Here There Be Dragons:
Navigating Saturn's Treacherous Dust Hazards

David Seal

Cassini Mission Planner

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Why Do You Wear Your Seat Belt?

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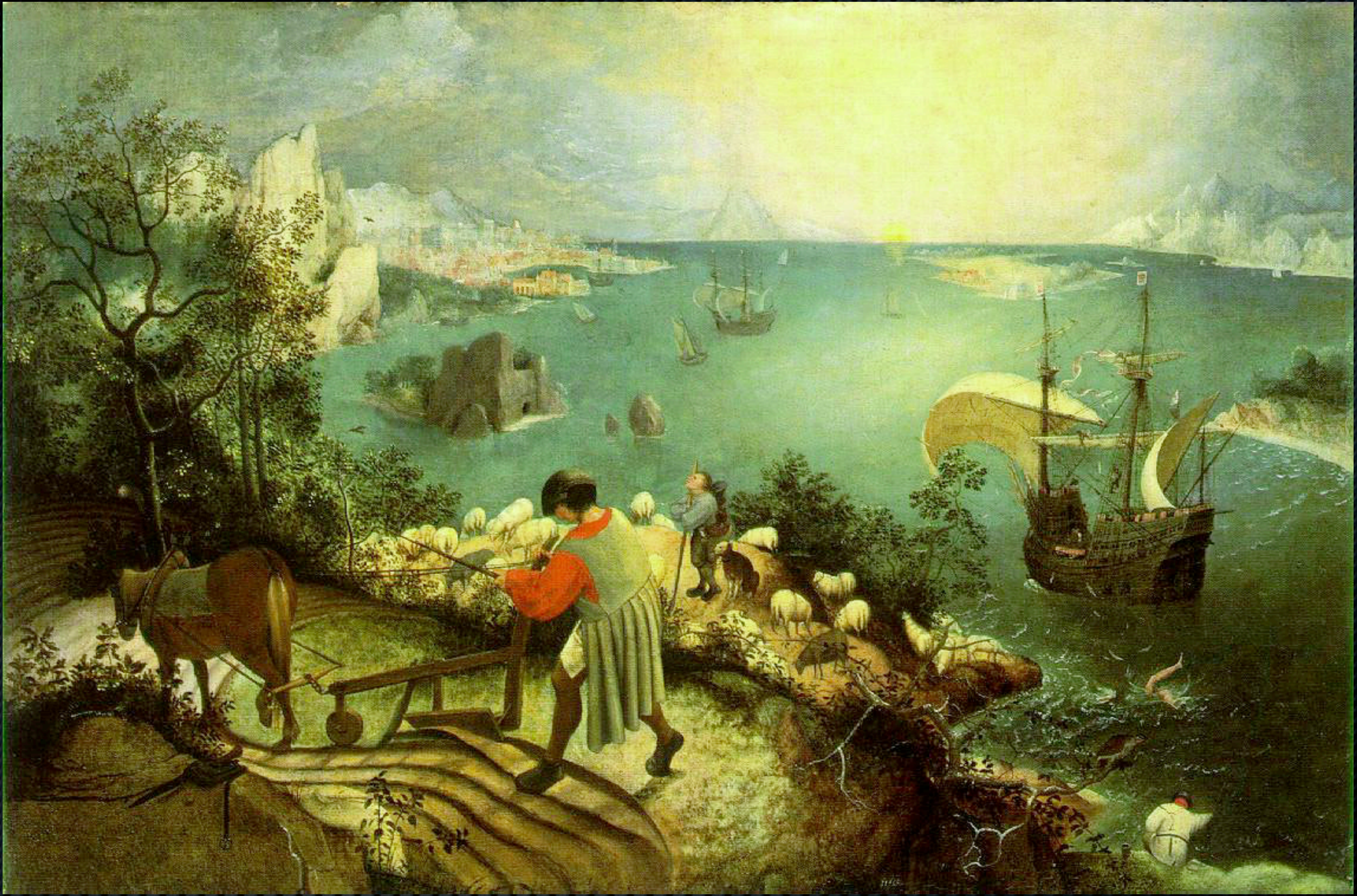
Risk Management

Likelihood: low

Impact: very high

Mitigation: wear seat belt, buy car with airbags, drive defensively, don’t text/drink and drive, avoid bad weather, etc.

Other low-Ps: losing keys; theft; struck by meteorite; nuclear war



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Planetary Rings

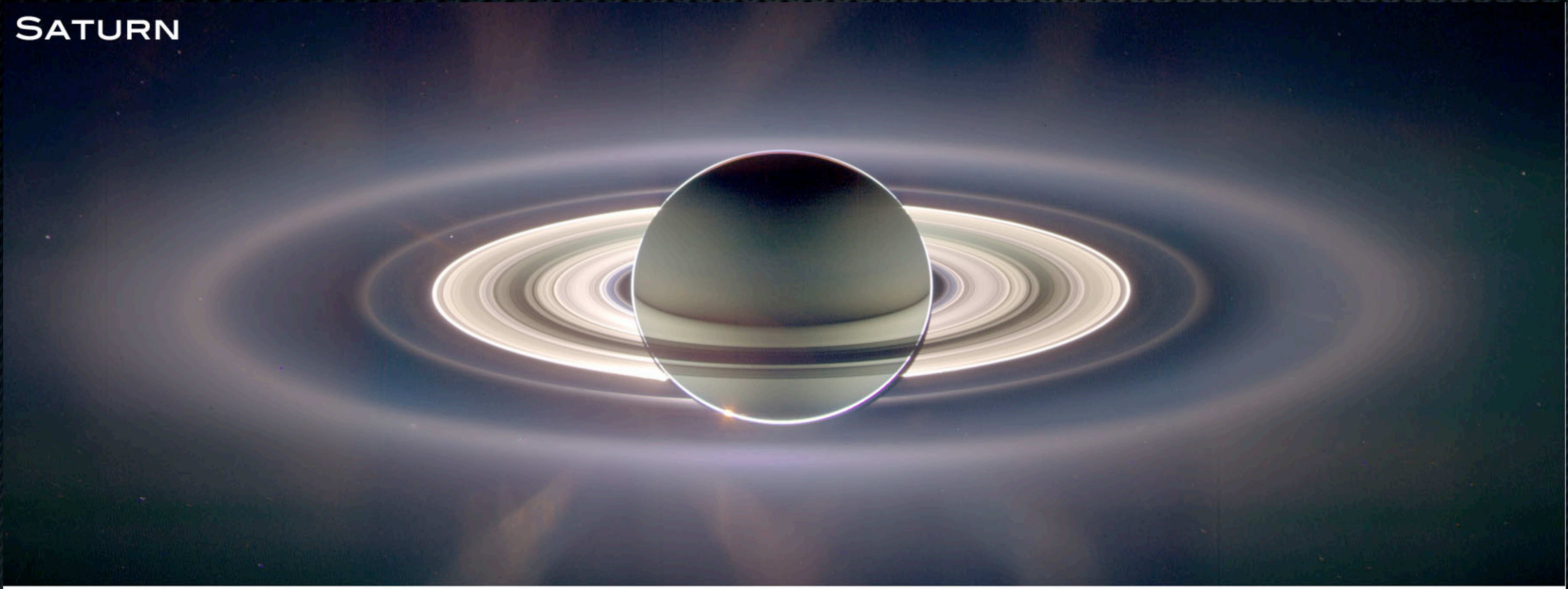
All of the outer planets have ring systems

Until Cassini, missions to the outer planets elected to avoid them altogether (or so they thought)

Cassini managed hazards extensively

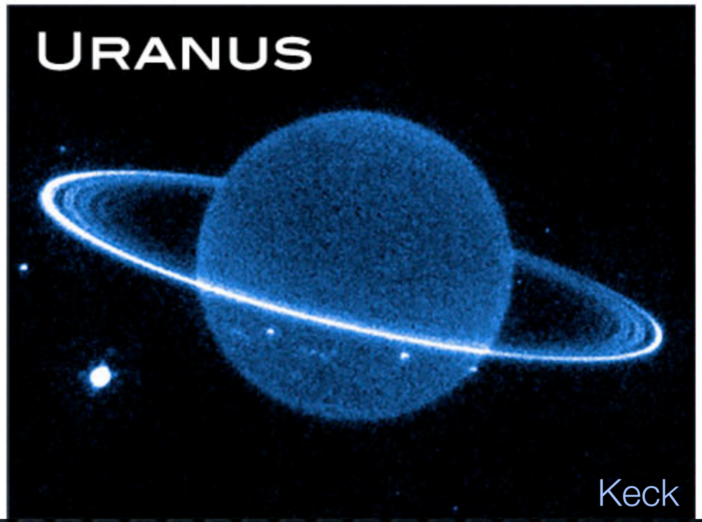
Juno, New Horizons are upcoming

Outer Planet Ring Systems



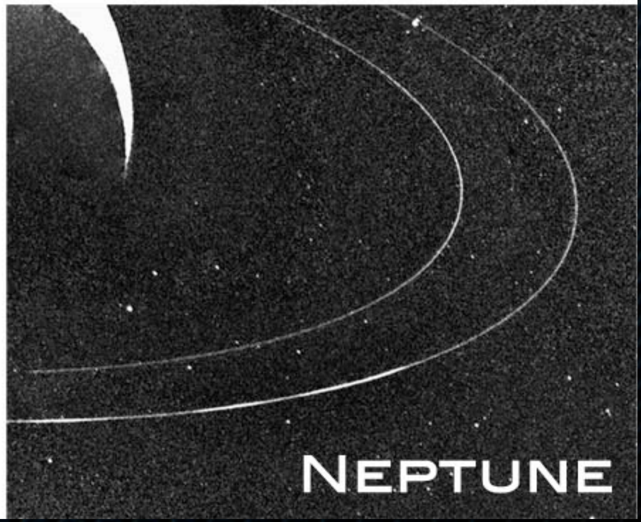
SATURN

JUPITER



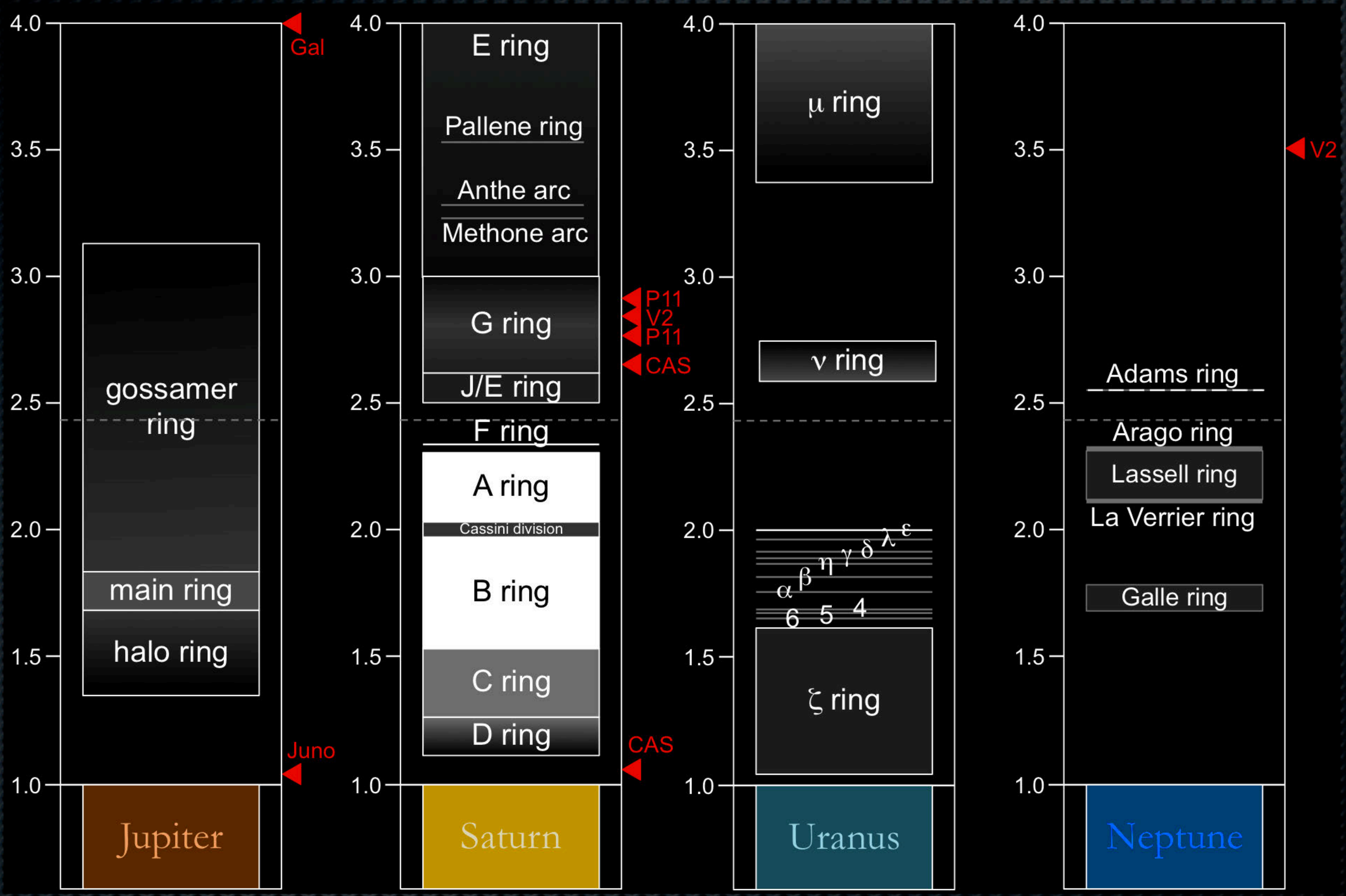
URANUS

Keck



NEPTUNE

Outer Planet Ring Systems


4.0
3.5
3.0
2.5
2.0
1.5
1.0
Gal
gossamer ring
main ring
halo ring
Juno
Jupiter
E ring
Pallene ring
Anthe arc
Methone arc
G ring
J/E ring
F ring
A ring
Cassini division
B ring
C ring
D ring
Saturn
P11
V2
P11
CAS
CAS
μ ring
ν ring
ε
λ
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η
β
α
4
5
6
ζ ring
Uranus
V2
Adams ring
Arago ring
Lassell ring
La Verrier ring
Galle ring
Neptune

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Historical Encounters

- Jupiter
  - Pioneer 10, 11, Voyager 1, 2, Ulysses, Galileo, Cassini, New Horizons
- Saturn
  - Pioneer 11, Voyager 1, 2, Cassini
- Uranus, Neptune
  - Voyager 2

Saturn’s Rings

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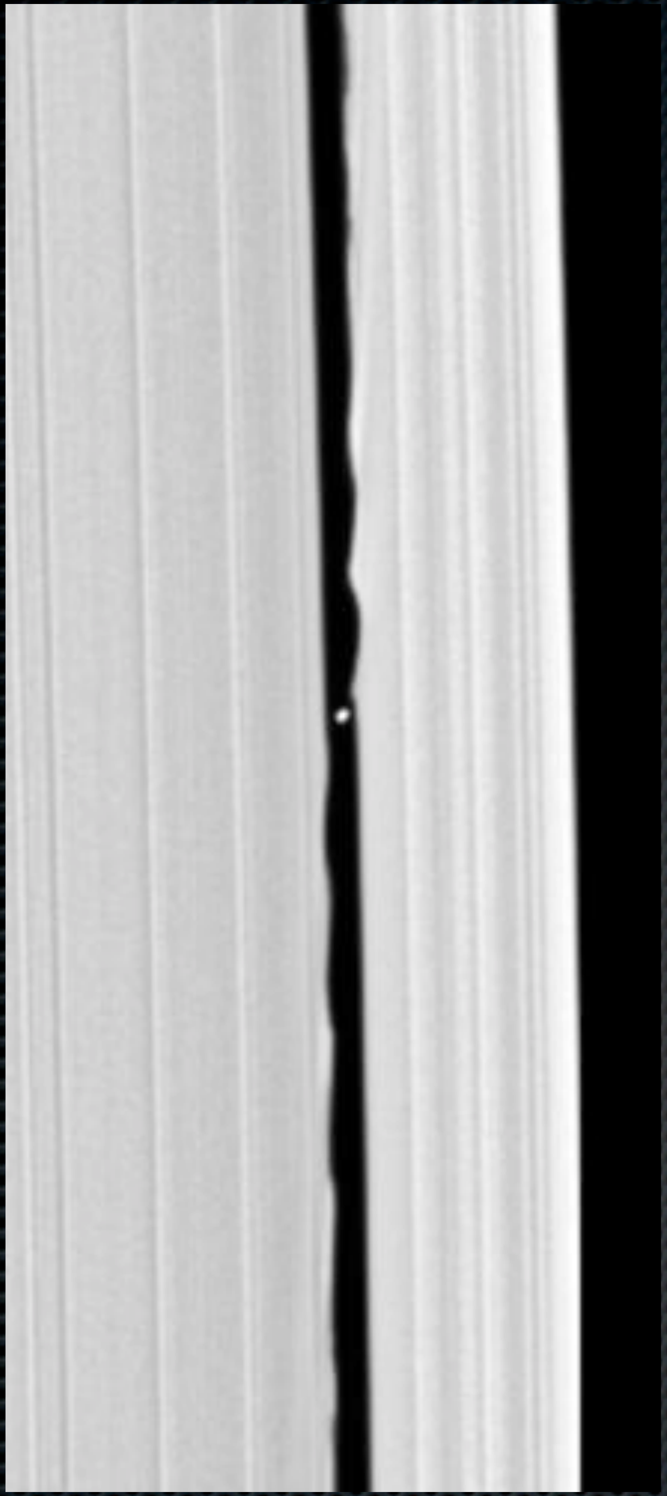
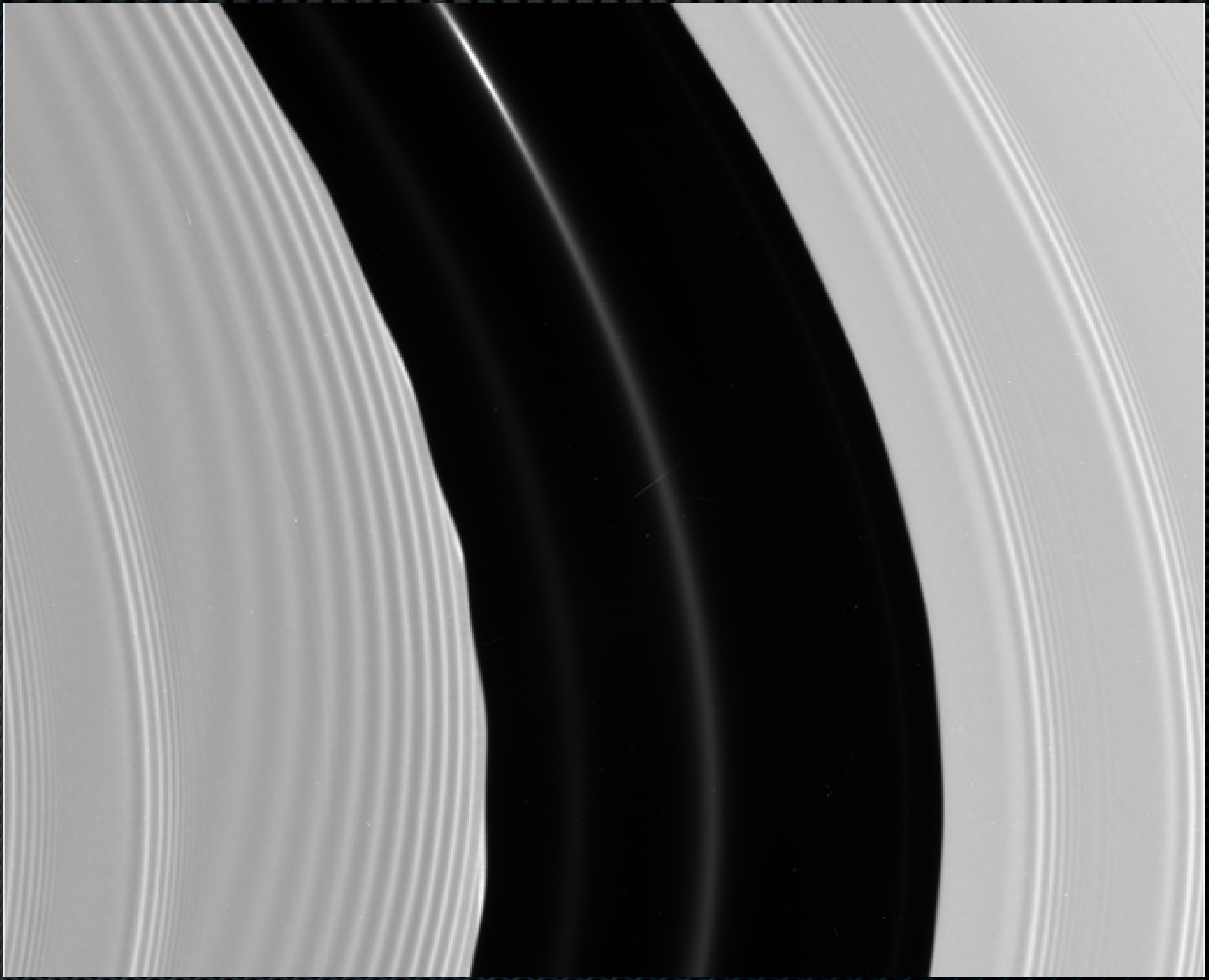
Saturn’s Rings





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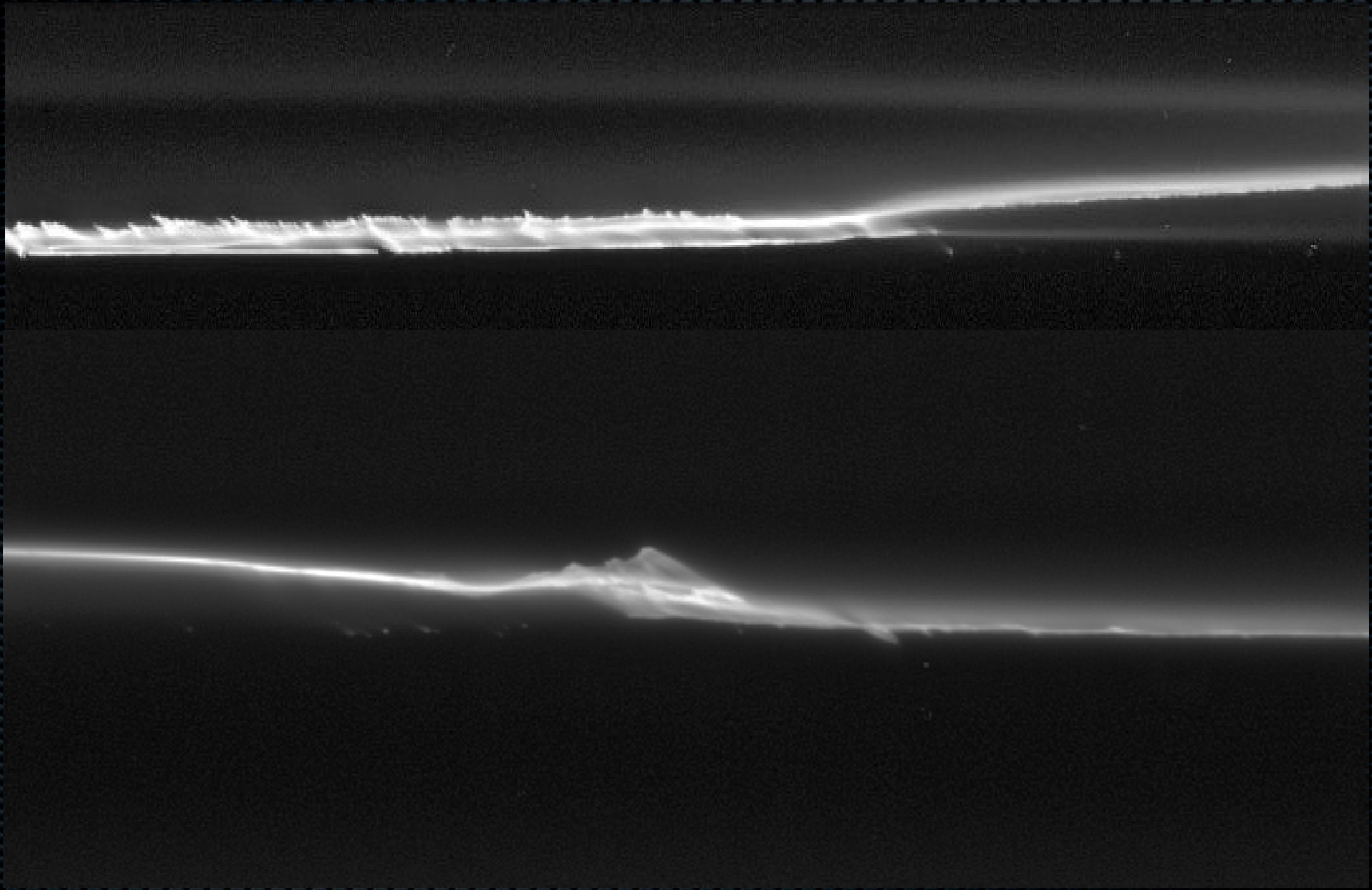
Saturn’s Rings



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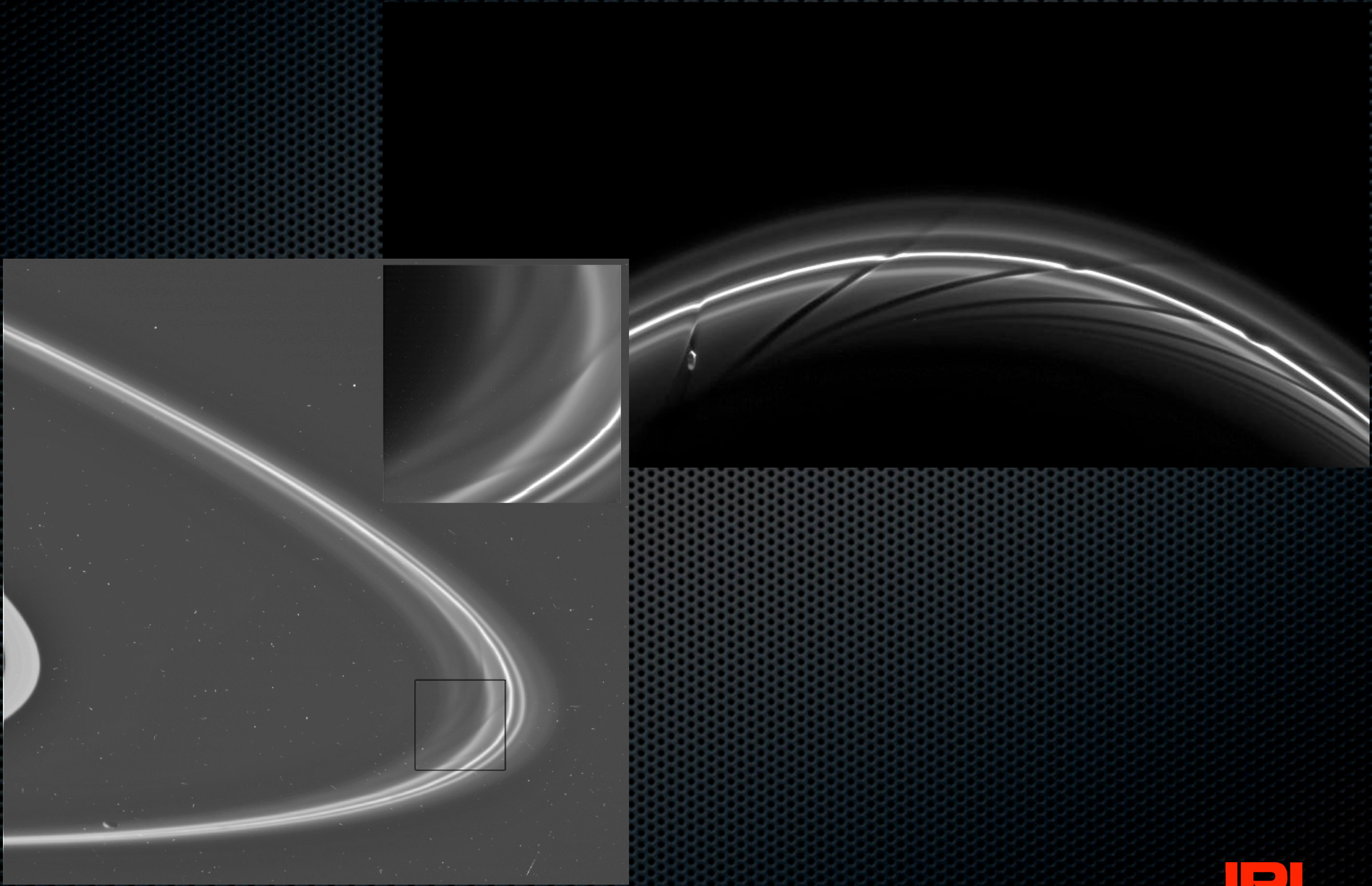
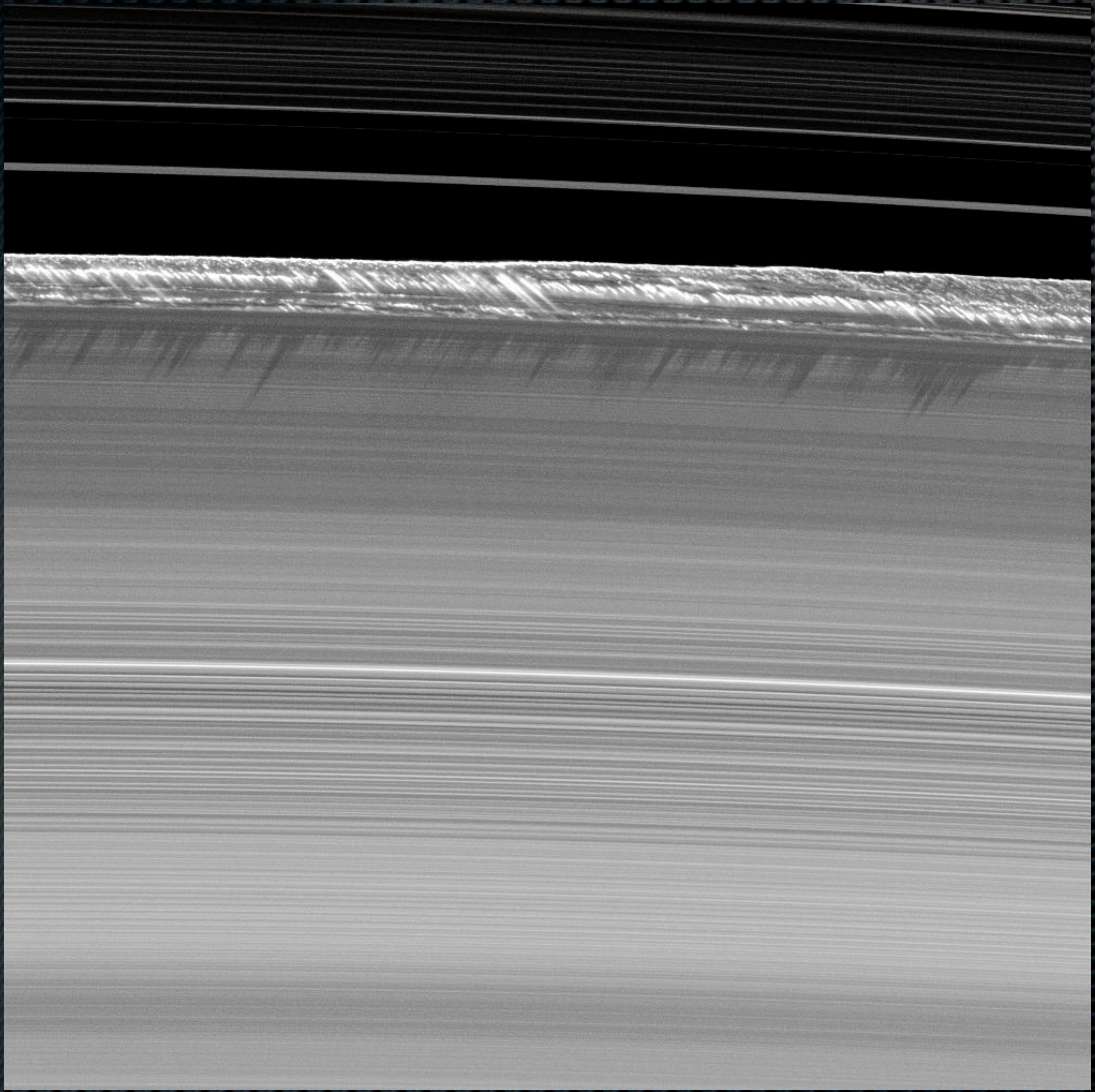
Saturn’s Rings



Saturn's Rings



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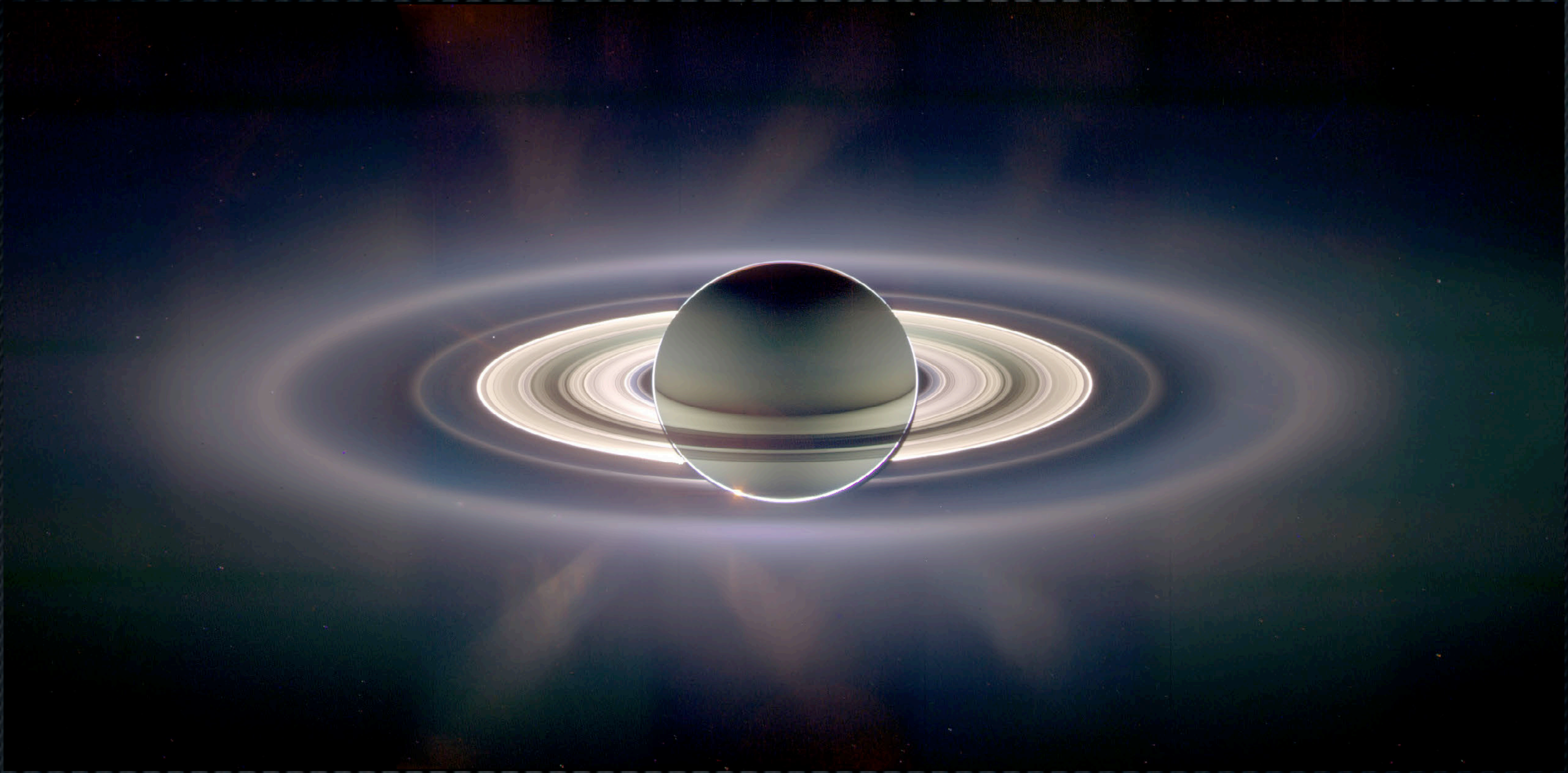
Saturn’s Rings



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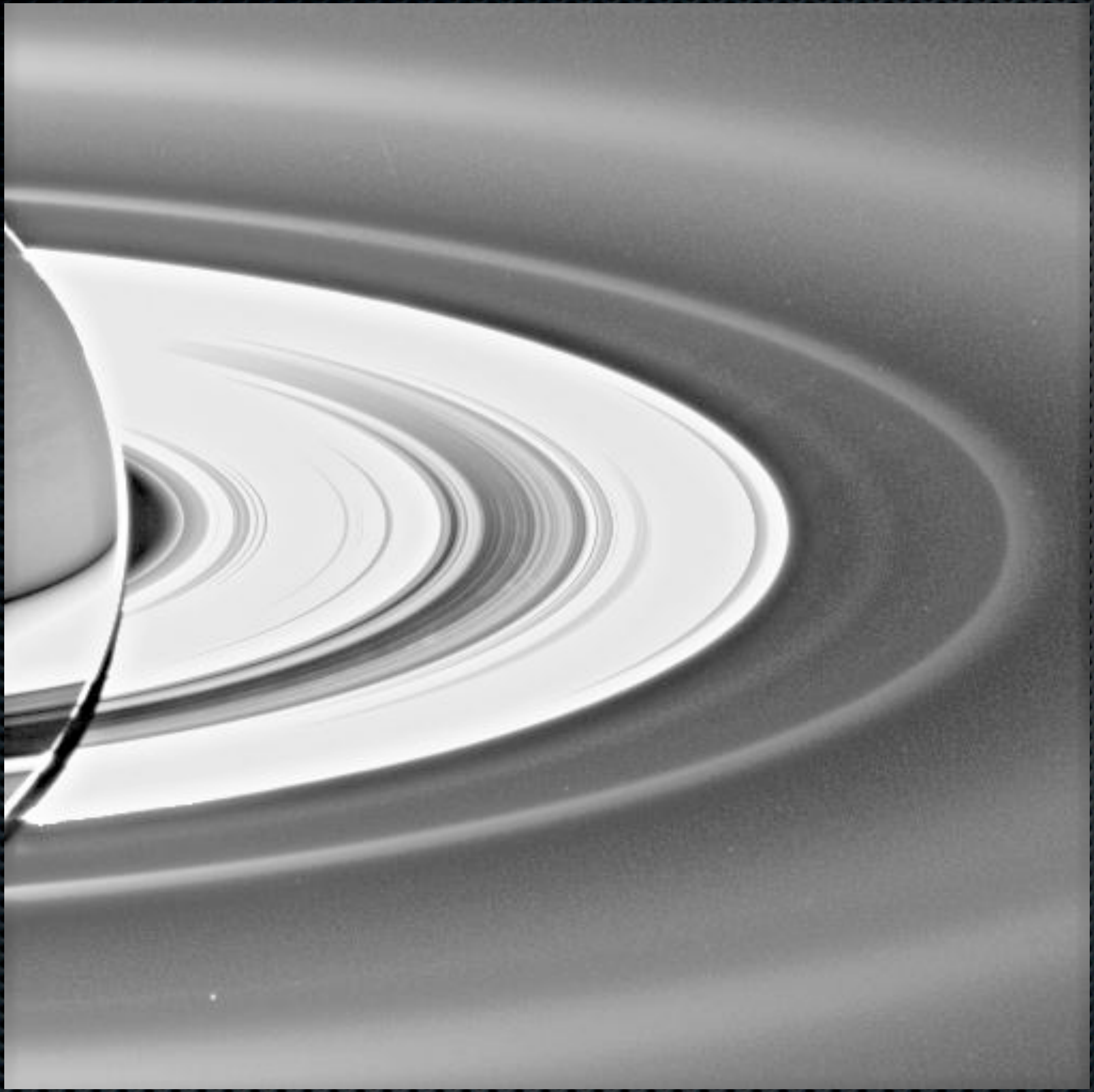
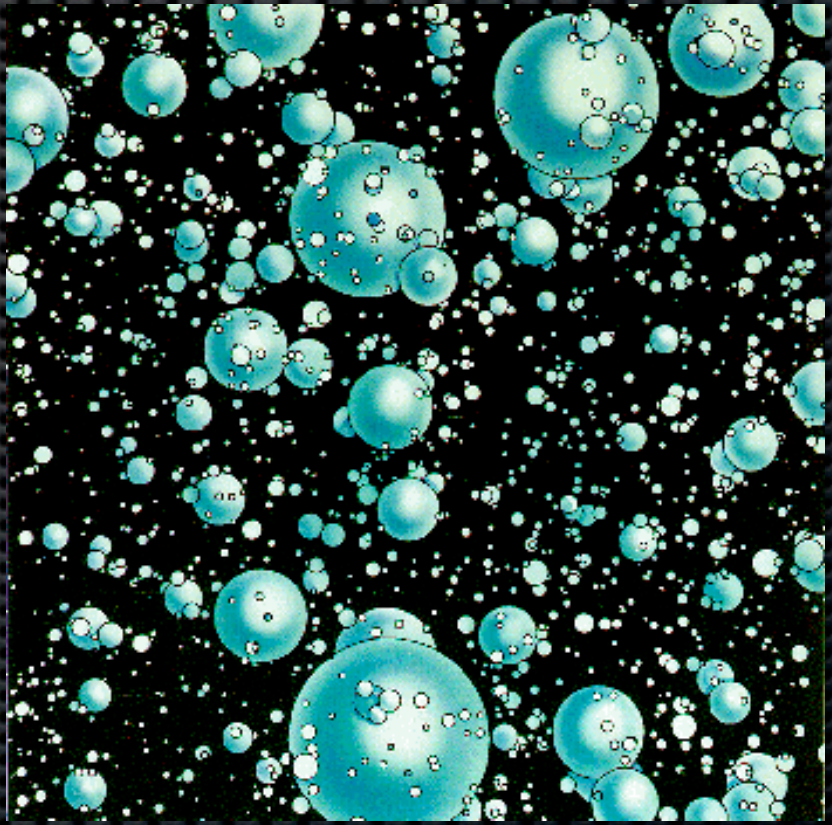
Saturn’s Rings





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Classic Real-World Conundrum

We don't fully understand the environment

We go to Saturn to study / learn about the environment

We need to watch out for hazards in Saturn's environmental

We need to understand the environment to make decisions about those hazards

See #1

Cassini Approach

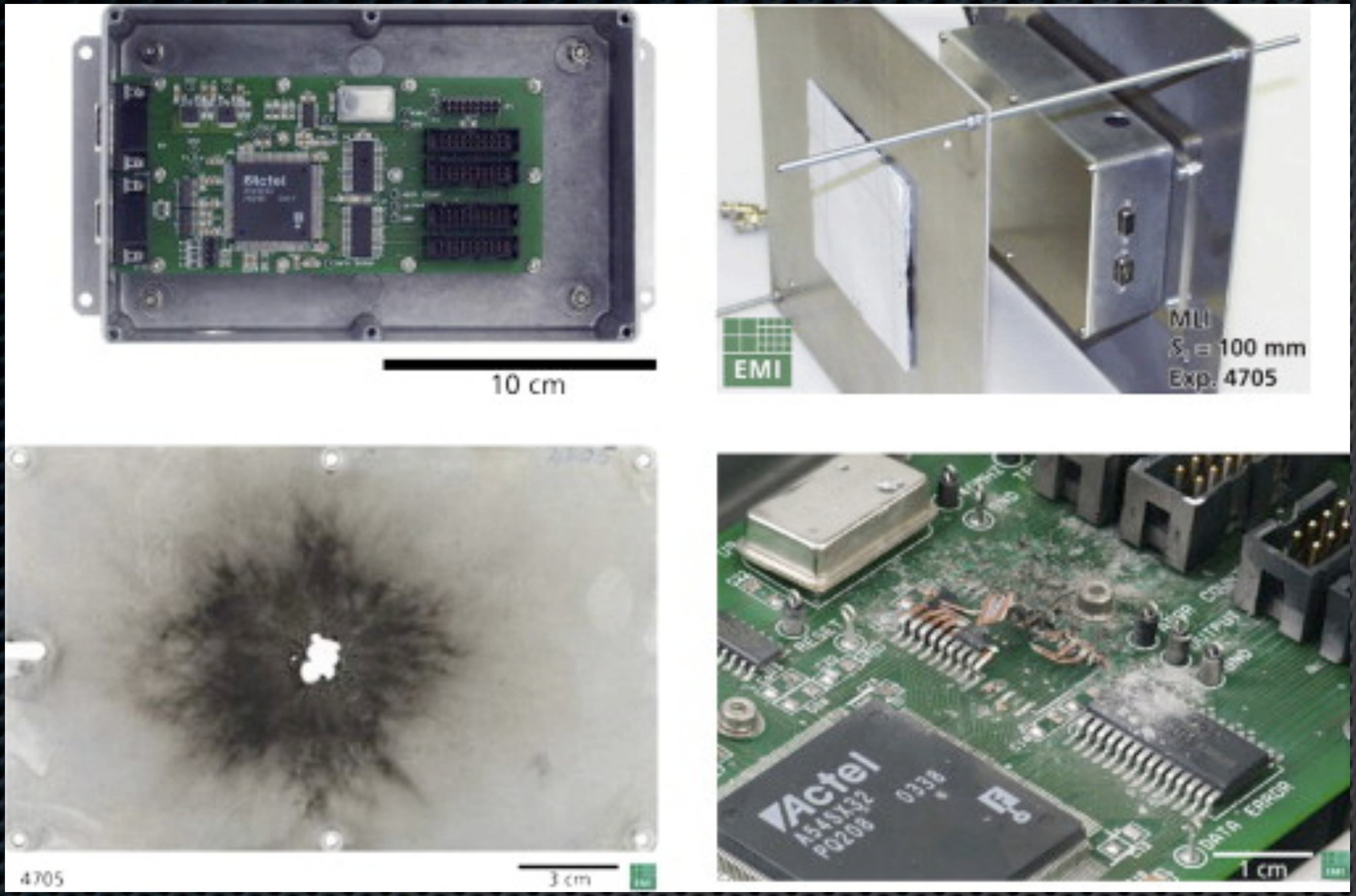
Ring hazard workshop - Ames, 1995

Vulnerability assessment, hazard modeling 1990-present

Risk mitigation

- Trajectory (re)design
- Attitude enforcement
- Protective cover (for main engines)

Hypervelocity Impacts


10 cm
EMI
MLI
S_1 = 100 mm
Exp. 4705
4705
3 cm
Actel
A54SX32
PQ208
0338
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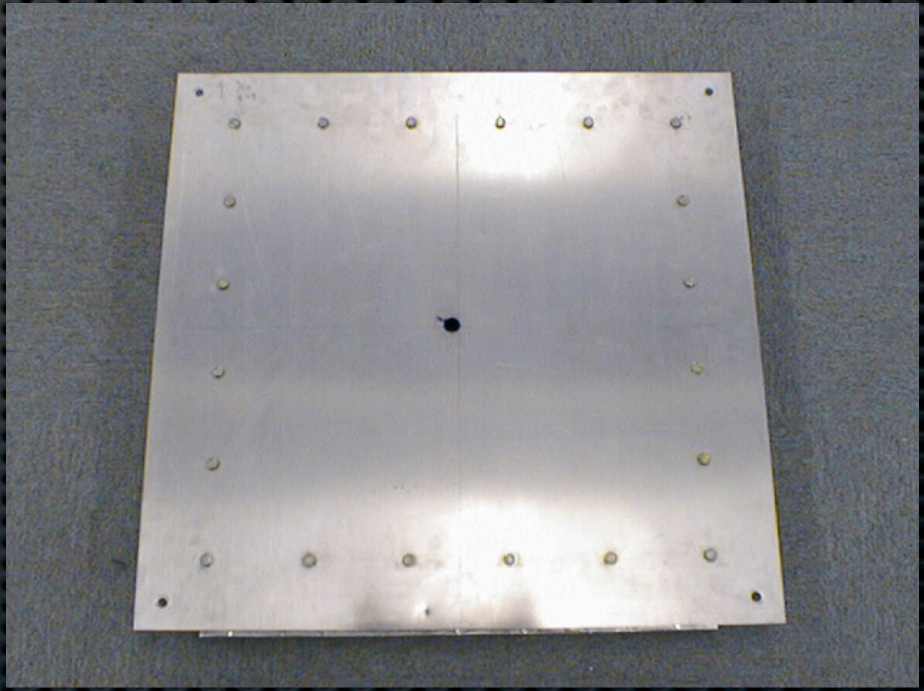
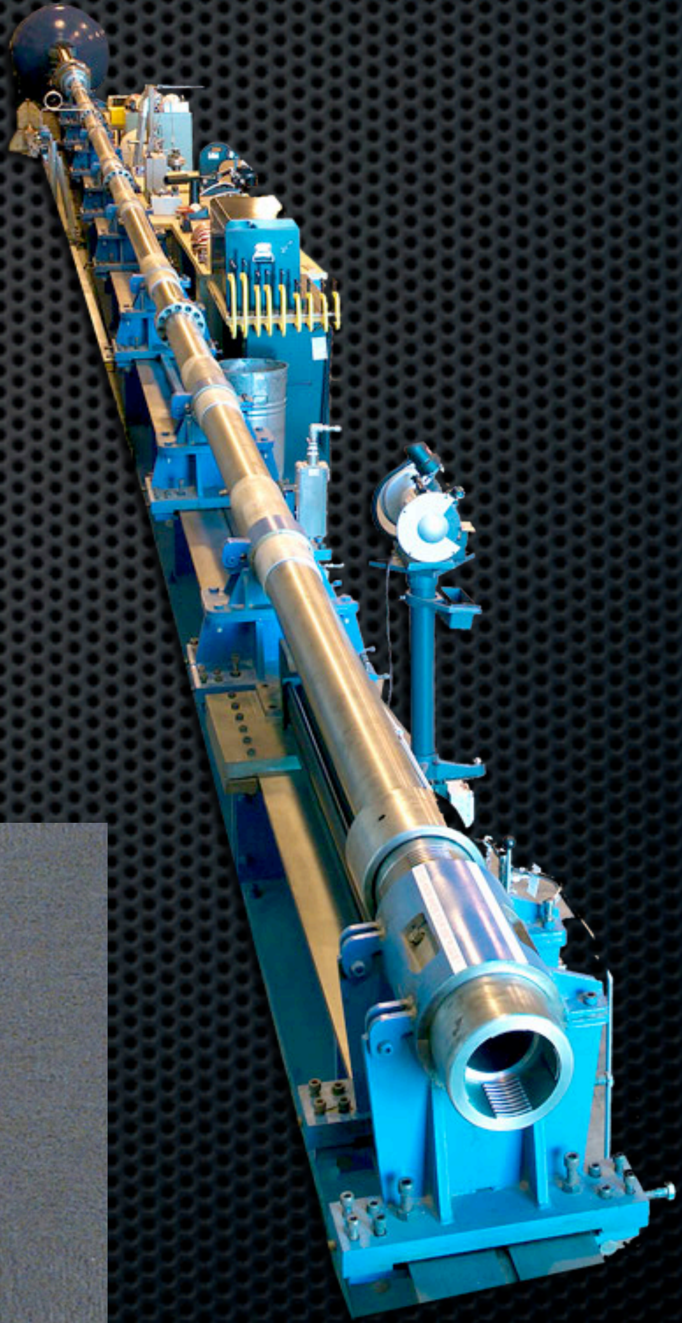
1 cm





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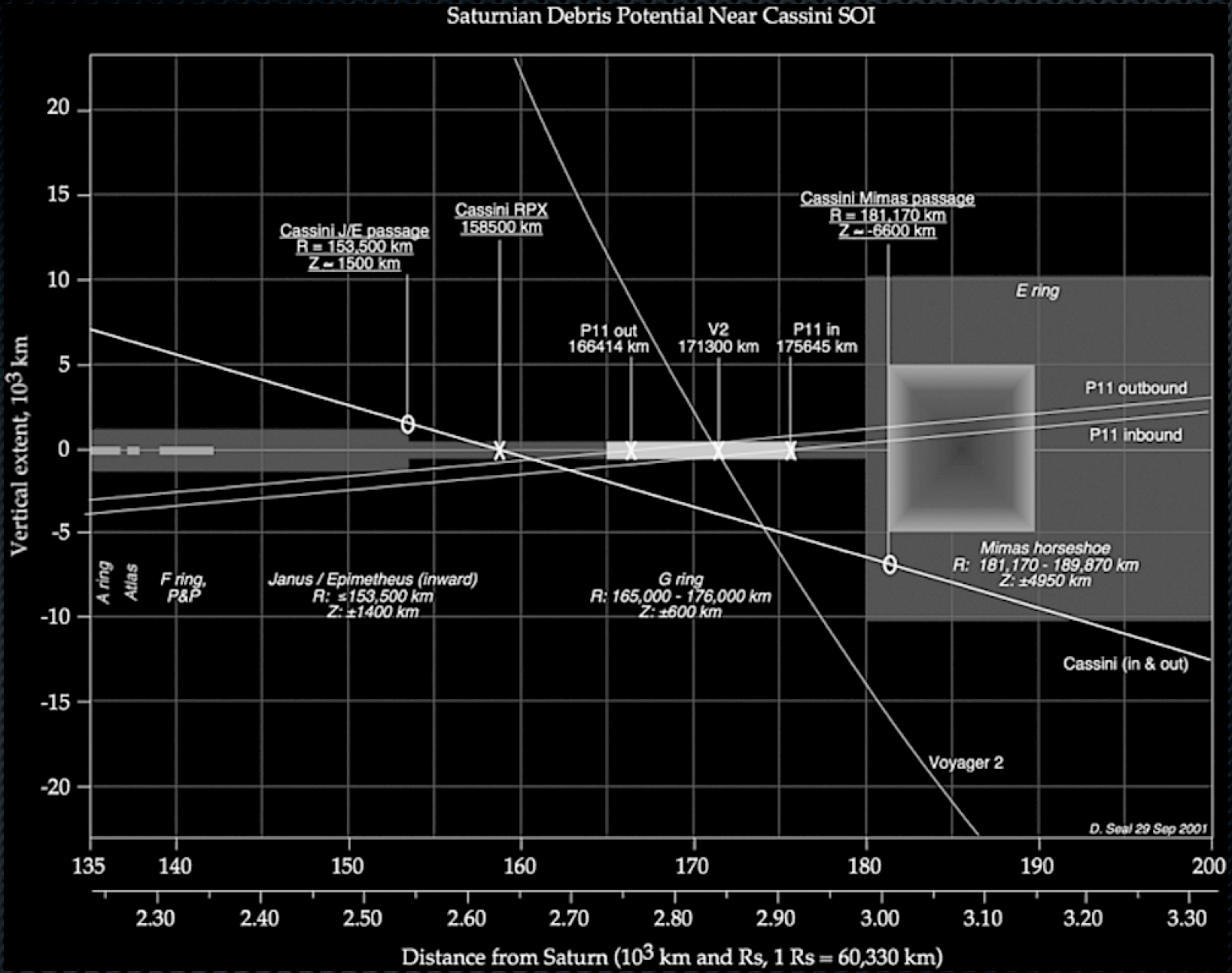
Cassini Saturn Orbit Insertion



Saturnian Debris Potential Near Cassini SOI

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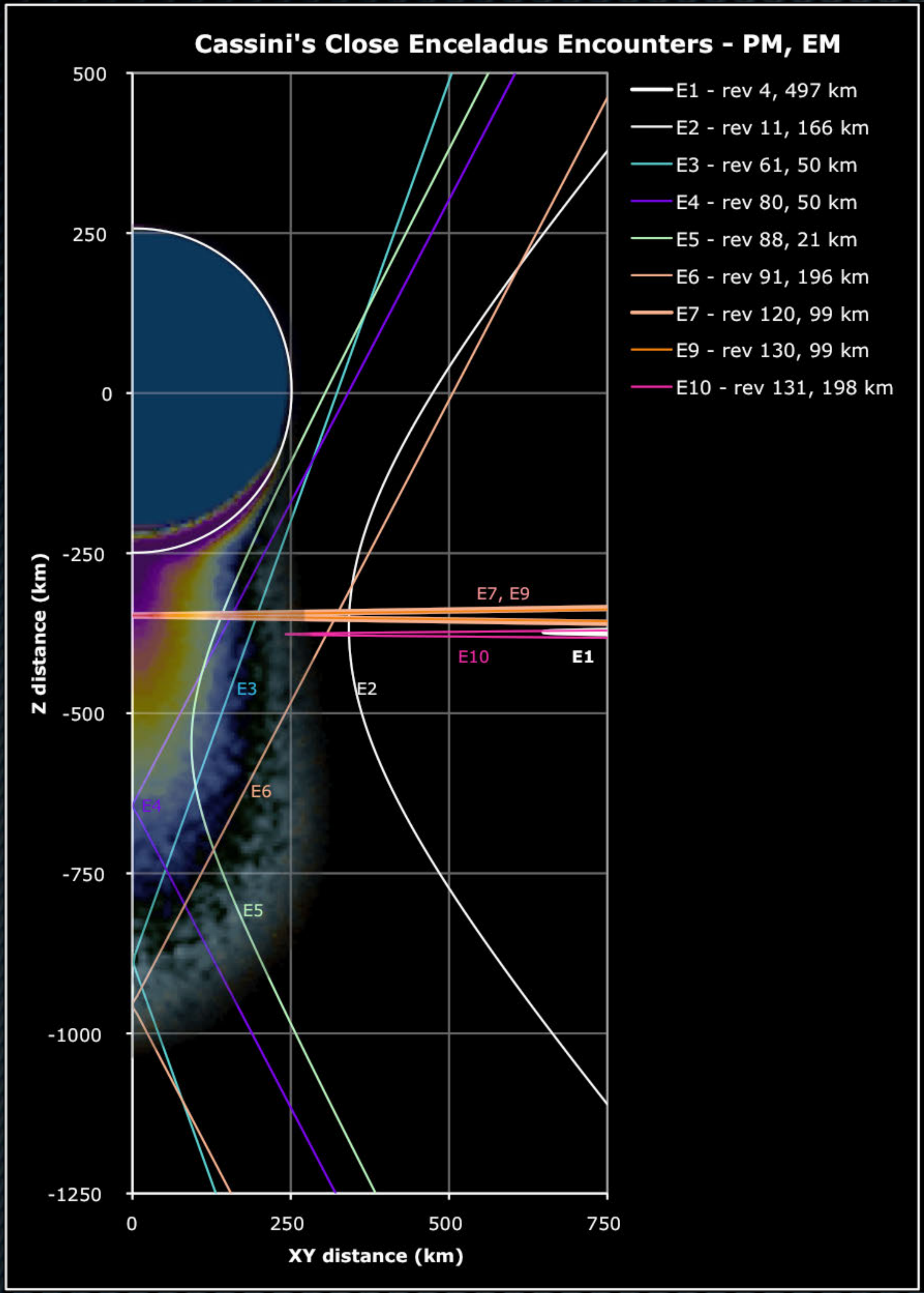
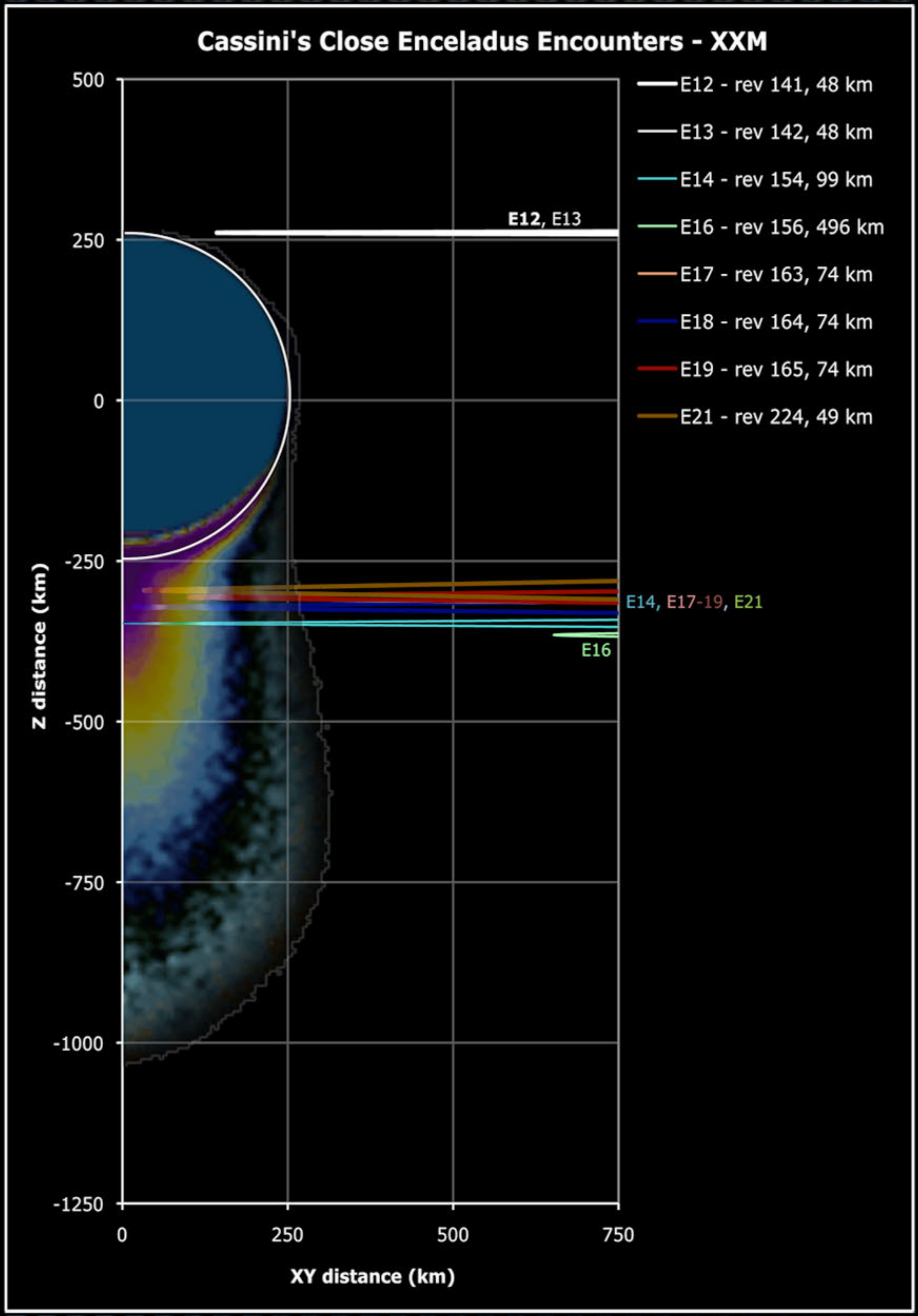
Enceladus’ Plumes


Cassini's Close Enceladus Encounters - PM, EM


Cassini's Close Enceladus Encounters - XXM

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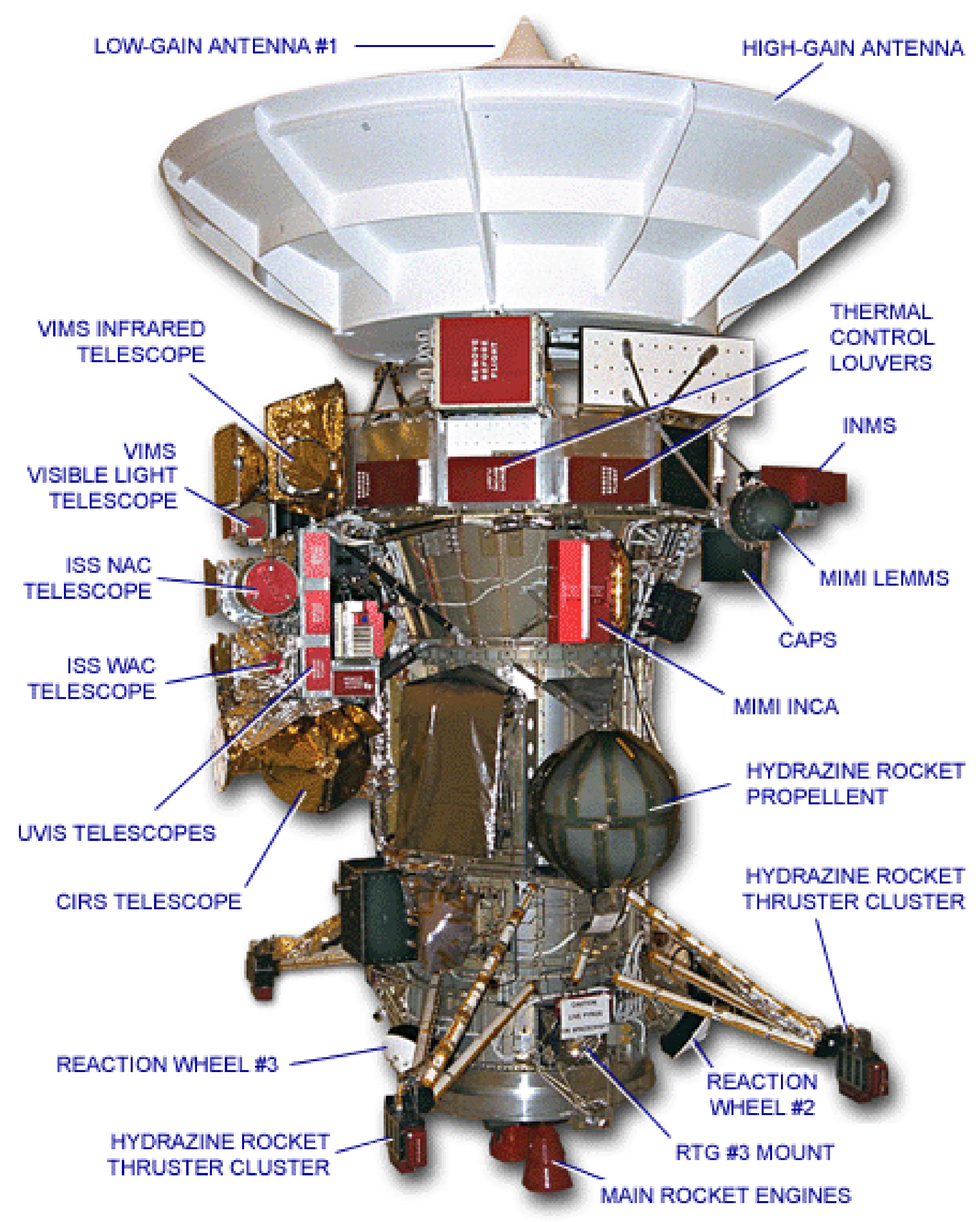
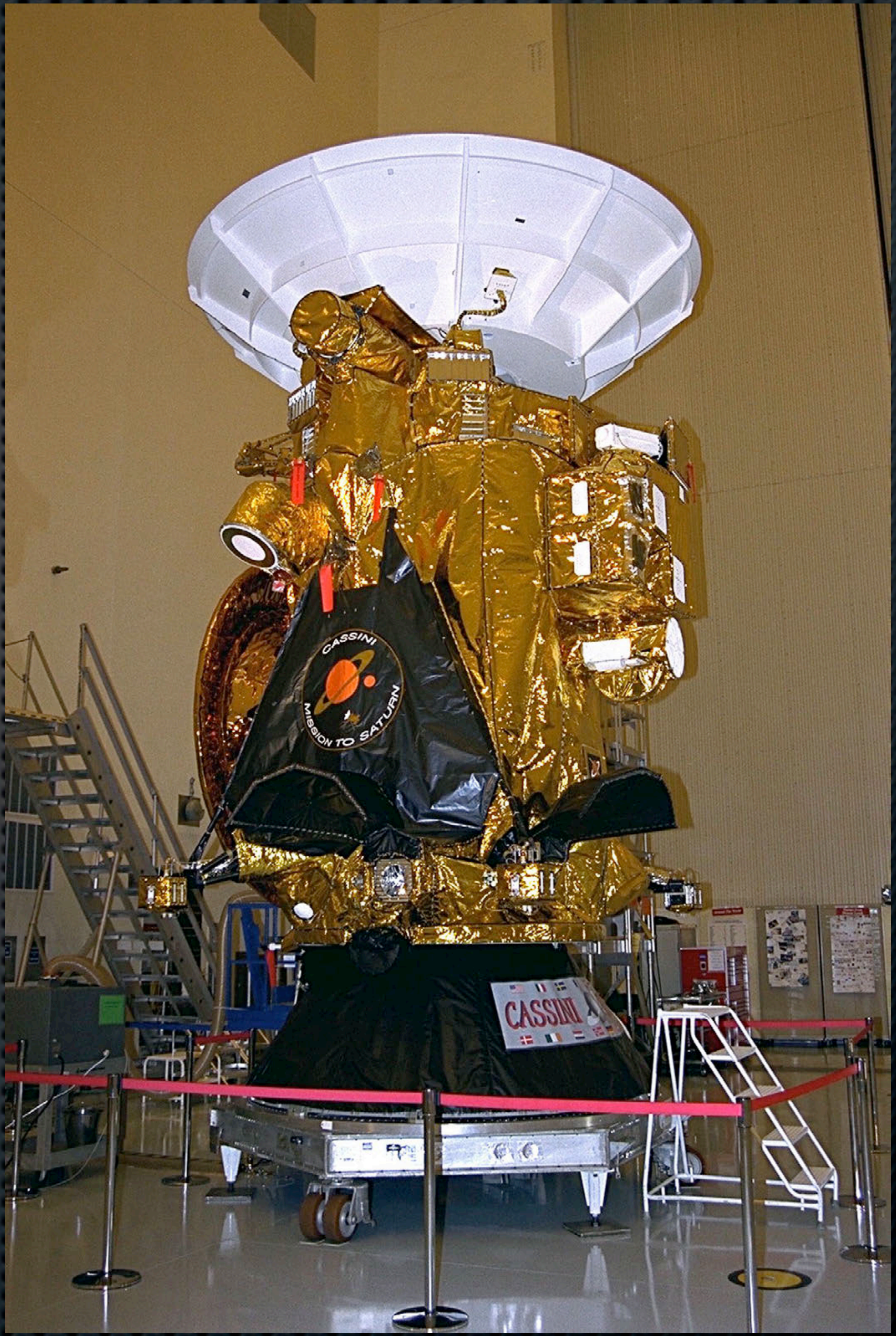
Protective Measures


LOW-GAIN ANTENNA #1
HIGH-GAIN ANTENNA
VIMS INFRARED TELESCOPE
THERMAL CONTROL LOUVERS
INMS
VIMS VISIBLE LIGHT TELESCOPE
ISS NAC TELESCOPE
MIMI LEMMS
CAPS
ISS WAC TELESCOPE
MIMI INCA
HYDRAZINE ROCKET PROPELLENT
UVIS TELESCOPES
CIRS TELESCOPE
HYDRAZINE ROCKET THRUSTER CLUSTER
REACTION WHEEL #3
REACTION WHEEL #2
HYDRAZINE ROCKET THRUSTER CLUSTER
RTG #3 MOUNT
MAIN ROCKET ENGINES


CASSINI
MISSION TO SATURN
CASSINI

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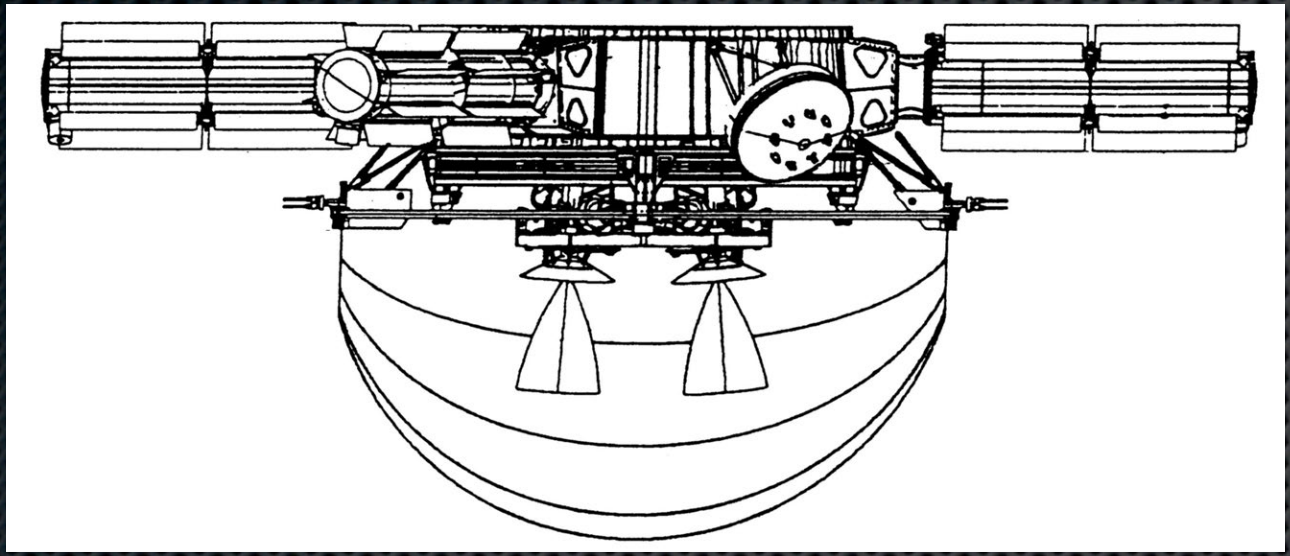
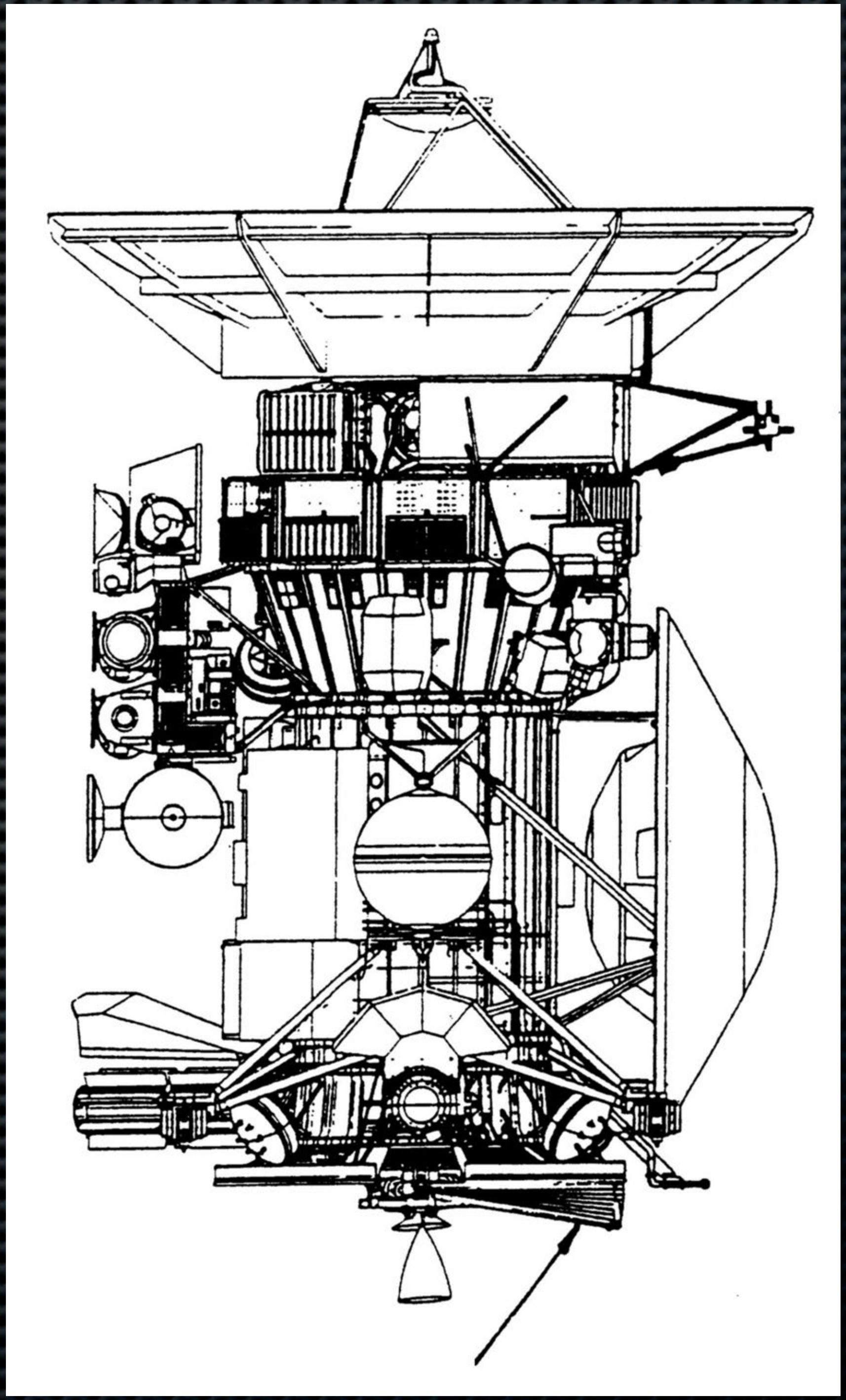
Protective Measures

Main engine cover
“baby buggy”



Dual drive actuator



Stowed cover

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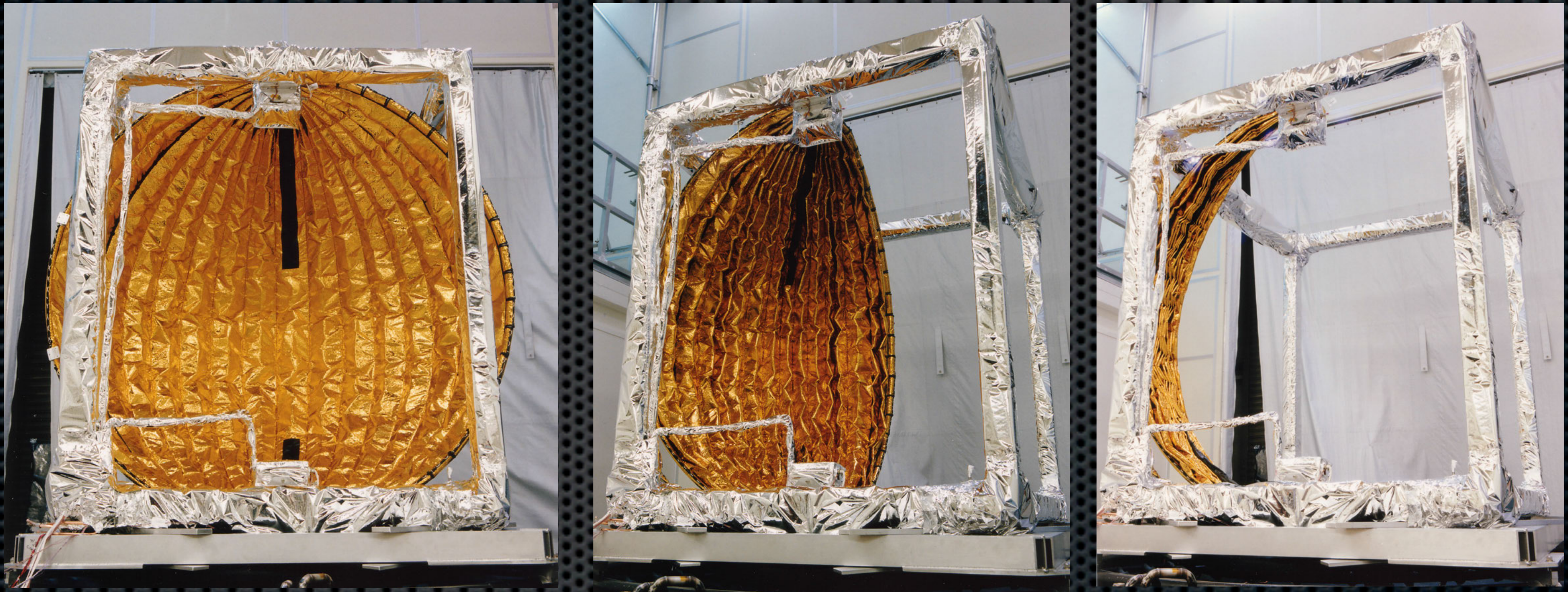
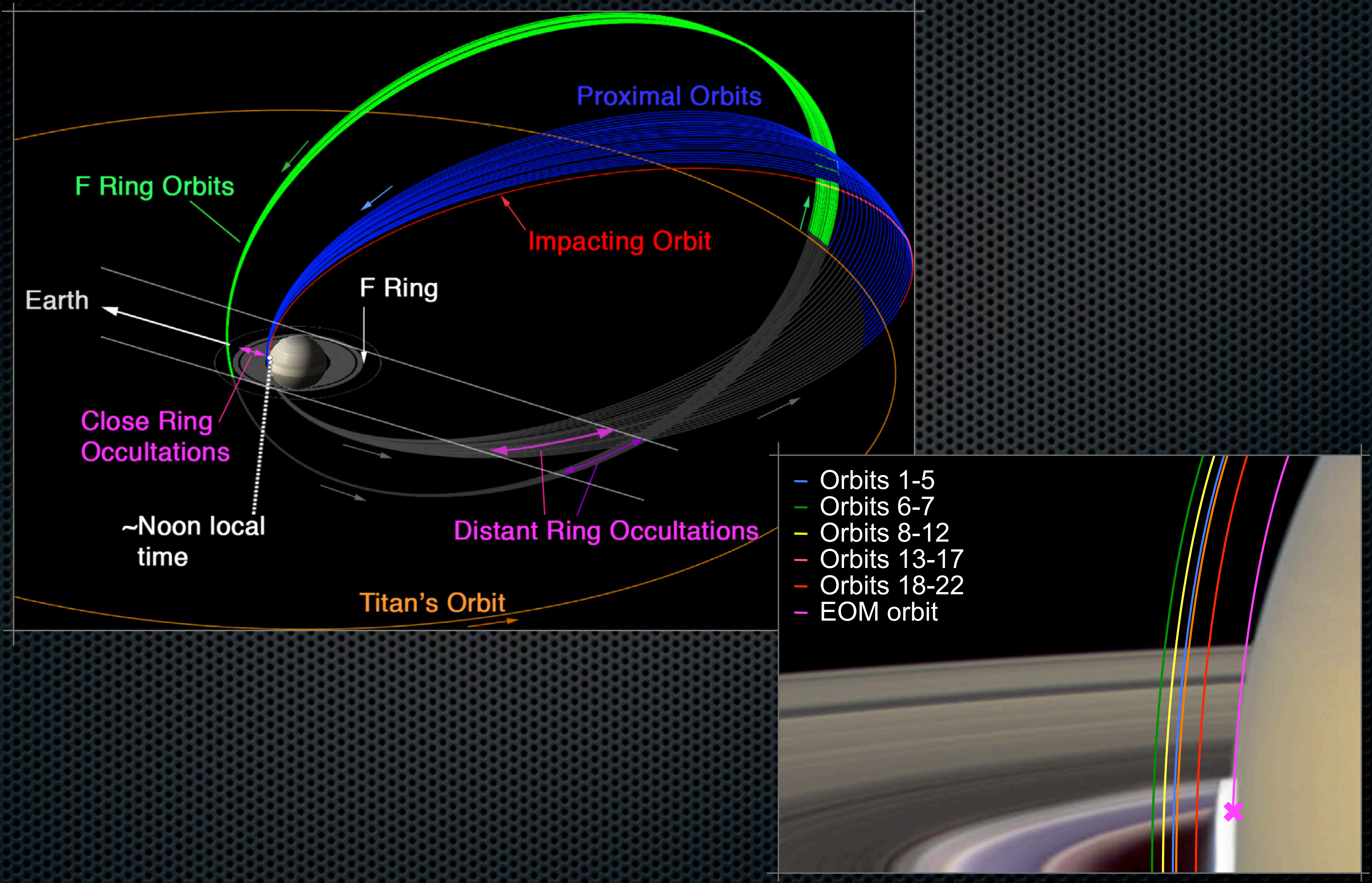
Protective Measures

Main engine cover



Proximal Orbits


Proximal Orbits
F Ring Orbits
Impacting Orbit
F Ring
Earth
Close Ring Occultations
~Noon local time
Distant Ring Occultations
Titan's Orbit
Orbits 1-5
Orbits 6-7
Orbits 8-12
Orbits 13-17
Orbits 18-22
EOM orbit

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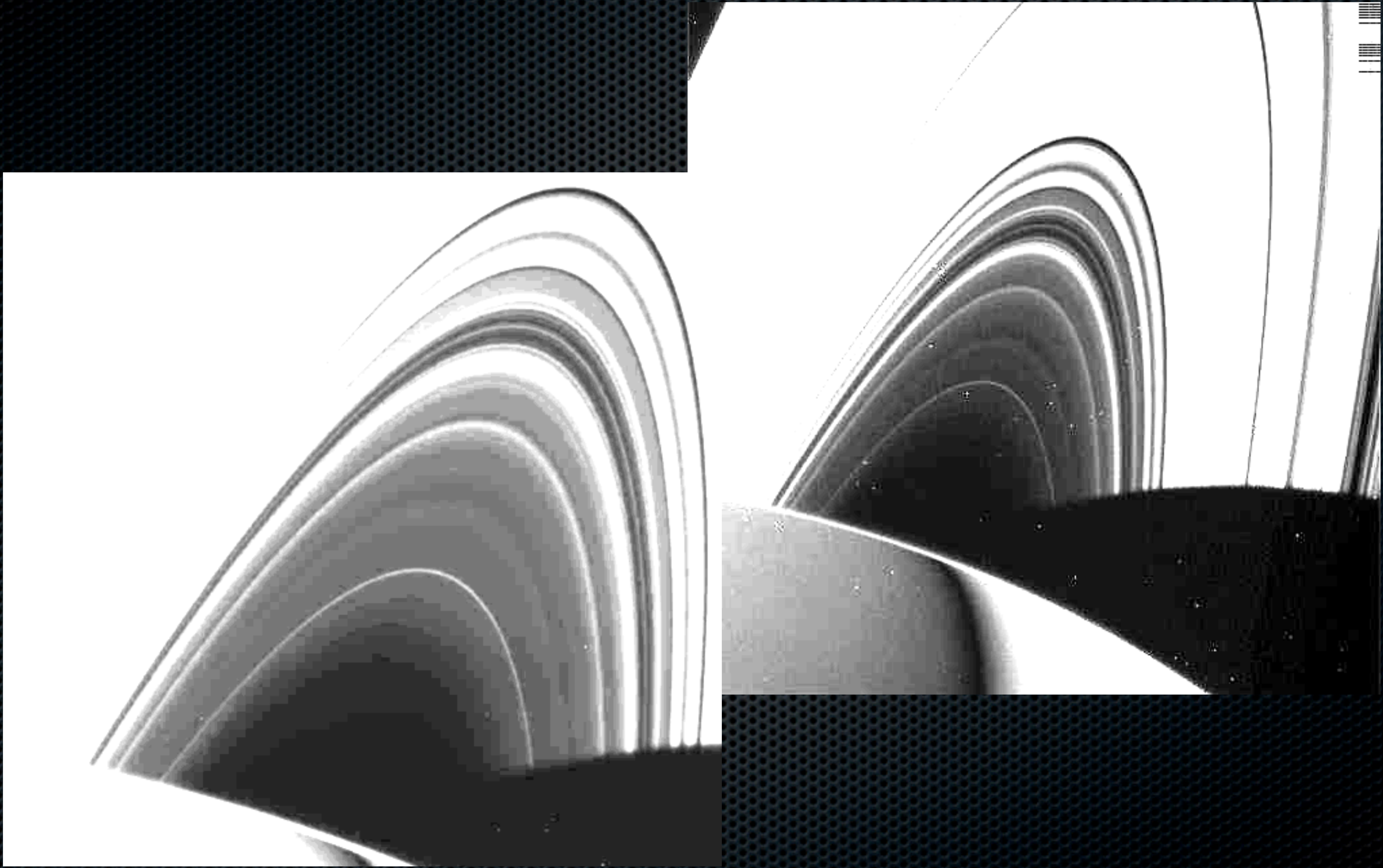
Saturn's D Ring



> *"The whole point of leaving home is to go somewhere, not to endlessly circle the block"*
>
> *- Wes Huntress, former NASA Associate Administrator for Space Science*

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