The Spectrograph Users Group (The SUG)

Activities and Observations

Flagg Typinski

Thomas Ashcraft, Jim Brown, Richard Flagg, Wes Greenman,
Dr. Chuck Higgins, Dr. Andrew Mount, Whitham Reeve,
Dr. Francisco Reyes, Jim Sky, Dr. Jim Thieman, Dave Typinski

Radio Jove Meeting, July 3, 2014, NRAO Green Bank

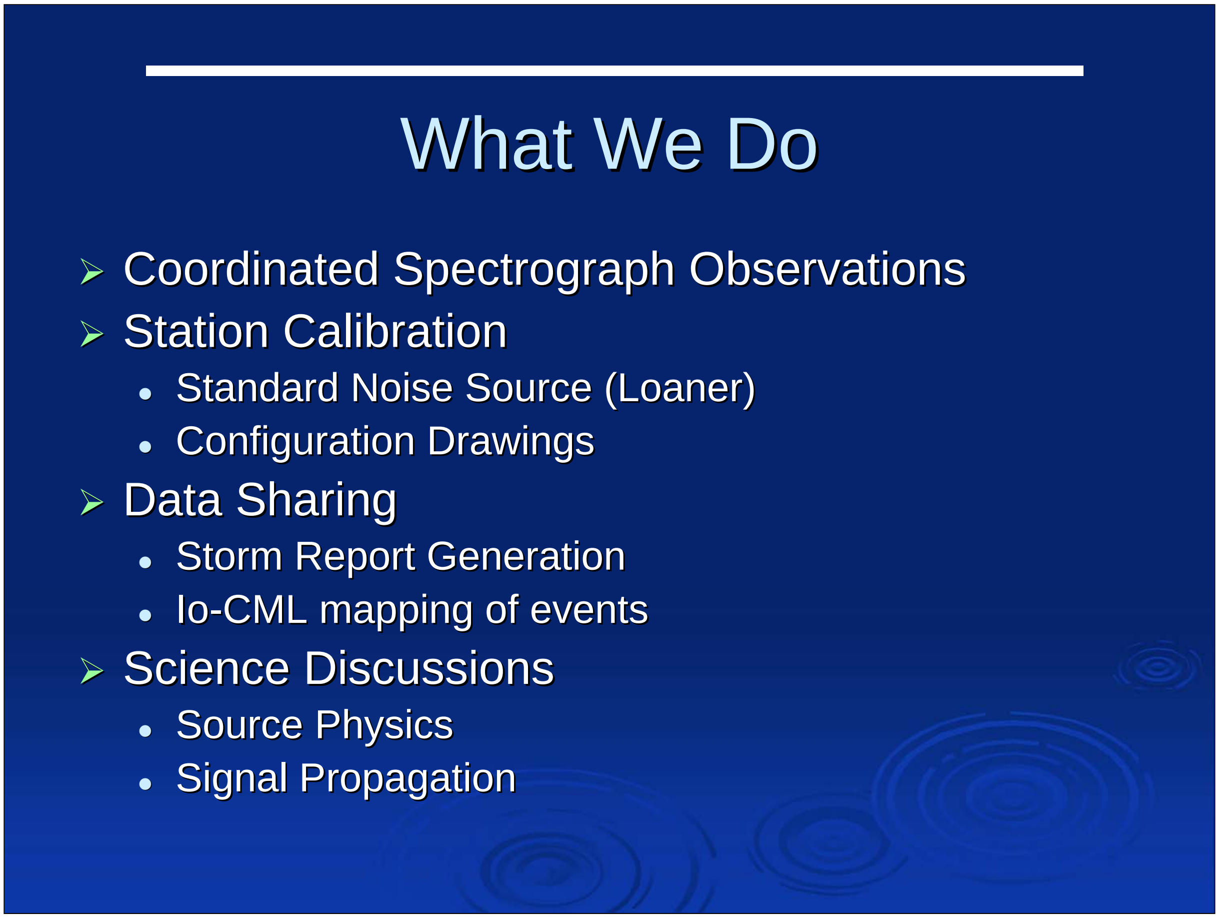
Who We Are

Participant	Observatory / Org	Loc	Spectrograph Instrumentation
Ashcraft	Heliotown	NM	FSX-4; Jove array
Brown	HNRAO	PA	FSX-2; Dual Jove arrays
Flagg	WCCRO	HI	FS-200; LPDA
Greenman	Radio Alachua	FL	FSX-1; Jove, Carr, & polarimeter arrays
Dr Higgins	MTSU	TN	Jupiter emission scientist
Dr Mount	MRAO	SC	FSX-3; Jove array
Reeve	RvO	AK	FSX-5; LPDA
Dr Reyes	UF	FL	Jupiter emission scientist
Sky	RadioSky	KY	Software genius
Dr Thieman	NASA GSFC	MD	Jupiter emission scientist
Typinski	AJ4CO	FL	FS-200, DPS, TWB; TFD array

Scientists, engineers, and amateurs working together. Couldn't ask for a better group – or to rephrase it - talk about herding cats.

Where We Are

For the first time Jupiter emissions can be viewed using several spaced spectrographs – allowing us to study, among other things, the effects of propagation thru the earth's ionosphere. Spaced spectrographs help us to sort out features intrinsic to the emission mechanism and those features due to propagation.



The Spectrograph Users Group (SUG) is a subset of Radio Jove participants who are interested in the dynamic spectra of Jupiter's decametric radio emissions. We hold biweekly telecon discussions to keep each other informed and involved. The main thrust of the SUG during the last year involved instrument calibration, coordinated observing, and discussion of source physics and propagation phenomena. We deal primarily with Jovian emission events, with solar emission keeping everyone warm during the Jovian off-season.

http://www.radiojove.org/SUG/

- Predictions / Observing Schedule
- Publications
- System Diagrams
- Telecon Minutes
- Observing Reports
- Calibration Reports
- Reference Materials

We maintain a web page with various prediction information, diagrams and reports.

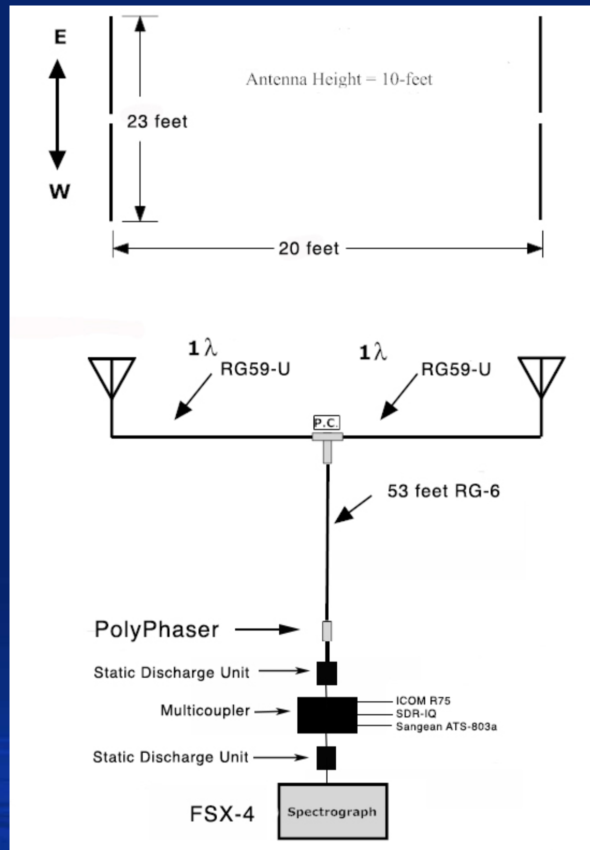
System Diagrams

Only if we know the details of each observing stations configuration can we make valid comparisons of data.

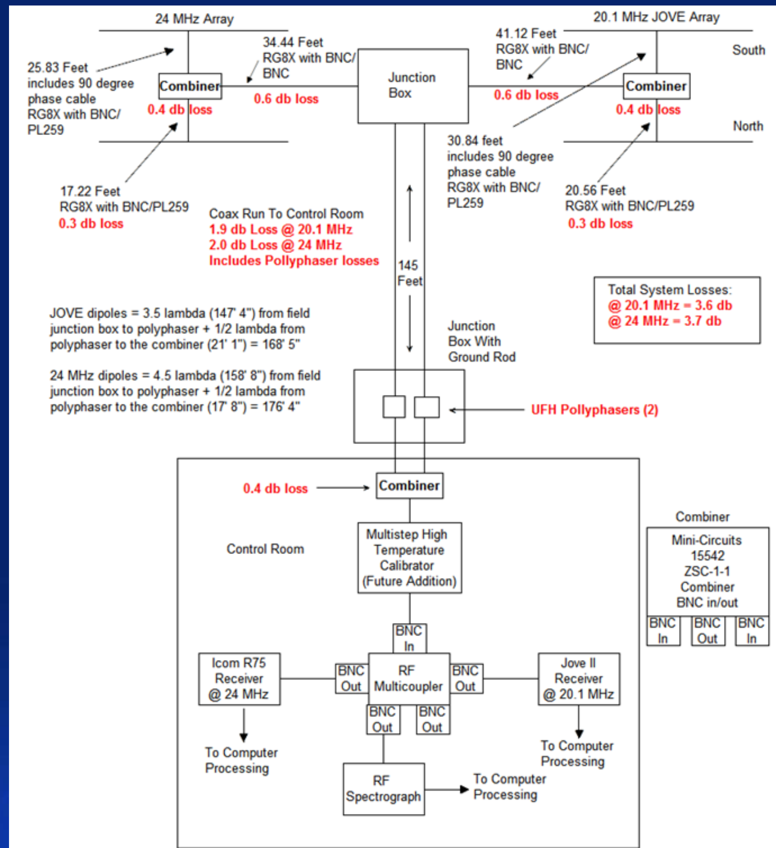
Jove Antenna

Thomas Ashcraft
Heliotown Obs.
Lamy. New Mexico

35.50N, 105.89W



Experimental Array
Two dual dipoles
20.1 and 24 MHz
Power Combined



Jim Brown
HNRAO

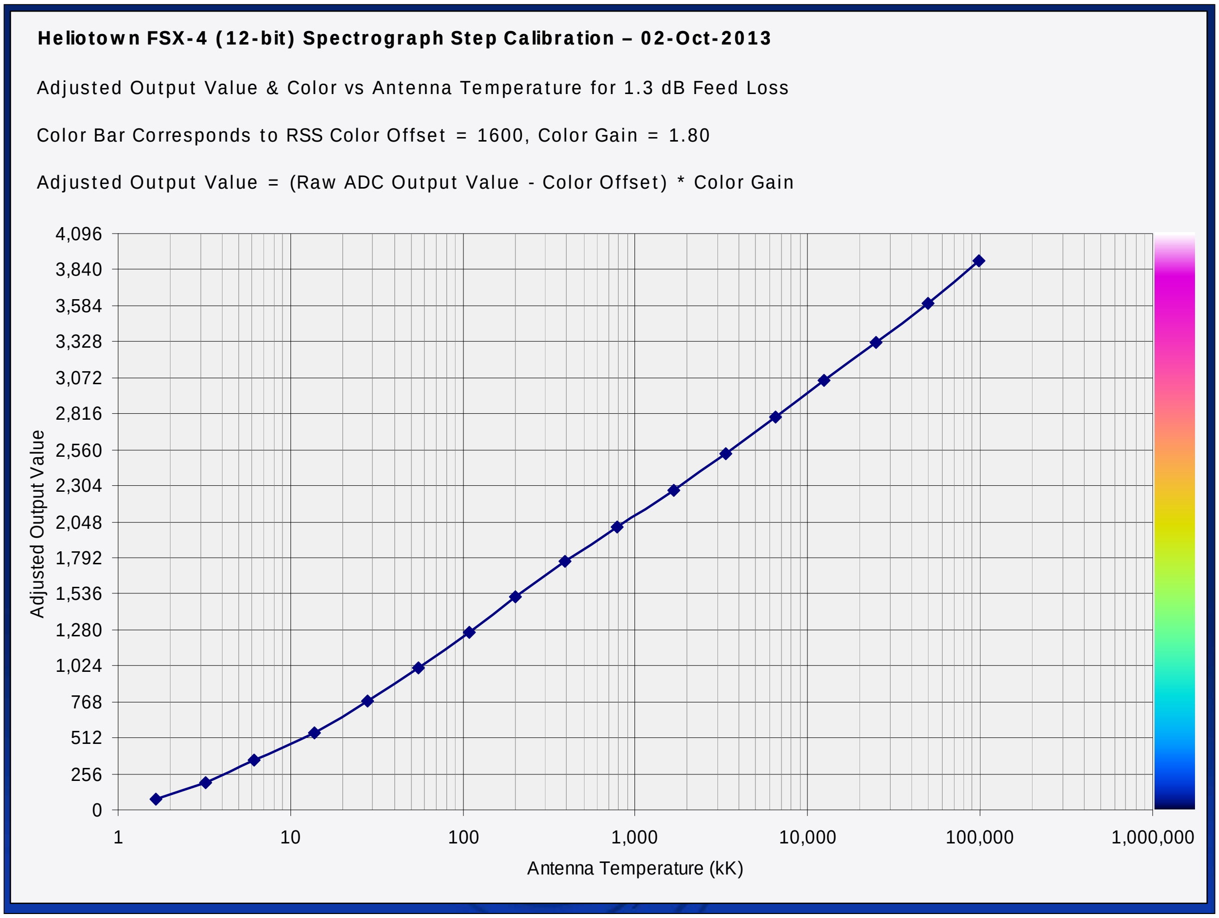
Dick → Dave

Instrument Calibration

The spectrograph itself is calibrated using a hot noise source and a step attenuator. This method measures the instrument response in terms of ADC count for different input temperatures.

A calibrated “loaner noise source” package was used by (and remains available to) all SUG participants. The package consists of an HP 461 noise source calibrated against a pair of 5722 noise diodes, a step attenuator, cables, and an instruction manual.

With the results of step calibration runs and the information in the system diagrams, we are able to provide calibrated antenna temperature response curves specific to each station.



After the step cal data is processed, we arrive at a calibration chart.

This calibration is only valid for this particular observatory configuration shown in the system diagram, and then only when the RSS software is set for the noted color offset and color gain parameters.

An Excel spreadsheet is available for each observatory. Different color gains and offsets may be entered in the spreadsheet to produce an associated response curve. Each spreadsheet is valid for its associated observatory only.

Processing steps:

1) Calculate equivalent antenna temperature at each step cal step by taking into account feed line attenuation.

2) Time-average the SPS file data over a 50 second window (each cal step is one minute long).

3) Produce a two-dimensional array of time-averaged ADC output versus frequency channel and input temperature.

4) Frequency-average the ADC data over the observing bandwidth (usually 300 channels), leaving a one-dimensional array of ADC output versus input temperature.

5) Perform the adjustments for RSS color offset and color gain.

6) Plot re resulting curve.

Coordinated Observation

Statistics

SUG Observation Summary 2013–14

- A successful observing season!

SUG Observations 08 Sep 2013 – 01 Apr 2014 (elongation +60° to -90°)

Source	Event Count
Io-A	19
Io-C	11
Io-A/C	3
Io-B	29
Possible Io-D	7
non-Io-A	45
non-Io-C	15
non-Io-A/C	5
non-Io-B	17
Total	**151**

Emission Type	Event Count
L	125
S	6
N	11
S N	6
L S	2
L N	1
Total	**151**

Emission Polarization	Event Count
RCP	129
LCP	19
RCP + LCP	3
Total	**151**

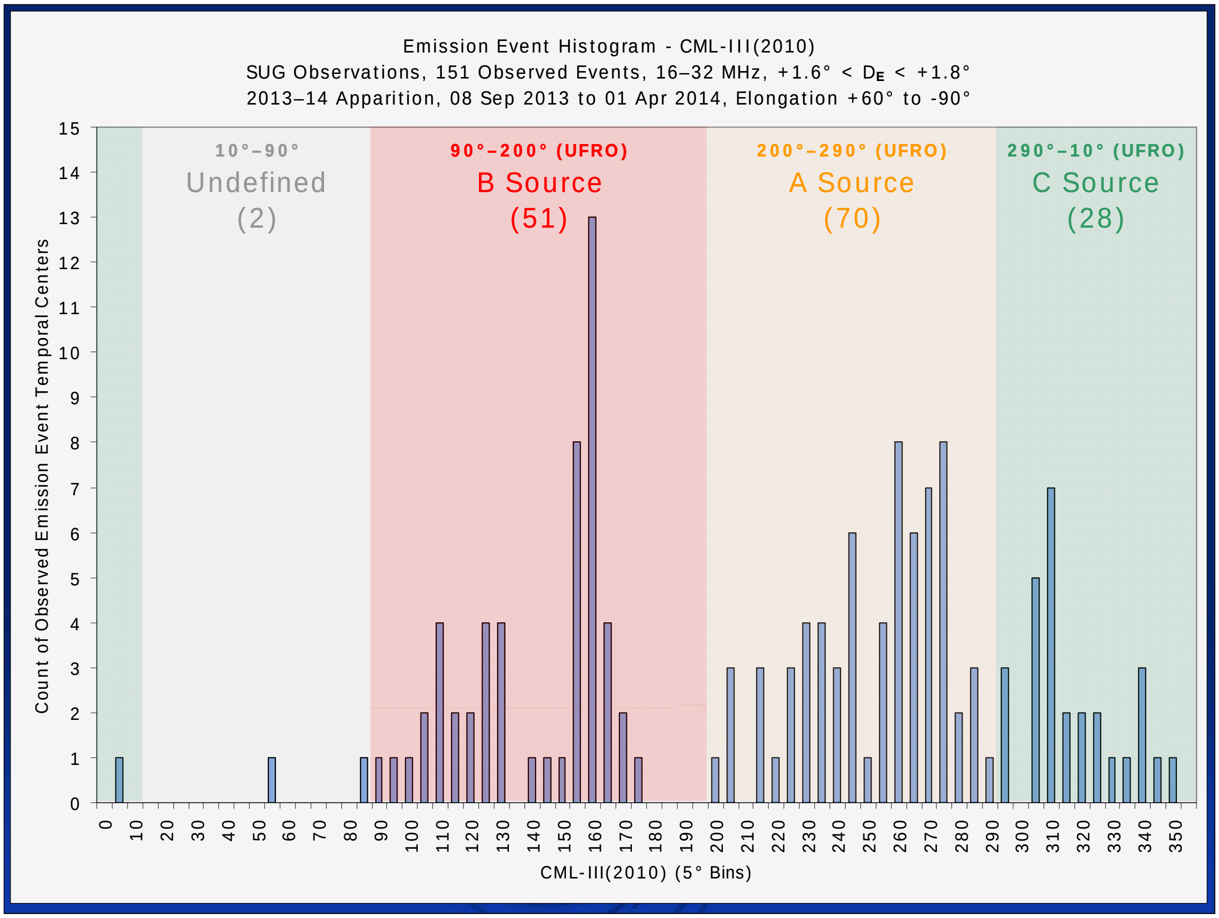
Our definition of an "emission event" is continuous emission of a single polarization with gaps of no more than 30 minutes. Long gaps with no emission and/or a switch to the opposite circular polarization is counted as the end of one event and the beginning of another event. In several cases, well-defined S bursting and/or S-N events are also counted as a separate events, even when followed closely by L bursting.

The Io-A/C events are events of a single polarization that extend well into the neighboring region; as such, they do not fit within either the Io-A or Io-C pigeon holes.

Similarly, the non-Io-A/C events span the border between the A and C regions in CML-III.

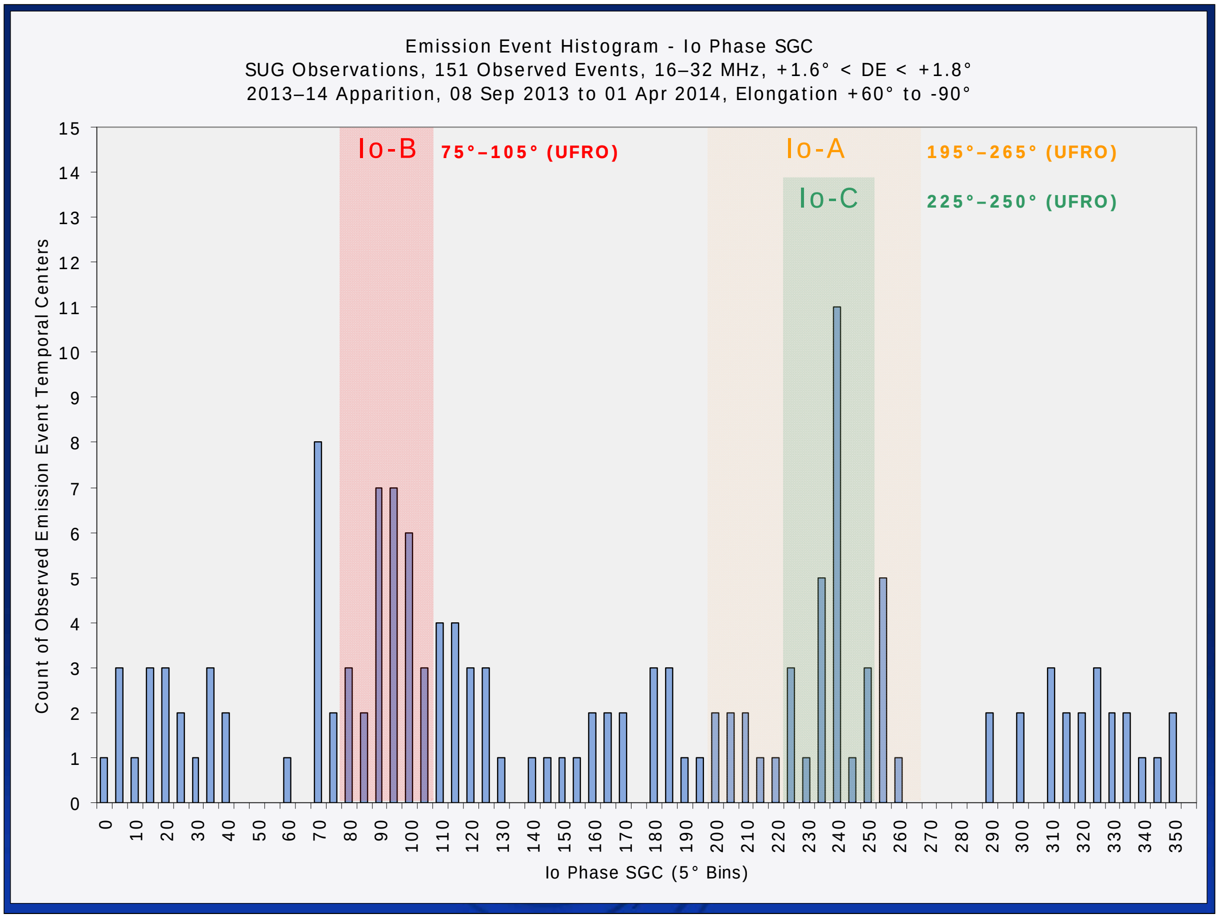
The zone definitions are those used by UFRO. All SUG event ephemerides are from JPL: **http://ssd.jpl.nasa.gov/horizons.cgi**

NOTE: the possible Io-D observations await confirmation via comparison with LWA1 observations.



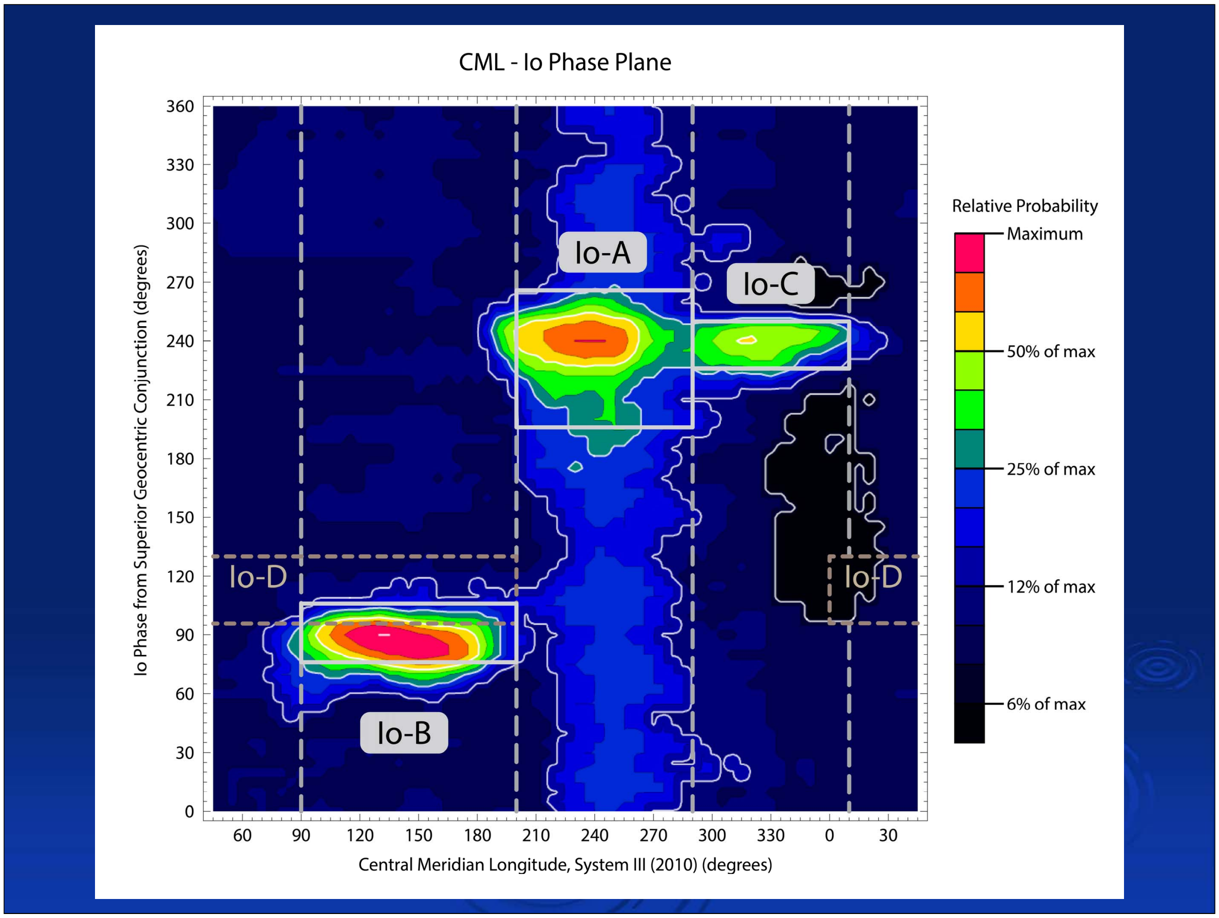
This histogram shows the occurrence of SUG events against CML-III(2010). The zone definitions are those used by UFRO.

All SUG event Io and CML-III ephemerides are from JPL: **http://ssd.jpl.nasa.gov/horizons.cgi**



This histogram shows the occurrence of SUG events against Io phase relative to superior geocentric conjunction. The zone definitions are those used by UFRO.

All SUG event Io and CML-III ephemerides are from JPL: **http://ssd.jpl.nasa.gov/horizons.cgi**



Here is the phase plane against which the SUG observations were referenced. It should be noted that observations define the source locations, not the other way around. As you will find out in other talks, the sources move around slightly as the jovicentric declination of Earth increases and decreases on its 12-year cycle. Also, this is a map of occurrence probabilities, ***not*** a map of emission intensity.

The Io and non-Io zones (with the exception of Io-D) are marked according to the University of Florida Radio Observatory (UFRO) Io-CML definitions; see **http://ufro1.astro.ufl.edu/decframe.htm** . UFRO does not define an Io-D zone.

The Io-D zone is marked according to the definition provided by Carr, et al. in "Physics of the Jovian Magnetosphere." Io-D is listed as LCP dominant with a maximum emission frequency of 18 MHz.

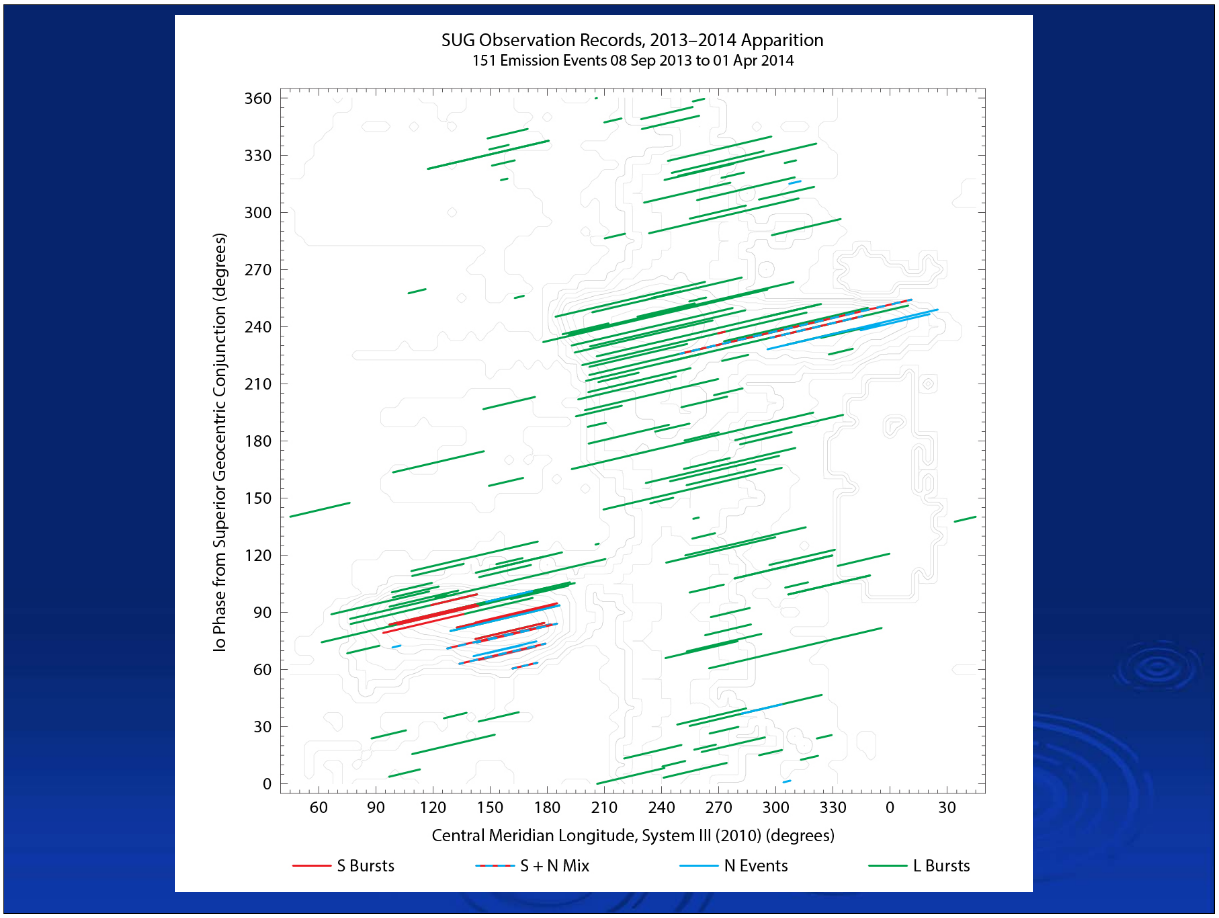
About CML-Io Plane Probabilities

This Io-CML phase plane image attempts to depict the relative probability of receiving Jovian emissions at 20.1 MHz. This is done by first making an average of probability data generated from observations made at 18, 20 and 22 MHz at the University of Florida Radio Observatory (UFRO) from 1957 to 1994. The resulting average is then scaled so that the peak probability, in the Io-B source region, becomes 100% relative probability.

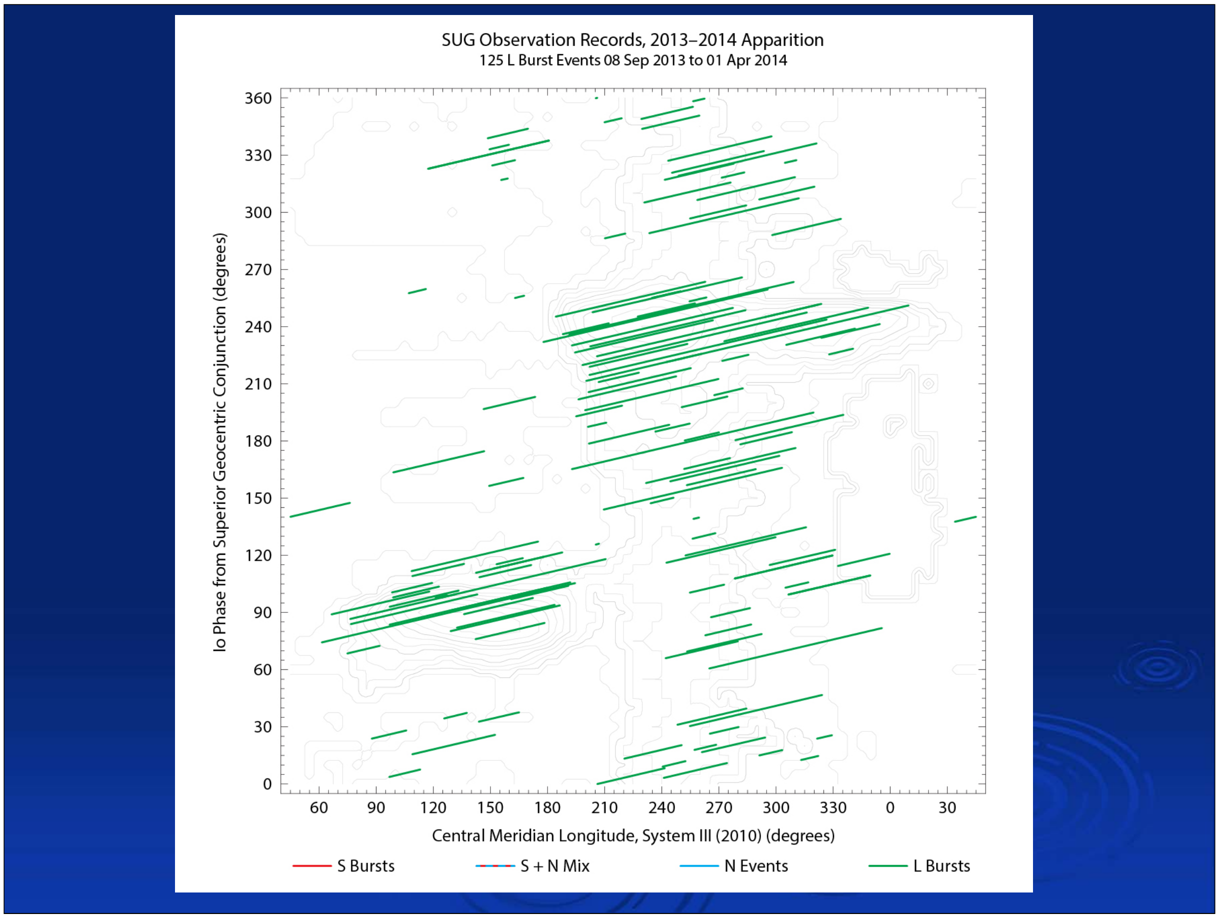
The probability of observing Jovian emissions is affected by many variables. Some of these are the observing frequency, transparency of the earth's ionosphere, duration of the observing session, antenna gain, receiver sensitivity, galactic background noise level, man-made noise level, position of Jupiter relative to the Sun, and the jovicentric declination of Earth.

While this image is a useful guide for the Jove observer, it cannot be used to predict events with absolute certainty.

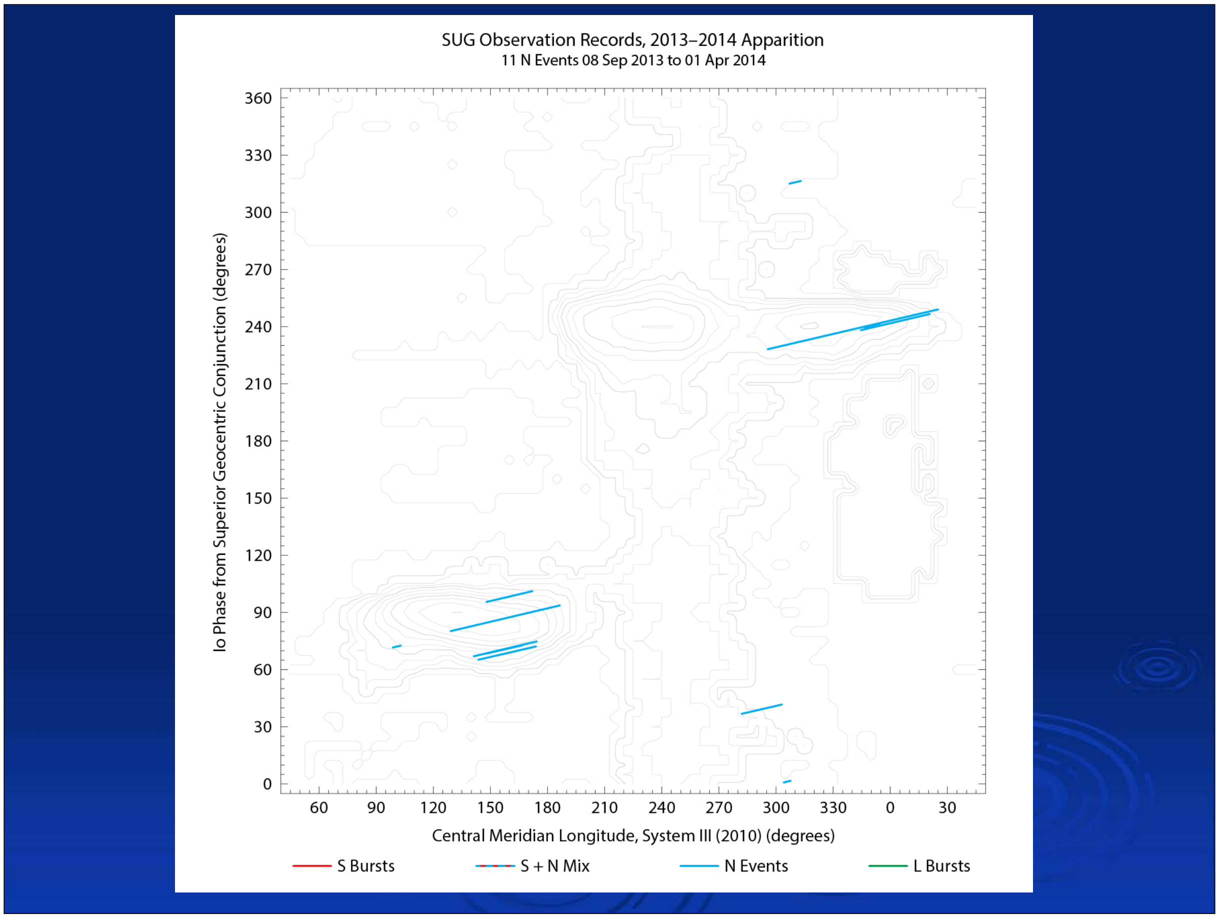
Thanks to Drs. Chuck Higgins, Francisco Reyes, and James Thieman, for their assistance in making this UFRO data available, and to Dave Typinski for generating the phase plane graphic images.



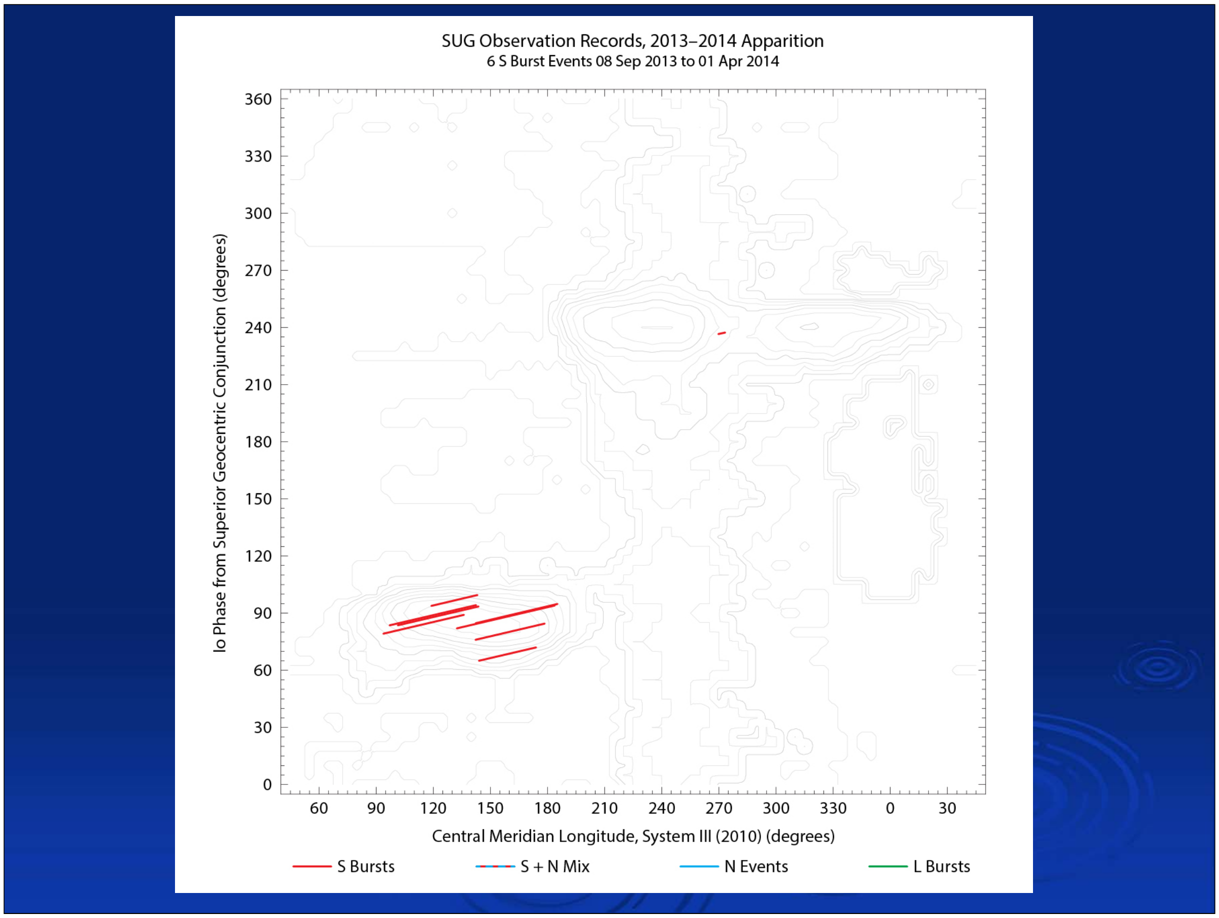
All SUG observed emission events, 2013-14 apparition;
151 events.



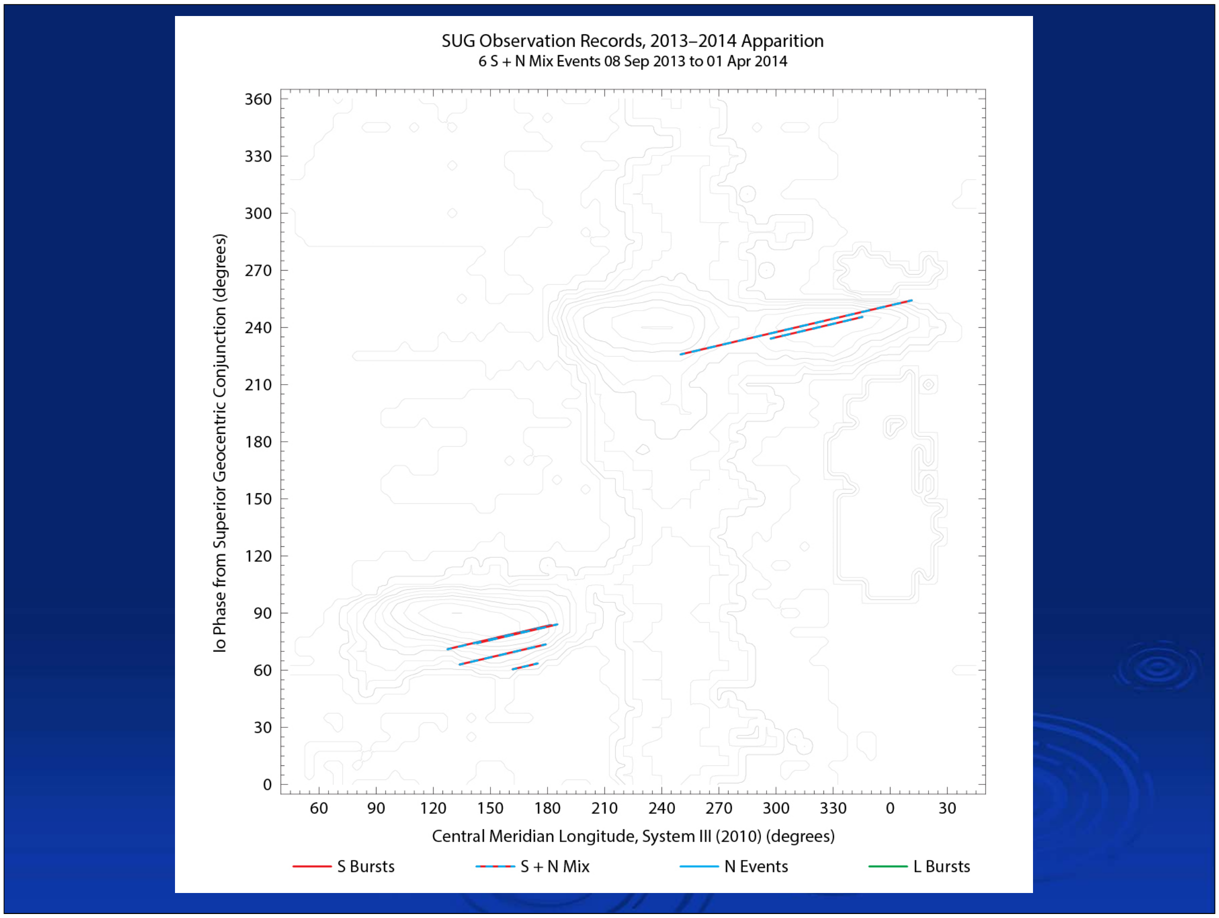
L busts; 125 events.



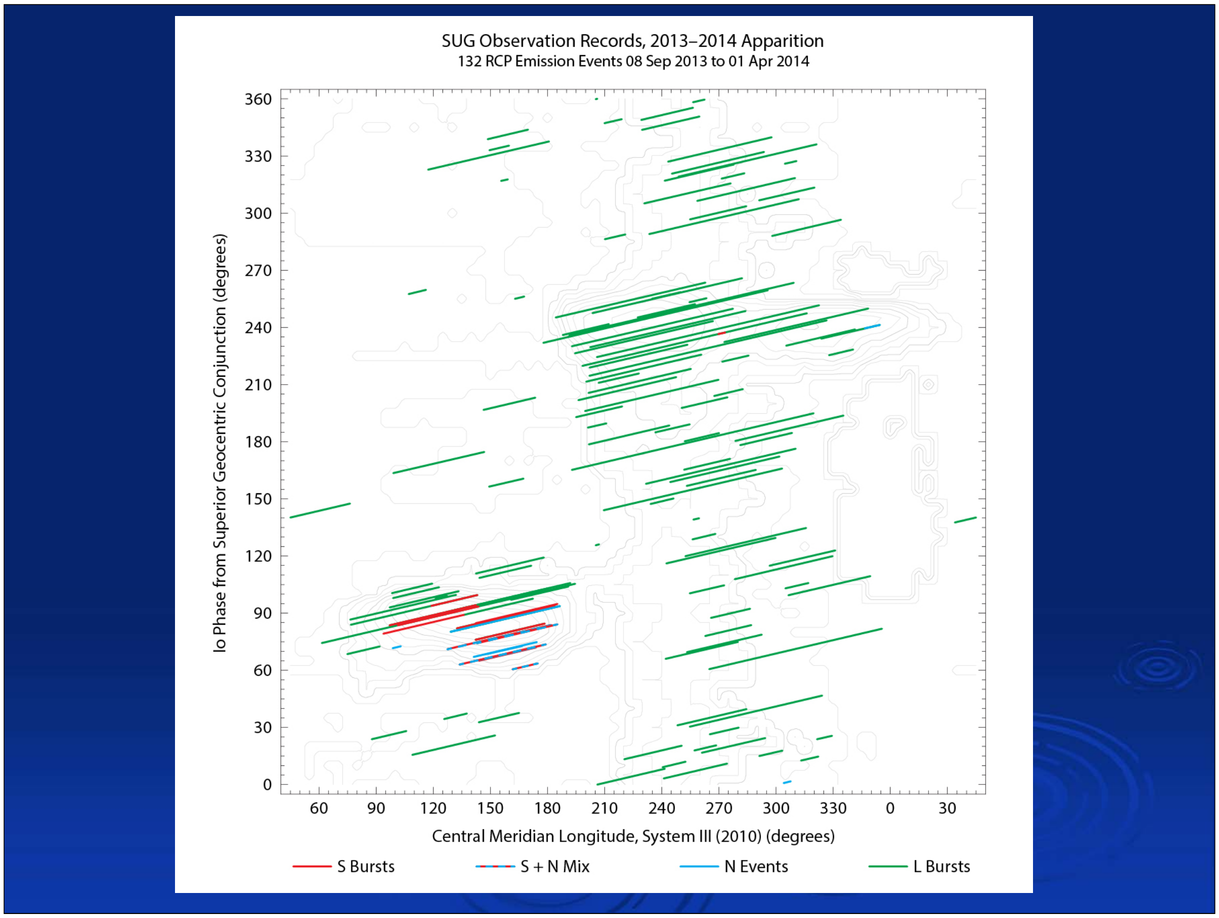
N events, 11 events.



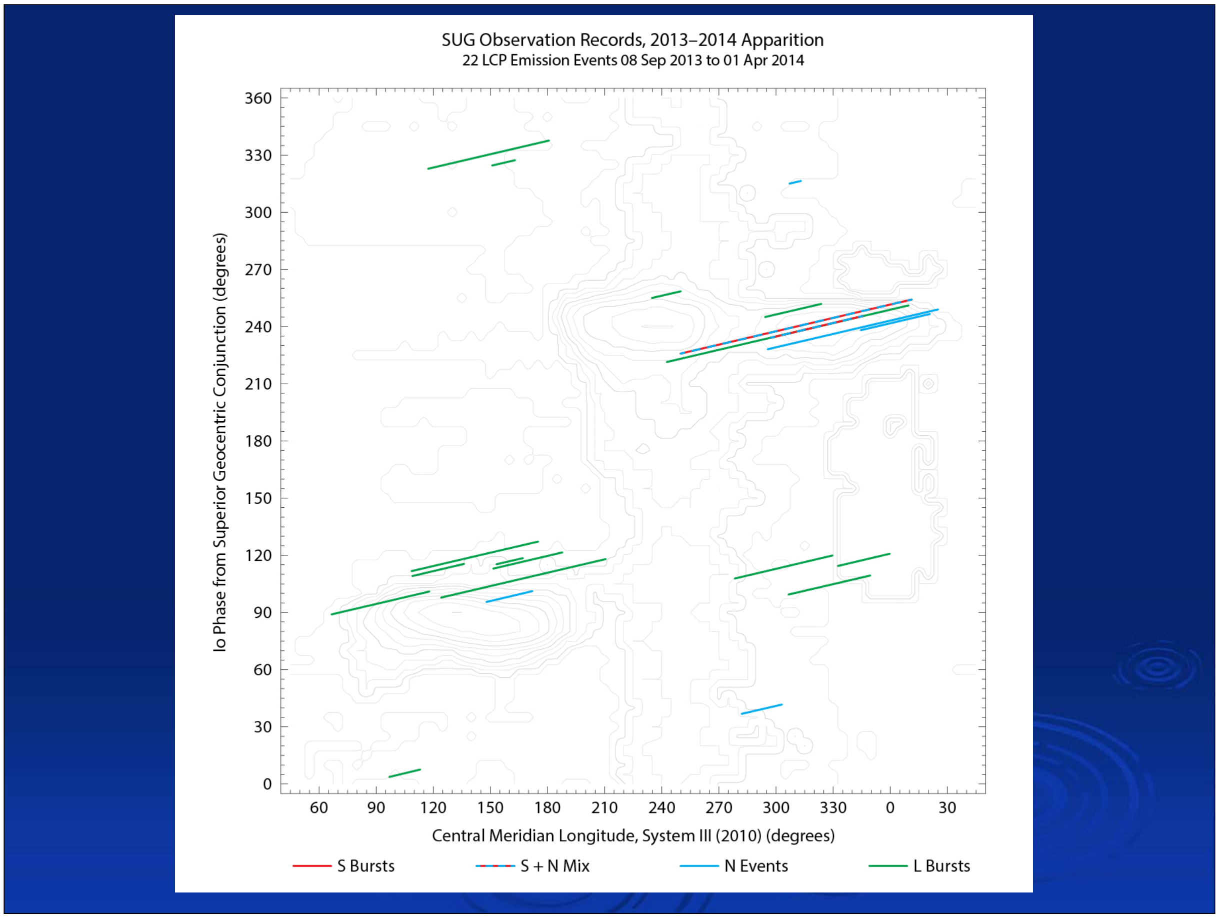
S bursts, 6 events.



SN events, 6 events.

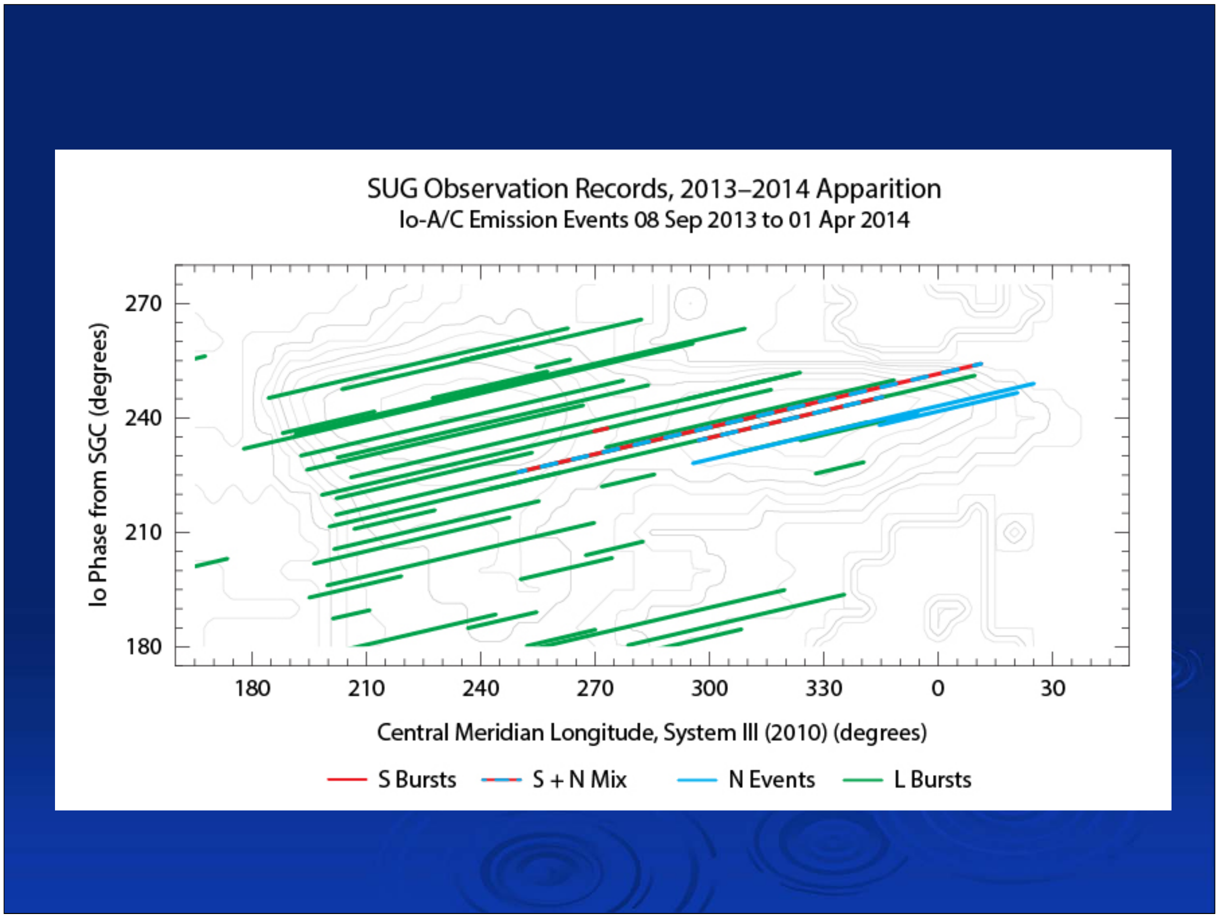


RCP events, 132 events.

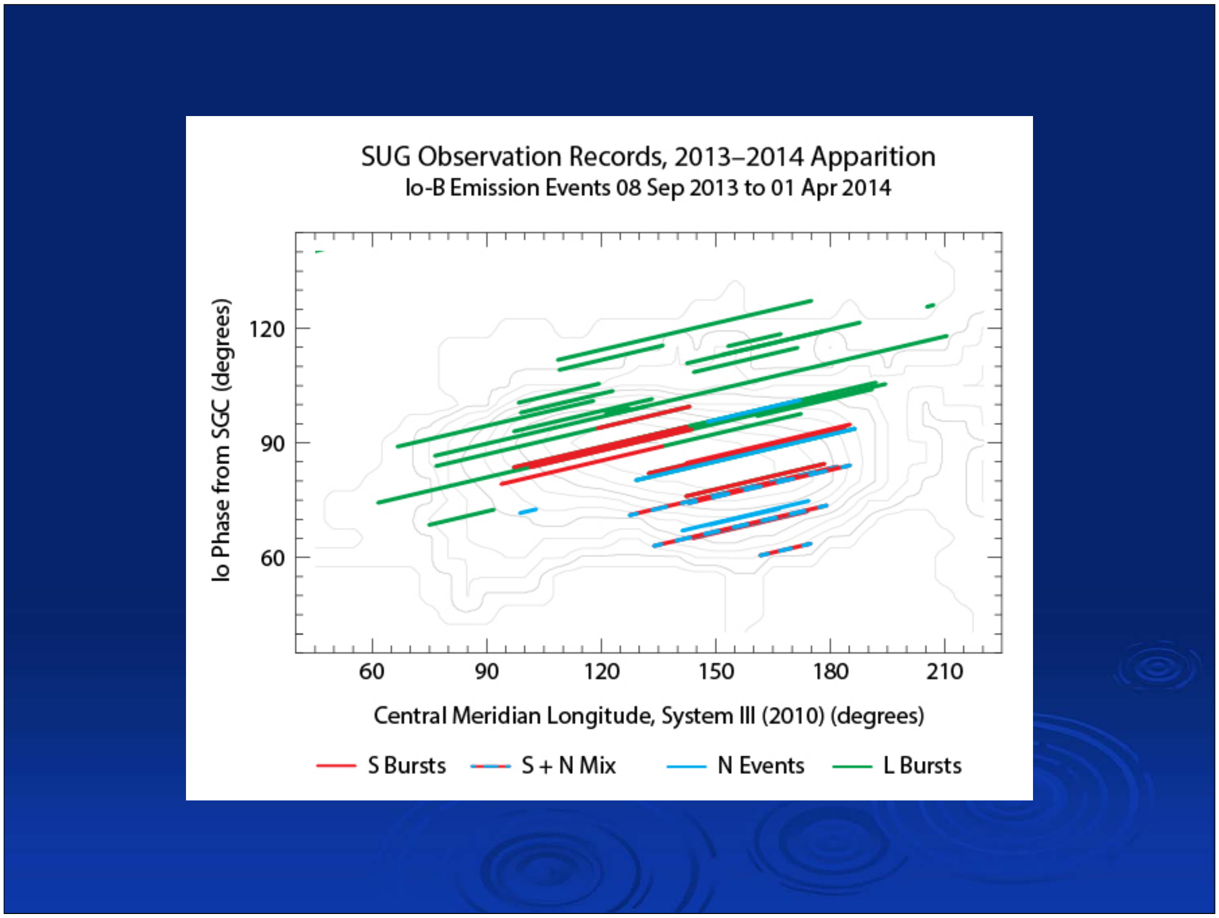


LCP events, 22 events.

The 7 LCP events just above the Io-B region are possibly Io-D. These await confirmation via comparison with LWA1 observations.



Here is a zoomed in view of all SUG events (RCP and LCP) in and near the Io-A and Io-C zones.

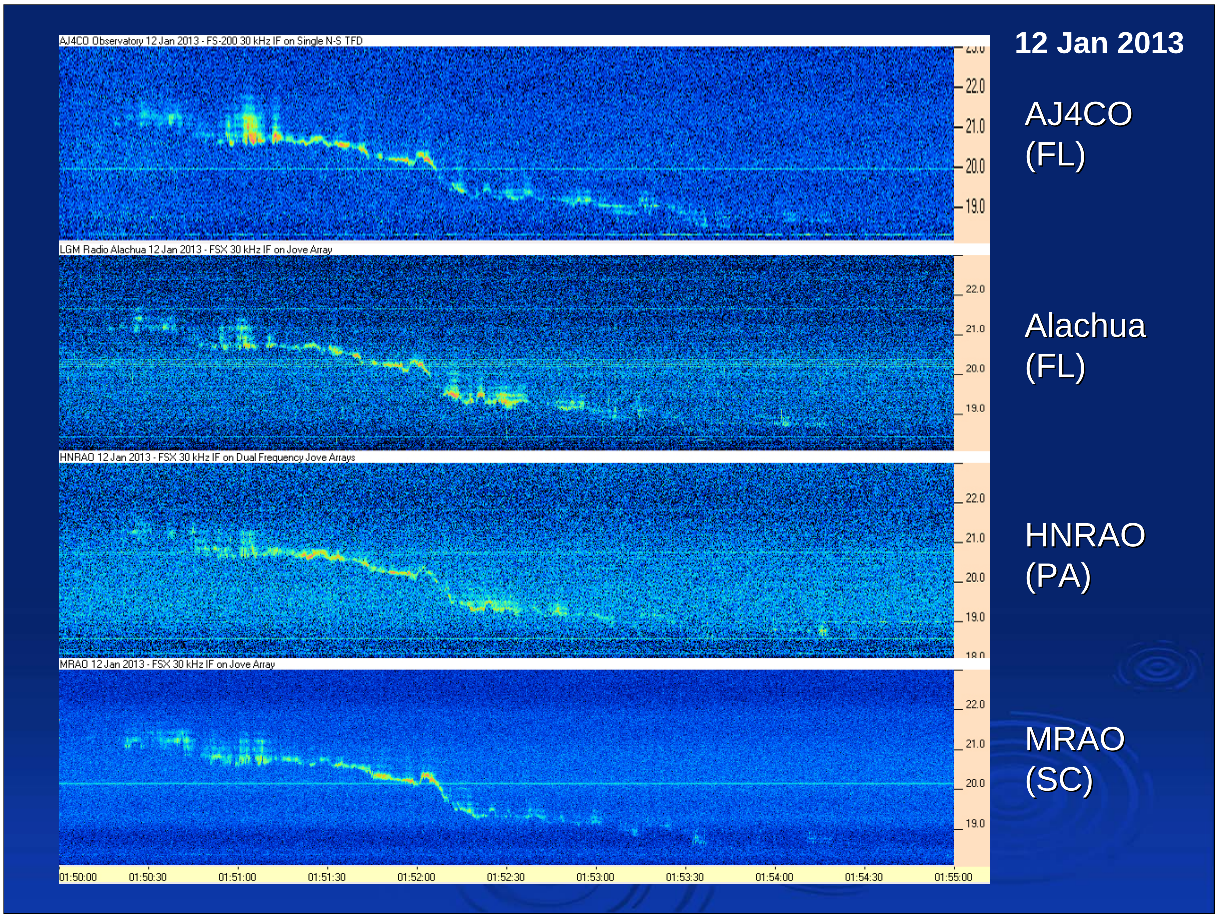


Here is a zoomed in view of all SUG events (RCP and LCP) in and near the Io-B zone.

Coordinated Observation

12 Jan 2013

Io-B



Observations of 12 Jan 2013. 5 minute span, 18-23 MHz.

Part of the genesis of the SUG was this comparison by Richard Flagg in Brown & Flagg, "Observations of Jovian Emissions by Multiple Spaced Spectrographs", SARA (2013). The spectrograms here, covering a single Io-B N event, are taken from "image set 7" in that publication.

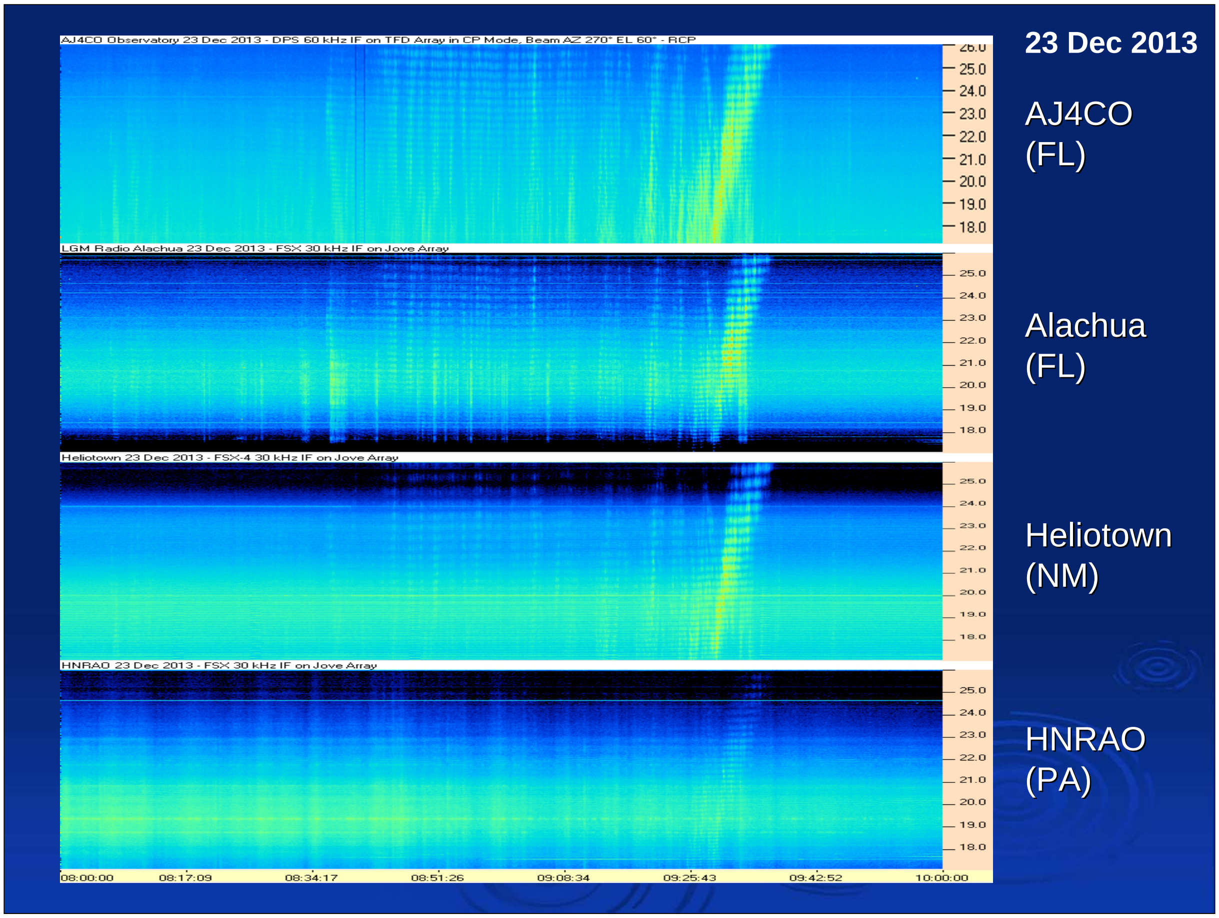
Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array

Reference available in the Publications section of the SUG site: **http://www.radiojove.org/SUG/**

23 Dec 2013

Io-B



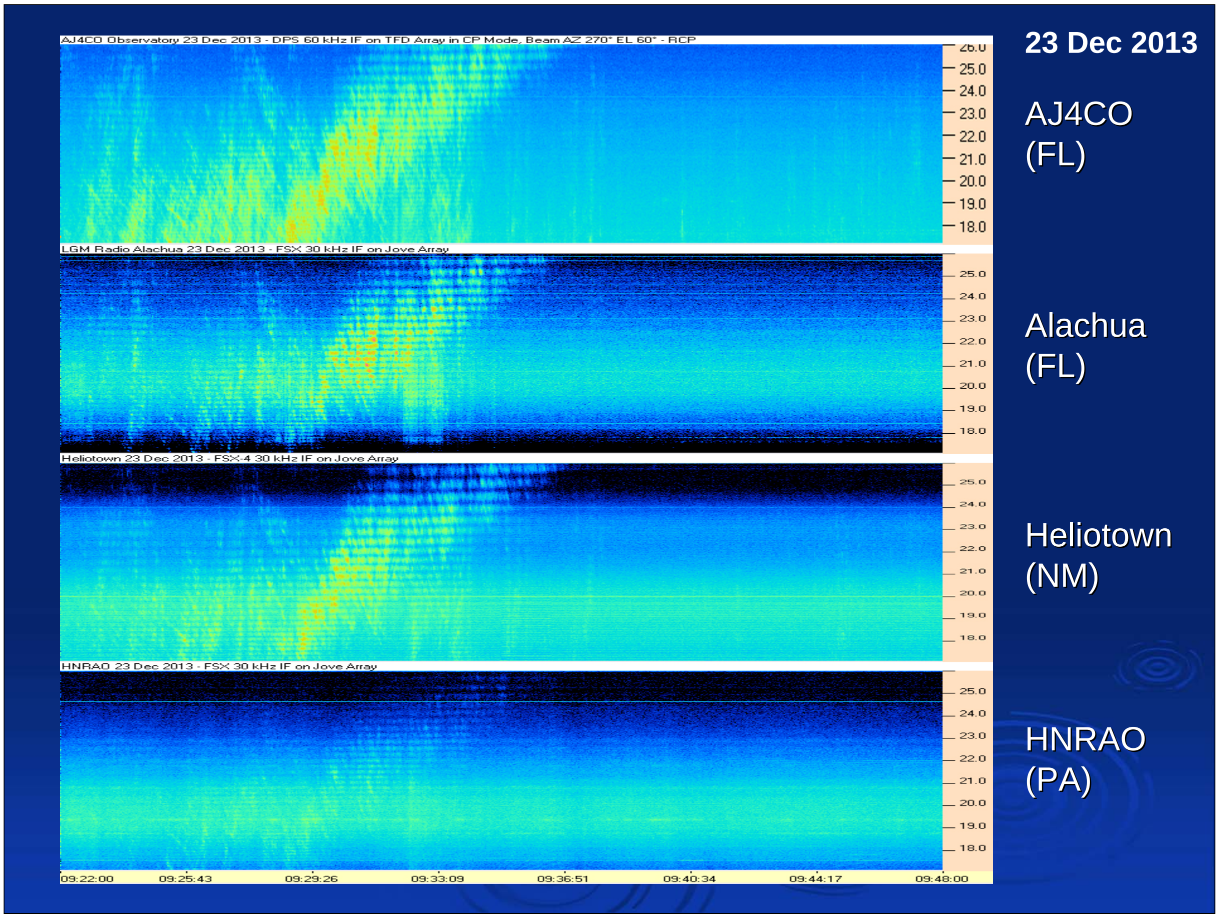
Observations of 23 Dec 2013. 120 minute span, 17-26 MHz.

There was very good correlation between distant observers for this storm.

The DPS shows deep Faraday banding due to bad hybrids (discovered due to this storm).

Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array

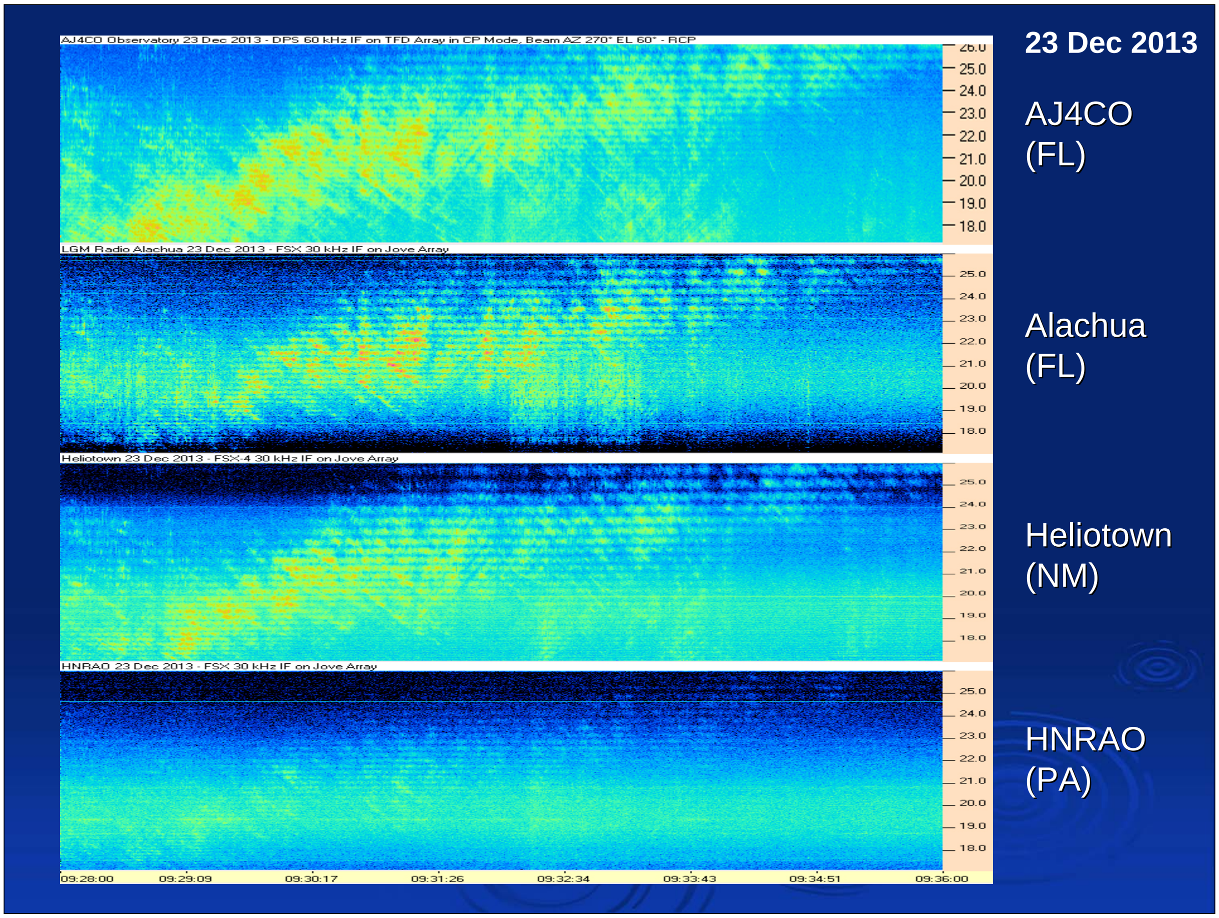


Observations of 23 Dec 2013. 26 minute span, 17-26 MHz.

Good correlation.

Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array



Observations of 23 Dec 2013. 8 minute span, 17-26 MHz.

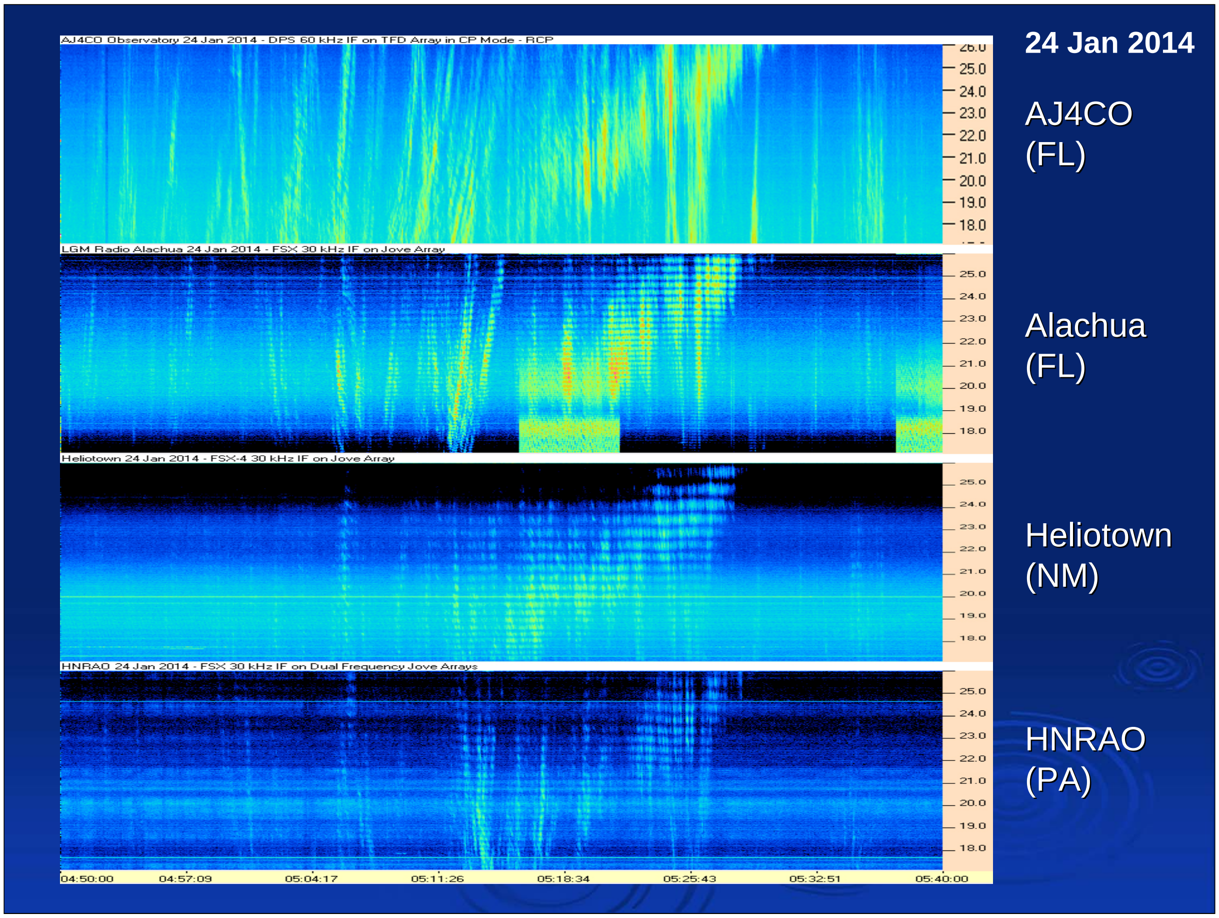
A few differences can now be seen, but overall still very good correlation even on this 8-minute time scale.

Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array

24 Jan 2014

Io-B



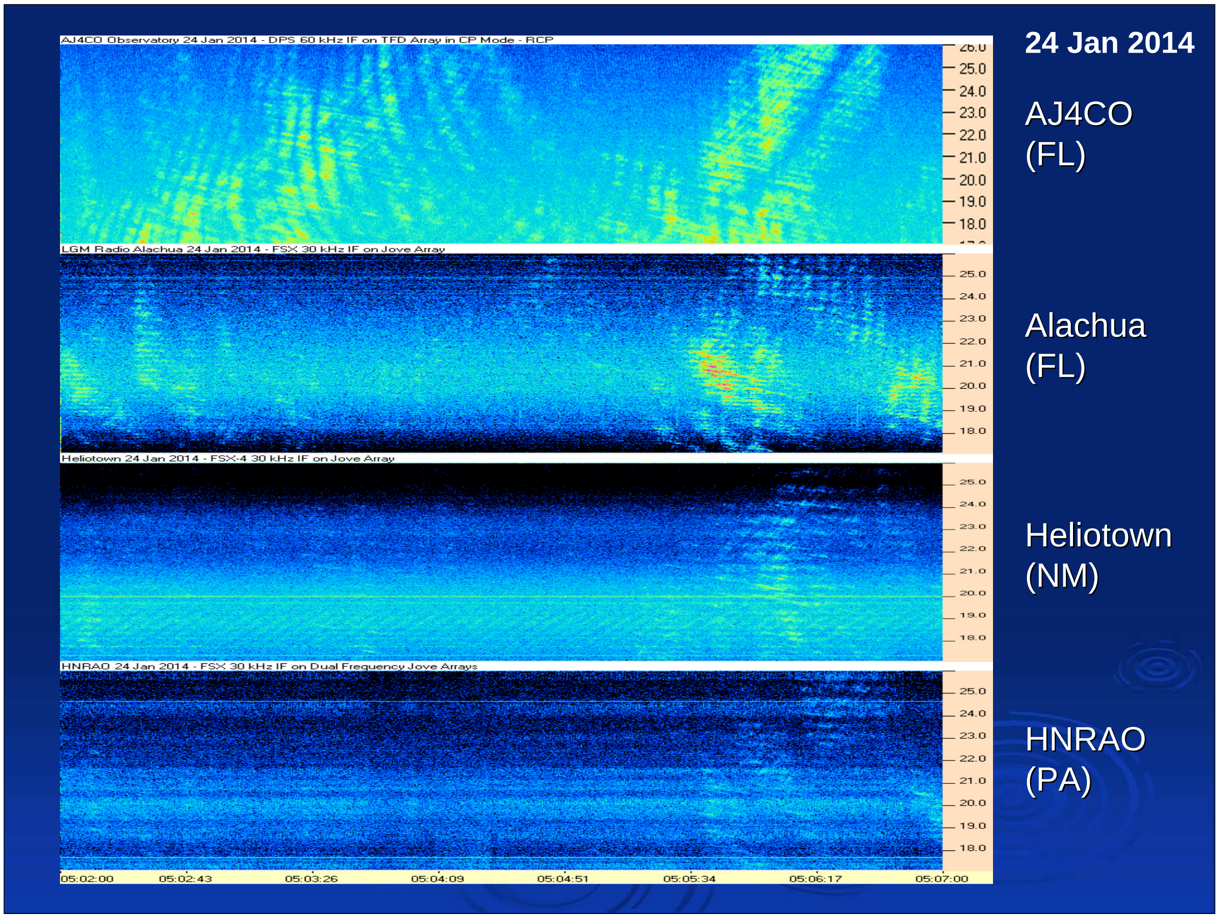
Observations of 24 Jan 2014. 50 minute span, 17-26 MHz.

In contrast to the Dec 23 Io-B storm, this Jan 24 Io-B had relatively poor correlation between distant observers. Even at this very long time scale, there are many differences in the dynamic spectra shown in these spectrograms.

NOTE: The AJ4CO spectrogram reflects circular polarization, which explains the lack of Faraday banding. This, however, cannot explain any of the other differences.

Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array

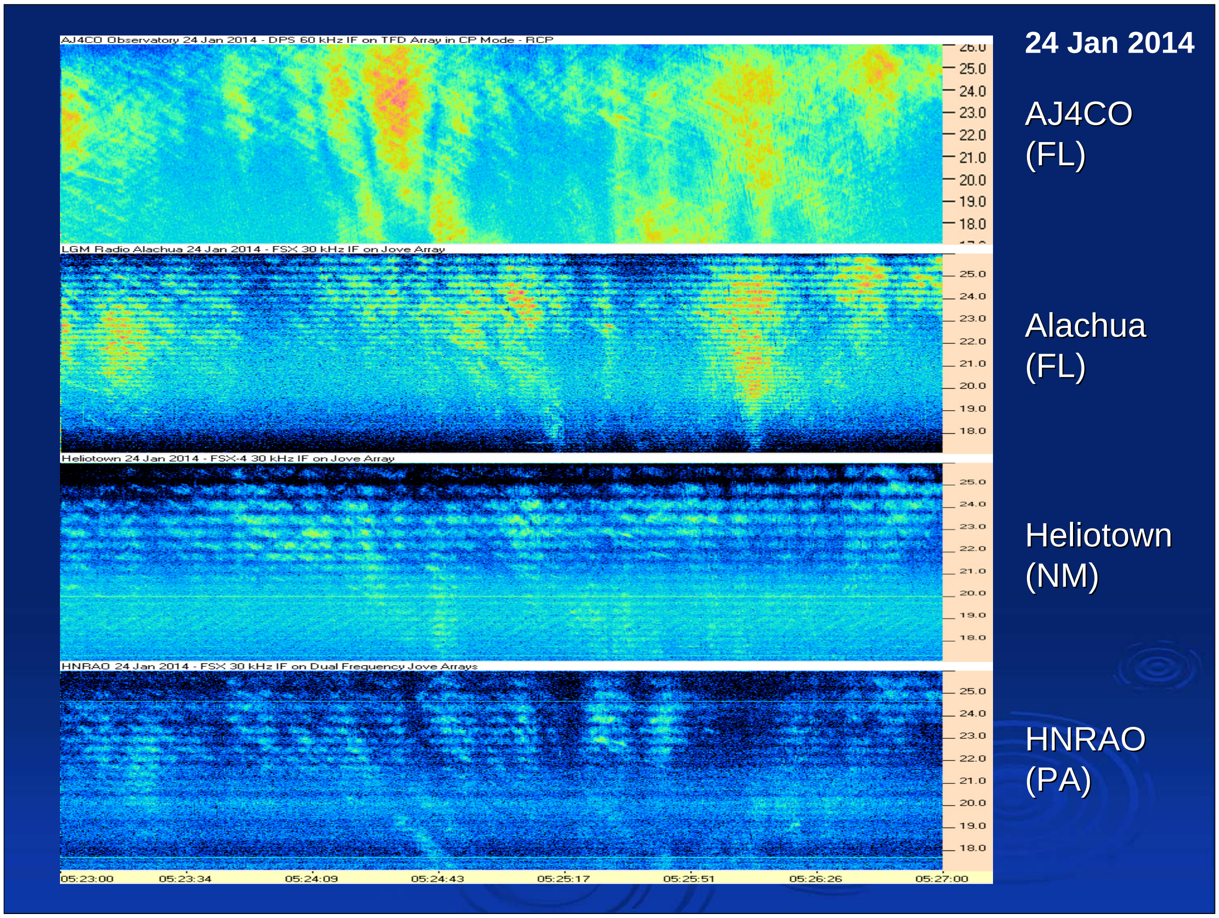


Observations of 24 Jan 2014. 5 minute span, 17-26 MHz.

At this 5-minute time scale, there is an incredible amount of difference between the widely spaced observers – and even between the not-so-widely spaced observers: AJ4CO and Alachua are only 10 miles apart.

Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array

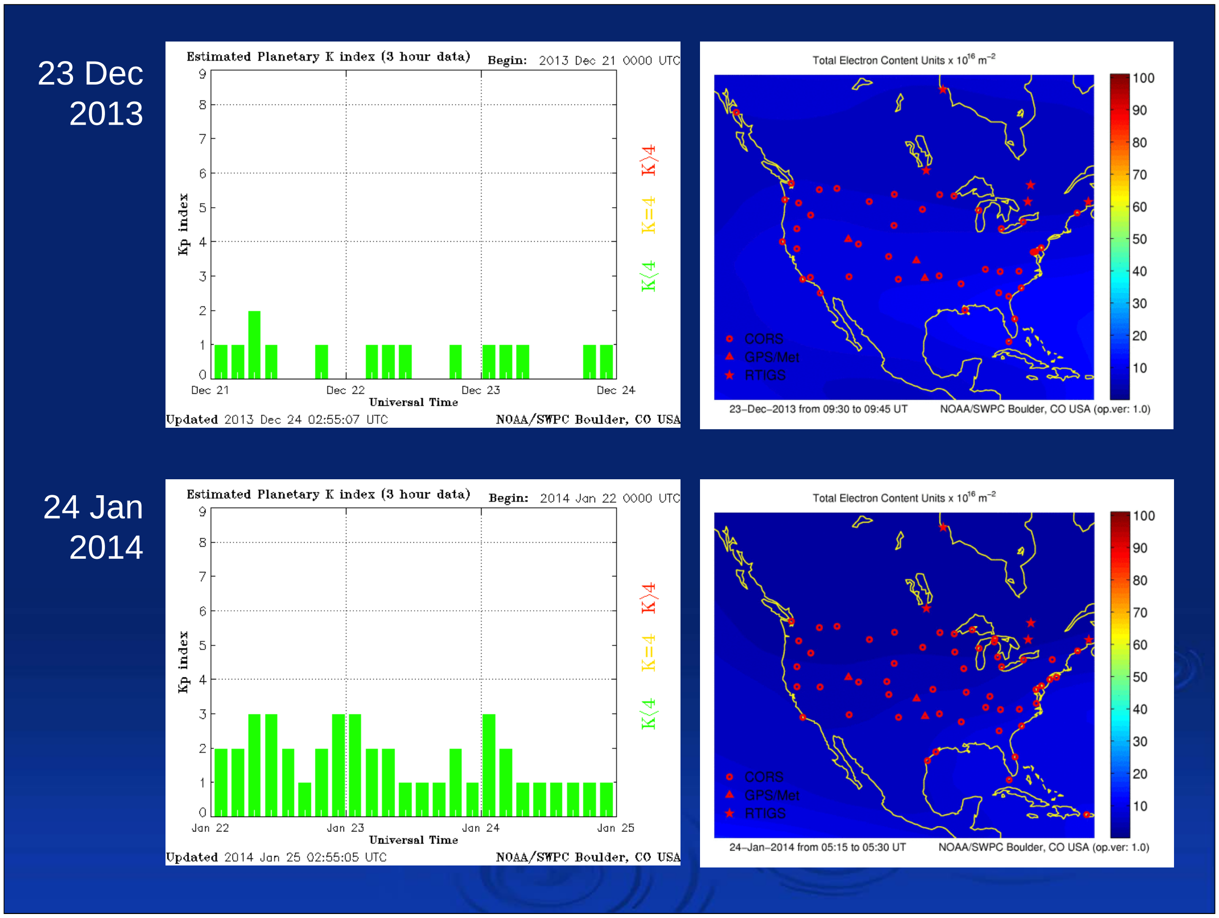


Observations of 24 Jan 2014. 4 minute span, 17-26 MHz.

Is this even the same storm? On this 4-minute time scale, the differences are striking.

Note that there are differences in gain due to different observatory antenna configurations.

1) AJ4CO (FL), Typinski, FS-200, single N-S TFD antenna
2) Alachua (FL), Greenman, FSX, Jove array
3) HNRAO (PA), Brown, FSX, 4-element, dual-frequency, dual Jove array
4) MRAO (SC), Mount, FSX, Jove array



The obvious question is: why does the Jan 24 Io-B exhibit far less correlation between observers than the Dec 23 Io-B?

The Total Electron Count (TEC) in the ionosphere was not radically different; it was slightly less for the Jan 24 storm.

The planetary K index, however, was slightly elevated on Jan 24 compared to Dec 23. Could the K index, an indicator of geomagnetic instability, affect the degree of observed correlation between stations? We must be careful not to extrapolate from only these two data points. More observations, more comparisons – along with many more hours of data reduction and analysis – may give us a few more clues.