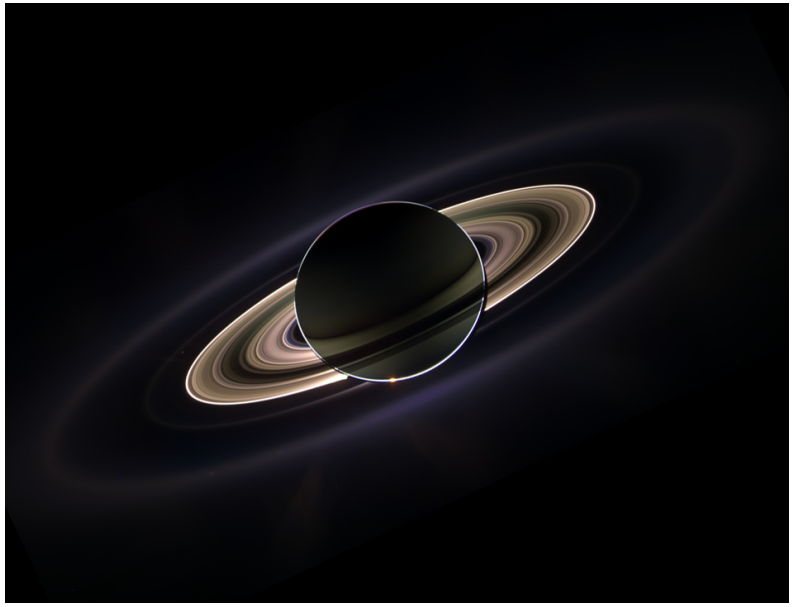
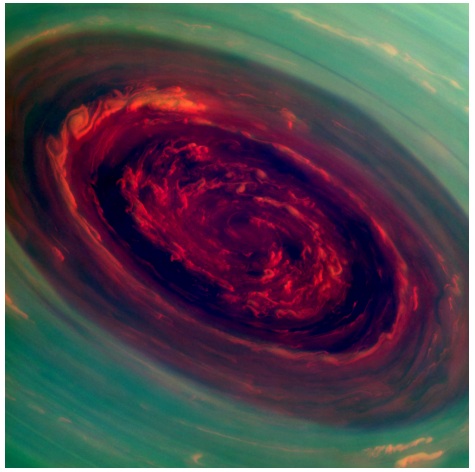
Linda Spilker
Cassini Project Scientist
Outer Planets Assessment Group
15 July 2013

Cassini Solstice Mission: Introduction

- Key Cassini events
  - New Cassini Program Manager
  - New Participating Scientists
  - Recent Flybys
- Latest Science Highlights
  - Last Rhea Flyby
  - Titan Ice Floats
  - Meteor Strikes in Rings
  - Kronoseismology
  - Polar Hurricane
  - Auroral Campaign
  - Enceladus Plume Variability
- Upcoming Cassini Senior Review
- Wave at Saturn campaign





New Program Manager: Earl Maize

New Cassini Participating Scientists

Caitlin Griffith

Alex Hayes

Henrik Melin

Francis Nimmo

Christopher Parkinson

Mark Perry

Joe Spitale

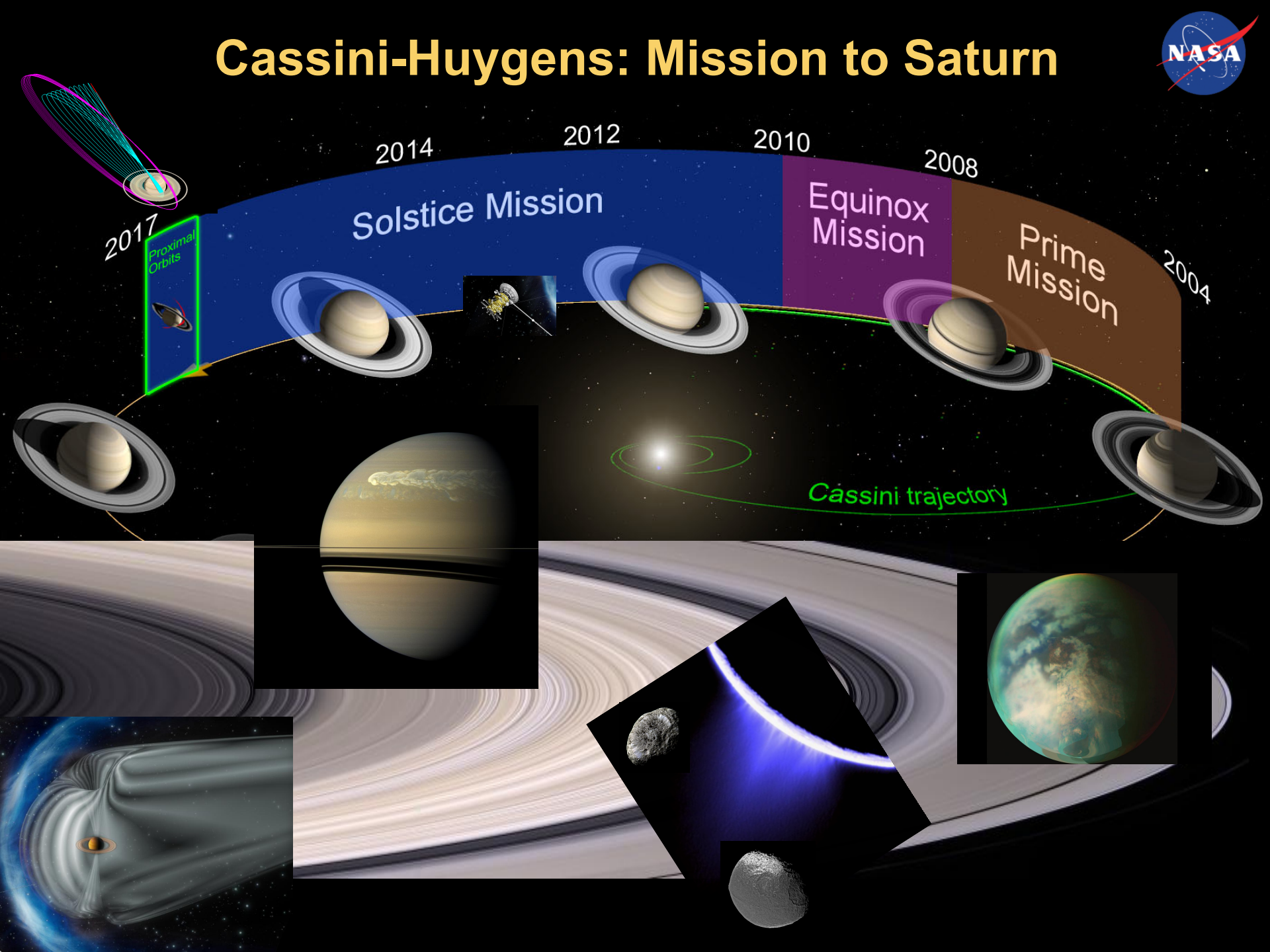
Matt Tiscareno

Ann Verbiscer

New Participating Scientists

PI	Instruments/DWG	Institution	Title	Discipline	E-mail
Caitlin Griffith	primary: VIMS occasional: CIRS, RADAR /TWG	University of Arizona	Titan's Methane Cycle: An analysis of Cassini Data	Titan	Griffith@lpl.arizona.edu
Alex Hayes	RADAR / TWG (VIMS, ISS through proposal Co-Is)	Cornell University	Seas, Lakes, Channel Networks and Hillslopes: A Coupled Analysis to Explore the Evolution of Titan's Polar Landscapes	Titan, Icy Satellites	hayes@astro.cornell.edu
Henrik Melin	UVIS, VIMS	Space Environment Technologies	Simultaneous infrared and ultraviolet observations of Saturn's aurora using Cassini VIMS and UVIS	Saturn, Magnetosphere	h.melin@gmail.com
Francis Nimmo	RSS, RADAR, NAV / ISWG	University of California, Santa Cruz	Integrating shape and gravity data to investigate Saturnian satellite structure and evolution	Icy Satellites	fnimmo@es.ucsc.edu
Christopher Parkinson	UVIS (main), CIRS, VIMS, ISS / SWG	University of Michigan	Analysis of Extreme and Far Ultraviolet Observations of Saturn¹s Atmosphere	Saturn (main), Icy Satellites	theshire@umich.edu
Mark Perry	INMS / MAPS WG	John Hopkins Univ., APL	Analysis of INMS observations of ions and neutrals in Saturn's inner magnetosphere	Magnetosphere, Icy Satellites	mark.perry@jhuapl.edu
Joe Spitale	ISS / ISWG	Planetary Science Institute	Instantaneous Jet Source Locations on Enceladus: Testing the Tidal Control Hypothesis	Icy Satellites: Enceladus Jets	jnspitale@psi.edu
Matt Tiscareno	ISS / RWG (comm. with ISWG)	Cornell University	Dynamics of Saturn's Rings and Moons	Rings (mainly), Icy Satellites	matthewt@astro.cornell.edu
Anne Verbiscer	ISS, VIMS, CIRS / ISWG	University of Virginia	Spectrophotometric Analysis of Thermally Anomalous Terrain on Icy Saturnian Satellites	Icy Satellites	verbiscer@virginia.edu

Cassini-Huygens: Mission to Saturn



Flybys

T89 – Titan flyby (1978 km) Feb. 17, 2013

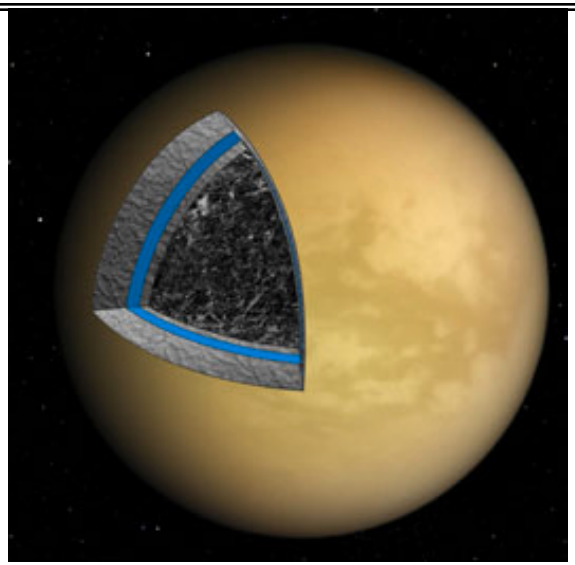
- RSS gravity flyby (1 of 4 in CSM) to understand possible ocean and soft interior

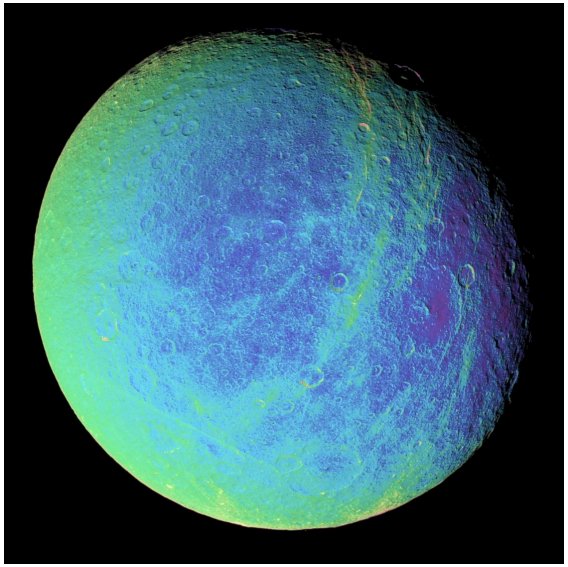
R4 – Rhea flyby (997 km) Mar. 9, 2013

- Determined gravity to understand internal structure, measured dust environment, and imaged surface in UV, IR, and visible

T90 – Titan flyby (1400 km) Apr. 5, 2013

- ORS flyby: CIRS searched for atmospheric seasonal change and VIMS looked for surface evolution in southern fall

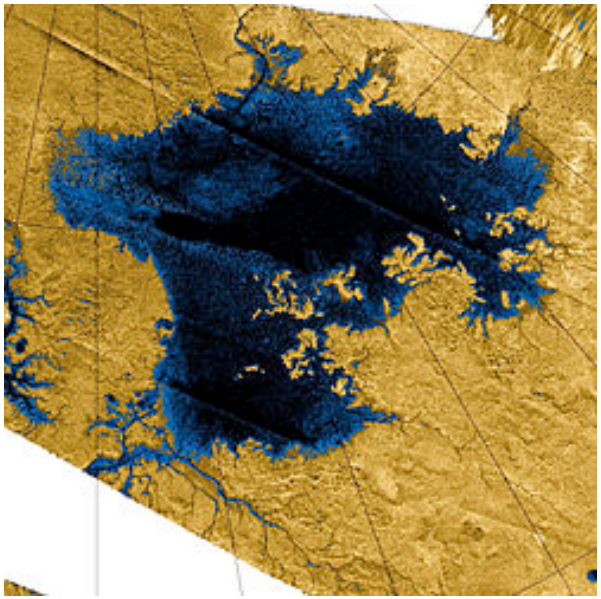




Flybys

T91 – Titan flyby (970 km) May 23, 2013

- RADAR flyby to addresses Titan lake depths and seasonal change and to understand relationship between Titan's gravity and surface topography



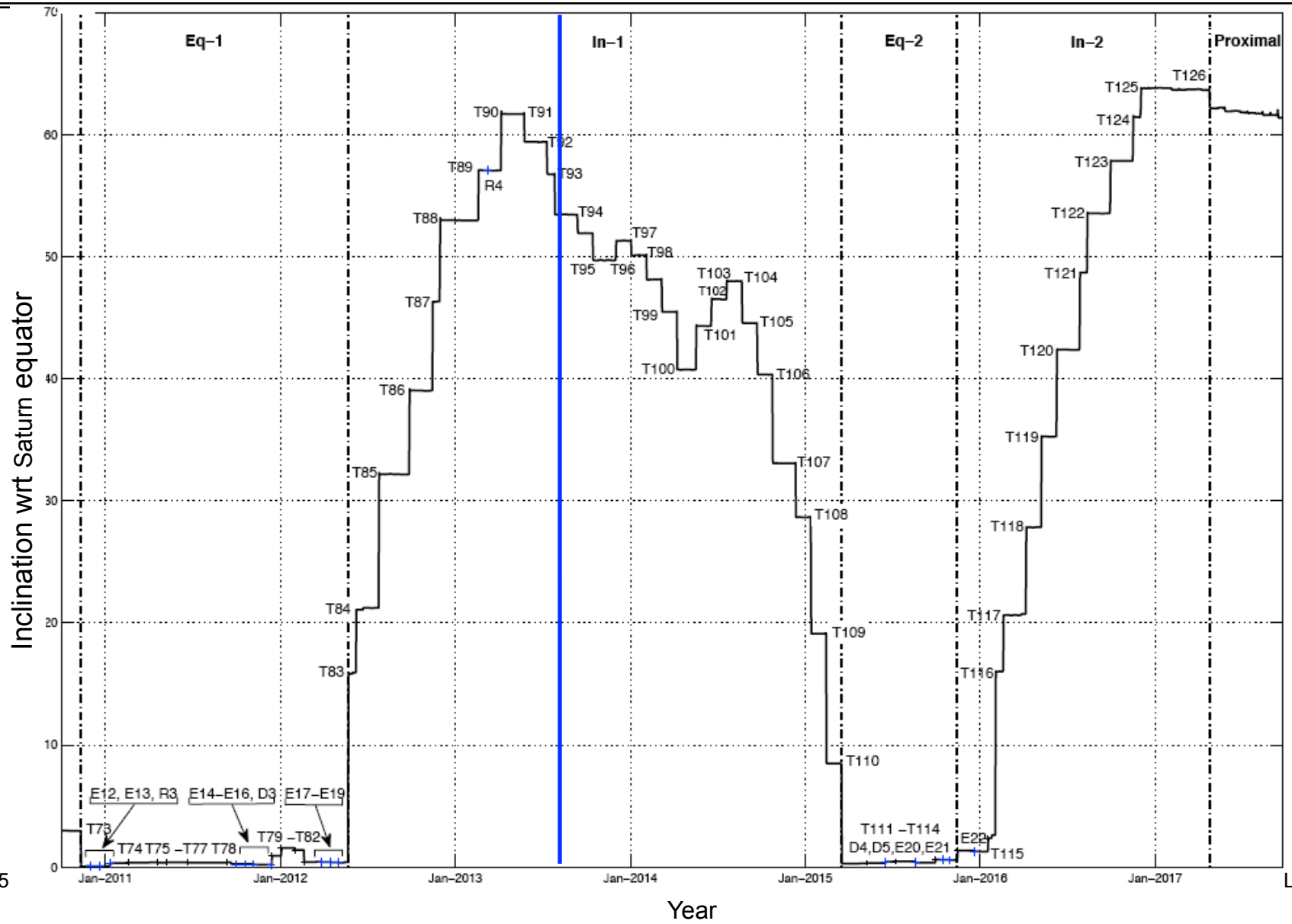
T92 – Titan flyby (964 km) Jul. 10, 2013

- RADAR flyby: stereo pair (T91 and T92) to look for lake change and surface porosity

T93 – Titan flyby (1400 km) Jul. 26, 2013

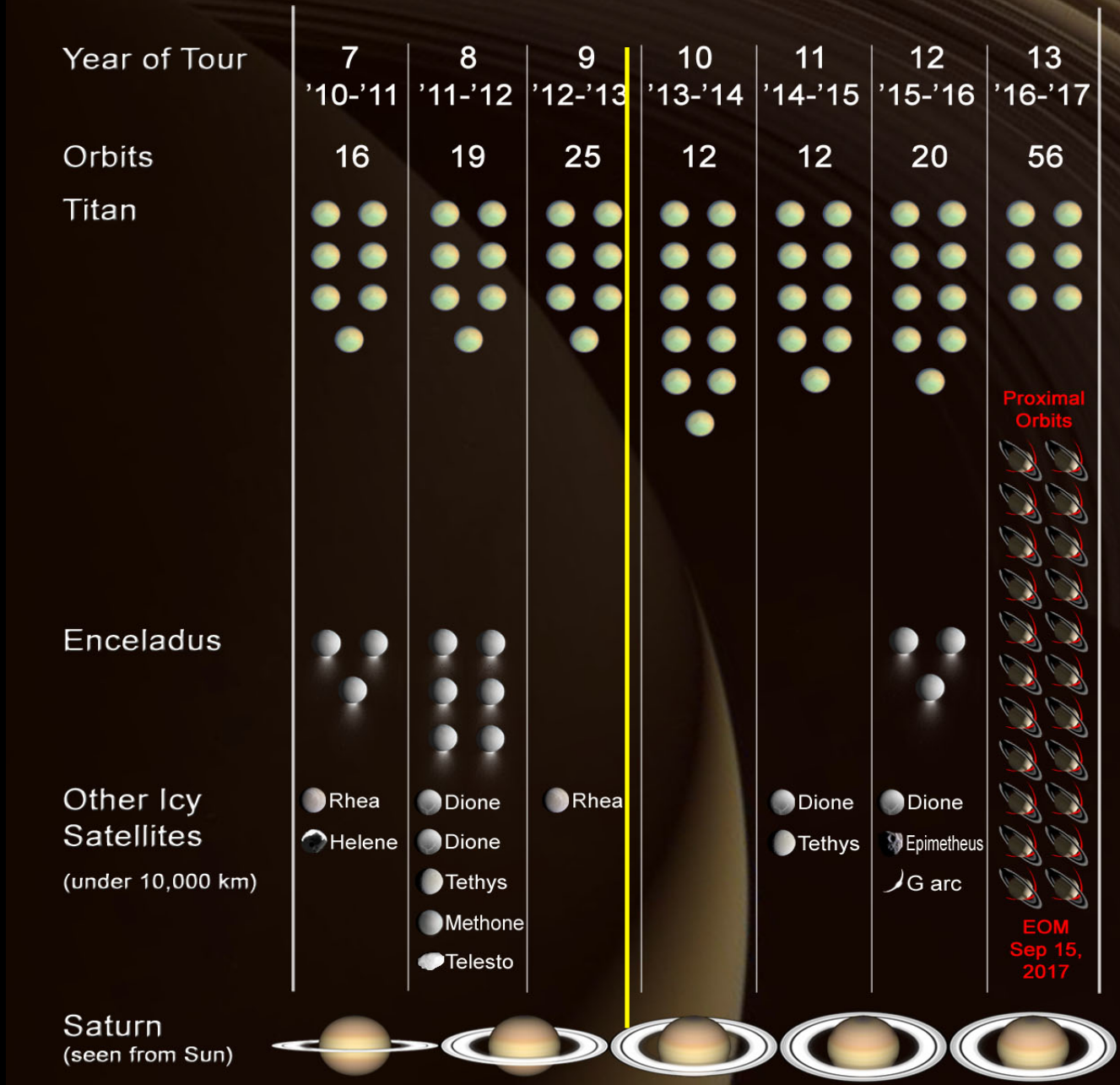
- ORS flyby: Search for lake specular reflections and monitor mid-latitude cloud formation

Solstice Mission Inclination Profile

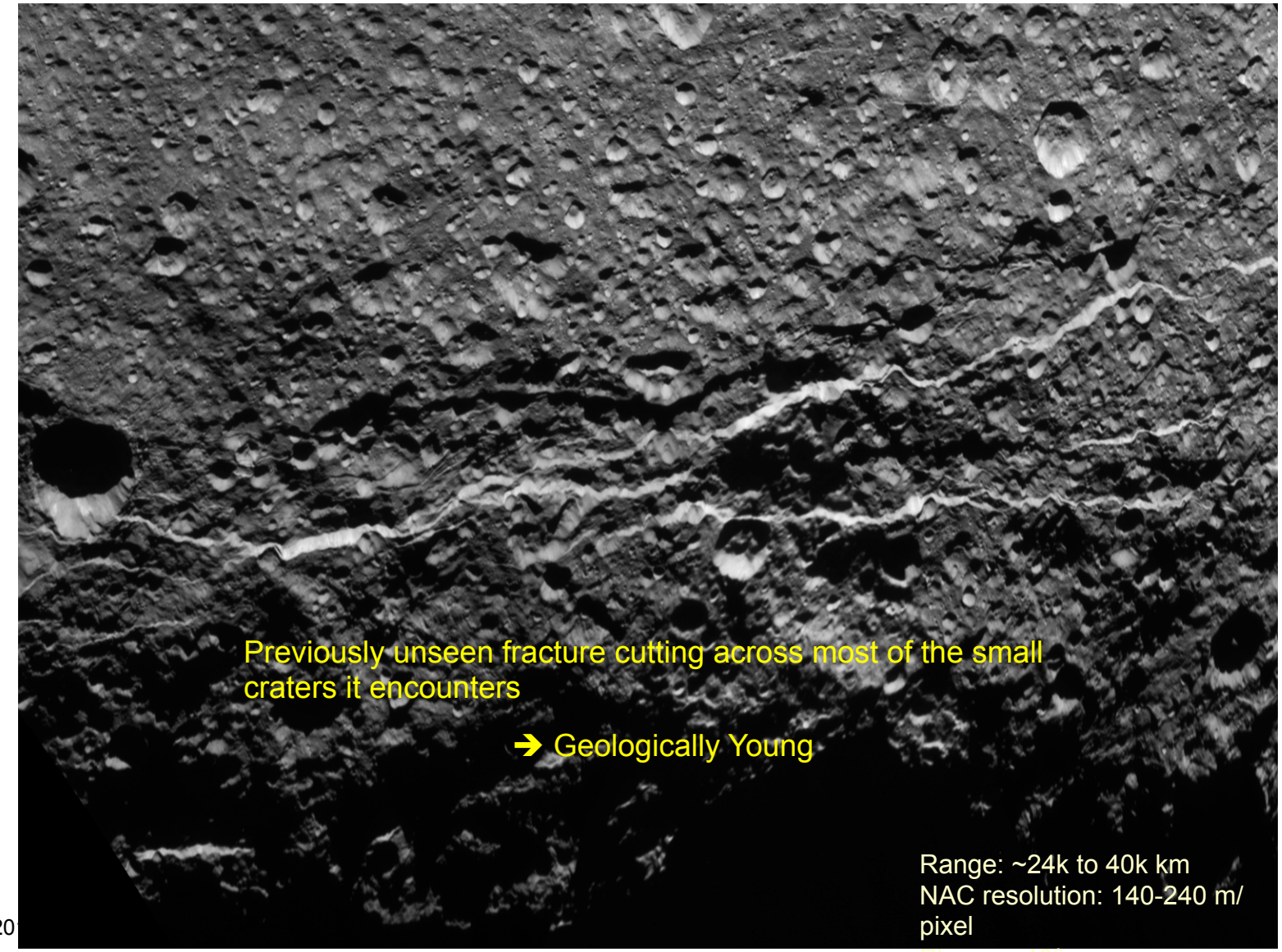


Cassini Solstice Mission Overview

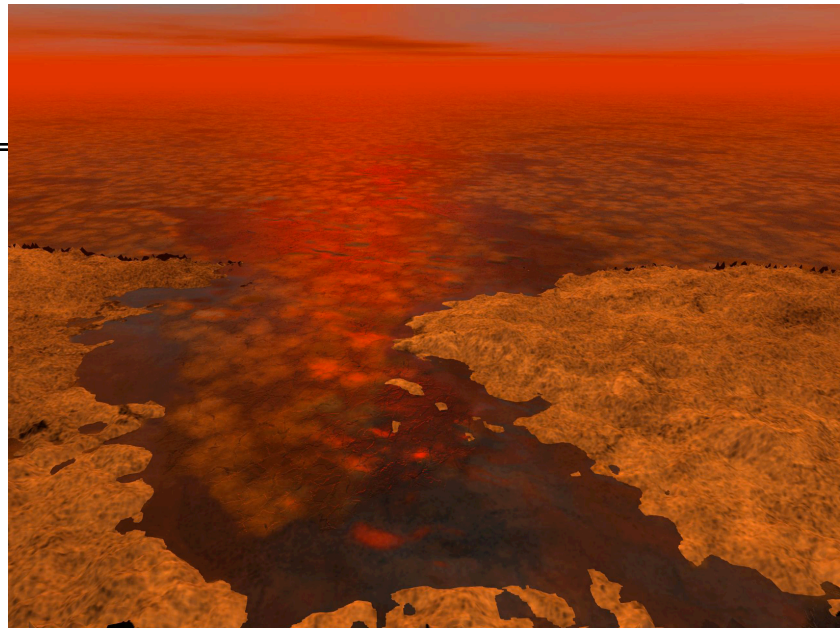
October 2010 - September 2017



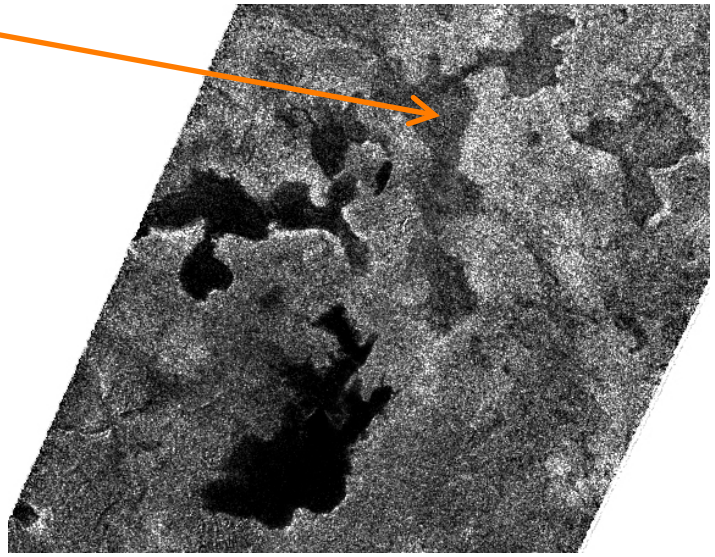
Last Rhea Flyby of the Cassini Mission!



Titan Ice Floats



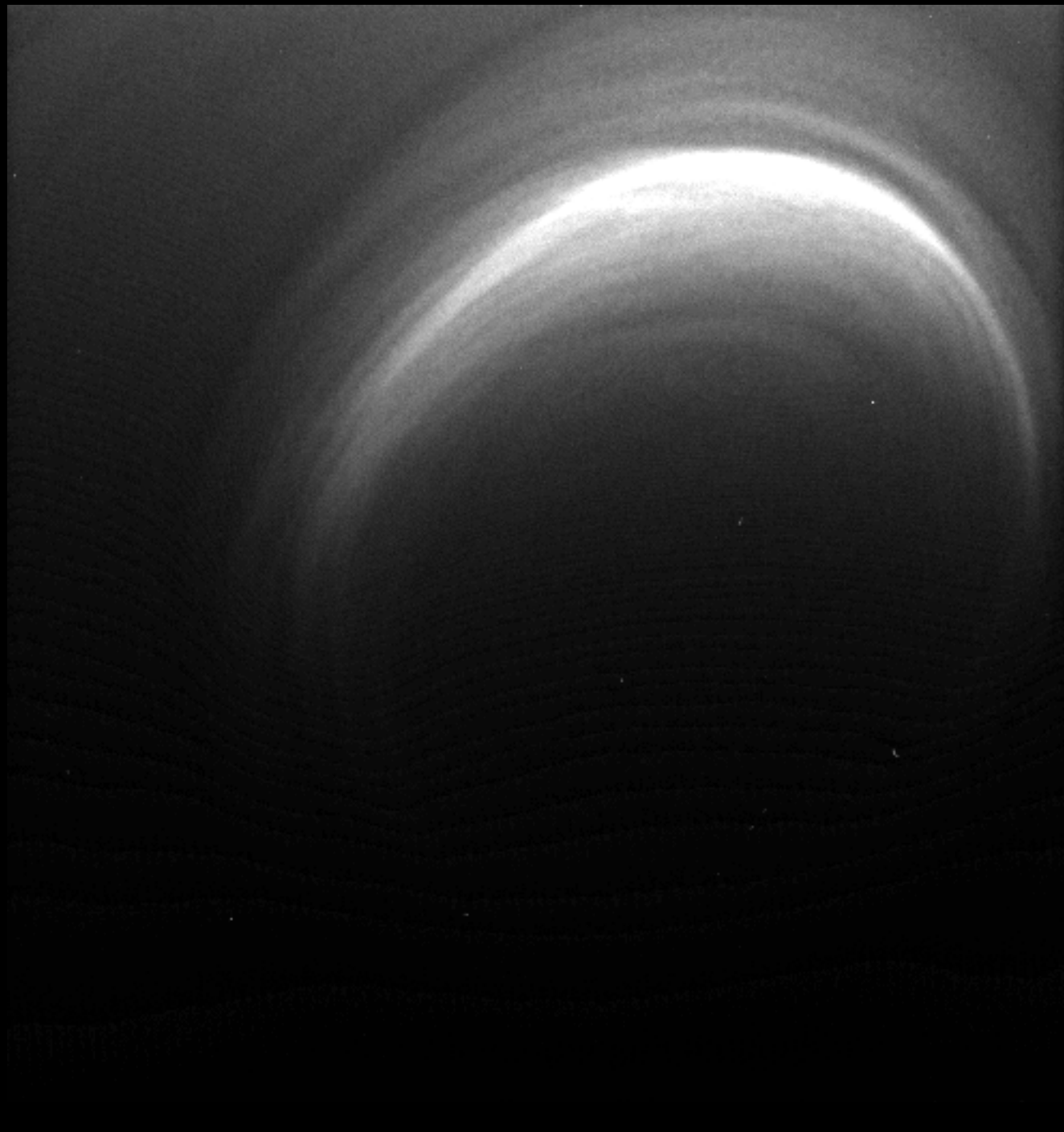
- **Seasonal ice in Titan's lakes probably floats*.**
- Methane ice exists if winter temperature is below freezing point of pure methane (-297°F).
- Ethane ice formed with 5 to 10% air will initially float but will sink if the temperature drops by just a few degrees.
- Radar data acquired in the winter shows a granular lake texture suggesting that ice may be making the lake surface bumpier in the winter than the flat, calm summer lakes.
- **Unlike water ice in Earth's oceans, ice in Titan's lakes and seas may float, sink and rise again to the surface as the temperature changes.**



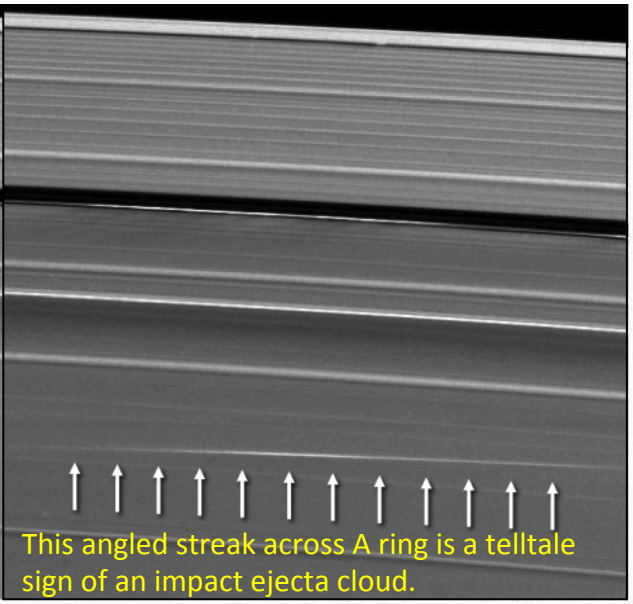
Recent Titan Radar images show some of Titan's lakes. The top right lakes show a granular texture that may indicate floating ice.

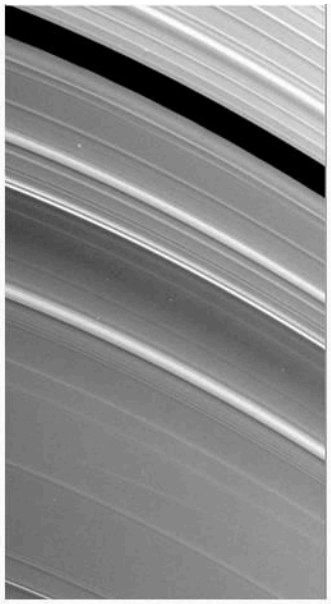
* "Does Ice Float in Titan's Lakes and Seas?", Jason D. Hofgartner, Jonathan I. Lunine, *Icarus, In Press, Accepted Manuscript*, *Available online 30 November 2012*

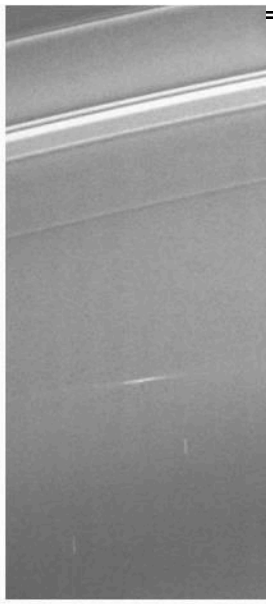
Cassini T92
ISS movie of
Titan’s south-polar
vortex



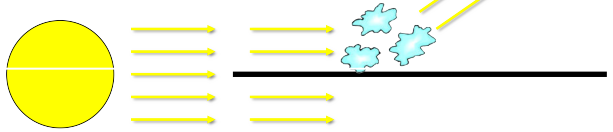
Meteor Strikes in Saturn's Rings

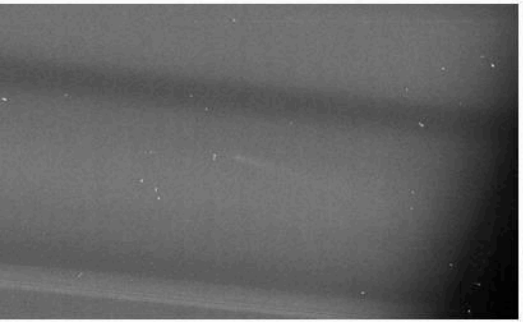


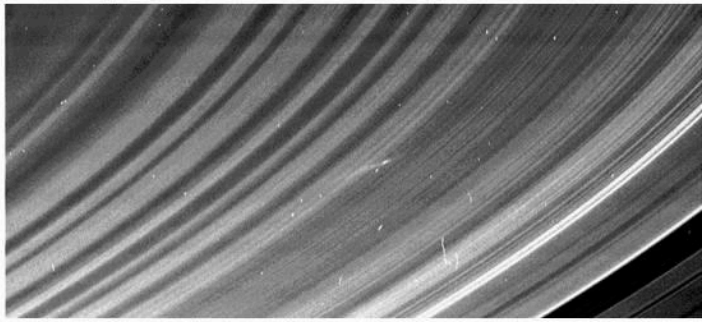




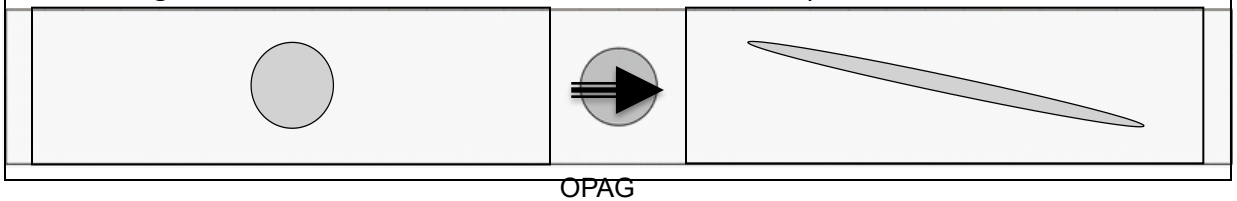
Ejecta clouds became more visible during 2009 equinox.





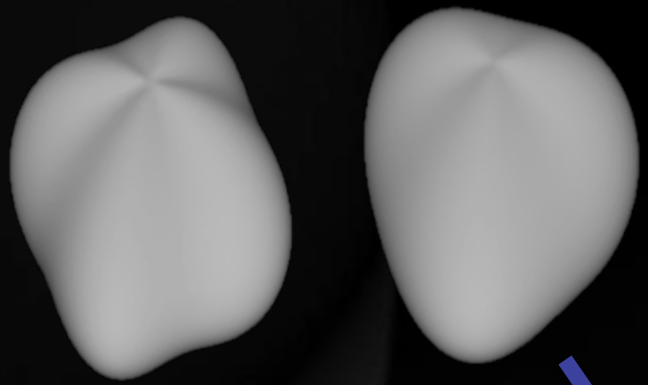


An orbiting cloud shears with time, as material closer to the planet orbits at a faster rate.

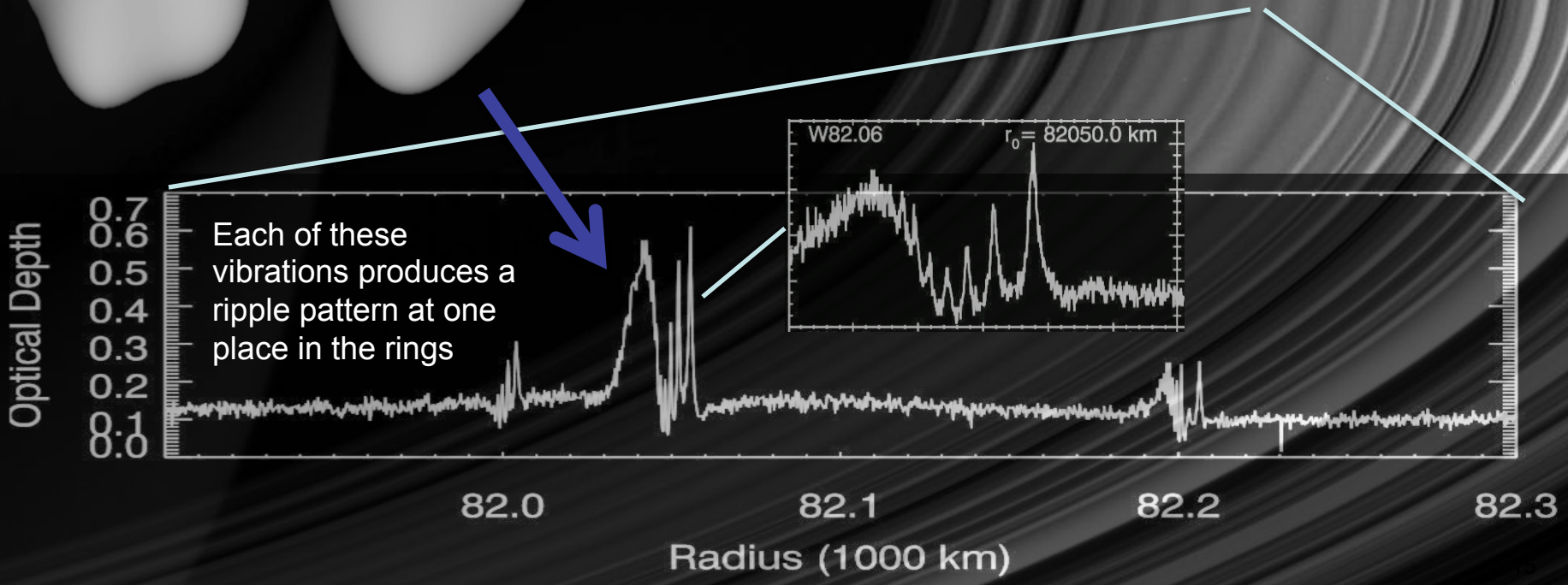


A Seismograph as Big as Saturn's Rings

Cassini scientists have discovered that Saturn's rings act as a seismograph that records large-scale oscillations, probably emanating from deep within the planet, that "ring" Saturn like a bell. In the same way that helioseismology tells us about activity inside the sun, "Kronoseismology" provides a completely new way to probe structure and activity in Saturn's interior.



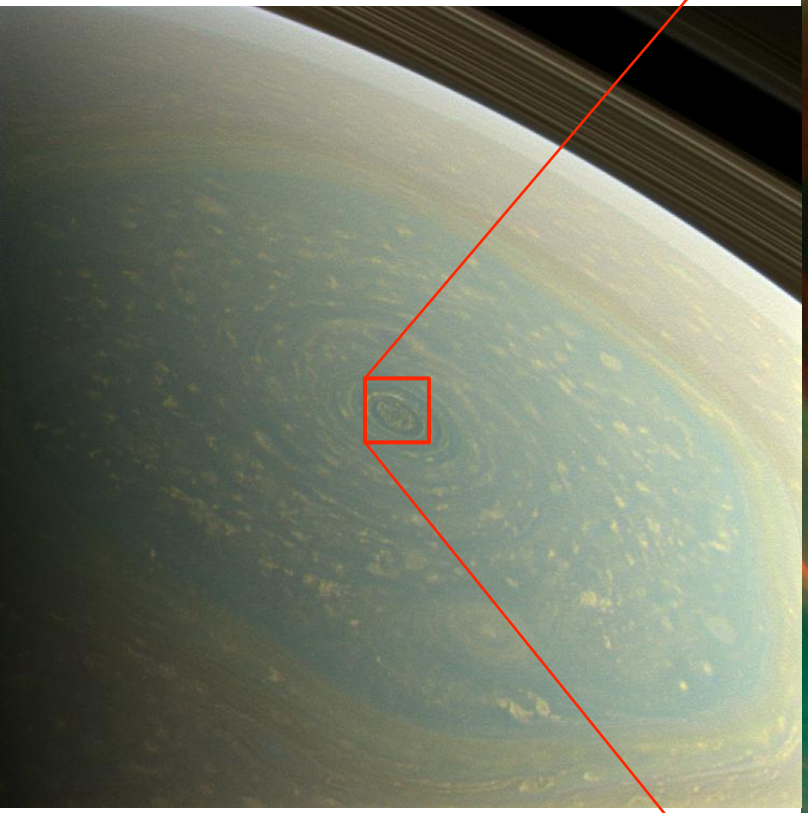
These oscillations distort Saturn's shape in distinctive ways (highly exaggerated here)

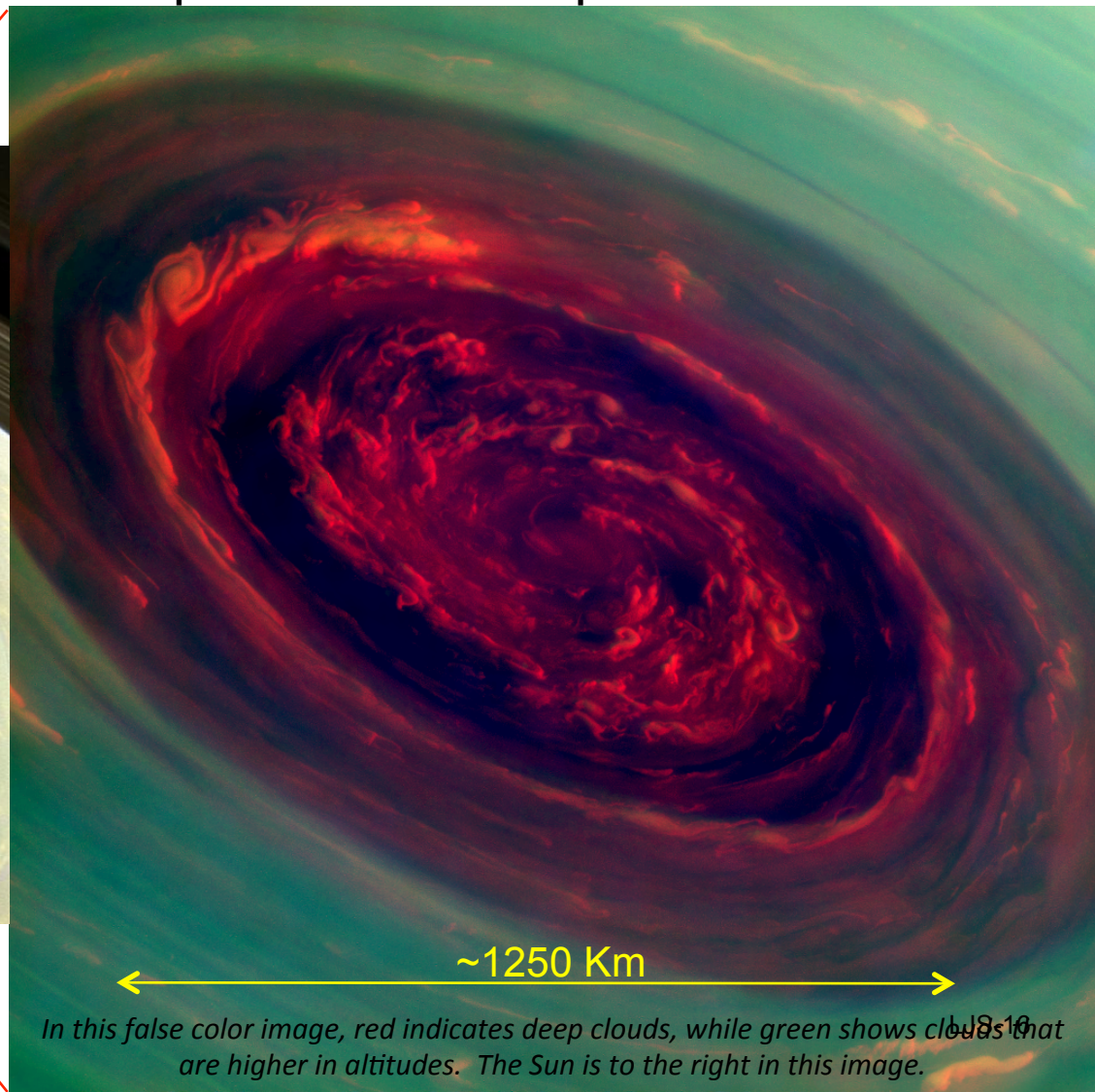


* Kronoseismology: Using Density Waves in Saturn's C Ring to Prove the Planet's Interior, M.M. Hedman and P.D. Nicholson, CRSR, Cornell University *Astrophysical Journal*

Eye Spied: Saturn's Behemoth Polar Hurricane

Stunning new views from NASA's Cassini spacecraft reveal the eye of an enormous hurricane locked in place at Saturn's north pole.

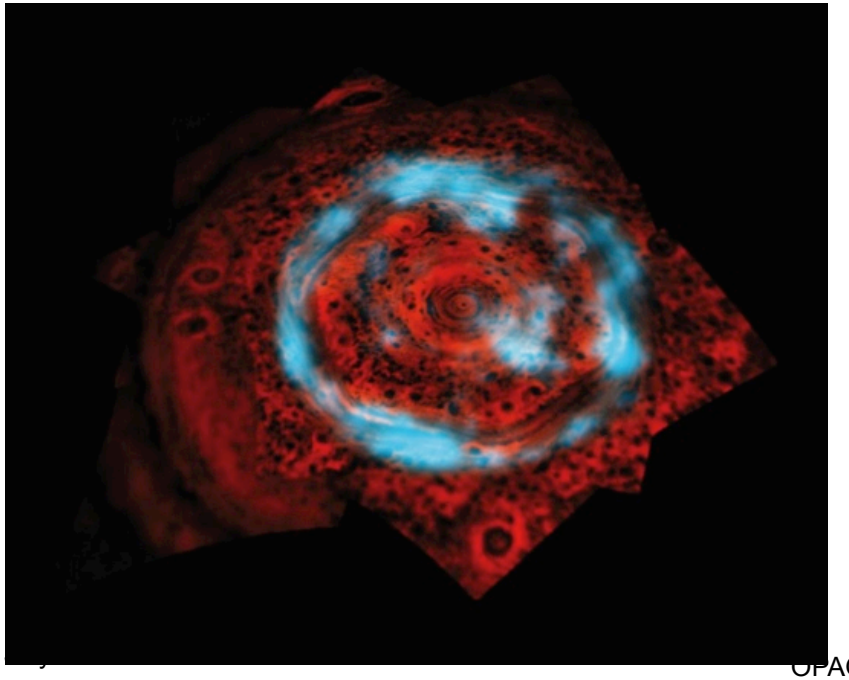


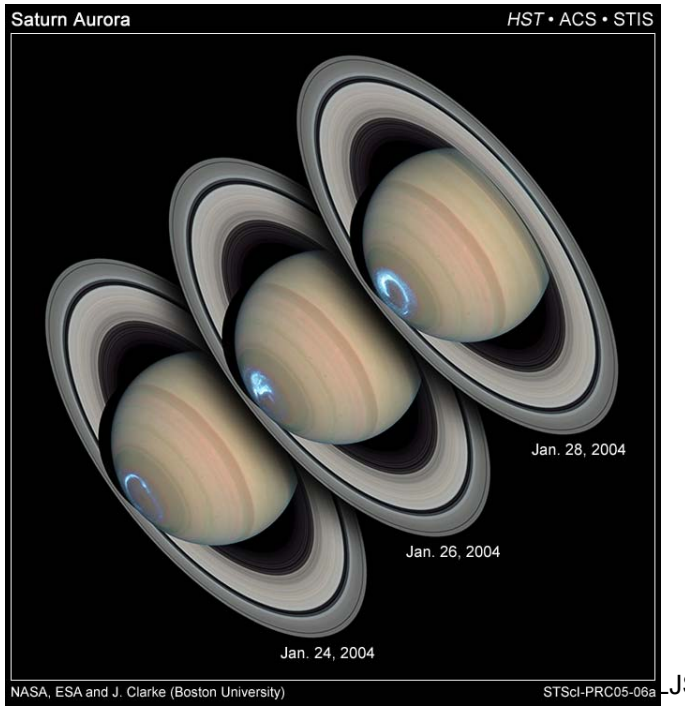


In this false color image, red indicates deep clouds, while green shows clouds that are higher in altitudes. The Sun is to the right in this image.

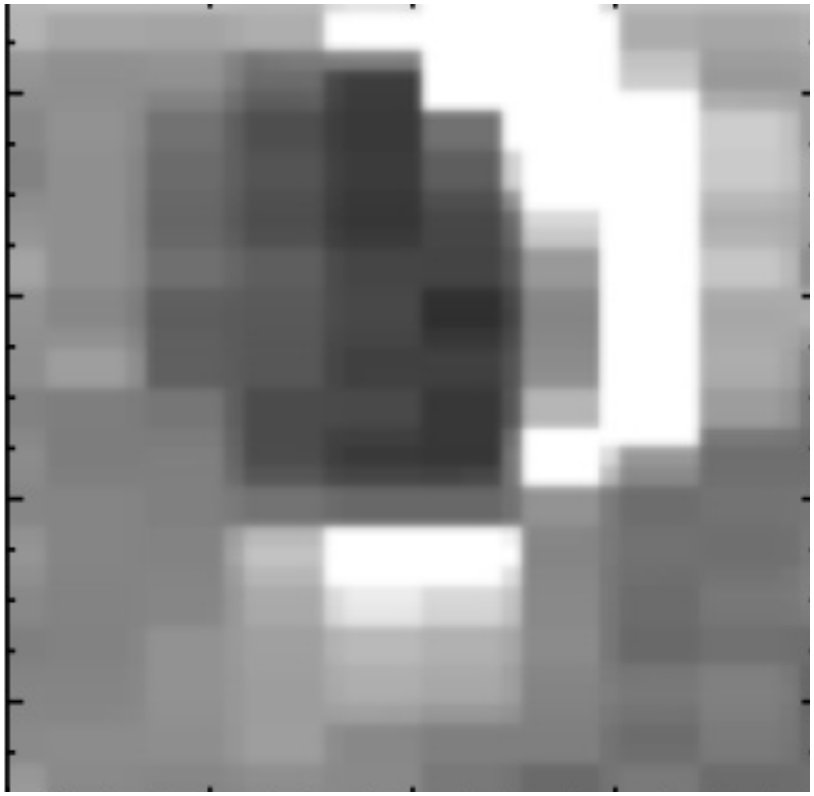
Saturn Auroral Campaign (April-May 2013)

Cassini auroral observations of Saturn's northern and southern aurora have been designed to coincide with Solar Maximum and with observations of Saturn's northern aurora by HST and ground-based IR

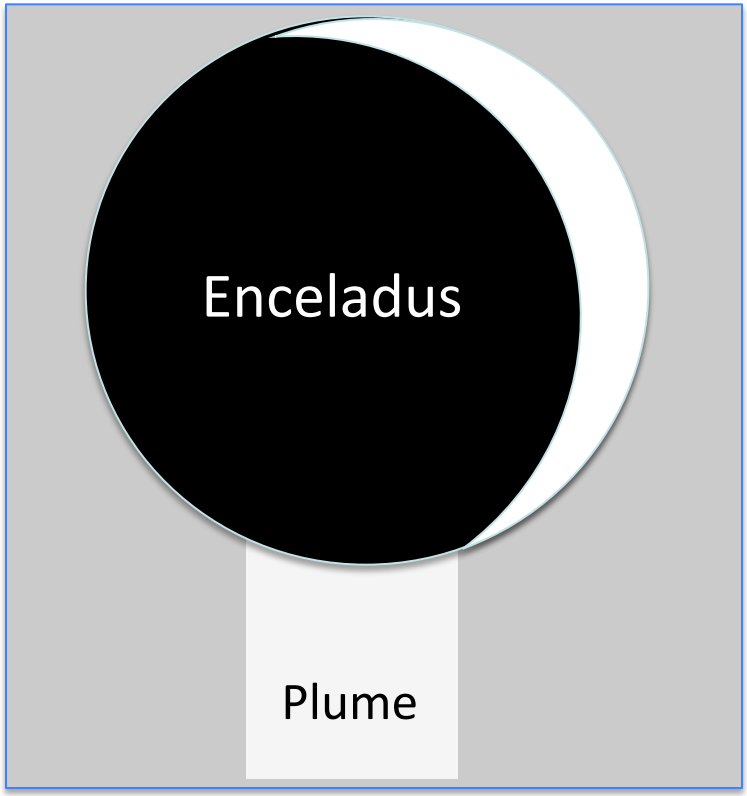




Variable Plume Activity on Enceladus

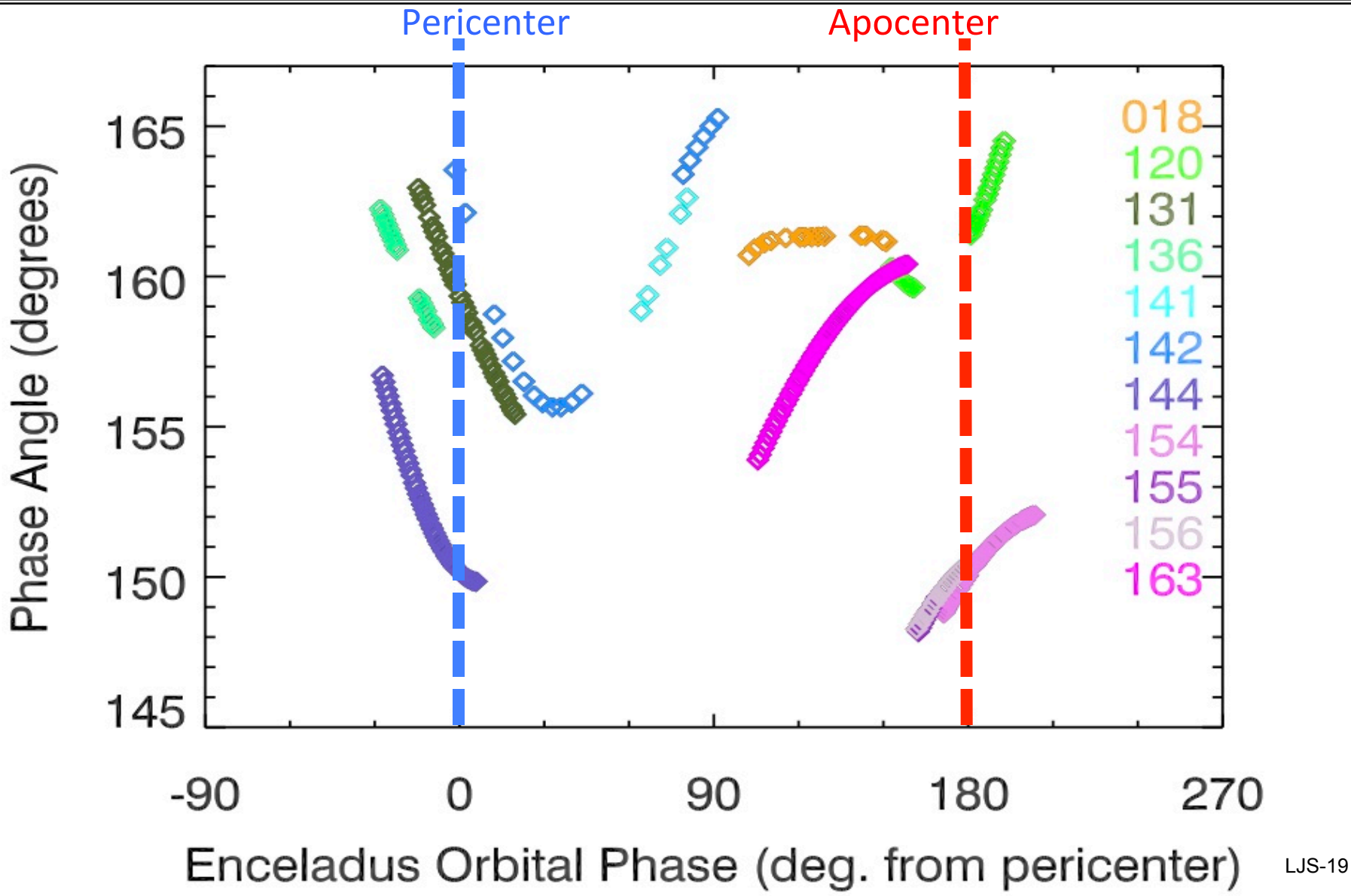


VIMS plume image
(wavelength 0.9-1.1 microns)

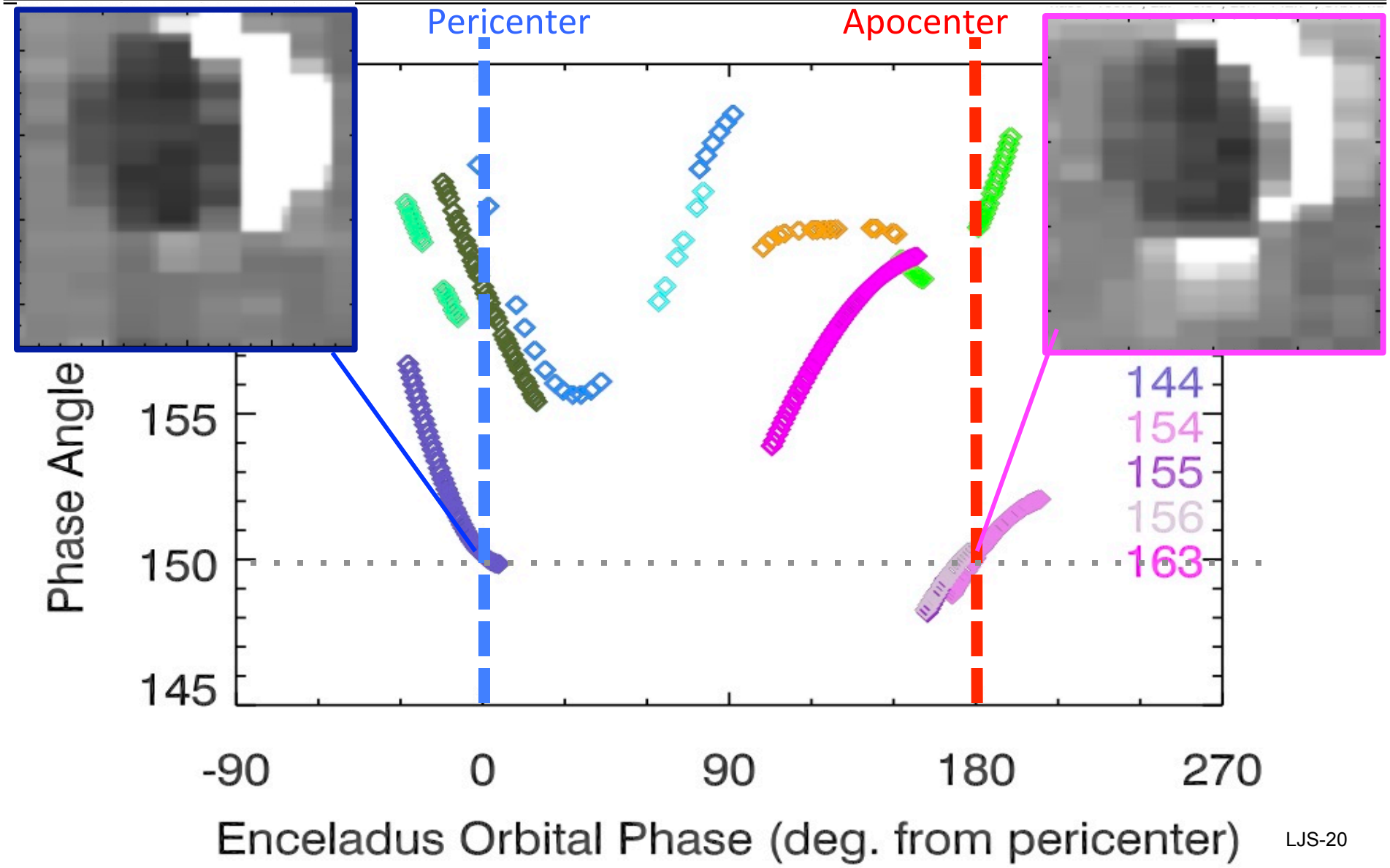


Interpretive Drawing

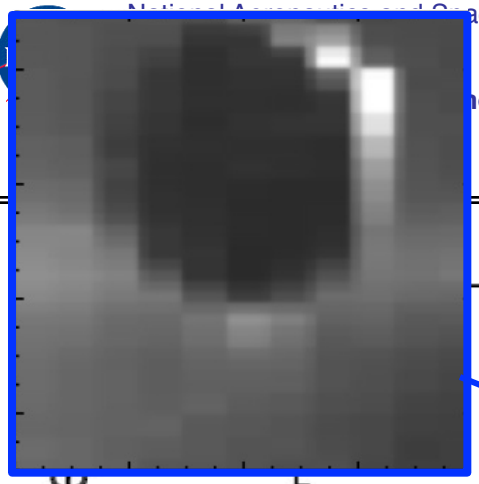
VIMS data cover a wide range of phase angles and orbital phases

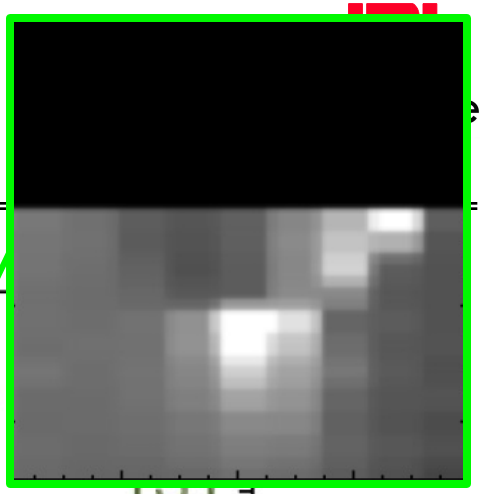


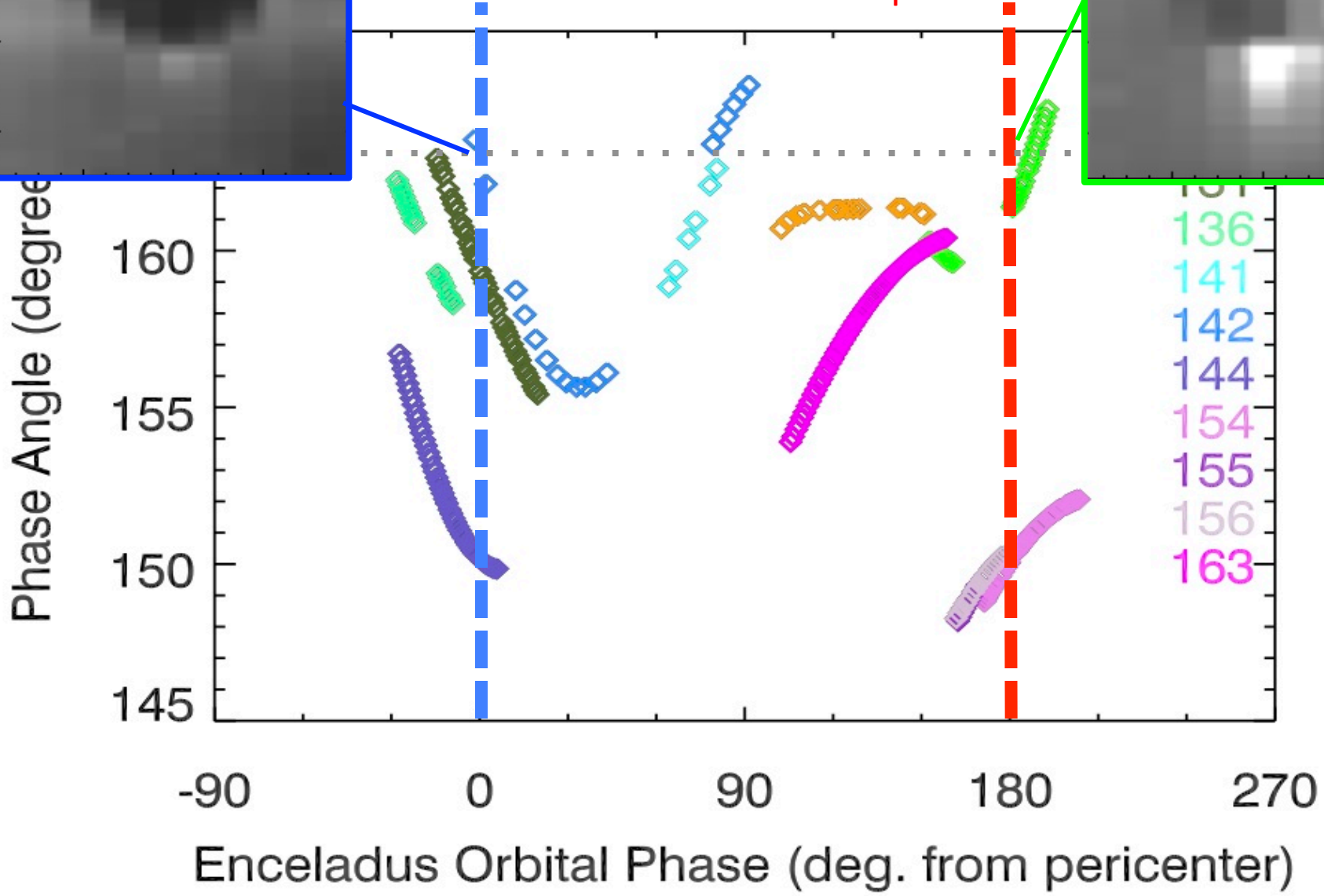
The plume is brighter when Enceladus is near its orbital apocenter



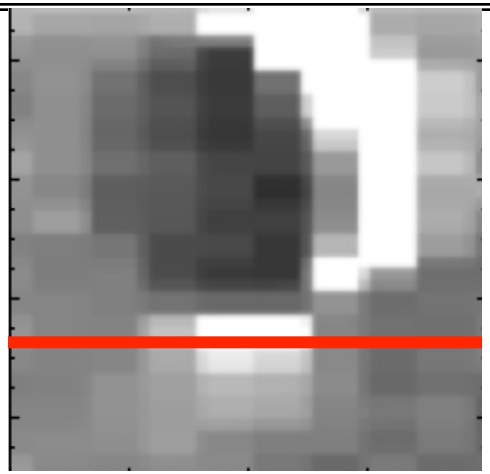
This trend is seen consistently over a range of phase angles







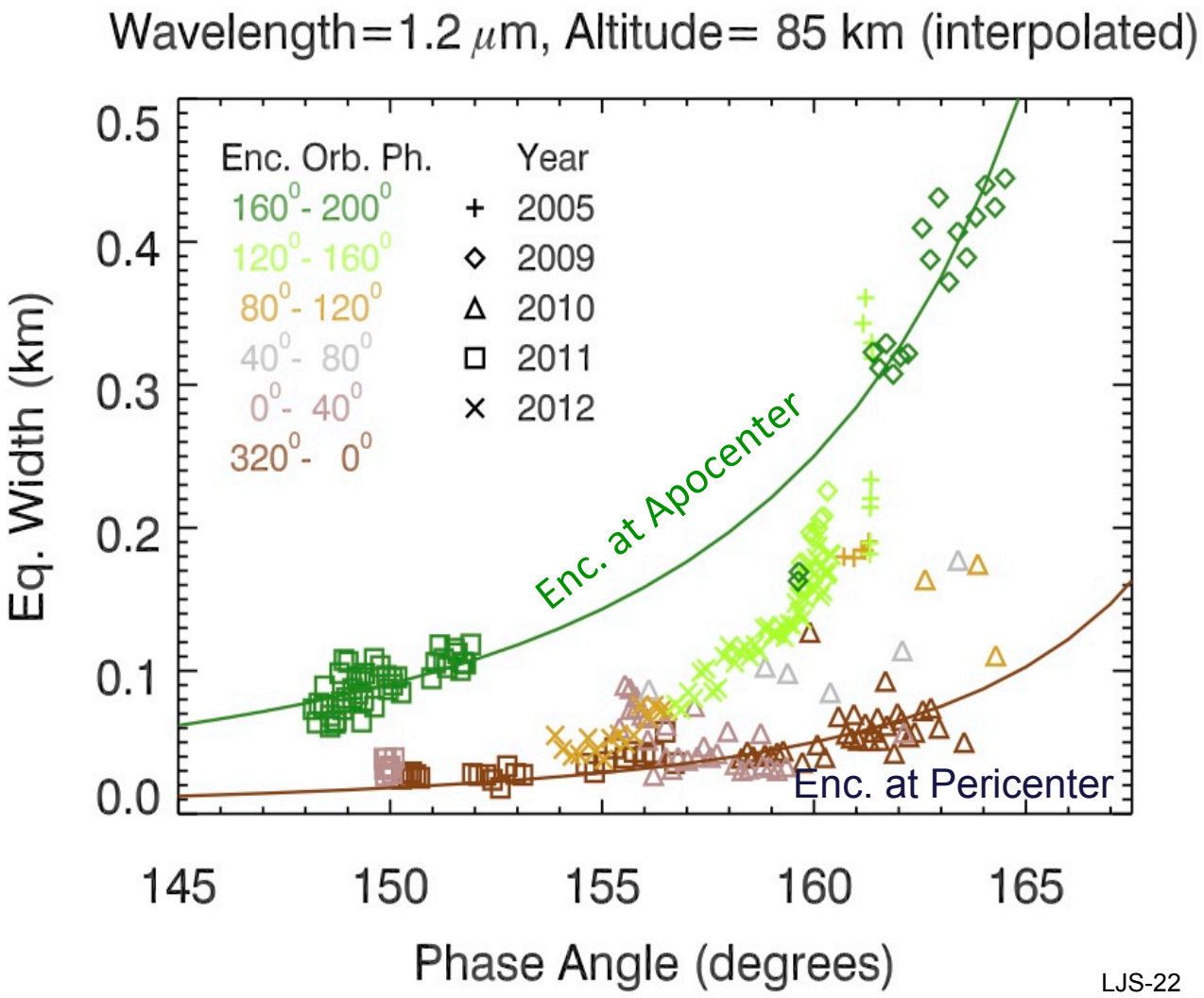
Enceladus Plume Variability



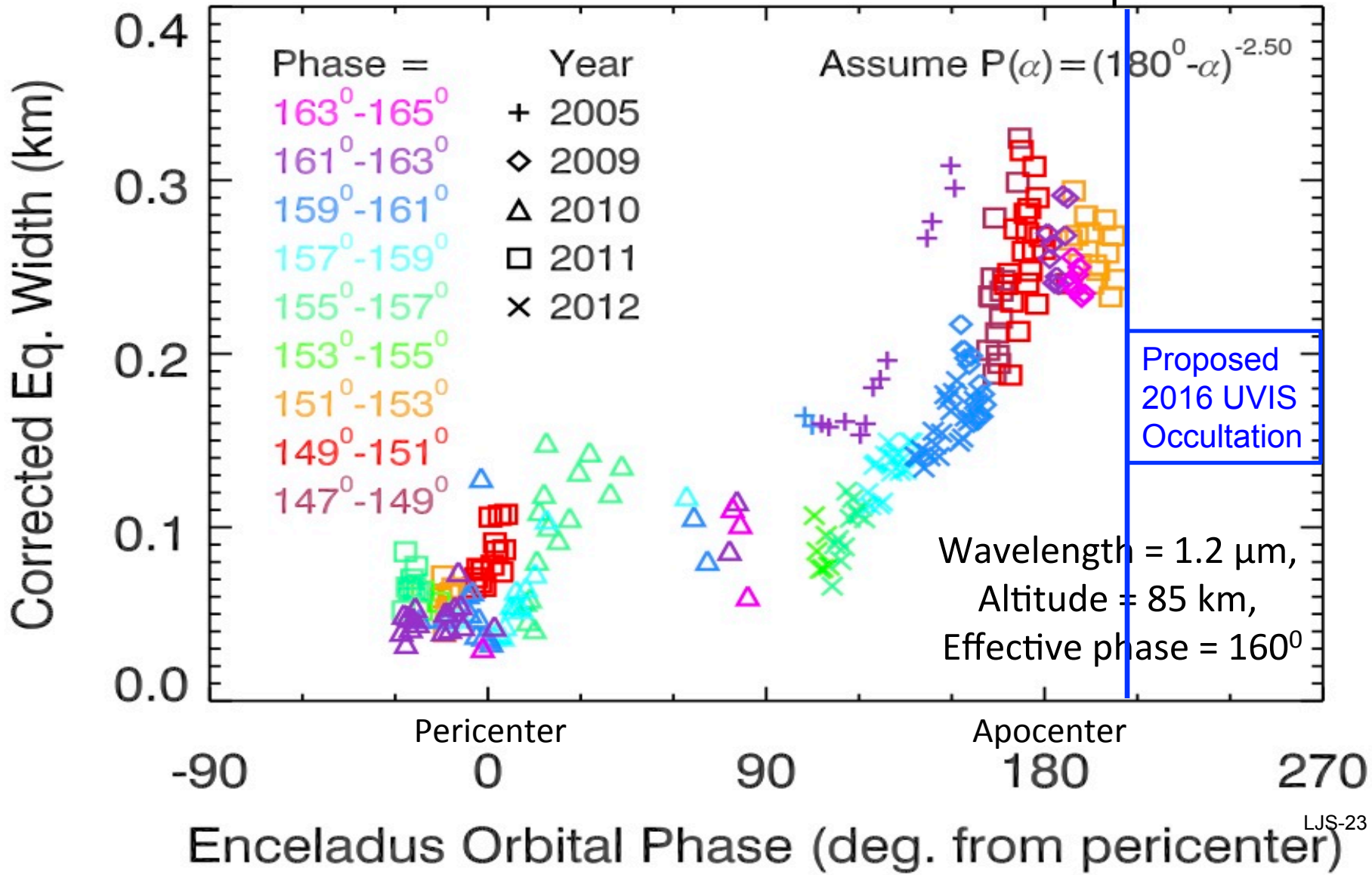
VIMS image

Plume is consistently brighter when Enceladus is near apocenter of its orbit.

Hedman et al., Science



After correcting for phase angle variations, the plume's brightness follows consistent trends with Enceladus' orbital phase.



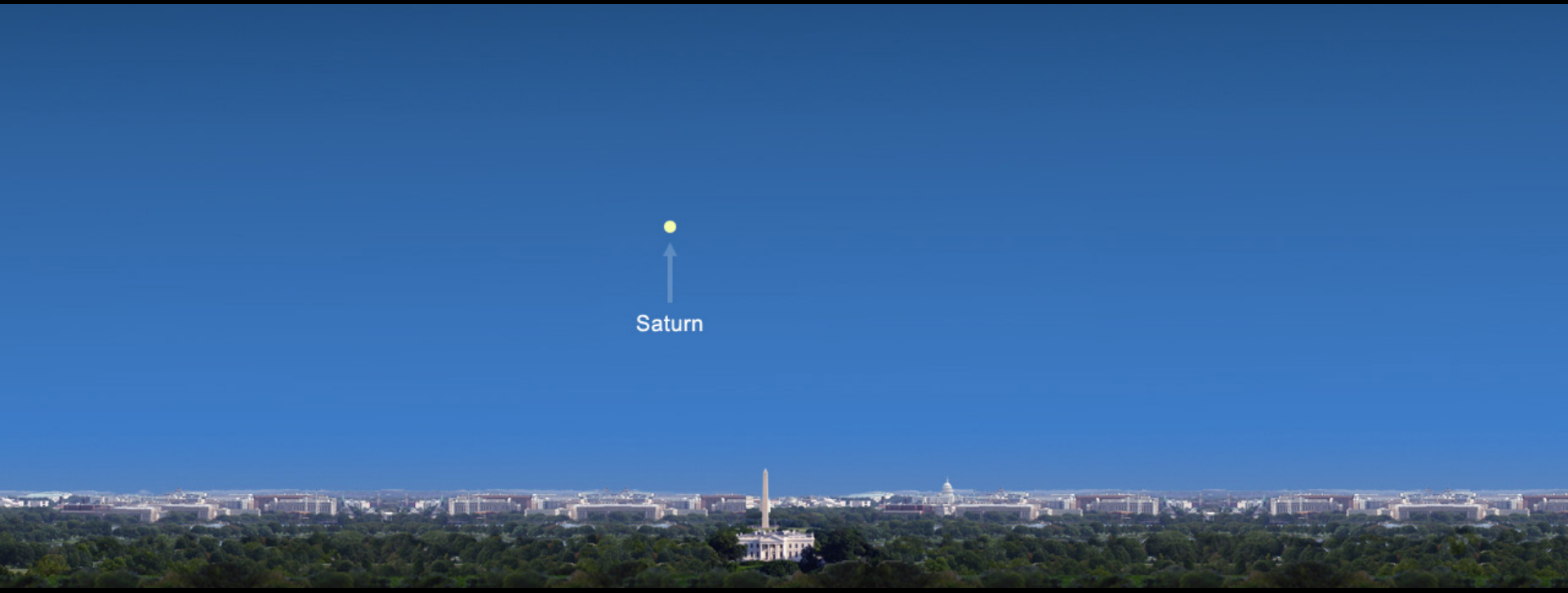
Consolidated Senior Review

- ***Assume*** similar format and schedule as past Planetary Science Division (PSD) Consolidated Senior Review (no guidelines released yet)
  - Senior review in 2014 (SR every 2 years) to provide best balanced science for scarce funding available
    - Missions: Cassini, LRO, MSL, MER, MEX, MRO, ODY
    - Science merits and performance will be evaluated
  - 35-page proposal to address FY15 – FY16 extended mission
    - Cassini requesting addition of FY17 (final year of tour) to proposal as well
  - Two funding options: baseline and 85% option
- Cassini Proposal Submitted — Late May
- Questions from Panel to Project Offices — Mid-June
  - In addition, report on changes in Operations and Science
- Face to Face visit/oral presentation — Late June
- Senior Review Report submitted to PSD — Mid-July
- PSD Notification to Project Offices — FY15 start – 2 months


Cassini Solstice Mission Overview
October 2010 - September 2017
Year of Tour
7 '10-'11
8 '11-'12
9 '12-'13
10 '13-'14
11 FY15
12 FY16
13 '16-'17
Orbits
16
19
25
12
12
20
56
Titan
Enceladus
Other Icy Satellites
(under 10,000 km)
Rhea
Helene
Dione
Dione
Tethys
Methone
Telesto
Rhea
Dione
Tethys
Dione
Epimetheus
G arc
Proximal Orbits
EOM Sep 15, 2017
Saturn
(seen from Sun)

On July 19, 2013, at 5:27 pm EDT, look up and wave as NASA's Cassini spacecraft photographs Earth from Saturn.
For more information see:
http://saturn.jpl.nasa.gov/waveatsaturn

The View from Washington



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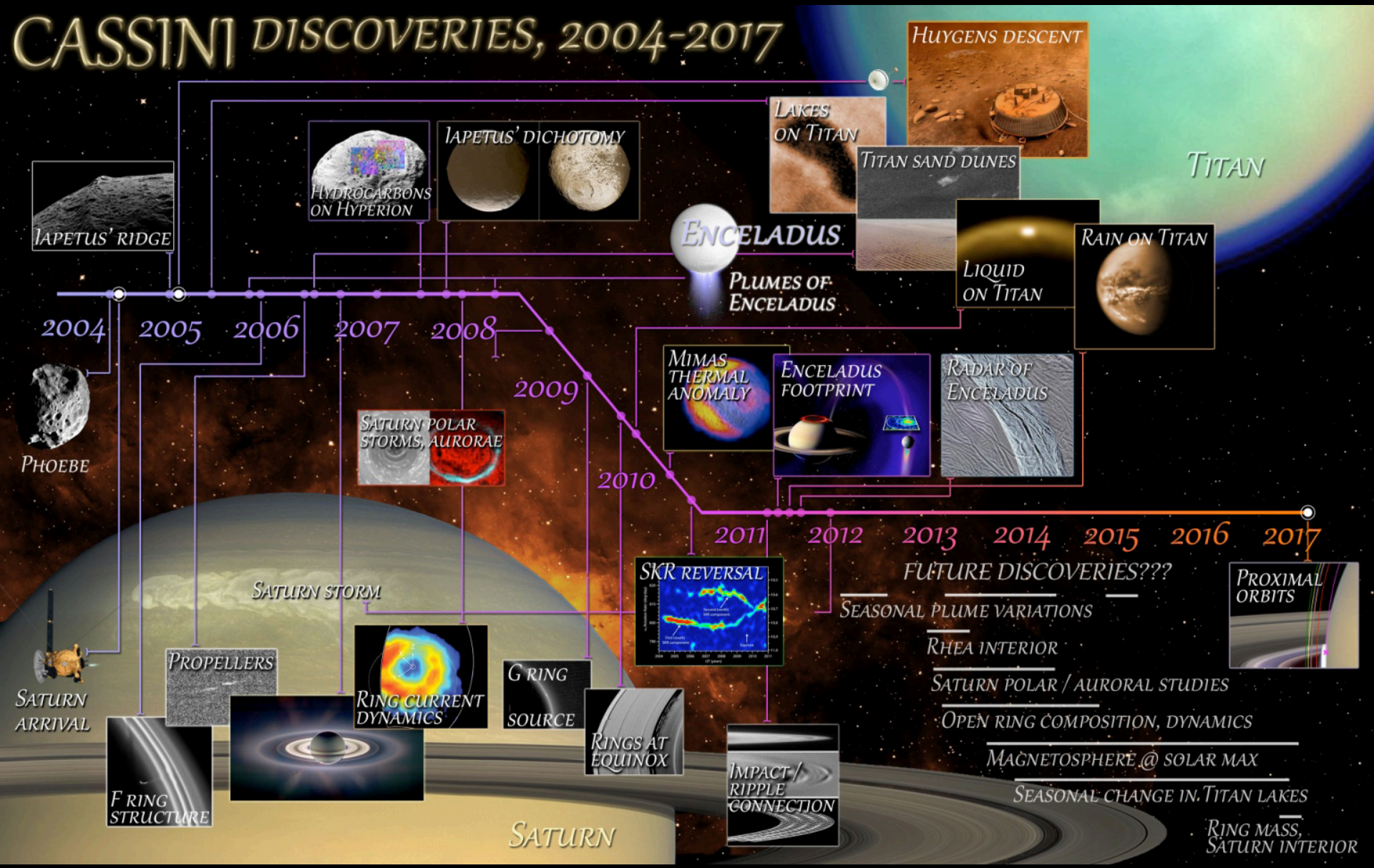

CASSINI DISCOVERIES, 2004-2017
HUYGENS DESCENT
LAKES ON TITAN
TITAN SAND DUNES
TITAN
IAPETUS' RIDGE
HYDROCARBONS ON HYPERION
IAPETUS' DICHOTOMY
ENCELADUS
PLUMES OF ENCELADUS
LIQUID ON TITAN
RAIN ON TITAN
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
MIMAS THERMAL ANOMALY
ENCELADUS FOOTPRINT
RADAR OF ENCELADUS
PHOEBE
SATURN POLAR STORMS, AURORAE
SKR REVERSAL
SATURN STORM
FUTURE DISCOVERIES???
PROXIMAL ORBITS
SEASONAL PLUME VARIATIONS
RHEA INTERIOR
SATURN POLAR / AURORAL STUDIES
OPEN RING COMPOSITION, DYNAMICS
MAGNETOSPHERE @ SOLAR MAX
SEASONAL CHANGE IN TITAN LAKES
RING MASS, SATURN INTERIOR
SATURN ARRIVAL
PROPELLERS
RING CURRENT DYNAMICS
G RING SOURCE
RINGS AT EQUINOX
IMPACT / RIPPLE CONNECTION
F RING STRUCTURE
SATURN

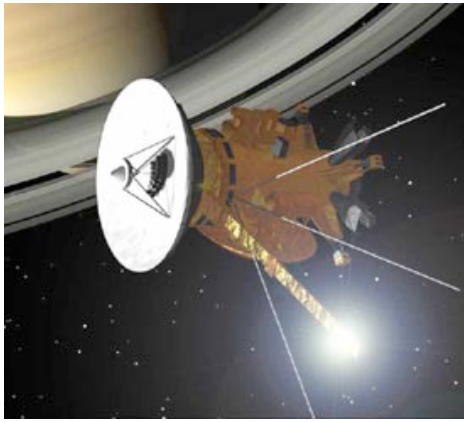
END

Cassini Plasma Spectrometer (CAPS) Status

- CAPS powered off in June 2011 as a result of a high rail to chassis short
- CAPS turned on March 16, 2012 – in time for E17 and E18 flybys
- CAPS functioned normally from March 16 to June 1, 2012
- CAPS solid state power switch (SSPS) tripped off on June 2, 2012
  - Multiple (at least 3) different hard and soft shorts occurred
- Extensive review conducted by NASA Engineering and Safety Center (NESC) team in conjunction with JPL, Cassini and CAPS teams
- NESC completed briefing to JPL and SwRI on April 26, 2013
- Final report TBD but expect no changes from briefing
- Summary of findings:
  - No root cause for shorts could be determined
  - If CAPS were to be be switched on again, the shorts will likely continue
  - High and low rail shorts are not benign to the power subsystem and represent a risk to the extended mission
- For the foreseeable future, CAPS will remain off

Baseline Allocation

- Cassini will be the only outer planet Flagship mission flying and collecting data through the mid- to late- portion of this decade



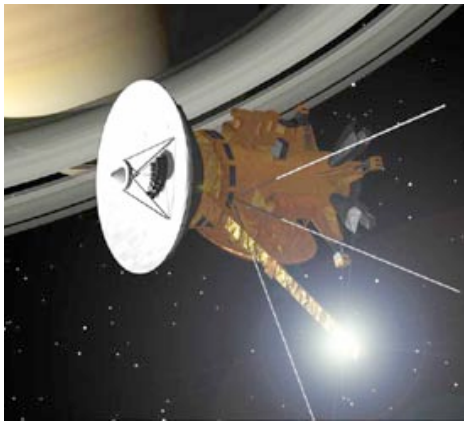
- Continued funding of Cassini will:
  - maintain the current scientifically rich tour
  - continue training of next generation of planetary scientists
  - continue healthy international collaboration, and
  - return multidisciplinary, synergistic science data as only a Flagship can do

Past SR: 17 Science Campaigns: 85% funding

Titan	Icy Satellites	Rings	Magneto-sphere	Saturn
(E.1.1) Titan Great Seas	(E.2.1) Enceladus	*(E.3.1) Changing Rings	(E.4.1) Periodicities	*(E.5.1) Aftermath of Giant Storm
(E.1.2) Titan Global Seasonal	(E.2.2) Rhea and Dione	(E.3.2) Composition, Origin, and Evolution of Rings	*(E.4.2) Aurora: Imaging the Magneto-sphere	(E.5.2) Seasonal and Temporal Changes
(E.1.3) Titan Interior Ocean	(E.2.3) Small Moons	(E.3.3) Rings, Protoplanets, and Exoplanets	(E.4.3) Magneto-spheric Interactions of Satellites	*(E.5.3) Polar Studies
			(E.4.4) Water Dominated Magneto-sphere	(E.5.4) Probe Saturn's Interior

Green: fully/primarily accomplished
Yellow: partially accomplished
Red: significant risk of being precluded

Effects of 85% Allocation



- 85% allocation will result primarily in loss of jobs
  - Cassini spacecraft is built and launched, no major hardware purchases remain
  - Cassini is in orbit at Saturn, 7-year cruise is complete
- Loss of personnel would result in science loss and increased science risk in FY13-14
  - Loss of operationally complex Ka-band science: Would reduce RSS operations and analysis costs
  - Fewer people to implement science observations resulting in fewer and less complex science observations
  - Slower response to instrument anomalies, would be best efforts basis
  - Reduced calibration support, less well validated data to PDS
  - Slower response time to new discoveries, additional opportunities might be missed
  - *Severely impact funding, educating and mentoring of the next generation of planetary scientists (team associates and postdocs)*

Cassini Solstice Science

- Cassini Solstice Mission enables unprecedented opportunities for unique, groundbreaking science
- Unique, compelling Juno-like end of mission science
- Direct relevance to the Planetary Decadal Survey and NASA's exploration program
- New Participating Scientist program actively involves broader science community