Highlights of Radio and Plasma Wave Science Results from Early in Cassini's Orbital Tour

W. S. Kurth

On behalf of the RPWS Team

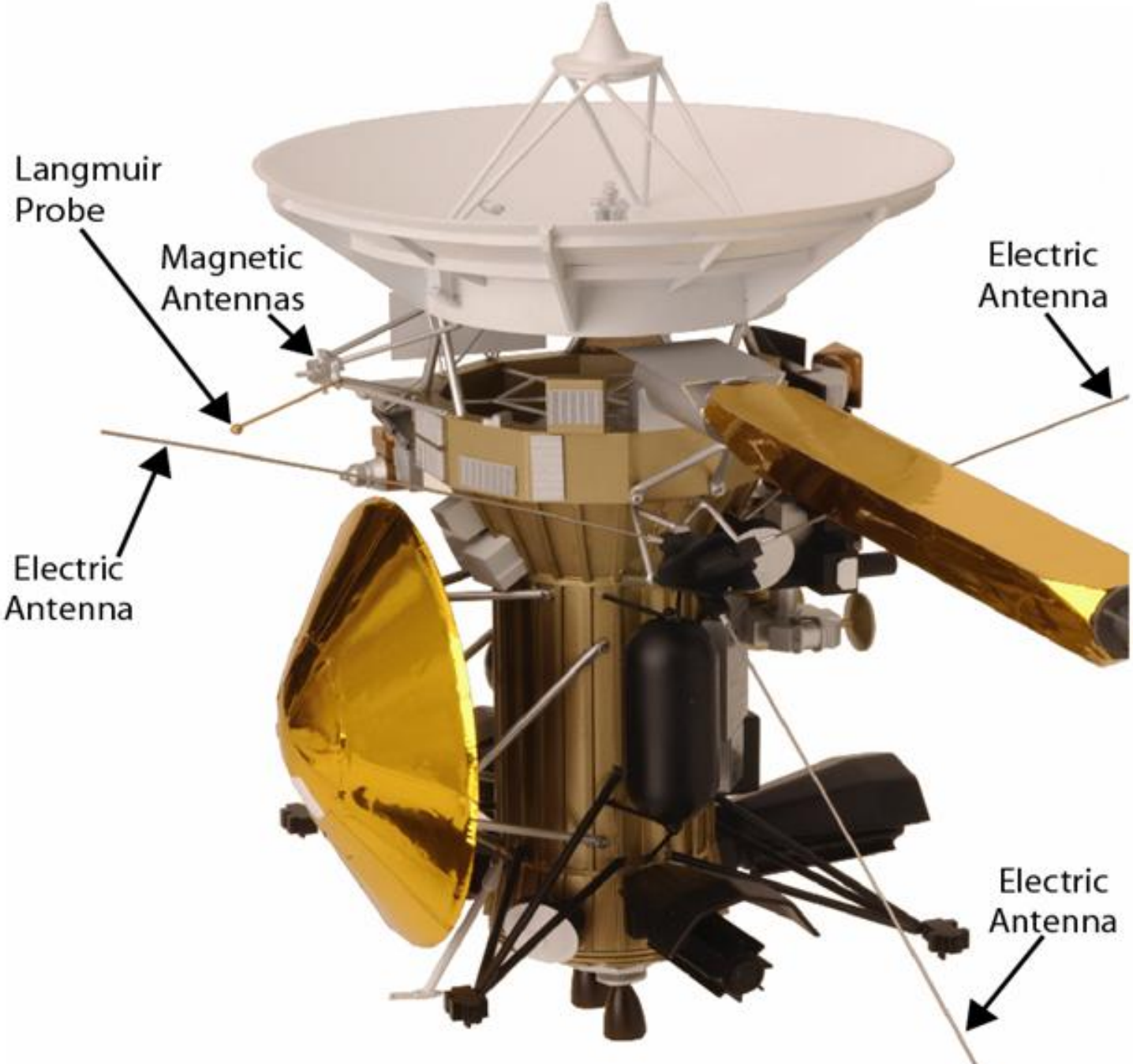
CHARM Presentation

25 October 2005

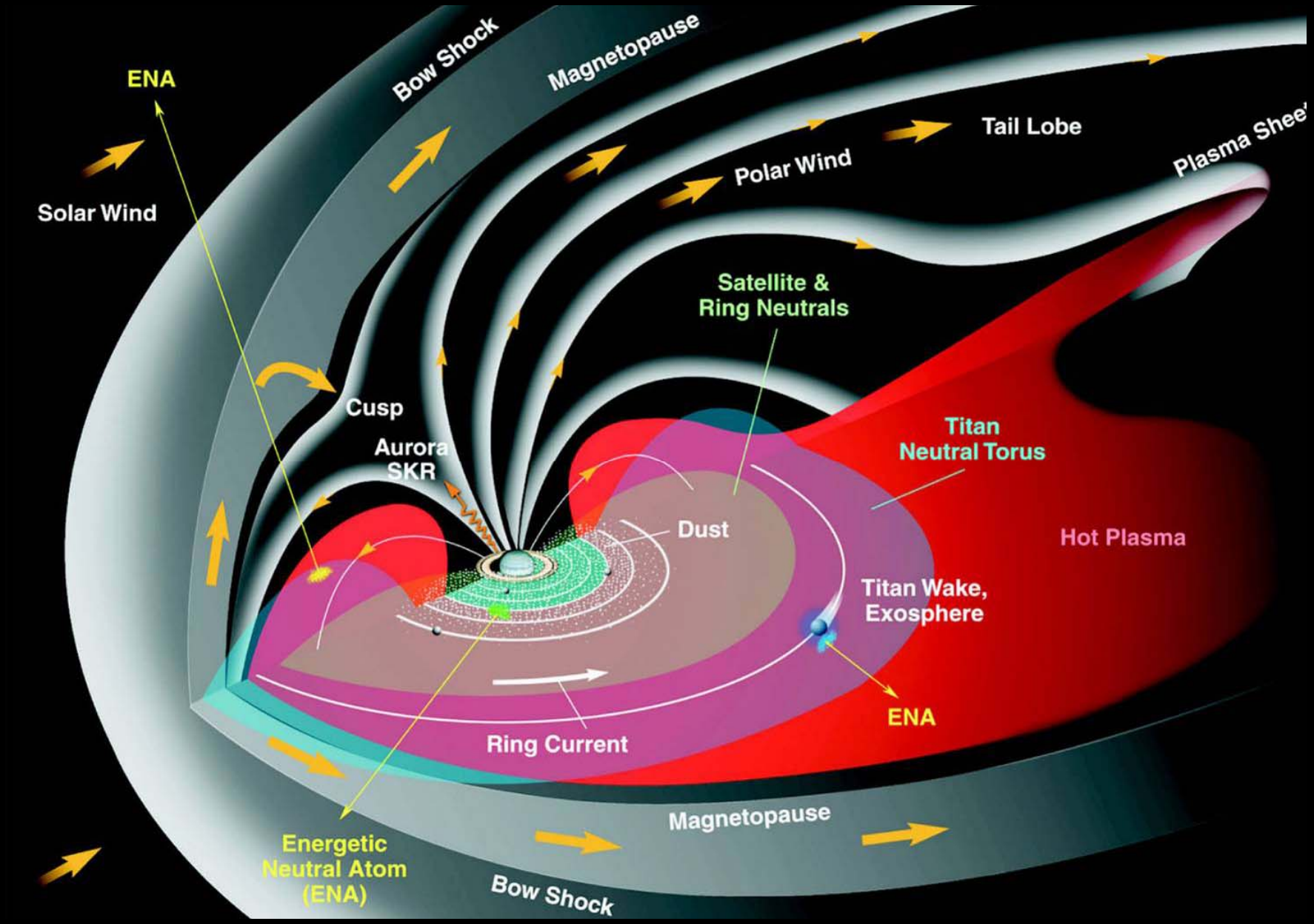
Topics

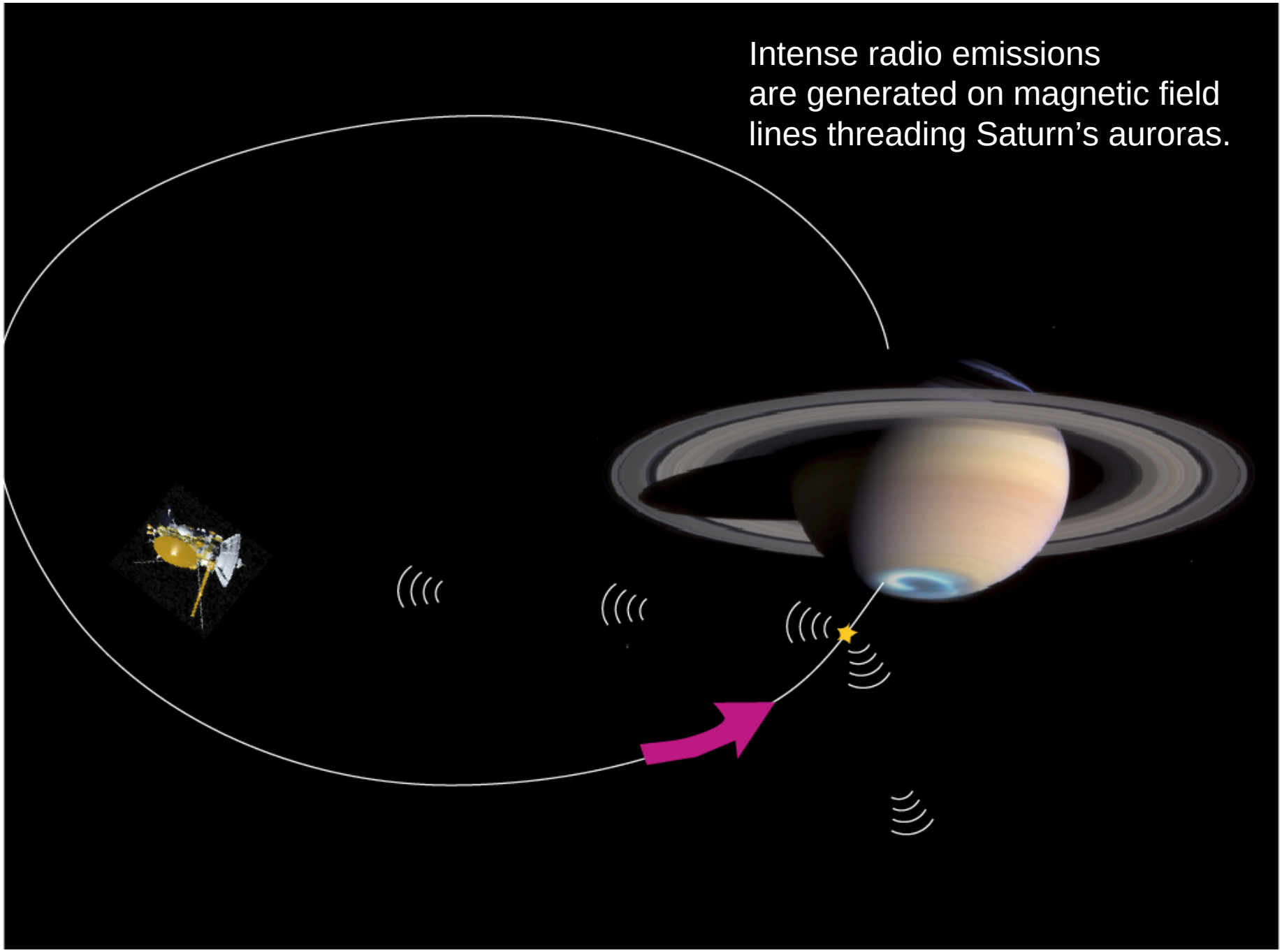
- Saturn Kilometric Radiation
  - What is it?
  - Association with auroras on Saturn
  - The radio ‘rotation’ period
- Saturn Electrostatic Discharges (Lightning)
  - What are they?
  - Occurrence and comparison with Voyager observations
- Dust impacts

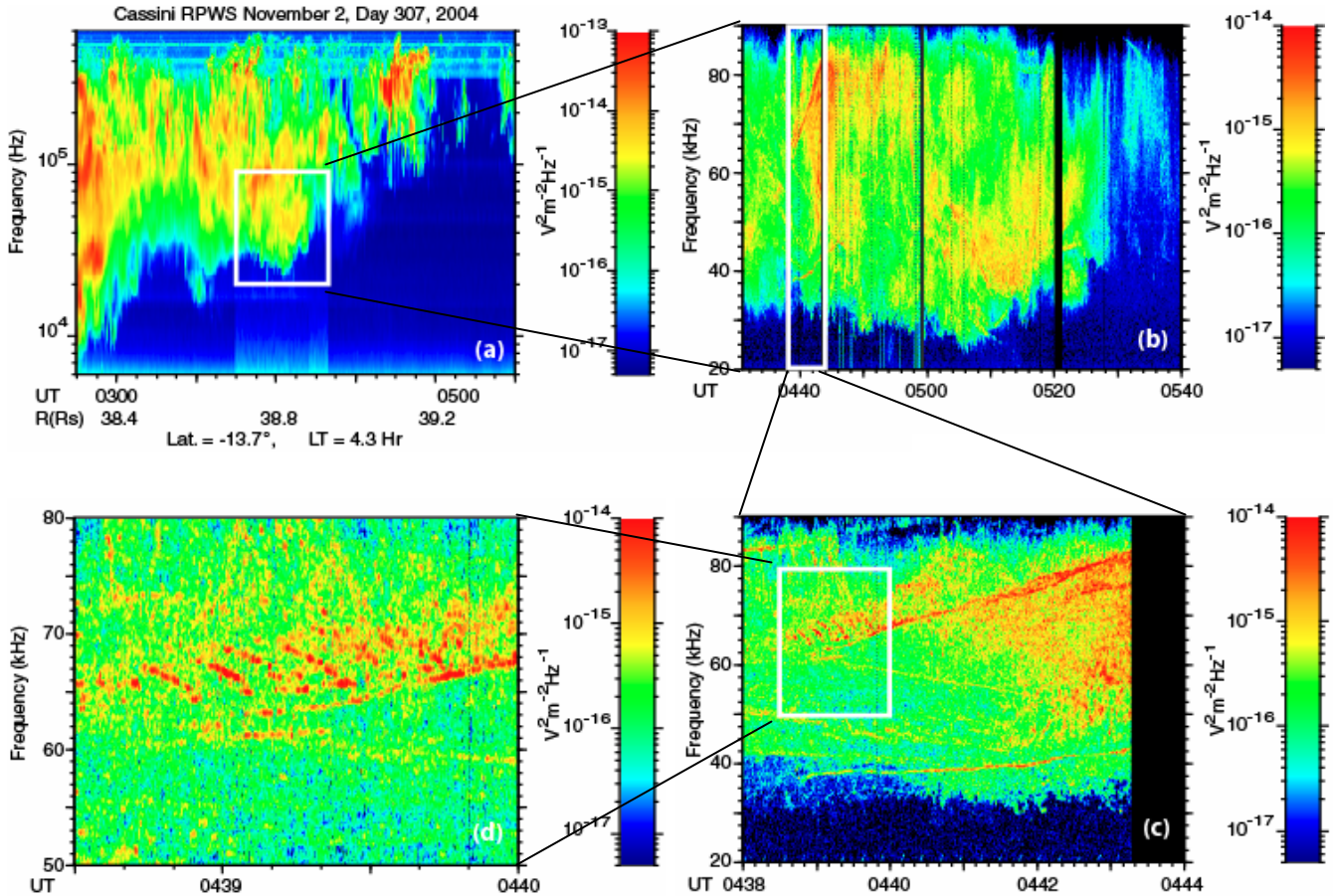
The Radio and Plasma Wave Instrument



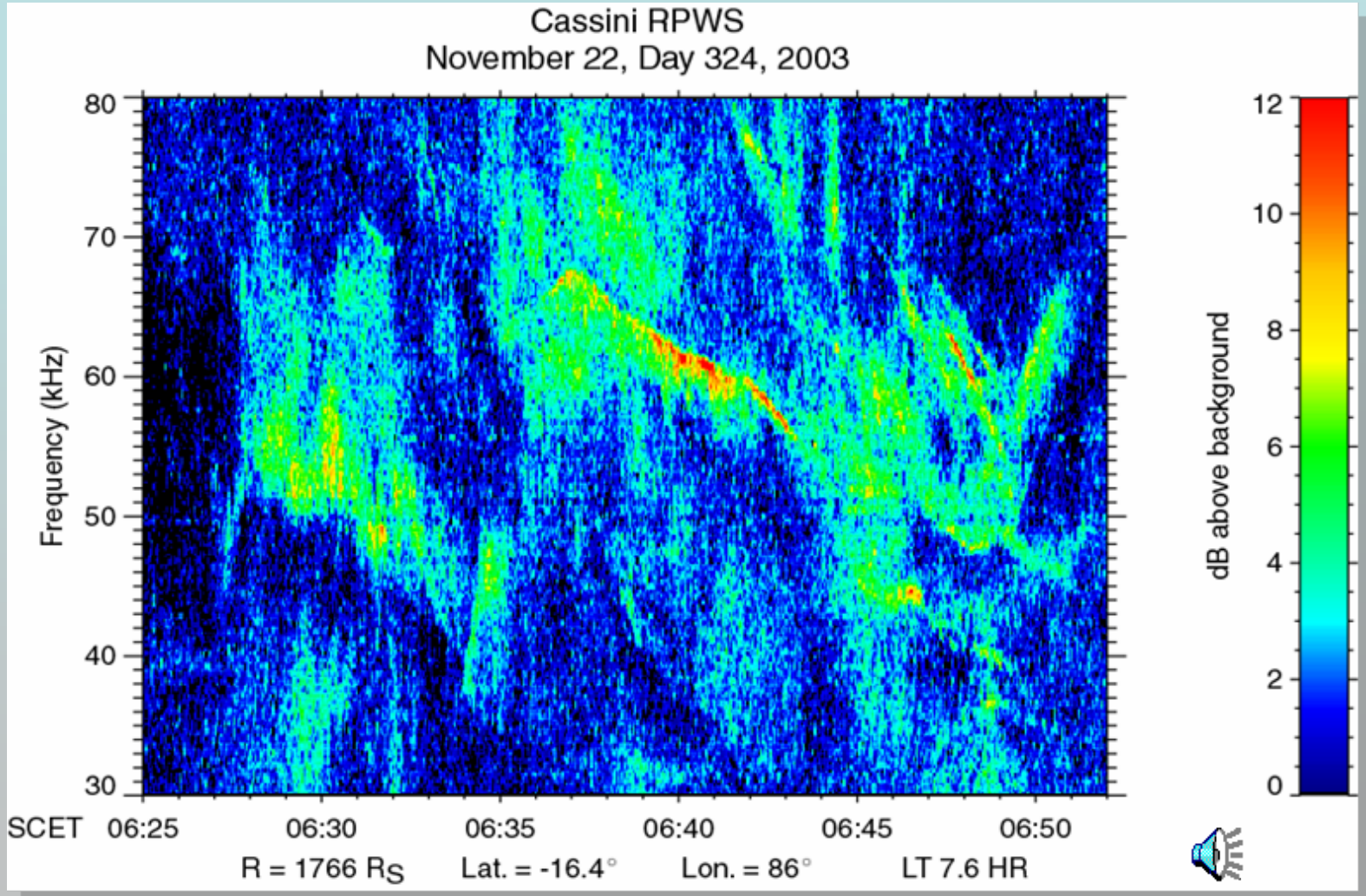
Saturn's Magnetosphere

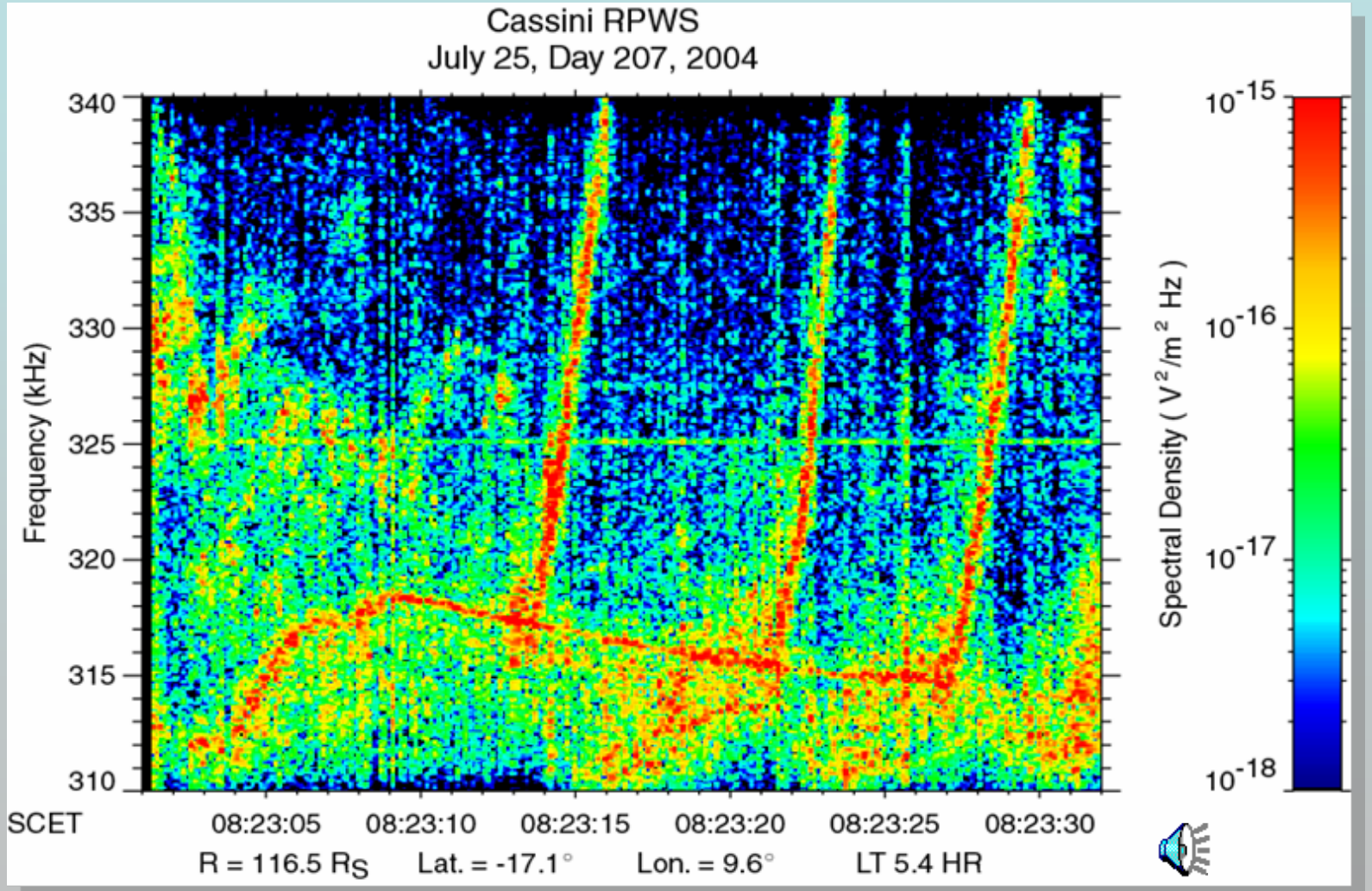



Intense radio emissions
are generated on magnetic field
lines threading Saturn's auroras.

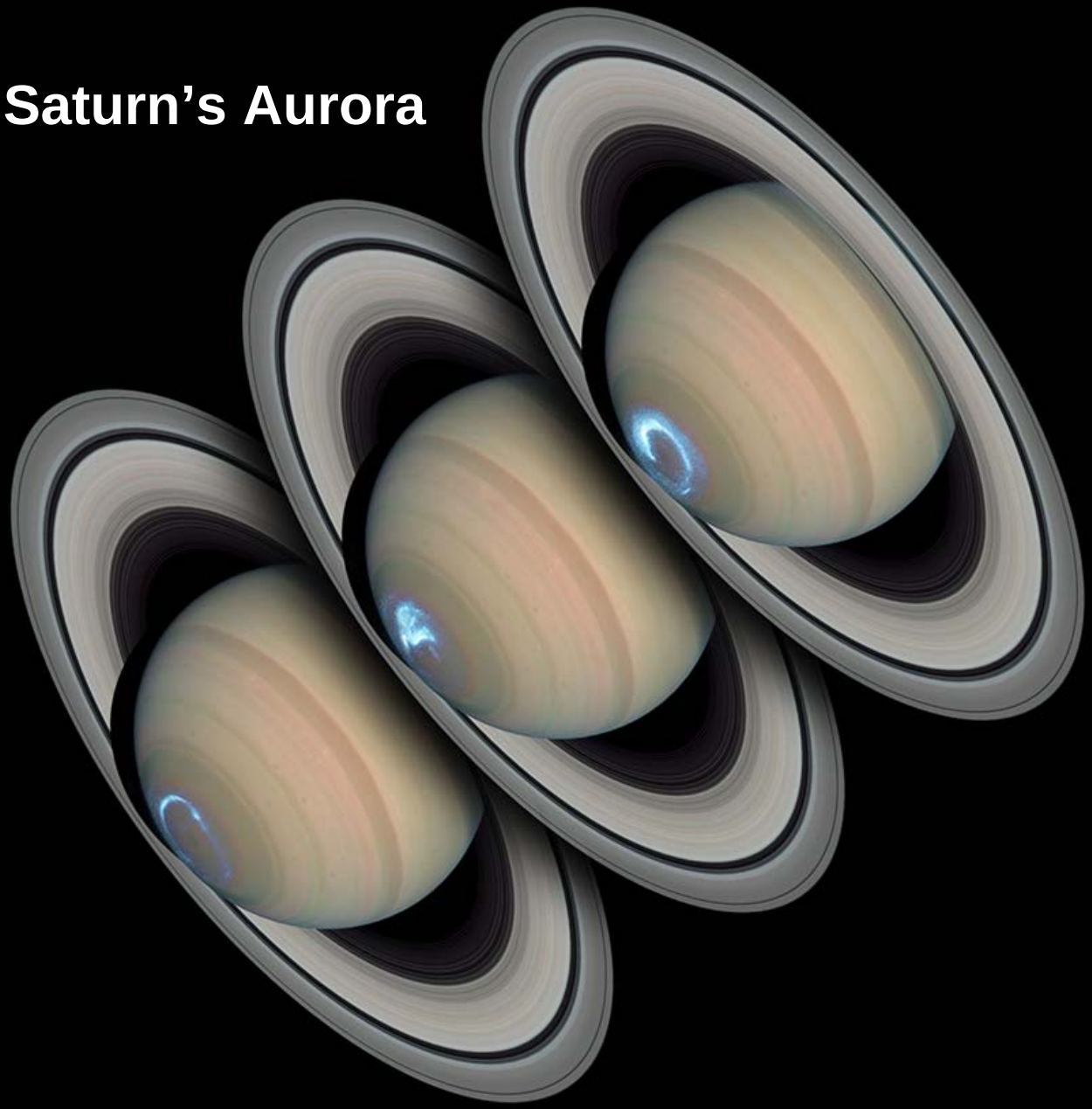


Saturn kilometric radiation is composed of a bewildering array of fine structure.

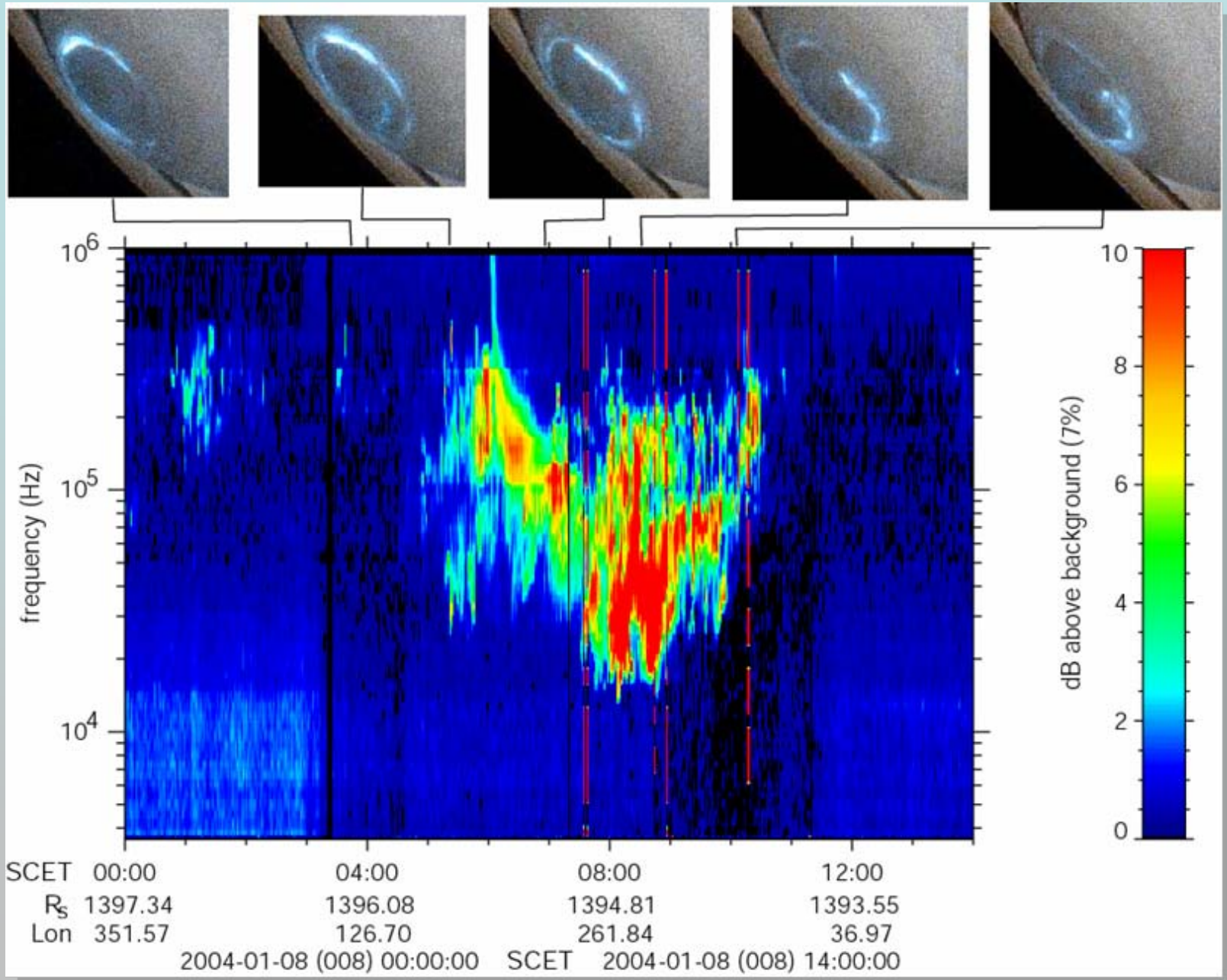

Cassini RPWS
November 22, Day 324, 2003
Frequency (kHz)
80
70
60
50
40
30
SCET 06:25
06:30
06:35
06:40
06:45
06:50
R = 1766 RS
Lat. = -16.4°
Lon. = 86°
LT 7.6 HR
dB above background
12
10
8
6
4
2
0

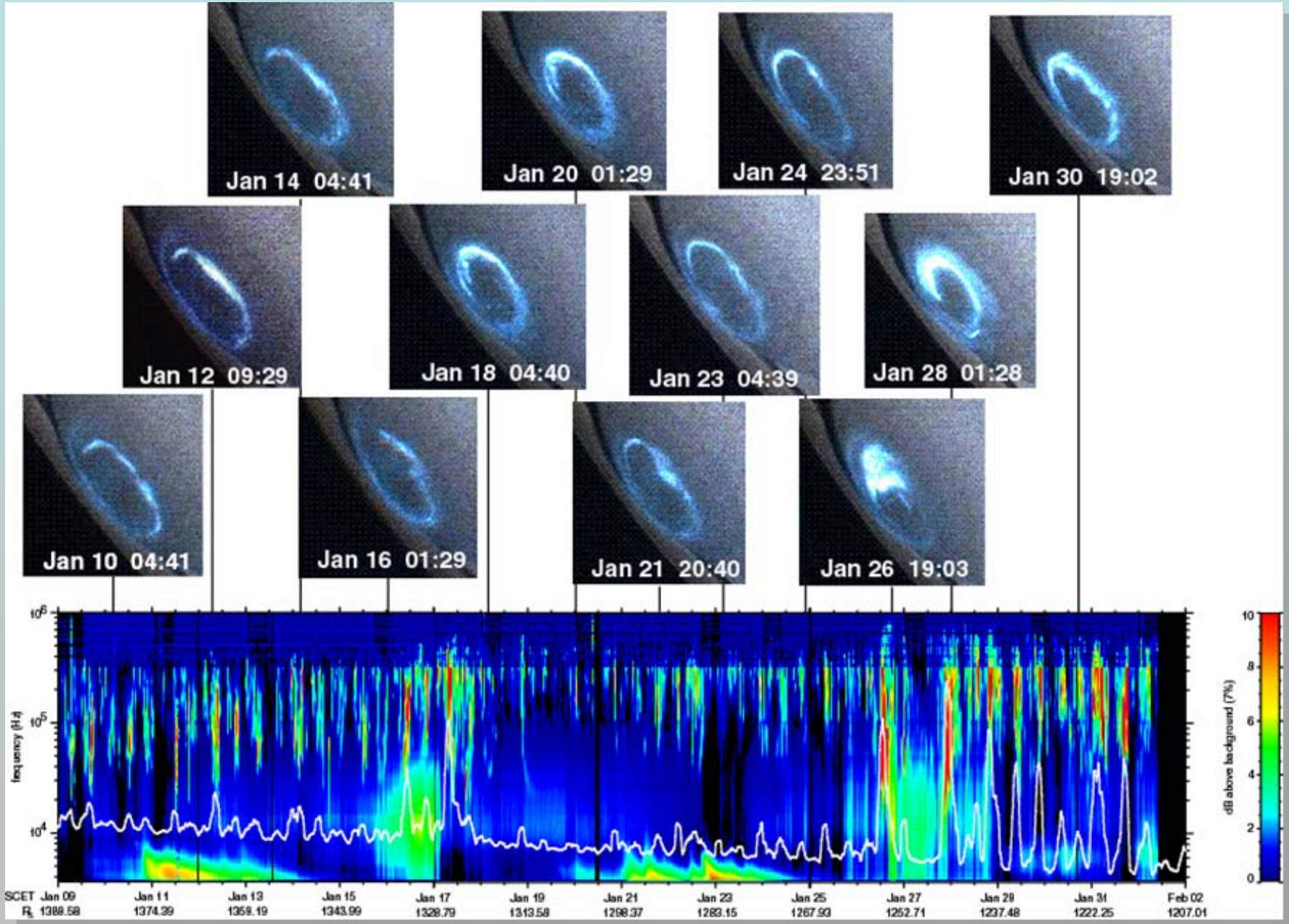

Cassini RPWS
July 25, Day 207, 2004
Frequency (kHz)
340
335
330
325
320
315
310
SCET
08:23:05
08:23:10
08:23:15
08:23:20
08:23:25
08:23:30
R = 116.5 RS
Lat. = -17.1°
Lon. = 9.6°
LT 5.4 HR
Spectral Density (V²/m² Hz)
10-15
10-16
10-17
10-18

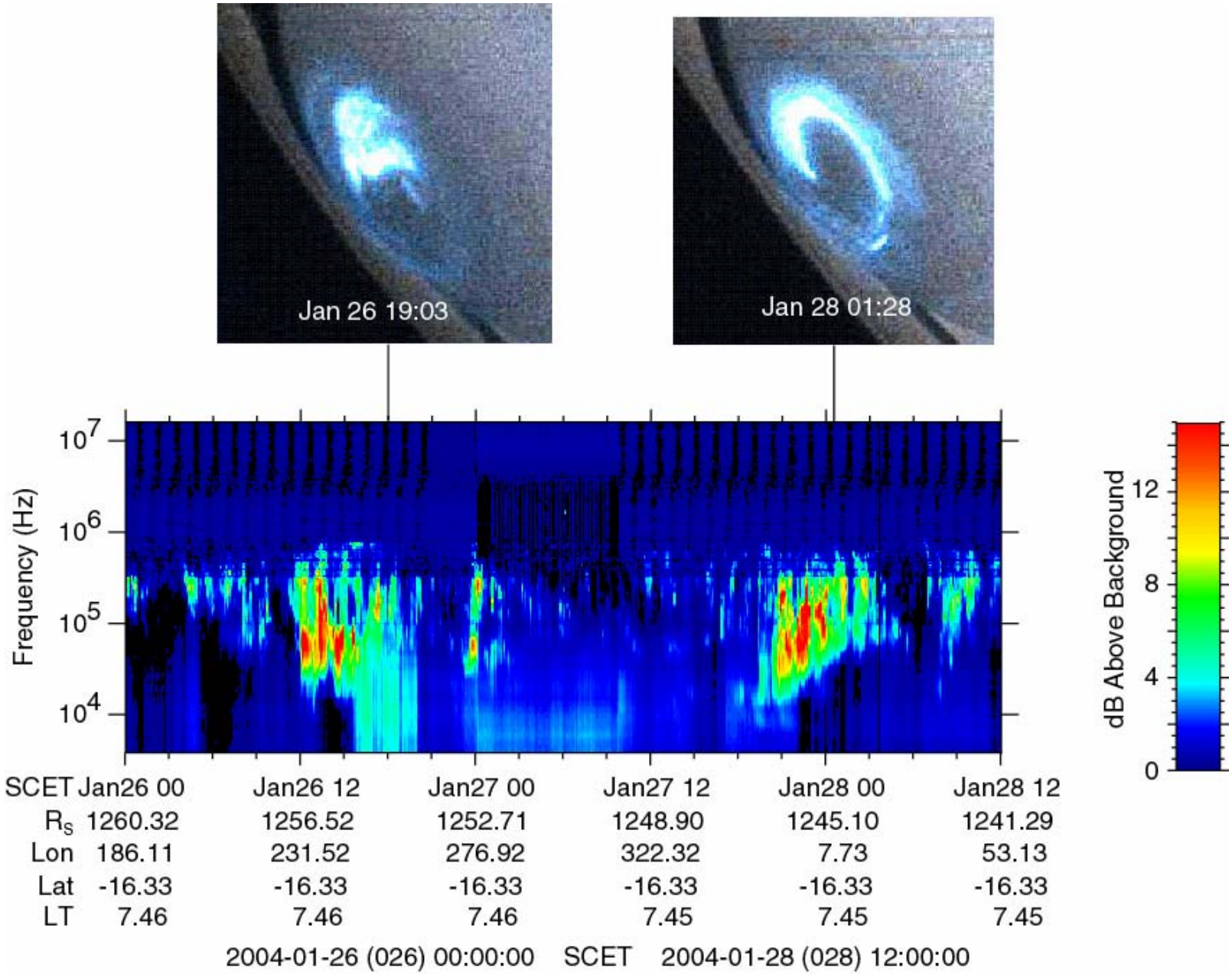
Saturn’s Aurora



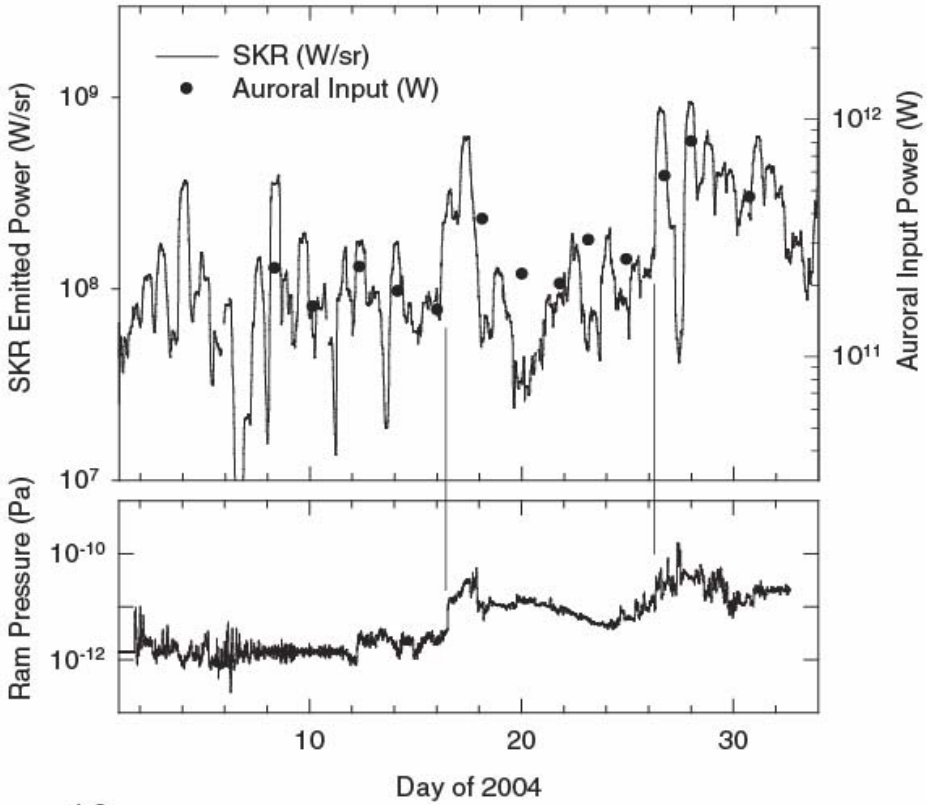
HST images courtesy of John Clarke

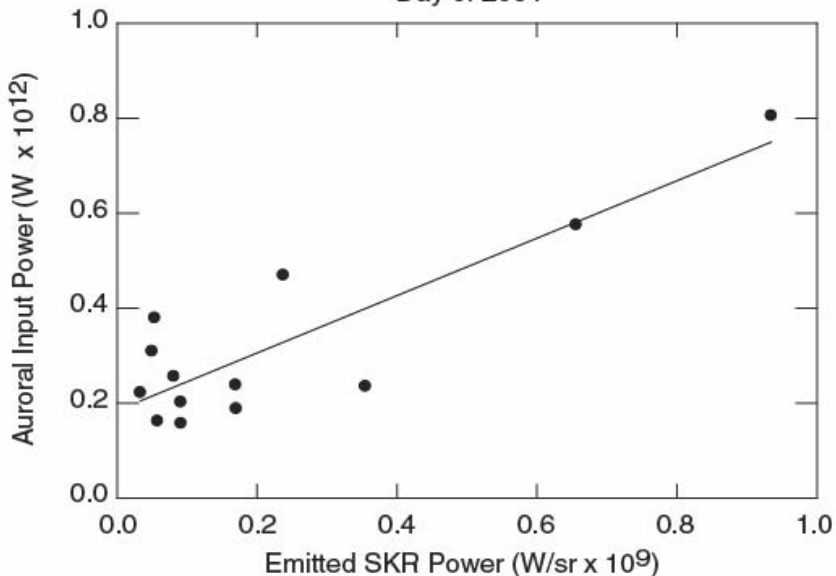

frequency (Hz)
10^6
10^5
10^4
dB above background (7%)
10
8
6
4
2
0
SCET 00:00 04:00 08:00 12:00
R_S 1397.34 1396.08 1394.81 1393.55
Lon 351.57 126.70 261.84 36.97
2004-01-08 (008) 00:00:00 SCET 2004-01-08 (008) 14:00:00

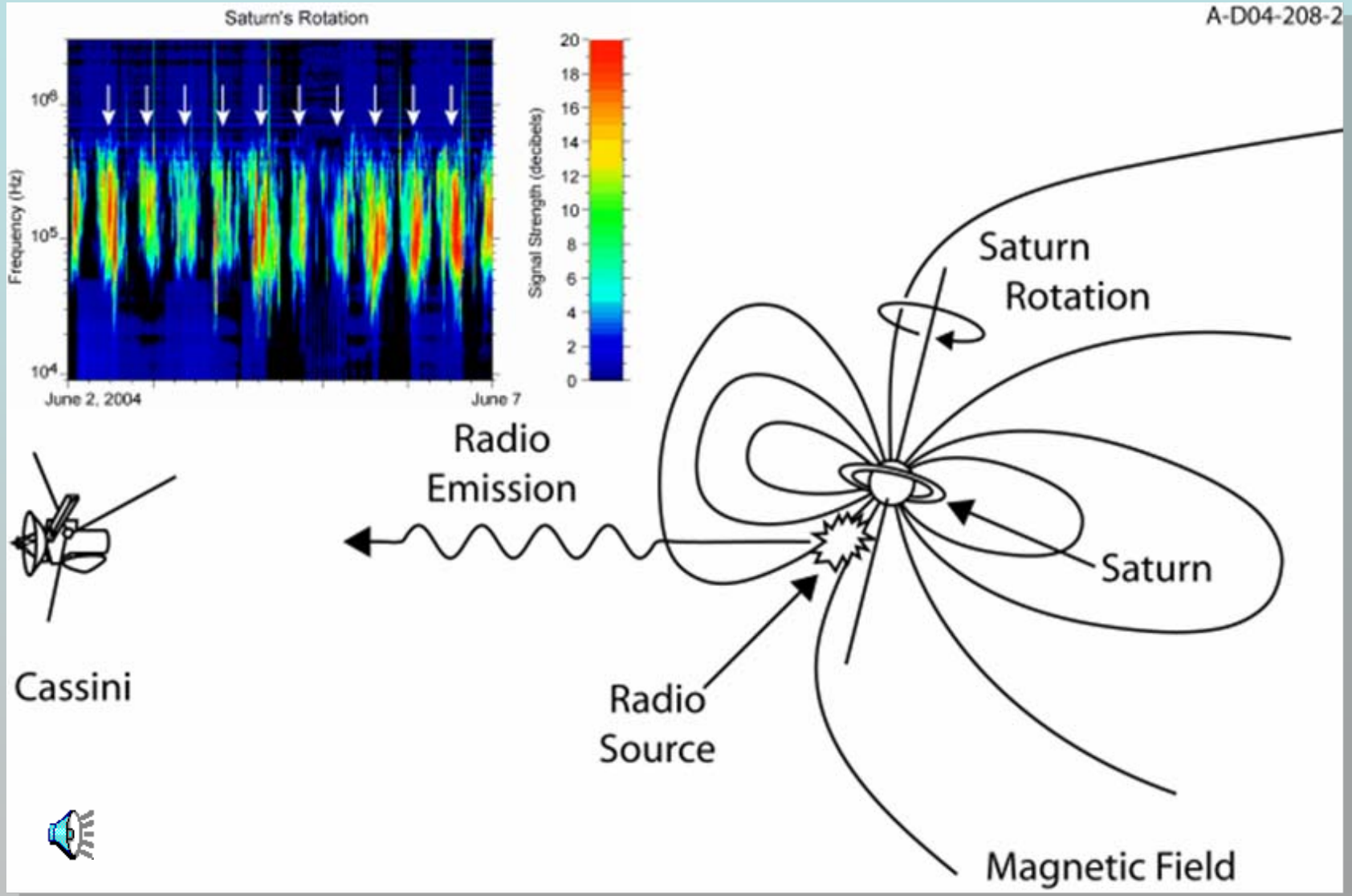

Jan 14 04:41
Jan 20 01:29
Jan 24 23:51
Jan 30 19:02
Jan 12 09:29
Jan 18 04:40
Jan 23 04:39
Jan 28 01:28
Jan 10 04:41
Jan 16 01:29
Jan 21 20:40
Jan 26 19:03
frequency (Hz)
dB above background (7%)
SCET Jan 09 Jan 11 Jan 13 Jan 15 Jan 17 Jan 19 Jan 21 Jan 23 Jan 25 Jan 27 Jan 29 Jan 31 Feb 02
R_S 1388.58 1374.39 1359.19 1343.99 1328.79 1313.58 1298.37 1283.15 1267.93 1252.71 1237.48 1222.25 1207.01


Jan 26 19:03
Jan 28 01:28
Frequency (Hz)
10^7
10^6
10^5
10^4
dB Above Background
0
4
8
12
SCET Jan26 00 Jan26 12 Jan27 00 Jan27 12 Jan28 00 Jan28 12
R_S 1260.32 1256.52 1252.71 1248.90 1245.10 1241.29
Lon 186.11 231.52 276.92 322.32 7.73 53.13
Lat -16.33 -16.33 -16.33 -16.33 -16.33 -16.33
LT 7.46 7.46 7.46 7.45 7.45 7.45
2004-01-26 (026) 00:00:00 SCET 2004-01-28 (028) 12:00:00

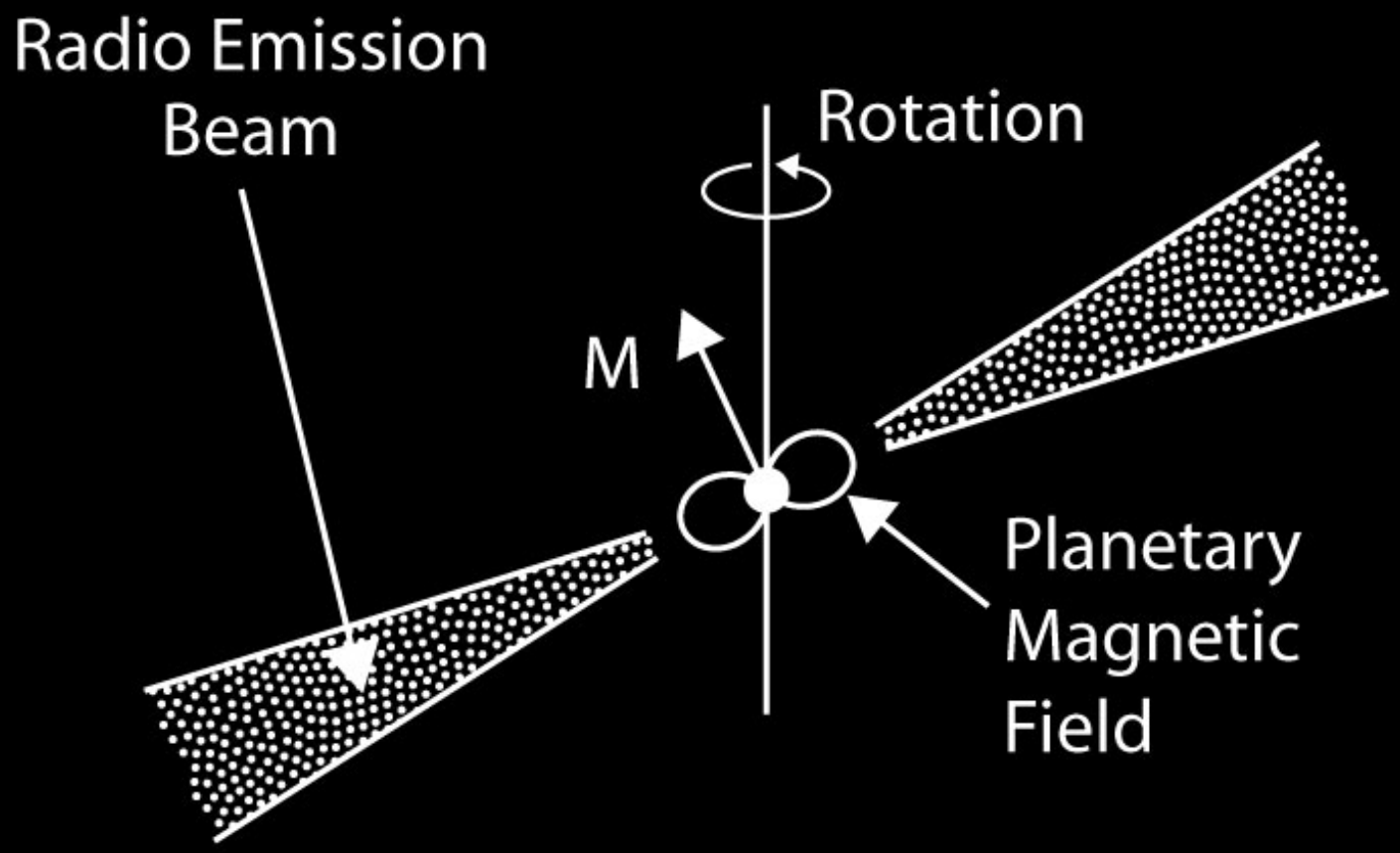
Joint observations of Saturn kilometric radiation, Saturn's UV aurora, and the impinging solar wind shows that all three are correlated.





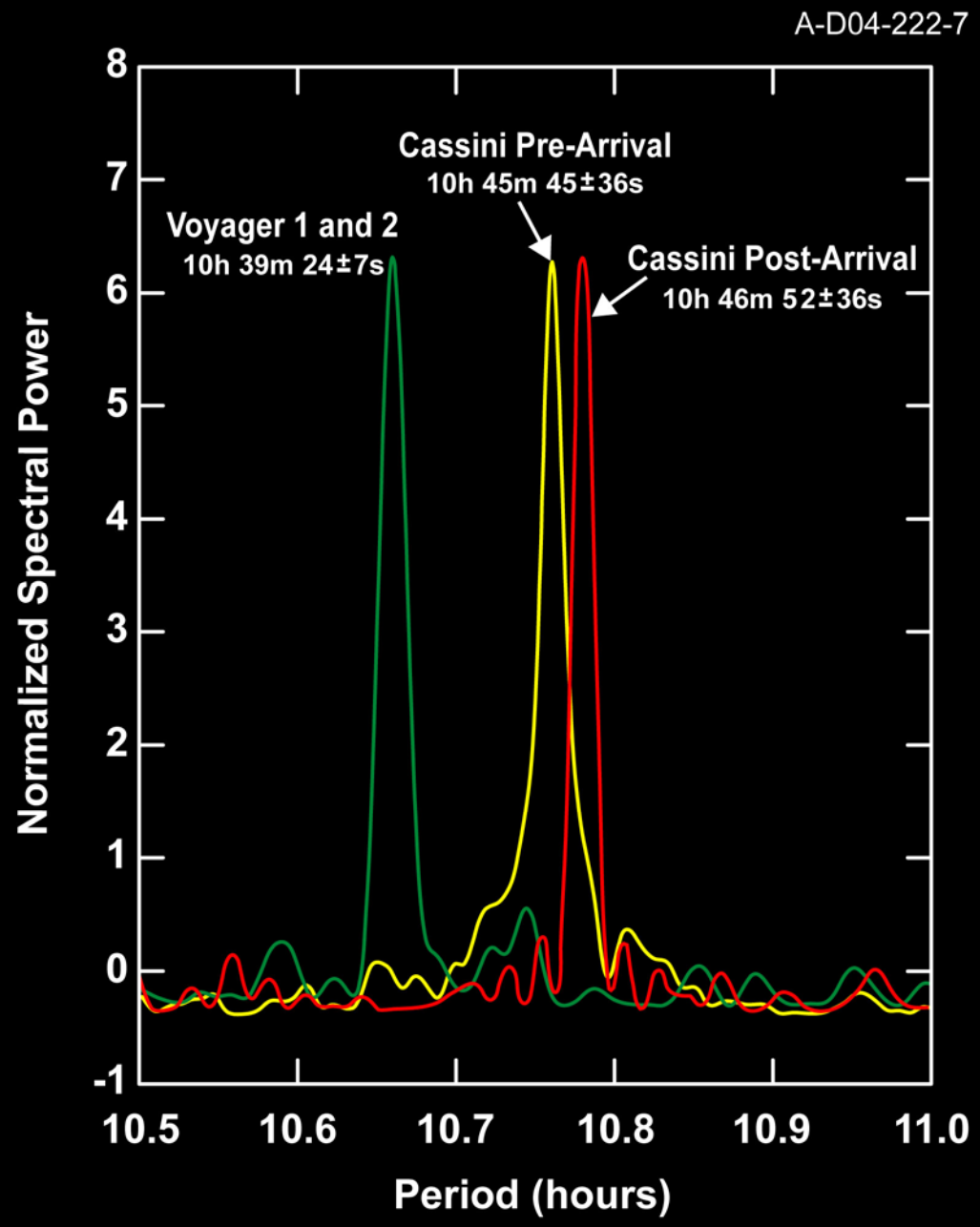

Saturn's Rotation
A-D04-208-2
Frequency (Hz)
10^6
10^5
10^4
June 2, 2004
June 7
Signal Strength (decibels)
20
18
16
14
12
10
8
6
4
2
0
Saturn
Rotation
Radio
Emission
Saturn
Cassini
Radio
Source
Magnetic Field

The Rotation Periods of The Giant Planets



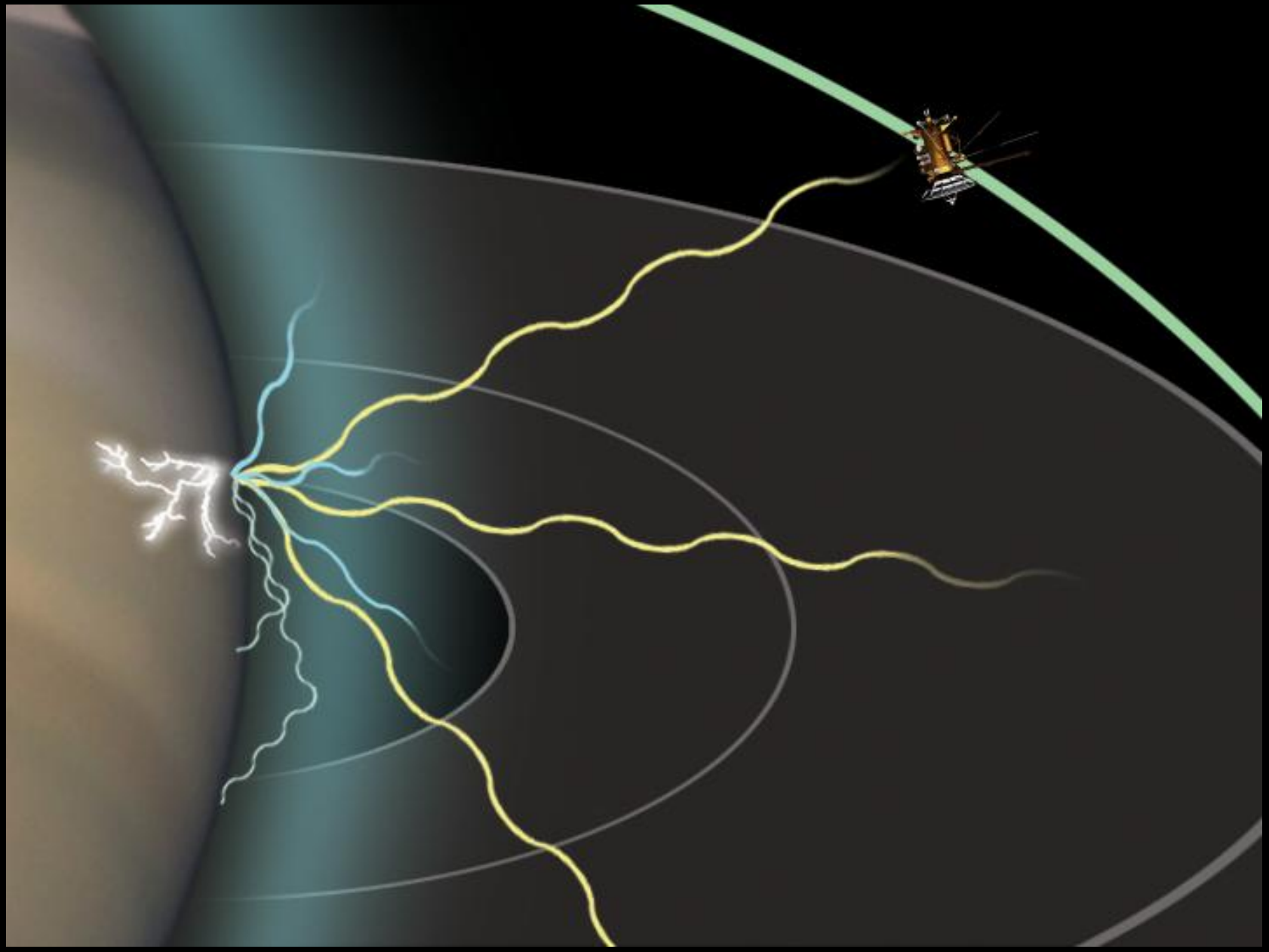
Saturn Radio Modulation Period

The period of the ‘rotational’ modulation of SKR has varied significantly not only since the Voyager 1 flyby in 1980, but even over the Cassini approach and orbital tour phases.



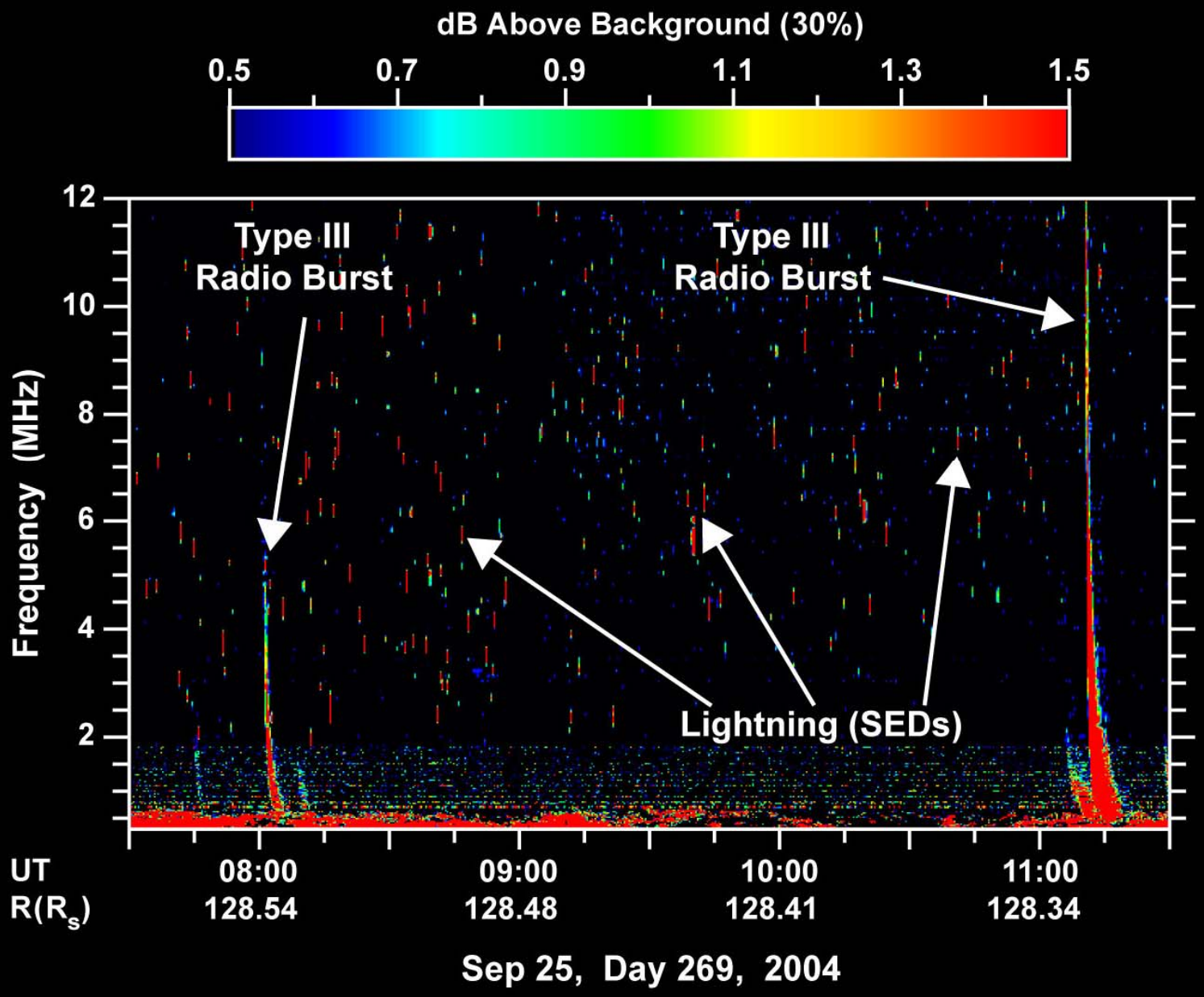
SKR Summary

- Saturn Kilometric Radiation is a radio emission produced as a part of the process which produces auroras on Saturn.
- The intensity of SKR correlates with the intensity of the aurora and both are stronger when the solar wind pressure is larger.
- Fine spectral features in the SKR spectrum are due to tiny radiation sources moving up and down magnetic field lines threading the aurora
- The 10h 45m period of SKR is thought to be related to the rotation of the deep interior of the planet, but we are puzzled by its variation in time.



Saturn Lightning (SEDs)

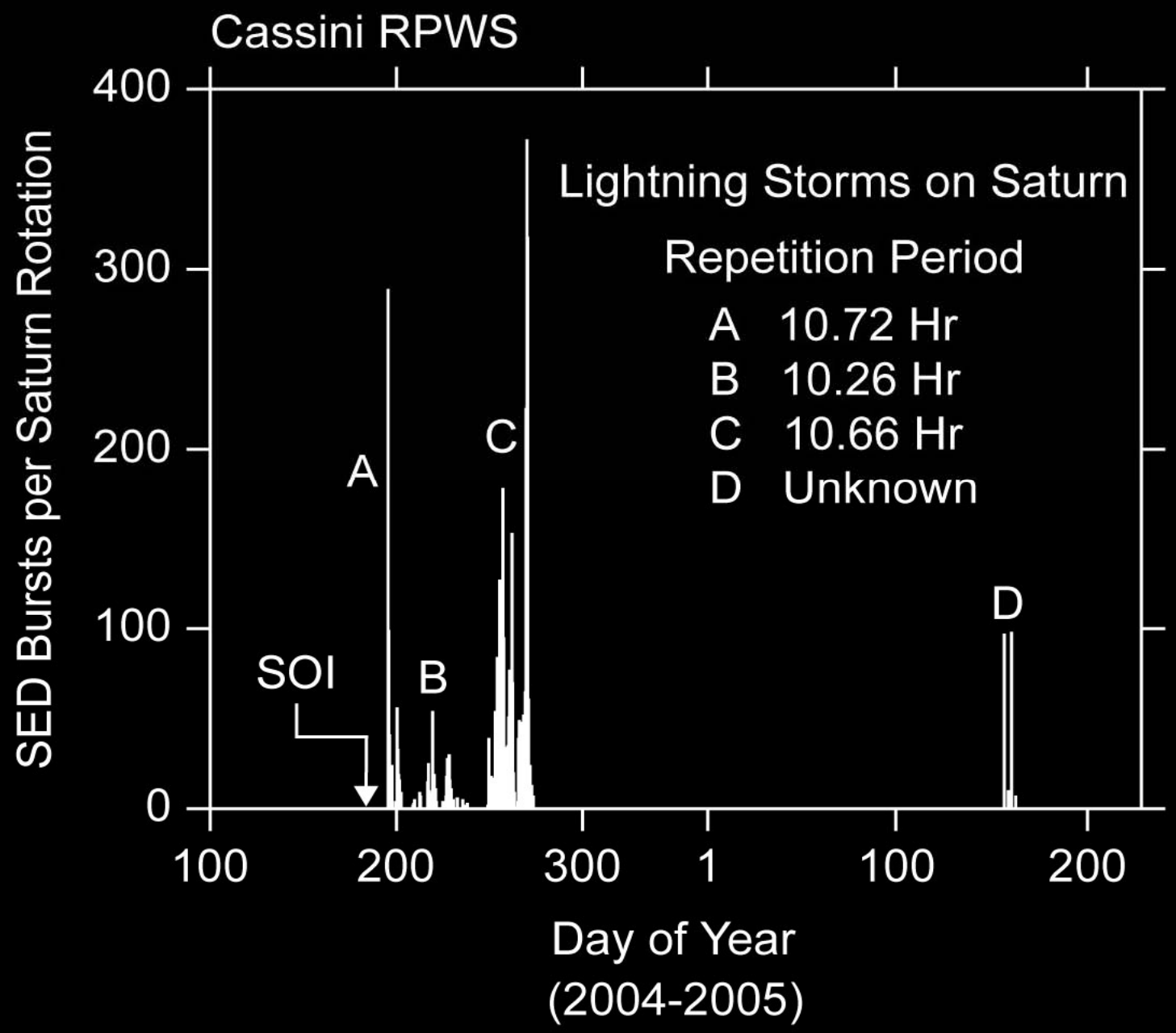
A-D05-142-1

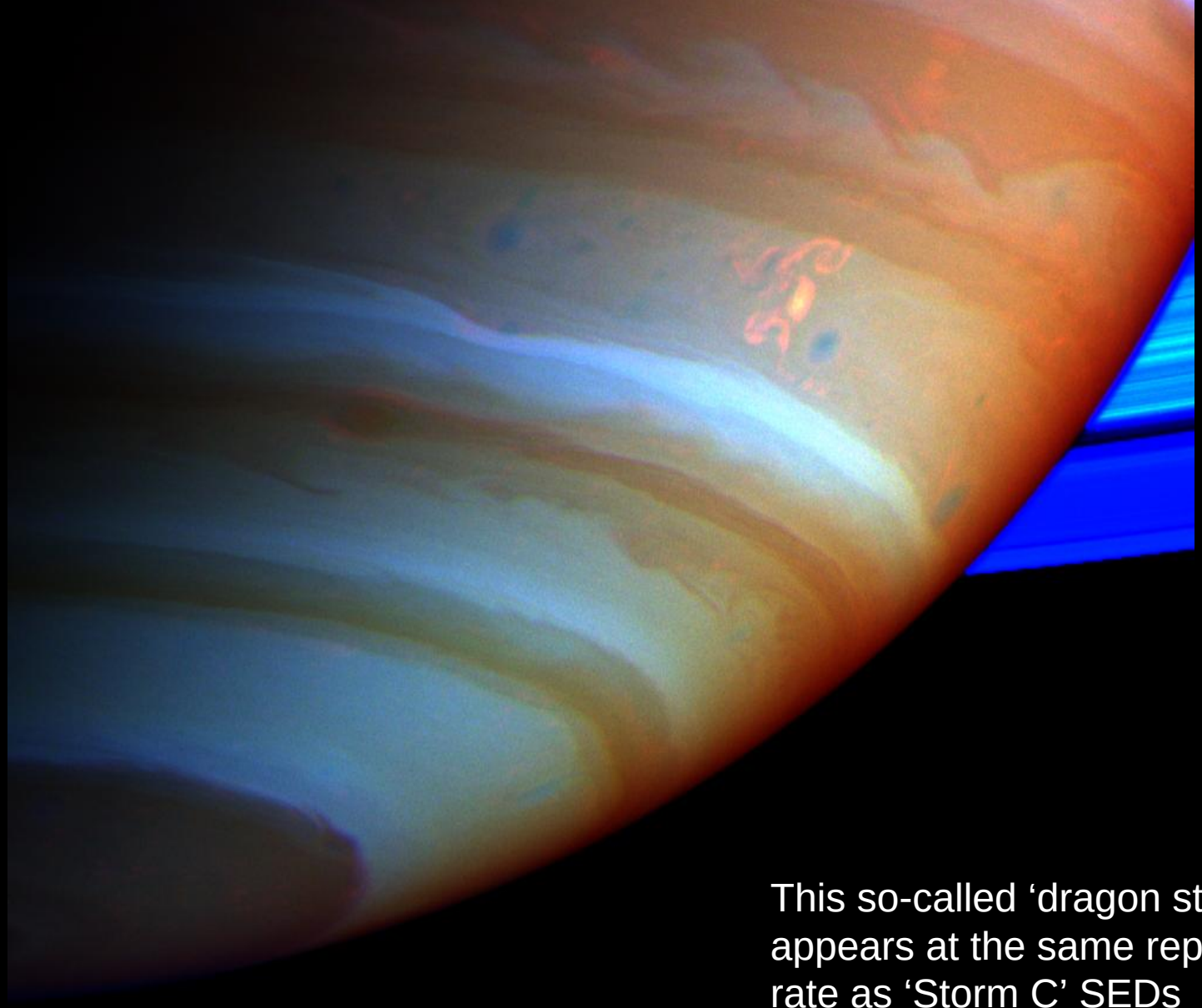


Source of Saturn electrostatic discharges inferred from Voyager observations in the early 1980’s.

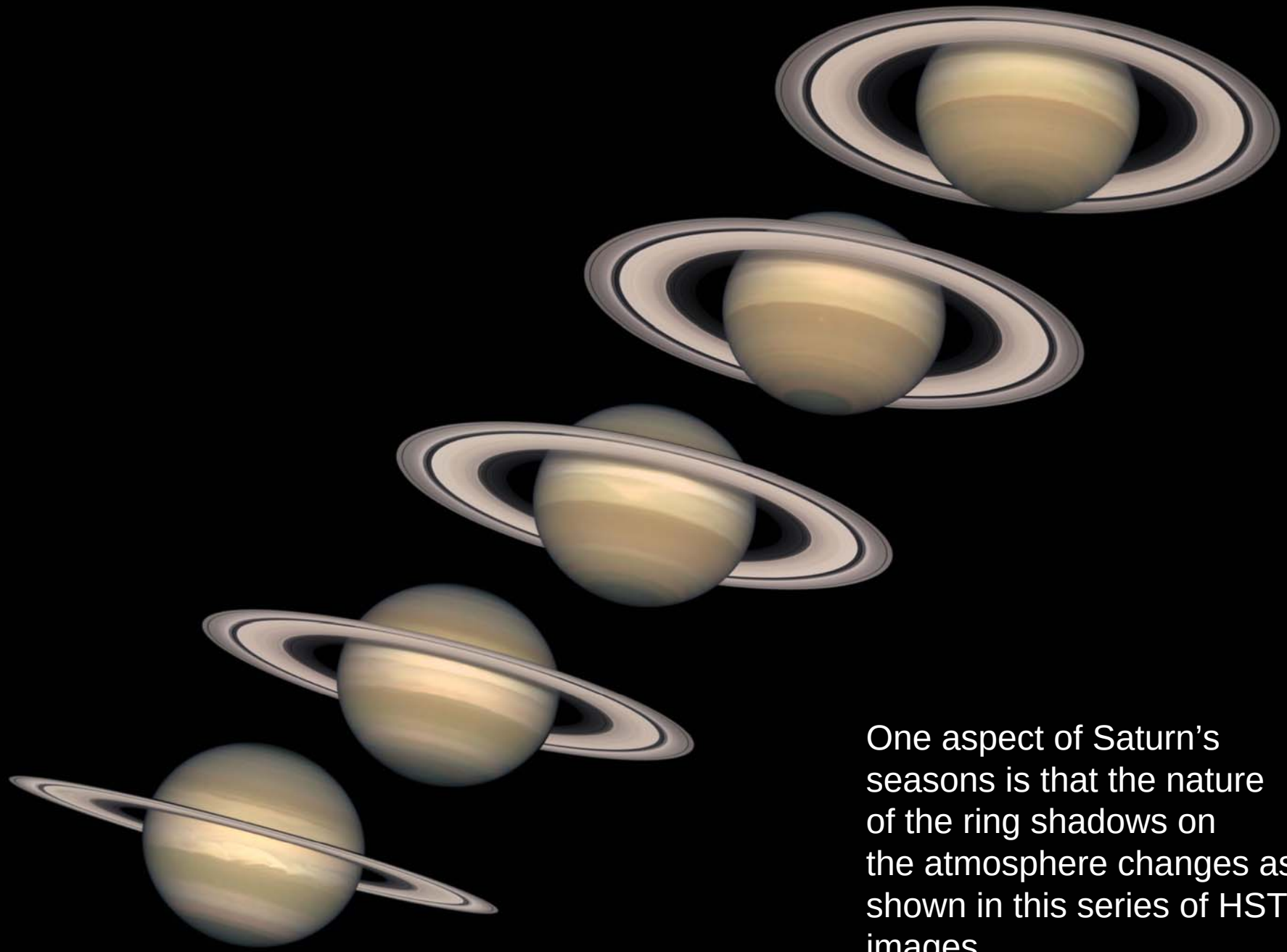
Lightning Storms at Saturn

A-D05-173-3





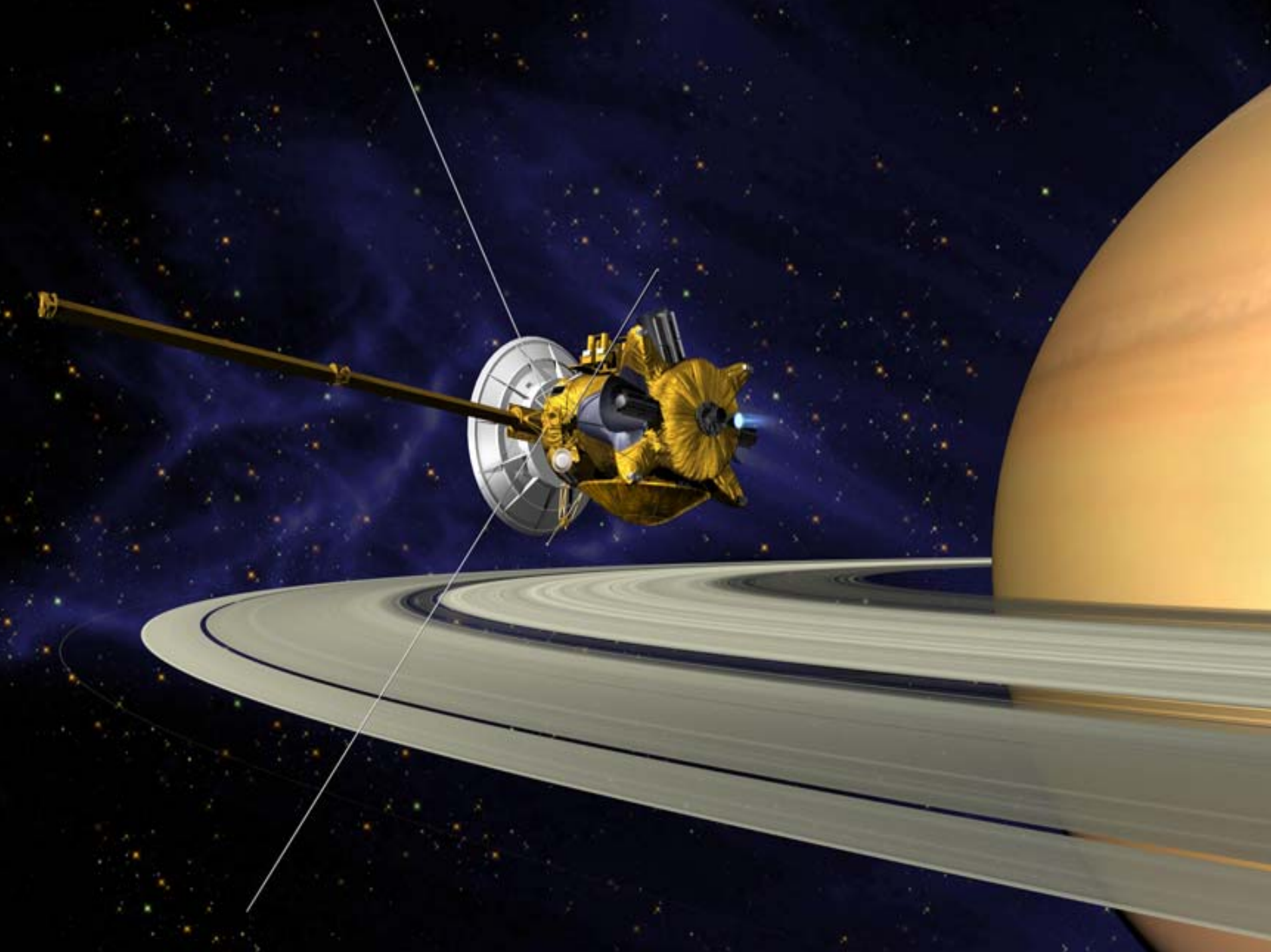
This so-called ‘dragon storm’ appears at the same repetition rate as ‘Storm C’ SEDs

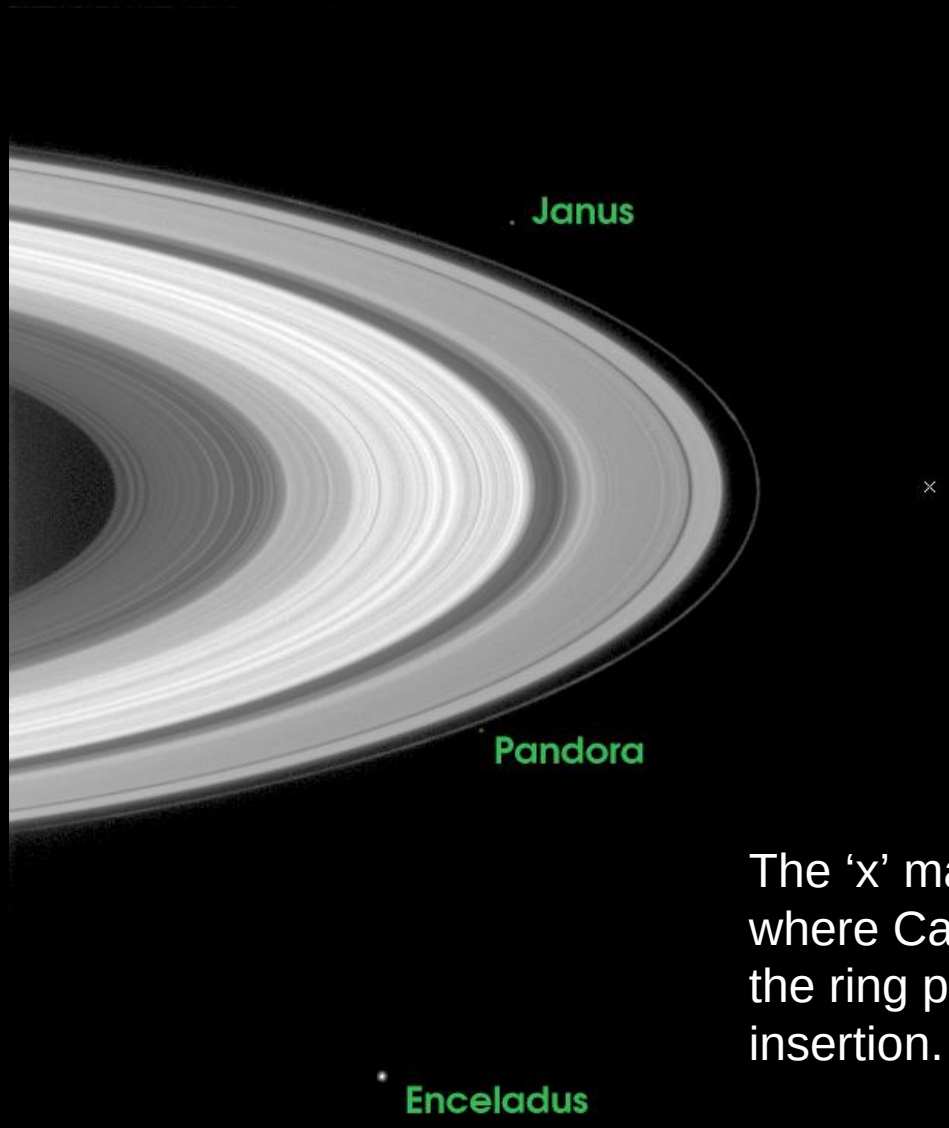


One aspect of Saturn’s seasons is that the nature of the ring shadows on the atmosphere changes as shown in this series of HST images.

Lightning Summary

- Saturn electrostatic discharges are radio emissions produced by lightning in Saturn’s atmosphere.
- There is a correspondence between some of the observed SEDs and a convective cloud feature in the atmosphere.
- The occurrence of SEDs observed by Cassini is much less regular than that observed by the Voyagers.
- One possible reason for the difference in the occurrence of SEDs now vs. in the Voyager era is the season on Saturn, possibly related to the nature of the ring shadow on the ionosphere or atmosphere.

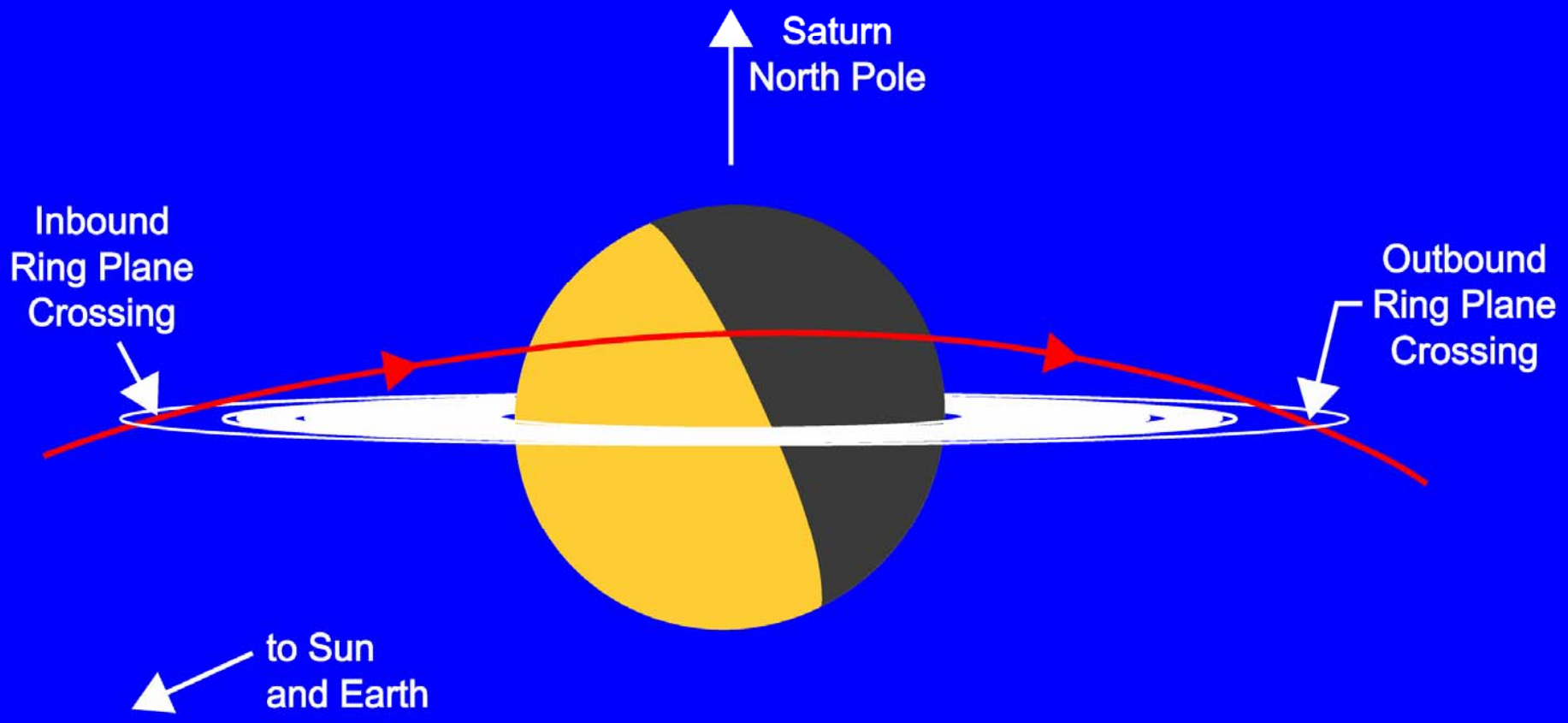




The ‘x’ marks the location where Cassini passed through the ring plane prior to orbit insertion.

Dust Impacts at the Ring Plane Crossings

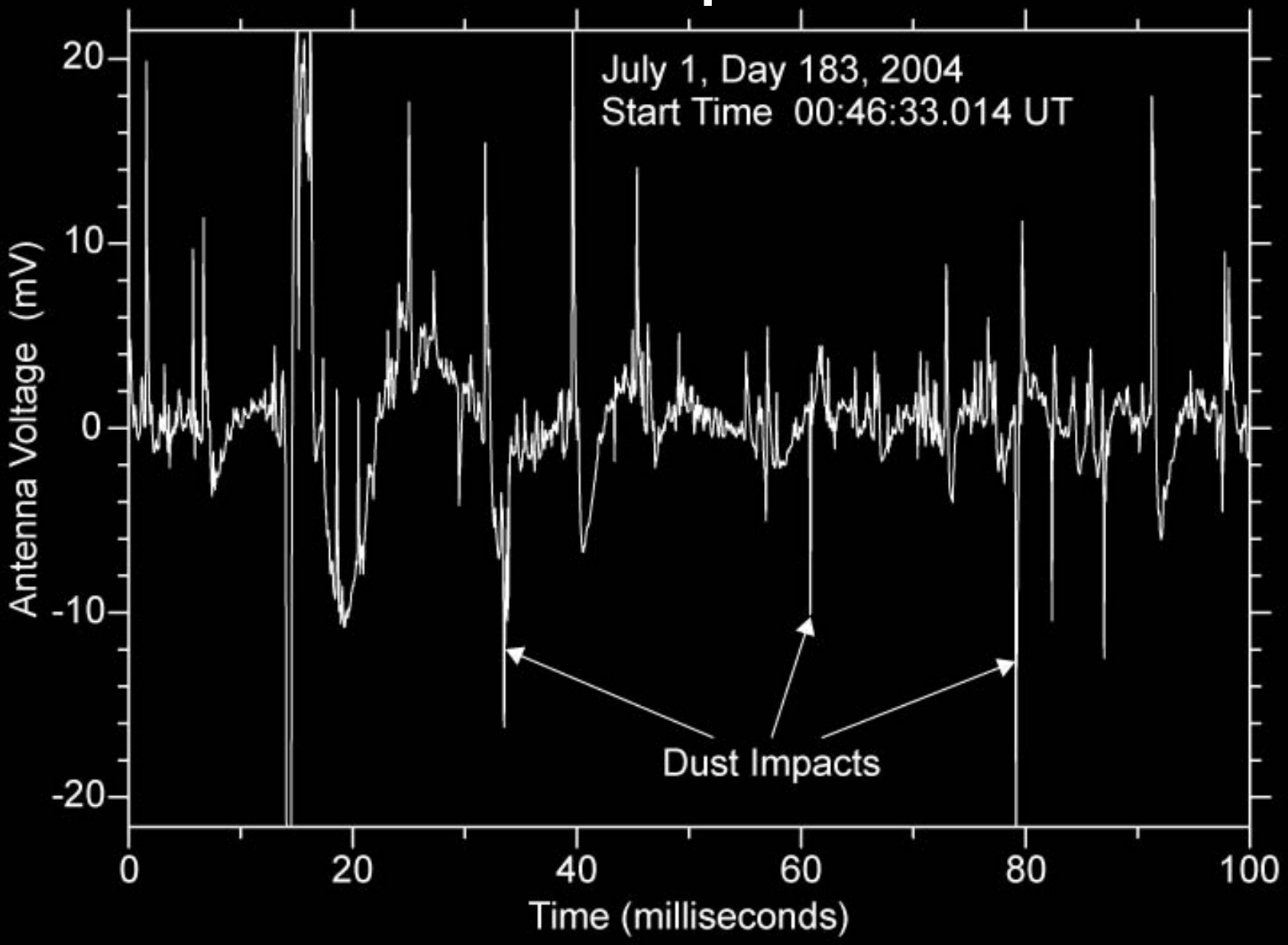
A-D04-218-5



Inbound

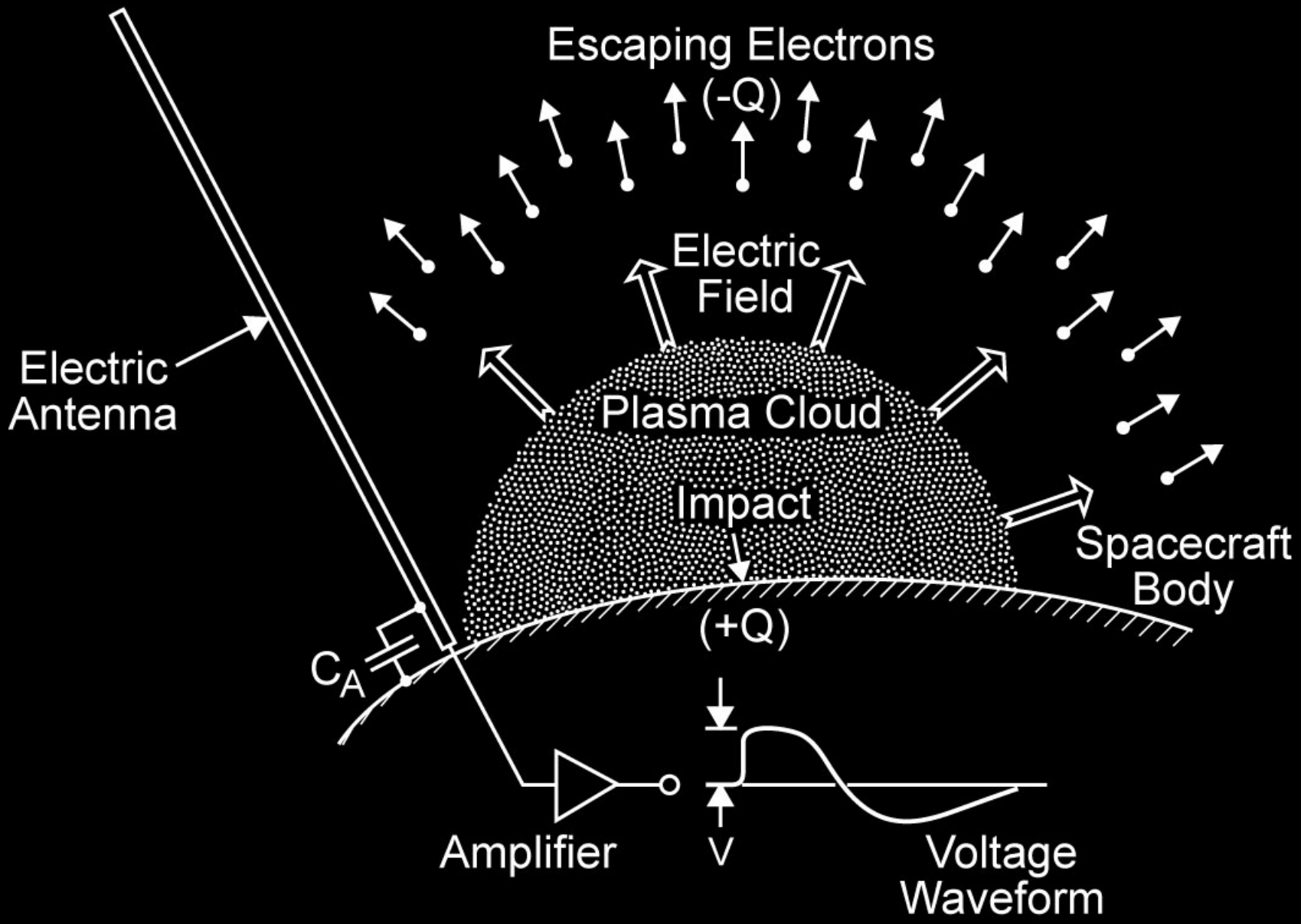
Outbound

Dust Impacts



Dust Impact Coupling Mechanism

A-D05-83-1



Dust Summary

- The RPWS is an effective dust detector, utilizing the entire spacecraft as a target.
- However, the RPWS cannot determine the dust velocity, or composition, as can be done with CDA.
- Just before and after Saturn orbit insertion, RPWS detected more than 1000 dust impacts per second as it crossed the ring plane.

RPWS Links

- RPWS home page, including links to sounds and animations included in this presentation:
  - http://cassini.physics.uiowa.edu/cassini/
- Space audio page including sounds from Cassini RPWS and other plasma wave investigations:
  - http://www-pw.physics.uiowa.edu/space-audio/