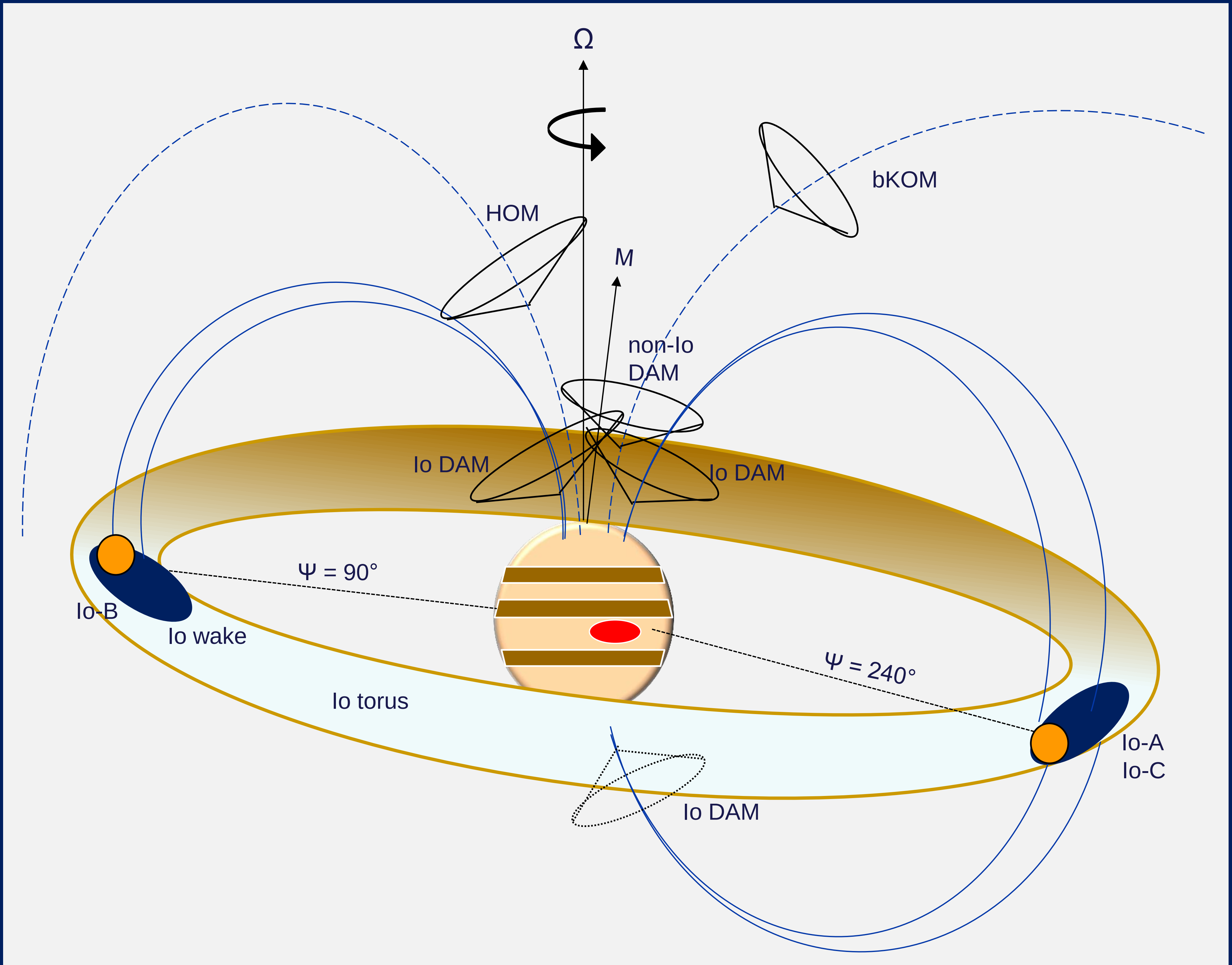
Fine Structure in Jovian Decametric Emission using LWA1

Chuck Higgins
Middle Tennessee State University
Tracy Clarke
NRL Code 7210
Jinhie Skarda
Undergraduate, Stanford University

Collaborators:
Kazumasa Imai, Kochi National College of Technology, Japan
Francisco Reyes, University of Florida
Jim Thieman, NASA/GSFC
Masafumi Imai, Kyoto University, Japan

Jupiter Radio Emission Overview



bKOM – broadband kilometric emission (auroral origins)

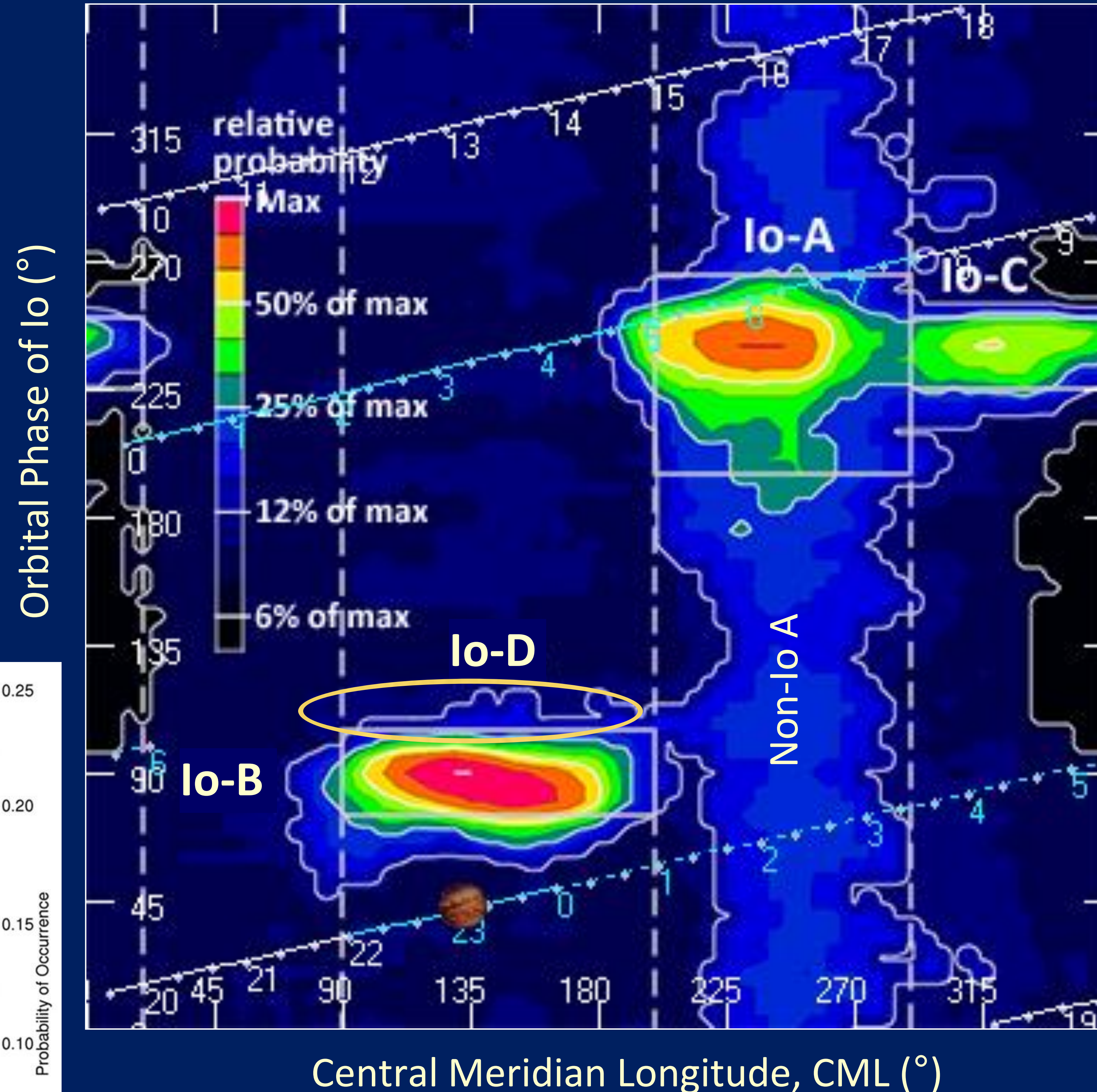
HOM – hectometric emission (auroral)

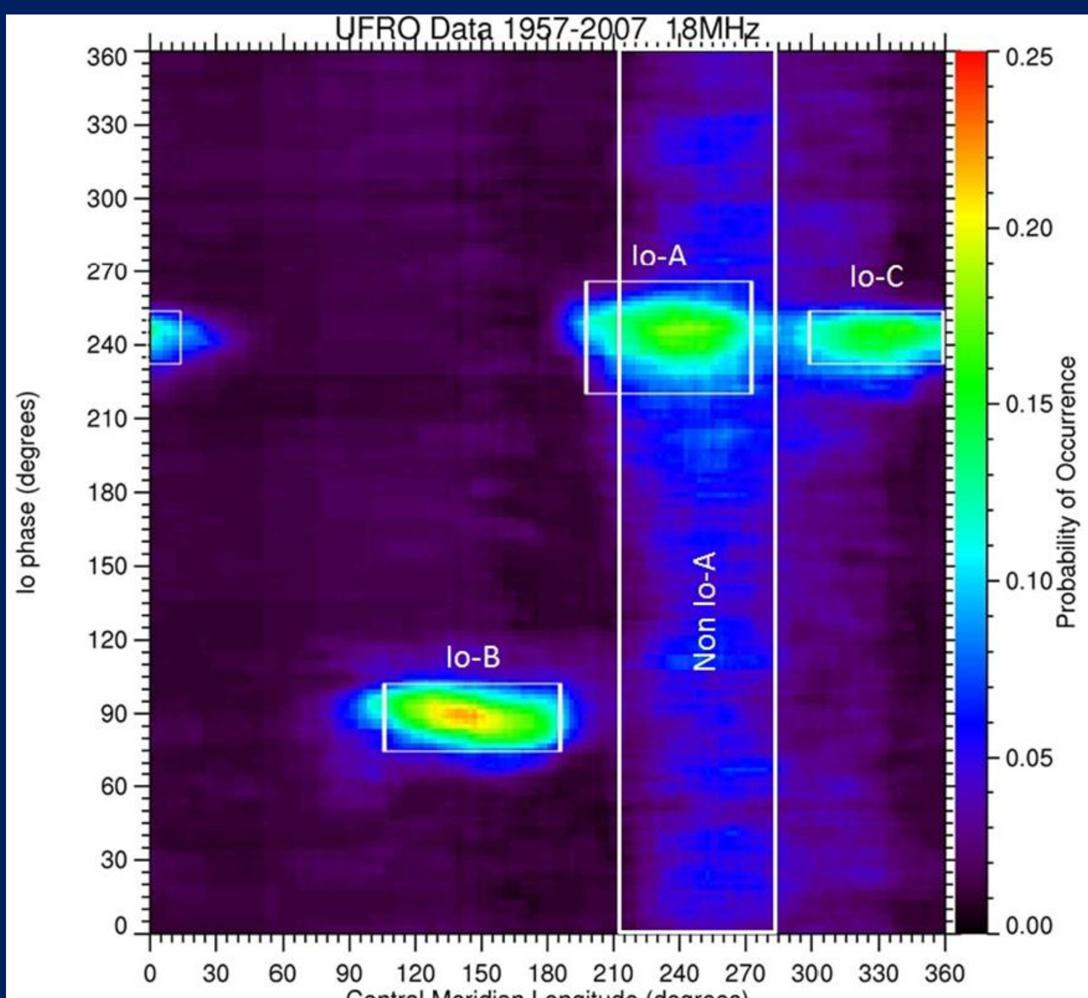
Non-Io-DAM – auroral decametric (related to HOM)

Io-DAM – decametric emission tied to Io flux tube and Io torus

DAM Occurrence Probability Maps

	CML	Io Phase
Io-A	200-270 °	205-270 °
Io-B	105-185 °	80-110 °
Io-C	300- 20 °	225-260 °
Io-D	90-200 °	95-130 °

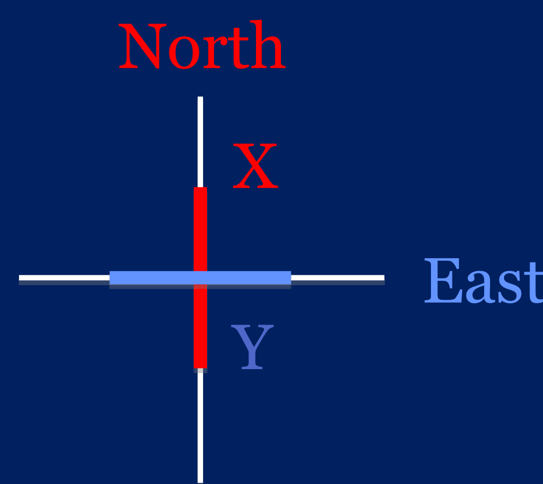




Data Reduction and Analysis

- 2 Beams: Jupiter & Offbeam
- 19.6 MHz bandwidth
- ~ 242 Hours (> 20 Terabytes) of observations
- Data analysis implemented python packages *numpy, matplotlib, & lsl*

Data Reduction and Analysis



Basis change to r, l

$$r = \frac{(x + iy)}{\sqrt{2}}$$

$$l = \frac{(x - iy)}{\sqrt{2}}$$

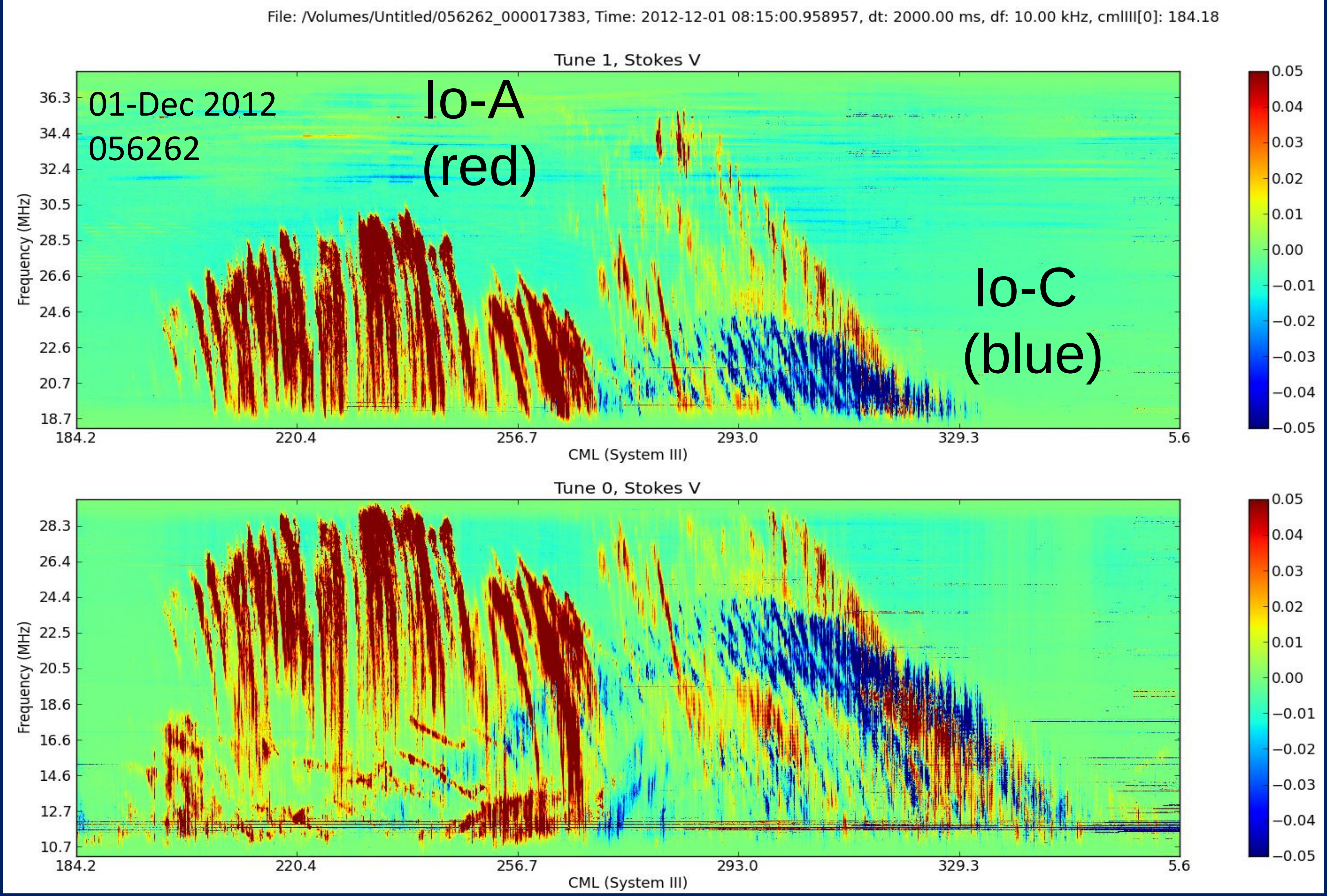
Use Fourier transforms to convert to frequency spectra

Convert to Stokes *V*

$$V = R^2 - L^2$$

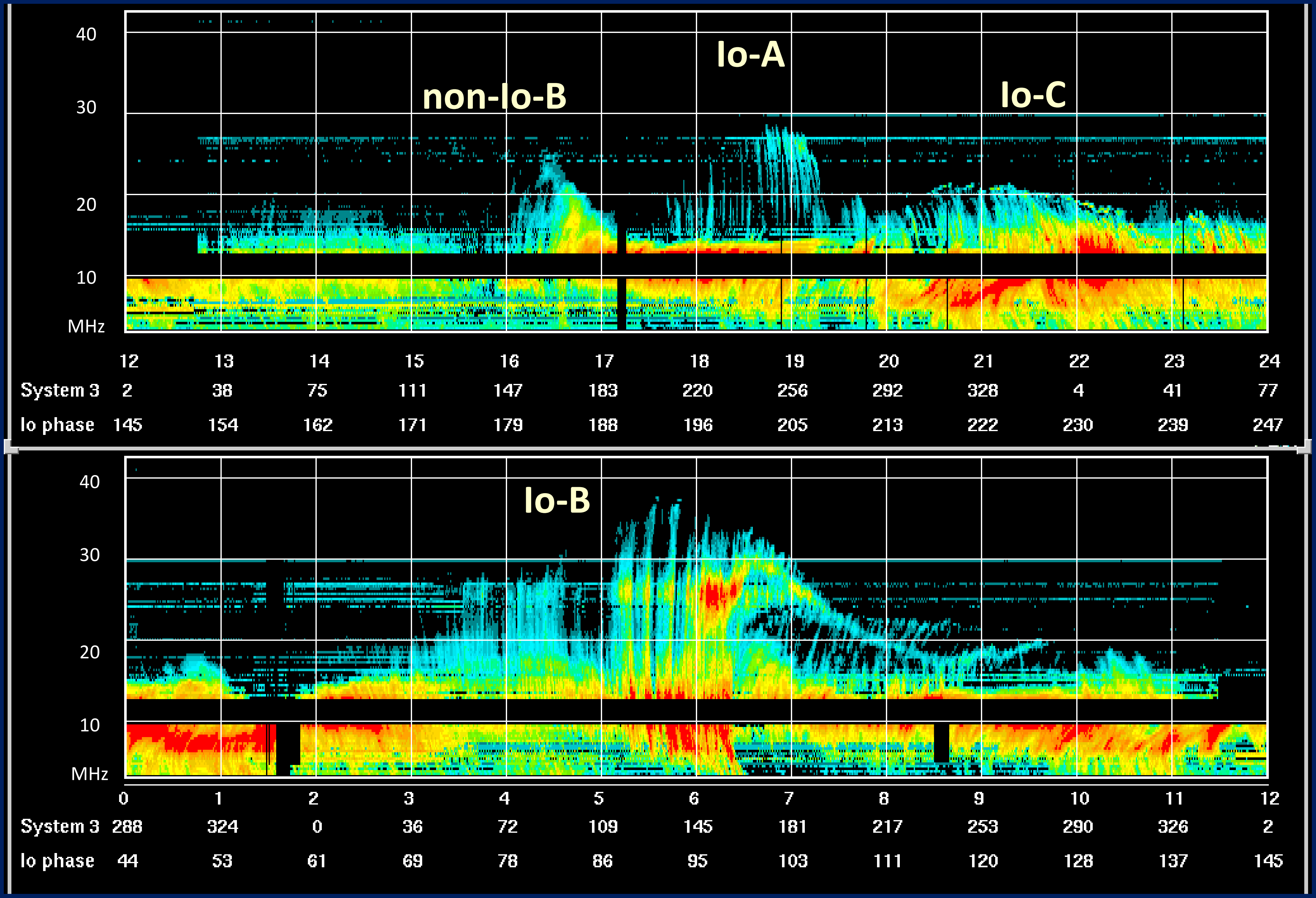
Output

Io-A, Io-C Emission



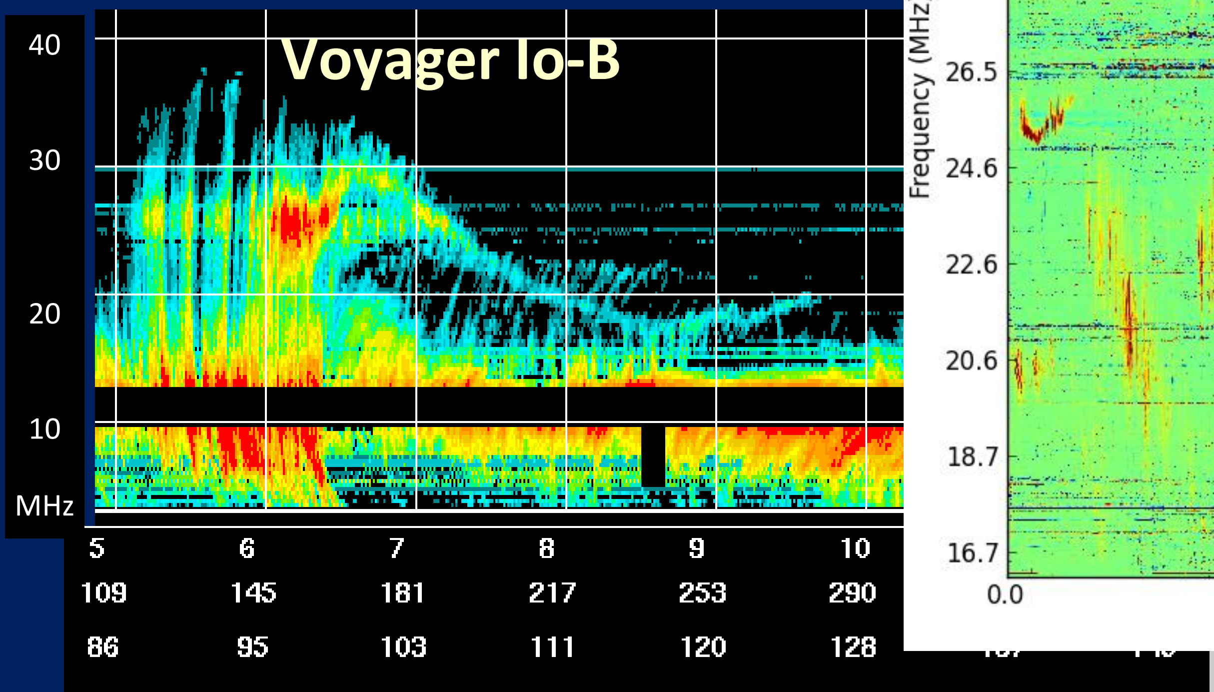
Voyager Observations (for comparison)

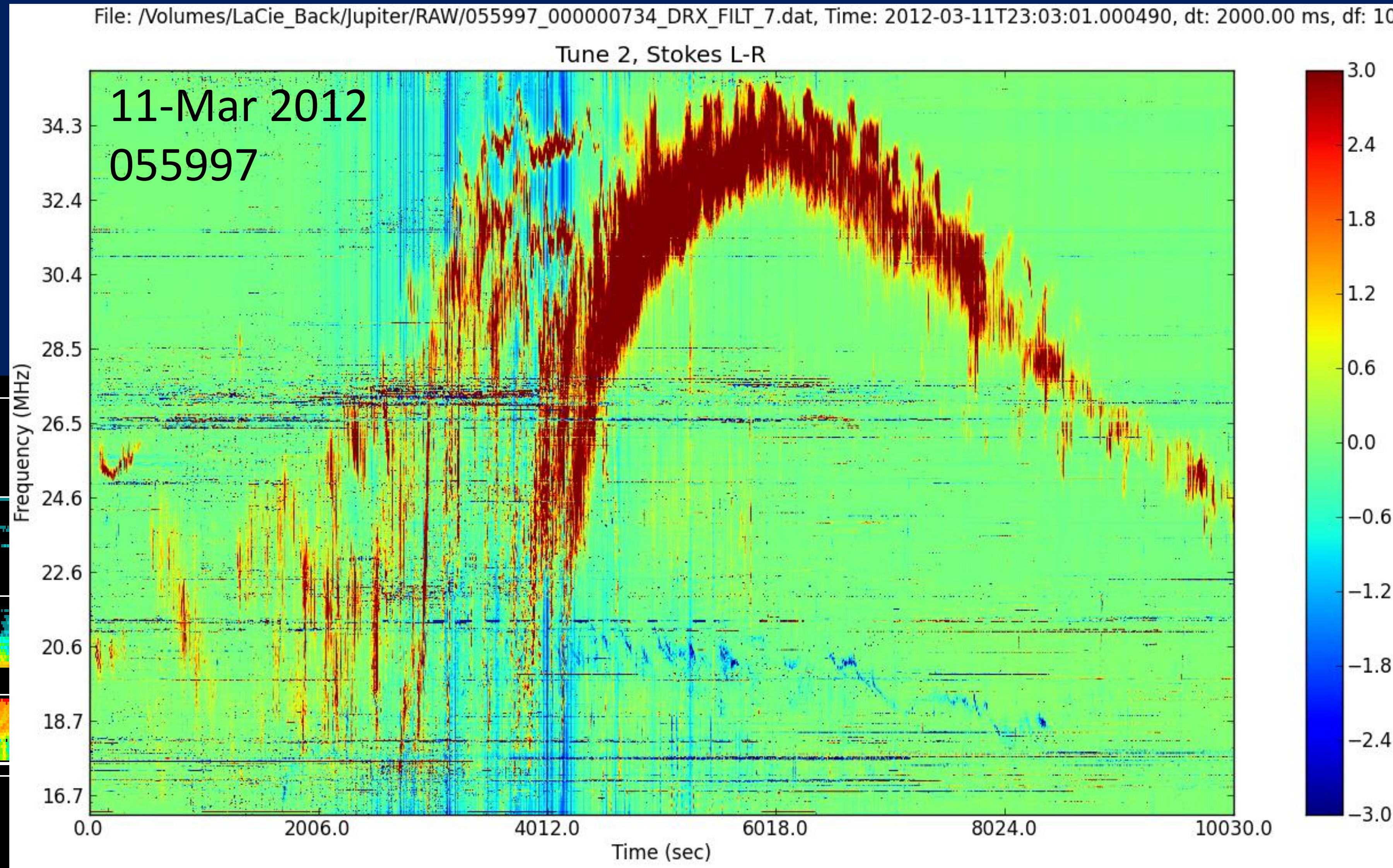
July 16, 1979

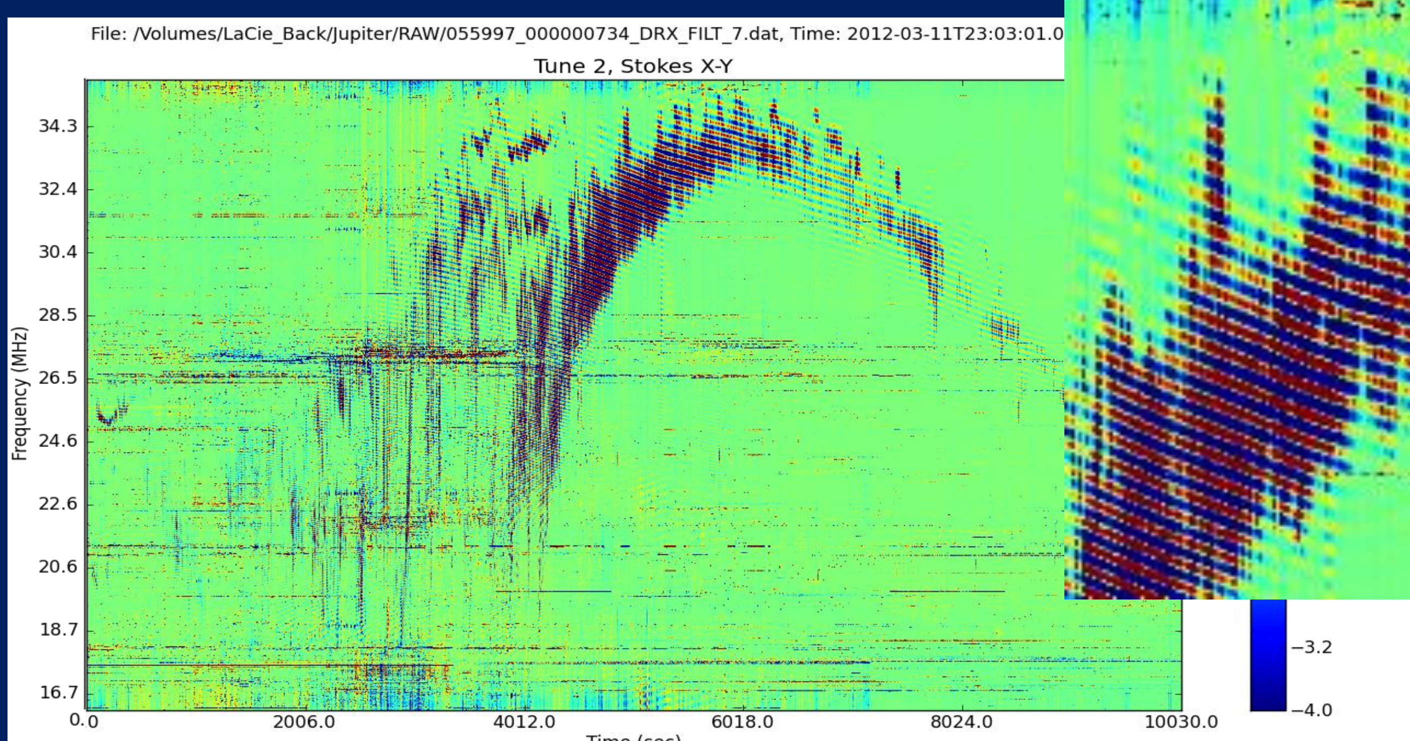


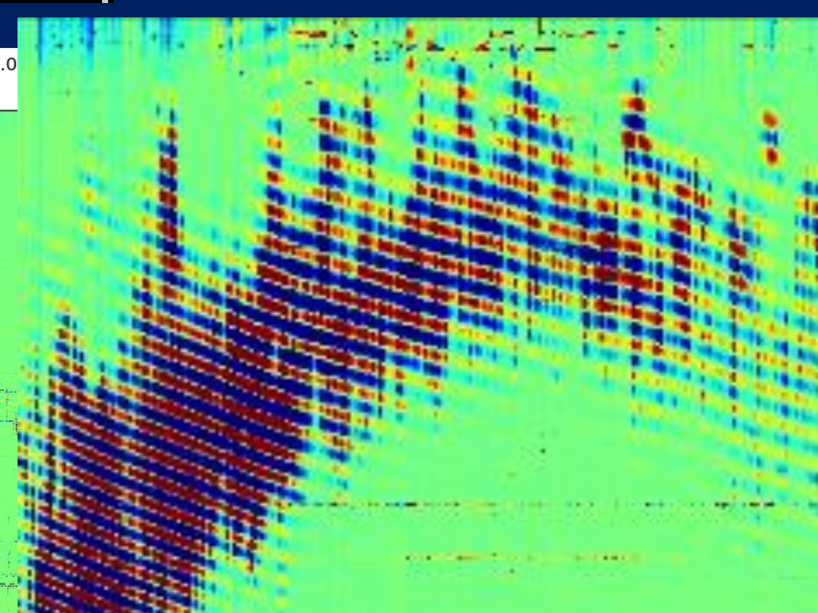
Io-B Event

LWA1 data show beautiful similarity to Voyager observations



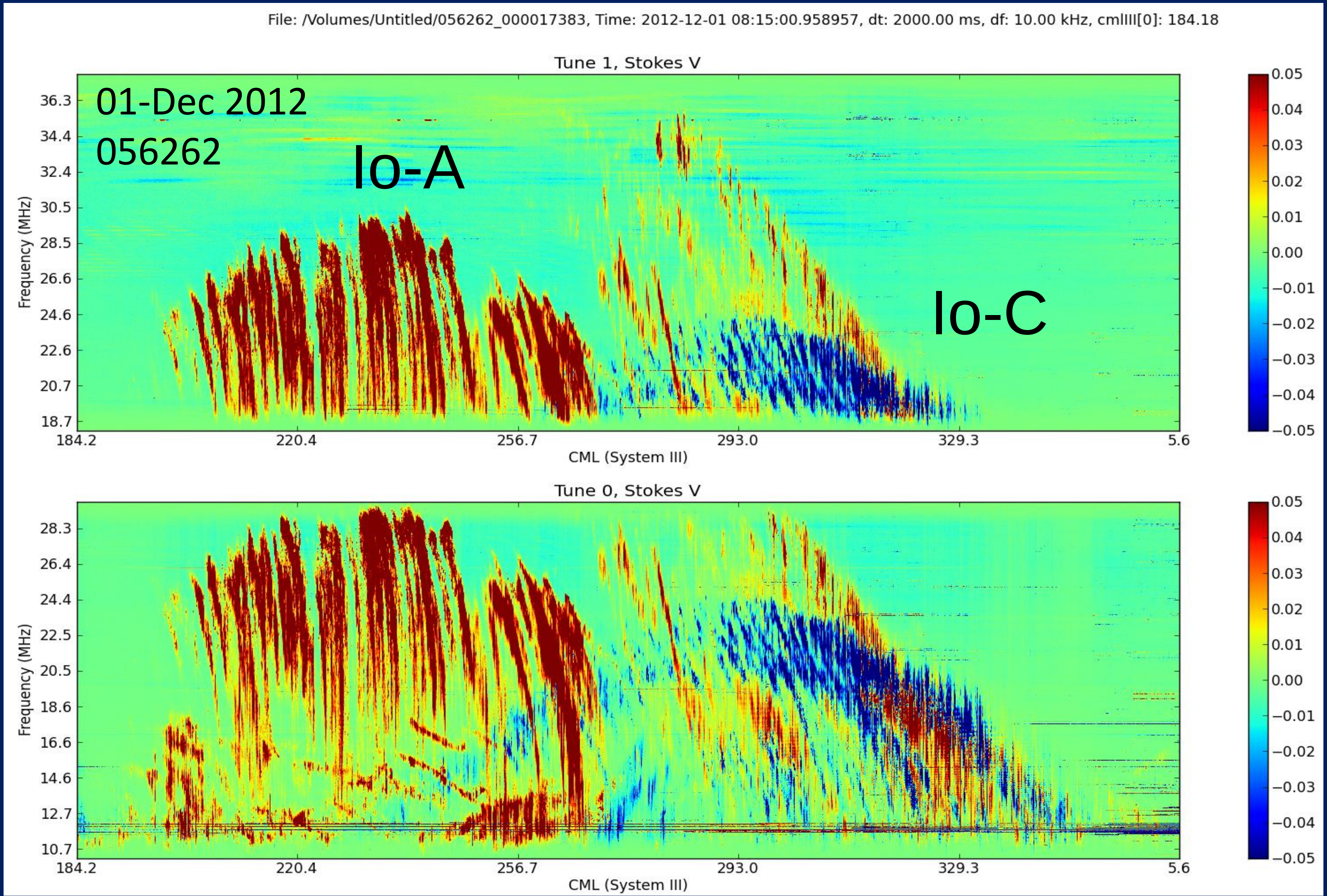






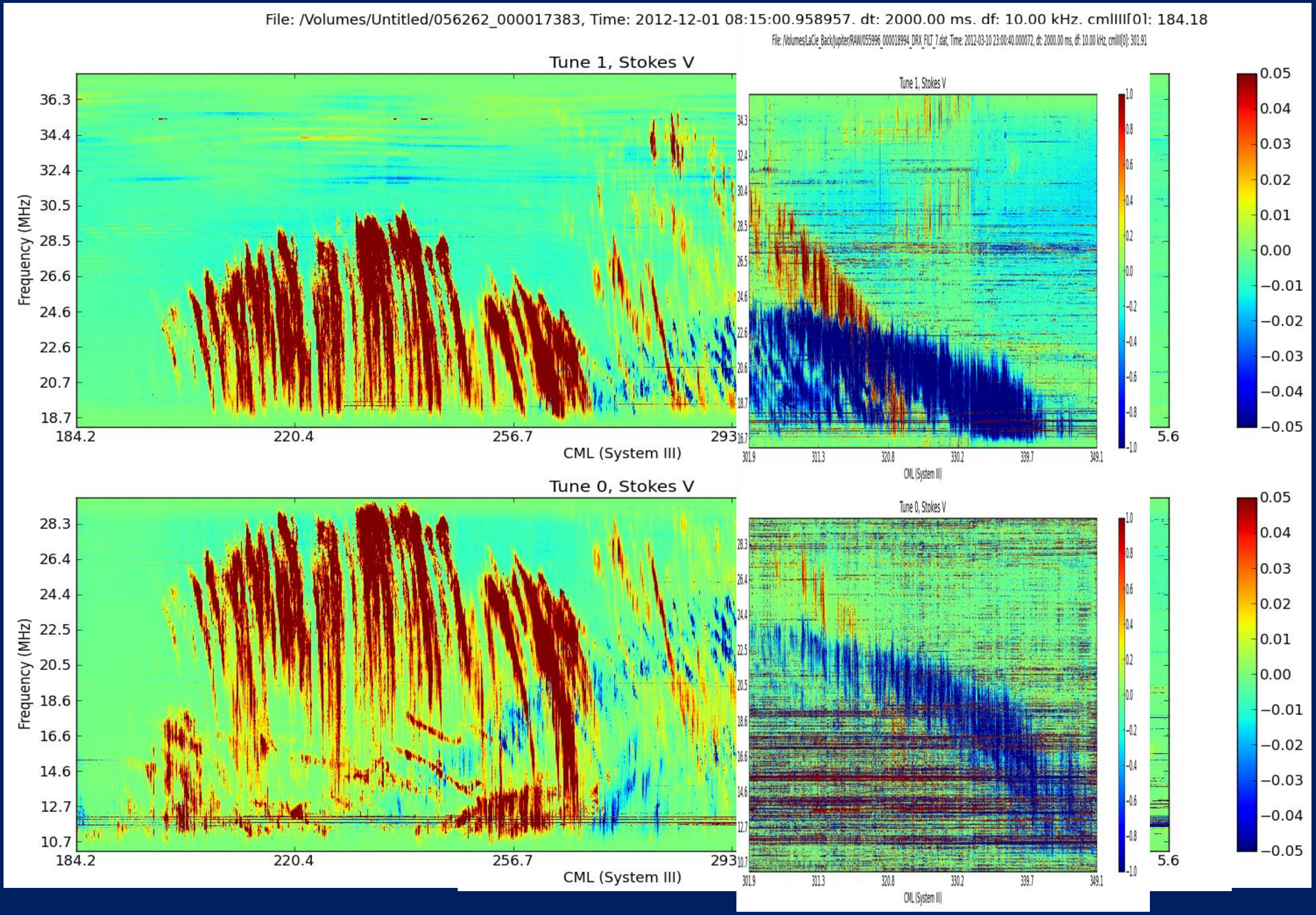
Ionosphere-Induced Faraday Lanes

Io-A, Io-C Emission



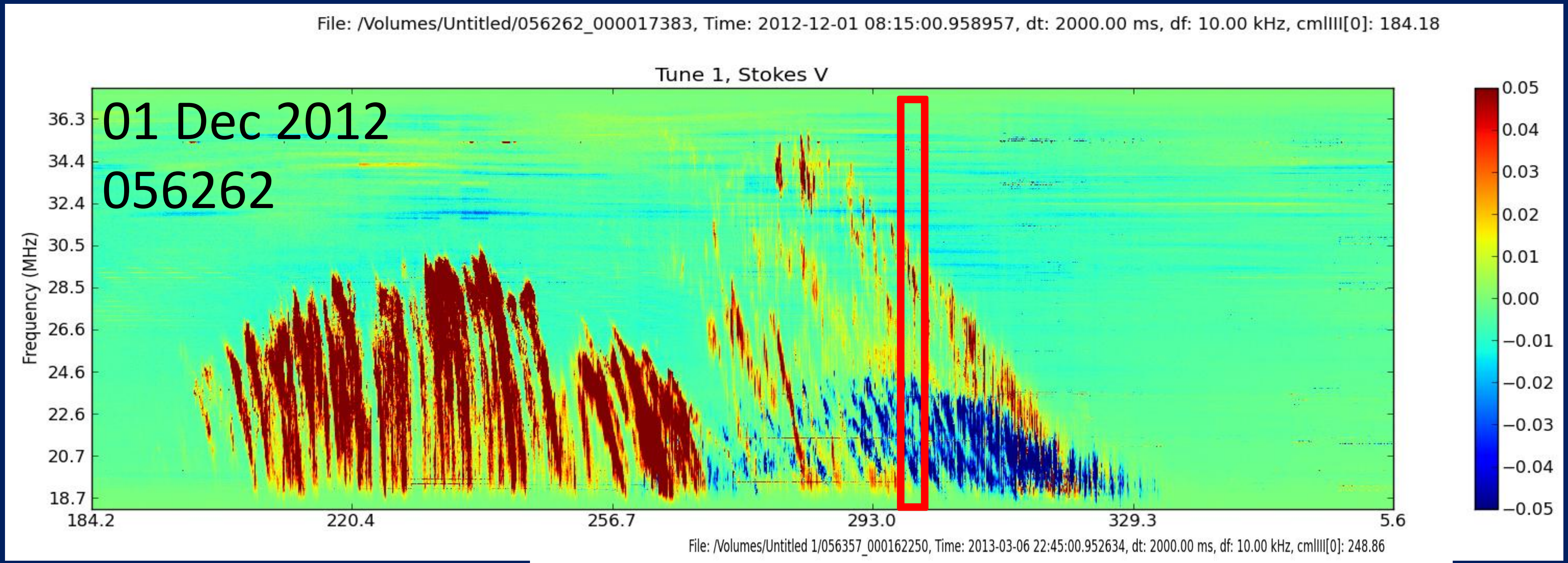
- RH and LH polarizations observed simultaneously – good test of the CMI theory
- Are RX and LO modes coming from the same hemisphere?

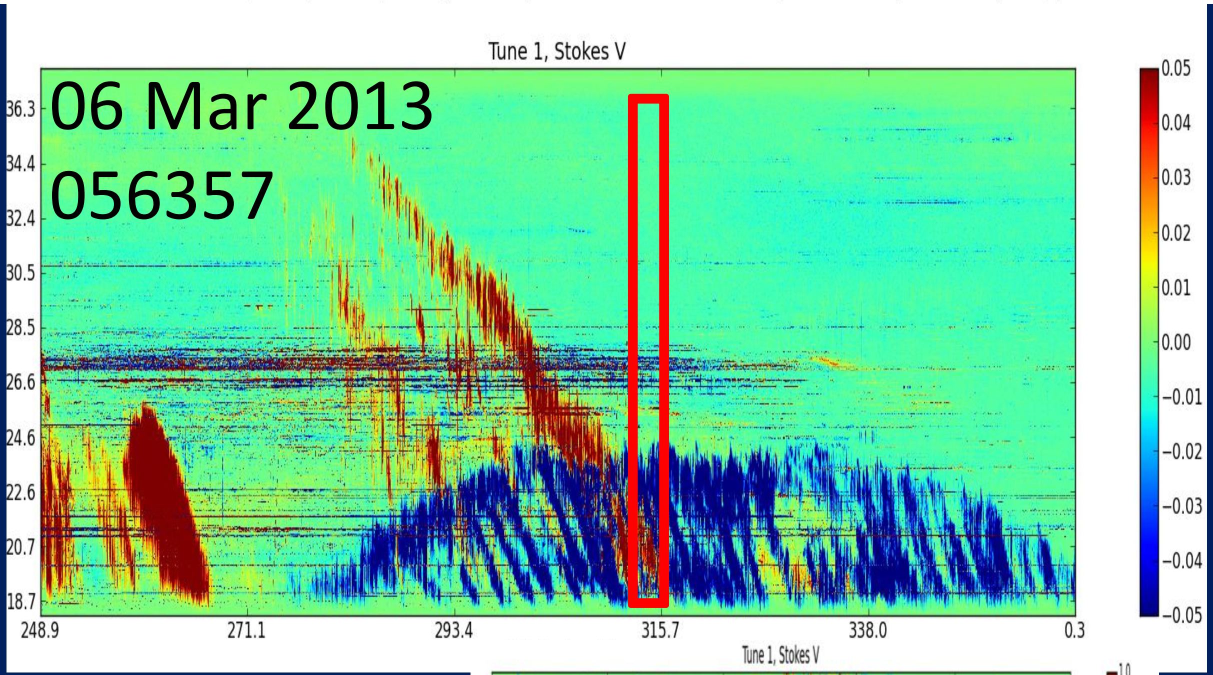
Io-A, Io-C Observations
Remarkable Consistency in Emission Structure

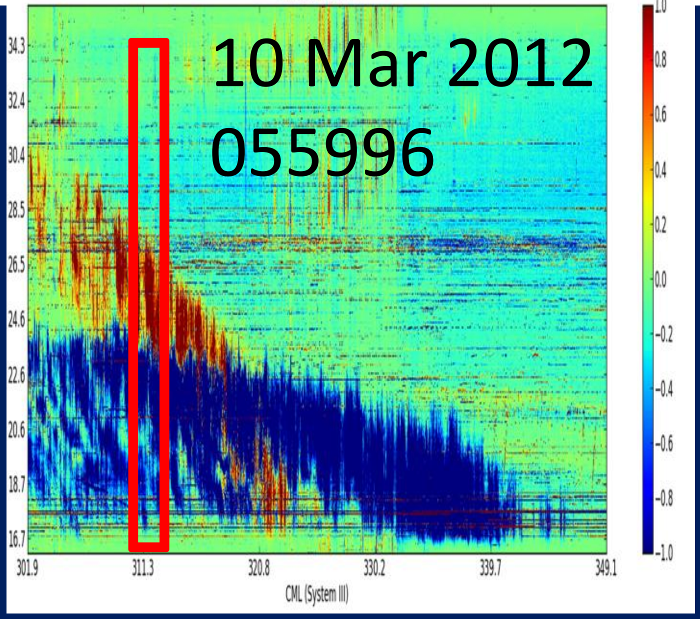


Io-A, Io-C Observations

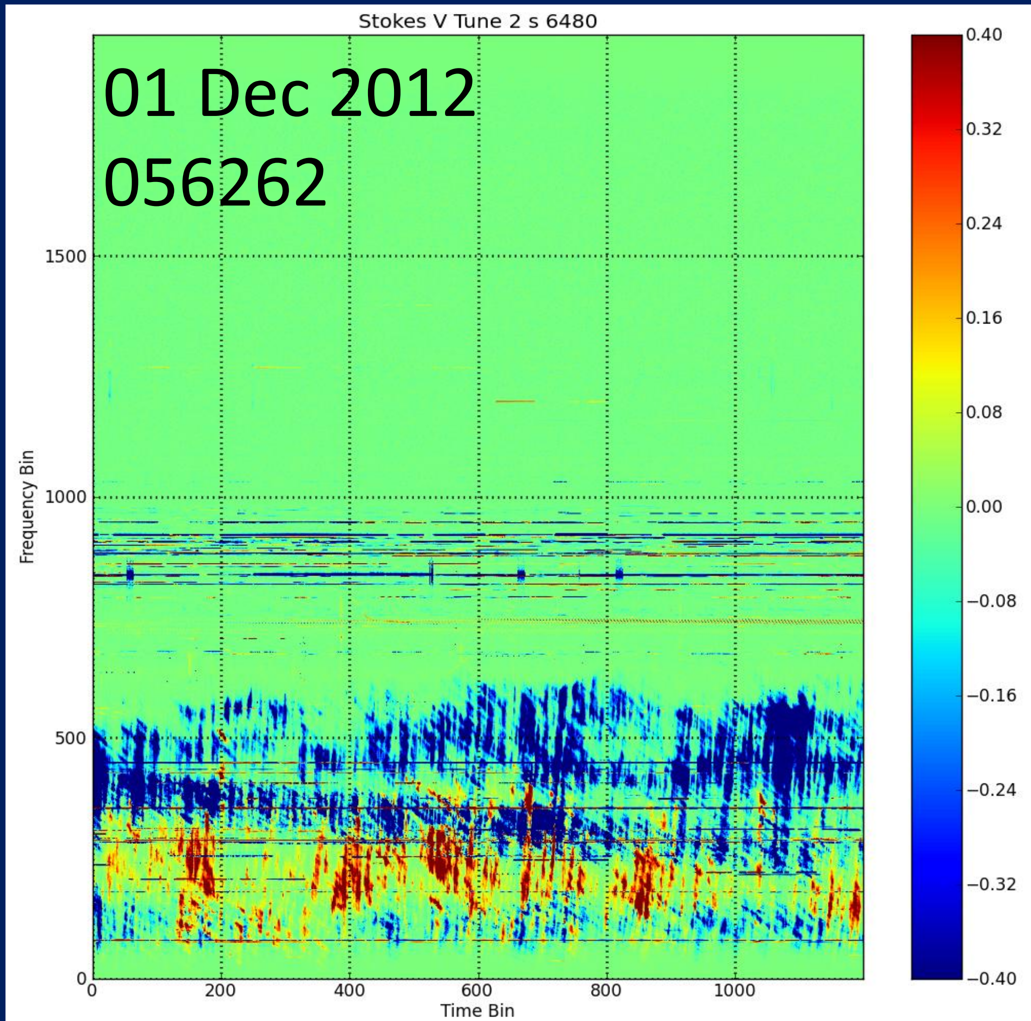
- Excellent Spectral & Temporal Resolution
- Remarkable Consistency of the Io-A/C Emission Structure
- Similar Propagation Geometry

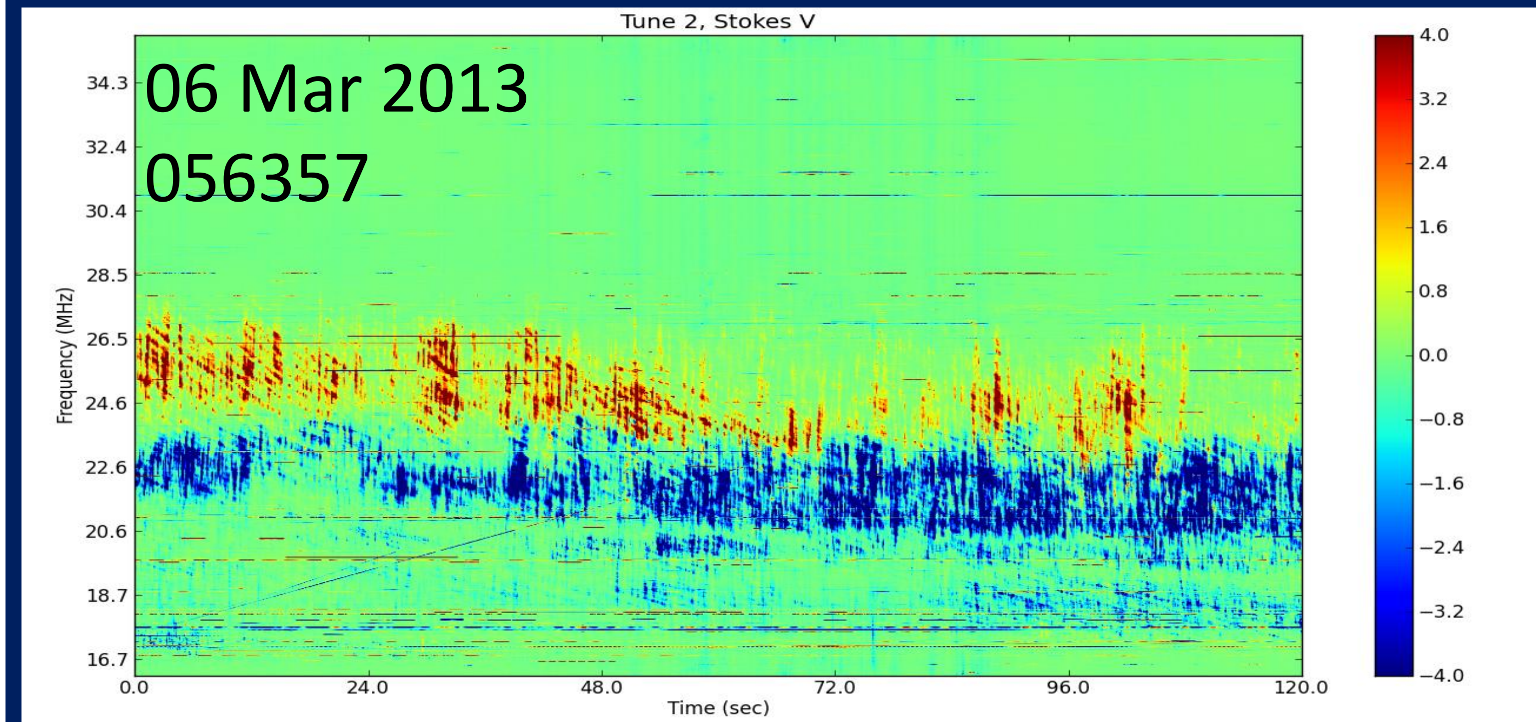


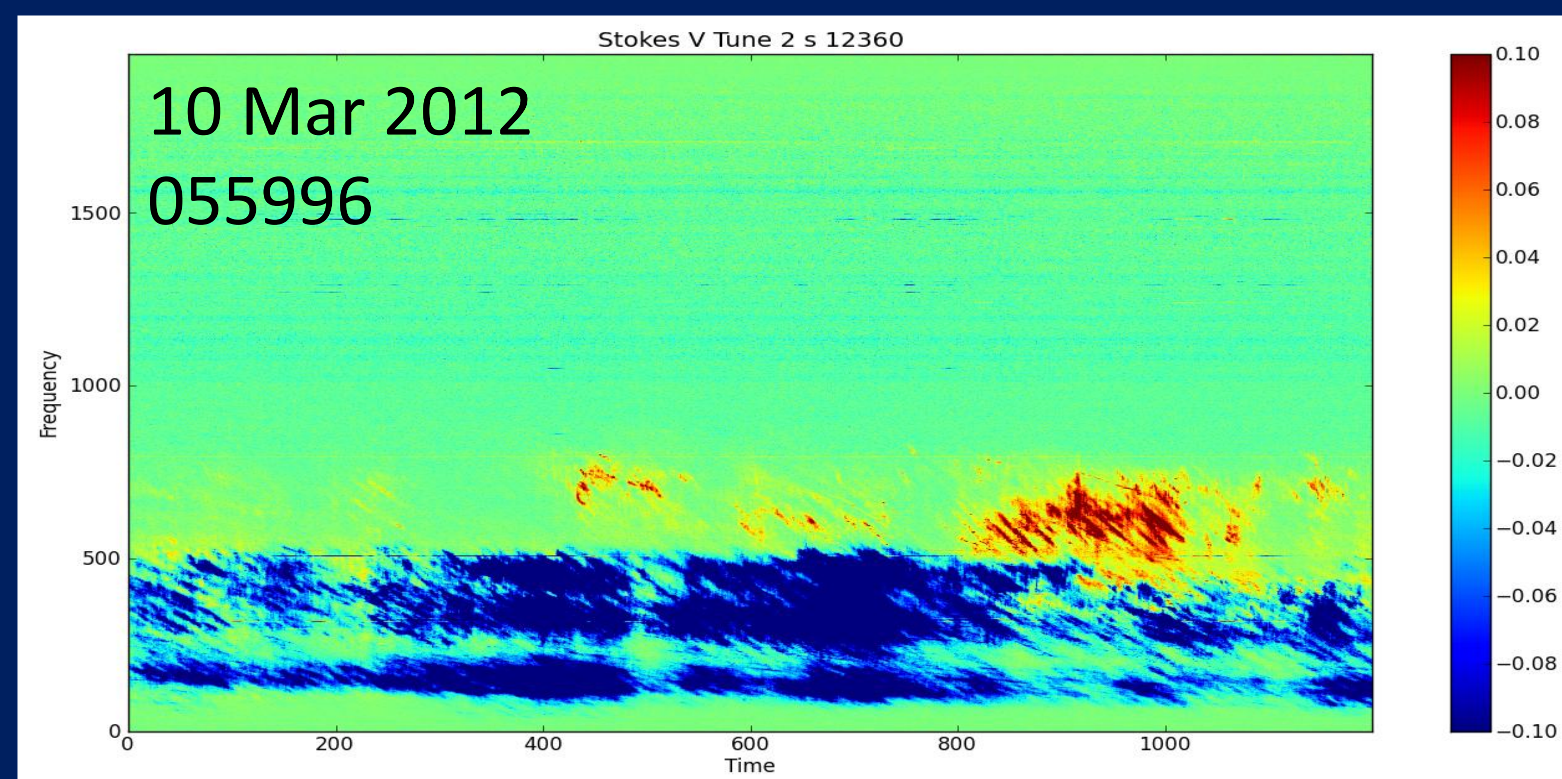




Io-A/C Modulation Lanes

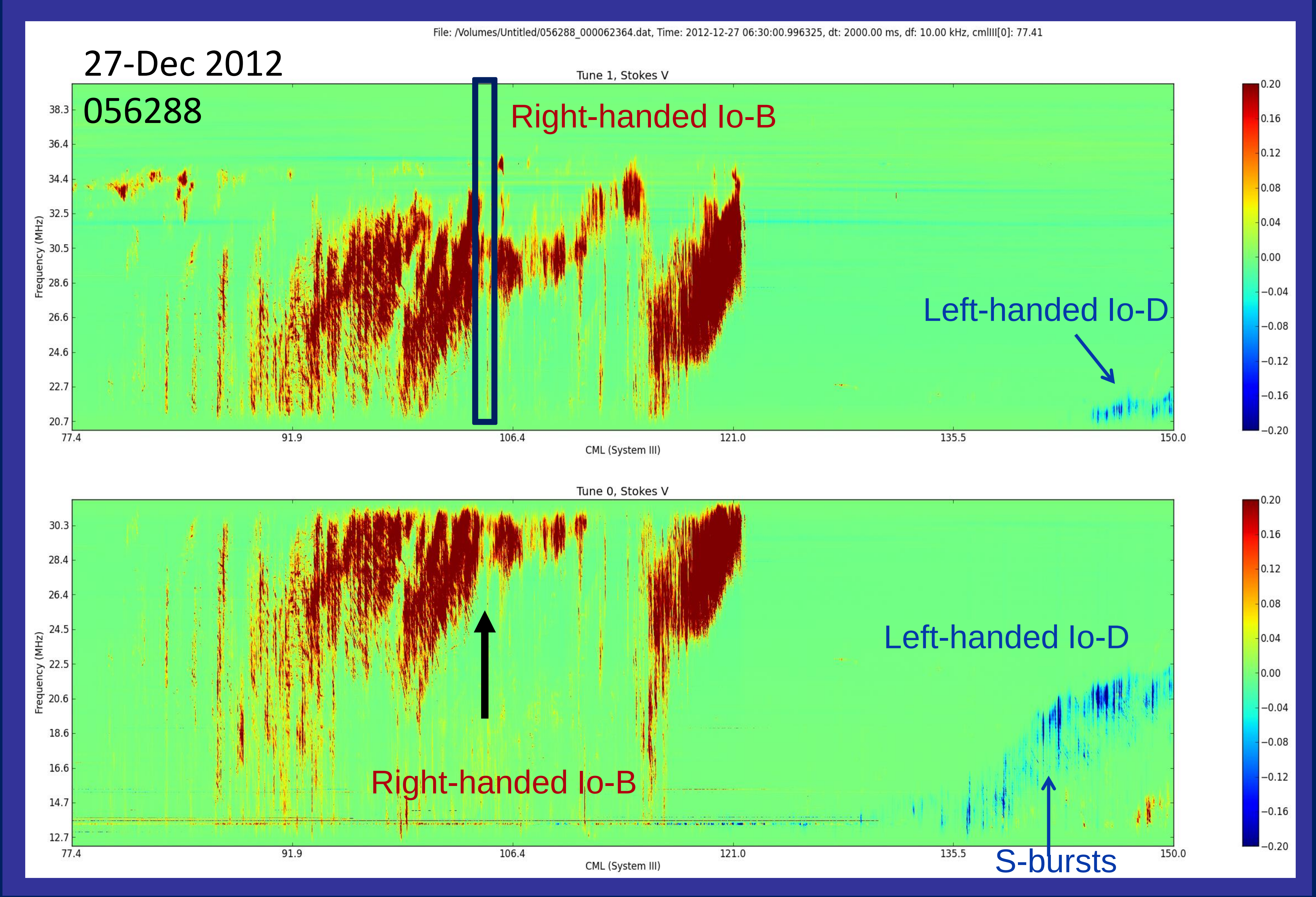






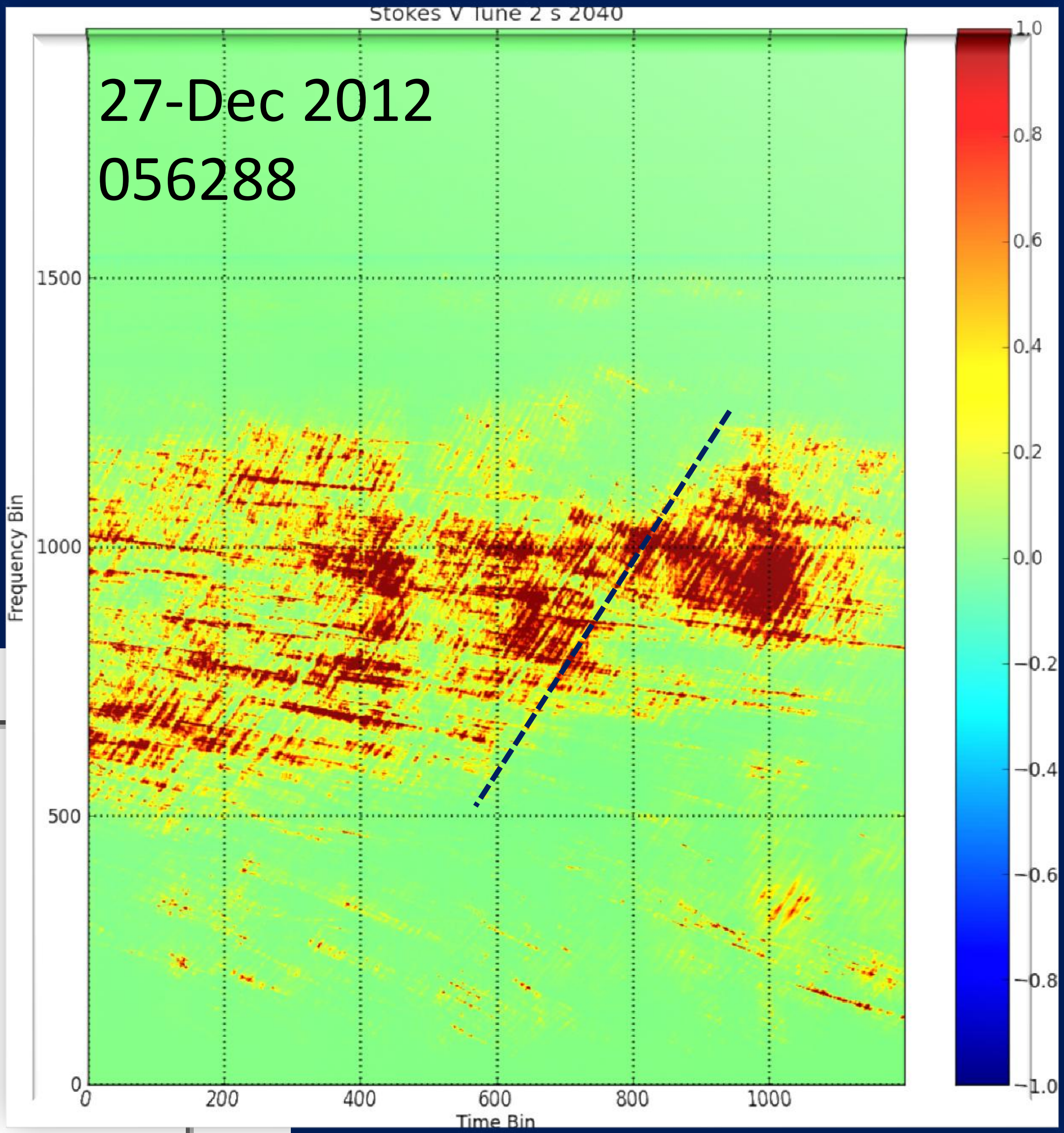
- Modulation Lanes show continuity across RH and LH sources
- Argues for RH and LH emission from the SAME hemisphere
- Contradicts CMI theory – RX mode growth rates are ~10^3 higher than LO mode
- Mode conversion?

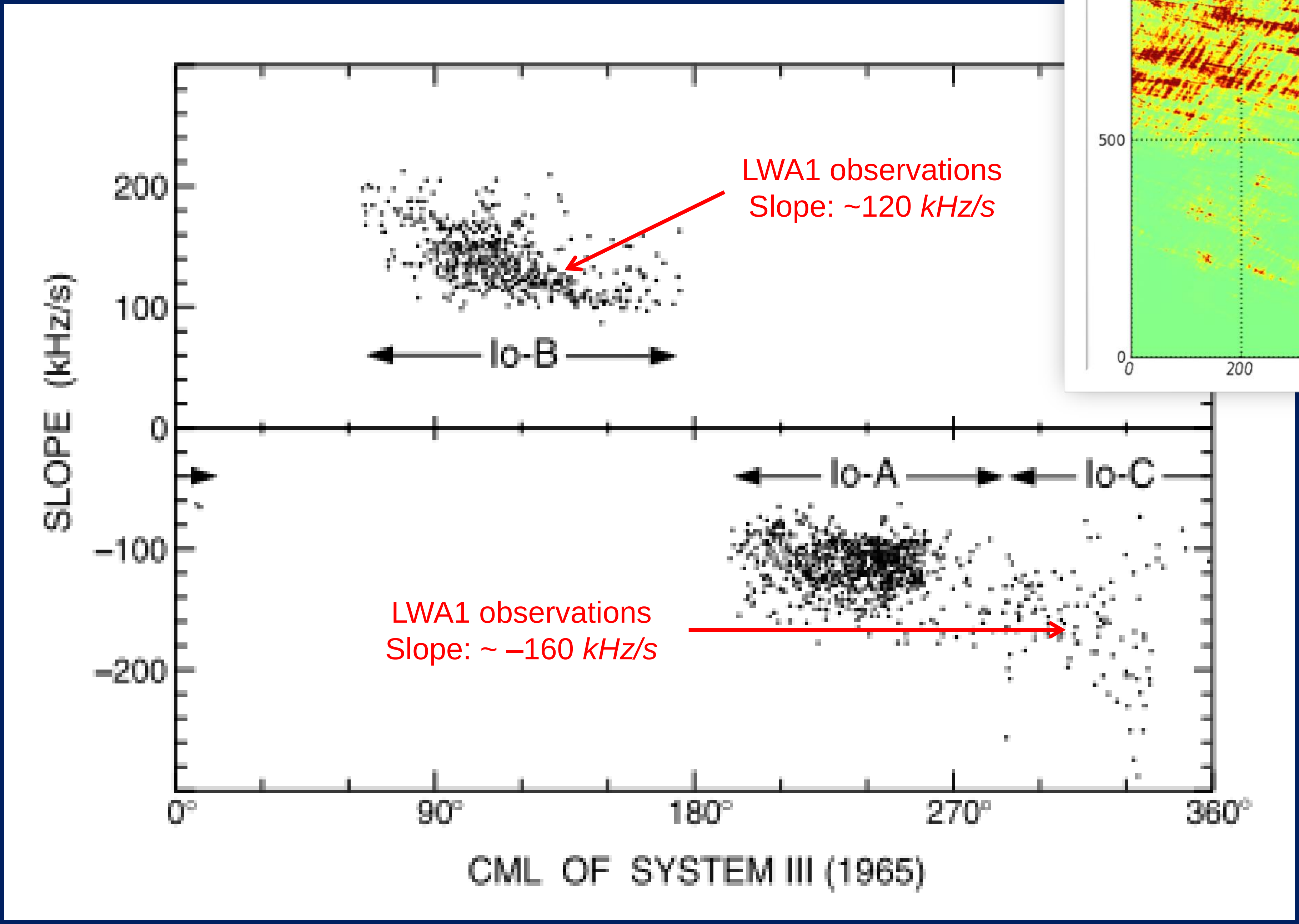
Io-B, Io-D Observations



Io-B Modulation Lanes

Previous data 21-23 MHz observations from 1966 – 1979 (Riihimaa, 1978, 1993)





S-Bursts

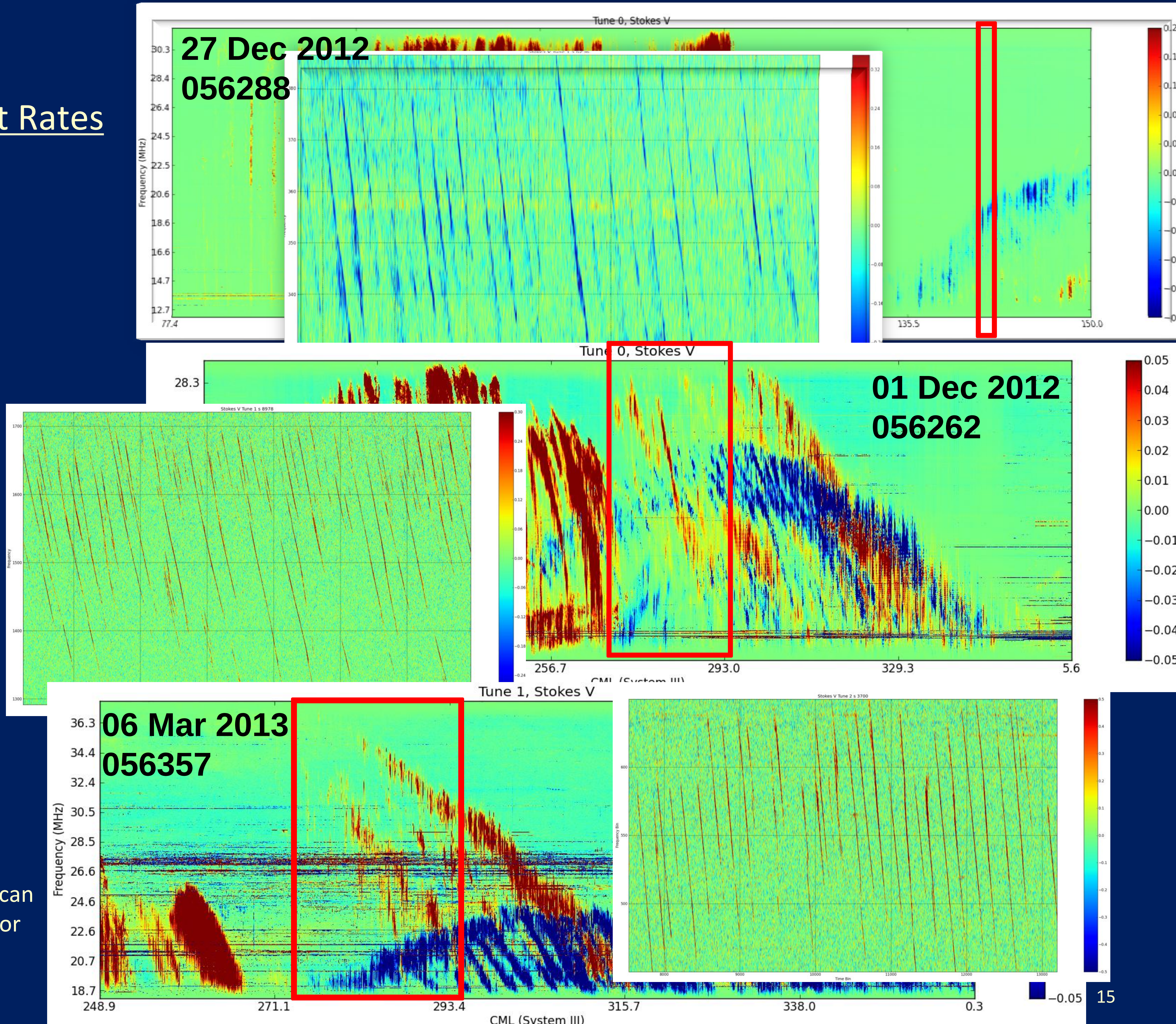
<u>S-burst Drift Rates</u>

<u>Io-D</u>
–12 MHz/s
at 19 MHz

<u>Io-A/C</u>
–18 MHz/s
at 25 MHz

<u>Io-A</u>
–23 MHz/s
at 24 MHz

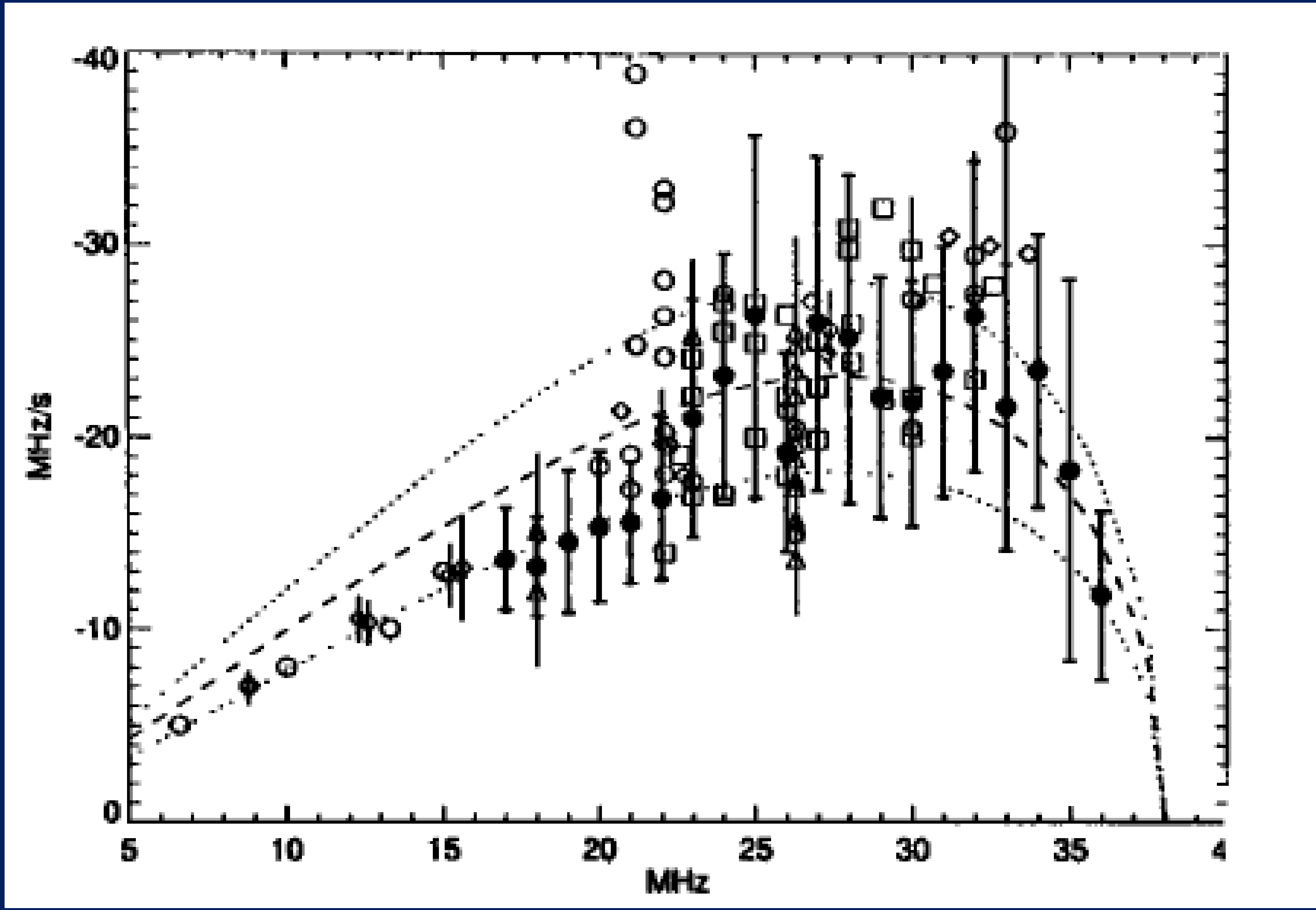
s-burst drift rates can vary significantly for each storm



S-burst Drift Rates

- Io related emission
- CMI emission ~5 keV electrons accelerated from Io to Jupiter
- Magnetically mirrored near Jupiter resulting in a loss cone of amplified X-mode waves
- Adiabatic theory predicts the maximum drift rates (~30 MHz/s)
- Good remote sensing tool for Jovian magnetosphere

S-burst Drift Rate vs Frequency



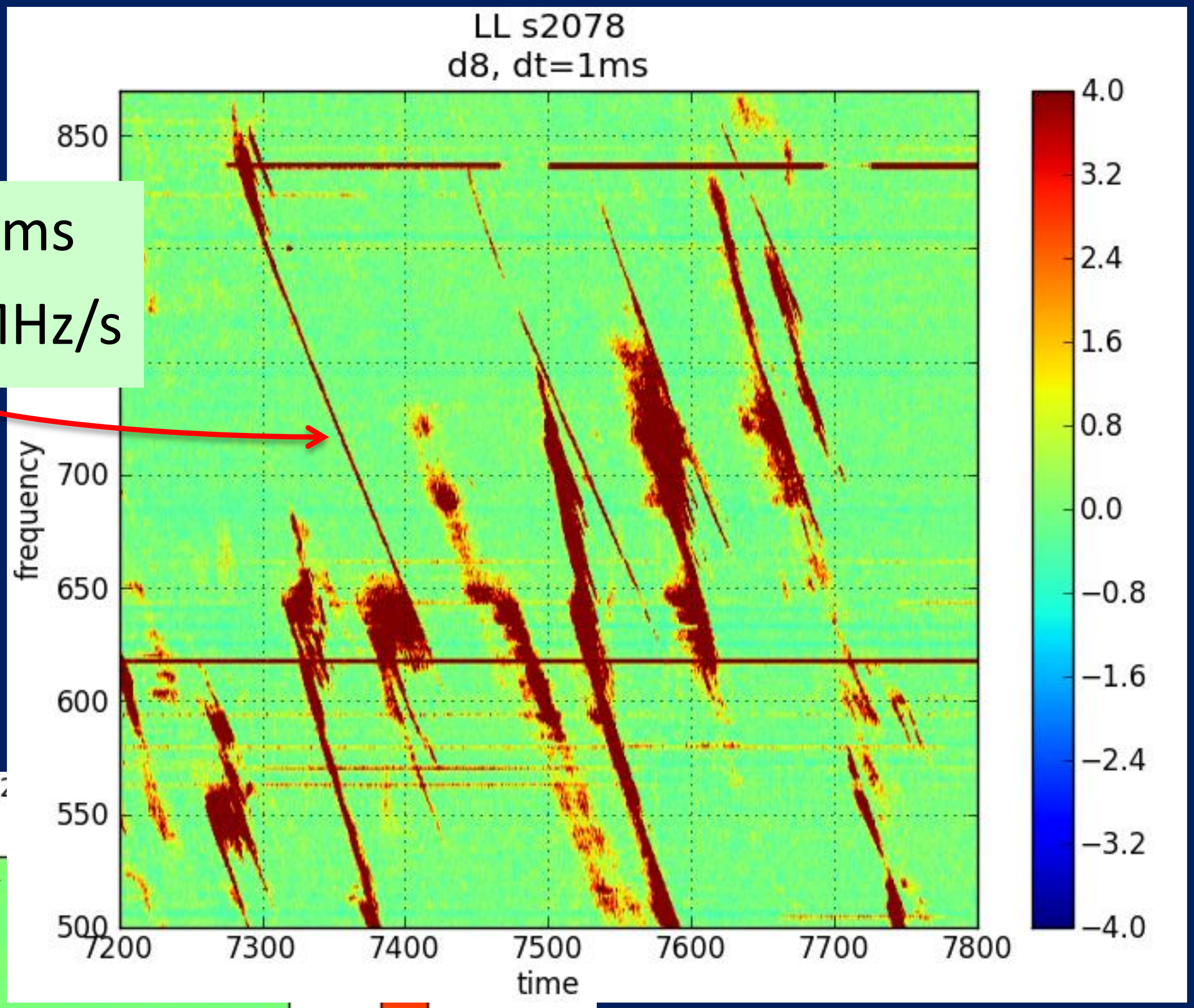
From Zarka et al., 1996

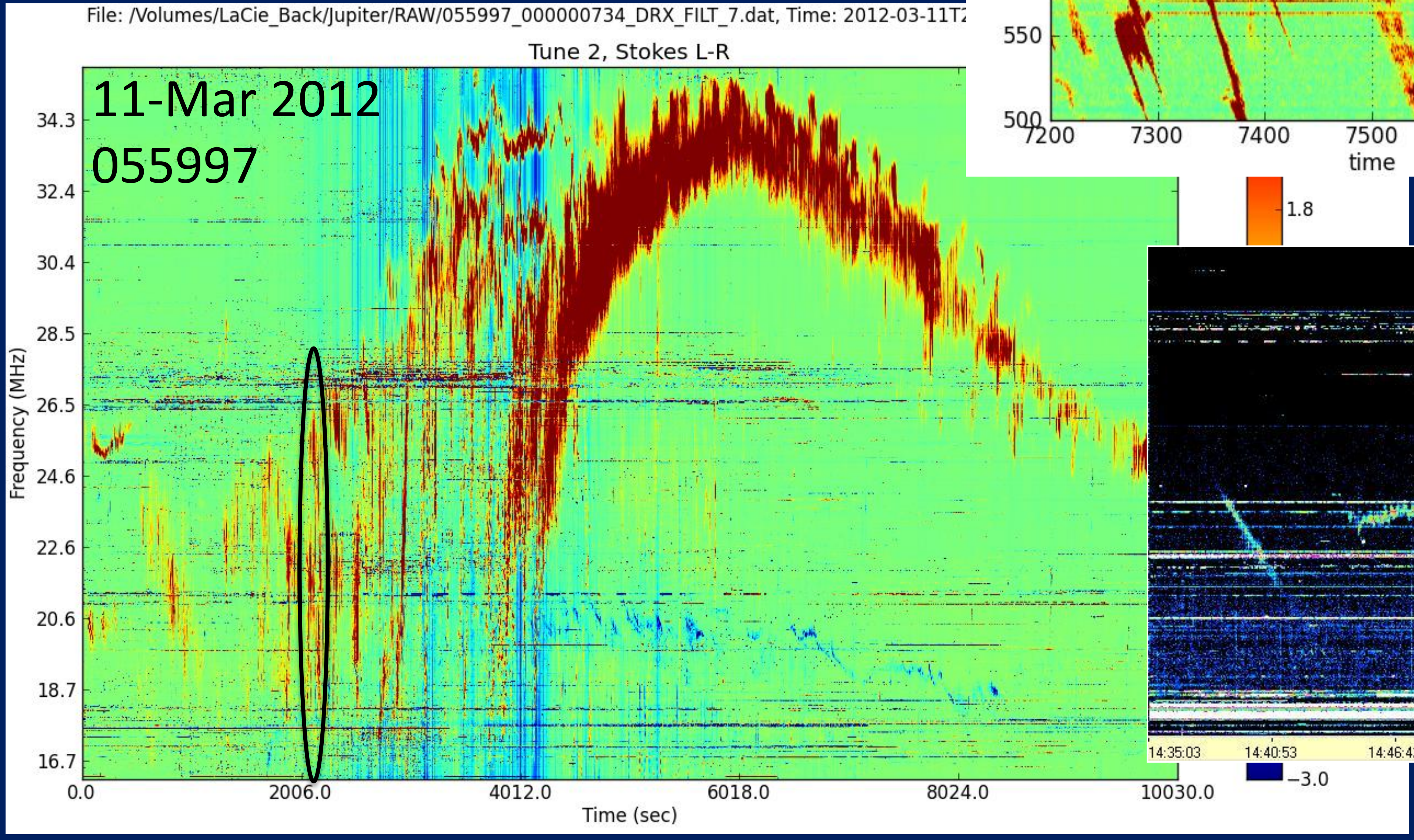
LWA1 data can verify this model

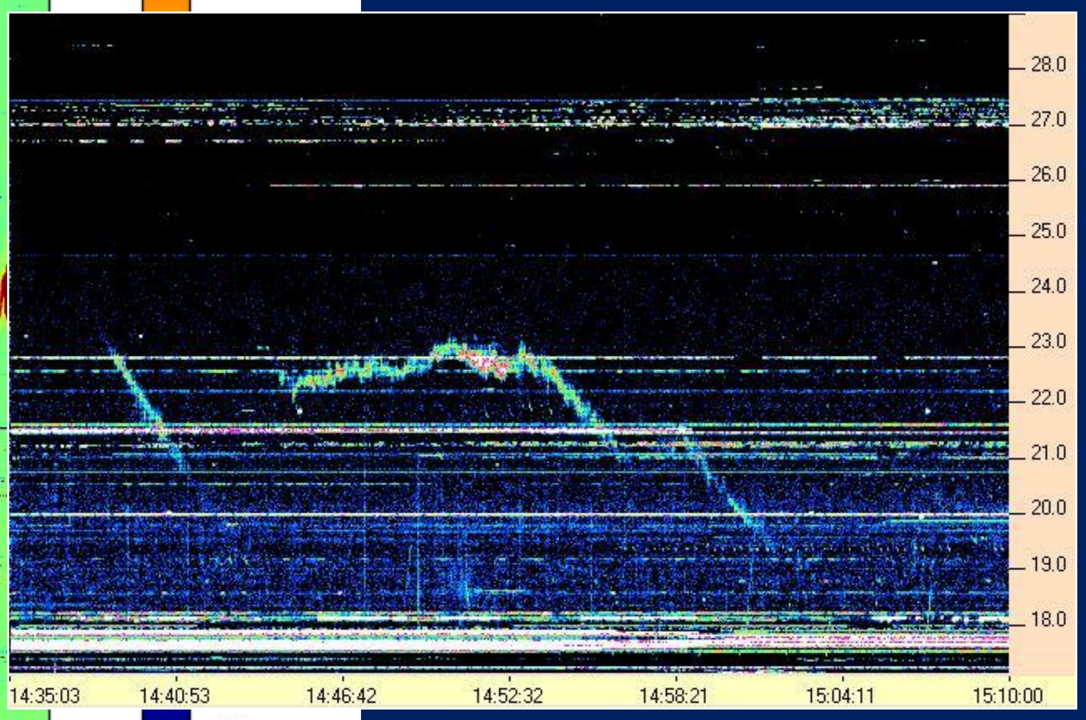
Possible Investigation:
How do the drift rates of Io-A, B, C, and D vary?

Io-B S-Bursts and N-events

- S-bursts and Narrow band (N) events show interactions (triggering and quenching)
- Argues for co-spatial sources







N-event during an Io-B storm
22-June 2012
Hawk's Nest Radio Observatory, PA

Summary of LWA1/Jupiter Studies

- LWA1 is an excellent instrument for Jupiter decameter studies
  - Observations show excellent spectral and temporal resolution
  - Allows for the analysis of fine structures

- Modulation Lanes observations can be used to check CMI theory
  - Are the RX and LO modes coming from the same hemisphere?

- S-burst drift rates at high frequencies
  - CMI amplified waves after electron acceleration by Alfvèn waves in Io's wake
  - Test the adiabatic model along the Io Flux Tube (max frequency)

- Narrow band (N) event characteristics (S-burst/N-event interactions)
- LH and RH emission can be used for Faraday rotation studies

Upcoming Observations

- 100 beam hours, Oct 2013 – Feb 2014
- Targeting many Io-B, Io-D observations
- Focus on emission fine structures

Juno Mission, ~2015-2017
Coordinated observations?