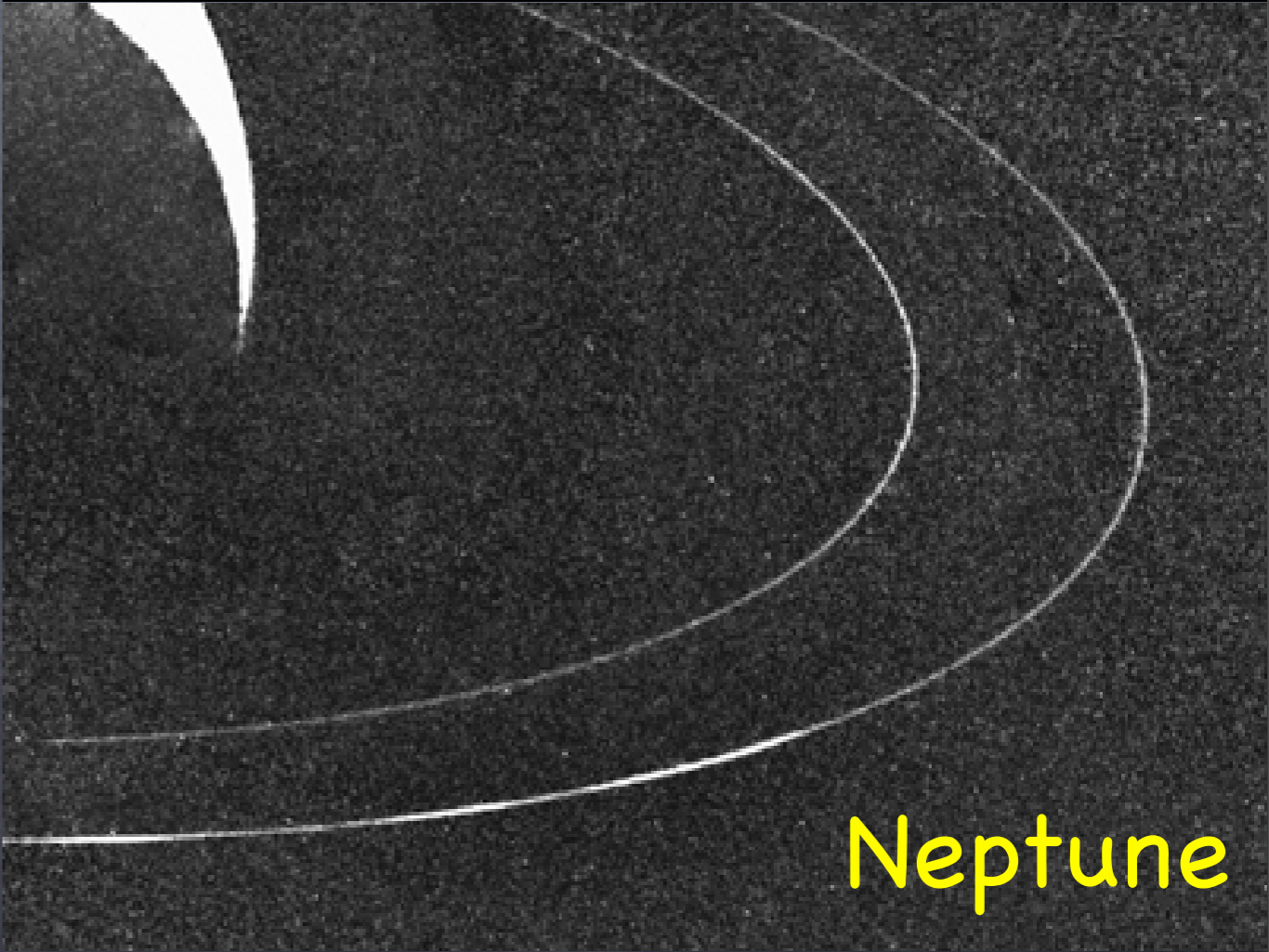
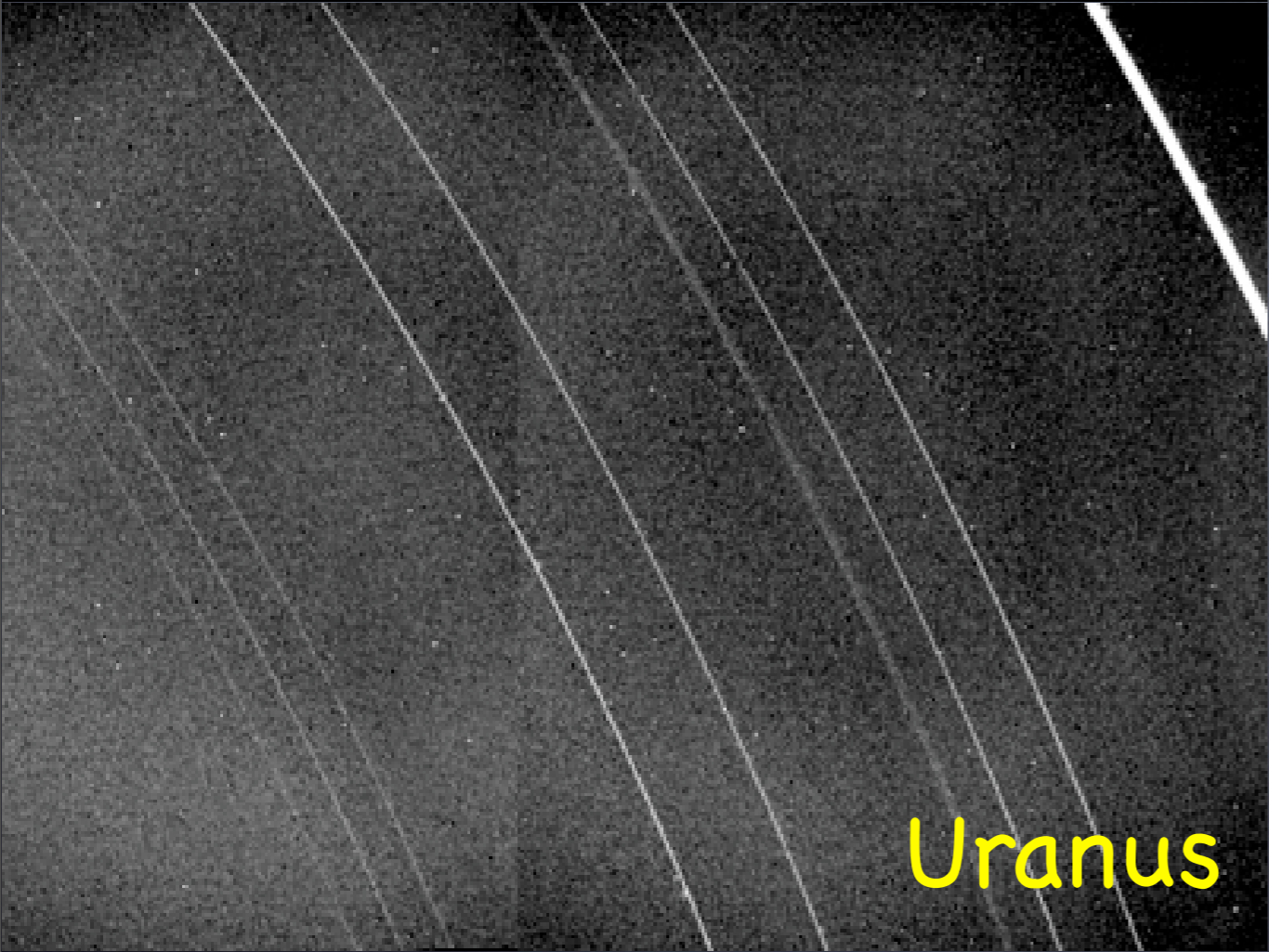
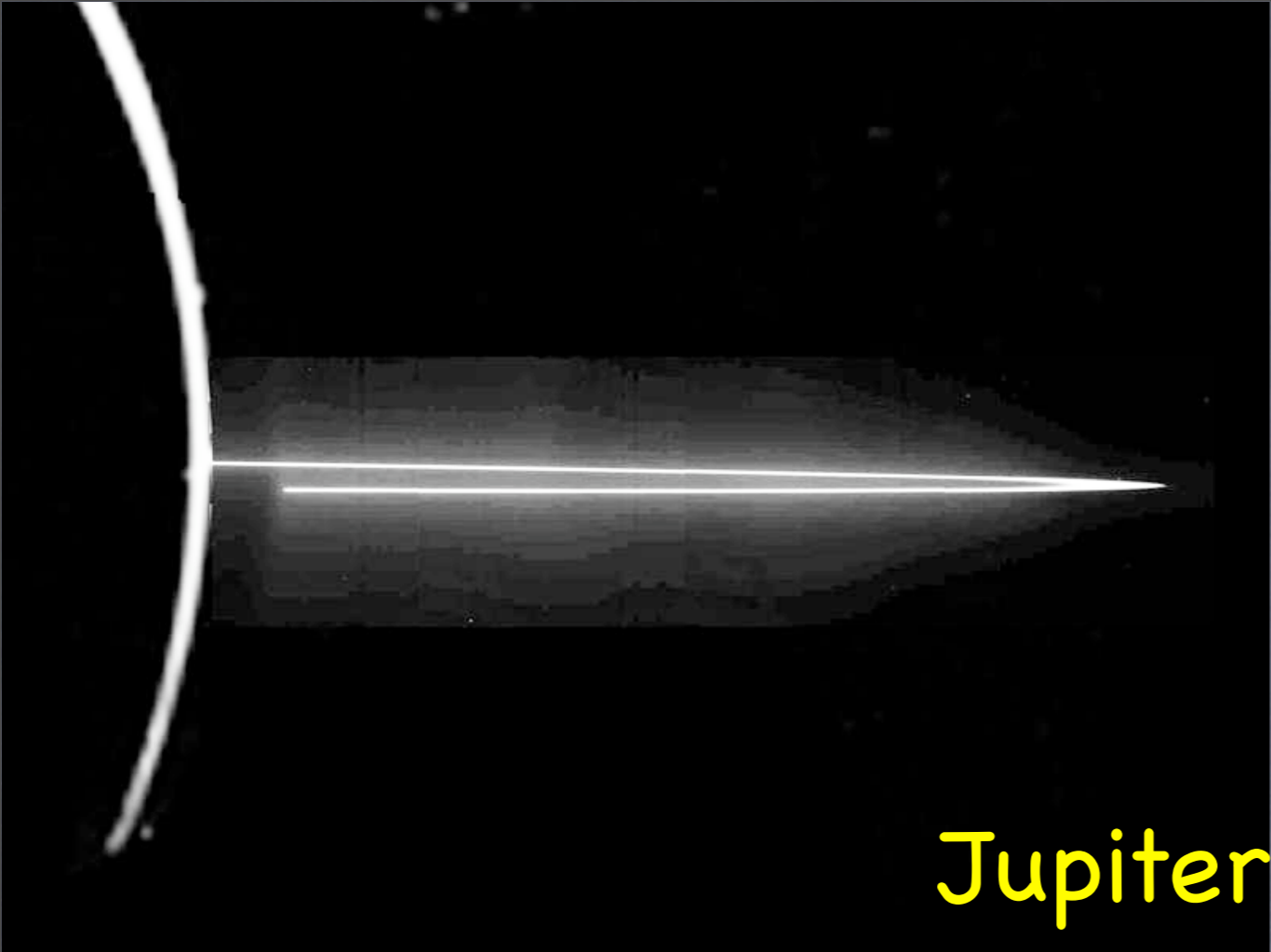


Planetary Rings and the Cassini Mission Lecture #1

Mark R. Showalter
SETI Institute

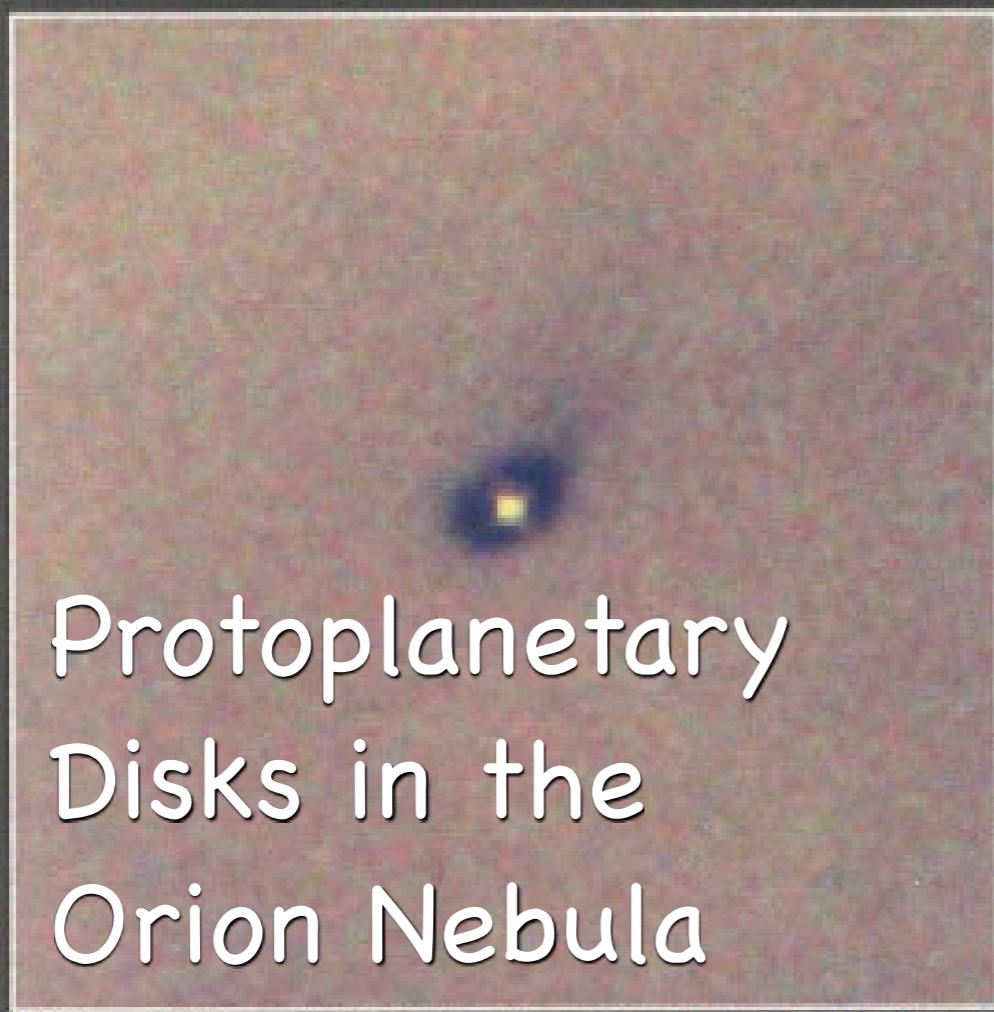
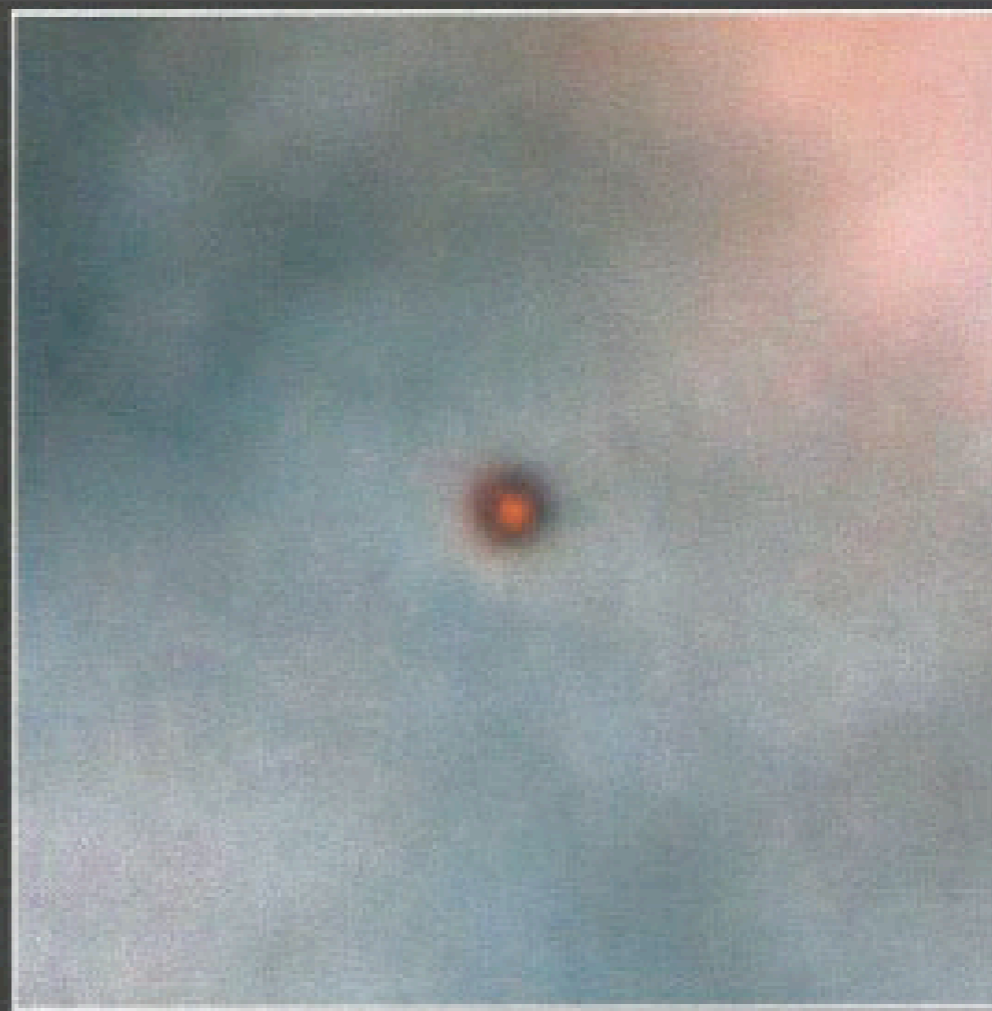
COSPAR WORKSHOP
Wednesday, July 23, 2007

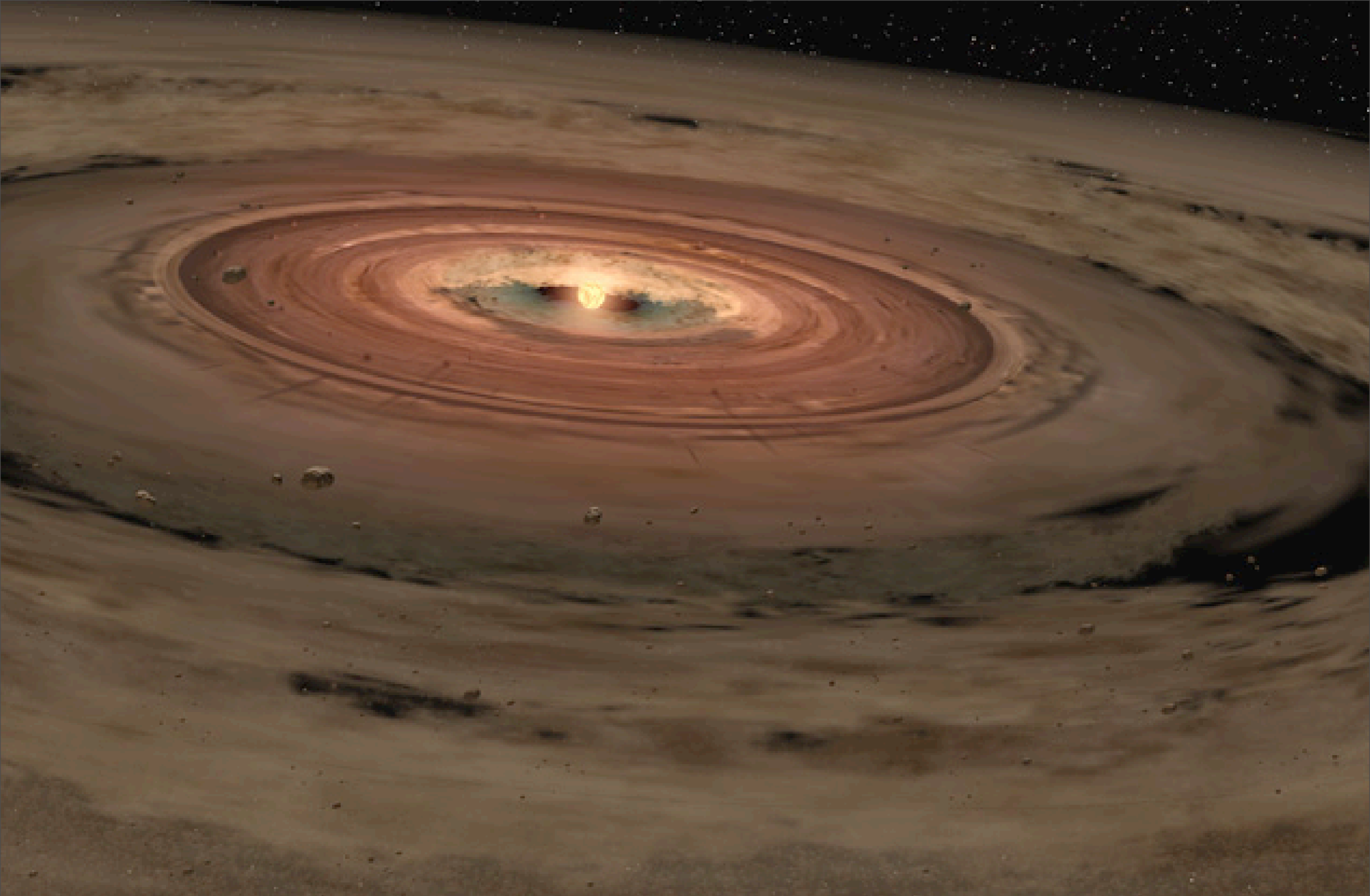


Why Study Rings?



Orion Nebula in HST



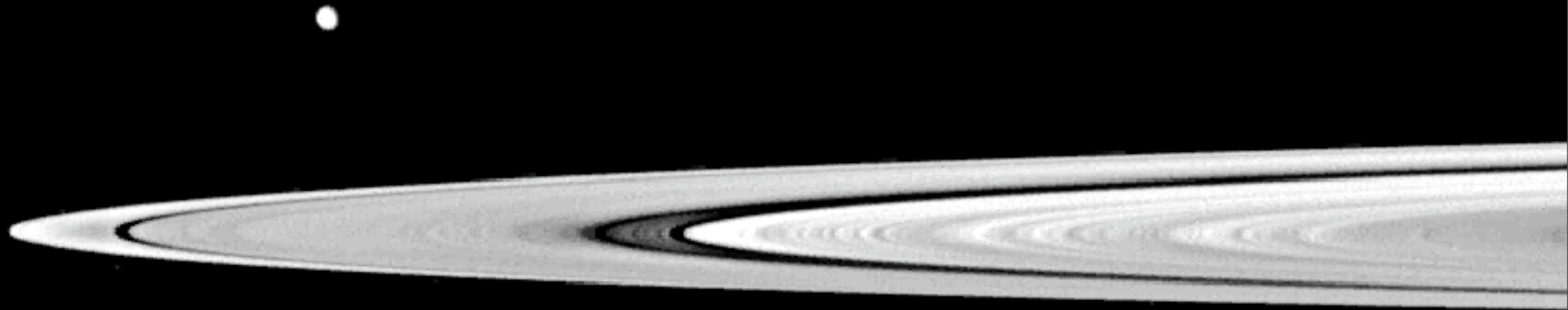


Artist's Conception of a Protoplanetary Disk

Cassini Crosses the Ring Plane



Cassini Crosses the Ring Plane



Cassini Crosses the Ring Plane



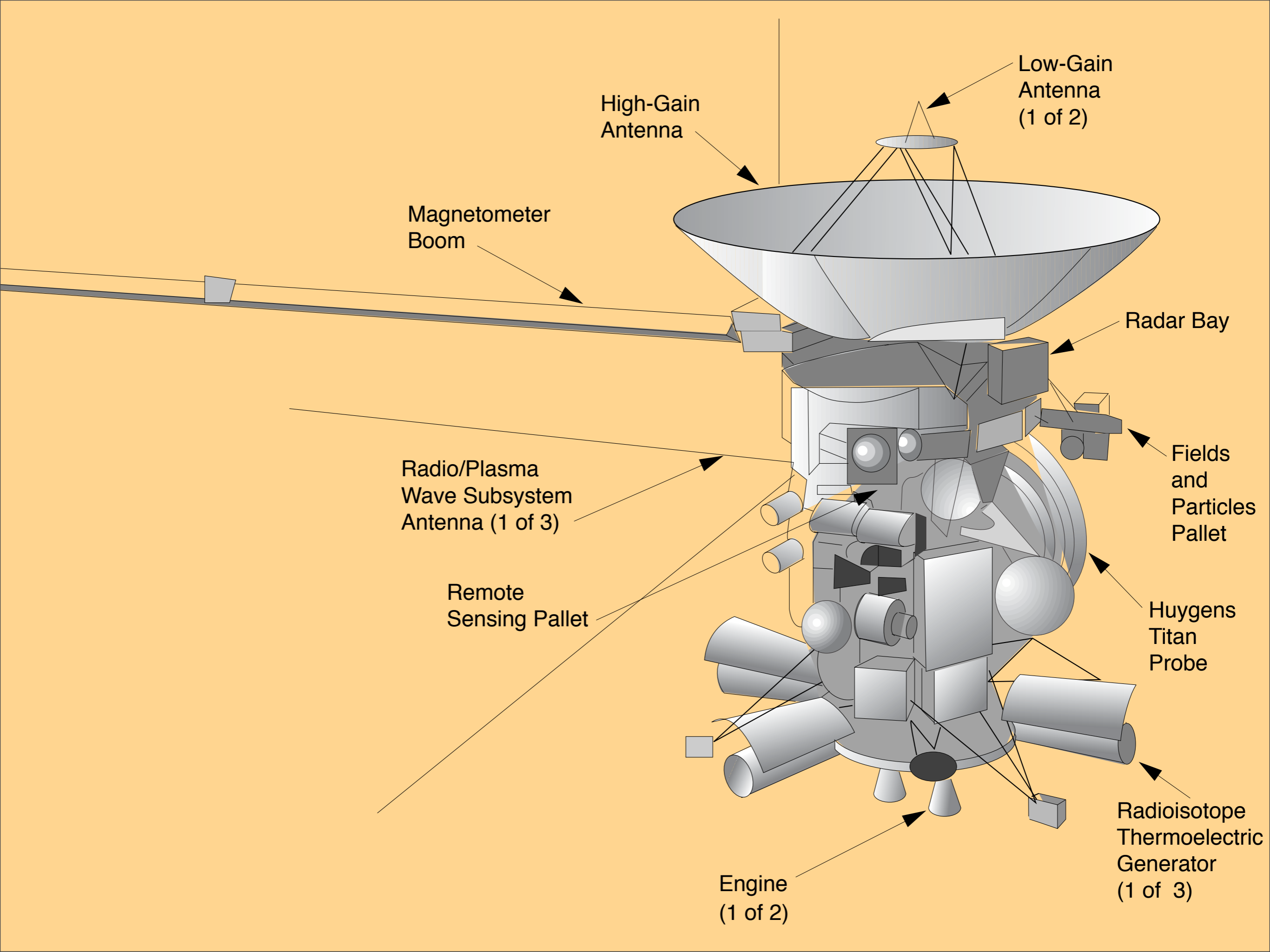
Cassini Approaches Saturn



<http://saturn.jpl.nasa.gov/>

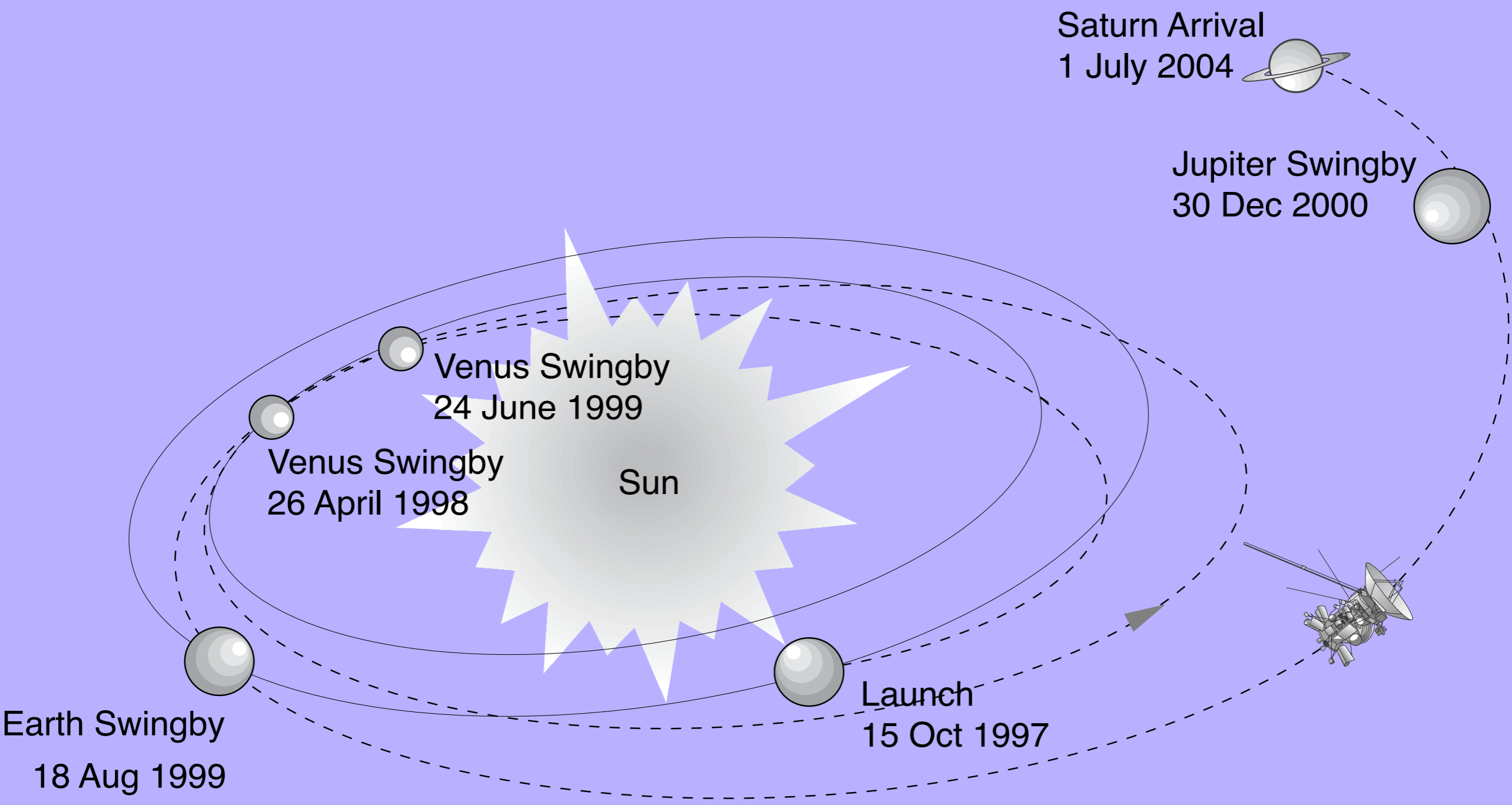
<http://saturn.jpl.nasa.gov/multimedia/images/raw/>



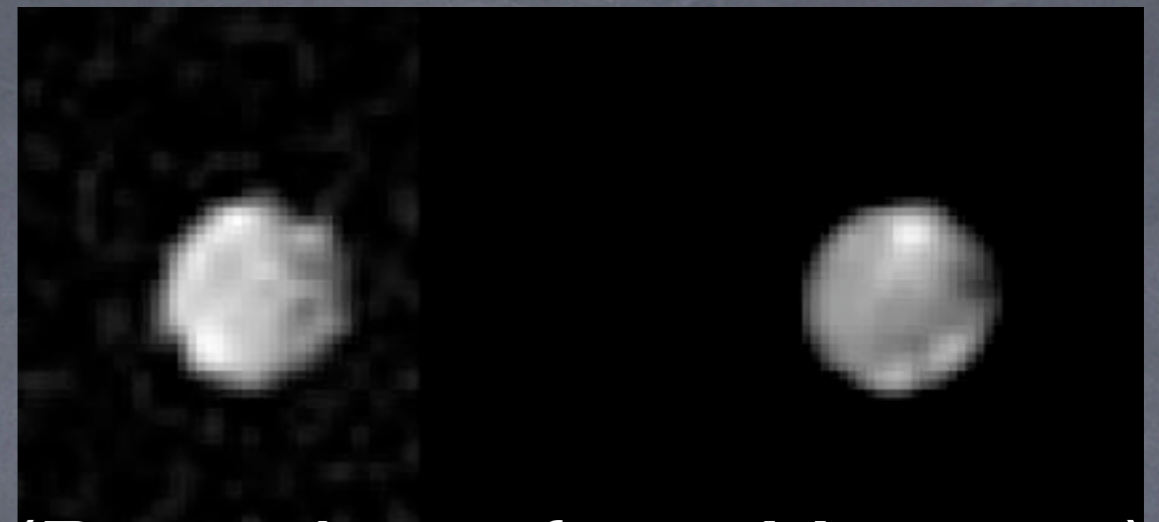




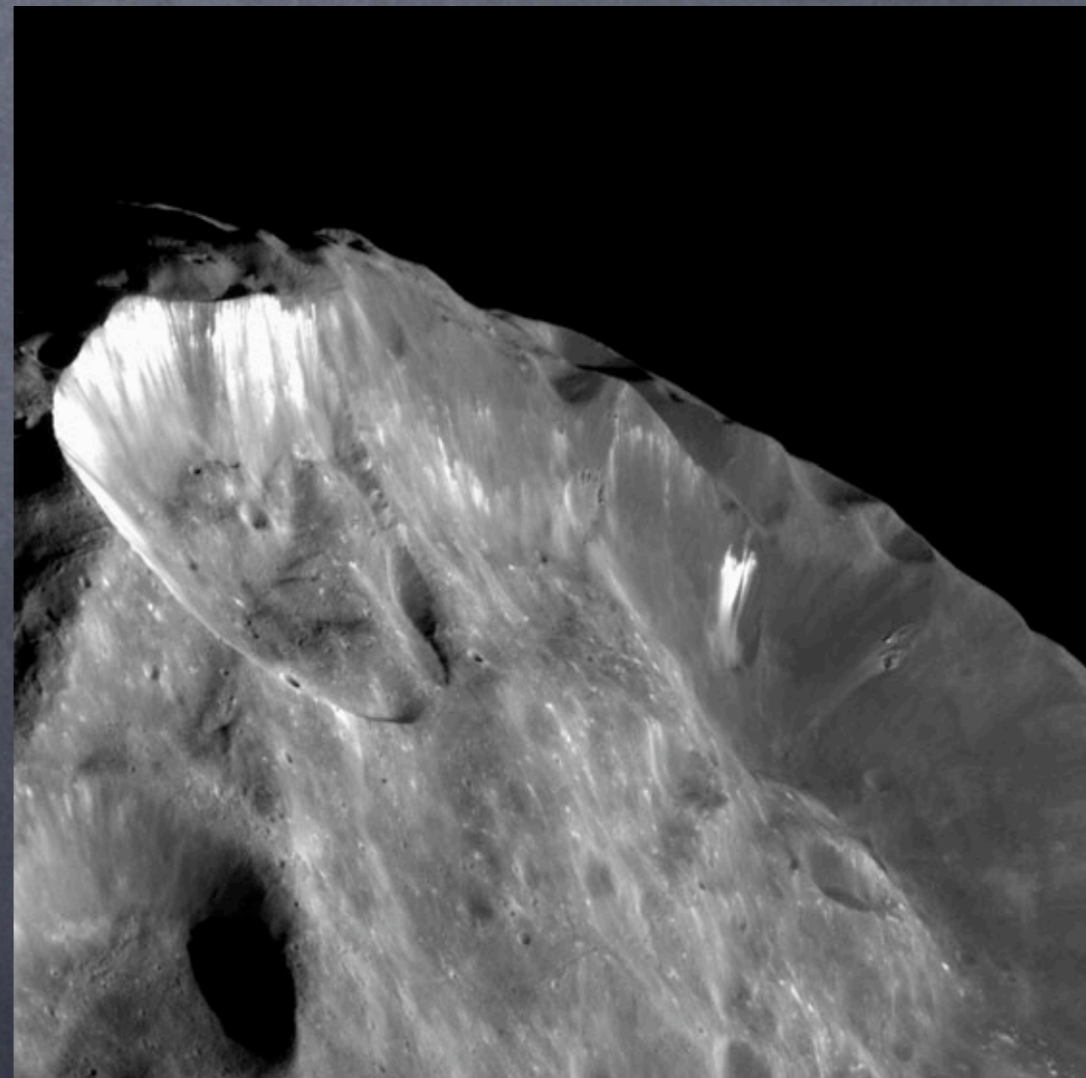
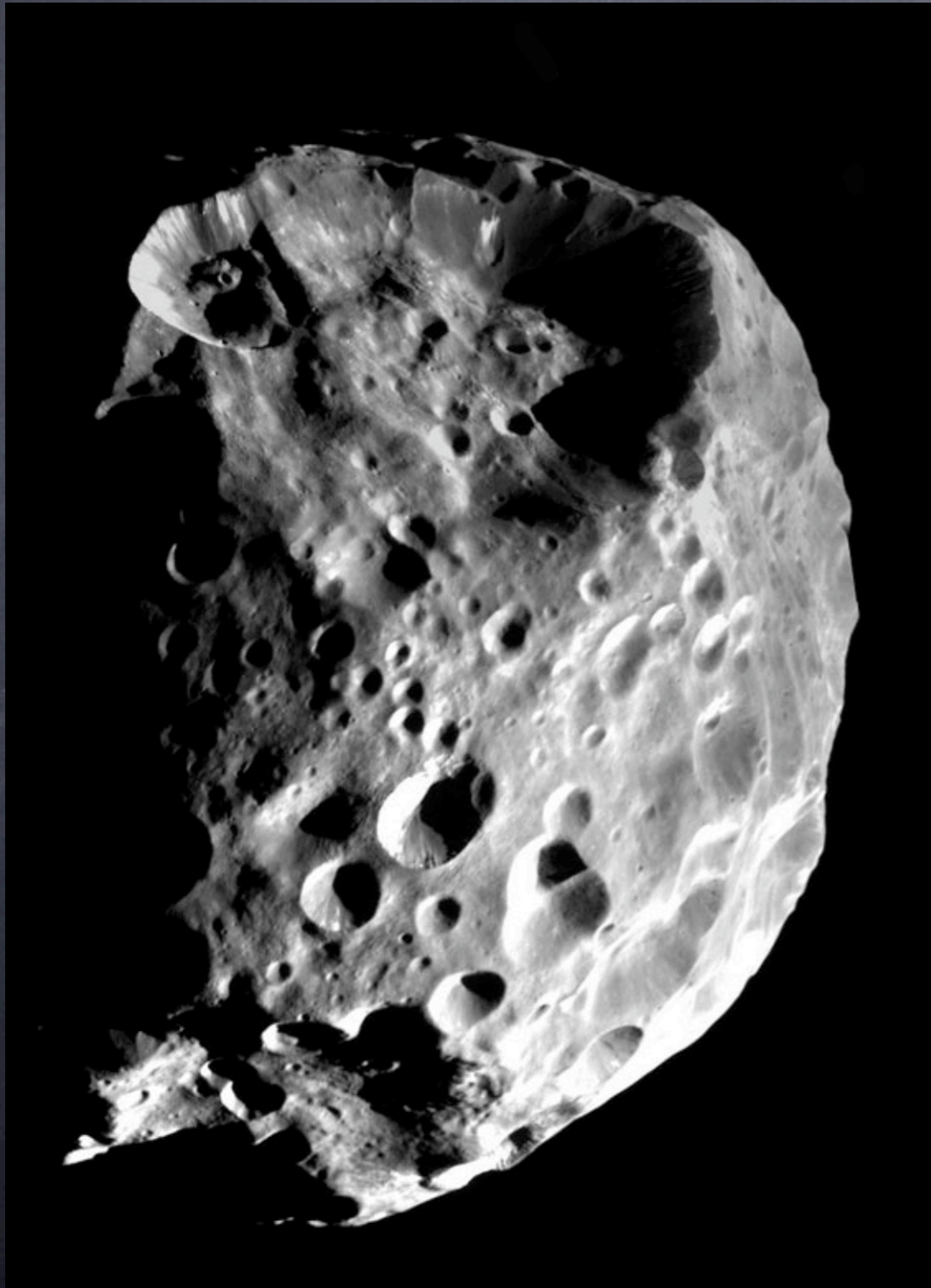
October
15, 1997



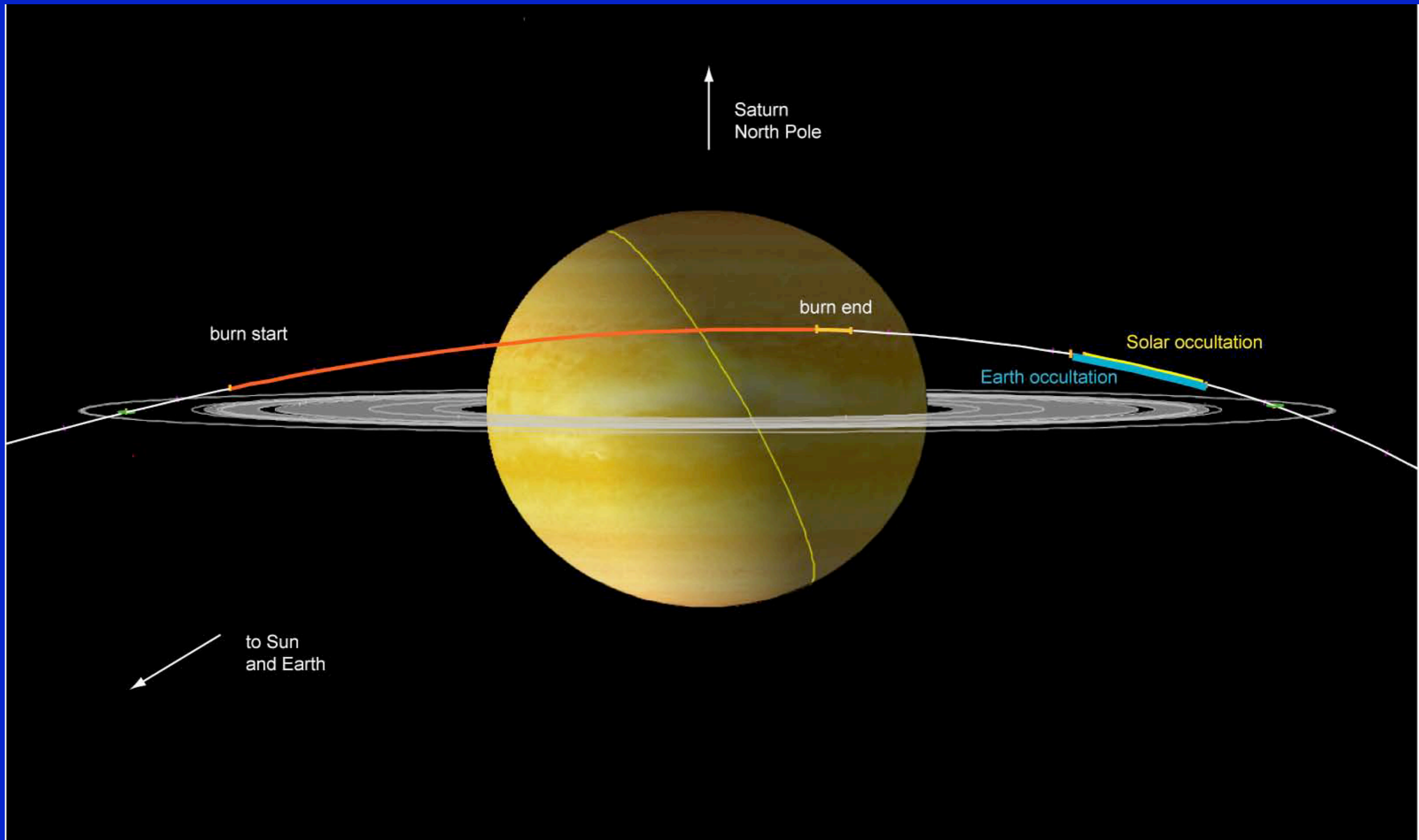
Phoebe

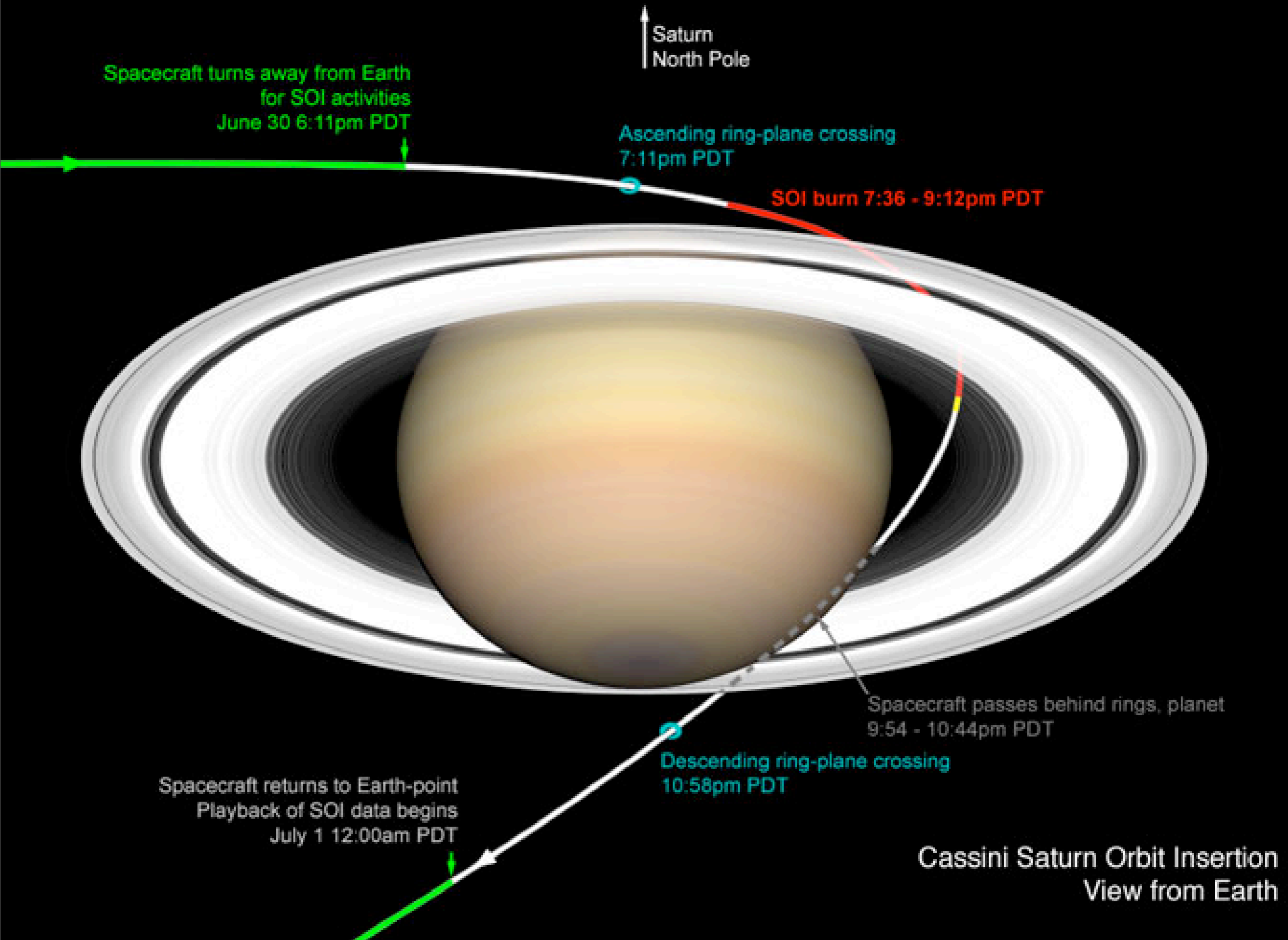


(Best views from Voyager)

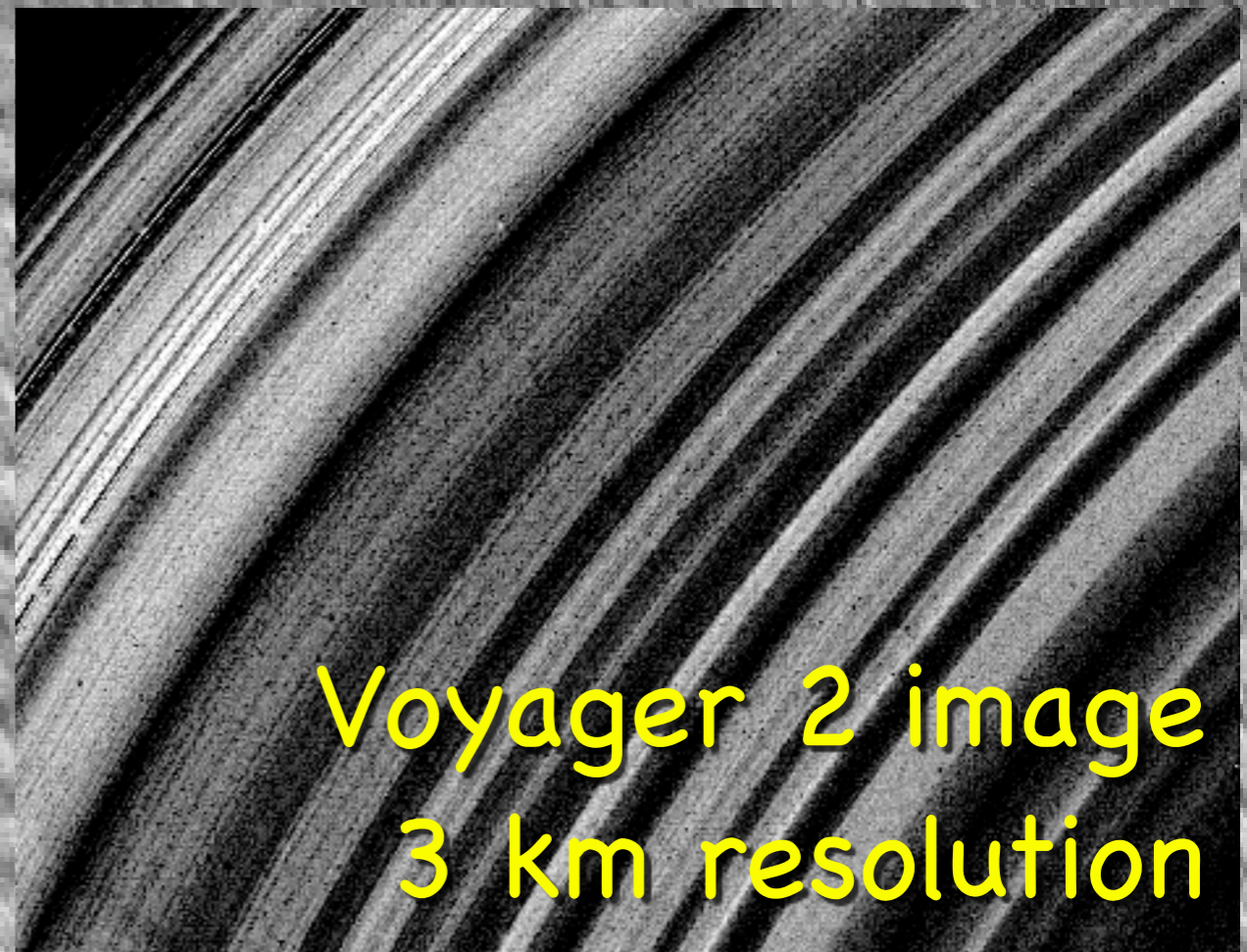


Saturn Orbit Insertion





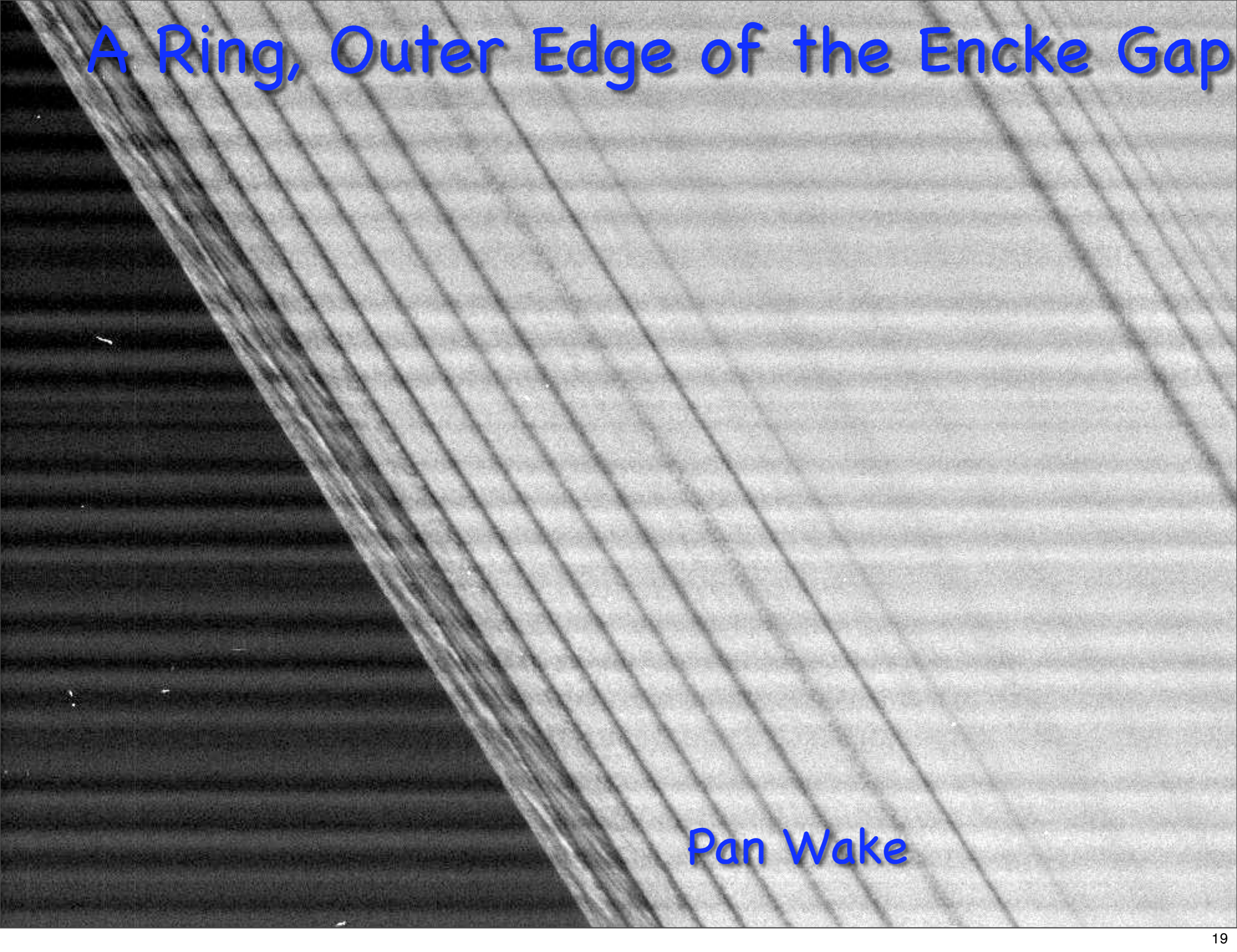
B Ring at 150 meter resolution:
There's structure all the way down!



F Ring at Fine Resolution

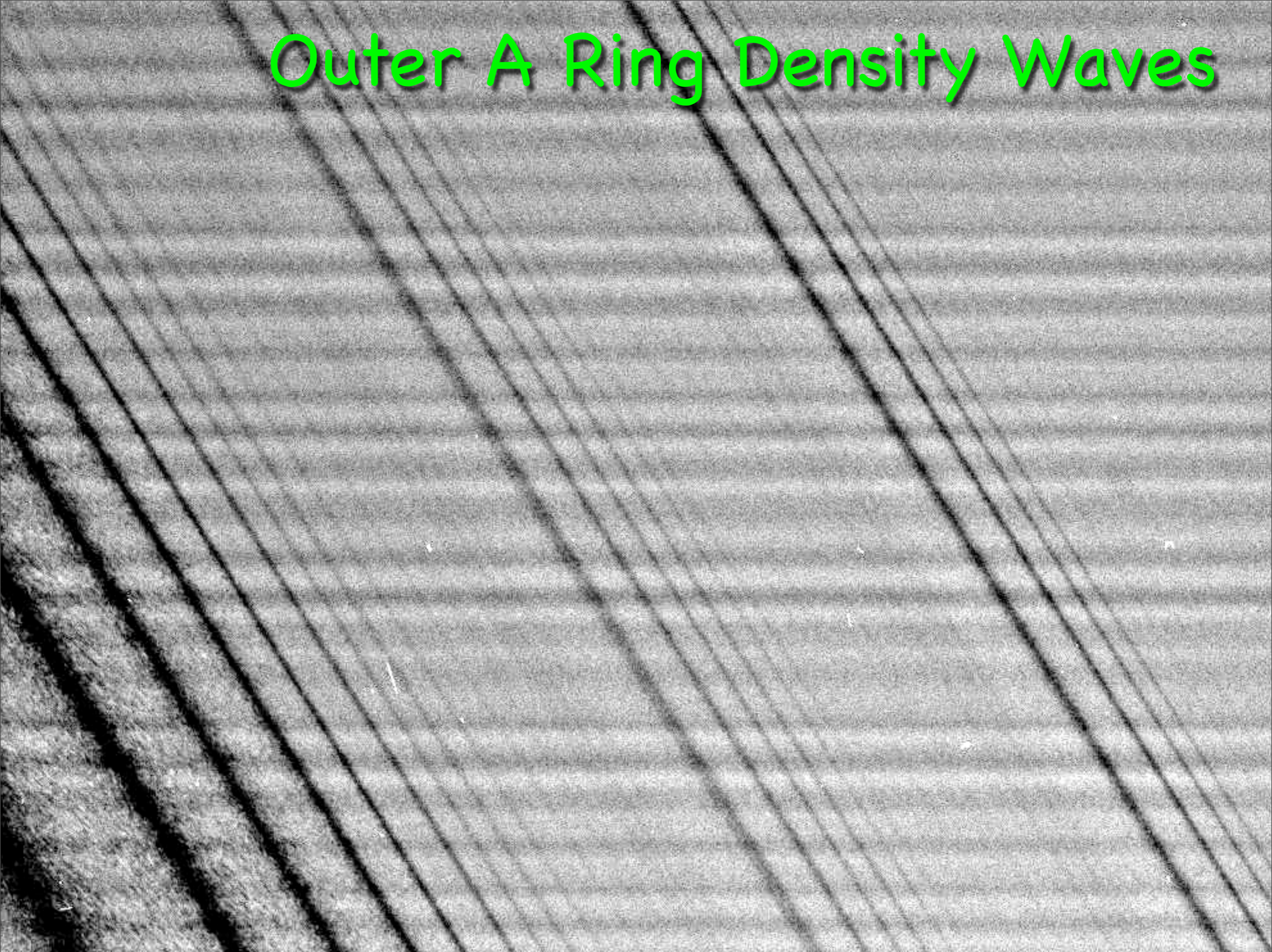


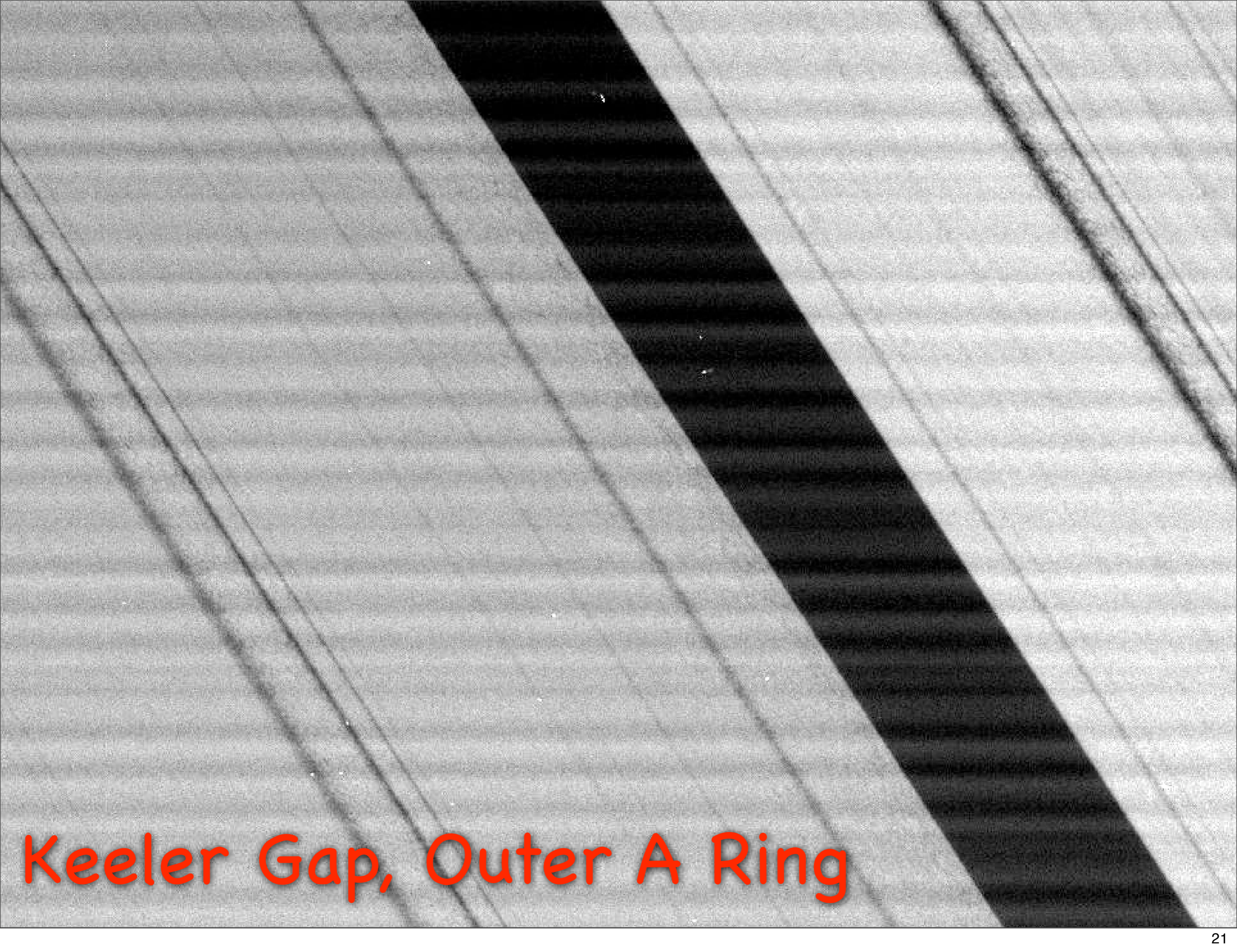
A Ring, Outer Edge of the Encke Gap



Pan Wake

Outer A Ring Density Waves



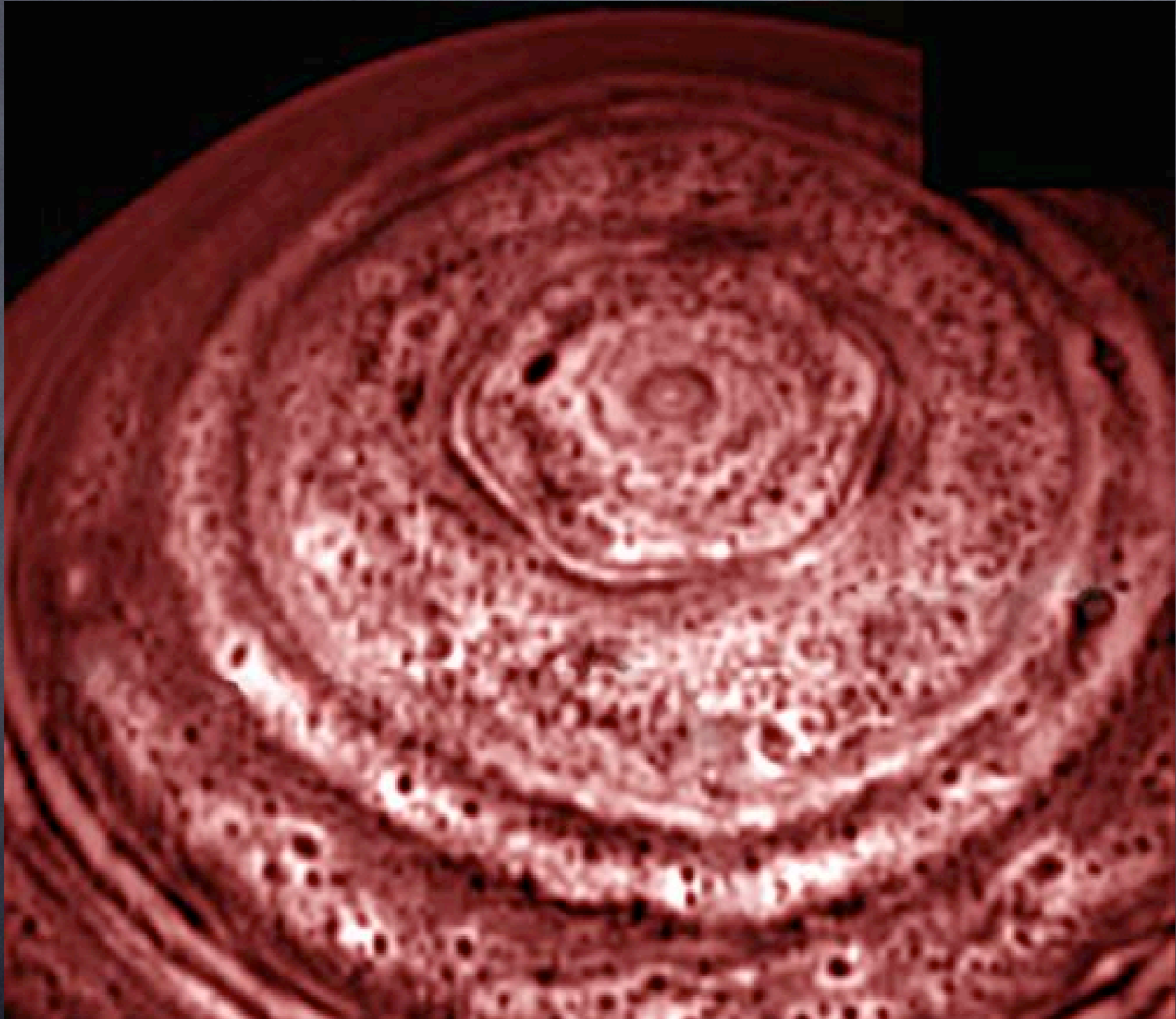


Keeler Gap, Outer A Ring

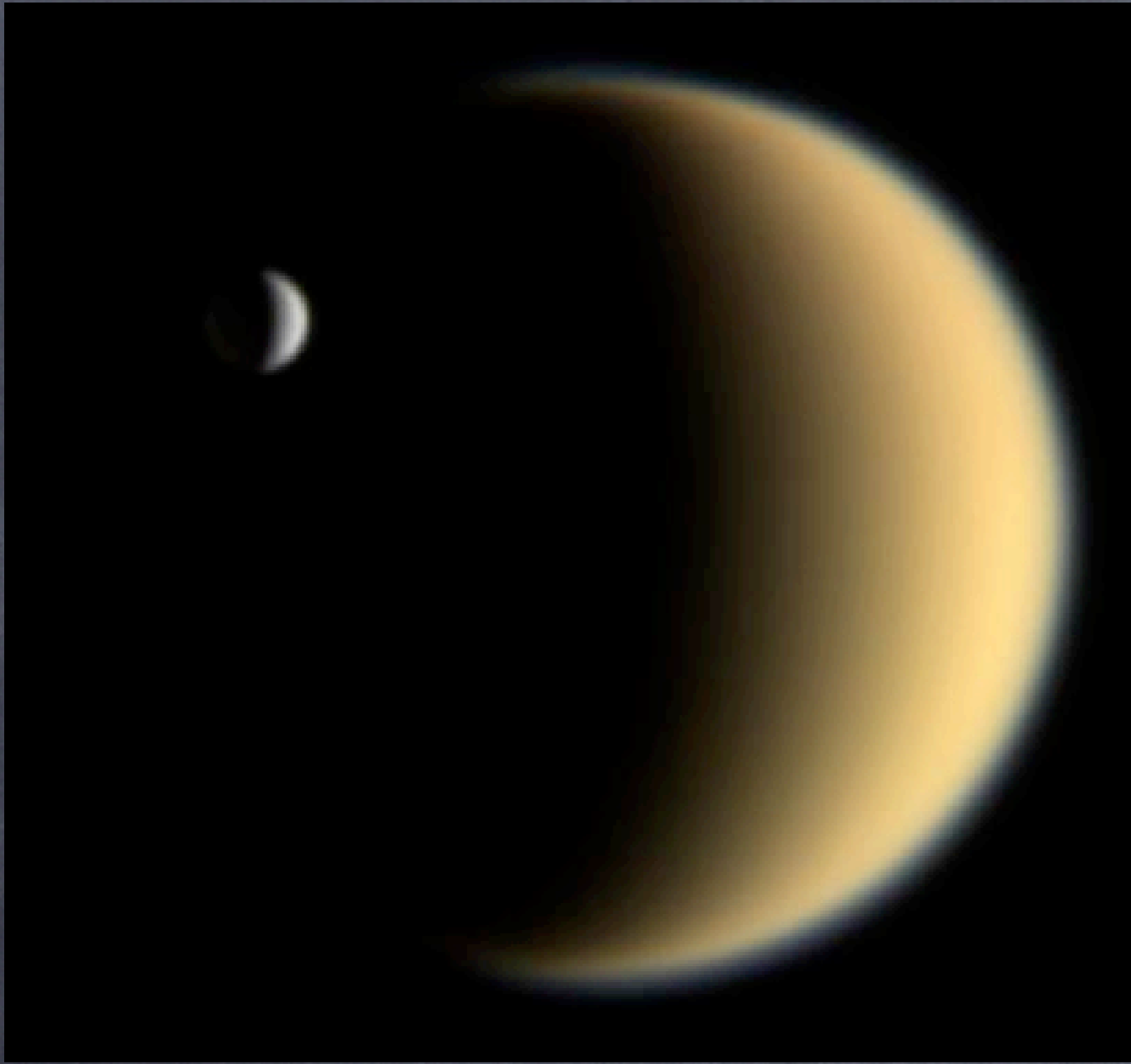
Moons of Saturn



Saturn's North Pole

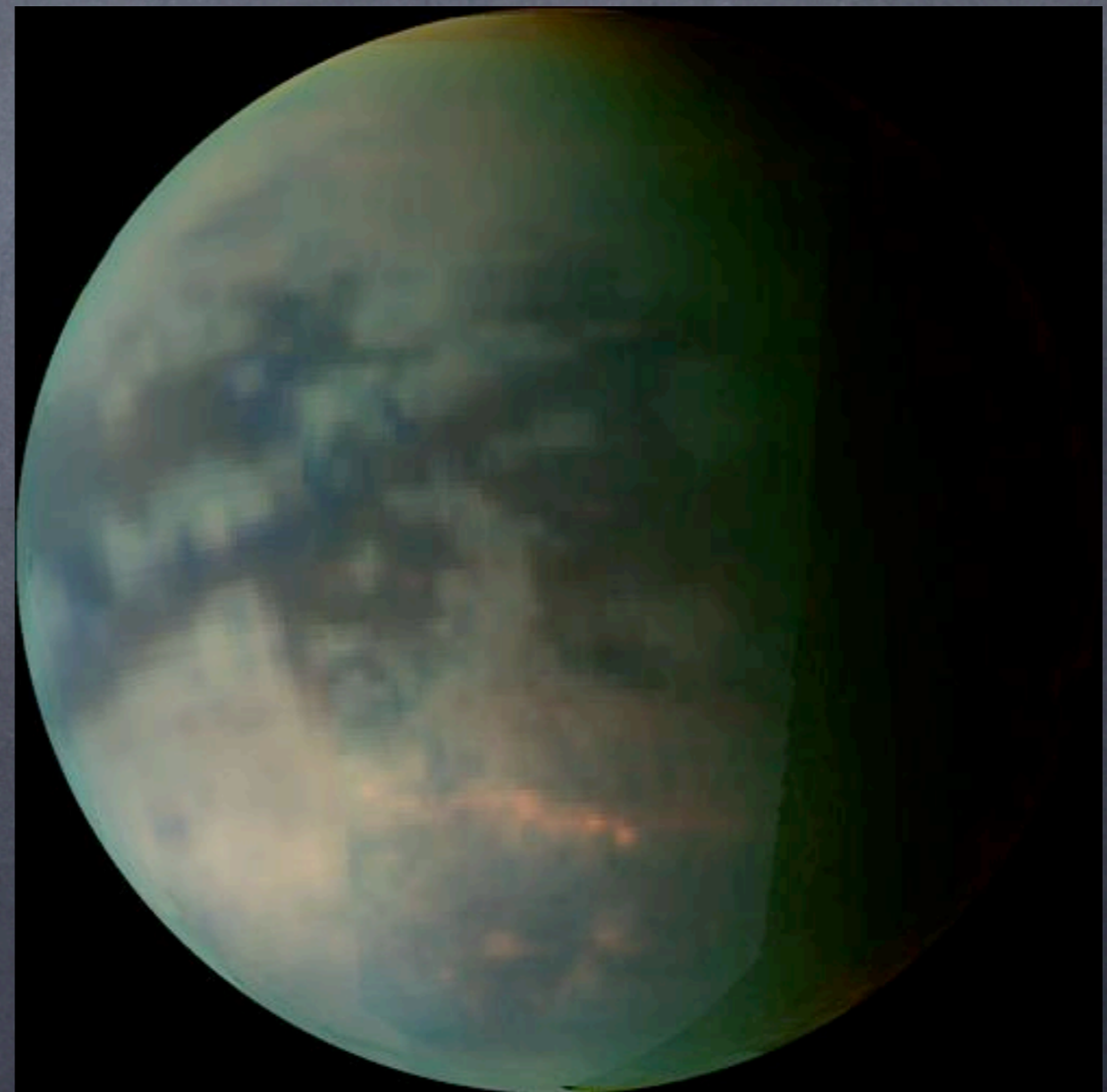


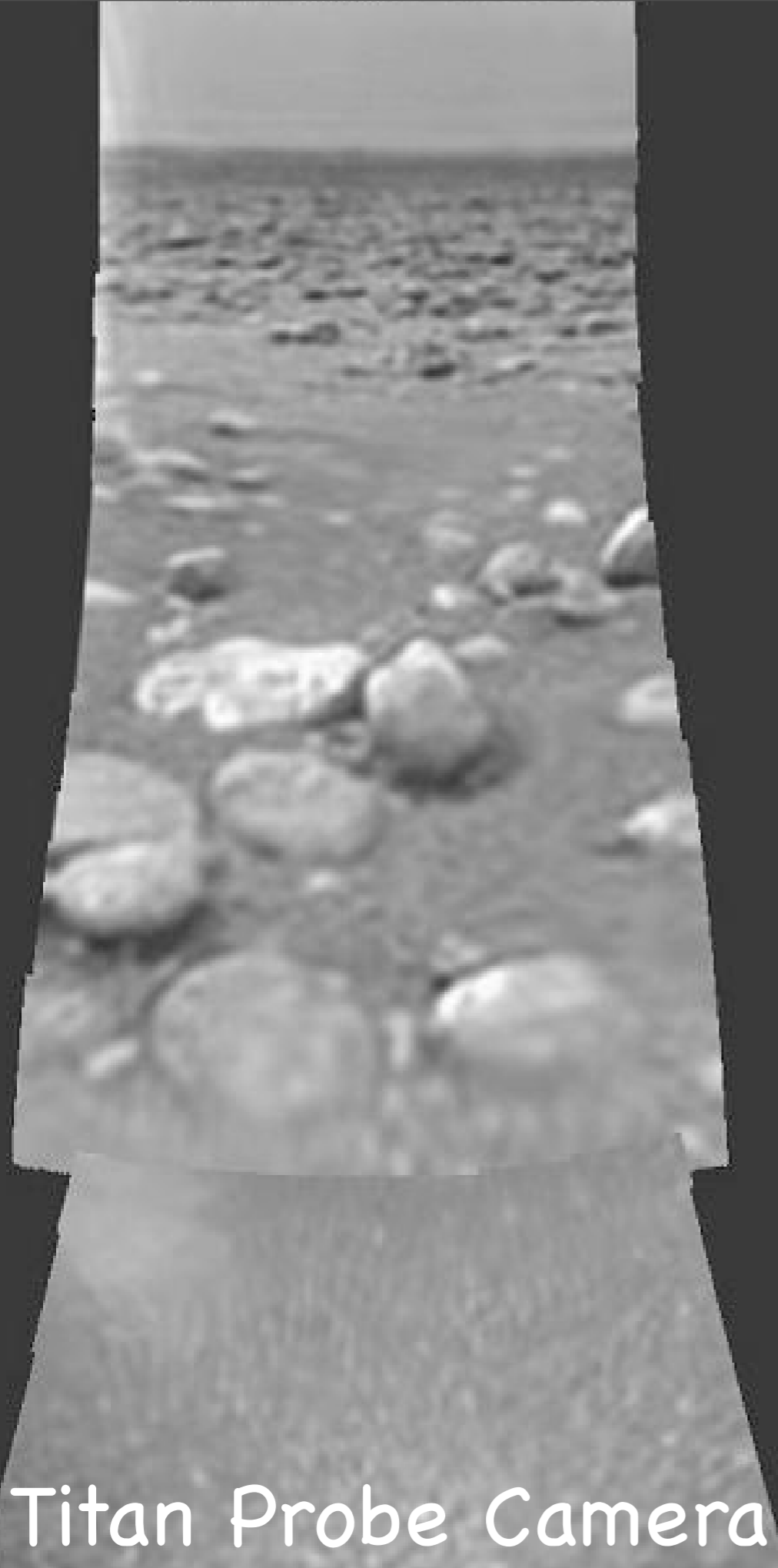
Views of Titan



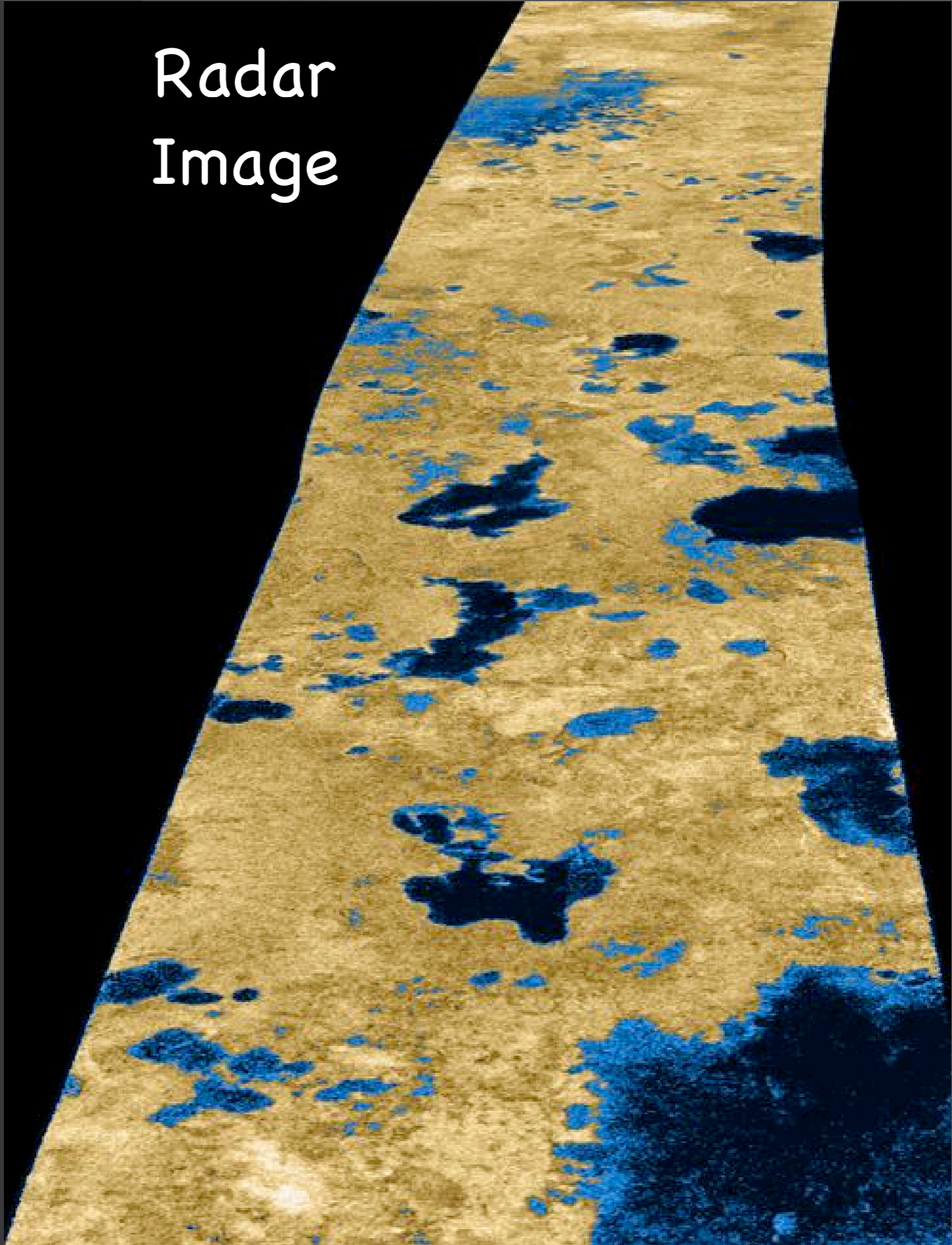
Visual wavelengths

IR wavelengths





Titan Probe Camera



Radar Image

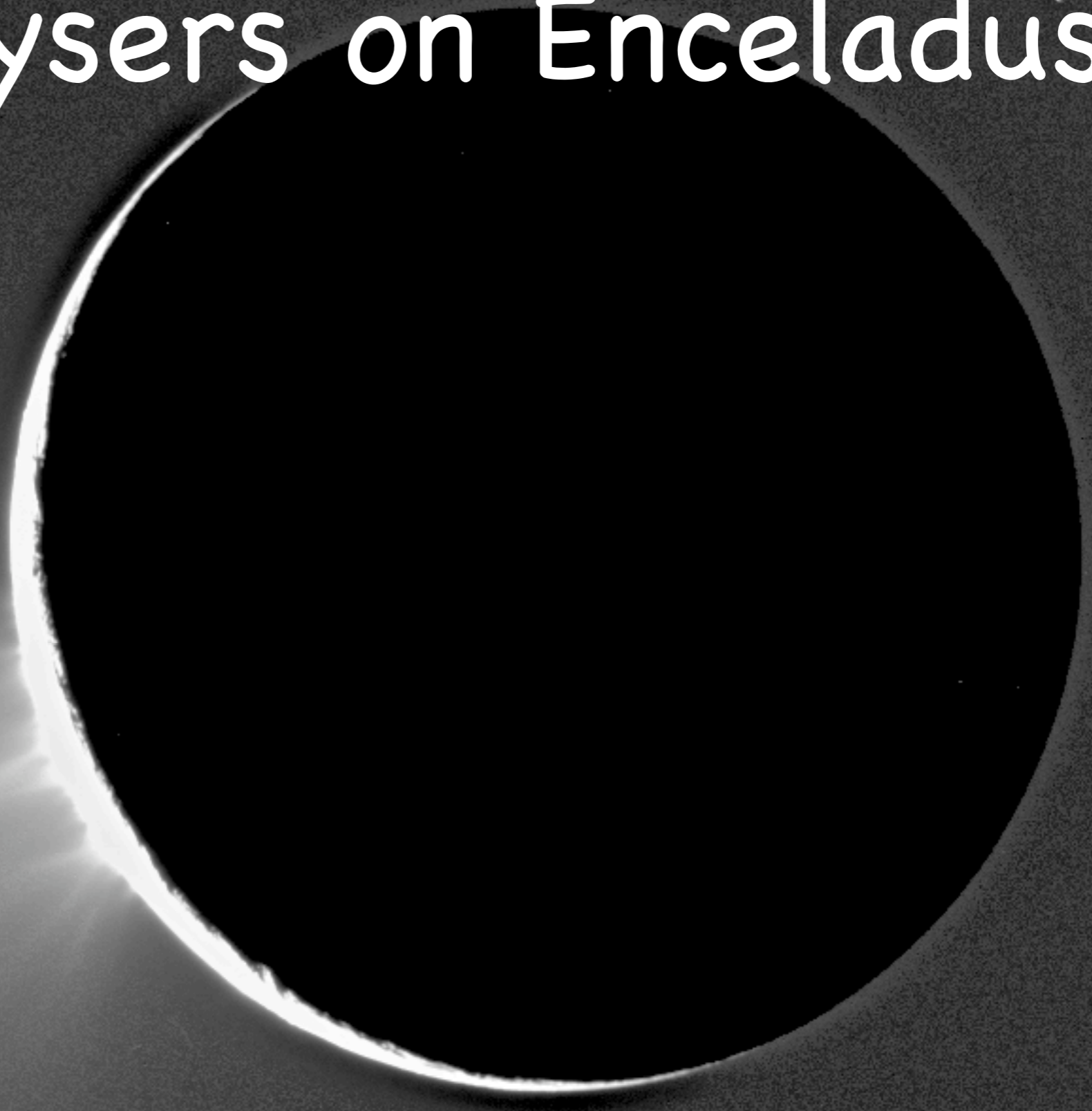
The View from Saturn's Shadow



The View from Saturn's Shadow



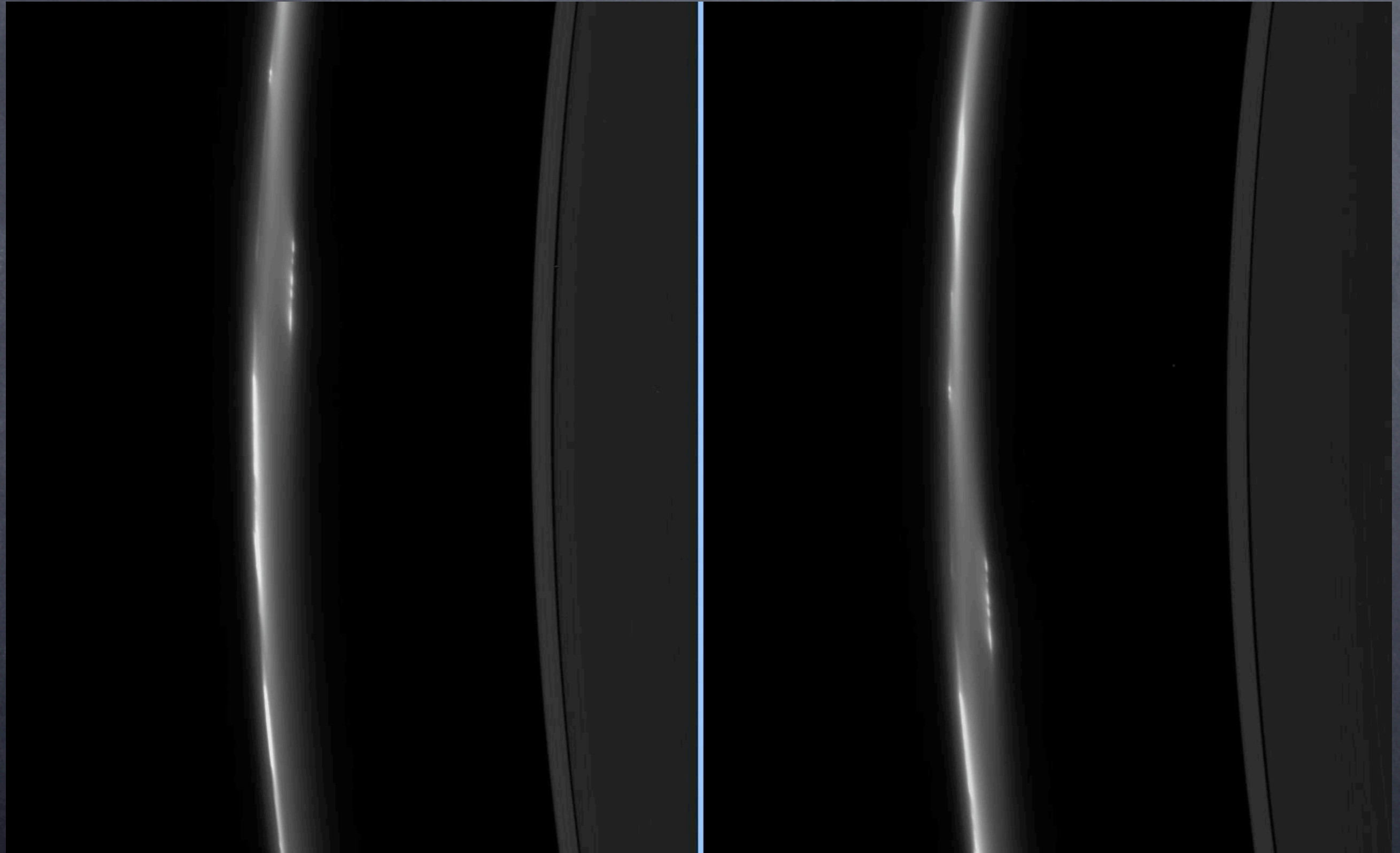
Ice Geysers on Enceladus



The Shadow of Enceladus in the E Ring

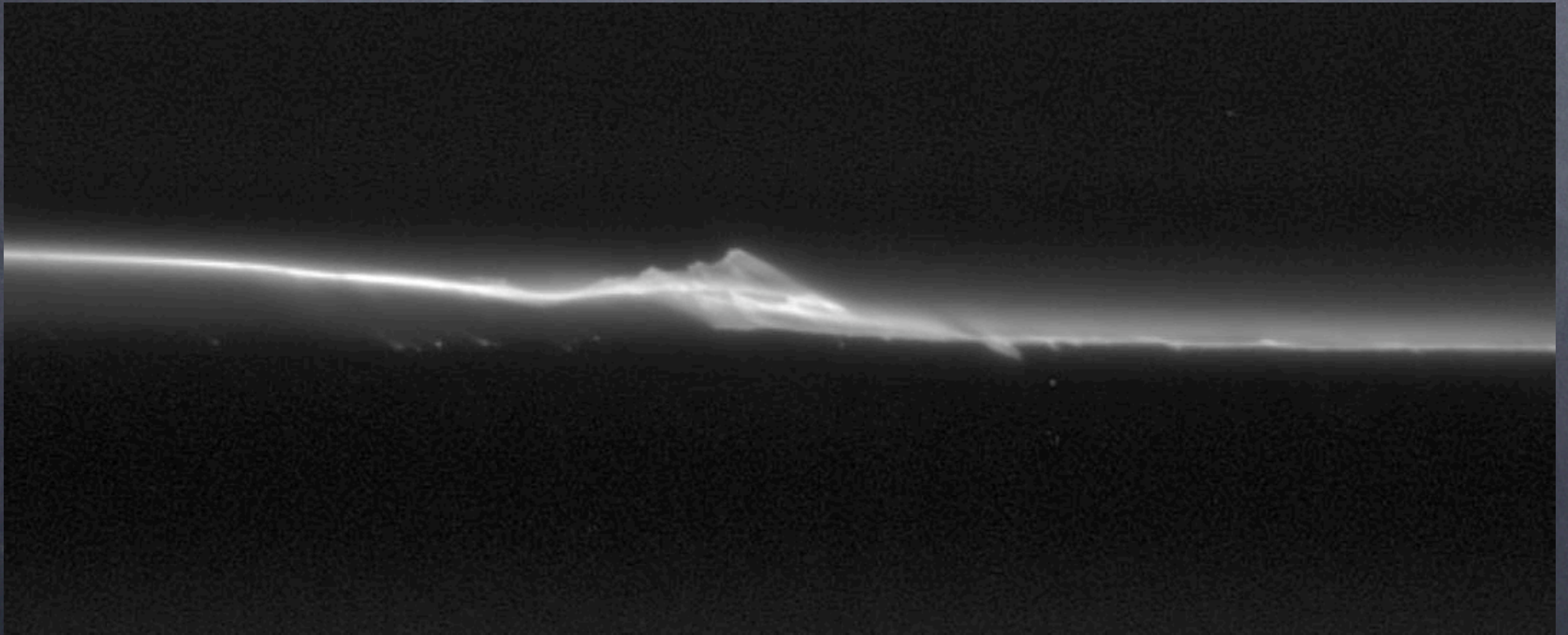


A new feature 200 km inward from the F ring core



What is this ?!?!?

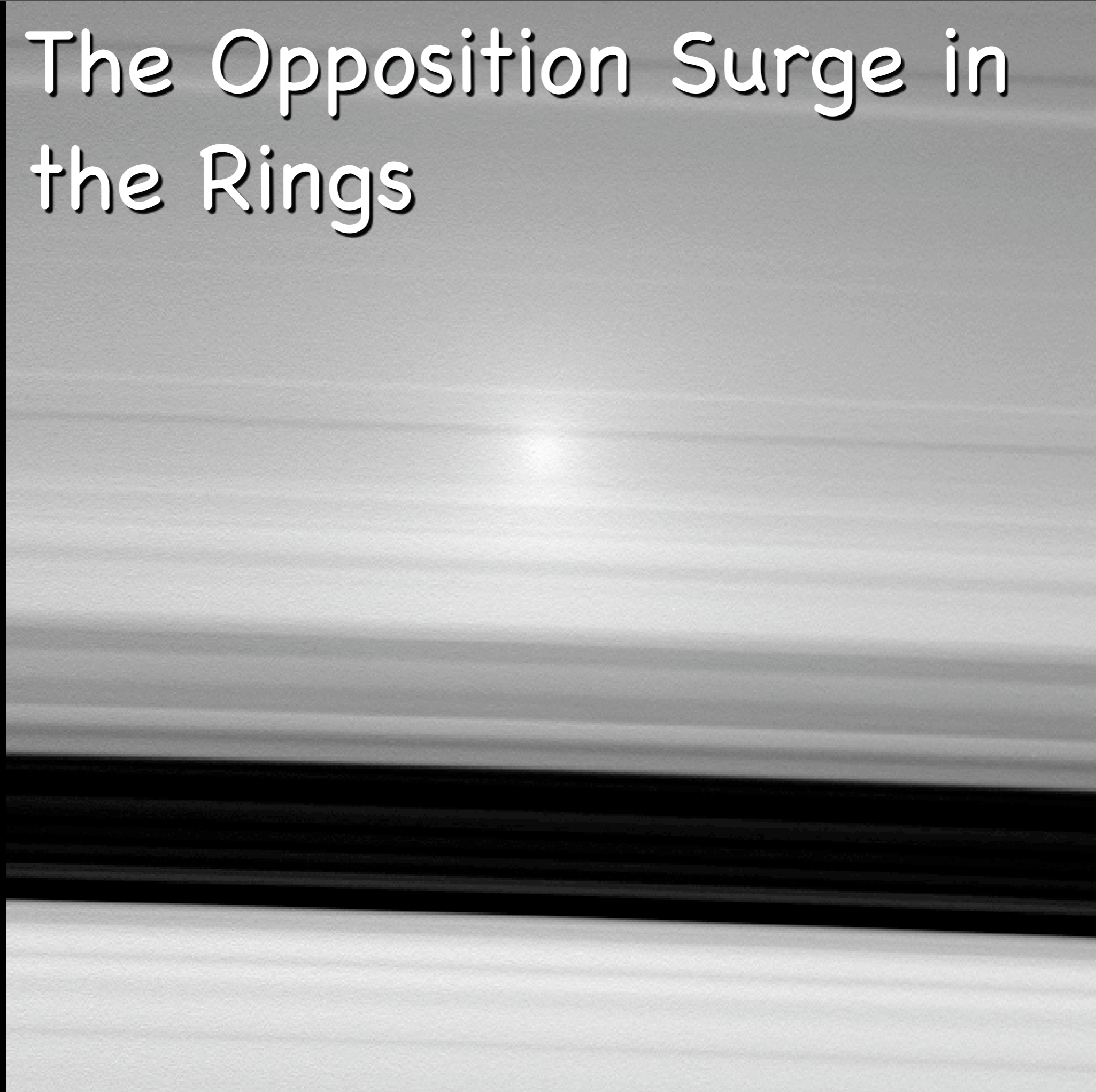
The aftermath of a ring impact?



Spokes in the B Ring

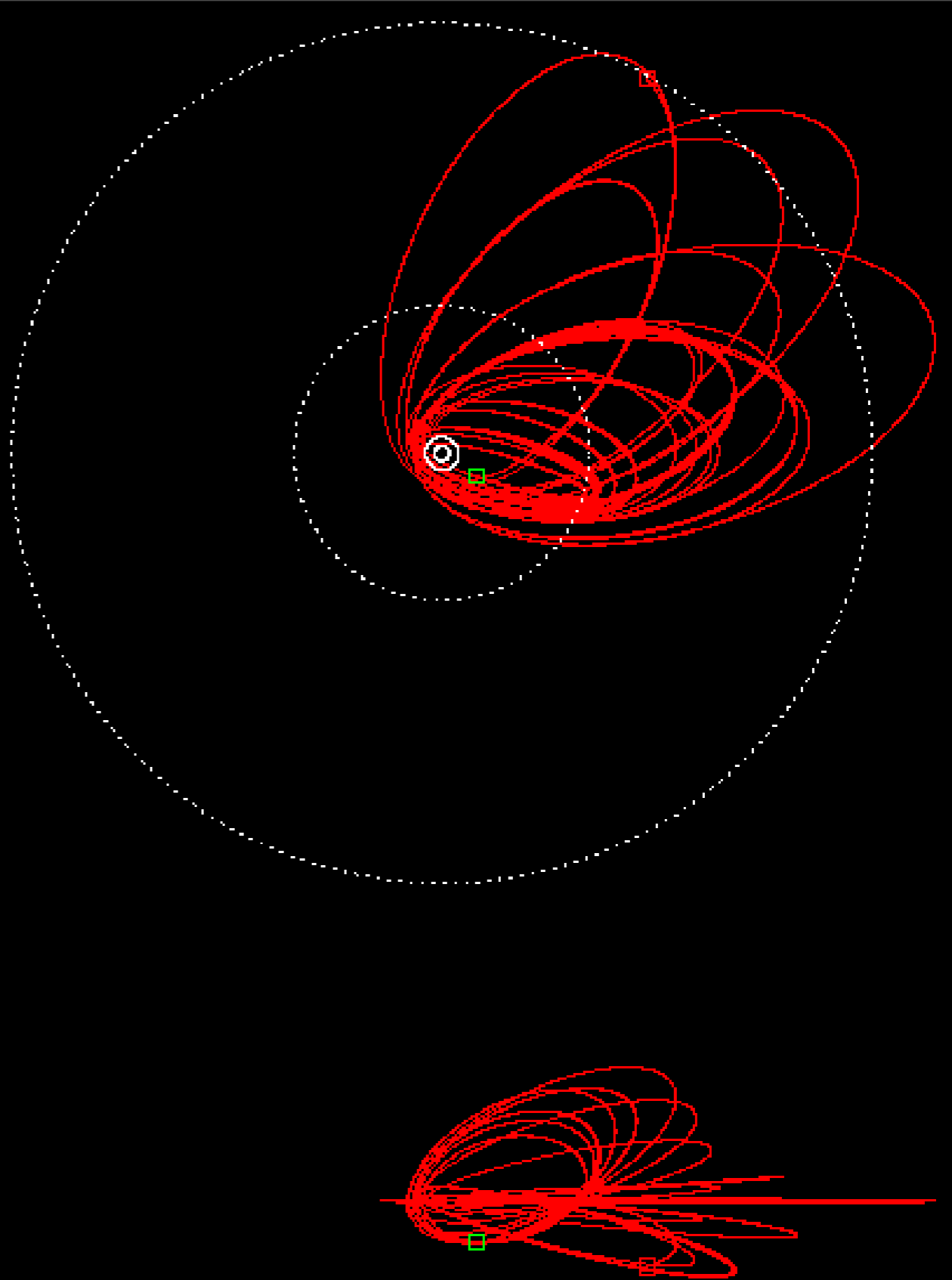


The Opposition Surge in the Rings



Satellite Mutual Event



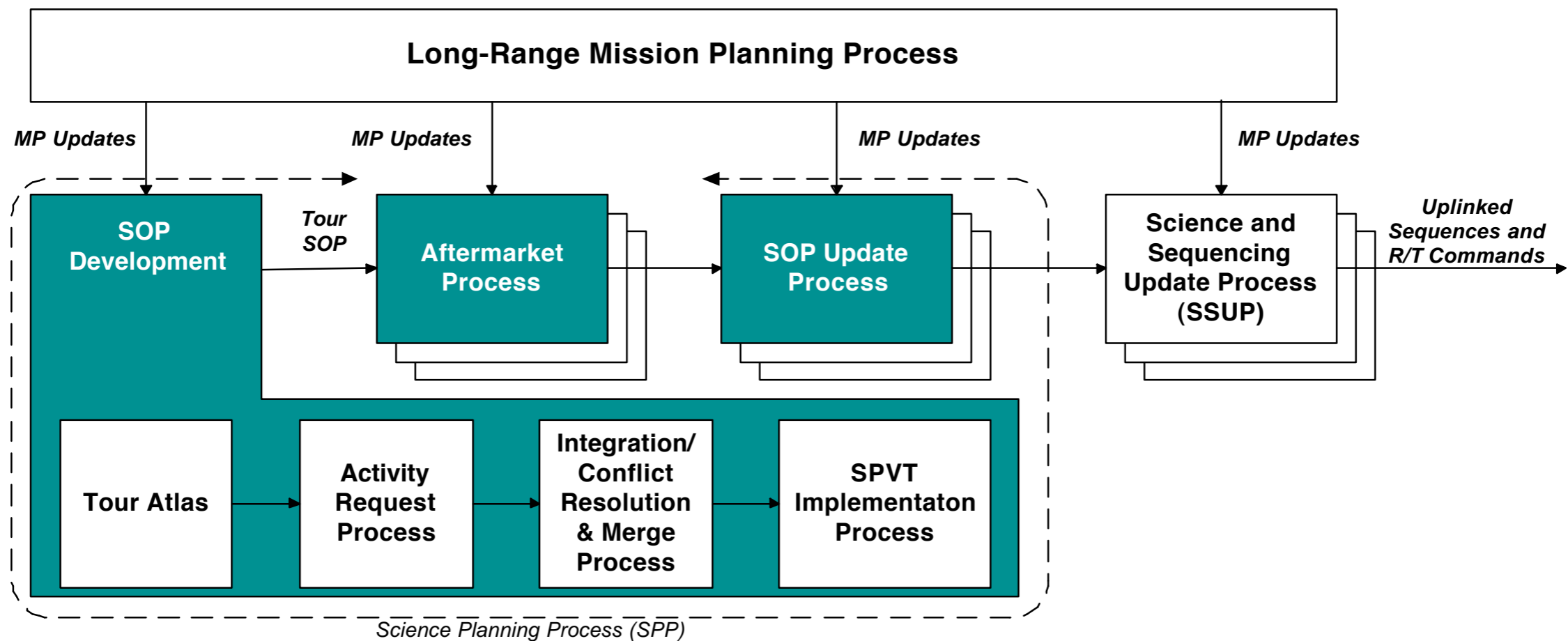


Cassini Extended Mission has been approved by
NASA: 2 more years and probably 4.

What Mission Work is Really Like...



Science Planning Process Context



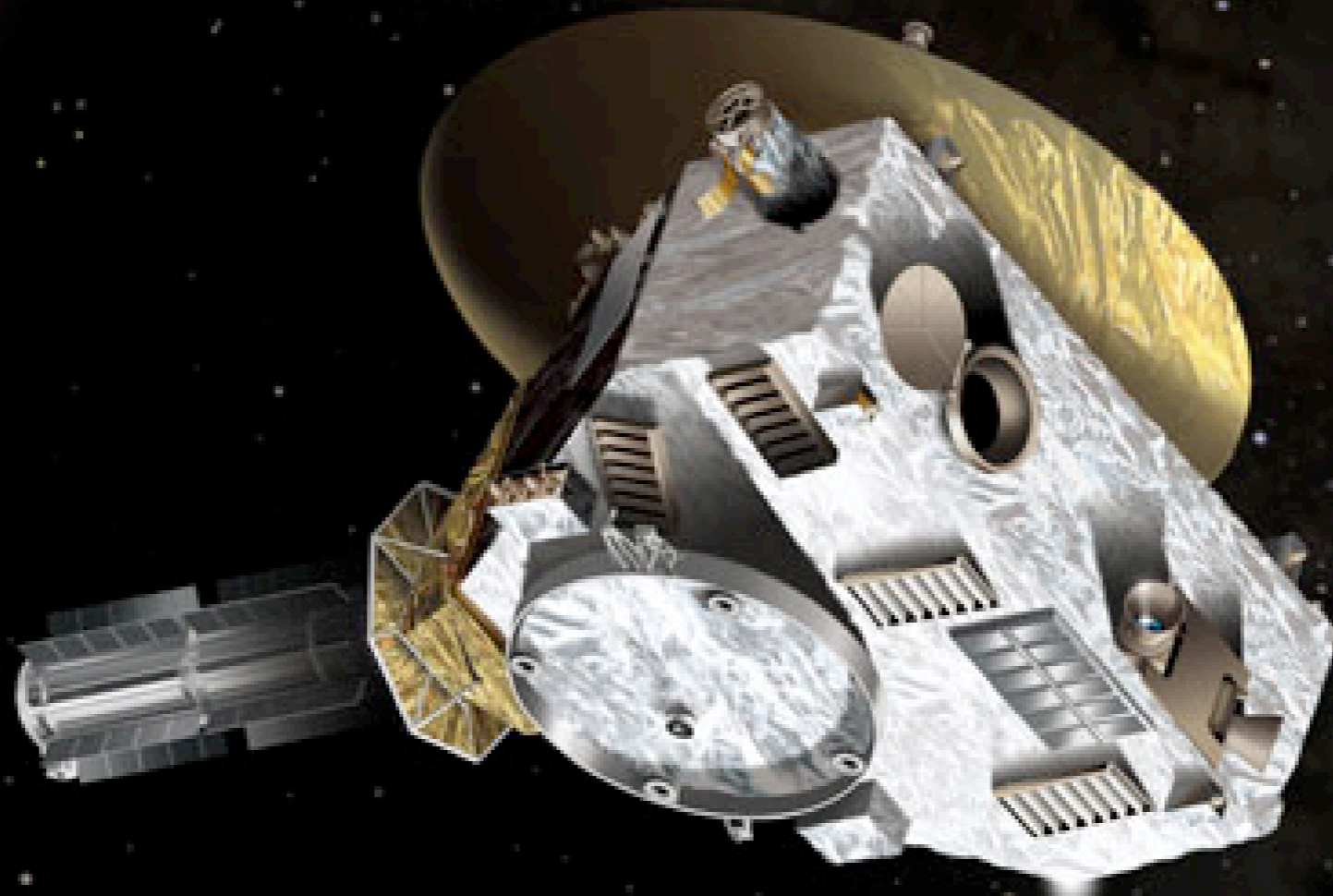
TWT/OST SEGMENT SUMMARY OF TOUR SEQUENCES

8/24/2004

		Days from Sequence Start																								
DET	Start Rev	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	End Rev	End Time (S)
04:00	0	MAG														SOST	MAG						0	2004-171		
05:52:00	0	MAG						SOI	TOST	MAG														0	2004-212T	
03:32:00	0	MAG				SATURN																		0	2004-256T	
03:35:00	0	SATURN																				0	2004-292T			
03:30:00	A	SATURN				TOST	RINGS				MAG								A	2004-320T						
04:49:00	B	MAG										SATURN				TOST	SAT		B	2004-351T						
02:22:00	C	MAG								SOST	MAG								SOST	MAG		C	2005-022T			
03:38:00	3	MAG						SATURN				TOST	SOST	X-Discipline						3	2005-058T					
03:36:00	4	X-Discipline				SOST	X-Discipline										MAG	TOST	X-Discipline				5	2005-099T		
01:15:00	6	XD	RINGS	SAT	TOST	X-Discipline								RINGS	SAT	X-Discipline						7	2005-134T			
05:50:00	8	X-Discipline		RINGS	SAT	X-Discipline								RINGS	SAT	X-Discipline						9	2005-169T			
03:34:00	10	X-Discipline		RINGS	SA	X-Discipline								SA	SOST	SAT	X-Discipline						SAT	12	2005-212T	
00:00:00	12	SOST	SAT	X-Discipline								RINGS	TOST	X-Discipline						13	2005-242T					
04:43:00	14	XD	RINGS	T	X-Discipline								SATURN	S	X-Discipline						15	2005-281T				
05:57:00	16	XD	SOST	X-Discipline								T	SAT	X-Discipline						17	2005-316T					
01:01:00	18	X-Discipline				SOST	X-Discipline										18	2005-351T								
02:21:00	19	X-Discipline		MAG	T	X-Discipline								TOST	SOST	X-Discipline						20	2006-027T			
03:03:00	21	X-Discipline										SAT	TOST	X-Discipline						21	2006-070T					
03:35:00	22	X-Discipline				T	SOST	X-Discipline										22	2006-112T							
01:15:00	23	X-Discipline		SATURN	T	X-Discipline								TOST	SAT	X-Discipline						24	2006-154T			
03:39:00	25	X-Discipline				SATURN	TOST	X-Discipline										25	2006-198T							
01:06:00	26	X-Discipline		TOST	RINGS	X-Discipline								SATURN	27	2006-231T										
01:06:00	27	X-Discipline										TOST	RINGS	SA	MAG	RINGS	X-Discipline				28	2006-263T				
02:22:00	29	XD	TOST	RINGS	X-Discipline								TOST	SA	RINGS	X-Discipline				30	2006-295T					
02:26:00	31	XD	TOST	RINGS	SAT	X-Discipline				RINGS	SAT	X-Discipline				RINGS	33	2006-328T								
03:30:00	33	X-Discipline		RING	SA	RINGS	X-Discipline				T	SA	RINGS	X-Discipline				T	RINGS	XD	36	2007-005T				
05:50:00	37	X-Discipline				TOST	S	RINGS	X-Discipline				TOST	SATURN	X-Discipline				R	39	2007-048T					
05:52:00	39	RINGS		TOST	X-Discipline				SATURN	T	X-Discipline				RINGS	TOST	XD	41	2007-087T							
04:04:00	42	X-Discipline				SATURN	RINGS	TOST	X-Discipline				RINGS	T	X-Discipline				43	2007-124T						
00:00:00	44	XD	RINGS	SAT	T	X-Discipline								SAT	SOST	T	X-Discipline						SAT	46	2007-162T	
01:10:00	46	Rings	T	X-Discipline								SOST	X	TOST	X-Discipline						47	2007-195T				
01:06:00	48	X-Discipline		TOST	SAT	X-Discipline										48	2007-223T									
02:20:00	49	X-Discipline										SOST	TOST	X-Discipline				SOST	X-Discipline				49	2007-265T		
05:51:00	50	X-Discipline				SOST	R	TOST	X-Discipline								RINGS	X-Discipline				51	2007-304T			
04:40:00	52	X-Discipline				SOST	R	TOST	X-Discipline				MAG	RINGS	MAG	TOST	RING	MAG				53	2007-348T			
00:00:00	54	SATURN				TOST	MAG								SATURN	TOST	MAG				RINGS	MAG		56	2008-022T	
03:35:00	57	MAG	RINGS				MAG				SATURN				MAG				58	2008-047T						
05:51:00	59	MAG	SATURN	TOST	SATURN	RINGS	MAG				RINGS	S	RINGS						61	2008-083T						
05:50:00	62	RING	TOST	SATURN				RINGS								SATURN				64	2008-110T					
01:18:00	65	RINGS								SATURN				RINGS	TOST	RINGS	SATURN						TOST	R	70	2008-152T
02:27:00	70	R	MAG	RINGS	MAG	RINGS	SATURN				MAG	SATURN	MAG	?	74	2008-187T										

New Horizons at Jupiter

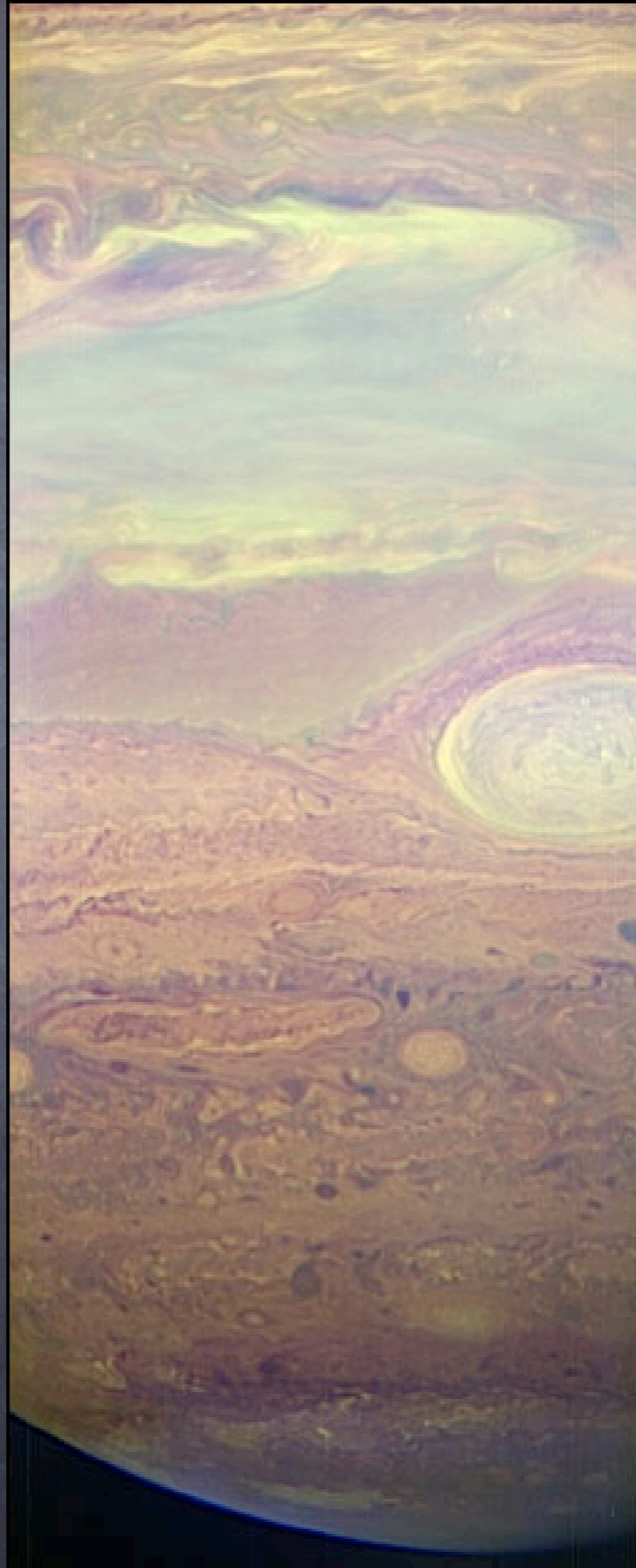
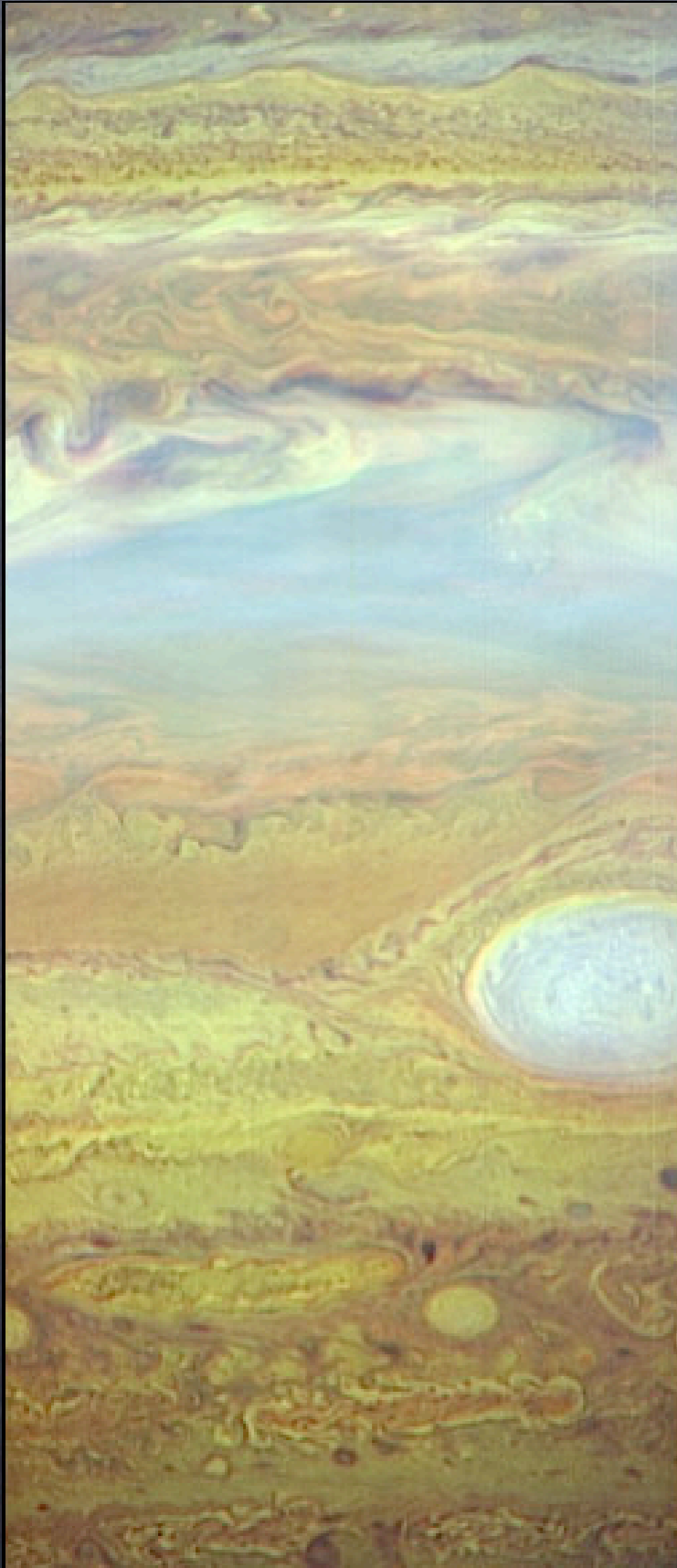
February 28, 2007



<http://pluto.jhuapl.edu/>

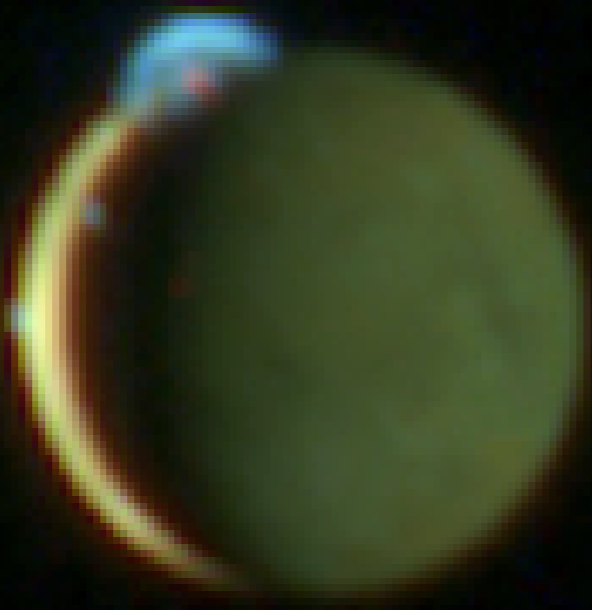
Jupiter's Storms

February 27,
2007



False Color from
IR images
 $1.25-2.5 \mu\text{m}$

Low-Resolution Color Imaging



Io & Europa Together
March 2, 2007

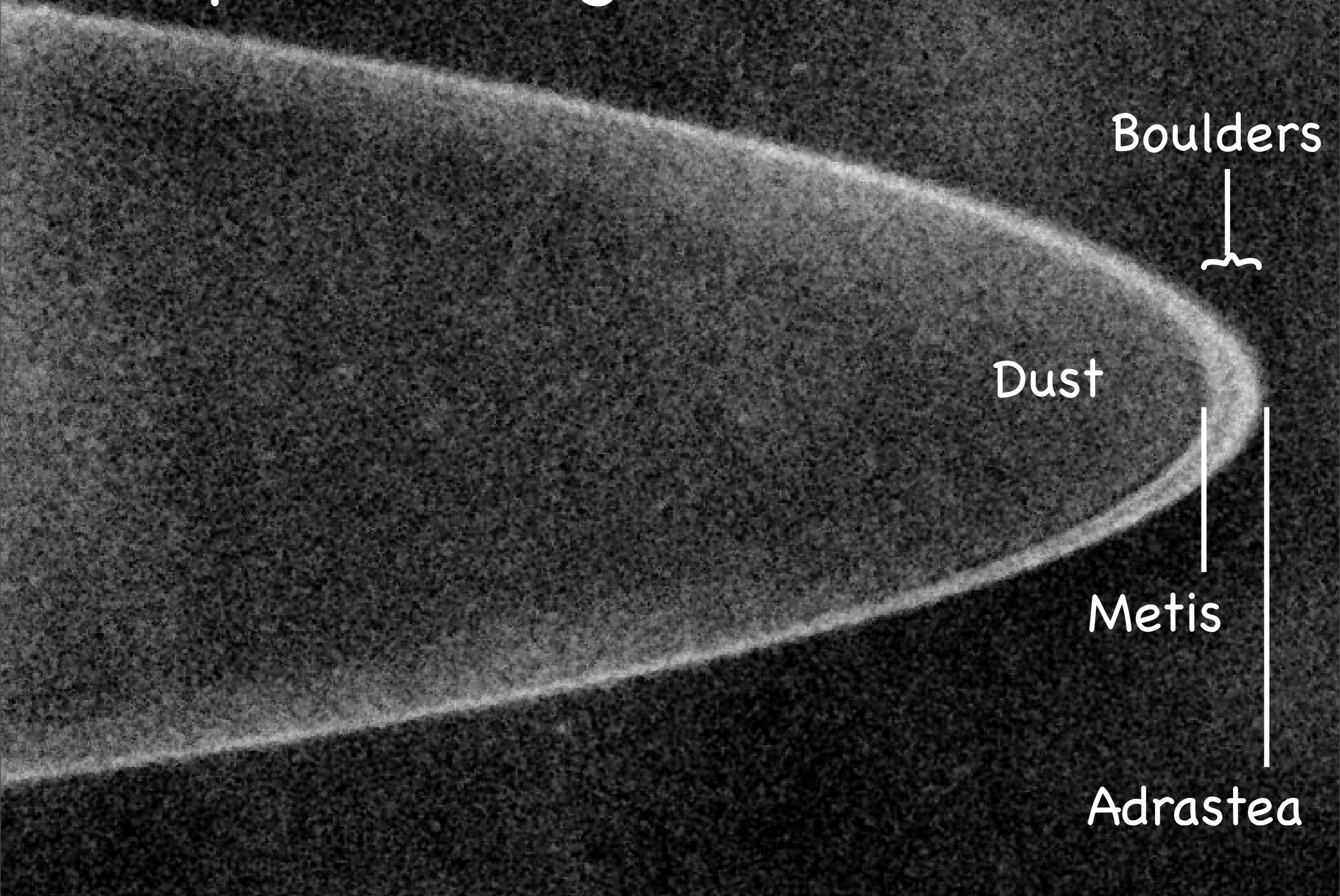
Active volcano on Io



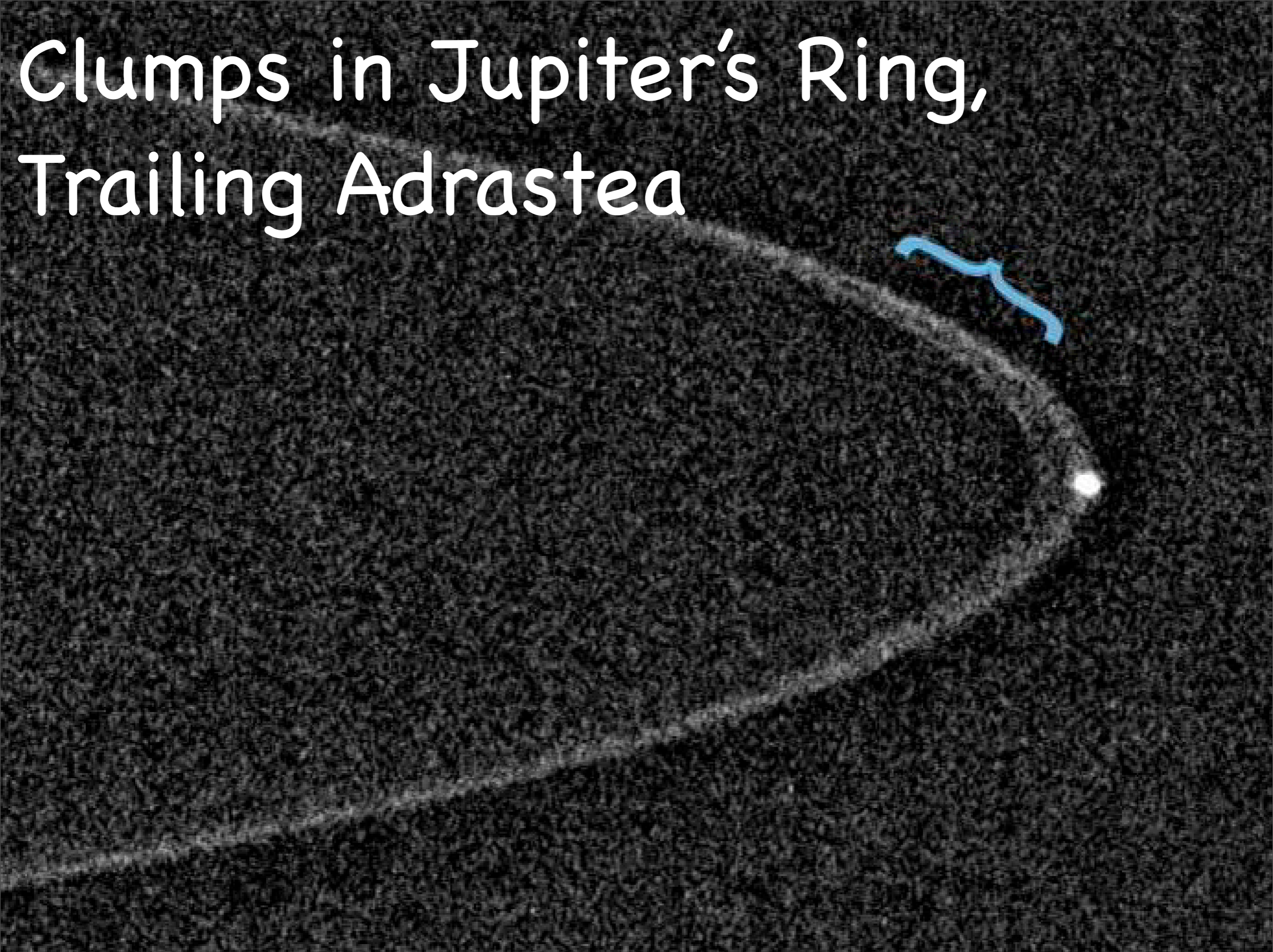
Active volcano on Io



Jupiter's Rings in backscatter



Clumps in Jupiter's Ring, Trailing Adrastea



Backscatter

Forward-Scatter

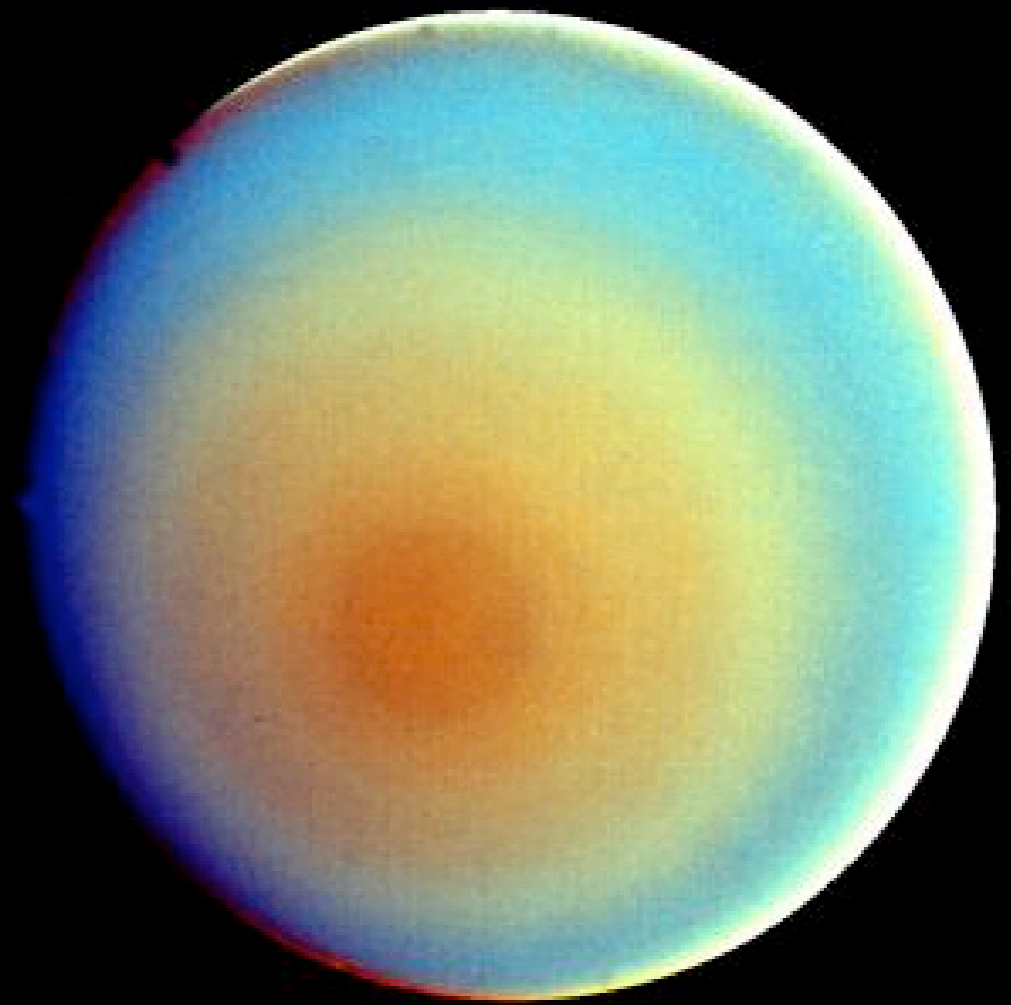
Dust

Uranus

Voyager Images, January 1986



True color



Enhanced color

<http://photojournal.jpl.nasa.gov/>

Uranian Rings

in back-scattered light

epsilon

lambda

delta

gamma

eta

beta

alpha

4

5

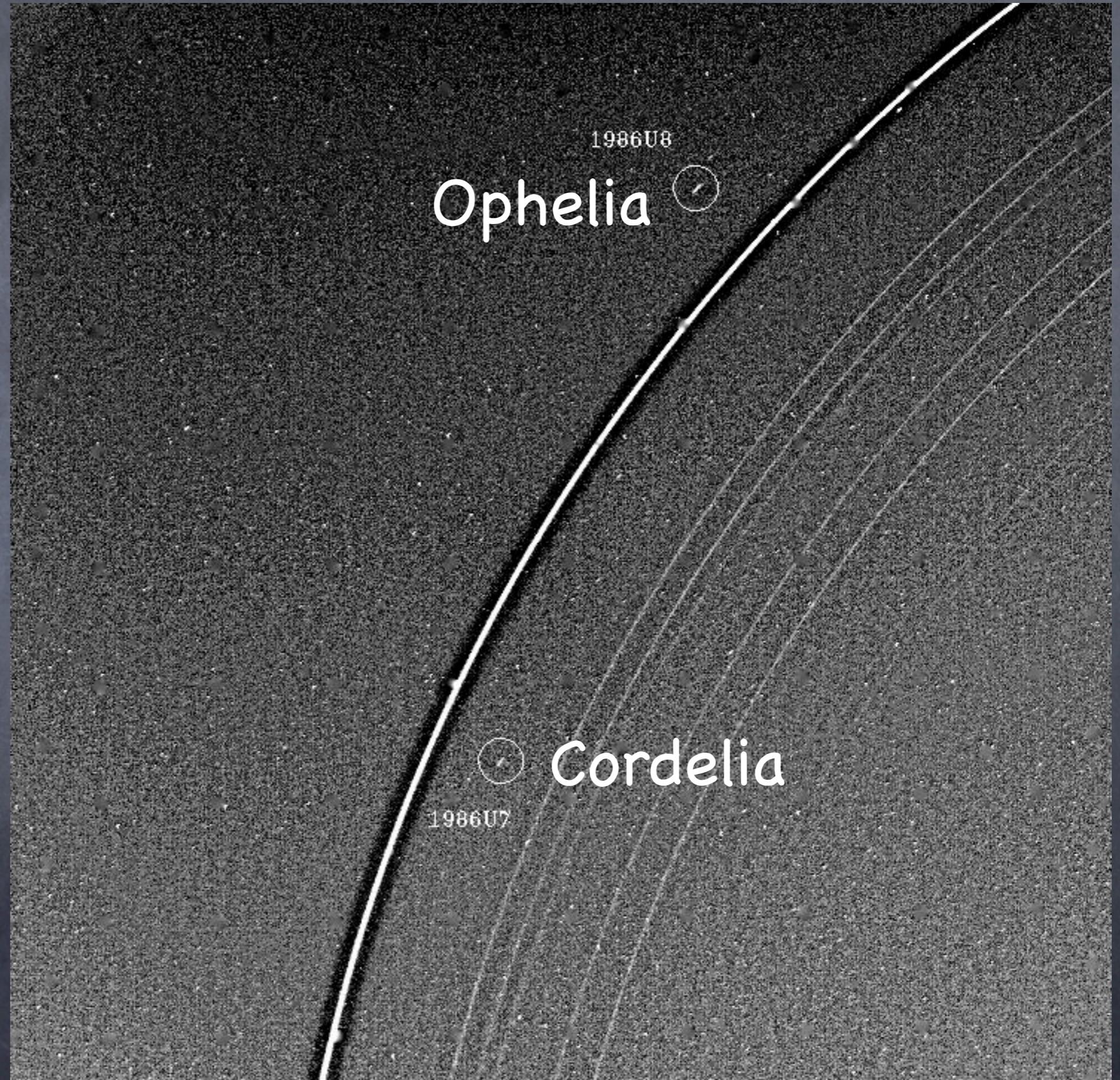
6



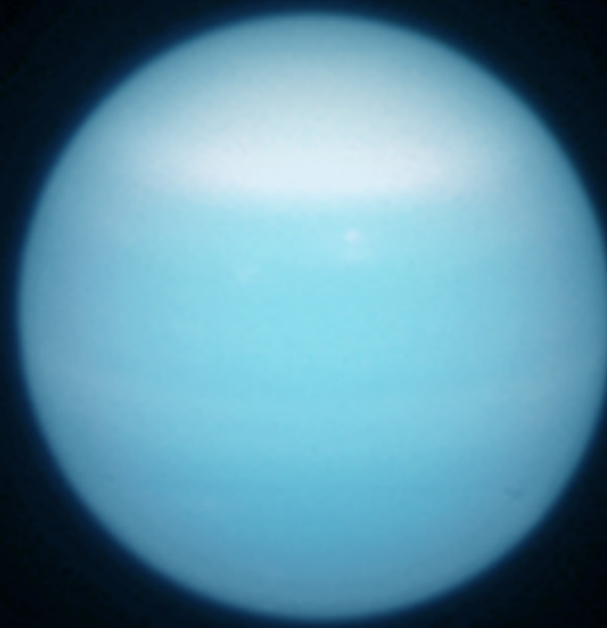


Uranian dust belts
in forward-scattered light

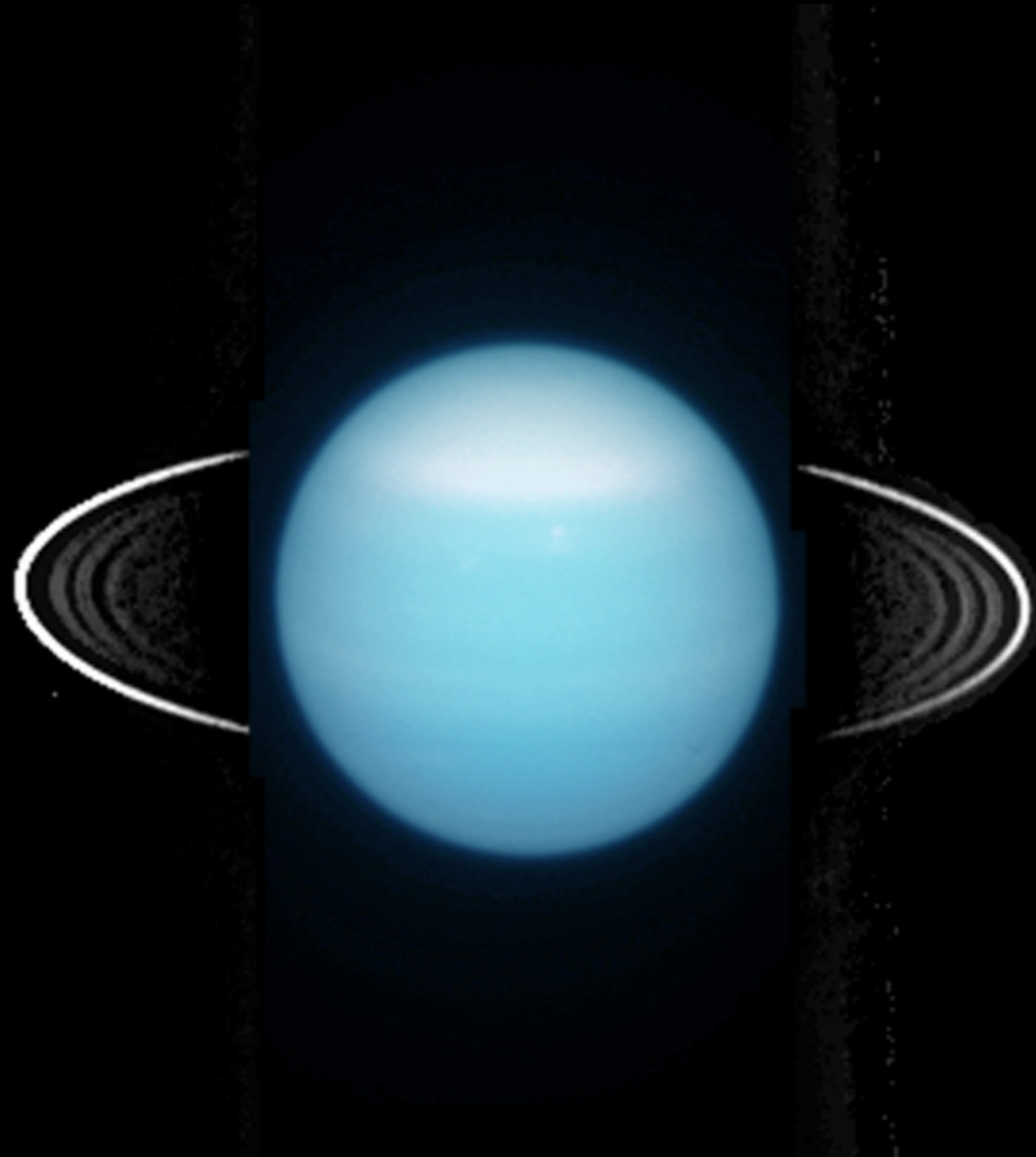
Two small
moons
"shepherd"
the ϵ ring



Uranus: August 2003

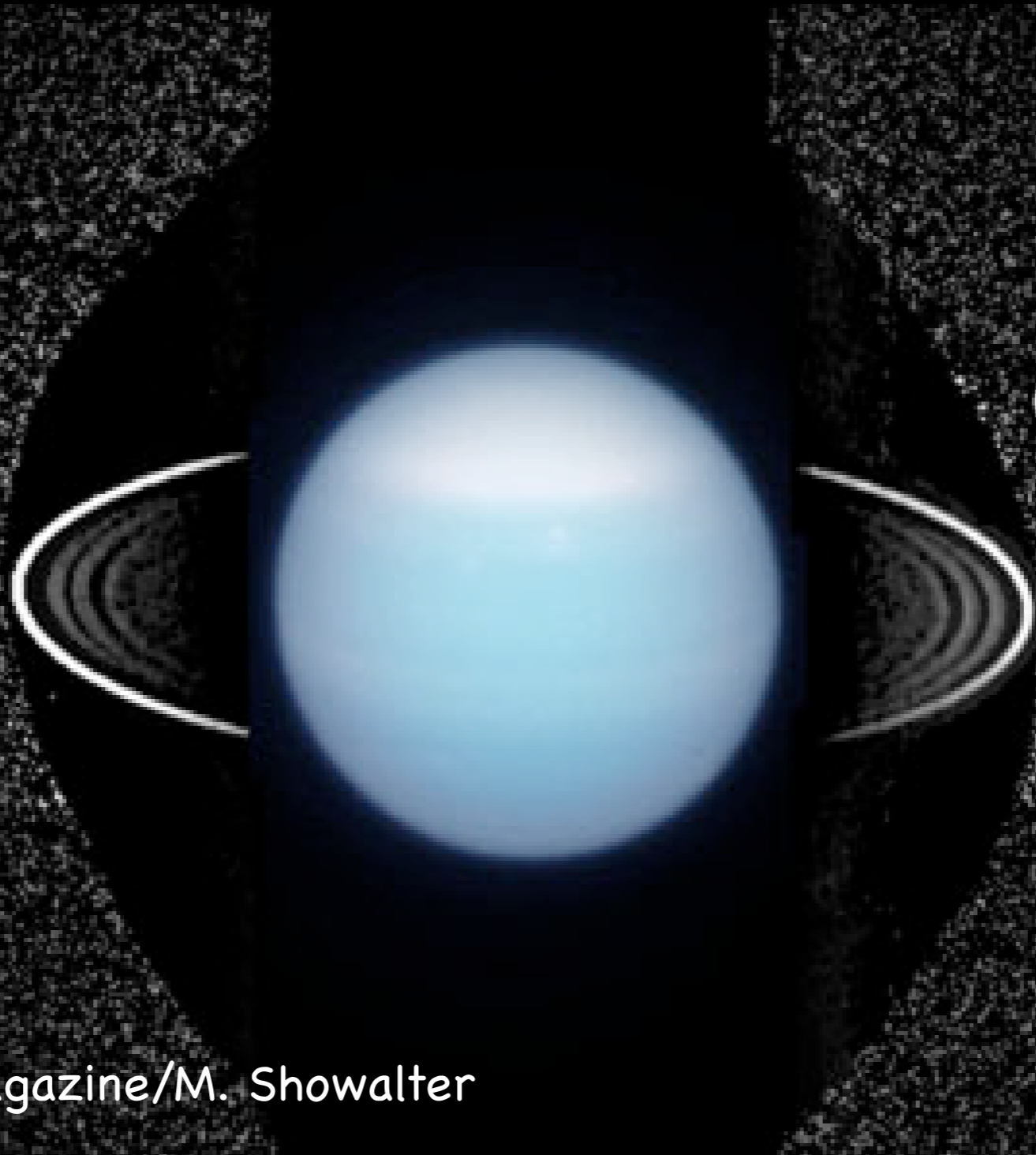
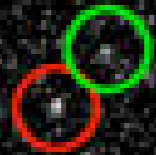


Uranus: August 2003



- Recovery of "Perdita"
- Discovery of "Cupid"

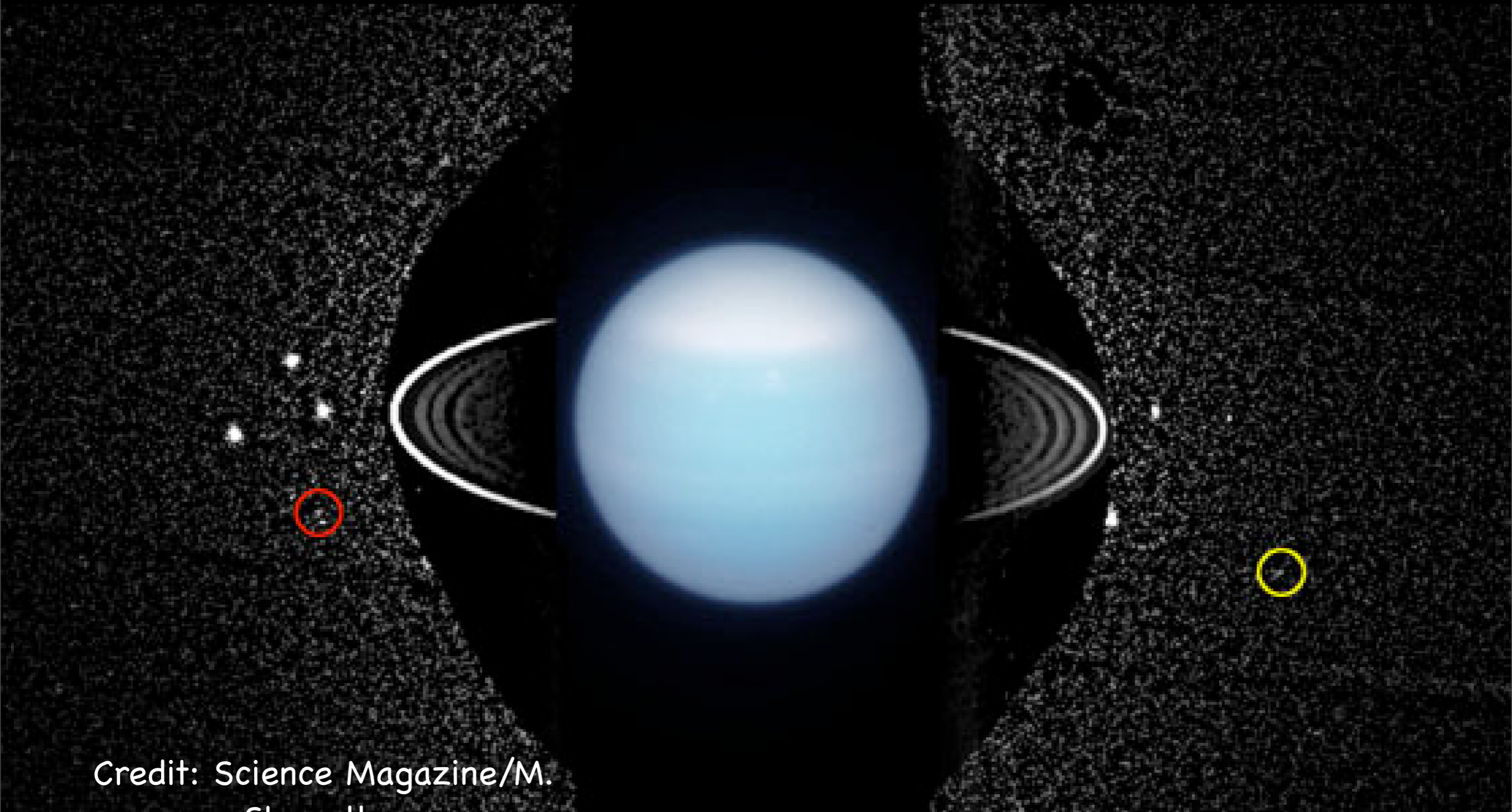
Orbit 1



Credit: Science Magazine/M. Showalter

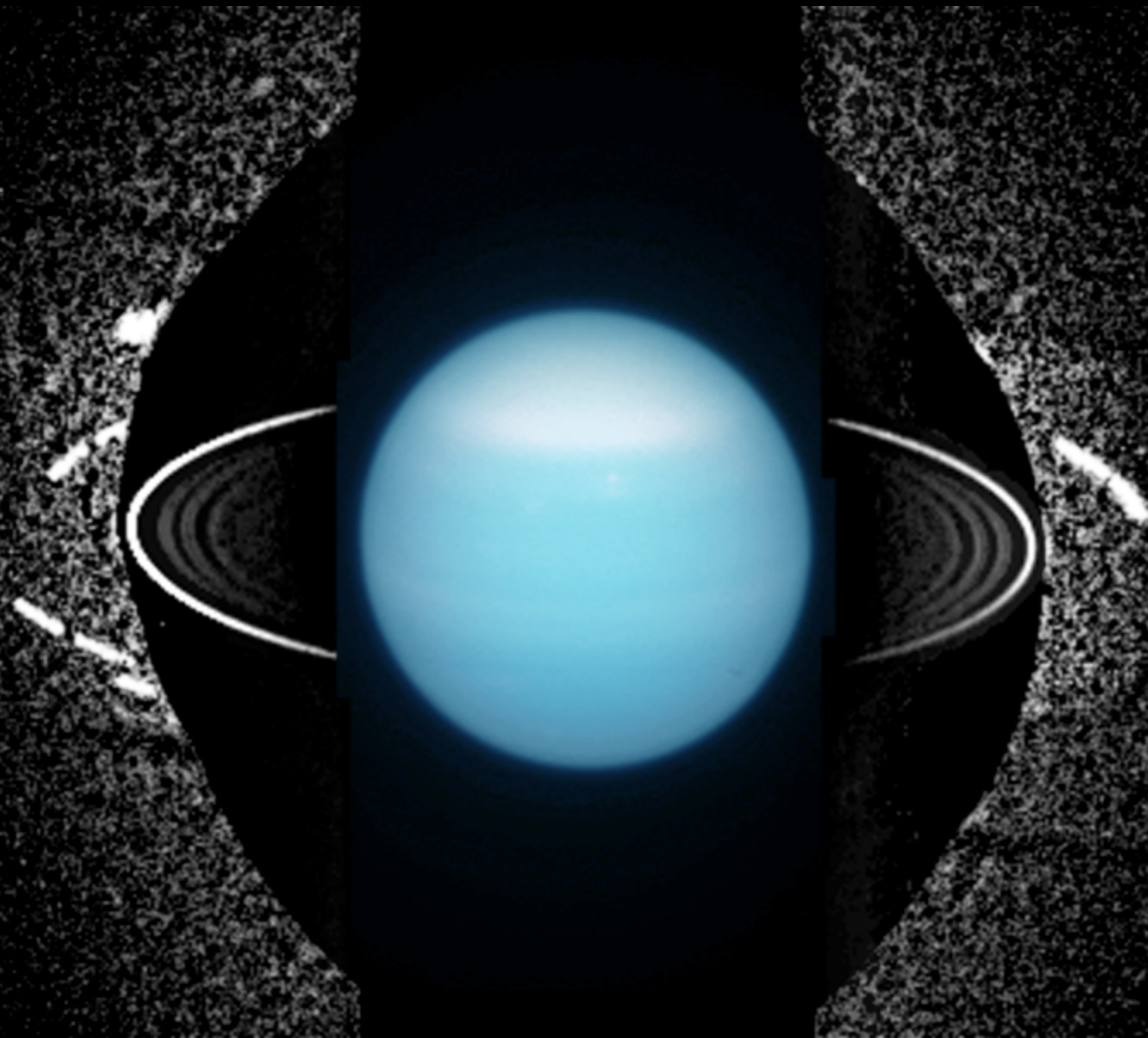
- Recovery of "Perdita"
- Discovery of "Mab"

Orbit 2



Credit: Science Magazine/M.

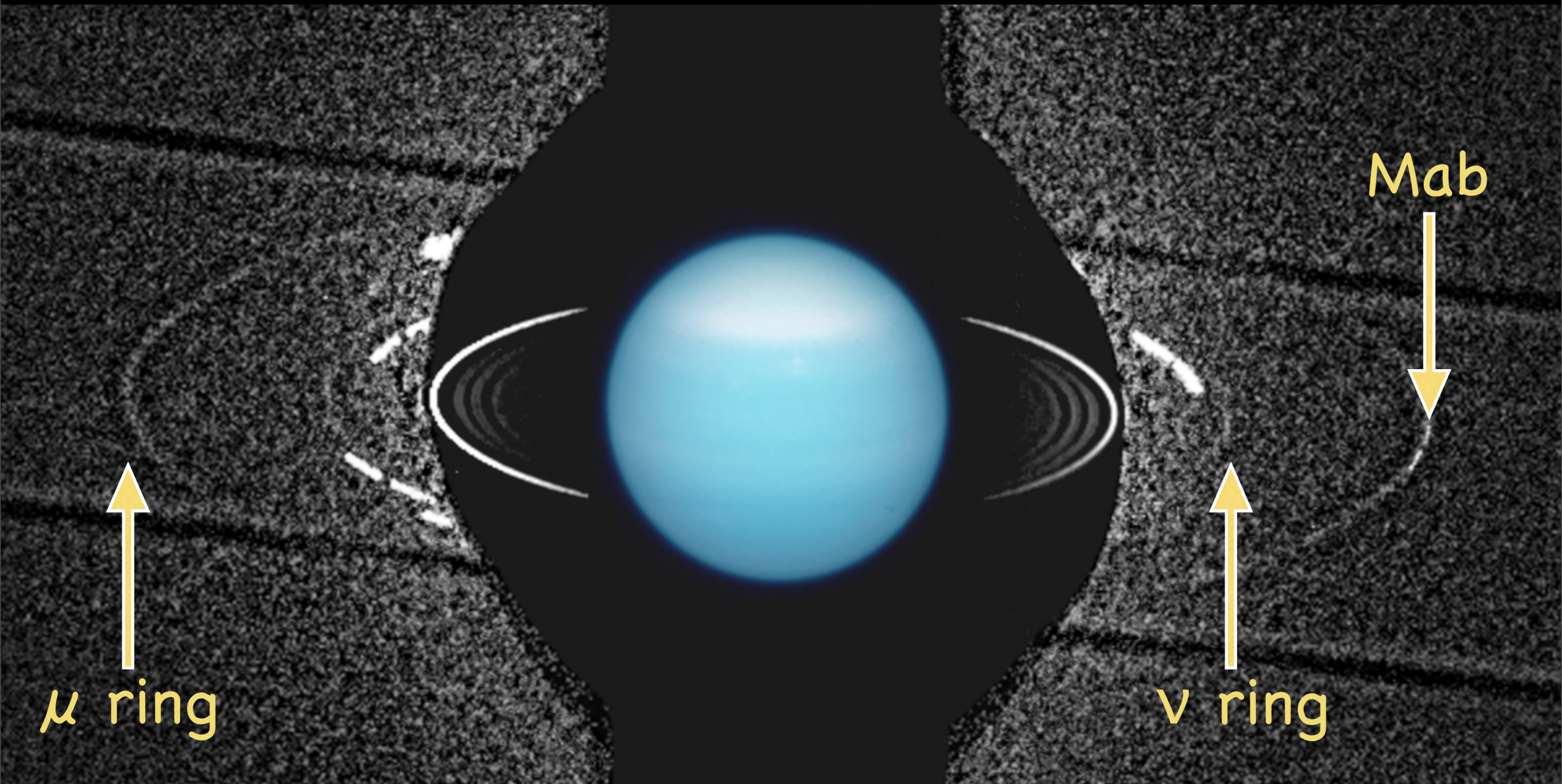
Uranus: August 2003

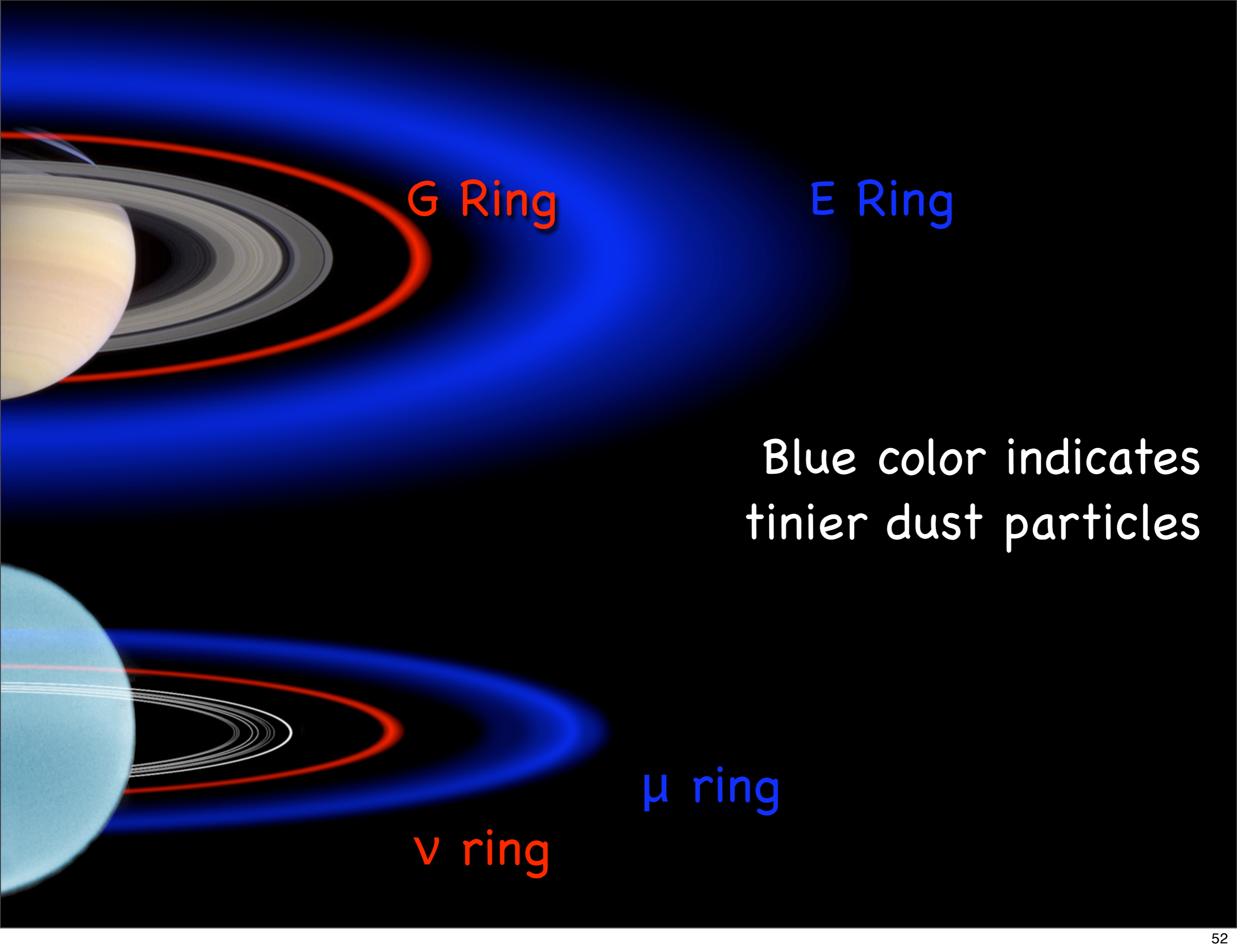


Mab



Uranus: August 2003





G Ring

E Ring

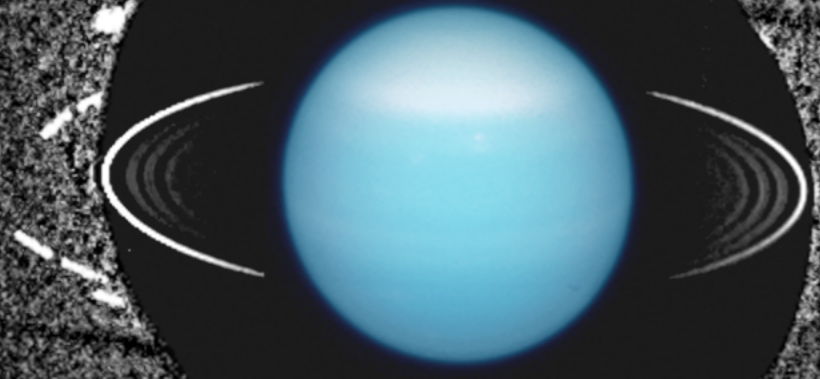
Blue color indicates
finer dust particles

μ ring

V ring

Equinox 2007

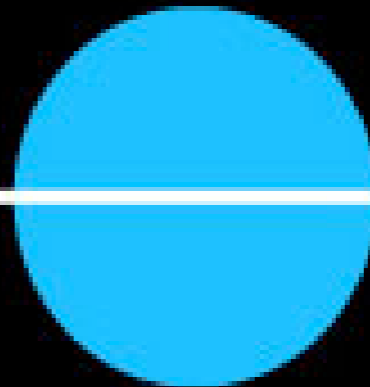
2003



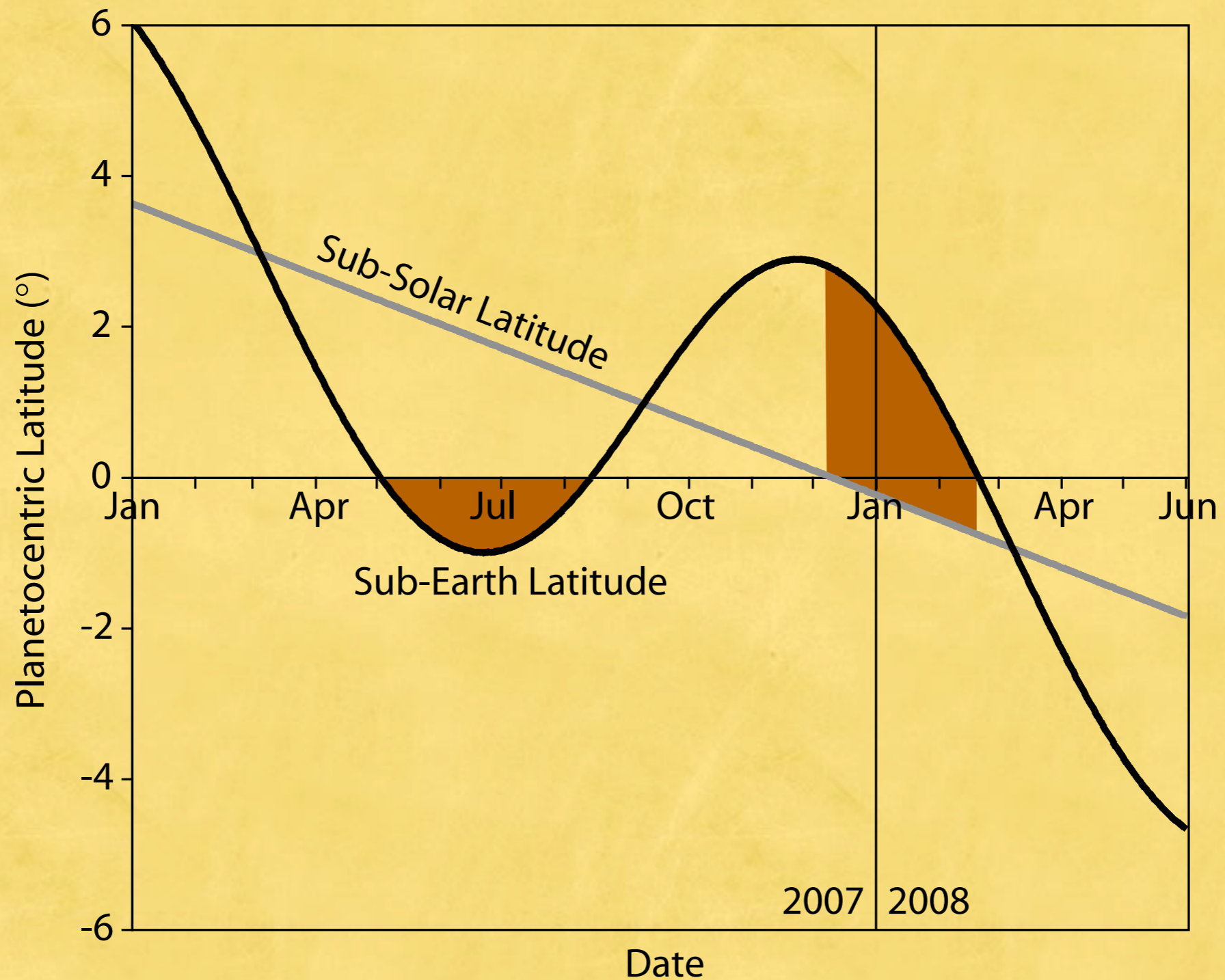
2005



2007



Uranian Ring Plane Crossing 2007–2008

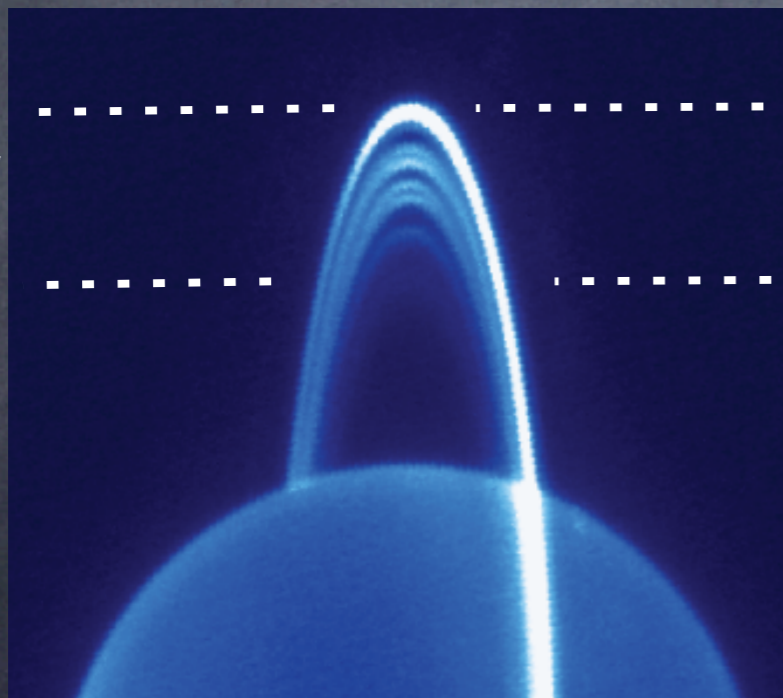


The Uranian Ring System Through the Years:

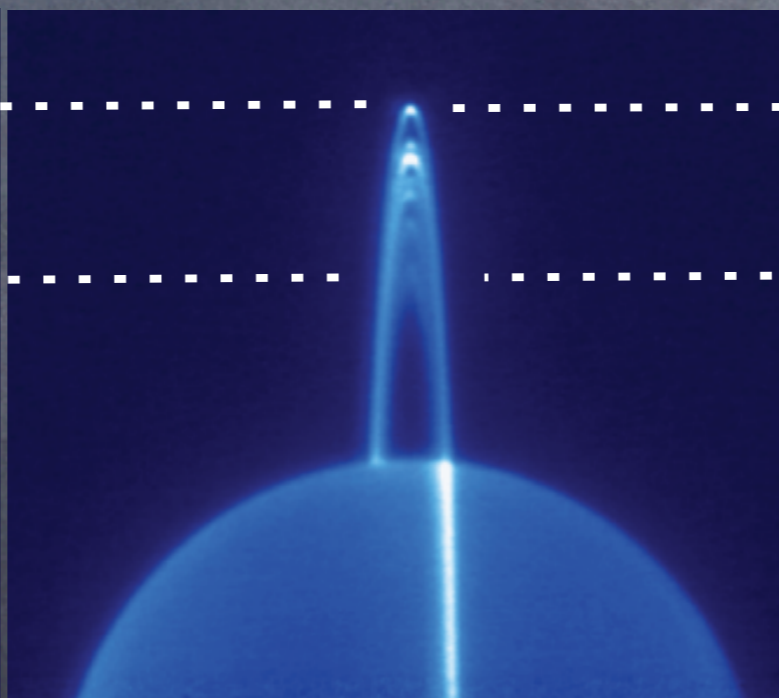
Keck Telescope Adaptive Optics

δ
 γ
 η
 β
 α
6
5
4

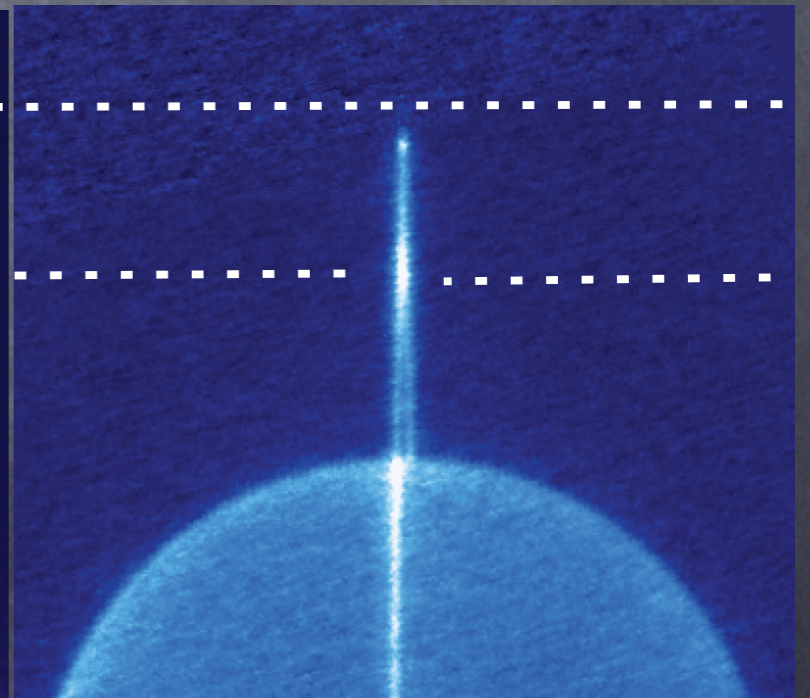
ϵ
 ζ



July 2004



August 2006



May 2007