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MMS observations of magnetotail reconnection

Rumi Nakamura, Takuma Nakamura, Wolfgang Baumjohann, Joachim Birn, Jim Burch, Kevin Genestreti, Barbara Giles, Michael Hesse, Tsugunobu Nagai, Victor Sergeev, Roy Torbert, Ali Varsani, Diana Rojas-Castillo, Simon Wellenzohn

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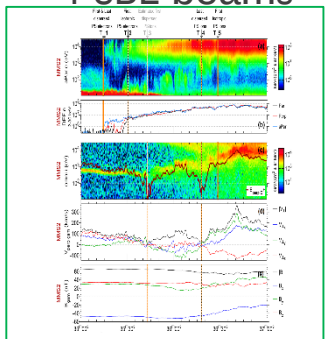
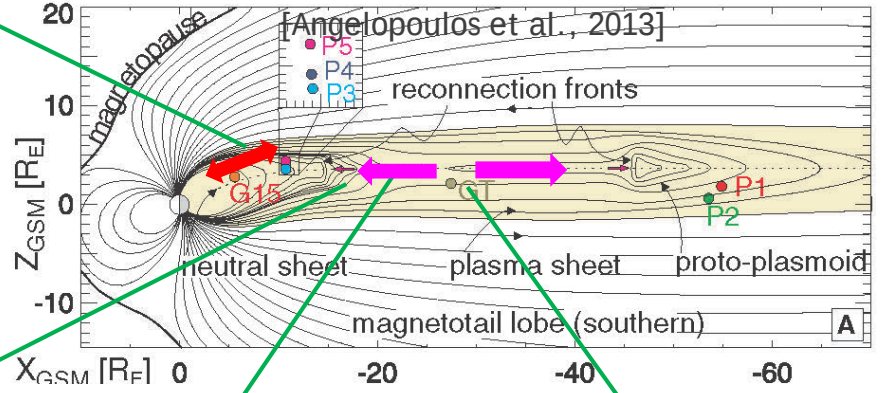
OBSERVATIONS OF RECONNECTION SIGATURES IN MAGNETOTAIL

- Insitu-detection of diffusion region
- Remote-sensing of reconnection
  - High-energy beams
  - Busty bulk flows
- Jet interaction with ambient plasma
  - Flow braking/bouncing
  - Dipolarization fronts

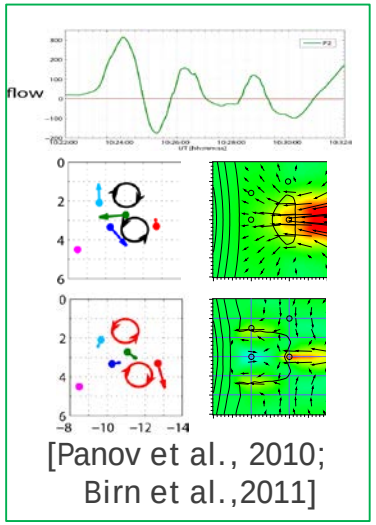
PSBL beams



[Varsani et al., 2018]

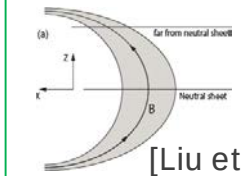


flow braking/bouncing

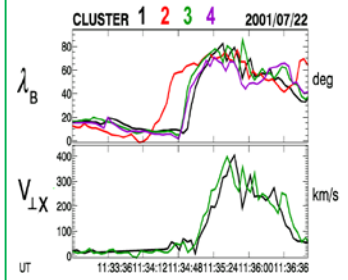


[Panov et al., 2010; Birn et al.,2011]

dipolarization front (dipolar flux bundle)

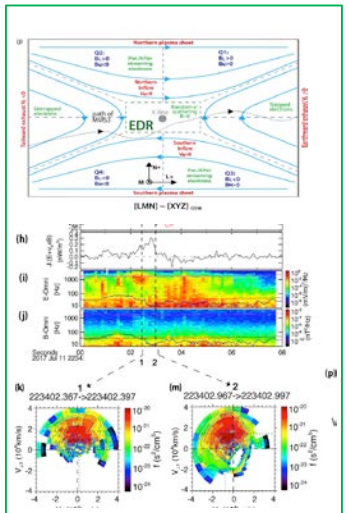


[Liu et al., 2013]



[Nakamura et al., 2002]

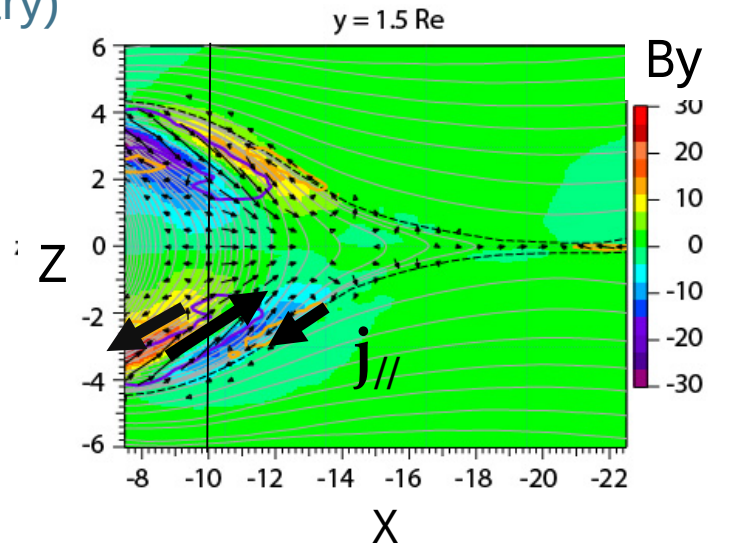
magnetic reconnection

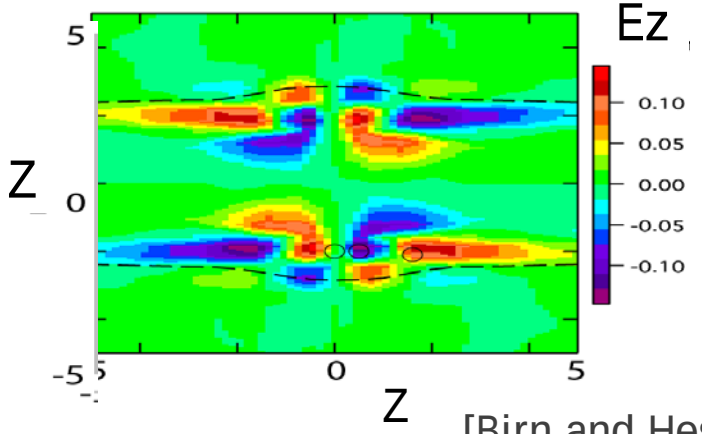


[Torbert et al., 2018]

LARGE SCALE CONTEXT OF RECONNECTION JET

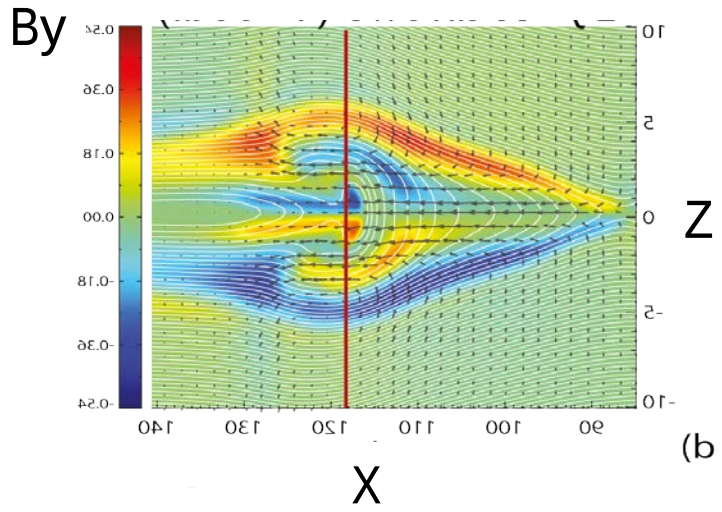
Reconnection jets interacting with dipolar field (boundary)

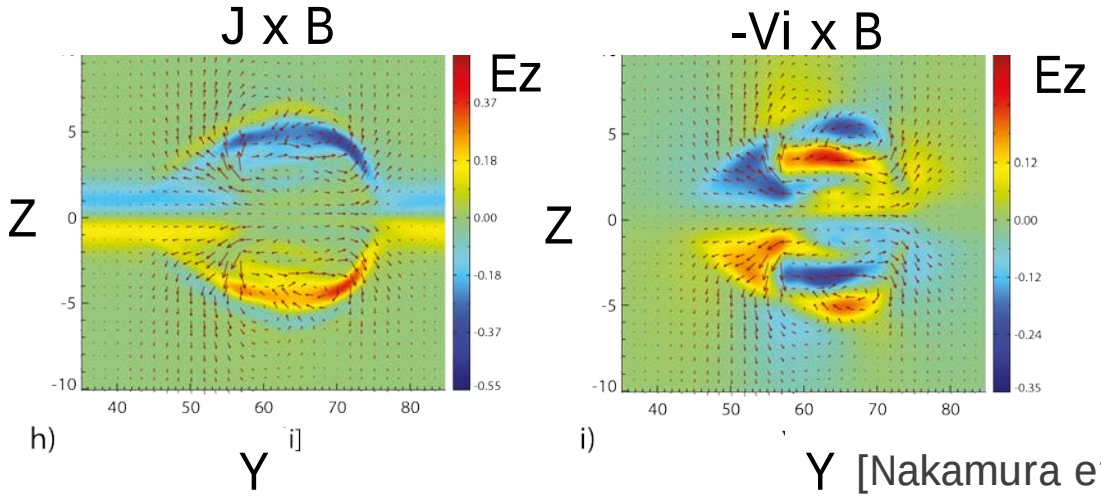




[Birn and Hesse, 2014]

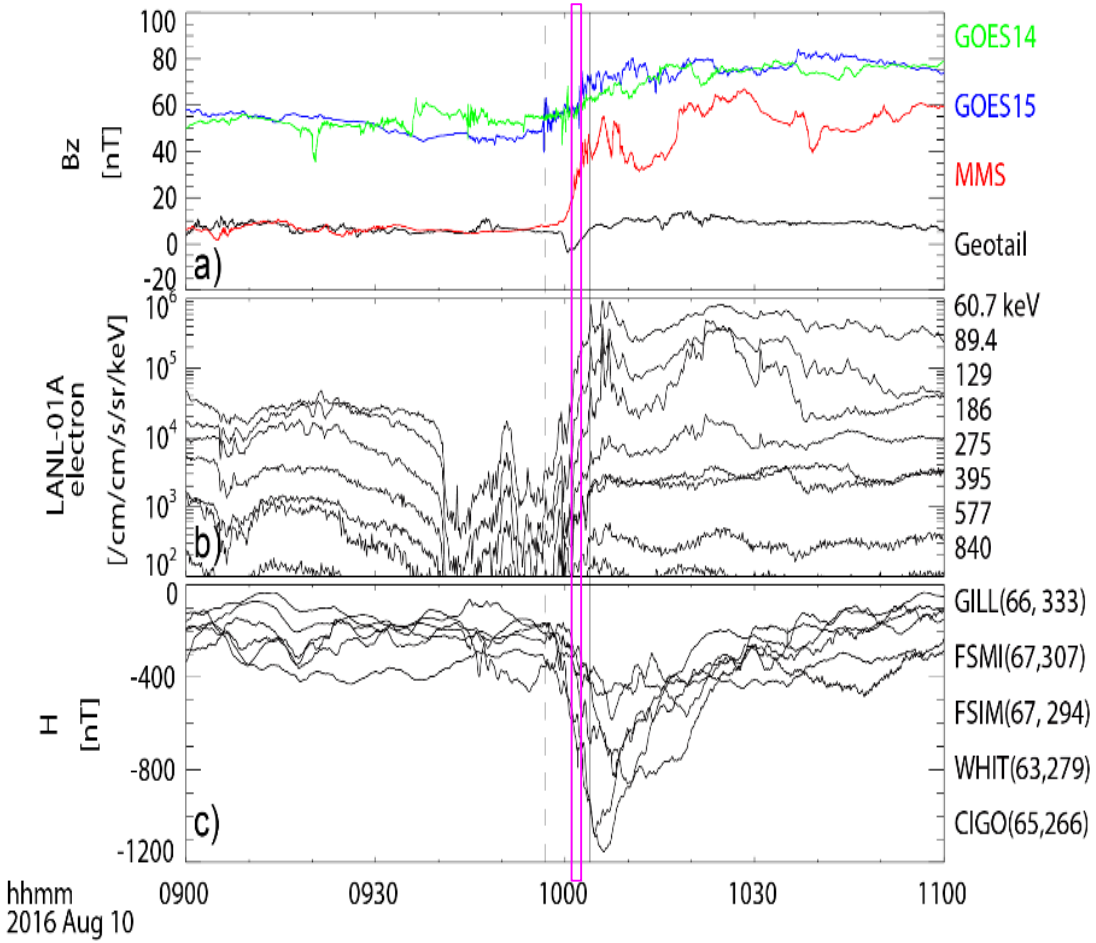
Reconnection jets in Hall-simulation

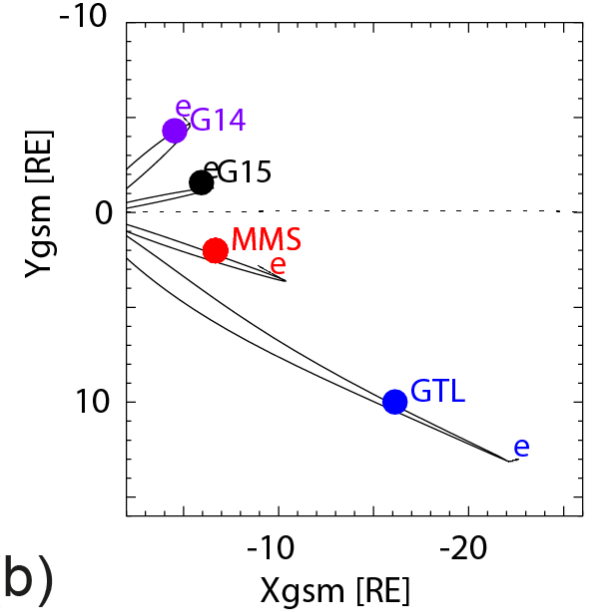


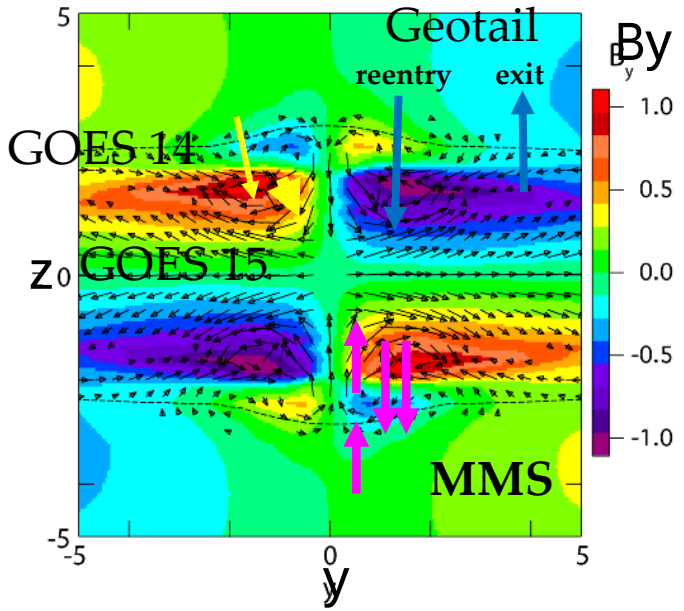


[Nakamura et al., 2018]

2016/08/10 SUBSTORM DIPOLARIZATION EVENT







[Nakamura et al., 2017]

- MMS at southward/westward edge of BBF
- Large-scale context from multi-point measurements (substorm current wedge)

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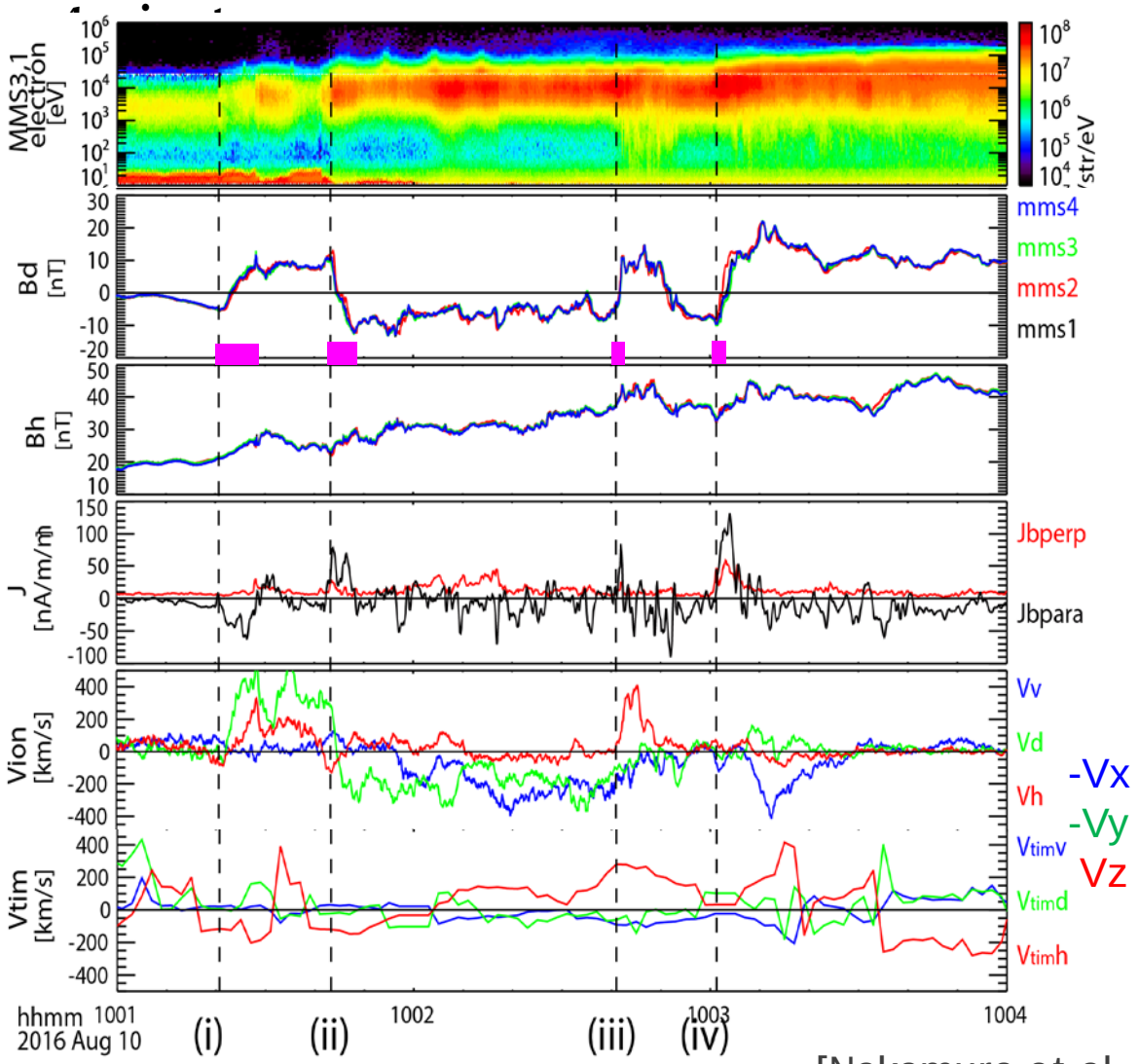
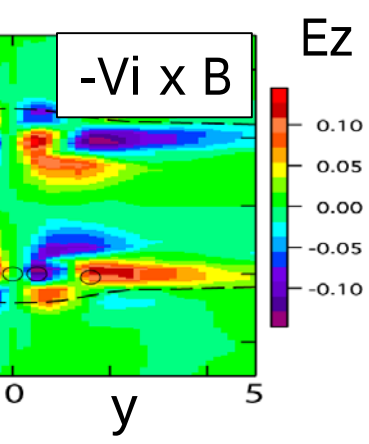
MMS AT OUTER PLASMA SHEET

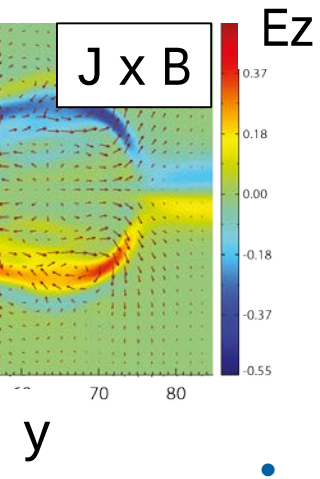
- Expansion of outer plasma sheet/PSBL (β <0.3)
- Multiple-dipolarizations
- Field aligned current (FAC) layers
  (i) downward (anti-para) FAC
  (ii-iv) upward (para) FAC
- High-speed dawn-dusk flow(i,ii)
  Vy<0 (-Vd) → Vy>0 (+Vd)
- Equatorwad (convection) flow Vz>0 (+Vh)
- Earthward (parallel) flow (-Vv) event(iii)
- Plasma sheet motion changes from outward (i,ii) to inward/dawnward (iii,iv)

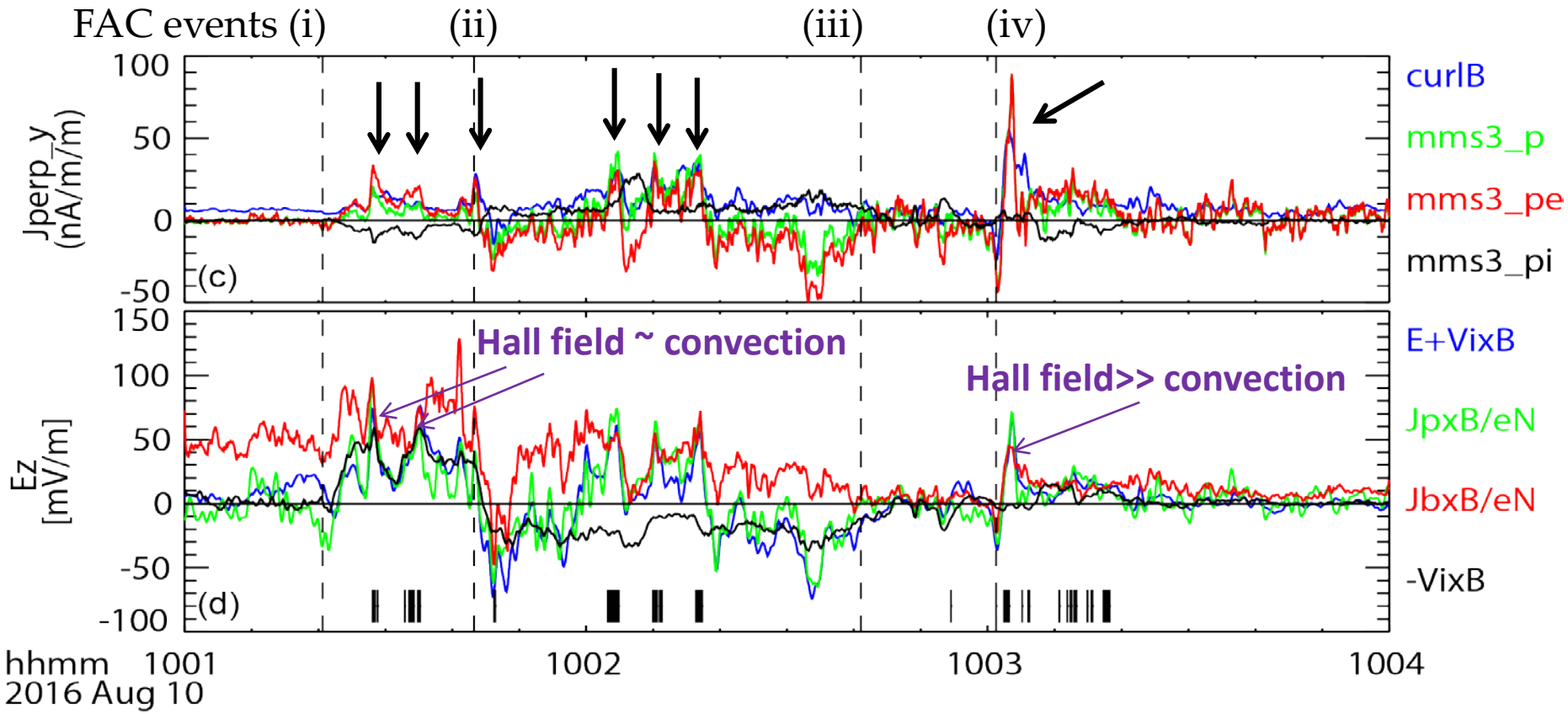


[Nakamura et al., 2018]

MMS: HALL ELECTRIC FIELDS AND J_PERP SPIKES





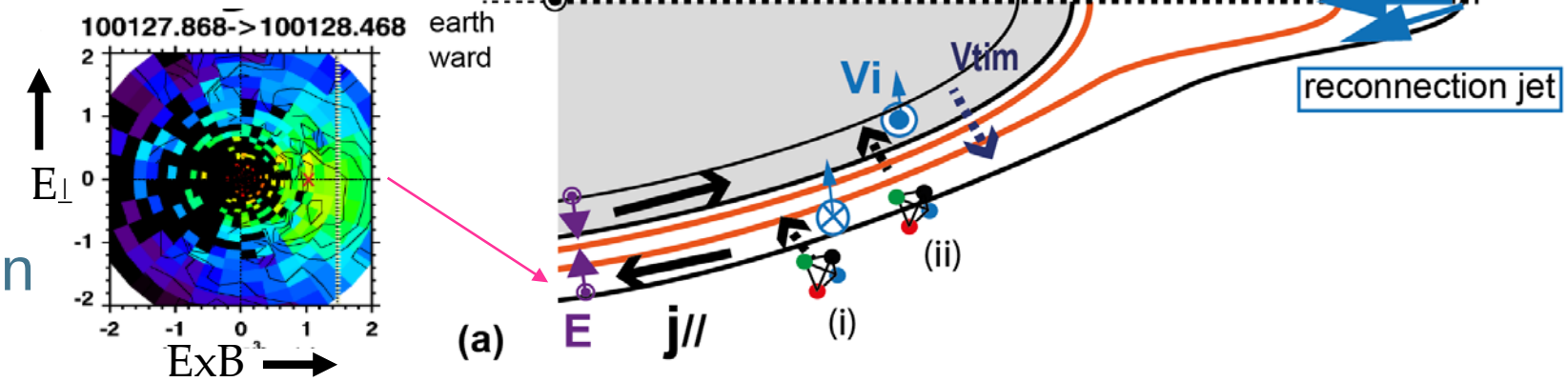


[Nakamura et al., 2018]

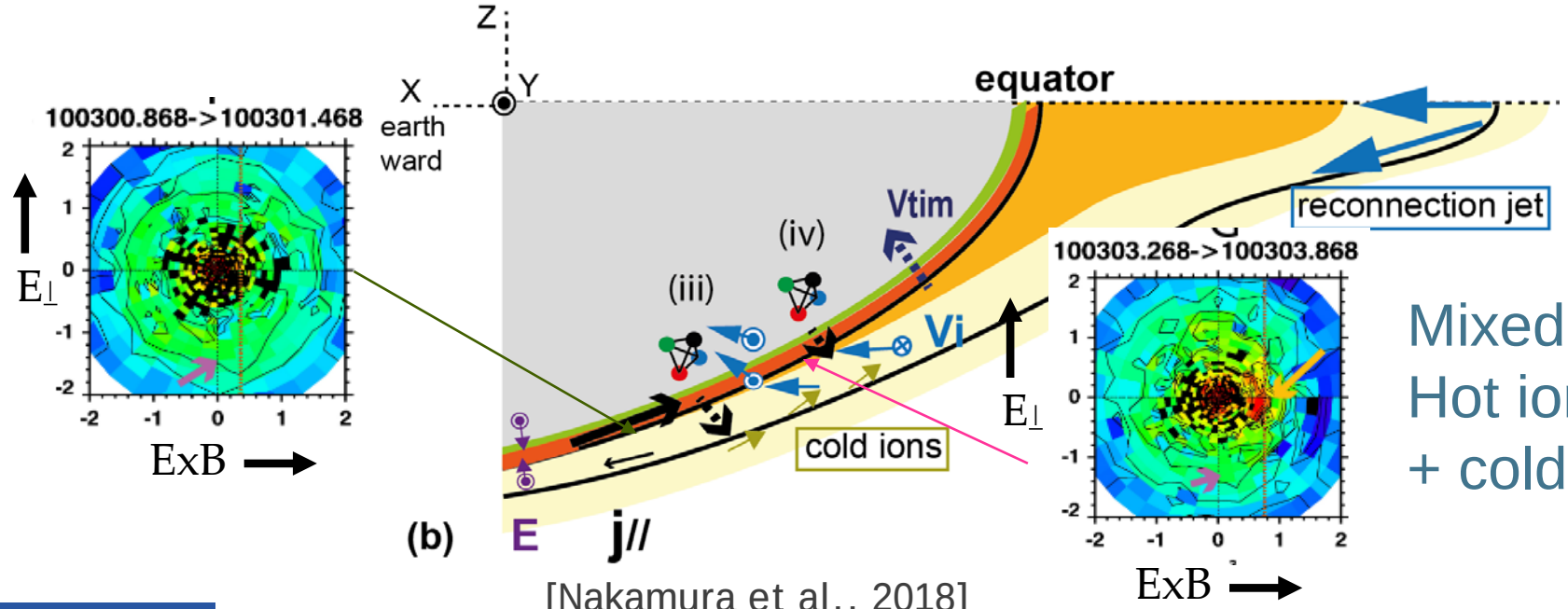
- Hall fields E + Vi x B = J x B (confirmed from particle and curlometer current)
- Hall E comparable to –VixB for events (i,ii) but dominates for event (i)
- Transient Hall current enhancements surrounding the field-aligned (FAC) current events.

ION CHARACTERISTICS IN HALL CURRENT LAYERS

Slow ion drift along ExB direction



Hot ion flows along -Eperp



Mixed ion component
Hot ion flows Eperp
+ cold ExB ions

[Nakamura et al., 2018]

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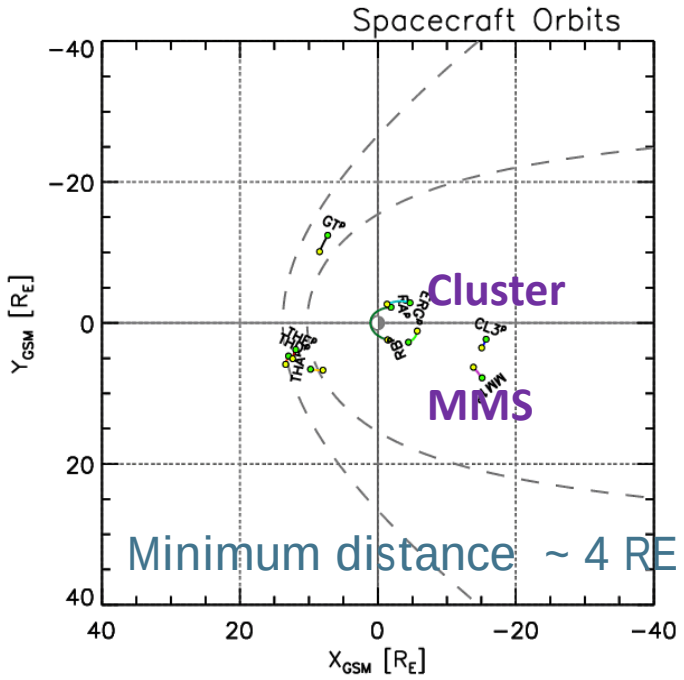
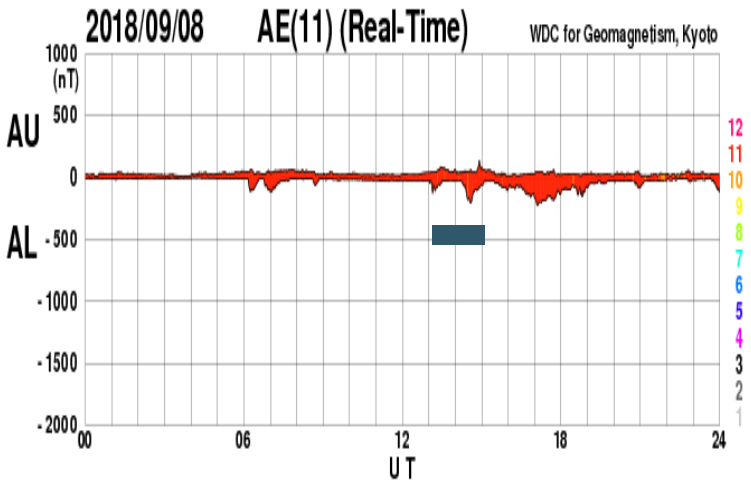
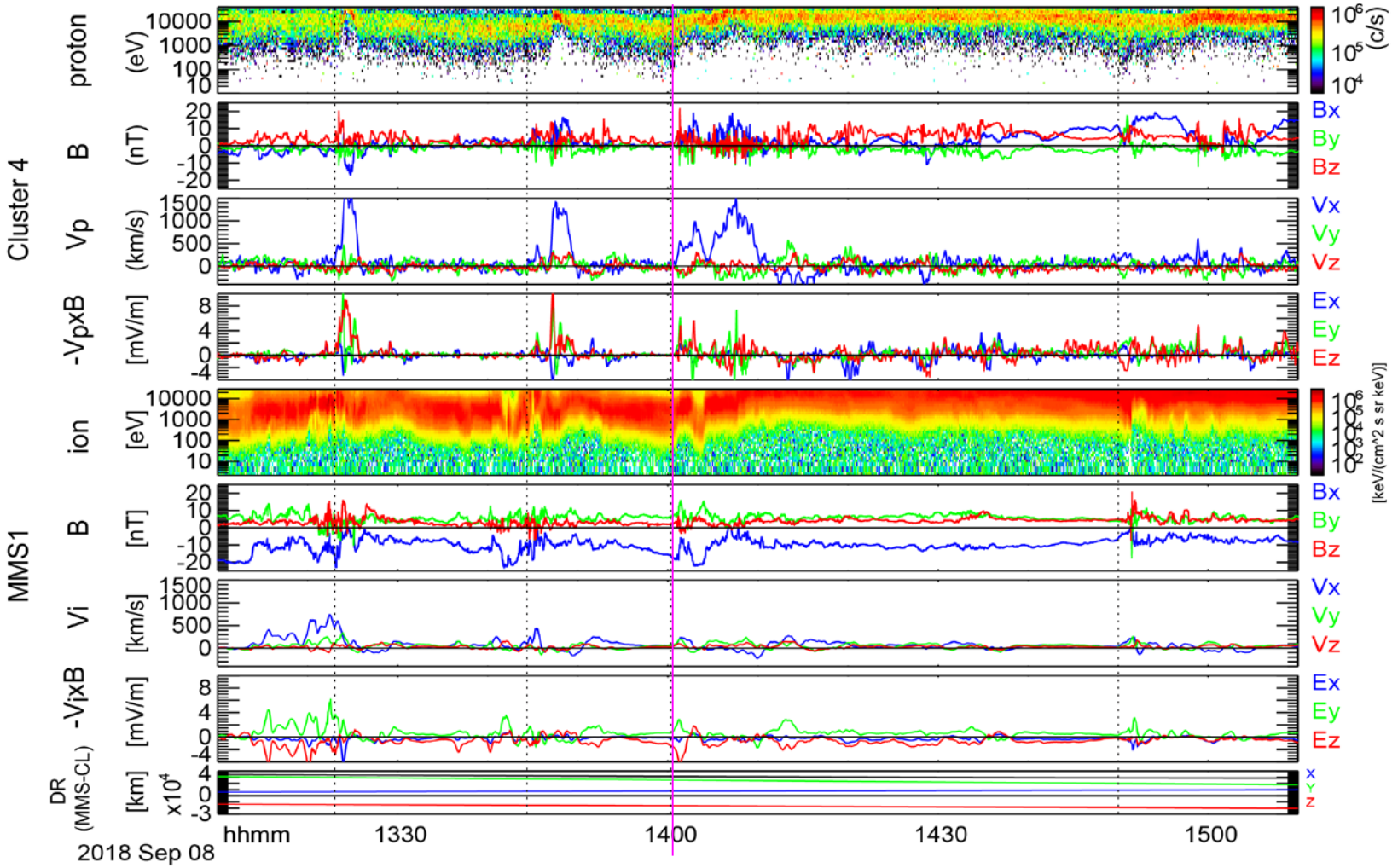
MMS 2018 CONJUNCTION EVENTS WITH CLUSTER (SC: X~-17 R_E)



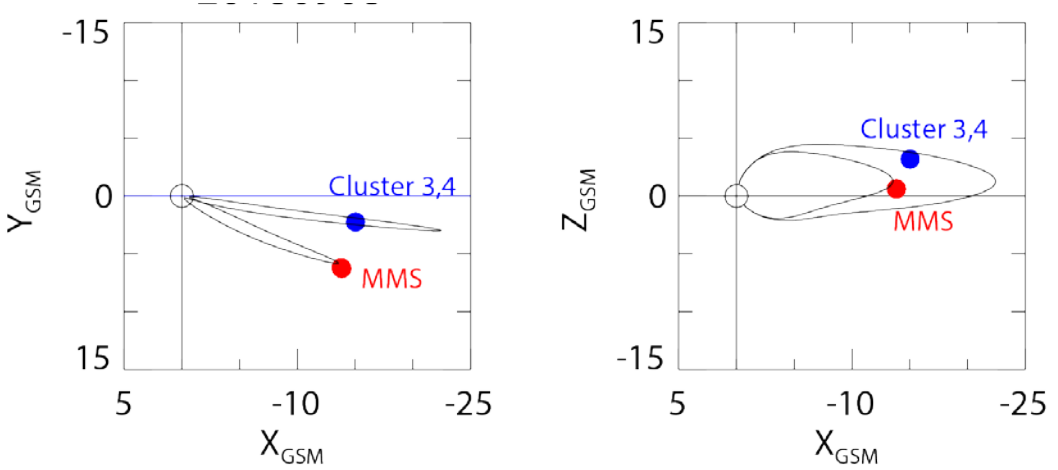




MMS-CLUSTER NEAR-SIMULTANEOUS BBF/DIPOLARIZATION FRONT OBSERVATIONS

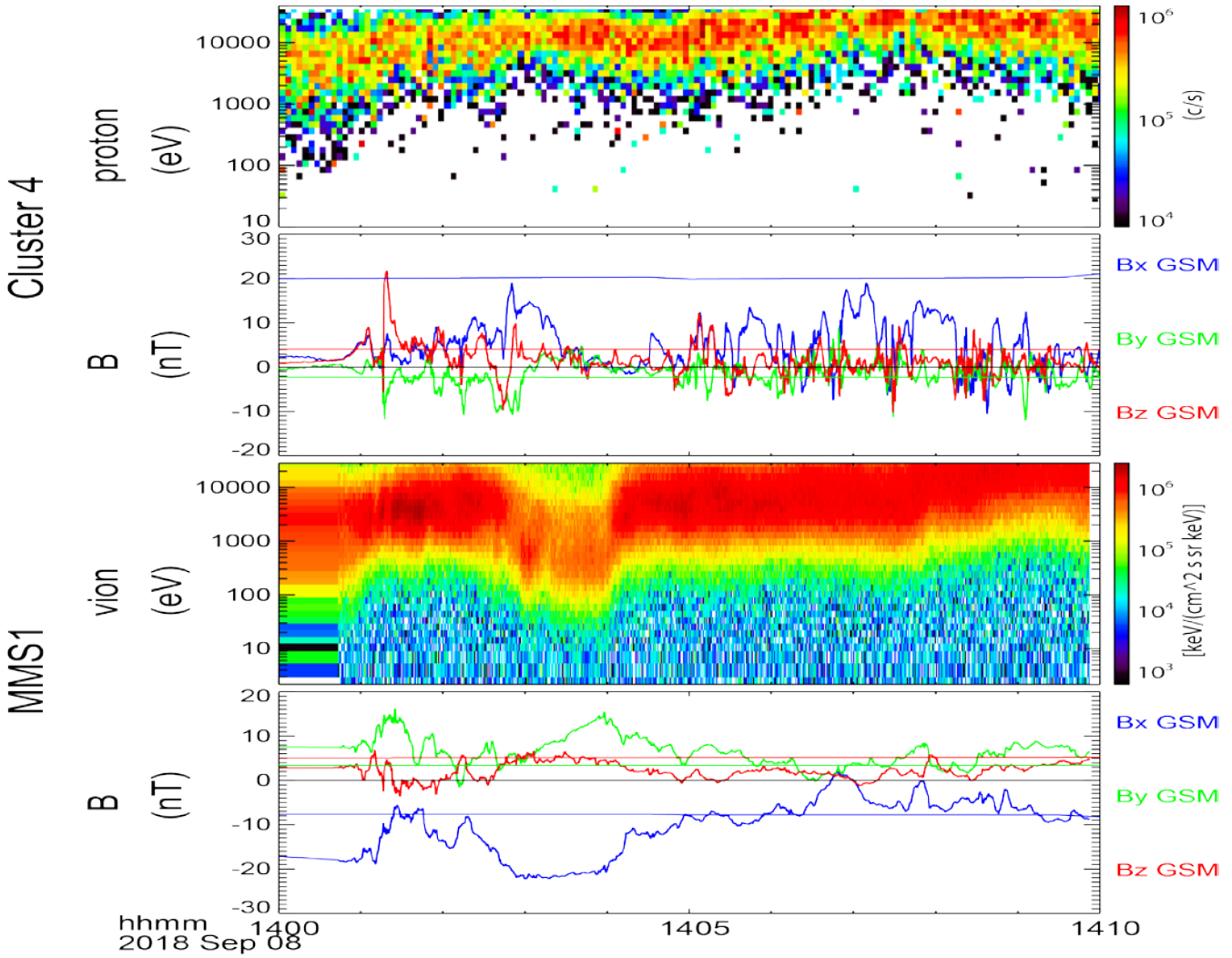
2018/09/08 14 UT

$\Delta R(Cluster\text{-}MMS) = (-1.2, -4.0, 2.6)\ R_E$

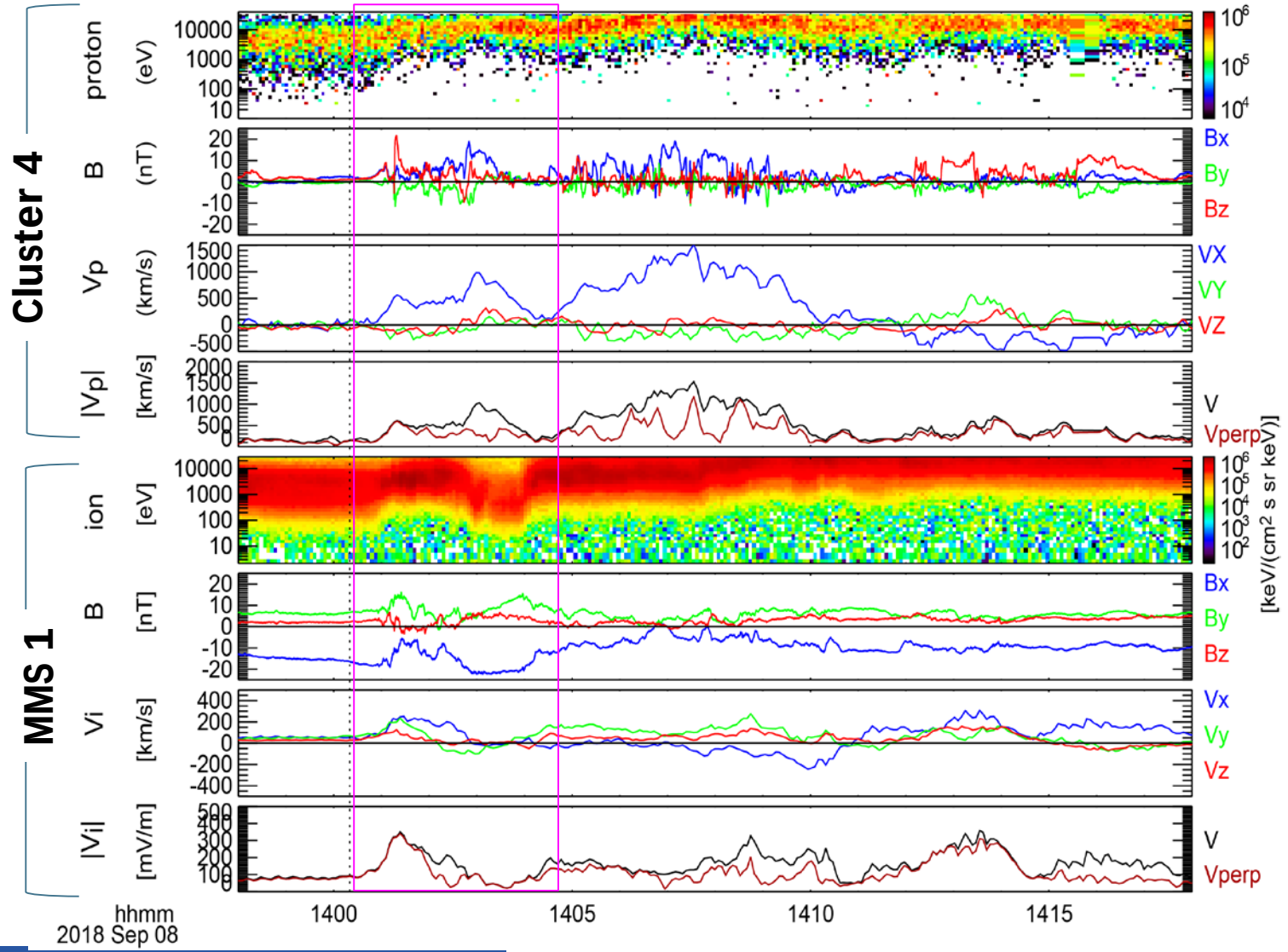


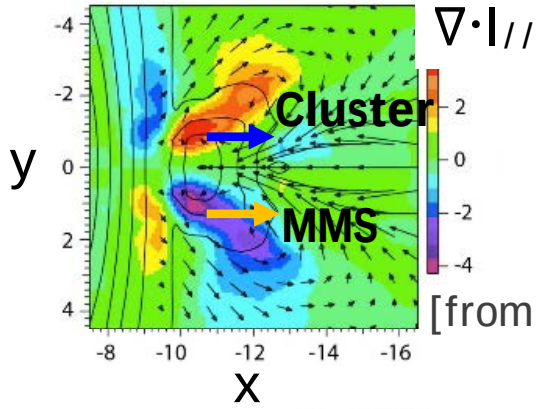
(Predicted Cluster model field line/field values from T15 model are too tale-like, since both SC crossed equator)

- *After DP, CS thinning followed by northward motion*

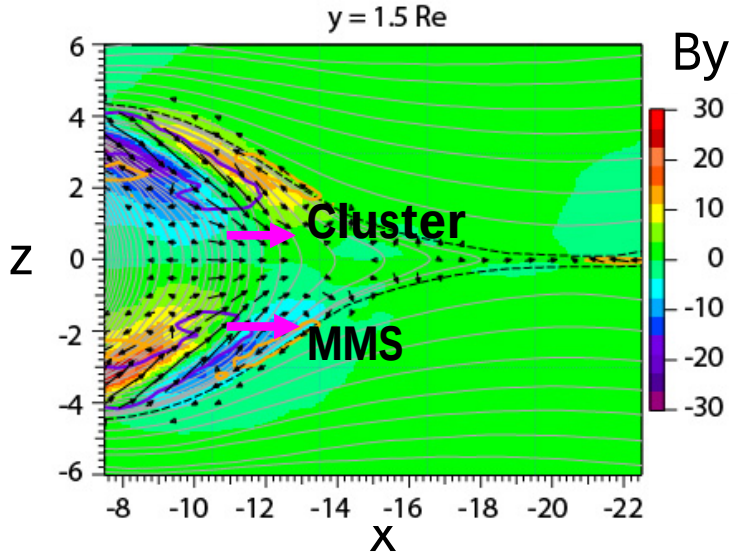


2018/09/08 FLOW VORTEX EVENT



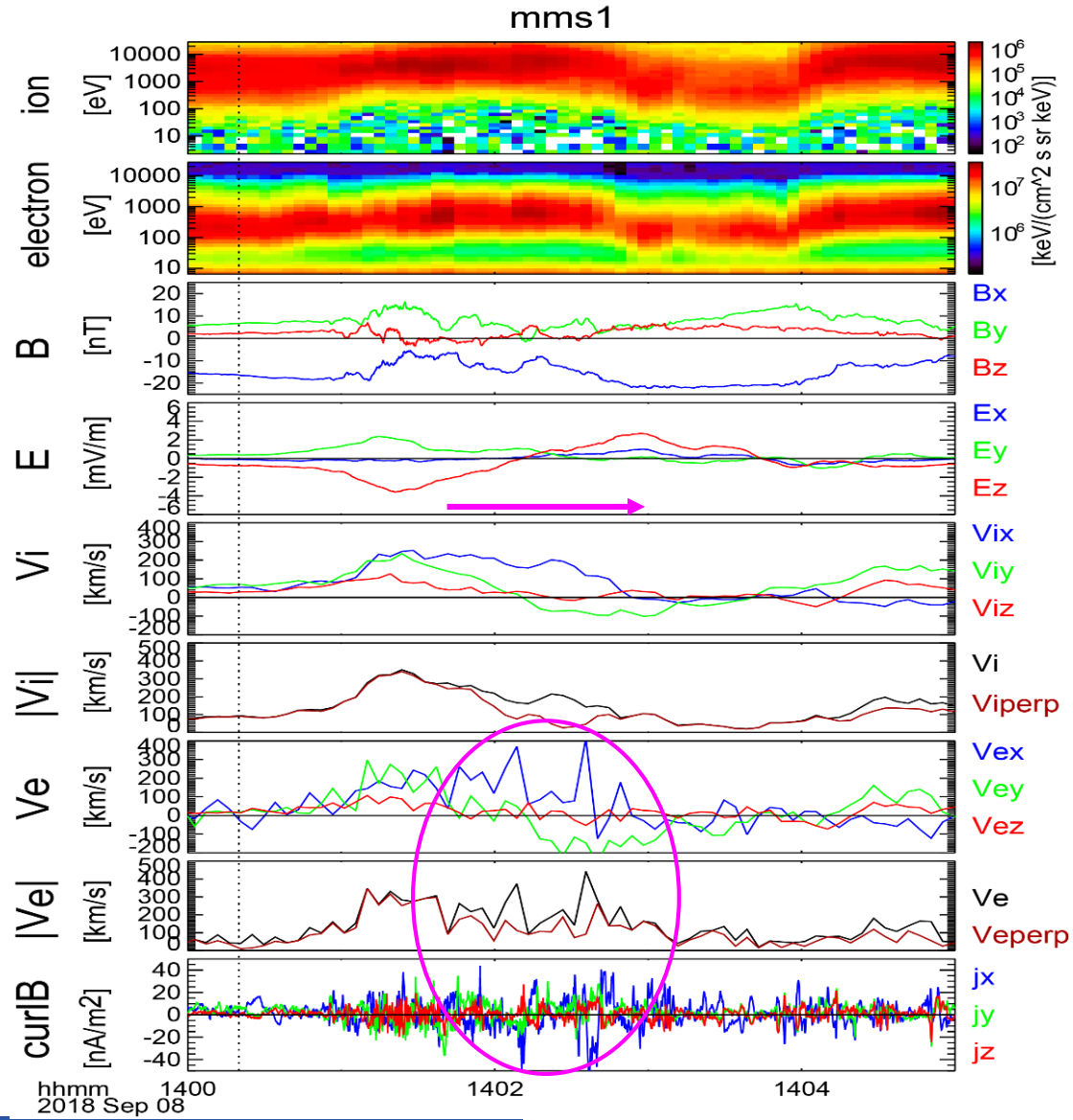


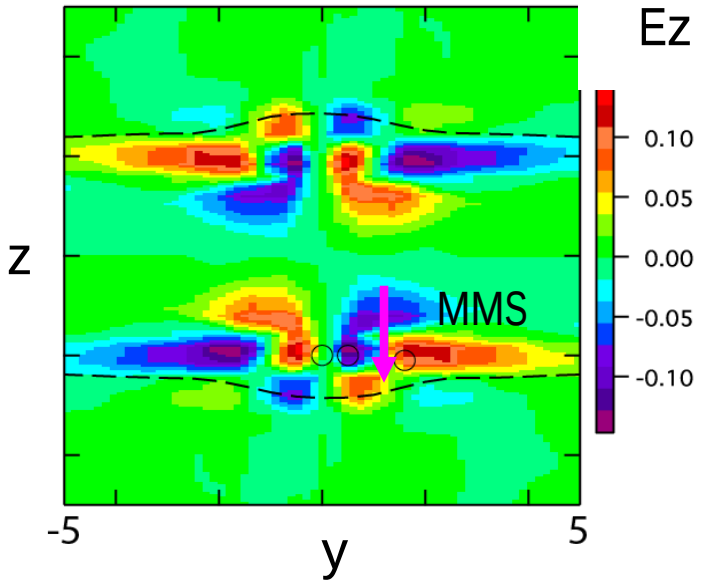
[from Birn et al., 2013]



- Dipolarization front
- Enhanced Vperp → Vpara

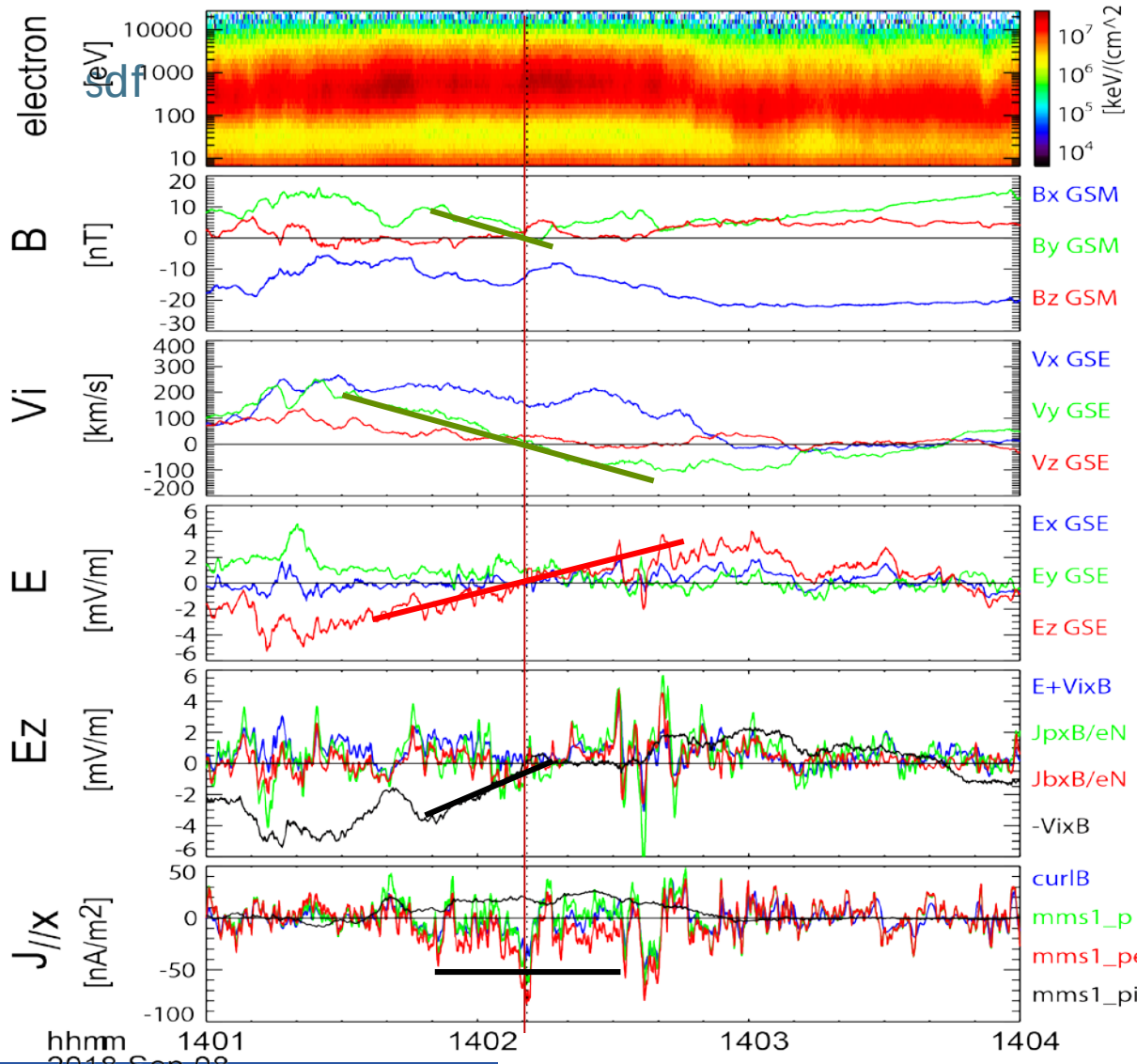
MMS: EZ & FIELD ALIGNED CURRENT



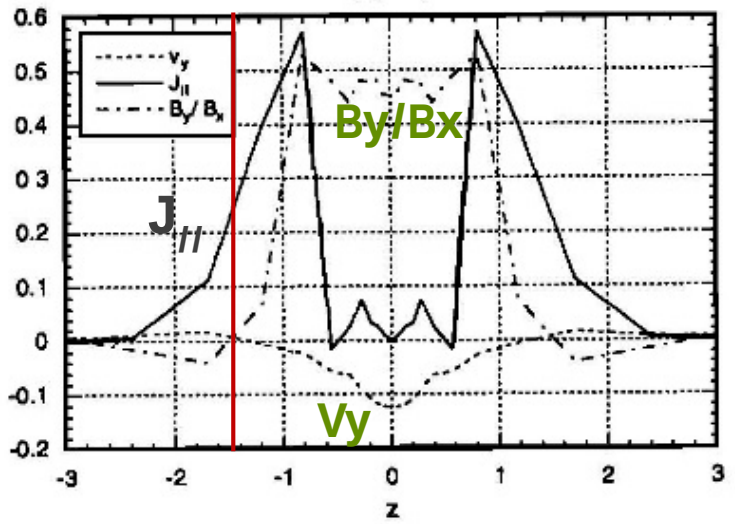


Multiple layers of upward (jx < 0) field-aligned electron currents at Ez, Vi, Ve reversal region

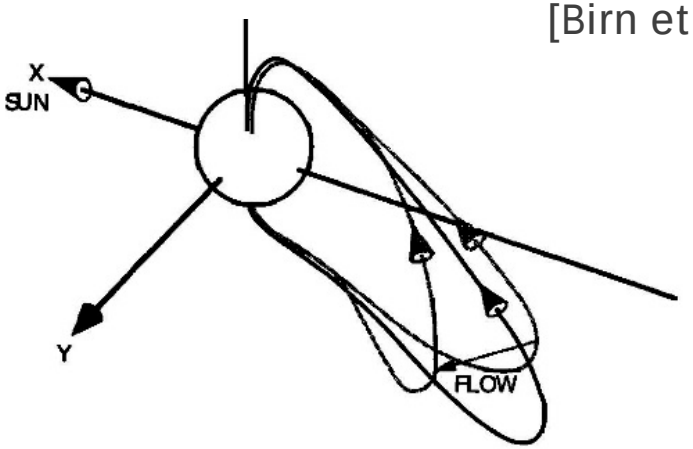
SHEAR IN CONVECTION FLOWS



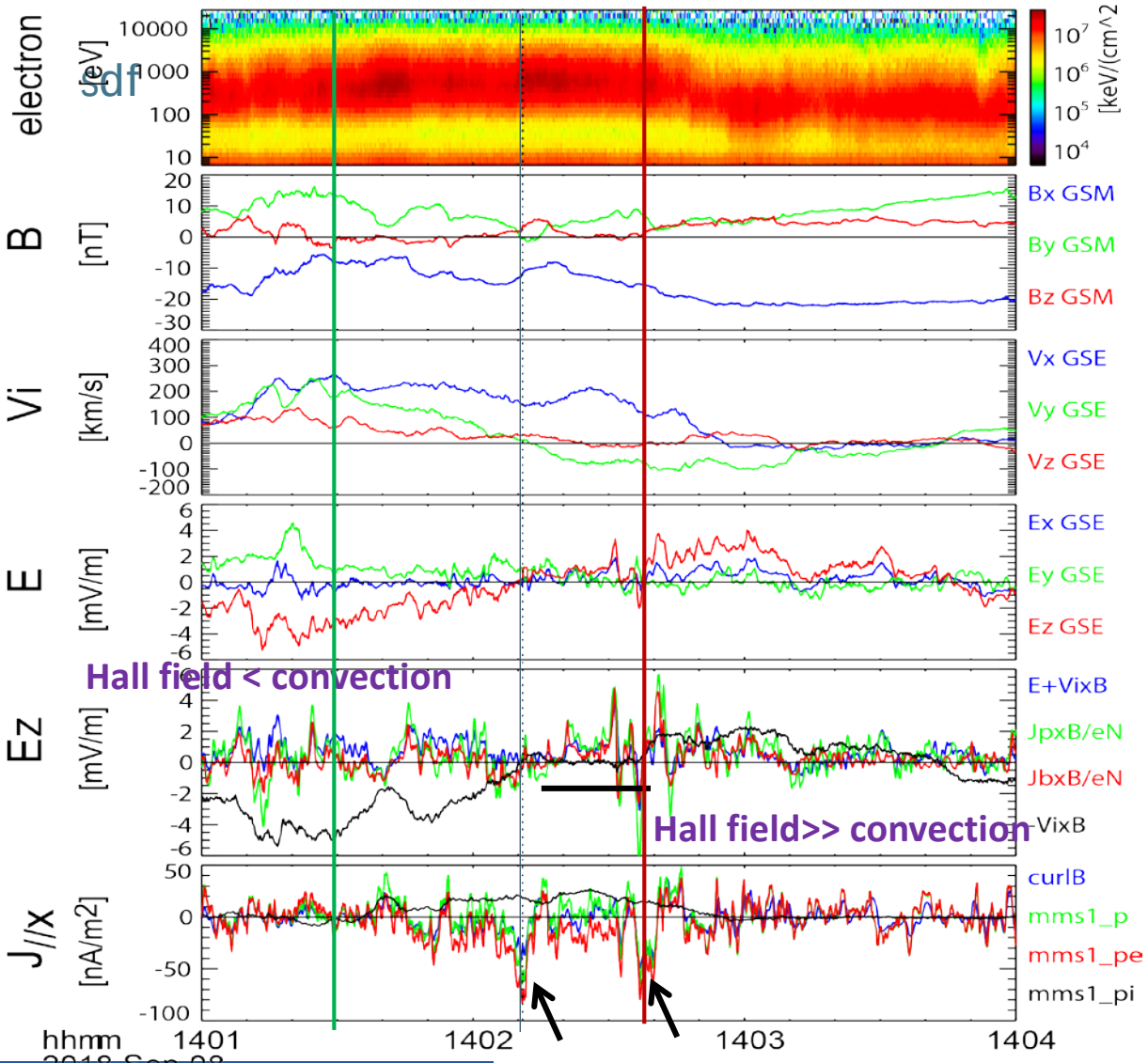
For dawnside x=-5.6, y=-3, t=160

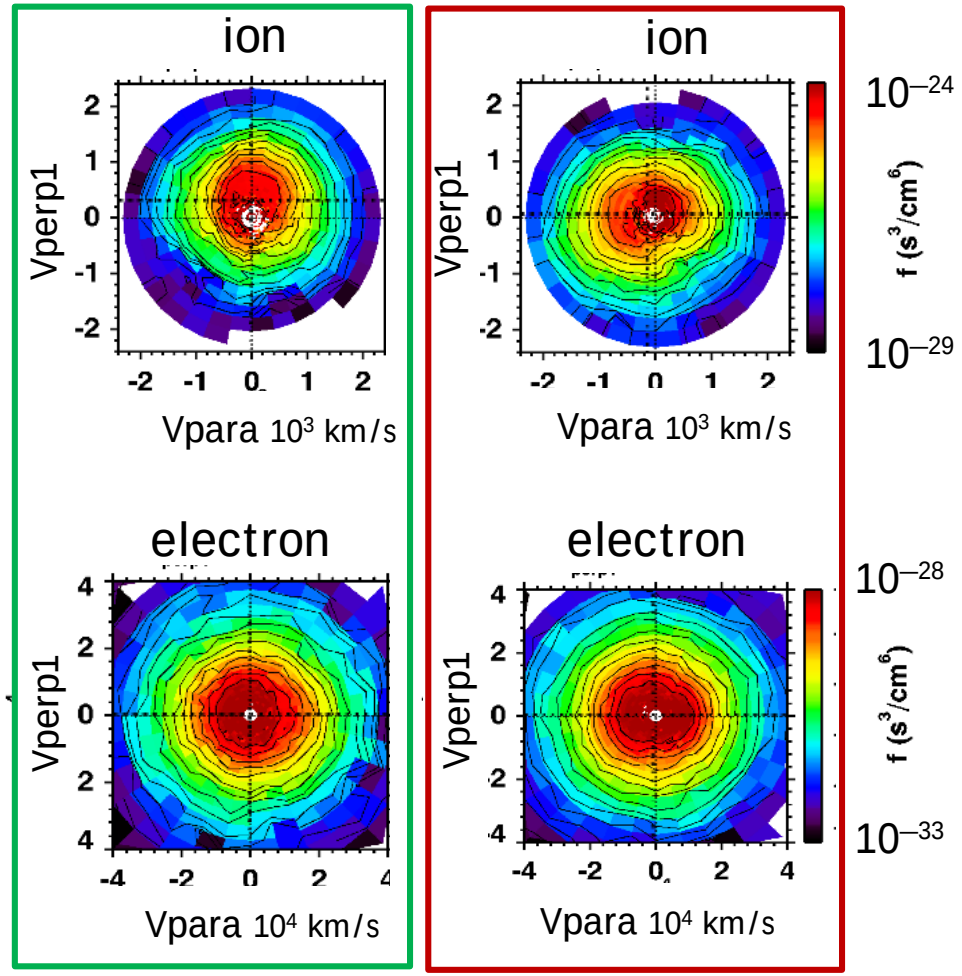


[Birn et al., 1996]



CONVECTION V.S. HALL- FIELDS & SMALL SCALE PROCESSES





Vperp

-Vpara, heating cold core ions

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SUMMARY

- Off-equatorial flow shear associated with dipolarization in the near-Earth magnetotail is well explained by the effects due to localized reconnection jets
- Both Hall effect & effects localized convection flow contribute to E normal (to the CS) and forms intense perpendicular current layers at off-equator flow shear region
- Contribution from convective flows dominates near the center of the current sheet, while Hall-effect becomes important at the off-equatorial region
- Multiple intense upward currents (downward going electrons) are detected in the off-equator side of the flow shear region suggesting contribution of kinetic processes in the current wedge formation