

Skylight Astronomical Society

Probes to the Outer Solar System Past, Present and Future

Spotlight on: Cassini

Terry P. Riopka, President of Skylight Astronomical Society - 2018

Probes to the Outer Solar System Past and Present

Launch
Date

1972 Pioneer 10

1973 Pioneer 11

1977 Voyager 2

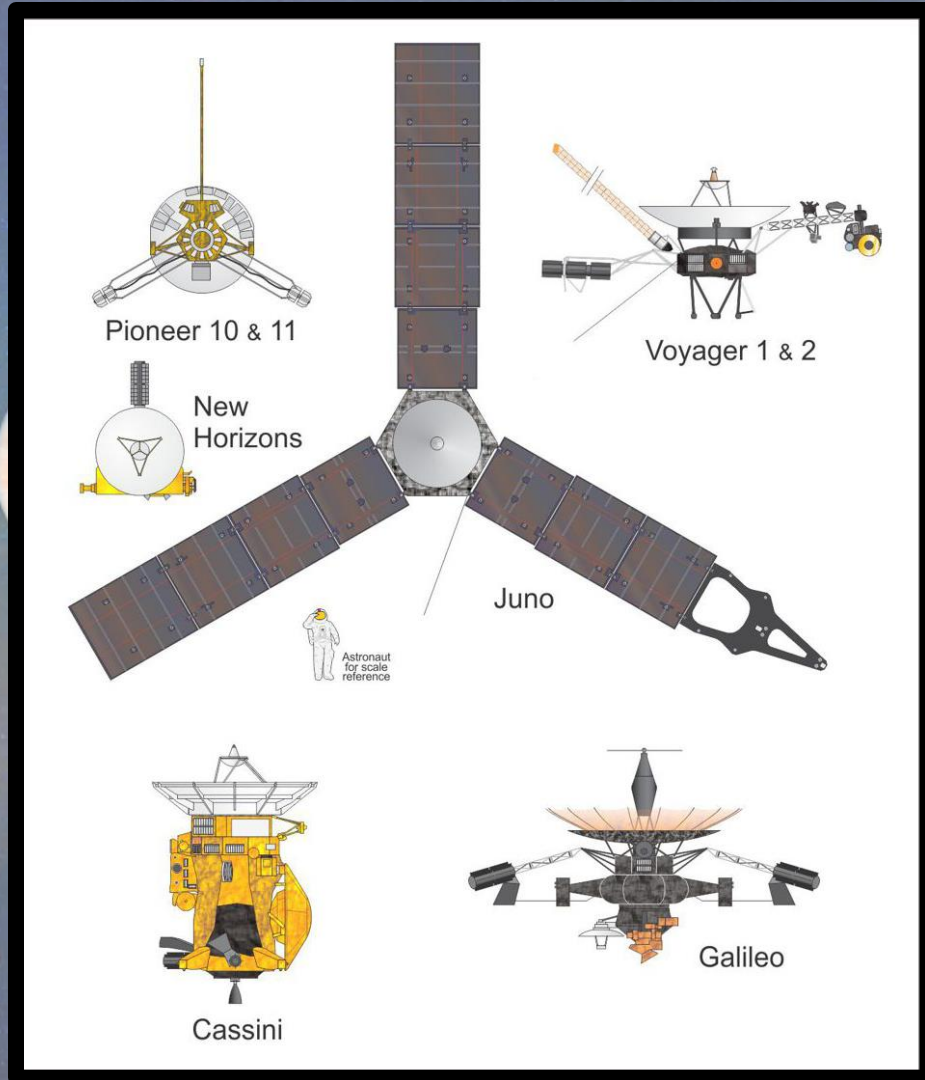
Voyager 1

1989 Galileo

1997 Cassini-Huygens

2006 New Horizons

2011 Juno



Probes to the Outer Solar System

Cassini-Huygens



1982 – ESA/NASA joint mission to Saturn-Titan proposed

1988/1989 – received full funding

1994-1997 – lawsuits and protests against Cassini launch

Worse case scenario (1 in a million) during flyby

- entire population (5 billion) exposed, causing additional 5000 deaths over decades

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© Night launch on Titan IVB/Centaur
October 15, 1997

- 2nd-largest unmanned interplanetary spacecraft, 8.7 mi of cabling
- powered by 3 radioisotope thermoelectric generators (RTGs) using 33 kg (73 lb) of PU-238

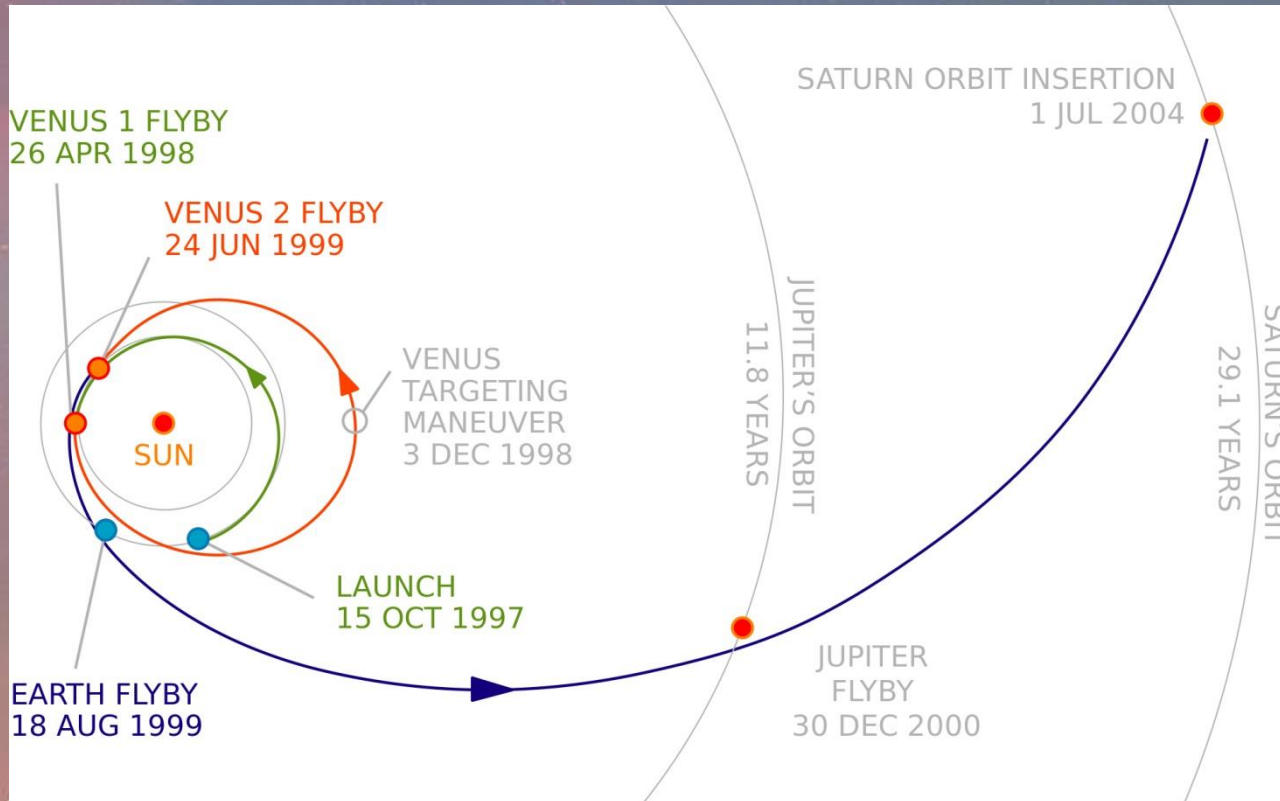
Probes to the Outer Solar System

Cassini-Huygens

Spacecraft	Instruction Memory	Imaging System	Data Rate	Data Storage
Pioneer	Up to 5 of 222 commands	2-color imaging photopolarimeter	256 bits/s	6144 bytes
Voyager	6 computers, total 32K RAM	800x800 slow-scan vidicon; 2 cameras each w/ 8 filters	115,000 bits/s	64 Kb 8-track digital tape
Galileo	6 RCA1802 (comp to Apple II) 176K RAM	800x800 CCD with 8-position filter wheel	134,000 bits/s (Actual: 160 bits/s with compression)	4-track 114MB digital tape
Cassini	2 MIL-STD-1750A	2 1024x1024 CCD cameras with 2x12 filters and 2x9 filters	366,000 bits/s 2700 photos per month	2 Gbit solid state recorders

Probes to the Outer Solar System

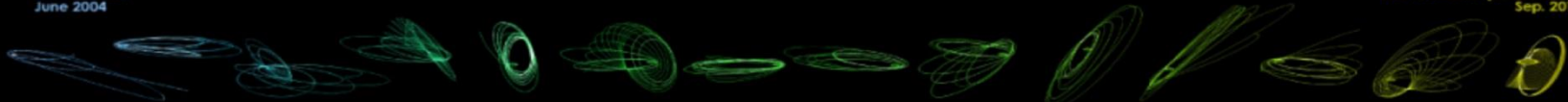
Cassini-Huygens



- flyby of asteroid 2685 Masursky at a distance of 1.6 million
- 26,000 pictures of Jupiter
- Improved accuracy general theory of relative prediction from 1/1000 to 1/51,000

Saturn arrival
June 2004

End of Mission (Saturn entry)
Sep. 2017



2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
3 orbits	17 orbits	17 orbits	19 orbits	44 orbits	24 orbits	20 orbits	16 orbits	19 orbits	22 orbits	11 orbits	18 orbits	26 orbits	38 orbits

Titan flybys (127)

Cassini-Equinox

Cassini-Solstice



Enceladus Flybys (23)



Icy Satellite Flybys (15)



Proximal Orbits
(22 pass between planet and rings)



Saturn atmospheric entry
Sep. 15, 2017

Saturn seasons (northern)

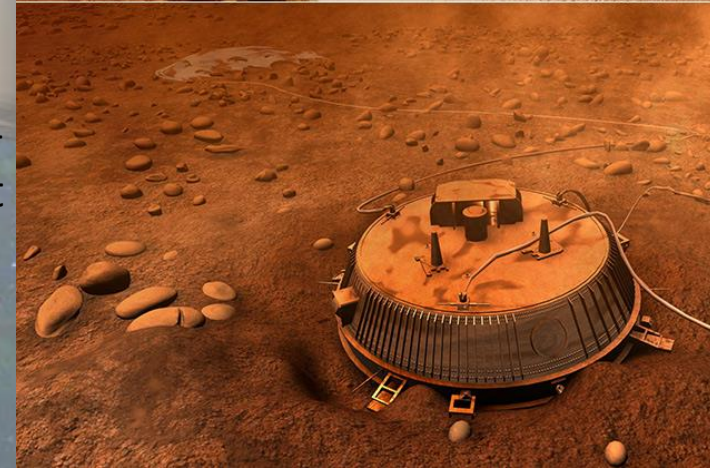
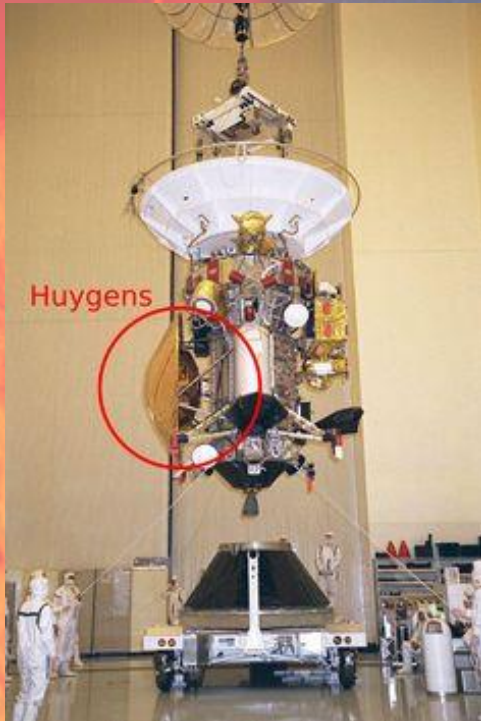


Probes to the Outer Solar System

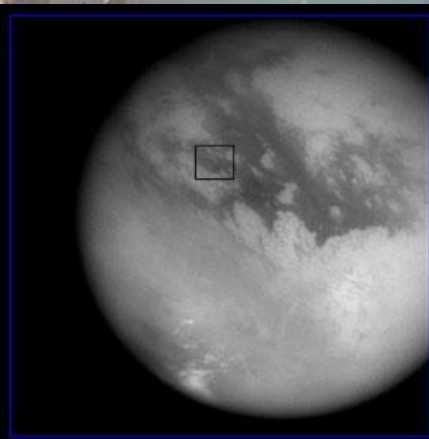
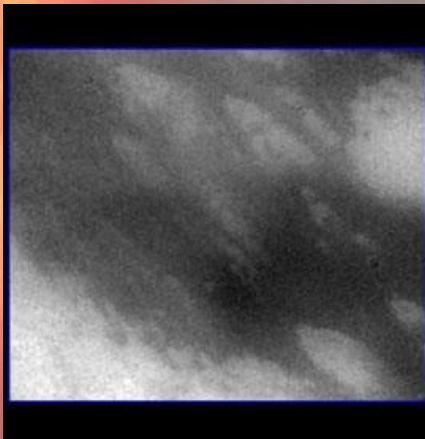
Huygens

- detached from Cassini on Dec. 25, 2004
- landed on Titan on Jan. 14, 2005 after 4 hour descent
- sent back data for 90 min. after touchdown
- Cassini angle and distance relative to Huygens had to change to compensate communication for Doppler shift

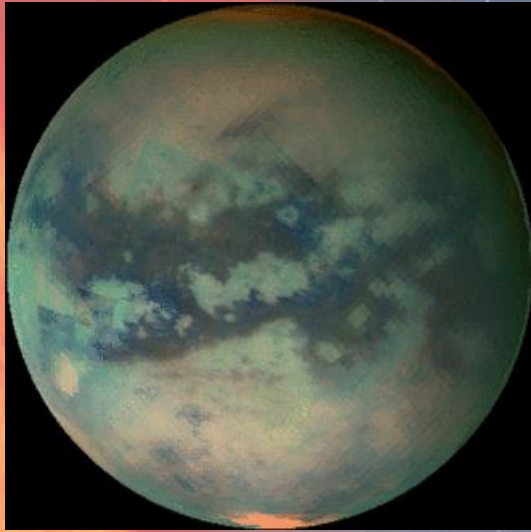
Entry speed: 6.2 km/s



- first spacecraft to land on Titan, on a body in the outer solar system, and first landing on a moon other than our own



Titan



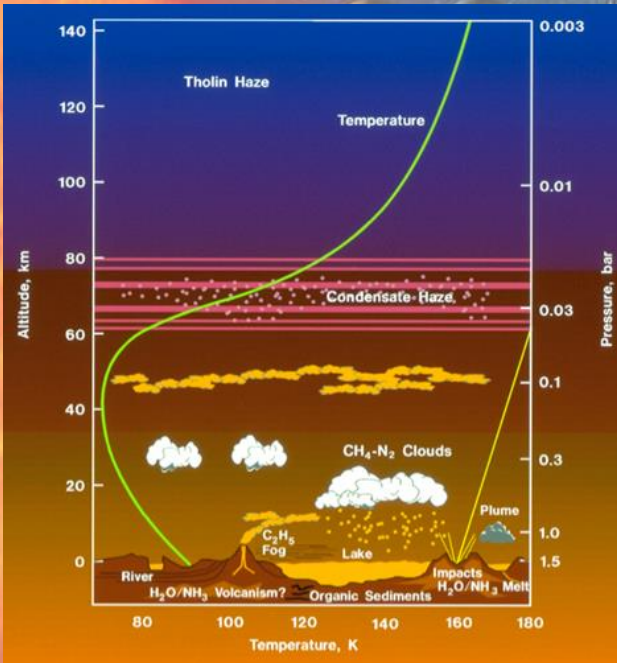
Titan –Global View



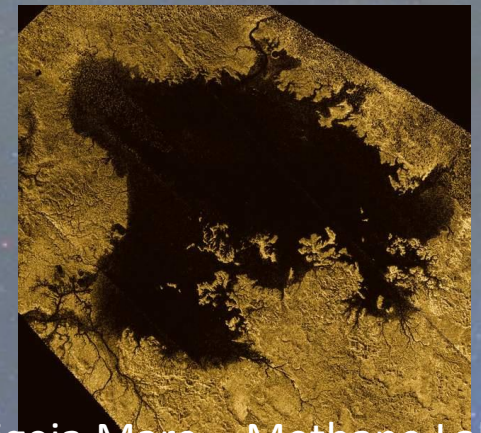
South Polar Vortex



Huygens Landing Spot



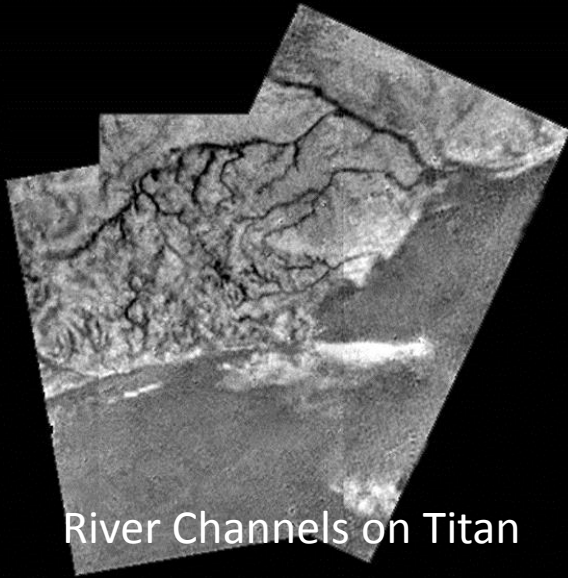
- surface: damp sand made of ice grains, temperature -291F
- rocks 2-6 inches in size
- orange sky, brightness comparable to light 10 min after sunset on Earth
- solar disk 1/10 of our size



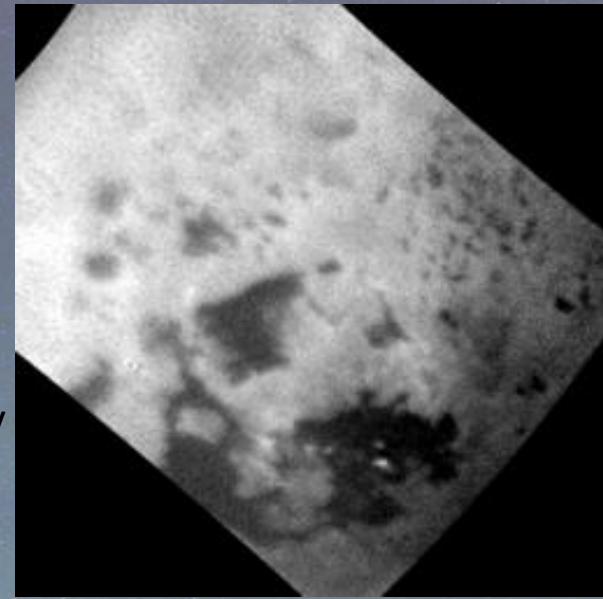
Ligeia Mare – Methane Lake

Titan

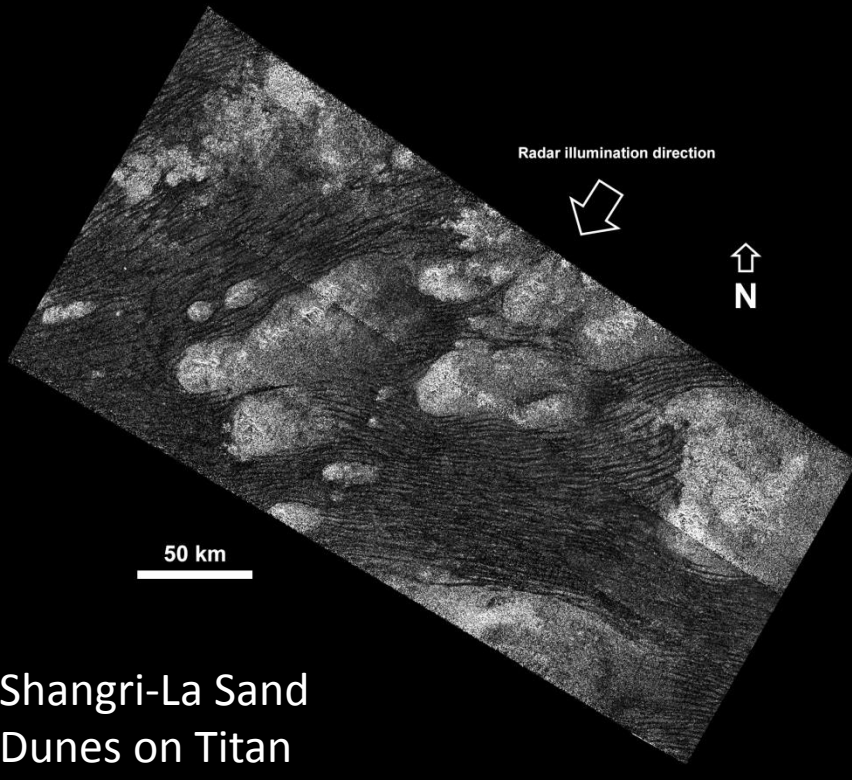
- larger than Mercury but 40% as massive
- 98.4% nitrogen, 1.6% methane, rest hydrocarbons
- supporting evidence for water/ammonia layer & ice shell decoupled from solid core



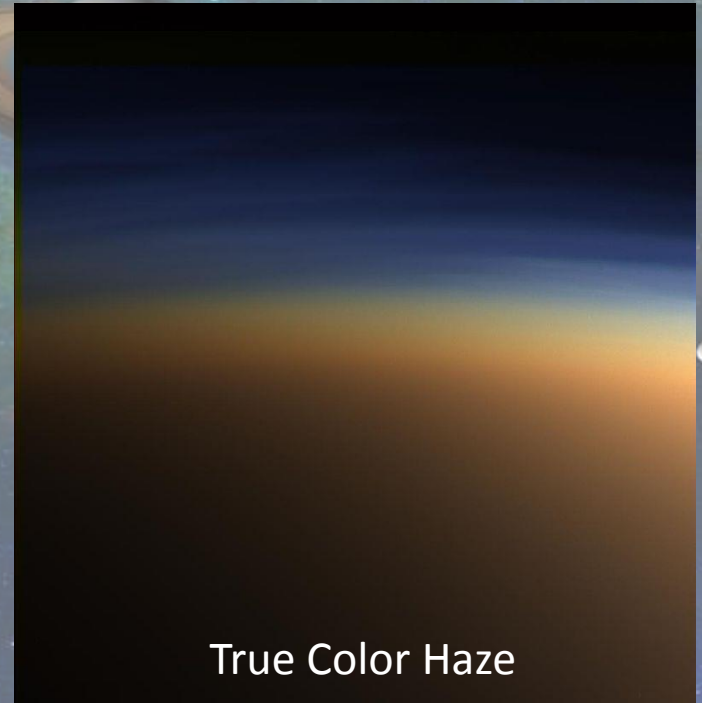
River Channels on Titan



Forming Methane Clouds

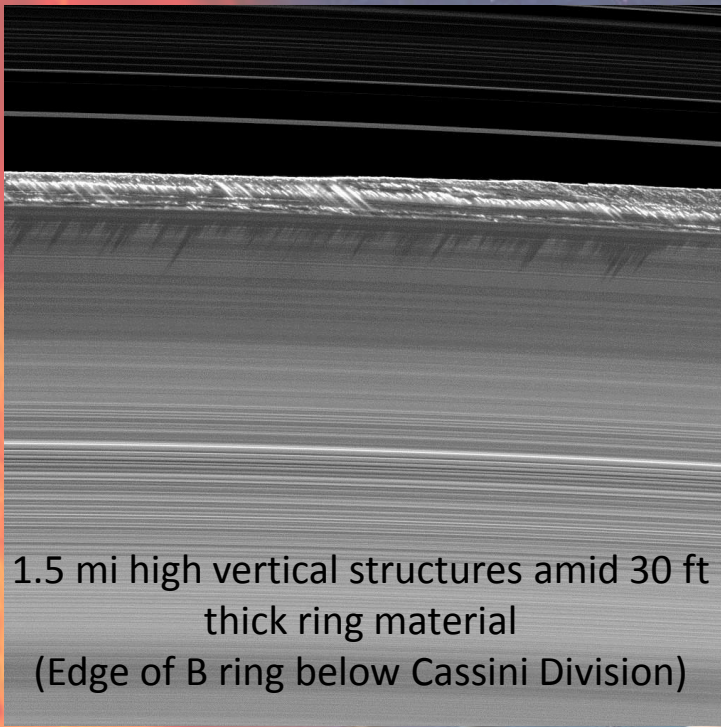


Shangri-La Sand Dunes on Titan

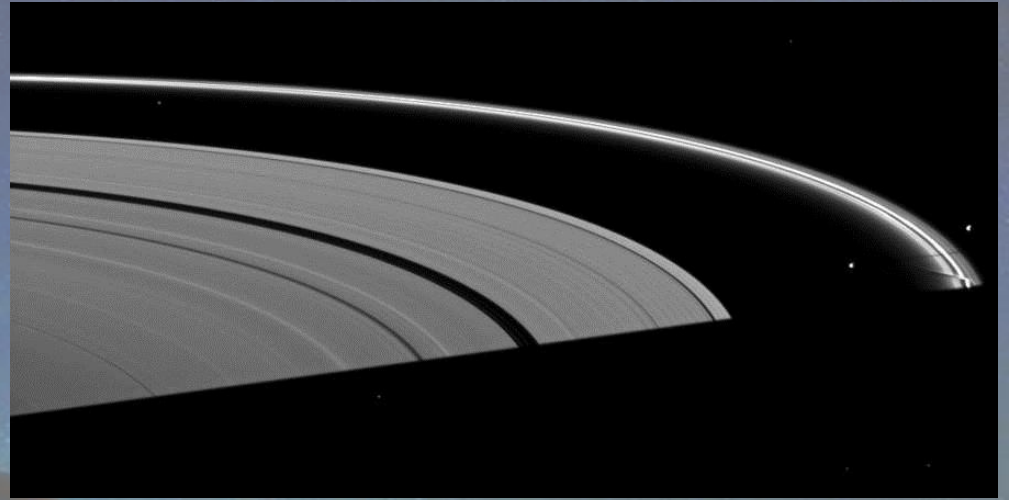


True Color Haze

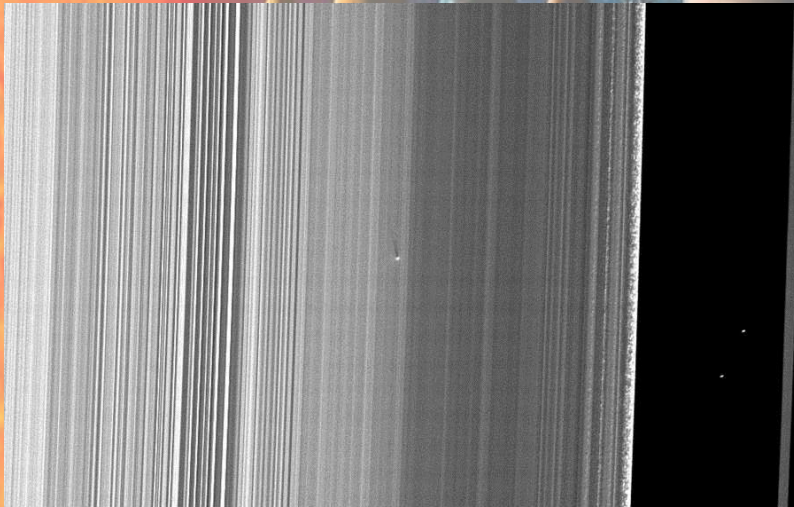
Saturn's Rings



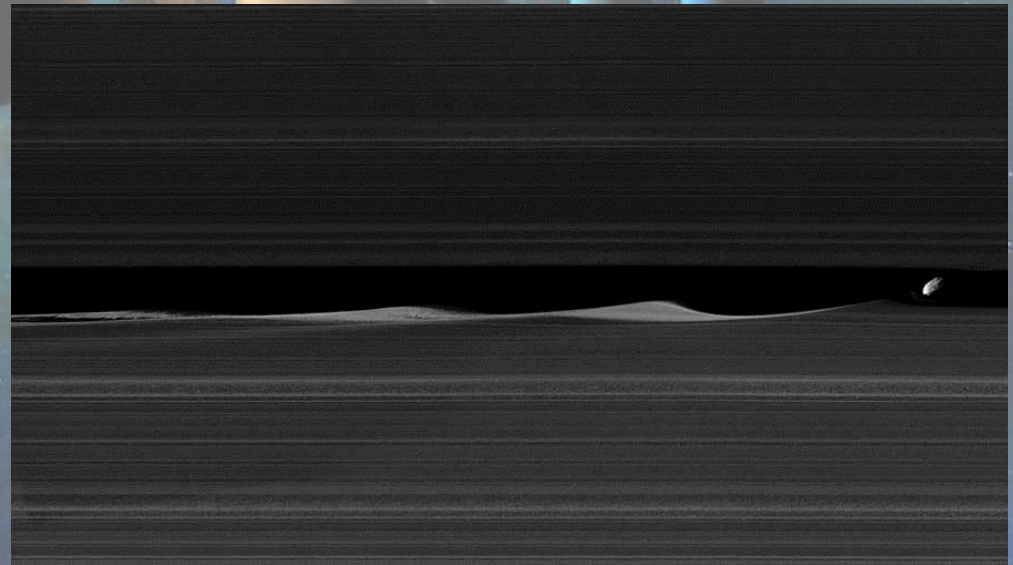
1.5 mi high vertical structures amid 30 ft thick ring material
(Edge of B ring below Cassini Division)



Pandora and Prometheus Shephard Moons

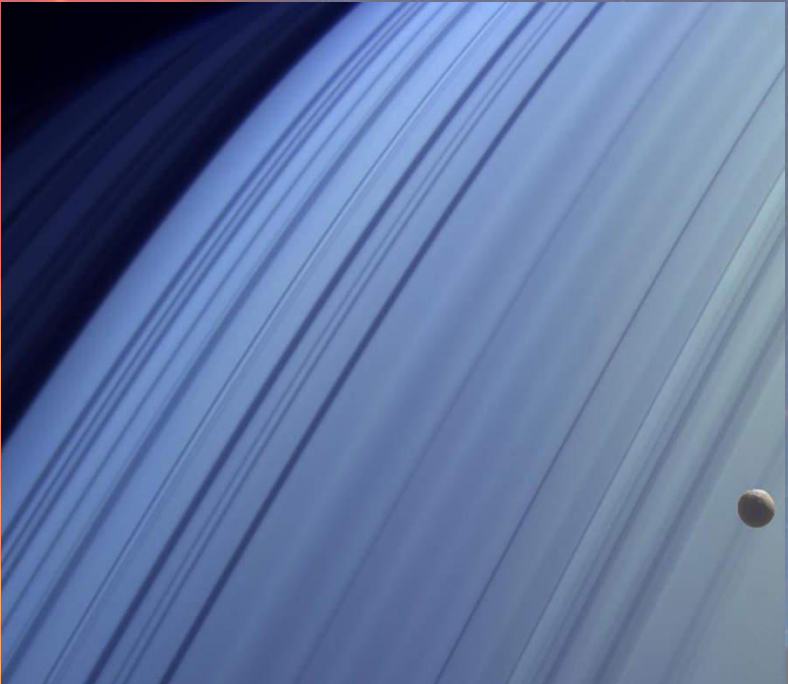


Moonlet Forming Inside Rings

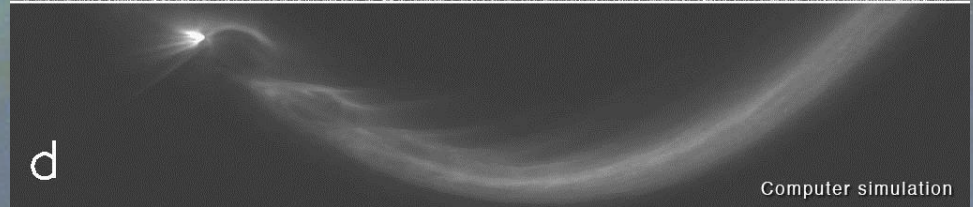
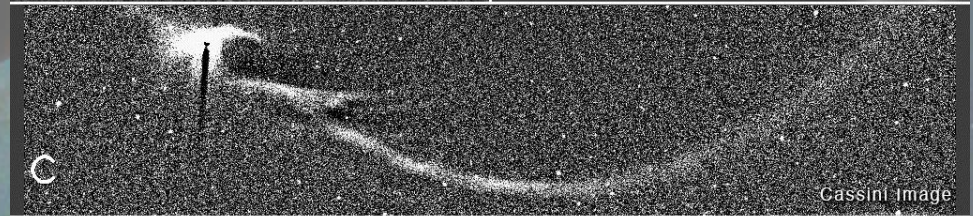
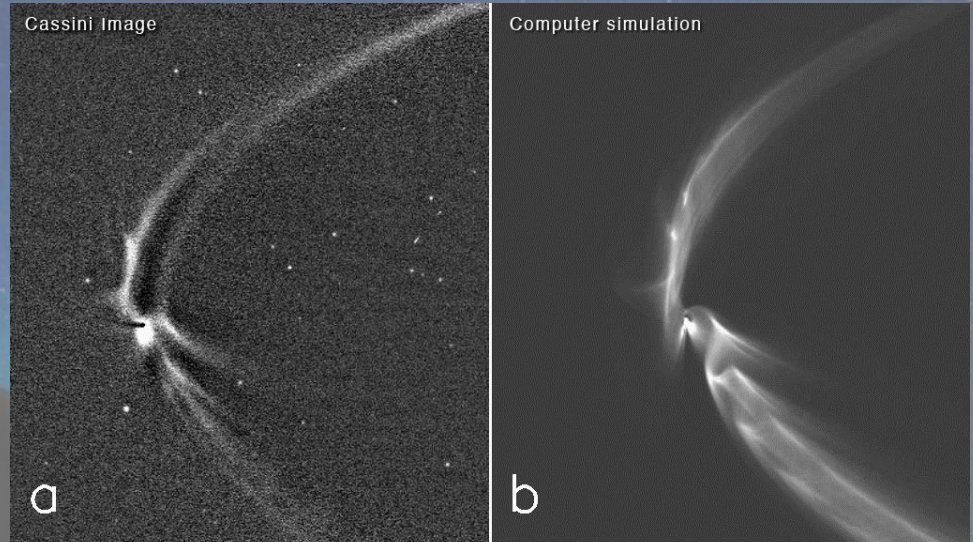


Newly discovered Daphnis Moon Causing ring waves

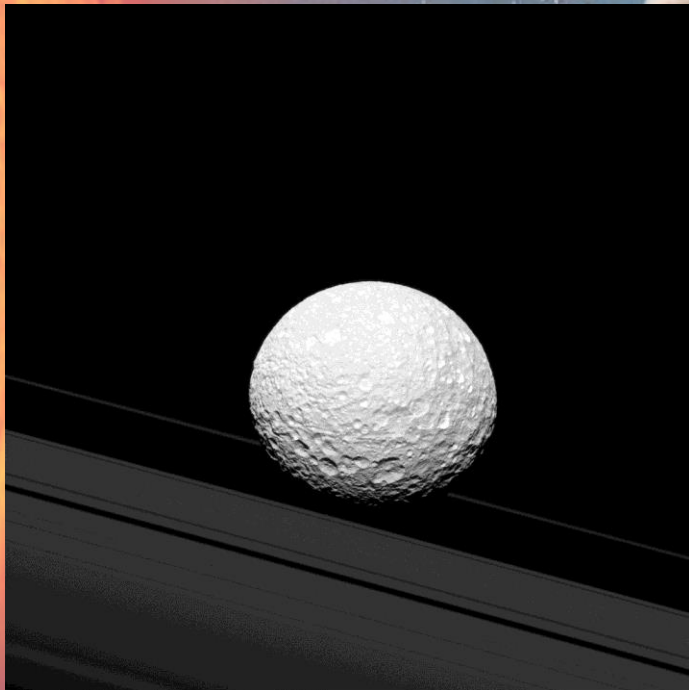
Saturn's Rings



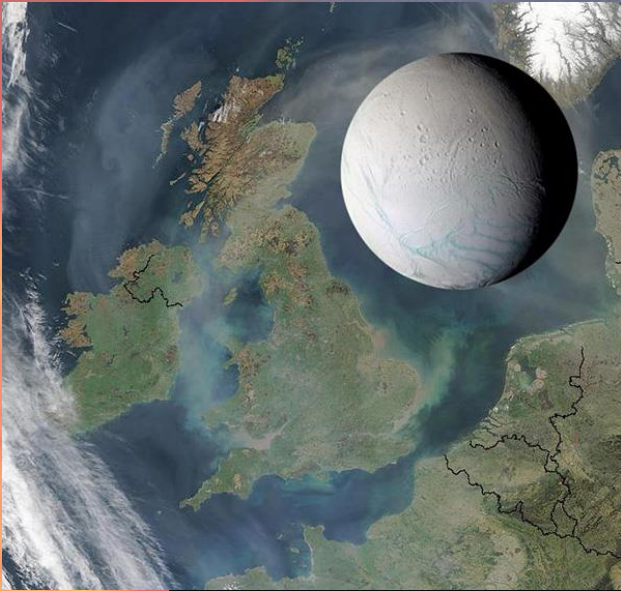
Mimas and the Cassini Division



Enceladus guysers feed tendrils

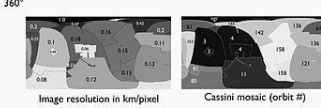
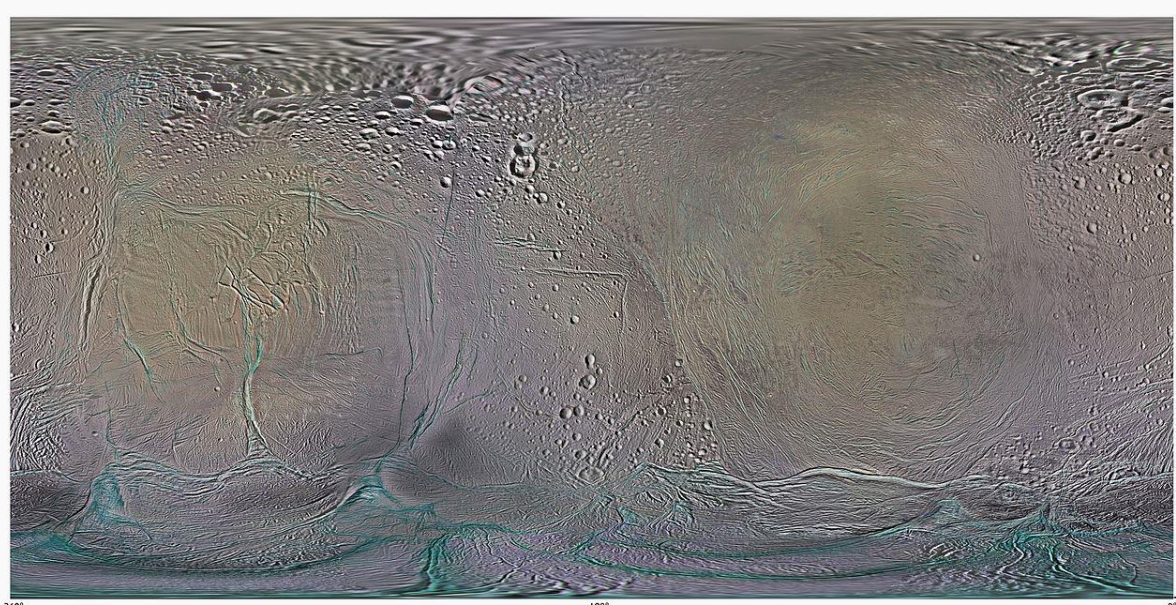


Saturn's Moons



Enceladus

- evidence of large salty internal ocean of liquid water in Enceladus
- one of the most likely places in the Solar System to host alien microbial life



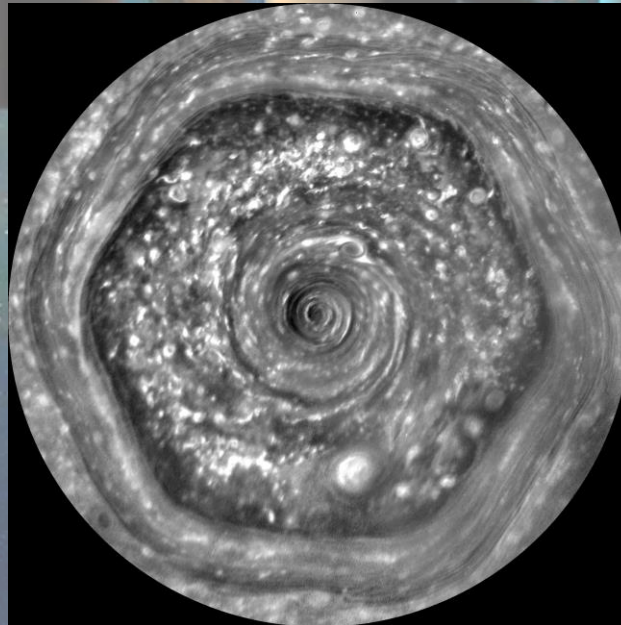
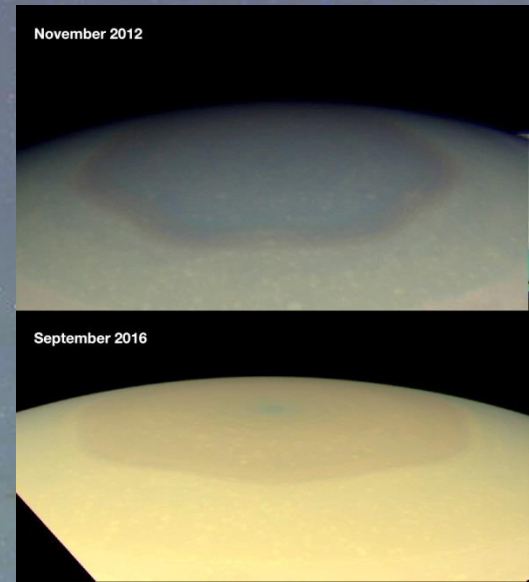
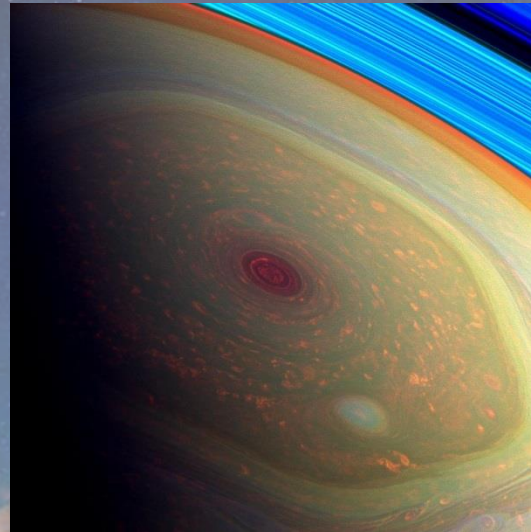
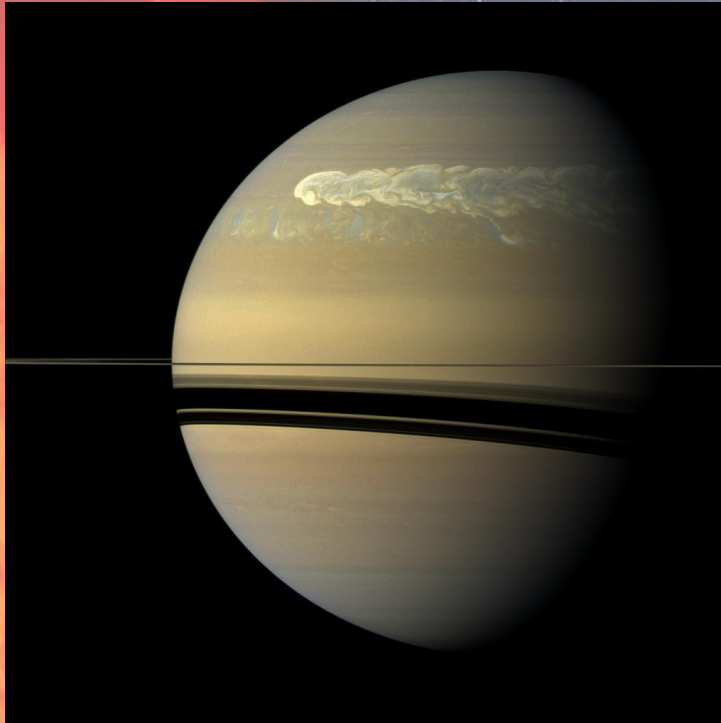
Global 3-Color Map of Enceladus (IR3-GRN-UV3)

April 2014

Cartographic control and digital mosaic construction by Dr. Paul Schenk (LPI, Houston)
Cassini ISS images acquired 2004-2014
Simple cylindrical map projection at 100 meters/pixel (@ Equator)



Saturn – The Planet



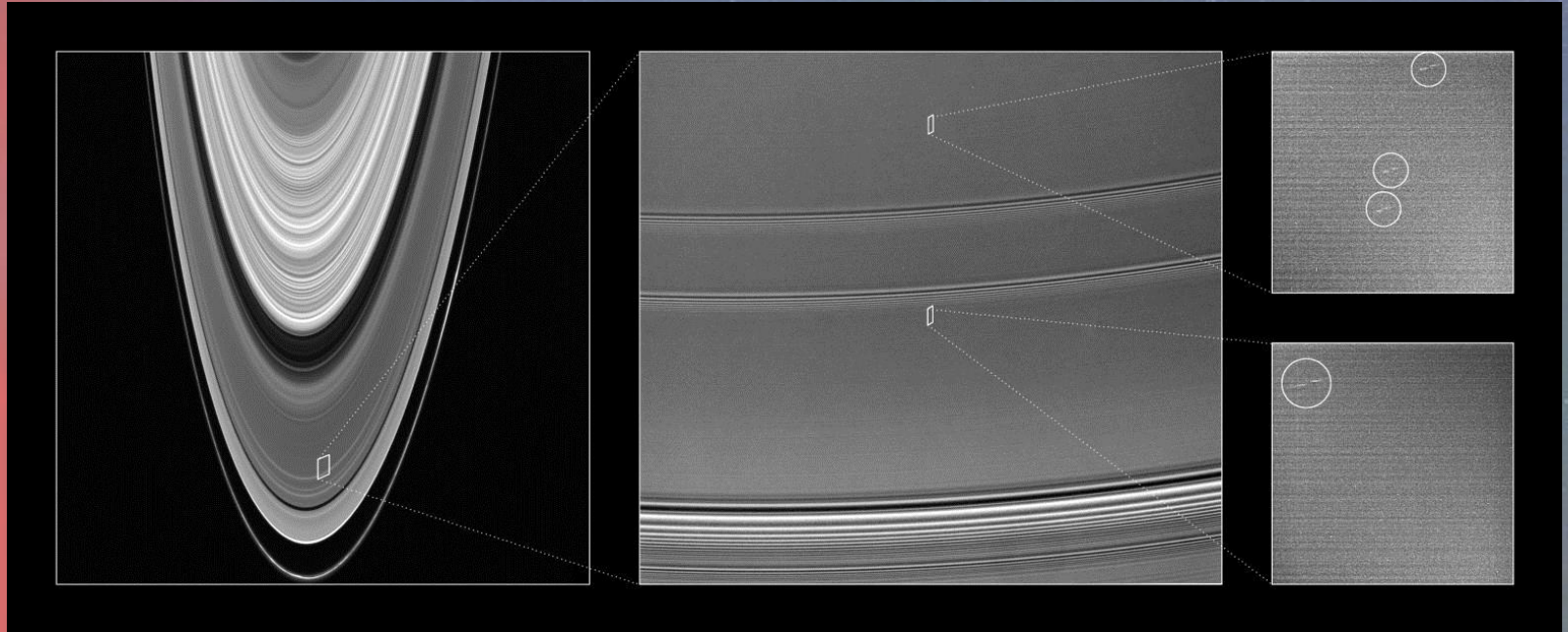
The Great
Hexagon
Hurricane

- Aftermath of Great White Spot storm – caused temperature spike of 149F above normal, and ethylene gas spike 100 times larger than thought possible
- Largest, hottest stratospheric vortex ever detected, initially larger than Red Spot

Cassini – The Grand Finale

Orbits 271-293 (22 orbits)

Orbit 274: Propellers – football field sized moonlets in between density waves



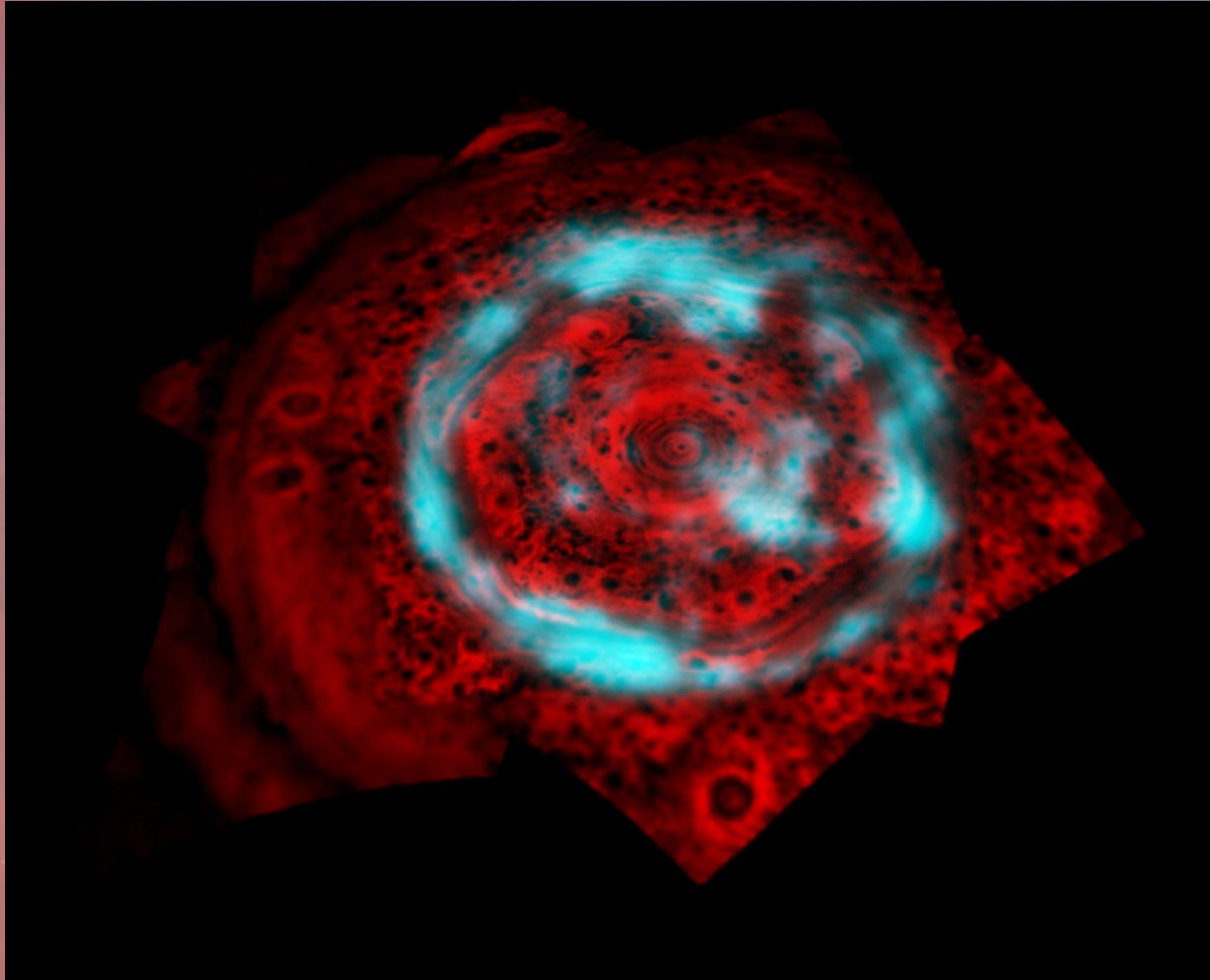
Orbits 274-280 – Gravity experiments, ring occultation experiments, scooping up dust particles

Fun Fact #4998

- over a decade, Cosmic Dust Analyzer collected only 36 interstellar dust particles - identified through direction, speed (45,000 mi/hr) and composition

Cassini – The Grand Finale

Orbit 279: Close-up of Northern Aurora - Composite image of visual and infra-red

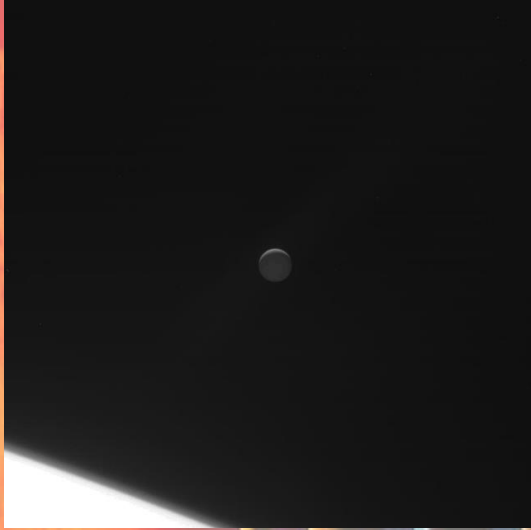


Orbit 288: First direct sampling of Saturn's atmosphere (continued for last 5 orbits)

Orbit 292: "Goodbye kiss" from Titan

Cassini – The Grand Finale

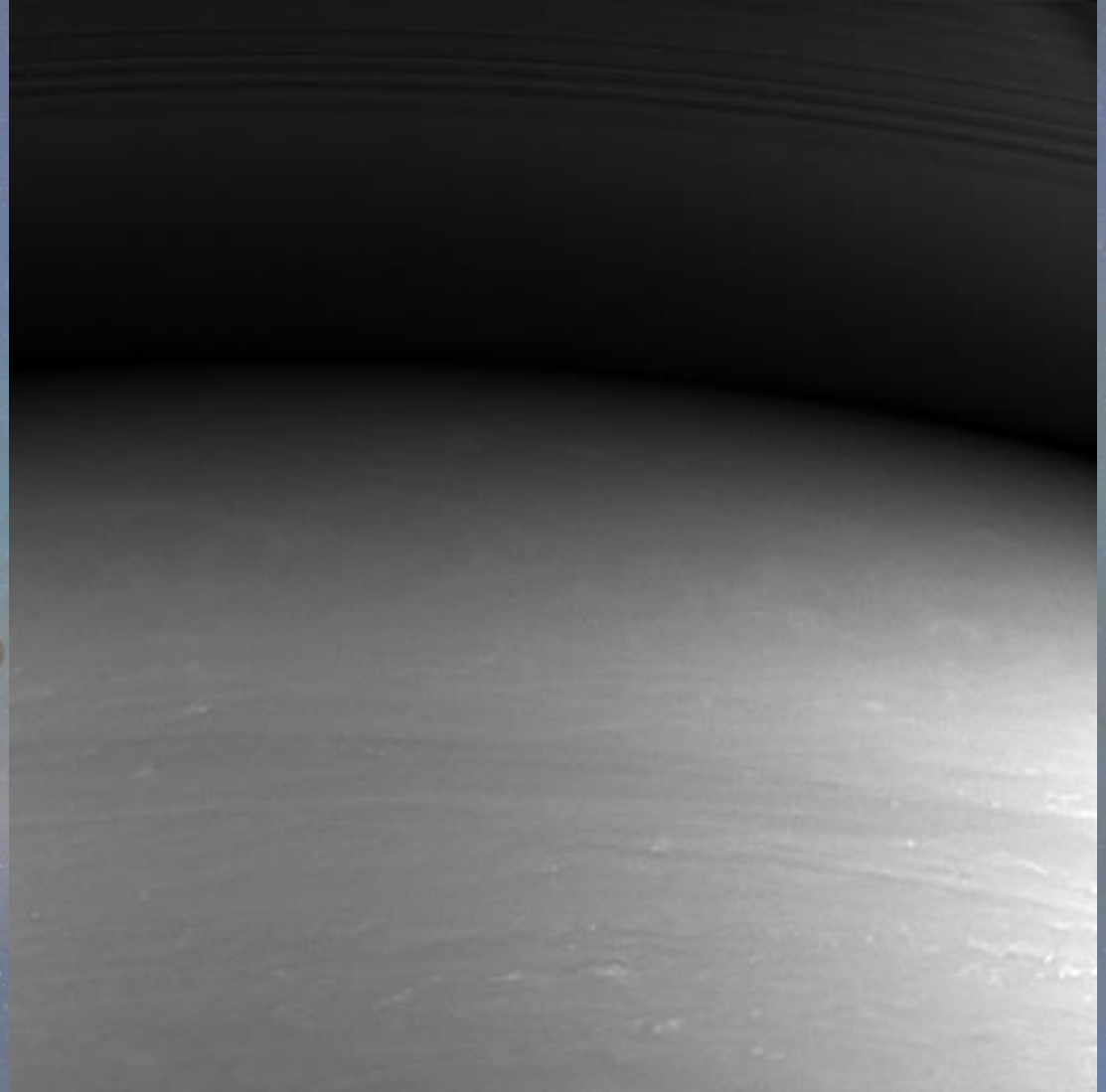
Orbit 293: Final orbit – 3.5 hours from end of mission, data transmitted in near real-time



Enceladus



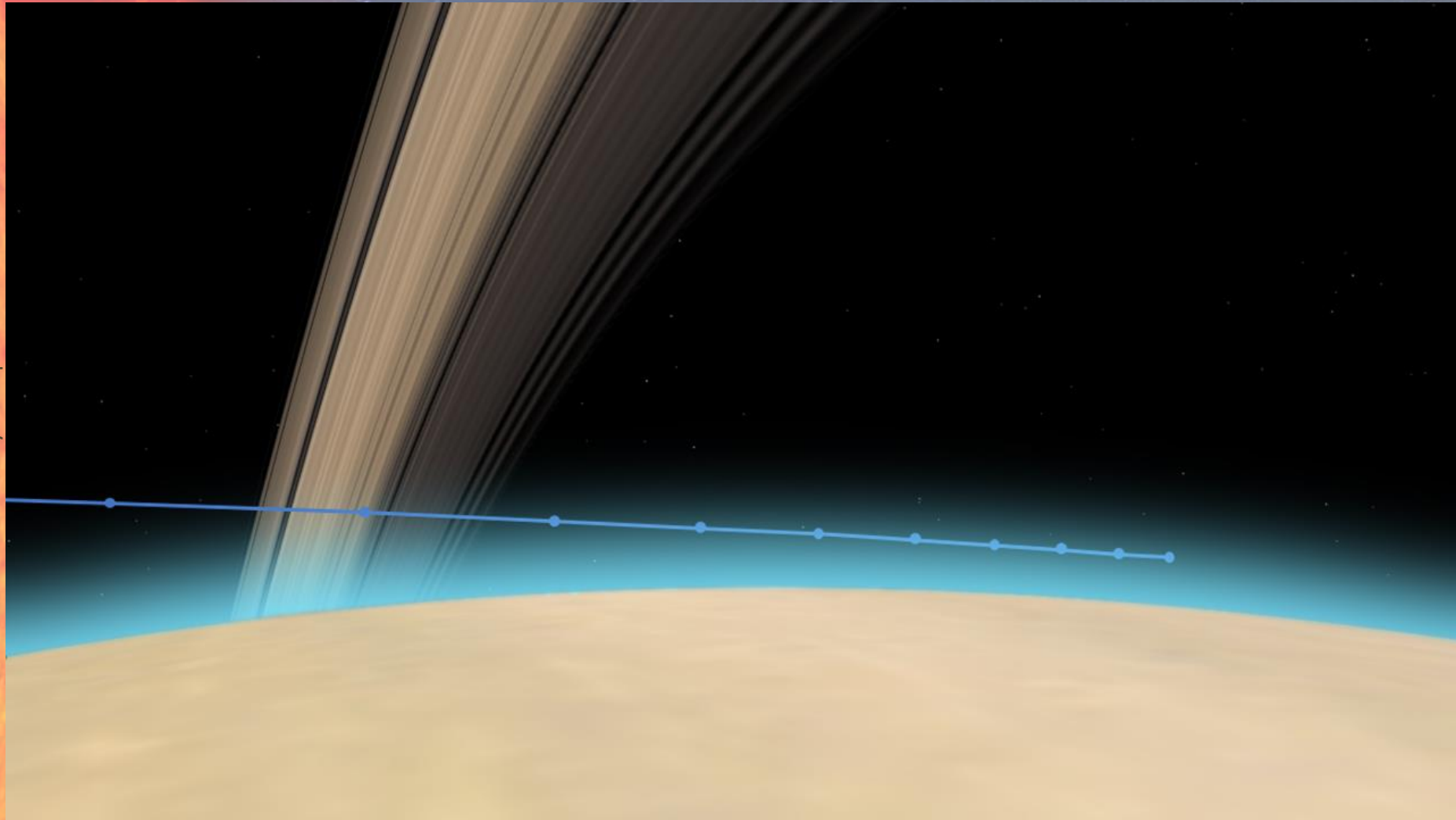
Titan



Last image

Cassini – The Grand Finale

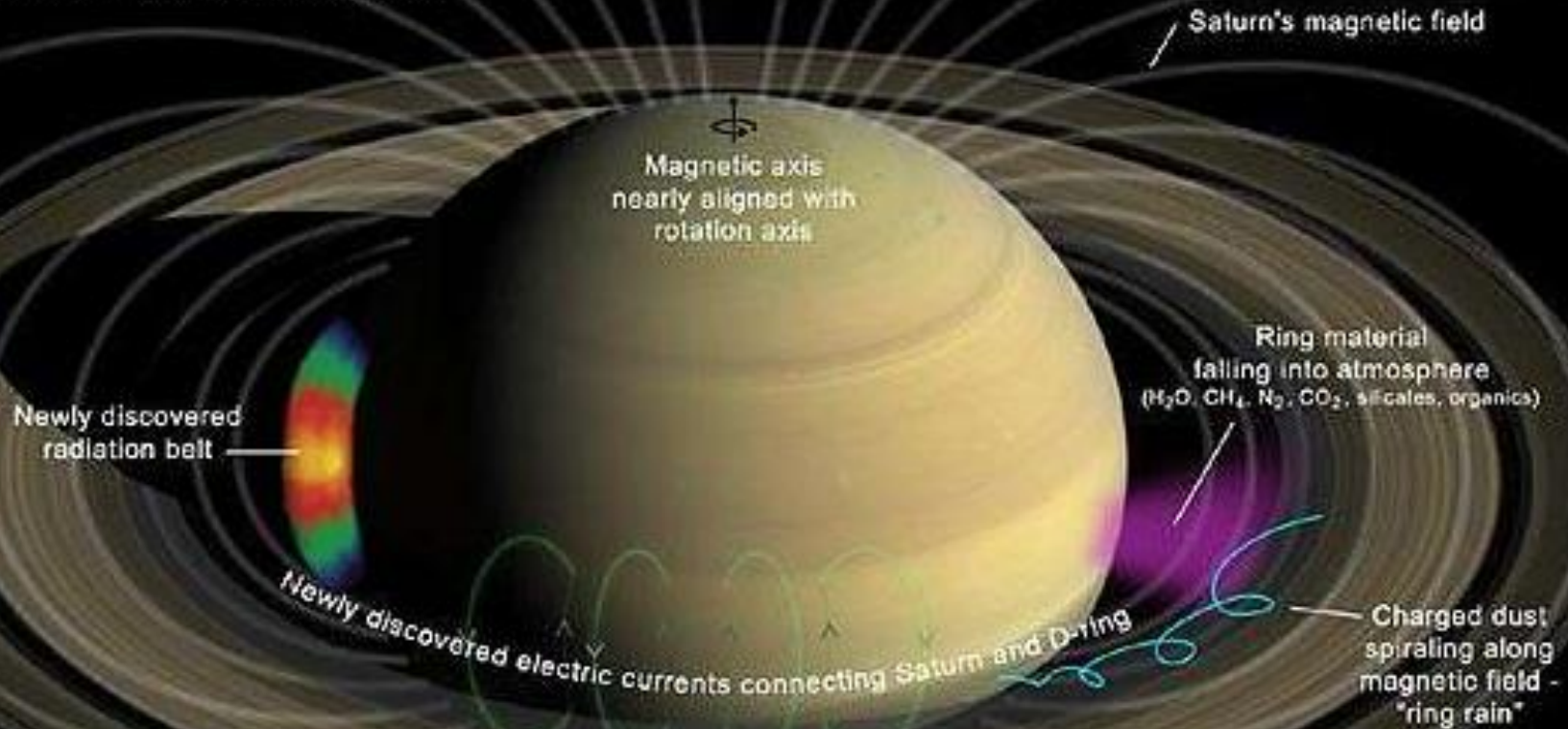
Orbit 293: Atmospheric entry begins 7:54am EDT, loss of signal 7:55am EDT



Cassini plunge shown in 10 second tick marks

Cassini – The Grand Finale

CASSINI: New Saturn Science



Probes to the Outer Solar System

End

Thank you!

