Interaction of Flux Transfer Events and Kelvin-Helmholtz Waves at Earth's Magnetopause

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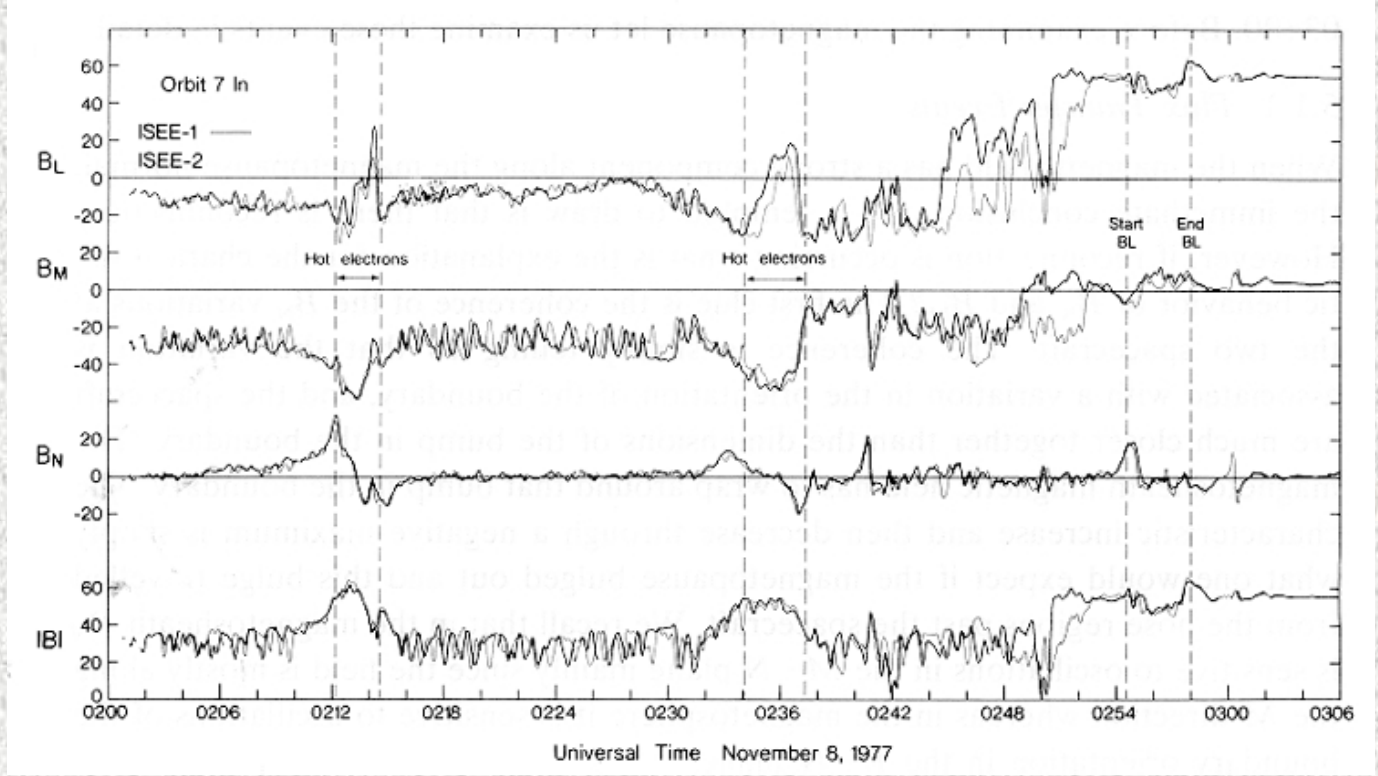
Flux Transfer Events

- Bipolar signatures in the normal magnetic field component at the magnetopause.
- Can be either inside the magnetosphere or the magnetosheath.
- Often contain a mixture of magnetospheric and magnetosheath plasma.



Russell & Elphic, 1978

FTE Models

plenty of them:

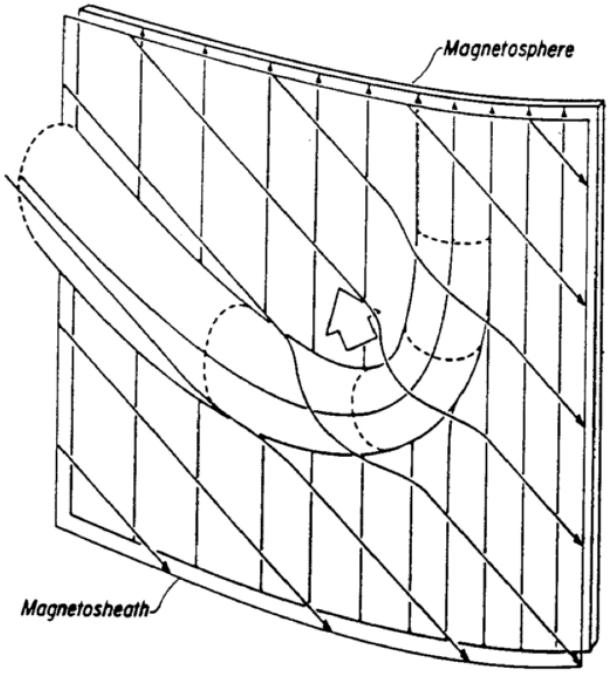


Fig. 1. The Russell-Elphic model of elbow-shaped flux transfer events [*Russell and Elphic*, 1978].

From Scholer, 1995

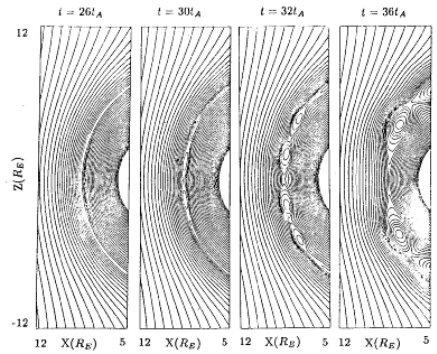


Fig. 2. Enlarged snap-shots of the magnetic field configurations for Case A.

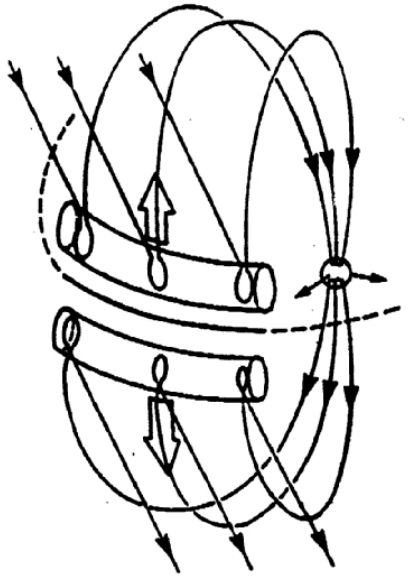
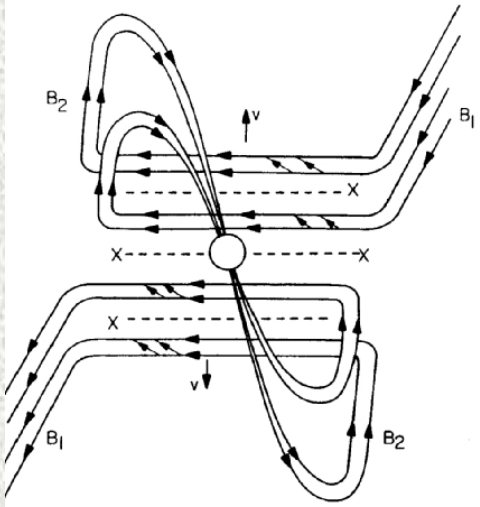


Fig. 5. View from the Sun toward the magnetopause of t bursty single X line reconnection model of FTEs [*Lockwo et al.*, 1990].



. 2. View toward the sun of the multiple X line model FTEs. The horizontal portions of the FTE flux tubes are gnetic islands embedded in the magnetopause [*Sonnerup*, 7].

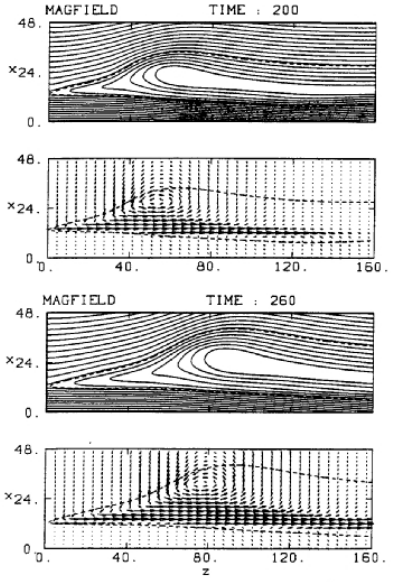
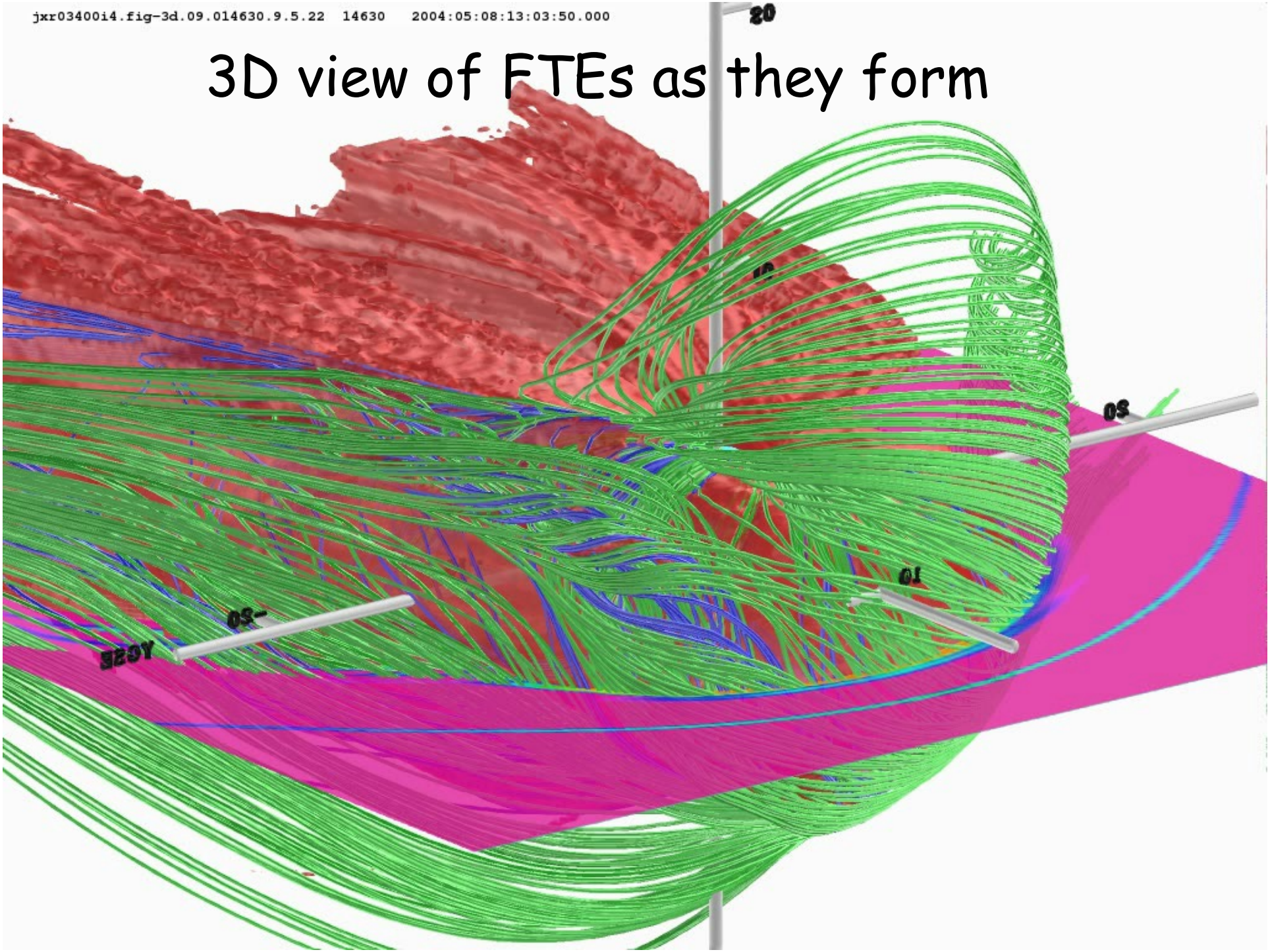
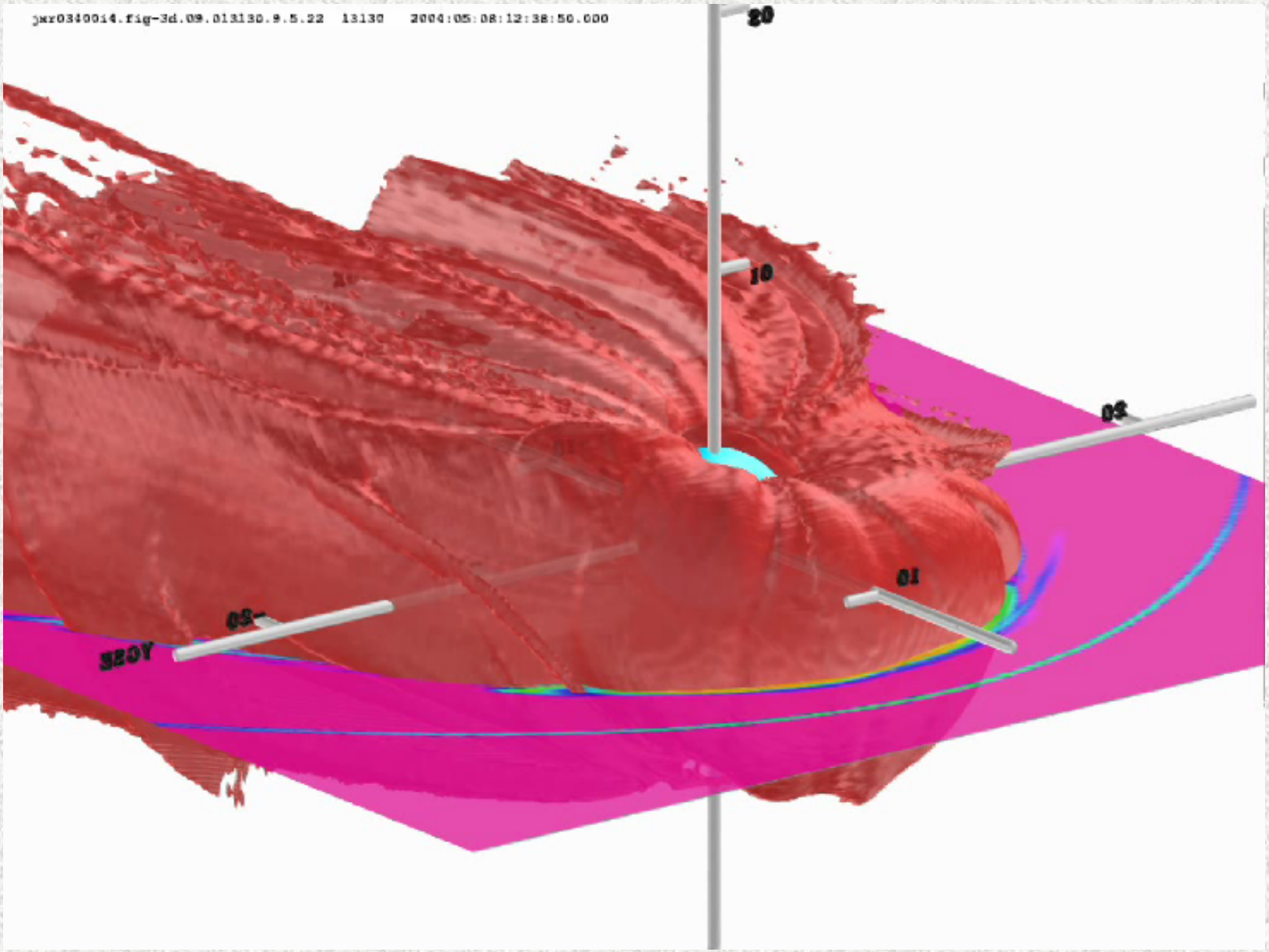


Fig. 6. Evolution of the magnetic field configuration and of the flow pattern in two-dimensional MHD simulations of the bursty single X line reconnection model [*Scholer*, 1989].

3D view of FTEs as they form

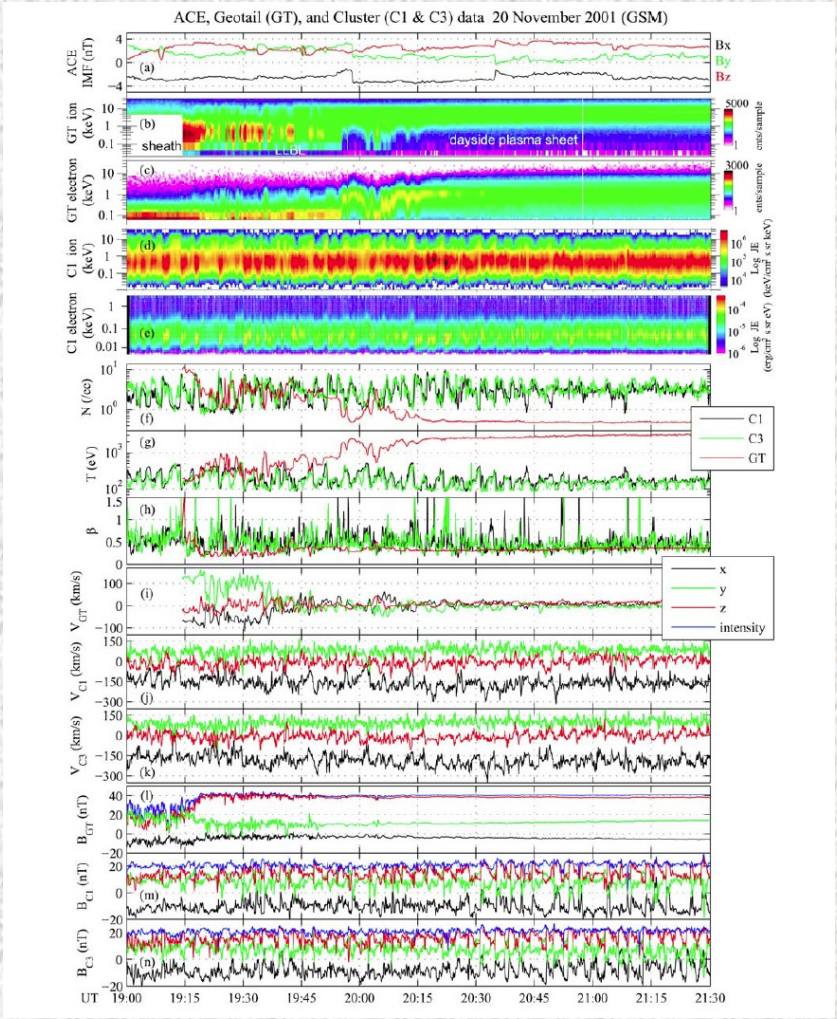


3D movie of FTEs as they form

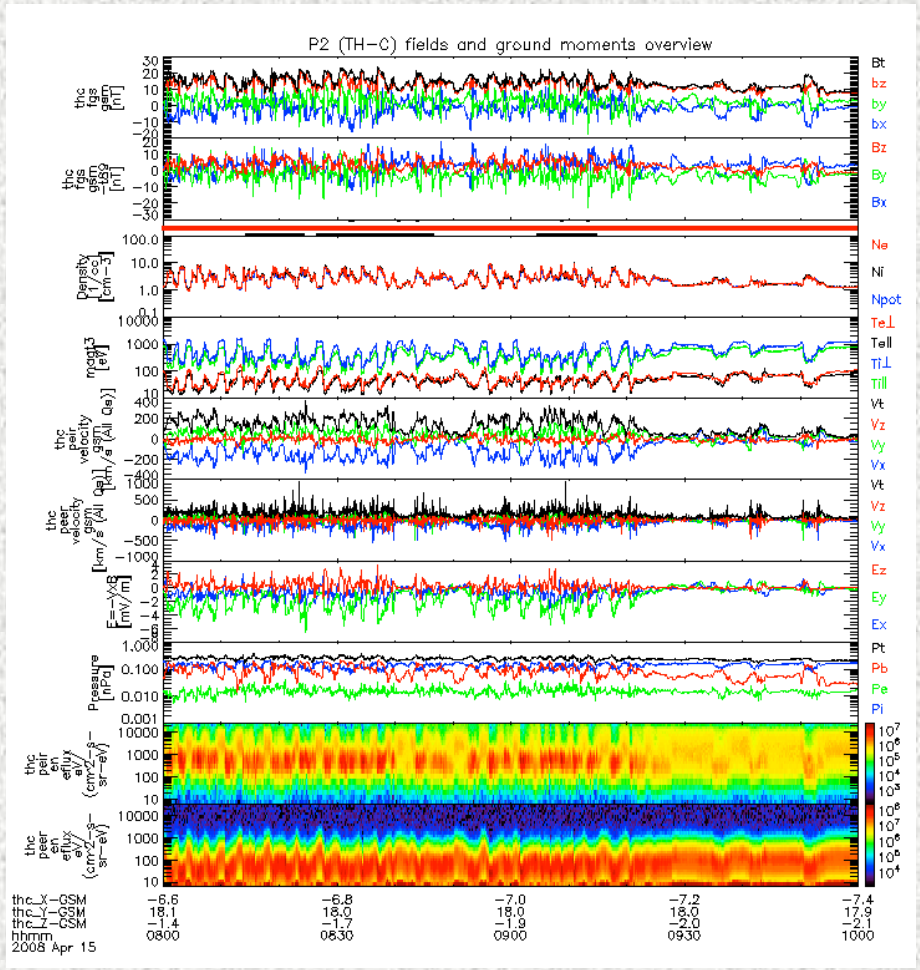


Kelvin-Helmholtz waves

- Usually observed at the flank magnetopause.
- Thought to occur only during NBZ and large SW speed.
- Observed often, but how often → Shiva's paper → 21% of all time.



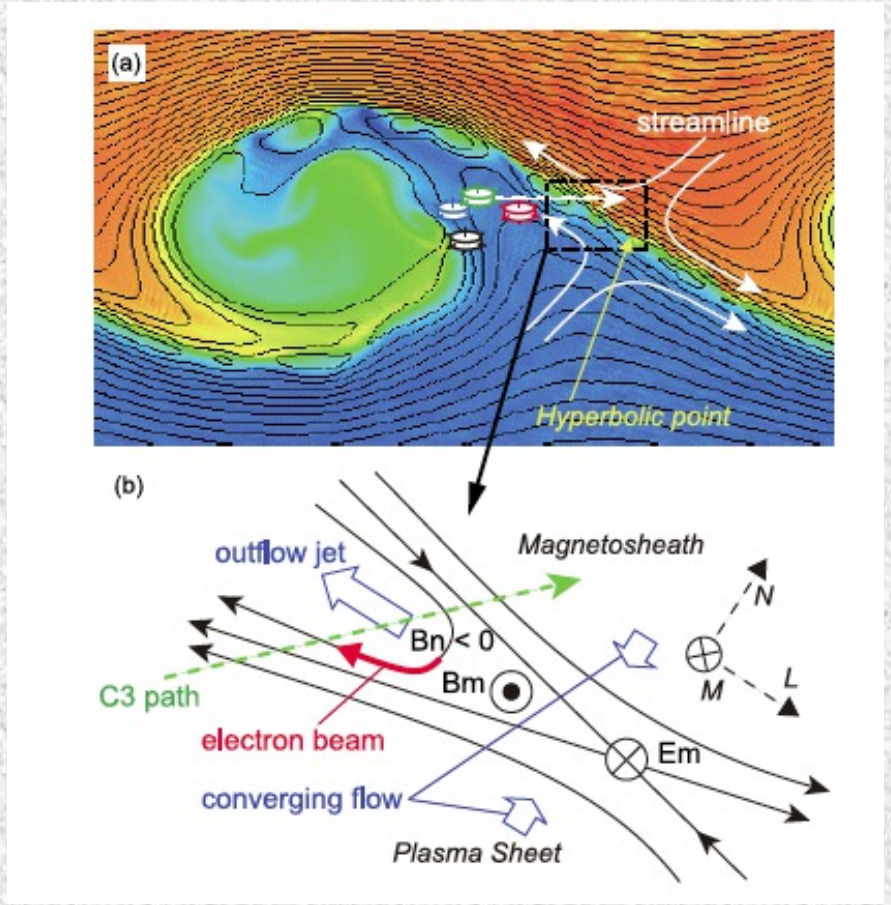
Cluster data, Hasegawa et al., 2009

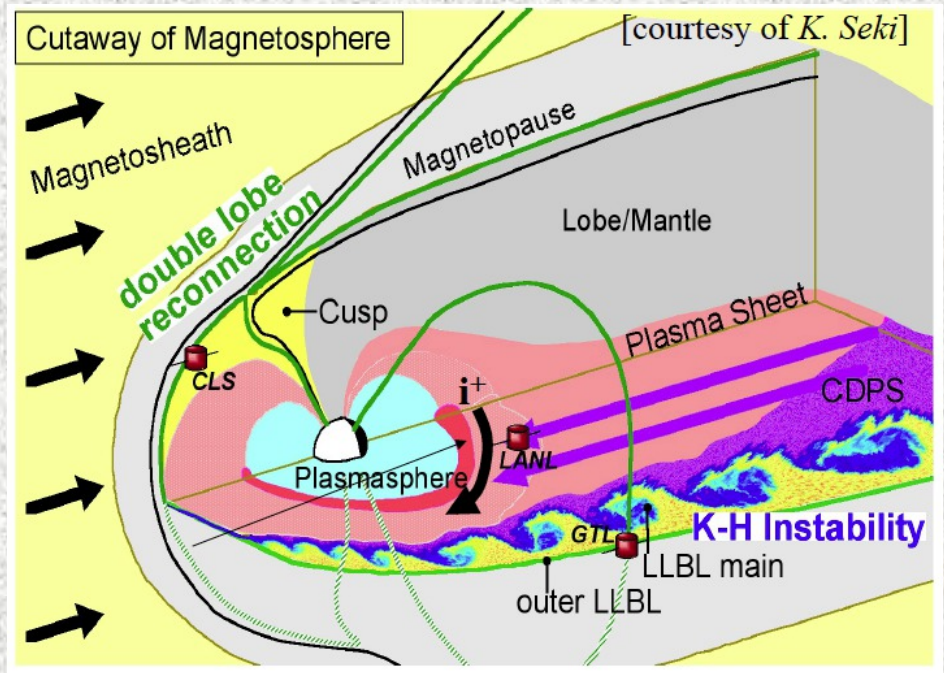


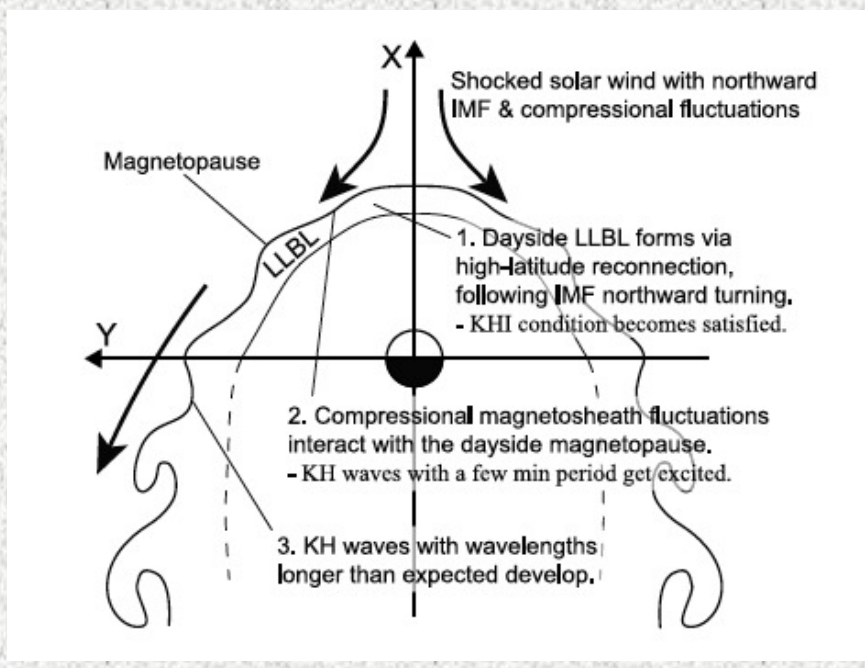
THEMIS-C, April 15, 2008 0800-1000 UT

Kelvin-Helmholtz waves

- Which leads to schematics …..

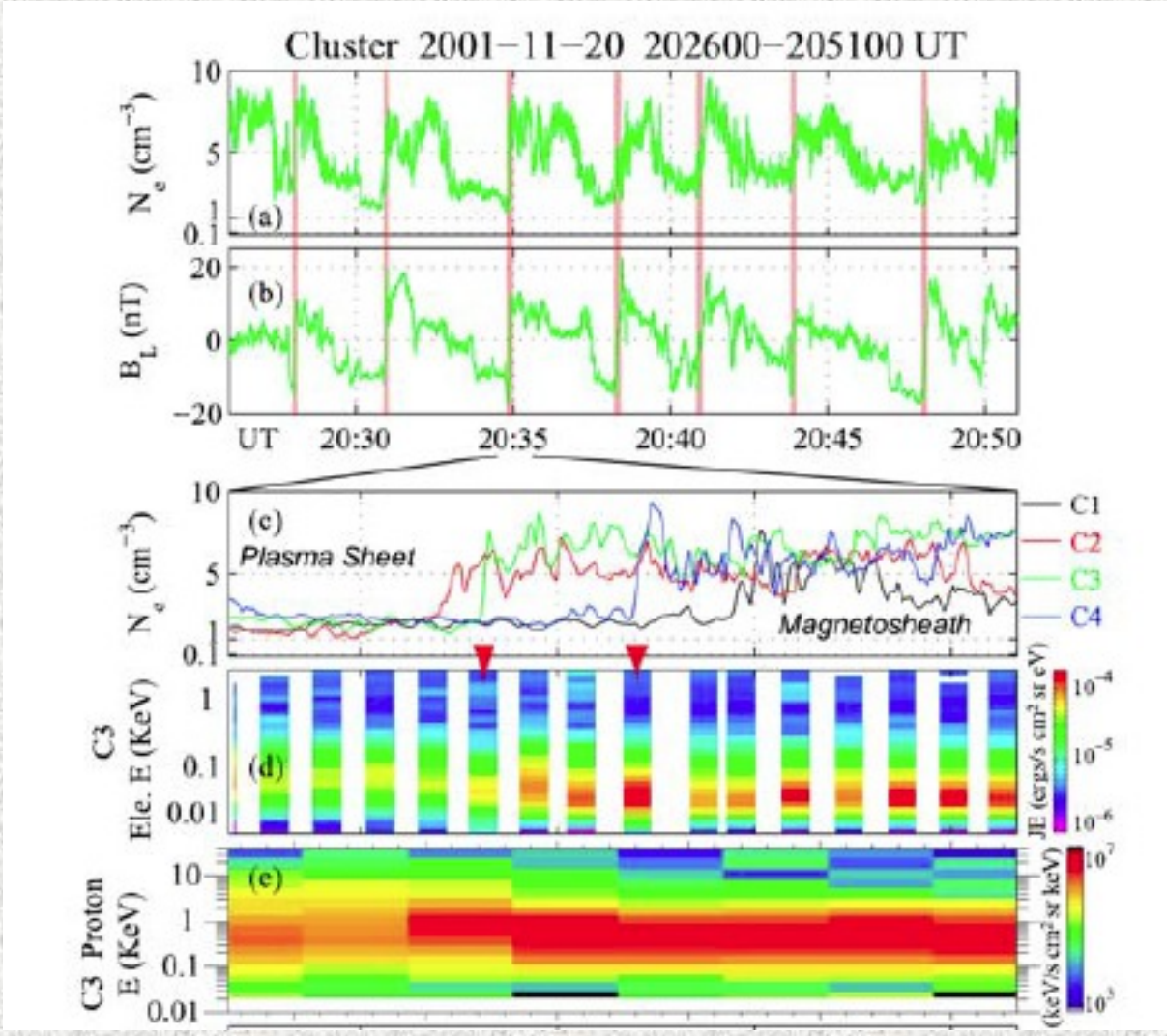






Kelvin-Helmholtz waves: more detail

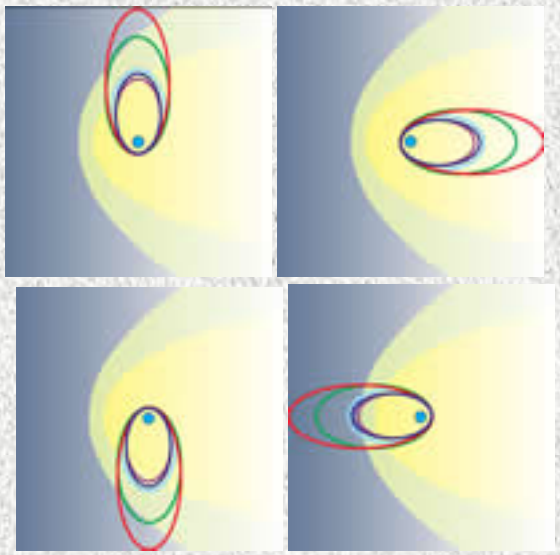
- Sawtooth signature not too different from FTEs.
- Period usually smaller (2m) versus FTEs (5min).

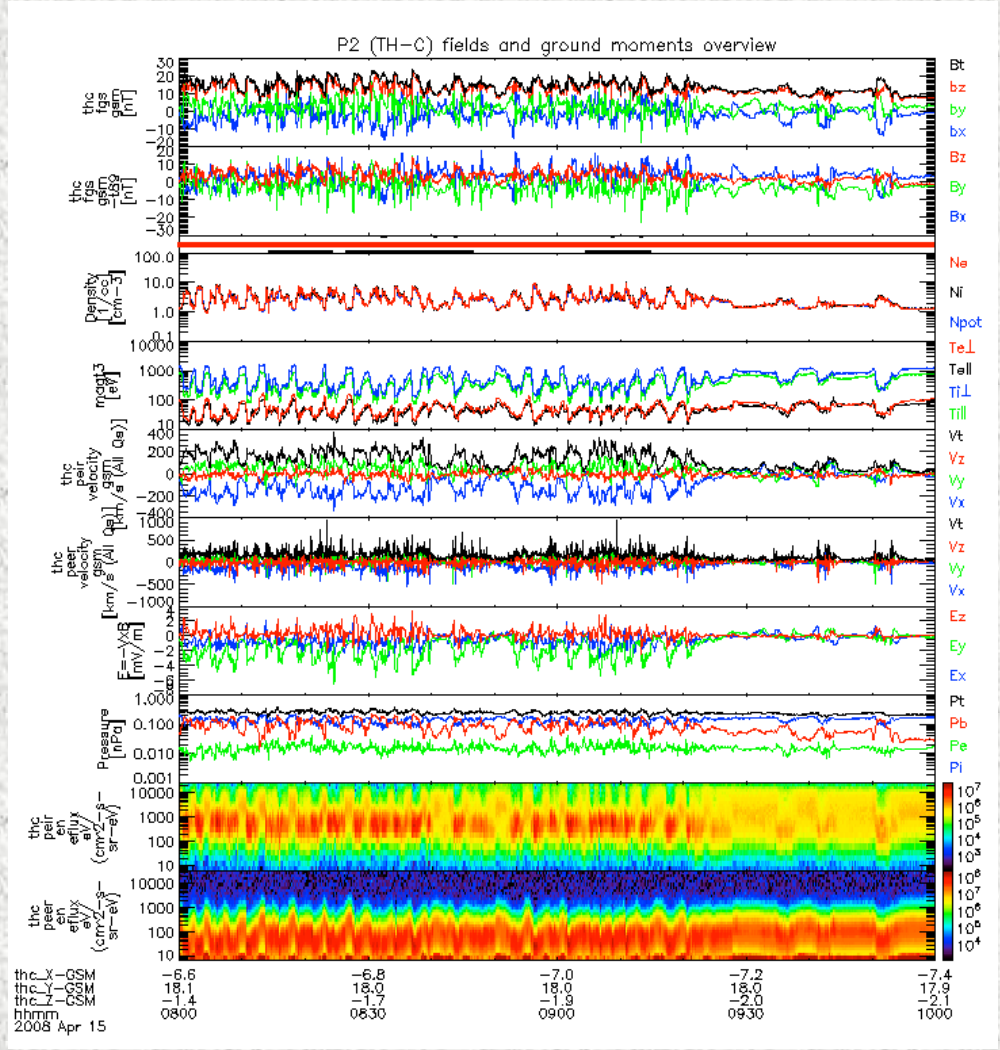


Cluster data, Hasegawa et al., 2009

THEMIS observations of Kelvin-Helmholtz waves

- THEMIS orbits are ideal to observe flank magnetopause.
- THEMIS observes “wavy structures” during ~50% of MP crossings. Lately we determined ~21% are KH waves.
- Some periodic structures may be FTEs, some may be directly driven by the SW of foreshock waves, but most are KH.

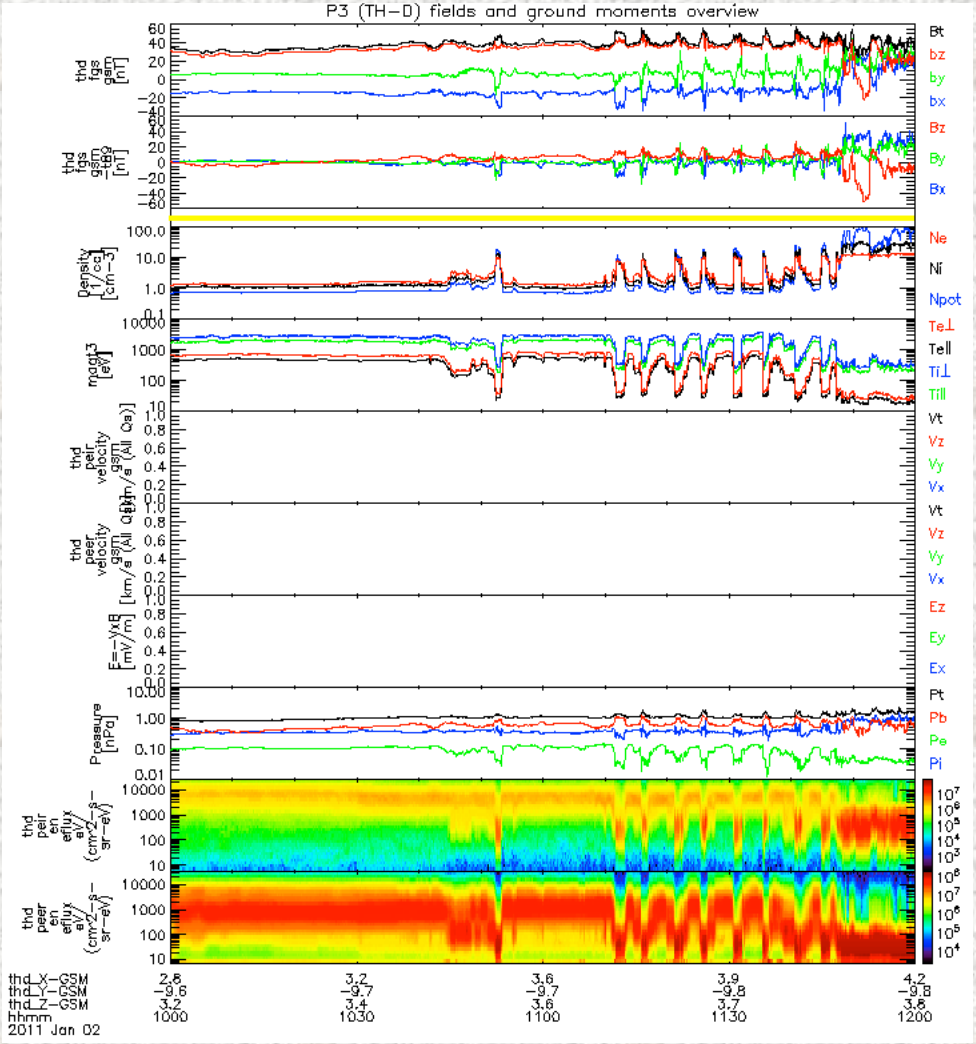




THEMIS-C, April 15, 2008 0800-1000 UT

Kelvin-Helmholtz or Flux Transfer Events?

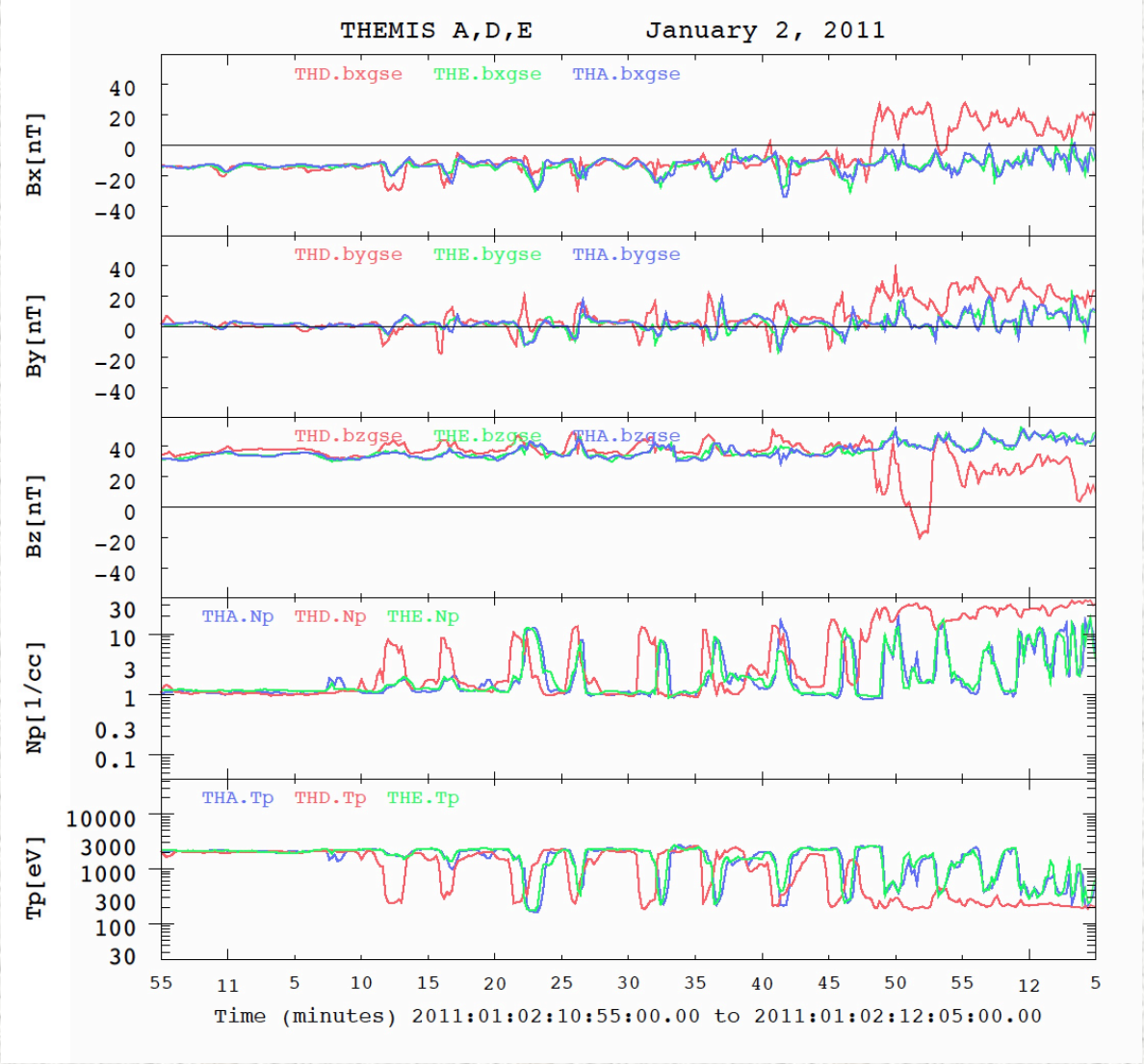
- Sometimes periodic structures at flank MP have FTE signatures.
- Strong bipolar BN signatures and enhanced core field, but bipolar B_N separated by zero B_N intervals.
- FTEs possibly trigger KH.



THEMIS-D, January 2, 2011 1000-1200 UT

Kelvin-Helmholtz or Flux Transfer Events?

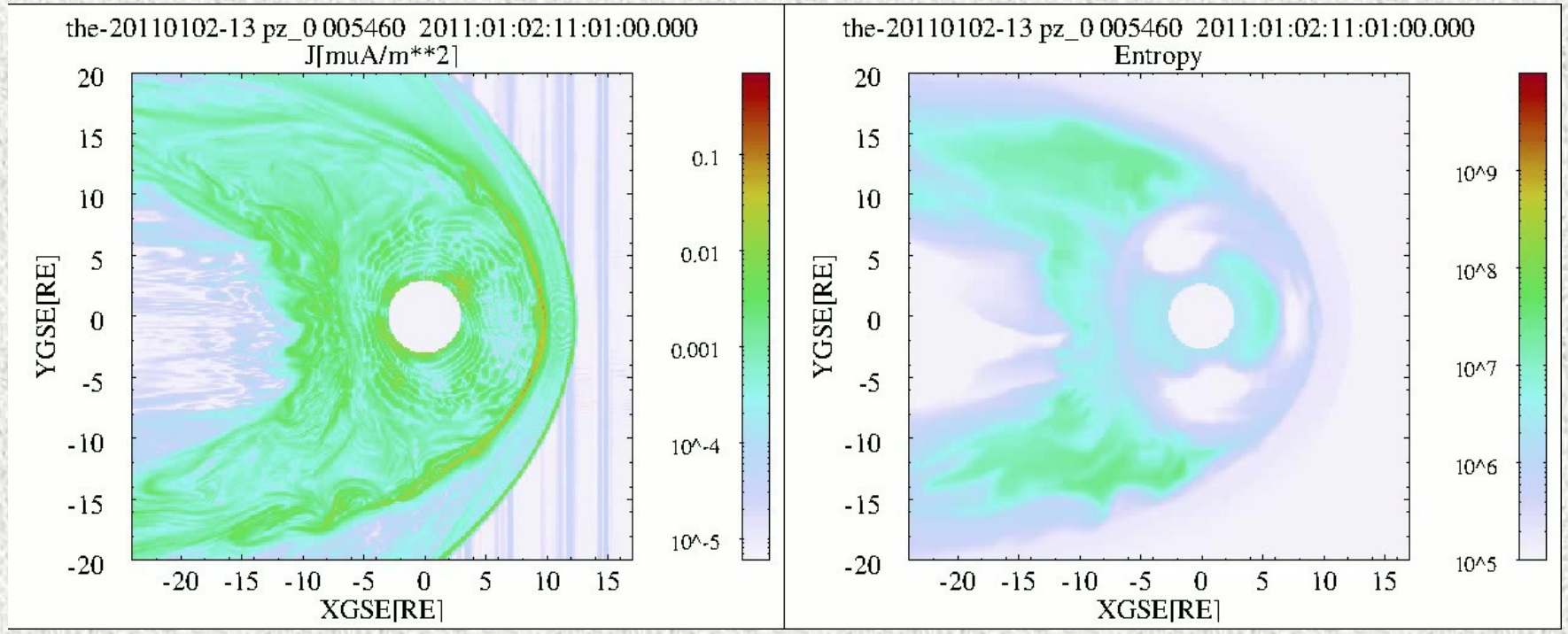
- Sometimes periodic structures at flank MP have FTE signatures.
- Strong bipolar BN signatures and enhanced core field, but bipolar B_N separated by zero B_N intervals.
- Can FTEs possibly trigger KH?



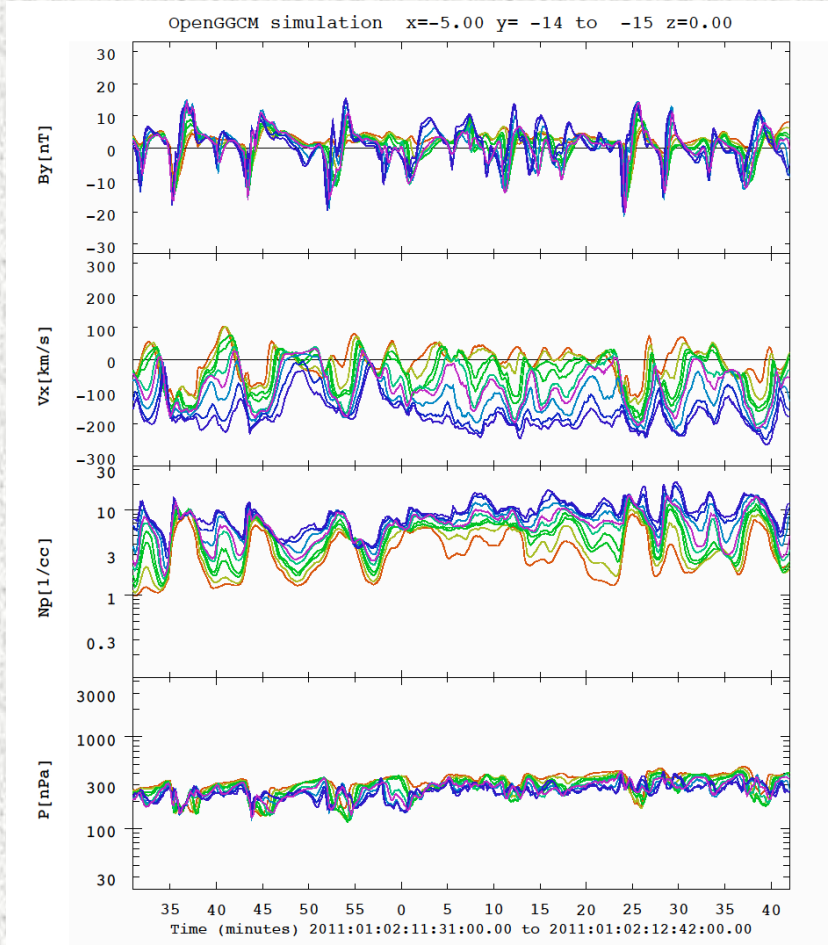
THEMIS-D, January 2, 2011 1000-1200 UT

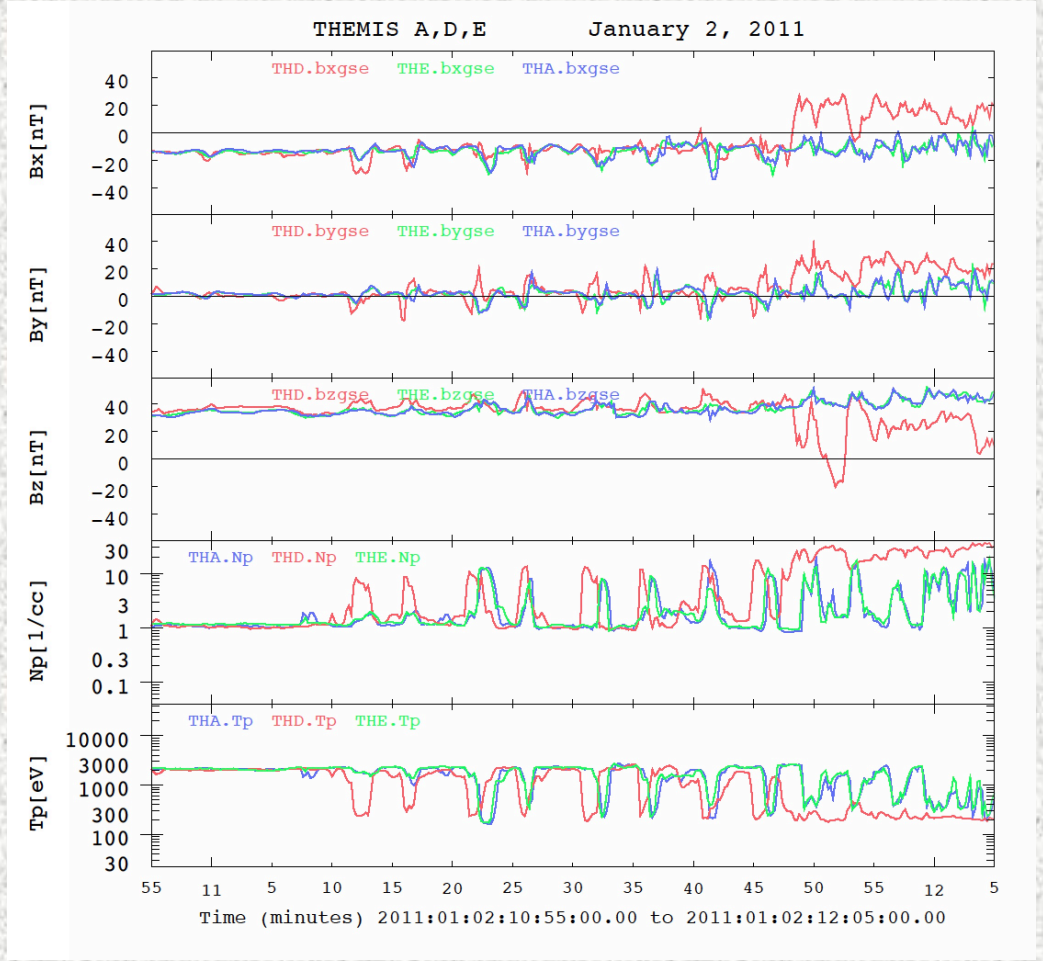
FTEs triggering KH?

- OpenGGCM simulation shows structures first at nose of MP.
- As they move along flank, they turn into large amplitude waves
- Entropy shows waves clearly.

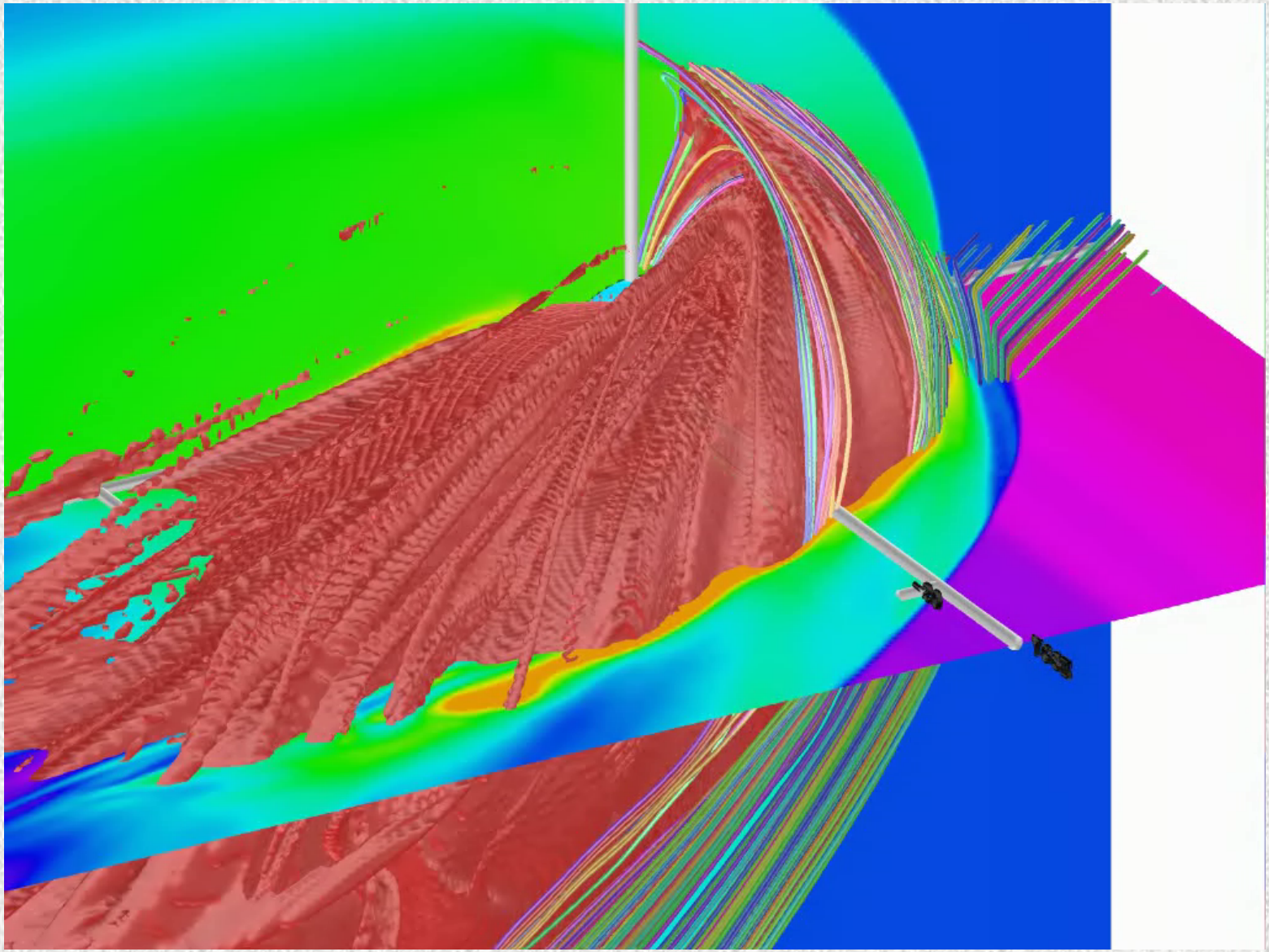


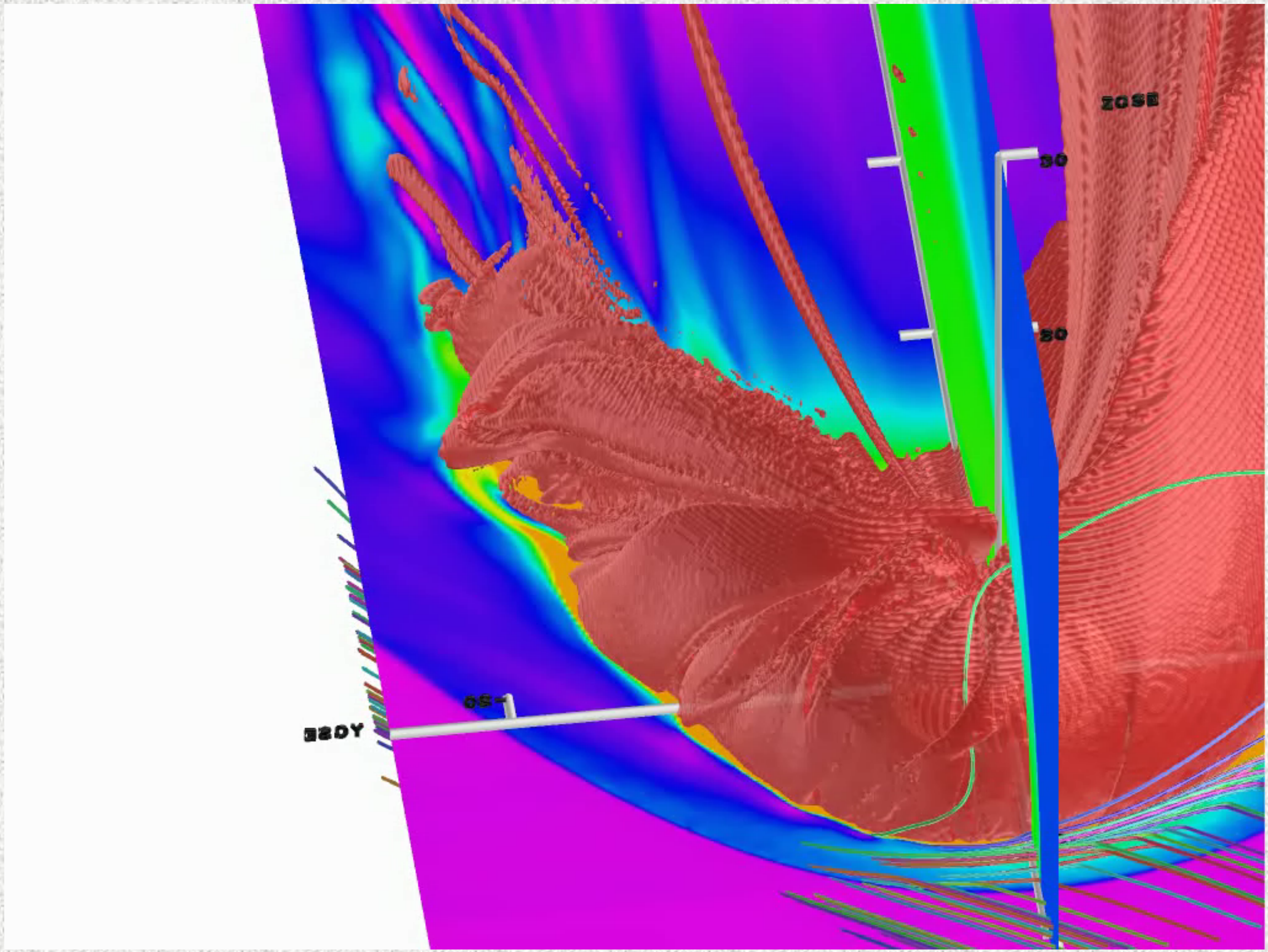
Model-Data Comparison





FTEs triggering KH?





Summary and Conclusions

- THEMIS observations and OpenGGCM simulations show evidence of FTEs triggering KH waves.
- FTEs become wrapped up in breaking KH wave vortices → sheath plasma enters the magnetosphere.
- Observations of reconnection signatures in KH vortices may not (as previously thought) indicating reconnection within the vortices (difficult to explain anyways), but the signature of a “captured” FTE.
- FTE capture may be an effective plasma entry mechanism, in particular if the FTE flux is already closed.