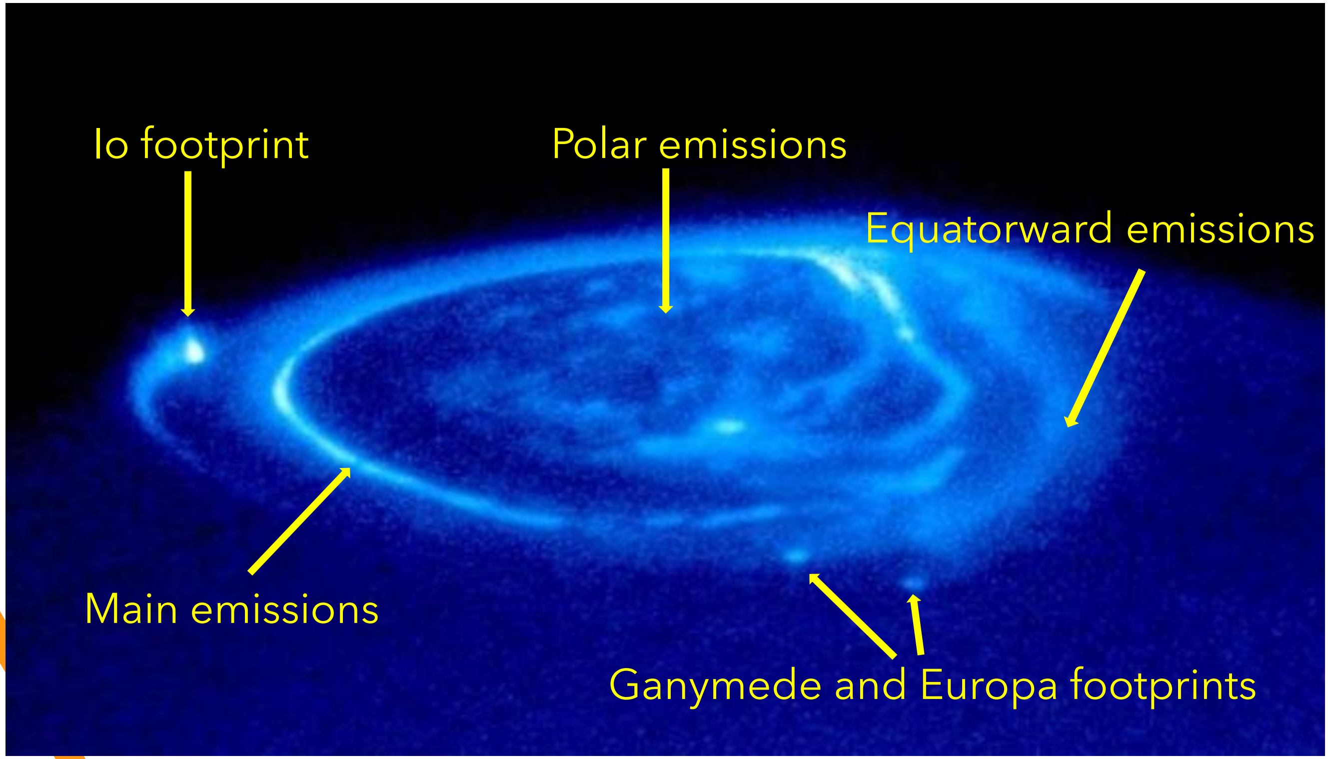
Jupiter's polar auroral bright spot as seen by Juno's multi-instruments

Kamolporn Haewsantati
LPAP, STAR Institute
K.Haewsantati@uliege.be
Thesis advisor: Dr. Bertrand Bonfond

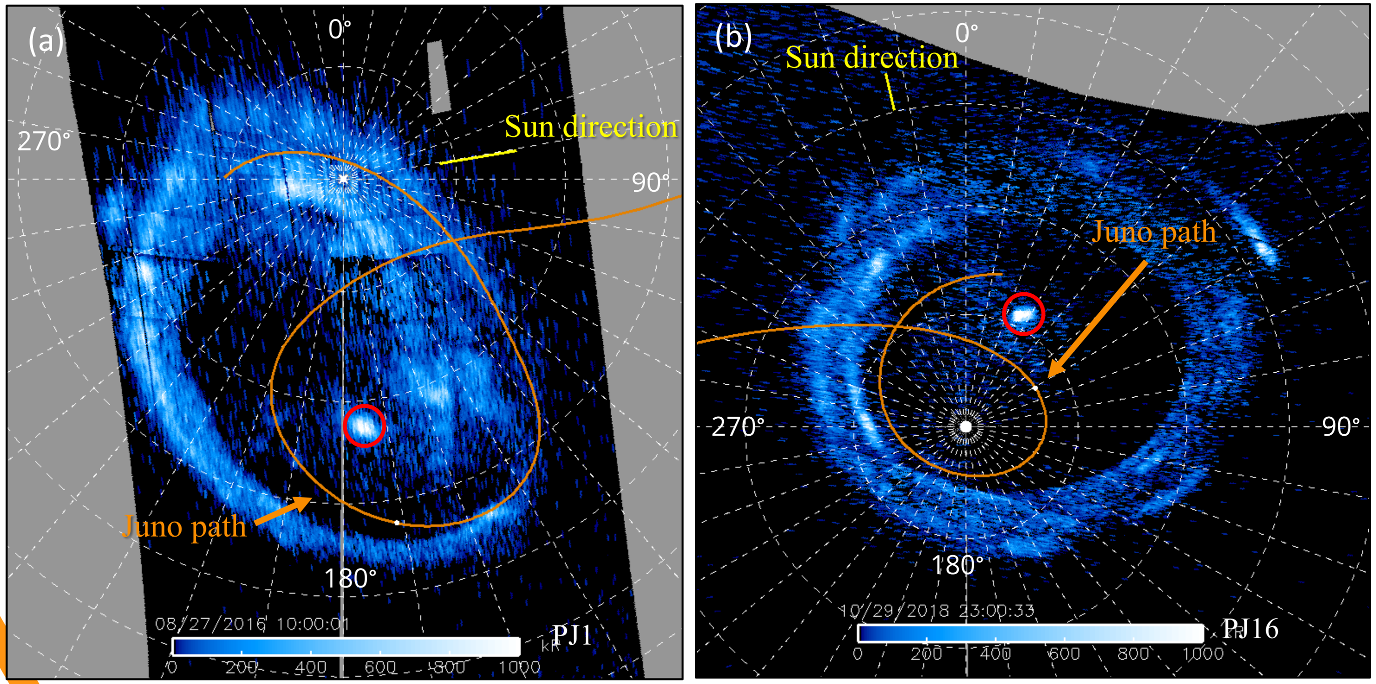
Jupiter's auroras



HST FTIS FUV image of Jupiter's northern aurora with three main regions, taken in 1998.
(Credit: Clarke et al., 2004)

- The light emission produced by the interactions between precipitating **high energy particles** and the **atmospheric particles**
- Complex morphology
- Main components: the **main emissions**, the **polar emissions**, the **equatorward emissions**, and the **satellites' footprints**

Jupiter's auroral bright spot



Jupiter's auroras acquired by Juno-UVS contain the bright spot feature in (left) the northern hemisphere and (right) the southern hemisphere.

- The emissions in Jupiter's polar auroras
- Spot/compact shape
- Very dynamic and very bright in UV aurora

Summary from previous study

- Occurrence from both N&S hemispheres
- The emitted power is tens GWs, some bright spot emissions can reach up to a hundred GWs.
- The time interval between two consecutive brightening: ~2-40 minutes, same range as X-ray pulsed emissions
- Reappearance of bright spot emissions within a Juno perijove in the same system III position period ~25 min, indicative of quasiperiodic pulsations
- The system III positions of bright spots:
  - Northern hemi. : region around 175° system III longitude and 65° latitude
  - Southern hemi. : scattered around the polar region
  - Mostly at the edge of the swirl region
- Bright spot emissions can be seen at any local times, contrast from previous studies
- Cannot exclude the relation with cusp-like processes but would be much more complex

Haewsantati et al. (2021), Morphology of Jupiter's Polar Auroral Bright Spot Emissions via Juno-UVS Observations

Current study: multi-instruments observations

-> Study three events during which Juno flew close to the field lines connecting to bright spot emissions.

Observations

- PJ3, Northern hemisphere
- PJ15, Southern hemisphere
- PJ33, Southern hemisphere

Instruments

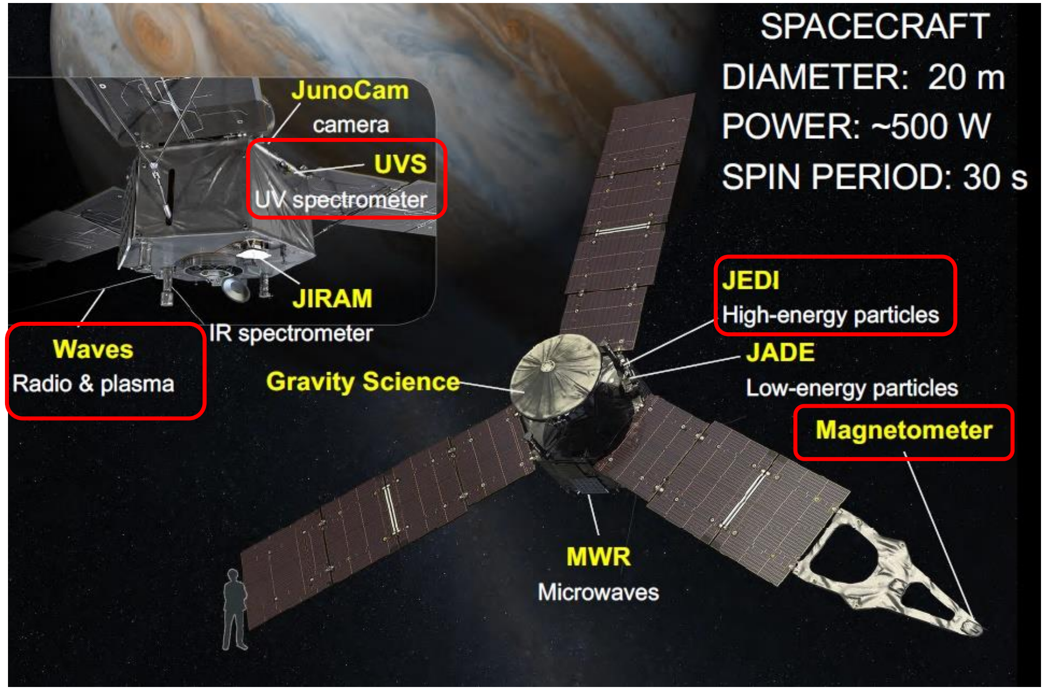
- UV image: Juno-UVS
- Particles: JEDI
- Waves: Waves
- Magnetic field: MAG

Haewsantati et al. (2022), In preparation

Instruments

Ultraviolet Spectrograph (Juno-UVS)

- 68-210 nm wavelength range with dog bone-shaped slit
- Acquired a Jupiter’s aurora image every ~30 seconds as Juno’s spin period
- Polar projection: altitude 400 km above 1 bar level

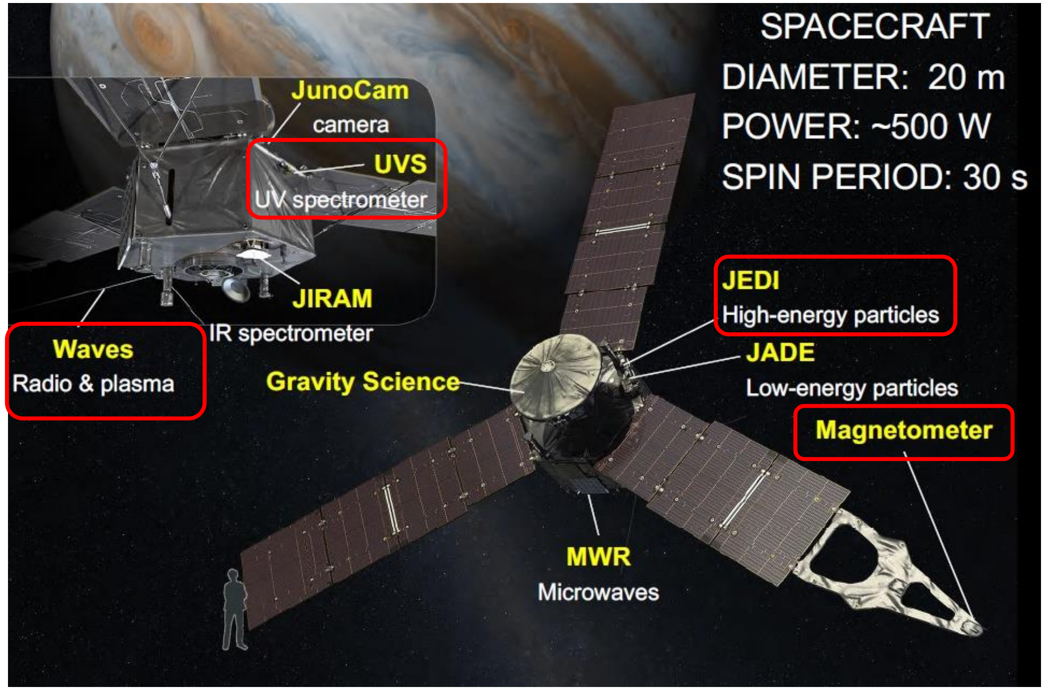


Juno spacecraft and instruments

Instruments

Waves

- Electric field spectra: 50 Hz to 41 MHz, magnetic field spectra: 50 Hz to 20 kHz
- A sample rate of one spectrum per 1s
- Determine electromagnetic/quasi-electrostatic by *E/cB* ratio along with the electron cyclotron frequency (F_{ce}) and the electron plasma frequency (F_{pe})

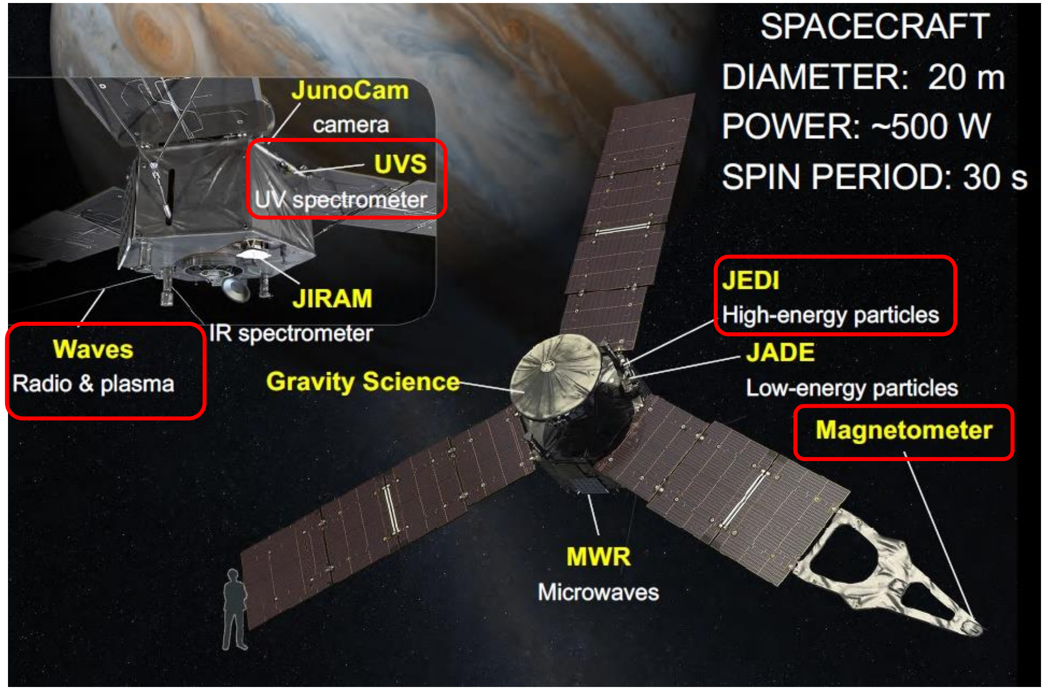


Juno spacecraft and instruments

Instruments

Jupiter Energetic-particle Detector Instrument (JEDI)

- Measures the energy, angular, and compositional distributions
- Electrons: ~25 to ~1,200 keV
- Ions: ~10 keV to >1.5 MeV for protons and ~150 keV to >100 MeV for oxygen and sulfur
- Two sensors coverage ~360° along the plane roughly perpendicular to the Juno spin axis and a sensor cover nearly ~180° along Juno spin axis

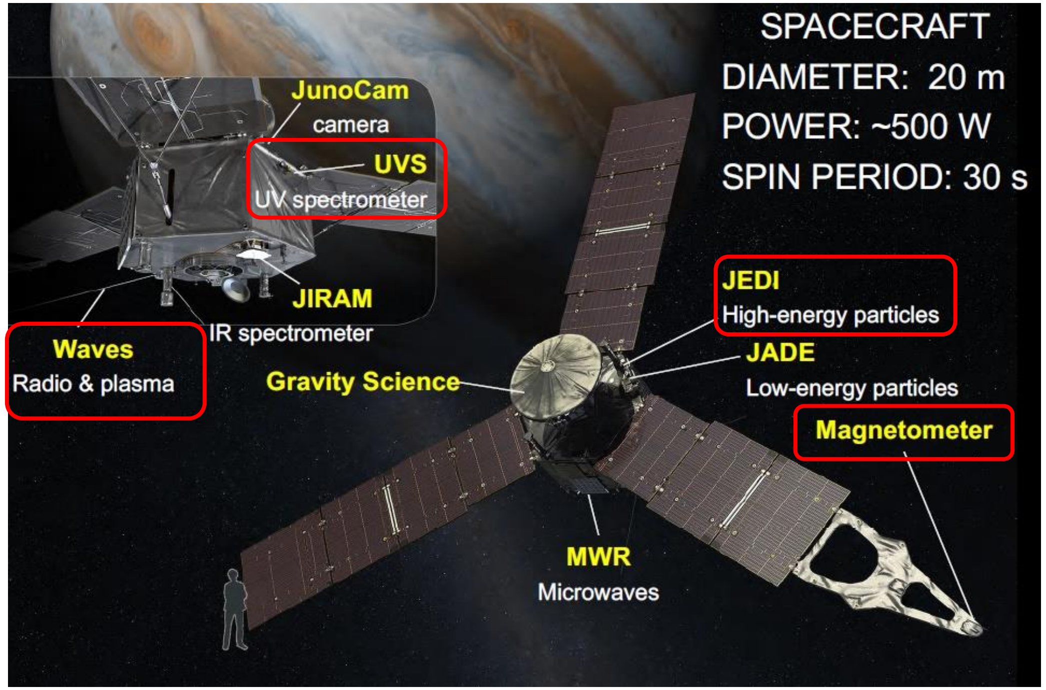


Juno spacecraft and instruments

Instruments

Juno magnetometer (MAG) instrument

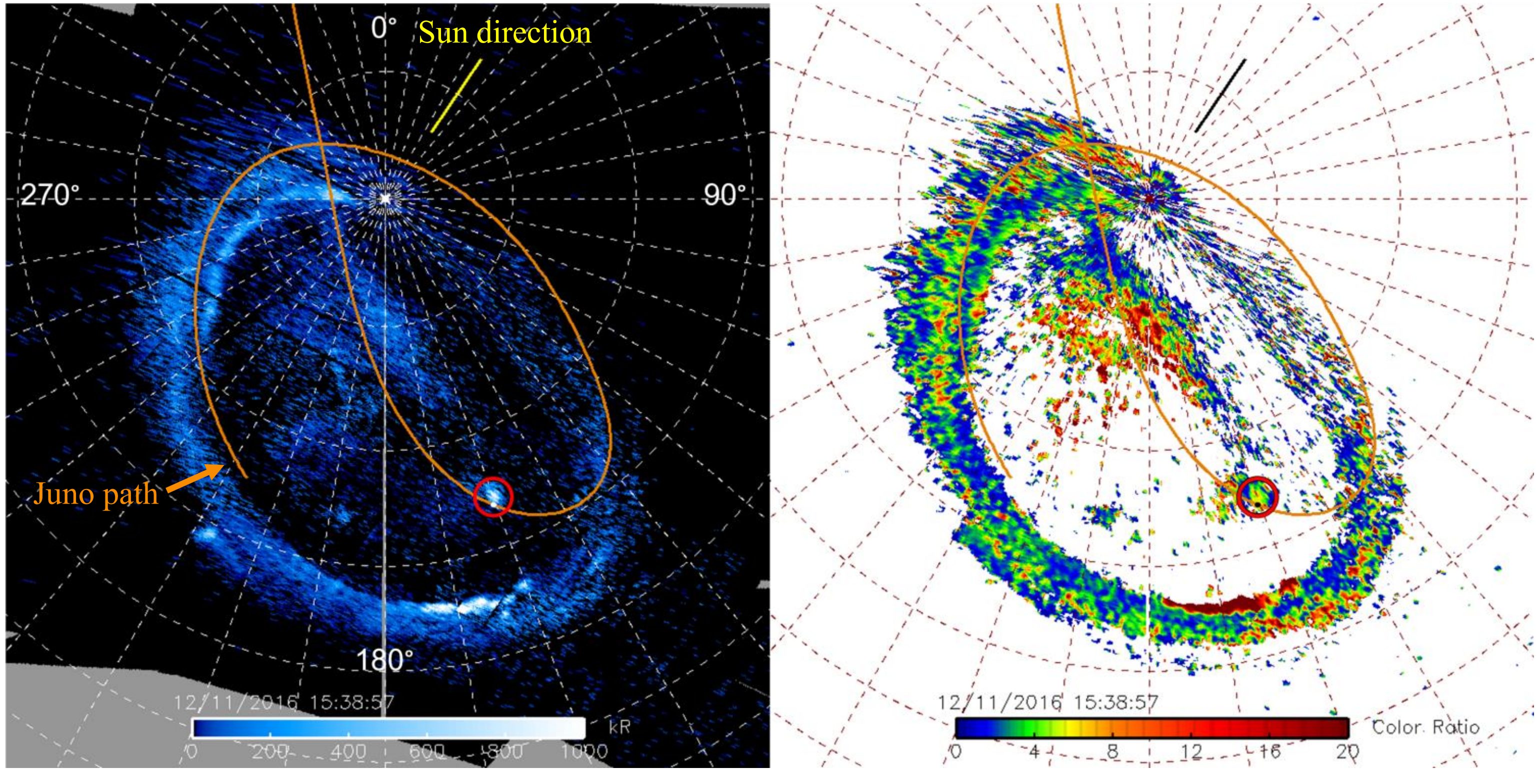
- Three components of the magnetic field vectors in the range of ~1 nT to ~16x10^5 nT
- Sample rate of 64, 32, or 16 measurements per second
- Focus on the 1-s resolution magnetic field perturbations



Juno spacecraft and instruments

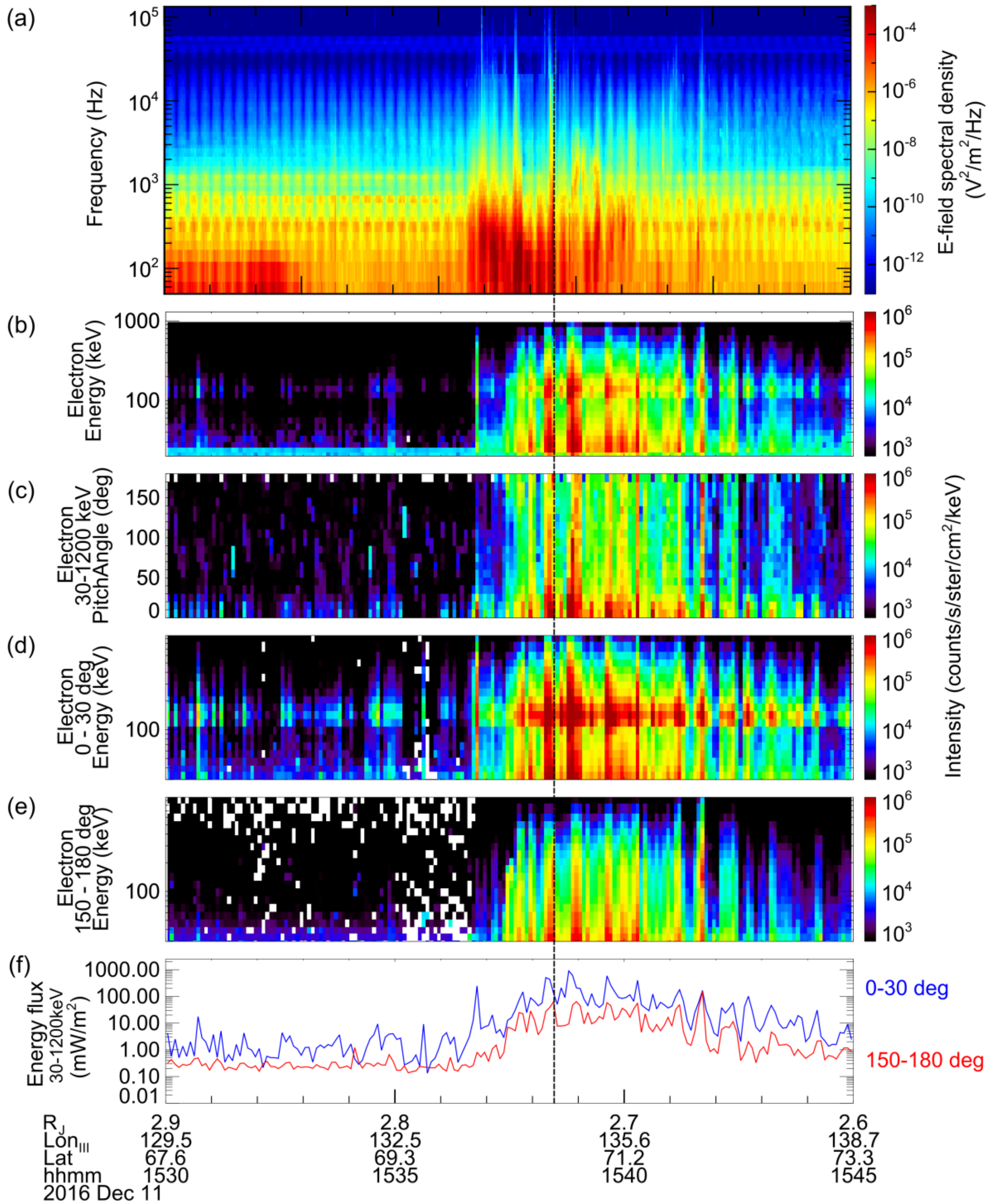
PJ3 results

- 11 Dec 2016 time 15:38:26 UT
- 64.38°N latitude and 159.61° SIII longitude
- Power ~20 GW



PJ3 results

- An intensification of whistler-mode hiss waves (upward direction away from Jupiter) during 15:36 UT - 15:40 UT, a few seconds before the enhancement of upward electrons
- Electron intensities started to increase at 15:37 UT until ~15:42 UT
- 15:38 - 15:39 UT, the upward electron flux reached ~900 mW/m^2 while the energy flux of downward electron was below 70 mW/m^2



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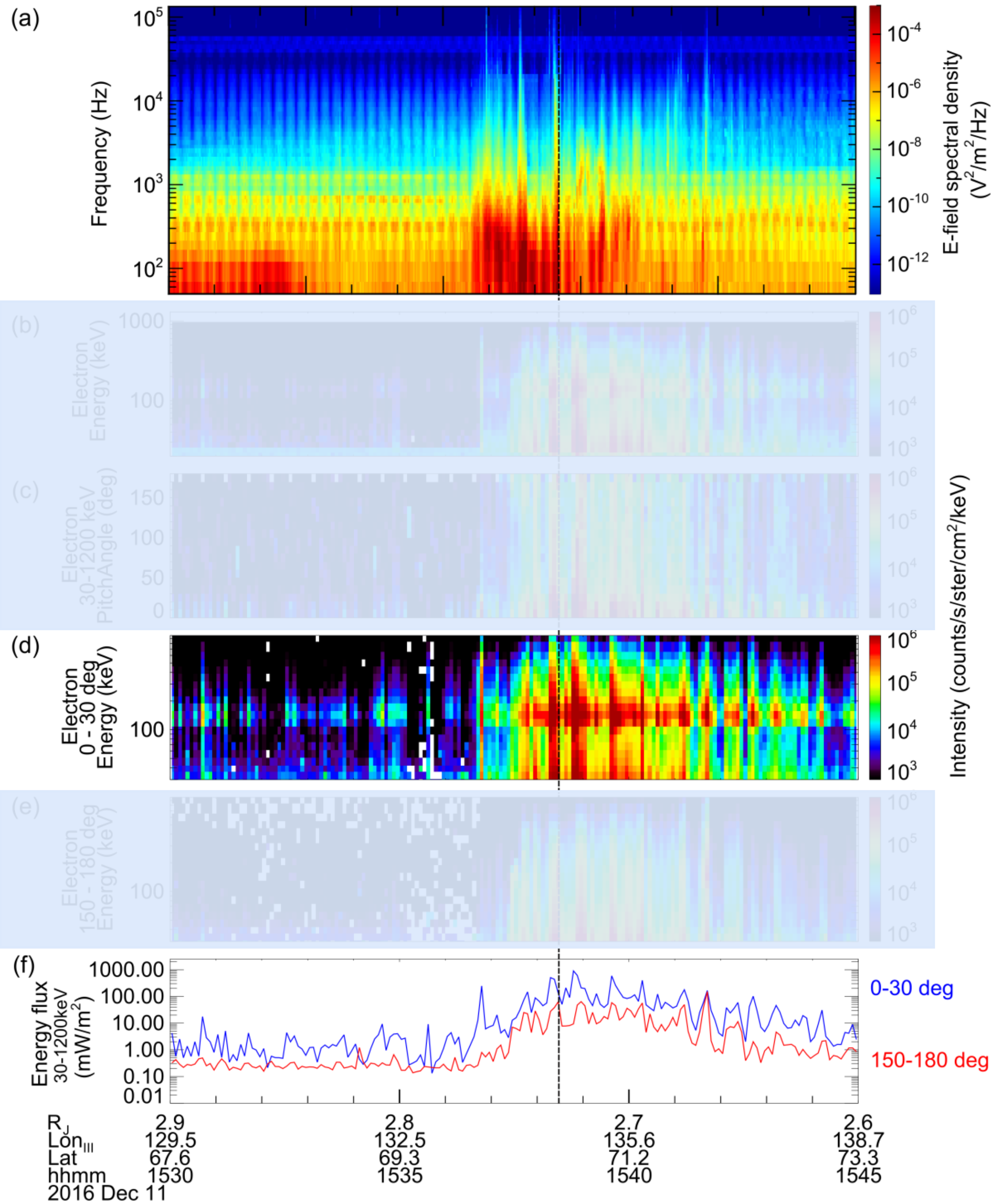
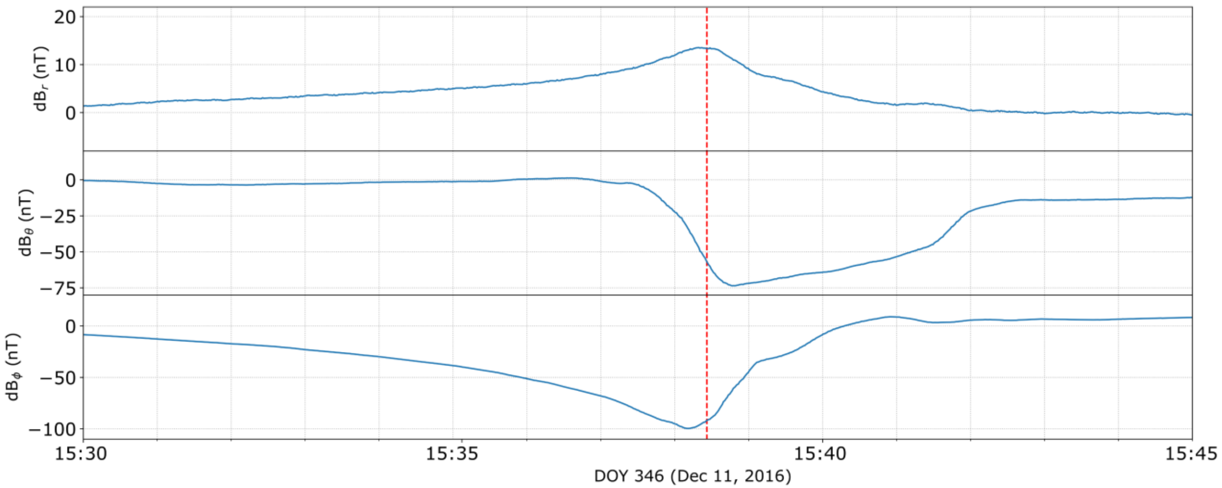
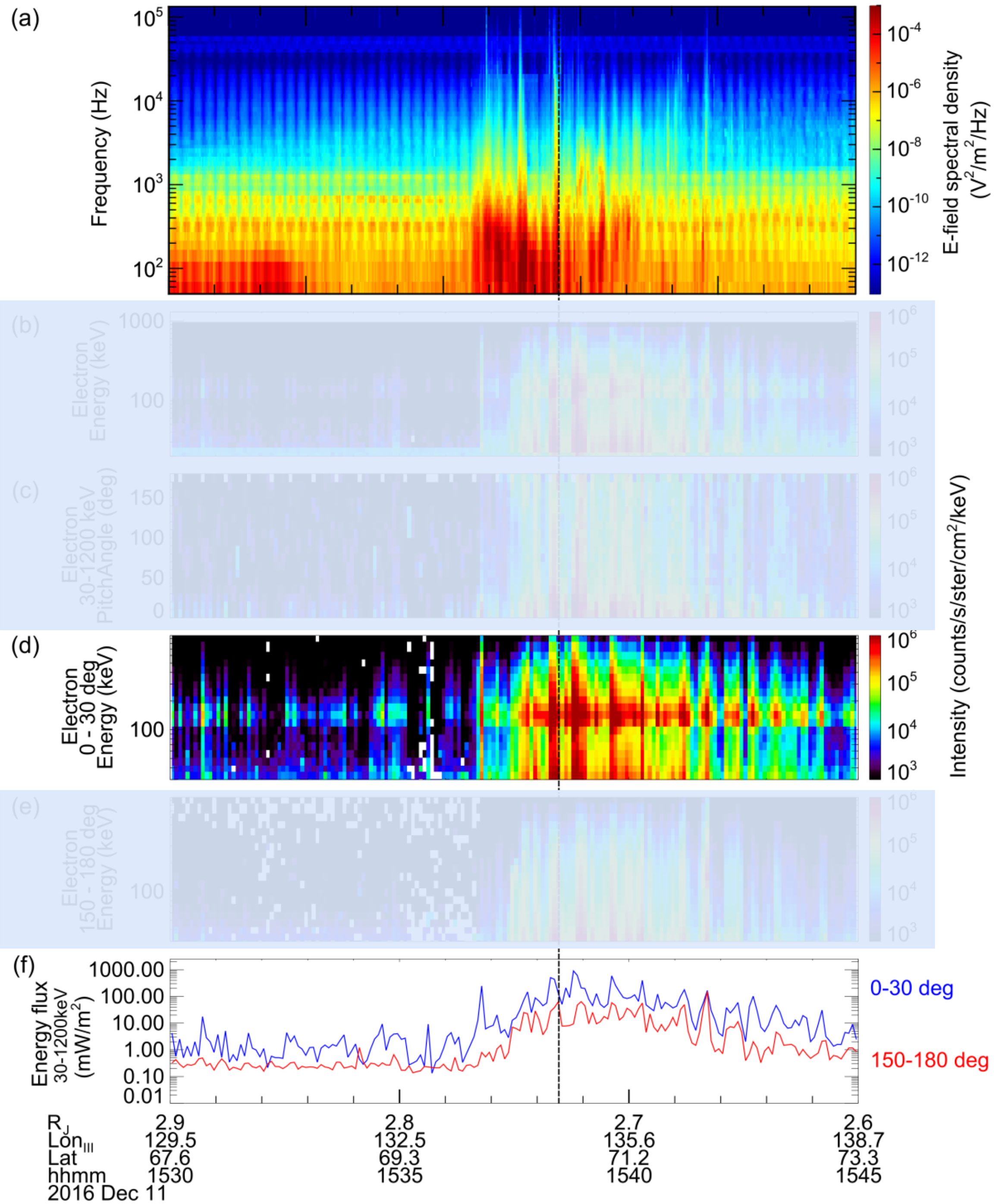


PJ3 results

- A deflection in all three components at ~15:40 UT
- Significant and indicate the presence of strong field aligned currents





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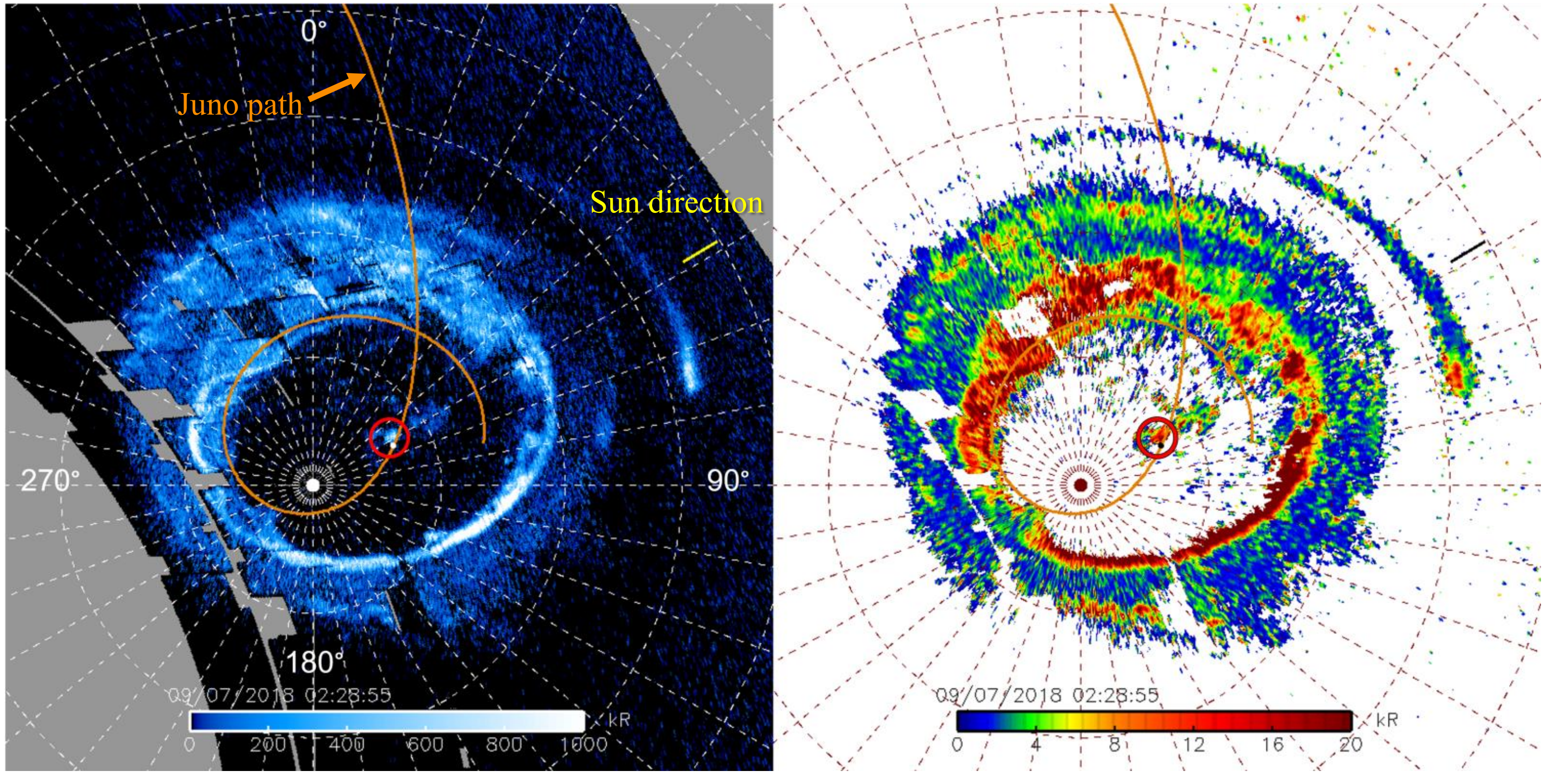
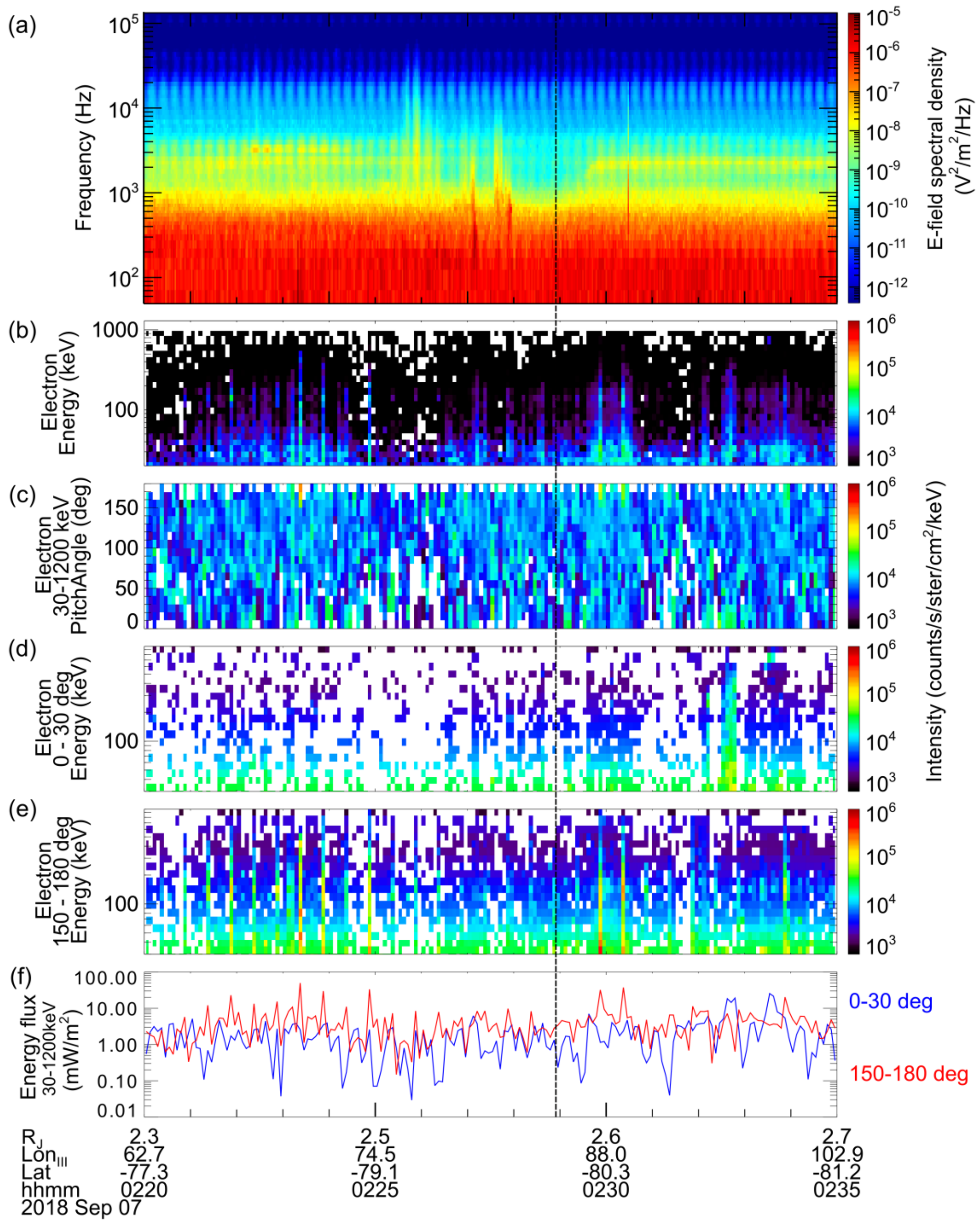
PJ15 results

- 7 Sep 2018 time 02:28:55 UT
- 82.88°S latitude and 58.19° SIII longitude
- Power ~6.4 GW
- High color ratio (around 15) indicating high energy particles precipitating in the atmosphere



PJ15 results

- Intensifications of whistler-mode wave, upward direction
- Intensified before 02:28 UT and damped in the 02:28 - 02:30 UT range -> corresponds to the bright spot crossing according to the JRM09 magnetic field model
- An intensification dominated by upward electrons just before 02:25 UT, i.e., right before Waves observed its intensification
- Two intensifications upward electrons (energy flux 30-40 mW/m^2) near 02:30 UT



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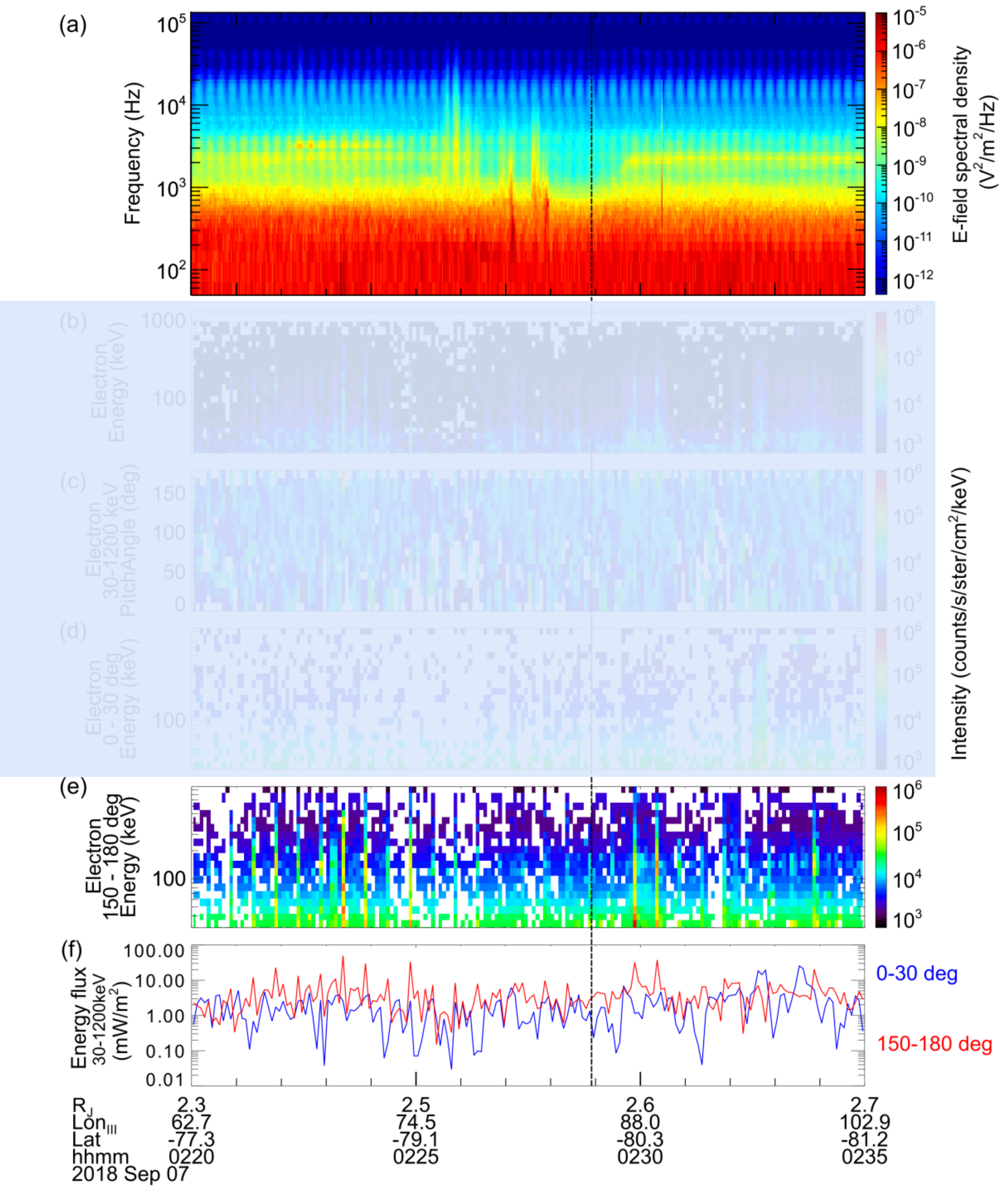

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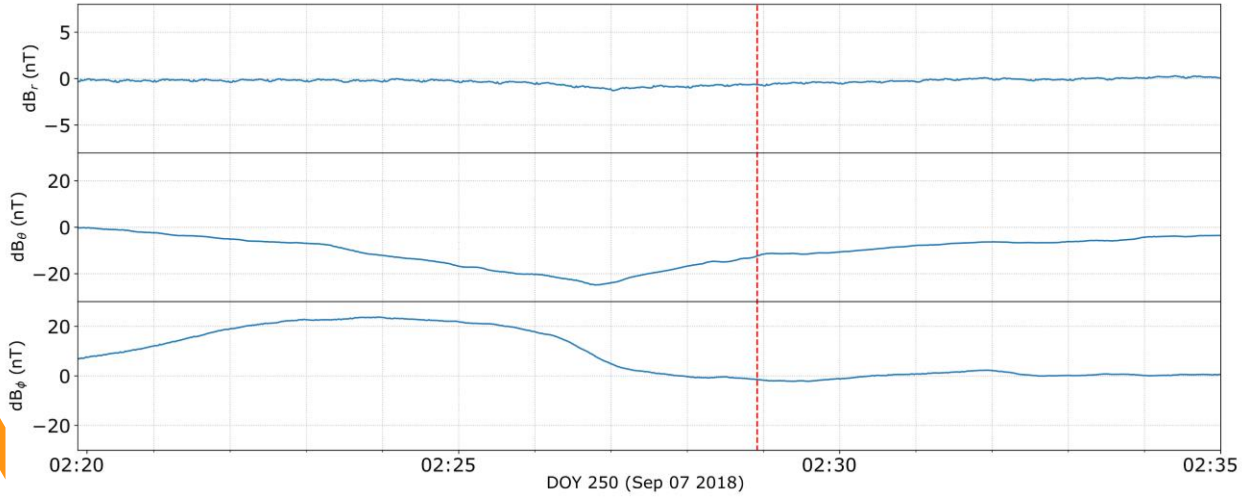
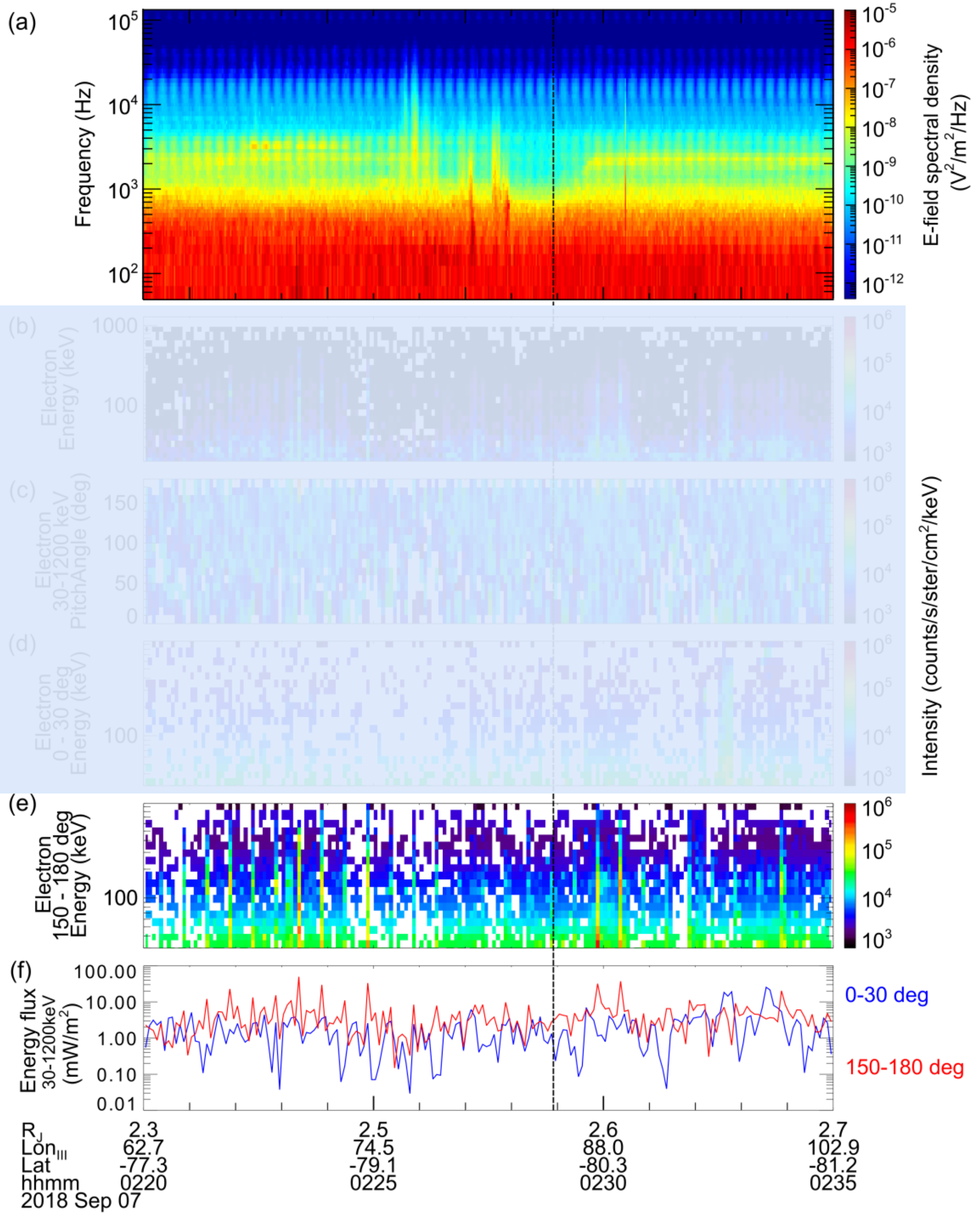
PJ15 results

- Magnetic field deflection in all three components but small amplitude





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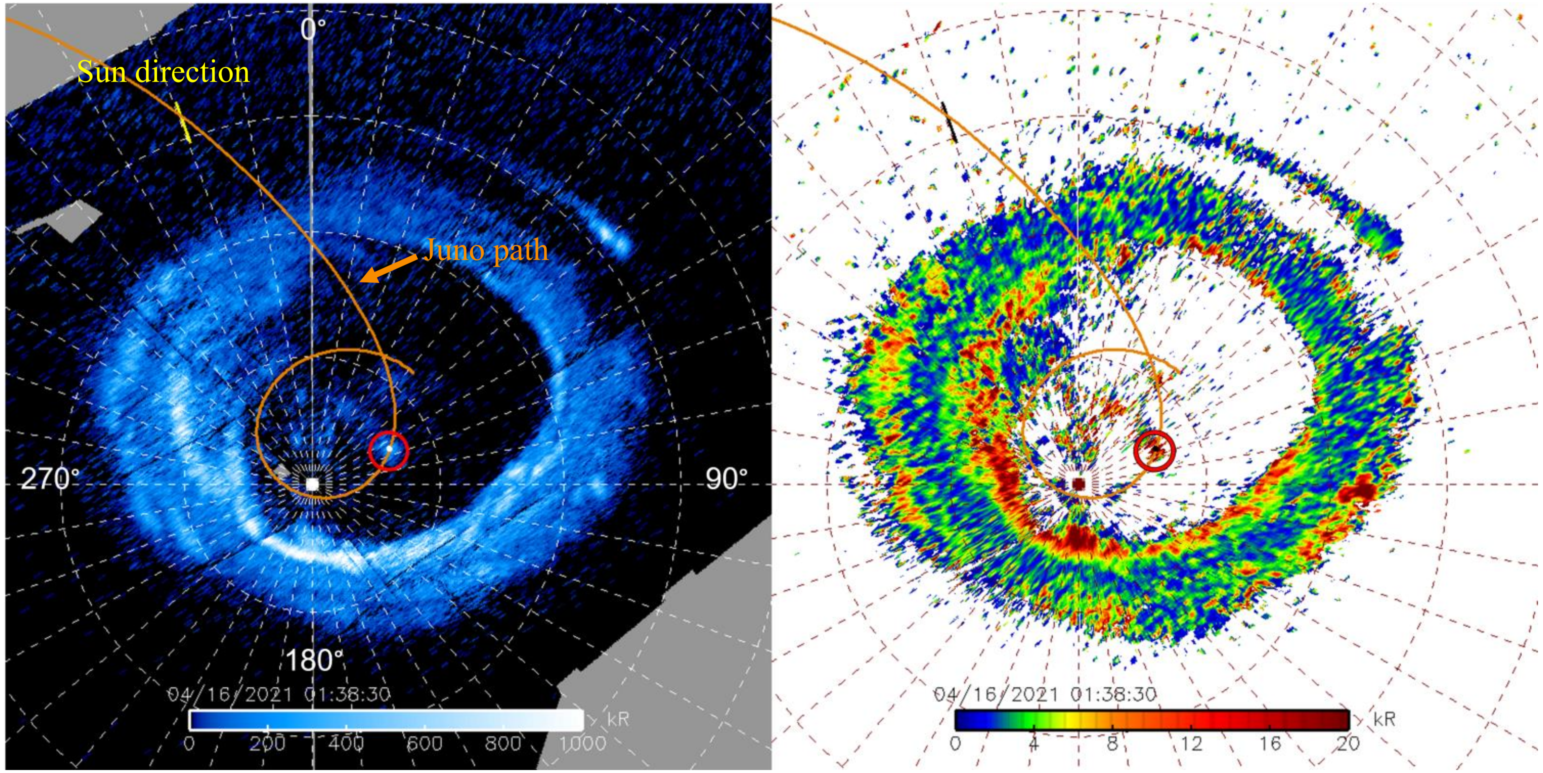
PJ33 results

- 16 Apr 2021 time 01:38:30 UT
- 83.51°S latitude and 59.50° SIII longitude
- Power ~10 GW



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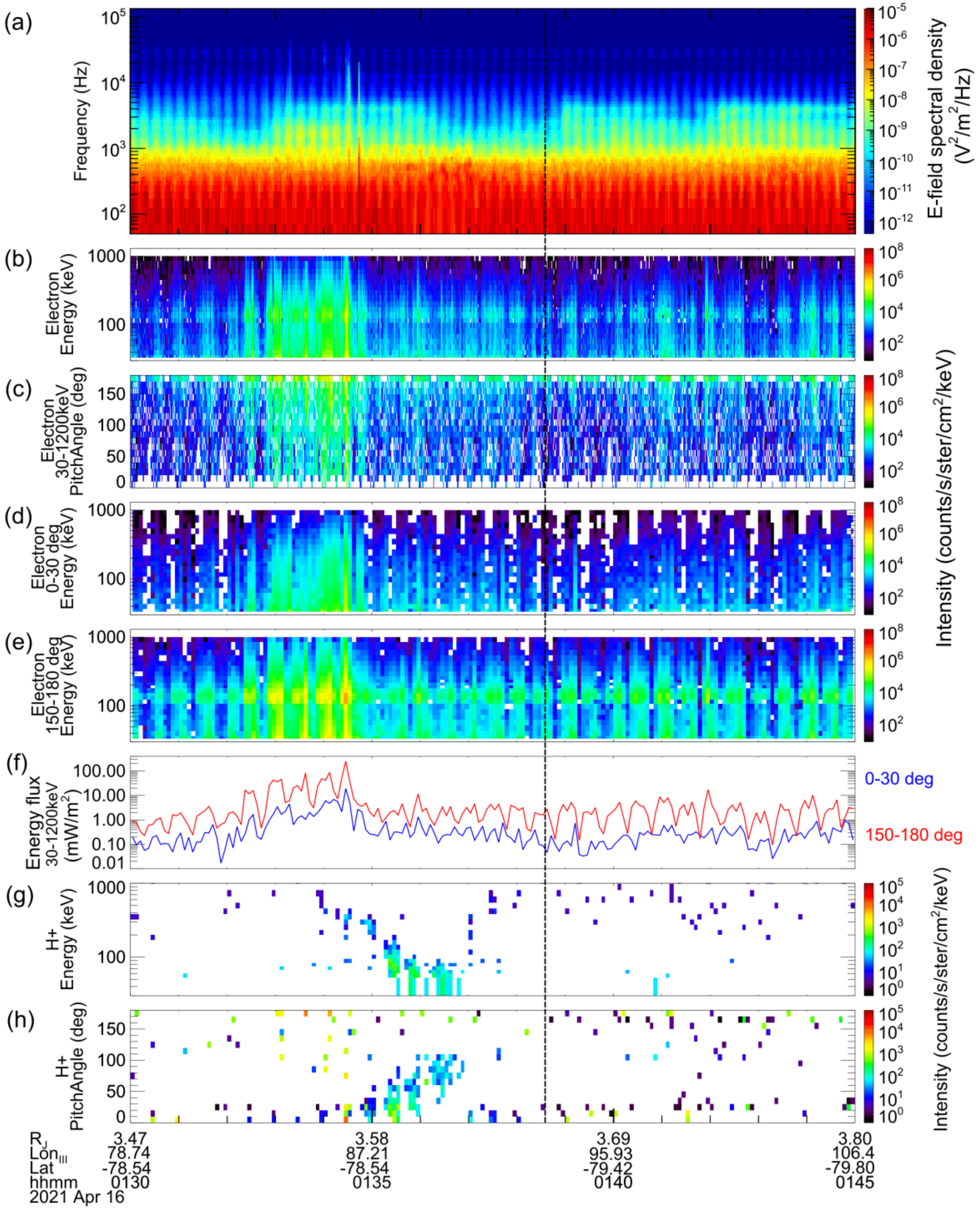
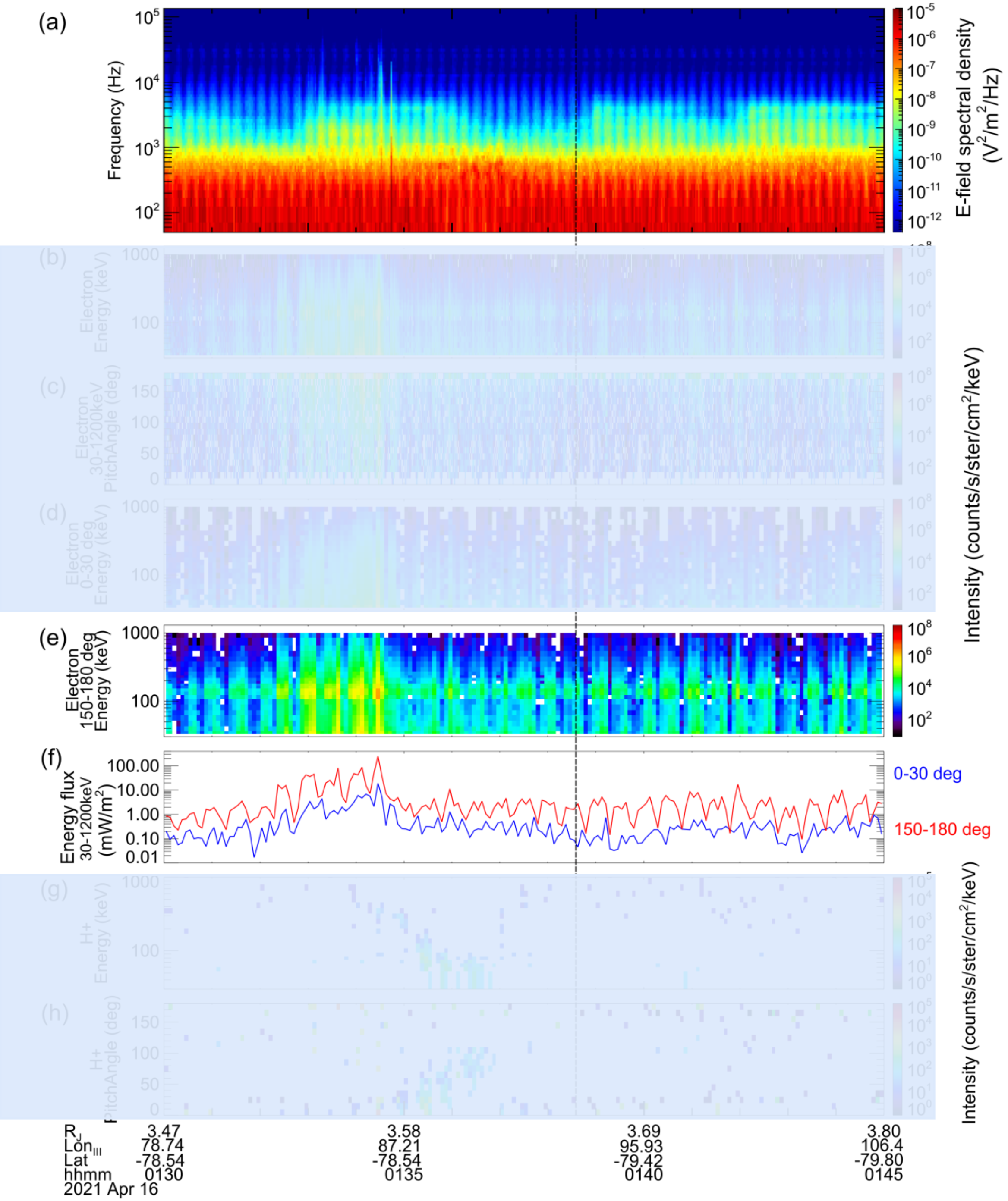
PJ33 results

- Intensifications of whistler-mode wave, at ~01:33-01:37 UT
- Intensity enhancement of upward electron beam (energy >500 keV) at ~01:33 UT – 01:35 UT
- Electron energy flux decreased after 01:35 UT and continued to be small during the UVS bright spot detection time



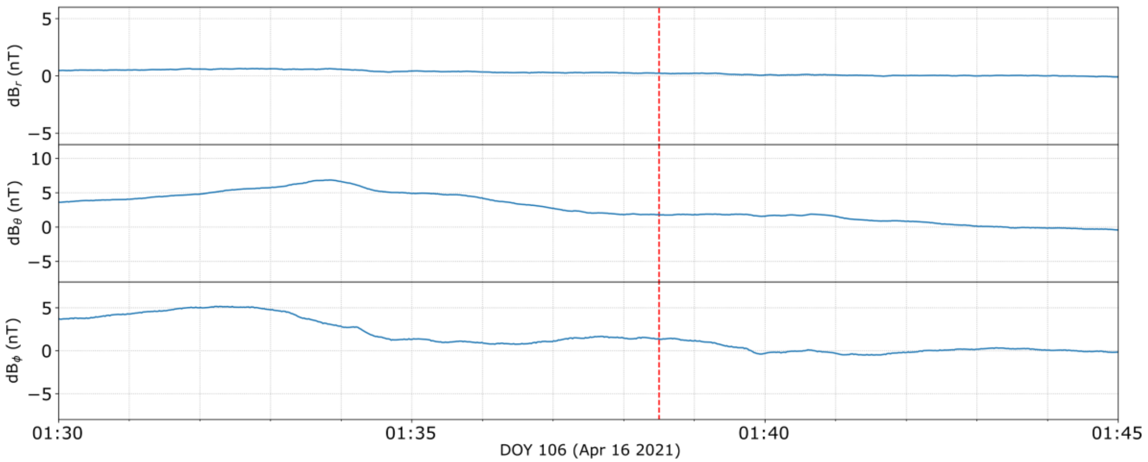
PJ33 results

- Intensifications of whistler-mode wave, at ~01:33-01:37 UT
- Intensity enhancement of upward electron beam (energy >500 keV) at ~01:33 UT – 01:35 UT
- Electron energy flux decreased after 01:35 UT and continued to be small during the UVS bright spot detection time



PJ33 results

- No significant of magnetic field deflection in all three components



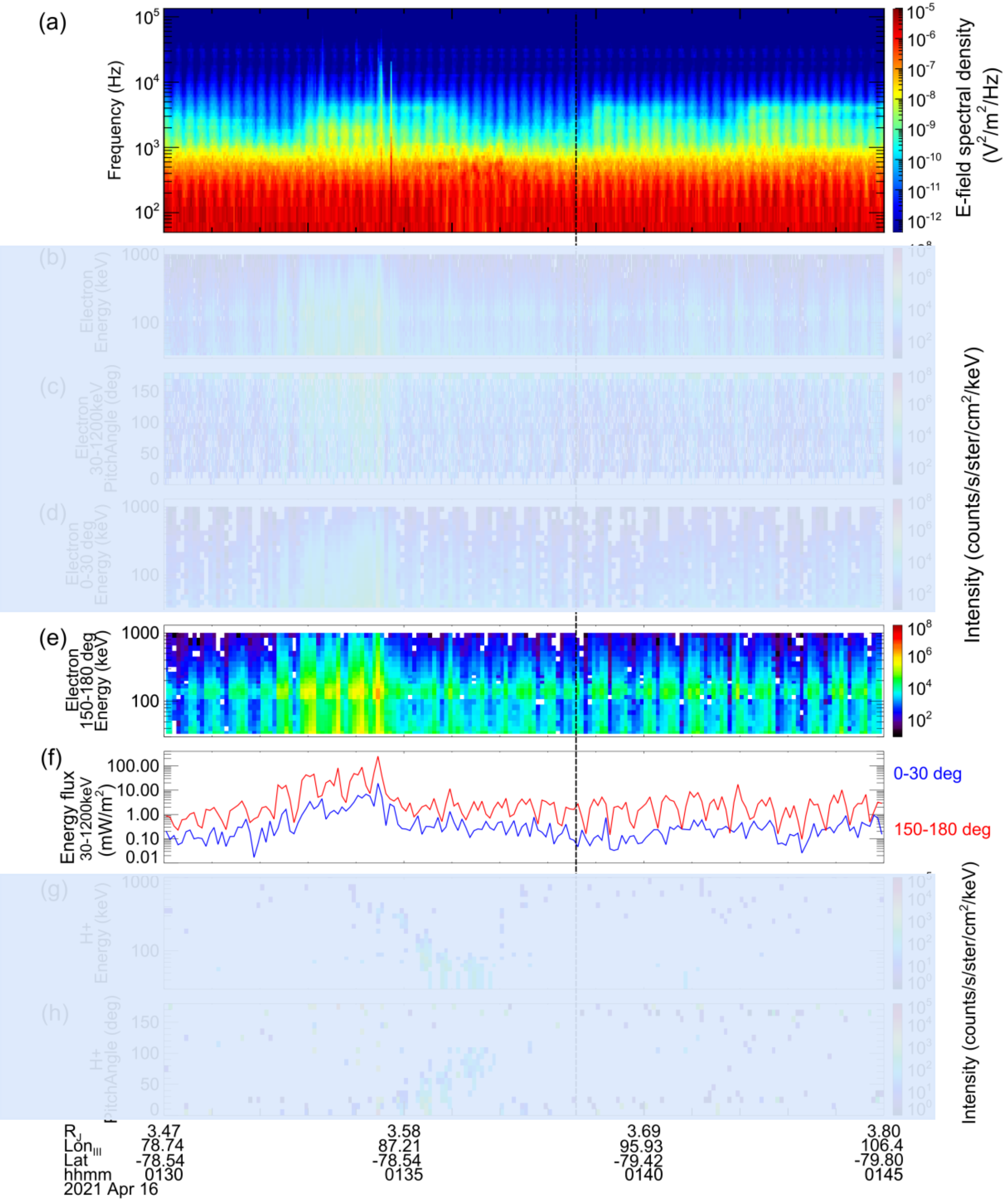


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Table 1. Summary data for bright spot in situ observation

		PJ3	PJ15	PJ33
Date		11-Dec-16	7-Sep-18	16-Apr-21
Juno footprint position (Lat, SIII Lon)		(63.65°, 160.20°)	(-83.04°,63.93°)	(-83.37°,65.50°)
Juno altitude (R_J)		1.8-1.7	1.5-1.6	2.58-2.69
Bright spot crossing time (UT)		15:38:26	02:28:55	01:38:30
Bright spot position (Lat, SIII Lon)		(64.38°, 159.61°)	(-82.88°, 58.19°)	(-83.51°, 59.50°)
Bright spot power (GW)		15.30	5.58	10.81
JEDI	**electron direction and enhancement time**	Upward during 15:36 UT - 15:42 UT	Upward, 2 peaks (31.9 and 37.4 at time ~ 02:30 UT)	Upward during 01:33 UT - 01:35 UT
	maximum electron energy flux (mW/m^2)	899.82 at 15:38:47 UT	49.62 at 02:23:22 UT	860.52 at 01:34:29 UT
	electron direction[a]	Upward	Upward	Upward
	average electron energy flux[b] **(mW/m^2)**	267.24	3.1	0.22
	proton direction	upward	upward	upward then perpendicular
Waves	**Whistler-mode intensification**	15:37 UT - 15:40 UT	02:26 UT - 02:28 UT	01:33 UT - 01:37 UT
	waves direction	upgoing	upgoing	no analysis
MAG		A perturbation with small amplitude during 15:38 UT - 15:42 UT	A small deflection but less obvious	no significant deflection

[a] at bright spot crossing time
[b] during bright spot crossing (±10 s)

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Summary

- An enhancement of **upward electron** flux observed by JEDI are found in all three events -> the particle acceleration region takes place below the spacecraft
- The intensification of **whistler-mode waves** at the time of the particle enhancements -> wave-particle interactions contribute to the acceleration of particles which cause the UV aurorae
- Time delays between UVS observation and waves and particles observation possibly caused by the uncertainty of mapping from the JRM09 magnetic field model
- The fixed in System III position of bright spot -> the processes giving rise to them take place close to the planet
- Magnetospheric currents might not play the major role on bright spot emission
- Possible causes -> magnetic reconnection near Jupiter's pole & Alfvenic resonance
- Confirmed by further study on high resolution magnetohydrodynamic simulations of the Jovian magnetosphere, the flyby over the bright spot through or below the particle acceleration region

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Thank you

Q&A