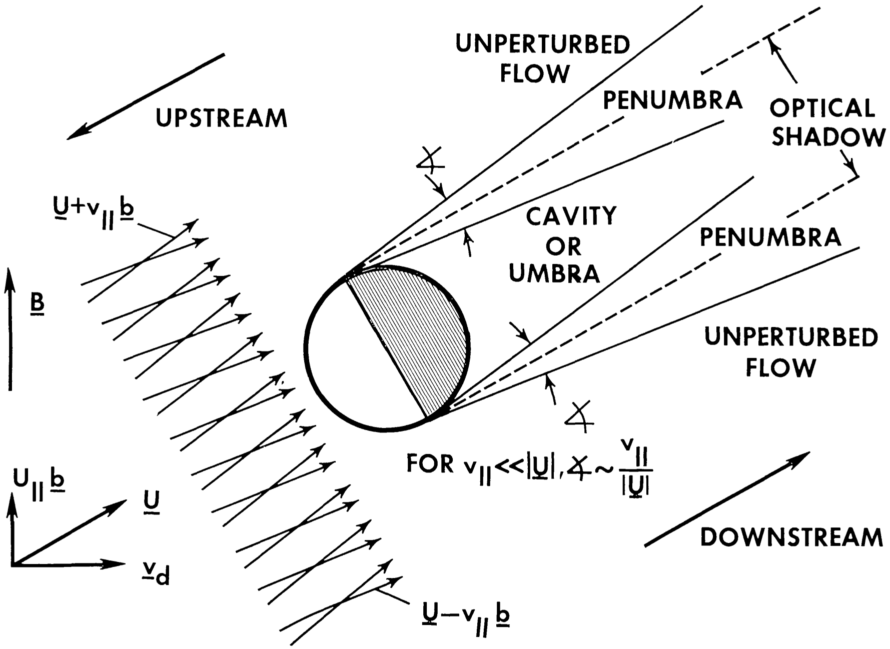
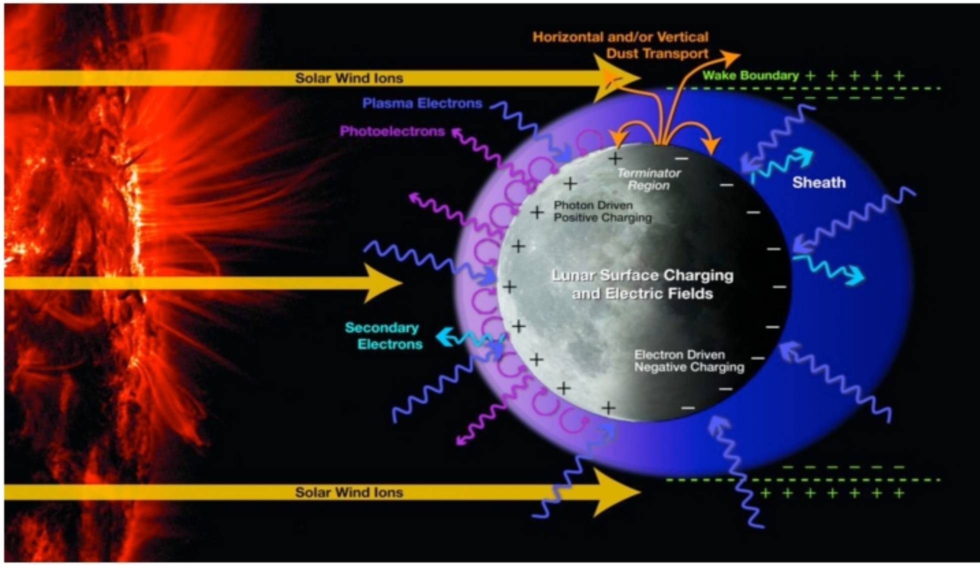
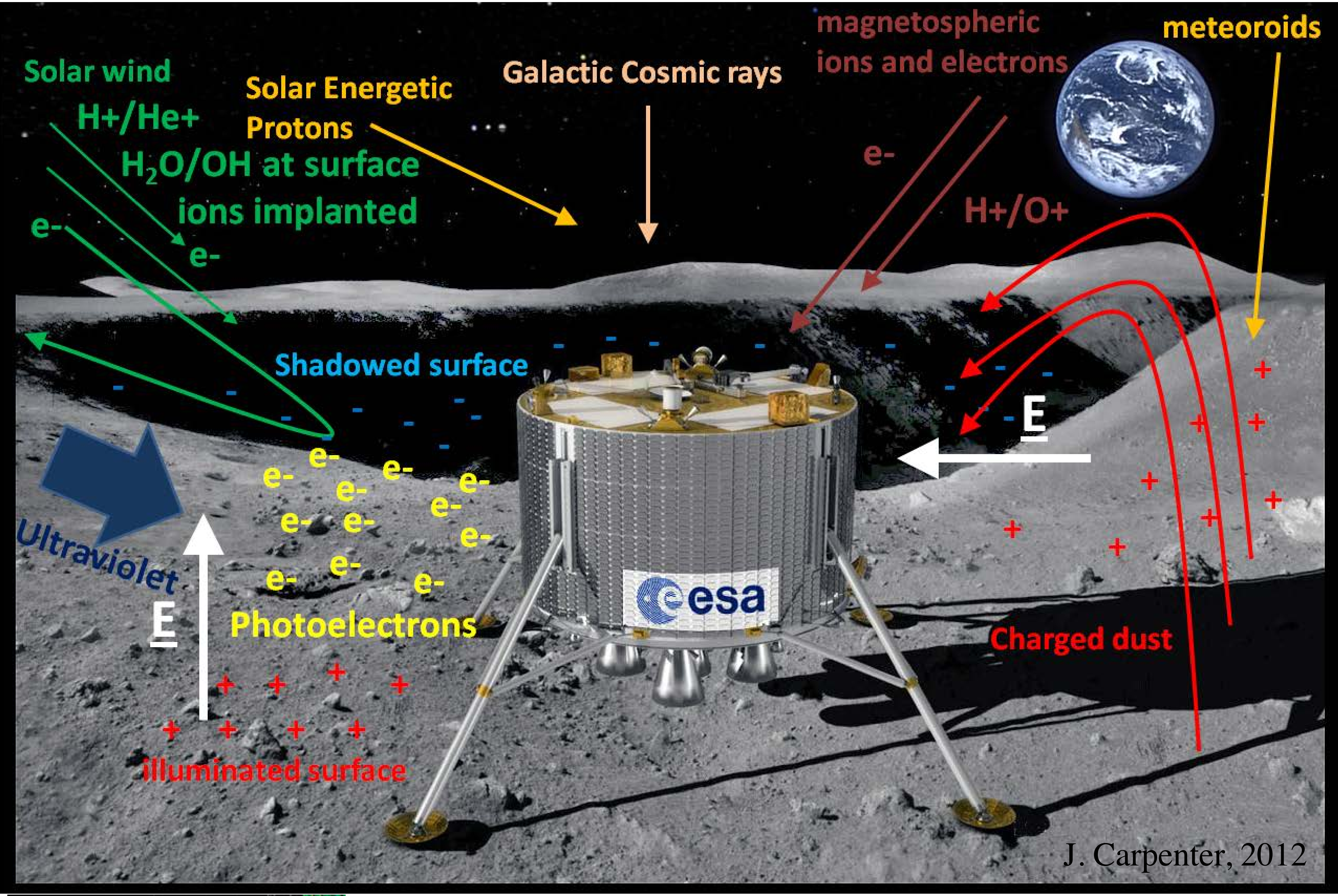
Dusty Plasma Processes on the Surfaces on Airless Planetary Objects

M. Horanyi and the CCLDAS Team

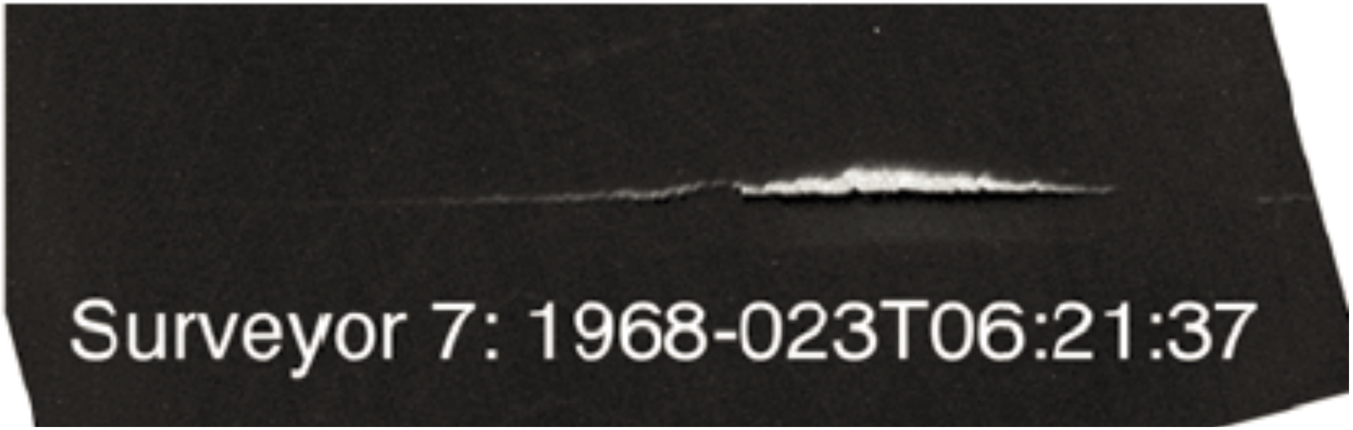




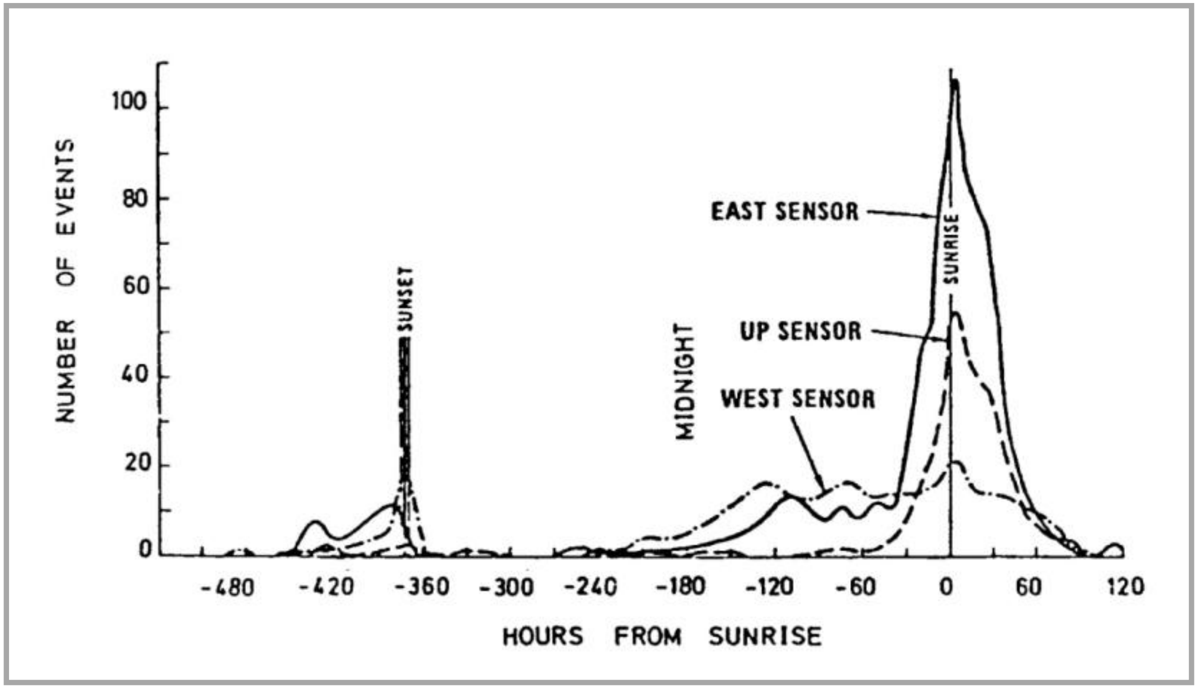
Objects without a global magnetic field or an atmosphere in a flowing plasma:
Moon, Phobos, Deimos, Asteroids, moons in planetary magnetospheres


Solar wind
H+/He+
H2O/OH at surface
ions implanted
e-
e-
Solar Energetic
Protons
Galactic Cosmic rays
magnetospheric
ions and electrons
e-
H+/O+
meteoroids
Shadowed surface
E
Ultraviolet
e-
Photoelectrons
E
illuminated surface
esa
Charged dust
J. Carpenter, 2012

Many issues remained open.



Images shortly after sunset



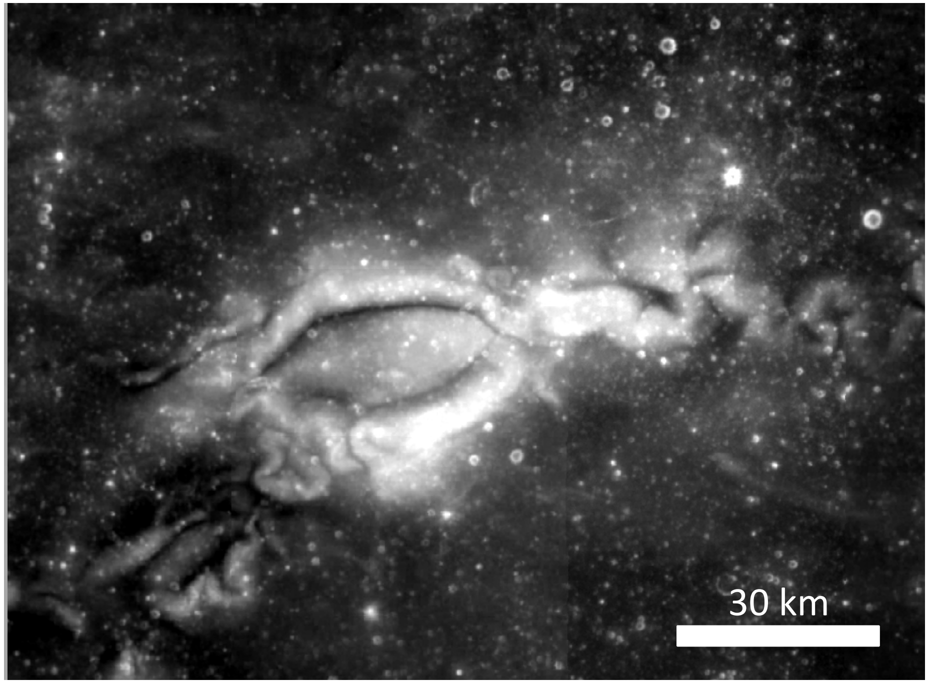
LEAM:
Lunar Ejecta and
Meteorite Experment

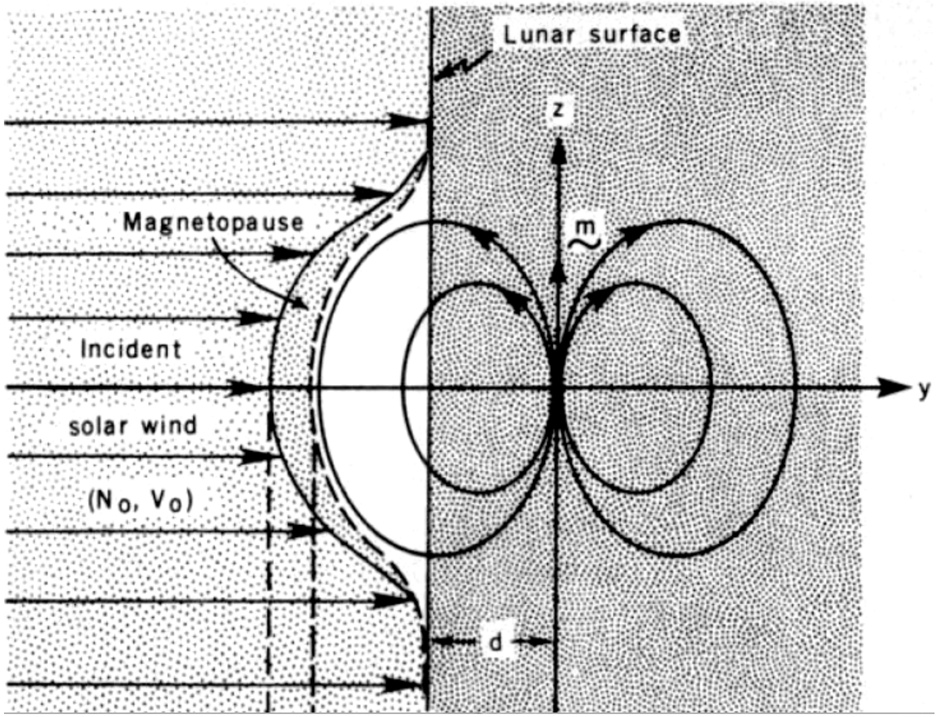
Lunar Science and Engineering: charge state, the size and velocity distribution of levitated/transported lunar fines as a function of local time, and position along the lunar orbit.

Basic Plasma Science: buildup and collapse of a plasma and photoelectric sheath, and its changing properties with dust loading.

Planetary and Astrophysical Sciences: Understand the mechanism leading to dust transport on airless bodies. Reliably distinguish between interplanetary and interstellar grains, measure their fluxes, size and velocity distributions, and composition.

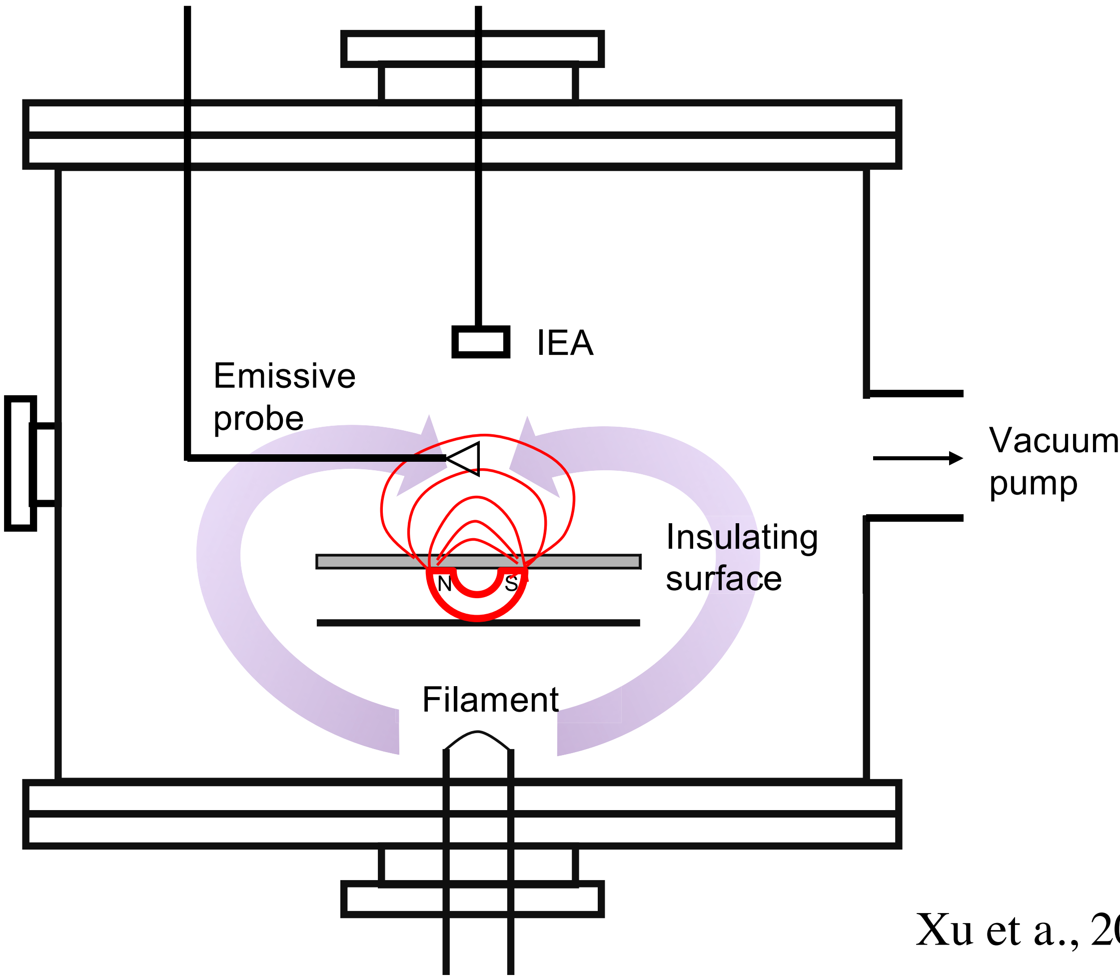
Magnetic fields can be important.





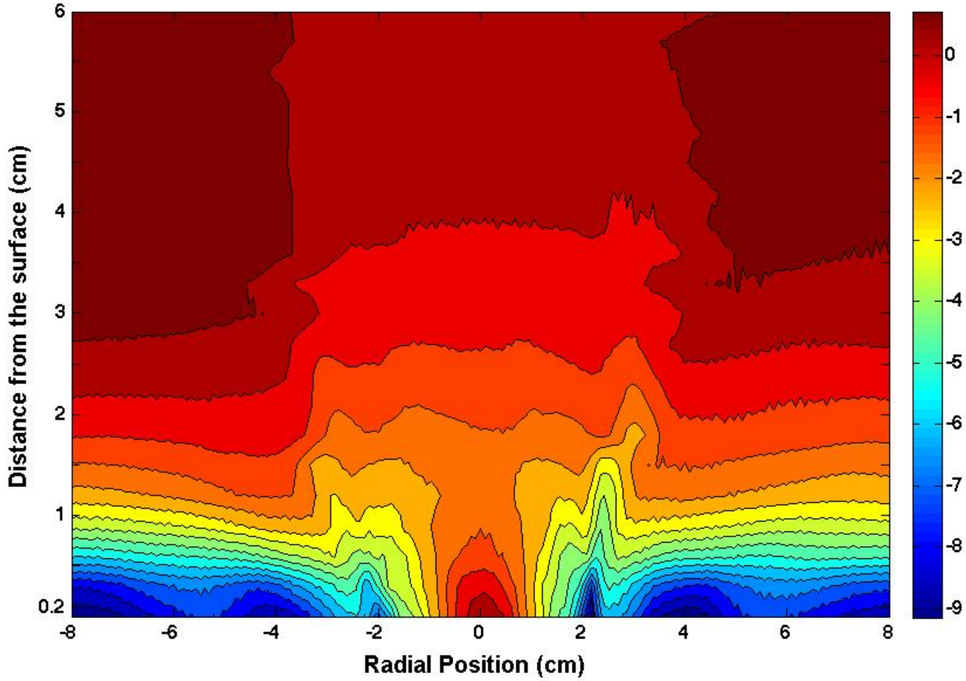
Hood and Schubert, 1980

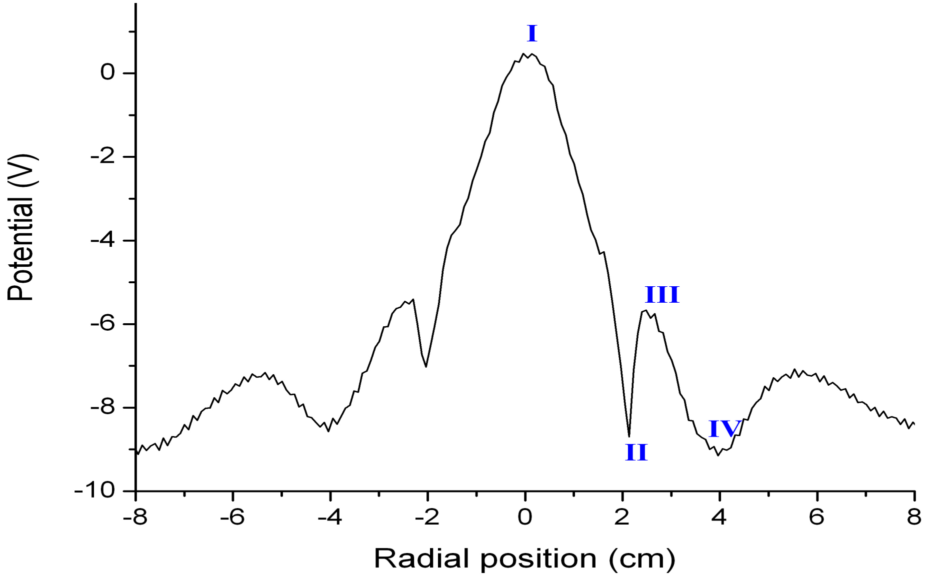
Small-scale experiments are helpful.



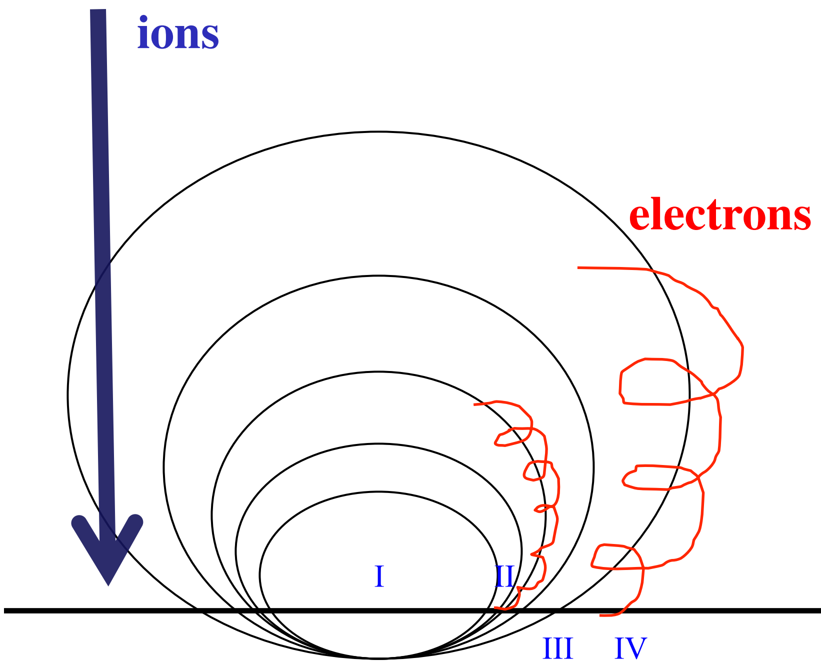
Xu et a., 2012

Strong localized electric fields emerge.

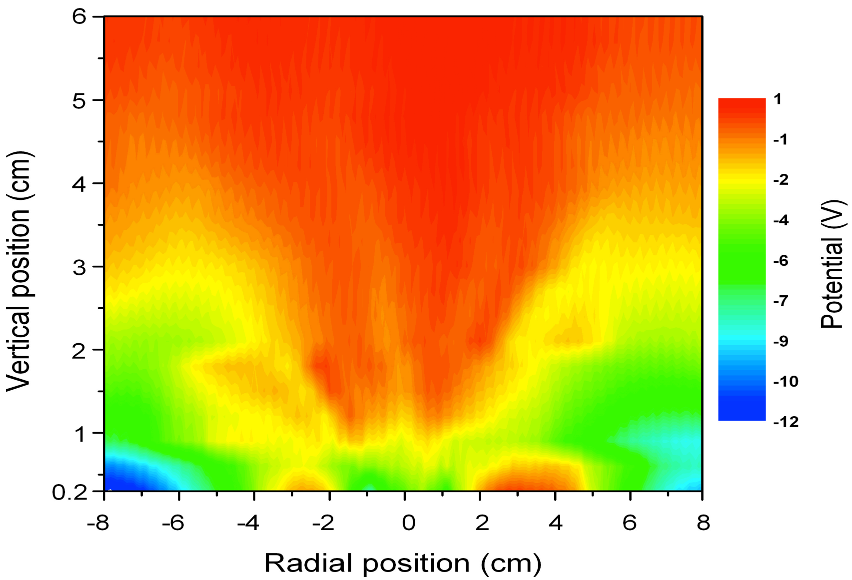


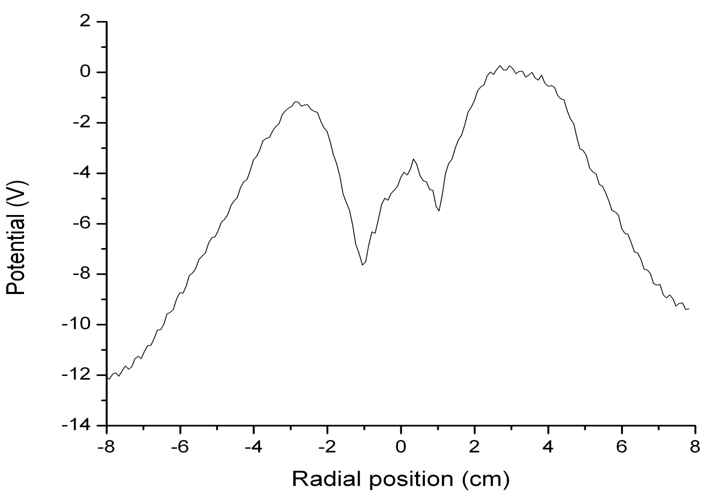


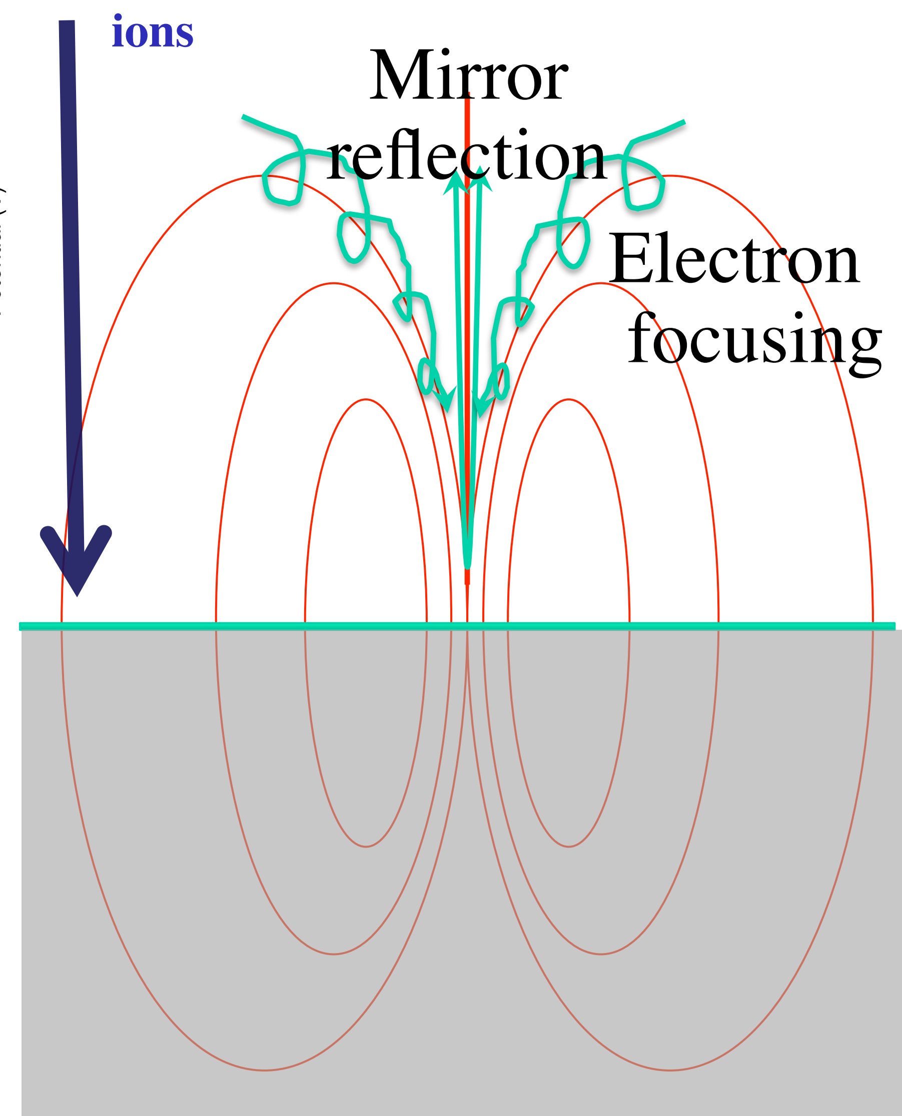
Potential distribution



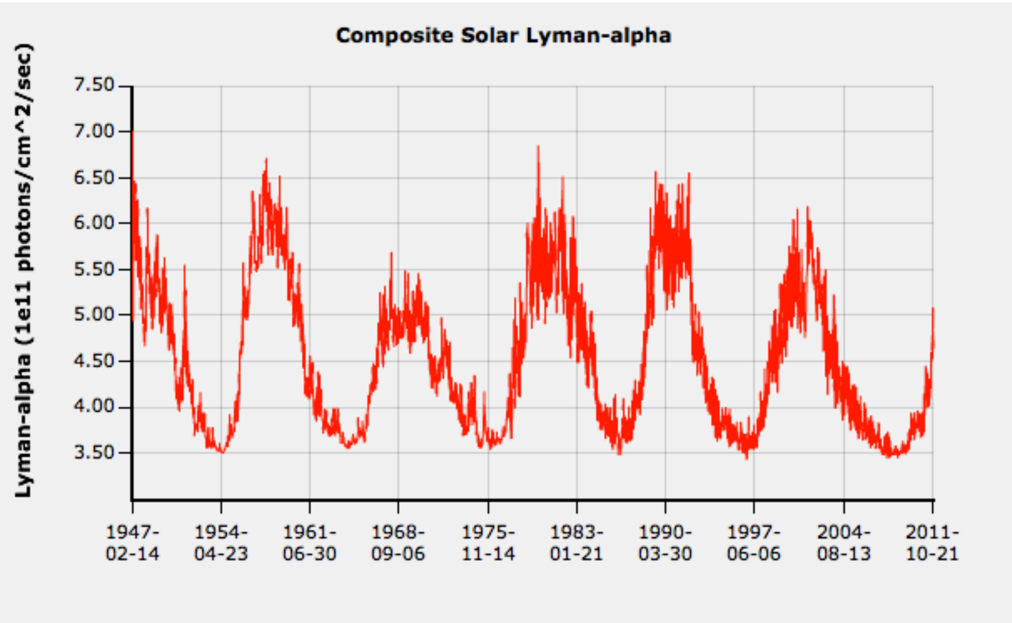
The configuration of **B** matters.

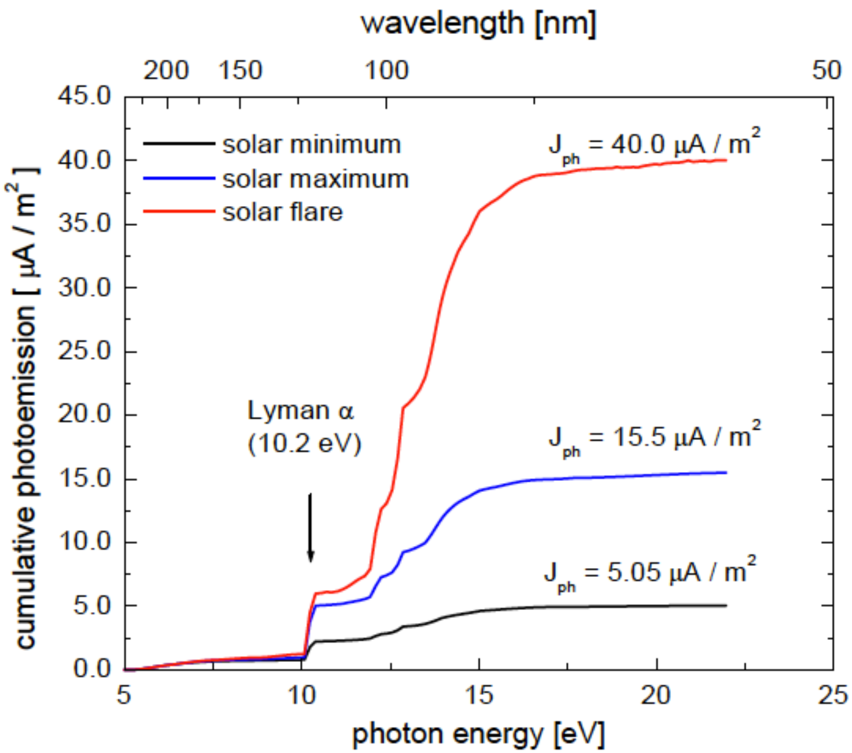






UV radiation drives dayside charging.

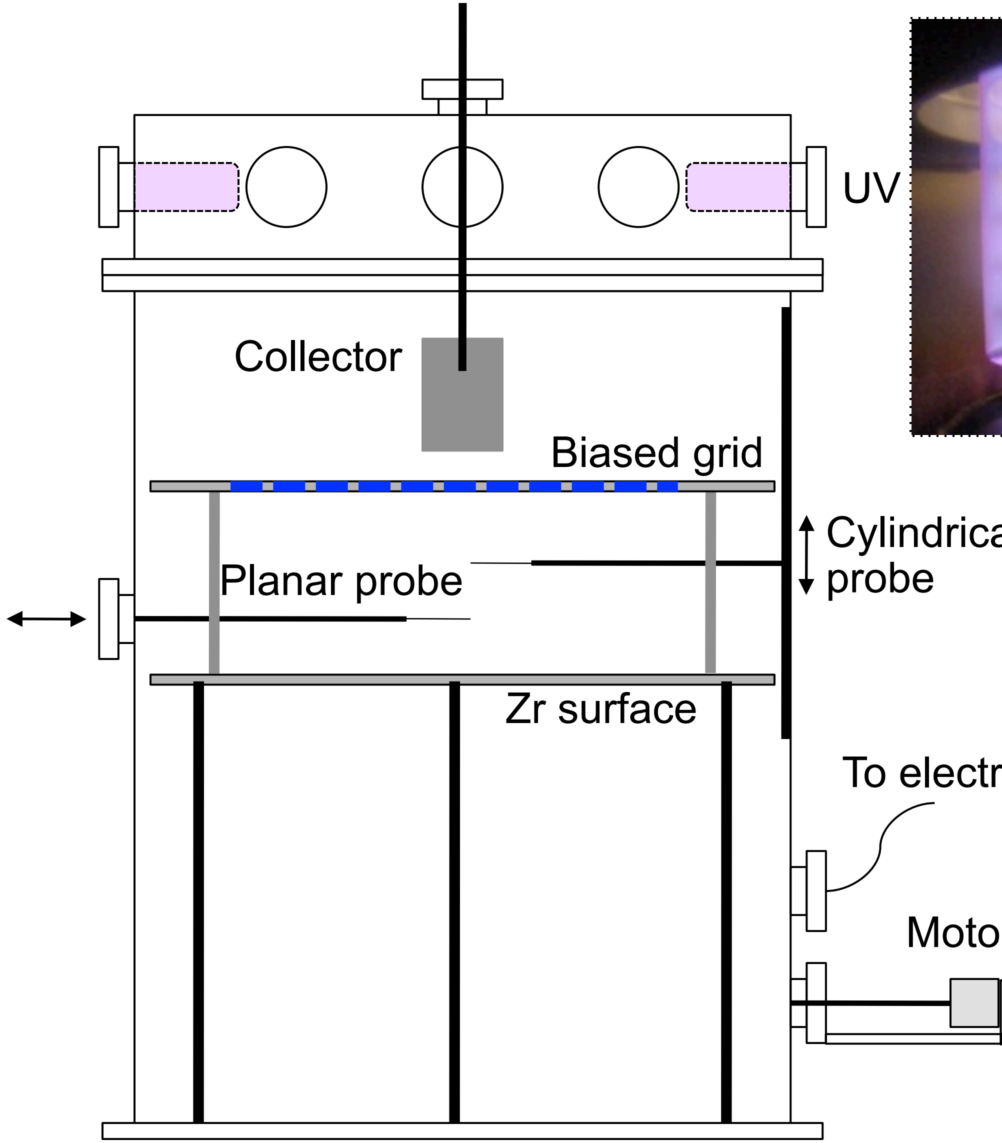


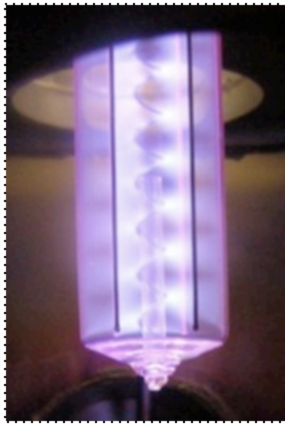


Sternovsky et al., 2008

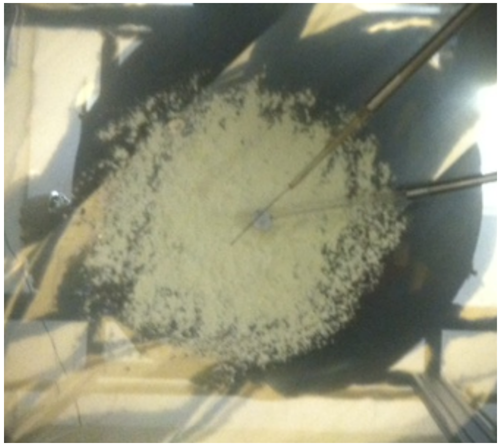
UV experiments are hard.

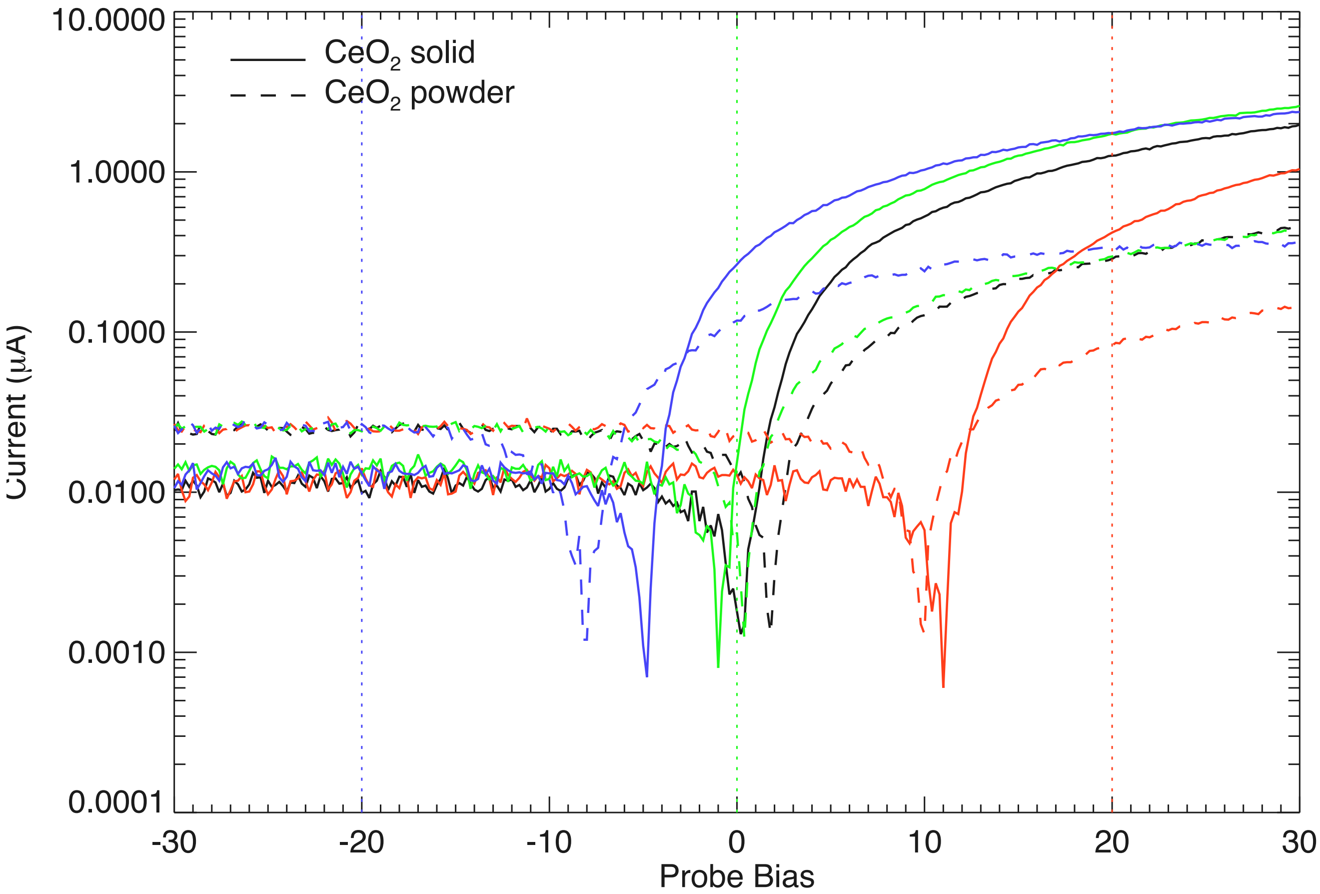
- 0.6 m^3, 60-cm diameter vacuum chamber
- 10^{-6} Torr operating vacuum
- Collector and grid aid in obtaining clean measurements
- Xe-excimer UV lamps peak emission at 172 nm (7.21 eV)





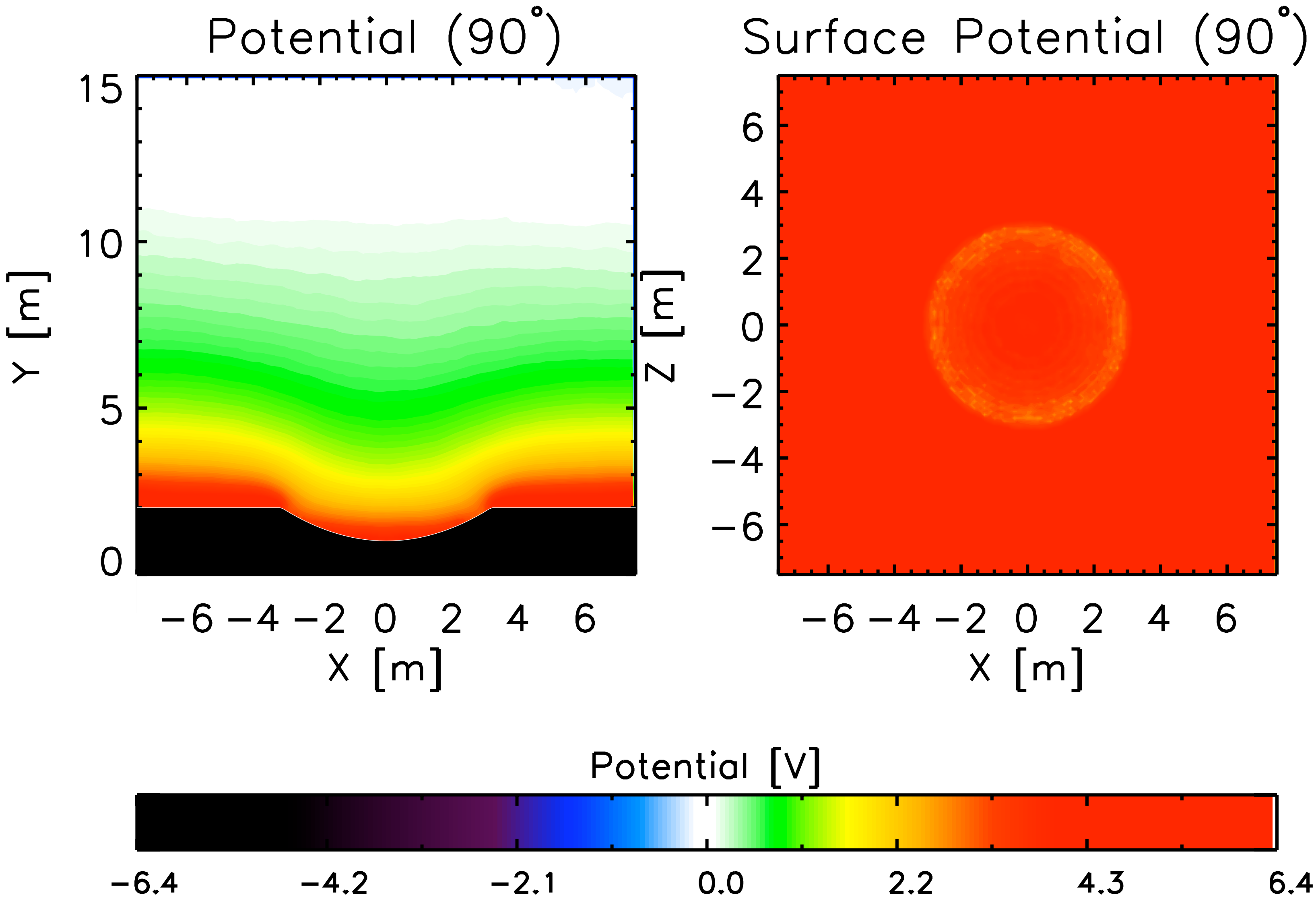
UV Charging (Cerium-Oxide)





Dove et al., 2011, 2012

Topography effects everything.



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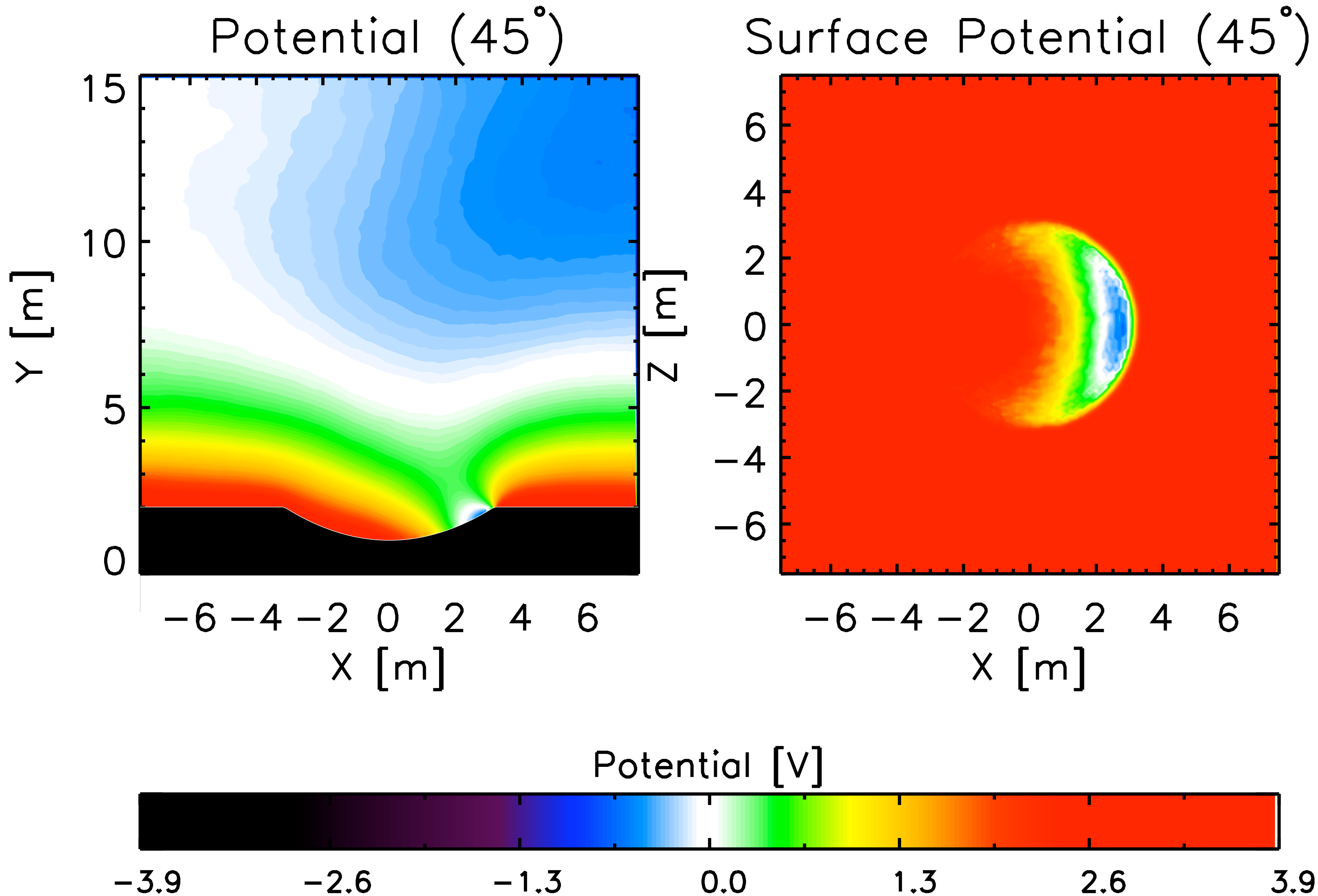
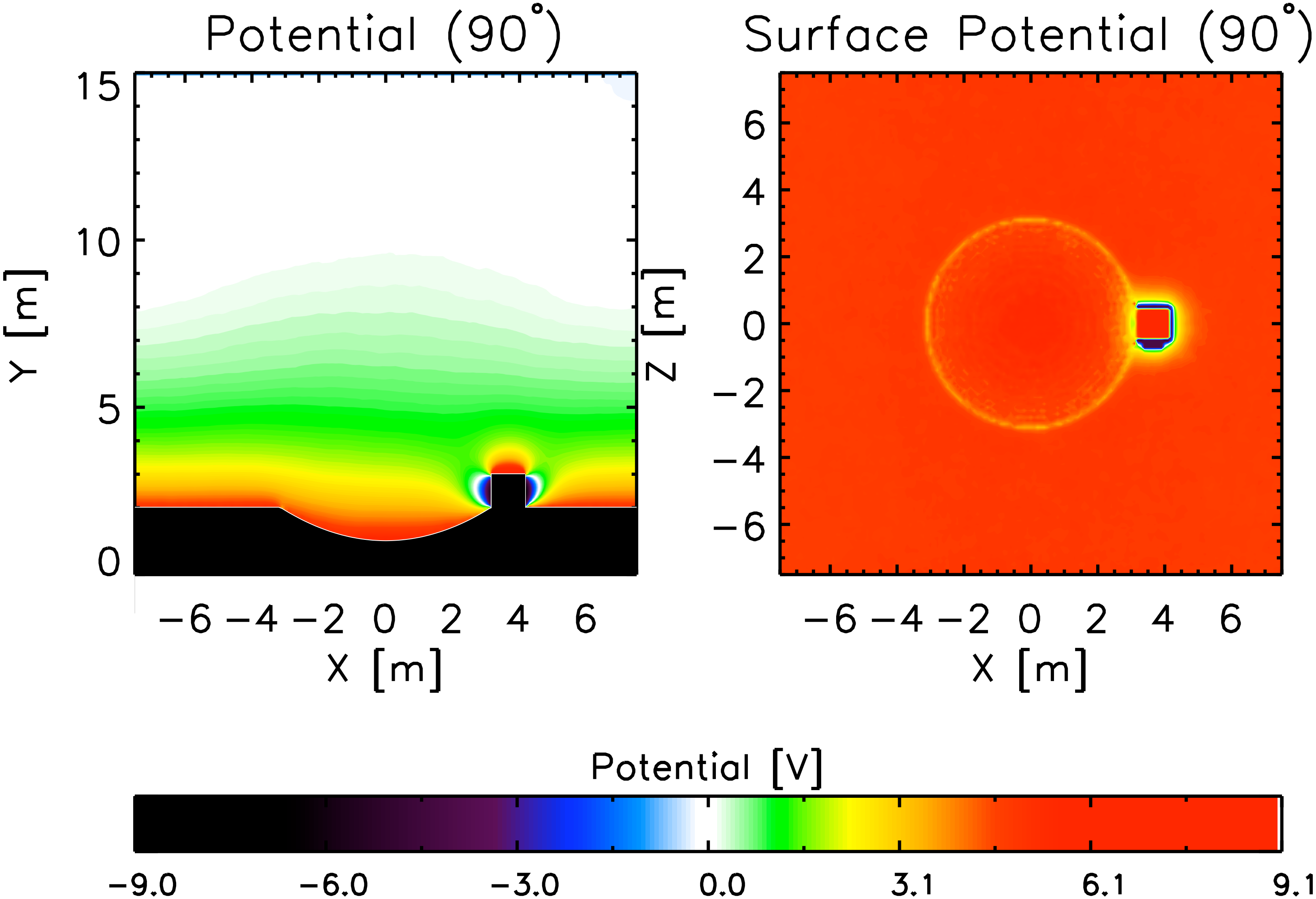


A spacecraft alters its environment.



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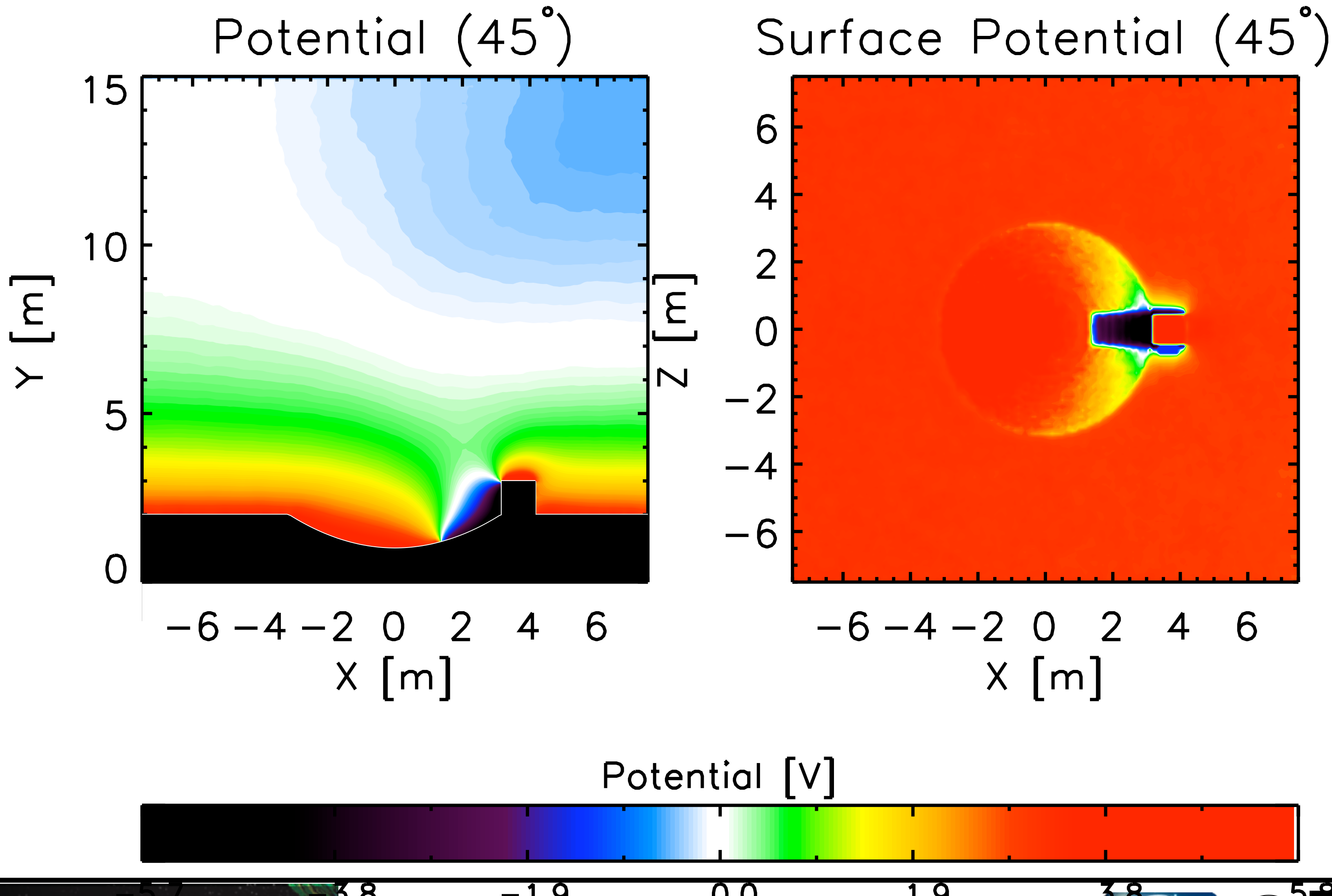
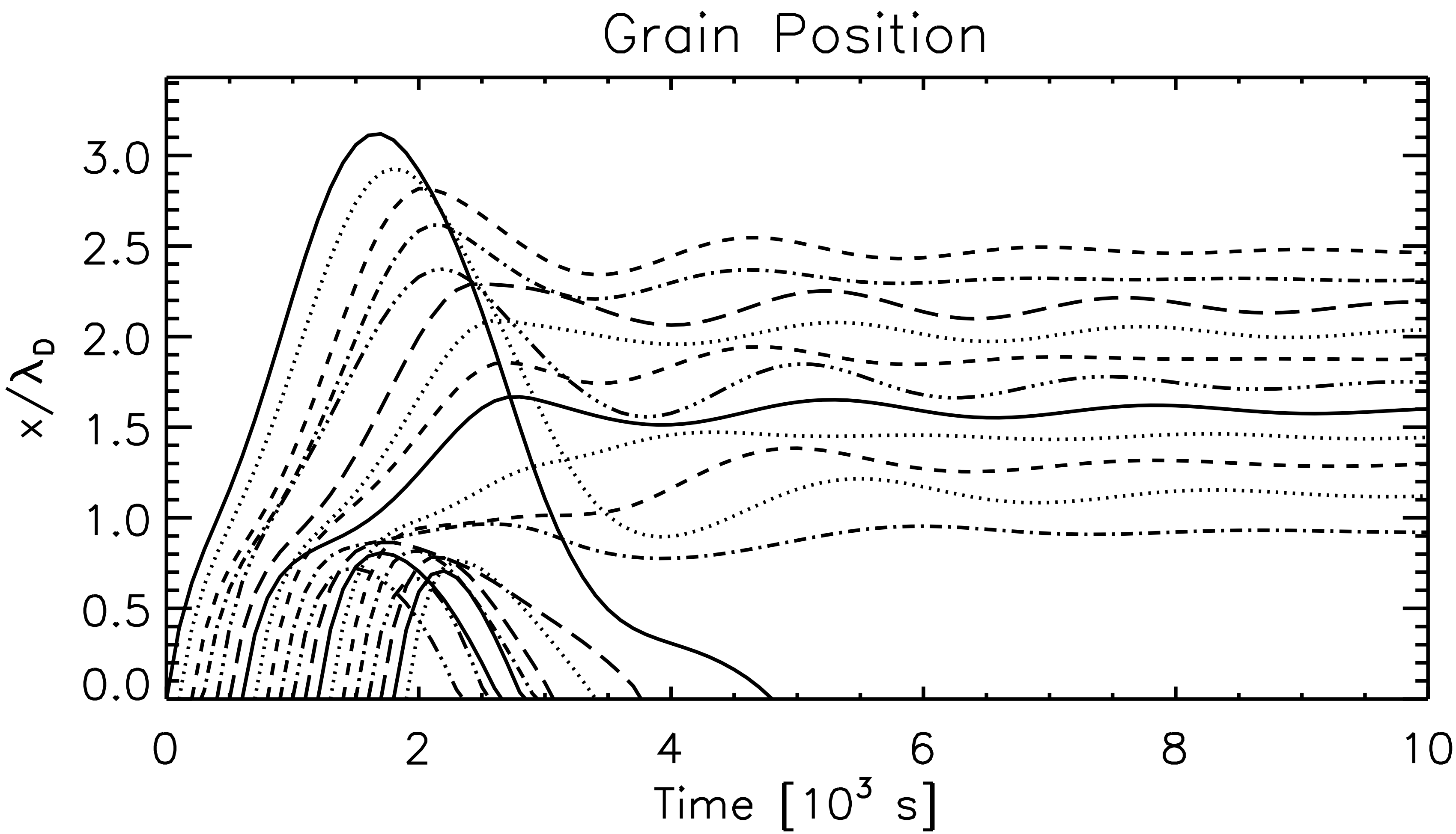
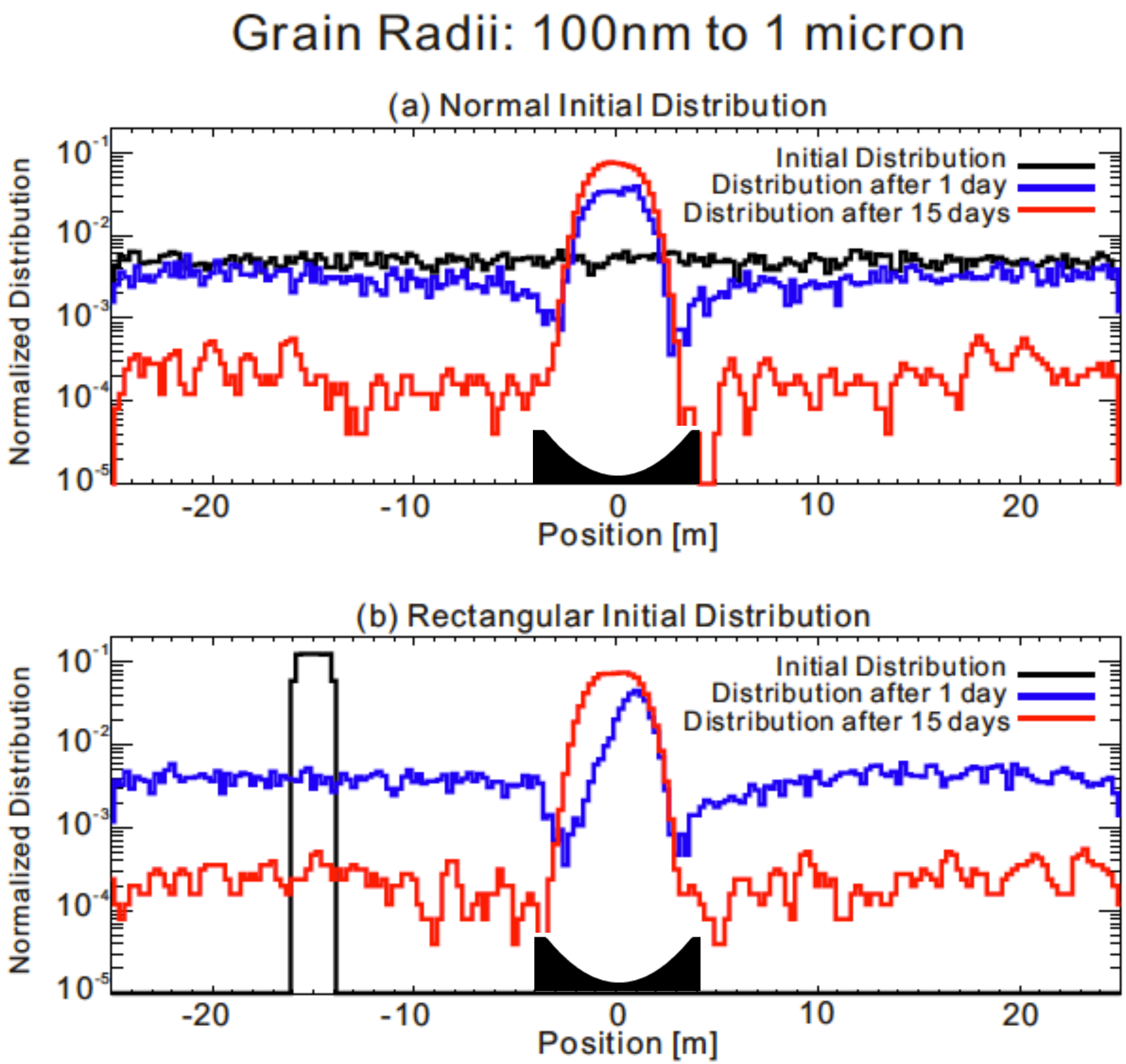


Dust moves around the surface.



Szalay et al., 2012

Dust accumulates in craters.

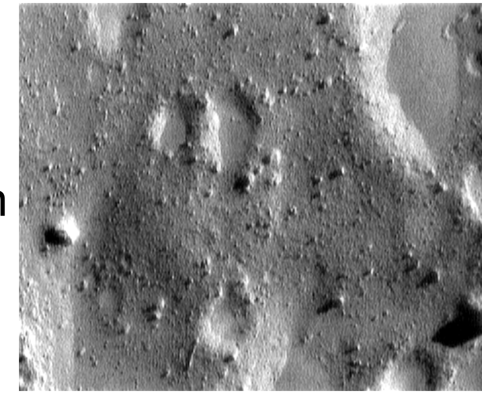


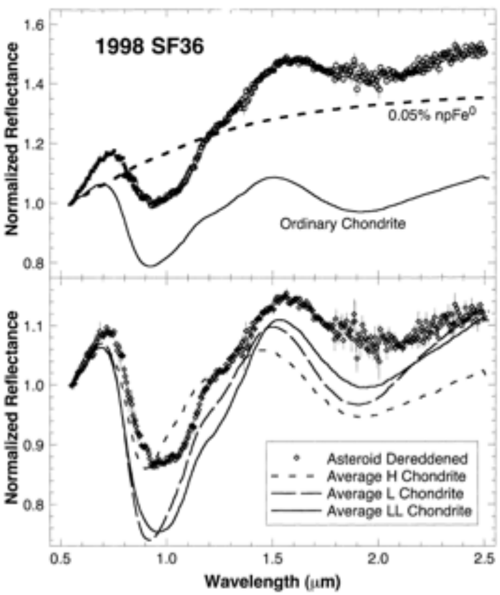
Poppe et al., 2012

Dust ponds can form.

Classification:
C - Carbonaceous
S - Silicaceous
M - Metallic

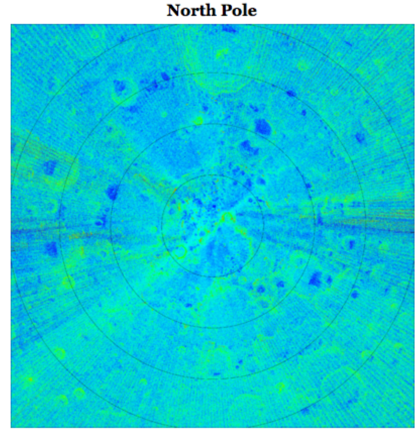
"Ponding" on Eros



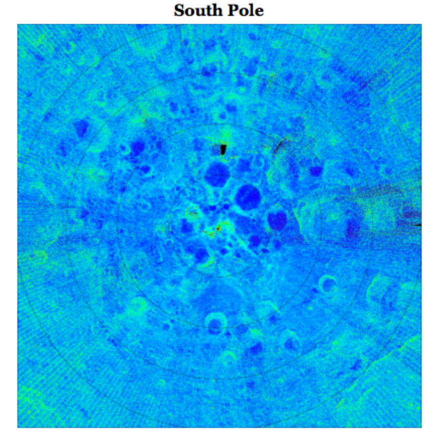


LRO - LAMP

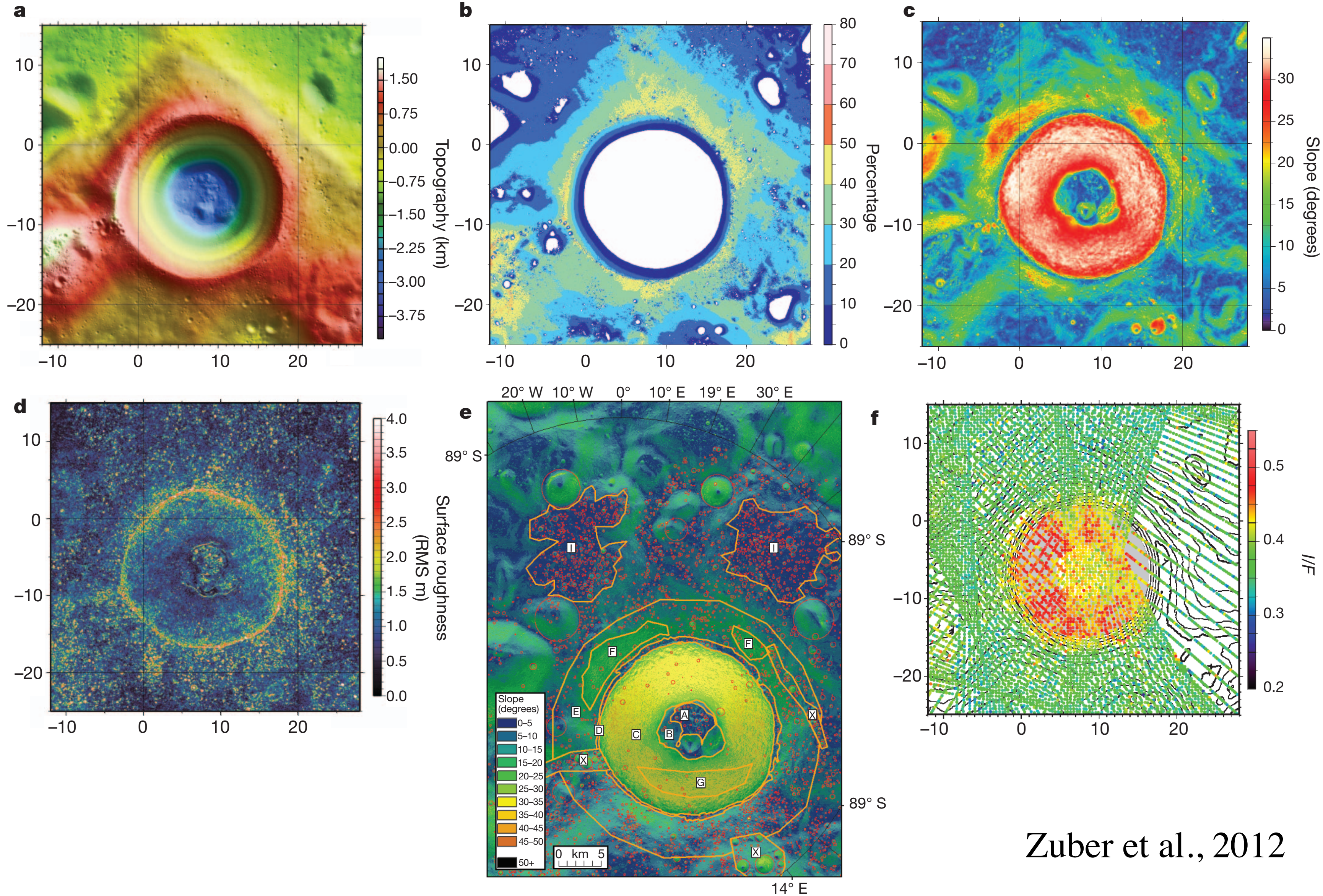
North Pole



South Pole



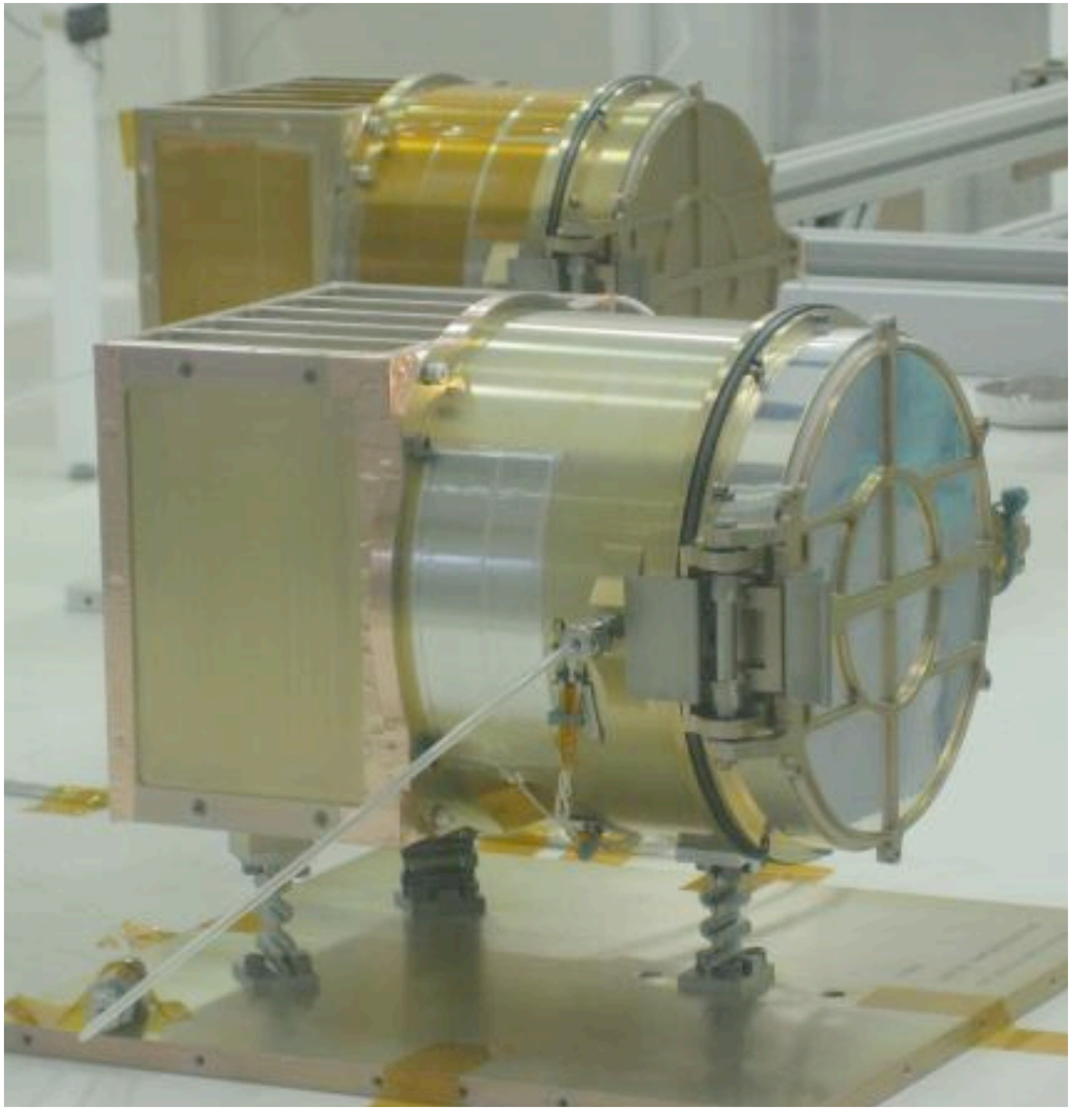
Even a fine dust layer can interferes with remote sensing search for volatiles.



Zuber et al., 2012

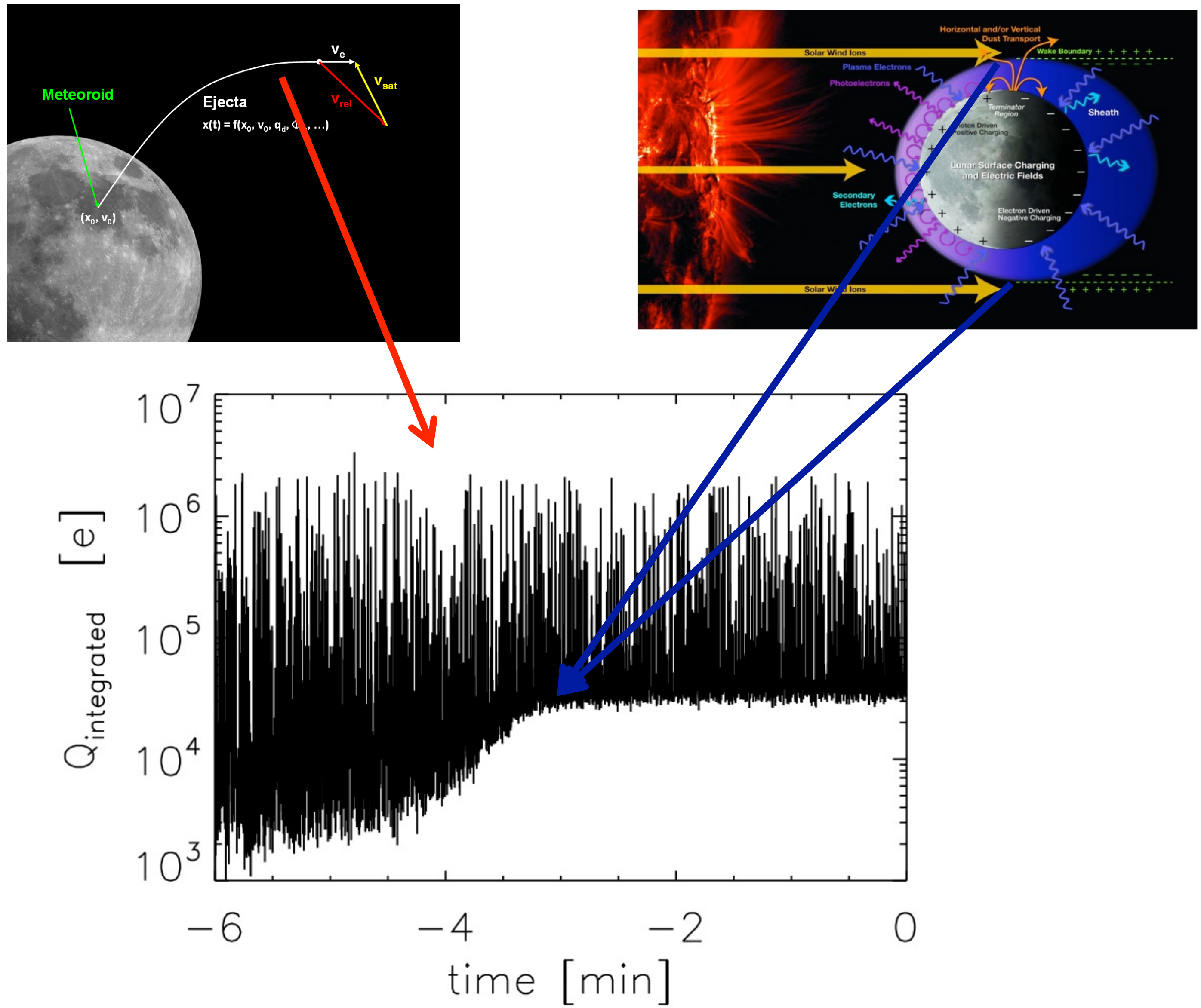
LUNAR SCIENCE FORUM

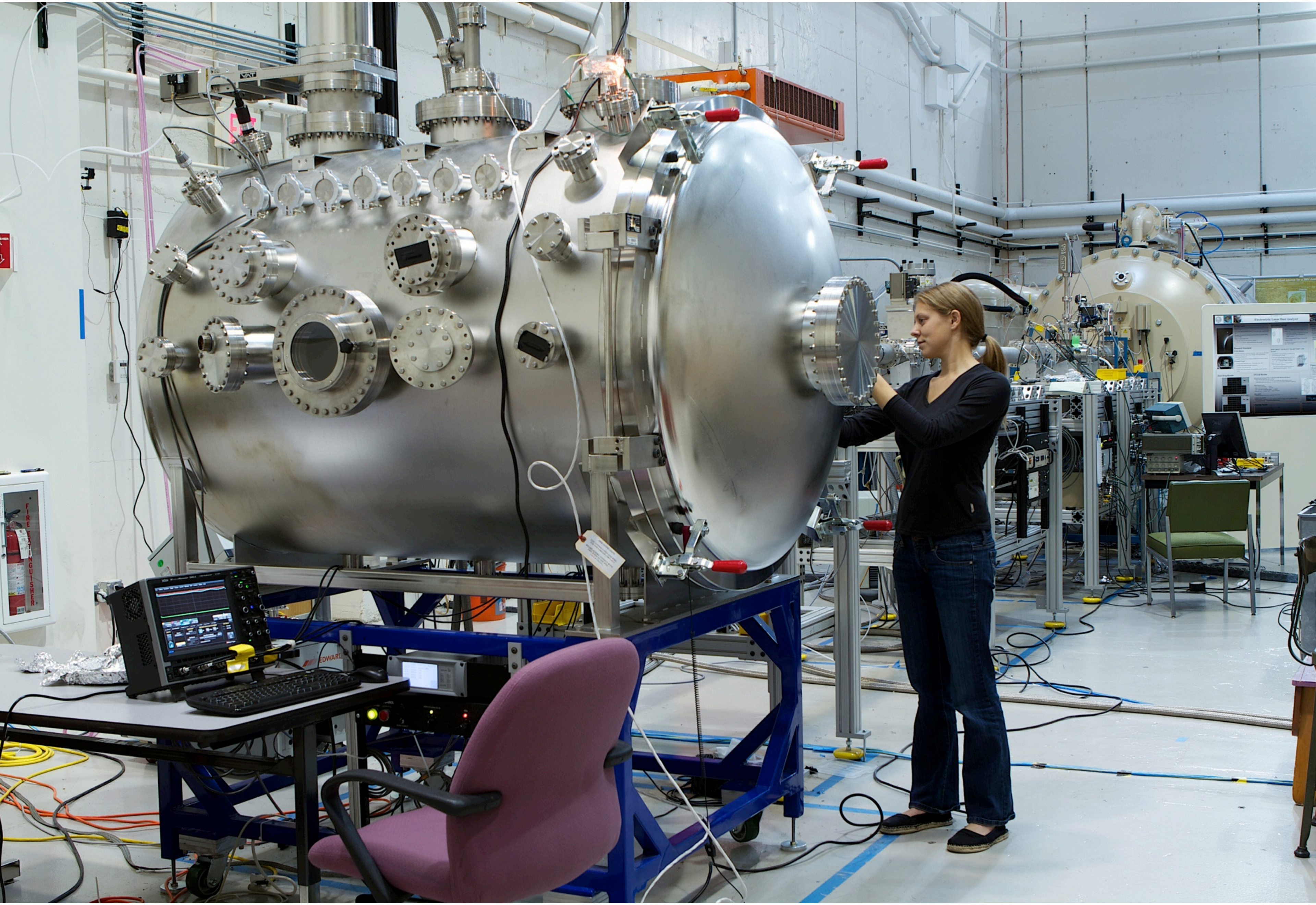
LADEE/LDEX will help.



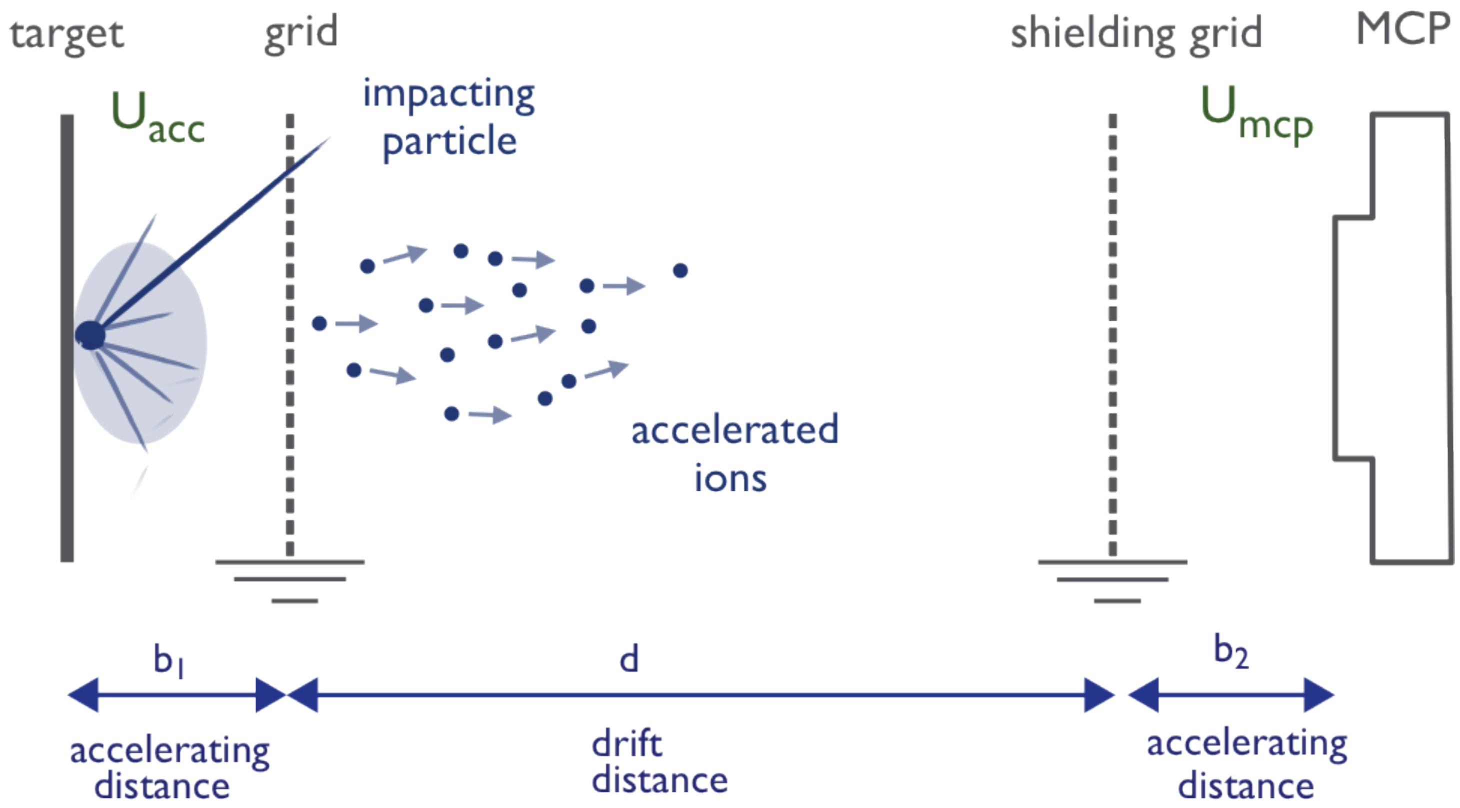
Pre-Shipment Review
June 7, 2012

LDEX will map the lunar dust environment.

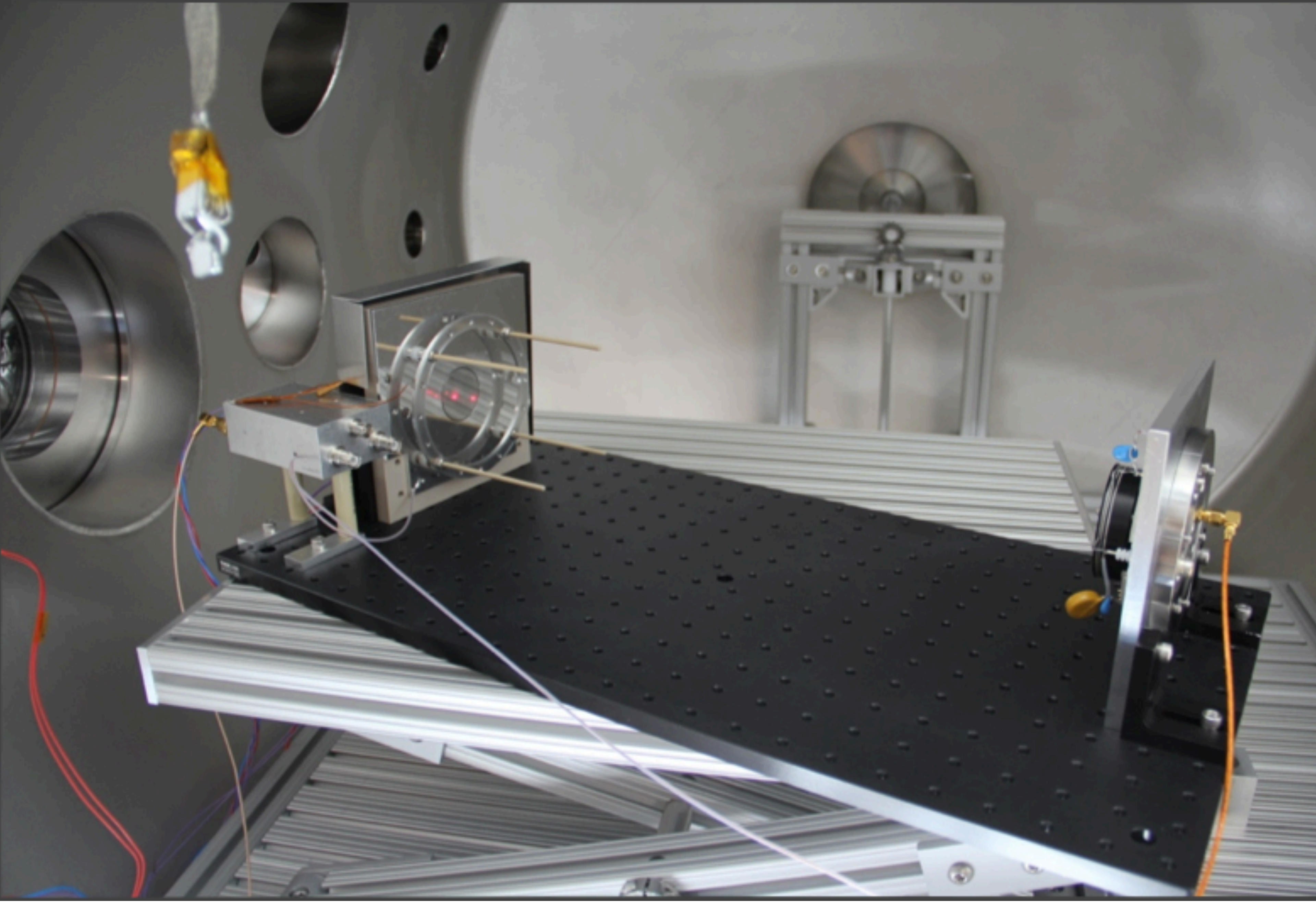



FIRE EXTINGUISHER

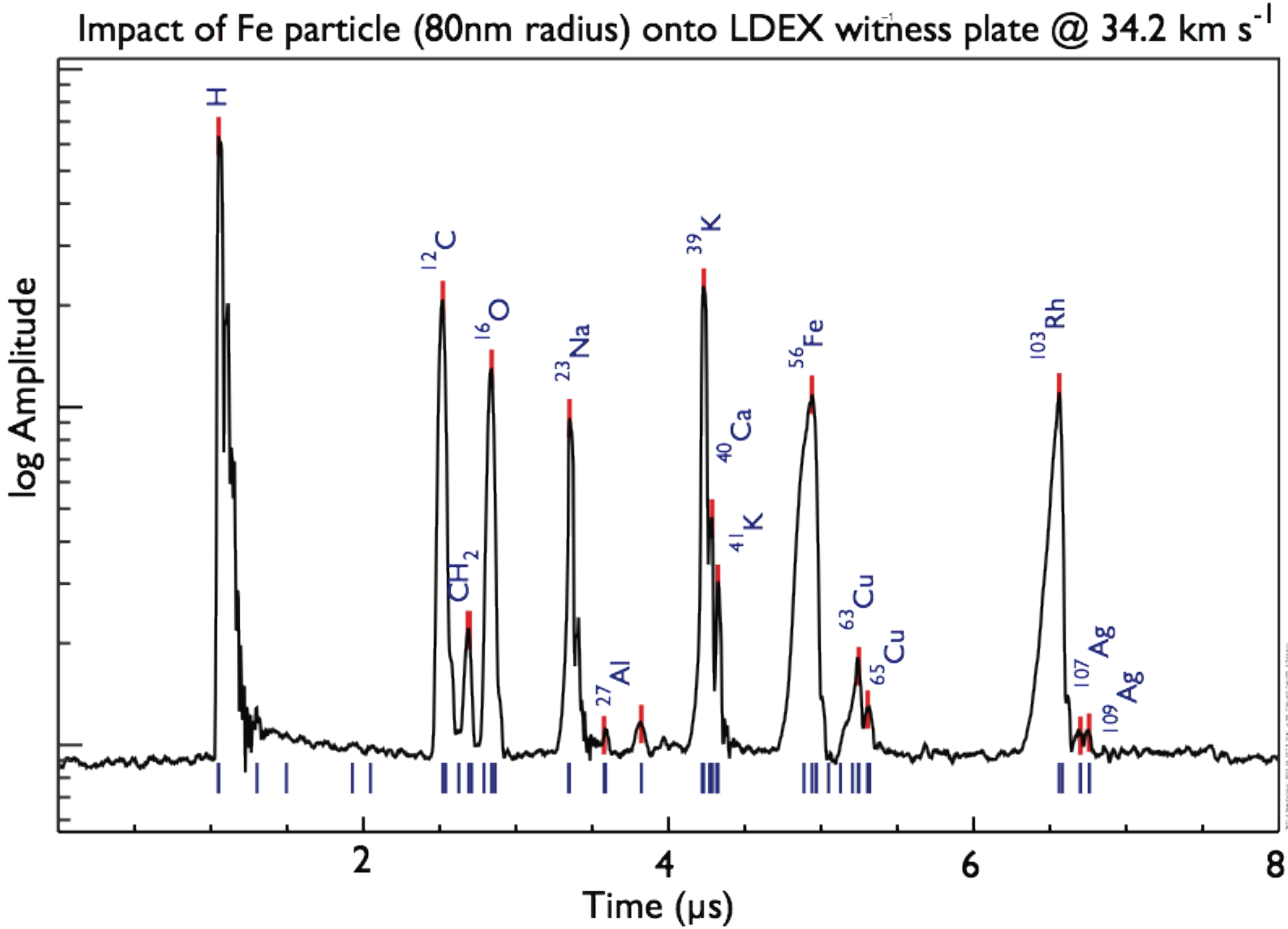
Linear Time-of-Flight Mass Spectrometer



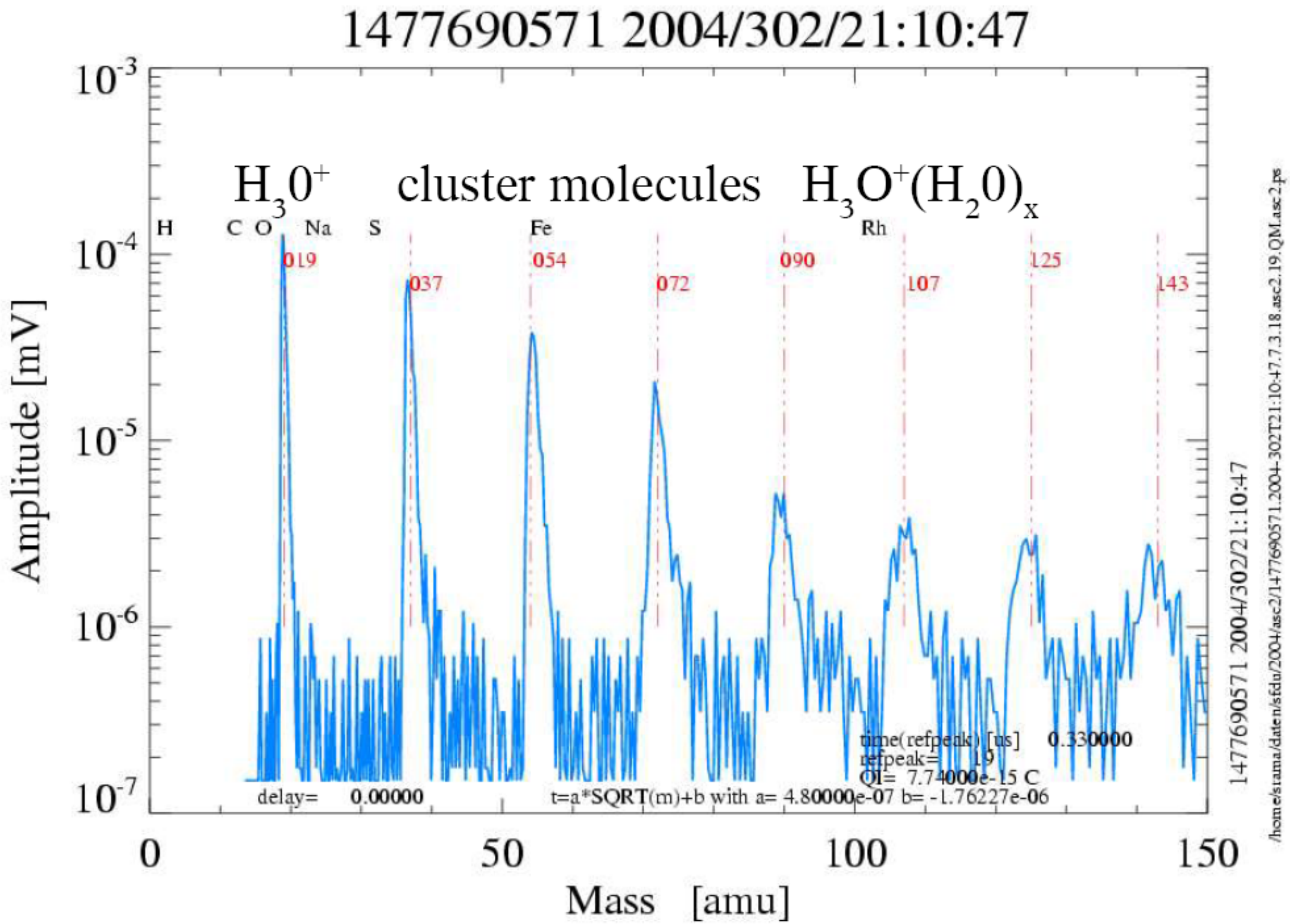
- Measures velocity distribution of the ions
- Narrow instrument aperture - filtering the angular distribution
- Few secondary ions due to ejecta



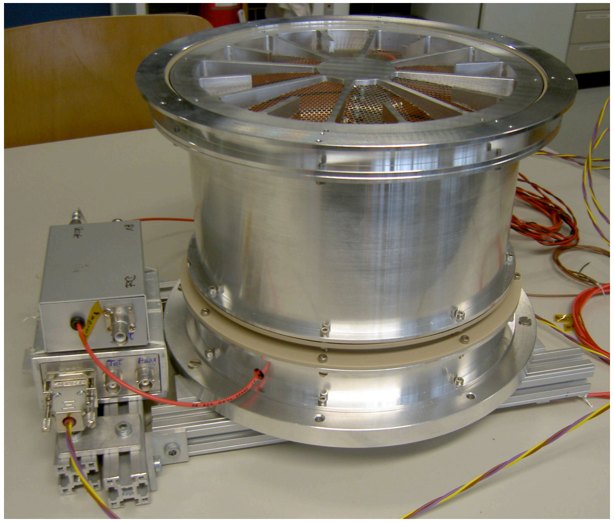
Time-of-Flight Mass Spectrum

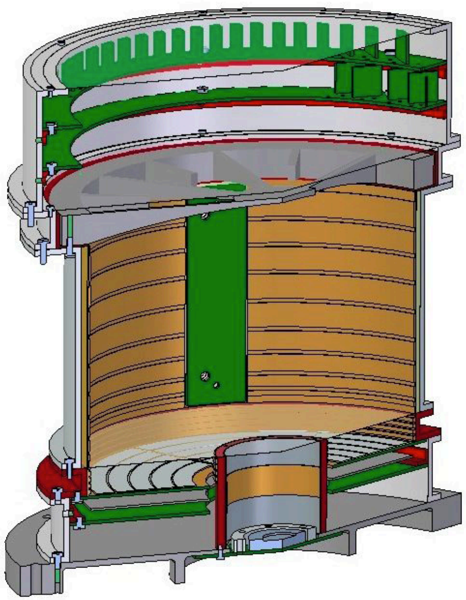


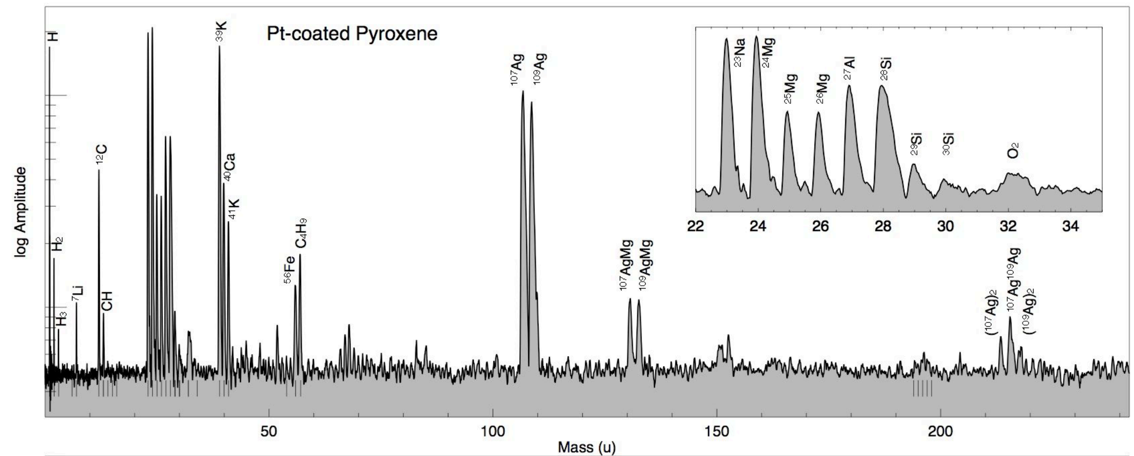
A dust detector in orbit can unabiguously detect ice from the surface.

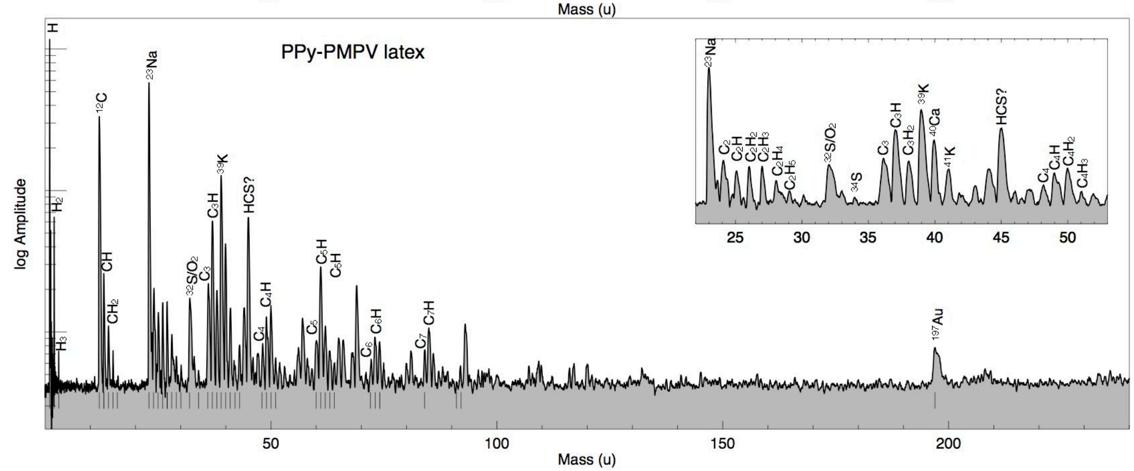


Dust instruments are ready.









Strategic Knowledge Gaps

III. Understand how to work and live on the lunar surface.

E. Plasma environment and charging

Strategic Knowledge Gap	Research and Analysis	Earth-based Testing	ISS / ISTAR	LEO	Robotic Lunar Missions	Narrative
Determining near-surface plasma environment and nature of differential electrical charging at multiple lunar localities (includes PSRs)	⊙ !	○ !	○	○	●	The lunar near-surface electrical field and plasma environment is poorly known due to lack of direct, long term observations. Significant questions remain as to the degree of charging of hardware on the lunar surface, particularly night-side of the lunar terminator. Also, surface and surface-placed objects may undergo large changes in potentials during passages of solar storms. Direct observation is required in order to understand the variations of the electrical 'ground' defined by the plasma currents to an object placed on the surface. In PSRs, the lack of an obvious charge reservoir (i.e., low conductivity surface and obstructed plasma) suggests the possibility of poor electrical dissipation for tribocharging objects like drills, and rover tires. A surface mission would directly complement LADEE. **This is enabling surface operations and human safety.** .

Laboratory experiments, modeling, and instrument development remain essential!