Aurora at Planets Lacking Global Magnetic Fields

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(***thanks Francois!***)

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Outline

I. Auroral Emission at Venus and Mars

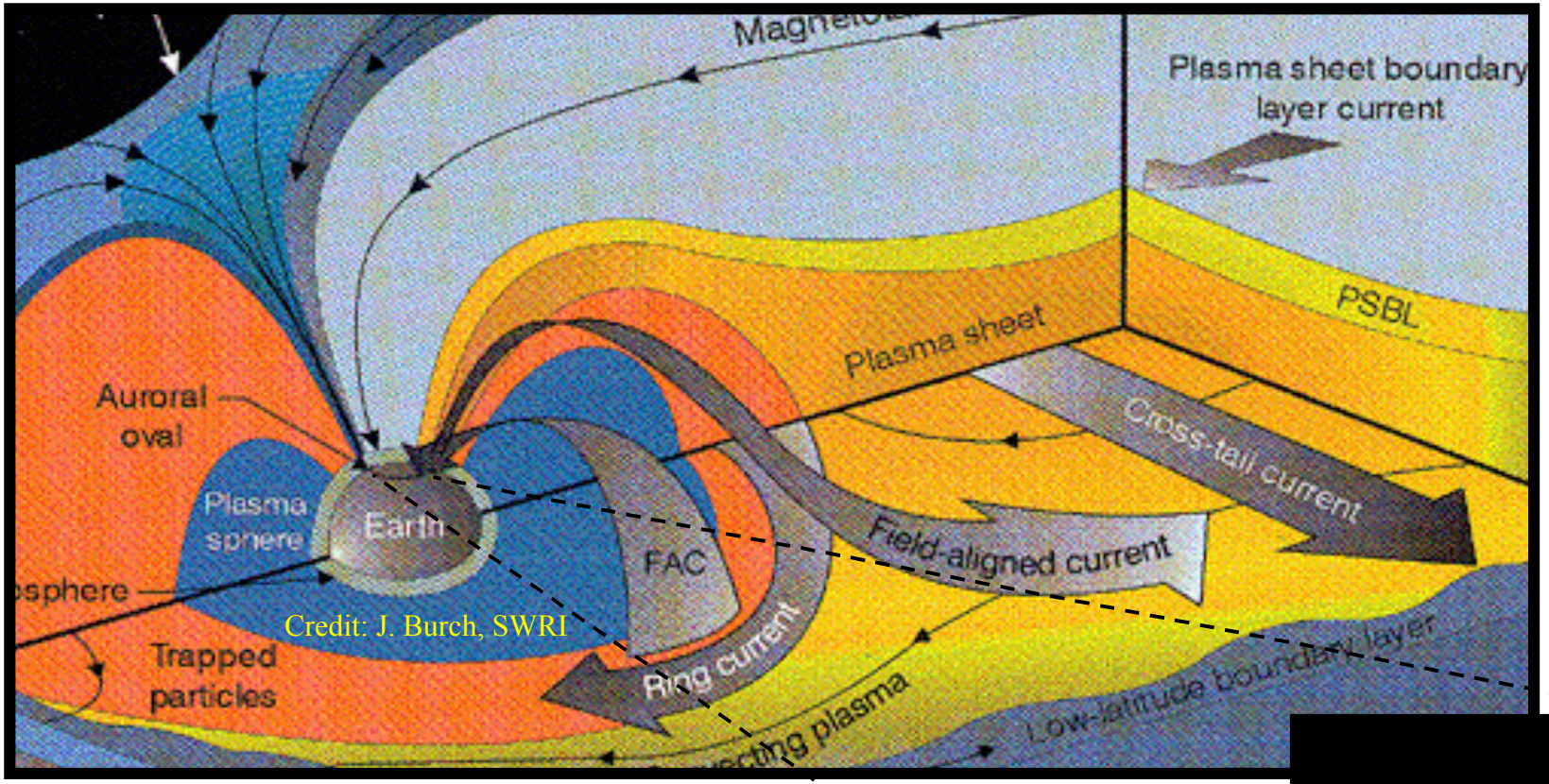
II. Auroral Particles at Mars

III. Acceleration Mechanisms

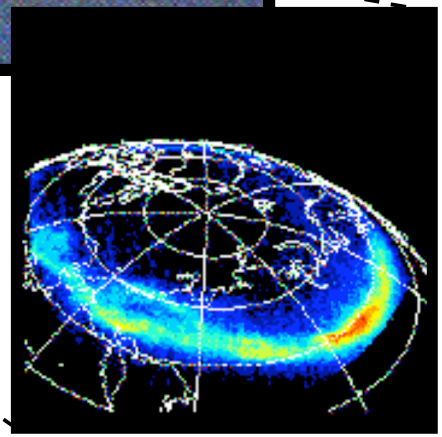
IV. Outstanding Questions

Goals: Review an emerging research area in planetary aurora, and promote discussion

Aurora at Earth

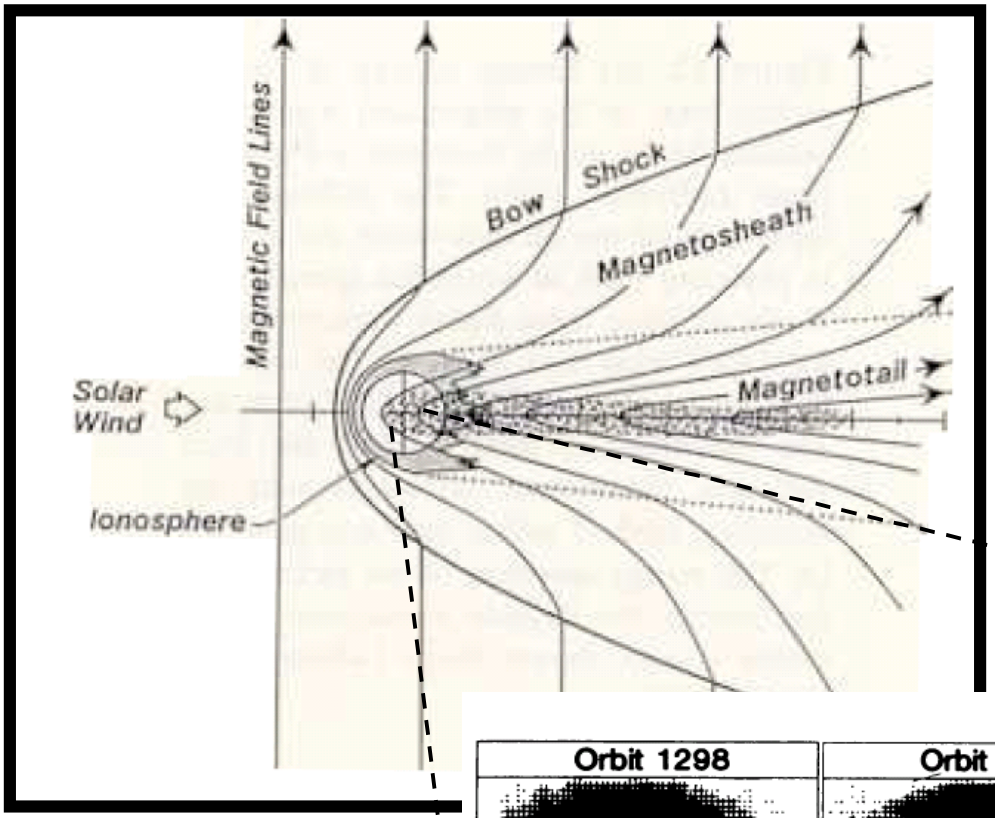


- Solar wind drives large-scale current system
- Creates parallel electric fields and waves
- Accelerates electrons down into atmosphere
- Emission of oxygen, nitrogen, …



Polar UVI Data

Auroral Emission at Venus



Venus auroral emission diffuse, patchy, highly variable.

Not controlled by planetary magnetic fields!

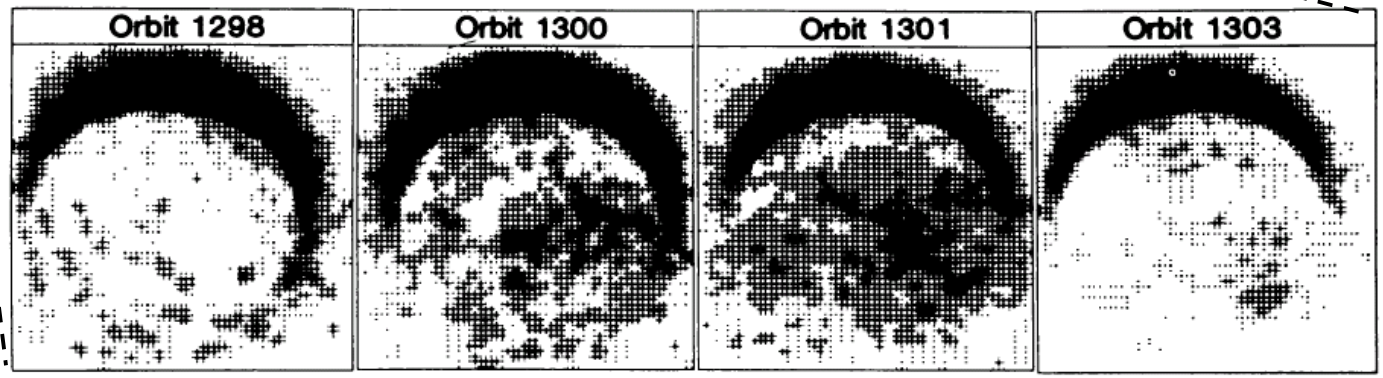
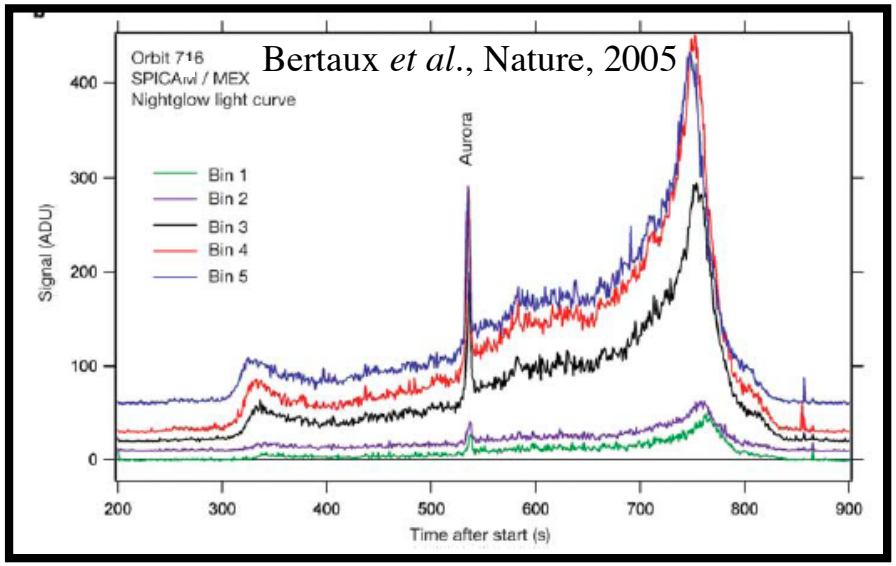
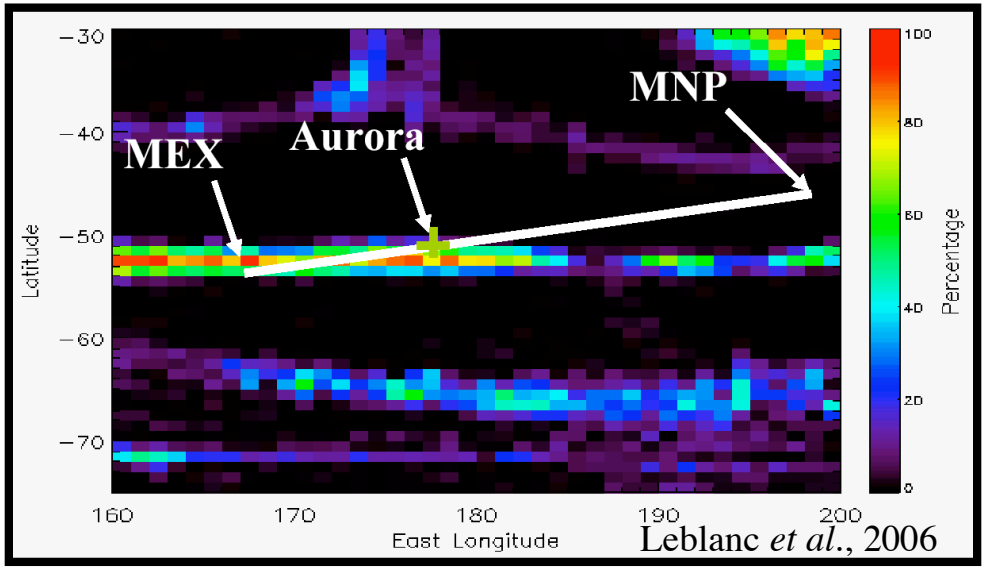
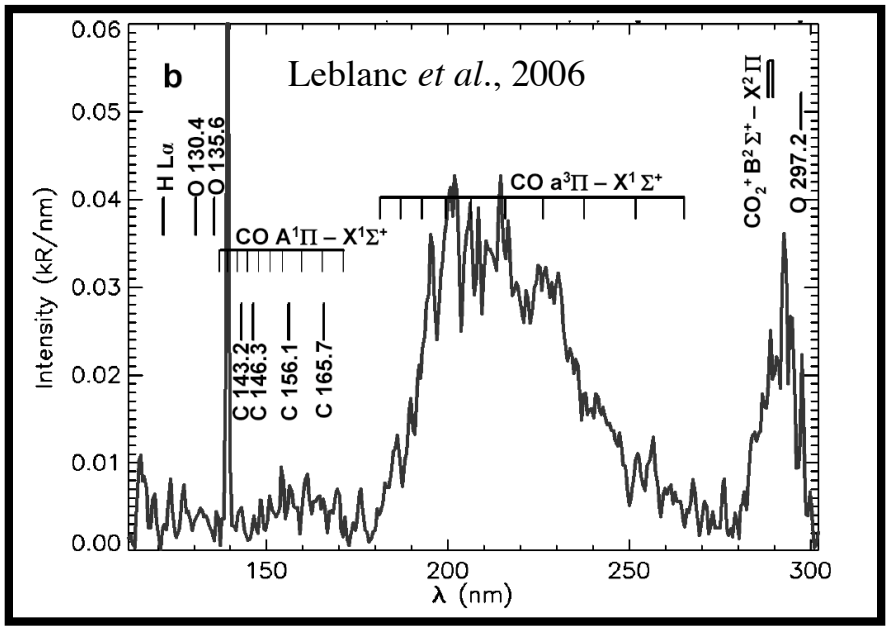


Fig. 8. Series of brightness images from the PV OUVS for the orbital sequence of June 25–July 1, 1982 with apoapsis near midnight. Note expansion and intensification of emissions to fill the nightside in orbit 1301. Missing orbits were not imaged at 1304 Å. From Phillips *et al.* (1986).

Auroral Emission at Mars





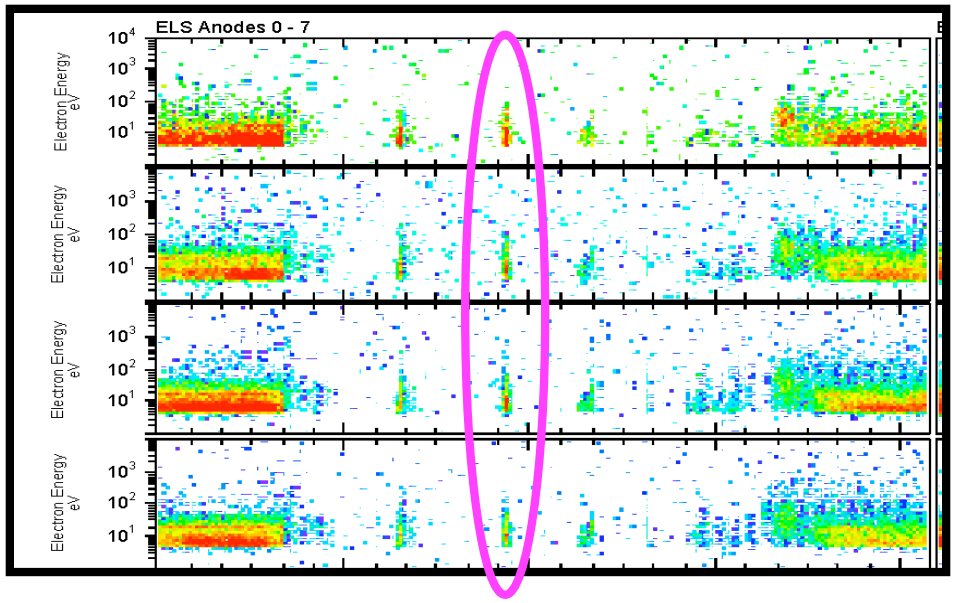


- Mars Express SPICAM UV spectrograph
- Wavelengths associated with CO_2 excitation
- Associated with crustal magnetic cusp
- Only one reported emission event initially
- Now more events observed…
- Emission faint compared to Earth aurorae

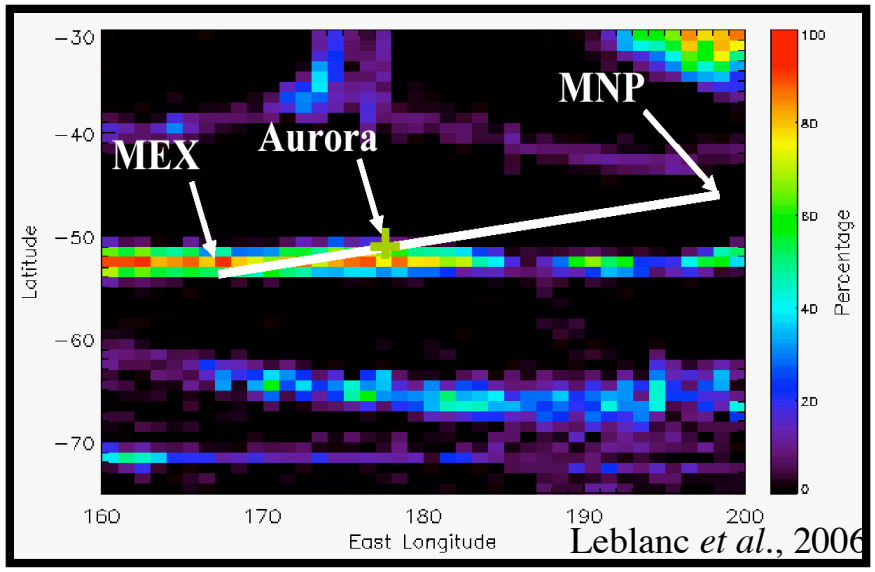
Auroral Particle Sources

Low Energy Electrons from Day Side

ASPERA-3 ELS Data



Time of UV emission



Leblanc *et al.*, 2006

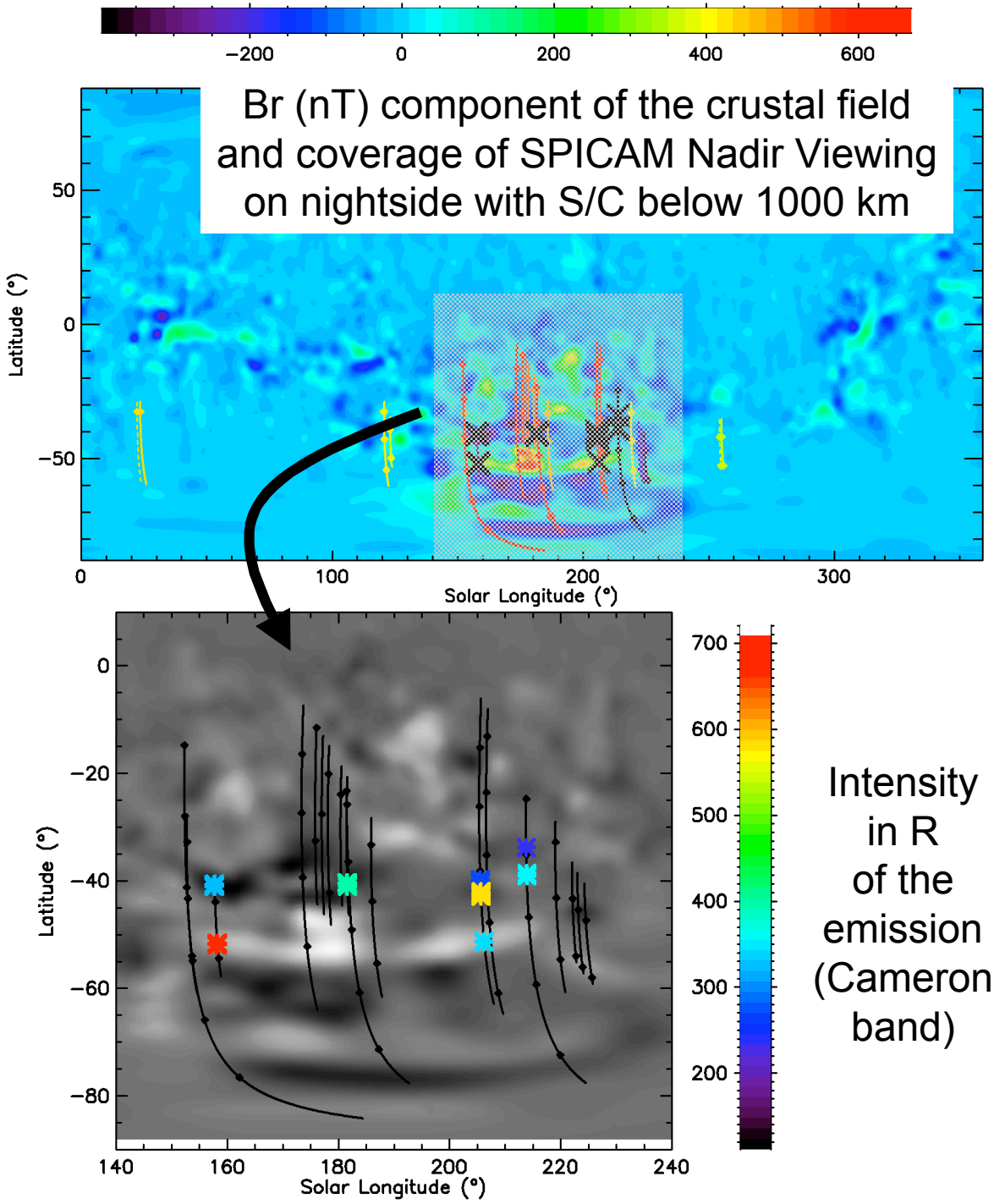
- Mars Express and auroral emission located in same long cusp
- Mars Express ASPERA-3 saw bursts of day side photoelectrons at same time as emission
- **Comparison of observed to modeled UV emission line ratios suggest low energy particle source**

8 New Aurora events detected by SPICAM

Observations with Nadir Viewing on the nightside with S/C below 1000 km in altitude

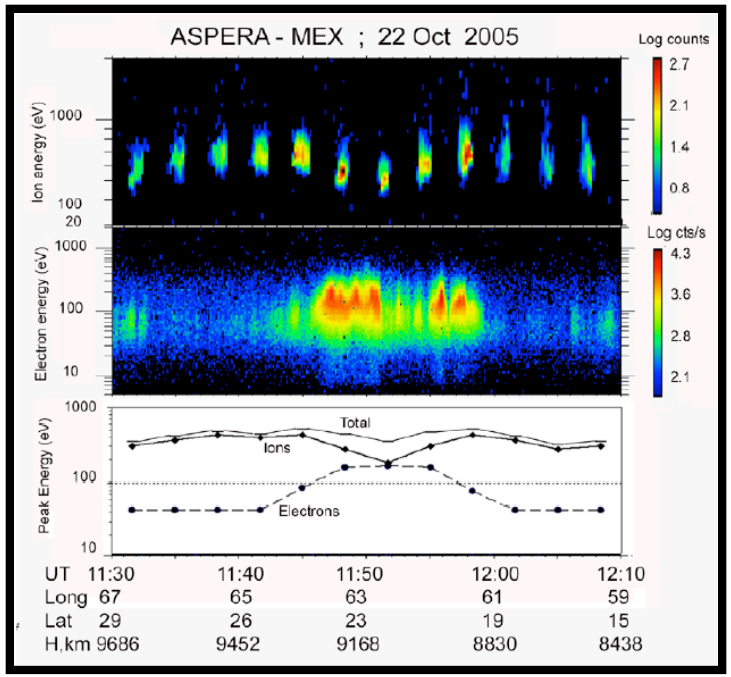
- Excellent correlation with Aspera-3/ELS measurements

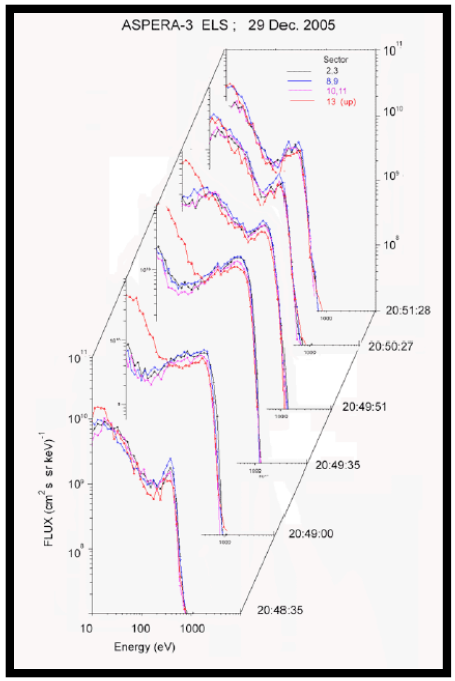
Work in Progress



Auroral Particle Sources

Higher Energy Night Side Electrons (Mars Express)



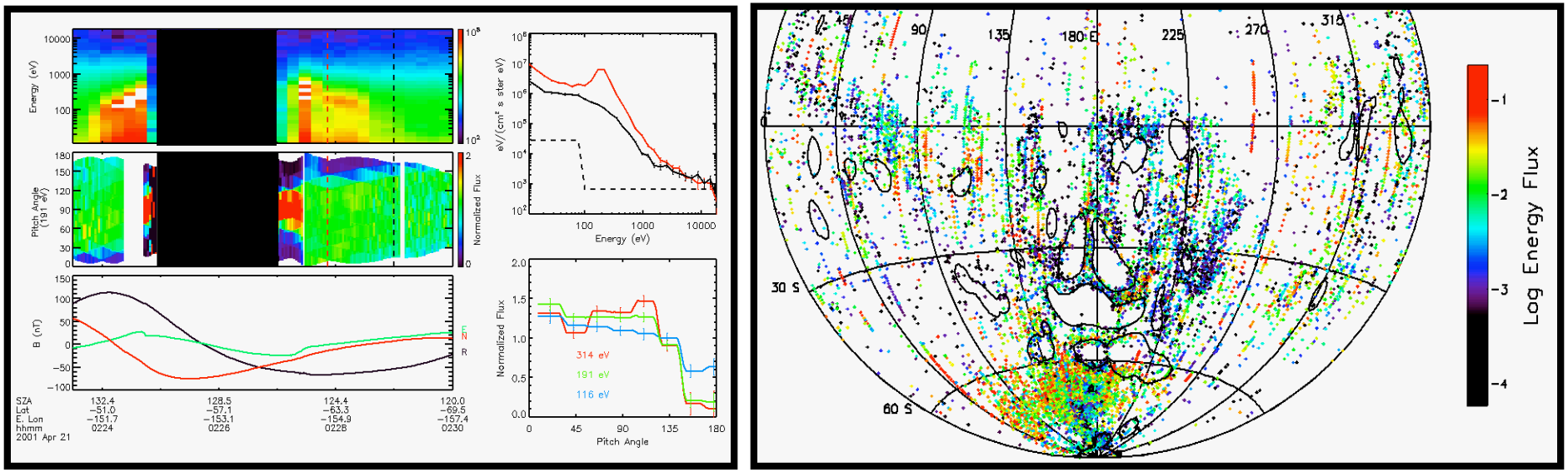


Lundin *et al.*, 2006

- Mars Express ASPERA-3 sees high-altitude auroral-like particle signatures
- Beams of electrons and ions with energies of 100's of eV or more
- Electrons moving downward, ions moving upward
- Association with crustal fields
- **Observations consistent with Earth-like auroral field-aligned acceleration**

Auroral Particle Sources

Higher Energy Night Side Electrons (MGS)



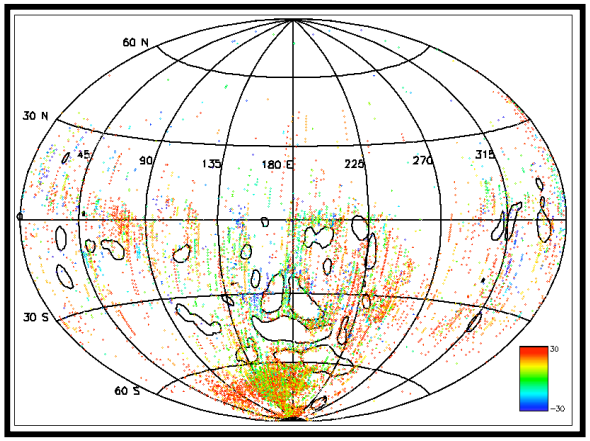
Brain *et al.*, 2006

- Mars Global Surveyor also sees night side auroral-like electron signatures (400 km alt.)
- Peaked electron distributions with energies up to 4 keV
- Associated with open/closed crustal field line boundaries
- Field perturbations consistent with 1 uA/m^2 current
- Models suggest should produce observable UV emission, localized night side ionosphere

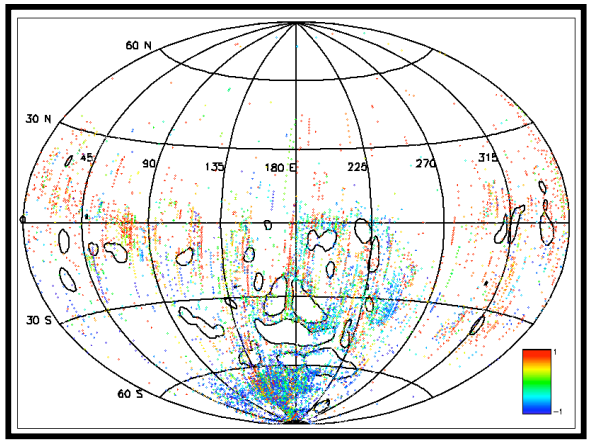
Auroral Particle Sources

Solar Wind Influences

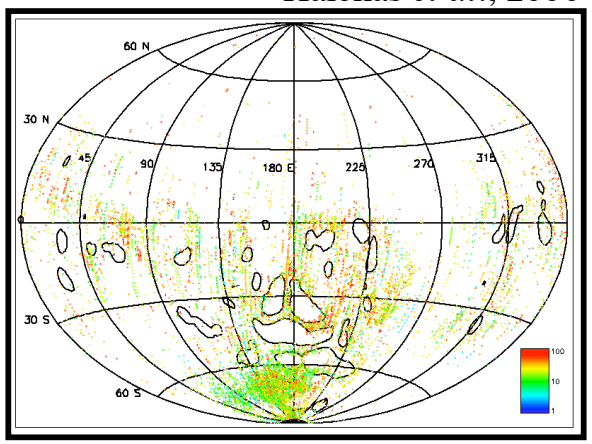
Halekas *et al.*, 2006



Subsolar Latitude



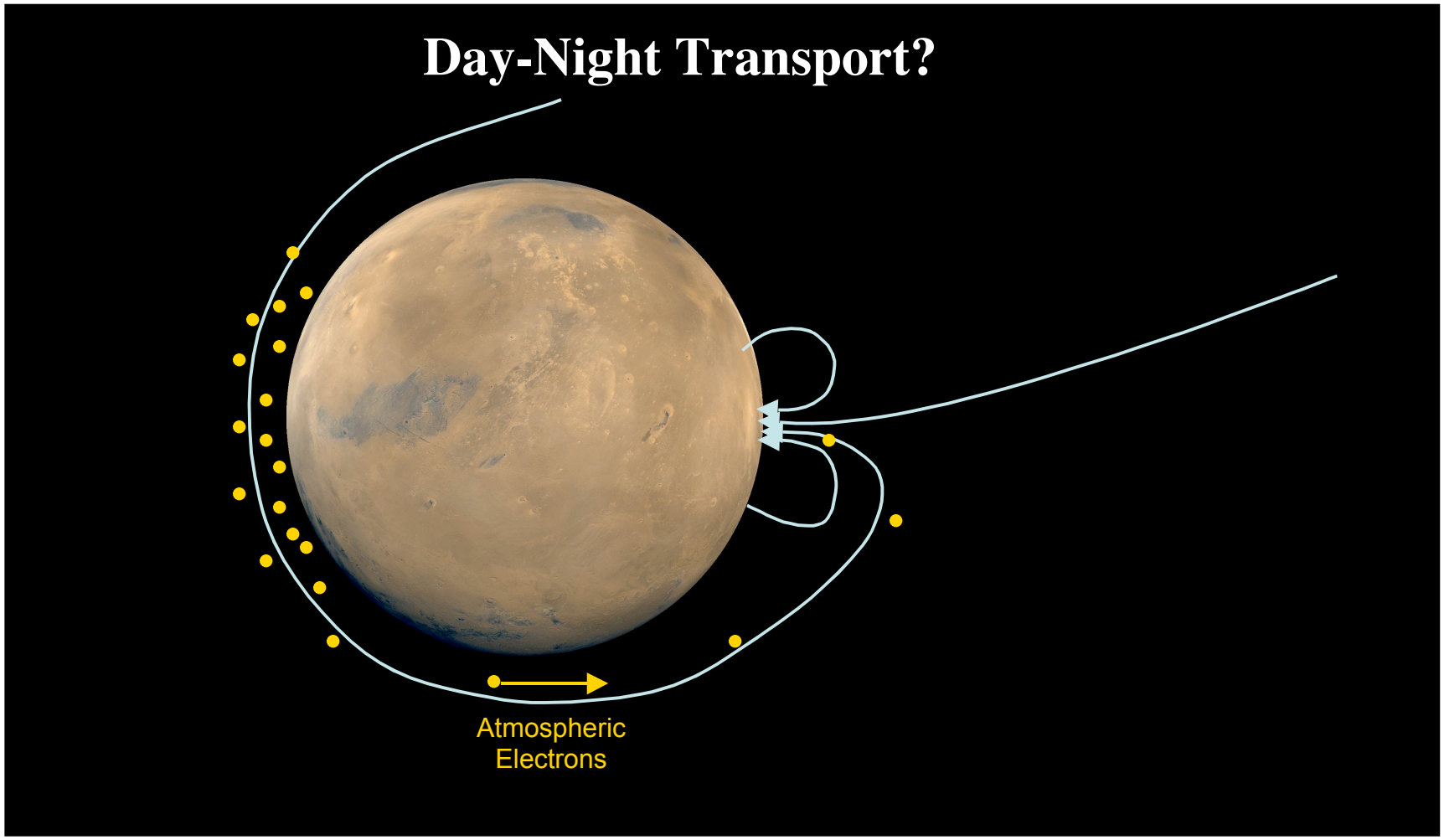
IMF Draping Direction



SW Pressure Proxy

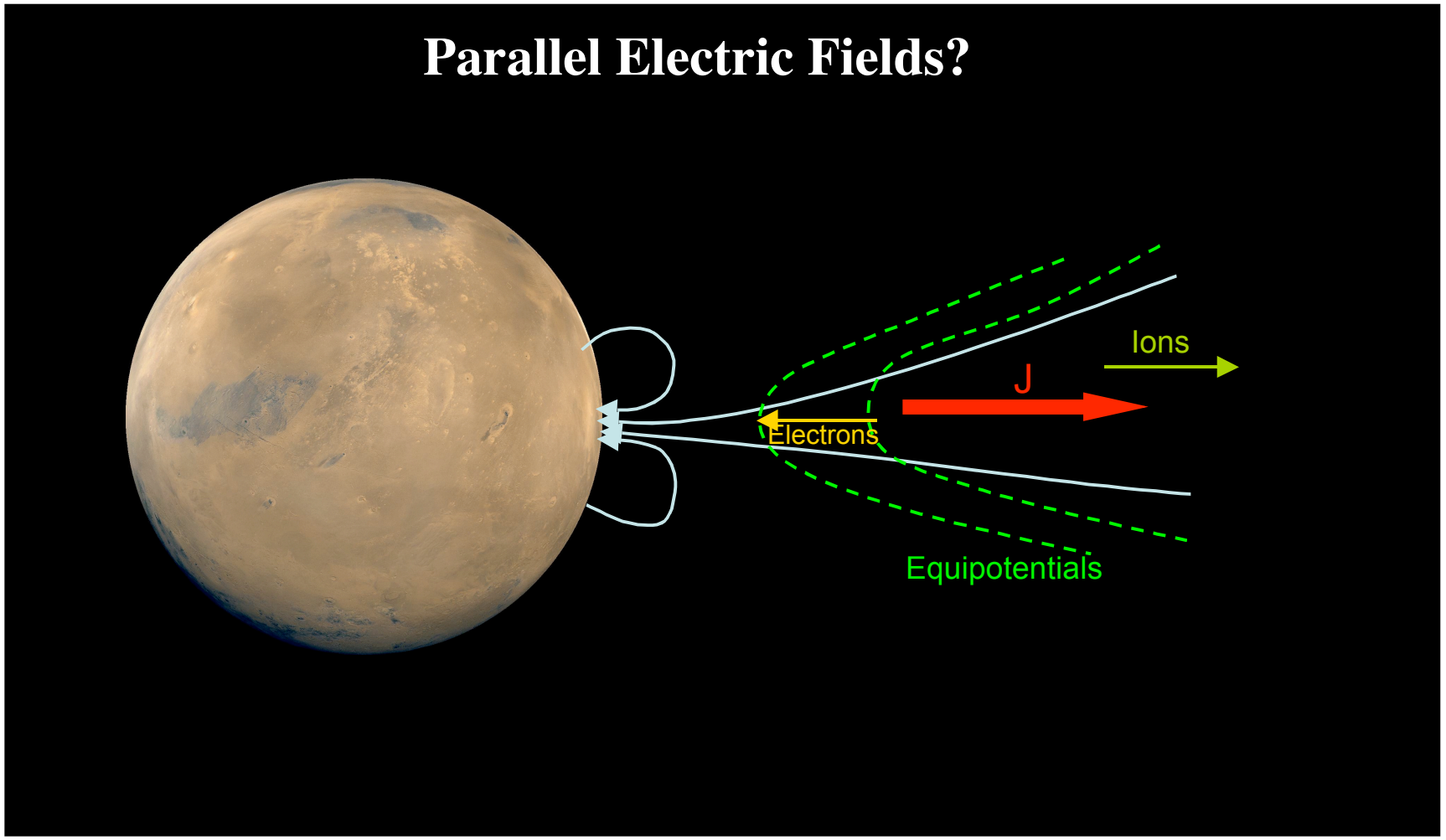
- MGS spectra depend on external conditions
- Likelihood of observation depends on season, IMF direction, solar wind pressure
- Most energetic MGS spectra 50% likely to occur during a Solar Energetic Particle event
- First UV emission reported by MEX also occurs during SEP event

Auroral Acceleration Mechanisms



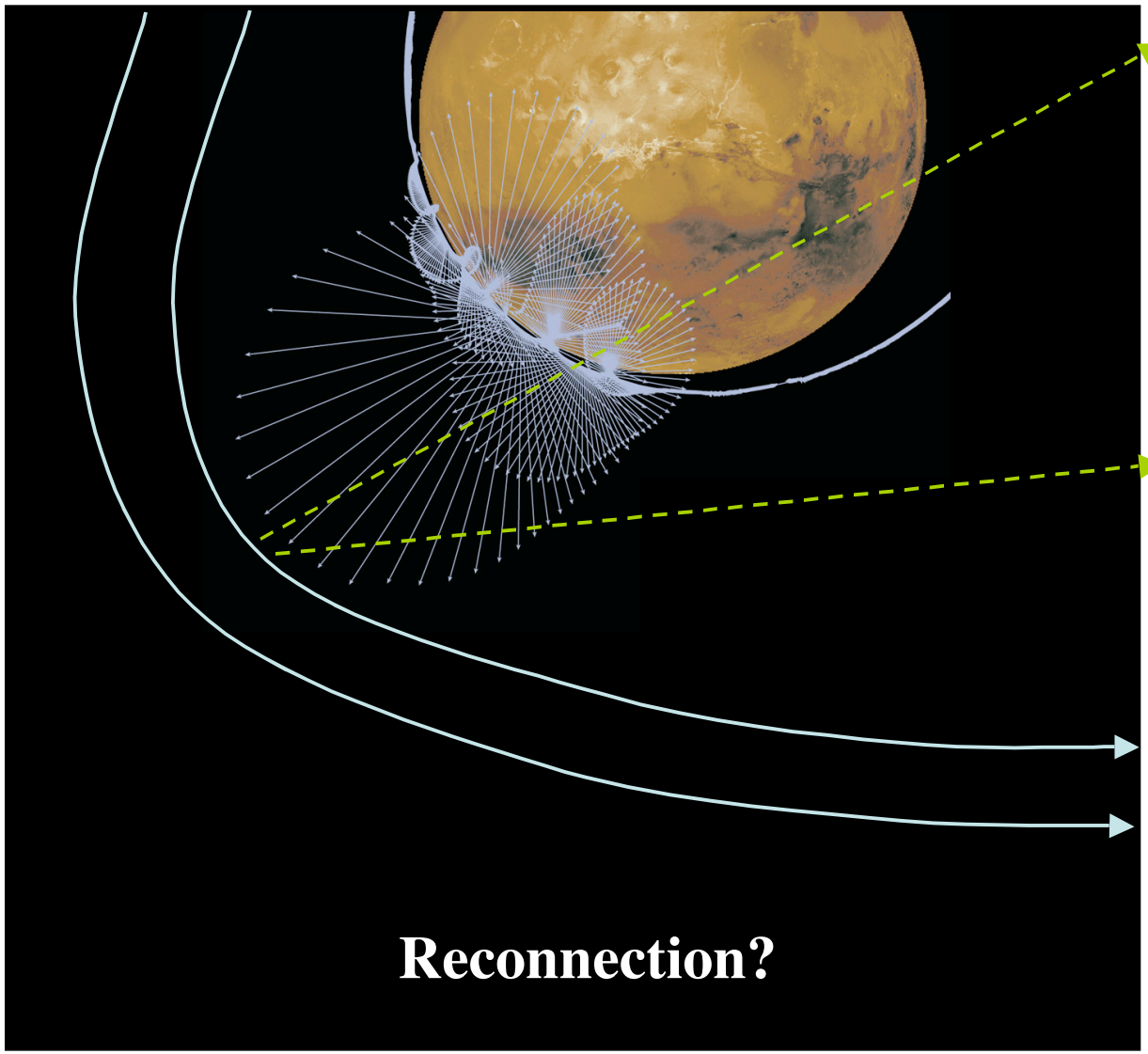
- Low energy electrons (photoelectrons?) created on dayside
- Transported to night side along open field lines
- Night side photoelectrons observed by Mars Express & MGS

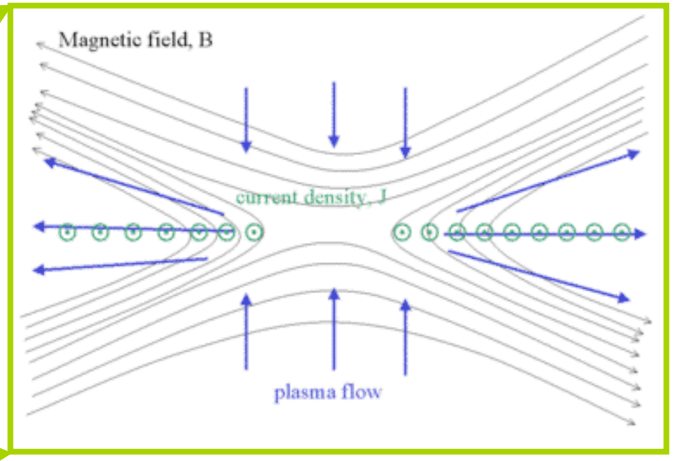
Auroral Acceleration Mechanisms



- At Earth, field-aligned current systems are driven by the solar wind.
- How could a stable field-aligned current system be generated by the interaction of the solar wind with Mars' highly non-dipolar crustal fields?

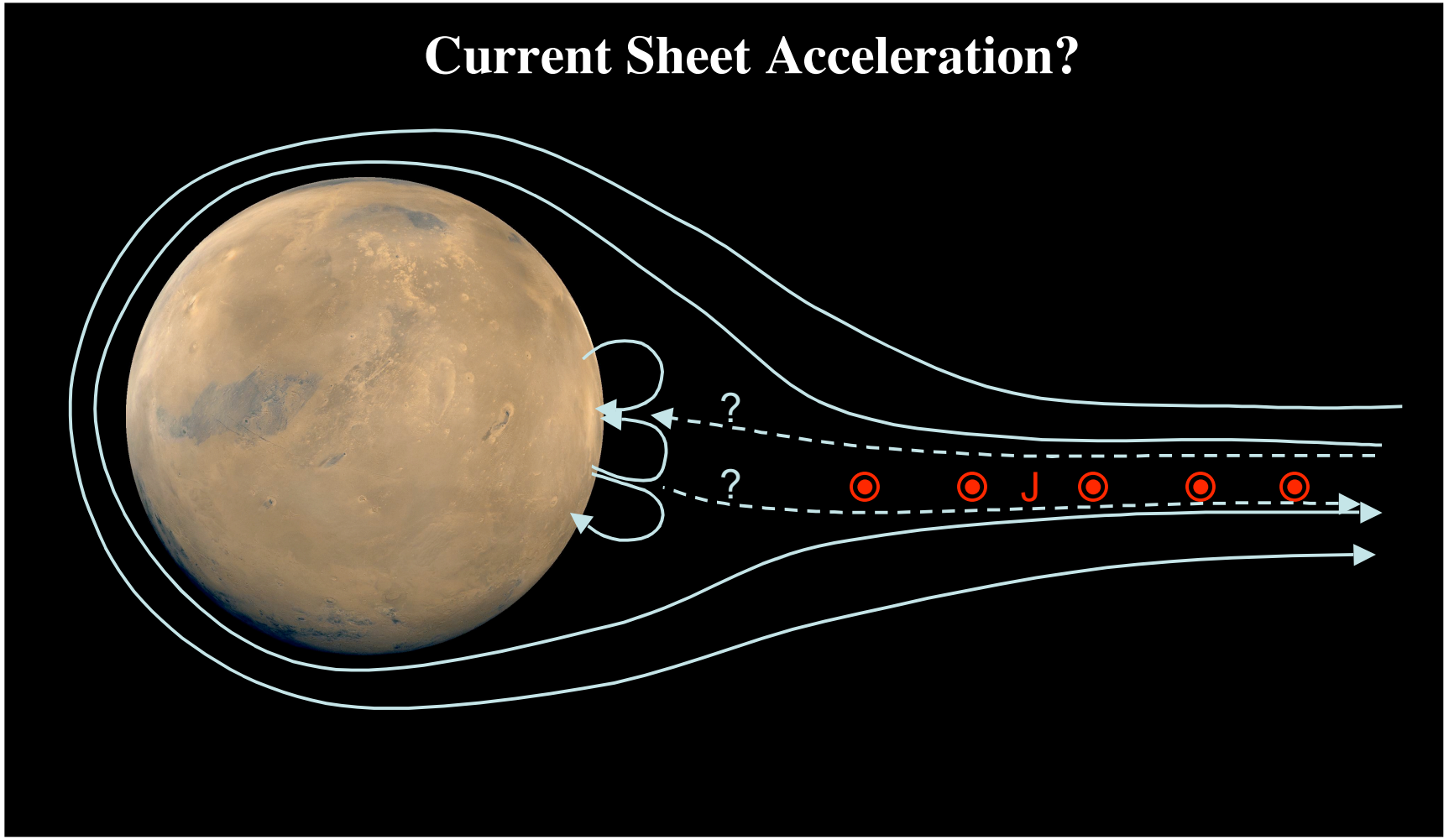
Auroral Acceleration Mechanisms





- Reconnection is definitely important in constraining ***access*** of accelerated electrons to the Martian atmosphere, but is it also important for directly ***accelerating*** them?

Auroral Acceleration Mechanisms



- Current sheets are observed in MGS data, with associated accelerated electrons
- Can current sheet electrons penetrate down to regions with moderate to strong crustal fields (via reconnection?)?

Outstanding Questions

(Mars-focused)

- How common is Martian auroral emission?
- Is there observable visible emission?
- What particles are responsible for the emission?
- If peaked electron distributions are not responsible for the observed UV emission, then what prevents them from creating emission?
- How are peaked electron distributions formed/maintained?
- Do external conditions / SEP events influence emission?

Do the same auroral physics operate at Venus and Mars as at Earth?