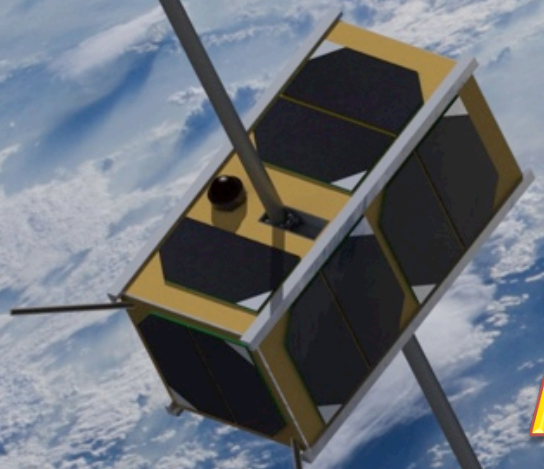
LWA Users Meeting Aug 1, 2019

Jupiter Radio CubeSat and its Collaboration with LWA



Kazumasa Imai

National College of Technology, Kochi College, Japan

KOSEN-1 Team

NASA Radio JOVE Team

2014 JGR

Probing Jovian decametric emission with the long wavelength array station 1

T. E. Clarke, C. A. Higgins, J. Skarda, K. Imai, M. Imai, F. Reyes, J. Thieman, T. Jaeger, H. Schmitt, N. P. Dalal, J. Dowell, S. W. Ellingson, B. Hicks, F. Schinzel, and G. B. Taylor
J. Geophys. Res. Space Physics, 119 (12), 9508-9526, doi:10.1002/2014JA020289.

2016 ApJ

The beaming structures of Jupiter's decametric common S-bursts observed from the LWA1, NDA, and URAN2 radio telescopes

M. Imai, A. Lecacheux, T. E. Clarke, C. A. Higgins, M. Panchenko, J. Dowell, K. Imai, A. I. Brazhenko, A. V. Frantsuzenko, and A. A. Konovalenko
Astrophys. J., 826, 176, doi:10.3847/0004-637X/826/2/176.

2018 JGR

Concurrent Jovian S-burst beaming as observed from LWA1, NDA, and Ukrainian radio telescopes

M. Imai, A. Lecacheux, T. E. Clarke, C. A. Higgins, M. Panchenko, V. V. Zakharenko, A. I. Brazhenko, A. V. Frantsuzenko, O. N. Ivantyshin, A. A. Konovalenko, and V. V. Koshovyy, J. Geophys. Res. Space Physics, 124, doi:10.1029/2018JA026445.

2018 PRE8

Jupiter's Io-C and Io-B decametric emission source morphology from LWA1 data analysis

K. Imai, C.A. Higgins, M. Imai, and T.E. Clarke

Planetary Radio Emissions VIII, edited by G. Fischer, G. Mann, M. Panchenko, and P. Zarka, Austrian Academy of Sciences Press, Vienna, pp.89-101, 2018.
(doi: 10.1553/PRE8s89)

2018 PRE8

Morphology of the Jupiter Io-D decametric radio source

C. Higgins, T. E. Clarke, K. Imai, M. Imai, F. Reyes, and J. Thieman

Planetary Radio Emissions VIII, edited by G. Fischer, G. Mann, M. Panchenko, and P. Zarka, Austrian Academy of Sciences Press, Vienna, pp.77-88, 2018.
(doi: 10.1553/PRE8s77)

2018 PRE8

Jovian decametric emission with the Long Wavelength Array station 1 (LWA1)

T. E. Clarke, C. A. Higgins, M. Imai, and K. Imai

Planetary Radio Emissions VIII, edited by G. Fischer, G. Mann, M. Panchenko, and P. Zarka, Austrian Academy of Sciences Press, Vienna, pp31-44, 2018.
(doi: 10.1553/PRE8s31)

Long Wavelength Array Station 1 (LWA1)

Socorro, New Mexico, USA
(From 2012)

- 256 Dual Polarization Antennas
- Frequency Range 10 – 88 MHz
- 4 Beams: 8° Beam Size @20MHz
- Full Stokes Parameters

Jupiter Radio Observation

Two Overlapping 16 MHz Beams Covering 10-40 MHz

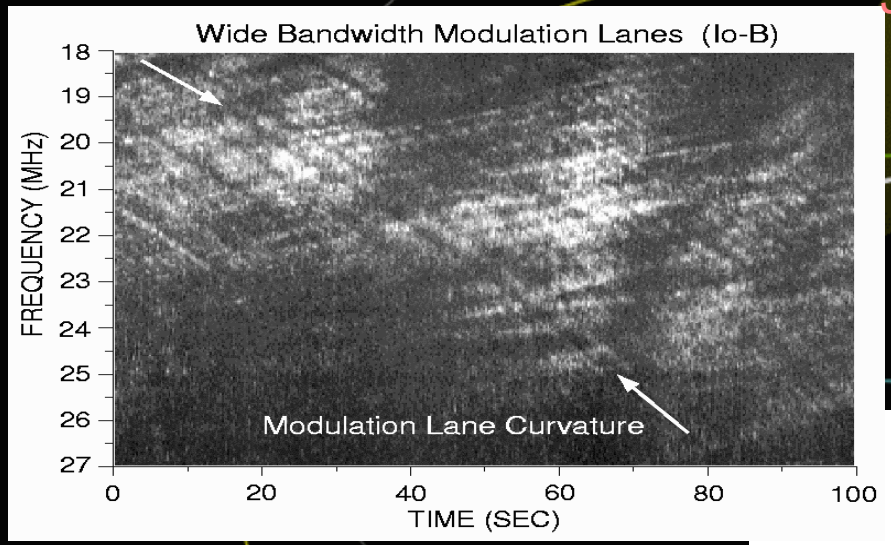
High Resolution Mode
0.21 ms and 5 kHz

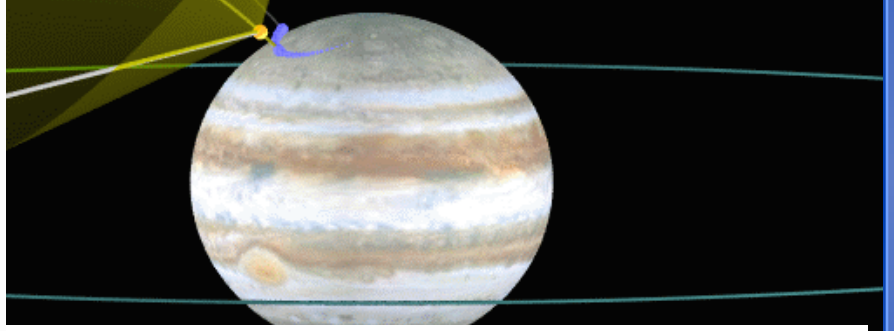
Low Resolution Mode
40 ms and 20 kHz

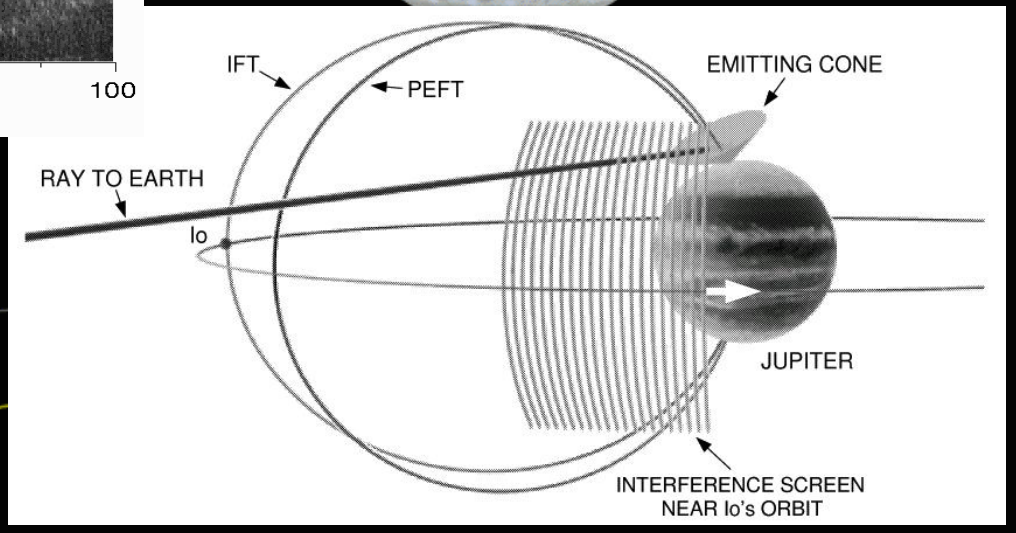
August 4, 2010

Remote Sensing of Jupiter's Radio Source by using Modulation Lane Method

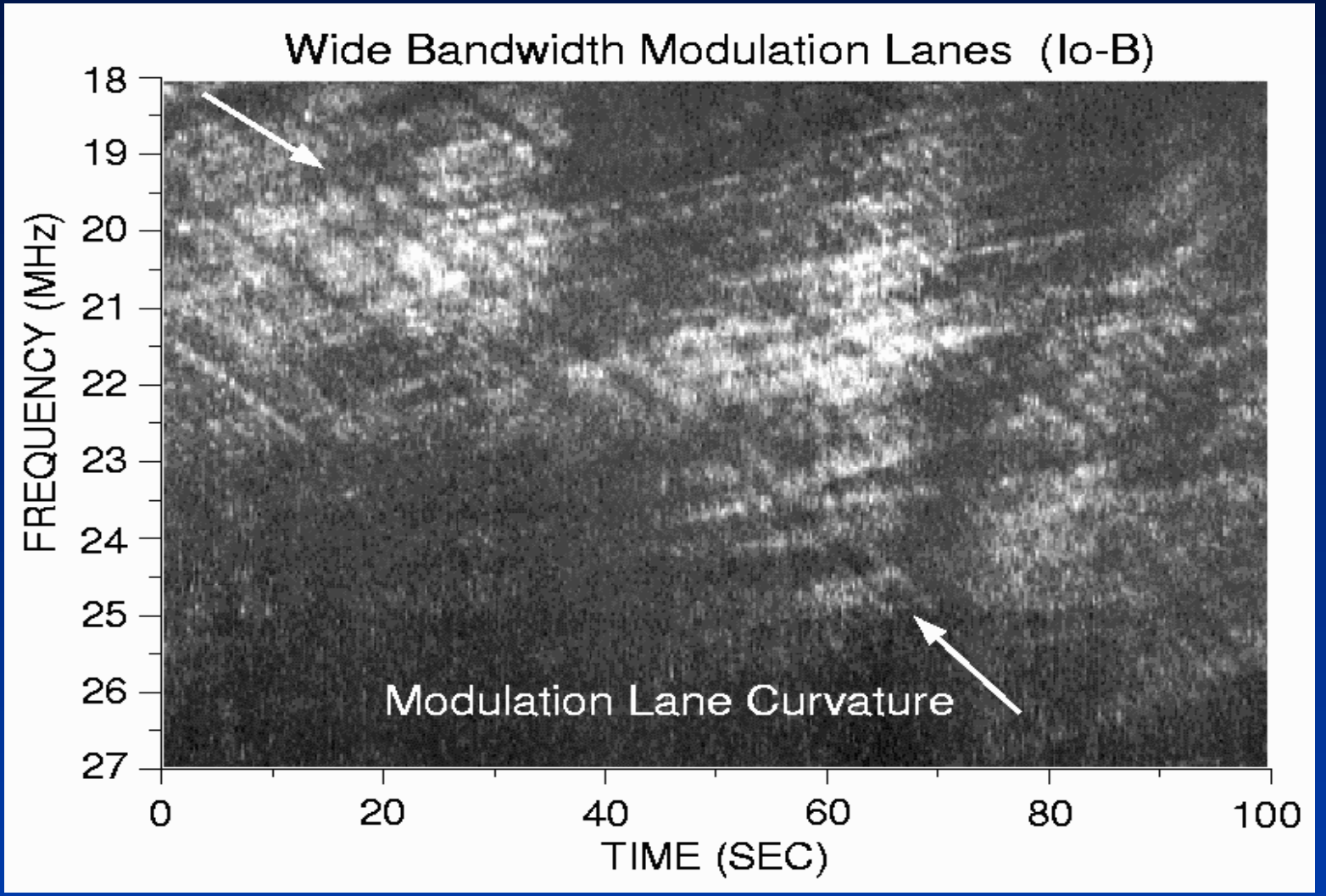
Imai et al.: GRL(1992),PRE3(1992), JGR(1997),
JGR(2002),PRE6(2006)



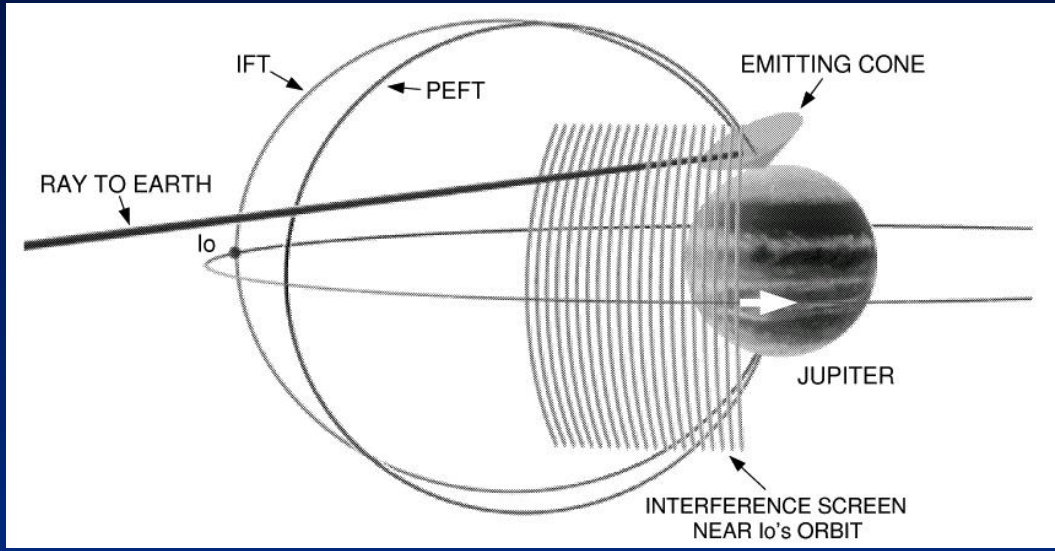


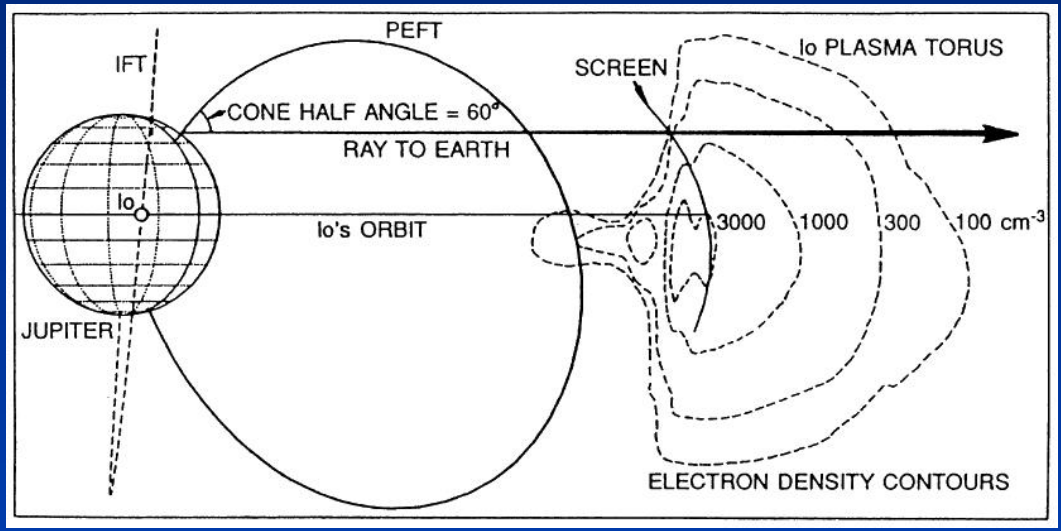


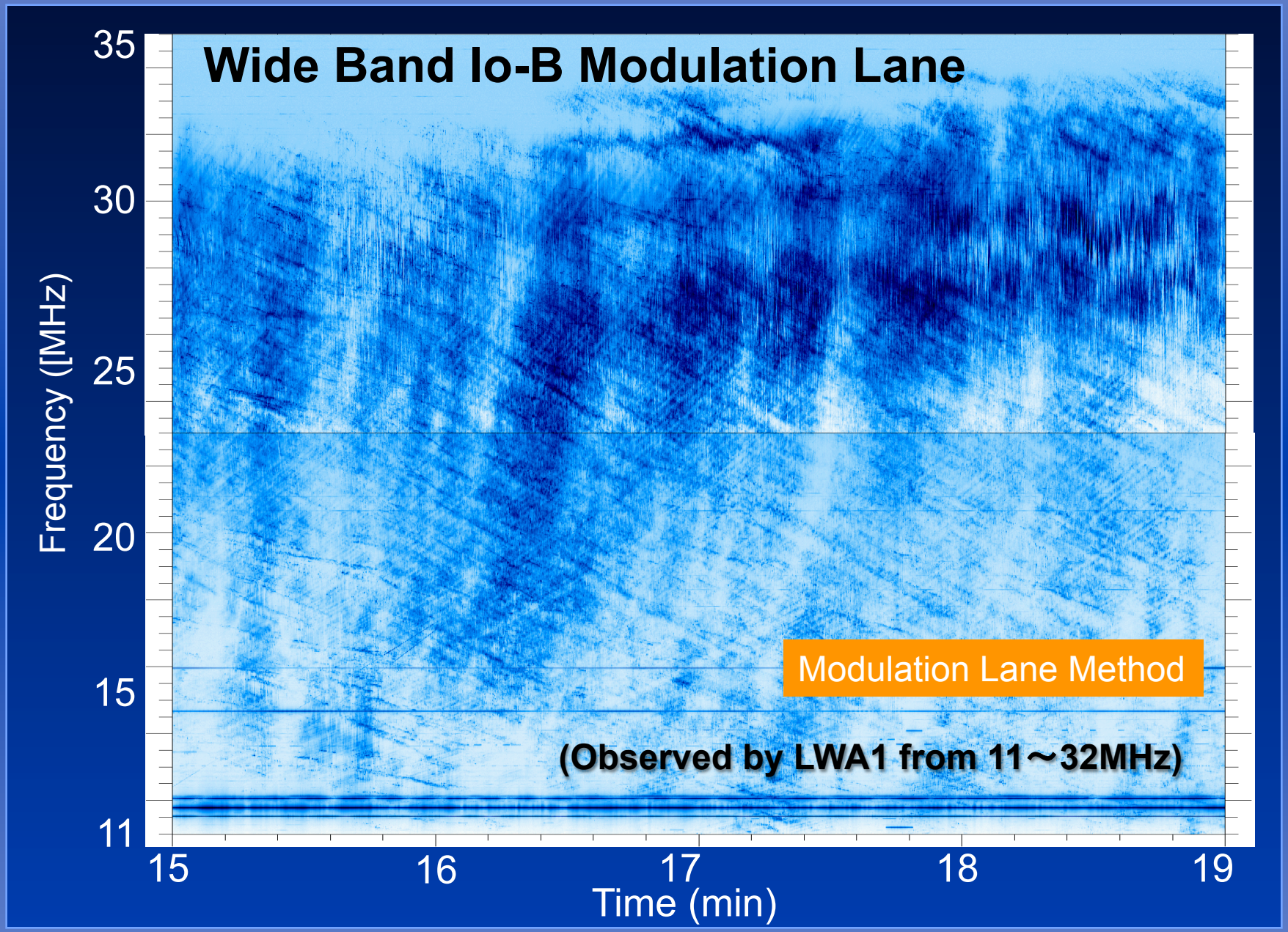
Modulation Lane Method



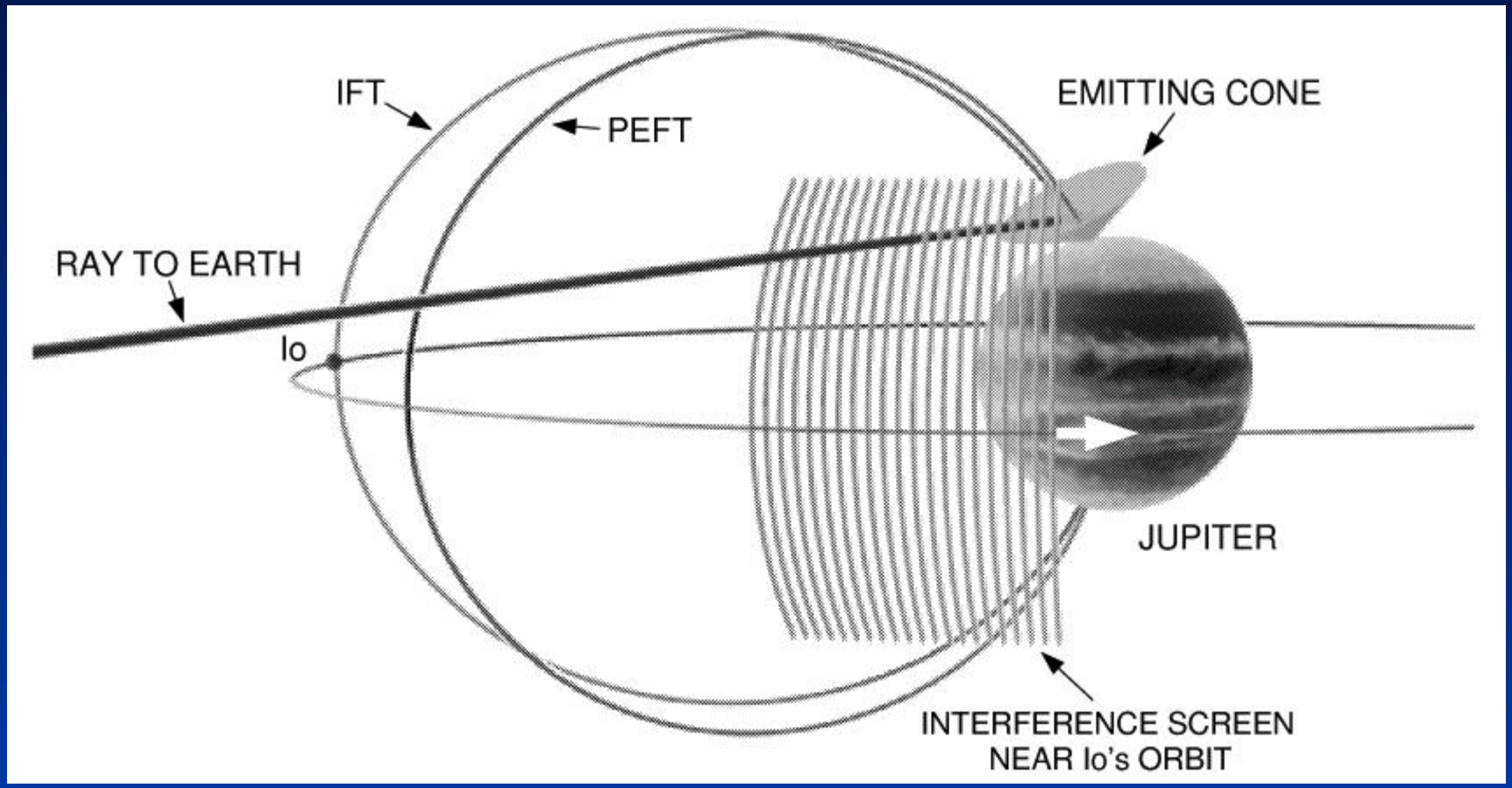
Modulation Lane Method

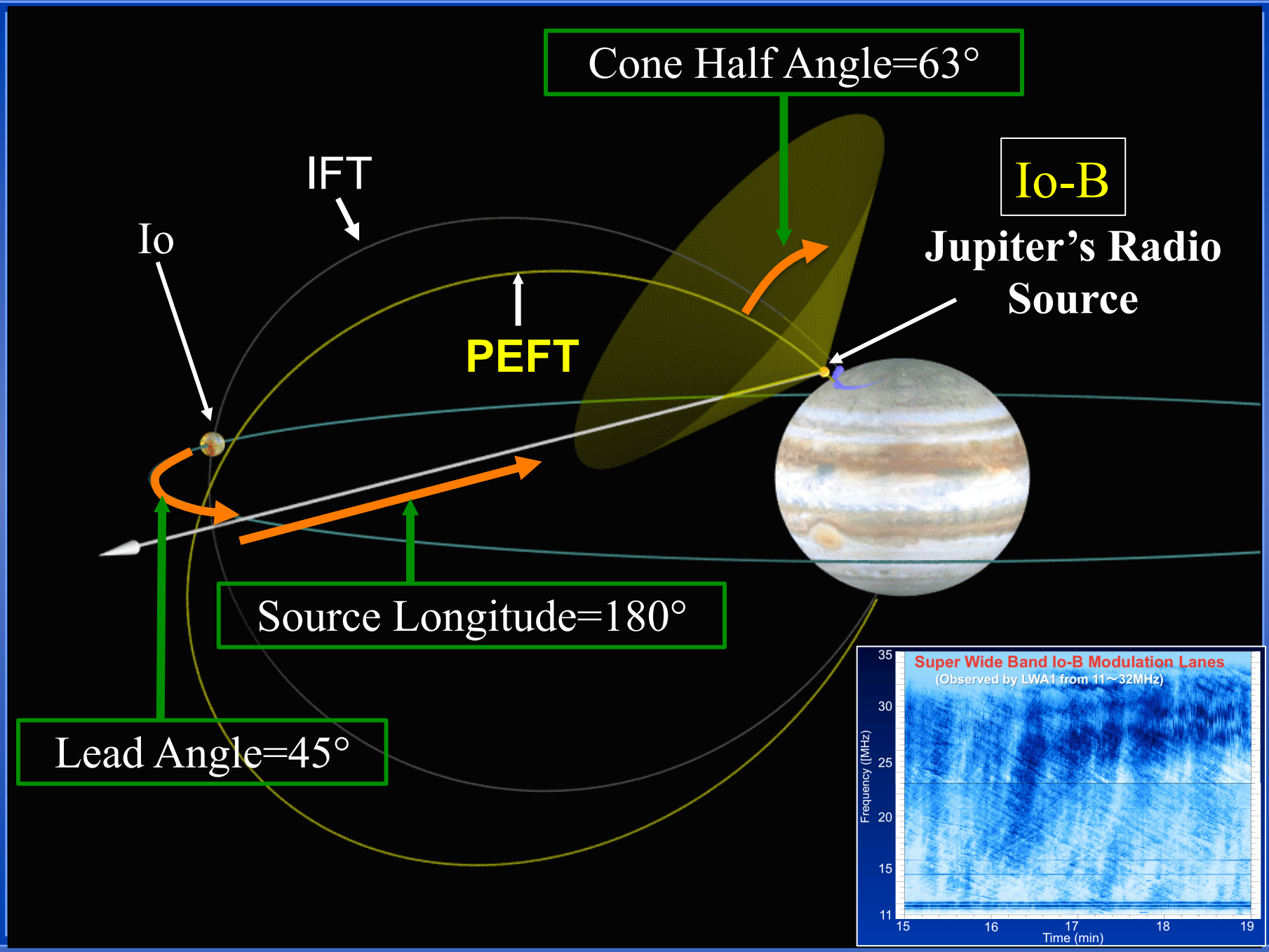


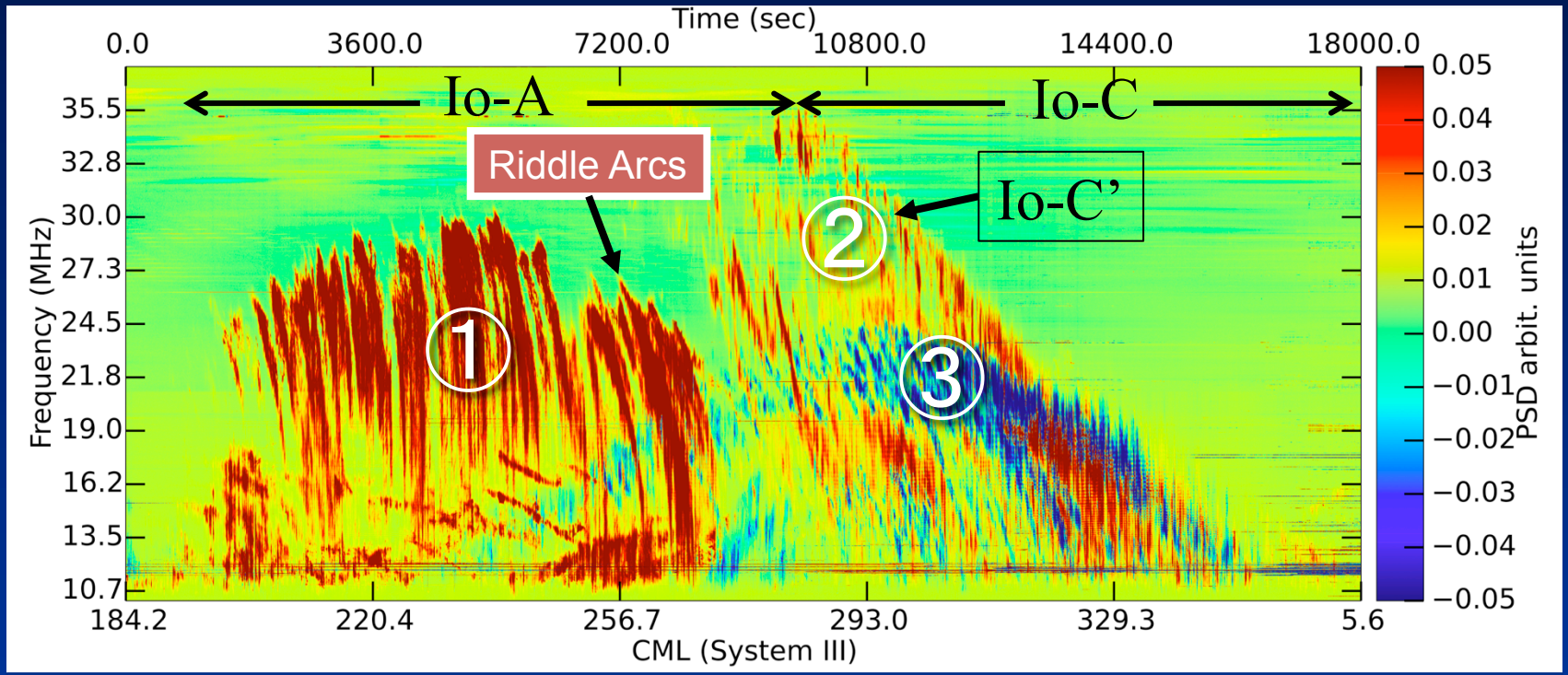



Wide Band Io-B Modulation Lane
Frequency ([MHz)
35
30
25
20
15
11
15
16
17
18
19
Time (min)
Modulation Lane Method
(Observed by LWA1 from 11～32MHz)

Modulation Lane Method


IFT
PEFT
EMITTING CONE
RAY TO EARTH
Io
JUPITER
INTERFERENCE SCREEN
NEAR Io's ORBIT

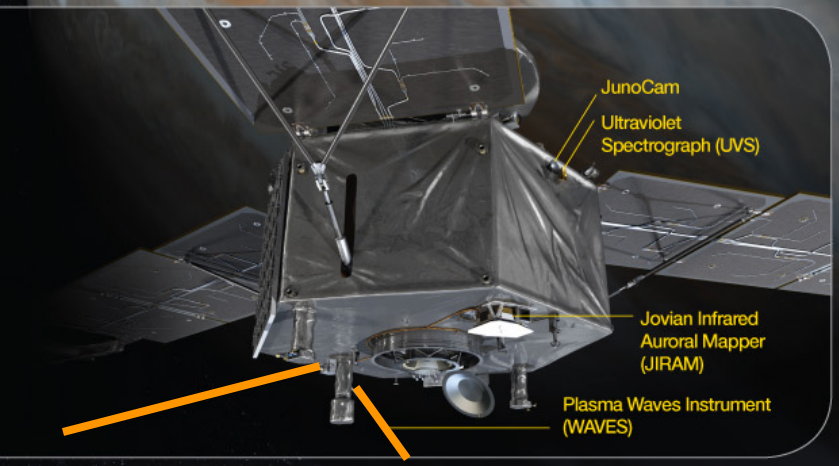

Cone Half Angle=63°
IFT
Io
PEFT
Io-B
Jupiter's Radio Source
Source Longitude=180°
Lead Angle=45°
Super Wide Band Io-B Modulation Lanes
(Observed by LWA1 from 11~32MHz)
Frequency (MHz)
35
30
25
20
15
11
15
16
17
18
19
Time (min)



Io-A/Io-C burst recorded on 1 December 2012 by LWA1

National Aeronautics and Space Administration

Juno Spacecraft



SPACECRAFT DIMENSIONS

Diameter: 66 feet (20 meters)
Height: 15 feet (4.5 meters)

For more information:
missionjuno.swri.edu &
www.nasa.gov/juno

Juno's Instruments

Gravity Science and Magnetometers
Study Jupiter's deep structure by mapping the planet's gravity field and magnetic field

Microwave Radiometer
Probe Jupiter's deep atmosphere and measure how much water (and hence oxygen) is there

JEDI, JADE and Waves
Sample electric fields, plasma waves and particles around Jupiter to determine how the magnetic field is connected to the atmosphere, and especially the auroras (northern and southern lights)

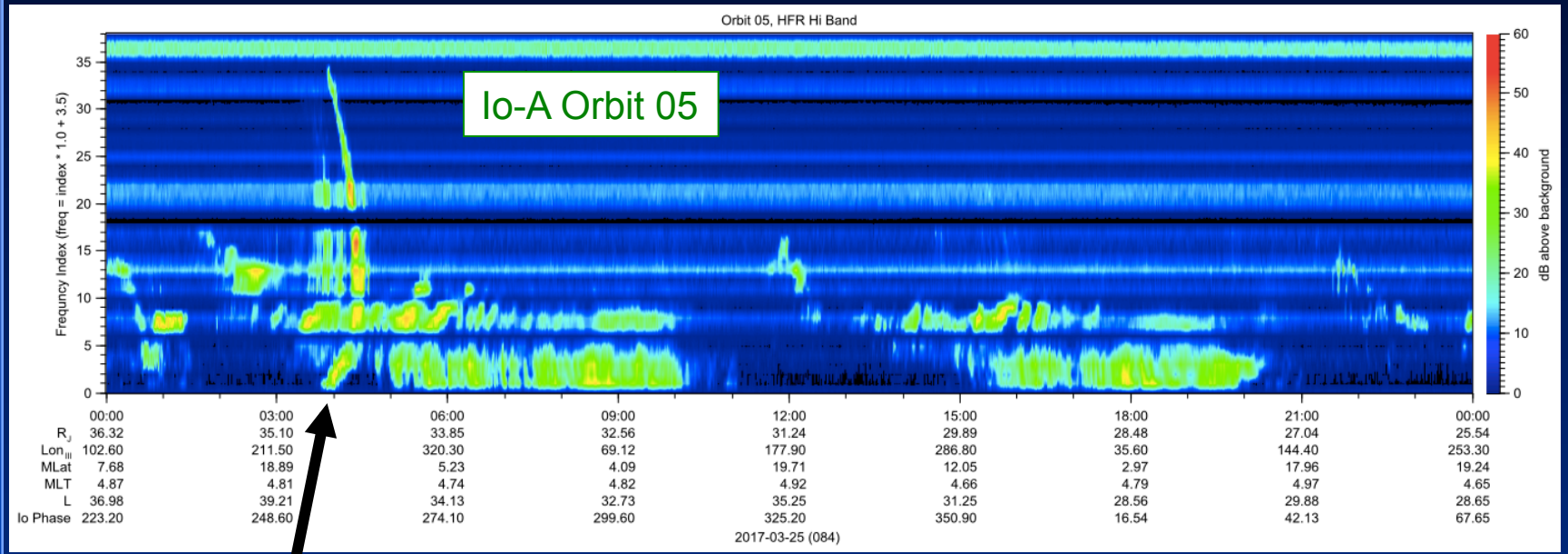
UVS and JIRAM
Using ultraviolet and infrared cameras, take images of the atmosphere and auroras, including chemical fingerprints of the gases present

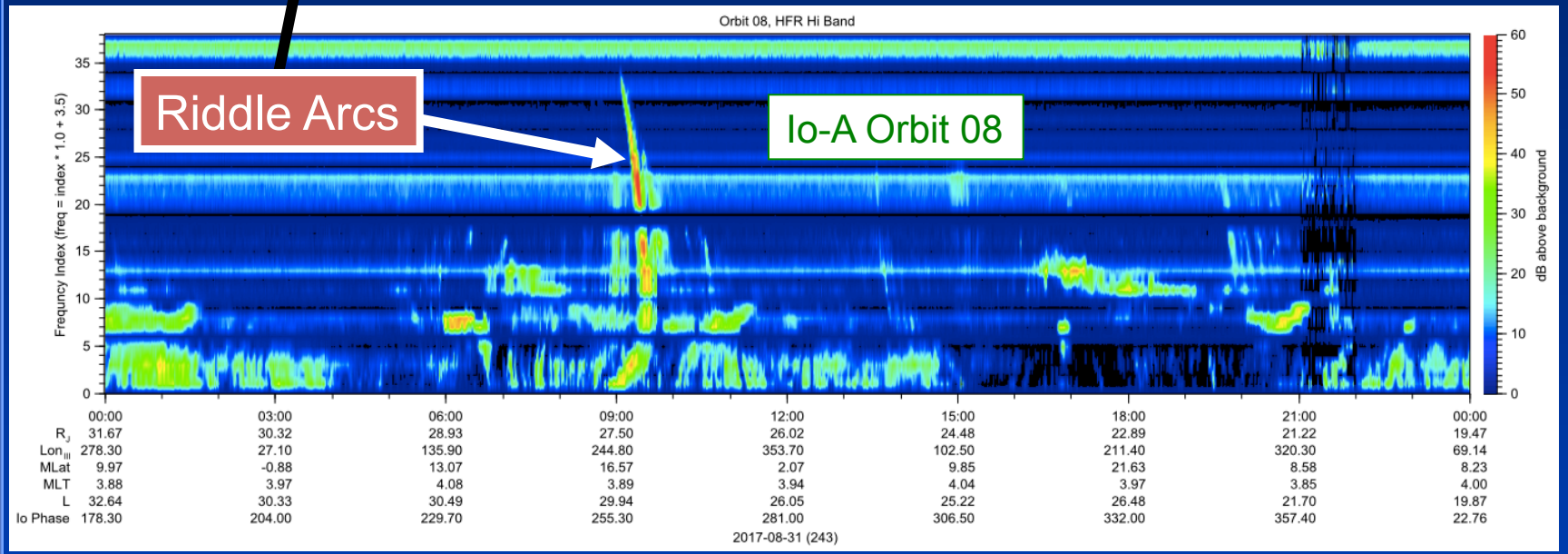
JunoCam
Take spectacular close-up, color images

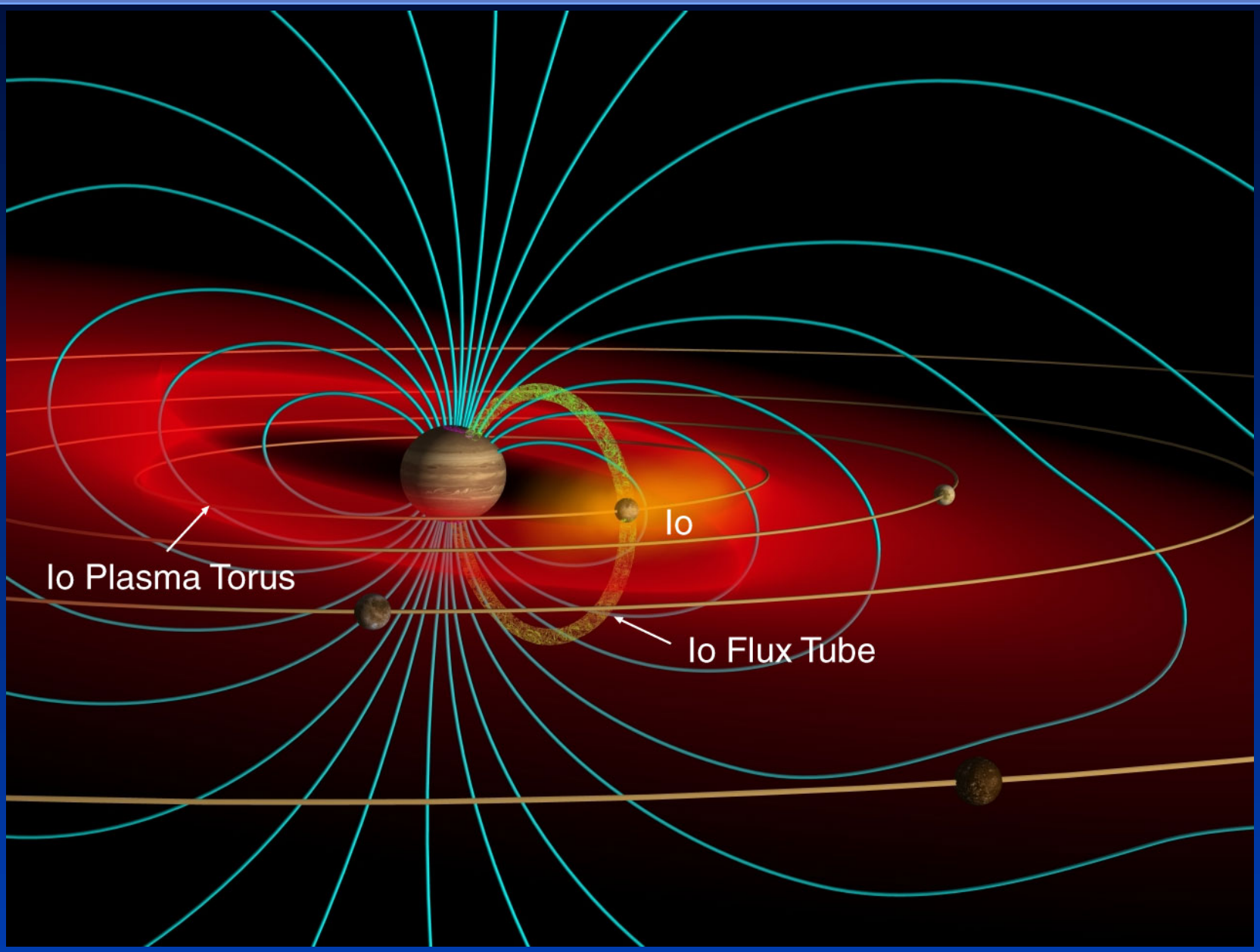
National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

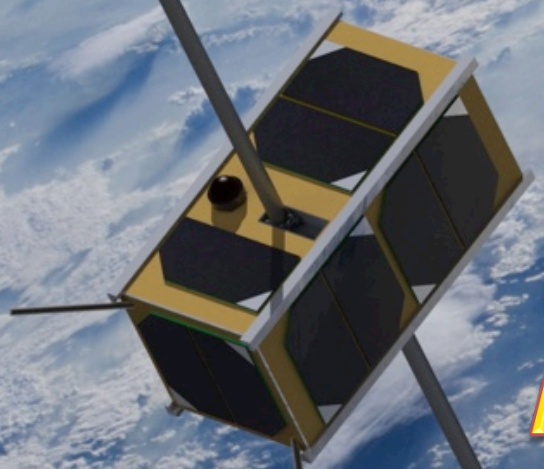

Orbit 05, HFR Hi Band
Io-A Orbit 05
Frequncy Index (freq = index * 1.0 + 3.5)
dB above background
00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00
R_J 36.32 35.10 33.85 32.56 31.24 29.89 28.48 27.04 25.54
Lon_III 102.60 211.50 320.30 69.12 177.90 286.80 35.60 144.40 253.30
MLat 7.68 18.89 5.23 4.09 19.71 12.05 2.97 17.96 19.24
MLT 4.87 4.81 4.74 4.82 4.92 4.66 4.79 4.97 4.65
L 36.98 39.21 34.13 32.73 35.25 31.25 28.56 29.88 28.65
Io Phase 223.20 248.60 274.10 299.60 325.20 350.90 16.54 42.13 67.65
2017-03-25 (084)


Orbit 08, HFR Hi Band
Riddle Arcs
Io-A Orbit 08
Frequncy Index (freq = index * 1.0 + 3.5)
dB above background
00:00 03:00 06:00 09:00 12:00 15:00 18:00 21:00 00:00
R_J 31.67 30.32 28.93 27.50 26.02 24.48 22.89 21.22 19.47
Lon_III 278.30 27.10 135.90 244.80 353.70 102.50 211.40 320.30 69.14
MLat 9.97 -0.88 13.07 16.57 2.07 9.85 21.63 8.58 8.23
MLT 3.88 3.97 4.08 3.89 3.94 4.04 3.97 3.85 4.00
L 32.64 30.33 30.49 29.94 26.05 25.22 26.48 21.70 19.87
Io Phase 178.30 204.00 229.70 255.30 281.00 306.50 332.00 357.40 22.76
2017-08-31 (243)


Io
Io Plasma Torus
Io Flux Tube

LWA Users Meeting Aug 1, 2019

Jupiter Radio CubeSat and its Collaboration with LWA



Kazumasa Imai

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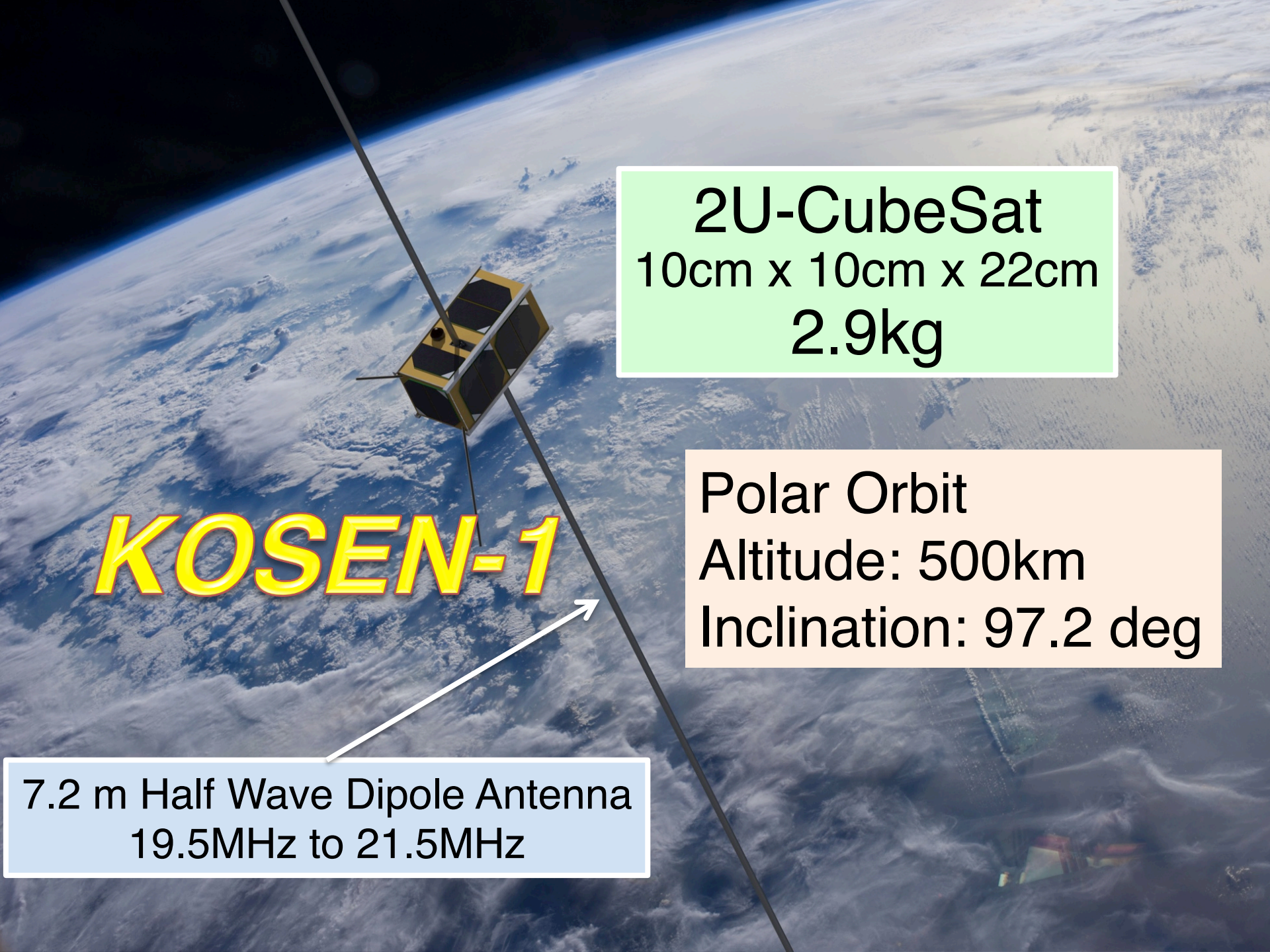
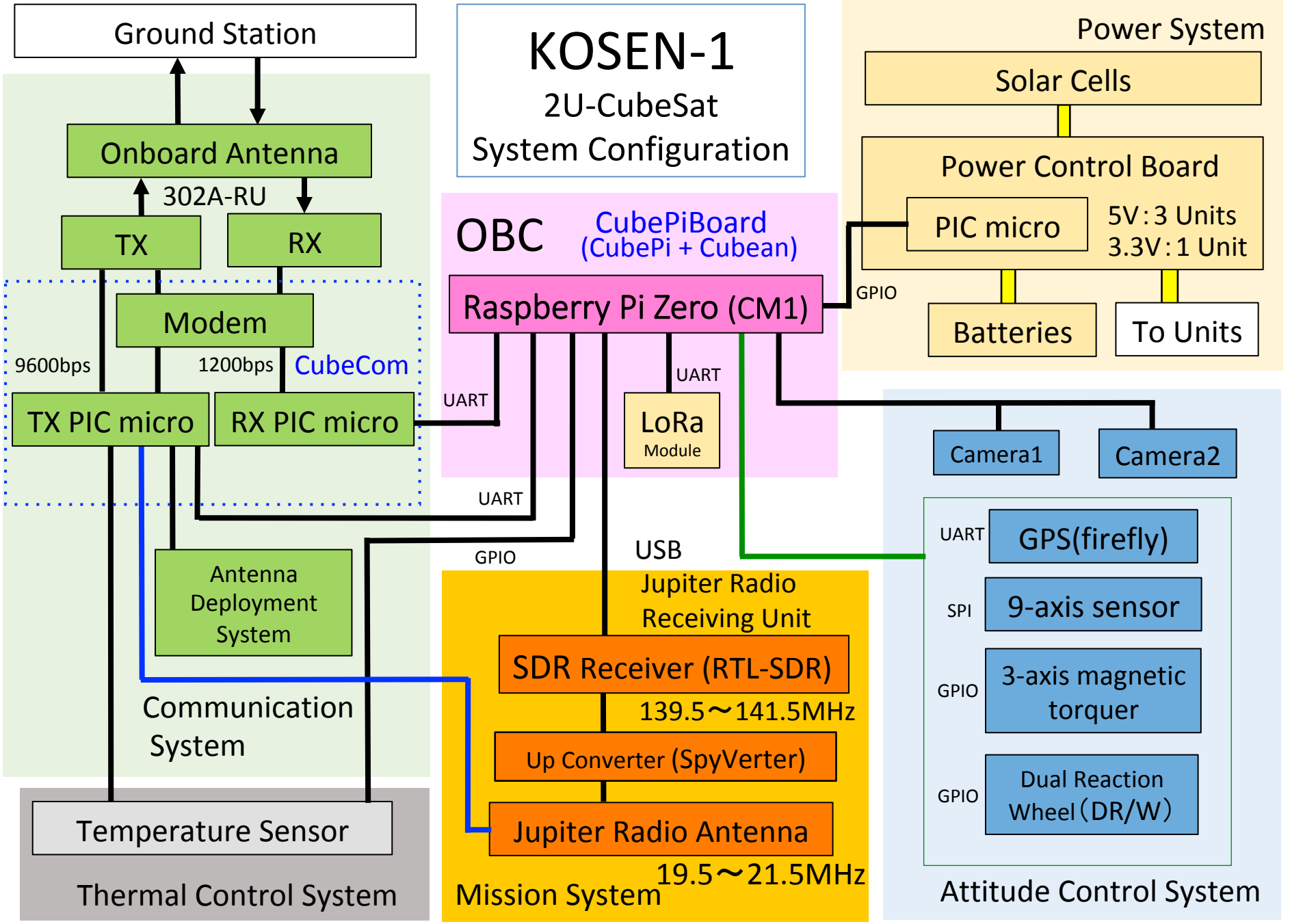
KOSEN-1 Team

NASA Radio JOVE Team

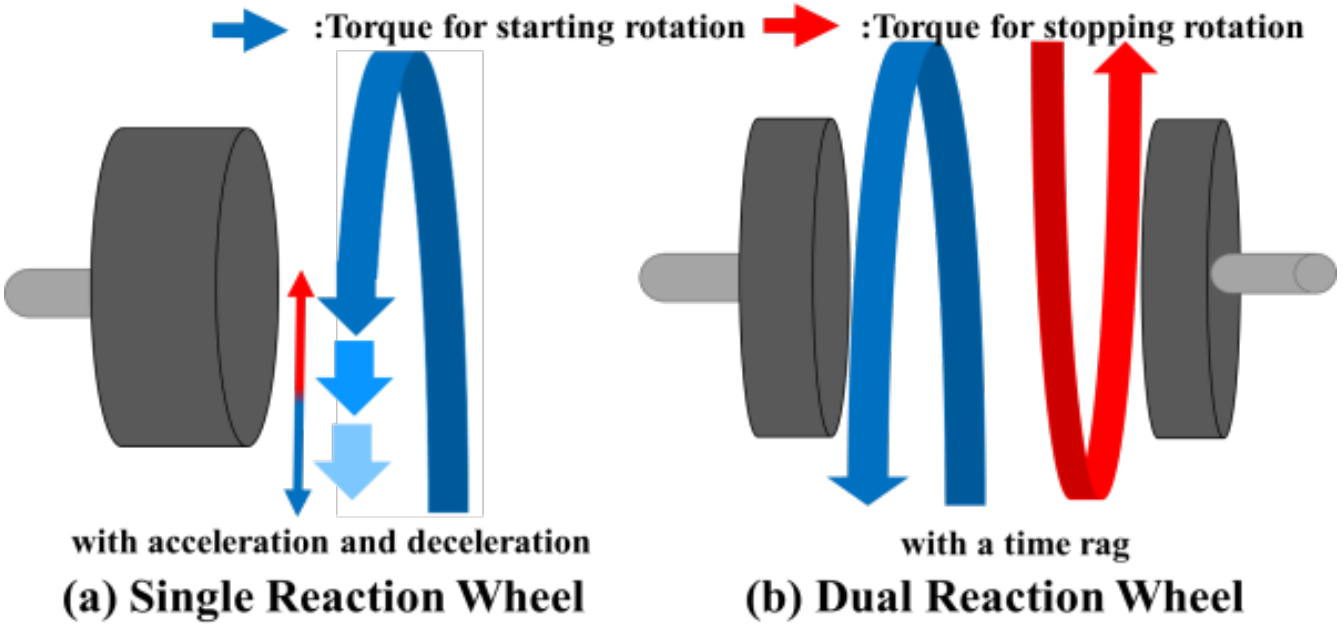
Innovative Satellites 2

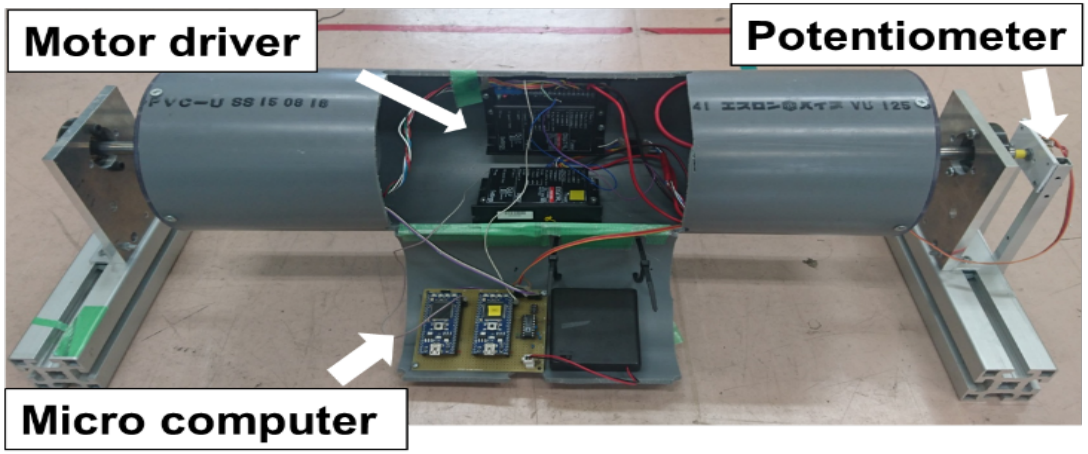
Innovative Satellite Technology Demonstration Program


KOSEN-1
2U-CubeSat
10cm x 10cm x 22cm
2.9kg
Polar Orbit
Altitude: 500km
Inclination: 97.2 deg
7.2 m Half Wave Dipole Antenna
19.5MHz to 21.5MHz


Ground Station
KOSEN-1
2U-CubeSat
System Configuration
Power System
Solar Cells
Power Control Board
PIC micro
5V : 3 Units
3.3V : 1 Unit
Batteries
To Units
GPIO
Onboard Antenna
302A-RU
TX
RX
OBC
CubePiBoard
(CubePi + Cubean)
Raspberry Pi Zero (CM1)
Modem
9600bps
1200bps
CubeCom
TX PIC micro
RX PIC micro
UART
UART
LoRa
Module
UART
Camera1
Camera2
UART
GPS(firefly)
SPI
9-axis sensor
GPIO
3-axis magnetic
torquer
GPIO
Dual Reaction
Wheel（DR/W）
Attitude Control System
Antenna
Deployment
System
GPIO
USB
Jupiter Radio
Receiving Unit
SDR Receiver (RTL-SDR)
139.5～141.5MHz
Up Converter (SpyVerter)
Jupiter Radio Antenna
19.5～21.5MHz
Mission System
Communication
System
Temperature Sensor
Thermal Control System

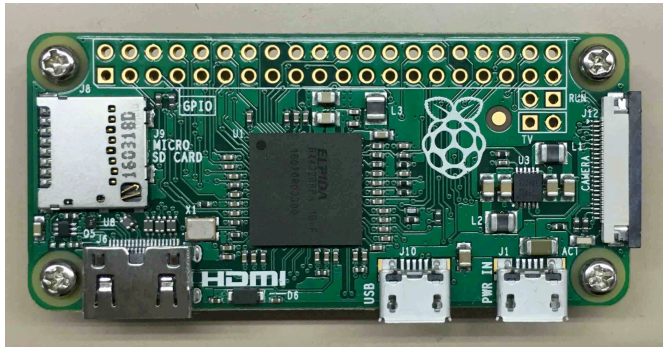
Dual Reaction Wheel

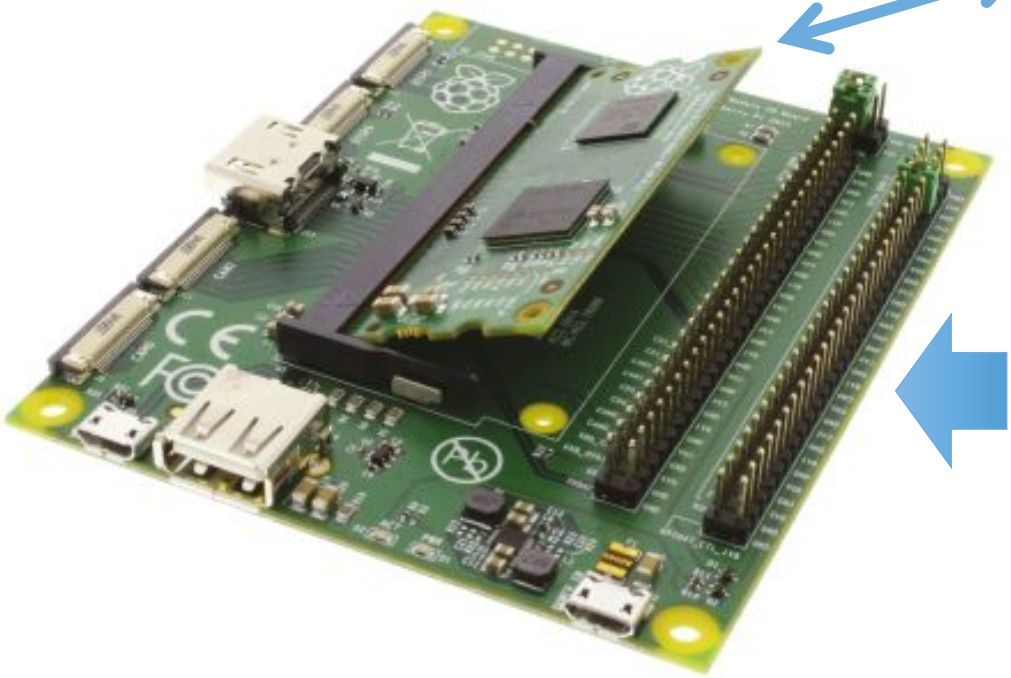




Onboard Computer

Raspberry Pi Zero





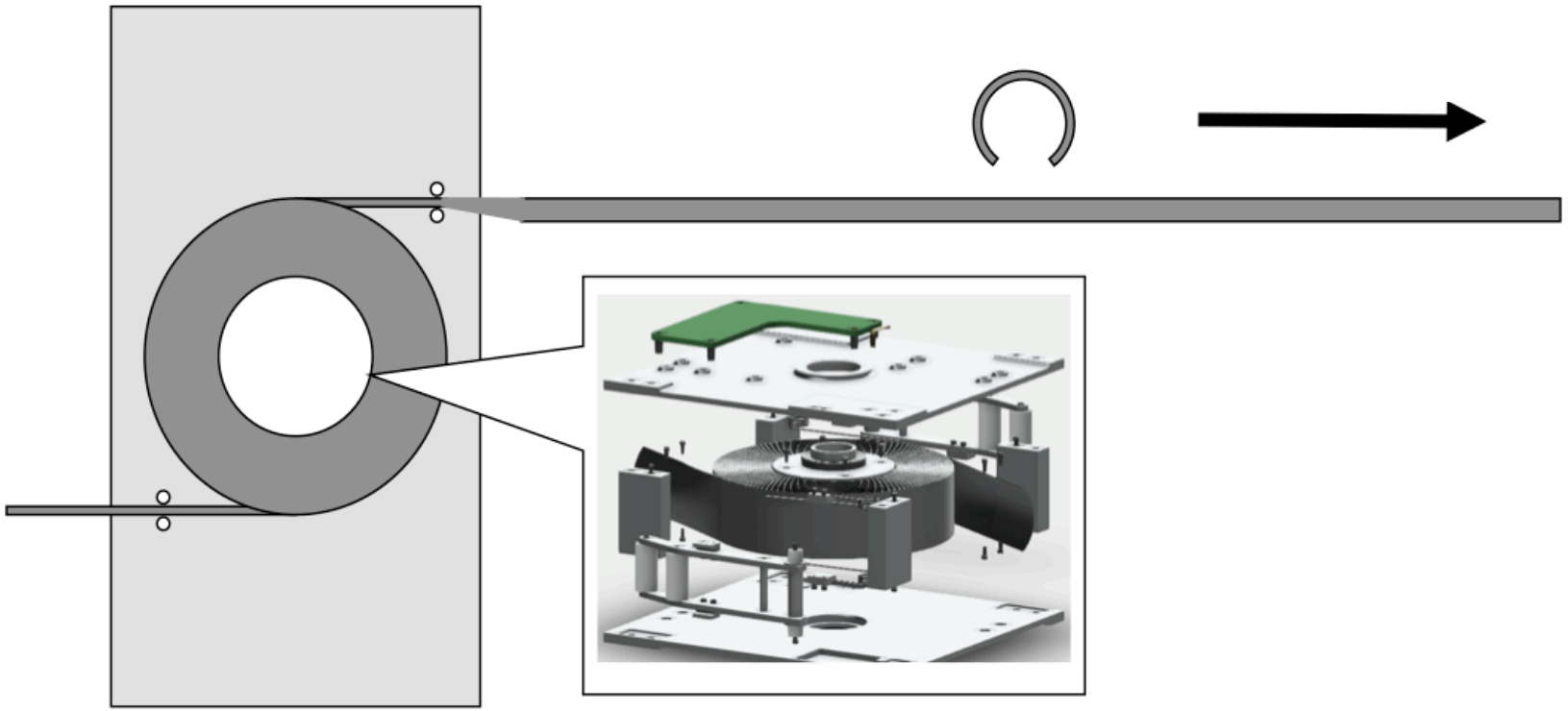
Raspberry Pi Compute Module (CM1)

Cubean

CubePiBoard

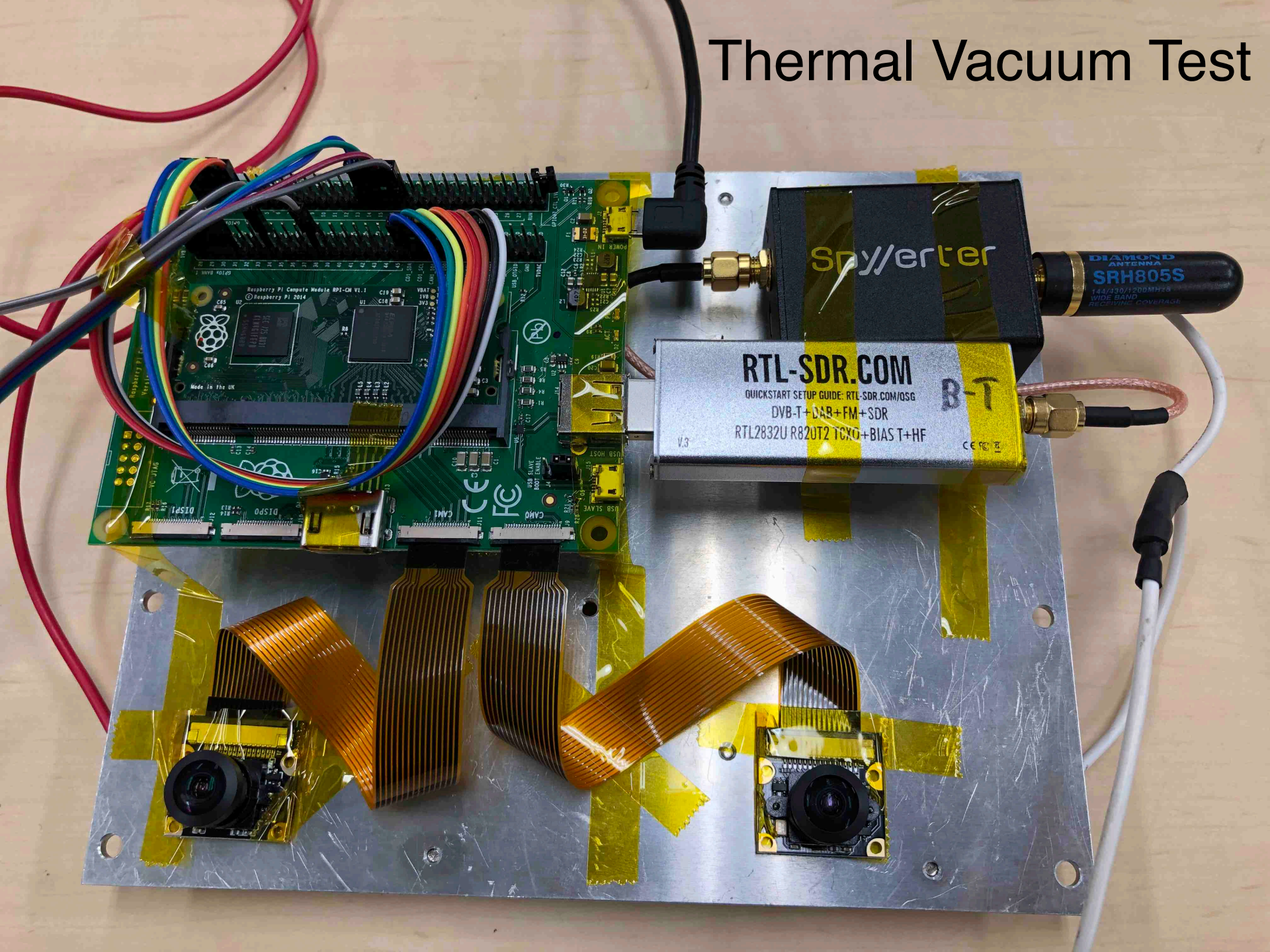
CubePi

Dipole Antenna for Jupiter Radio Reception

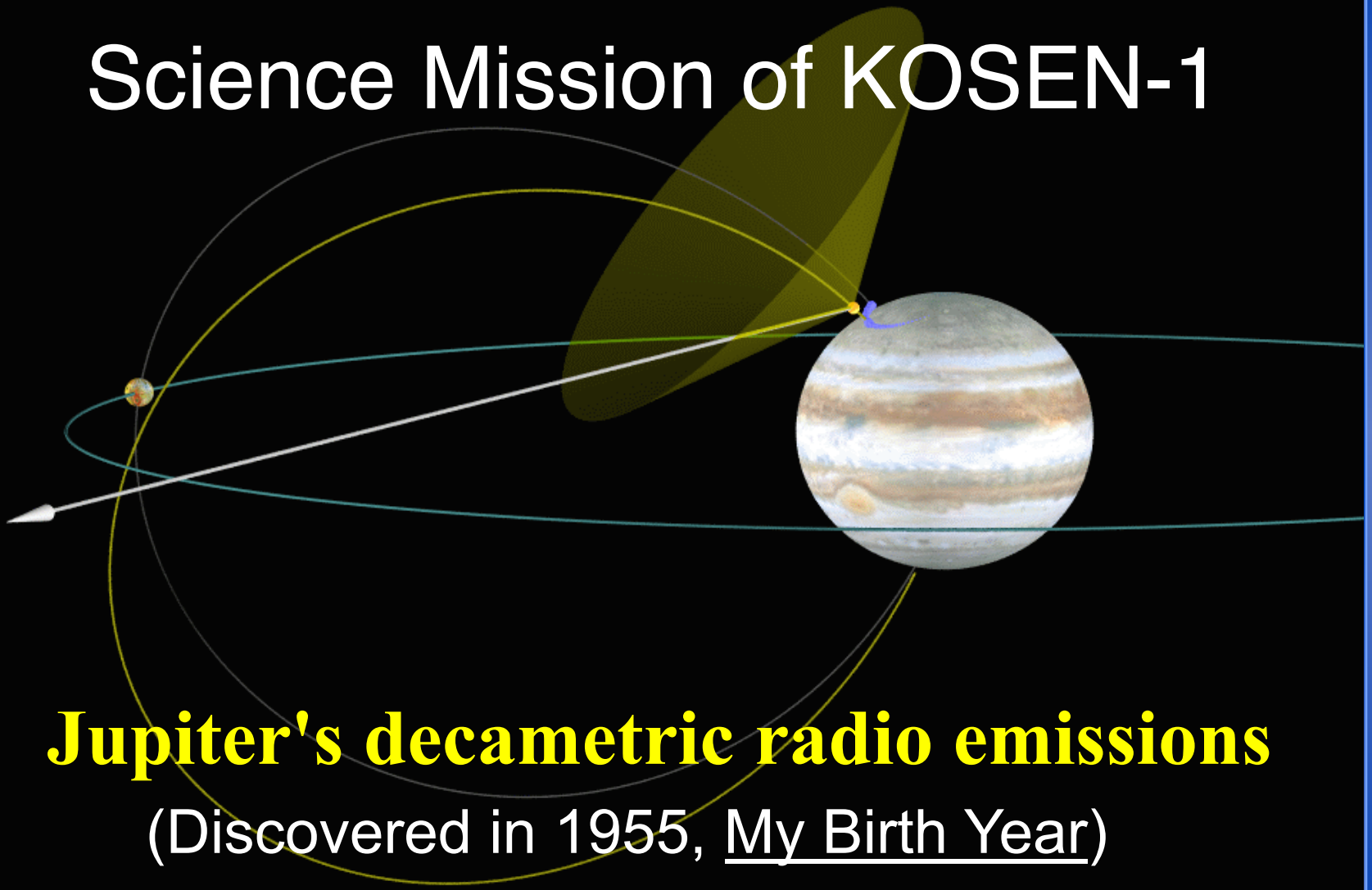


7.2 m Half Wave Dipole Antenna
19.5MHz to 21.5MHz

Thermal Vacuum Test

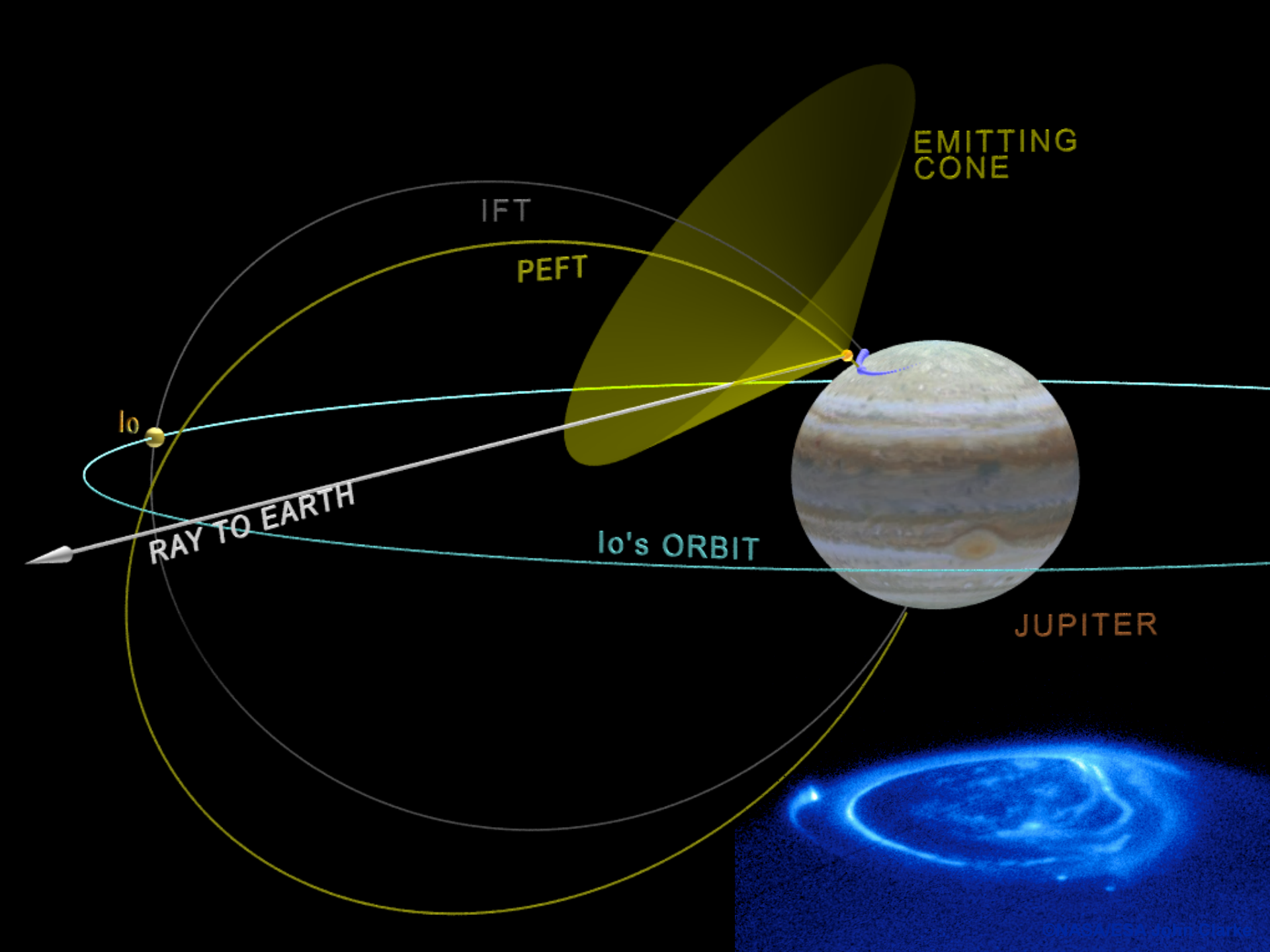


Science Mission of KOSEN-1



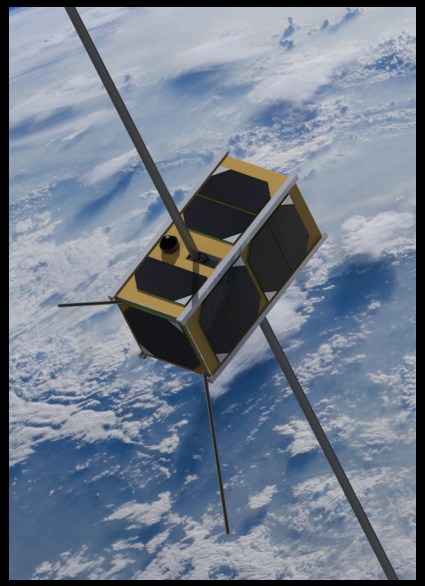
Jupiter's decametric radio emissions

(Discovered in 1955, My Birth Year)


EMITTING
CONE
IFT
PEFT
Io
RAY TO EARTH
Io's ORBIT
JUPITER

Imai Lab.

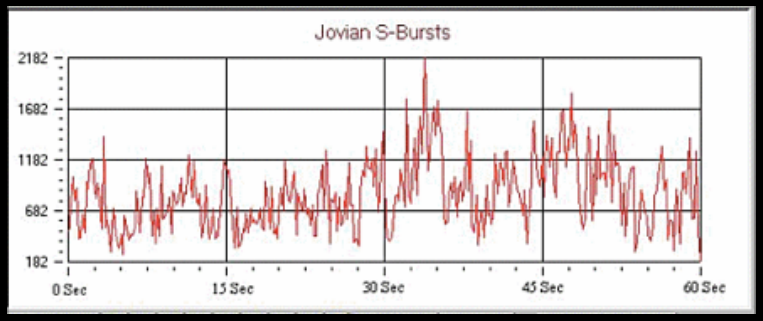
Mission

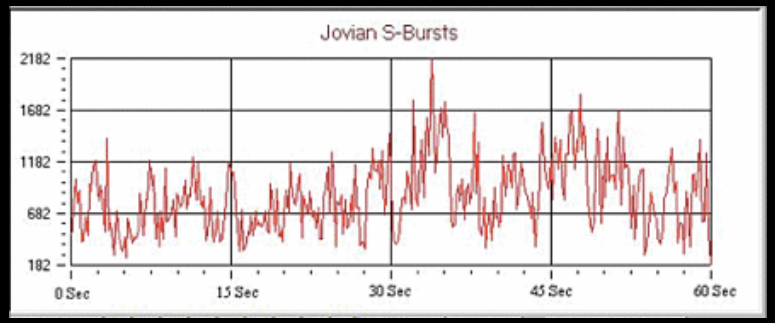


correlation analysis

Data from a CubeSat

Data from the ground



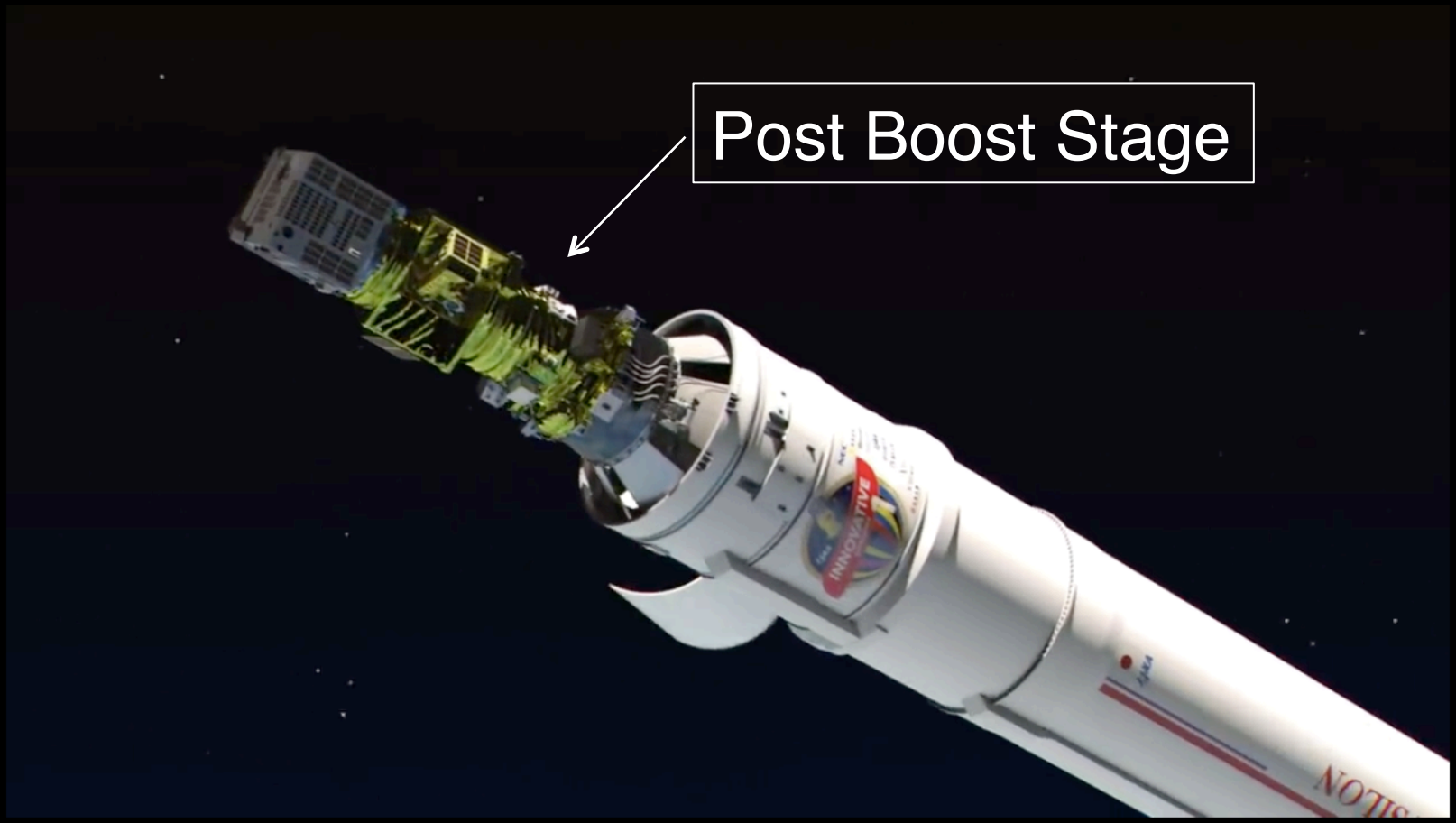


The purpose of this project is to measure the delay time by using a correlation analysis method.

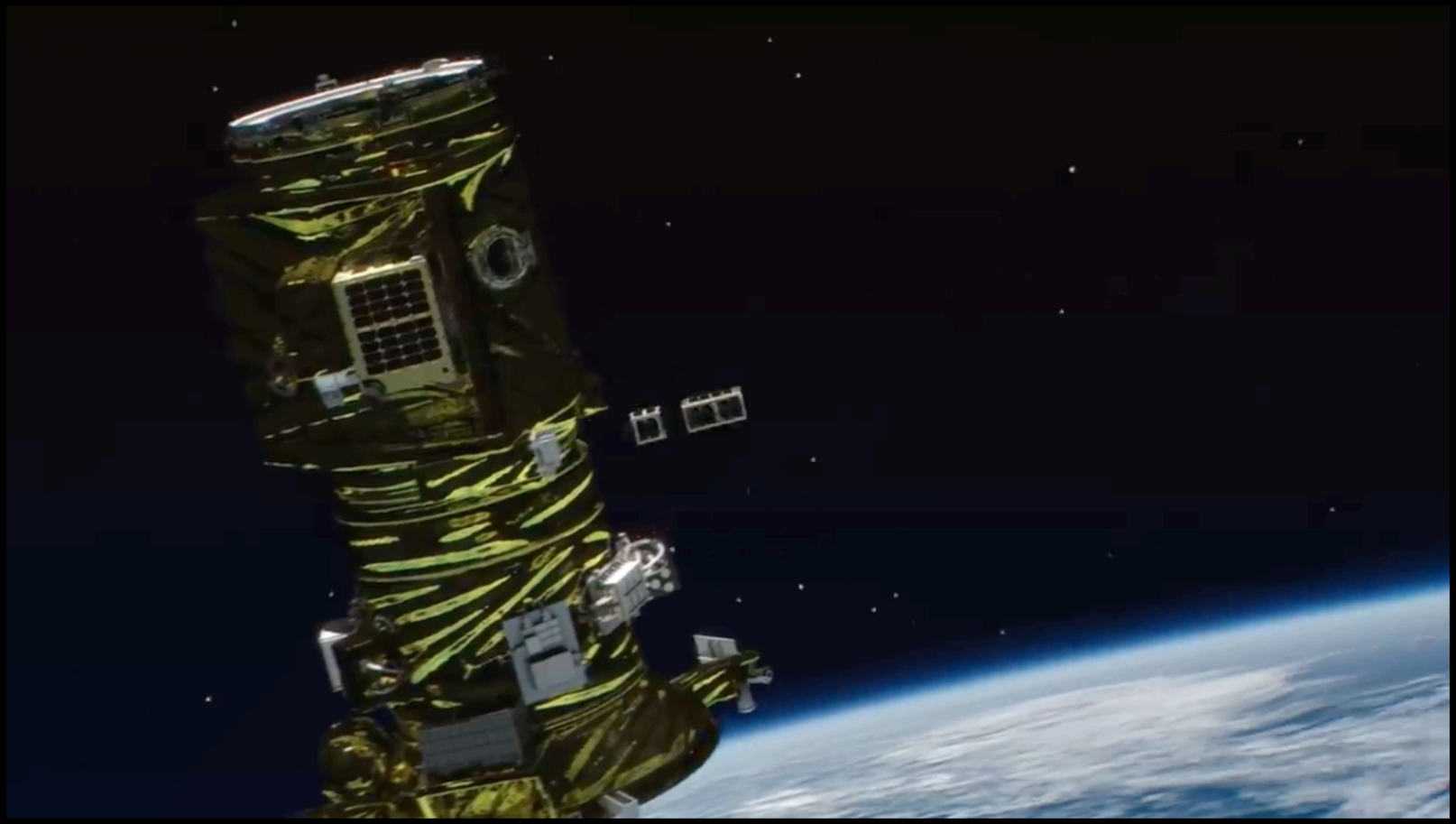

To be launched
by a JAXA
Epsilon rocket
at the end of
2020!!
EPSILON
©JAXA

https://www.youtube.com/watch?v=wZm50MfdCLc&t=2s

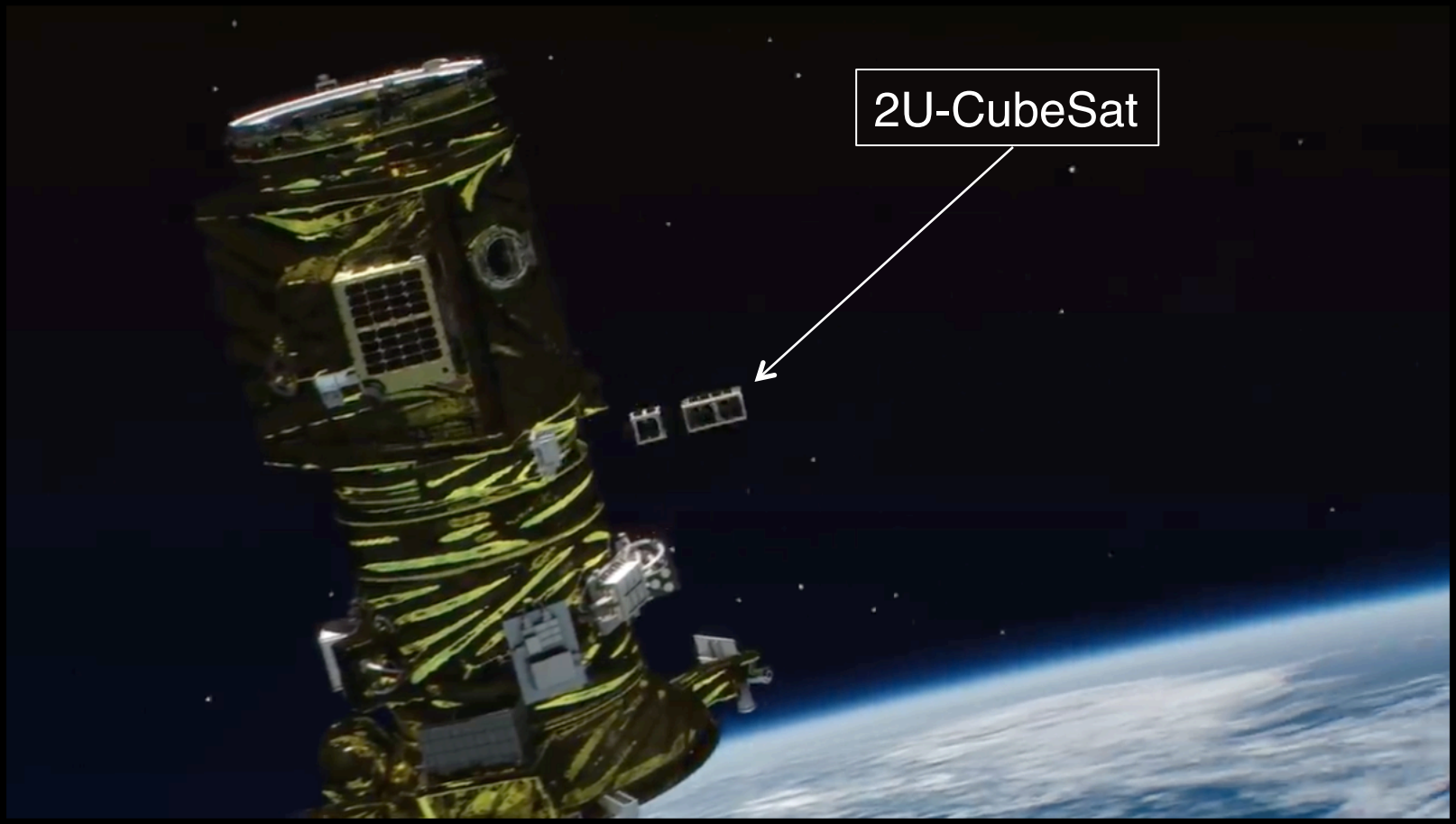
https://www.youtube.com/watch?v=wZm50MfdCLc&t=2s



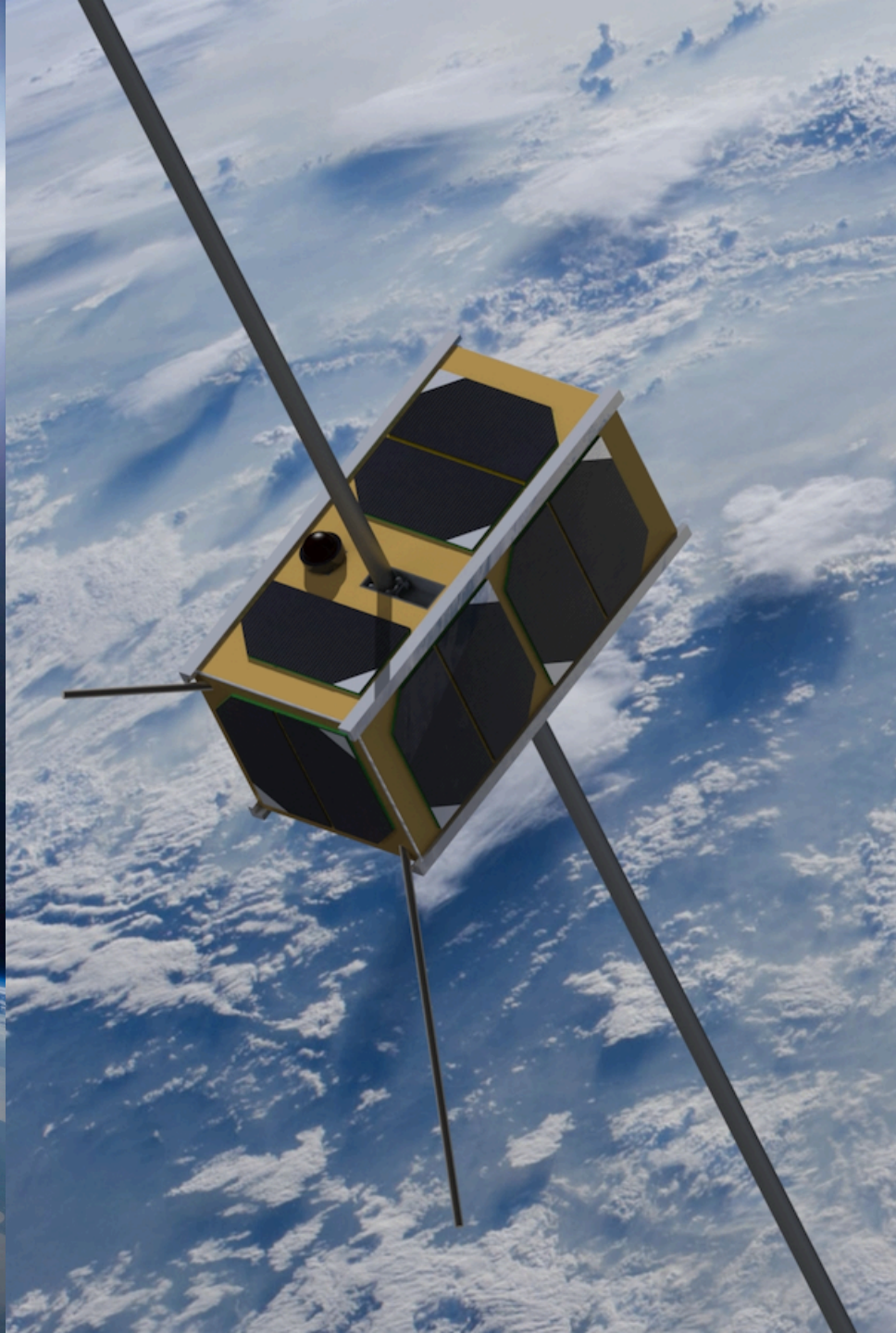
https://www.youtube.com/watch?v=wZm50MfdCLc&t=2s



https://www.youtube.com/watch?v=wZm50MfdCLc&t=2s



https://www.youtube.com/watch?v=wZm50MfdCLc&t=2s



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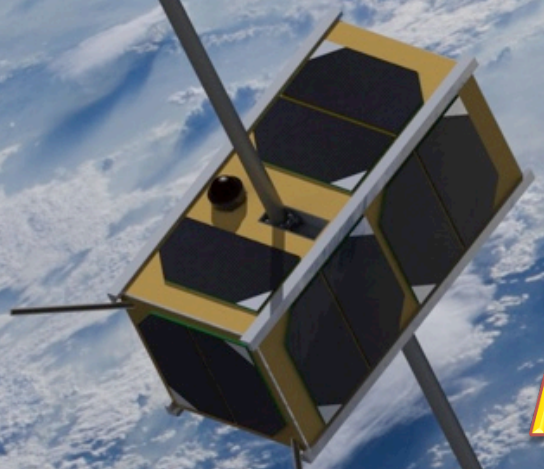

Kazumasa Imai

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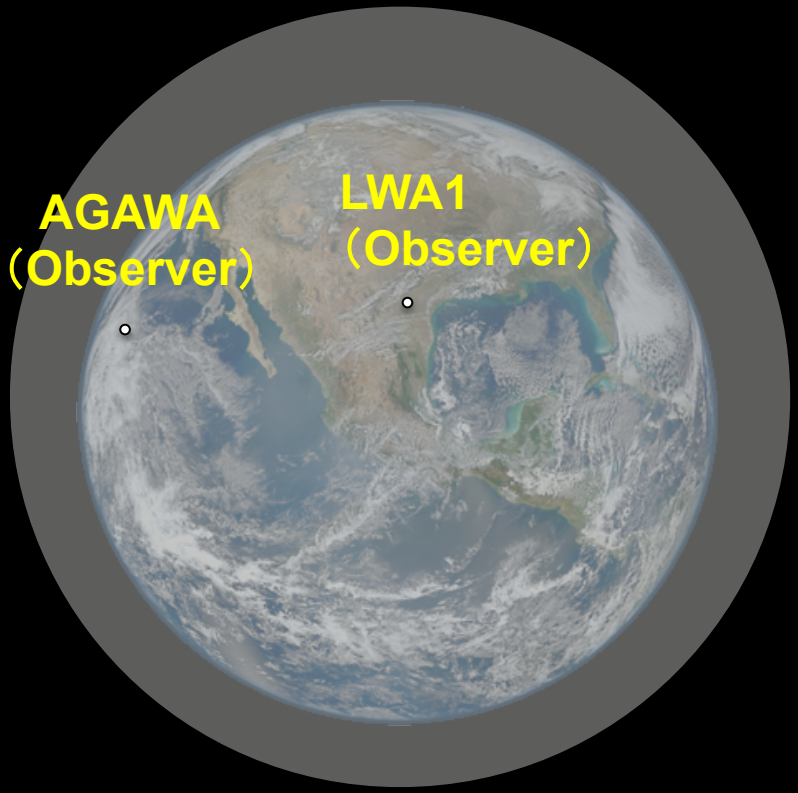
KOSEN-1 Team

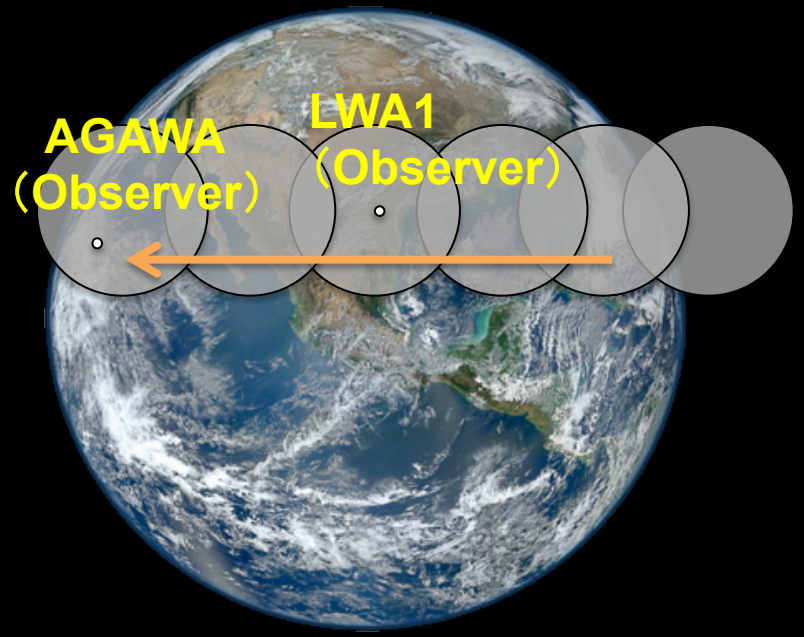
NASA Radio JOVE Team

Model of Beam Structure

※Looking from Jupiter



Flashlight-like beaming



Beacon-like beaming

Long Wavelength Array Station 1 (LWA1)

VLA site, New Mexico, USA

The Long Wavelength Array (LWA) is a low-frequency radio telescope designed to produce high-sensitivity, high-resolution images in the frequency range of 10-88 MHz.