CLUSTER

Cluster–Double Star–THEMIS

Science Coordination

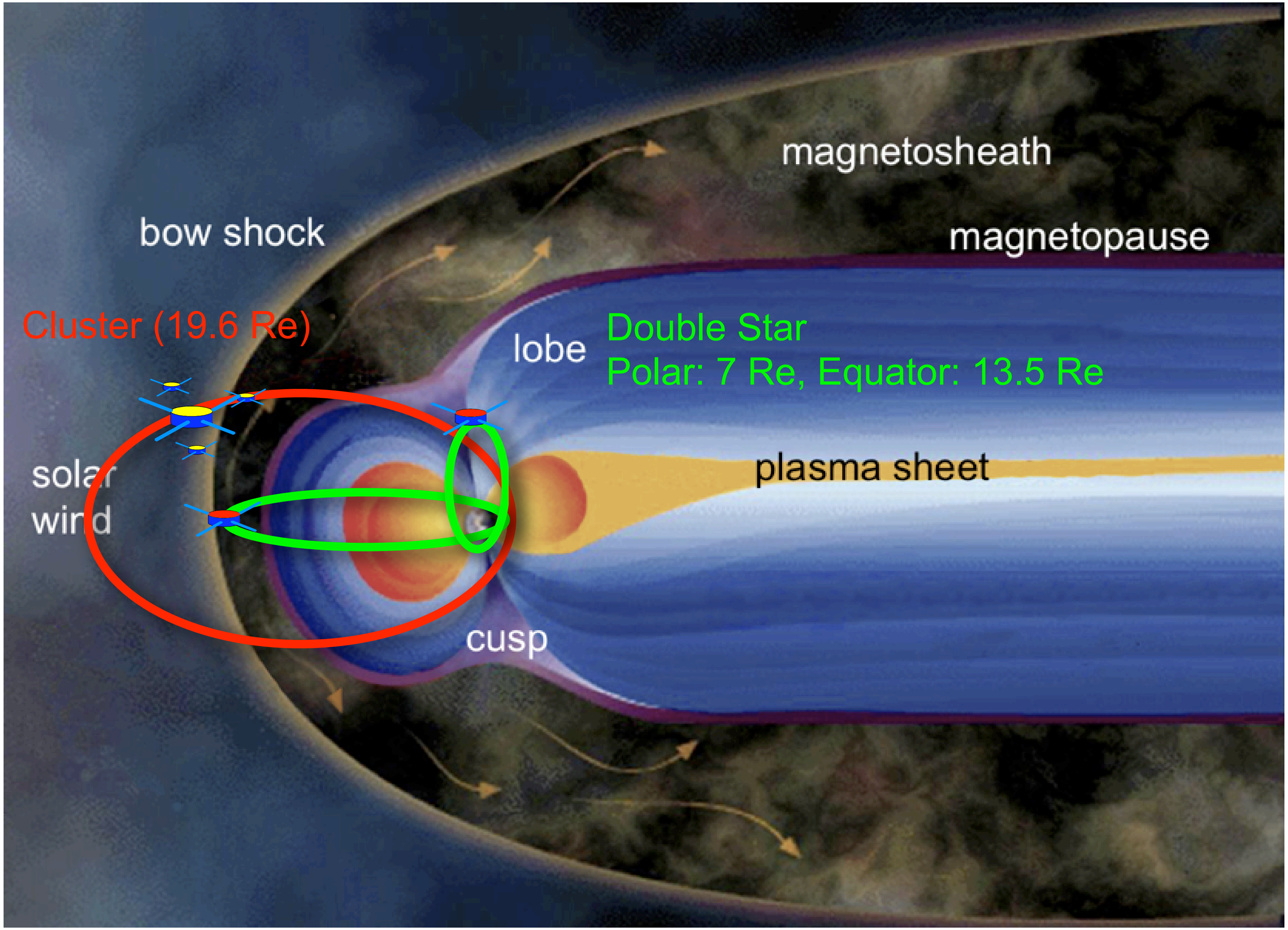
C.P. Escoubet[1], M. Hapgood[2], M.L. Goldstein[3], and M.G.G.T. Taylor[1],

[1]ESA/ESTEC (NL), [2]RAL (UK), [3]GSFC (USA),

- Some Cluster results (relevant to THEMIS objectives)
- Cluster–Double Star–THEMIS coordination
  - a few orbital conjunctions

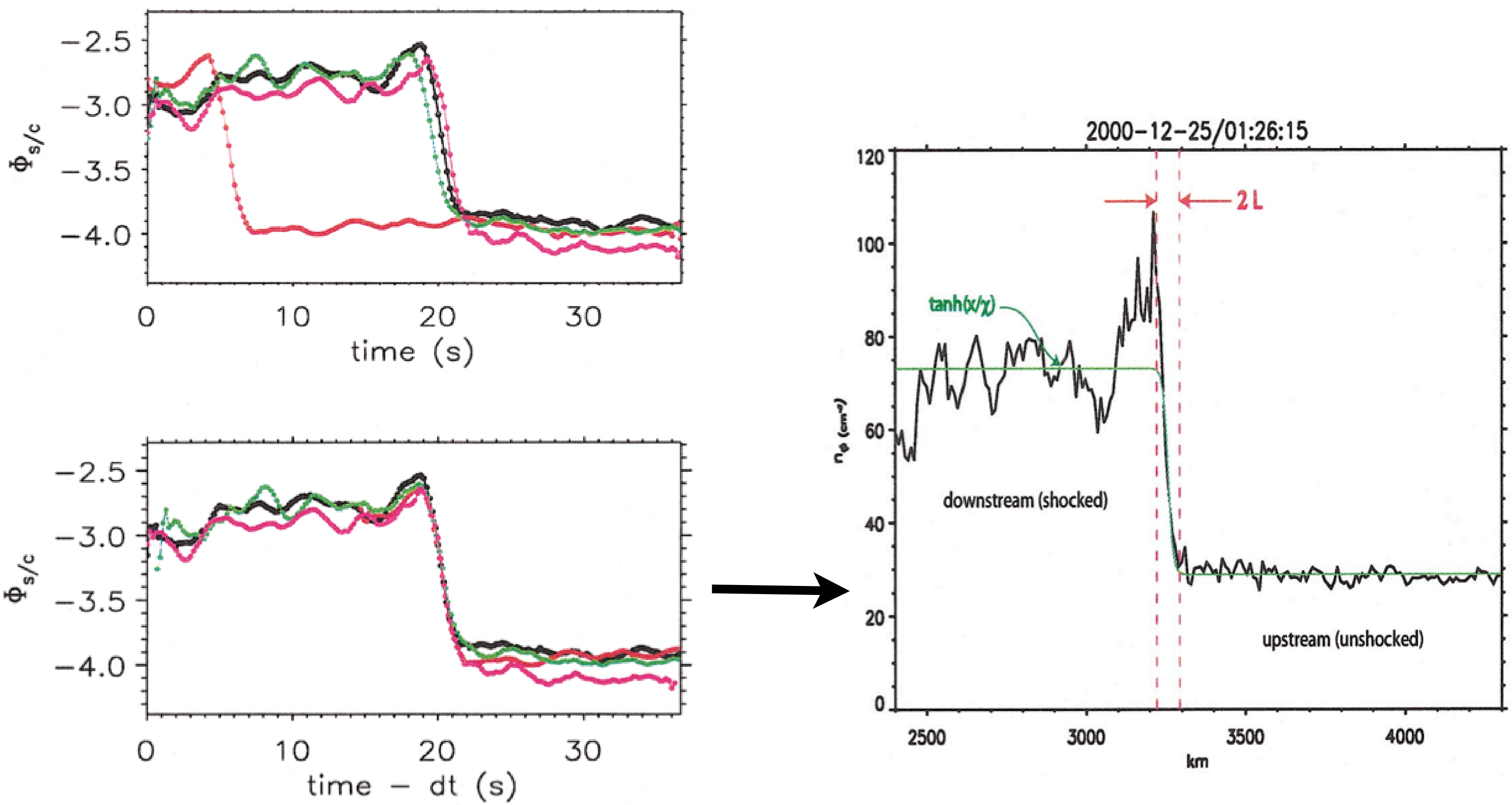
CLUSTER

Cluster–Double Star orbits, dayside



CLUSTER

Bow shock thickness using 4 s/c

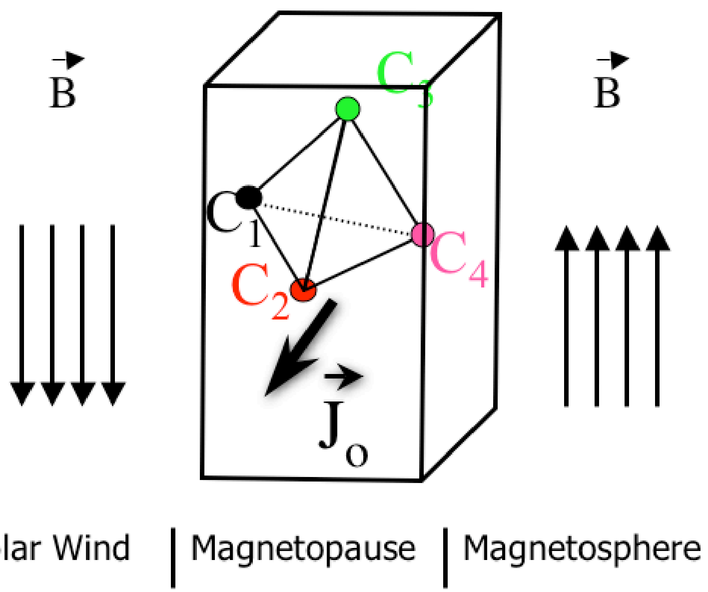


- bow shock thickness proportional to downstream ion gyroradius

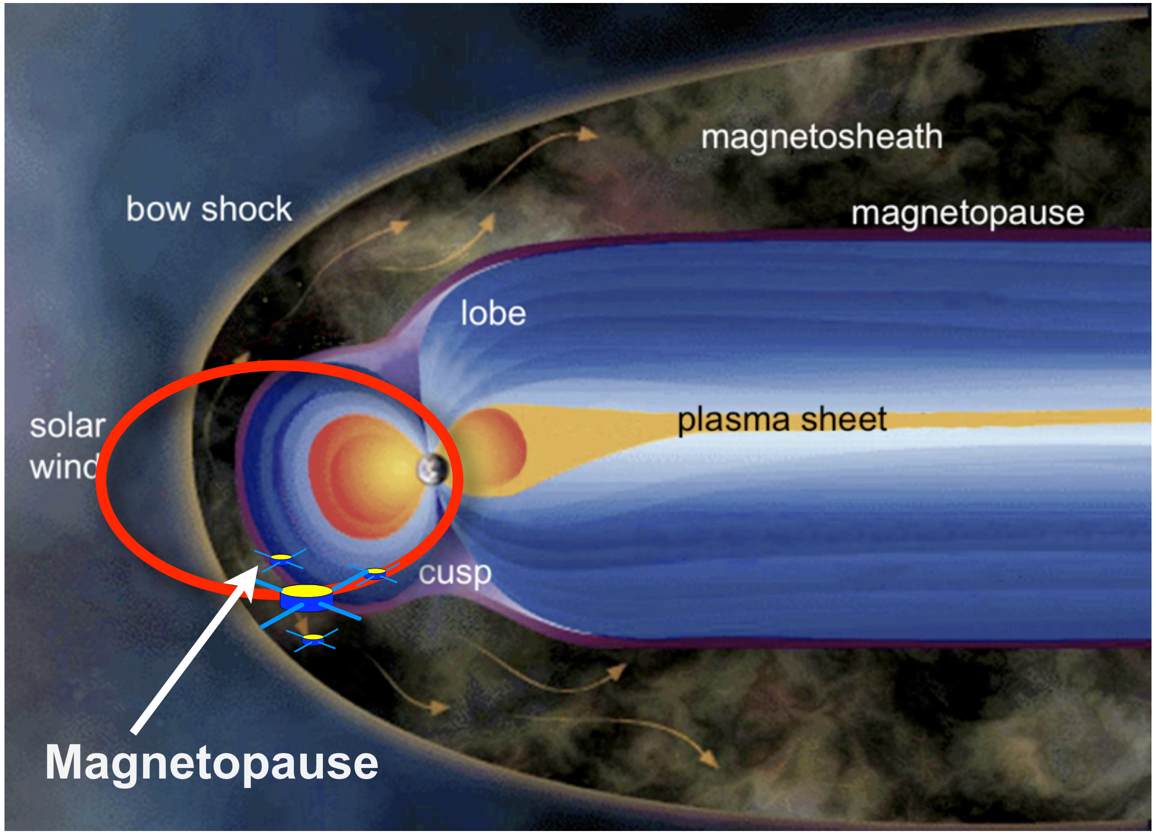
[Bale et al., 2003]

CLUSTER

Chapman-Ferraro Current

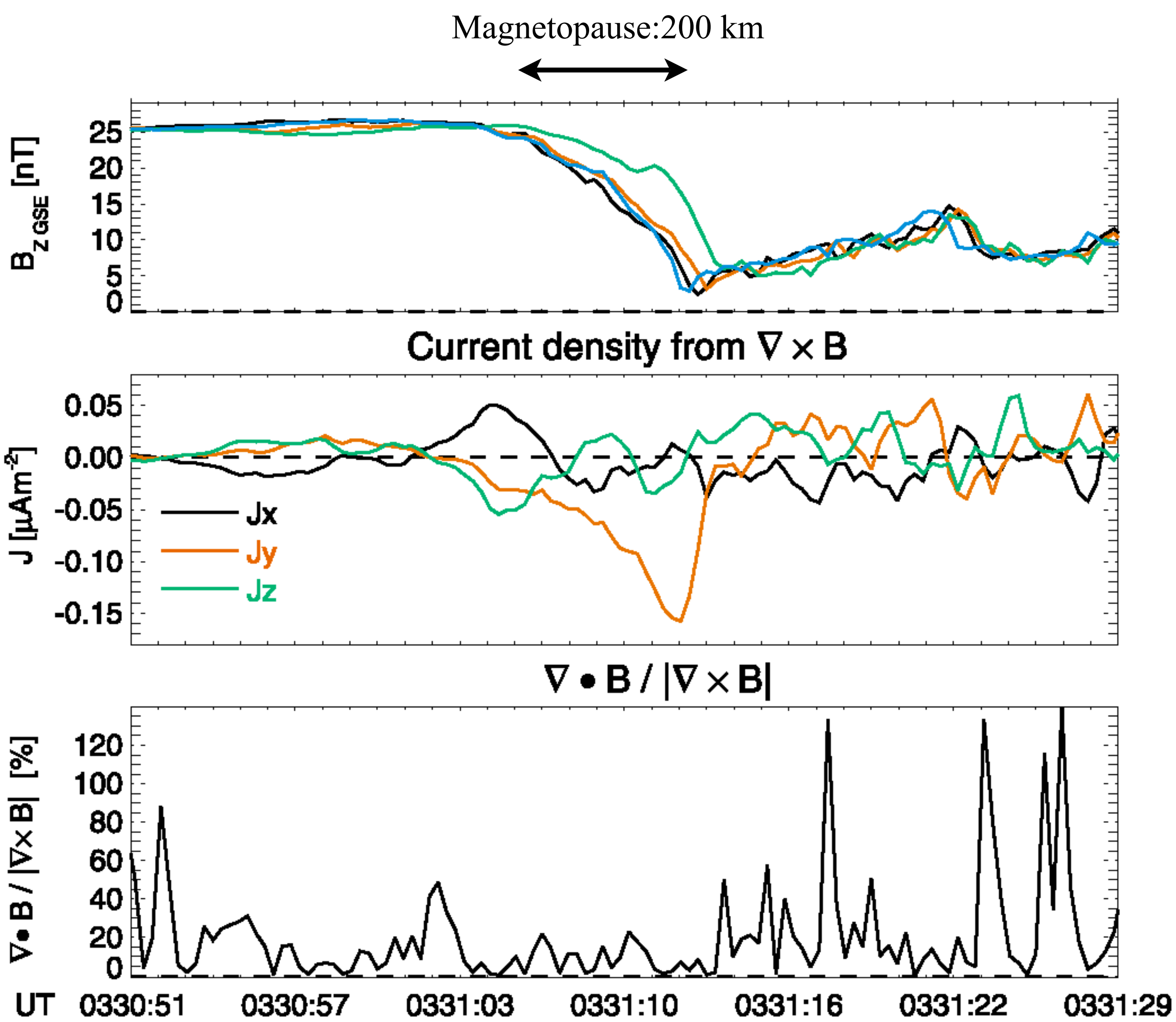


Current is given by $\vec{J}_o = \text{curl } \vec{B}$



CLUSTER

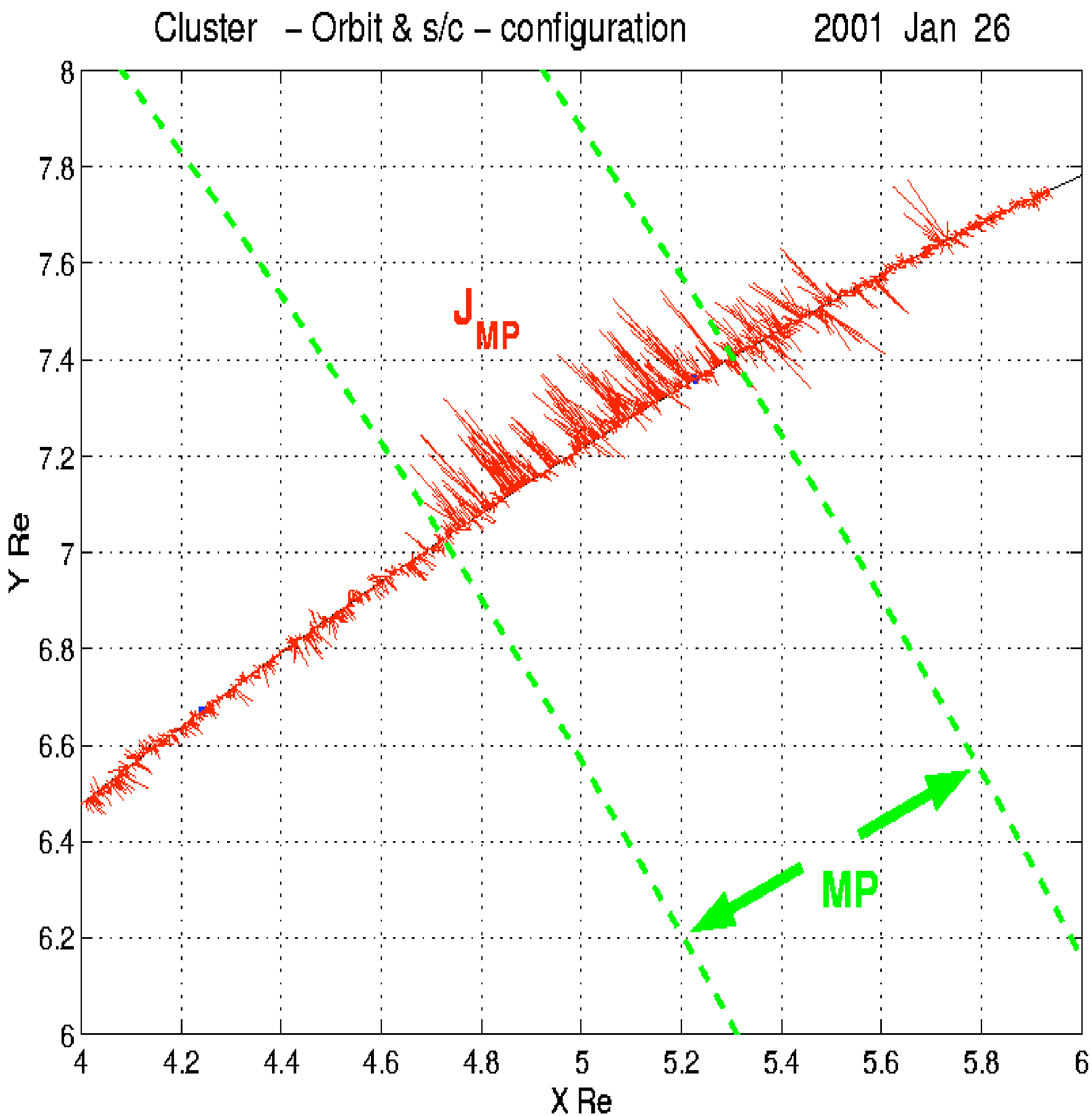
Magnetopause current density with 4 s/c



- Magnetopause Thickness and current
  - s/c separation 100 km
  - all s/c inside current sheet
  - J=0.15 uAm-2

[Haaland et al., 2004]

CLUSTER

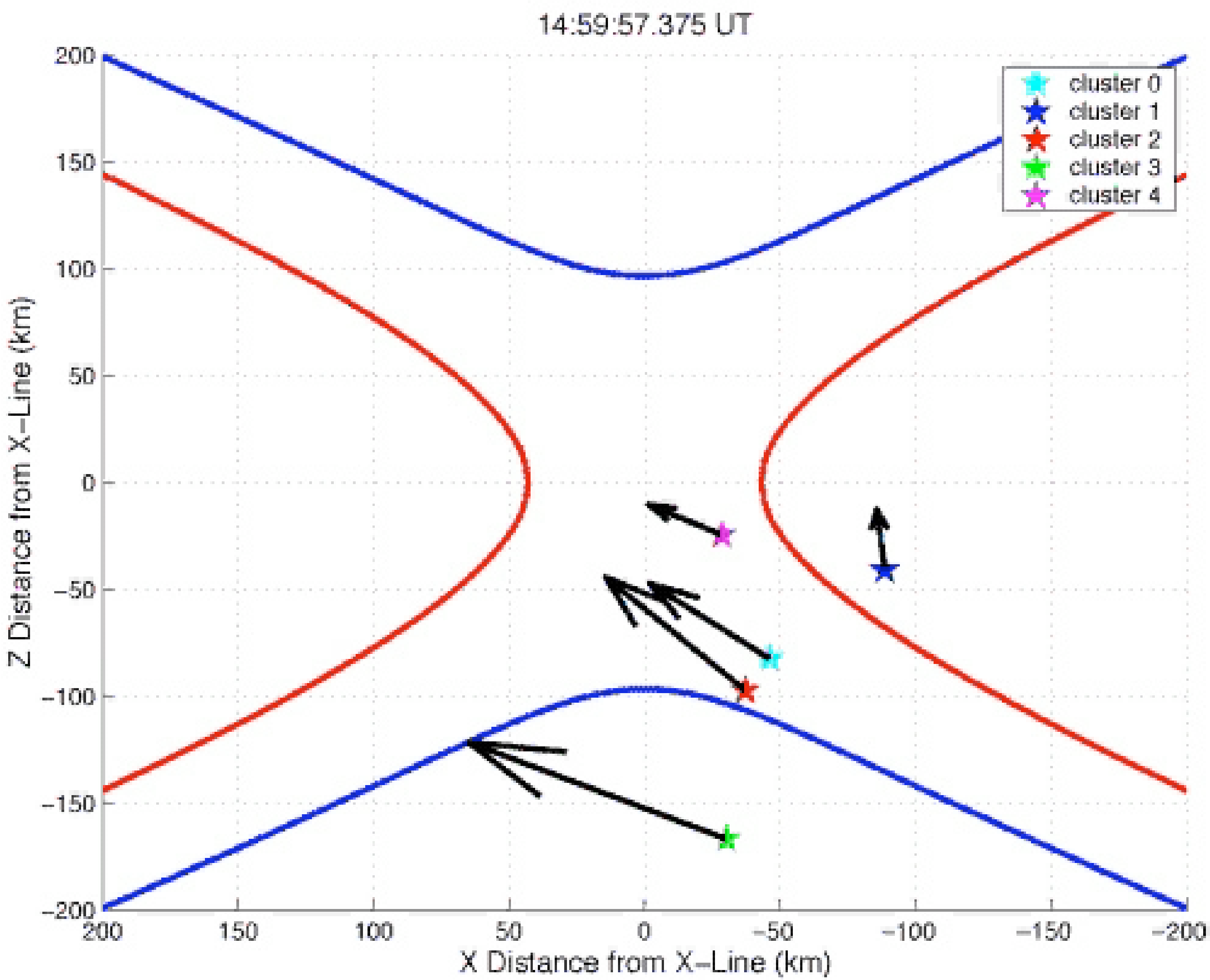


- Current vector plotted along s/c trajectory
- Magnetopause current variability due to magnetopause motion
- Current vector aligned with magnetopause model

[Dunlop et al., 2002]

CLUSTER

Reconnection observed in B direction

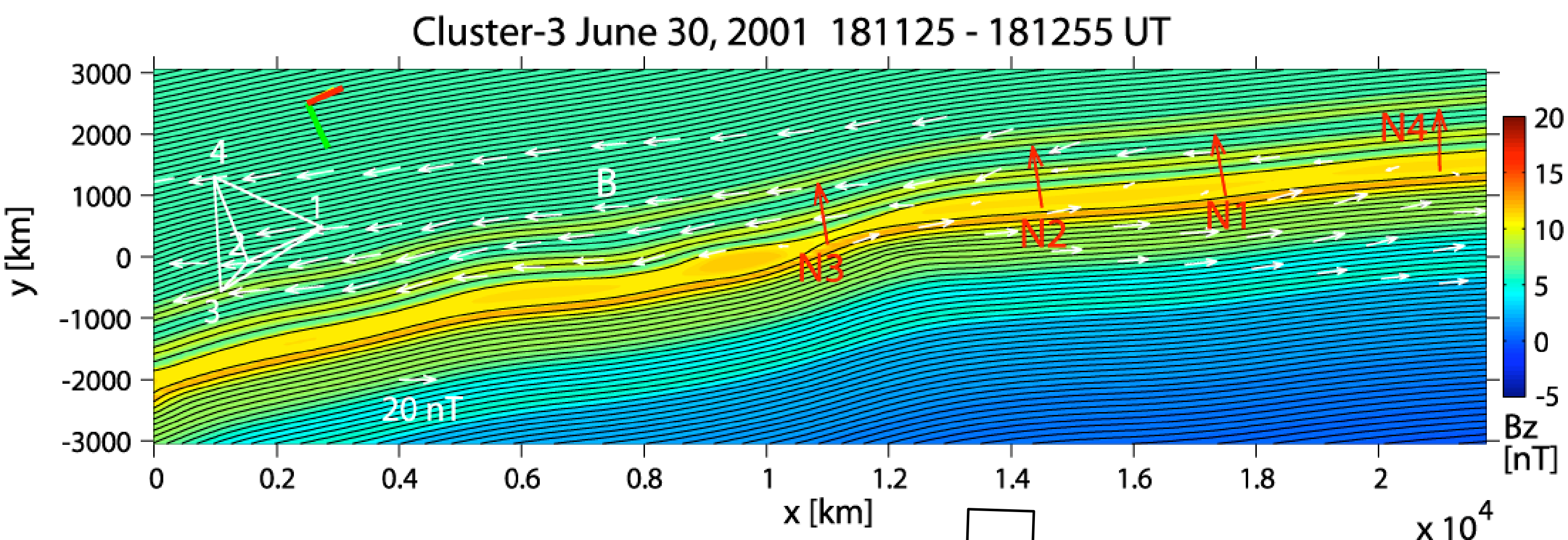


18 March 2002

- Spacecraft separation: 100km
- Cluster 2 (red): closest approach at 1 km from X line
- Cluster 4: 3.5 km from X line

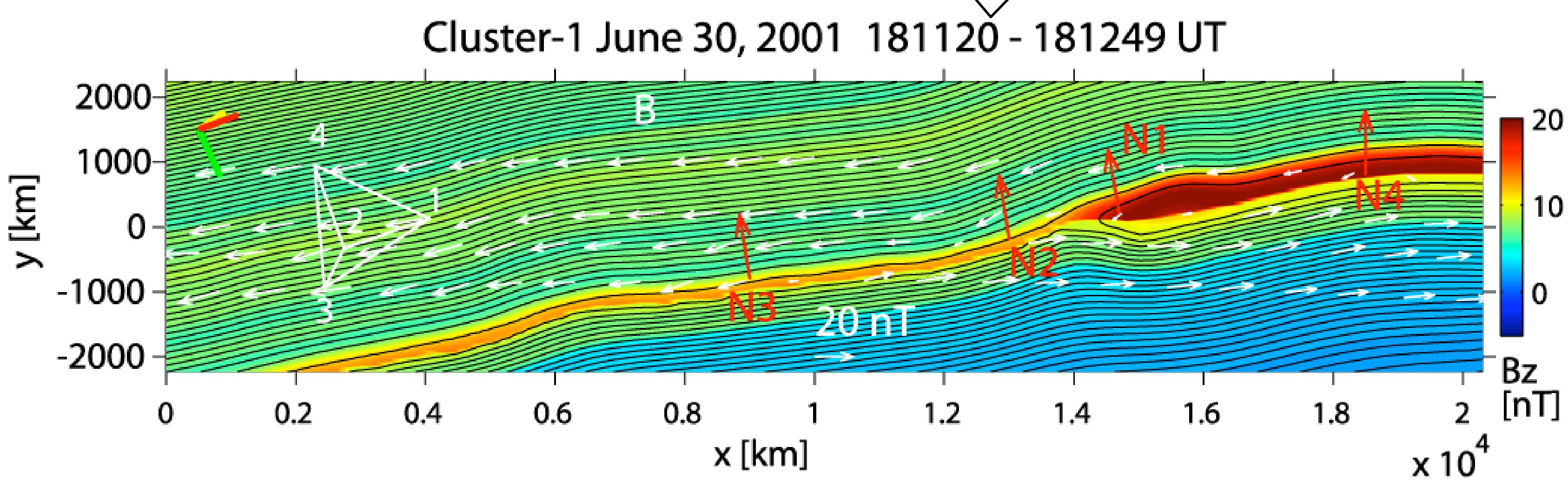
[Wendel and Reiff, 2006]

CLUSTER



20 s

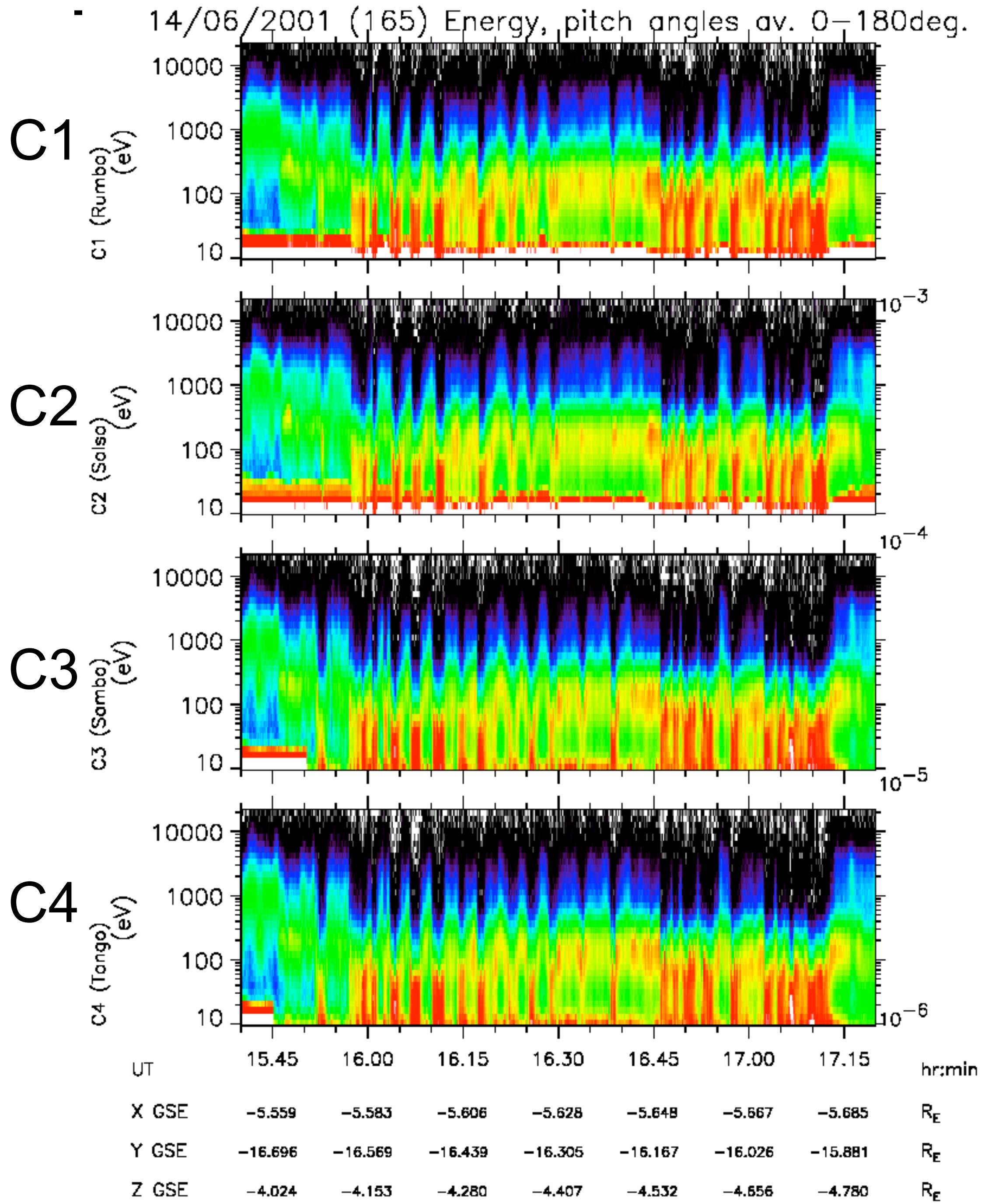
Reconnection onset

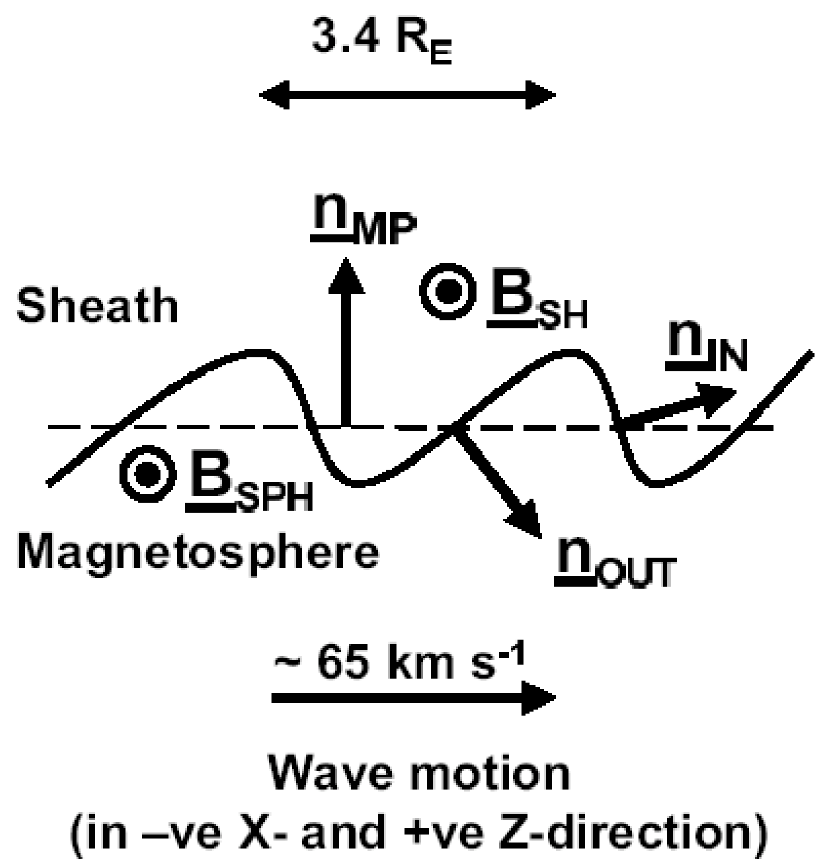


[Hasegawa and Sonnerup, 2003]

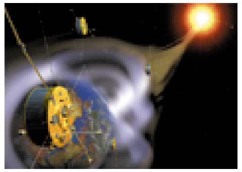
CLUSTER

Kelvin-Helmholtz waves

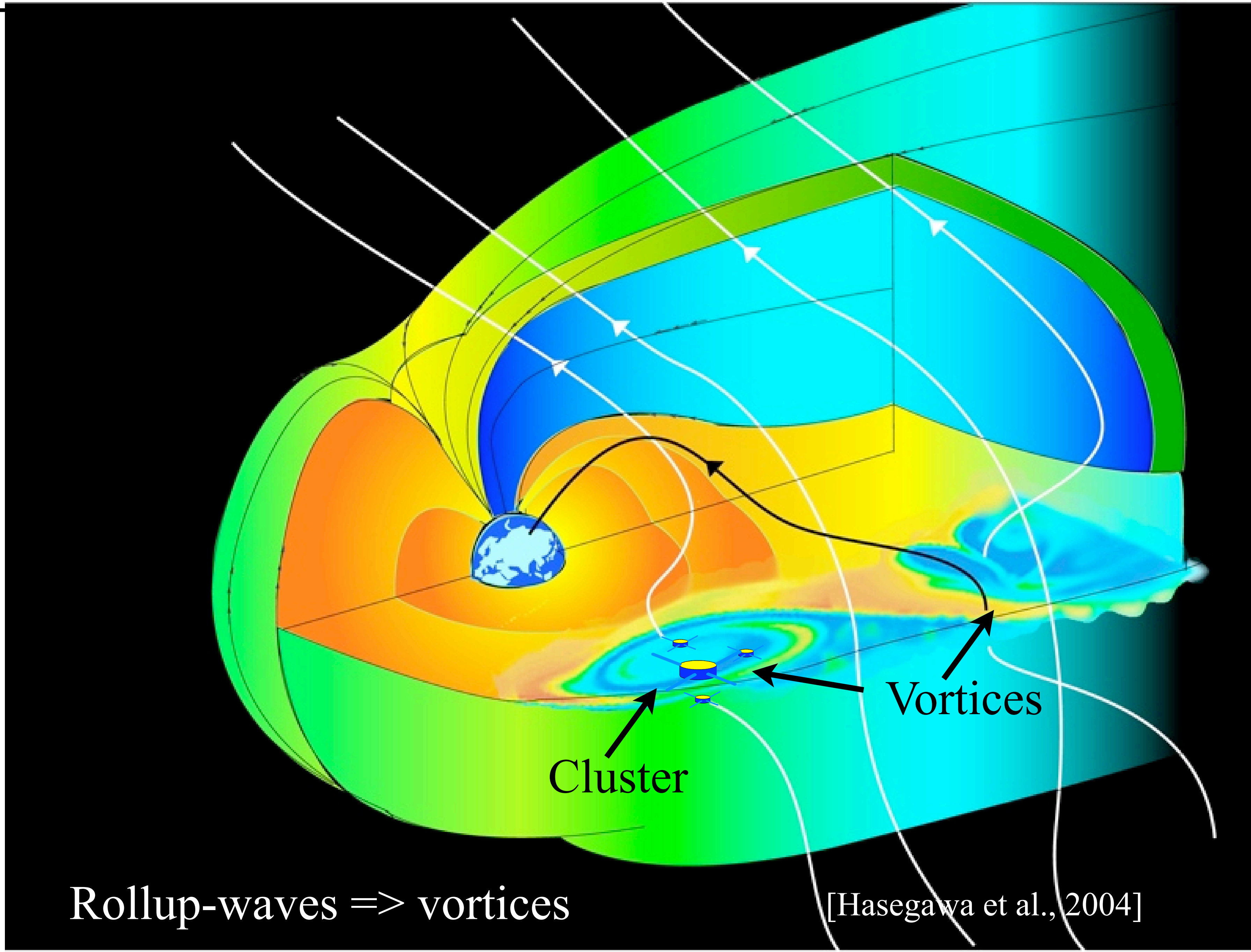


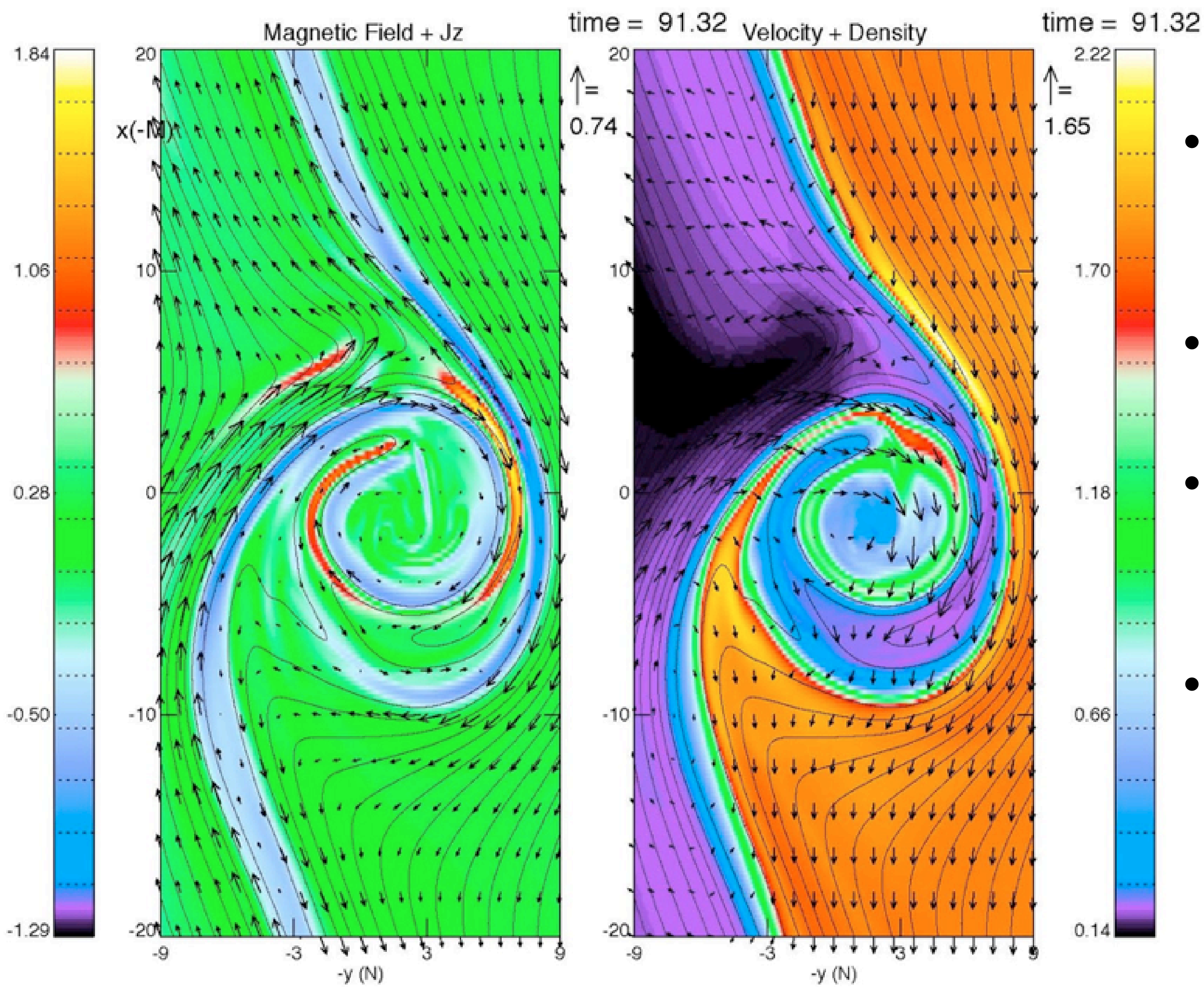


[Owen et al., 2003]



CLUSTER

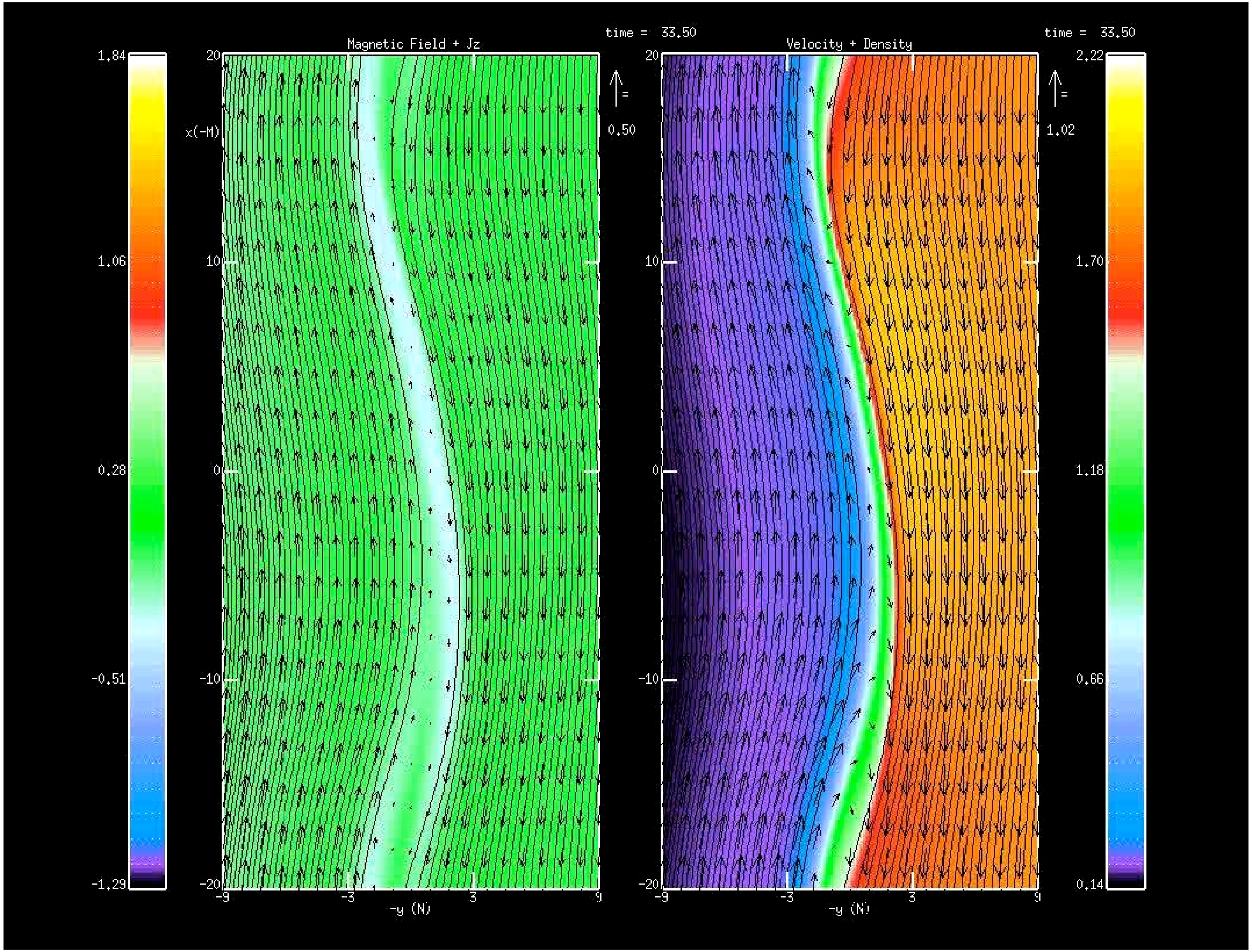

Vortices
Cluster
Rollup-waves => vortices
[Hasegawa et al., 2004]



- MHD simulation of Kelvin-Helmholtz vortices
- Reconnection taking place inside vortices
- Also observed on Cluster CIS data (Walen test)
- wave length ~ 6Re

[Nykyri et al., 2006]

CLUSTER



[Nykyri et al., 2006]

CLUSTER

esa

Magnetic Null

- (C.J. Xiao *et al.*, Nature Physics, 2 July 2006)

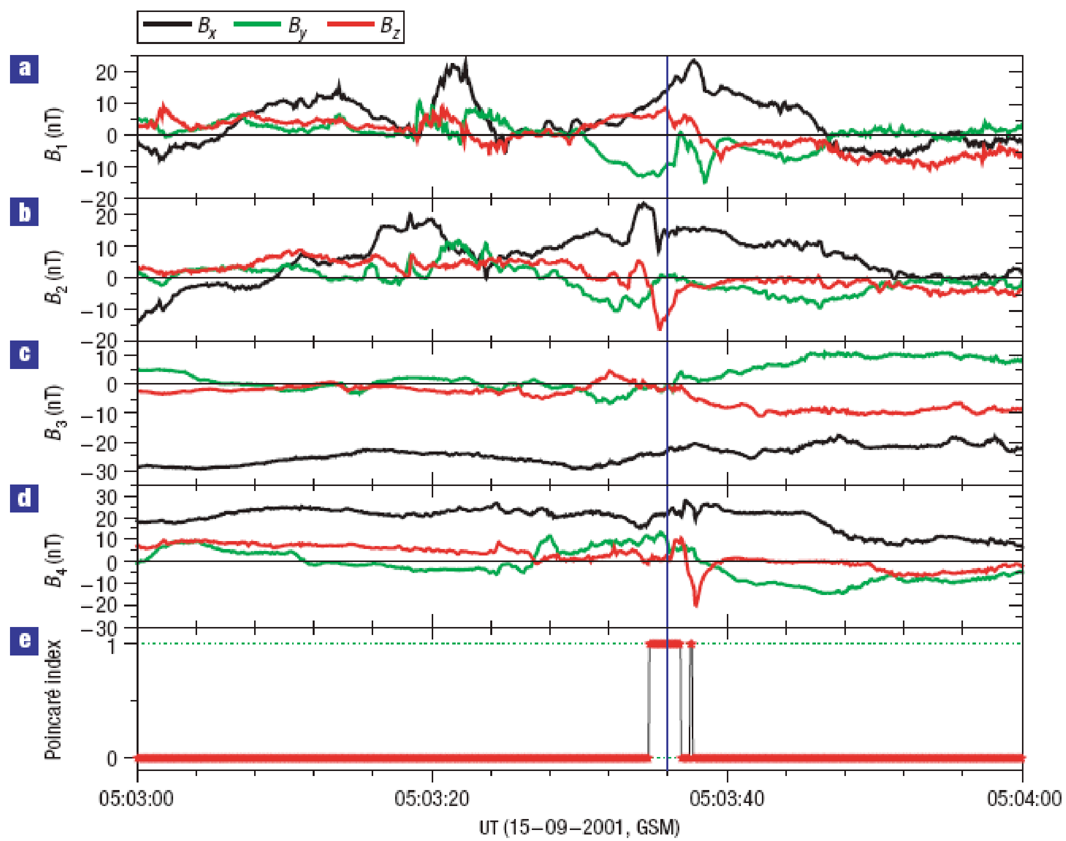
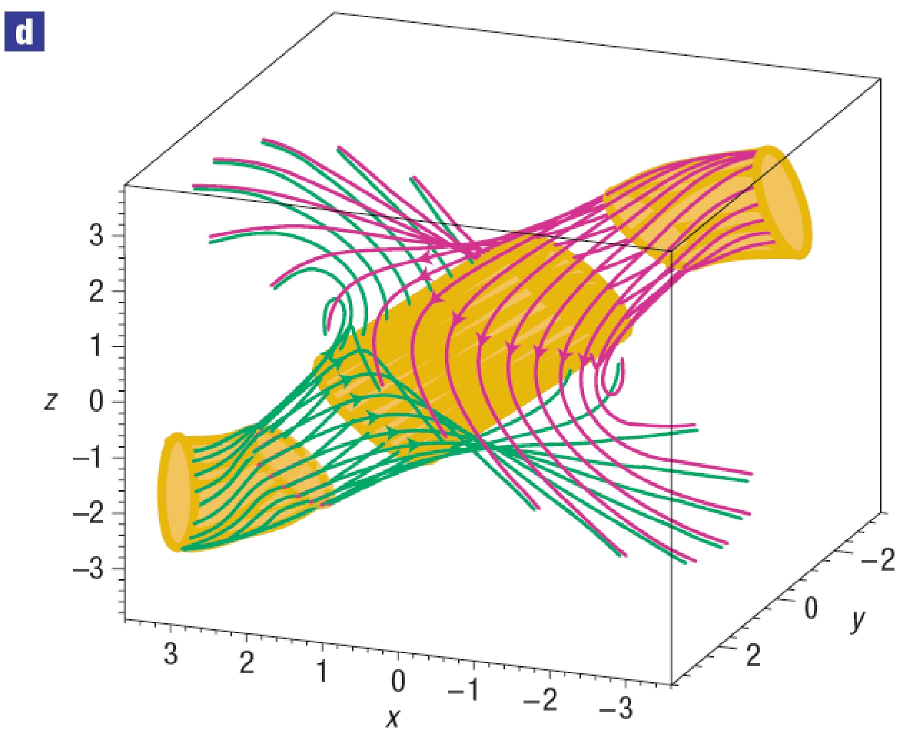


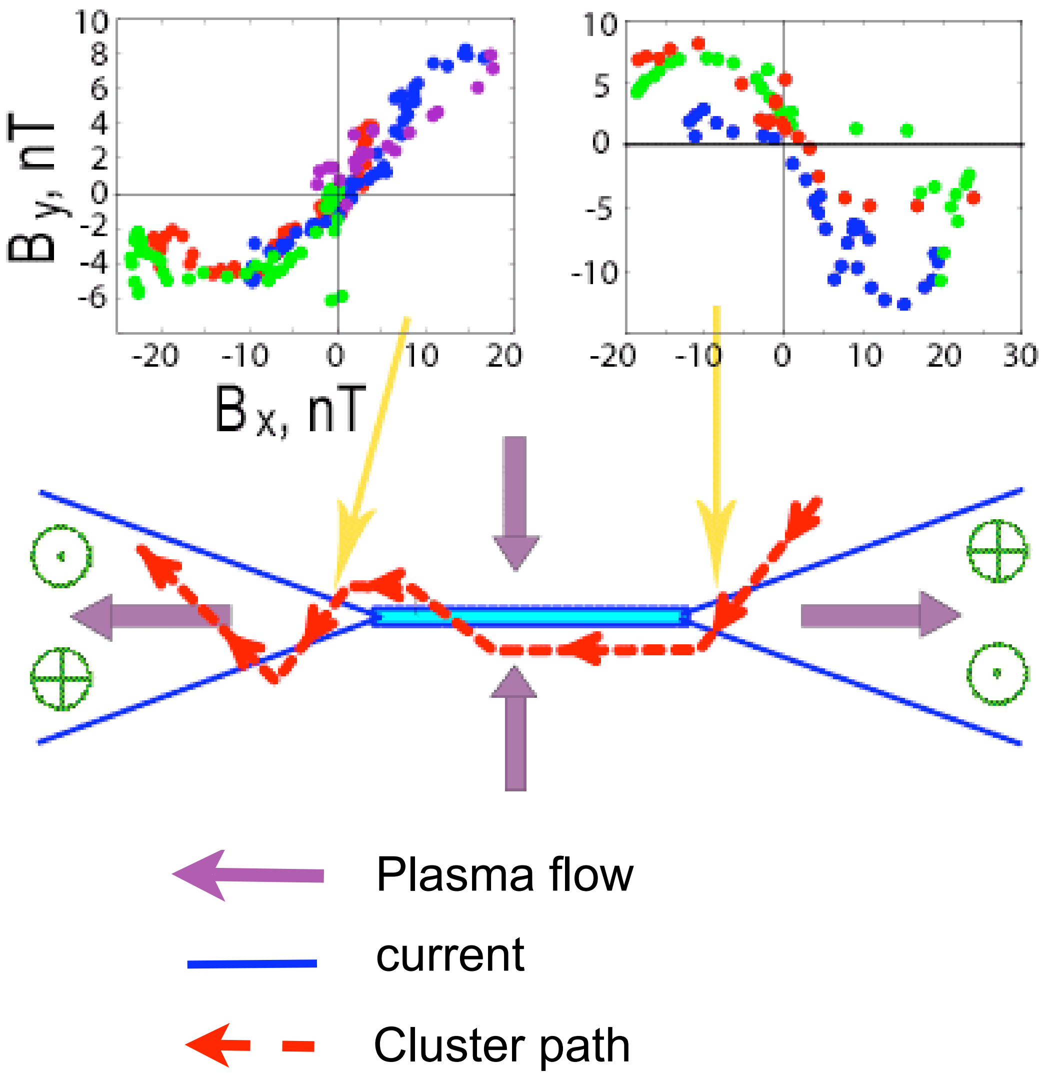
Figure 3 **The high-resolution (0.04 s) magnetic field data of four Cluster spacecraft, and the calculated Poincaré index during 05:03–05:04 UT on 15 September 2001. a–d,** The magnetic field data of C1–C4. The black, green and red lines indicate the *x*, *y* and *z* component, respectively. **e**, The Poincaré index calculated from intercalibrated high resolution (0.04 s) data. The vertical blue line shows the time 05:03:36 UT when a null point is found to exist inside the Cluster tetrahedron based on 4-s resolution data.

Magnetic Null …



The inferred spiral structure of the magnetic field around the null

Bifurcated current sheet

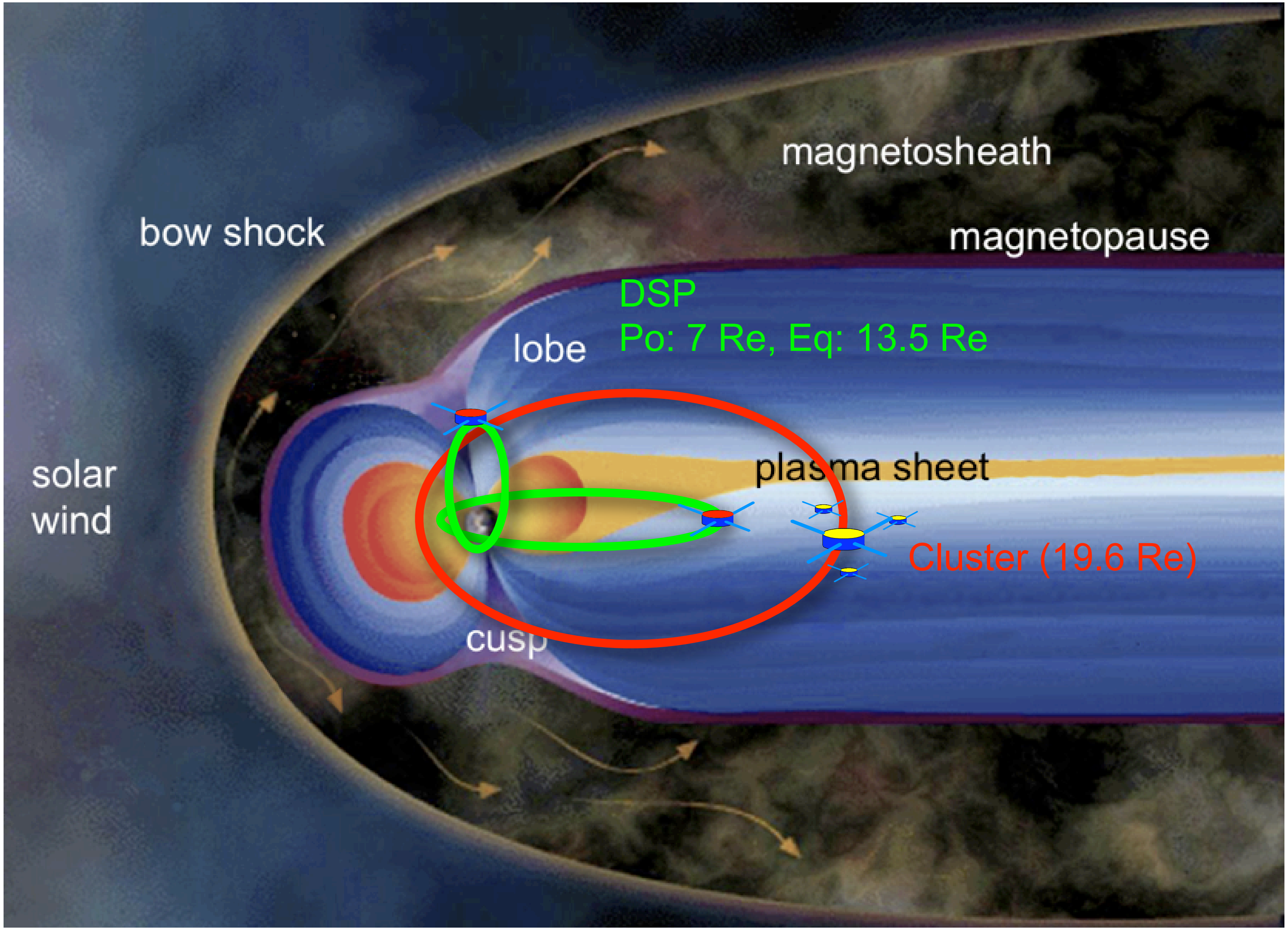


- Hall Effect (δB_y) measured during outer crossing
- 500 km thin current sheet around an X-line bifurcated on both sides
- Flow reversal and field line curvature reversal are proof that an X-line moved tailward over Cluster

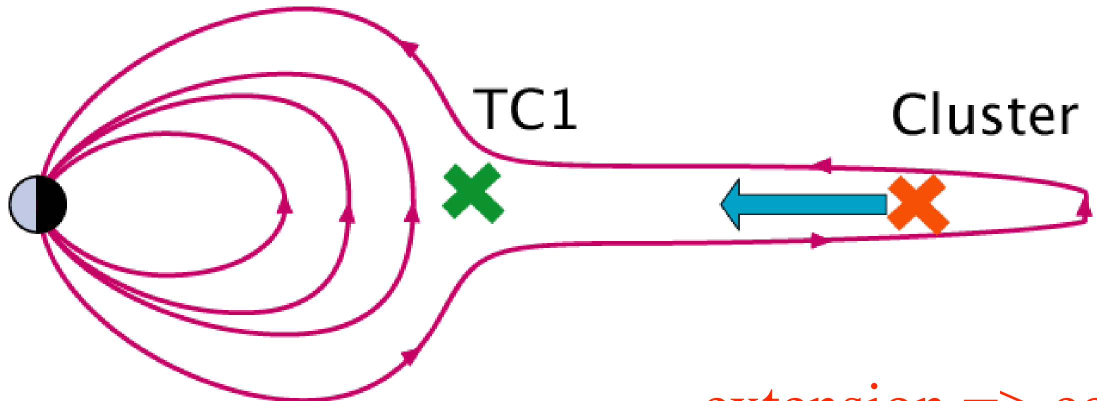
[Runov et al., 2003b]

CLUSTER

Cluster–Double Star orbits, tail

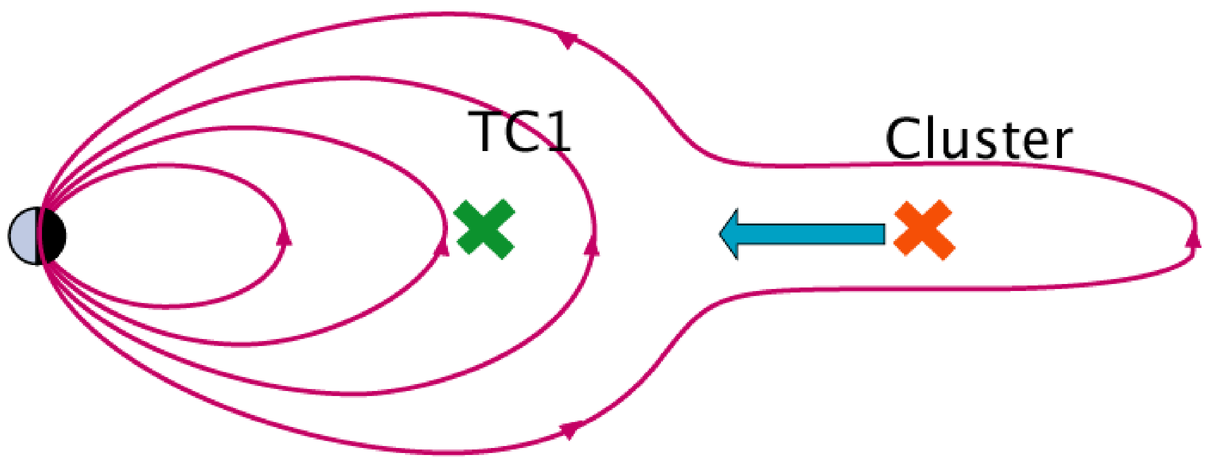


Bursty bulk flow and dipolarization



extension => comparison midnight-morning

Bursty bulk flow but no dipolarization



→ The magnetic topology in the inner magnetosphere can control the earthward penetration of dipolarization

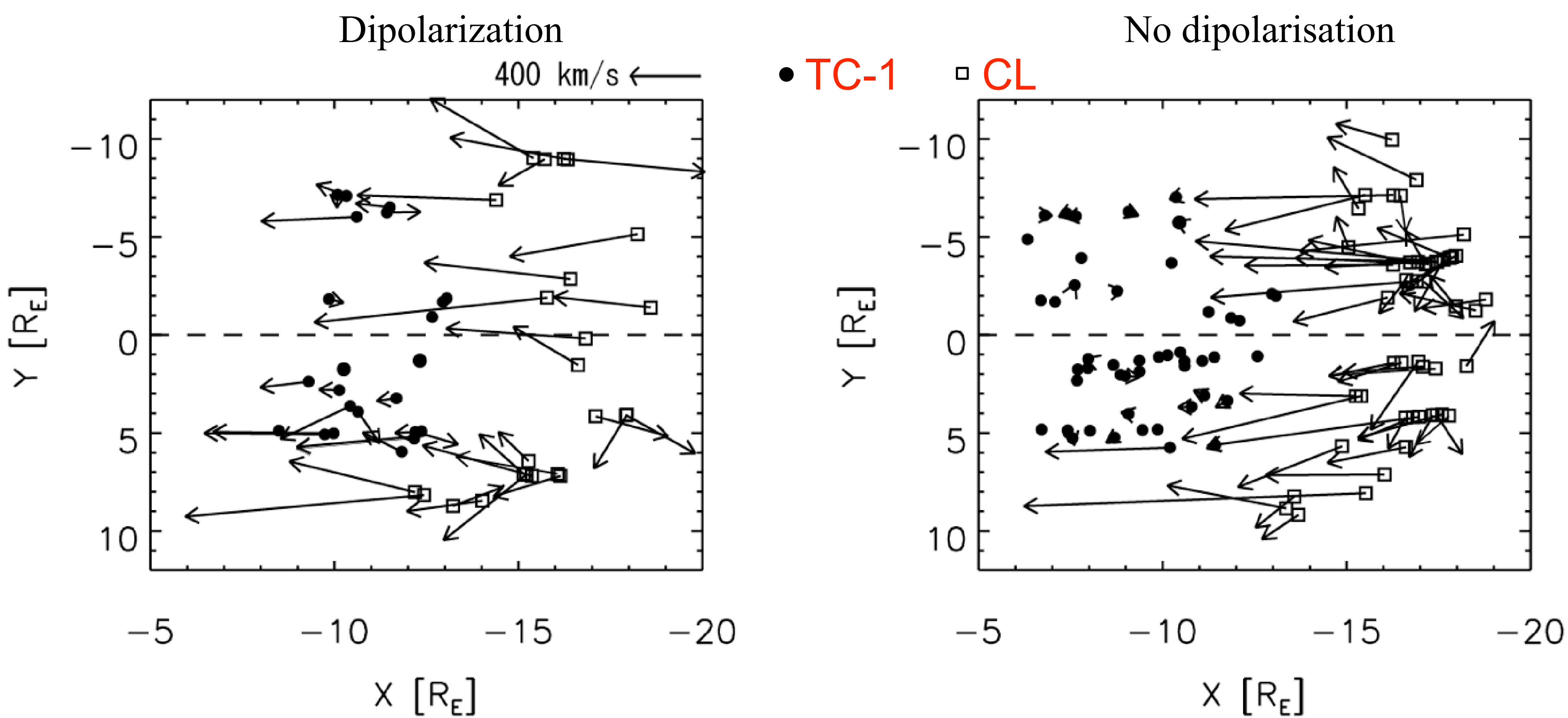
[Nakamura et al., 2006]

CLUSTER

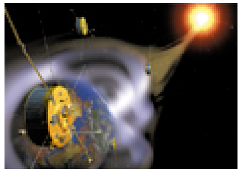
esa

Bursty Bulk Flows and Dipolarization

- TC1 dipolarization events are far from X~-8 RE
- The flow pattern observed by Cluster has similar features independent of the dipolarization at TC1

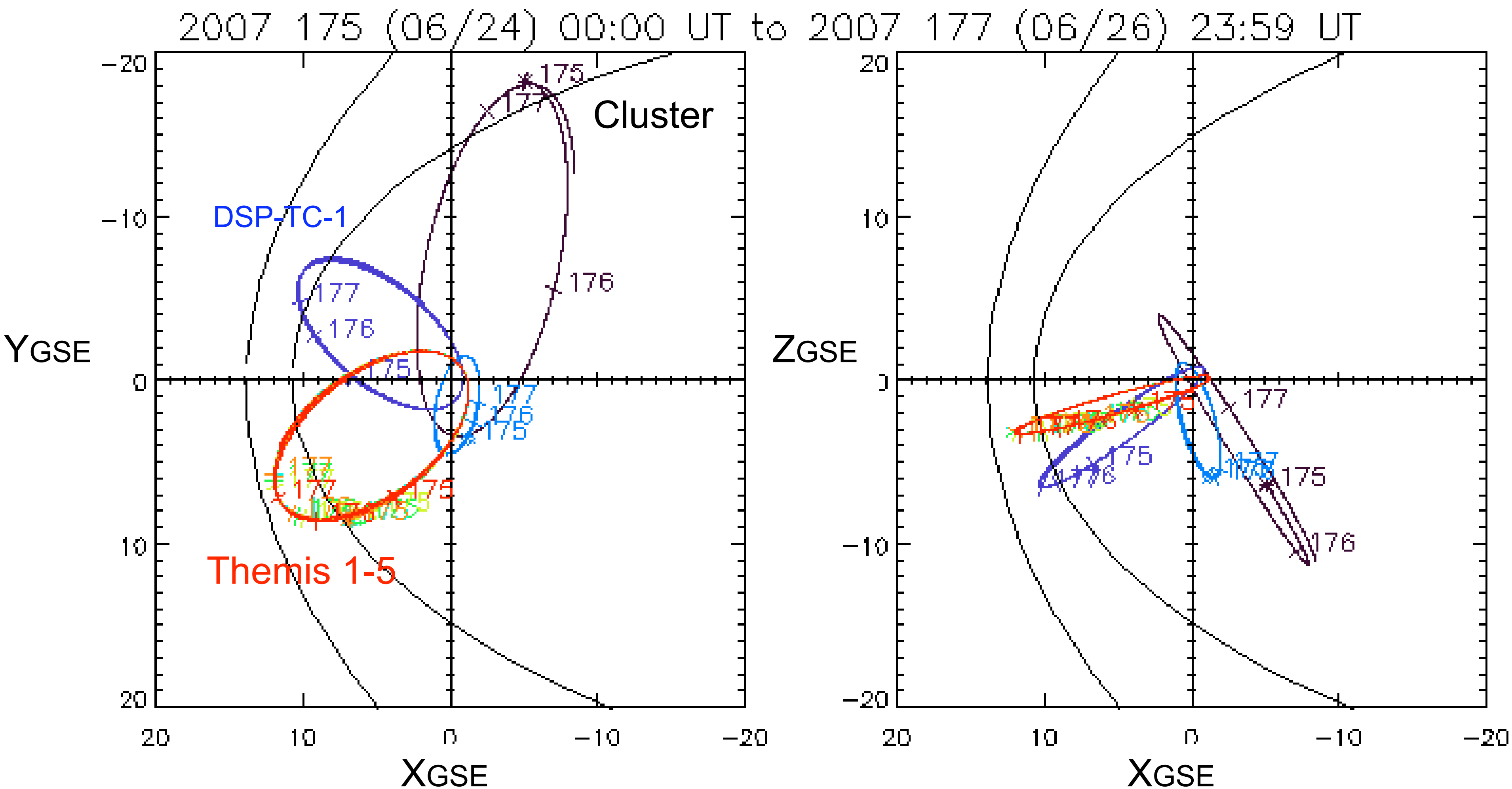


[Nakamura et al., 2006]



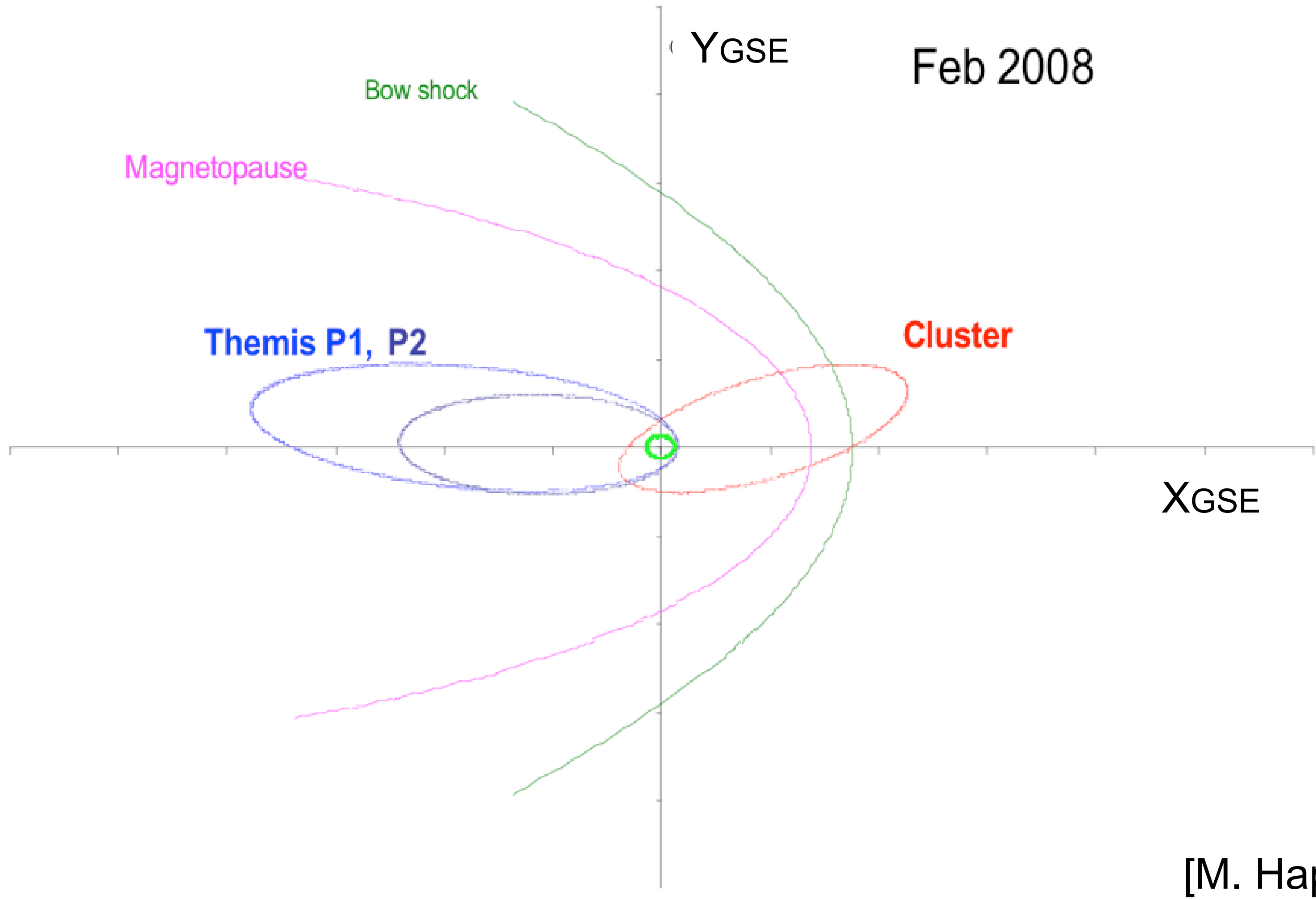
CLUSTER

Conjunctions THEMIS-Cluster-Double Star, June 07
(before THEMIS full deployment)



Note Double Star TC-1 re-entry in atmosphere beginning of Oct 2007

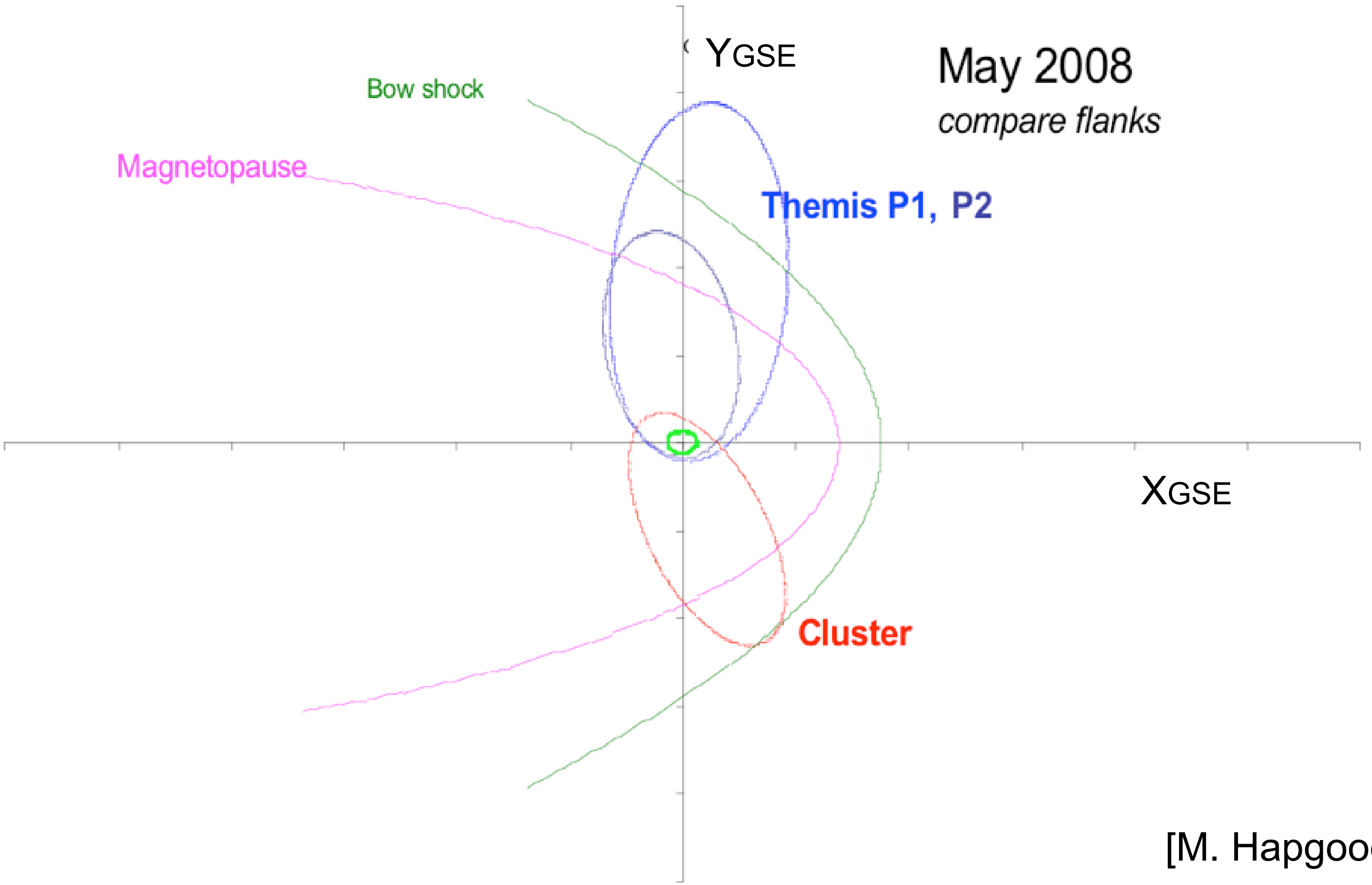
Conjunctions THEMIS-Cluster: tail and mid-altitude auroral zone



[M. Hapgood]

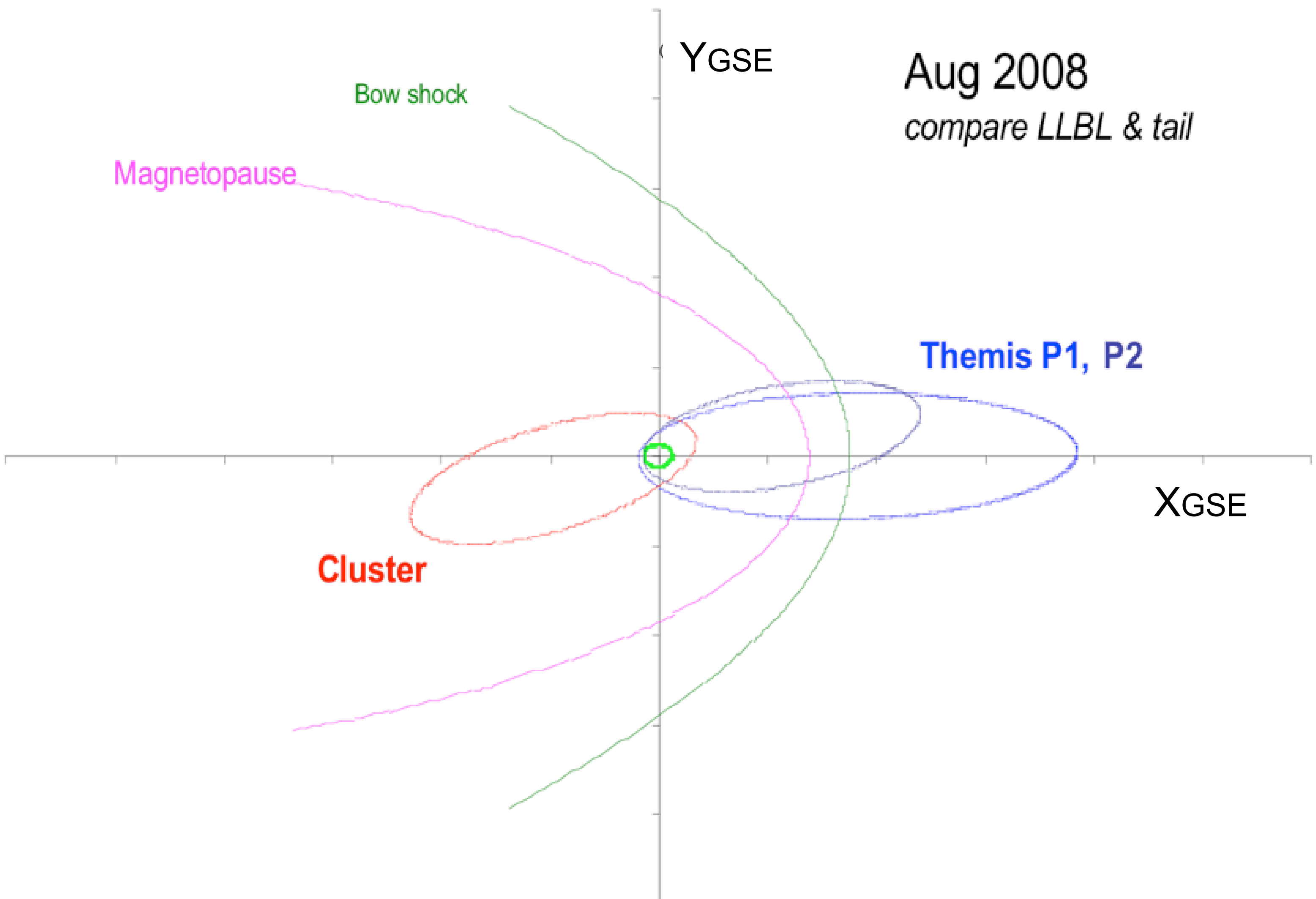
Note in 2009 Cluster will cross the auroral acceleration region around perigee

Conjunctions THEMIS-Cluster: compare dawn and dusk flanks



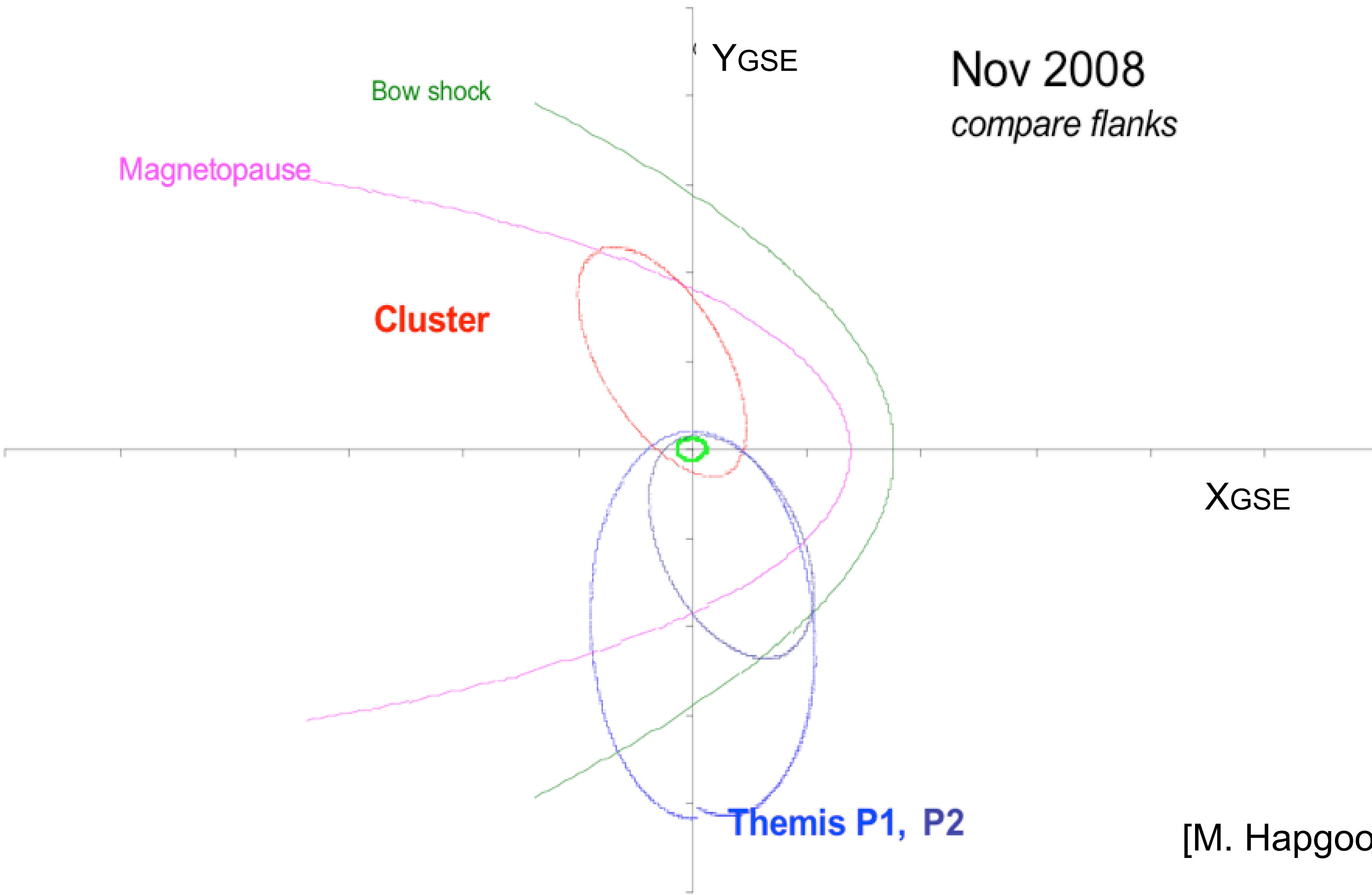
[M. Hapgood]

Conjunctions THEMIS–Cluster: LLBL-Tail & mid-alt. cusp-magnetopause



[M. Hapgood]

Conjunctions THEMIS–Cluster: compare dawn and dusk flanks



[M. Hapgood]

Summary and Conclusion

- Exciting new science with 11 spacecraft in the magnetosphere simultaneously: 5 THEMIS, 4 Cluster, and 2 Double Star
- Double Star TC-1 will cease operation in October 2007. TC-2 might continue if there are no thermal problems this summer
- Cluster has been extended to the end of 2009 (with review at end of 2007)