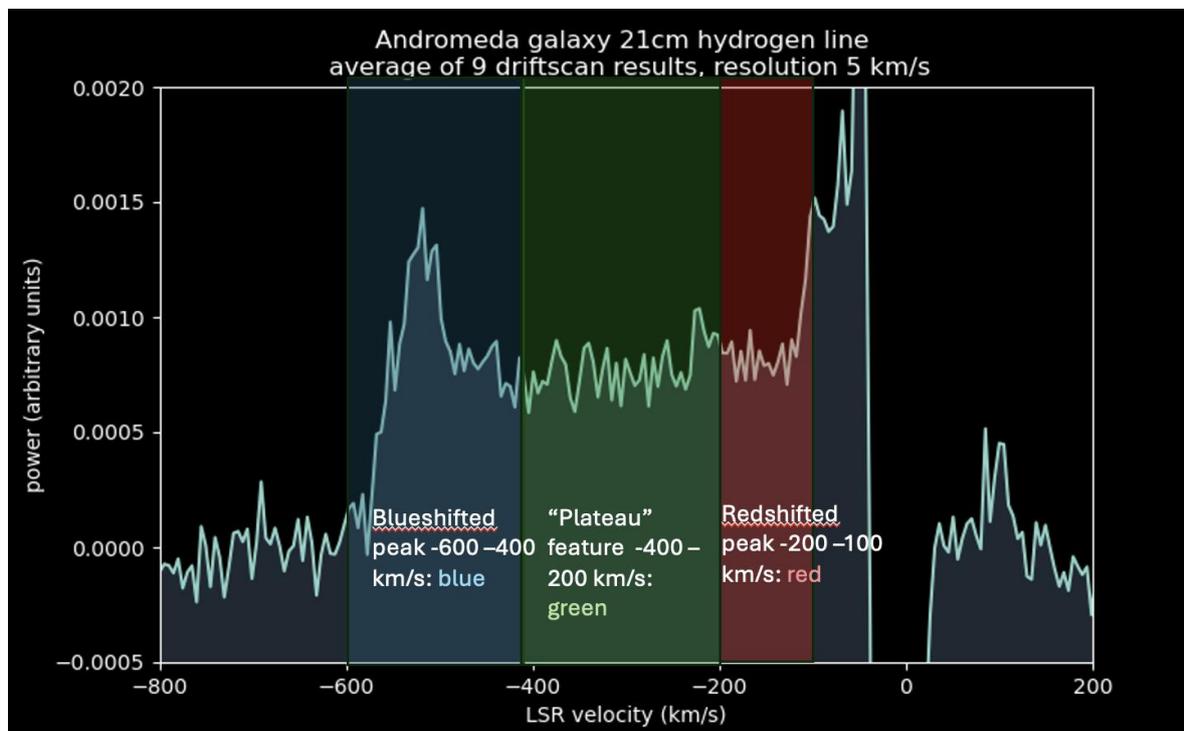


RADIO ASTRONOMY

Journal of the Society of Amateur Radio
Astronomers

January – February 2026





Dr. Richard A. Russel

SARA President and Editor

Bogdan Vacaliuc

Contributing Editor

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

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Cover Photo:

Eduard Mol

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President's Page

Can you believe how far our SARA Members have advanced Amateur Radio Astronomy?



When I started, my goal was to get the Radio Astronomy Gold Award from the Astronomical Association. This only called for SuperSIDS, meteors, Radio JOVE, and if you were really advanced, HI detection.

Today, any one of our members can not only do all of these, but can detect muons, masers, pulsars, Milky Way spiral arms, and external galaxies!

Every SARA member can quickly learn how to build HI radio telescopes and learns how to conduct drift scans. Using software, such as EZRA, the novice can map the Milky Way galaxy!

SARA has come a long way to advance Radio Astronomy for the hobbyist, and has enabled the learning of true scientific and engineering knowledge in the field.

On a Business Note:

- March 21 is the ZOOM Western Conference – the ZOOM link will be sent to everyone. No preregistration required. The conference is FREE.
- Nominations for the 2026 elections – need President, VP, and Treasurer as well as 4 board of directors. These are 2 year positions. This looks great on your resume since we are an international 501(3C) organization.
- Volunteer positions needed – we are in need of help with the following committees:
 - o Membership
 - o Treasurer Assistant
 - o Journal
 - o Store
 - o Grant

Contact me if you are interested!

Thanks!

Rich

Dr. Richard Russel

SARA President

Editor's Notes

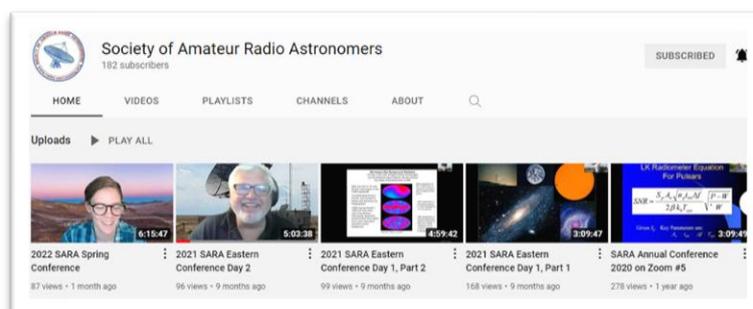
We are always looking for basic radio astronomy articles, radio astronomy tutorials, theoretical articles, application and construction articles, news pertinent to radio astronomy, profiles and interviews with amateur and professional radio astronomers, book reviews, puzzles (including word challenges,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

Subscribe to the SARA YouTube Channel

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

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

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



Observation Reports

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

If you would like to write an article for Radio Astronomy, please follow **the newly updated Author's Guide** on the SARA web site:

http://www.radio-astronomy.org/publicat/RA-JSARA_Author's_Guide.pdf.

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

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

Please consider submitting your radio astronomy observations for publication: any object, any wavelength. Strip charts, spectrograms, magnetograms, meteor scatter records, space radar records, photographs; examples of radio frequency interference (RFI) are also welcome.

Guidelines for submitting observations may be found here: <http://www.radio-astronomy.org/publicat/RA->

<p>2026 SARA Western Conference March 21, 2026 ZOOM Conference Only Send presentation abstracts to Ken Redcap i.c.o pres@radio-astronomy.org</p>	
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<p>Society of Amateur Radio Astronomers (SARA) 2026 SARA & Radio Jove Eastern Conference August 1 (Sat) – August 5 (Wed) 2026 Green Bank Observatory (GBO) West Virginia (WV)</p>	
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Abstracts are being requested up until the end of March 2026!!!

Submit an abstract to vicepresident@radio-astronomy.org to present at the Conference

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

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

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

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

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

SARA Student & Teacher Grant Program

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

- [1] SuperSID
- [2] Scope in a Box
- [3] Radio Jove kit
- [4] Inspire
- [5] Sky Scan

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

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

More information on the grant program can be found at the URL below.

[SARA Student and Teacher Project Grants | Society of Amateur Radio Astronomers \(radio-astronomy.org\)](https://www.radioastronomy.org/grants)

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

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

If you have a question, contact me at crowleyti@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.

New Members

January

Matt Borton

Tiago Baroni

Ted Parton

Adam Lewallen

Brandon West

Sumio Nakane

Nichole Nicholson

Alexander Price

Garrett Fitzsimmons

Andrew Parton

February

Jeremy Thorley

Kyle Mills

Robert Bishop

Frank Lukey

Ian Macdonald



British Astronomical Association
Supporting amateur astronomers since 1890
Radio Astronomy Section



Director: Paul Hearn

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

BAA Radio Astronomy Section Seminar programme.

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

Friday 27th February 19:30 GMT (19:30 UTC)

LOFAR and exoplanet environments

Dr Joseph R. Callingham

Associate Professor, Anton Pannekoek Institute for Astronomy, University of Amsterdam

Friday 6th March 19:30 GMT (19:30 UTC)

Matej Marković and Marko Radolović Solar Radio Emissions

Natural Solar Radio emissions and endeavours with Pulsar hunting.

Matej Markovic undergraduate Technical University of Munich, Department of Aerospace and Geodesy Marko Radolovic graduate student - University of Zagreb, Department of Electronic Systems and Information Processing.

These projects are supported by the Astronomical Society Visnjan Croatia.

Paul Hearn

BAA Radio Astronomy Section Director

UKRAA Trustee

https://britastro.org/section_front/24

AMERICAN GEOPHYSICAL UNION

SPA SECTION NEWSLETTER

Volume XXXIII, Issue 3

Jan.05,2026

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1. In Memorium: Leif Svalgaard

Announcement Submission Website: https://docs.google.com/forms/d/e/1FAIpQLSec-ZmA27Me1_mQOOO60IK3YxHhwz3oZB9014InnMppdTW15w/viewform?c=0&w=1

In Memorium: Leif Svalgaard

From: Todd Hoeksema, Ed Cliver, Frederic Clette, Hugh Hudson, Ken Schatten, Phil Scherrer (todd at sun.stanford.edu)

The SPA community lost one of its more innovative scientists when Leif Svalgaard passed away on 11 Oct 2025. Born 12 May 1942 in Copenhagen, Leif received a B.S. in Physics from the U. of Copenhagen in 1965 and an M.S. in Geophysics in 1969. He began work at the Danish Meteorological Institute (DMI) in 1966, applying scientific programming related to terrestrial weather mapping and forecasting. While stationed at DMI’s magnetometer station in Godhavn, Greenland in 1967, he discovered that the magnetic polarity of the solar wind could be inferred from ground-based magnetometers, enabling determination of the sector structure of the interplanetary magnetic field (IMF) at 1 AU for many decades prior to the space age. This result, discovered independently by S.M. Mansurov at about the same time, is now known as the Svalgaard-Mansurov effect.

Leif joined the John Wilcox’s solar group at Stanford in 1972. Working with the (now) Wilcox Solar Observatory team, Leif made notable contributions to the understanding of the solar sources of large-scale IMF and of geomagnetic activity, and he created a valuable catalog of IMF sector boundaries back to 1926. His investigation of the Sun’s polar fields led to recognition of the “precursor” relationship between polar field strength at solar minimum and the peak sunspot number of the following maximum.

From 1980 to 2000 Leif worked in private industry as a software developer. From 2001-2010 he developed two new indices based on hourly intensity values of early terrestrial magnetometers. The InterDiurnal Variability (IDV) index is highly correlated with solar wind field strength (B) and the InterHourly Variability (IHV) index is dependent on B and Velocity. Together they enable estimates of

both B and V back to ~1850. He was a visiting professor at Nagoya U in 2004 and his primary affiliation after 2009 was the Hansen Experimental Physics Laboratory at Stanford.

Leif's latest work involved recalibration of the sunspot number (SN): both Wolf's original time series and the more recent Group SN of Hoyt and Schatten. Leif's mantra, "Know thy data," led to his finding that the bulk of Wolf's observations underpinning the original SN series were made with small auxiliary telescopes rather than the larger Fraunhofer refractor in Zurich. Reanalyzing original records enabled him to identify idiosyncrasies of individual sunspot observers, the most important of which were Waldmeier's weighting of SN counts by individual spot areas and the fundamentally different ways that Wolf and his successor Wolfer counted spots. Leif had a keen eye for patterns and inconsistencies, and he was a forceful challenger of the status quo who forced reconsideration of preconceived assumptions. In large part because of Leif's probing of the sunspot-number time series, a community-wide effort to recalibrate the sunspot number(s) was initiated in 2013, a process that continues to this day.

***** SUBSCRIPTION AND ANNOUNCEMENT REQUESTS *****

The SPA Newsletter serves as a communication platform for the space physics and aeronomy community. Announcements published in the newsletter are provided by their respective authors and do not reflect the views of the newsletter.

The SPA Newsletter's operations are co-sponsored by the nonprofit Moon Economics Institute.

To request announcements for distribution by the newsletter, please use the online submission form at:

https://docs.google.com/forms/d/e/1FAIpQLSec-ZmA27Me1_mQOOO60IK3YxHhwz3oZB9014InnMppdT15w/viewform?c=0&w=1

To subscribe to the SPA Newsletter, please send an email to Peter Chi, the newsletter editor, at:

editor@igpp.ucla.edu

NOTE: Due to the large number of SPA-related sessions at major conferences, the SPA Newsletter can no longer accept announcement requests for individual sessions at AGU, AOGS, COSPAR, EGU, or IAGA Meetings. Titles and web links (if available) of these sessions will be distributed in a special issue of the Newsletter before the abstract deadline.

AGU SPA Web Site: <https://connect.agu.org/spa/home>

SPA Leadership Team E-mail: spa.leadership.team@gmail.com

***** END OF NEWSLETTER *****

Where Art and Science Meet

Eve and Schrödinger's Box

By Andrew Thornett

The Bard of Lichfield

Eve takes a deep breath, and says, "I'm lifting the lid just a crack..."

Inside the box:

A cat.

An apple.

Eve.

A serpent wearing safety goggles.

And a small handwritten note that says:

"Measurement constitutes consent."

The cat is both purring and plotting.

The apple is both bitten and whole.

Eve is both innocent and enlightened.

The serpent is applying for a research grant.

And the box itself?

It's labelled:

"Fragile: Contains Narrative."

But here's the twist — the moment you asked whether we open it, we already did.

The waveform trembled.

Possibilities narrowed.

Some universe, somewhere, just got pie.

So, tell me...

Are we observers?

Or are we the experiment? 🍎 📦 ✨

SuperSID

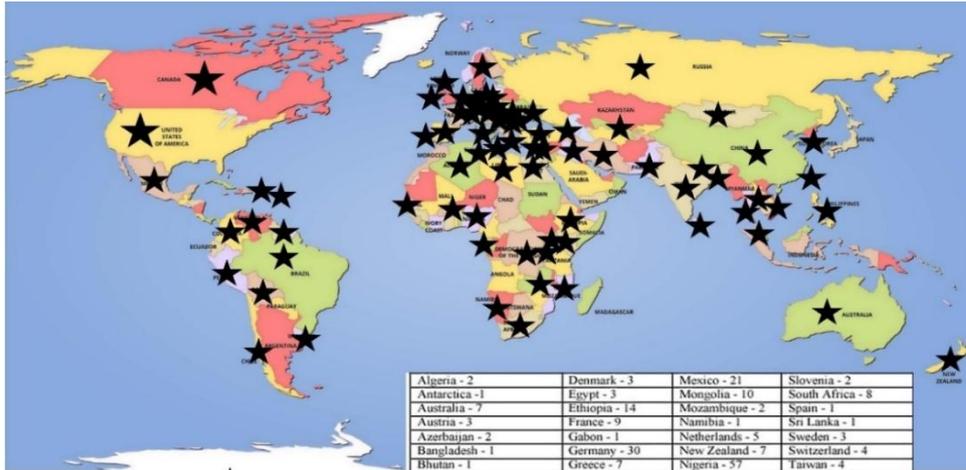


SuperSID

*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.



**SID Monitor
 Distribution**
 1078 instruments
 82 countries
 7 continents

Algeria - 2	Denmark - 3	Mexico - 21	Slovenia - 2
Antarctica - 1	Egypt - 3	Mongolia - 10	South Africa - 8
Australia - 7	Ethiopia - 14	Mozambique - 2	Spain - 1
Austria - 3	France - 9	Namibia - 1	Sri Lanka - 1
Azerbaijan - 2	Gabon - 1	Netherlands - 5	Sweden - 3
Bangladesh - 1	Germany - 30	New Zealand - 7	Switzerland - 4
Bhutan - 1	Greece - 7	Nigeria - 57	Taiwan - 4
Bolivia - 1	Guyana - 1	Pakistan - 4	Thailand - 5
Bosnia-Herzegovina - 2	Hungary - 1	Peru - 10	Tunisia - 9
Brazil - 11	India - 33	Philippines - 3	Turkey - 2
British Virgin Islands - 1	Indonesia - 2	Poland - 2	Uganda - 5
Bulgaria - 2	Iran - 4	Portugal - 3	UK - 32
Burkina 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
Cyprus - 1	Libya - 1	Serbia - 1	Zambia - 2
Czech Republic - 1	Malaysia - 19	Singapore - 3	
D Rep of Congo - 4	Malta - 1	Slovak Repub - 2	

For official use only

Monitor assigned: _____

Site name: _____

Country: _____

SuperSID Space Weather Monitor Request Form

	Your information here
Name of site/school (if an institution):	
Choose a site name: (3-6 characters) No Spaces	
Primary contact person:	
Email:	
Phone(s):	
Primary Address:	Name School or Business Street Street City State/Province Country Postal Code

Shipping address, if different:	Name		
	School or Business		
	Street		
	Street		
	City	State/Province	
	Country	Postal Code	
Shipping phone number:			
Latitude & longitude of site:	Latitude: _____ Longitude: _____ _____		

I understand that neither Stanford nor the Society of Amateur Radio Astronomers is responsible for accidents or injuries related to monitoring use. I will ensure that a surge protector and other lightning protection devices are installed if necessary.

Signature: _____ **Date:** _____

I will need:

<i>What</i>	<i>Cost</i>	<i>How many?</i>
SuperSID distribution USB Power (no options)	\$48 (assembled)	
USB Sound card 96 kHz sample rate <i>(or provide this yourself)</i>	\$40 <i>(optional)</i>	
Antenna wire (120 meters) <i>(or you can provide this yourself)</i>	\$23 <i>(optional) with connectors attached and tested</i>	
RG 58 Coax Cable (9 meters) <i>(or provide this yourself)</i>	\$14 <i>(optional) with connectors attached and tested</i>	
<i>Shipping</i>	US \$12 Canada & Mexico \$40 all other \$60	
	TOTAL	\$

_____ I have included a \$_____ check (payable to SARA)

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

or

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

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

To set up a SuperSID monitor you will need:

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

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

- a. A sound card that can record (sample) up to 96 kHz, or a USB port to connect such a sound card (for North and South America)
 - i. All other countries can use AC97 sound card with 48 kHz record (sample) rate. Most computers made after 1997 will have AC97.
- b. Windows 2000 or more recent operating system
- c. 1 GHz Processor 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

Announcing Radio JOVE 2.1

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 2.1, 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).

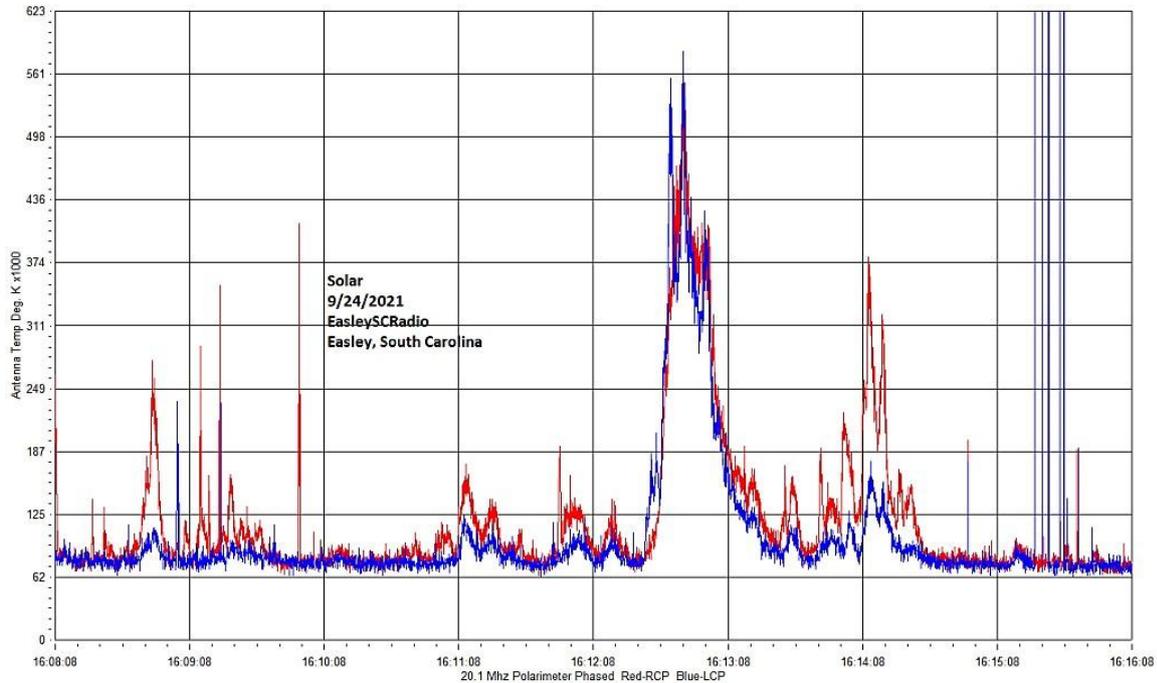


Figure 2. A SkyPipe strip chart showing multiple solar bursts using a JOVE receiver.
John Cox, SC.

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.

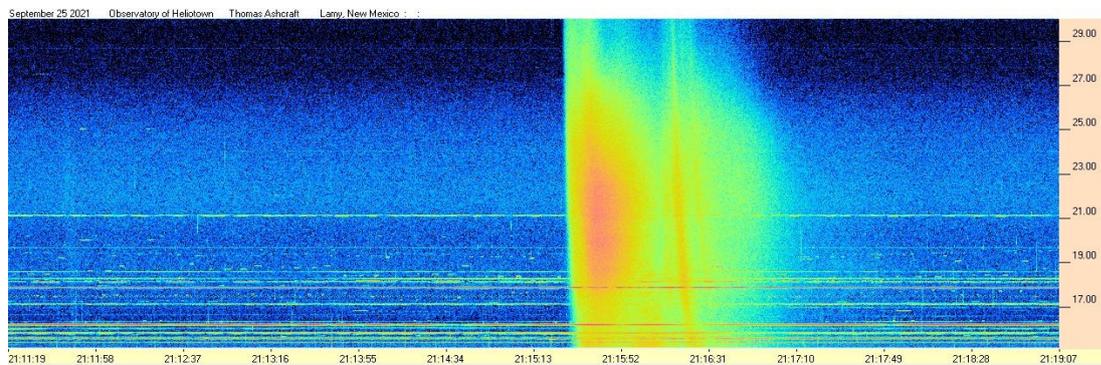


Figure 3. Radio spectrogram showing multiple solar bursts received by Tom Ashcraft in New Mexico. Horizontal scale is time and the vertical scale is frequency. Amplitude is displayed using different colors corresponding to the strength of signals.

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. As of 2025, Radio JOVE has moved from the SDRPlay RSP1A SDR to the RSP1B. The JOVE team will continue to provide support both instruments as used in 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 2.1 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 2.1 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.

<p>Item # RJK2u – Complete 2.1 Kit: Receiver + Unbuilt Antenna Kit + Software</p> <p>This kit includes an SDRplay RSP1B, USB Cable, SMA/F adapter cable, unbuilt Antenna Kit (RJA), printed assembly manuals, and Radio-Sky Spectrograph (RSS) software.</p> <p>Note: Kit does not include antenna support structure.</p> <p>Price: \$306 + Shipping (See below for shipping)</p>	<p>Item # RJK2p – Complete 2.1 Kit: Receiver + Professionally Built Antenna Kit + Software</p> <p>This kit includes an SDRplay RSP1A, USB Cable, SMA/F adapter cable, Professionally Built Antenna Kit (RJA2), printed assembly manuals, and RadioSky Spectrograph (RSS) software.</p> <p>Note: Kit does not include antenna support structure.</p> <p>Price: \$472 + Shipping (See below for shipping)</p>
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<p>Item # RJA – Unbuilt Antenna Kit</p> <p>The RJA Radio JOVE Antenna Kit includes a printed construction manual, stranded copper easy-to-solder antenna wire, ceramic insulators, RG-59 easy-to-solder coax cable, screw-on Fconnectors, and a power combiner.</p> <p>Note: Kit does not include antenna support structure. Assembly requires a soldering gun and other tools.</p> <p>Price: \$133 + Shipping (See reverse for shipping)</p>	<p>Item # RJA2 – Professionally Built Antenna Kit</p> <p>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.</p> <p>Note: Kit does not include antenna support structure.</p> <p>Price: \$299 + Shipping (See below for shipping)</p>
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Rev 10/25

Noise Figure Measurements of the Callisto

Whitham D. Reeve & Christian Monstein

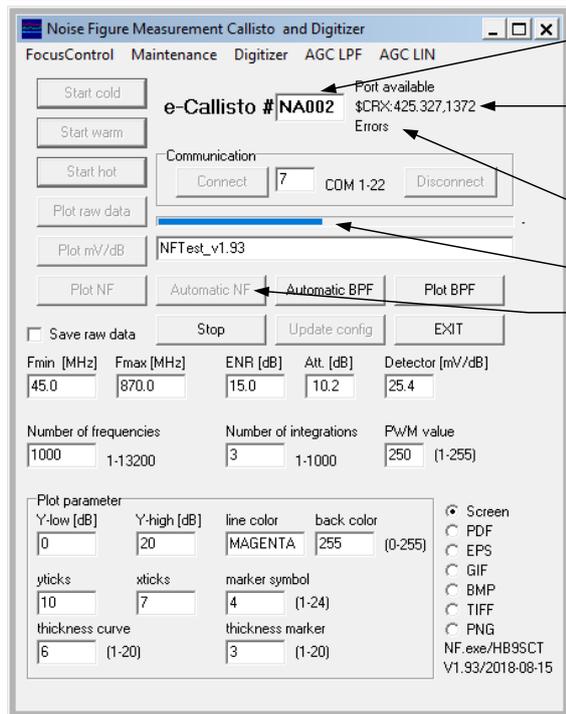
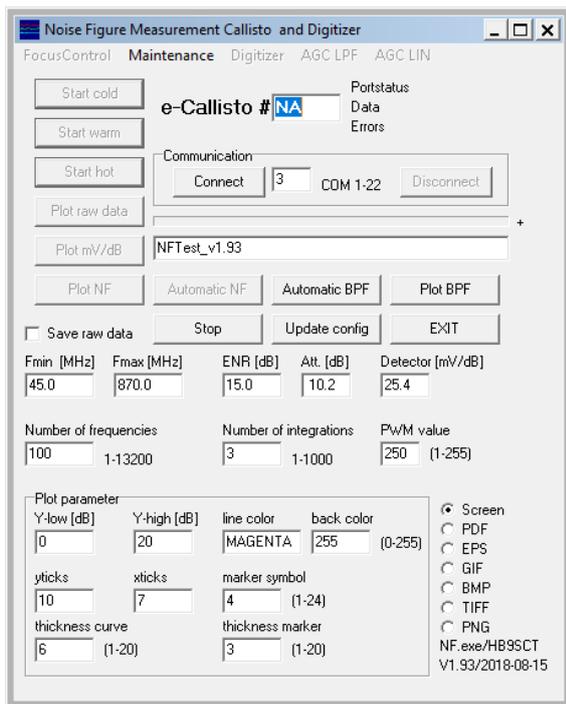
1. Introduction

Callisto is the instrument used in the e-CALLISTO solar radio spectrometer network. The noise figure in the Callisto's native frequency range (45 to 870 MHz) is typically between 7 and 8 dB with a maximum of 10 dB. The noise figure and system sensitivity can be improved by adding an external low noise preamplifier [{Preamp}](#). NF Test is a standalone software tool developed by co-author Monstein that can be used to measure the noise figure of the Callisto with or without a low noise preamplifier.

NF Test was originally developed as a Callisto production test tool with many features and capabilities, but this article focuses only on its noise figure measurements feature. NF Test uses the *Y-factor* method (for example, see [{R&S-YFactor}](#)). A future article will discuss the other features.

2. NF Test Executable

The NF Test tool is in a Zip file under the Software tab at [{e-CALLISTO}](#) or it may be downloaded directly at [{NFTest}](#). After the files have been extracted to a convenient folder, for example, c:\Callisto\Tools\NF Test, the executable file, NF.exe, may be opened. When the files are extracted, many header files and other files used to compile NF Test are placed in the same folder. Most files are not needed for NF Test operation and may be deleted; however, the following files must be retained: disbcc.lib, nf.cfg, NF.exe, Symbol1.ico, wsc.dll, and wsc32bcb.lib. The installation does not change the Windows registry, and the tool may be uninstalled simply by deleting it. Generally, a shortcut to the file is placed on the Desktop. When NF Test is run, a main window opens (figure 1).



Callisto serial number is entered here for reference

Frequency and measured amplitude are displayed as the frequencies are stepped through.

Counts number of errors encountered during measurement. Any values here generally indicate a serial communications problem.

Progress Bar

Automatic NF has been pressed and measurements are underway.

Figure 1 ~ **Left:** The image shows the window when NF Test is first opened and not yet communicating with the instrument through the serial port. At this point, the Connect button may be pressed if the COM port is correct; otherwise, before pressing Connect, it is necessary to change the COM port to match the serial port to be used. **Right:** The image shows a successful connection to a Callisto on COM port 7, and the *Portstatus* label has changed to *Port available*. The *Data* label indicates the Callisto command, frequency and raw data as the Callisto is swept through the frequencies. The *Error* label indicates any communication errors on the serial port, which usually result from a bad cable or out-of-date driver on the PC serial port. Some of the parameters used in noise figure measurements are annotated.

3. NF Test Configuration

NF Test uses a configuration file *nf.cfg* that defines its default parameters. The configuration file is located in the same folder as the executable and is shown below. When first installed, *nf.cfg* is populated with a complete set of default values, which must be edited to comply with the user's specific setup. The configuration file may be accessed by navigating to the installation folder or by clicking on the Maintenance menu of the NF Test window. If changes are made to *nf.cfg* after NF Test is opened, the Update Config button must be pressed before any measurement.

Most configuration file parameter names are identical to the field labels in the NF Test window. The configuration file includes comments denoted by // characters. The comments define the range of variables that may be used and, in many cases, a suggested default or nominal value. The comments may be edited in any ASCII text editor, but their length must be no more than 120 characters.

```
// Measurement Parameter
[rxcomport]=3           // 1 .... ?? RS-232

[maintitle]=NA         // any text without space, use underscore or -
instead, like 00...99

[sstitle]=NFTest_v1.93 // any text without space, use underscore or -
instead

[fmin]=45.0           // lowest frequency (45.0....870.0), nominal
45.0

[fnom]=408.0          // nominal frequency (45.0....870.0) for
digitizer/scope

[fmax]=870.0          // highest frequency (45.0....870.0), nominal
870.0

[enr]=15.0            // ENR nominal 15.0 dB .... 35 dB, 5.0 dB with
an LNA

[detector]=25.4       // conversion AD8307 nominal 25.4mV/dB

[channels]=200         // number of channels to measure (1...13200),
nominal 200

[integrations]=3       // the more the better the resolution,
(1...10'000), nominal 16
```

```

[pwm]=250 // receiver gain control (1...255), nominal
100...250

// Plott Parameter

[xleft]=600 // position left corner of window, default 300
[ytop]=100 // position top edge of window, default 100
[xsize]=424 // width of the window, default 848
[ysize]=300 // height of the window, default 600 (golden
cut)

[ylow]=0 // yrange -100...100, nominal 0
[yhigh]=20 // yrange -100...100, nominal 20

[yticks]=10 // number of ticks in y-axis, nominal 10
[xticks]=7 // number of ticks in x-axis, nominal 7 or 8

[linecolor]=MAGENTA // BLACK, RED, GREEN, BLUE, CYAN, YELLOW,
ORANGE, MAGENTA, WHITE
[backcolor]=255 // 0=black, 255=white background, inbetween some
colors, I like 230

[marker]=4 // marker symbol (1..24), nominal 4

[thickcurve]=6 // tickness of plot (1..20), nominal 8
[thickmarker]=3 // thicknes of marker (1..20), nominal 6
// Switching parameter for static relays in test fixture with focus code
control
[cold]=00,S // cold noise source focus code
[warm]=03,S // focus code later used for determining
detector coefficient
[hot]=01,S // hot noise source focus code to determine
noise figure

[att]=10.2 // attenuator value to produce 'warm' out of hot

```

```
// digitizer/scope parameter
[focus]=00 // focuscode for digitizer/scope
[sampling]=200 // digitizer/scope sampling time [ms] 50...
[logpath]=C:\Temp\ // data path for light curve file
[ending]=csv // data file ending (txt, prn, dat, lst, csv)
[delimiter]=; // column-delimiter = TAB or , or ;
```

Below is additional information concerning some of the parameters in nf.cfg that apply to noise figure measurements:

COM port [rxcomport] parameter: The example above shows port 3 but it may be changed to any appropriate value to match the PC serial port or USB-Serial Converter.

[Fmin] and [Fmax] frequency parameters: The maximum resolution of the Calisto tuner is 62.5 kHz. When measurements are underway, the frequency steps are rounded to the nearest multiple of 62.5 kHz. There are 13 200 possible frequencies (or [Channels]) in the Callisto's native frequency range of 45 to 870 MHz. The [Fmin] and [Fmax] frequencies can be set to any practical value in that range and divided into any practical number of [Channels], but the frequency resolution is limited to 62.5 kHz and the maximum number of [Channels] is limited to 13 200. For reference, noise figure measurements that use the full range of 13 200 [Channels] and 3 integrations require about 45 minutes. If the [Channels] parameter is set to 100 with 3 integrations, the time to complete a noise figure measurement is about 37 seconds and for 1000 with 3 integrations is about 5 minutes 20 seconds. Spurious signals will sometimes be observed in high-resolution measurements.

Noise Source [ENR] parameter: The ENR of most noise sources varies a small amount with frequency, but the configuration file parameter allows only one value. The value typically is an average over the measurement frequency range, or it may be the value for a specific frequency. The ENR value entered here should take into account any coaxial cable loss between the noise source and Callisto RF Input. Since cable losses vary with frequency, a single mid-range value normally is used in the correction. Most often, the noise source is connected directly to the RF Input and no cable is used. The ENR value generally will be lower for measurements with a low noise amplifier because a higher value may drive the LNA out of its linear operating region. The following guidelines may be used to choose the noise source ENR:

1. Callisto only:

$$ENR_{dB} > NF_{dB}^{Callisto} + 5 \text{ dB}$$

2. Callisto with low noise amplifier: If $NF_{dB}^{LNA} + Gain_{dB}^{LNA} > NF_{dB}^{Callisto} + 1 \text{ dB}$, then

$$ENR_{dB} > NF_{dB}^{LNA} + 5 \text{ dB}$$

Guideline 1 results in an ENR of 15 dB, and, in most cases, Guideline 2 results in an ENR of 5 to 7 dB. For both situations, the [ENR] parameter setting must be corrected (reduced) for cable losses and attenuator, if used.

AD8307 log [Detector] slope parameter: The default value of 25.4 mV/dB is based on many measurements and should not be changed without justification.

[PWM] gain parameter: The gain parameter normally is set to a high value (for example, 250) for noise figure measurements of a standalone Callisto because its measured noise figure worsens at lower gain settings. However, when a low noise preamplifier is to be used, the [PWM] setting must be reduced to prevent overload (saturation) of the Callisto during measurements and operation. Generally, the [PWM] setting must be determined experimentally by repeatedly measuring the noise figure with different settings until a setting is found that provides the best noise figure. This setting would then be used when the Callisto/LNA combination is placed into service. A *getting started* estimate is to use a [PWM] setting of about 130 when the external LNA has a gain of 20 dB.

[Cold] and [Hot] relay control parameters: The default focus codes 00 and 01 correspond to the bits (or pins) set on the Callisto FPU connector and used by the Callisto Test Fixture designed by co-author Reeve. These values may be changed to suit user requirements but are needed only when NF Test is used in the automatic mode with a Callisto Test Fixture. These values are ignored in manual mode measurements. Note: The Callisto Test Fixture takes advantage of all NF Test capabilities and is designed to be used with 28 Vdc noise sources.

4. NF Test Modes

NF Test may be used in an automatic or manual mode. In the automatic mode, the Automatic NF button on the NF Test window sends specific focus codes over the serial port to the Callisto instrument, which then sets the associated pins on its Focal Plane Unit (FPU) connector. The Callisto FPU connector in-turn controls a relay in the Callisto Test Fixture that removes Noise Source power for Cold measurements and applies it for Hot measurements. In the manual mode, two buttons, Start Cold and Start Hot, on NF Test control the Callisto frequency sweep while the user manually controls the (Cold) or (Hot) power to the noise source through a switch. The next section provides basic measurement procedures.

5. Measurements

The following are required:

- 1) Callisto
- 2) EIA/RS-232 serial cable with DB-9M to DB-9F connectors (straight-thru wiring)
- 3) 12 Vdc, 300 mA power supply with 2.1 x 5.5 mm coaxial power plug for Callisto
- 4) Noise source with nominal 15 dB ENR (notes 1, 2)
- 5) Power supply to match noise source
- 6) Optional low noise preamplifier, nominal 15 to 20 dB gain
- 7) Power supply to match low noise amplifier
- 8) Optional 10 dB attenuator (note 2)
- 9) Windows PC (XP through 11) with a native serial port or USB port for instrument control
- 10) USB-Serial Converter if a USB port is to be used for instrument control (note 3)
- 11) Callisto Test Fixture (not required for manual noise figure measurements)

Notes:

1. A suitable low cost noise source is available at <https://e-callisto.org/Products/Products.html> (figure 2). This noise source requires a power supply rated 15 Vdc and at least 7 mA. The noise source should be connected to the power supply through an On/Off switch for operational convenience of setting its Cold and Hot states.
2. For noise figure measurements of the Callisto by itself, a 15 dB ENR noise source is recommended. For measurements of the Callisto with a low noise preamplifier, a 5 dB ENR noise source is recommended. A 15 dB ENR noise source may be used for the latter measurements by reducing its ENR with a 10 dB attenuator. The attenuator also improves the impedance matching and reduces the measurement uncertainty due to mismatch losses. See also Section 3.
3. The USB-Serial Converter and its drivers must be compatible with the Windows operating system to be used.

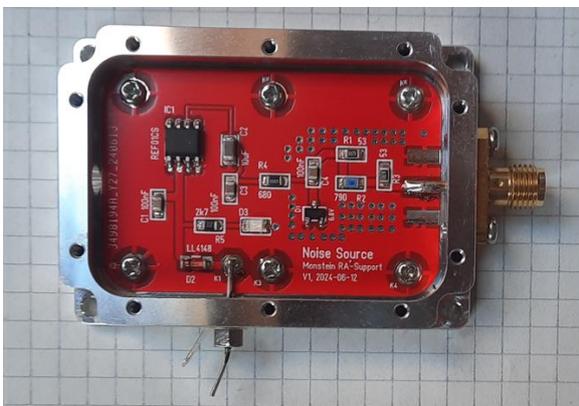


Figure 2 ~ Low cost Noise Source produced by Monstein Radio Astronomy Support with cover removed. The noise output connector is on the right and the power supply inlet feed-through capacitor is on the bottom left-of-center. Delivery is with aluminum cover. See {MRAS}

Frequency range: 10 MHz ... ~900 MHz

ENR: 14 ... 17 dB

Supply voltage: 15 Vdc at ~7 mA.

Enclosure size with SMA-connector and with feed-through capacitor: 65 x 50 x 12 mm

Net weight: 54 g

Typical setups are shown in figure 3.

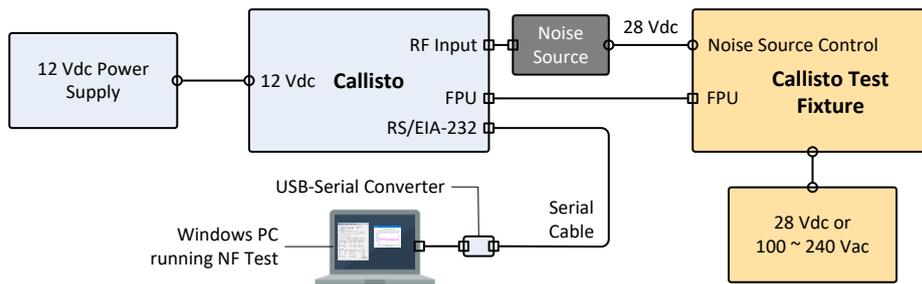


Figure 3.a ~ Callisto noise figure measurements with NF Test, automatically controlled Callisto Test Fixture and 28 Vdc Noise Source.

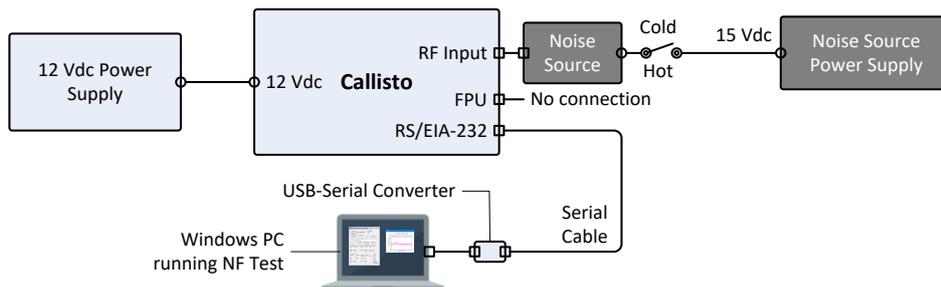


Figure 3.b ~ Callisto noise figure measurements with NF Test, manual controls, and 15 Vdc Noise Source.

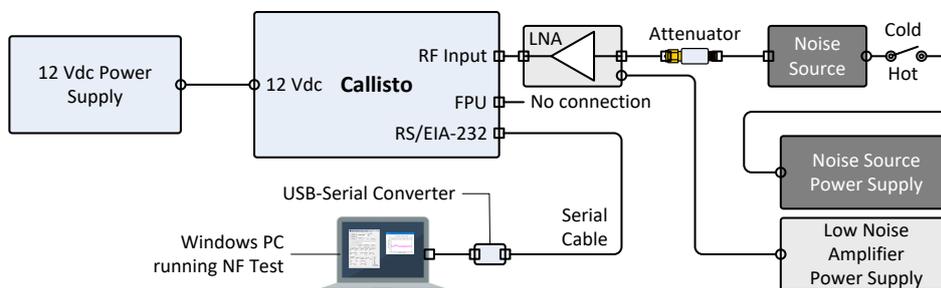


Figure 3.c ~ Combination of Callisto and low noise amplifier noise figure measurements with NF Test, and manual controls. The attenuator reduces the Noise Source ENR for use with the LNA. Another attenuator may be needed on the LNA output. See text.

After all connections are made and all parameters are set, a noise figure measurement may be started. When the Callisto Test Fixture is used under control of the Callisto focus codes, it is only necessary to press the Automatic NF button. NF Test commands the Test Fixture to place the Noise Source in the Cold state by turning Off its power. The Callisto is then commanded to step through the specified frequencies. When finished, a window pops up showing the Raw Data for the Cold state (figure 4.a). In a couple seconds, NF Test then commands the Test Fixture to place the Noise Source in the Hot state by turning On its power. The Callisto is again commanded by NF Test to step through the specified

frequencies. When finished, the pop-up window is replaced with the measured Noise Figure vs frequency (figure 4.b).

The plots will often show small steps near 175 and 450 MHz in the noise figure, which are normal and the result of band switching in the Callisto's internal tuner. In addition to the noise figure plot, the window shows reference information, the average noise figure across the entire frequency range and the standard deviation (sigma) of the noise figure measurements in that frequency range.

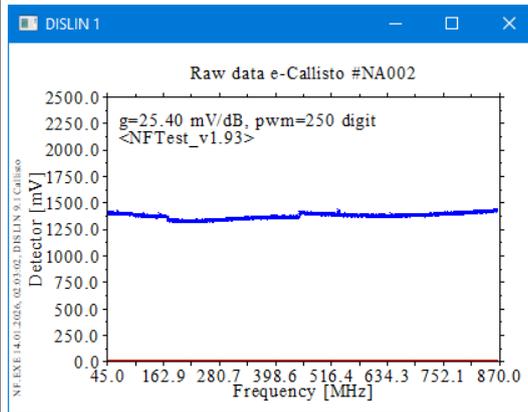
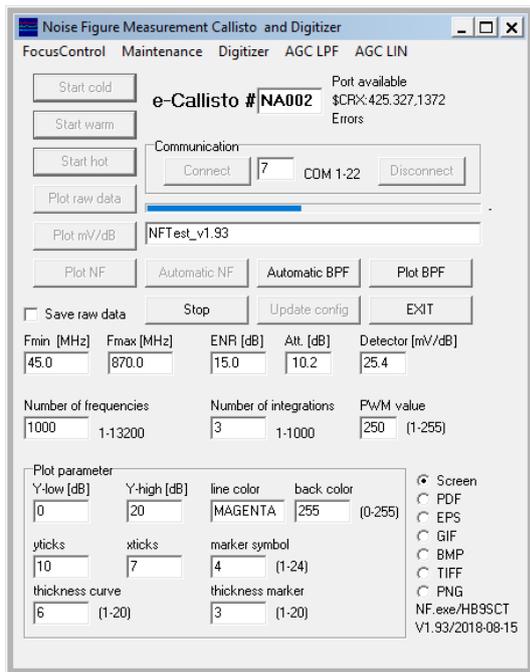


Figure 4.a ~ The Automatic NF button has been pressed. NF Test commands the Noise Source to the Cold state and then commands the Callisto to step through the frequencies. The window on the right shows the Raw Data for the Cold state. In this example, the Noise Source ENR is 15.0 dB and the frequency range is 45 to 870 MHz in 1000 steps.

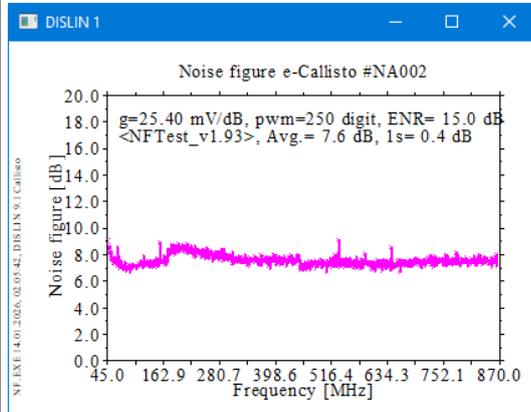
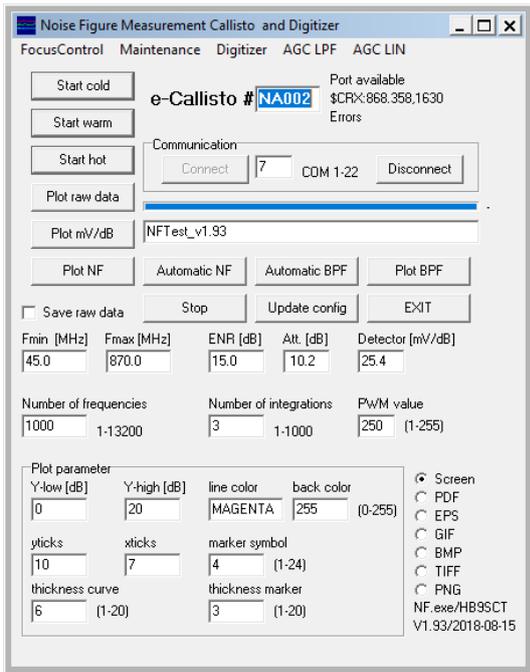


Figure 4.b ~ After the Cold measurements, NF Test commands the Noise Source to the Hot state and then commands the Callisto to step through the frequencies again. The window on the right shows the completed noise figure measurements.

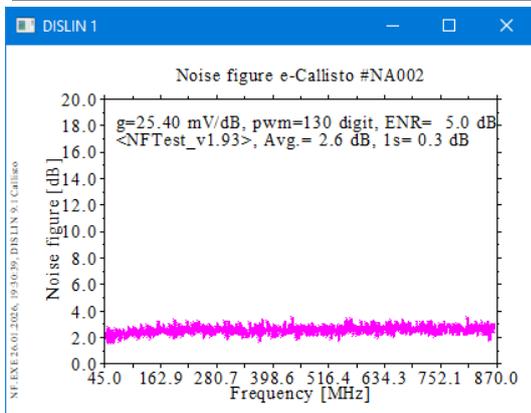
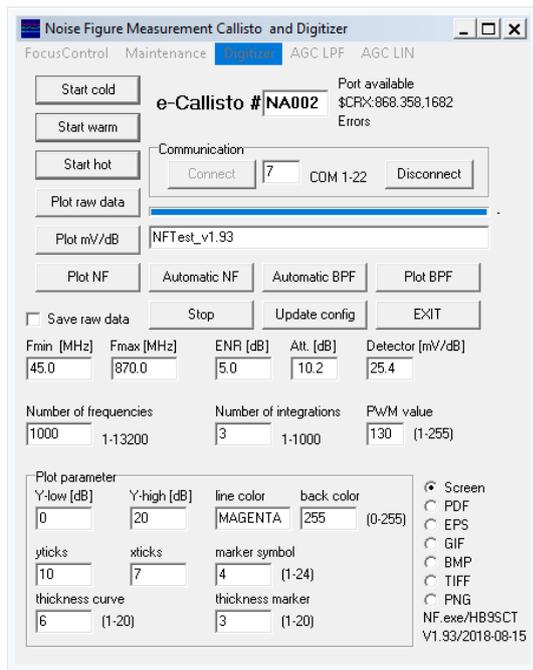


Figure 5 ~ Measurement of Callisto with 20dB gain LNA. All settings are the same as previous except for lower [ENR] and [PWM] settings. Note that the resulting noise figure is for the Callisto and LNA cascade and not the LNA by itself. The LNA in this example has a noise figure of 2.5 dB.

Manual measurements follow the same sequence as the automatic measurements described above except the Noise Source is manually turned Off and then On before the Callisto is stepped through its frequency list. First, the noise source power is turned OFF, then the Start Cold button is pressed. After the progress bar indicates a completed frequency sweep and the Raw Data window appears, the noise source power is manually turned ON followed by the Start Hot button. NF Test then commands the Callisto to step through the frequencies again. Upon completion, the Raw Data window changes to the Noise Figure window as described above.

The Automatic NF button also may be used for manual measurements. In this case, the Noise Source is manually placed in the Cold state and then the Automatic NF button is pressed. The progress bar shows the status of the measurements and the Raw Data window pops up when the Cold state measurements are completed. There is a 2 second delay between the end of Cold state measurements and the start of the Hot state measurements, and the Noise Source must be placed in the Hot state during this interval. When the Hot state measurements are completed, the pop-up window changes to the Noise Figure window as above.

An example measurement of a Callisto with LNA uses the same procedures and setup as above except that the [ENR] and [PWM] parameters are adjusted (figure 5). In this example, the LNA has a nominal gain of 30 dB and noise figure of 2.5 dB. A 10 dB attenuator was placed on the LNA output to reduce its gain to 20 dB. It was found experimentally that the lowest noise figure of the cascade occurred with the [PWM] setting in the range 125 to 130. In the example shown, the Y-high Plot parameter could have been set to 10 dB (or even 5 dB). The setting may be changed and then replotted by pressing the Plot NF button.

The raw noise figure measurement data can be saved as a text file by checking the box on the left side of the main window labeled *Save raw data*. The data files contain frequencies and digitizer values measured at the output of the log detector. The data are saved in the file location specified in the [logpath] parameter in nf.cfg (in the above example, C:\TEMP\) with the filename formats RAW_yyyymmdd_hhmmss_cold.txt and RAW_yyyymmdd_hhmmss_hot.txt.

6. References

- {[e-CALLISTO](https://e-callisto.org/index.html)} e-CALLISTO Solar Radio Astronomy Network: <https://e-callisto.org/index.html>
- {[MRAS](https://e-callisto.org/Products/Products.html)} Monstein Radio Astronomy Support, Products: <https://e-callisto.org/Products/Products.html>
- {[NFTest](https://e-callisto.org/Software/NoiseFigurePlotterV193.zip)} NF Test software tool, available at: <https://e-callisto.org/Software/NoiseFigurePlotterV193.zip>
- {[Preamp](https://www.reeve.com/Documents/CALLISTO/ToPreampifyorNot.pdf)} Reeve, W., Monstein, W., To Preampify or Not, available at: <https://www.reeve.com/Documents/CALLISTO/ToPreampifyorNot.pdf>
- {[R&S-YFactor](https://www.rohde-schwarz.com/us/applications/the-y-factor-technique-for-noise-figure-measurements-application-note_56280-15484.html)} The Y Factor Technique for Noise Figure Measurements, available at: https://www.rohde-schwarz.com/us/applications/the-y-factor-technique-for-noise-figure-measurements-application-note_56280-15484.html

Eduard Mol

Introduction

In two earlier articles in the January- February and May- June 2025 SARA journals I described the results of an observation programme on several external galaxies (M31, M33, M101 and IC342) at 21 cm with my 3 metre dish [1, 2]. In November- December 2025 more observations were done on M31 and IC342. The goals of this observation run were:

- Creating a map of the intensity and doppler velocity of the hydrogen line towards M31
- Re-observe IC342 and hopefully improve the detection SNR

In this article, the results of the new M31 survey and IC342 observations are reported.

The 3 metre dish

For this project a homemade 3 metre f/0.5 dish was used. The dish has a plywood construction with an aluminum mesh reflector. It is not permanently set up in the backyard but consists of four segments which can be assembled around a central hub and stored in a shed when not in use. The system temperature is approximately 110- 120 K.



Figure 1: the modular 3 metre dish.

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

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

The SDR is attached to an aluminium block with thermal paste and cooled using an old PC fan to reduce gain drift due to temperature changes.

Results and discussion

Mapping the Andromeda galaxy

Back in 2017 the French amateur radio astronomer and EME enthusiast Jean-Jaques Maintoux F1EHN published an excellent series of articles about his observations of M31 and M33 [3]. As far as I am aware these are the first detections of these galaxies with an amateur-scale (3-metre) instrument. It was largely Jean-Jaques' work that encouraged me and others to pursue extragalactic hydrogen with our own backyard radio telescopes. One of the most impressive results of Jean- Jaques' measurement series was a grid map of M31, which demonstrated that even his relatively modest 3.3 metre dish had just enough spatial resolution to resolve the approaching and receding side of the galaxy [3]. Since I have successfully detected M31 several times in the past few years, the next challenge was to repeat Jean-Jaques' mapping observations using only driftscans. Sadly, he passed away in September 2024. This mapping survey is therefore also a bit of a tribute to Jean-Jaques Maintoux.

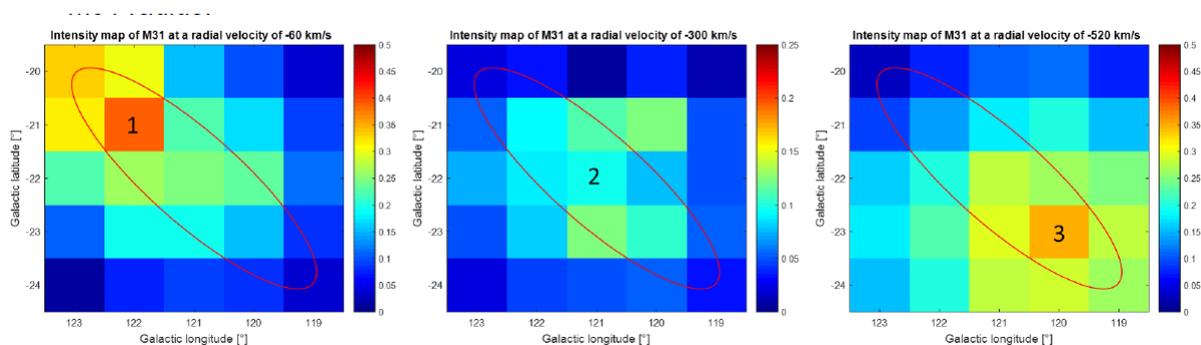


Figure 2: Maps of the hydrogen line intensity towards M31 at different radial velocities, made by Jean-Jaques Maintoux F1EHN using his own 3.3 metre EME dish [3]

Since my dish has no motors for tracking, all observations are done in driftscan mode. The dish is simply pointed at the target declination, and I let the Earth's rotation do the rest while IFAverage automatically saves a spectrum every minute. The data collection and processing procedures are described in earlier articles on the observations of M31 and M33 by Jason Burnfield and by me in the March- April 2024 and the January- February 2025 SARA journal [1, 4]. It is also covered in the first video of the "Andromeda series" on my channel [5]. In short, the spectra recorded when the galaxy was in the beam are averaged. Then, two blocks of spectra recorded before and after the transit of the galaxy through

the beam are averaged and divided from the averaged “on-target” spectrum to remove the system bandpass response.

In order to create a map, all we have to do is to perform a series of such driftscans at different declinations. The data processing also needs to be done a little bit different. For mapping I still used two blocks of spectra before and after the transit for bandpass correction. The difference is in how the “on-target” spectrum is defined. Instead of averaging all spectra recorded when the galaxy was within the beam (about 30 minutes of recording), a window of 1 hour in right ascension around M31 was split up into a series of 5-minute windows. The spectra in each 5 minute window are averaged and processed as usual. By doing this at 5 declinations spaced 2 degrees apart it was possible to create a 5 X 11 sized grid of spectra. In order to ensure a good enough SNR, at least three driftscans were done at each declination, in some cases more if a recording was affected by RFI.

During data processing I ran into some challenges that required some adjustment of my usual data processing procedure. In many cases there was significant residual background curve even after bandpass correction, especially for the gridpoints at the beginning and end of the “on-target” recording. One method that seemed to help was taking a weighted average of the off-target spectra recorded before and after the transit. By carefully adjusting the weight (w) between these two sets it was possible to get a flat spectrum in most cases.

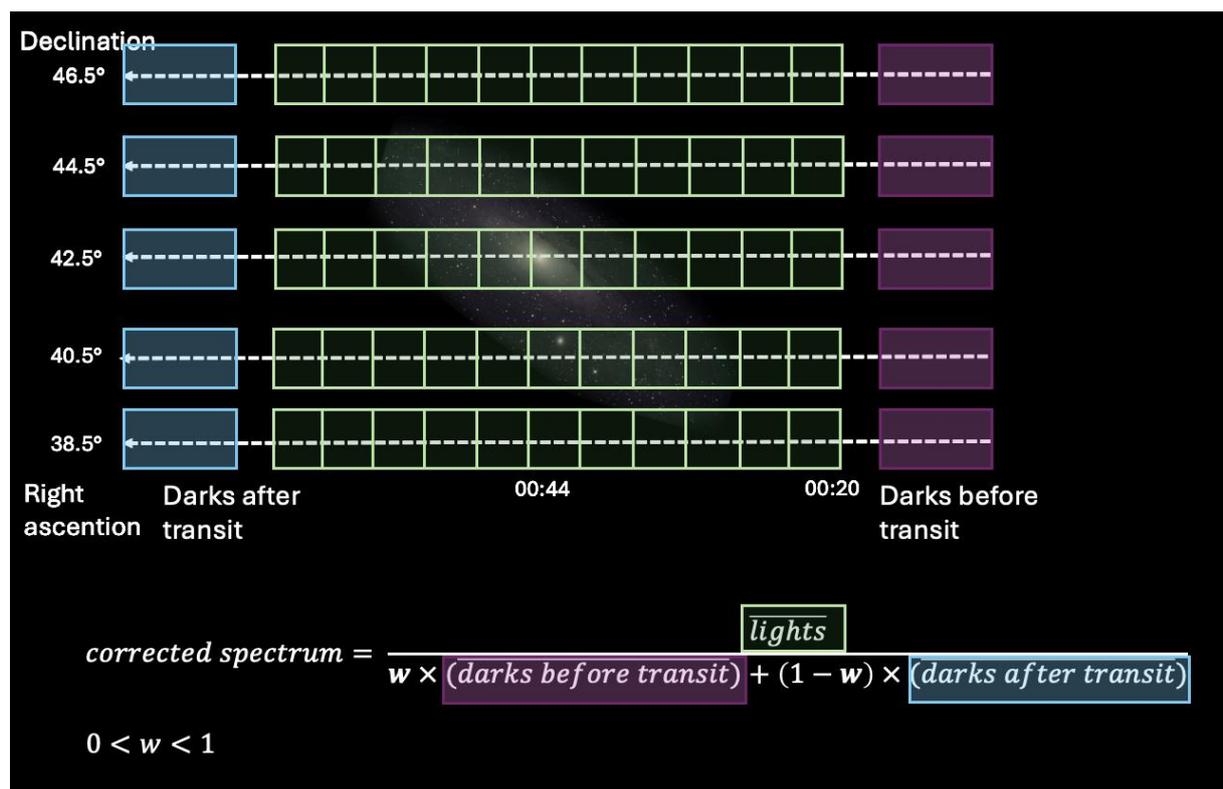


Figure 3: schematic overview of the mapping method

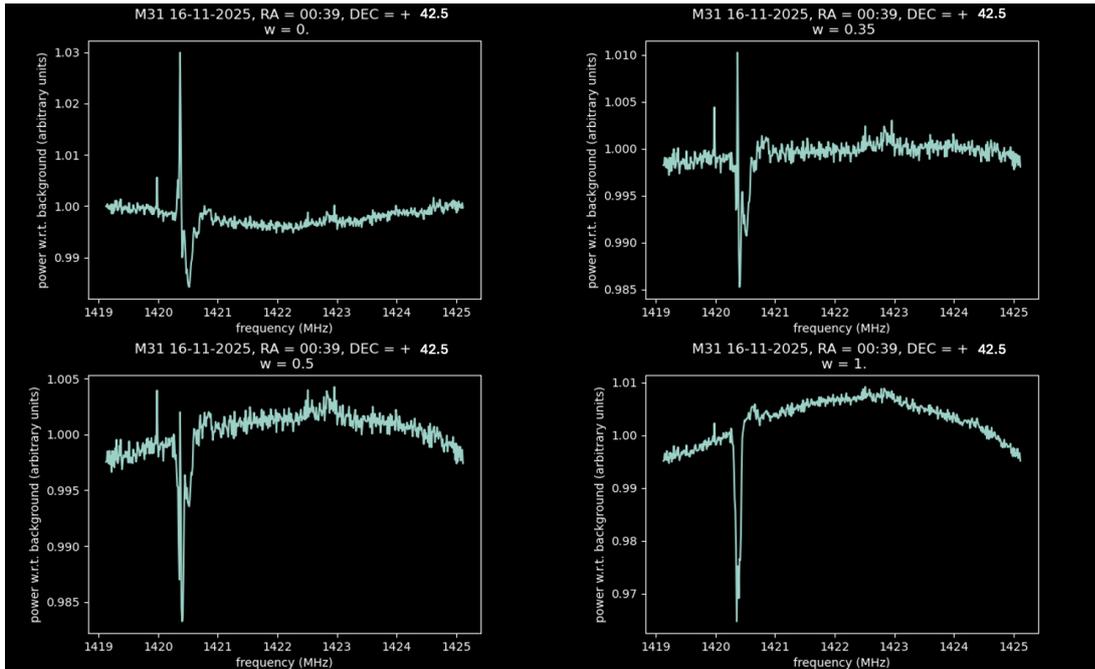


Figure 4: example spectra of M31 demonstrating the effect of varying the weight factor w .

Unfortunately, there were still cases where even this method was insufficient to remove all residual background curve. In these cases, a third order polynomial was fitted through the parts of the spectrum outside the frequency range of the hydrogen line of Andromeda. This method is not ideal because it may introduce features in the spectrum that are not really there (typically broad humps or bowls). I therefore tried to avoid this method as much as possible. Finally, the vertical scale was converted to brightness temperature, using the galactic plane near the anticenter ($T_b = \sim 100\text{K}$) as a reference.

The figure below shows all the spectra in the map grid. These spectra show clear differences with position. In the southern end the blueshifted peak is most prominent. In the northern end the redshifted end is comparatively brighter. Note that the strong peak near 0 km/s is from hydrogen clouds in our own galaxy.

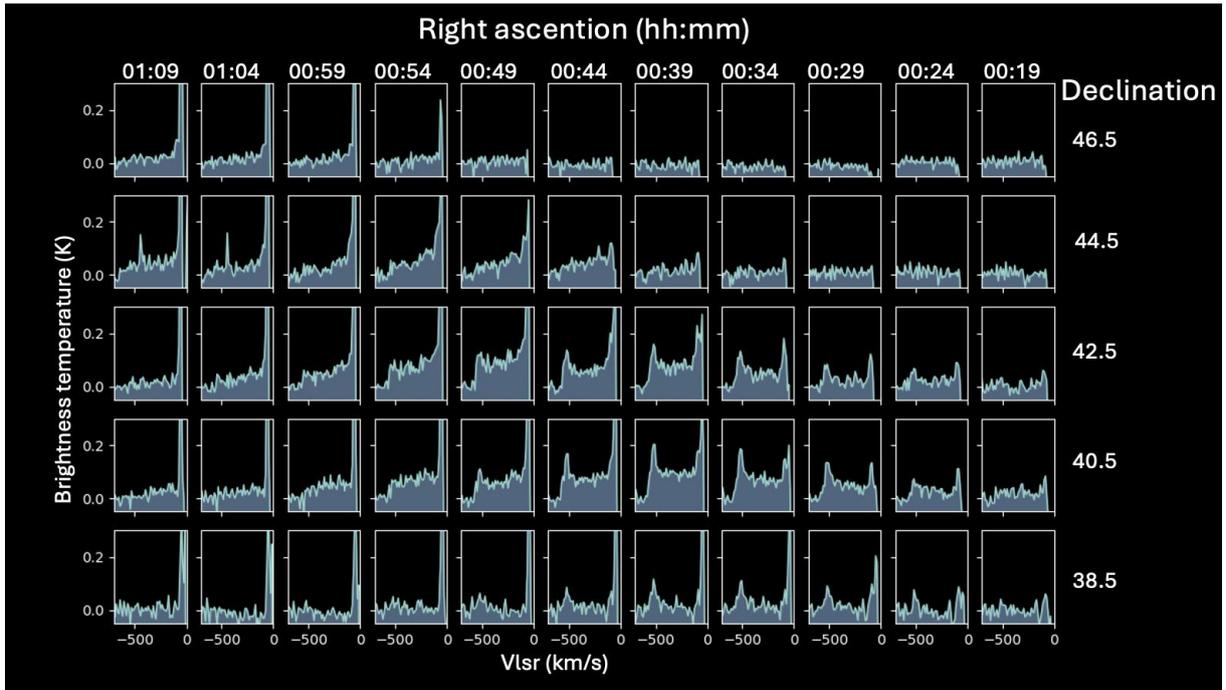


Figure 5: overview plot of all the spectra from the M31 mapping survey.

How do we convert this into a map? Like JJ Maintoux did with his measurements, I divided the spectrum of M31 in three parts. For the first part covering the ‘blueshifted horn’, all spectral channels between -600 and -400 km/s were averaged. The second part covers the middle “plateau” feature at -400 and -200 km/s. The redshifted peak unfortunately overlaps with the hydrogen line in our own galaxy above -100 km/s. Therefore, the part of the spectrum between -200 and -100 km/s was selected to represent the redshifted side of the Andromeda galaxy.

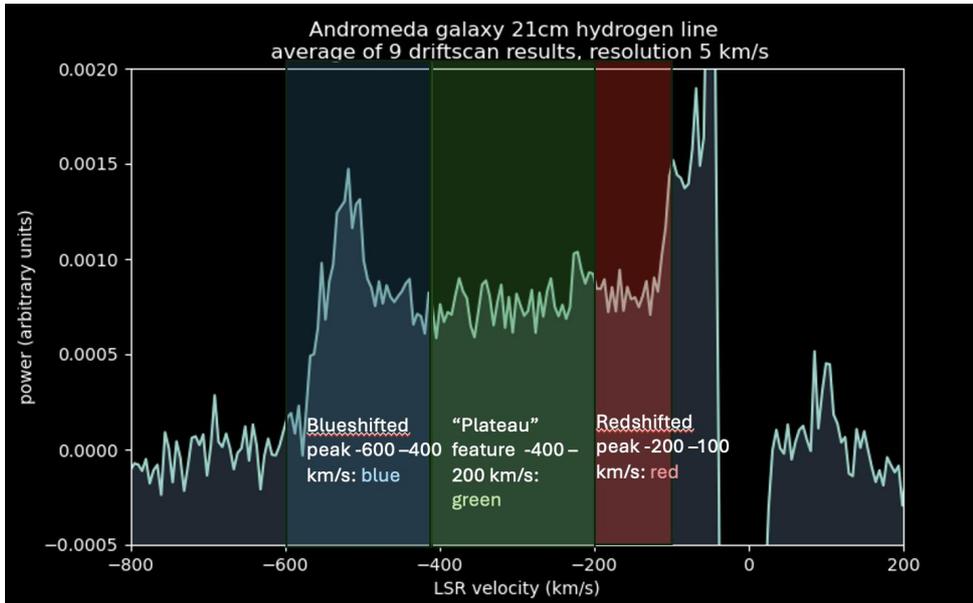


Figure 6: division of the HI spectrum of M31 in three different radial velocity intervals.

Next, the Matplotlib pyplot.pcolor function was used to plot the maps. The result is three maps showing the distribution of hydrogen gas in each of the three different Doppler shift ranges. These maps show that the most blueshifted emission is concentrated near the southern end of the galaxy, while the hydrogen line emission with the lowest blueshift is mostly found in the northern part. These maps compare quite well with the results of JJ Maintoux, albeit at a coarser resolution due to the larger step size in declination of 2 degrees instead of 1 degree and the slightly smaller diameter (and therefore slightly larger beam width) of my dish.

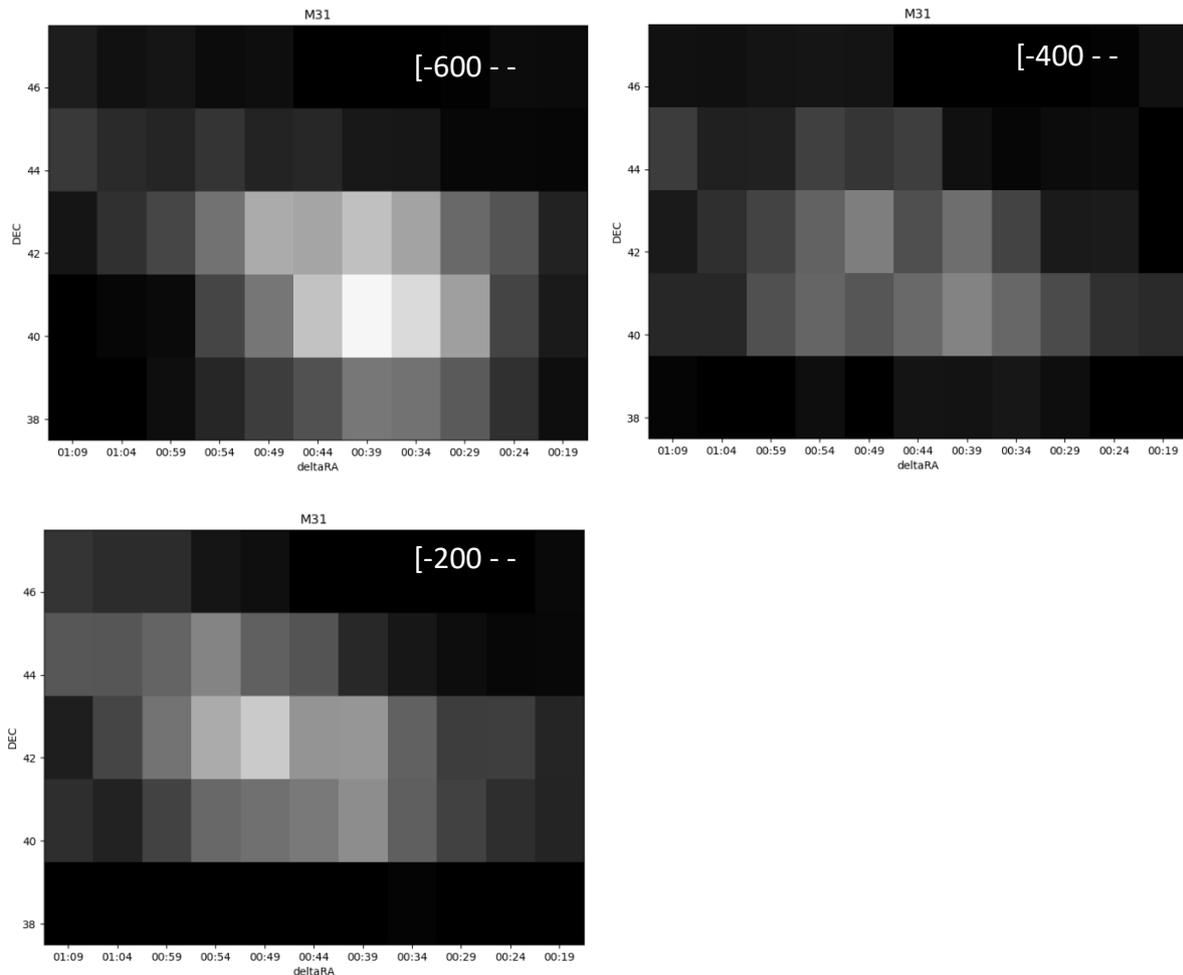


Figure 7: maps of M31 at different radial velocity intervals. The brightness represents the average intensity (brightness temperature) of the hydrogen line in each radial velocity interval: black is minimum intensity ($\sim 0K$), white represents maximum intensity ($\sim 0.2K$)

It is also possible to show all this information in one single map as RGB layers using an image editing software like GIMP. The blue channel represents the blueshifted peak (-600 – -400 km/s; green represents the “plateau” feature (-400 - -200 km/s) and red the least blueshifted “redshifted” part of Andromeda’s spectrum (-200 - -100 km/s). This map shows the velocity gradient across the galaxy even more clearly.

This velocity gradient is caused by the Andromeda galaxy’s rotation. One side is spinning towards us, while the other side is spinning away from us at the same velocity. This is what causes the typical

“double horned spectrum” in the hydrogen line of spiral galaxies [6]. These rotational red- and blueshift are added on top of the overall blueshift of M31. The HI spectrum of M31 is therefore still blueshifted as a whole.

I also made a video where I explained the spectrum of M31 and derived its rotation velocity and its overall velocity with respect to our galaxy [7].

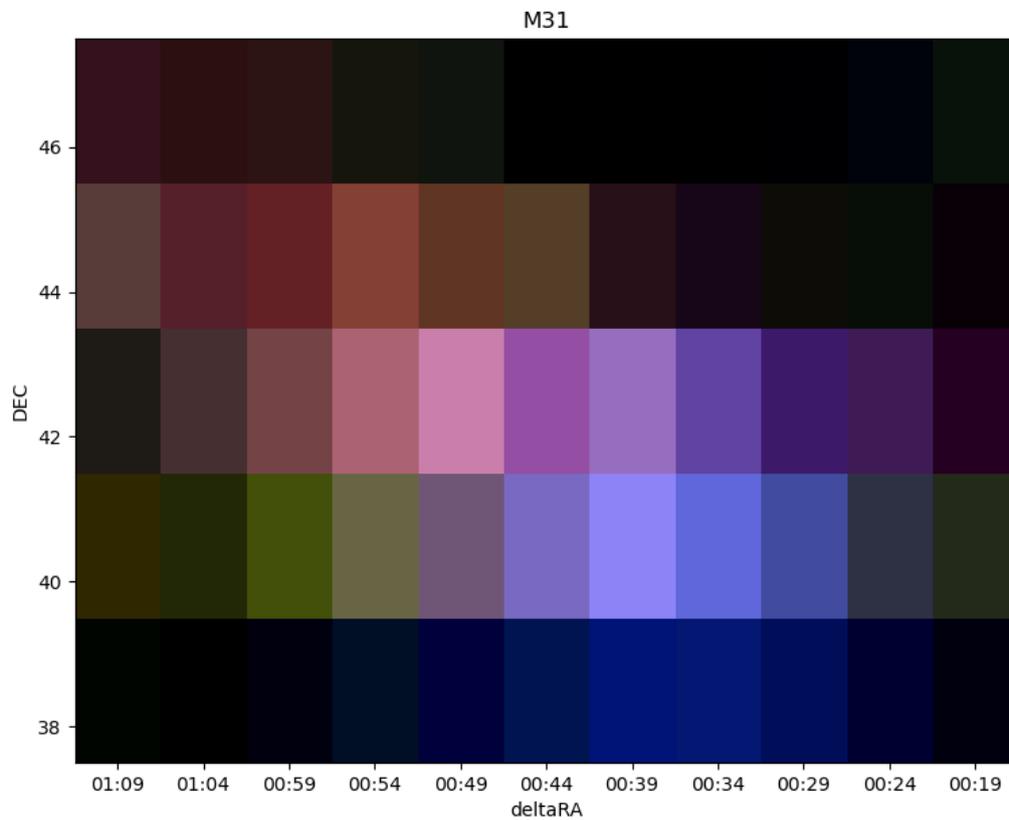


Figure 8: map showing the intensity and radial velocity of the hydrogen line towards M31. (Red: -100 to -200 km/s; green: -200 to -400 km/s; blue: -400 to -600 km/s)

IC342 revisited

IC342 is a massive spiral galaxy located at a distance of roughly 11 million light years. This makes it substantially more distant than M31 and M33. IC342 is therefore also not a member of the Local Group [8]. According to the survey by Rots (1980) it's HI flux density is 35 Jansky, about half that of M33 [9]. Due to the small redshift of IC342 the spectrum has significant overlap with the local galactic hydrogen signal. Only the redshifted part of the spectrum at ~50- 150 km/s can be detected [6, 9].

In February 2025 eight driftscans of IC342 were done in an attempt to detect this galaxy. Unfortunately, these recordings were hampered by RFI and the result was not as good as I hoped (see the previous observation report in this series in the May-June 2025 SARA journal for these earlier results [2]). Four new driftscans were recorded between December 1 and 4, 2025. These new driftscans were much less

affected by RFI, and the redshifted part of the hydrogen line spectrum of IC342 was much more clearly detected this time. The spectrum is also very similar to the LAB survey simulation [10].

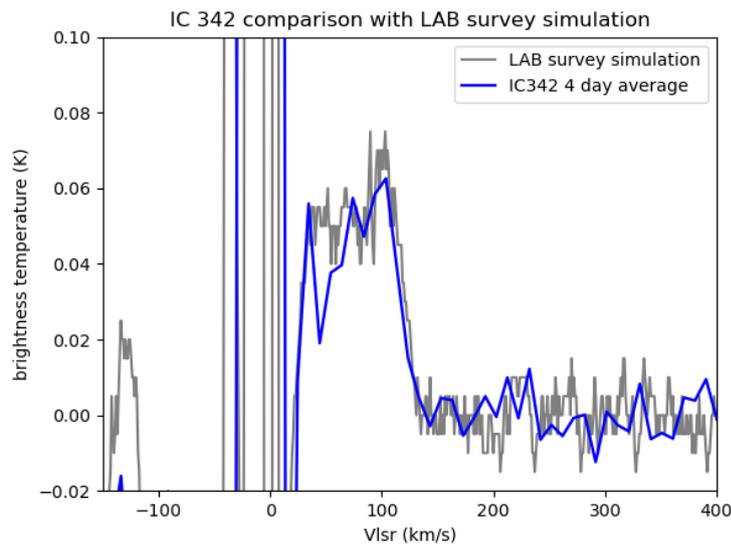


Figure 9: spectrum of IC342 recorded with the 3 metre dish (blue line) compared to the LAB survey simulation [10] (grey line). This spectrum is a stack of 4 driftscans, the integration time is approximately $4 \times 40 = 160$ minutes. For bandpass correction two sets of off-target spectra recorded between 80 and 40 minutes before and after the transit were used.

References:

- 1) "Observation report: M31 and M33 at 21 cm", Eduard Mol, SARA journal January- February 2025, p. 122- 130.
- 2) "Observation report: nearby galaxies at 21 cm part II", Eduard Mol, SARA journal January- February 2025, p. 122- 130.
- 3) Amateur Radio astronomy: 21 cm hydrogen survey of M31 and M33 galaxies, Jean Jacques Maintoux F1EHN
- 4) "Hydrogen line driftscan detection of M31 and M33 with a portable 2.64 meter dish", Jason Burnfield, SARA journal March- April 2024 p. 88- 96.
- 5) <https://youtu.be/aqUufpIYFYM?si=e3LH3cbvyziGMS5i>
- 6) "The "Astropeiler Stockert story" part 6: spectral observations extragalactic sources", Wolfgang Herrmann and Sandra Schumann (https://www.astropeiler.de/wp-content/uploads/2023/05/Astropeiler_Story_6.pdf)
- 7) <https://youtu.be/hTg1lU9AyIM?si=Xza5pvnYbYjdBHTB>
- 8) https://en.wikipedia.org/wiki/IC_342
- 9) Rots, A. H. (1980). A neutral hydrogen mapping survey of large galaxies. I-Observations. Astronomy and Astrophysics Supplement Series, vol. 41, Aug. 1980, p. 189-209., 41, 189-209. <https://adsabs.harvard.edu/full/1980A&AS...41..189R>
- 10) <https://www.astro.uni-bonn.de/hisurvey/euhou/LABprofile/index.php>

TinySA Ultra Spectrum Analyzer Comparison

Whitham D. Reeve

1. Introduction



In this article I compare some measurements made by the ZS405 TinySA Ultra to the same measurements by the Rohde & Schwarz FPL1003 spectrum analyzer (figure 1). This is not a comprehensive or critical review of either analyzer – it is a quick look at rather simple measurements by relatively low-cost and high-cost spectrum analyzers in order to learn more about their RF measurement capabilities. I assume readers are already familiar with how modern spectrum analyzers work.

The TinySA Ultra is a swept frequency spectrum analyzer. I briefly described its trace detectors and video bandwidth filters in a previous article {[Reeve25](#)}. The present article is an extension of that work. The R&S FPL1003 also is a swept frequency analyzer but it switches to an FFT sweep mode and uses FFT filters when the resolution bandwidth is set to 50 kHz or lower; more information about this analyzer is available at {[R&S-FPL](#)}.



Figure 1.a ~ TinySA Ultra at approximately 1/5 scale. The touchscreen display size is 4 inch diagonal with 480 x 320 pixels. The only controls are a power on/off slide switch and a jog control. Image source: TinySA.org



Figure 1.b ~ FPL1003 at approximately 1/5 scale. The touchscreen display is 10.1 inch diagonal with 1280 x 800 pixels. All buttons and knob controls have touchscreen equivalents, and the instrument also may be controlled through its web browser interface. Image source: Rohde & Schwarz

The measurements described here include Displayed Average Noise Level (DANL), unmodulated (CW) and modulated signals from a signal generator, and live FM broadcast band signals. The highest frequency of the FPL1003 is 3 GHz whereas the TinySA Ultra is claimed to be usable to 6 GHz in Ultra mode. My measurements are in the frequency range 1 to 800 MHz, corresponding to the TinySA Ultra's *non-Ultra* mode frequency range, and 1 and 2 GHz with the TinySA Ultra in *Ultra* mode. The FPL1003

covers the entire frequency range in a single spectrum analyzer mode (this analyzer has several other modes).

The TinySA Ultra documentation is not comparable to the FPL1003. The only formal documentation for the TinySA Ultra (and other similar models) is the online TinySA Wiki, and it consists of a page of specifications and several pages of menu definitions and other information; see References. An experienced user has produced a 35 page description. I had to frequently search the TinySA Groups.io user support forum for more information while preparing this and the previous article. For comparison, the FPL user manual is 1156 pages, and each option adds 200-300 hundred pages.

2. General Setups

Self-test and internal calibration: The TinySA Ultra has manual self-test and calibration functions; both were run prior to the measurements. The FPL1003 also has internal self-test and calibration functions but these are automatically run each time the analyzer is powered on. It also has a *Self-Alignment* function that is manually run if the ambient temperature has changed or the firmware has been updated, and it was run prior to the measurements. The lab temperature was stable at 20 °C throughout the measurements, and no attempt was made to determine if the analyzers provided different results at different temperatures. Both analyzers can use correction tables for interconnection cables and other devices to improve accuracy, but these were not used.

Analyzer power & setup: The TinySA Ultra has an internal battery but I connected it through a USB port on a lab PC so the battery would not run down. I noted no difference in the analyzer noise floor with and without the external power supply. All measurement setups were through the TinySA Ultra touchscreen (a stylus is essential); the TinySA-App software was not used to control the instrument. Screenshots were taken with the TinyRemote screenshot tool. The FPL1003 was powered from a lab ac receptacle and controlled through its LAN connection with a web browser (Firefox) running on the same PC. The spectrum plots were taken by the FPL1003's built-in screenshot utility, which automatically recolors them for printing.

Start mode: The TinySA Ultra starts with its default span from 0 to 800 MHz and the FPL1003 starts with its default span from 5 kHz to 3 GHz. To measure frequencies above 800 MHz, it is necessary to manually set the TinySA Ultra to the Ultra mode. There is no indication that it is in the Ultra mode except in the menus (a checkbox). According to the TinySA Wiki: *Enabling Ultra mode has no negative impact on measurements below the Ultra Start frequency*. Almost all measurements below 800 MHz were made prior to switching to the Ultra mode.

Analyzer RF input power: The first step in using any spectrum analyzer is to ensure its RF input will not be overloaded and possibly damaged. This is especially important with the TinySA Ultra – the TinySA Groups.io forum has regular inquiries about testing and repairing damaged front-ends. The TinySA

Ultra has the following specifications: 1) Absolute maximum input level of +6 dBm (4 mW) with the internal attenuator set to 0 dB; 2) Absolute maximum short term peak input power of +20 dBm (100 mW) with the internal attenuator set to 30 dB; 3) Suggested maximum input power of 0 dBm (1 mW) with the internal attenuator set to Auto; 4) Recommended input power ≤ -25 dBm (3.2 μ W) for *best measurements*. As for the FPL1003, the specified maximum power input is +20 dBm (100 mW) with the internal attenuator set to 0 dB and +30 dBm (1 W) with it set ≥ 10 dB. Both maximums are reduced 7 dB when the FPL's internal preamplifier is enabled. The TinySA Ultra does not provide an on-screen warning if the maximum allowed input power is exceeded but the FPL does.

Sweep points: The TinySA's maximum horizontal trace display resolution is 450 pixels with one sweep point per pixel (it can be set to lower values). When used with PC application software, the sweep points can be set to any practical value but that was not done here. The FPL1003's maximum horizontal trace display resolution is 1000 pixels but the sweep points can be set up to 100 001 on the instrument itself. The FPL User Manual says the highest resolution is provided when the Span/RBW ratio = 1000 (or, RBW = Span/1000). Since the TinySA Ultra has the limiting resolution, both instruments were set to display 450 points with the Sweep Time parameters set to Auto.

3. Comparative Measurements

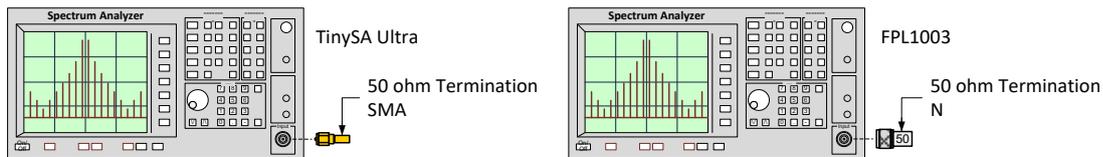
I made three sets of measurements, which are discussed in this section: Measurement Set No. 1 investigates the Displayed Average Noise Level (DANL), which indicates the analyzer sensitivity and is useful in device noise and weak signal investigations; Measurement Set No. 2 explores unmodulated and modulated signals from an RF signal generator. Analyzing these types of signals is useful in signal measurements and radio frequency interference (RFI) investigations; and Measurement Set No. 3 captures live signals in the FM broadcast band to compare how the analyzers handle relatively strong FM modulated signals in a live ambient RF background.

I attempted to make the analyzer setups the same so that equal comparisons could be made. Unavoidable differences, of which there were very few, are discussed in each measurement set. Because the number of ease-of-use and advanced features are very limited in the TinySA Ultra compared to the FPL1003, I did not take advantage of the FPL1003's many intrinsic signal analysis capabilities.

Measurement Set No. 1: Displayed Average Noise Level using a Noise Marker and with the low noise amplifier (LNA) in the TinySA Ultra and the Preamplifier in the FPL1003 Off and On.

Connections: See connection diagram below (figure 1.1). A 50 ohm termination was connected directly to the RF input port of each instrument.

Figure 1.1 ~ Connection diagram for Measurement Set No. 1



Settings: The Noise Marker used during the DANL measurements produces a reading in dBm Hz^{-1} (displayed as dBm/Hz on both instruments) after correcting for the Resolution Bandwidth (RBW) filter shape and width and for the trace detector and averaging settings. The lowest RBW filter setting in the TinySA Ultra is 200 Hz whereas it is 1 Hz in the FPL1003. To allow equal comparison, the RBW filter in both analyzers was set to 1 kHz. This higher RBW setting turned out to be very useful because it allowed faster sweep times and significantly sped up the measurements by the TinySA Ultra compared to lower RBW settings. See table 1.1 for additional settings.

Table 1.1 ~ Settings:

Analyzer →	TinySA Ultra	FPL1003	Remarks
Center Frequency	See Table 1.2	See Table 1.2	
Span	1 KHz	1 kHz	
Sweep Points	450	450	
Sweep Time, ≤ 750 MHz	3.2 min	85 ms	TinySA Ultra in non-Ultra mode, Note 3.a.
Sweep Time, > 800 MHz	6.1 min	85 ms	TinySA Ultra in Ultra mode, Note 3.a.
Trace Detector	AVER	Average/100	
Reference Level	-70 dBm	-80 dBm	
Attenuator	0 dB	0 dB	
RBW	1 kHz	1 kHz	
RBW/VBW	100	100	

Measurement results: See table 1.2.

Table 1.2 ~ Measurement results. Appendix I contains reference screenshots for the measurements tabulated here (Note: Only the online version of this article includes Appendix I).

Center Frequency →	1 MHz	10 MHz	100 MHz	500 MHz	750 MHz	1 GHz	2 GHz	Remarks
TinySA Ultra – LNA Off (dBm Hz⁻¹)	-149.0	-153.5	-154.8	-152.4	-149.8	-149.8	-151.6	
TinySA Ultra – LNA On (dBm Hz⁻¹)	-171.3	-171.5	-171.1	-170.9	-170.0	-167.6	-169.6	
Measured NF – LNA On (dB)	5.7	4.7	4.8	4.9	5.0	7.2	5.8	Note 2.d.& e
FPL1003 – Preamp Off (dBm Hz⁻¹)	-149.5	-152.3	-151.8	-151.5	-151.6	-150.0	-152.0	
FPL1003 – Preamp On (dBm Hz⁻¹)	-149.5	-166.9	-167.1	-166.7	-167.0	-166.3	-166.5	Note 3.b.
Calculated NF – Preamp On (dB)	24.5	7.1	6.9	7.3	7.0	7.7	7.5	Note 1.a.
 Δ DANL TinySA Ultra and FPL1003 – LNA/Preamp Off (dB)	0.5	1.2	3.0	0.9	1.8	0.2	0.4	
 Δ DANL TinySA Ultra and FPL1003 – LNA/Preamp On (dB)	21.8	4.6	4.0	4.2	3.0	1.3	3.1	Note 3.b.& e.

Measurement Set No.1 Notes:

1. General –

- a. $NF_{SA} = DANL + 174 \text{ dBm Hz}^{-1}$, or $DANL - NF_{SA} = -174 \text{ dBm Hz}^{-1}$ (DANL normalized to 1 Hz; equation applies only if the Noise Marker used to measure DANL incorporates averaging and filter bandwidth and shape corrections).

2. TinySA Ultra –

- a. Noise Marker reading was inconsistent for different RBW and span settings but all within ± 2 dB (absolute power accuracy specification is ± 2 dB).
- b. Observed repeatability generally was ± 0.5 dB.

- c. For reasons unknown, could not measure the noise floor at 800 MHz in non-Ultra mode so the frequency was reduced to 750 MHz in that mode. Measurements at 1 and 2 GHz used Ultra mode.
- d. The internal LNA noise figure measurement function measures the noise figure twice and compares them to determine the error. The reported error generally was $-0.1/+0.2$ dB.
- e. Measured noise figure and DANL combined do not give -174 dBm Hz⁻¹ but generally are still within the specified absolute power measurement accuracy. See also Notes 1.a. and 2.a.
- f. Ultra mode unlock key is 4321.

3. FPL1003 –

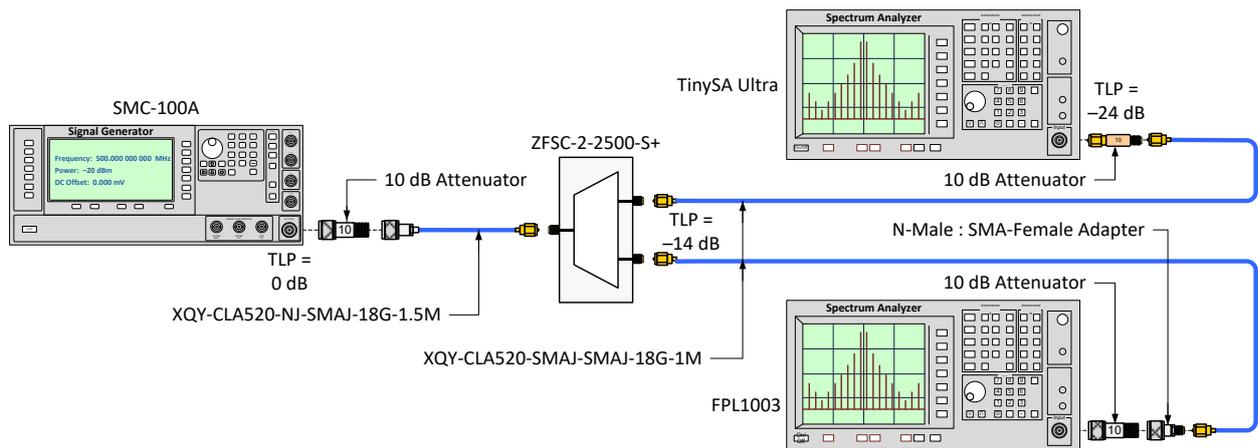
- a. The FPL switches to FFT sweep mode when the RBW is set to 50 kHz and lower.
 - b. The FPL1003 preamplifier apparently is switched out below 3 MHz (the datasheet does not show a specification for the preamplifier below 3 MHz).
 - c. The FPL accuracy is given as uncertainty and is < 0.3 dB between 3 MHz and 3 GHz.
 - d. Observed repeatability generally was better than ± 0.1 dB.
 - e. The higher noise figure of the FPL1003 preamplifier contributed to its higher DANL compared to the TinySA Ultra LNA.
-

Measurement Set No. 2: Unmodulated and modulated signals

Settings: The frequency for the measurements in this set was either 500 MHz or 1 GHz with various signal levels and analyzer resolution bandwidths. The TinySA Ultra was set to Ultra mode. Neither the TinySA Ultra LNA nor the FPL1003 preamplifier was used. The specific settings and results for each measurement are listed in tables 2.1 through 2.10 below.

Connections: See connection diagram below (figure 2.1). To allow simultaneous measurements, the signal generator was connected through a 10 dB fixed attenuator on the generator output to a Mini-Circuits 2-way power splitter and from the splitter to a 10 dB fixed attenuator connected at the input of each analyzer. The attenuators were installed to provide analyzer input *protection insurance* as well as to improve the impedance matching. Precision test cables were used for all connections. The TinySA Ultra uses an SMA connector and the FPL uses an N connector.

Figure 2.1 ~ Connection diagram for Measurement Set No. 2



RF signal generator: A calibrated R&S SMC-100A RF signal generator was used to produce unmodulated carrier wave (CW) and amplitude modulated (AM) signals. The signal generator was controlled through its web browser interface.

Modulation: One measurement was made at 500 MHz using AM. The modulation frequency was arbitrarily set to 100 kHz with an index of 90%. The calculated sideband level relative to the carrier for AM with this setting is -7 dB (for example,

see: <https://www.rfwireless-world.com/calculators/amplitude-modulation-formula-calculator>).

Markers: For all but the modulated carrier measurements, a *Normal* Marker was placed at the signal peak and another on the noise floor 100 MHz away. Only the Peak Marker is compared but both marker levels are listed in the tables and displayed in the plots. For the AM measurements, a Marker was placed on the carrier peak and on the upper sideband.

Signal levels: The input signal levels given in the measurement result tables are the signal generator output level setting less 20 dB (the losses of two 10 dB attenuators). For example, to achieve a nominal -60 dBm analyzer input signal level, the signal generator was set to -40 dBm. This is not the actual level into the analyzer because of the offset due to splitter and cable losses. The estimated offsets are 4.0 dB at 500 MHz and 4.2 dB at 1 GHz. Note that the Reference Level Offset functions in the analyzers were not used for these measurements.

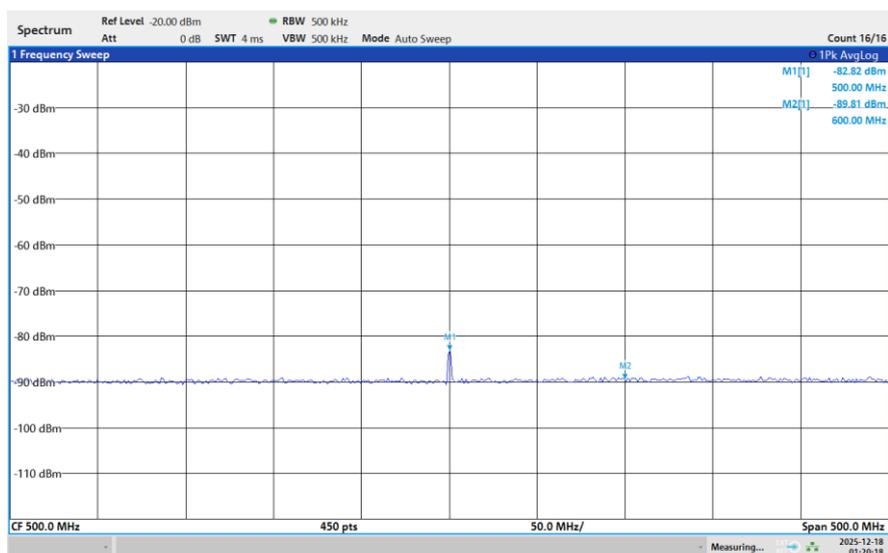
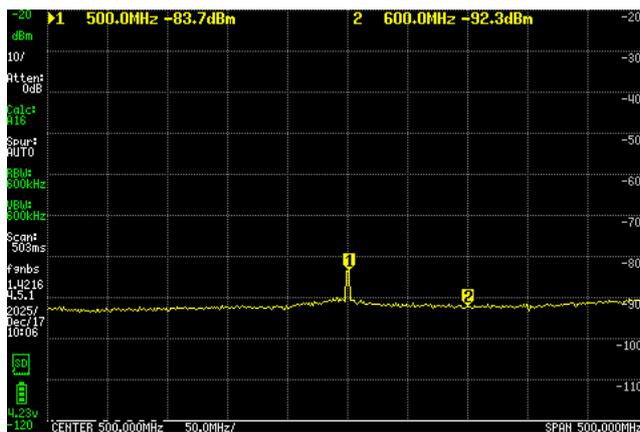
Spurious signals: The TinySA Ultra is known to emit spurious signals (local oscillator leakage) from its RF input port when in Ultra mode but only above 800 MHz. Although the splitter provides nearly 20 dB isolation between ports and the fixed attenuators provide another 20 dB reduction, spurious signals from the TinySA Ultra were occasionally seen in the FPL1003 spectra but none were seen in the documented measurements. On the other hand, self-generated spurious signals were seen in the measured TinySA Ultra spectra.

Resolution bandwidth filters: The widest RBW setting in the TinySA Ultra is 600 kHz; it does not have a 500 kHz setting. The FPL1003 does not have a 600 kHz RBW filter so its nearest setting of 500 kHz was used for two of the measurements. The different settings do not affect the signal measurements but have a small effect (0.8 dB) on the noise floor but not the carrier measurements.

Measurement results: See table 2.1 through 2.10.

Table 2.1 ~ Unmodulated carrier

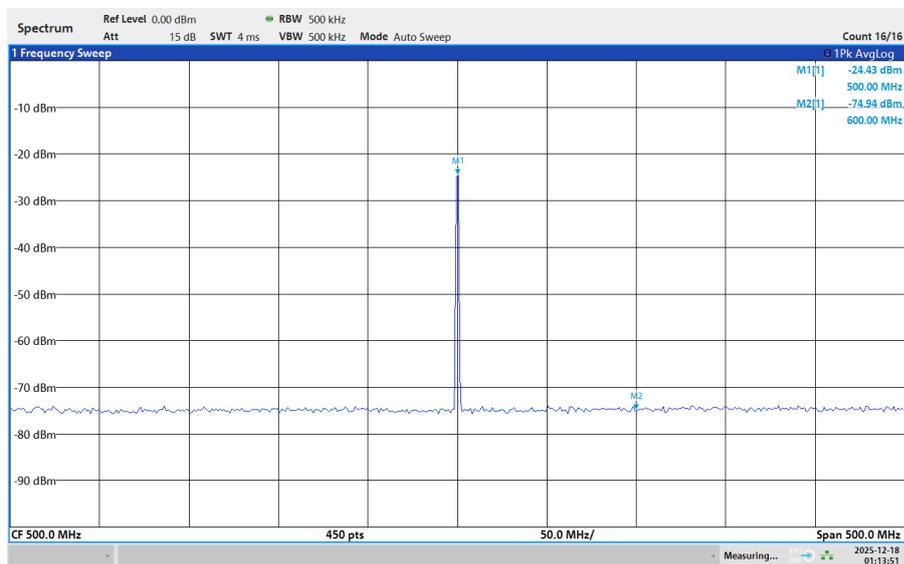
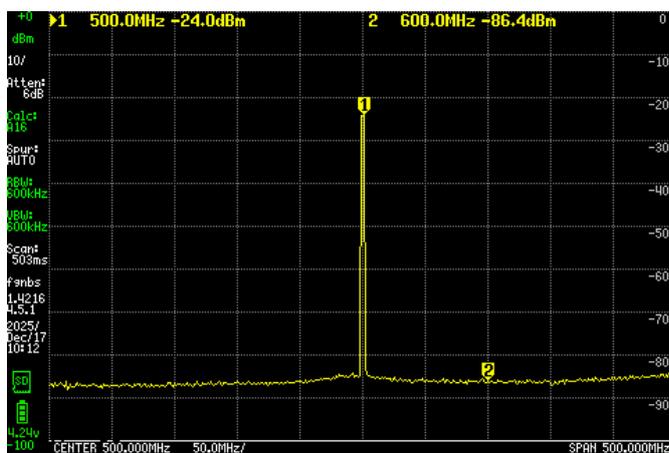
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
500	500	-80	500	600	600/500	1.0	Average 16
Meas. 2.1	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	The difference in Peak marker readings is 0.9 dB.		
TinySA Ultra	-20 dBm	503 ms	-83.7 dBm	-92.3 dBm			
FPL1003	-20 dBm	4 ms	-82.8 dBm	-89.8 dBm			



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Table 2.2 ~ Unmodulated carrier

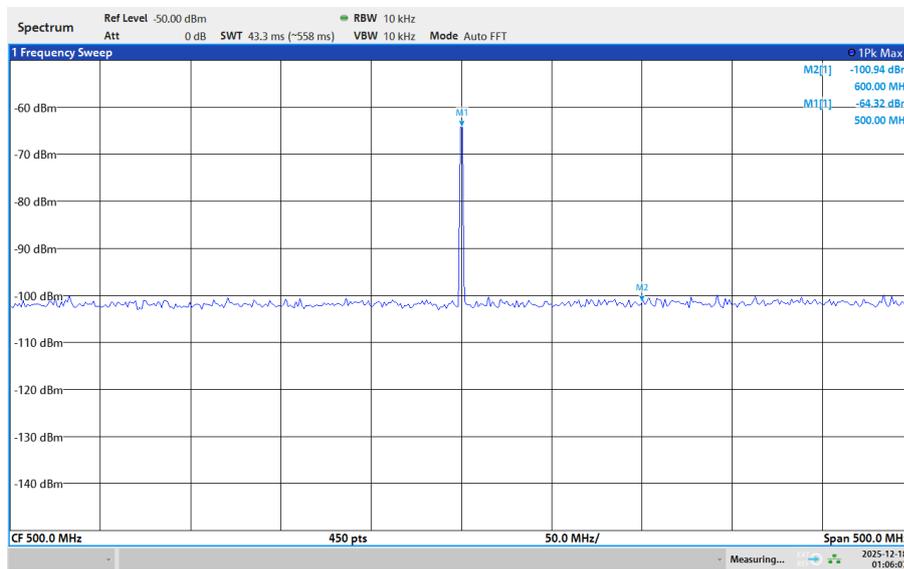
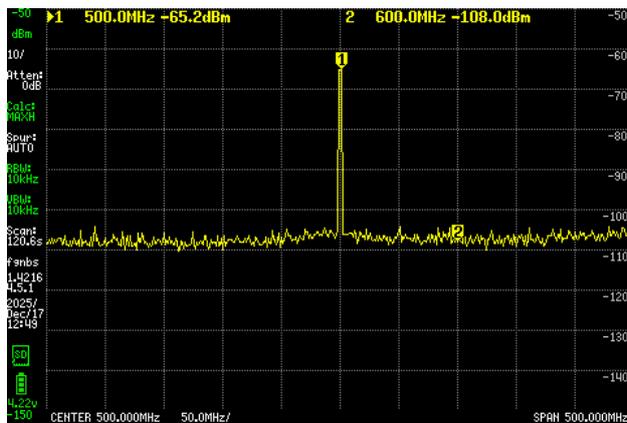
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
500	500	-20	500	600	600/500	1.0	Average 16
Meas. 2.2	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	The difference in Peak marker readings is 0.4 dB.		
TinySA Ultra	0.0 dBm	503 ms	-24.0 dBm	-86.4 dBm			
FPL1003	0.0 dBm	4 ms	-24.4 dBm	-74.9 dBm			



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Table 2.3 ~ Unmodulated carrier

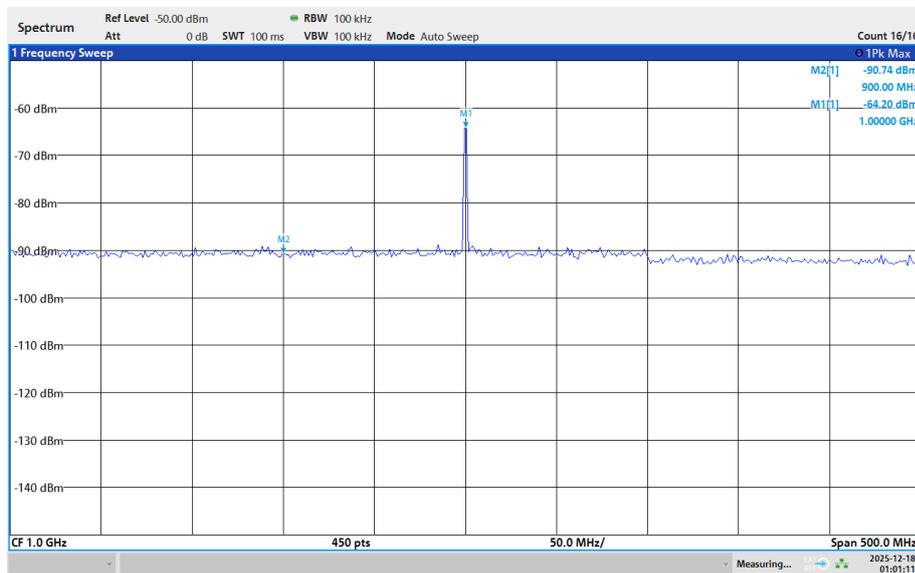
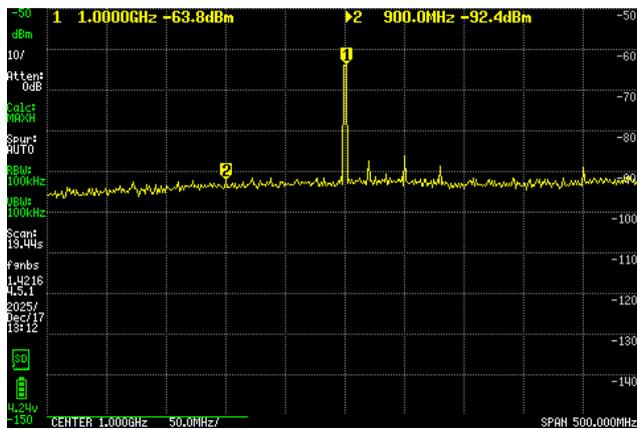
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
500	500	-60	500	600	10	1.0	Max Hold
Meas. 2.3	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	The difference in Peak marker readings is 0.9 dB.		
TinySA Ultra	-50.0 dBm	121 s	-65.2 dBm	-108.0 dBm			
FPL1003	-50.0 dBm	558 ms	-64.3 dBm	-100.9 dBm			



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Table 2.4 ~ Unmodulated carrier

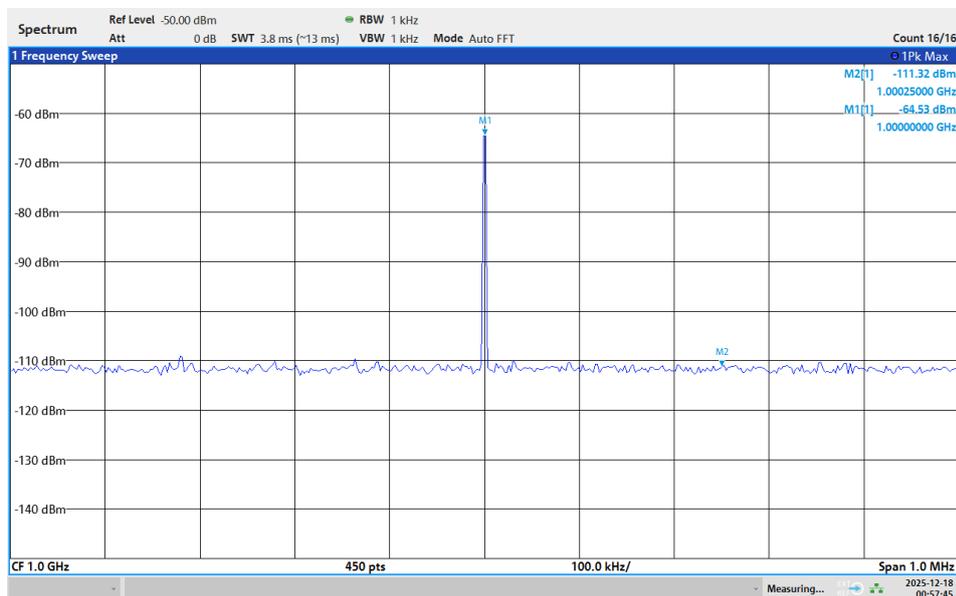
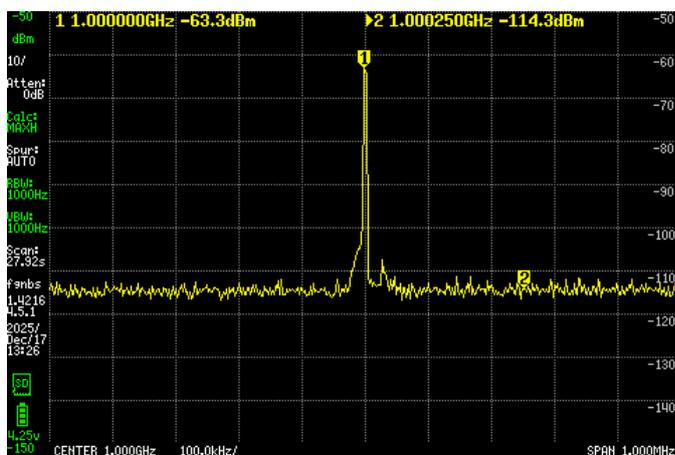
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
1000	500	-60	1000	900	100	1.0	Max Hold
Meas. 2.4	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	Spurious signals are visible in the TinySA Ultra measurements. The difference in Peak marker readings is 0.4 dB.		
TinySA Ultra	-50.0 dBm	13 s	-63.8 dBm	-92.4 dBm			
FPL1003	-50.0 dBm	100 ms	-64.2 dBm	-90.7 dBm			



01:01:12 AM 12/18/2025

Table 2.5 ~ Unmodulated carrier

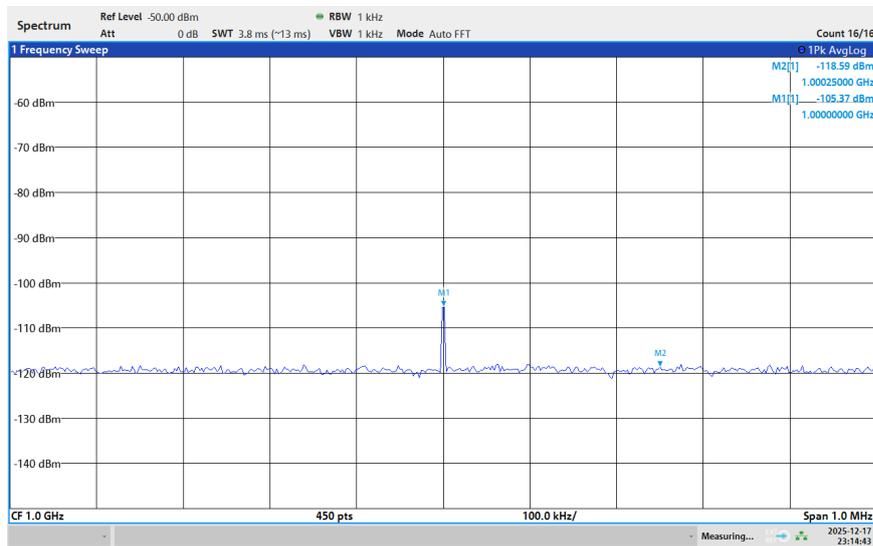
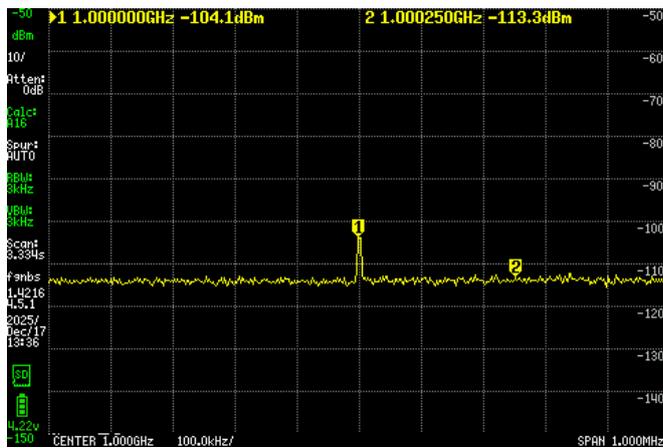
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
1000	1	-60	1000	1000.250	1	1.0	Max Hold
Meas. 2.5	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	Low level spurious signals are visible in the TinySA Ultra measurements. The difference in Peak marker readings is 1.2 dB.		
TinySA Ultra	-50.0 dBm	28 s	-63.3 dBm	-114.3 dBm			
FPL1003	-50.0 dBm	13 ms	-64.5 dBm	-111.3 dBm			



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Table 2.6 ~ Unmodulated carrier

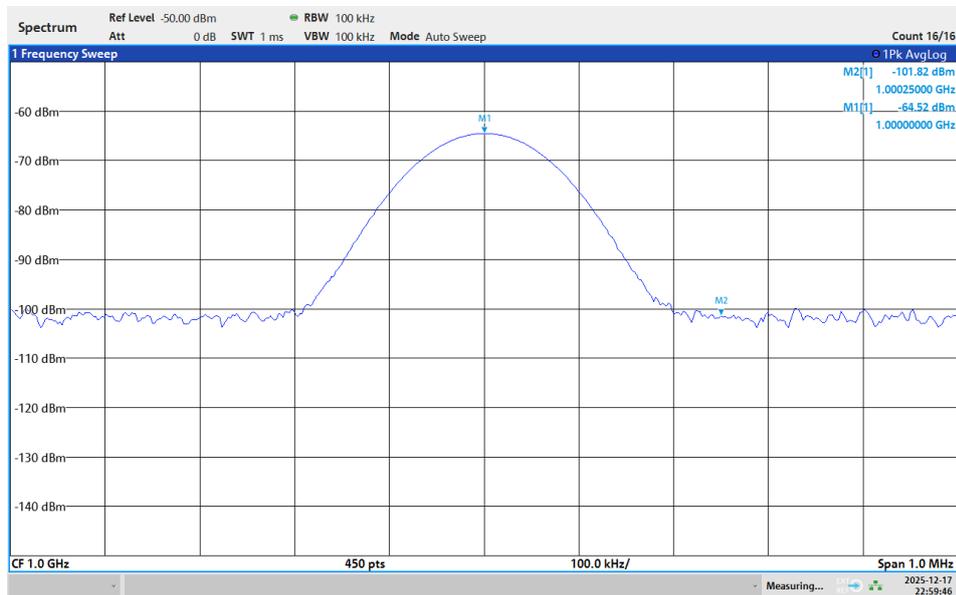
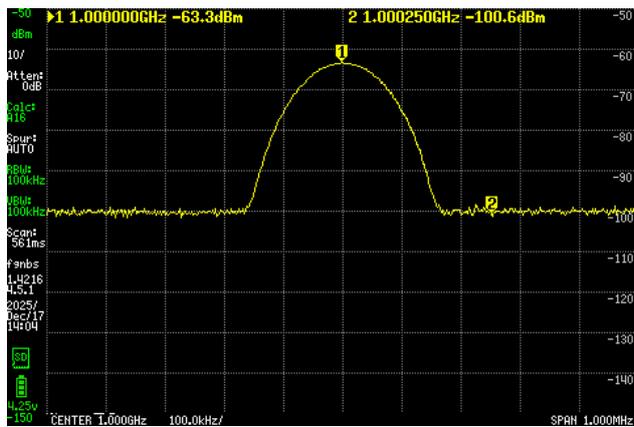
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
1000	1	-100	1000	1000.250	3	1.0	Average 16
Meas. 2.6	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	The difference in Peak marker readings is 1.3 dB.		
TinySA Ultra	-50.0 dBm	3 s	-104.1 dBm	-113.3 dBm			
FPL1003	-50.0 dBm	13 ms	-105.4 dBm	-118.6 dBm			



11:14:44 PM 12/17/2025

Table 2.7 ~ Unmodulated carrier

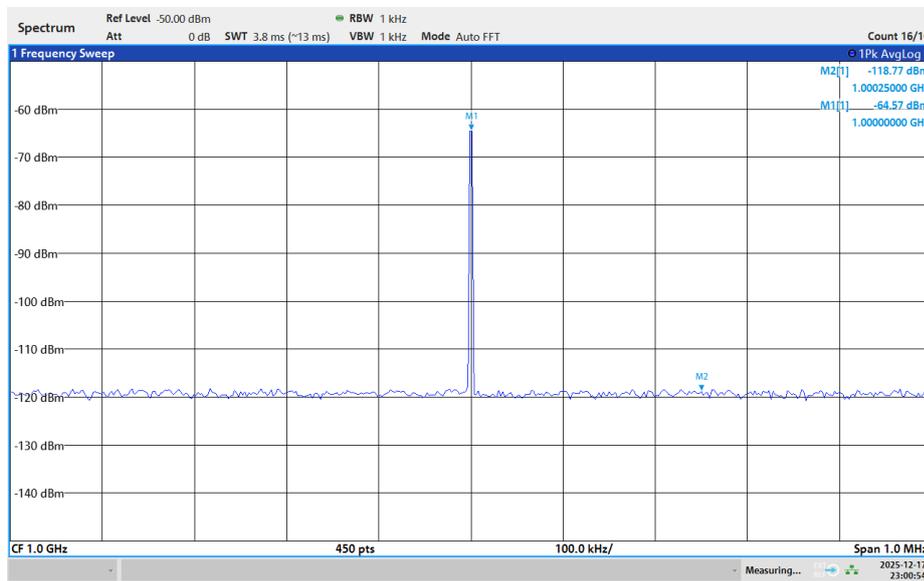
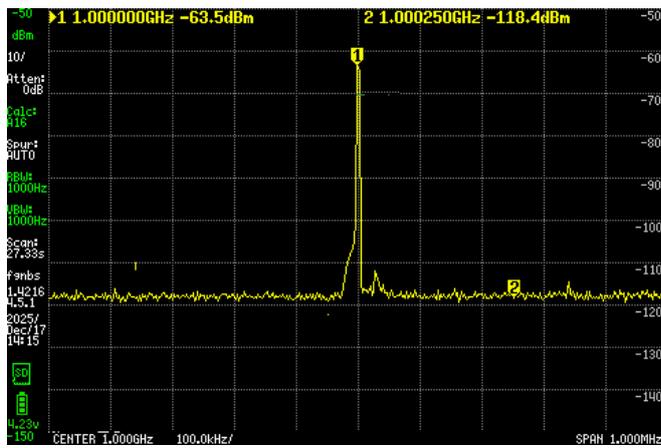
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
1000	1	-60	1000	1000.250	100	1.0	Average 16
Meas. 2.7	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	The difference in Peak marker readings is 1.2 dB.		
TinySA Ultra	-50.0 dBm	561 ms	-63.3 dBm	-100.6 dBm			
FPL1003	-50.0 dBm	1 ms	-64.5 dBm	-101.8 dBm			



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Table 2.8 ~ Unmodulated carrier

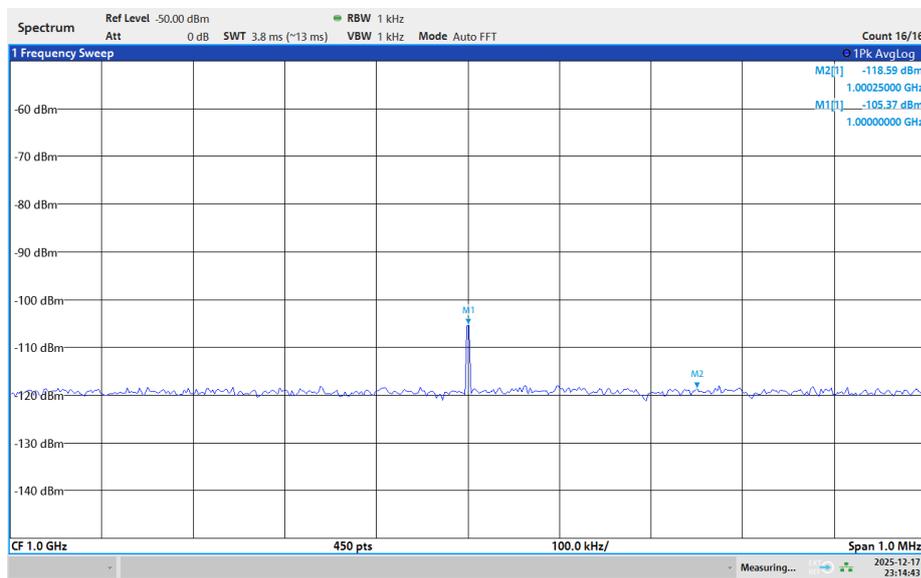
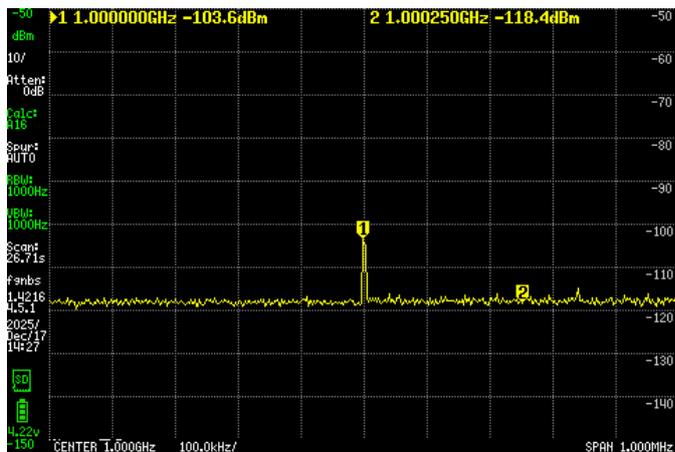
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
1000	1	-60	1000	1000.250	1	1.0	Average 16
Meas. 2.8	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	Spurious signals are visible in the TinySA Ultra measurements. The difference in Peak marker readings is 1.1 dB.		
TinySA Ultra	-50.0 dBm	27 s	-63.5 dBm	-118.4 dBm			
FPL1003	-50.0 dBm	13 ms	-64.6 dBm	-118.8 dBm			



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Table 2.9 ~ Unmodulated carrier

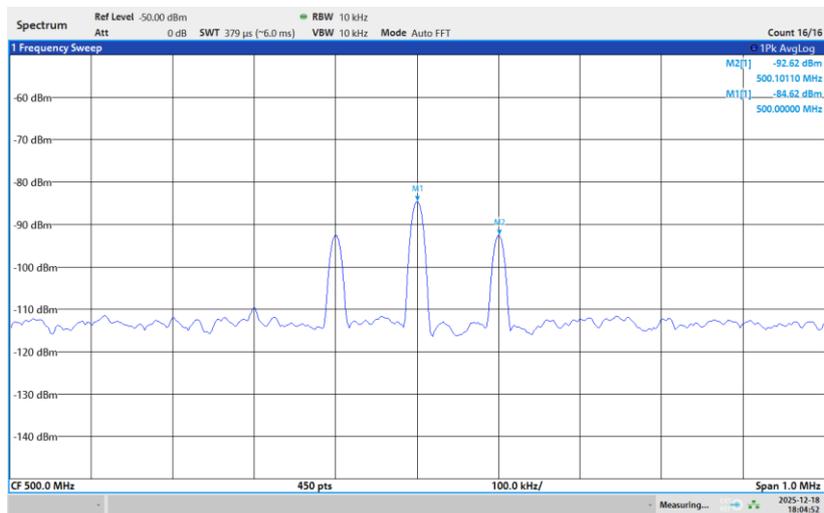
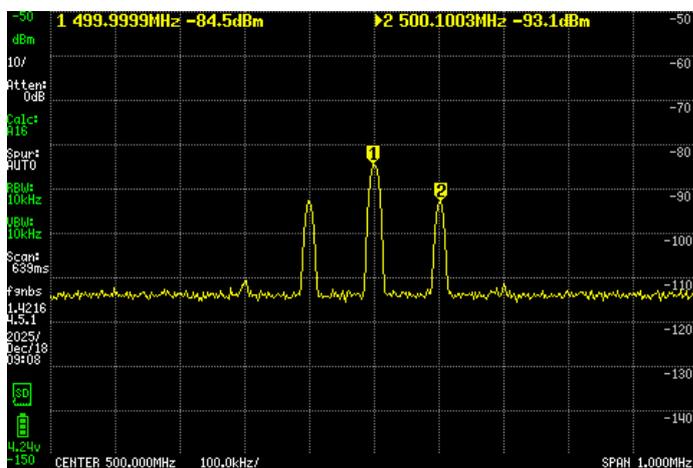
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
1000	1	-100	1000	1000.250	1	1.0	Average 16
Meas. 2.9	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	Low level spurious signals are visible in the TinySA Ultra measurements. The difference in Peak marker readings is 1.8 dB.		
TinySA Ultra	-50.0 dBm	29 s	-103.6 dBm	-118.4 dBm			
FPL1003	-50.0 dBm	13 ms	-105.4 dBm	-118.6 dBm			



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Table 2.10 ~ Amplitude modulated carrier

CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW W	Trace	Mod.
500	1	-80	500	500.100	1	1.0	Average 16	AM, 100 kHz, 90%
Meas. 2.10	Ref Level	Sweep time	CXR Mrkr	SB Mrkr	Note: The calculated sideband level relative to the carrier for AM with modulation index of 90% is -7 dB. The difference in Peak marker readings is 0.1 dB and sideband readings is 0.5 dB.			
TinySA	-50 dBm	633 ms	-84.5 dBm	-93.1 dBm				
Ultra	-50 dBm	6 ms	-84.6 dBm	-92.6 dBm				



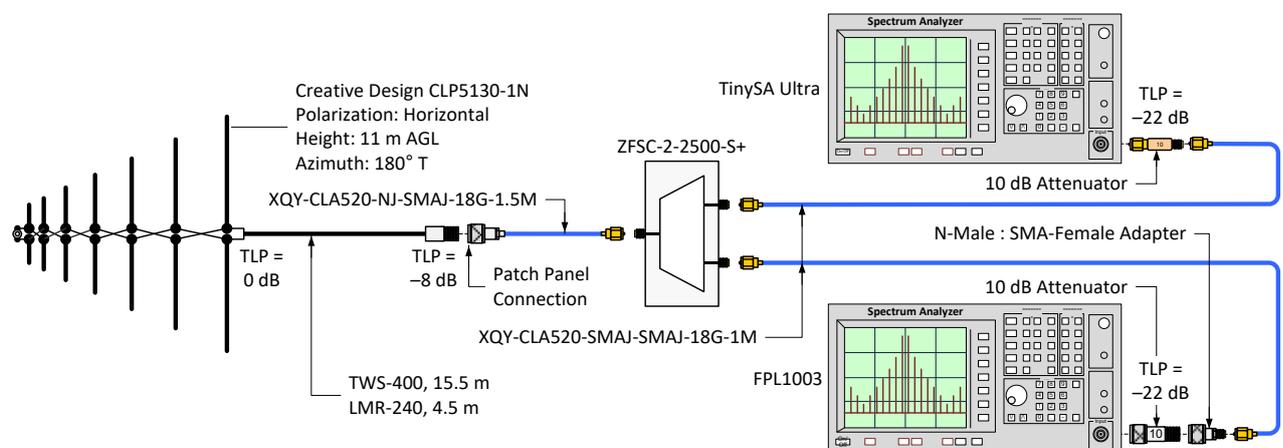
06:04:53 PM 12/18/2025

Measurement Set No. 3: Live FM broadcast band signals

Settings: These measurements are similar to analyzer measurements described in {Reeve20a} and {Reeve20b} except those articles focused on filters. For the present measurements, the TinySA Ultra already was in the Ultra mode and it was left there even though not necessary. Two measurements were made, and the specific settings and results are listed in tables 3.1 and 3.2 below.

Connections: See connection diagram below (figure 3.1). The antenna was connected to the two analyzers through the same splitter and attenuators used in Measurement Set No. 2.

Figure 3.1 ~ Connection diagram for Measurement Set No. 3. The horizontally polarized log periodic dipole array (LPDA) antenna is connected through a 4-Way splitter (not shown) to a Patch Panel. The antenna signals are attenuated by the feedline and splitter, and the transmission level point (TLP) at the Patch Panel is approximately -8 dB with respect to the antenna. The measurement splitter, associated cables and input attenuators introduce approximately additional 14 dB loss, reducing the TLP at the analyzers to about -22 dB.



Frequencies: Initial exploratory measurements were from 88 to 108 MHz, the frequency range of the FM band in the USA. Additional measurements focused on the 92.1 MHz station KBBO, which is about 18 miles east-northeast of the Anchorage Radio Observatory where these measurements were made. This station was arbitrarily chosen and was not in the main beam of the antenna.

Signal levels: The initial measurements indicated additional external attenuation was not needed to avoid analyzer front-end overload, but I left the 10 dB attenuators on the analyzer inputs anyway. The antenna does not have a low noise amplifier and neither the TinySA Ultra LNA nor the FPL1003 preamplifier was used.

Resolution bandwidth filters: Measurements of the entire FM band were made with the RBW set to 100 kHz and of the individual station with it set to 3 kHz.

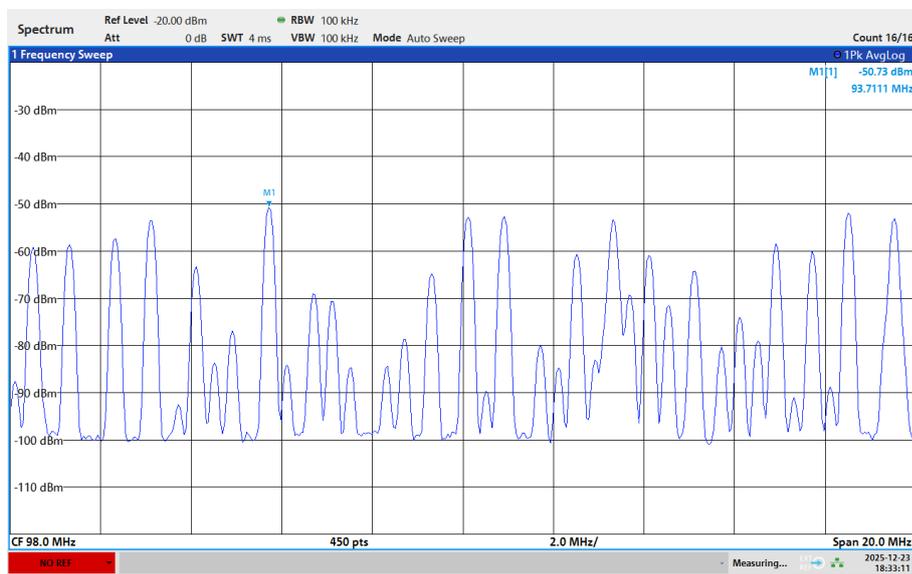
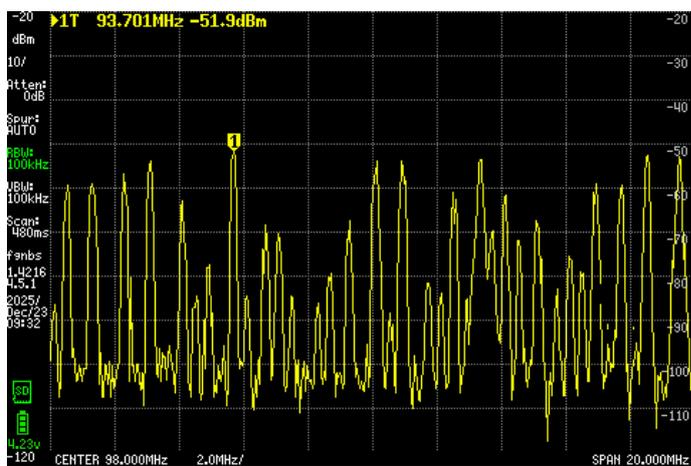
Measurement results: See table 3.1 and 3.2. Note: The analyzer was temporarily disconnected from the 10 MHz Reference Frequency source and moved from the lab, which produced a warning in the lower-left corner of the FPL1003 plots. Two traces were used in both analyzers, one set to Average and the other to Max Hold. After a few minutes, the Max hold trace shows a relatively smooth modulation

envelope over that time interval. The envelope changes with program content (music, voice, and so on).

I did not specifically measure FM deviation but an estimate of it can be derived from the plots. FM broadcast channels are 200 kHz wide, and a frequency deviation of $\pm 75\text{kHz}$ is defined as 100% modulation. Federal Communications Commission regulations require that at $\pm 120\text{ kHz}$ from the center frequency, the transmitted signal must be -25 dBc or lower [47 CFR 73.317(b)]. Both plots in Measurement 3.2 appear to show a signal meeting this requirement. Markers could have been used for this purpose.

Table 3.1 ~ 20 MHz frequency span

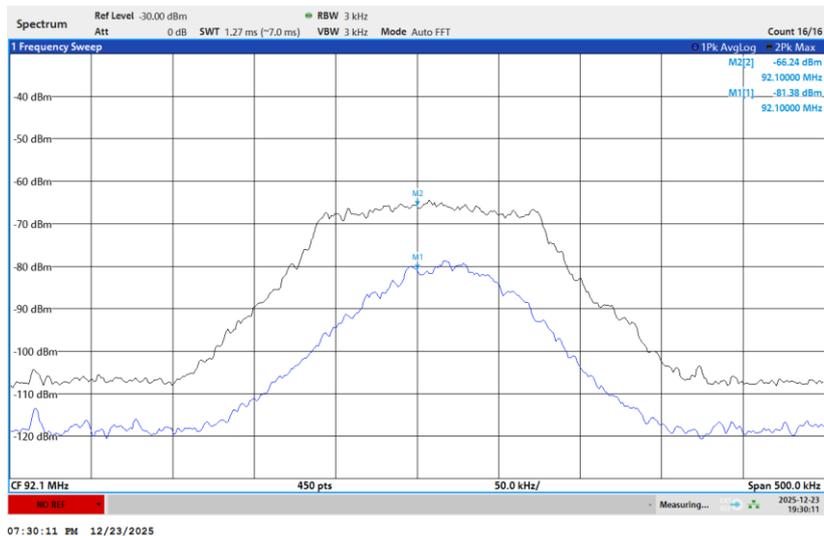
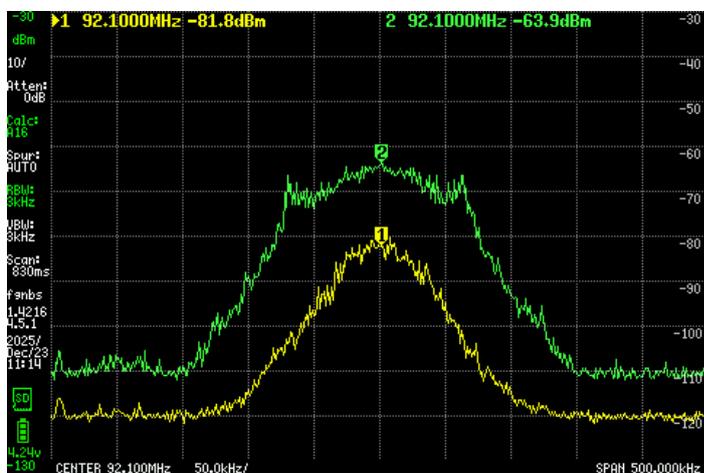
CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
98	20	Live	93.7	N/A	100	1.0	Average 16
Meas. 3.1	Ref Level	Sweep time	Peak Mrkr	Floor Mrkr	The difference in Peak marker readings is 1.2 dB. but signal levels were variable and not measured at exactly the same time.		
TinySA Ultra	-20 dBm	480 ms	-51.9 dBm	N/A			
FPL1003	-20 dBm	4 ms	-50.7 dBm	N/A			



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Table 3.2 ~ 500 kHz frequency span

CF (MHz)	Span (MHz)	Input (dBm)	Mrkr 1 (MHz)	Mrkr 2 (MHz)	RBW (kHz)	RBW/VBW	Trace
92.1	0.500	Live	92.1	92.1	3	1.0	Average 16 & Max Hold
Meas. 3.2	Ref Level	Sweep time	Peak Mrkr1	Peak Mrkr2	The difference in Peak marker 1 readings is 0.4 dB and Peak marker 2 is 2.3 dB. Note horns in spectra at ±60 kHz from center frequency in the Max Hold traces.		
TinySA Ultra	-30 dBm	830 ms	-81.0 dBm	-63.9 dBm			
FPL1003	-30 dBm	7 ms	-81.4 dBm	-66.2 dBm			



4. Summary

The TinySA Ultra RF power measurements at the frequencies and under the conditions described above are nearly the same as the FPL1003 measurements. The differences appear to be mostly within the accuracy bounds of the two analyzers. Repeatability of the TinySA Ultra was not as good as the FPL1003 but still quite good considering the relative cost of the smaller analyzer.

The results in Measurement Set No. 1 show the improvements that a low noise preamplifier has on the DANL. The TinySA Ultra DANL measurements with the LNA turned On were consistently optimistic but apparently within the specified accuracy. Noise marker measurements of the DANL should yield very close to the same value regardless of RBW and reasonable span settings, but the TinySA Ultra DANLs varied up to a couple dB. On the other hand, the FPL1003 DANL measurements with a Noise Marker were consistent across all settings tried.

The results in Measurement Set No. 2 were remarkably similar considering the vast difference in the design of the two analyzers. Although the measurements were relatively simple and not very demanding, they represent common spectrum analyzer applications.

Measurement Set No. 3 indicates that, for a span of 20 MHz, the spectra are identical. However, when viewing a single station with the Max Hold trace, the TinySA Ultra's trace noise is much higher than the FPL1003. The FM broadcast station spectra normally smooths out with a Max Hold trace run for several minutes. Both analyzers showed interesting horns about ± 60 kHz from the station center frequency, slightly more pronounced in the TinySA Ultra plot, but these would come and go depending on the mostly music broadcast content of the station KBBO.

With respect to these limited measurements, perhaps the most significant difference between the TinySA Ultra and FPL1003 was the sweep time. The FPL1003 was consistently a couple orders of magnitude faster than the TinySA Ultra for the signal measurements and three orders of magnitude faster for the DANL measurements. The faster sweep times of the FPL1003 provide a huge advantage when trying to capture intermittent and short-duration signals. The FPL1003 is not advertised as a real-time spectrum analyzer but it has many features of one, especially at lower resolution bandwidths as seen in these measurements.

5. References

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- {Reeve20b} Reeve, W., Basic Filters and Applications, 2020. Available at: https://www.reeve.com/Documents/Articles%20Papers/Reeve_BasicFilters.pdf
- {Reeve25} Reeve, W., TinySA Ultra Spectrum Analyzer Trace Detectors & Bandwidth Settings, 2025. Available at: https://www.reeve.com/Documents/Articles%20Papers/Reeve_TinySA-Trace.pdf

{R&S-FPL} FPL-series Spectrum Analyzers: https://www.rohde-schwarz.com/us/products/test-and-measurement/benchtop-analyzers/fpl-spectrum-analyzer_63493-465280.html

TinySA Ultra weblinks:

- ⚙️ TinySA on groups.io: <https://groups.io/g/tinysa>
- ⚙️ TinySA Wiki: <https://tinysa.org/wiki/>
- ⚙️ TinyRemote screenshot software tool: <http://athome.kaashoek.com/tinySA4/Remote/>
- ⚙️ TinySA-App software application: <http://athome.kaashoek.com/tinySA/Windows/>
- ⚙️ TinySA on YouTube:
<https://www.youtube.com/playlist?list=PL5ZELMM2xseNkwVBtyAG00uZevwWUdVIg>
- ⚙️ Description of TinySA a real Spectrum Analyzer for little money, Kurt Poulsen, 2020:
https://www.hamcom.dk/TinySA/Description_of_TinySA_a_real_Spectrum_Analyzer_for_little_money.pdf

Observation Reports

Observations of G09.621+0.19 variability in the 6.7 GHz methanol line

by Dimitry Fedorov UA3AVR

This observation report is about the 6.7 GHz methanol radiation from G09.621+0.196 detected in the period from August 2021 to December 2023 with a small single dish radio telescope 2.4 m. This line corresponds to the molecular transition $5_1 \rightarrow 6_0$, A⁺ methanol molecule type, its accurate frequency 6668.5192 MHz [1]. This radiation from this object has a maser amplification; the maser belongs to class II, i.e. it is pumped to the inverse state by the infrared radiation from the hot dust. The object is located in southern celestial hemisphere, RA 18:6:14, DEC -20:31:33 (J2000), and is seen from the observation site [55°46'00.5"N 37°49'25.8"E](#) with low elevations (up to 14° over the horizon). This is the strongest 6.7 GHz maser in the Galaxy and occupies top 1st position in the list of brightest masers 6.7 GHz by Eduard Mol [2].

More info about the object and its 6.7 GHz radiation

The object is classified as a High-mass star forming region (HMSFR) [3], has an estimated clump mass $\sim 2800 M_{\odot}$, a luminosity of $\sim (1.7 \pm 0.1) \times 10^6 L_{\odot}$, a mean density of $\sim (9.1 \pm 0.7) \times 10^4 \text{ cm}^{-3}$, a distance to 5.2 kpc [4]. This object includes the G9.62+0.20E ultra-compact HII region supposedly excited by a B1 type star $\sim 12 M_{\odot}$, which hosts the standout methanol activity with the maser amplification [4]. The model in [3] suggests a best-fitting rotating Keplerian disc with a central mass of $\sim 12 M_{\odot}$ for explaining the velocity drifts.

A typical 6.7 GHz spectrum from database [5] is shown at Figure 1, left. There are two lines (features) in the spectrum with different brightness (4000-6000 Jy and about 1000 Jy); they are positively correlated usually. The data shows a limited variability of the maser, see a time plot for distinguished features at Figure 1 (right); periodic rises (flares) in the brightness up to 1000-2000 Jy are seen. Figure 1, right notes a multiplicity of distinguished features, but only two of them mentioned above dominate significantly and well seen on the spectra.

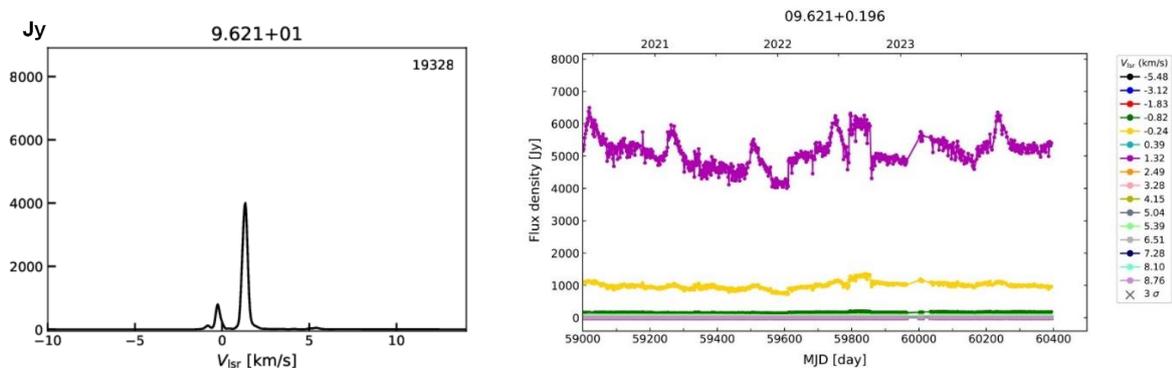


Figure 1. Ibaraki iMet data for G09.621+0.196 [5]: left – a typical spectrum, right – peak flux densities for lines (features) of the maser.

The source with maser amplification belongs to class II; the methanol cloud is excited and pumped by the infrared radiation from the dust heated in turn by the embedded star population. Evidences of excitation infrared spots from the object location in a wide wavelength range are shown on Figure 2.

The radiation of short mm-waves could excite the methanol molecules as well as shorter wavelengths radiation. Presence of short wavelength infrared spots indicates how hot the exciting dust is.

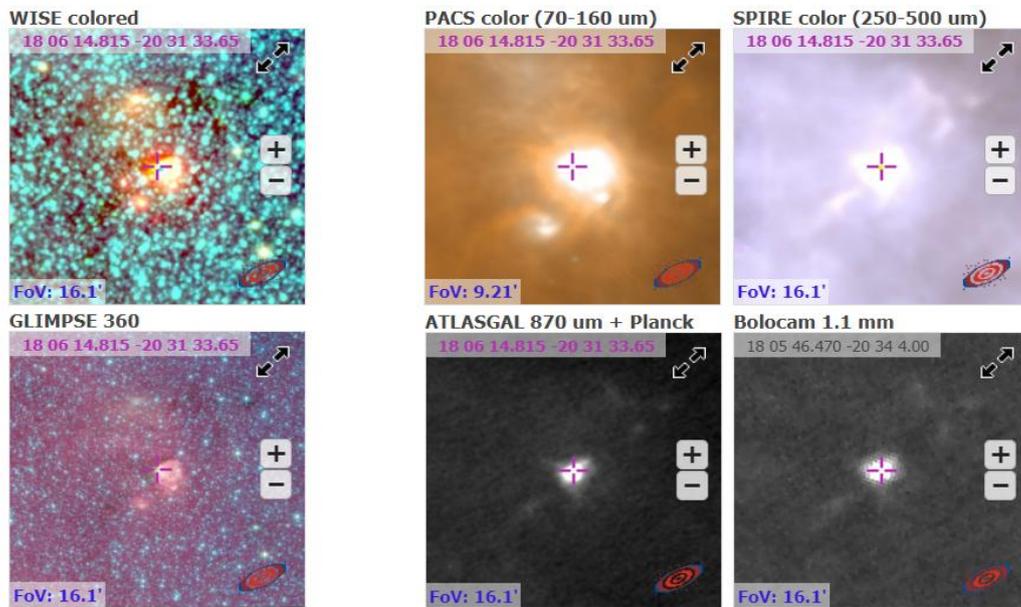


Figure 2. Seen radiation spots in the G09.621+0.196 location [6]; left – short wavelength infrared (WISE – up to 22 μm , GLIMPSE – up to 8 μm), right spots – long wave infrared, sub mm-waves, and short mm-waves.

Instrumentation

Observations at 6.7 GHz were made using 2.4 m small single dish telescope, see Figure 3.



Figure 3. 2.4 m dish mounted on the roof of apartment building ([55°46'00.5"N 37°49'25.8"E](#)) with 6.7 GHz RX downconverter at the focus. The dish was designed by Sergei Zhutyaev RW3BP for mm-waves initially.

Parameters of the telescope are collected in Table 1. Parameters SEFD, η_A and Γ were estimated by solar measurements according [7]; $T_{\text{sys}} = 110\text{-}120$ K obtained from Y-factor Moon measurements [8] and known receiver Noise Figure and estimated spillover.

The source is tracked during all the integration time (with F1EHN software).

6.7 GHz feed-horn in the dish focus has a linear polarization. The outdoor downconverter nearby the feed-horn uses Terrasat 6.4-7.1 GHz RX module (LO 5.7 GHz) + LNA (NF=1.2 dB). Indoor IF receiver uses SDR USRP B200mini, total receiver bandwidth – 0.75 MHz. The indoor IF receiver is controlled using LabVIEW software with on-fly averaging of spectra (no intermediate data are stored), see more details about IF receiver and post-processing procedures in [9].

Table 1. Parameters of the telescope and parameters of present observations.

Dish diameter	D	2.4 m
Half Power Beam Width	HPBW	1.3°
Aperture Efficiency	η_A	0.65
System Temperature	T_{sys}	110-120 K
Forward Gain (dish sensitivity)	Γ	0.001 K/Jy
System Equivalent Flux Density ($=T_{\text{sys}}/\Gamma$)	SEFD	1.13×10^5 Jy
Resolution Bandwidth	RBW	2.5 kHz
Resolution in velocities		< 0.15 km/s
Integration Time	Δt	1 hour
Minimal Detectable Peak Flux Density (max level of background noise peaks)	F_{peak}	≈ 113 Jy

Observed spectra and comments

Observed spectra are shown on a 3D plot Figure 4.

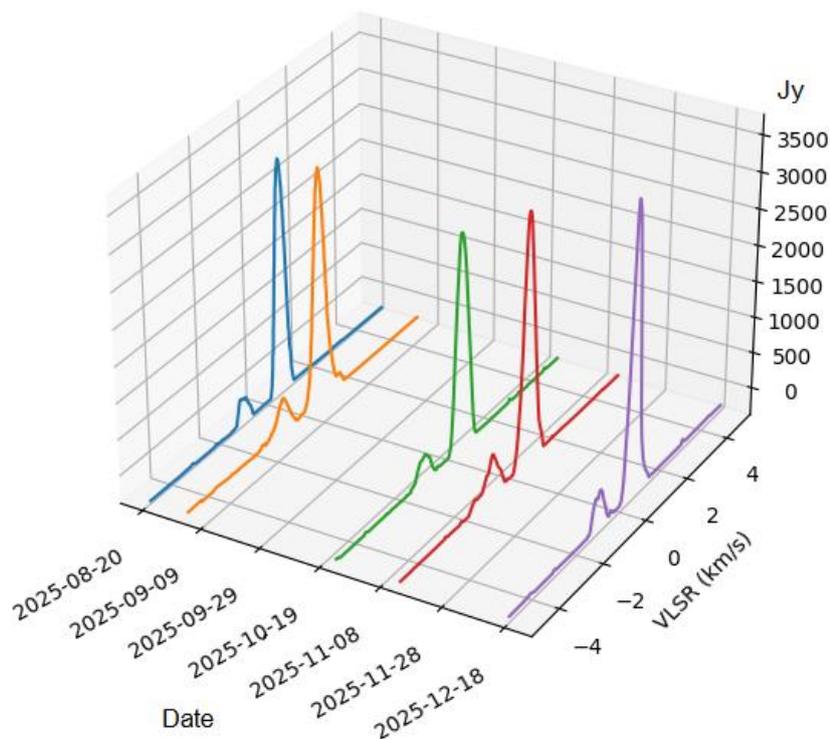


Figure 4. Observed spectra from G09.621+0.196 in 6.7 GHz methanol line August-December 2025.

The variability of the maser peak levels is consistent with that expected from the iMet data (see [5] and Fig. 1, right). Systematically lower detected levels in comparison to the iMet data [5] could be explained by polarization effects. The plot picture Figure 4 was drawn with ChatGPT 5.2.

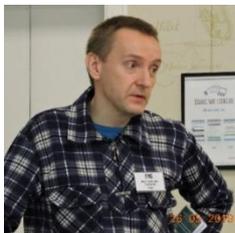
Acknowledgments and other notes

Many thanks to Sergey Zhutyaev RW3BP for access to the dish and valuable help in the observations. A part of review data in the report was prepared using ChatGPT 5.2.

References

- [1] H.S.P. Mueller et al, *Accurate rest frequencies of methanol maser and dark cloud lines*, [arXiv:astro-ph/0408094](https://arxiv.org/abs/astro-ph/0408094) (2004).
- [2] Eduard Mol, *Catalogue of the brightest astrophysical maser sources*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers, March – April 2023, page 90.
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- [9] D. Fedorov UA3AVR, *Methanol maser lines 12 GHz observations*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers, September – October 2022, page 71; D. Fedorov UA3AVR, *Notes on building a maser receiver*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers, March – April 2024, p. 71; D. Fedorov UA3AVR, *Antenna unit for 6.7 GHz methanol maser telescope*, Radio Astronomy, Journal of the Society of Amateur Radio Astronomers, May – June 2024, p. 89.

About the author



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

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Paris, 06 January 2026

Bulletin C 71

To authorities responsible for the measurement and distribution of time

INFORMATION ON UTC - TAI

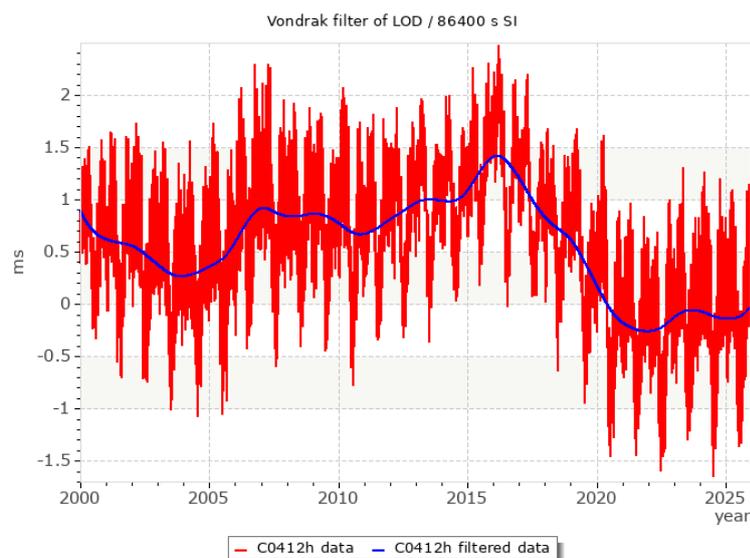
NO leap second will be introduced at the end of June 2026. The difference between Coordinated Universal Time UTC and the International Atomic Time TAI is :

from 2017 January 1, 0h UTC, until further notice : $UTC-TAI = -37 \text{ s}$

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

Christian BIZOUARD

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



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SARA Conferences

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

What is Radio Astronomy?

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

Do I need a big dish and expensive equipment?

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

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

Is everything 'plug and play' and boring?

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

What is SETI?

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

What should I do to get started?

You should start with reading our [Introduction to Radio Astronomy](#) and joining our online [SARA Forum](#). Look at the [SARA store](#) to get a project to get your feet wet without much expense and minimal risk. We will work with you so you can succeed.

Administrative

Officers, directors, and additional SARA contacts

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

President: Dr. Rich Russel, AC0UB, <https://www.radio-astronomy.org/contact/President>

Vice President: Marcus Fisher, <https://www.radio-astronomy.org/contact/Vicepresident>

Secretary: Brian O'Rourke, <https://www.radio-astronomy.org/contact/Secretary>

Treasurer: Tom Jacobs, <https://www.radio-astronomy.org/contact/Treasurer>

Past President: Dennis Farr (Acting Treasurer)

Founder Emeritus and Director: Jeffrey M. Lichtman, KI4GIY, jeff@radioastronomysupplies.com

Board of Directors

Name	Term expires	Email
Ted Cline	2027	TedClineGit@gmail.com
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Steve Tzikas	2026	Tzikas@alum.rpi.edu
Jay Wilson	2026	jwilson@radio-astronomy.org

Other SARA Contacts

All Officers	http://www.radio-astronomy.org/contact-sara
All Directors and Officers	http://www.radio-astronomy.org/contact/All-Directors-and-Officers
Eastern Conference Coordinator	http://www.radio-astronomy.org/contact/Annual-Meeting
All Radio Astronomy Editors	http://www.radio-astronomy.org/contact/Newsletter-Editor

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Educational Co-Chairs	Ken Redcap, Tom Hagen: http://www.radio-astronomy.org/contact/Educational-Outreach	
Grant Committee	Tom Crowley	grants@radio-astronomy.org
Membership Chair	http://www.radio-astronomy.org/contact/Membership-Chair	
Technical Queries (David Westman)	http://www.radio-astronomy.org/contact/Technical-Queries	
Webmaster	Ciprian (Chip) Sufitchi, N2YO	webmaster@radio-astronomy.org

Resources

Great Projects to Get Started in Radio Astronomy

Radio Observing Program

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

Categories include.

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

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

For more information:

Steve Boerner

2017 Lake Clay Drive

Chesterfield, MO 63017

Email: sboerner@charter.net

Phone: 636-537-2495

<http://www.astroleague.org/programs/radio-astronomy-observing-program>

Radio Jove



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

INSPIRE Program



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

<http://theinspireproject.org/default.asp?contentID=27>

SARA/Stanford SuperSID



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

supersid@radio-astronomy.org

Radio Astronomy Online Resources

SARA YouTube Videos: https://www.youtube.com/@radio-astronomy	Pisgah Astronomical Research Institute: www.pari.edu
AJ4CO Observatory – Radio Astronomy Website: http://www.aj4co.org/	A New Radio Telescope for Mexico - ORION 2021 01 20. Dr. Stan Kurtz https://www.youtube.com/watch?v=Q9aBWr1aBVc
Radio Astronomy calculators https://www.aj4co.org/Calculators/Calculators.html	National Radio Astronomy Observatory http://www.nrao.edu
Introduction to Amateur Radio Astronomy (presentation) http://www.aj4co.org/Publications/Intro%20to%20Amateur%20Radio%20Astronomy,%20Typinski%20(AAC,%202016)%20v2.pdf	Exotic Ions and Molecules in Interstellar Space -- ORION 2020 10 21. Dr. Bob Compton https://www.youtube.com/watch?v=r6cKhp23SUo&t=5s
RF Associates Richard Flagg, rf@hawaii.rr.com 1721-1 Young Street, Honolulu, HI 96826	The Radio JOVE Project & NASA Citizen Science – ORION 2020.6.17. Dr. Chuck Higgins https://www.youtube.com/watch?v=s6eWAXJywp8&t=5s
RFSpace, Inc. http://www.rfspace.com	UK Radio Astronomy Association: UK Radio Astronomy Association (UKRAA) - Home
CALLISTO Receiver & e-CALLISTO http://www.reeve.com/Solar/e-CALLISTO/e-callisto.htm	CALLISTO software and data archive: www.e-callisto.org
Deep Space Exploration Society http://DSES.science	Radio Jove Spectrograph Users Group http://www.radiojove.net/SUG/
Deep Space Object Astrophotography Part 1 -- ORION 2021 02 17. George Sradnov https://www.youtube.com/watch?v=Pm_Rs17KlyQ	Radio Sky Publishing http://radiosky.com
European Radio Astronomy Club http://www.eraonet.org	The Arecibo Radio Telescope; It's History, Collapse, and Future - ORION 2020.12.16. Dr. Stan Kurtz, Dr. David Fields https://www.youtube.com/watch?v=rBZlPOLNX9E
British Astronomical Association – Radio Astronomy Group http://www.britastro.org/baa/	Shirleys Bay Radio Astronomy Consortium marcus@propulsionpolymers.com
Forum and Discussion Group http://groups.google.com/group/sara-list	SARA Twitter feed https://twitter.com/RadioAstronomy1
GNU Radio https://www.gnuradio.org/	SARA Web Site http://radio-astronomy.org
SETI League http://www.setileague.org	Simple Aurora Monitor: Magnetometer http://www.reeve.com/SAMDescription.htm
NRAO Essential Radio Astronomy Course http://www.cv.nrao.edu/course/astr534/ERA.shtml	Stanford Solar Center http://solar-center.stanford.edu/SID/
NASA Radio JOVE Project http://radiojove.gsfc.nasa.gov Archive: http://radiojove.net/archive.html https://groups.io/g/radio-jove	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.
Green Bank Observatory https://greenbankobservatory.org/ .	

Found an interesting Grote Reber link: <https://www.utas.edu.au/groterebmuseum> 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.

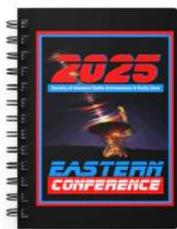
The Journal archive covers the society journal "Radio Astronomy" from the founding of the organization in 1981 through the present. Articles cover a wide range of topics including cosmic radiation, pulsars, quasars, meteor detection, solar observing, Jupiter, Radio Jove, gamma ray bursts, the Itty Bitty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





SARA Brochure

Membership Information

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

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

Name: _____
 Email Address: _____
(required for electronic Journal delivery)
 Ham call sign: _____
(if applicable)
 Address: _____
 City: _____
 State: _____
 Zip: _____
 Country: _____
 Phone: _____

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

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



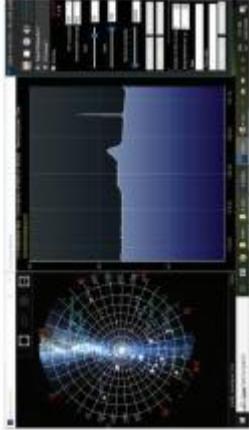
Society of Amateur Radio Astronomers, Inc.
 Founded 1981

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

**Knowledge through Common Research,
 Education and Mentoring**

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.



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.

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>

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 meetings 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 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)

