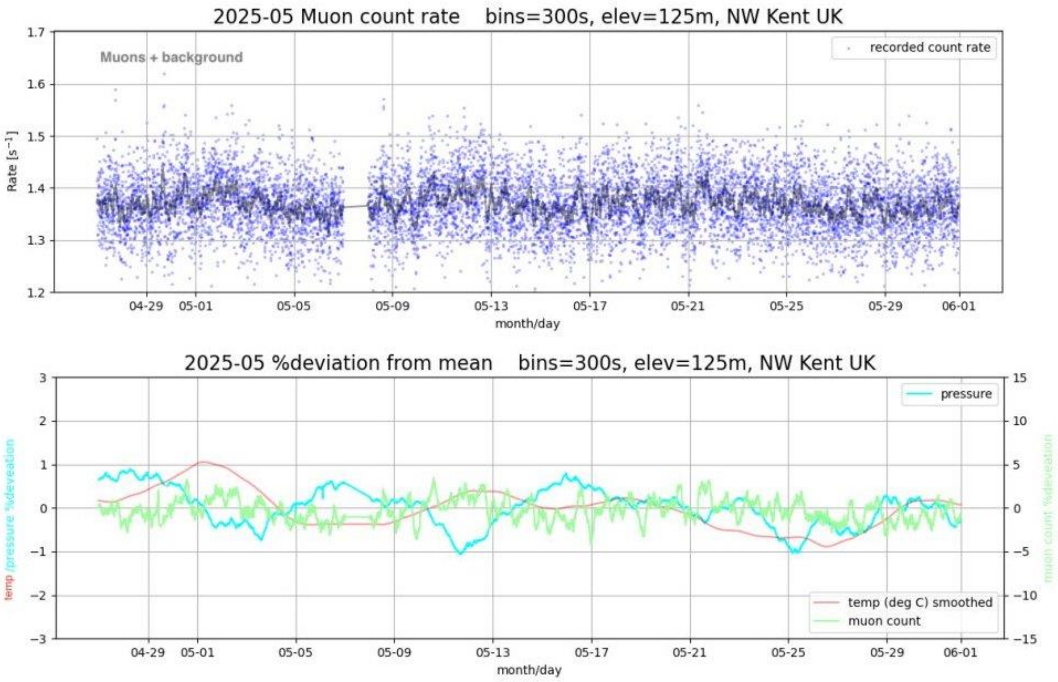


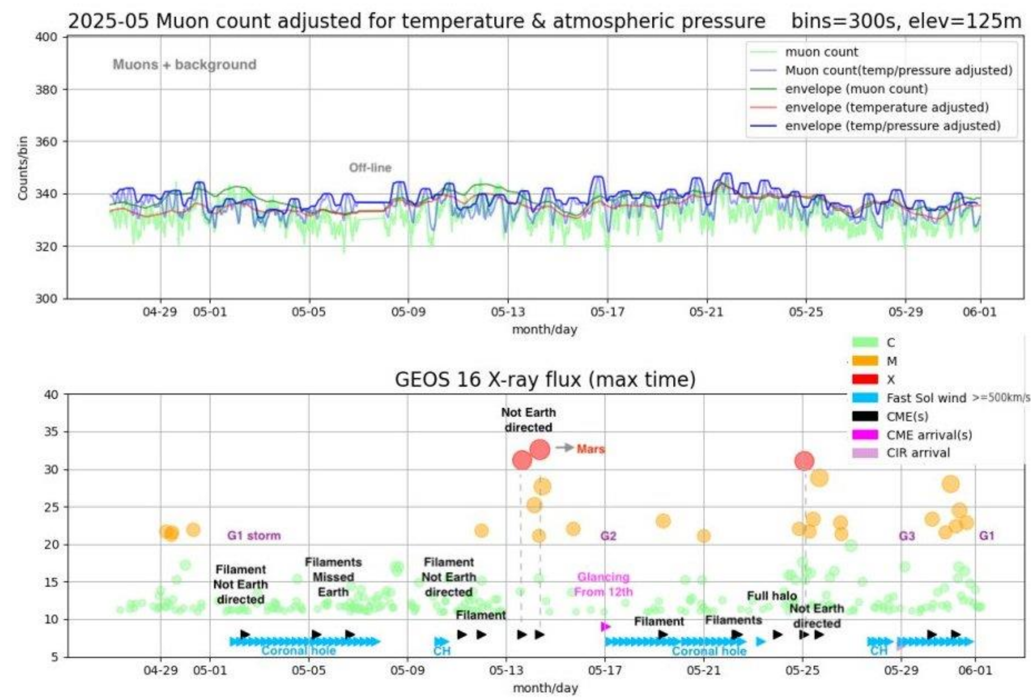




Colin Clements recorded a strong emission from the X1.7 flare on the 13th. All three frequencies show the burst, 151Mhz going off-scale. The M-flares on the 26th also produced strong emissions shown in the lower chart. 610MHz has its strongest peak after the other signals have returned to normal, although it is still within the decay phase of the M1.4 flare. Colin also reported emissions on the 8th from the C6.4 flare around 14:00UT, 610MHz showing much lower noise levels this time.

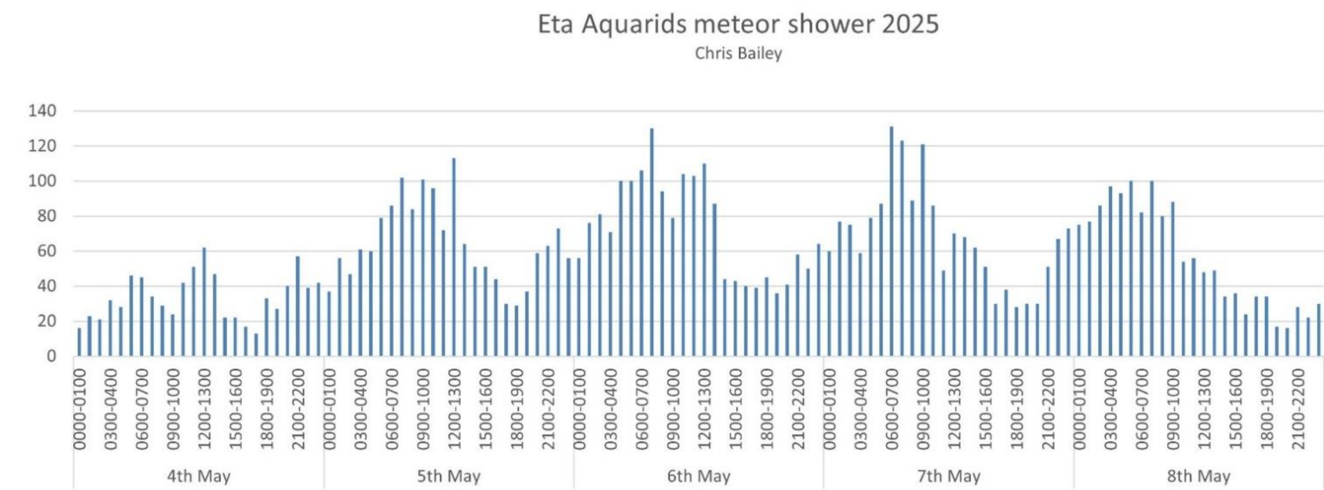
MUONS

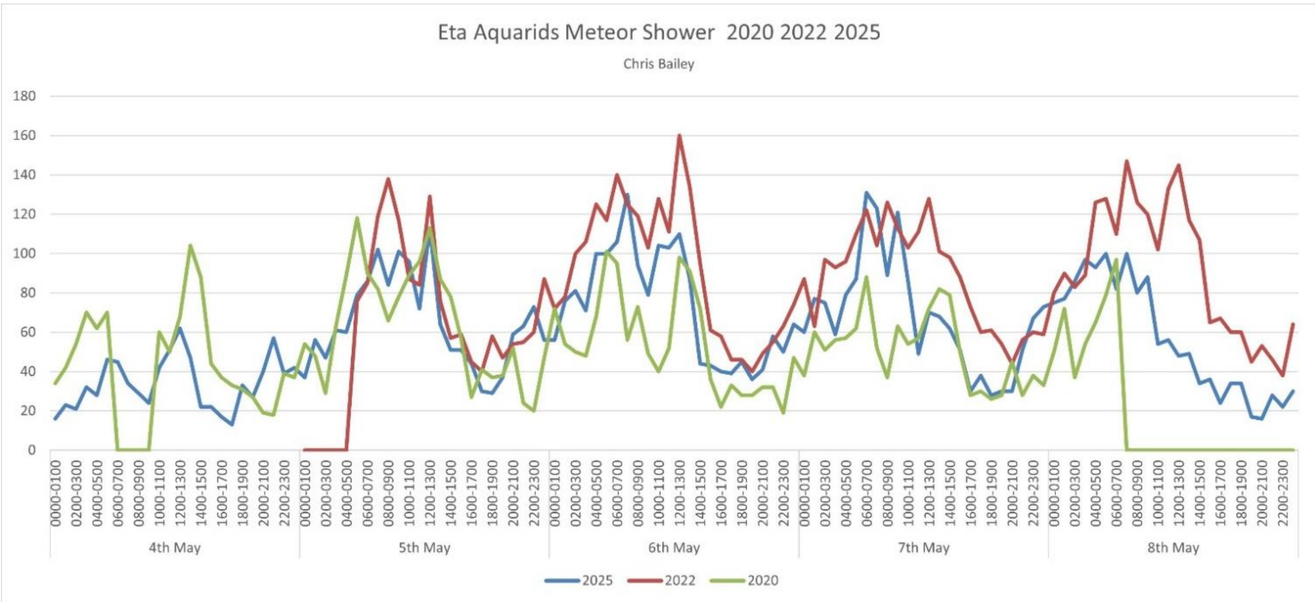




Mark Prescott's muon charts show a fairly stable flux through the month, with slightly lower counts in the first and last weeks with the faster solar winds. There is a short break when the sensor was offline on the 7th. The counts increased slightly around the 20th – 22nd despite the continuing faster solar wind. There is also a small peak on the 16th / 17th during the period with only very weak flaring. It also matches the active magnetic disturbances shown on page 5 of this report.

METEORS





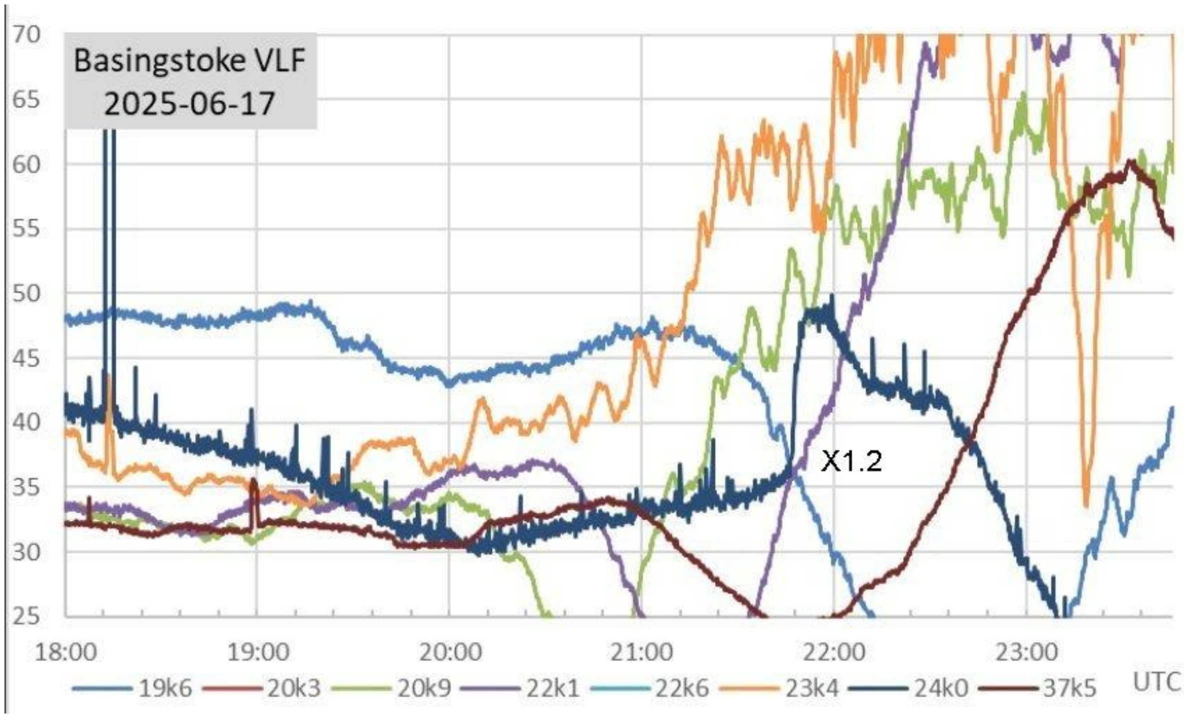
Chris Bailey recorded meteor counts during the Eta-Aquarid shower over May 4th to 8th. The top chart shows just the 2025 data, the highest counts being around 08 to 10UT in the morning. There is also a strong peak at 12-13UT on the 5th. The lower chart compares these figures with those from 2020 and 2022. The 2020 counts were generally lower, while the counts in 2022 were higher, showing much more activity on the 8th. Midday peaks are also evident in all three years.

Radio Sky News started as a summary of the monthly SID recordings in 2005 May. We had just four or five observers, and I produced a simple list of the timings reported along with a few lines of text and the occasional chart. The current activity chart shows the low level of activity at the end of solar cycle 23. Magnetic data was included in 2011, and the number of observers had increased considerably. Many more recordings could be included, marking the start of solar cycle 24. The 'summary' was renamed Radio Sky News in 2022. Thanks to all our observers, and I hope that it continues to be of interest as cycle 25 fades.

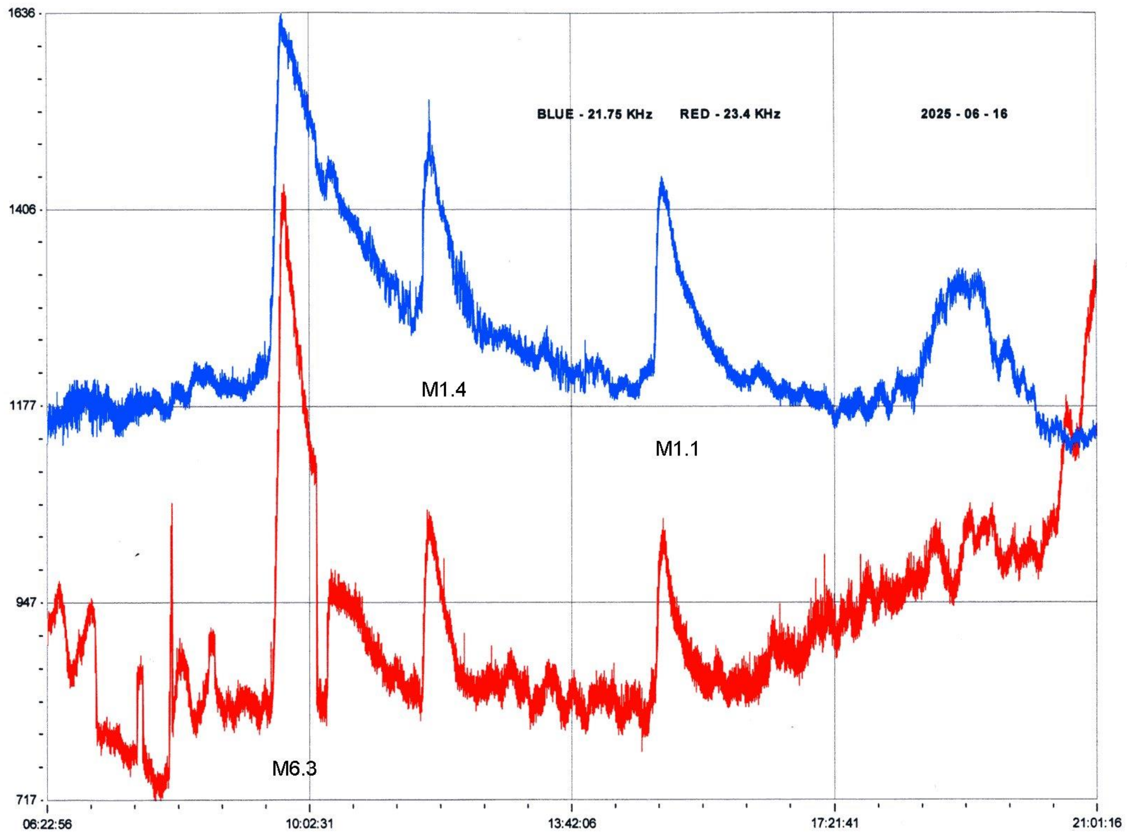
RADIO SKY NEWS **2025 JUNE**

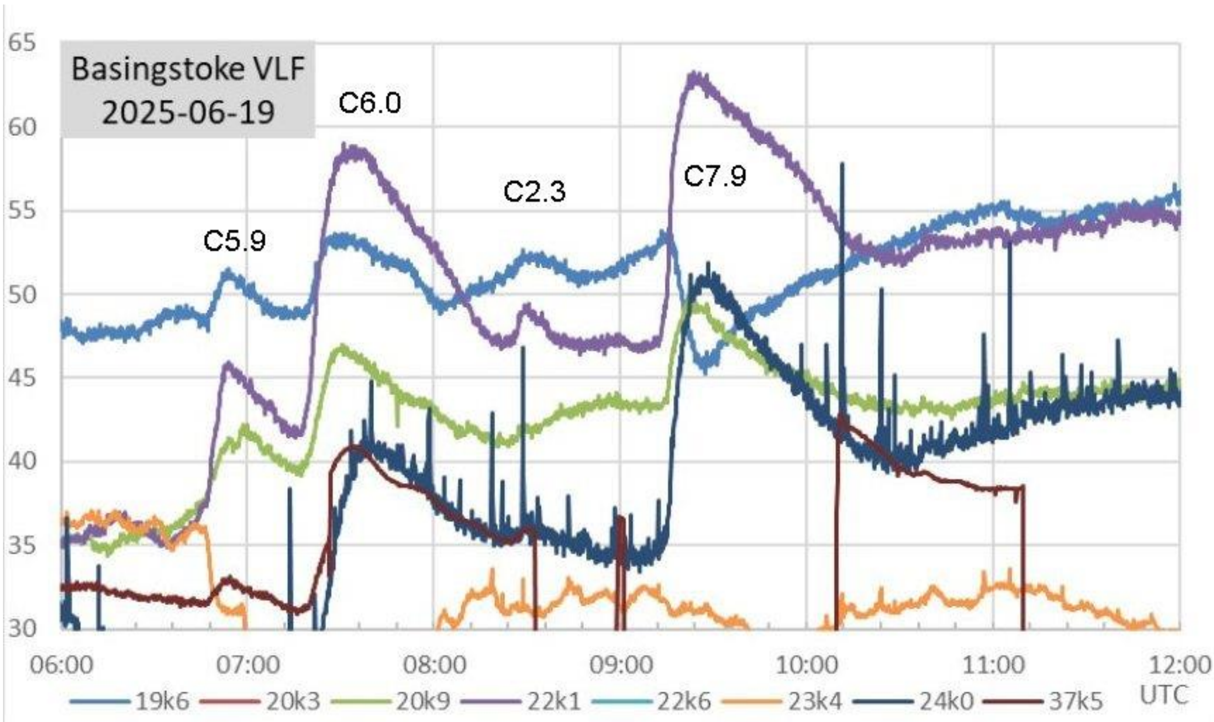
VLF SID OBSERVATIONS

Solar flaring activity in June was quite low with just fifty classified flares recorded as SIDs. This is the lowest since 2025 January when forty-five were recorded. Our daytime in June is considerably longer than in January, so it probably represents even lower activity than the numbers suggest. The satellite data shows that there were two X-class flares, an X1.9 close to midnight on the 19th and an X1.2 at 21:53UT on the 17th. Paul Hyde recorded this one on the 24kHz signal from Cutler, USA. His recording shows a clear SID, fading into the sunset. All the other signals were well past their local sunset times and are mostly very noisy.

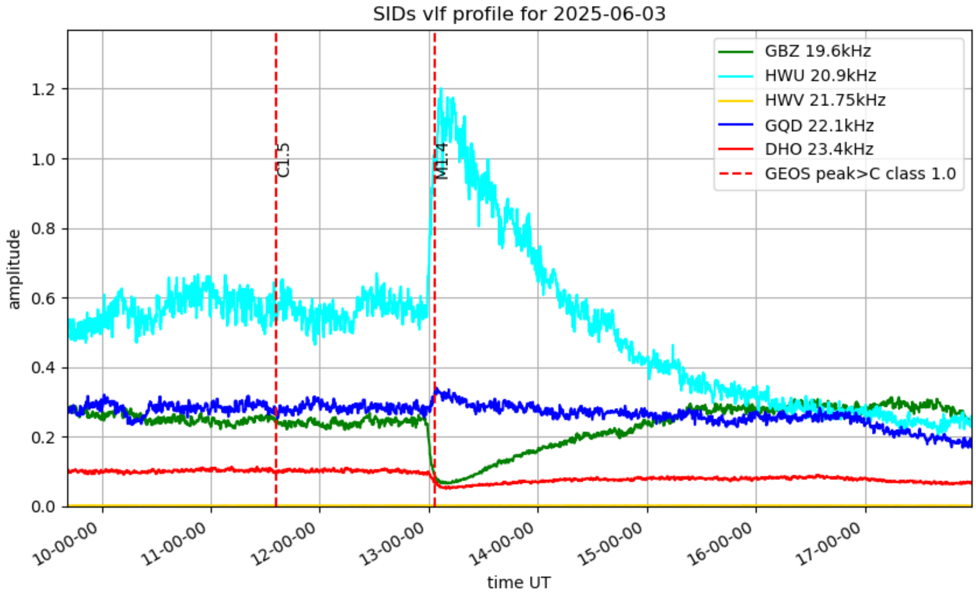


Most of June's activity was around mid-month, with a very quiet period in the last week when nothing was recorded. There were mostly just C-flares in the first two weeks, followed by four days of stronger flaring leading up to the X1.2. Colin Clements' recording shows the run of M-flares on 16th. 23.4kHz (red trace) has a short signal drop-out just after 10:02, an effect becoming more common on this signal. 21.75kHz also shows a minor drop-out at the same time.

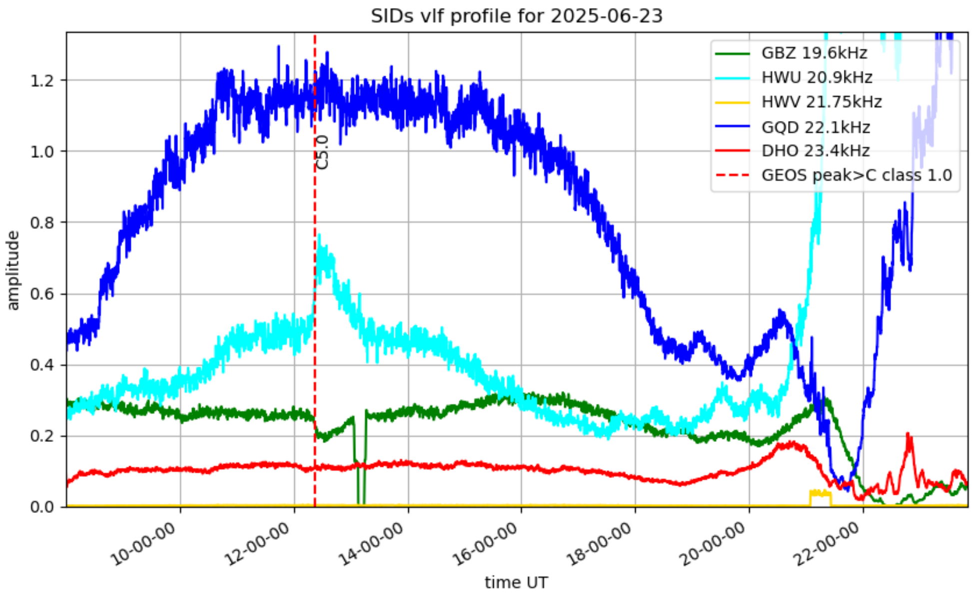




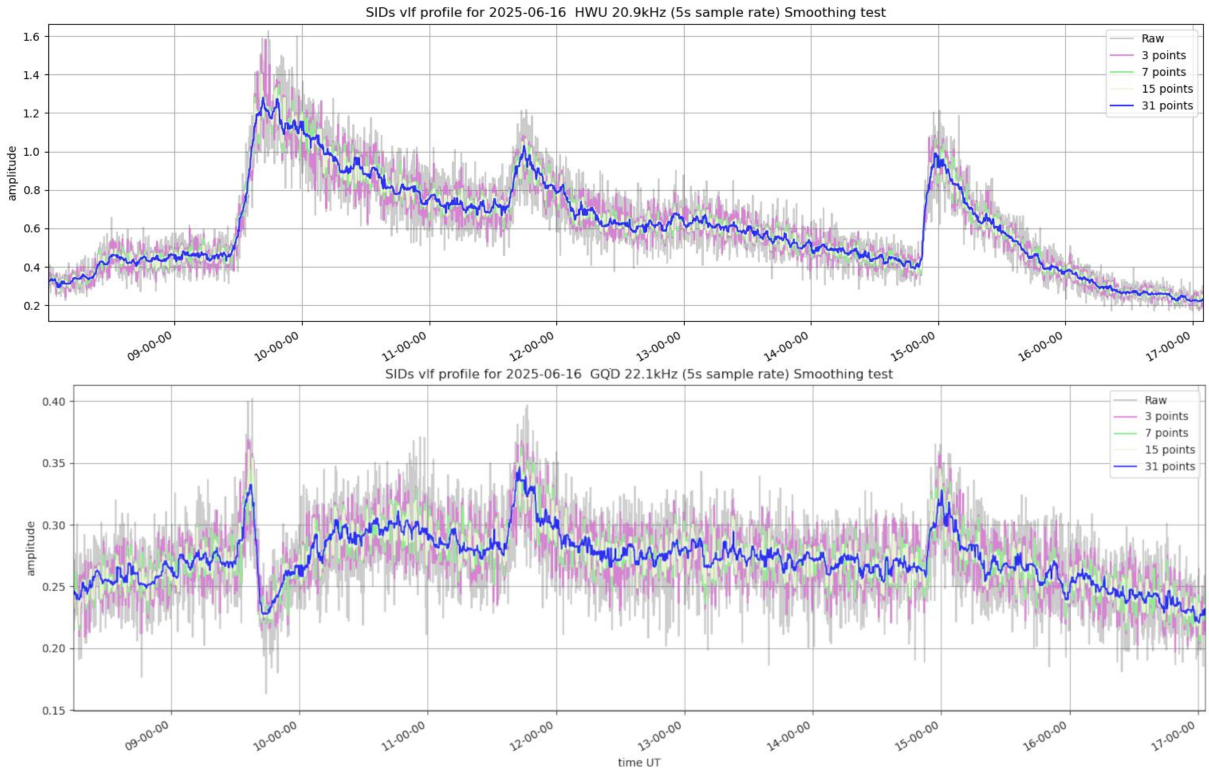
Paul Hyde's recording shows the run of C-flares on the 19th. The small C2.3 flare produced clear SIDs on both 19.6kHz and 22.1kHz, while the longer paths are much less clear. 23.4kHz shows its usual break between 07 and 08UT and appears very noisy and unresponsive to the flares.



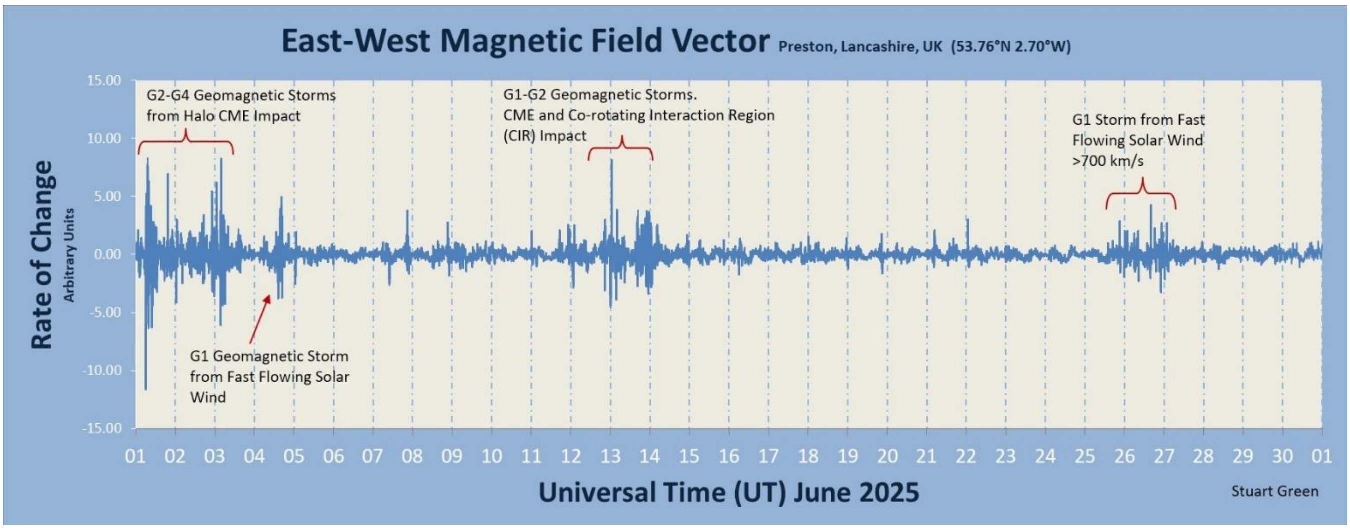
Mark Prescott's recording from the 3rd shows the M1.4 flare peaking at 13:05UT, along with the much weaker C1.5. 20.9kHz shows a very strong SID from the M1.4, with smaller SIDs on the other signals. The C1.5 has a very weak effect at 20.9kHz but is rather lost in the noise. 22.1kHz also shows a very small dip matching the C1.5, but it does not look very SID-like. Mark's recording from the 23rd shows a very strange diurnal curve at 22.1kHz compared with its flat shape on the 3rd. The other signals on his recording look fairly normal, responding well to the C5.0 flare at 12:26. My receiver saturated on the 23rd which was rather unusual, but I have no other recordings for comparison.



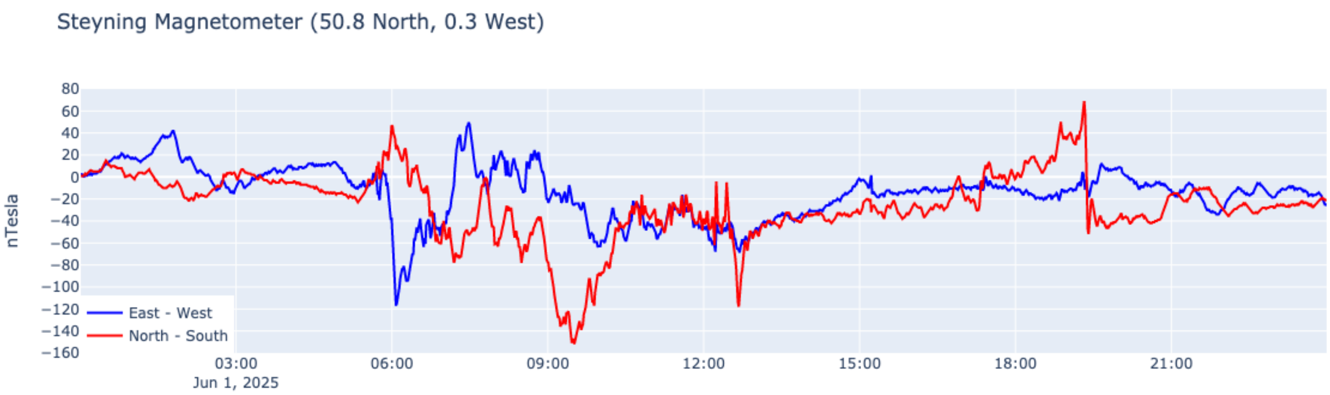
Mark has also included comparison charts for the M6.3 flare on the 16th (shown on the next page). The top panel shows HWU 20.9kHz with clean 'shark's Fin' SIDs for all three of the flares. The lower panel is GQD 22.1kHz with a rather noisier signal. The M6.3 flare at 09:45 shows what we have called a 'spike and wave' SID, where the signal goes through an in phase / out of phase interference pattern. Mark notes that in geophysics language this is known as a +90° peak/trough wavelet, more accurately describing the effect.



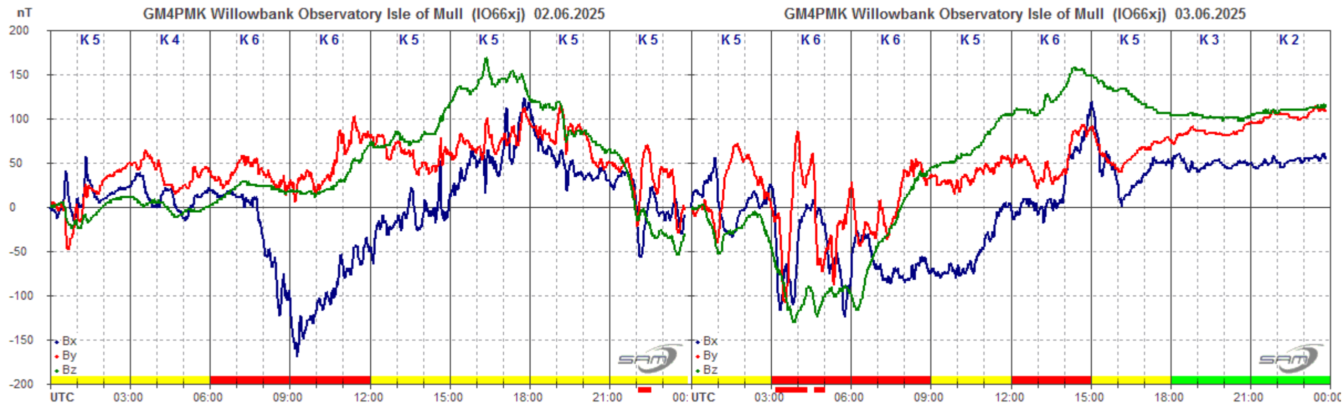
We often get interference problems at VLF, the lower cut-off for CE compliance being 150kHz, but tracking the source can be a problem. Colin Briden noticed a pulsing signal at 38.64kHz, with a related signal at 41kHz. Rotating the loop aerial had no effect, indicating a local source. After much time switching off various items of domestic equipment, the source was found to be an electric toothbrush charger!



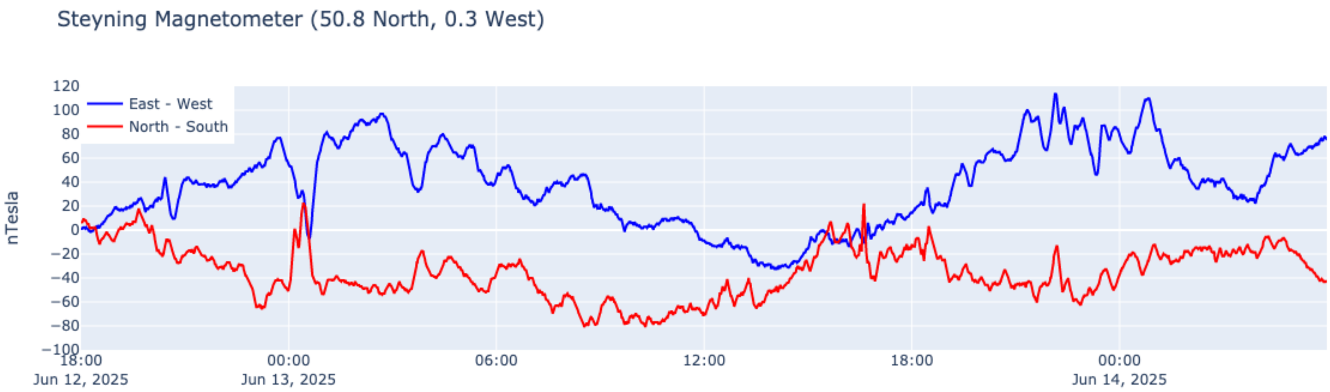
Stuart Green's summary of the magnetic activity in June shows a rather quiet month, matching the pattern of SID numbers recorded. May ended with a strong coronal hole solar wind, the disturbance continuing into the first few days of June. This was a combination of an earlier CME and a fast solar wind. Nick Quinn's recording from the 1st shows a strong disturbance starting about 06UT continuing through most of the day:

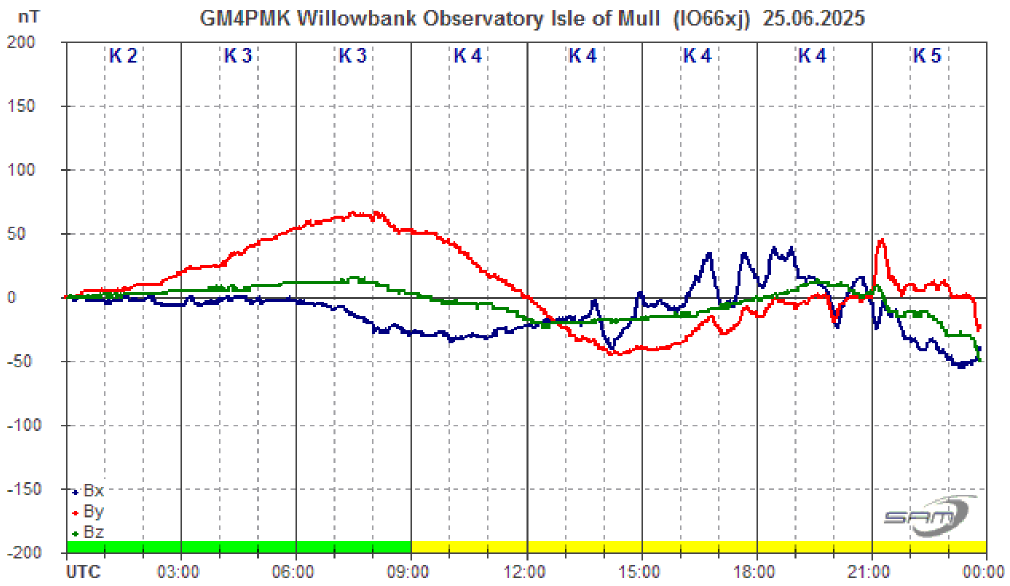


There is a very sharp change in the North-South axis at 19:20, also seen in the other recordings. This appears to be the arrival of a CME reported in the STCE bulletin from an M8.1 flare at 00:005UT on May 31st. There is also a smaller spike at about 12:30 that may also be linked to the CME impact.



Strong activity continued through the 2nd and 3rd, shown in Roger Blackwell's recording. This was aided by another coronal hole with a fast solar wind. There was a short active period in the afternoon of the 4th, but the disturbance then faded out over the next few days. Magnetic activity remained fairly quiet until the 12th, when another mixture of coronal hole winds and glancing CME impacts produced some mild disturbance. Nick Quinn's recording starts at 18:00 on the 12th, ending at 06:00 on the 14th, and shows some rapid turbulence with fairly small changes in the magnetic field.

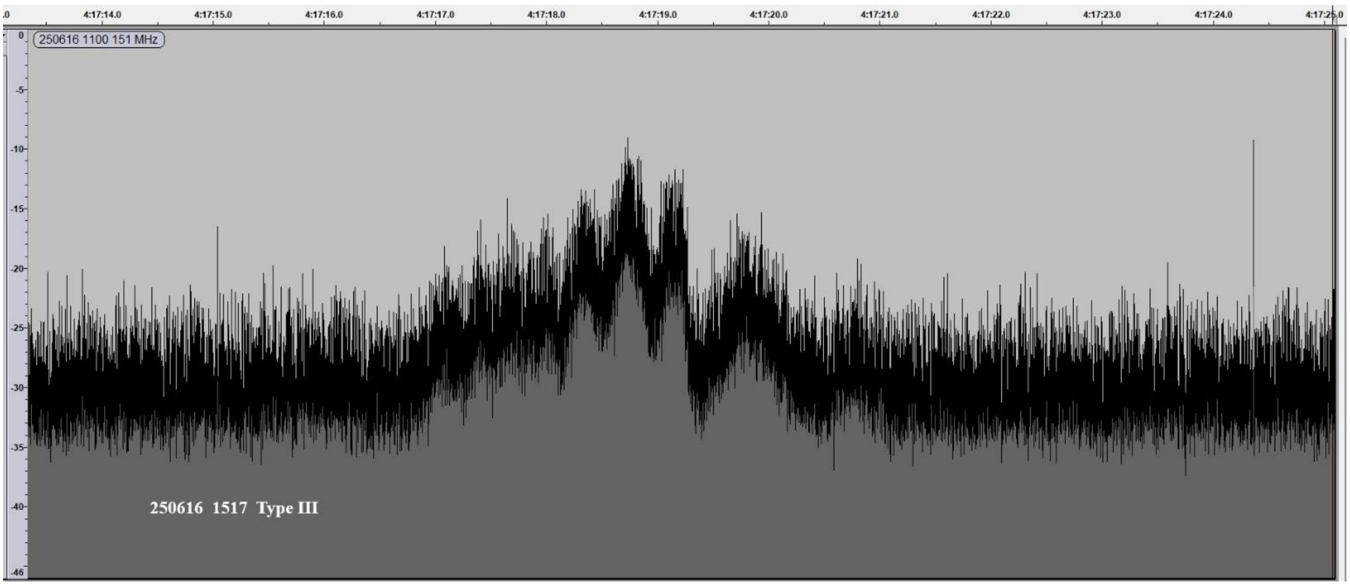




Roger Blackwell's recording shows the mild disturbance starting on the 25th, produced by further periods of faster solar wind. Unfortunately, his magnetometer had several periods off-line, and so the following few days are missing.

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

SOLAR EMISSIONS

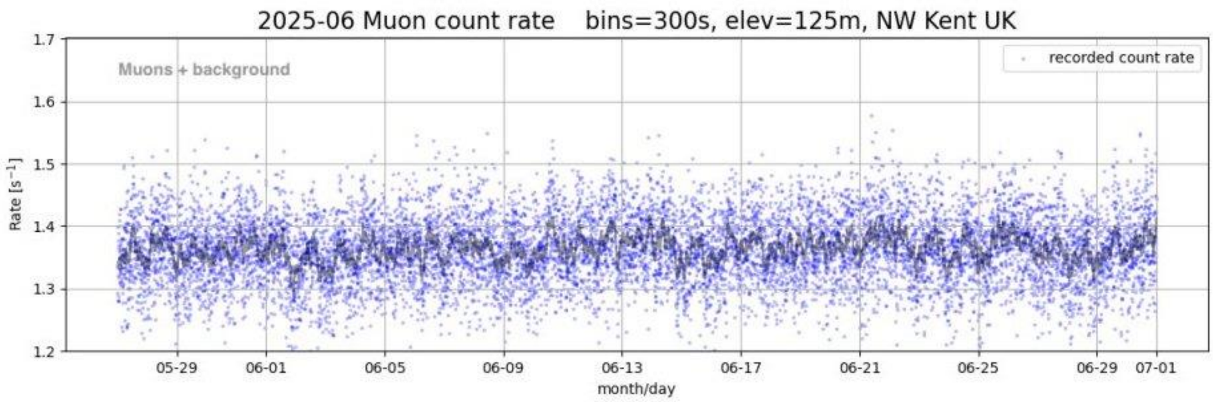


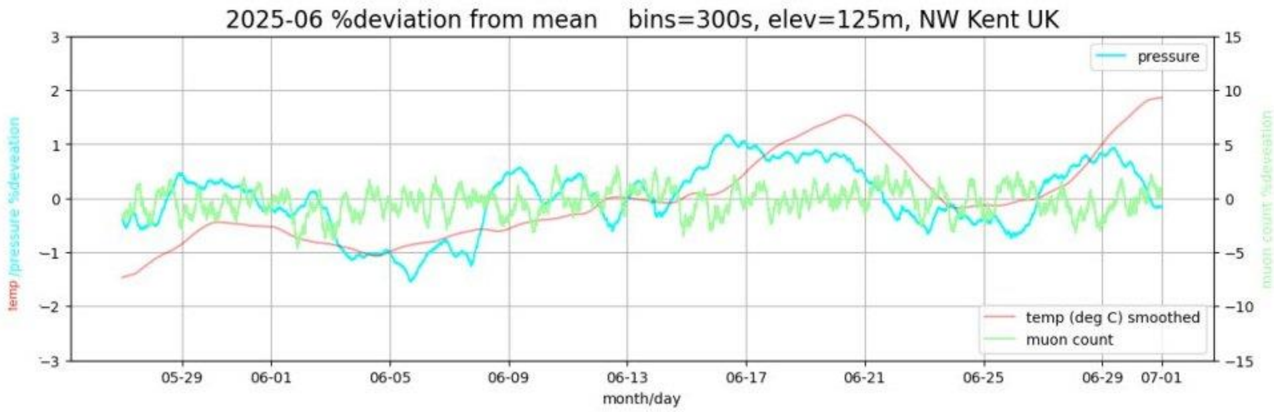
Colin Briden recorded a type III 151MHz emission at 15:17UT on the 16th. It has an amplitude of about 15-20dB, but only lasted for about 5 seconds, much shorter than usual. Our peak timings for the M1.1 flare on the 16th were around

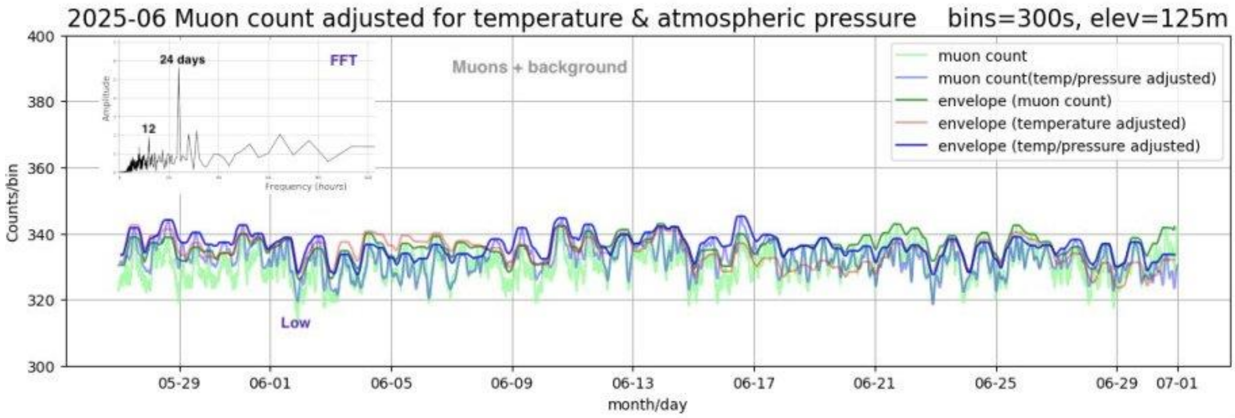
14:53-15:00, matching the satellite listing of the X-ray peak at 14:55. Our SID timings did show a long decay time for the flare. Colin's receiver has a sample rate of 41k cycles / second.

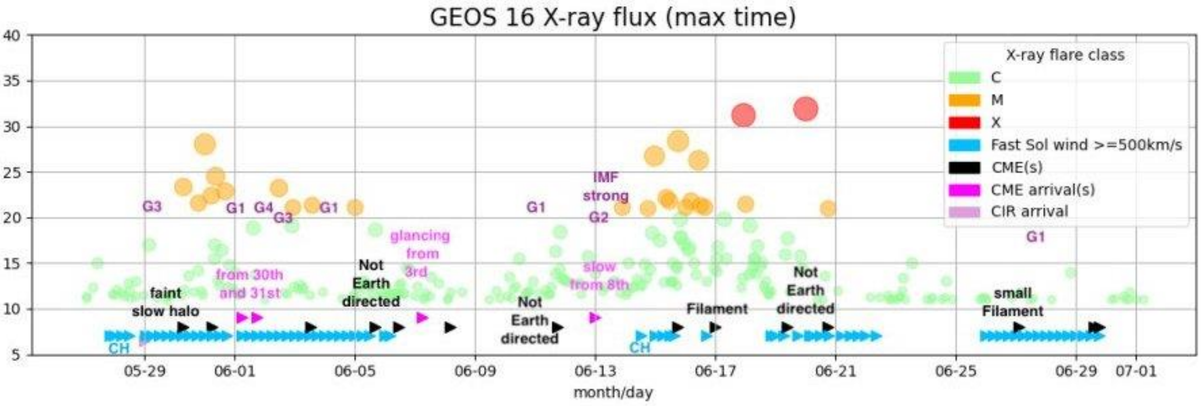
No other emissions were reported.

MUONS

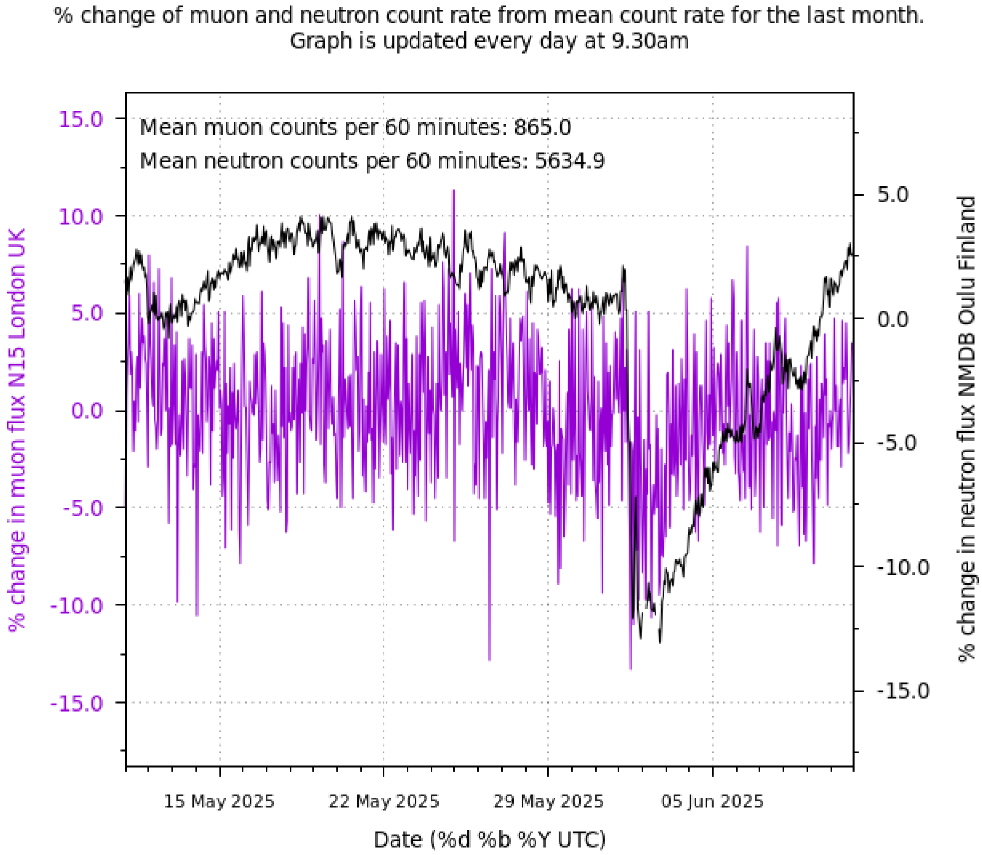








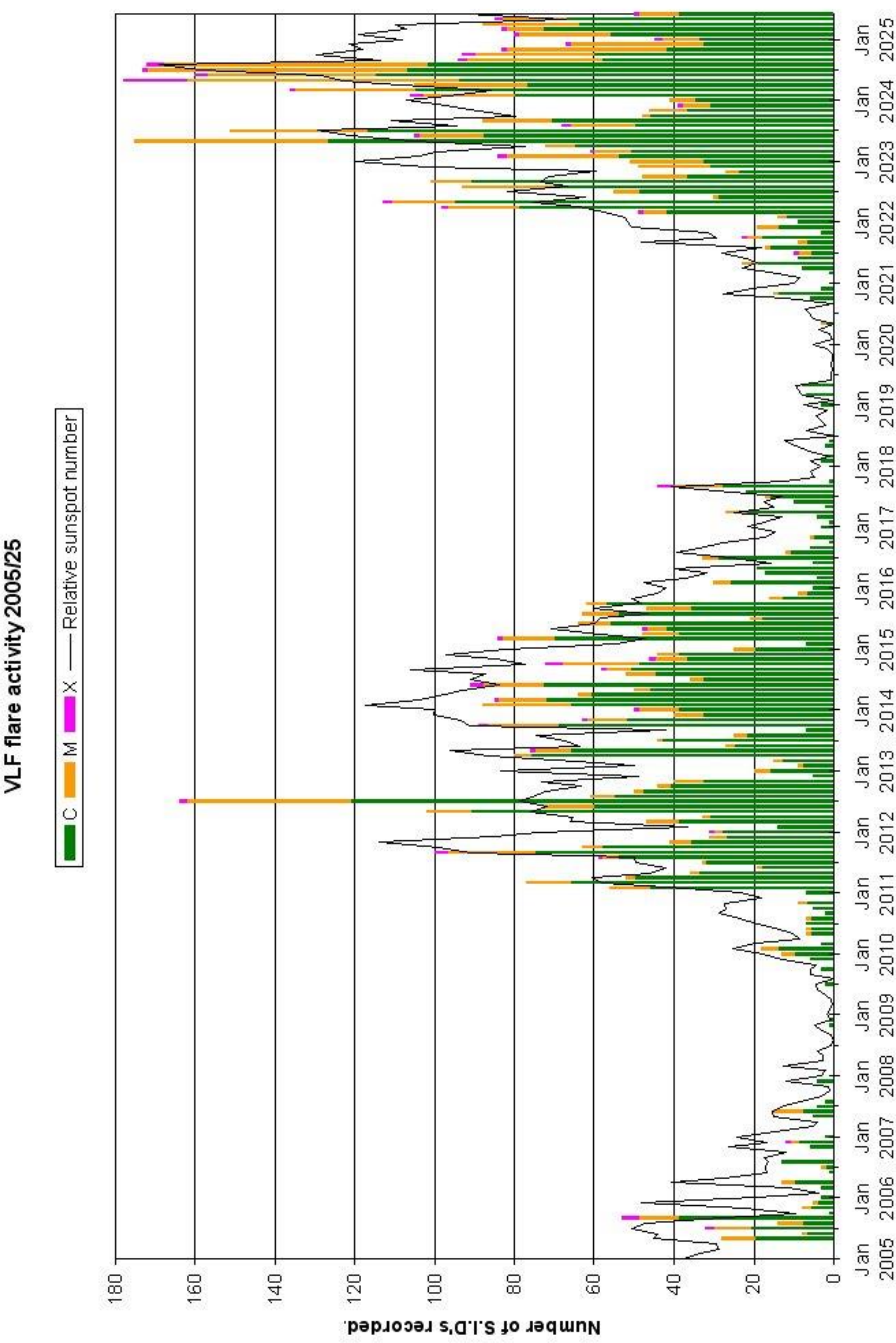
Mark Prescott's Muon charts show a fairly flat count through most of June. Inset is an FFT of the chart data, showing strong 12- and 24-hour diurnal peaks. There is a small drop in the flux on the 2nd, matching the CME timing. There is another dip between the 13th and 17th which also matches the other activity recorded.



Andrew Thomas has also been recording the muon flux. His recording (purple trace) is mostly from May but includes the first week of June showing the sharp drop on the 2nd from the CME impact. Andrew has added the Oulu (Finland) neutron data shown in the black trace. Andrew's recording method is different to that used by Mark Prescott, but the effect of the CME is similar.

Muon recording has become much easier now that the UKRAA have their sensor available, so more observations would be welcome.

BARTELS CHART



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

Observation of the H167α radio recombination line towards Cygnus X with a 3 metre dish

Eduard Mol

Introduction

Besides the famous 1420.4 MHz line, hydrogen also has hundreds of radio recombination lines (RRLs) in the radio spectrum. In contrast to the neutral hydrogen line, hydrogen RRLs are very faint (typically <1 Kelvin) and their occurrence is not widespread but limited to ionized gas (HII regions). For these reasons, observation of RRLs with typical amateur radio telescopes with 3 metre diameter or smaller has long been deemed unfeasible [1]. In recent years, the availability of SDRs and low noise preamplifiers combined with improved observation and data processing methods have made it possible to detect the faint hydrogen line spectra of nearby galaxies using amateur radio telescopes. This was pioneered by Steve Olney [2] and the late Jean-Jaques Maintoux [3] and later followed up by the late Job Geheniau [4], Jason Burnfield [5] and Eduard Mol [6] (the author of this article). With the driftscan technique hydrogen line features as faint as 40 millikelvins can be detected. Based on these earlier successes with detecting nearby galaxies I was motivated to carry out an experiment trying to detect the H167α RRL using my own 3 metre dish. It was decided to target the Cygnus X complex- a region where RRL emission is widespread over a ~5X5 degree area, which allows for the detection of faint RRLs using smaller instruments with wider beamwidths. The results of this RRL survey are summarized and discussed in this report.

A brief introduction to hydrogen RRLs

Radio recombination lines are the result of transitions between electronic states of atoms [1]. In the case of lower order transitions the energy gap is large and the resulting photon will have a wavelength in the UV or optical regime. In the case of hydrogen, the transition from the second energy level with quantum number n=2 to the ground state n=1 is known as the Lyman alpha emission line in the ultraviolet. Astrophotographers are very familiar with the deep-red Balmer hydrogen-alpha line in the visible spectrum, which is caused by the transition from n=3 to n=2 [7]. At higher n levels the energy difference between adjacent states becomes increasingly small, as described by the Rydberg equation

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Where λ is the wavelength of the spectral line, R_H the Rydberg constant of hydrogen, and n_1 and n_2 the quantum numbers of the lower and higher energy levels involved in the transition. At very high n_1 and n_2 the wavelength of the resulting transition will be all the way in the radio spectrum. Usually these very high energy levels are not populated, thus we do not observe RRL emission from neutral hydrogen clouds. However, when an ionized hydrogen atom encounters a free electron (“recombination”), this electron can initially end up in a very high energy level. As the electron decays to lower energy states recombination line photons are emitted. In outer space these conditions are found in HII regions, where hydrogen is ionized by intense (UV) radiation from young OB stars [1].

Besides hydrogen all other elements can produce RRLs as well, but because hydrogen makes up the vast majority of interstellar gas hydrogen RRLs are most often observed [1]. Helium and carbon RRLs are also fairly common but generally much weaker than hydrogen RRLs, while RRLs of other elements are rarely reported [8].

Radio recombination lines are designated with the chemical symbol of the element producing the line, the quantum number of the lower level in the transition and a greek letter indicating the difference in energy levels. For example, H100α is the transition from n=101 to n=100 of the hydrogen atom, while H100β would be n=102 to n=100 [1].

Where to observe RRLs with a small(ish) dish

It would seem logical to aim at HII regions with the brightest RRL emission. However, in practice this is surprisingly not the case. Let's consider the Omega nebula, one of the strongest RRL sources in the sky. The Astropeiler group reported a brightness temperature of 0.76 Kelvin at the H166α line with their 25-metre dish [1]. The nebula itself is quite small- about 0.5 degrees across in optical images. Assuming the extent of the RRL emission is similar it would fit within the 0.6-degree beam of the 25 metre dish. A 3 metre dish has a 69 times smaller area than the 25 metre Stockert dish. Assuming similar dish and main beam efficiencies the intensity of the hydrogen RRL towards the Omega nebula would also be 69 times weaker when observed with the 3 metre dish, or about 11 milliKelvins… this is well below the detection limit.

Instead, it may be more fruitful to target the most extended HII regions which are several degrees across. Cygnus X is perhaps the most promising target for RRL detection with amateur radio telescopes. Landecker (1984) produced maps of Cygnus X showing the peak intensity and velocity of the H166α RRL [9]. This map demonstrates that the RRL emission is not particularly intense (between 50 and 220 milliKelvins) but very widespread over a region about 5X5 degrees across. This means that the RRL emission region would practically fill the 5-degree beam of the dish and partially compensate for it's relatively small size.

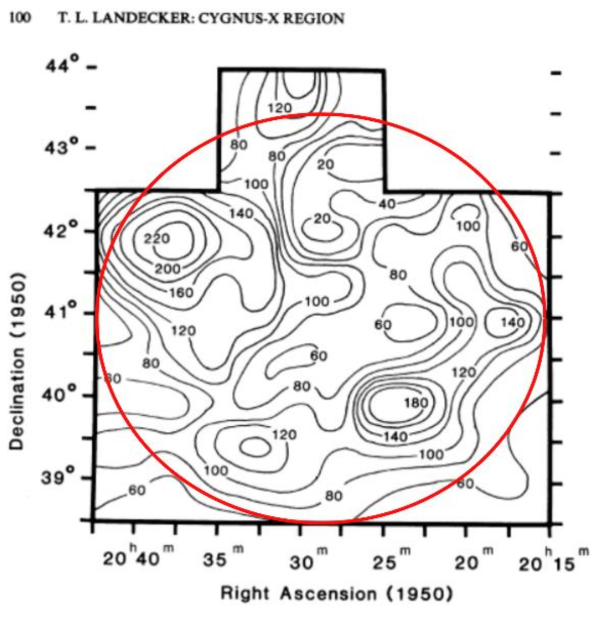


Figure 1: map of the H166a RRL emission towards the Cygnus X region. Contours are in units of milliKelvins. The red circle marks the 5 degree half-power beam width of the 3 metre dish (adapted from Landecker 1984).

Cygnus X is an area of intense star formation at a distance of approximately 1.4 kPc (~4600 lightyears). It contains several star forming regions as well as large amounts of molecular and ionized gas [10]. The brightest spot of RRL emission in the Landecker map (at RA +41 DEC 20h38m) coincides with the star forming regions W75 and DR21, which are visible as a ridge of strong continuum emission in radio maps. The other bright RRL spot (at DEC +40 RA 20h25m) corresponds to the HII region IC 1318, which is also a strong continuum radio source and visible as a bright emission nebula in the optical spectrum. The weaker RRL emission filling the rest of the map is presumably associated with smaller HII- and star forming regions or with diffuse ionised gas.

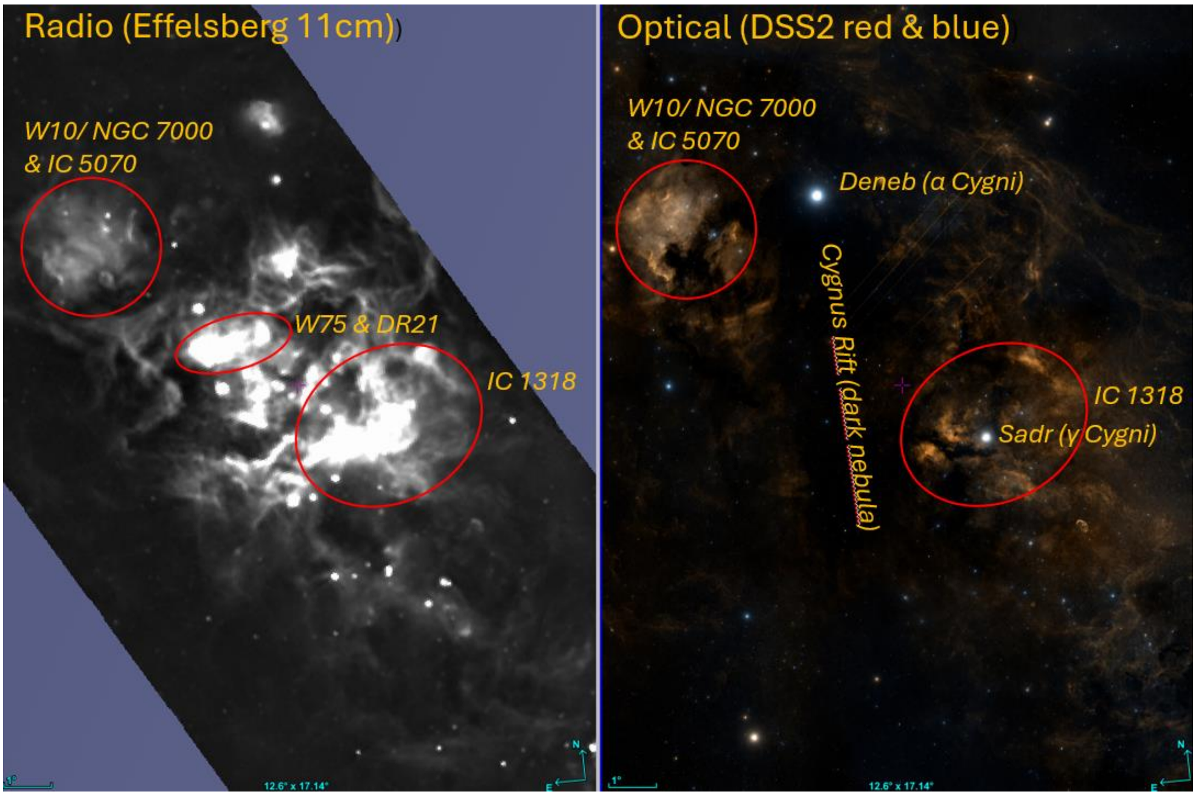


Figure 2: Radio and optical images of Cygnus X. Left: 11cm (Effelsberg/ MPIfR/ Aladin Sky Atlas); right: optical (DSS2 R+B/ Aladin Sky Atlas)

Methods

The modular 3 metre dish

For this project a homemade 3 metre f/0.5 dish was used. The dish has a plywood construction with an aluminium mesh reflector. It is not permanently set up in the backyard but consists of four segments which can be assembled around a central hub and stored in a shed when not in use. The system temperature is about 110- 120 K, as estimated following the "SNR method" described in [11]. In summary, the electronics chain of the 3 metre dish setup consists of the following components:

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

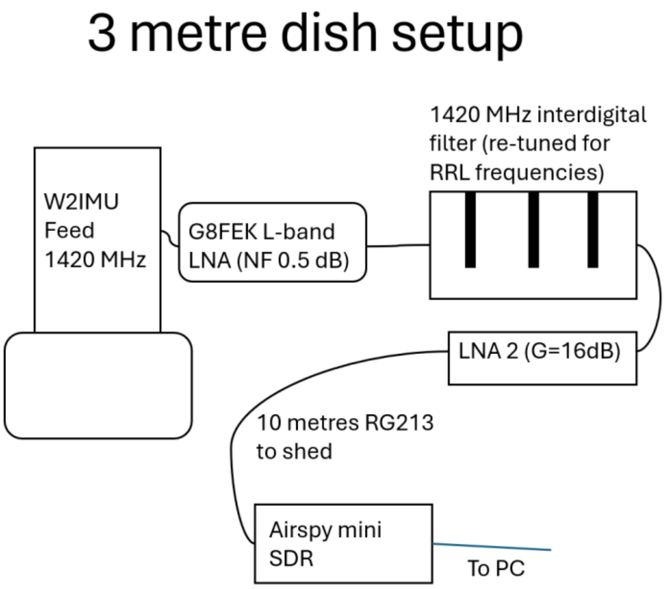


Figure 3: left: block diagram of the receiver chain; right: the 3 metre dish fully assembled.

Mitigating thermal drifting

One of the challenges encountered during this project was the effect of changing temperature during driftscan observations. This not only impacted the overall gain of the system, but the gain change was also slightly uneven over the 6 MHz passband of the SDR. This caused a significant residual curve in the spectrum even after background removal. A rather crude experiment was carried out to find out whether the LNA, filter and SDR were sensitive to temperature change by warming each of these components with a hairdryer and monitoring the spectrum with SDR# IFaverage. It was found that the SDR was the most sensitive to temperature change, while the LNA and the filter were sensitive to a much smaller extent. Even though the SDR was cooled to ambient temperature by an old PC fan, a few degrees of temperature change in the garage would be enough to slightly alter the gain and spectral response.

The LNA, filter and second amplifier were all wrapped in insulation material to limit temperature drifting at least to some extent. The SDR was initially placed on an aluminum heatsink suspended in a large 50L tub of water which acted as a thermal buffer: this greatly improved system stability but was obviously impractical as a long-term solution. Later the SDR was placed on two heavy blocks of aluminum cooled by an old PC fan, which proved to be sufficient for the purposes of this experiment.

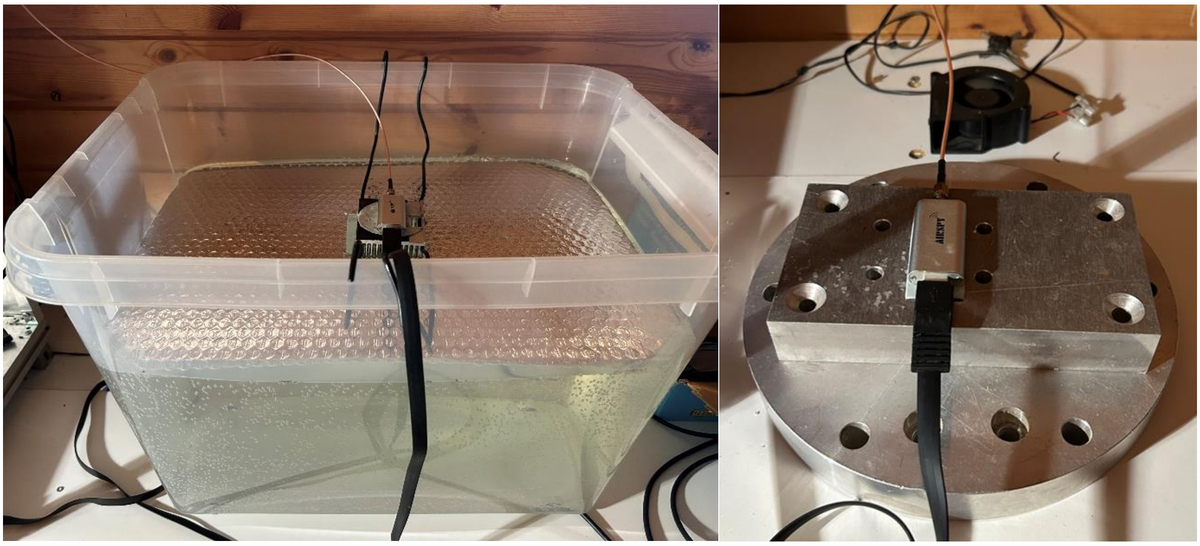


Figure 4: methods for thermally stabilizing the SDR. Left: using 50 litres of water as thermal mass; right: using aluminium blocks and a PC cooling fan. In both cases the SDR is attached to the heatsink with thermal paste to ensure optimal heat exchange.

RFI mitigation

All amateur radio astronomers have to deal with RFI to some extent: most of us are working with small, low-cost equipment in suburban backyards surrounded by noisy electronics. Especially with very faint radio sources such as external galaxies or RRLs any amount of RFI can ruin or at least vastly complicate observations. Because my location is at the edge of a village the RFI situation is not too bad but there are still nearby interference sources. Daytime observations are often complicated by regularly spaced RFI spikes in the spectrum, of which the source is unclear (possibly nearby solar panel transformers). During nighttime this type of RFI disappears but there are usually still a few spikes remaining. The intensity of these spikes varies with the pointing direction of the dish, which indicates that the RFI is likely being picked up via the sidelobes. It was possible to minimize the RFI spikes by pointing the dish at an azimuth of 147 degrees, at this position the RFI sources were presumably located in a null of the dish radiation pattern. Observations of the H166α line were still heavily impaired by RFI, but luckily the spectrum around the H167α line was less affected.

Data collection and processing

Since the 3 metre dish has no tracking capability all data collection was done in driftscan mode. The data collection and processing procedures are described in an earlier articles on the observations of M31 and M33 by Jason Burnfield and by me in the March- April 2024 and the January- February 2025 SARA journal [5, 6]. Briefly, an integrated spectrum is saved every minute using SDR# with the IFaverage plugin. Two blocks of off-target “pre- transit” and “post-transit” spectra are averaged and divided from the averaged “on- target” spectrum for bandpass correction. In the case of Cygnus X, a 30-minute block of spectra centered on the Cyg X continuum peak (RA = 20h30m, DEC = +41:00) is used as the “on-target” spectrum, while two 30-minute blocks of spectra centered 50 minutes before and after the transit (at RA = 19h40m and RA = 21h20m) are used as off-target darks. After bandpass correction the frequency axis is converted to LSR velocity, using an Astropy script developed by T. J. Dijkema [12] to obtain the LSR correction factor for the location and time of the observation. Results from multiple transits are then averaged together to improve the signal-to-noise ratio (SNR). Finally, residual slope (if present) is removed by fitting and subtracting a second-order polynomial through the background, and the resolution is reduced by averaging adjacent FFT bins to improve the SNR even further. Finally, the vertical scale of the spectrum is converted to brightness temperature, using earlier observations of the hydrogen line towards Cygnus X (~100K according to LAB survey simulations) as a calibration point. It is assumed that the radio telescope’s performance is similar at the H166α and

H167α RRL frequencies (1424.7 MHz and 1399.4 MHz). Because the telescope is not independently calibrated at these frequencies this assumption has not been tested, and the calculated brightness temperatures should be treated as a rough estimate at best.
Besides spectroscopic observations of Cygnus X, the continuum signal was also extracted from the driftscans by averaging all spectral channels and plotting the average intensity against time or right ascension.

Results and discussion

Continuum observations

Cygnus X is not only an RRL source but also a continuum source. In fact it contains several strong continuum sources in a small area, which all add up when observed with a small dish with a several degrees wide beam. This makes Cygnus X one of the strongest continuum sources in the sky, at least for small amateur telescopes. Another strong continuum source, the radio galaxy Cygnus A, is located at the same declination as Cygnus X and can thus be observed in the same driftscan. However, because Cygnus A and Cygnus X are only a few degrees apart and the beamwidth of the dish is 5 degrees, Cygnus A is only seen as a small bump at RA = 20:00 [11].

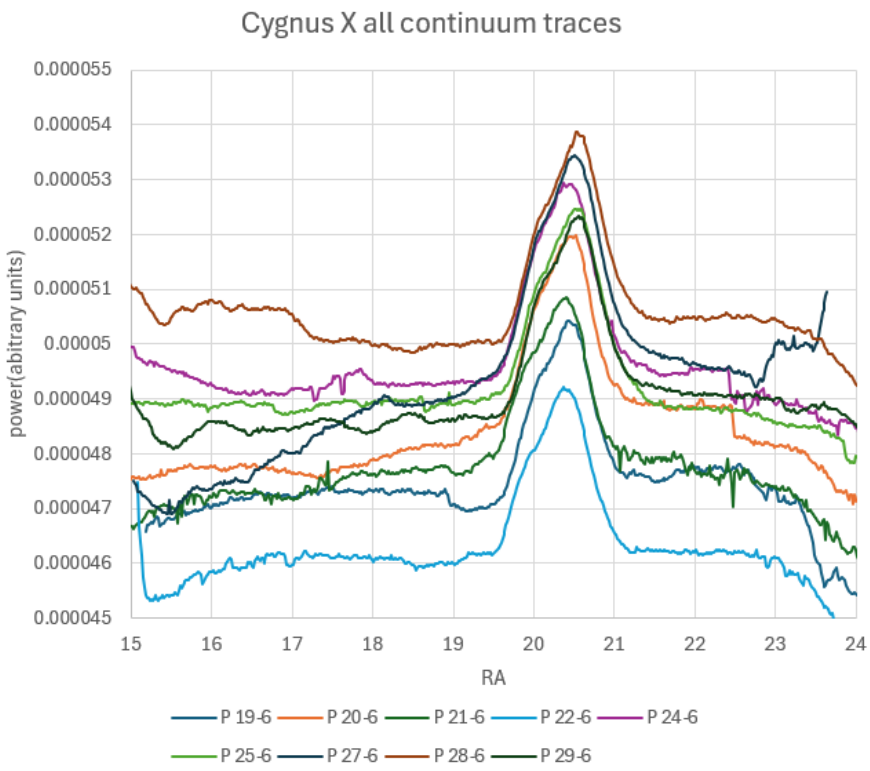


Figure 5: continuum results from all driftscans

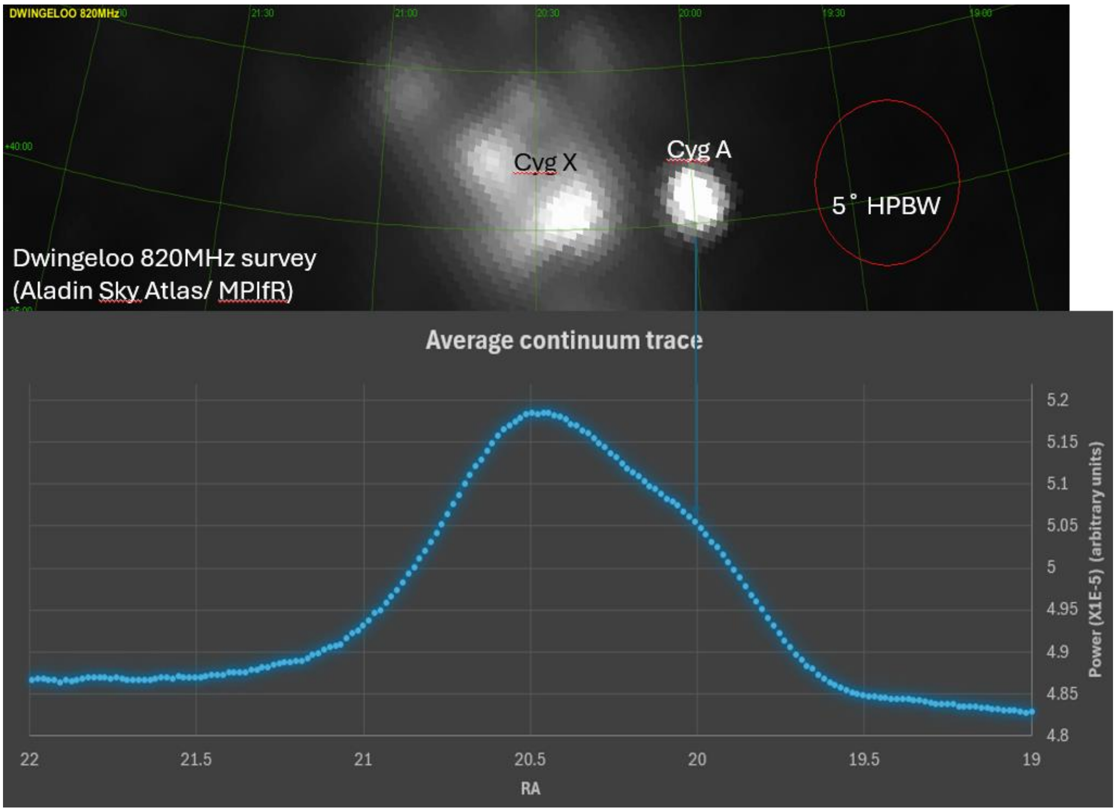


Figure 6: average of all continuum traces compared to a radio map of the Cygnus region.

Possible detection of the H167α line

Initially, it was attempted to detect the H166α RRL at 1424.734 MHz since this line is closer to the hydrogen line at 1420.4 MHz. Unfortunately there were a number of persistent RFI spikes right in the frequency range where the RRL was expected. Subsequent efforts were soon redirected to H167α at 1399.368 MHz, which was less affected by RFI. There was still a persistent RFI spike at 1400 MHz but this was just far enough away from the line rest frequency to not overlap with the RRL.

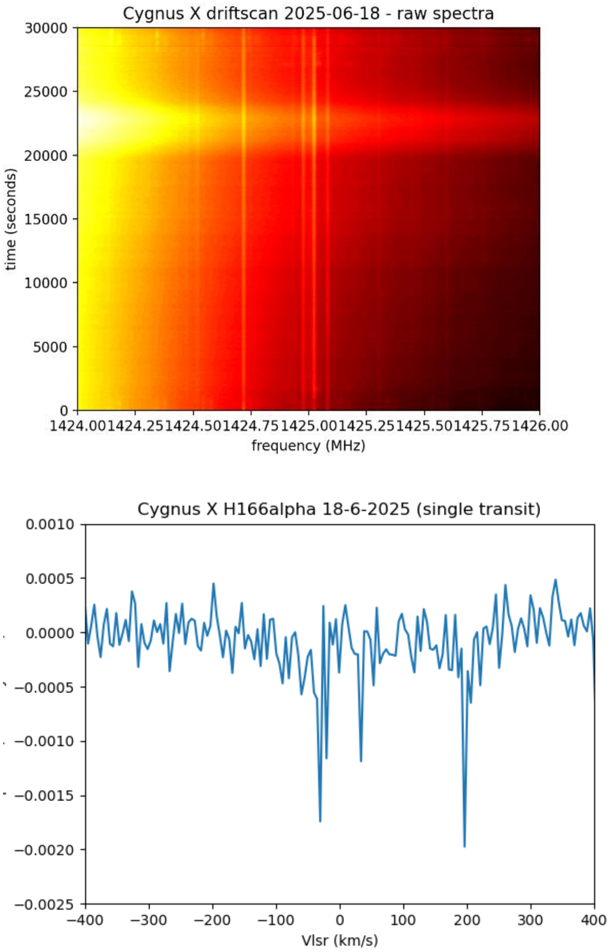


Figure 7: first attempt at detecting the H166a RRL. Right: waterfall plot of all spectra from the driftscan. the broad horizontal band is continuum emission from Cygnus A and Cygnus X, the vertical lines are RFI spikes. Right: spectrum towards Cygnus X (40 minutes of spectra centered on the continuum peak averaged, divided by two averaged 40 minute blocks of spectra before and after transit). The RRL, expected at 0 km/s, is obscured by several RFI spikes (sharp negative peaks).

A total of 9 nighttime driftscans was recorded between June 19 and June 29. The results from 8 of these driftscans were averaged together, only the data from June 21 were excluded because of a strong residual background curve that was very difficult to remove.

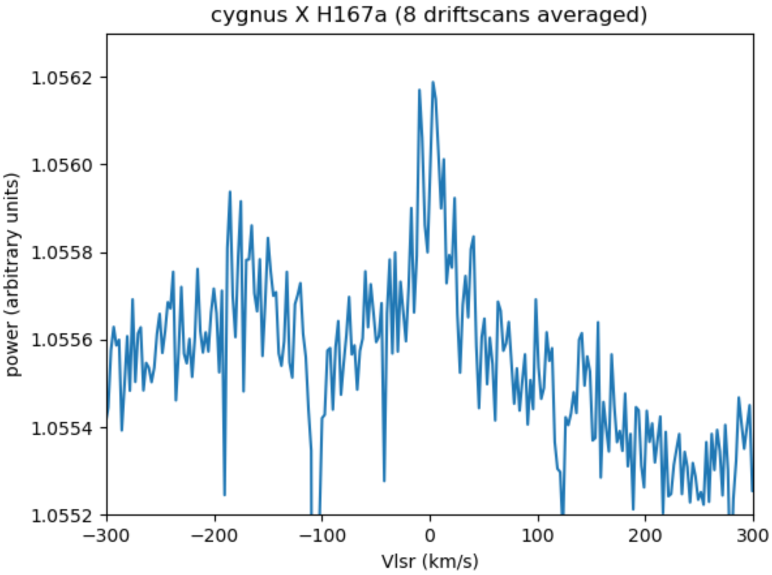


Figure 8: averaged spectrum of 8 driftscans (resolution 11.7 KHz)

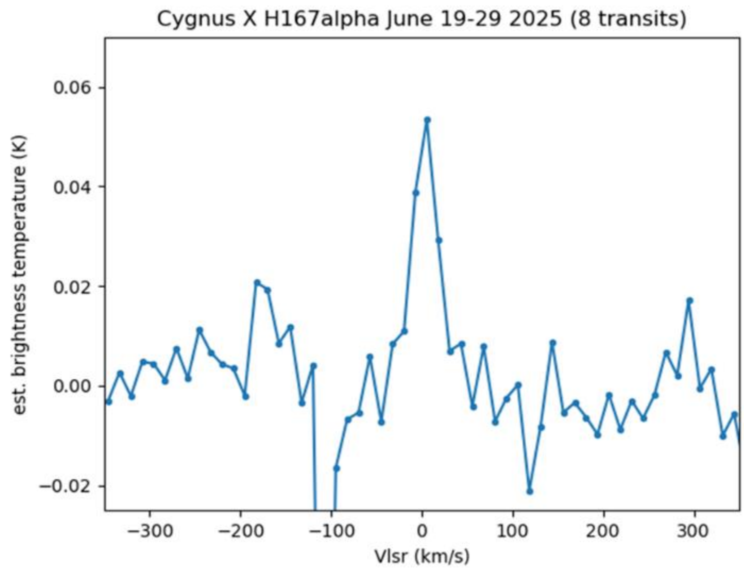


Figure 9: end result from 8 driftscans after decreasing the resolution to 59 KHz and removing residual background curve with a 2nd order polynomial.

Testing the detection

LSR velocity and line parameters

The peak LSR velocity and FWHM of the detected line were estimated with gaussian fitting. A comparison with measurements from professional observatories remains difficult, because with the wide beam of the 3 metre dish we are getting an average of the whole region. Landecker (1984) reported a spread in velocity between -15 and +15 km/s in their H166a mapping observations towards Cygnus X, with most of the observed points falling between -5 and +5 km/s [9]. The observed LSR velocity of 2.6 km/s is therefore broadly consistent with the average LSR velocity of the whole Cygnus X region. Ideally the entire series of driftscans would be repeated a few months later to see if the signal stays at the same LSR velocity throughout the year, but obviously this would be a very time-consuming project.

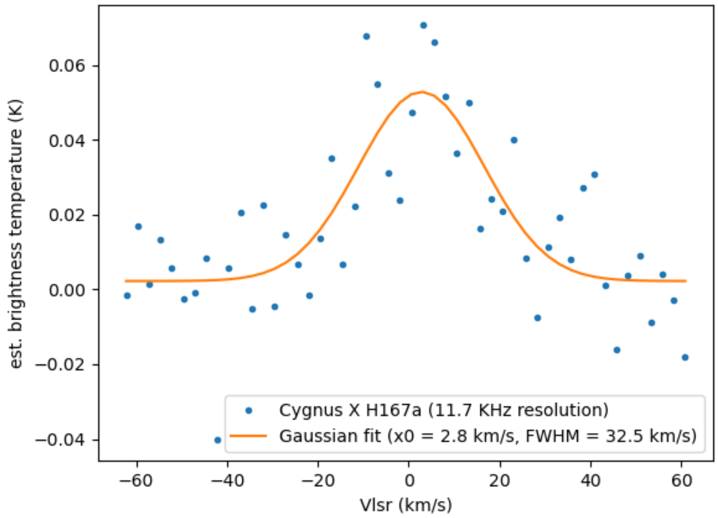


Figure 10: Gaussian profile fit of the H167a data

Repeatability of the detection

The signal was detected in nearly all the 30-minute integrations from individual driftscans, albeit with a low SNR (<3). As can be seen in the waterfall plot below (figure 11) the signal is clearly present in most of the spectra from the driftscans between June 19 and June 29, except for June 21 and June 29. The spectrum from June 21 had significant residual background curvature which could obscure the faint RRL signal. The reason for the apparent nondetection on June 29 is unclear. Overall, the successful detection on 7 out of 9 driftscans suggests that the signal is indeed real.

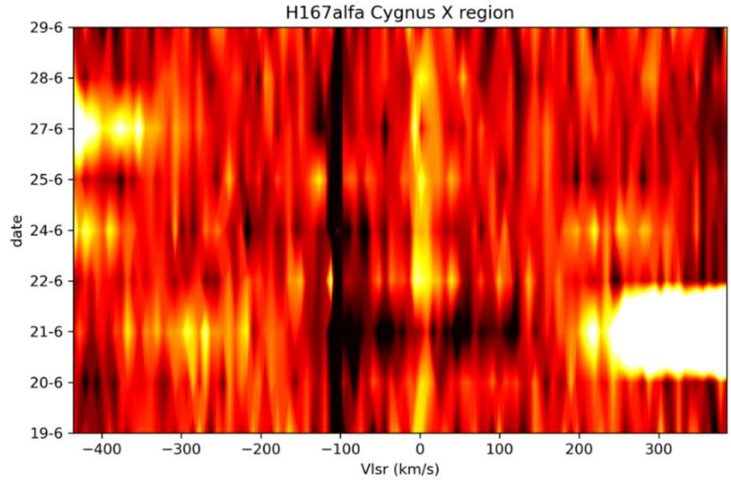


Figure 11: Waterfall plot showing the spectra of all 9 driftscans

Association with Cygnus X

If the detected signal is truly an RRL from the Cygnus X region, it should disappear when Cygnus X is out of the dish beam. Because the driftscan recordings lasted the entire night this was easy to test. A 30-minute block of spectra centered at RA 18:50 (100 minutes before the transit of Cygnus X) was processed in the exact same way as the Cygnus X data. As expected no RRL-like signature was present above the noise floor.

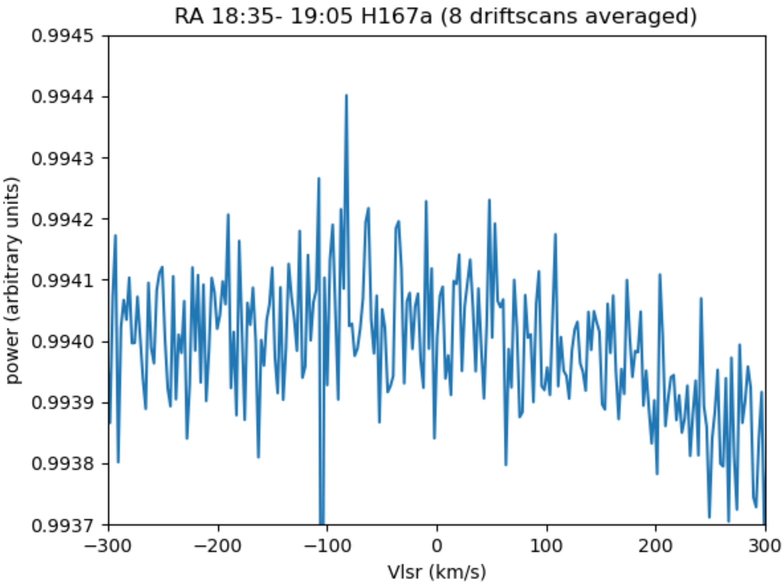


Figure 12: Averaged spectrum of 8 driftscans centered at RA 18:50

Conclusion and outlook

The detection of the H167α RRL towards Cygnus X is the most challenging project undertaken with the modular 3 metre dish so far. As far as I am aware it is the first detection of an RRL using a 3-metre class instrument, at least within the SARA community. Over the course of this project I learned a few key points. First of all, it is possible to detect RRLs and similar faint spectral lines with relatively small amateur telescopes, as long as the angular size of the source is large enough to (at least partially) fill the telescope beam. In such a scenario spatial integration can compensate for the small collection area to some extent. Besides Cygnus X, other regions where RRL emission is widespread over several degrees (for example the inner galactic plane) may also be detectable with a 3 metre class setup. Secondly, RFI was a major obstacle during this project but it could be mitigated by carefully planning the right observation strategy. Planning driftscan observations as much as possible during nighttime when RFI is less prevalent at my location helped a lot. Searching for an azimuth angle where RFI was minimal also helped. Despite these efforts observation of the H166α line was still hampered by RFI spikes, but there are several more Hα RRLs in the L-band and eventually the detection of H167α proved successful.

Ideally an additional set of driftscans would be recorded later in the year to repeat and hopefully confirm the detection, and to accumulate even more integration time to further increase SNR. However, because these observations are very time-consuming and the modular dish can only be set up during stable weather it will probably take a while before this project will be revisited.

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12) https://gitlab.camras.nl/dijkema/HPIB/blob/185d241ad9bd7507ed90c9fa91fe0a63009d3ee e/vlsr.py

Marconi Radio Museum Salvan

Christian Monstein

On July 15th 2025, I finally managed to visit the Marconi Museum in Salvan in the French speaking part of Switzerland with my wife Brigitte. Below are a few translations from French and German posters taken during my visit.

The Marconi path offers the visitor the opportunity to relive the experiences of the Nobel Prize Winner, Guglielmo Marconi, who carried out his first trials in Salvan during the summer of 1885. Duration 30 – 40 minutes.

Having arrived most probably at the beginning of the summer in 1885, Guglielmo Marconi immediately began to look for accommodations for himself and his brother, Alfonso. At first, he rented a chalet belonging to a certain Mr. Ducret. One week later, his brother left; Guglielmo moved to a house called "La Coccinelle" which is nearby. In those days, the building was situated in a street with the premonitory title of "Millionaires' Row".

It was there, on the second floor where Guglielmo Marconi constructed and improved the different pieces of apparatus which enabled him to establish his wireless contacts in the summer of 1895. The only tangible souvenir of the great Italian physician and his experiments left in the village were a few lengths of copper wire negligently forgotten in his room.

Photo: C. Monstein 2025

Maurice Gay-Balmaz, Marconi's young assistant ~

Salvan, summer 1895, Fontanil: Maurice Gay-Balmaz, 10 years old, was intrigued by a "strange apparatus lying in the grass" when its owner suggested he gave him a hand. Without realising what was happening, the youngster from the village of Salvan was about to help the future Nobel Prize winner Guglielmo Marconi. "In the morning." The young Maurice told us. "we went to 'Rochers du soir', me with a receiver slung across my shoulder, him with a transmitter." The numerous trials soon led to a radio link between Salvan and les Maracottes, a distance of more than 1.5 kilometres (about a mile).

1895, the Pierre Bergère

Summer 1895: concentrating on his strange apparatus, a 21-year-old Italian tourist sent out wireless signals from the Pierre Bergère (a local erratic rock) in Salavan.

His young helper from Salvan, Maurice Gay-Balmaz, went into the neighbouring meadows with an aerial and receiver. After numerous trials, a connection was established between Salvan and the heights. Marconi had just succeeded in establishing the first wireless mile in history.

Photo: Christian Zufferey, Foundation Marconi Aug. 2022

Gugliemo Marconi was born in Bologne in1874

His father was a rich, Italian landowner, while his mother's family owned the Jameson whiskey distilleries in Dublin, Passionate about science from his adolescence, Guglielmo performed his very first experiments on the top floor of the Villa Griffone in Italy, after reading an article describing Hertz's experiments on electromagnetic waves. Marconi was then vacationing at Andorno near Santuario di Oropa in the Italian Alps and he immediately started to develop a system using these waves to communicate without wire.

The Marconi Company

Gifted with a keen business mind, Marconi founded the Marconi Wireless Telegraph Company in 1900. His apparatus rapidly became a symbol of excellence and reliability. The Marconi Company became one of the jewels of the British telecommunication Industry (40'000 employees throughout the world), and was bought up by Ericson in 1997 for 1.77 billion Euros.

Director of the Radio Museum Yves Fournier

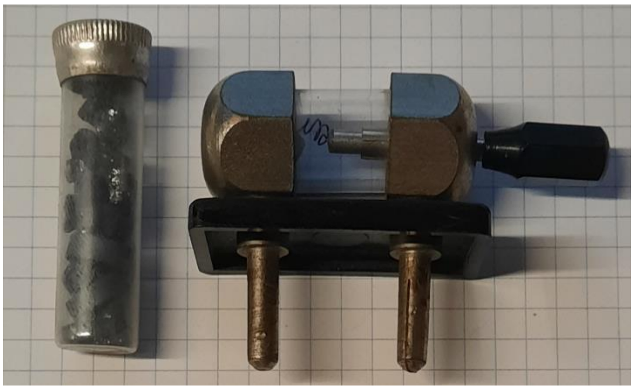
Yves FOURNIER was born in 1964 in Martigny, Switzerland. He completed his studies in contemporary history and Swiss history at the University of Fribourg and worked until 2016 as a history teacher and a member of the management team at the Collège de l'Abbaye in Saint-Maurice, Switzerland. He was then appointed as an inspector responsible for upper secondary schools in the canton of Valais (grammar schools, colleges, and vocational education centers).

After defending his doctoral thesis on political ideology in the interwar period, he was awarded first prize in the SHVR competition in 1993. He has authored numerous articles on political ideology and international history and contributed to the *Historical Dictionary of Switzerland (HDS)* as well as to various journals, including *Année francophone internationale* (Quebec).

His wide-ranging cultural activities also led him to explore the history of science. Following the publication of *"Salvan, sur les pas de Marconi" / "Salvan on Marconi's Footsteps"* (1996/2000), he co-authored several articles with Professor Gardiol, which appeared in *EMEA Channels* (London, 2001), *TRACES* (École Polytechnique Fédérale de Lausanne, 2002), and *Microwave Journal* ("Salvan, Cradle of

Wireless," USA, 2006). He is also co-author of the book *"Marconi and Salvan: The Beginnings of Wireless Telegraphy"* (published by Porte-Plumes, 2009). He serves as President of the Marconi Foundation (Salvan, Switzerland) and was awarded the honorary title *"Cavaliere dell'Ordine al Merito della Repubblica Italiana"* (Order of Merit of the Italian Republic) in 2004.

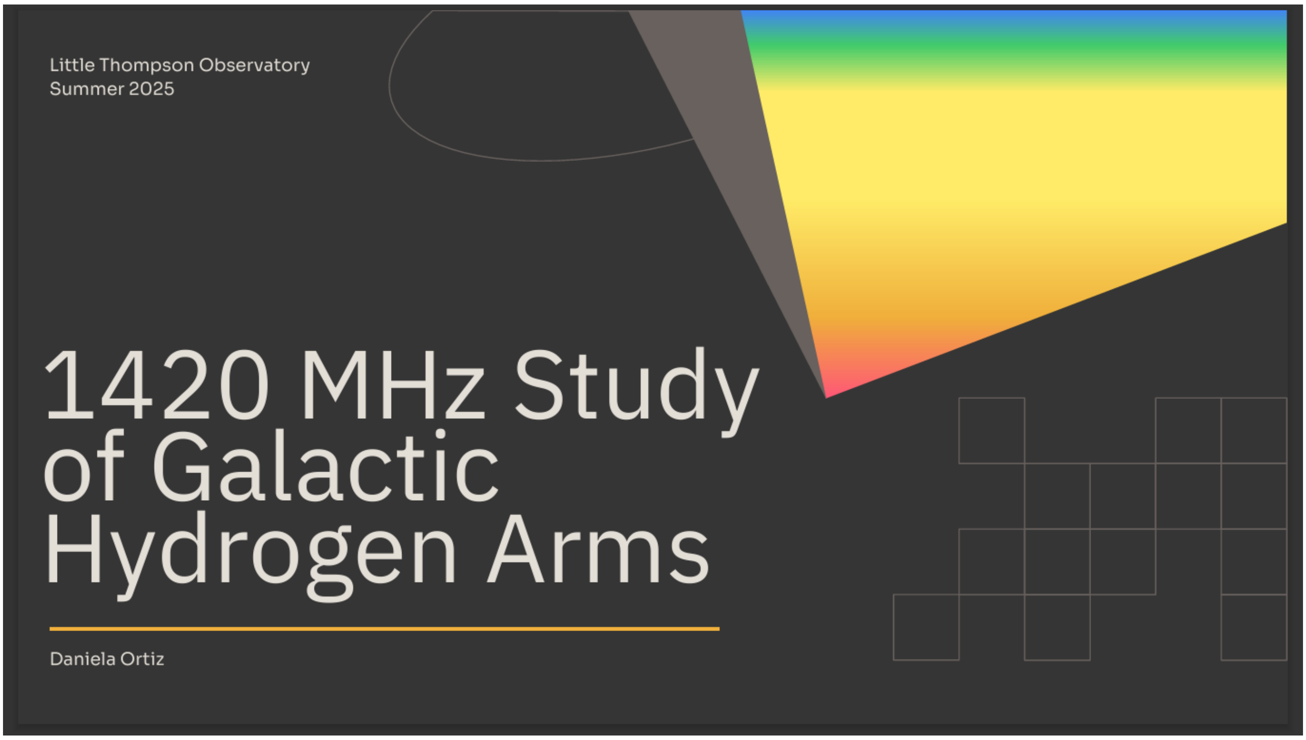
He also played a major role in securing recognition for Salvan by the ITU (International Telecommunication Union) as a "Heritage Site of Telecommunications." This title was officially awarded in September 2008 in the presence of Princess Elettra Marconi, daughter of the inventor, Swiss President Pascal Couchepin, and Dr. H. Touré, Secretary-General of the ITU.

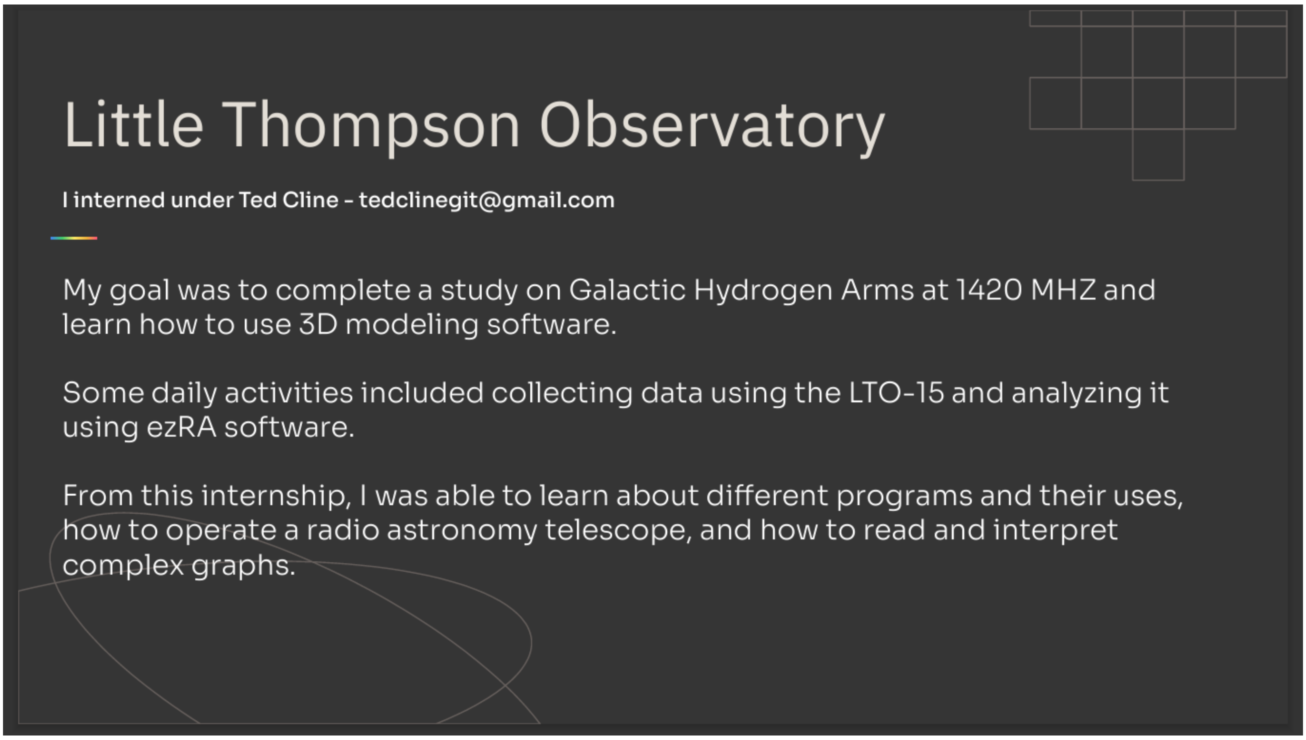


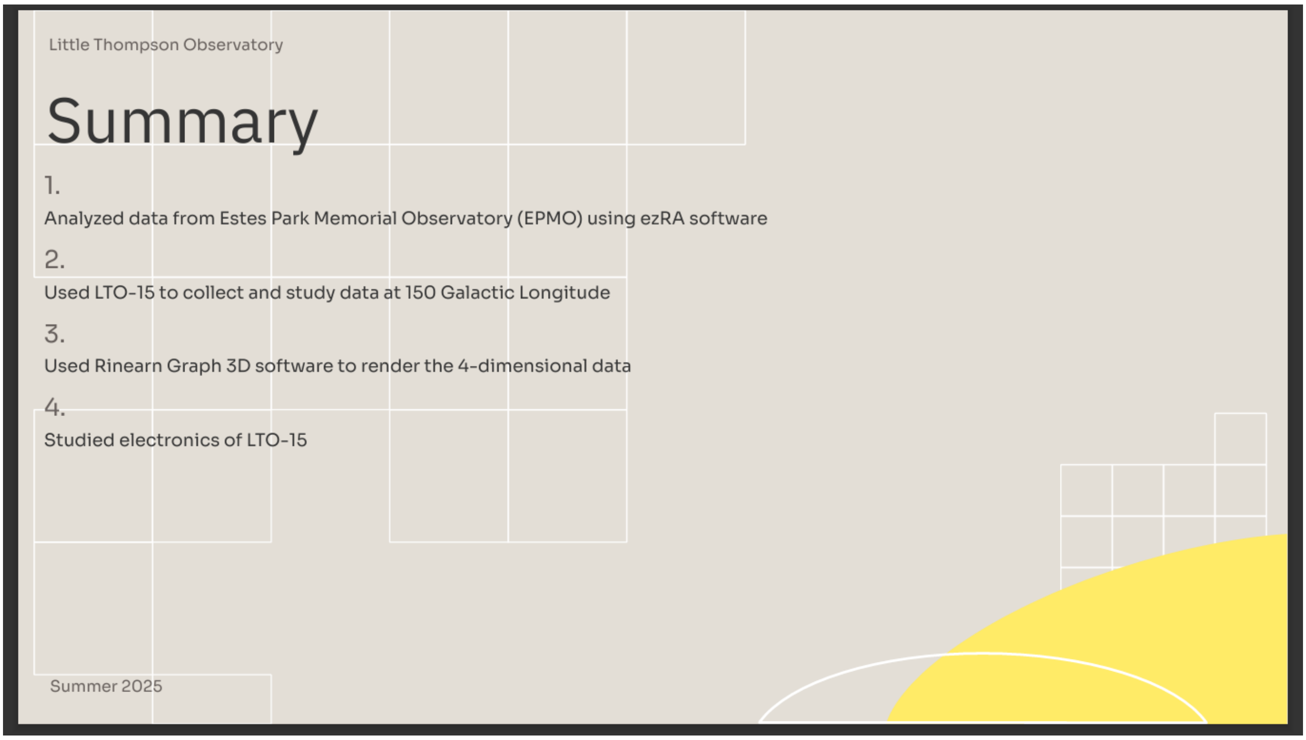
The authors' contribution to the museum after the visit, a crystal detector together with spare galena crystal which he kept in his radio-stuff-collection for more than 60 years.

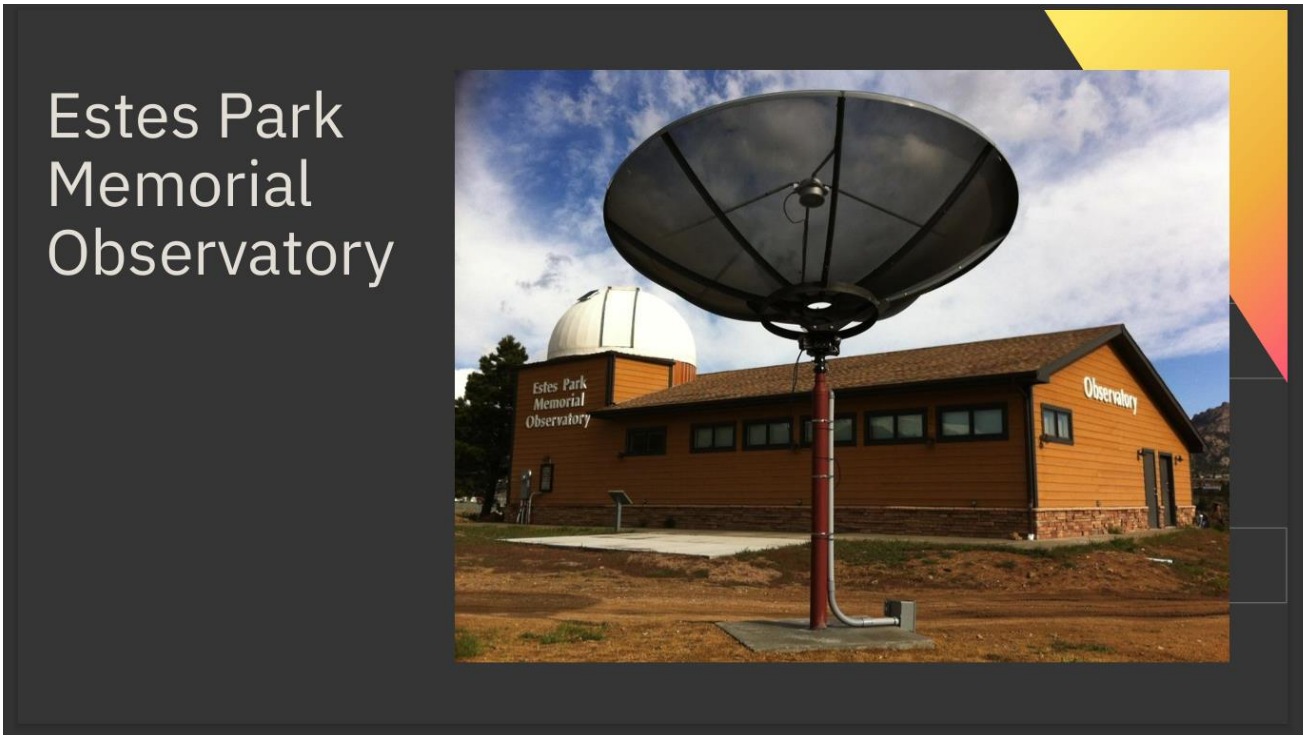
Photo: C. Monstein 2025

More information about Marconi and the museum in Salvan, Switzerland:
https://www.valleedutrient.ch/de/fondation-marconi

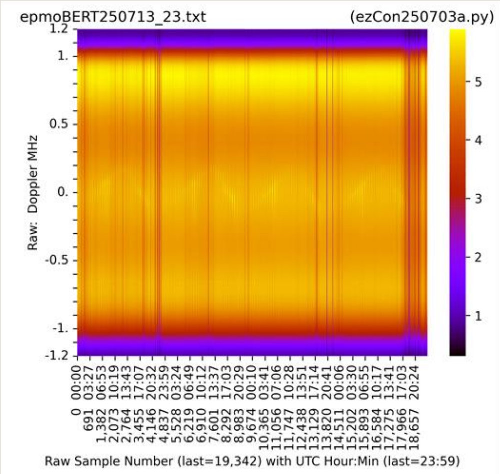

Little Thompson Observatory
Summer 2025
1420 MHz Study of Galactic Hydrogen Arms
Daniela Ortiz


Little Thompson Observatory
I interned under Ted Cline - tedclinegit@gmail.com
My goal was to complete a study on Galactic Hydrogen Arms at 1420 MHZ and learn how to use 3D modeling software.
Some daily activities included collecting data using the LTO-15 and analyzing it using ezRA software.
From this internship, I was able to learn about different programs and their uses, how to operate a radio astronomy telescope, and how to read and interpret complex graphs.

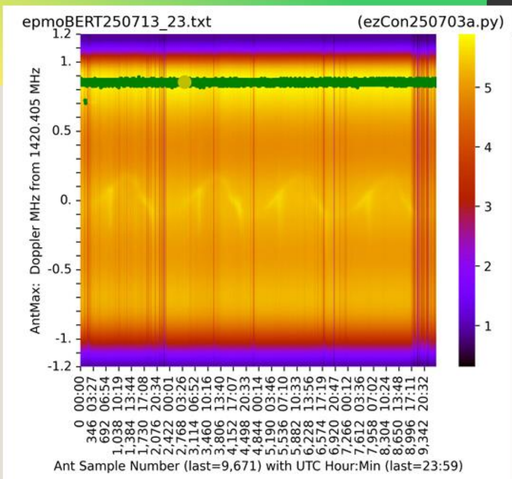

Little Thompson Observatory
Summary
1.
Analyzed data from Estes Park Memorial Observatory (EPMO) using ezRA software
2.
Used LTO-15 to collect and study data at 150 Galactic Longitude
3.
Used Rinearn Graph 3D software to render the 4-dimensional data
4.
Studied electronics of LTO-15
Summer 2025


Estes Park Memorial Observatory
Estes Park Memorial Observatory
Observatory

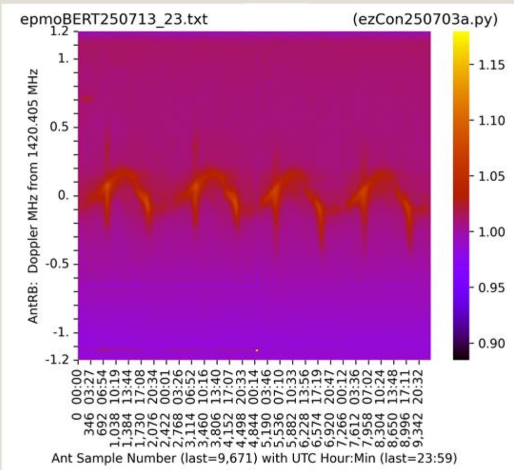
Analyzing EPMO Data



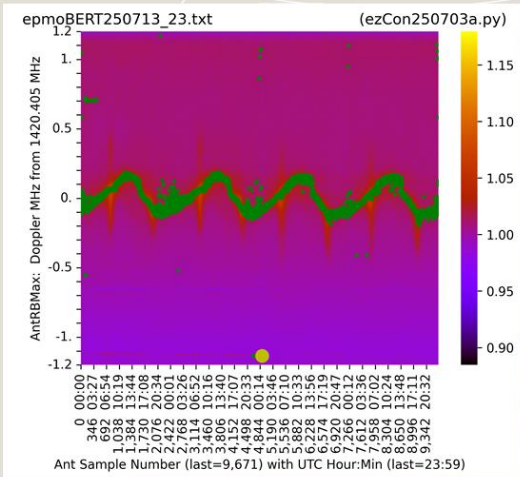
Raw data from EPMO on 07/13/25, showing intensities for 256 frequencies (vertically) by sample number (horizontally).



The brightest value of each sample is marked with a green dot. This does not yet lie on the yellow sine curve in the middle, so we need to trim the data.

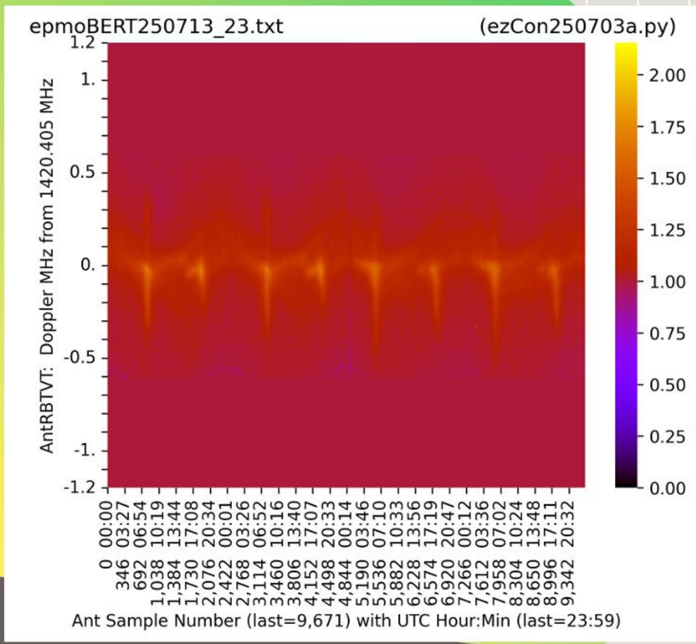


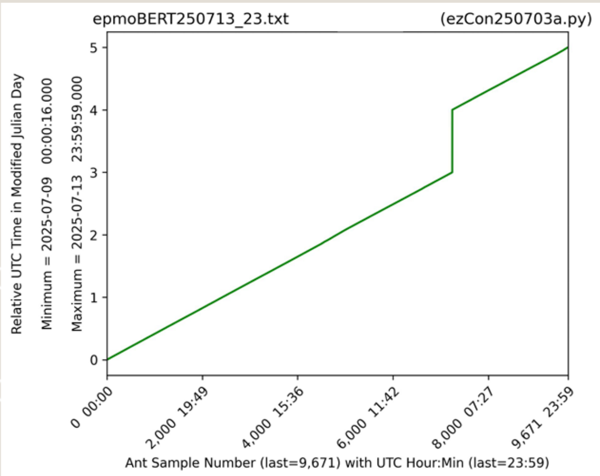
The program analyzed the raw data and highlighted the galactic hydrogen signal.



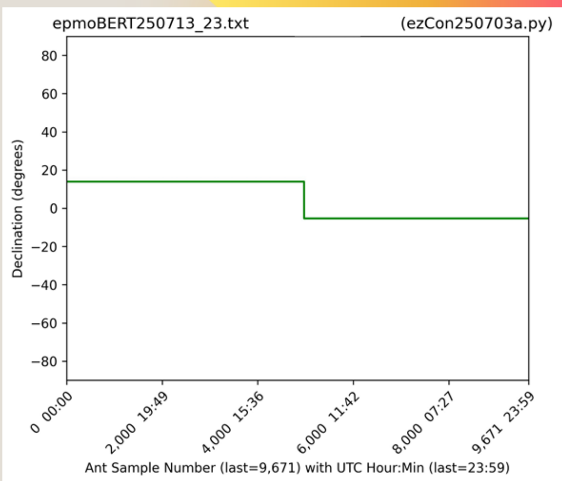
Now, the maximum values are mostly the desired galactic hydrogen.

Further processing improved the galactic hydrogen signal and adjusted for the Earth's and Sun's velocity relative to the Sun's neighborhood of stars.

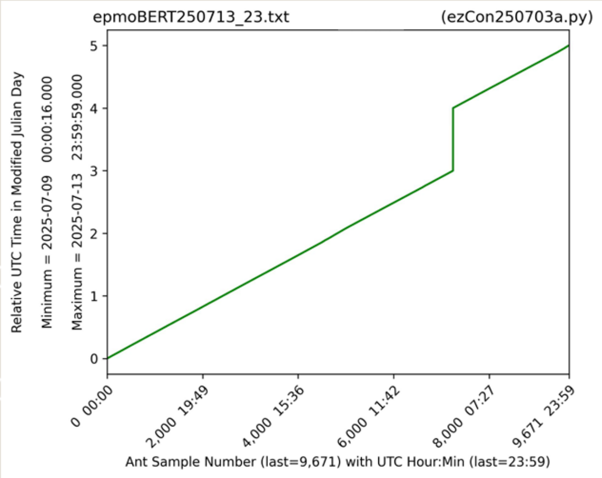




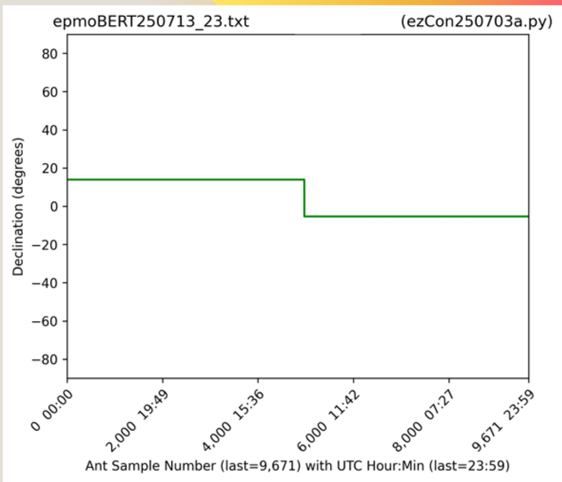
This graph shows when data samples were collected. The vertical segment of the line shows that time continued, but samples were not collected.



This graph shows at what declination in degrees data was taken from. The vertical line indicates a jump in the elevation angle (the telescope pointing was changed).

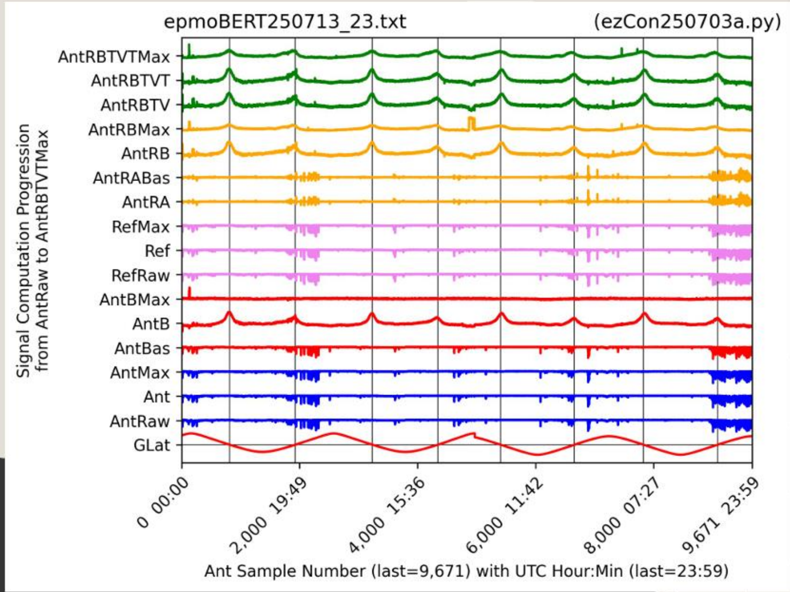


This graph shows when data samples were collected. The vertical segment of the line shows that time continued, but samples were not collected.



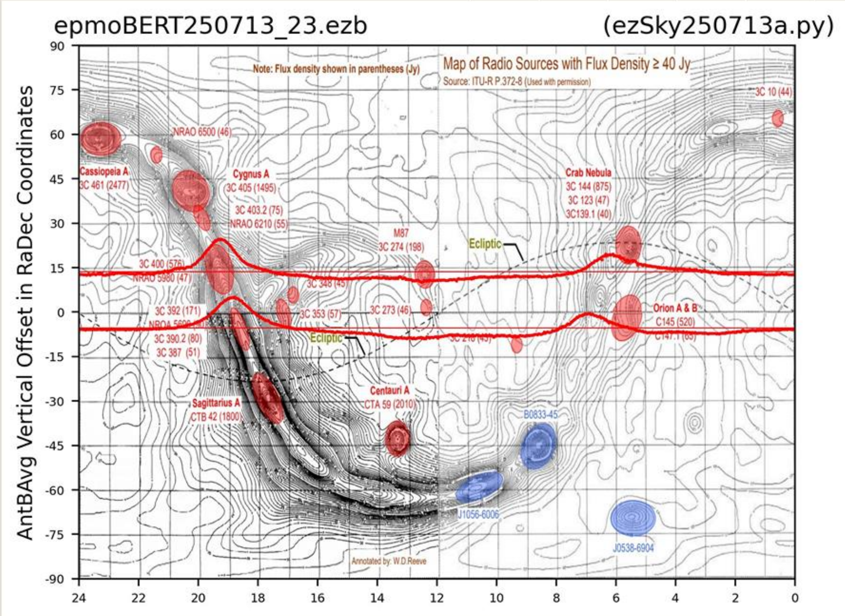
This graph shows at what declination in degrees data was taken from. The vertical line indicates a jump in the elevation angle (the telescope pointing was changed).

This graph is used to study and refine the data set. This presents four days of data.

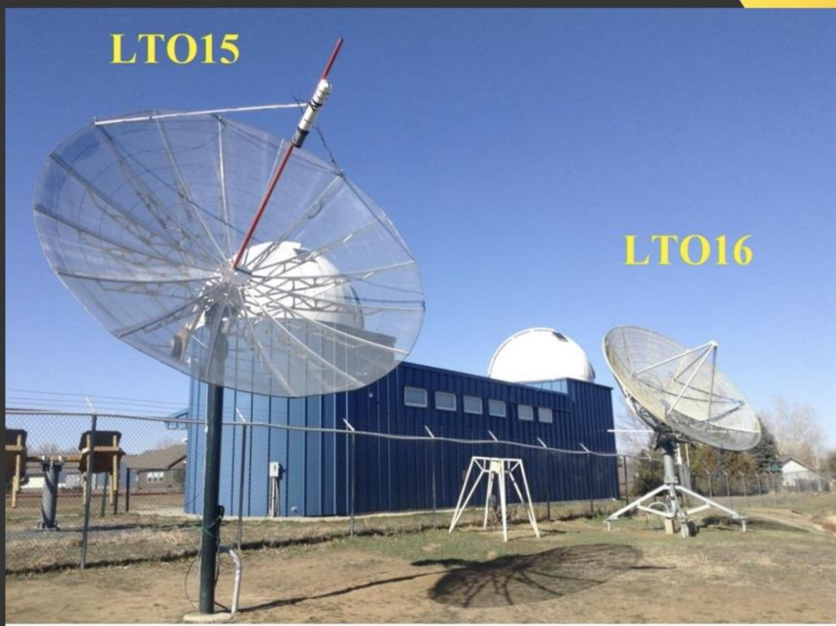


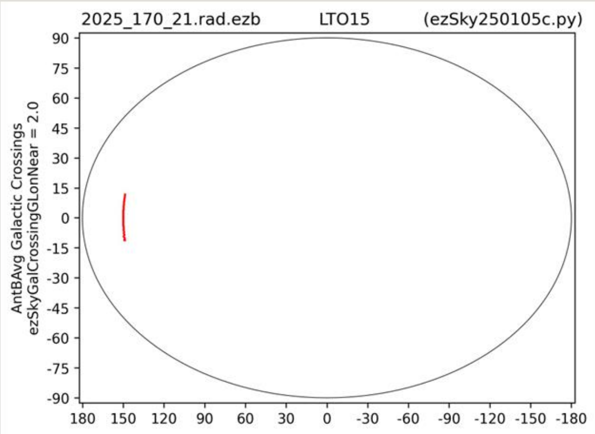
Plotting the data on the radio sky shows the intensity peaks align the galactic plane.

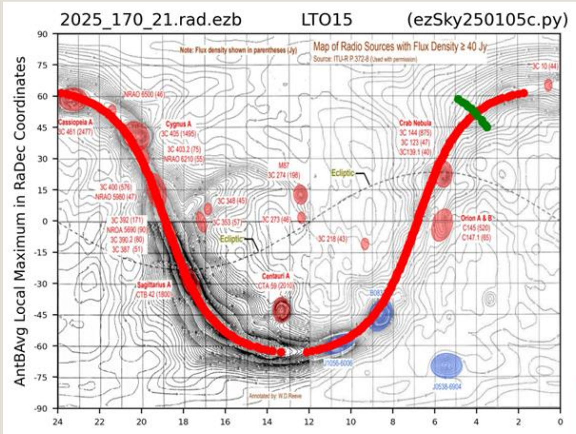
This confirms correct antenna pointing, antenna Earth location, and time setting.



LTO 15







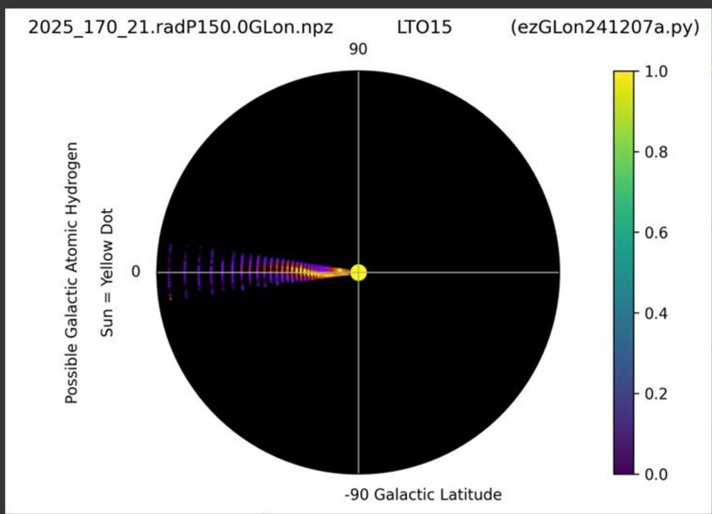
The red line on the left graph shows where the data was collected in galactic coordinates.

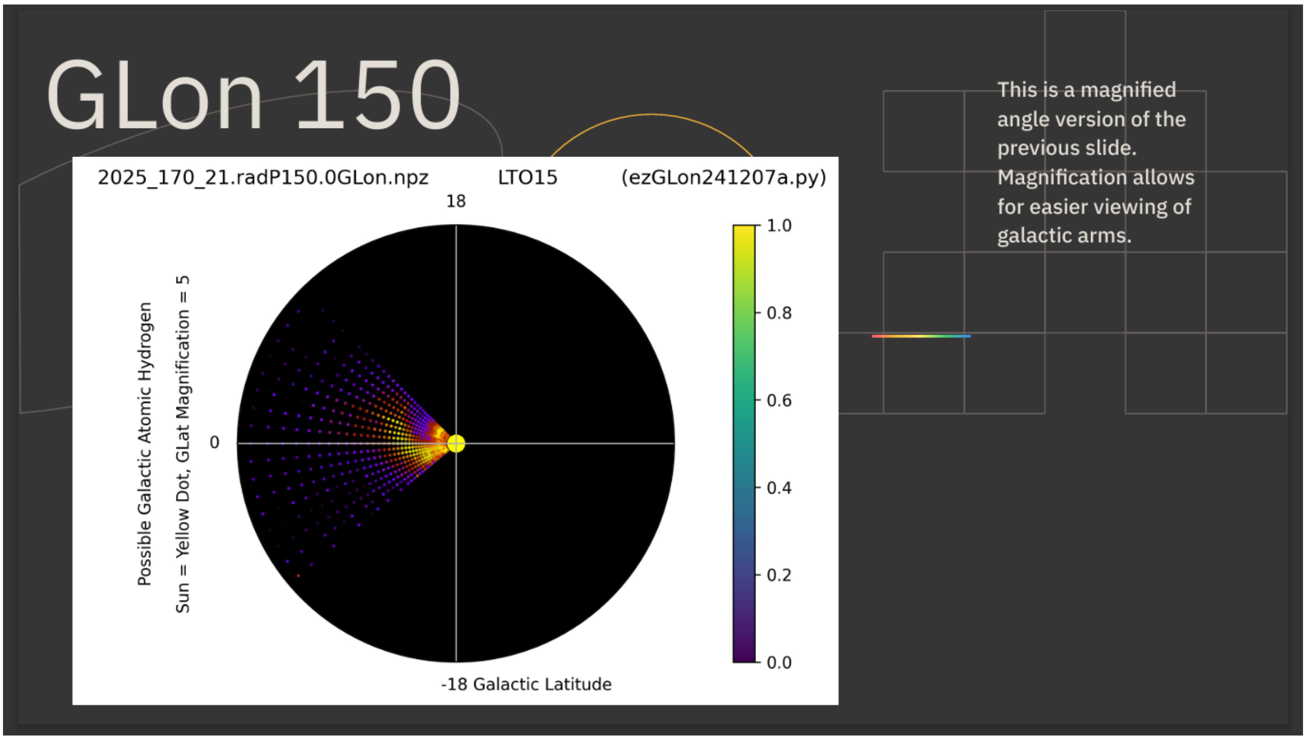
The green line on the right graph shows where the data was collected in Right Ascension Declination coordinates.

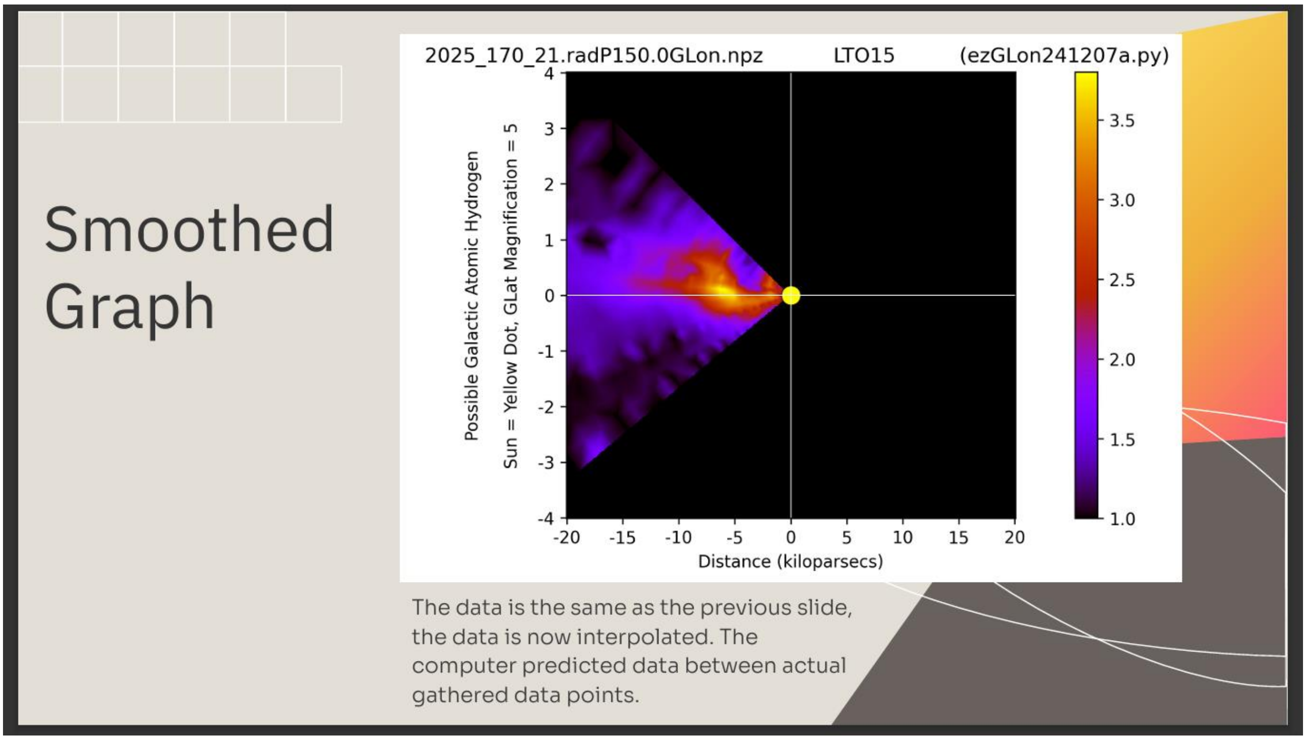
GLon 150

This is the data I took of our galaxy at the galactic longitude of 150 degrees. The search for galactic hydrogen allows astronomers to map the galaxy's arms.

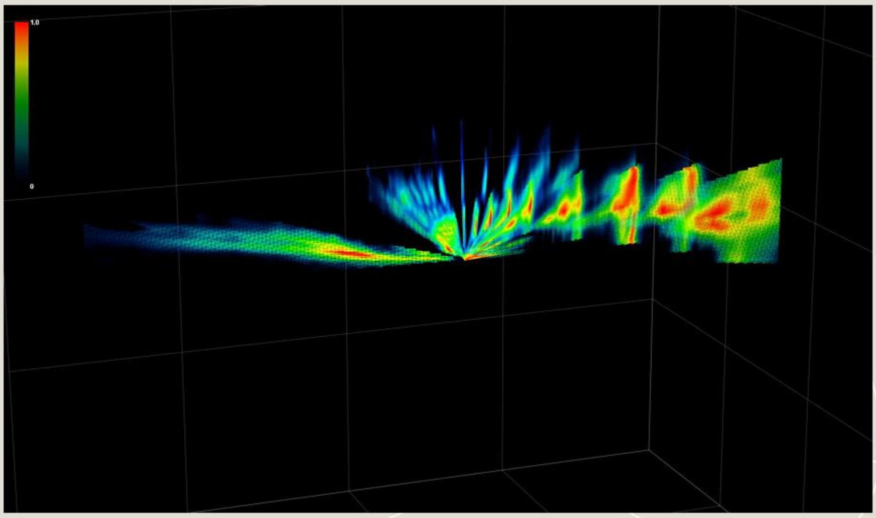
Yellow shows a higher concentration of galactic hydrogen. Purple indicates a smaller amount of galactic hydrogen.




GLon 150
2025_170_21.radP150.0GLon.npz LTO15 (ezGLon241207a.py)
18
0
-18 Galactic Latitude
Possible Galactic Atomic Hydrogen
Sun = Yellow Dot, GLat Magnification = 5
1.0
0.8
0.6
0.4
0.2
0.0
This is a magnified angle version of the previous slide. Magnification allows for easier viewing of galactic arms.

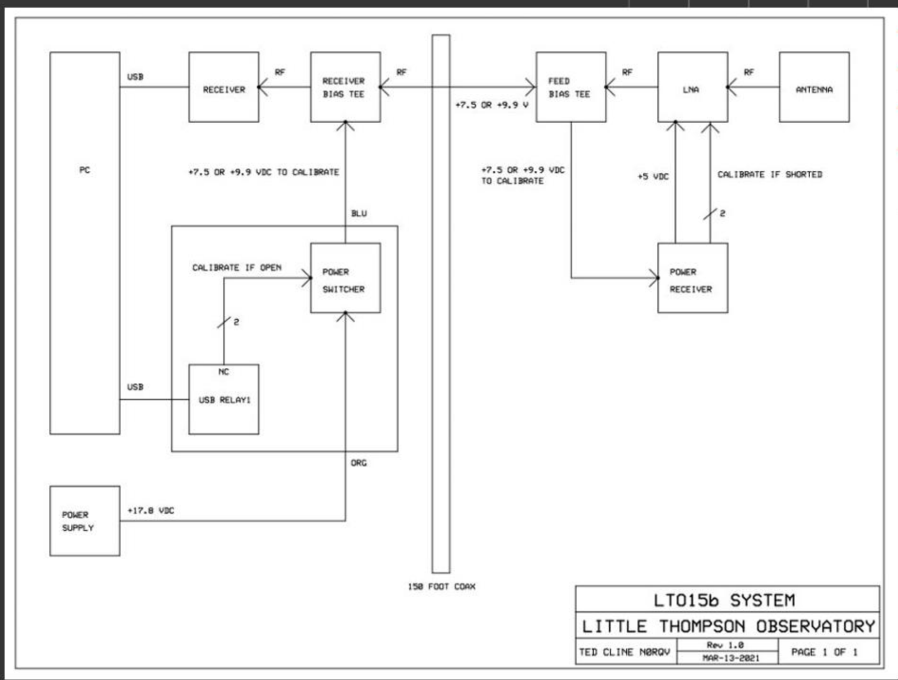

Smoothed Graph
2025_170_21.radP150.0GLon.npz LTO15 (ezGLon241207a.py)
Possible Galactic Atomic Hydrogen
Sun = Yellow Dot, GLat Magnification = 5
4
3
2
1
0
-1
-2
-3
-4
-20 -15 -10 -5 0 5 10 15 20
Distance (kiloparsecs)
3.5
3.0
2.5
2.0
1.5
1.0
The data is the same as the previous slide, the data is now interpolated. The computer predicted data between actual gathered data points.

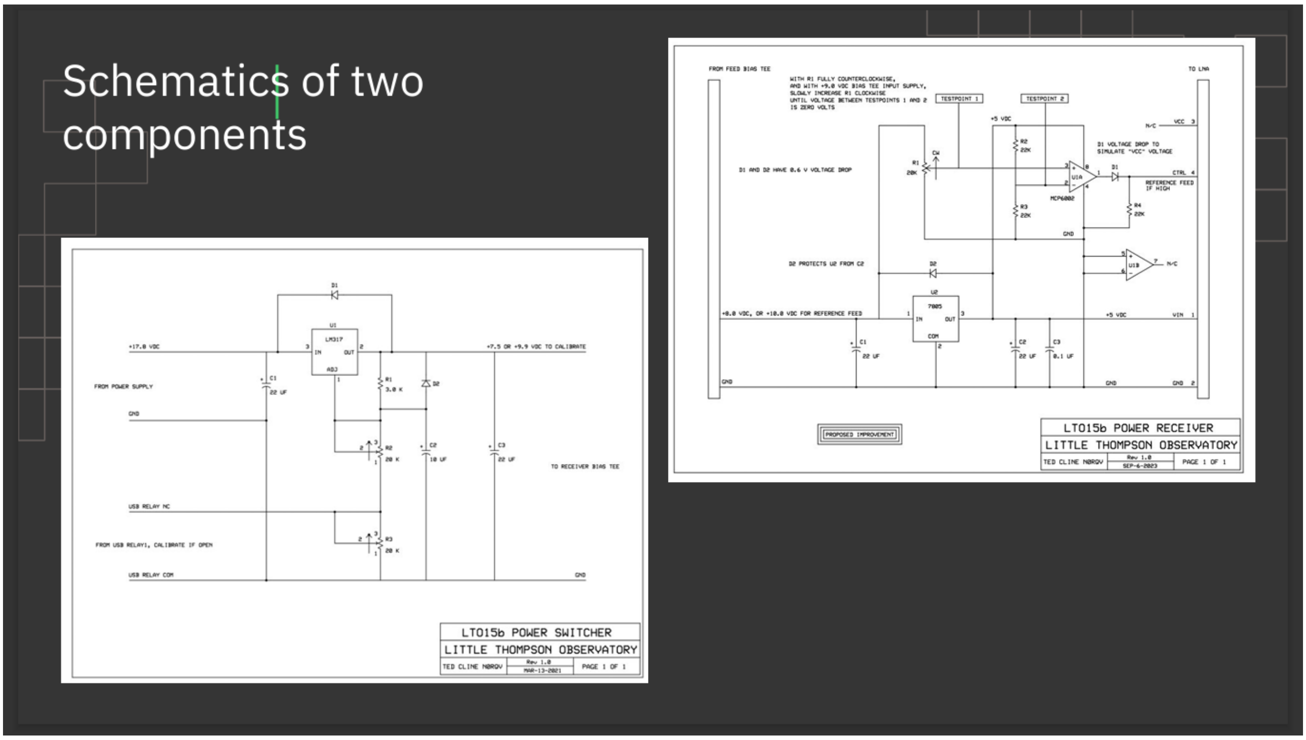
Rinerarn Graph 3D software to model data



Cross sections of constant galactic longitude radiating from the Sun showing at least two galactic arms.

Block diagram of the LTO-15 radio telescope system




Schematics of two components
LT015b POWER SWITCHER
LITTLE THOMPSON OBSERVATORY
LT015b POWER RECEIVER
LITTLE THOMPSON OBSERVATORY


Thank you

ezRA's ezCol data collection program in one command line

Dr Andrew Thornett, M6THO,
Lichfield Radio Observatory (LRO), Lichfield, UK www.astronomy.me.uk

Introduction to ezRA

There are a variety of software options available for detecting and processing hydrogen data. My personal preference is Easy Radio Astronomy Suite, written by Ted Cline (https://github.com/tedcline/ezRA). This software suite includes a group of Python scripts and will run on Windows or Linux. It is free of charge (like nearly all amateur radio astronomy software). It contains its own data collection program (ezCol) but its analysis scripts work well with data collected using SDR Sharp software (https://airspy.com/download/ or https://www.rtl-sdr.com/rtl-sdr-quick-start-guide/sdrsharpdownload/).

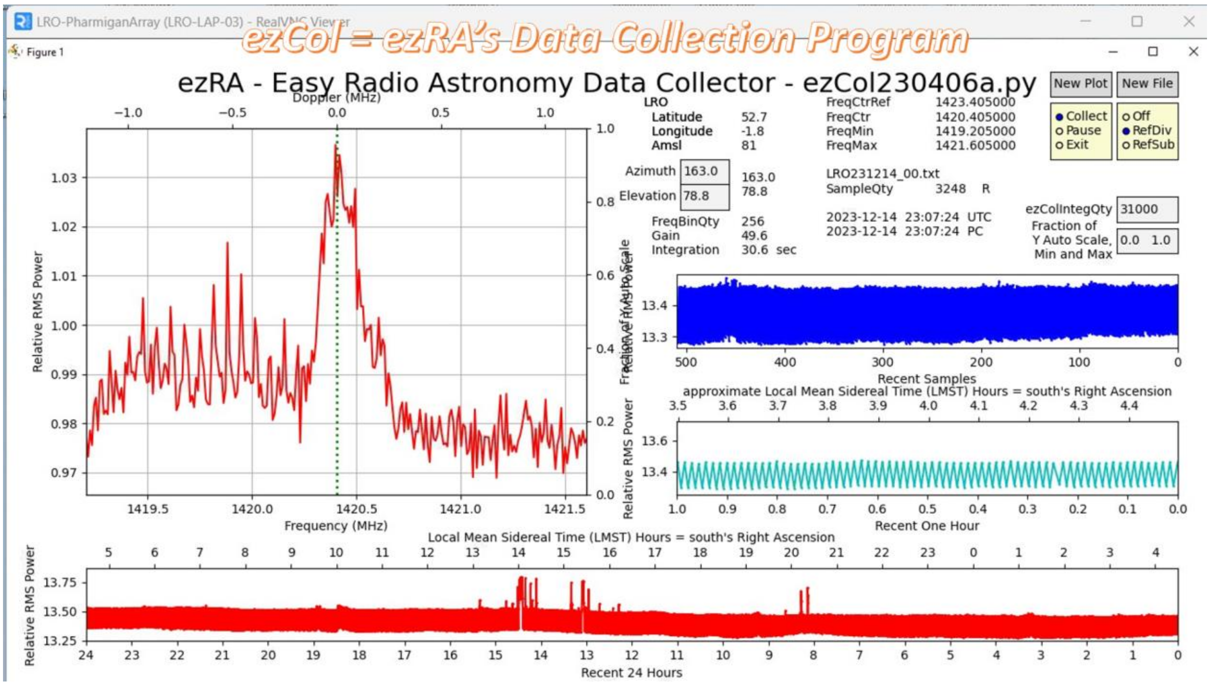
In both cases, data is collected using drift scans of the sky. Drift scan imaging, also known as transit imaging, is a method used in astronomy to capture images of celestial objects (in this case the Milky Way itself) as they move across the sky. In this technique, a telescope is fixed in position while the Earth's rotation causes the Milky Way to drift through the field of view. In professional observatories, this method can provide higher resolution images over large fields compared to traditional tracking techniques, and drift scan imaging is widely used in surveys that require continuous, wide-area coverage, making it an essential tool in modern astronomical research (https://www.vaia.com/en-us/explanations/physics/astrophysics/drift-scan-imaging/#:~:text=Drift%20scan%20imaging%2C%20also%20known%20as%20transit%20imaging%2C,objects%20to%20drift%20through%20the%20field%20of%20view).

In amateur observatories, the use of drift scans means that the mount can be set to point in one azimuth direction only without needing to be moved. The scanning process allows data to be collected over the whole 360-degree azimuth circle as the Earth rotates about its axis during the day.

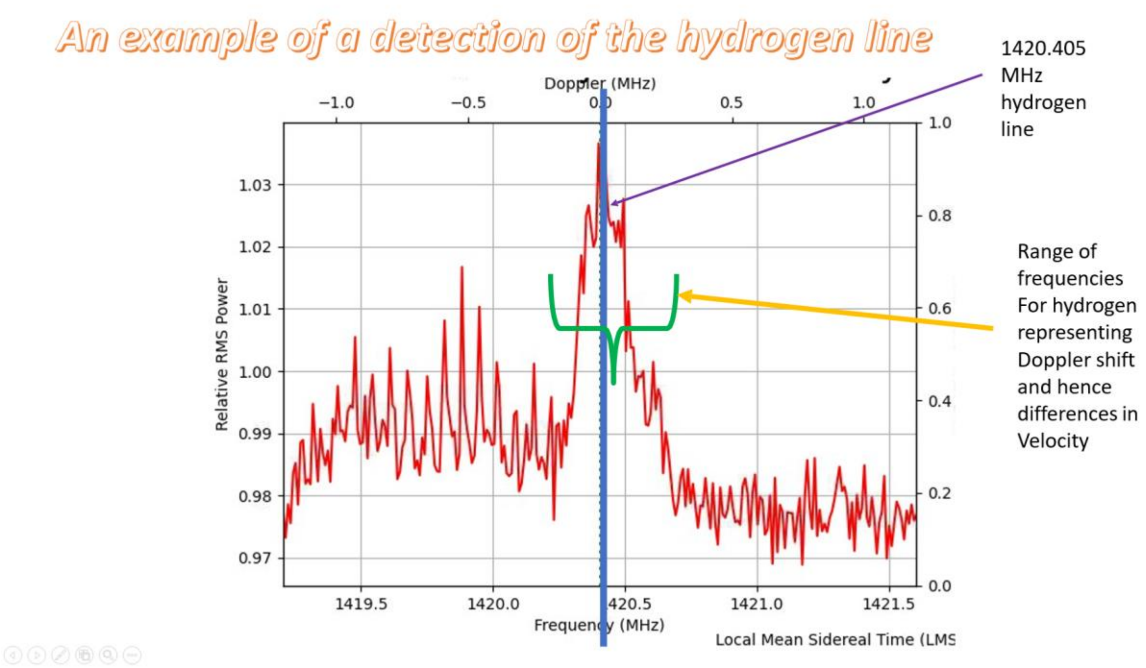
This current paper reviews the options open to amateur radio astronomers who wish to use ezRA's data collection software, ezCol, through an analysis of the ezCol command line included in the batch files at Lichfield Radio Observatory (LRO).

I have used the 13 March 2025 version of ezCol, which is the latest available version on Github as of the date of submission of this paper.

Screenshot from ezCol showing data collection in action (below):



Screenshot showing example of hydrogen collection using ezCol (below):



Batch File used for ezCol at Lichfield Radio Observatory (LRO):

cd C:\
cd C:\Data\ezRA_Program+Data\LRO\
py ..\ezRA\ezCol.py -ezRAObsLat 52.7 -ezRAObsLon -1.8 -ezRAObsAmsl 81.0 -ezRAObsName LRO-H1(Ptarmigan)_SAWB_FreqRef1417-405_Integ280000_BndWdth2-4_ -ezColAzimuth 163 -ezColElevation 84.4 -ezColCenterFreqRef 1417.405000 -ezcolBiasTeeOn +1 -ezColIntegQty 280000 -ezColRefAction 1
REM Parameter -ezColBandWidth 2.000 can also be used to adjust bandwidth
REM Default for bandwidth is 2.4 MHz
REM Ted Cline's usual -ezColCenterFreqRef 1423.405000
Pause

Highlighting the LRO command line within the batch file above:
py ..\ezRA\ezCol.py -ezRAObsLat 52.7 -ezRAObsLon -1.8 -ezRAObsAmsl 81.0 -ezRAObsName LRO-H1(Ptarmigan)_SAWB_FreqRef1417-405_Integ280000_BndWdth2-4_ -ezColAzimuth 163 -ezColElevation 84.4 -ezColCenterFreqRef 1417.405000 -ezcolBiasTeeOn +1 -ezColIntegQty 280000 -ezColRefAction 1

Reviewing each of the parameters used in the LRO ezCol command line:

-ezRAObsLat 52.7 -ezRAObsLon -1.8 -ezRAObsAmsl 81.0	Set observatory latitude, longitude and height above sea level.
-ezColAzimuth 163 -ezColElevation 84.4	Set Azimuth & Elevation that telescope is pointed for drift scan.
-ezColCenterFreqRef 1417.405000	Set reference frequency. I have used 3MHz below hydrogen (1420.405MHz), although default (and most commonly used) is 3MHz above (1423.405MHz).
-Turn the bias tee power supply on	Set observatory latitude, longitude and height above sea level.
-ezColIntegQty 280000	Set number of samples to integrate together for one data point = gives time length of each data point – the amount of time depends on computer/receiver speed, etc., so different telescopes may have different numbers for same integration time.
-ezColRefAction 1	Sets the display method during data collection on screen – this does NOT affect collected data. 1 = RefDiv = divide the sample by the reference value.
-ezRAObsName LRO-H1(Ptarmigan) _SAWB_FreqRef1417-405_Integ280000_BndWdth2-4_	Although this says Observatory Name = the file name root to which ezCol adds numerical identifiers

The full list of available parameters in ezCol:

```
    -ezRAObsLat    40.2        (Observatory Latitude  (degrees))
    -ezRAObsLon  -105.1        (Observatory Longitude (degrees))
    -ezRAObsAmsl 1524.0        (Observatory Above Mean Sea Level (meters))
    -ezRAObsName bigDish8      (Observatory Name)
    -ezColFileNamePrefix bigDish8 (Data File Name Prefix)

    -ezColCenterFreqAnt 1420.405  (Signal         Frequency (MHz))
    -ezColCenterFreqRef 1423.405  (Dicke Reference Frequency (MHz))
    -ezColBandWidth       2.400  (Signal        Bandwidth (MHz))

    -ezColFreqBinQtyBits  8     (For  256 freqBinQty frequencies)
    -ezColFreqBinQtyBits  10    (For 1024 freqBinQty frequencies)

    -ezColGain       999.9      (Use max gain)
    -ezColOffsetPPM  5          (Tuner offset Parts-Per-Million (integer)
    -ezColAntBtwnRef  5         (number of Ant samples between Ref samples)

-ezColAzDeg     180.0      (Azimuth        pointing of antenna (degrees))
-ezColElDeg      45.0      (Elevation      pointing of antenna (degrees))

-ezColRaH       20.0       (Right Ascension    pointing of antenna (hours))
-ezColDecDeg     40.7      (Declination        pointing of antenna (degrees))

-ezColGLatDeg    0.0       (Galactic Latitude  pointing of antenna (degrees))
-ezColGLonDeg    30.0      (Galactic Longitude pointing of antenna (degrees))

-ezColVerbose     1        (Turn on Verbose mode)
-ezColDashboard   0        (Turn off graphical display)
-ezColDispGrid    1        (Turn on graphical display plot grids)

-ezColUsbRelay   0         (No relays driving a feed Dicke reference)
-ezColUsbRelay   11        (1 SPST HID relay,     driving feedRef ON or OFF)
-ezColUsbRelay   15        (1 SPST non-HID relay, driving feedRef ON or OFF)
-ezColUsbRelay   21        (2 SPST HID relays, #1 driving feedRef ON or OFF)
-ezColUsbRelay   22        (2 SPST HID relays, #2 driving feedRef ON or OFF)
-ezColUsbRelay   29        (2 SPST HID relays, driving a latching feedRef relay with pulses)

-ezColIntegQty  31000      (Number of readings to be integrated into one sample)
-ezColTextFontSize  11     (Size of text font)
-ezColSampleMax     10     (last sample number before exit)
-ezColSecMax       3600.2  (maximum number of seconds before exit)
-ezColRefAction      1     (0/1/2 for initial Off/RefDiv/RefSub)
-ezColYLimL      0.1  0.4  (Fraction of Y Auto Scale, Min and Max)

-ezDefaultsFile ..\defaults.txt  (Optional additional file of default arguments)
```

Further information.

Further information about this project is available on the www.astronomy.me.uk website or by contacting me using the “contact us” page on that website.

Callisto Gain Settings

Whitham D. Reeve and Christian Monstein

Introduction

The gain of the Callisto solar radio spectrometer is determined by the [agclevel] parameter in the configuration file (callisto.cfg). The parameter specifies the PWM (Pulse Width Modulation) setting used by the processor to control the RF tuner gain. if the setting is too high, front-end overload and distortion may occur; if too low, the receiver sensitivity may suffer. The relationship between the PWM setting and the receiver gain is the subject of this article.

The optimum setting usually is determined experimentally based on the gain of the user's system including the antenna, low noise preamplifier (if any), and coaxial cables. Many installations use an up-converter to enable observations at frequencies below 45 MHz, which is the lower frequency limit of the tuner in the Callisto instrument (the native tuning range is 45 to 870 MHz). The up-converter may have gain or loss, depending on its design, and this also must be taken into account in the Callisto PWM setting.

Gain control circuit

The Callisto processor outputs the PWM signal to a lowpass filter, which produces a dc voltage that is the average of the PWM waveform (figure 1). The voltage is applied to the RF and IF gain control pins of the RF tuner through a resistive voltage divider (figure 2). The [agclevel] parameter can be set anywhere in the range 0 to 250 and the resulting filter output voltage can vary from approximately 1.2 to 2.5 Vdc (figure 3). The actual voltage at the output of the lowpass filter can be read back through a serial terminal Command Line Interface for troubleshooting purposes or through the NF.exe software tool used during manufacture test of the instruments.

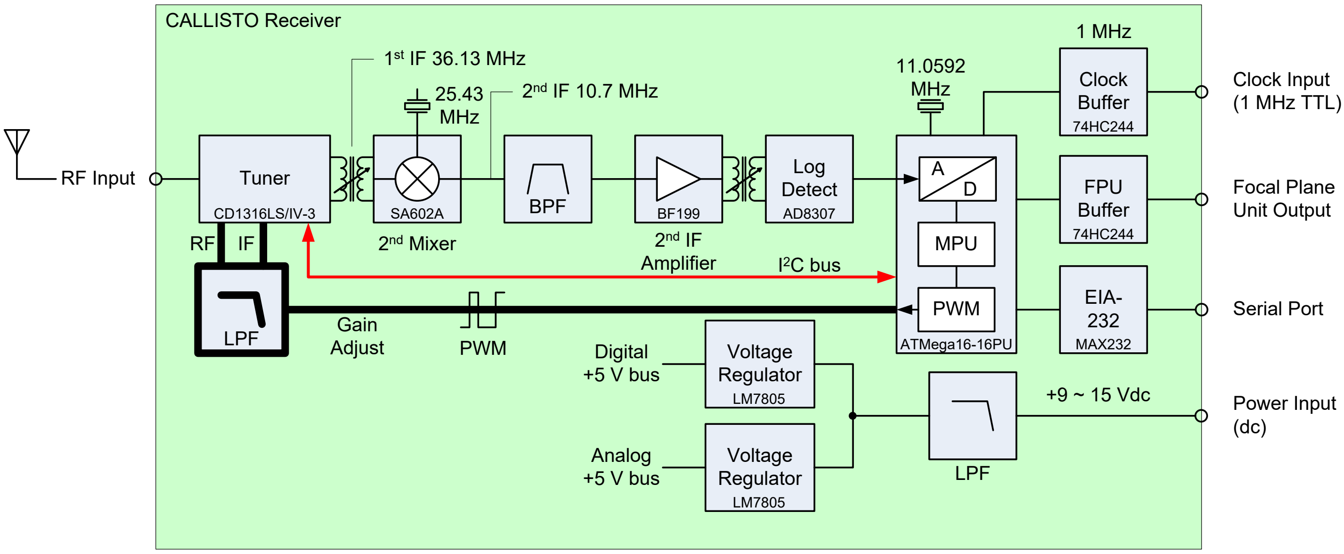


Figure 1 ~ Callisto block diagram. The gain control circuit is shown by heavy black lines from the ATMega processor to the tuner through the lowpass filter. Both RF and IF gains are proportionately controlled. Because of the tuner design, the IF gain voltage is set to 36% of the RF gain voltage through a resistive voltage divider.

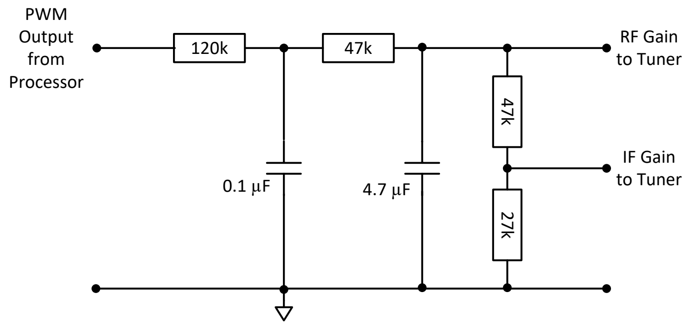


Figure 2 ~ Gain control circuit showing the PWM lowpass RC filter and voltage divider for the RF and IF gain inputs to the RF tuner.

The voltage measured at the instrument's log detector output is plotted as a function of RF input signal level for PWM settings of 50 through 250 (figure 3). The Callisto linear dynamic range varies with the PWM setting. For example, with PWM = 250, the output is linear from about –80 to –110 dBm and with PWM = 50 is linear from about –55 to –100 dBm. An equivalent plot is provided showing the output after the log detector output voltage has been converted by the analog-digital converter (ADC) in the processor (figure 4). The log detector output in mV is converted into digits according to: Digits = (mV/2500) x 256. The original measured data is provided at the end of this document.

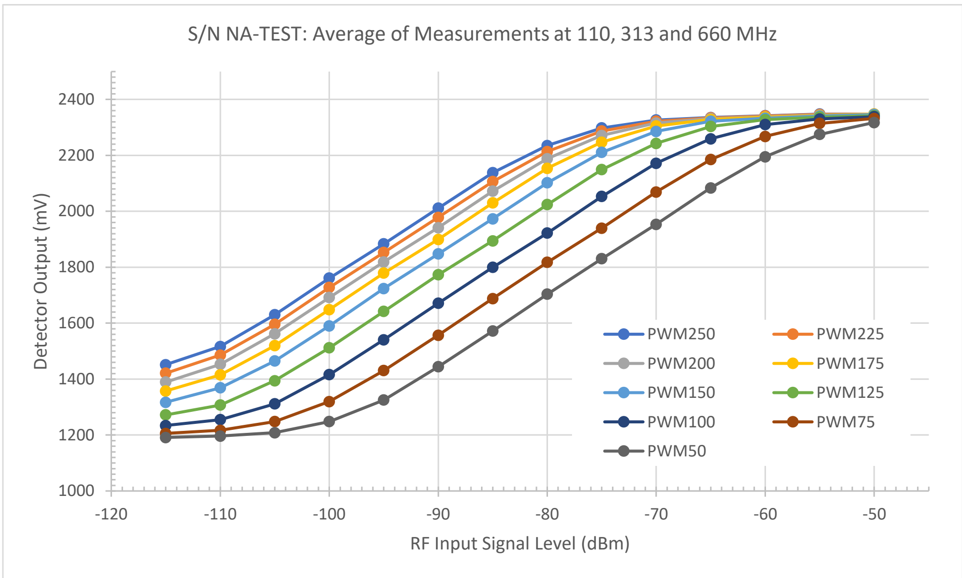


Figure 3 ~ Log detector output as a function of the RF input signal level for PWM settings from 50 to 250. The plotted values are the average of measurements in the middle of each RF tuner band as follows: 45 – 175 MHz: 110 MHz Ctr 175 – 450 MHz: 313 MHz Ctr 450 – 870 MHz: 660 MHz Ctr

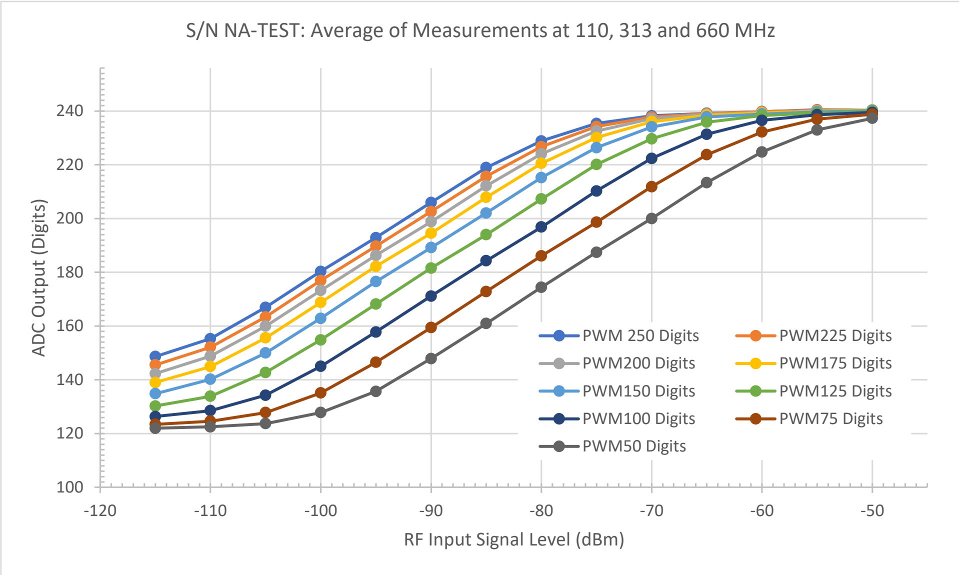


Figure 4 ~ ADC output digits as a function of the RF input signal level for PWM settings from 50 to 250. The plotted values are the average of measurements in the middle of each RF tuner band as follows: 45 – 175 MHz: 110 MHz Ctr 175 – 450 MHz: 313 MHz Ctr 450 – 870 MHz: 660 MHz Ctr

These plots help determine how much change to the PWM setting is necessary to provide more or less gain. Generally, it is desirable to set the gain such that the average, or background, level measured by the instrument is approximately 1/2 of the ADC full scale; that is, (2500 mV/2 =) 1250 mV or 128 digits

For an input power of –90 dBm (a level where all PWM settings produce a linear response curve), the output change is:

(2011 mV – 1671 mV) / (PWM250 – PWM100) = 2.27 mV/PWM = 0.23 digits/PWM

However, gain is not a linear function of the PWM setting over the full PWM range. A better PWM range is, say, PWM100 to PWM150, in which case the output change is:

(1848 mV – 1671 mW) / (PWM150 – PWM100) = 3.54 mV/PWM = 0.36 Digits/PWM

The change in the PWM setting is:

(Desired background digits – Existing background digits)/(0.36 Digits/PWM)

Example: Say the observed background level is 100 digits instead of the desired 128 digits. In this case, the PWM should be increased by about:

(128 Digits – 100 Digits) / (0.36 Digits/PWM) = 76 PWM.

For this example, the PWM would be increased from its present setting by 76. Say the present PWM setting is 105, then the setting would be increased from PWM105 to PWM181.

The reverse is also true. For example, if the present background level is 150 digits, then to have a desired level of 128 digits:

(128 Digits – 150 Digits)/(0.36 Digits/PWM = –61 PWM.

For this example, if the present setting is PWM180, the new setting would be PWM180 – 61 = PWM119.

Comments

- The above are approximations based on the measurements of one instrument. Slightly different results may be expected with different instruments. Also, the background noise levels at e-CALLISTO stations vary over a wide range. Therefore, the calculations described here provide only a starting point for the PWM setting at any given station and instrument. Experimentation will be necessary to find the optimum setting.
- The Callisto noise figure varies with PWM setting and is lowest (best) when the PWM setting is highest (near PWM250). The noise figure of the RF tuner in the Callisto degrades with lower PWM settings. When the Callisto is operated at lower PWM settings, it often means there is a preamplifier between the antenna and instrument. The preamplifier should be placed as near to the antenna as possible and designed for low noise and high enough gain so that it controls the system noise figure.
- The PWM setting in the configuration file callisto.cfg usually can be changed on the fly. However, not every Windows operating system supports this, so it is suggested that the callisto.exe application be restarted after changing the PWM setting in the callisto.cfg file.

The above plots are based on the following table of the log detector Output Voltage vs RF input Power for different PWM settings. The table shows the average values for measurements in the middle of each RF tuner band.

NA-TEST : No Enclosure : Average of measurements at 110, 313 and 660 MHz

Input Pwr	**PWM 250**	**PWM225**	**PWM200**	**PWM175**	**PWM150**	**PWM125**	**PWM100**	**PWM75**	**PWM50**
(dBm)	(mV)	(mV)	(mV)	(mV)	(mV)	(mV)	(mV)	(mV)	(mV)
-50	2347	2347	2347	2348	2346	2342	2338	2332	2317
-55	2348	2347	2344	2342	2341	2337	2330	2314	2275
-60	2342	2341	2338	2337	2333	2328	2310	2268	2195
-65	2335	2334	2332	2329	2322	2303	2259	2185	2084
-70	2326	2322	2316	2305	2286	2243	2172	2069	1953
-75	2298	2287	2271	2247	2211	2149	2053	1940	1831
-80	2235	2214	2188	2154	2102	2024	1922	1818	1704
-85	2138	2106	2072	2030	1973	1894	1800	1688	1572
-90	2011	1978	1941	1900	1848	1773	1671	1557	1444
-95	1884	1853	1819	1779	1724	1642	1541	1431	1325
-100	1761	1728	1692	1648	1590	1512	1416	1320	1248
-105	1630	1596	1562	1520	1465	1394	1311	1248	1208
-110	1517	1486	1453	1415	1369	1307	1255	1217	1196
-115	1452	1421	1390	1357	1317	1272	1234	1206	1191

Reading SDFITS Files Using Astropy

Jack Ganssle N3ALO (jack@ganssle.com)

Abstract

In addition to the Web interface, the Skynet 20 meter telescope produces a binary SDFITS file containing data and keywords of an observation. It seems most FITS readers are not compatible with these files. In this essay I show how one can use Astropy and Python to probe and examine these files.

Introduction

Green Bank's 20 meter radio telescope produces data which is displayed graphically and in tables of text data. It will also return a file in SDFITS format, the "SD" referring to "Single Dish." Unfortunately, most of the programs we use for processing astrophotography data cannot read these files. Pixinsight returns this error message **"*** Error: PCL Legacy FITS Format Support: The FITS file contains no readable image.**" As a radio telescope is basically a single-pixel camera, not finding a "readable image" is unsurprising.

However, the Astropy package for Python has tools that make accessing these files, and any FITS-format file, relatively easy. While I am far from an expert in using Astropy, the following describes some of what I've learned by using these tools to probe SDFITS files.

The Python programming language is commonly used in astronomy, and the open source Astropy package makes doing many astronomical tasks pretty simple. Need to convert equatorial coordinates to azimuth and elevation? Sure, one could write some spherical trig equations, but Astropy has built-in routines that trivialize the task.

Astropy has an extension (https://docs.astropy.org/en/latest/io/fits/index.html) specifically designed to handle FITS files.

File Structure

FITS and SDFITS files are comprised of one or more Header Data Units (HDUs), which are list-like structures that include header information and binary tables or data arrays.

In the case of the 20 meter, the data array is the raw data from the telescope.

Header information is a collection of keywords and associated parameters. Examples:

```
OBSMODE = 'onoff    '
CONTROL = 'SKYNET   '           / Control mode
RA      = '00:40:09.78'         / Start RA
DEC     = '40:38:12.70'         / Start Dec
```

In practice, the 20m returns two HDUs. The first, called the "primary" HDU, merely contains about 66 keywords relating to the overall observation session. The second holds the telescope's raw data and a set of keywords for each scan.

But what is a scan? It's the telescope's sweeping the selected bandwidth. If you've picked, say, 1024 channels, there are 1024 intensity readings in each scan. They are saved in groups of four scans:

- Frequency 1 polarization 1
- Frequency 2 polarization 1
- Frequency 1 polarization 2
- Frequency 2 polarization 2

… where "Frequency 1 and 2" are the two frequencies you've selected when initiating the observation. Scan 0 is the first scan using frequency 1 and polarization 1, scan 3 is the first frequency 2 polarization 2, scan 4 is the second time the telescope acquired frequency 1 polarization 1, etc.

It's important to understand that each scan has its own set of keywords. That makes it possible to figure out which scan is which of the two frequencies, which is an "on" versus an "off" scan, etc. ("On" scans are those aimed at the object of interest; "off" are those aimed away from it to get a sky background reading).
To use the FITS module in your Python code, import it:

```
from astropy.io import fits
```

Then, open the FITS file:

```
file_input = fits.open(file_input_name)
```

Note that this is not an ordinary Python "open" call – it's a call into the Astropy FITS module.
To get the keywords for the primary HDU, that is, the keywords that apply to the entire session:

```
hdr = file_input[0].header
```

The "0" selects HDU 0, the primary HDU.

Keywords are organized one per 80-column card. Old-timers will recognize this atavistic notion as from the punched card era. As such, there are no end-of-line delimiters. To get a pretty printout add the "repr" method:

```
print(repr(hdr))
```

Bring in the entire second HDU, both keywords and scan data, as follows:

```
data = file_input[1].data
```

Here, "1" selects the second HDU.
This can result in a lot of memory usage. 60 seconds of data is nearly 20 MB, which won't stress a modern desktop computer, but suggests that the use of numpy will speed things up a lot if you plan on doing much math on the data.

To retrieve the value of a keyword, issue a statement like:

```
key_data = data[“keyword_name”][scan_number]
```

For instance:

```
key_data = data[“DATE-OBS”][23]
```

… returns the date and time of scan number 23.
A list of all of the keywords I have observed from the 20 meter are in the appendix.

If doing an on/off scan you'll want to check the keywords of each scan to separate the types of data. As you're looping through the scans (with, in this case, variable **loop_scans**):

```
flg = data["OBSMODE"][loop_scans]
on_off_target_flag = flg[0:8].decode("utf-8")
```

Here we're extracting keyword "**OBSMODE**". Unlike data from other keywords, **OBSMODE** returns binary, so use the **decode** method. The **flg[0:8]** slice selects the ASCII describing "**onoff:on**" or "**onoff:of**".

It's sometimes useful to extract the names of all of the keywords in HDU1. Use:

```
cols = file_input[1].columns
col_names_hdu1 = cols.names
```

You can then get the value associated with any of these names by:

```
str(data[col_names_hdu1[keyword_name_index]][scan_index])
```

… where **keyword_name_index** is the index into the names and **scan_index** is the scan number.

The actual scan data is accessed the same way, since there is a keyword **DATA** whose value is the list of intensities for the scan. Get the data for all scans into a variable by:

```
spectrum = data['DATA']
```

It's useful to find its size in the normal Python way:

```
shape = spectrum.shape
```

Variable **shape** will be in the format (number_of_scans, number_of_samples_per_scan).

One may wish to compute the average of many scans. Remember that these are grouped into four scan types, for the two frequencies and two polarizations. The code could look like this:

```
for loop_scans in range(0, shape[0], 4):# shape[0] is the number of
scans
  if on_off_target_flag == "onoff:on":
    on_target_count += 1
    on_target_freq1_pol1 = on_target_freq1_pol1 + spectrum[loop_scans]
    on_target_freq1_pol2 = on_target_freq1_pol2 +
spectrum[loop_scans+2]
    on_target_freq2_pol1 = on_target_freq2_pol1 +
spectrum[loop_scans+1]
    on_target_freq2_pol2 = on_target_freq2_pol2 +
spectrum[loop_scans+3]
  else:
    off_target_count += 1
    off_target_freq1_pol1 = off_target_freq1_pol1 +
spectrum[loop_scans]
```

```
    off_target_freq1_pol2 = off_target_freq1_pol2 +
spectrum[loop_scans+2]
    off_target_freq2_pol1 = off_target_freq2_pol1 +
spectrum[loop_scans+1]
    off_target_freq2_pol2 = off_target_freq2_pol2 +
spectrum[loop_scans+3]
```

The scan data is very similar to that you get from the Skynet Web interface, but the magnitudes are a little different. I believe the Skynet data has some sort of calibration applied to it, but this remains a bit of a mystery to me.

I have written a Python program that reads SDFITS files from the 20 meter and creates a .csv file of the data for further analysis, graphing, etc. Drop me an email if you'd like a copy. And comments, corrections and insight are always more than welcome.

Appendix – List of Observed Keywords from the 20 meter Telescope

Keywords and typical values in HDU0. Note that even the comments after the "/" character are returned in the **`hdr = file_input[0].header`** request:

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                    8 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in
'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode:
2001A&A...376..359H
DATE    = '2025-07-25T06:01:48' / date and time this HDU was created
ORIGIN  = 'Skynet RTN'         / Produced by Skynet Robotic Telescope
Network
OBSERVAT= 'Green Bank Observatory' / Name of observatory
TELESCOP= 'GreenBank-20'       / Antenna used to acquire data
INSTRUME= 'CYBORG  '           / Instrument used to acquire this image
SDFITVER= 'skyfits ver17.03.27' / this file created by Cyborg
FITSVER = '1.7     '           / FITS definition version
OBSERVER= 'Society of Amateur Radio Astronomers Stephen Tzikas,
Director' / Skyn
OBSID   = 'Skynet_138154'
PROJID  = 'Skynet_138154'
PROJCODE= 'Skynet_60881_observation_name_138154'
FRONTEND= 'Rx1_2   '
BACKEND = 'Spectrometer'
FD_POLN = 'Linear  '
DATE-OBS= '2025-07-25T06:01:48.000' / Start of Observation
OBSFREQ =              1420.41 / Primary Observing Frequency, MHz
OBSBW   =               15.625 / Bandwidth, MHz
OBSNCHAN=                 4096
OBJECT  = observation_name' / Target object name
OBSMODE = 'onoff   '
CONTROL = 'SKYNET  '           / Control mode
RA      = '00:40:09.78'        / Start RA
DEC     = '40:38:12.70'        / Start Dec
HREF    =               9.9792 / Commanded Center H, degrees
VREF    =              40.6367 / Commanded Center V, degrees
```

```
COORDREF= 'RA_DEC_ '           / Type of center coordinates
BMAJ    =    0.726082434570366 / Beam Major axis, degrees
BMIN    =    0.726082434570366 / Beam Minor axis, degrees
SCANLEN =              21600.
COMMENT Geodetic coordinates of the Green Bank 20-meter telescope
SITELONG=            -79.82552 / E. longitude of intersection of the
az/el axes
SITELAT =             38.43685 / N. latitude of intersection of the
az/el axes
SITEELEV=                 835. / height of the intersection of az/el
axes
HISTORY BASENAME Skynet_60881_ observation_name_138154_88089
HISTORY DATAMODE HIRES
HISTORY CONTROL SKYNET        / Project control mode
HISTORY BALANCE      1.200   / IF Power Balance target
HISTORY SCANNAME 2025_07_03_19
HISTORY PROJCODE Skynet_60881_ observation_name_138154
HISTORY DATADIR  /raid/scratch/cyborg/SkynetData/Skynet_60881_
observation_name/Cyborg
HISTORY DATAROOT /raid/scratch/cyborg/SkynetData
HISTORY FOCUS       37.071           / 20-meter box focus position
HISTORY RFFILTER     1355_1435        / Receiver feed/filter
HISTORY START,STOP channels  204, 3891   / range for continuum
HISTORY IF Attenuators     0.00,    0.00    /
HISTORY LO1 tuning      6870.4100      / Actual LO1 synthesizer
setting, MHz
HISTORY HIRES bands   1420.4100,  1420.4100 / HIRES band centers, MHz
HISTORY TBIN        0.00419430       / Roach Integration, sec
HISTORY ACCLEN      2048             / Roach accumulation length
HISTORY OFFSYS    RADEC             / Offset coordinate system
HISTORY NOISECAL  HI             / Noise Cal level
HISTORY PRECAL   2             / Precal in seconds
HISTORY POSTCAL   2             / Postcal in seconds
HISTORY CRYOTEMP   16             / Cryogenic 15K temperature (K)
HISTORY BOXTEMP   25             / Receiver box temp (C)
HISTORY POWER_XL   0.53           / XL IF power
HISTORY POWER_YR   0.37           / YR IF power
HISTORY WARNING   None             / Warning of error conditions
HISTORY Downloaded from
https://skynet.unc.edu/download/fits?radio_obs=138154   OBJECT
observation_name
```

Keywords and typical values in each of the HDU1 scans:

```
BANDWID             -15625000.0
DATE-OBS            2025-07-25T06:01:48.0
DURATION            0.3
EXPOSURE            0.268435
TSYS                100.0
TDIM7               (4096,1,1,1)
TUNIT7              Counts
CTYPE1              FREQ-OBS
CRVAL1              1420410000.0
CRPIX1              2048.0
CDELT1              -3814.697265625
CTYPE2              RA
CRVAL2              10.04073
CTYPE3              DEC
CRVAL3              40.6369
CRVAL4              -5
```

```
OBSERVER            socamrad_21318
OBSID               138154
SCAN                88089
OBSMODE
b'onoff:on\x00\x96\xf9\x9e\xf2\x7f\x00\x00\x00\x10\x80\x00\x00\x00\x00\
x00\x03'
FRONTEND            Rx1_2
TCAL                9.1715
VELDEF              RADI-OBS
VFRAME              0.0
RVSYS               0.0
OBSFREQ             1420410000.0
LST                 75319.0
AZIMUTH             67.733
ELEVATIO            46.9954
TAMBIENT            22.0
PRESSURE            684.0
HUMIDITY            0.5
RESTFREQ            1420405752.0
FREQRES             0.003814697265625
EQUINOX             2000.0
RADESYS             FK5
TRGTLONG            10.04073
TRGTLAT             40.6369
SAMPLER             R:-5:1
FEED                1
SRFEED              0
FEEDXOFF            0.0
FEEDEOFF            0.0
SUBREF_STATE        1
SIDEBAND            L
PROCSEQN            1
PROCSIZE            1
LASTON              0
LASTOFF             1
TIMESTAMP           2025_07_25:06:01:48
VELOCITY            0.0
ZEROCHAN            0.0
SIG                 T
CAL                 F
CALTYPE             HIGH
INT                 0
FDNUM               0
IFNUM               0
PLNUM               0
CALSTATE            0
NSAMPS              1
SWPINDEX            0
SWPVALID            0
MJD                 60881.25125
UTSECS              21708.000000100583
```

Hydrogen Line Doppler Mapping of Eight Nearby Galaxies Using the 20m Skynet Dish at Greenbank Observatory

Dr Andrew Thornett, M6THO, Lichfield Radio Observatory, Lichfield, UK www.astronomy.me.uk
Jason Burnfield, Electronics Engineer III, Data Acquisition Group, National Radio Astronomy Observatory (NRAO), Domenici Science Operations Center (DSOC): Rm. 257

Greenbank 20m Skynet Radio Telescope.

The 20 m telescope 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 has 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 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).

Though professional and educational use dominates, SARA members (Society of Amateur Radio Astronomers) 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 Eight Galaxies Outside the Milky Way.

The current paper describes the results of our study of eight galaxies outside the Milky Way, in order to demonstrate the ability and features of this telescope, and to explore the predominant features of different sources. We choose both galaxies located within the local group and some further away, in order to explore the differences between these groups.

Methodology.

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

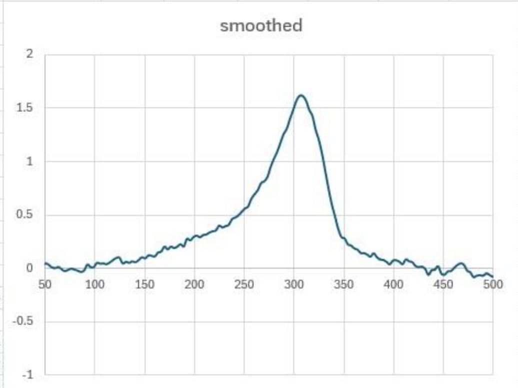
- L-Band
- High Resolution
- Centre Frequency set to 1420.4 MHz
- 1 second “ON”
- 1 second “OFF”
- 3-10 repetitions for a total of 10 seconds for each (dependent on brightness of galaxy)
- 1.5 degrees Az and El offset for “OFF”
- Alternatively use tracking mode and capturing separate off-target calibration observation

Analyzing the Data:

Our method involved taking 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 analyzing 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 colored cells in the velocity maps 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 maps were colored using conditional formatting with a 3-colour scale (white, yellow, black) representing 90th percentile, 50th percentile, and 10th percentile of all amplitudes in the map.

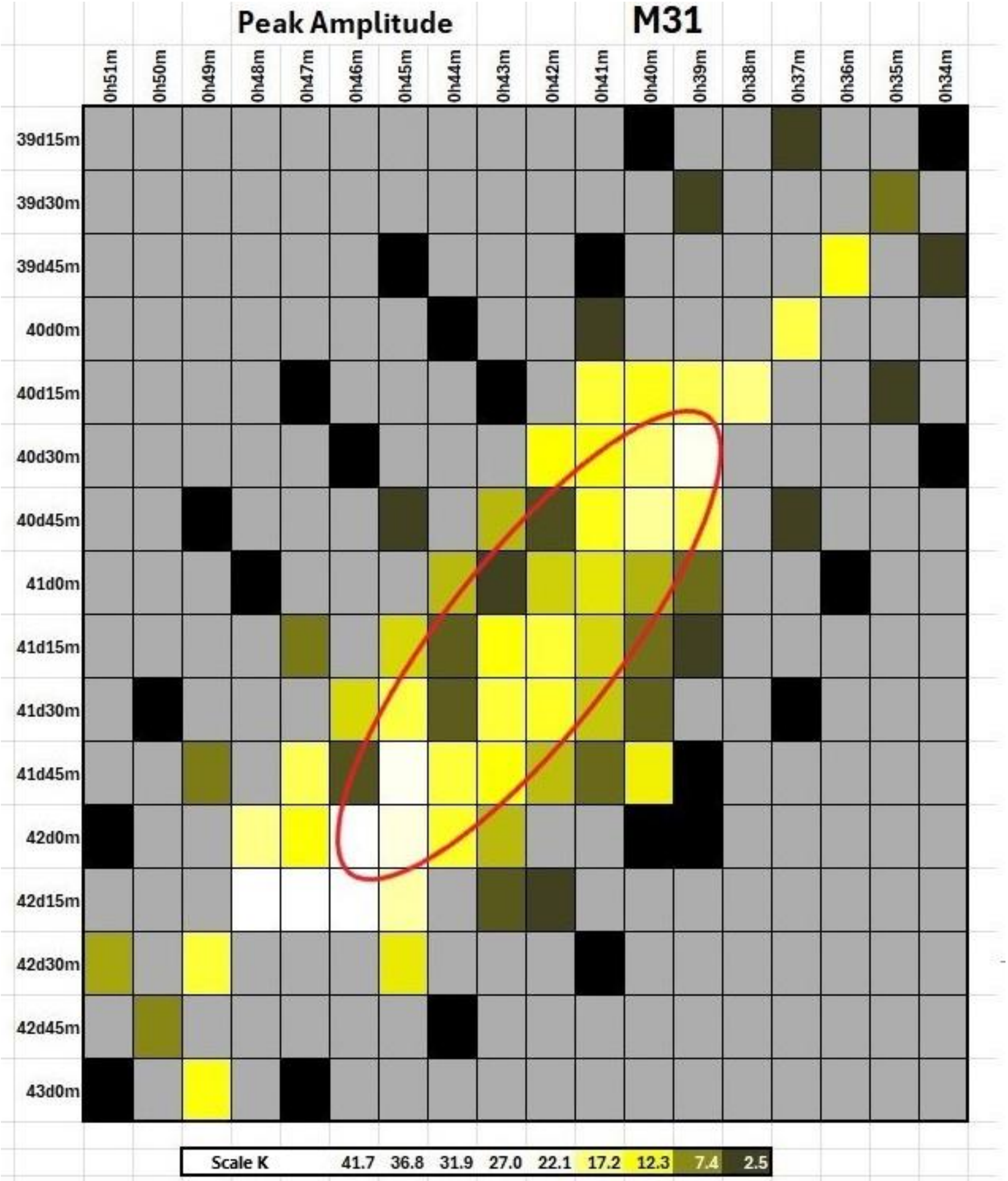
An example of processing within Excel during this study (below):

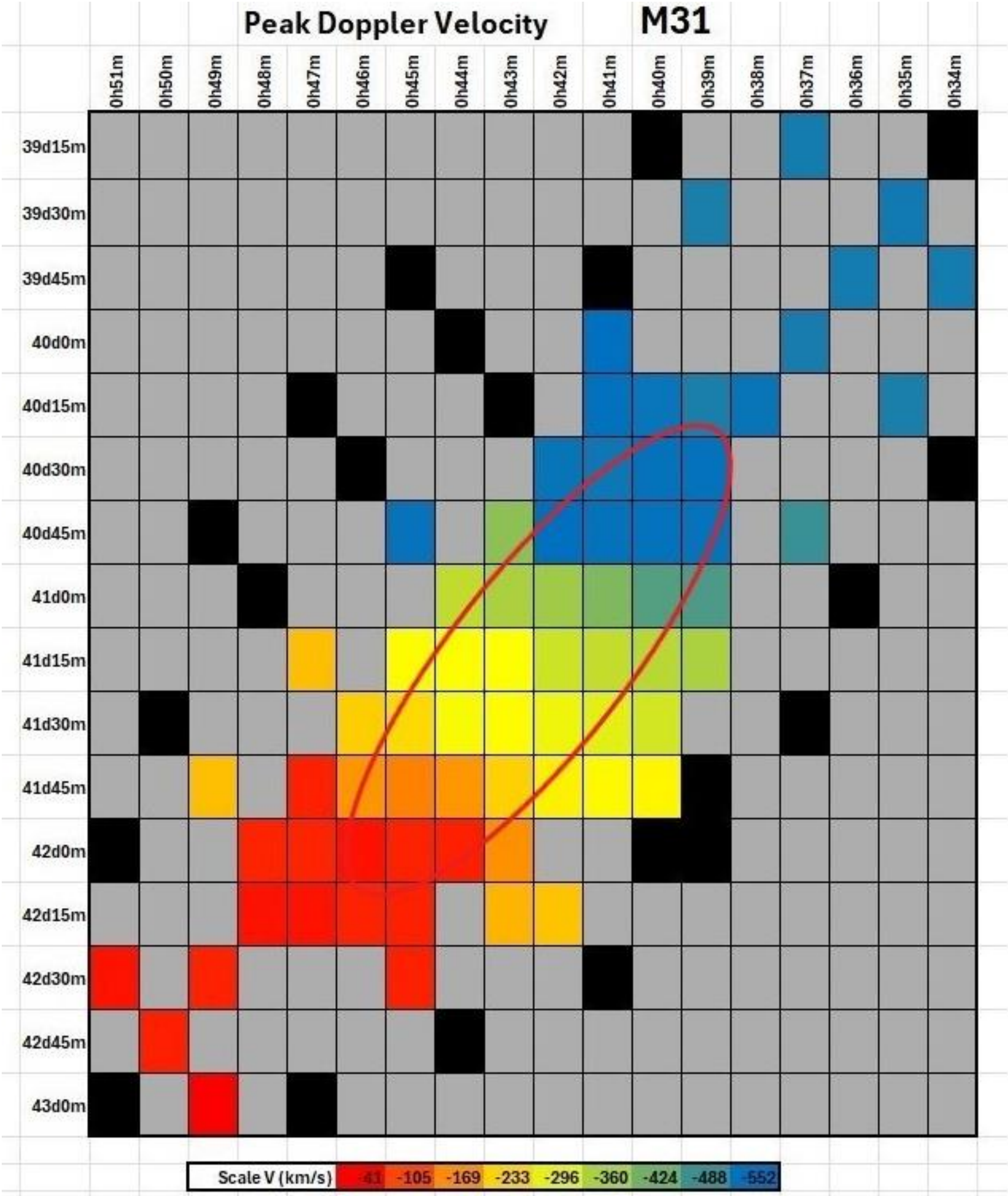
	A	B	C	D	E	F	G	H	I	J	K	L	M
49	# POWER_XLYR=[1.23, 1.19]												
50	# VELDEF=RADI-OBS												
51	# VELOCITY=0.000												
52	# NPOL=2												
53	# POLMODE=Linear												
54	# POLTYPE=XXYY												
55	# WARNING=None												
56	# NOISECAL=HI												
57	# PRECAL=5												
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



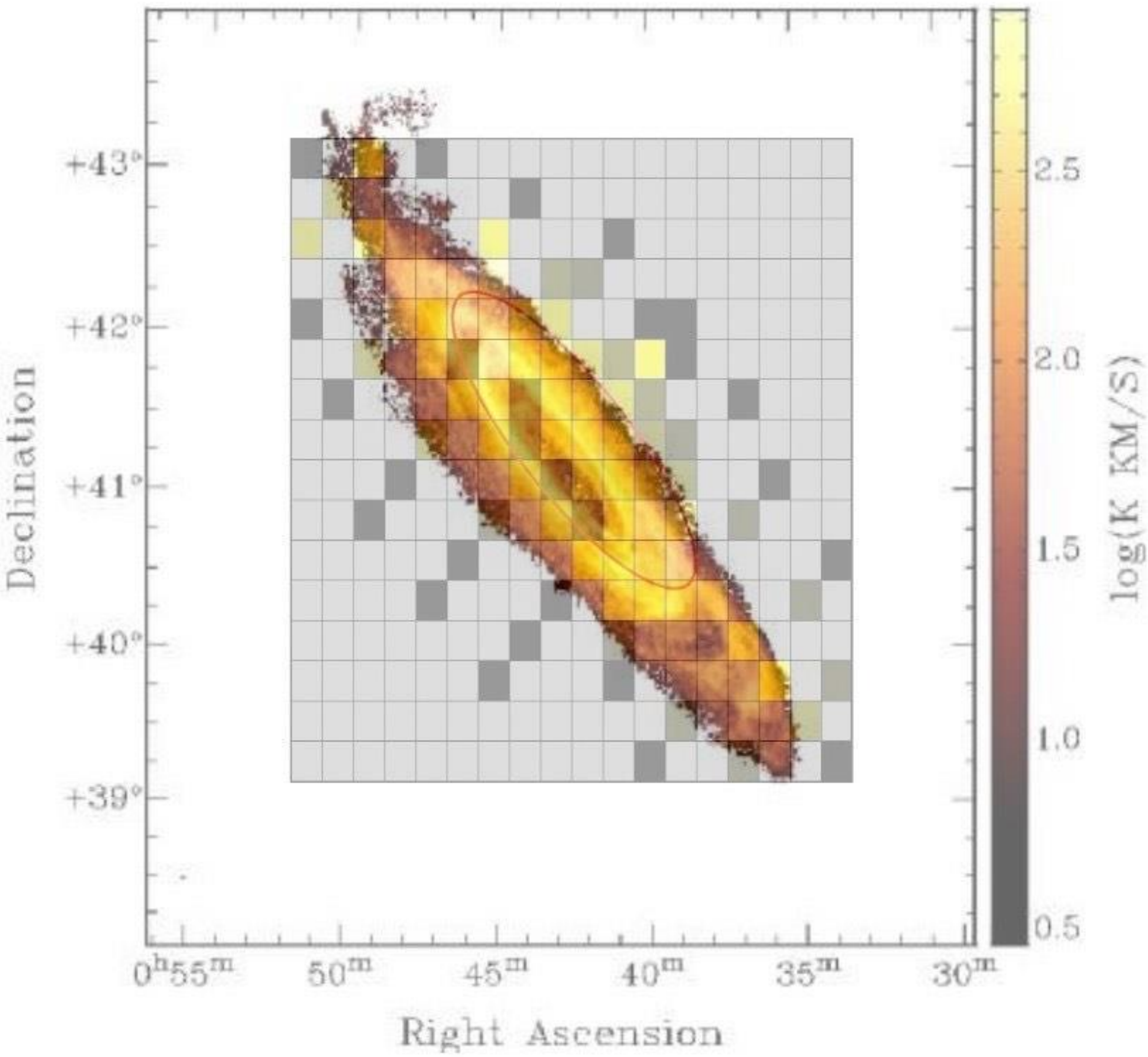
Results:

Results from M31:

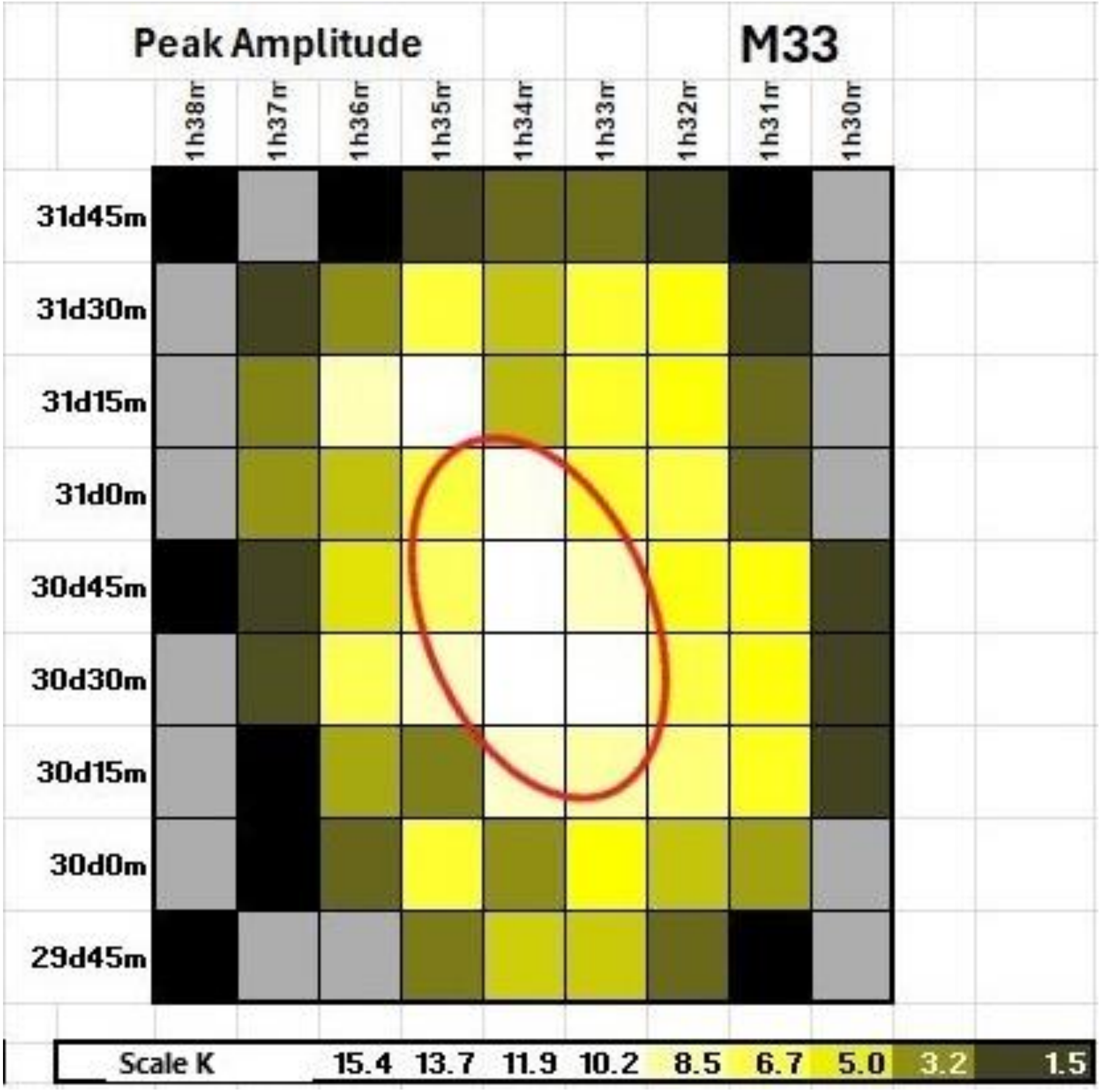


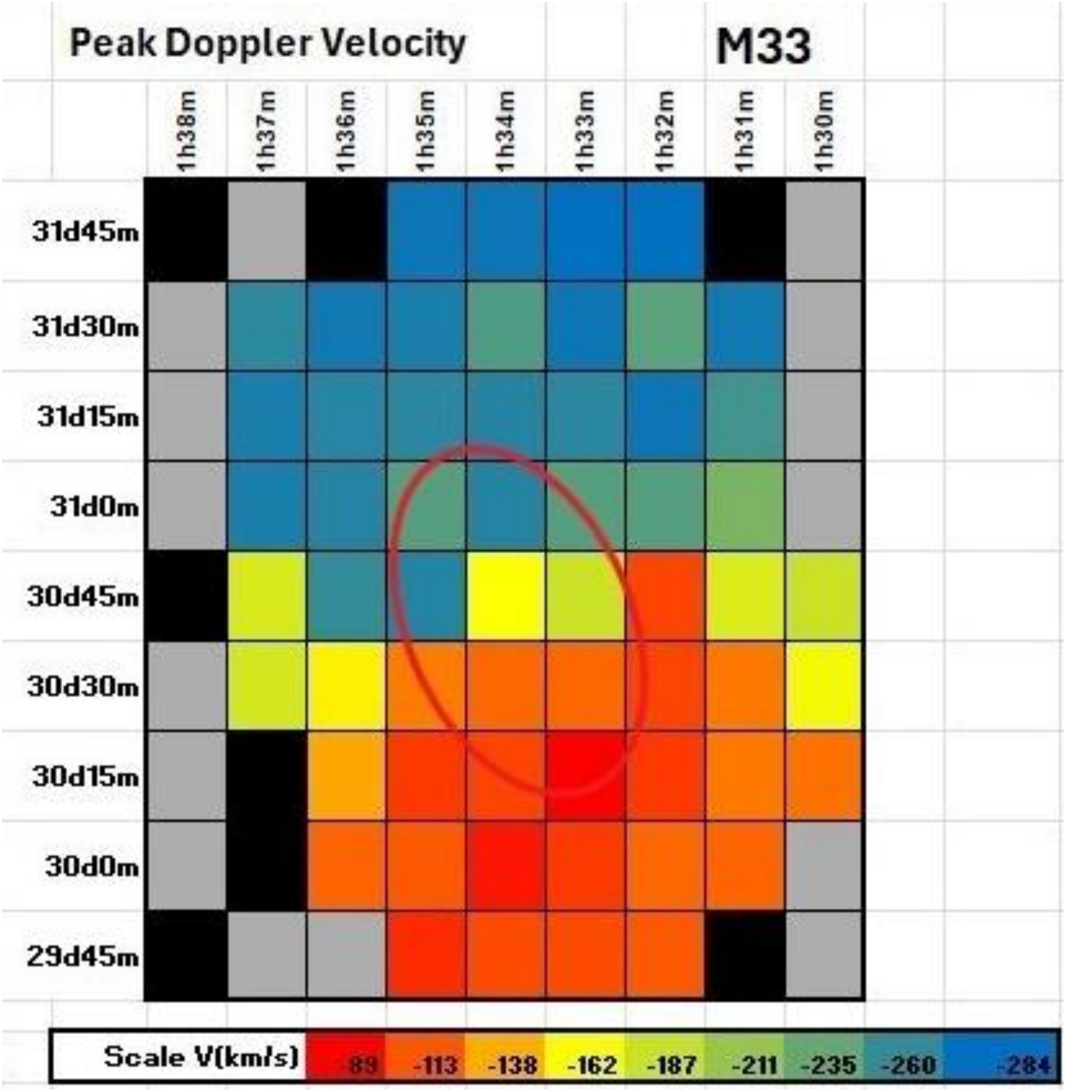

Peak Doppler Velocity
M31
0h51m
0h50m
0h49m
0h48m
0h47m
0h46m
0h45m
0h44m
0h43m
0h42m
0h41m
0h40m
0h39m
0h38m
0h37m
0h36m
0h35m
0h34m
39d15m
39d30m
39d45m
40d0m
40d15m
40d30m
40d45m
41d0m
41d15m
41d30m
41d45m
42d0m
42d15m
42d30m
42d45m
43d0m
Scale V (km/s)
-41
-105
-169
-233
-296
-360
-424
-488
-552

M31 Contour Overlay

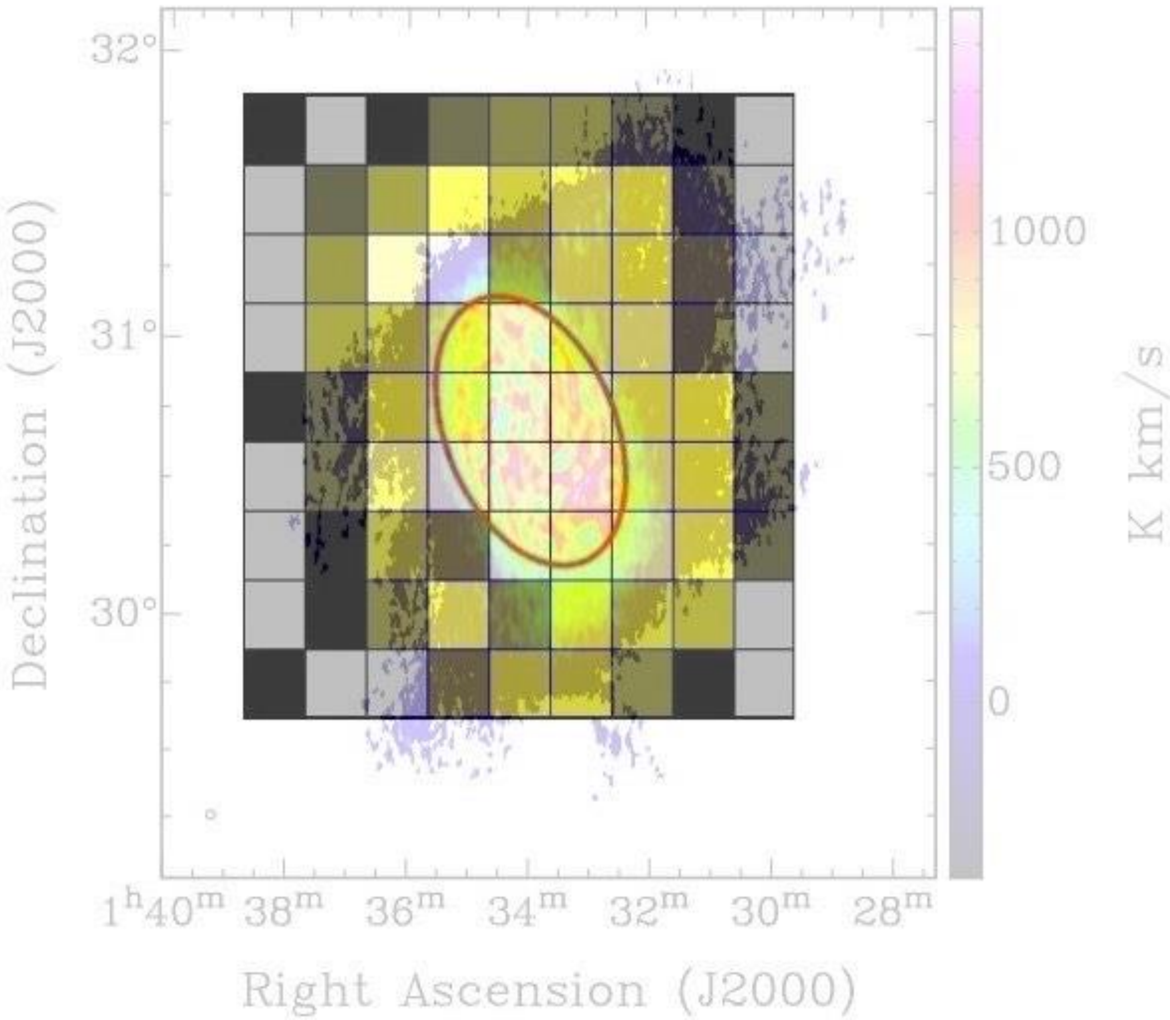


Results from M33:

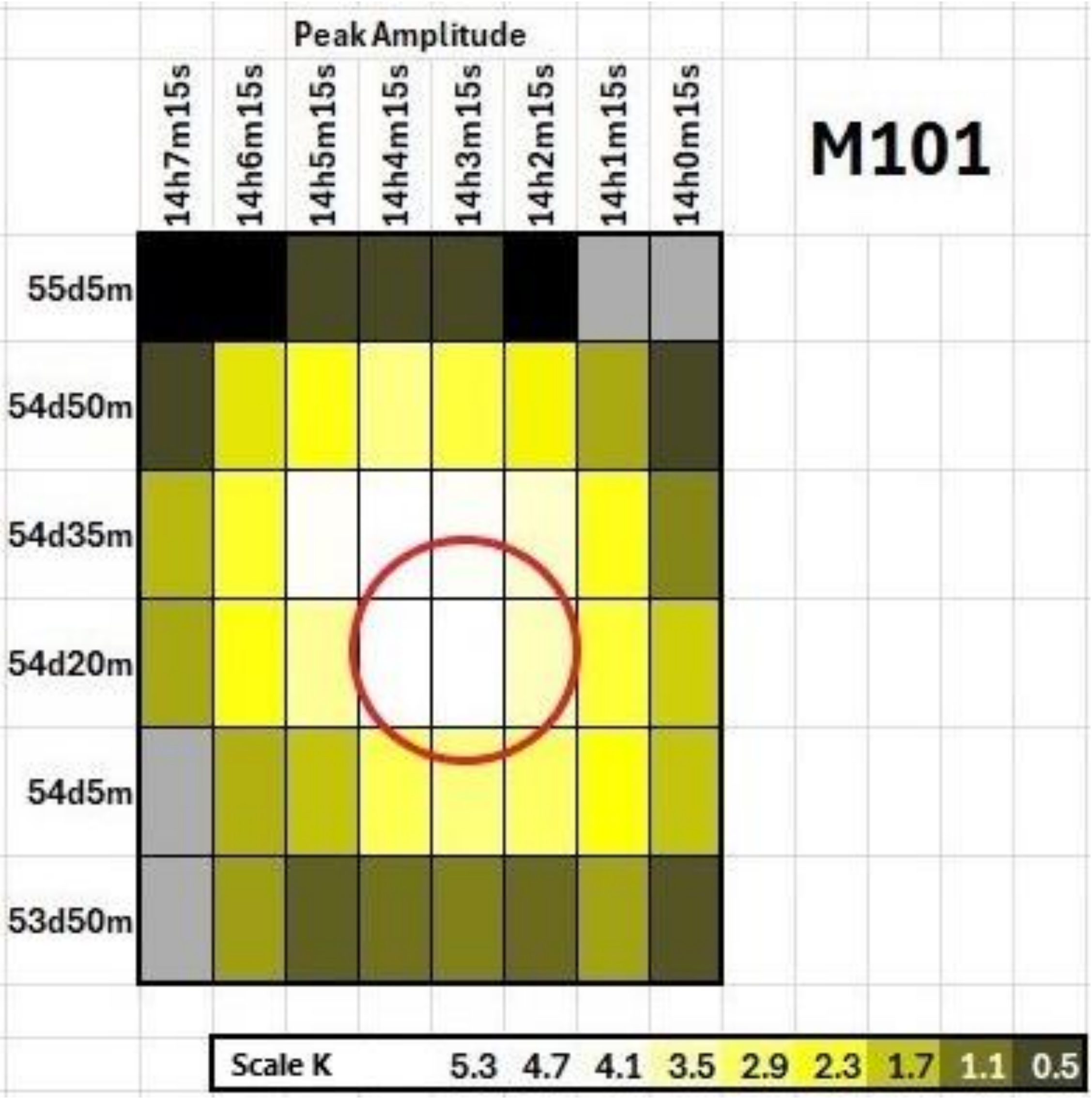


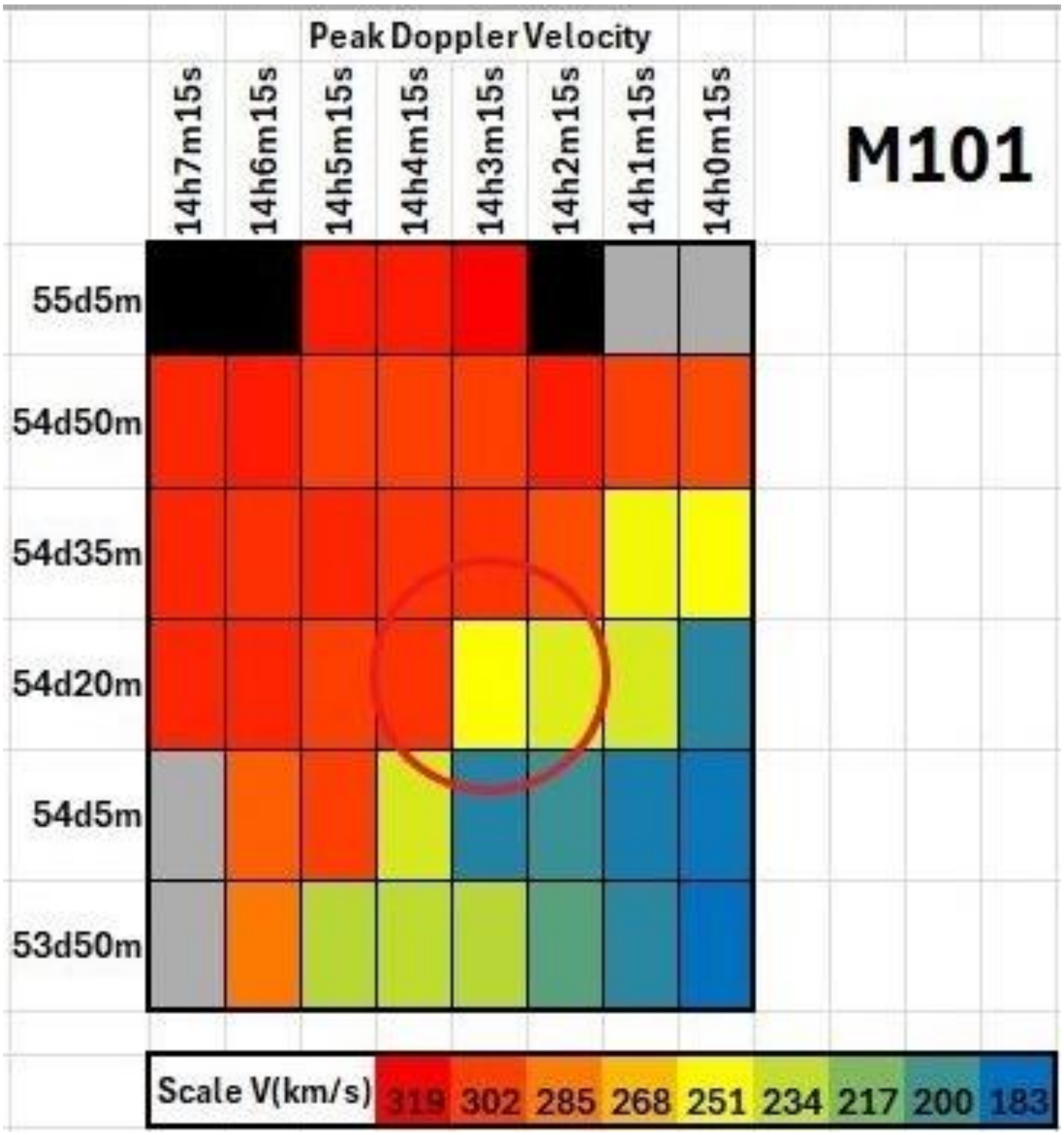

Peak Doppler Velocity
M33
1h38m
1h37m
1h36m
1h35m
1h34m
1h33m
1h32m
1h31m
1h30m
31d45m
31d30m
31d15m
31d0m
30d45m
30d30m
30d15m
30d0m
29d45m
Scale V(km/s)
-89
-113
-138
-162
-187
-211
-235
-260
-284

M33 Contour Overlay



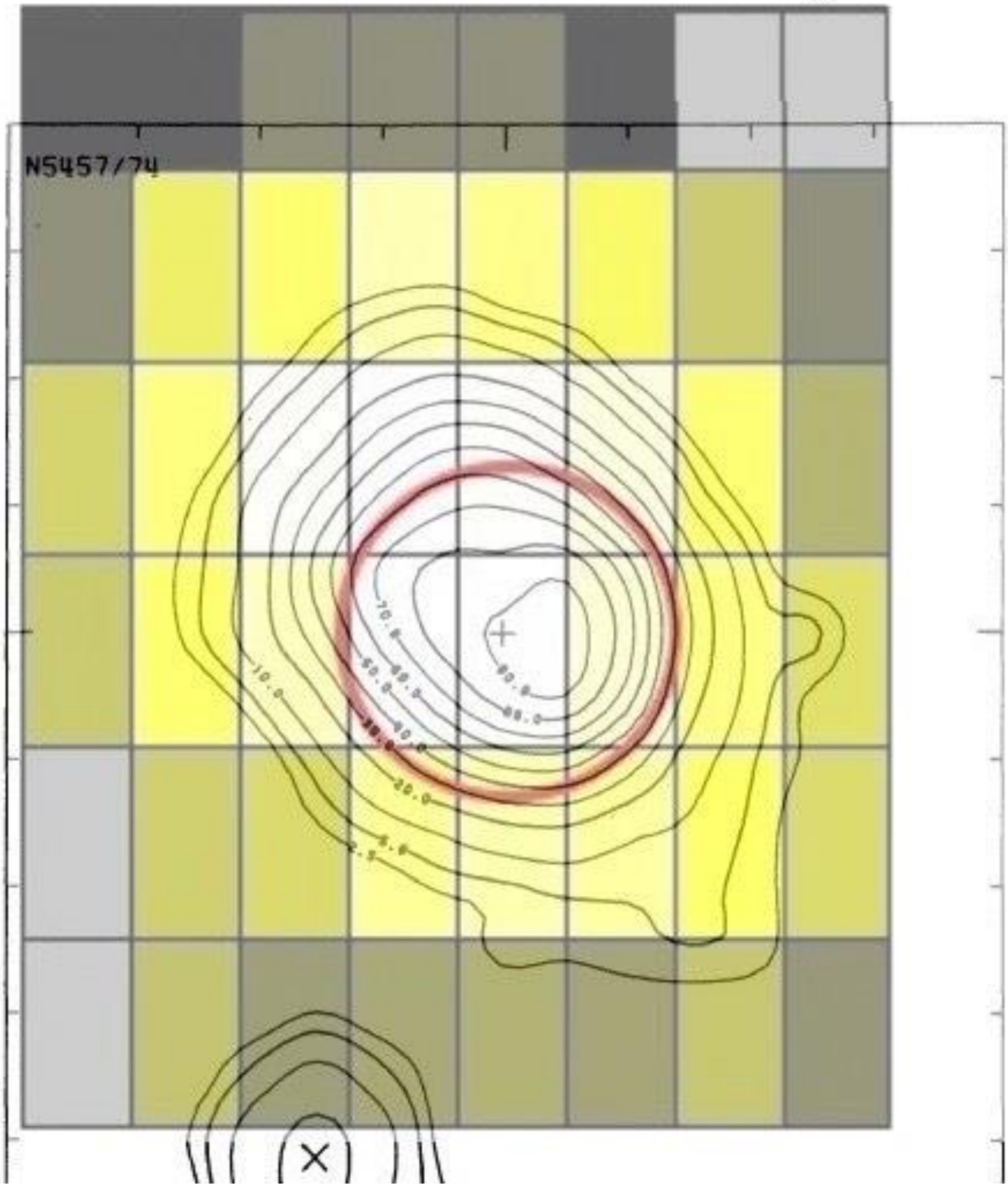
Results from M101:



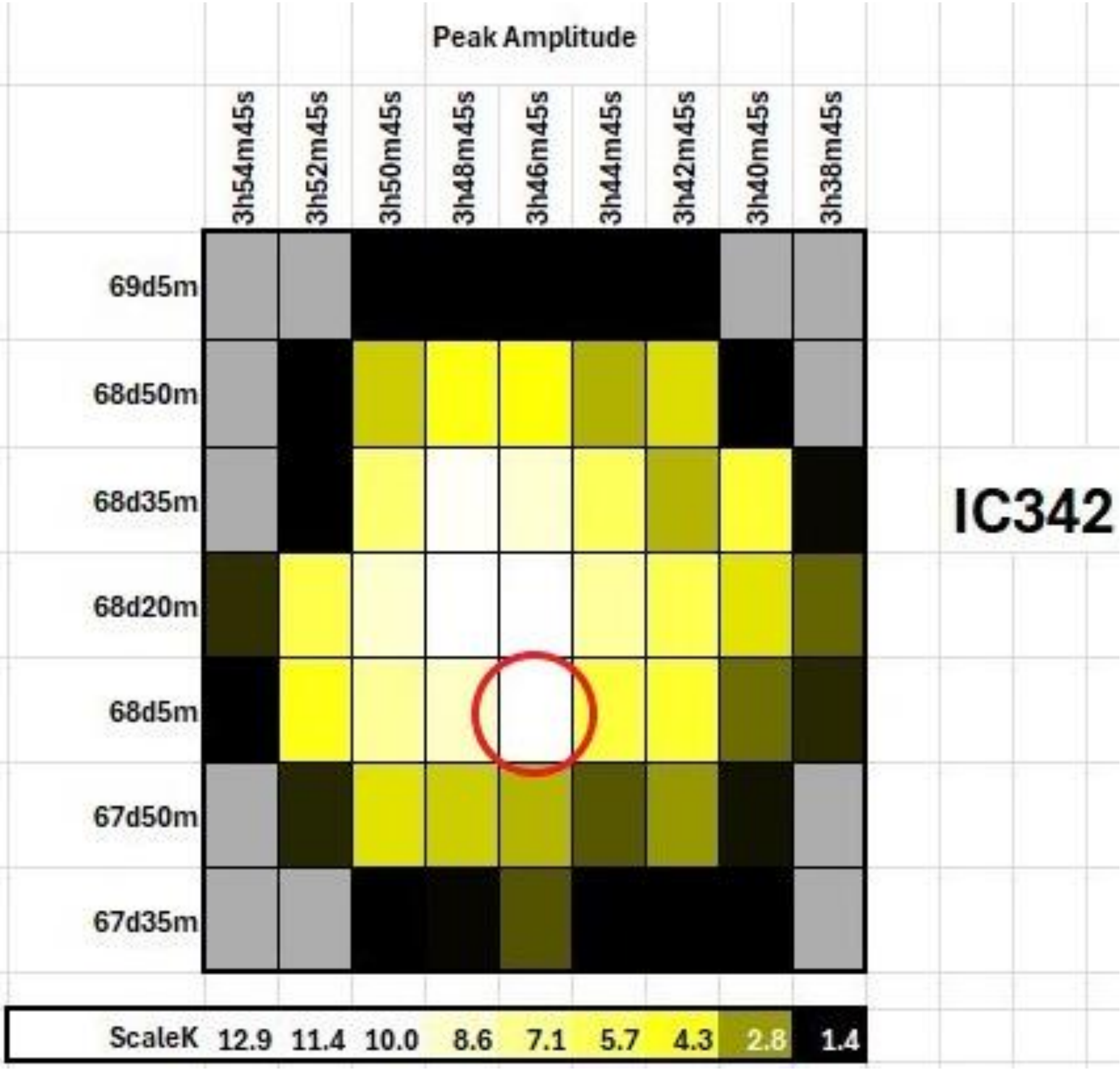


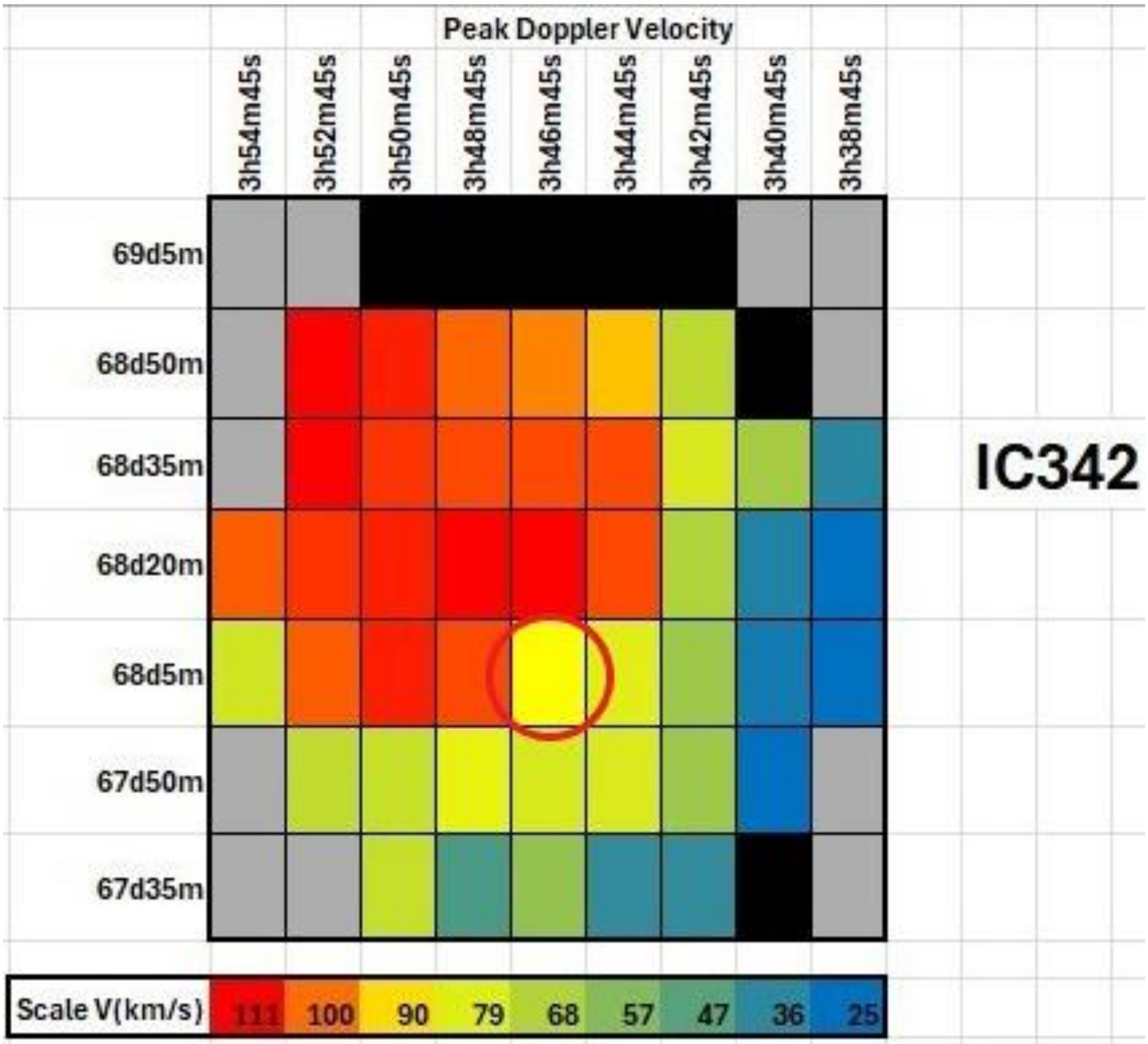
Peak Doppler Velocity
14h7m15s
14h6m15s
14h5m15s
14h4m15s
14h3m15s
14h2m15s
14h1m15s
14h0m15s
M101
55d5m
54d50m
54d35m
54d20m
54d5m
53d50m
Scale V(km/s)
319
302
285
268
251
234
217
200
183

M101 Contour Overlay

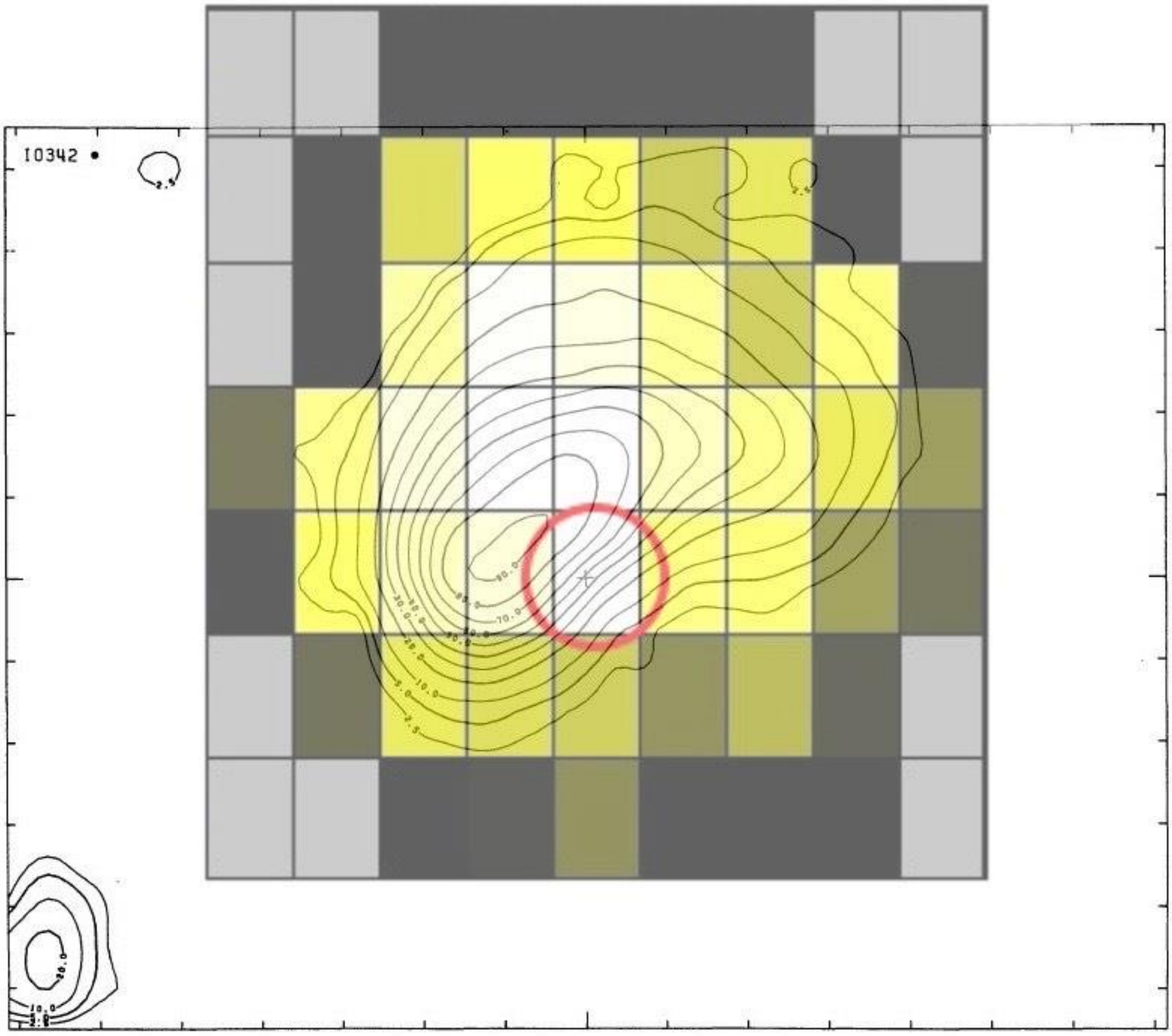


Results from IC342:

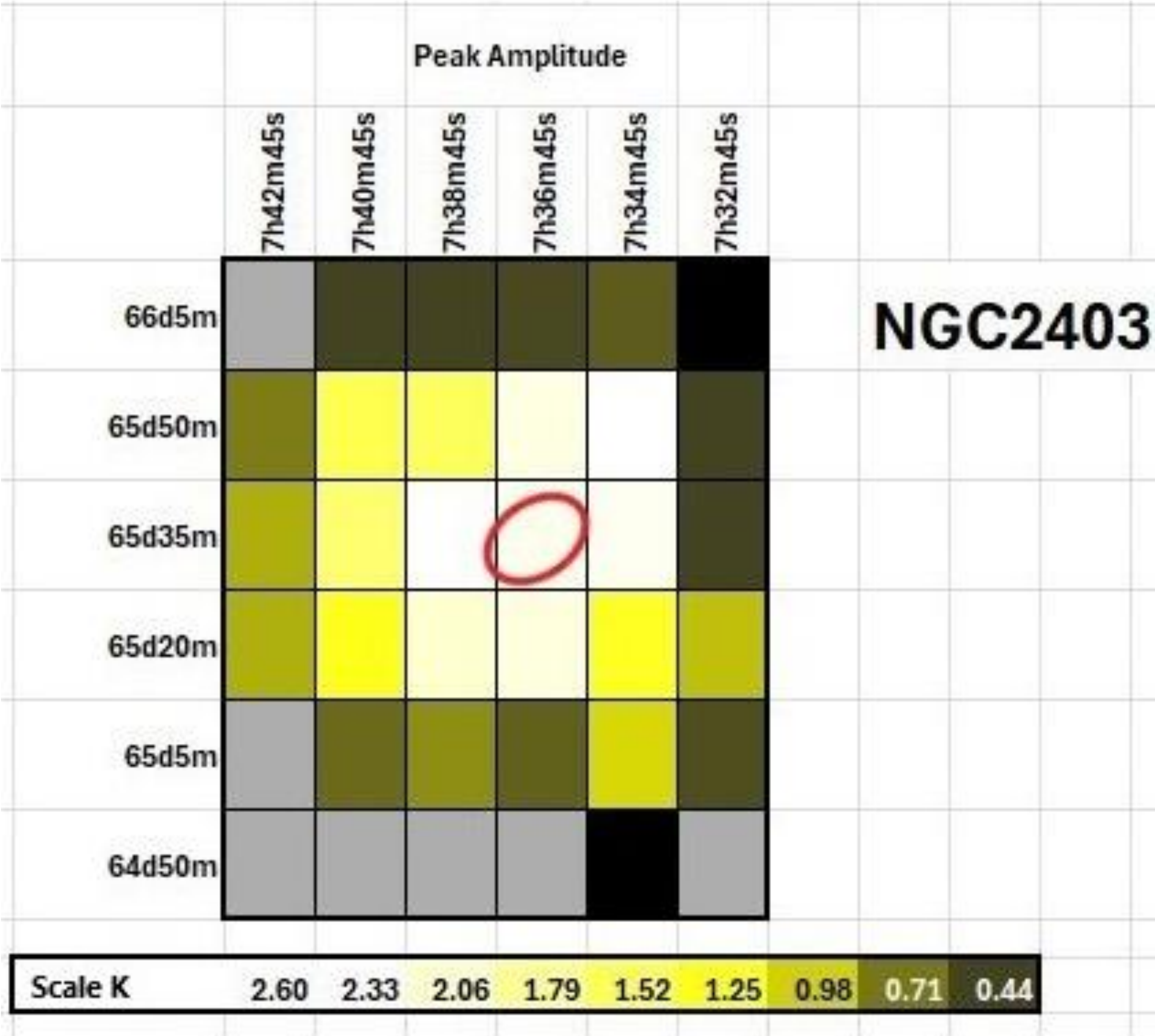


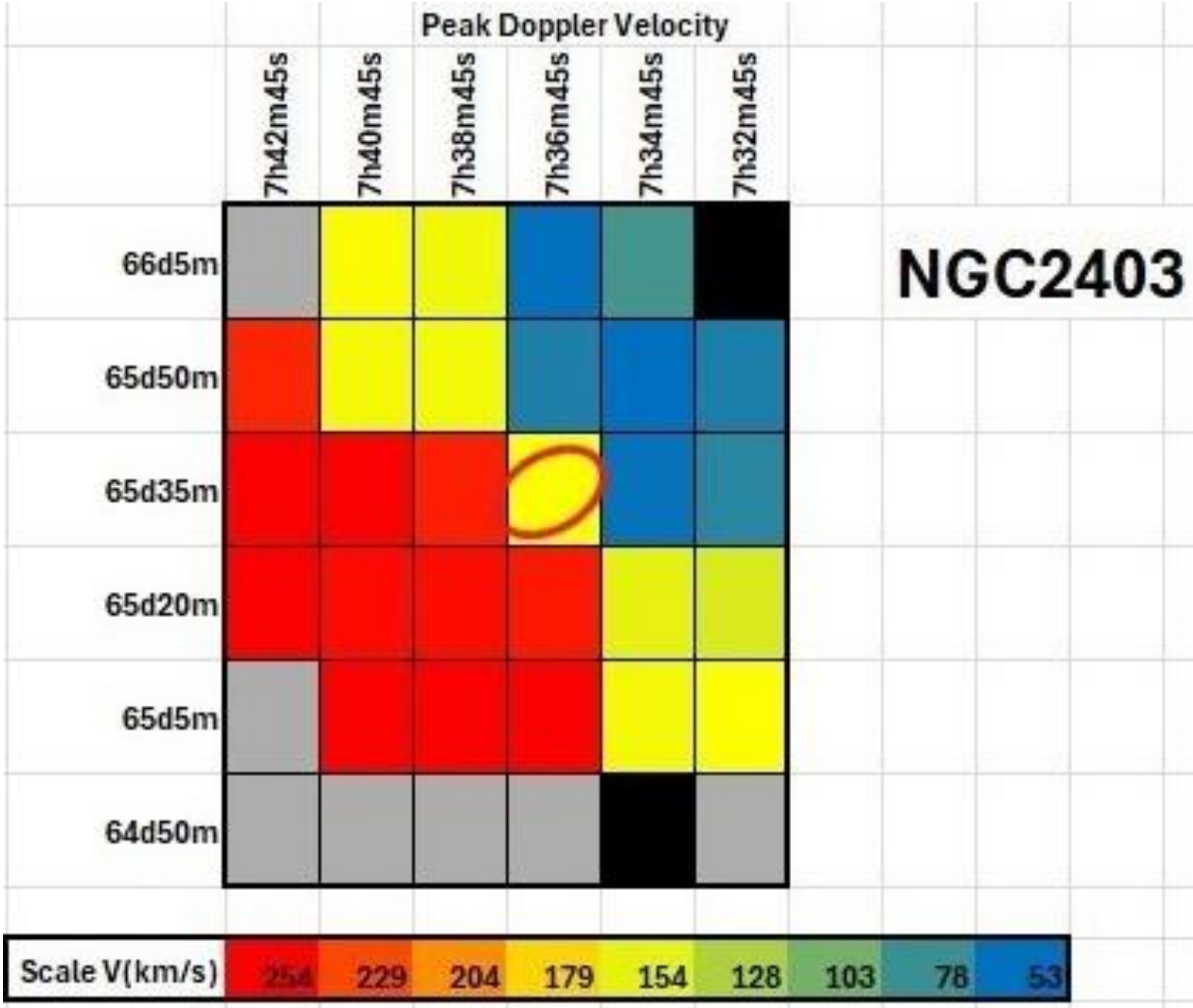

Peak Doppler Velocity
3h54m45s
3h52m45s
3h50m45s
3h48m45s
3h46m45s
3h44m45s
3h42m45s
3h40m45s
3h38m45s
69d5m
68d50m
68d35m
68d20m
68d5m
67d50m
67d35m
IC342
Scale V(km/s)
111
100
90
79
68
57
47
36
25

IC342 Contour Overlay

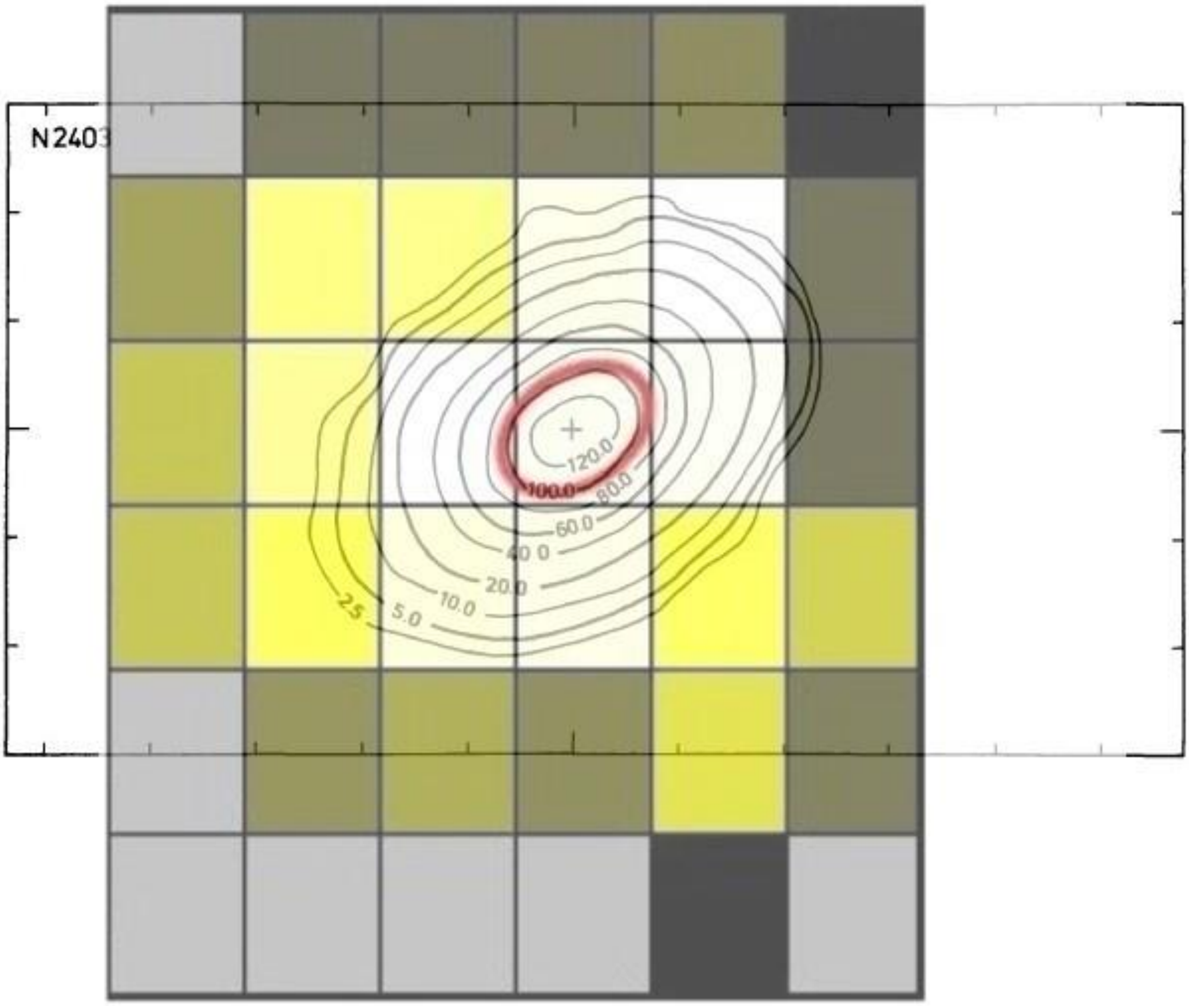


Results from NGC2403:

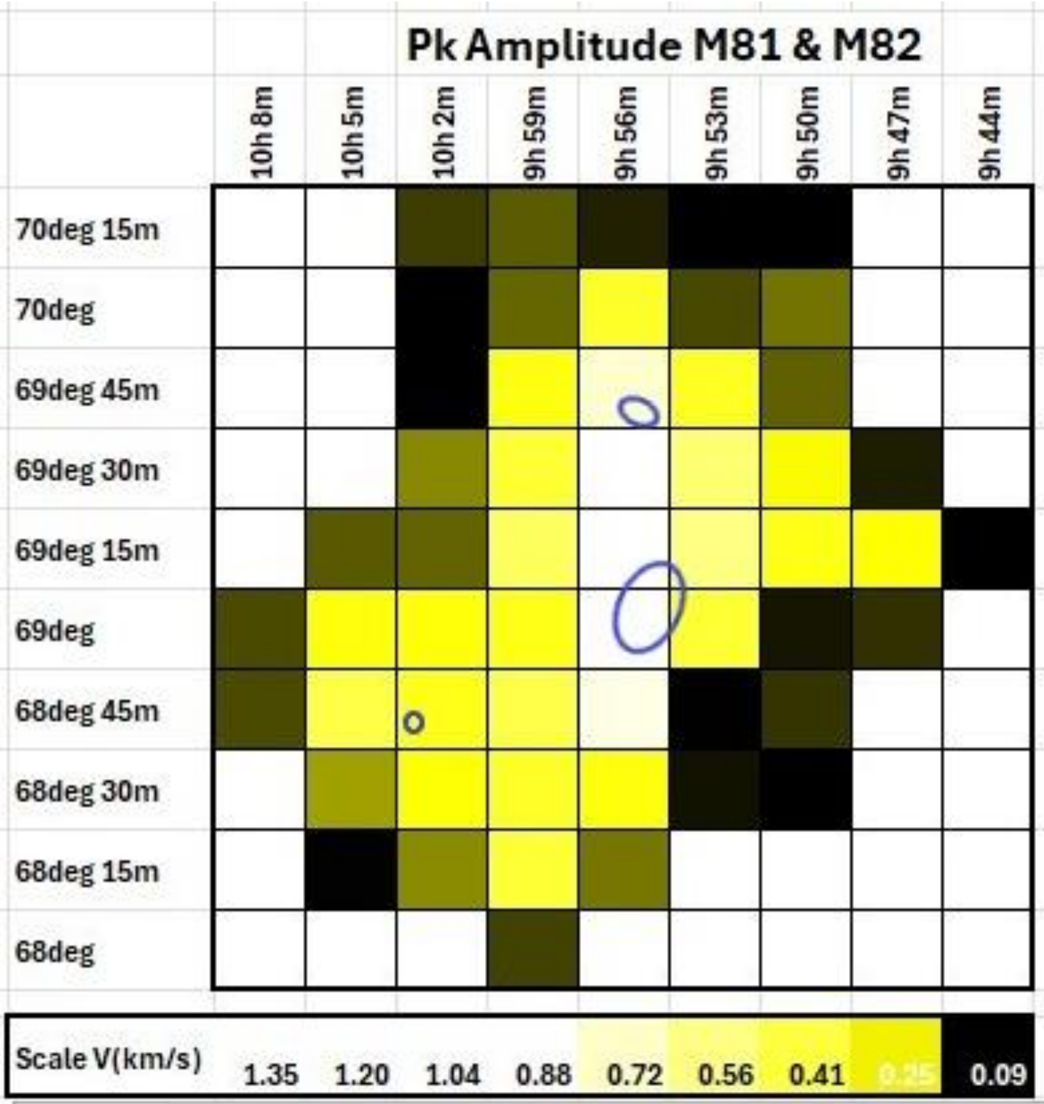


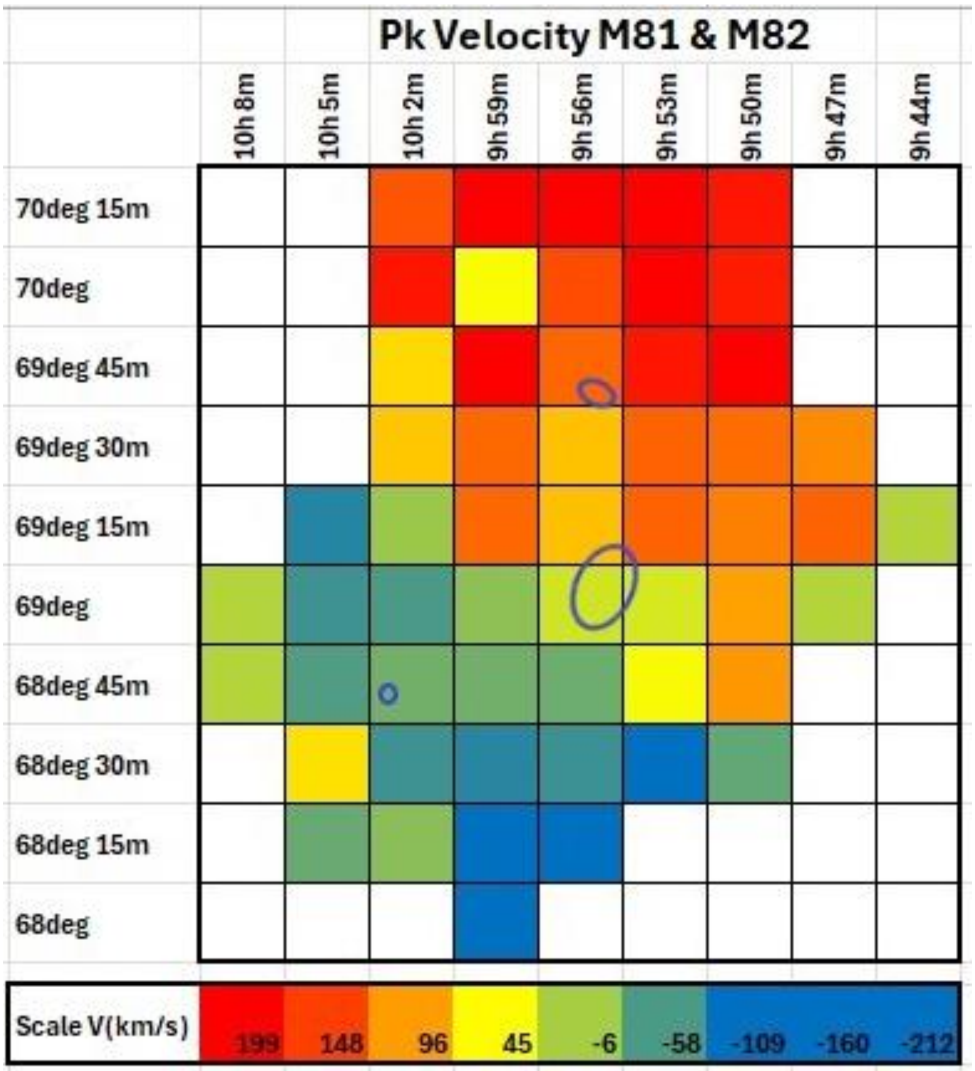

Peak Doppler Velocity
7h42m45s
7h40m45s
7h38m45s
7h36m45s
7h34m45s
7h32m45s
66d5m
65d50m
65d35m
65d20m
65d5m
64d50m
NGC2403
Scale V(km/s)
254
229
204
179
154
128
103
78
53

NGC2403 Contour Overlay

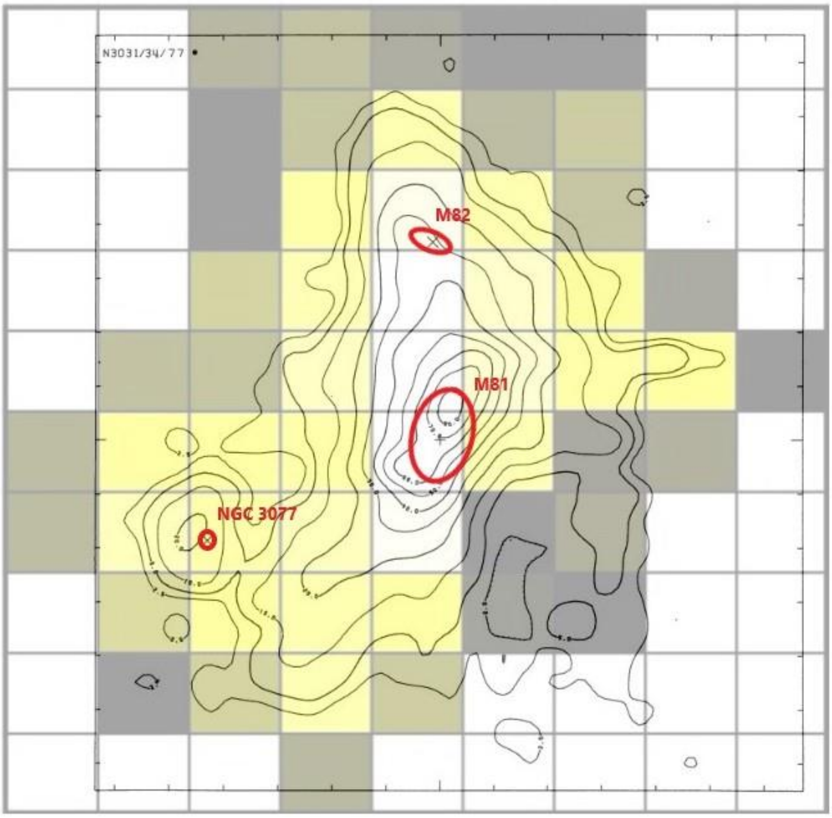


Results from M81, M82, and NGC3077:




Pk Velocity M81 & M82
10h 8m
10h 5m
10h 2m
9h 59m
9h 56m
9h 53m
9h 50m
9h 47m
9h 44m
70deg 15m
70deg
69deg 45m
69deg 30m
69deg 15m
69deg
68deg 45m
68deg 30m
68deg 15m
68deg
Scale V(km/s)
199
148
96
45
-6
-58
-109
-160
-212

M81, M82, & NGC 3077 Contour Overlay



Where we go from here.

We plan to conduct a more detailed study of M81 and M82 and their environs, in order to ascertain the extent to which the two galaxies overlap, and their effects upon each other.

Further information.

Further information about this project is available on the www.astronomy.me.uk website or by contacting me using the “contact us” page on that website.

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https://greenbankobservatory.org/about/telescopes/20m/

Laurent Chemin, Claude Carignan and Tyler Foster – H I Kinematics and Dynamics of Messier 31
https://arxiv.org/pdf/0909.3846v1.pdf

Radio Skynet. https://www.danreichart.com/radio

Society of Amateur Radio Astronomers. https://radio-astronomy.org/

S. Z. Kam, C. Carignan, L. Chemin, T. Foster, E. Elson, T. H. Jarrett – H I Kinematics and Mass Distribution of Messier 33 https://arxiv.org/pdf/1706.04248.pdf

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

Two bright star-forming regions of Cygnus X observed in several species

by Dimitry Fedorov UA3AVR

Common and introductory notes, info about observed regions

This report is about observation of two bright star-forming regions, DR21 and IC1318 (also known as γ Cygni nebula, Sadr region, Butterfly nebula) with 20 m Green Bank telescope in Skynet Network, see the telescope dish in Figure 1 and resources with Skynet user info in [1,2]. Both regions are parts of huge star brewing complex Cygnus X, see its infrared image by Spitzer cameras in Figure 2. They are observed in HII hydrogen radio recombination line H166α (1424.7 MHz) and hydroxyl OH molecular lines 1665 and 1667 MHz. These lines can work as tracers of star-forming regions; spots of ionized hydrogen can be well seen by its recombination emission.

Figure 1. Green Bank 20 m telescope dish.

Radio recombination lines (RRL) of ionized hydrogen HII are too weak to be detected even by a 20-meter antenna in the L-band.

Nevertheless, the angular size of observed regions can be large enough to fill the antenna beam making their detection in RRLs possible. The Cygnus X itself is large

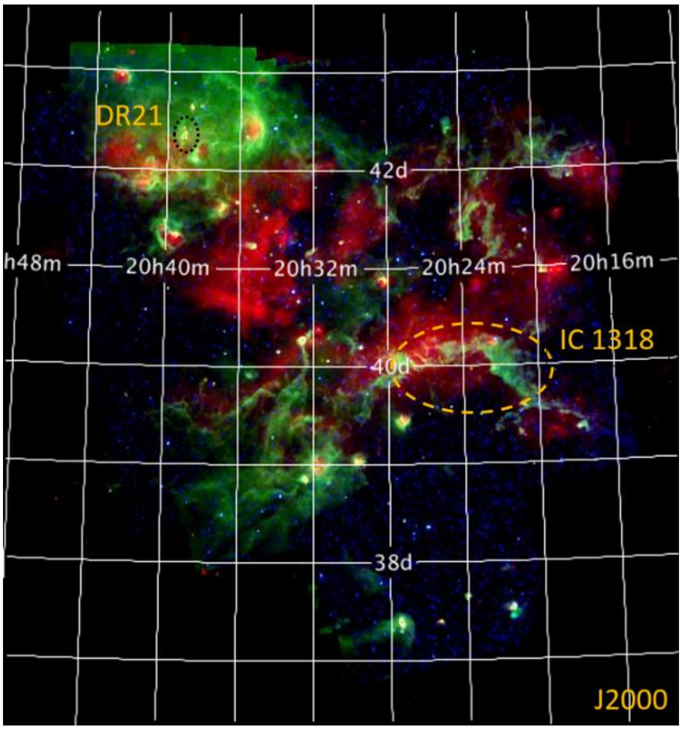


Figure 2. Infrared image of Cygnus X star brewing complex. Picture taken from https://irsa.ipac.caltech.edu/data/SPITZER/Cygnus-X/. Colors are by Spitzer's infrared cameras 3.6 μm (blue), 8 μm (green) and 24 (red) μm.

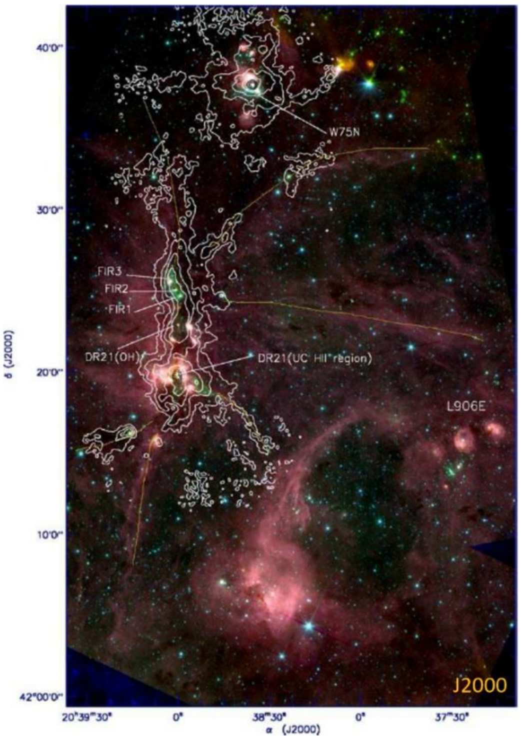


Figure 3. Detailed view of DR 21 region in infrareds and sub-millimeters. Colors are by Spitzer's infrared cameras 3.6 μm (blue), 4.8 μm (green) and 8 μm (red), contours – 850 μm (SCUBA JCMT) [4].

enough (about 5° of angular size) to fill the beam of a small single dish giving a chance for its detection in L-band RRLs by amateur means [3].

Locations of both observed regions are also shown at Figure 2. The size of DR21 regions was approximately marked according its infrared and sub-millimeter sizes, see Figure 3. Distance to the region is about 2-3 kpc, many of HII compact spots were detected there, far-infrared (FIR) luminosity 1.5×10^5 L⊙ [4]. The shape of DR21 appears elongated, especially in far-infrared, sub-millimeter and millimeter waves, what can be well seen in images Figure 4.

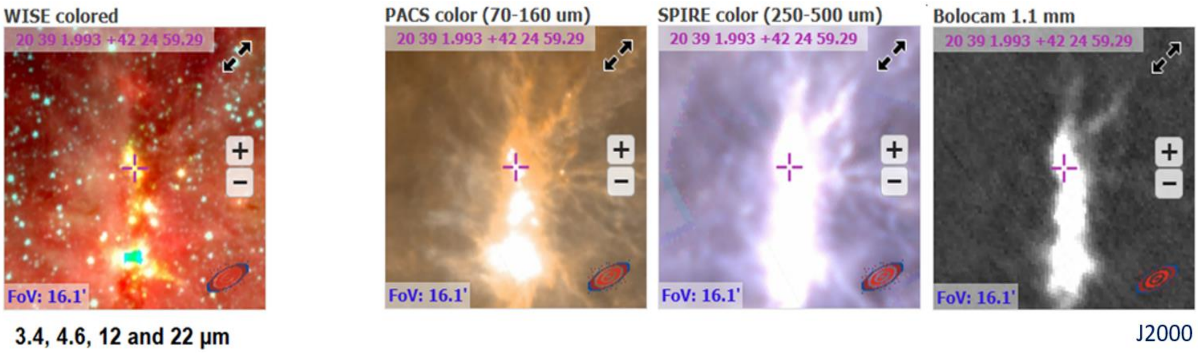


Figure 4. Infrared, far-infrared, sub-millimeter and millimeter wave images of DR21. Pictures were taken from https://maserdb.net/object.pl?object=G81.764+0.596.

As expected, the HII cloud containing DR21 is larger than the elongated in FIR region on Figure 3 and Figure 4 and can fill the antenna beam enough for detection. DR21 and regions around are forming the brightest RRL spot in Cygnus X as follows from comparison Fig. 1 and Fig. 3 in [5] and also from the fact that nearby recombination lines (like H165α, H166α, H167α) have comparable brightness.

Figure 6. Sadr region in 3 colors: red – sulfur SII, green – hydrogen Hα, blue – oxygen OIII (celestial north is approximately at the top), [Universe with Dr Dave, New image IC1318](#)

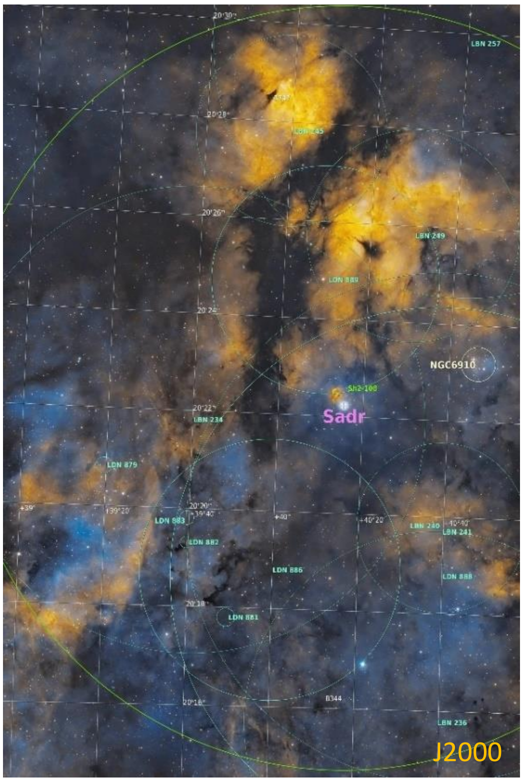


Figure 5. Sadr region in 2 colors: orange – hydrogen Hα, blue – oxygen OIII, [Achint Thomas photography, Astrophotography: The Butterfly nebula](#).

The region IC1318 is well seen visually and popular among astrophotographers (amateur astronomers), many impressive and fascinating images were released, see Figure 6 and Figure 5. Images were shot with narrowband filters for different optical lines.

The nebula IC1318 was formed after supernova SNR G78.2+2.1 explosion about 10 000 years ago; the pulsar PSR J2021+4026 in the region is also considered as this supernova remnant. This pulsar is seen in gamma rays and X-rays, has period about 265 milliseconds with observed glitches, and is quiet in the radio frequencies [6]. Its radio silence can be explained by the gamma ray jets might be wide, but radio jets are narrower and missing the Earth with no radio detections.

The Sadr star is not physically associated with the nebula; it is located much closer to us. Infrared pictures of IC1318 can be succeeded from whole Cygnus X images. IC1318 is divided to A, B and C parts. As expected, B and C are forming a spot of RRL emission in Cygnus X, which is rather bright in L-band as follows from comparison Fig. 1 and Fig. 3 in [5].

For more info about radio recombination lines (RRL) see [7] and [8], ch. 14.3. This report is based on single observations, but molecular emission from star-forming regions is often variable, and a lot of info could be extracted from periodic observations of molecular lines. Molecular emission can be with maser amplification and not; moreover, an absorbption of background comtinuum radiation in molecular clouds may occur with appearing of molecular apsorption lines [9].

Present L-band receiver of the telescope provides data in two linear polarizations only, not circular. Nevertheless, this gives additional opportunity to reduce background noise by averaging the two polarizations, what especially important for detecting weak sources.

Instrumentation and observation parameters.

Instrument characteristics were adopted form calibration procedures made for OH/IR star observation in May 2025 [10]. They are collected in **Error! Reference source not found.**.

Table 1. Parameters of the telescope and observations

Dish diameter	**D**	20 m
Aperture Efficiency	η_A	0.6*
Main Beam Efficiency (calculated from $\eta_B \approx \eta_A/0.75$ [11])	η_B	0.8
System Temperature	$\mathbf{T_{sys}}$	60 K (X-pol), 62 K (Y-pol)
Forward Gain (dish sensitivity)	$\mathbf{\Gamma}$	0.068 K/Jy
System Equivalent Flux Density (=$\mathbf{T_{sys}}/\Gamma$)	SEFD	880 Jy (X-pol), 910 Jy (Y-pol)
Half Power Beam Width (HPBW)	θ_{HPBW}	0.73° (H166α), 0.63° (OH lines)
Resolution in velocities (H166α, 1424.7 MHz)		≈ 3.2 km/s
Resolution in velocities (OH, 1665 MHz and 1667 MHz)		< 3 km/s
Integration Time	Δt	200 s

*Supposed value. ChatGPT have founded the same value for η_A of 20 m Green Bank dish with L-band receiver.

The System Temperatures $\mathbf{T_{sys}}$ for both linear polarizations were obtained from wideband calibration with Cygnus A source. The L-band receiver in Skynet was tuned in High Resolution Data Acquisition Mode with 1024 channels. Path Type of the telescope was set as "Track" with Duration 200 s; this setting provides the integration time Δt for observed sources 200 s.

Spots of hydrogen RRL emission are presumably extended sources. The Antenna Temperature $\mathbf{T_a}$ induced by the extended source with Brightness Temperature $\mathbf{T_B}$ is (see [8], ch. 8.2.3)

$$T_a = \eta_B \, f_{Beam} \, T_B \,, \tag{1}$$

where $\mathbf{f_{Beam}}$ – the Beam Filling Factor, $\boldsymbol{\eta_B}$ – the Main Beam Efficiency. The Beam Filling Factor shows how much the source fills the antenna beam. If the beam and sources are Gaussians $\mathbf{f_{Beam}}$ is given by

$$f_{Beam} = \frac{\theta_s^2}{\theta_s^2 + \theta_{HPBW}^2} \,, \tag{2}$$

where θ_s – the source angular size by ½ of brightness, θ_{HPBW} – the Half Power Beam Width of antenna.

The sizes of observed regions was estimated from the H166α map of Cygnus X, Fig. 3 [5], see Figure 7. **Error! Reference source not found.** gives calculated Beam Filling Factors and expected antenna temperatures according the source brightness form this map. In addition, the Beam Filling Factors were calculated for hydroxyl OH lines in assumption that OH molecular clouds have the same size as RRL spots, see **Error! Reference source not found.**.

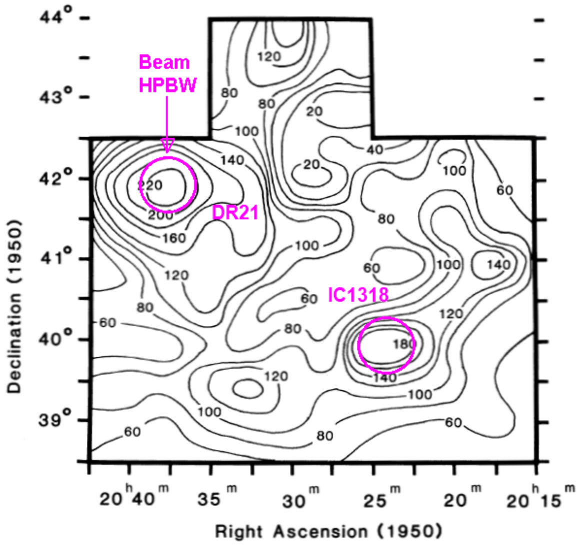


Figure 7. Cygnus X map in H166α [5], Fig. 3. Contours – brightness T_B isotherms in mK. Magenta cycles shows the antenna beam size HPBW and pointing to the observed regions.

Table 2. Beam Filling Factor and expected Antenna Temperatures for H166α line.

	Source size, θ_s	Beam Filling Factor, f_{Beam}	Exp.Antenna Temperature, T_a
DR21	1.3°	0.76	0.15 K
IC1318	0.8°	0.55	0.1 K

Table 3. Beam Filling Factors for OH lines.

	Source size, θ_s	Beam Filling Factor, f_{Beam}
DR21	1.3°	0.81
IC1318	0.8°	0.62

The Beam Filling Factors for OH lines can be useful for estimations of absorption in OH clouds and, possibly, emission of OH clouds when they are considered as extended sources.

The conversion of observed Antenna Temperatures into source Brightness Temperatures is based on the inversion of formula (1). In practice, the multiplier $T_{sys}/(f_{Beam}\ \eta_B)$ is applied to the Skynet output spectral data after the background noise levels have been normalized to 1. Values in flux density units (in Jy) can be obtained with multiplier =SEFD after such normalization when the source is considered point-like.

Observation results:

H166α line from DR21 and regions around

The result of averaging of X and Y linear polarizations is shown on Figure 8. The peak value of the line in Brightness Temperatures T_B is higher than expected.

Raw Skynet data are available here, observations 2025-07-04.

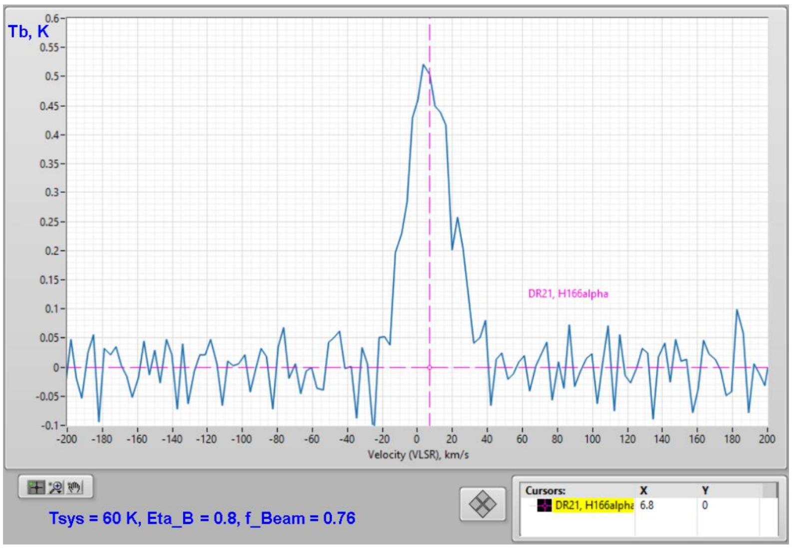


Figure 8. RRL line H166α from DR21 and around.

OH 1665 MHz line from DR21 location

The result of averaging of X and Y linear polarizations is shown on Figure 9 and Figure 10. This emission line has obtained from the simultaneous observation as the RRL line H166α above. Its peak might not coincide with a maximum from the region.

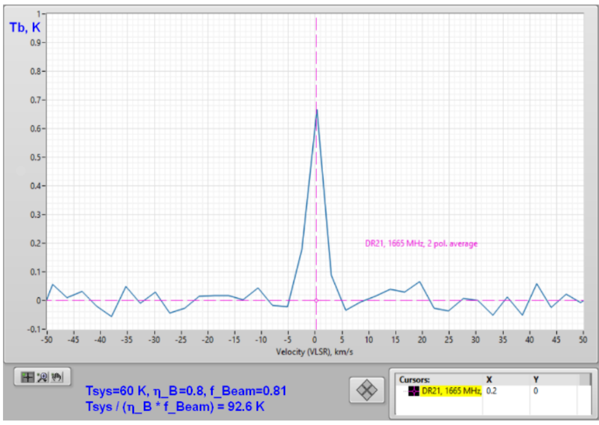


*Figure 9. OH 1665 MHz line from DR21 location in Brightness Temperatures **T**$_B$.*

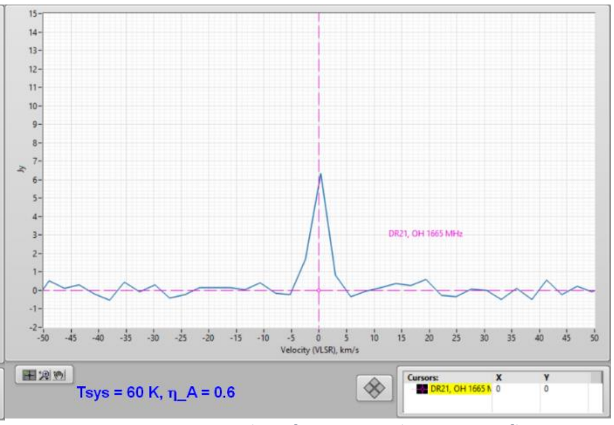


Figure 10. OH 1665 MHz line from DR21 location in flux density units (Jy).

Figure 9 presents the line in Brightness Temperatures in assumption that the source (OH cloud) has the same size as the H166α DR21 spot. Figure 10 presents the line in flux density units in assumption that the source is point-like. The antenna beam is rather wide, and it is possible the beam sees nearby located OH maser from W75 region as it follows from maserdb.net data, https://maserdb.net/object.pl?object=G81.764+0.596.

OH 1667 MHZ line from DR21 location

The result of averaging of X and Y linear polarizations is shown on Figure 11; this line has obtained from the simultaneous observation as the RRL line H166α above. This is an absorption line; its backoff is presented in Brightness Temperatures. This absorption line is plotted on Figure 11 in assumption that the source (OH cloud) has the same size as the H166α DR21 spot.

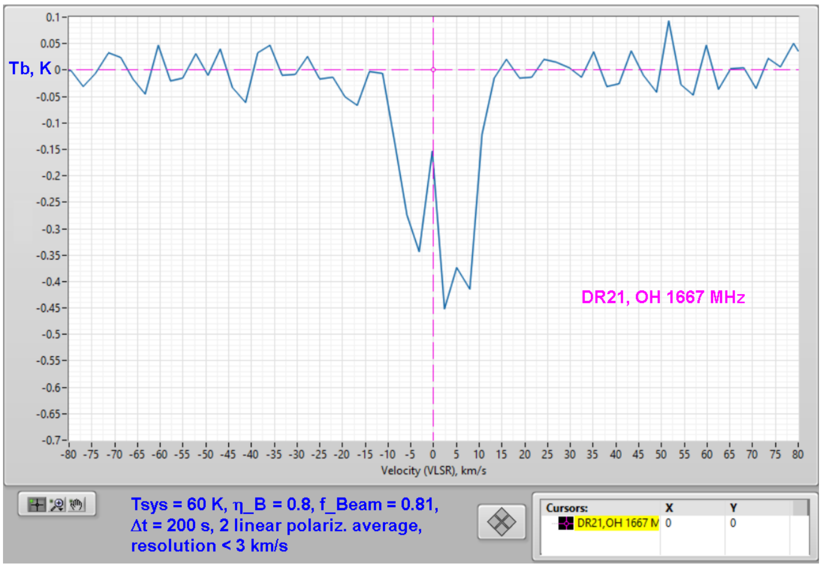


Figure 11. OH 1667 MHz absorption line from DR21 and around.

This line has obtained from the same observation as the RRL line H166α above. The backoff on the Figure 11 spectrum might not coincide with possible deepest one from the region.

H166α line from IC1318

The result for X and Y linear polarizations is shown on Figure 12 and Figure 13. Raw Skynet data are available here, observations 2025-07-25. Results for linear polarizations are unexpectedly different; in the X-polarization plot only a trace of the line is guessed under the background noise peaks. The lines are presented in Brightness Temperatures **T**$_B$; max of Y-polarization line is higher than expected.

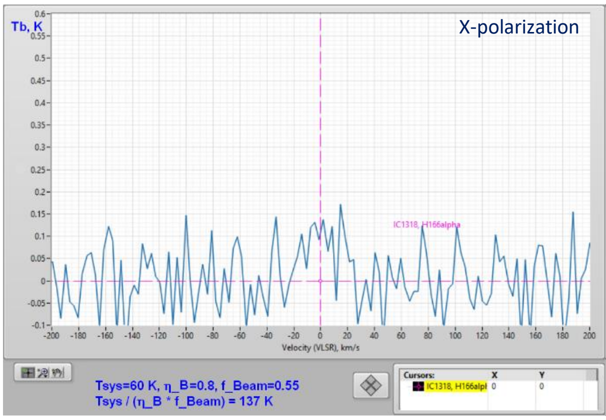


Figure 12. A trace of H166α line from IC1318 under the background noise peaks, X-polarization.

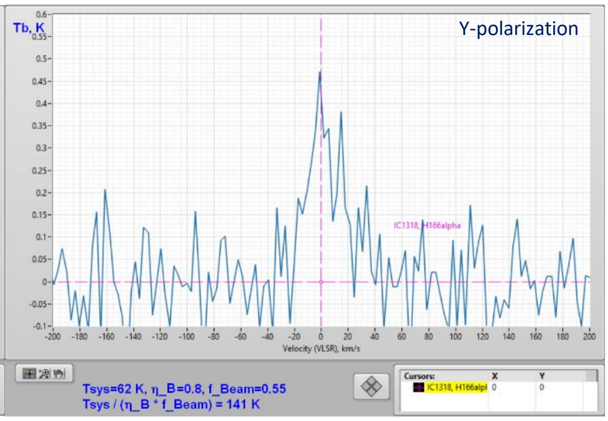


Figure 13. H166α line from IC1318, Y-polarization.

The difference of levels in both polarizations may occur because of malfunction in the receiver; however, no traces of malfunction were found in previous and following Skynet observations of other SARA users.

OH 1665 MHz lines from IC1318

The result for linear X- and Y-polarizations is shown on Figure 14 and Figure 15. These results have obtained from the simultaneous observation as the RRL line H166α from IC1318 above.

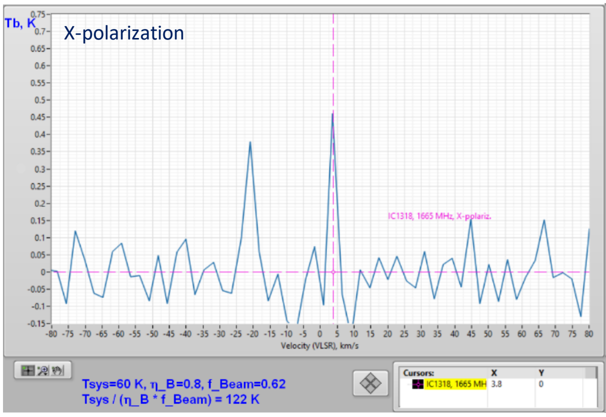


Figure 14. Spectrum around expected OH 1665 MHz line from IC1318, X-polarization.

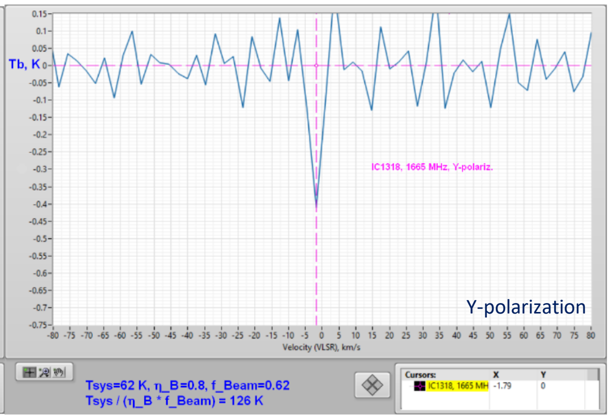


Figure 15. OH 1665 MHz line from IC1318, Y-polarization.

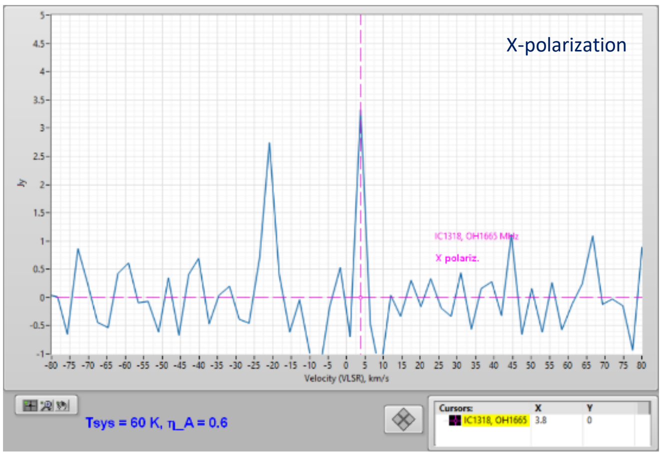


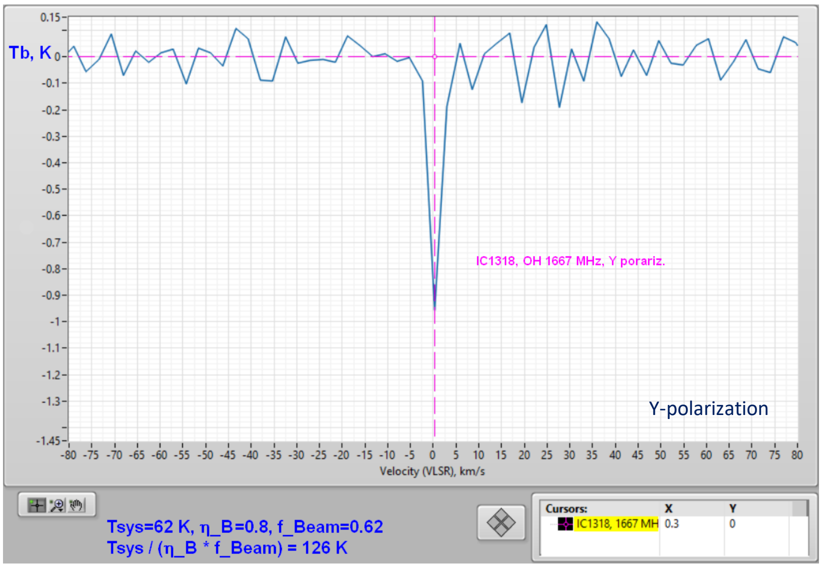
Figure 16. Spectrum around expected OH 1665 MHz line from IC1318, X-polarization in flux density units.

The X-polarization spectrum looks like if the emission OH 1665 MHz line is detected; but y-polarization spectrum tells about presence the absorption line. The peak brightness on Figure 14 might not coincide with a maximum from the region if this a real emission line, not RFI or a receiver malfunction in X-polarization. The Y-polarization spectrum looks like a real absorption line; its sharp spike can be explained by low plot resolution about 3 km/s.

The backoff in the absorption line Figure 15 might be not coincide with possible deepest one from IC1318. Figure 14 and Figure 15 presents the lines in Brightness Temperatures in assumption that the source (OH cloud) has the same size as the H166α IC1318 spot. The spectrum of emission about 1665 MHz like if it comes from a point-like source is shown on Figure 16.

OH 1667 MHZ absorption line from IC1318

The result for Y-polarization is shown on Figure 17. This line has obtained from the simultaneous observation as the RRL line H166α from IC1318 above. This is an absorption line presented in Brightness Temperatures. This absorption line is plotted in assumption that the source (OH cloud) has the same size as the H166α IC1318 spot.



The backoff on the Figure 17 spectrum might not coincide with possible deepest one from the region.

There was no even a trace of the line beneath the noise peaks in the X-polarization.

Summary and concluding notes

Two star-forming regions, DR21 and IC1318, were observed in the following species: the radio recombination line H166α and the OH hydroxyl molecular lines at 1665 and 1667 MHz. Observations were conducted using the Green Bank 20-meter dish, operated by Skynet.

Radio recombination lines are typically weak, even for this telescope, but the spatial extent of the emitting regions can fill the antenna beam, making them detectable. While DR21 is not particularly large in angular size in the infrared, its H166α emission region is wide enough to fill the beam.

Obtained brightness temperatures in H166α lines are higher than expected, suggesting a possible overestimation of the system temperature $\mathbf{T}_{sys}$. The $\mathbf{T}_{sys}$ values were obtained from calibration procedures using the standard source Cygnus A, located near the observed regions [10].

Skynet allows for simultaneous observations in two different frequency bands (in high-resolution mode, a secondary frequency can be selected). The OH hydroxyl lines were observed concurrently with the H166α line. However, since the antenna beam was centered on the H166α emission regions, it may not have been aligned with the maximums of OH emission or the deepest absorption backoffs.

The OH hydroxyl lines were presented in brightness temperatures $\mathbf{T}_B$ in assumption that the OH clouds have the same size as H166α spots. In additions, the emission lines were presented in flux density units (in Jy) like when they came from point-like sources. The antenna beam is rather wide, and the line 1665 MHz from DR21 region and around has probably its source in nearby located W75 region.

The OH lines were reported in brightness temperature $\mathbf{T}_B$, assuming the OH clouds have the same spatial extent as the H166α regions. Additionally, the emission lines were converted to flux density units (Jy) under the assumption of a point-like source. Given the wide beam, the 1665 MHz line near the DR21 region likely originates from the nearby W75 region.

A strange behavior of spectral lines from IC1318 was observed. Substantially different spectra were obtained in different linear polarizations X and Y. The Y-polarization results can be considered confident, showing clear detections of the H166α line and OH absorption features at 1665 and 1667 MHz. In contrast, the X-polarization data were drastically different: only a faint trace of the H166α line was visible beneath the noise, the 1665 MHz OH line exhibited a possible double-peaked emission feature (unless it was RFI), and nothing was detected at 1667 MHz. This discrepancy could indicate a malfunction in the Skynet receiver's X-polarization channel, though no such issues were found in previous or subsequent observations by other SARA users.

Acknowledgments
To Stephen Tzikas for maintaining Skynet services for SARA members.

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About the author

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

Observation Reports

Observations of Meteors
Using HF and Low VHF
Signal Source

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grro@sbcglobal.net

Meteor Observations are possible using signal sources in the HF and low VHF bands.

Listed below is a table of sources used and quality of the signal rating when observed using a discone antenna and a HackRF SDR receiver.

HF and Low VHF Signal Sources – Updated 7-24-2025 - Order by Name

Name	Frequency (MHz)	Rating	Comments
AMOR	26.20	*	New Zealand Not always detectable
CMOR	17.45 29.85 38.15	** ***** ***	Located in Ontario, Canada
Davis MST Radar	1.94 32.55 33.2 55.0	* *** *** *	Davis Station, Antarctica
HAARP	2.7 ~10.0	*	When active
HRMP	40.92	*	Harvard Radio Meteor Radar
Kyoto	31.57		Meteor Radar Japan
JORN	8.992 10.153 22.950	* ** ****	Australian RAAF OTH Radar
Jicamarca Incoherent Scatter Radar	49.9	**	Lima, Peru
McMurdo	36.17	**	Antarctica
Nostradamus	20.500 29.294	**** *	French OTH, military, reported on other frequencies.
Pluto II	25.380	**	RAF Cyprus OTH Radar
ROTHR	---		US Navy, frequency hopping OTH radar. Not useful for meteor work.
SAAMER	32.55	*	Southern Argentina Meteor Radar

Notes:

- One “*”, it is detectable, “****” it is very good most of the time.

-Yes the “sweet spot” for this type of observation is ~40 to 100 MHz, but with powerful signal sources you can use lower frequencies.

-This is not a complete list; any signal source with a CW emission can be used, this includes weather FAX sources in the HF band.

Software:

The best software I have found for collection of data is “HROFFT”, but there are a number of other programs available for this type of observation. You can down load HROFFT100f.zip from this web page:

Colorgramme Lab Software:
http://radio.meteor.free.fr/fr/logiciels.html#3

I also use Stellarium 0.21.3 for analysis of events; this shows most of the major and many of the minor meteor showers. The web page is listed below.

Stellarium:
https://stellarium.org/

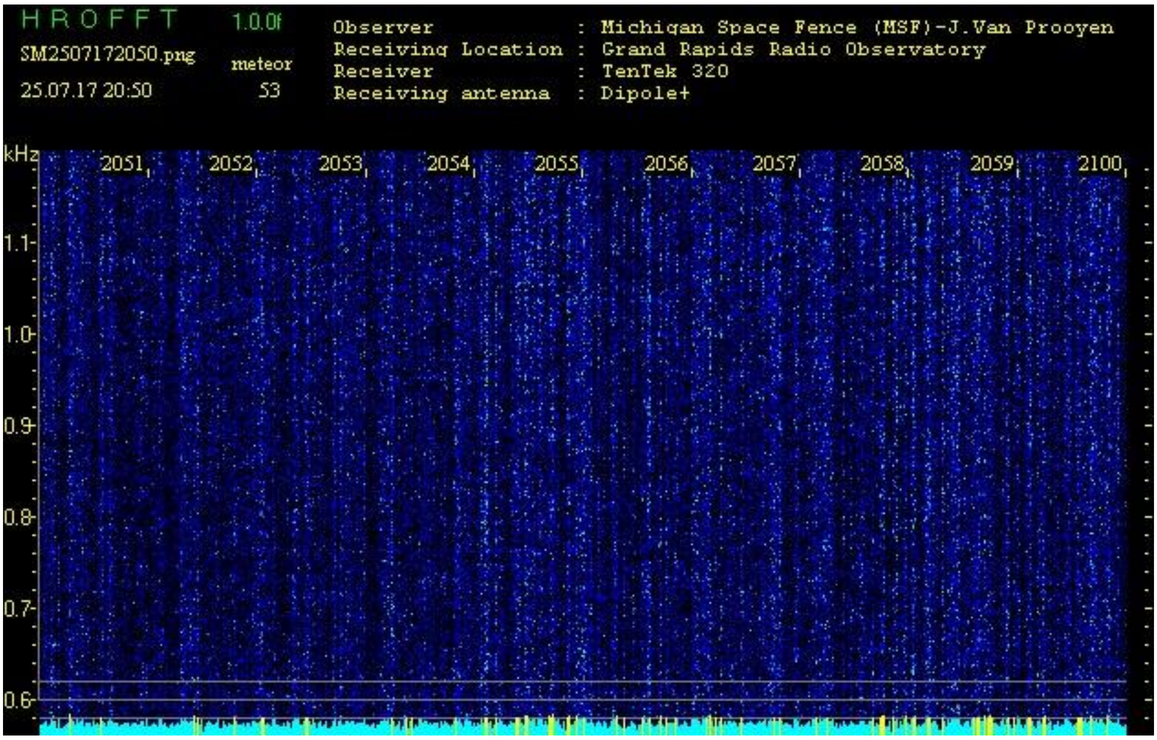
Setup:

Using a dipole antenna, a HF receiver (Ten Tec RX-320), the audio from the receiver is used as an input to the computer with HROFFT being used to collect the data. I monitor CMOR (see table above for information); 24 x 7 looking for meteor events.

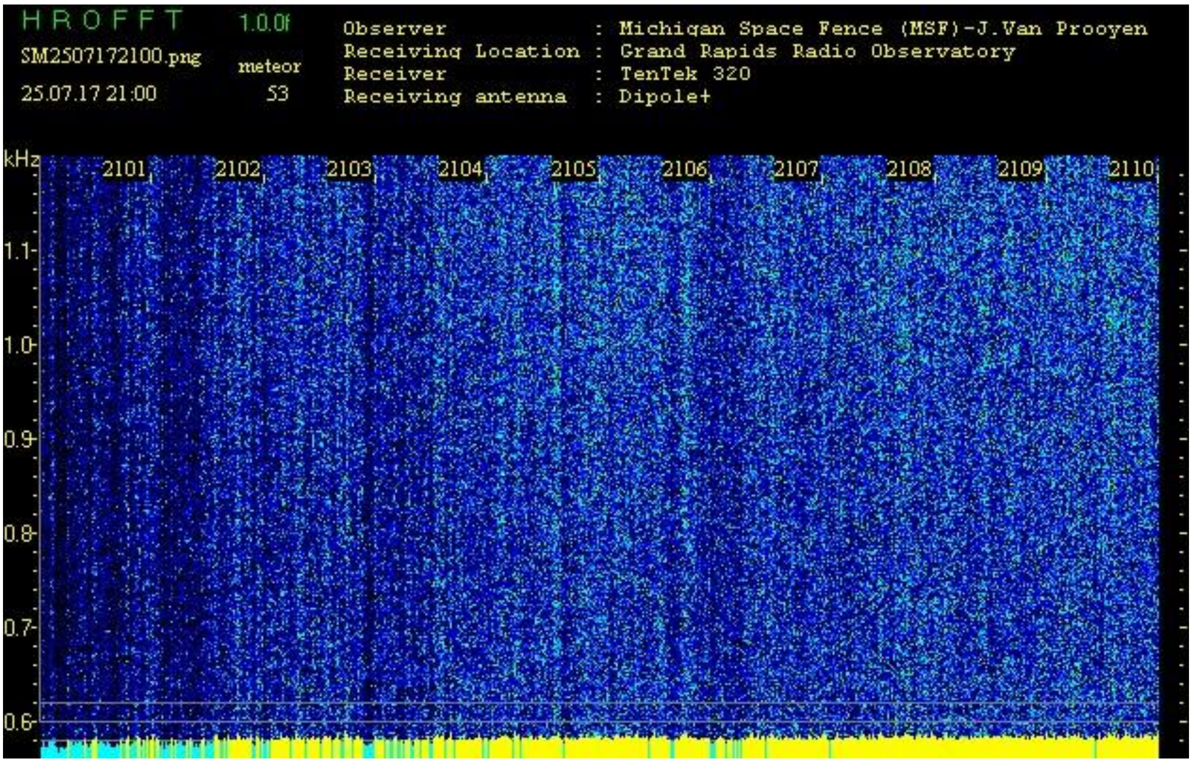
Results:

One of my areas of research is looking for “meteor storms” or “meteor outbursts”. Shown below is such an event. Note each plot is a 10 minute segment.

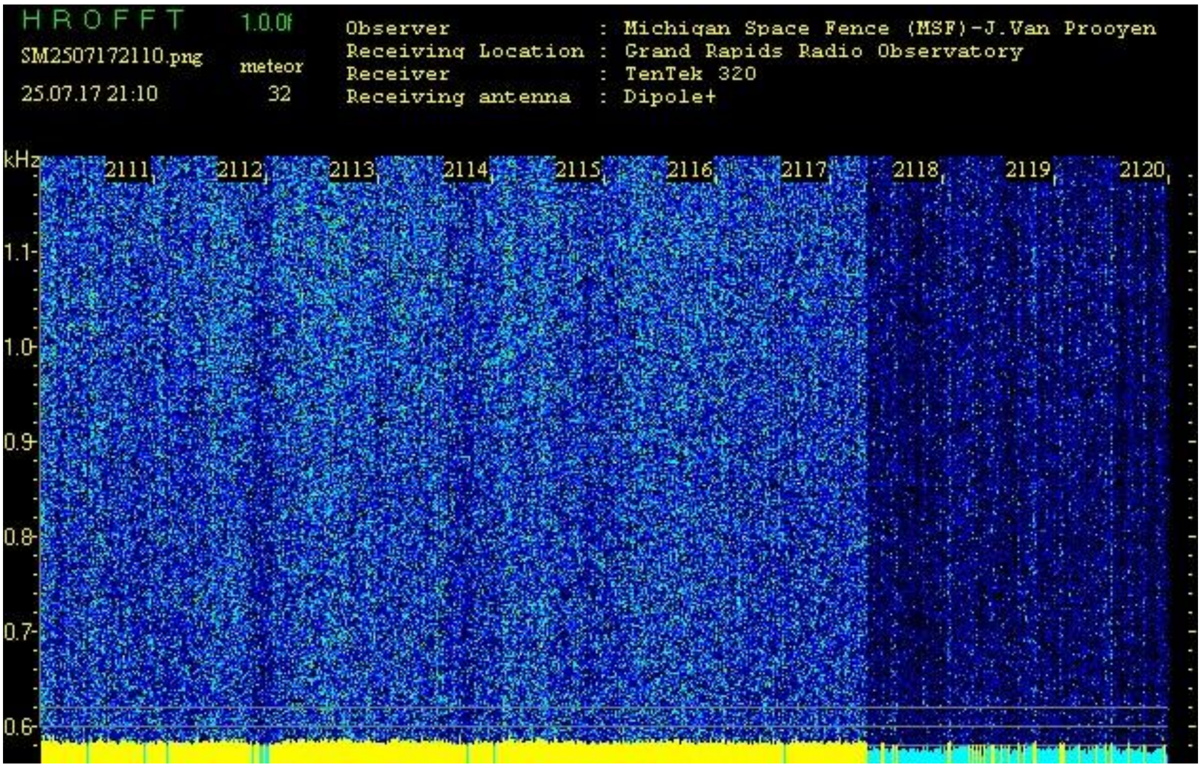
The plot below shows normal background before the onset of the event.



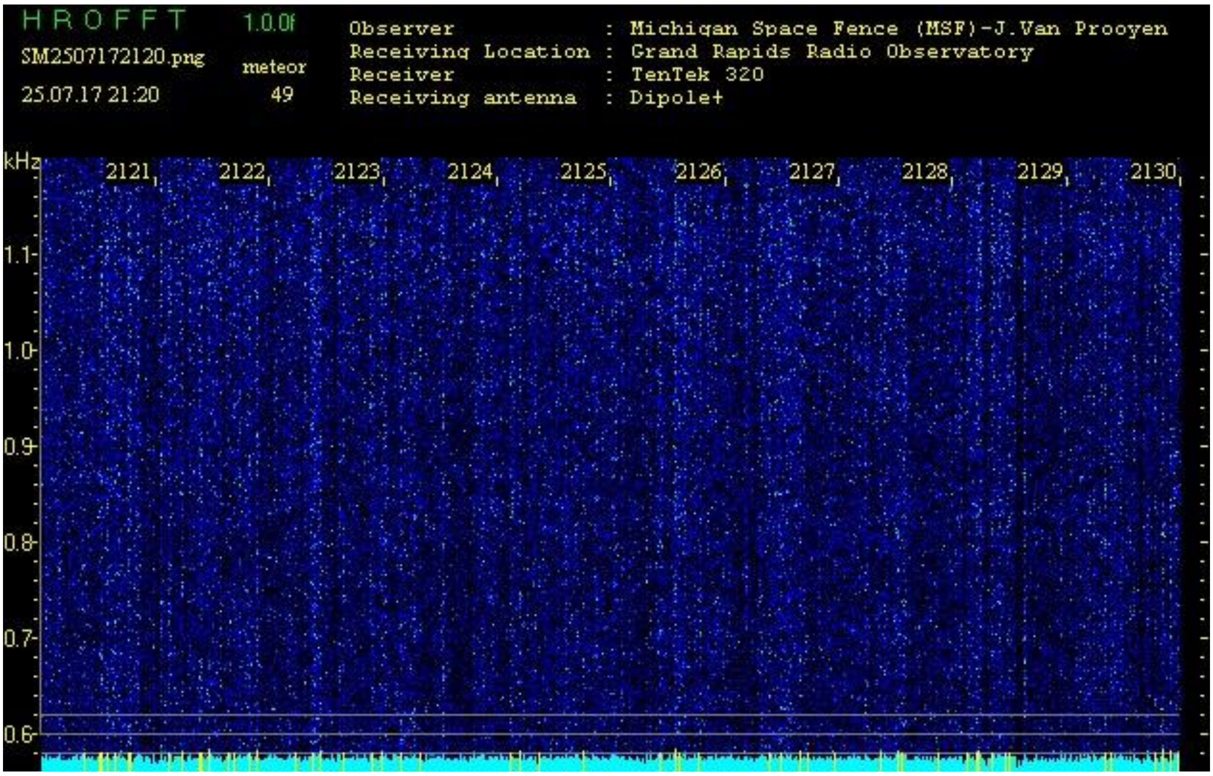
The plot below shows the start of the meteor storm. Note that the software cannot correctly count the number of meteors due to the large number of meteors detected.



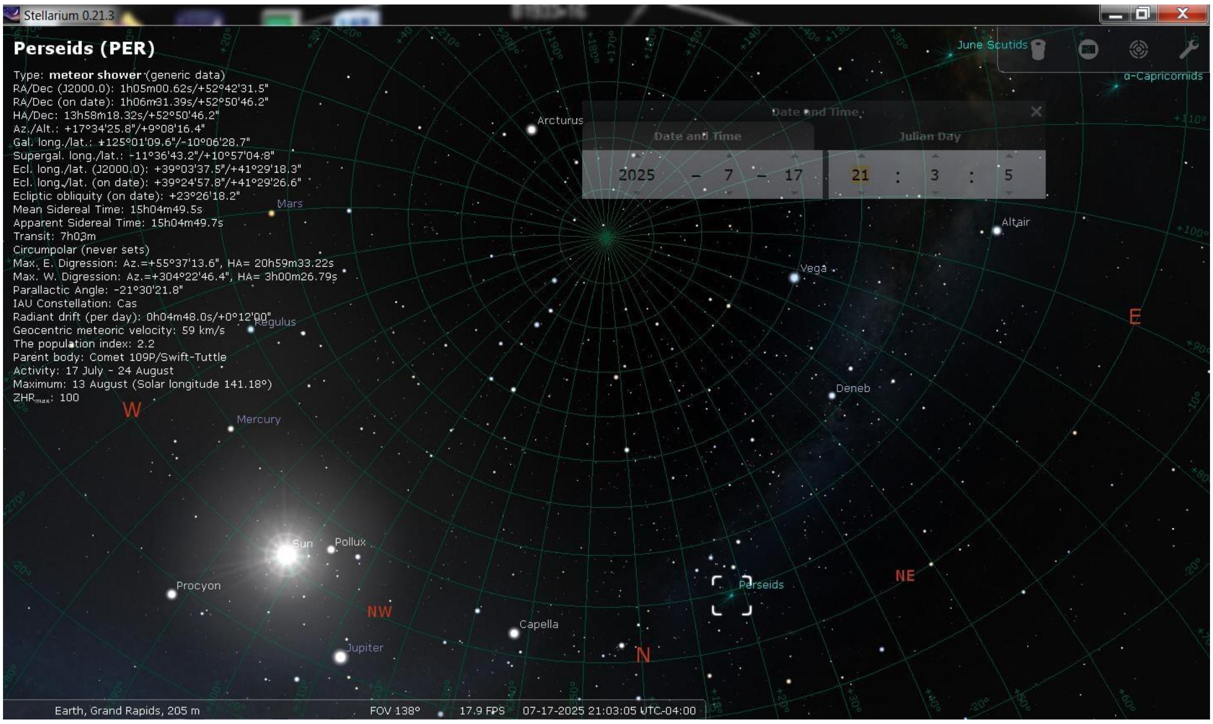
The plot below shows the end of the meteor storm. Note the end is sometimes very abrupt as the Earth passes through the edge of the meteor storm.



This plot shows a return to normal background.

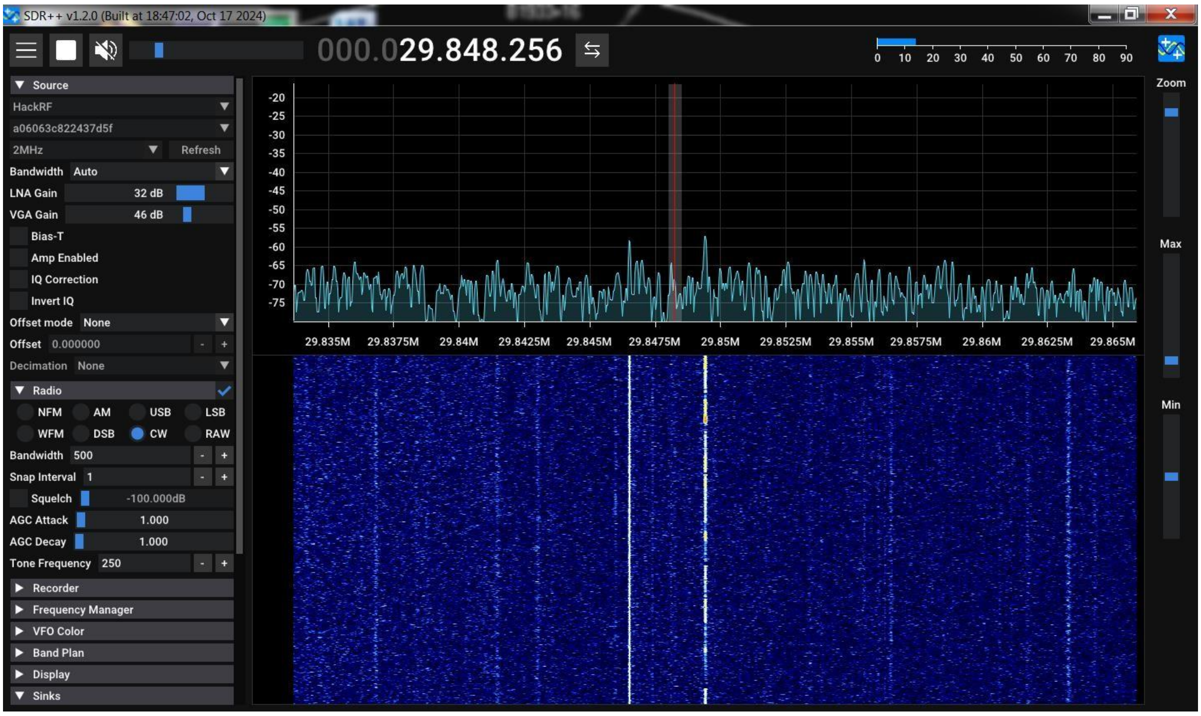


Analysis is done to find the meteor shower that may have generated the meteor storm.
In this case Stellarium was used, an example is show below:



In this case it appears that the meteor shower that generated the meteor storm may have been from the Perseids meteor shower. We have seen meteor storms that had no associated meteor shower. These may be indicators of an unknown (i.e. “new” meteor shower) or an old meteor shower that has re-appeared.

Background Information:
If you are located in the eastern part of the US or Canada a good signal source is CMOR. Shown below is output from my HackRF SDR receiver connected to a discone antenna showing CMOR’s 29.85 MHz signal.



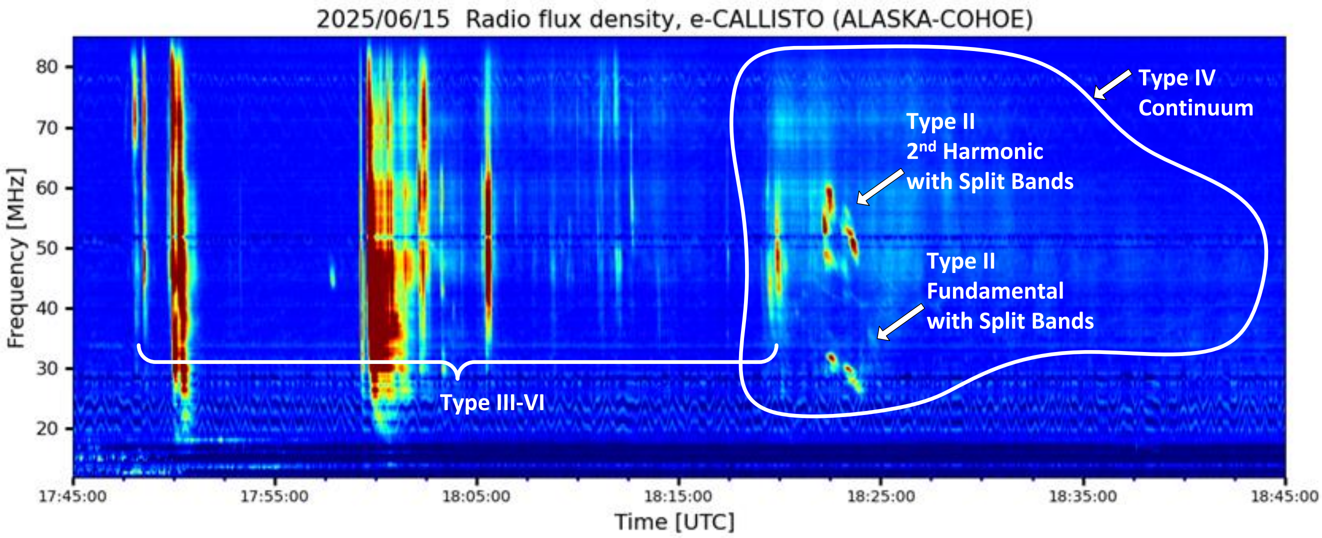
Summary:

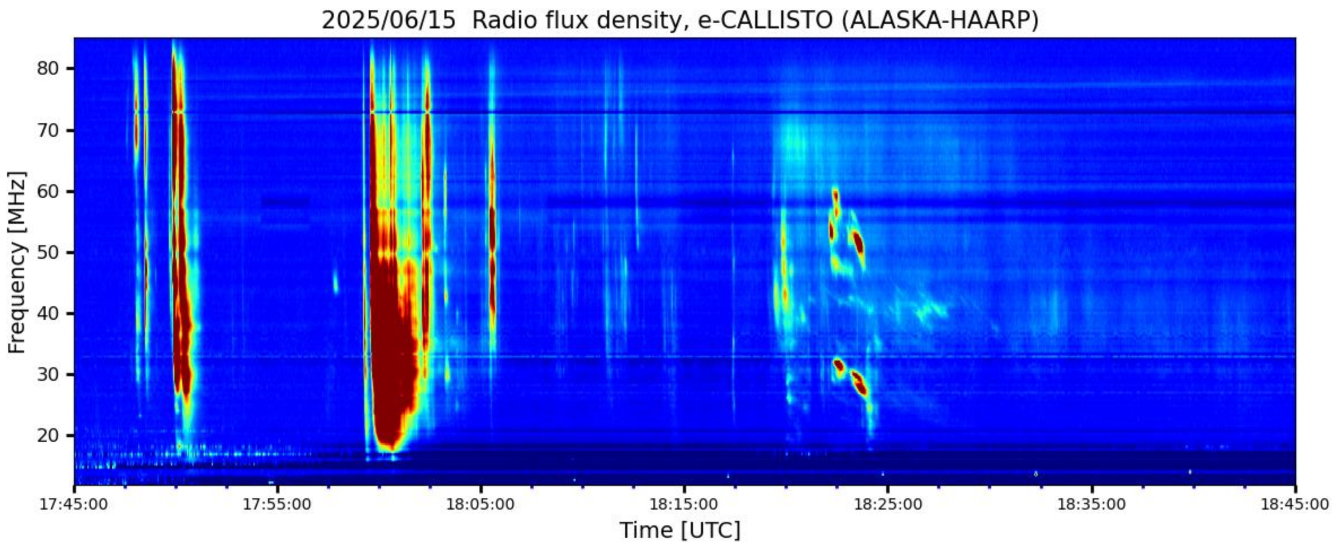
These plots demonstrate that meteor work can be done with signal sources that normally have other uses. In fact almost any signal source that is a "CW" (Continuous Wave) signal can be used for meteor observations.

Solar Radio Observations in Alaska on 15 June 2025

Whitham D. Reeve & Christian Monstein

An M8.4 solar x-ray flare was observed by Space Weather Prediction Center (SWPC) at 1745 and followed over the next hour by numerous radio emission events including Type II, III, IV and VI covering a very wide frequency range; definitions of solar radio burst types follow the spectrogram images below. The spectrograms were recorded by Callisto instruments at Cohoe and the HAARP facility near Gakona. Both stations are in Alaska and part of the e-CALLISTO Solar Radio Spectrometer Network {https://e-callisto.org/index.html}.





Spectrograms from Cohoe (upper) and HAARP (lower). The Cohoe spectrogram has been annotated. A Type III fast radio sweep occurred first at about 1748. Another Type III event that occurred about 1800 looks close to a Type V (Type III with continuum). The entire sequence of Type III emissions are classified as Type VI because they lasted at least 10 minutes with no break more than 30 minutes. The Type IV continuum starts about 1800 and continues through the end of the image. The Type II first appears about 1820 as blotchy spectra with a 2nd harmonic and what appears to be split bands.

Type II: Slow frequency drift bursts usually accompanied by a second harmonic and lasting 3 – 30 minutes. The upper frequency of the fundamental can reach 150 MHz while the lower frequency observed on the ground is between 5 and 20 MHz depending on the local ionospheric cutoff frequency. The source of a Type II emission generally is accelerated plasma mass that produces a magneto-hydrodynamic shockwave as it passes through the corona. Type II emissions are unpolarized.

Type III: Fast frequency drift bursts that occur singularly, in groups, or storms often with underlying continuum and sometimes accompanied by a second harmonic. Single Type III bursts last 1 – 3 seconds whereas a group can last 1 – 5 minutes. Storm durations are minutes to hours. The frequency range can be as high as 1 GHz but the lower frequency depends on the local ionosphere at the ground observation location. Type III bursts originate at active regions and flares through a relativistic electron beaming process that is not yet fully understood. Type III emissions can be moderately polarized. The bursts discussed here all originated at the same active region (4114).

Type IV: Broadband, smooth continuum lasting 0.5 to 2 hours, sometimes with slow frequency drift. Frequencies can reach the lower UHF. As with other solar radio phenomena, the lower frequency observed on the ground is limited by the ionosphere. The sources of Type IV emissions are flares and proton emissions and eruptive prominences that produce magneto-hydrodynamic shockwaves in the solar corona.

Type VI: Series of Type III bursts over a period of 10 minutes or more, with no period longer than 30 minutes without activity.

Discussion:
The lower frequency limits of the solar radio emissions recorded by a ground station are limited by the local ionosphere. It is noted that the limit at HAARP is slightly lower than at Cohoe, a characteristic often observed and possibly due to an ionospheric trough above the higher latitude HAARP facility. The overall morphology, or structure, of the received radio emissions is very similar at the two locations even though they are 400 km apart. Any differences could be accounted for by differences in the antenna and receiver sensitivities as well as the ionosphere. The spectrograms span the times when the two locations were in the solar dawn to noon sectors, equivalent to mid-morning and local solar times of 9:45 to 10:45 am.

References:
e-CALLISTO: https://e-callisto.org/index.html
Solar Radio Emissions at HF and VHF/UHF: https://reeve.com/Solar/Solar.htm

Acknowledgement for data use: Institute for Data Science FHNW Brugg/Windisch, Switzerland
Acknowledgement for Python code: Spectrograms produced by Christian Monstein

Observation Report
AD8302 Super Simple Interferometer
Survey of Southern Sky around 1800 RA

Otte Obs 90W 42N

by Mike Otte

mike.ott96@gmail.com

During the Fall of 2024, I was following the progress of Jan Lustrup on Facebook Amateur Radio Astronomy site and he published his list of successful observations of radio sources. Included in his list were some sources he had not achieved yet. All were near RA 1800. I sent him a comment that these source were pretty close to strong sources NGC6618 and CTB52 and would be hard to resolve. Also he would have to wait for a different time of year to get away from the Sun's interference.

My interferometer consists of 2 x 3M solid TVRO dishes 10.6 M apart, 2 x NooElec Sawbirds on each dish, feeding a AD8302 phase detector with a 1000X gain opamp and measured by a 16F17145 PIC microcontroller with 12bit A/D and DS3231 clock. The microcontroller does measuring, smoothing, time keeping (in sidereal time), data line forming, which is sent serially to a terminal program which logs it into a file. Logging in RA saves time converting from UT or LT. Saves steps in the analysis and figuring out the day of the data when crossing 0000 UT. My interferometer has been working reliably and sensitive to some radio sources as low as 50 Jy. I don't have a choice in frequency because I don't use a SDR but only the bandpass filters in the Saw Birds.

At the end of May 2025, I decided to see if I could resolve the relatively strong radio sources in the RA 1800 area and declination below -10. I went over a few other radio source lists including 3C, CTA, CTB, Westbrook and picked out the stronger sources in the southern sky. These were 100 Jy and above. I realized the surveys were at other frequencies like 960 Mhz but still felt we might have a chance.

This is not like Hydrogen surveys where you are looking at HI mainly in the Milky way. Here you are measuring continuum and plotting the relative strength as you drift scan across the sky creating a picture of the Milkyway. Also, HI measurements include spectrum and the doppler velocity of the HI you are looking at.

Doing simple interferometry, you're measuring position of the source. We are not forming images.

When the HI signal is detected with both dishes, it locks on and gives a cosine wave whose period (Fringe Period) is mathematically related to the declination and whose amplitude can be related to the brightness of the source.

To measure fringe period, I have a Python program that plots the data in 1 hour segments and makes a list of peaks according to time. From this list of peaks I subtract one from another and get the Fringe Periods. Then I use a Libre Calc chart to lookup the declination. Looking at the chart it is obvious which are the good peaks, and which are noise. Also, python has parameters in the "peak" equation that determines how much higher than the surrounding data and how wide the peaks must be.

Taking several fringe periods and averaging them also helps with noise.

I did try feeding the fringe data into an online Fourier calculator with mixed results. It would show 2 to 4 peak frequencies, and some were stronger than others. They were never close to the predicted Fringe Period. Too confusing for now.

Table 1 - Possible radio sources in southern sky near 1800 RA

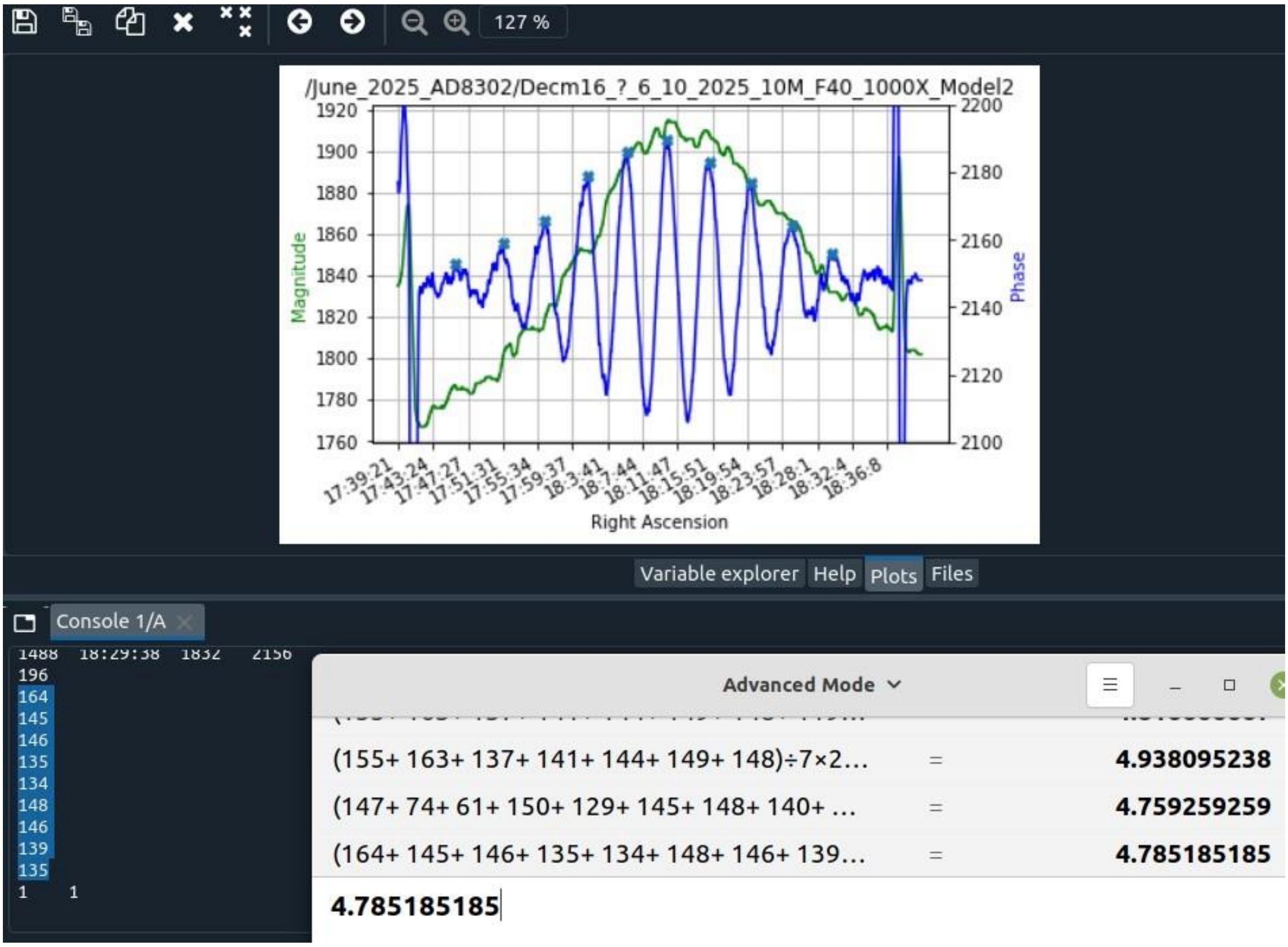
Declination	Source	RA	Dec	Flux_960
-9	CTB56	18 33	-8.7	100
-10				
-11	CTB50	18 18	-11.9	330
-12	CTB53	18 26	-12.3	190
-13				
-14	W37	18 16	-13,7	260
-15				
-16	CTB52/ W38/ M17	18 20 23.242	-16 16 37.23	540
-17				
-18	W33	18 10	-18	190
-19				
-20	CTB49	18 08 58.085	-19 59 27.27	150
-21	CTB47	18 04 42.299	-21 38 45.99|	150
-22	W28 M20	17 58	-22	360
-23	CTB45	18 01 02.838	-23 30 02.09	200
-24	CTB46	18 03 46.018	-24 20 50.23	150
-25	W29	18 01 02.838	-24.2	260
-26				
-27				
-28	CTB42	17 46 04.501	-28 51 07.81	750
-29				
-30				
-31				
-32				
-33				
-34	CTB40	17 26 18.953	-34 23 33.98	360

Resolution of the interferometer in radians = 1.22 * wavelength / baseline for the

3 M dish:

1.22×.21÷3×57.3 = 4.89 deg for my interferometer with baseline of 10.6M:

1.22×.21÷10.6×57.3 = 1.38 deg



The image above shows how the Fringe period was calculated. In blue on the left bottom is the list of sample periods for the Green ‘x” on the graph. The sample period was 2 sec. So, adding the 9 sample periods, dividing by 9 and multiplying by 2 sec gives the fringe period in seconds. Then divide this by 60 seconds to give the fringe period in minutes. The answer for this data was 4.78 min which for my spacing of 10.M and declination of -16 should have been 4.71 min.

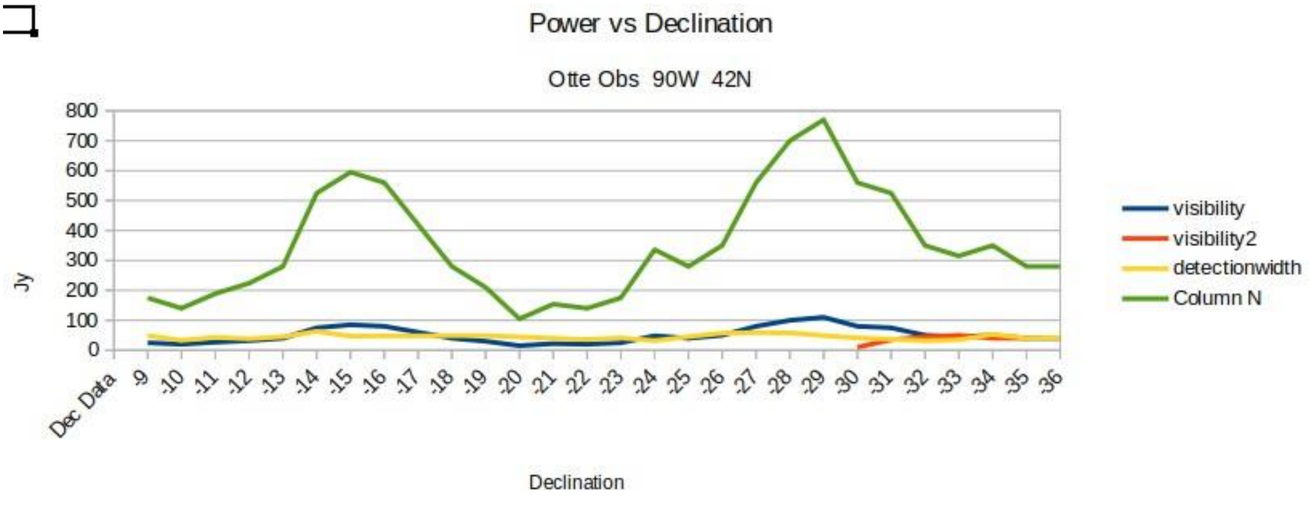
Other data gathered from this graph was the amplitude of the highest peak fringe, it’s RA, and the beginning and end fringe RA. The tallest peak is at RA 18:11 and its height is read using the scale on the right of the chart, about 80 units. These data were written down for each day and each day the dishes were moved 1 degree further south.

This data was collected during June and July of 2025.

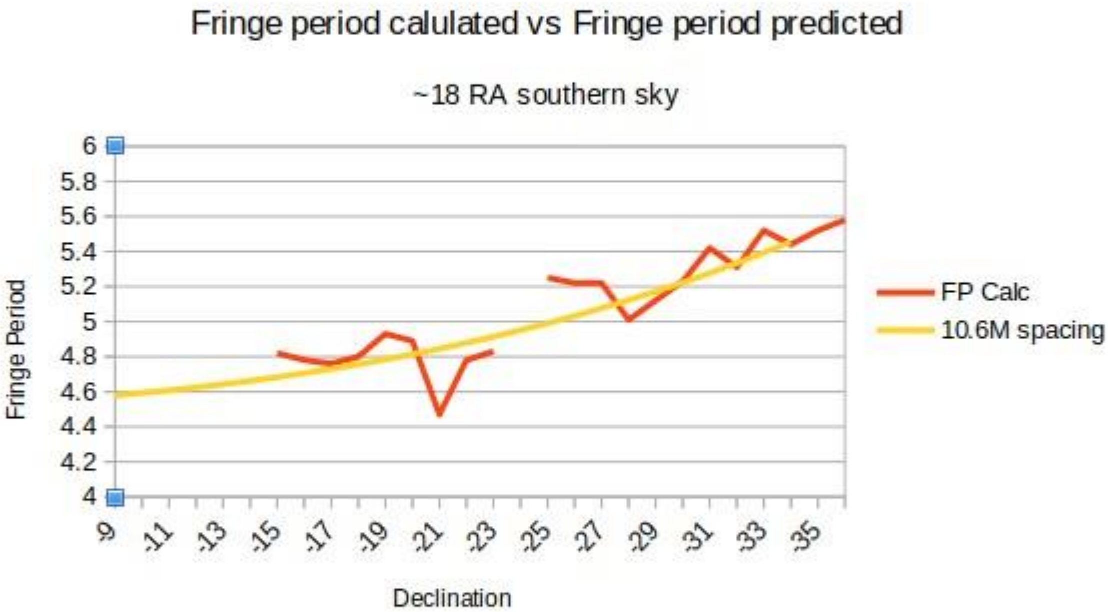
Table 2 - Daily Survey Data

Dec Data	Begin RA	End RA	Length of detection	Peak RA	Pk Height	FP Calc
-9	18 10	18 59	49	18 35	25	
-10	18 08	18 41	33	18 20	20	
-11	17 51	18 34	43	18 16	27	
-12	17 54	18 32	38	18 13	32	
-13	17 55	18 40	45	18 14	40	4.69
-14	17 31	18 34	63	18 12	75	
-15	17 44	18 31	47	18 13	85	4.82
-16	17 43	18 36	48	18 11	80	4.78
-17	17 43	18 36	48	18 10	60	4.76
-18	17 41	18 30	49	18 08	40	4.8
-19	17 41	18 30	49	18 08	30	4.93
-20	17 41	18 25	44	17 58	15	4.89
-21	17 37	18 17	40	18 04	22	4.47
-22	17 42	18 18	36	17 57	20	4.78
-23	17 48	18 29	41	17 58	25	4.83
-24	17 08	17 40	32	17 30	48	
-25	17 21	18 06	45	17 41	40	5.25
-26	17 13	18 10	57	17 41	50	5.22
-27	17 14	18 15	59	17 41	80	5.22
-28	17 20	18 18	58	17 53	100	5.01
-29	17 18	18 07	49	17 43	110	5.12
-30	17 26	18 07	41	17 39	80	5.23
-31	17 25	18 02	37	17 38	75	5.42
-32	17 29	18 01	32	17 38	50	5.31
-33			35		45	6.31
-34			53		50	7.31

On Table 2 you can see some trends. The peak RA drifts down from 18:30 to 17:40 area as the declination increase from -9 to -34 and at declination minus 31,32 a second peak is forming in the low RA 1700s which isn't included in these cells. There are two large peaks at Declination, minus 17 and minus 29 which correspond the CTB52 and CTB42. CTB40 has a nice peak at minus 34 declination and that is right at the edge of my southern horizon.



This trend chart shows the same data but the green curve in Jy instead of A/D units. Instead of seeing ~14 sources, I see 4 peaks that seem to associate with stronger sources. Looks like I need better data or stronger tools to resolve these sources. I was hoping Fringe period was going to help but it doesn't seem precise enough to differentiate the sources.



Conclusions?
The equipment I have does not resolve these sources.

The data gets distorted with interference. I get strong, couple minute long lasting spikes that I assume are airplanes. By choosing different days of week, they could be lowered in frequency. So, taking data on more days could help.

Having multiple baselines on the interferometer could be used to create one dimension image. This could be more dishes too, create more baselines.

How about a perpendicular baseline, like a mill's cross?

References:
Jan Lustrup on Facebook "Amateur Radio Astronomy"
https://www.facebook.com/groups/1819174114777651

The Radio sources in this area were search for in→:
https://heasarc.gsfc.nasa.gov/W3Browse/all/dixon.html

Galactic Plane Crossing Longitudes by Declination

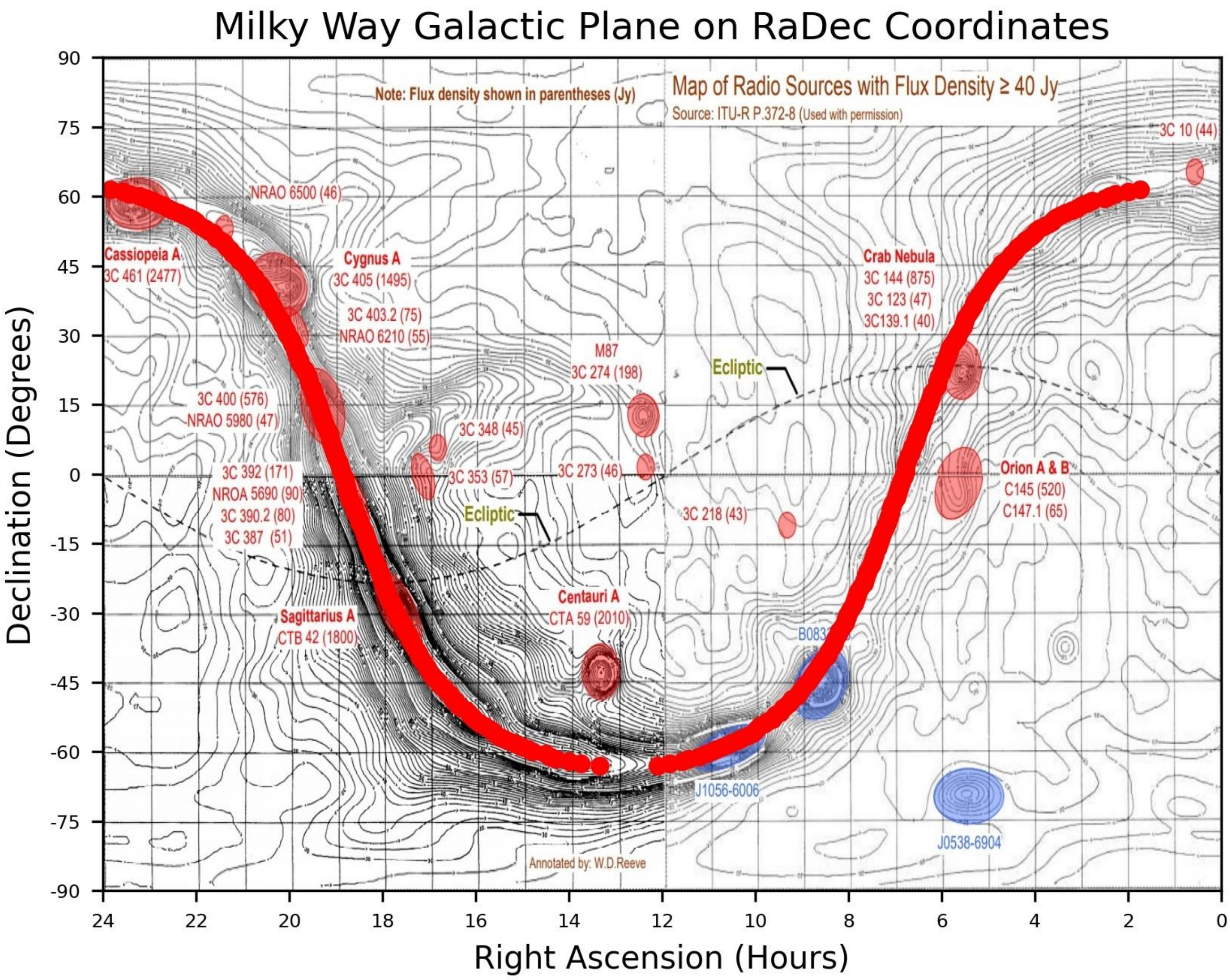
- Ted Cline N0RQV, Aug-2-2025

Drift-scans are an easy way to collect radio astronomy data from the radio sky. An antenna is placed at a constant Azimuth and Elevation angle above the horizon, and records the sky as the Earth rotates once per day. Data is recorded along one Declination line across the whole sky, often recording the plane of our Milky Way Galaxy at 2 Galactic Longitudes.

The Declination recorded is determined by the antenna's Azimuth and Elevation sky pointing and the antenna's location on the Earth (Latitude). The Right Ascension along that Declination is determined by the antenna's Azimuth and Elevation sky pointing, the antenna's location on the Earth (Longitude) and the date and time.

Wow, quickly using 4 coordinate systems !
Wikipedia offers detailed articles of Earth Latitude and Longitude
https://en.wikipedia.org/wiki/Geographic_coordinate_system and
    Azimuth and Elevation
    Right Ascension and Declination

Galactic Latitude and Longitude
  https://en.wikipedia.org/wiki/Astronomical_coordinate_systems



Here the plane of our Milky Way Galaxy appears as a large red sinusoidal curve on the RaDec (Right Ascension – Declination coordinates) map of the sky, because the plane of the Galaxy does not match the plane of the Earth's equator.

The center of our Galaxy is near Sagittarius A, near RaDec 17.6, -29.0, and defines Galactic Longitude 0.0, with positive Galactic Longitudes immediately to the left, and negative Galactic Longitudes immediately to the right.

With the goal of studying the Galactic plane with drift-scans, a given antenna Azimuth and Elevation determines the Declination recorded, which may include 2 Galactic Longitudes. There are no Galactic plane crossings available above Declination 63.0 degrees, nor below Declination -63.0 degrees.
But for observation planning purposes, which Galactic Longitudes are recorded for each Declination drift-scan?

Here is a listing by half degree Declinations.

Declination (Degrees),	Left Galactic Longitude (Degrees),	Right Galactic Longitude (Degrees)
90.0	none	none
...	...	...
63.5	none	none
63.0	123.9	123.9
62.5	118.2	127.6
62.0	115.7	130.1
61.5	113.8	132.0
61.0	112.3	133.6
60.5	110.9	135.0
60.0	109.6	136.3
59.5	108.4	137.4
59.0	107.3	138.5
58.5	106.3	139.6
58.0	105.3	140.6
57.5	104.3	141.6
57.0	103.4	142.5
56.5	102.5	143.4
56.0	101.6	144.3
55.5	100.8	145.1
55.0	99.9	145.9
54.5	99.1	146.8
54.0	98.3	147.6
53.5	97.5	148.3
53.0	96.7	149.1
52.5	96.0	149.9
52.0	95.2	150.6
51.5	94.5	151.4
51.0	93.8	152.1
50.5	93.0	152.8
50.0	92.3	153.5
49.5	91.6	154.2
49.0	90.9	154.9
48.5	90.2	155.6
48.0	89.5	156.3
47.5	88.9	157.0
47.0	88.2	157.7
46.5	87.5	158.3
46.0	86.9	159.0
45.5	86.2	159.7
45.0	85.5	160.3
44.5	84.9	161.0
44.0	84.2	161.6
43.5	83.6	162.3

Declination (Degrees), Left Galactic Longitude (Degrees), Right Galactic Longitude (Degrees)

43.0	83.0	162.9
42.5	82.3	163.5
42.0	81.7	164.2
41.5	81.0	164.8
41.0	80.4	165.4
40.5	79.8	166.1
40.0	79.2	166.7
39.5	78.6	167.3
39.0	77.9	167.9
38.5	77.3	168.6
38.0	76.7	169.2
37.5	76.1	169.8
37.0	75.5	170.4
36.5	74.9	171.0
36.0	74.3	171.6
35.5	73.7	172.2
35.0	73.1	172.8
34.5	72.5	173.4
34.0	71.9	174.0
33.5	71.3	174.6
33.0	70.7	175.2
32.5	70.1	175.8
32.0	69.5	176.4
31.5	68.9	177.0
31.0	68.3	177.6
30.5	67.7	178.2
30.0	67.1	178.8
29.5	66.5	179.3
29.0	65.9	179.9

28.5	65.4	-179.5
28.0	64.8	-178.9
27.5	64.2	-178.3
27.0	63.6	-177.7
26.5	63.0	-177.2
26.0	62.4	-176.6
25.5	61.9	-176.0
25.0	61.3	-175.4
24.5	60.7	-174.8
24.0	60.1	-174.3
23.5	59.5	-173.7
23.0	59.0	-173.1
22.5	58.4	-172.5
22.0	57.8	-172.0
21.5	57.2	-171.4

Declination (Degrees), Left Galactic Longitude (Degrees), Right Galactic Longitude (Degrees)

21.0	56.7	-170.8
20.5	56.1	-170.2
20.0	55.5	-169.7
19.5	55.0	-169.1
19.0	54.4	-168.5
18.5	53.8	-168.0
18.0	53.2	-167.4
17.5	52.7	-166.8
17.0	52.1	-166.2
16.5	51.5	-165.7
16.0	51.0	-165.1
15.5	50.4	-164.5
15.0	49.8	-164.0
14.5	49.3	-163.4
14.0	48.7	-162.8
13.5	48.1	-162.3
13.0	47.6	-161.7
12.5	47.0	-161.1
12.0	46.4	-160.6
11.5	45.9	-160.0
11.0	45.3	-159.5
10.5	44.7	-158.9
10.0	44.2	-158.3
9.5	43.6	-157.8
9.0	43.1	-157.2
8.5	42.5	-156.6
8.0	41.9	-156.1
7.5	41.4	-155.5
7.0	40.8	-154.9
6.5	40.2	-154.4
6.0	39.7	-153.8
5.5	39.1	-153.3
5.0	38.6	-152.7
4.5	38.0	-152.1
4.0	37.4	-151.6
3.5	36.9	-151.0
3.0	36.3	-150.4
2.5	35.7	-149.9
2.0	35.2	-149.3
1.5	34.6	-148.8
1.0	34.1	-148.2
0.5	33.5	-147.6
0.0	32.9	-147.1

Declination (Degrees), Left Galactic Longitude (Degrees), Right Galactic Longitude (Degrees)

-0.5	32.4	-146.5
-1.0	31.8	-145.9
-1.5	31.2	-145.4
-2.0	30.7	-144.8
-2.5	30.1	-144.3
-3.0	29.6	-143.7
-3.5	29.0	-143.1
-4.0	28.4	-142.6
-4.5	27.9	-142.0
-5.0	27.3	-141.4
-5.5	26.7	-140.9
-6.0	26.2	-140.3
-6.5	25.6	-139.8
-7.0	25.1	-139.2
-7.5	24.5	-138.6
-8.0	23.9	-138.1
-8.5	23.4	-137.5
-9.0	22.8	-136.9
-9.5	22.2	-136.4
-10.0	21.7	-135.8
-10.5	21.1	-135.3
-11.0	20.5	-134.7
-11.5	20.0	-134.1
-12.0	19.4	-133.6
-12.5	18.9	-133.0
-13.0	18.3	-132.4
-13.5	17.7	-131.9
-14.0	17.2	-131.3
-14.5	16.6	-130.7
-15.0	16.0	-130.2
-15.5	15.5	-129.6
-16.0	14.9	-129.0
-16.5	14.3	-128.5
-17.0	13.8	-127.9
-17.5	13.2	-127.3
-18.0	12.6	-126.8
-18.5	12.0	-126.2
-19.0	11.5	-125.6
-19.5	10.9	-125.0
-20.0	10.3	-124.5
-20.5	9.8	-123.9
-21.0	9.2	-123.3
-21.5	8.6	-122.8
-22.0	8.0	-122.2
-22.5	7.5	-121.6

Declination (Degrees), Left Galactic Longitude (Degrees), Right Galactic Longitude (Degrees)

-23.0	6.9	-121.0
-23.5	6.3	-120.5
-24.0	5.7	-119.9
-24.5	5.2	-119.3
-25.0	4.6	-118.7
-25.5	4.0	-118.1
-26.0	3.4	-117.6
-26.5	2.8	-117.0
-27.0	2.3	-116.4
-27.5	1.7	-115.8
-28.0	1.1	-115.2
-28.5	0.5	-114.
-29.0	-0.1	-114.1
-29.5	-0.7	-113.5
-30.0	-1.2	-112.9
-30.5	-1.8	-112.3
-31.0	-2.4	-111.7
-31.5	-3.0	-111.1
-32.0	-3.6	-110.5
-32.5	-4.2	-109.9
-33.0	-4.8	-109.3
-33.5	-5.4	-108.7
-34.0	-6.0	-108.1
-34.5	-6.6	-107.5
-35.0	-7.2	-106.9
-35.5	-7.8	-106.3
-36.0	-8.4	-105.7
-36.5	-9.0	-105.1
-37.0	-9.6	-104.5
-37.5	-10.2	-103.9
-38.0	-10.8	-103.3
-38.5	-11.4	-102.7
-39.0	-12.1	-102.1
-39.5	-12.7	-101.4
-40.0	-13.3	-100.8
-40.5	-13.9	-100.2
-41.0	-14.6	-99.6
-41.5	-15.2	-99.0
-42.0	-15.8	-98.3
-42.5	-16.5	-97.7
-43.0	-17.1	-97.0
-43.5	-17.7	-96.4
-44.0	-18.4	-95.8
-44.5	-19.0	-95.1

Declination (Degrees),   Left Galactic Longitude (Degrees),   Right Galactic Longitude (Degrees)

-45.0	-19.7	-94.5
-45.5	-20.3	-93.8
-46.0	-21.0	-93.1
-46.5	-21.7	-92.5
-47.0	-22.3	-91.8
-47.5	-23.0	-91.1
-48.0	-23.7	-90.5
-48.5	-24.4	-89.8
-49.0	-25.1	-89.1
-49.5	-25.8	-88.4
-50.0	-26.5	-87.7
-50.5	-27.2	-87.0
-51.0	-27.9	-86.2
-51.5	-28.6	-85.5
-52.0	-29.4	-84.8
-52.5	-30.1	-84.0
-53.0	-30.9	-83.3
-53.5	-31.7	-82.5
-54.0	-32.4	-81.7
-54.5	-33.2	-80.9
-55.0	-34.1	-80.1
-55.5	-34.9	-79.2
-56.0	-35.7	-78.4
-56.5	-36.6	-77.5
-57.0	-37.5	-76.6
-57.5	-38.4	-75.7
-58.0	-39.4	-74.7
-58.5	-40.4	-73.7
-59.0	-41.5	-72.7
-59.5	-42.6	-71.6
-60.0	-43.7	-70.4
-60.5	-45.0	-69.1
-61.0	-46.4	-67.7
-61.5	-48.0	-66.2
-62.0	-49.9	-64.3
-62.5	-52.4	-61.8
-63.0	-56.1	-56.1
-63.5	none	none
...	...	...
-90.0	none	none

Ted Cline is an active volunteer at the Little Thompson Observatory in Berthoud Colorado USA, http://www.starkids.org

He received his Master of Engineering from Cornell University in 1981.

He enjoyed work at IBM and 22 years at Hewlett-Packard in computer product research and development, and later, online technical support.

He now encourages others to explore the entry into radio astronomy.

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

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

Paris, 07 July 2025

Bulletin C 70

To authorities responsible for the measurement and distribution of time

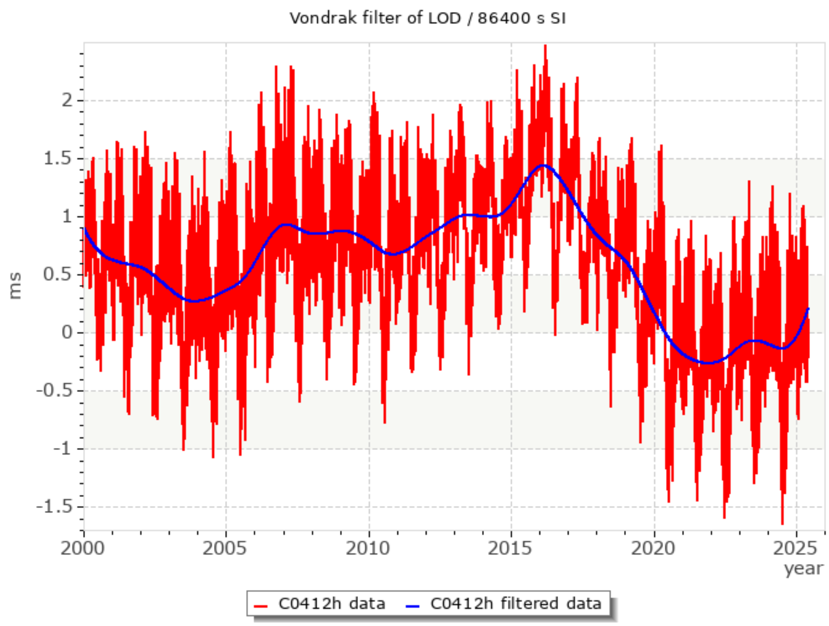
INFORMATION ON UTC - TAI

NO leap second will be introduced at the end of December 2025. The difference between Coordinated Universal Time UTC and the International Atomic Time TAI is:

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

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

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



Last leap second: 31 December 2016.....TAI–UTC: 37 s.....Next leap second: Not scheduled

Journal Archives and Other Promotions

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

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

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

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

SARA Online Discussion Group

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

SARA Conferences

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

What is Radio Astronomy?

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

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

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

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

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

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

Administrative

Officers, directors, and additional SARA contacts

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

President: Dr. Rich Russel, AC0UB, https://www.radio-astronomy.org/contact/President
Vice President: Marcus Fisher, https://www.radio-astronomy.org/contact/Vicepresident
Secretary: Brian O'Rourke, https://www.radio-astronomy.org/contact/Secretary
Treasurer: Tom Jacobs, https://www.radio-astronomy.org/contact/Treasurer
Past President: Dennis Farr
Founder Emeritus and Director: Jeffrey M. Lichtman, KI4GIY, jeff@radioastronomysupplies.com

Board of Directors

Name	Term expires	Email
Ted Cline	2027	TedClineGit@gmail.com
Dennis Farr	2026	dennisfarr@verizon.net
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Jay Wilson	2026	jwilson@radio-astronomy.org

Other SARA Contacts

All Officers	http://www.radio-astronomy.org/contact-sara	
All Directors and Officers	http://www.radio-astronomy.org/contact/All-Directors-and-Officers	
Eastern Conference Coordinator	http://www.radio-astronomy.org/contact/Annual-Meeting	
All Radio Astronomy Editors	http://www.radio-astronomy.org/contact/Newsletter-Editor	
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Contributing Editor	Bogdan Vacaliuc	bvaculiuc@iee.org
Educational Co-Chairs	Ken Redcap, Tom Hagen: http://www.radio-astronomy.org/contact/Educational-Outreach	
Grant Committee	Tom Crowley	grants@radio-astronomy.org
Membership Chair	http://www.radio-astronomy.org/contact/Membership-Chair	
Technical Queries (David Westman)	http://www.radio-astronomy.org/contact/Technical-Queries	
Webmaster	Ciprian (Chip) Sufitchi, N2YO	webmaster@radio-astronomy.org

Resources

Great Projects to Get Started in Radio Astronomy

Radio Observing Program

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

Categories include.

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

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

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

Radio Jove

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

INSPIRE Program

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

SARA/Stanford SuperSID

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

Radio Astronomy Online Resources

SARA YouTube Videos: https://www.youtube.com/@radio-astronomy	Pisgah Astronomical Research Institute: www.pari.edu
AJ4CO Observatory – Radio Astronomy Website: http://www.aj4co.org/	A New Radio Telescope for Mexico - ORION 2021 01 20. Dr. Stan Kurtz https://www.youtube.com/watch?v=Q9aBWr1aBVc
Radio Astronomy calculators https://www.aj4co.org/Calculators/Calculators.html	National Radio Astronomy Observatory http://www.nrao.edu
Introduction to Amateur Radio Astronomy (presentation) http://www.aj4co.org/Publications/Intro%20to%20Amateur%20Radio%20Astronomy,%20Typinski%20(AAC,%202016)%20v2.pdf	NRAO Essential Radio Astronomy Course http://www.cv.nrao.edu/course/astr534/ERA.shtml
RF Associates Richard Flagg, rf@hawaii.rr.com 1721-1 Young Street, Honolulu, HI 96826	Exotic Ions and Molecules in Interstellar Space -- ORION 2020 10 21. Dr. Bob Compton https://www.youtube.com/watch?v=r6cKhp23SUo&t=5s
RFSpace, Inc. http://www.rfspace.com	The Radio JOVE Project & NASA Citizen Science – ORION 2020.6.17. Dr. Chuck Higgins https://www.youtube.com/watch?v=s6eWAxJywp8&t=5s
CALLISTO Receiver & e-CALLISTO http://www.reeve.com/Solar/e-CALLISTO/e-callisto.htm	UK Radio Astronomy Association http://www.ukraa.com/
Deep Space Exploration Society http://DSES.science	CALLISTO software and data archive: www.e-callisto.org
Deep Space Object Astrophotography Part 1 -- ORION 2021 02 17. George Sradnov https://www.youtube.com/watch?v=Pm_Rs17KlyQ	Radio Jove Spectrograph Users Group http://www.radiojove.net/SUG/
European Radio Astronomy Club http://www.eracnet.org	Radio Sky Publishing http://radiosky.com
British Astronomical Association – Radio Astronomy Group http://www.britastro.org/baa/	The Arecibo Radio Telescope; It's History, Collapse, and Future - ORION 2020.12.16. Dr. Stan Kurtz, Dr. David Fields https://www.youtube.com/watch?v=rBZlPOLNX9E
Forum and Discussion Group http://groups.google.com/group/sara-list	Shirleys Bay Radio Astronomy Consortium marcus@propulsionpolymers.com
GNU Radio https://www.gnuradio.org/	SARA Twitter feed https://twitter.com/RadioAstronomy1
SETI League http://www.setileague.org	SARA Web Site http://radio-astronomy.org
NRAO Essential Radio Astronomy Course http://www.cv.nrao.edu/course/astr534/ERA.shtml	Simple Aurora Monitor: Magnetometer http://www.reeve.com/SAMDescription.htm
NASA Radio JOVE Project http://radiojove.gsfc.nasa.gov Archive: http://radiojove.net/archive.html https://groups.io/g/radio-jove	Stanford Solar Center http://solar-center.stanford.edu/SID/
Green Bank Observatory https://greenbankobservatory.org/ .	https://www.csiro.au/ There's a wealth of info on this site of the Australian National Science Agency. It's much more than just radio astronomy. Looking under "Research" opens a real family tree of interesting pages of things they are involved with.

Found an interesting Grote Reber link: https://www.utas.edu.au/groterebermuseum Their gallery is interesting, but sure wish they had some captions to indicate who and what some of it is about. I can guess, knowing some of Grote's stories, but others might need more info. Several pictures show the University of Tasmania 26m dish that was once one of the NASA worldwide Satellite Tracking and Data Network (STDN) dishes like the ones at the Pisgah Astronomical Research Institute (www.pari.edu). PARI's dishes were the first qualification units for that network.

For Sale, Trade and Wanted

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

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

Scope in a Box

radio-astronomy.org/store.

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

SuperSID Complete Kit

radio-astronomy.org/store.

SARA Publication, Journals and Conference Proceedings (various prices)

radio-astronomy.org/store.

SARA Journal Online Download

radio-astronomy.org/store.

The Journal archive covers the society journal "Radio Astronomy" from the founding of the organization in 1981 through the present. Articles cover a wide range of topics including cosmic radiation, pulsars, quasars, meteor detection, solar observing, Jupiter, Radio Jove, gamma ray bursts, the Itty Bitty Telescope (IBT), dark matter, black holes, the Jansky antenna, methanol masers, mapping at 408 MHz and more.

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

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

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





SOCIETY OF AMATEUR RADIO ASTRONOMERS
EST. 1981

My gpa
is a radio
astromonomer

Ask me
about my
antennas

2025
EASTERN
CONFERENCE

My gpa
is a radio
astronomer

Ask me
about my
antennas

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

2025
EASTERN
CONFERENCE

Radio
JOVE

2025
EASTERN
CONFERENCE

2025
EASTERN
CONFERENCE

2025
EASTERN
CONFERENCE

2025
EASTERN
CONFERENCE

SARA Brochure

Membership Information

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

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

Name: ____________________

Email Address : ____________________
(required for electronic Journal delivery)

Ham call sign: ____________________ (if applicable)

Address: ____________________

City: ____________________

State: ____________________

Zip: ____________________

Country: ____________________

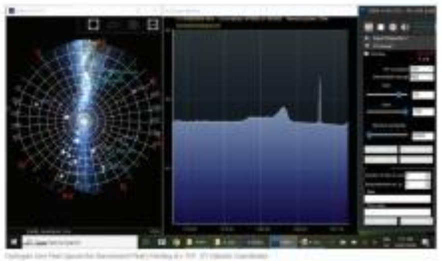
Phone: ____________________

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

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

How to get started?

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



Society of Amateur Radio Astronomers, Inc.

Founded 1981

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

Knowledge through Common Research, Education and Mentoring

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

http://radio-astronomy.org

Why Radio Astronomy?

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

The Society of Amateur Radio Astronomers

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

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

SARA members have many interests, some are as follows:

SARA Areas of Study and Research:

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

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

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

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

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

How do I get started?

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

How do amateurs do radio astronomy?

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

Is amateur radio astronomy instrumentation expensive?

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

What are amateurs actually looking for in the received data?

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

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

SARA Members discussing the IBT (Itty Bitty Telescope)