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# Charging of Planetary Surfaces and Dust Particles

as possible study cases

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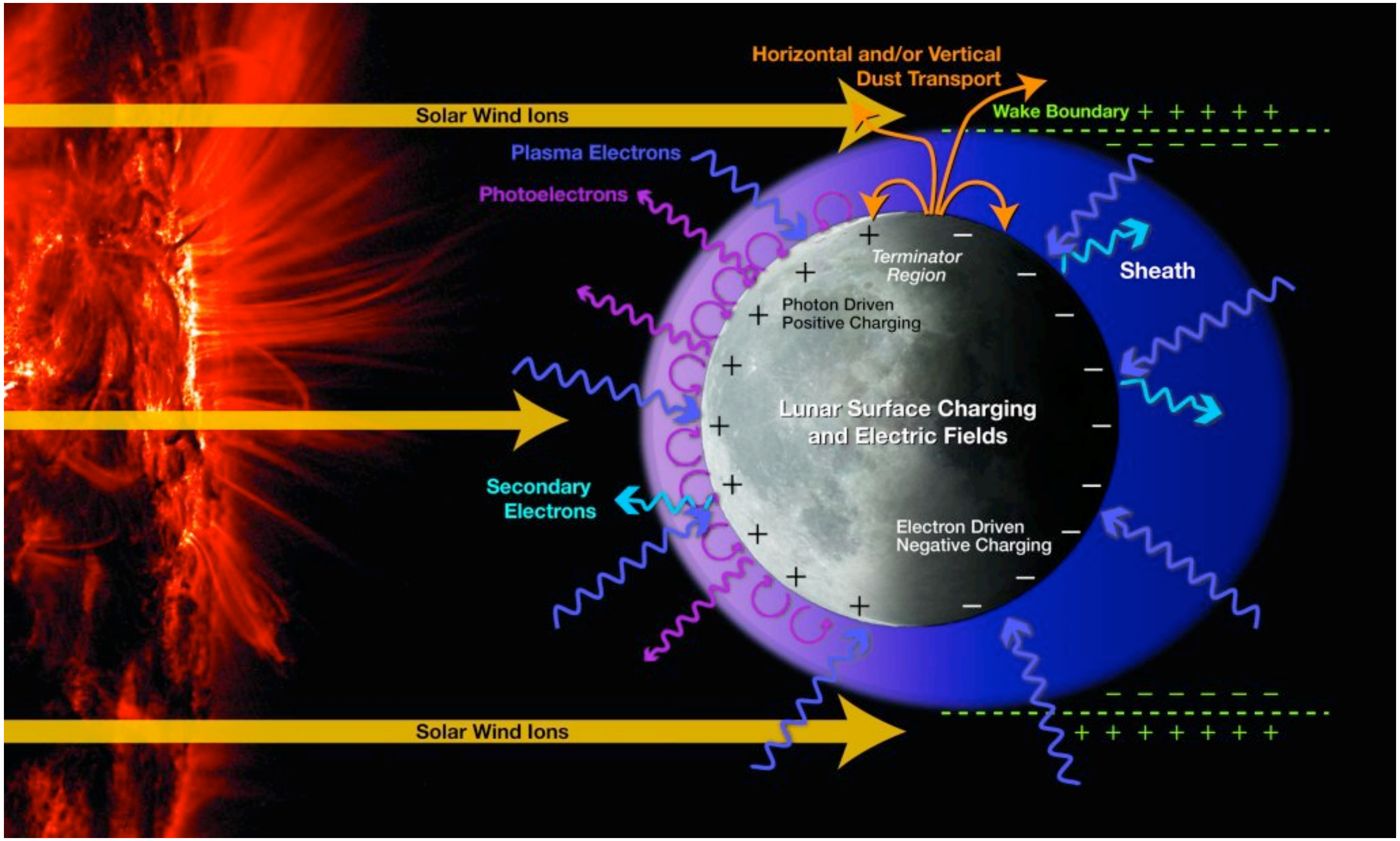
# The Earth’s Moon



- ✓ Local interaction of the surface and the impinging plasma
- ✓ Charged dust ejection and transport
- ✓ Mission ARTEMIS (in orbit in March 2011, 2 s/c)

# The Earth’s Moon

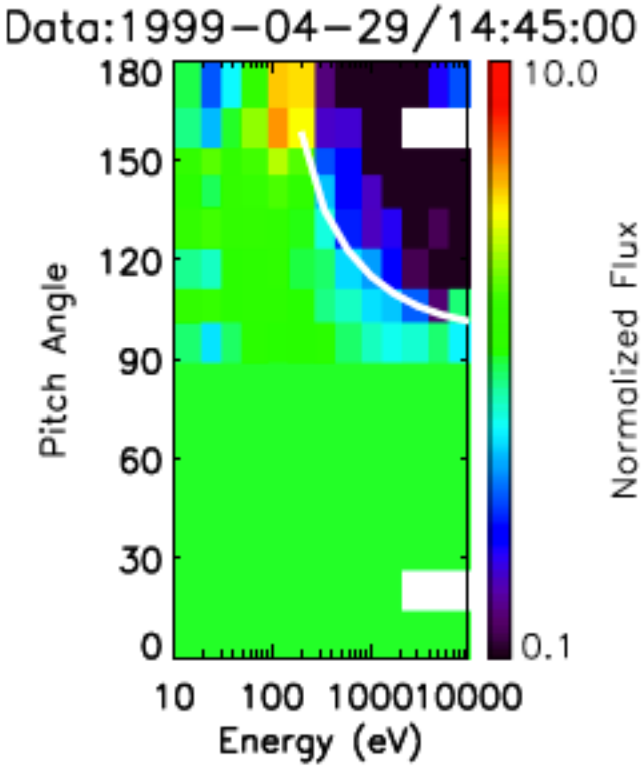
✓ Surface typically charged positive in sunlight and negative in shadow

Table 1. Typical Ambient Plasma Properties and Resulting Lunar Surface Potentials

| | Tail Lobe | Plasma Sheet | Solar Wind | Wake | SEP Event |
|---|---|---|---|---|---|
| Electron density | $0.001-0.5\ \text{cm}^{-3}$ | $0.01-1\ \text{cm}^{-3}$ | $0.5-10\ \text{cm}^{-3}$ | $0.001-0.1\ \text{cm}^{-3}$ | $0.001-0.1\ \text{cm}^{-3}$ in wake |
| Electron temperature | <100 eV | 100 eV to 2 keV | 5–30 eV | 50–150 eV | 50 eV to 1 keV in wake |
| Lunar surface potential | −150 to 0 V | −1000 to 0 V | <20 V | −200 to 0 V | −1000 to −4000 V in wake |

✓ Variable potentials (changing solar illumination and plasma conditions)

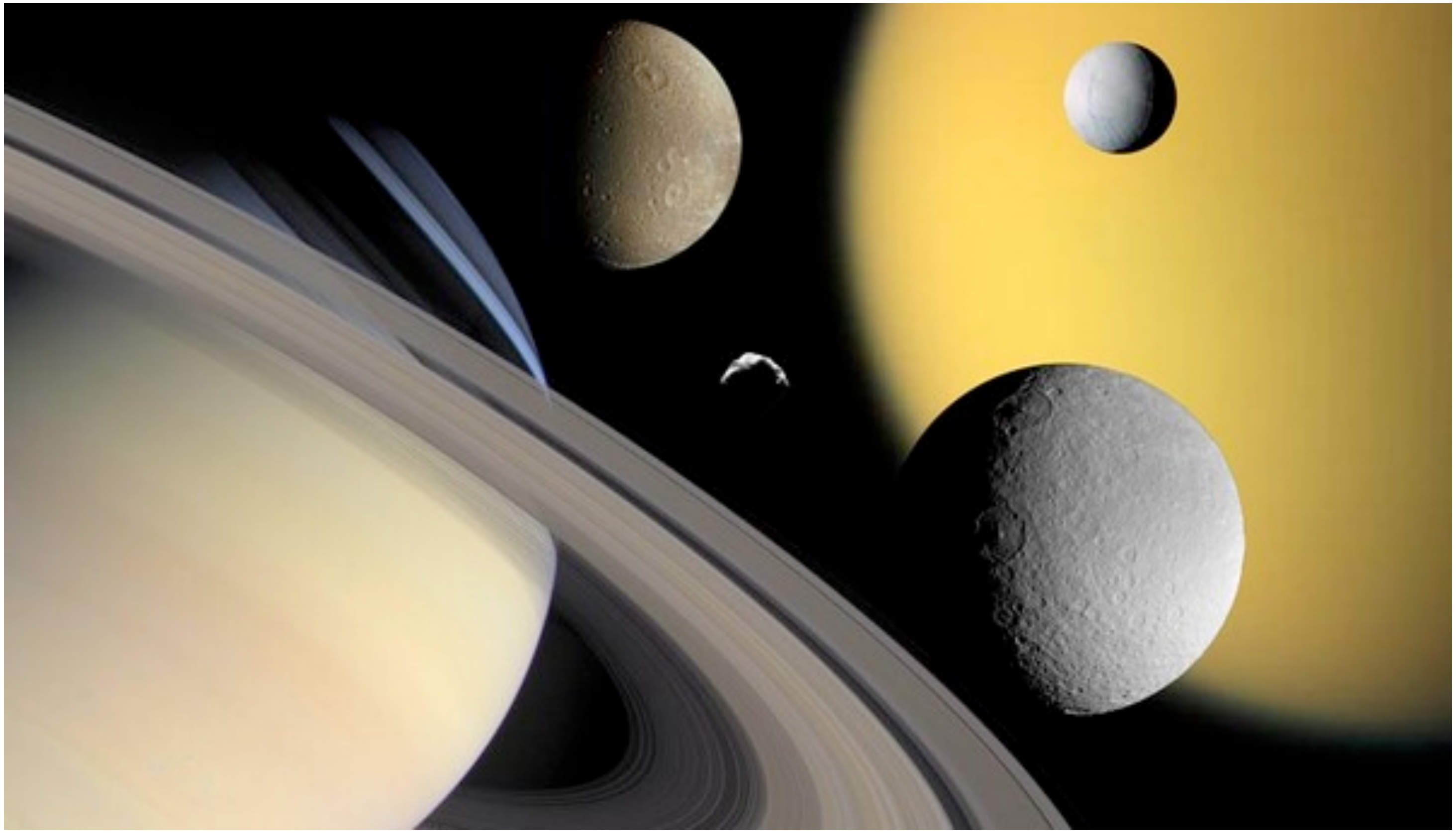
Halekas et al., GRL, 2007; JGR, 2008



Lunar Prospector observations:

○ Field-aligned electron beam with energies corresponding to the potential difference btw surface and the spacecraft

# Icy satellites of giant planets

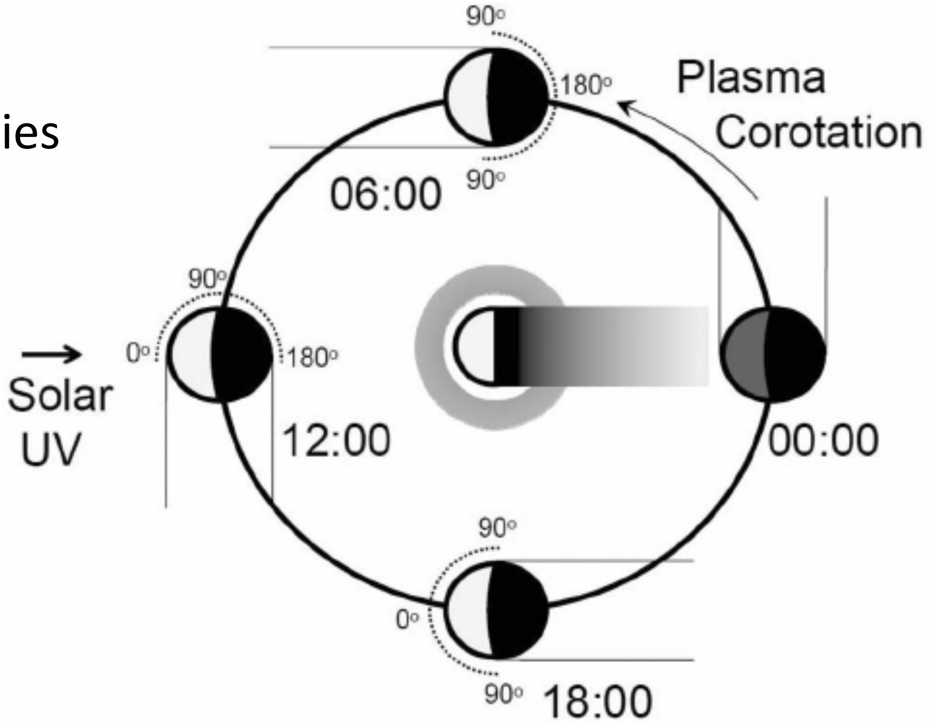


- ✓ Numerous plasma absorbing moons
- ✓ Low surface conductivity (ice)
- ✓ Mission CASSINI (2004-2017, numerous icy moon flybys)

# Icy satellites of giant planets

- ✓ More diverse interaction geometries
- ✓ Strong LT effects

Roussos et al., JGR, 2010



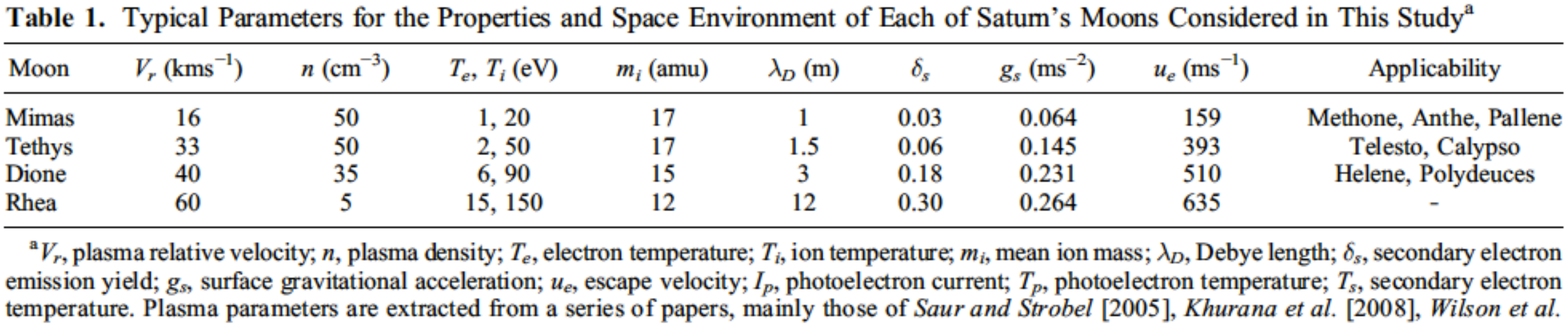


**Table 1.** Typical Parameters for the Properties and Space Environment of Each of Saturn's Moons Considered in This Study[a]

| Moon | $V_r$ (kms$^{-1}$) | $n$ (cm$^{-3}$) | $T_e$, $T_i$ (eV) | $m_i$ (amu) | $\lambda_D$ (m) | $\delta_s$ | $g_s$ (ms$^{-2}$) | $u_e$ (ms$^{-1}$) | Applicability |
|---|---|---|---|---|---|---|---|---|---|
| Mimas | 16 | 50 | 1, 20 | 17 | 1 | 0.03 | 0.064 | 159 | Methone, Anthe, Pallene |
| Tethys | 33 | 50 | 2, 50 | 17 | 1.5 | 0.06 | 0.145 | 393 | Telesto, Calypso |
| Dione | 40 | 35 | 6, 90 | 15 | 3 | 0.18 | 0.231 | 510 | Helene, Polydeuces |
| Rhea | 60 | 5 | 15, 150 | 12 | 12 | 0.30 | 0.264 | 635 | - |

[a] $V_r$, plasma relative velocity; $n$, plasma density; $T_e$, electron temperature; $T_i$, ion temperature; $m_i$, mean ion mass; $\lambda_D$, Debye length; $\delta_s$, secondary electron emission yield; $g_s$, surface gravitational acceleration; $u_e$, escape velocity; $I_p$, photoelectron current; $T_p$, photoelectron temperature; $T_s$, secondary electron temperature. Plasma parameters are extracted from a series of papers, mainly those of *Saur and Strobel* [2005], *Khurana et al.* [2008], *Wilson et al.*

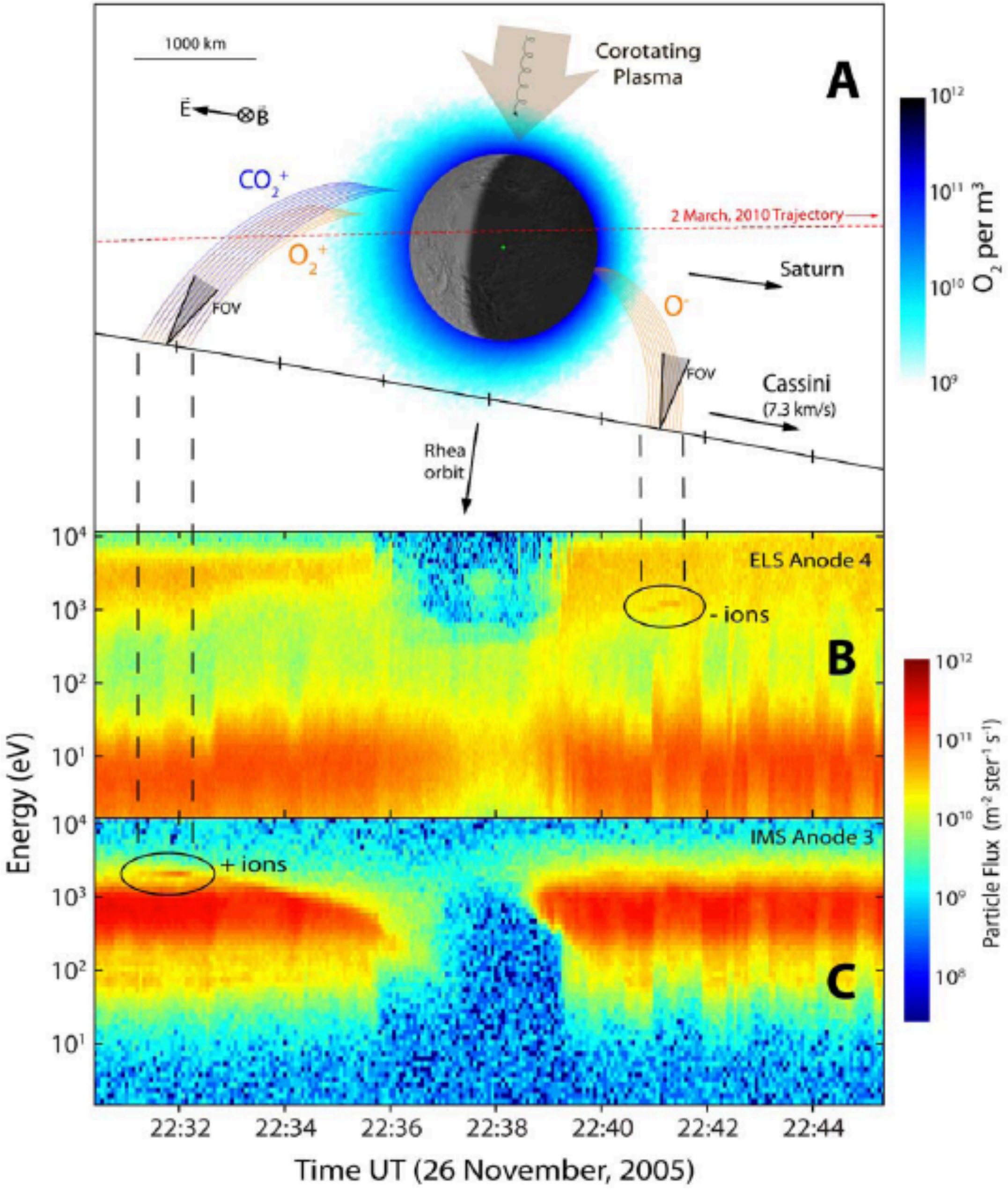
# Rhea

✓ When positively charged, electrons are absorbed

✓ When negatively charged, electrons are reflected

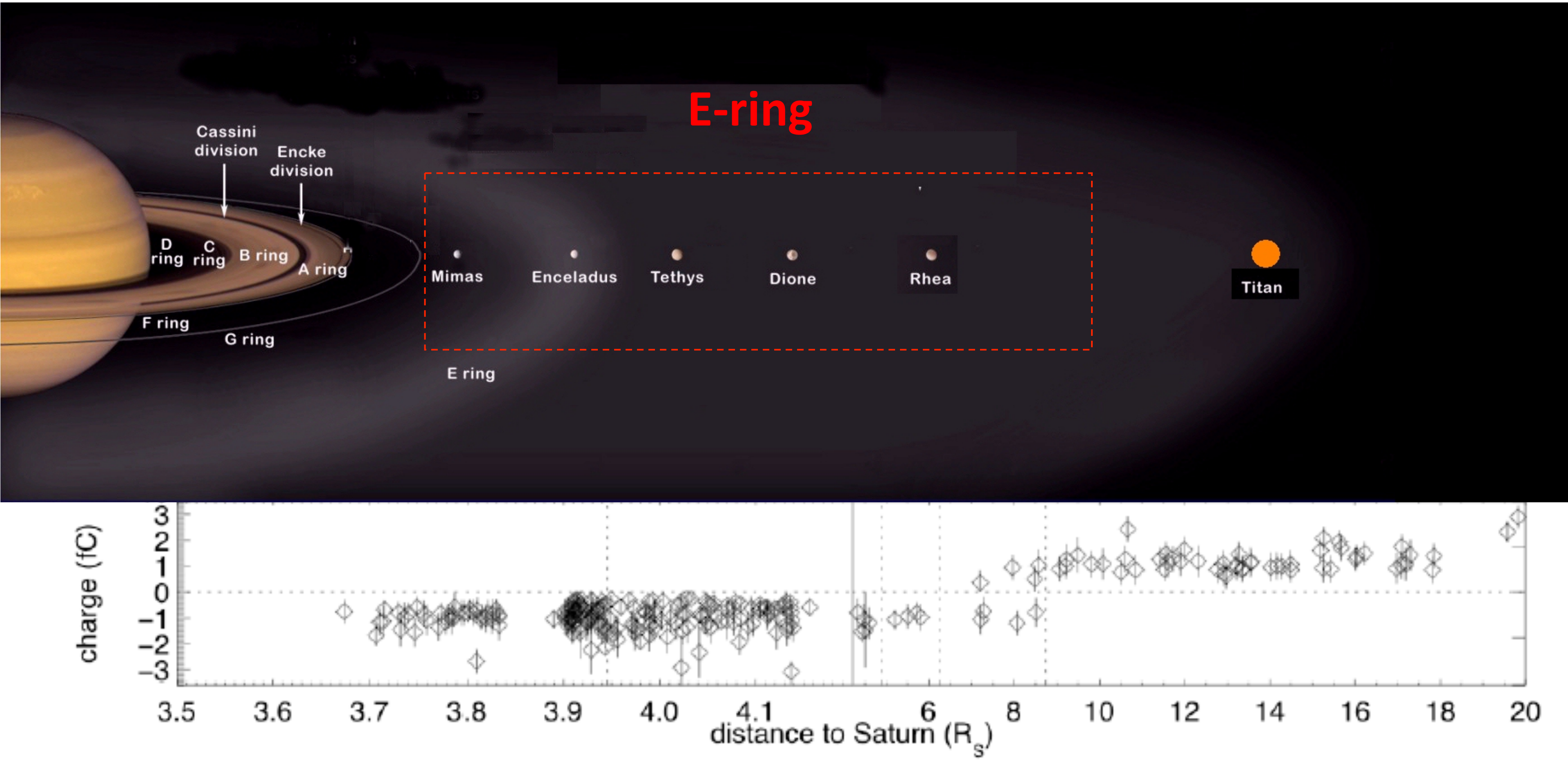
✓ Observed by Cassini/CAPS

Jones et al., AGU, 2010



Teolis et al., Science, 2010

# Dust particles
# (Saturn’s E-ring, comets, interplanetary)



- ✓ Dust charge measured by Cassini CDA

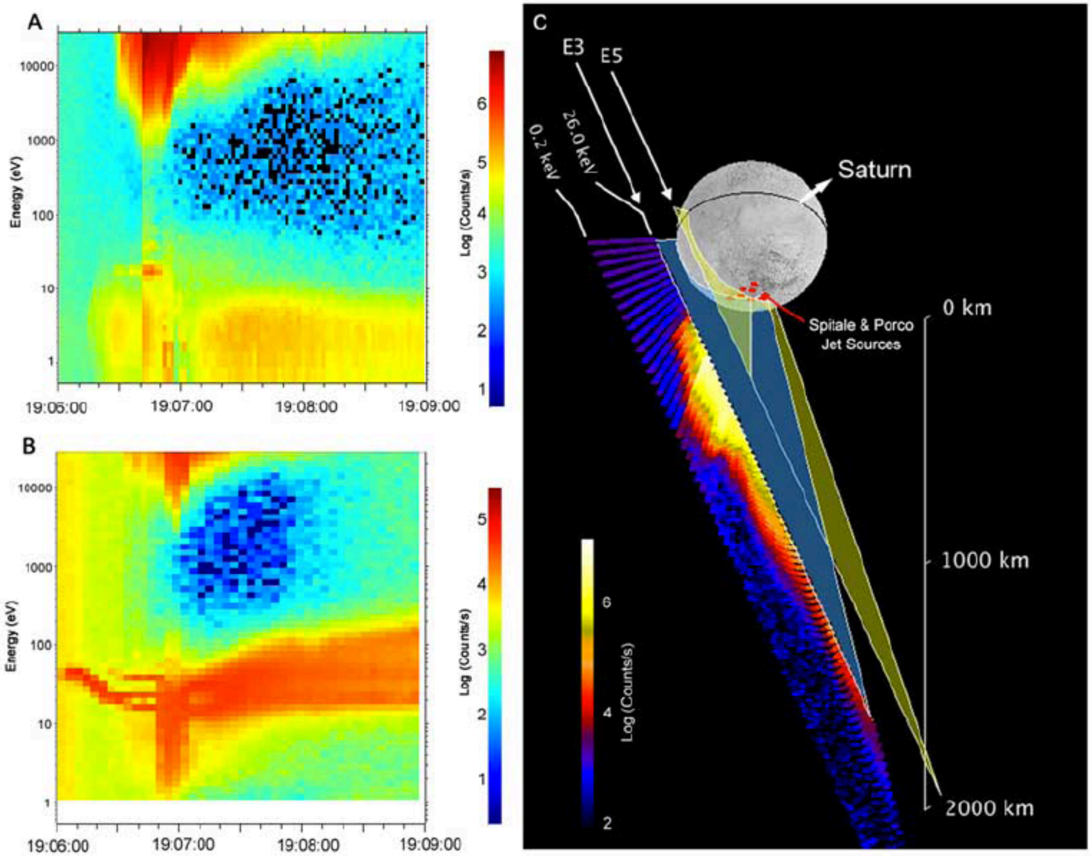
# Dust particles
# (Saturn’s E-ring, comets, interplanetary)

✓ Enceladus

✓ Dust streams

✓ Charge separation of oppositely-charged grains observed by Cassini/CAPS

Jones et al., GRL, 2008



# Summary

✓ Artificial AND Natural satellite-plasma interactions

*(Hopefully) convincing science cases presented*

✓ Use of SPIS to better understand particle data observed in planetary environments, not only for instrument response

*Simulation tools should enable one to conduct such studies*