Cluster observations of a reconnection diffusion region: Energetic electrons and magnetic islands

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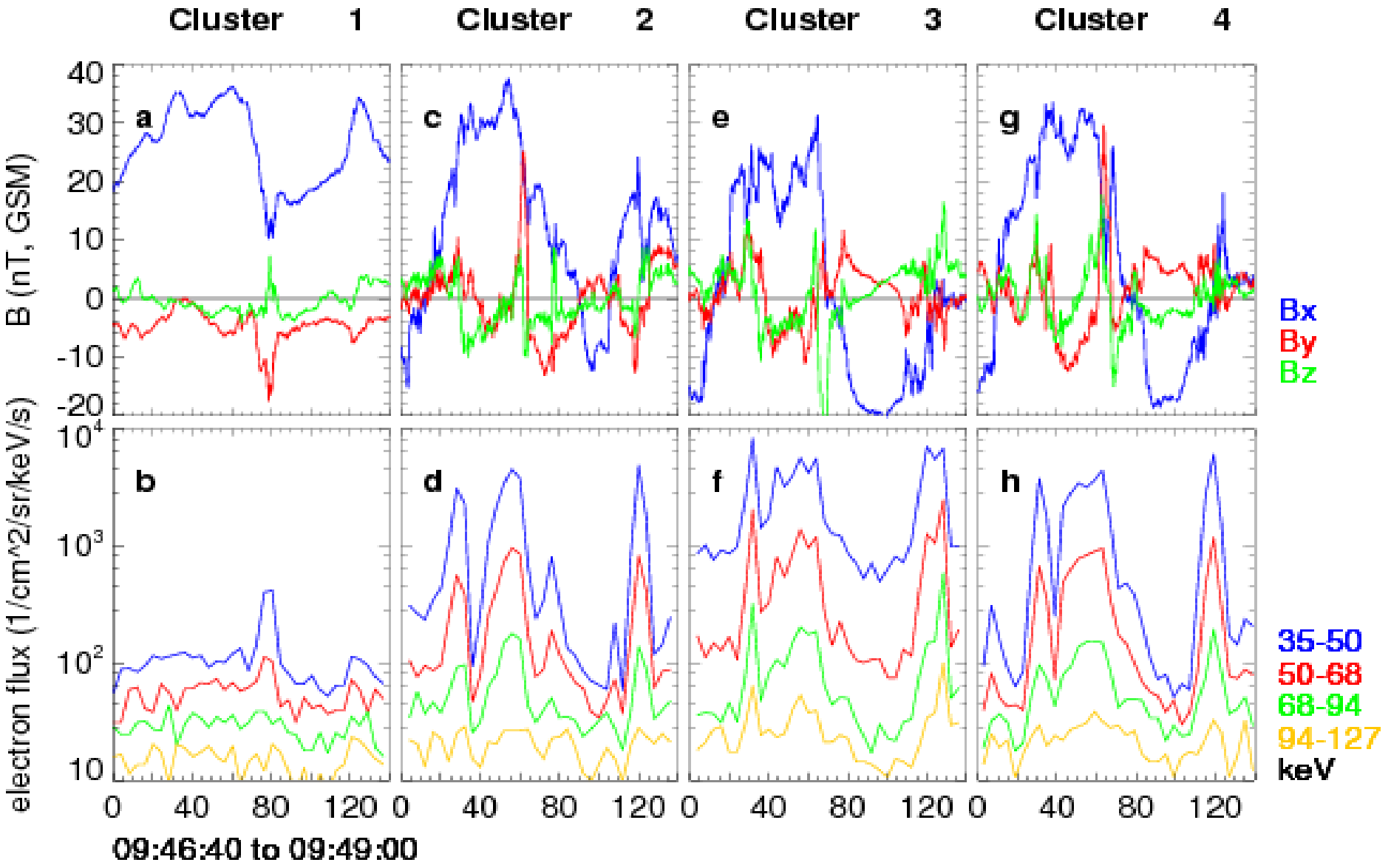
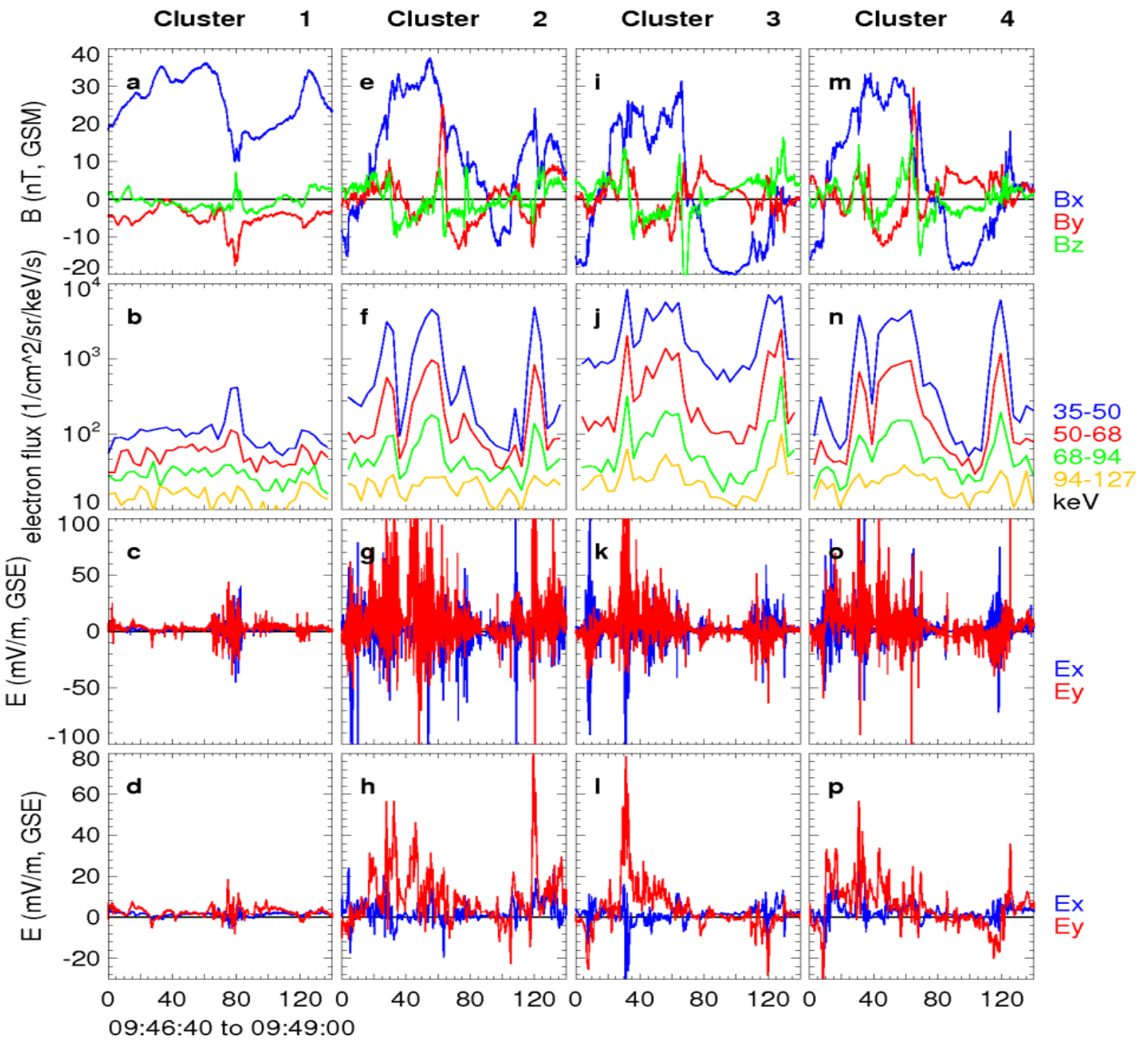
Mechanisms for e acceleration

- Acceleration by DC E -
  1) At the X line (Hoshino, 2005; Pritchett, 2006);
  2) Along separatrices in guide field reconnection (Drake et al., 2005)
- Fermi acceleration due to contracting islands (Drake et al., 2006)

e bursts and B pulses: ~ 1-1



e bursts and spiky E (significant DC, but not necessarily along B)



Summary of B pulse features

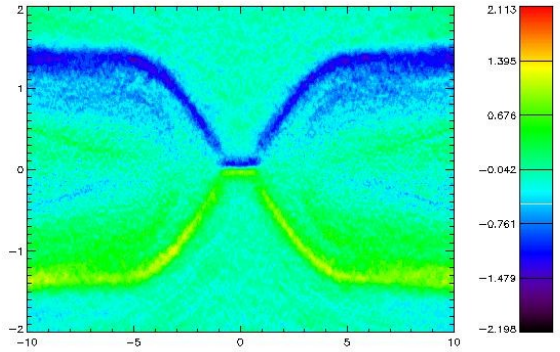
- bipolar Bz
- decreases in Bx
- some have unipolar By
- Bz pulses rise gradually and fall sharply

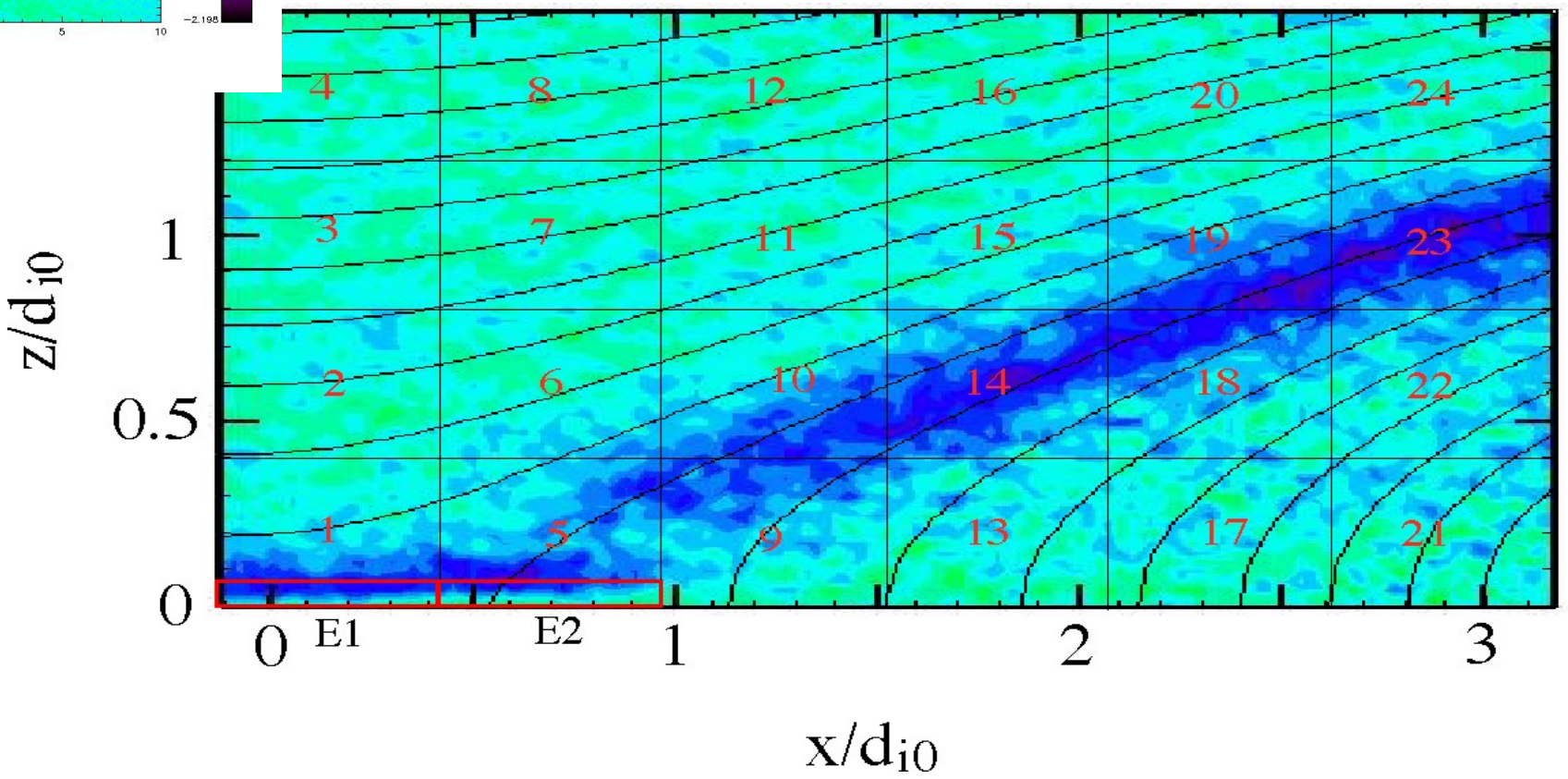
What are the magnetic pulses?

- Are they due to fast passages of X lines? No, because electrons are hot throughout the B pulse time.
- Are they due to localized current structures? Yes!

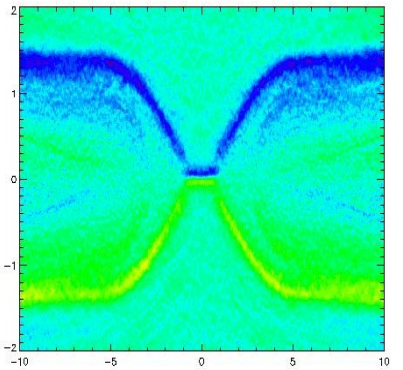
Establish a map of electron distribution functions

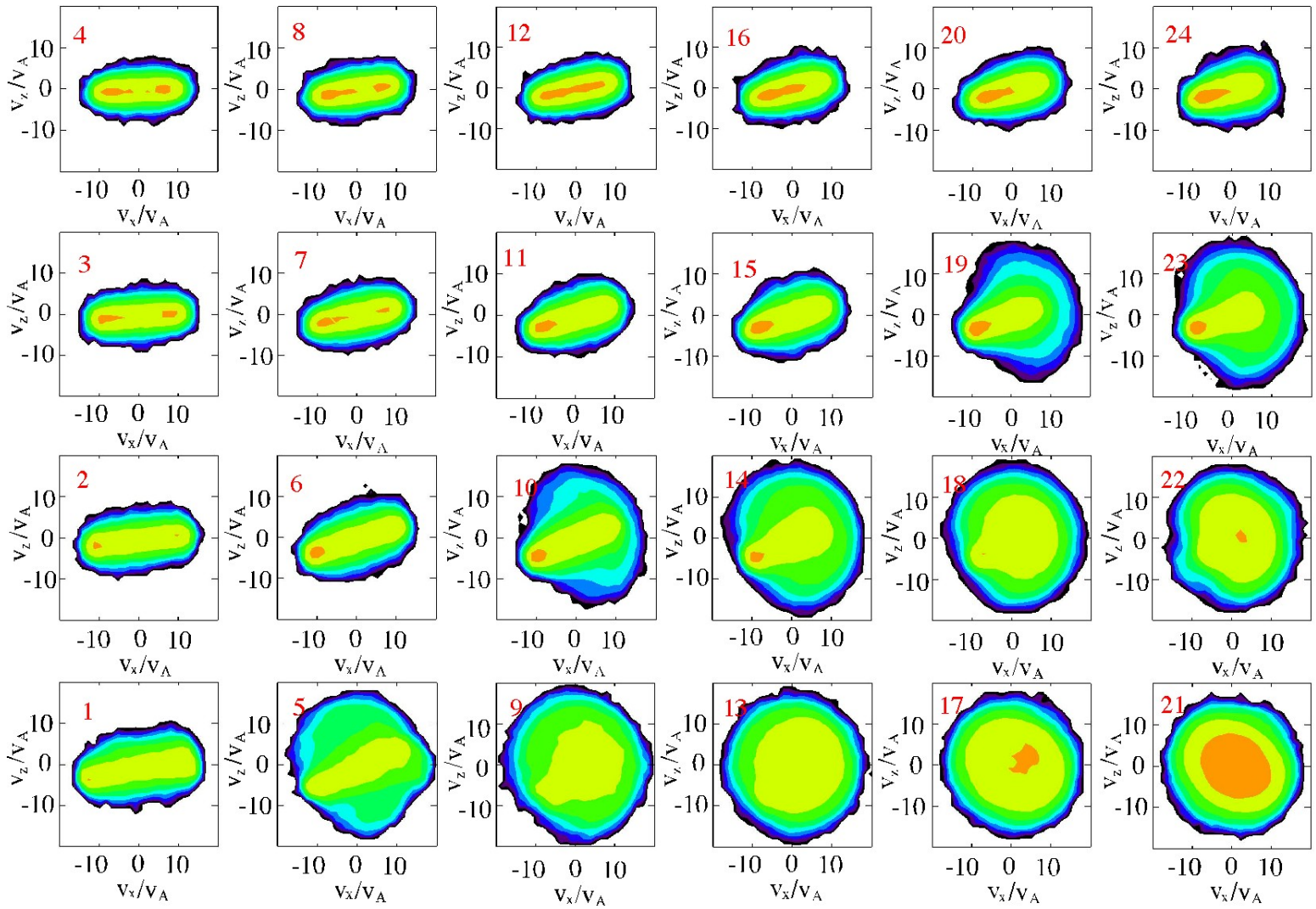
2D PIC

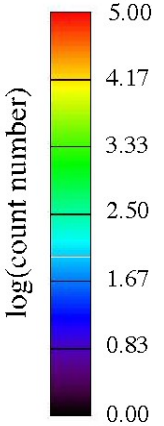




2D PIC results: cold vs. hot

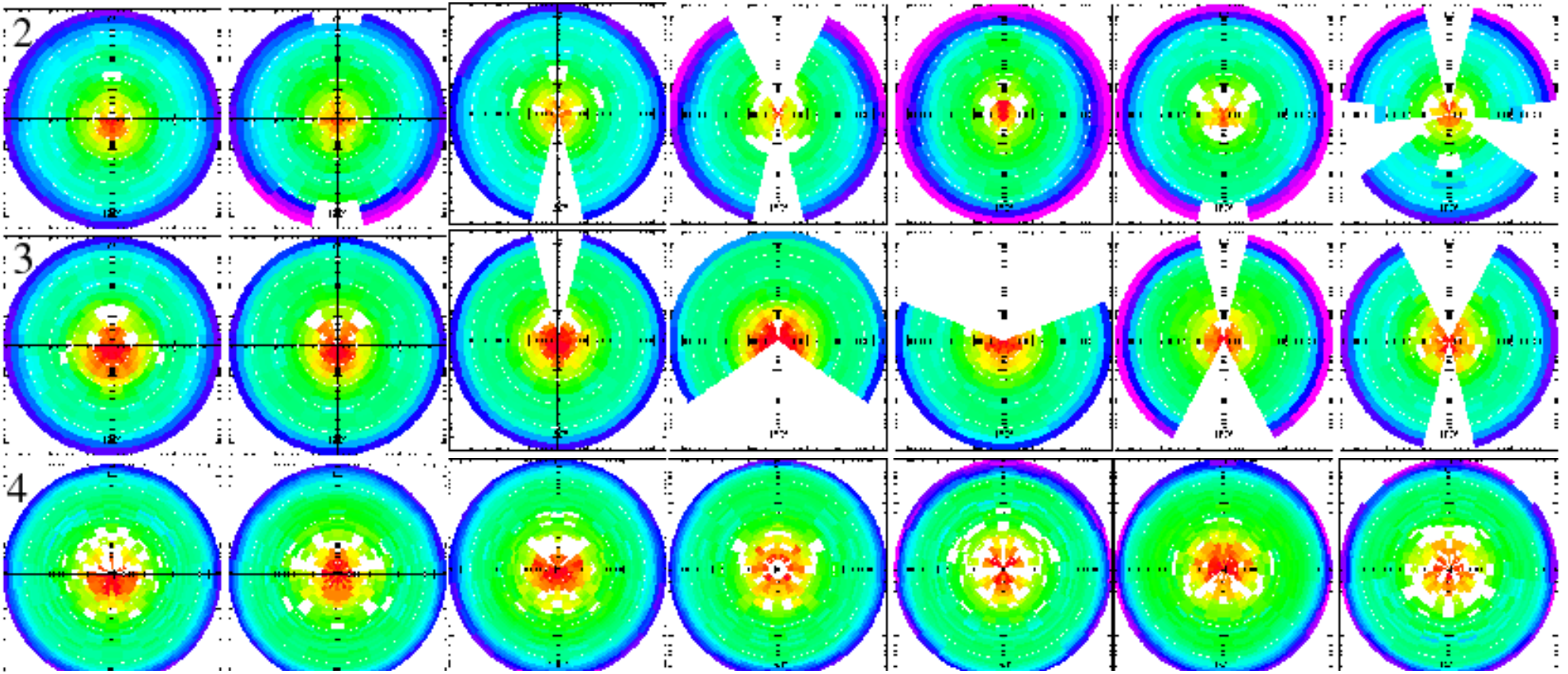


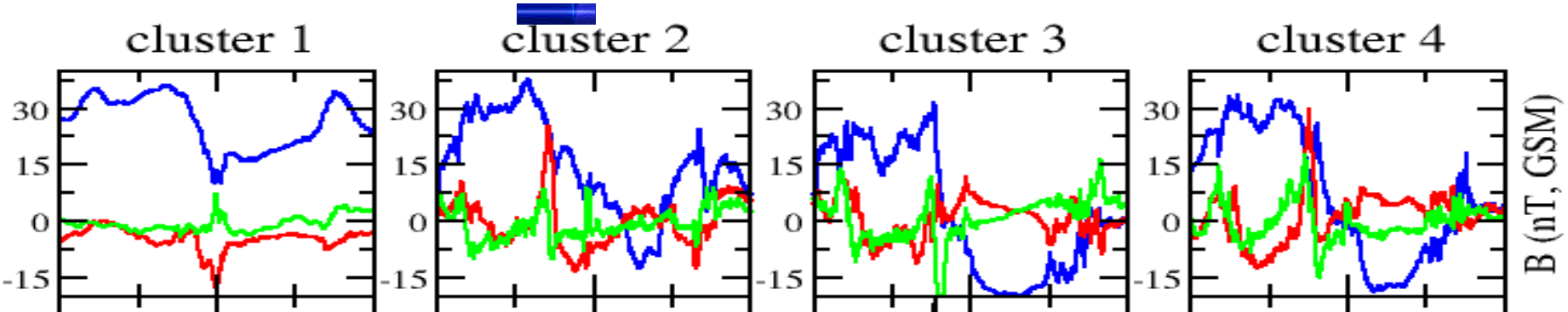




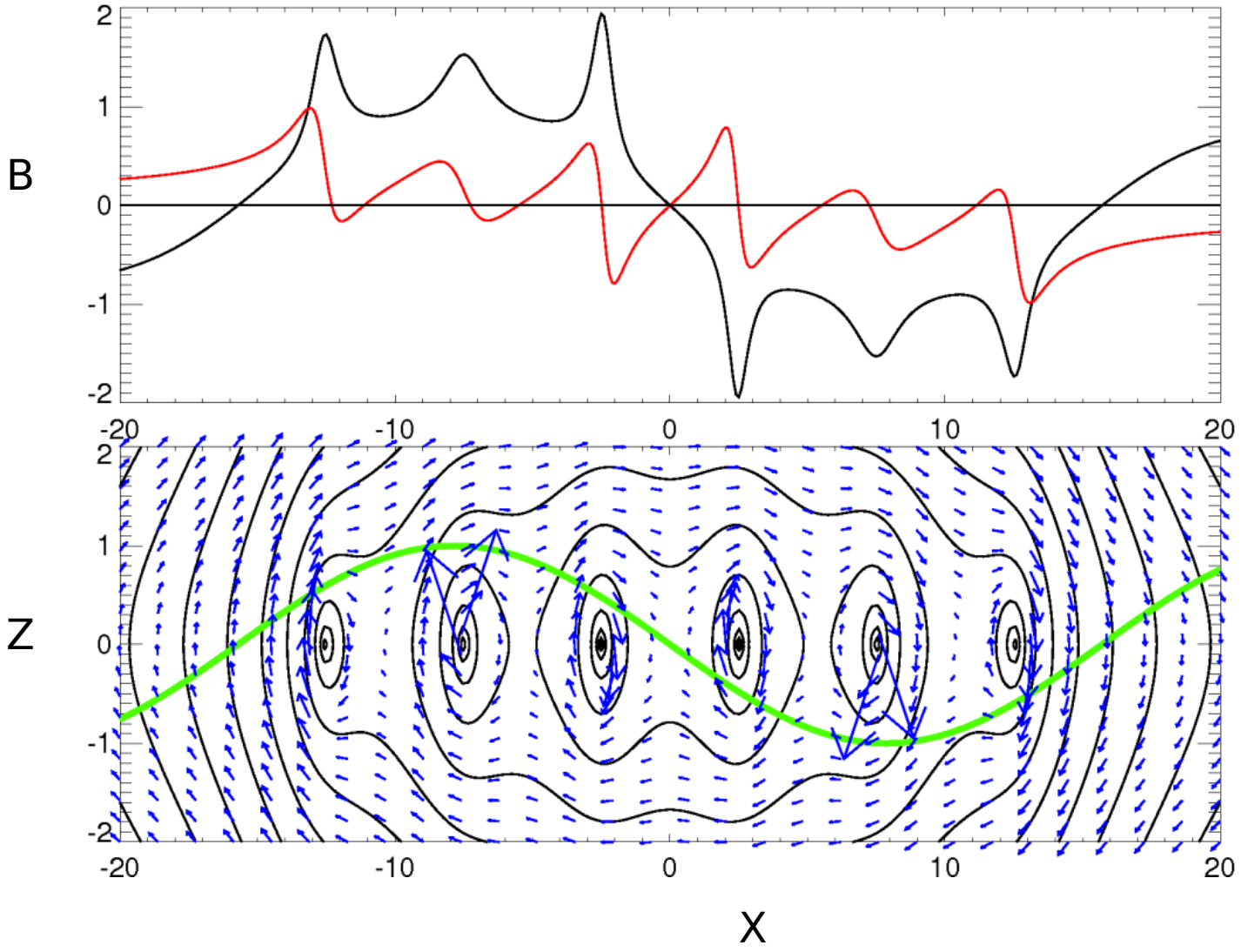
Electron distribution functions in v_X - v_Z plane

Electrons are hot within bipolar Bz pulses



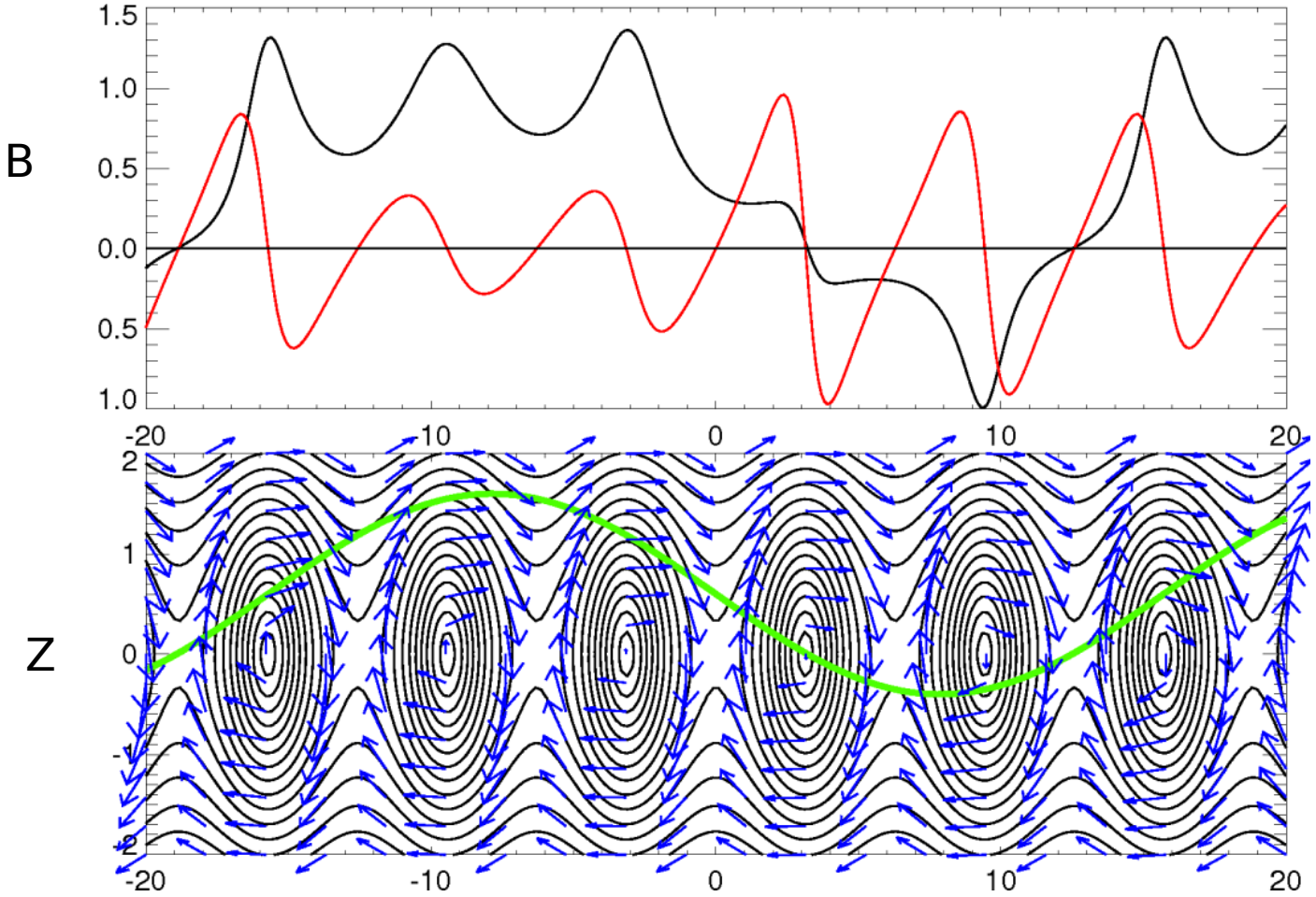


Harris Sheet + 6 line currents



If a periodic chain of islands…

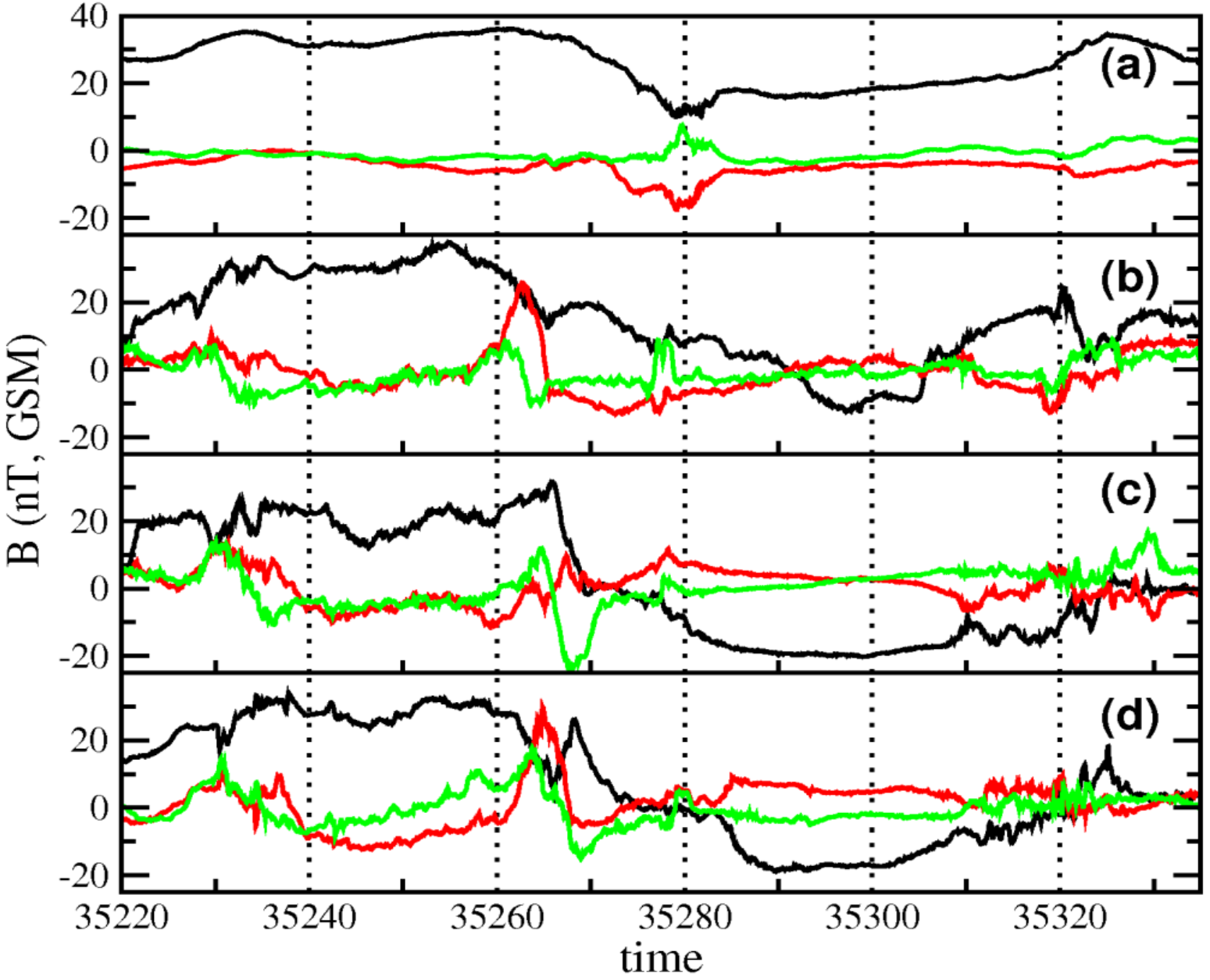
Fadeev solutions



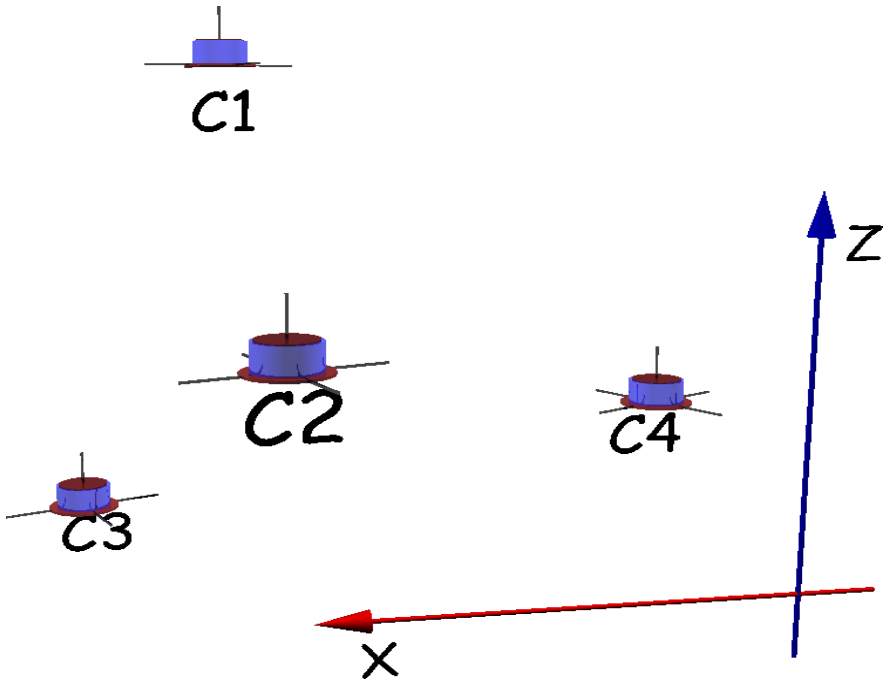
Learned from the simple models:

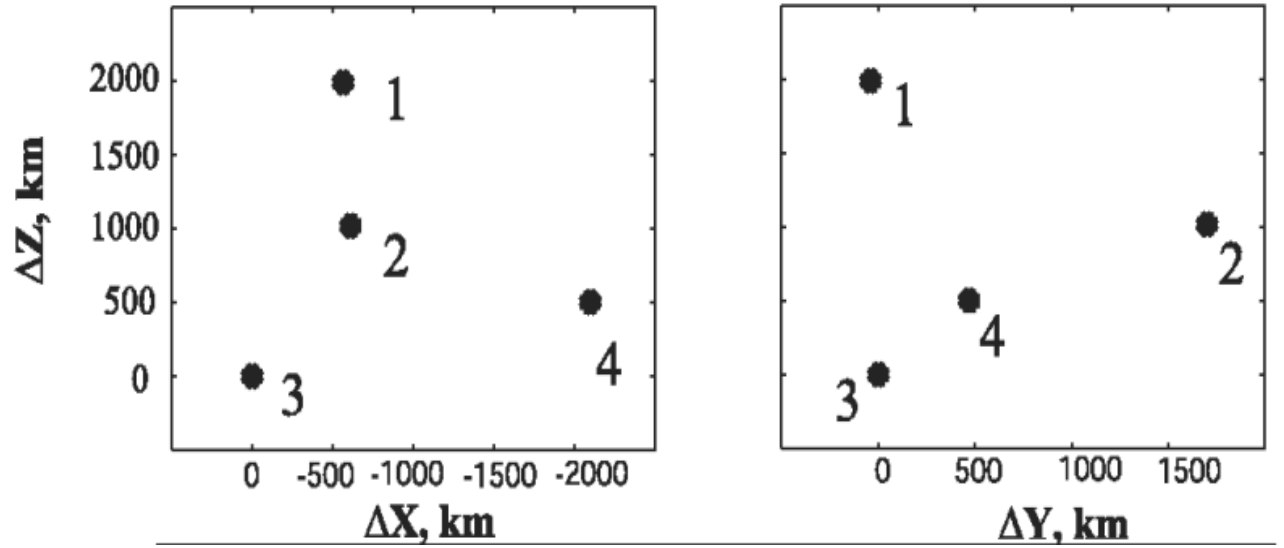
- localized current structures can account for observed Bx and Bz.
- Asymmetry of Bz pulses is likely due to that there are only a few magnetic islands.

4 s/c view of B islands



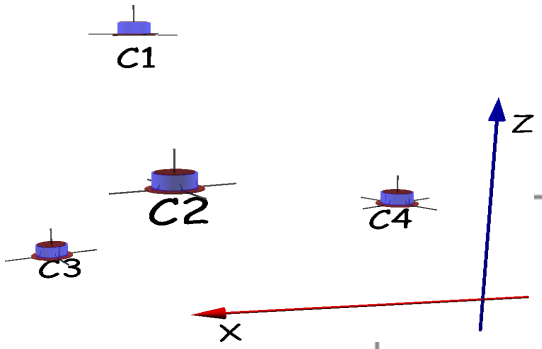
Cluster Positions

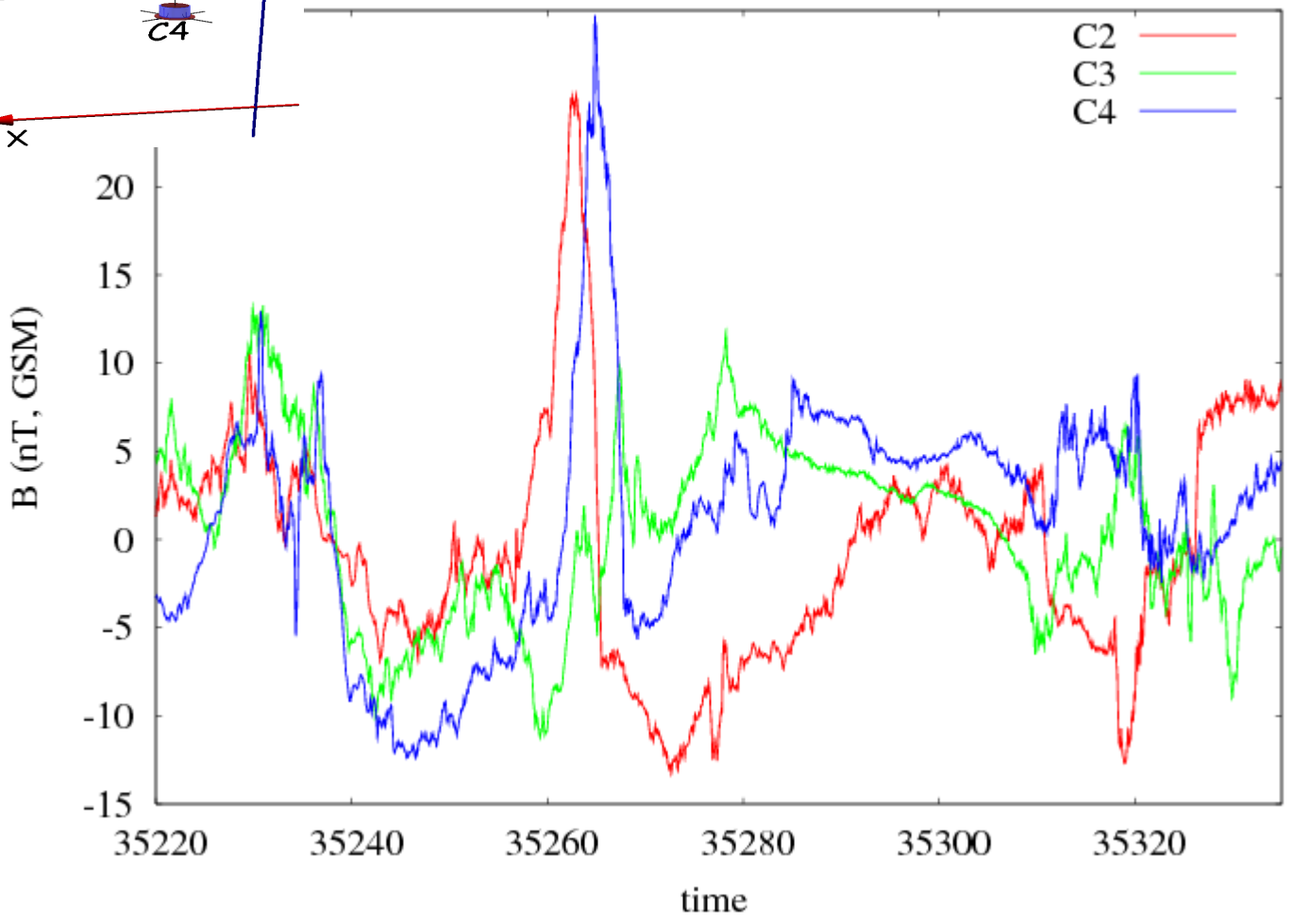




Runov et al., 2003

Core field correlation: C2 and C4

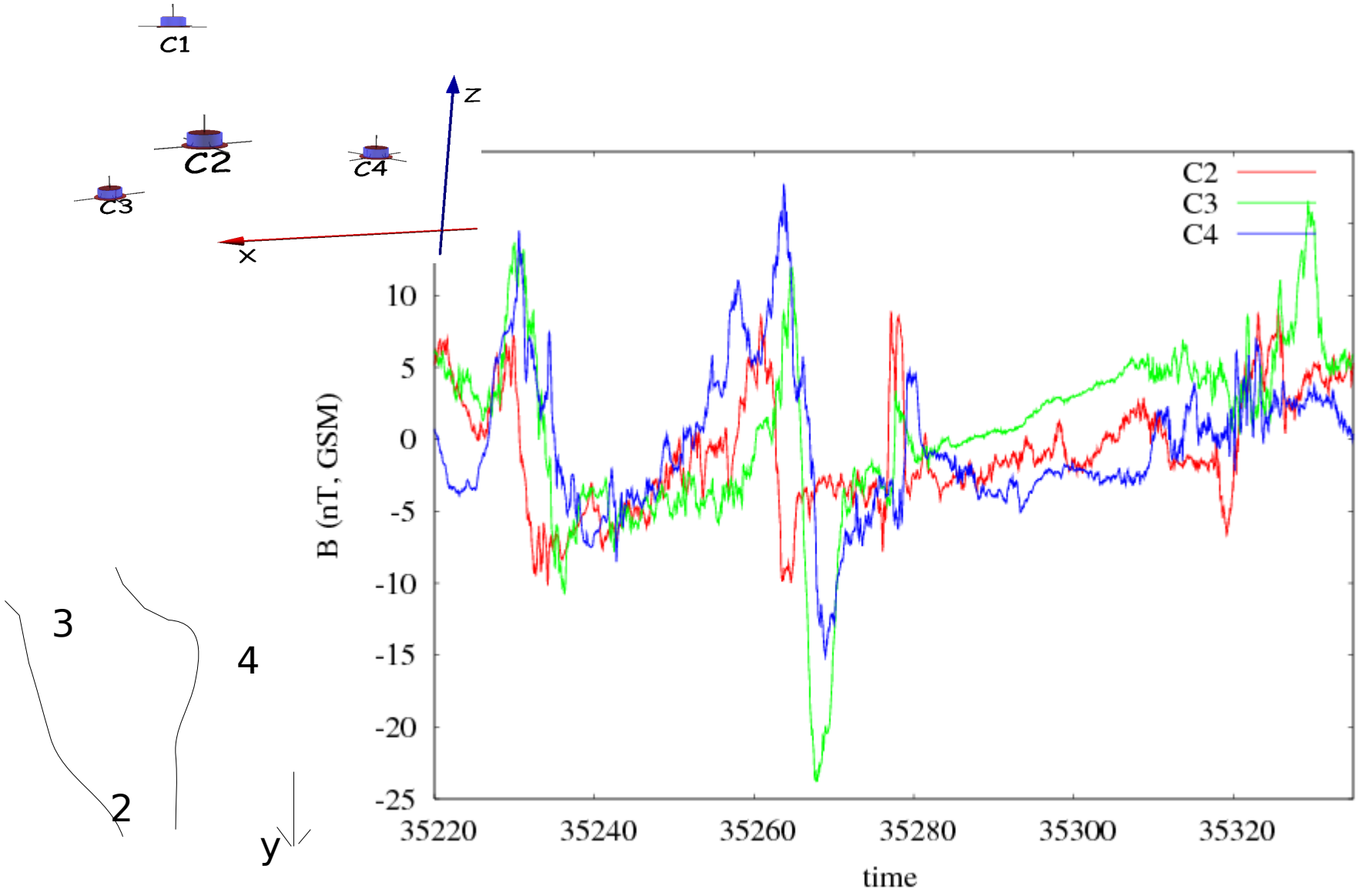




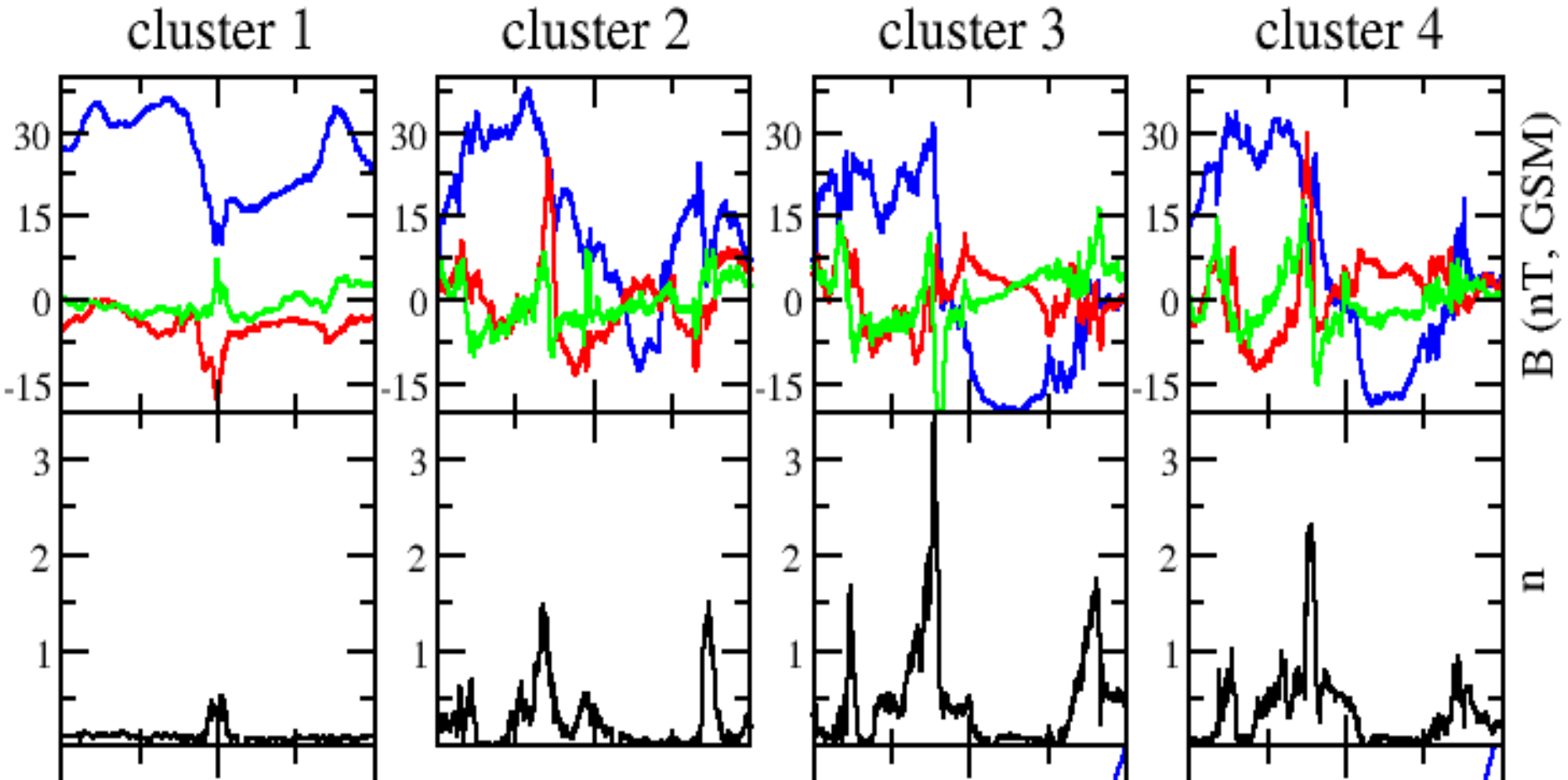
V~500 km/s

island size
~2500 km
~2 di

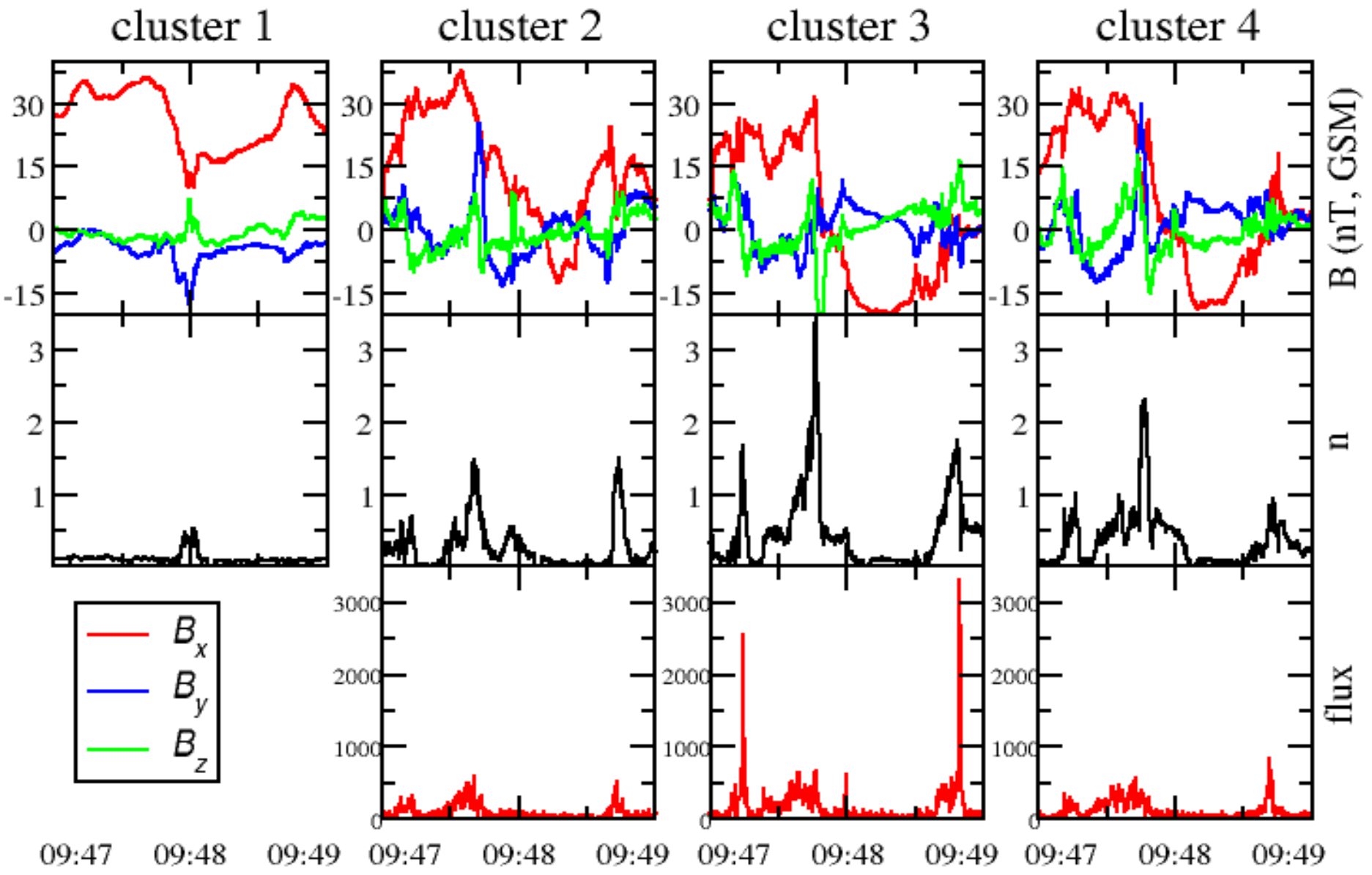
Bz correl. (C2,3,4): y dependence



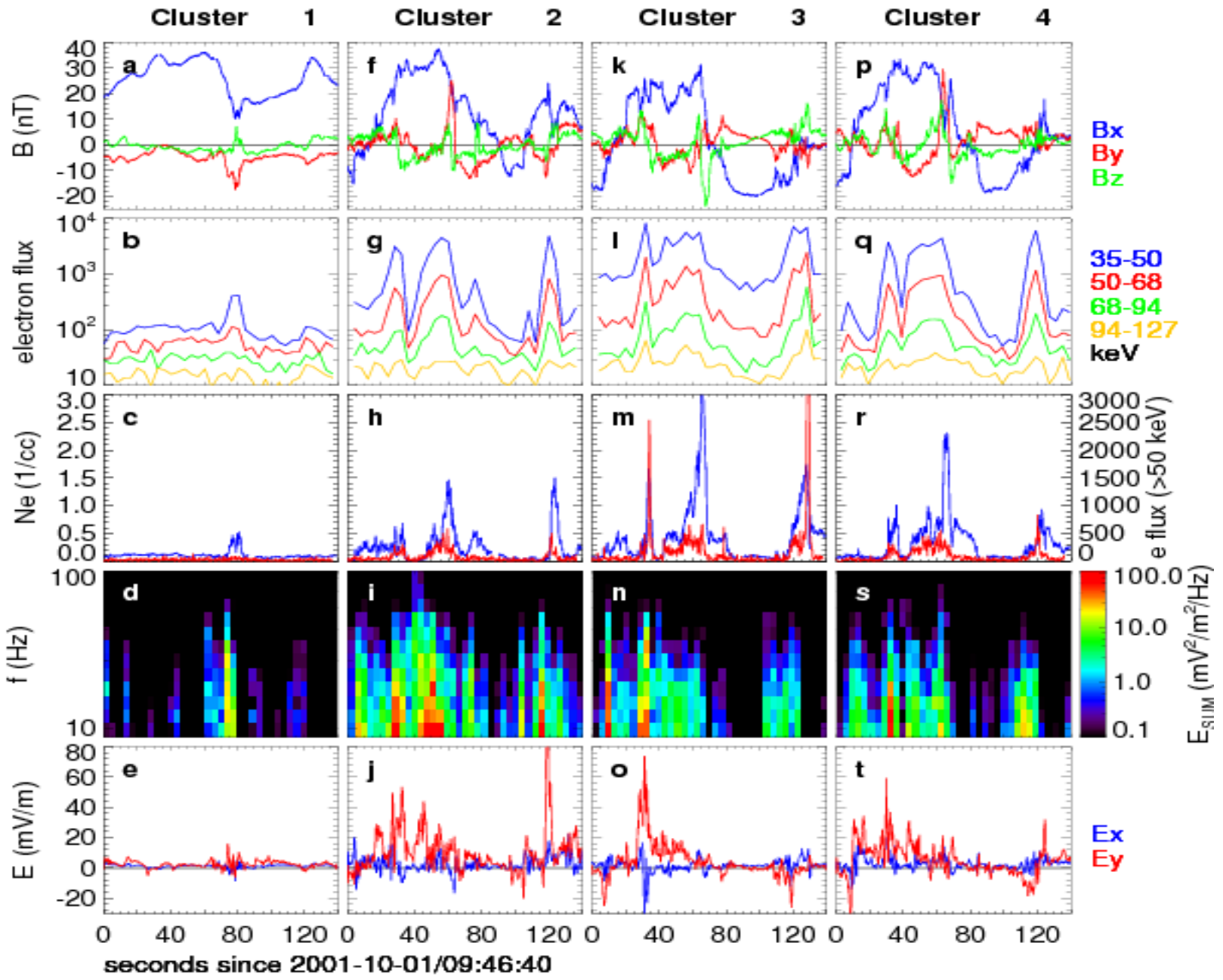
Density enhances within islands



Electron flux peaks at high n core



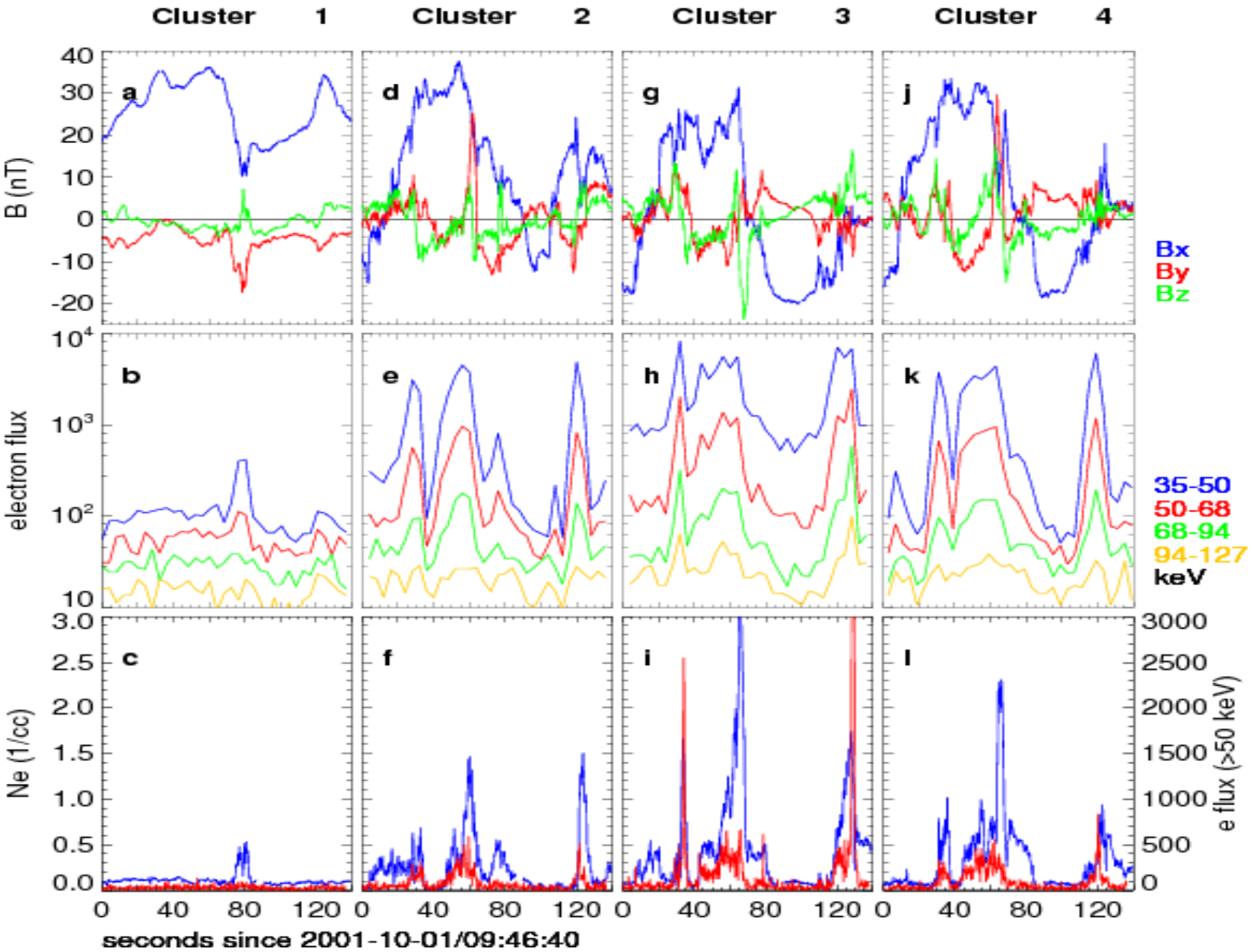
E fluctuations and DC E at one edge of islands



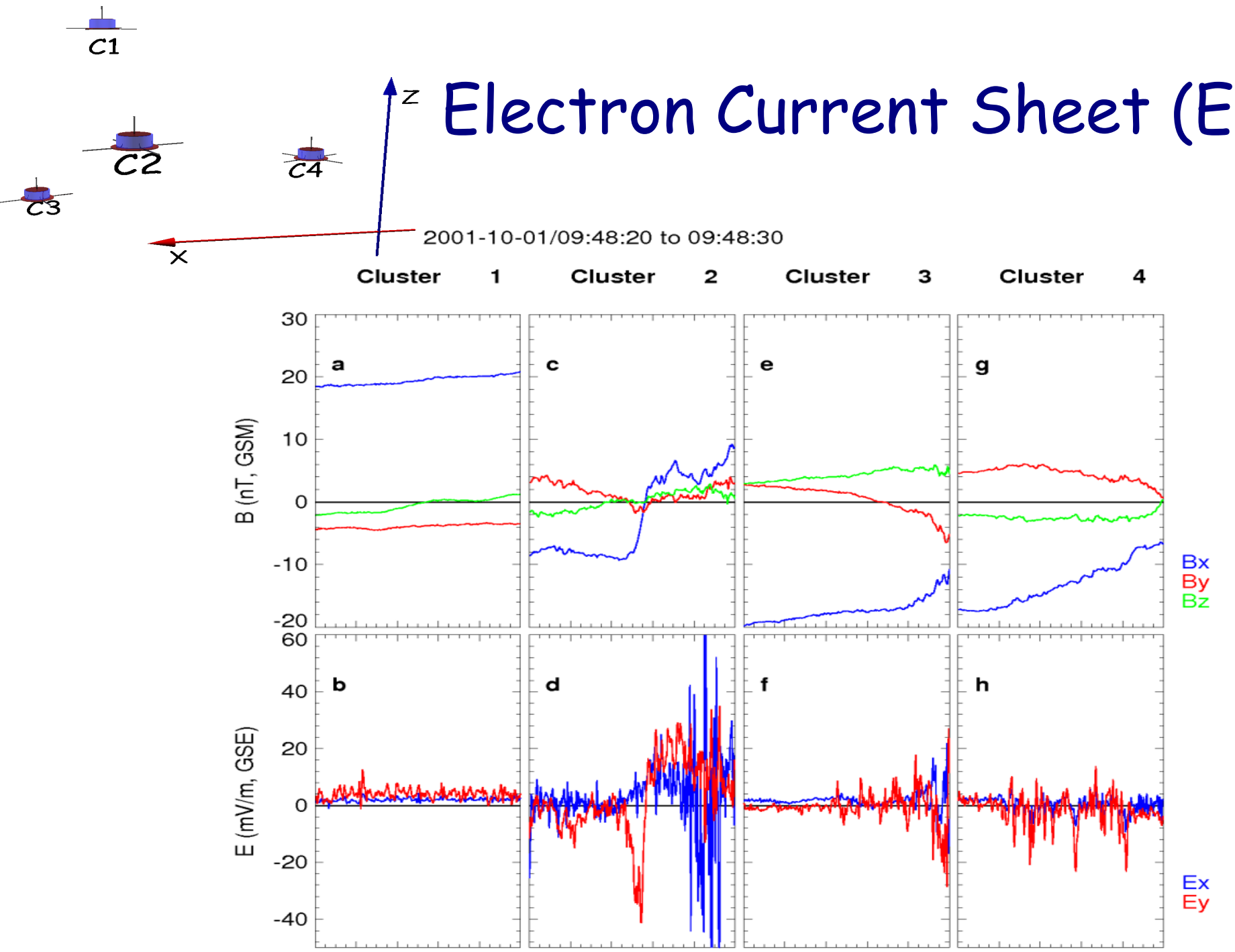
Sum. of observed island properties

- bipolar Bz
- unipolar By (not always)
- DC E and E fluctuations at one edge
- highly enhanced n within
- hot electrons within
- 1-1 correspondence with major energetic electron bursts.

Energetic electrons at ECS



Electron Current Sheet (ECS)



$$N=[0.02,0.89,-0.45];Vcs\sim 40(\pm 30)km/s\sim 2(\pm 1.5)d_e/s$$

Summary

- The flux of energetic electrons up to 100 keV peaks at the high density core within magnetic islands, a feature that is yet to be explained.
- Data support electron acceleration within islands and at the electron current sheet.
- The existence of islands and the asymmetric properties of islands are consistent with guide field reconnection.