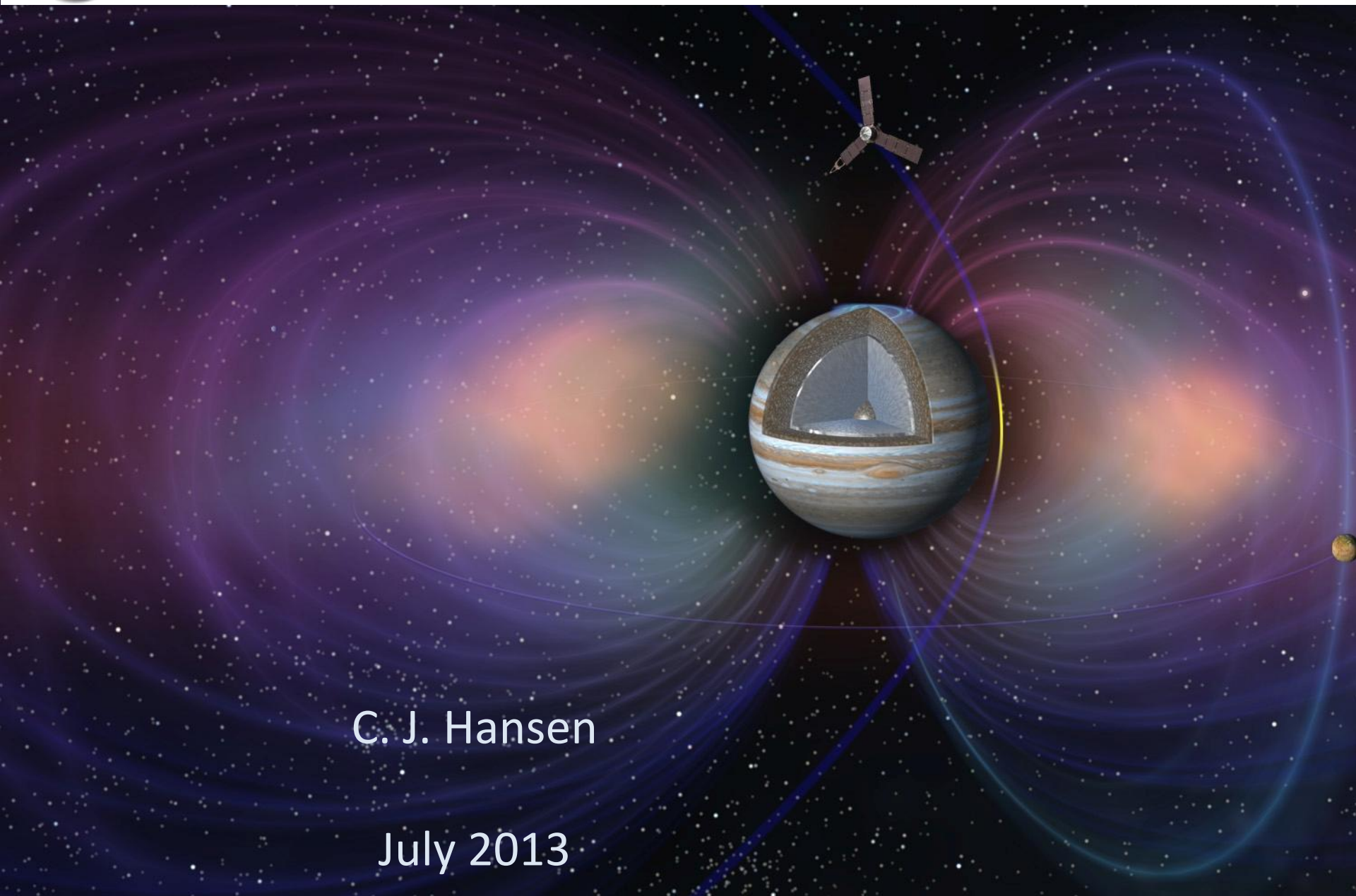
Juno Status and Earth Flyby Plans



C. J. Hansen

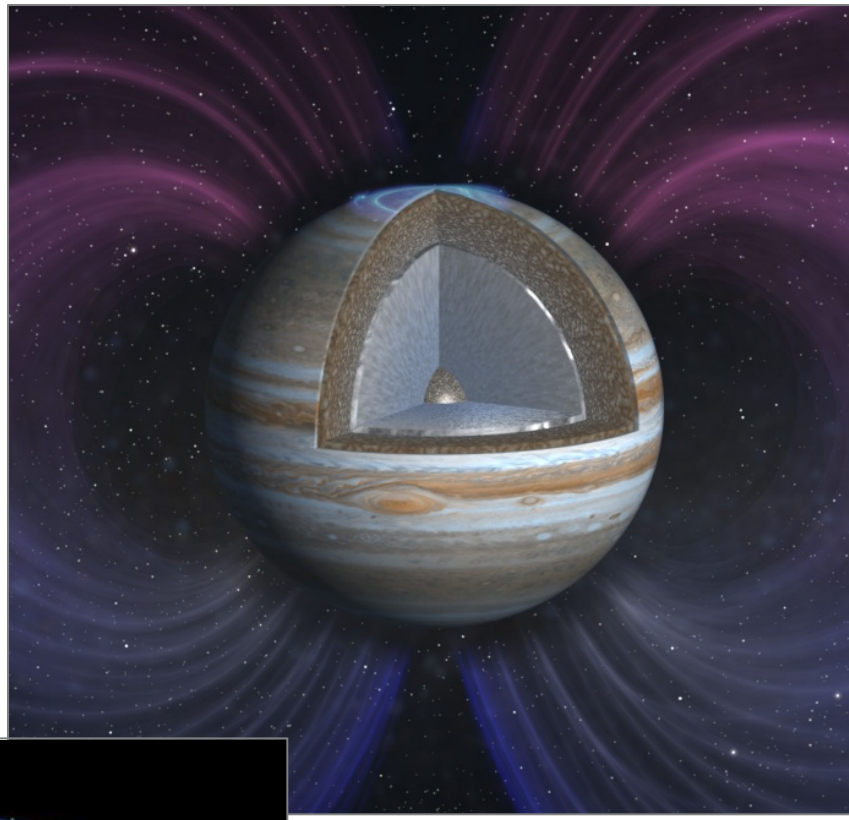
July 2013

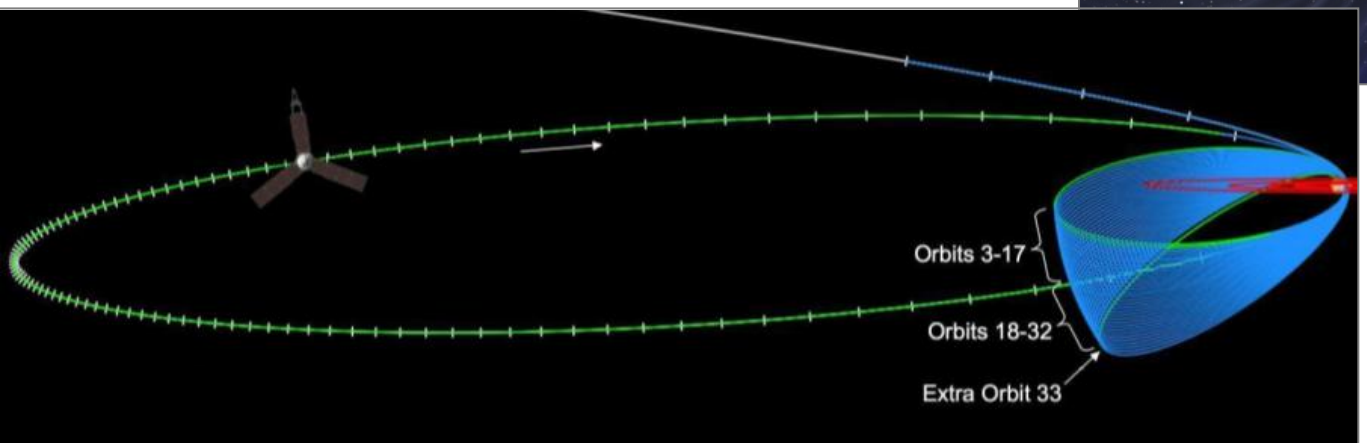
Juno Science Objectives

Juno will improve our understanding of the history of the solar system by investigating the origin and evolution of Jupiter.

To accomplish this goal, the mission will investigate Jupiter's **Origin, Interior, Atmosphere and Magnetosphere.**

What we learn from Juno also will tell us how giant planets form and evolve, helping us understand the evolution of planetary systems in general.



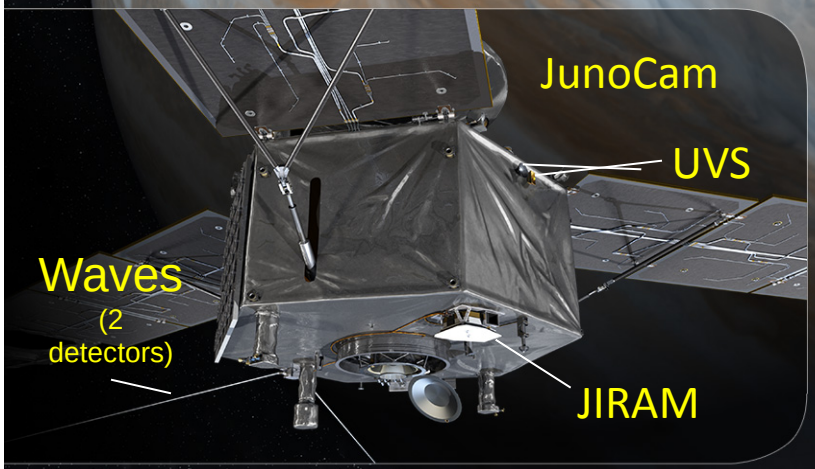


One (earth) year polar orbit

Juno Science Themes

- Origin
  - Determine O/H ratio (from water abundance) and constrain core mass to decide among alternative theories of origin (accretion vs. gravitational collapse, how far from sun did Jupiter actually form?)
- Interior
  - Understand Jupiter's interior structure and dynamical properties by mapping its gravitation and magnetic fields
- Atmosphere
  - Map variations in atmospheric composition, temperature, cloud opacity and dynamics to depths greater than 100 bars at all latitudes
- Magnetosphere
  - Characterize and explore the 3-dimensional structure of Jupiter's polar magnetosphere and auroras

Spacecraft & Payload



SPACECRAFT
Diameter: 66 feet (20 m)
Height: 15 feet (4.5 m)
976 kg dry mass

Solar powered – arrays are 2.7m x 9m

Spins at 2 rpm

JEDI
(6 sensors)

JADE
(4 sensors)

Gravity Science
(2 sensors)

Magnetometer
(2 sensors, 4 support cameras)

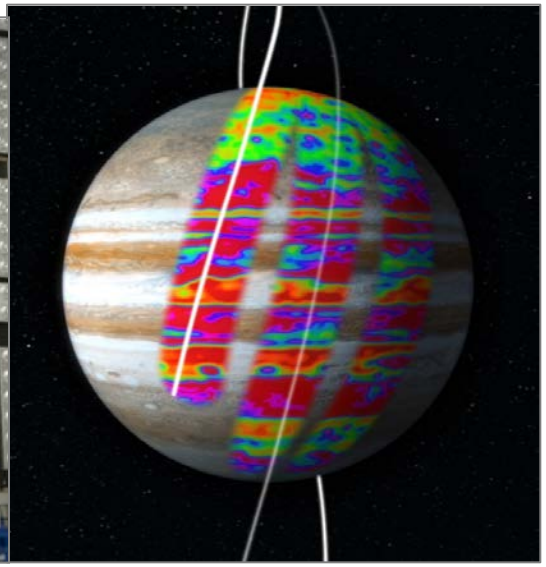
MWR
(6 sensors)

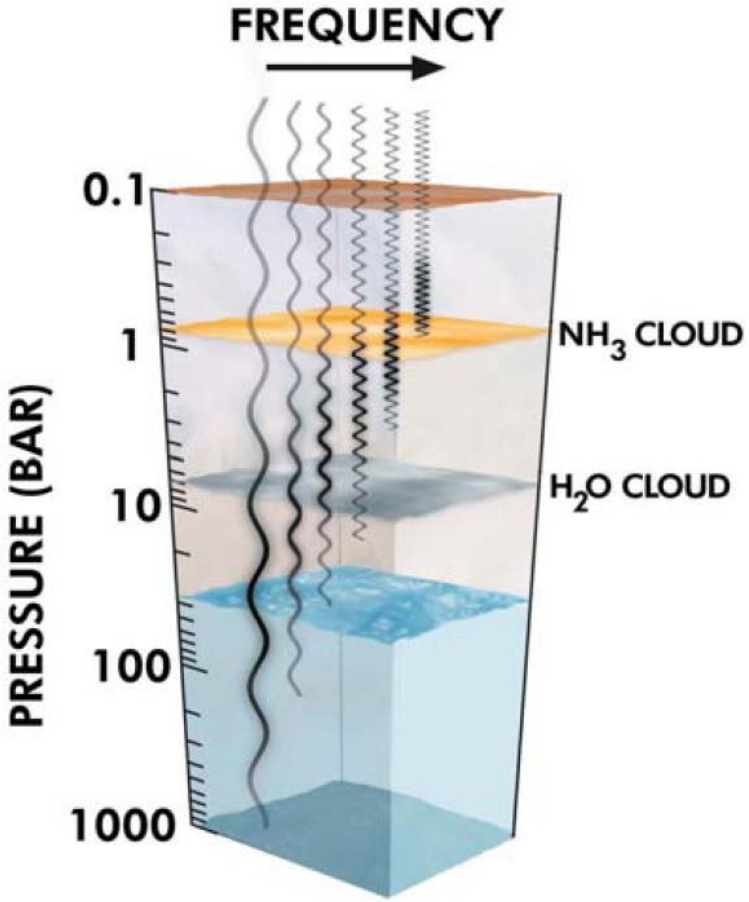
Juno's science instruments (1)

MICROWAVE RADIOMETER

Juno's Microwave Radiometer measures thermal radiation from the atmosphere to as deep as 1000 bars pressure (~500-600km below the visible cloud tops).

Determines water and ammonia abundances in the atmosphere all over the planet





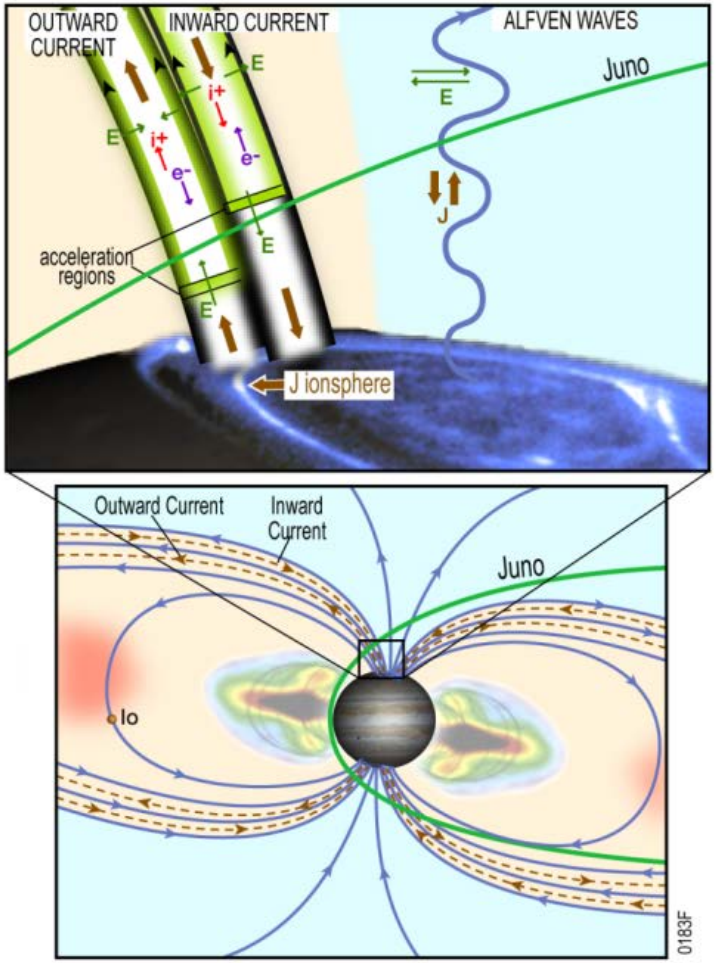
Thermal emission mapped pole-to-pole at 6 longitudes

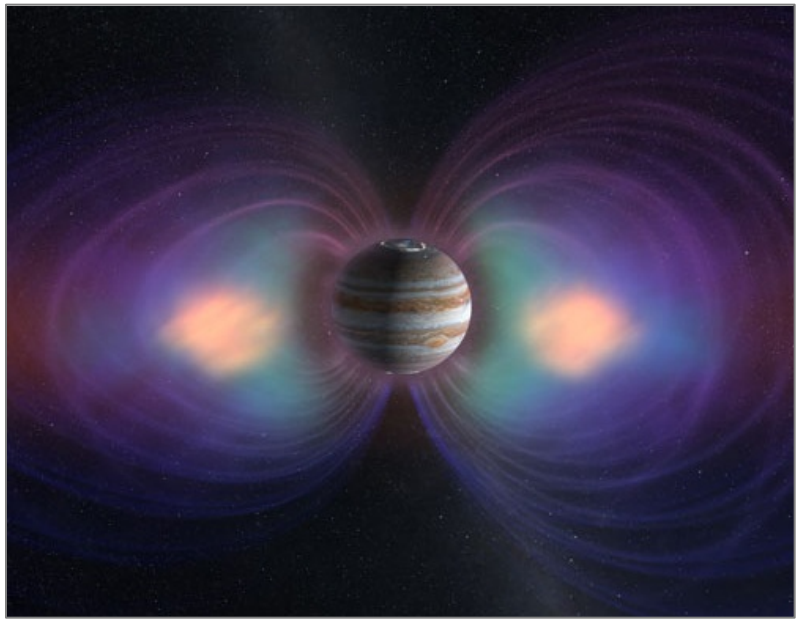
Juno's science instruments (2)

JEDI, JADE, MAG & WAVES

Sample particles, magnetic fields, electric fields and radio waves around Jupiter to study the dynamics of Jupiter's magnetosphere

JEDI detects high energy particles, JADE detects low energy particles



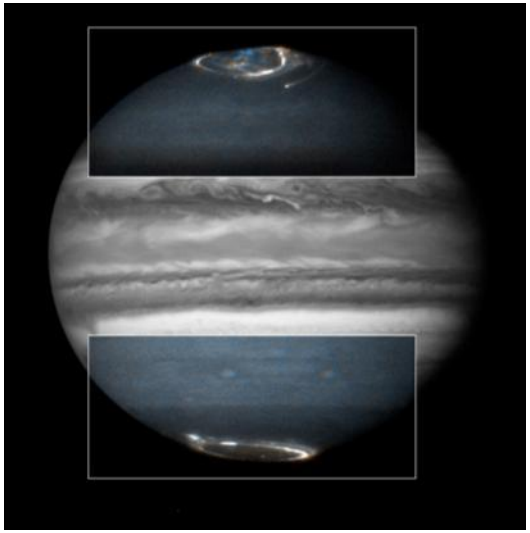


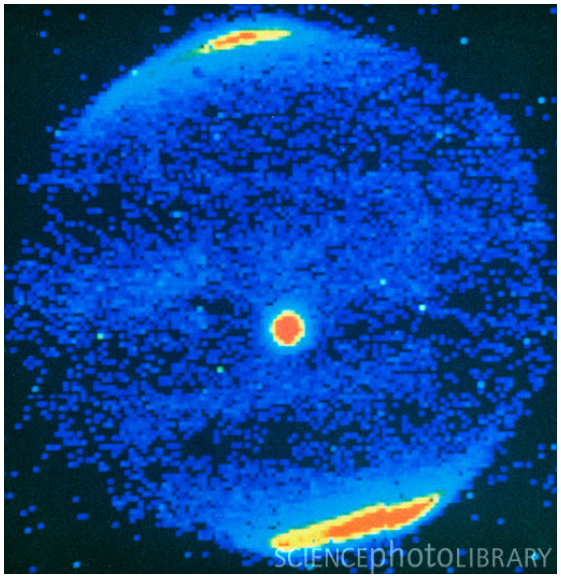
Jupiter's magnetosphere near the planet's poles is a completely unexplored region

Juno's Science Instruments (3)

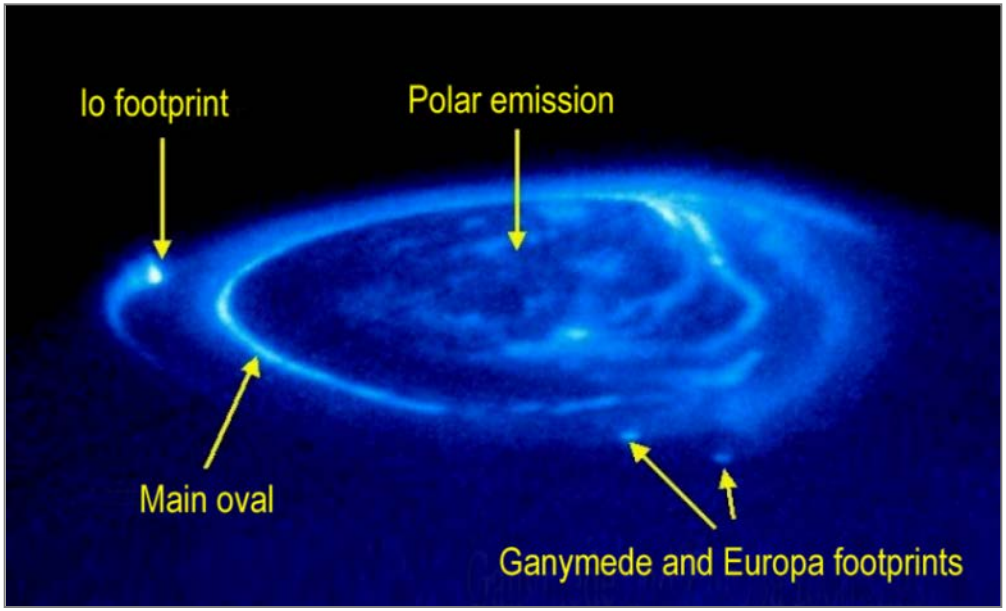
UVS (Ultraviolet Spectrometer) & JIRAM (Jovian Infrared Auroral Mapper)

Image the atmosphere and aurora, at ultraviolet and infrared wavelengths





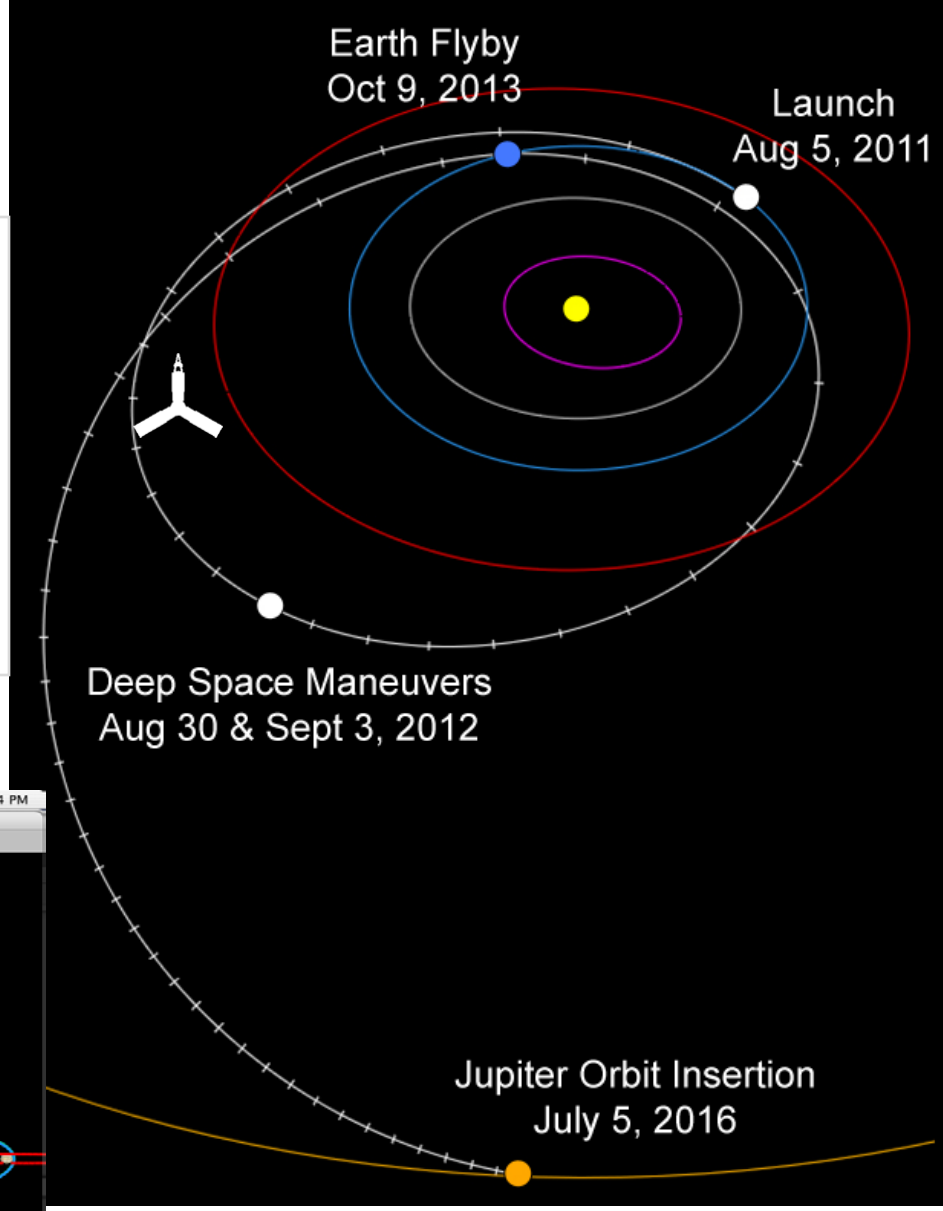
Infrared image at 3.4 micron from the IRTF



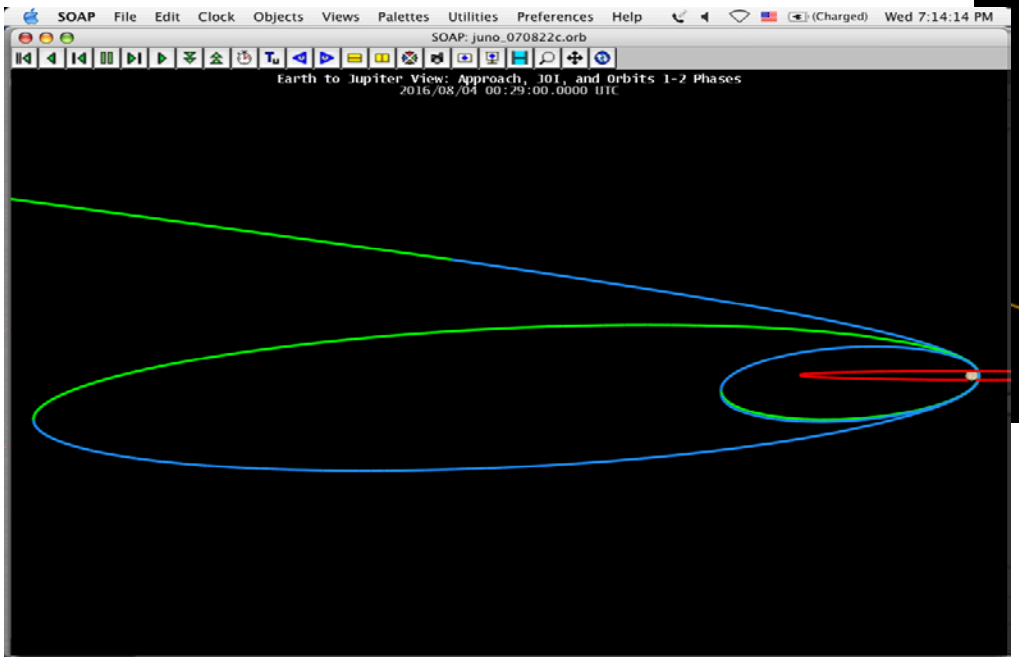
UV image from HST

Juno's Trajectory

- 5-year cruise to Jupiter, arriving 4 July 2016
- Mission duration about 1 year at Jupiter, ending with de-orbit into Jupiter in 2017



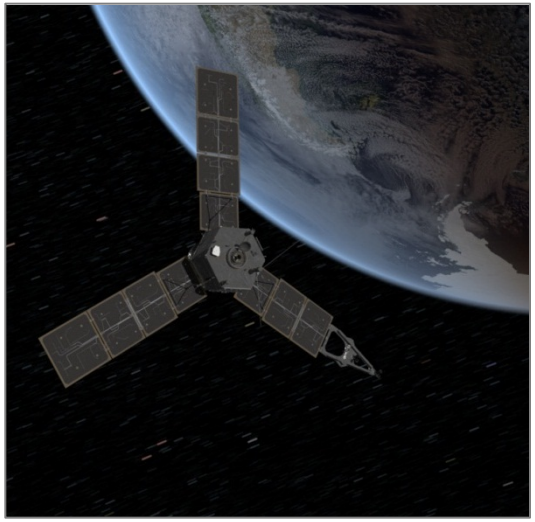
Initial Orbits

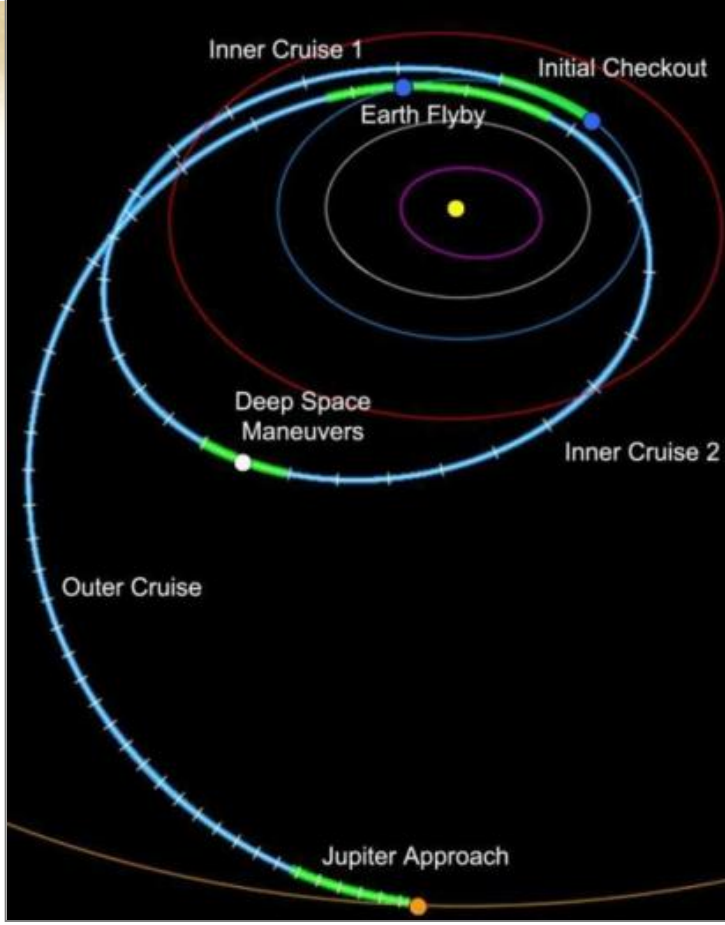


- ~3.5 month initial orbit
- Period reduction maneuver 19 Oct
- Prime mission begins 30 Oct 2016

On the way to Jupiter

Earth flyby on 9 October 2013





- In the middle of the DPS meeting (celebrate!)
- Lots of outreach activities planned

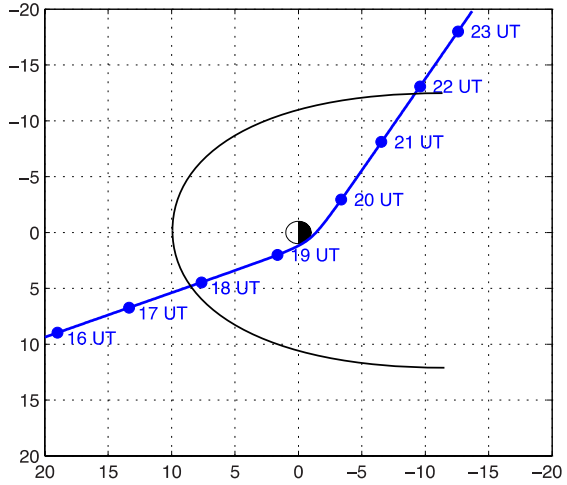
Earth Flyby Science Team Goals

- Emulate an 11- day orbit, but not rigorously (several important timing differences)
  - Test jovian data collection style
- Use the earth flyby to test instruments in a well-known magnetospheric environment
  - Coordinate with earth orbiters
  - Time within magnetosphere ~10 hr
  - Good “calibration” opportunity because earth’s magnetosphere is well-characterized
- Showcase what Juno will be able to do at Jupiter

Timeline

- Data rate from June through September 2013 for science = 0
  - All instruments currently on collecting cruise science data will be powered off with exception of the magnetometer
- Data rate starts to pick up again October 1
  - UVS power on at -4.5d
  - JEDI power on at -3d
  - WAVES power on at -3d
  - JunoCam power on at ~-8hr to collect lunar data
  - JIRAM power on at ~-6hr to collect lunar data
- Earth closest approach is October 9
- JADE and MWR will be off the entire time of earth flyby
  - MWR is powered back on at +10.5d

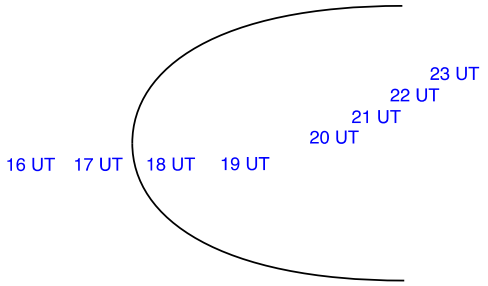
Juno Trajectory through Earth's Magnetosphere



- Juno's pass through Earth's magnetosphere based on latest available trajectory

- Magnetopause shown at 10 R_E could be as close as 6 or 7, or as distant as 12 R_E

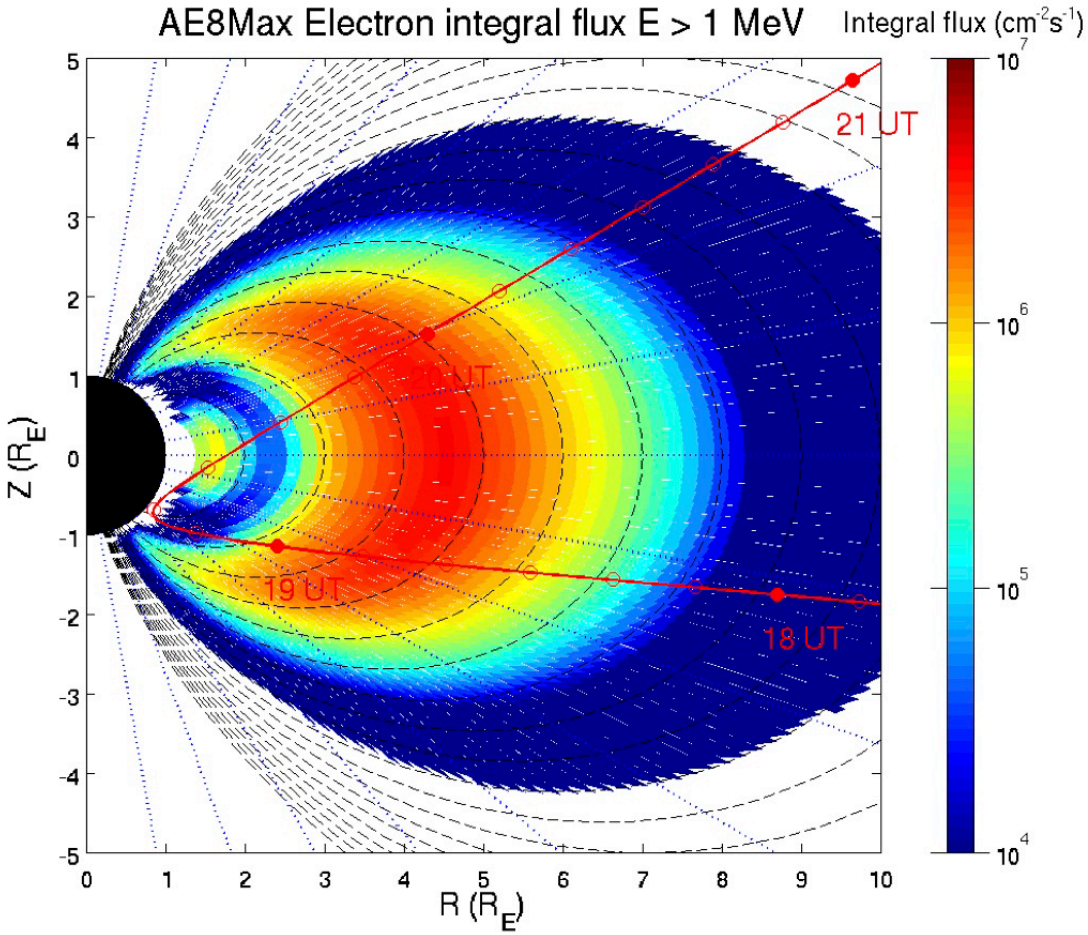
- Exit on dawn side



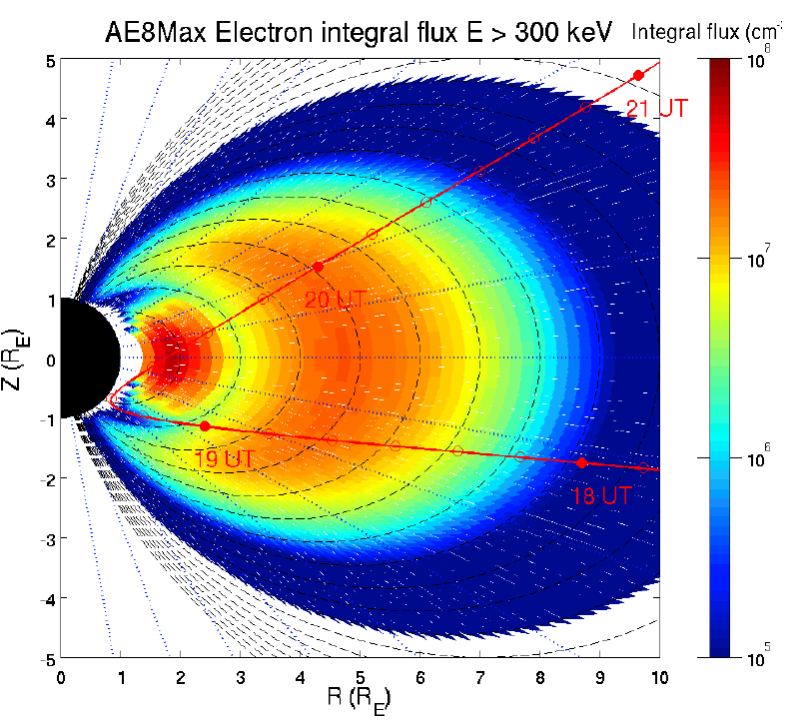
Radiation Belts
Electron Flux with E > 1 MeV

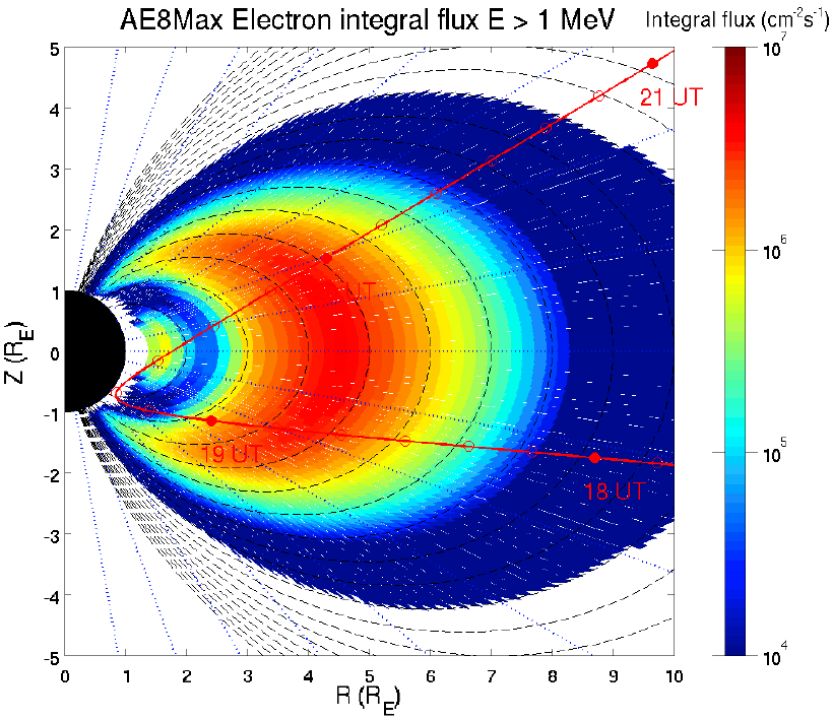
- Pass directly through heart of inner belt

- About 1.5 hr to cross entire radiation belts. We can compare particle and wave observations with THEMIS and RBSP

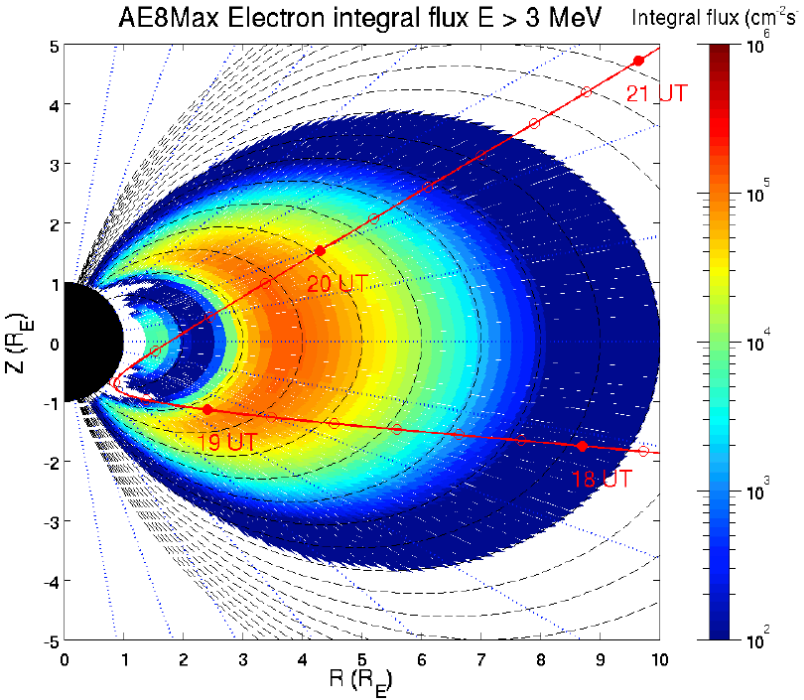


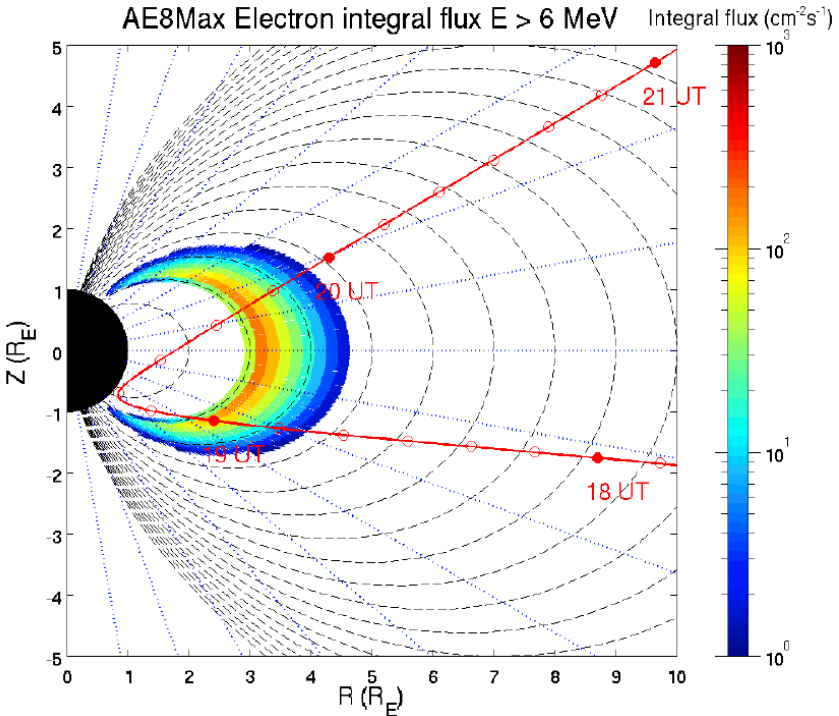
- Based on latest available trajectory
- 10 min tickmarks

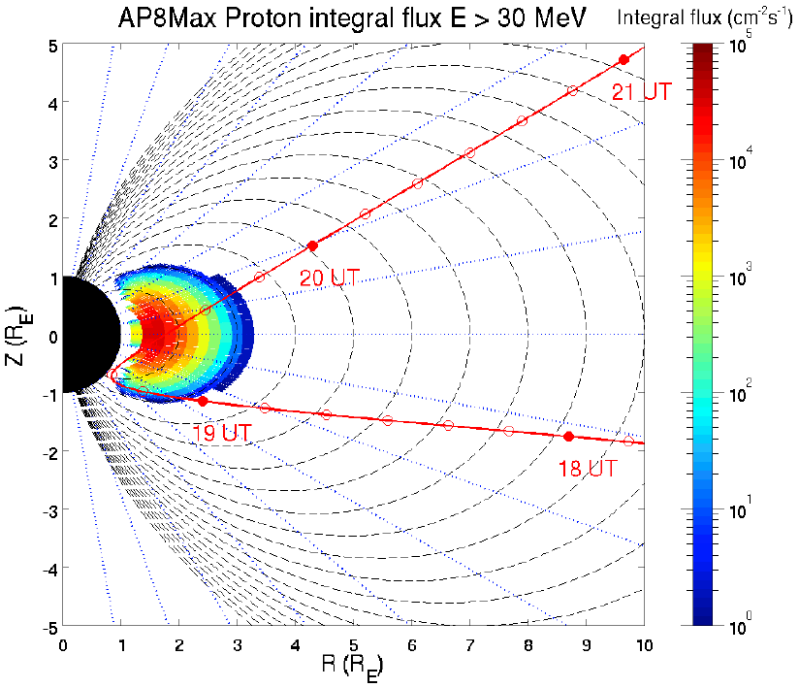


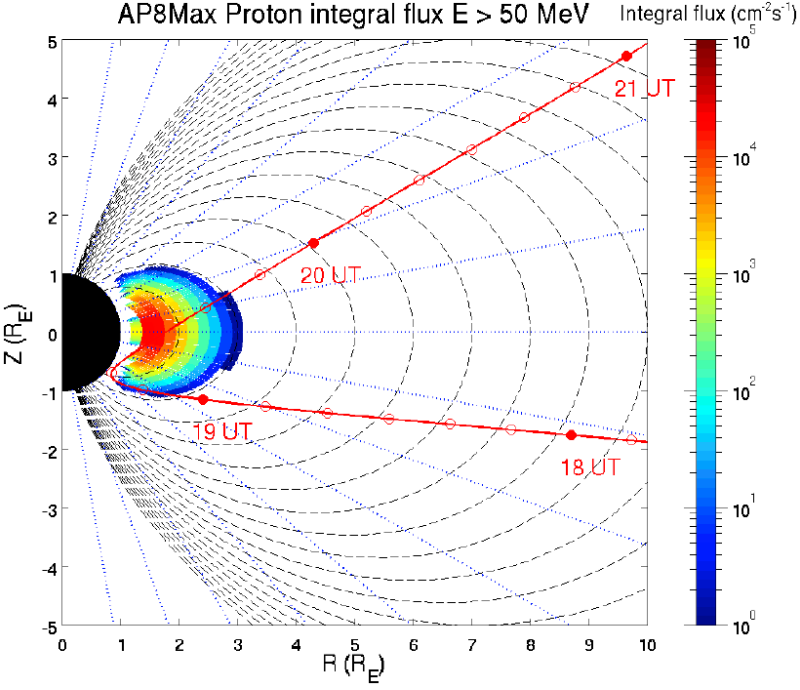


Electron flux for various energies

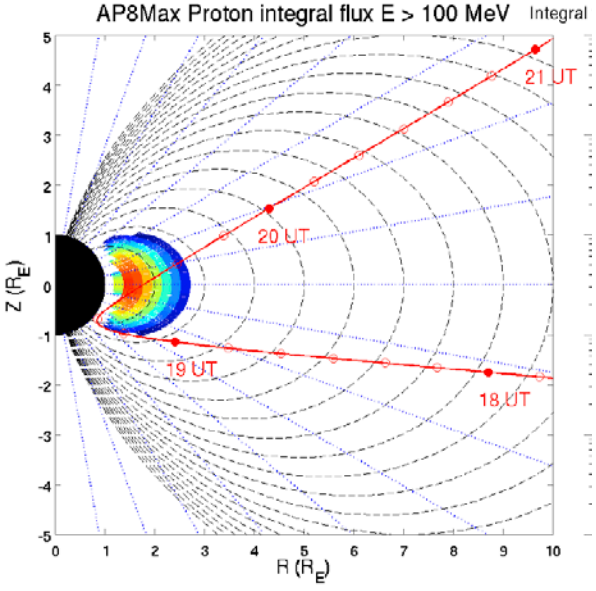


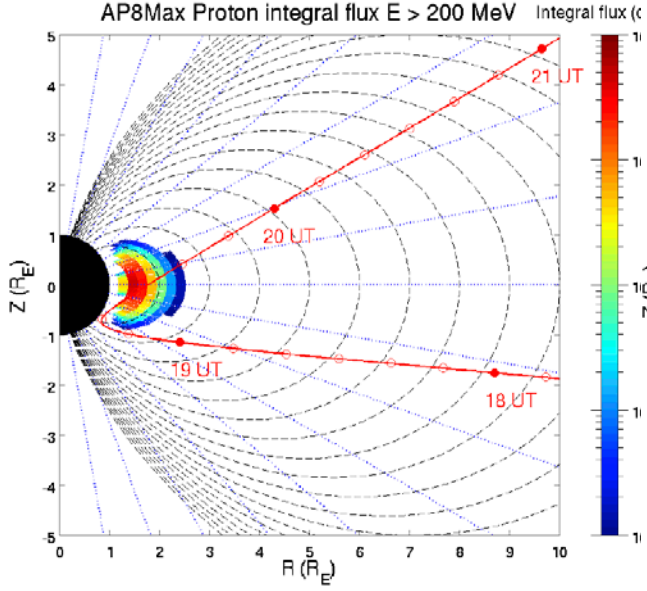


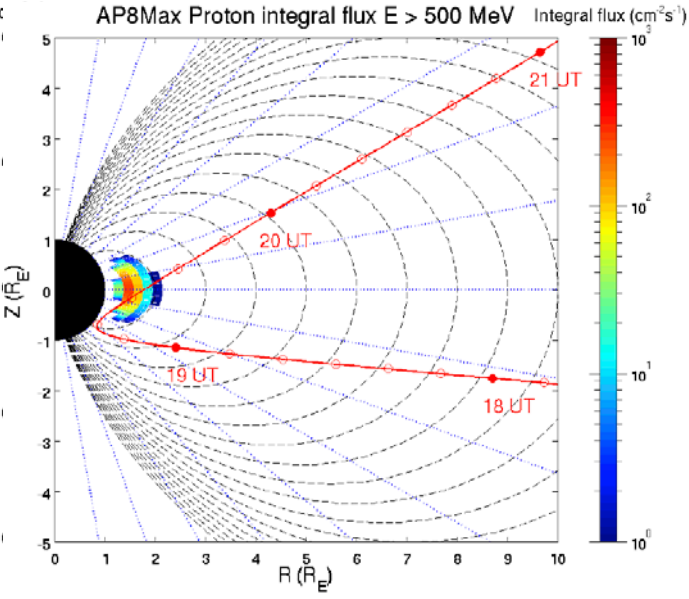


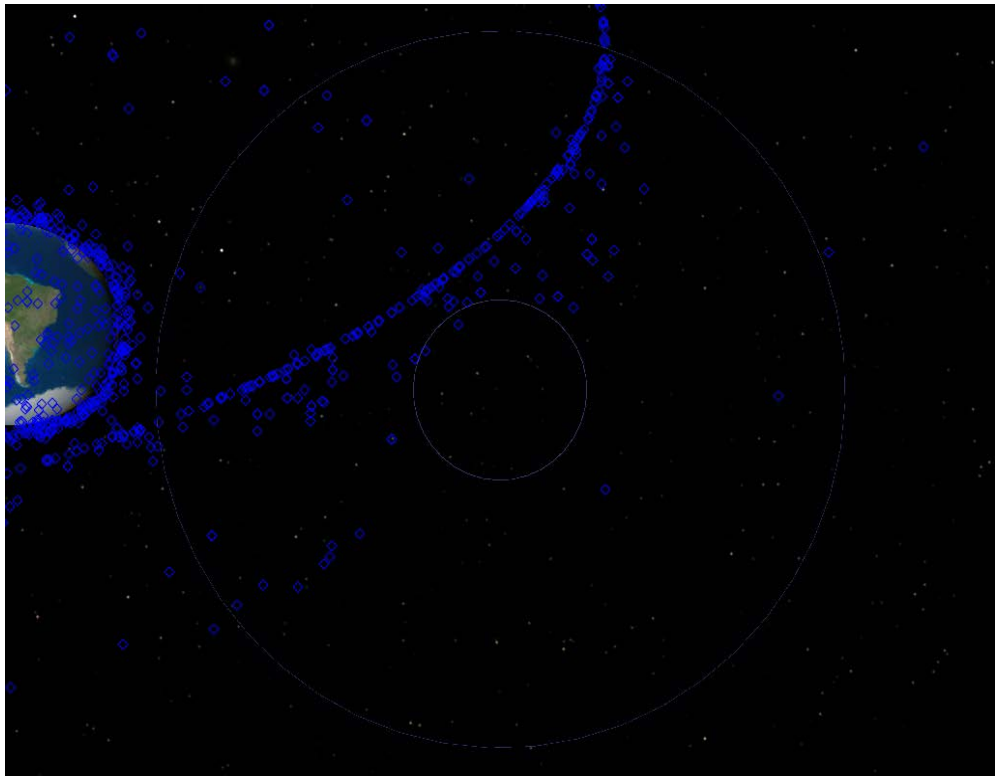


Proton flux for various energies









MAG EFB: ASC

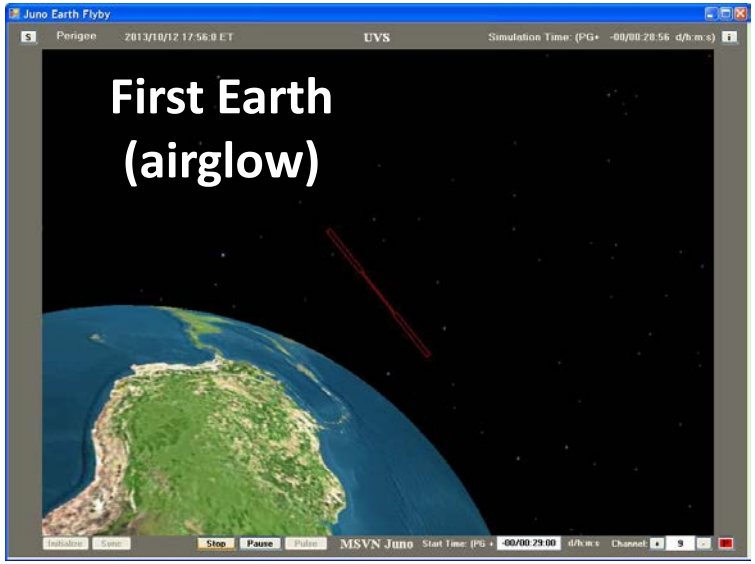
- Imaging of Earth-orbiting satellites to characterize detection of non-stellar objects (NSO's)

- Imaging of earth and moon in last few days as spacecraft approaches

A few days out…

UVS Earth Flyby Plans

- Turn on at C/A-6h, warmup for 1hour, take data for 6 hours (C/A-5h to C/A+1h)
- From C/A-5h to C/A-1h, observe Moon
  - Get sensitivity at EUV wavelengths using reflected sunlight and comparing with LRO-LAMP results
- From C/A-20min to C/A, observe Earth
  - Earth's airglow
  - Track southern auroral region
- From C/A to C/A+1h, close door for dark observation
  - Get effectiveness of Ta shielding using high-energy electrons (and possibly protons) in radiation belts (RBSP provides state of radiation belts)



JEDI EFB

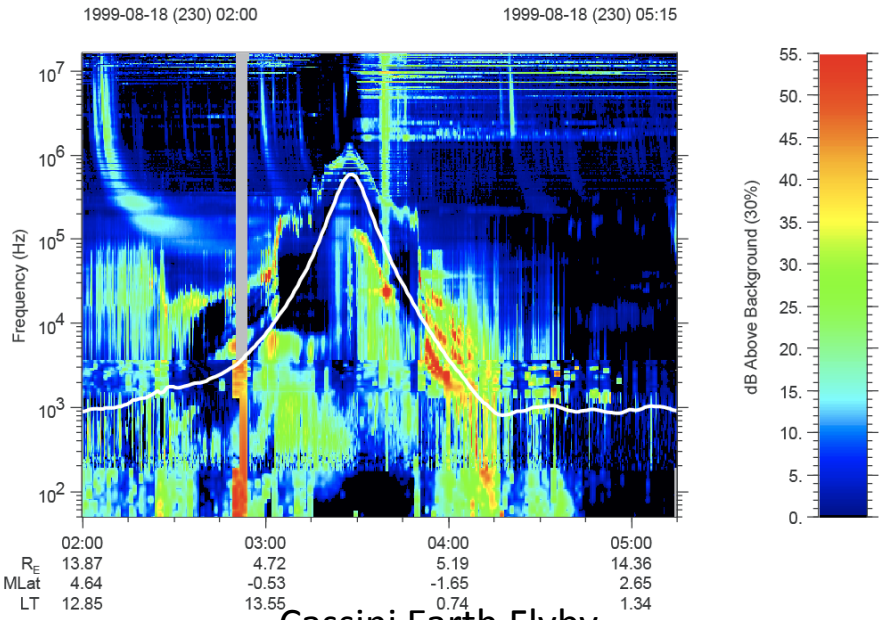
Motivation: JEDI measures energetic particles and these are not routinely encountered in the solar wind (e.g., SW electrons very cold) – this is our chance to have predictable flux of energetic particles that we roughly understand

Main goals:

- Practice Jupiter orbit scenario – how well do we capture a fast changing environment with our instrument
- Calibrate our channelization of the data with roughly known inputs
- Return a lot of event data to understand the instrument response to energetic ions.

Waves at Earth

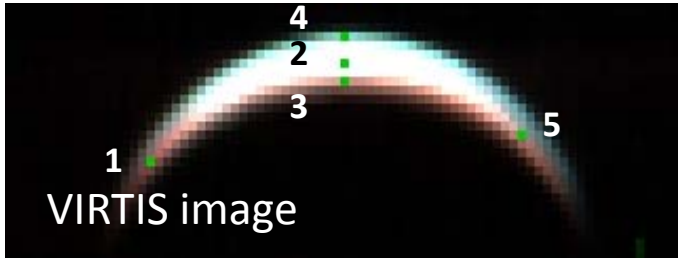
- Waves Objectives:
  - Exercise Waves in a science-orbit like manner
  - Gather as much information as possible on the functionality and performance of the Waves solar array noise cancellation algorithm.
  - Detect man-made radio transmissions as evidence for an inhabited Earth.

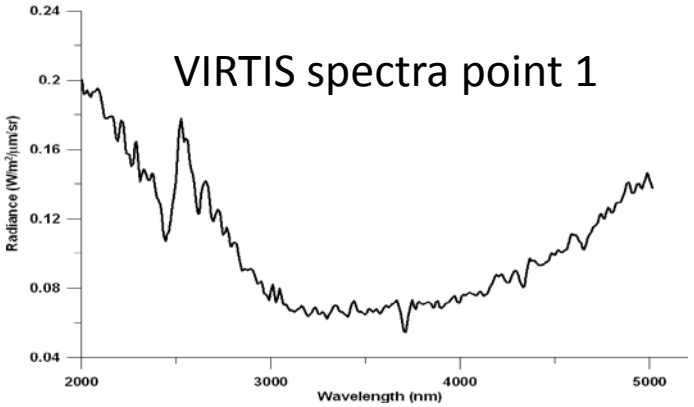


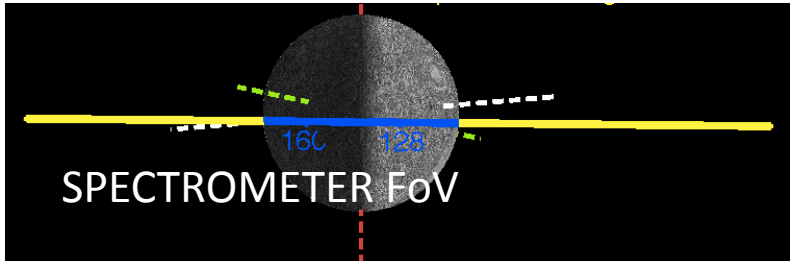
Cassini Earth Flyby

JIRAM Moon Flyby

- JIRAM will observe the Moon from Oct-09T13:47 to Oct-09T14:20
  - About 60 images and spectrometer data will be taken
- JIRAM calibration is known, but a check against the moon is desirable (especially the Spectrometer)







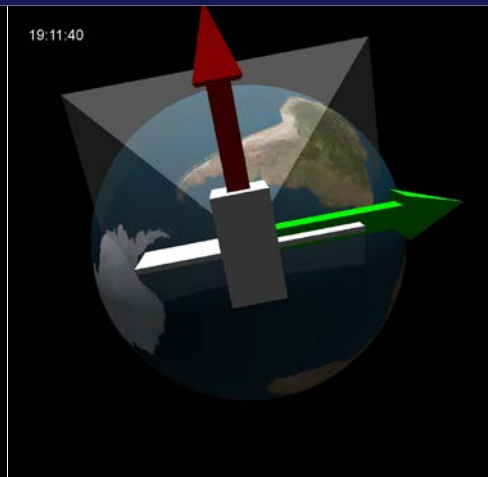
JunoCam Earth Flyby

Objectives:

- Image extended targets
- Process images with JunoCam map projection tools
- Distribute data to public

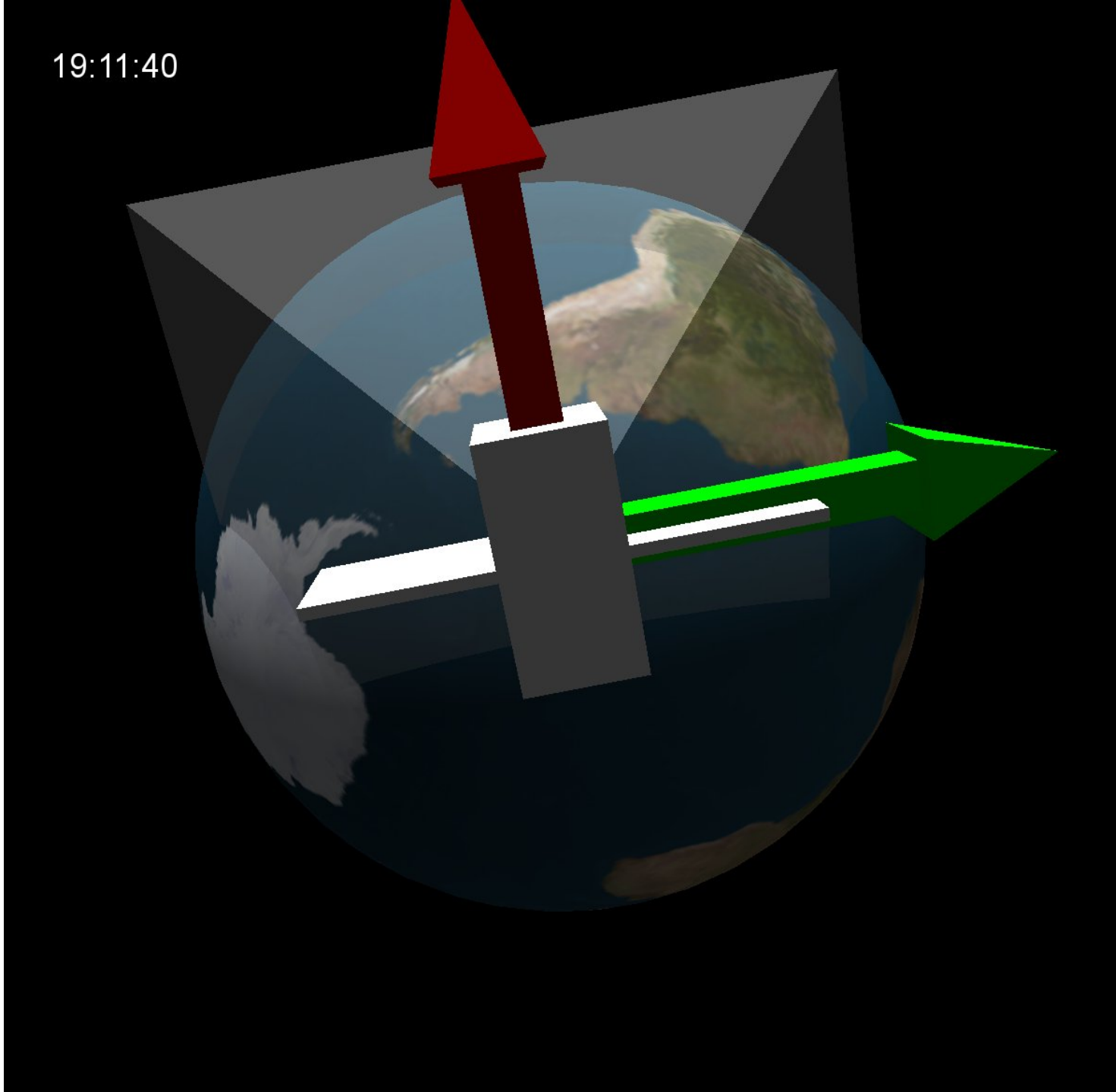
Targets:

- Earth (Seven 4-color images)
- Moon (1)
- Jupiter (1 green)
- Radiation noise (1 red)



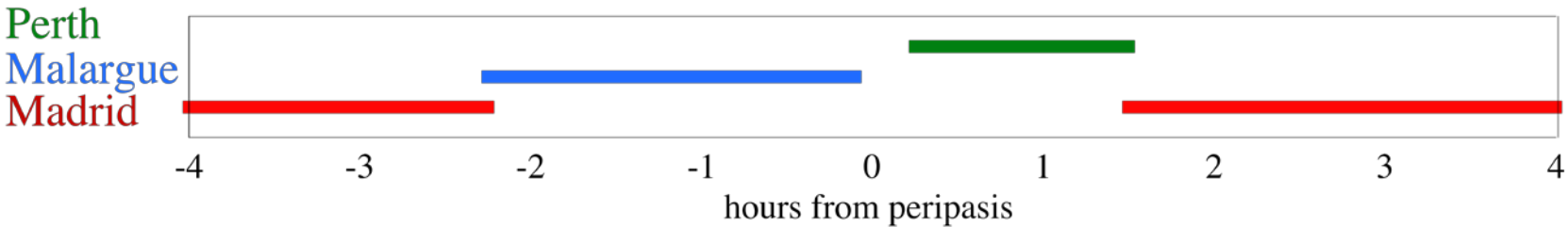
C/A -10m

The s/c is south of the previous view so now we pick up a little of the Antarctic and almost all of South America



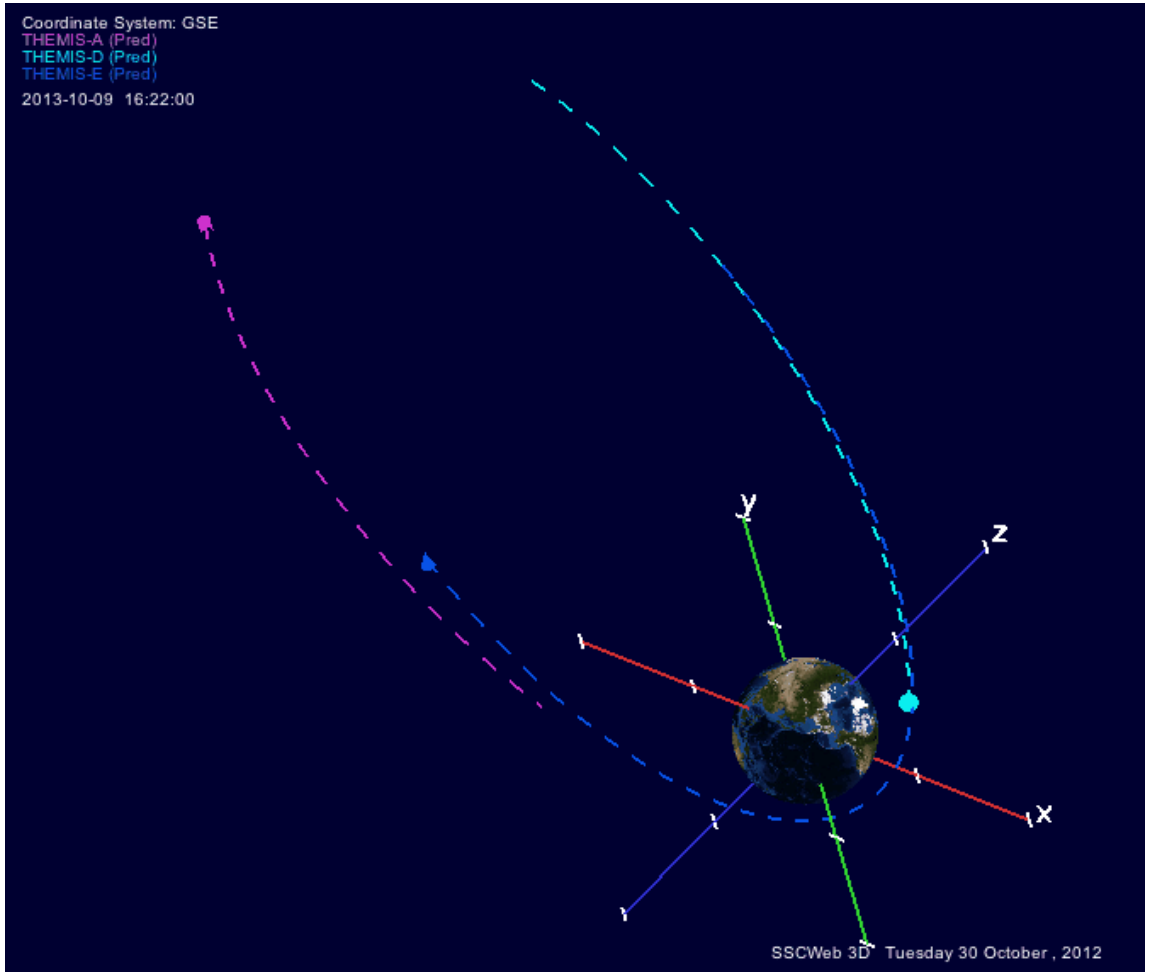
Juno Gravity Science at Earth Flyby

- Most Earth fly-bys exhibit an unexpected energy gain change
  - Equivalent to a maneuver of a few mm/s
  - Easily detected in comparing 2-way Doppler data before and after flyby
- Cause of energy gain is unknown
  - Most likely due to error in gravity models applied to hyperbolic orbits
  - But might be some non-gravitational force not modeled
- Juno will gather unique data to investigate flyby anomaly
  - Continuous DSN tracking for 7 days centered on periapsois, except for gap from 2.25 hours before periapsis to 1.5 hours after periapsis
  - ESA tracking from 2.25 hours before periapsis to 7 minutes before periapsis and from 20 minutes after periapsis to 1.5 hours after periapsis
  - Juno IMU (Inertial Measurement Unit) will be on during flyby, including accelerometers which can measure non-gravitational forces large enough to cause anticipated anomaly



Coordination with Earth Orbiters

There will the possibility of inter-calibration with instruments on the THEMIS and RBSP spacecraft



- THEMIS (Time History of Events and Macroscale Interactions during Substorms) has 5 identical earth-orbiting satellites

- Measures magnetic and electric fields and ions and electrons with energies from 25 keV to 6 MeV

- Location of THEMIS A,D,E between plus and minus 3 hrs of JUNO closest approach.

Location of RBSP Spacecraft During JUNO Earth Flyby

Onboard instrumentation for potential calibration of JUNO instruments:

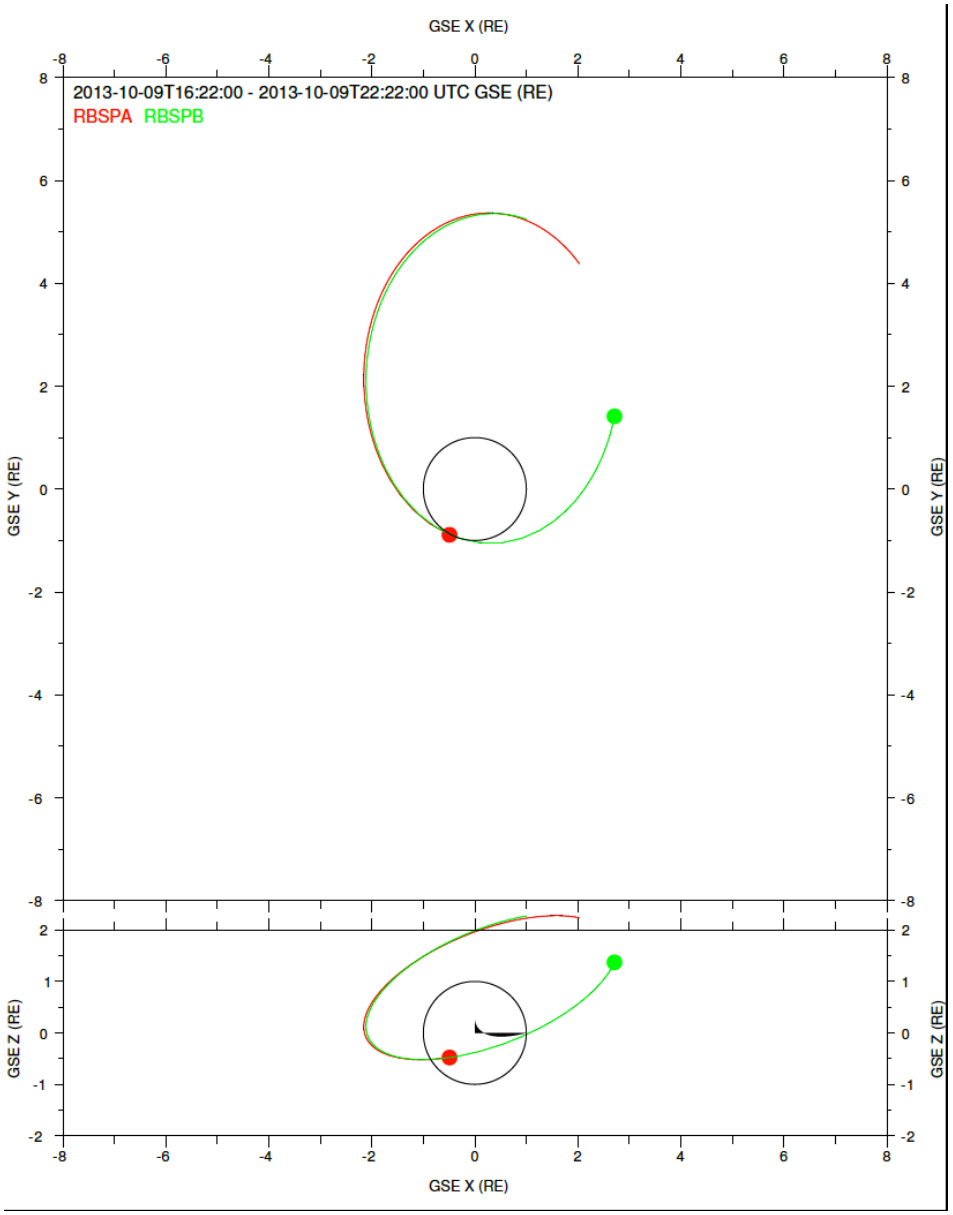
RBSPICE: Ion (few keV- >1 MeV) and electrons (20-800 KeV)

MagEIS: Energetic ion and electrons from 30 keV to ~2 MeV.

REPT: Energetic electrons (2-20 MeV) and Ions (20-200MeV)

RPS: Energetic ions (60 MeV – GeV)

EMFISIS: Electromagnetic Waves



This document was reviewed and approved for export, see Juno-Generic-13-012.