On the short-scale spatial variability of electron inflows in electron-only magnetic reconnection in the turbulent magnetosheath observed by MMS

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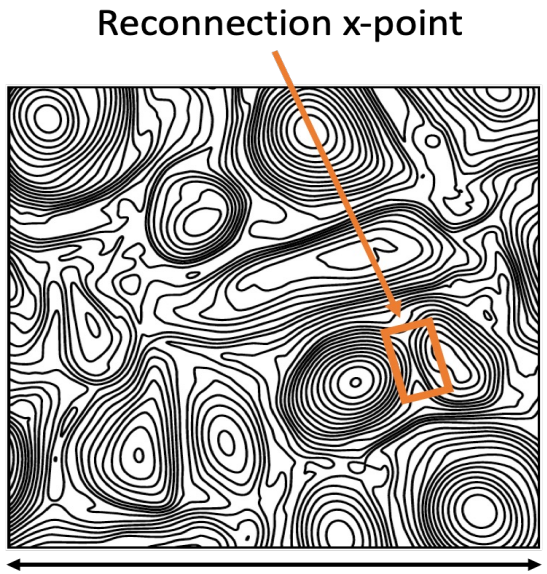
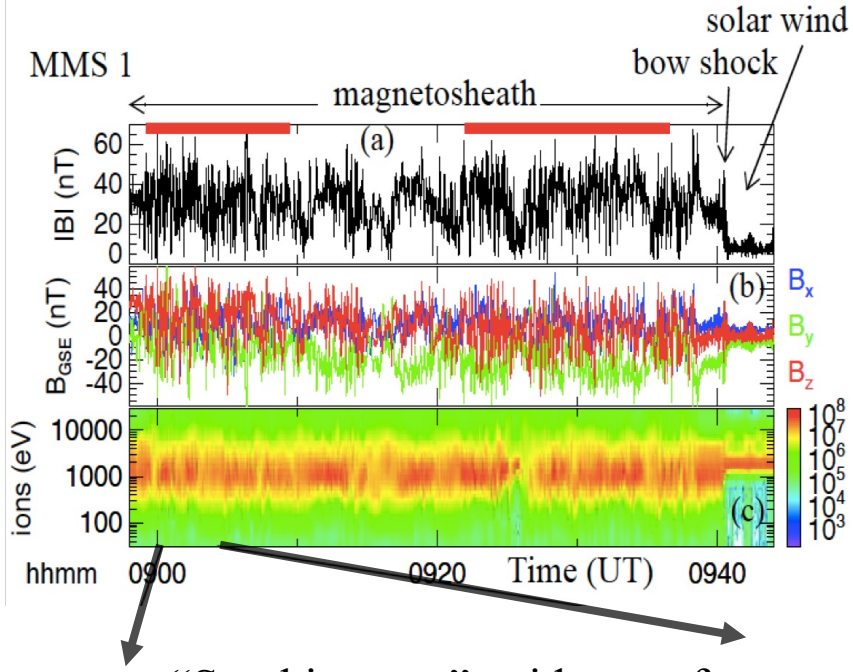
Where is “electron-only” reconnection observed?

MMS Event: (Phan et al., 2018, Nature)

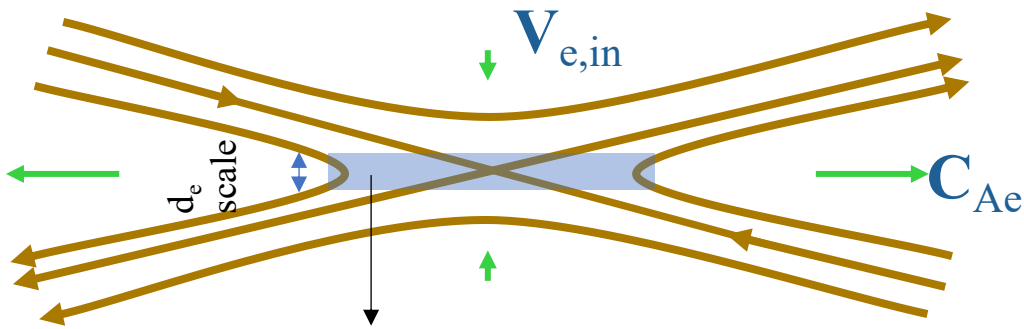


Multiple ion scale magnetic structures embedded in turbulence with thin (d_e-scale) current sheets.



“Smoking gun” evidence of electron-only reconnection observed within this interval.

Schematic of electron-only reconnection

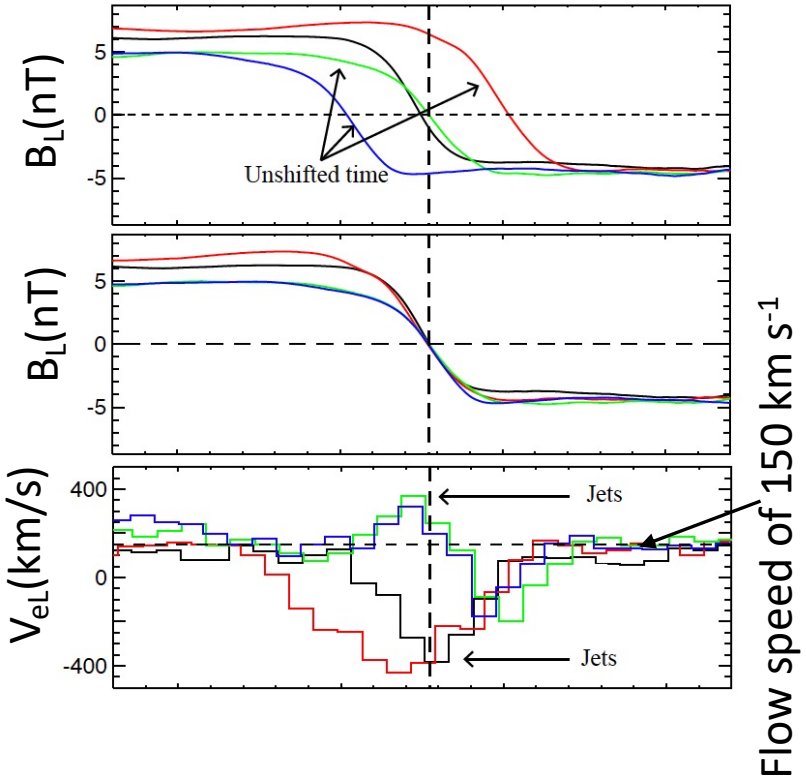


Electron diffusion region (EDR)

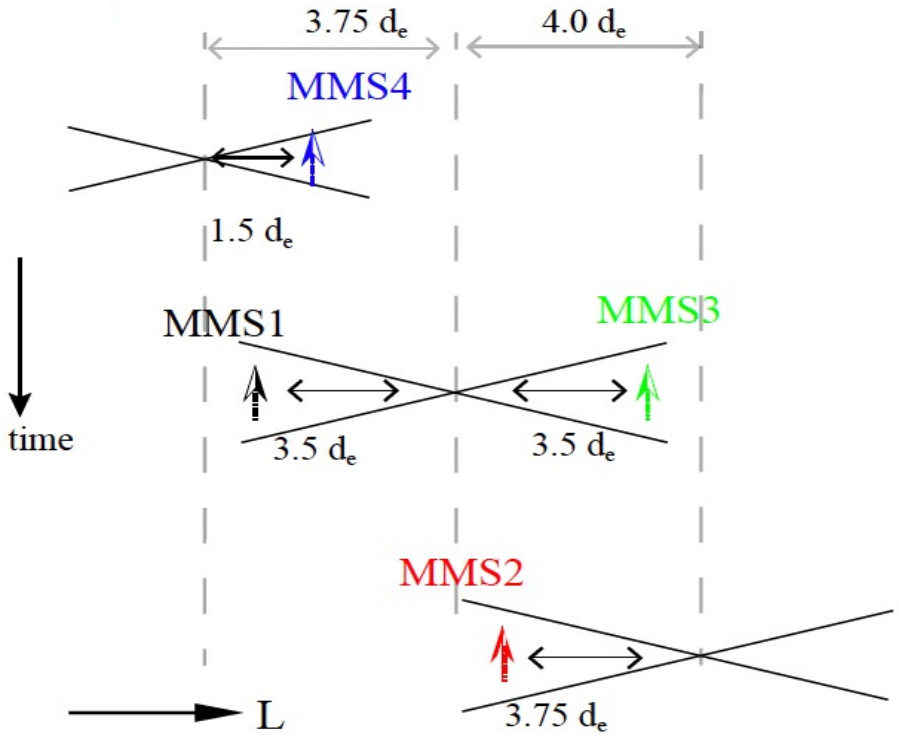
No ion jet signatures observed.

Determining 4-spacecraft locations in electron-only reconnection

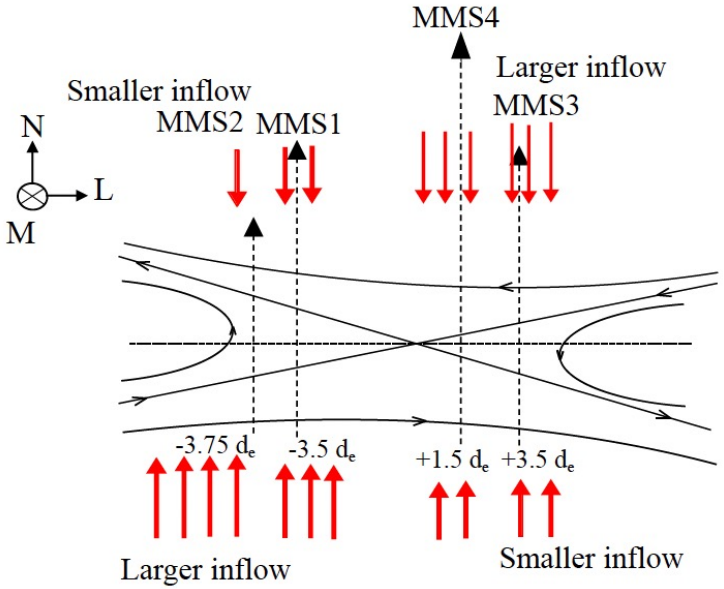
Reconnecting magnetic fields & electron jets



Dynamic spacecraft orientation

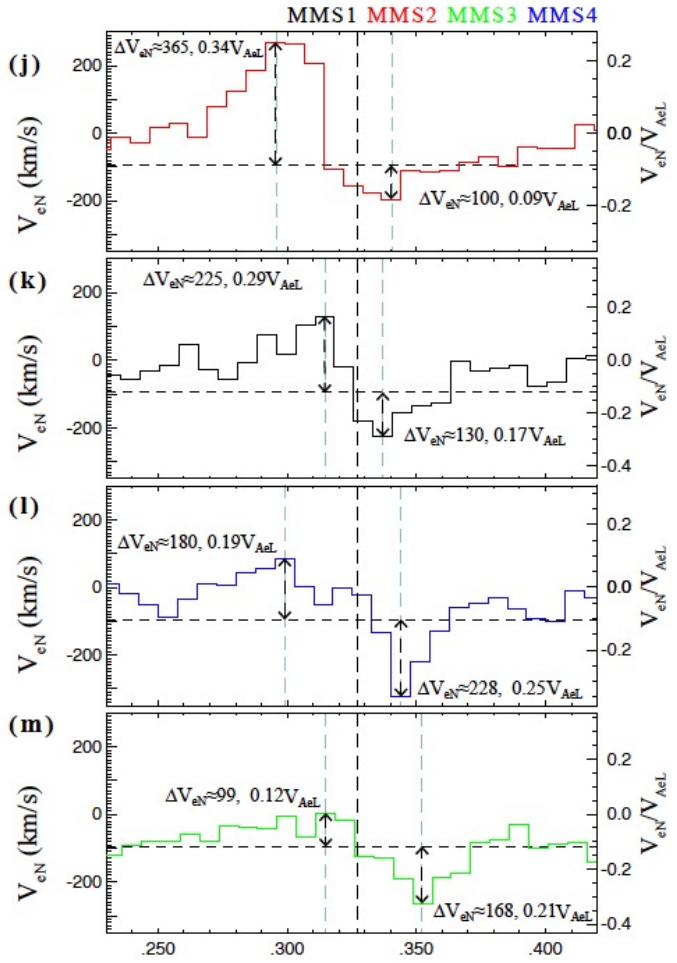


Spacecraft orientation in static frame



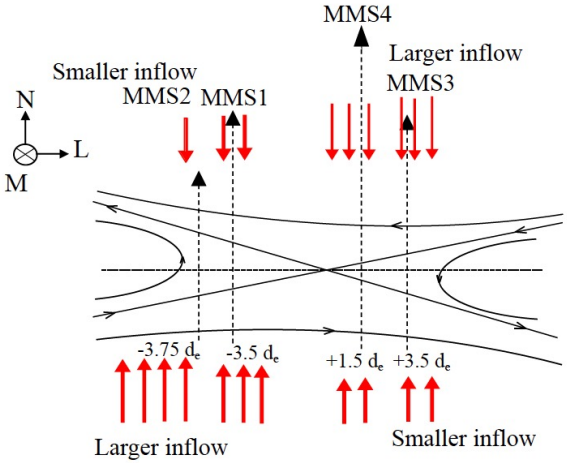
Comparison of observations with simulations

Observations: Electron inflows from left to right of the X-line

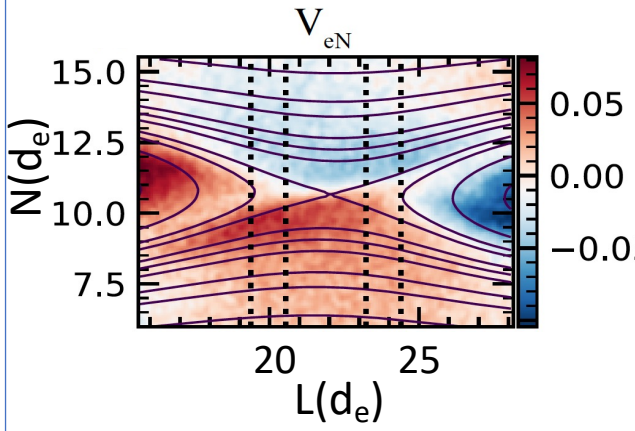


2016 Dec 09 09:03 UT (s)

Spacecraft orientation in a static frame



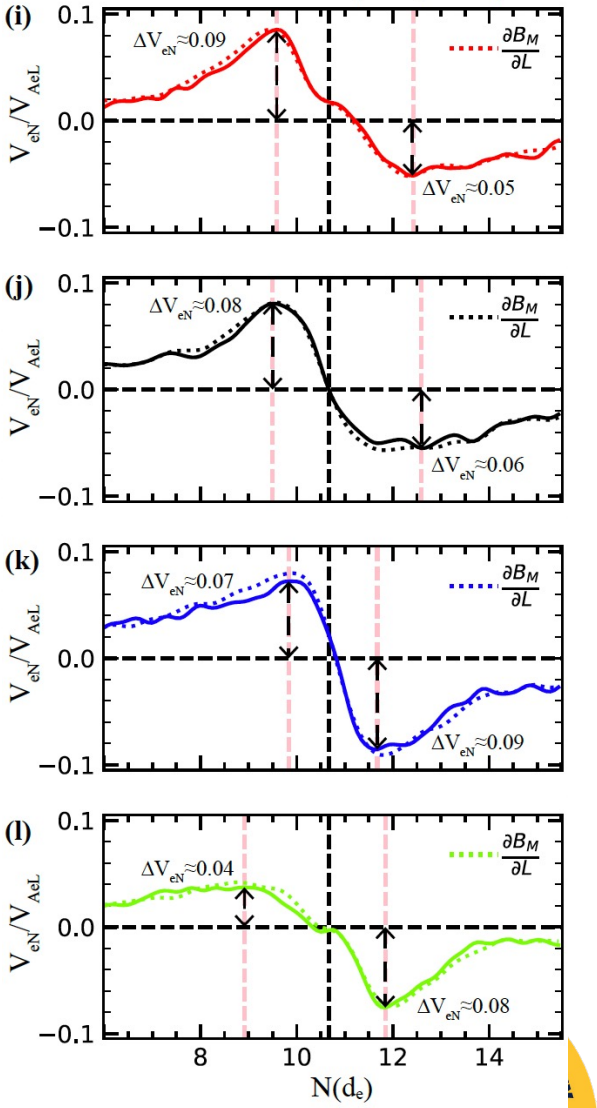
Electron inflows in 2D simulation



Remarkable similarity of electron inflows in simulation and observation!

1d cuts of electron inflows in 2D simulation

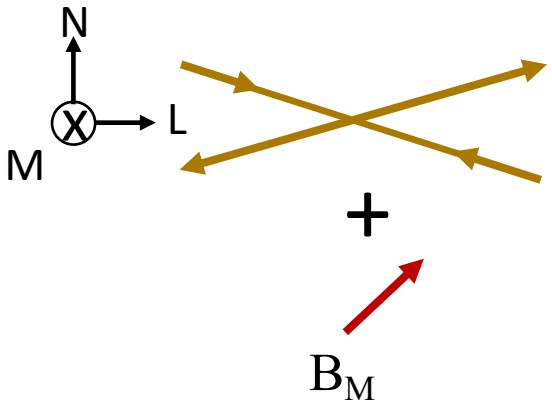
L=19.4, 20.5, 23.22, 24.4



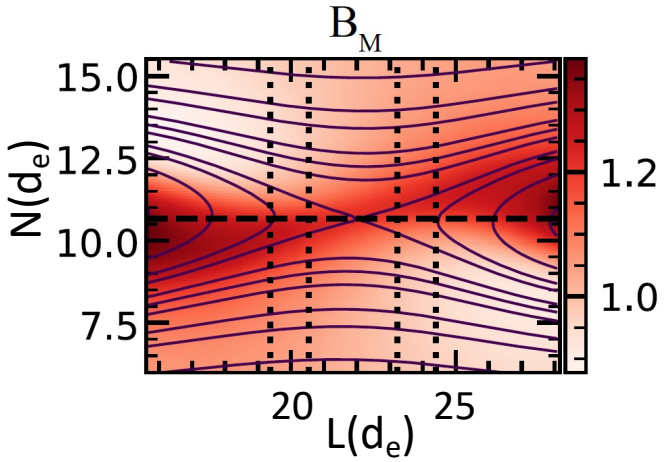
What makes the asymmetry pattern in inflows?

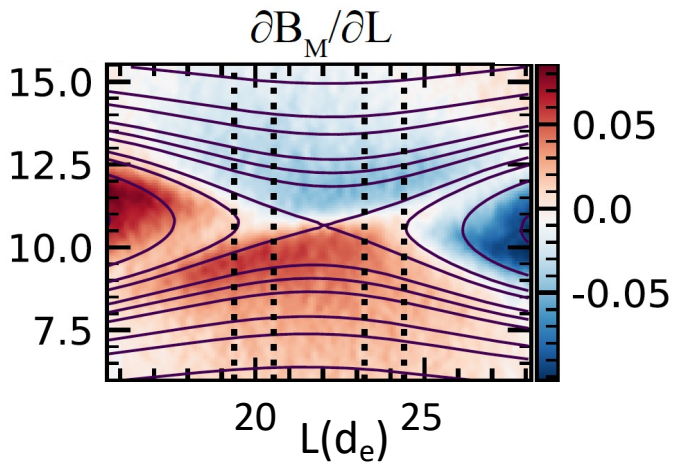
⇒ Tilt in the guide field structure produces asymmetry in inflows

Guide field reconnection

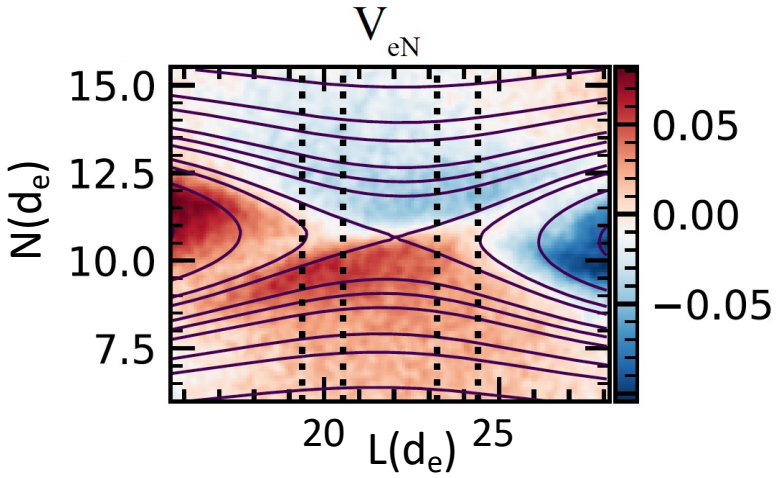


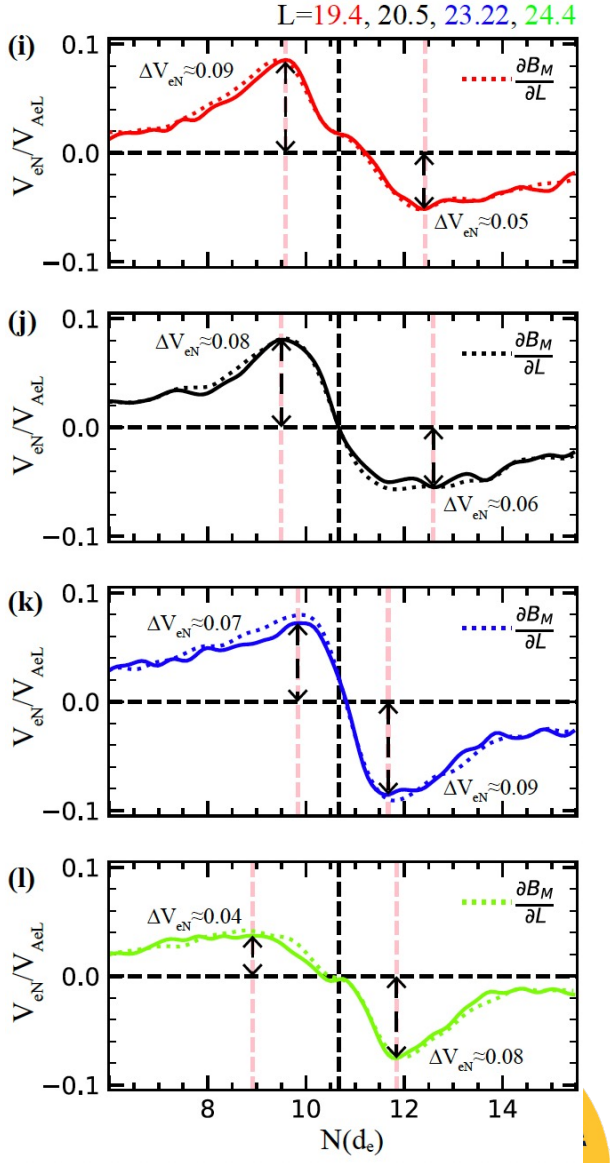
Out-of-plane (guide) magnetic field





$\mathbf{V_e} = -c/(4\pi)\ \nabla \times \mathbf{B}$ (from Ampere's law)





Summary and Discussion

- The inflow asymmetry was larger further away from the X-line, and the inflow asymmetry reversed on opposite sides of the X-line.

- The 2D simulation reproduced the same asymmetry pattern in inflows V_{eN} observed by the MMS spacecraft. Due to the tilt of the out-of-plane (guide) magnetic field structure in the reconnection plane enhancing the inflow asymmetry downstream from the X-line.

- Even though the spacecraft were only separated by few d_e distances, the inflow amplitudes differed largerly among all MMS probes. However, the peak-to-peak inflow strengths in the normalized units of V_{AeL} among all spacecraft did not show as much variation.

- Since the inflows can be used as a measure for reconnection rate (e.g., Burch et al. 2020), we estimate the reconnection rate to be ~$0.21V_{AeL}$ in this electron-only reconnection event.