

IOWA

Department of Physics and Astronomy: University of Iowa

The Dust and Plasma Environment of the Moon

Jasper S. Halekas

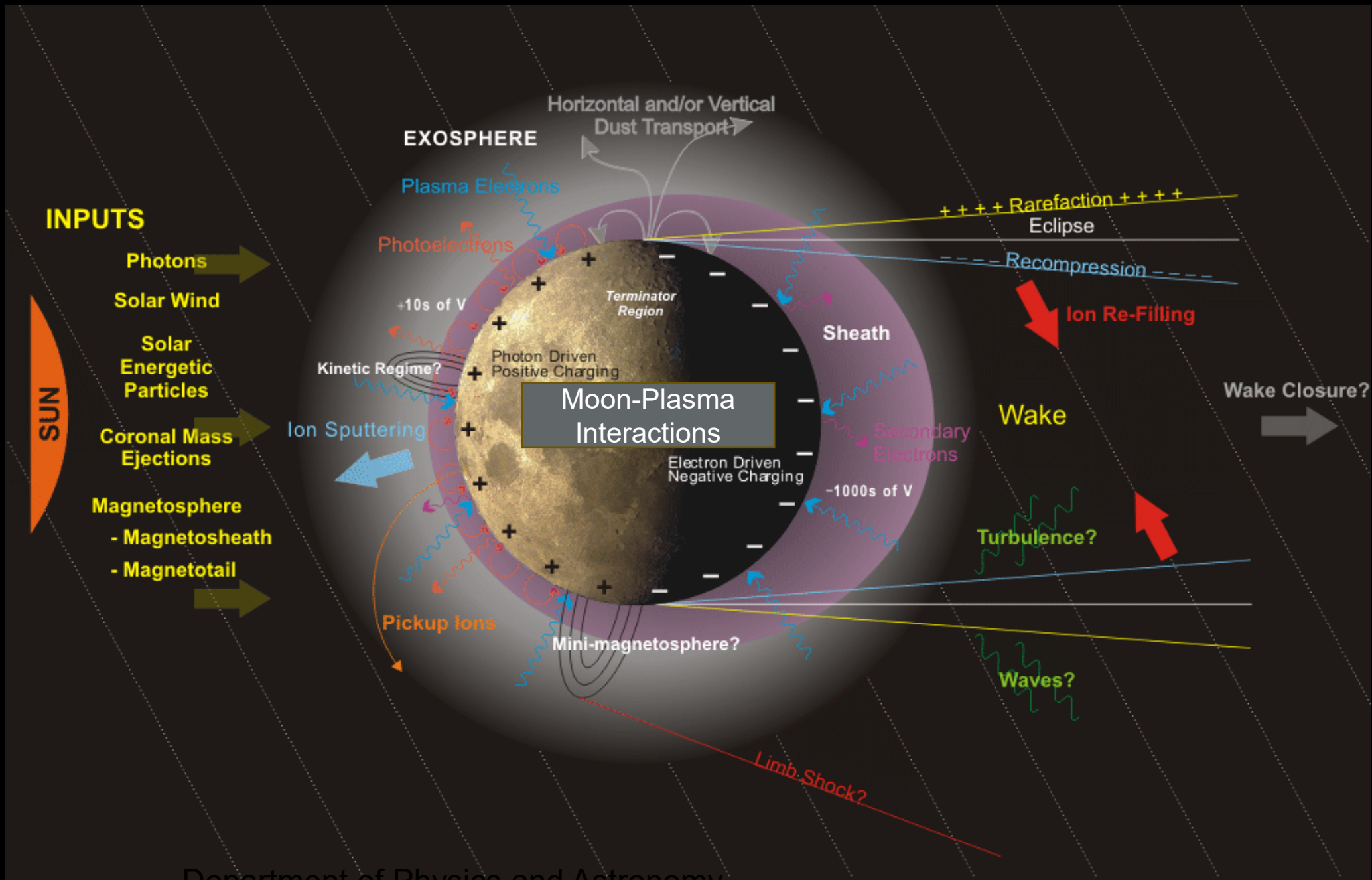
Decadal-Level Science with Humans on the Moon



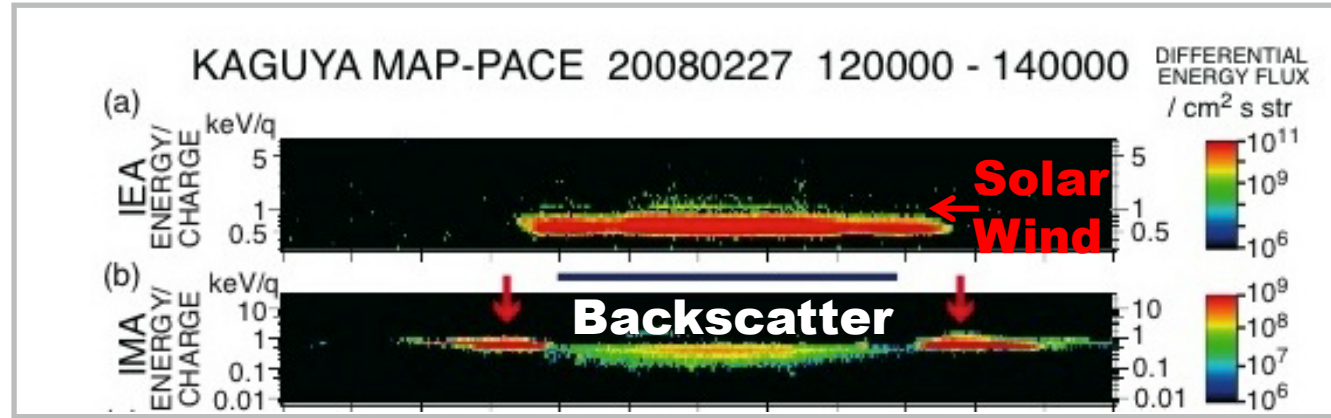
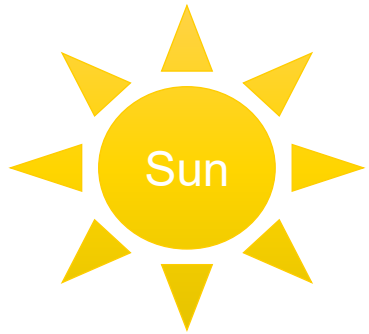
Outline

- I. Global Moon-Plasma Interactions
- II. Near-Surface Plasma Sheath + Dust
- III. Crustal Magnetic Fields
- IV. Connections & Traceability

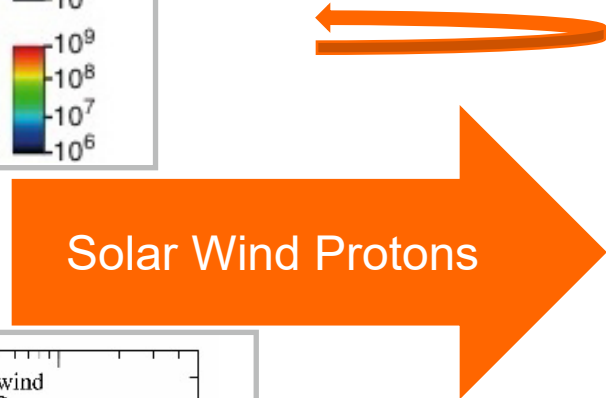
Global Moon-Plasma Interactions



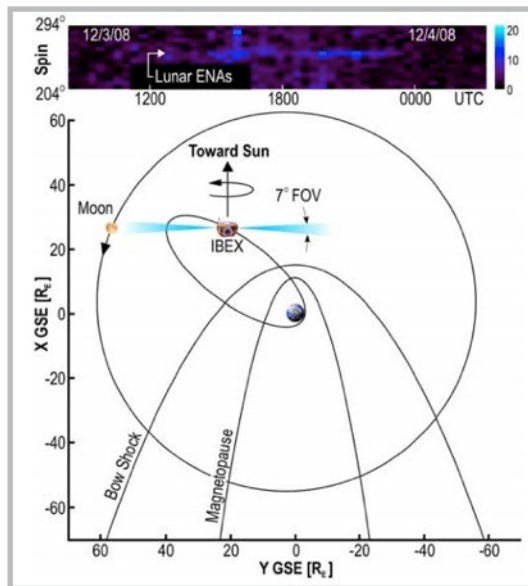
Surface Interaction



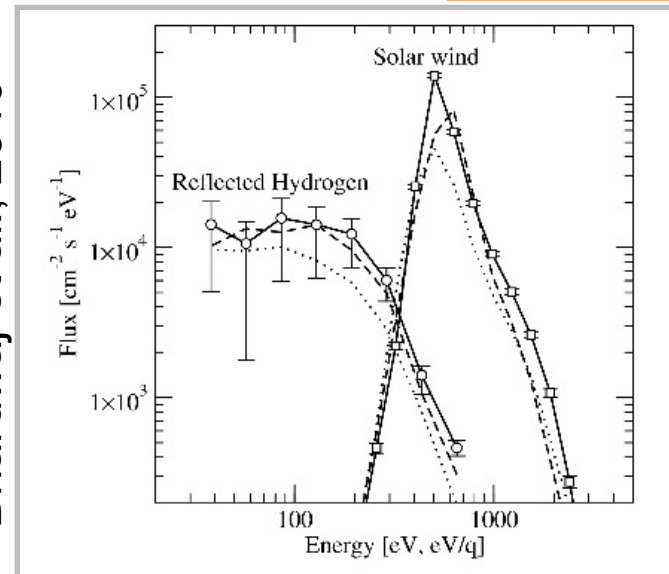
Saito et al., 2009



McComas et al., 2009



Bhardwaj et al., 2010

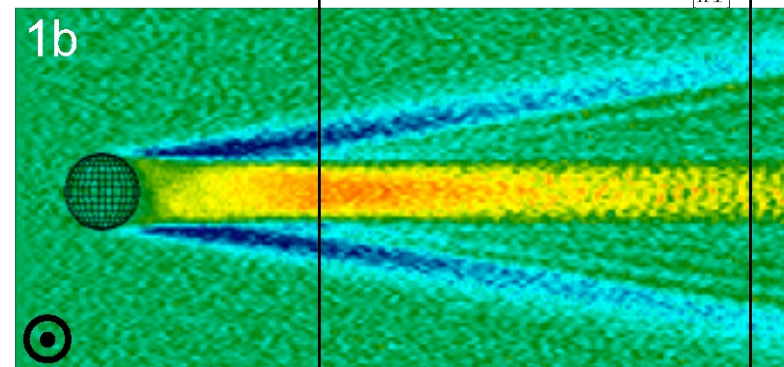
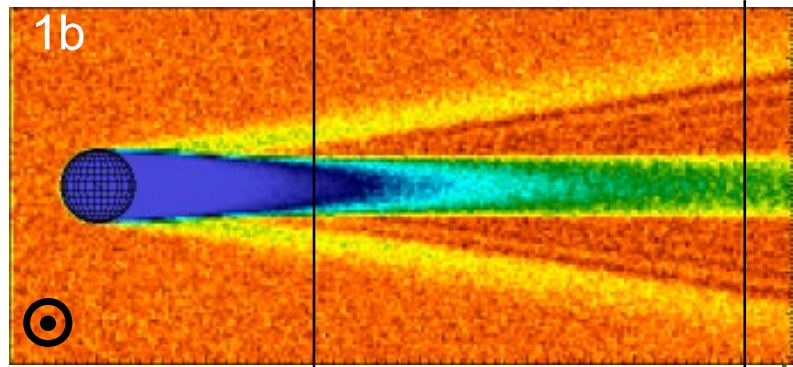
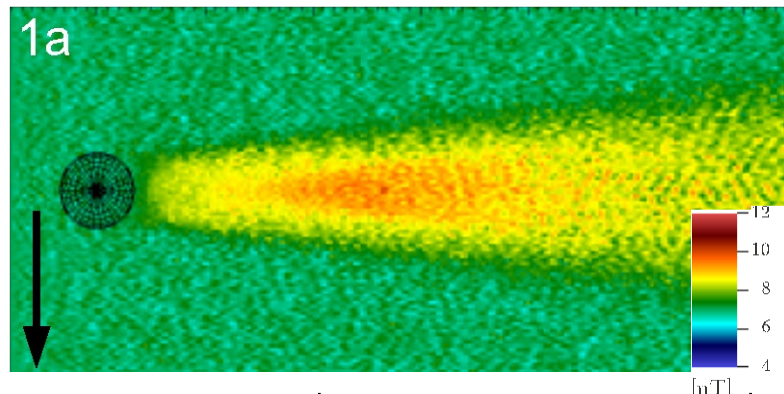
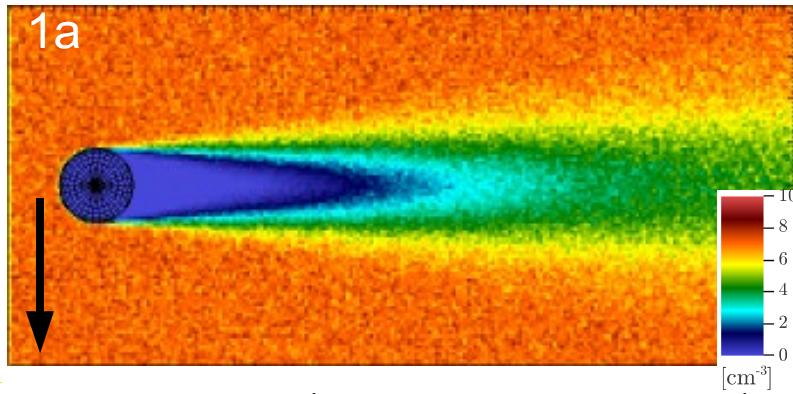


Lunar Regolith

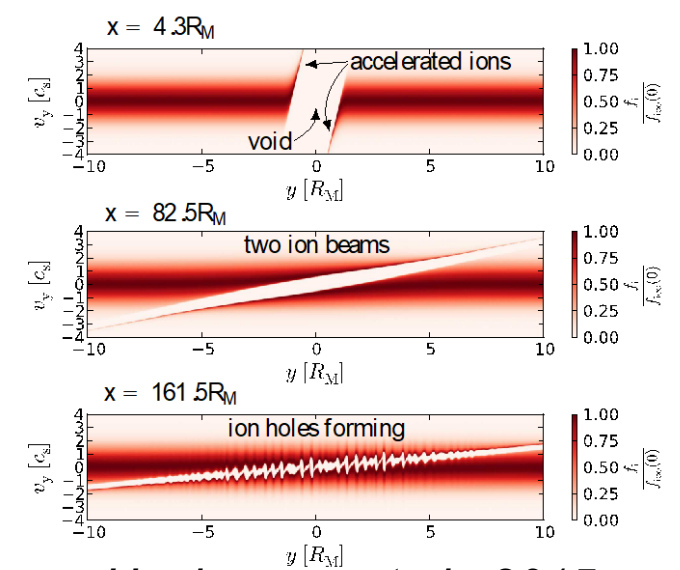
Lunar Wake

Density

Magnetic Field

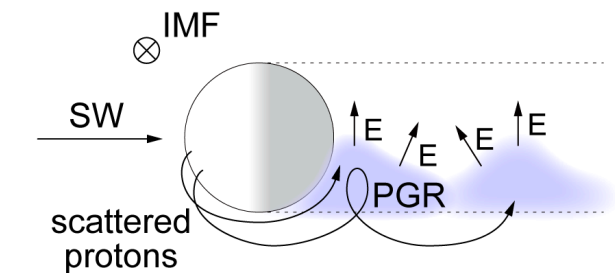


Holmstrom et al., 2012

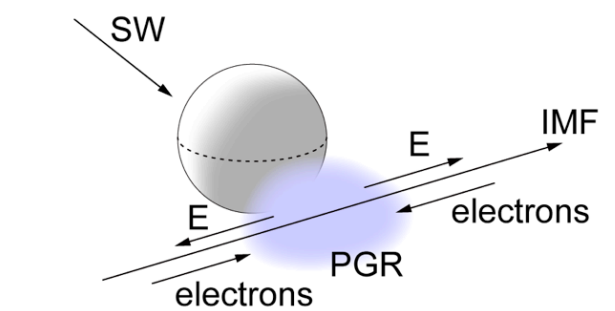


Haakonsen et al., 2015

a side view

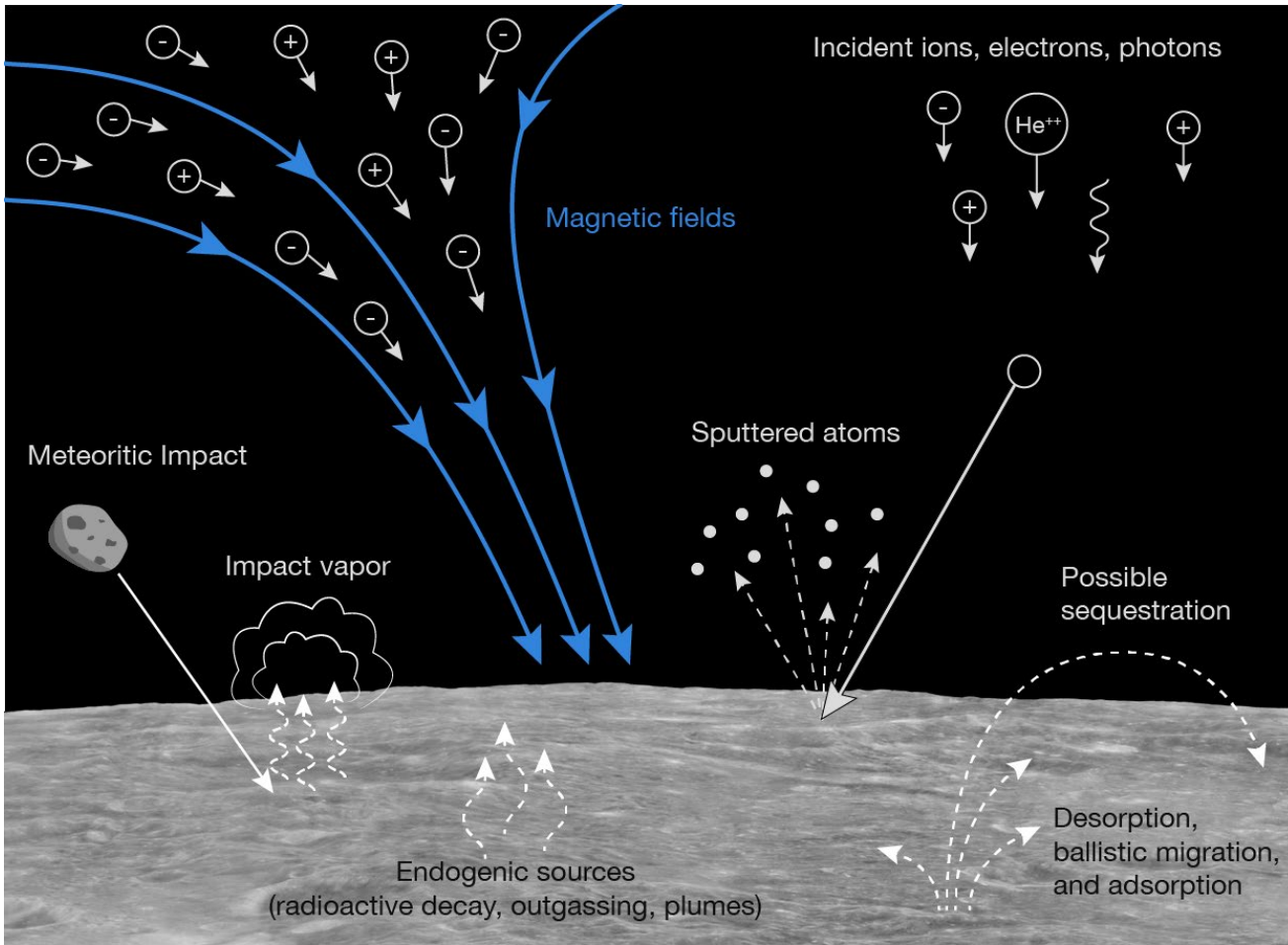


b tilted view



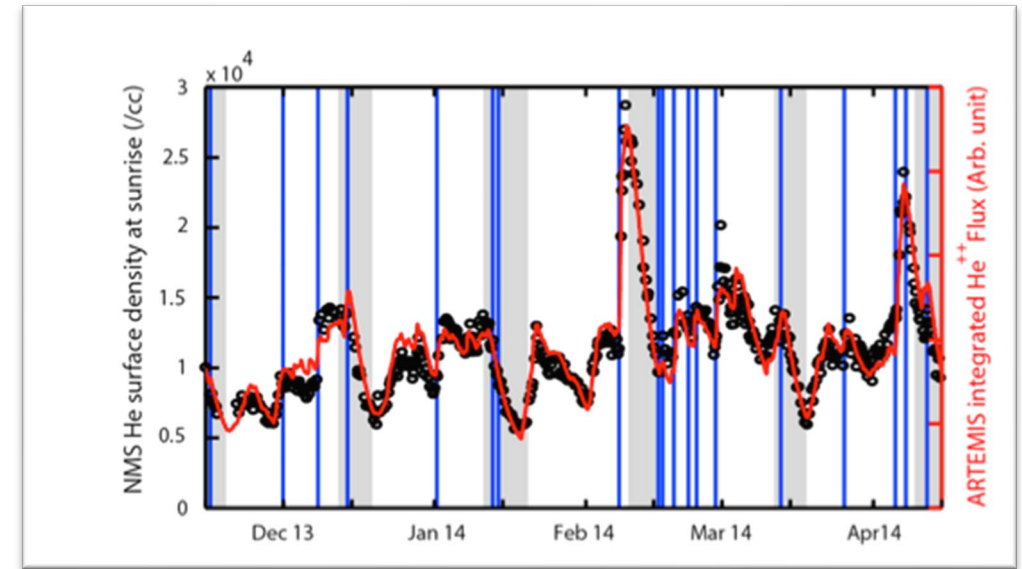
Nishino et al., 2009, 2010

Exosphere/Ionosphere



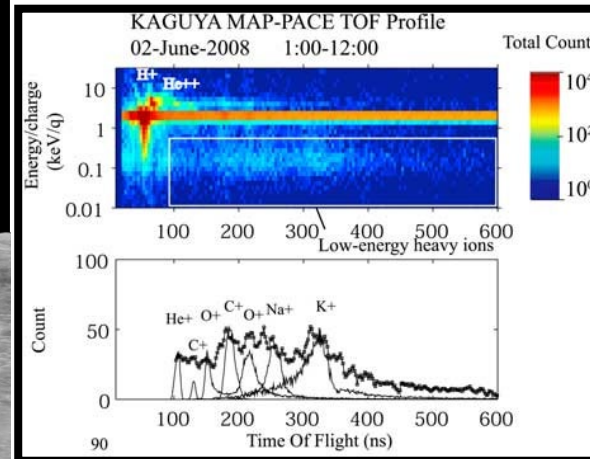
Planetary Decadal Survey

Plasma Source

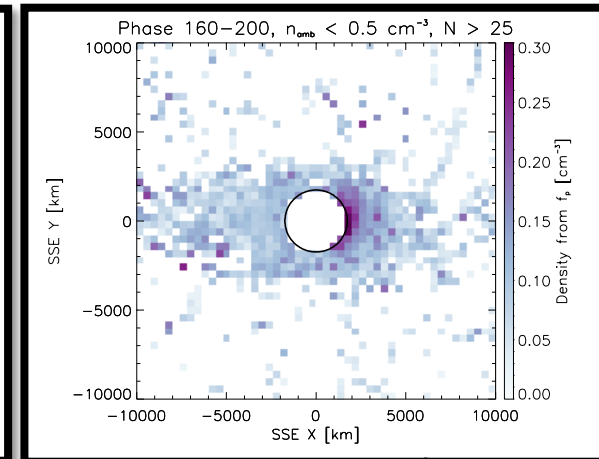


Benna et al., 2015

Plasma Sink

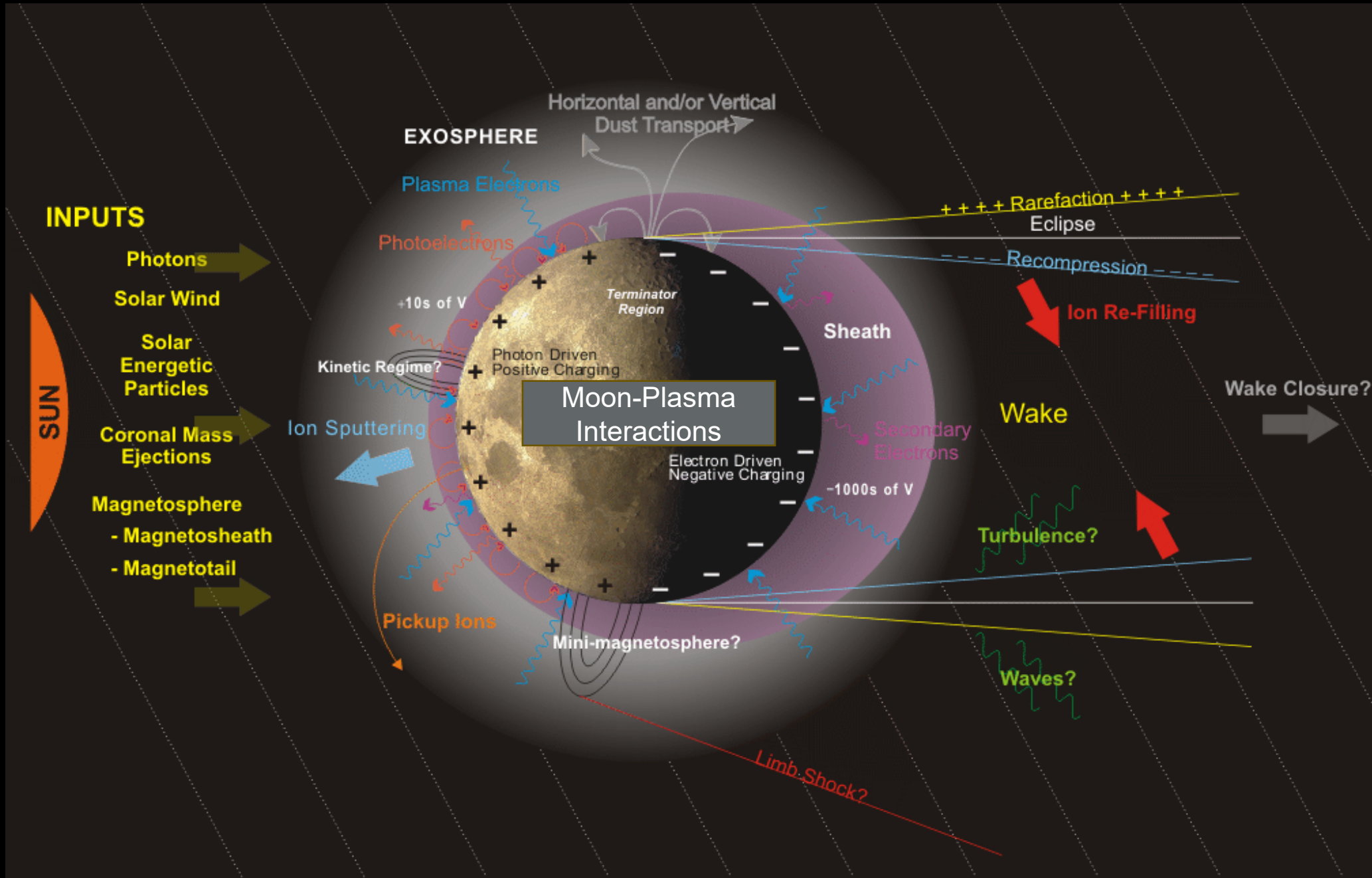


Yokota et al., 2009

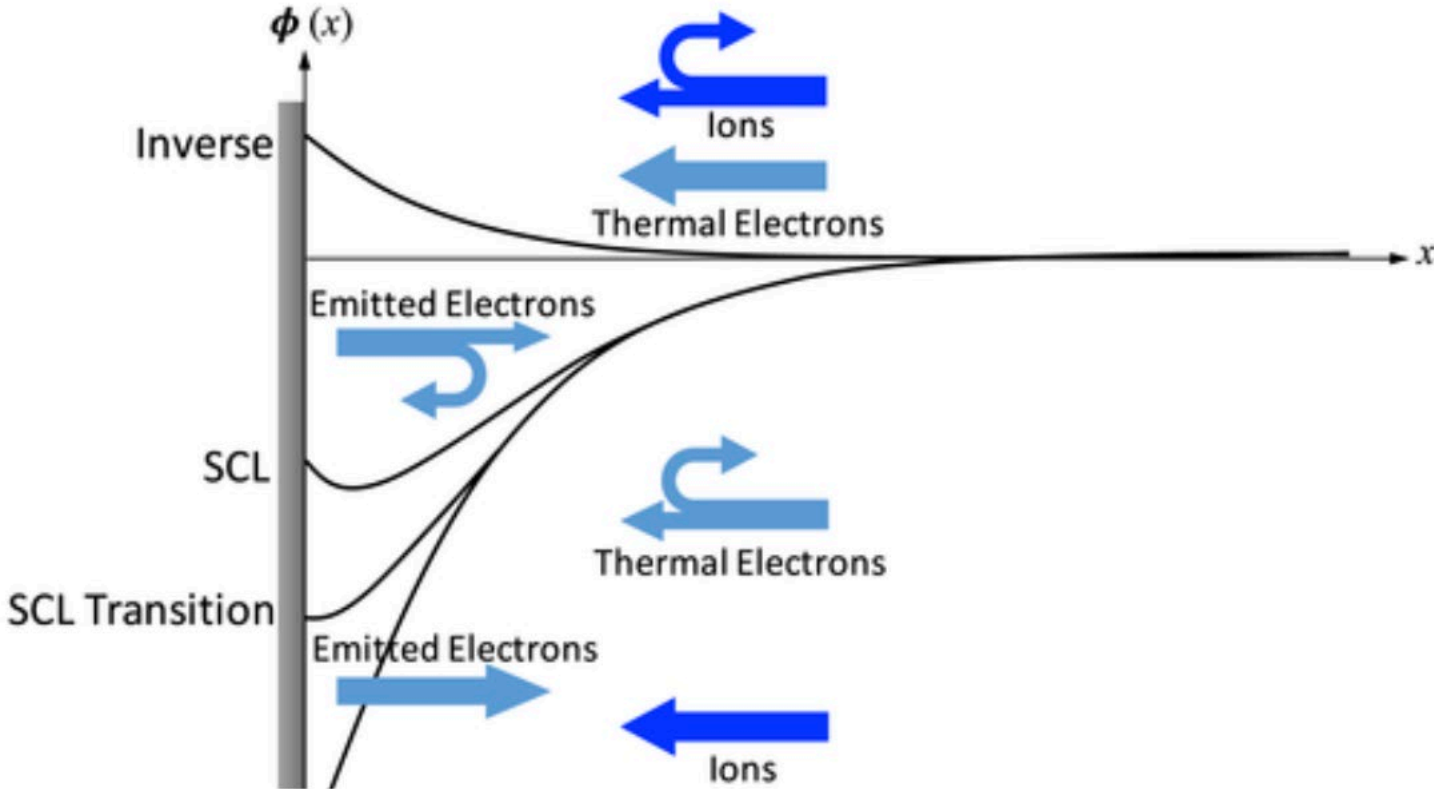


Halekas et al., 2018

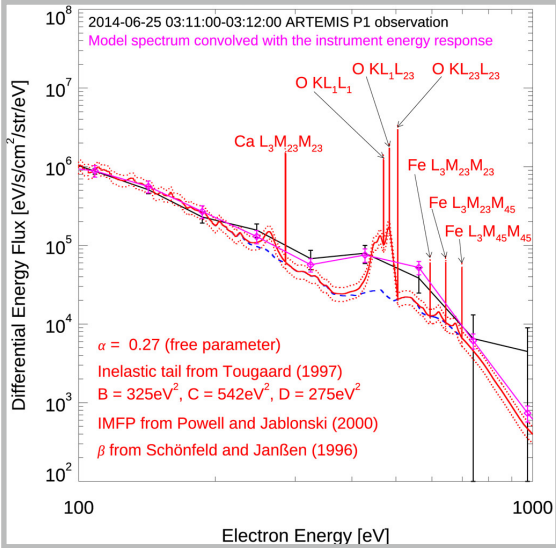
Near-Surface Plasma Sheath + Dust



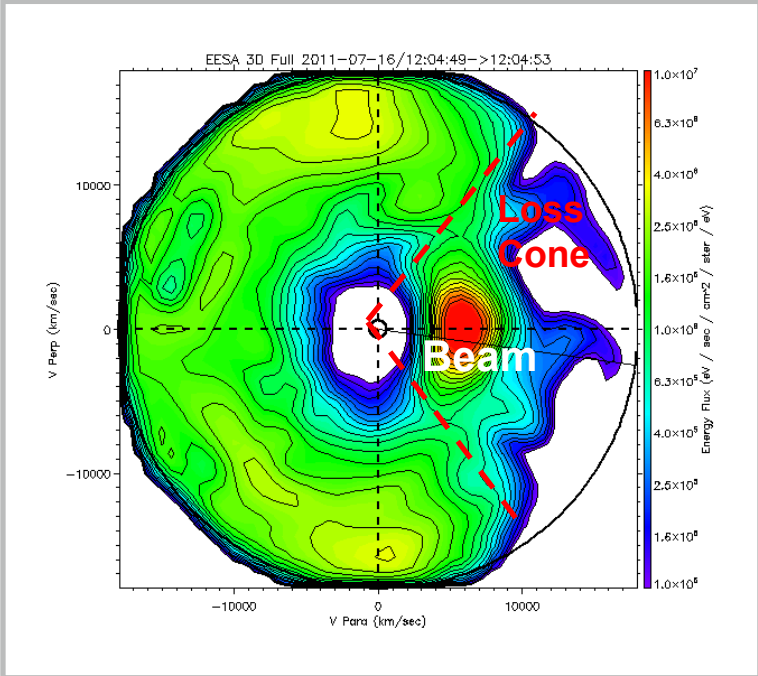
Charging & Currents



Wang et al., 2016

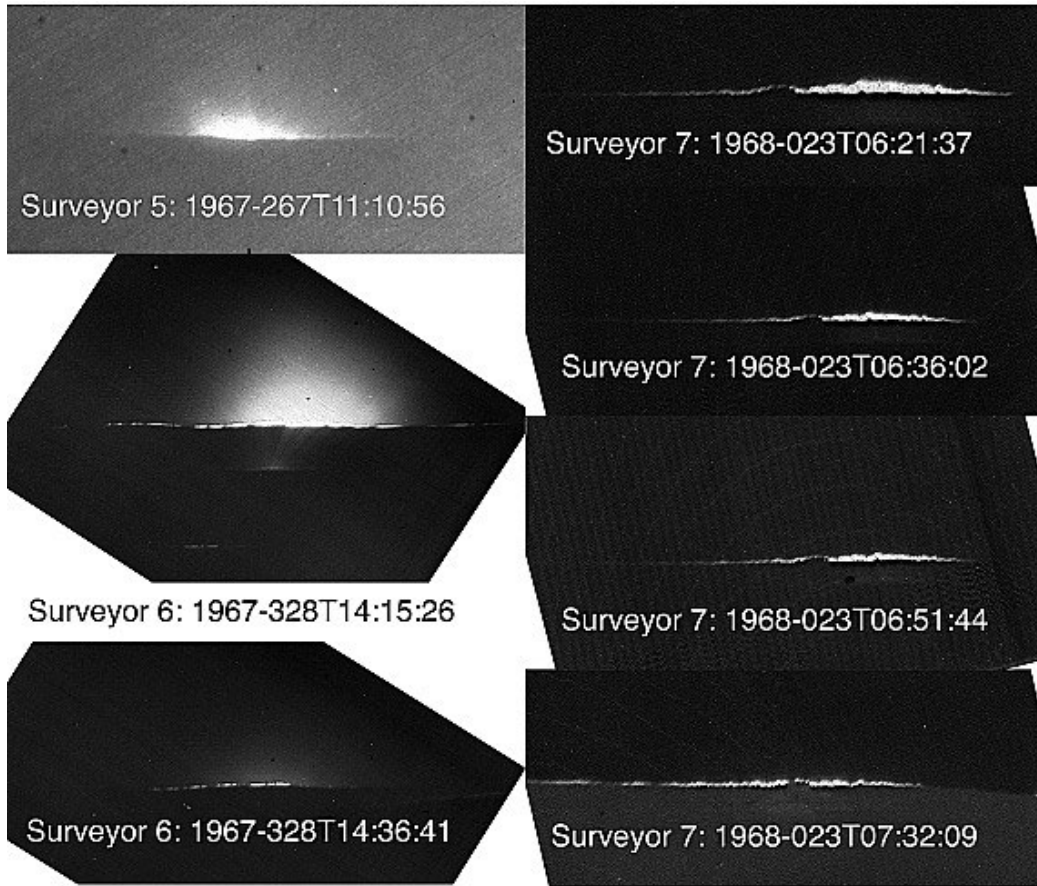


Kato et al., 2023

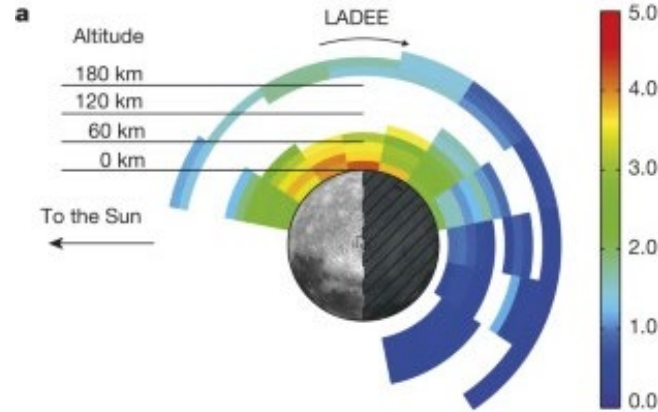


Halekas et al., 2011

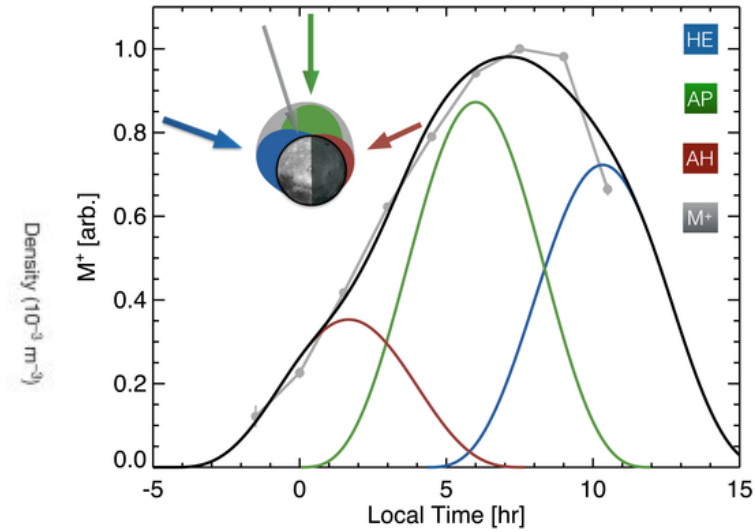
Dust: Observations



Rennilson and Criswell, 1974



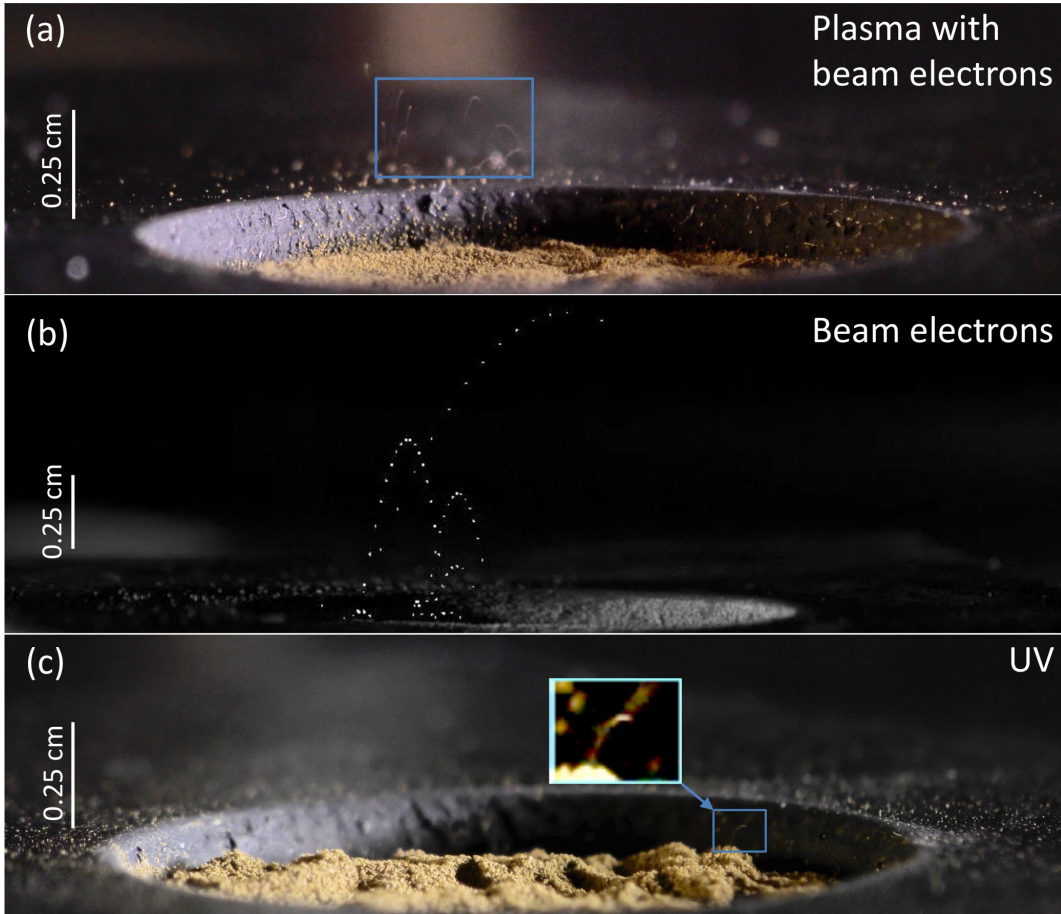
Horanyi et al., 2015



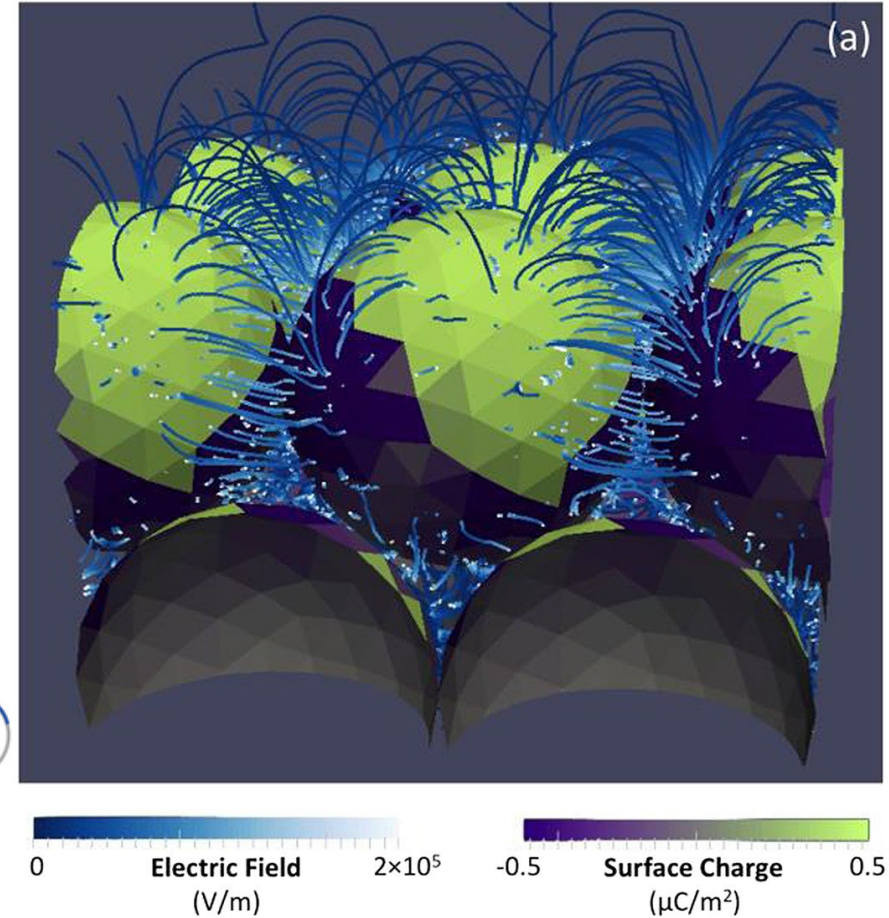
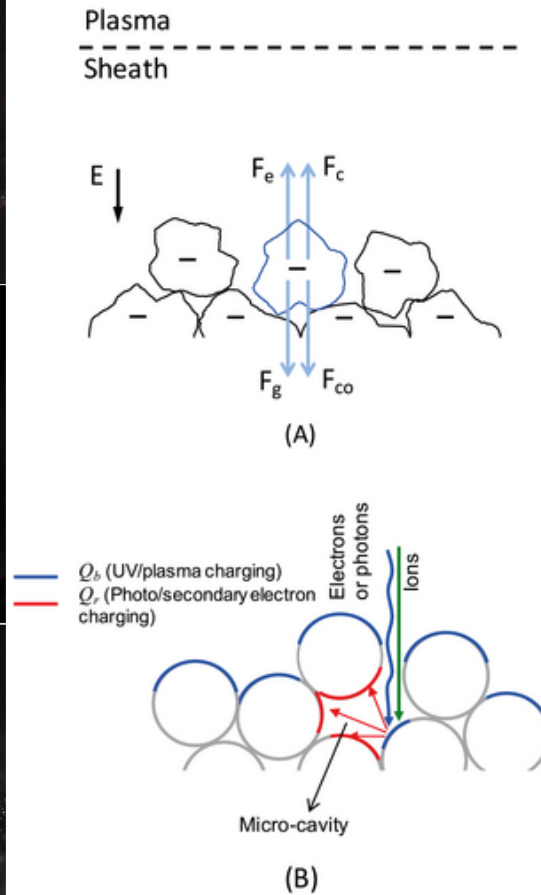
Szalay et al., 2017



Dust: Physics

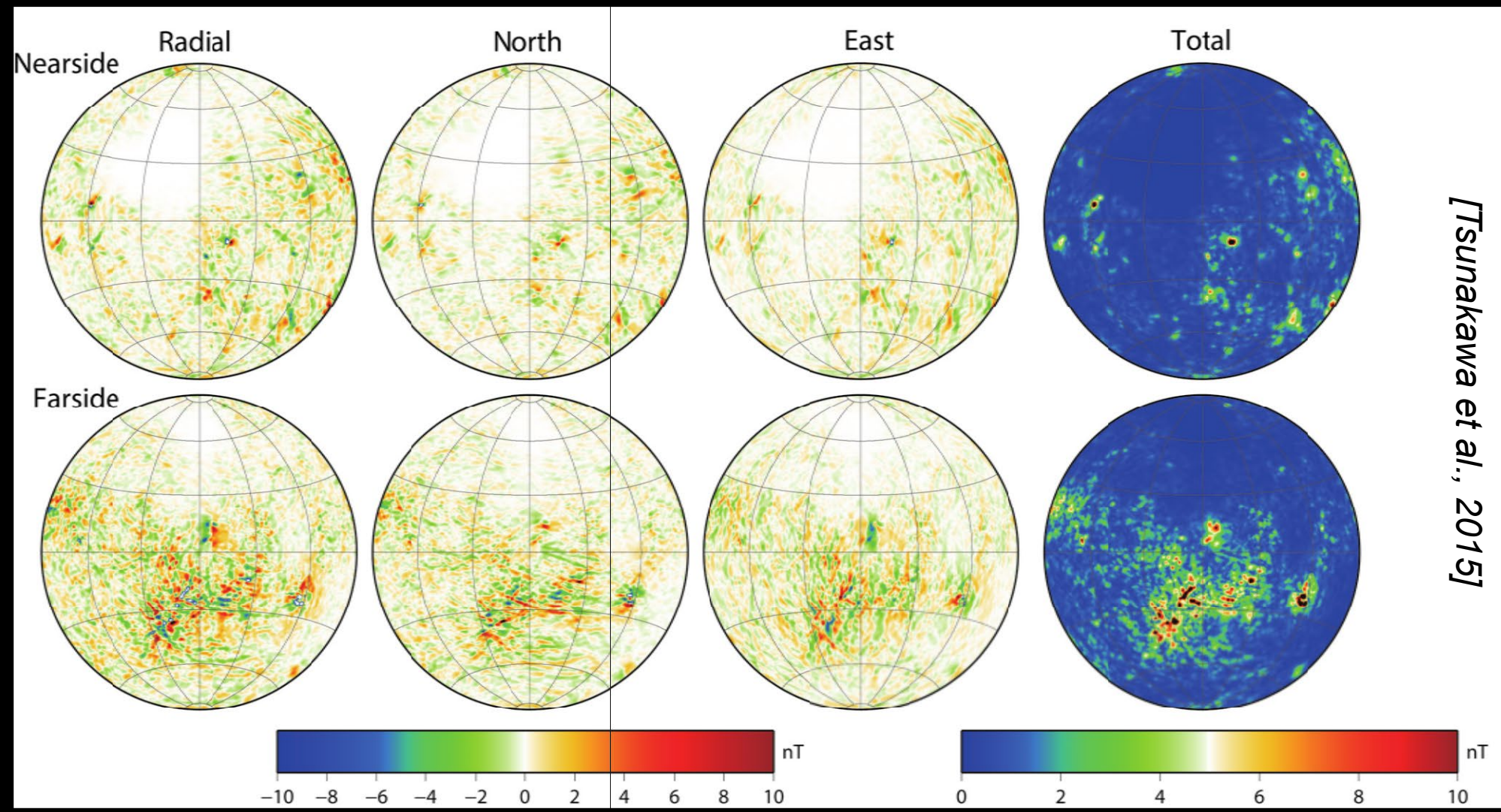


Sickafoose et al., 2002; Wang, 2016



Zimmerman et al., 2016

Crustal Magnetic Fields

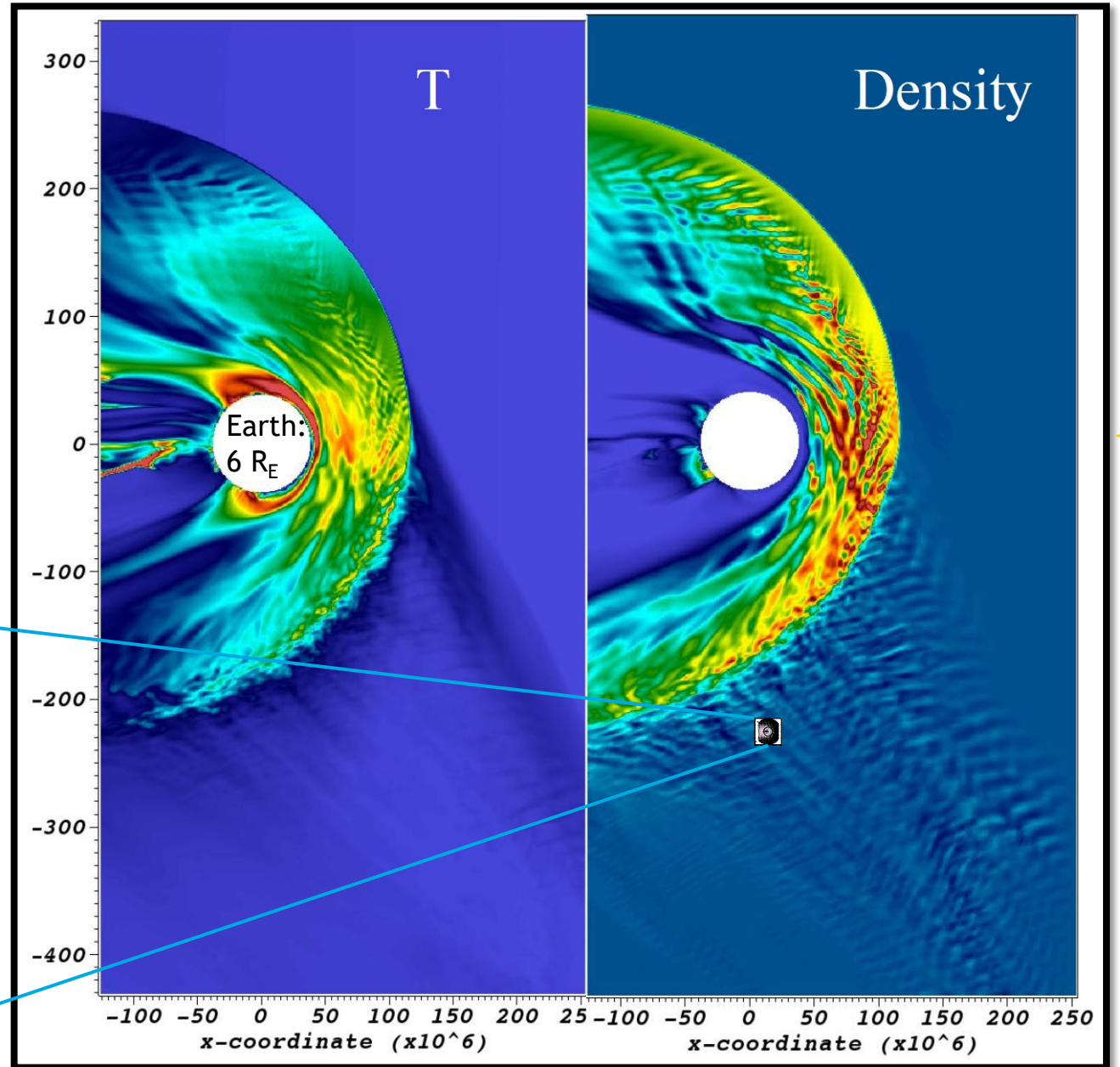
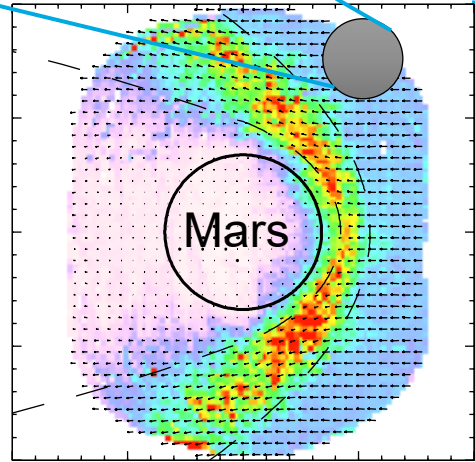
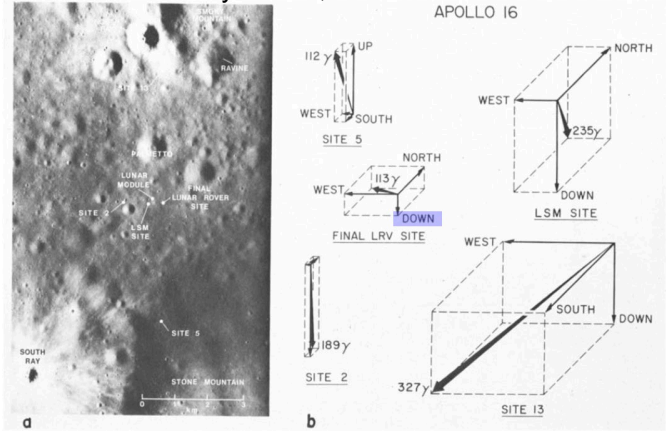
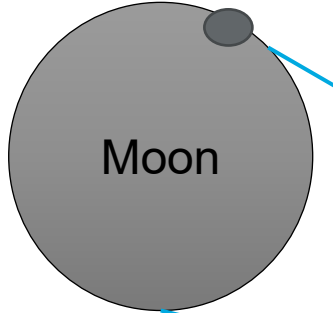


[Tsunakawa et al., 2015]

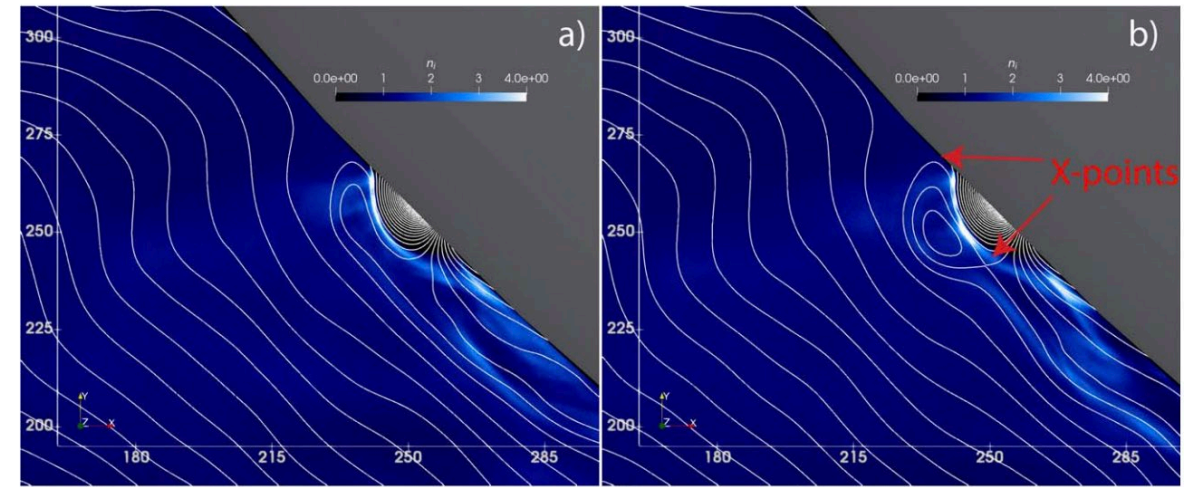
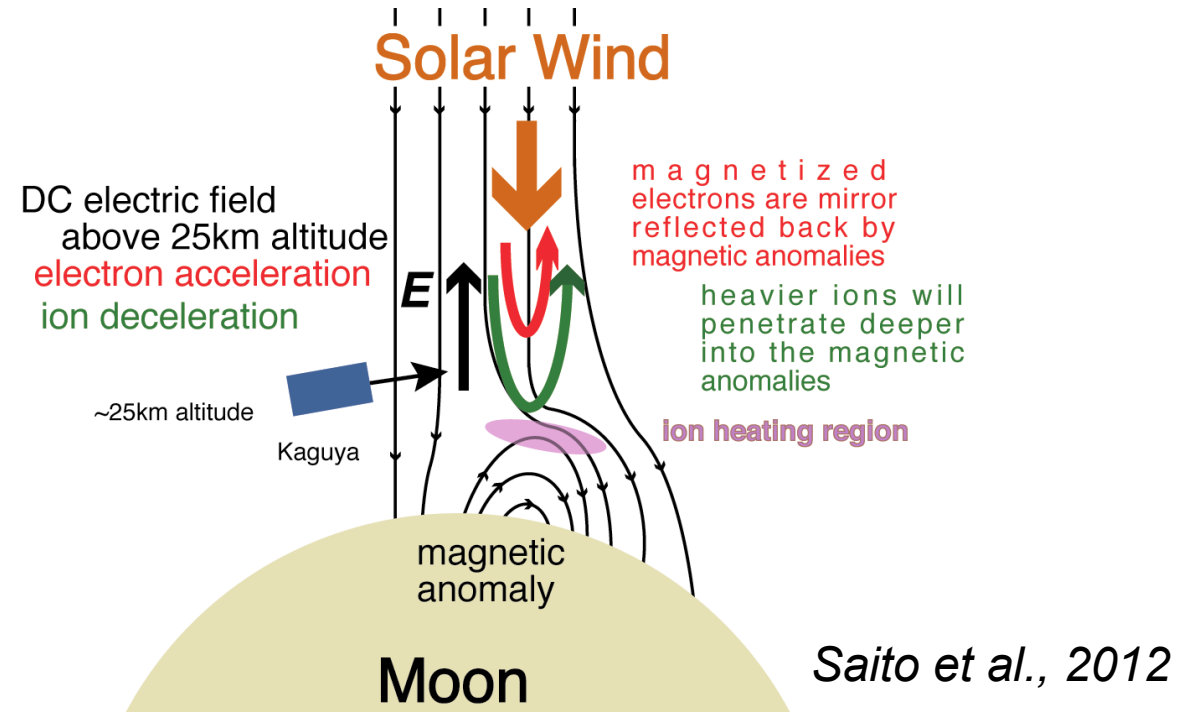
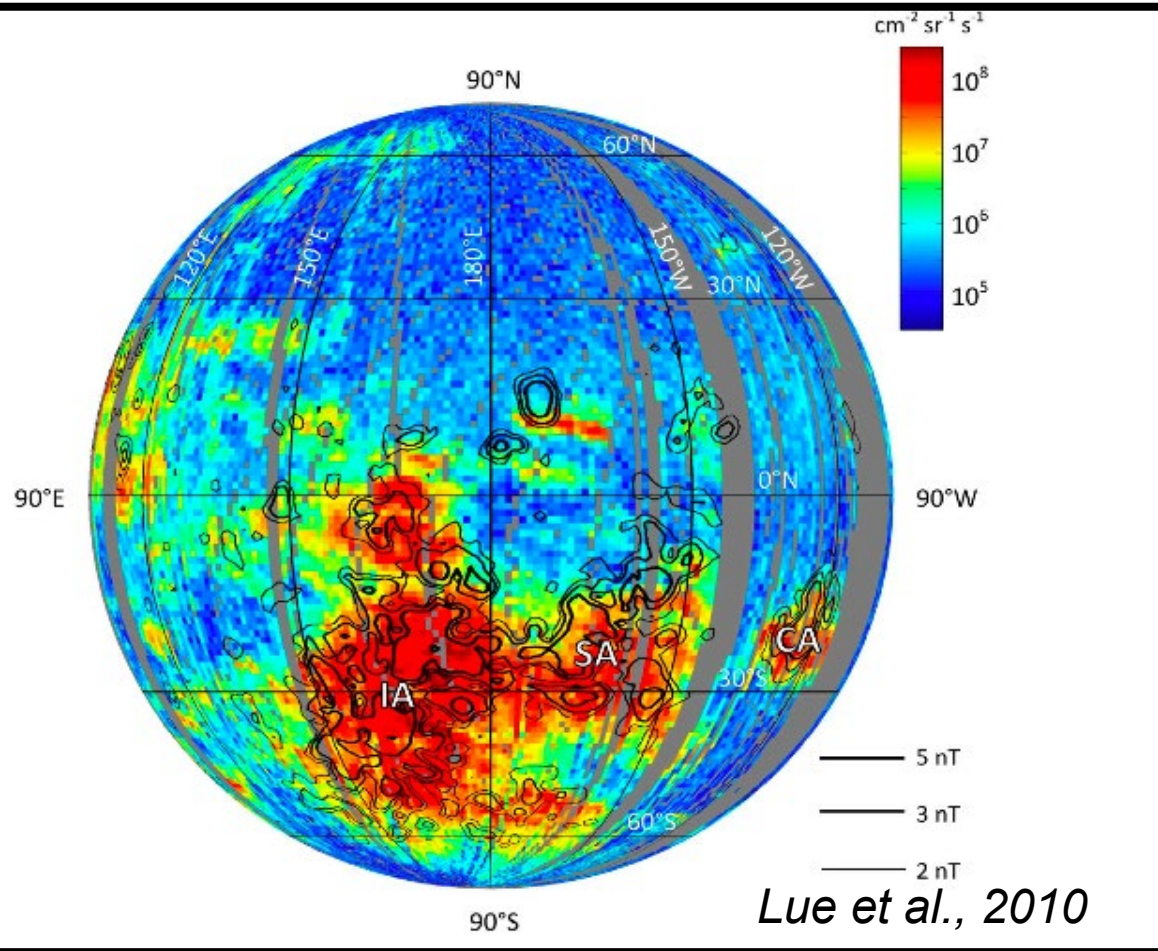
The Moon is Small

Dyal et al., 1974

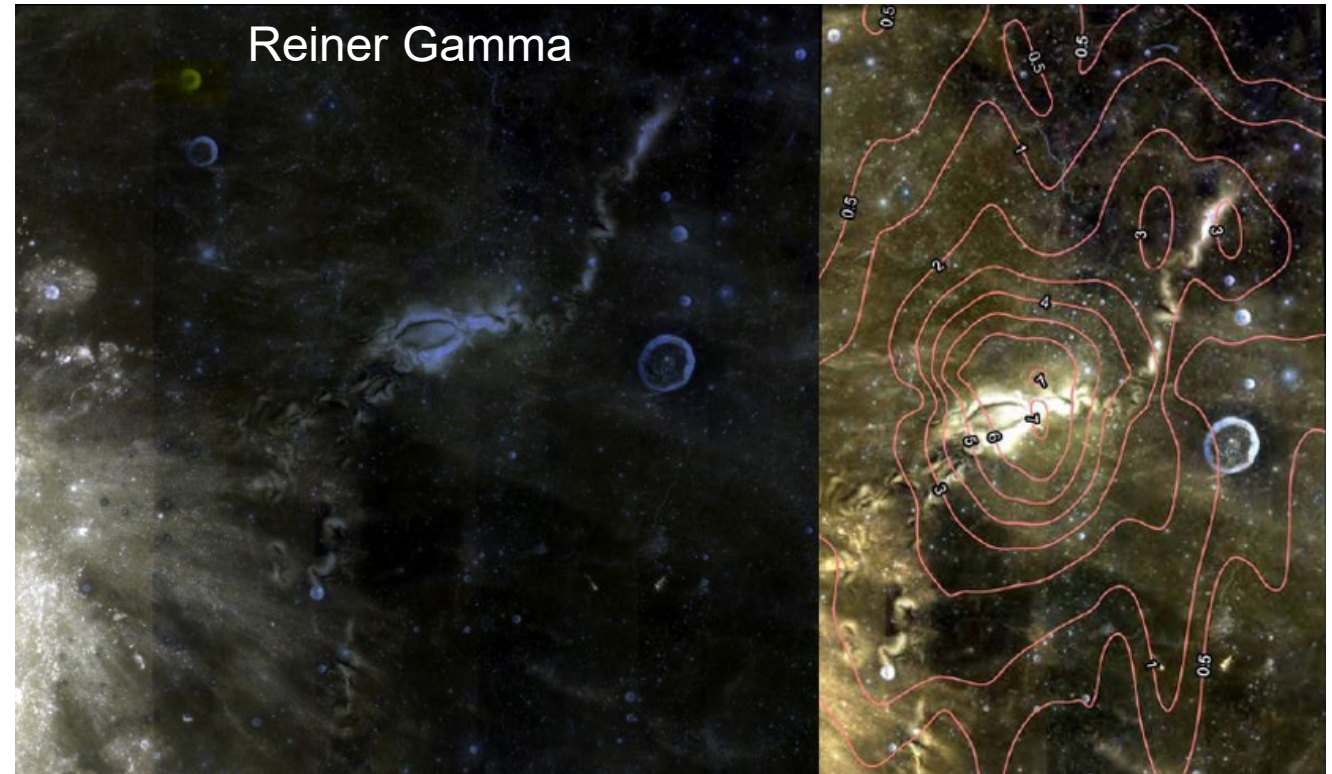
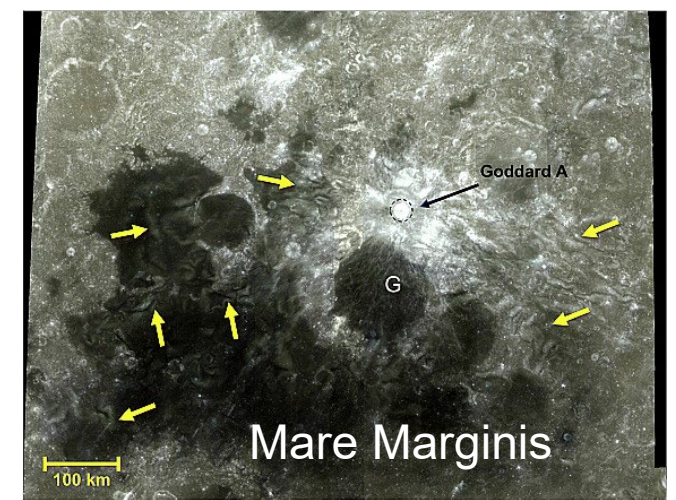
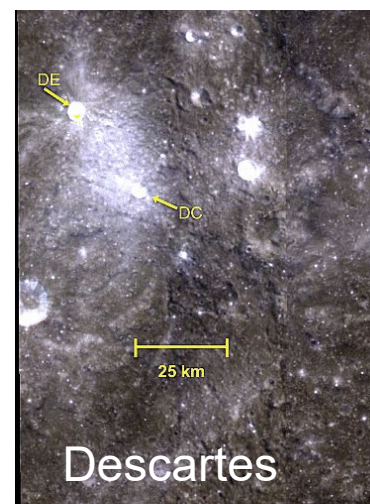
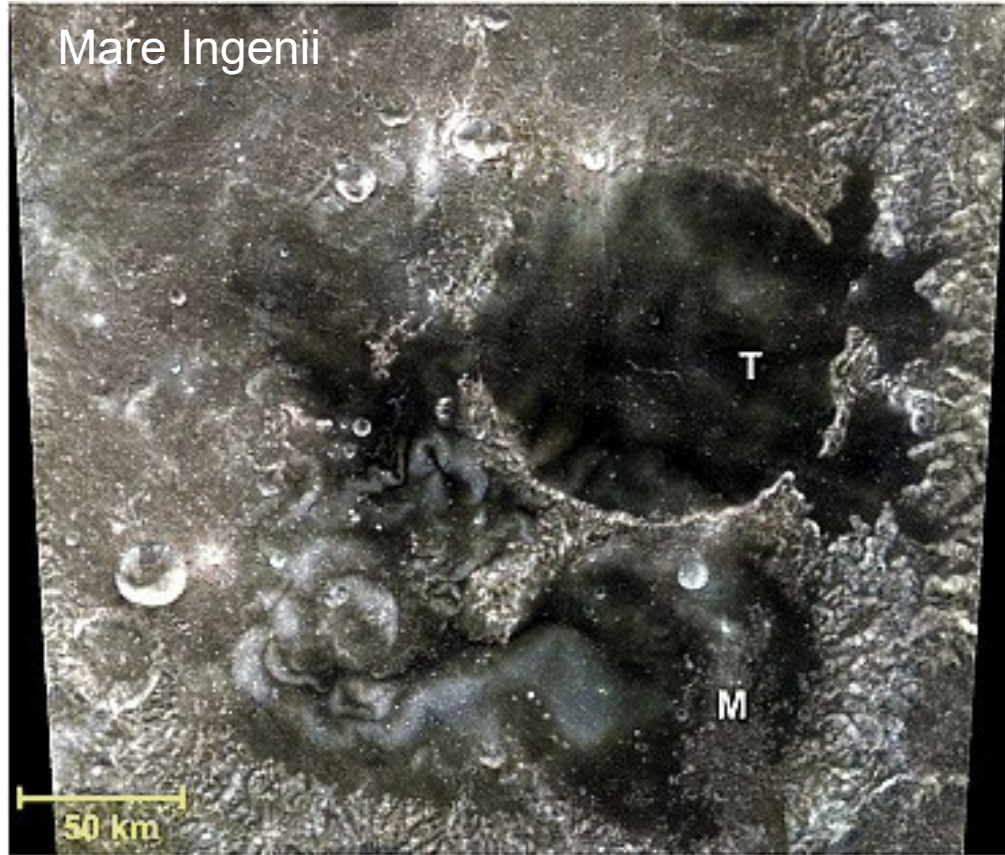
Magnetic Anomaly



Plasma Interactions



Surface Weathering



Blewett et al., 2011

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Connections & Traceability

Planetary Decadal

- Q5.2b What processes control the origin and evolution of magnetic fields?
- Q5.5a How do space weathering processes modify surface characteristics and composition?
- Q6.1d What role does the space environment play in forming and liberating the volatiles contained within surface bounded exospheres?
- Q6.3g What controls the transport and sequestration of volatiles in solid-surface exospheres?
- Q6.5d How do magnetic fields influence the loss of volatiles from objects with surface boundary exospheres?
- Q6.5e How is the escape of volatiles from the Moon, Mercury, and other bodies with surface boundary exospheres driven by photon, charged particle, and micrometeorite influx?

Heliophysics Decadal

→ Science Theme: *New Environments: Exploring our Cosmic Neighborhood and Beyond*

- What can we learn from comparative studies of planetary systems?
 - Interactions of plasmas with solid body surfaces and atmospheres

→ B.4.2. Emerging Opportunity 2

- Leverage upcoming opportunities through the lunar, Mars, and planetary exploration programs to enable cross-cutting solar and heliospheric research from emerging platforms and unique environments
- References 2007 Report: “*Heliophysics Science and the Moon*” heavily

Moon to Mars

- LPS-2: Advance understanding of the geologic processes that affect planetary bodies by determining the interior structures, characterizing the magmatic histories, characterizing ancient, modern, and evolution of atmospheres/exospheres, and investigating how active processes modify the surfaces of the Moon and Mars.
- LPS-3: Reveal inner solar system volatile origin and delivery processes by determining the age, origin, distribution, abundance, composition, transport, and sequestration of lunar and Martian volatiles.
- HS-3: Investigate and characterize fundamental plasma processes, including dust-plasma interactions, using the cislunar, near-Mars, and surface environments as laboratories.

Why Humans?

→ Sample return – duh!

→ But also:

- Humans have the ability to quickly set up complex monitoring equipment, react in real time to measurements obtained and environmental conditions, and move equipment to different locations based on local surveys
- Keep in mind that local magnetic fields (and thus plasma properties) are likely to vary on scales of 10s to 100s of m
 - These fields cannot be measured from orbit, and are difficult to measure from a robotic platform