Deep dielectric charging of the Moon

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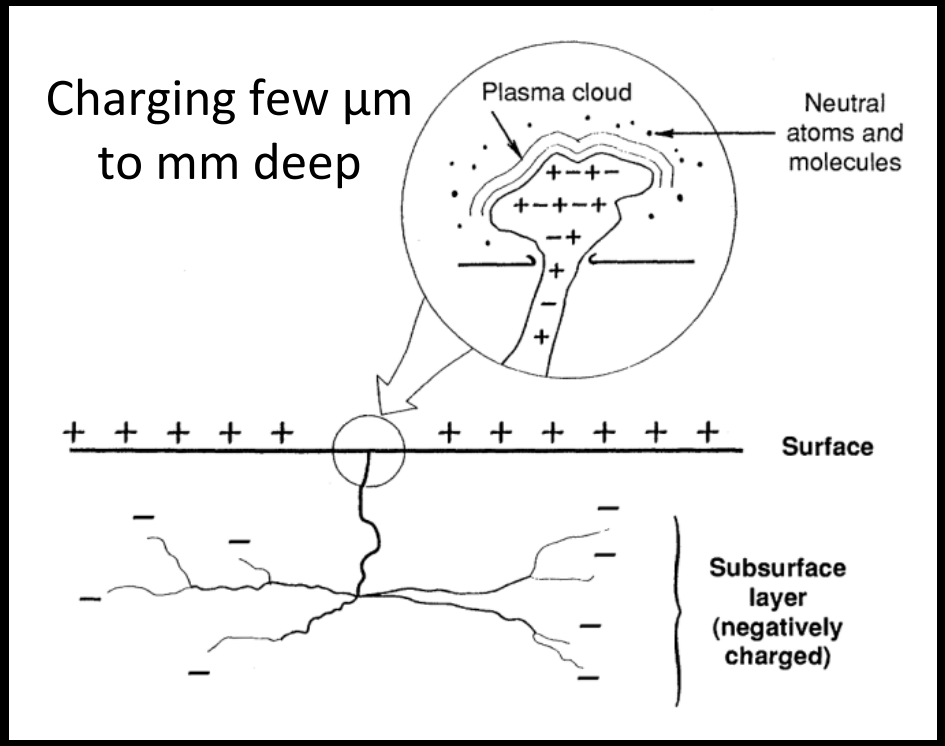
Planetary Surface Discharges

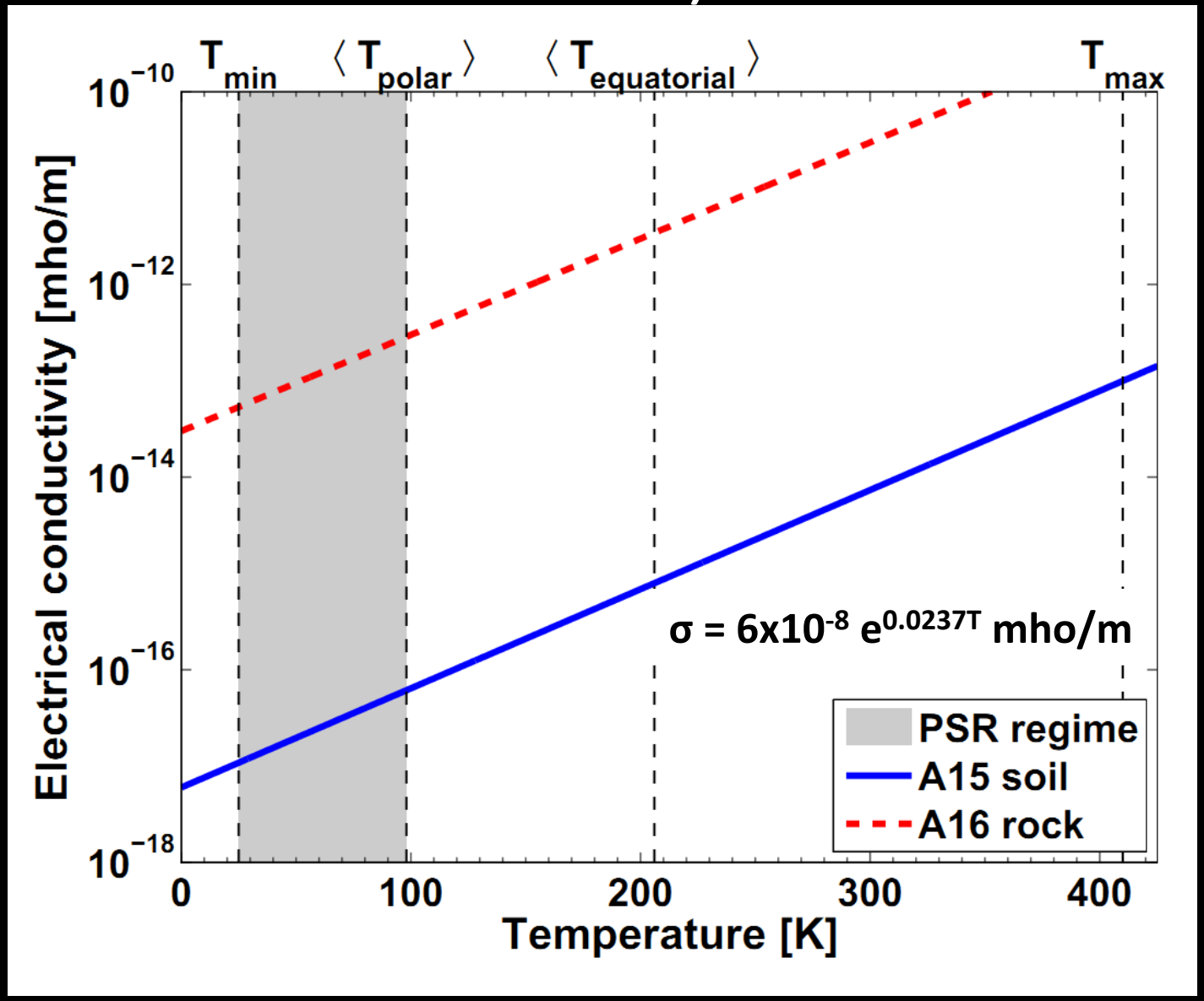
- Campins and Krider (1989): experiments simulating Io in Jupiter's radiation belt
- Effects
  - Plasma creation
  - Melting and boiling
  - Mechanical changes
  - Chemical changes
  - Optical changes



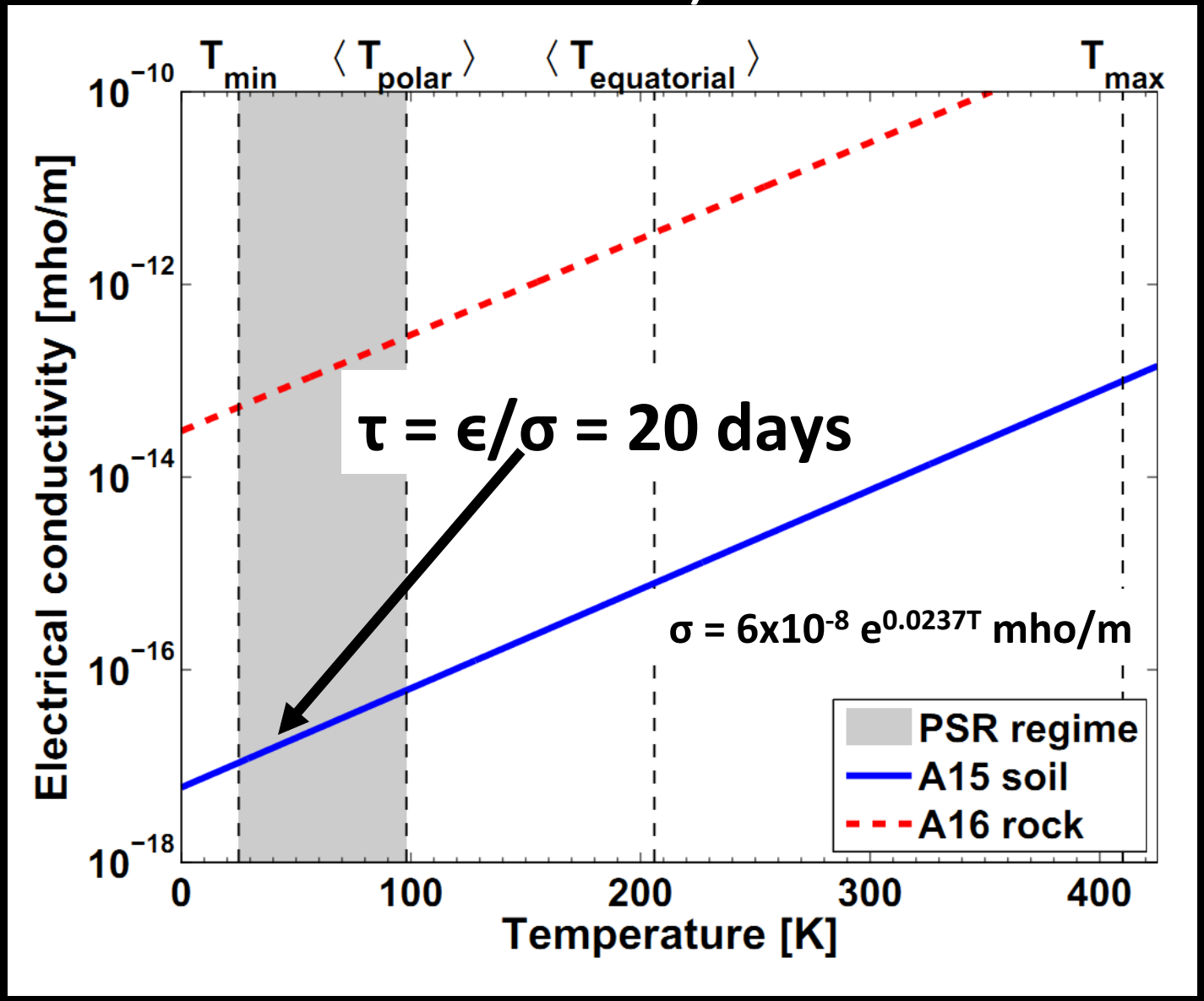
Estimating Dielectric Breakdown

- Breakdown (solid → plasma) at 10^6 - 10^7 V/m (Green and Frederickson, 2006; Sorenson et al., 2000)
  - Field needed to accelerate free electron within dielectric to ionization energy in one mfp
- Fluence needed for breakdown: 10^{10} – 10^{11} charged particles/cm^2 (Frederickson et al., 1992)
- Ignore other currents
- Dielectric constant for regolith: 2 (Olhoeft and Strangway, 1975)

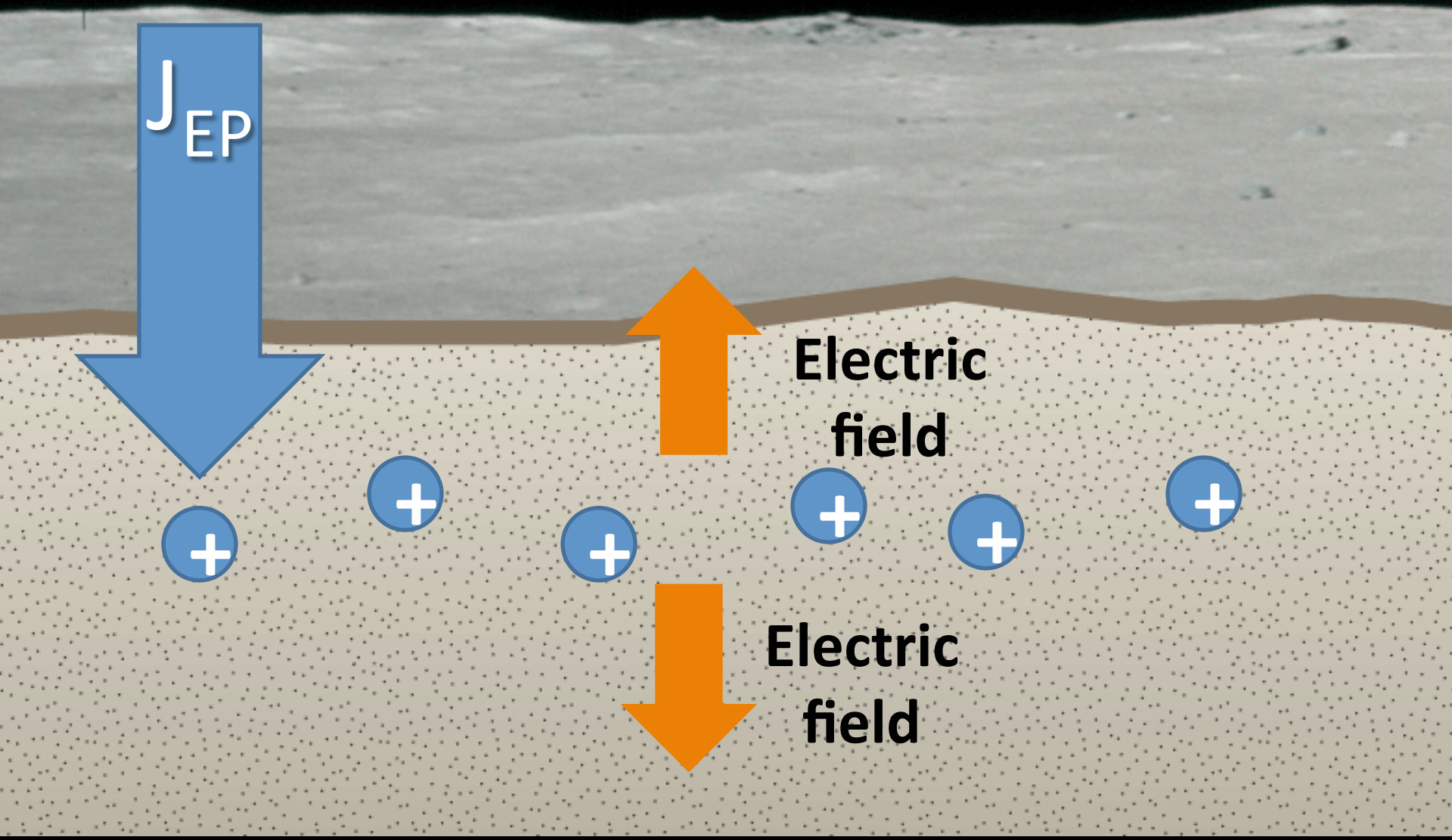
Regolith's Conductivity (Olhoeft et al., 1974)



Regolith's Conductivity (Olhoeft et al., 1974)

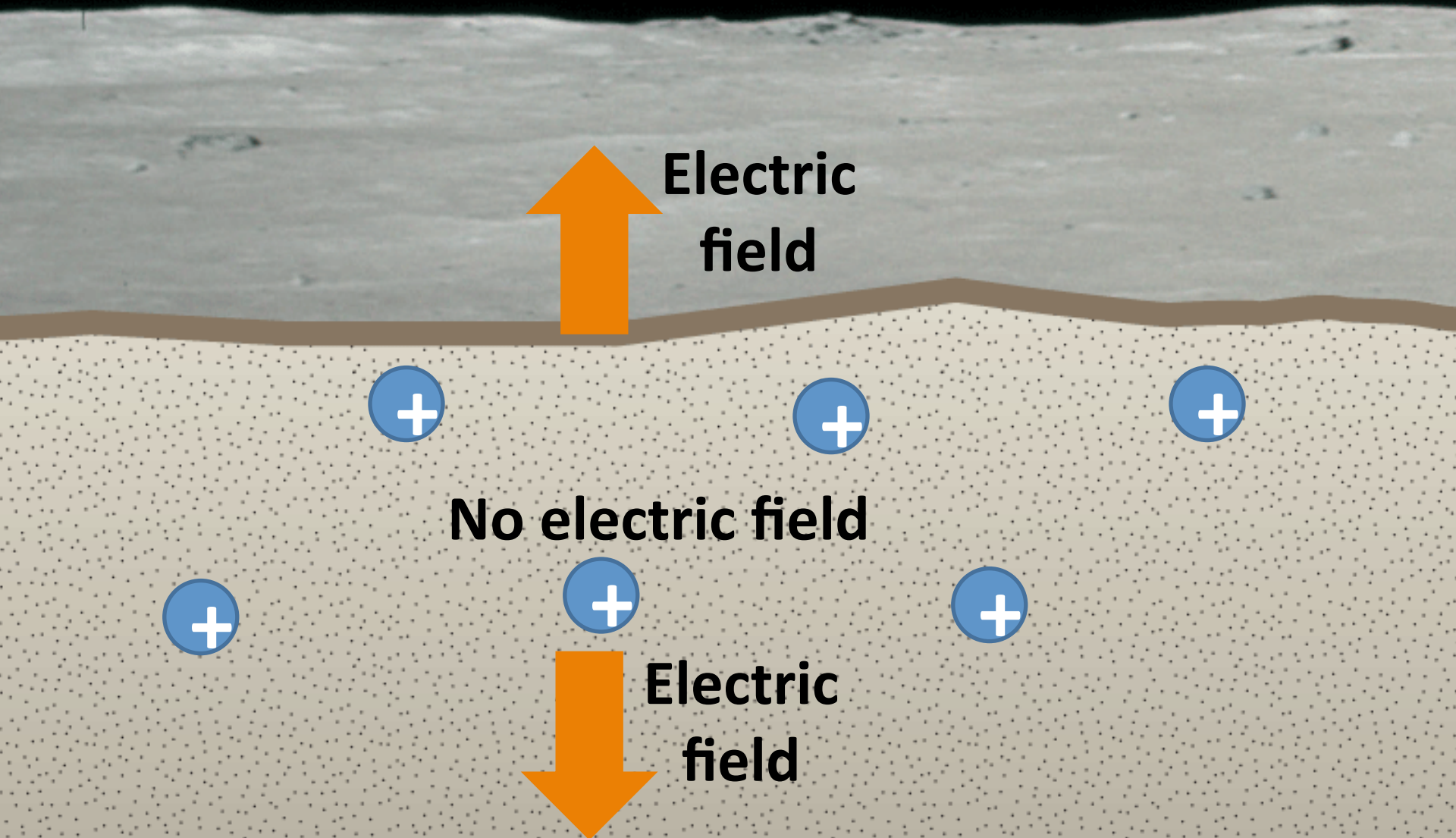


Single Layer Model



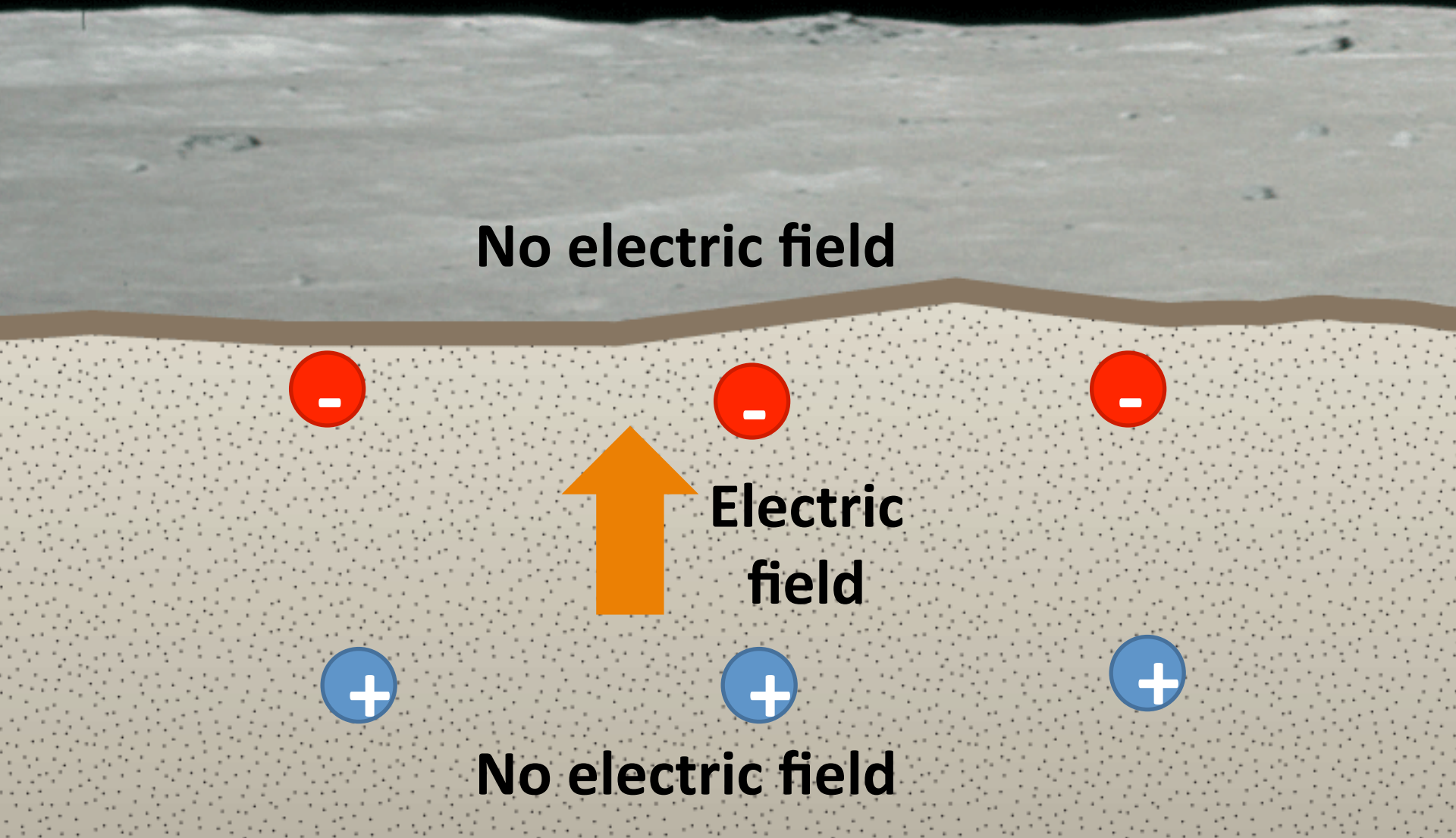
Single Layer Model

- Symmetric dissipation current density



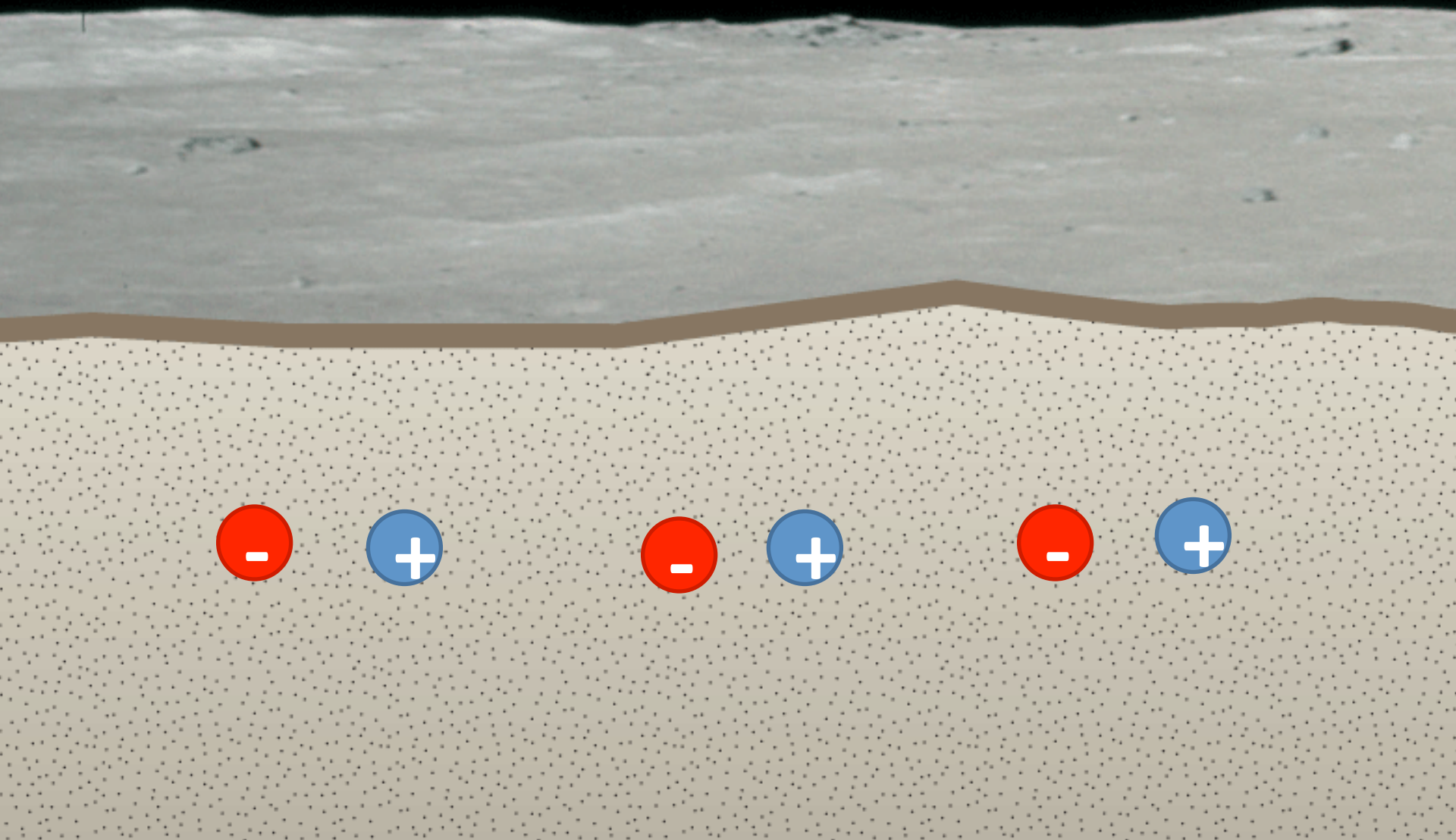
Double Layer Model

- Non-overlapping proton layer and electron layer

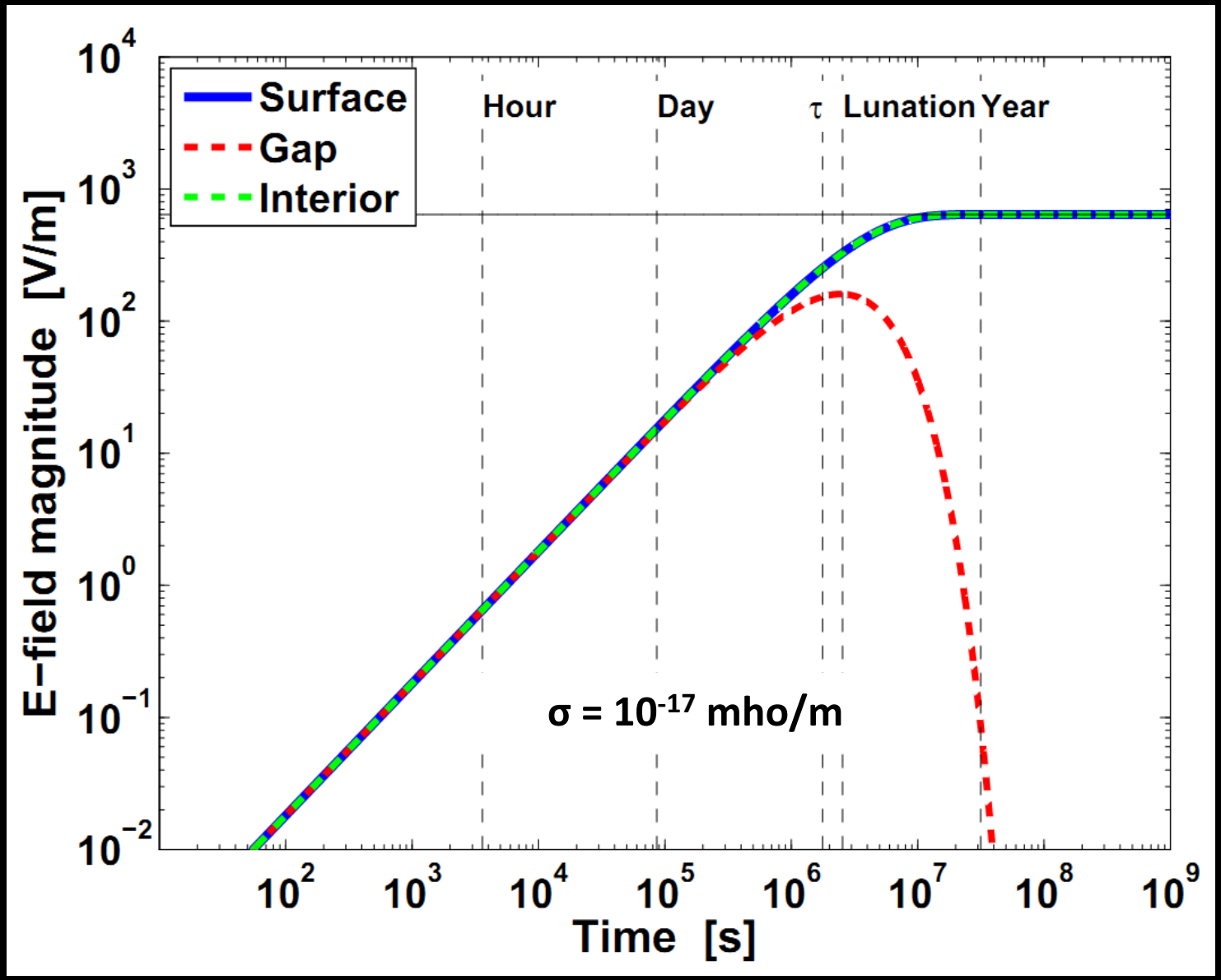


Double Layer Model

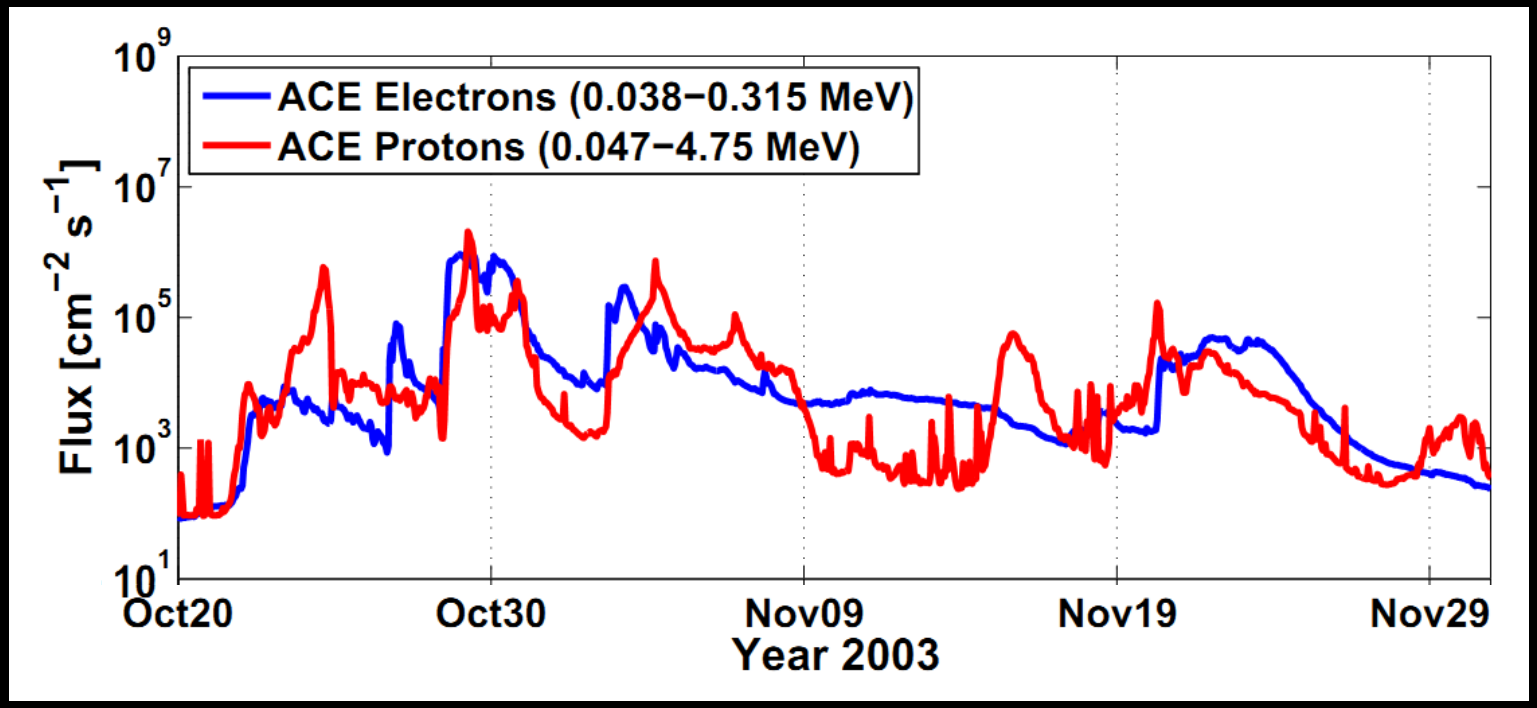
- Discharging → no electric field



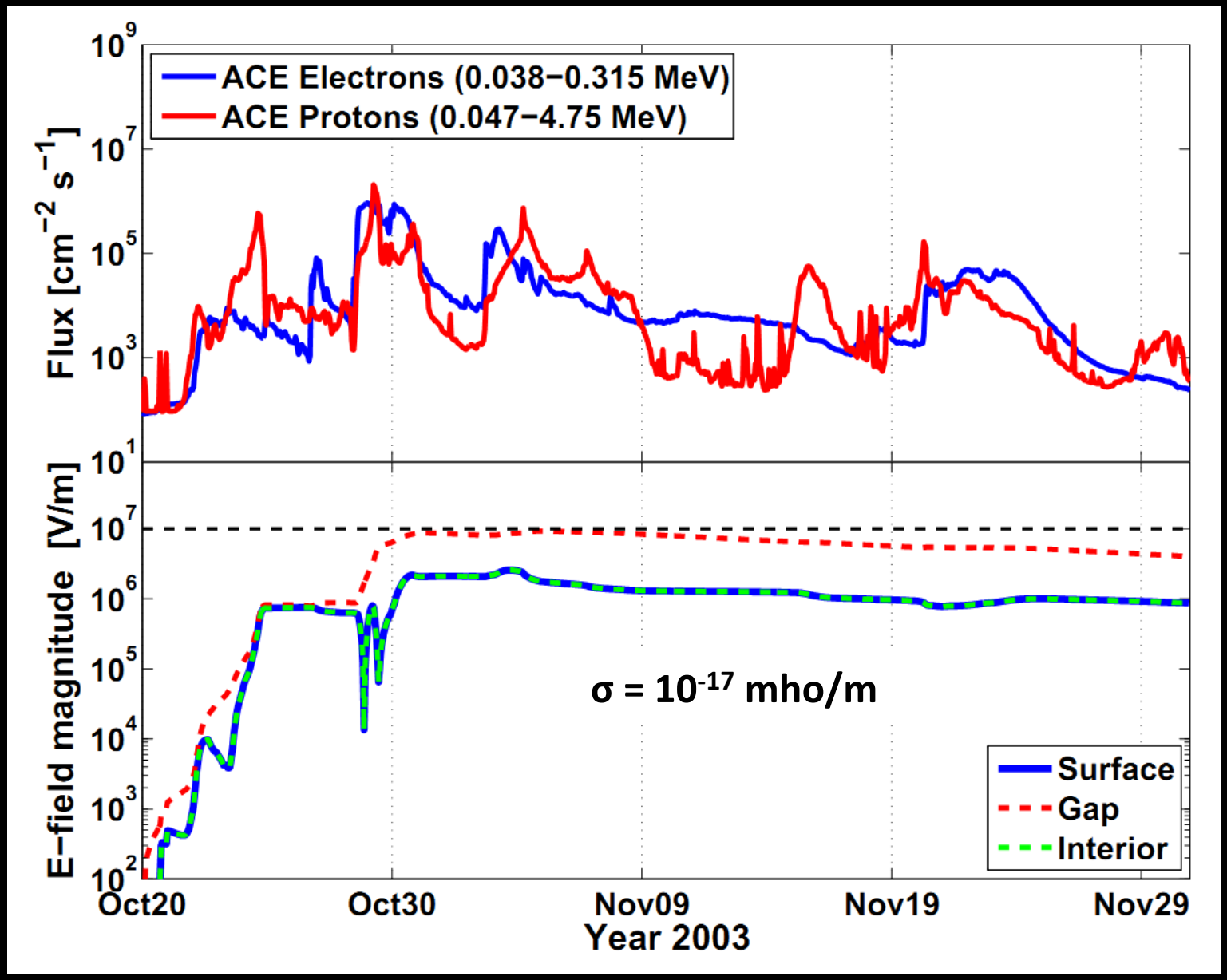
Galactic Cosmic Rays: E_{max} = 600 V/m



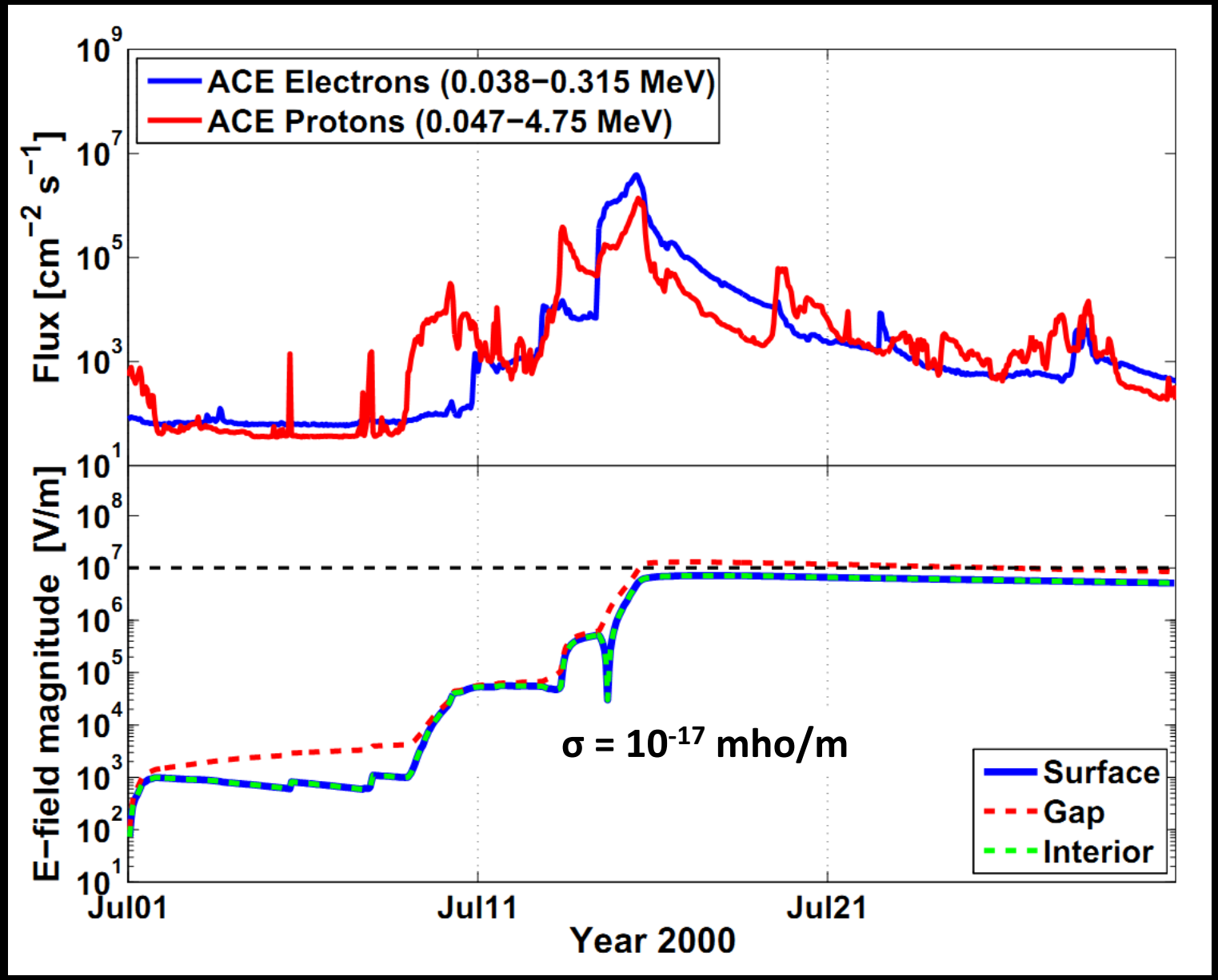
Halloween Storms



Halloween Storms: $E_{max} = 9.2 \times 10^6$ V/m

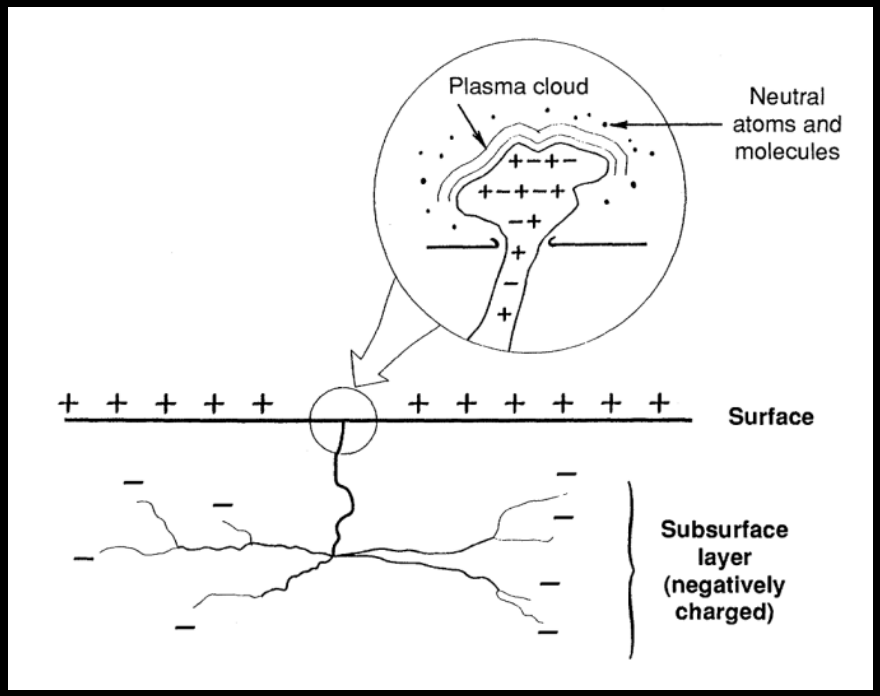


Bastille Day: $E_{max} = 1.3 \times 10^7$ V/m



Conclusions

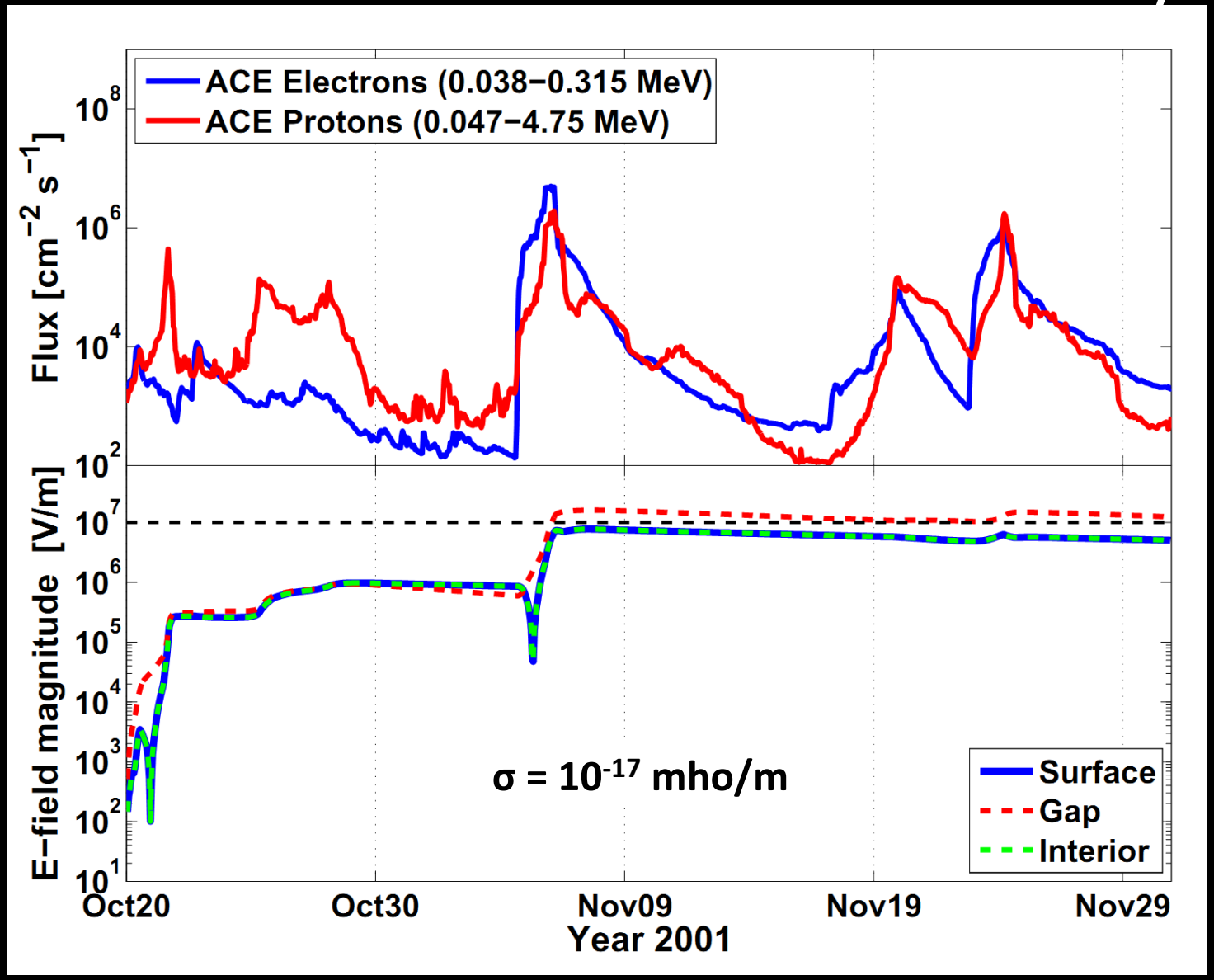
- Galactic cosmic rays → 600 V/m field
- Strong solar energetic particle events → dielectric breakdown likely in permanently shadowed regions



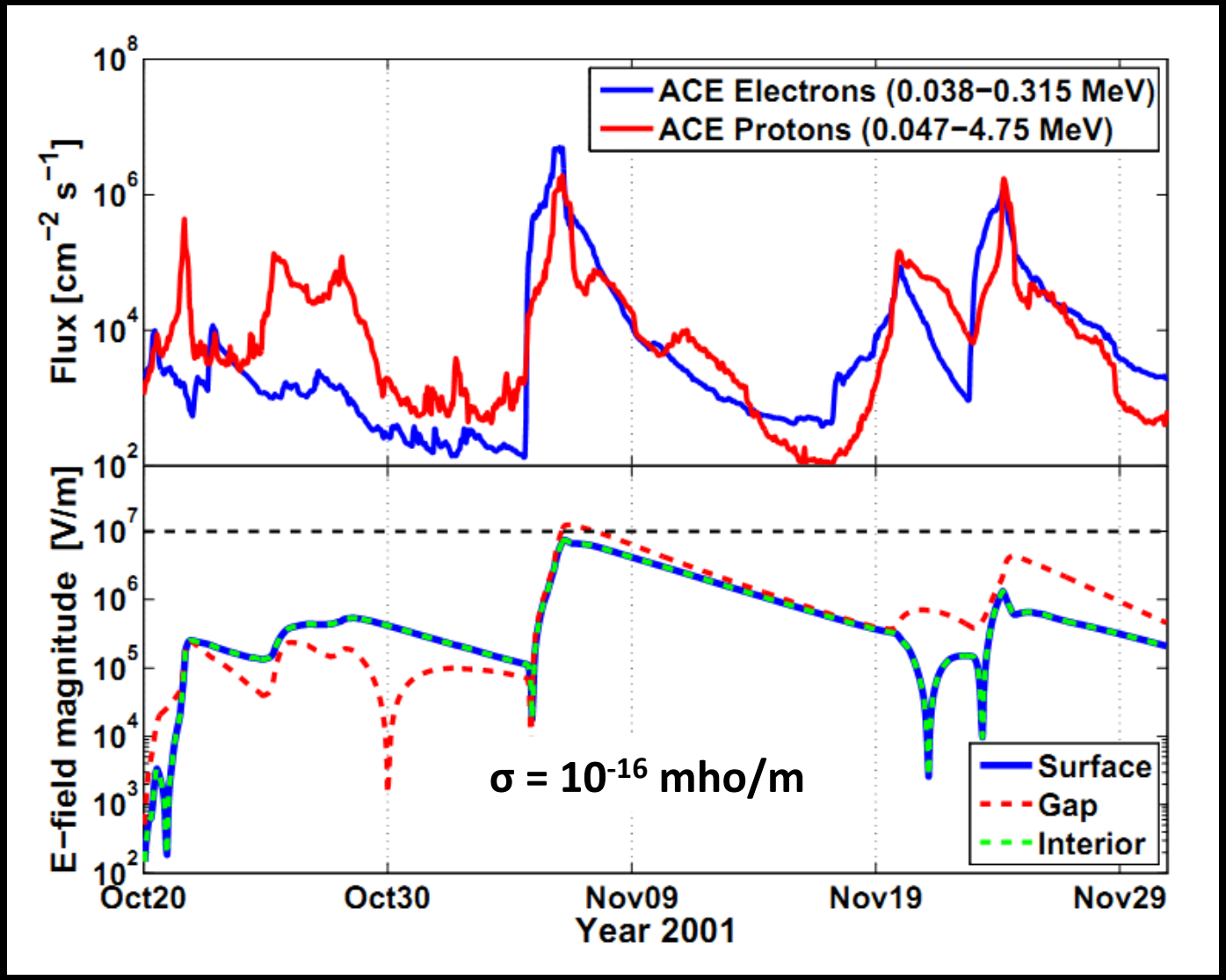
Campins and Krider (1989)

Supplementary Material

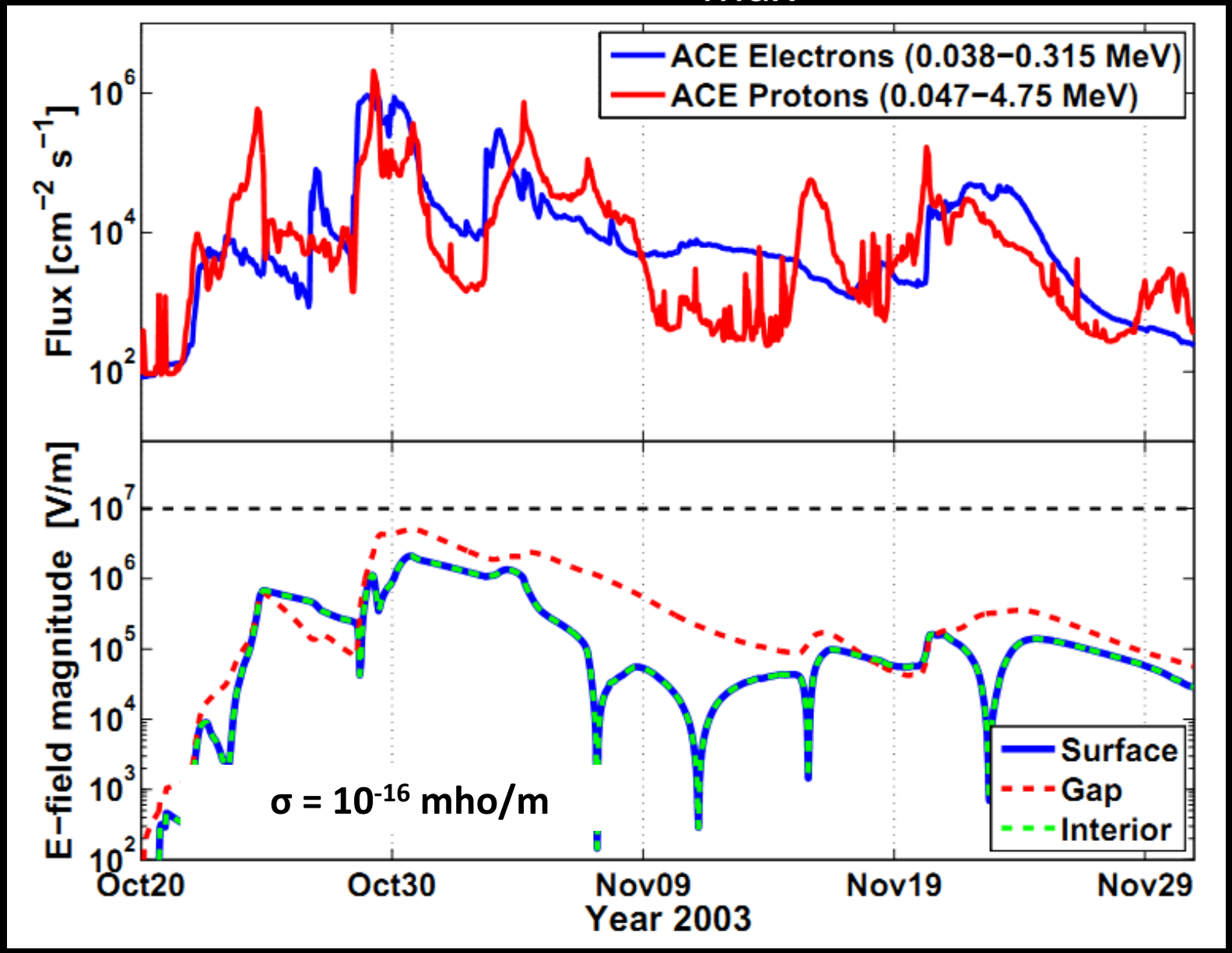
Nov. 2001 Event: Max E = 1.6e7 V/m



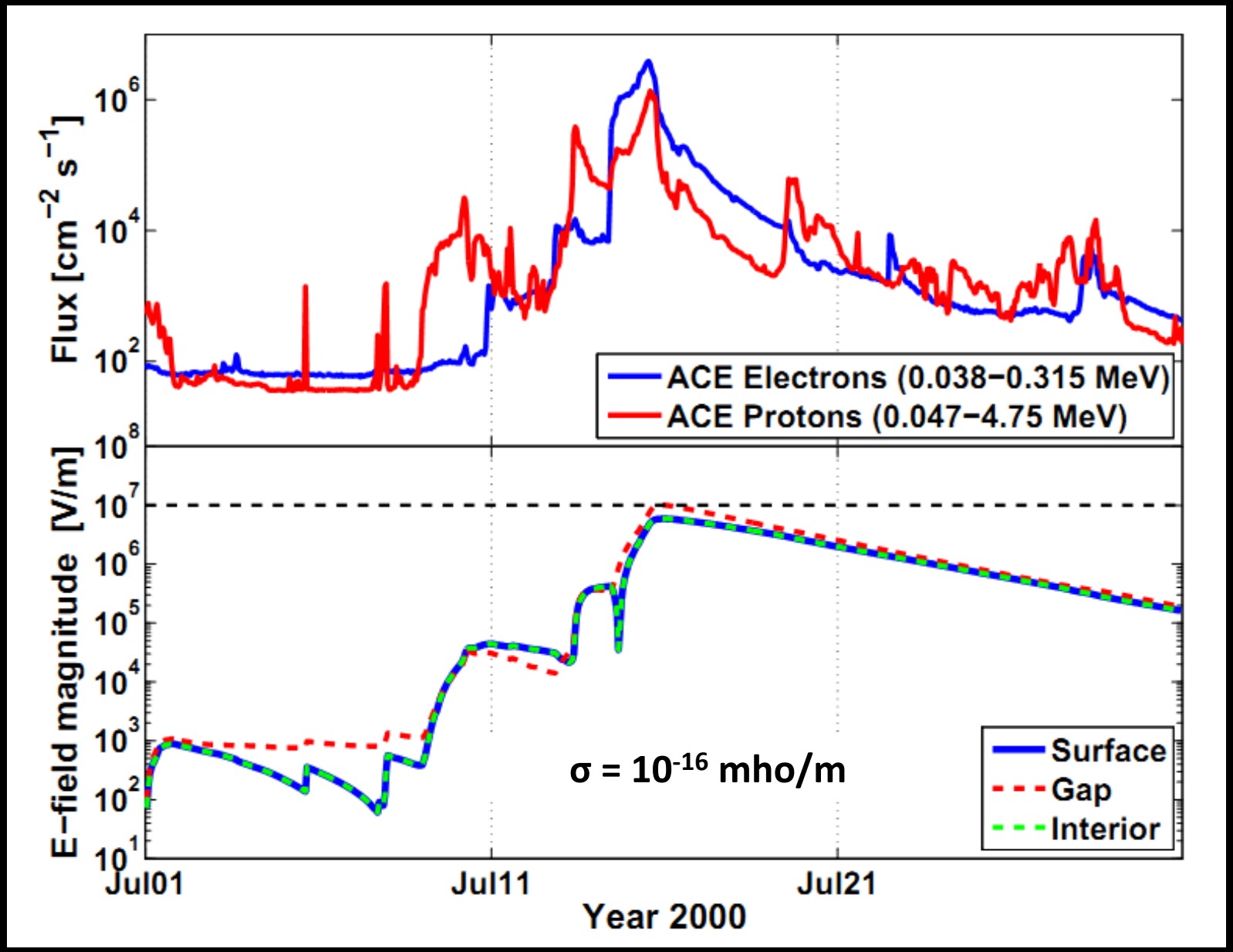
Nov. 2001 Event: Max E = 1.2e7 V/m



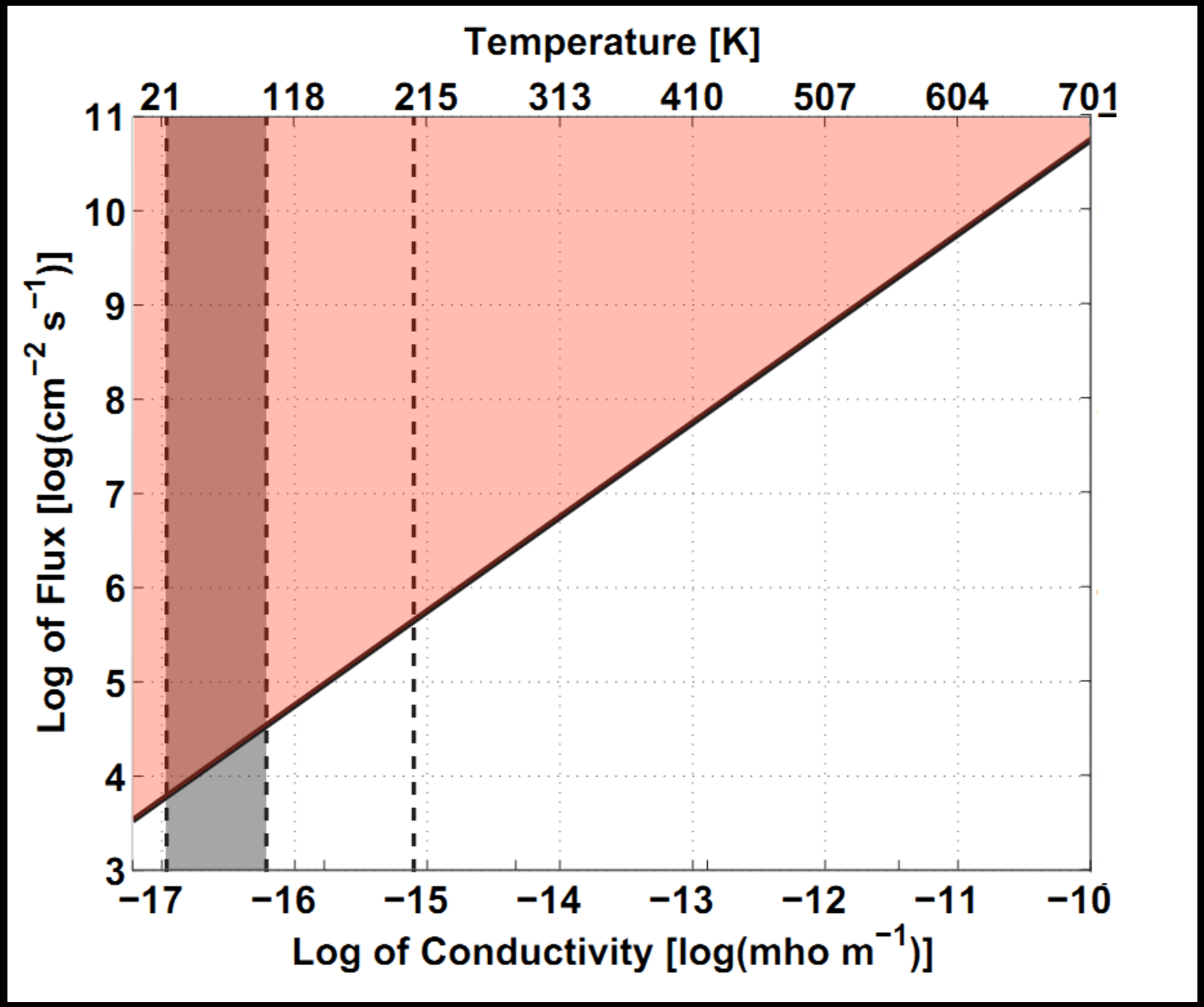
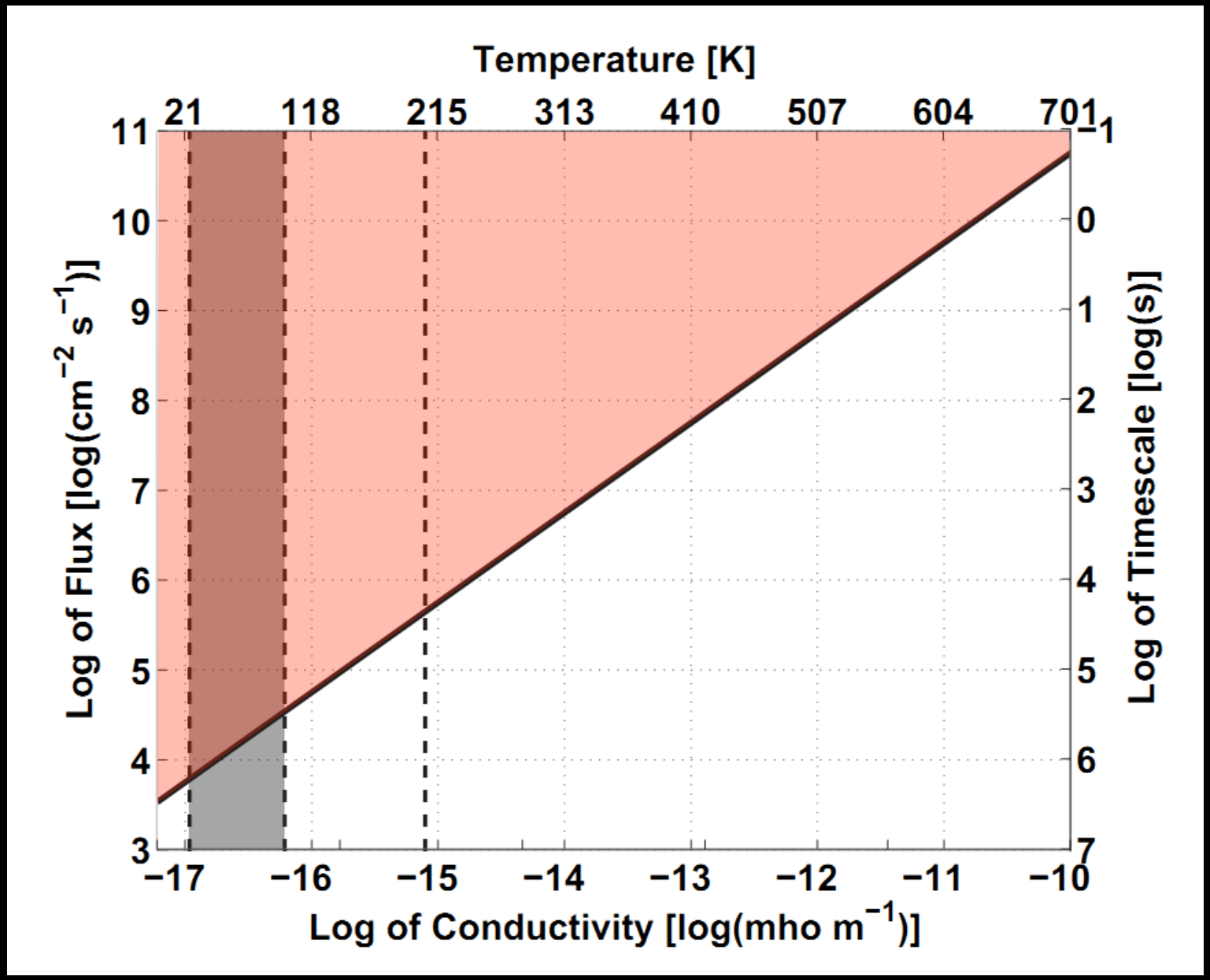
Halloween Storms: $E_{max} = 5x10^6$ V/m



Bastille Day: $E_{max} = 10^7$ V/m



Dieletric Breakdown of Lunar Regolith



Dieletric Breakdown of Lunar Regolith