

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

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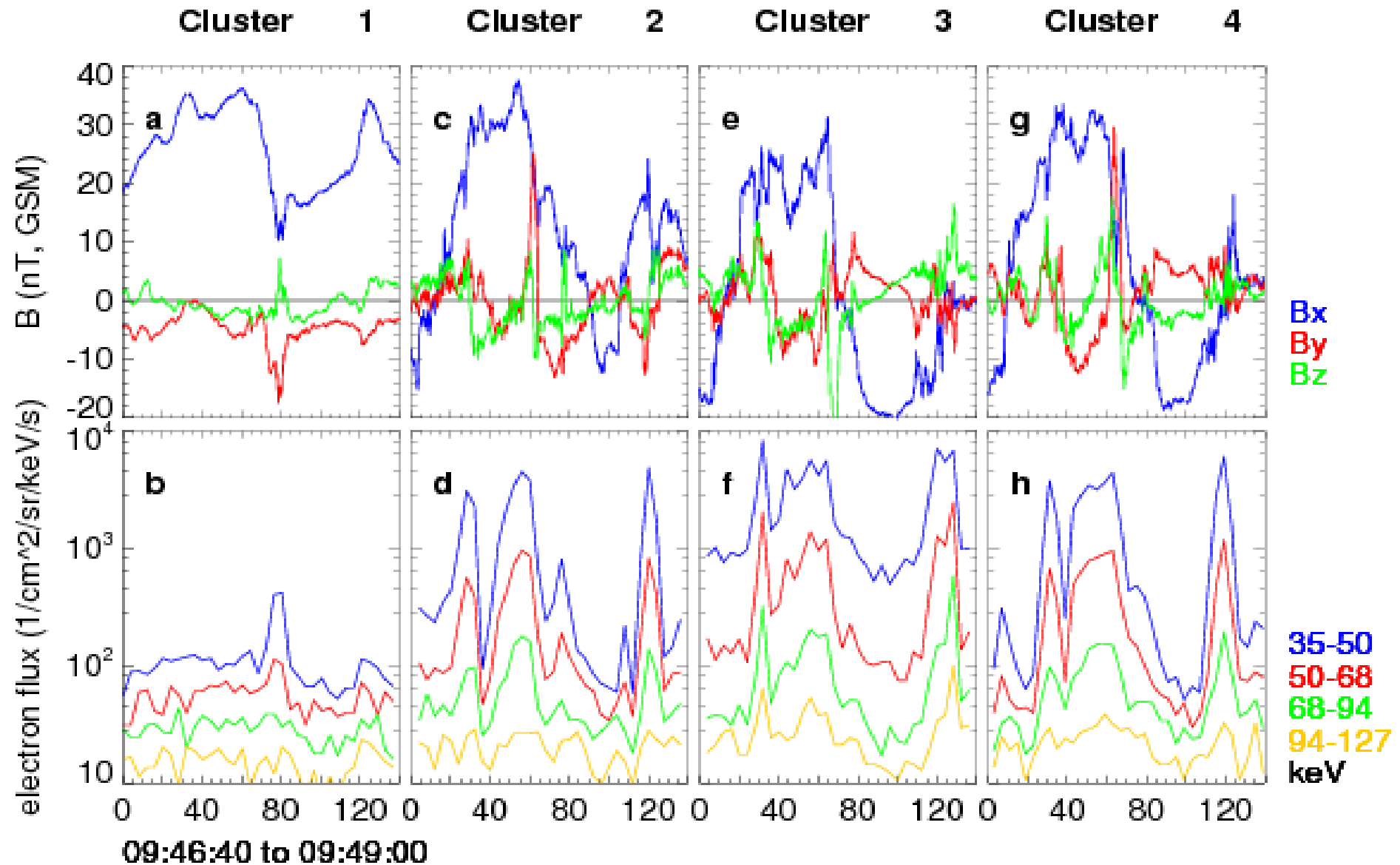
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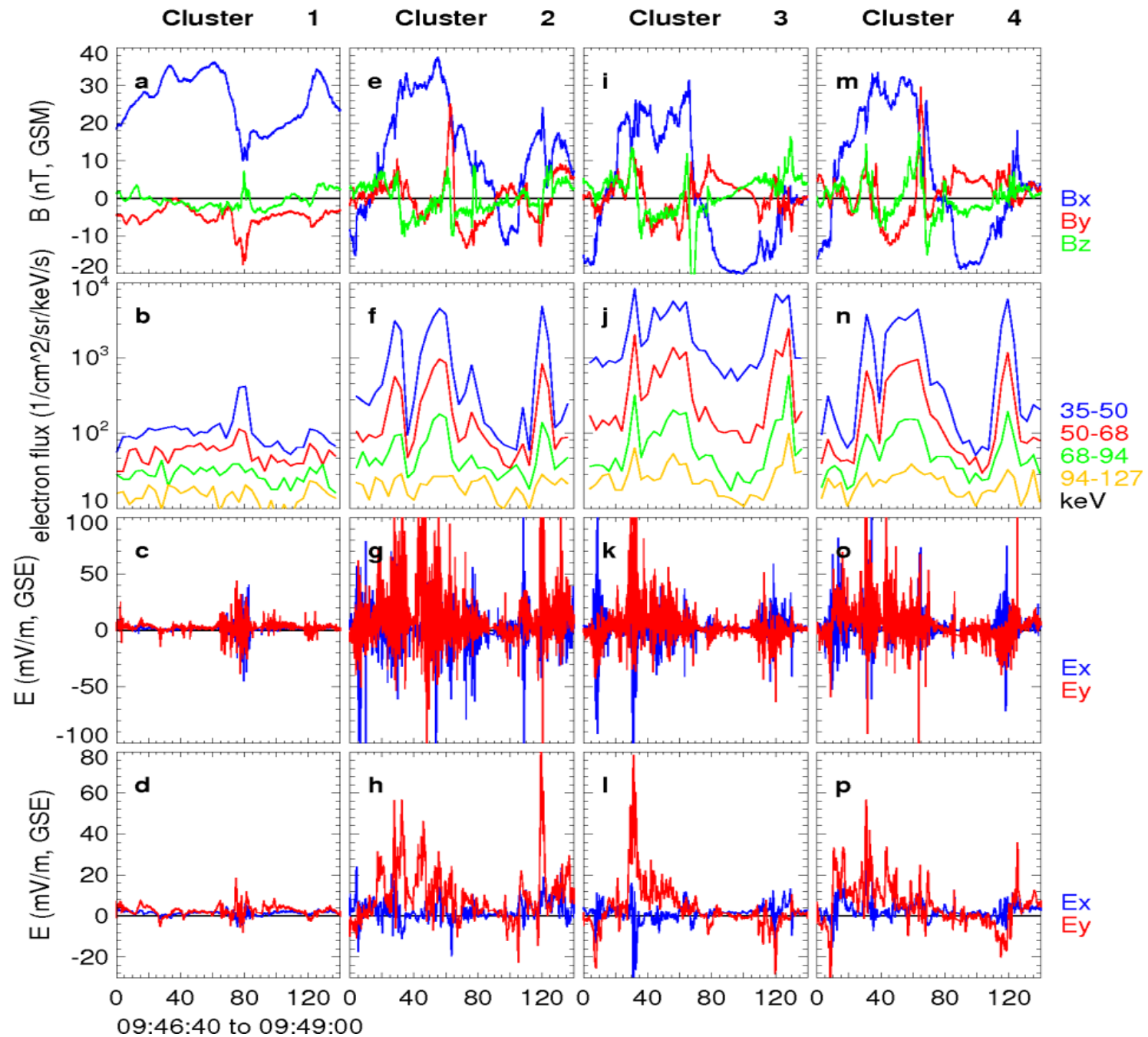
Mechanisms for e acceleration

- 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

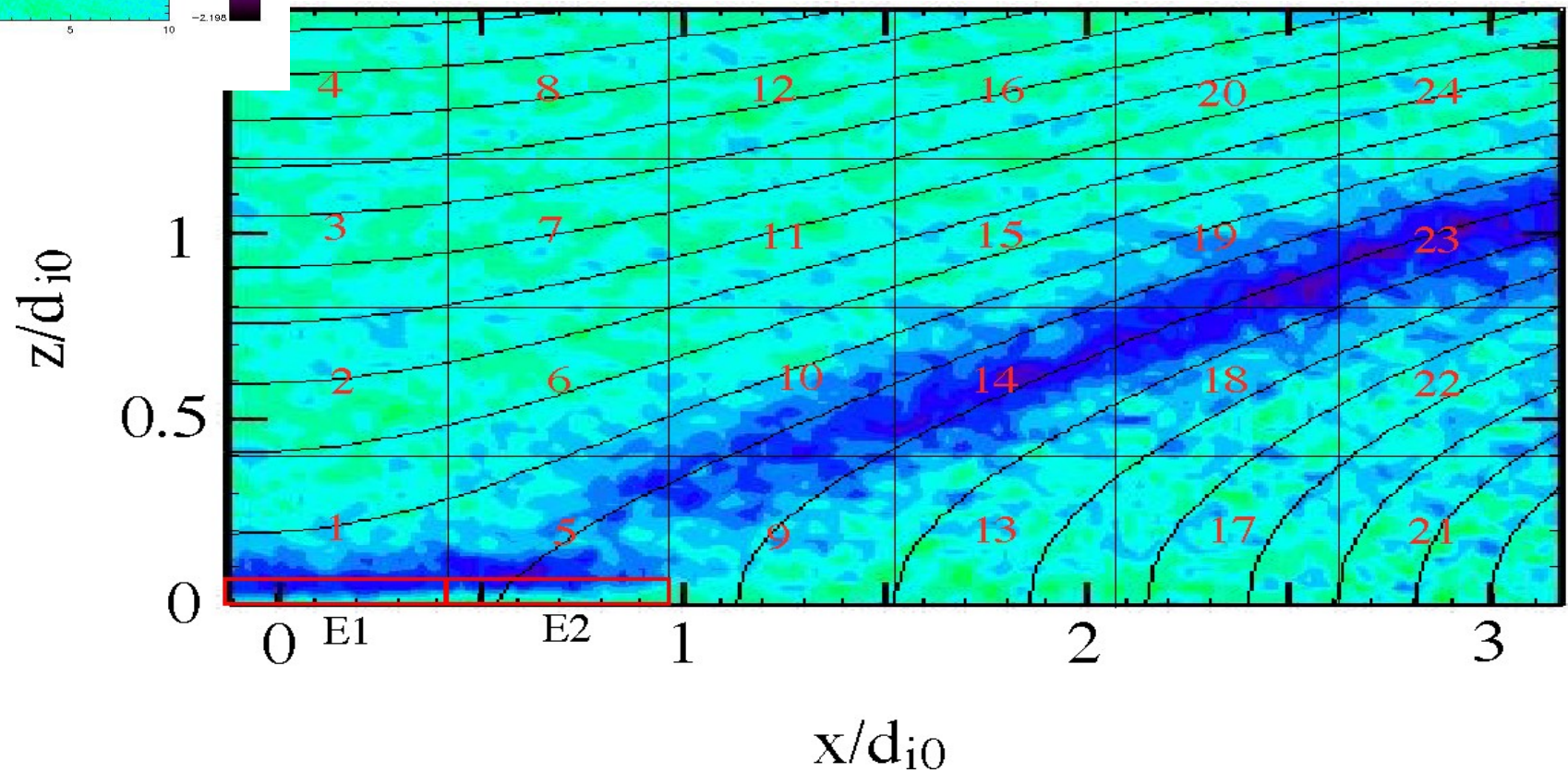
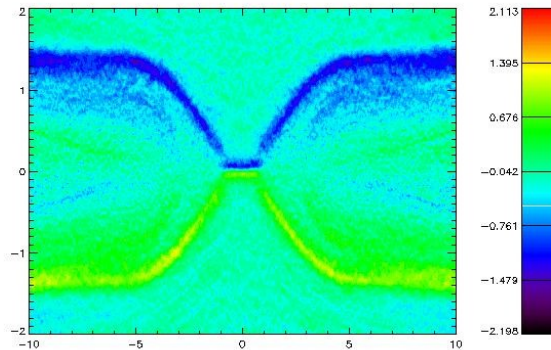
- bipolar B_z
- decreases in B_x
- some have unipolar B_y
- B_z pulses rise gradually and fall sharply

What are the magnetic pulses?

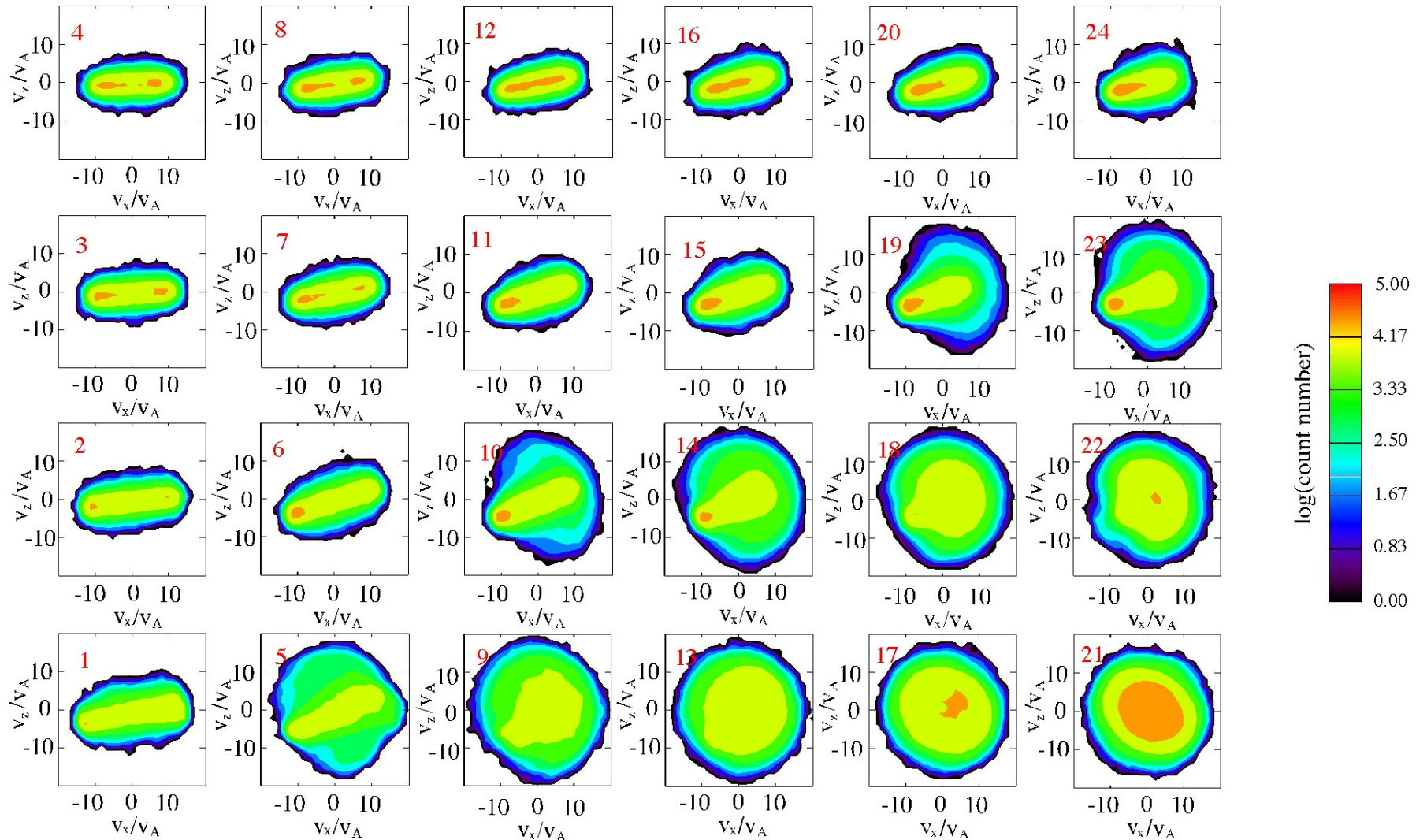
- Are they due to fast passages of X lines? No, because electrons are hot throughout the B pulse time.
- Are they due to localized current structures?
Yes!

Establish a map of electron distribution functions

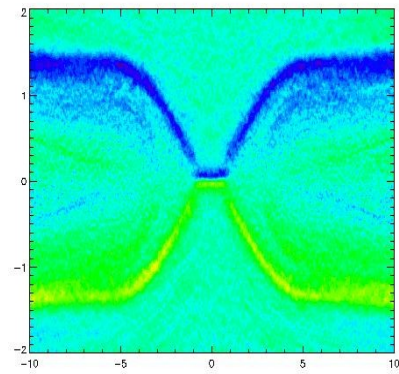
2D PIC



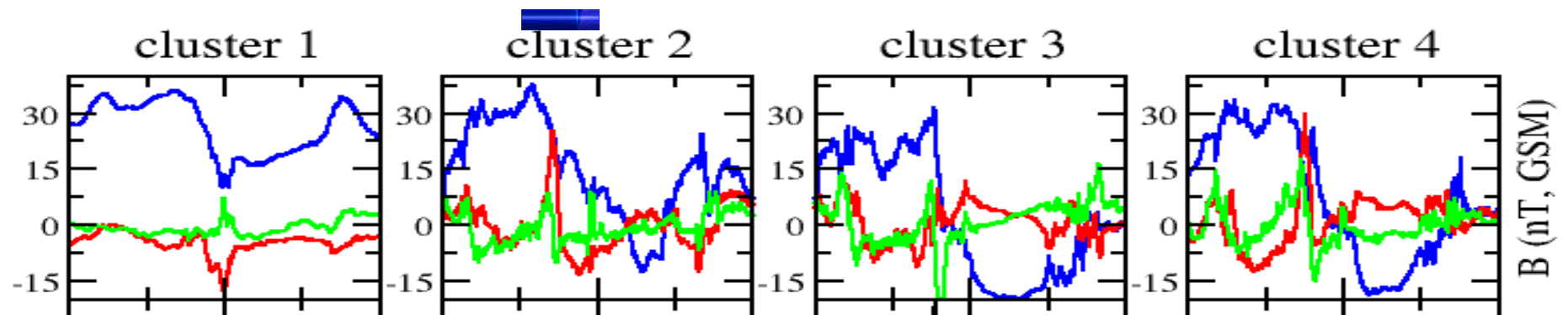
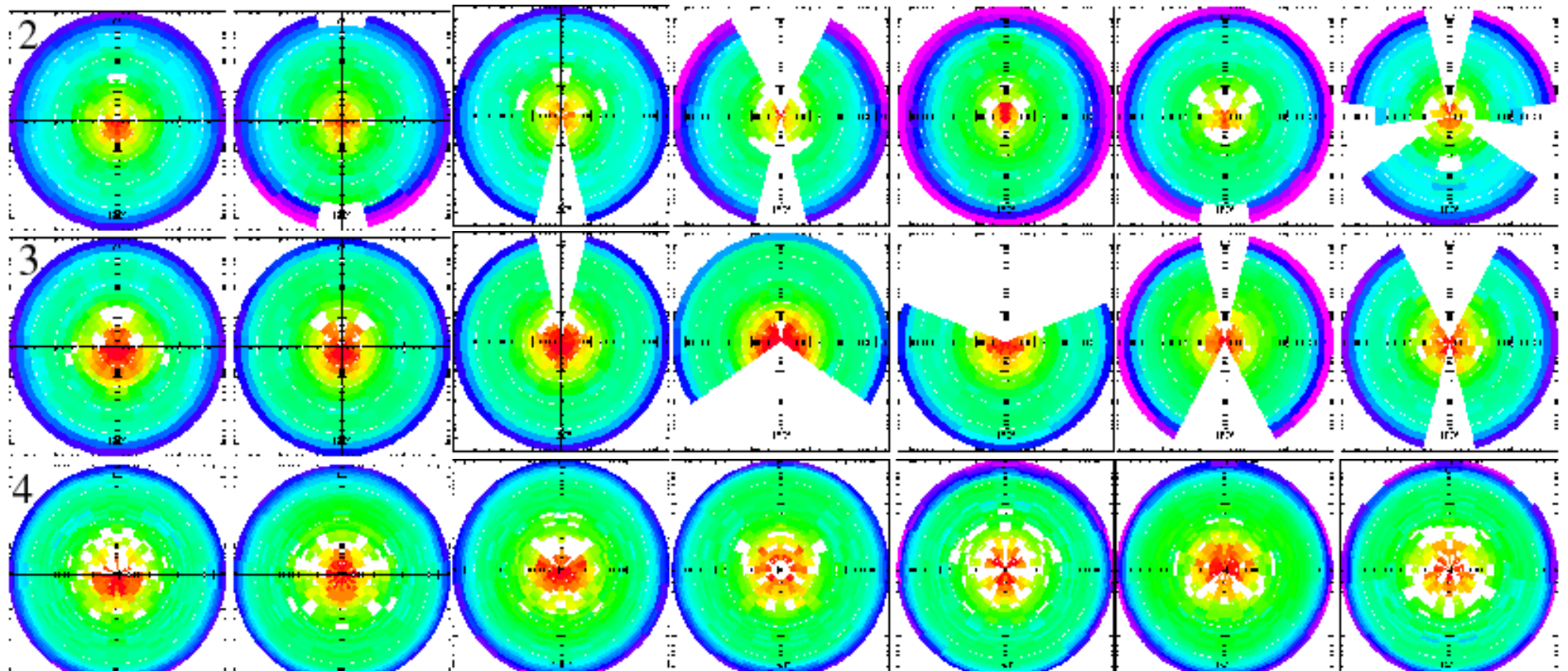
2D PIC results: cold vs. hot



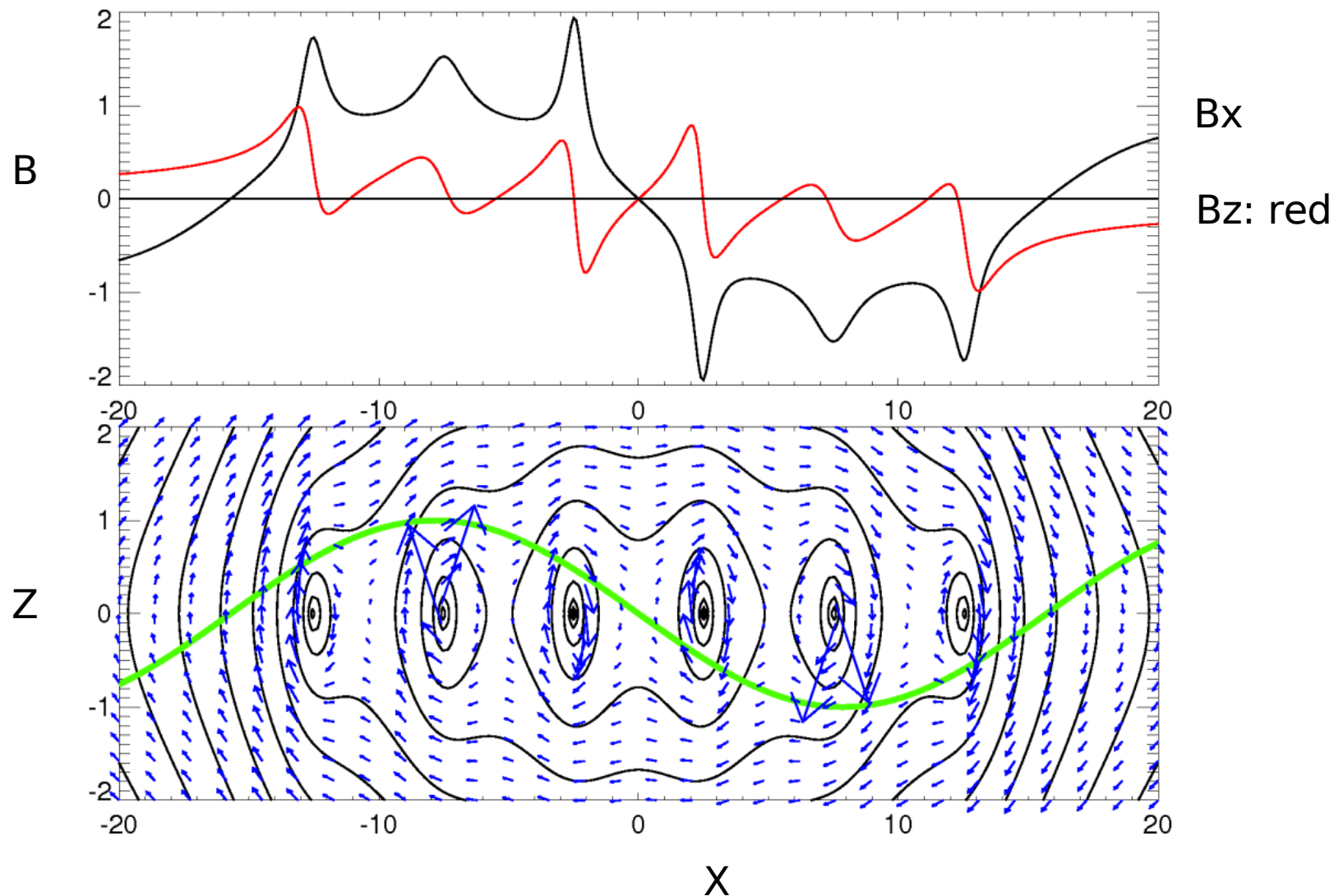
Electron distribution functions in $v_x - v_z$ plane



Electrons are hot within bipolar Bz pulses

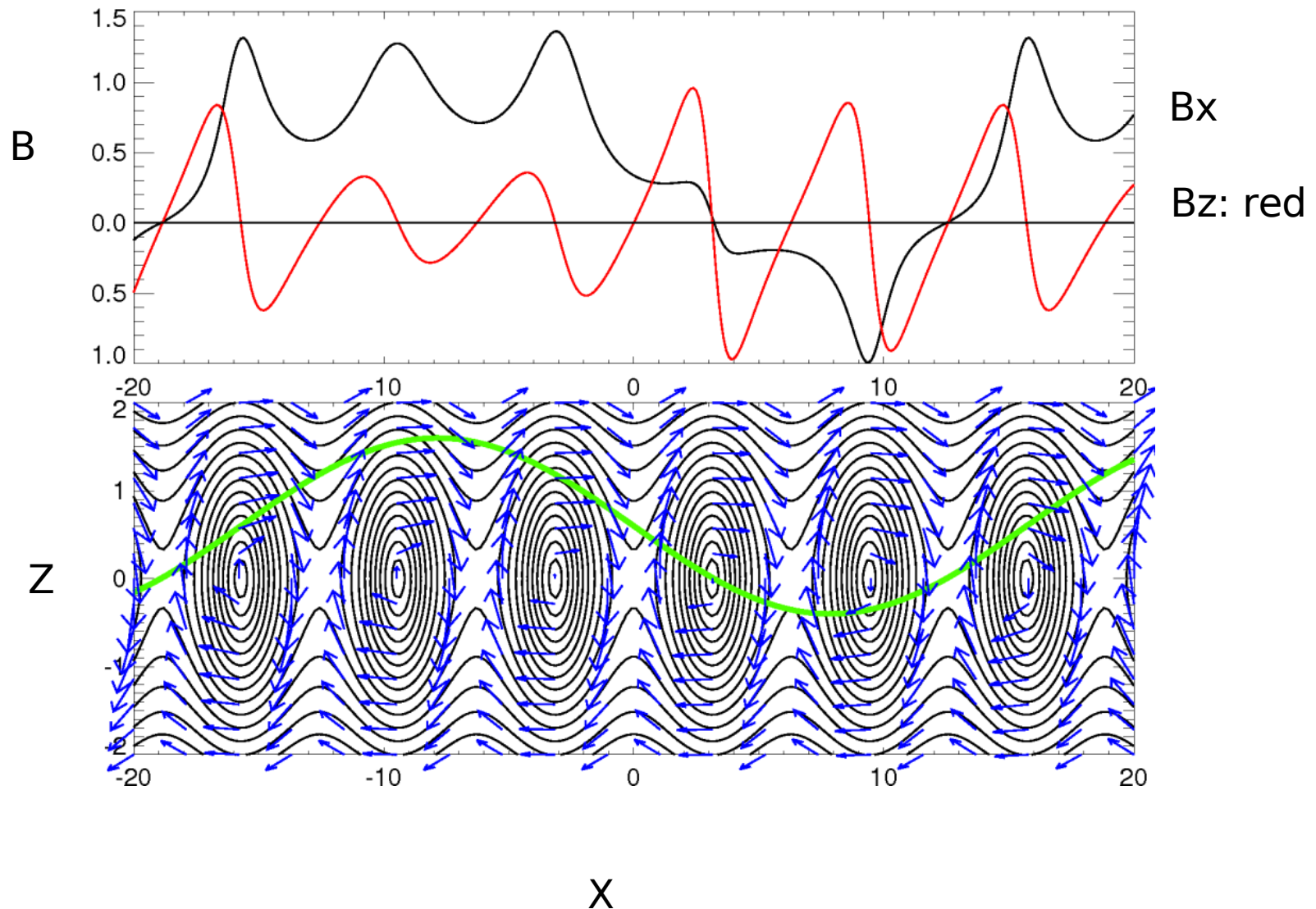


Harris Sheet + 6 line currents



If a periodic chain of islands...

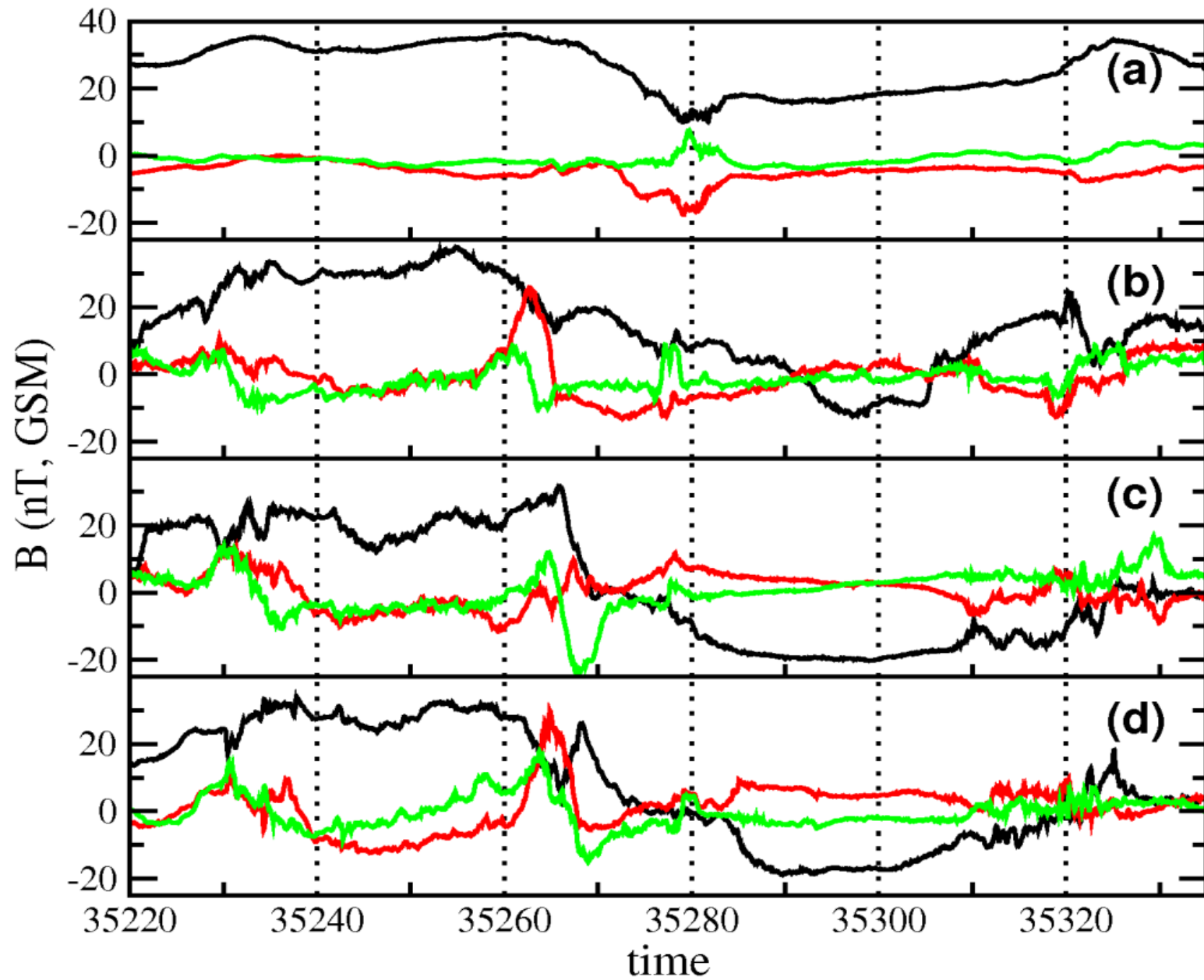
Fadeev solutions



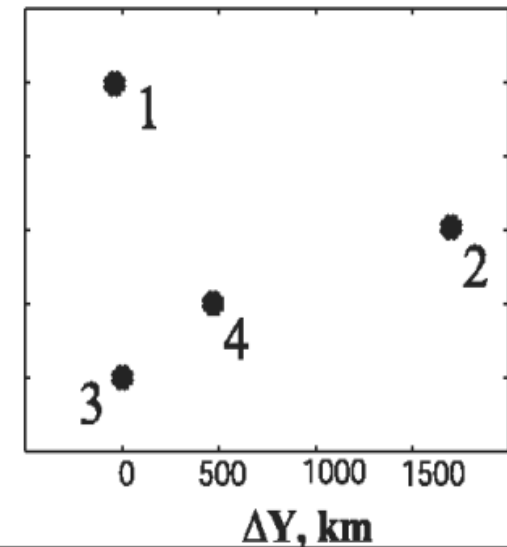
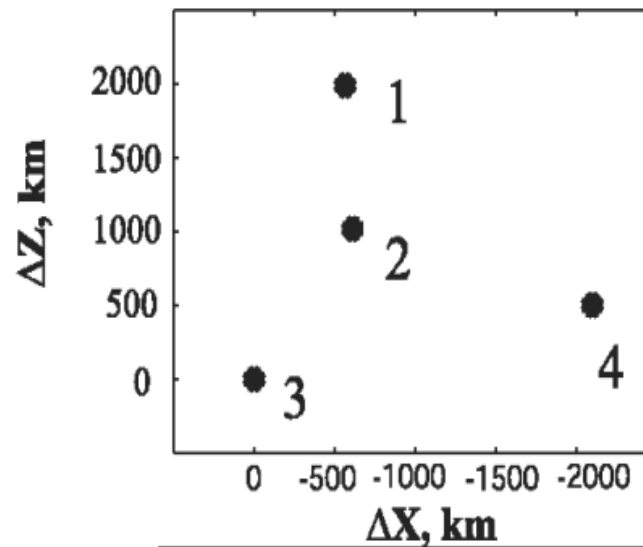
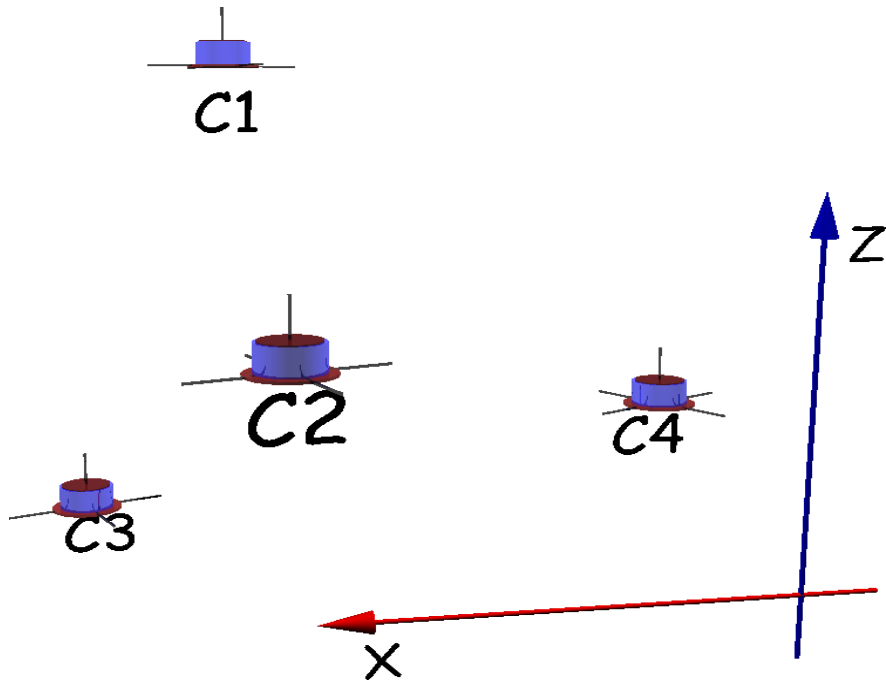
Learned from the simple models:

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

4 s/c view of B islands

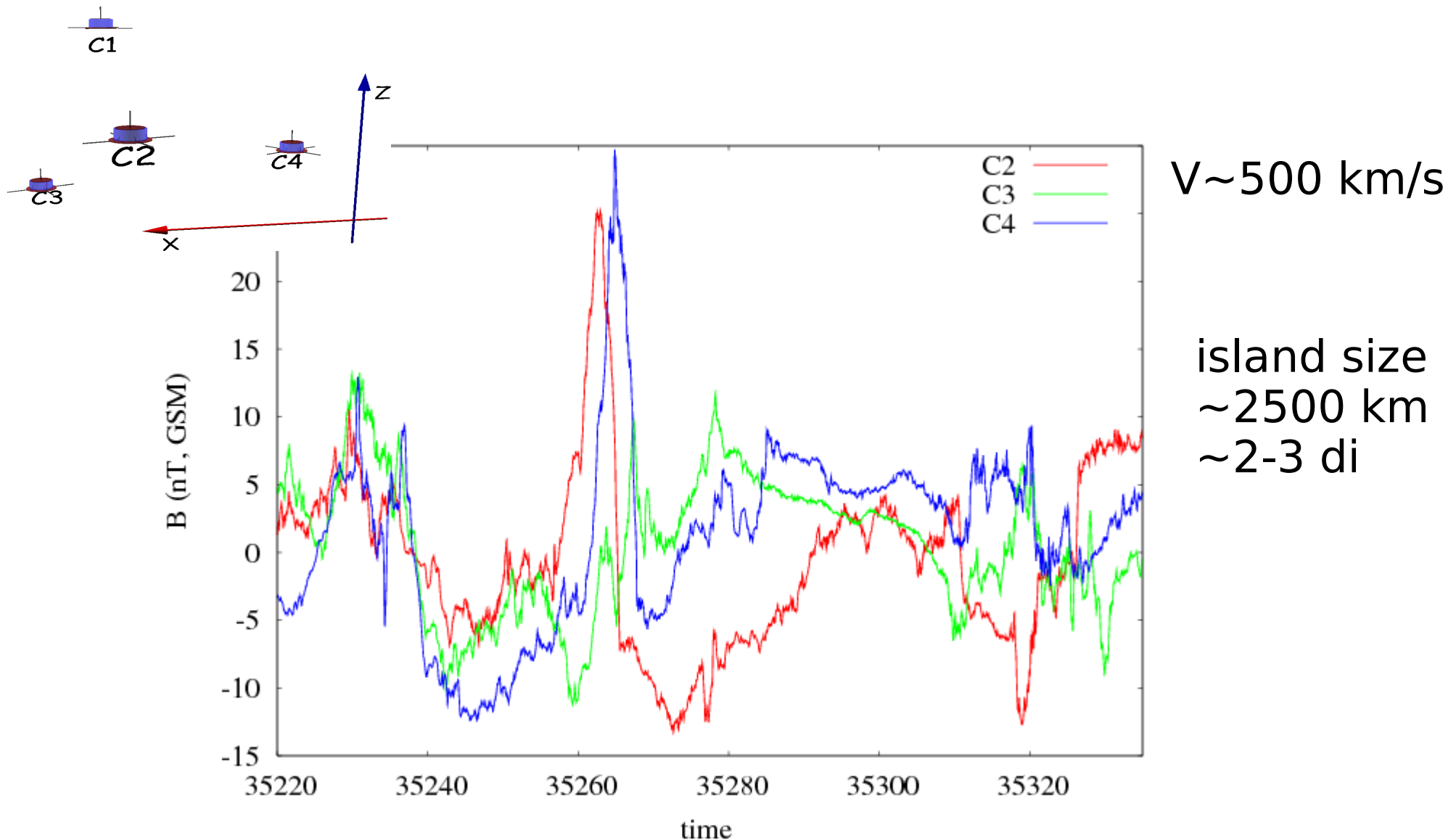


Cluster Positions

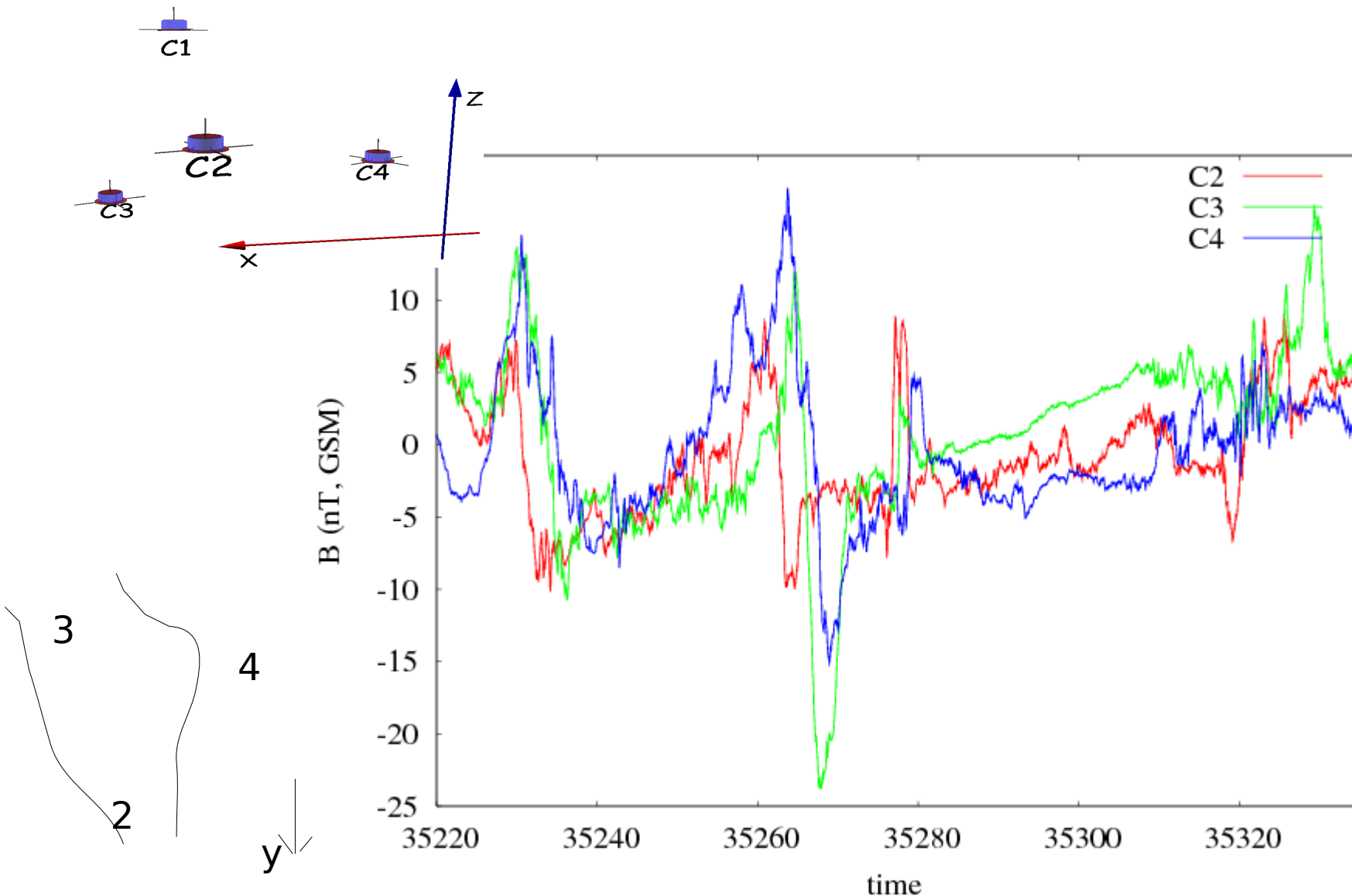


Runov et al., 2003

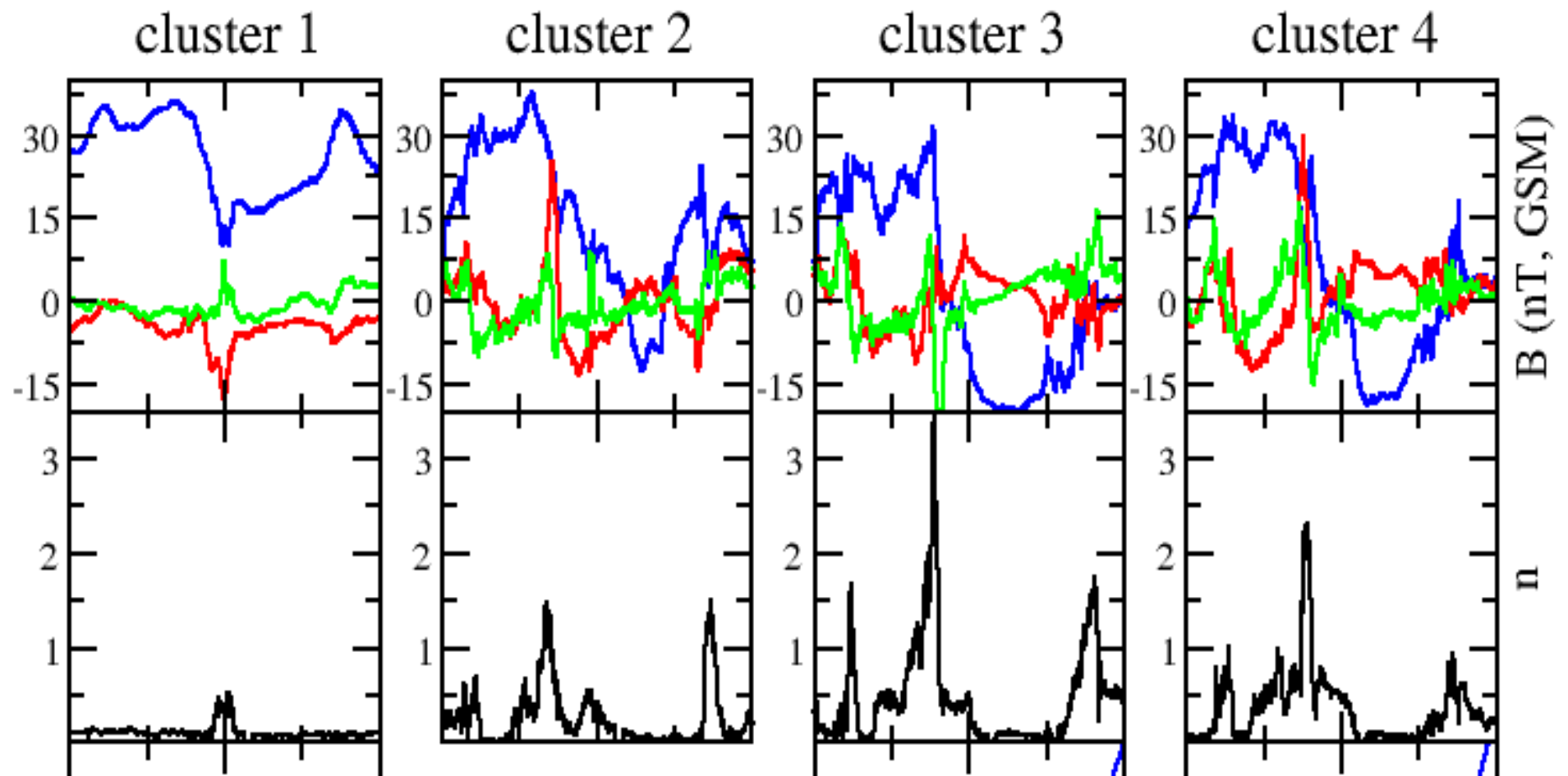
Core field correlation: C2 and C4



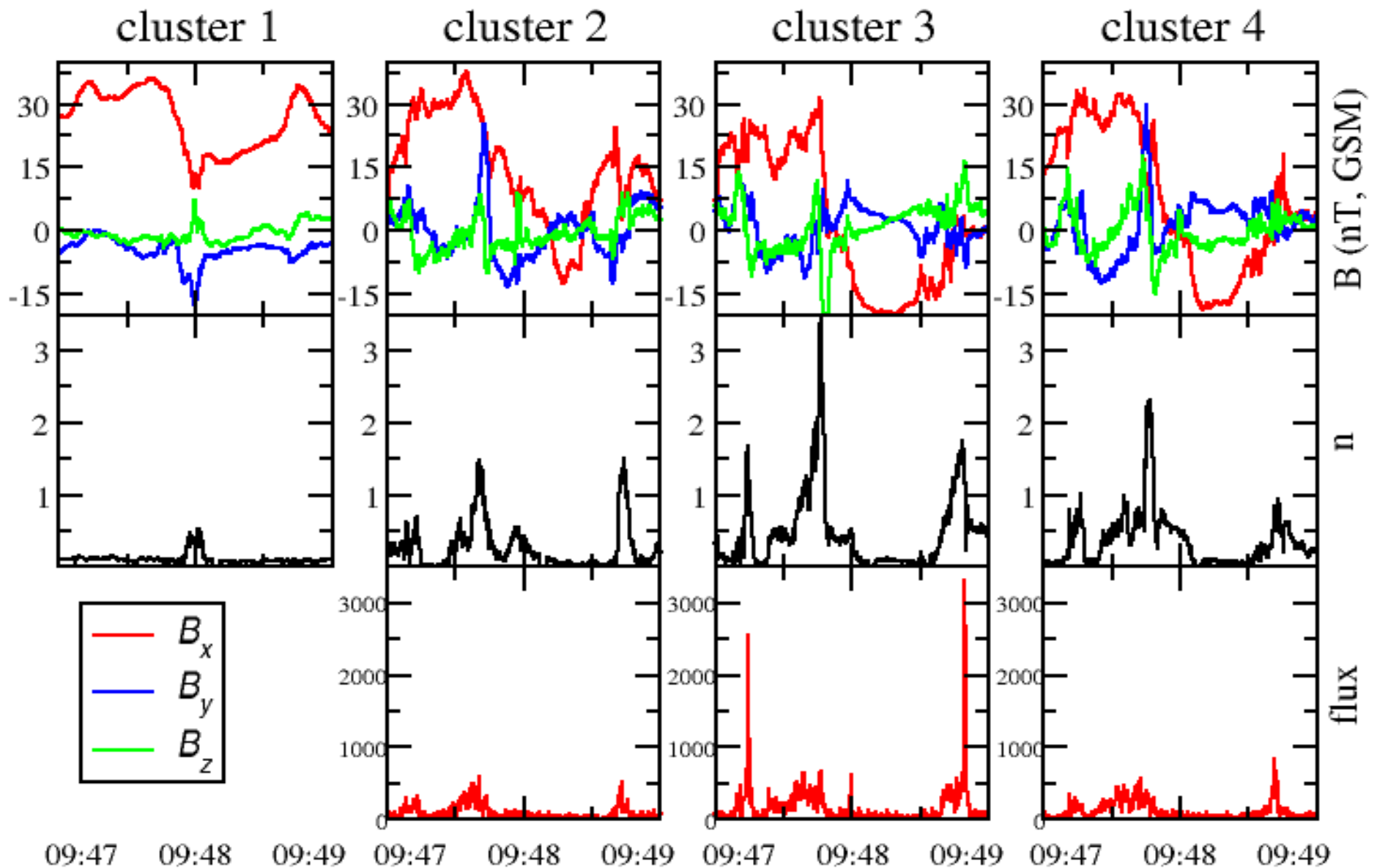
Bz correl. (C2,3,4): y dependence



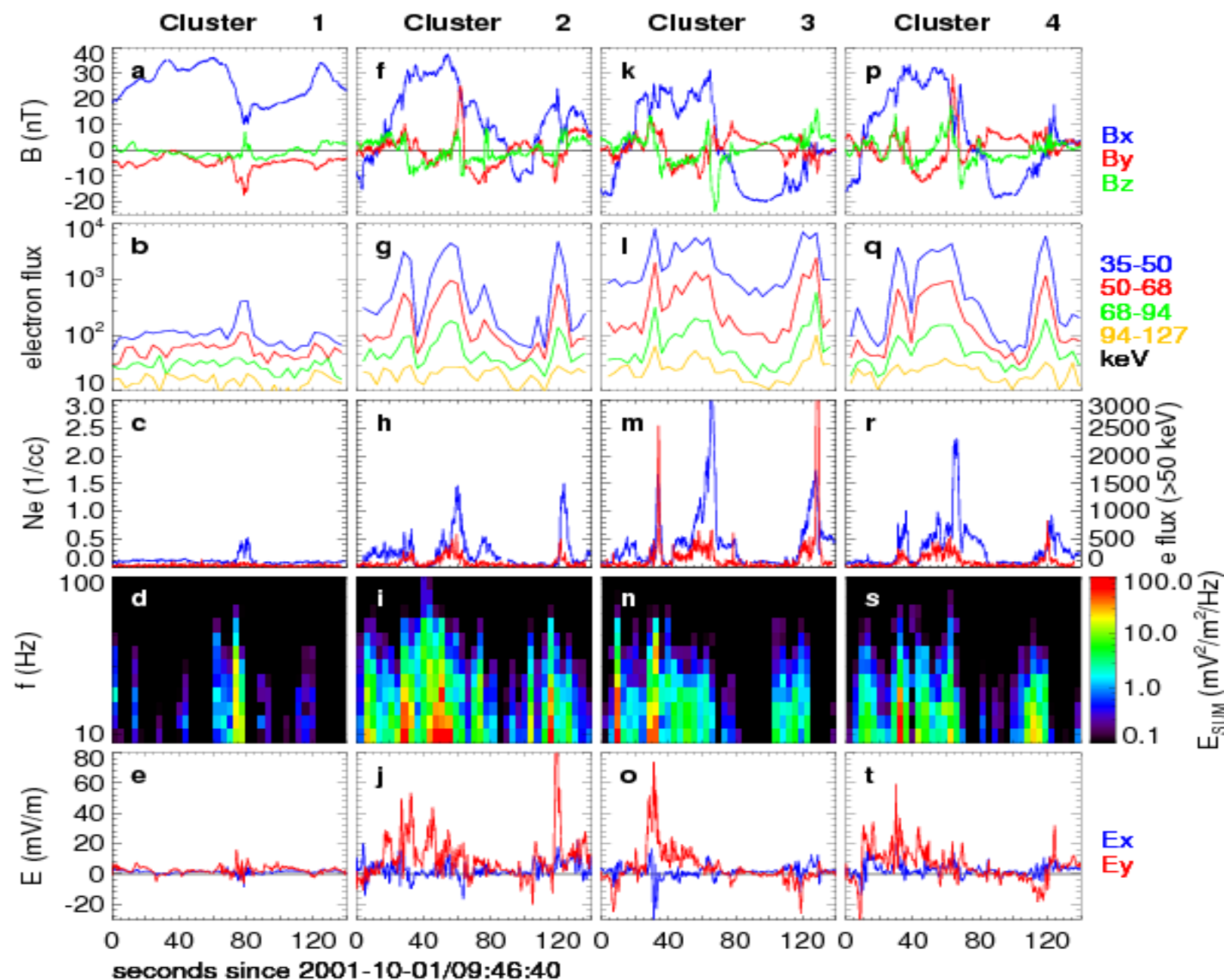
Density enhances within islands



Electron flux peaks at high n core



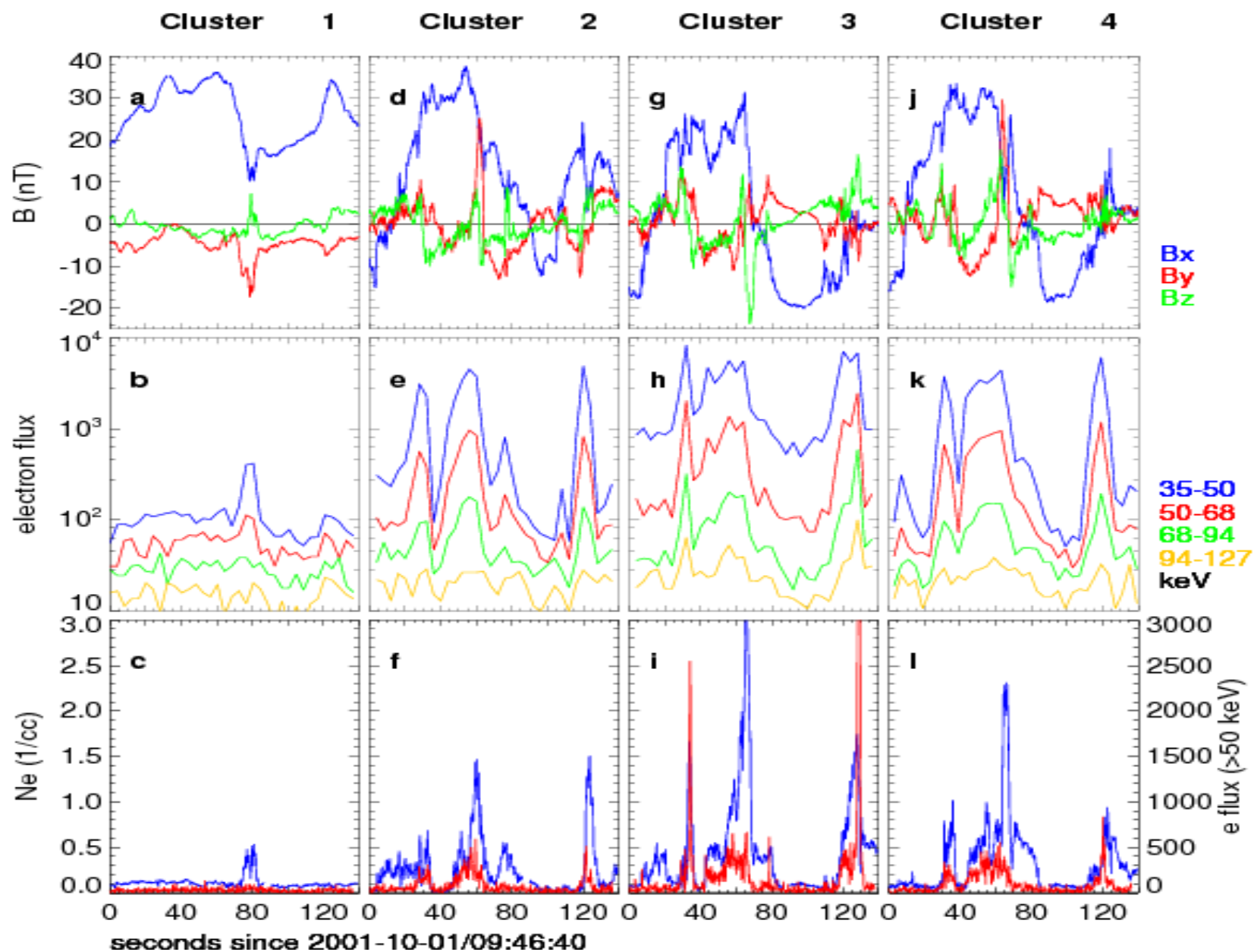
E fluctuations and DC E at one edge of islands

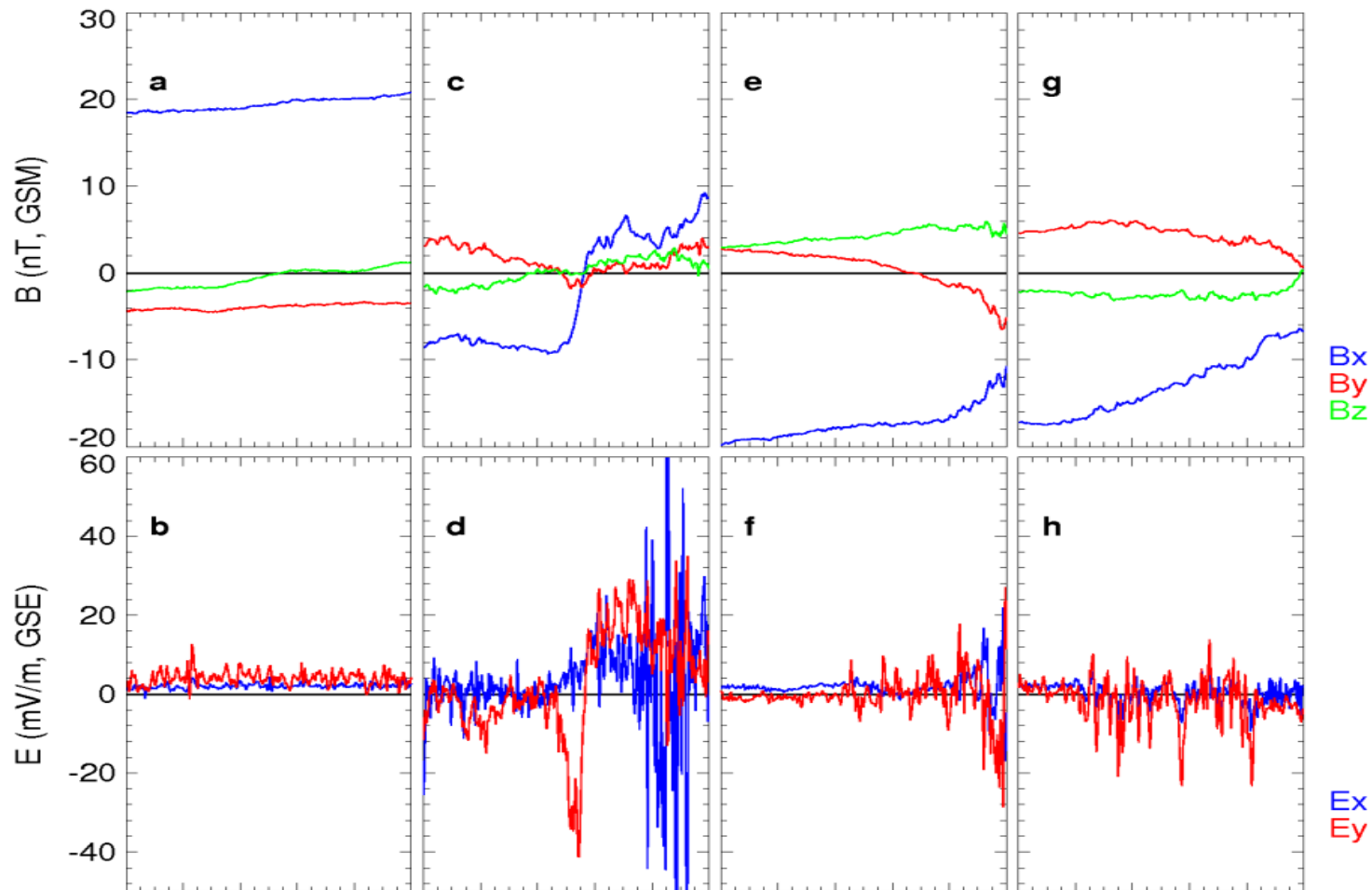
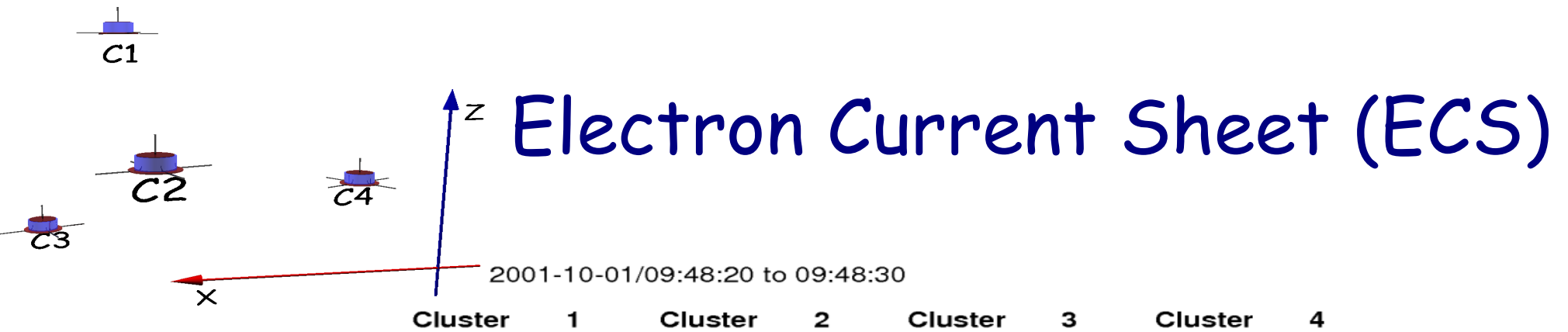


Sum. of observed island properties

- bipolar B_z
- unipolar B_y (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





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

Summary

- The flux of energetic electrons up to 100 keV peaks at the high density core within magnetic islands, a feature that has 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.