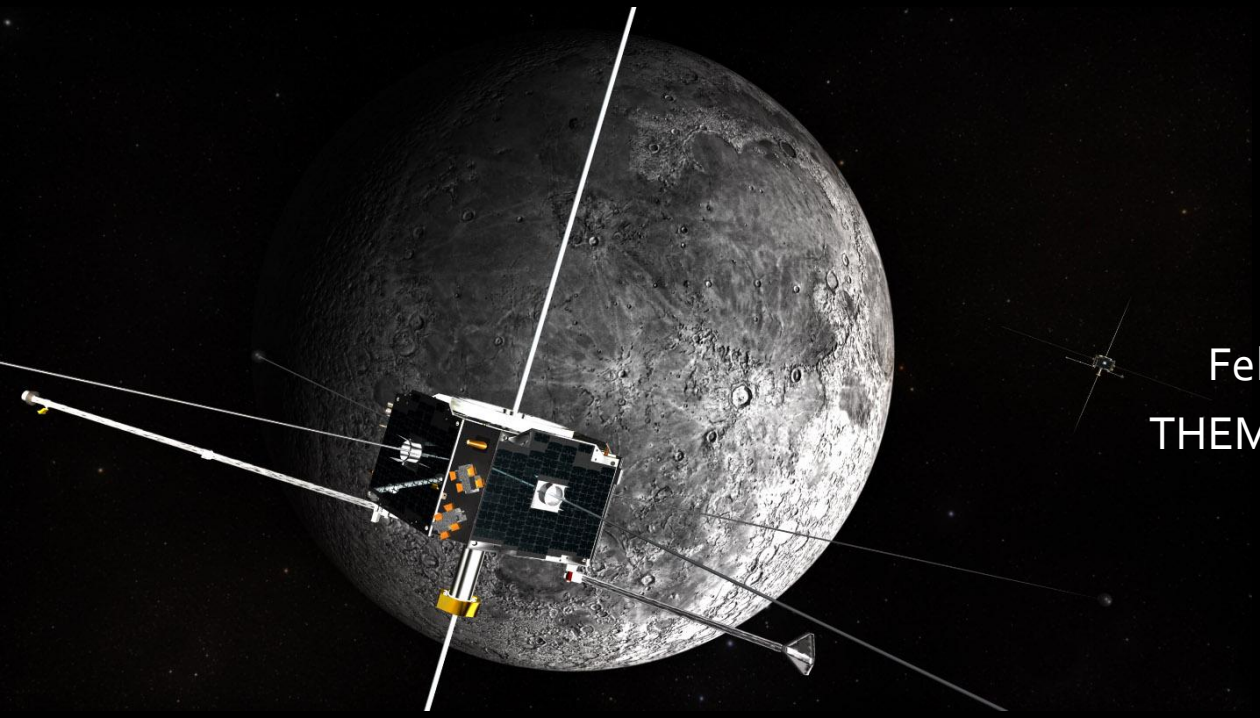
ARTEMIS observations of micrometeoroid-impact charging of the lunar surface

A. R. Poppe, S. Xu, L. Liuzzo
poppe@ssl.berkeley.edu
Space Sciences Lab., Univ. of California at Berkeley

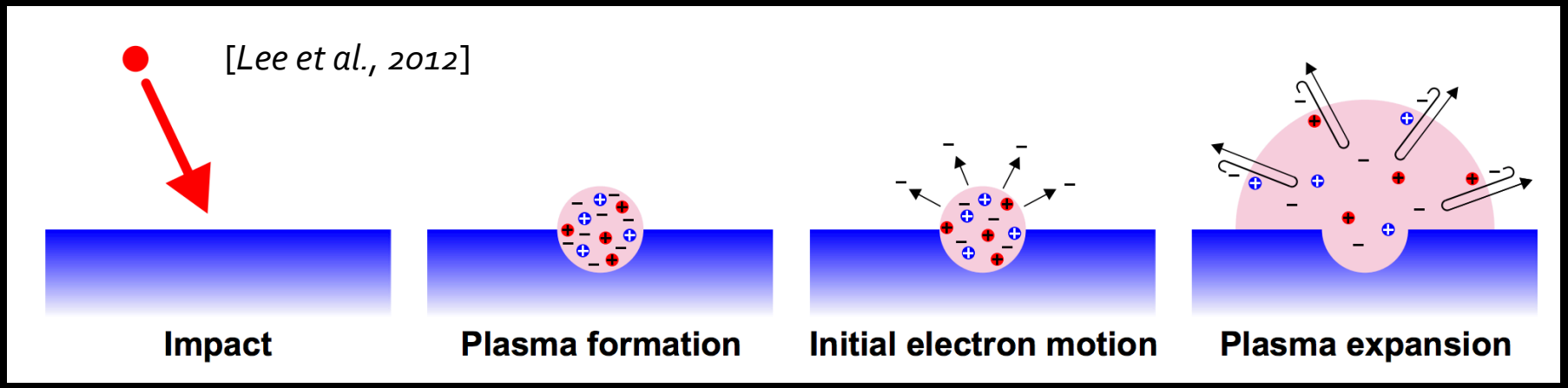
J. S. Halekas
Univ. of Iowa

Y. Harada
Kyoto Univ.



February 23, 2022
THEMIS/ARTEMIS SWT

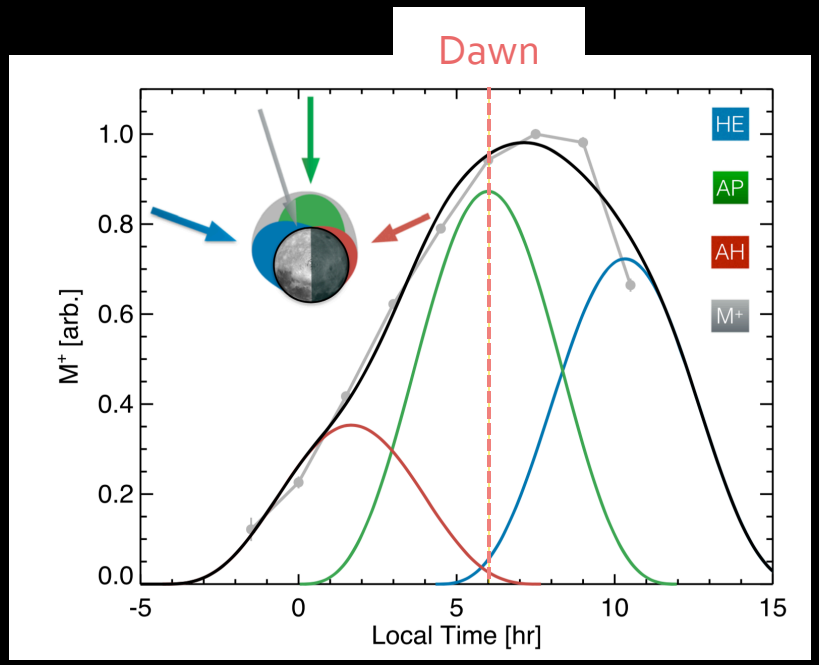
Micrometeoroid-Impact Charging



Hyper-velocity MM impacts are known to efficiently generate free charge

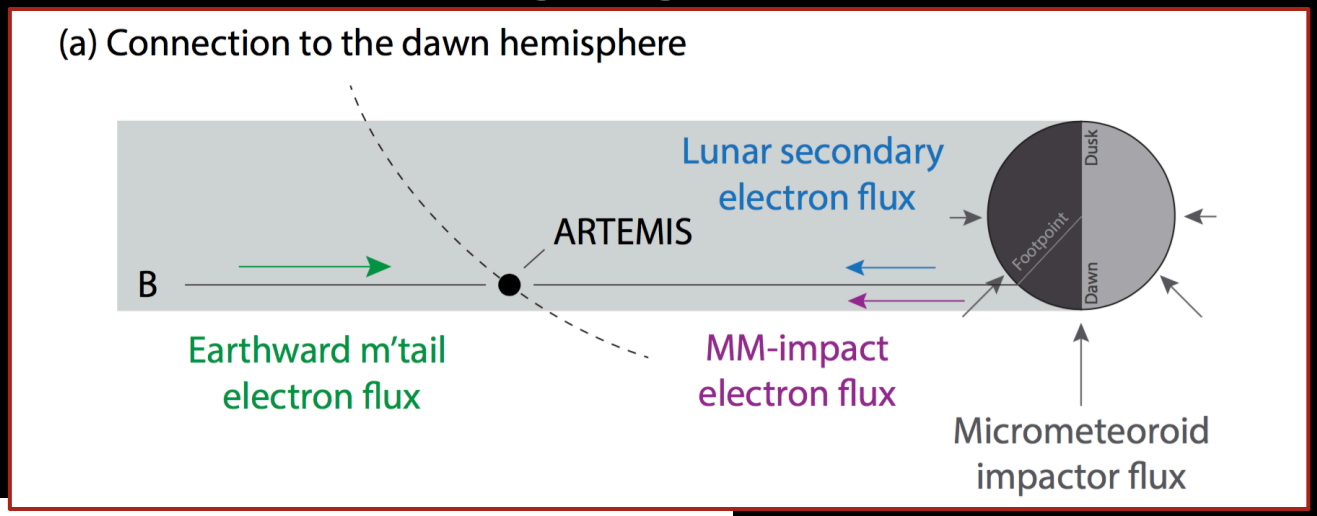
LADEE/LDEX measurements show that the MM-impactor flux is highly concentrated near dawn (~6-8 LT)

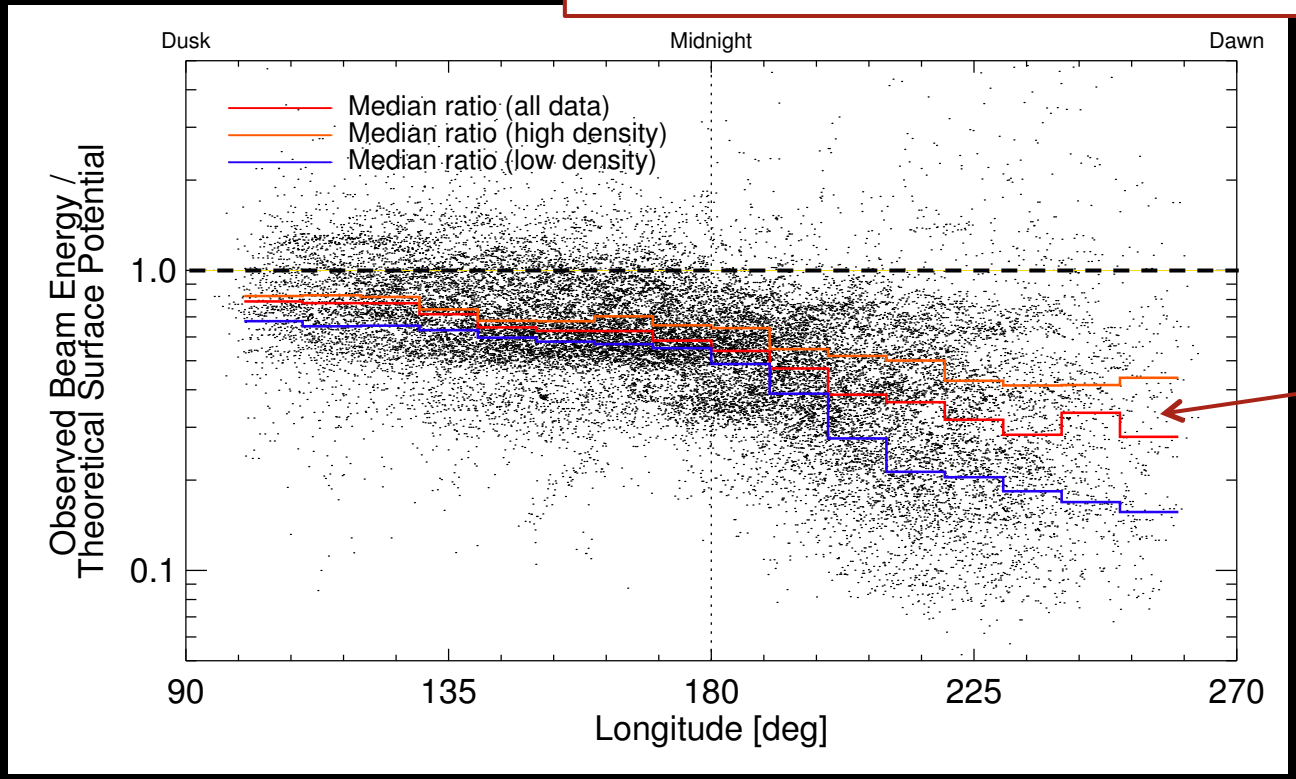
[e.g., *Horányi et al., 2015*; *Szalay and Horányi, 2016*]



MM-Impact Surface Charging at the Moon

Electron reflectometry by ARTEMIS can remotely sense the lunar surface potential





MM-impact charging drives the dawnside lunar surface potential less negative than plasma currents do

Main Points

Geophysical Research Letters

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Key Points:

- Acceleration, Reconnection, Turbulence, and Electrodynamics of the Moon's Interaction with the Sun observes negative surface potentials on the lunar nightside in the magnetotail lobes smaller than expected from tail-plasma charging

ARTEMIS Observations of Lunar Nightside Surface Potentials in the Magnetotail Lobes: Evidence for Micrometeoroid Impact Charging

A. R. Poppe[1], S. Xu[1], L. Liuzzo[1], J. S. Halekas[2], and Y. Harada[3]

[1]Space Sciences Laboratory, University of California at Berkeley, Berkeley, CA, USA, [2]Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA, [3]Department of Geophysics, Kyoto University, Kyoto, Japan

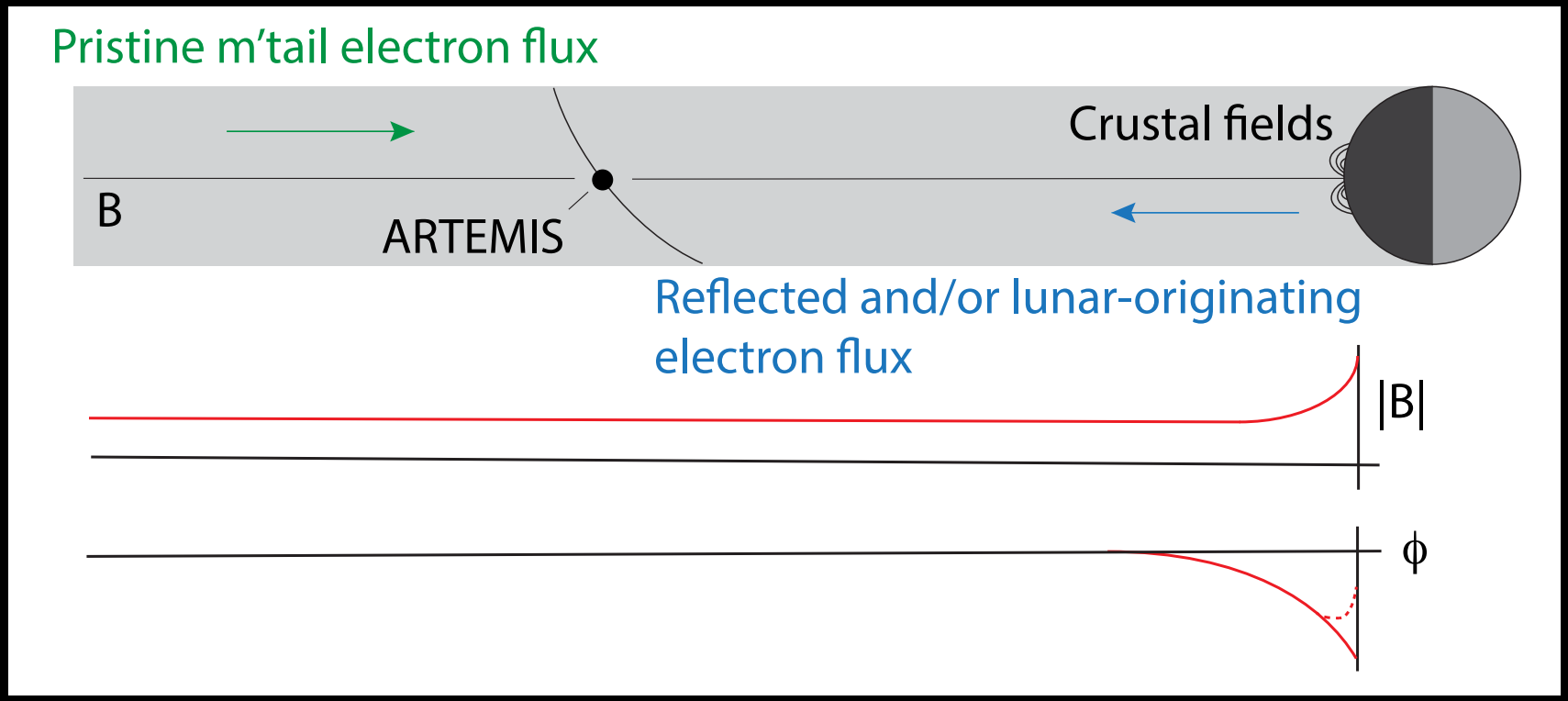
Summary (adapted from *Poppe et al., GRL, 2021*):

1. Using electron reflectometry, ARTEMIS can sense the electrostatic potential of the lunar surface (w.r.t. the spacecraft)
2. During periods in the low-density terrestrial magnetosphere, ARTEMIS observes *less negative* nightside potentials than expected from theory
3. These low-magnitude potentials are highly correlated with connection to the lunar dawn hemisphere
4. Micrometeoroid-impact charging dominates the surface and near-surface plasma environment in shadowed, low-density environments
5. Other planetary bodies may be subject to this process under such conditions

Backup Slides

Surface Charging & Electron Reflectometry (ER)

Main charging currents are ambient ion/electron collection, photoemission (dayside), and secondary electron emission

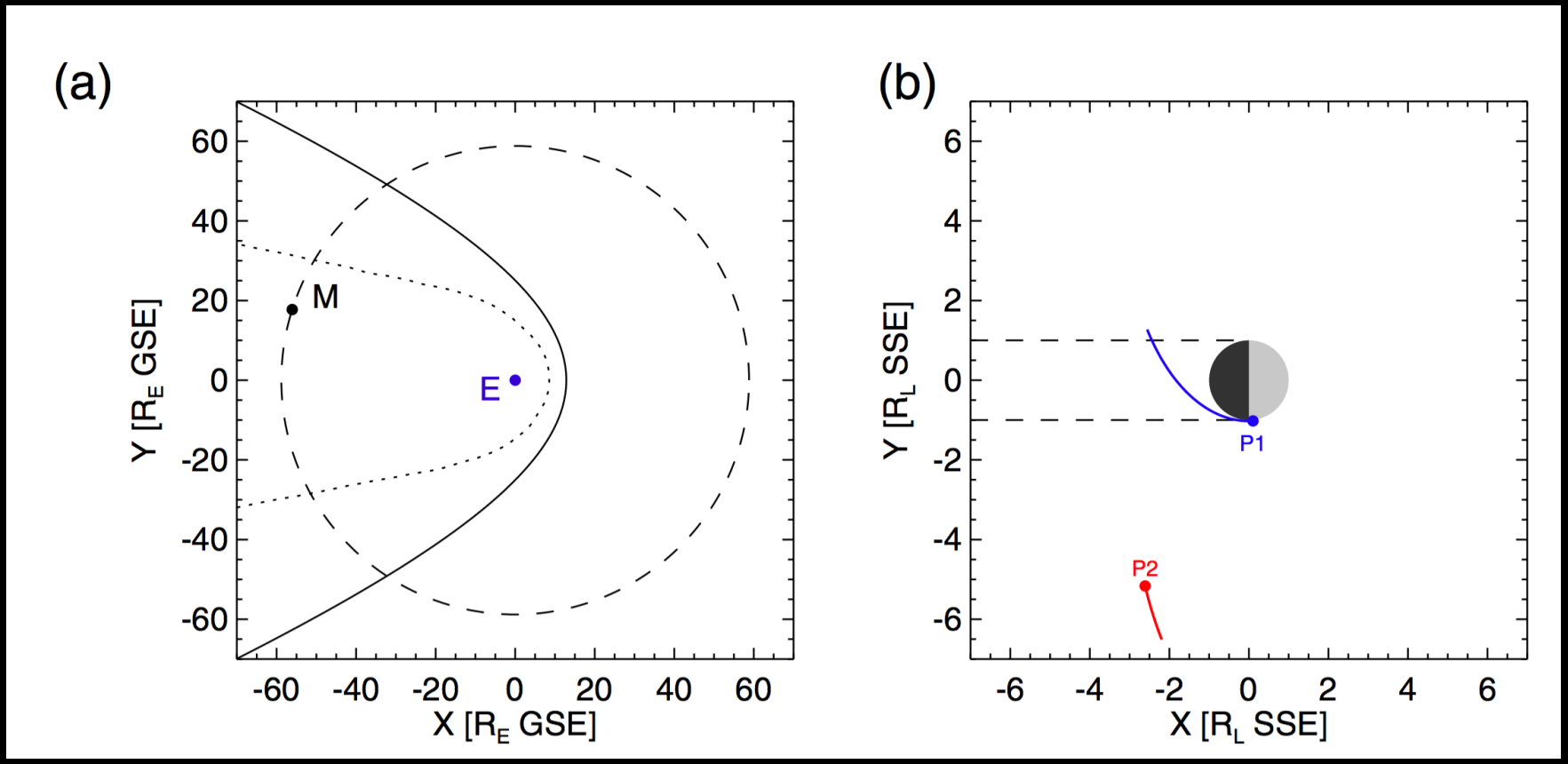


Remotely sensed electron distributions inform us about the crustal magnetic field strength *and* the electrostatic potential at lunar surface

See also: *Anderson et al., 1976*; *Halekas et al., 2002, 2005, 2008, 2011*; *Poppe et al., 2011, 2012, etc.*

An 'Anomalous' ARTEMIS ER Observation

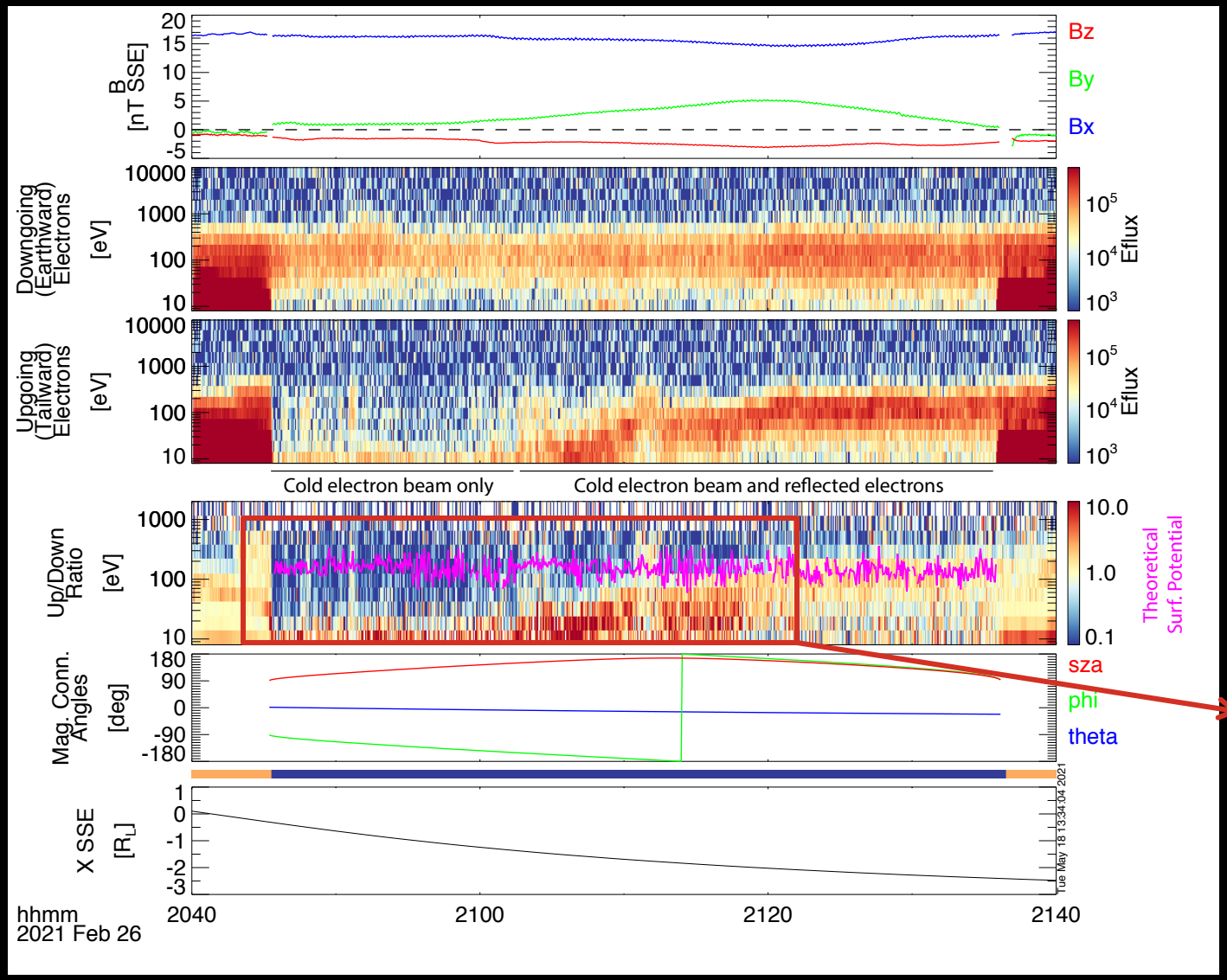
Feb 26, 2021



(1) Moon within the terrestrial magnetotail

(2) ARTEMIS P1 transits through the lunar shadow & is magnetically connected to nightside surface

An 'Anomalous' ARTEMIS ER Observation



Sun-Earth aligned B - Lobes

Down-going electron flux

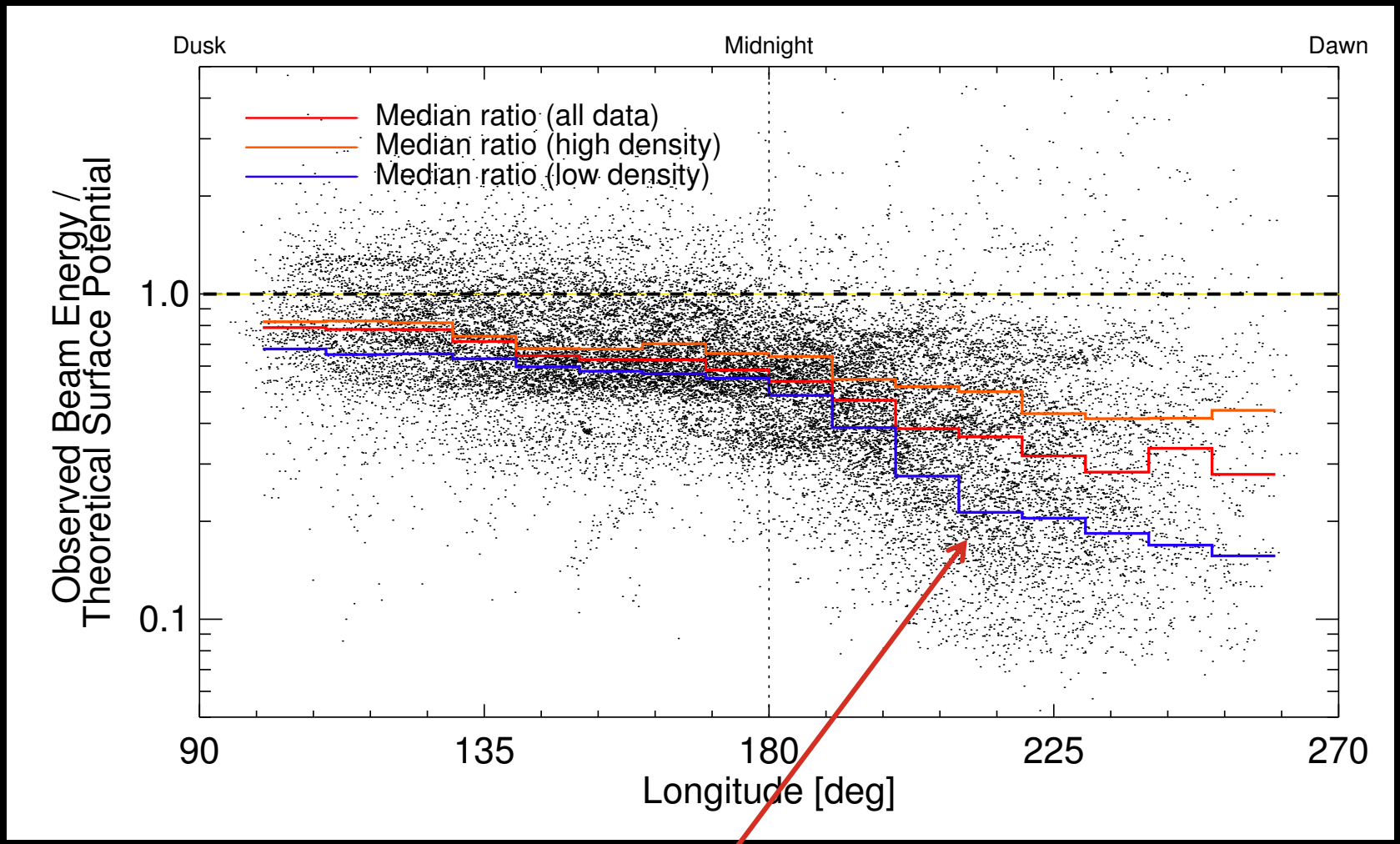
Up-coming electron flux

Up/Down electron flux ratio

Theory (pink) predicts surface potentials of -100 to -200 V, but upcoming beam is only 10 to 20 V

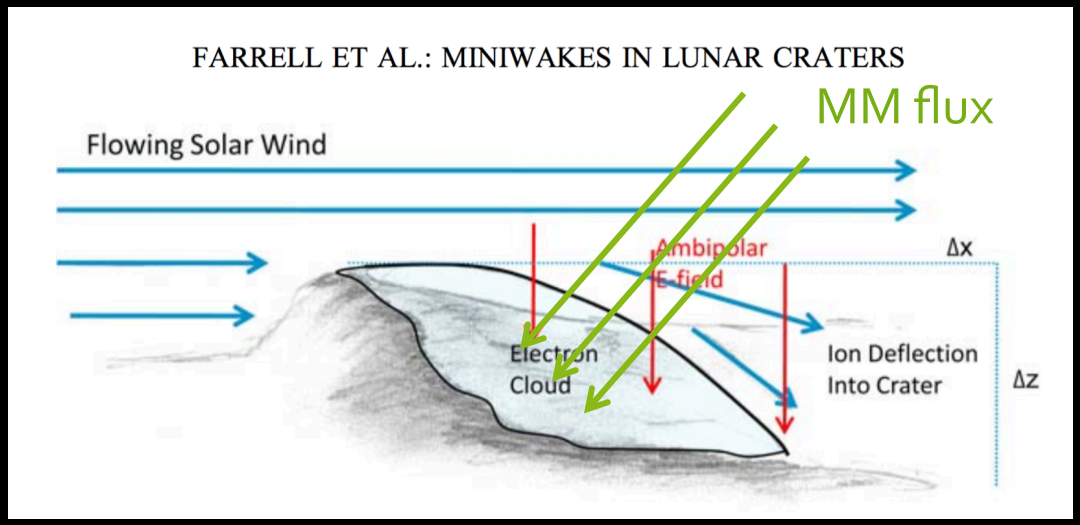
Why is the nightside lunar surface *less negative* than theory predicts?

Aggregated ARTEMIS Observations



Inferred surface potentials are consistently *less negative* than theory for the **dawn hemisphere,** increasingly so for lower ambient densities, consistent with MM-impact charging of the lunar surface

MM-Impact Surface Charging: Implications



MM-impact charging may be an important charging process in mini-wake / non-neutral shadowed regions – i.e., a "current of last resort"?

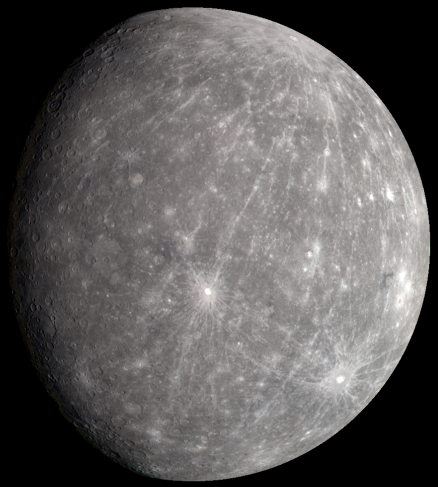
[e.g., *Farrell et al., 2010*; *Zimmerman et al., 2011, 2013*]

MM-impact charging may be important at other airless bodies with either:

(a) low-density ambient plasmas, and/or

(b) high-flux or high-velocity micrometeoroid impact distributions

Ganymede



Mercury

MM-Impact Surface Charging at the Moon