The sodium ion enhancement at Mercury's high latitude magnetosphere during flux transfer event showers: MESSENGER observations

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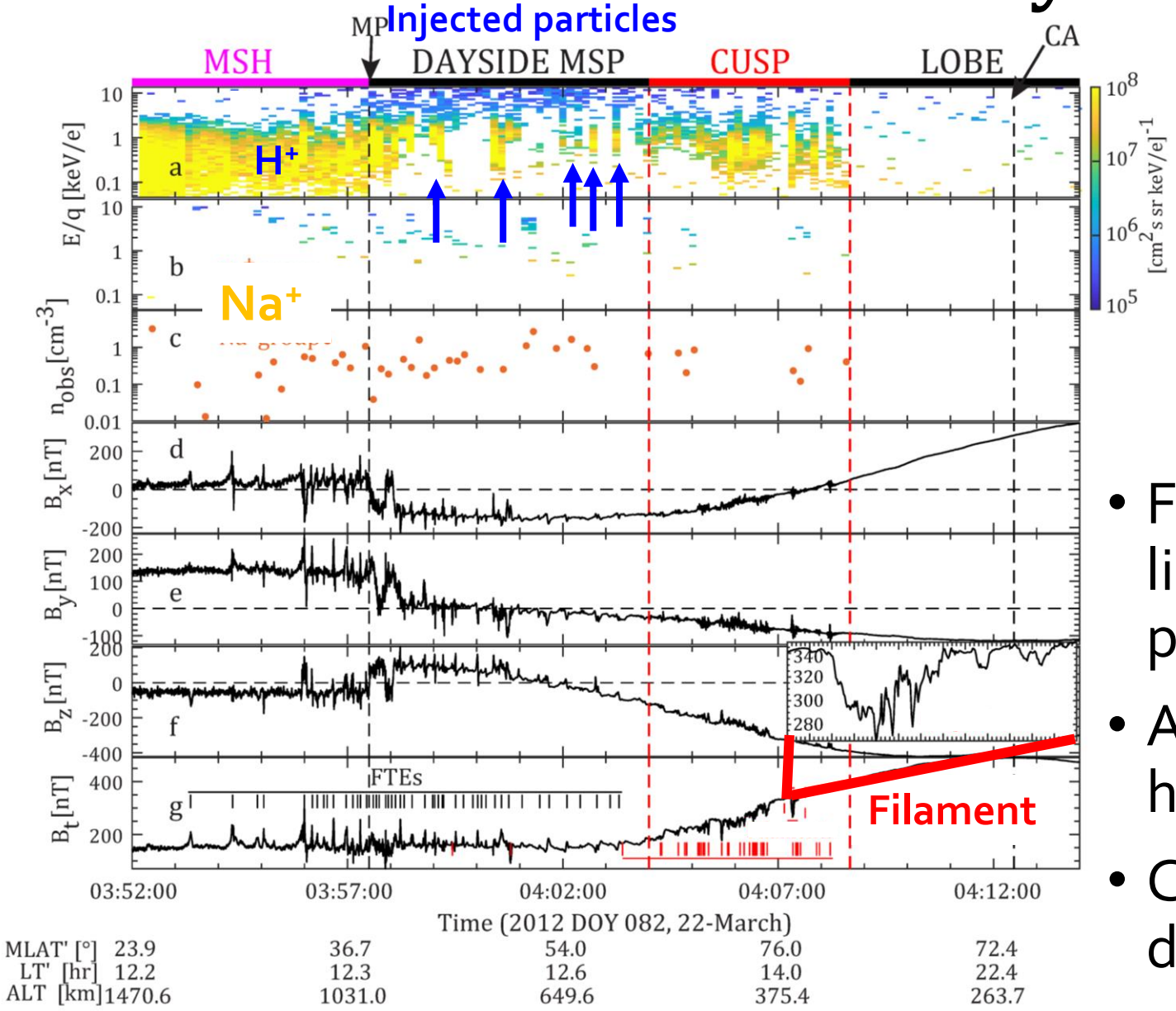
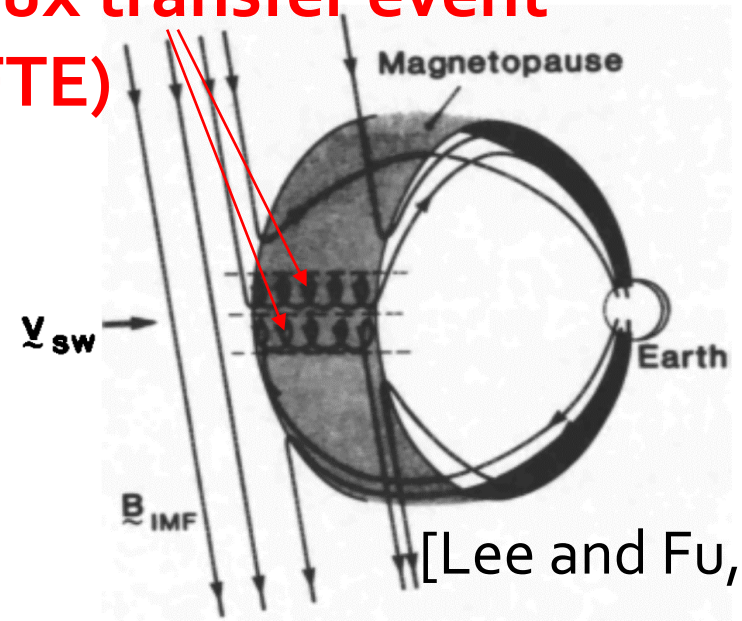
FTE Shower at Mercury



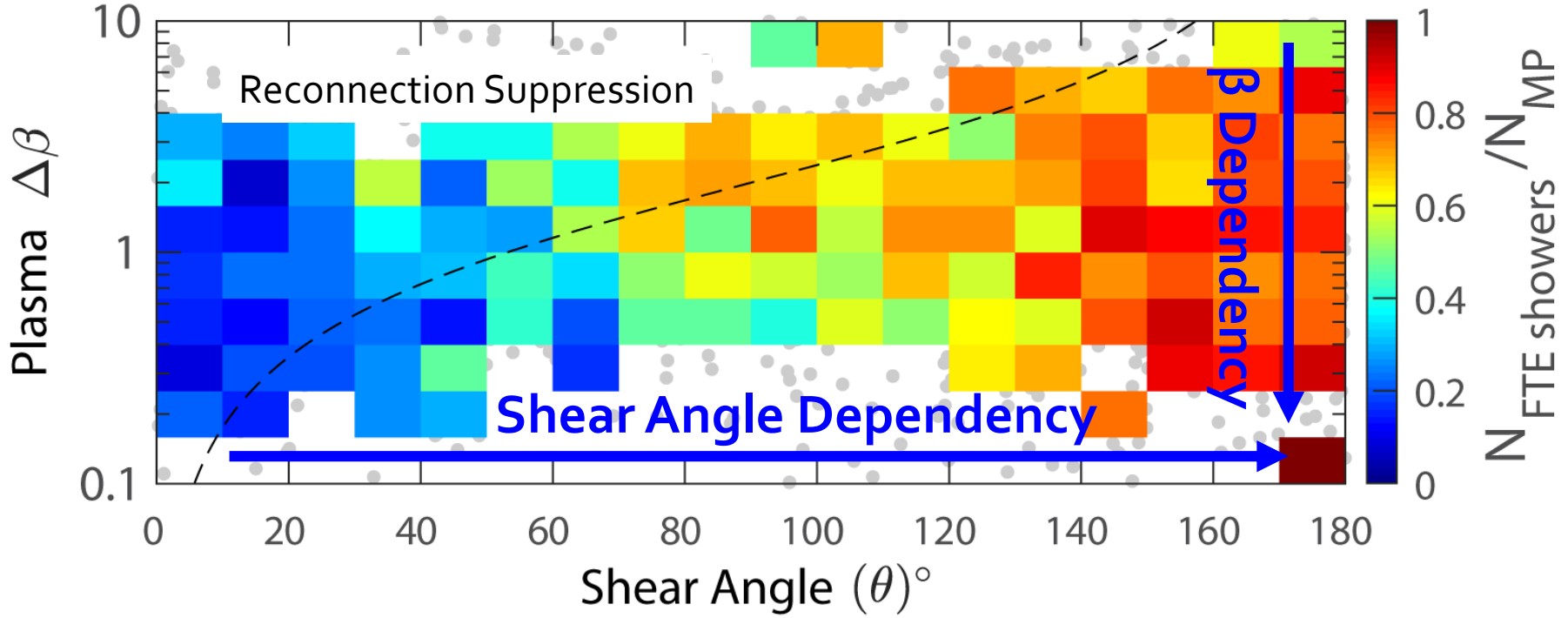
Flux transfer event (FTE)



[Lee and Fu, 1985]

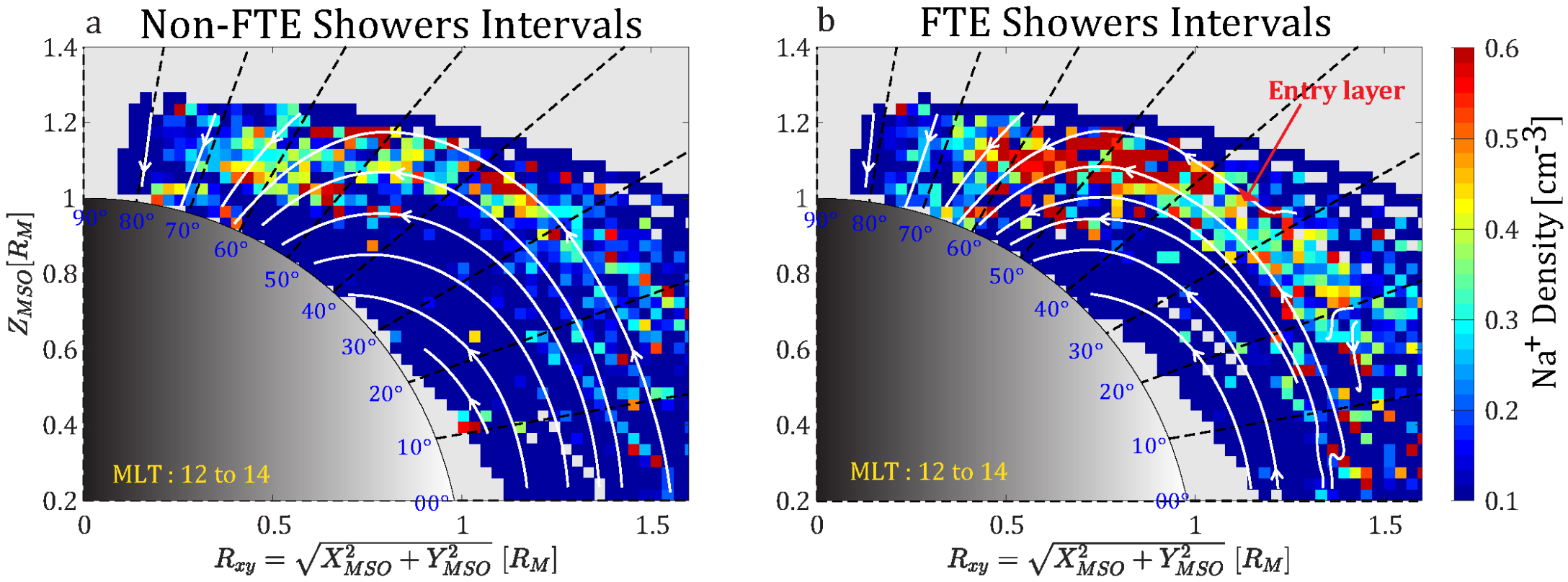
- FTEs contain open magnetic field lines, transport magnetic flux and particle flux
- An FTE "Shower": large-number, high frequent FTEs
- Cusp filament, diamagnetic decrease due to injected particles

Dependence on Plasma β and Magnetic Shear



- Sun et al. [2020, doi:10.1029/2020GL089784]: 1953 (~ 52%) of 3748 dayside magnetopause from MESSENGER correspond to FTE showers.
- The occurrence of FTE showers depends on plasma beta and magnetic shear angle

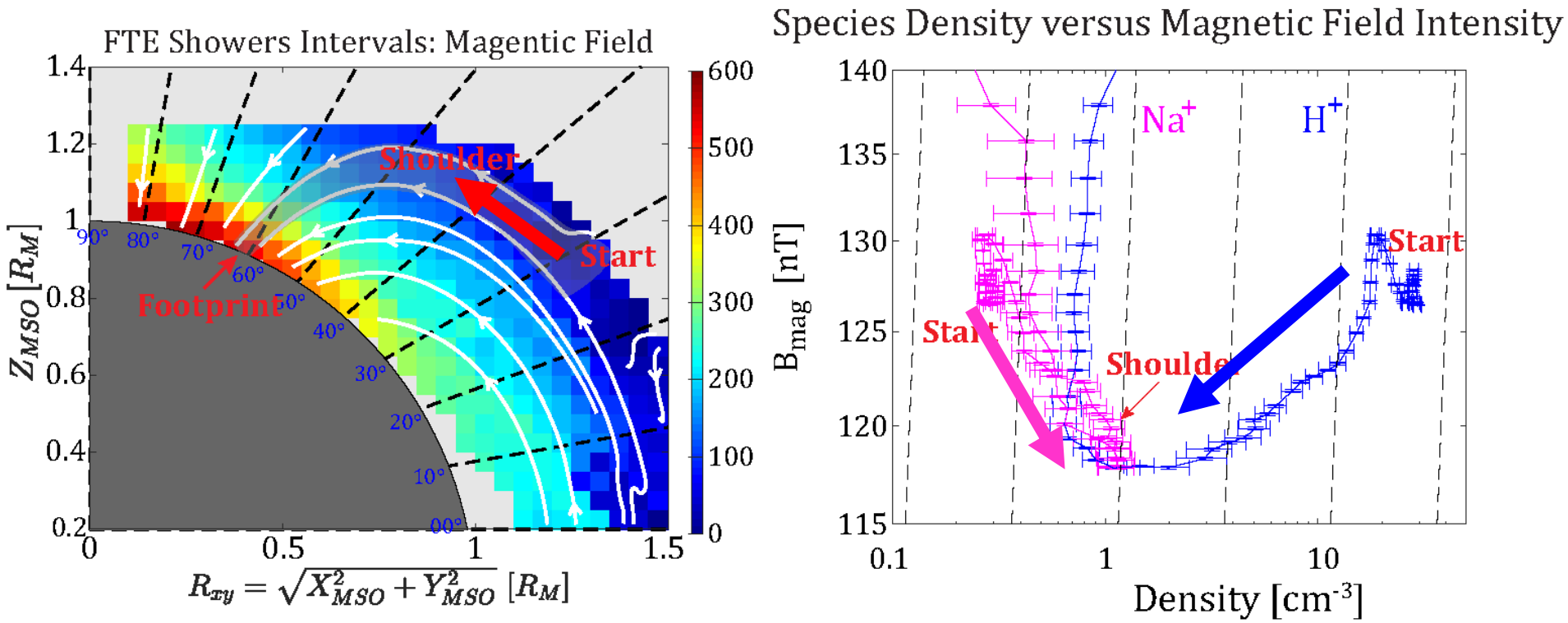
FTE Shower Influences Sodium Ions



FTE shower interval:

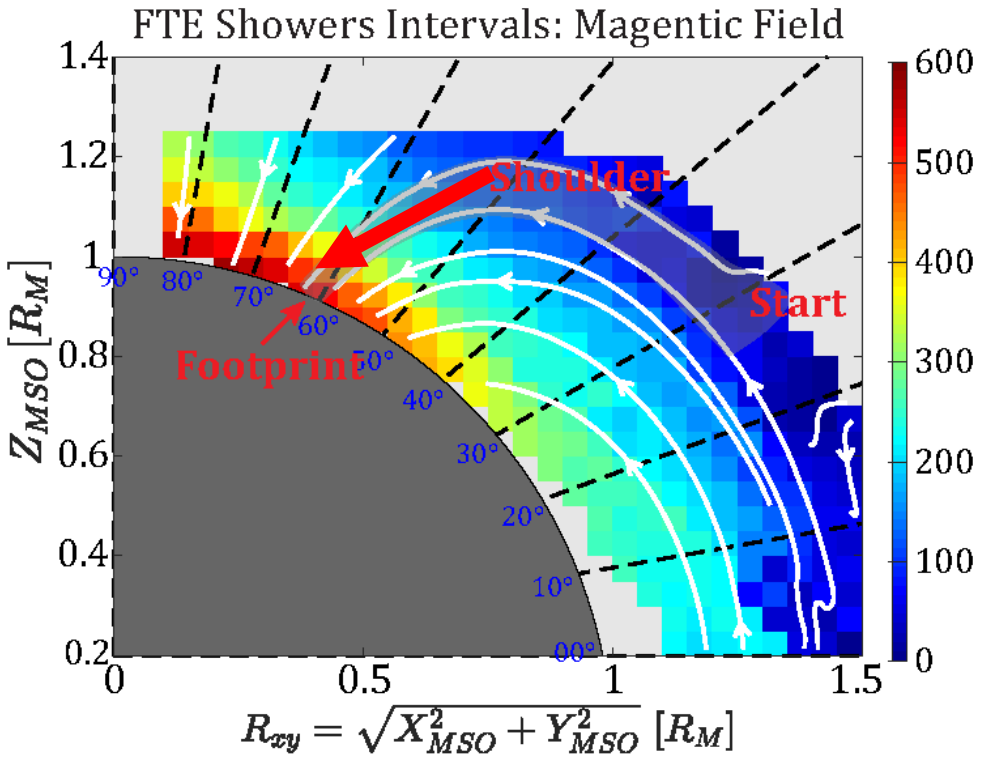
- Sodium-group ions (Na^+) significantly enhance on the high latitude magnetosphere above the northern cusp.
- Entry Layer: the newly opened magnetic field lines.

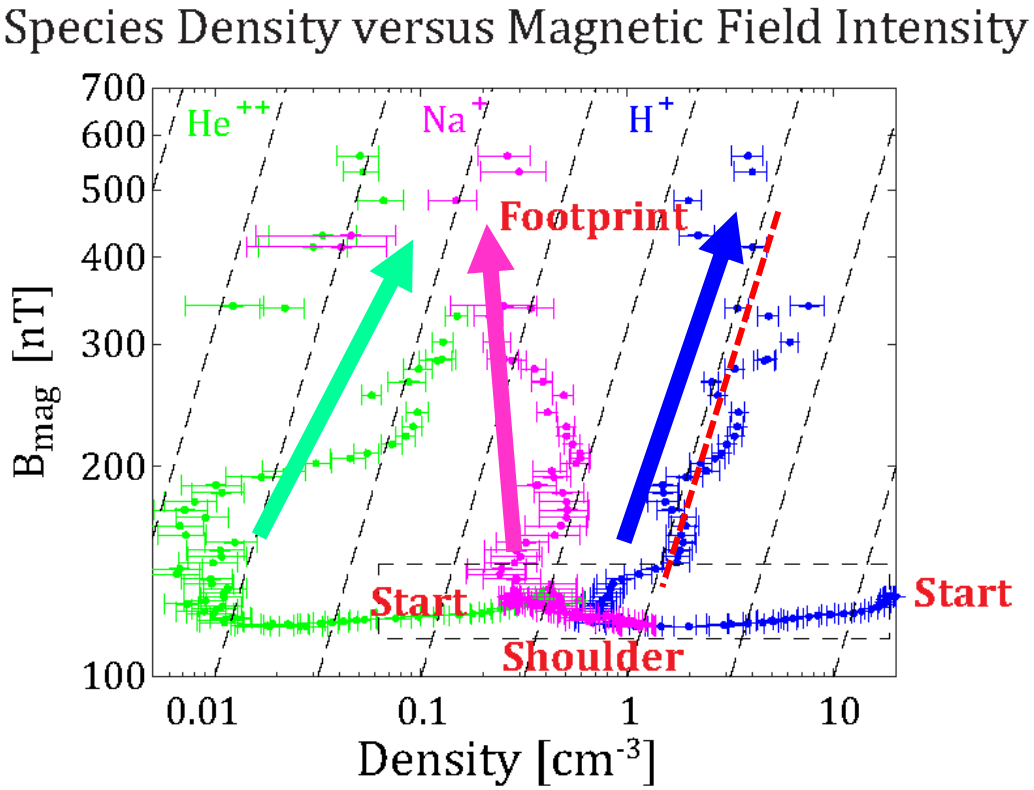
Trace the Entry Layer: Start to Shoulder



- H^+ transported poleward. Na^+-group accumulate from "start" to "shoulder".
- Solar wind particles lose while the Na^+ increase, indicating the Na^+ are continuously generated.

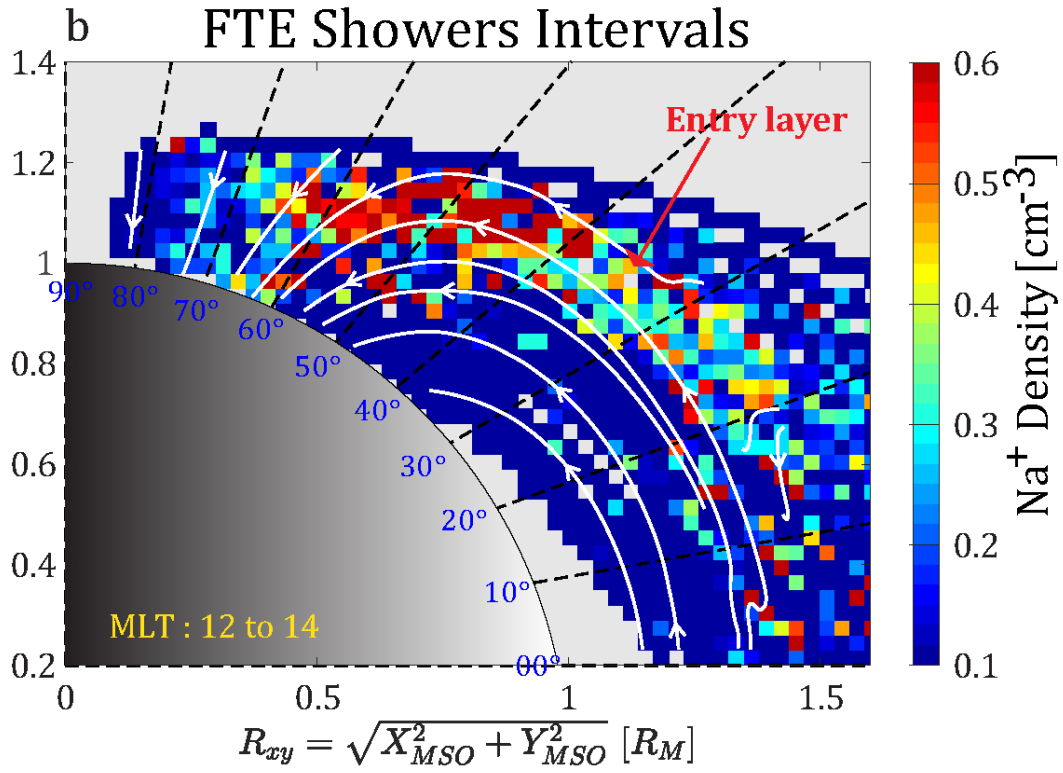
Trace the Entry Layer: Shoulder to Footprint

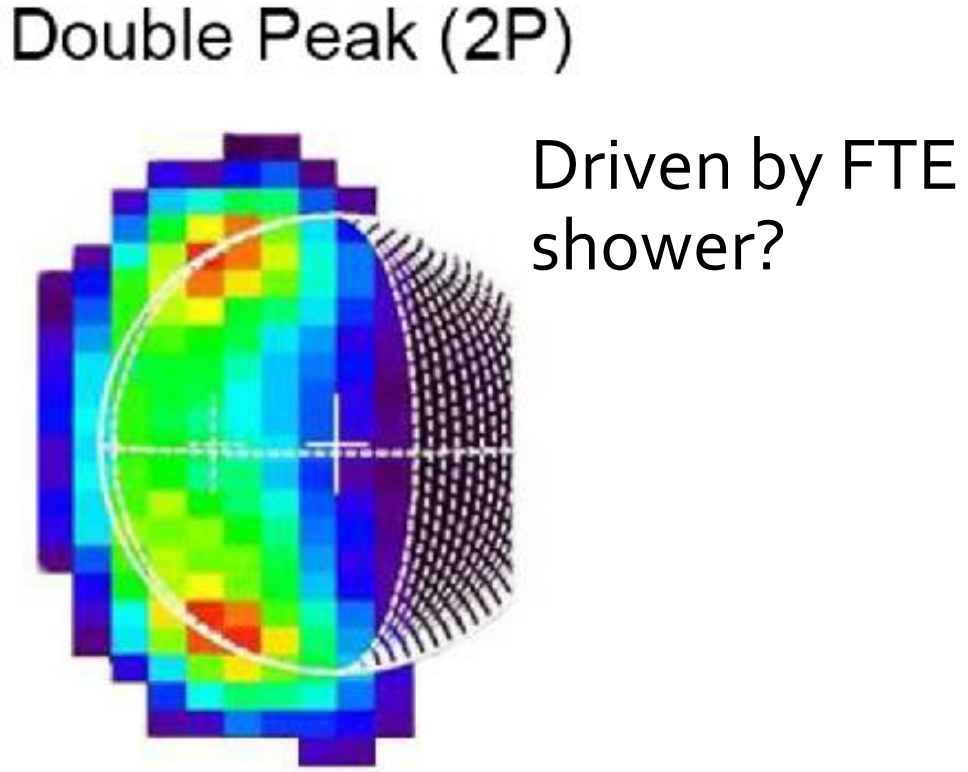




- $n_{density}$ / B_{mag} = Const. The plasma content is conserved along the same flux tube.
- The precipitation rate is 1.64×10^{25} s^{-1} for H^+, and is 1.0×10^{24} s^{-1} for He^{++}

Sputtering Influence Exospheric dynamics





Driven by FTE shower?

The sputtered Na+: 6.0×10^{23} s^{-1} (a lower limit).

The neutral Na surface density: 10^9 m^{-3}.

Then the sputtered column density: 10^{14} m^{-2}.

The background neutral Na is 10^{15} m^{-2} [Cassidy et al., 2015].

Na emission patterns identified in Mercury's exosphere

[Mangano et al. 2015]

Conclusions

- FTE showers form a solar wind entry layer converging toward the cusp, which leads to a high estimated solar wind charged particle precipitation rate on the Mercury's surface (> 10^{25} s^{-1}).
- The Na^+ is significantly enhanced in the entry layer during the intervals of FTE showers in ~ 10 minutes.
- FTE showers enhanced the precipitation rate and Na^+ in the high latitude region on time scales of ~ 10 minutes, which is comparable to the time scales of rapid variations in Mercury's exosphere near the magnetospheric cusps observed by ground-based telescopes.
- The exospheric enhancement response time due to FTE showers (~ 10 minutes) is much faster than what is expected for exospheric temporal variations due to stimulated desorption (~hours) or impact vaporization.