Asymmetric reconnection at the terrestrial bow shock – MMS observations

H. Gunell, **M. Hamrin**, O. Goncharov,

A. De Spiegeleer, S. Fuselier,

B. J. Mukherjee, A. Vaivads

UMEÅ UNIVERSITY

Ref.: Hamrin et al., JGR 2019.
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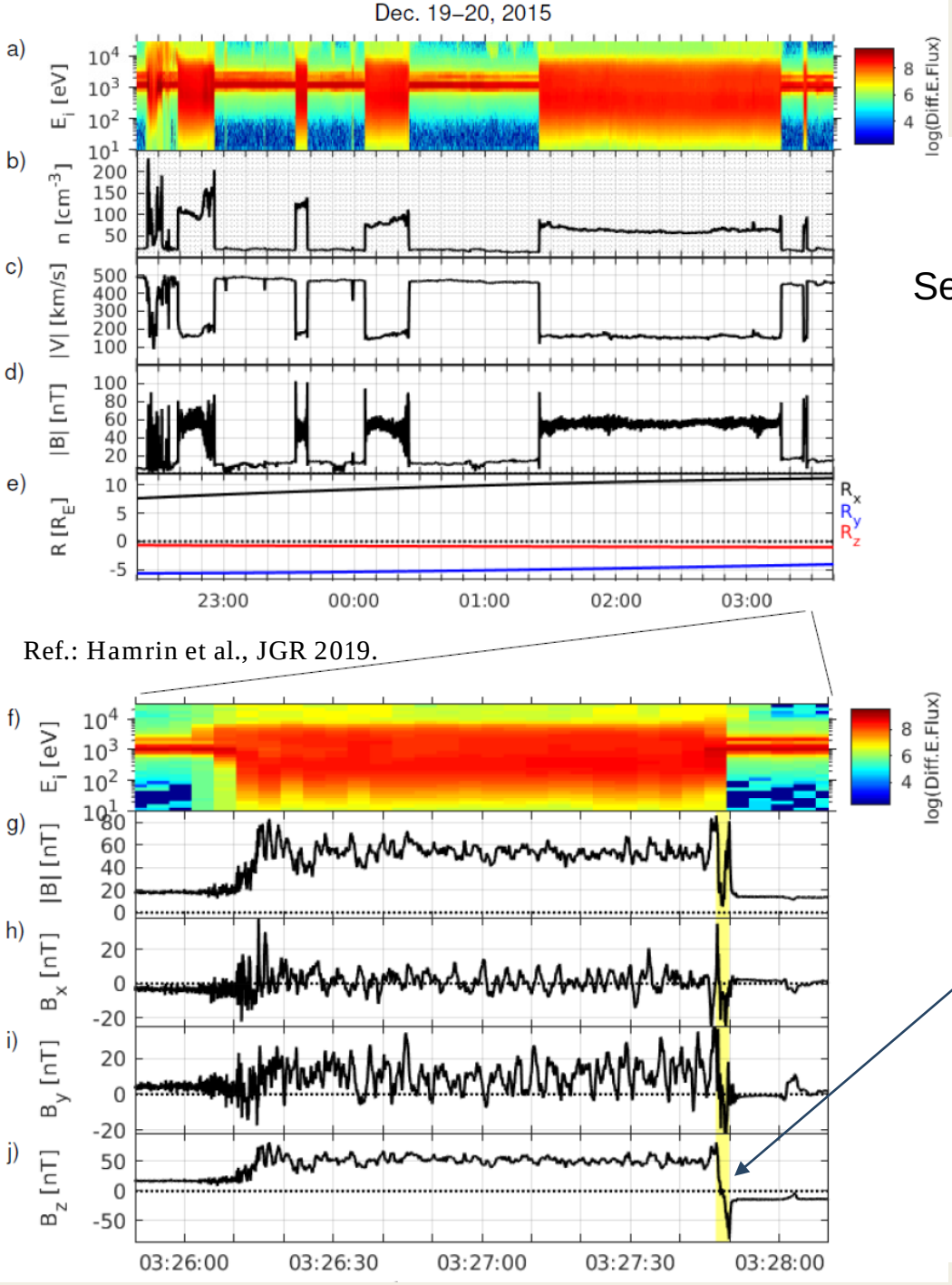
MMS overview



Several bow shock crossings Dec 19-20, 2015.

Ref.: Hamrin et al., JGR 2019.

A directional discontinuity (DD) exactly on a quasi-perpendicular bow shock (θ_{Bn}~85°).

170° B field rotation.

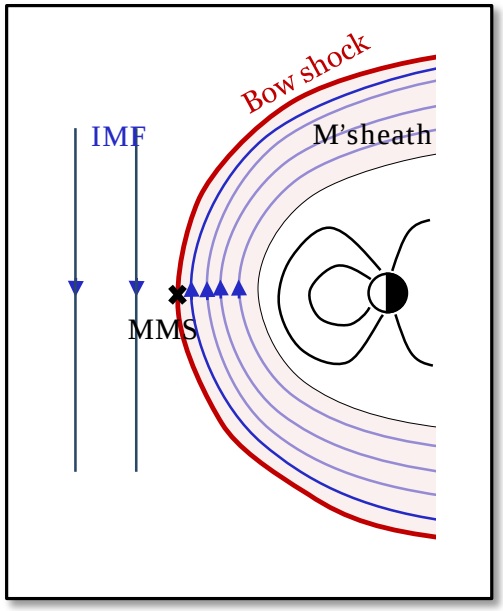
No burst data. ☹

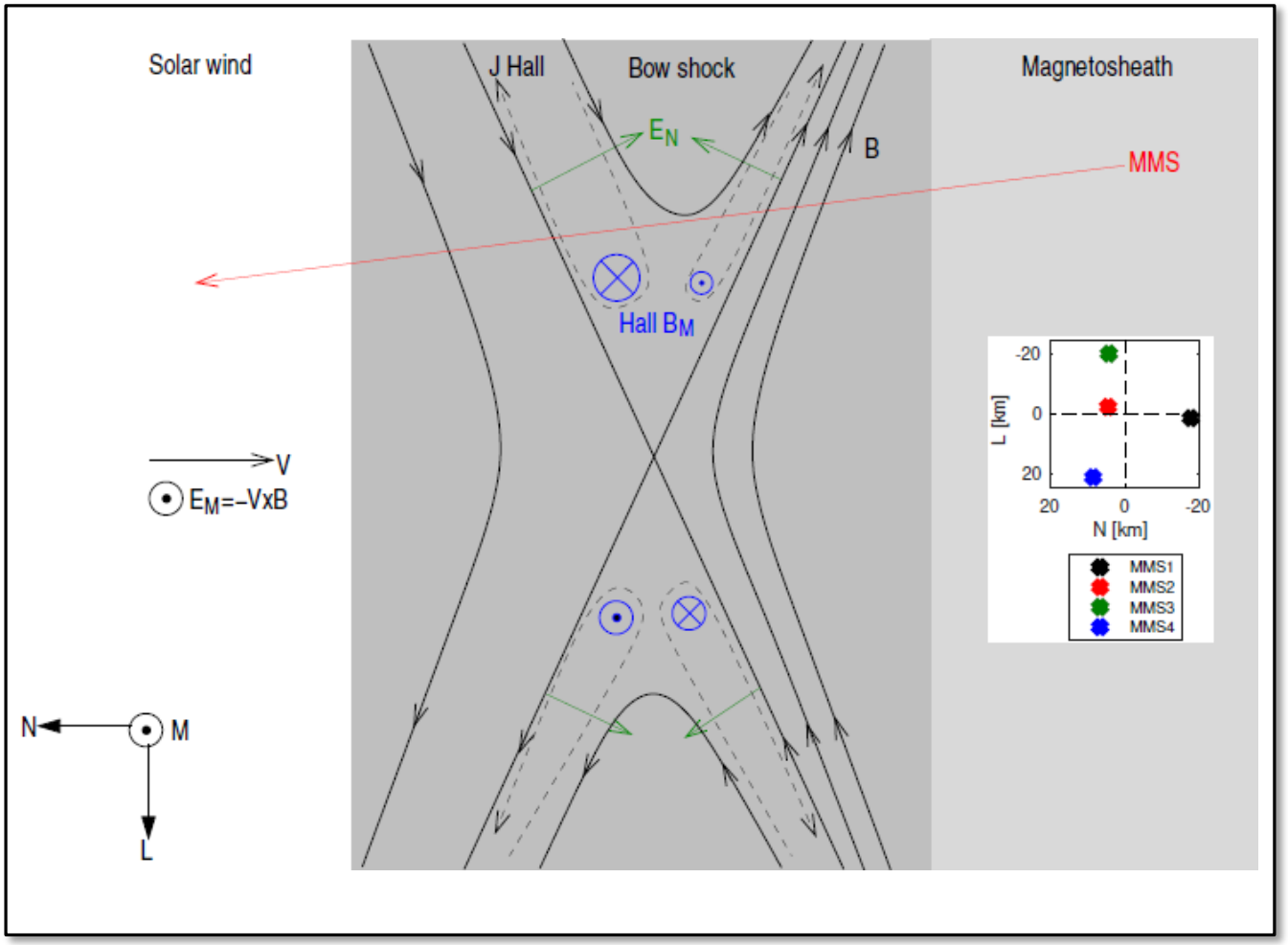
Maria.Hamrin@space.umu.se, 2020

Asymmetric reconnection?
Different from the magnetopause case

Magnetosheath side
High B and N

Solar wind side
Low B and N
Supersonic!





Distorted properties.

Local LMN system.
N from timing. V_{tim}~170 km/s
M from MVA.

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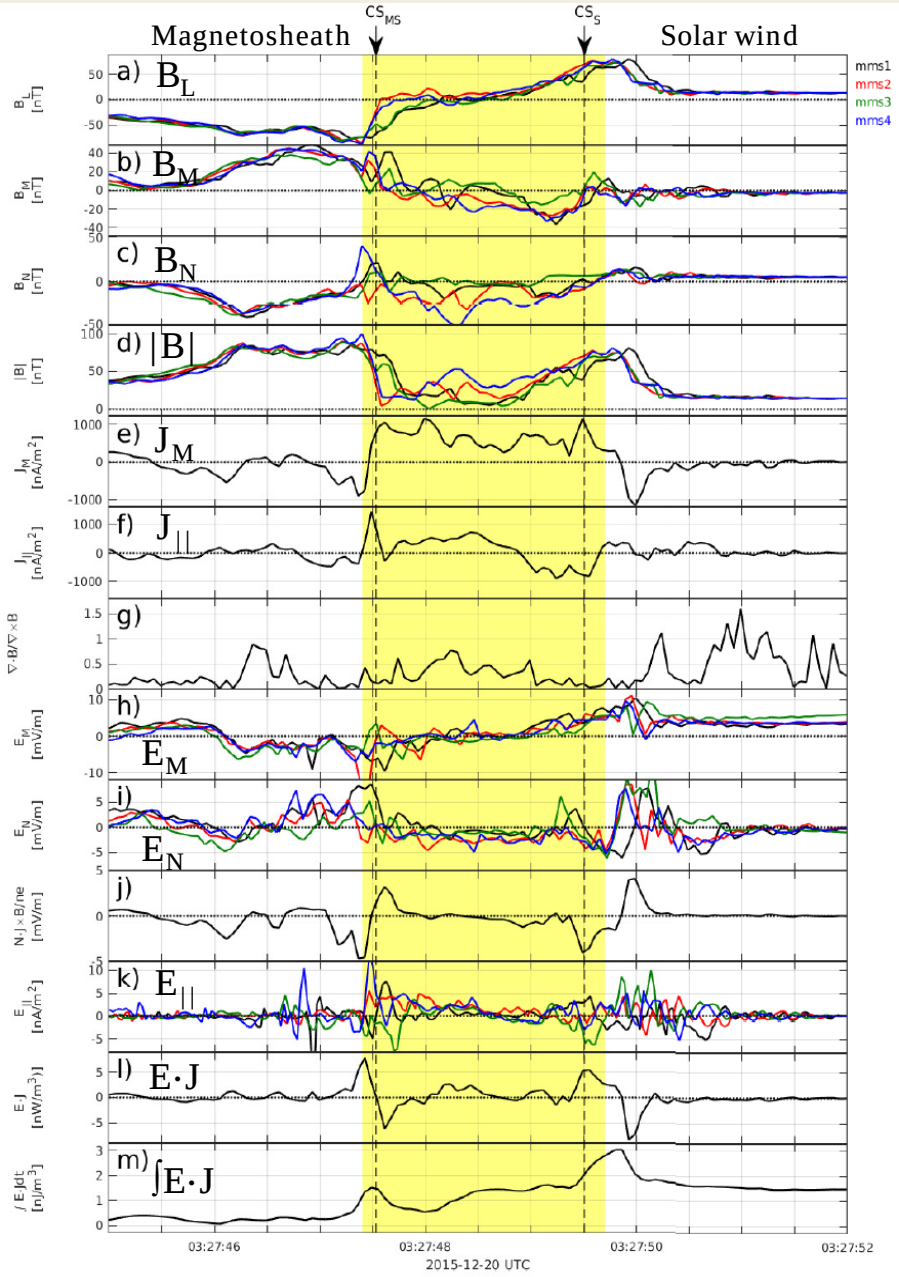
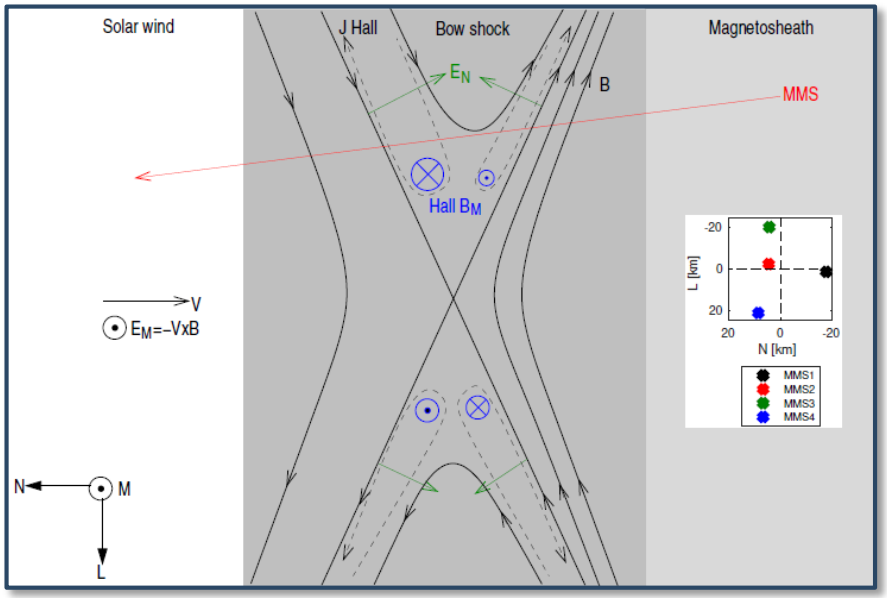
Details in the shock (LMN) system



M'sheath. Possible guide field ~-10 nT.

c) $B_N<0$. Magnetic connection.

d) Magnetic null displaced toward M'sheath.



e-g) Strong J_M and distorted $J_{||}$.

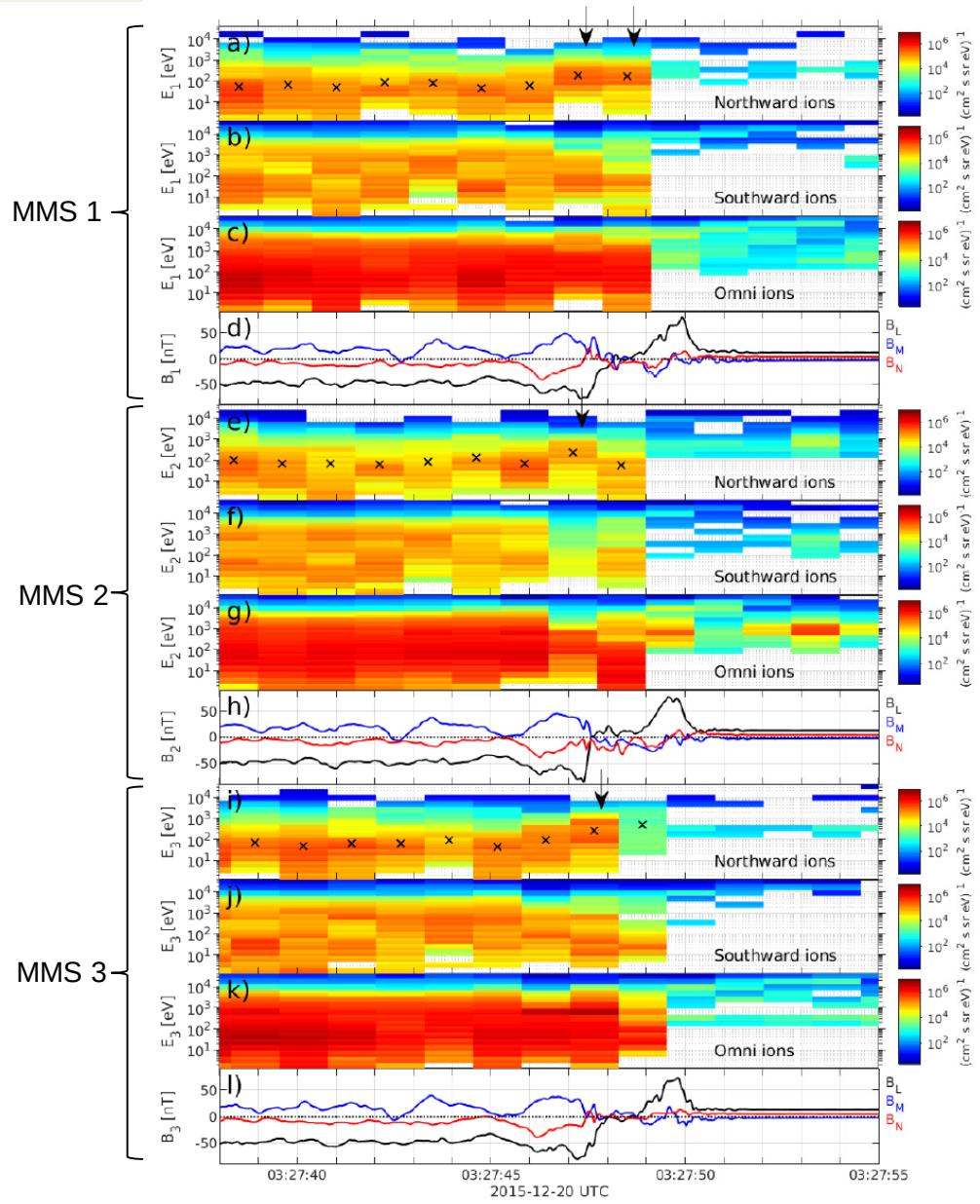
h) Asymmetric E_M: Inflow from supersonic side.

i-k) Bipolar $E_N \approx \pm 5$ mV/m can accelerate ions.
Potential drop ~260 eV.
$E_{||}$ patchy but pointing away from X-line.

l-m) $\int E \cdot J dt > 0$. Net energization of the plasma.

Ref.: Hamrin et al., JGR 2019.

Energization of the ions



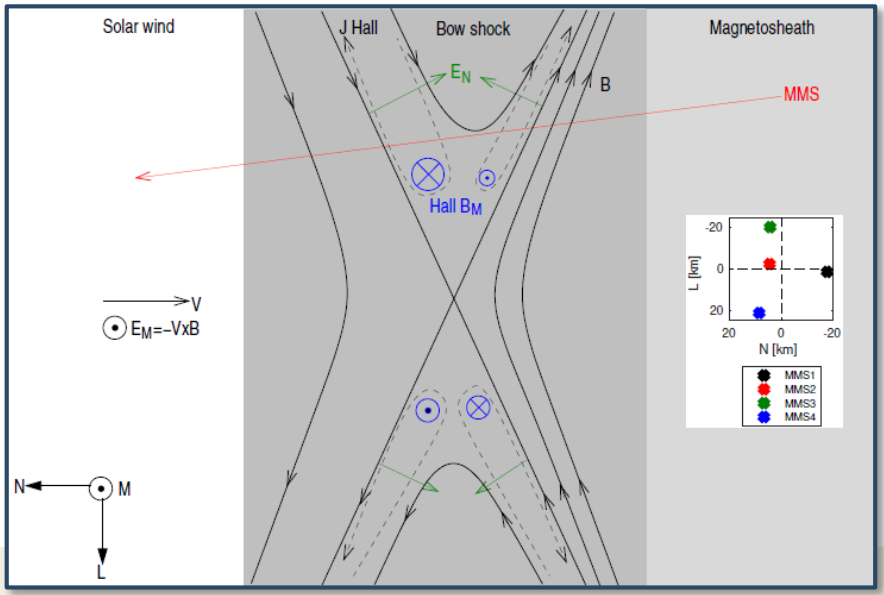
Ref.: Hamrin et al., JGR 2019.

∫E·Jdt>0 and bipolar EN suggests energization of the ions.

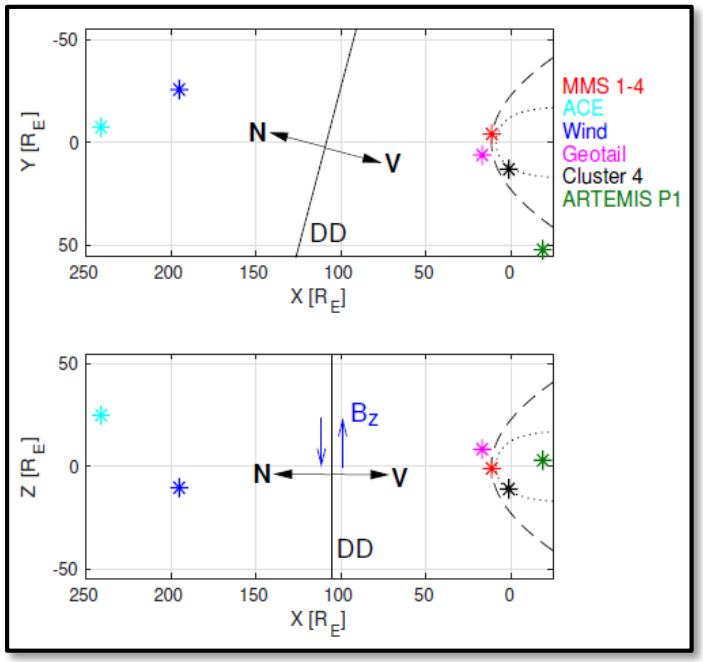
No burst data.

Sub-spin resolution HPCA ion data using available sectors.

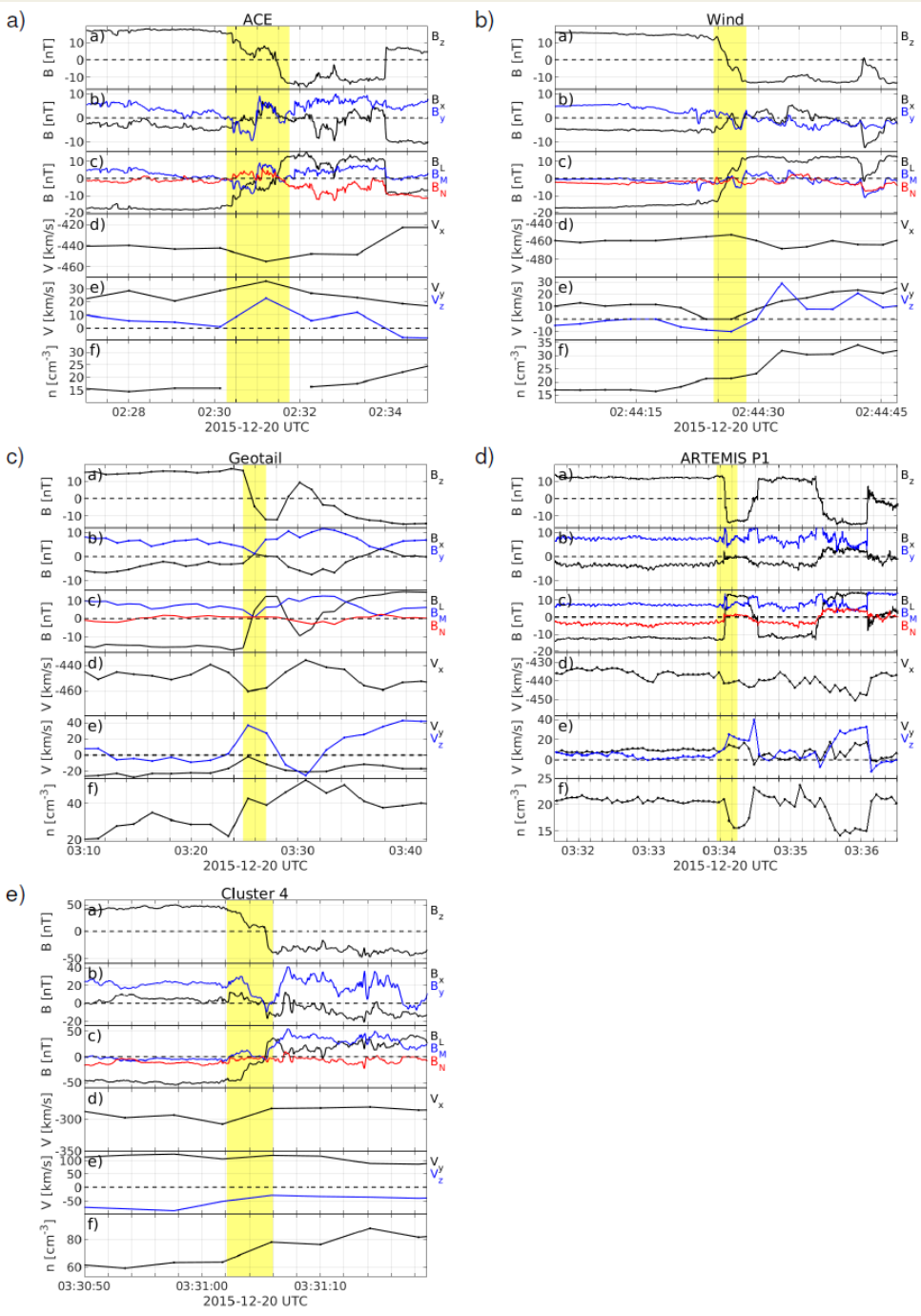
Energy of northward moving ions are elevated 200-300 eV at the as compared to the magnetosheath proper.



Up- and downstream observations of DD



- DD evolves.
- No indications of ongoing reconnection (Hall fields and Alfvénic accelerated jets).
- Compression at the bow shock.
  B_L flip: ±70 nT (MMS) and ±50 nT (C4).
- Reconnection ignited as the DD was compressed at the bow shock?



Ref.: Hamrin et al., JGR 2019.

Summary and conclusions

- Unique observations of reconnection at a quasi-perpendicular bow shock.
  - Bifurcated current sheet. Hall magnetic and electric fields
  - B_N indicating a magnetic connection
  - $J_{||}$ and $E_{||}$
  - Indications of ion energization: E_N, $E \cdot J > 0$, sub-spin HPCA data
- The up- and downstream spacecraft do not see indications of reconnection.
- We suggest: Reconnection temporarily triggered as the DD was compressed at the shock.
- Asymmetric reconnection of a “new type”:
  - B and N are both higher on one side (magnetospheat)
  - Plasma flow supersonic on the other side.

- Planning for simulations (SMILEI, EM, PIC)...

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THANK YOU!

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