# Observations of lower hybrid drift waves in a disturbed electron diffusion region in Earth's magnetotail

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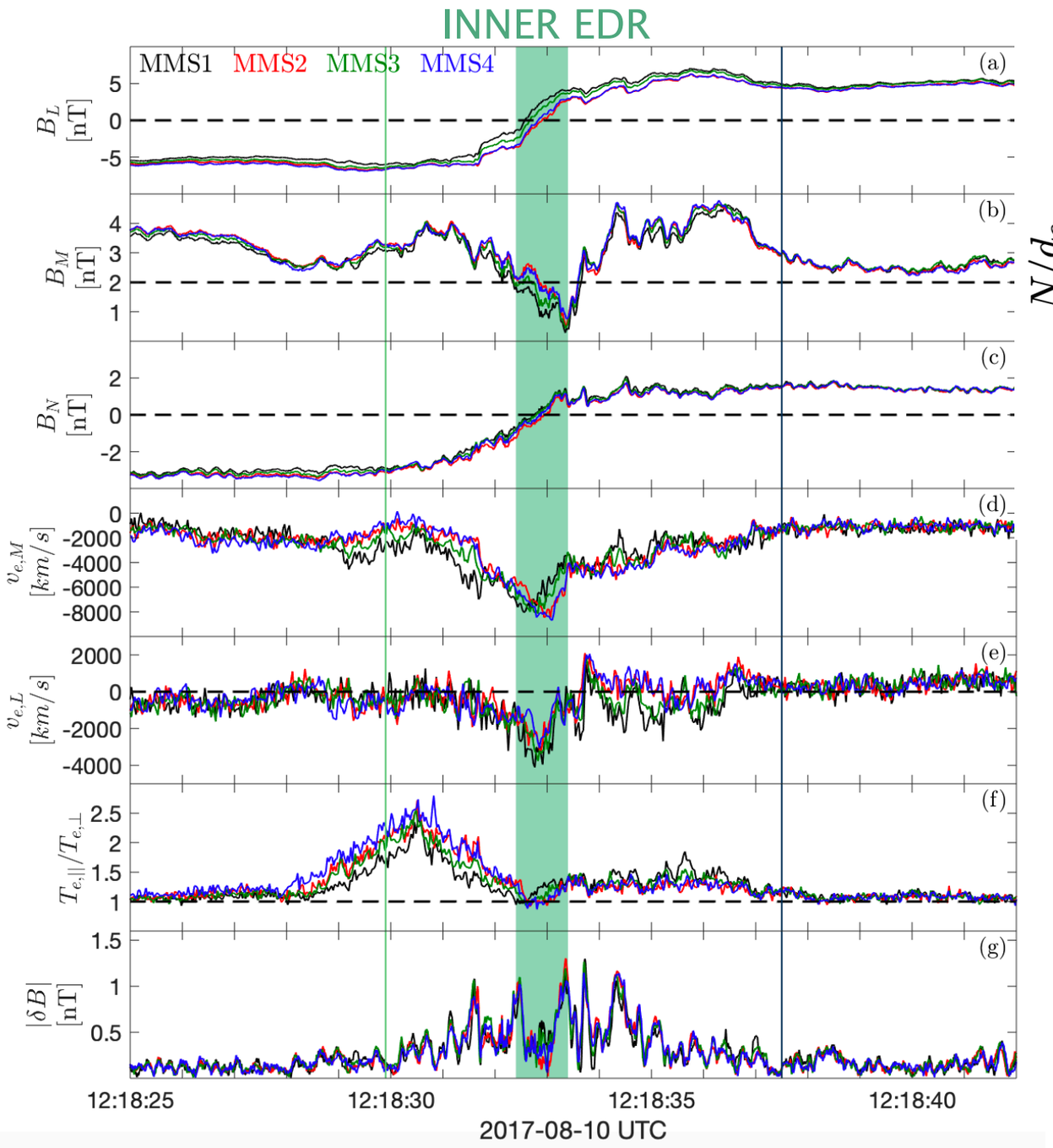
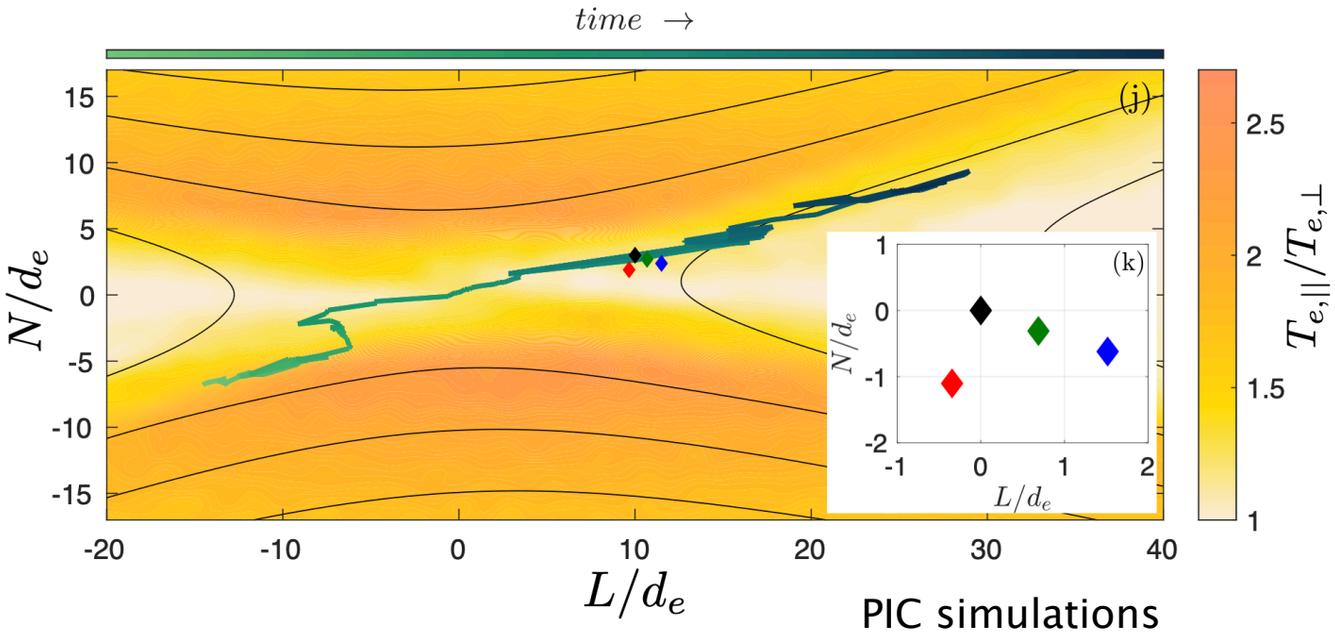
# EDR encounter in the magnetotail



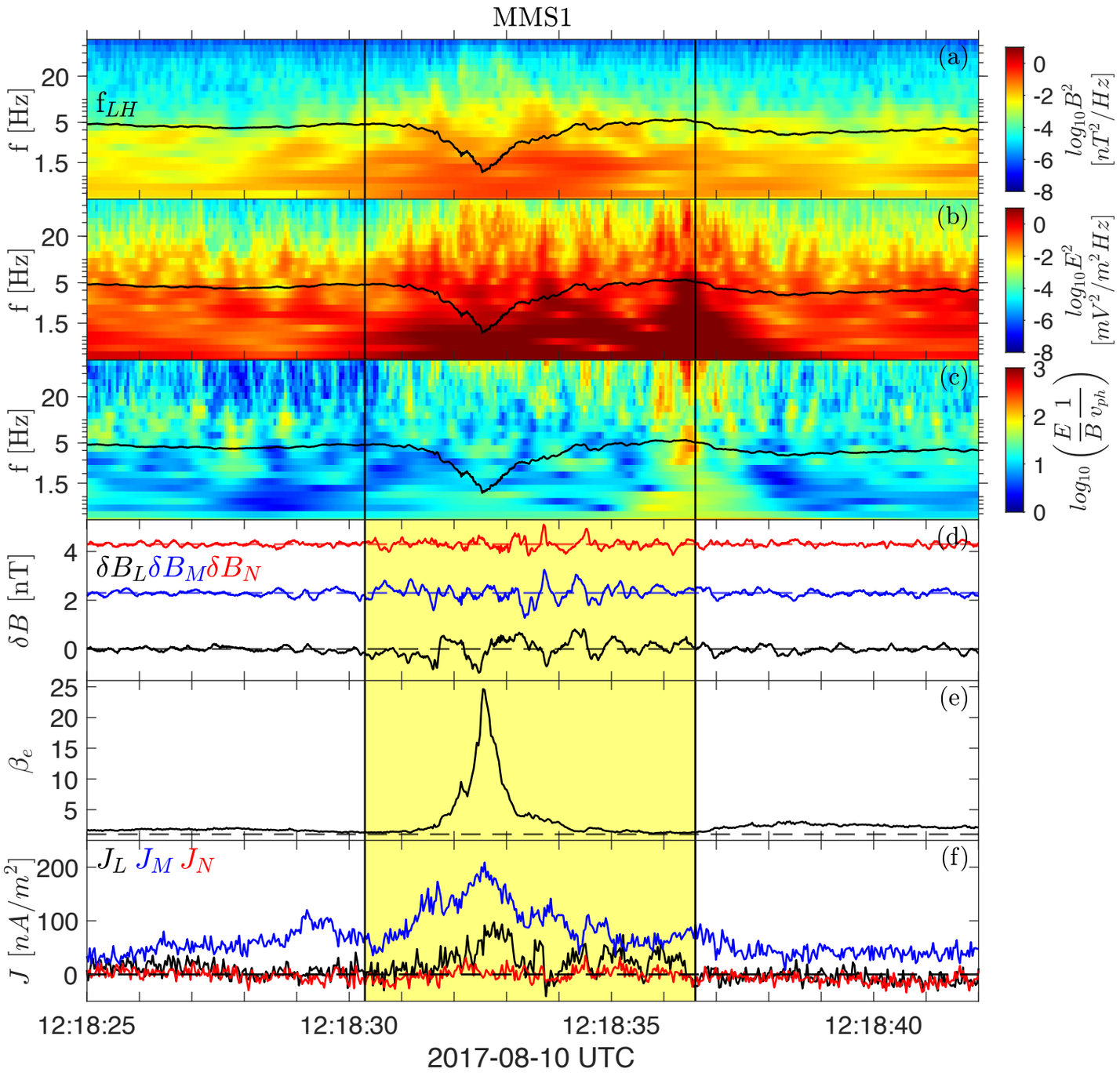

PIC simulations
[Le et al., PRL, 2013]

**Weak guide field** of 13% of the upstream magnetic field. [Zhou et al., ApJ, 2019].

Electron scale current sheet $d_{CS} \sim 2\ d_e$

Significant **magnetic field fluctuations** (18 % of upstream B) in the EDR

# Waves are consistent with electromagnetic LHDW within the EDR




Characteristics of the waves:

– **f ~ fLH**

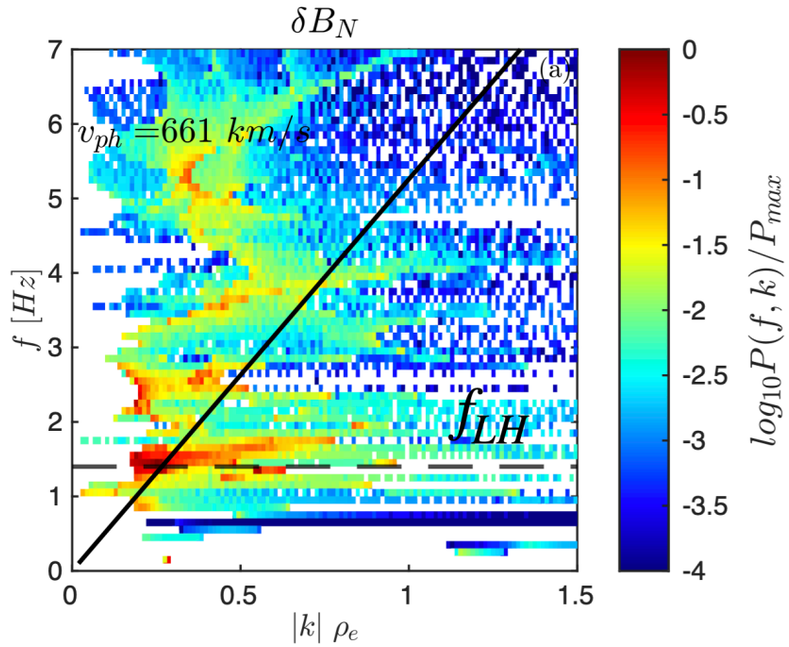
– power is high at the **center of the current sheet**

– wave vector along M, ⊥ **to B**

– **electromagnetic** ($\frac{E}{B} \gg v_{ph}$ in the electrostatic case)

– $|\mathbf{k}|\rho_e \sim 0.3$ and $|\mathbf{k}|\sqrt{\rho_e \rho_i} \sim 2.7$

– All three components of B




$$f(P_{max}(\delta B_N)) = 1.4\ Hz$$

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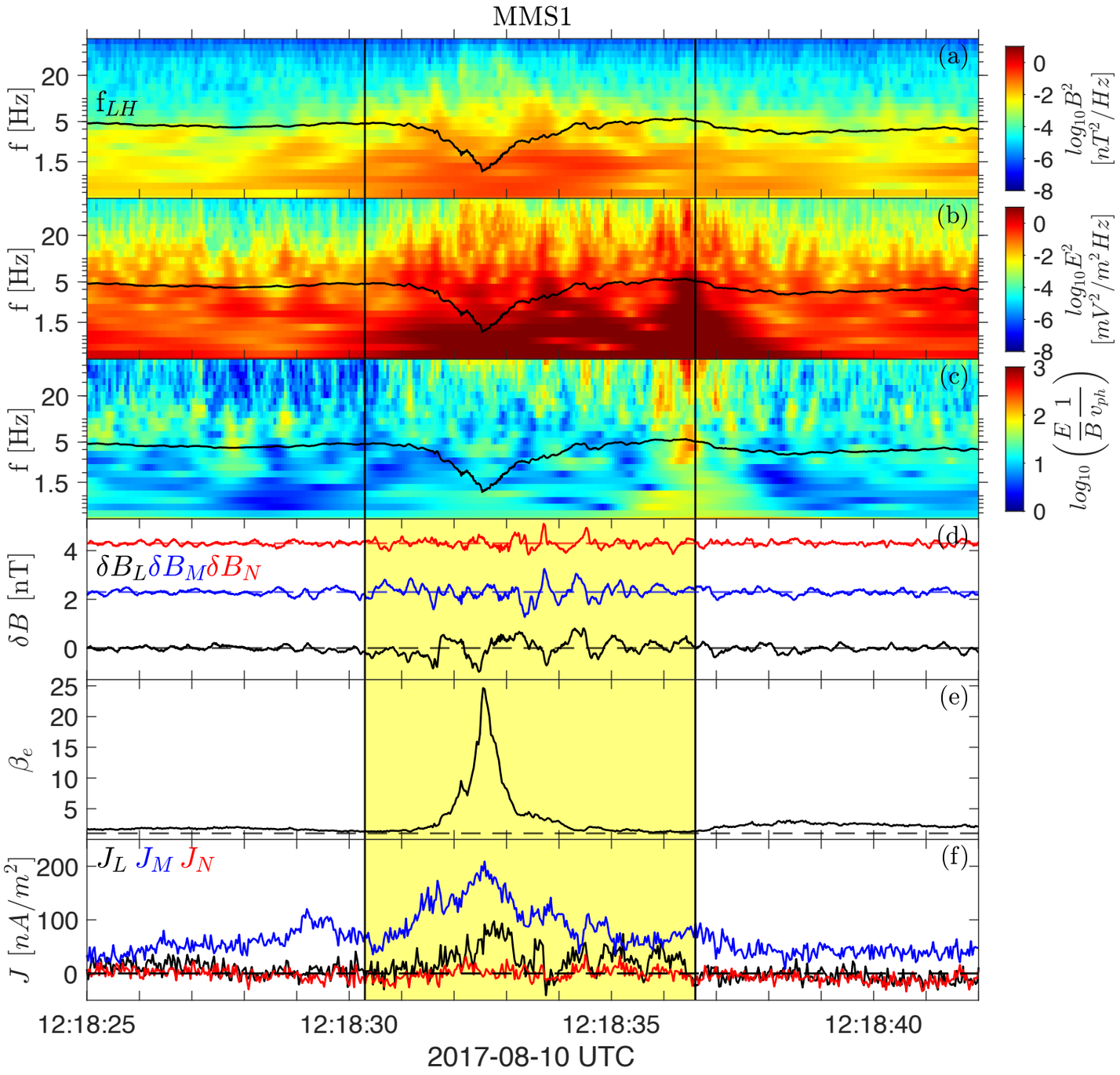


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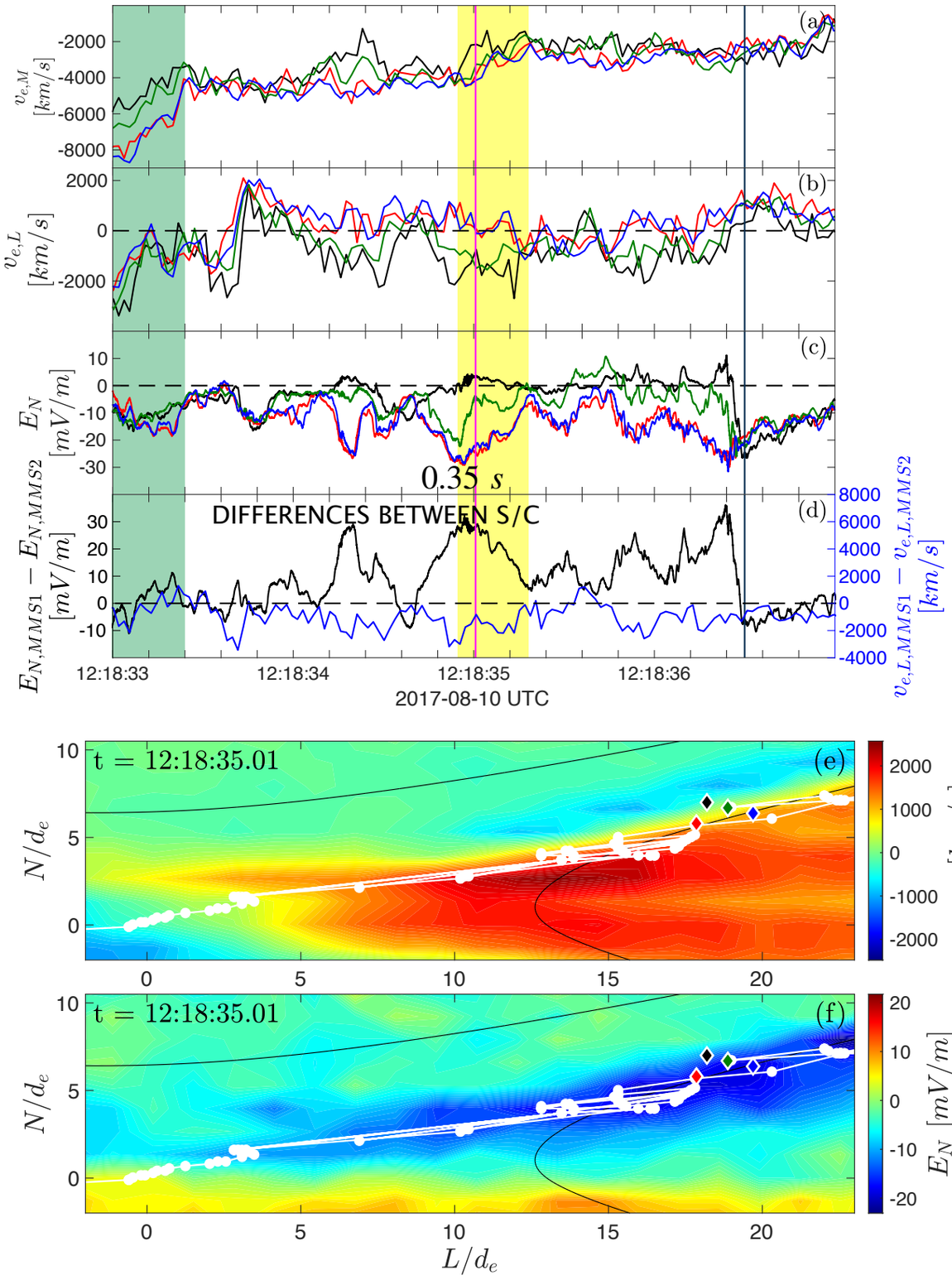
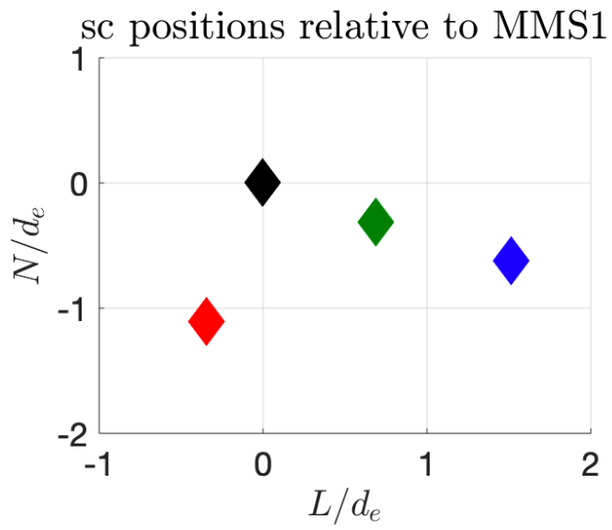
The observed waves are consistent with the **electromagnetic contribution of LHDI** [Daughton, Phys. Plasmas, 2003], [Yoon et al., Phys. Plasmas, 2002] or **MTSI** [Ji et al., PRL, 2004]

# Oscillations in $E_N$ and $V_{e,L}$ are related to LHDW in the EDR

INNER EDR




- **Strong spatial gradients** ($L_{grad} \sim 0.5\ d_e$) not destroyed by the instability.

- **Oscillations** are **not expected** in the 2D laminar picture.
They are related to the **LHDW in the center of the electron scale layer.**

$T_{osc}/2 \sim 0.35\ s \sim T_{LHDW}/2$

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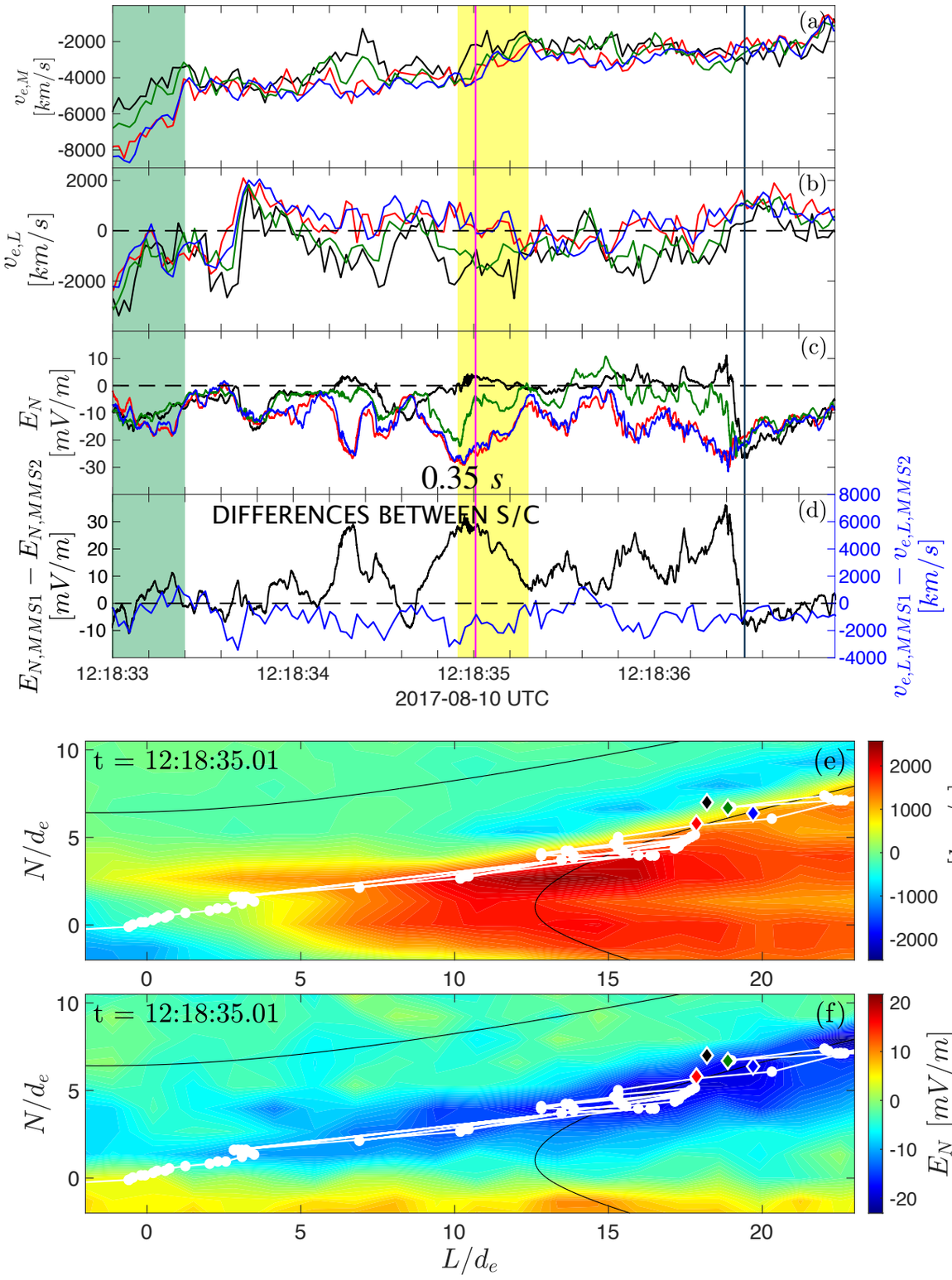


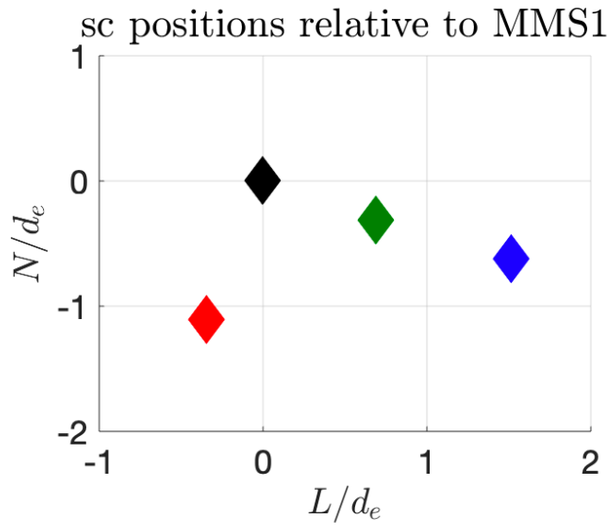


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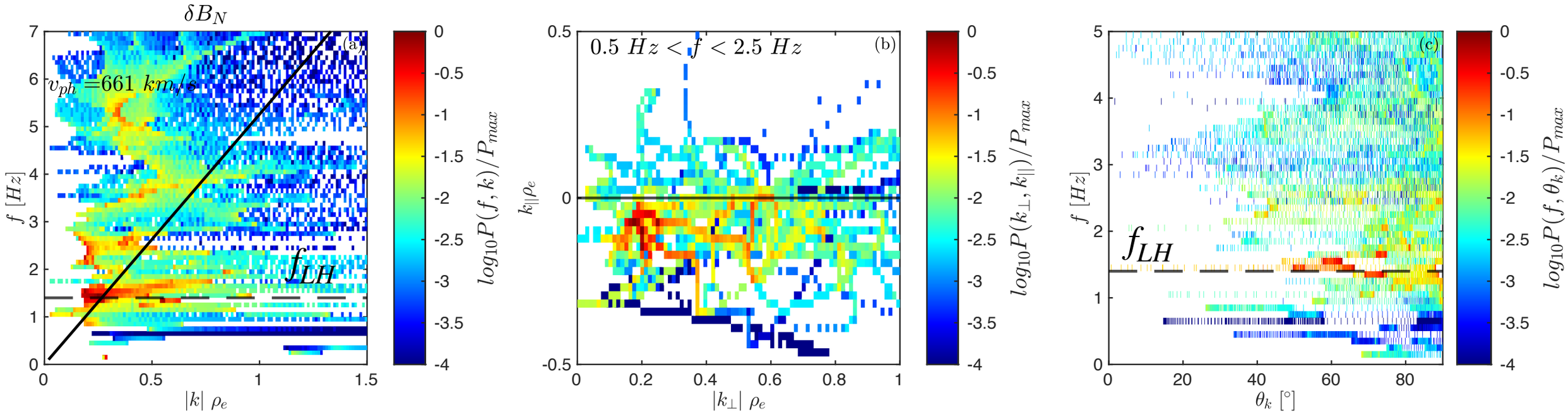
Thank you for you attention!

# Extra

# Analysis of the waves in the EDR




Properties of the waves:

$f(P_{max}(\delta B_N)) = 1.4\ Hz$

$v_{ph} \sim 668\ km/s$

$\hat{\mathbf{k}} = [0.0423,\ -0.9484,\ 0.3141]\ GSM$
$= [0.1279,\ -0.9595,\ 0.2505]\ LMN$

$|\mathbf{k}|\rho_e \sim 0.3$

$|\mathbf{k}|\sqrt{\rho_e\rho_i} \sim 2.7$

$\lambda \sim 480\ km \sim 2.2\ \sqrt{\rho_i\rho_e}$

**k** is directed along the direction of the current (-M)

The waves propagate close to perpendicularly to B

And they have a rather **long wavelenght**