

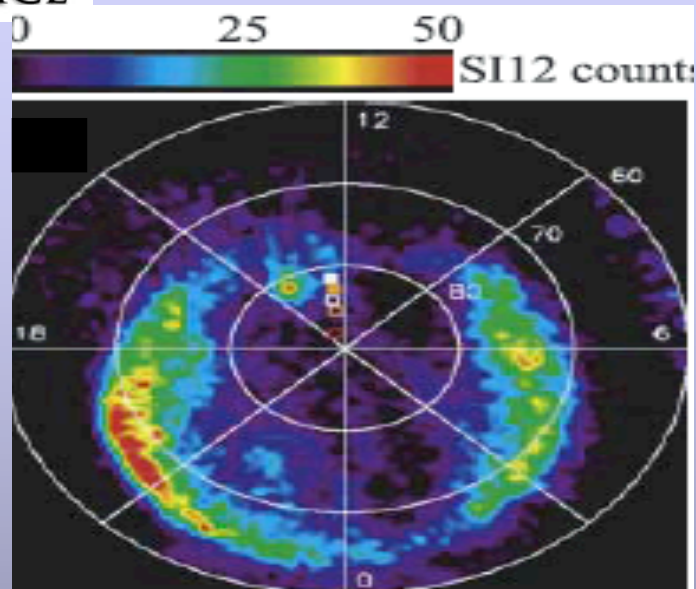


Cluster Electron Observations of Northward IMF Reconnection

P. H. Reiff, D. E. Wendel, A.
Fazakerley, M. Goldstein, E. Lucek



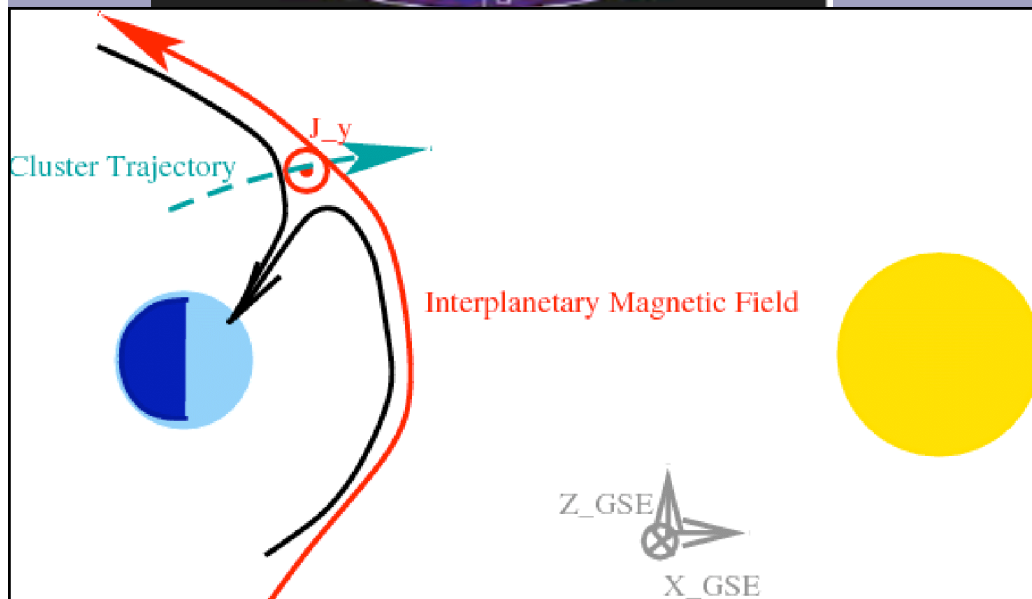
RICE



March 18, 2002

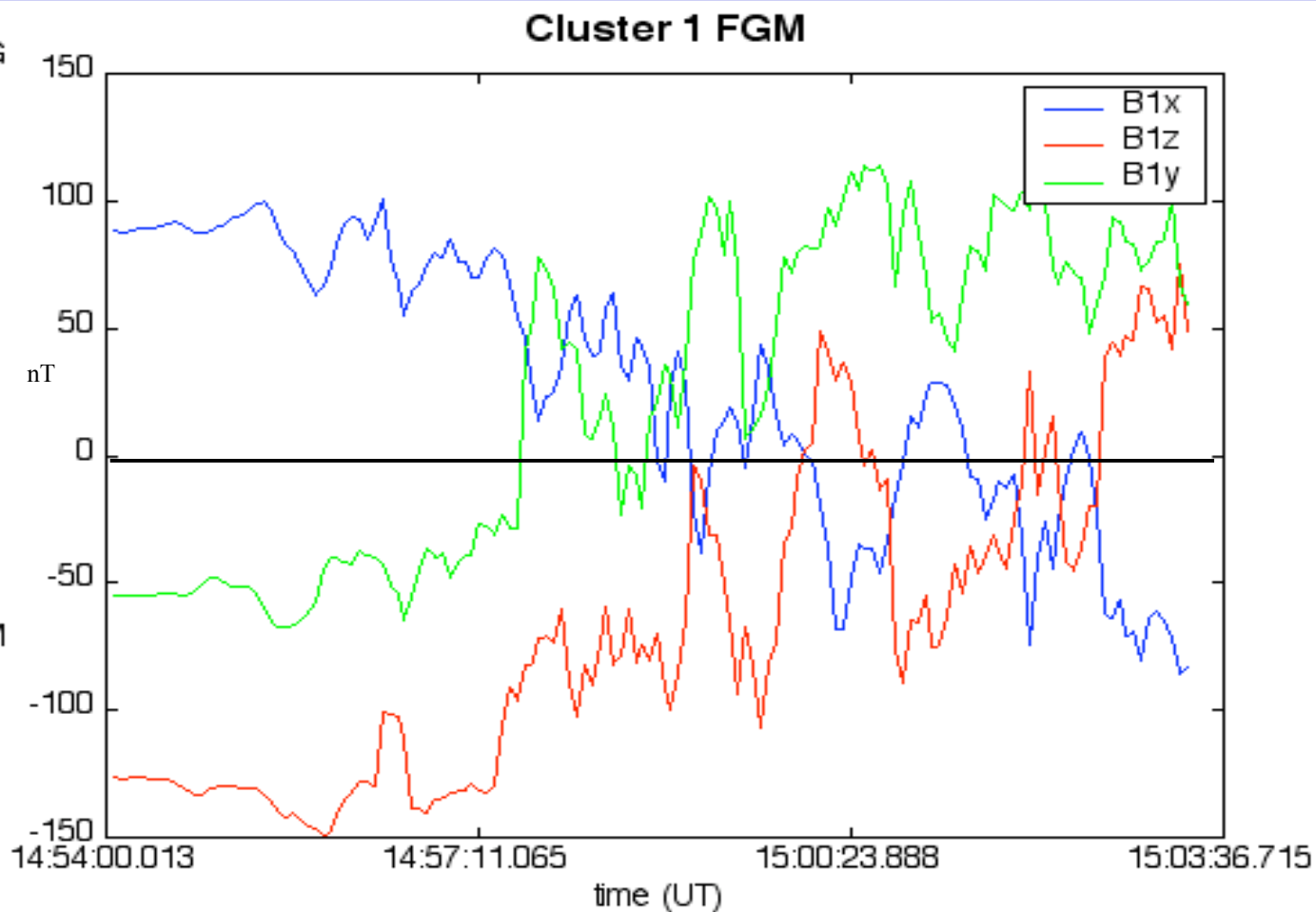
14:50 - 15:03 UT:

- Cluster traveled from the mantle northward and sunward into the magnetosheath
- Phan, et. al., mapped the location of cluster during its magnetopause crossing to the location of the ionospheric footprint observed by IMAGE.
- 81° lat. and 14 MLT, $\sim 6-7 R_E$





FGM (GSE): $\sim 60\text{-}70^\circ$ draping



Rotate data to magnetopause-aligned

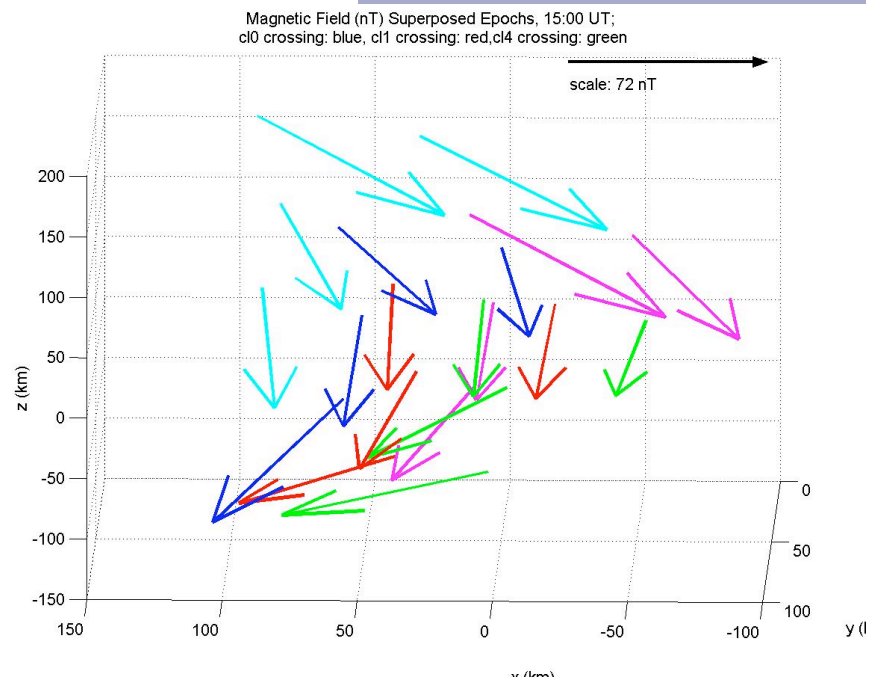
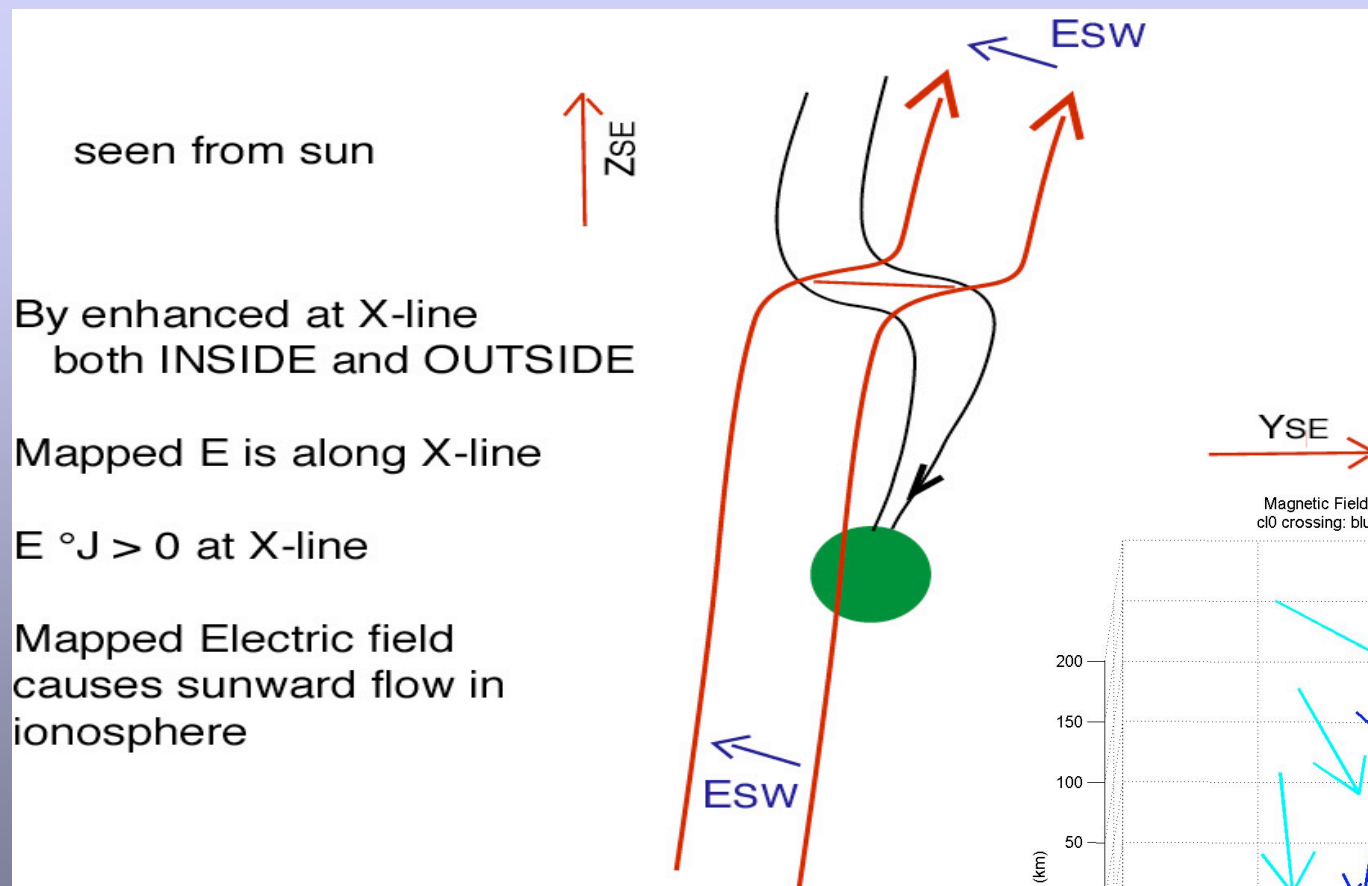
Coordinates (60 deg tilt)

Several crossings; one at 1500 is slowest with minimum fields

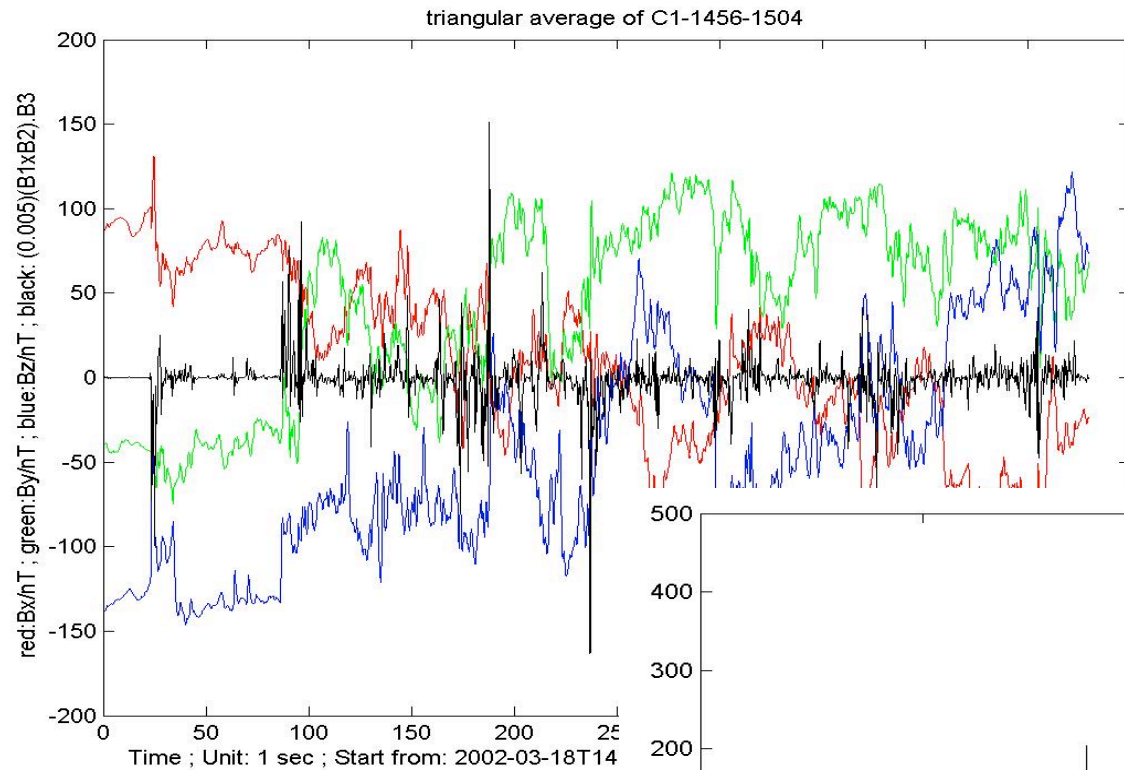
Note fields inside (left) and outside (right) are not exactly anti-parallel. Small B_y gets enhanced near the xline



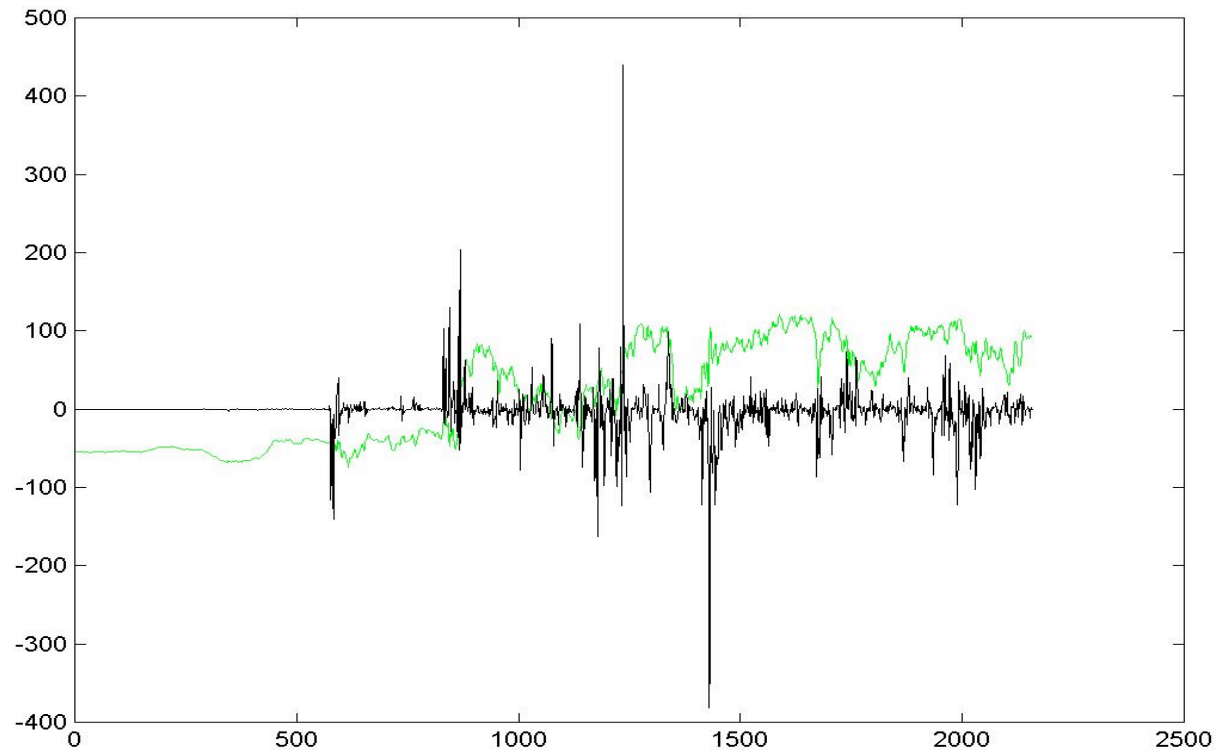
Topology: Rotation through B_y



Rotational Discontinuity Finder

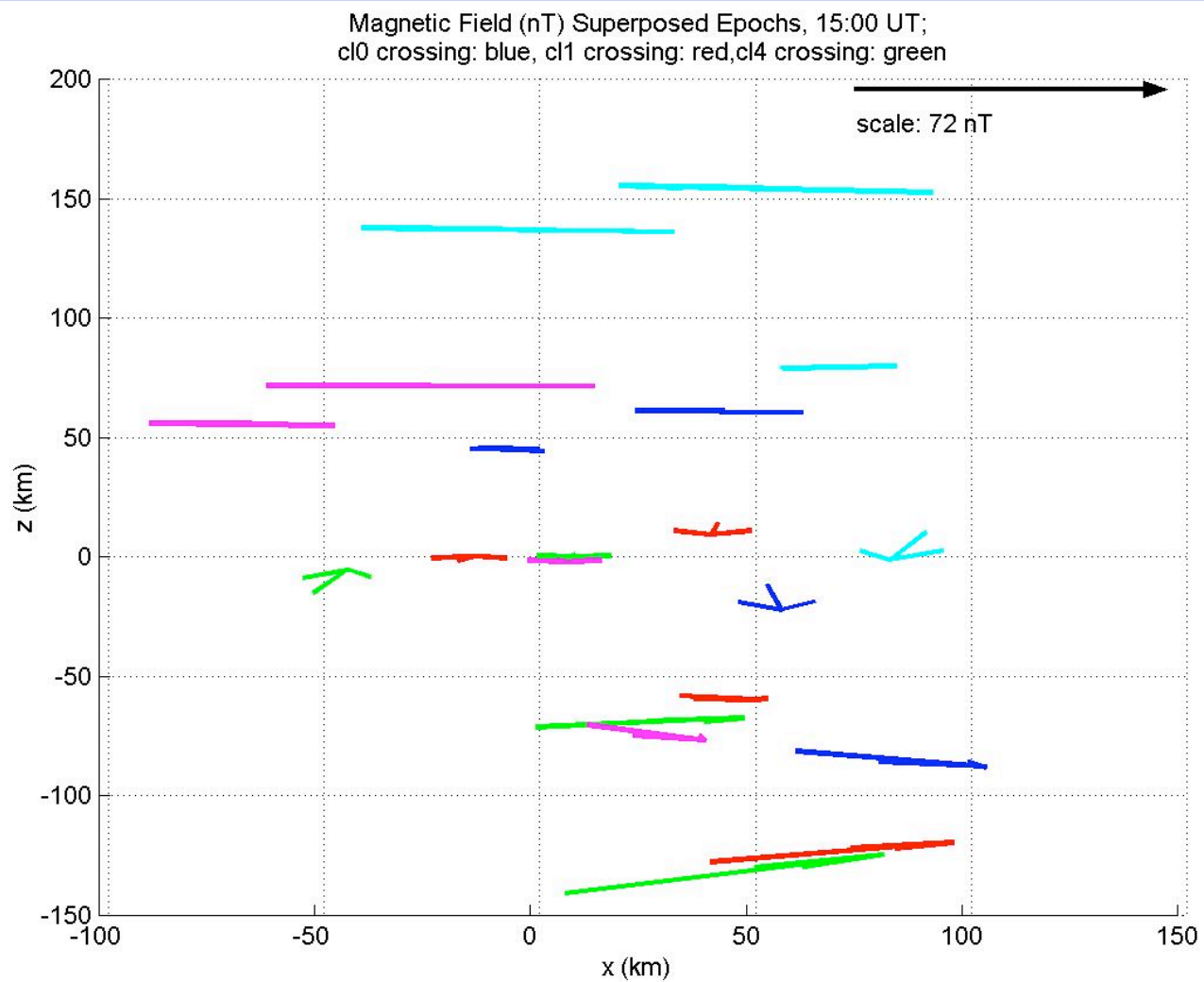


Black trace:
(Michel et al)
 $(B_1 \times B_2) \cdot B_3$



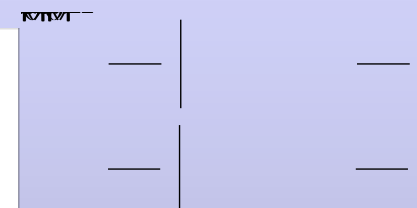
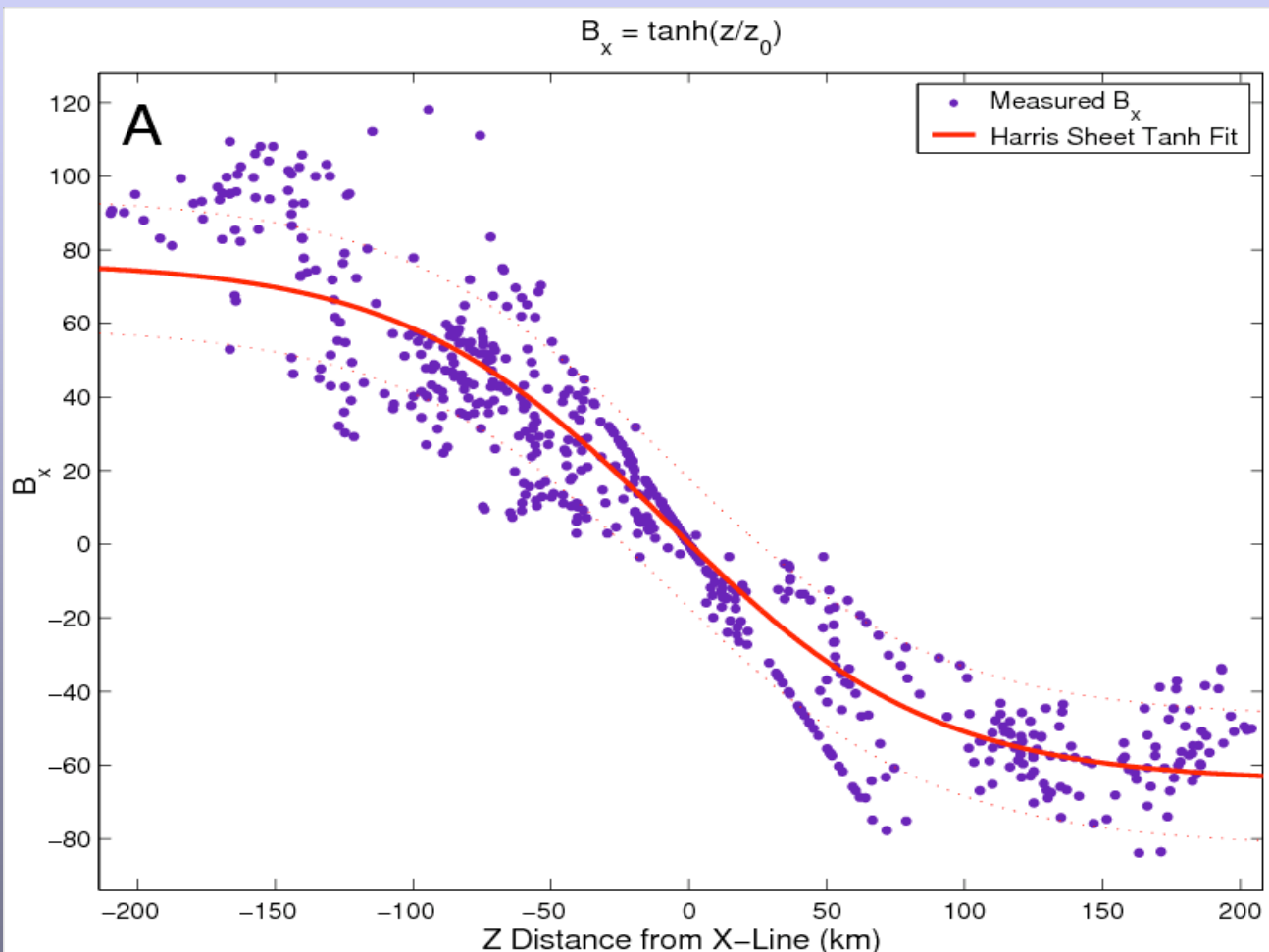


X-Line Structure Superposed Epochs





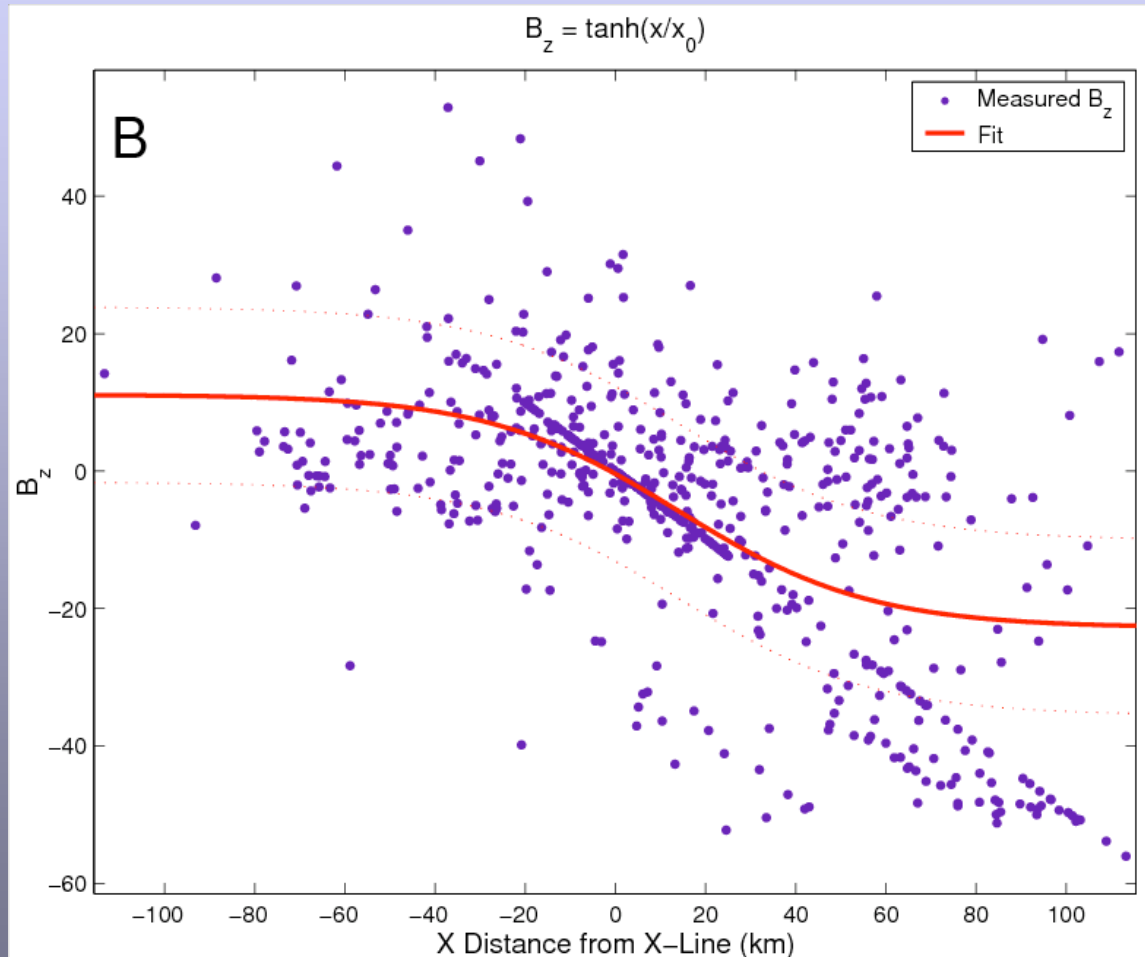
X-Line Structure: Harris Sheet Fit ($B_x(z)$)



Current sheet thickness:
~85 km



X-Line Structure: Harris Sheet Fit: $B_z(x)$



Normal component more difficult because of low-frequency boundary waves which are also occurring but is roughly 10 nT



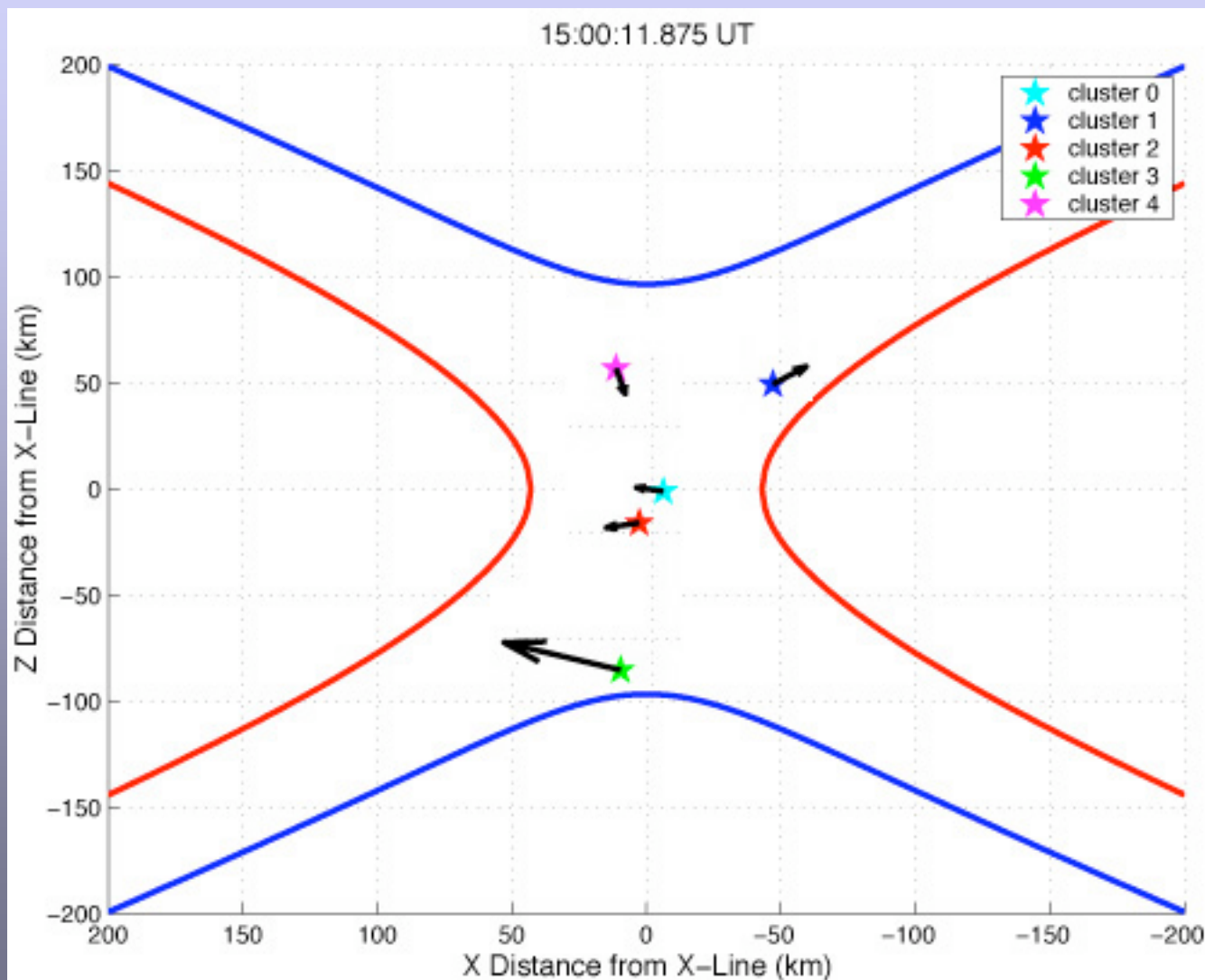
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X-Line Structure and Motion

X-line frame
Determined
from the Harris
fits

The s/c with the
smallest
measured field
is used to place
the entire group

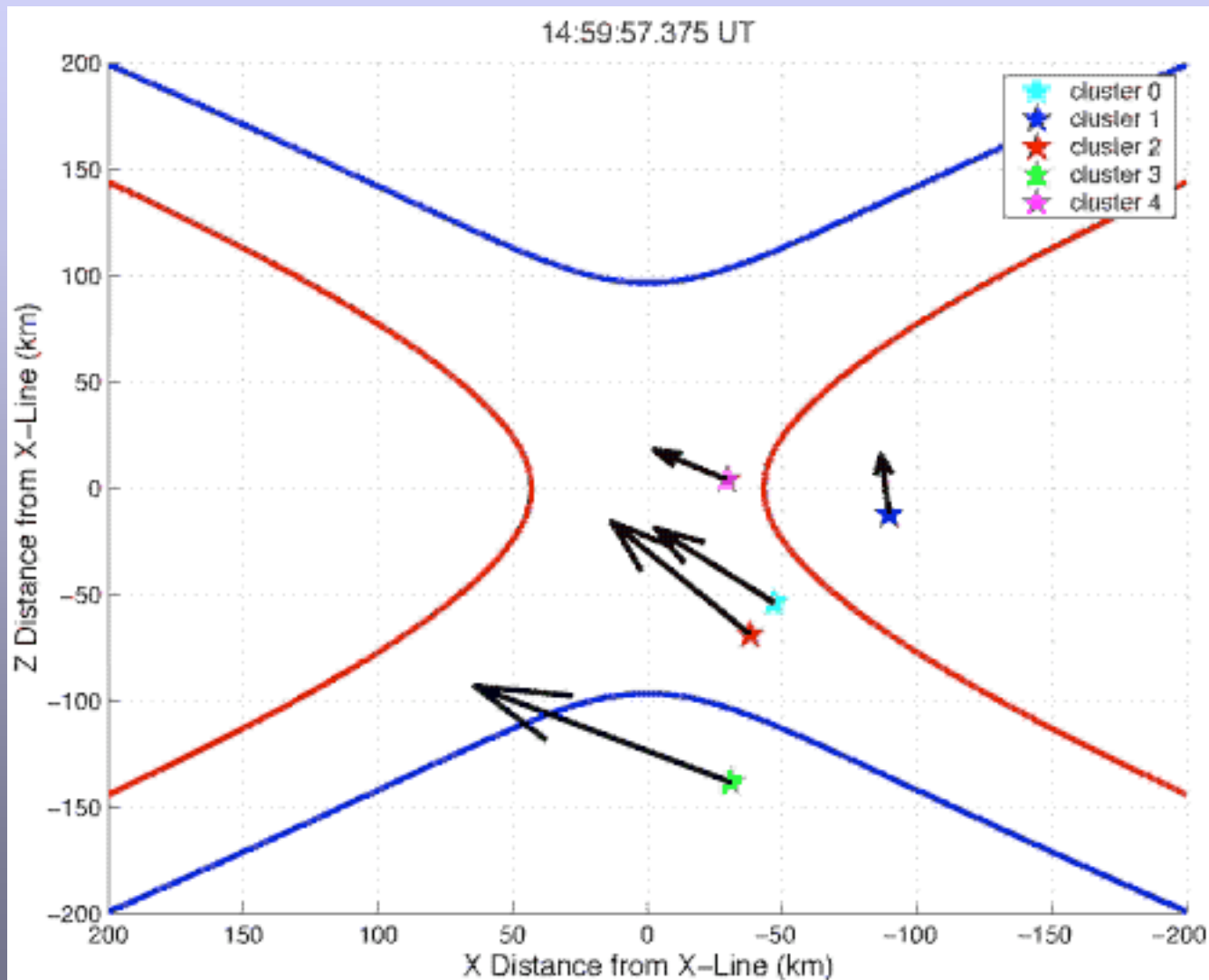
Xline appears
instantaneously!





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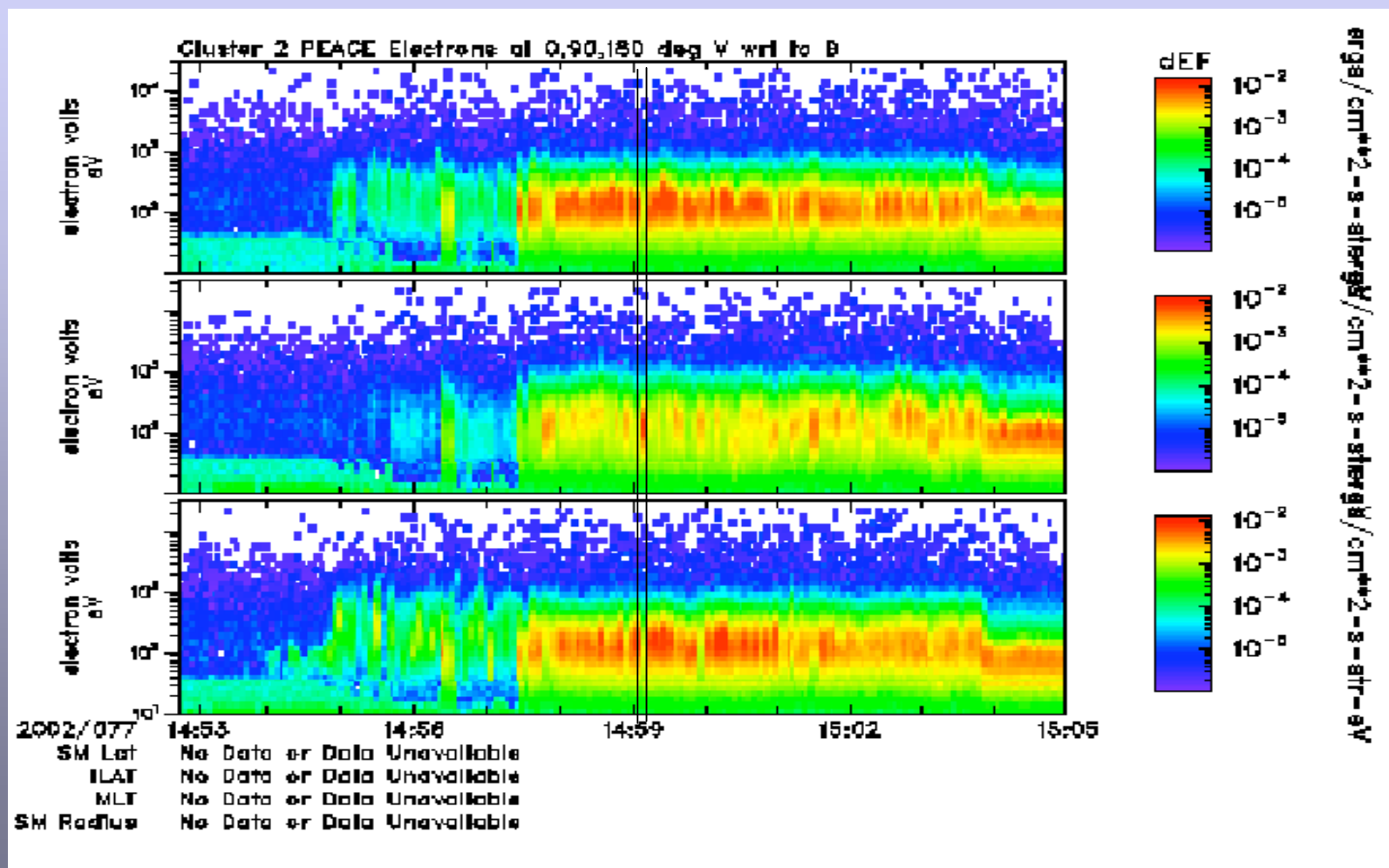
X-Line Structure and Motion



Movie of
Xline structure
and motion
available from
<http://space.rice.edu/cluster>



Perpendicular Electron Flows



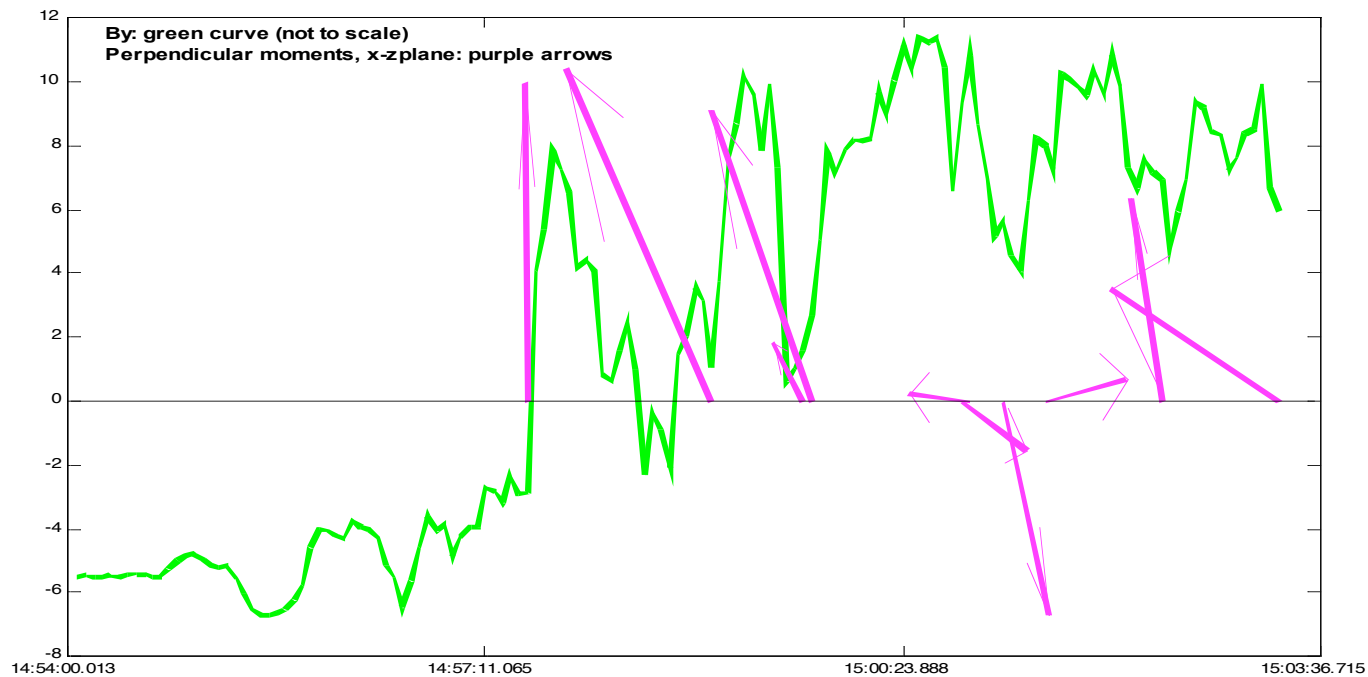
3D distributions show it is a real flow, not pancake distribution



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Ion Diffusion Region ?

Strong electron flows (purple) at edges of B_y enhancement

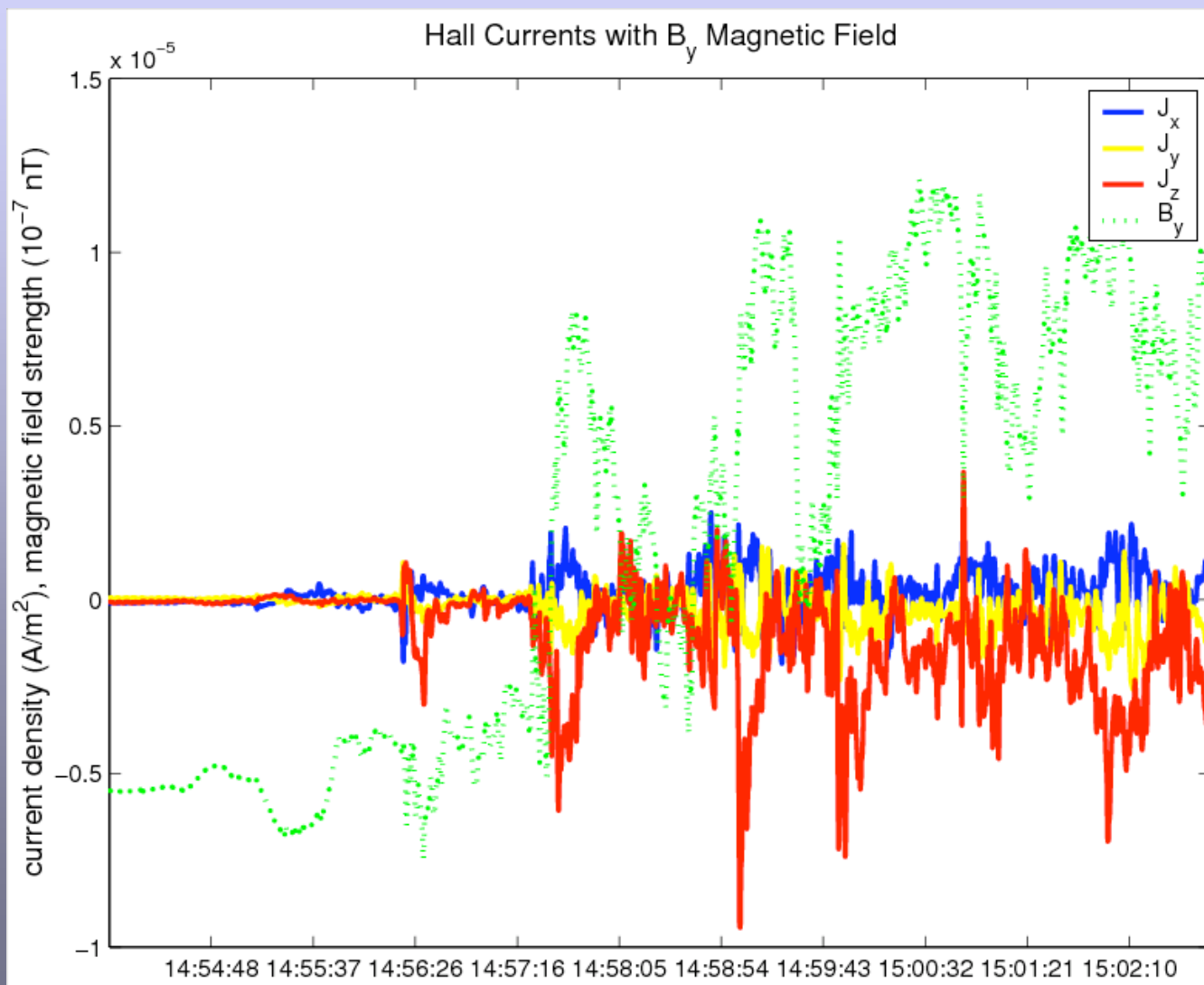


$$\mathbf{E}' = \mathbf{E} + \mathbf{v} \times \mathbf{B} / c = \mathbf{j} / \sigma + \frac{m_e}{ne^2} \left[\frac{\partial \mathbf{j}}{\partial t} + \nabla \cdot (\mathbf{v} \mathbf{j} + \mathbf{j} \mathbf{v}) \right] - \frac{\mathbf{j} \times \mathbf{B} / c}{ne} - \frac{\nabla \cdot \mathbf{p}_e}{ne}$$

↓ collisions
↓ Electron inertial terms
↓ Hall term (ion inertial)
↓ Electron total pressure term

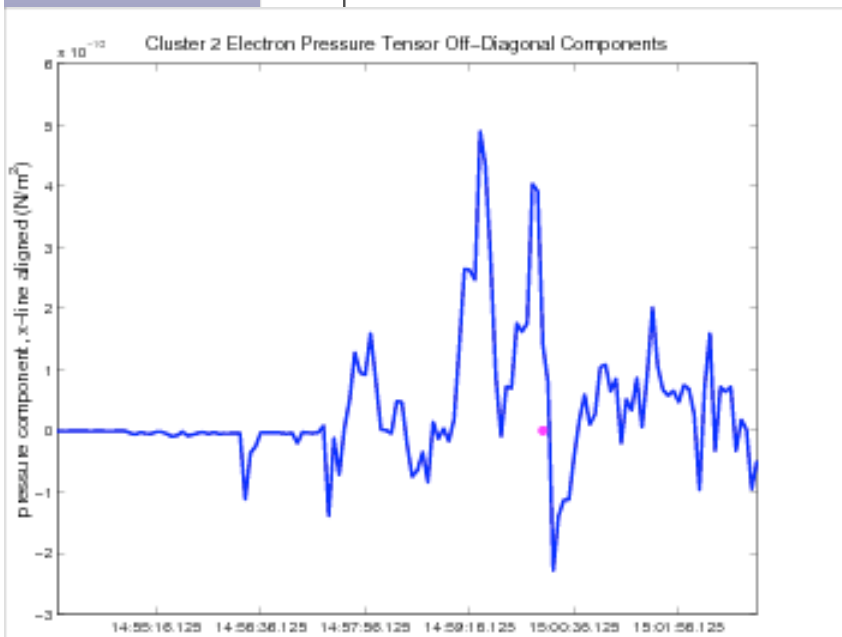
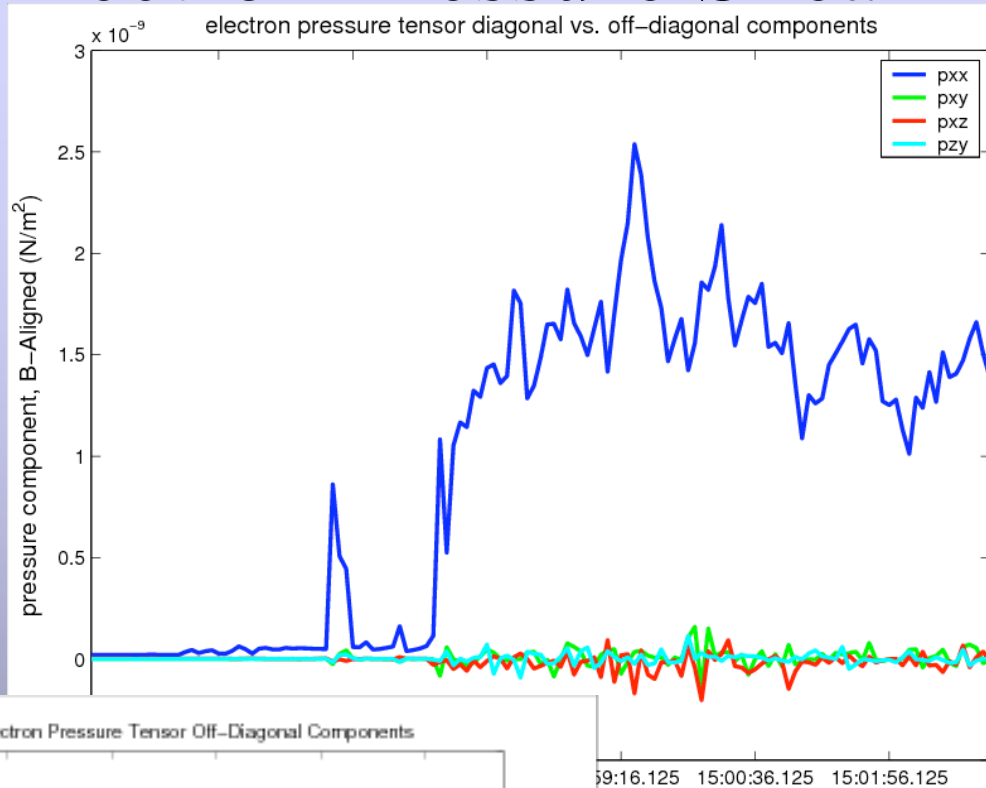


Curlometer Current \implies Hall Current?





Electron Pressure Shear



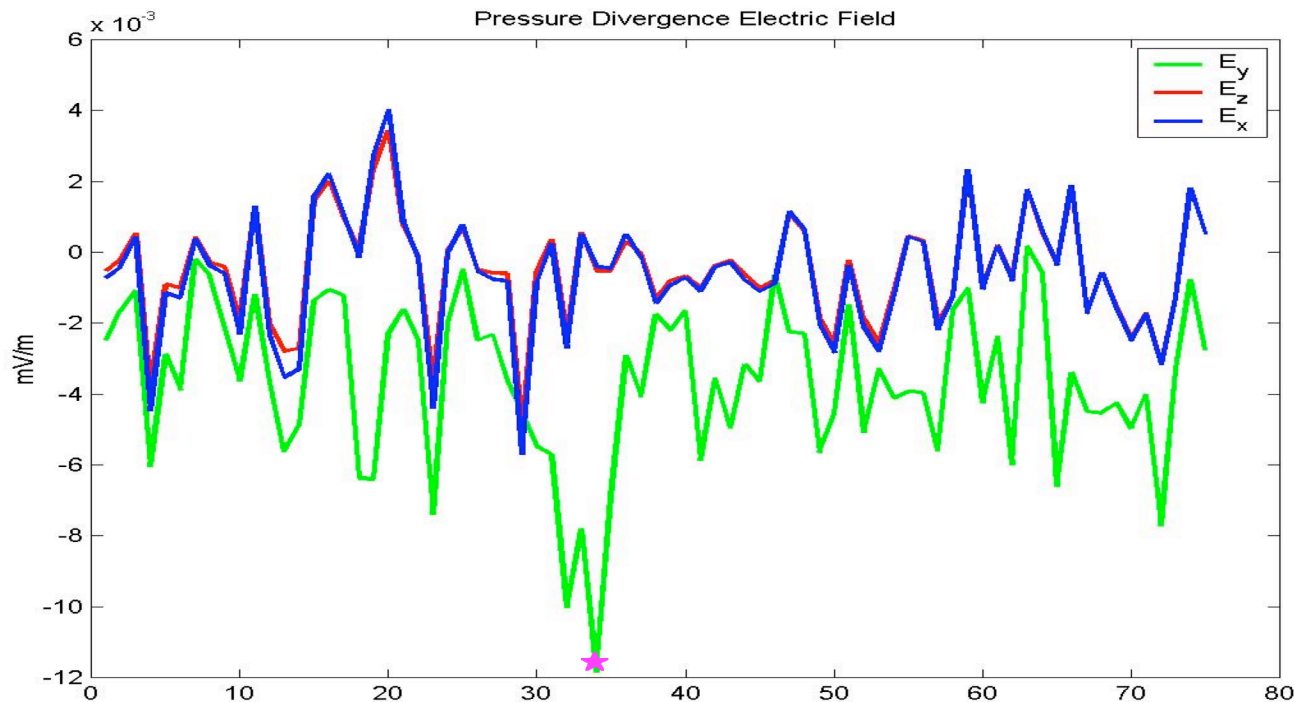
– Electron pressure tensor (symmetric tensor) off-diagonal component P_{xy} ($= P_{yx}$) in magnetopause-aligned coordinate system

- has magnitude $\sim 15\%$ diagonal terms
- has expected asymmetry

- slowly rotates from y to x via B_z
- then magnetized and symmetric with respect to B
- odd symmetry owing to change in sign of B_z



Pressure Divergence Electric Field



-12 mV/m
 -15% of Hall
 electric field
 $-.3v_A B_0$

$$\mathbf{E}' = \mathbf{E} + \mathbf{v} \times \mathbf{B} / c = \underbrace{\mathbf{j} / \sigma}_{\text{collisions}} + \frac{m_e}{ne^2} \left[\frac{\partial \mathbf{j}}{\partial t} + \underbrace{\nabla \cdot (\mathbf{v}\mathbf{j} + \mathbf{j}\mathbf{v})}_{\text{Electron inertial terms}} \right] - \frac{\mathbf{j} \times \mathbf{B} / c}{ne} - \frac{\nabla \cdot \mathbf{p}_e}{ne}$$

Hall term (ion inertial)
Electron total pressure term

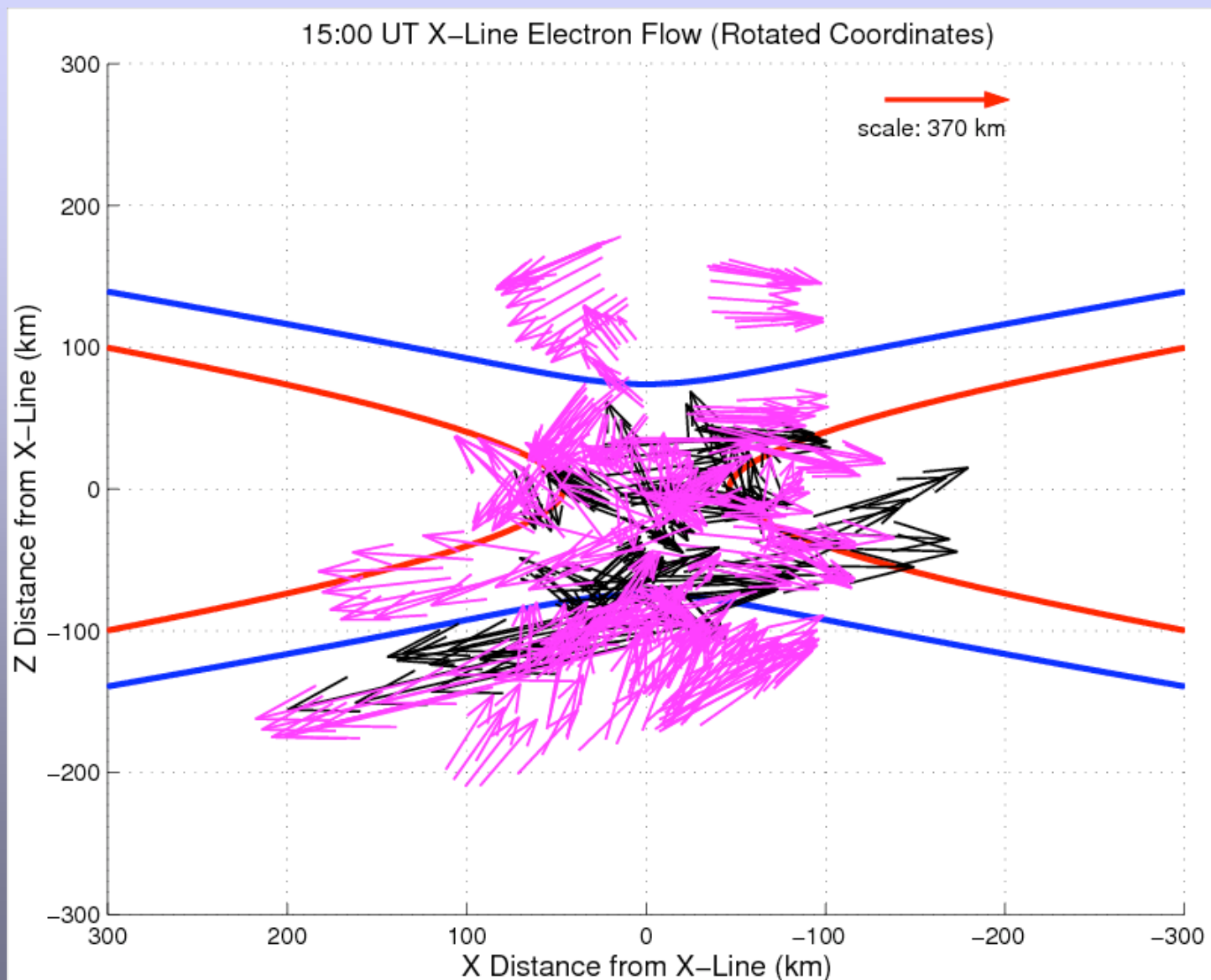


Superposed Electron Flows

Accelerated
Flows along
the xline
near the xline

Purple has a
component
along -y

black a
component
along +y (-E)





Summary

- Magnetic Field structure and electron flows consistent with reconnection structure (overdraped lobe possible to explain exterior flow)
- (Nearly) anti-parallel reconnection with out-of-plane component that enhances during crossing
- Single X-Line oscillates but does not fly tailward
- Current Sheet ~ 85 km thick
- Cluster spacecraft comes within ~ 1 km of x-line.
 - Inside Ion diffusion region
 - Electron demagnetization and offdiagonal pressure seen



Backup



J_y Curlometer Current

