STATISTICAL MAPPING OF MAGNETIC TOPOLOGY AT VENUS

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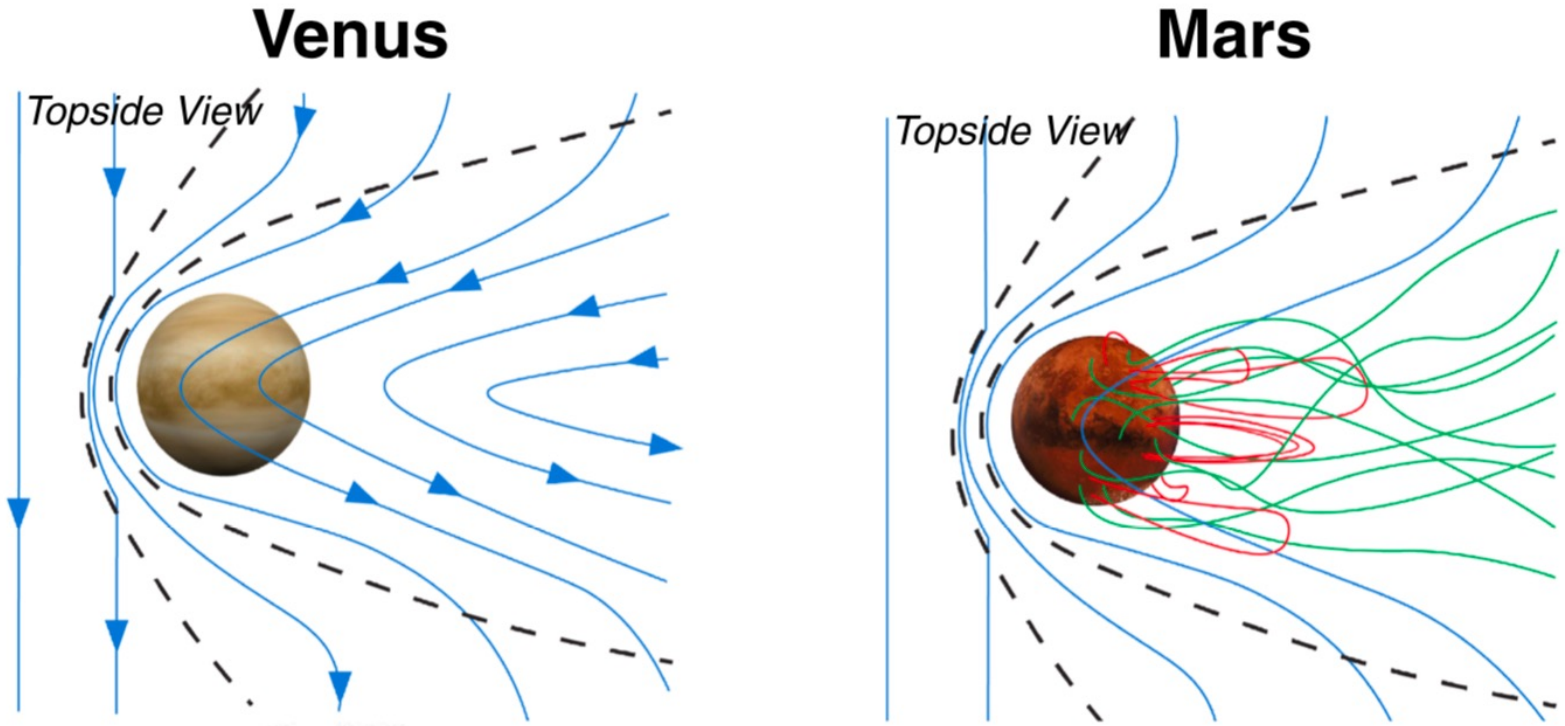
INTRODUCTION

- **Solar wind interaction with Venus and Mars**



- Mars with crustal fields
  - Dynamic B topology
  - Closed/open/draped
- Venus, insignificant crustal fields
  - When IMF dips into the ionosphere, different topologies can be defined
  - Conduit for energy and particle exchange between the ionosphere and solar wind

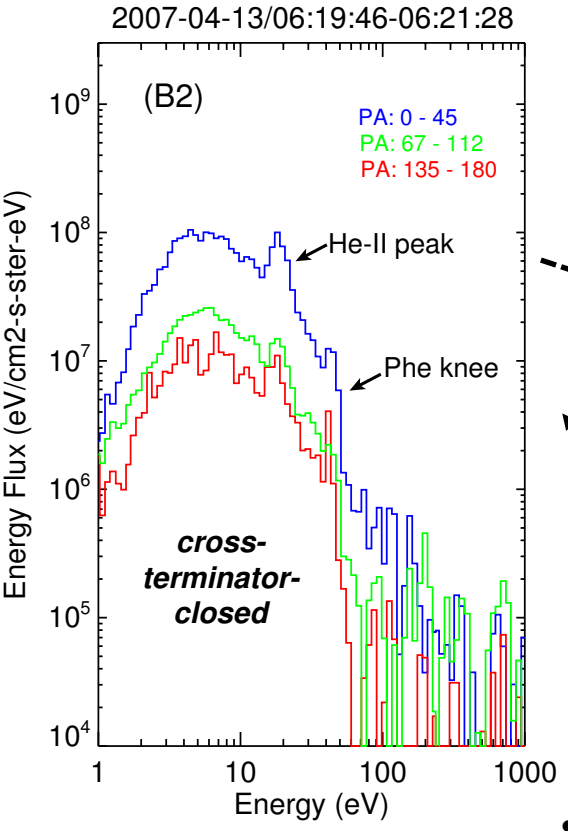
Xu et al. [JGR, 2020]

MOTIVATION

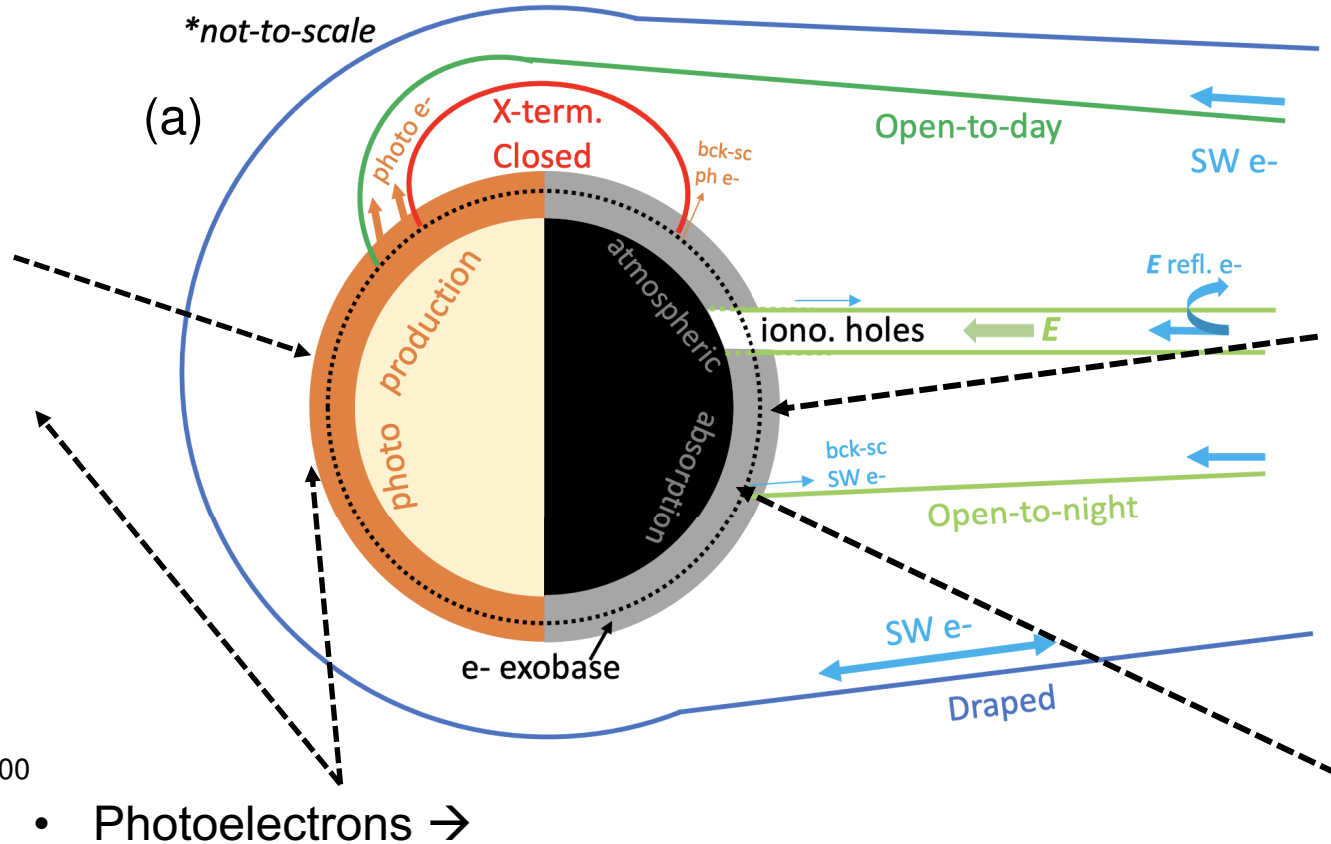
- Magnetic topology:
  - Provides important information regarding the magnetization of Venus's ionosphere
  - A power full tool to characterize cold planetary ion outflow/inflow at Venus
    - A conduit for planetary ions in the ionosphere to be energized and escape
  - Important for characterizing energetic electron precipitation, a source for ionization, thermal plasma heating, and auroral emission

METHODOLOGY

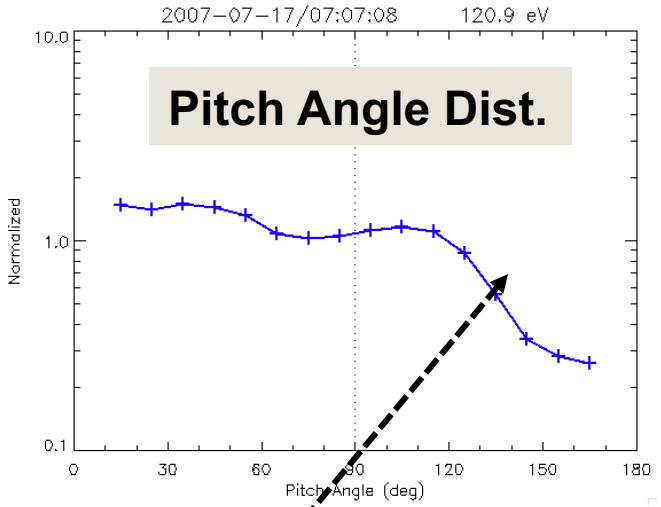
Energy Dist.



Xu et al. [GRL, 2021]

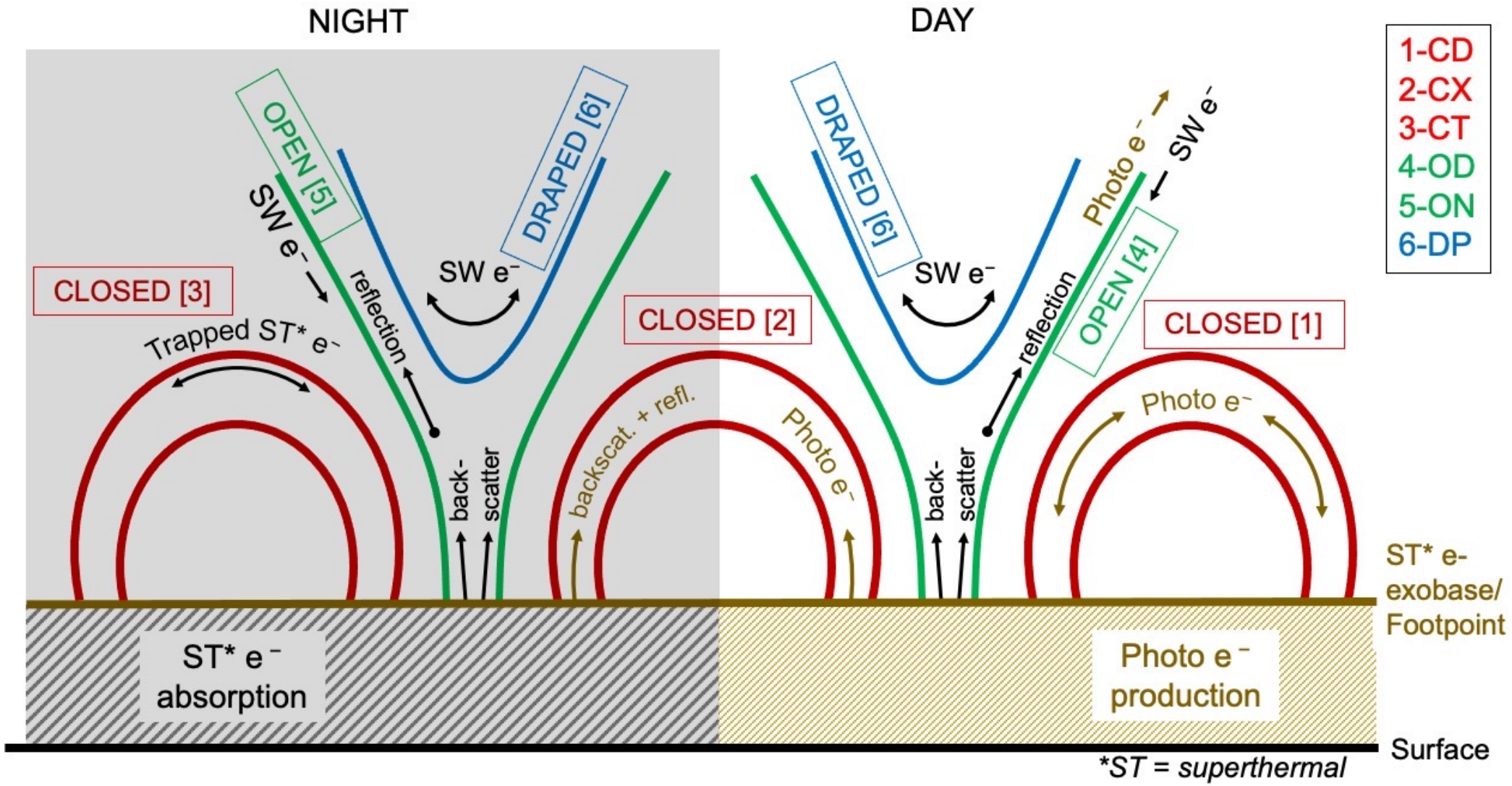


Pitch Angle Dist.



- Photoelectrons → dayside ionosphere connectivity
- Loss cone → nightside ionosphere connectivity

METHODOLOGY: TOPOLOGY (6 TYPES) & SUPERTHERMAL ELECTRONS (STE)

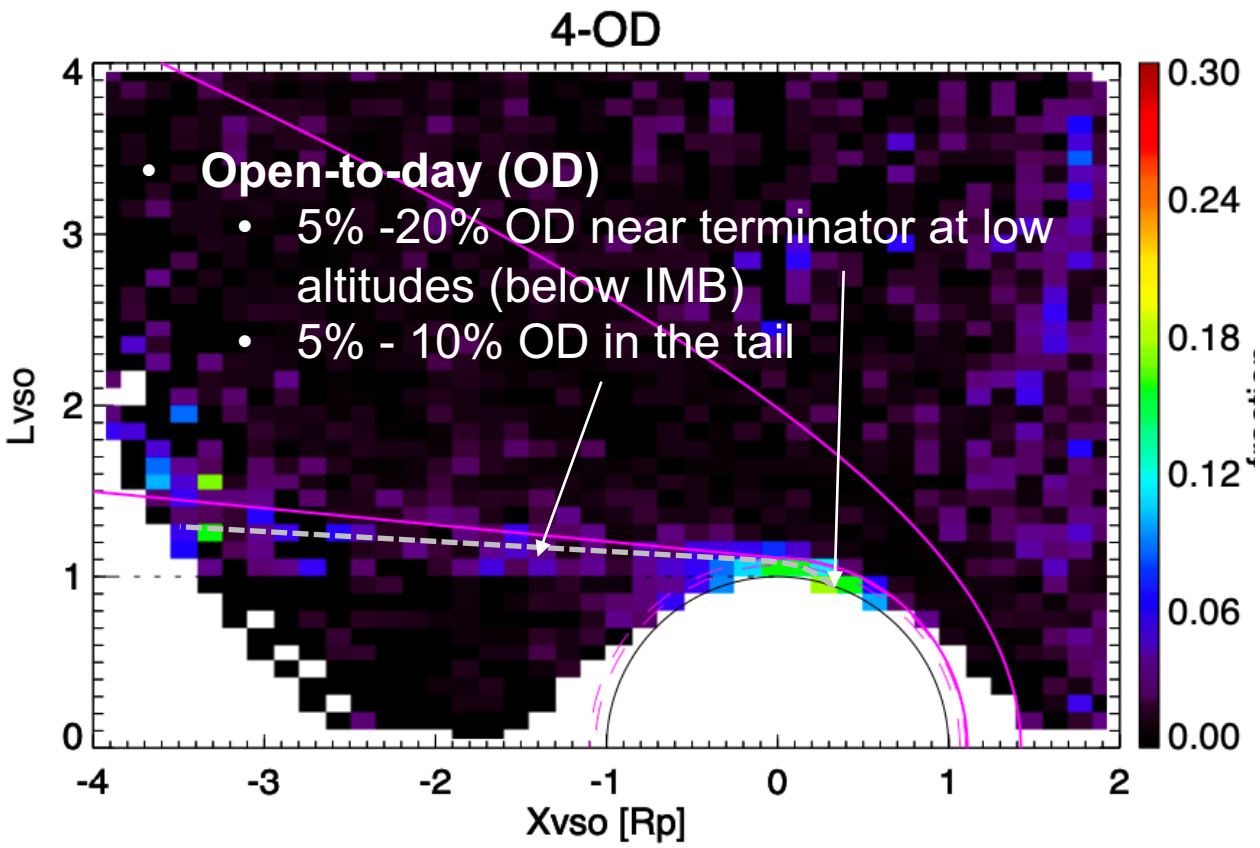


METHODOLOGY

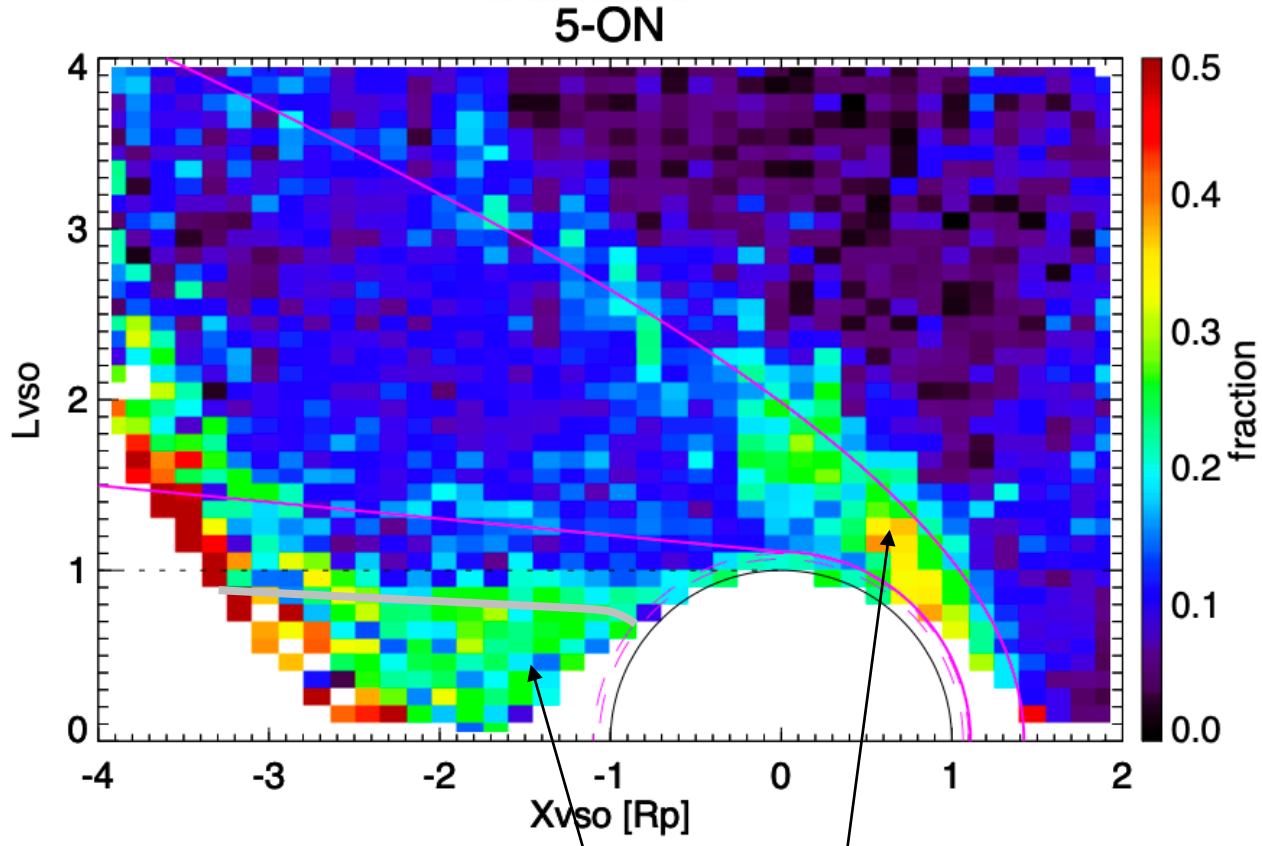
- Defining mag topology, i.e., magnetic connectivity to collisional atmosphere/ionosphere (e- exobase)
  - One end: open
  - Two ends: closed
  - None: draped

- Determining magnetic topology:
  - Electron pitch angle distribution (PAD):
    - One-sided loss cone: intersecting atmosphere on one end, open
    - Double-sided loss cone: intersection on both ends, closed
  - Electron energy spectra for field-aligned directions:
    - Photoelectrons in one direction, solar wind electrons in another, open
    - Photoelectrons in both directions, closed
  - Solar wind electrons in both directions with no loss cone, draped

RESULTS - OPEN

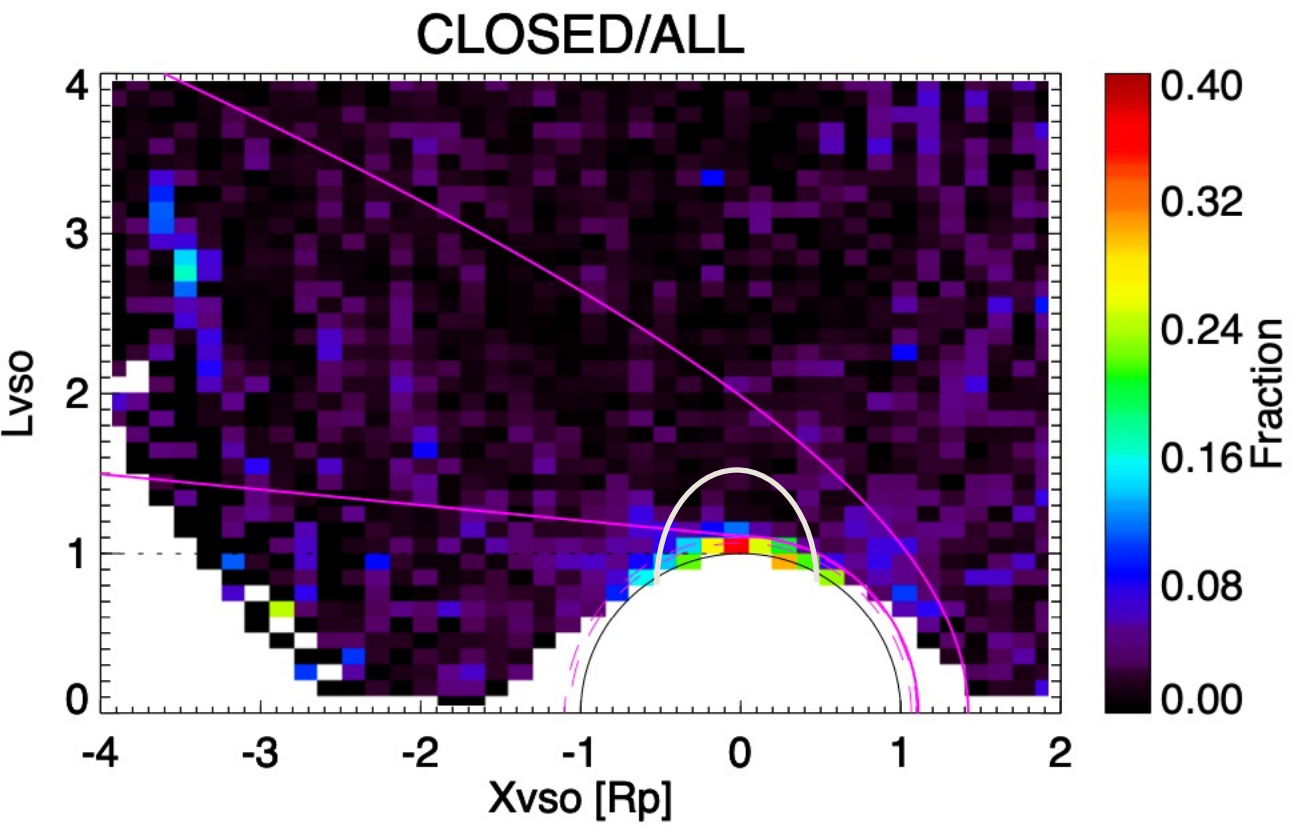


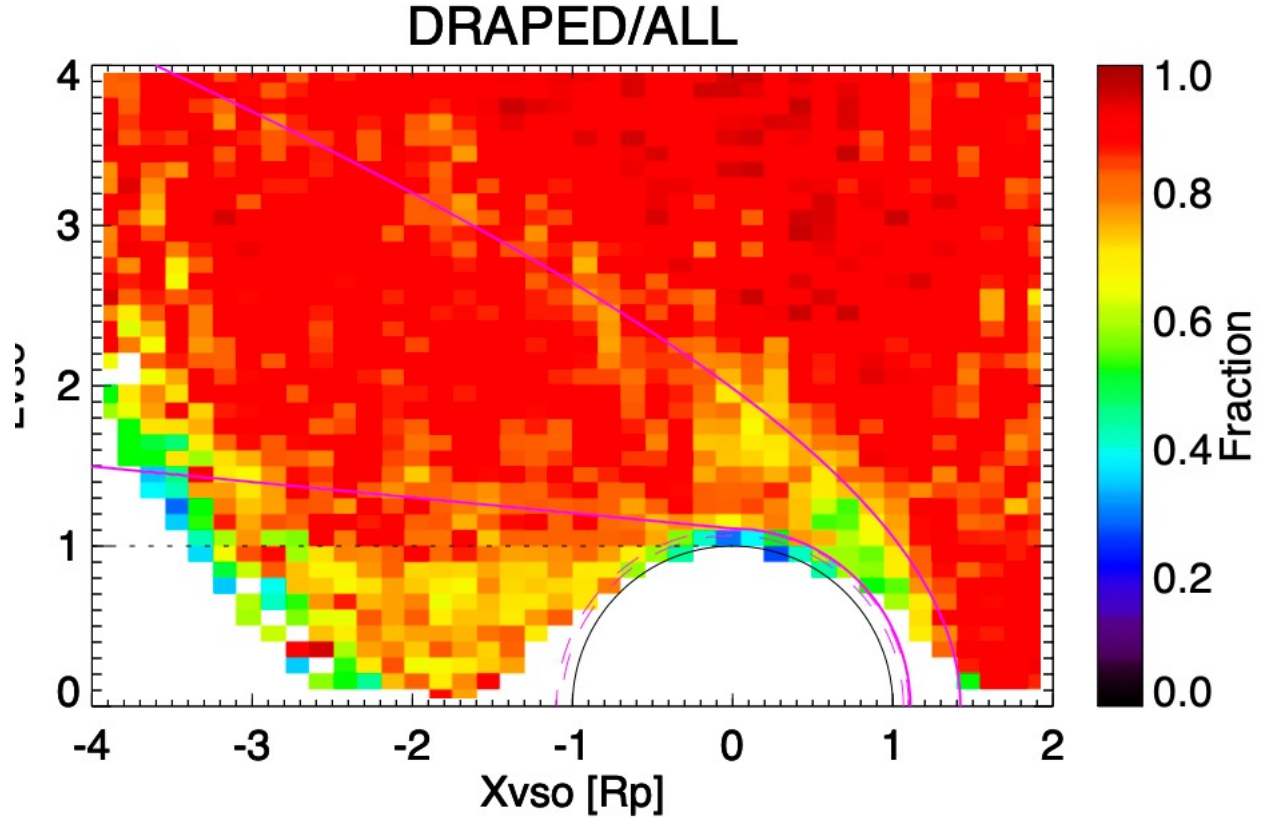
- **Open-to-day (OD)**
  - 5% -20% OD near terminator at low altitudes (below IMB)
  - 5% - 10% OD in the tail



- **Open-to-night (ON)**
  - 20%-30% ON in the tail, especially inside the optical shadow
  - 20%-40% ON in sheath, PA anisotropy (misidentification)

RESULTS – CLOSED+DRAPED



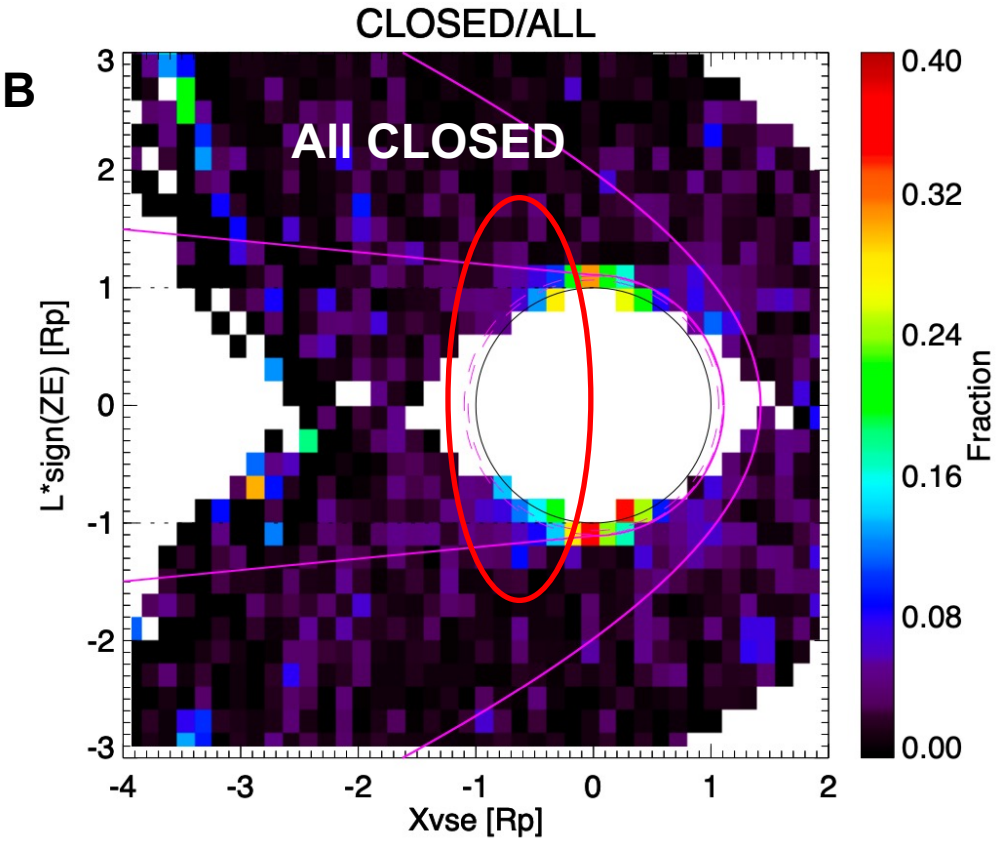


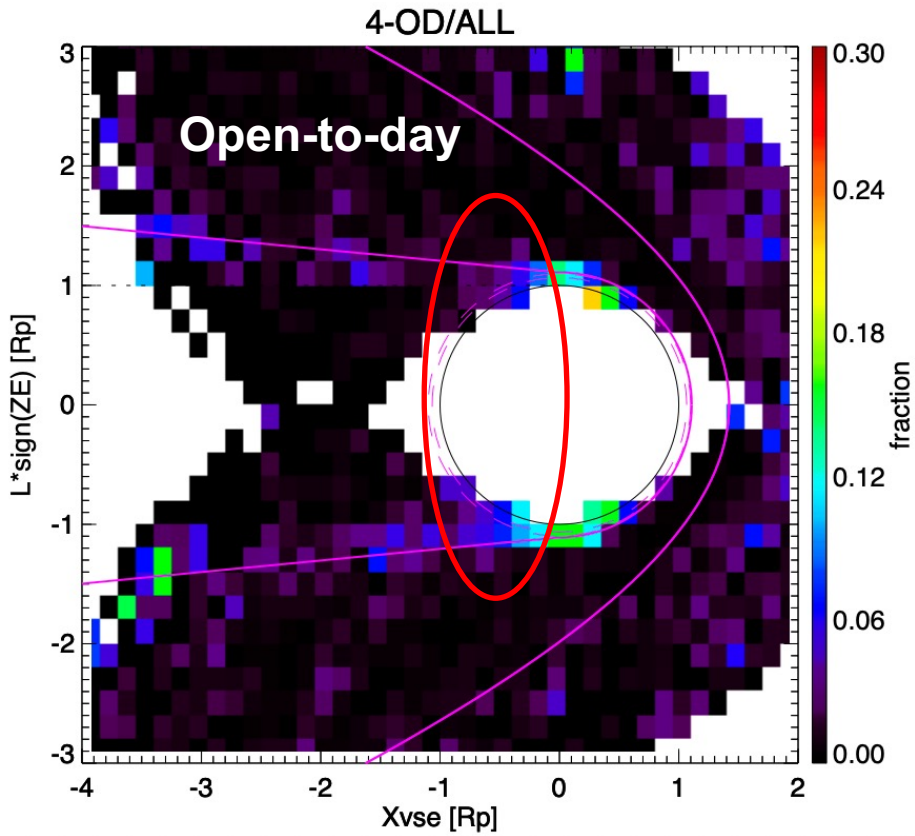
- **All CLOSED combined**
  - 10%-35% CLOSED, mostly near the terminator
  - Unexpected topology, formation mechanism unknown

- **DRAPED**
  - Complementary to other types, dominant topology except for in the ionosphere

RESULTS – VSE ASYMMETRY

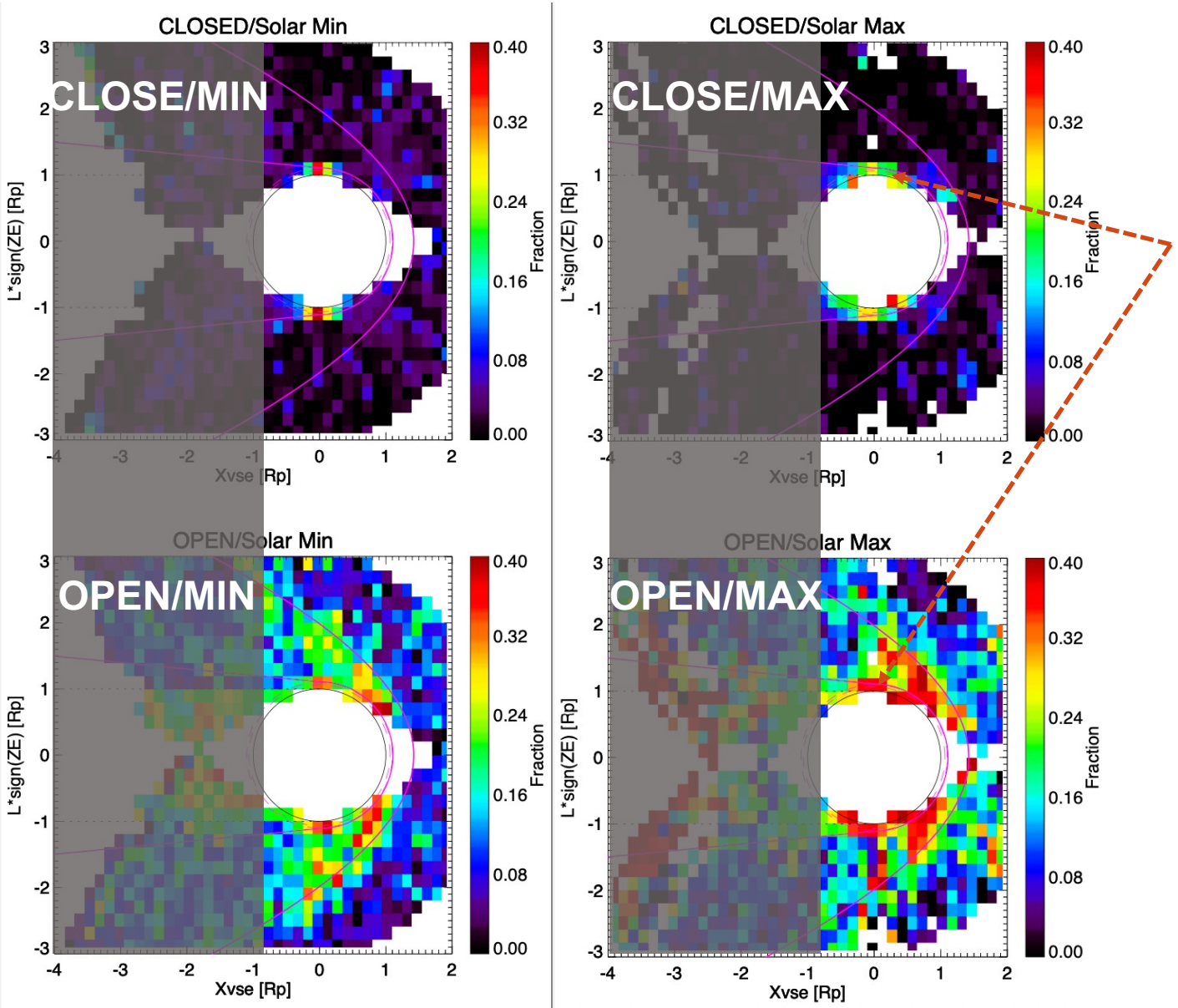
E = -U x B





- **All CLOSED (left) + Open-to-day (right): higher occ. rate past terminator at $Z_E < 0$**
  - **More magnetic connectivity to dayside ionosphere in –E than +E**
  - **More ionospheric magnetization in –E than +E?**

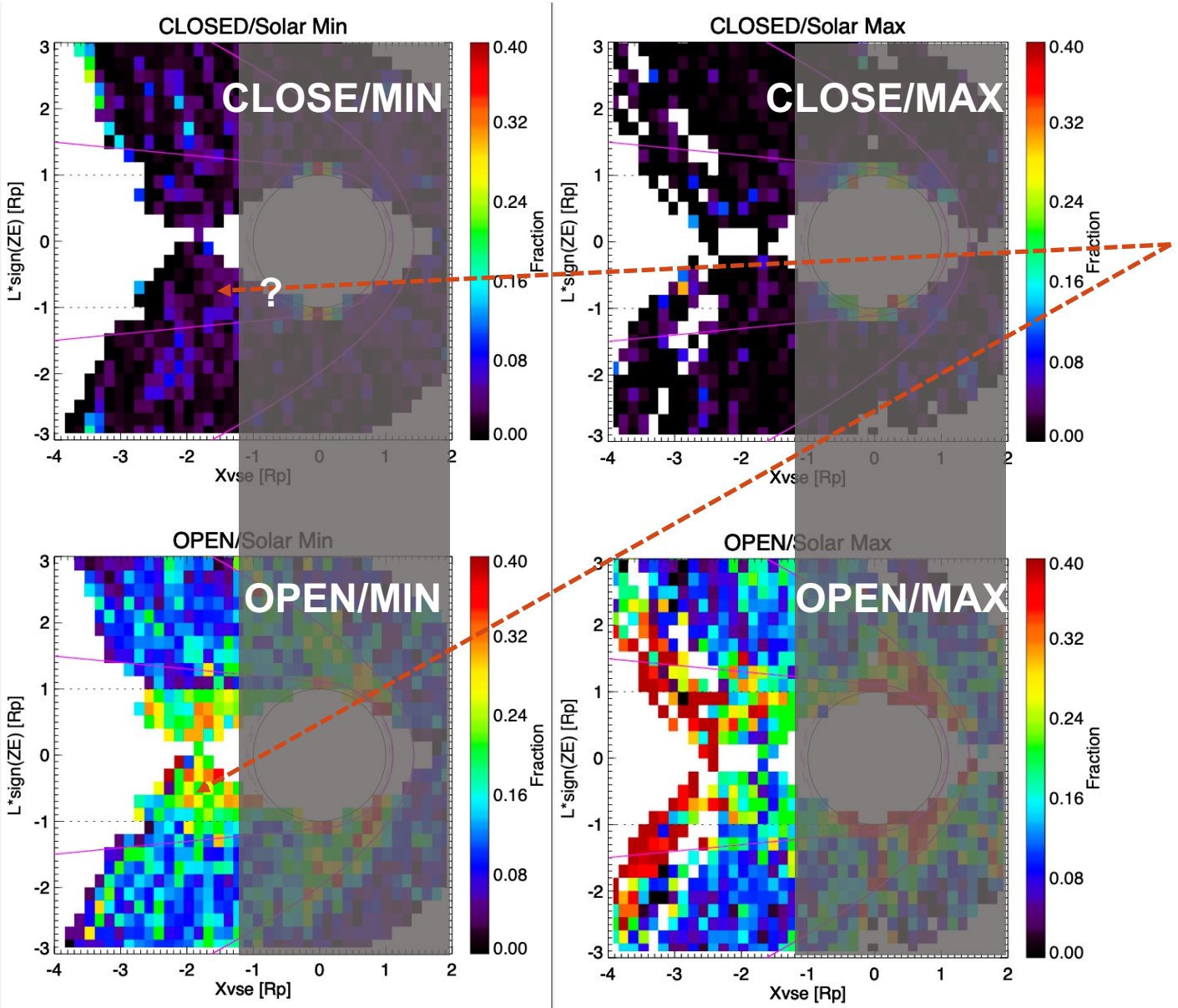
RESULTS – SOLAR CYCLE EFFECTS



- More CLOSED/OPEN near terminator during solar **MAX** (right column)
  - More dayside magnetic connectivity during solar maximum

- *Solar Min: 2007-2011*
- *Solar Max: 2011-2014*

RESULTS – SOLAR CYCLE EFFECTS



- More OPEN (maybe closed too?) in the tail during solar **MIN** (right column)
  - More nightside magnetic connectivity during solar minimum

- *Solar Min: 2007-2011*
- *Solar Max: 2011-2014*

CONCLUSIONS

- First case studies of magnetic topology at Venus done by Xu et al. [GRL, 2021]
- This study - ***first statistical mapping*** of Venus magnetic topology
  - CLOSED: a surprising topology, distributed near the terminator with a 10%-35% occ rate
  - OPEN: distributed low altitudes and tail with a ~40% occ rate
  - DRAPED: dominant topology
- Driver effects
  - **VSE:** More dayside magnetic connectivity in –E than +E
  - **Solar cycle:**
    - More dayside magnetic connectivity during solar max
    - More nightside magnetic connectivity during solar min