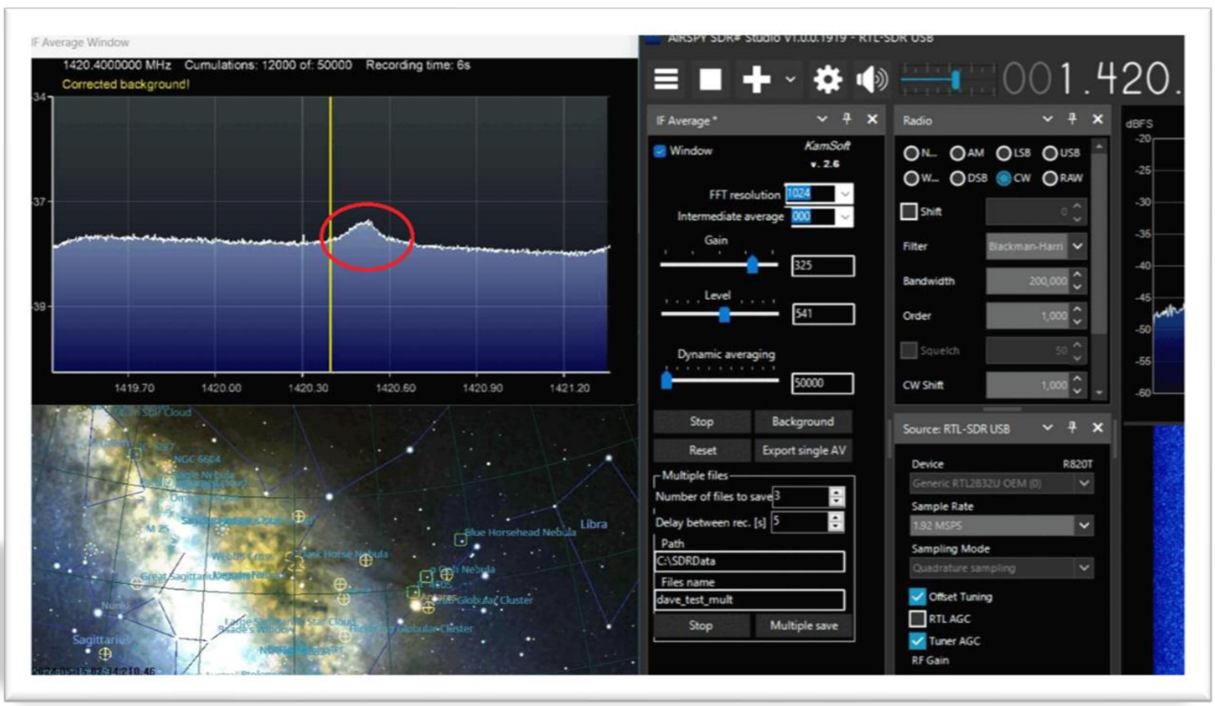
RADIO ASTRONOMY

Journal of the Society of Amateur Radio Astronomers
May - June 2024



First Light on new member, David Adam's, Radio Telescope

Dr. Richard A. Russel
SARA President and Editor

Bogdan Vacaliuc
Contributing Editor

Radio Astronomy is published bimonthly as the official journal of the Society of Amateur Radio Astronomers.

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:
David Adams

Contents

President's Page 2
Editor's Notes 3
SARA 2024 Eastern Conference 4
SARA NOMINATIONS 15
SARA NOTES 16
VINTAGE SARA - Charles Osborne 19
News: (May - June 2024) 23
Technical Knowledge and Education: (May - June 2024) 40
SuperSID 41
Announcing Radio JOVE 2.0 44
John Cook's VLF Report 50
BAA RA Section programme 2024 74
Featured Articles 76
More Experience with the AD8302 - Mike Otte 76
Antenna unit for 6.7 GHz methanol maser telescope - *Dimitry Fedorov* 89
April 8, 2024 Total Eclipse Observations at 12 GHz - Bruce Randall 99
Interferometer Measurements in Interstellar Communications: Methods and Observations – William J. Crilly, Jr. 104
Observation Reports 116
X8.7 Flare Observed at Radio Frequencies - Whitham D. Reeve 116
April 8, 2024 Eclipse Observations at 408MHz from Rock Hill, South Carolina - Bruce Randall 118
First light – Hydrogen spin-flip emission observation with 1 meter dish - David Adams 121
Sudden Frequency Deviations and Radio Blackout Observed at Anchorage, Alaska - Whitham D. Reeve 123
Journal Archives and Other Promotions 126
What is Radio Astronomy? 127
Administrative 128
Officers, directors, and additional SARA contacts 128
Resources 129
Great Projects to Get Started in Radio Astronomy 129
Radio Astronomy Online Resources 131
SARA Brochure 135

President's Page

Officer nominations will be coming out next month. Volunteer for a board or officer position and learn how to manage an International 501(c)(3).

I want to thank Kammie Russel for setting up the NEW SARA On-Demand store! She designed the artwork on the different SWAG items and set up the store.

This store is autonomous and does not need any of the SARA staff to be involved in the transactions.

NOTE: since it is an on-demand store, each item is produced and sent after it is ordered. So, no exchanges or refunds are available.

Check the store out at: https://saragifts.org/

Note: this is the SARAGIFTS store. The SARA store at our website handles the memberships, telescopes and conference registrations.

Membership renewals for 2025 are coming up. Be sure to renew for 2025.

The Eastern conference is in August. Sign up to be online so you don't miss the lectures. This also includes the Eastern Conference Proceedings

Rich

SARA President

Editor’s Notes

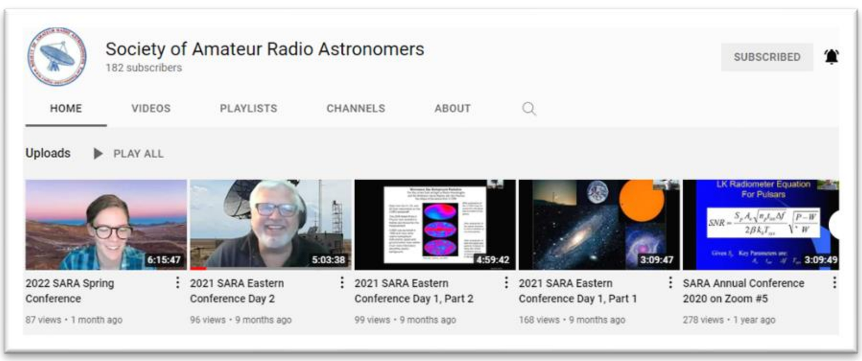
We are always looking for basic radio astronomy articles, radio astronomy tutorials, theoretical articles, application and construction articles, news pertinent to radio astronomy, profiles and interviews with amateur and professional radio astronomers, book reviews, puzzles (including word challenges,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

Subscribe to the SARA YouTube Channel

SARA has a YouTube channel at: https://www.youtube.com/@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 2024 Eastern Conference

2024 SARA Eastern Conference
and
Global Radio Astronomy Symposium

Green Bank Observatory
Green Bank, West Virginia, 2024
4-7 August 2024

The 2024 SARA Eastern Conference and Global Radio Astronomy Symposium will be held at the Green Bank Observatory, West Virginia, Sunday through Wednesday, 4-7 August 2024. The conference will also be available as a fully interactive online event.

With radio astronomy as its foundation, the Green Bank Observatory (GBO) is a world leader in advancing research, innovation, and education.

The first trailblazers of American radio astronomy called Green Bank Observatory home over 60 years ago. Today, their legacy is alive and well. Nestled in the mountain ranges and farmland of West Virginia, within the National Quiet Zone, radio astronomers are listening to the remote whispers of the universe, in order to discover answers to our most astounding astronomical questions.

Schedule: Conference meetings will be held in the main auditorium of the Jansky Laboratory at Green Bank Observatory with presentations by SARA members, GBO staff and distinguished speakers. Security and health restrictions permitting, tours of the facility, radio telescopes and laboratories will be conducted. Certain locations are open only to U.S. citizens who submit for a security review two weeks prior; however, most areas will be open to all attendees. ***Fully interactive online participation will be available for those who cannot attend in person.***

Key advantages of in-person attendance are training and hands-on use of the historical 40-foot radio telescope as well as user tutorial and supervised control of the 20 Meter radio telescope.

Sunday through Tuesday evenings, round table discussions and refreshments are scheduled in the Drake's Lounge, and there will be space outside for attendees to set up and display their own portable radio astronomy systems and optical telescopes.

Meals in the GBO cafeteria are included in the registration fee for in-person attendees.

Virtual online sessions are available for those who cannot attend in person.

Lodging is not included in the conference registration fee.

A small number of on-site dormitory rooms may become available for conference speakers, support staff and SARA officers. Other conference attendees may request rooms on a standby basis, but it is highly recommended that attendees arrange off-site accommodations.
RV/camping sites and a cabin are available at the nearby Boyer Station Campground. Call 1.304.456.4667 to inquire. The Elk Springs Resort is about 12 miles away. The Snowshoe Mountain area has several lodging facilities.

For other accommodations, please go to https://www.snowshoemtn.com/plan-your-trip/lodging .Numerous VRBO / Airbnb properties and private rentals are near GBO.

A list of many properties is at https://pocahontascountywv.com/lodging/ . Many chain accommodations are located about 30 miles away in Elkins, but that drive takes at least an hour due to mountainous roads.

Registration: Registration for in-person attendance by SARA members at the Conference is $275.00 (USD) if received by July 1, 2024, which includes meals but not lodging. The fee for family members or other guests who do not participate in conference sessions is $75.00, which includes meals and evening activities. Registration by July 1st for non-members is $295.00, which includes a year's membership in SARA. SARA members wishing to renew their membership at the same time as they register may also pay $295 and should include a renewal comment with their payment.

Late registration after July 1, 2024, is $350.00. Registration closes on July 31.

Registration is now available at the SARA Online Store:

https://www.radio-astronomy.org/store/

- - - -

Capstone Presentation

By Dr. Jay Lockman

Principal Scientist, Green Bank Telescope

Dr. Felix James "Jay" Lockman is the Green Bank Telescope Principal Scientist. He provides advice and assistance to researchers and the observatory staff on issues related to the scientific priorities for the GBT and its role in the wider observatory and in the US astronomical community. He also assists in setting long-term scientific goals for Green Bank and in setting priorities for new instrumental development based on the needs of the U.S, astronomical community.

Dr. Lockman received his B.S. from Drexel University and his Ph.D. from the University of Massachusetts, Amherst. He held a postdoctoral fellowship at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and a second postdoc at NRAO before joining the NRAO scientific staff. In 1993 he became Green Bank site director, a position he held for six years before returning to the resident scientific staff in Green Bank. He has served on numerous advisory panels for the NSF and NASA and in 2007 was elected to a three year term on the Board of Directors (the "Council") of the American Astronomical Society.

Dr. Lockman's research interests include the structure and evolution of the Milky Way, and the structure of the interstellar medium. He is currently doing studies of gas flows into and out of galaxies, using the Green Bank Telescope and other instruments to make extremely sensitive measurements of neutral hydrogen beyond the disk of the Milky Way. He recently discovered that there is a cloud of gas falling into the Milky Way that contains enough gas to make more than a million new stars like the Sun. He is also involved in collaborations with scientists using the Planck satellite to study interstellar dust and the cosmic Infrared background.

Dr. Lockman is known around the world for his outstanding presentation on the *Great Courses* educational video series entitled ***Radio Astronomy: Observing the Invisible Universe***.

Featured Presentation

By Ellie White

West Virginia Alliance for STEM and the Arts
NASA Outreach Ambassador

Ellie White is a science communicator from Barboursville, West Virginia who serves as Board member and secretary of the nonprofit West Virginia Alliance for STEM and the Arts. She is co-founder and a principal with Planet STEAM. She received a B.S. in Physics from Marshall University in 2021 and has worked on astronomy research, instrumentation, and outreach projects with the Green Bank Observatory, the National Radio Astronomy Observatory's Central Development Laboratory, the UC Berkeley SETI Research Center, and SETI Institute. Ellie was a 2021 recipient of the SETI Forward Award and was a TEDx speaker at Marshall University 2020.Works.

Ms. White participated in SARA Eastern conferences for many years as a student and later as a data analyst and Breakthrough Listen system operator. Many SARA members first got to know Ellie through work she began as a student which she shared at our conferences: She founded Cat's Eye Enterprises, LLC, which successfully raised awareness about science through a line of handmade dolls in the likeness of scientists. SARA is honored to showcase the Grote Reber doll which Ellie created especially for our conferences at Green Bank.
Ellie has produced many YouTube videos that educate students and the public about the importance of radio astronomy. Among them are *The Open Source Radio Telescope Project* and *Astronomy and Mentorship—Our Bridge to the Future.*

Ellie and her family are prominently featured in the recently released film ***Small Town Universe***, which opened to international acclaim. Trailers for the film open with Ellie discussing the importance of the Green Bank Observatory to science in general and the local community in particular.

Ellie will present an overview of emerging SETI research.

What Green Bank Observatory Visitors Need to Know

COVID Restrictions. GBO reserves the right to impose requirements for vaccinations and masks. SARA will notify all registrants should GBO issue a policy statement. Should GBO policies adversely impact a conference registrant, they may change their registration from in-person to virtual / online and receive a refund for the difference. Should GBO close the campus for any reason, all registrations will be changed to virtual / online.

No Cellular Phone Service. GBO is in the National Radio Quiet Zone and there is no wireless phone service in the area. Use of wi-fi devices and satellite phones such as Iridium or Globalstar near the facility is not allowed, and severe restrictions are placed on digital cameras, although film cameras without electronic flash are allowed. There is a computer lab available during the day.

Pre-Conference Activities. Suggested pre-conference activities include free self-guided tours of the Green Bank Observatory Science Center and reasonably priced guided tours of the radio telescope area. Full details with a link for ticket purchase: https://greenbankobservatory.org/visit/

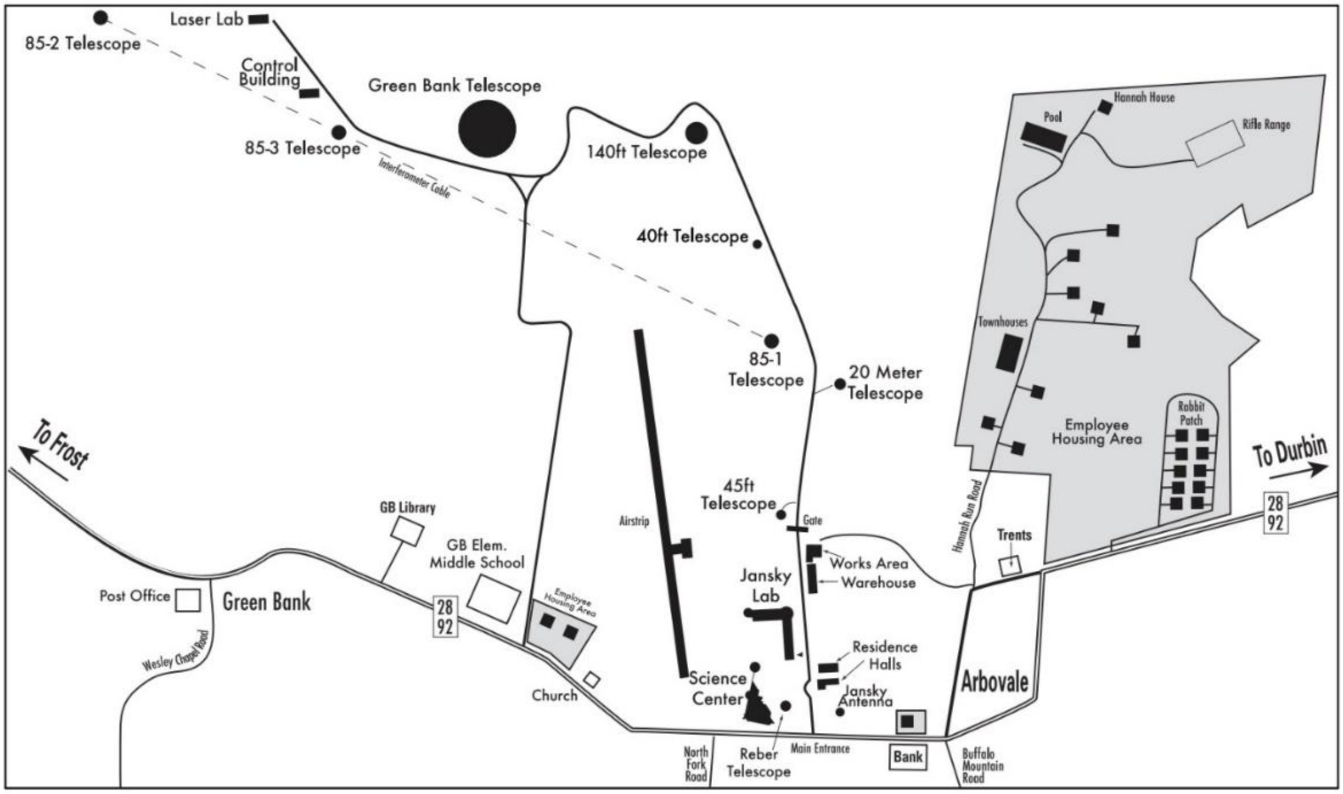
An overall guide to other activities and attractions in the area: https://pocahontascountywv.com/things-to-do/

Contact: Please contact the conference coordinator, B.J. Wilson, if you have any questions or if you would like to help with the conference: vicepresident@radio-astronomy.org

Additional Information: Additional details and updates will be published online at www.radio-astronomy.org and in the SARA journal, *Radio Astronomy*.

National Radio Quiet Zone and Major Roads to Green Bank

Green Bank Observatory Site Map



2024 SARA Annual Eastern Conference
and
Global Radio Astronomy Symposium

DAY	TIME	SPEAKER	TITLE
Sunday 8/4/2024	**Preconference Activities and Workshops**		
	8:30-11:30 AM	On-your-own no-cost tours of Green Bank Observatory Science Center, exhibits, gift shop. Suggested lunch at the GBO Starlight Café. Bus tour tickets are sold at the gift shop, but online advance purchase is highly recommended.	
	12:00 Noon	Registration at Jansky Lab Building, just down the road from Science Center. Ask at the gift shop if you need directions. (Zoom session open at 1630 UTC)	
	12:45 PM	Jay Wilson, Chair Dr. Rich Russel SARA President	Administrative Announcements Safety, RFI Rules and Security Reminder Preconference Welcome
	1:00 PM	Ed Harfmann	Introduction to Radio Astronomy
	2:15 PM	Charles Osborne	Radio Astronomy Hints and Kinks
	2:45 PM	Break	
	3:00 PM	Skip Crilly	40 Ft. Radio Telescope Overview (End of day's online session)
	3:20 PM	Skip Crilly	40 Ft. Radio Telescope Hands-On Workshop
	5:15 PM	Dinner at GBO Cafeteria	
	6:30 PM	Set Up Outside Experiments and Demonstrations	
	6:30 PM	Steve Tzikas	20m GBO Skynet Robotic Radio Telescope Workshop
	8:00 PM	Social at Drake's Lounge Informal technical roundtable Astronomy on the Lawn: Outside equipment demonstrations. 40-foot radio telescope available for individual use. Parking Lot Flea Market	

Note: Times are for Green Bank, WV, which is U.S. Eastern Daylight Time (UTC minus 4).

	SARA Annual Conference and Global Radio Astronomy Symposium *In-Person at Green Bank Observatory with Interactive Online Sessions*		
Monday 8/5/2024	7:45 AM	Breakfast at GBO Cafeteria	
	8:30 AM		Registration at Jansky Lab Building
	9:00 AM	Jay Wilson, Chair	Administrative Announcements Safety, RFI Rules and Security Reminders
	9:15 AM	Dr. Rich Russel SARA President	Welcome and Conference Opening
	9:30 AM	Steve Tzikas	SARA Section Updates
	9:45 AM	David Westman or Bob Stricklin	Western Conference Recap
	10:00 AM	Dr. Rich Russel	SARA Online Programs Online Drake's Lounge -- SARA RTOP SARA Drake's Lounge for Australia/New Zealand
	10:15 AM	Refreshment Break and Poster Session	
	10:30 AM	Dr. Wolfgang Herrmann Astropeiler Stockert	Research Update
	11:15 AM	Ellie White	SETI Programs
	12:00 PM	Lunch at GBO Cafeteria	
	1:00 PM	Sue Ann Heatherly	Education and Outreach at GBO
	1:45 PM	Dr. Marcello Montici	Visit to ALMA
	2:15 PM	PARI Staff	Pisgah Astronomical Research Institute
	2:45 PM	Refreshment Break and Poster Session	
	3:00 PM	Skip Crilly	Interferometer Measurements in Interstellar Communication
	3:30 PM	Dr. Wayne McCain	Radio Astronomy STEMSAT Progress Report
	4:00 PM	Jason Burnfield	Hydrogen Line Detection of Nearby Galaxies Using Drift Scanning with a 3 Meter Dish
	4:30 PM	Open Mike	
	5:00 PM	Bruce Randall SARA Secretary	Election Instructions (End of day's online session)
	5:15 PM	Dinner at GBO Cafeteria	
	6:15 PM	Flea Market in Dorm Parking Lot	
	7:00 PM	Social at Drake's Lounge. Astronomy on the Lawn: Outdoor experiments 40-foot radio telescope available for individual use	

SARA Annual Conference and International Radio Astronomy Symposium *In-Person at Green Bank Observatory with Interactive Online Sessions*			
Tuesday 8/6/2024	7:45 AM	Breakfast at GBO Cafeteria	
	9:00 AM	Jay Wilson	Administrative Announcements
	9:05 AM	Charles Osborne	Comments from SARA Historian
	9:15 AM	Dr. Rich Russel SARA President	SARA Announcements SARA Elections conducted by Bruce Randall Installation of Officers Business Meeting
	10:00 AM	Coffee Break and Poster Session	
	10:15 AM	Ritwik Sharma	Guidance System for CHART
	10:45 AM	Dimitry Fedorov	Low SNR Observations of Masers
	11:30 AM	Little Thompson Observatory	Software for Easy Radio Astronomy
	11:45 AM	Bruce Randall	Black Body Test Loads for Calibration
	12:30 PM	Lunch at GBO Cafeteria	
	1:30 PM	Group Picture	
	1:45 PM	Whitham Reeve	Design of New Front End Electronics / Analog Receivers (ARX) for Long Wavelength Array Systems
	2:30 PM	Jesse Alexander	Super KNOVA
	3:15 PM	Refreshment Break and Poster Session	
	3:30 PM	DSES	System Updates and New Observations
	4:00 PM	SARA Australia - NZ	Observation Reports from the Southern Hemisphere
	4:30 PM	Open Mike	Open Mike
	5:15 PM	Dinner at GBO Cafeteria	
	6:15 PM	Flea Market in Dorm Parking Lot	
	8:00 PM	Social at Drake Lounge. Astronomy on the Lawn: Outdoor experiments 40 foot radio telescope available for individual use	

Note: Times are for Green Bank, WV, which is U.S. Eastern Daylight Time (UTC minus 4).

SARA Annual Conference and International Radio Astronomy Symposium *In-Person at Green Bank Observatory with Interactive Online Sessions*			
Wednesday 8/7/2024	7:45 AM		Breakfast at GBO Cafeteria
	9:00 AM	Jay Wilson	Administrative Announcements
	9:15 AM	Dr. Jay Lockman	Capstone Presentation
	10:15	Open Mike	
	10:45	Dr. Rich Russel SARA President	Conference Wrap-Up End of Online Session
	11:00	Sue Ann Heatherly	Technical Tours
	12:30		Lunch at GBO Cafeteria

Note: Times are for Green Bank, WV, which is U.S. Eastern Daylight Time (UTC minus 4).

2024 SARA Eastern Conference
and
Global Radio Astronomy Symposium

Note: Times are for Green Bank, WV, which is U.S. Eastern Daylight Time (UTC minus 4).

UTC TIME CONVERSION TABLE

EDT US Eastern Daylight Time	UTC Same UTC Calendar Day for Conference Agenda Times
0700	1100
0800	1200
0900	1300
1000	1400
1100	1500
1200	1600
1300	1700
1400	1800
1500	1900
1600	2000
1700	2100
1800	2200
1900	2300

SARA NOMINATIONS

SARA Annual Conference – Nominations

As required by Section 3 of SARA By-Laws (see below), this is the official call for nominations for SARA officers and board members. If you are interested in running for office and would like to know more about the positions, please contact a board member or SARA President Rich Russel. The requirement to be on the board is to attend the board meetings at the annual meeting and to actively participate in board-related activities. Board attendance can be done by teleconference. If you are unable to attend the annual meetings, then the director at large position may be for you. This position is a full board position except that attending the annual meeting is not required. The following positions will be up for election in Aug 2024: President, Vice-President, two Directors at Large and two regular Directors. If you would like to run for one of the available SARA officer or board positions, please send a note to Secretary Bruce Randall copying President Rich Russel.

Contact information:

Bruce Randall:	brandall@comporium.net
Dr. Rich Russel:	drrichrussel@netscape.net

Please Note: It is important to get someone's permission before nominating them!

Text from the By-Laws: SECTION 3:

Elections of Directors and Officers will be accomplished by the President placing an initial call for nominations in "The Journal" no less than ninety (90) days prior to the regular scheduled meeting. Two (2) nominations from different members will be required to nominate a member for an office. No less than thirty (30) days prior to this meeting (in a newsletter issued prior to the meeting), the President will place a notice of the results of the nominations in "The Journal", along with a ballot for the members to use to vote for the nominee of their choice. This ballot will be forwarded to the Secretary for collection and counting at the regular meeting.

Responsibilities of Directors:

The Director needs to respond to and vote on business brought before the BOD. This includes the SARA annual meeting, email meetings, and teleconference meetings such as Zoom.

Responsibilities of President:

A. The President shall preside over all business of the Society. The President will appoint committees as needed and will be an ex-officio member of all committees.
B. The President will be the official spokesman for the Society and will perform all other duties normally assigned to the office of a President.

Responsibilities of Vice-President:

A. The Vice President shall preside and assume the duties of the President in any case where the President cannot assume his normal duties, or at the request of the President.
B. The Vice President will also have the primary duties of promoting the Society in the areas of public relations, information, and membership recruiting.
C. The Vice President shall be responsible for organizing and conduction the annual meeting.

SARA NOTES

SARA Student & Teacher Grant Program

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

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

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

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

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

All that is required is the SARA grant request form be filled out and sent in. If it needs more work for approval, we will work with the 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)

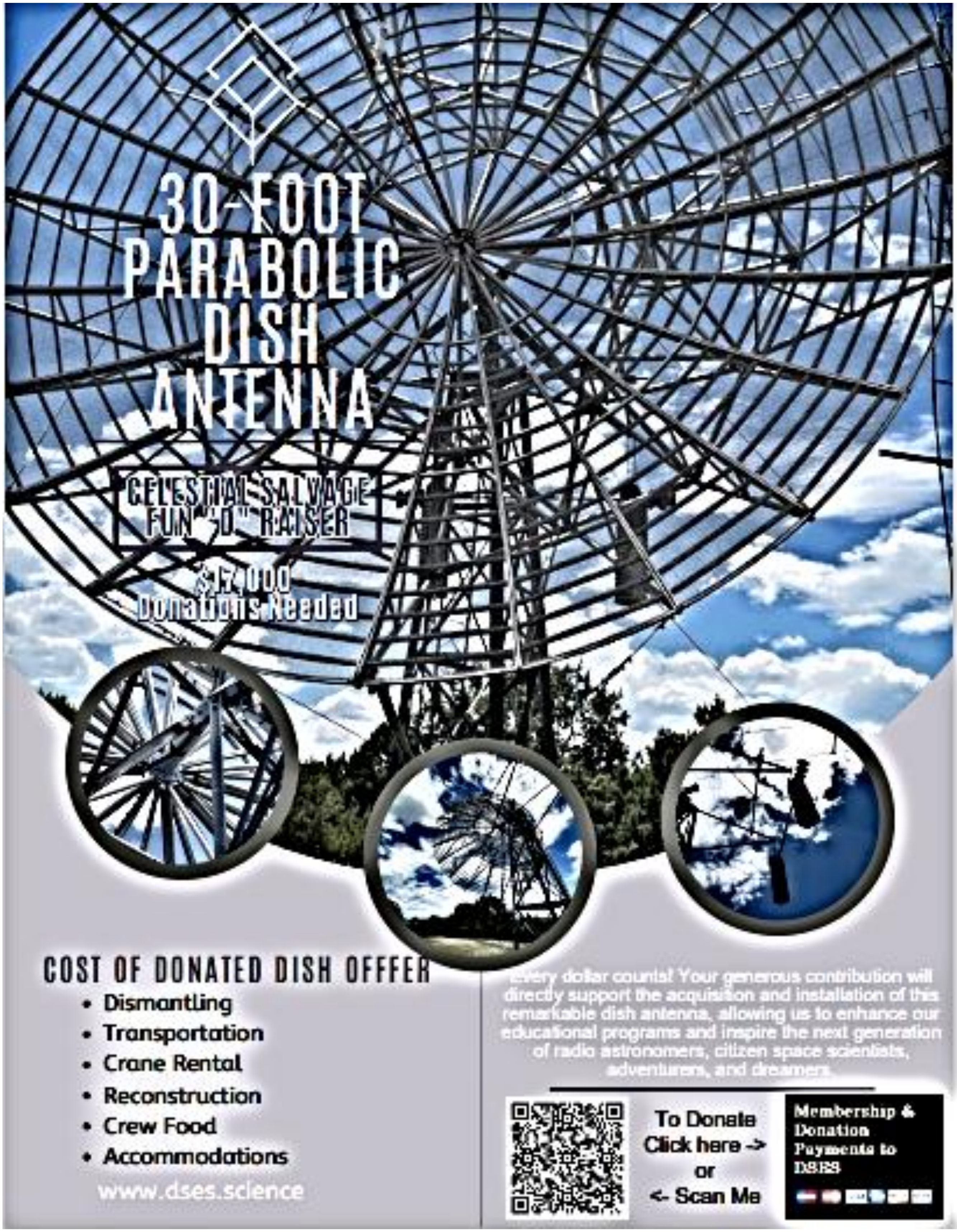
RTOP is designed to demonstrate how to take observations using various radio telescopes. It will also cover how to record and analyze data.

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.


30-FOOT PARABOLIC DISH ANTENNA
CELESTIAL SALVAGE FUN "D" RAISER
$17,000 Donations Needed
COST OF DONATED DISH OFFFER
• Dismantling
• Transportation
• Crane Rental
• Reconstruction
• Crew Food
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www.dses.science
Every dollar counts! Your generous contribution will directly support the acquisition and installation of this remarkable dish antenna, allowing us to enhance our educational programs and inspire the next generation of radio astronomers, citizen space scientists, adventurers, and dreamers.
To Donate Click here -> or <- Scan Me
Membership & Donation Payments to DSES

Vintage SARA

Charles Osborne, SARA Historian

Tribute to Bill Lakatosh W4TJ (ex AA4TJ) Silent Key

We lost another good friend on April 4th. Bill Lakatosh worked in Charlottesville for the NRAO Central Development Lab for most of his working life. I can't remember if I met Bill via NRAO, SARA, or ham radio. But I've known him for 30+ years. Here's Bill and his buddy Walker, who I'm sure misses him as much as we do.

For those who have not been to Green Bank WV Green Bank Observatory a little explanation is in order. Not everyone wants to live in a remote community with no cellphones or WiFi. It's much easier to accumulate a staff of front-end designer's in Charlottesville VA near UVA. NRAO started the Central Development Lab [https://public.nrao.edu/cdl/] to do research and build low noise amplifiers and associated hardware for Green Bank, the VLBA, and the VLA. Eventually it also served EVLA and the Atacama Large Millimeter Array (ALMA) and others on contract. It's sort of the North American equivalent of Australia's CSIRO.

Green Bank can do front ends themselves. But many of the best modules were designed and built in Charlottesville. They also do millimeter wave electroformed feeds and gold plating.

For example, everyone knows about the Voyager spacecraft nearing fifty years in flight. Today they are outside the solar system. But 47 years of travel has only gotten them to 22.5 Light Hours (0.0026 LY) from Earth. Like most NASA spacecraft their mission was really 12 years expected lifetime. Anything beyond that was just gravy. It was a lofty goal to send a spacecraft on a "Grand Tour of the Planets" when the alignment came in the 1970's. I'm not sure they'd really done all the math to know if gravitational assist could be used to speed up and slingshot a craft on to the next world when it was launched. Jupiter and Saturn went well. Software on board was improved in flight in the 69kB computer to allow higher data rates. But they were running out of link budget by Uranus and Neptune. A 10ft dish and 24watts only goes so far.

NRAO Central Development Lab was contracted to see what could be done to improve the sensitivity of the VLA to help receive Voyager at Neptune. The 8.4 GHz front ends were upgraded in time. And the data rates vastly improved. Bill Lakatosh was instrumental in this.

I can remember one trip to CDL when Bill showed me some unpackaged devices waiting to be incorporated into cryocooled LNAs. The devices were the size of flakes of pepper in a 2"x2" waffle pack. He said: "Don't sneeze. That's $10,000 worth of FETs."

A number of interesting articles by Marian Pospieszalski and Bill Lakatosh can be perused at:
https://scholar.google.com/scholar?hl=en&as_sdt=0%2C47&q=author%3A%22W+Lakatosh%22&btnG=
Marian Pospieszalski and Bill's daughter Amy wrote a fitting tribute to him that I'm hard pressed to add anything to:

--- Amy and Marian's tribute---

> *This is how I will always remember my dad, Bill Lakatosh, in his happy place, on his ham radio tower! My dad passed peacefully, though unexpectedly, in his sleep on April 4th. I am grateful to have had my dad live with us for the last seven years, since my mom passed, and can't thank Walker (and the kids) enough for helping to make that possible. Together we cared for my dad and grandma through Covid and lived with four generations under the same roof!*
>
> *My dad was the best dad and grandfather. He was always happy to lend a hand to anyone in need of help. He was brilliant and could build anything. His sister, my dearly departed Aunt Pat, once told me that he missed his high school graduation because he was on his radio! He told me he started building his own electrical equipment at the age of 9, inheriting his dad's (who was an electrician) love for electronics. He built not only a house full equipment enabling him to bounce signals off the moon (moon bounce) and talk to people all over the world, but he also built a close-knit ham radio family of some of the best people you will ever meet. They have been there for me over the last few weeks helping us figure out where my dad's equipment should be placed to help others, clear out his ham room, and dismantle his tower.*

He worked for the National Radio Astronomy Observatory in Charlottesville and was thrilled that his grandkids, Connor and Mia, are students at UVA and often visit observatory hill.

My dad's good friend and coworker, Marian, wrote this in his tribute to my dad and I am so very grateful that he shared many of his accomplishments:

Bill was a very valued and very much liked member of the LNA group since joining NRAO in 1985 until his retirement in 2008. Before he served in US Armed Forces and was a veteran of Vietnam War (crew on evac helicopters). He first worked in the steel industry in Pennsylvania, but with its demise, his love of ham radio led him to switch his profession to electronics. In the ham radio community Bill was especially known for his Earth Moon Earth activities. Bill's joining NRAO was related to two big CDL projects at that time: equipping the VLA with 8.4 GHz receivers for the reception of the data from Voyager 2 spacecraft during its encounter with Neptune and construction of receivers for the VLBA. At that time, he built all VLA 8.4 GHz amplifiers and *all VLBA Q-band amplifiers. It was very exciting time in the development of radio astronomy instrumentation, as the introduction of new semiconductor structures with progressively shorter gates allowed us to push the deployment of cryogenic HEMTs receivers to higher and higher frequencies. This led to CDL participation in Wilkinson Microwave Anisotropy Probe project and Bill built all forty W-band amplifiers for WMAP radiometers, crucial to WMAP great success. After, until his retirement he contributed greatly to building and testing amplifiers for the EVLA project.*

I will keep in grateful memory his friendship, his cheerful nature and his contributions.

----end tribute---

During another memorable visit to CDL I remember seeing some LNAs which had LEDs inside. I asked what they were for and was told they had found they could more efficiently adjust the bias point on the devices by using ultraviolet light. Amazing stuff you'd never think of.

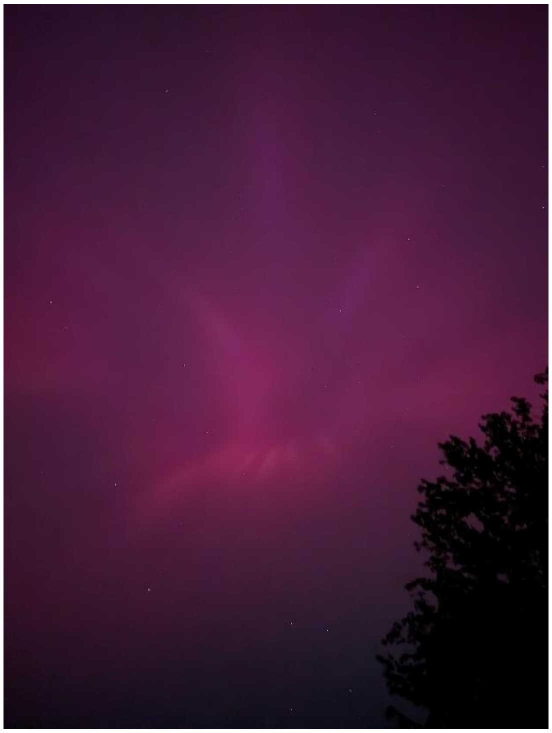
5G and car radars are helping bring some of the millimeter wave frequencies into more common vernacular. But the lists still vary. To help understand the bands mentioned:
https://www.everythingrf.com/tech-resources/frequency-bands

Q-Band: 33-50GHz (6~9mm wavelength)
V-Band: 50-80GHz (4~6mm wavelength)
W-Band: 80-90GHz (2.7~4mm wavelength)

I am grateful for friends like Bill Lakatosh which ham radio, radio astronomy, and our Fraternity of like-minded scientists and engineers brings together.

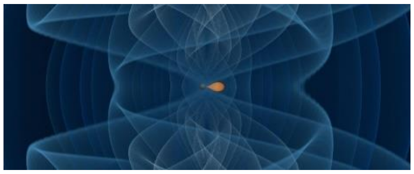
News: (May - June 2024)

Nancy Atkinson ~ What a Weekend! Spectacular Aurora Photos from Around the World
https://www.universetoday.com/166955/what-a-weekend-spectacular-aurora-photos-from-around-the-world/#more-166955



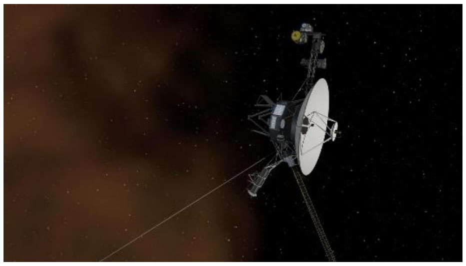
Credit: B. Vacaliuc, Harriman TN, USA (first ever aurora observation in his life)

Michelle Starr ~ Incredibly Rare Cosmic Object Detected in Gravitational Waves for The First Time
https://www.sciencealert.com/incredibly-rare-cosmic-object-detected-in-gravitational-waves-for-the-first-time
https://dcc.ligo.org/LIGO-P2300352/public/



Credit: I. Markin/Potsdam University, T. Dietrich/Potsdam University and Max Planck Institute for Gravitational Physics, H. Pfeiffer, A. Buonanno/Max Planck Institute for Gravitational Physics

Robert Lea ~ NASA's Voyager 1 spacecraft finally phones home after 5 months of no contact



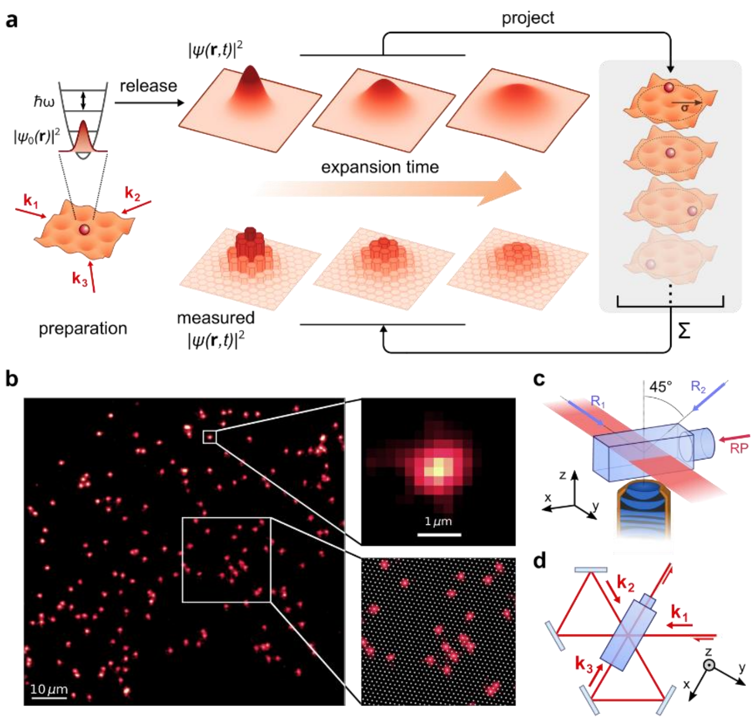
https://www.space.com/voyager-1-communications-update-april-2024

Credit: NASA

Robert Lea ~ Cosmic fountain is polluting intergalactic space with 50 million suns' worth of material
https://www.space.com/gas-outflow-galaxy-space-pollution-cosmic-fountain
https://academic.oup.com/mnras/article/530/2/1968/7642869

Credit: ESO/A. Watts et al.

Ben Turner ~ Stunning image shows atoms transforming into quantum waves — just as Schrödinger predicted
https://www.livescience.com/physics-mathematics/quantum-physics/stunning-image-shows-atoms-transforming-into-quantum-waves-just-as-schrodinger-predicted

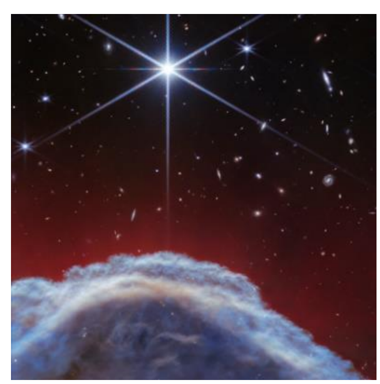


Joris Verstraten, et. al ~ In-situ Imaging of a Single-Atom Wave Packet in Continuous Space
https://arxiv.org/abs/2404.05699

Credit: Verstraten, et al.

Bethany Downer ~ Webb Captures Top of Iconic Horsehead Nebula in Unprecedented Detail
https://webbtelescope.org/contents/news-releases/2024/news-2024-119

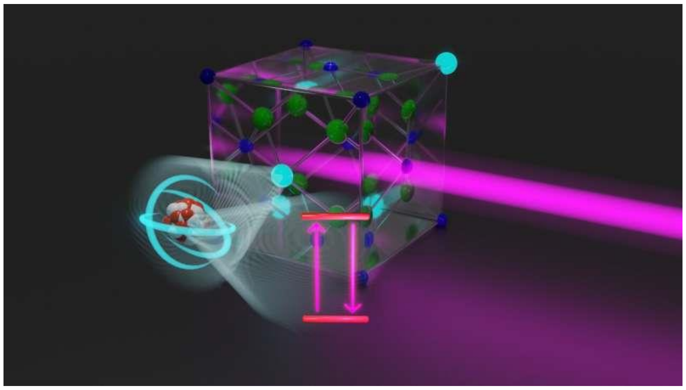
Credit: NASA and STScI



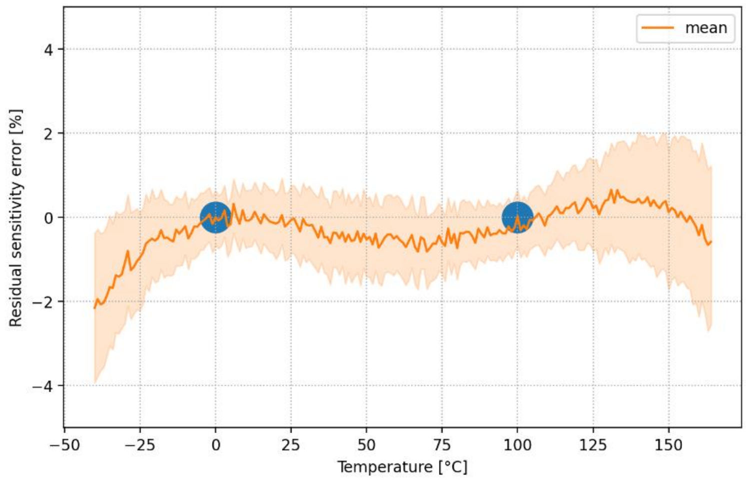
Vienna University of Technology ~ Laser excitation of Th-229 nucleus: New findings suggest classical quantum physics and nuclear physics can be combined
https://phys.org/news/2024-04-laser-nucleus-classical-quantum-physics.html

https://dx.doi.org/10.1103/PhysRevLett.132.182501

Credit: TU Wien



Gael Close and Moritz Berger ~ Bayesian Sensor Calibration
https://towardsdatascience.com/bayesian-sensor-calibration-9ef53e6c6271



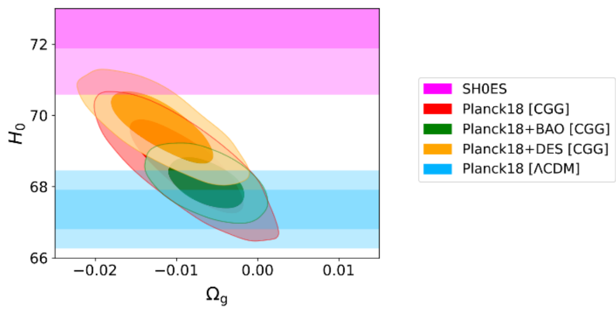
https://doi.org/10.1109/JSEN.2022.3199485

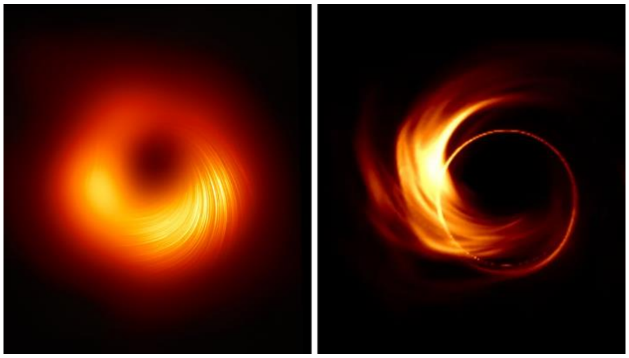
Credit: Gael Close

Robert Lea ~ Does a cosmic 'glitch' in gravity challenge Albert Einstein's greatest theory?
https://www.space.com/cosmic-glitch-gravity-challenges-general-relativity-einstein
Robin Y. Wen et al JCAP03(2024)045, https://iopscience.iop.org/article/10.1088/1475-7516/2024/03/045

Credit: EHT collaboration

Credit: Robin Y. Wen, et. al.

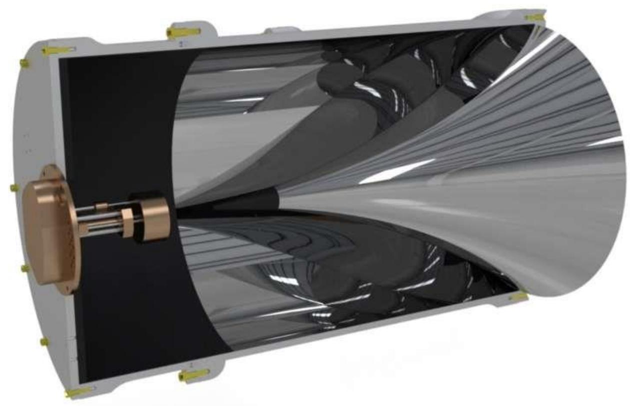




Ingrid Fadelli ~ The BREAD Collaboration is searching for dark photons using a coaxial dish antenna
https://phys.org/news/2024-05-bread-collaboration-dark-photons-coaxial.html

https://dx.doi.org/10.1103/PhysRevLett.132.131004

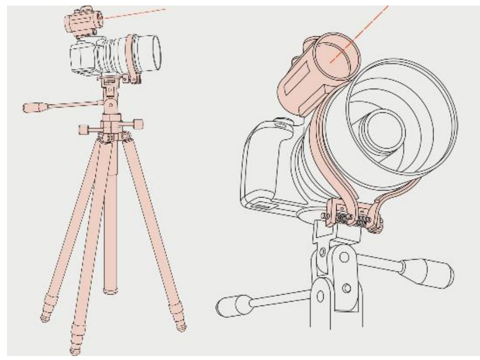
Credit: BREAD Collaboration



David Schneider ~ Electronically Assisted Astronomy on the Cheap Take surprisingly detailed images of the heavens with budget hardware

https://spectrum.ieee.org/electronically-assisted-astronomy

Credit: James Provost



Celia Luterbacher ~ Energy scientists unravel the mystery of gold's glow

https://actu.epfl.ch/news/energy-scientists-unravel-the-mystery-of-gold-s--2/

Bowman, A.R., Rodríguez Echarri, A., Kiani, F. et al. Quantum-mechanical effects in photoluminescence from thin crystalline gold films. Light Sci Appl 13, 91 (2024). https://doi.org/10.1038/s41377-024-01408-2

Credit: iStock/Getty Images

Lucas Van Wyk Joel ~ Astronomers' simulations support dark matter theory
https://phys.org/news/2024-04-astronomers-simulations-dark-theory.html

https://dx.doi.org/10.1093/mnras/stae819

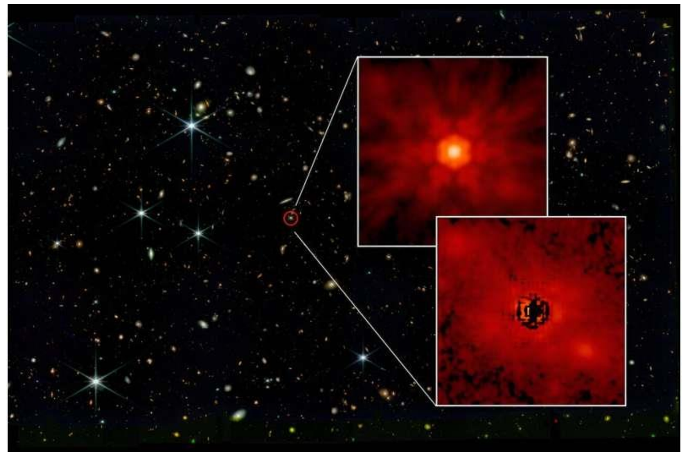
Credit: Pixabay/CC0 Public Domain

Jennifer Chu ~ Astronomers observe elusive stellar light surrounding ancient quasars

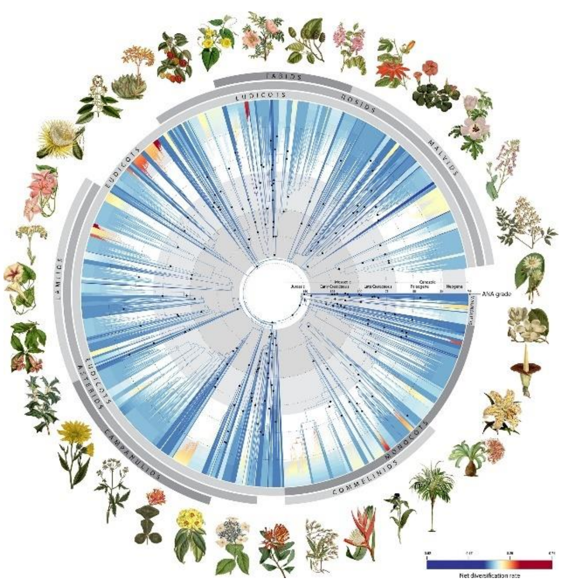
https://phys.org/news/2024-05-astronomers-elusive-stellar-ancient-quasars.html

Minghao Yue et al 2024 ApJ 966 176, https://dx.doi.org/10.3847/1538-4357/ad3914

Credit: Courtesy of Minghao Yue, Anna-Christina Eilers; NASA



University of Michigan ~ Biologists Construct Groundbreaking Tree of Life Using 1.8 billion Letters of Genetic Code



https://scitechdaily.com/biologists-construct-groundbreaking-tree-of-life-using-1-8-billion-letters-of-genetic-code/

Zuntini, A.R., Carruthers, T., Maurin, O. et al. Phylogenomics and the rise of the angiosperms. Nature 629, 843–850 (2024). https://doi.org/10.1038/s41586-024-07324-0

https://treeoflife.kew.org/

Credit: RGB Kew

Rod Boyce ~ Scientists' research answers big question about our system's largest planet

https://phys.org/news/2024-05-scientists-big-largest-planet.html

P. A. Delamere et al, Signatures of Open Magnetic Flux in Jupiter's Dawnside Magnetotail, AGU Advances (2024). https://dx.doi.org/10.1029/2023AV001111

Credit: NASA, ESA and J. Nichols, University of Leicester

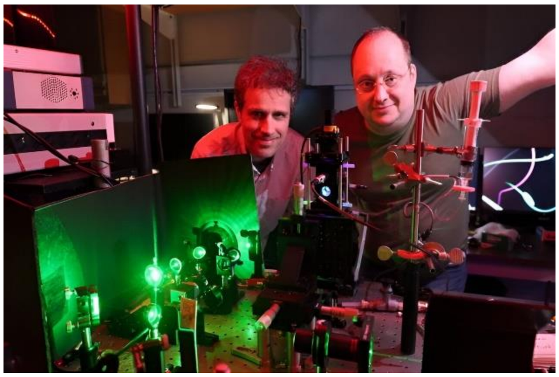
Erika Morphy ~ A humble Bluetooth device has successfully connected to a satellite in orbit

https://www.techspot.com/news/102866-humble-bluetooth-device-has-successfully-connected-satellite-orbit.html

https://hubblenetwork.com/blog/2024/04/29/Hubble-Network-First-Connection/

Credit: TechSpot

University of California, Irvine ~ Research team discovers new property of light

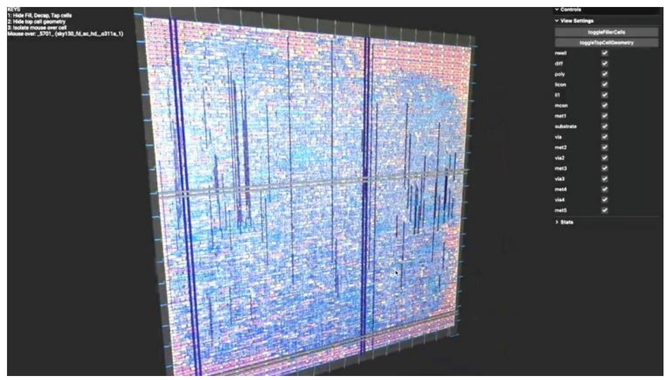


https://phys.org/news/2024-05-team-property.html

ACS Nano 2024, 18, 13, 9557–9565
https://dx.doi.org/10.1021/acsnano.3c12666

Credit: Lucas Van Wyk Joel / UC Irvine

Nick Evanson ~ Self-taught hardware engineer discovers that GPUs really are ridiculously complex and hard to design after all

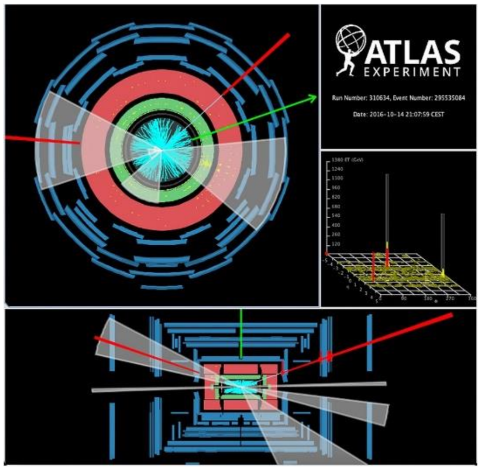


https://www.pcgamer.com/hardware/graphics-cards/self-taught-hardware-engineer-discovers-that-gpus-really-are-ridiculously-complex-and-hard-to-design-after-all/

https://github.com/adam-maj/tiny-gpu

Credit: Adam Majmundar

Argonne National Laboratory ~ New Particle? AI Detected Anomaly May Uncover Novel Physics Beyond the Standard Model



https://scitechdaily.com/new-particle-ai-detected-anomaly-may-uncover-novel-physics-beyond-the-standard-model/

https://doi.org/10.1103/PhysRevLett.132.081801

Credit: CERN

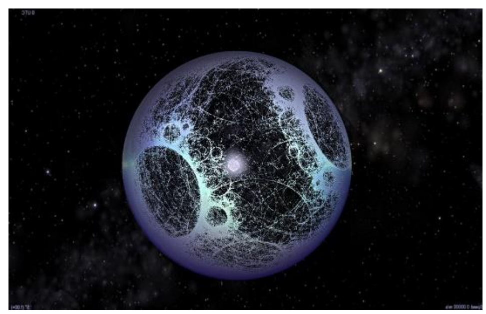
Jamie Carter ~ Total solar eclipse 2027: A complete guide to the 'eclipse of the century'

https://www.space.com/total-solar-eclipse-2027-complete-guide-where-when-how-to-see-it

Credit: Created using MapHub.net. Source: (Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community), path from Xavier M Jubier

Evan Gough ~ Astronomers are on the Hunt for Dyson Spheres

https://www.universetoday.com/166921/astronomers-are-on-the-hunt-for-dyson-spheres/



Monthly Notices of the Royal Astronomical Society, Volume 531, Issue 1, June 2024, Pages 695–707,
https://doi.org/10.1093/mnras/stae1186
Credit: SentientDevelopments.com/Eburacum45

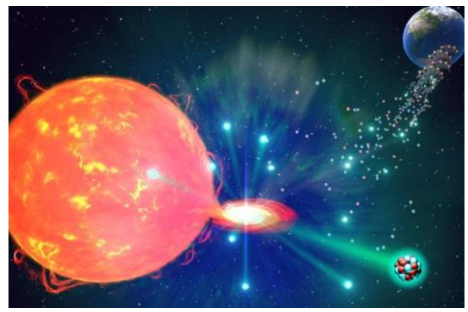
Michael Nunez ~ Exclusive: AI startup Tenyx's fine-tuned open-source Llama 3 model outperforms GPT-4

https://venturebeat.com/ai/exclusive-ai-startup-tenyxs-fine-tuned-open-source-llama-3-model-outperforms-gpt-4/

https://huggingface.co/tenyx/Llama3-TenyxChat-70B

Credit: VentureBeat made with Midjourney

National Astronomical Observatory of Japan ~ Astronomers propose a new stellar theory to explain the origin of phosphorus

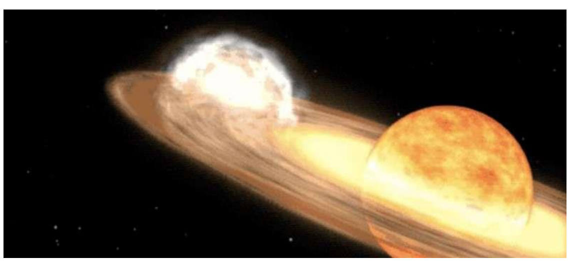


https://phys.org/news/2024-05-astronomers-stellar-theory-phosphorus.html

Kenji Bekki and Takuji Tsujimoto 2024 ApJL 967 L1, https://dx.doi.org/10.3847/2041-8213/ad3fb6

Credit: NAOJ

Daniel Strain ~ Q&A: How to catch a glimpse of a new star about to appear in the night sky



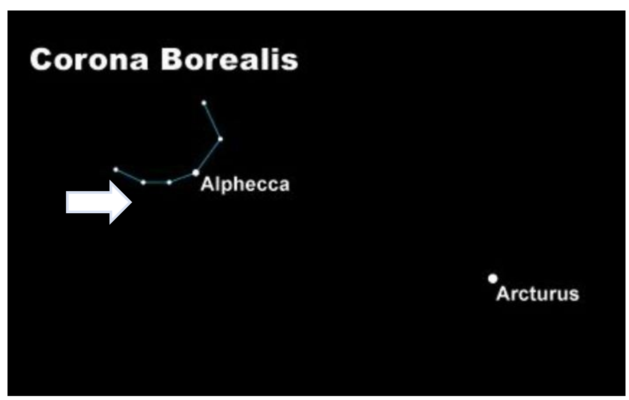
https://phys.org/news/2024-04-qa-glimpse-star-night-sky.html

Credit: NASA/Conceptual Image Lab/Goddard Space Flight Center

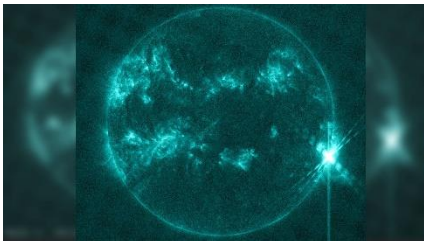
Mark Thompson ~ We're Now Just Weeks Away from a Stellar Explosion You Can See with Your Own Eyes

https://www.universetoday.com/167320/were-now-just-weeks-away-from-a-stellar-explosion-you-can-see-with-your-own-eyes/

Credit: EarthSky



Meredith Garofalo ~ Sun unleashes massive X8.7 solar flare, biggest of current cycle, from super-active monster sunspot (video)



https://www.space.com/sun-solar-flare-sunspot-ar3664-x88-class-may-14-2024

https://cosmicopia.gsfc.nasa.gov/solarmag.html

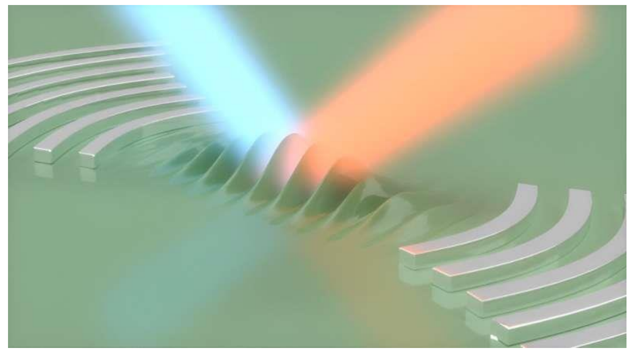
Credit: NASA/SDO

Luke Auburn ~ New surface acoustic wave techniques could lead to surfing a quantum internet

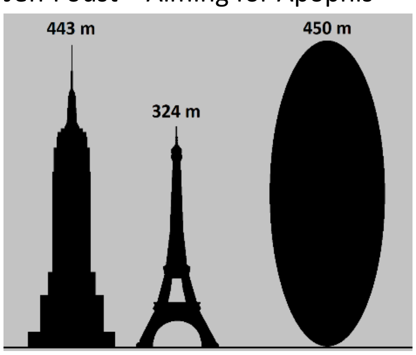
https://phys.org/news/2024-05-surface-acoustic-techniques-surfing-quantum.html

https://dx.doi.org/10.1038/s41467-024-48167-7

Credit: Arjun Iyer



Jeff Foust ~ Aiming for Apophis



https://spacenews.com/aiming-for-apophis/

Credit: Phoenix CZE, Creative Commons Attribution-Share Alike 4.0 International license

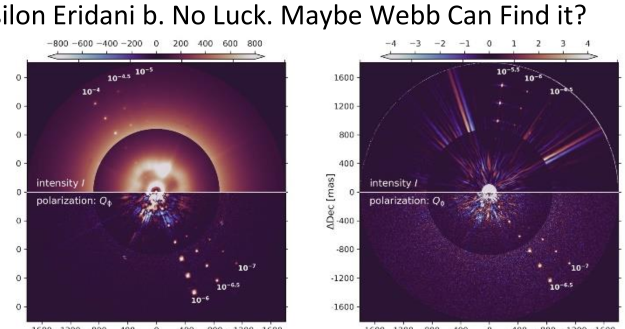
Credit: Blue Origin

Mark Thompson ~ Astronomers Try to Directly Observe Epsilon Eridani b. No Luck. Maybe Webb Can Find it?

https://www.universetoday.com/166975/astronomers-try-to-directly-observe-epsilon-eridani-b-no-luck-maybe-webb-can-find-it/#more-166975

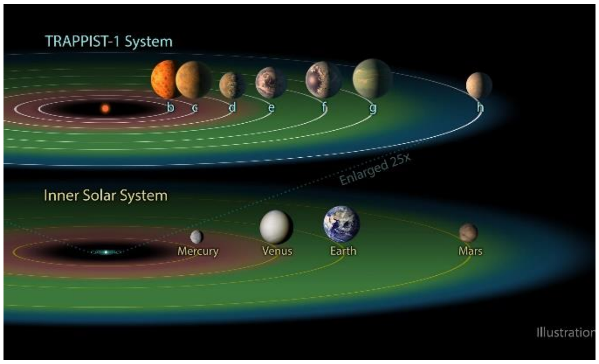
https://arxiv.org/abs/2404.19504

Credit: C. Tschudi et al, Fig 6, 7



Evan Gough ~ TRAPPIST-1 Outer Planets Likely Have Water

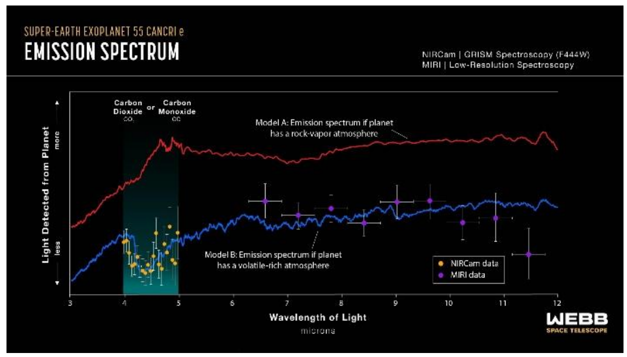
https://www.universetoday.com/166941/trappist-1-outer-planets-likely-have-water/#more-166941



https://arxiv.org/abs/2405.02401

Credit: NASA/JPL

Space Telescope Science Institute ~ Super-Earth Surprise: Webb Finds Atmosphere on Rocky Exoplanet for the First Time

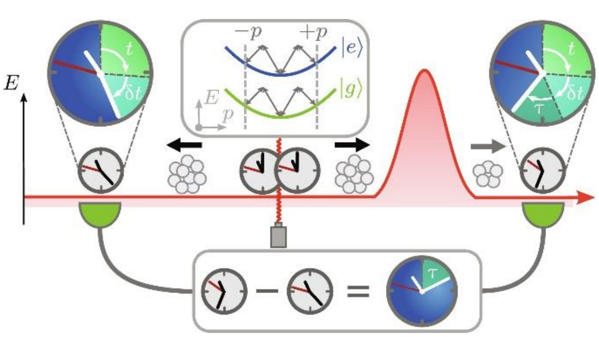


https://scitechdaily.com/super-earth-surprise-webb-finds-atmosphere-on-rocky-exoplanet-for-the-first-time/

https://www.nature.com/articles/s41586-024-07432-x

Credit: NASA, ESA, CSA, Joseph Olmsted (STScI), Renyu Hu (NASA-JPL), Aaron Bello-Arufe (NASA-JPL), Michael Zhang (University of Chicago), Mantas Zilinskas (SRON)

Michaela Hütig ~ Researchers call for a new measurement of time for tunneling particles

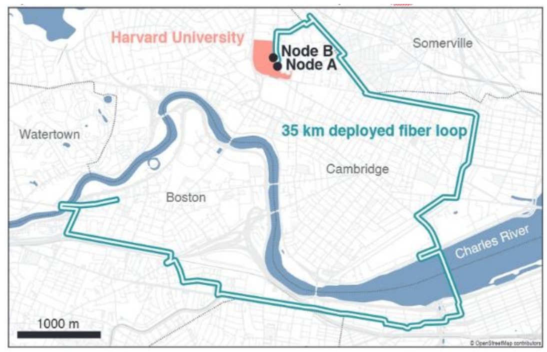


https://phys.org/news/2024-05-tunneling-particles.html

https://dx.doi.org/10.1126/sciadv.adl6078

Credit: P. Schach, E. Giese, Fig. 4

Bart Machielse, Aziza Suleymanzade, Can Knaut, Yan-Cheng Wei, and Nicholas Mondrik ~ Delivering quantum information – a field-deployed quantum network

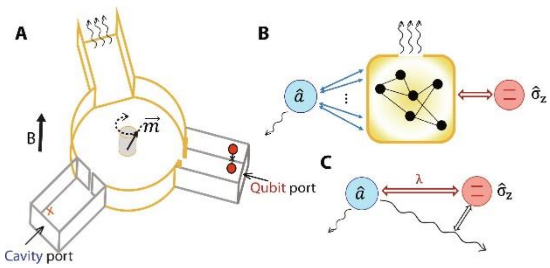


https://aws.amazon.com/blogs/quantum-computing/delivering-quantum-information-a-field-deployed-quantum-network/

https://www.nature.com/articles/s41586-024-07252-z

Credit: B. Machielse, et. al, Fig. 1

University of Massachusetts Amherst ~ Physicists Develop Groundbreaking Device for Advanced Quantum Computing

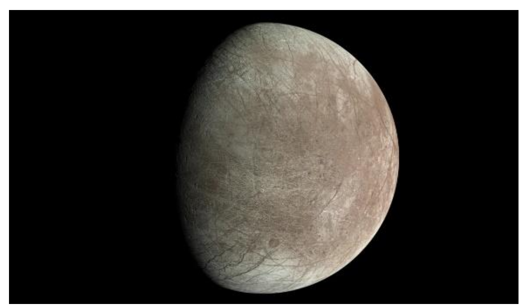


https://scitechdaily.com/physicists-develop-groundbreaking-device-for-advanced-quantum-computing/

https://doi.org/10.1126/sciadv.adj8796

Credit: Y-Y Wang, et. al. Fig. 1

Stephen Luntz ~ NASA’s Flyby of Europa Suggests "Something" Stirring Beneath the Ice

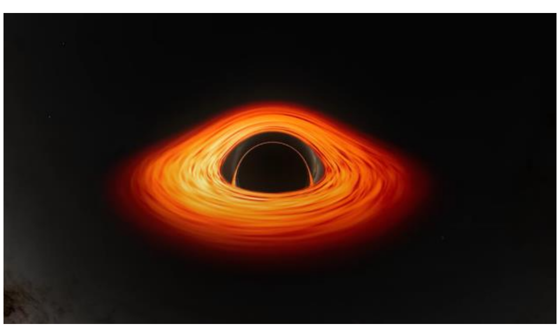


https://www.iflscience.com/nasas-flyby-of-europa-suggests-something-stirring-beneath-the-ice-74251

https://www.nasa.gov/missions/juno/nasas-juno-provides-high-definition-views-of-europas-icy-shell/

Credit: NASA/JPL-Caltech/SwRI/MSSS. Image processing: Björn Jónsson (CC BY 3.0)

Robert Lea ~ Fall into a black hole in mind-bending NASA animation (video)

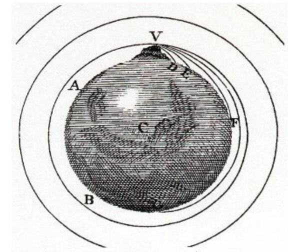


https://www.space.com/fall-into-black-hole-mind-bending-animation

https://www.space.com/black-hole-week-nasa-may-2023
https://www.youtube.com/watch?v=dGEIsnBRWGs

Credit: NASA's Goddard Space Flight Center/J. Schnittman and B. Powell

Simon Sharwood/Geoff Huston ~ Starlink offers 'unusually hostile environment' to TCP/A transport protocol's view of Starlink

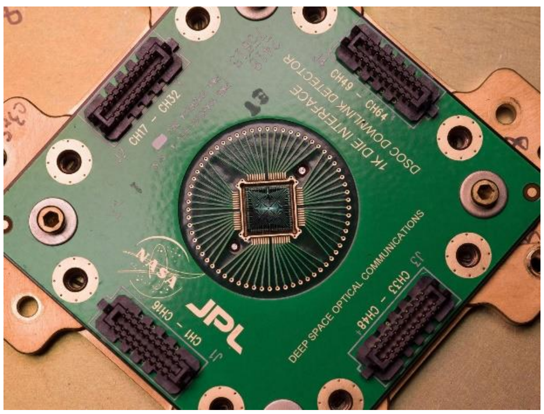


https://www.theregister.com/2024/05/22/starlink_tcp_performance_evaluation/
https://blog.apnic.net/2024/05/17/a-transport-protocols-view-of-starlink/

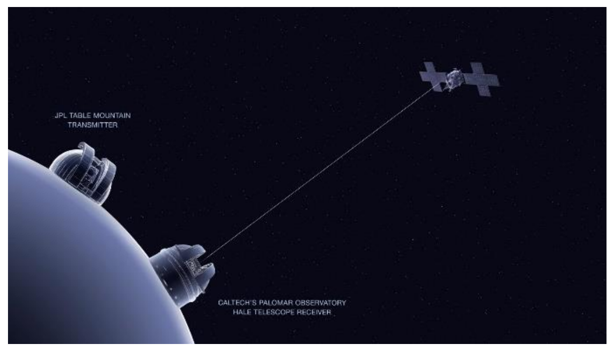
Credit: Isaac Newton, Principia Mathematica

Jet Propulsion Laboratory ~ 5 Fast Facts: NASA's Deep Space Optical Communications (DSOC) Experiment

https://scitechdaily.com/5-fast-facts-nasas-deep-space-optical-communications-dsoc-experiment/

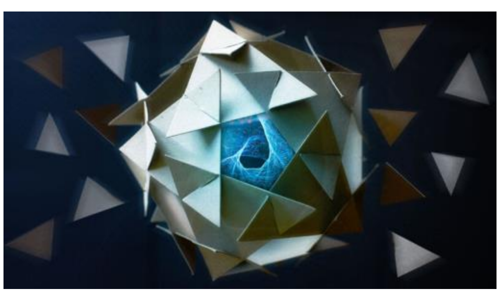


Credit: NASA/JPL-Caltech



Kyle Orland ~ Here's what's really going on inside an LLM's neural network

https://arstechnica.com/ai/2024/05/heres-whats-really-going-on-inside-an-llms-neural-network/



https://www.anthropic.com/research/mapping-mind-language-model

Templeton, et al., "Scaling Monosemanticity: Extracting Interpretable Features from Claude 3 Sonnet", Transformer Circuits Thread, 2024. https://transformer-circuits.pub/2024/scaling-monosemanticity/index.html *Credit: Aurich Lawson | Getty Images*

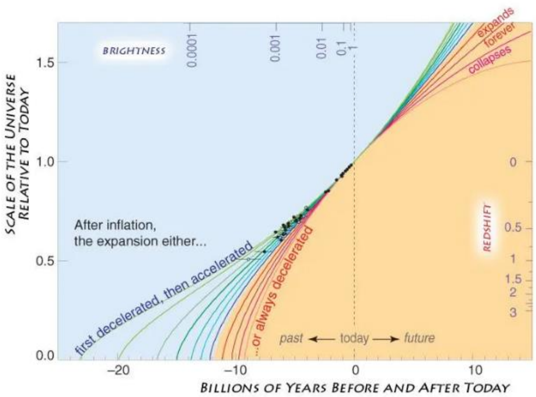
Mark Thompson ~ Hubble Sees a Brand-New Triple Star System

https://www.universetoday.com/167046/hubble-sees-a-brand-new-triple-star-system/

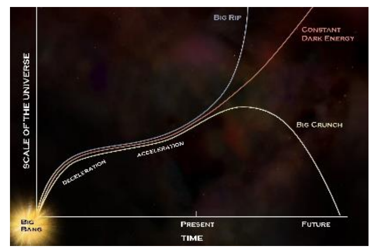
https://science.nasa.gov/missions/hubble/hubble-views-the-dawn-of-a-sun-like-star/

Credit: NASA, ESA, G. Duchene (Universite de Grenoble I); Image Processing: Gladys Kober (NASA/Catholic University of America)

Ethan Siegel ~ Why physicists now question the fate of the Universe



https://bigthink.com/starts-with-a-bang/physicists-question-fate-universe/

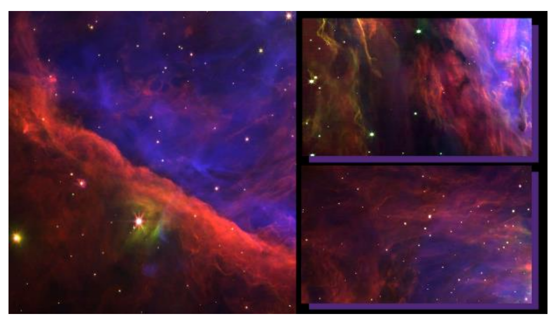


Credit: NASA/CXC/M. Weiss

Credit: Saul Perlmutter/UC Berkeley

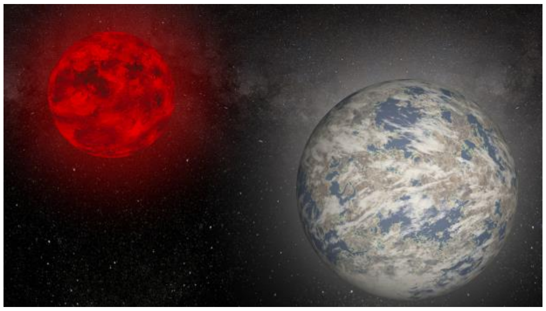
Robert Lea ~ James Webb Space Telescope sees Orion Nebula in a stunning new light (images)

https://www.space.com/james-webb-space-telescope-orion-nebula-m42-new-light



Credit: NASA/ESA/CSA, E. Dartois, E. Habart, PDRs4All ERS team

Robert Lea ~ NASA space telescope finds Earth-size exoplanet that's 'not a bad place' to hunt for life

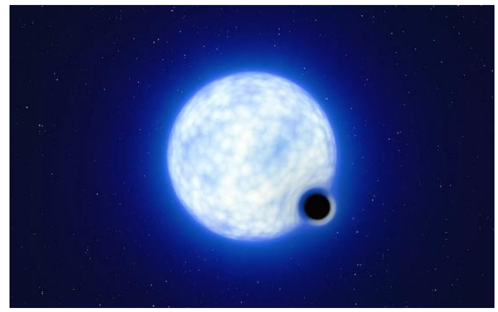


https://www.space.com/gliese-12-b-tess-exoplanet-hunt-for-life

Credit: Robert Lea (created with Canva)

Colin Stuart ~ Did this Black Hole form without a Supernova?

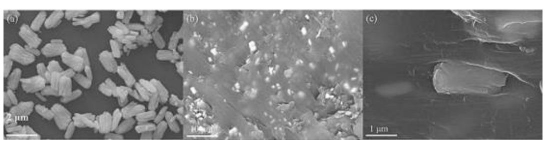
https://skyandtelescope.org/astronomy-news/did-this-black-hole-form-without-a-supernova/



Credit: ESO/L. Calçada

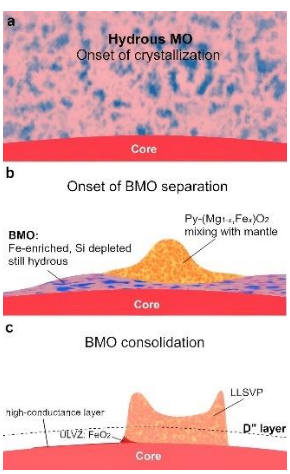
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.132.191403 (new work)
https://doi.org/10.1038/s41550-022-01730-y (original work)

Hefei Institutes of Physical Science ~ Researchers create new type of composite material for shielding against neutron and gamma radiation



https://phys.org/news/2024-05-composite-material-shielding-neutron-gamma.html

https://dx.doi.org/10.1016/j.compscitech.2024.110567



Science China Press ~ Earth's mysterious D" layer: A relic of ancient oceans and planetary collisions

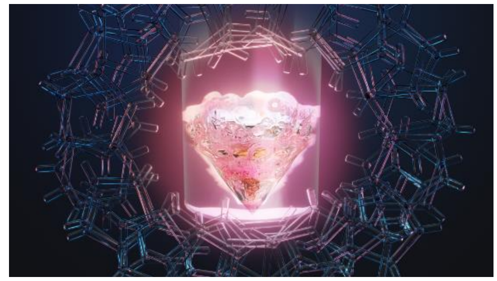
https://phys.org/news/2024-05-earth-mysterious-d-layer-relic.html
https://dx.doi.org/10.1093/nsr/nwae169

Credit: Science China Press

Dawn M. Levy ~ Promethium bound: Rare earth element's secrets exposed
https://www.ornl.gov/news/promethium-bound-rare-earth-elements-secrets-exposed

https://www.nature.com/articles/s41586-024-07267-6

Credit: Jacquelyn DeMink, art; Thomas Dyke, photography/ORNL, U.S. Dept. of Energy



Laura Simmons ~ Does Everyone Hear a Voice in Their Head When They Read?

https://www.iflscience.com/does-everyone-hear-a-voice-in-their-head-when-they-read-74312

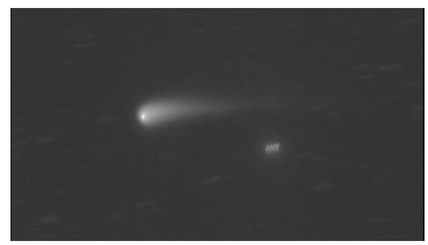
https://www.tandfonline.com/doi/full/10.1080/17522439.2015.1028972

Credit: Manop Boonpeng/Shutterstock.com

[Astronomy] Joe Rao ~ A comet approaching Earth could become brighter than the stars this fall

https://www.space.com/comet-tsuchinshan-atlas-fall-2024

Credit: Gianluca Masi/The Virtual Telescope Project



Jules Bernstein ~ International planet hunters unveil massive catalog of strange worlds

https://phys.org/news/2024-05-international-planet-hunters-unveil-massive.html

https://dx.doi.org/10.3847/1538-4365/ad4484

Credit: W. M. Keck Observatory/Adam Makarenko

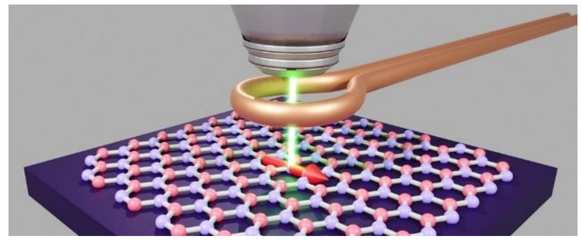
Matt Swayne ~ Researchers' Study Suggests That, Once Upon a Time, There Was No Entanglement

https://thequantuminsider.com/2024/05/28/researchers-study-suggests-that-once-upon-a-time-there-was-no-entanglement/
https://arxiv.org/abs/2405.03418 *(theoretical paper)*

David Neild ~ Physicists Demonstrate Room Temp Quantum Storage in 2D Material
https://www.sciencealert.com/physicists-demonstrate-room-temp-quantum-storage-in-2d-material

https://www.nature.com/articles/s41563-024-01887-z

Credit: Eleanor Nichols, Cavendish Laboratory

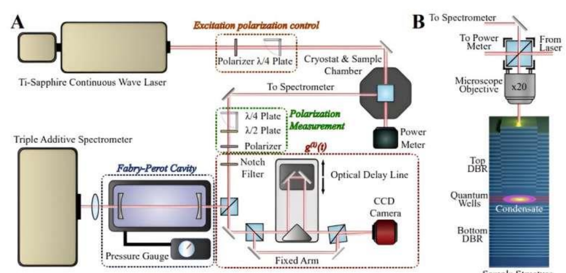


Jessica Barnett ~ Hi-C Rocket Experiment Achieves Never-Before-Seen Look At Solar Flares

https://www.nasa.gov/centers-and-facilities/marshall/hi-c-rocket-experiment-achieves-never-before-seen-look-at-solar-flares/

Credit: NASA

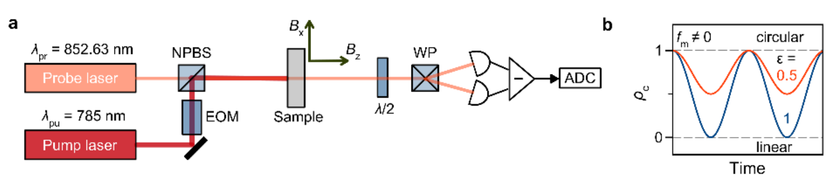
Eimear Bruen ~ On-chip GHz time crystals with semiconductor photonic devices pave way to new physics and optoelectronic applications



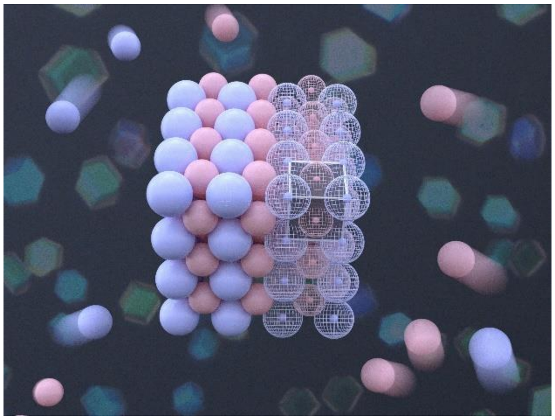
Credit: Science (2024). DOI: 10.1126/science.adn7087
https://phys.org/news/2024-05-chip-ghz-crystals-semiconductor-photonic.html

Alex Greilich, Nataliia E. Kopteva, Vladimir L. Korenev, Manfred Bayer, "Exploring nonlinear dynamics in periodically driven time crystal: from synchronized to chaotic motion", arXiv:2406.06243 [cond-mat.mes-hall], https://arxiv.org/abs/2406.06243

Credit: A. Greilich, et. al, Extended Fig. 1



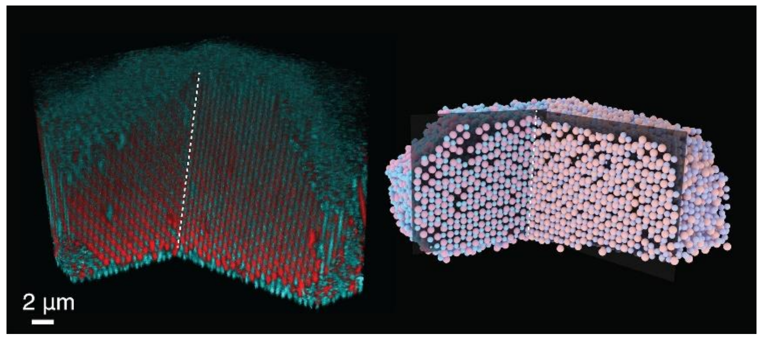
New York University ~ Scientists develop 'X-ray vision' technique to see inside crystals



https://phys.org/news/2024-06-scientists-ray-vision-technique-crystals.html

https://dx.doi.org/10.1038/s41563-024-01917-w

Credit: Shihao Zang, NYU



Technical Knowledge and Education: (May - June 2024)

Charlotte Lytton ~ Physicist Claudia de Rham: 'Gravity connects everything, from a person to a planet'

https://www.theguardian.com/science/2024/apr/21/theoretical-physicist-claudia-de-rham-the-beauty-of-falling-gravity-book-interview

https://iai.tv/iai-academy/courses/info?course=massive-gravity

https://press.princeton.edu/books/ebook/9780691237497/the-beauty-of-falling

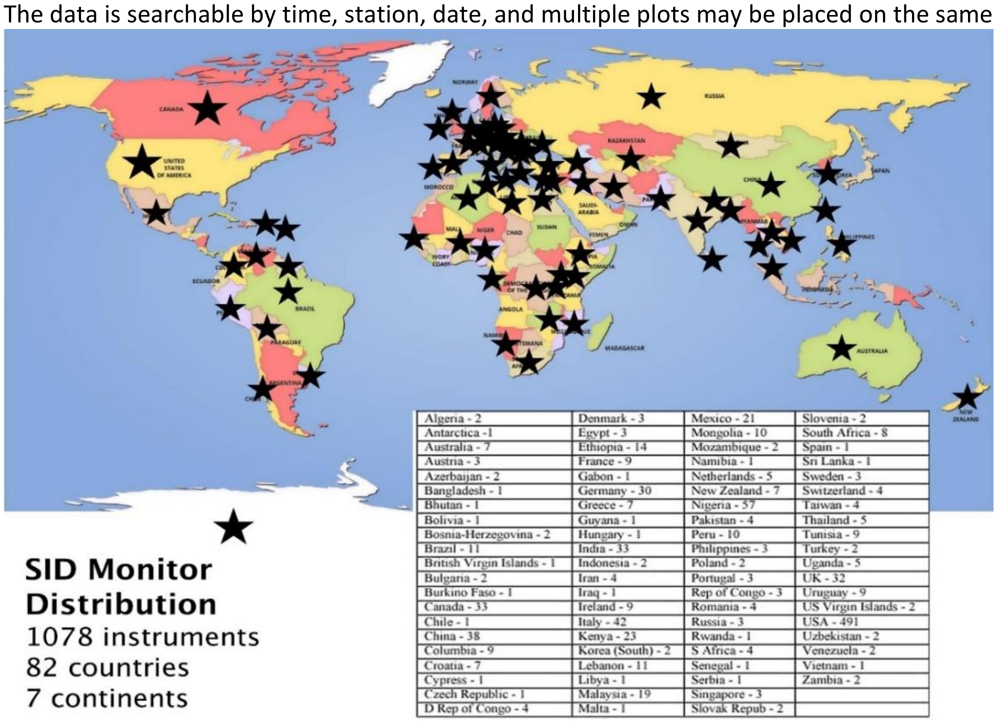
SARA ~ ezRA – Easy Radio Astronomy Analysis Tutorials:
- *Simple Overview: https://youtu.be/sgid9zn9KkY*
- *Analysis 1- Introduction and Data Collectors*: https://youtu.be/ig_jPTuS8ZA
- *Analysis 2- Spreadsheet Analysis*: https://youtu.be/HkrIN9d6Hd8
- *Analysis 3- Signal Progression*: https://youtu.be/VIp7L6gIZPY
- *Analysis 4- More Plots and ezb file*: https://youtu.be/K02MADafOhc
- *Analysis 5- Interference Filters*: https://youtu.be/FeFk9EvITtc
- *Analysis 6- ezSky*: https://youtu.be/UNwS0f9X7kE
- *Analysis 7- AntXTVT and VLSR* : https://youtu.be/0ezig90GNBc
- *Analysis 8- ezGal*: https://youtu.be/i0St2X7ODKM

SARA ~ *Radio Astronomy Video Series: Constants, Variables and Formulas, Radio Astronomy Formulas:*
- *Introduction to Radio Astronomy: https://youtu.be/AOgvjRXnins*
- *Lesson 1- Parabolic Dish Gain*: https://www.youtube.com/watch?v=2bx5K9jUc_w
- *Lesson 2 -Parabolic Dish Half Power Beamwidth*: https://www.youtube.com/watch?v=XWOMRrwjkl8
- *Lesson 3 -Thermal Noise*: https://youtu.be/MMJ6Xvapt10
- *Lesson 4 -Focal Length and f/D*: https://youtu.be/Am6t06KqFPE
- *Lesson 5 -Feed Illumination Angle*: https://youtu.be/4RZzPzVBSJ4
- *Lesson 6 -Pointing Offset Gain Loss*: https://youtu.be/dQ8wAaTtm40
- *Lesson 7 -Measuring System Temperature (TSys)*: https://youtu.be/4gVUFFxra-U
- *Lesson 8 -Coax Attenuation Interpolation*: https://youtu.be/3B8hV6vFyo8
- *Lesson 9 -Pulsar math including electron density, distance, and age*: https://youtu.be/Bymdp--_3JU
- *Lesson 10 -Distance Math - AU, Parallax, Parsecs and Light Years*: https://youtu.be/6fo0y3fDOZs
- *Lesson 11 -Doppler Frequency and Relative Velocity Calculations*: https://youtu.be/8zKloAVpnJc
- *Lesson 12 -Pointing to the Milky Way using a Compass and Protractor*: https://youtu.be/33xeUSji94U
- *Lesson 13 -Radiometer Equation Basics*: https://youtu.be/vAyypJ8f2z8
- *Lesson 14 -Noise Figure and Noise Factor Calculations*: https://youtu.be/GD6wZhW5NPA
- *Lesson 15 -Interpreting Stokes Parameters*: https://youtu.be/wUVsbfURIsg
- *Lesson 16 -Velocity Factor, Speed of Light in a Coax Cable: https://youtu.be/WWuqRyb4Ad8*
- *Lesson 17 -Interferometry Fringe Spacing: https://youtu.be/rYhUKFn7IWg*

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 monitor use. I will assure that a surge protector and other lightning protection devices are installed if necessary.

Signature: ____ Date: ____________________________

I will need:

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

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

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

or

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

____

____

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

To set up a SuperSID monitor you will need:

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

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

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

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

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

5 Surge protector and other protection against a lightning strike

---

Return this form to: SuperSID@radio-astronomy.org
or mail to:

SARA 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.

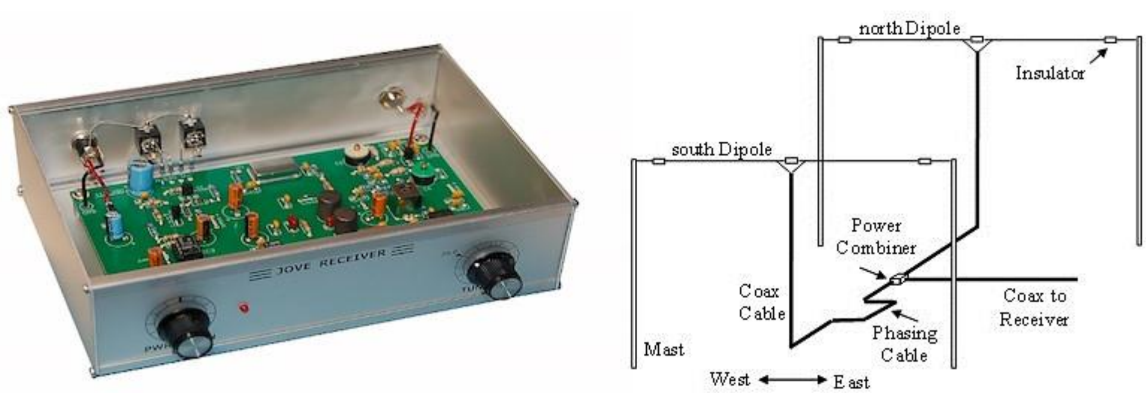

Figure 1. A Radio JOVE RJ1.1 receiver and a schematic of the dual-dipole antenna.

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).

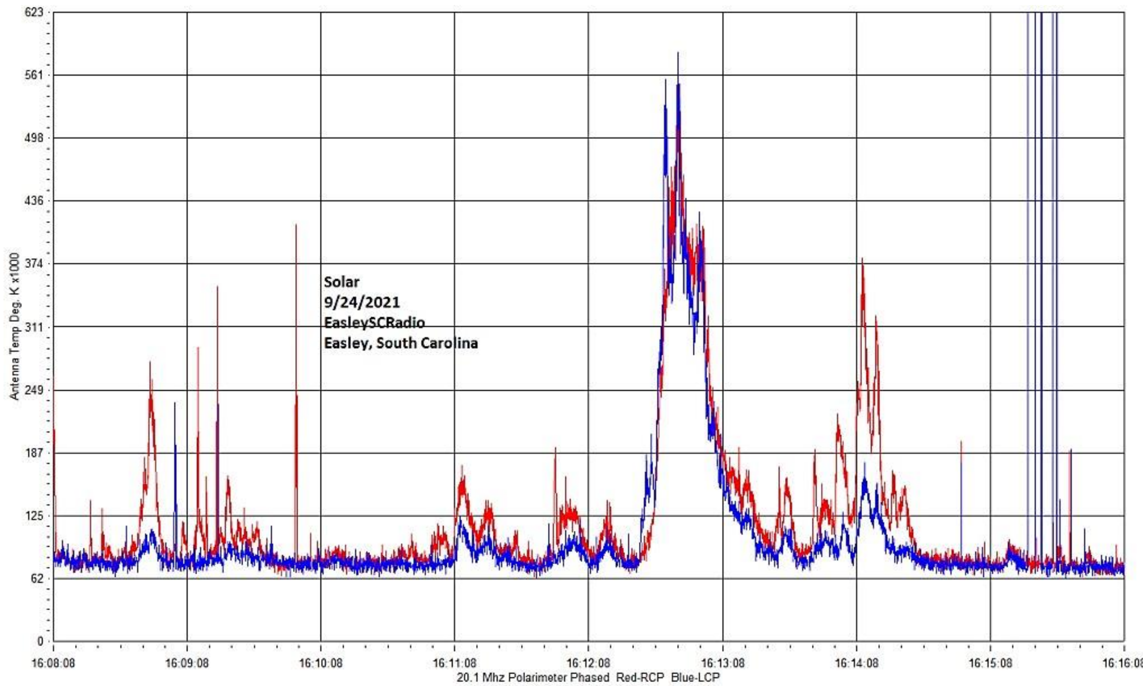

Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver. John Cox, SC.

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.

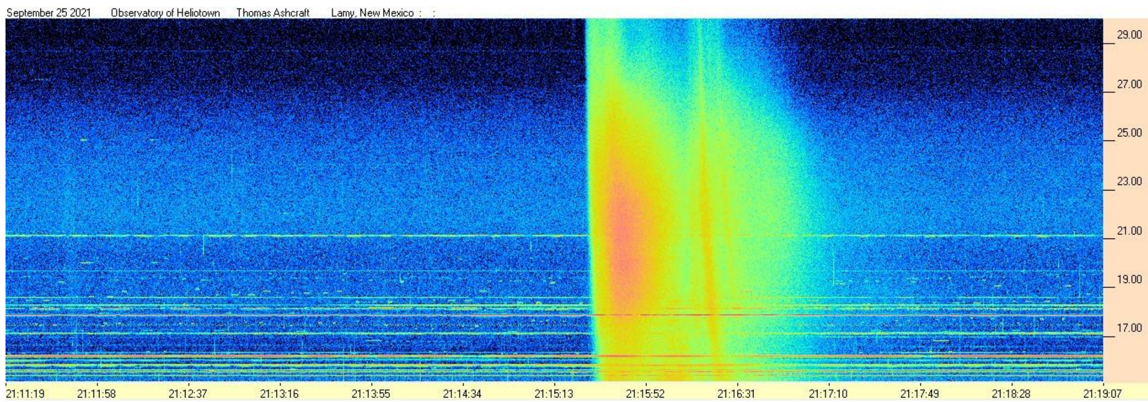

Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time, and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

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
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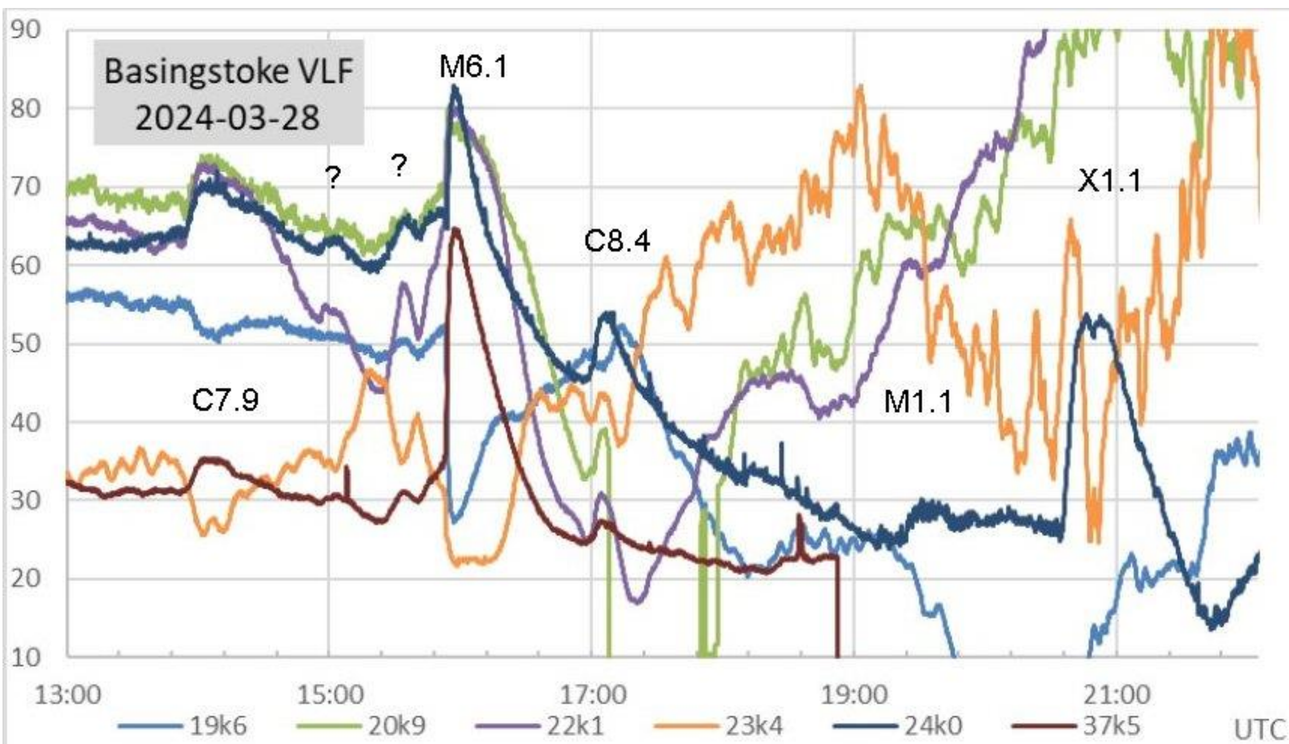
BAA Radio Astronomy Section, Director: Paul Hearn

RADIO SKY NEWS **2024 MARCH**

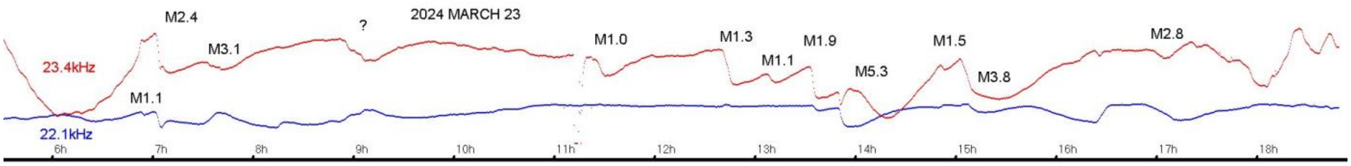
VLF SID OBSERVATIONS

Solar activity in March started quietly but increased dramatically from the 23rd. as AR13615 approached the centre of the visible disc. This was a very large and complex sunspot group and produced a barrage of M-class flares. We recorded 11 M-flares on the 23rd, 5 on the 24th, 4 on the 26th, and 3 on the 28th. Observers monitoring 24kHz were also lucky to catch the X1.1 flare between 20:30 and 21:30UT.

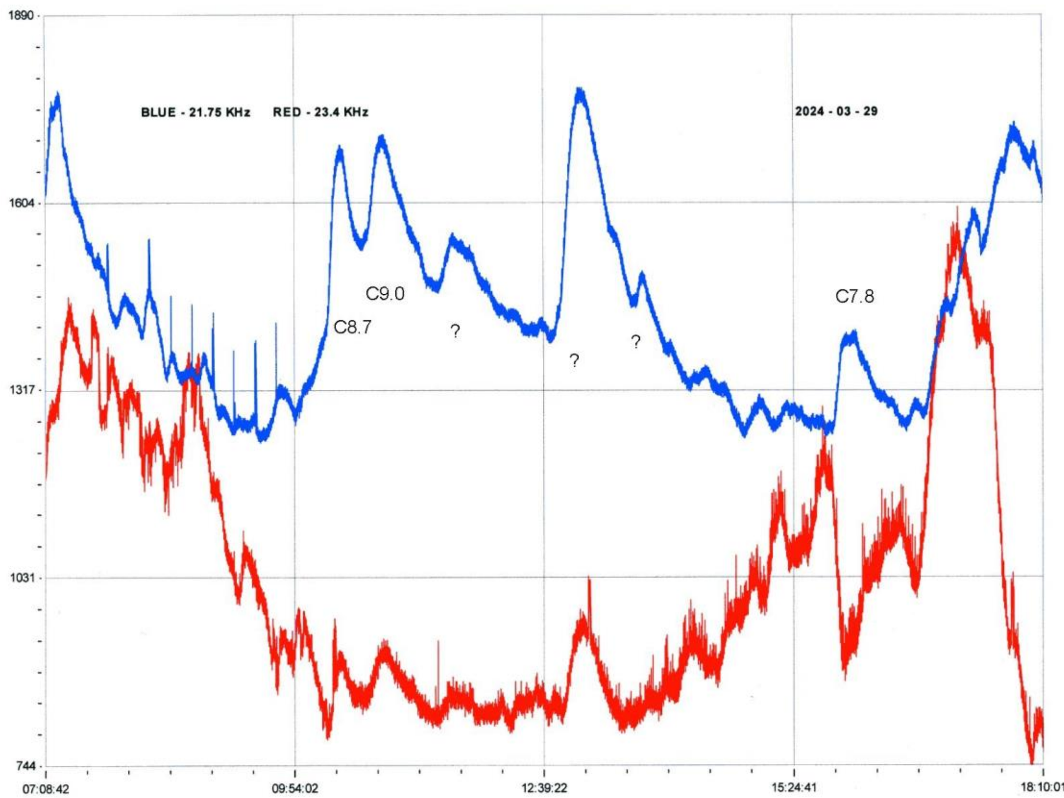


Paul Hyde's recording shows this well, while the European signals are well into night conditions. 37.5kHz had been switched off earlier, presumably due to the continuing volcanic activity. The chart also shows some of the other activity in the afternoon of the 28th, 23.4kHz being particularly chaotic and difficult to analyse. There were a number of flares unclassified in the SWPC bulletin, marked with a ?.

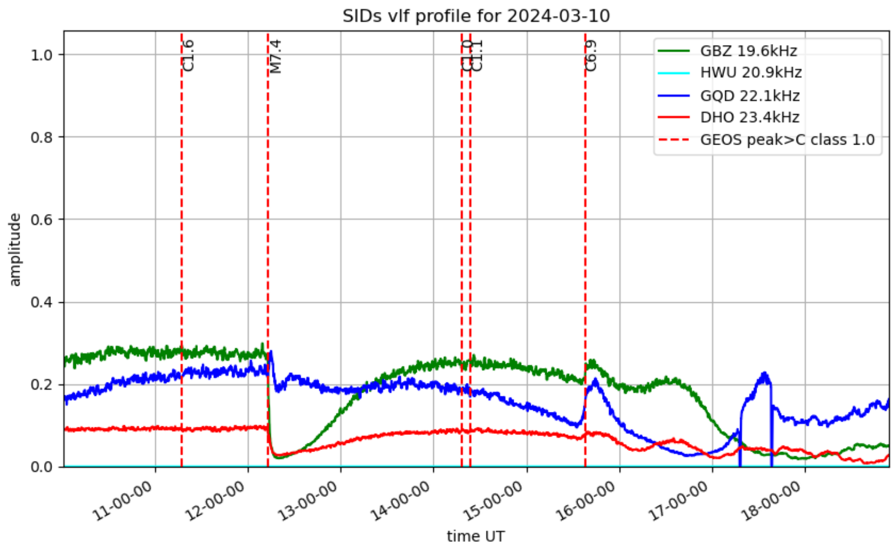
The large number of flares has made it very hard to separate individual events, particularly on the 23rd. We all have different paths to the transmitters, and so our timings for individual flares vary according to how they appear to overlap. This overlapping problem is clear in my own recording:



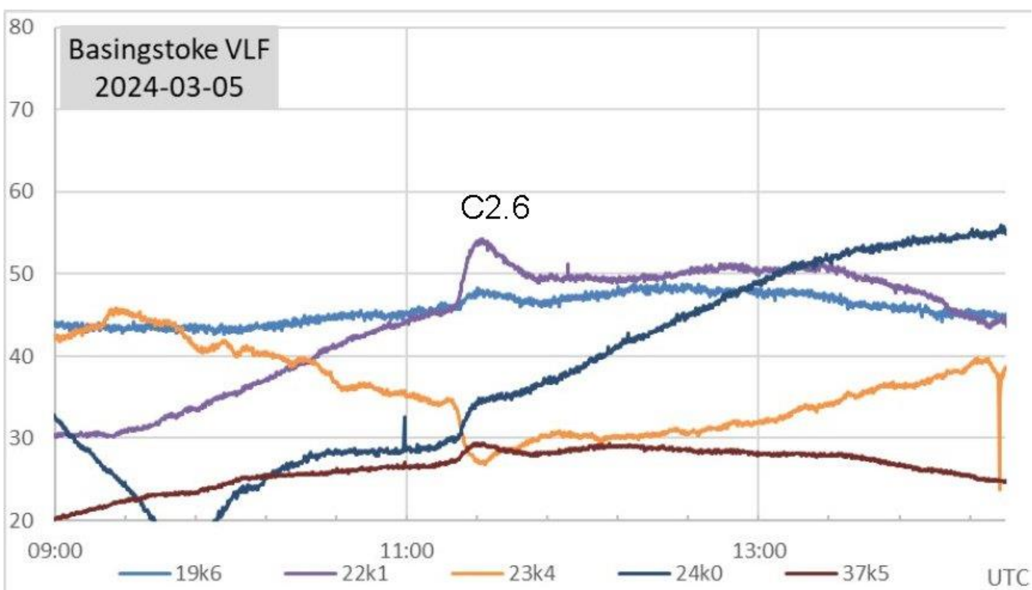
Luckily the usual 7-8AM break in 23.4kHz was not present on the 23rd, but 22.1kHz has remained fairly undisturbed by some of these events.



This recording by Colin Clements shows the strong C-class flares on March 29th. The C9.3 and C9.9 flares later in the evening are not shown. The unclassified events have produced very clear SIDs. AR13615 by this time was getting closer to the solar limb, and so the flares were not so directly aimed at the Earth.

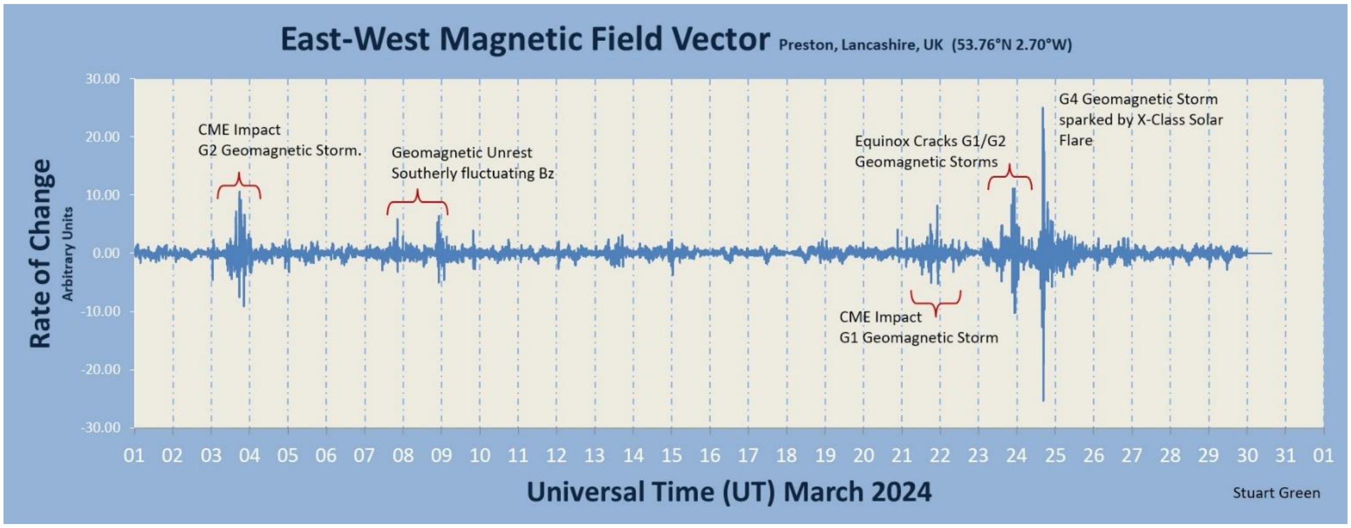


Mark Prescott's recording from the 10th shows a slightly less active period, although there is an M7.4 flare, well isolated from other activity. The C1.0 and C1.1 flares have not produced SIDs, but the later C6.9 is very clear.

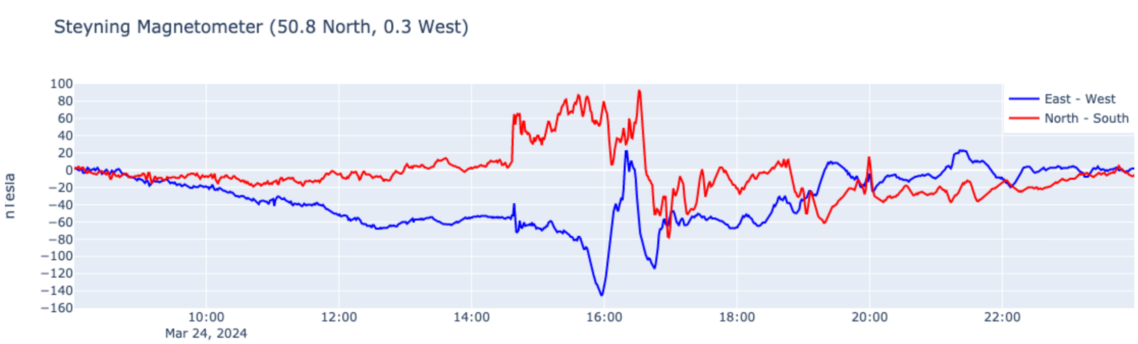


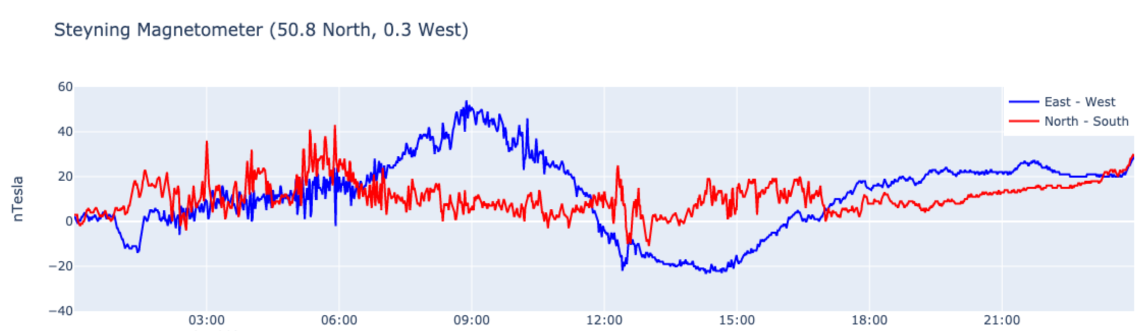
Background activity early in March was much lower, allowing weaker flares to produce clear SIDs. Paul Hyde recorded this C2.6 flare on the 5th with very stable signals.

MAGNETIC OBSERVATIONS

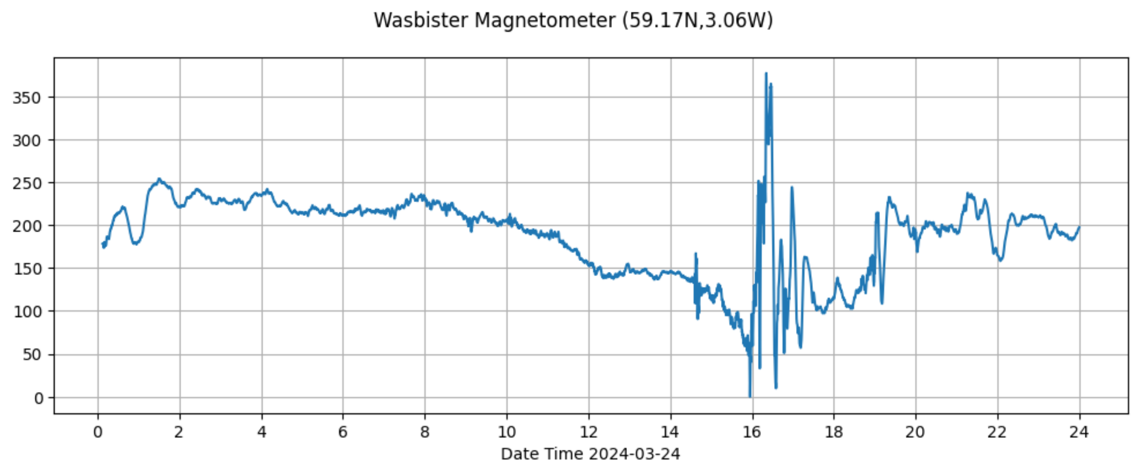


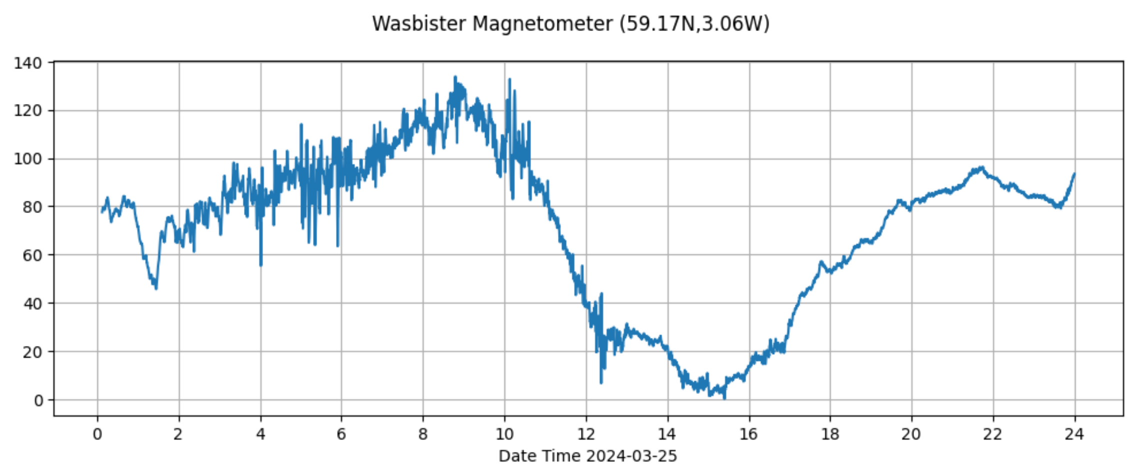
Stuart Green's summary of the Month's magnetic activity also shows a quiet start to March, with the most active period matching the barrage of M-flares in the last week. The large spike on the 24th is from a CME that produced a very active magnetic storm. Satellite data recorded by STCE shows that the CME was from an X1.1 flare at 01:30UT in the morning of the 23rd. It was from AR13615, but badly timed for us to record as a SID. We did record the CME arrival at 14:40 on the 24th, well shown in these charts by Nick Quinn:

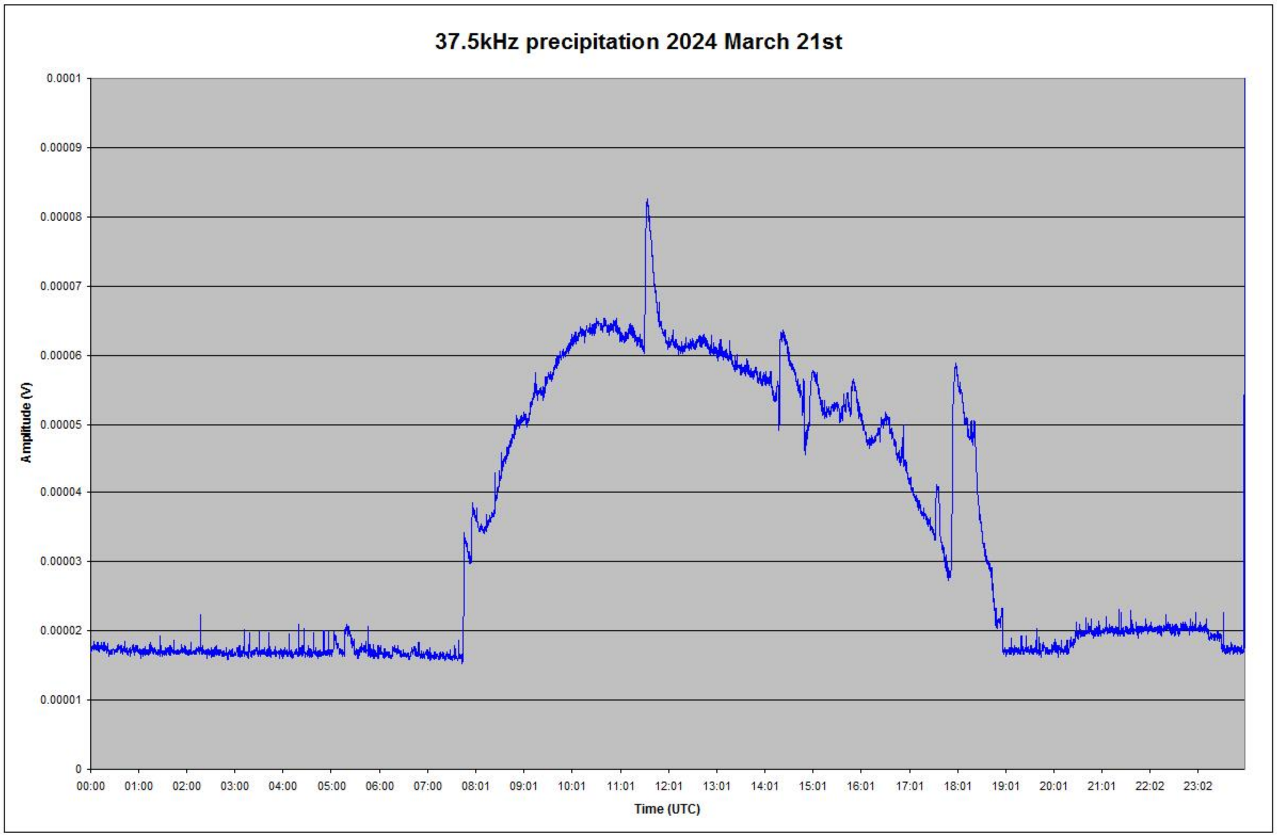




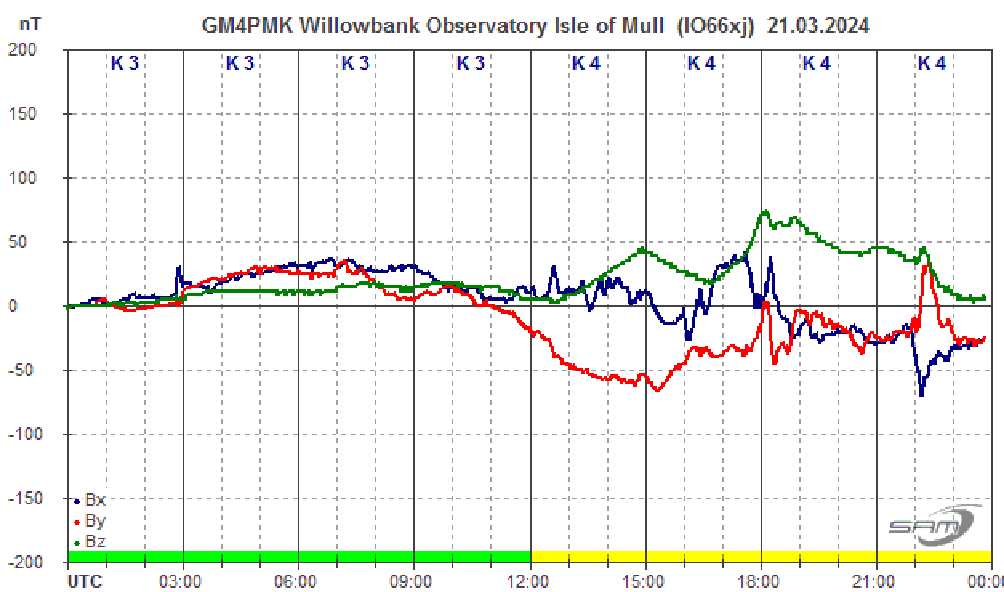
The CME sudden impact follows a very stable period and is followed by +/-100nT disturbance. This appears to fade away over the next six hours but is then followed by over 12 hours of very turbulent activity on the 25th. Recordings by Callum Potter in Orkney show very similar behaviour:



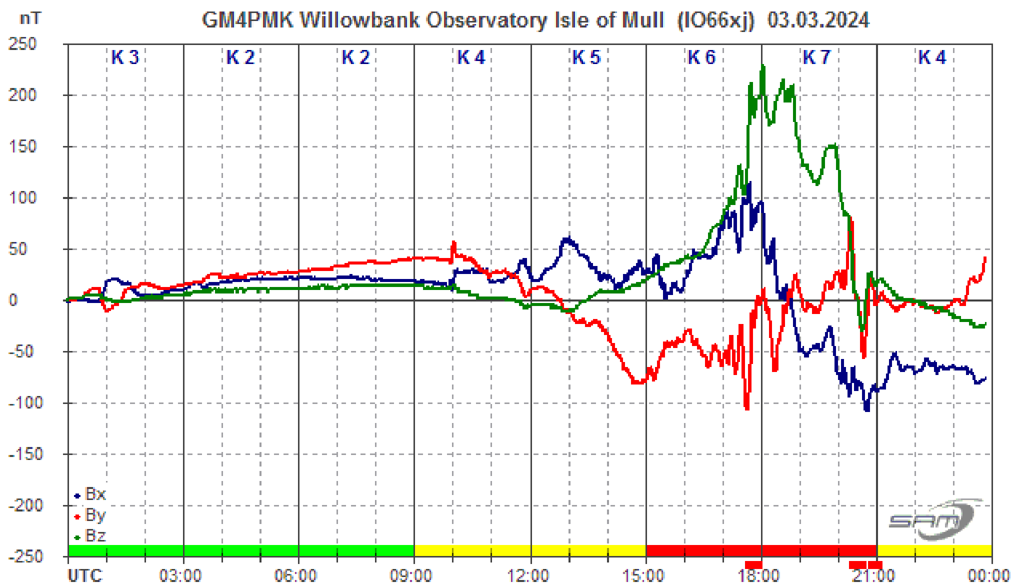




37.5kHz Grindavik has been on and off with the volcanic activity, one of its brief on periods catching magnetic activity on the 21st. Mark Edwards' recording shows the C8.7 flare around 11:30, with a response to the magnetic activity after 14:00. Roger Blackwell's recording from the 21st shows a possible CME impact around 03UT, with disturbance during the rest of the day:



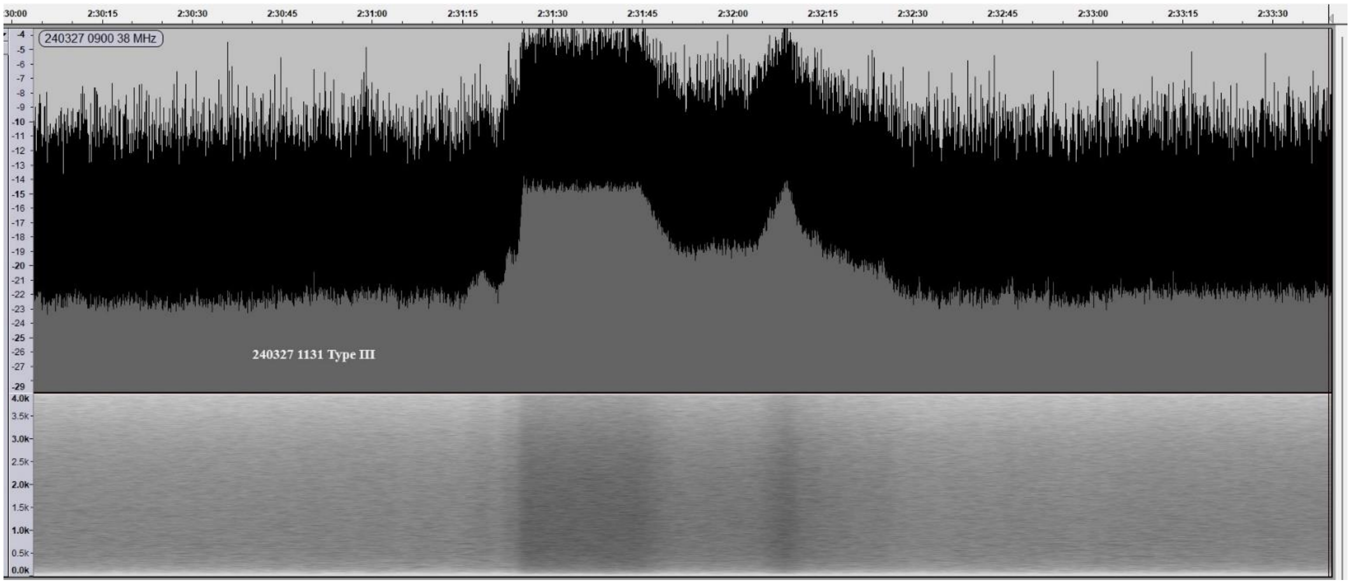
Callum Potter's recording also shows this feature. The mild disturbance continued into the 22nd and 23rd. The Sun-Earth alignment during the equinox periods allows good access for the solar magnetic field into our polar regions, also providing good aurora viewing opportunities.



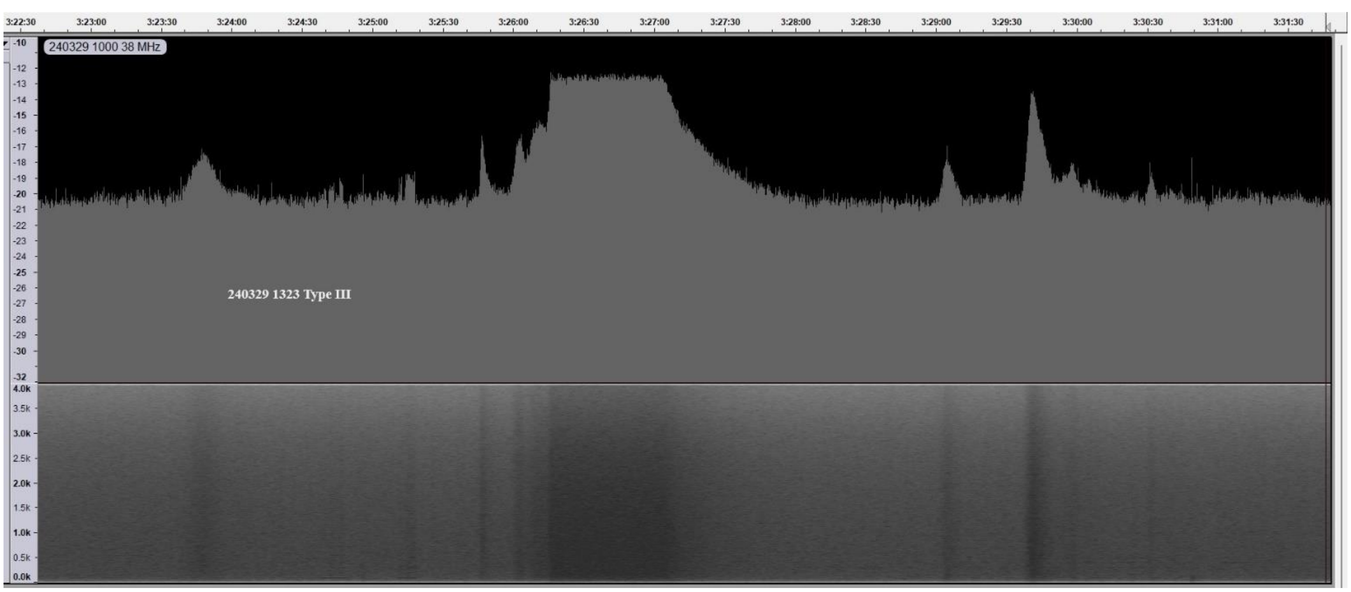
Roger Blackwell's recording from the 3rd shows another CME arrival. The impact can be seen at 10UT, STCE data linking it to a flare on February 28th. It was therefore a very slow CME, but the magnitude of the disturbance is again very high with some rapid turbulence. It did not last long, fading out just after midnight.

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

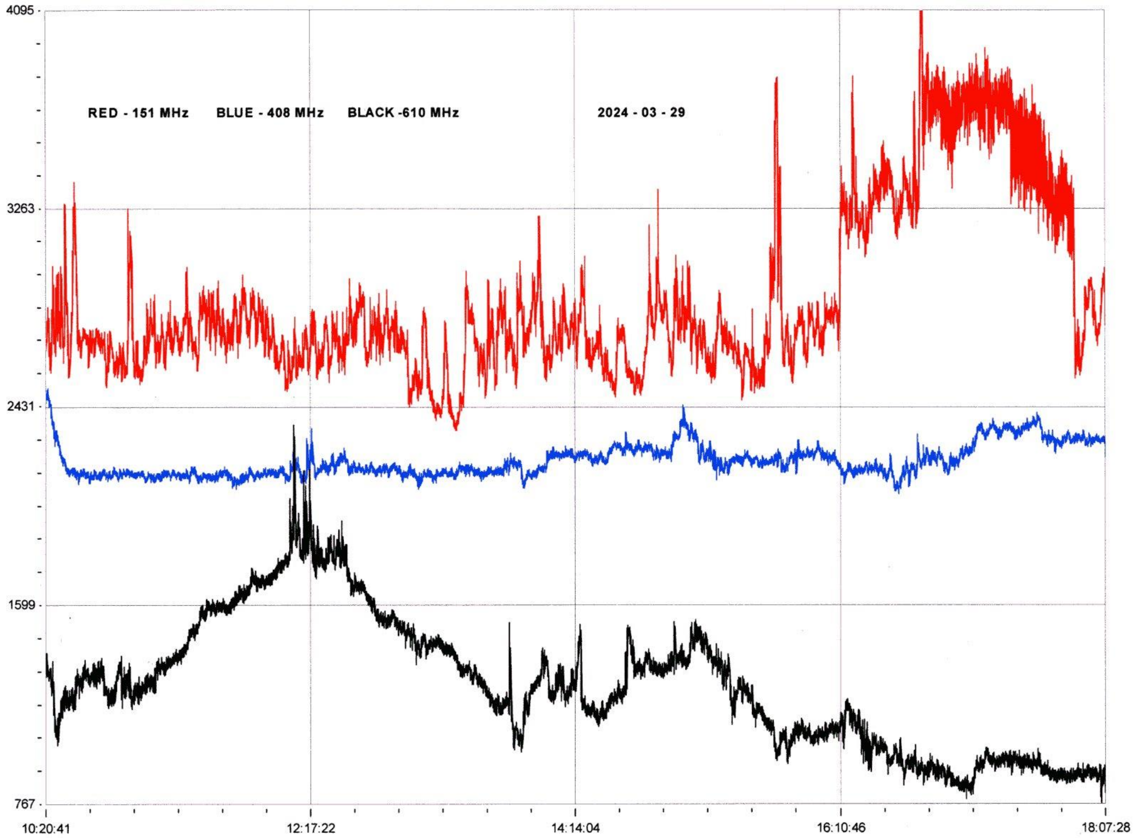
SOLAR EMISSIONS



Colin Briden has made recordings of type III 38MHz solar emissions on the 27th and 29th March. The timings of both of them match some of the unclassified flares that we recorded. They each have amplitudes of just under 10dB. Colin notes that they also have elements of a type V emission with a very clean spectrum.

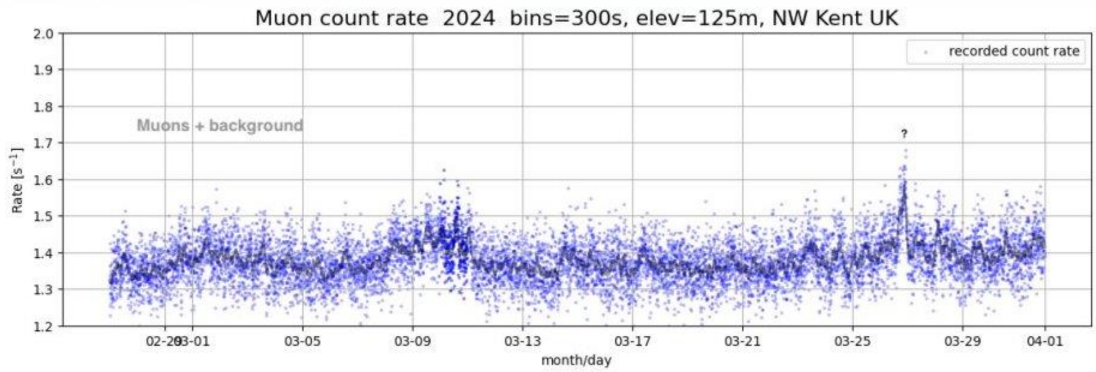


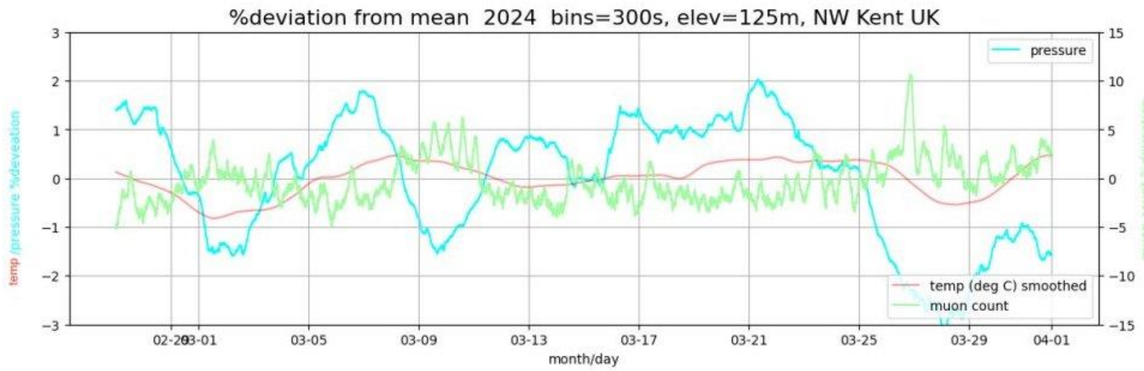
Colin Clements also made VHF recordings on the 29th:

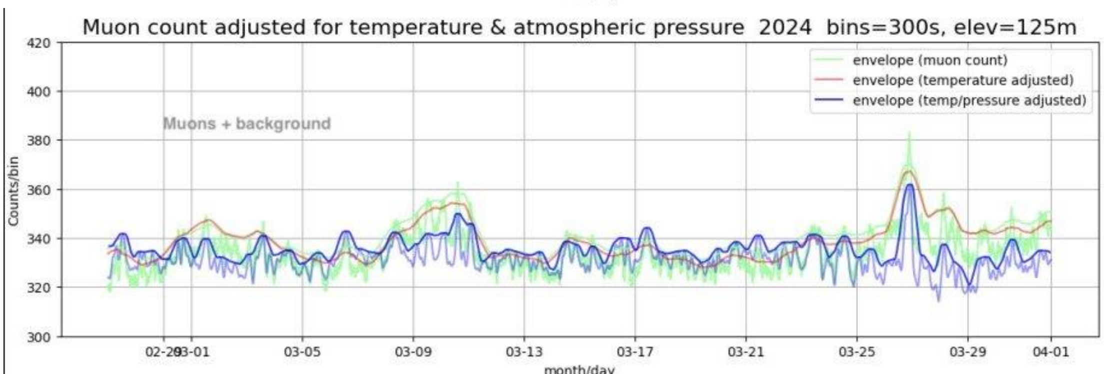


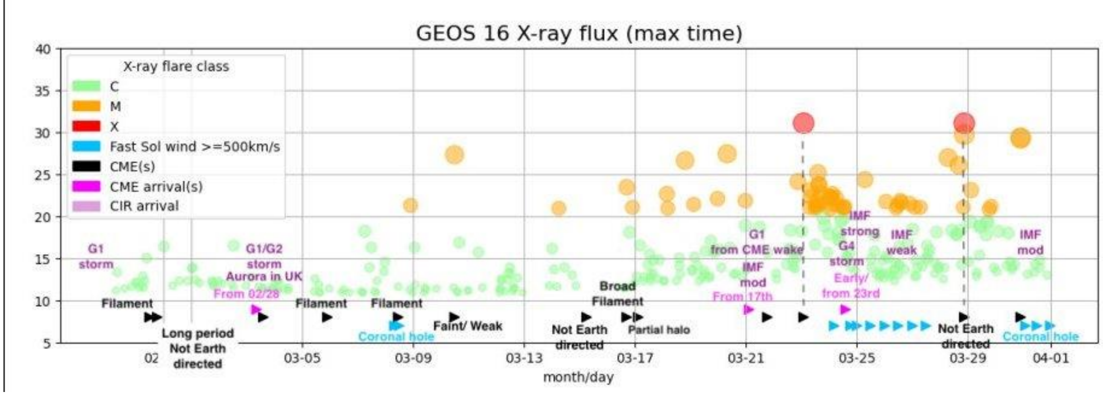
610MHz (black) shows a strong signal around 10:30 to 14:00, covering much of that unclassified activity. 151MHz (red) shows some activity over this period, but also has a strong signal after 16:10, covering the C7.8 and C9.3 flares. 408MHz has remained flat throughout the day. VHF emissions were also recorded on the 10th, 18th, 19th, 23rd, 24th and 26th, although difficult to link with specific flares. Some 610MHz activity on the 23rd probably relates to the run of M-flares in the afternoon.

MUONS







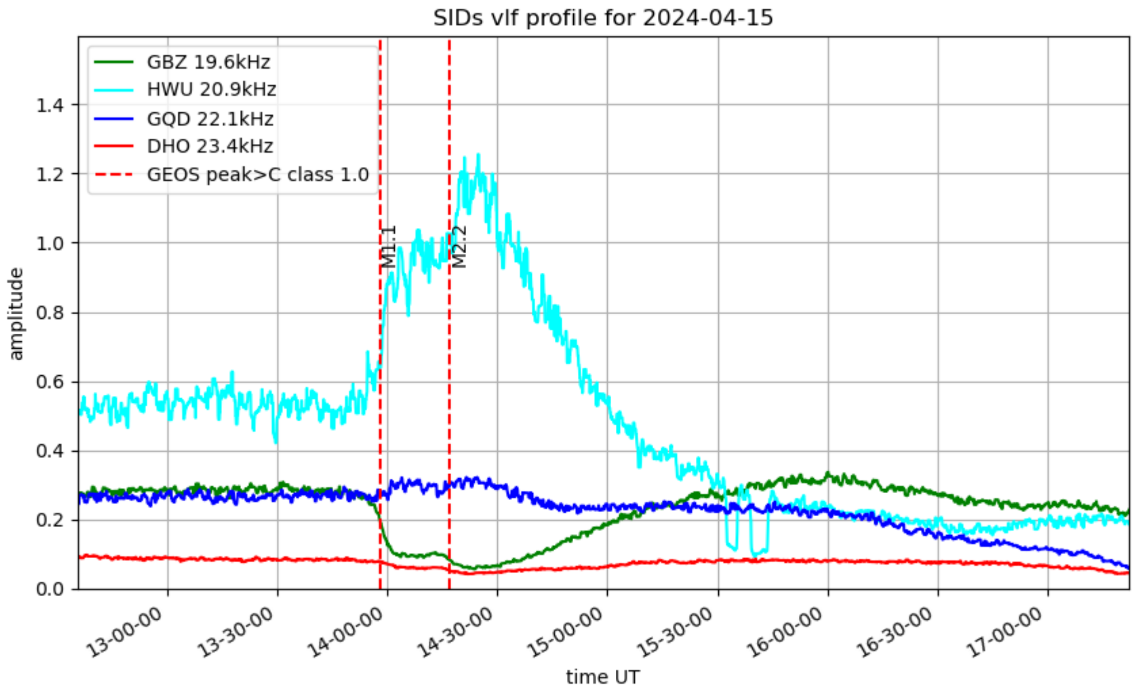


Mark Prescott's muon charts show a mild increase in flux around the 9th and 10th, with a much larger increase between the 25th and 29th. The precise cause of these is not clear, although they do occur shortly after some stronger flare and magnetic activity. The equinox alignment of the magnetic fields may well allow increased precipitation following these events, so increasing the measured flux. They both also match periods of low atmospheric pressure, adding to the effect. The lower chart is corrected for temperature and pressure variations, but that has only slightly reduced the peaks.

RADIO SKY NEWS **2024 APRIL**

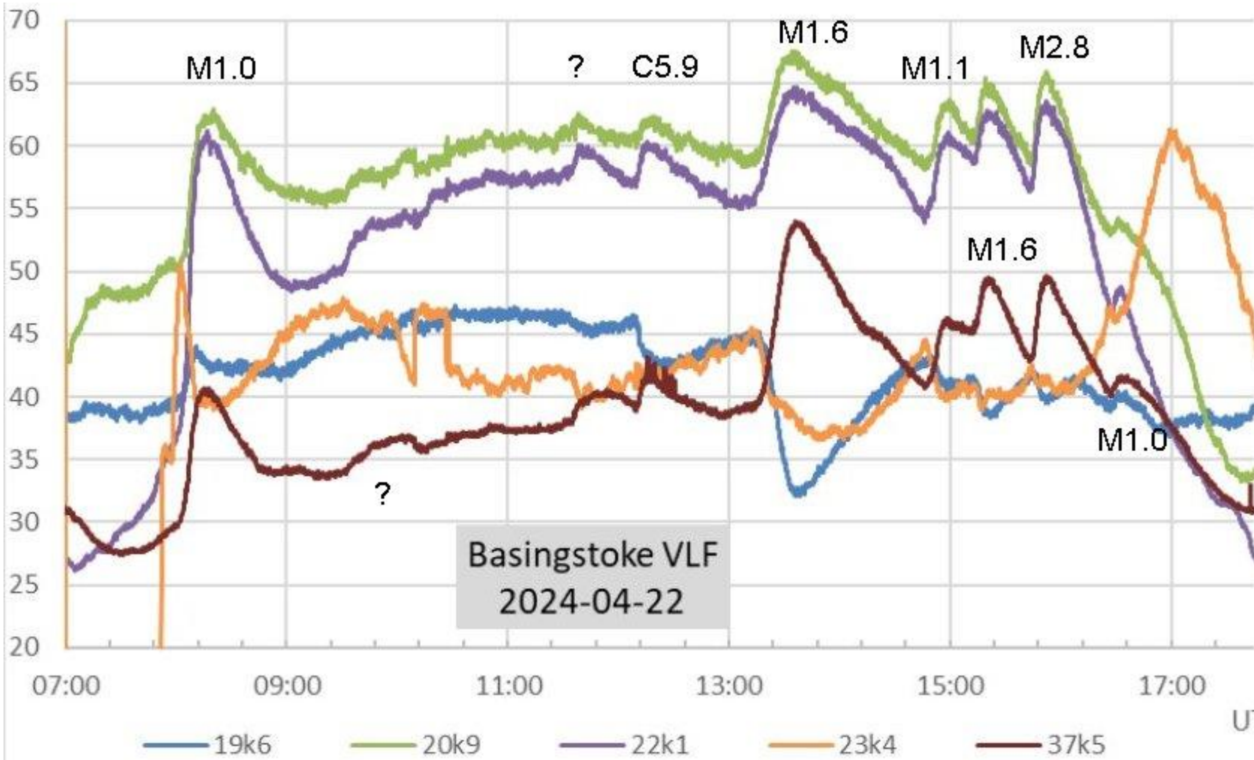
VLF SID OBSERVATIONS

Flare activity in April was slightly lower than in March, but there were still plenty of strong M-class flares with a generally high background X-ray flux. The month started very quietly, with just a single SID recorded between the 1st and 9th. Activity increased in the second half of the month, with plenty of M-class flares hiding the smaller C-class flares. Multiple peaks were a problem again, with a very difficult triple on the 15th:

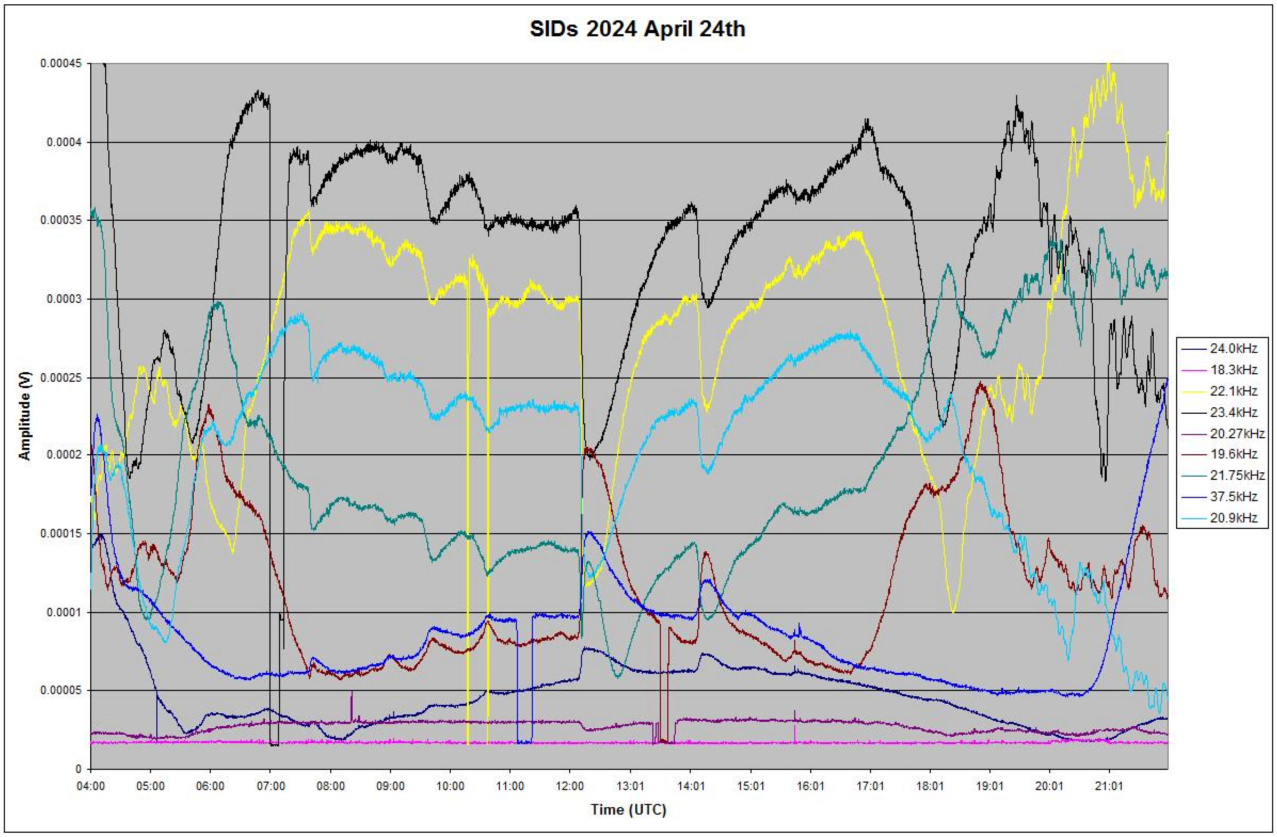


Mark Prescott's chart shows SIDs from two of these, the way that all of our observers recorded them. Satellite X-ray data lists an M1.1 flare peaking at 13:58UT, followed by an M1.4 peaking at 14:04. The M2.2 is listed at 14:17. Two active regions were involved; AR13639 for the M1.1 and M2.2, AR13634 for the M1.4.

Activity further increased after this, with a rapid sequence of M-flares on the 22nd. The recording from Paul Hyde shows these on several signals:

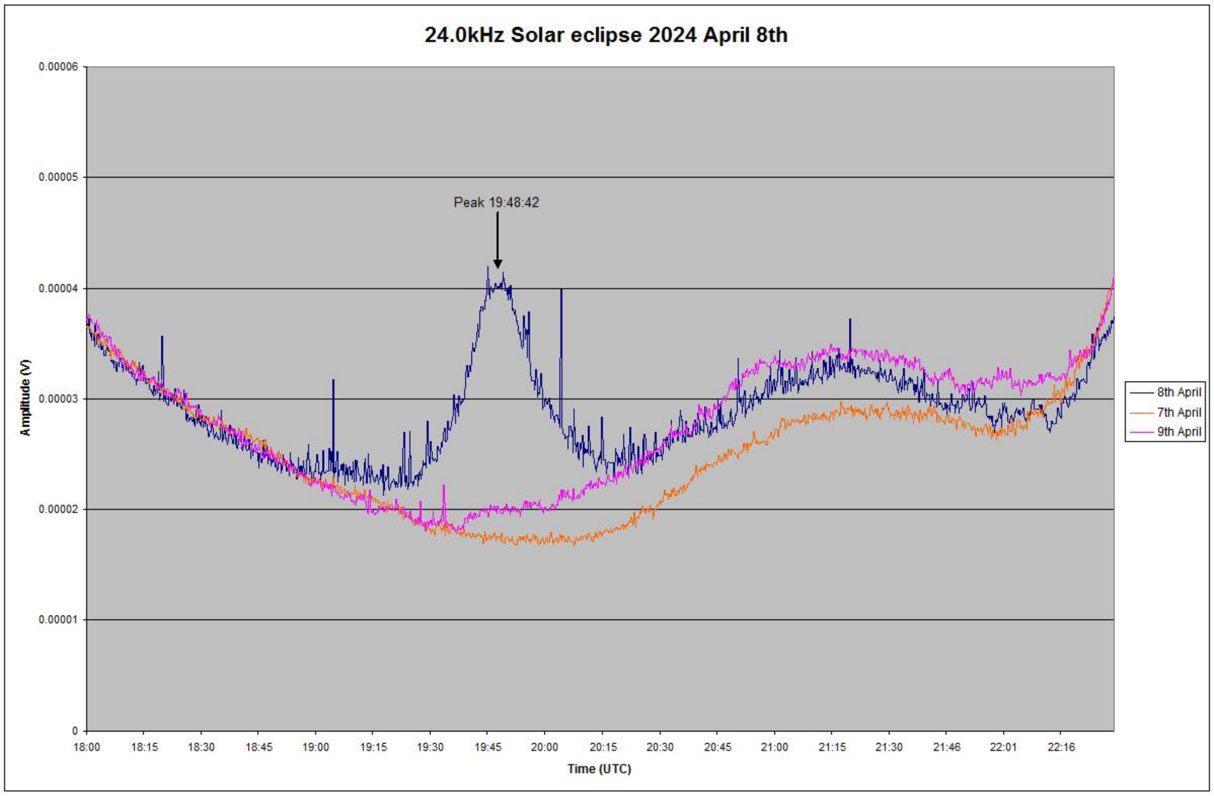


23.4kHz and 19.6kHz have not produced clear SIDs from all of these events, while 20.9kHz and 22.1kHz are very clear. The afternoon sequence of SIDs are all overlapping, with three active regions flaring. The 24th also produced many overlapping SIDs, shown here by Mark Edwards:

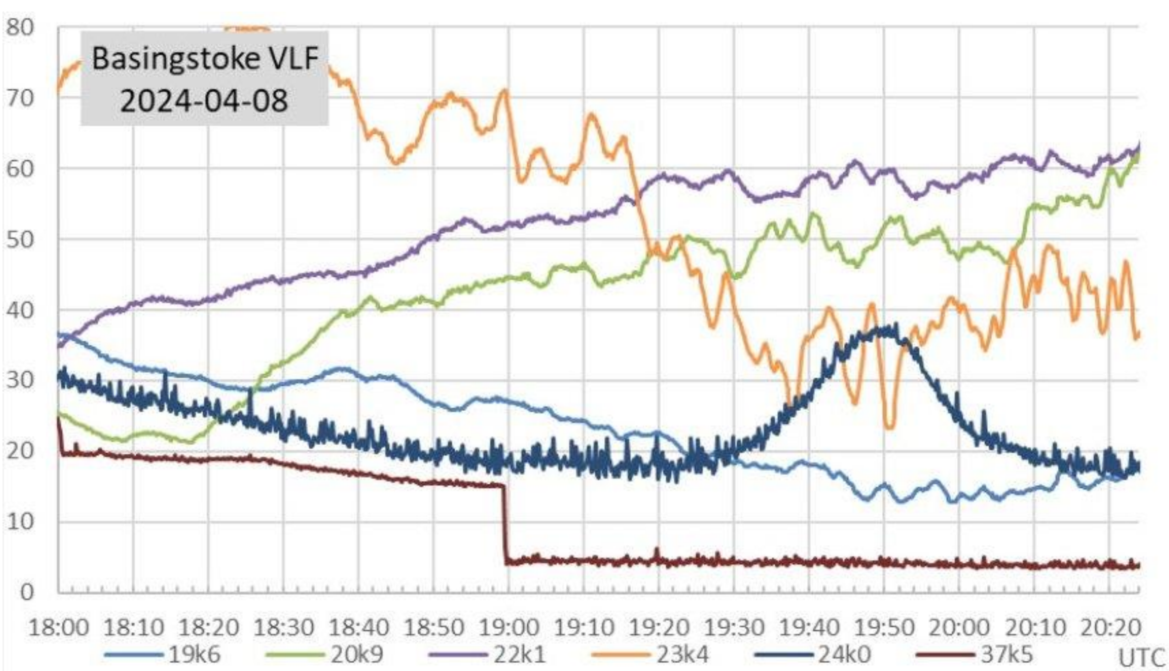


Most of these are C-class, with an M1.4 prominent at 12:15UT.

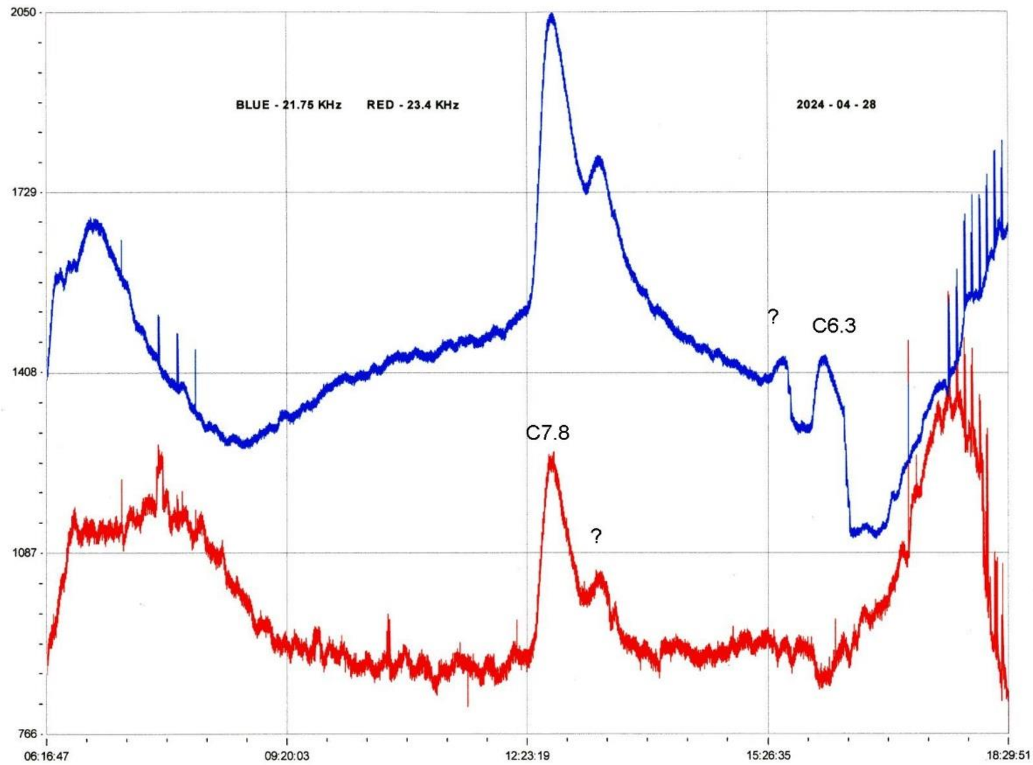
There was a solar eclipse on April 8th, visible mostly from the USA. The most westerly parts of the UK were able to catch a glimpse at sunset, but the trans-Atlantic signal paths were also included.



Mark Edwards' 24kHz recording shows a significant symmetrical rise in the 24kHz signal peaking at 19:48UT, blue trace. Pink and orange show the 9th and 7th, with more normal quiet curves. Mark notes that the symmetry of the curve was rather unexpected, given the long path length. There would presumably have been several reflection points on the ionosphere.

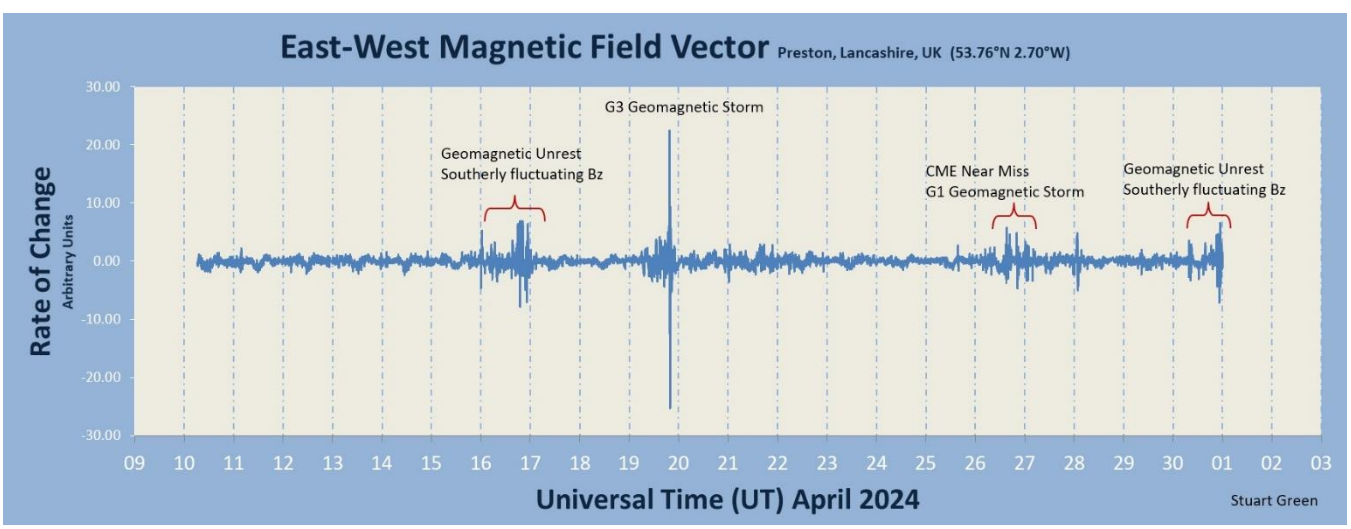


Paul Hyde's recording shows a very similar response at 24kHz, the other local signals well past sunset.

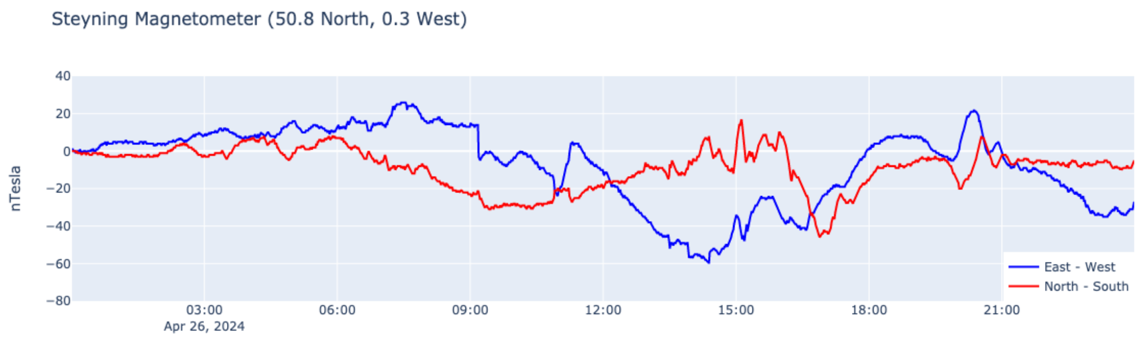


Colin Clements recorded the C7.8 and C6.3 flares on the 28th. There were also two unclassified events that show clearly. The second pair were rather close to the sunset and are less clear at 23.4kHz.

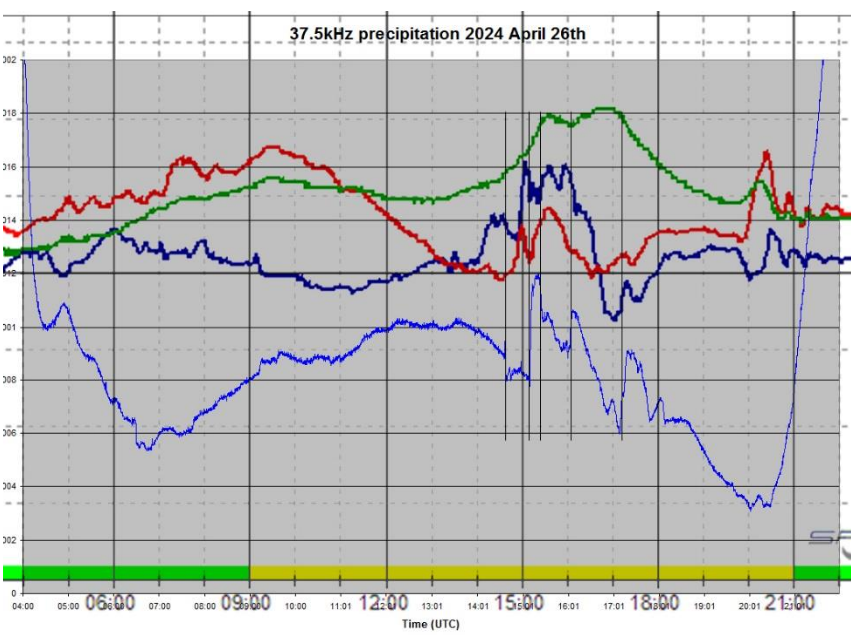
MAGNETIC OBSERVATIONS



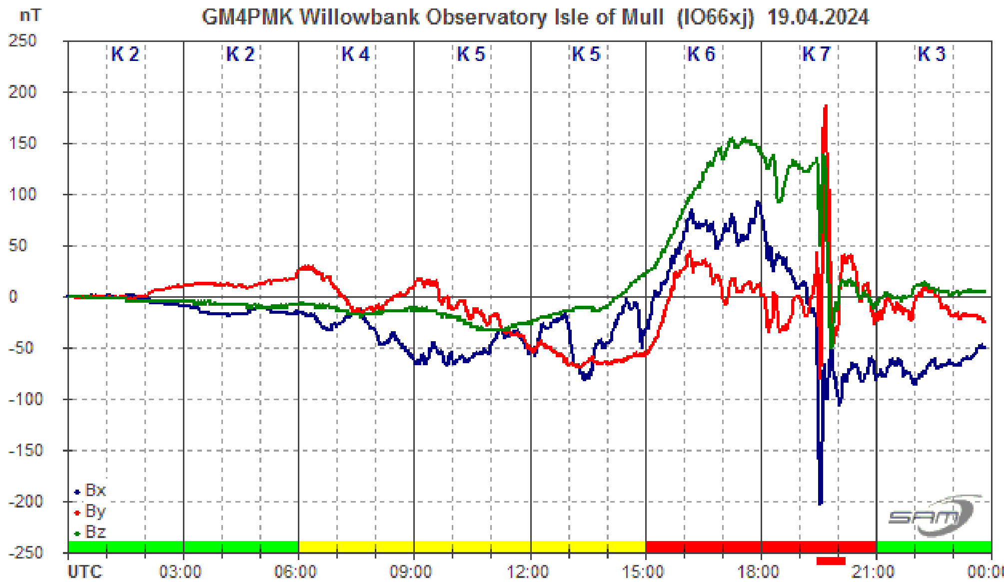
Stuart Green’s summary starts on the 10th and is deceptively quiet. The first few days are missing while the sensor was being relocated. There were plenty of CMEs associated with the stronger flares, but they were mostly directed away from Earth and were fairly weak. There were also a number of coronal holes present, with stronger winds responsible for some of the magnetic disturbance. A CME glancing blow seems to have been responsible for a storm on the 26th:



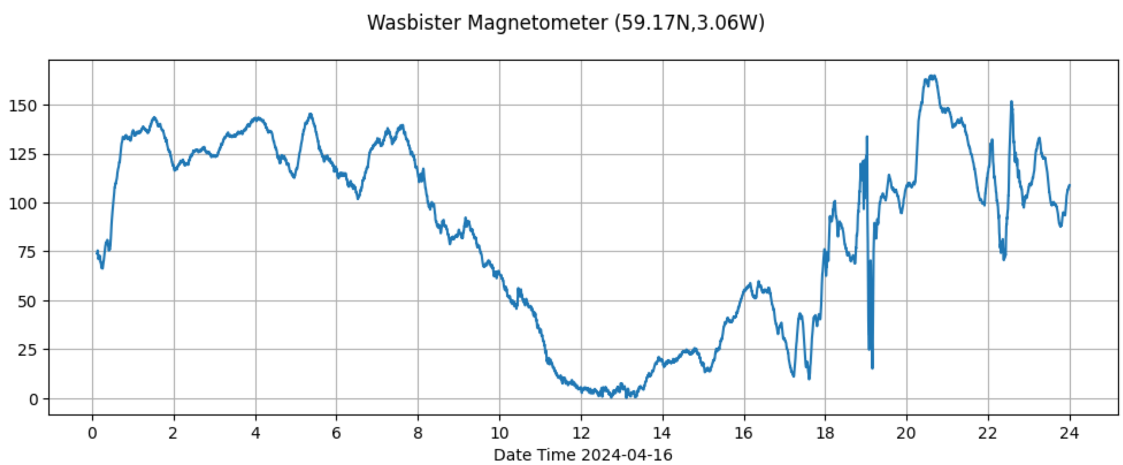
Nick Quinn’s recording shows the disturbance lasting through most of the day, fading out after about 21UT. Mark Edwards also recorded a strong response on the 37.5kHz Grindavik signal, matching well with the magnetic recordings. He has overlaid Roger Blackwell’s magnetic data on his VLF chart:



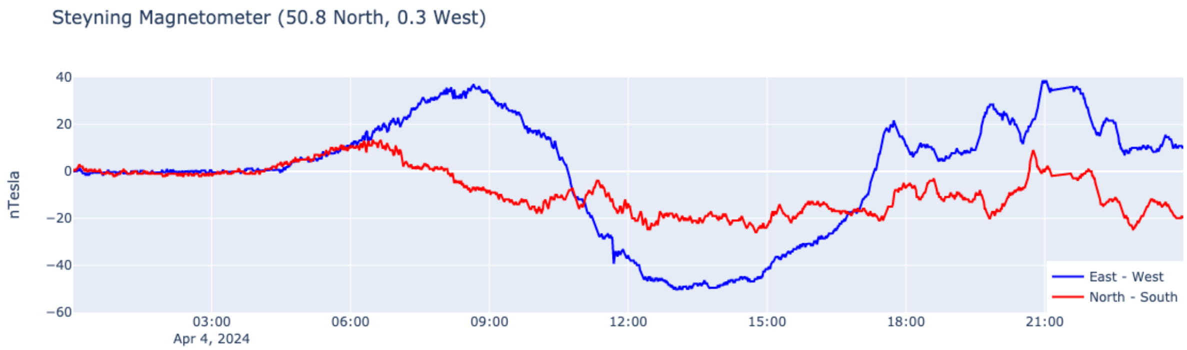
The vertical black lines help to show the alignment between the magnetic and VLF effects. The light blue trace is the 37.5kHz signal.



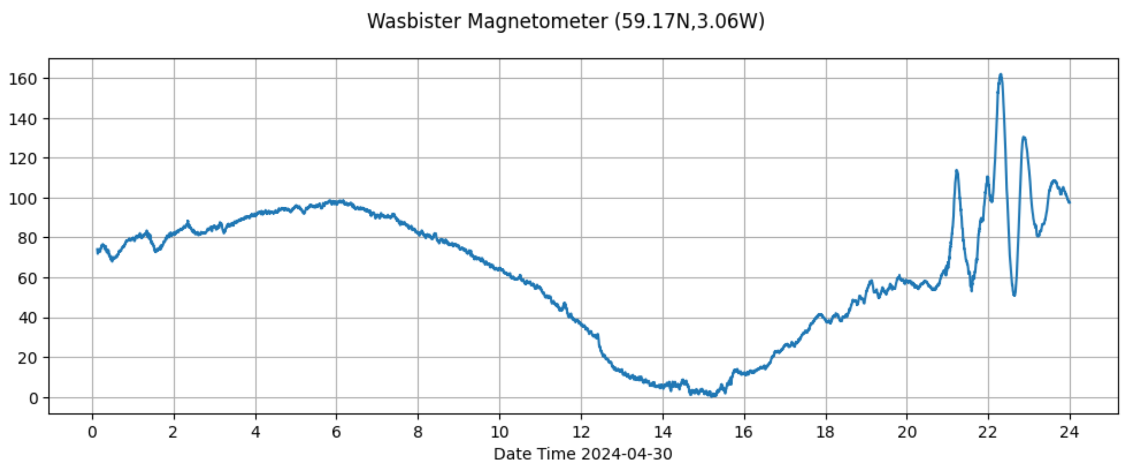
Roger Balckwell's recording from the 19th shows the strongest magnetic disturbance in April. The very sharp spike at 19:30 is about +/-200nT and may be an impact feature although it is not clear from the data to hand. The STCE bulletin lists a CME from the 15th as being the source. It also lists a CME arrival on the 15th from a flare on the 12th. Callum Potter's recording from the 16th shows the resulting disturbance, again showing a sharp spike shortly after 19UT. This was a slightly weaker storm of about 150nT.



Nick Quinn recorded the much weaker magnetic disturbance on the 4th from a coronal hole solar wind:

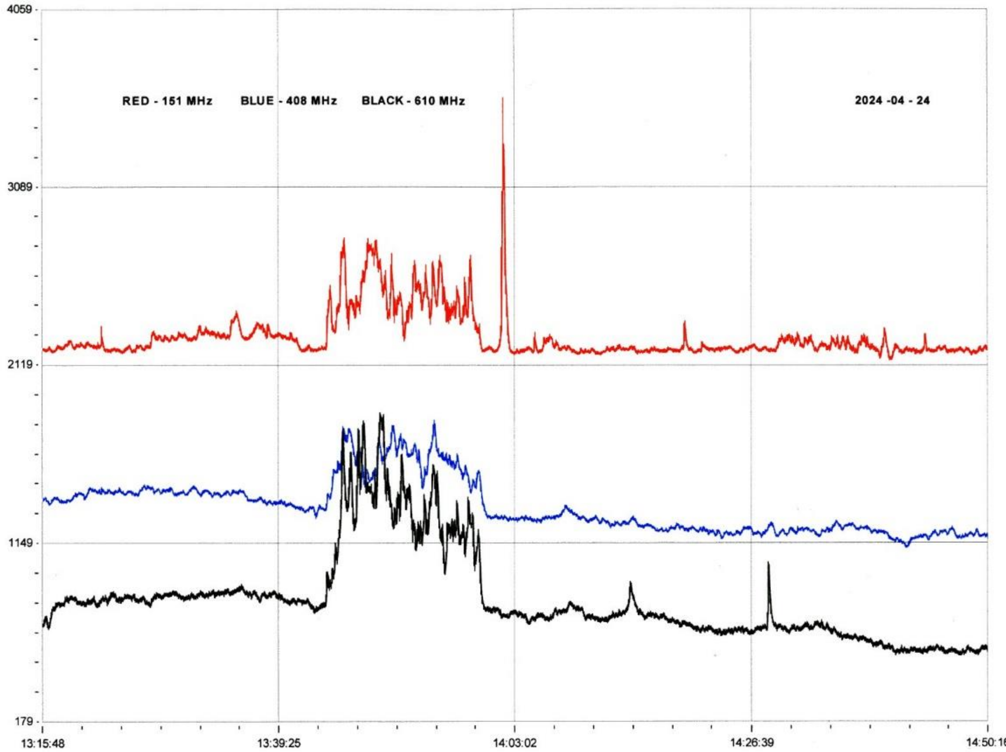


April ended with further solar wind disturbances, continuing into the start of May. Callum Potter's recording shows the disturbance starting about 21UT on the 30th.

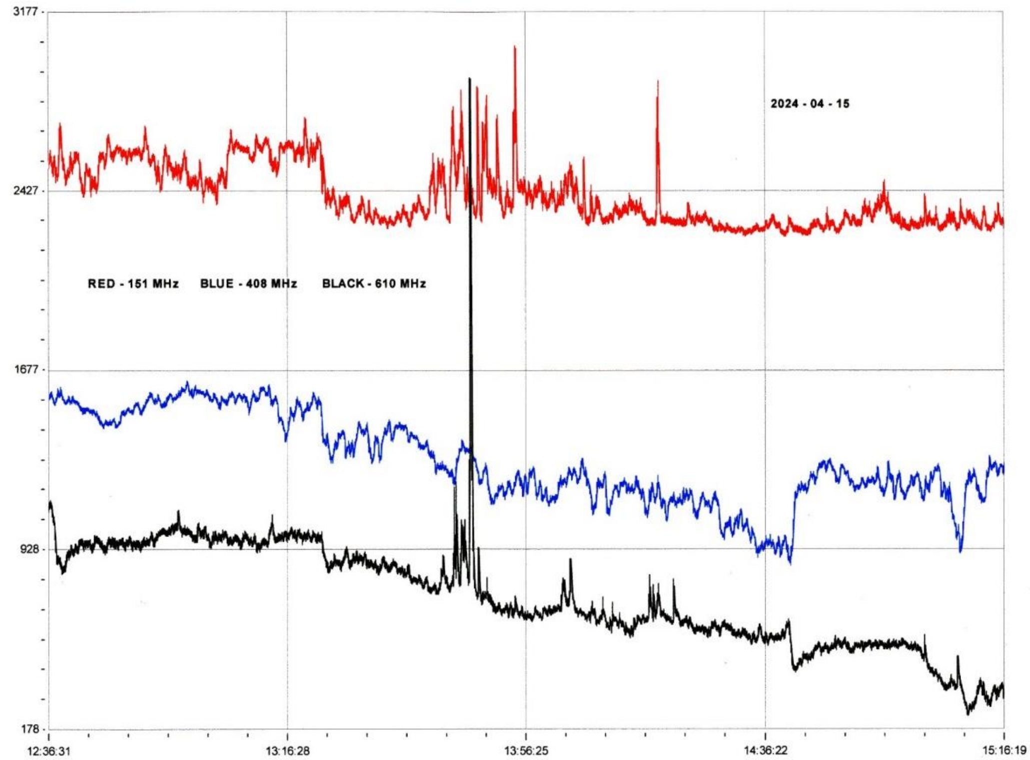


Magnetic observations received from Roger Blackwell, Stuart Green, Callum Potter, Nick Quinn, and John Cook.

SOLAR EMISSIONS

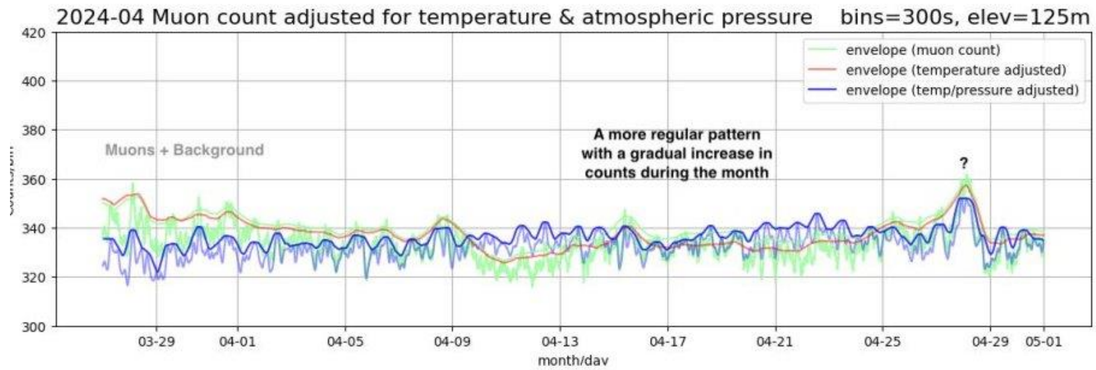


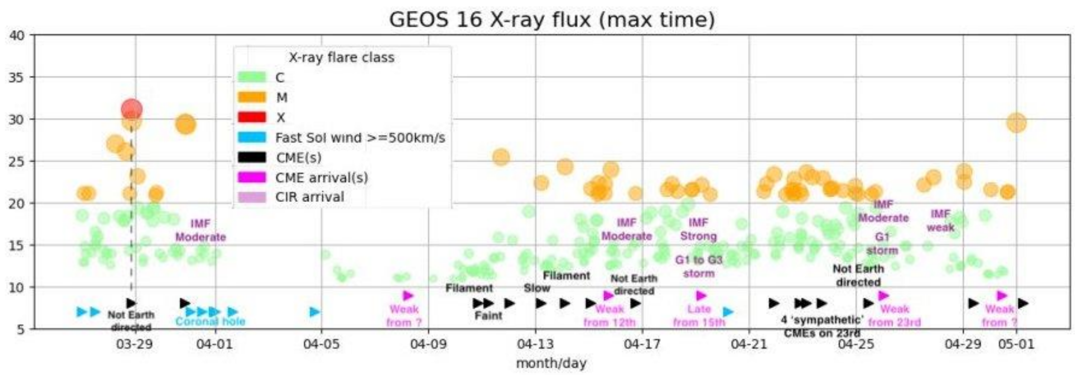
Colin Clements VHF recording from the 24th shows a strong emission at all three frequencies between 13:40 and 14:00UT. This sits between the M1.4 and C9.8 flares that we recorded, matching an unclassified flare in the SWPC satellite data.

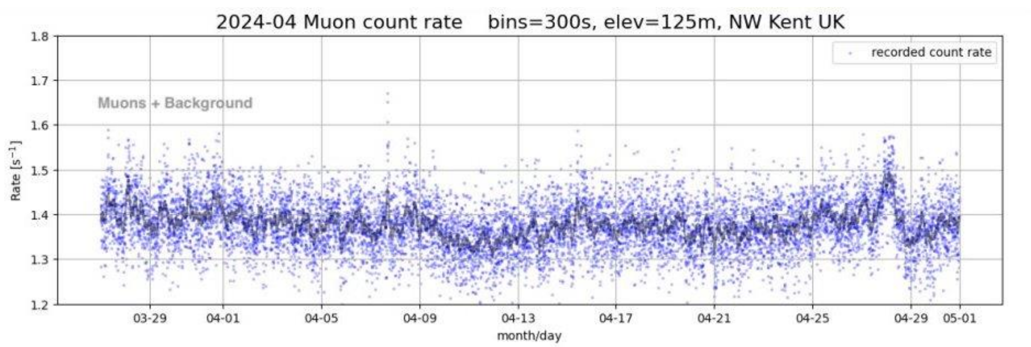


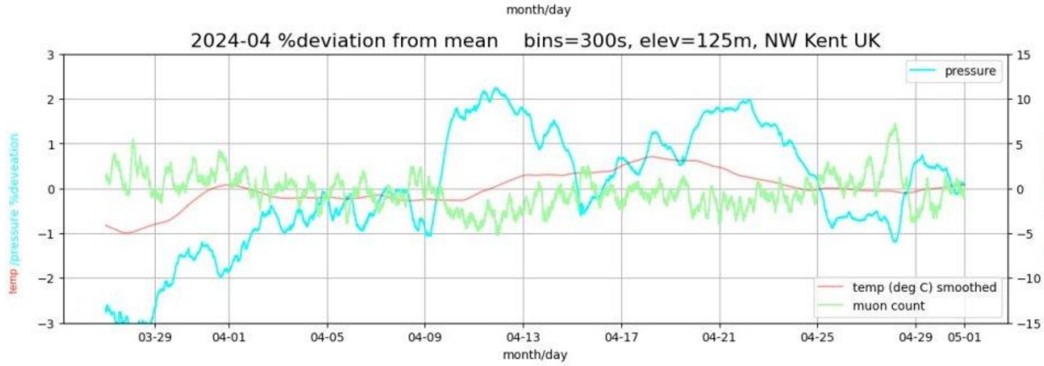
Colin's recording from the 15th possibly shows 610MHz and 151MHz emissions related to the M1.1/M1.4/M2.2 flares illustrated earlier in this report. The peak of these emissions occurs roughly at the start time of the first flare of the triple.

MUONS

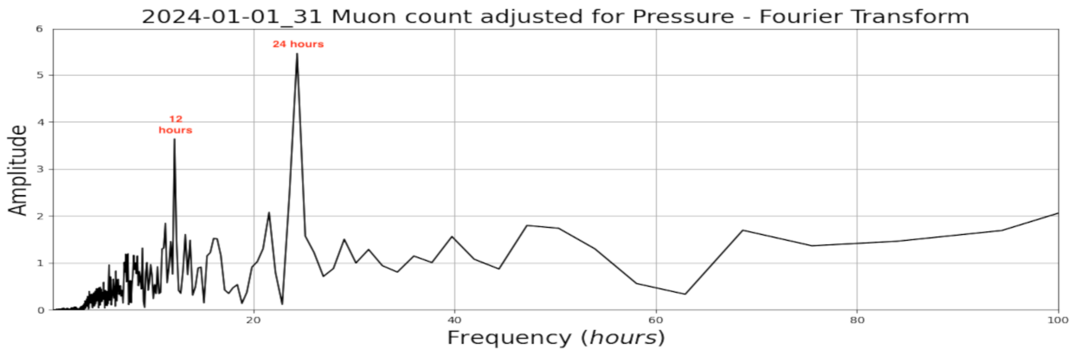

2024-04 Muon count adjusted for temperature & atmospheric pressure bins=300s, elev=125m
envelope (muon count)
envelope (temperature adjusted)
envelope (temp/pressure adjusted)
Muons + Background
A more regular pattern
with a gradual increase in
counts during the month
?
month/day

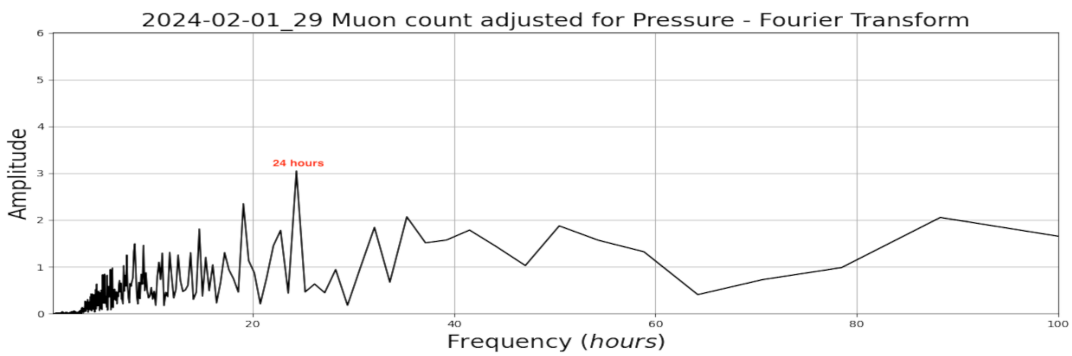

GEOS 16 X-ray flux (max time)
X-ray flare class
C
M
X
Fast Sol wind >=500km/s
CME(s)
CME arrival(s)
CIR arrival
IMF
Moderate
Not Earth
directed
Coronal hole
Weak
from ?
Filament
Faint
Slow
Filament
Weak
from 12th
Not Earth
directed
IMF
Moderate
IMF
Strong
G1 to G3
storm
Late
from 15th
4 'sympathetic'
CMEs on 23rd
Not Earth
directed
IMF
Moderate
G1
storm
Weak
from 23rd
IMF
weak
Weak
from ?
month/day

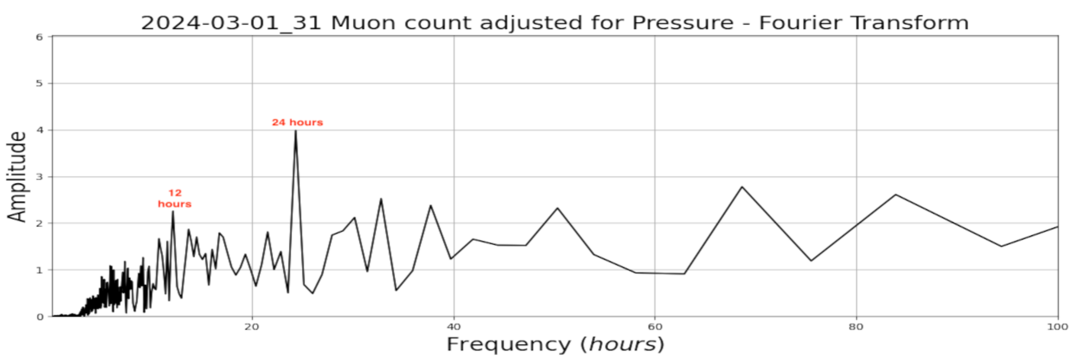

2024-04 Muon count rate bins=300s, elev=125m, NW Kent UK
recorded count rate
Muons + Background
Rate [s⁻¹]
month/day

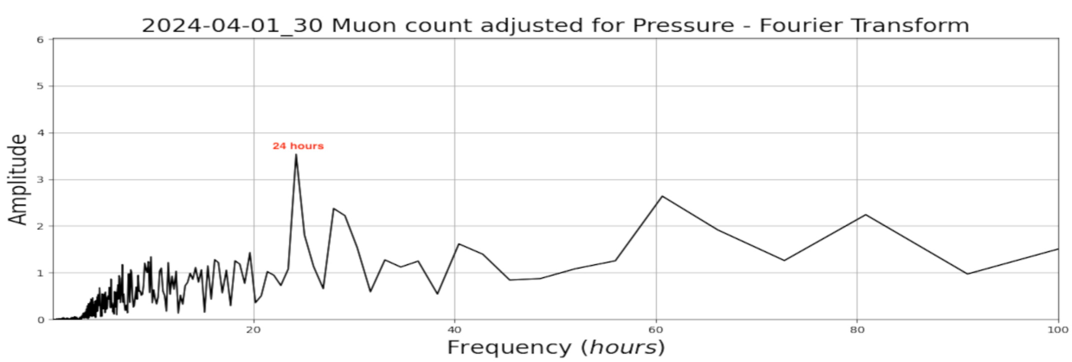

2024-04 %deviation from mean bins=300s, elev=125m, NW Kent UK
pressure
temp (deg C) smoothed
muon count
temp /pressure %deveation
month/day

The Muon charts from Mark Prescott show a very stable start to April, reflecting the low flare activity. The counts increase and become more variable as the flare activity increased after the 9th, with a distinct peak on the 28th. This appears to follow a general weakening in the interplanetary magnetic field following a weak CME.



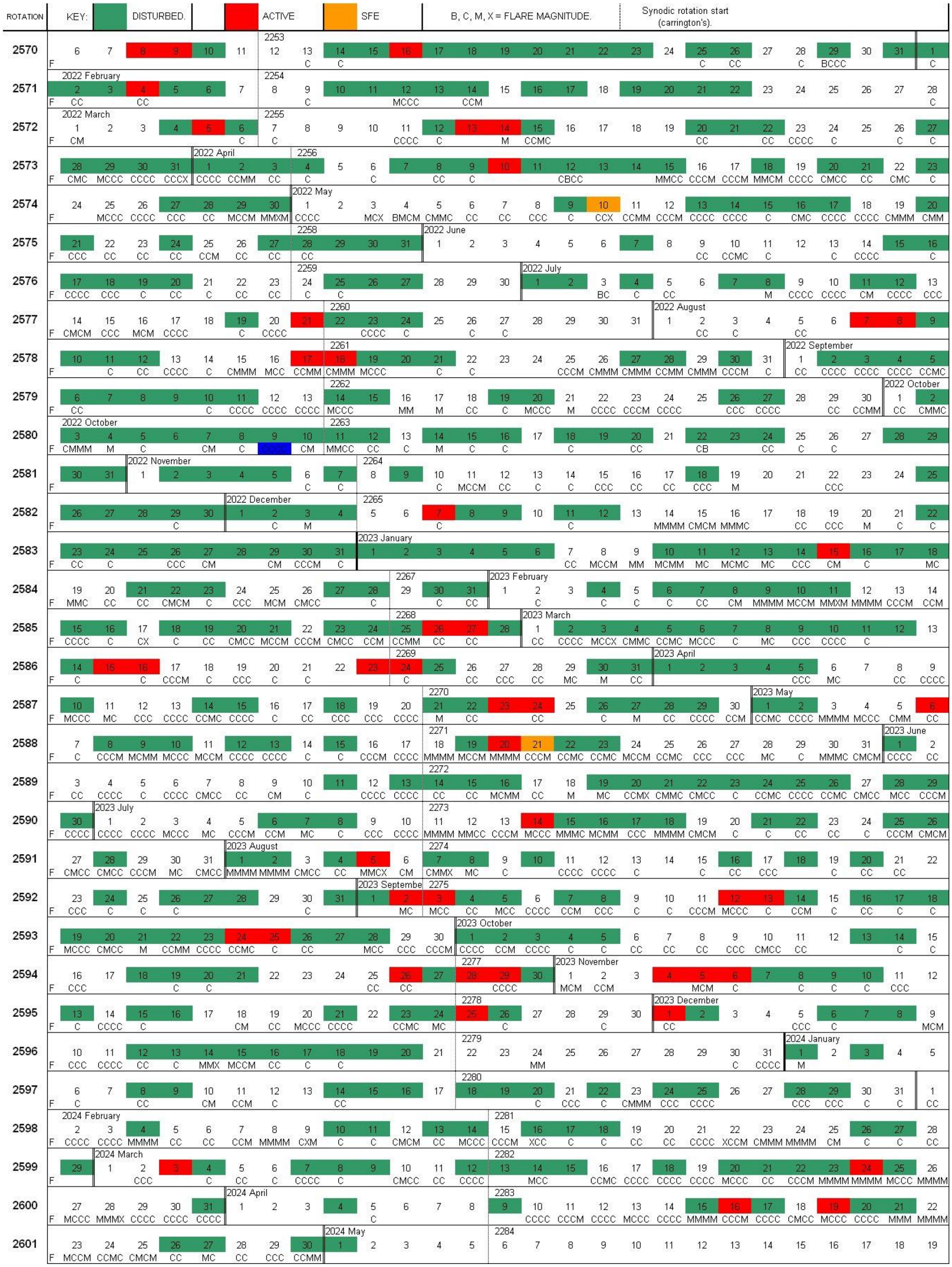


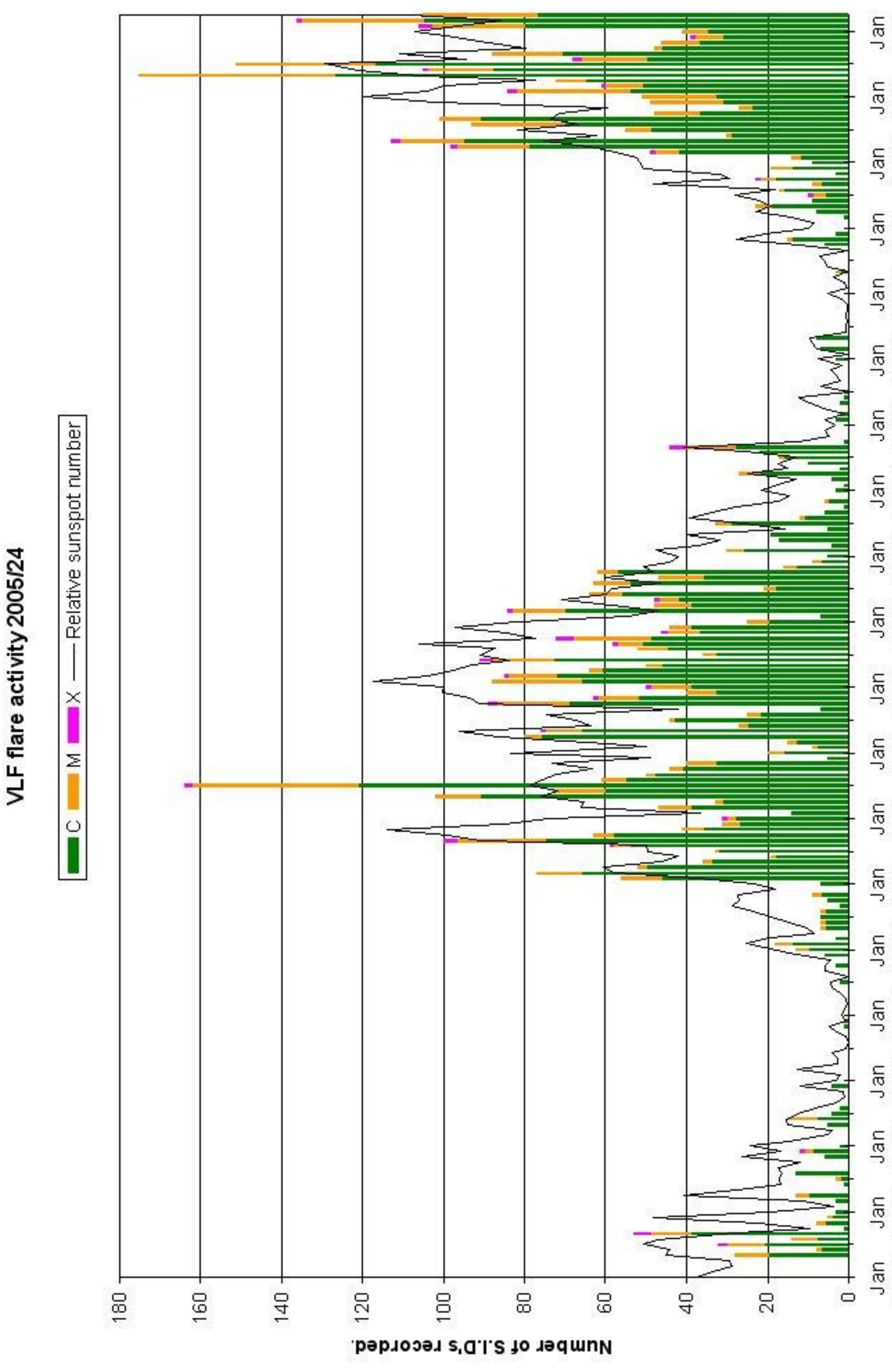




Mark has also created Fourier transforms of the muon counts each month so far this year. The 24-hour diurnal period stands out well in April, with little evidence of the 12-hour period.

BARTELS CHART




VLF flare activity 2005/24
C
M
X
Relative sunspot number
Number of S.I.D's recorded.
0
20
40
60
80
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Jan 2005
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Jan 2013
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Jan 2015
Jan 2016
Jan 2017
Jan 2018
Jan 2019
Jan 2020
Jan 2021
Jan 2022
Jan 2023
Jan 2024

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Radio Astronomy Section

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Friday September 6th 19:30 BST (18:30 UTC)

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Dr Jonathon Pierce University of Hertfordshire and Dr Luke Holden University of Sheffield

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Featured Articles

More Experience with the AD8302

by Mike Otte W9YS
mike.otte96@gmail.com

Abstract: In this article I will describe continuing experiments using the AD8302 Phase detector in an interferometer telescope . This is very simple method compared to normal interferometers requiring more expensive hardware and software to combine the signals. The software is a data logger. The analysis can be done in a spreadsheet.

Introduction:
Normally, interferometers require combining two signals either by addition or multiplication. Originally for an amateur this was done physically with combiners such as tees, Wilkinson combiners, or reverse CATV splitters. The combining can be done in software but requires receivers with the local oscillators in phase or are the same. Even then the data has to be synchronized through some method internally with noise source or externally with common signals.

Using the AD8302 as the detector you measure the phase between the two signals directly. There are no oscillators. The frequency you are measuring at is determined by the band pass filters and in this case, they are in the sawbirds. External band pass filters can be added too.

My current setup is:

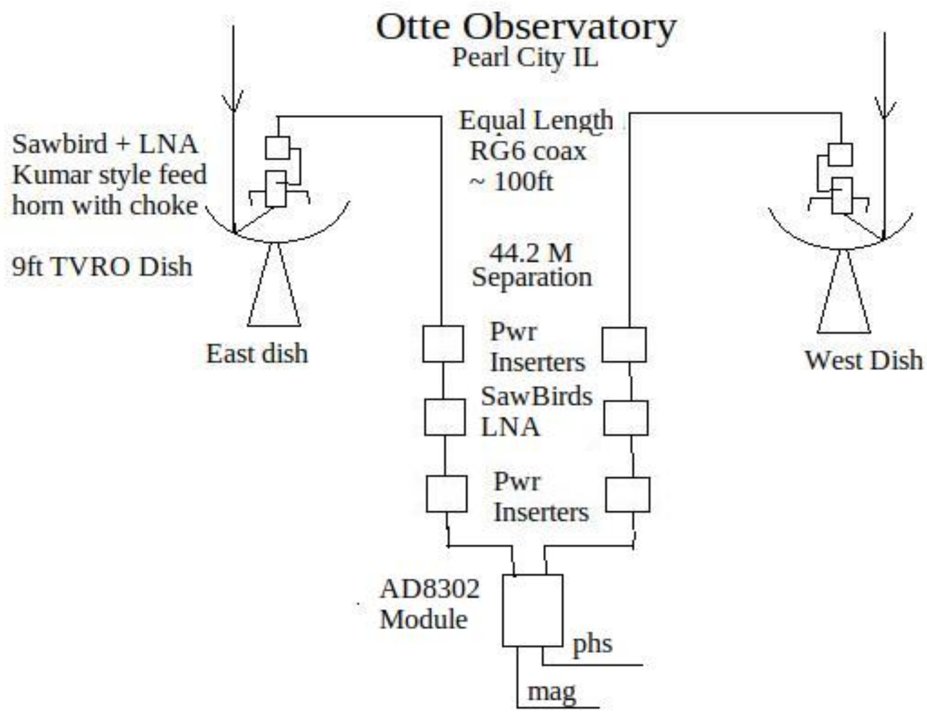


Figure1
Signal Flow Diagram

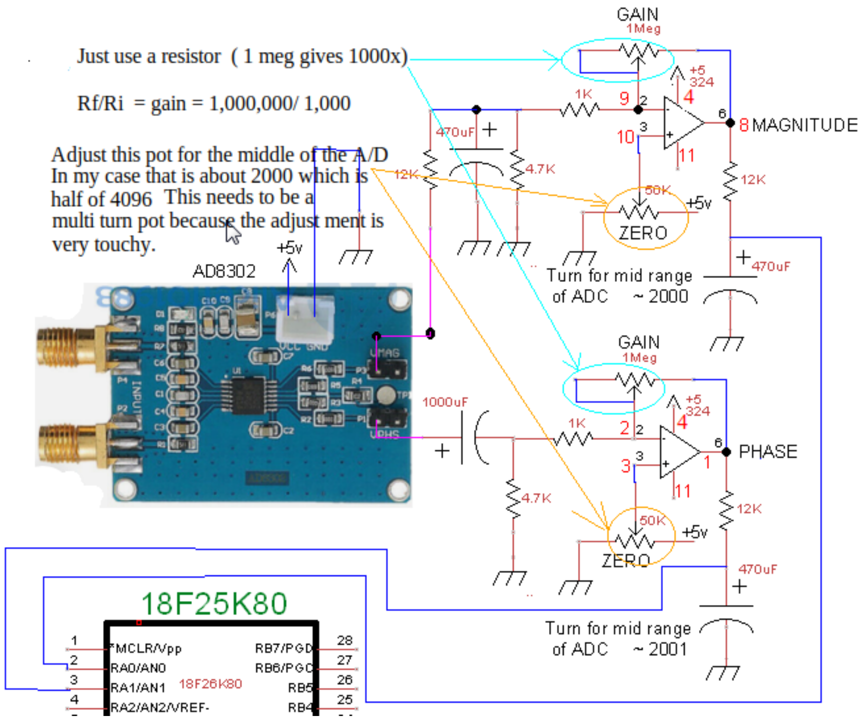
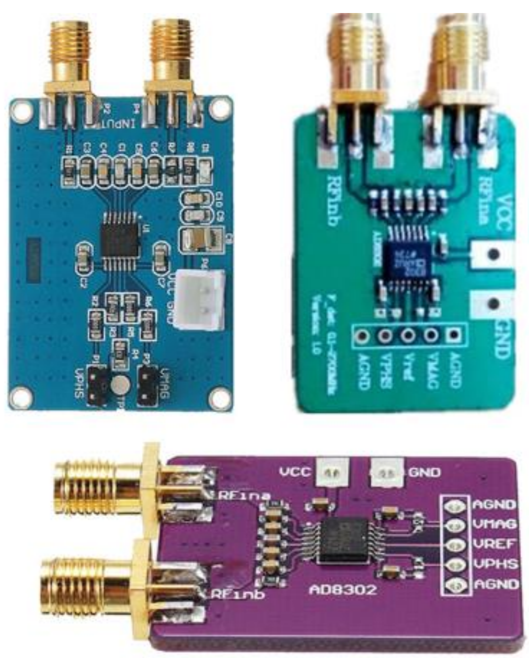


Figure 2
AD8302 Schematic

Color of my AD8302:



These prototyping boards all have an AD8302 mounted, supply RF inputs through the SMA connectors and supply output signals through solder connection or connection pins. The package is a TSSOP so to solder on your own ad8302 chip on a protoboard would be challenging. The main difference is the "blue" board has more power supply decoupling capacitors to prevent noise and has a power indicating led. The chip only draws 8ma at 2.7-5.5 vdc but the led adds 12 ma. Mine is Blue.

Magnitude -60dB to 0 dB is 0 to 1.8vdc output biased near .9vdc when inputs floating
Phase 0 to 180 deg is 0 to 1.8vdc output biased near .9vdc when inputs floating
Frequency Low to 2.7 Ghz
Uses: gain/loss/phase in receive , transmit, instrumentation and now radio astronomy.

Caveats using the AD8302:
There is a 50 ohm resistor to ground on each of the signal inputs. So when using "sawbirds" that have both signal and voltage on the coax this is a problem. Five volts can cause 0.5 watt dissipation which will destroy the resistor and cause noise on the signal. Isolation is the answer. Either an isolator capacitor or a voltage inserter could be used as an isolator.

Temperature gain drift is a minor problem. I mounted the board with the chip side toward my protoboard to isolate it somewhat inside a sandwich. Even then it will detect me in my chair. I have built a metal box to isolate it even more. Another method I use is to leave the observatory and let it do the work.

What's an Op Amp:
When I tried the AD8302 out the first time, all I got was garbage. Months later I saw on Facebook Amateur Radio Astronomy some diagrams of AD8302 interferometer systems with op amp circuits. They were smoothing and amplifying the output signals. I did not know where to set the "gain" pot so I set it midway at about 50 % which was about 50X on the old circuit. I explored the cosmos at that point and wrote the article a few months ago. Some of the sources only moved the a/D a few bits but noticing the timing it was obvious that I was detecting the source. I have increased the gain of the Op Amp to 1000X since, which is a compromise between seeing a smoother signal for the sources but not making the noise overwhelming. The Sun will give more than full scale swing on the larger system.

To set the gain is easy because Operational Amplifiers have programmable gain by choosing 2 resistors – Ri the input resistor and Rf the feedback resistor. In my case I am using 1000X gain with Ri=1kohm and Rf = 1Megohm. Op amps also have two inputs and I use the second (plus) input to set the output in the middle of the A/D range by adjusting a pot. These signals are low frequency so the cheap low end single supply type like LM324 works just fine.

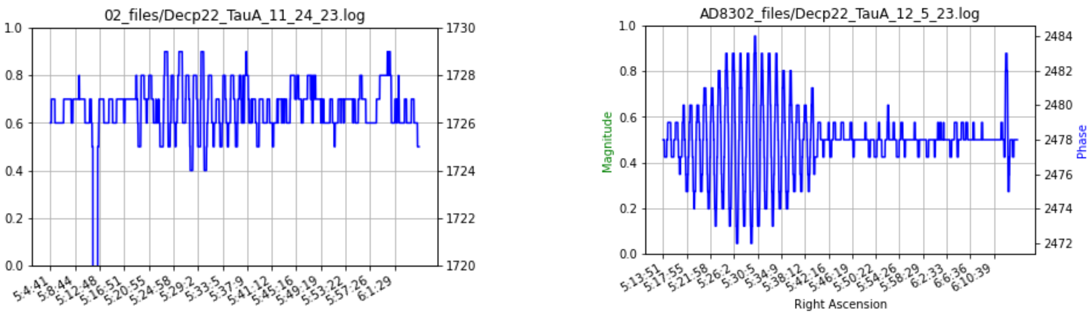


Figure 3
Comparison of Gain

This shows a comparison of the gain of the Op Amp, the left being 50X and the right 100X.

I also added lots of big capacitors and resistors to calm the signal. In the microcontroller I also added “smoothing” routine sometimes called a “boxcar” in the microcontroller which does a running average of 10 samples. Still there is noise but when you have a source come through it is nice and regular.

How a A/D works:
The A/D changes the analog voltage to a digital number. This system is using a PIC microcontroller with a 12 bit A/D inside. 12 bit means the A/D has 4096 steps in its conversion with the reference being 0 -5 vdc this calculates to 0.00122 volt per step. The AD8302 puts out about 900 millivolts no signal and the source’s interferogram will be above and below this point. I use the “zero” pot on the circuit diagram to adjust the no signal point to about 2000 counts which is the center of the 0 to 4096 range. You will be working with counts and not voltages.

The microcontroller also runs a Real Time Clock that is programmed as a Sidereal Clock for the logging data. The logging data is assembled in CSV style packets and sent through the serial port to the PC. The PC using a serial terminal receives the data packets and saves them into a file. Here is an example of the data packets. (sidereal time, magnitude, phase)

4:19:52, 1880,2024
4:19:54, 1880,2026
4:19:56, 1880,2027

Then, daily, I run a “data exploring” file in Python that shows a graph for each hour of the file and graphs both the magnitude and the phase. When a source comes into view it shows regular sine wave shaped signals. So, in Figure 3 you see the response of Tau A. On the right side of the charts are the “counts” from the A/D and the center is about 2478 counts. The highest peak to peak response is about 2482 counts (+- 4). This is the “visibility” and compares to the Jy values.

The period of these sine waves is the Fringe Period which can be calculated with the following formula. Note the fringe period is the inverse of the Fringe Rate.

Fringe rate = Baseline / wavelength *angular rotation of earth * cos declination ex: Fringe period = $(44.2\ M / .21M * 7.3 \times 10^{-5} * \cos 40)^{-1}$ = 84.96 sec

Equation 1

So, this graph gives three pieces of information. It tells the time of maximum which gives the Right Ascension. It gives the Fringe period from which you calculate the Declination. Gives the Peak-to-Peak response which is the "Visibility" and isn't sensitive to temperature drift like an SDR in Radiometer mode.

Sampling rate:
I over sample. I sample at 2 second intervals but average over 10 samples. So, this is a "running" average and probably needs to be locked down more. Your sample period should be enough to capture the curves you're trying to form. At 1420 Mhz and a spacing of 5 Meters the fringe period is 12 minutes, that is 3 degrees! Your source may not be this wide.

Fringe Period:
I gave you the Fringe Period formula earlier. Let's calculate a few (Base is the distance between antennas)

Source(declination, name)	Base = 44.2 M	Base = 10 M	Base = 5 M
59 , Cas A	126.37 sec	9.31 minutes	17.97 minutes
41 , Cyg A	86.24 sec	6.35 min	12.26 min
22 , Tau A	70.2 sec	5.17 min	9.91 min
-5 , M42	65.3 sec	4.81 min	9.29 min
-29 , Sag A	74.4 sec	5.48 min	10.58 min

Table 1

Minimum hardware configuration:
This takes two or more antennas, Lna's(2x per antenna), a AD8302 board, some soldering to put in the op amp, an A/D that you may already have. It works great for finding sources. So much more positive than the radiometer signal.

Identifying sources:
My Radio Astronomy method is drift scanning. So I set the antennas to a declination, set the logging file name to describe that (declination, what is my target, what is my spacing, date), wait 24 hours, and then explore what I have found. The reason I use sidereal time is obvious when you think of south facing antennas then LMST is the same as Right Ascension. Using planetarium software like Stellarium or Kstars where you place your cursor shows up as RA and Dec. On Kstars I have placed "Flags" at radio sources above 200 Jy so I know what is influencing my signal. You'll get the sine wave signal even if the declination is off several degrees on a stronger source. The fringe period is the FP of the influencer, so that is how you tell who is who. The Sun is a big influencer and will be proudly present on any interferogram even 30+ degrees away.

The Python data exploring program I have written plots the data. It also measures the period between the peaks. The interface also allows re-ranging of the vertical scale so the peak-to-peak values can be measured. I write down the detections in a written log (date, RA, Visibility, width, possible source name) and have been thinking about how to store these electronically in some catalog or database. They are not as easy as spectrum data to put into a "heat" map and make a pretty picture.

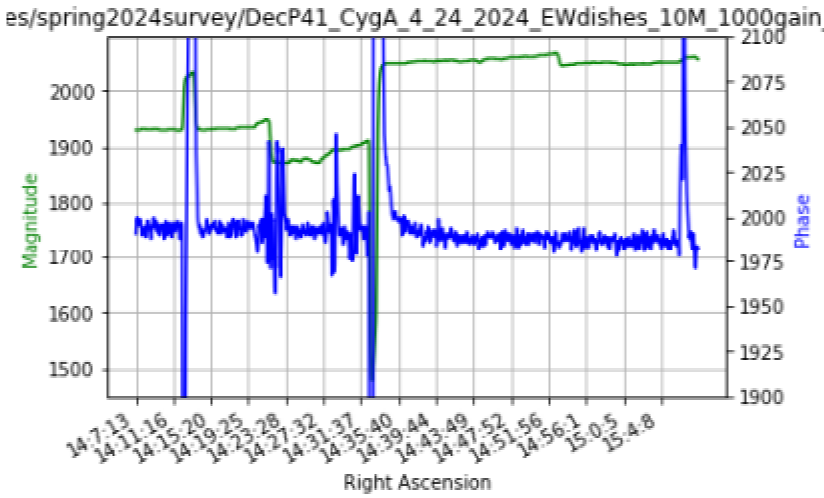
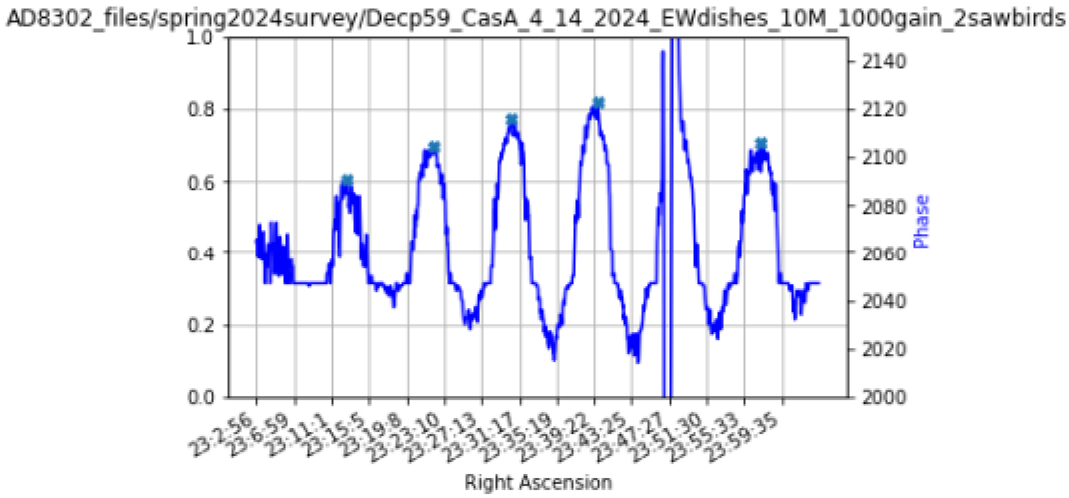


Figure 4
Noise Spikes

Besides the interfometric type detections, there is a lot of noise signals. Also, I get really big, wall to wall, spikes that I think are airplane radar. They last a lot longer than plain noise, some cases minutes.

Some detections:



peaks		RA	pwr	phase
289	23:12:41	1734	2091	
568	23:22:6	1723	2105	
811	23:30:18	1739	2116	
1090	23:39:42	1728	2123	
1609	23:57:12	1720	2106	
289				
279				
243				
279				
519				

(289+279+243+279+519) / *6 samples * 2 sec sample / 60 sec/min =8.94 minute*

That's pretty close to 8.99 minutes using the formula.

The visibility is about 100 units, 120 if symmetrical.

The time is off about 12 minutes because of the hill my antennas are on.

Figure 5

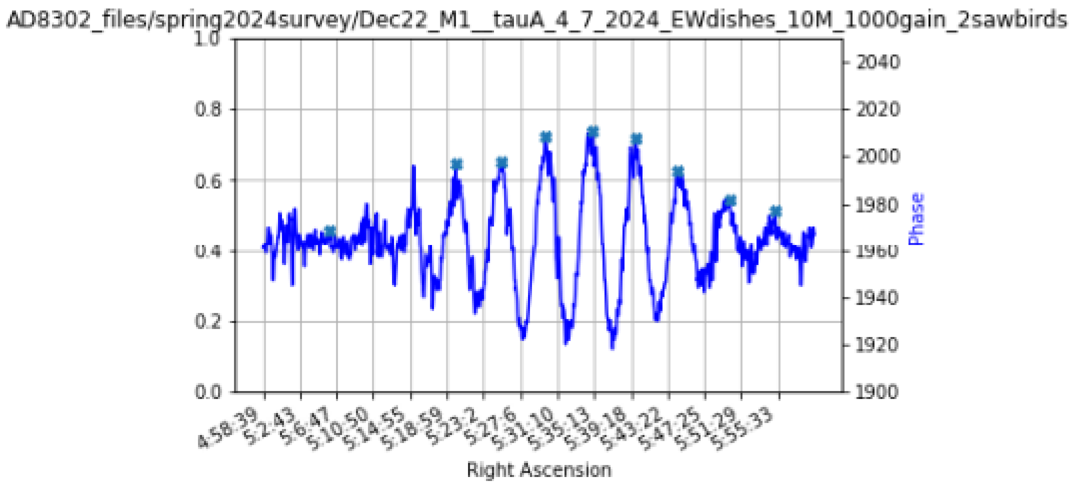


Figure 6

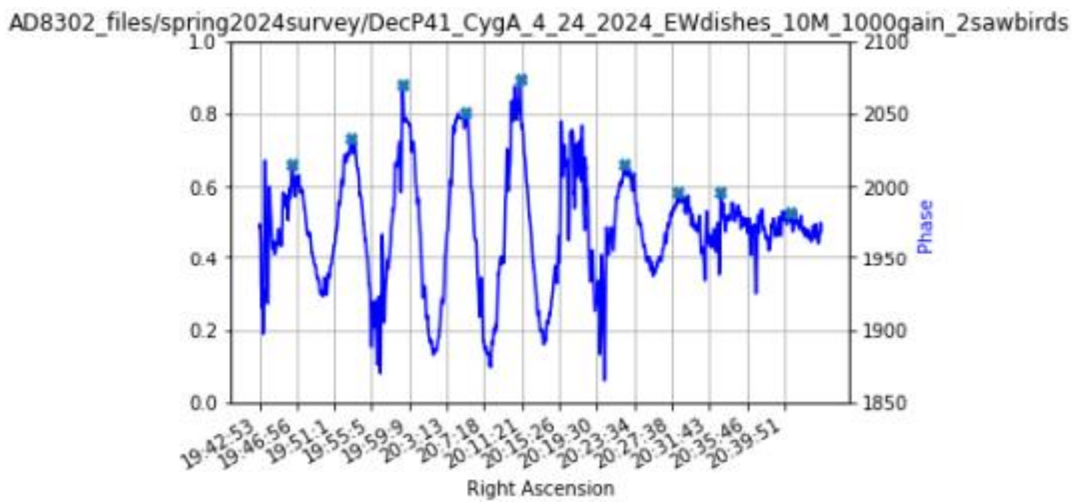


Figure 7

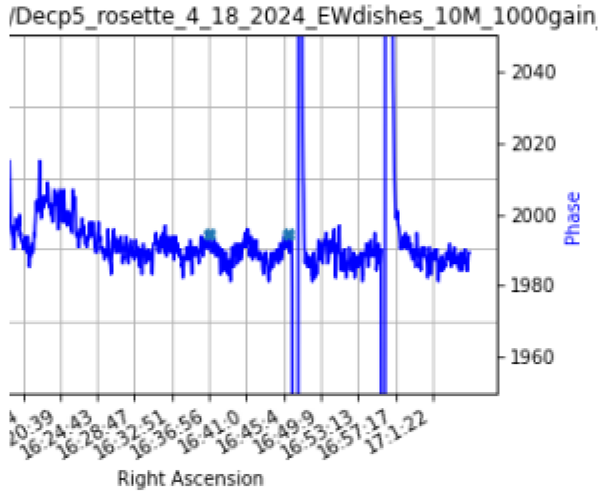


Figure 8
Hercules A not Rosette

Visibility

Source	A/D counts = amplitude	Reference Flux
Sag A	130	3650
Cas A	120	2240
Cyg A	175	1255
NGC6618	65	1060
Tau A	80	926
Orion A	65	520
Virgo A	25	198
Herc A	10	39

Table 2
A/D count Visibility to Flux comparison

Using small antennas:
So, I wanted to try smaller antennas. I have a "Horn of Plenty" and the dish in a box from the local observatory. I set them up and they did not work! I tried twice and then had to scratch my head. It came to me while driving home the next day. "They were different polarizations." I set them both for vertical polarization and ta da! It works! So, interferometry with AD8302 can be done on small dishes.

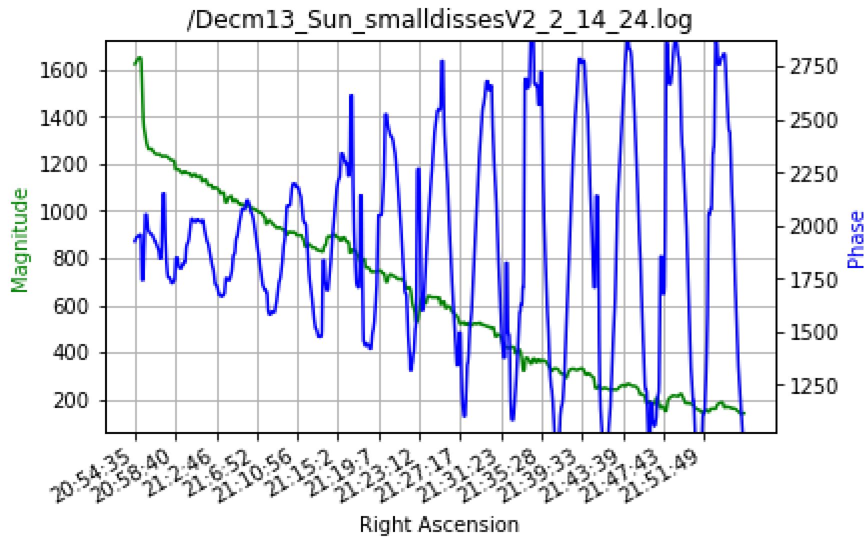
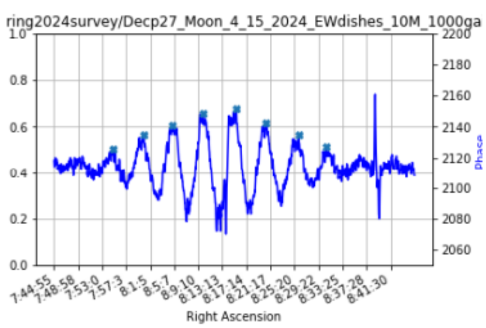


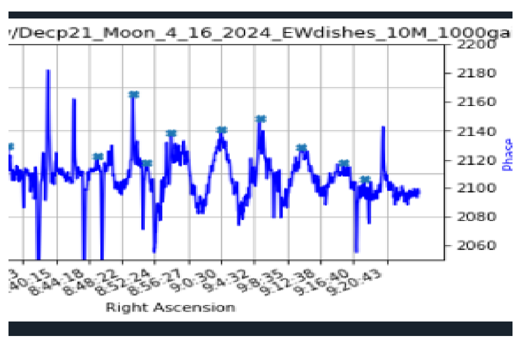
Figure 9

Dishes are 10M apart and that gives about 5 minute period fringes.
The vertical grid lines are 4 minutes apart.

Catch the Moon:

In another experiment I wanted to catch the Moon with interferometry. I had many failures 2 years ago with using radiometry. The Moon's temperature is about 270 deg which should give about 900 Jy. That should be detectable. So, the scientific method says, "Is it repeatable?". So, I repeated it twice, even though the second night it was storming.





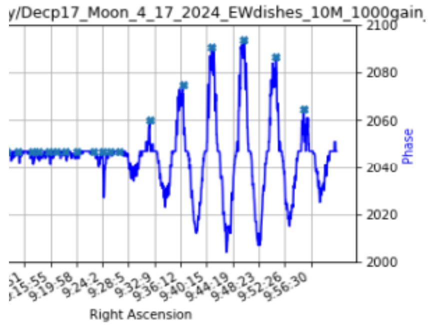


Figure 10
3 Nights of the Moon

Is the Magnitude output useful?
The magnitude output is an output voltage proportional to the decibel ratio of signals applied to east antenna and west antenna. I have been recording the magnitude output of the AD8302 but have not found a use for it yet. On strong sources it seems to have an inflection somewhere in the middle but not exactly in the middle of the detection. On interference signals that maybe come from airplane radars, it strongly spikes with the interference and even sometimes precedes that interference. I have not included the data on most graphs in this article.

Things to work on:
Sometimes the curves are not symmetrical vertically. Like something is blocking them. Maybe this is the charging and discharging of the big series capacitor. Maybe some component is failing or complaining. Circuit work!

My big dishes baseline is not level. I live in the hills, nothing is level. The dishes are 10.6 meter apart and the hinge points differ by 30 inches at 10M spacing which is better than 11ft at the old 44.2 M spacing.

After the article by Jim Abshier, I had to investigate shorter baselines. I am not sure in the formulas where base line affects amplitude? But I do understand that wide sources could smear together and fill in the peaks and valleys.

Also thinking about adding a third dish perpendicular to the east dish. Adding baselines.

I am making band pass comb filters to narrow the detection and will try them next.

Conclusions:

Not much work has been done with the AD8302 except building forward and reverse power measurements. Jan Lustrup and Jim Sky are the only two that I have found that considered it for radio astronomy. The AD8302 makes a fine detector for interferometry. I am sure we are not using it in the intended way. It does take additional LNA's to make it sensitive enough. I would like to see more amateur radio astronomers try this method out. There is a lot to discover!

References:

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

Rosette Nebula Visibility, by Jim Abshier,, SARA Journal, Jan-Feb 2024

Astropeiler Stockert
https://www.astropeiler.de/en/info-zum-2-x-12-meter-interferometer/

Analog Devices AD8302
https://www.analog.com/media/en/technical-documentation/data-sheets/ad8302.pdf

Author:

Mike Otte has a BS in Computer Information Science. He also is a Journeyman Maintenance Electrician, Instrumentman, DCS Programmer, and Jack of all trades. He has always loved data and getting knowledge out of data. He is a member of IMO International Meteor Organization and has collected Radio Meteor data for RMOB and Video Meteor data using Metrec for 20+ years. He lives on a farm, so he has plenty of room for antennas.

Antenna unit for 6.7 GHz methanol maser telescope

by Dimitry Fedorov UA3AVR

Here I would share some details about the antenna unit of my methanol maser telescope 6.7 GHz [1] with a small single dish. The line 6.7 GHz of methanol corresponds to the transition $5_1 \rightarrow 6_0$, A^+ type molecule, II class of maser excitations; its exact frequency is 6668.5192 MHz. Outdoor part of the telescope consists of the dish 1.8 m and antenna unit, see ***Figure 1***. The antenna unit, in its turn, includes the dish feed and 6.7 GHz downconverter with LNA; its functional schematic is shown at ***Figure 2***. The dish collects radiation from observed source and directs it to the dish feed. Following stages are the Low Noise Amplifier (LNA) and downconverter. The downconverter shifts the signal spectrum to intermediate frequency (IF, about 969 MHz). Local oscillator (LO) drives the LO input of the downconverter; its frequency is 5700 MHz, i.e. lower the input signal frequency. IF signal is amplified additionally before the long coax interconnection to the indoor part of the telescope (IF receiver).

Figure 1. 6.7 GHz methanol maser telescope, the outdoor part, summer 2023.

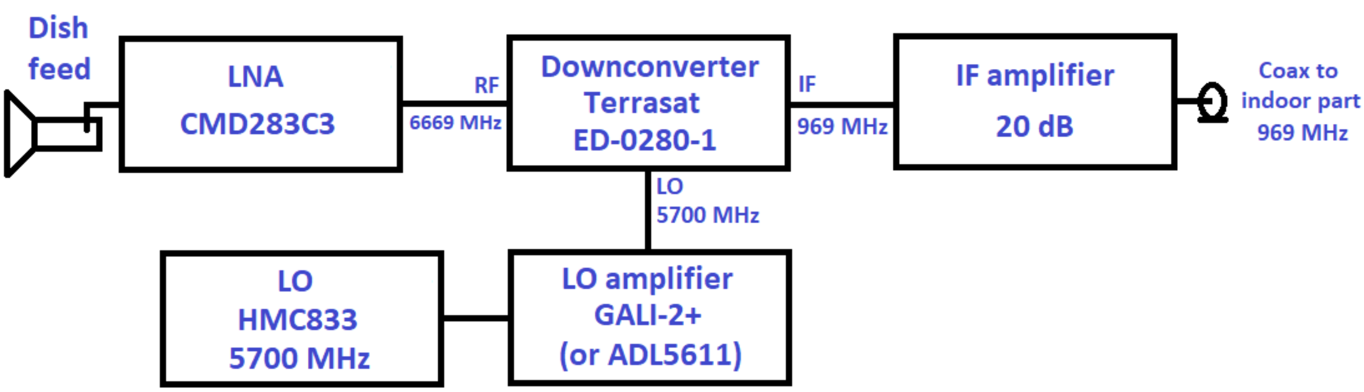


Figure 2. Schematic of the antenna unit.

For the indoor IF receiver I used Ettus USRP B200mini SDR module with especially written LabVIEW software. Assembled antenna unit in May 2024 version is shown on ***Figure 3***. As one can see (***Figure 3*** right), the dish feed and LNA are connected immediately without intermediate cables to minimize the input circuit losses and total own noise of the telescope.

Downconverter

The downconverter is the heart of the antenna unit; I would consider it first. The downconverter applies Terrasat RX module from eBay, 6.4-7.1 GHz, part number ED-0280-1 (MDC6471-035). This module contains an inner filter; no additional filtering is needed with converting to intermediate frequencies about 1 GHz. The module successfully works with local oscillator (LO) frequencies < 6.4 GHz; in my downconverter LO frequency =5700 MHz was used. The module has a single supply voltage input +5.5V according the mark near supply bus, but the module well works with +5V supply. Measured parameters (Noise Figure and conversion gain) with this LO 5.7 GHz are shown on ***Figure 4***. Characteristics of the module were obtained for several different LO levels and supply voltage +5V. Additional plot for +5.5 V supply is shown for reference in *Appendix*.

The LO input of the Terrasat module is driven by PLL based on HMC833 chip. Such PLL with a control board from Chinese manufacturers can be bought on eBay or AliExpress, see ***Figure 3*** left where the control board indicator lights by red digits. Its reference source (TCXO – Temperature Compensated Crystal Oscillator, 25 MHz) is not too accurate and temperature stable; so, frequency monitoring is needed during observations. Another option is an external OCXO (Oven Controlled Crystal Oscillator), but I would recommend removing original TCXO; otherwise, the PLL lock may be unstable.

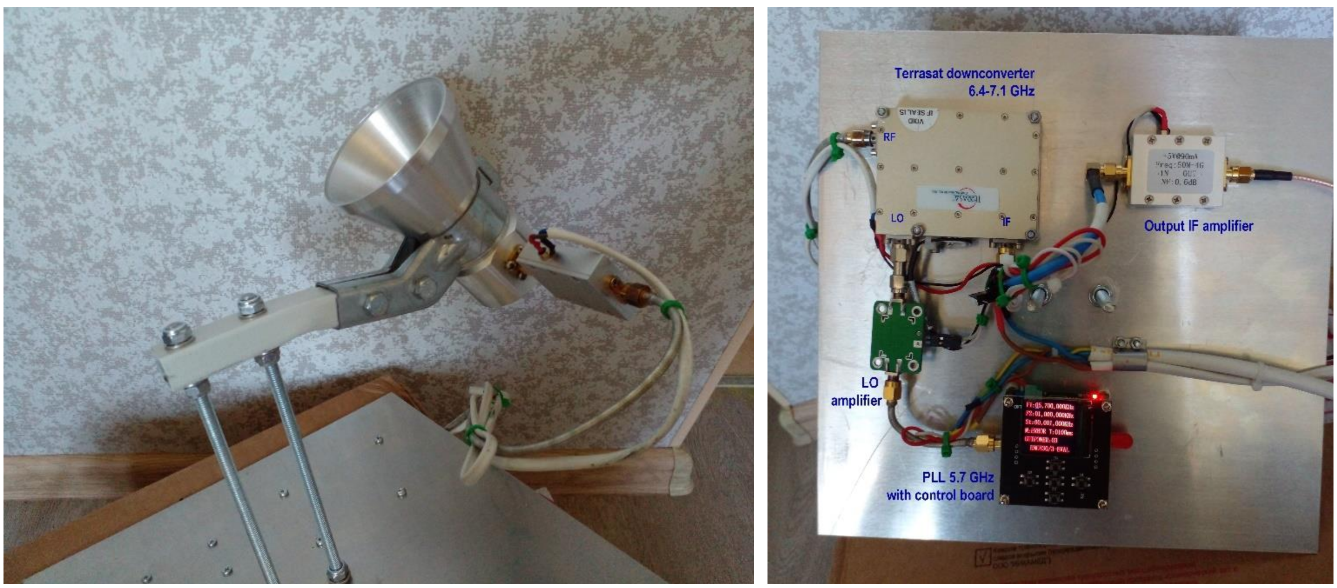


Figure 3. Assembled antenna unit, version of May 2024.

Figure 4. NF and conversion gain of Terrasat RX module for different LO levels, Lo frequency =5.7 GHz (R&S FSV, Noise Figure options in frequency conversion mode, the noise head – Noisecom NC346A precision).

The output level of HMC833 was unsatisfactory low for driving the Terrasat module; an additional amplifier is used to increase the level somewhat higher, up to about several dBm at 5700 MHz. A board from old Chinese amplifier was used as a gain block; its original broken chip was just replaced by GALI-2+ amplifier form Mini-Circuits. Output IF amplifier in enclosure is also of China origin from AliExpress, see ***Figure 3*** left. It was declared by the seller as a LNA with Noise Figure 0.6 dB, but its real noise is much higher. Its measured NF was more than 2 dB at 900 MHz; this amplifier should not be considered as Low Noise, but it can work successfully as an IF gain block at the Terrasat module output.

The Terrasat module can work as a first stage after the dish feed; the Noise Figure a bit higher 2 dB (see ***Figure 4***) allows to get some results in observations of strongest masers. Nevertheless, better results can be obtained with additional LNA before the downconverter module.

LNA 6.7 GHz

The Low Noise Amplifier is composed using Qorvo chip CMD283C3 [2]. The chip was designed up to 6 GHz, but it works well higher and can be applied for methanol line frequency with somewhat higher Noise Figure.

Assembled LNA in enclosure is shown on Figure 5; the lid of enclosure is covered by RF absorbing material. Picture of LNA board (PCB) is shown on Figure 6; the board was manufactired on Rogers AD250 0.02" laminate.

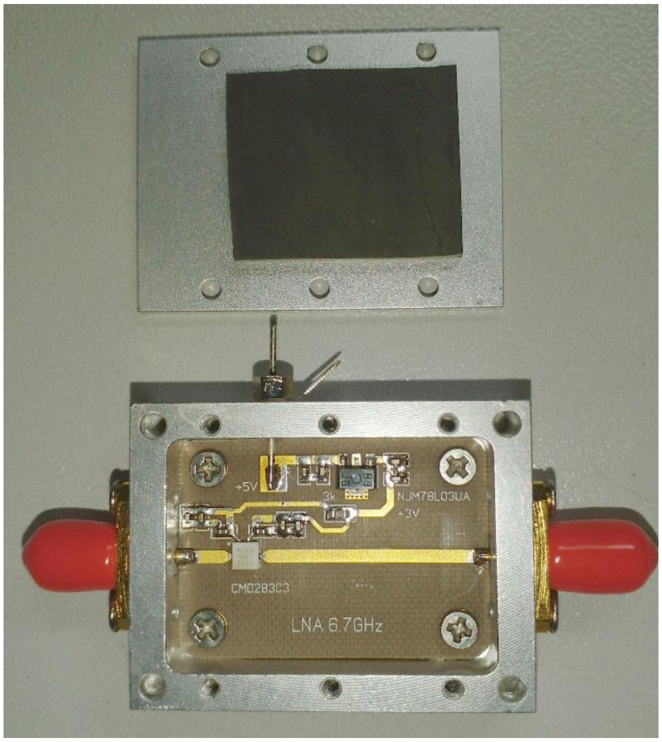


Figure 5. Assembled LNA 6.7 GHz.

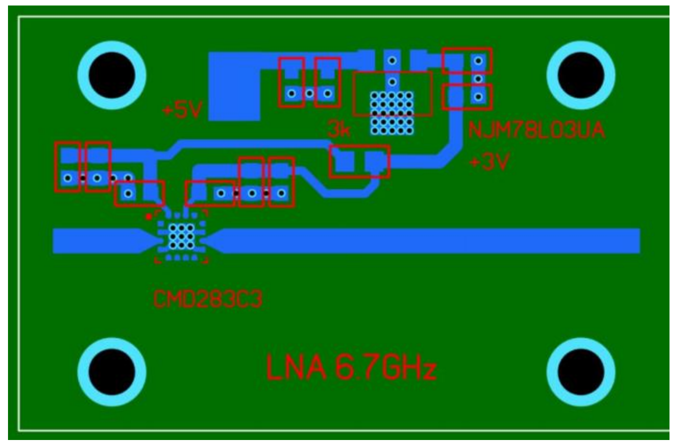


Figure 6. PCB picture for LNA 6.7 GHz. This LNA includes the linear (low-dropout, LDO) voltage regulator NJM78L03UA. Values of decoupling capacitors can be taken according test schematics in datasheets. Sizes of the board 38x24 mm.

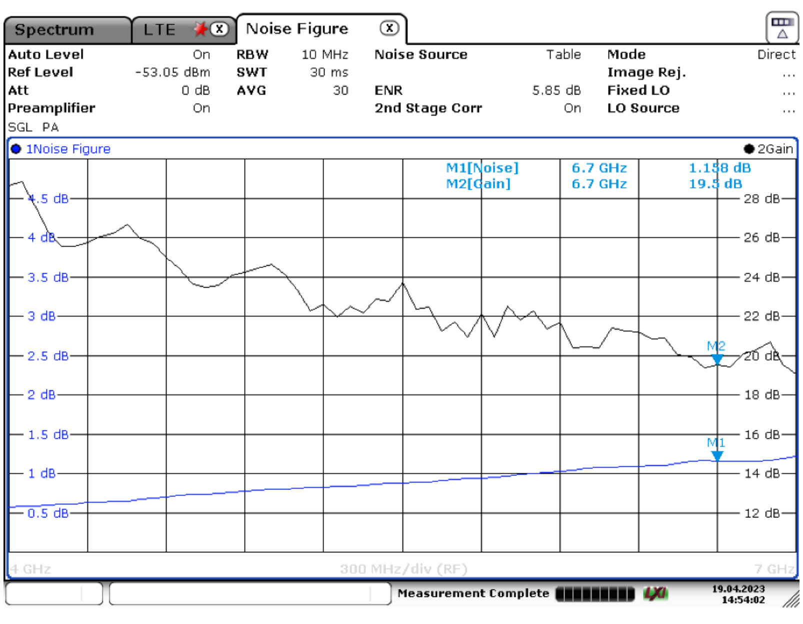


Figure 7. Measured Noise Figure and operating gain of LNA (R&S FSV, Noise Figure options, the noise head – Noisecom NC346A precision).

Results of Noise Figure (NF) and gain measurements are shown on Figure 7; obtained result for NF is <1.2 dB near the methanol line frequency. This value is higher then could be expected from datasheet's plots outside the nominal working range, see [2], but it is definitely better than for ready sample LNA from Mini-Circuts ZX60-83LN-S+ with NF>1.6 dB at 6.7 GHz [3].

There is a hidden issue with this design of LNA 6.7 GHz. The enclosure of LNA is the same as for output IF amplifier, see ***Figure 3*** left; it is convenient to apply ready milled aluminum enclosures from cheap Chinese devices, which can be easily bought on AliExpress or eBay. The cavity of this enclosure is resonant at nearby frequencies, as it can be seen from S-parameter tests. Figure 8 shows measured S-parameters with RF absorbing material on the enclosure's lid (left) and without in (right). Right plots show the resonant behavior of S-parameters; hence, a usage of RF absorber inside the enclosure cavity is compulsory.

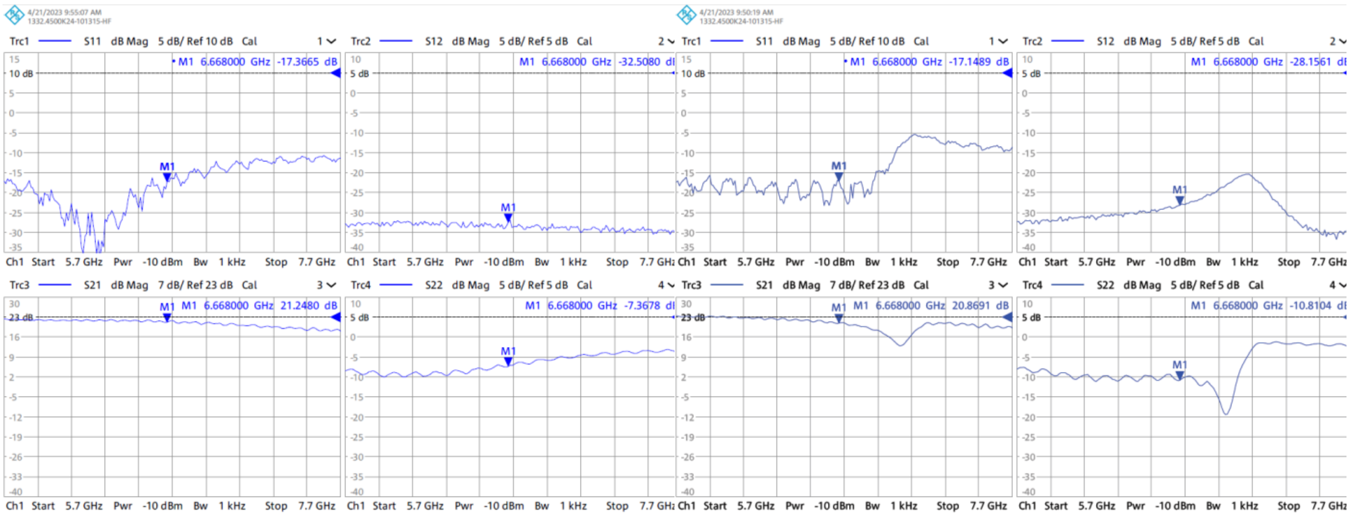


Figure 8. S-parameters of the Low Noise Amplifier: left – with RF absorber on the lid, right – without RF absorber. The resonating behavior on the right plots is seen noticeably. Tested with vector network analyzer R&S ZNA.

Another issue of this design is the LNA is unstable and prone to self-oscillations even with RF absorber on the enclosure's lid. They may appear when input and output loads are reflecting with VSWR>2.5-3. The feedhorn as a dish feed at the input is significantly reflecting rather far from working frequencies. Fortunately, the LNA works well and stably when its output is loaded by above described Terrasat module.

The dish feed

The feedhorn used for the dish feed is seen on ***Figure 3*** right or with an attempt to look inside on Figure 9. It was designed initially for 5.7 GHz (6 cm) amateur band and lathed from an aluminum alloy; I just remastered it for 6.7 GHz shortening its probe. The probe is mounted (soldered) to SMA flange connector forming a coaxial-waveguide transition to circular waveguide. Sliced model view of the transition in shown on Figure 10. The size data after remastering can be extarcted from drafts in Figure 11. The distance between back wall of the waveguide and flare is not


Figure 9. The feedhorn, looking inside.

critical and should be larger 50-70 mm (more than 0.7-1 λ in waveguide).

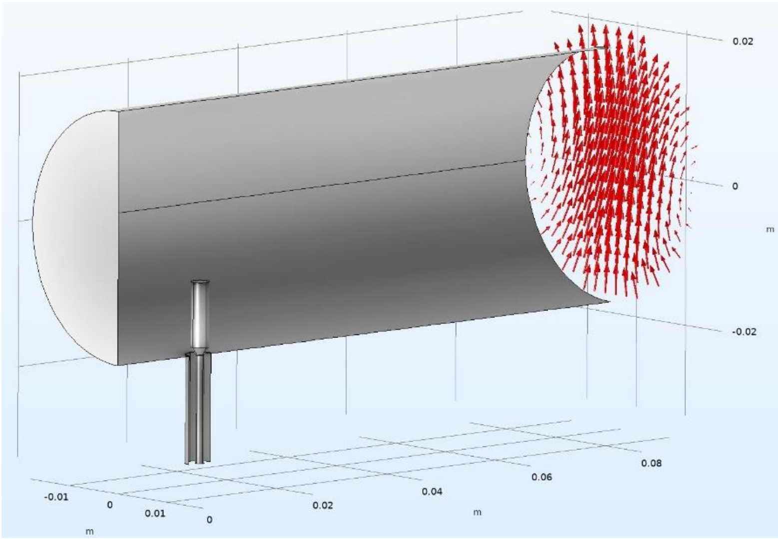


Figure 10. Modelled view of coaxial-waveguide transition.

The waveguide works in the main mode TE_{11}, however the waveguide of diameter 35 mm allows the mode TM_{01} at 6.7 GHz too. TM_{01} can be considered as a higher mode; additional analysis showed this mode is almost not exitated and propagated. TM_{01} has more than 240 mm of wavelength in 35 mm circular waveguide; thus, 6.7 GHz is close to critical frequency for TM_{01}. Further explorations of the feedhorn were done for TE_{11} mode only. The red arrows at Figure 10 show the electic field for TE_{11}.

This feedhorn was modelled in Comsol multipysics by parts: the coaxial-waveguide transition id 3D RF module and flare part in 2D axisymmetric RF module.

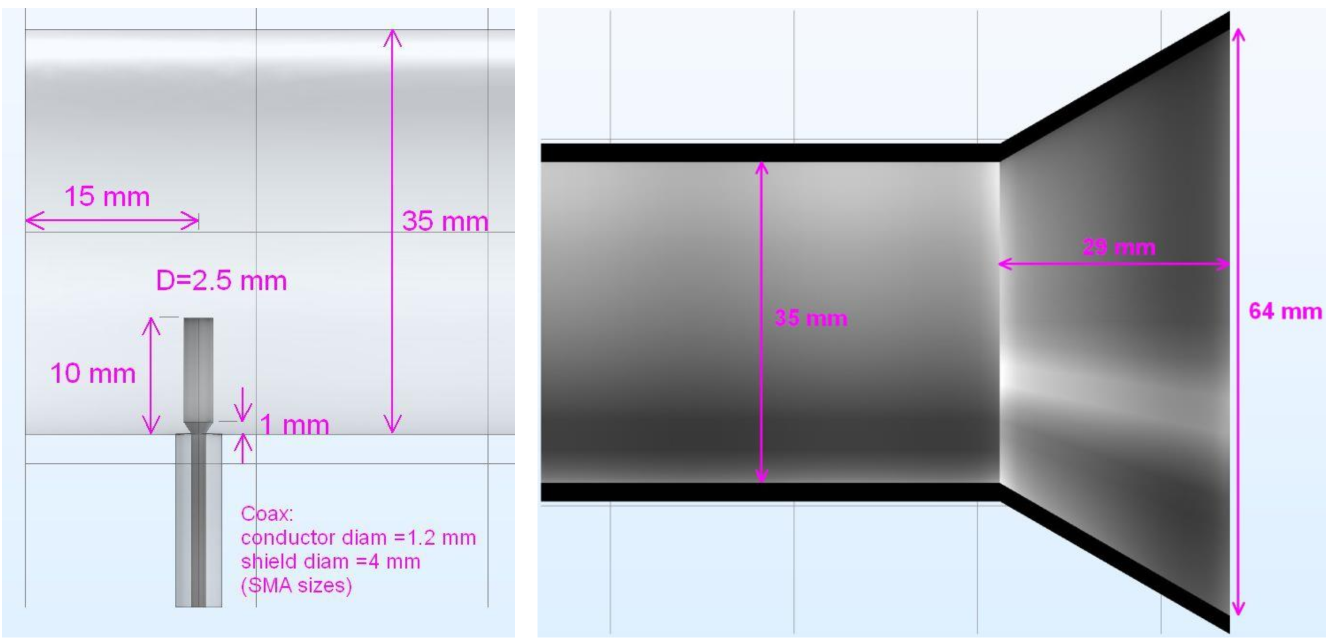


Figure 11. Feedhorn sizes: left – the coaxial-waveguide transition, right – the feedhorn flare.

According modelling the coaxial-waveguide transition has reflection coefficient from the coaxial side –18.55 dB at 6.7 GHz; the flare part has the reflection coefficient less –24 dB at 6.7 GHz. This coincides with measurement data of the feedhorn as a whole, see Figure 12. VSWR of the feed <1.3 at working frequency was considered satisfactory.

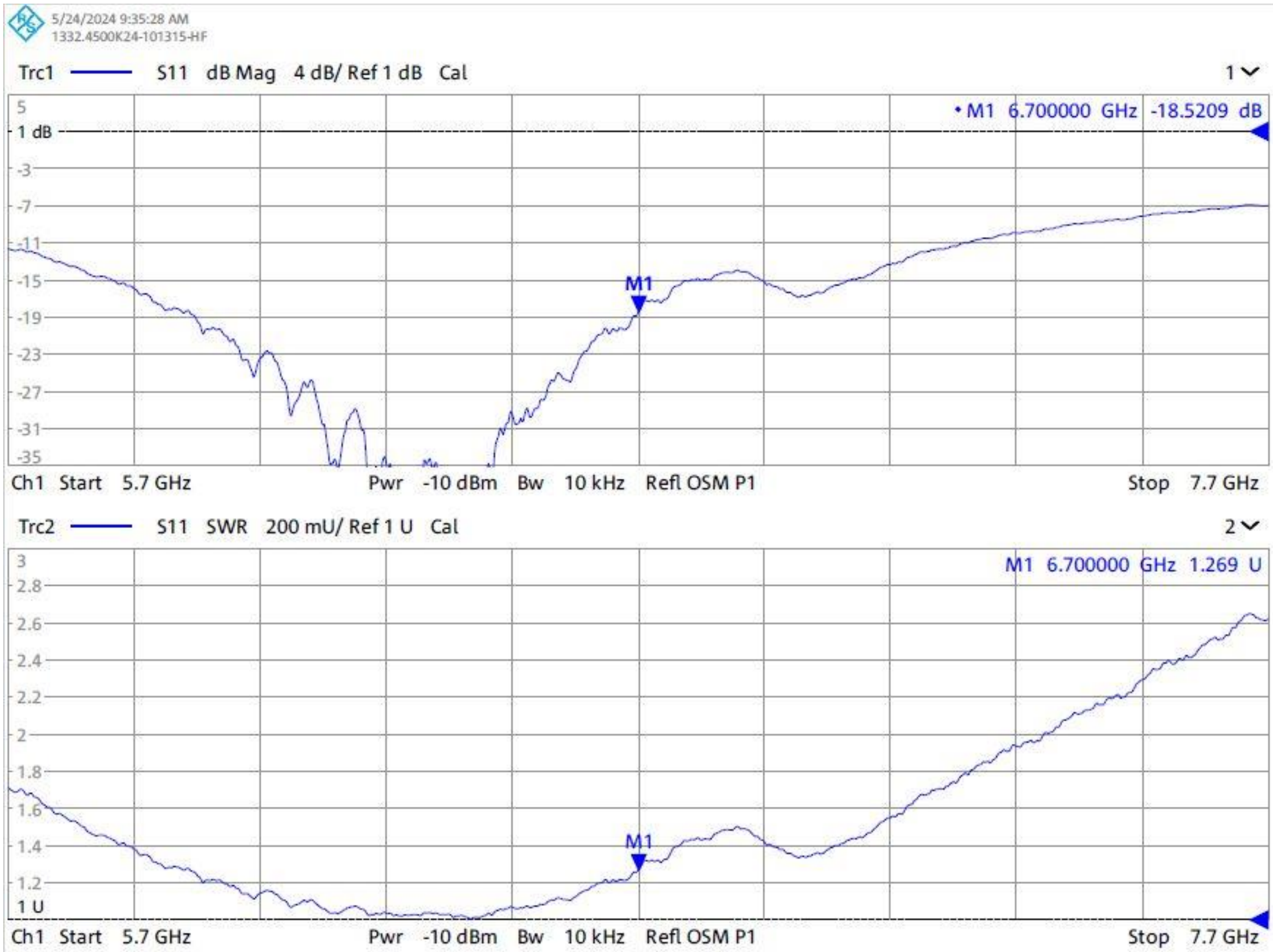


Figure 12. Measured data for reflections of the feedhorn at 6.7 GHz (R&S ZNA)

The far field pattern is calculated for the flare in 2D axial symmetric model; it is shown in Figure 13. As one can see visually the pattern is obtained axially symmetric too. The red arrows at Figure 13 left show the electic field for the excitating mode TE_{11}.

The axial symmetric data for far field pattern in Comsol were used for calculation of the Aperture Efficiency of telescope antenna, i.e. when this feed illuminates the dish [4]. This knowledge is needed for estimation of the dish Forward Gain (G or sensitivity), see [1].

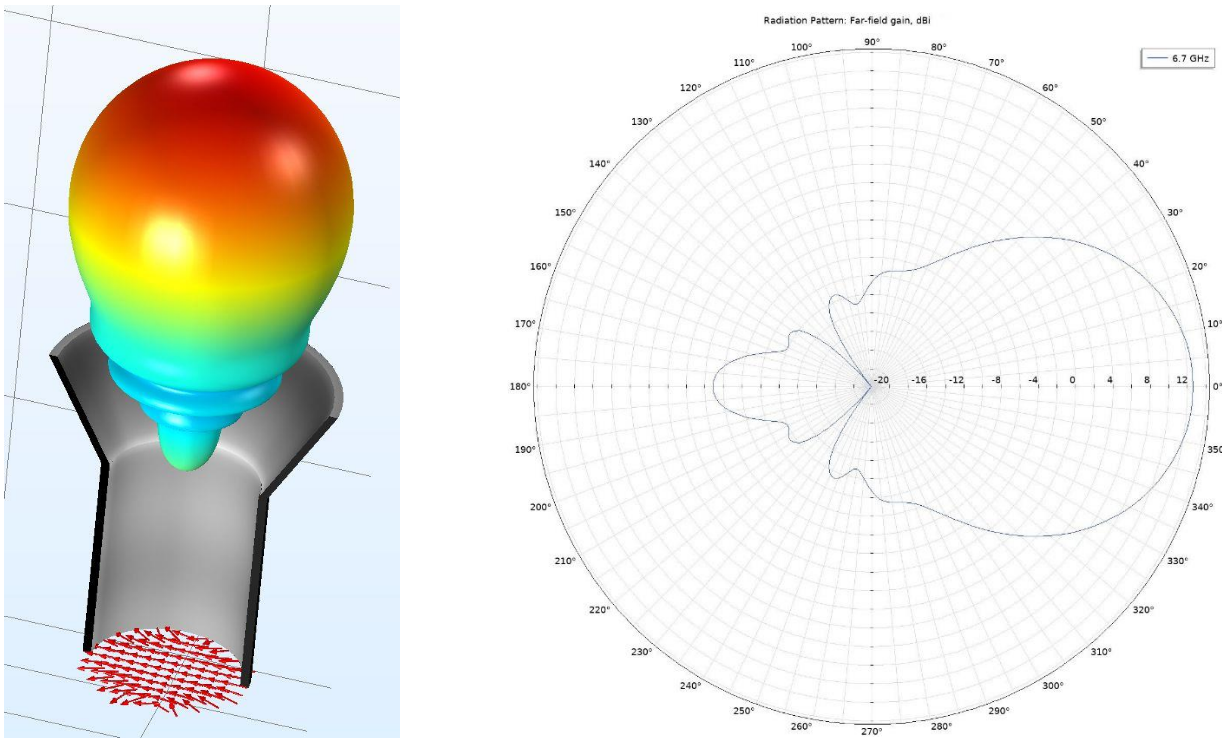


Figure 13. Far field pattern of the feed: left – 3D pattern with a slice of the flare, right – 2D polar plot of the pattern.

The Aperture Efficiency can be interpreted as a product of taper η_t and spillover η_S efficiencies, $\eta_A \approx \eta_t\,\eta_S$(see [5], [6] chap. 4). They are considered as main contributors which are defining an optimum in the Aperture Efficiency. The $\eta_t\,\eta_S$ value was calculated from known axially symmetric far-field pattern of the feed according to the formula [5]

$$\eta_A \approx \eta_t\,\eta_S = 2\cot^2\frac{\theta_0}{2}\cdot\frac{\left(\int_0^{\theta_0}\sqrt{F(\theta)}\tan\frac{\theta}{2}\,d\theta\right)^2}{\int_0^{\pi}F(\theta)\sin\theta\,d\theta}, \qquad (1)$$

where $F(\theta)$ corresponds to the far-field pattern of the feed in linear power units, θ_0 – is a half of aperture angle seen form the feed point (the feed's phase center). This formula was derived immediately for prime focus dishes and, as I expect, gives good approximating values η_A for offset dishes too. Other components like Ruse term or ohmic losses, possible defocusing, cross-polarization errors ([6] chap. 4) were not taken into account; then, calculations by formula (1) may be giving a bit overestimated value for the Aperture Efficiency.

For my dish 1.8 m at ***Figure 1*** θ_0 = 53 deg and result of calculations by (1) η_A=0.64. However, this is not an optimum of illumination of the dish; a maximum of the Aperture Efficiency η_A=0.74 is achieved at θ_0 = 40 deg. Therefore, in the telescope ***Figure 1*** the dish is under illuminated. It would be noted an under illumination is better for the noise performance of dish antennas; in this case the antenna collects less noise from the warm ground and surroundings and the system temperature ***T_{sys}*** is lower. The angle θ_0 = 40 deg corresponds to f/D (focus distance to dish diameter) about 0.7.

Concluding remarks

Parts and modules of the antenna unit worked successfully under specified conditions during 6.7 GHz maser observations in 2023 [1,4,7] by a telescope with 1.8 m dish ***Figure 1***. Now the design of the antenna unit is changed (see ***Figure 3***) for use with another dish expecting improvements in the Aperture Efficiency. Another place where the antenna unit can be improved is to apply more accurate and stable LO with OCXO reference. Measured characteristics of downconverter module Terrasat 6.4-7.1 GHz are given; if additional info about LNA design or dish feed is needed, please, ask the author.

Appendix

Here the plot of measured characteristics for Terrasat downconverter module 6.4-7.1 GHz with nominal power supply +5.5V is shown at Figure 14.

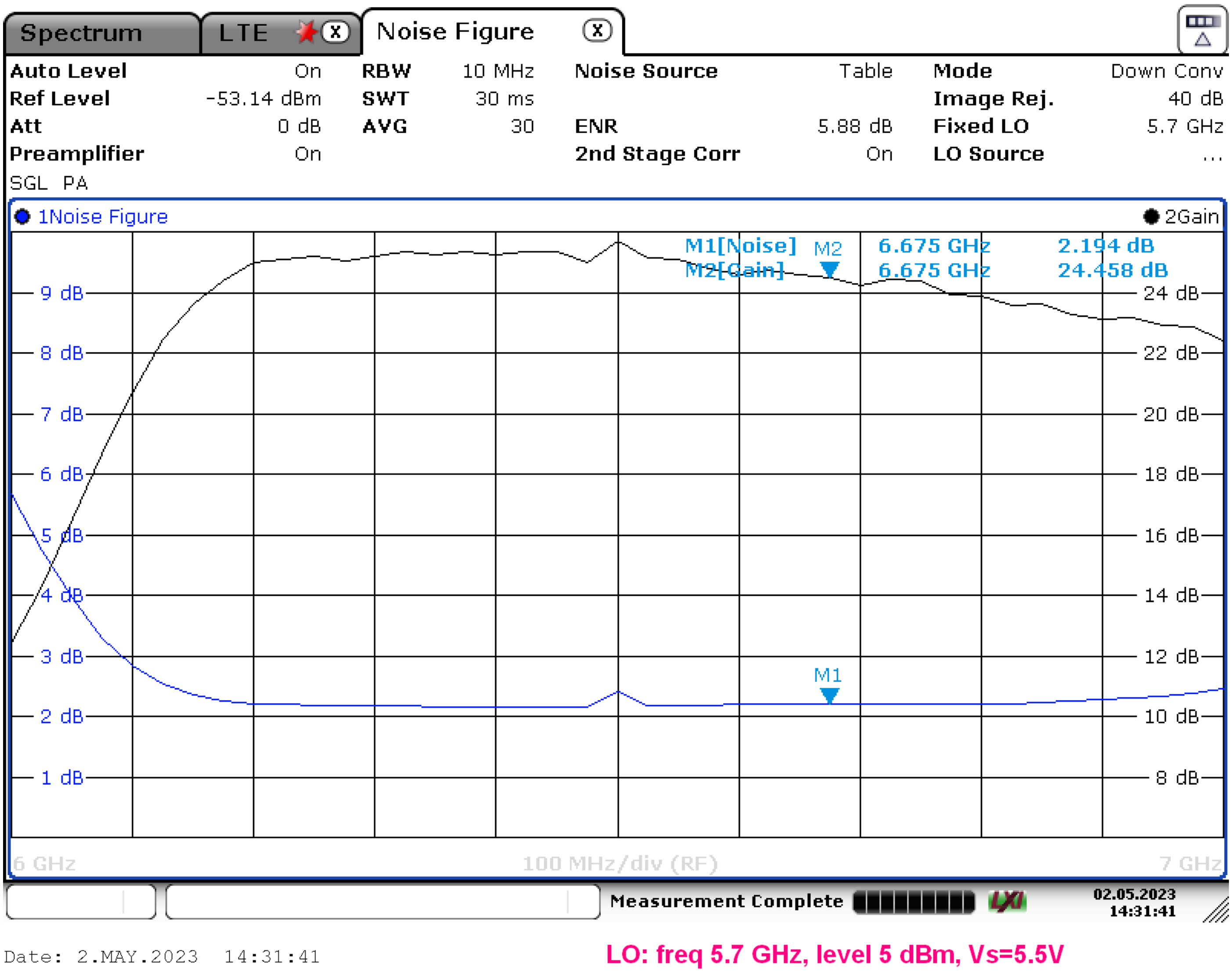


Figure 14. NF and conversion gain of Terrasat RX module for nominal supply +5.5V, LO frequency =5.7 GHz (R&S FSV, Noise Figure options in frequency conversion mode, the noise head – Noisecom NC346A precision).

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About the author

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

April 8, 2024 Total Eclipse Observations at 12 GHz

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University of Texas, Richardson, where SARA held the Western Conference, was in the path of totality. My IBT (Itty Bitty Telescope) with a more advanced power meter [1] and a laptop computer running Radio-SkyPipe [2] was set up to observe. The university people did a great job of assuring a good place to set up with 120V power available. This was by the science building where there were many students to participate as well. I had to put on the teacher hat to explain solar radio power and black body radiation. I fielded many intelligent questions and now feel more optimistic about our future engineers and scientists. Figure 1 shows the students. Figure 2 is the IBT setup. Figure 3 is physics students having a discussion with me about black body radiation and radio temperature.

Figure 1 University of Texas Students

Figure 2 IBT Setup

Figure 3 Discussion with Students

The power meter in the setup has an audio tone that varies its pitch in proportion to the radio power level. This tone helps in accurately aiming the IBT at the sun. This tone also indicates what is happening during calibration. The pitch is lowest during cold sky calibration. When the hot calibration load is put on the dish surface, the pitch goes high as it responds to the black body radiation of the calibration load plus my hand. As my hand is removed, the temperature settles to the calibration load. This leaves temperature spikes each side of the hot calibration for easier identification in the output file. This is also a teaching moment showing my hand is a radio power emitter because of its physical temperature. Many students wanted to verify that they were also emitting radio power too.

During the eclipse, three types of measurements were taken: the sun, cold sky, and a hot reference load on the surface of the dish. All measurements were recorded by Radio-SkyPipe. For the sun measurement, the IBT was carefully aimed at the sun and tracked for about a minute.

The cold sky reading was taken by aiming the antenna at an elevation of 80°. This is well away from the sun around 60° and any ground noise as well.

The hot reference was taken with a carefully shaped piece of wood placed in the center of the dish antenna surface with the 80° elevation used for cold sky. From previous experiments, this piece of wood added 58K to the receiver temperature. (Figure 4) Use of wood as a microwave absorber came from the British International Microwave Handbook {3]. The red PEX pipe ring is used to support an edge shield for the dish. This shield was used for moon temperature measurements. The shield was not needed here and could cause problems with the April winds common to the Dallas area.

Figure 4 Dish with Calibration Load

Often the sun would drift off the antenna and the level would drop while I answered questions. All the activity with people resulted in a chaotic output file.

Data Analysis of File

The Radio-SkyPipe file had problems because of a setup error. Sky-Pipe can poll for data or accept data pushed by the data source. The power meter was set to ***push*** data and Sky-Pipe was set to ***poll*** for data. This resulted in a file that was not directly readable. The file recovery in Sky-Pipe along with some work to fix the time stamps in Excel® restored the data.

All analysis was done by exporting from Radio-SkyPipe to a .csv file. Microsoft Excel® used the .csv file for all results.

Figure 5 shows the raw data points from the Excel® graph. The cold sky is pretty clear from the line of points at the lowest level. Hot calibration has a row of points about 4000 counts higher. Solar data is less obvious. Overall, the graph looks pretty chaotic. Attempts to sort the chaotic sun data, cold sky, hot calibration, and misaimed sun data did not lend itself to automation. Manual sorting of sun, cold, hot, and other data was a manageable task.

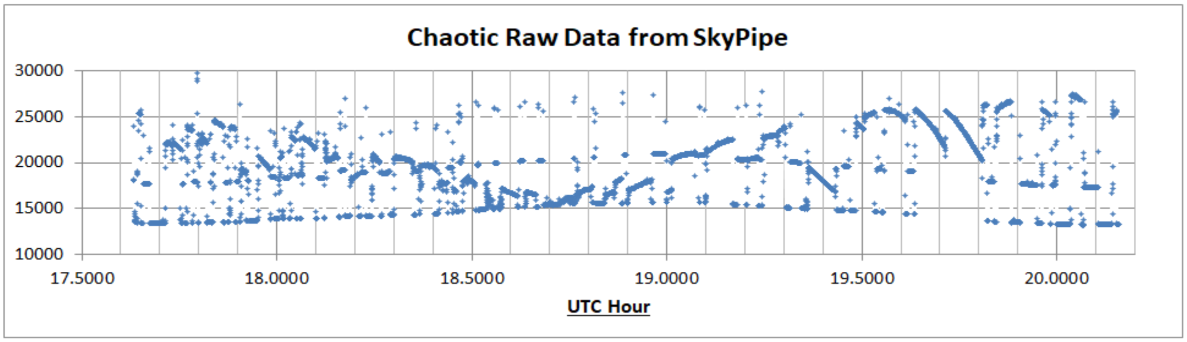

Figure 5 **Sky-Pipe Data**

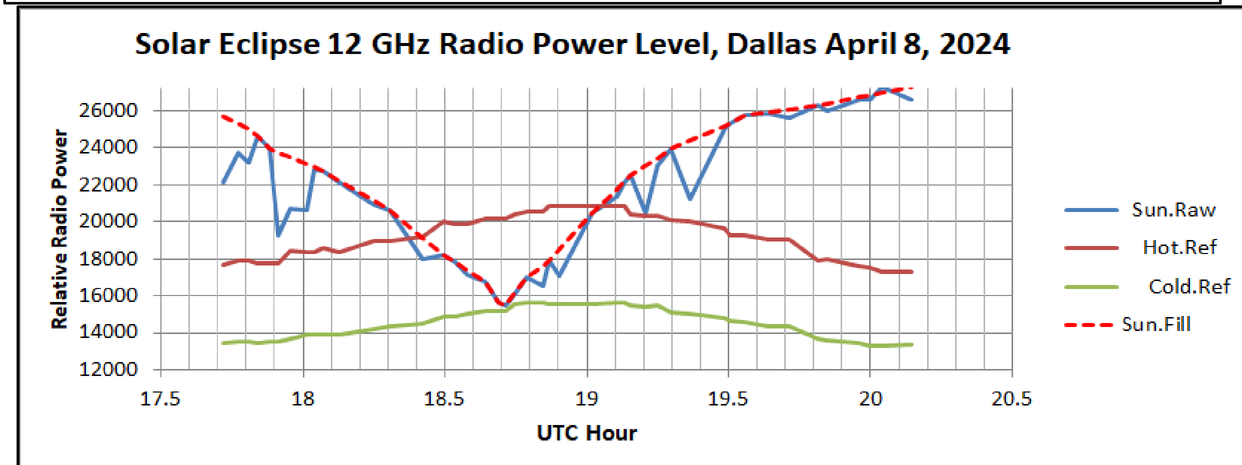

Figure 6 **Data Sorting Process**

Figure 6 shows the results of the sorting process. The cold sky and hot reference were reasonable. The sun readings were not good. By eliminating the points where the IBT was not properly aimed at the sun, the red dotted curve results. This is quite reasonable. Both cold and hot measurements changed as the ambient air temperature changed. This was compensated for by the spread sheet.

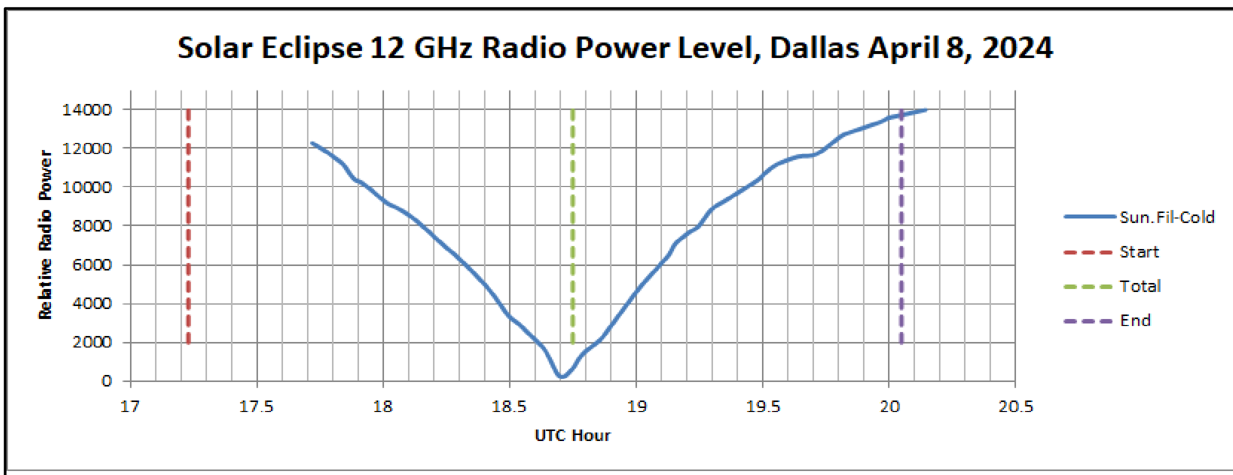

Figure 7 **Cold Sky Adjusted**

In Figure 7 the cold sky counts were subtracted from the red dotted curve in figure 6. During totality the reading should have a low temperature from the blackbody radiation from the moon. This is low enough that it is not visible with the IBT. Next the hot reference temperature was applied to the scaling of this graph.

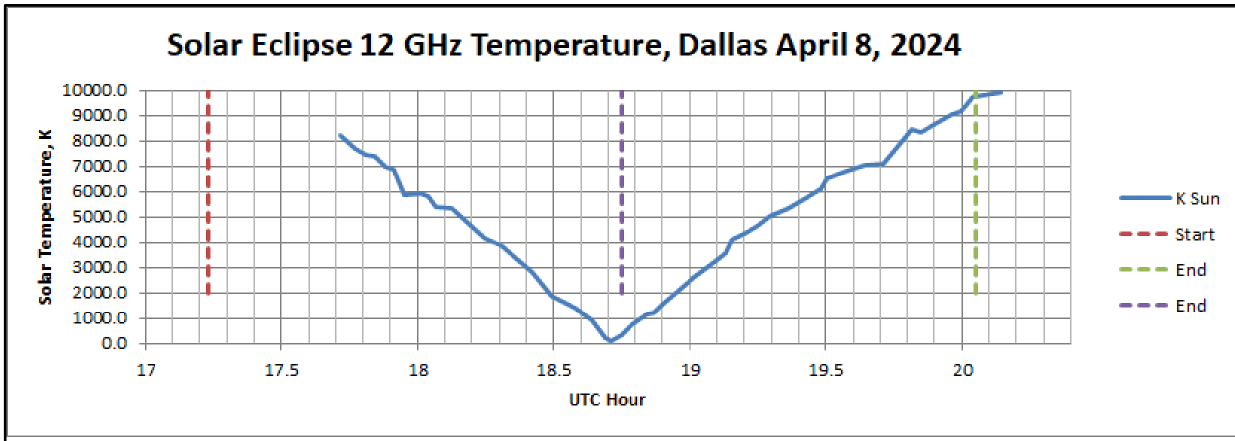

Figure 8 Readings Converted to Kelvin Temperature

The 58 Kelvin temperature of the reference load was used to establish the sun temperature.

TLoad = 58 K from previous measurements of calibration load.

An adjustment is needed for the dish beamwidth being larger than the sun.

$$AntFactor = \frac{BeamWidth^2}{SunDia^2} = \frac{3.5^2}{0.5^2} = 49$$

$$SunTemp = TLoad \frac{ColdAdjSun}{(Hot - Cold)} AntFactor$$

This calculation was done for each measurement point. There is some uncertainty in *TLoad* and *Beamwidth* so the temperature values may have significant errors.

From this, the sun's temperature is about 10,000 K and falls as the solar surface is obstructed during the eclipse. Unfortunately, the equipment setup was not complete until about ½ hour after first contact, so the "before" measurements are missing. The 10,000 K is short of the 13,484 K calculated in Appendix A. Reported 2800 MHz Solar Flux [4] was stable at 125 SFU (Solar Flux Units) from April 7 to April 9, so noticeable variations at 12 GHz are unlikely.

I would like to offer thanks to the University of Texas and especially the many science students who interacted with this experiment.

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[6] https://www.sws.bom.gov.au/World_Data_Centre/1/10

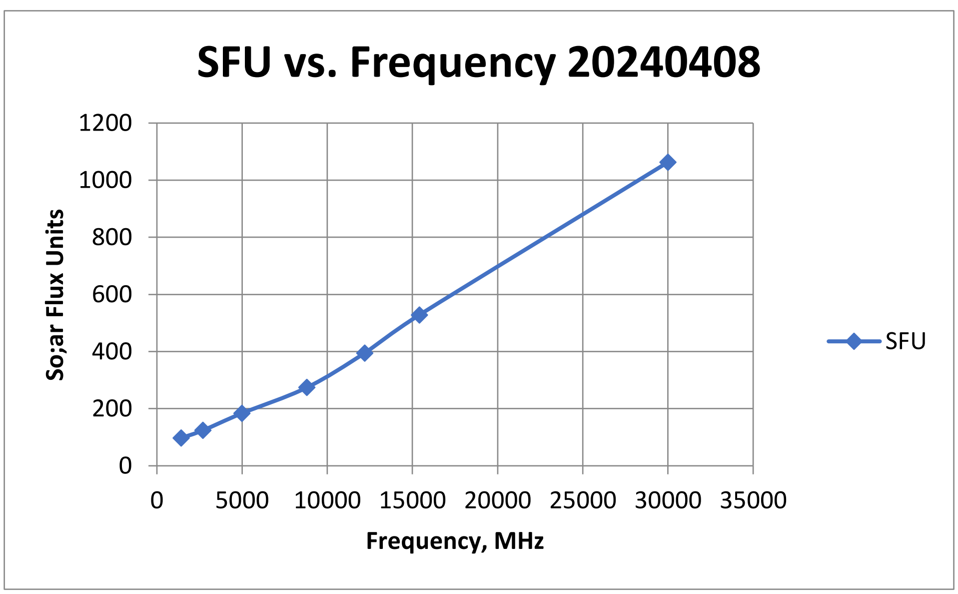
Appendix A Calculation of expected Solar Temperature at 12 GHz

8-Apr-24 **SFU Data From Learmonth Observatory, Australia**

http://www.sws.bom.gov.au/Solar/3/4/2 SFU data for today

https://www.sws.bom.gov.au/World_Data_Centre/1/10 SFU historical records

Web	Calc	Web	Calc	
Freq MHz	**Lambda**	**SFU**	Temp K	SFU = 2*k*Ts *Ws / L^2 * 10^22
1415	0.212	97	246146	
2695	0.111	124	86744	Ts = SFU / 2 / k / Ws * L^2 / 10^22
4995	0.060	184	37470	
8800	0.034	274	17977	
12200	**0.025**	**395**	**13484**	**SFU estimate for curve fit**
15400	0.019	528	11312	
30000	0.010	1063	6001	



Interferometer measurements in interstellar communications: methods and observations

William J. Crilly Jr.

Green Bank Observatory, West Virginia, USA

***Abstract*— Extraterrestrial communication signals are hypothesized to be present in an extensive search space. Using principles of communication theory and system design, methods are studied and implemented to reduce the signal search space, while considering intentional transmitter detectability. The design and observational work reported in this paper adds material to previous related reports: arXiv:2105.03727v2, arXiv:2106.10168v1, arXiv:2202.12791v1, and arXiv:2203.10065v1. In the current work, a two-element radio interferometer telescope and receiver algorithms are utilized to perform differential angle-of-arrival and multi-bandwidth measurements of $\Delta t\ \Delta f$ polarized pulse pairs. The system enhances extraterrestrial signal detectability, while reducing signal false positives caused by noise and radio frequency interference. Statistical analysis utilizes a Right Ascension filter spanning celestial coordinate ranges that include the previously determined anomalous celestial direction: 5.25 ± 0.15 hr Right Ascension, -7.6° ± 1° Declination. Observations were conducted during a duration of 61 days, comprising 244 hours of interferometer measurements.**

***Index terms*— Interstellar communication, Search for Extraterrestrial Intelligence, SETI, technosignatures**

I. Introduction

In the Search for Extraterrestrial Intelligence (SETI), many hypotheses and associated experimental methods have been proposed to analyze and try to explain the detection of unknown-cause apparent extraterrestrial radio signals, in the presence of noise, Radio Frequency Interference (RFI) and natural astronomical objects.[1][2][3] Interferometers have been used in SETI since 1975.[4]

In the experimental work reported in this paper, a two-element interferometer and signal processing system is used to implement an automated RFI excision method, narrow-bandwidth multi-pulse detection algorithm, and a differential phase measurement of two-tone pulsed narrowband signals, facilitating a differential celestial angle-of-arrival measurement method.

Previous experimental work has suggested an anomalous celestial pointing direction, having an apparently significant number of $\Delta t\ \Delta f$ polarized pulse pairs, at 5.25 ± 0.15 hr Right Ascension (*RA*), -7.6° ± 1° Declination (*DEC*).[5][6][7][8]

The current work reported here presents measurements that tend to confirm the presence of anomalies in the same celestial pointing direction as the previously determined anomalous direction.

Many explanatory hypotheses exist and are the topic of ongoing and/or further work.

II. Hypothesis

The hypothesis in this work is similar to those in previous work, [5][6][7][8], with the primary difference that a radio interferometer is used to filter narrow bandwidth received signals using differential RF phase measurements across interferometer elements. The phase measurements identify differential angles-of-arrival of spectral components of discoverable communication-like signals that are expected to be rarely found in random noise.

Hypothesis: Narrow-bandwidth energy-efficient interstellar communication signals are expected to be explained using an Additive White Gaussian Noise (AWGN) model, while using a radio interferometer with receiver algorithms that reduce RFI, and provide Signal-to-Noise Ratio (SNR) reduction. Receiver filters provide differential angle-of-arrival measurements of $\Delta t\ \Delta f$ polarized pulse pairs having celestial coordinates centered on a prior anomalous celestial direction: 5.25 ± 0.15 hr *RA* and -7.6° ± 1° *DEC*. In the current work, the time difference Δt, between narrow bandwidth pulses in a pair, is equal to zero seconds.

Discoverable communication-like $\Delta t\ \Delta f$ polarized pulse pairs observed with the interferometer are expected to not indicate measurements similar to those expected from an AWGN signal model. Falsification of the stated AWGN-cause hypothesis therefore compels activities that produce alternate and auxiliary hypotheses, topics of ongoing and/or further work.

Salient conjectures in this hypothesis and experimental design are that interstellar communication signals

(1) have high information capacity [5],
(2) are energy efficient [5],
(3) occupy a wide bandwidth [5],
(4) indicate measurements approaching those of AWGN,[5][9]
(5) exceptionally transmit high SNR narrow bandwidth pulse pair components, readily discoverable in random noise, [5][10],
(6) minimally interfere with known and likely communication systems[5], and
(7) indicate repetition at celestial pointing directions during long duration experiments[7].

Details of transmitter design rationale are described at III. Transmitter Design in [5].

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III. Method of Measurement

Objectives

Facilitate hypothesis falsification

Given an interest to attempt to falsify the hypothesis [11], the experiment is designed to attempt to remove all contributions to the detection of non-AWGN signals. Following the experiment, if Δt Δf polarized pulse pairs appear anomalous with statistical power, then the hypothesis is falsified, compelling alternate and auxiliary hypotheses to be proposed and tested.

Right Ascension filter

The AWGN-explanation hypothesis is falsified when anomalies are discovered at particular values of pointing *RA*, after relatively long duration experiments.

Machine design

Measurement machines ideally should be automated, from antenna voltage measurement, to the presentation of results in figures. Traceability, repeatability and equipment and human error tracking can then proceed. For example, RFI confounds almost all hypotheses related to SETI. Consequently, the machine that excises suspected RFI should include a repeatable and documented process, and include a process that stores RFI that has been excised, to facilitate follow-up and future RFI hypothesis testing.

Associated measurements

Various measurements may aid hypothesis falsification. Examples of associated measurements include RF frequency, frequency separation between simultaneous narrowband pulses, SNR, power measurements in various bandwidths, interferometer complex cross-correlation, and RFI excision measurements.

Measurement System

Antenna system

The antenna system is located in a rural location having low and controlled local RFI.

The two interferometer antenna elements are offset-fed paraboloids, each approximately eight-feet in diameter, separated along an East-West baseline at a distance of 32 wavelengths of 1425 MHz. Each antenna feed comprises a pair of two half-wave spaced, phased folded dipoles per linear polarization, combined in a 90 degree hybrid combiner, to generate right-hand and left-hand circular polarized voltages per feed. The four dipoles are placed in a truncated conical shaped reflector. Low noise amplifiers are located at each feed. In the current work, the element antennas' right-hand circular polarized signals are processed.

Interferometer element performance is tested using a combination of artificial sources driving helical test antennas, and astronomical objects. Each element's Azimuth and Elevation is measured and transmitted to instrumentation. Antenna elements are set to a *DEC* of -8°, and Azimuth at 180°, confirmed with continuum and interferometer correlation measurements of astronomical object NRAO 5690.

Receivers

Right-hand circular-polarized voltages from the feed are applied to downconverters that output in-phase and quadrature-phase (I+Q) zero-IF baseband signals, using a 1425 MHz local oscillator, phase locked to an oven-controlled crystal oscillator, stabilized to GPS satellite signals. The two I+Q signals from the two interferometer elements are digitized in a four channel synchronous 8-bit digitizer, triggered by a three second interval pulse, synchronized to GPS satellite signals. UTC time is produced by a GPS receiver output, in a coded signal centered at one kHz, and applied at baseband to one channel of the four channel digitizer, to ensure the sample time integrity of the antenna signals.

Four complex FFTs are calculated per 3 s interval, two adjacent-time, one for each antenna element, at a bin bandwidth of 3.7Hz and 0.27s interval per FFT. Measurements of each candidate are made, e.g. MJD, *RA*, SNR, RF Frequency, $\mathrm{Log}_{10}\Delta f$/MHz, RFI excision values.

RFI excision

First-level filtered candidate signals cover the frequency range of 1398 to 1451 MHz, with RFI excision implemented at the time of data capture, and described as follows.

Due to the regulatory spectral allocation of human communication systems, RFI is often observed to be concentrated in RF frequency. A hypothetical high capacity interstellar communication system, on the other hand, might be expected to have wide-bandwidth noise-like characteristics. These differences have led to the design of an excision method that stores measurements of a limited number of repetitive narrow bandwidth received signals in a file separate from the file that stores desired candidate signals.

The FFT receiver is partitioned to create 256 FFT bin segments, to determine the presence of suspected RFI. As a four hour duration file is filled with candidate measurement records, the number of candidate signals is counted in each segment. A per segment record count threshold, set to a value of ten, is implemented. The segment count threshold sets the count at which the segment is determined to be an RFI corrupted segment. Subsequent records in this segment are saved to an RFI file, in lieu of a first-level candidate file, up to two hundred RFI records per segment.

Each measurement record in the candidate file contains segment count values that estimate the segment spacing from the measured pulse candidate segment to the nearest excised RFI segment, above and below the candidate segment.

The threshold to excise a segment is set to balance the excision of potentially desired segments with the need to excise suspected RFI segments. When RFI is present, RFI excision of RFI segments typically stabilizes within a few minutes of the beginning of a four hour file being created. An RFI maximum count per 0.27 s, set to one hundred, prevents files from becoming too large with sustained RFI.

RFI is sometimes observed at, or near, harmonics of 1 MHz and 100 kHz. Consequently, a fixed filter is utilized that rejects candidates within 15 kHz of harmonics of 100 kHz.

In a zero-IF receiver, RFI is sometimes observed near the region close to the LO frequency. The range of 1424 to 1426 MHz is therefore excised.

Second-level filtered candidate signals have low and high end-of-range excision, resulting in the overall frequency range of 1405 to 1435 MHz. This second-level excision was implemented as a result of intermittent RFI discovered near the start and end of the first-level frequency range, after the 61 day experiment began.

Interferometer phase measurement

RF amplitude and phase is calculated in each 3.7 Hz bandwidth FFT bin of each interferometer element. The difference in RF phase measurement between the East and West interferometer elements is then calculated, represented by $\Delta\Phi_{INT.RF}$. The absolute value of the difference between $\Delta\Phi_{INT.RF}$ values of two Δt=0 Δf separated components of polarized pulse pairs is calculated, expressed as $|\Delta\Delta\Phi_{INT.RF}|$.

$|\Delta\Delta\Phi_{INT.RF}|$ is further described in ***First and second-level candidate filters***, below.

Interferometer complex correlation

The use of a high frequency resolution complex FFT in each interferometer element receiver becomes part of an FX type correlator, i.e. a cascade of an FFT per element receiver, a complex conjugate multiply per frequency bin and an IFFT to calculate the correlation per delay tap. [13] Delay taps have an increment of 16 ns.

The complex correlation provides a sensitive measurement of wide bandwidth emission from natural celestial sources. Natural celestial sources potentially transmit narrow bandwidth spectral components that might appear similar to intentional communication signals.

Multi-bandwidth power measurements

Average power measurements are performed in 954 Hz and 50 MHz bandwidths. The 954 Hz bandwidth power measurement provides the noise value, after bandwidth scaling, in the measurement of 3.7 Hz bandwidth SNR.

First and second-level candidate filters

First-level candidate records are defined to be a set of measurements that pass the first-level filter, i.e. FFT output bins that measure SNR greater than 8.5 dB on each interferometer element, and absence of RFI excision. The measurements of first-level candidates are saved to a four hour duration file at the time of signal acquisition. First-level candidates are produced at a rate of approximately fifteen records per 3 seconds.

In second-level candidate filtering, a first-level candidate input file is chosen, per MJD day, to cover the *RA* direction of interest, 5.25 hr *RA*. Second-level candidate output records are defined to be a set of records culled from first candidate records that meet the additional requirements of RF frequency range, pulse pair frequency spacing Δf<100 kHz, and interferometer $|\Delta\Delta\Phi_{INT.RF}|$ < 0.1 radian. The number of second-level output candidates was 1,280 during the 61 day experiment. Second-level output candidates' measurement records are sorted by increasing $|\Delta\Delta\Phi_{INT.RF}|$, to facilitate binomial-model likelihood calculations.

$|\Delta\Delta\Phi_{INT.RF}|$ is defined as follows,

$$\Delta\Delta\Phi_{INT.RF}(i) = (\Phi_{INT.RF.WEST}(i) - \Phi_{INT.RF.EAST}(i)) \\ -(\Phi_{INT.RF.WEST}(i-1) - \Phi_{INT.RF.EAST}(i-1)), \qquad (1)$$

where $\Phi_{INT.RF}(i)$ is the interferometer RF phase measurement, per FFT bin, per element. The count index i increments with the FFT bin-sorted SNR East > 8.5 dB and SNR West > 8.5 dB Δt=0 polarized pulse pair candidates.

SNR threshold

The SNR threshold of 8.5 dB is approximately 3 dB below the SNR threshold used in previous work [5][6][7][8]. The difference is explained as follows.

Assuming a Rayleigh-distributed amplitude probability per FFT bin, given a single receiving antenna element, the following amplitude density applies [14],

$$p_{RA}(r) = (r/\sigma^2)\exp(-r^2/2\sigma^2), \qquad (2)$$

with r ≥ 0, equal to the Gaussian noise amplitude density variable and σ^2 the Gaussian noise variance. The cumulative probability of a pulse event having amplitude from r to infinity is equal to

$$P_{RA}(r) = \exp(-r^2/2\sigma^2). \qquad (3)$$

In a two element interferometer with an FFT having N_{FFT} frequency bins, after RFI excision, the number of first-level candidates having a cumulative amplitude in both elements above the threshold r, per FFT interval, is

$$N_{CANDIDATES} = N_{FFT}\exp(-r^2/2\sigma^2)\exp(-r^2/2\sigma^2), \quad (4)$$

resulting in a factor of two in the exponential,

$$N_{CANDIDATES} = N_{FFT}\exp(-2r^2/2\sigma^2). \qquad (5)$$

Given a signal processing goal to produce a fixed number of potential signal candidates per FFT calculation, i.e. $N_{CANDIDATES}$ (5), the SNR threshold, $r^2/2\sigma^2$, may be reduced by 3 dB, compared to using a single antenna and receiver. A planned third interferometer element is expected to provide an additional 1.7 dB reduction in candidate SNR threshold.

IV. Observations

Observations were conducted between Dec. 6, 2023 and Feb. 4, 2024. The signal processing algorithms provided a total of 1,280 filtered and sorted measurement records, plotted in **Figs. 1-13**. The text below each of **Figs. 1-13** describe measurements of the 1,280 candidate pulse pairs, as they relate to the previously stated ***Hypothesis*** of this work. All figure image files were produced in the machine second-level candidate signal processing step, without human intervention.

In general, **Figs. 1-4** present measurements that tend to provide evidence to falsify the AWGN hypothesis, while **Figs. 5-13** present measurements that may be used to seek alternate and auxiliary explanations related to the measurements presented in **Figs. 1-4**.

Fig. 1 indicates the count per *RA* bin of filtered and sorted Δt=0 Δf polarized pulse pairs produced by the signal processing filters described in **Method of Measurement**.

Fig. 2 indicates the statistical power of sorted Δt=0 Δf polarized pulse pairs anomalies across *RA* bins, observed in **Fig. 1**.

Fig. 3 indicates the $\text{Log}_{10}\,\Delta f$/MHz per *RA* bin, to seek anomalies, in attempts to falsify the Poisson distribution expected in an AWGN explanatory hypothesis. The anomalies of low Δf values in *RA* bins 51 and 52 indicate that these *RA* bin responses contain signals dissimilar from AWGN.

Fig. 4 indicates the degree to which the cumulative effect of many low-valued Δf pulse pairs are presented in each *RA* bin, by calculating the sum of $\text{Log}_{10}\ \Delta f$ /MHz of pulse pairs observed per *RA* bin. *RA* bins 51 and 52 indicate that pulse pairs exist that are not explained by Poisson-distributed Δf frequency spacing, in AWGN. The calculation of Δf Likelihood in AWGN is presented in [5] Appendix C.

Fig. 5 indicates the East interferometer element relative average power measured at the same time in the 954 Hz wide segment that spans the FFT bin of the associated sorted $\Delta t=0$ Δf polarized pulse pair. Anomalous 954 Hz bandwidth power may present ways to explain various causes for outlier pulse pairs. Power is integrated over 0.27s.

Fig. 6 has a measurement rationale similar to that in **Fig. 5.** A wider bandwidth measurement of the East interferometer element relative average power, at 50 MHz, helps identify various explanatory causes of anomalous sorted $\Delta t=0$ Δf polarized pulse pairs. Power averaging time is 0.27 s.

Fig. 7 indicates the MJD time that the $\Delta t=0$ Δf pulse pair candidate was measured.

Fig. 8 indicates the RF frequency of the higher frequency component in the associated $\Delta t=0$ Δf polarized pulse pair.

Fig. 9 indicates the binomial model event probability that a pulse pair event will randomly be present in an *RA* bin, given the non-uniform sampling of *RA* in the 61 day experiment.

Fig. 10 indicates the Log_{10} Likelihood of SNR per pulse pair, per *RA* bin. The calculation of SNR Likelihood in AWGN is presented in [5] Appendix B.

Fig. 11. indicates the $|\Delta\Delta\Phi_{INT.RF}|$ measurement values per pulse pair in each *RA* bin.

Fig. 12 and **Fig. 13** indicate the number of 954 Hz segments between the nearest identified RFI segments and the segment containing the RF frequency of the $\Delta t=0$ Δf polarized pulse pair.

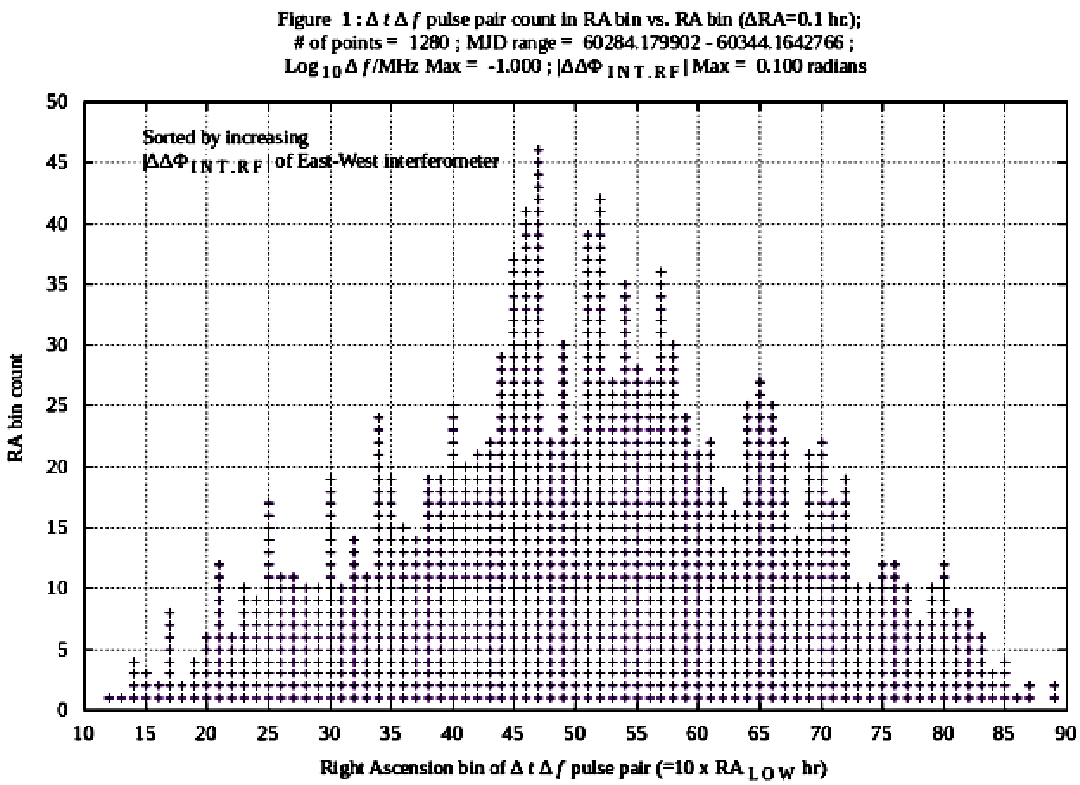

Figure 1: The count of 3.7 Hz bandwidth filtered Δt Δf polarized pulse pairs, having $\Delta t=0$, $\Delta f < 100$ kHz and pulse pair absolute Δf differential interferometer phase, $|\Delta\Delta\Phi_{INT.RF}| < 0.1$ rad., is plotted per *RA* bin. The experiment's duration was 244 hours during 61 days. The 5.15 and 5.25 hr *RA* bins, bins 51 and 52, indicate apparent anomalous counts of $\Delta t=0$ Δf pulse pairs. 5.25 ± 0.15 hr *RA* is the previously determined *RA* direction of interest. The $|\Delta\Delta\Phi_{INT.RF}| = 0.1$ rad. value corresponds to a sky pointing angle difference, of $\Delta f < 100$ kHz pulse pairs, of 0.028°. Anomalies are also apparent in bins 45, 46 and 47. The statistical power of count anomalies is calculated and shown in **Fig. 2.**

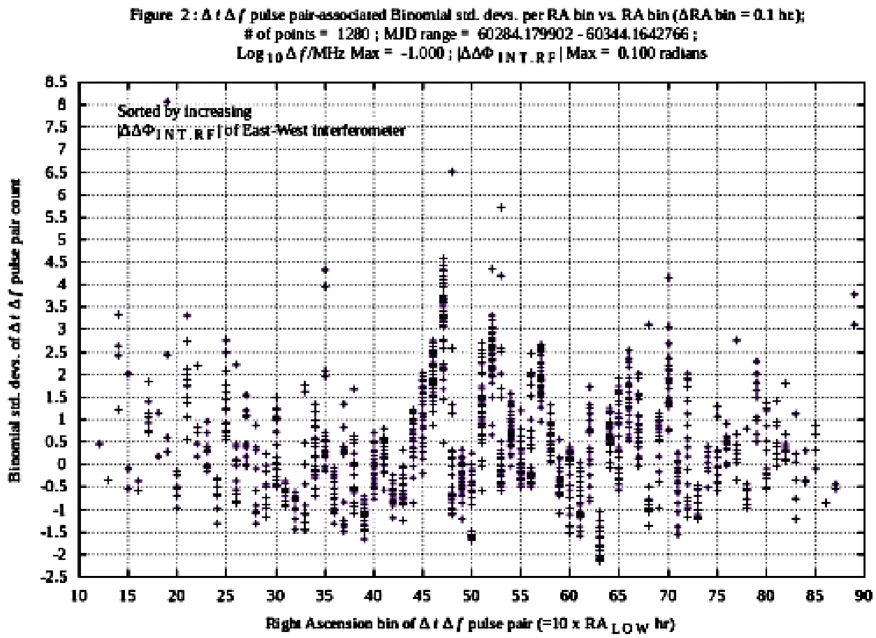

Figure 2: Each measured count of $\Delta t = 0$ Δf polarized pulse pairs, described in **Fig. 1**, has an associated binomial-distributed Likelihood, given the number of increasing $|\Delta\Delta\Phi_{INTRF}|$ sorted trials, measured count per *RA* bin and event probability. An expected value of count mean and standard deviation is calculated at each trial, for each *RA* bin, assuming an AWGN-explanatory cause and binomial statistics. These AWGN model statistics, together with measured event counts, are used to determine an effect size, based on the method in Cohen's **d** = Δmean / std.dev. The dimensionless method indicates the statistical power of anomalous counts in *RA* population bins. A Cohen's **d** value of 0.8 is considered to be a "large" effect size.[12] *RA* bins 51 and 52 indicate Cohen's **d** values surrounding 1 and 2.5 respectively.

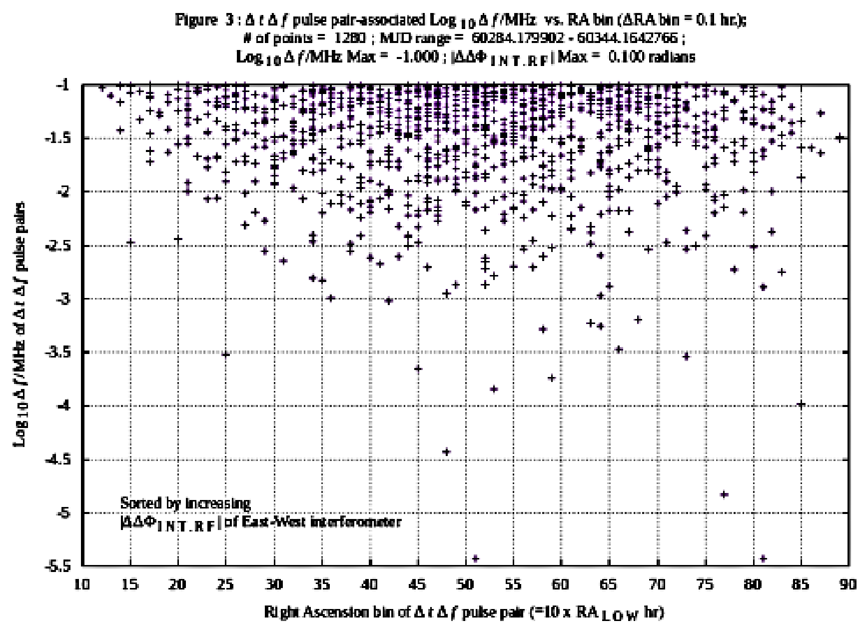

Figure 3: $\mathrm{Log}_{10}\Delta f$/MHz indicates anomalous close-spaced frequency components (one pulse pair having Δf=3.7 Hz, four pulse pairs having Δf< 2.5 kHz), in *RA* bins 51 and 52, respectively. The binomial distribution Likelihood of a noise-cause calculates to *pr.*=0.047 (1 seen in 2 trials at event *pr.* 0.024), and *pr.*=0.011, (4 seen in 38 trials at event *pr.* 0.024) respectively.

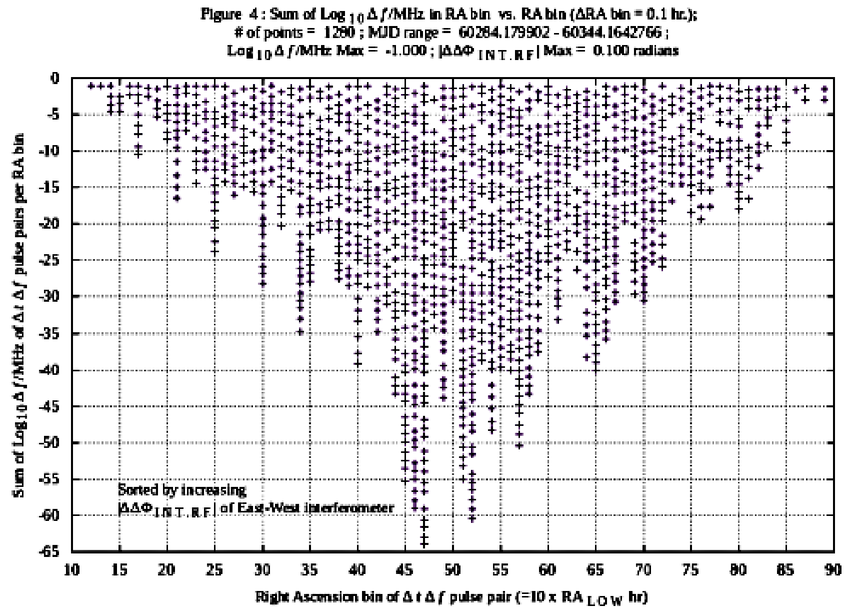

Figure 4: The sum of $\mathrm{Log}_{10}\,\Delta f$/MHz per *RA* bin indicates the repetitive significance of low-valued Δt=0 Δf<100 kHz pulse pairs. *RA* bins 51 and 52 indicate anomalies. Anomalies in other *RA* bins is a topic of further experimental work. The *DEC* beamwidth of each interferometer element is approximately 8°, greater than the *DEC* beamwidths used in previous experiments (≈0.6°-3°0),[5][6][7][8], suggesting a possibility that a similar explanatory cause might be present across *RA* bins, i.e. at different celestial coordinates.

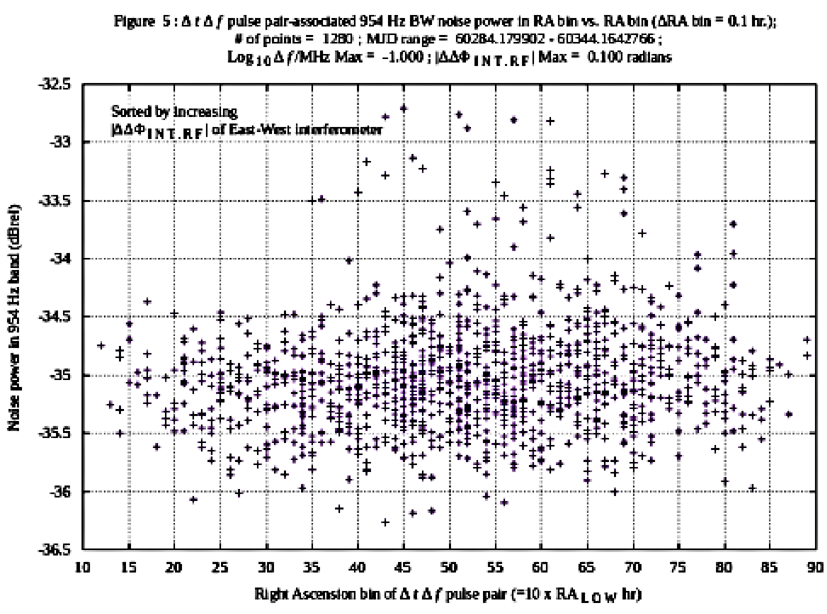

Figure 5: 954 Hz bandwidth integrated East element power is measured, during the 0.27 s FFT time window of the pulse pair, in the 256 bin FFT spectral segment containing the anomalous Δt=0 Δf polarized pulse pair. The 954 Hz bandwidth power measurements help determine if 954 Hz bandwidth power levels might explain narrow bandwidth spectral outliers, observed in **Fig. 1-4**. Approximately twenty anomalous *RA* bin 51 and 52 pairs are observed in **Fig. 1**, while approximately seven anomalous 954 Hz bandwidth *RA* bin 51 and 52 pairs are observed in **Fig. 5**. Work is underway to develop explanatory hypotheses that may explain the presence of narrow bandwidth signals in the absence of wide bandwidth power measurements. The West element data indicates a similar shortage of 954 Hz bandwidth power measurement outliers.

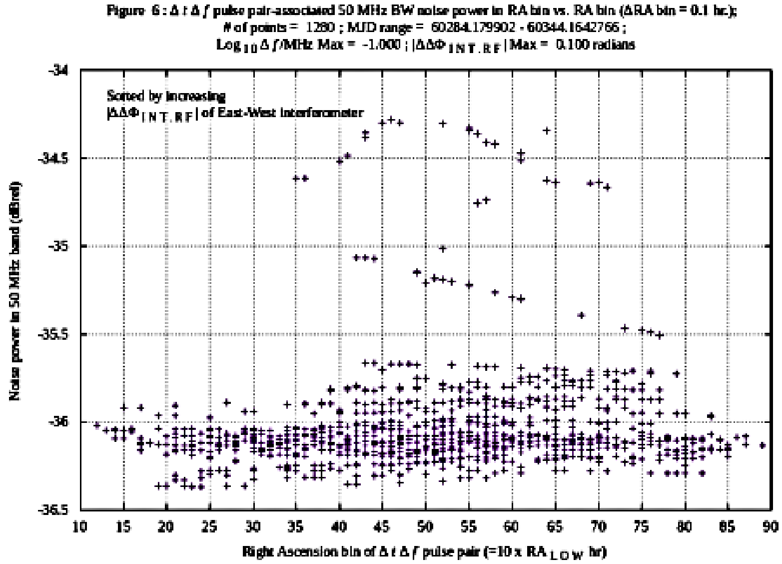

Figure 6: A measurement is made of 50 MHz bandwidth integrated East element power, during a 0.27 s FFT time window equal to that of the anomalous $\Delta t=0$ Δf pulse pairs. The measurement aids in examining whether or not continuum bandwidth power may explain narrow bandwidth spectral outliers, observed in **Fig. 1-4**. Approximately twenty anomalous *RA* bin 51 and 52 pairs are observed **Fig. 1**, while approximately four anomalous 50 MHz bandwidth *RA* bins 51 and 52 pairs are observed in **Fig. 6**. The measurement of the West element relative average power indicates a similar shortage of anomalous measurements.

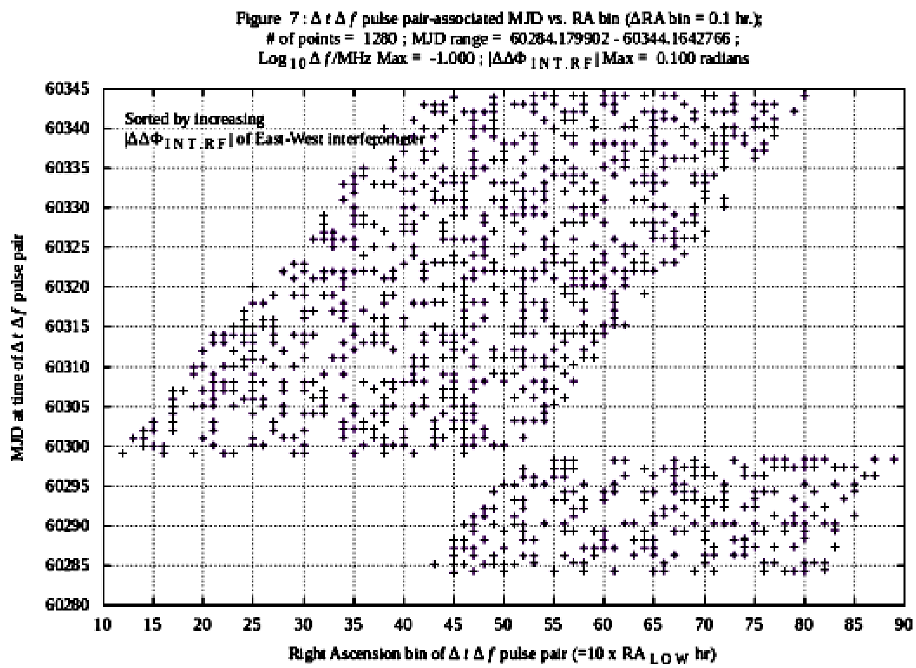

Figure 7: The MJD time associated with each polarized pulse pair event is plotted per *RA* bin. Four hour duration files are created, with measured MJD synchronized to UTC using a GPS clock. A single four hour duration file was processed per MJD, while including the 5.25 hr *RA* direction of interest. The number of pulse pair trials vs. *RA* bins have an expected triangular density, assuming a noise cause, which was measured and is shown in **Fig. 9**.

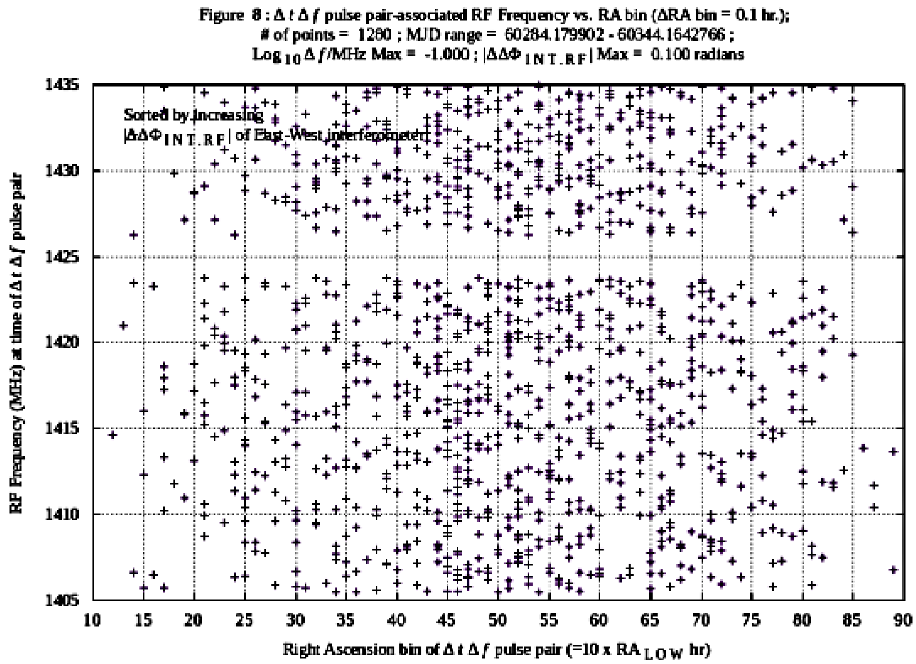

Figure 8: The RF frequency of the upper frequency of each of the Δt=0 Δf polarized pulse pairs is measured. Examination of RF frequency distribution is important because RFI is known to often be concentrated in RF frequency. High information capacity communication signals are expected to be approximately uniformly distributed in RF frequency.

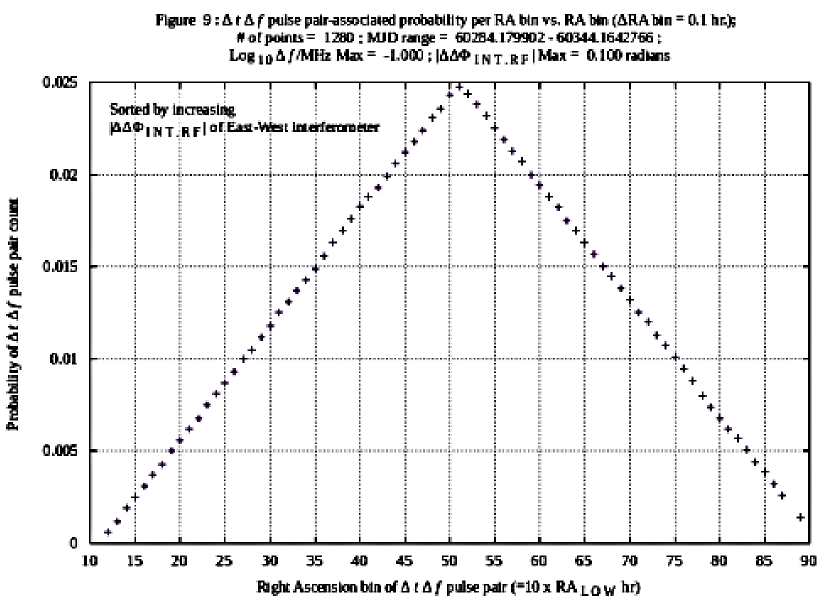

Figure 9: The probability of an *RA* bin randomly indicating a pulse pair event, due to noise, is calculated by accumulating the daily time-range contributions of each *RA* bin, then normalizing. The result shows the expected triangular binomial event density, as may be gleaned by observing **Fig. 7**. The probability values in **Fig. 9** are used to determine the two probabilities in the binomial Likelihood calculations per *RA* bin in **Fig. 2**, event *pr.*, and (1 - event *pr.*) , i.e. binomial event/non-event probability values.

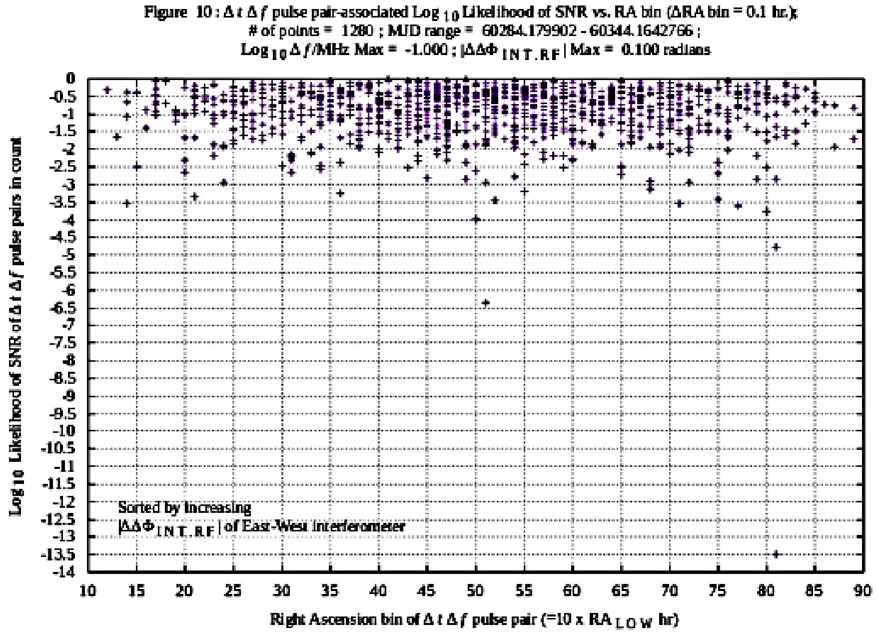

Figure 10: *RA* bins 51 and 52 indicate three possibly anomalous SNR measurements, while the majority of measurements in these two *RA* bins does not have many apparent outliers, relative to surrounding *RA* bins.

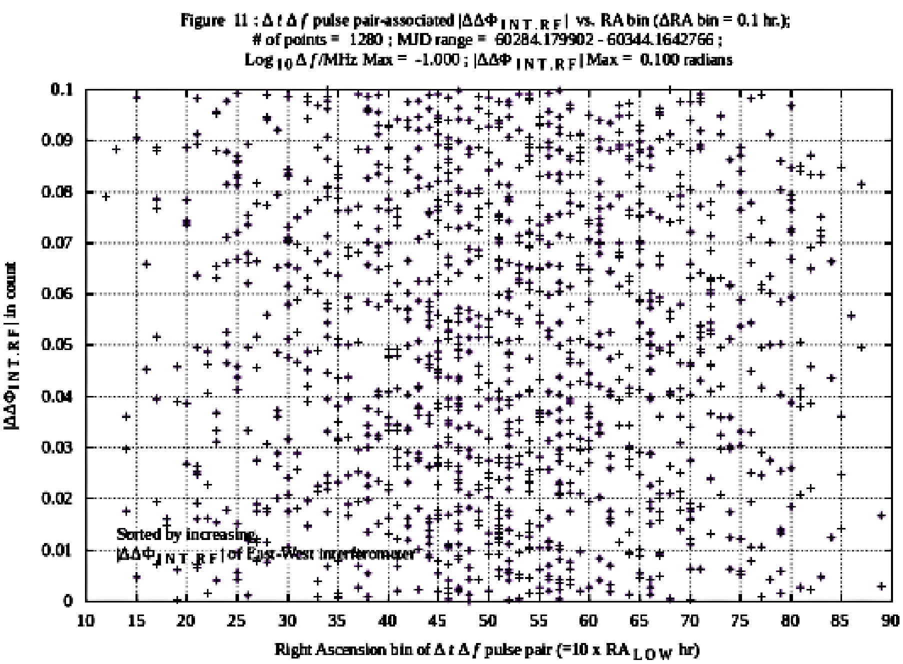

Figure 11: $|\Delta\Delta\Phi_{INT.RF}|$, prior to filtering and resulting from an AWGN explanatory model, is estimated to be uniformly-distributed over 0 to π. Exceptions include pulse pairs having a Ricean amplitude probability distribution, i.e. comprising a sine-wave signal and noise. The statistical power of low-valued $|\Delta\Delta\Phi_{INT.RF}|$ measurements is a topic of ongoing and future work.

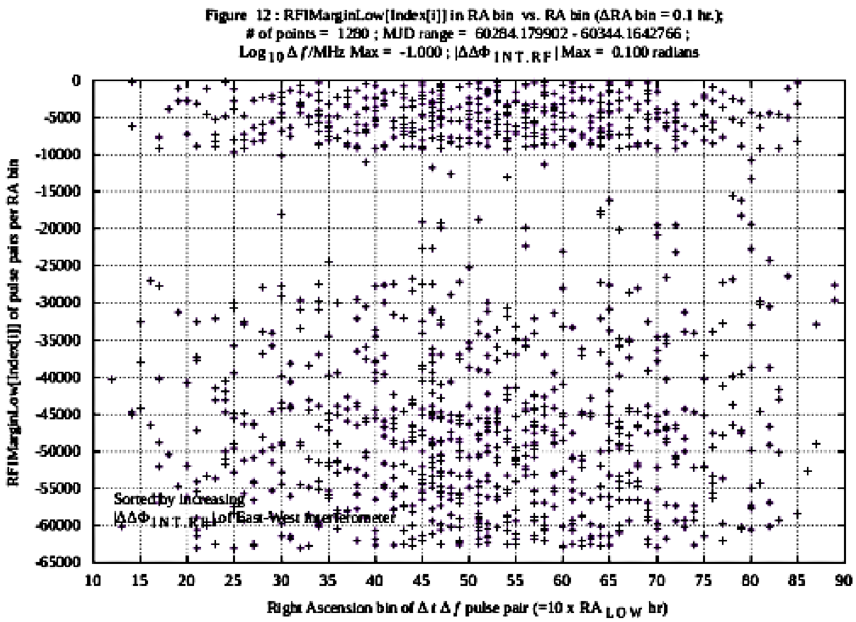

Figure 12: The low-sided RFI spectral margin is measured in units of 954 Hz sized segments, to provide potential indications that *RA* bins are corrupted by proximity to nearby excised RFI segments. If excessive numbers of RFI margin measurements have values near zero segment count differences, an RFI cause may be implied.

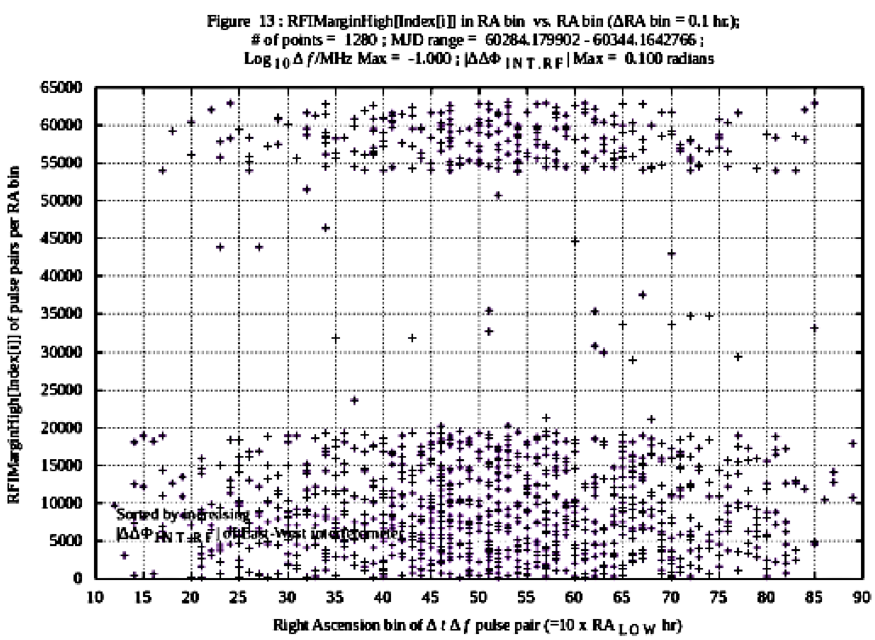

Figure 13: In the spectral direction opposite to that shown in **Fig. 12**, RFI margin is examined. These types of RFI margin measurements may be used to help contribute to the falsification of one type of RFI hypotheses, a topic of further work.

V. Discussion

The 5.25 hr RA direction indicates anomalies

The 5.25 ± 0.15 hr *RA*, -7.6° ± 1° *DEC* celestial direction has been associated with a significant number of anomalous pulse pair events in experimental work, since 2018.[5][6][7][8] In the current work, **Fig. 1** presents apparent confirmation that the *RA* bin 52 celestial direction is significant. **Fig. 2** adds statistical power to the *RA* bin 52 importance, because *RA* bin 52 shows a high number of large Cohen's **d** values. The grouping of the points around **d** = 2.5 in **Fig. 2** indicates that the number of anomalous *RA* bin 52 pulse pair events was sustained throughout the 1,280 sorted second-level candidate pulse pair events.

Choice of sorting parameter

The choice of the 1,280-sized heap sorting parameter, prior to calculating binomial statistics, may influence the effect size calculation, because sorting parameters that are correlated with a confounding scenario may skew results to the top of the sorted heap. For example, unusually high SNR is often correlated with the presence of RFI. If highest-to-lowest SNR is used to sort the full set of trials in the unsorted heap, RFI events may falsely appear to add significance, due to a potentially high number of RFI events observed at the top of the subsequently sorted heap. In general one should sort using a parameter that is correlated with the experimental characteristic that is being sought. In this experiment, low Δf pulse pair sky angle of arrival is sought.

The differential interferometer RF phase $|\Delta\Delta\Phi_{INT.RF}|$ was chosen as the sorting parameter because, among other measurements, $|\Delta\Delta\Phi_{INT.RF}|$ is thought to be the most indicative of pulse pair events having close to the same sky pointing direction, at low Δf, and in the same FFT time interval, i.e. Δt=0.

Associated measurements at $\Delta t = 0$

Two associated measurements, i.e. the 954 Hz and 50 MHz bandwidth average power measurements, shown in **Figs. 5-6**, do not show strong evidence of apparent response at the *RA* bins that show numerous anomalies, e.g. in **Figs. 1-4**, bins 47 and 52.

Uncorrelated and correlated noise

Each interferometer element has an equivalent receiver input noise power that is uncorrelated across elements, as well as a receiver input noise power that is correlated across elements. Correlated noise power across elements is expected to cause an increase in Δt=0 Δf polarized pulse pair counts, due to correlated spectral outliers, while not causing anomalies in low Δf measurements, because AWGN is expected to have a Poisson distribution of Δf measurements.[5]

Therefore, an increase in 954 Hz bandwidth noise power, due to an astronomical object, for example, may contribute to an increased count of polarized pulse pair candidates. Low Δf measurements, on the other hand, allows one to differentiate communication-like pulse pairs from astronomical object caused pulse pairs.

Further work is required to model and quantify correlated and uncorrelated noise measurements.

Absence of independent corroboration

To the author's knowledge, independent corroboration of pulsed signals in the *RA*, *DEC* direction of interest has not been conducted.

VI. Conclusions

The hypothesis in this work explains an experimental presence of Δt Δf polarized pulse pairs expected to be due to AWGN.

Difficulties arise while trying to conclude that AWGN explains 5.25 hr *RA* anomalies observed in this experiment, as follows:

(1) the variations in pulse pair counts across *RA*, shown in **Fig. 1**, is inconsistent with an AWGN explanation, and

(2) the statistical power of anomalous concentrations of pulse pair count statistics, shown in **Fig. 2**, is inconsistent with an AWGN explanation.

Consequently, the AWGN hypothesis is thought to be falsified in this experiment.

An important future activity is the development of experimental methods and source models to attempt to falsify alternate and auxiliary hypotheses, e.g. involving natural astronomical objects.

VII. Further Work

Observations reported here that contribute to falsification of the AWGN hypothesis compel alternate explanations of anomalous signal measurements.

Further work is underway to model, simulate and apply various astronomical object signals to the radio interferometer system. Pulsars, MASERs, Fast Radio Bursts, and continuum object simulated signals may be applied in digital and analog forms, to attempt to falsify auxiliary and alternate explanatory hypotheses.

Further work is underway that repeats long duration interferometer measurements. The observations using the *RA* filter, indicating anomalous celestial directions, is under study, using modified explanatory hypotheses.

Work is underway to add a third interferometer element to the system.

VIII. Acknowledgements

Many contributions of workers of many organizations, during many years, have made this project highly enjoyable. Special thanks are given to the Green Bank Observatory, National Radio Astronomy Observatory, Deep Space Exploration Society, Society of Amateur Radio Astronomers, SETI Institute, Berkeley SETI Research Center, Breakthrough Listen, Allen Telescope Array, The Penn State Extraterrestrial Intelligence Center, product vendors, and the open source software community. Guidance from family and friends is greatly appreciated.

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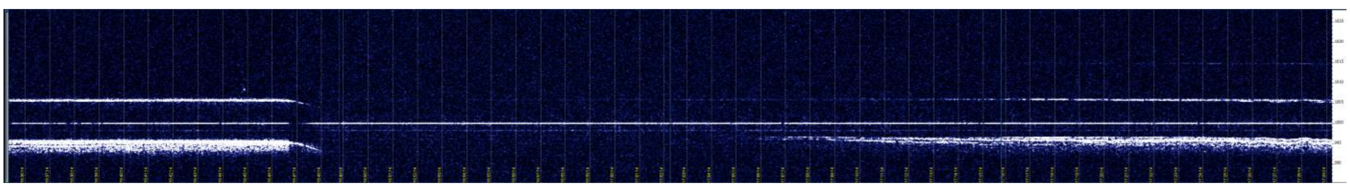
Observation Reports

X8.7 Flare Observed at Radio Frequencies

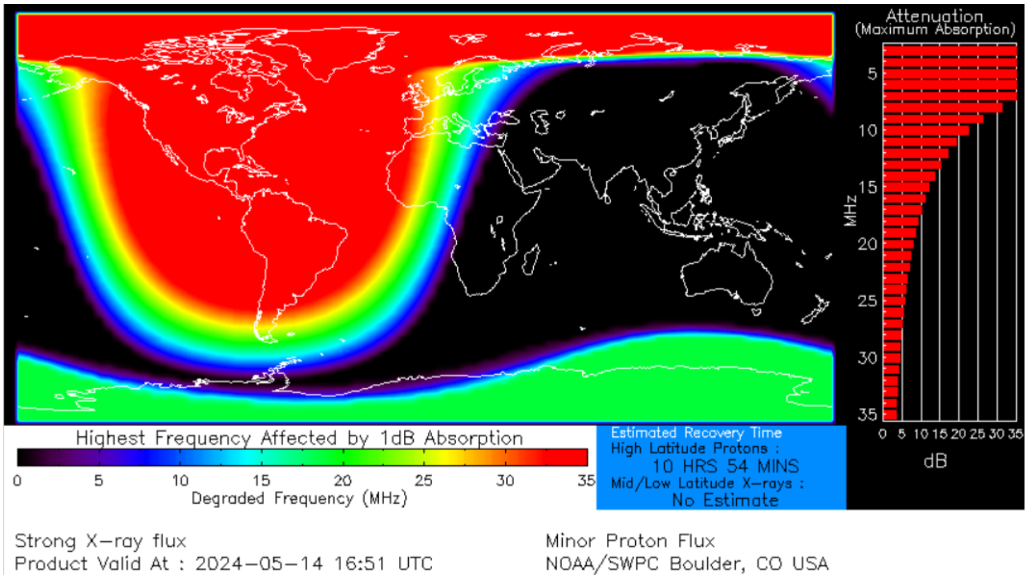
Whitham D. Reeve

An x-ray flare with magnitude X8.7 was observed on 14 May 2024. It was the strongest flare during solar cycle 24 up to that time. The flare radiation increased the electron density in the ionosphere's D-region, producing heavy absorption of HF radio signals and an HF radio blackout on Earth's sunlit side. Of particular interest was the almost instantaneous blockage at 1646:45 UTC of signals propagating from the time-frequency stations WWV in Fort Collins, Colorado and WWVH in Kekaha, Kauai, Hawaii to Anchorage, Alaska. The received signals at 15 and 20 MHz started to recover about 20 and 30 minutes later, respectively. The image below shows the event's time sequence in a narrowband horizontal waterfall spectrogram.



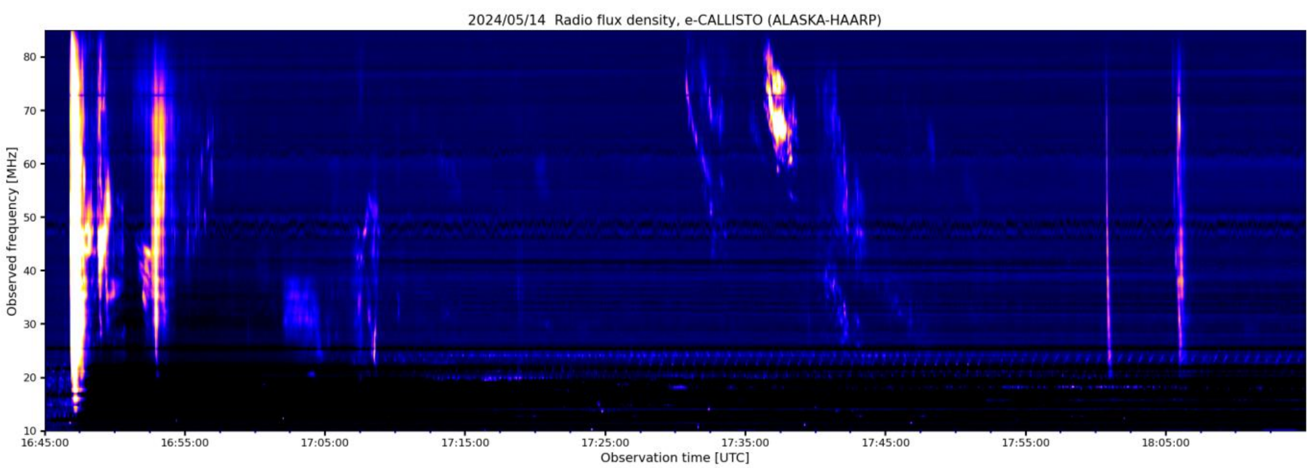
Narrowband spectra from 1636 to 1729 on 14 May 2024 UTC as observed at Anchorage, Alaska. Time is measured left-to-right with 1 minute tick-marks (faint vertical yellow lines). The frequency of the demodulated carrier is shown on the right vertical scale and extends from 985 at the bottom to 1030 Hz at the top. The receivers were tuned nominally 1 kHz above the carrier frequency and set to the LSB mode. The lower white trace at 995 Hz corresponds to a carrier frequency of 15 MHz, and the somewhat narrower trace at 1005 Hz near the middle of the frequency scale corresponds to a carrier frequency of 20 MHz. The thin continuous trace between 995 and 1005 Hz is a spurious signal. Note the almost instantaneous nature of the radio blackout and the relatively slow recovery. The receivers were Icom R-8600 *Communications Receivers,* and the antenna was an 8-element KMA-1832 log periodic dipole array. The waterfall spectra were produced by Argo software and consists of four 13 minute images that have been spliced together.

Another representation of the radio blackout phenomena on the sunlit side of Earth is seen in the D-Region Absorption Prediction (D-RAP) plot below. This plot is based on spacecraft data and a rather simple model.



The D-RAP plot at 1651 UTC shows absorption at low- and mid-latitudes exceeding 35 dB at low frequencies (right-hand scale) from flare radiation. Persistent and similarly heavy absorption was predicted earlier in the day for high latitudes from energetic particle precipitation (mostly protons) into the high-latitude ionosphere. The high-latitude absorption was associated with preflare solar activity. Image source: https://www.swpc.noaa.gov/products/d-region-absorption-predictions-d-rap

The Callisto radio spectrometer and LWA Antenna at the HAARP facility near Gakona, Alaska captured solar radio bursts at the time of the flare and are shown in the spectrogram below. Space Weather Prediction Center (SWPC) reported the flare "*produced Type II and Type IV sweeps, a 10 cm burst and a Castelli-U signature*"; however, the U-signature is not apparent in any of the e-CALLISTO spectrograms that captured this particular flare event. The U-signature phenomenon may have been observed by SWPC at frequencies above those being observed by the e-CALLISTO network, but SWPC did not specify the frequency range of their observation.



Callisto radio spectra from 10 to 85 MHz for the period 1645 to 1900 on 1 June 2024 shown in a broadband horizontal waterfall spectrogram. Strong Type III fast radio sweeps are seen at the time of the flare on the left side of the plot and banded Type II slow radio sweeps at about 1735 near the middle. The Type II was caused by a coronal mass ejection associated with the flare. Additional Type III sweeps can be seen near the right side of the chart. Image courtesy of Christian Monstein who used data archived at FHNW Brugg/Windisch and IRSOL Locarno, Switzerland.

April 8, 2024 Eclipse Observations at 408MHz from Rock Hill, South Carolina

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My home radio observatory was in the partial eclipse area. The eclipse magnitude was 0.828. The eclipse obscuration was 0.80. The obscuration is the part of the area of the sun that is covered. See the Solar Eclipse Glossary. [1] The sun's Radio power level should drop to about 20% of full view at the eclipse maximum. This equipment was left running in Rock Hill, SC while I was in Dallas for the SARA Western Conference and the total eclipse.

An existing antenna (figure 1.) with a wide enough beam width in the East-West direction to observe the eclipse event without moving the antenna was used. This antenna from a 2017 eclipse experiment was described in the SARA Journal, [2]. The receiver used is in figure 2. It is a homebuilt Dickie Switch receiver. The aluminum bracket on the left side of the receiver supports a Measurement Computing USB504 Data Logger. The receiver is calibrated in arbitrary power units. From lab tests with a signal generator and precision attenuators, its linearity of power and therefore temperature is very good.

Figure 1. Antenna Used

Figure 2. Receiver

The wide beamwidth antenna allowed capture of the whole eclipse with a fixed position but does add a few problems. There is a ripple pattern in both traces. This is stray reflections off of metal objects near the antenna. The wide beamwidth also collects more radio power from the galactic background. There is enough galactic background to affect readings.

Figure 3 shows the results. The first graph has the blue curve for the day before the eclipse. It shows the effect of the sun moving through the antenna pattern. The red curve shows the added effect of the eclipse. There seems to be a baseline shift of about 1.3 units between April 7 and April 8

In Figure 4, the non-eclipse reference was subtracted from the eclipse day graph. The 1.3 unit baseline shift was included.

At maximum eclipse the receiver residual is receiver preamp noise, galactic background and the desired solar radiation. A fixed antenna in a remote location does not lend itself to a cold sky calibration. It would be of interest to verify the level of the 408 MHz solar radiation at maximum eclipse. A graphical approach was used to get an approximation of received solar power at eclipse maximum.

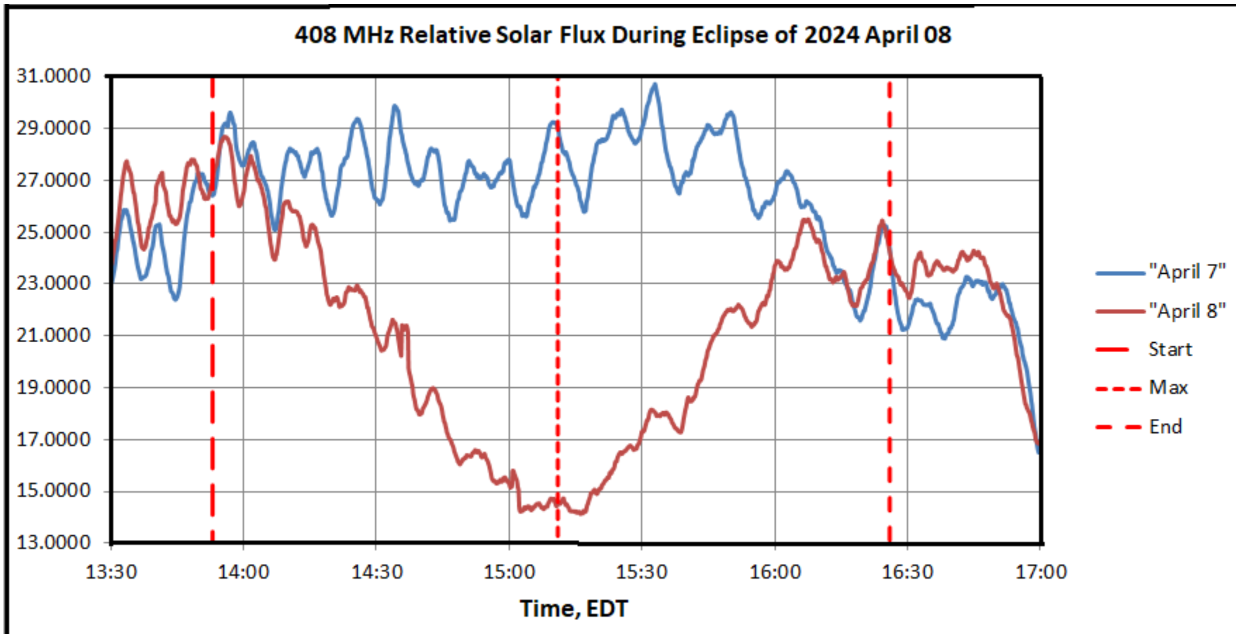


Figure 3.

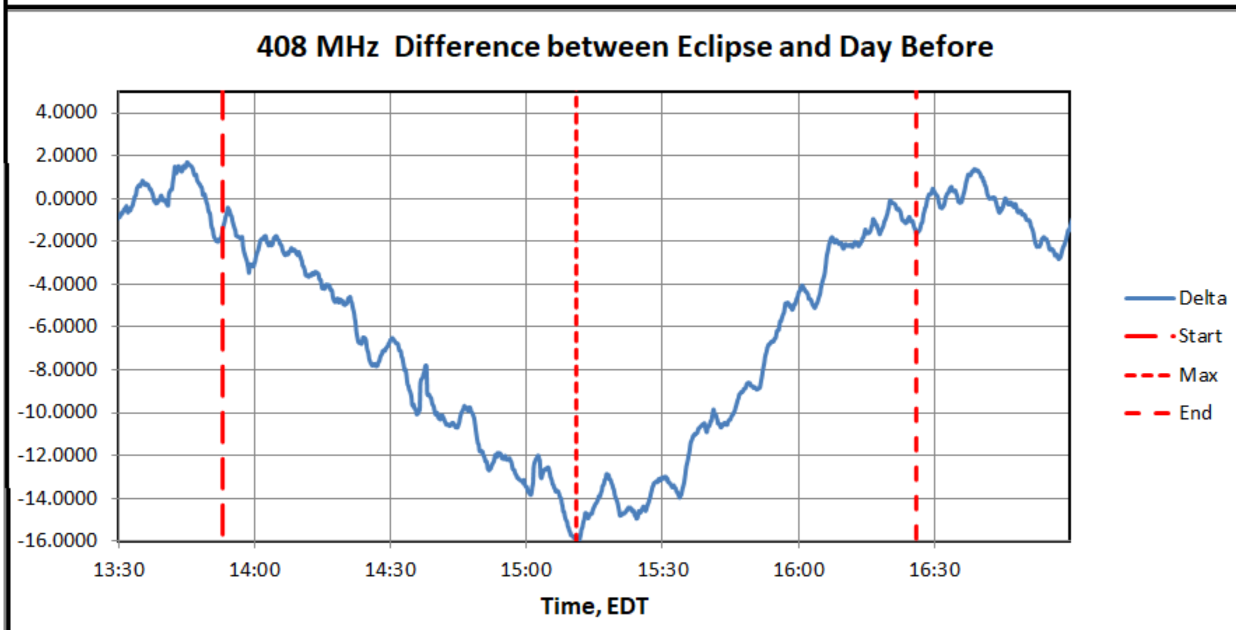


Figure 4

The eclipse minimum power graphical approach is shown in Figure 5. An Excel® spreadsheet was used to move the lines around on a graph. The line coordinates were used in calculations. The Galactic Estimate (Gal Est) line is an estimate of the galactic level during the eclipse. From looking at the galactic level from sky maps and the antenna pattern, a straight line is not too bad of an estimate. Note that this line is an estimate, not a direct measurement. Also, the lines for the sun peak the day before, and the maximum eclipse had to pick a visual average through some noise and the ripples due to stray reflections.

The radio diameter of the sun at 408 MHz also affects results. From the start and end of the eclipse, it appears that the radio diameter of the sun is slightly larger than the optical diameter. Kraus [3] on Fig. 8-35 shows the 50 cm solar diameter to be slightly larger the optical diameter.

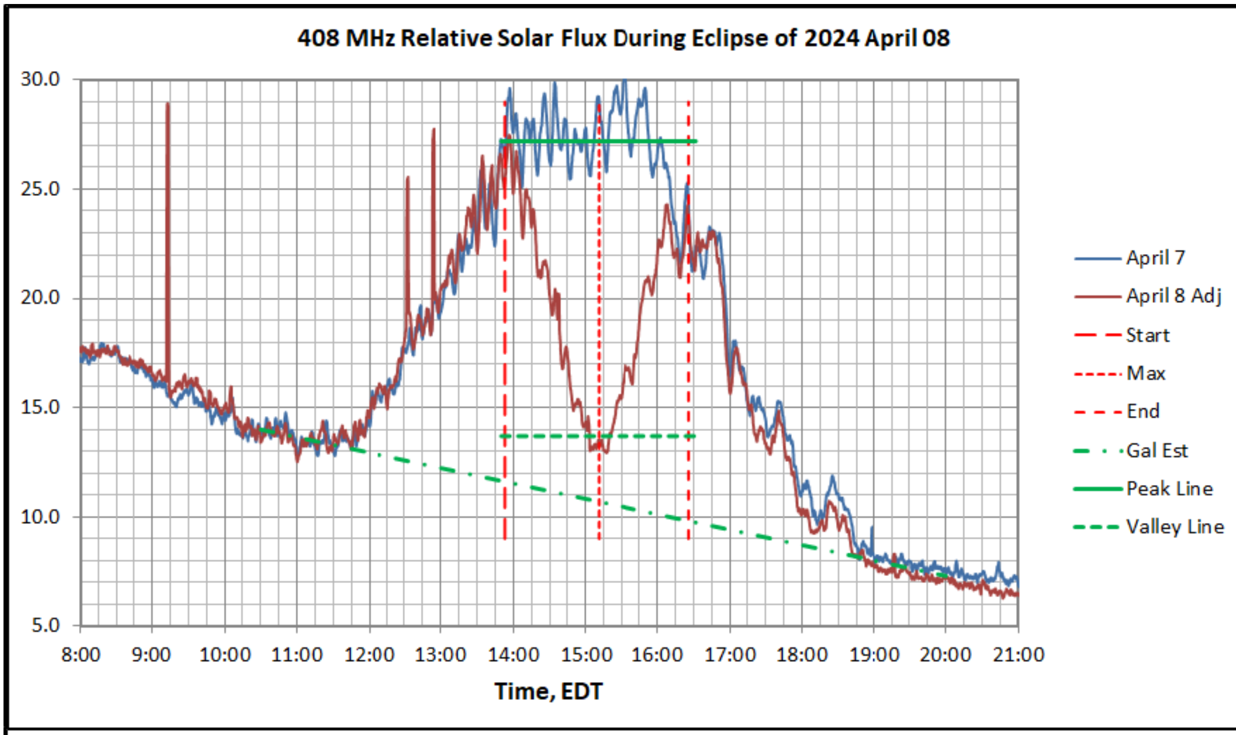


Figure 5. Obscuration Calculation by Graphical Method

Numeric values derived from the graph of Figure 5:

Galactic Level	10.65 units
Sun April 7 max	27.2 units
Sun April 8 eclipse max	13.7 units

$\frac{13.7-10.65}{27.2-10.65}\,100 = 18.4\%$ of full sun level at maximum eclipse.

Figure 4 shows a very rough 7% or so increase in solar diameter at 408 MHz.

These estimates are reasonable considering the effects of reflections, base line drift, and a crude estimate of galactic background on the results. Much better results would be available from a narrower beamwidth antenna and a tracking system to accurately follow the sun. There will be no more eclipses to measure for a while in North America.

References:

[1] https://eclipse.aas.org/eclipse-america/eclipse-glossary

[2] Bruce Randall, "August 2017 Eclipse Observations at 408MHz", *Radio Astronomy*, October 2017, PP 19-24.

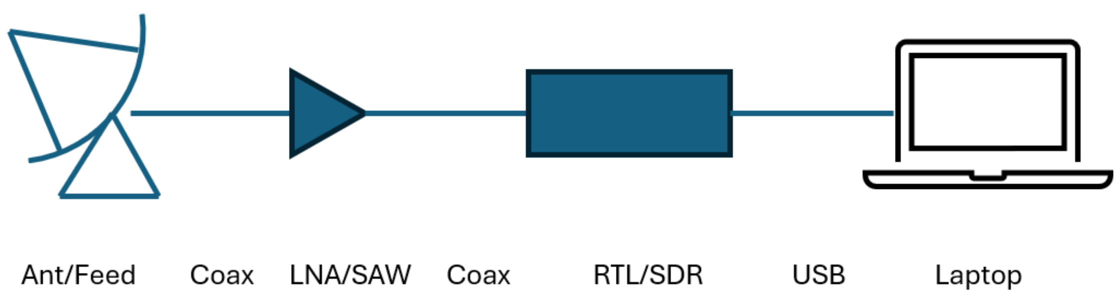
[3] John D. Kraus, *Radio Astronomy, Second Edition*, Powell, Ohio, Cygnus-Quasar Books, 1986.

First light – Hydrogen spin-flip emission observation with 1 meter dish
David Adams – 03 Jun 24

Components:

- Nooelec Mesh Antenna for Inmarsat, Iridium and Hydrogen Line
- Nooelec SAWbird+ H1 Saw filter and LNA
- RTL-SDR Blog V3
- Stellarium (s/w)
- SDR# and IF Average plugin (s/w)
- Chronolapse (s/w)

Block diagram:



Results:
Today, an amazing amount of science can be done on a very small budget. The cost of the hardware components to build this system was in the neighborhood of $300 (excluding laptop). The software was free.

Hydrogen is the most abundant element in the universe. Neutral hydrogen atoms emit energy at 1420.405751768 MHz when the electron's spin changes direction. This happens about once every 8 million or so years for each atom – but there are a lot of hydrogen atoms!

Once the system was assembled, I pointed the dish at the ground and captured a background sample with the IF Average plugin to SDR#. I then mounted the antenna and pointed it at 180 degrees azimuth and 20 degrees elevation. A capture was made for 24 hours, letting the earth turn and rotate my antenna through space. Figure 1 is my first view of the hydrogen emissions in one spiral arm of the Milky Way galaxy (noted by red circle).

The energy shown in figure 1 is centered slightly off-frequency. This is due to the doppler shift caused by the arm moving in a direction away from the earth. I have calculated the velocity of the arm relative to my location on earth to be roughly 31 km/sec.

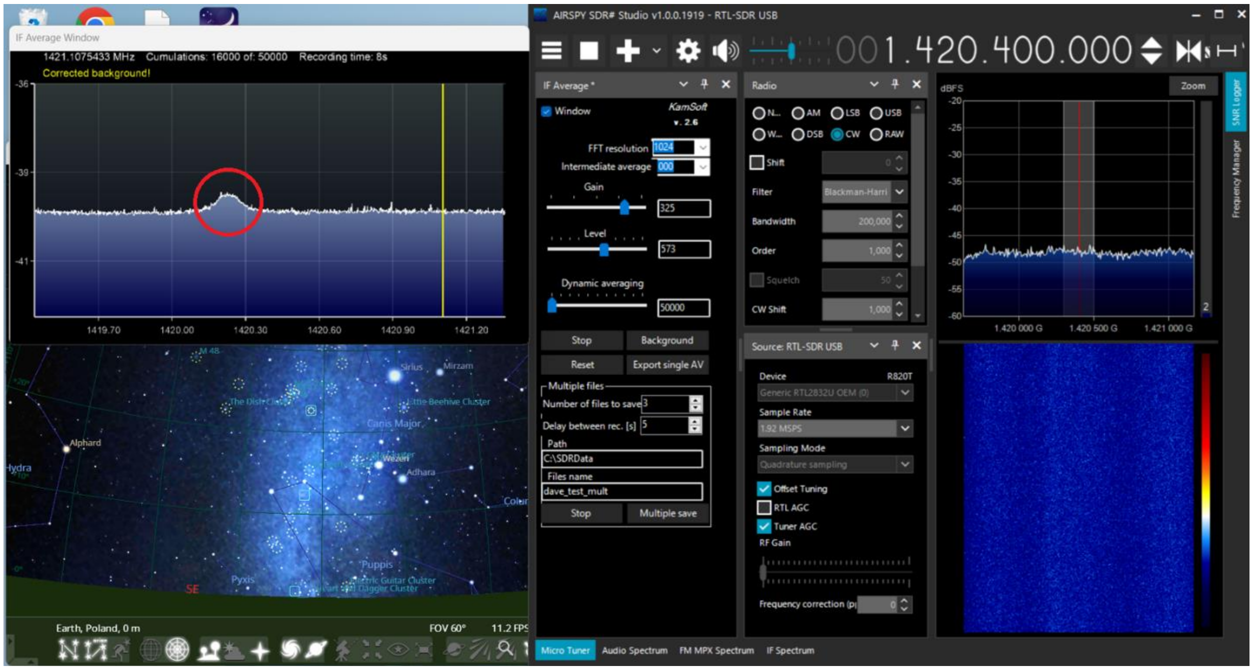


Figure 15

Another screen shot from my 24-hour capture shows a different spiral arm of the Milky Way galaxy. This energy (noted by red circle) is blue-shifted – meaning the spiral arm is moving towards my location on the earth.

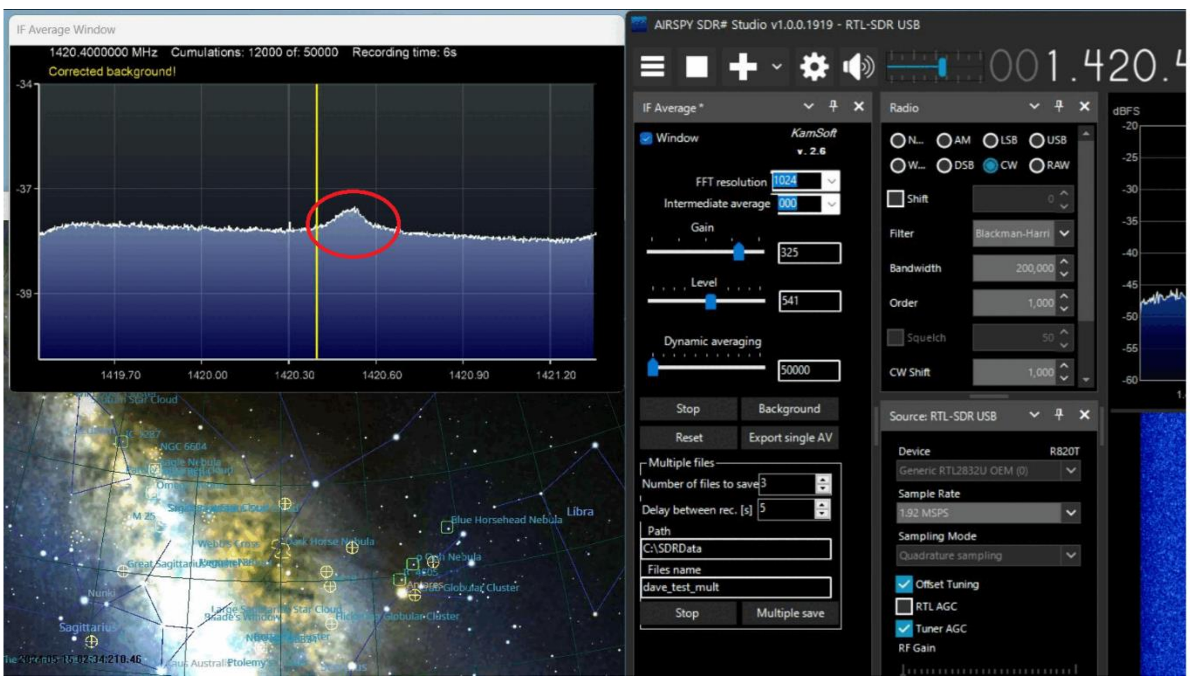


Figure 16

Thanks to all the members of SARA (Society of Amateur Radio Astronomers) for their resources, knowledge and encouragement. https://www.radio-astronomy.org/

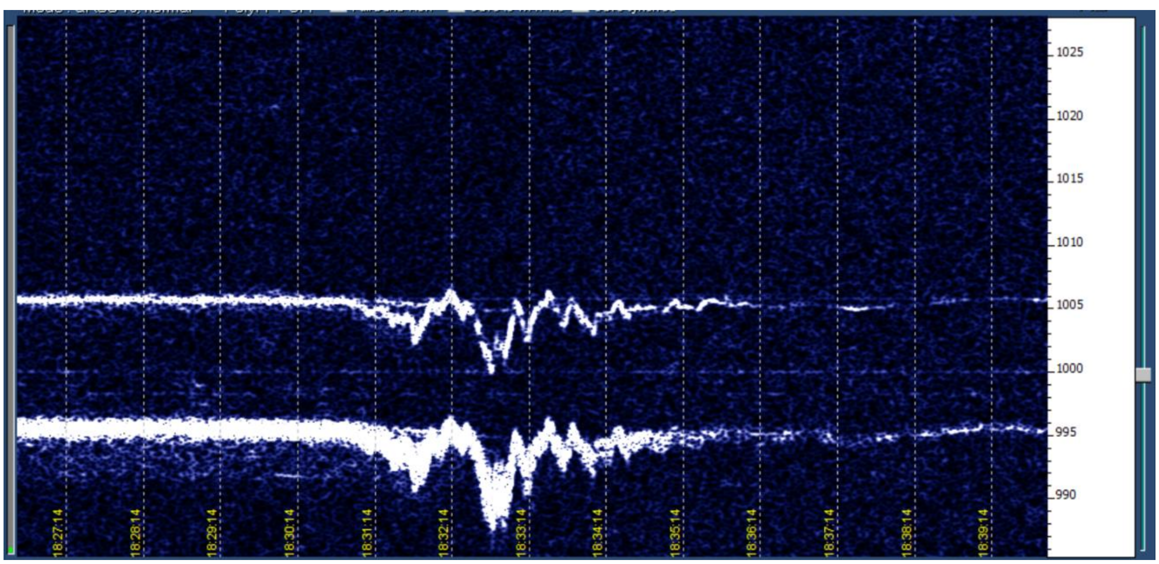
Sudden Frequency Deviations and Radio Blackout Observed at Anchorage, Alaska

Whitham D. Reeve

An X1.0 x-ray flare on 1 June 2024 produced interesting sudden frequency deviations (SFD), shown below, at 15 and 20 MHz as well as a broad radio blackout observed from 10 to 23 MHz, shown following. The flare began at 1824, peaked at 1836 and ended at 1849 UTC and was produced by active region 3697 on the southeastern quadrant of the Sun facing Earth. The flare also produced continuum radio emissions and radio bursts over a wide frequency range.

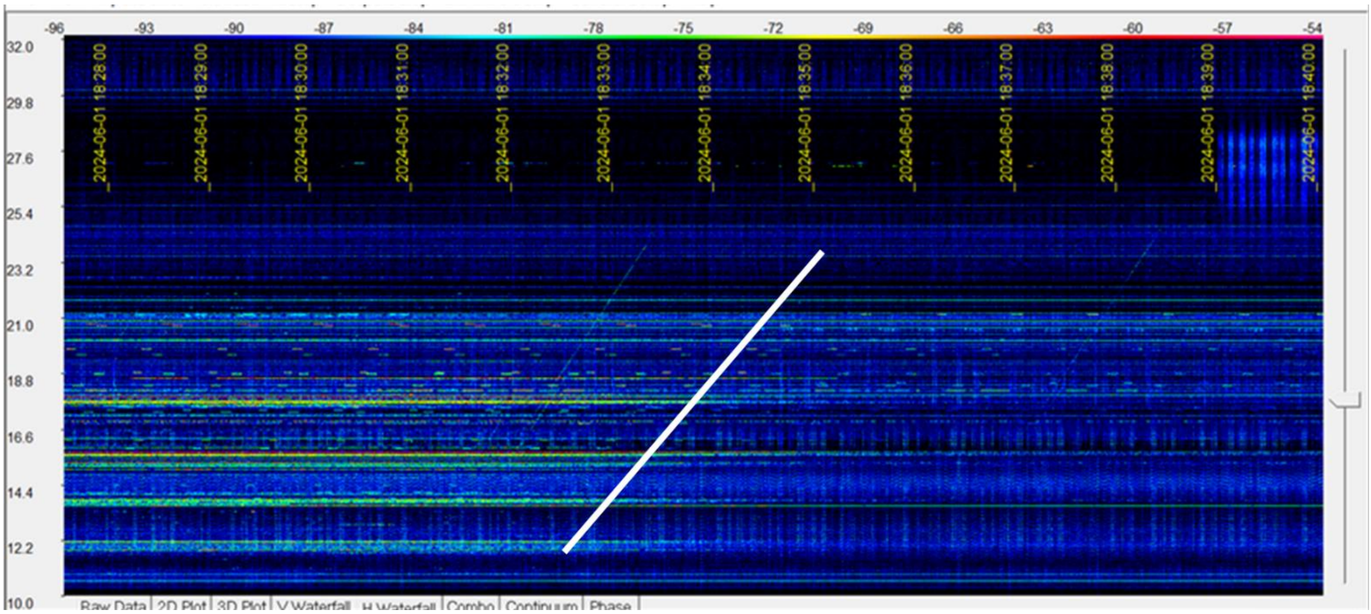
SFDs result from the reaction of the ionosphere and skywave radio propagation to flare radiation: {https://reeve.com/Documents/Articles%20Papers/Propagation%20Anomalies/Reeve_SuddenFreqDevConcepts_P1.pdf}. From that paper in italics:

> *Two ionospheric conditions are attributed to sudden frequency deviations, both caused by the x-ray, extreme ultraviolet and ultraviolet energy released by a solar flare. First, a slab of ionosphere below the reflection region along the radio path undergoes a rapid change in refraction index and, second, the ionosphere's reflection region undergoes a rapid vertical movement. Both conditions introduce a Doppler shift in the radio wave by changing the effective path length and, thus, the wave number. Either one or both together can cause a sudden frequency deviation.*



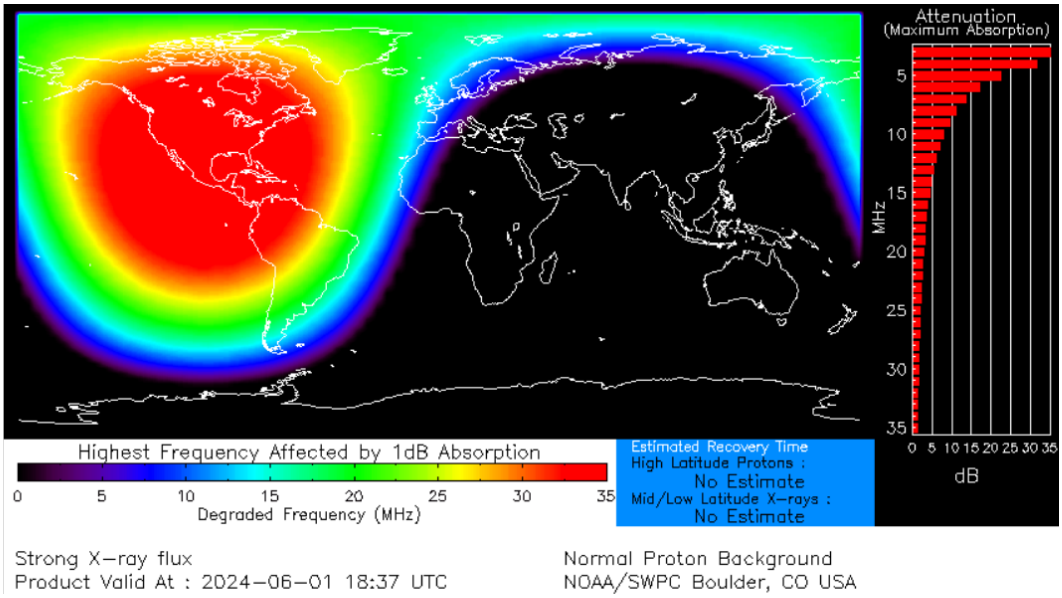
Narrowband spectra from 1827 to 1840 observed at Anchorage, Alaska. Time is measured left-to-right with 1 minute tick-marks (dotted vertical yellow lines). The frequency of the demodulated carrier is shown on the right vertical scale from 985 to 1030 Hz. The lower trace at 995 Hz corresponds to a 15 MHz carrier frequency (WWV or WWVH), and the trace at 1005 Hz near the middle of the frequency scale corresponds to a 20 MHz carrier frequency (WWV). The SFD starts at 1831 at both frequencies with maximum peak-to-peak deviation of approximately 9 Hz at 15 MHz and 5 Hz at 20 MHz. The SFDs show interesting time-correlated periodic structures lasting about 4 minutes. The fainter traces following the SFDs indicate the onset of the radio blackout and reduced received signal levels. The receivers were Icom R-8600 *Communications Receivers,* and the antenna was a KMA-1832 log periodic dipole array. The narrowband horizontal waterfall plot was produced by Argo software.

In addition to the sudden frequency deviations, a radio blackout was recorded from 10 to 23 MHz and is shown in the broadband horizontal waterfall spectra below.



Broadband horizontal waterfall spectra from 10 to 32 MHz (left vertical scale) covering the time period 1828 to 1842. The slanted white line, starting at about 1833 and 11 MHz, shows the approximate demarcation between preflare and postflare spectra with the reduction in received signals seen to the right of the line. Heavy local radio frequency interference is obvious in the spectra and is unaffected by the radio blackout. The timestamps along the top of the plot are at 1 minute intervals. Received signal power is indicated by the color palette above the timestamps. The receiver is an RFSpace CloudSDR *software defined radio receiver* connected to a KMA-1832 log periodic dipole array. The software is SpectraVue.

To complement the actual blackout recording above, the estimated radio frequency absorption levels at the time of the radio blackout are seen in the D-Region Absorption Prediction (D-RAP) plot below.



The D-RAP plot at 1837 UTC shows absorption at frequencies as high as 35 MHz over a wide range of latitudes on the sunlit side of Earth. The maximum absorption exceeded 30 dB at 5 MHz (right-hand scale) from the flare radiation. Image source: https://www.swpc.noaa.gov/products/d-region-absorption-predictions-d-rap

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: Jay Wilson, https://www.radio-astronomy.org/contact/Vicepresident
Secretary: Bruce Randall, NT4RT, https://www.radio-astronomy.org/contact/Secretary
Treasurer: Tom Jacobs, https://www.radio-astronomy.org/contact/Treasurer
Asst. Treasurer: Donna Hallin, 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

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Dr. Wolfgang Herrmann	2025	messbetrieb@astropeiler.de
Paul Butler	2025	paul.butler.melbourne@gmail.com
Charles Osborne	2025	k4cso@twc.com
Bob Stricklin	2024	bstrick@n5brg.com
Steve Tzikas	2024	Tzikas@alum.rpi.edu
Ted Cline	2025	TedClineGit@gmail.com
David Westman	2024	david.westman@engineeringretirees.org

Other SARA Contacts

All Officers	http://www.radio-astronomy.org/contact-sara	
All Directors and Officers	http://www.radio-astronomy.org/contact/All-Directors-and-Officers	
Eastern Conference Coordinator	http://www.radio-astronomy.org/contact/Annual-Meeting	
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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_Rs17KIyQ	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=rBZIPOLNX9E
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/
National Radio Astronomy Observatory http://www.nrao.edu	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

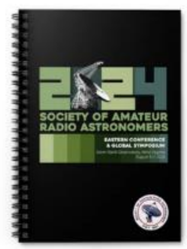
radio-astronomy.org/store.

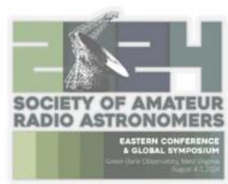
The Journal archive covers the society journal "Radio Astronomy" from the founding of the organization in 1981 through the present. Articles cover a wide range of topics including cosmic radiation, pulsars, quasars, meteor detection, solar observing, Jupiter, Radio Jove, gamma ray bursts, the Itty Bitty 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

SARA Brochure

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

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: ____________________

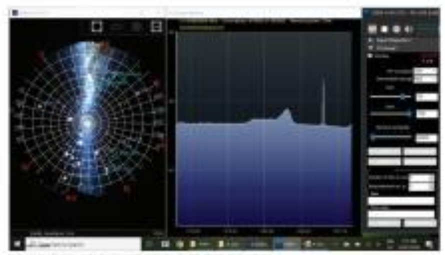
Please include a note of your interests. Send your application for membership, along with your remittance, to our Treasurer.

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.



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.

http://radio-astronomy.org

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.

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)