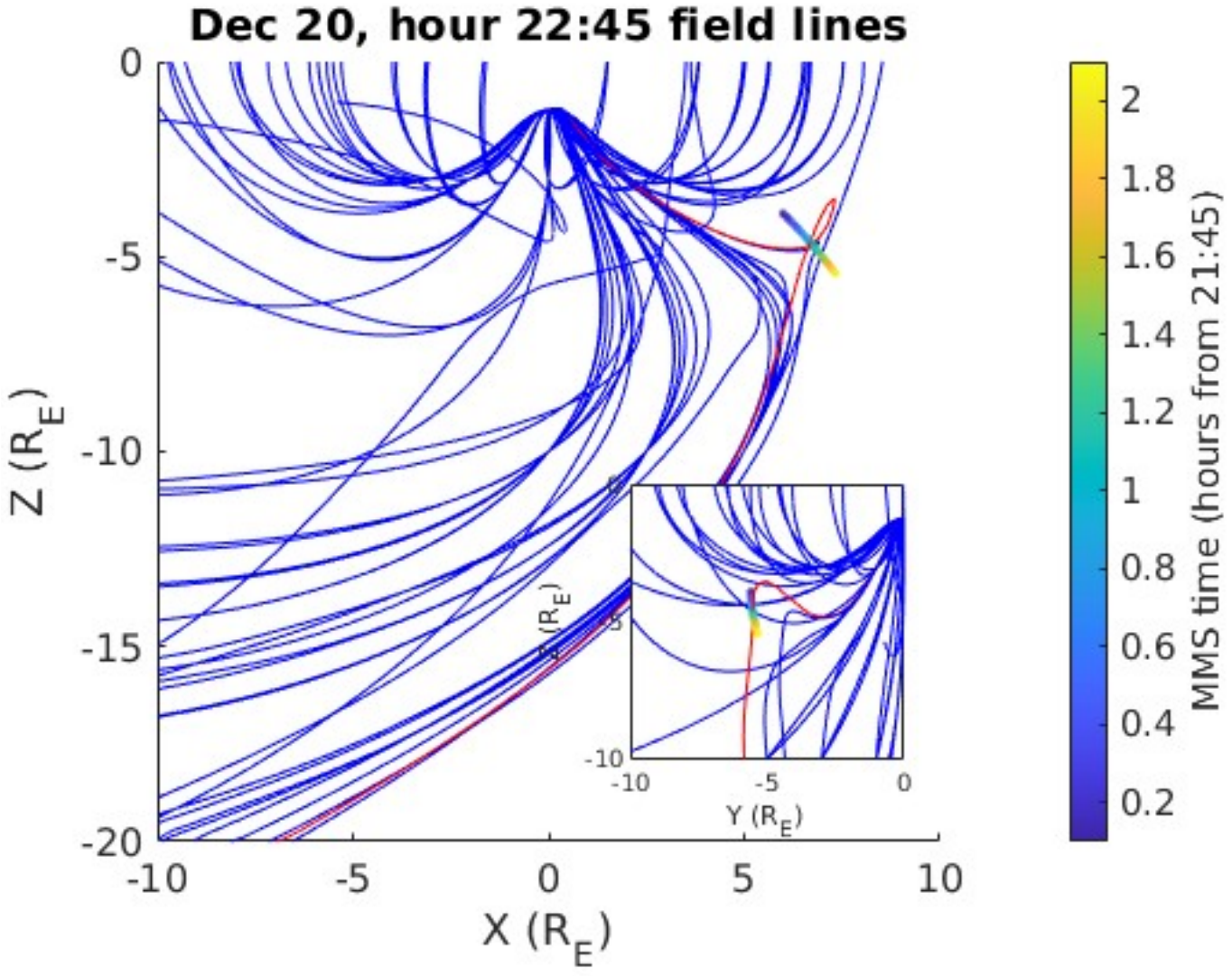
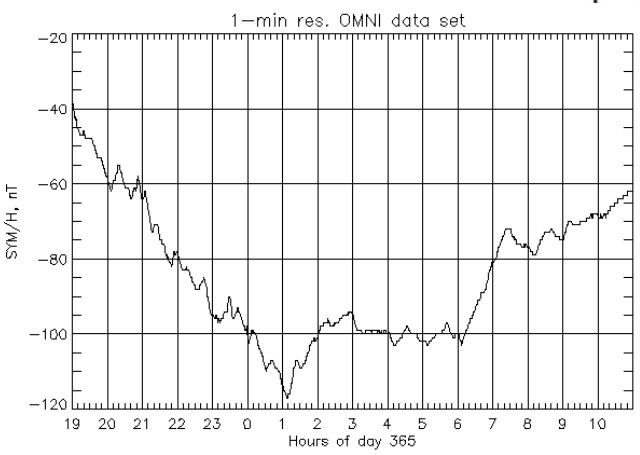


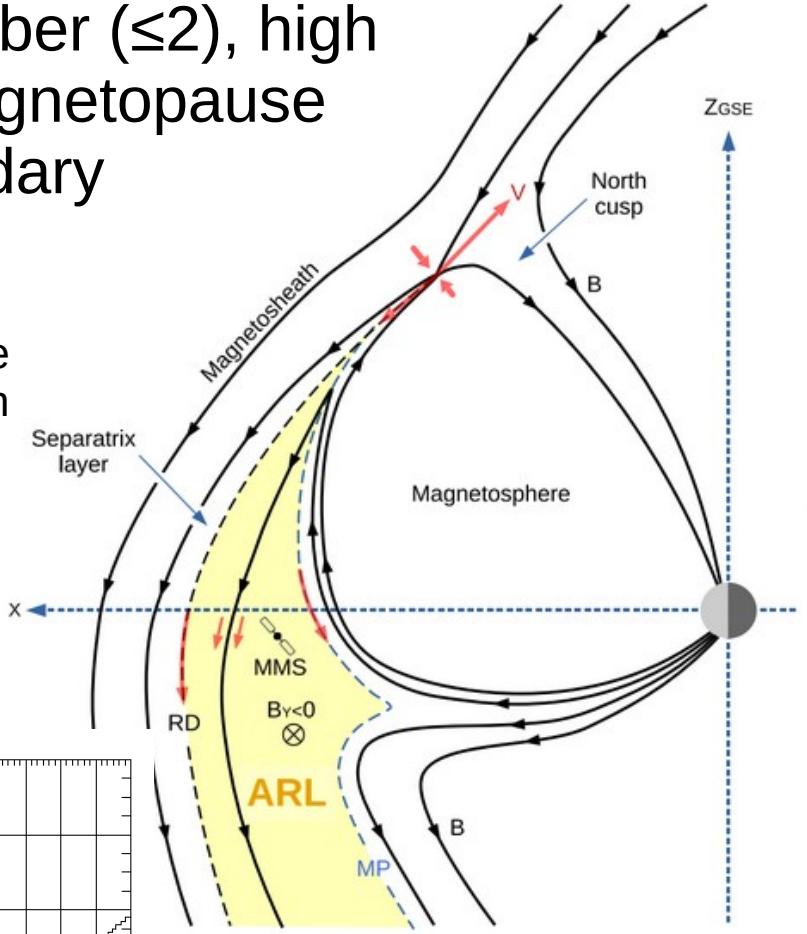
Global MHD simulations and MMS observations of the storm-time magnetopause boundary

Brandon Burkholder, L-J. Chen, S. Fuselier, D. Gershman, C. Schiff, J. Shuster, Y. Zou, B. Walsh, P. Reiff, S. Petrinec, A. Sciola

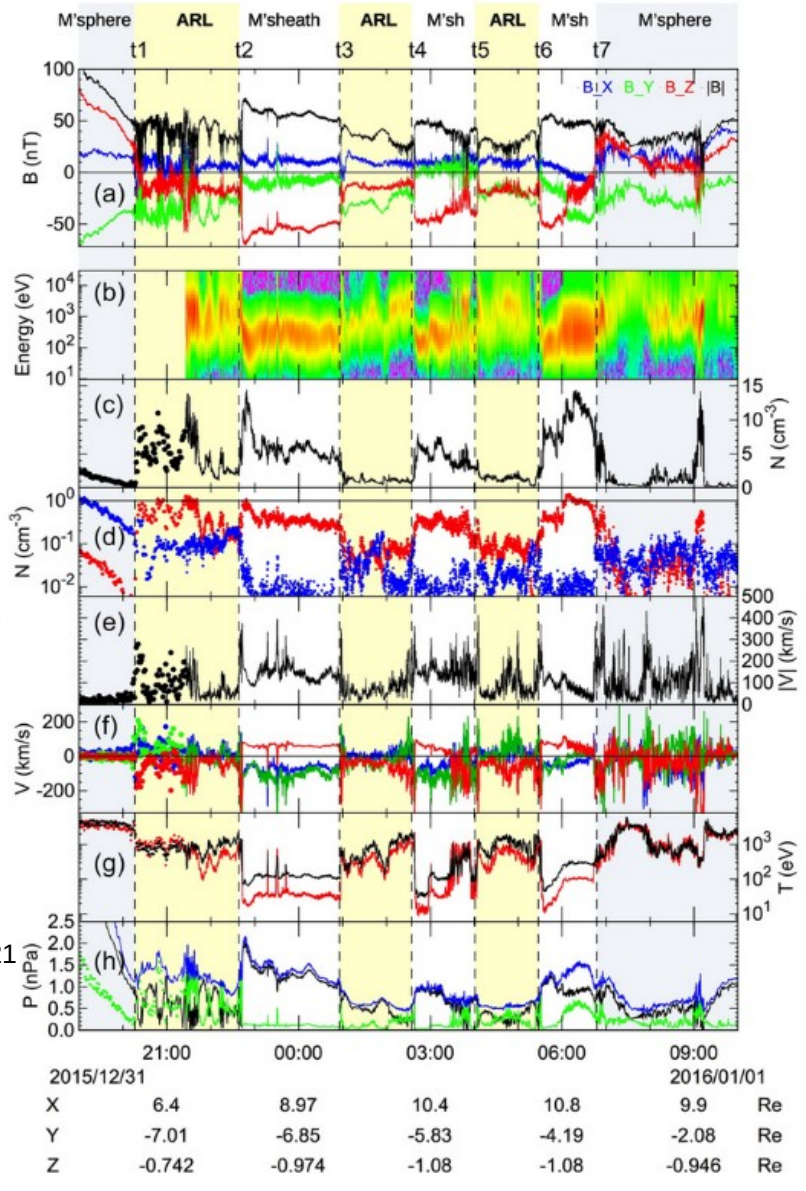
Low mach number (≤2), high dipole tilt, magnetopause boundary

- Paschmann et al., 2021 observed a wide magnetopause boundary layer with energized electrons and ions
- “considerable magnetospheric activity”



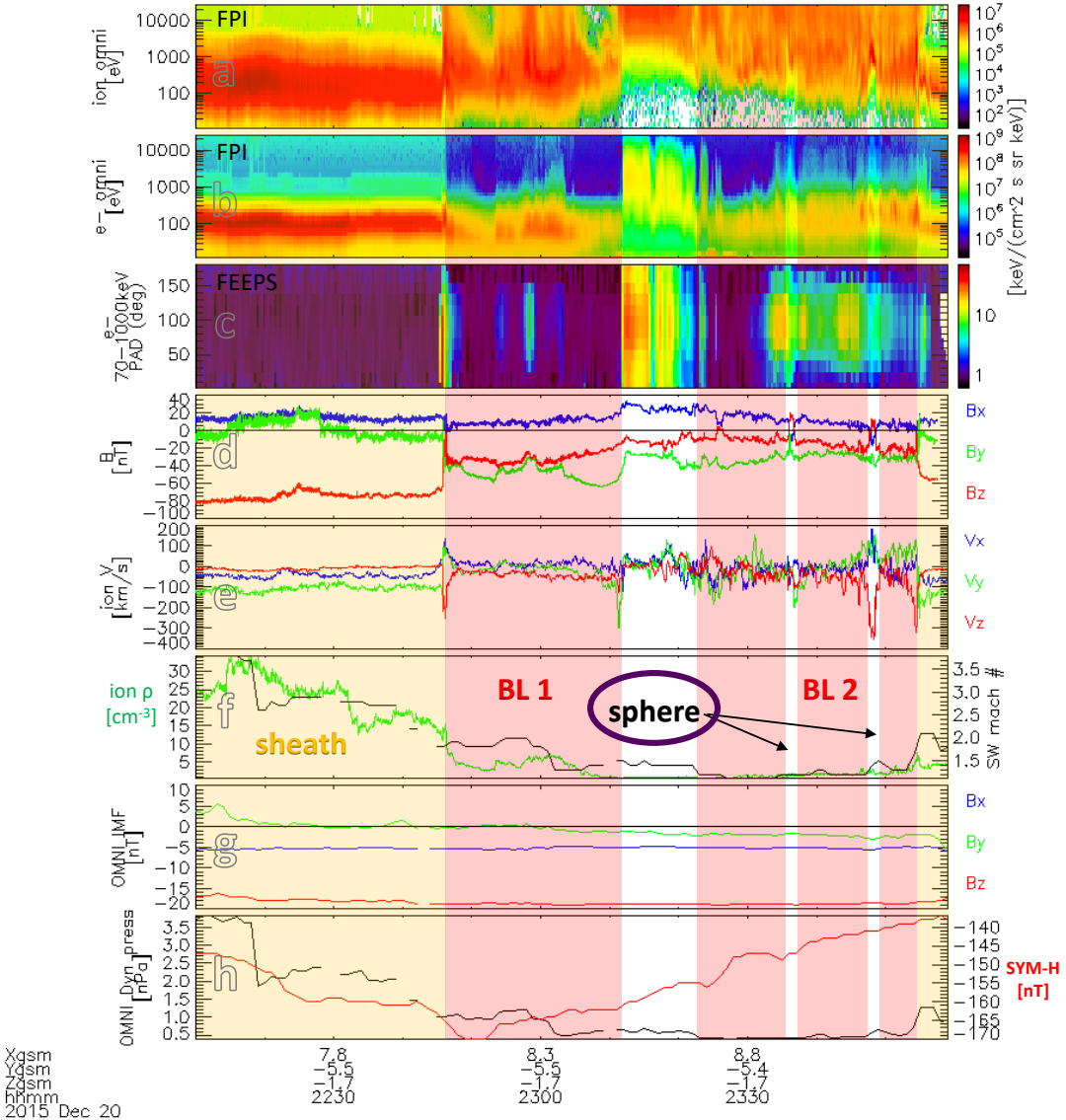


Paschmann et al., 2021



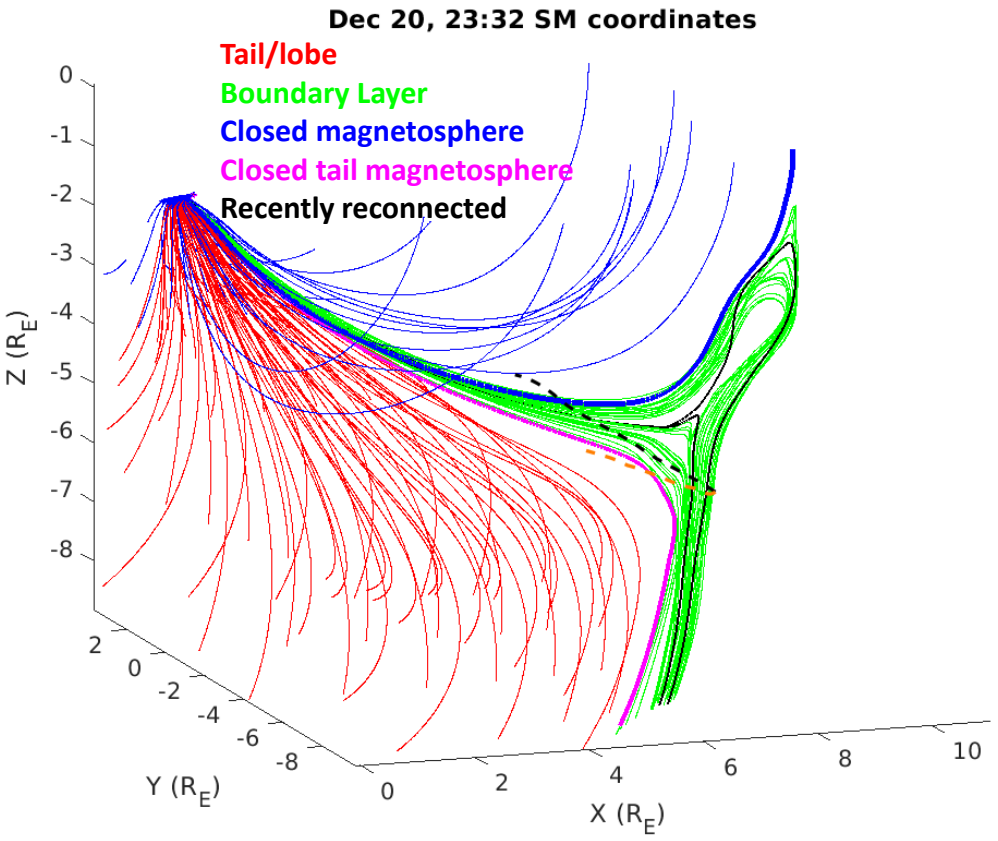
2015 Winter Solstice Storm

- This event has greater maximum SYM-H deflection by 50 nT(-170 nT compared to -120 nT). 22:40 is end of the main phase.
- Low mach number, high dipole tilt (-24º), but additionally cross into the magnetosphere
- First magnetosphere encounter has -Bz, 2 shorter encounters within BL2 have +Bz
- Assuming stationary boundaries BL1 is 0.5 R_E wide
- Submitted to GRL



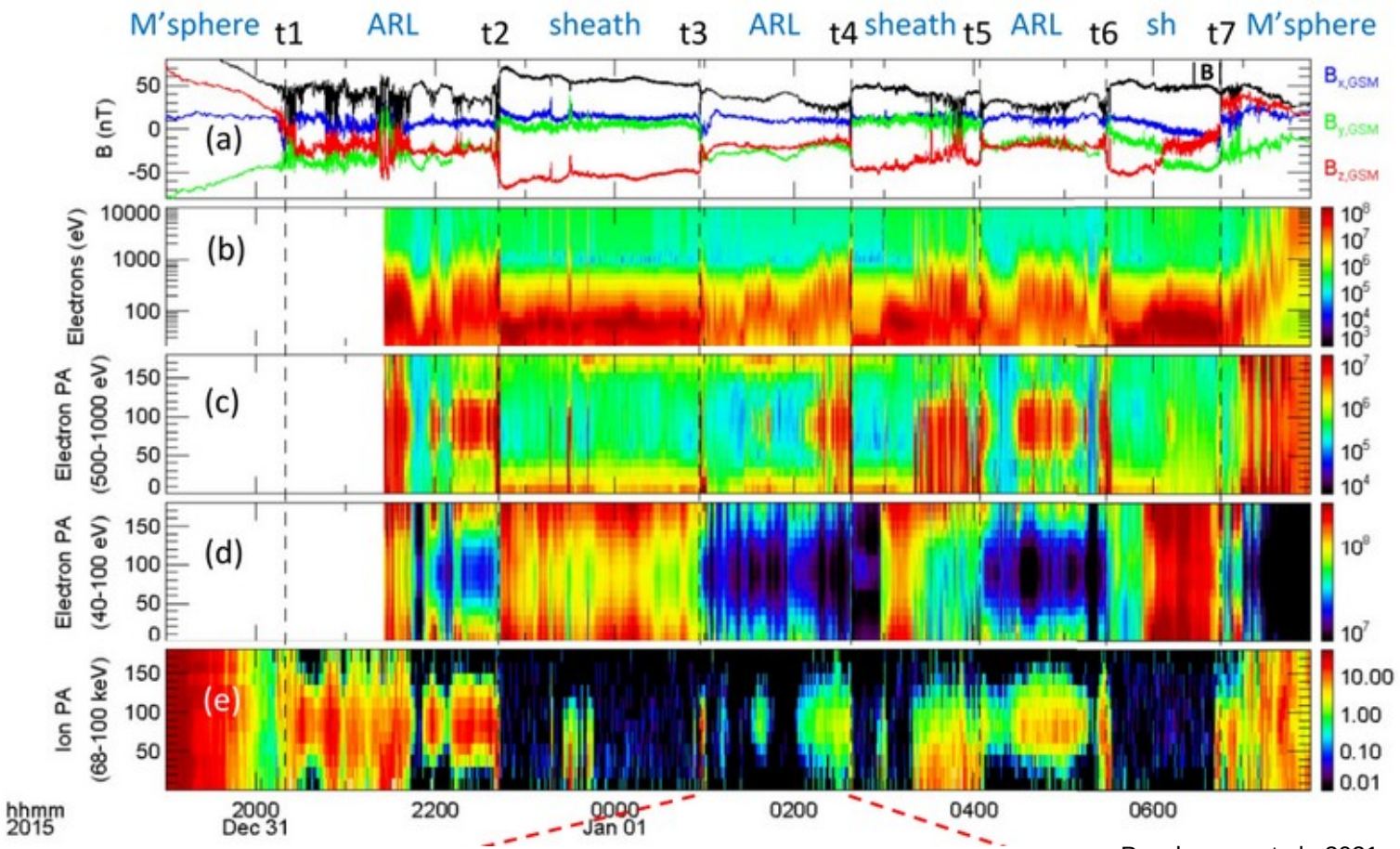
Where to find magnetospheric plasma with Bz < 0?

- (1) Exterior cusp region equatorward of the southern cusp - - - - -
- (2) Closed magnetotail field tailward of the - - - - - southern cusp



Boundary layer is on closed flux

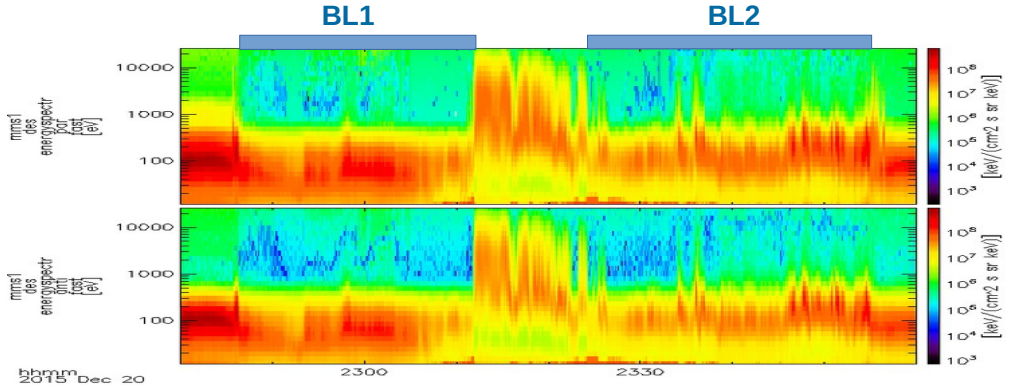
- Sheath core (40–100 eV)
- ARL core (500–1,000 eV)
- In the ARL, 40–100 eV electrons have maximum and nearly equal fluxes at 0 and 180 degrees, while 500–1,000 eV electrons peak at around 90 degrees.
- These characteristics are consistent with the ARL being located on closed field lines, with both ends anchored in the ionosphere, implying that reconnection had occurred both north and south of MMS.



Paschmann et al., 2021

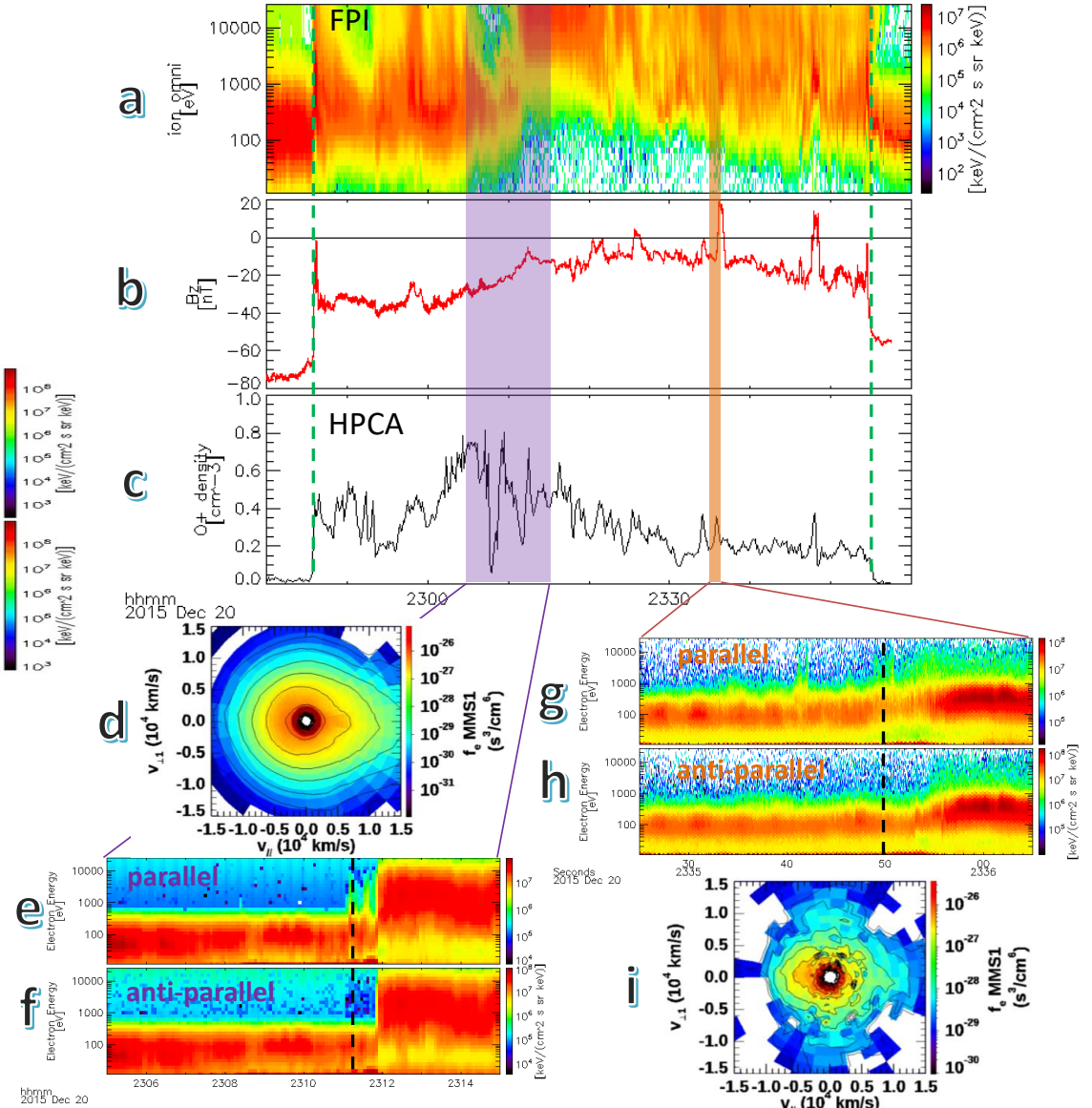
BL1 and BL2 also on closed flux

- Equal 0 and 180 degree mid/low energy electron fluxes in BL1 and BL2.



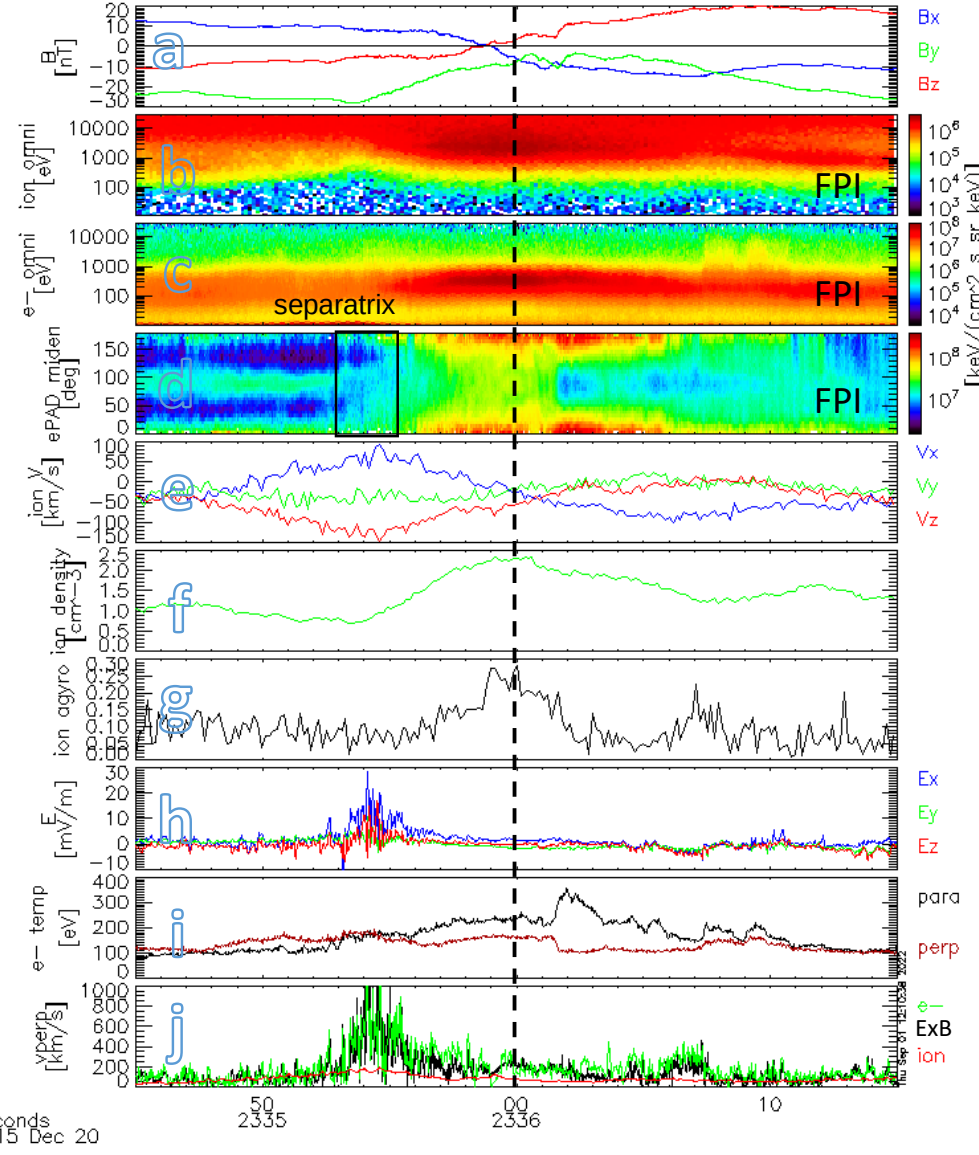
- Unidirectional > 1 keV electrons observed at magnetopause boundary – suggests a reconnection source: scenario (1) deeper in cusp?, scenario (2) northward of spacecraft

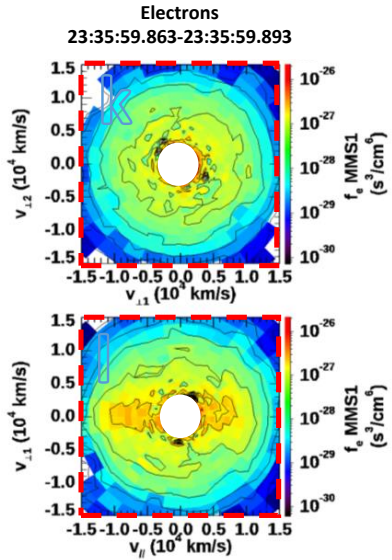
- Accessing the magnetosphere in BL2 region provides a key observation of local reconnection.

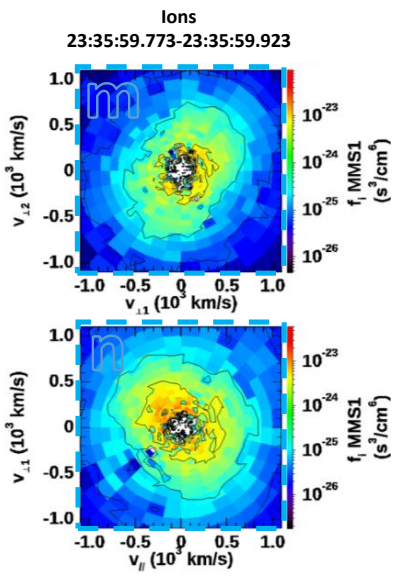


IDR near the southern cusp

- Local reconnection at the magnetopause boundary and near the southern cusp
- Supports Paschmann et al., 2021 hypothesis that “The closed magnetic field topology, inferred from the observed electron pitch angle distributions, implies the existence of a southern reconnection site, whose exact location is not known.”

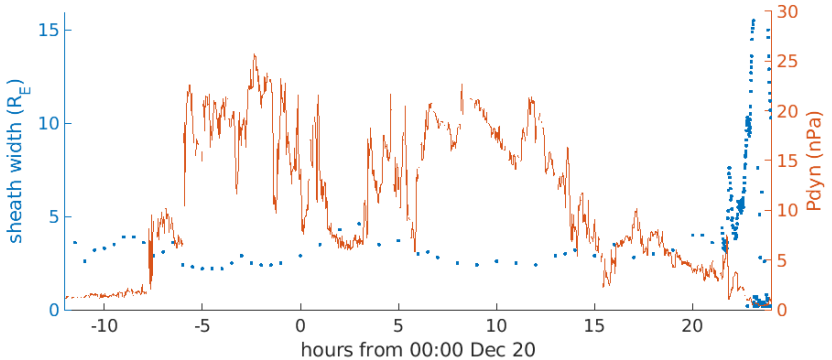


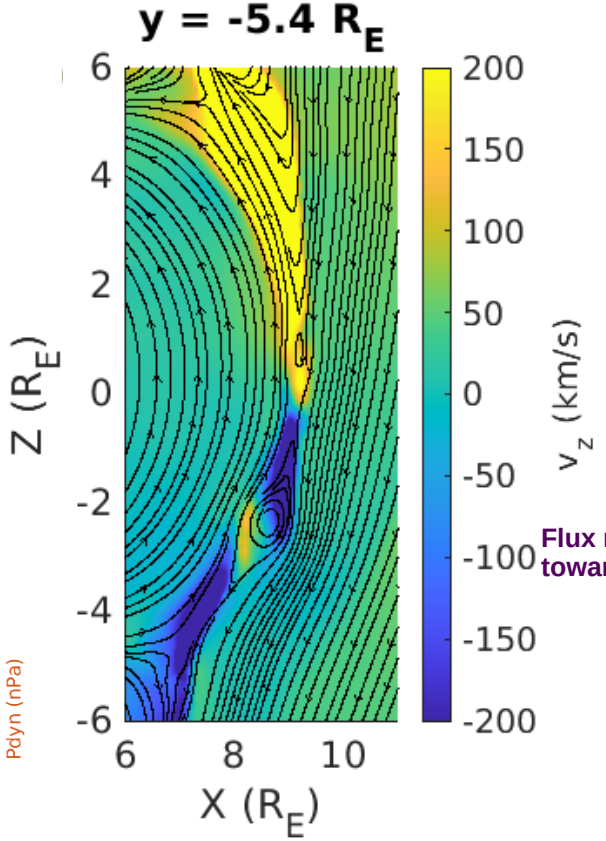


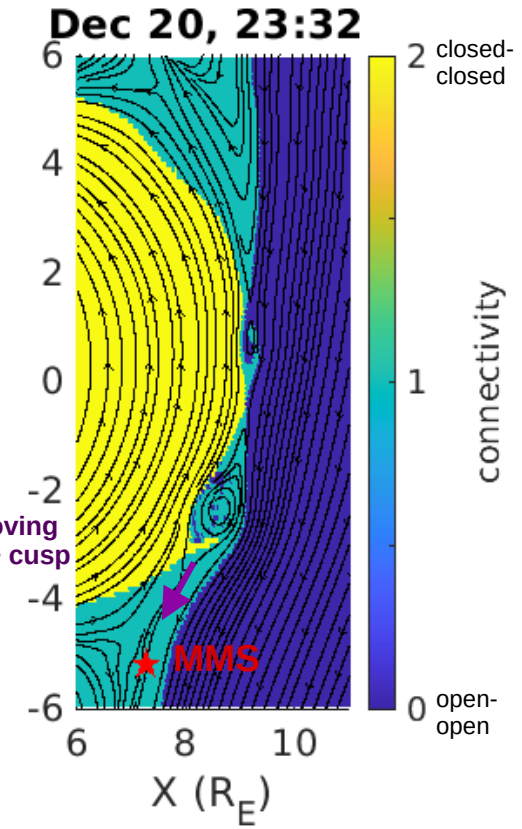


GAMERA Global MHD Simulation

- Flow reversal near southern cusp (z = -4 R_E).
- Closed flux region in the boundary layer.
- Reconnection dynamics during magnetosphere relaxation.

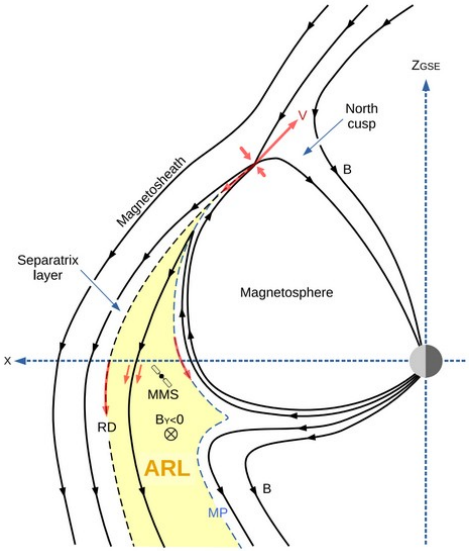




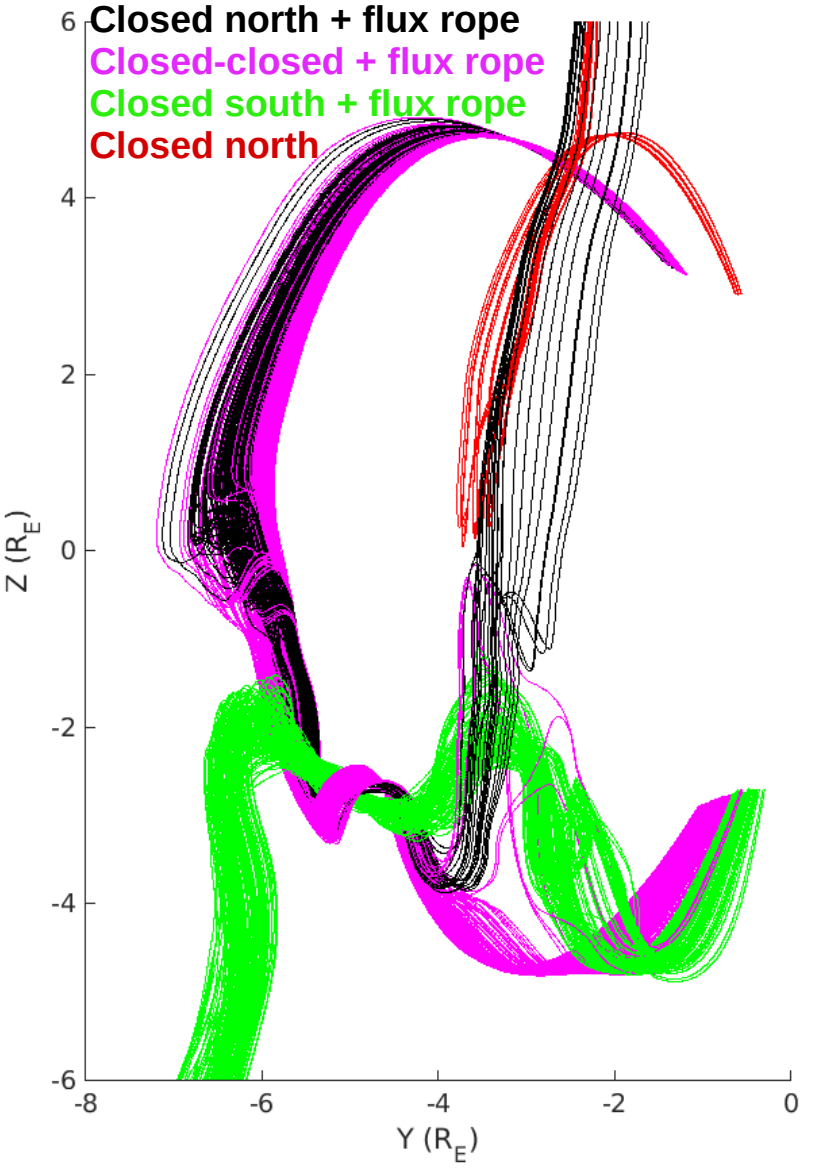


Flux Rope Mapping

- Reconnection and flux rope magnetic topologies lead to closed flux regions in the boundary layer
- Closed field regions of the boundary layer do not need to be formed due to “higher latitude” reconnection, 3-dimensional effects can do it as well



???



Summary

- During (1) large dipole tilt (2) low mach number solar wind (3) end of the main phase of a geomagnetic storm: MMS observes an energized boundary in between the magnetosheath and magnetosphere
- Equal 0 and 180 degree electron fluxes indicate the boundary layer is on closed field.
- During our event, IDR signatures at the magnetospheric boundary support that local reconnection was occurring in the vicinity of the southern cusp.
- Global MHD simulations show closed flux in the boundary layer near the southern cusp with a complicated reconnection topology.