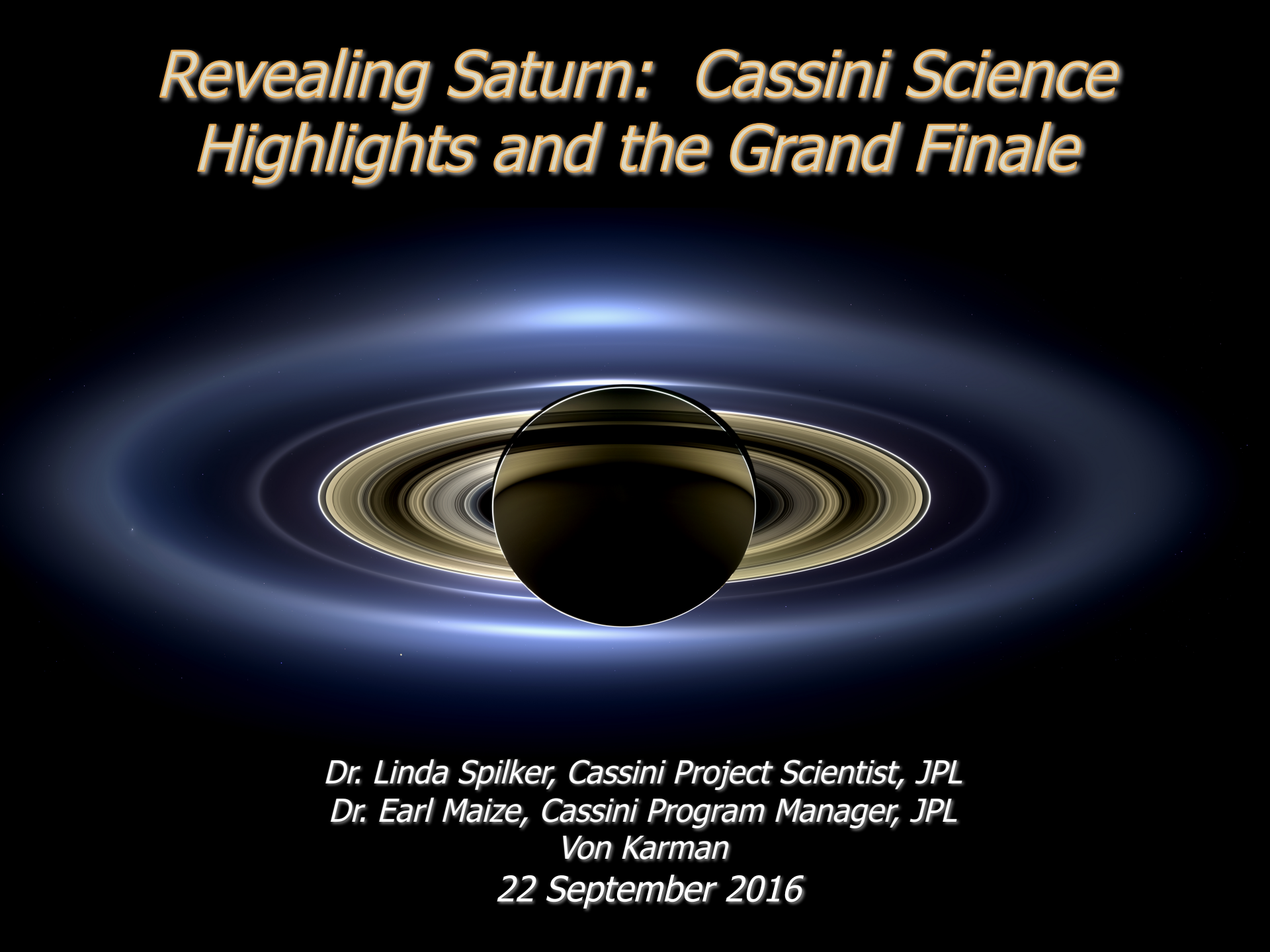
Revealing Saturn: Cassini Science Highlights and the Grand Finale

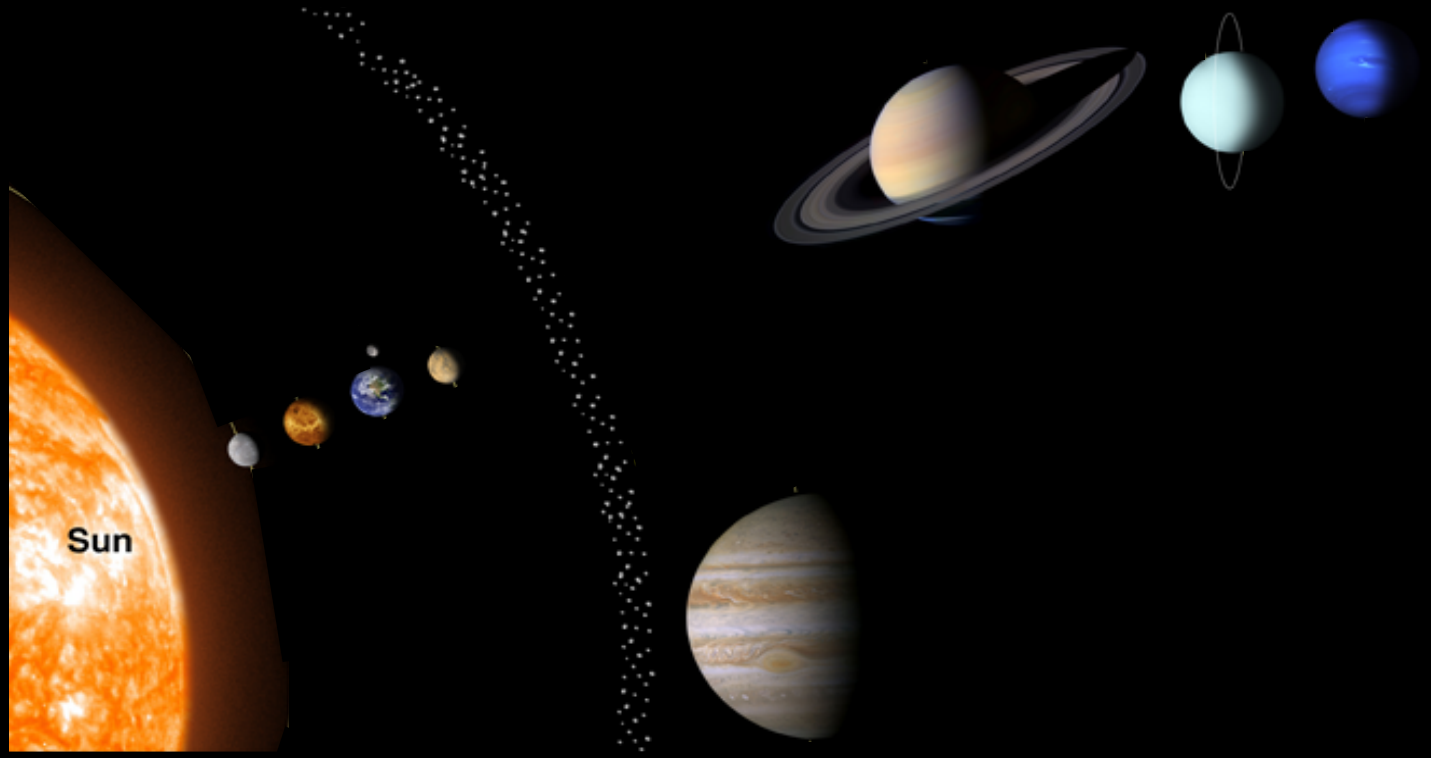


Dr. Linda Spilker, Cassini Project Scientist, JPL
Dr. Earl Maize, Cassini Program Manager, JPL
Von Karman
22 September 2016

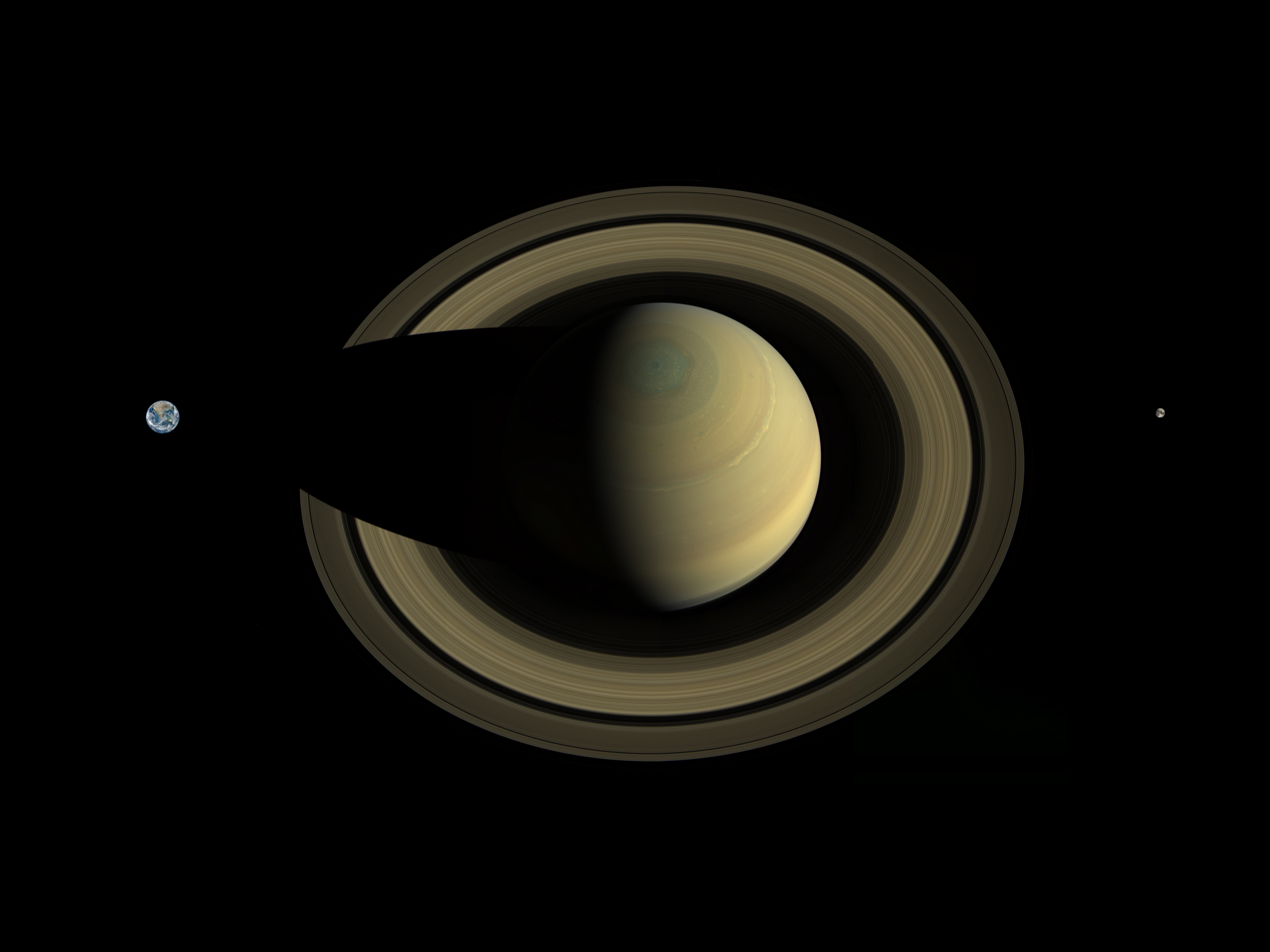
Grand Science Questions

- *Are We Alone in the Universe?*
  - Has life originated somewhere other than Earth?
  - How did life originate on Earth?

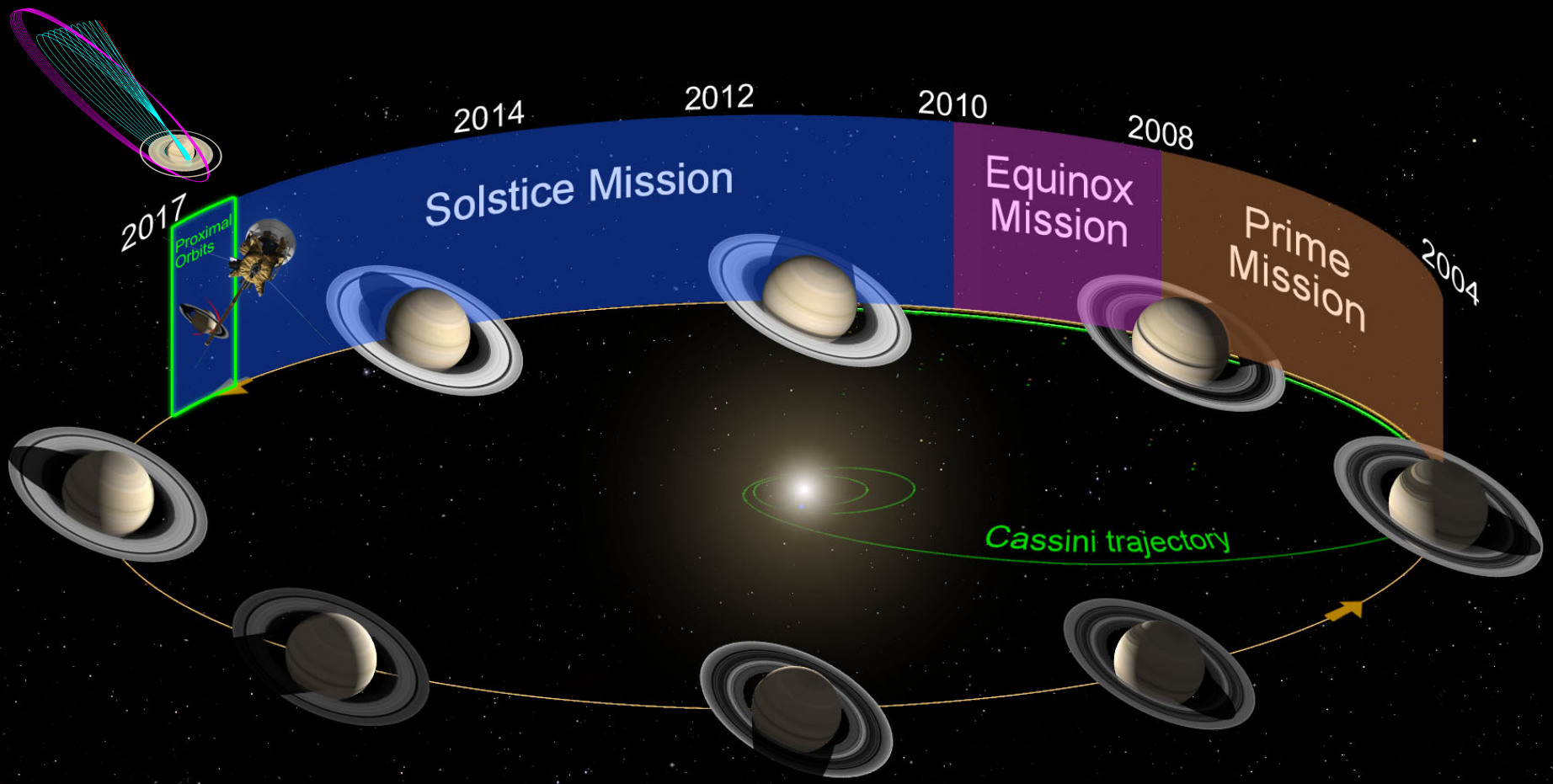
Grand Science Questions

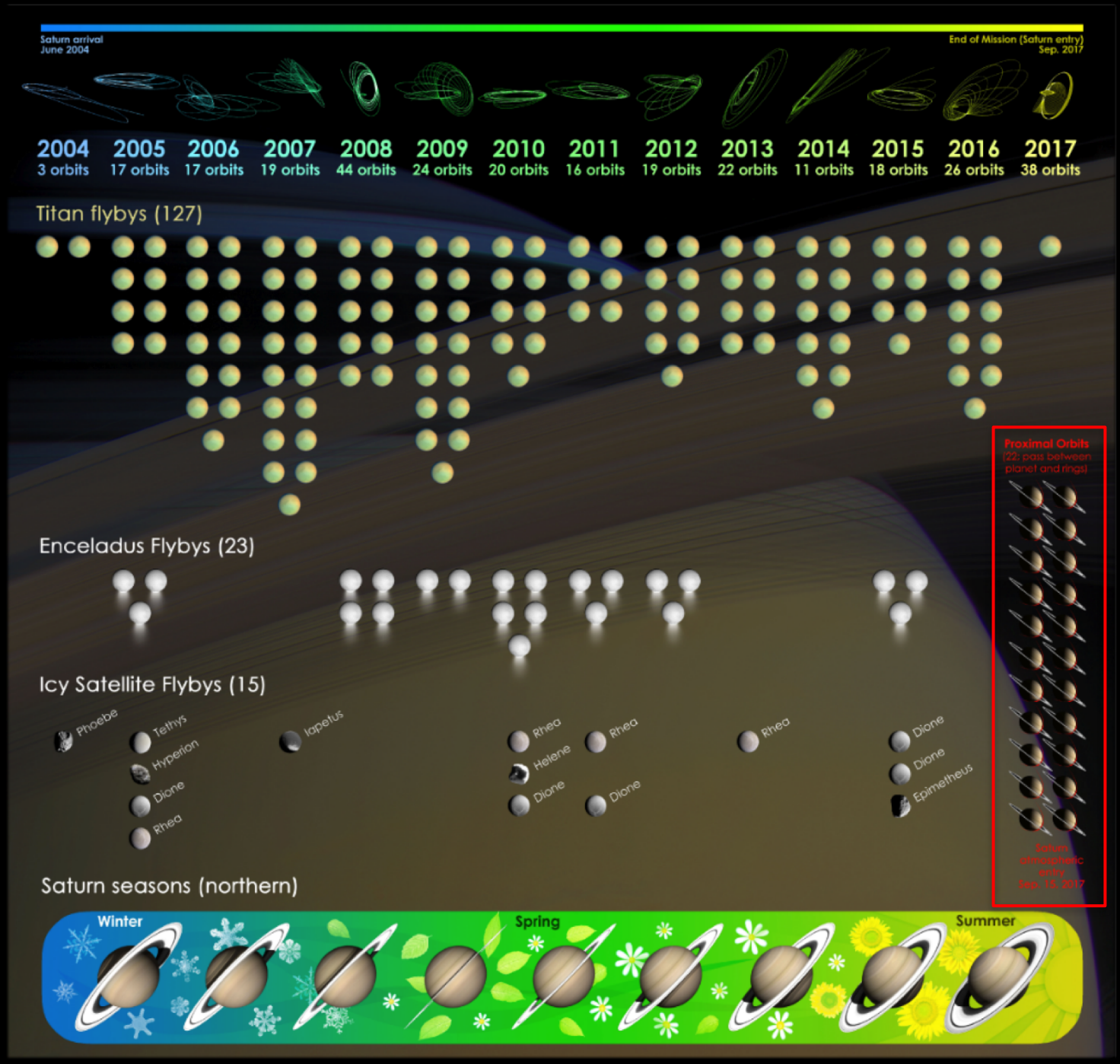


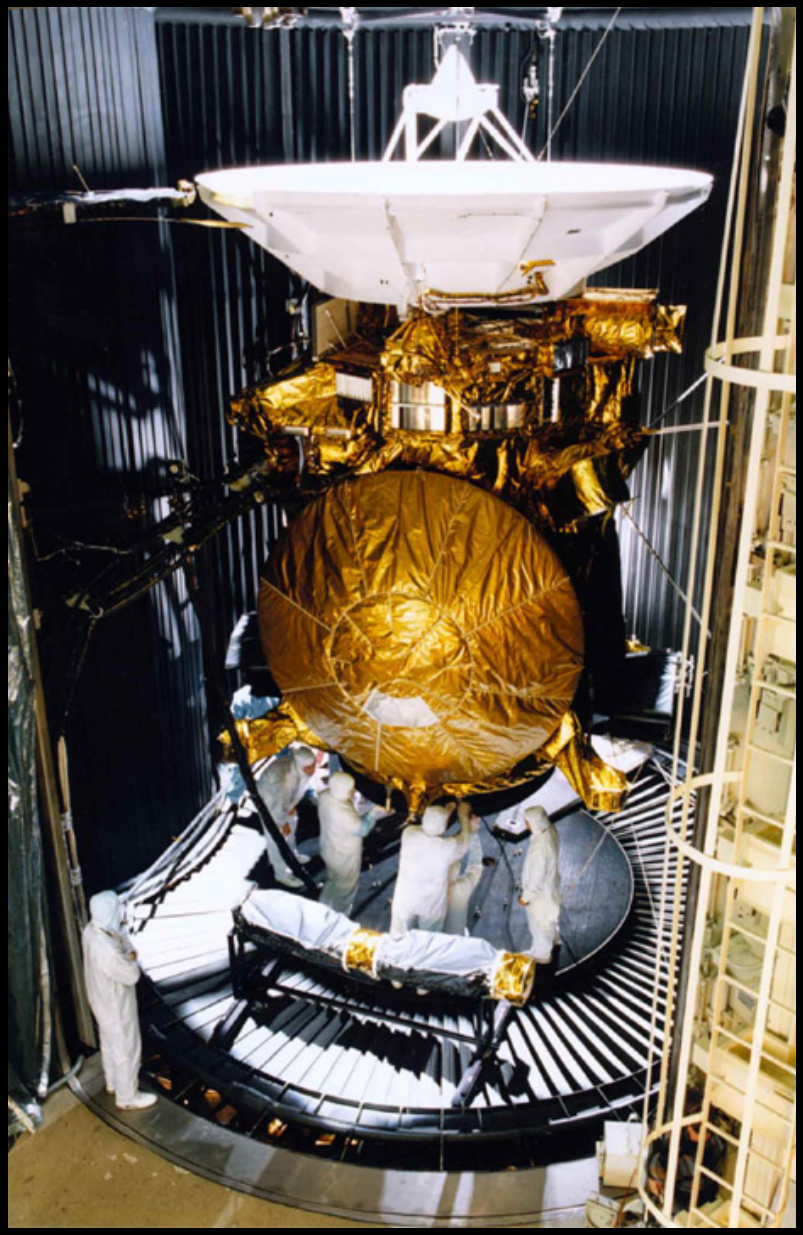
- *How did the solar system, and Earth within it, come to be?*
  - How is it evolving? Where is it headed?



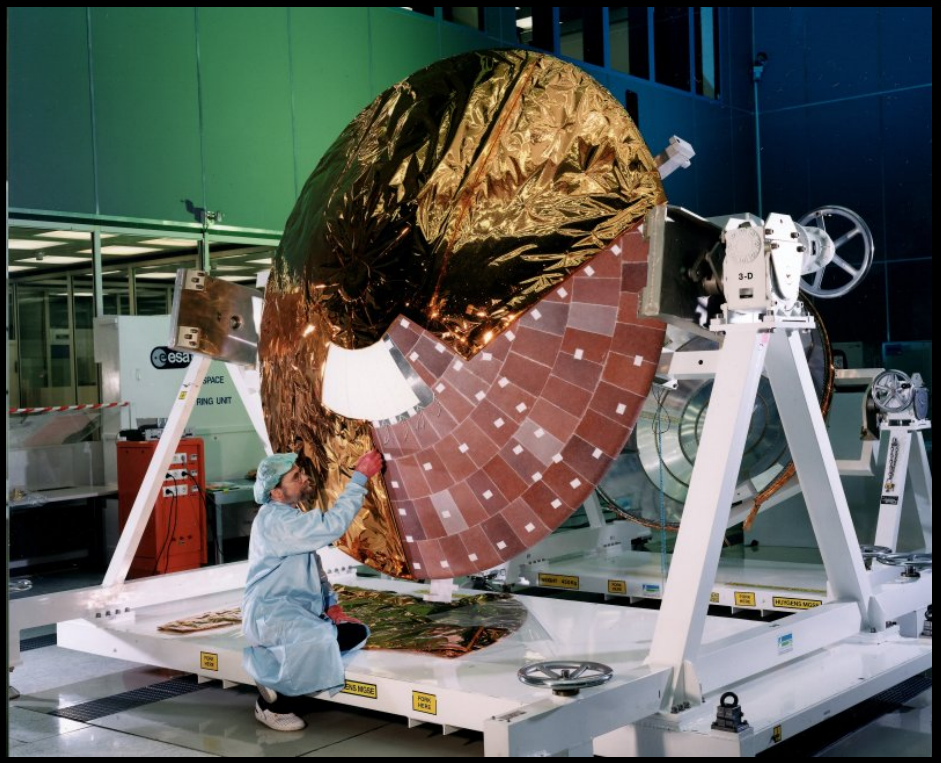
Cassini-Huygens Mission Overview




Saturn arrival
June 2004
End of Mission (Saturn entry)
Sep. 2017
2004 3 orbits
2005 17 orbits
2006 17 orbits
2007 19 orbits
2008 44 orbits
2009 24 orbits
2010 20 orbits
2011 16 orbits
2012 19 orbits
2013 22 orbits
2014 11 orbits
2015 18 orbits
2016 26 orbits
2017 38 orbits
Titan flybys (127)
Proximal Orbits
(22; pass between planet and rings)
Saturn atmospheric entry Sep. 15, 2017
Enceladus Flybys (23)
Icy Satellite Flybys (15)
Phoebe
Tethys
Hyperion
Dione
Rhea
Iapetus
Rhea
Helene
Dione
Rhea
Dione
Rhea
Dione
Dione
Epimetheus
Saturn seasons (northern)
Winter
Spring
Summer

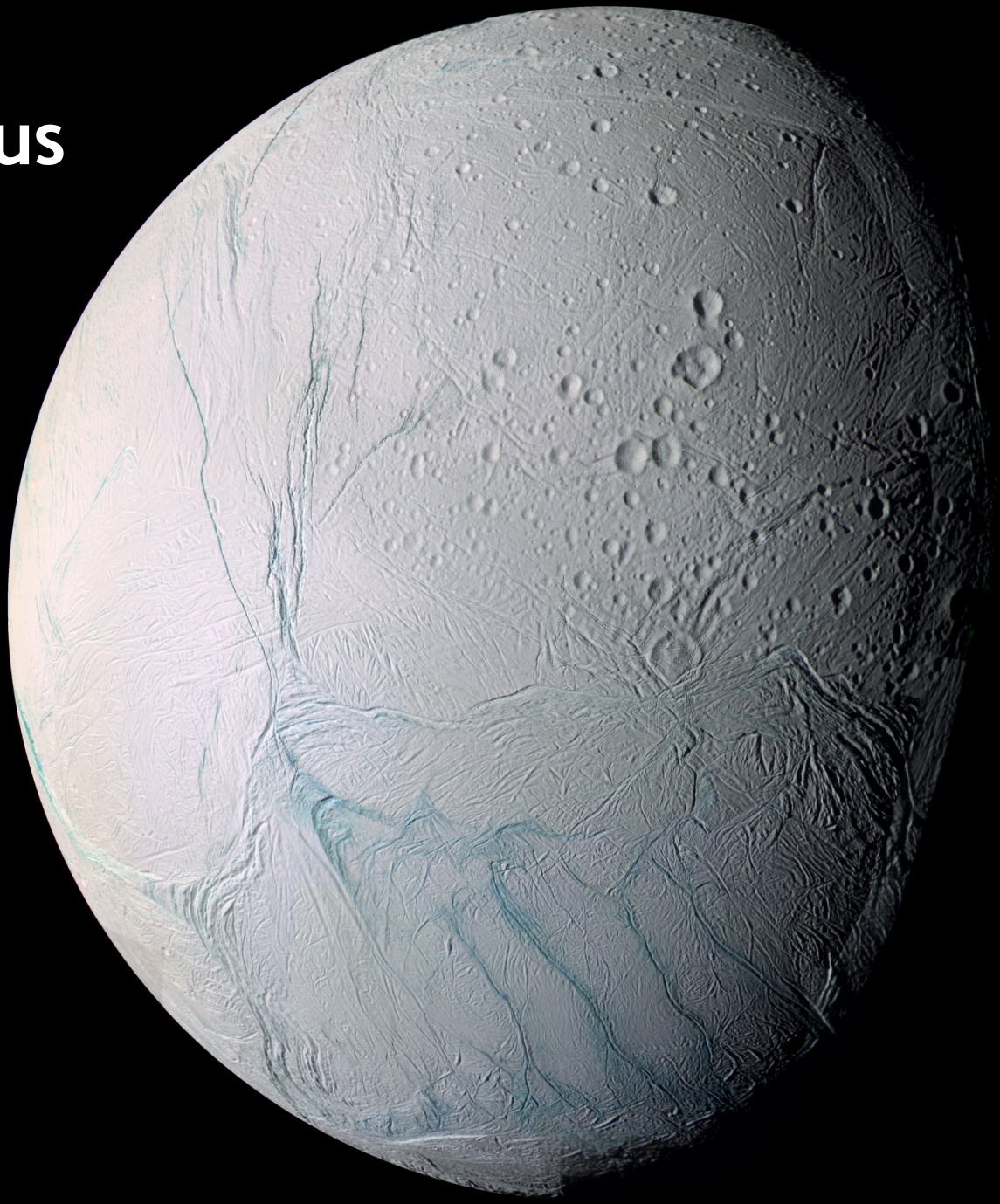


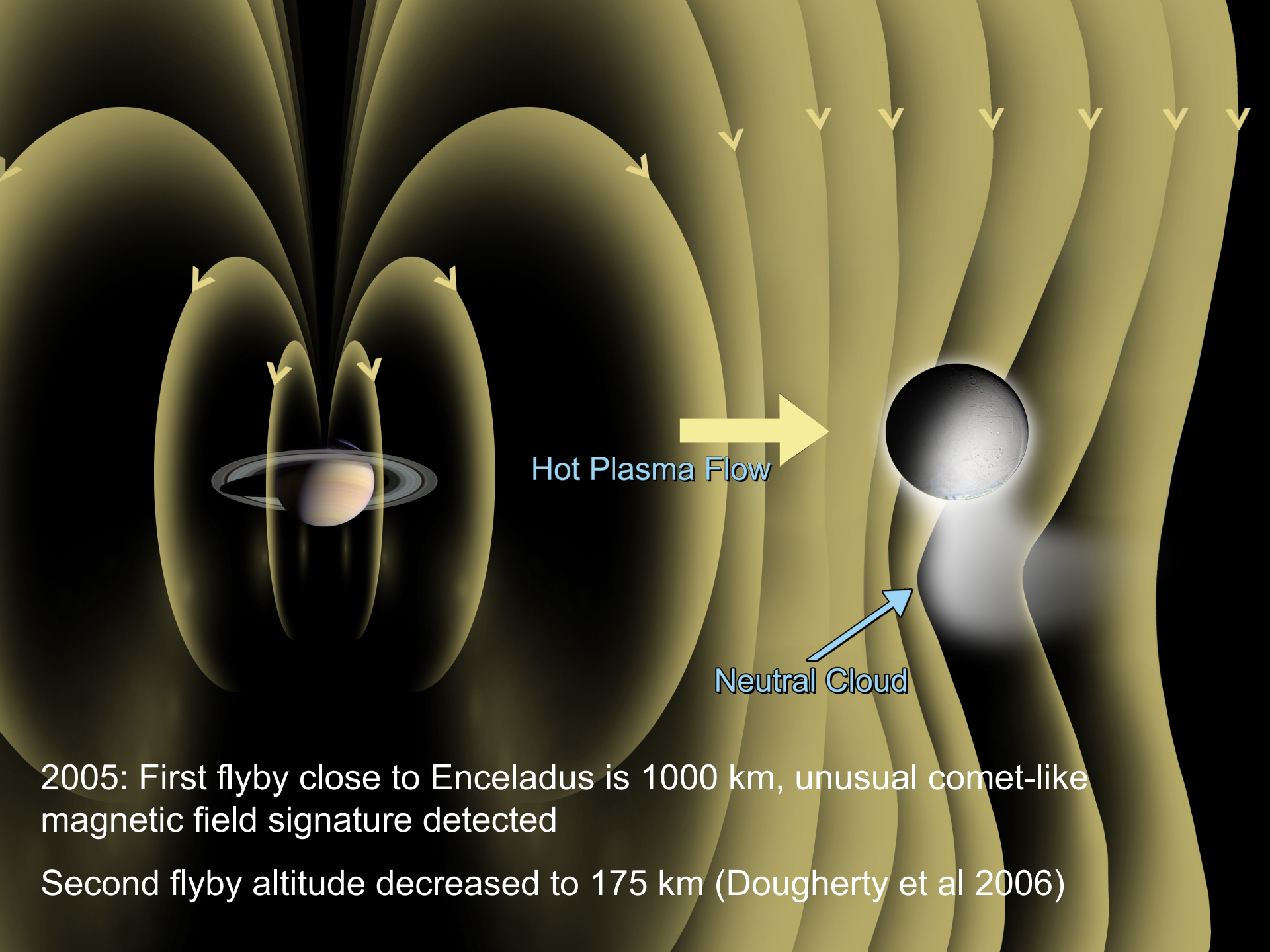
NASA Cassini Orbiter



European Space Agency (ESA) Huygens Probe

Enceladus

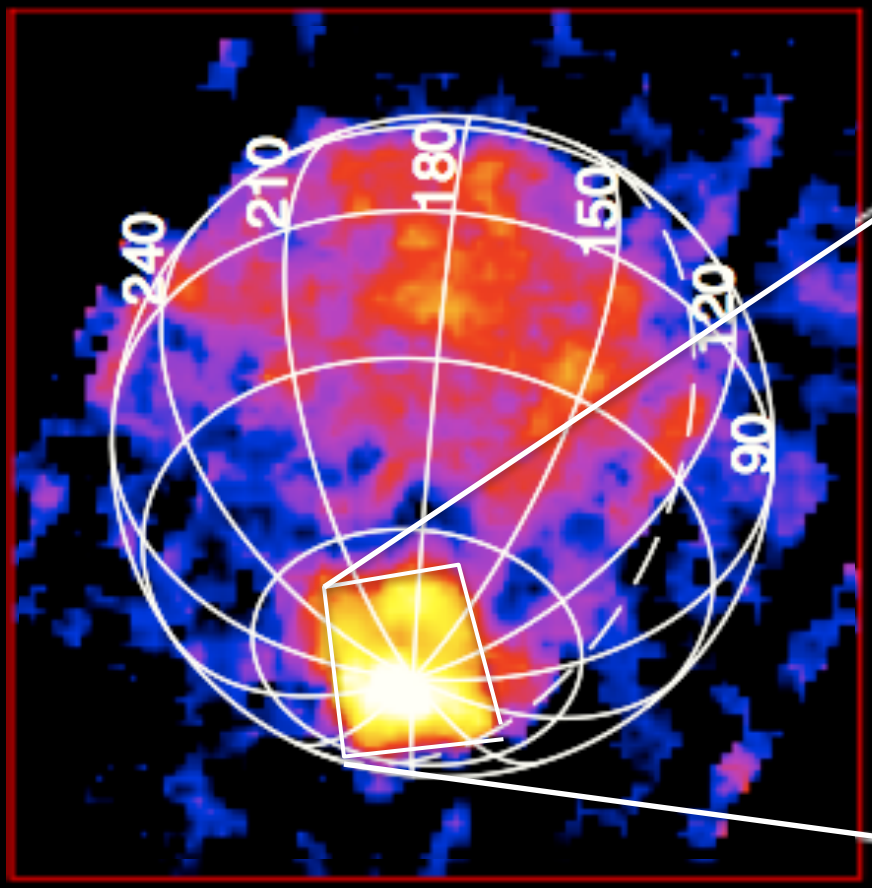


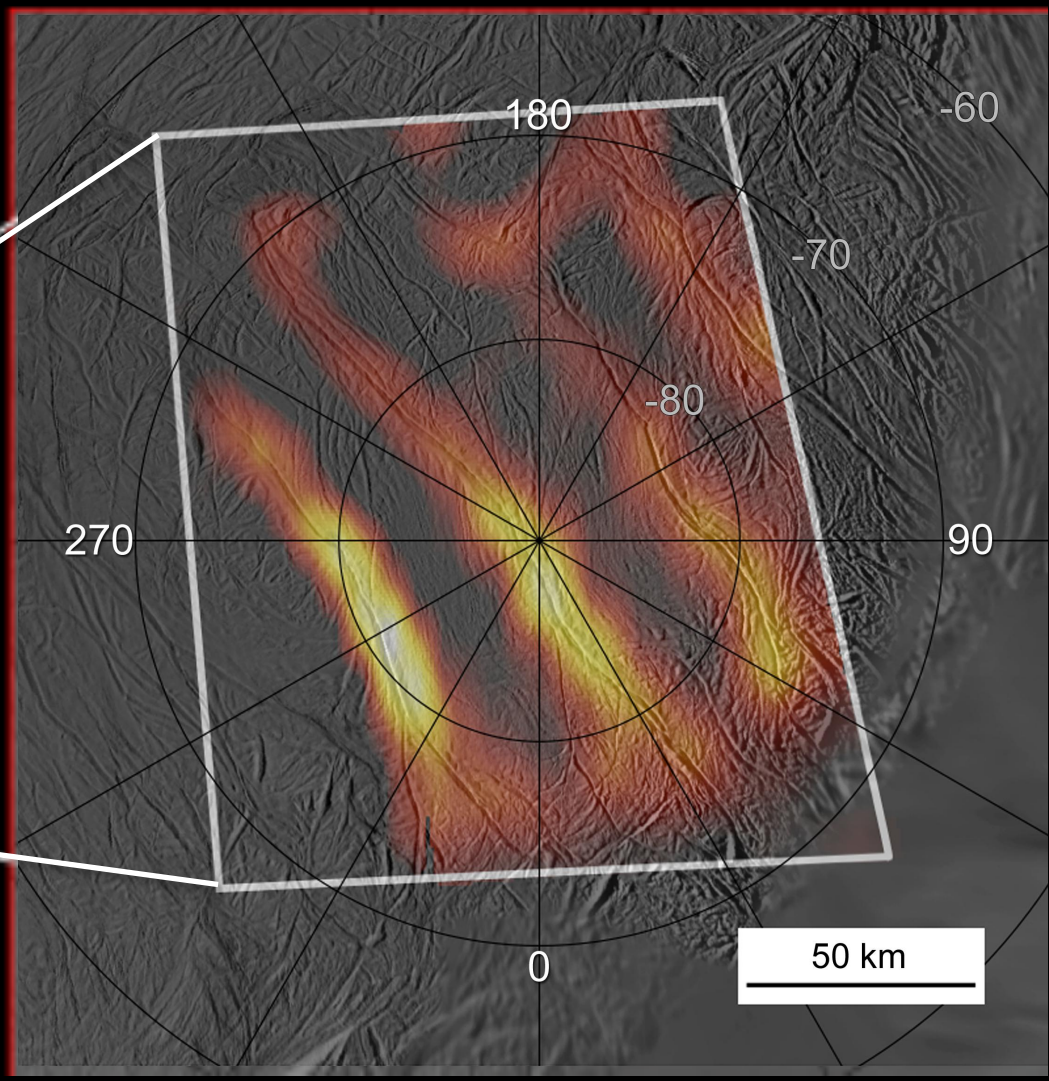


2005: First flyby close to Enceladus is 1000 km, unusual comet-like magnetic field signature detected

Second flyby altitude decreased to 175 km (Dougherty et al 2006)

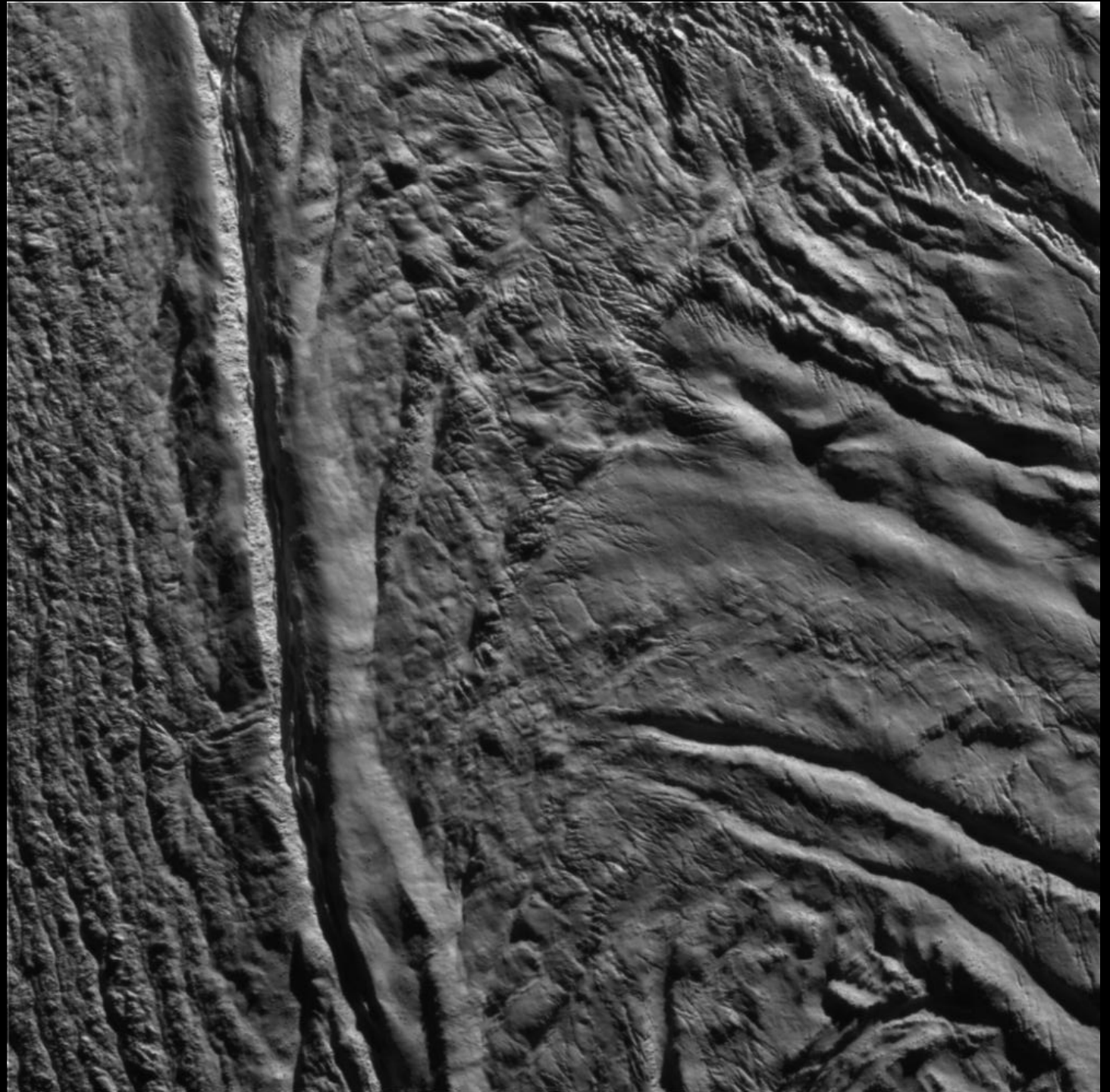
Infrared CIRS Heat measurement



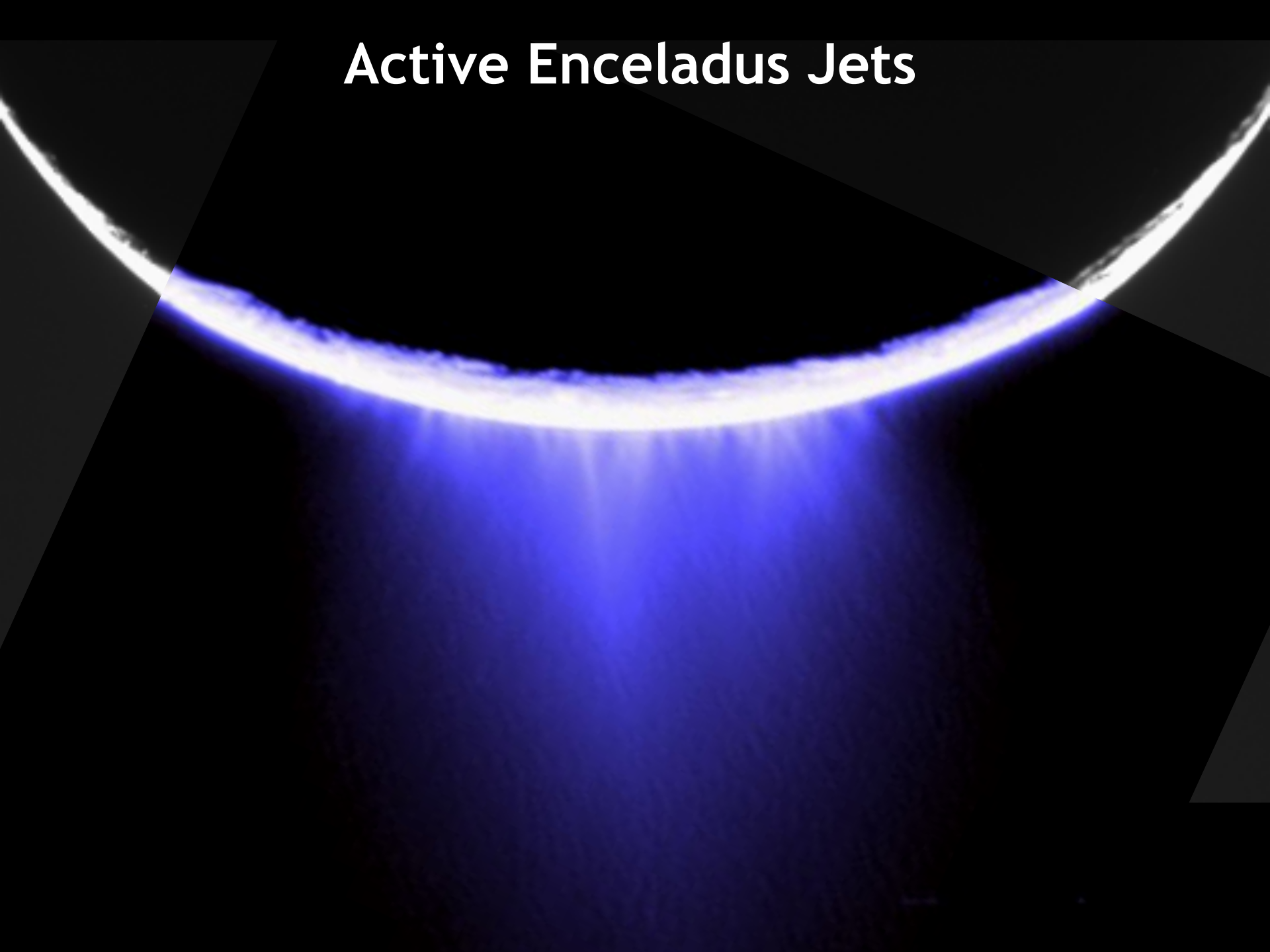


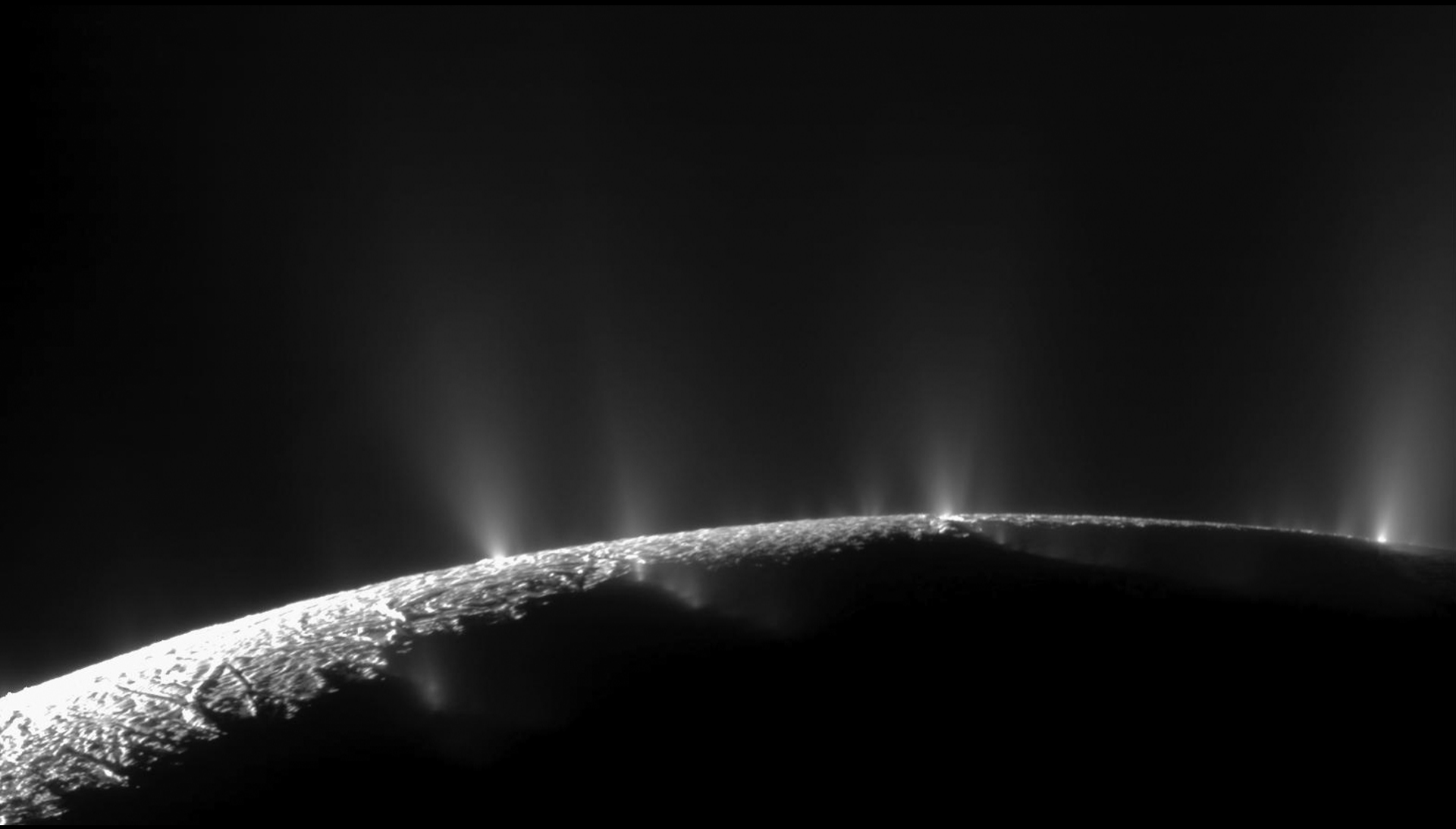
- Excess heat at south pole
- Tiger stripe origin

(Spencer et al., 2006)

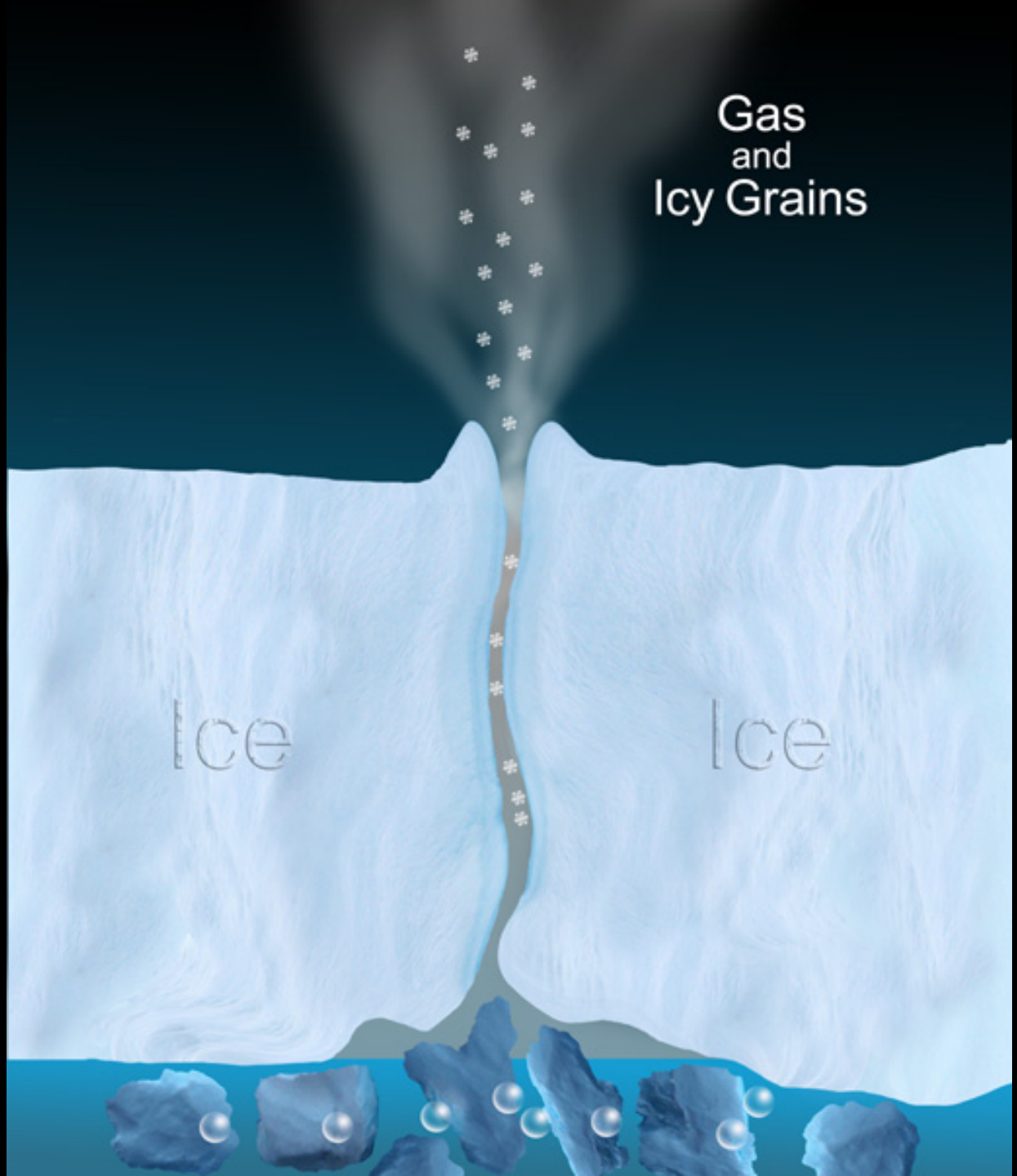


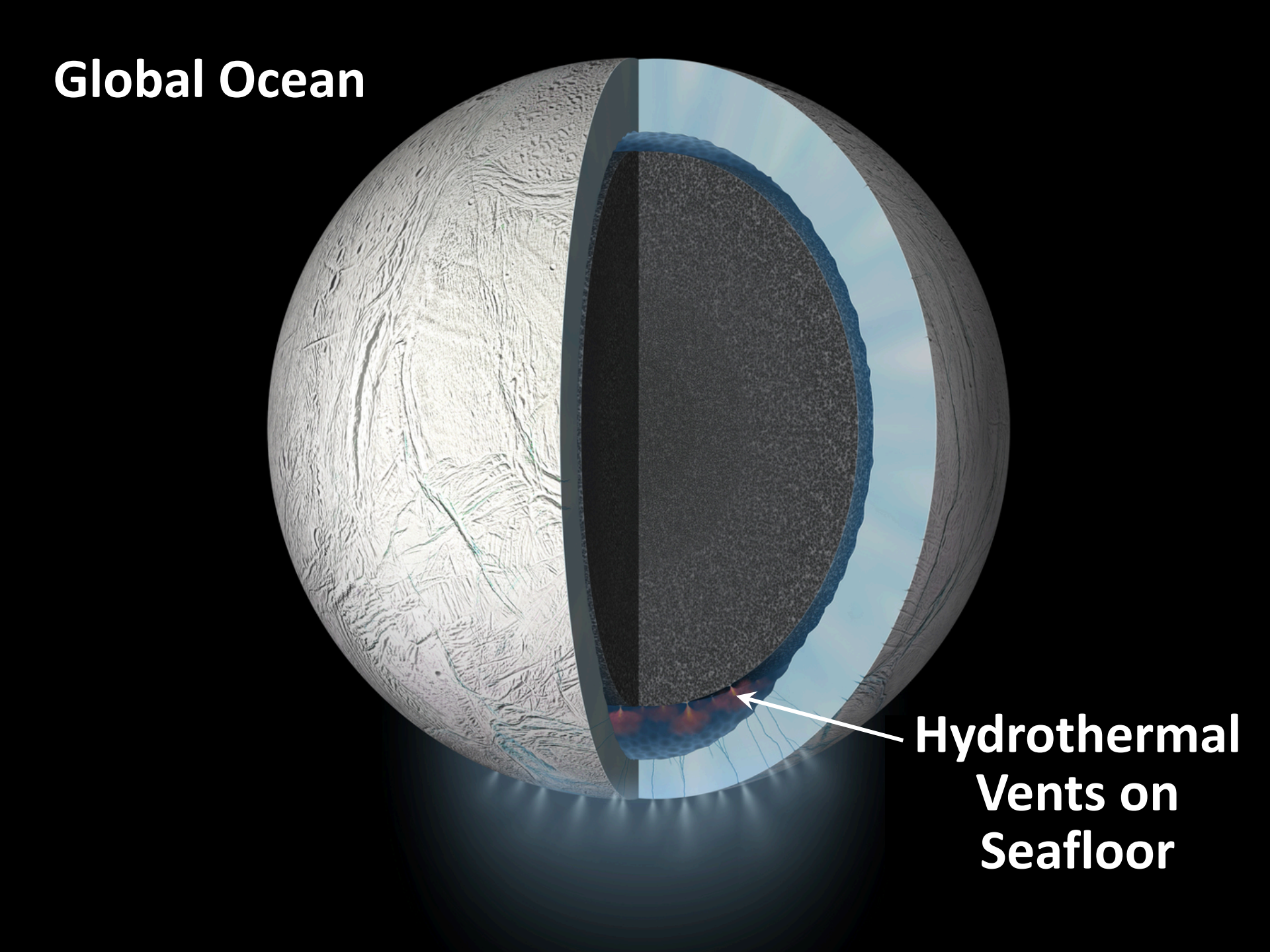
Active Enceladus Jets

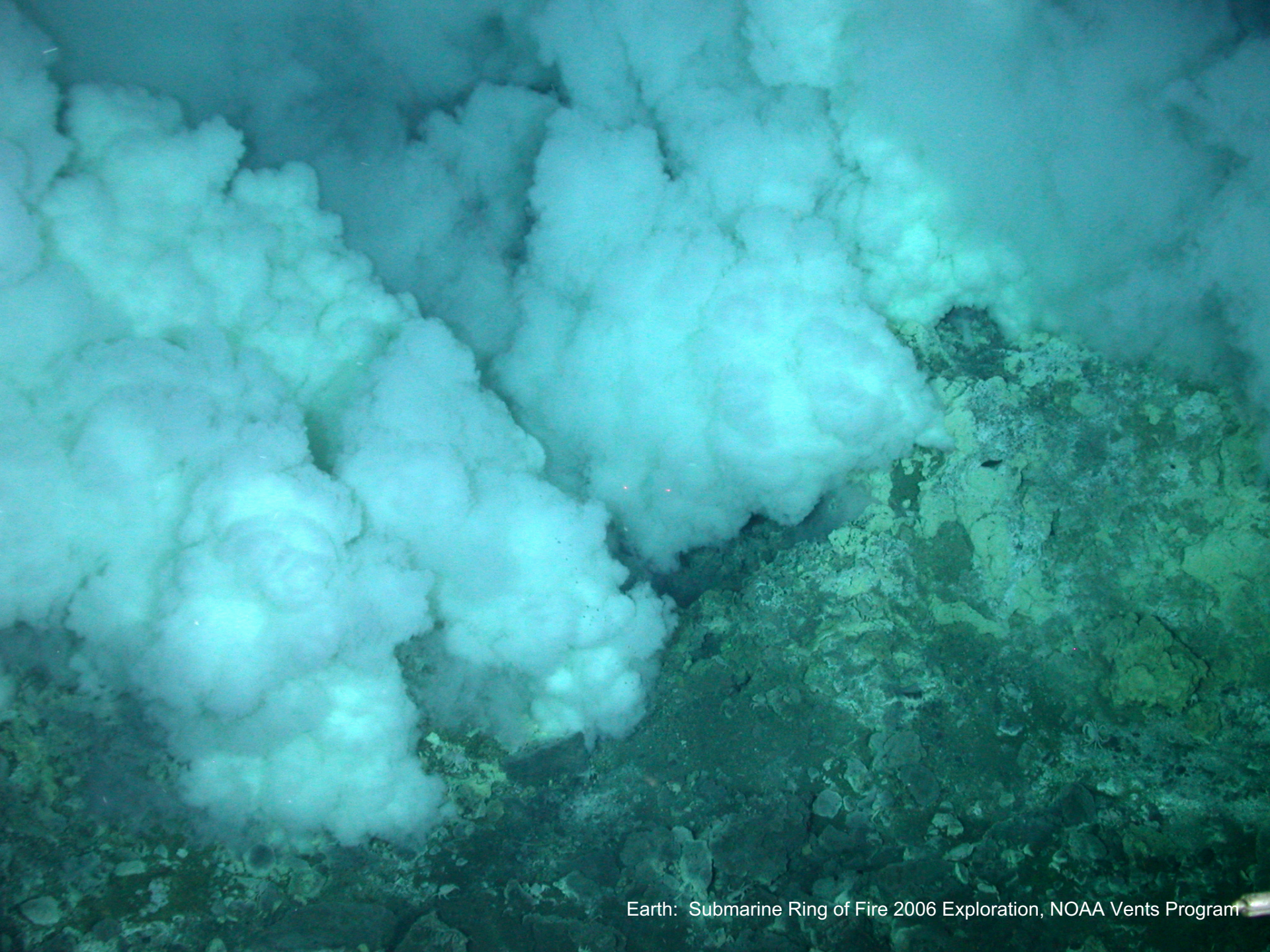




Enceladus fountain in France’s Versailles garden


Gas
and
Icy Grains
Ice
Ice


Global Ocean
Hydrothermal Vents on Seafloor

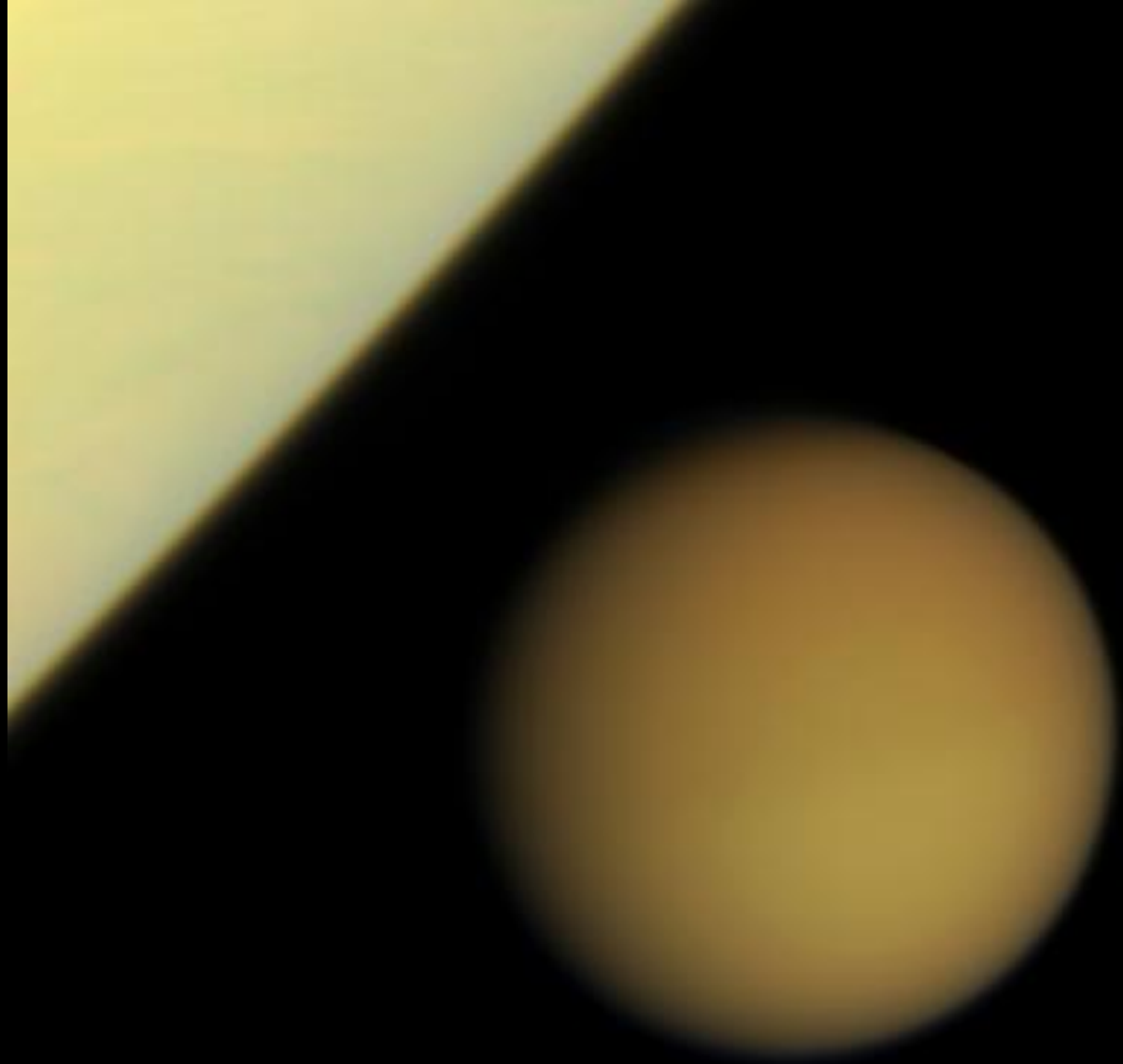

Earth: Submarine Ring of Fire 2006 Exploration, NOAA Vents Program

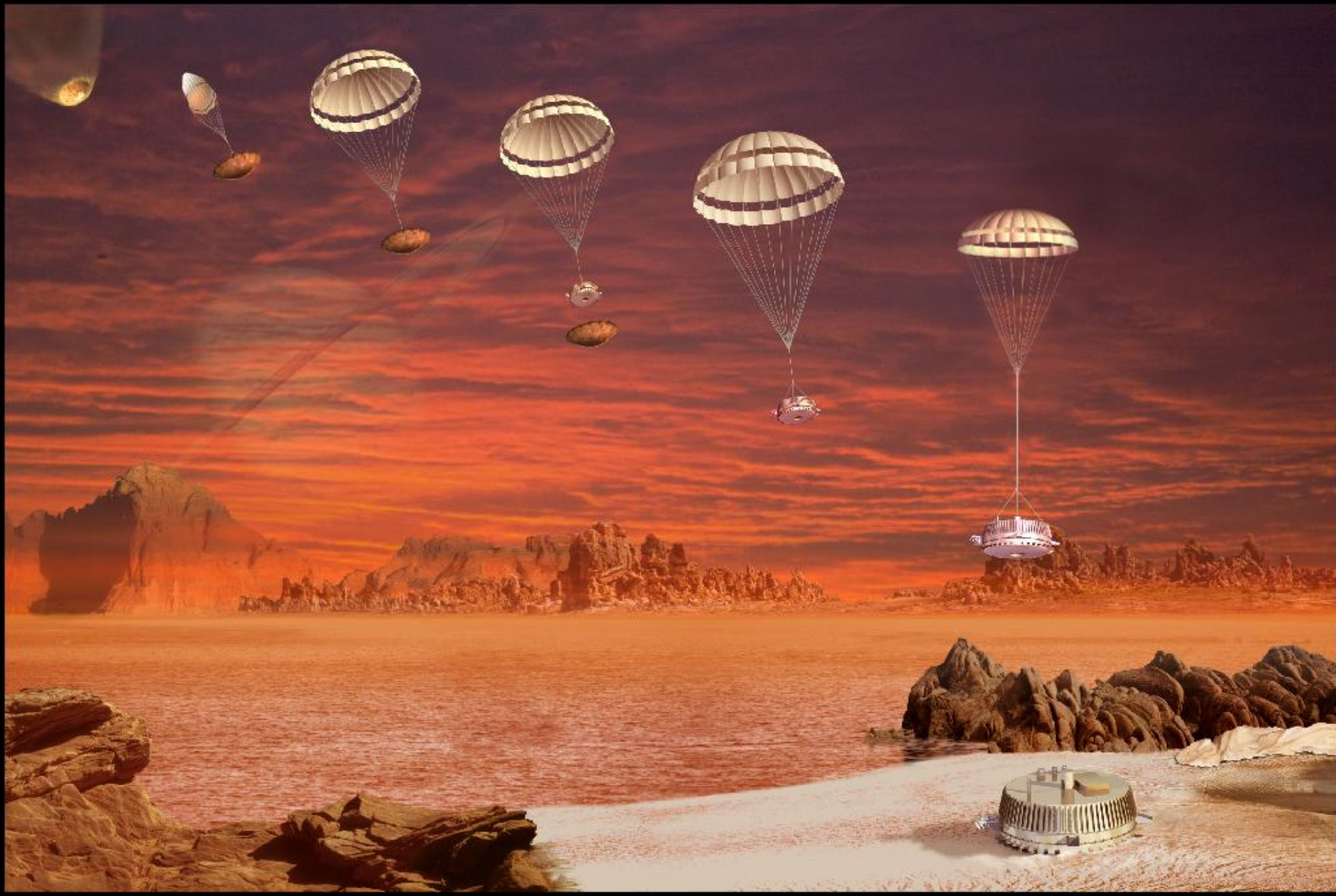
Earth: Submarine Ring of Fire 2006 Exploration, NOAA Vents Program

Life *in* Enceladus' Ocean?

Multiple factors *make plausible the idea that life exists there:*

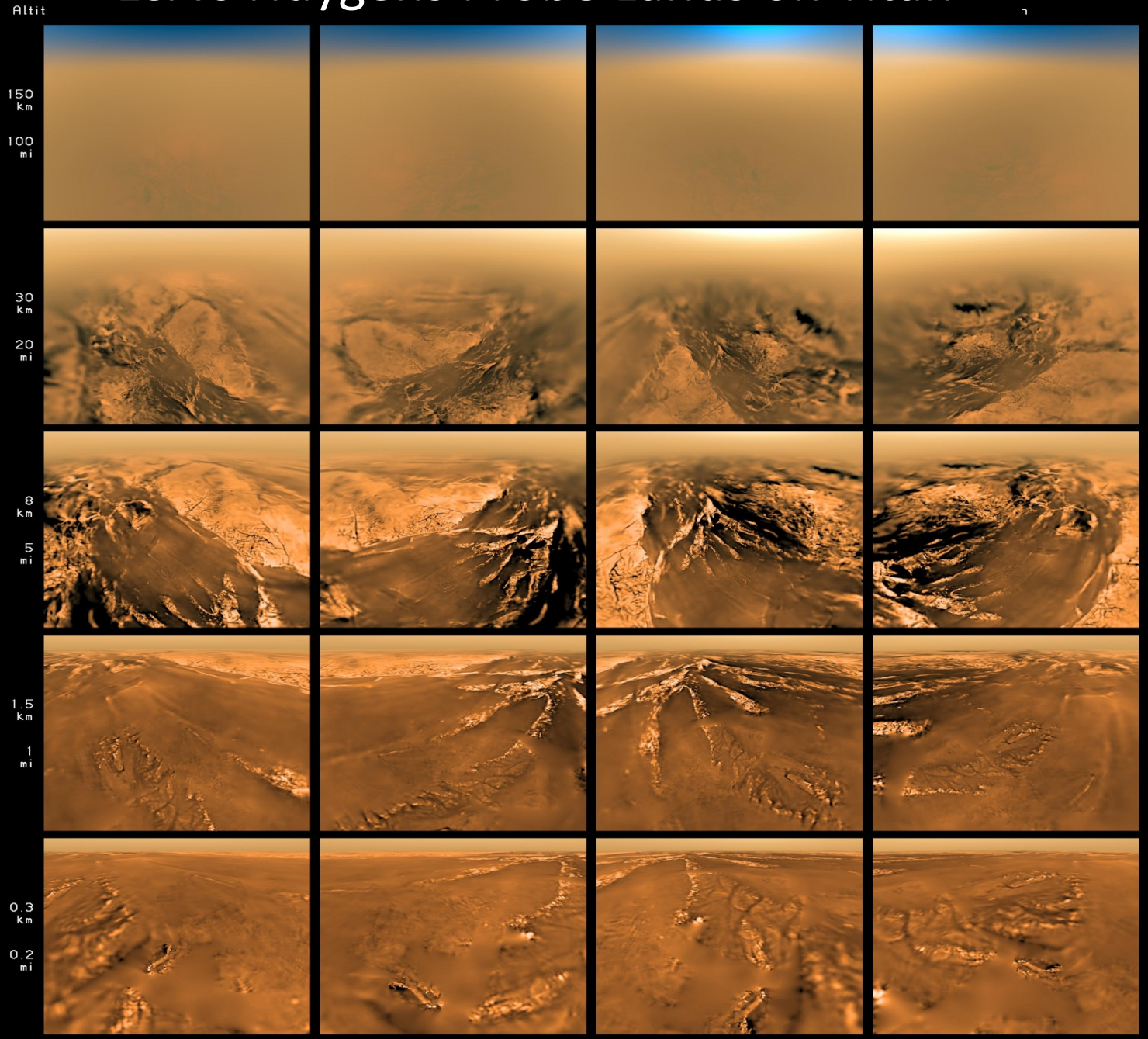
- Global, salty ocean
- Ocean is long-lived
- Organics in plume, coming from ocean
- Heat energy
- Hydrothermal vents on ocean seafloor



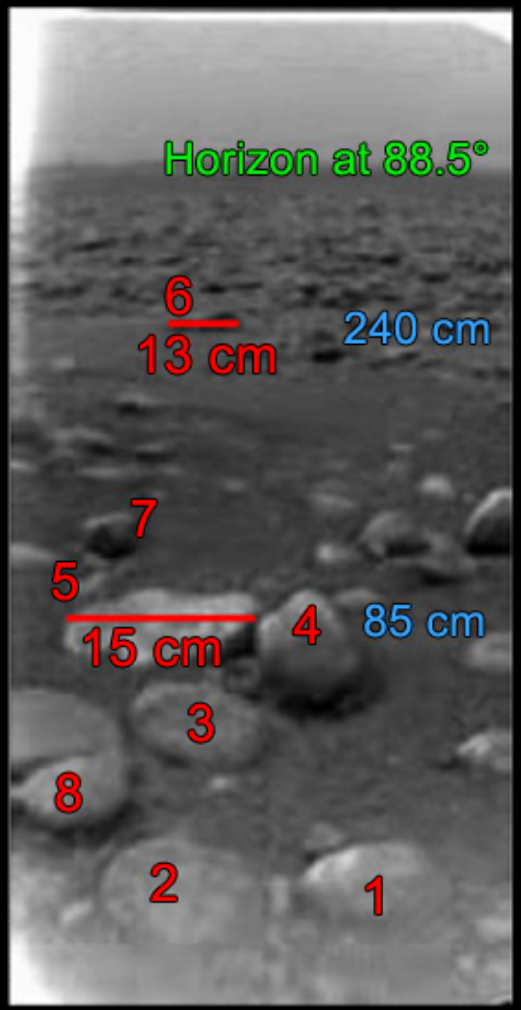


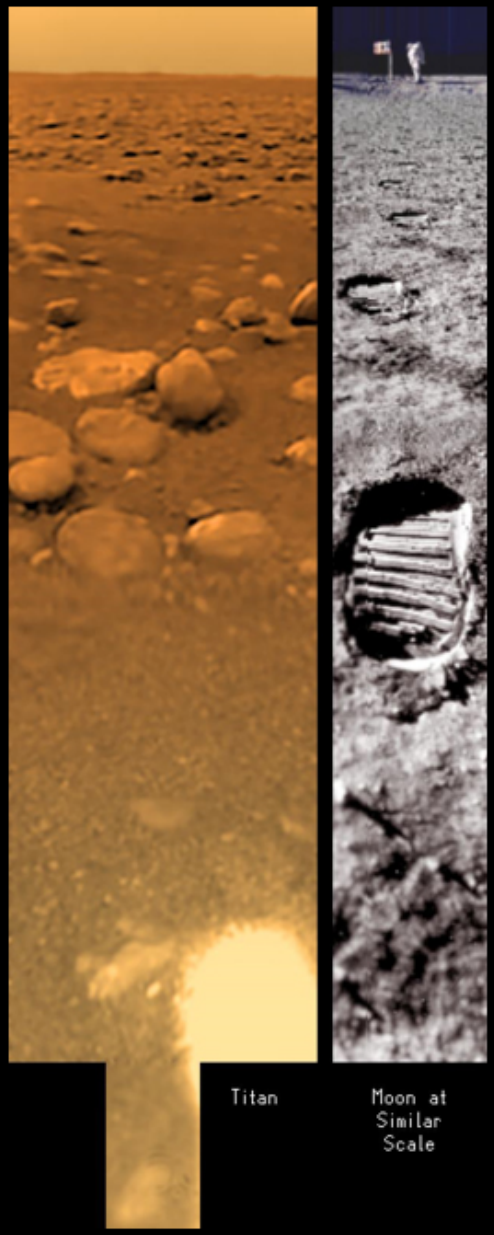
ESA's Huygens Probe Lands on Titan

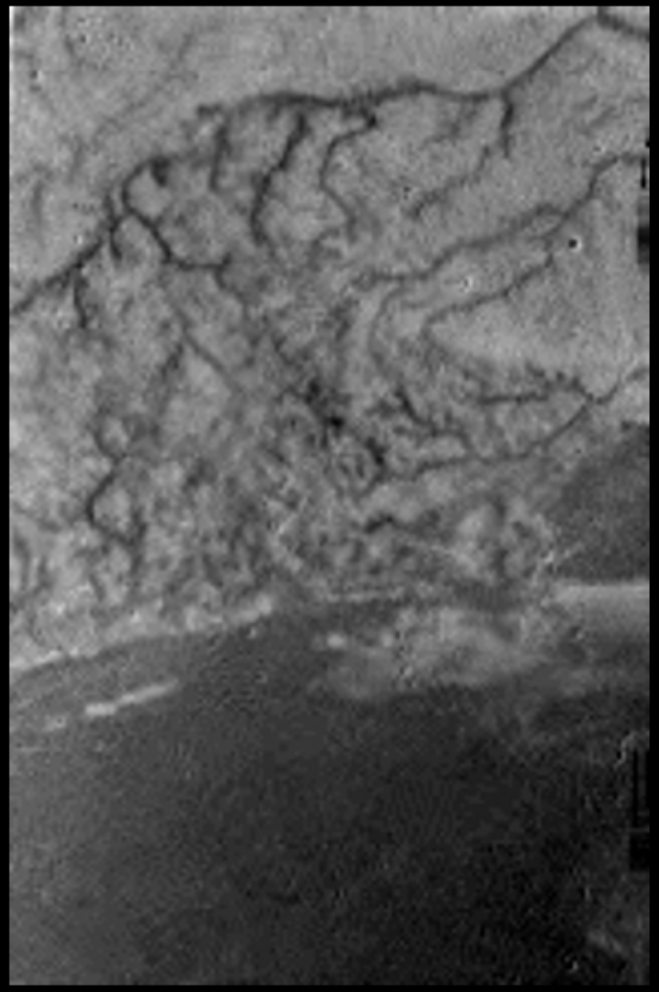
Haze clears at an altitude of 60 km



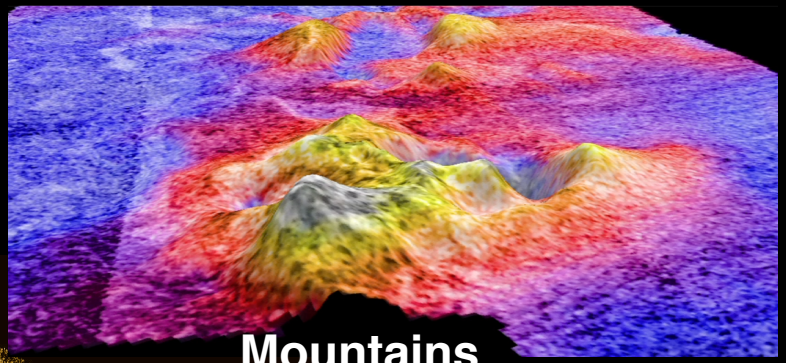
Huygens Images

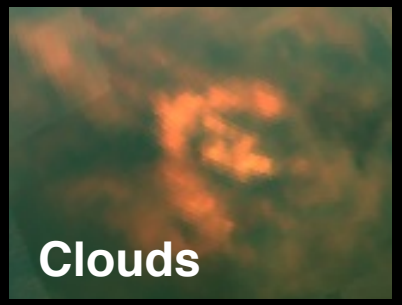


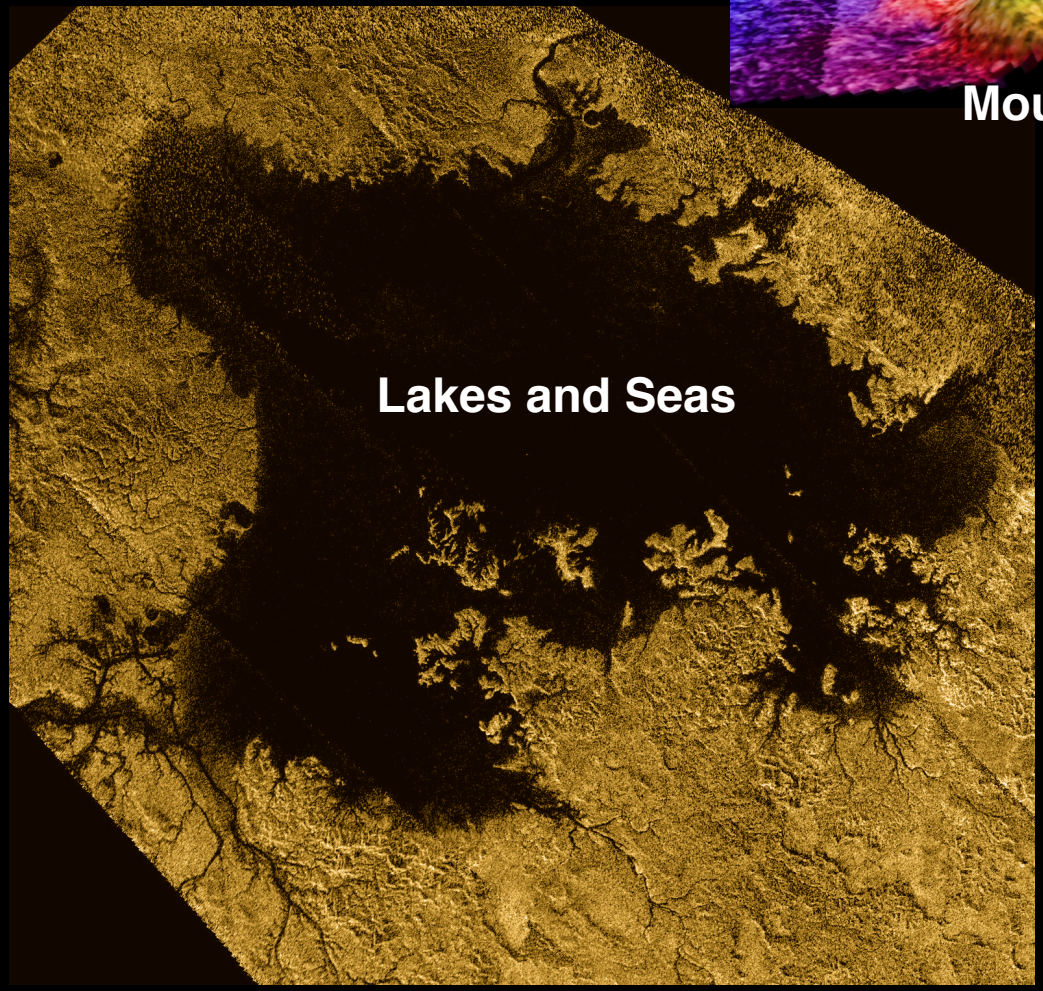


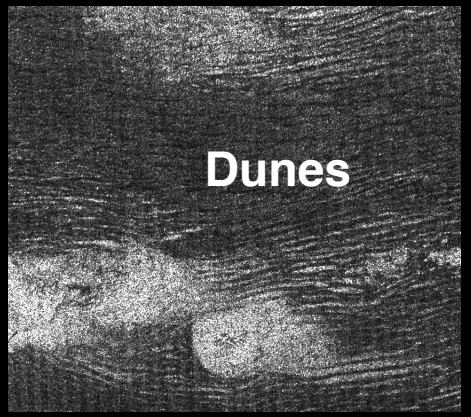


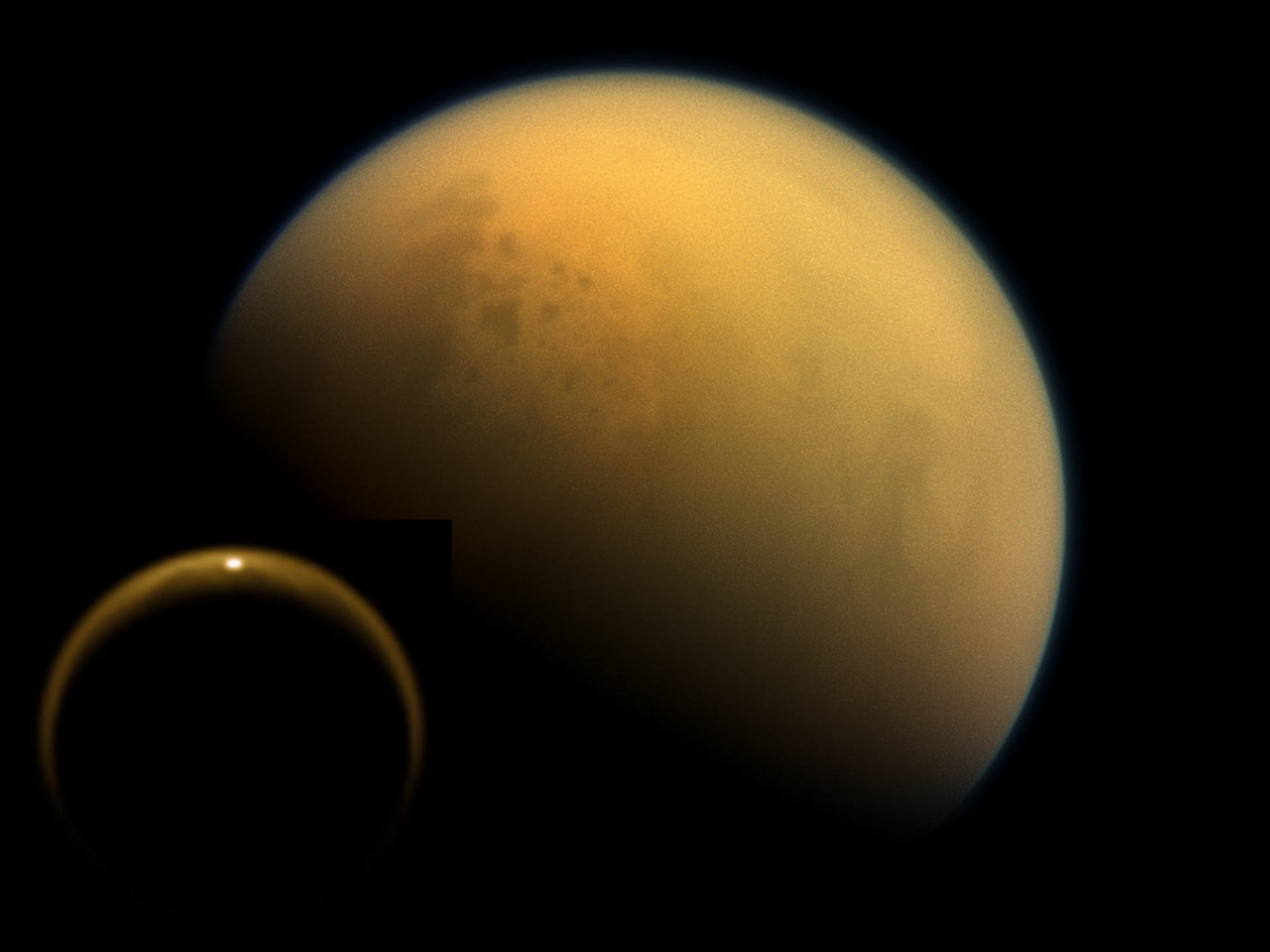
Titan: An Earth-like World



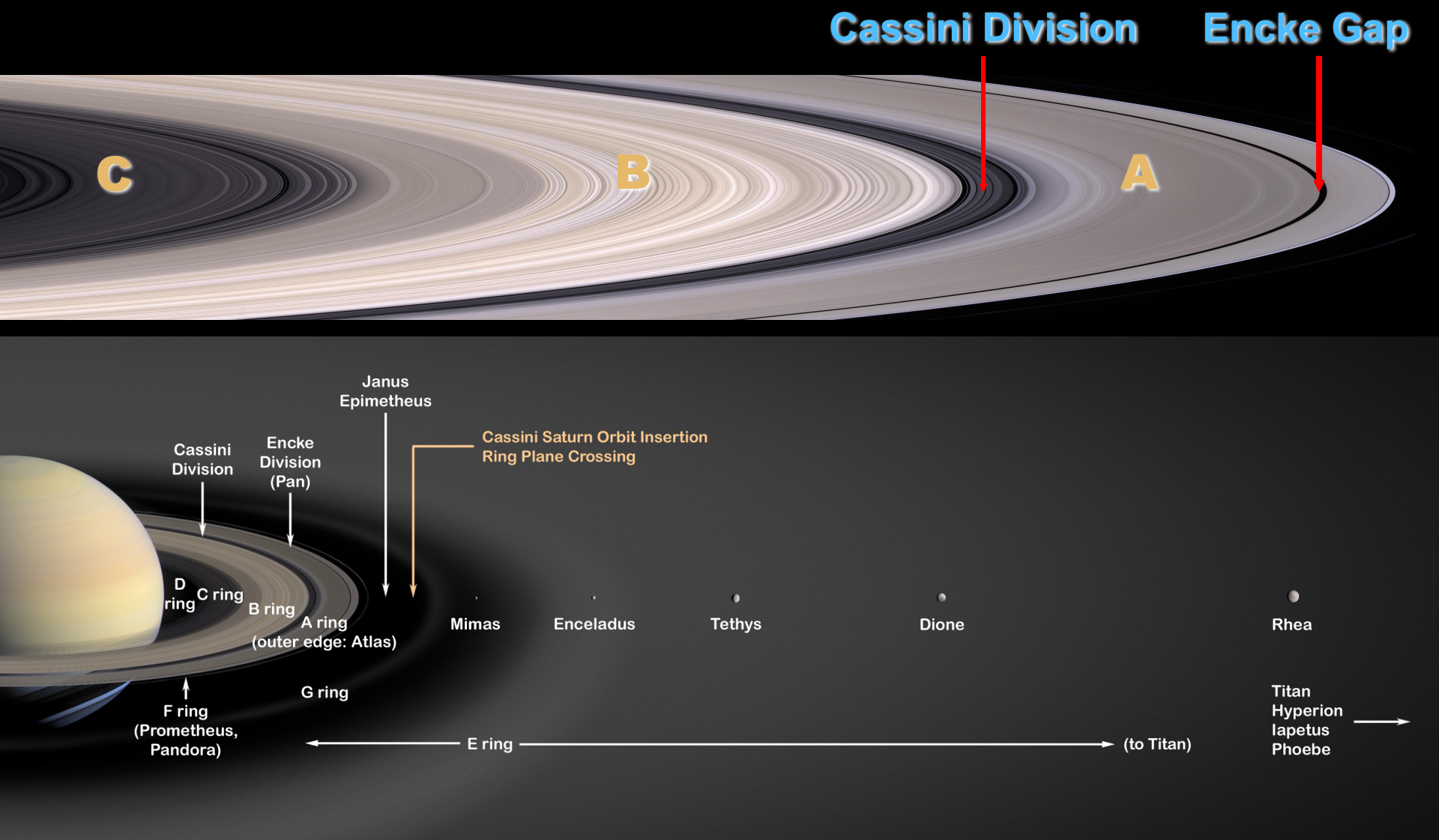


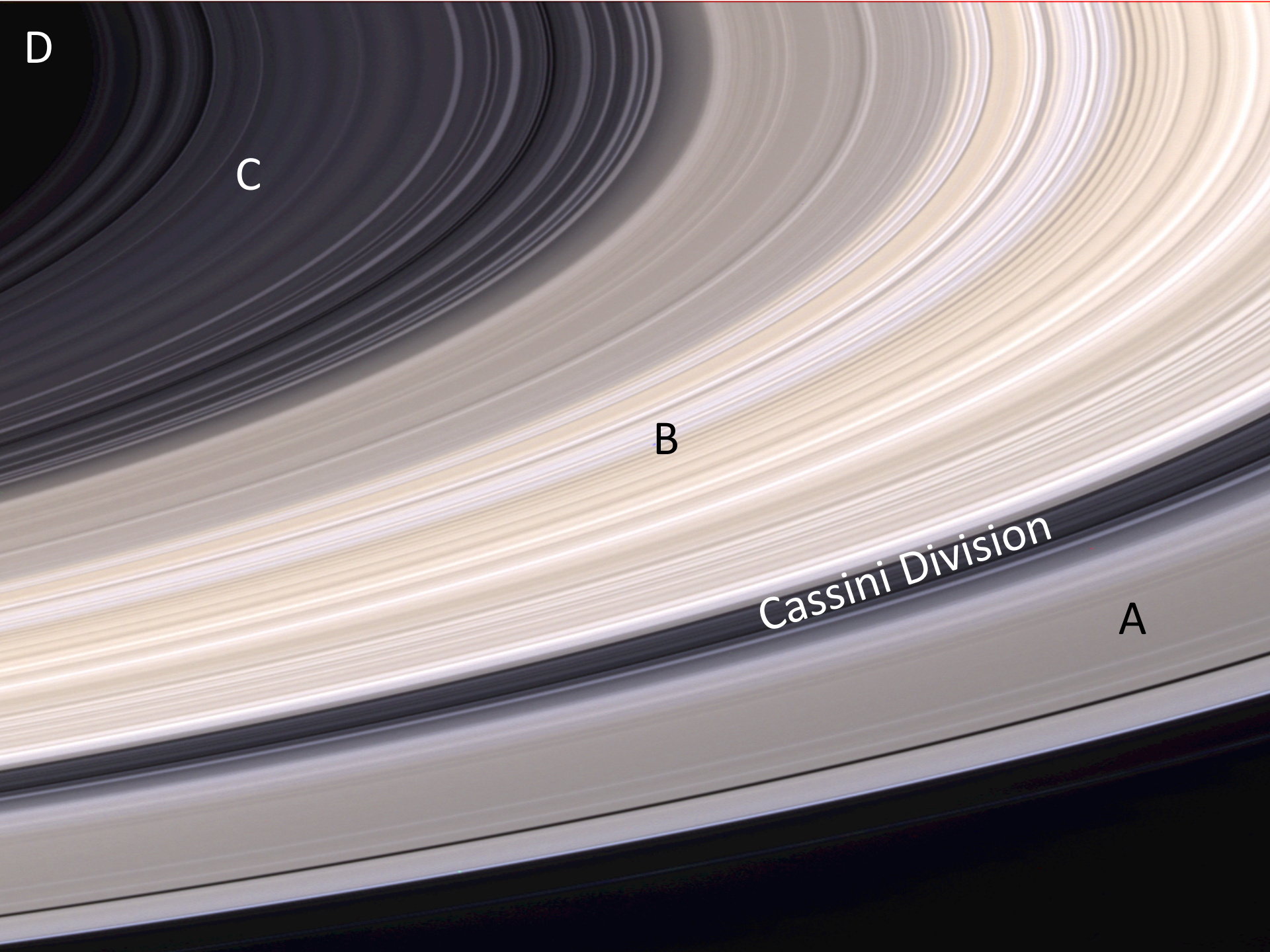


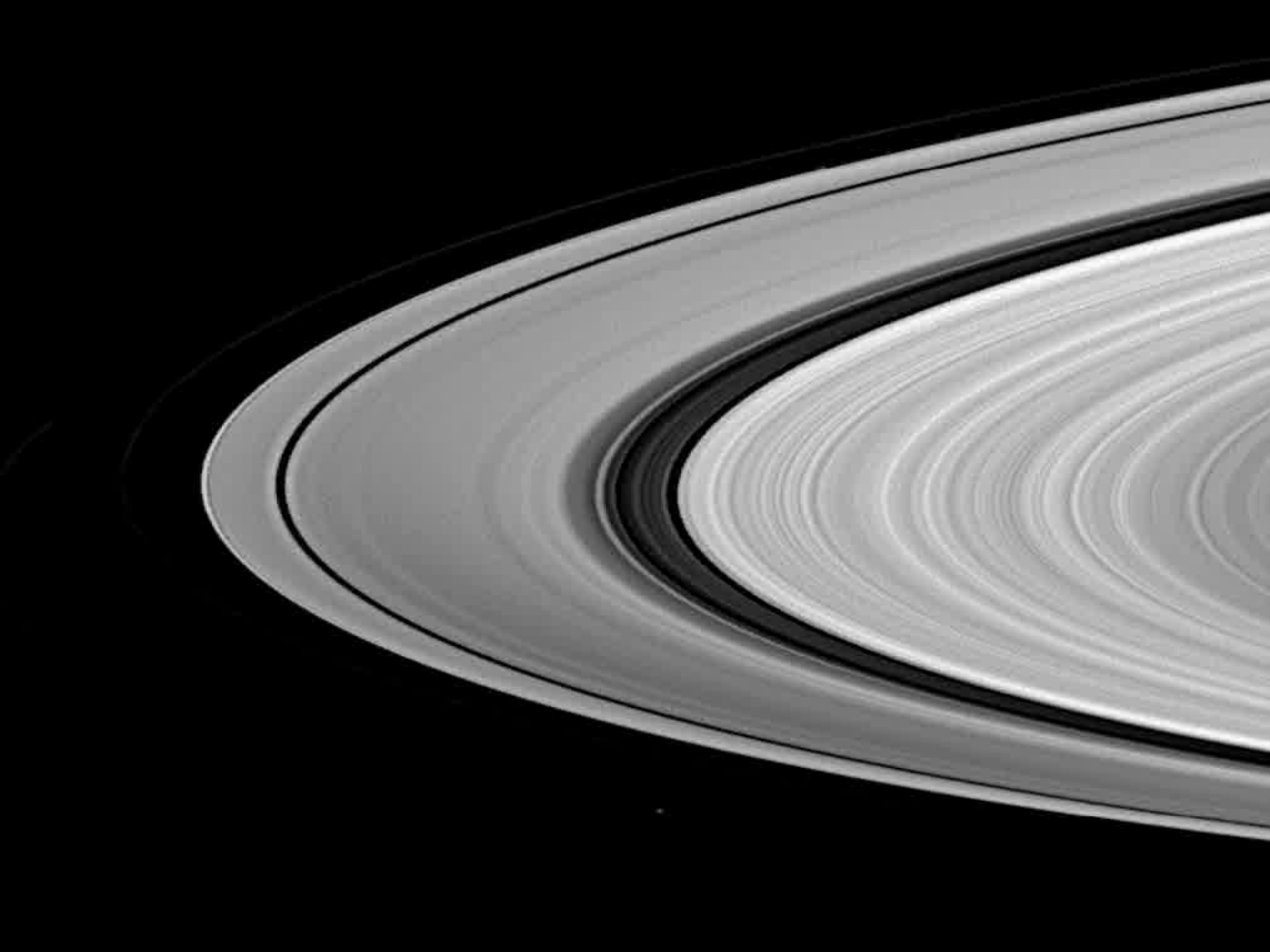




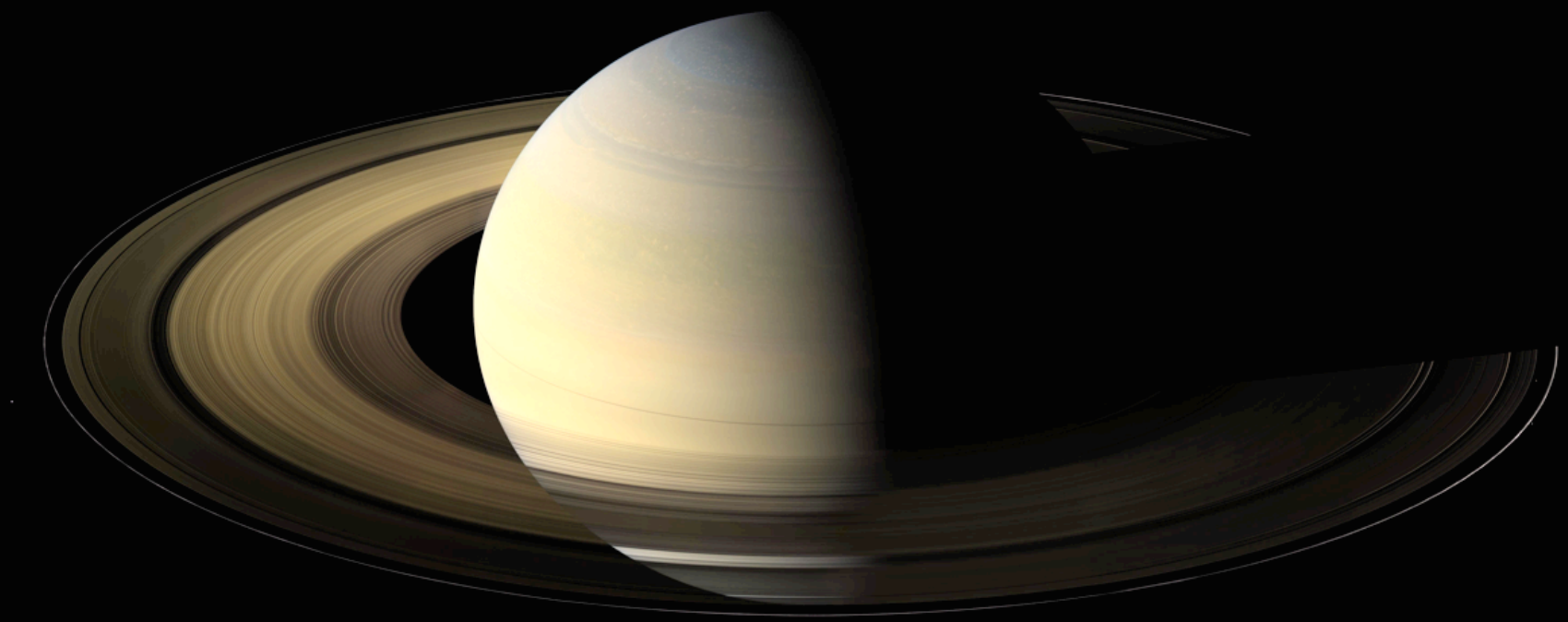
Saturn's Rings




D
C
B
Cassini Division
A

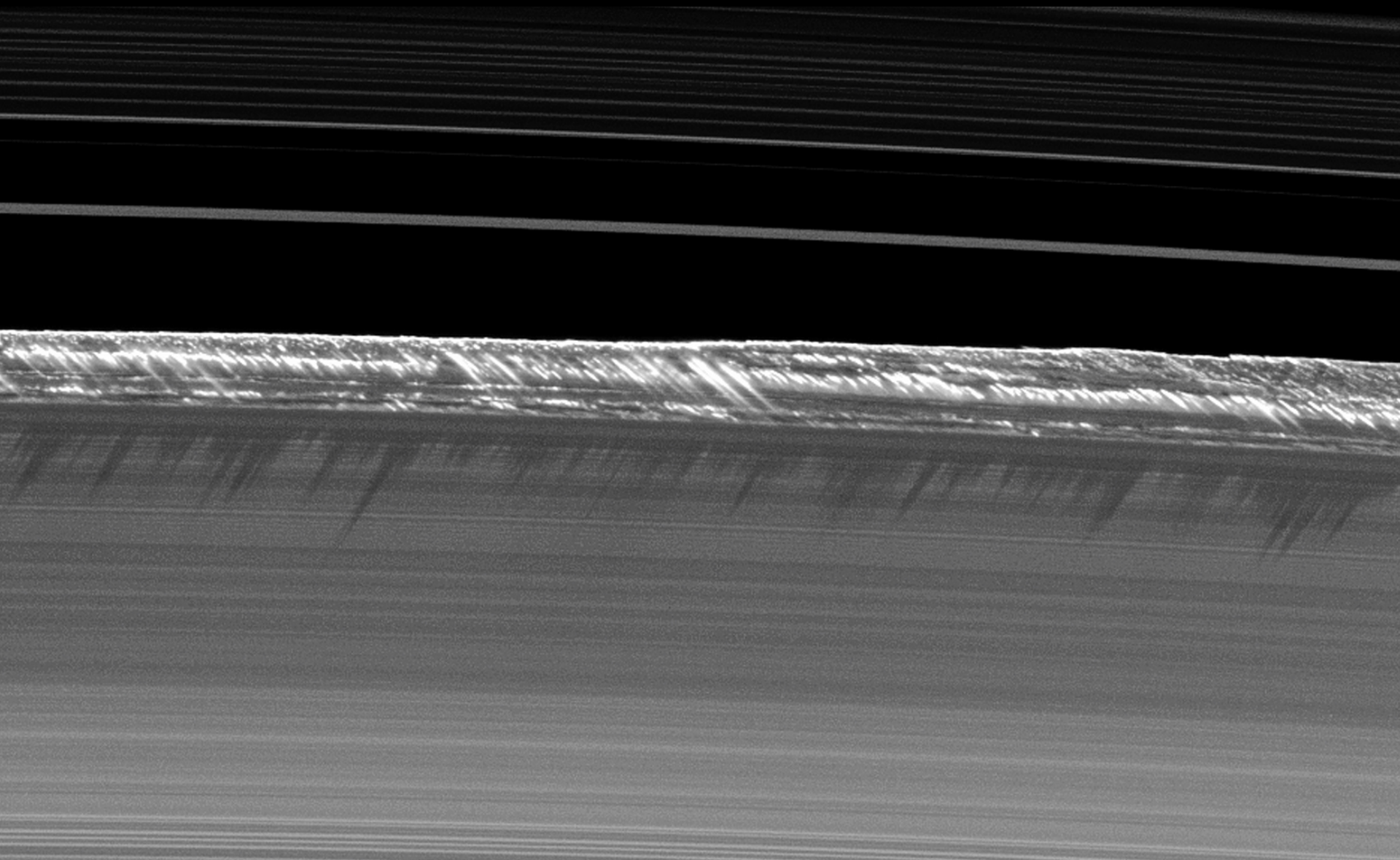


Saturn's Rings at Equinox

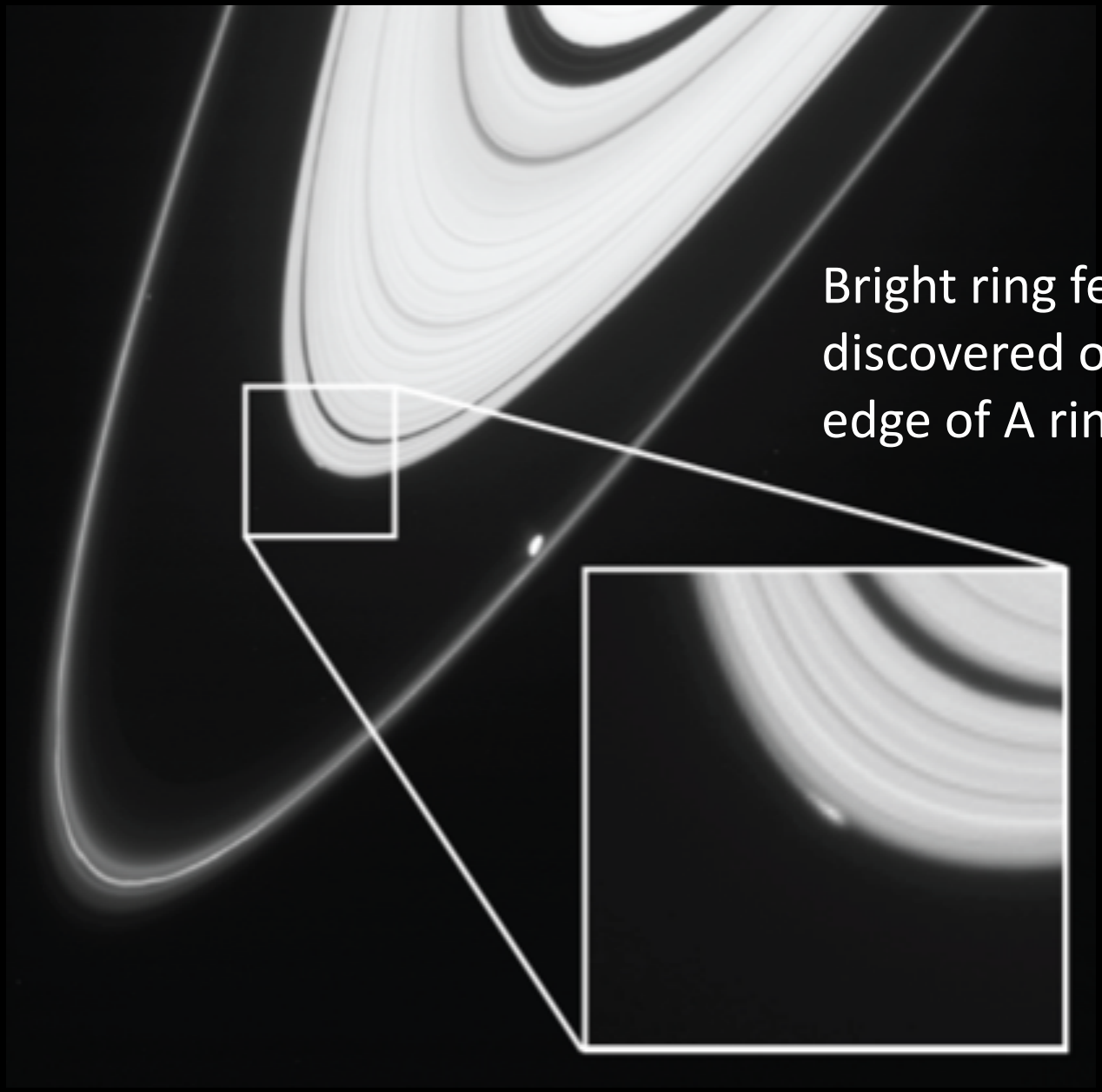


No Ring Shadow on the Planet which occurs only every ~15 Years!

Vertical Ring Structure



A New Moon is Born???

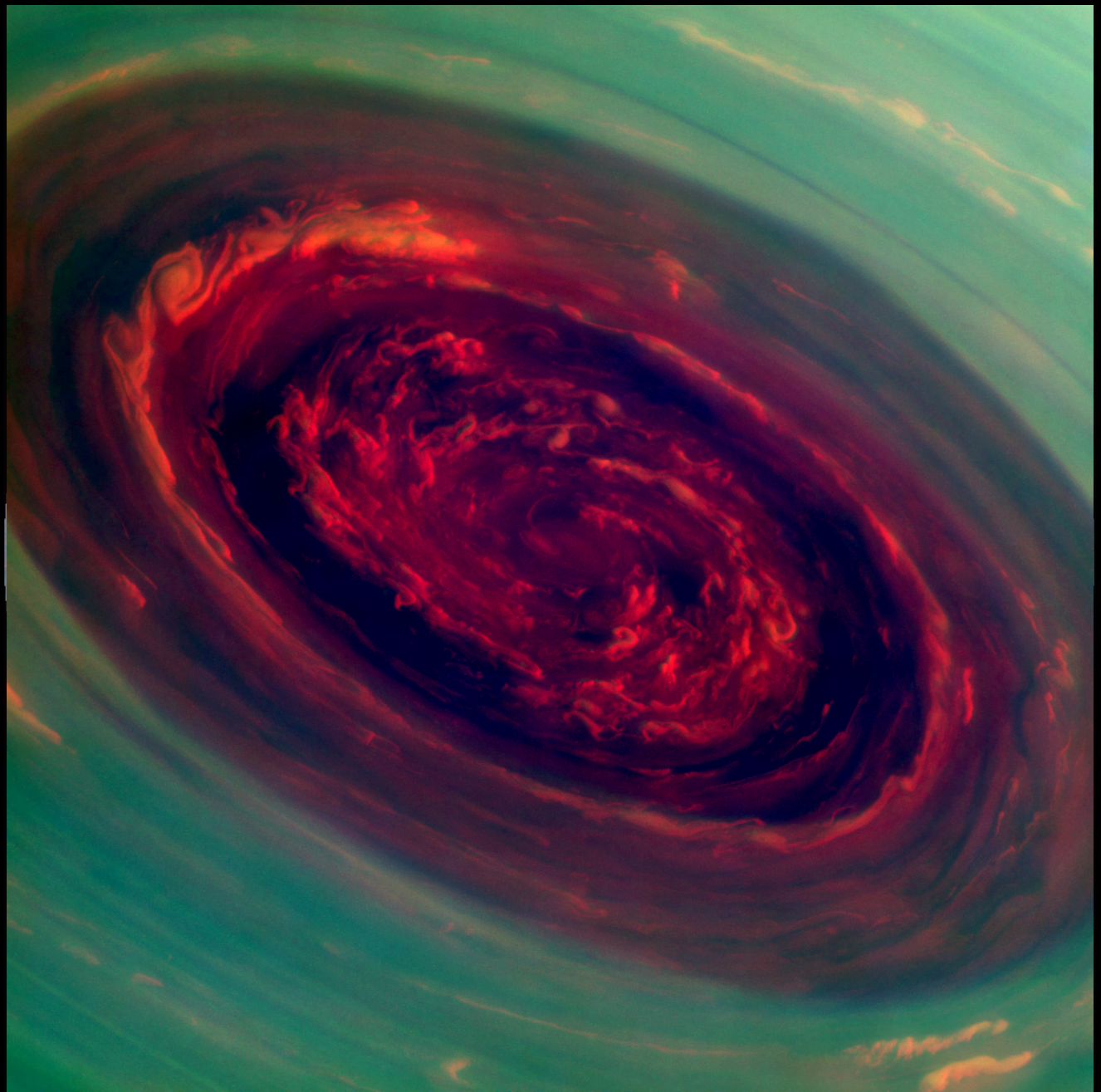


Bright ring feature discovered on outer edge of A ring

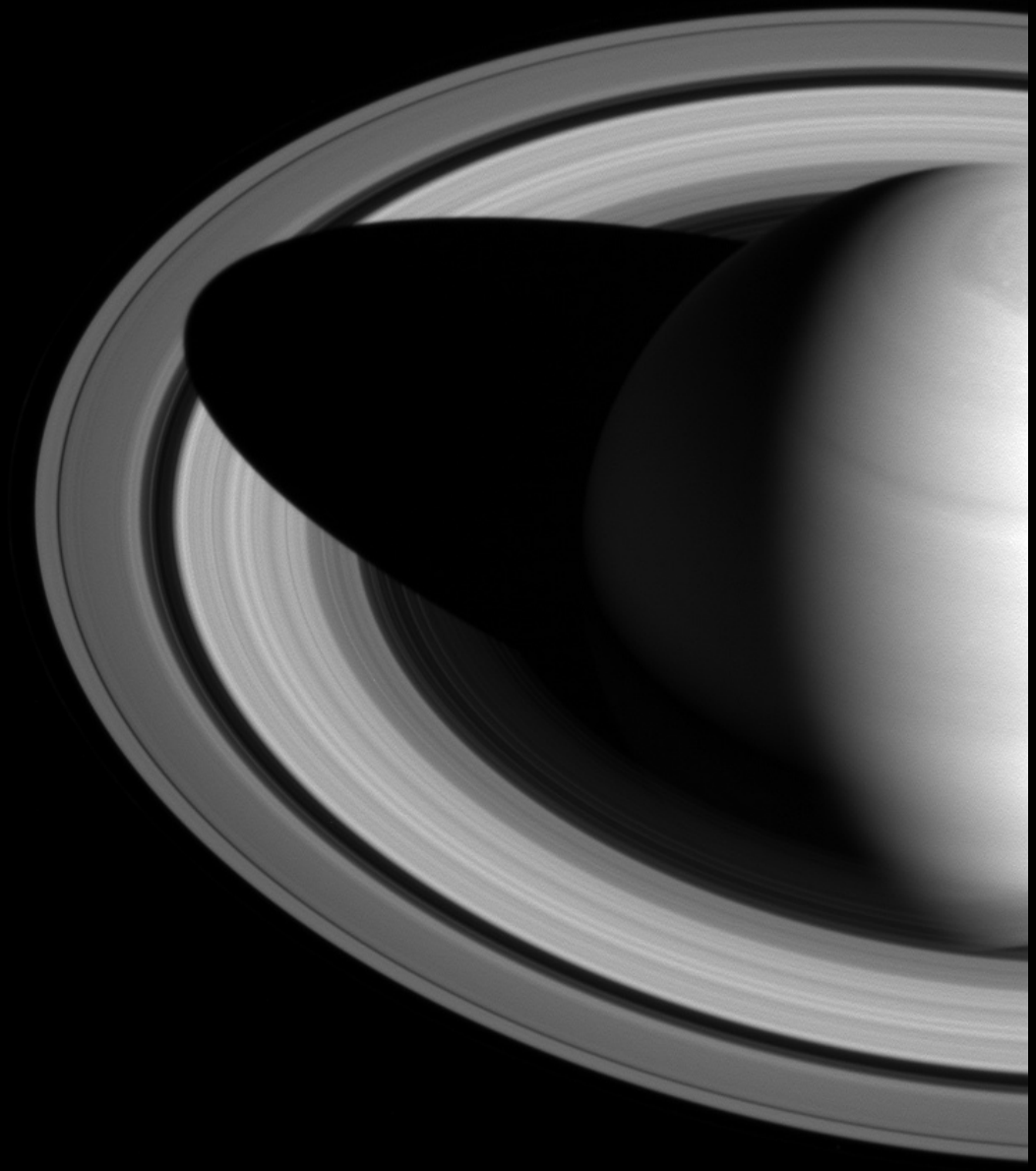
Appears to be associated with birth of small, icy infant moon nicknamed Peggy

Giant Storm: Head eats tail

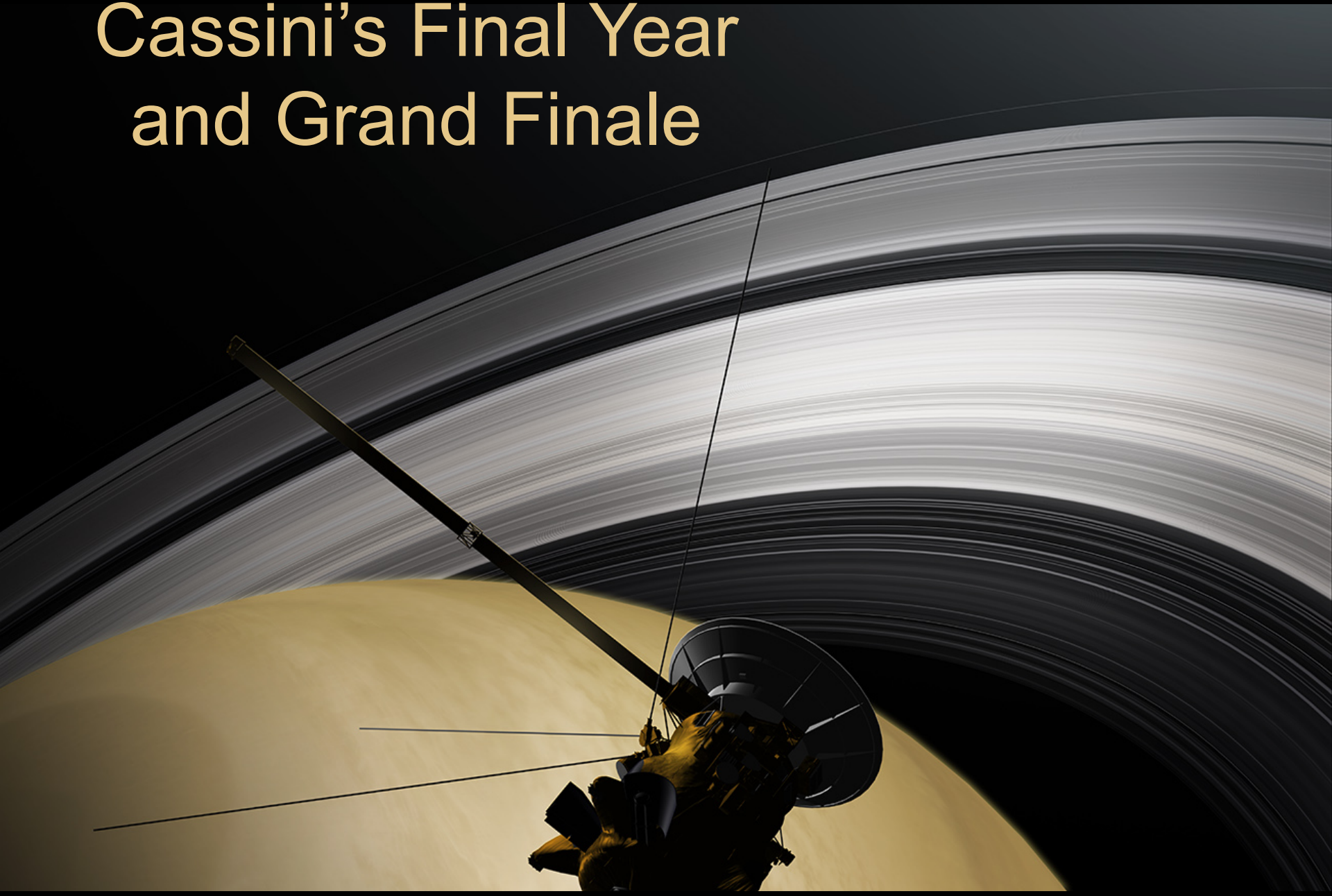
Hexagon and Giant hurricanes



Ring Shadow Marks Passing of Seasons

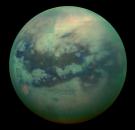


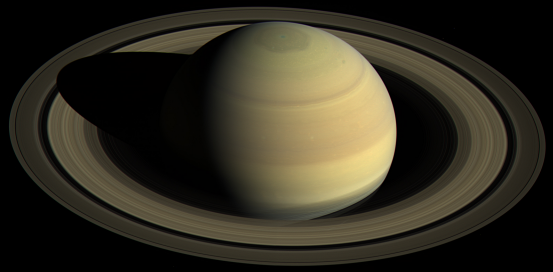
Cassini's Final Year and Grand Finale



- Cassini

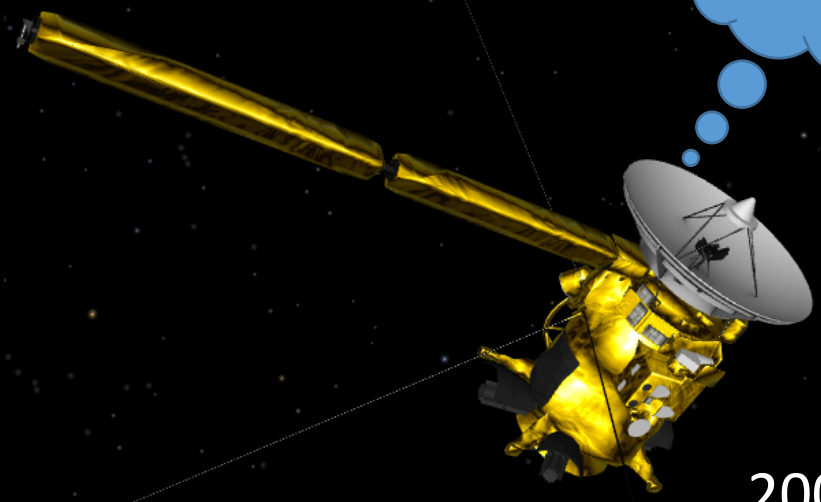
Centaur
Asteroids





Saturn

What's
Next?

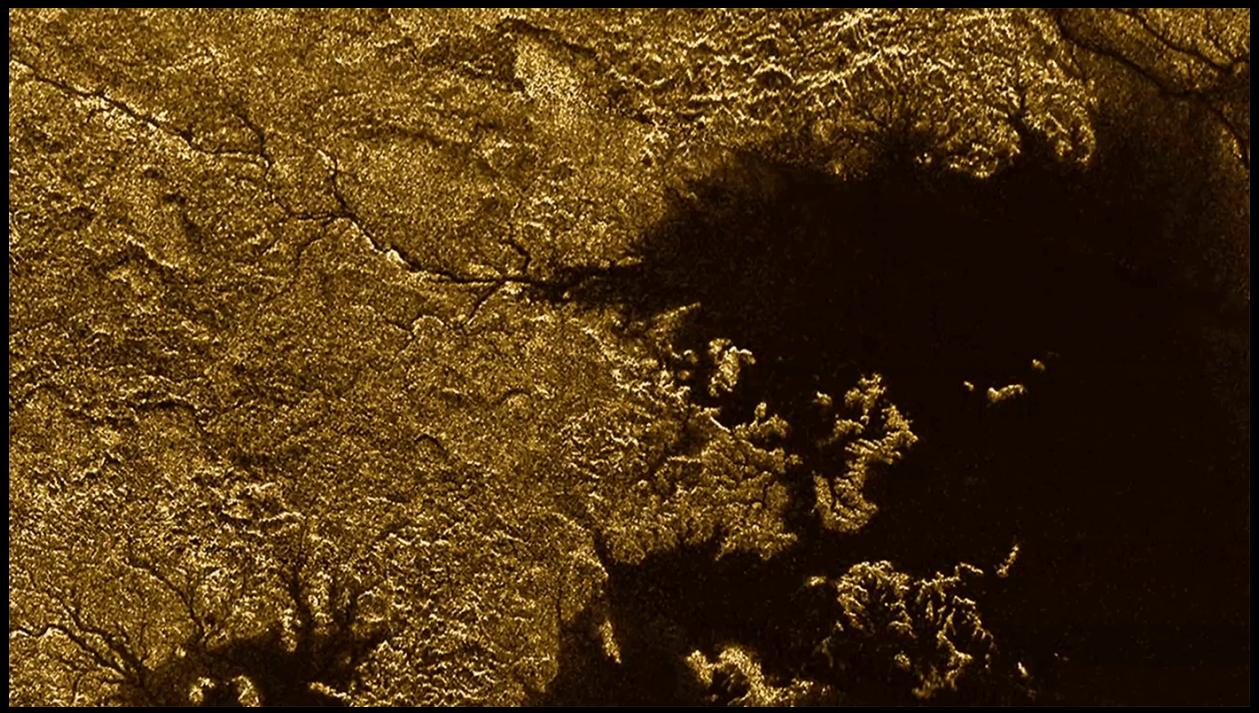


2009

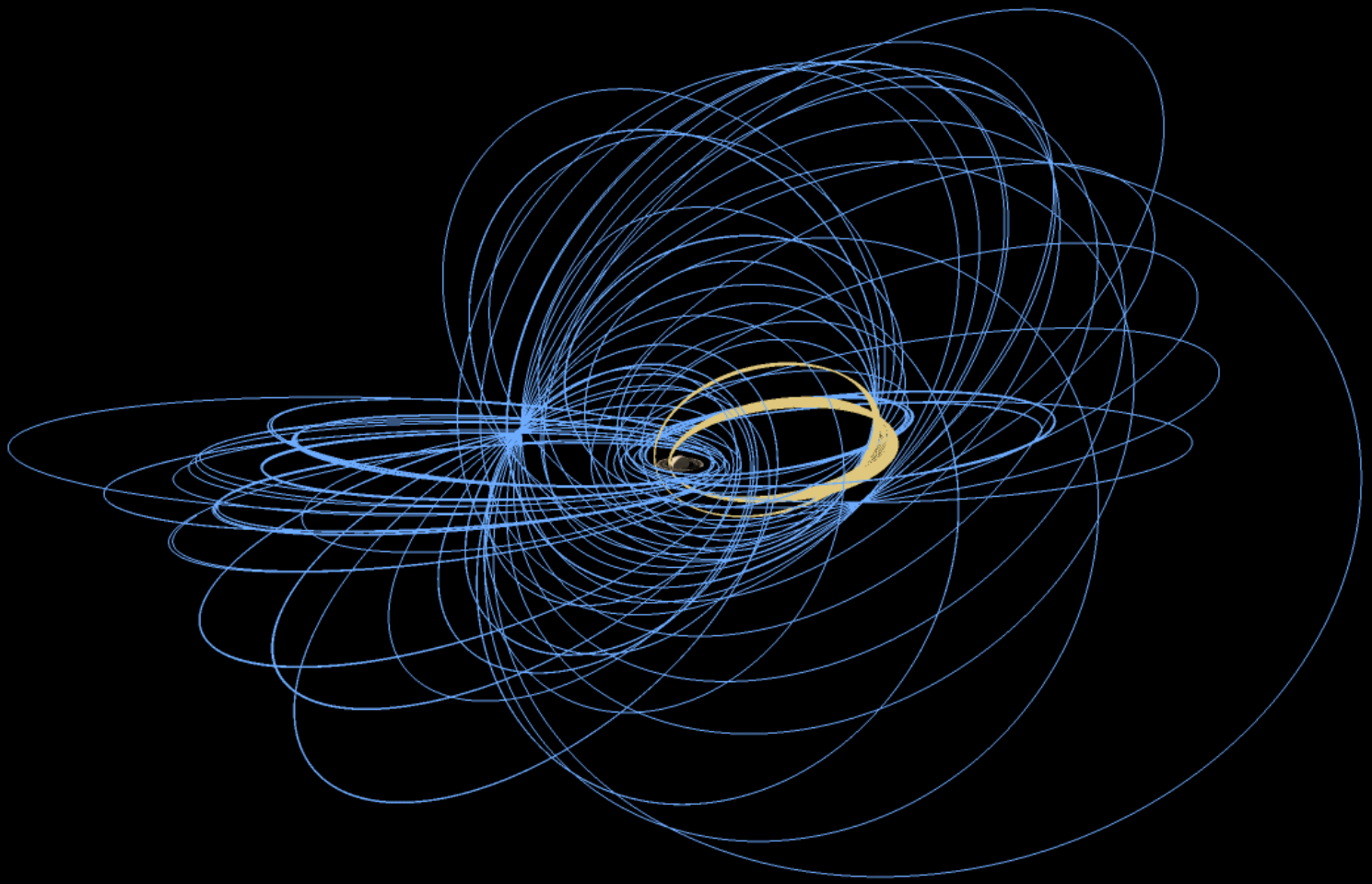
Gas
Giants

Protecting Saturn's Ocean Worlds

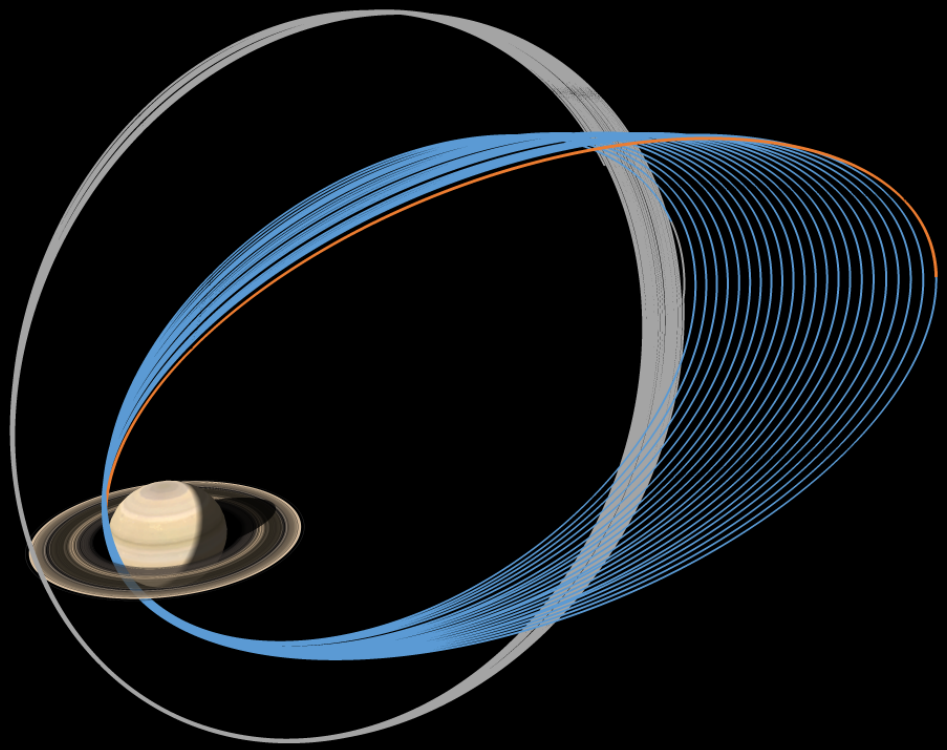
"You don't have to go home
(but you can't stay here)"



Solstice Mission Trajectory

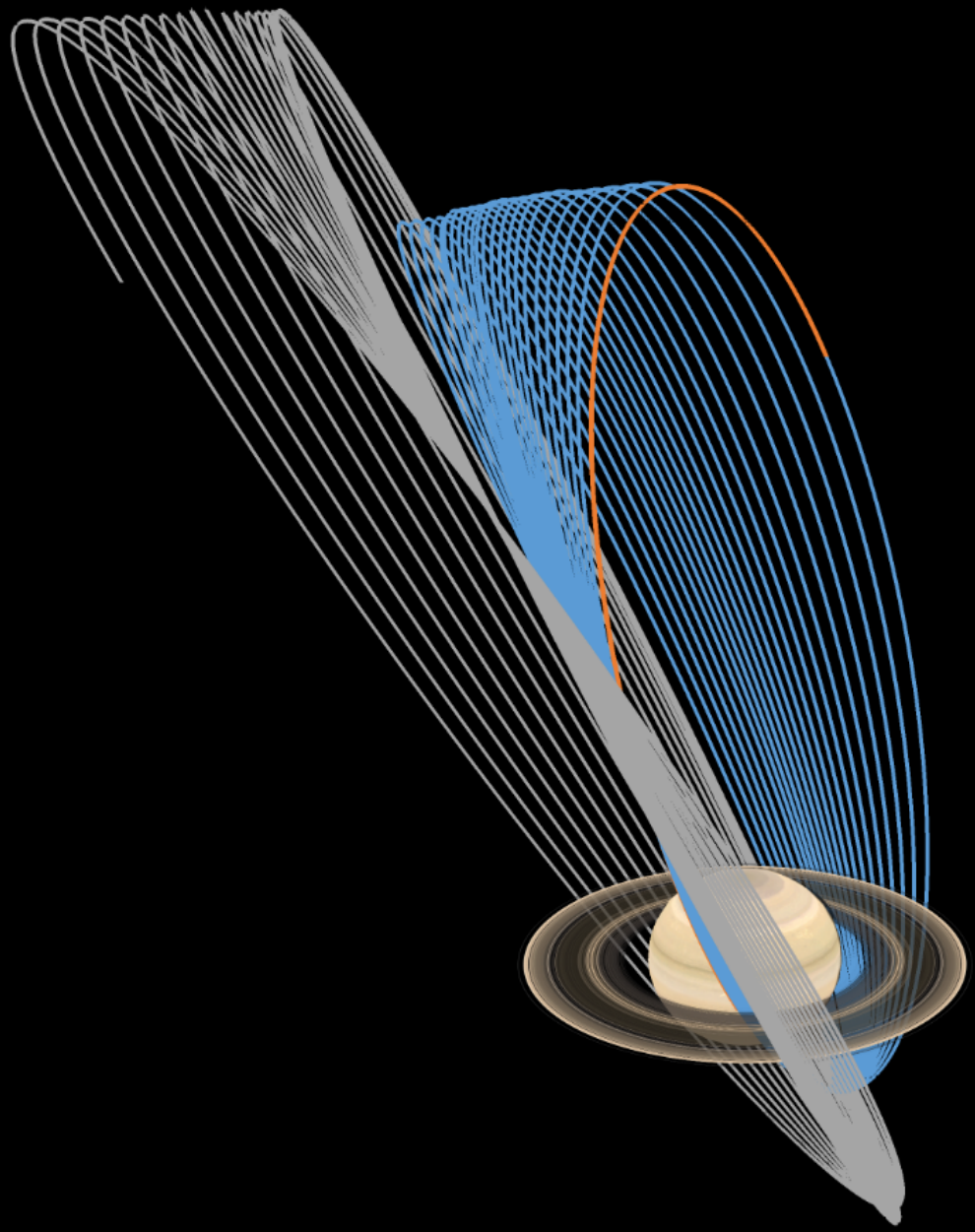


Key Orbital Characteristics of Final Orbits

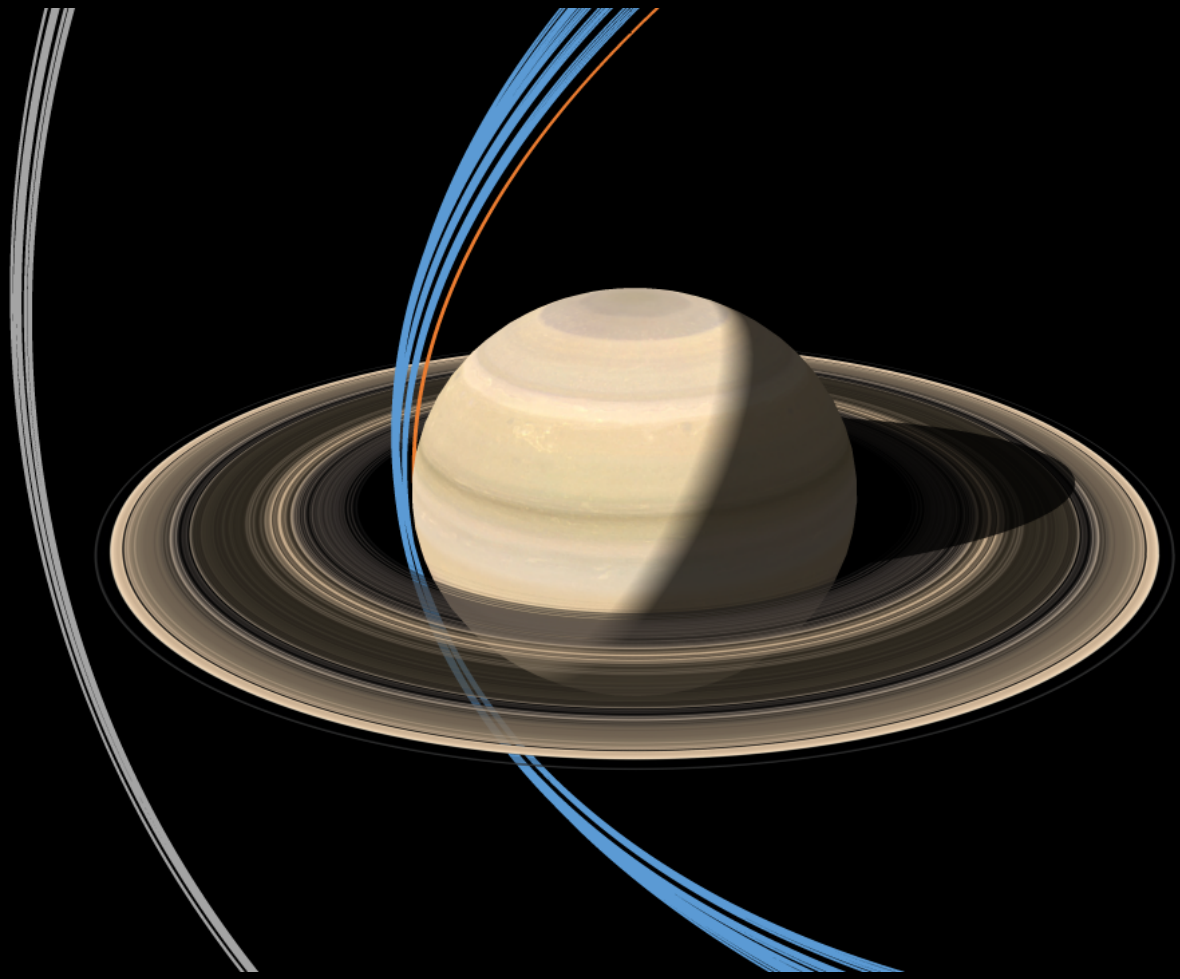


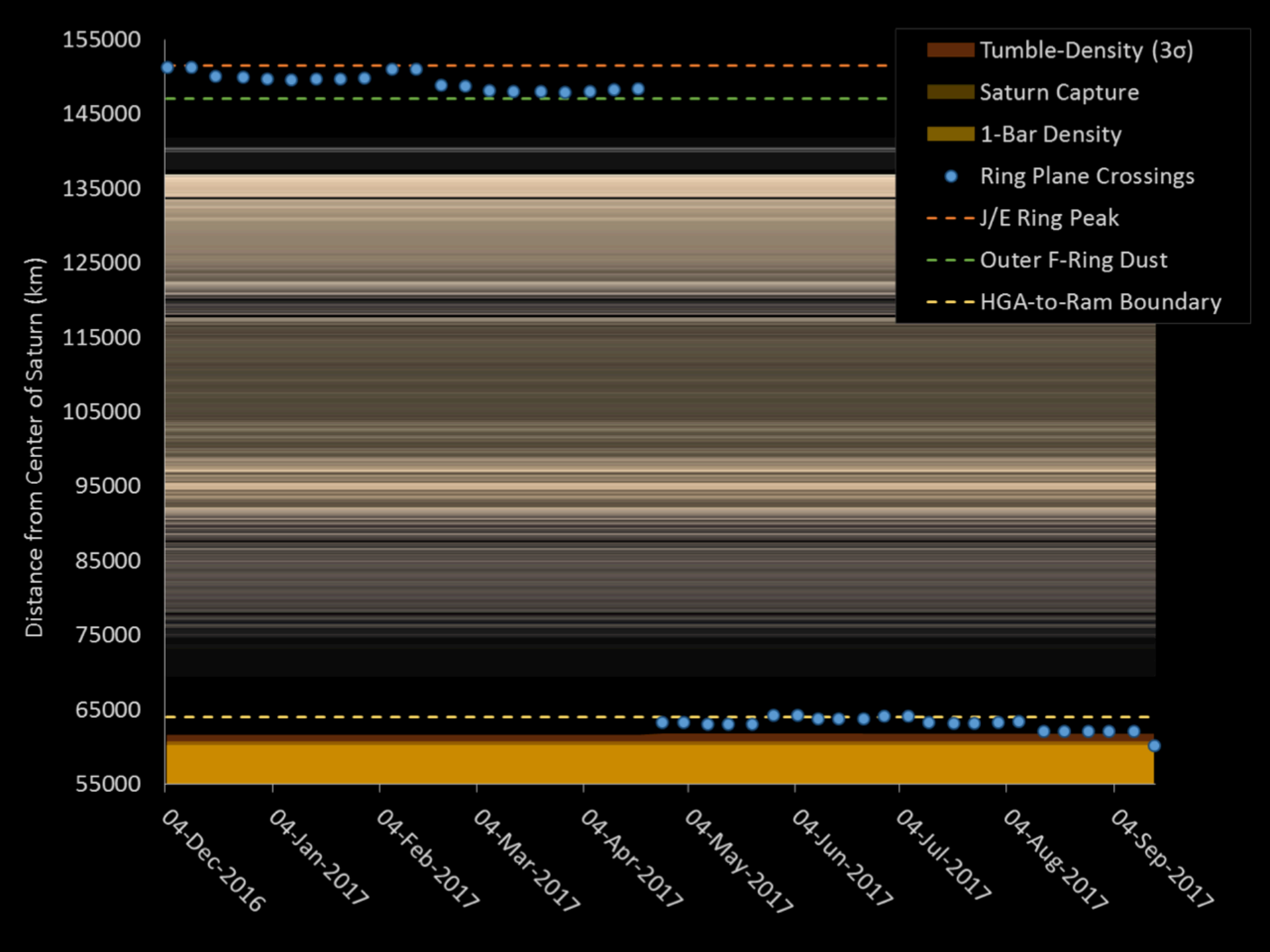
- 42 short-period orbits
  - Nov. 2016 to Sept. 2017
- 20 F ring orbits
  - Periapses just outside Saturn's F ring
  - Sets up Cassini for final jump to orbits inside D ring
- 22 Grand Finale orbits
  - Periapses in 2,400 km "clear" zone

F Ring and
Grand Finale
View from Earth

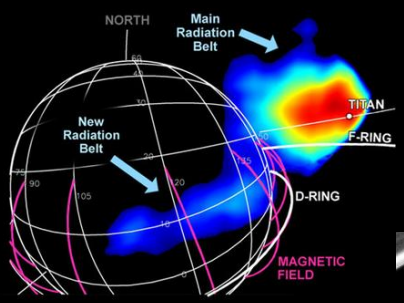


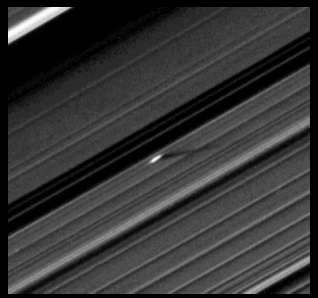
F Ring and Grand Finale Periapses

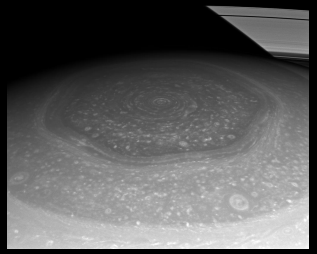



Distance from Center of Saturn (km)
155000
145000
135000
125000
115000
105000
95000
85000
75000
65000
55000
04-Dec-2016
04-Jan-2017
04-Feb-2017
04-Mar-2017
04-Apr-2017
04-May-2017
04-Jun-2017
04-Jul-2017
04-Aug-2017
04-Sep-2017
Tumble-Density (3σ)
Saturn Capture
1-Bar Density
Ring Plane Crossings
J/E Ring Peak
Outer F-Ring Dust
HGA-to-Ram Boundary

Final Orbits Science Summary







- Saturn internal structure
  - Gravitational & Magnetic Fields
- Ring mass
  - Address age of main rings
- Saturn's ionosphere, innermost radiation belts & inner D ring particles
- Highest resolution main ring observations
  - First Active Radar of the Rings
- Highest resolution Saturn polar observations and aurora
- Saturn atmosphere composition

Cassini Saturn science complements that from Juno mission to Jupiter

Grand Finale Timeline

November 30, 2016

- F-ring Orbits Begin
  - 20 orbits
  - 3 maneuvers

April 22, 2017

- Last Targeted Titan Flyby
  - Produces Grand Finale trajectory

April 23, 2017

- Grand Finale Begins
  - 22½ orbits
  - 9 non-targeted Titan flybys

April 26, 2017

- First dive through gap

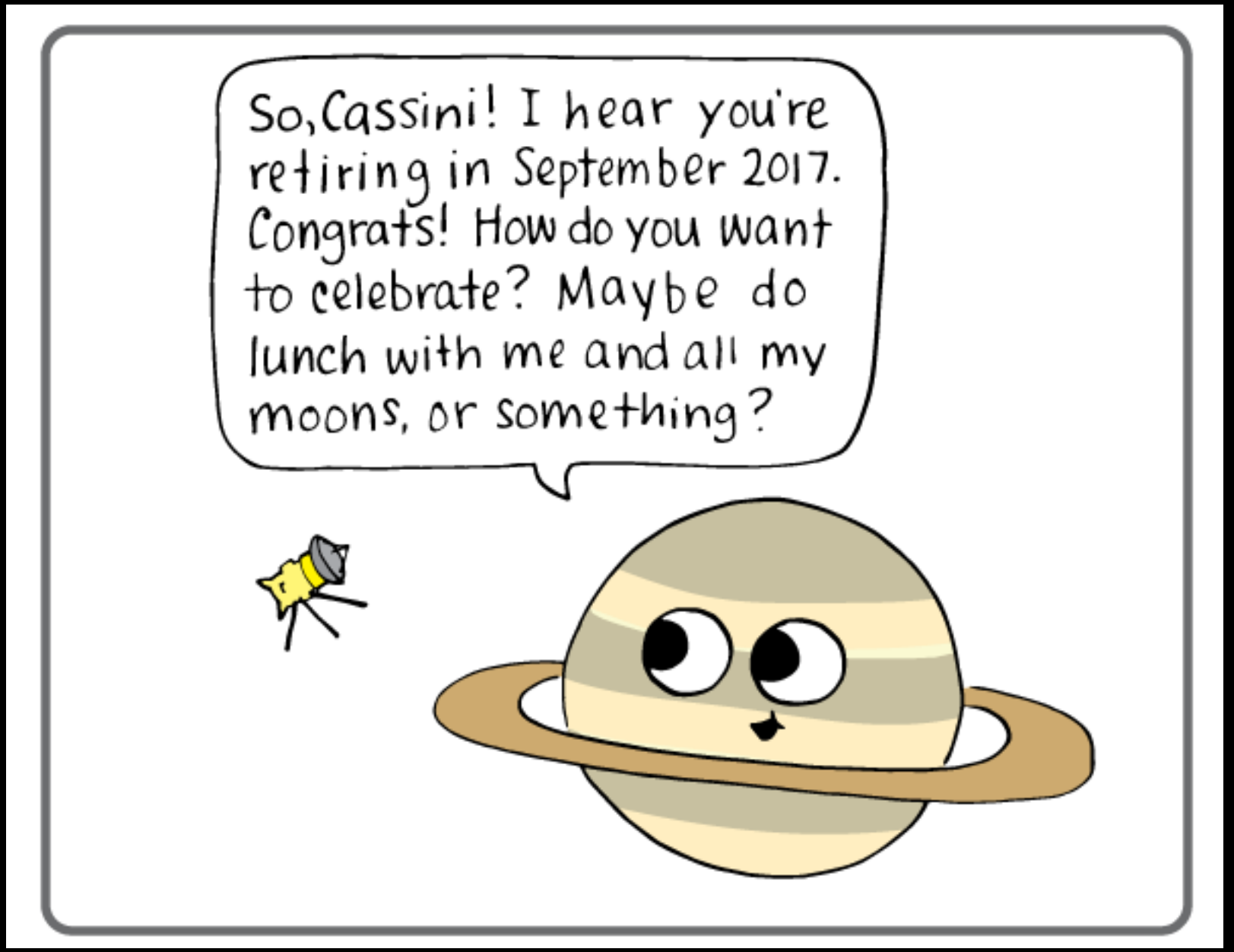
September 11, 2017

- Last Non-targeted Titan Flyby
  - Puts Cassini on impact trajectory

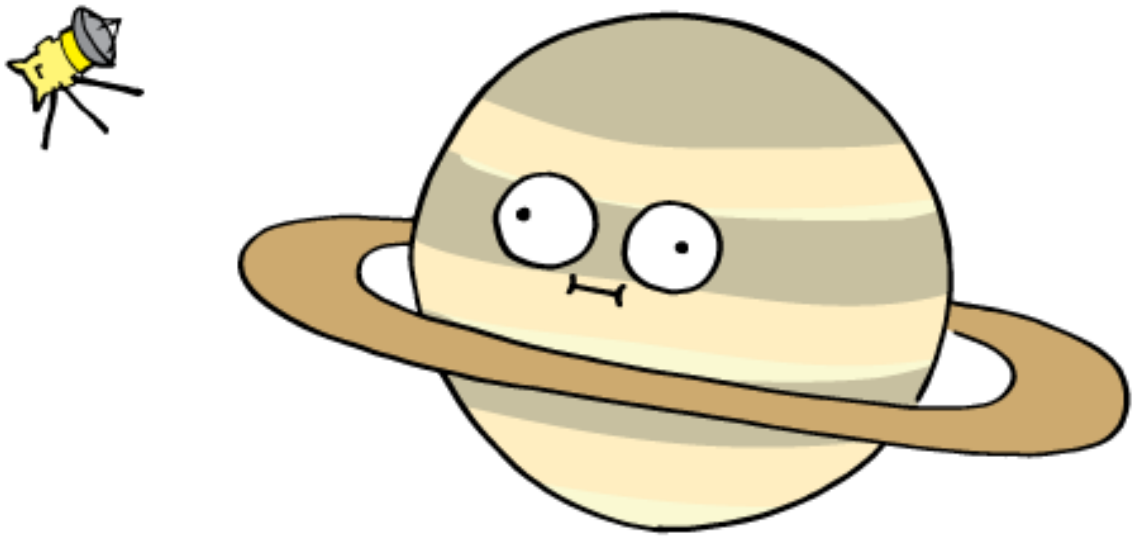
September 15, 2017

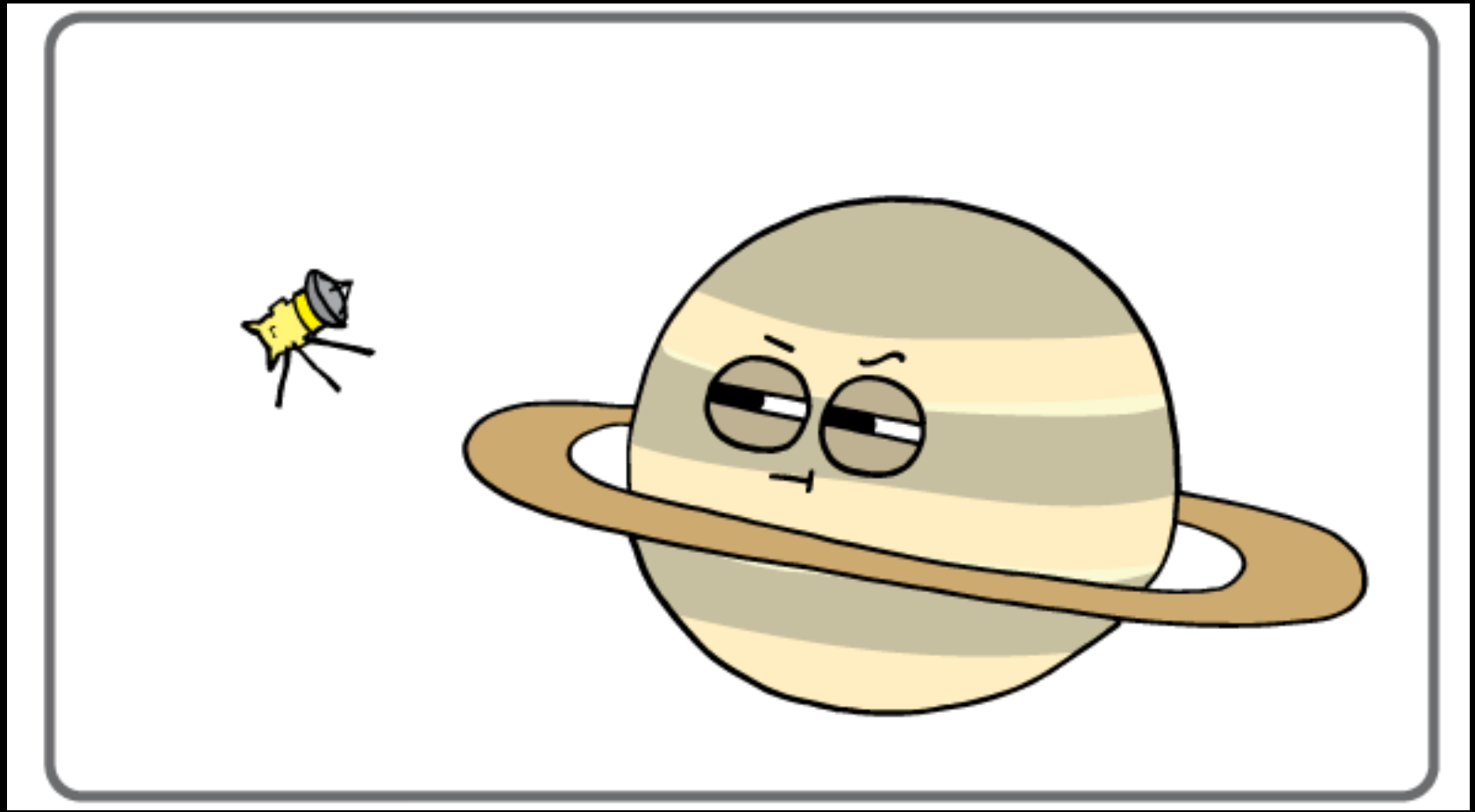
- Saturn Impact

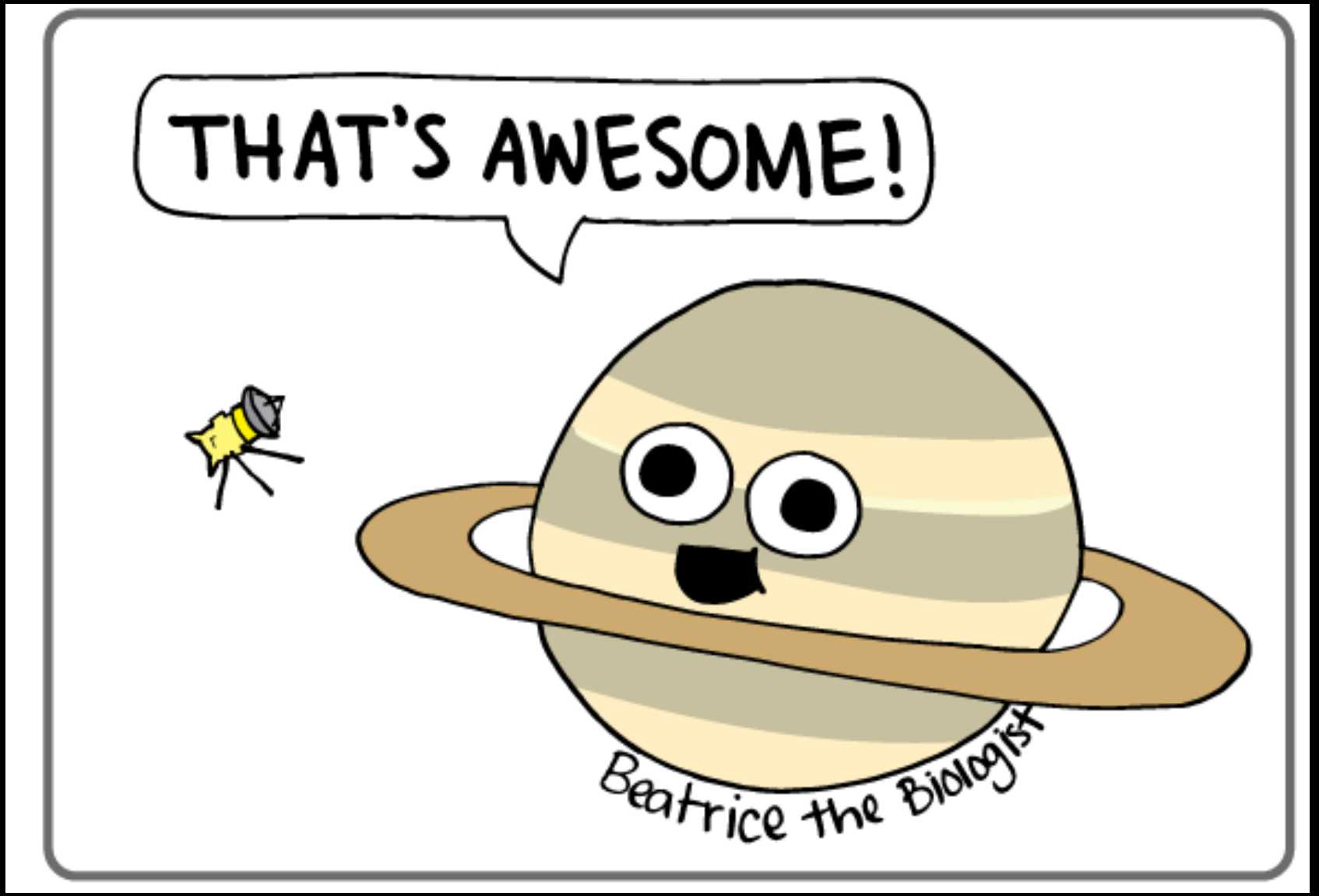




So, Cassini! I hear you're retiring in September 2017. Congrats! How do you want to celebrate? Maybe do lunch with me and all my moons, or something?

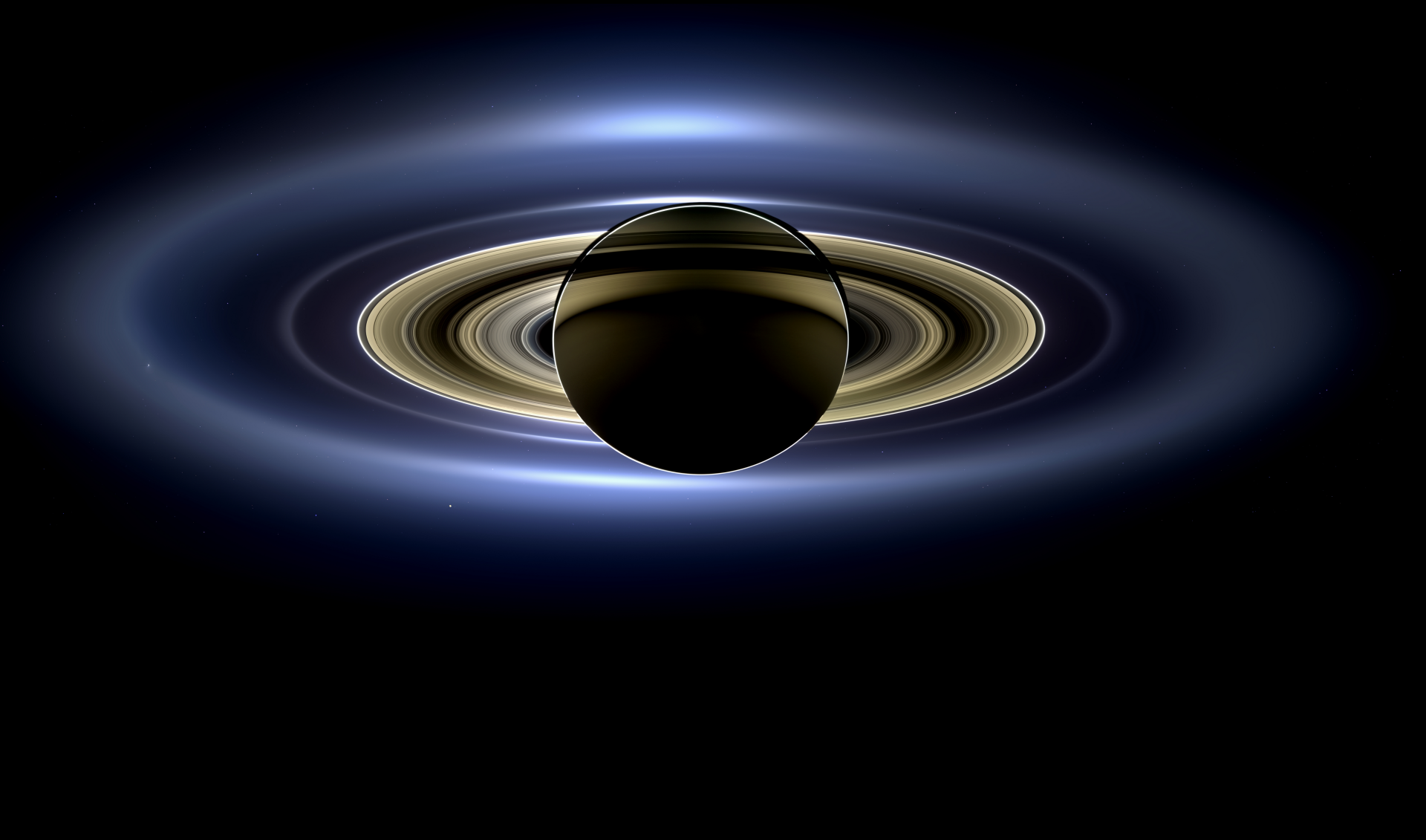
Nah. I'll just go barreling straight into your atmosphere, learning as much as I can before I'm crushed to death and vaporized in a spectacular whirling inferno beneath your mysterious, stormy clouds.

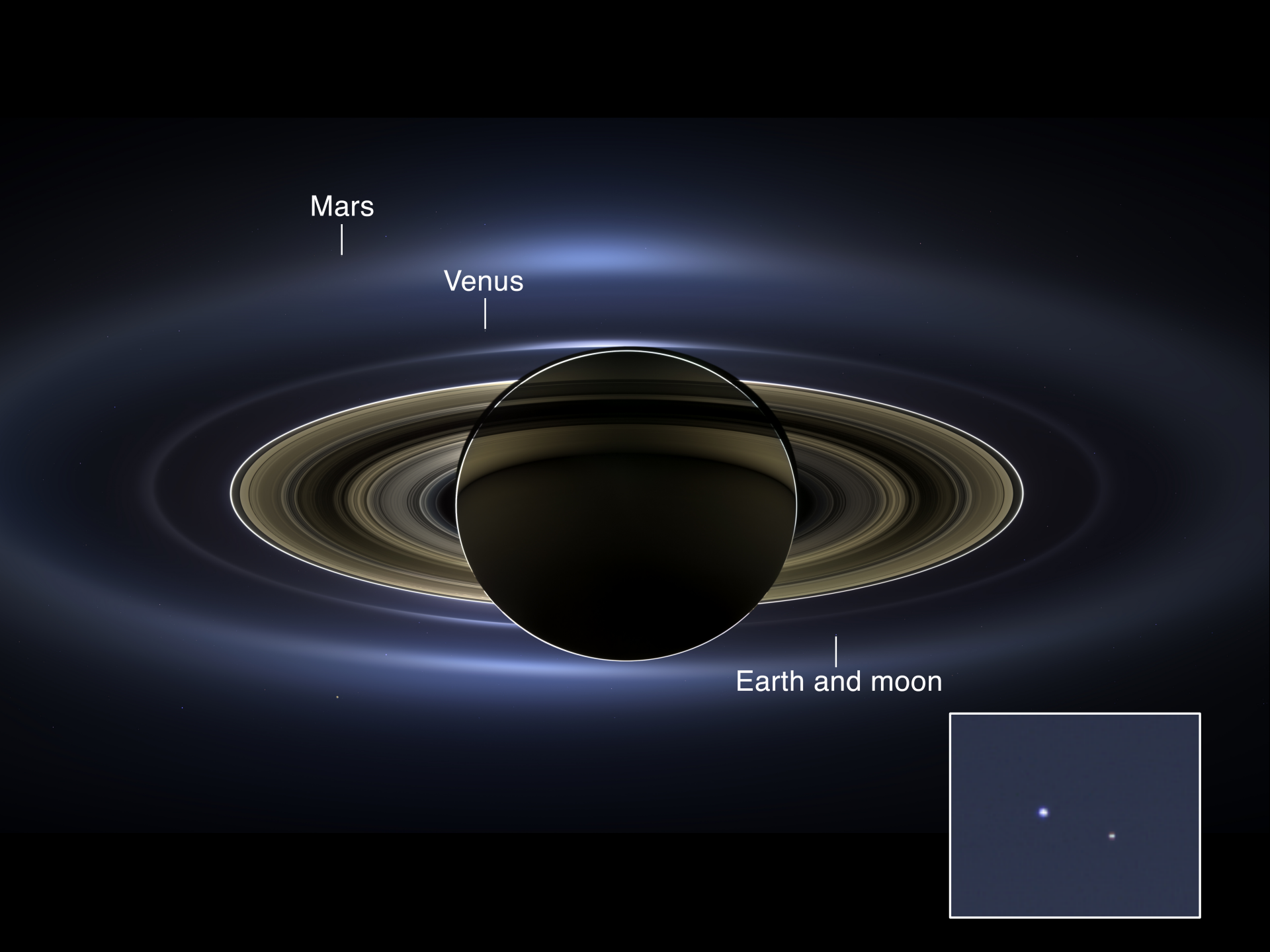





THAT'S AWESOME!
Beatrice the Biologist

Questions?




Mars
Venus
Earth and moon

Cassini Family saying Goodbye…