Cassini Solstice Mission

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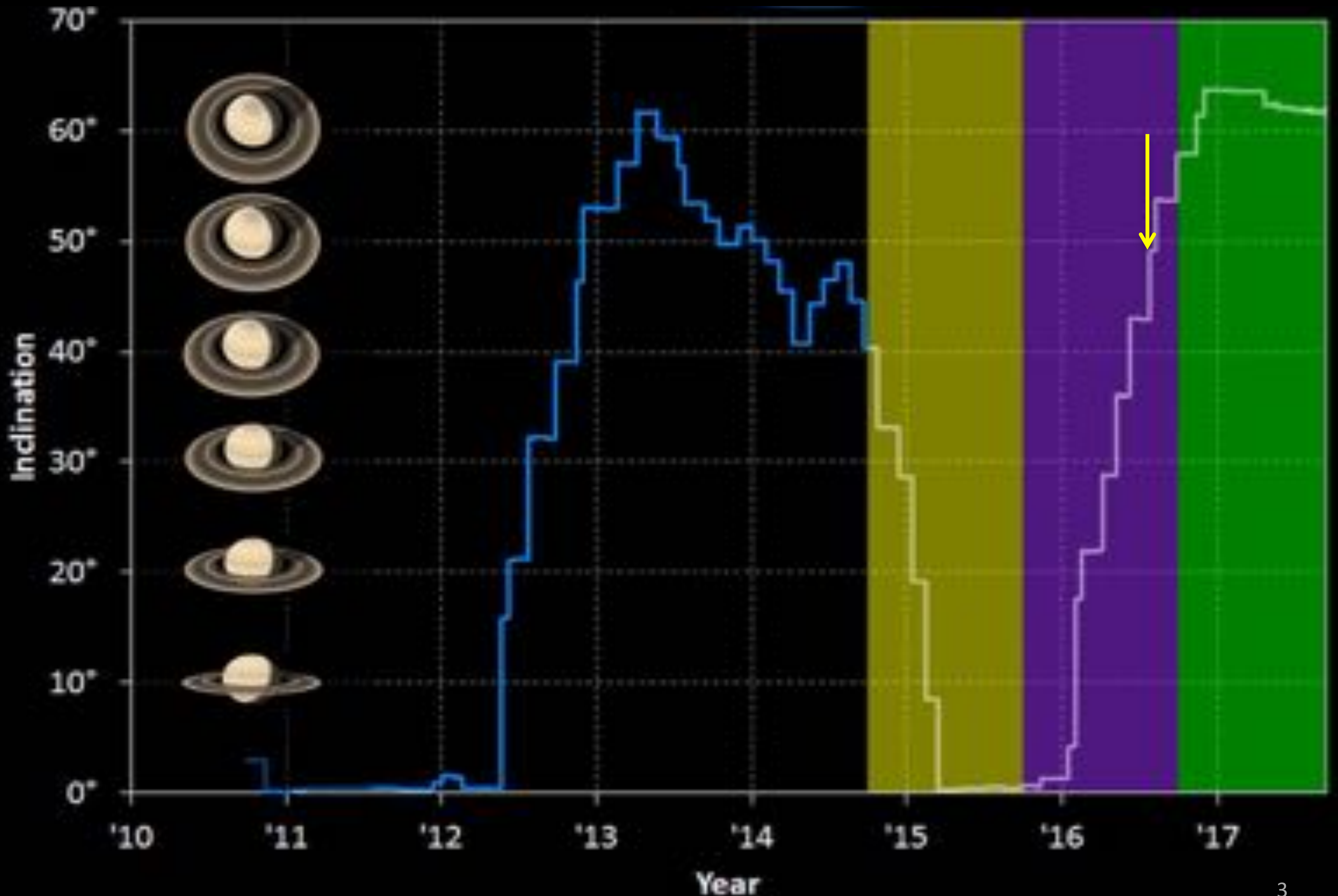
Cassini Resolution for CDAPS Program
(from June Cassini PSG meeting)

The CDAPS program has been incredibly successful in funding analysis and modeling of the wealth of data collected by Cassini. Continuation and expansion of CDAPS over the next decade (or a program like OPDAP [Outer-Planets-DAP]) will help to bridge the large gap before the next outer solar system mission and ensure that a knowledgeable cadre of outer planet scientists will be ready to operate and analyze data from these future outer planet missions.

Solstice Mission Inclination Profile



Enceladus Plume Occultation (923,000 km)

- Mar. 11, 2016

  UVIS occultation

  UVIS stellar occultation of Epsilon Orionis through Enceladus plume to see variation of plume gas with time.

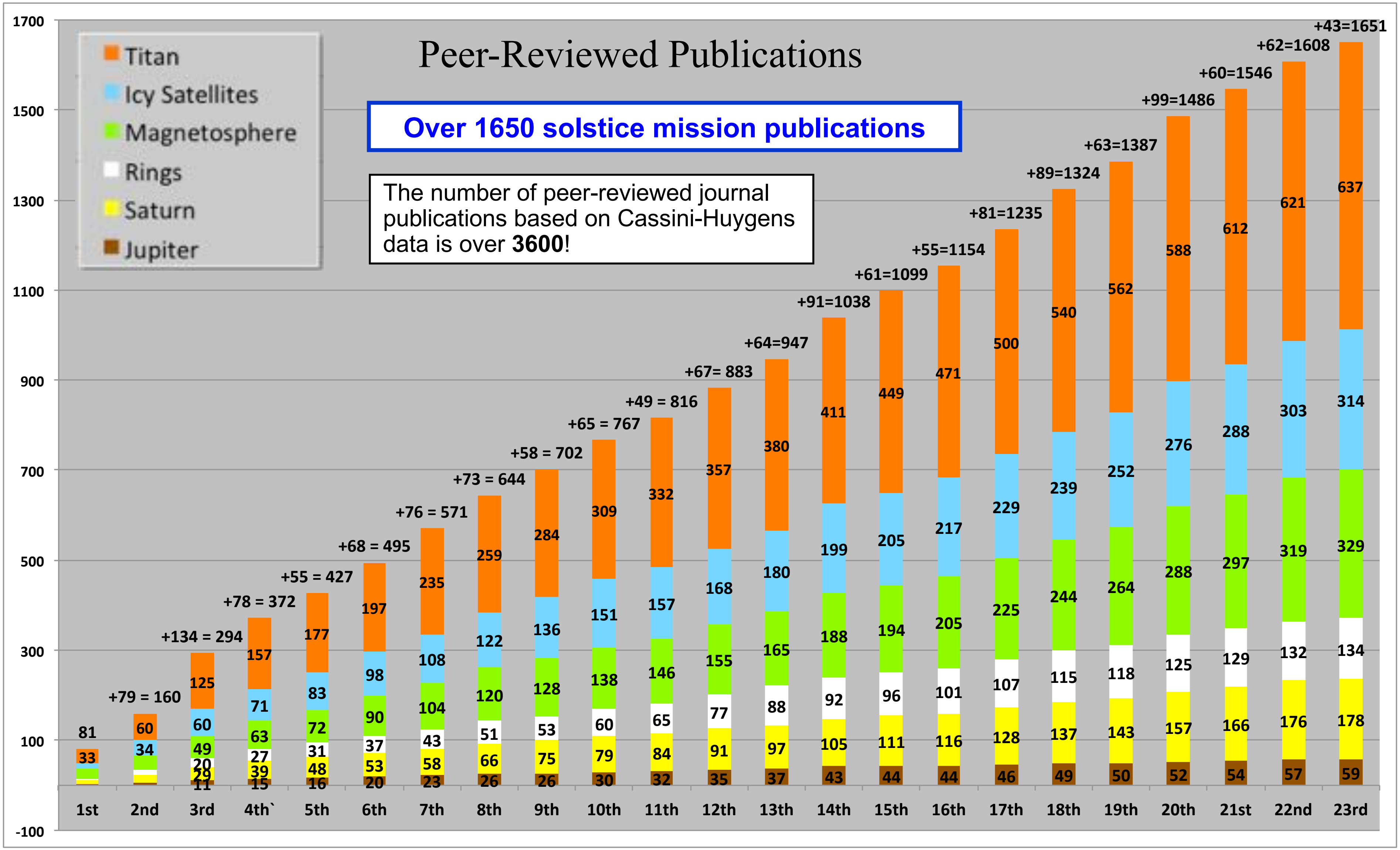
T118 – Titan flyby (990 km)

- Apr. 4, 2016

  INMS/UVIS flyby

  Only time in mission: UVIS solar occultation then INMS direct sampling of same region of atmosphere. Comparisons for atmospheric density.

Cassini Publications



Cassini Solstice Mission Quarters

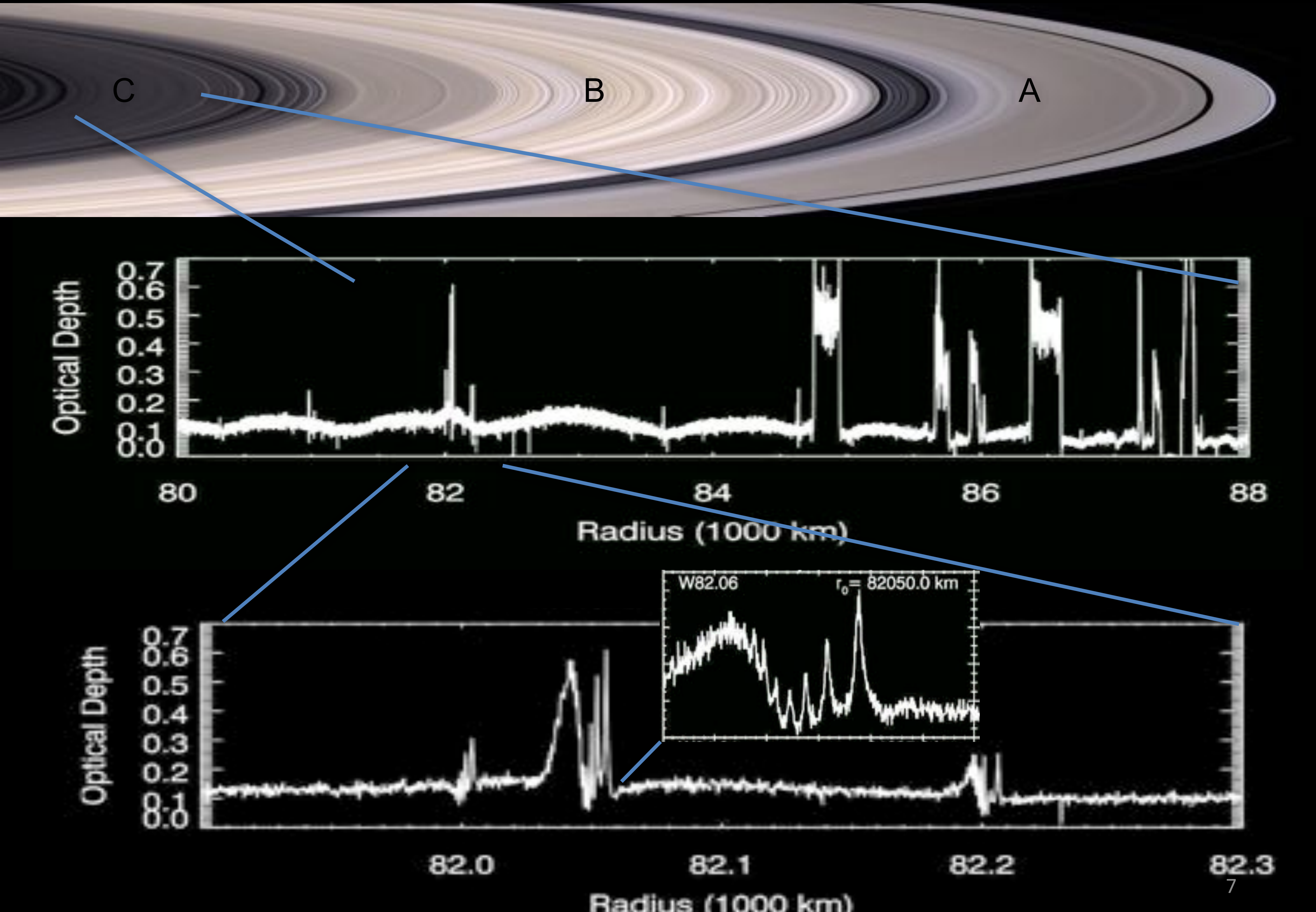
Saturn’s Rings: Less Than Meets the Eye?

Some parts of Saturn's B ring are 10 times more opaque than the A ring, but only 2-3 times more massive.

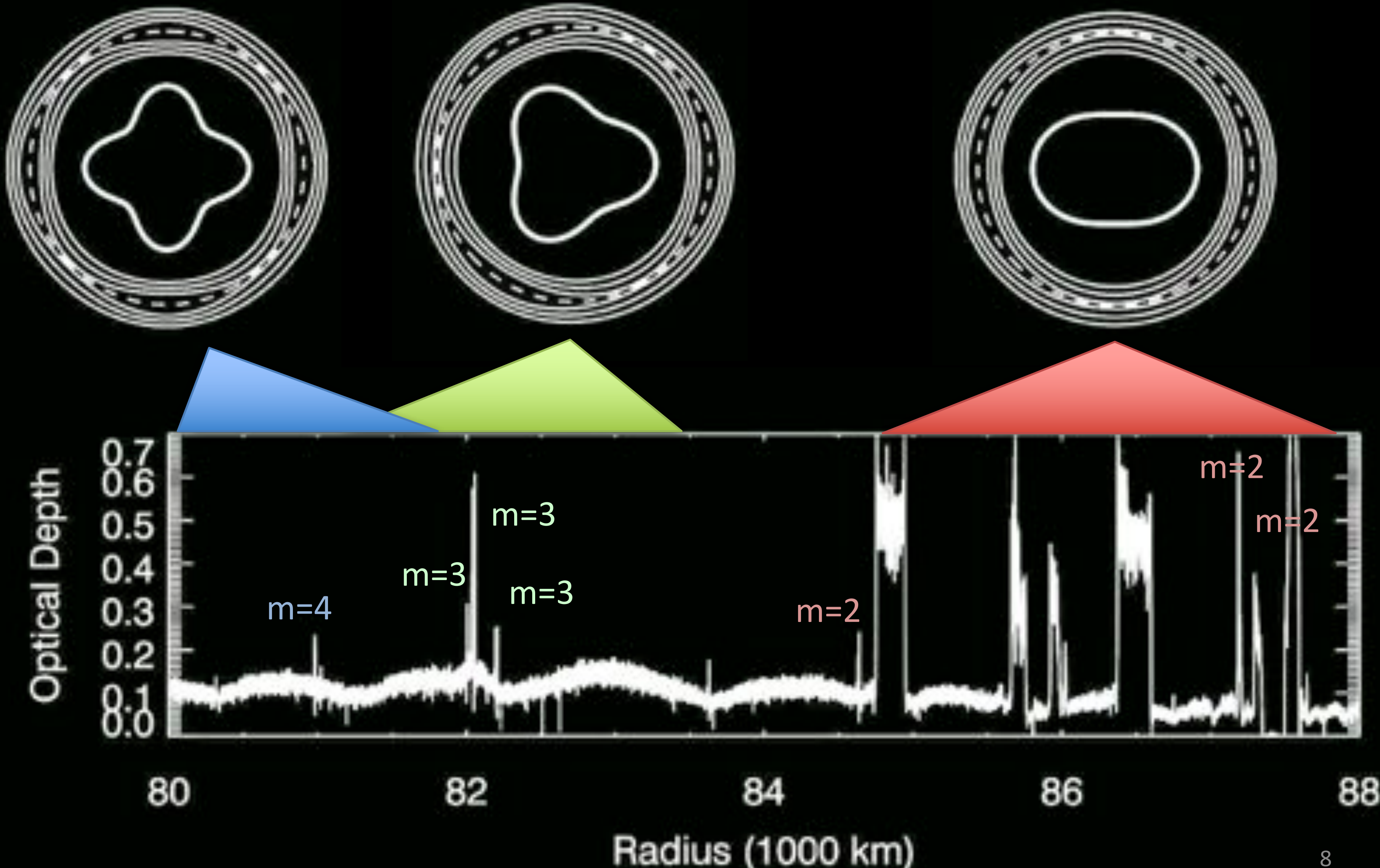
Mass of Saturn’s rings has implications for their age, less massive rings are younger

Cassini will measure mass of rings in Grand Finale orbits

Planetary Resonances in Saturn's C ring



For several waves, the derived mode-number is close to the predicted value, but there appear to be multiple waves generated by resonances with the m = 2 and m = 3 modes!

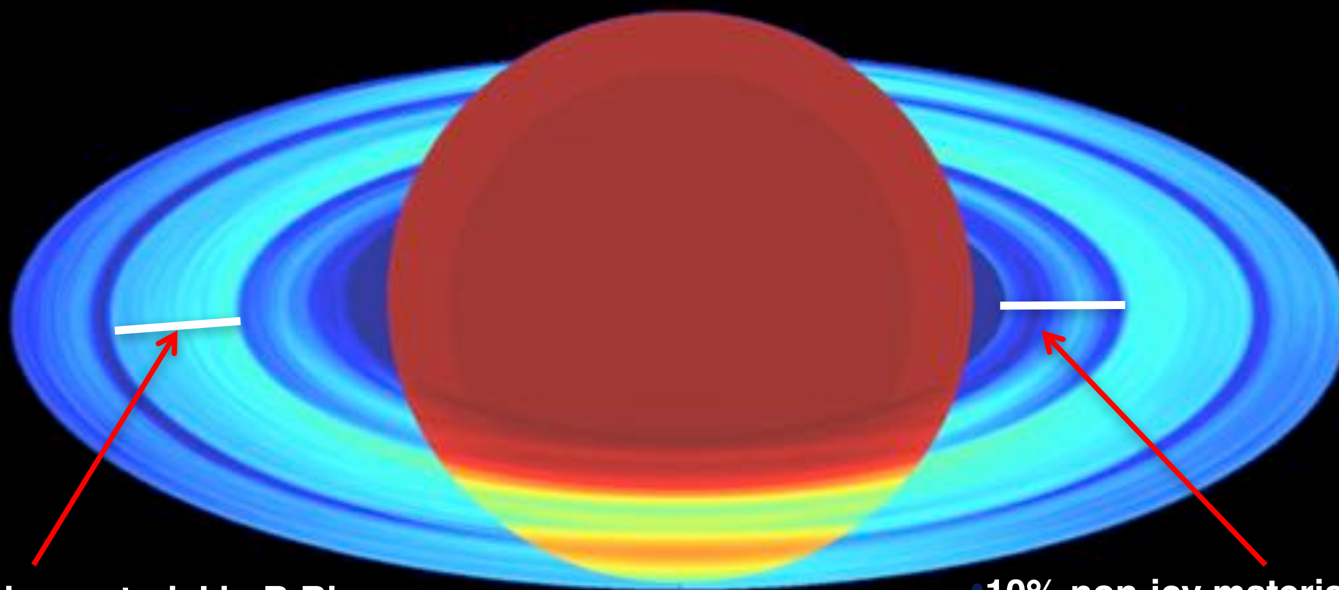


Cassini Not Affected by "Planet 9"

Cassini is not experiencing any unexplained deviations in its orbit around Saturn

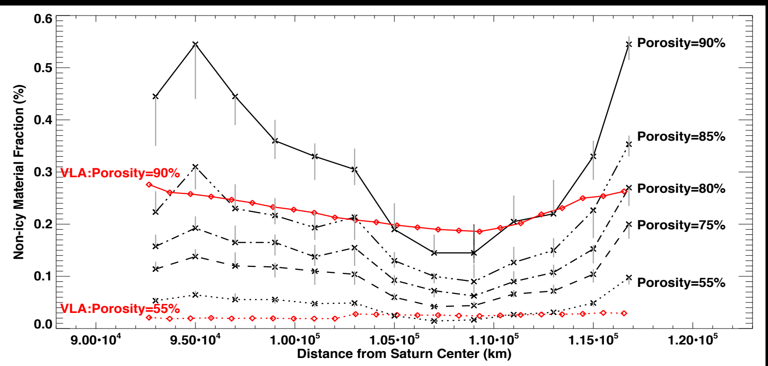
Precise knowledge of Saturn's orbit from Cassini data helped scientists estimate a range of probable locations for Planet 9

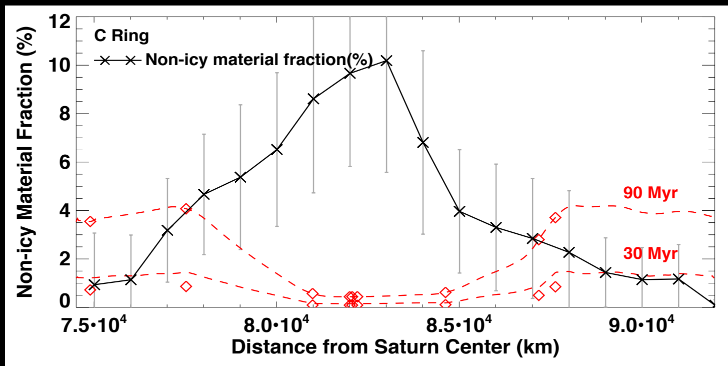
Exactly How Icy Are the Icy Rings?



1-2% non-icy material in B Ring:
Distribution suggests constant exposure age if mass density proportional to optical depth

10% non-icy material in a belt in the mid-C Ring:
Disrupted Centaur rubble or primordial core?





A year on Saturn. 1 Saturnian **calendar** day = 29.47 Earth days. *Note: rotation-based Saturnia day is 10 Earth hours*

Prime Mission Titan Activity	Extended Mission Titan Activity	Voyager Birthdays	XXM

January

M	T	W	T	F	S	S
				1	2	3
4	5	6	7	8	9	10
11	12 SOI	13	14	15	16	17 TA
18 TB	19 TC	20 T3	21	22 T4&T5	23	24
25	26	27	28 T6&T7	29	30 T8	31

February

M	T	W	T	F	S	S
1 T9	2 T10	3 T11	4 T12	5	6 T13	7 T14
8 T15	9 T16	10	11 T17&T18	12 T19	13 T20	14 T21
15 T22&T23	16 T24	17 T25&T26	18 T27&T28	19	20 T29&T30	21 T31&T32
22 T33	23 T34	24 T35	25 T36	26	27 T37&T38	28 T39&T40

March

M	T	W	T	F	S	S
1	2 T41	3 T42	4	5	6 T43&T44	7 EOM
8 T45	9	10	11 T46	12 T47	13 T48&T49	14
15 T50	16 T51	17 T52	18 T53	19 T54&T55	20 T56&T57	21 Equinox T58&T59
22 T60&T61	23	24 T62	25	26 T63	27 T64&T65	28 T66
29 V1	30 T67	31 T68&T69				

April

M	T	W	T	F	S	S
			1 T70 & 71	2	3	4 T72
5	6 T73	7	8 V2	9 T74	10	11 T75 & 76
12 T77	13	14	15 T78	16	17	18 T79
19 T80	20 T81&T82	21	22	23 T83	24 T84	25
26 T85	27	28 T86	29 T87	30 T88		

May

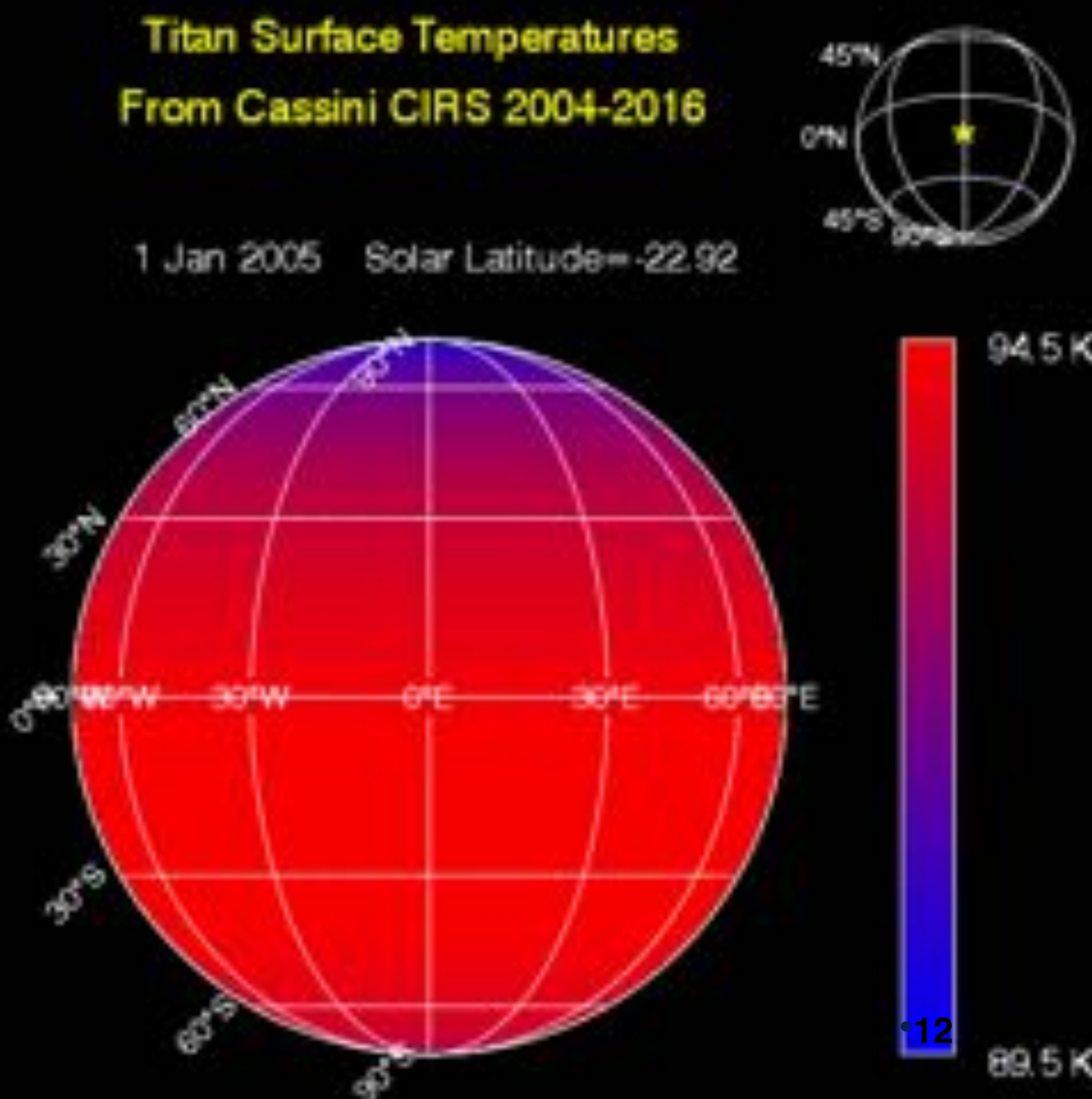
M	T	W	T	F	S	S
					1	2
3 T89 & 90	4	5 T91	6	7 T92&T93	8	9 T94
10 T95	11 T96	12 T97	13	14 T98	15 T99	16 T100
17 T101	18 T102	19 T103	20 T104	21 T105 & 106	22	23 T107
24 T108	25 T109	26 T110	27	28 T111	29	30 T112
31						

June

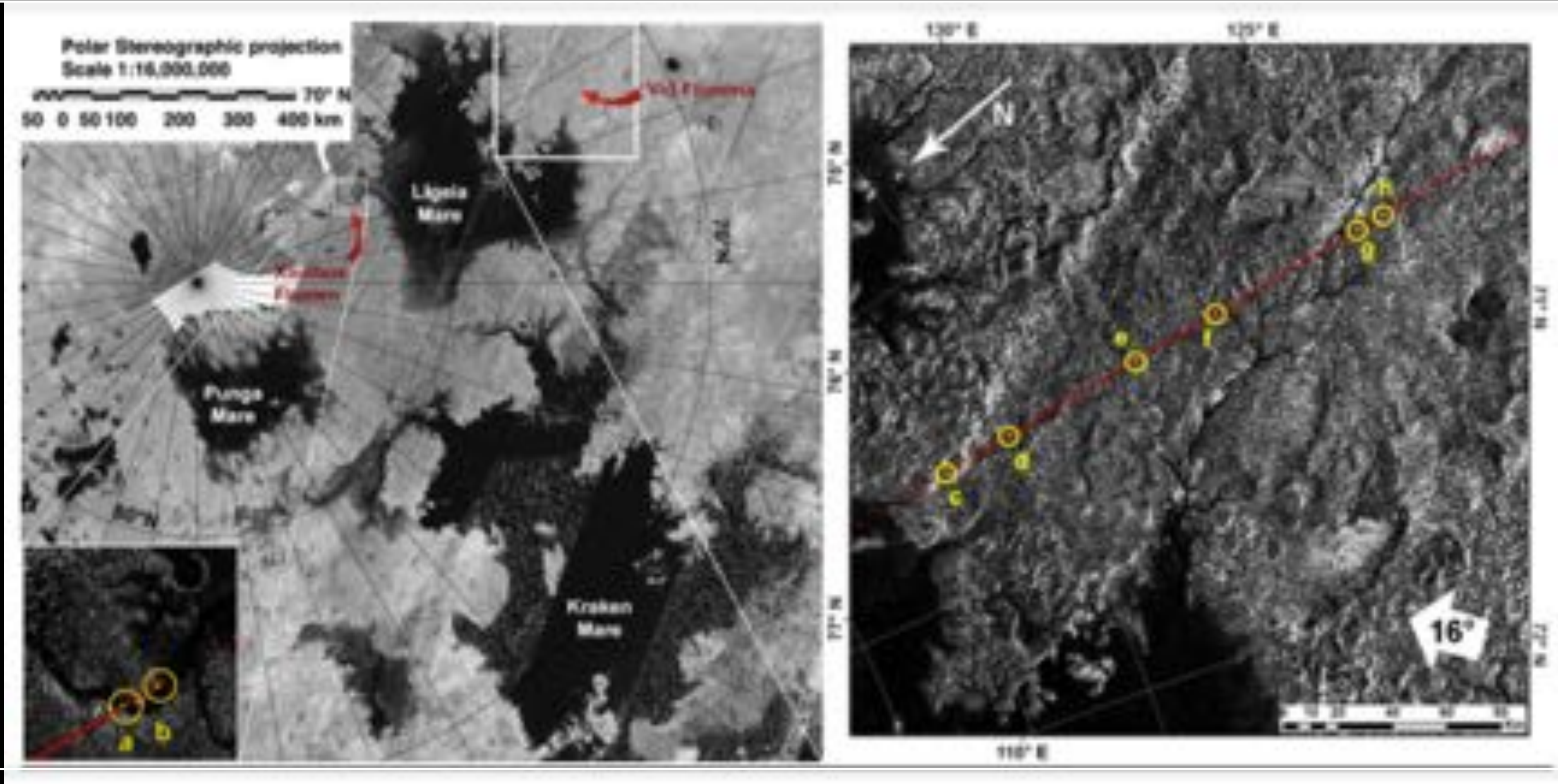
M	T	W	T	F	S	S
	1	2 T113	3	4 T114	5	6 T115&116
7 T117 &118	8	9 T119	10 T120	11 T121	12 T122	13 T123
14	15 T124	16 T125, *nT253*	17 nT255	18 *nT259,261*	19 *nT264*	20 T126
21 Solstice *nT273,275*	22 *nT278*	23 *nT283,285*	24 *nT288*	25 EOM *nT292*	26	27
28	29	30				

Seasons Change on Titan

Cassini's long lived mission has made it possible to observe seasonal temperature changes of Titan's surface.



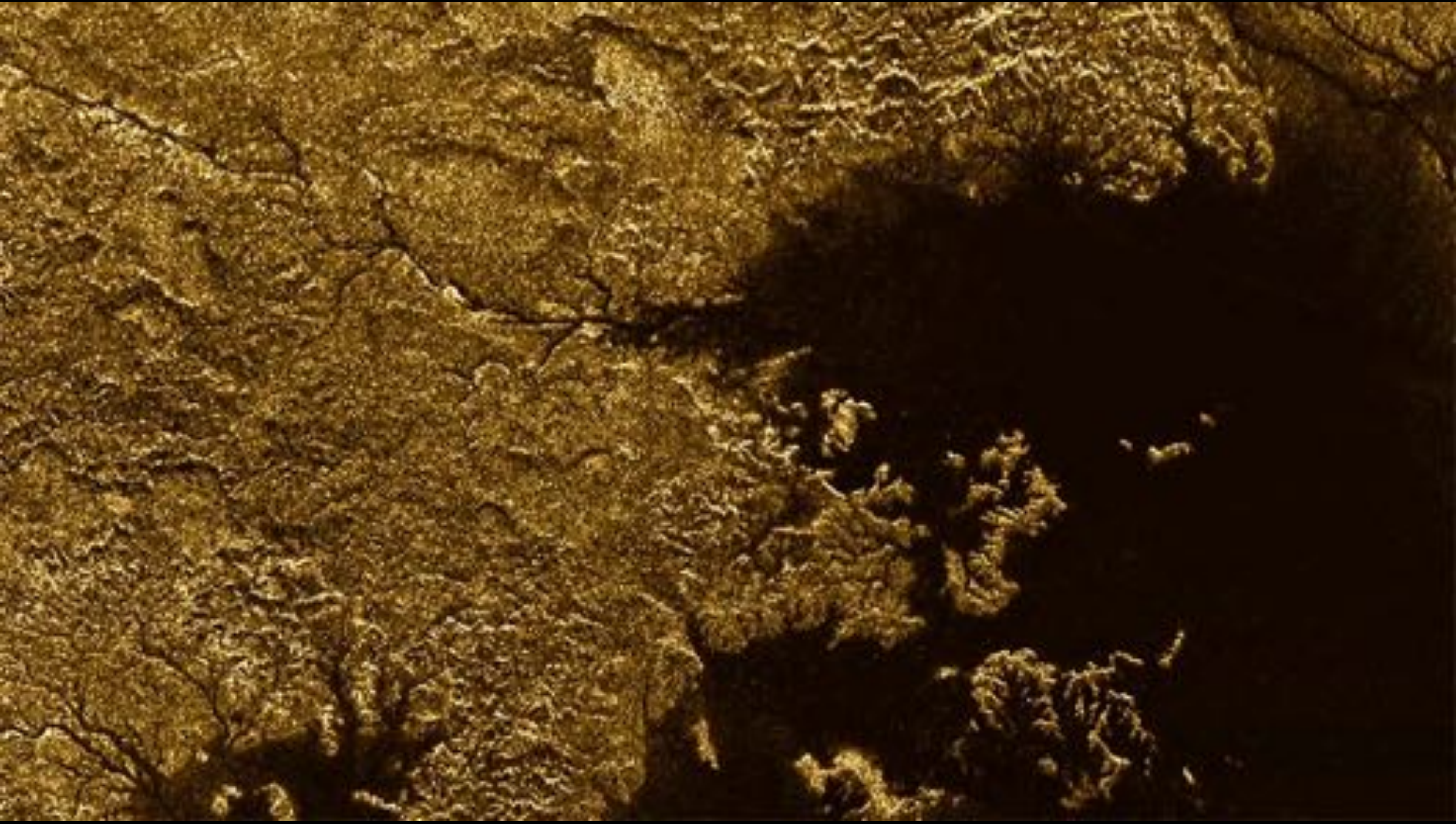
Flooded Canyons on Titan



- Titan seas and rivers look so similar to those on Earth
- Six RADAR measurements show that two Titan rivers, Xanthus Flumen and Vid Flumina, are mirror-smooth and at same height as adjoining sea near sea
- Upstream tributaries are higher and deeply cut into land providing evidence of liquid flow

Poggiali et al., Liquid-filled Canyons on Titan, Geophysical Research Letters, in press

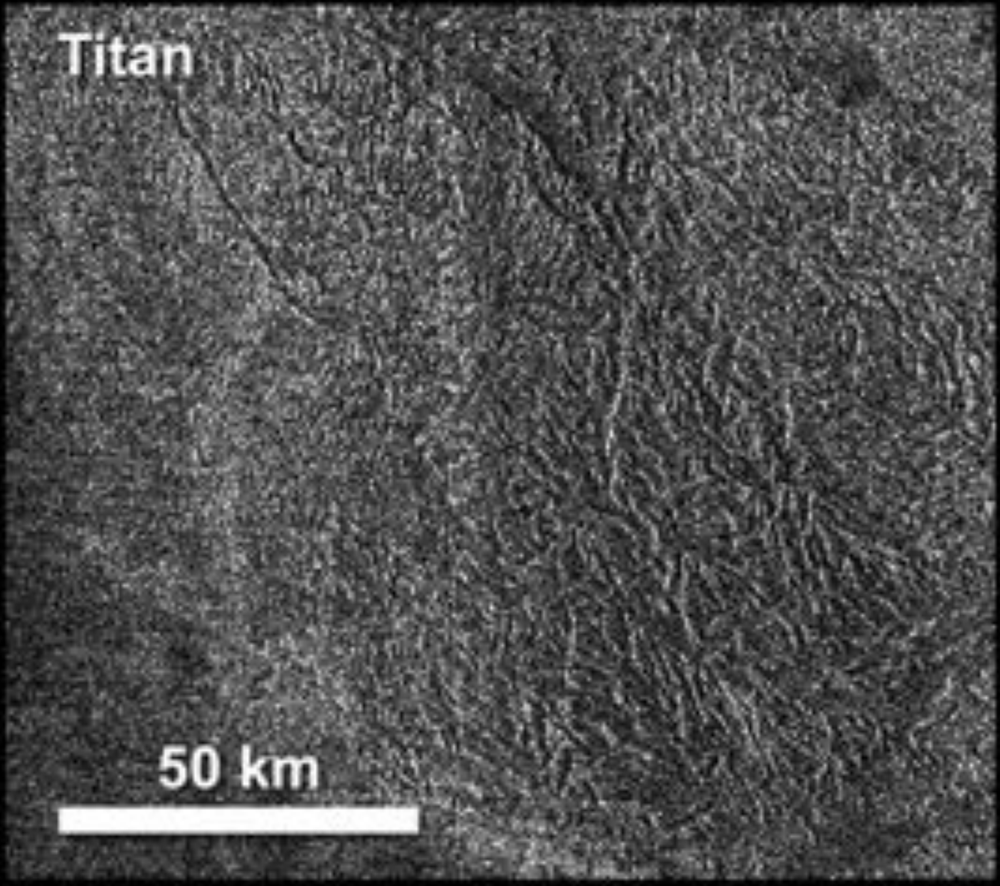
Canyons of Vid Flumina (upper left quadrant)

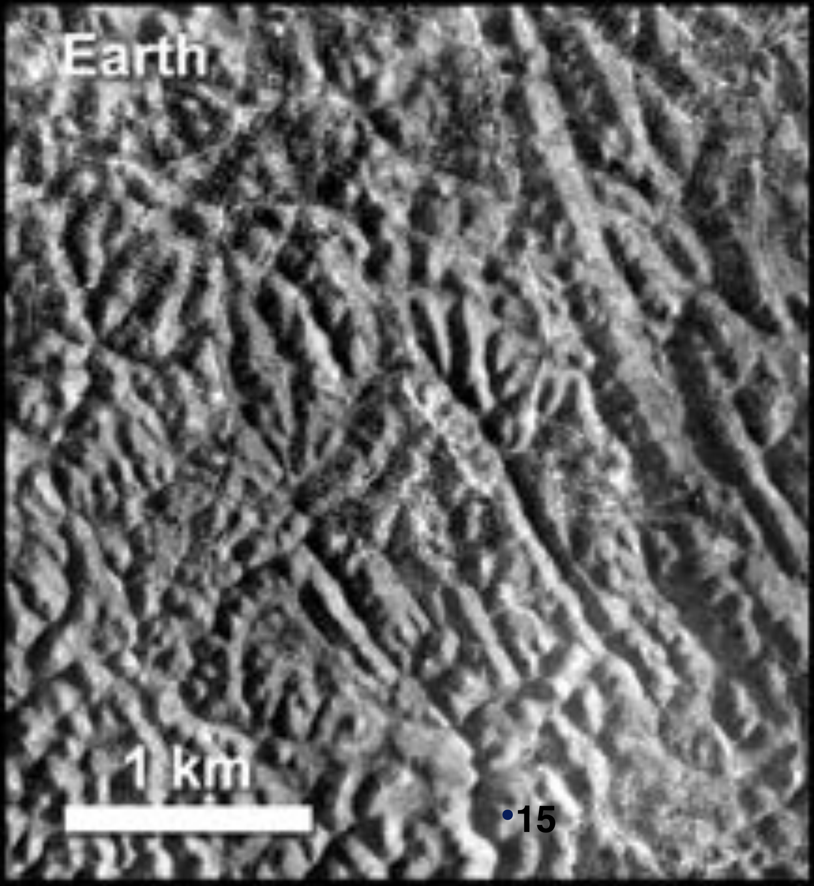


- Deep, steep-sided canyons (240 – 570 m deep) are flooded with liquid hydrocarbons
- Farther from sea, liquid is tens of meters higher than sea level

Labyrinth Terrains of Titan and Earth

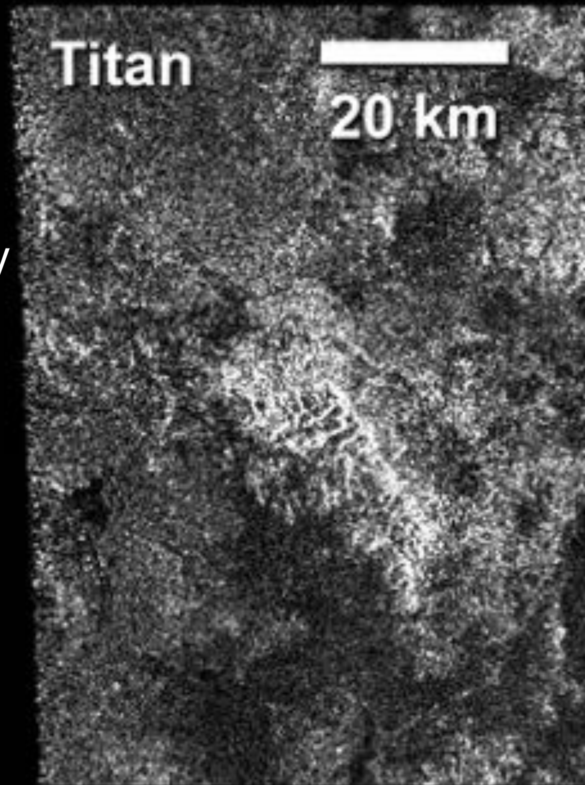
- “Labyrinth terrains” (karsts) on Titan (left) are thought to be higher areas that have been cut apart by rivers of methane, eroded as they were either uplifted or left standing above as the region around them lowered.
- An aerial photograph of a region in southern Java known as Gunung Kidul that resembles this Titan labyrinth is shown on the right.

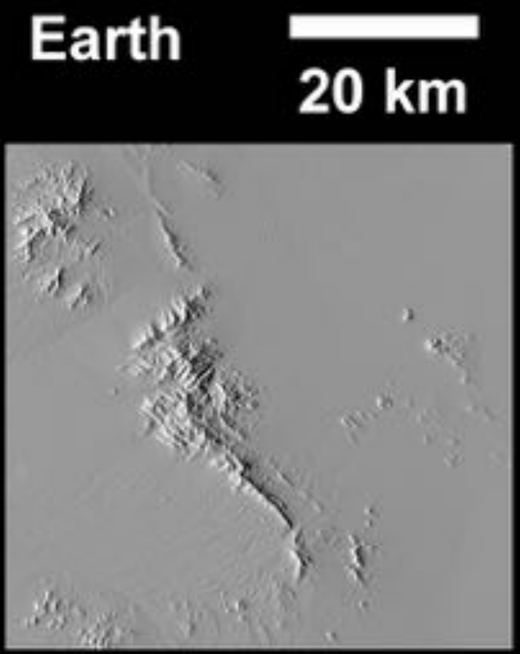


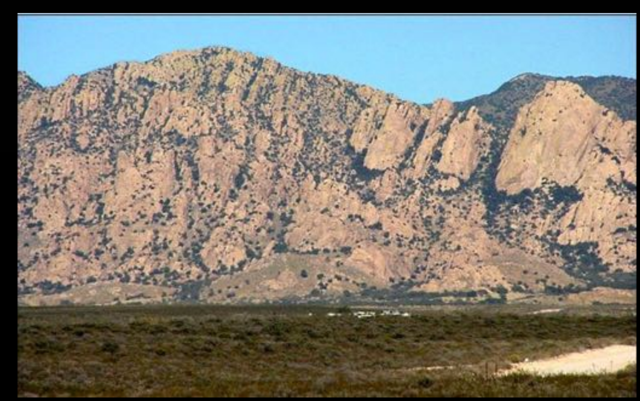


Tilted Thrust Fault on Titan and Earth

- Long ridge with jagged peaks (left) likely created by methane rainfall erosion.
- Some individual peaks rise about 800 meters above valley floor.
- Titan ridge has a considerably gentler slope on its left side than on its right.
- Dragoon Mountains in Arizona (right) has a shallow slope on one side and a steeper slope on fractured, faulted edge similar to Titan's ridge.
- Mountains shaped like this on Earth are fractured blocks of the planet's crust, thrust upward, then tilted and eroded.

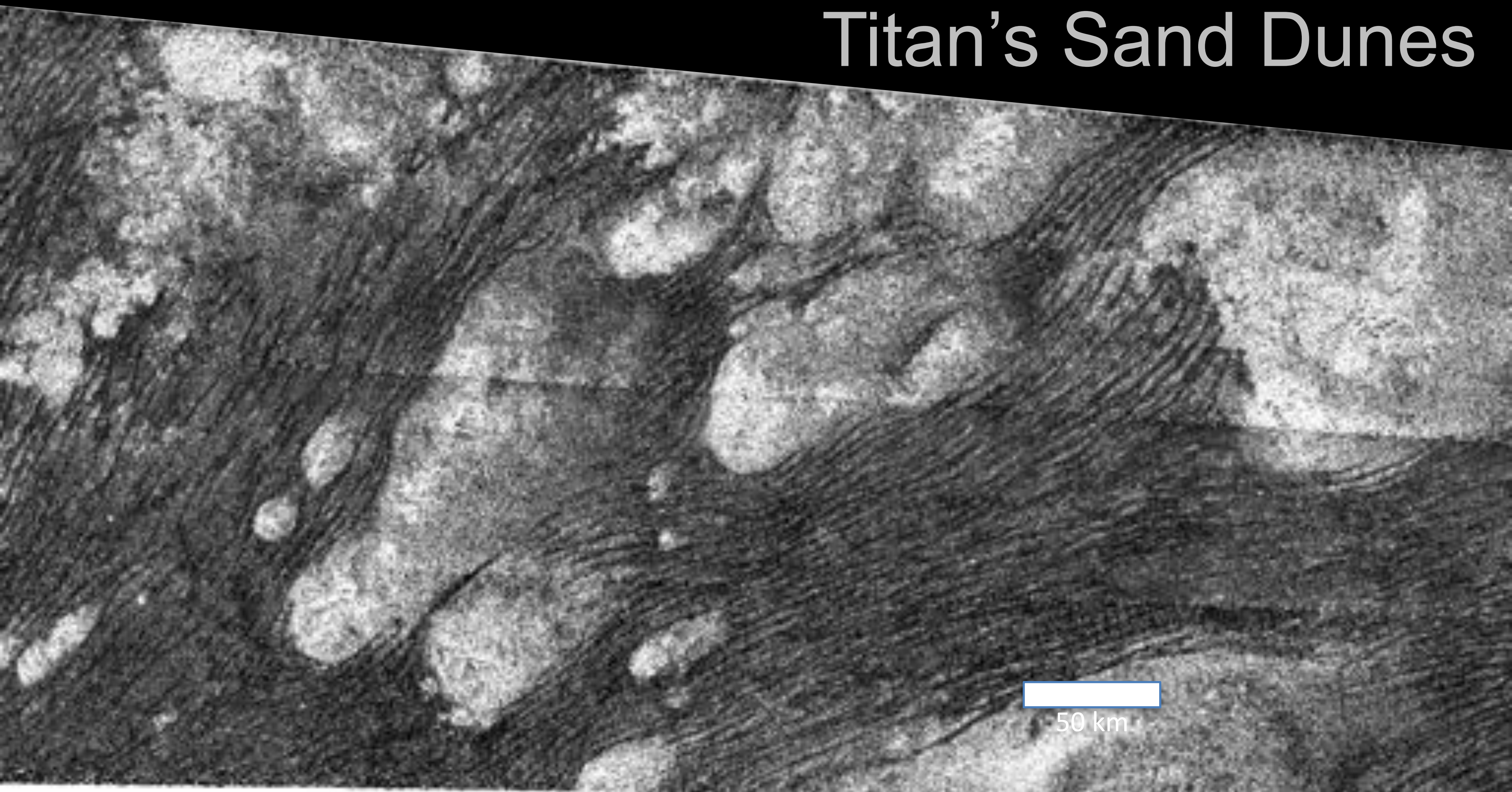






Dragoon Mountains, AZ

Titan's Sand Dunes

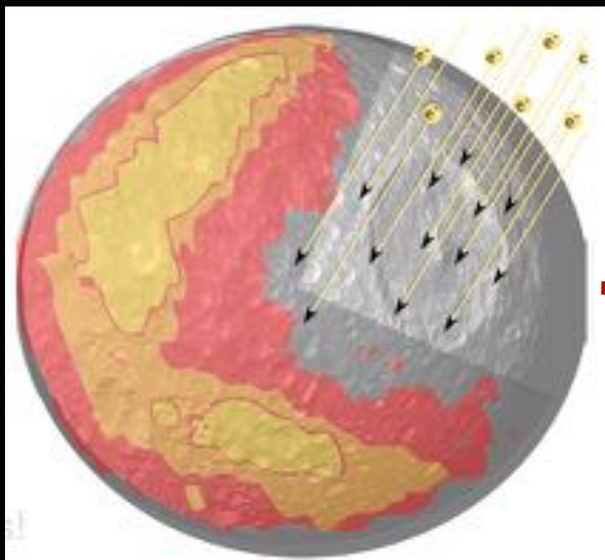


Titan (pass T121, July 25 2016)

Titan's sand dunes extend about 2/3 of the way around its equator. Besides giving us insight into the processes that have molded the surface, it adds a zenlike character.

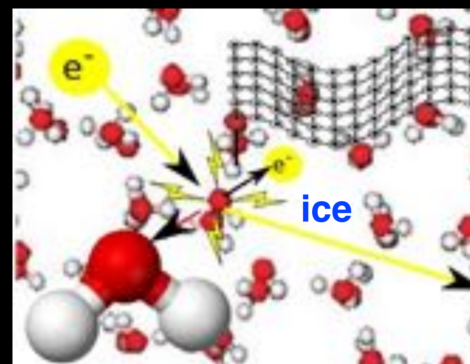
Irradiation of Icy Surfaces Produces PacMan

Electrons



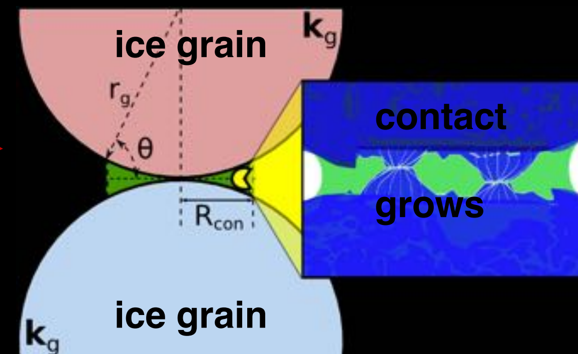
Thermal anomaly
Mimas

Electrons deposit energy



Excited water molecules
made mobile

Grains sintered
Improving conductivity



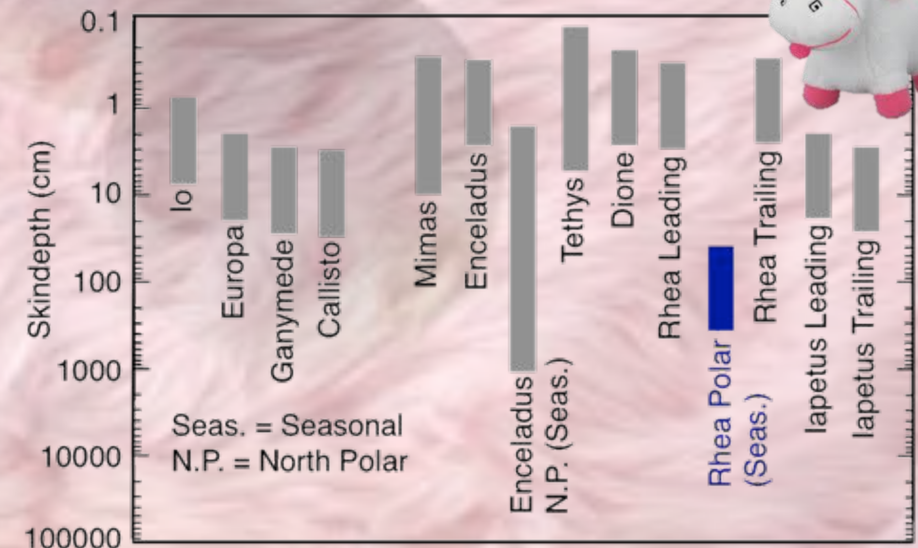
Mobile water molecules
anneal grain contacts

- Radiation-induced sintering of regolith ice by high energy electrons improve conductivity
- Produces thermal and optical anomalies on Mimas, Tethys & Dione
- Electron-induced thermal anomalies extend to cm depths allowing detection of thermal inertia differences

FLUFFY RHEA

- Analysis of seasonal temperature variations indicate that Saturn's moon Rhea has a very fluffy, powder-like polar surface, even down to several meters (blue bar at the right).

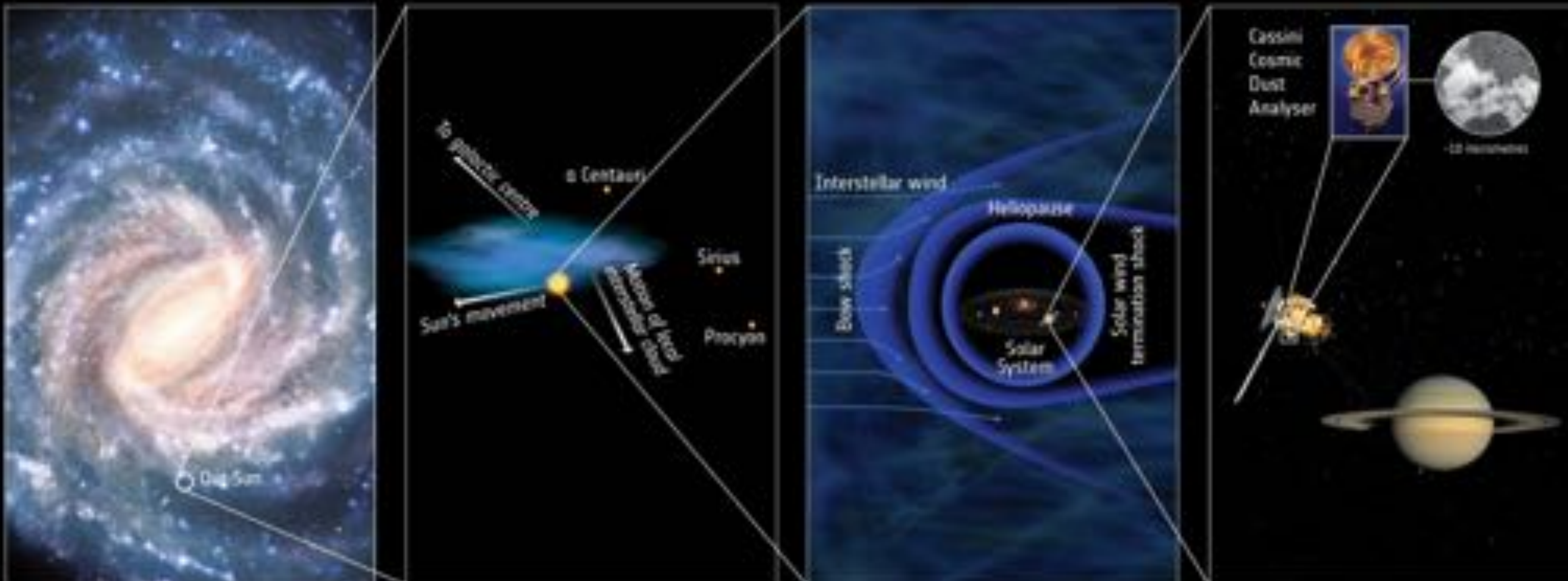
- Previously, it was speculated that Rhea's icy surface would compact, becoming more dense with depth.



- These new results show that fluffy surfaces seen on several moons across the Saturn system may exist even at great depths.

- A possible cause is the slow, but continual, surface bombardment by ice ring grains from the E-ring.

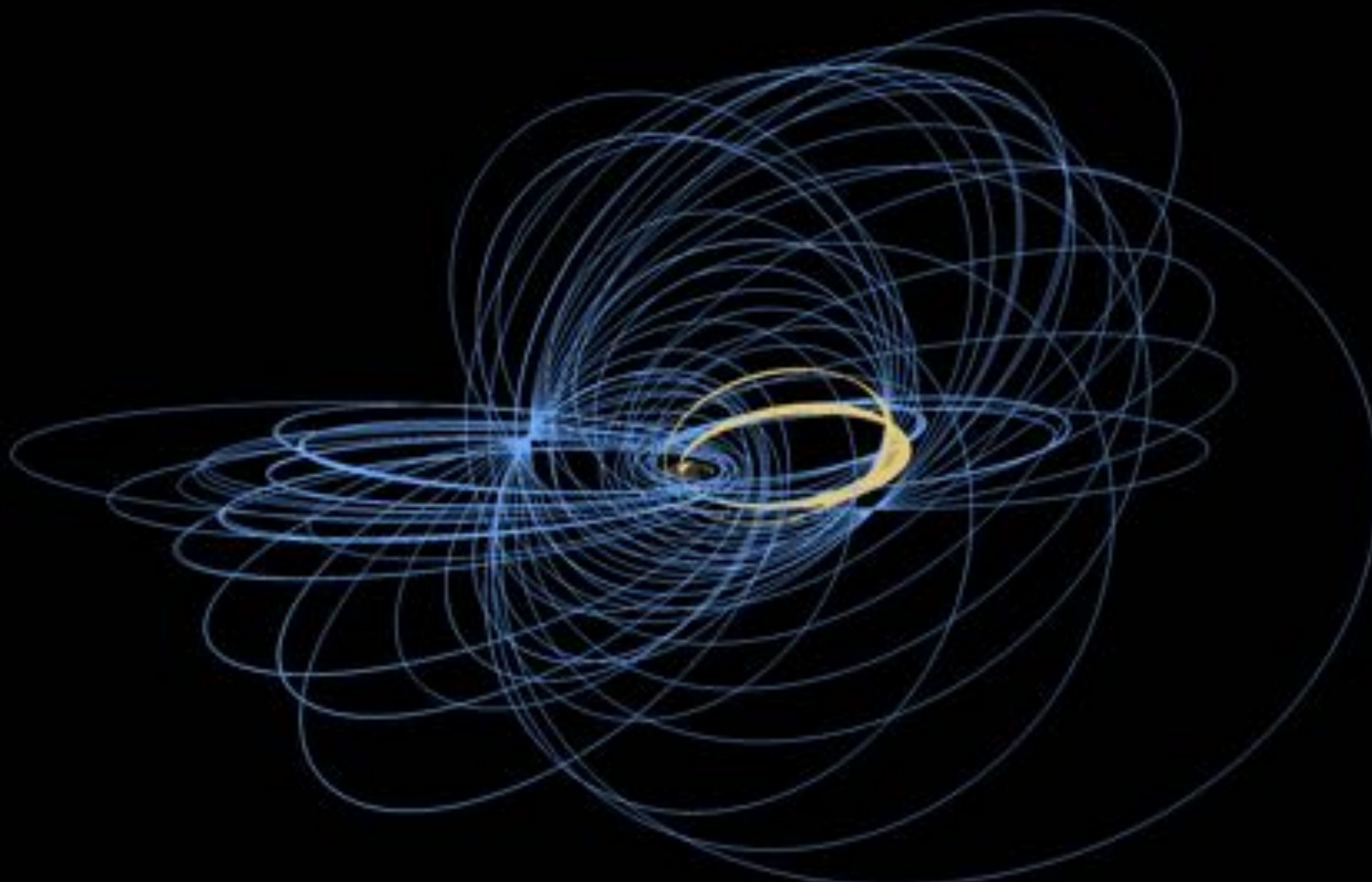
Sampling Interstellar Dust



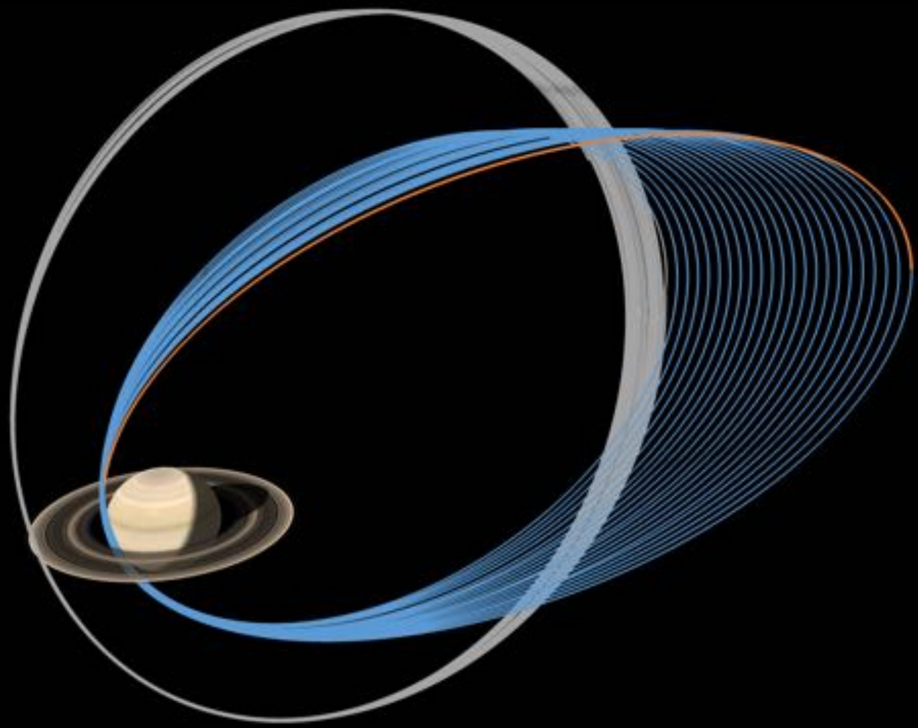
36 grains, out of millions sampled, are from beyond our solar system

Cosmic dust forms when stars die

Solstice Mission Trajectory



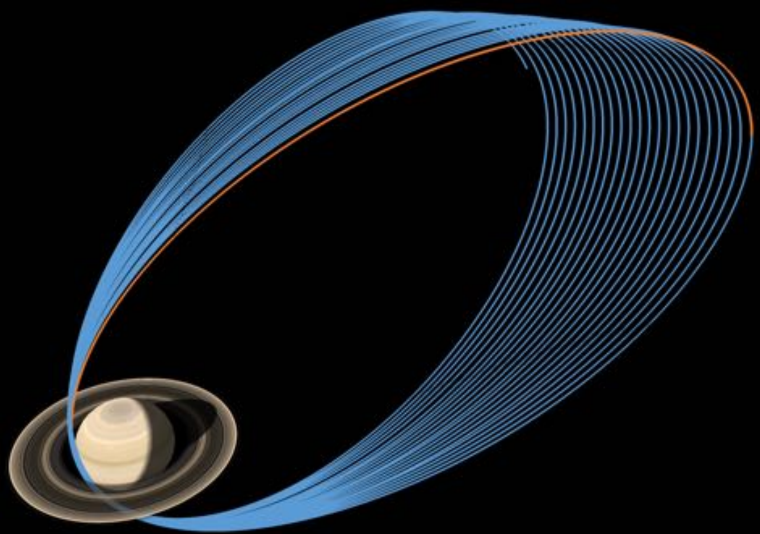
Key Orbital Characteristics of Final Orbits



- 42 short-period orbits
  - Nov. 2016 to Sept. 2017

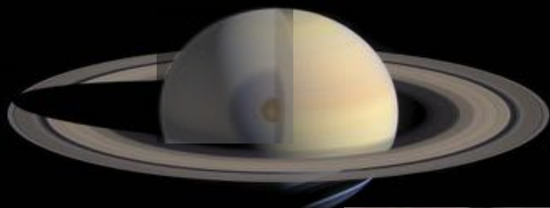
20 F-ring orbits
  - Periapses just outside Saturn's F ring
  - Sets up Cassini for final jump to orbits inside D ring
  - Scientifically rich
    - High resolution F and A ring observations
    - Ring occultations (Earth and Solar)
    - Auroral field line crossings at $r = 3.4 - 4\ R_S$

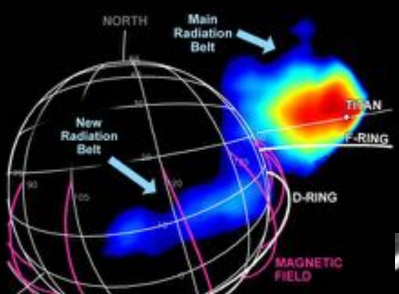
Grand Finale (Proximal) Orbits

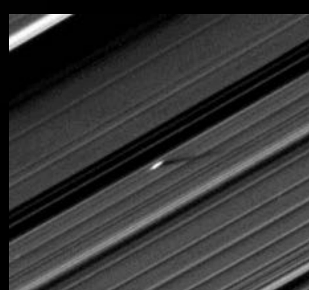


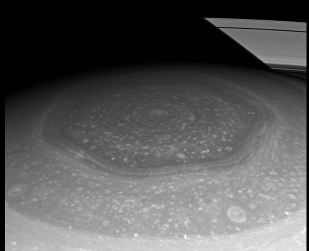
- 22 Grand Finale orbits
  - Periapses in 2,200 km “clear” region
  - First orbit April 2017 (next year during EGU!)
  - Critical inclination: 63.4°
- If delta v is available, go lower if Saturn upper atmosphere continues to shrink
- Current impact date: 15 September 2017
- Juno-like mission with Cassini instruments

Grand Finale 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

Cassini Saturn science complements that from Juno mission to

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

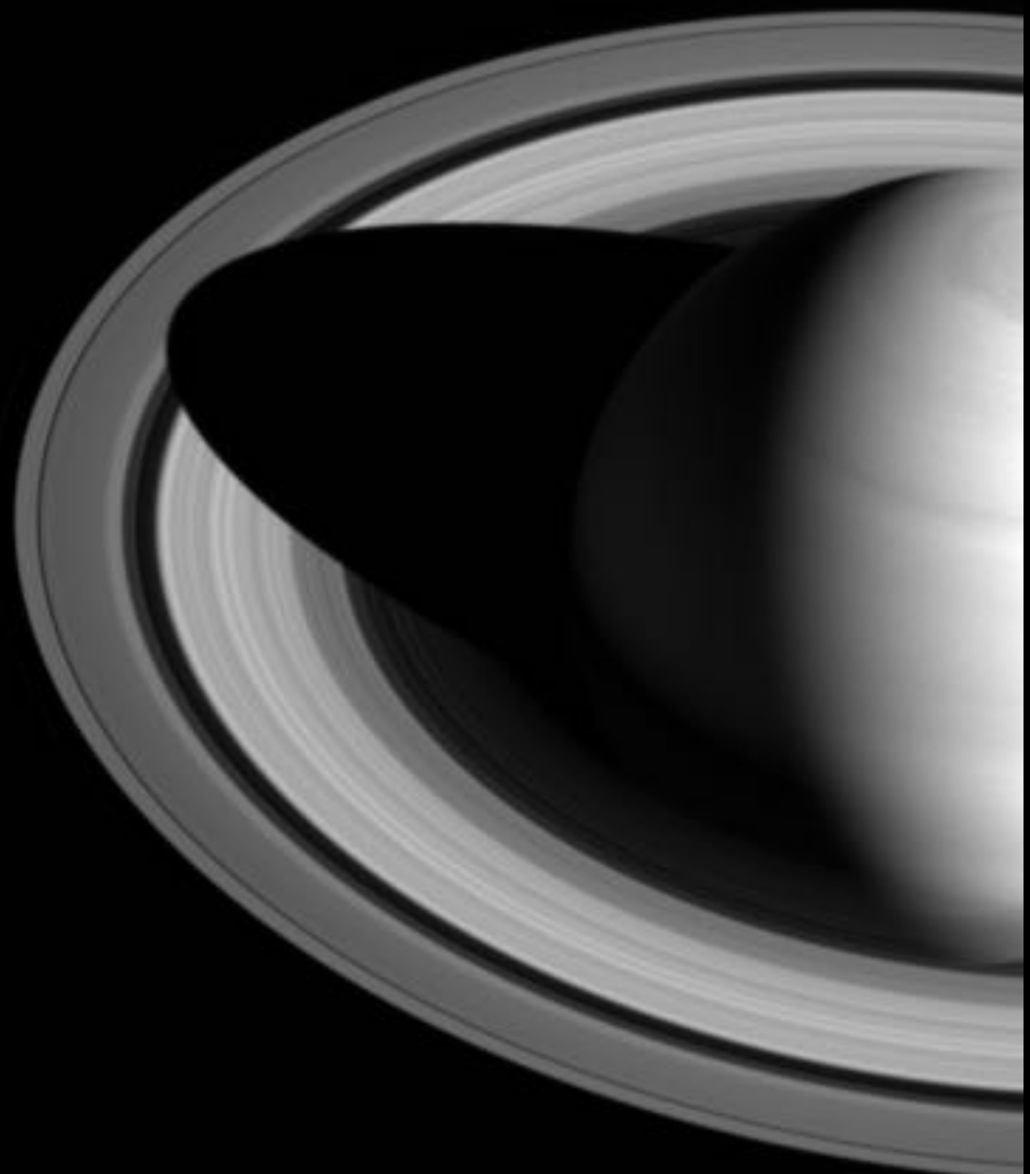
12 Mission "Lasts" in F-ring phase

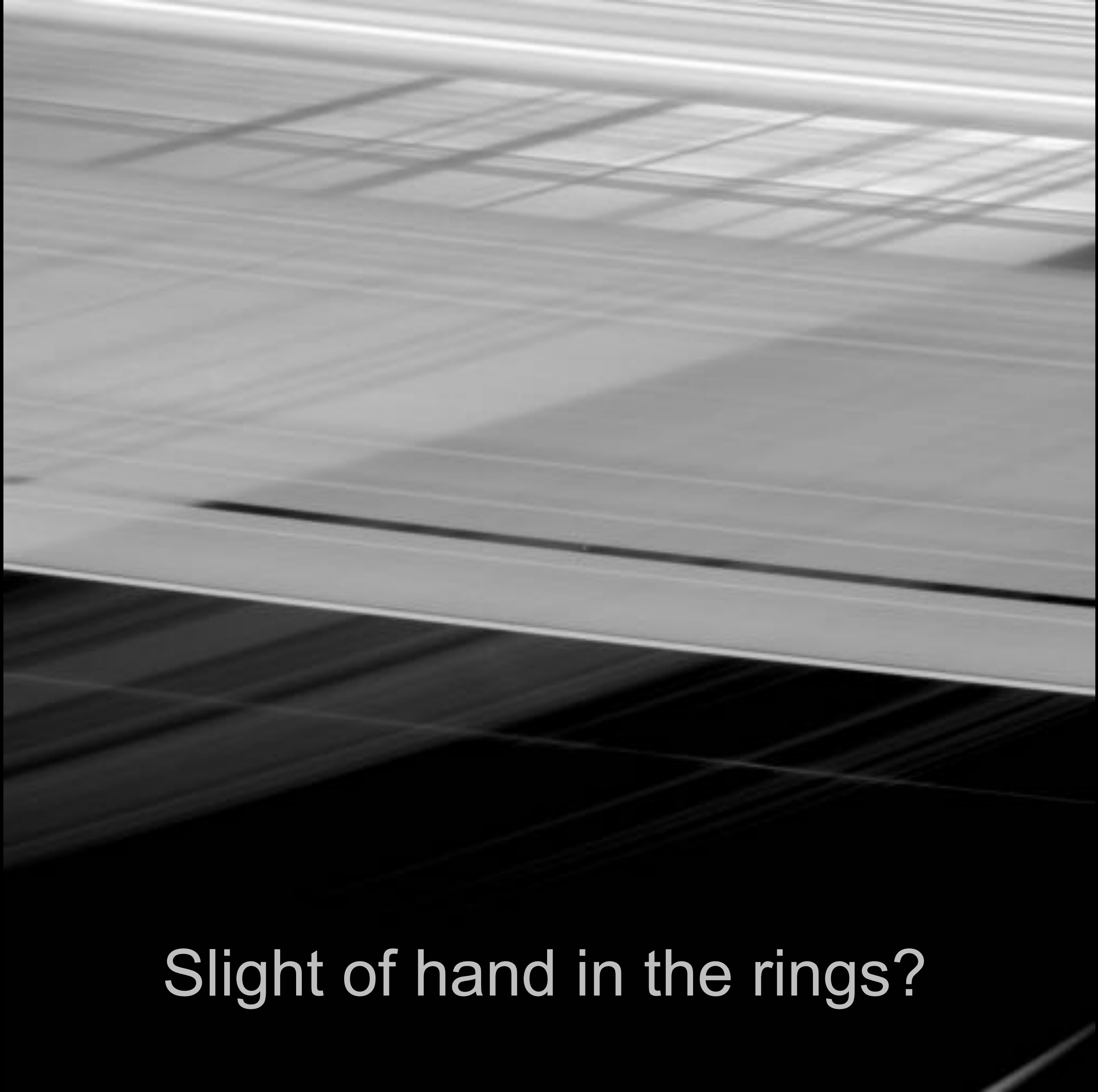
Last zero-phase ring mosaic	September 23, 2016
Last Titan Specular reflection (wind and waves)	September 27, 2016
Last Titan UV solar occultation	September 27, 2016
Final Bi-static of Titan	November 13, 2016
Last Titan Surface Temperature Map	November 29, 2016
Last Epimetheus	January 30, 2017
Last images to search for ring impact clouds	March 8, 2017
Last Mimas	April, 2017
Last Taste of Titan's atmosphere	April 23, 2017
Last RADAR pass over Titan's seas	April 23, 2017
Last Look (or not) at Magic Island (Titan)	April 23, 2017
Last view of Enceladus north pole with multiple instruments. Best color.	November 27, 2016

11 Mission "Bests/Firsts" in F-ring phase

Best Alpha Ori stellar ring occultations	August 21, 2016
Best Pandora (20k)	December 18, 2016
Best Daphnis (18k)	January 16, 2017
Best main ring radial scan	January through July 2017
Best/highest resolution UV image of A ring	February 6, 2017
Best propeller close-up images	February through April 2017
Best Pan (25K)	March 7, 2017
Best Atlas (13k)	April 12, 2017
Best ring high-phase mosaic	April 13, 2017
Longest Timespan looking for Titan lake changes	April 23, 2017
First look at the elevation of small lakes on Titan (possibly depth/composition)	April 23, 2017

Ring Shadow Marks Passing of Seasons





Slight of hand in the rings?

Questions?