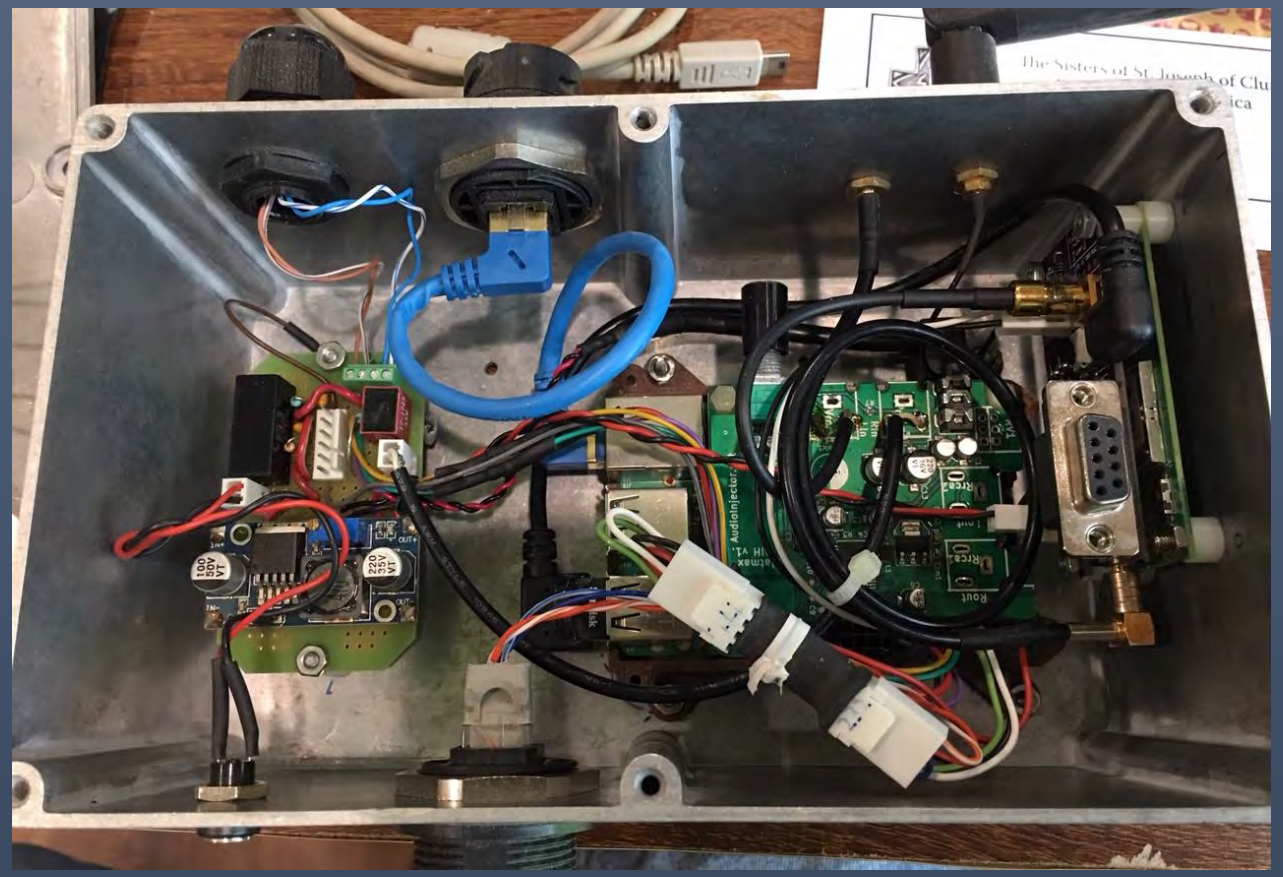
The W2NAF-KC3EEY VLF Observatory: Building Exciting New Developments from a Solid Foundation HamSCI Workshop 2024

Jonathan Rizzo
KC3EEY
jonathan.rizzo2@scranton.edu

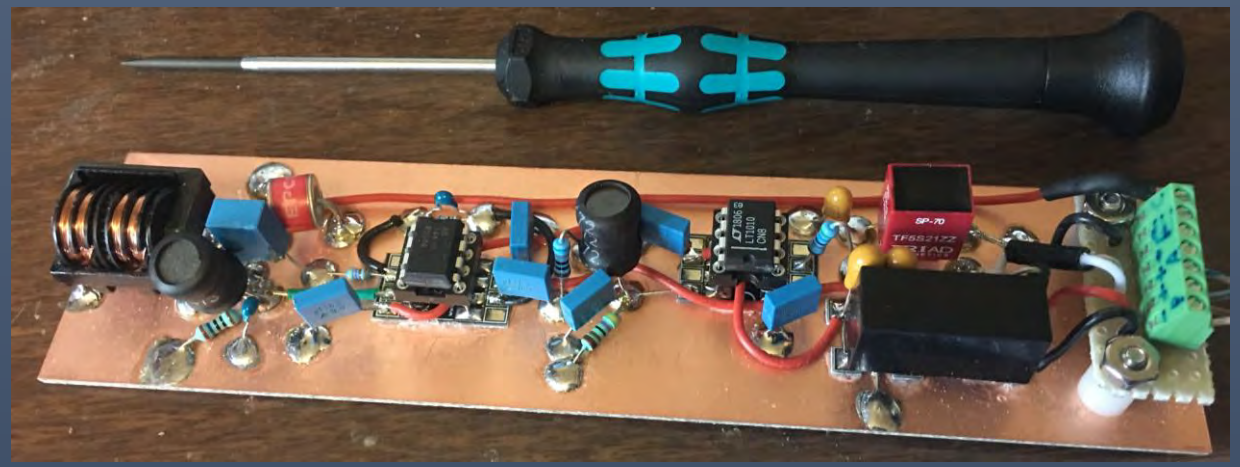
VLF Reception System

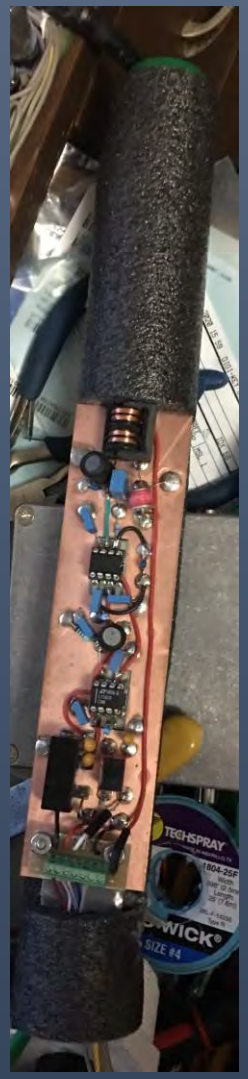
VLF Active Antenna



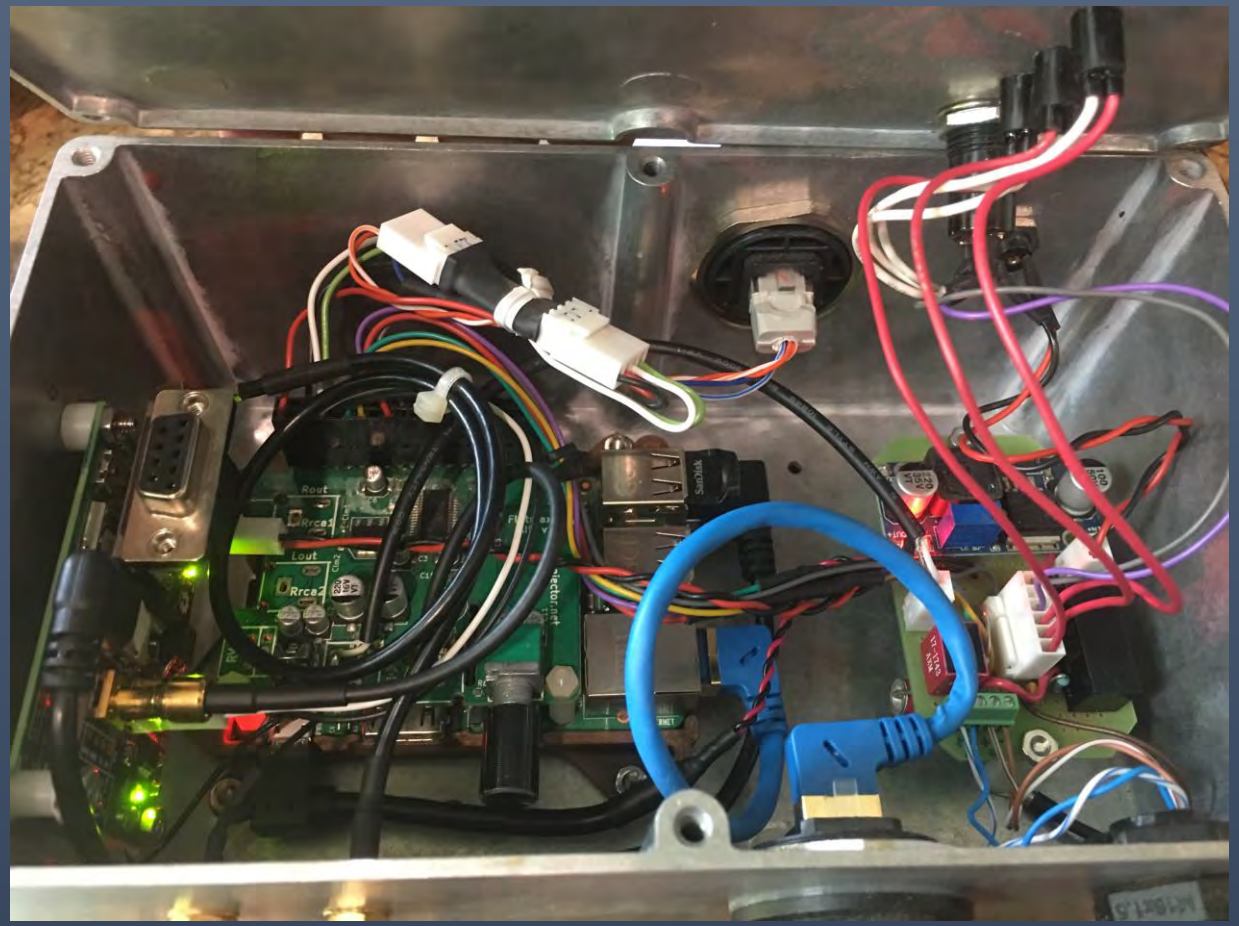
Backend Processor

VLF Active Antenna

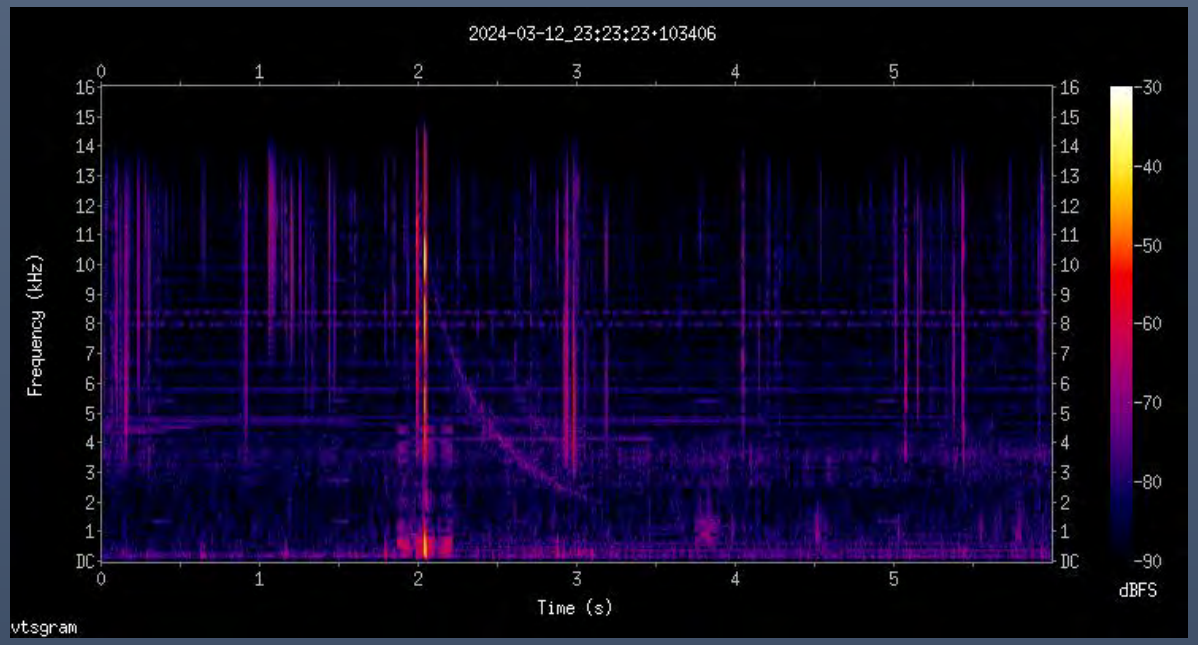


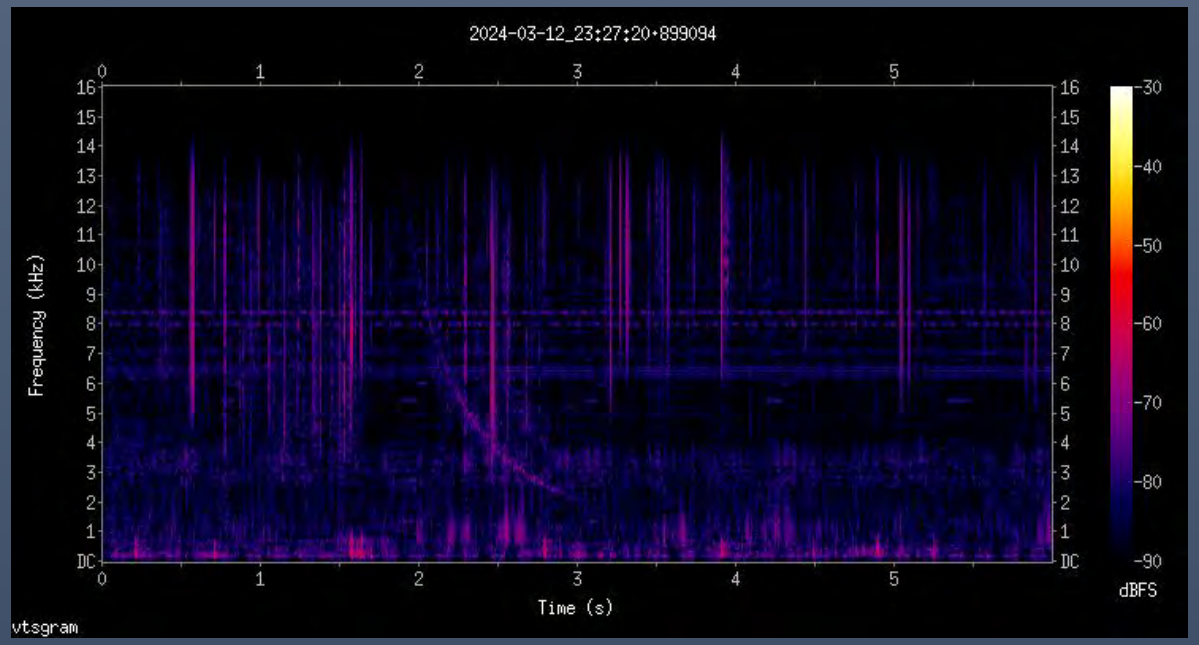


Raspberry Pi Enclosure

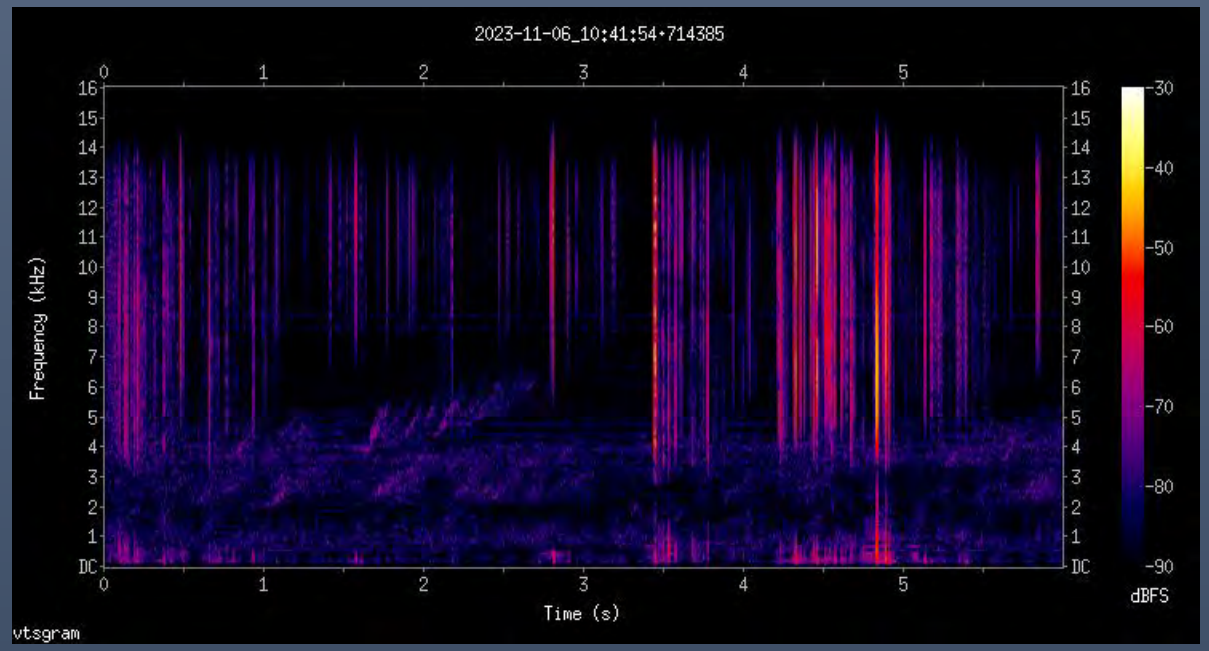


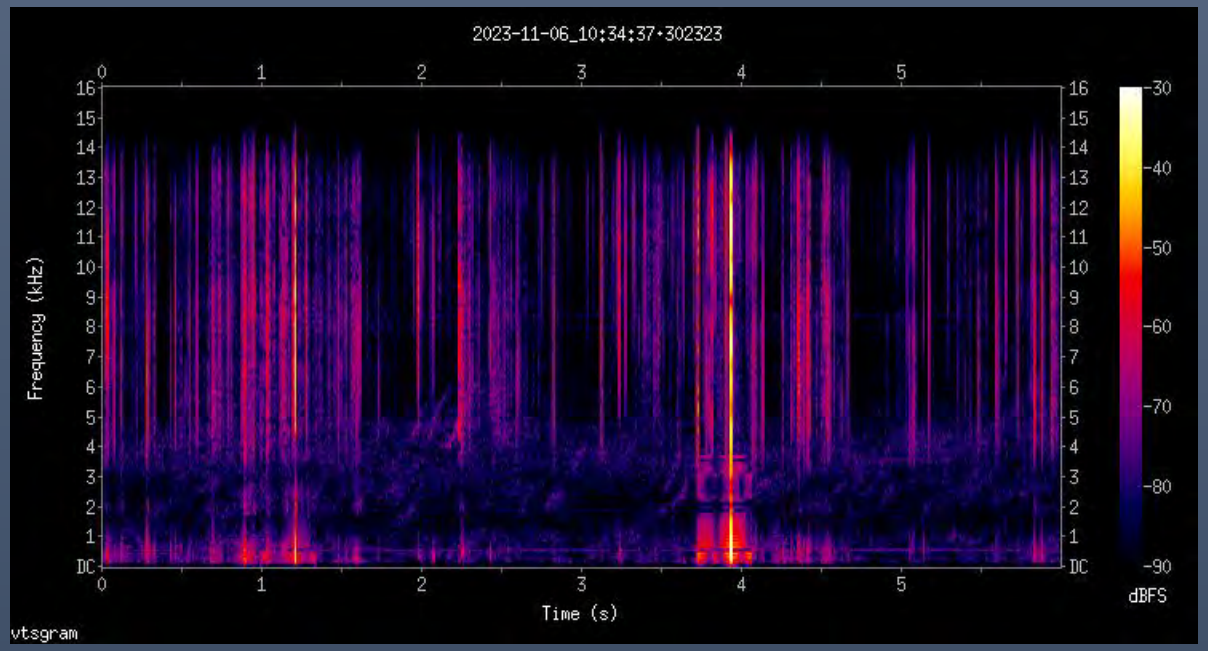
3-12-2024 Whistler Events



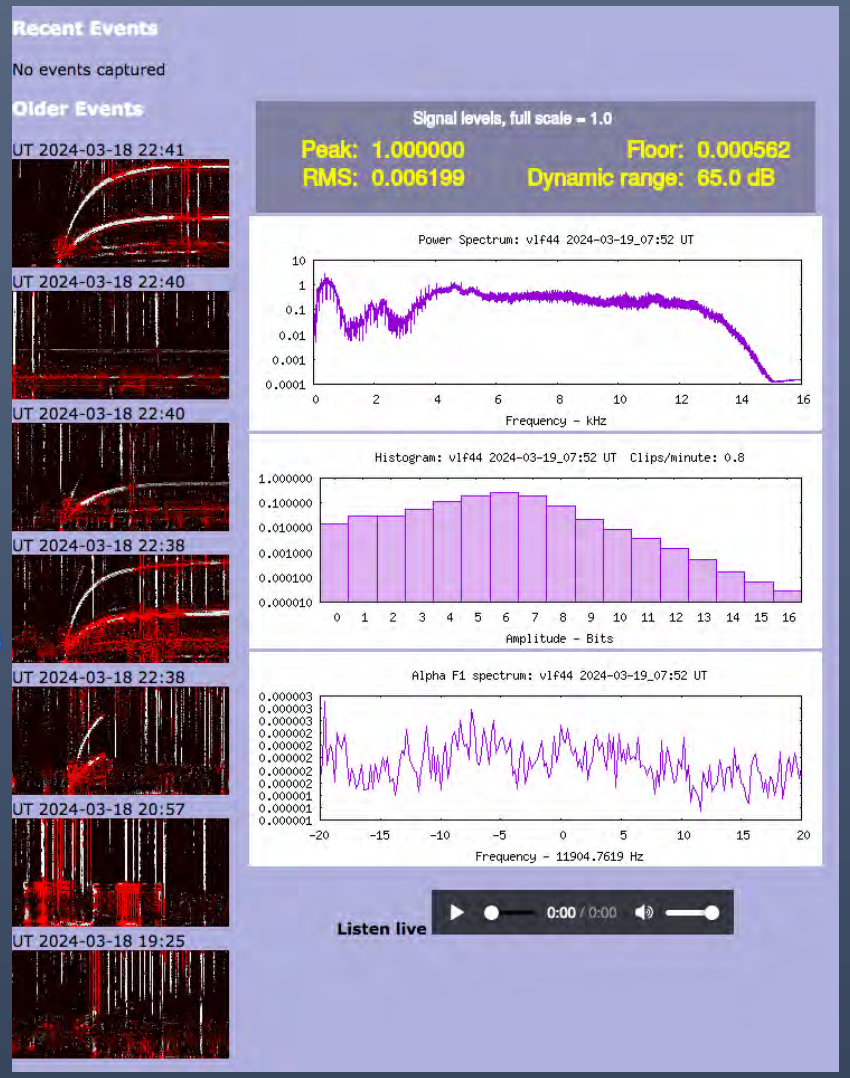


11-6-2023 Dawn Chorus Event

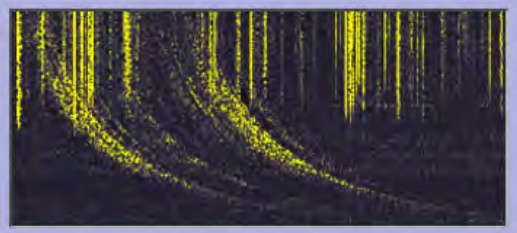




abelian.org vlf44 Data Uplink



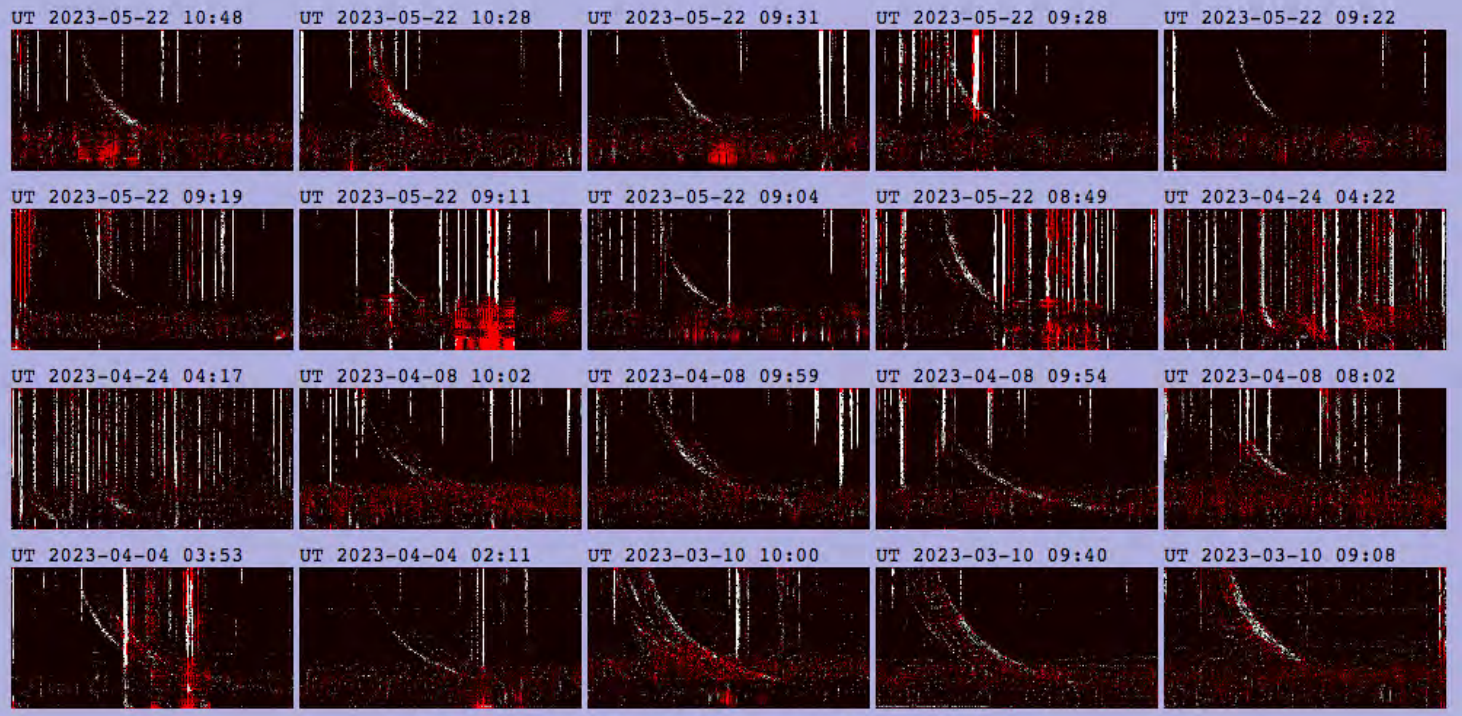
abelian.org vlf44 Data Uplink



Spring Brook Township, Pennsylvania

41.33N,75.60W *Jonathan Rizzo* Play Stream Detail Website

Event Gallery

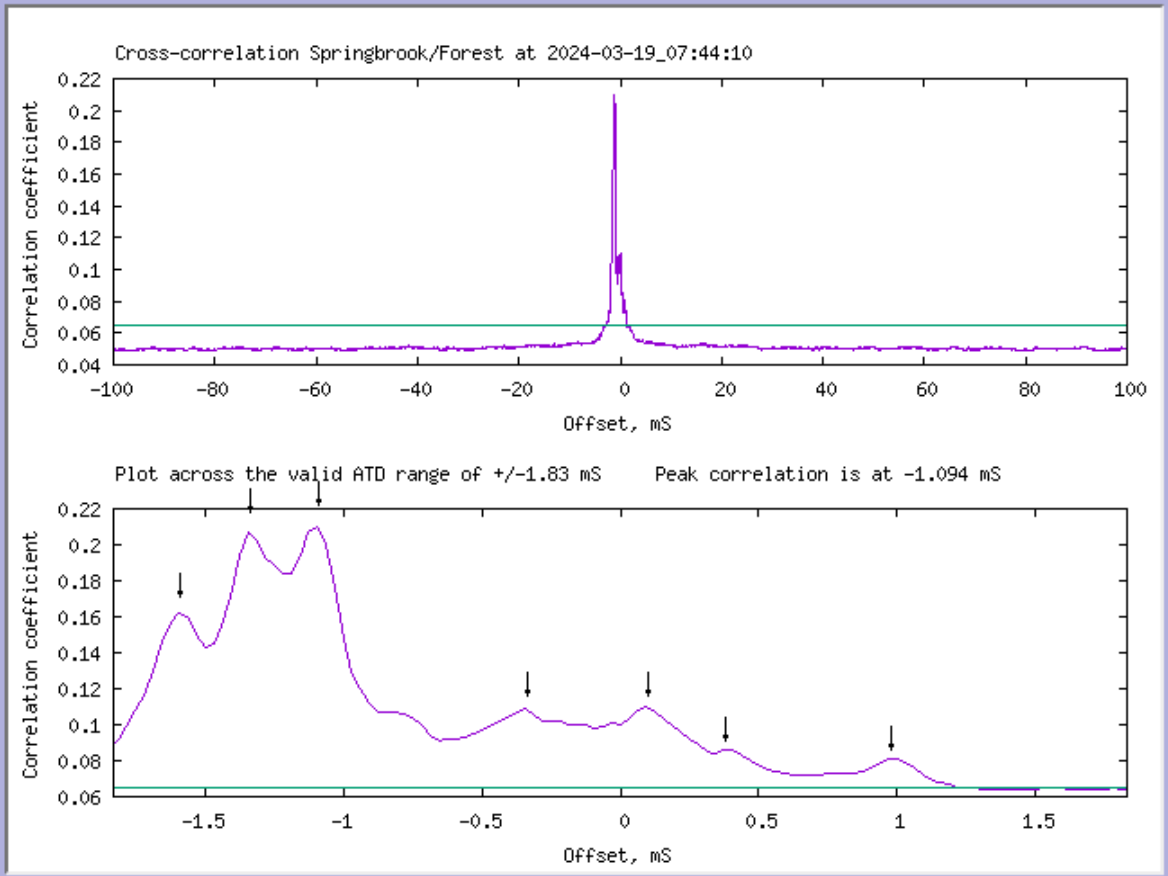


Edit events | Earlier events | Later events | Return to detail page

abelian.org vlf44 Data Uplink

Cross-correlation graphs

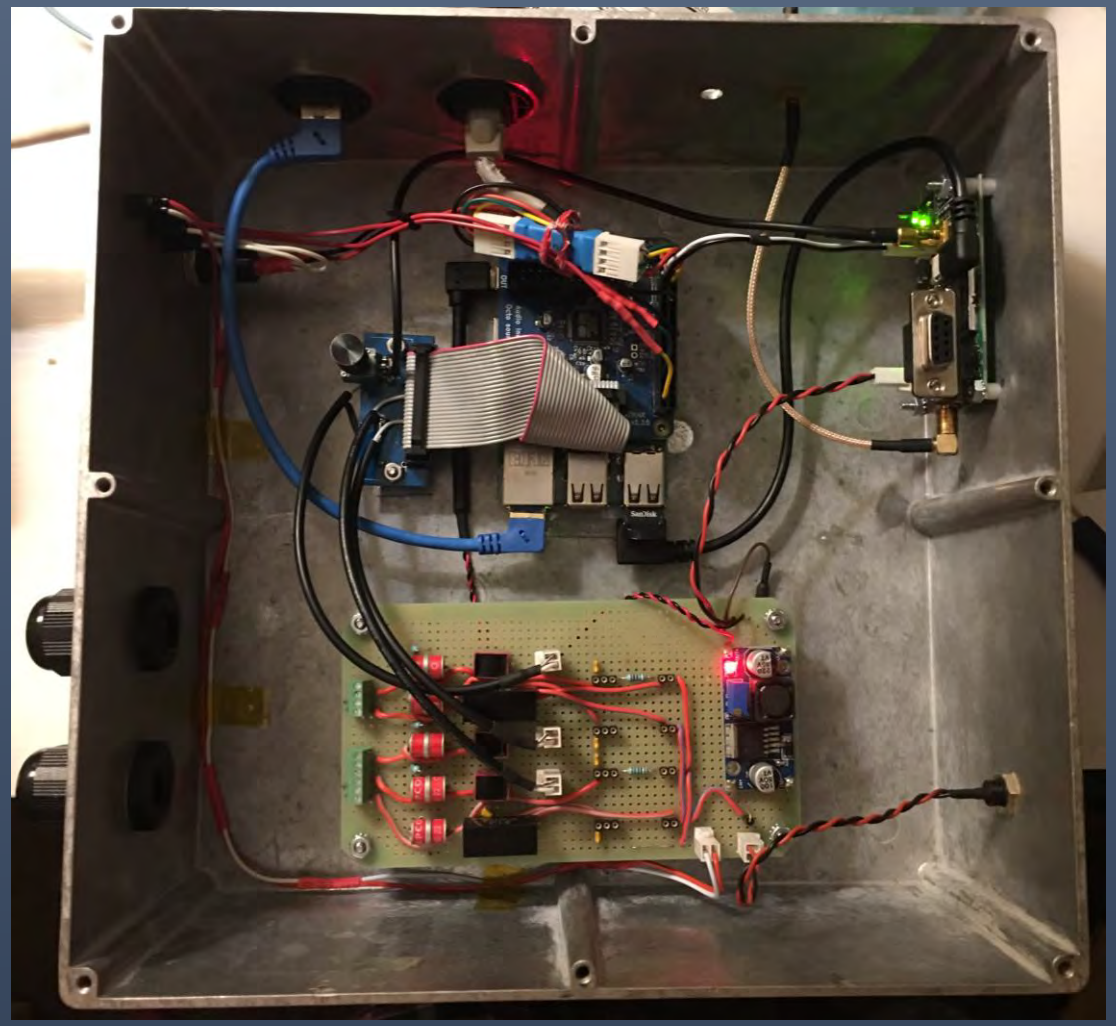
Updated every few minutes: Todmorden/Heidelberg Todmorden/Cumiana Todmorden/Forest Forest/Heidelberg Heidelberg/Cumiana Todmorden/Warsaw Springbrook/Forest

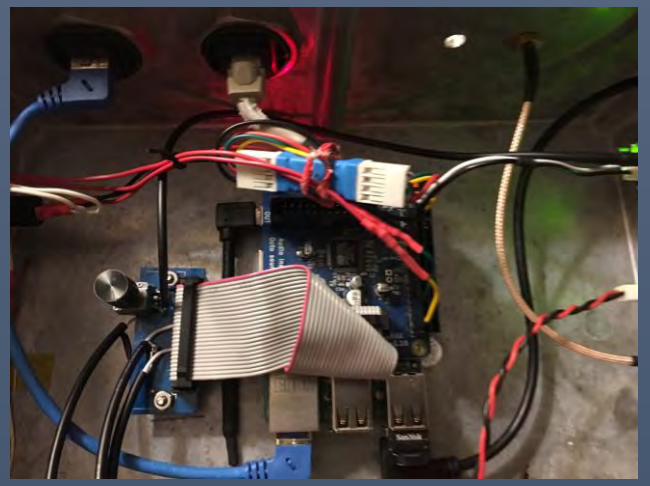


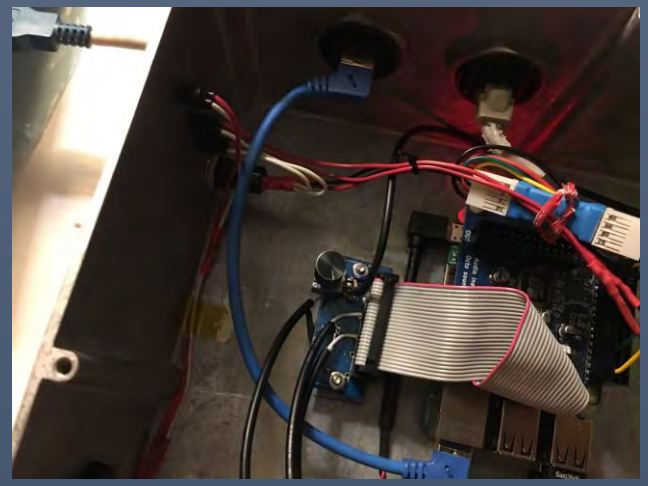
Red circles are the geomagnetic conjugates of the receiver sites.

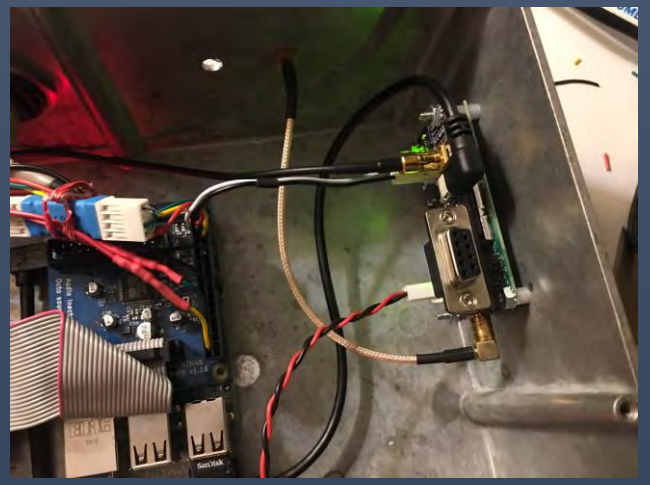
Stream	Site	Location	Operator	Conjugate	Website
vlf1	Todmorden, UK	53.703N,2.072W	Paul Nicholson	-47.014,17.072	http://abelian.org/todmorden-vlf/
vlf15	Cumiana, NW Italy	44.96N,7.42E	Renato Romero, Openlab	-30.067,14.525	http://www.vlf.it
vlf35	Forest, Virginia	37.34385N,79.28818W	Mike Smith	-60.269,-81.225	http://www.unixnut.net/efield.html
vlf38	Warsaw, Poland	52.16313N,21.03094E	Jacek Lipkowski	-42.130,35.301	https://klubnl.pl/wpr/en/
vlf39	Heathcote, Victoria	36.804163S,144.67559E	Leon Mow Radio Observatory	53.326,150.669	https://asv.org.au/ASV-Heathcote
vlf41	Heidelberg, Germany	49.443N,8.695E	Stefan Sch?fer	-38.055,20.264	http://www.iup.uni-heidelberg.de/schaefer_vlf/DK7FC_VLF_Grabber2.html
vlf44	Spring Brook Township, Pennsylvania	41.33N,75.60W	Jonathan Rizzo	-63.584,-74.699	

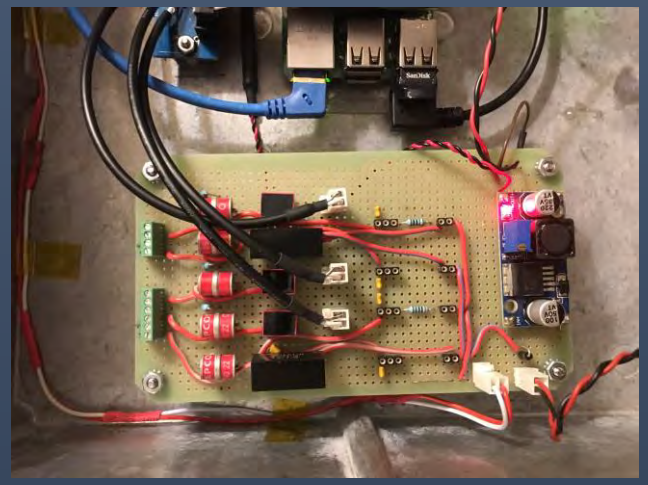
3-Channel VLF Data Acquisition System









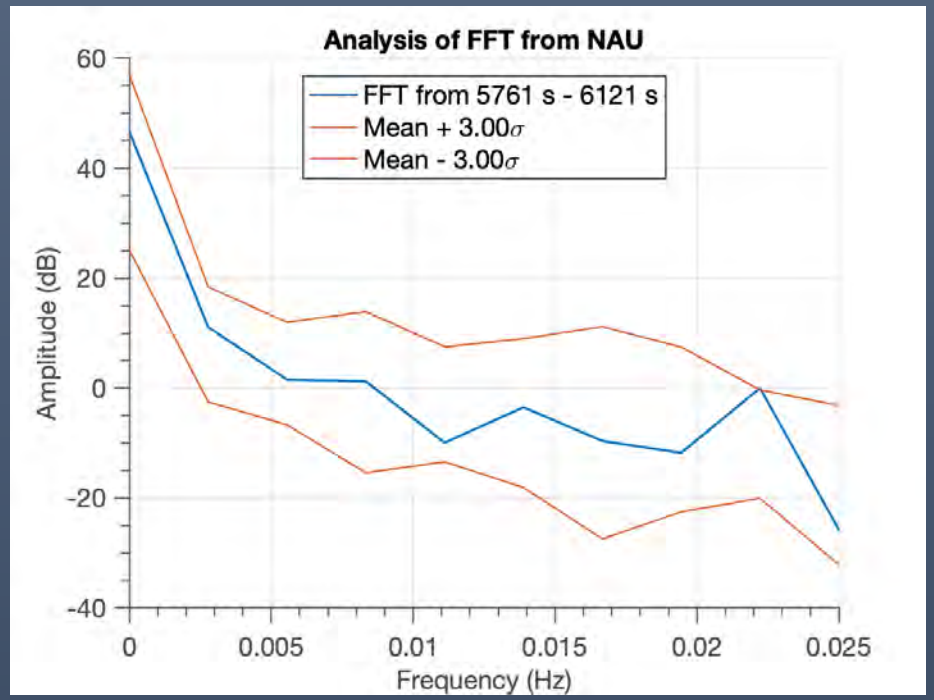


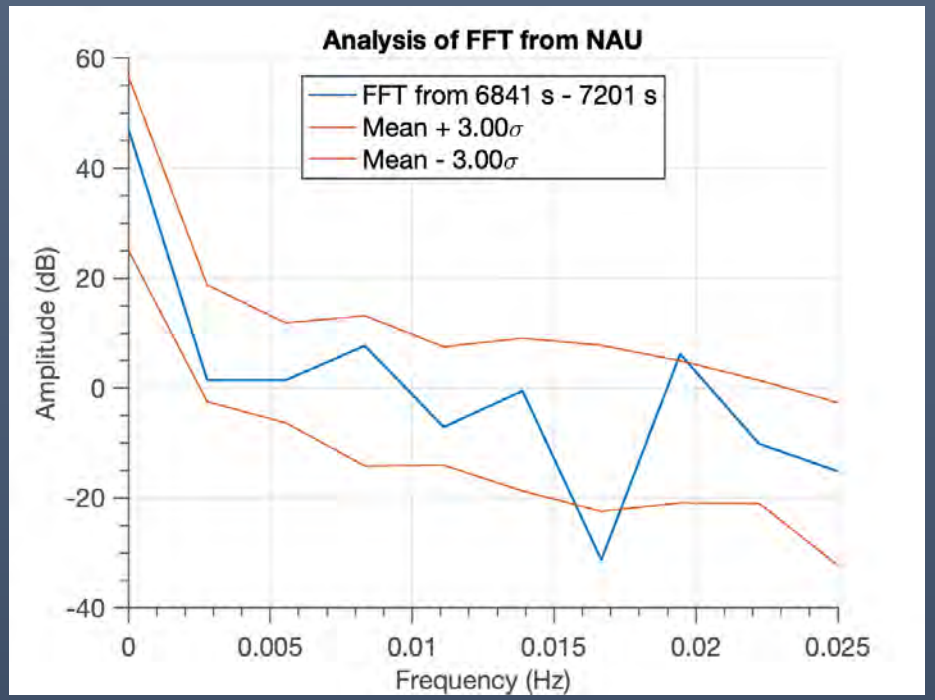
H-Field VLF Receiver

- In progress
- LT1028 frontend
- LT1010 line driver
- Two-channel for North-South and East-West loop orientations
- 24V power
- Isolated DC-DC converter and two audio isolation transformers
- 3-turn orthogonal loops using 14 AWG Romex wire
- Used in conjunction with an E-field probe VLF receiver for triple axis reception

EbNaut VLF Amateur Transmission Rig

A Possible Atmospheric Gravity Wave Observation from the Tonga Eruption

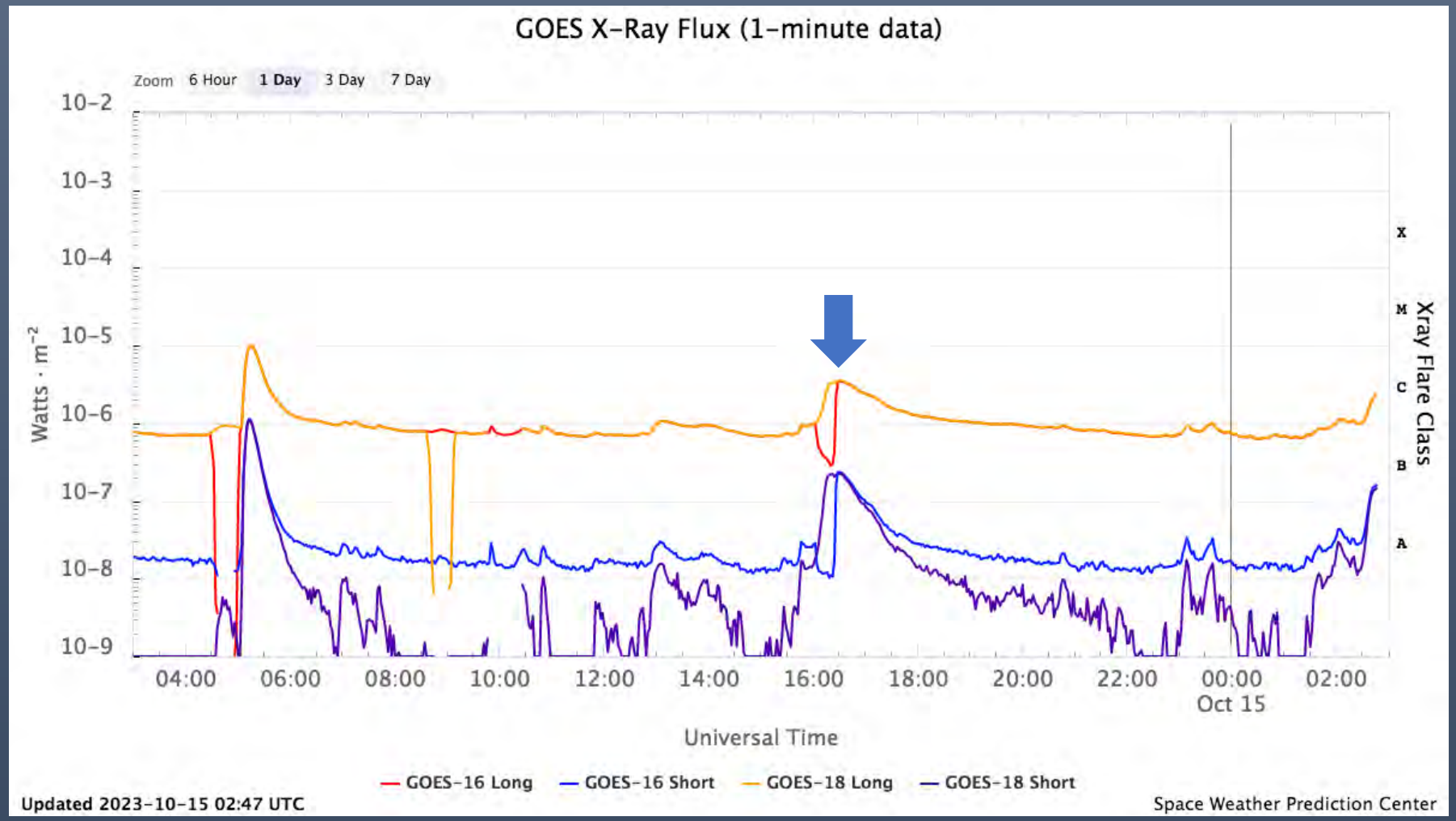




Fields	time	frequency
1	5761	0.0222
2	6841	0.0194

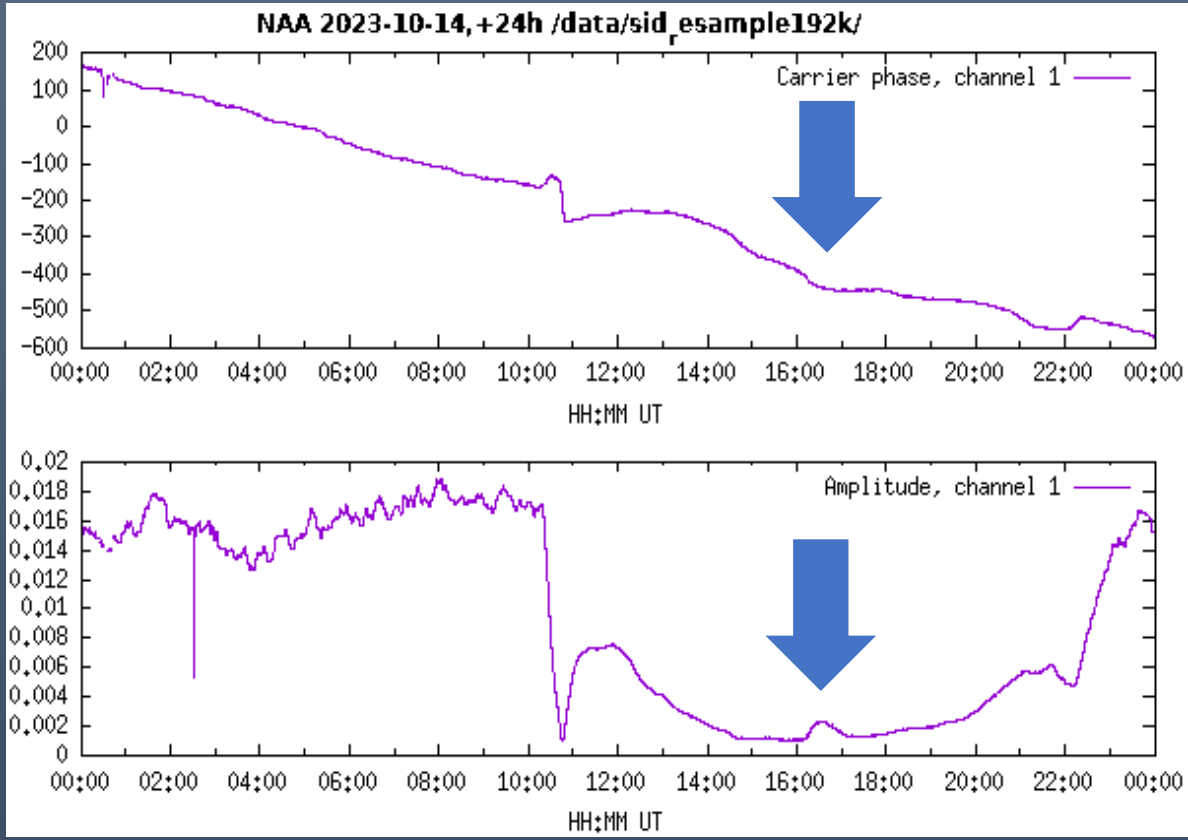
Credit to Matthew Woodward and Dr. Morris Cohen for the analysis and plots.

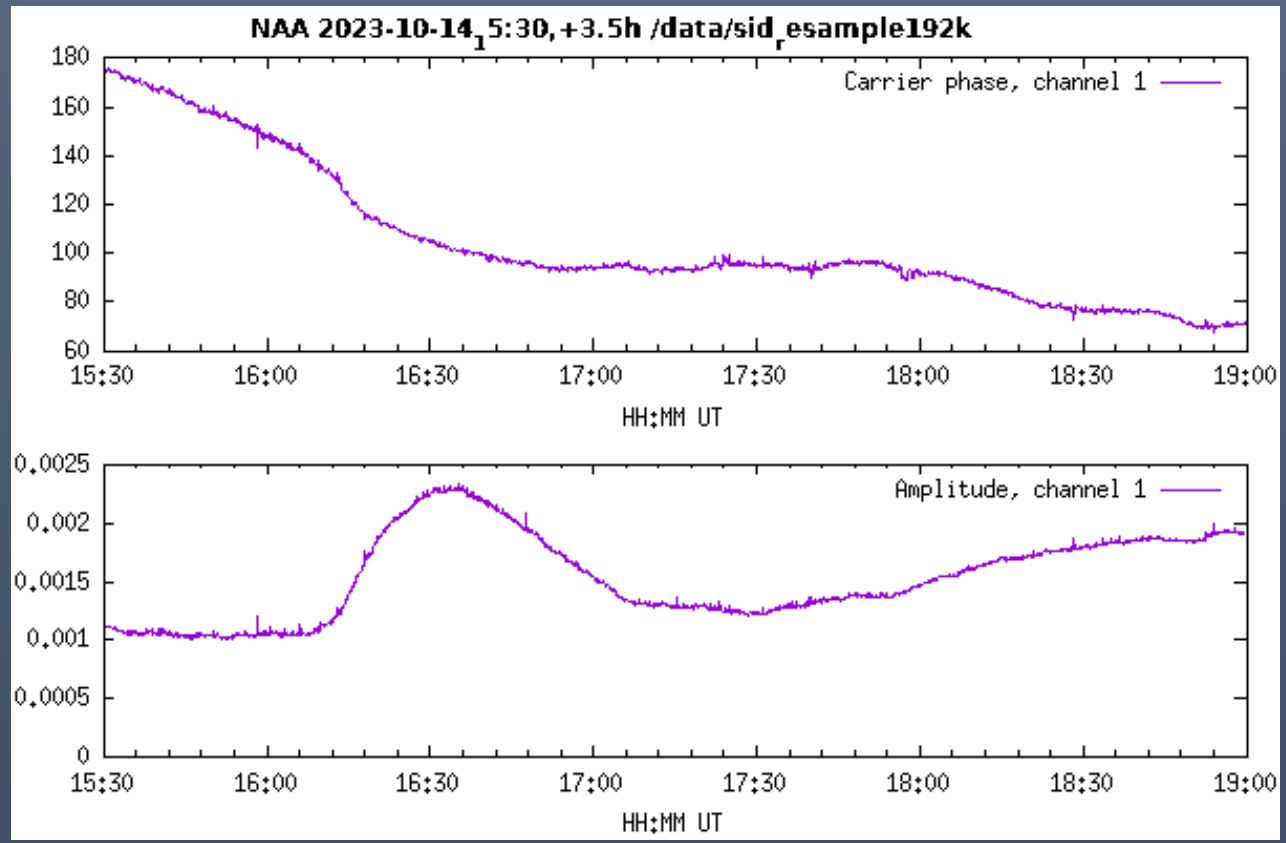
10/14/2023 Class C Solar Flare Event



- A class C solar flare occurred ~16:30UT, roughly around the same time as the annular eclipse.
- Observations in the VLF band indicate both the effects of the solar flare and the Moon's shadow.

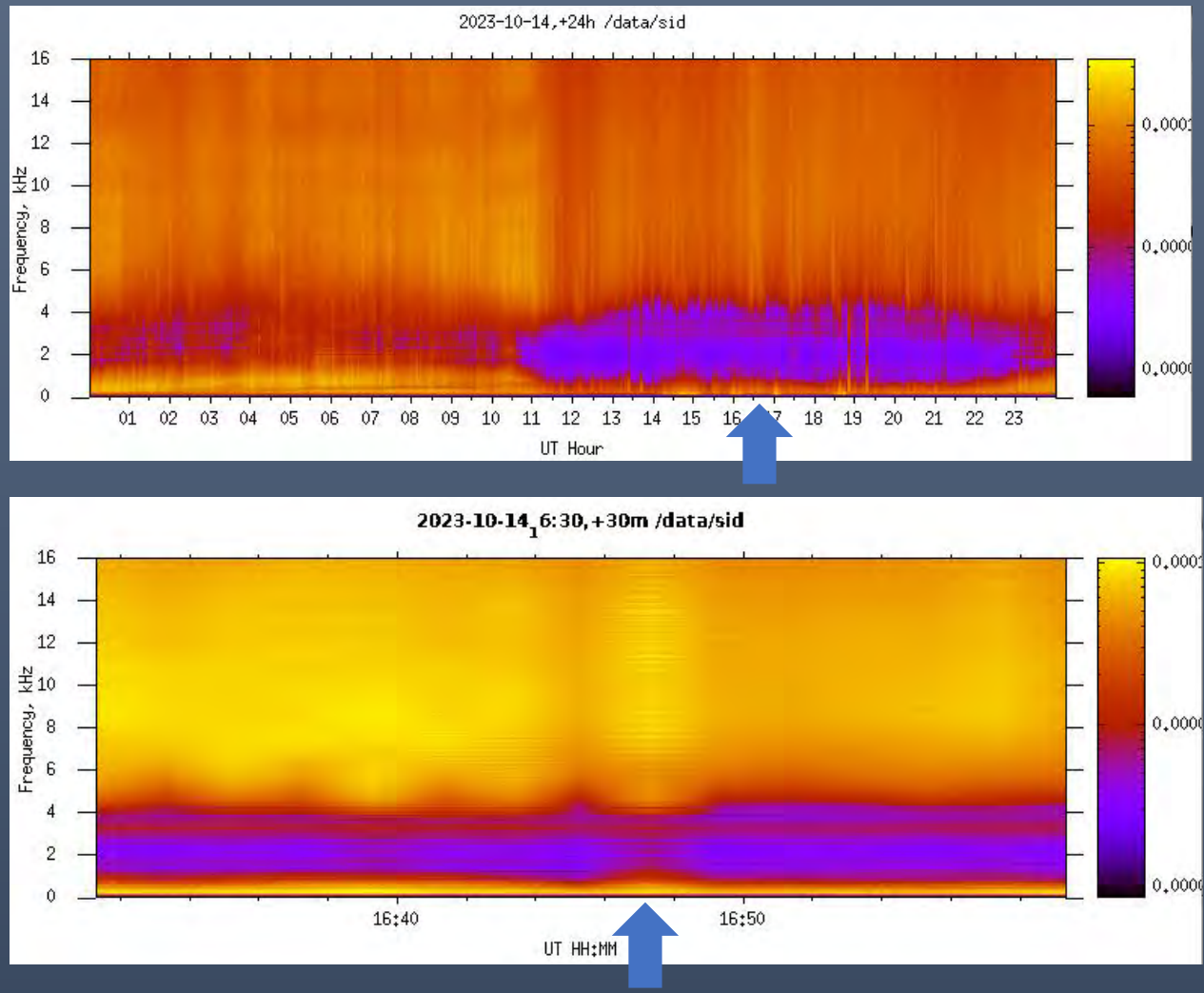
10/14/2023 NAA (24 kHz) Amplitude and Absolute Phase Observations





- An increase in signal amplitude (decreased signal absorption due to diminishing D layer caused by the moon's shadow and the class C solar flare) was observed in the US Navy VLF transmitter NAA (24 kHz) as a gradual peak.
- A phase change also occurred indicating a change in VLF propagation characteristics of the Earth-Ionosphere Waveguide (EIWG)
- The stacked plot on the right shows the observations in greater temporal detail.

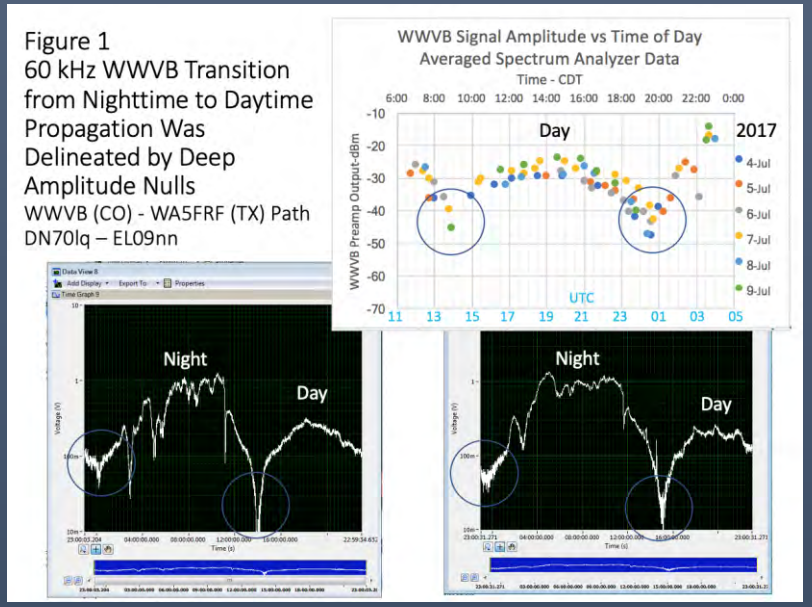
10/14/2023 Compressed Spectrogram of VLF Band (0-16 kHz) Observations



- Decreased absorption was observed in lightning sferics during the eclipse duration, showing a similar gradual peak.

Dawn/Dusk VLF Propagation Observations and Analysis with Steve Cerwin WA5FRF

Figure 1
60 kHz WWVB Transition from Nighttime to Daytime Propagation Was Delineated by Deep Amplitude Nulls
WWVB (CO) - WA5FRF (TX) Path
DN70lq – EL09nn



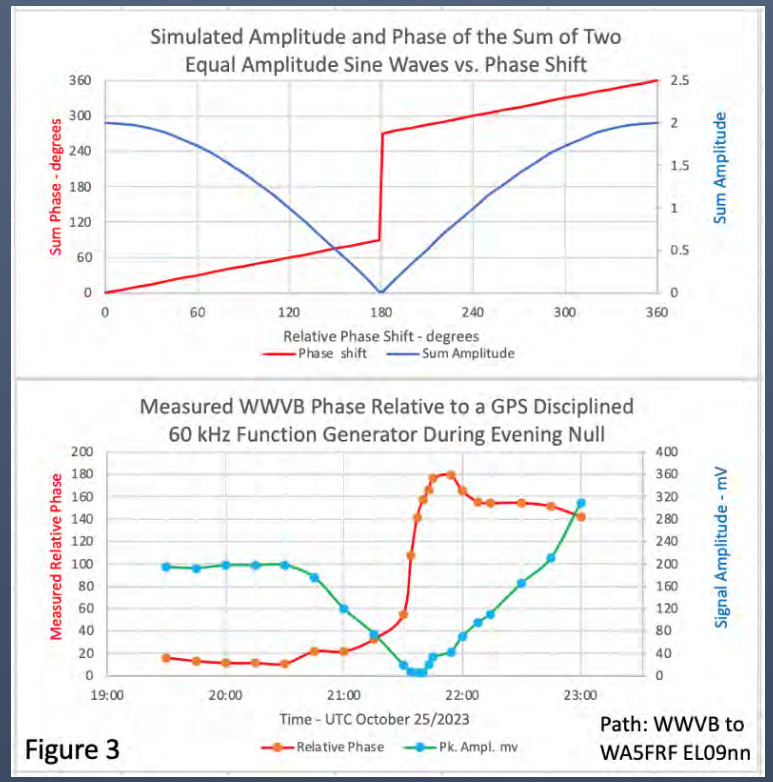
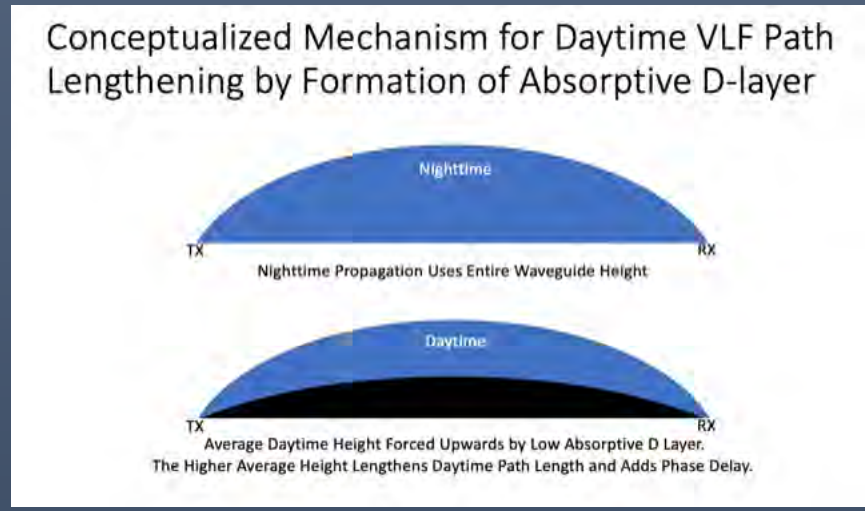
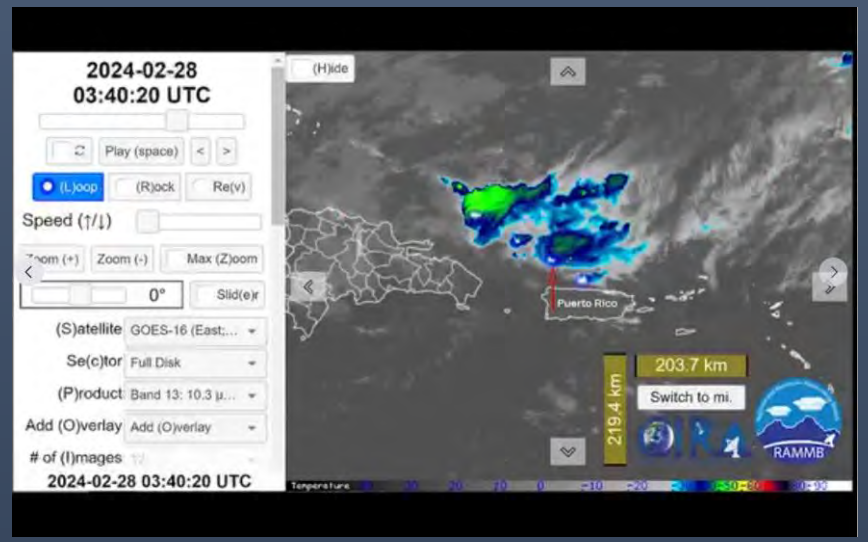


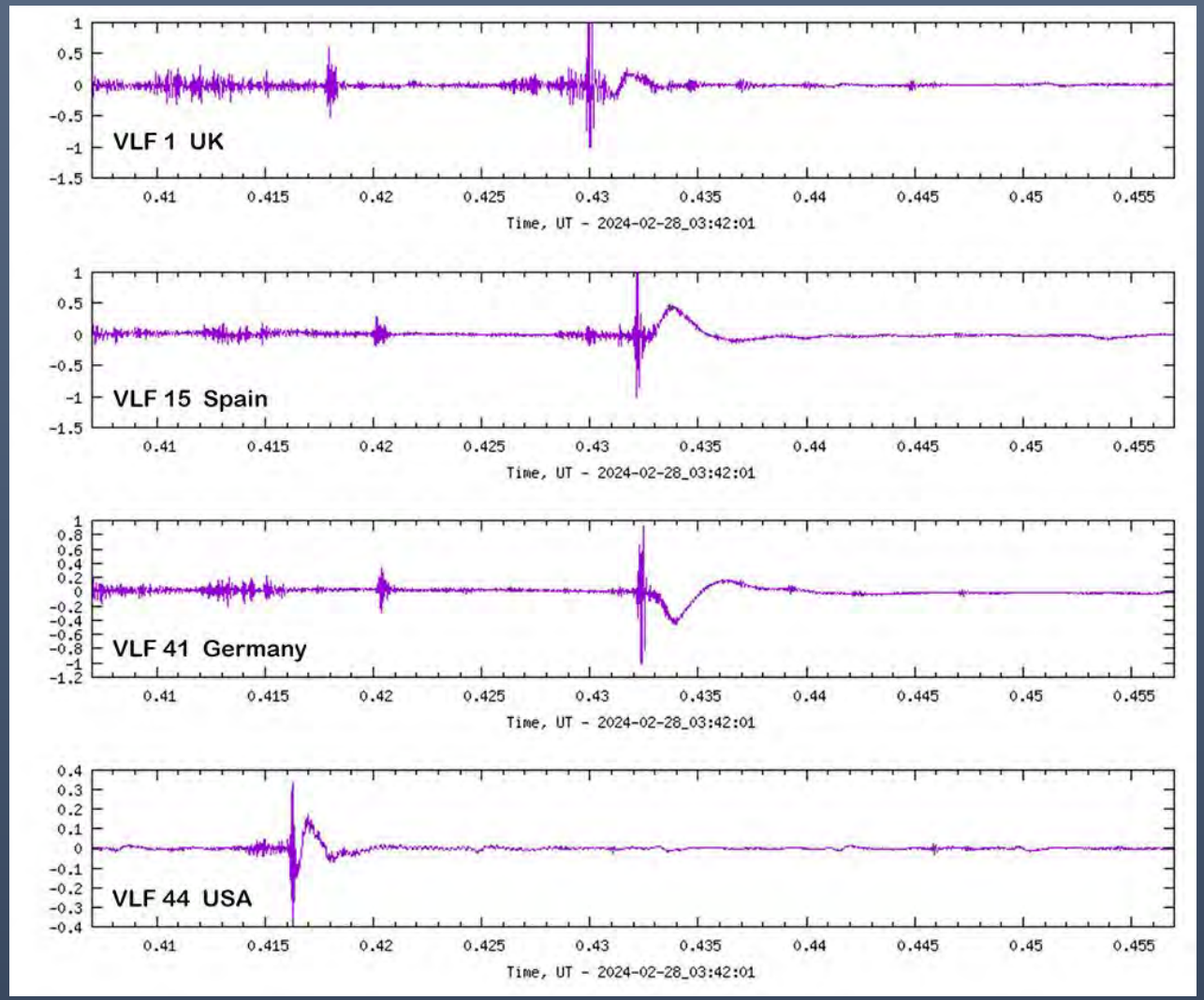
Figure 3



Credit to Steve Cerwin WA5FRF for analysis and illustrations.

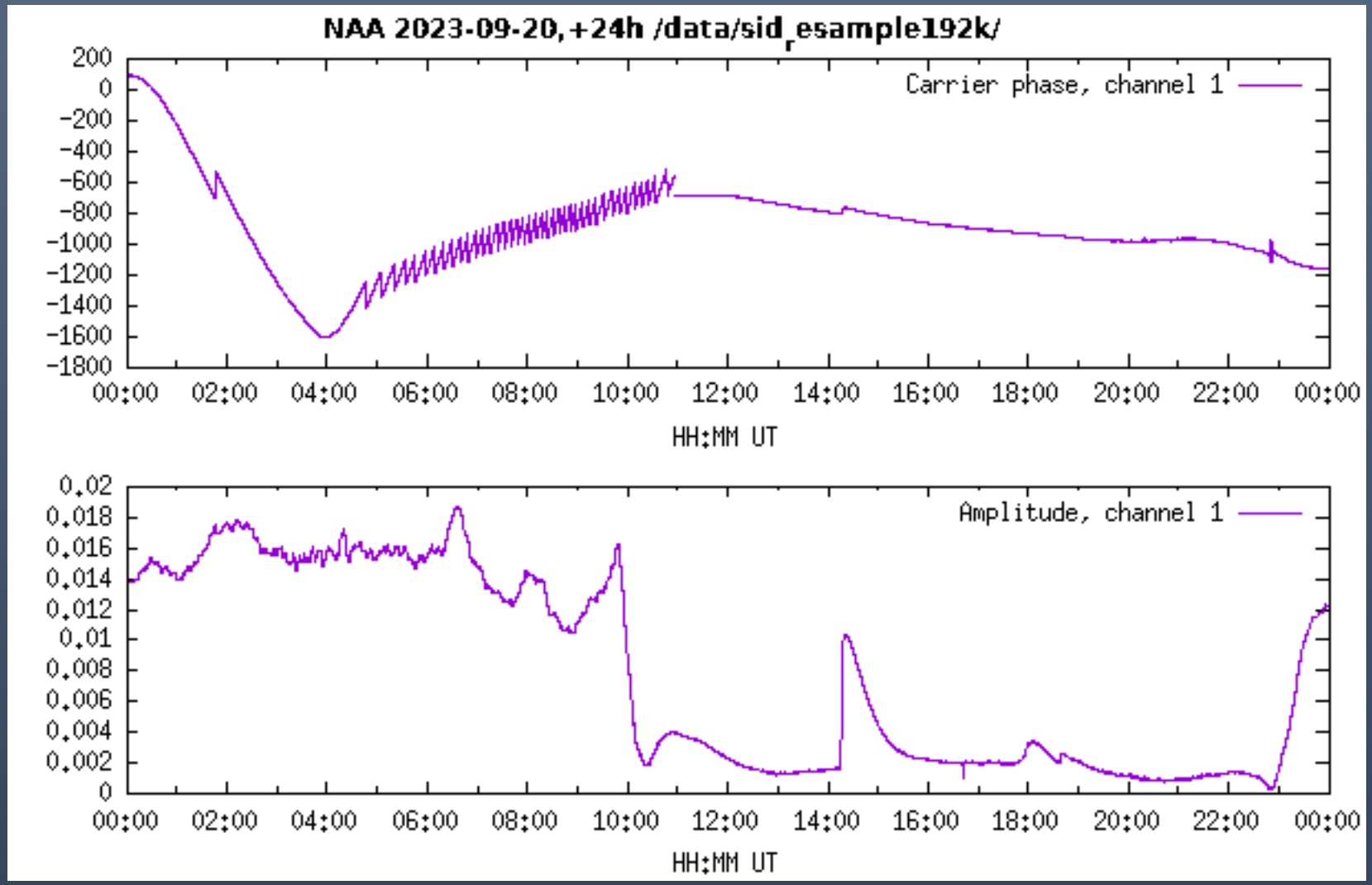
ELVES Observations in Optical and VLF





Credit to Frankie Lucena for images and analysis.

Auroral GNSS Reduced Availability

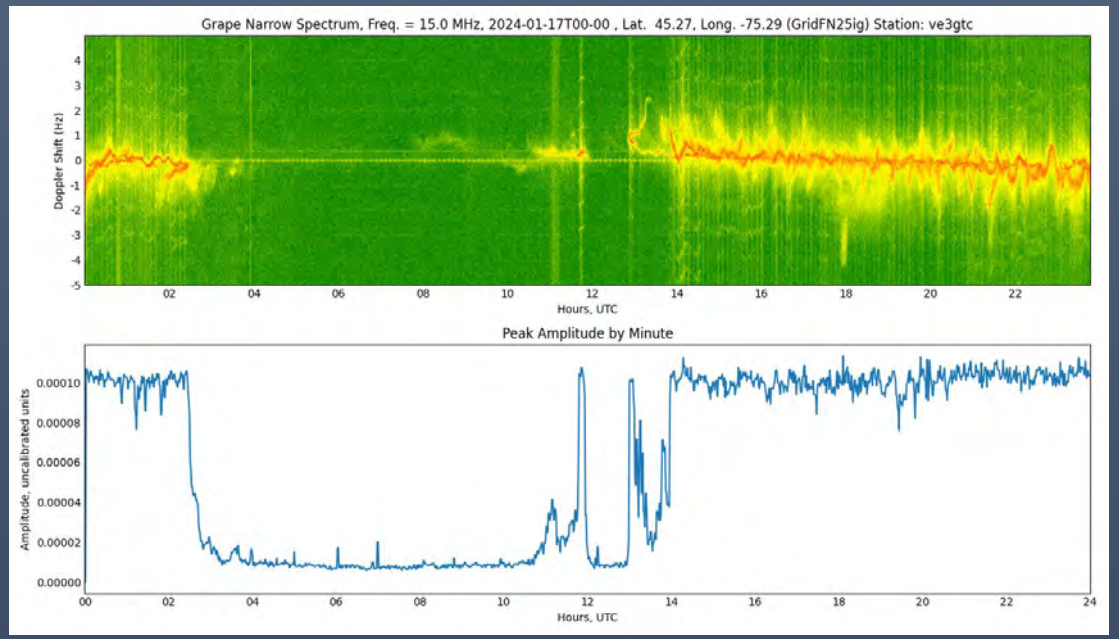


Sawtooth pattern in absolute phase due to error in the GNSS timing solution caused by the GNSS scintillation

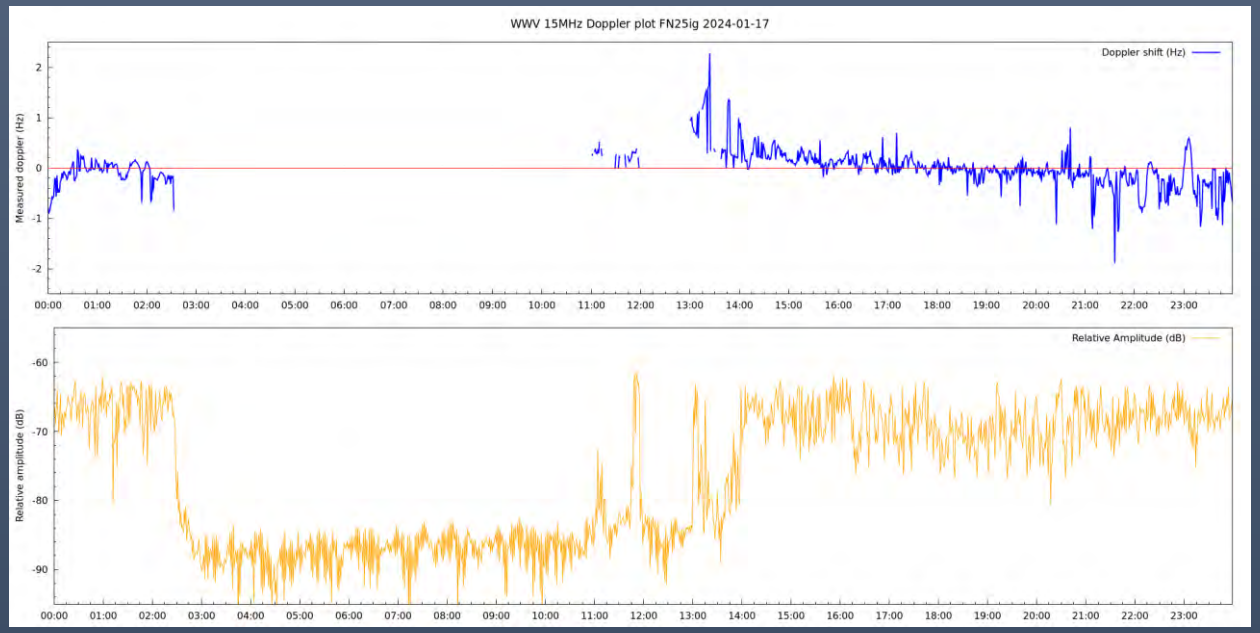
Increased small scale amplitude variability from ~1:30UT-~6:00UT

SIDs at ~14:00 and ~18:00

vlfrx-tools Grape Application



WWV carrier amplitude and doppler shift data collected with the Grape 1 DRF System



WWV carrier amplitude and doppler shift data collected with vlfrx-tools

Credit to Graham VE3GTC for these plots.

HamSCI VLF Network – Calling for Collaboration

- PIs and Co-PIs looking to acquire high quality VLF data and collaborate with HamSCI to help build the network.
- Funding to build VLF receiver kits.
- Radio Amateurs and Volunteers willing to install a VLF receiver kit at their radio-quiet location and upload data to a central server.
- Radio Amateurs and Volunteers to build their own kits. This is made possible with low-cost hardware and open-source software.
- Radio Amateurs and Volunteers to perform simple maintenance to keep their VLF receivers operating properly.

HamSCI VLF Network – Calling for Funding

- Cost is ~$300 per kit.
- Collaboration with HamSCI and the University of Scranton.
- Fielded by Radio Amateurs and Volunteers willing to install a VLF receiver kit at their radio-quiet location and upload data to a central server.
- Strategic locations welcome.
- Contact jonathan.rizzo2@scranton.edu or nathaniel.frissell@scranton.edu if interested.

HamSCI VLF Network – Calling for Volunteers

- Willing and excited to learn about the study and observation of VLF phenomena.
- Looking for something highly technical, hands-on, and with unique engineering challenges.
- Wanting to be at the cutting edge of science exploring fascinating topics in the ionosphere and magnetosphere.
- Interested in contributing to a community of amateurs, other volunteers, and professional scientists to further advance collective knowledge.

Benefits of the HamSCI VLF Network

- Global VLF receiver network capturing and analyzing the VLF spectrum.
- Better understanding of the ionosphere and magnetosphere.
- Lightning location network using a network of VLF receivers.
- Understanding VLF event footprints.
- Radio Amateur and Volunteer Learning.
- Collaboration between Radio Amateurs/Volunteers and Professional Scientists.

Outcomes of the HamSCI VLF Network

- Store of VLF spectrum data at each location.
- Sferic and stroke solutions from the network to augment existing lightning location networks.
- Database of whistlers, dawn chorus, periodic emissions, and other events at each location.
- Database of SID events from worldwide military VLF transmitters at each location.

Thank you!

- I'd like to offer my gratitude to the following:
  - Paul Nicholson for his endless support, vlfrx-tools, and *MANY* contributions to myself and the VLF community at large.
  - The VLF Community (VLF Natural Radio groups.io group, VLF Facebook Groups)
  - Gary Miller for his amazing support and updates to gpsd that includes Trimble timing receiver support.
  - Dr. Nathaniel Frissell W2NAF for endless support and motivation for this project.
  - Carl F. Eddy AA3WR for the countless support and inspiration he was to me.
- We gratefully acknowledge support to this project from NSF Grants AGS-2002278, AGS-1932997, and AGS-1932972.