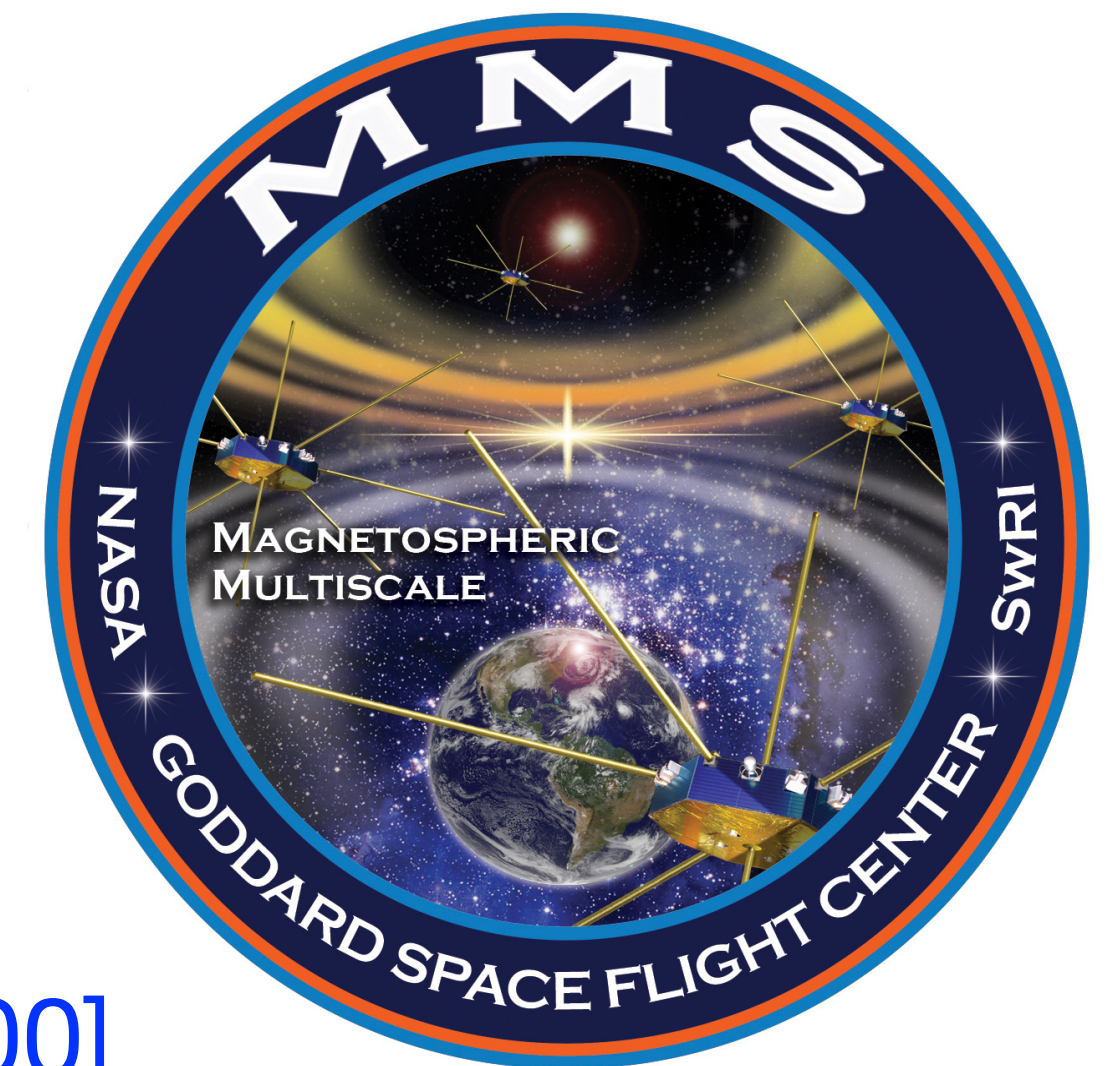


Langmuir and upper hybrid waves in Earth's magnetotail

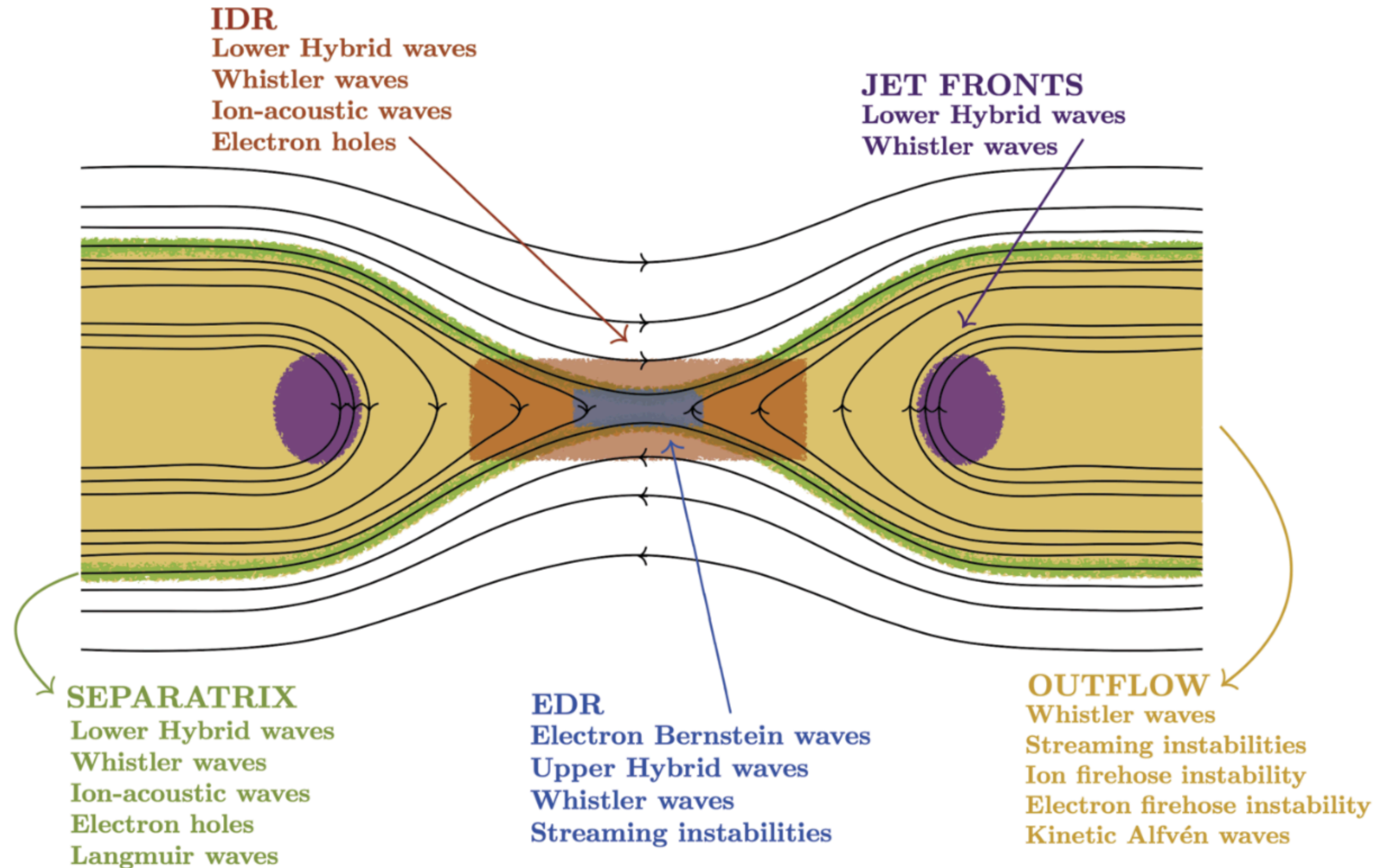
D. B. Graham, Yu. V. Khotyaintsev, M. André

Swedish Institute of Space Physics, Uppsala, Sweden



[Graham et al., JGR, 2023, doi:10.1029/2023JA031900]

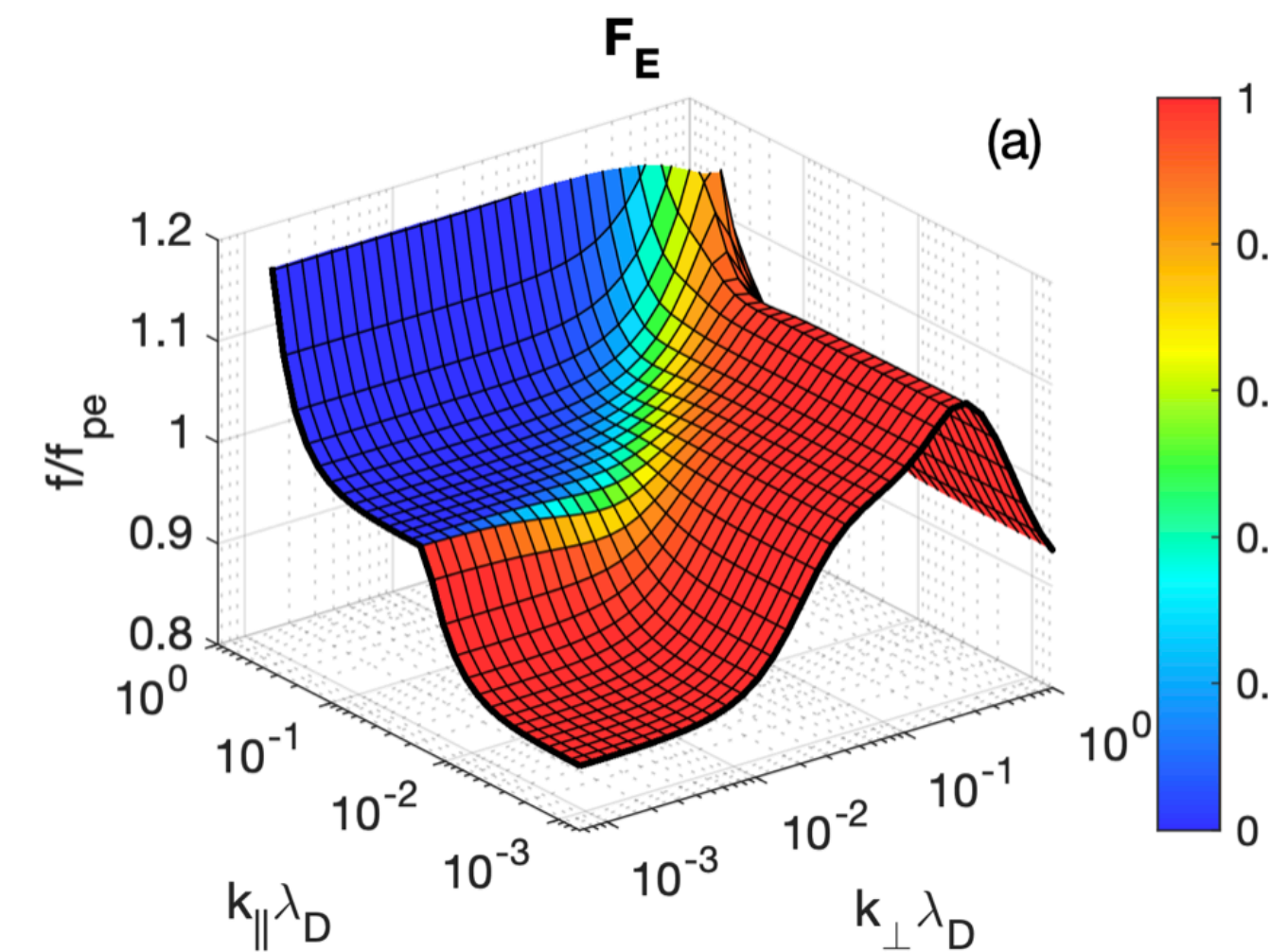
Waves and magnetic reconnection



[Graham et al., SSR, 2025]

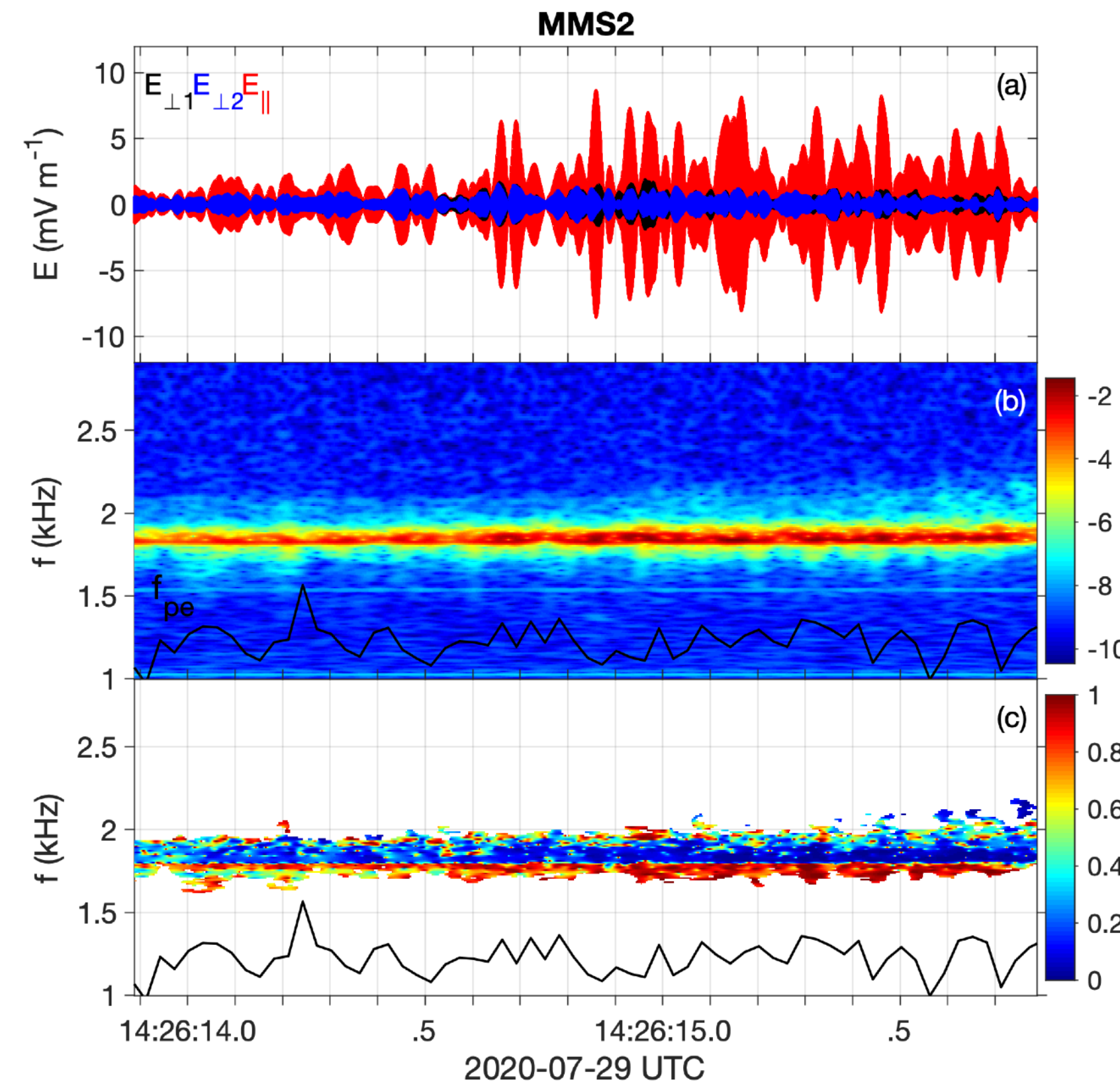
Waveform examples

Dispersion surface



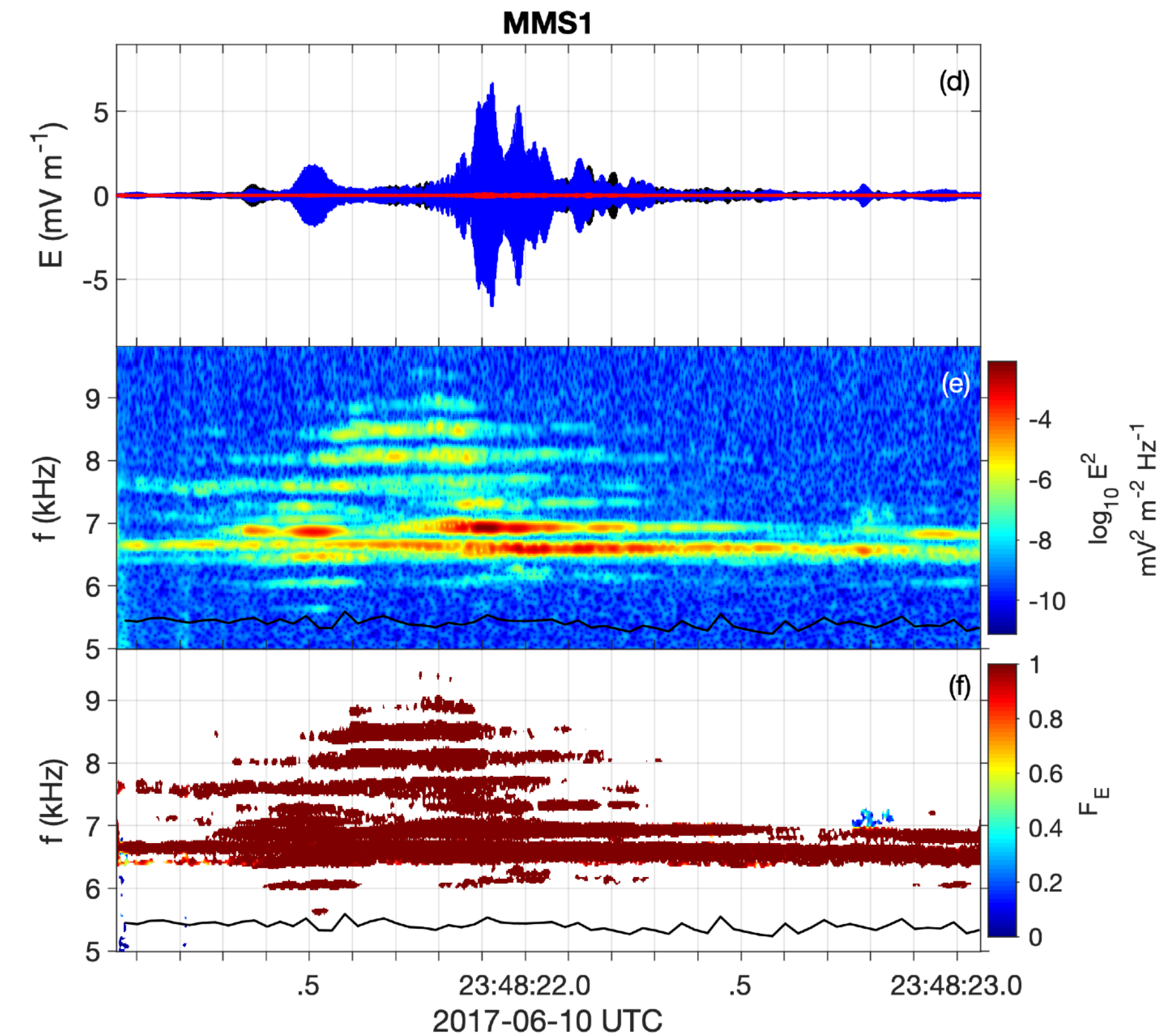
$$F_E = \frac{\sum E_{\perp}(t)^2}{\sum E_{\perp}(t)^2 + \sum E_{\parallel}(t)^2}$$

Langmuir wave



- Parallel electric fields

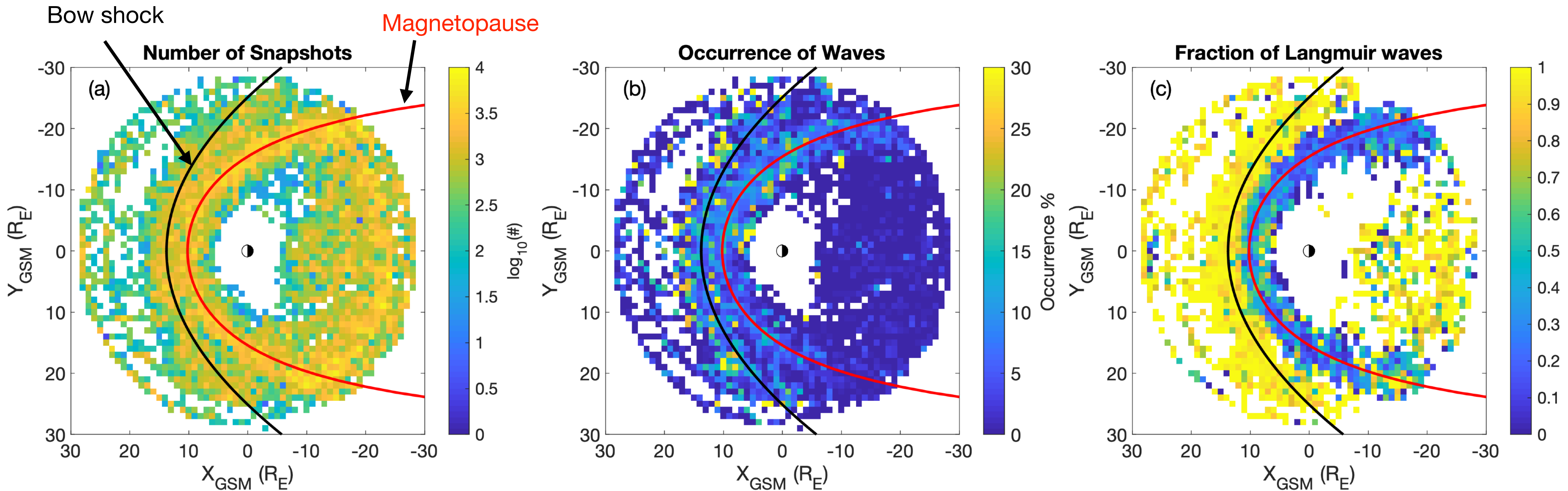
Upper hybrid wave



- Perpendicular electric fields

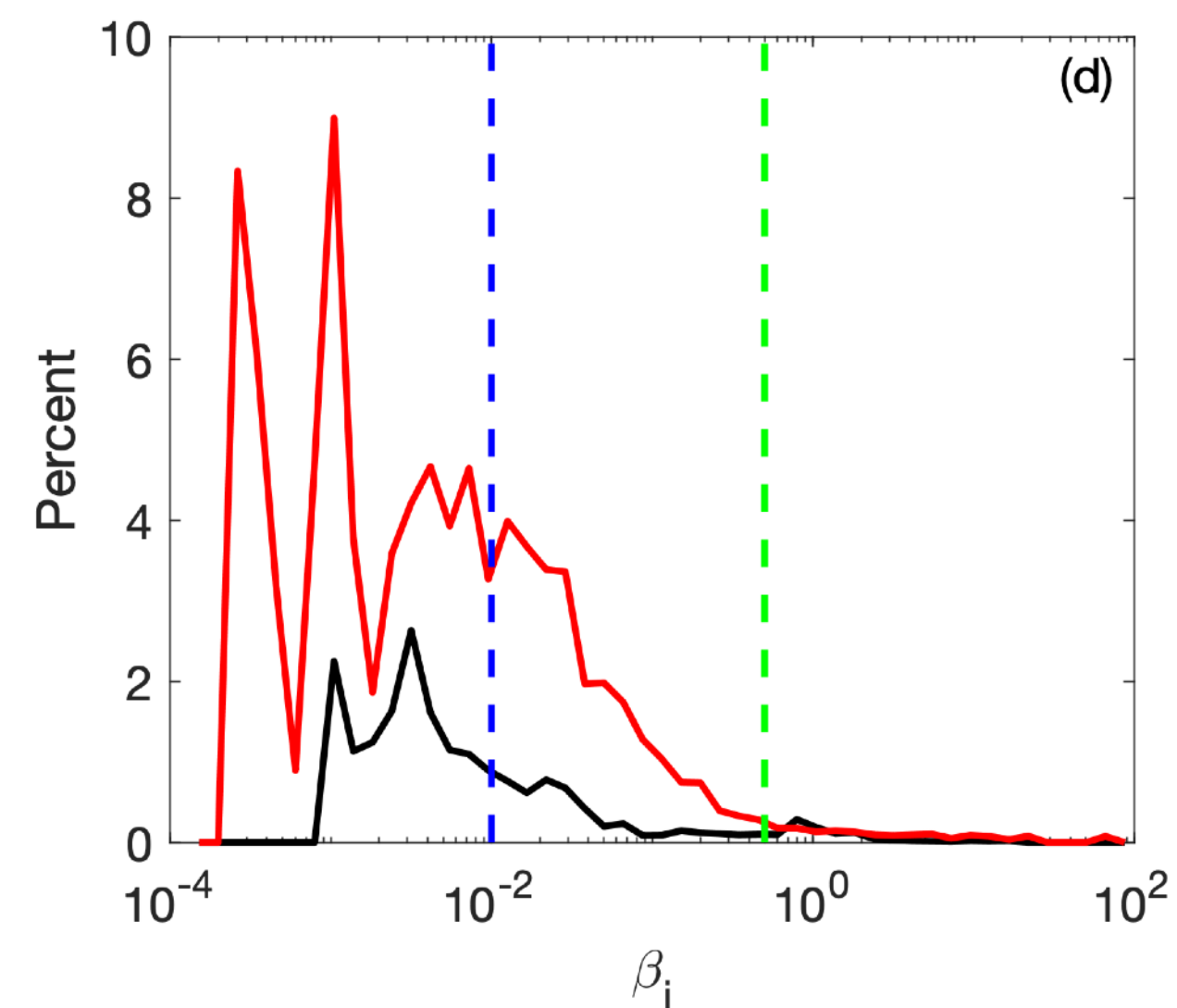
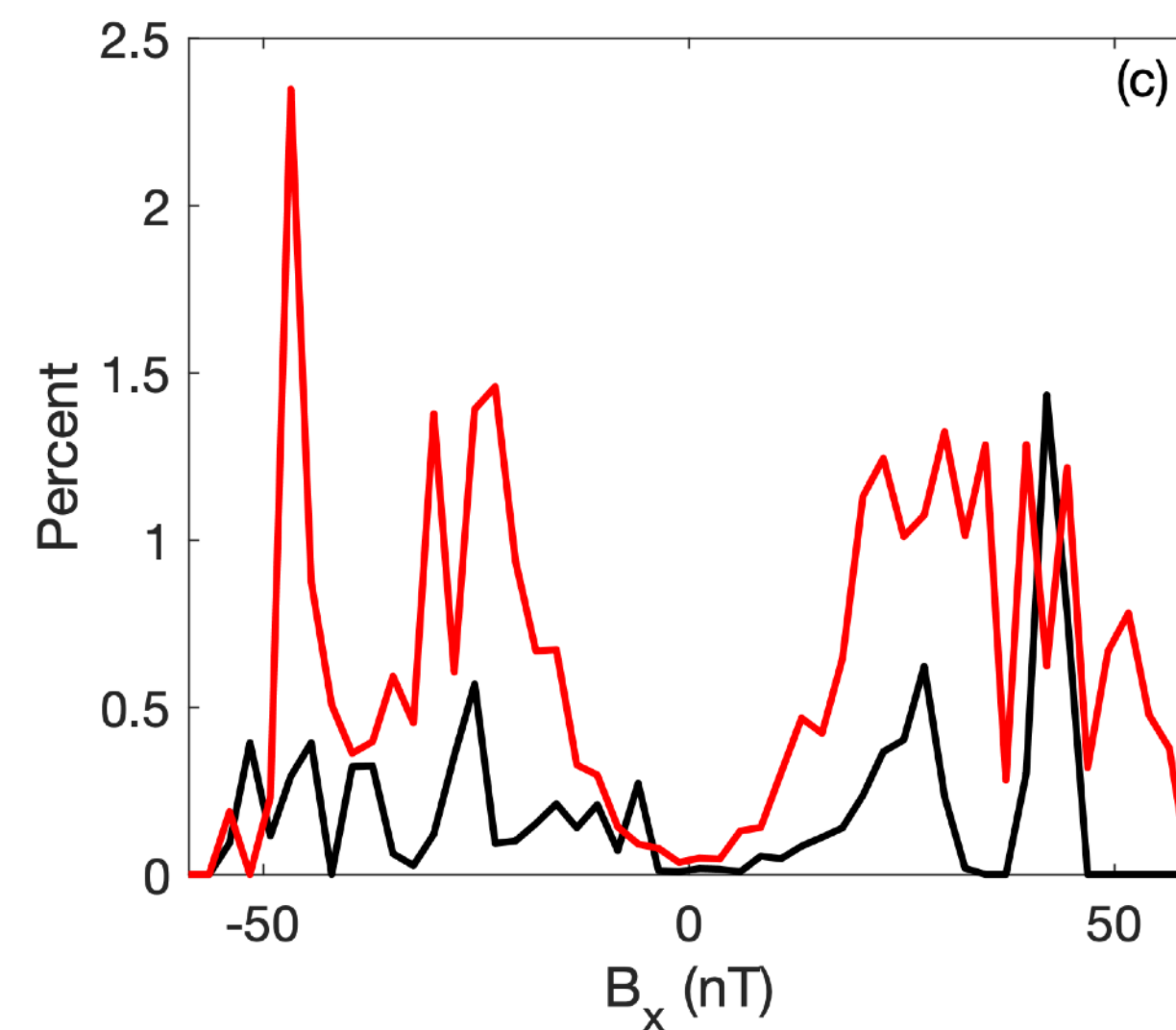
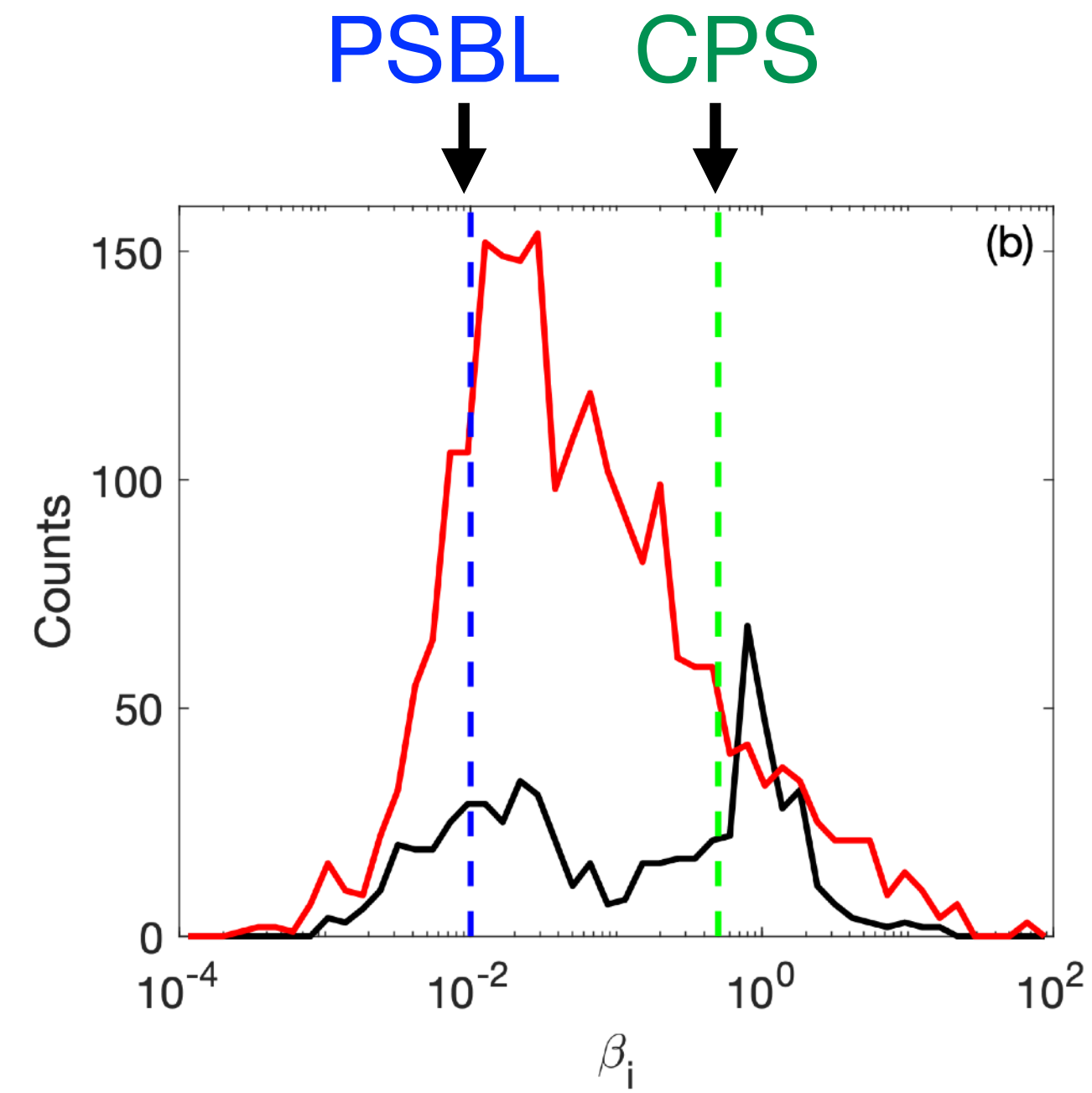
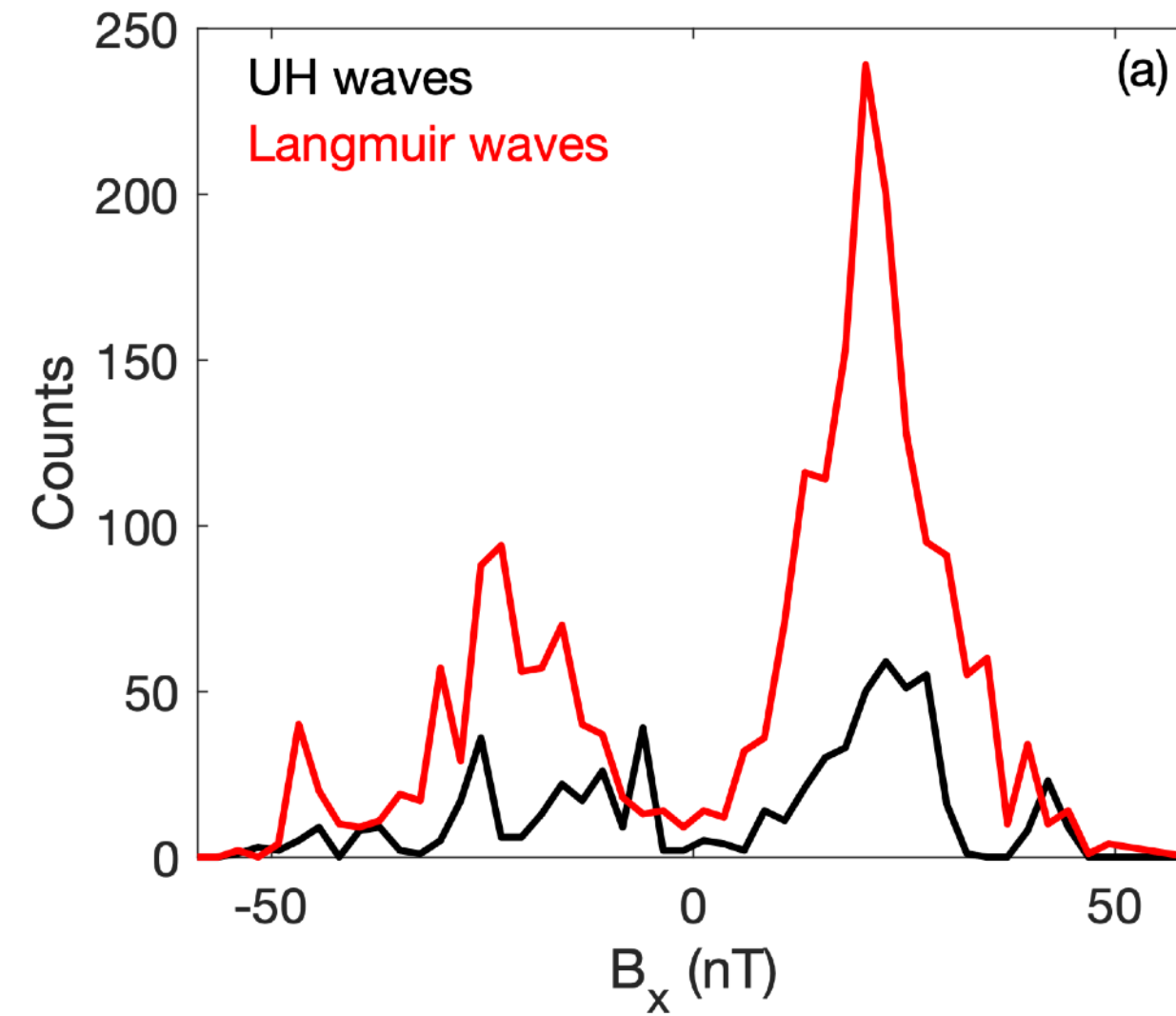
- Measured with MMS's EDP hmfe snapshots; 2 second duration, sampling rate 65.536 kHz.

Wave Occurrence



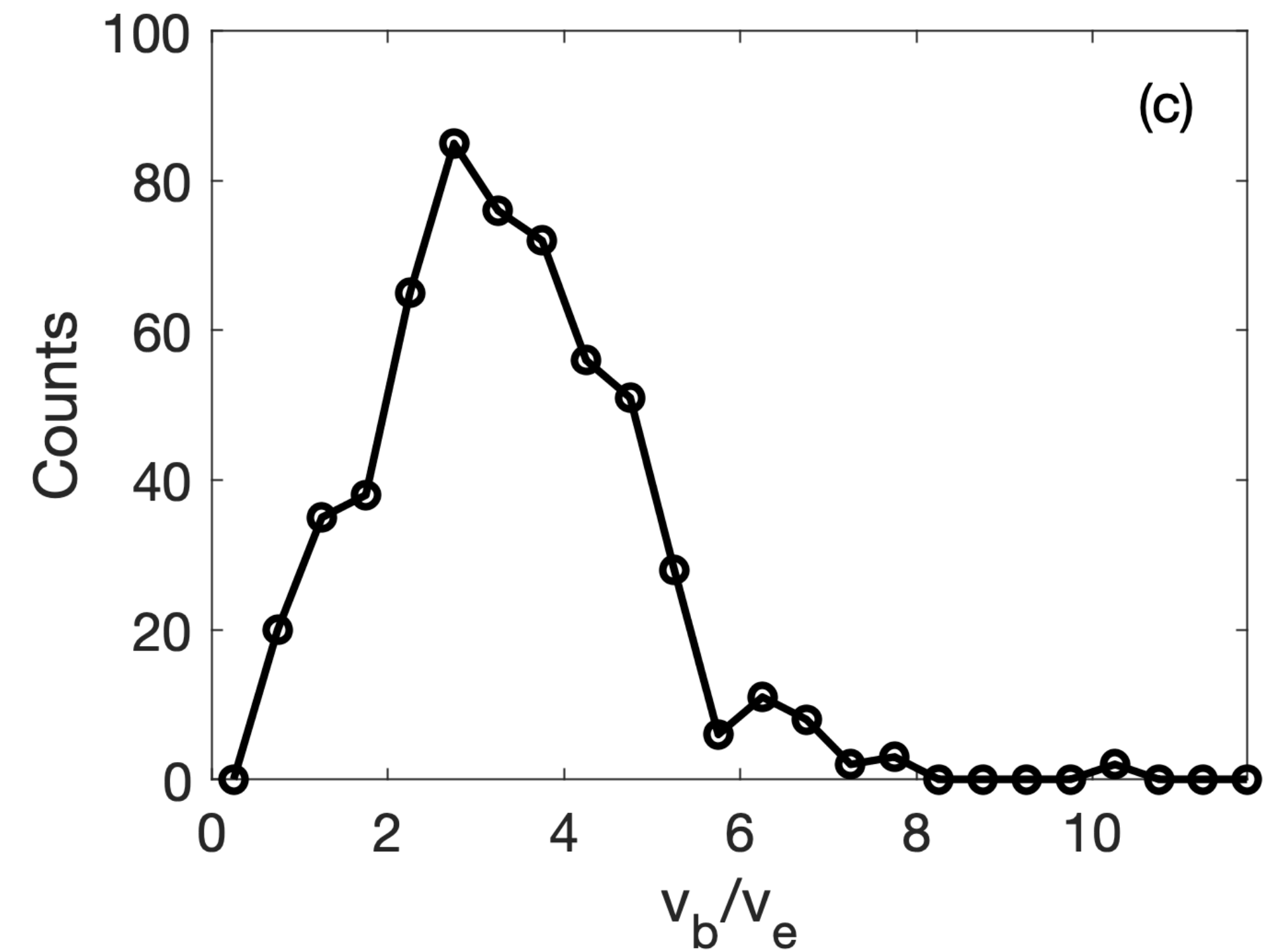
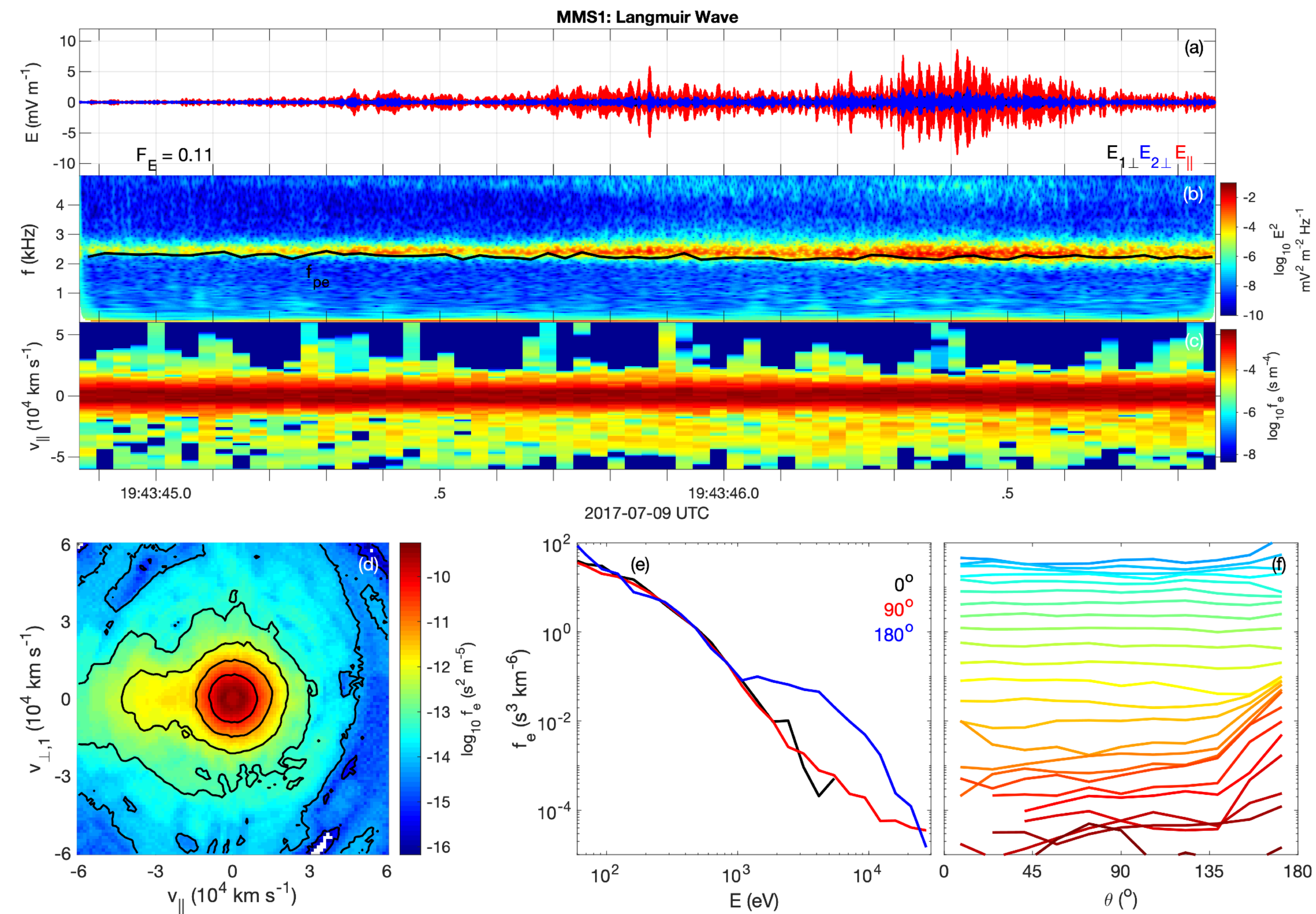
- UH waves primarily occur in near the magnetopause.
- Langmuir waves primarily occur in the electron foreshock and magnetotail.
- Electron foreshock: 43664 snapshots
- Magnetopause: 63535 snapshots
- Magnetotail: 2880 snapshots

Magnetotail wave properties



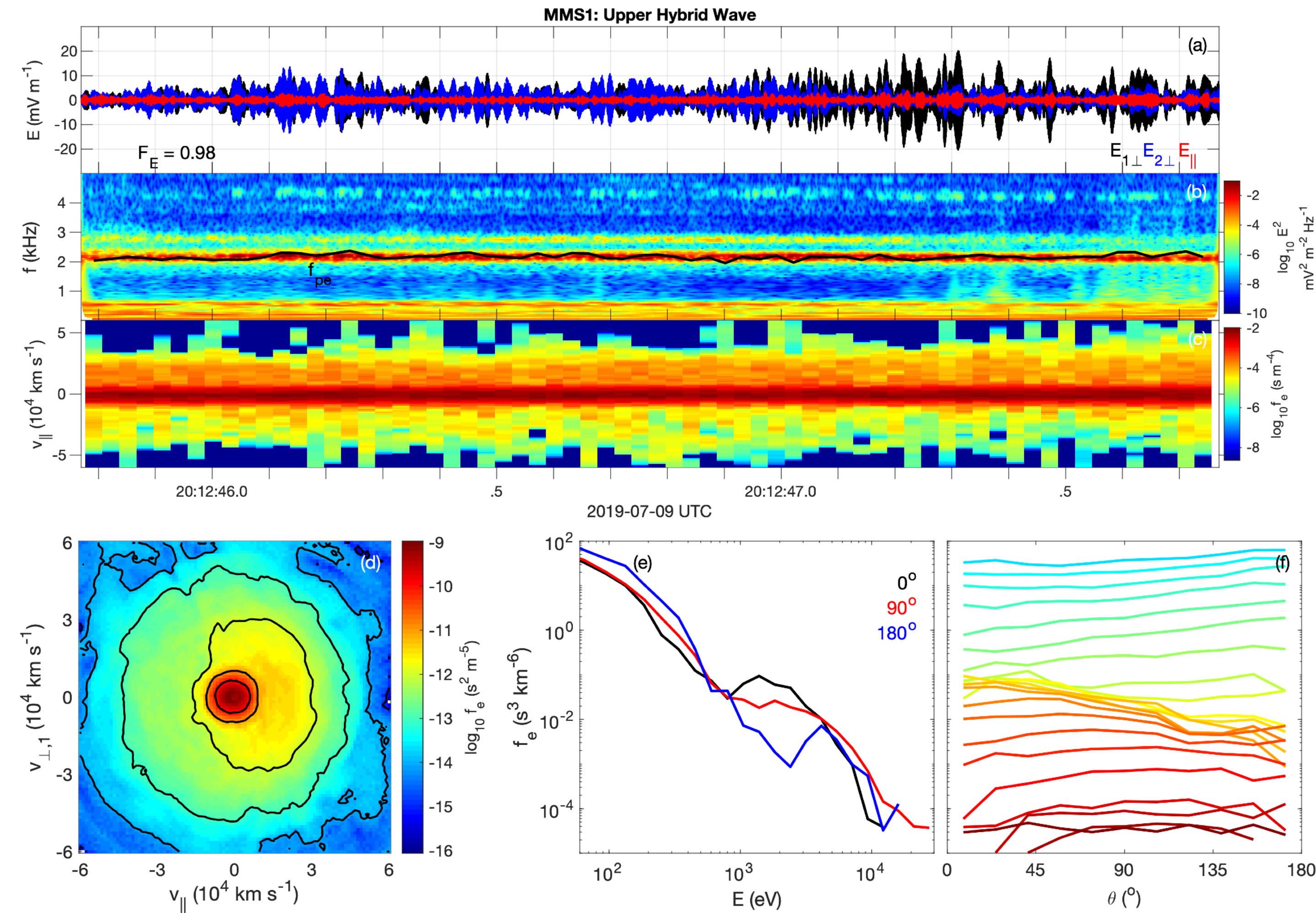
- Langmuir and UH waves are found in the plasma sheet boundary layer (PSBL) and central plasma sheet (CPS).
- Probability is highest in the PSBL.

Source of Langmuir waves

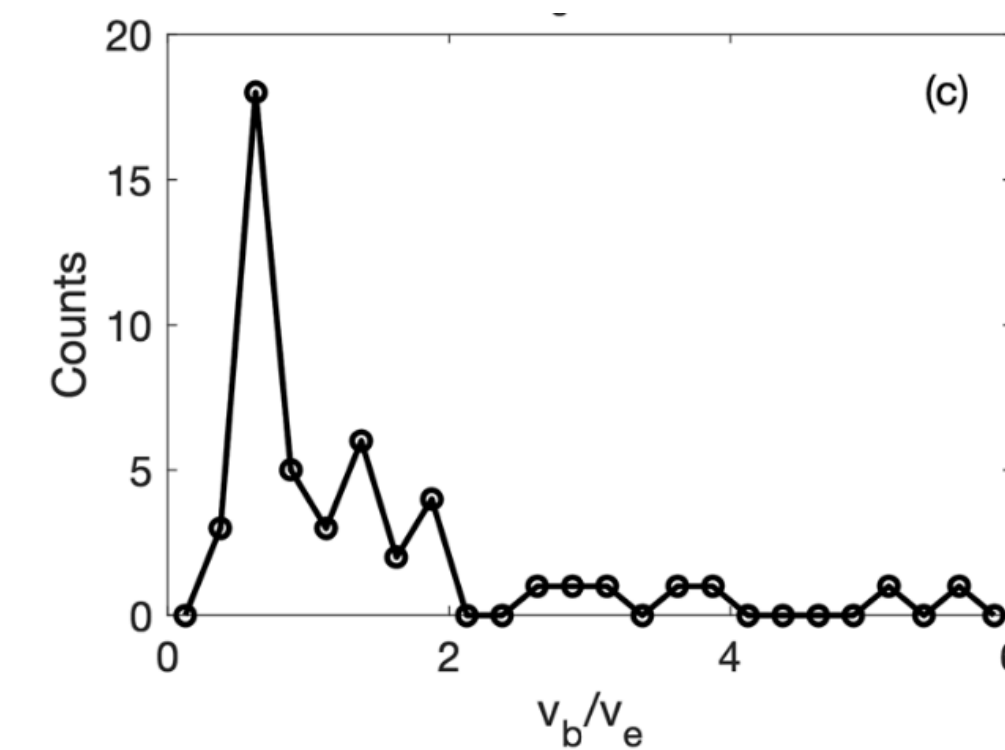


- Langmuir waves are generated by field-aligned beams.

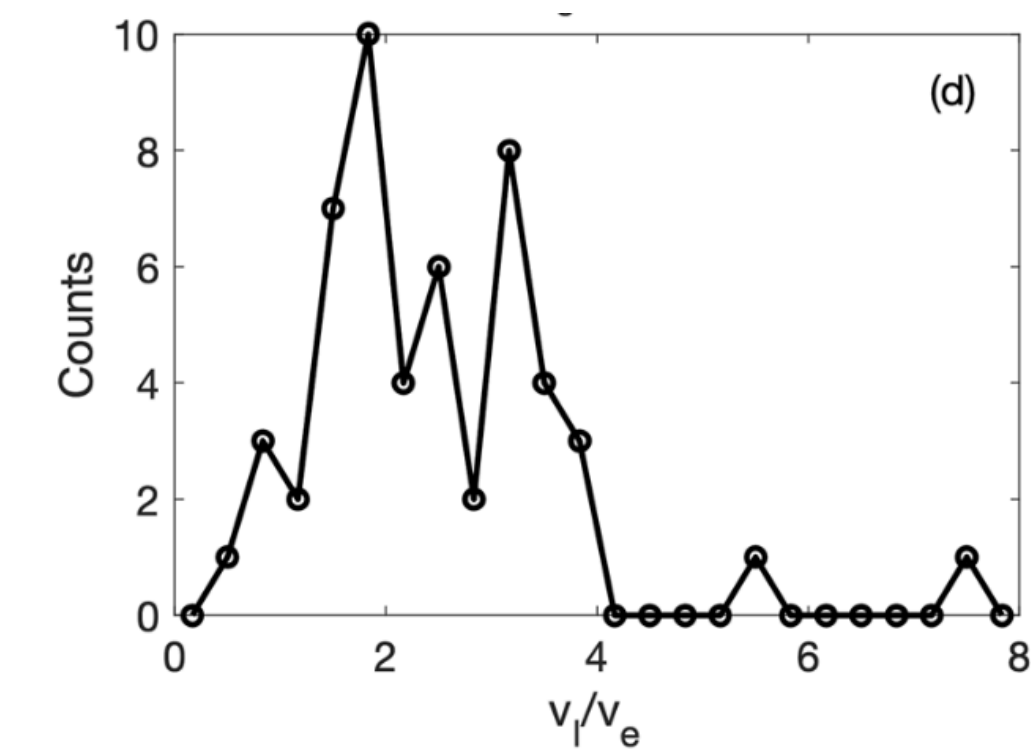
Source of upper hybrid waves



Beams

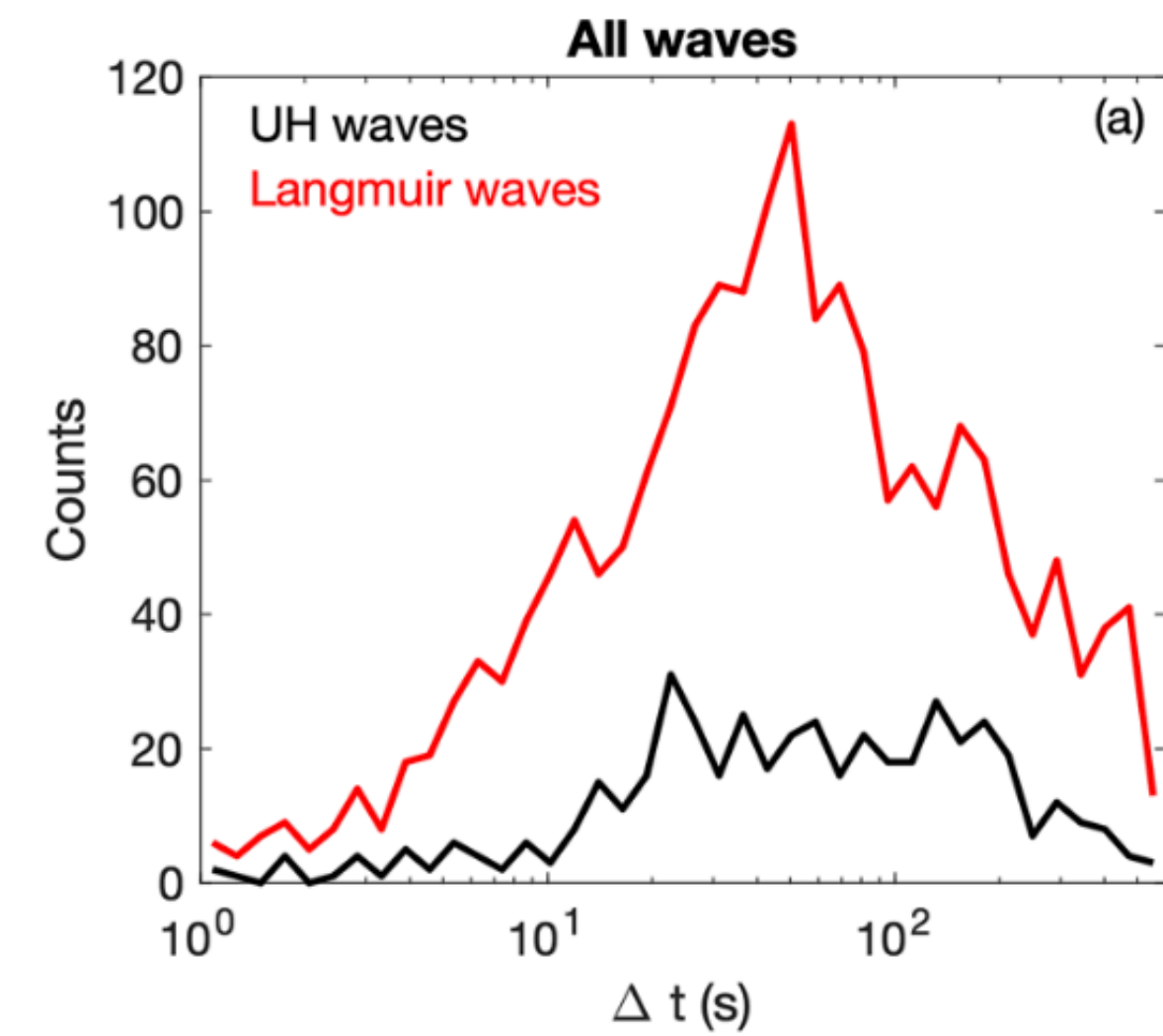
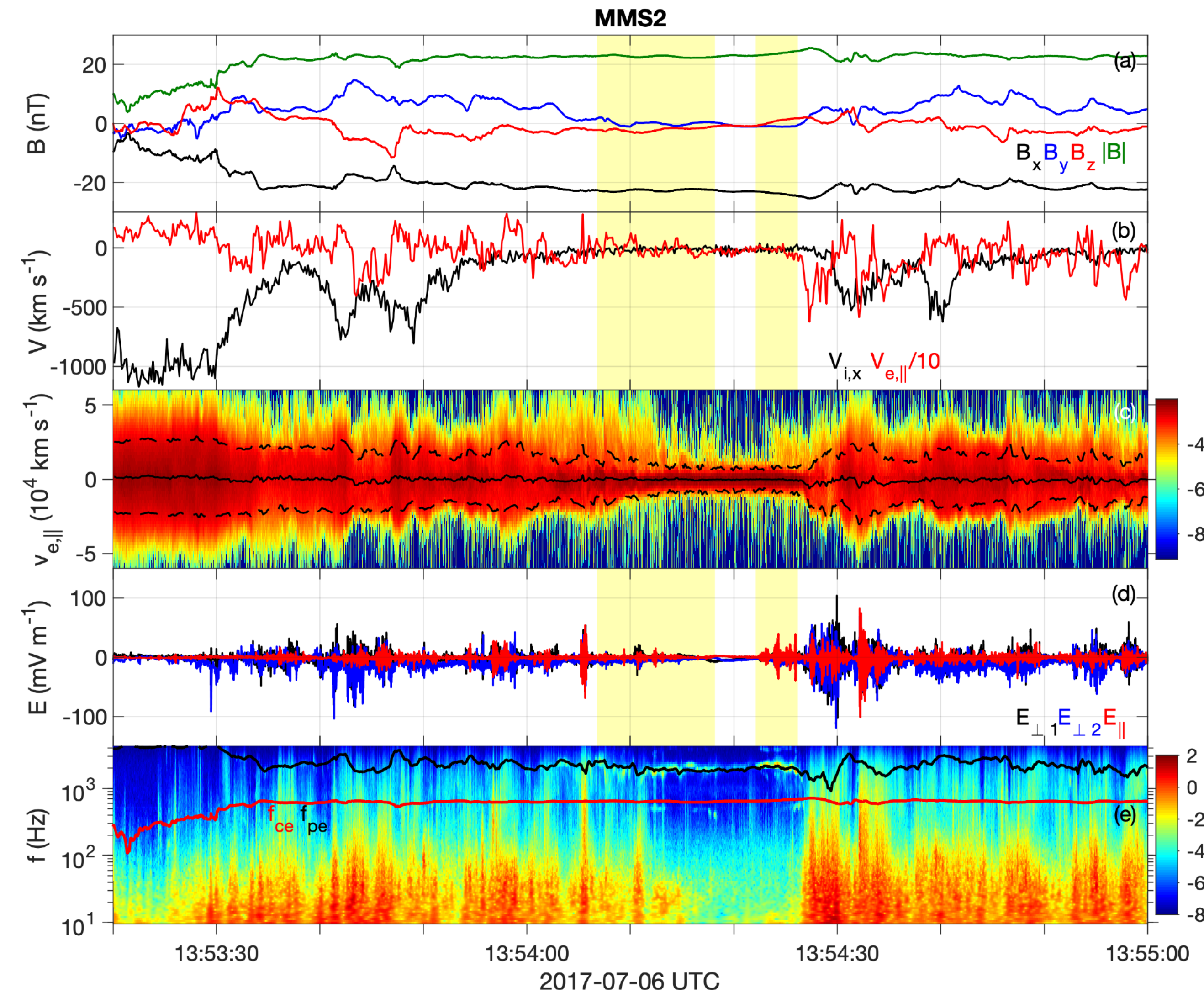


Loss cones

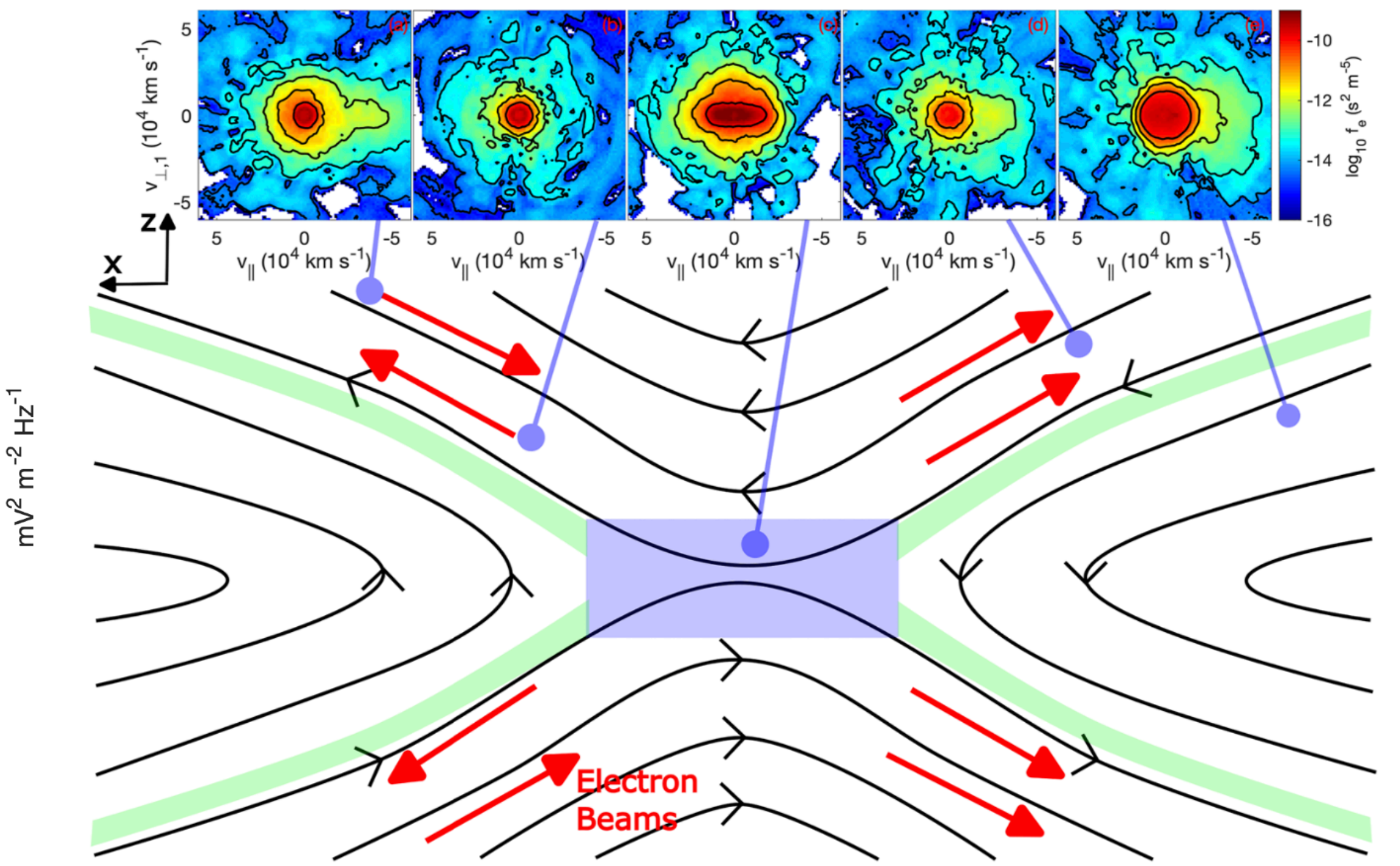


- Upper hybrid waves are associated with beam or loss-cone-like distributions.

Relation to magnetic reconnection



Statistically, waves are observed close to but outside ion jets.



Conclusions

- Large-amplitude plasma frequency waves are commonly observed in the near Earth plasma environment.
- Langmuir waves are generated by electron beams; upper hybrid waves are generated by beams or loss-cones.
- Plasma waves in the magnetotail are primarily generated in the PSBL near reconnection separatrices.

[Graham et al., JGR, 2023, doi:10.1029/2023JA031900]

