Electron Bernstein waves driven by electron crescents near electron diffusion region

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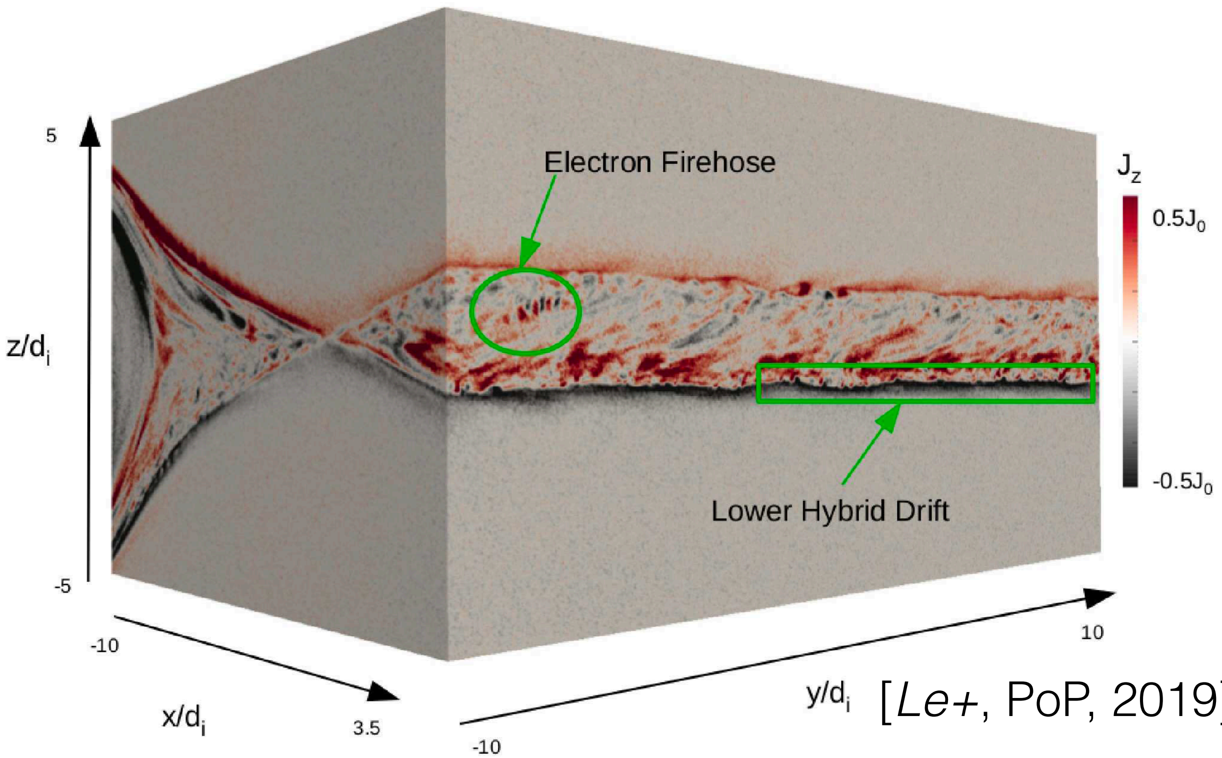
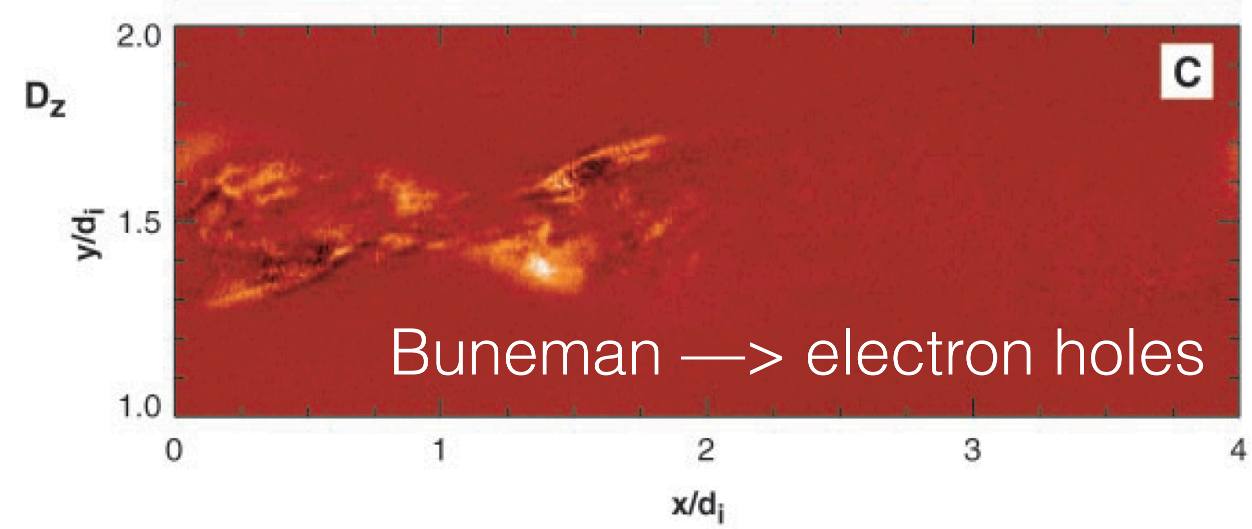
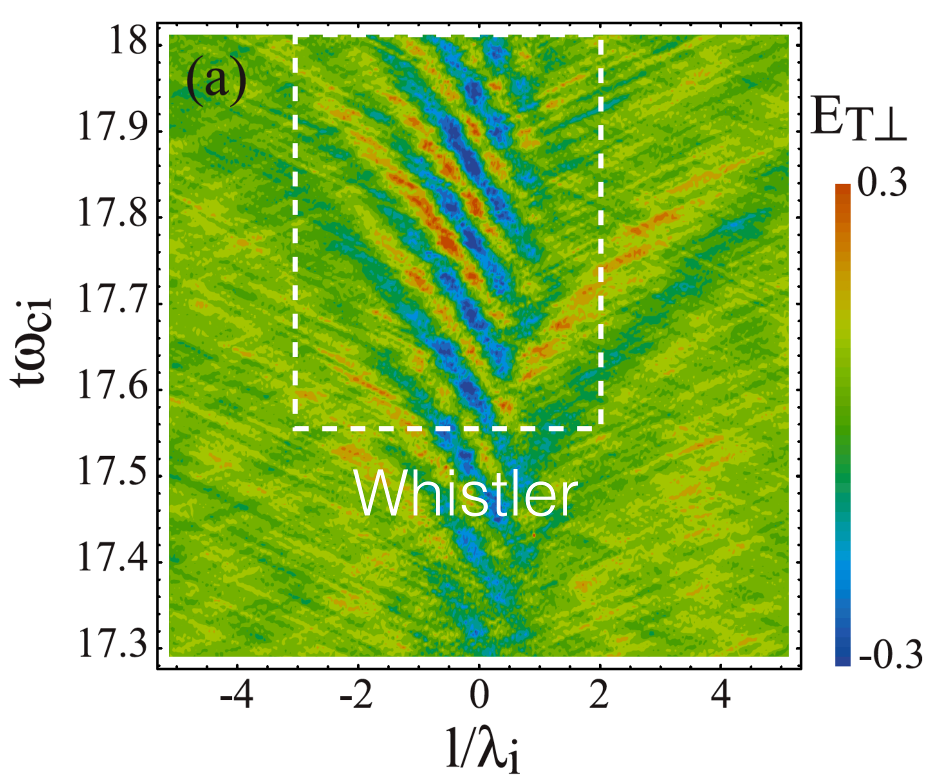
1. Plasma Waves in and near electron diffusion regions



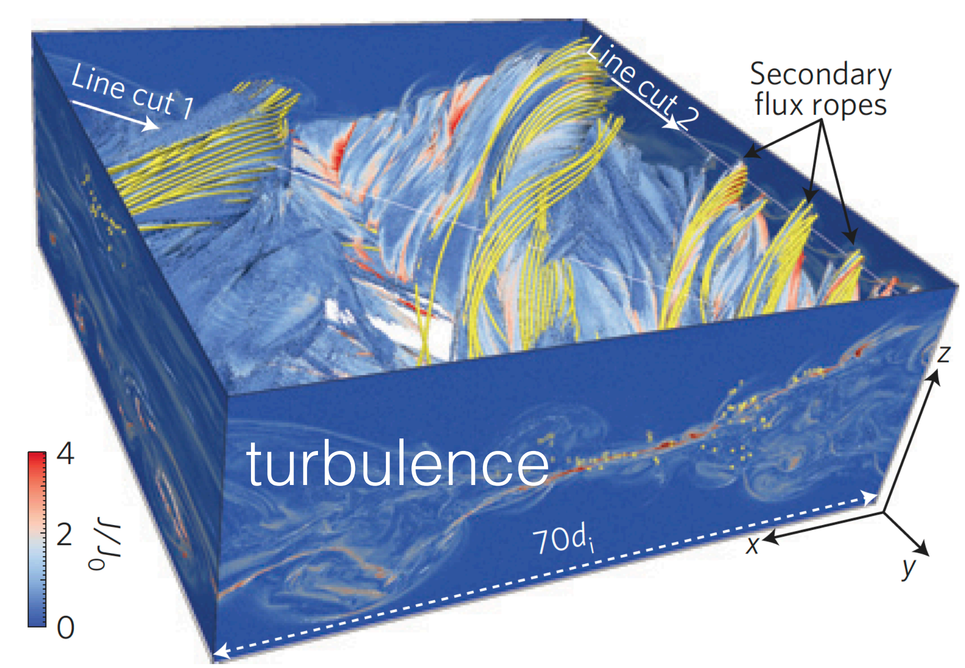
[*Le+*, PoP, 2019]



[*Drake+*, Science, 2003]



[*Fujimoto+Sydora*, GRL, 2008]

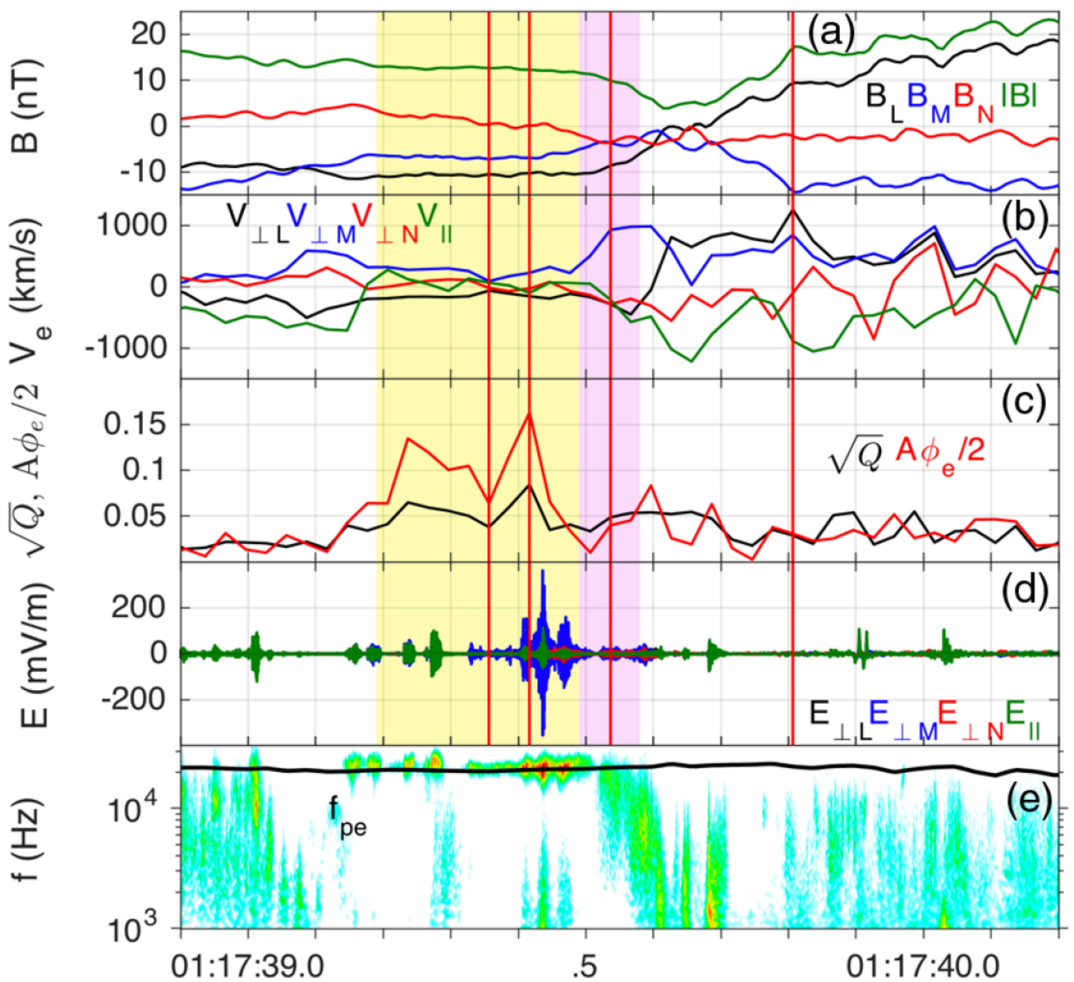


[*Daughton+*, NatPhy, 2011]

1. Plasma Waves in and near electron diffusion regions

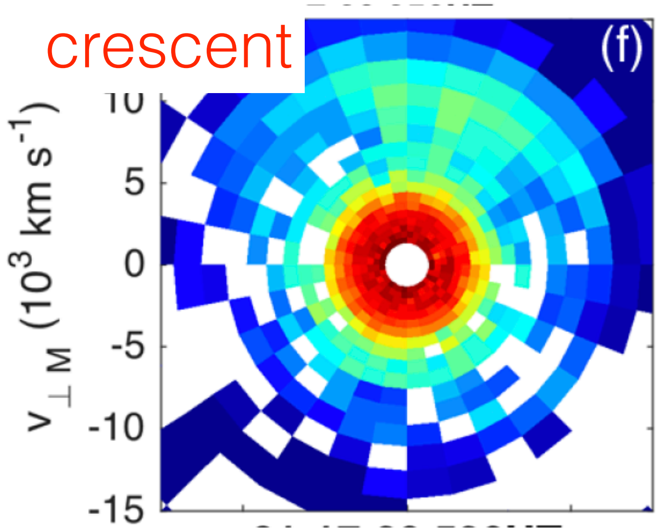
- Waves driven by agyrotropic electrons

EDR at dayside magnetopause



upper-hybrid waves

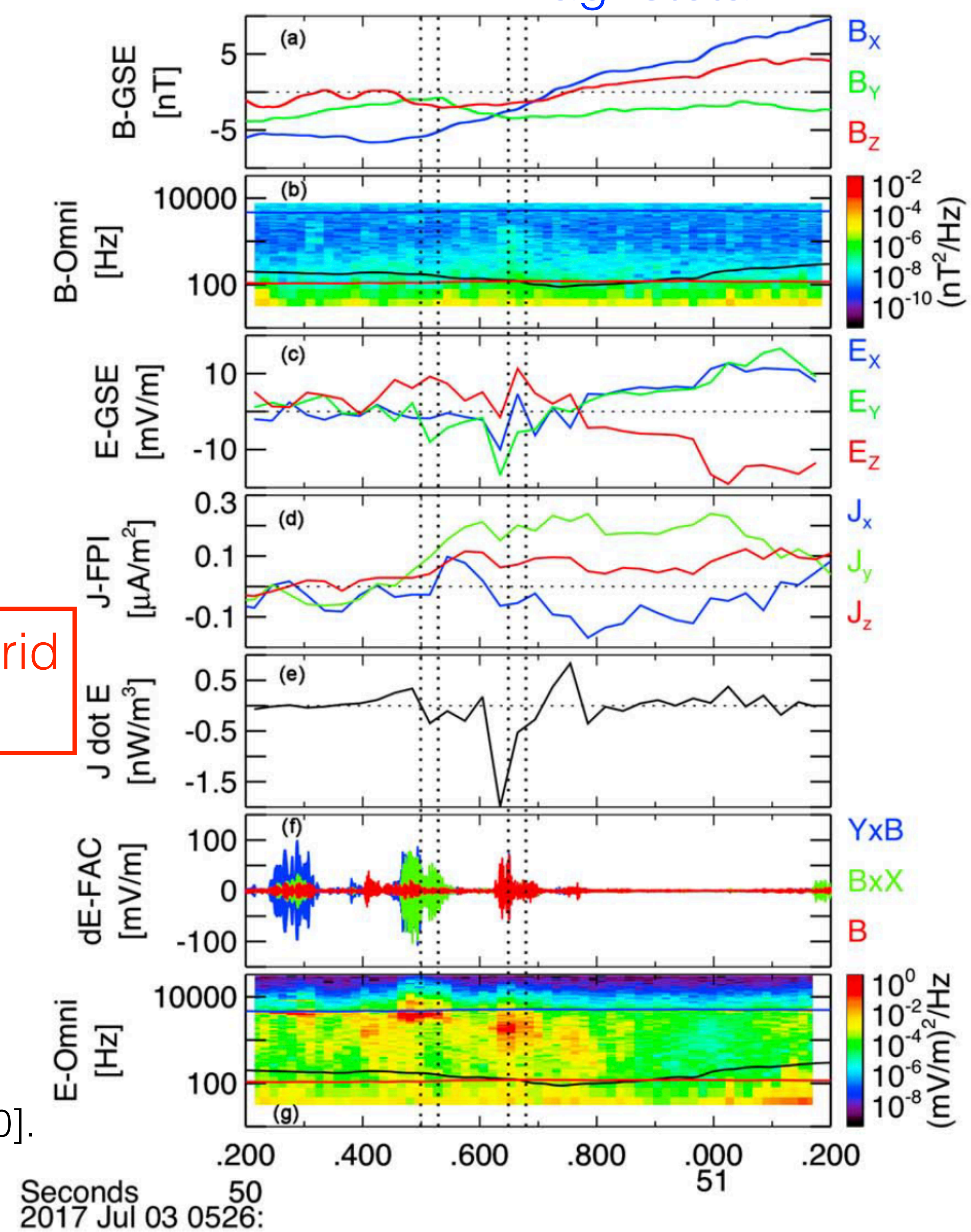
crescent



[*Graham+*, PRL, 2017],

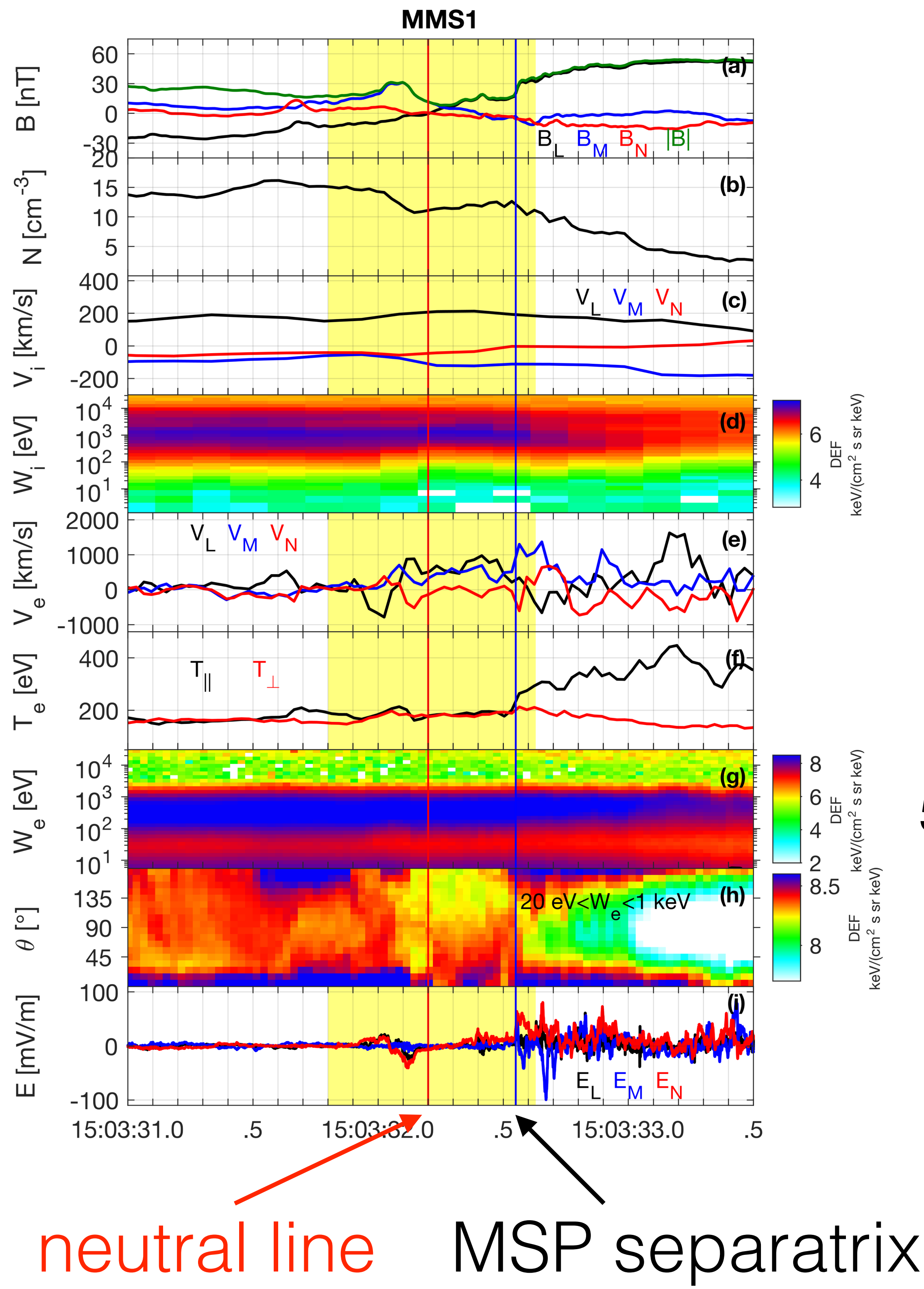
[*Burch+*, GRL, 2019],
[*Dokgo+*, GRL, 2019&2020].

EDR in magnetotail



2. Electron diffusion region at dayside magnetopause

- Electron diffusion region encounter

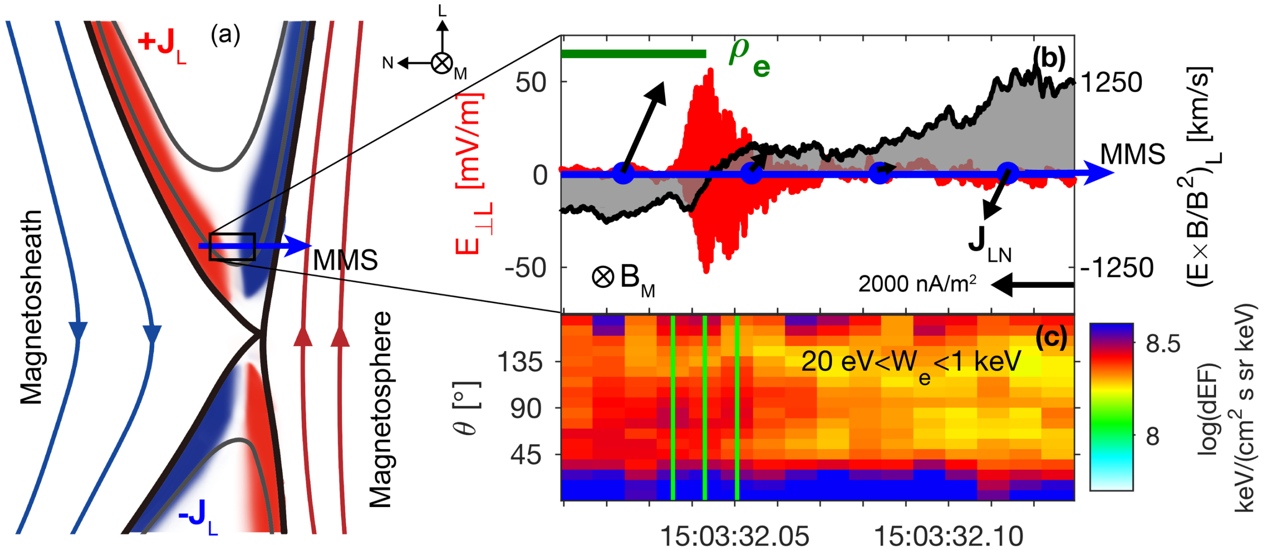


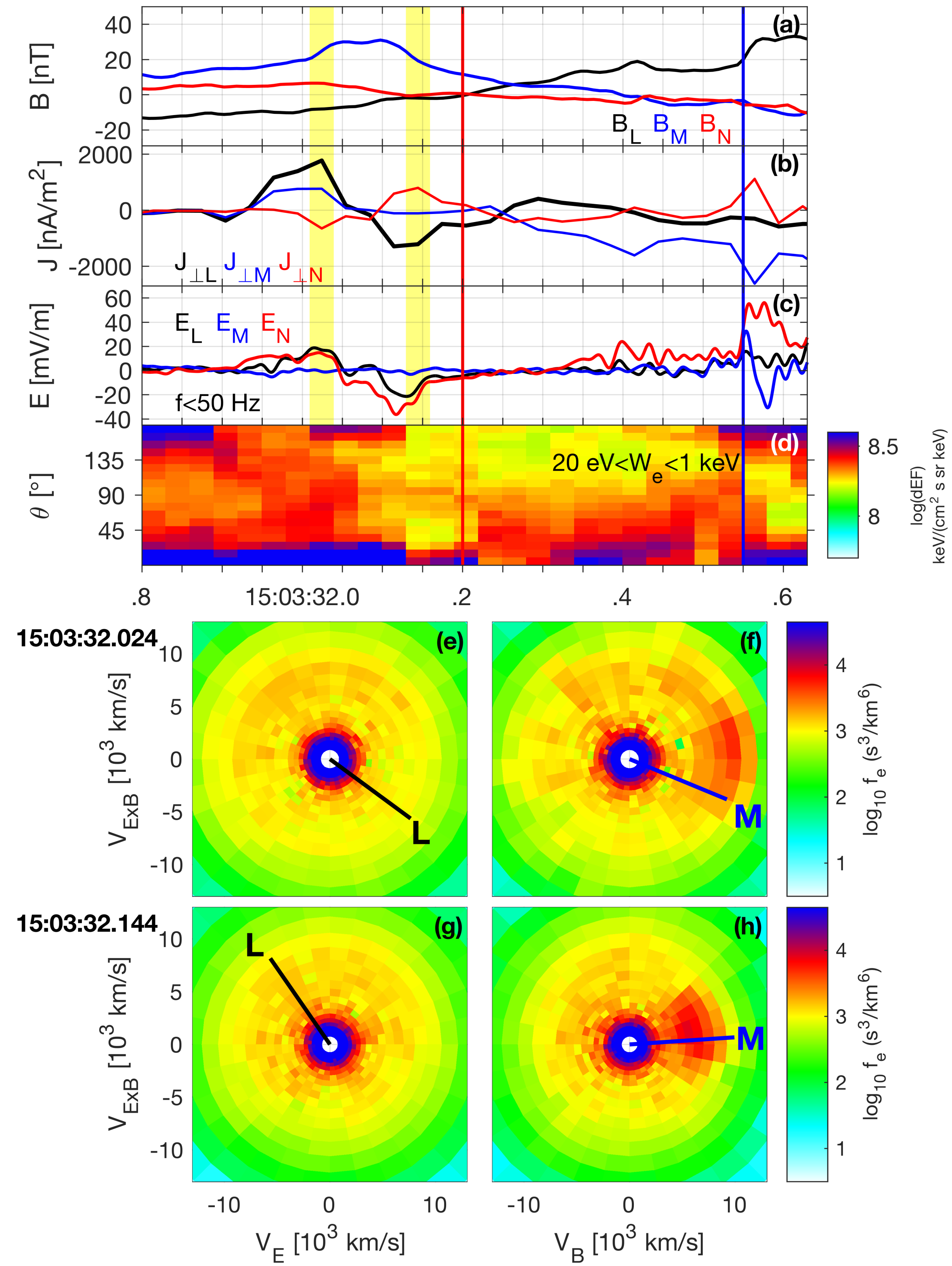
1. **B**: **B**$_L$ turning from negative to positive; Guide field ~12 nT; |B| minimal ~8.2 nT;
2. Number density decrease
3. Northward ion outflow
4. Strong electron jets with agyrotropic features
5. Strong Te anisotropy inside MSP separatrix
6. Strong **E**$_N$ at the MSP separatrix and wave activities

[*Li, Graham+*, NatureComms, 2020]

3. Electron Bernstein waves driven by crescents

- EBWs at the electron-scale Hall current reversal



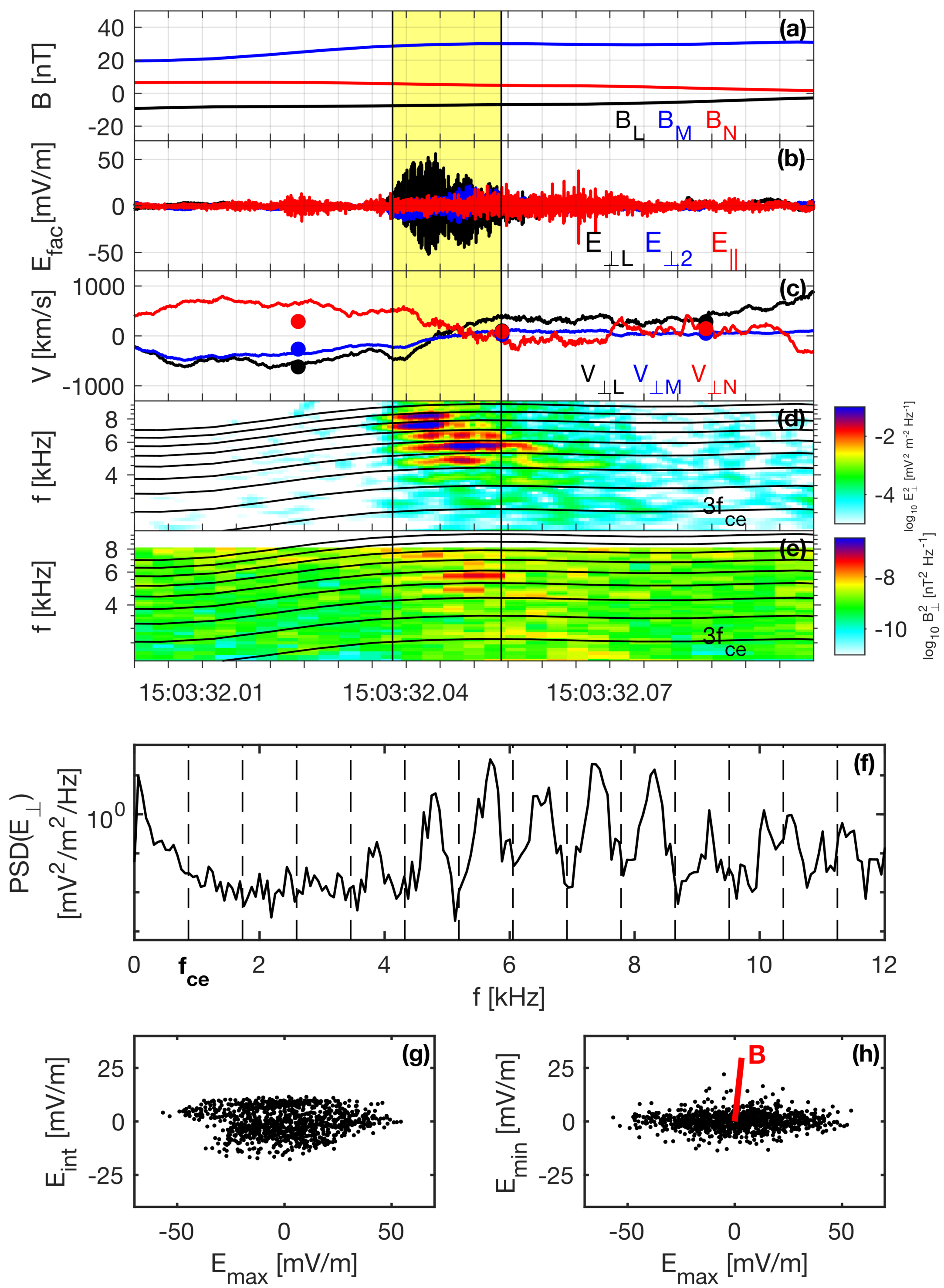


1. Strong Hall magnetic $\mathbf{B}_M$ on MSH side of neutral line
2. Reversal of the strong Hall current $\mathbf{J}_L$ at the $\mathbf{B}_M$ peak
3. Crescent-shaped electron distributions at the times of Hall current $\mathbf{J}_L$ peaks
4. Electron Bernstein waves observed at the $\mathbf{J}_L$ reversal

[*Li, Graham+*, NatureComms, 2020]

3. Electron Bernstein waves driven by crescents

- EBWs at the electron-scale Hall current reversal



[*Li, Graham+*, NatureComms, 2020]

1. ~60 mV/m E fluctuations

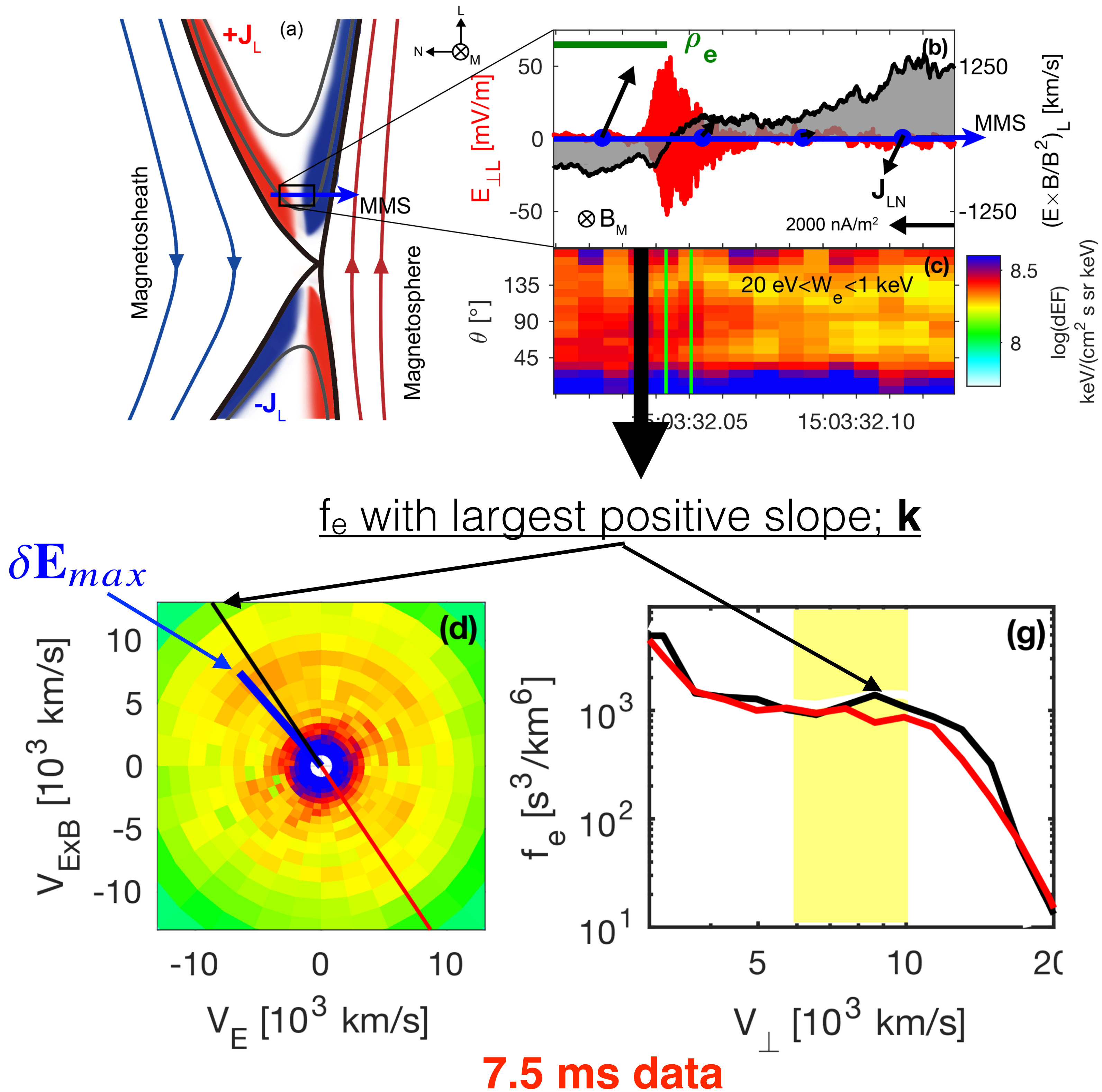
2. E spectral peaks separately by f_{ce} harmonics

3. extremely weak (~0.02 nT) B fluctuations

4. Quasi-linear; nearly perpendicular to ambient **B**

3. Electron Bernstein waves driven by crescents

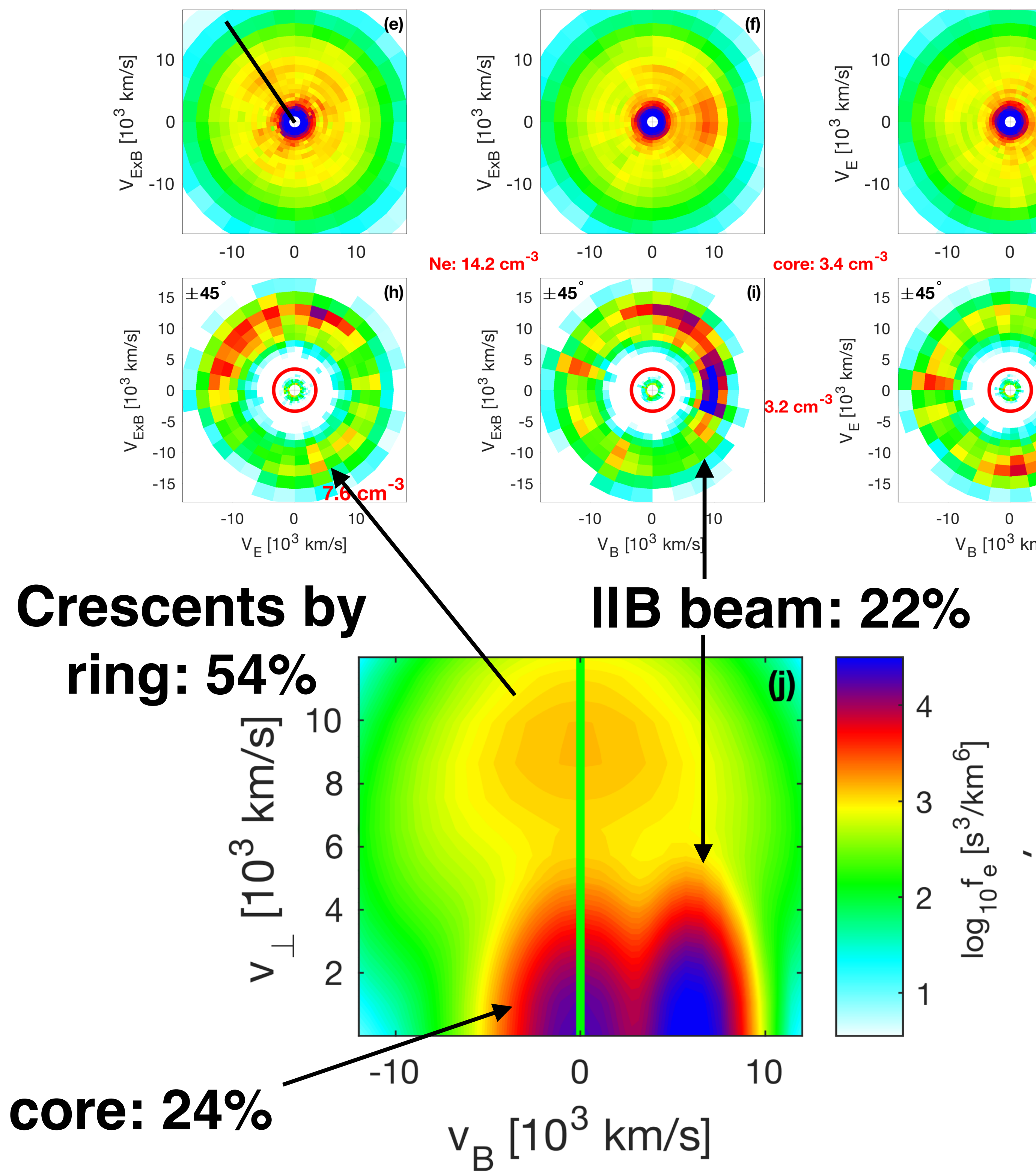
- EBWs driven by electron crescents

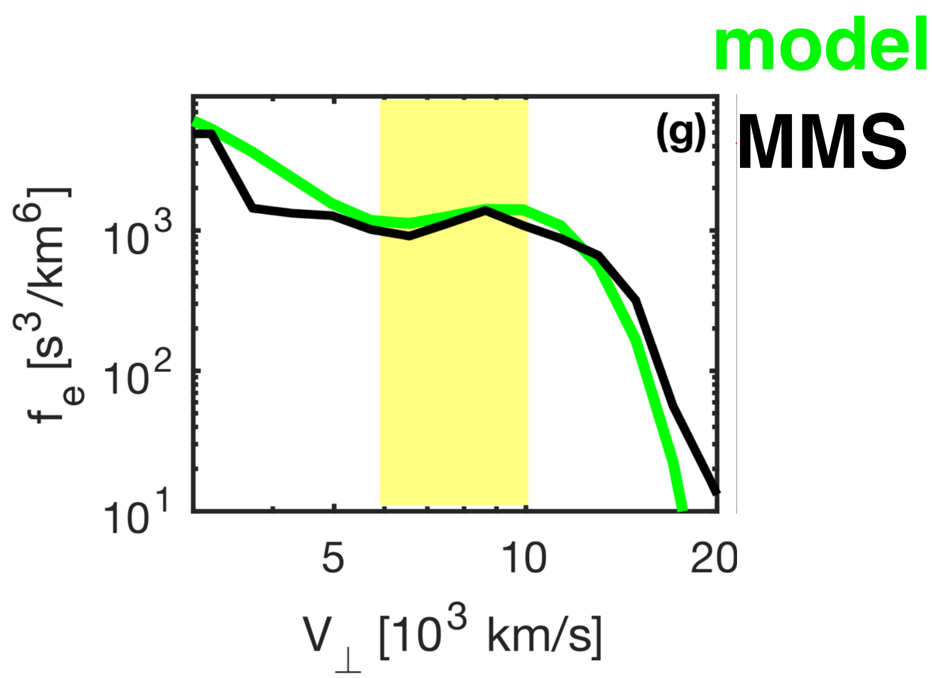


1. positive f_e slope along crescents
2. direction with largest positive slope is close to $\delta \mathbf{E}_{max}$
3. $$W_c = \frac{m_e n_c v_c^2}{2} \sim 10^4 W_E$$
   $$W_E = \frac{\epsilon_0 \mid \delta \mathbf{E} \mid^2}{2}$$
4. positive slope velocity 8000 km/s —> V_{ph}; frequency of peak wave power ~5.7 kHz; wavelength (1.4 km) is close to ρ_e

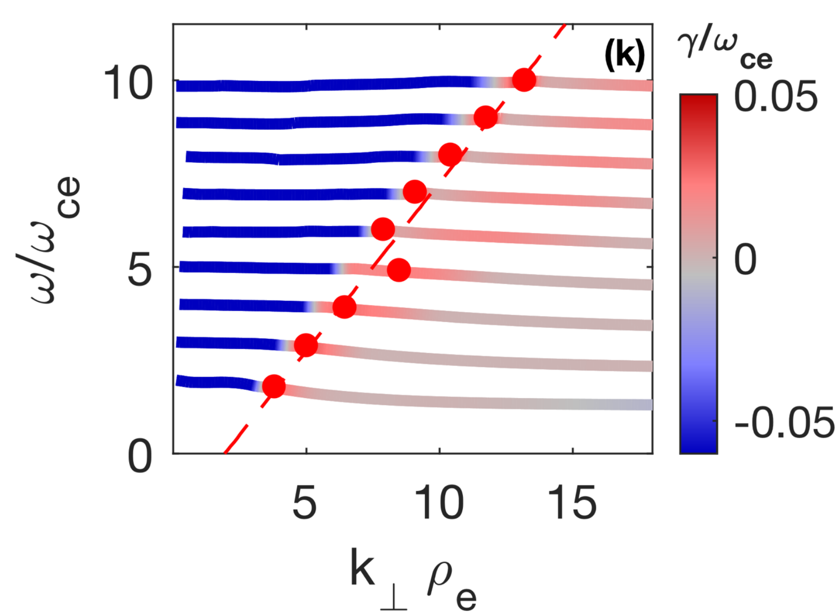
3. Electron Bernstein waves driven by crescents

- EBWs driven by electron crescents



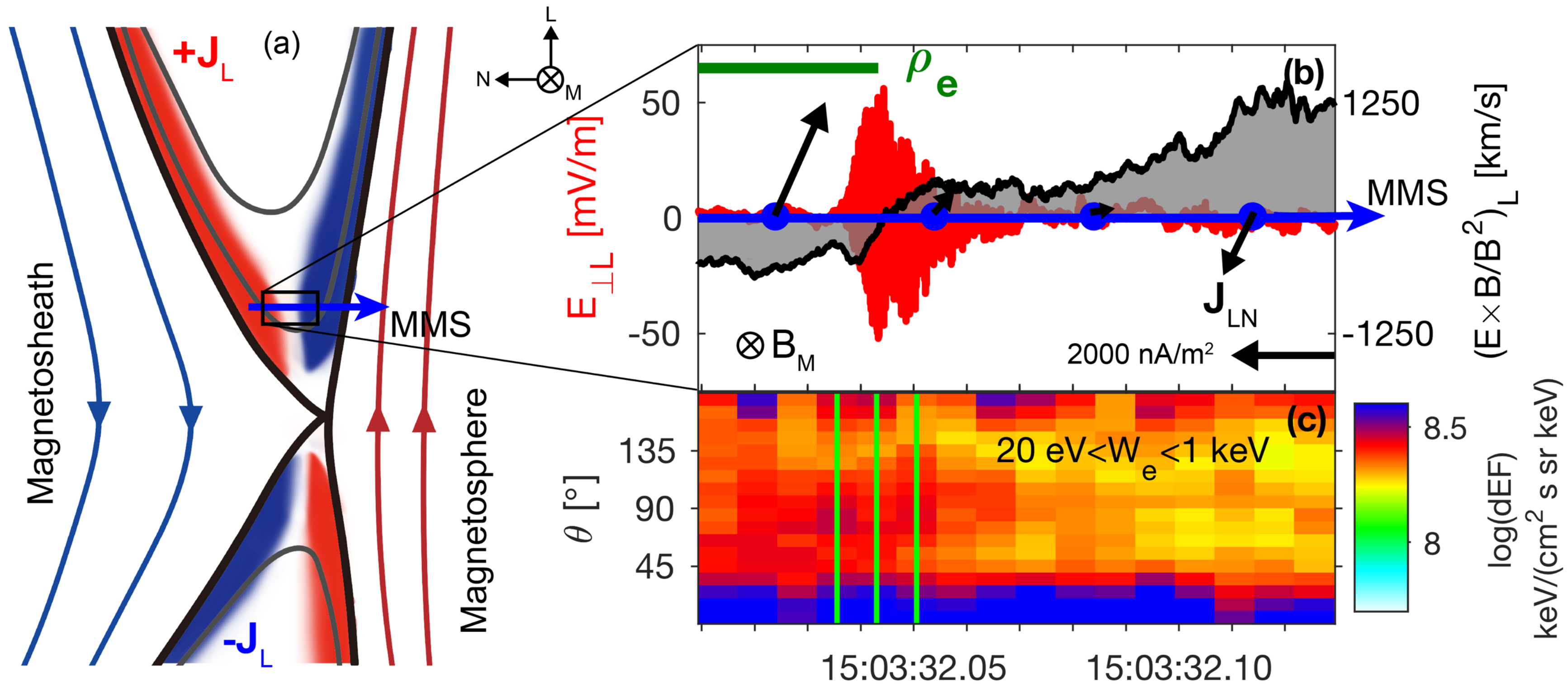


A fully kinetic linear solver [*Min and Liu*, 2016] gives unstable electron Bernstein mode.



4. Summary

- Electron Bernstein waves driven by crescents



1. Large-amplitude EBWs at the electron-scale boundary of the Hall current reversal near an EDR encounter.
2. The EBWs are driven by electron crescents.
3. The EBWs electric potentials are large enough to thermalize and diffuse the electron crescents near the EDR.

[*Li, Graham+*, NatureComms, 2020]

5. EBWs versus Upper-Hybrid waves