LWA1 Observations of Jupiter

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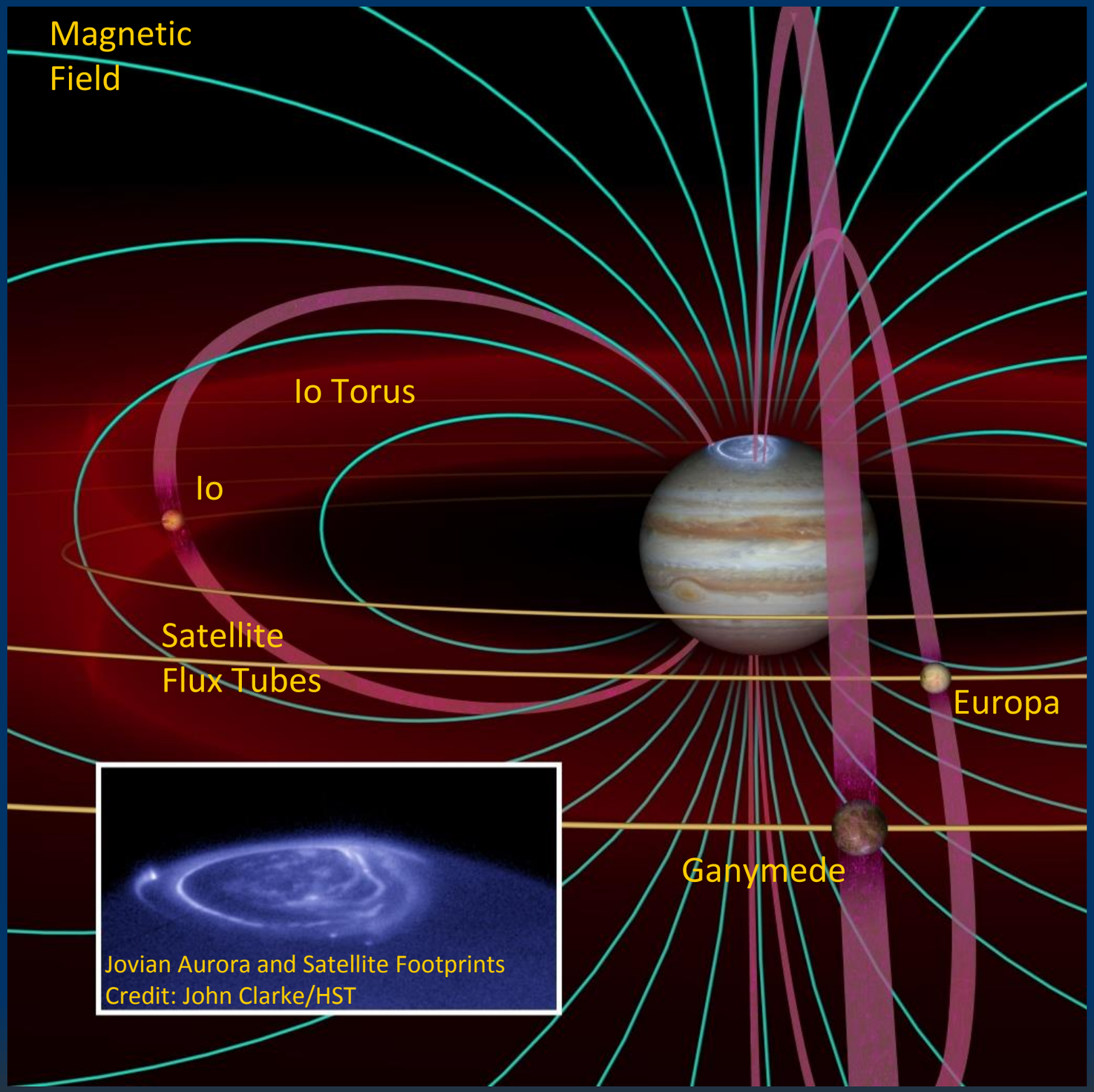

Credit: John Spencer/SWRI
Nature Cover, 2002

Acknowledgements:
U. New Mexico, LWA Team, NRL
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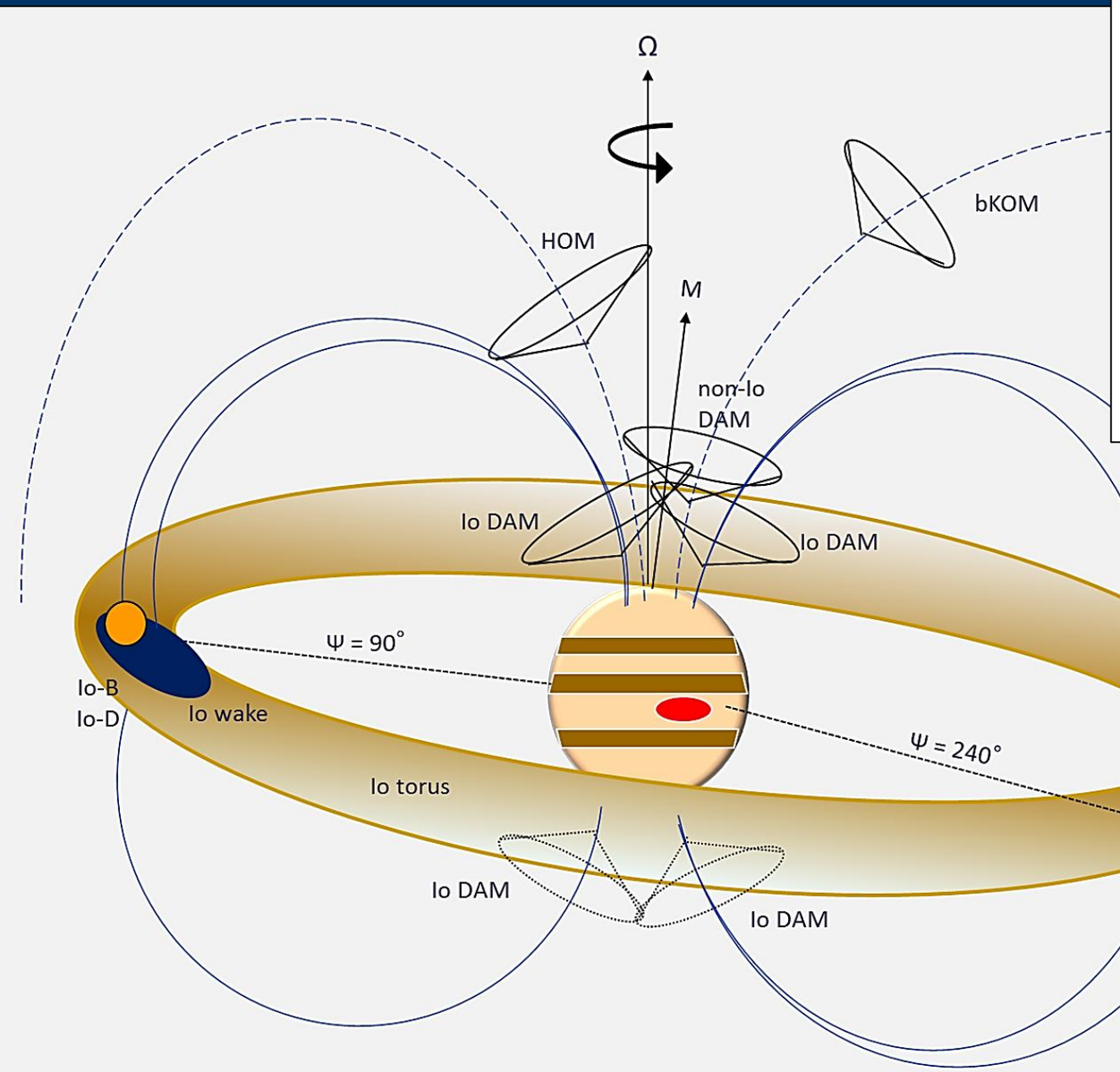
Radio Sources

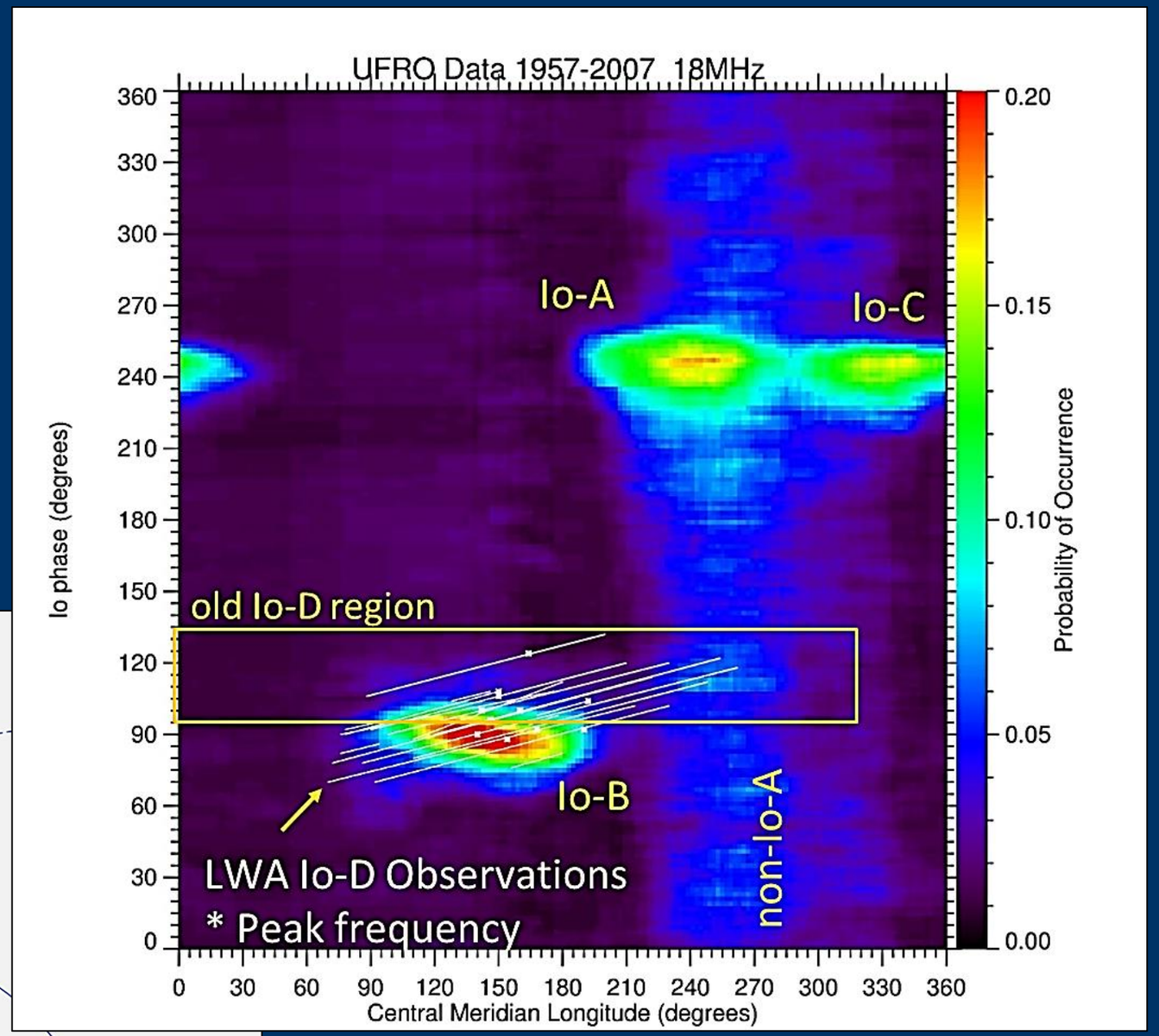
bKOM – broadband kilometric emission

HOM – hectometric emission

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

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

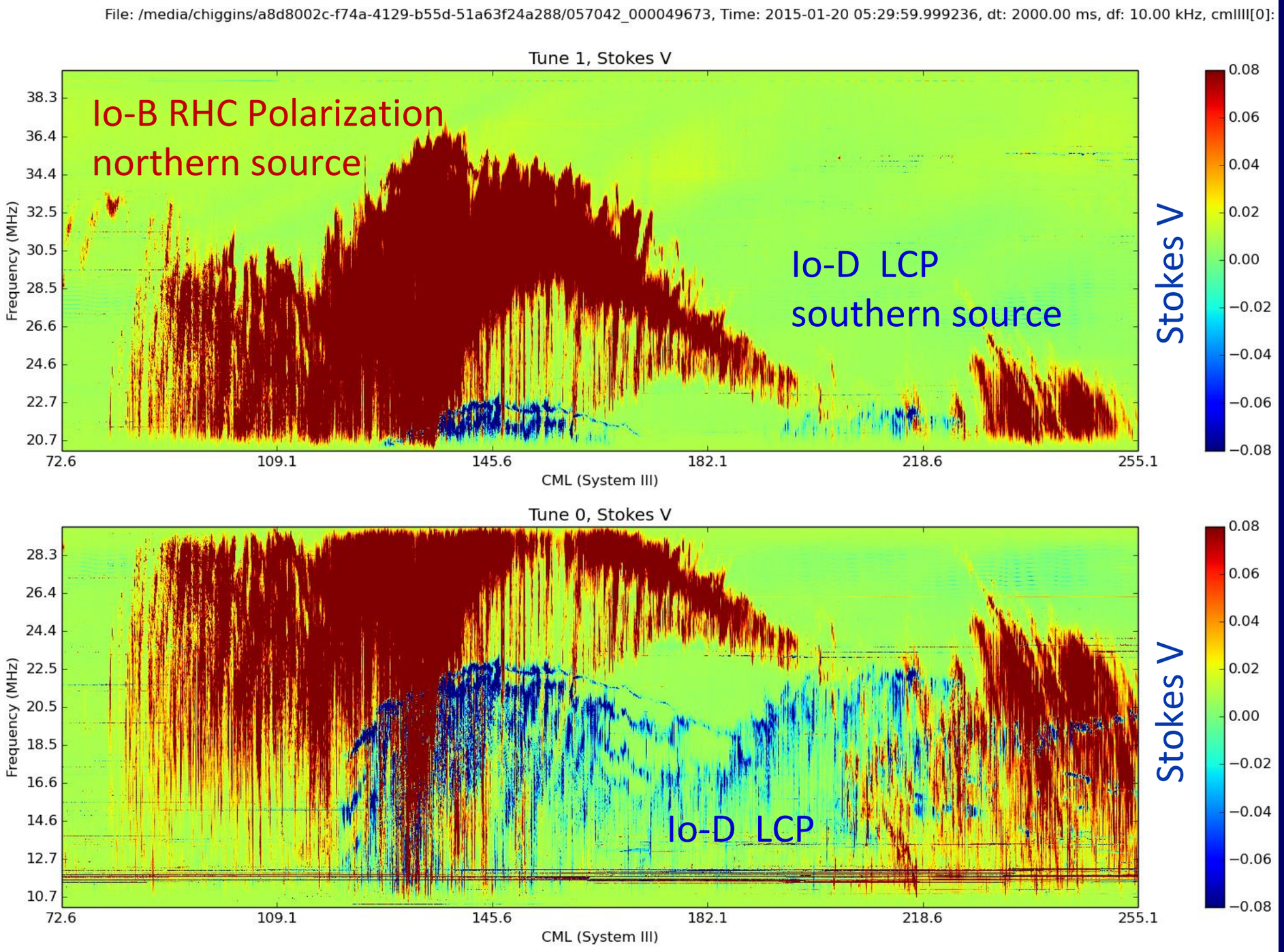




Background : 50 years of University of Florida Radio Observatory (UFRO) data at 18 MHz

- Sources need redefinition
- Source peak frequency – probe of B-field

LWA1 Io-D Observations 2015

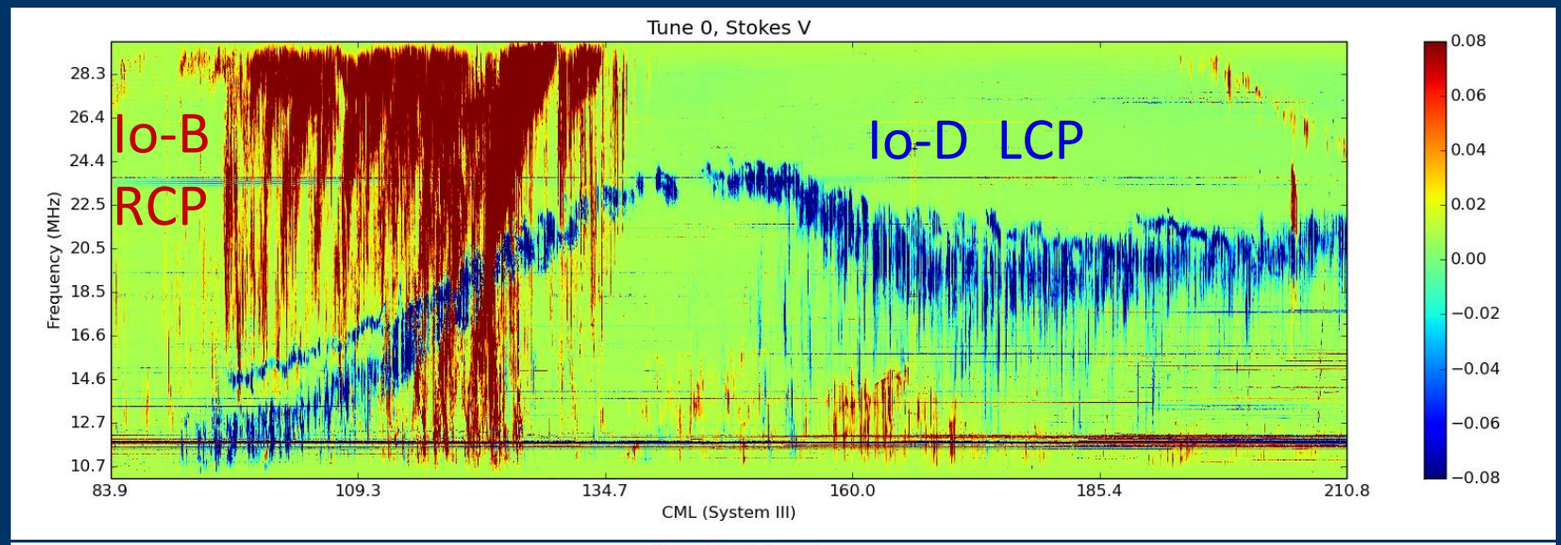


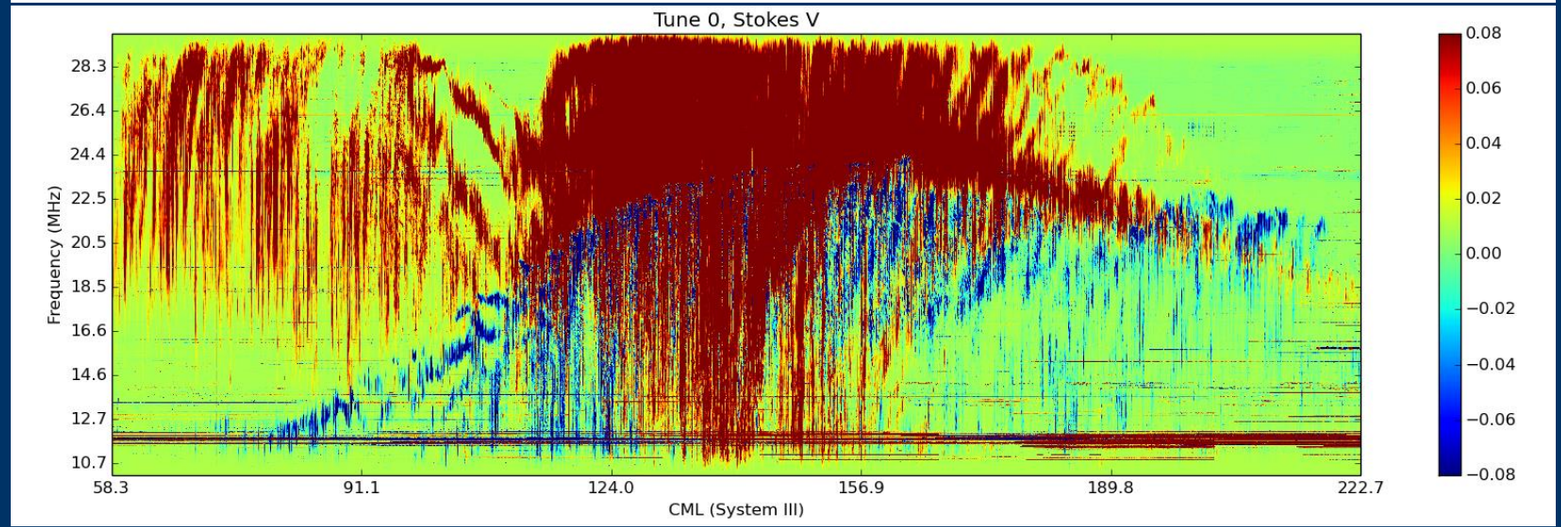
Great Observing Conditions!
Bandwidth: 16 MHz x 2 tunings
Resolution: 0.21 ms and 5 kHz

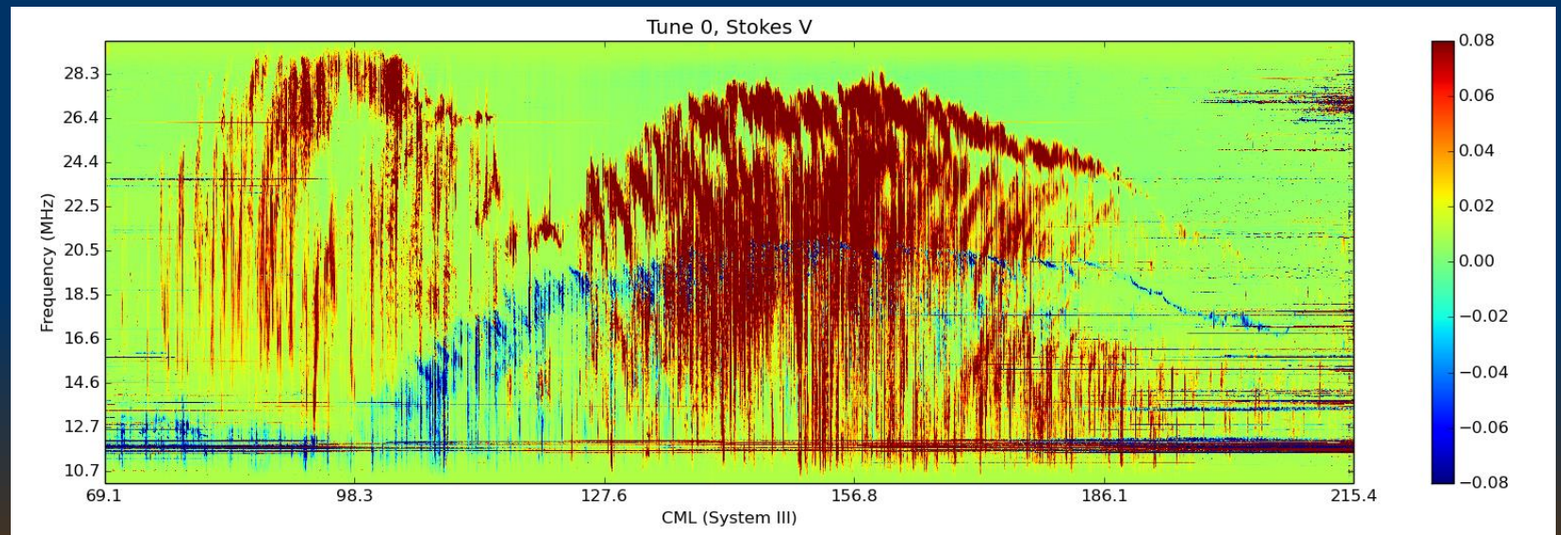
Jupiter

- Strong Emission
- Cyclotron Maser Mechanism (CMI)
- Spectral Structure
- Envelopes
- Nested Arcs
- Narrow bands
- Modulation Lanes
- L- bursts (~ 1s)
- S-bursts (~ ms)

LWA1 Jupiter Io-D Observations 2015





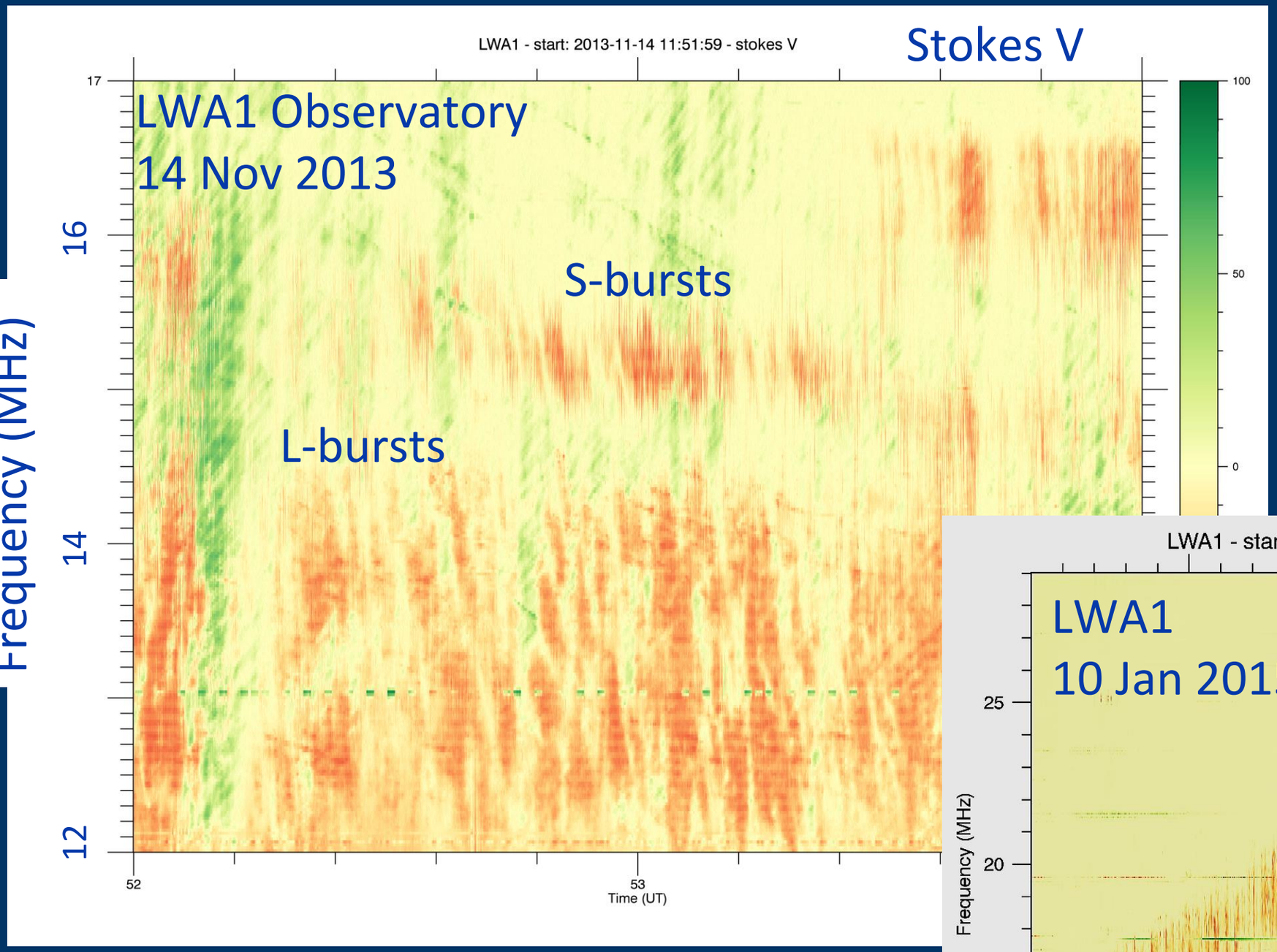


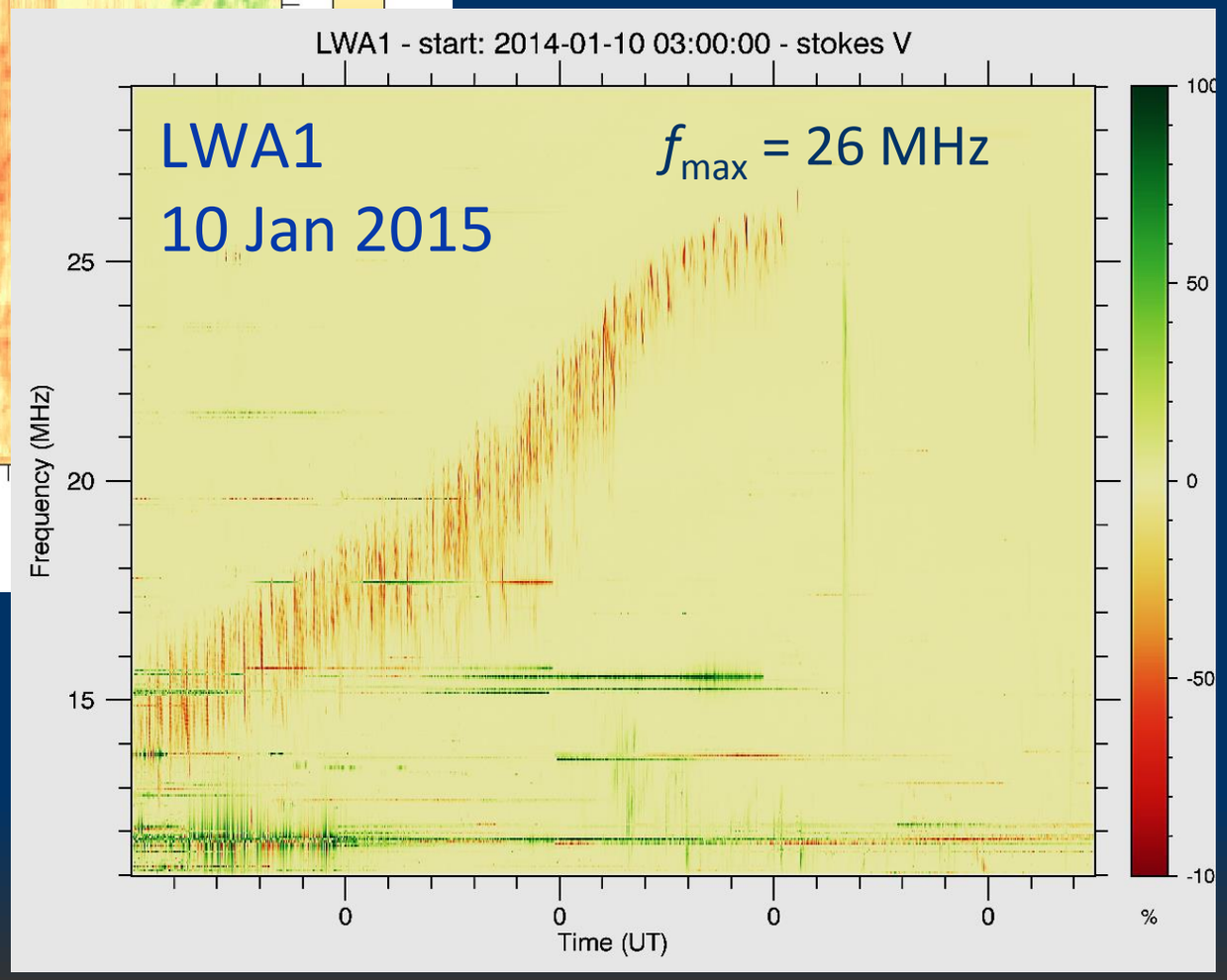
Io-D Characteristics

- Southern hemisphere source
- f = < 3 to > 24.5 MHz
- CMI X-mode emission
- Few keV electrons
- Highly LH circularly polarized (~0.85)
- Isolated arc structures (vertex early)
- Io-C/Io-D emission cone

- Envelope shape caused by source along southern Io-flux tube (Io's frame)
- Io-D Beaming angle ~80°

Io-D Observations





Io-D Spectral Structure

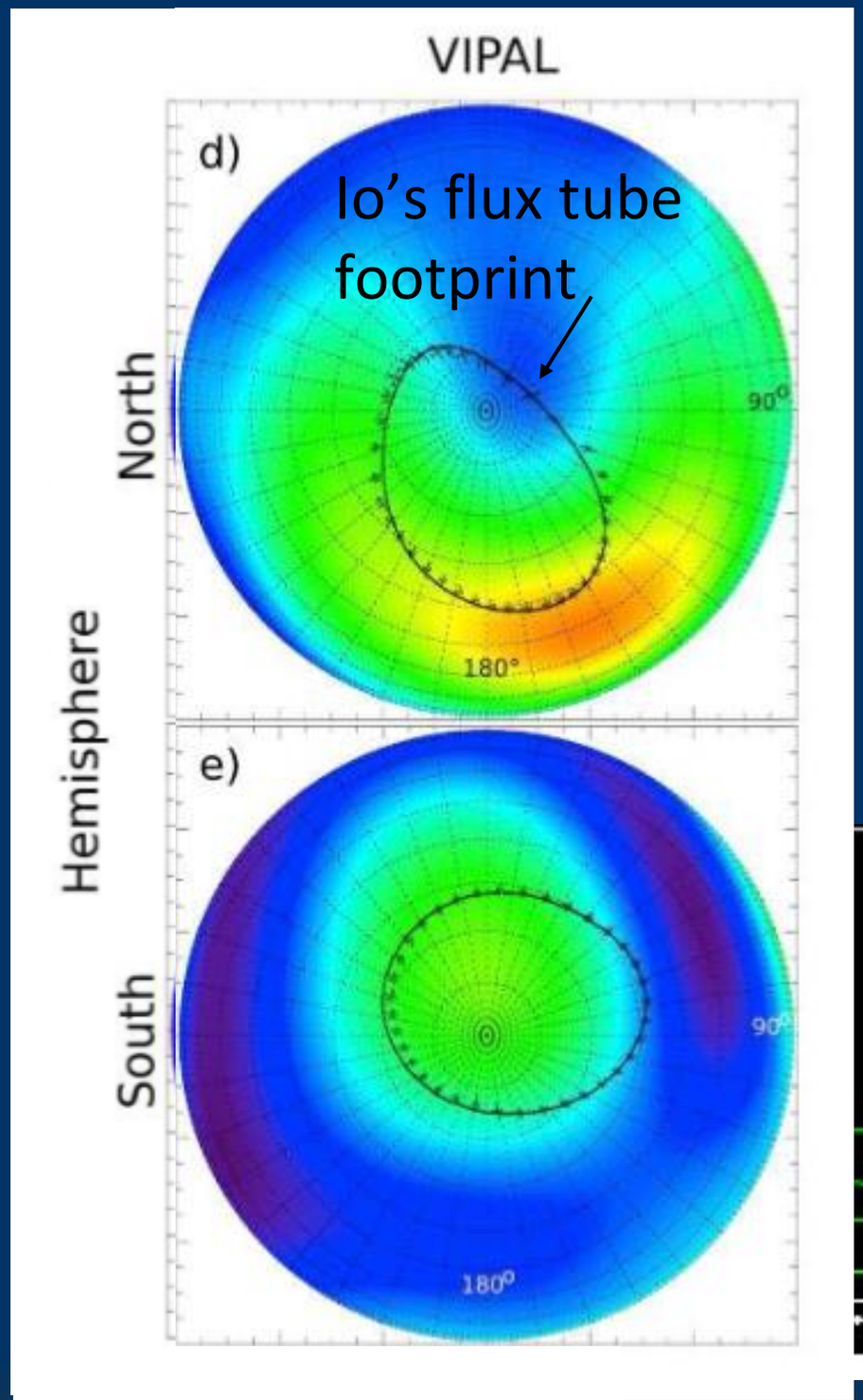
Nested Arcs

Modulation Lanes

L- and S-bursts

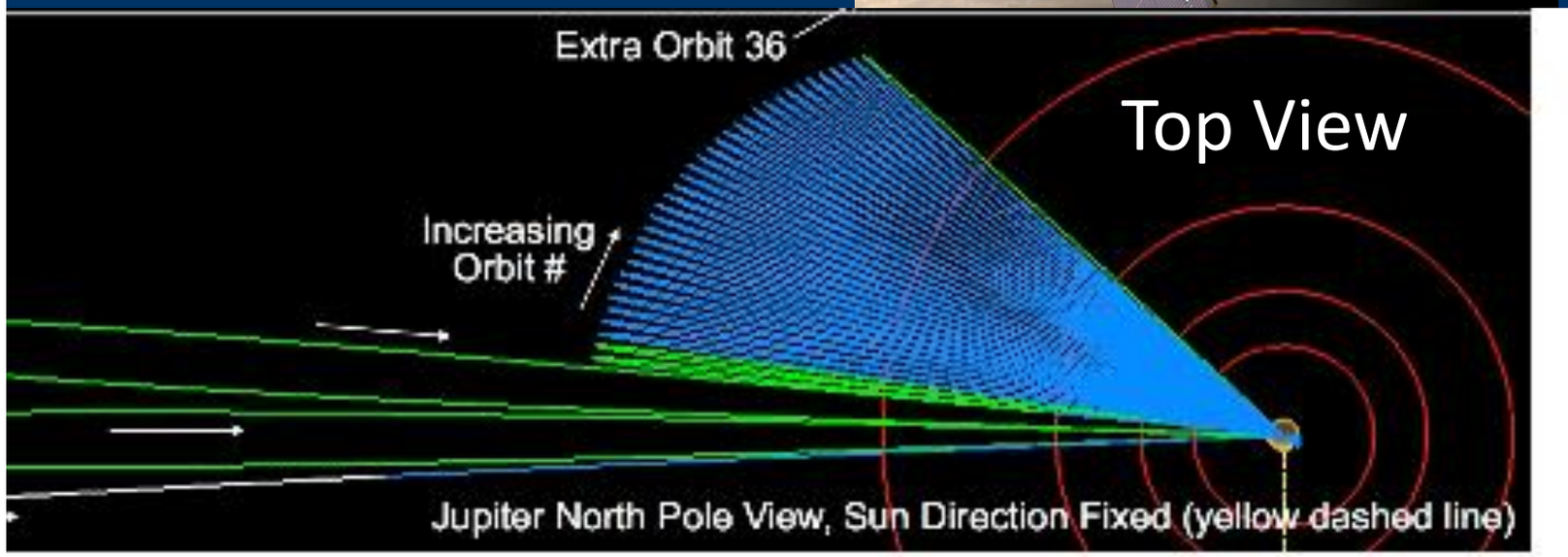
Magnetic Field Models

- B-Field model – 5th order using *in situ* data + satellite and auroral constraints
- Radio emissions can help



From Hess et al., 2011

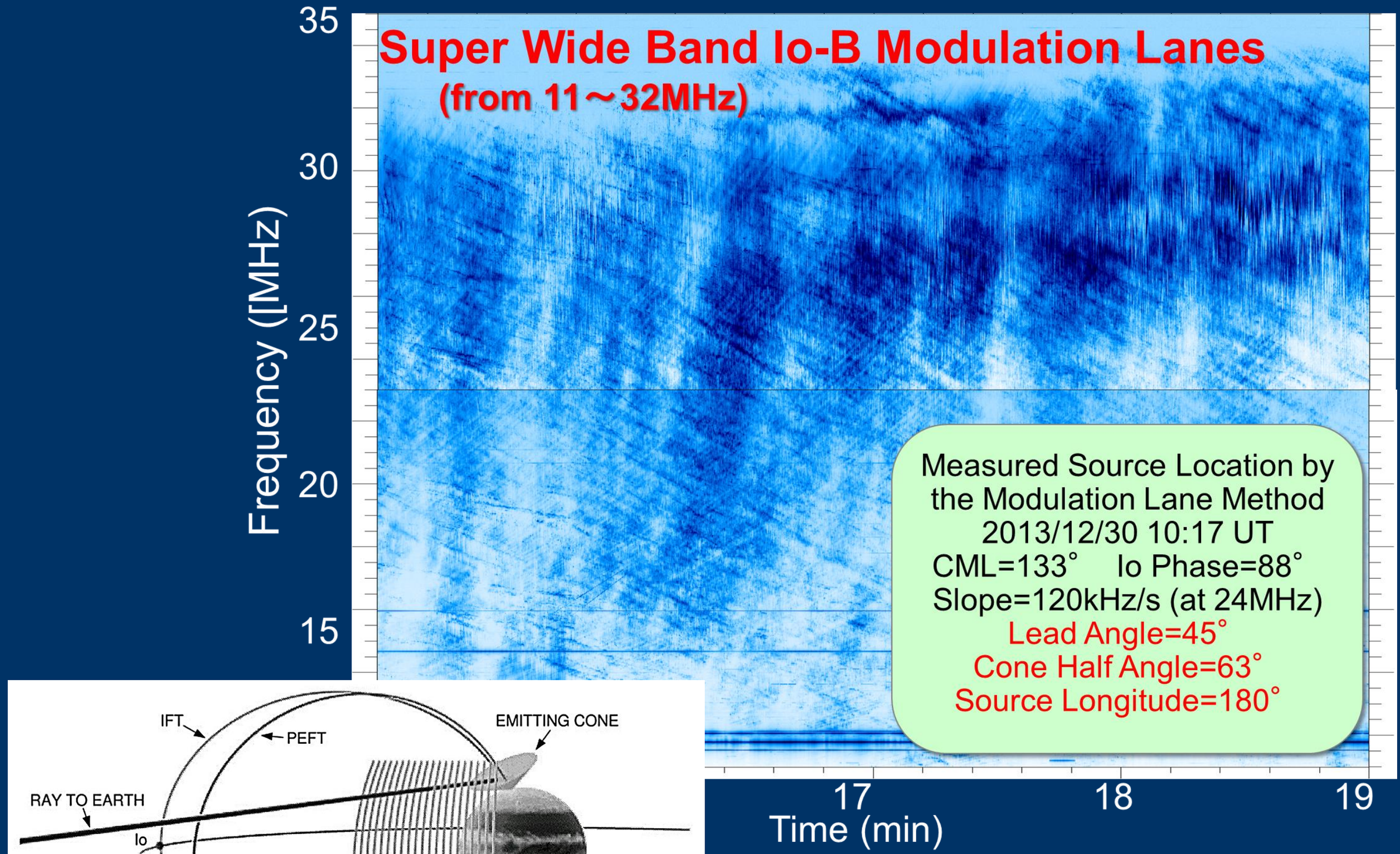
Juno Mission Orbits

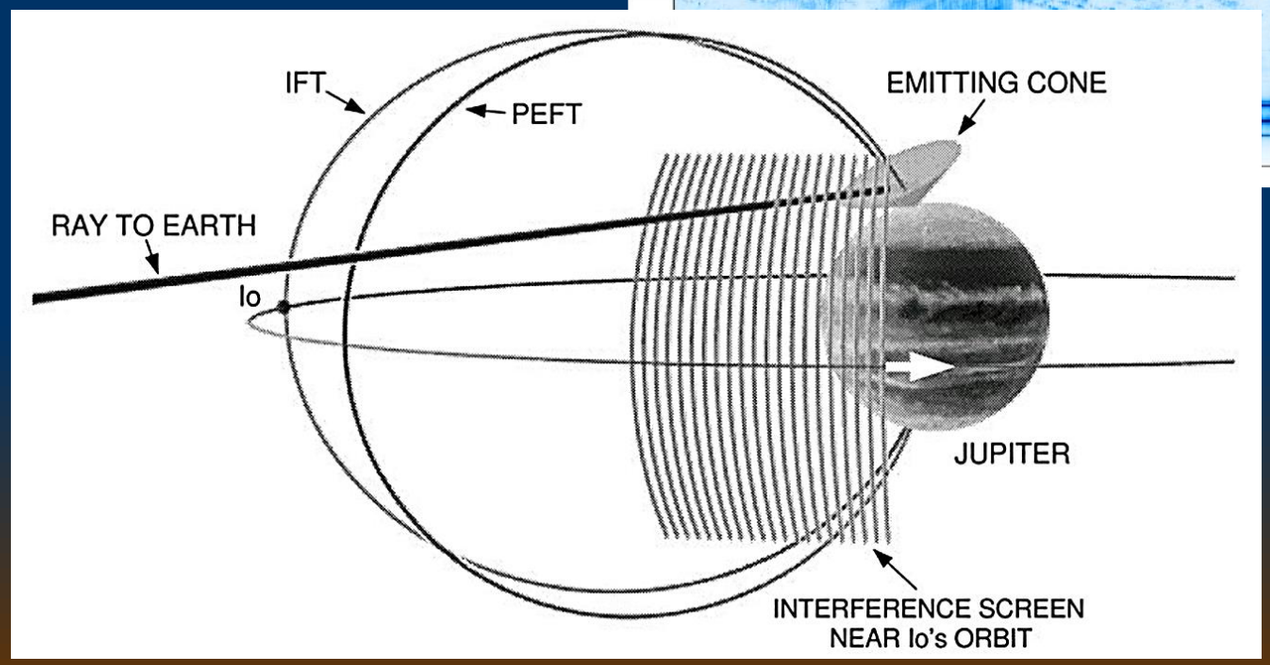


From Stephens, 2015, JPL

Super Wide Band Io-B Modulation Lanes

(from 11～32MHz)

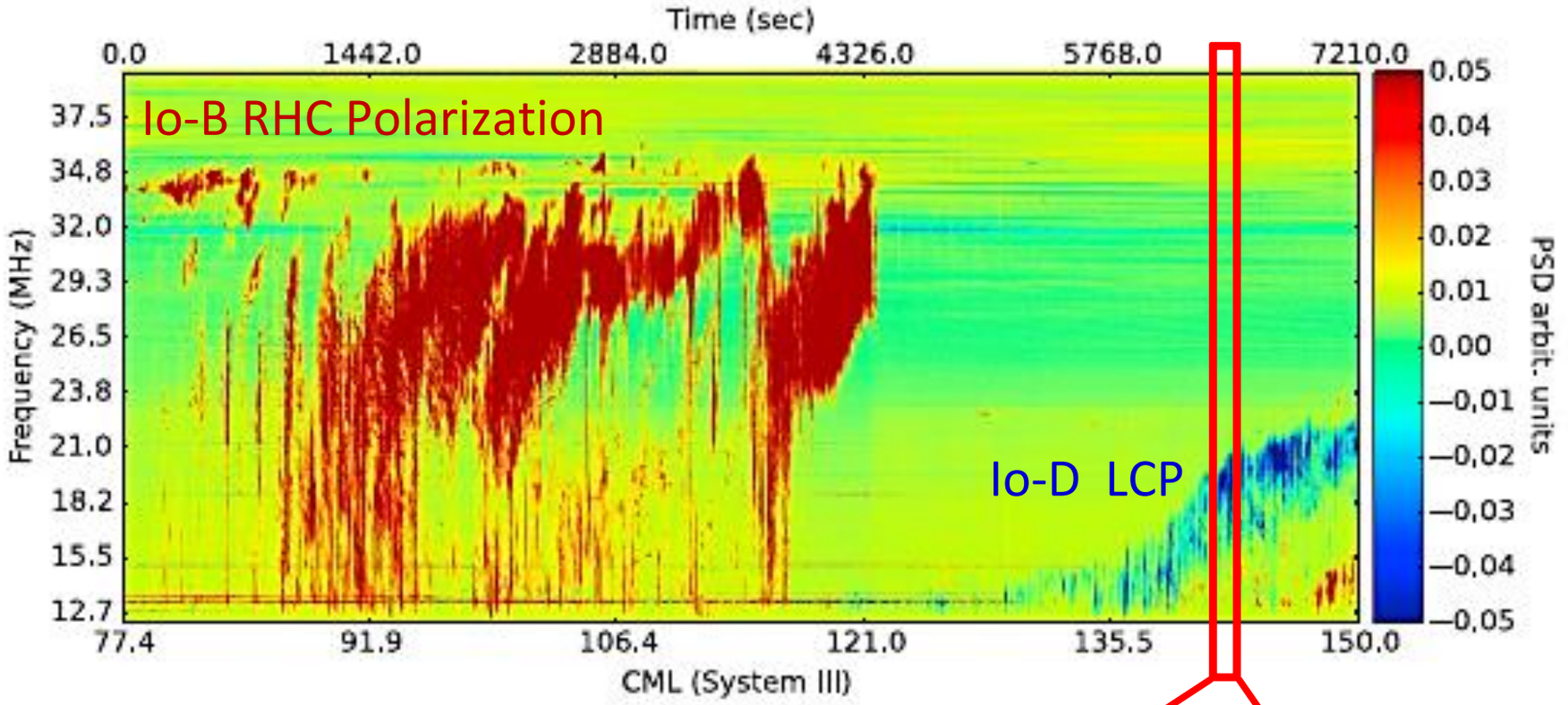




[Imai et al.,1992a,1992b,
1997,2002,2006]

Io-D S-Bursts

27 Dec 2012



From Clarke et al., 2014

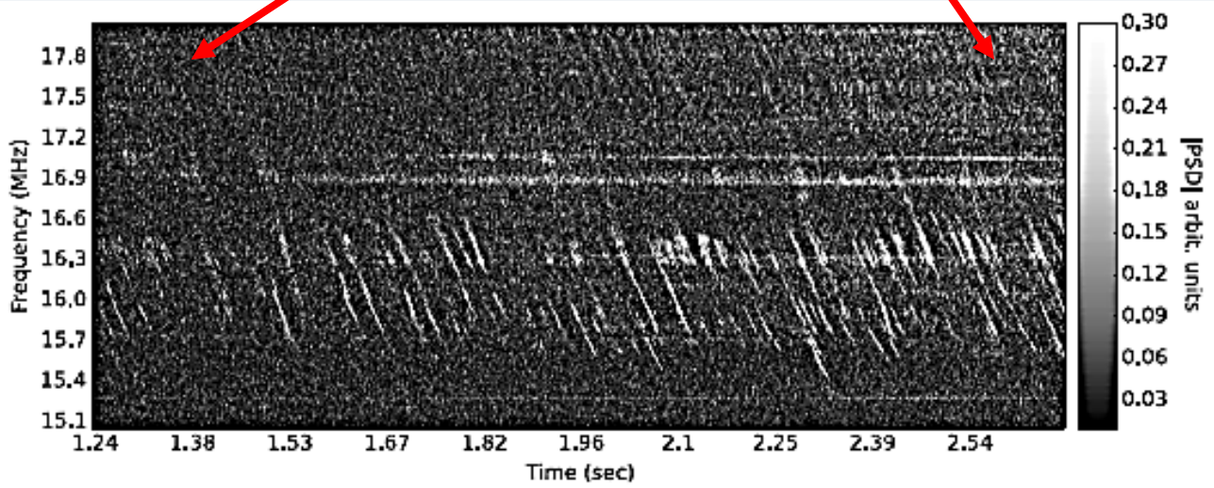


Figure 17. S bursts for the Io-D event on 27 December 2012 (see Figure 9) plotted at 0.25 ms temporal resolution and 10 kHz spectral resolution. The bursts are LHC but are shown in the figure as an absolute value in greyscale to enhance the visibility of the bursts. Times are shown relative to 6236 s into the burst with a total time of 1.44 s displayed.

<u>S-bursts</u>

- Io-related emission
- High-Intensity ms bursts
- CMI emission: ~5 keV electrons mirrored near Jupiter resulting in a loss cone of amplified X-mode waves
- Used to test emission theory

Resolution: 0.25 ms and 10 kHz
Timespan: 1.44 s
S-burst Drift Rates: –12 MHz/s at 19 MHz

Coordinate LWA1-NDA-URAN2 Observation for Jovian Decametric Radiation

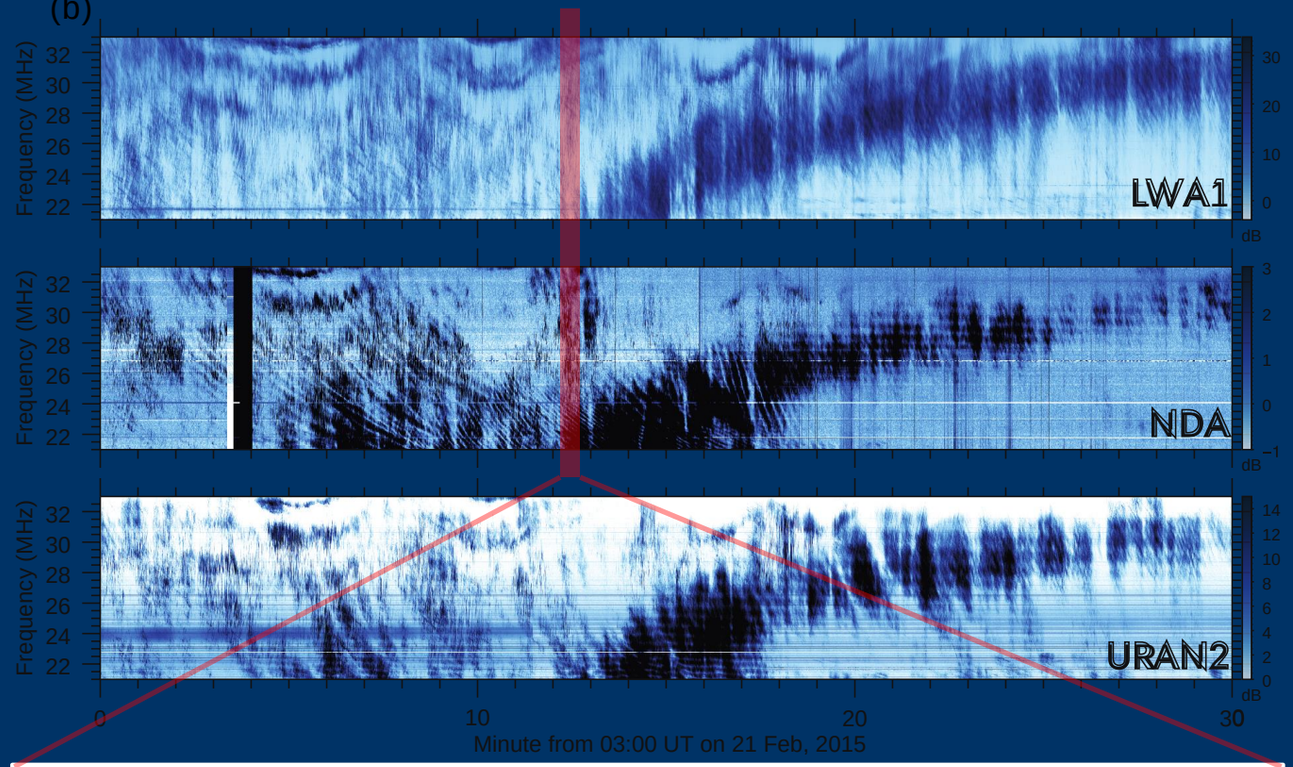
(a)

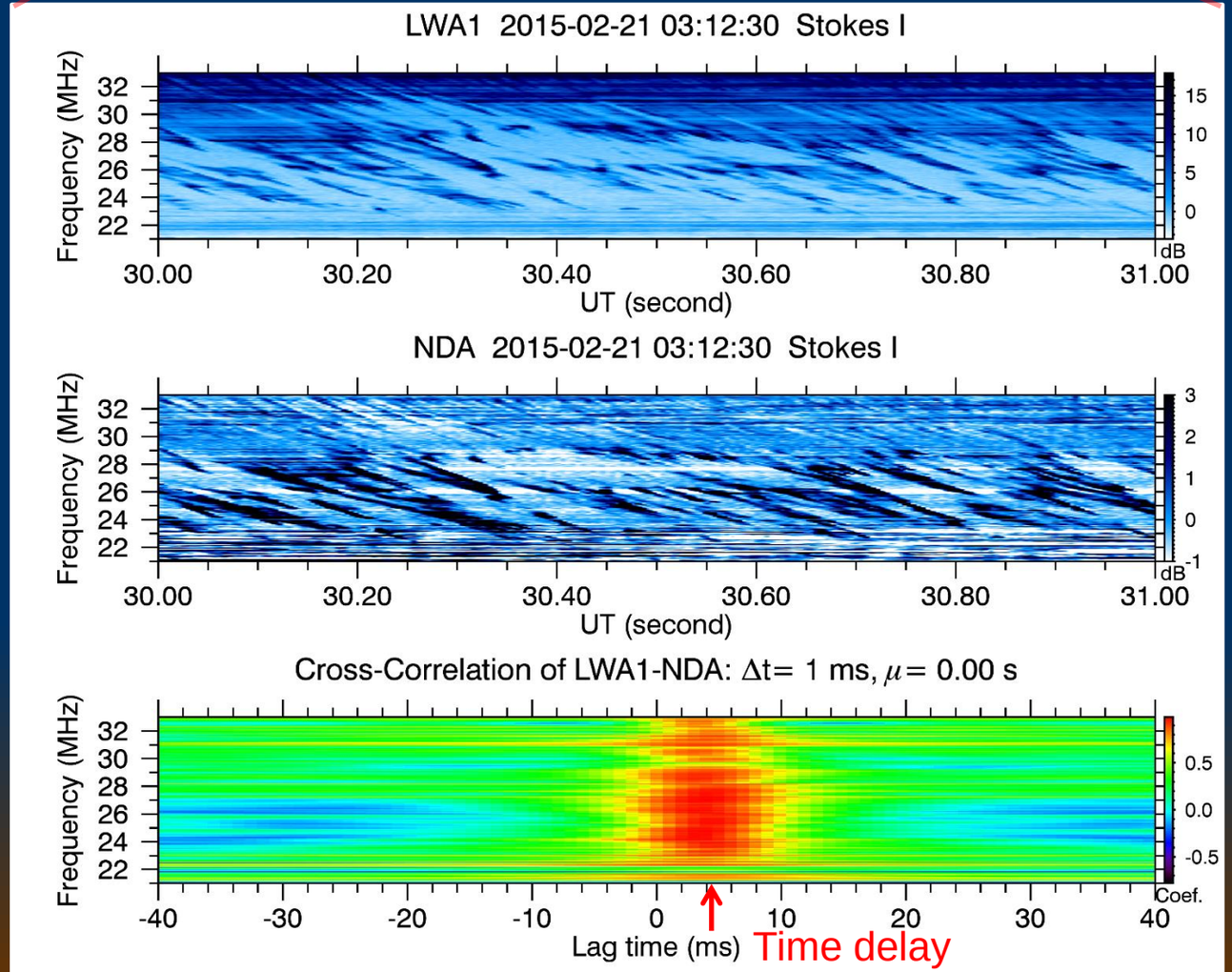
Nançay Decameter Array (NDA), Nançay, France

Long Wavelength Array One (LWA1), Socorro, NM, USA

URAN2, Poltava, Ukraine

(b)





Measuring time delay in a pair of LWA1-URAN2, LWA1-NDA, & NDA-URAN2 provides a clue to infer a beaming structure in Jovian millisecond bursts

→ More coordinated observations in 2016!

Summary of Jupiter Observations

- LWA1 shows fine spectral structure seen in Jupiter's emission
  - Io-related source emission regions need redefinition
  - Io-D f_{max}=26 MHz ---> implications for the southern hemisphere emission and B-field models
- Modulation Lane analysis – implies a very small single source (less than 100km) elongated along a Flux Tube – very powerful tool.
- LWA1-NDA-URAN2 coordinated observing shows beaming shape

Juno Mission 2016 – Ground-based DAM Coordinated campaign

The Radio JOVE Project – radio astronomy education