UCL

Small Scale Magnetic Reconnection in the Solar Wind.

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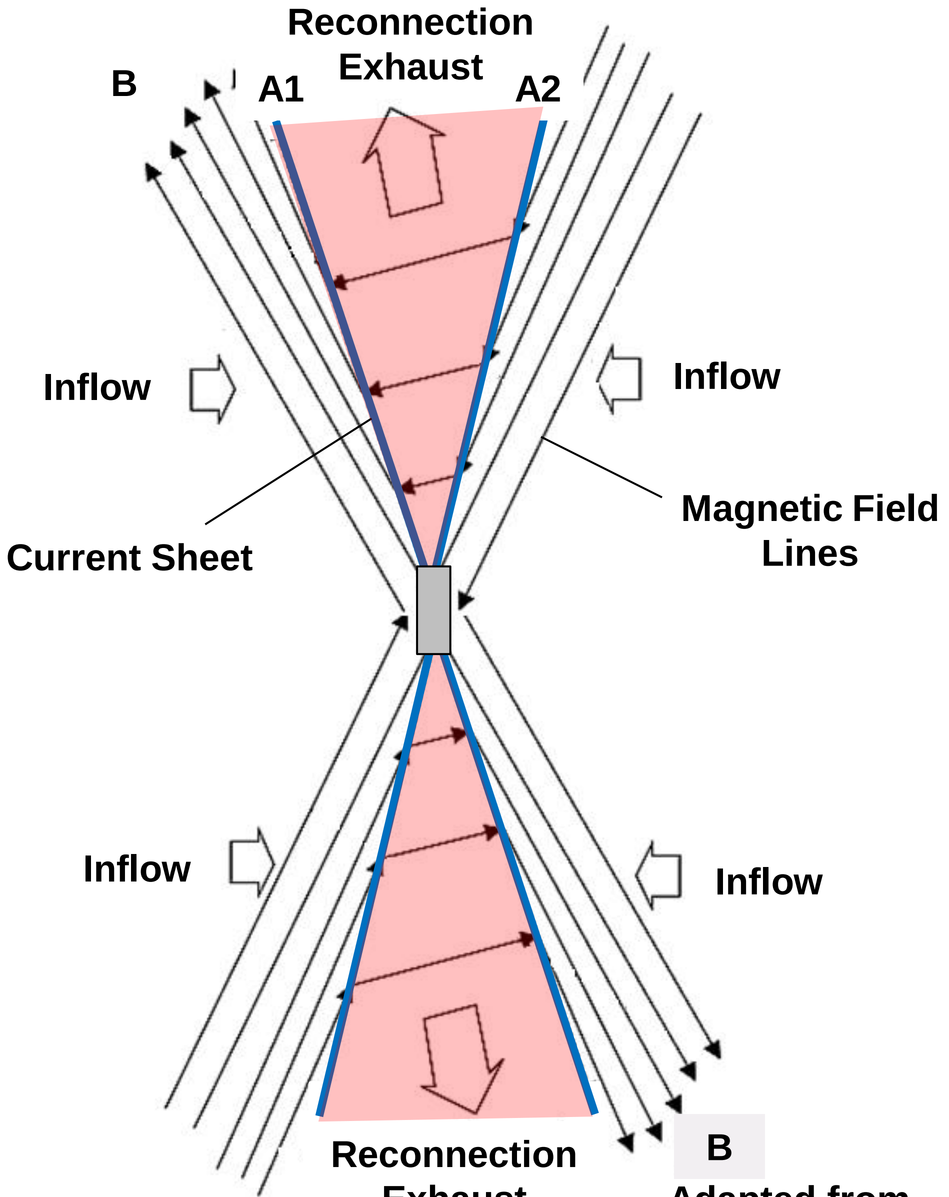
4. Cluster Active Archive

- First published study of solar wind reconnection made by Gosling, 2005.
- Bifurcated current sheet
- Magnetic field rotations over current sheets
- Enhanced plasma jet / reconnection exhaust
- Events seen by multiple widely separated spacecraft



Adapted from Gosling, J.T. (2005)

Aim of Project

- A statistical study of 50 events has suggested that reconnection in the solar wind is fundamentally extended and non patchy.

- Is this always the case?

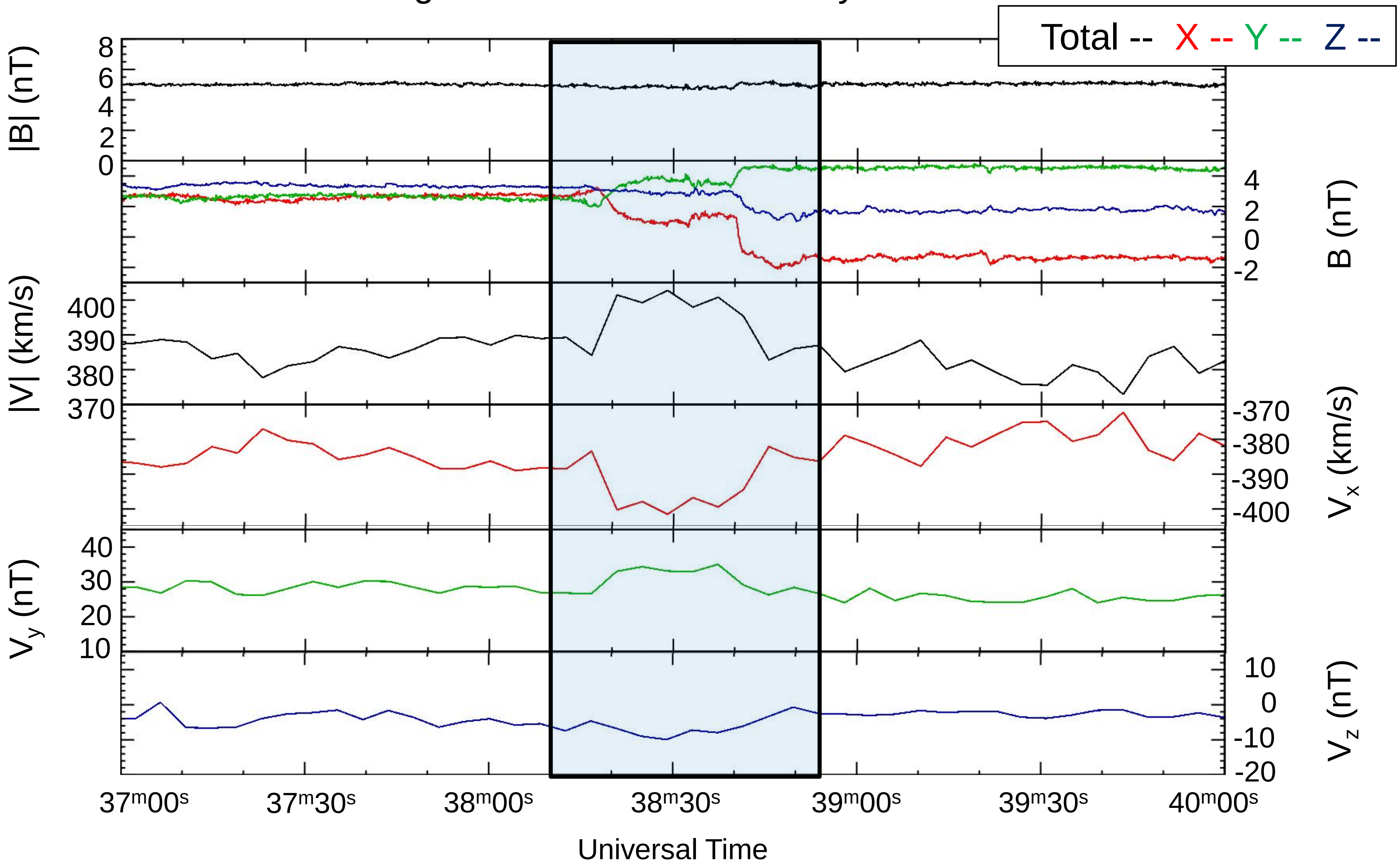
- Study magnetic reconnection structures

  – Test the consistency of the temporal and spatial structure of magnetic reconnection from large scales to small scales

  – using the 4 Cluster spacecraft, ACE and Wind; multi-scale capacity

Case Study: Event 2/3/2006

Cluster 3 magnetic field and ion velocity data in GSE

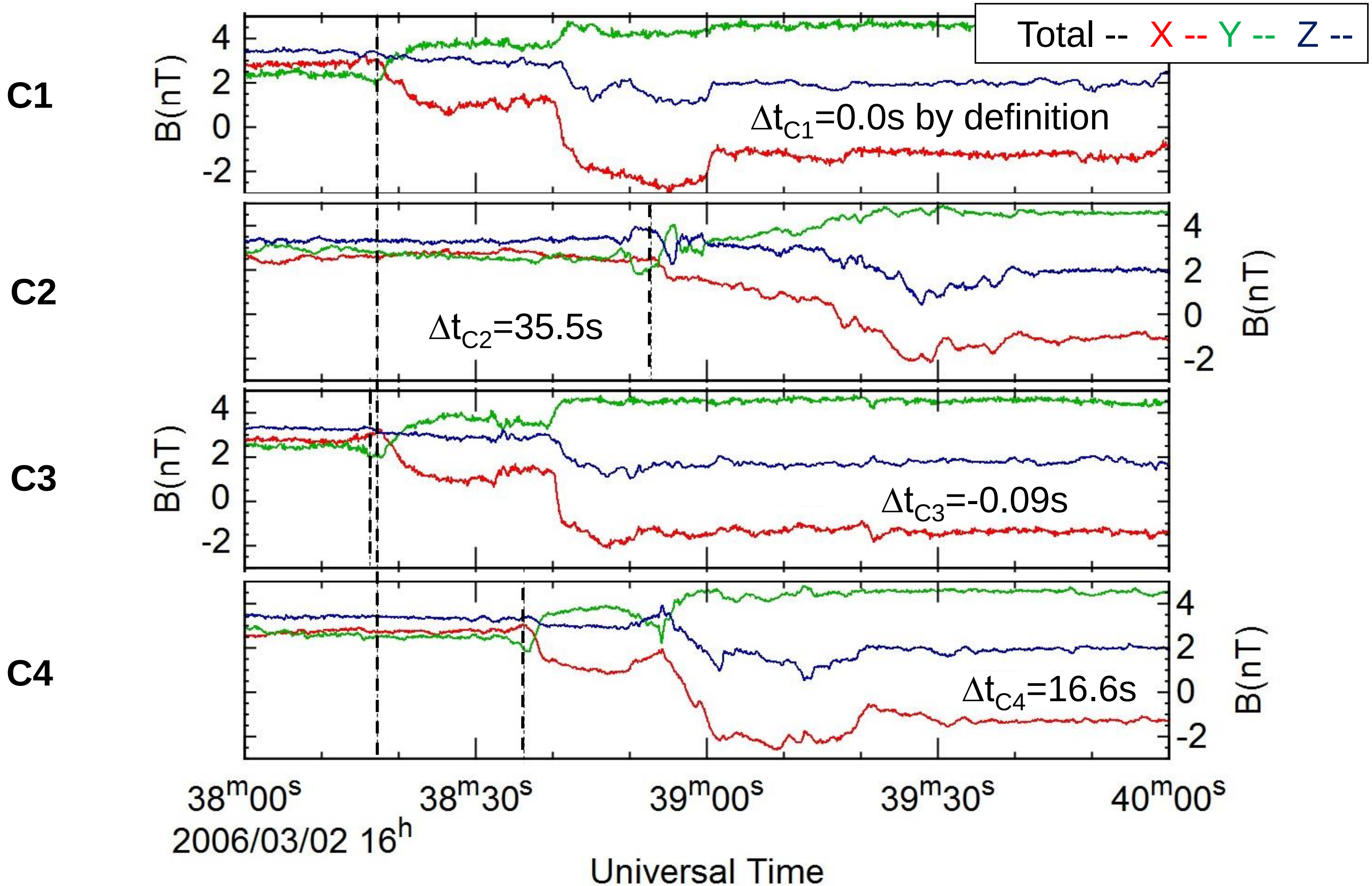


Event 2/3/2006: Characteristics at Cluster 3

- Magnetic field rotation in 2 steps over the event: 70°
- Velocity Enhancement approximately $20 kms^{-1}$
- Angle between two main current sheets: 30°
- Low plasma β either side of the event
- Alfvèn speed approximately 43km/s

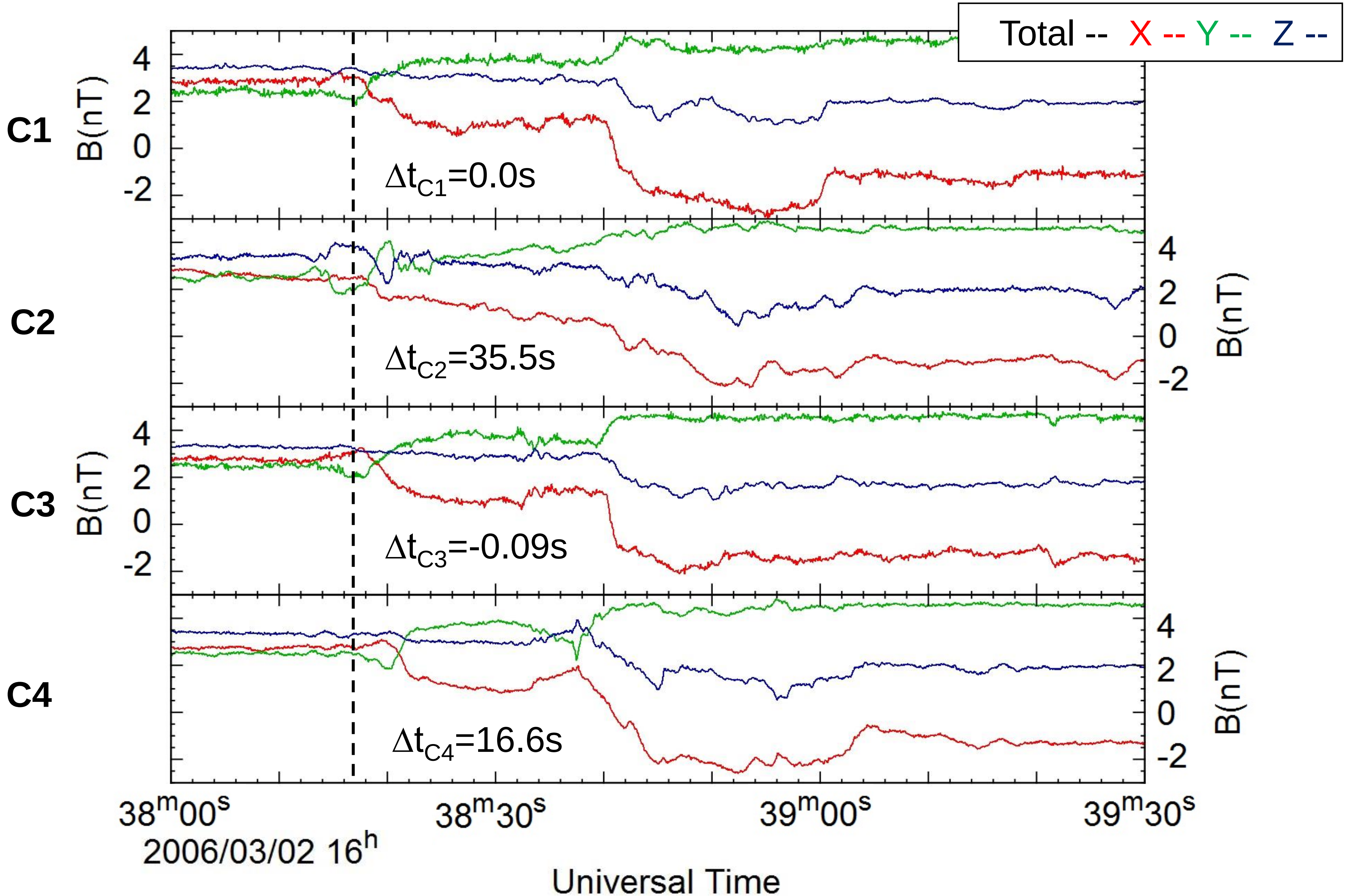
Event 2/3/2006: Magnetic Field Data

Comparing Magnetic field in GSE co-ordinates for the 4 Cluster spacecraft



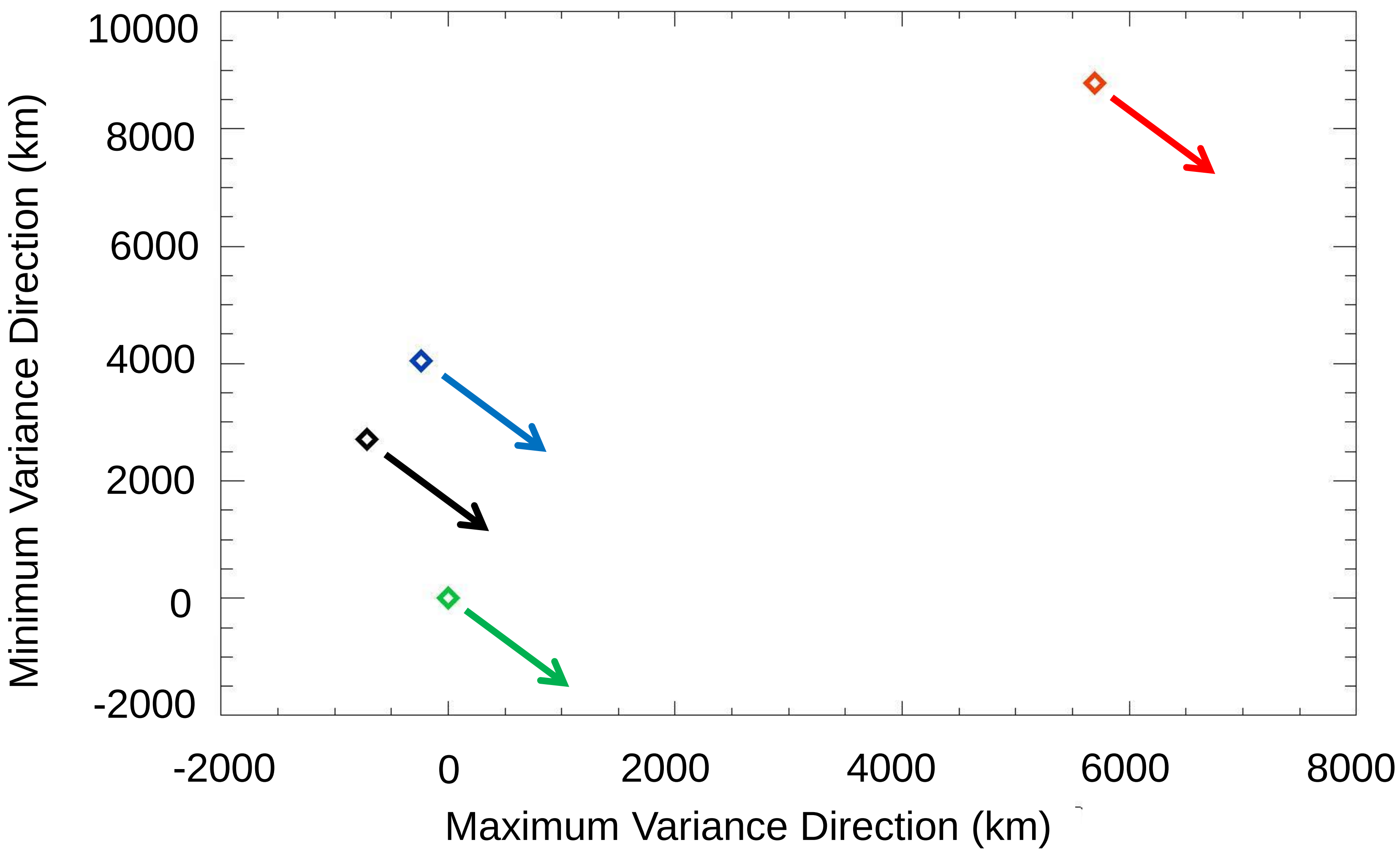
Event 2/3/2006: Magnetic Field Data

Time shifted Magnetic field in GSE co-ordinates for the 4 Cluster spacecraft



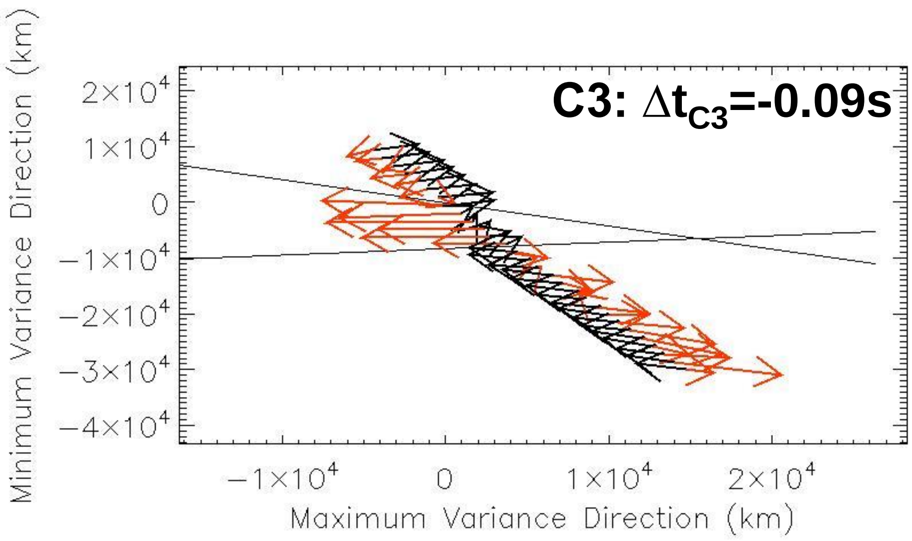
Event 2/3/2006: Relative Spacecraft Positions

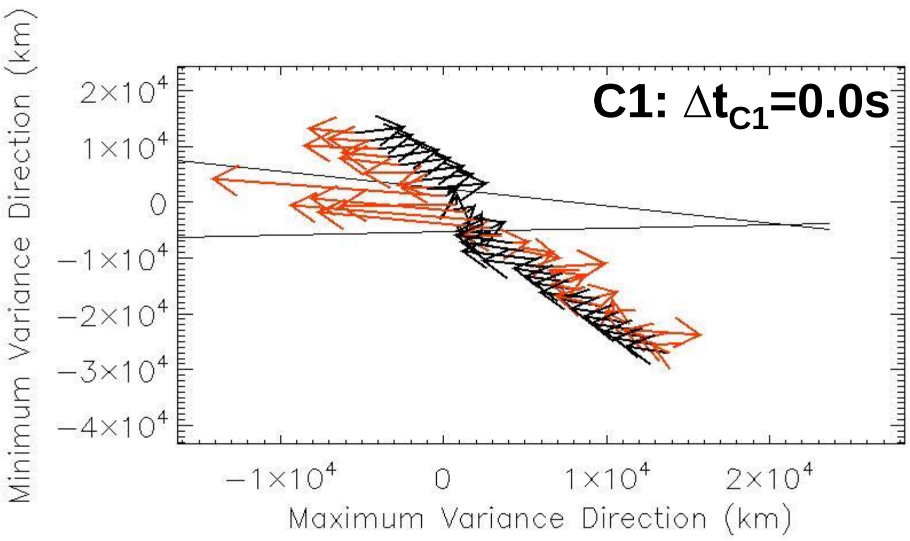
Black = C1, Red = C2, Green = C3, Blue = C4

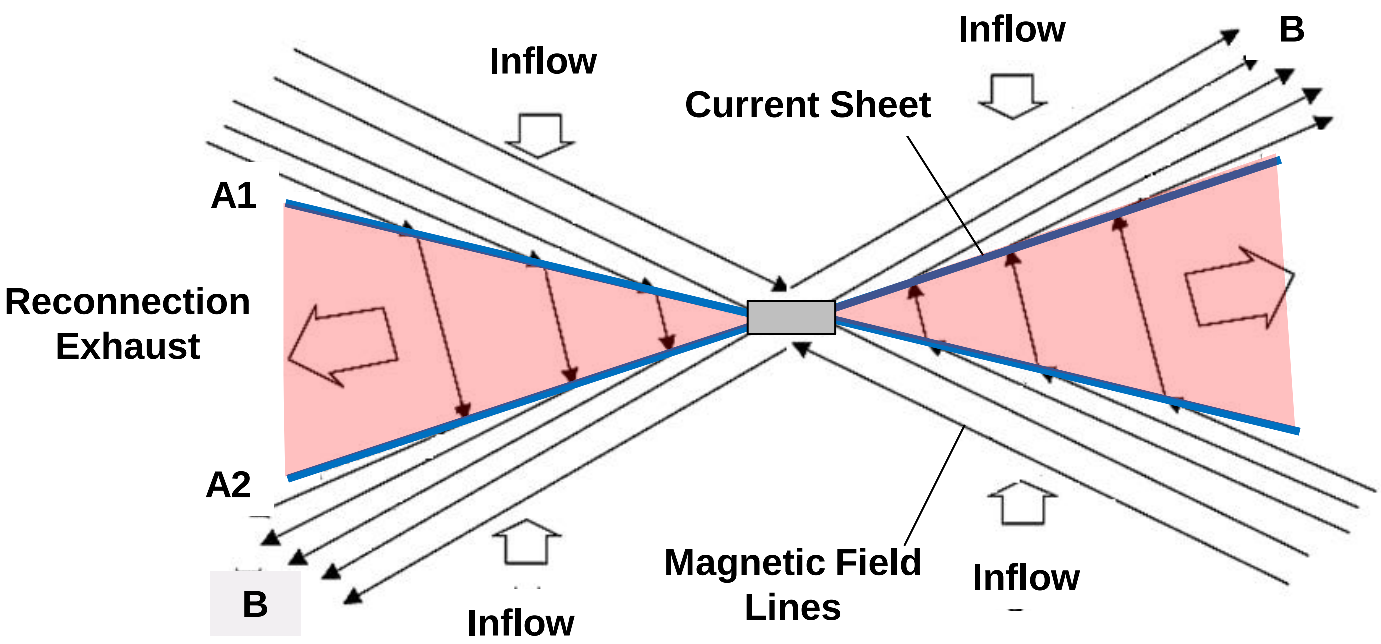


Event 2/3/2006: Spacecraft Crossings

Black = Magnetic field, Red = Total Ion Velocity







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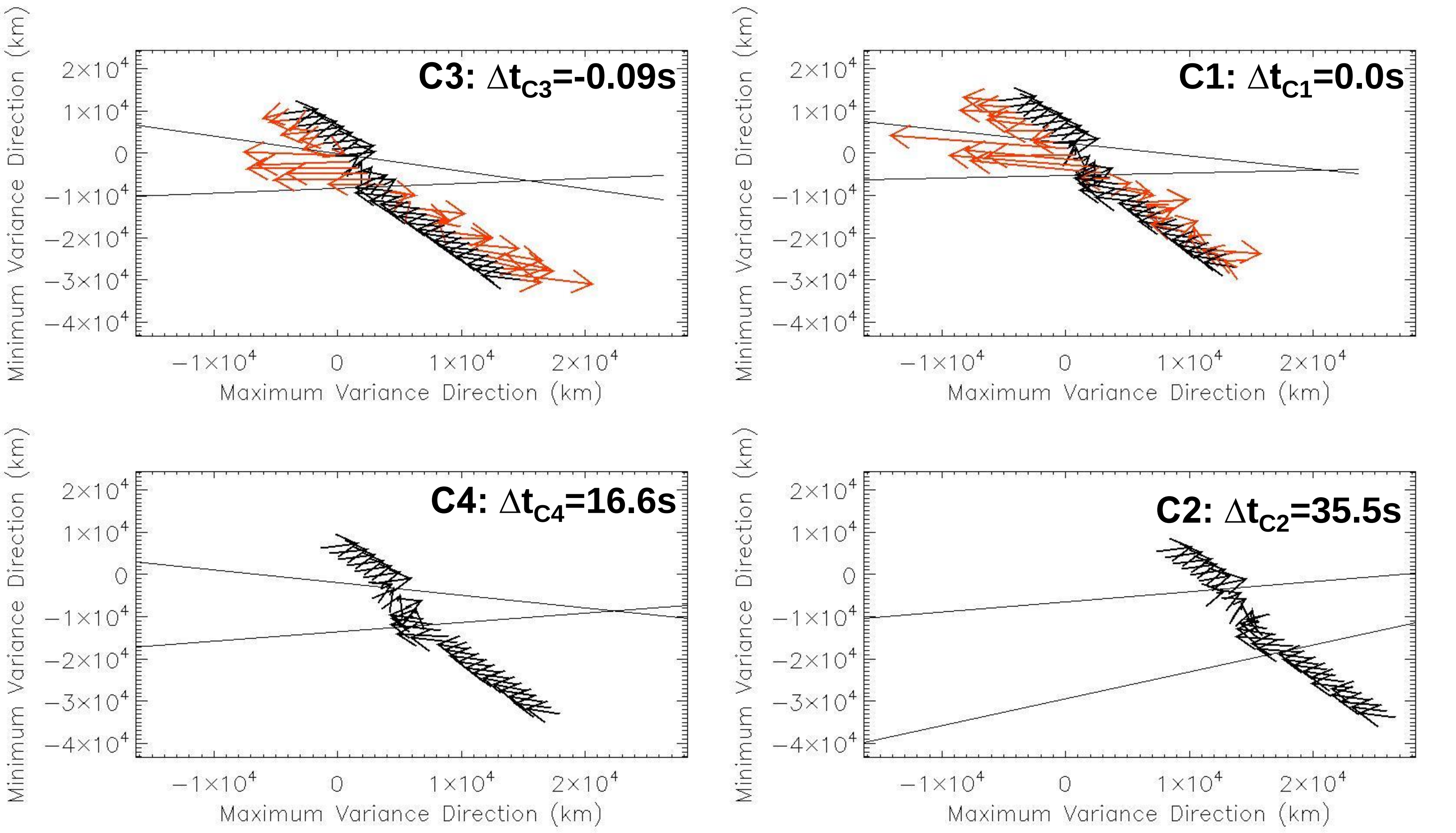


Discussion and Conclusion

- In the solar wind the current picture is of large-scale non-patchy events

- Reconnection seen at Cluster. Cluster 2 has a significantly different magnetic field structure.

- Cluster 2 sees event later but is also situated away from the other spacecraft so the change could be either spatial or temporal.

- Observational differences small in comparison to previous observations of solar wind reconnection scales. Suggests Reconnection can be small scale and/or patchy.

References

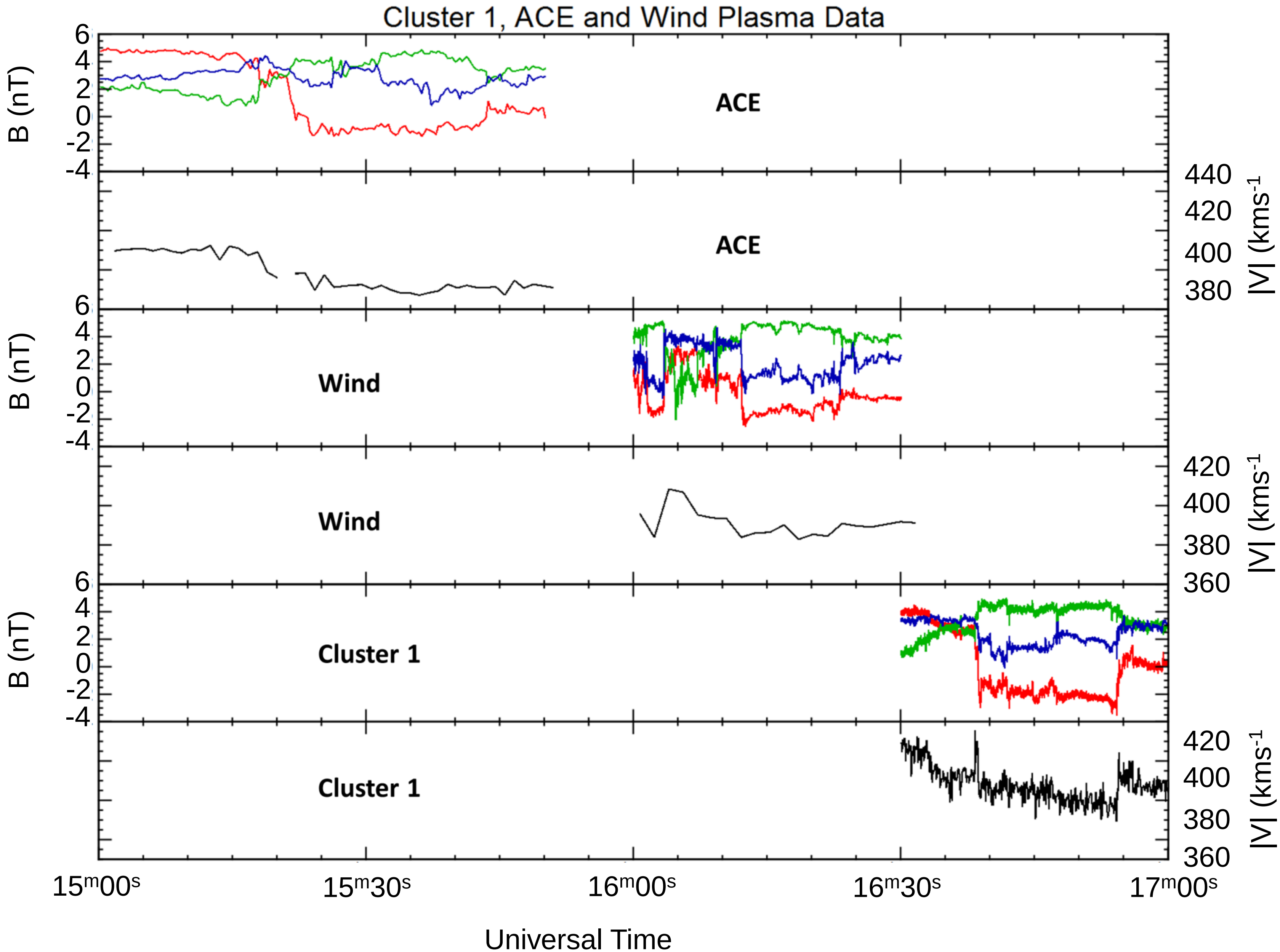
- Baumjohann, W. (1997): Wolfgang Baumjohann and Rudolf A. Treumann. Basics of Space Plasma Physics. Imperial College Press, 1997.

- Priest, E. R. (1984): Priest, E. R. (1984), Solar Magneto-Hydrodynamics, Geophys. Astrophys.Monogr. Ser., Springer, New York.

- Gosling, J.T (2005): J.T. Gosling, R.M. Skoug, D.J. McComas, C.W. Smith, J. Geophys. Res. 110, A01107, 2005

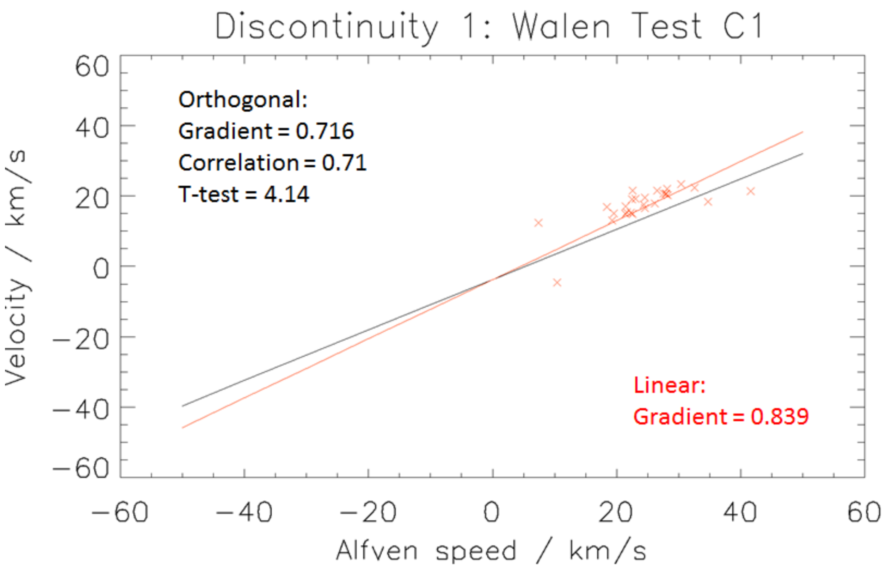
- Phan, T. D. (2006): T. D. Phan, J. T. Gosling, M. S. Davis, R. M. Skoug, M. Øieroset, R. P. Lin, R. P. Lepping, D. J.McComas, C. W. Smith, H. Reme, and A. Balogh. A magnetic reconnection X-line extending more than 390 Earth radii in the solar wind. Nature, 439:175–178, January 2006.
- Gosling (2007): J. T. Gosling, S. Eriksson,L. M. Blush,T. D. Phan,J. G. Luhmann,D. J. McComas,R. M. Skoug,M. H. Acuna,C. T. Russell, and K. D. Simunac. Five spacecraft observations of oppositely directed exhaust jets from a magnetic reconnection X-line extending > 4.26 10^6km in the solar wind at 1 AU

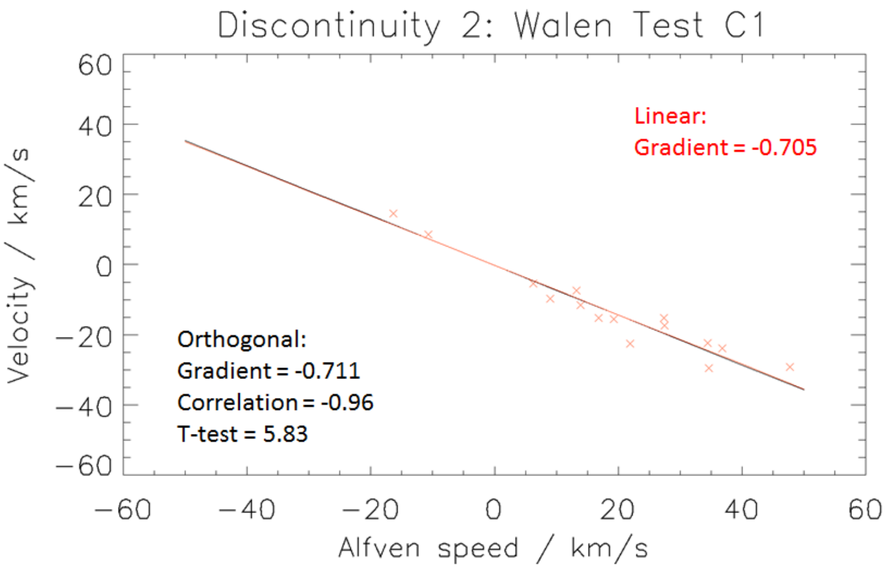
Also seen at ACE and Wind



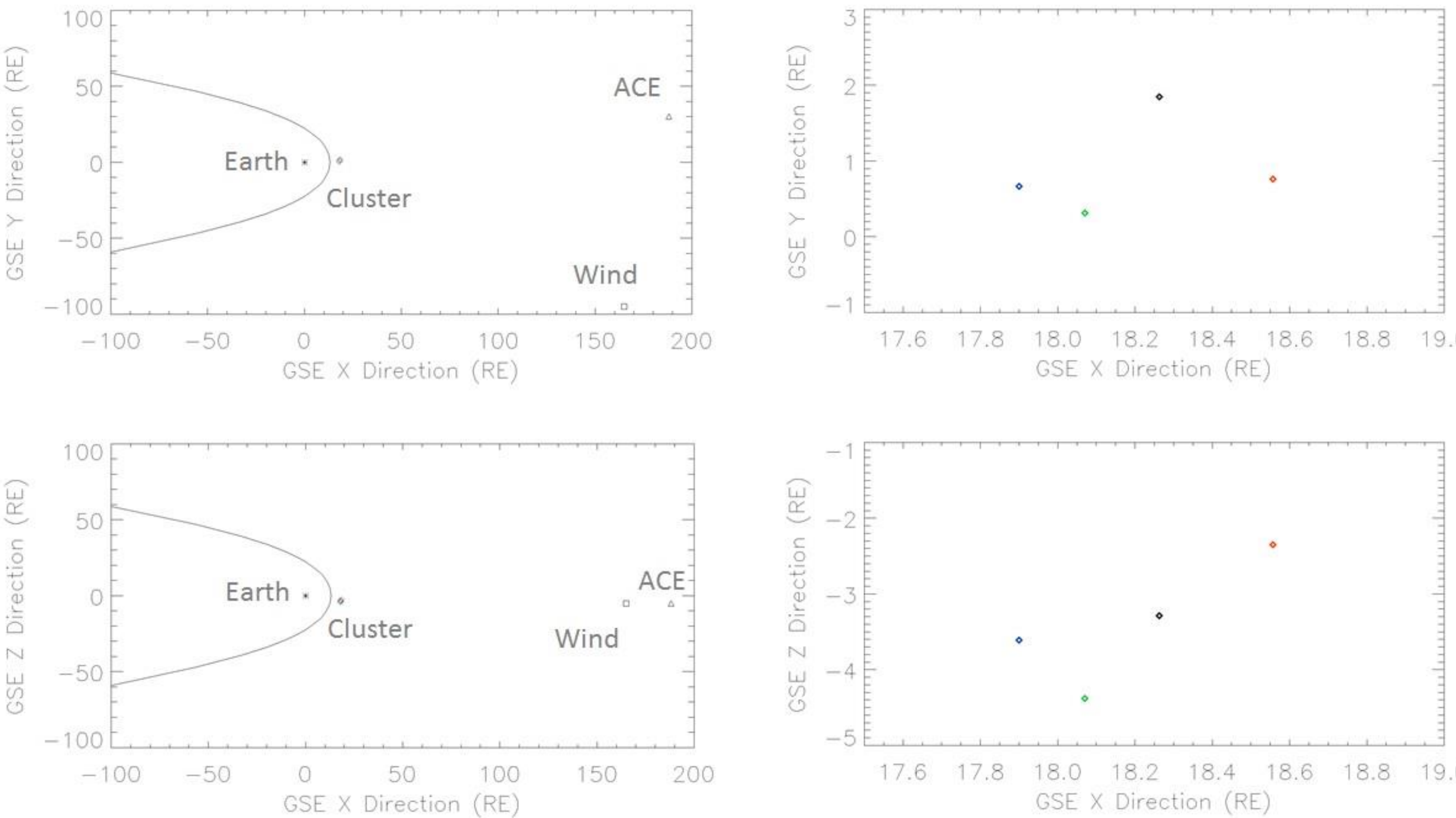
- Consistent with previous results

•The Walen test is weakly satisfied for the two rotations seen at Cluster 1 and 3. Consistent with the presence of slow mode shocks.



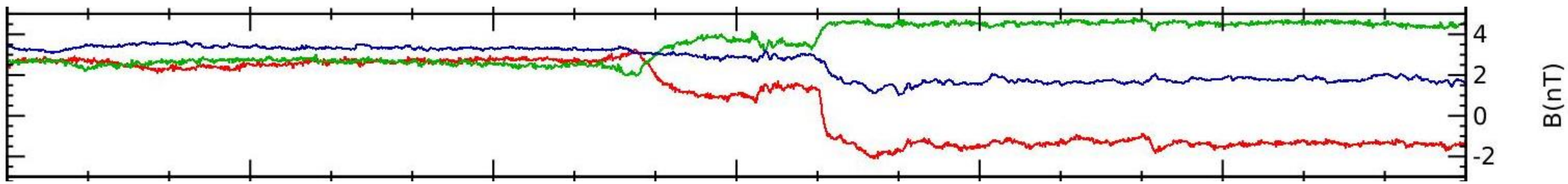


Spacecraft Positions



- Magnetic rotation over the event: 70°

Total -- X -- Y -- Z --

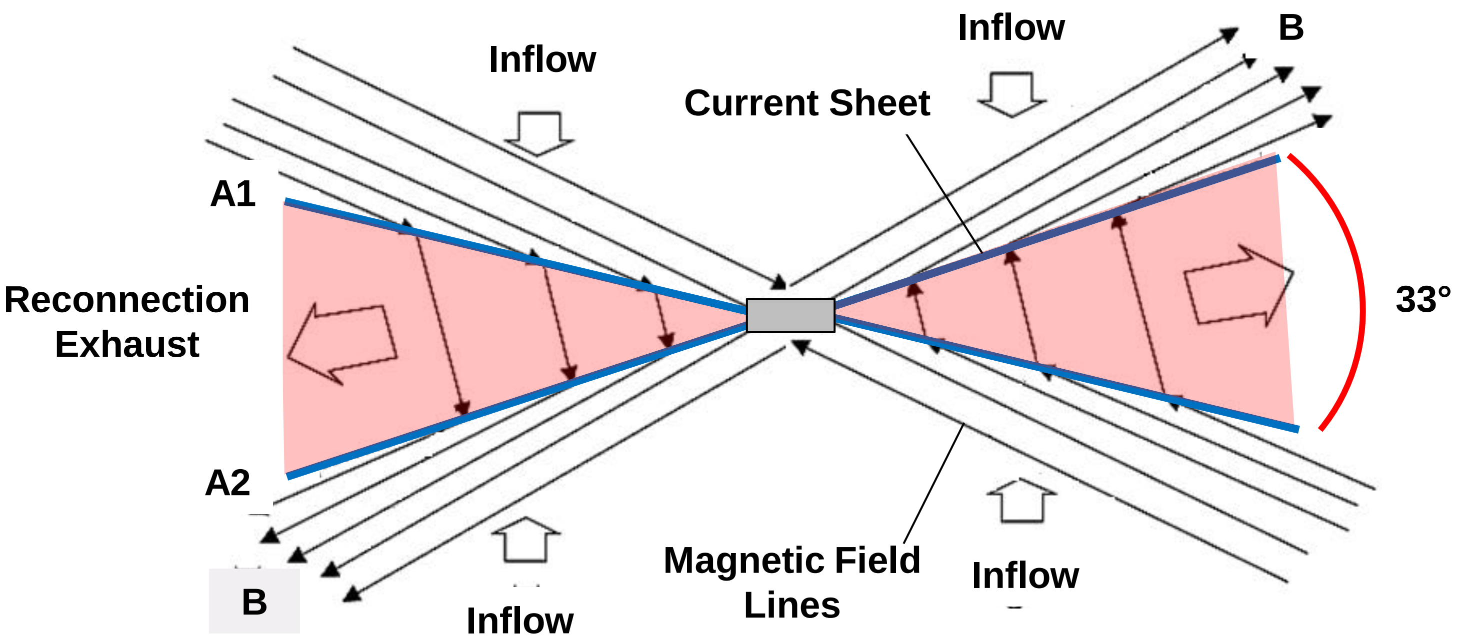


37m00s 37m30s 38m00s 38m30s 39m00s 39m30s 40m00s

Universal Time

Event 2/3/2006: Characteristics

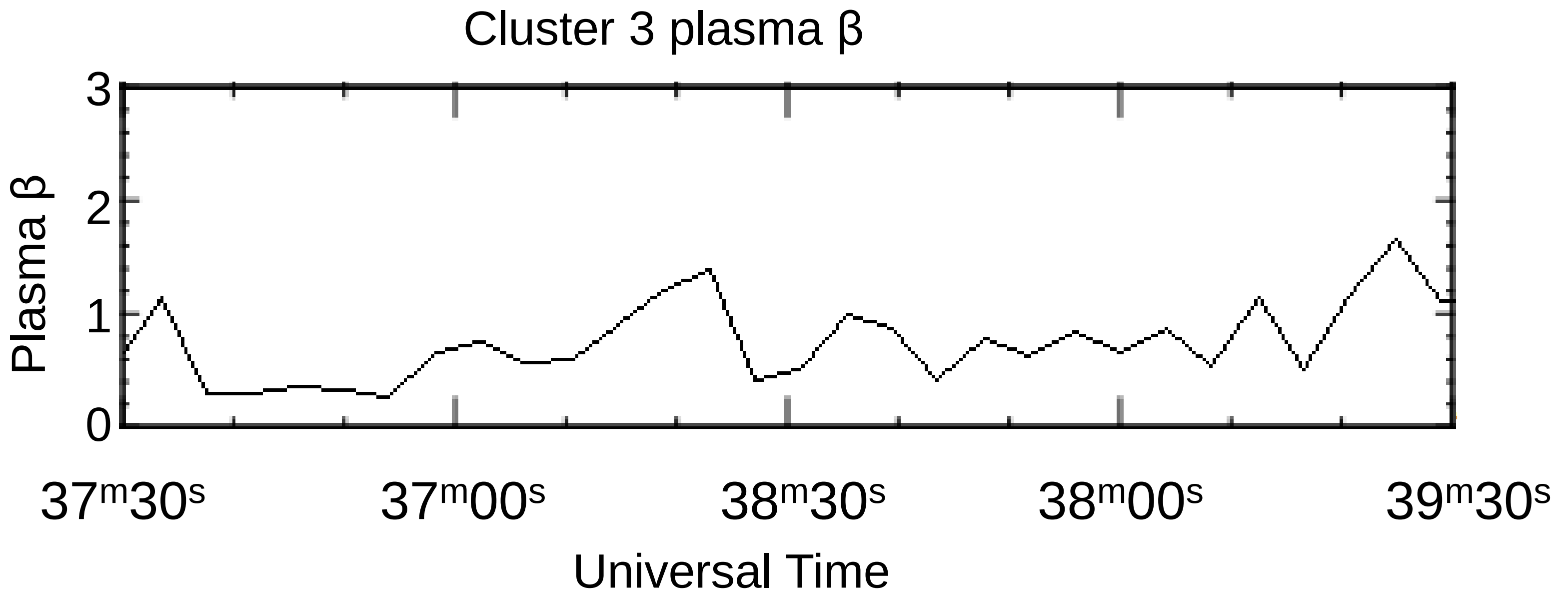
- Magnetic rotation over the event: 70°
- Angle between two main current sheets: 30°



Adapted from Gosling, J.T. (2005)

Event 2/3/2006: Characteristics

- Magnetic rotation over the event: 71°
- Angle between two main current sheets: 33°
- Low plasma β either side of the event



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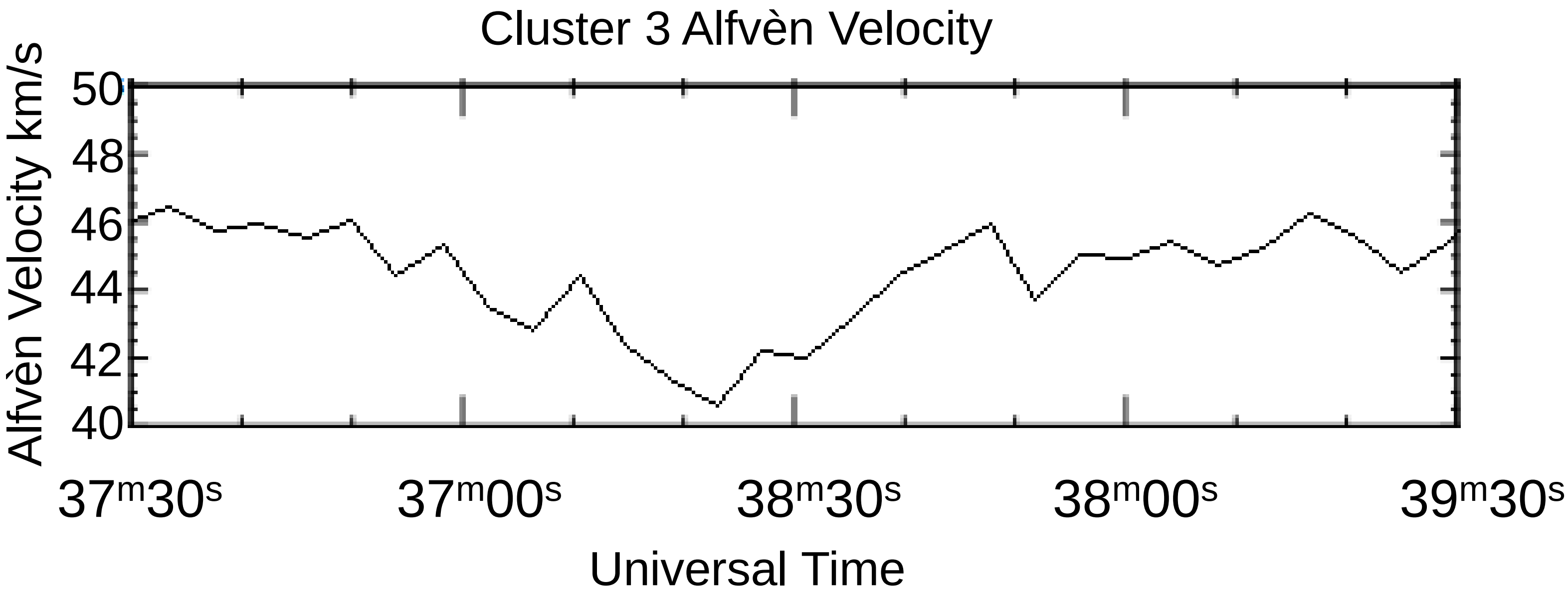
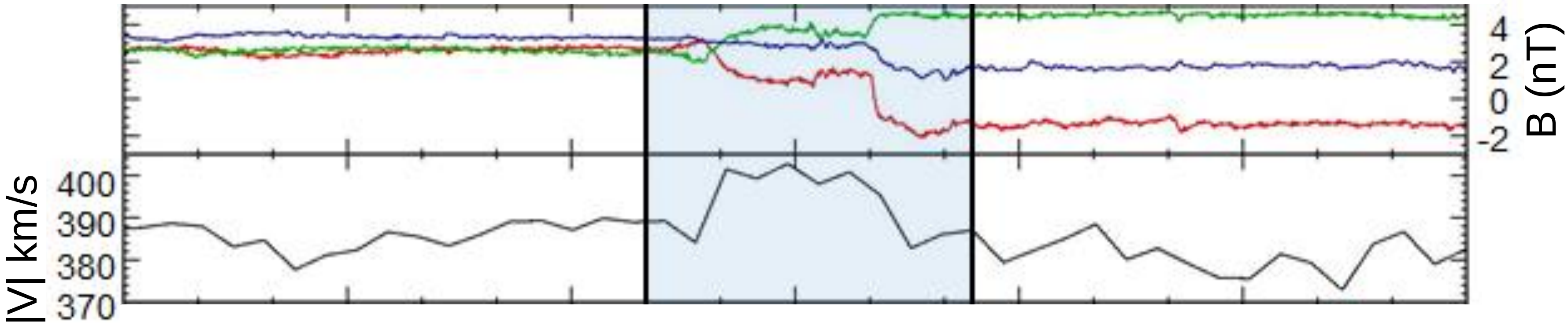


- Consistent with previous results

  •Double magnetic field rotation that bounds an ion velocity increase.

Cluster 3 magnetic field in GSE co-ordinates and ion Velocity

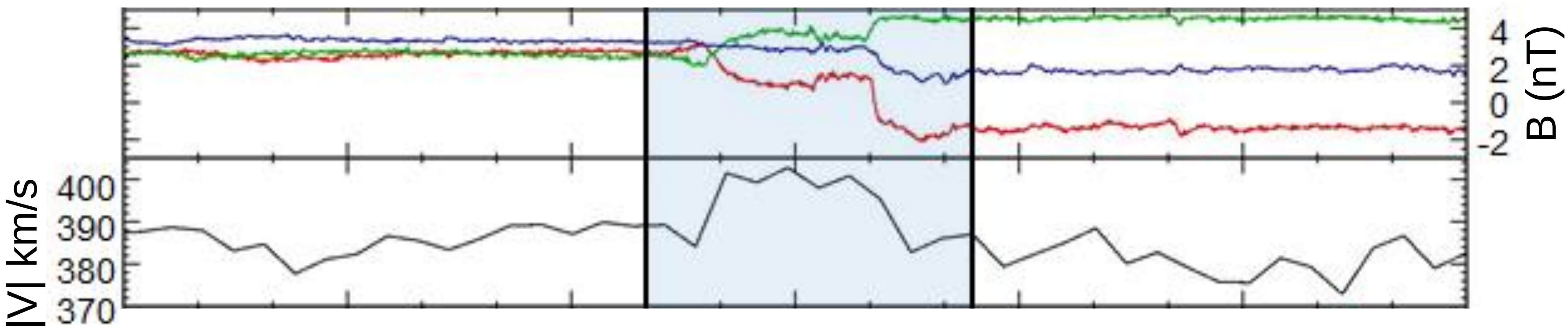


Event 2/3/2006: Consistency

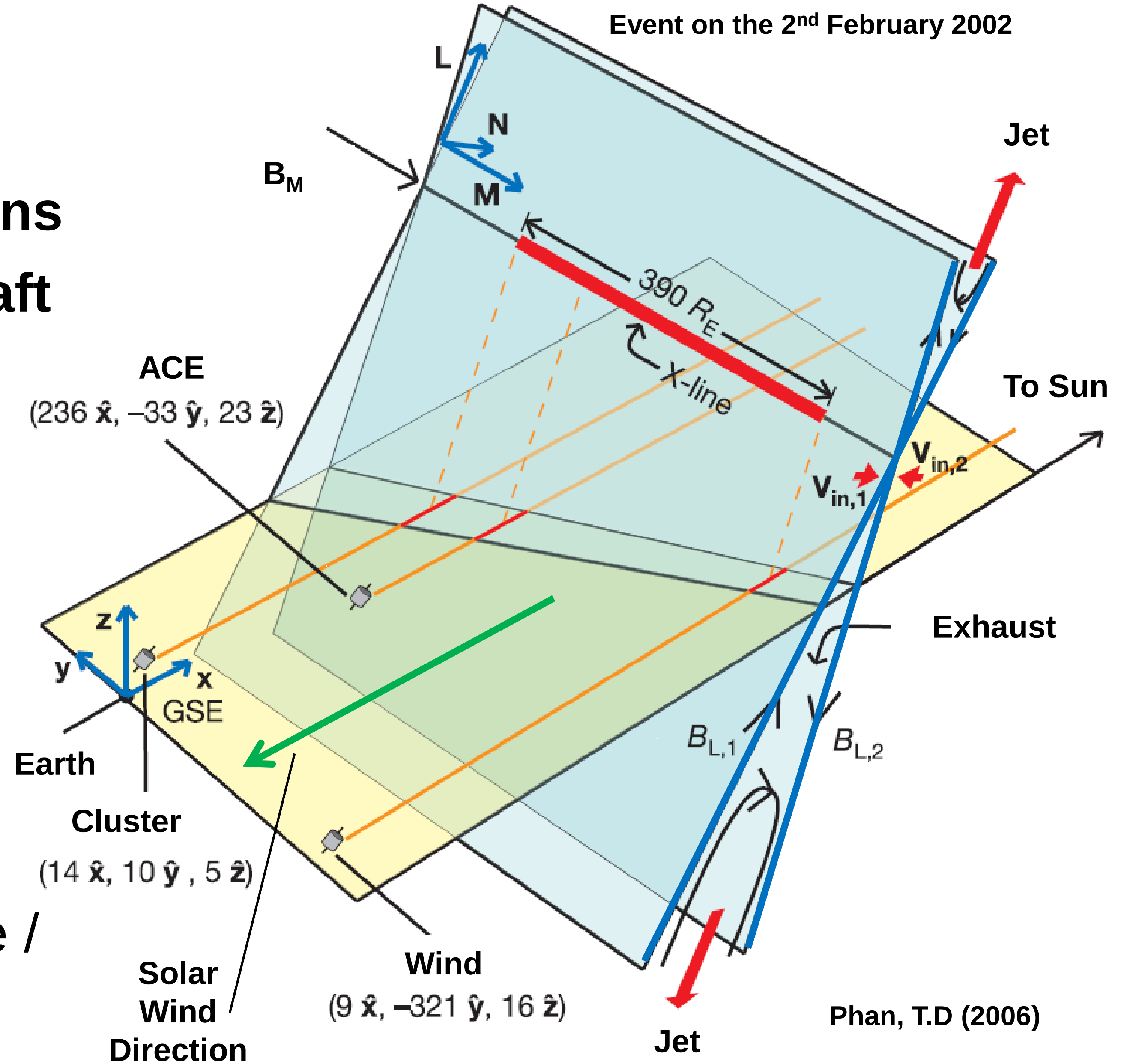
- Consistent with previous results

    •The changes in V and B are correlated on one edge of the exhaust and anti-correlated on the other.

Cluster 3 magnetic field in GSE co-ordinates and ion Velocity

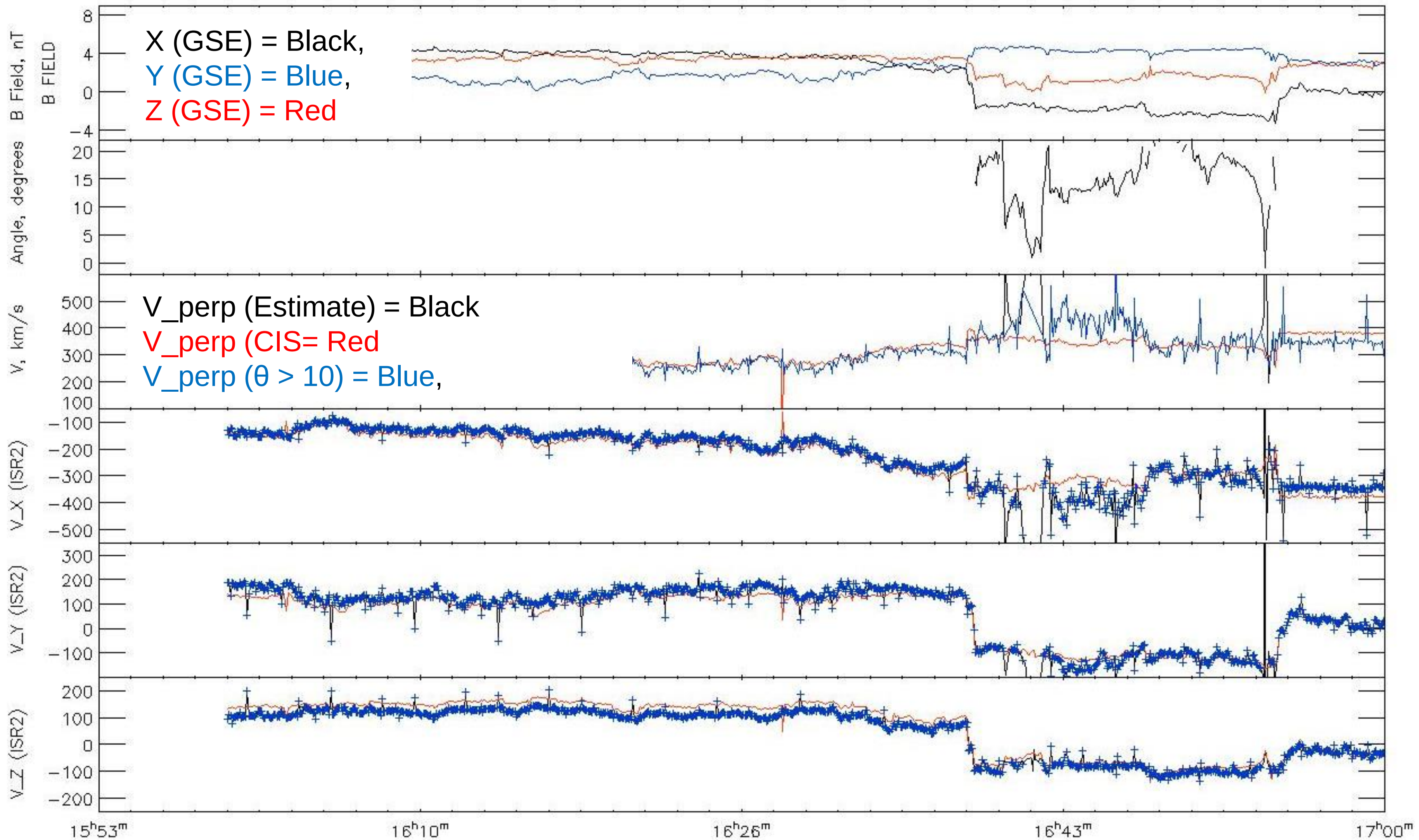


- Unconstrained **boundary conditions**
- **Multiple spacecraft** observations
- **Time scales** ≥ few hours
- **Length scales** ~100s R_E
- Different **plasma conditions** than frequently studied (e.g. Magnetopause / magnetotail)



Phan, T.D (2006)

Event 2/3/2006: Estimating Perpendicular Velocity



Event 2/3/2006: Spacecraft Crossings

Black = Magnetic field, Red = Perpendicular Velocity