Modeling Dust Clouds on the Moon

Jamey Szalay
Mihály Horányi

CCLDAS
University of Colorado at Boulder

DAP 2012

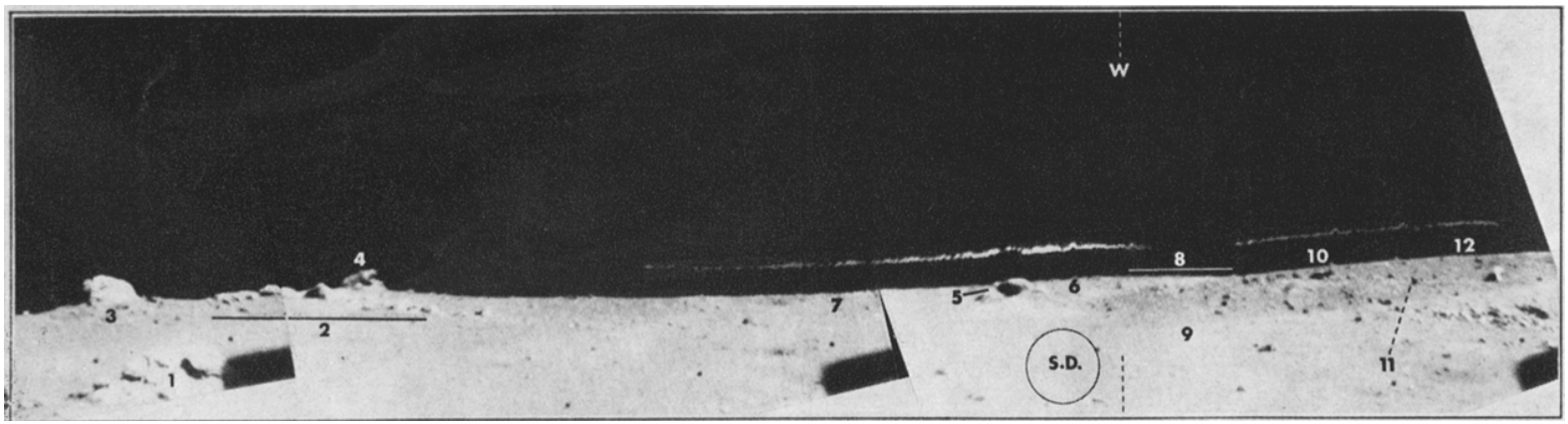
Motivation
- Surveyor Images
- LEAM

Model
- Sheath
- Grain Charging
- Dusty Sheath

Results
- Experimental Comparison
- Lunar

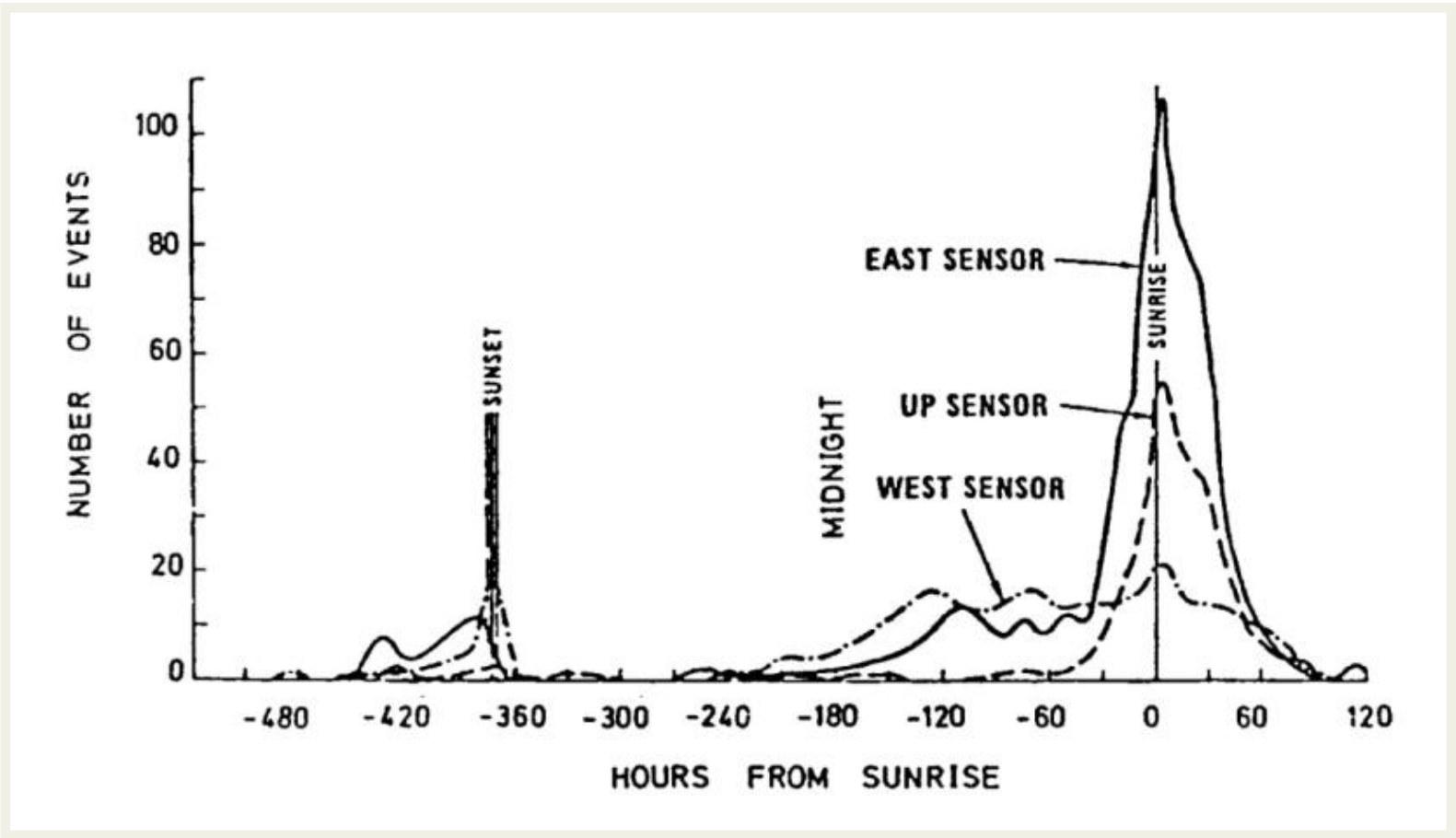
Conclusion

Surveyor 7 Horizon Glow



McCoy 1974

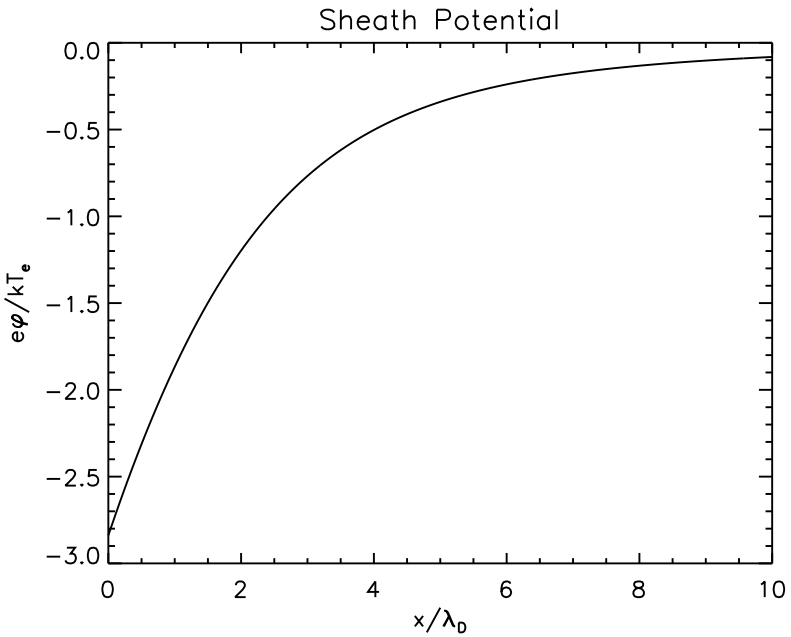
LEAM Terminator Measurements



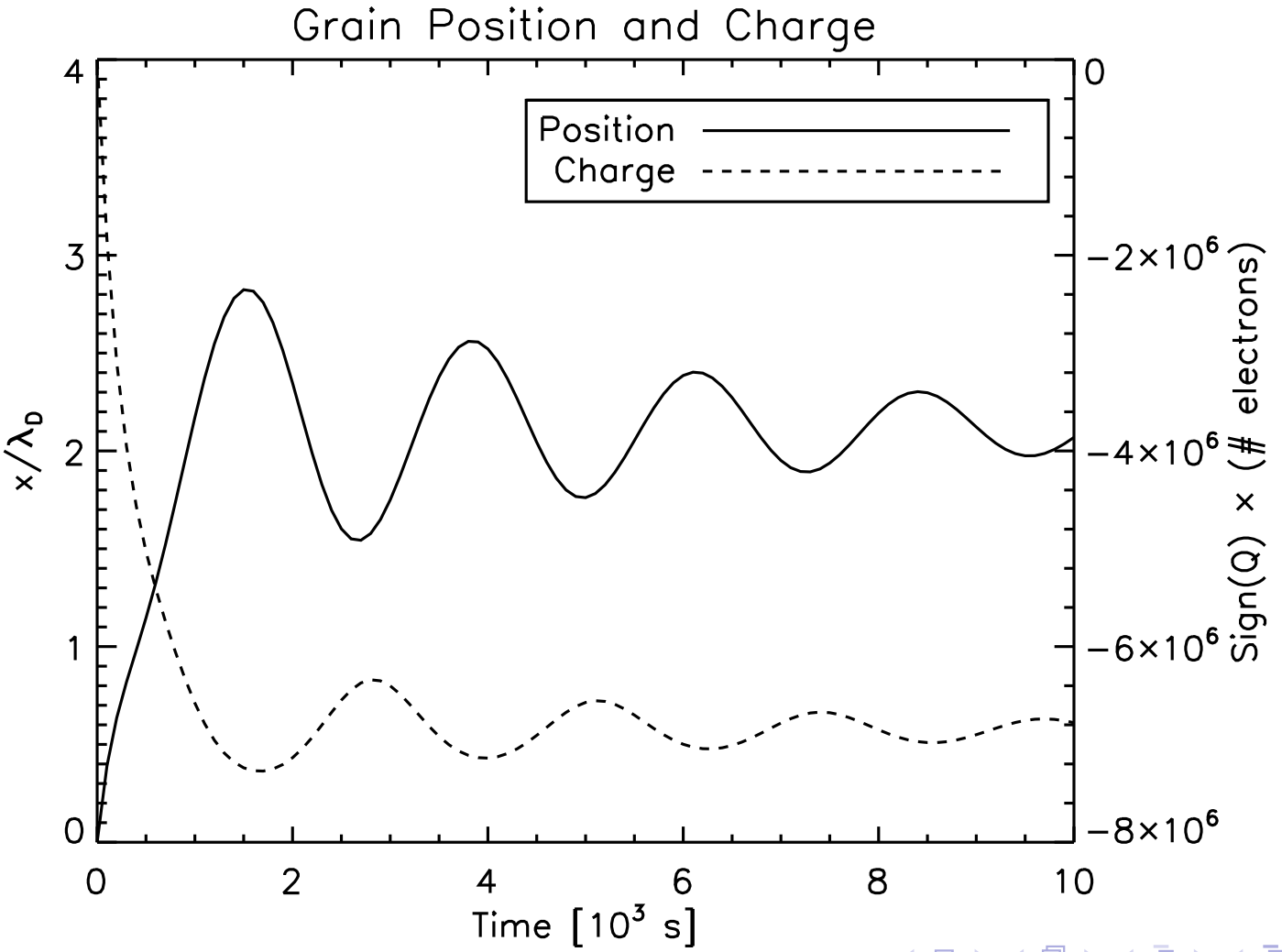
Berg 1976

Two Fluid Plasma Sheath

$$\frac{\partial^2 \varphi}{\partial x^2} = \underbrace{\frac{en_0}{\epsilon_0} e^{e\varphi/kT_e}}_{\text{electrons}} - \underbrace{\frac{en_0}{\epsilon_0}\left(1 - \frac{2e\varphi}{m_i v_{i,dr}^2}\right)^{-1/2}}_{\text{ions}}$$

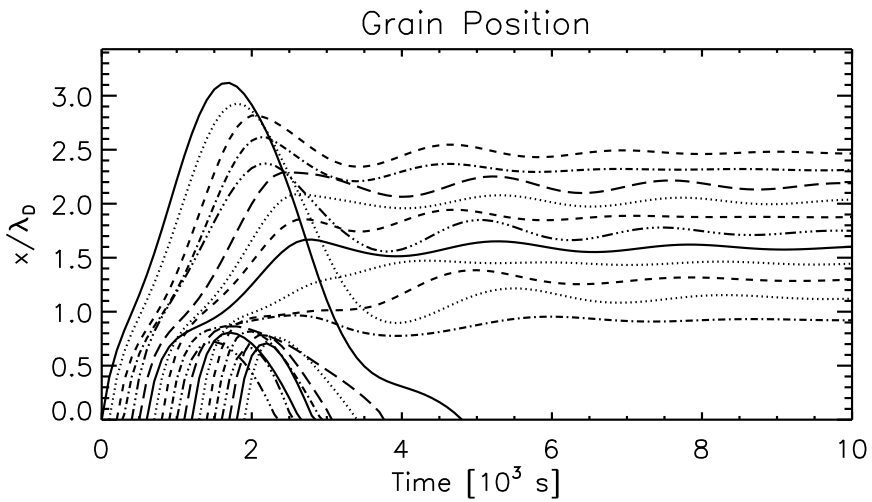


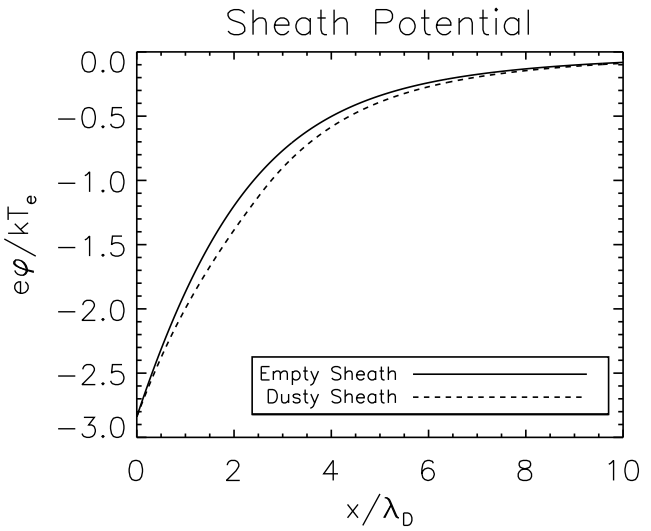
Grain Charging



Dusty Plasma Sheath

$$\frac{\partial^2\varphi}{\partial x^2} = \underbrace{\frac{en_0}{\epsilon_0}e^{e\varphi/kT_e}}_{\text{electrons}} - \underbrace{\frac{en_0}{\epsilon_0}\left(1-\frac{2e\varphi}{m_i v_{i,dr}^2}\right)^{-1/2}}_{\text{ions}} - \underbrace{\frac{\rho_d(x)}{\epsilon_0}}_{\text{dust}}$$

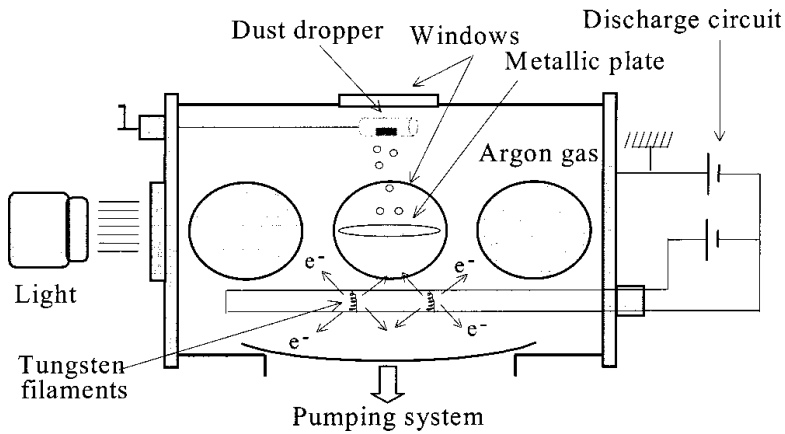




Arnas et al.

Simulation Parameters

- $T_e = 1.8$ eV
- Argon Plasma
- Glass spheres with radii $a = 22\ \mu m$



Arnas 1999

Arnas et al.

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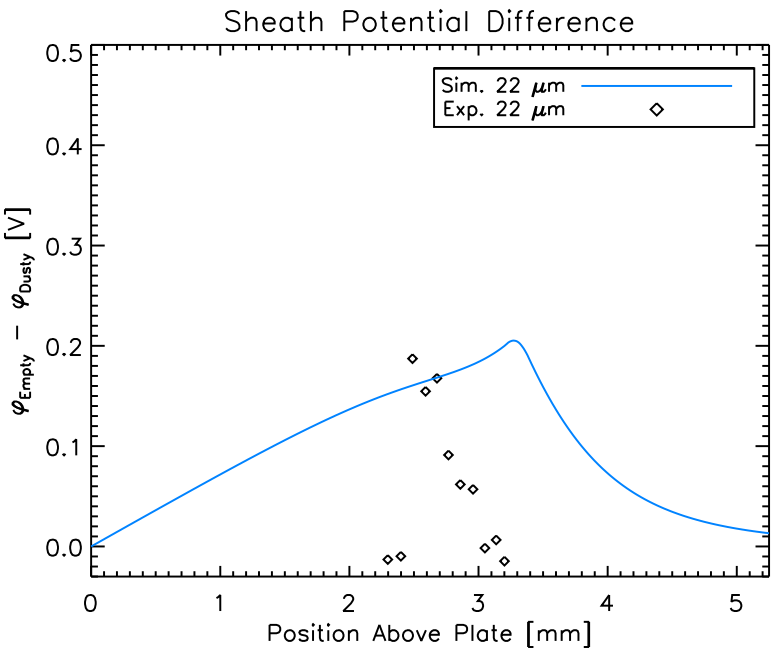
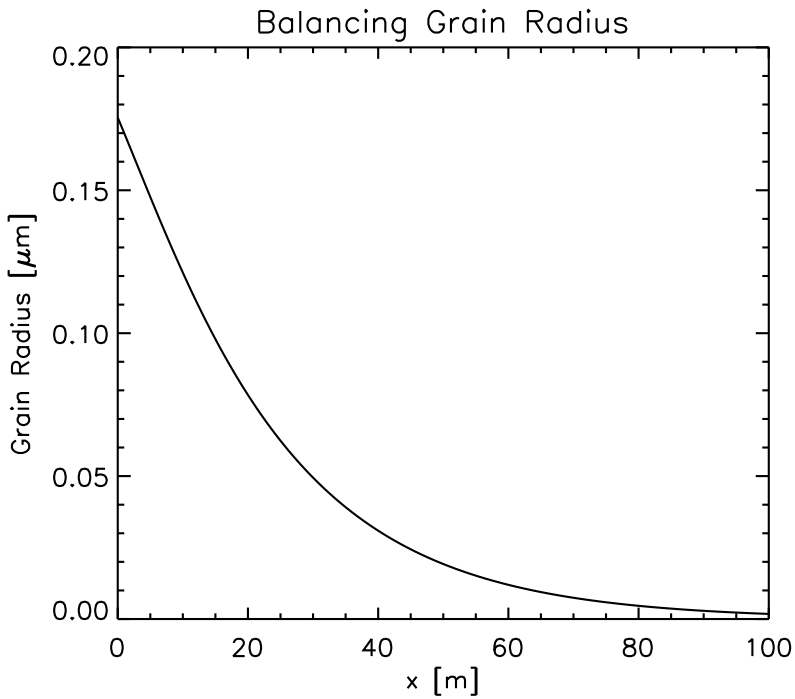


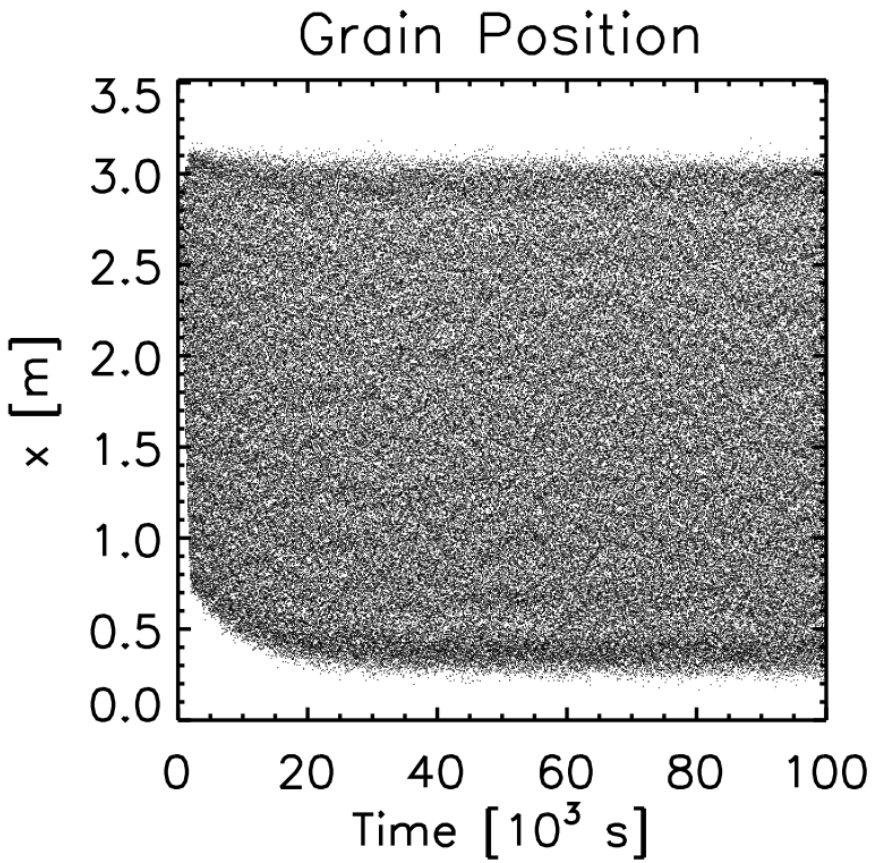
Lunar Inputs

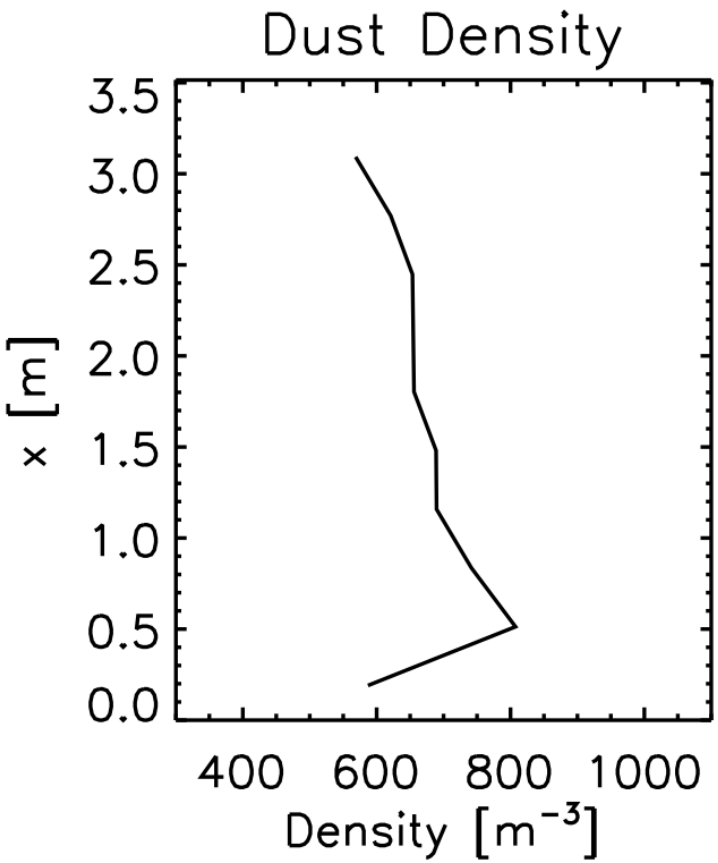
Simulation Parameters

- $T_e = 10$ eV
- $v_{sw} = 400$ km/s
- $a = 0.16\ \mu m$



Lunar Sheath





Comparison to Surveyor 7

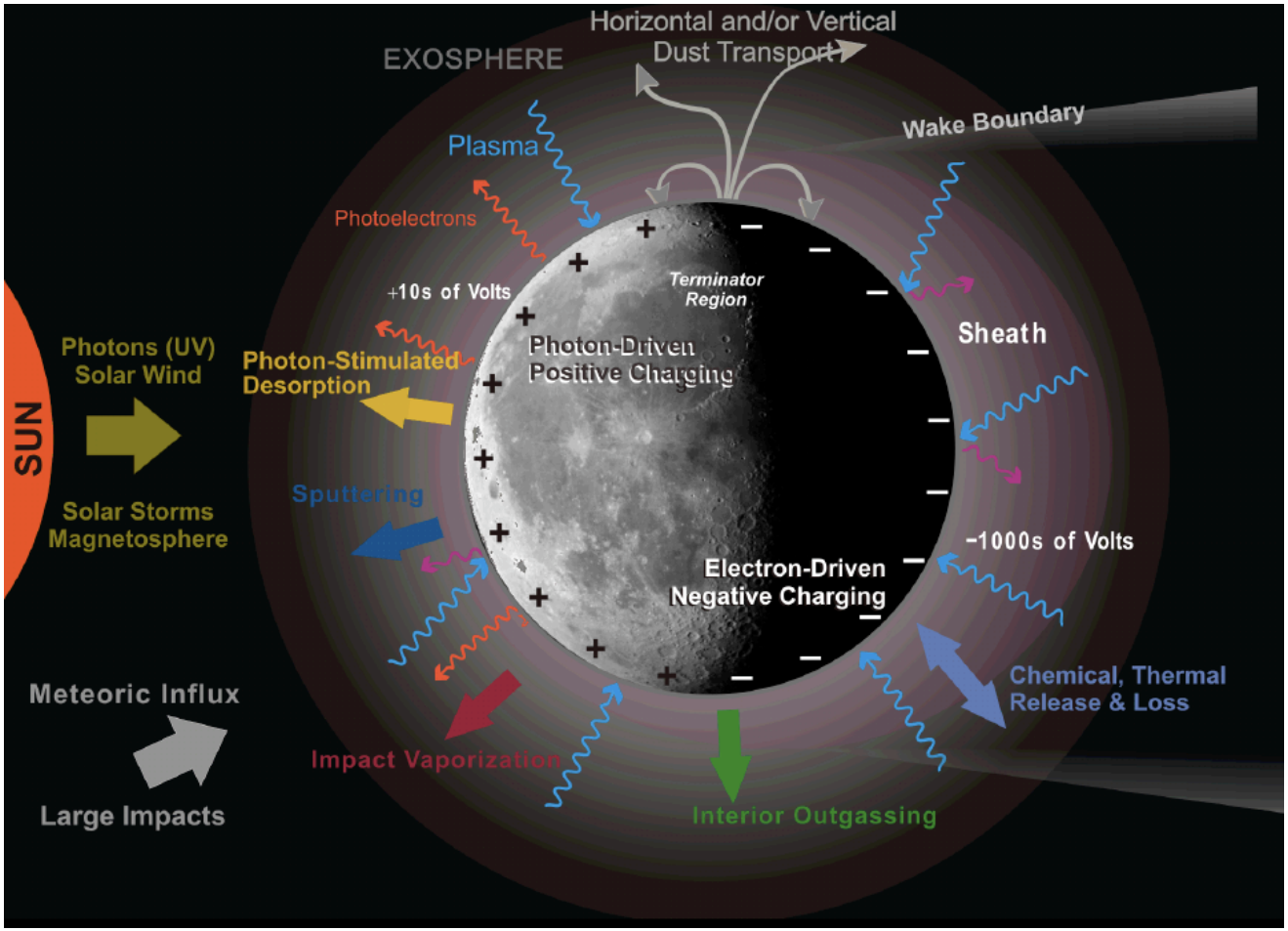
Surveyor 7

- $a = 6\ \mu m$
- $n_d = 10^6\ m^{-3}$

Model

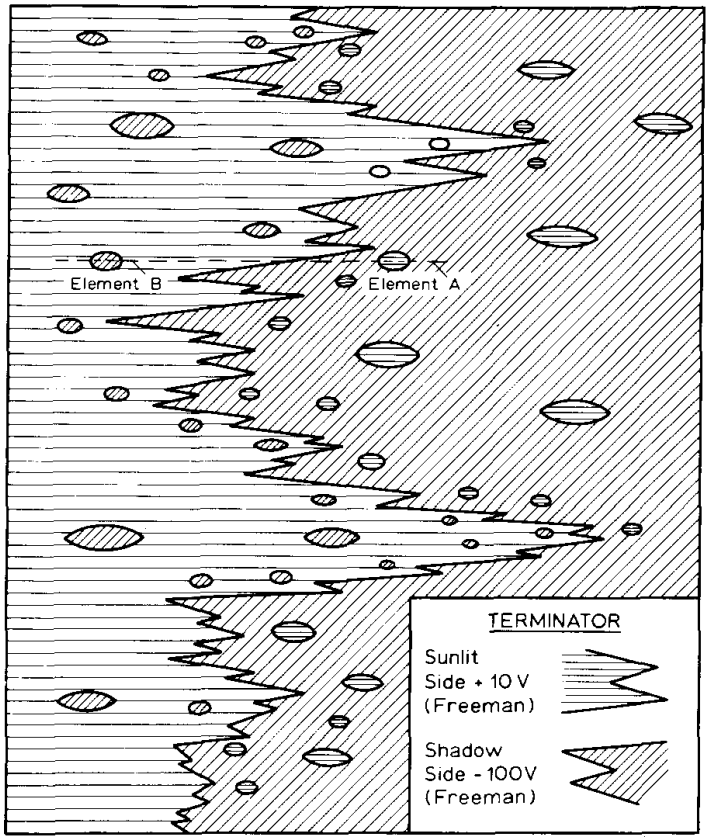
- $a = 0.16\ \mu m$
- $n_d = 10^3\ m^{-3}$

Charging

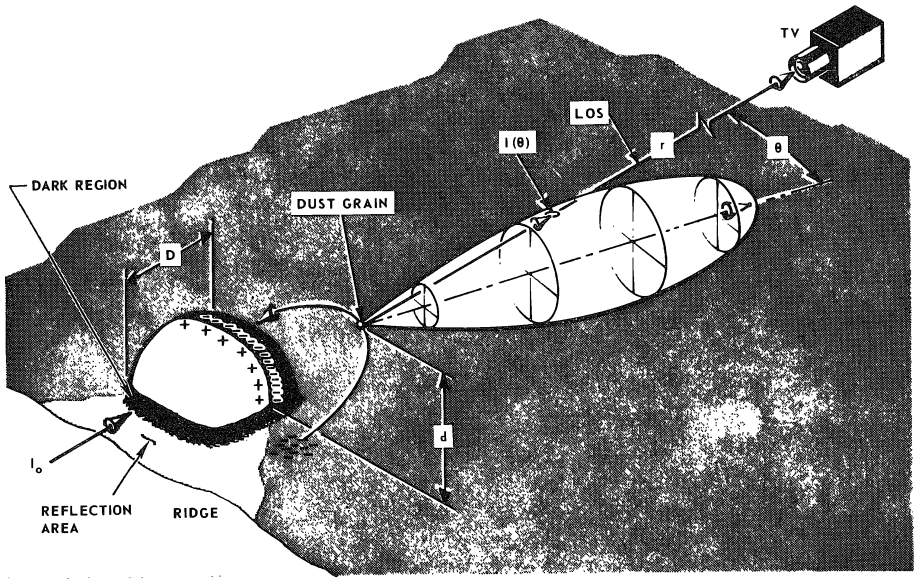


NASA/GSFC, UCB/SSL

Terminator



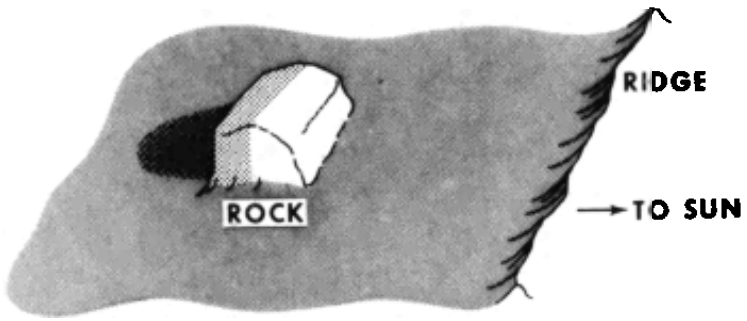
Berg 1978



Criswell 1972

Next Steps

- Photoemission
- Multi-size grain distributions
- 2D/3D
- Complex Geometries

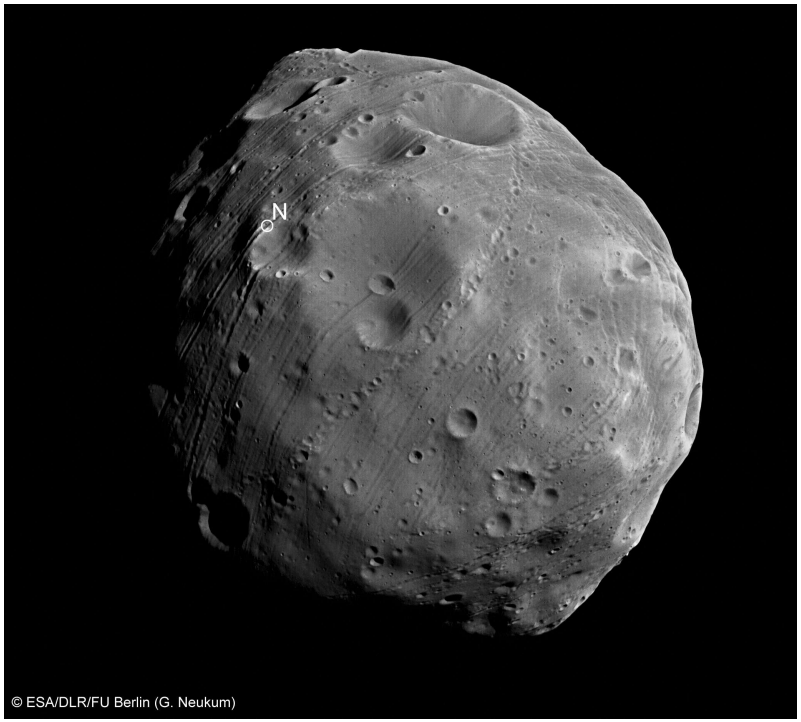


De and Criswell 1977

Scope

Other airless bodies

- Mercury
- 433 Eros & other asteroids
- Phobos/Deimos
- Many more

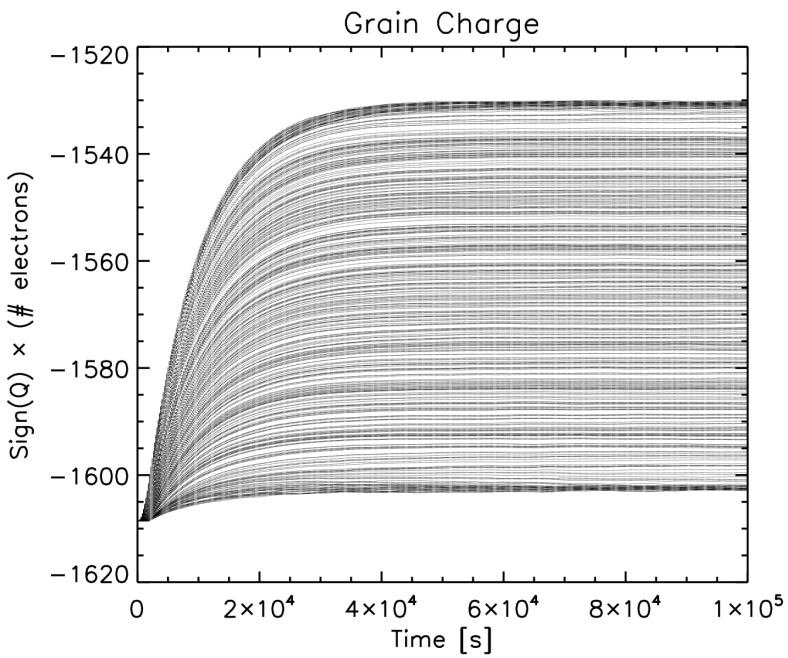


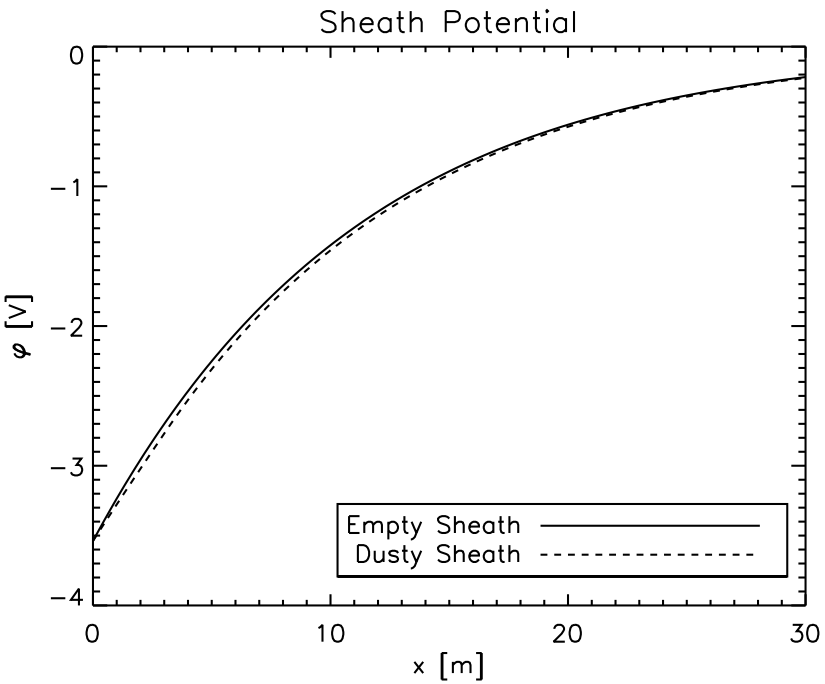
Acknowledgements

- Colorado Center for Lunar Dust and Atmospheric Studies
- CU Boulder

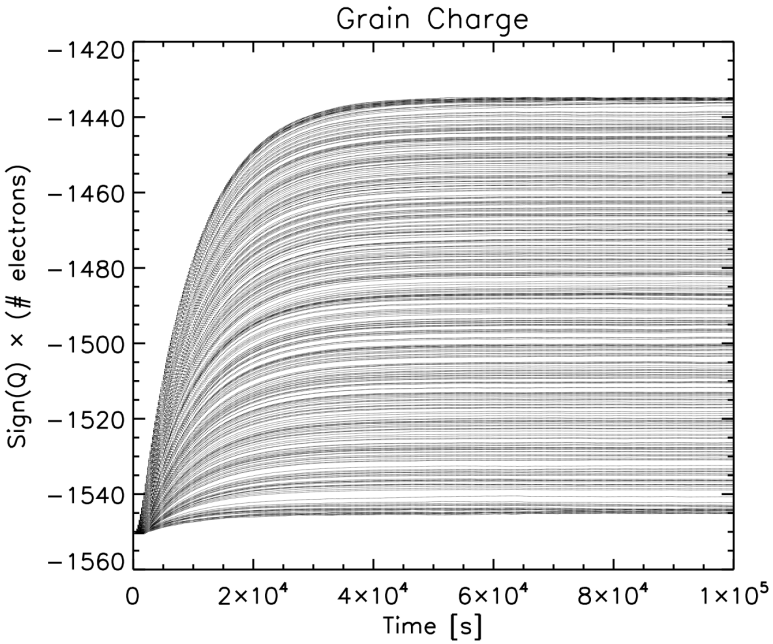
Questions?

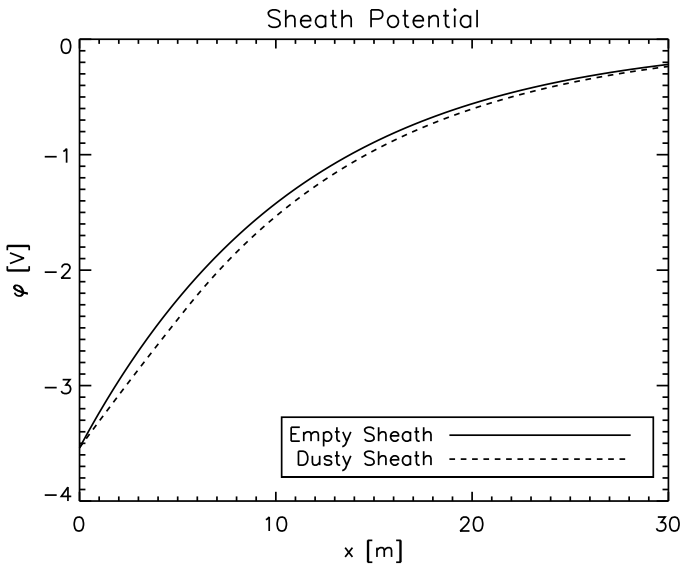
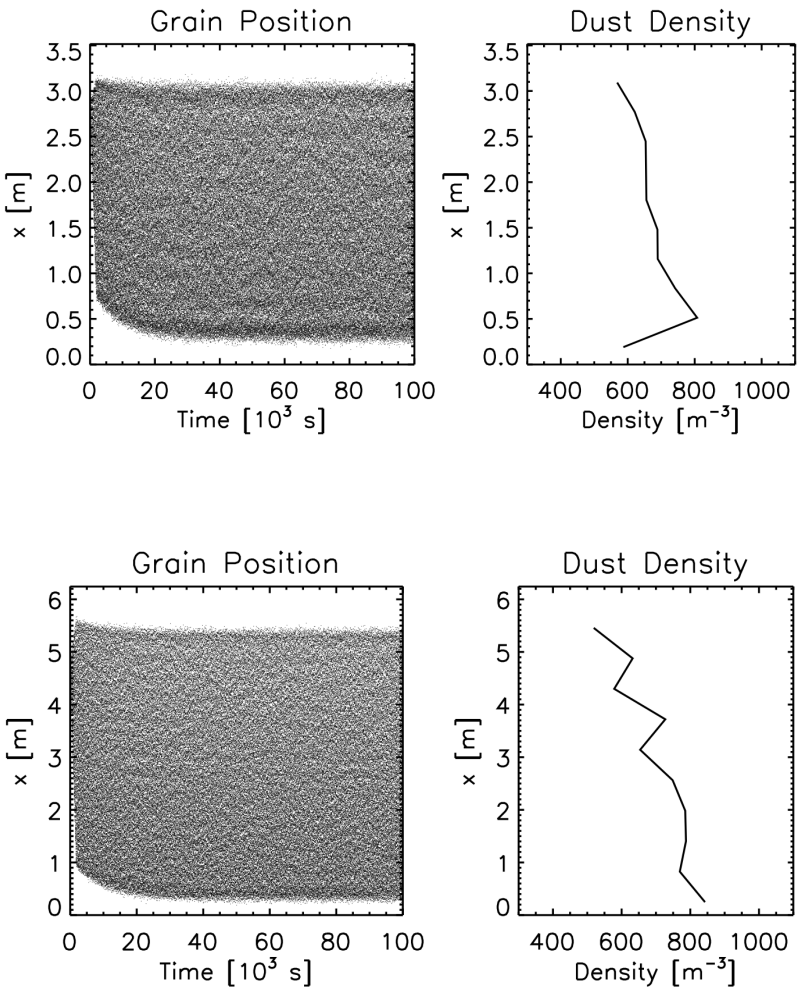
$a = 0.16\ \mu m$


Grain Charge
Sign(Q) × (# electrons)
−1520
−1540
−1560
−1580
−1600
−1620
0
2×10^4
4×10^4
6×10^4
8×10^4
1×10^5
Time [s]


Sheath Potential
φ [V]
0
−1
−2
−3
−4
0
10
20
30
x [m]
Empty Sheath
Dusty Sheath

$a = 0.15\ \mu m$


Grain Charge
Sign(Q) × (# electrons)
−1420
−1440
−1460
−1480
−1500
−1520
−1540
−1560
0
2×10⁴
4×10⁴
6×10⁴
8×10⁴
1×10⁵
Time [s]


Sheath Potential
φ [V]
0
−1
−2
−3
−4
0
10
20
30
x [m]
Empty Sheath
Dusty Sheath

Size Comparison