

Spectrograph Users Group Capabilities

May, 2016

Who We Are

Formed in 2013, The Spectrograph Users Group (SUG) is a group of observers and researchers interested in the dynamic spectra of Jovian and solar emission. Participants are listed in Table 1. More detail about each station may be found in Appendix 1.

Participant	Observatory / Org	Loc	Instrumentation / Description
Thomas Ashcraft	Heliotown	NM	FSX-4, Jove array
Jim Brown	HNRAO	PA	FSX-8S, 4-cross LWA array
Richard Flagg	WCCRO	HI	FS-200, LPDA
Dr Shing Fung	NASA GSFC	MD	Space plasma scientist
Wes Greenman	LGM	FL	FSX-1S, square TFD array
Dr Chuck Higgins	MTSU	TN	FSX-6S, square TFD array
Dr Andy Mount	MRAO	SC	FSX-3, Jove array
Whitham Reeve	CRO †	AK	FSX-5, LPDA
Dr Francisco Reyes	RHO †	FL	FSX-7S, square TFD array
Jim Sky	Radio-Sky Software	KY	Software genius
Dr Jim Thieman	NASA GSFC	MD	Jupiter emission scientist
Nathan Towne	Towne	OH	Experimental FPGA FFT, Jove array
Dave Typinski	AJ4CO Observatory	FL	FS-200, DPS, TWB, TFD array

Table 1 – SUG participants. † denotes station initial operation capability planned for Summer 2016.

Where We Are

A Google Earth view of participating SUG stations.



Figure 1 – Locations of SUG participating observatories.

Capabilities

Stations spanning 77° of longitude provide the ability to make simultaneous observations of Jovian and Solar emission in the upper HF band using multiple spaced spectrographs over a wide range of baselines.

Time and frequency resolution vary with the instrumentation available at each station. Most stations are capable of 170 millisecond time resolution and 50 kHz frequency resolution from 15 to 30 MHz.

Telescope sensitivity varies with the instrumentation and antenna array available at each station. Most stations have a 3σ sensitivity on the order of 200 to 400 kJy.

Station timing is kept via GPS, NTP, or WWV.

Amplitude calibration is performed via a calibrated wide band noise source shared between stations. Calibration periods vary from once per day to once per year or more.

Observations are made continuously at most stations. Recorded spectral data is in the form of SPS files (see Spectrograph Software section below) and is stored locally at each station. Most stations also elect to serve spectrograph data in real time via the Internet using the Radio Sky Spectrograph software.

Spectrograph Hardware

The spectrograph receiver has a pre-detection bandwidth of 30 kHz and typically steps through 300 channels in the frequency range 15 to 30 MHz at 2,000 channels per second for a sweep repetition rate of 6.7 sweeps per second (50 kHz channel spacing). A wide dynamic range logarithmic detector develops an analog voltage proportional to signal strength as the spectrograph steps through each channel. This analog voltage is digitized and passed to the controlling software for storage, processing, and display. The spectrograph frequency is set by a direct digital synthesis (DDS) oscillator controlled by a microcontroller (PIC), which communicates with the main computer via an RS232 serial link.

Several of the instruments operate in a dual polarization mode generating simultaneous right circular polarization (RCP) and left circular polarization (LCP) spectrograms.

Spectrograph Software

Custom spectrograph software – Radio Sky Spectrograph (RSS) – running on a Windows PC communicates with the PIC microcontroller and also generates a local spectrogram display and streams data to the Internet for remote viewing using custom client software. Data is saved locally in SPS files, the native file saving format of RSS, at each station. Conversion of native RSS format to CDF format makes possible wider data access via such facilities as the Paris Observatory VESPA system and the Planetary Data System.

Example Spectrograms

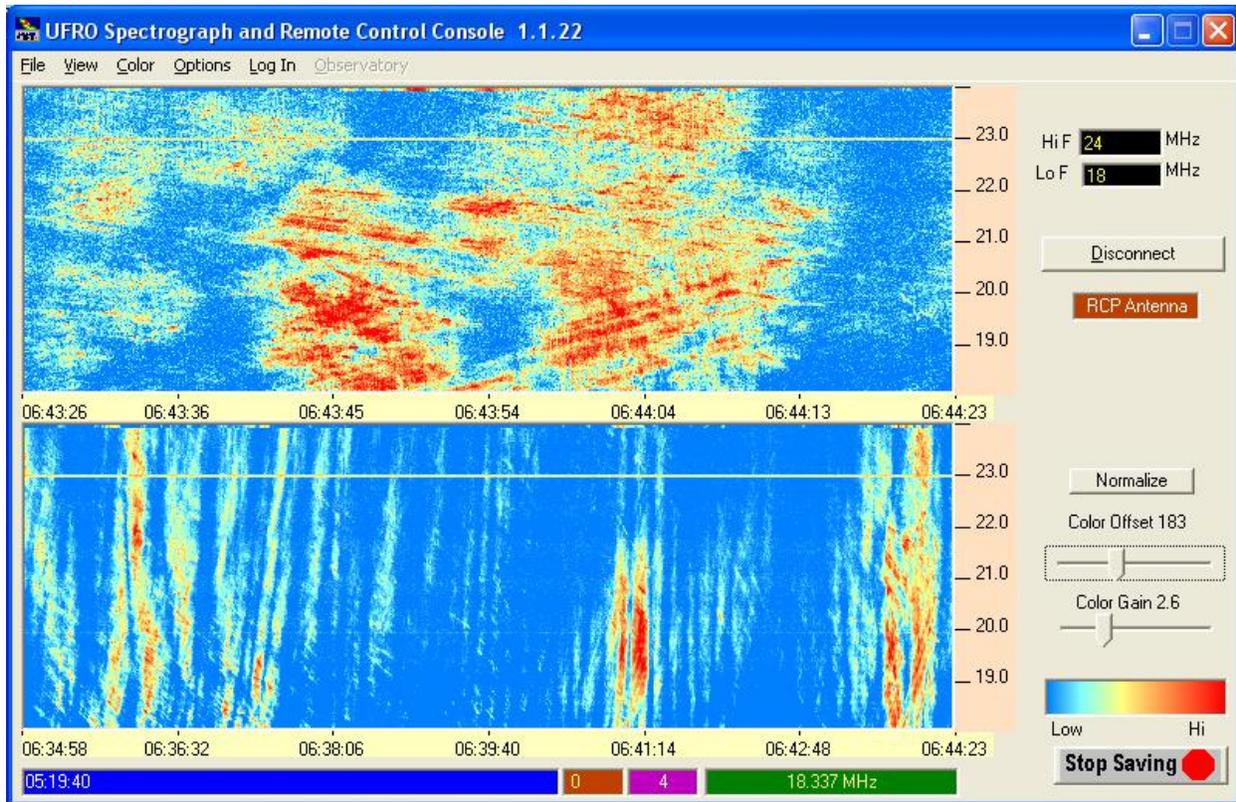


Figure 2 – Positive and negative frequency drift modulation lanes observed during an Io-B storm dominate the top display panel (1 minute duration). The bottom panel displays the last 10 minutes of activity. RCP single polarization mode. FS-200B spectrograph on 8-element RCP TP array at UF Radio Observatory.

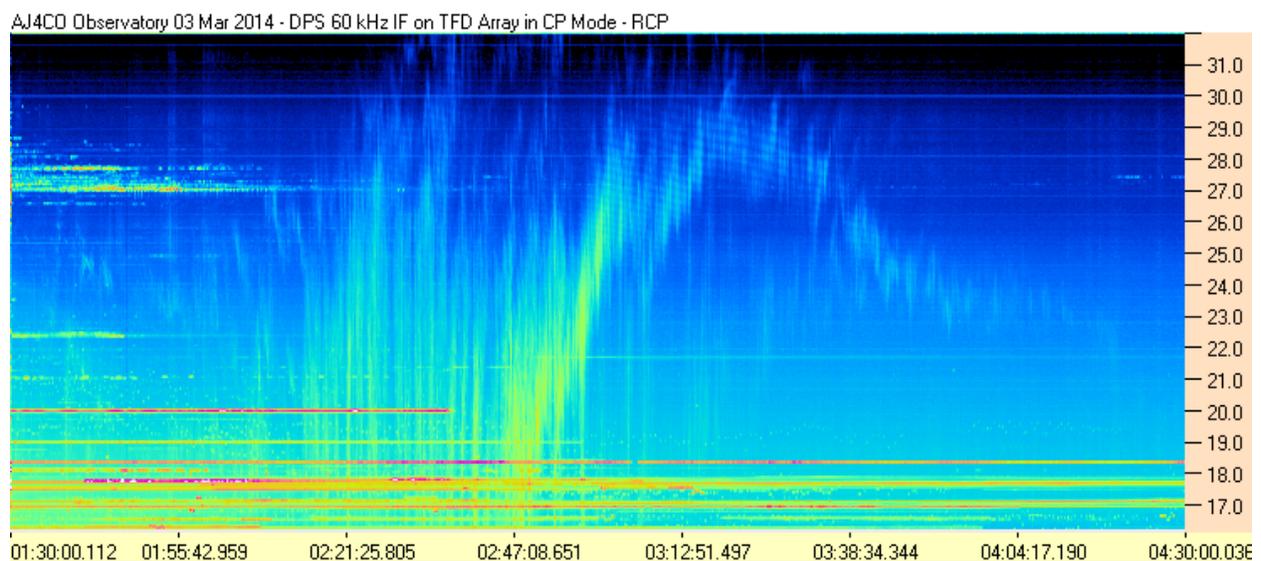
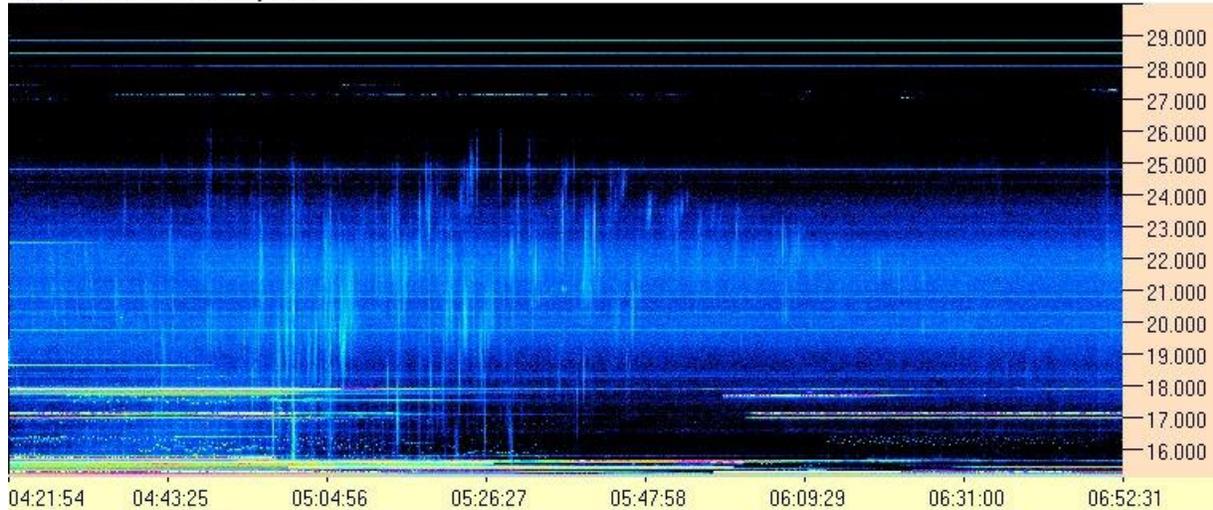


Figure 3 – Single polarization (RCP) display, Jovian Io-B storm.

02/17/2016 LGM TFD Array RCP Io-B



02/17/2016 LGM TFD Array LCP

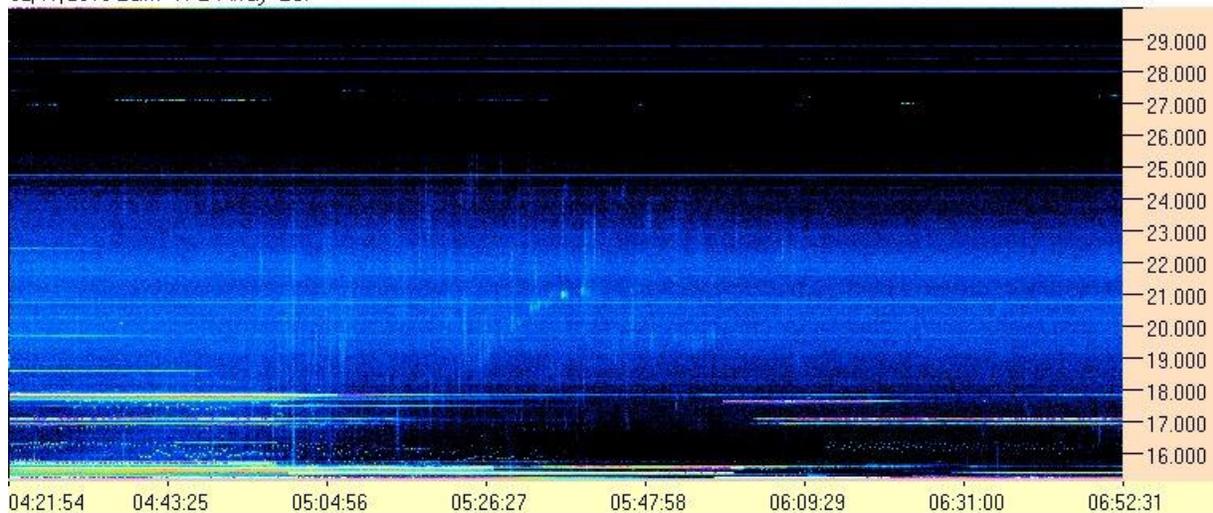
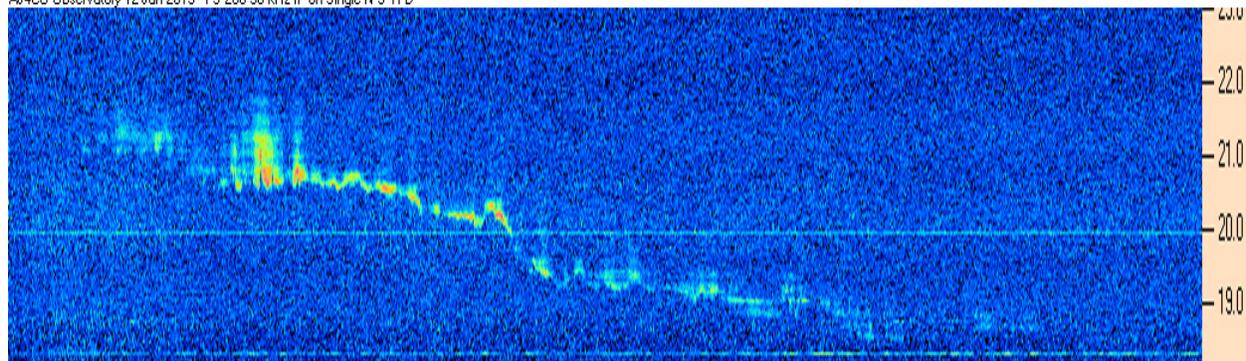


Figure 4 – Dual polarization display (RCP top panel, LCP bottom panel), Jovian decametric emission, Io-B L bursting in RCP and Io-D narrow band event (N event) in LCP circa 0530 UTC between 20 and 21 MHz.

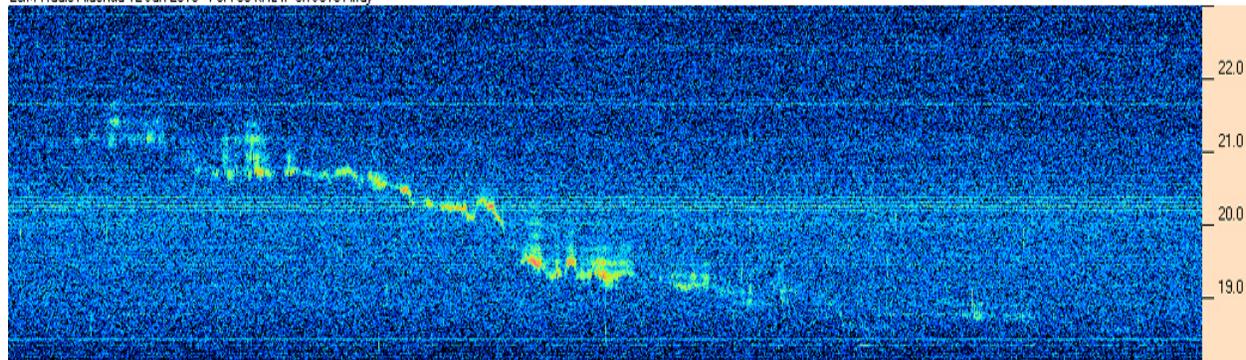
Spaced Spectrographs – Spectrogram Comparisons

An advantage afforded by multiple stations is the ability to observe the same event using widely-spaced instruments. Comparisons of the resulting spectrograms provide a guide as to whether some observed details are present near the emission source or generated during propagation through the terrestrial ionosphere.

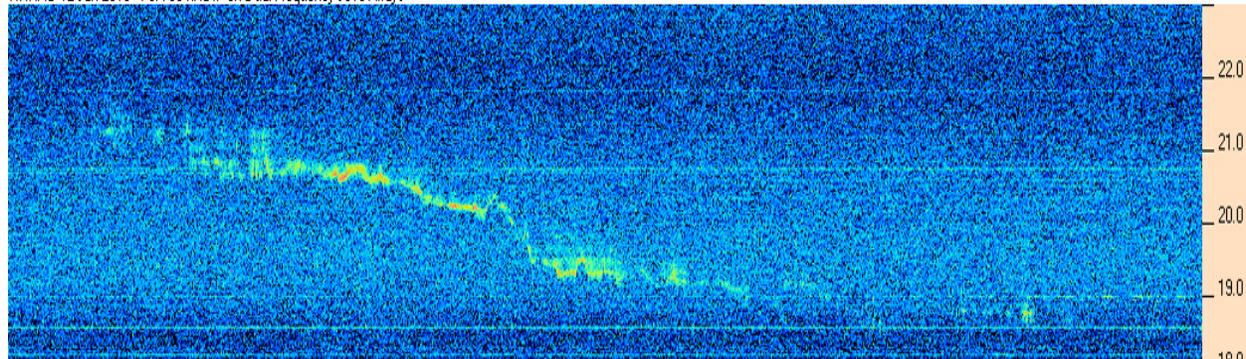
AJ4CD Observatory 12 Jan 2013 - FS-200 30 kHz IF on Single N-S TFD



LGM Radio Alachua 12 Jan 2013 - FSX 30 kHz IF on Jove Array



HNRAO 12 Jan 2013 - FSX 30 kHz IF on Dual Frequency Jove Arrays



MRAO 12 Jan 2013 - FSX 30 kHz IF on Jove Array

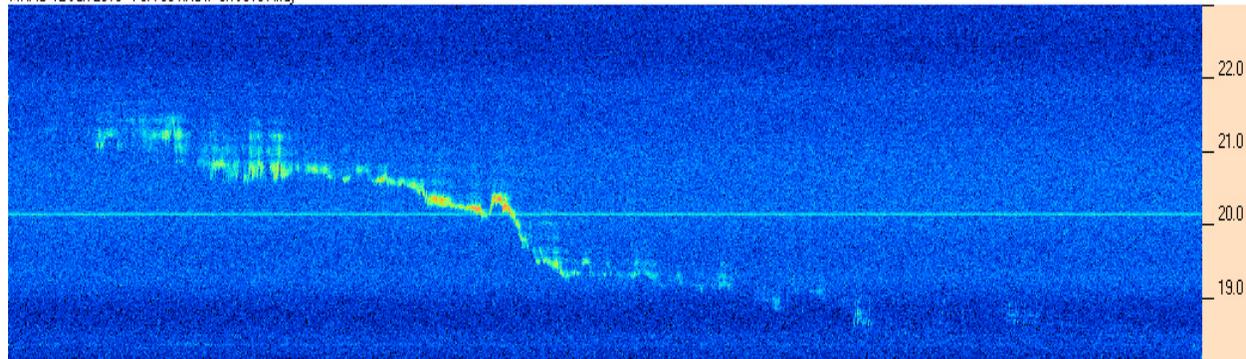
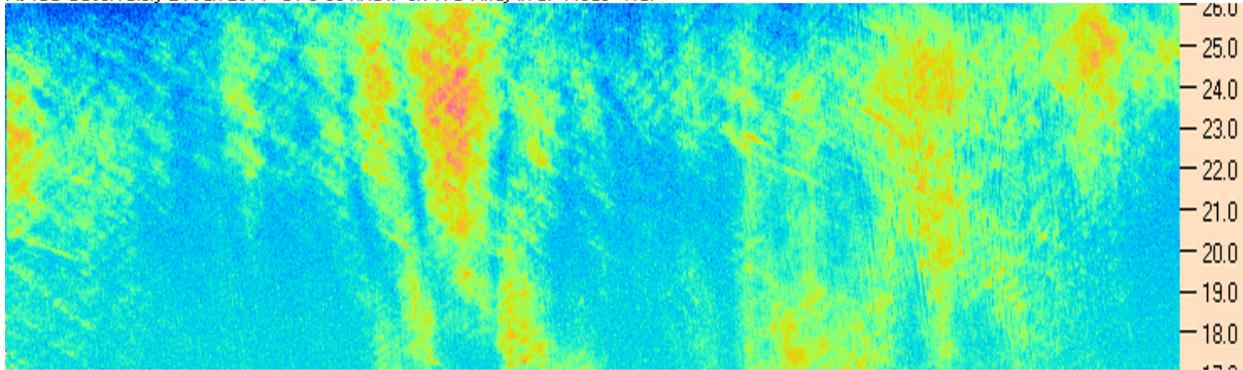
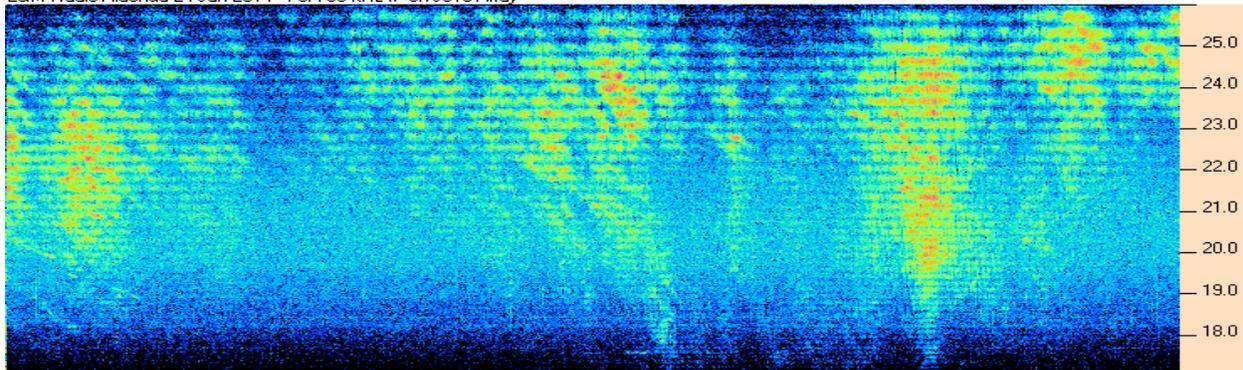


Figure 5 – Simultaneous spectrograms of Jovian N event emission during an Io-B storm, spaced spectrographs with multiple baselines between 10 and 1,400 miles. Horizontal Faraday bands are present as all stations were at the time using linearly polarized antennas. Most stations now employ circularly polarized arrays.

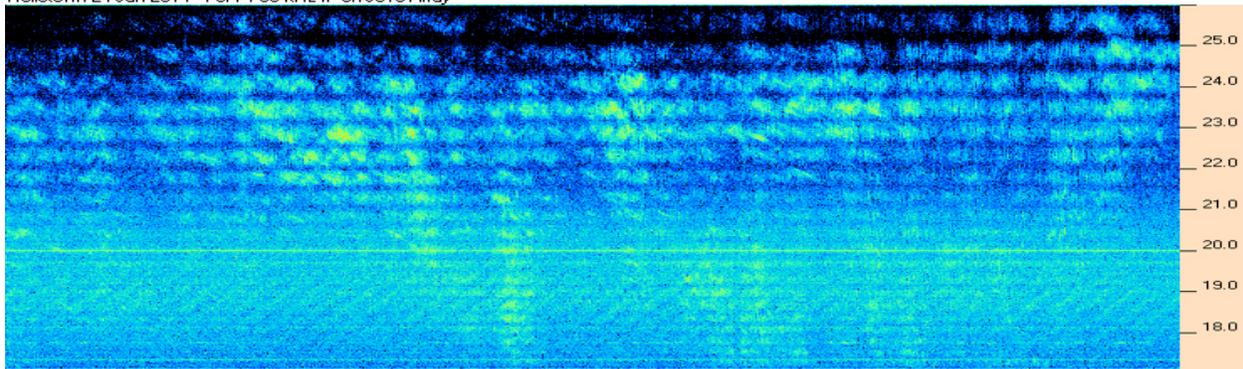
AJ4CD Observatory 24 Jan 2014 - DPS 60 kHz IF on TFD Array in CP Mode - RCP



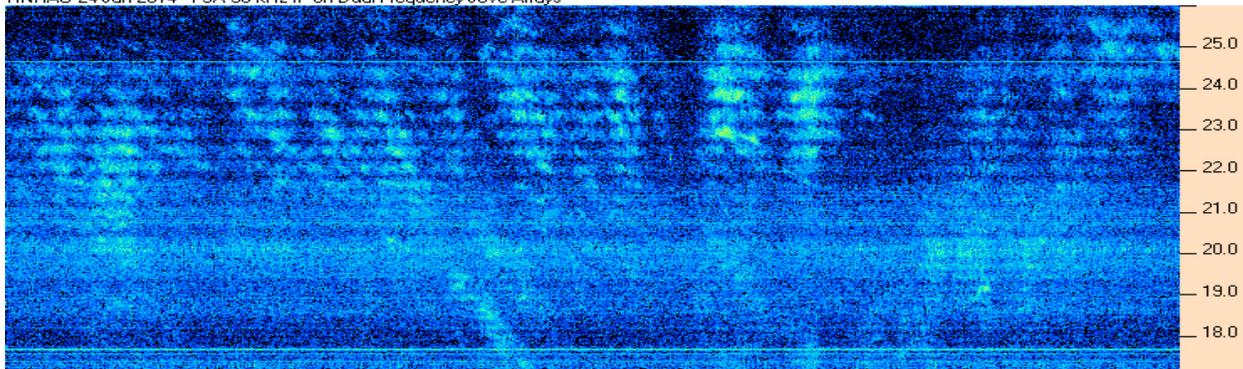
LGM Radio Alachua 24 Jan 2014 - FSX 30 kHz IF on Jove Array



Heliotown 24 Jan 2014 - FSX-4 30 kHz IF on Jove Array



HNRAO 24 Jan 2014 - FSX 30 kHz IF on Dual Frequency Jove Arrays



05:23:00 05:23:34 05:24:09 05:24:43 05:25:17 05:25:51 05:26:26 05:27:00

Figure 6 – Simultaneous spectrograms of Jovian L bursting during an Io-B storm showing sloped modulation lanes and horizontal Faraday bands, spaced spectrographs with multiple baselines between 10 and 1,400 miles.

Future Plans

Some participants within the SUG hope to provide data to the Paris Archive for the JUNO coordinated ground-based observations campaign.

Future enhancements to SUG observatories include dual-polarization capability at all stations and GPS-timing-triggered synchronized sweeps at all stations.

Appendix 1

Station details sorted by observatory name, part 1 of 2

	Station Abbreviation	AJ4CO	HNRAO	Heliotown	LGM	MTSU
	Contact	Dave Typinski	Jim Brown	Tom Ashcraft	Wes Greenman	Chuck Higgins
	Status	Active	Active	Active	Active	Active
Location	Observatory Name	AJ4CO Observatory	Hawk's Nest Radio Astro. Obs.	Heliotown	LGM Radio Alachua	Middle Tennessee State U
	Sation Lat	29° 50' 13" N	40° 40' 23" N	35° 30' 09" N	29° 48' 04" N	35° 50' 46" N
	Station Lon	82° 37' 17" W	80° 26' 16" W	105° 53' 37" W	82° 27' 32" W	86° 23' 32" W
	Time Zone	UTC-5 EST / UTC-4 EDT	UTC-5 EST / UTC-4 EDT	UTC-7 MST / UTC-6 MDT	UTC-5 EST / UTC-4 EDT	UTC-6 CST / UTC-5 CDT
	Web Site	Link	Link	Link	None	None
	Station Diagram	Link	Link	Link	Link	Link
	Diagram Date	31 Oct 2015	07 Jan 2016	03 Mar 2016	18 Jun 2013	21 Apr 2016
Antenna	Antenna 1	TFD Array	LWA-style Array	Jove Array	Square TFD Array	Square TFD Array
	Array Elements	8	8	2	4	4
	Arrangement	Two squares on N-S line	Four crosses in a square array	E-W wires on a N-S line	Square	Square
	Wire Height	9' 2"	8'	10'	9' 2"	9' 2"
	Ground Plane	Natural	Wire fencing ground screen	Natural	Natural	Natural
	Polarization	RCP and LCP	RCP and LCP	Linear	RCP and LCP	RCP and LCP
	Beam Steering	Manual	Manual	Manual	Manual	Manual
Spectrographs	Spectrograph 1	DPS	FSX-8S	FSX-4	FSX-1S	FSX-6S
	Front End BPF (MHz)	17-33	15-30	14-27	15-30 MHz	15-30
	IF BW (kHz)	30	30	30	30	30
	Sweep Rate	2000 chan/sec (fixed)	2000 chan/sec (fixed)	2000 chan/sec (fixed)	2000 chan/sec (fixed)	2000 chan/sec (fixed)
	Observing Range (MHz)	16-32	15-30	14-27	15-30	15-30
	Channel Count	300	300	400	300	200
	Input(s)	RCP, LCP from TFD Array	RCP, LCP from LWA Array	Jove Array	RCP, LCP from TFD Array	RCP, LCP from TFD Array
	Dual Channel Method	Correlated	Polarization switching	n/a	Polarization Switching	Polarization switching
	ADC Resolution (bits)	12	12	12	12	12
	Last Calibration Date	Daily	05 Mar 2016	02 Oct 2013	19 Dec 2015	24 March 2016
Operation Schedule	24 x 7 x 365	24 x 7 x 365	Manually Operated	24 x 7 x 365	Manually Operated	
Time Source	GPS-NTP-Pi (hardware)	Internet Time Server Pool	WWV	Internet Time Server Pool	Internet Time Server Pool	
Tming Software	Meinberg NTP Client	Meinberg NTP Client	Set manually @ each storm	Meinberg NTP Client	RSS Sntp Client	

Appendix 1

Station details sorted by observatory name, part 2 of 2

	Station Abbreviation	MRAO	WCCRO	Towne	Cohoe	RHO
	Contact	Andy Mount	Richard Flagg	Nathan Towne	Whit Reeve	Francisco Reyes
	Status	Active	Active	Experimental	Partly set up / Inactive	Planned / Inactive
Location	Observatory Name	Mountain Rest Astro. Obs.	Windward Comm. College	Towne	Cohoe	Rosemary Hill Obs.
	Sation Lat	34° 51' 19" N	21° 24' 37" N	39° 45' 34" N	60° 22' 06" N	29° 24' 00" N
	Station Lon	83° 08' 11" W	157° 48' 55" W	84° 22' 7" W	151° 18' 56" W	82° 35' 10" W
	Time Zone	UTC-5 EST / UTC-4 EDT	UTC-10 HST	UTC-5 EST / UTC-4 EDT	UTC-9 AST / UTC-8 ADT	UTC-5 EST / UTC-4 EDT
	Web Site	None	Link	None	Link	Link
	Station Diagram	TBD / In work	None	Link	TBD / In work	TBD / In work
	Diagram Date	TBD / In work	None	02/01/16	TBD / In work	TBD / In work
Antenna	Antenna 1	Jove Array	7-element LPDA (18–30 MHz)	Jove Array	LWA cross (5–90 MHz)	Square TFD Array
	Array Elements	2	1	2	2	4
	Arrangement	E-W wires on a N-S line	Az El mount	E-W wires on a N-S line	LWA Antenna	Square
	Wire Height	10'	25 ft	10'	N/A	9' 2"
	Ground Plane	Natural	n/a	Natural	3 x 3 m mesh	Natural
	Polarization	Linear	Linear	Linear	Linear or Circular (eventual)	Circular
	Beam Steering	Manual	Manual az / el	Manual	Omni-Directional	Manual
Spectrographs	Spectrograph 1	FSX-3	FS-200A	Experimental FPGA SDR	FSX-5 summer 2016	FSX-7S spring 2016
	Front End BPF (MHz)	18-30	18-28	21–38	18-30	15-30
	IF BW (kHz)	30	30	27 typical	30	30
	Sweep Rate	2000 channels per sec (fixed)	2000 channels per sec fixed	6.7 spectra per sec typical	2000 channels per sec (fixed)	2000 channels per sec (fixed)
	Observing Range (MHz)	18-28	18-28	19-40	TBD	15-30
	Channel Count	300	200 (fixed)	1024	TBD	300
	Input(s)	Jove Array	LPDA	Jove Array	TBD	TFD Square ARray
	Dual Channel Method	n/a	n/a	I & Q correlated samples	TBD	Polarization switching
	ADC Resolution (bits)	10	10	14	12	12
	Last Calibration Date	30 Jul 2013	TBD	None	TBD	TBD
Operation Schedule	24 x 7 x 365	24 x 7 x 365	Manually Operated	TBD	TBD	
	Time Source	Trimble Thunderbolt E GPS	Internet Time Server Pool	NTP	TBD	TBD
	Timing Software	Meinberg NTP Client	RSS SNTP Client	Thinking Man / Dimension 4	TBD	TBD