Effect of shock ripples on electron acceleration and reflection at quasi-perpendicular shocks

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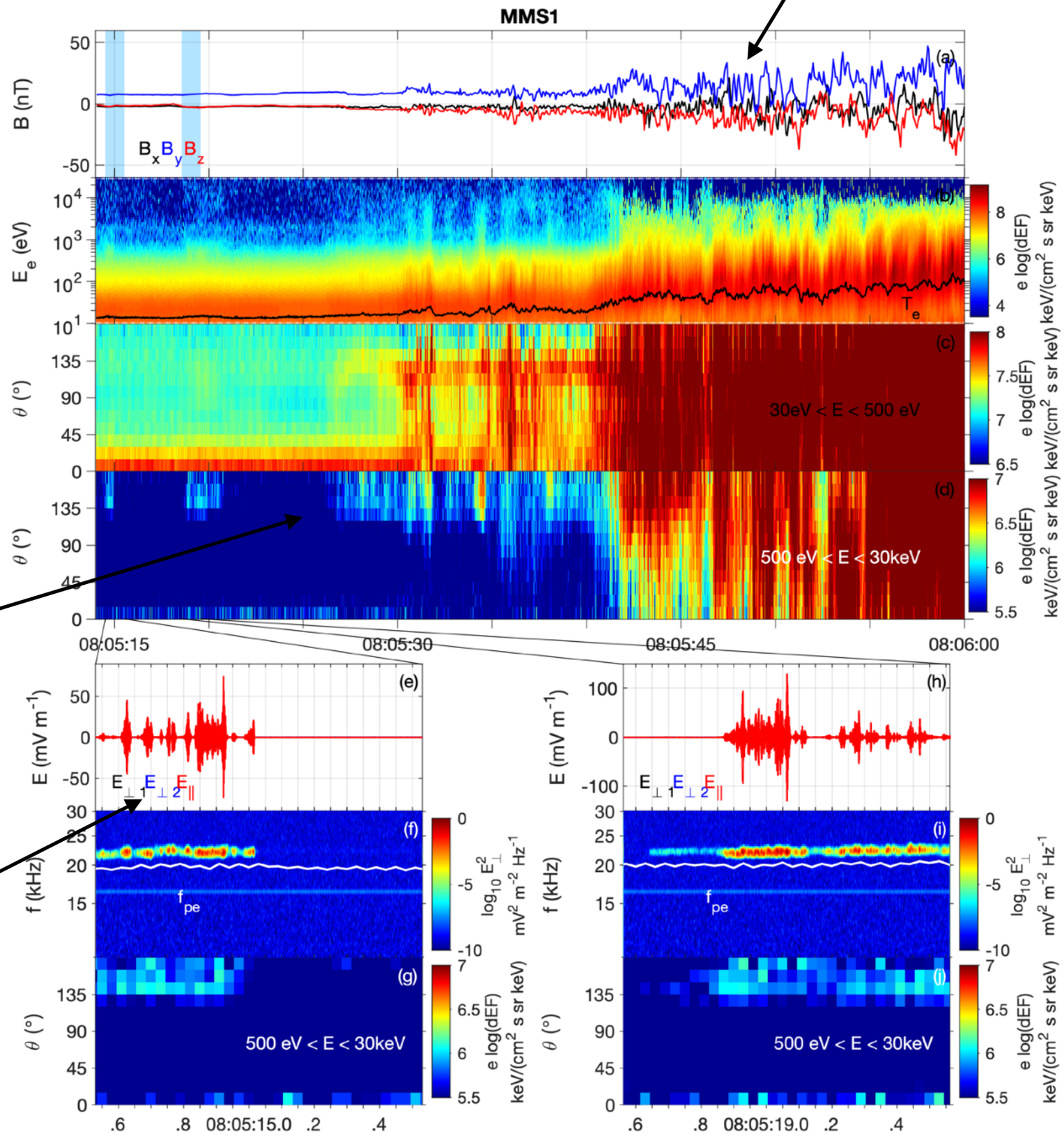
Motivation

- Solar wind electrons are accelerated and reflected at quasi-perpendicular shocks to form beams.
- These beams can generate Langmuir waves, which are subsequently converted to radio waves.
- Shock ripples have frequently been observed at quasi-perpendicular shocks.
- Shock ripples modify the magnetic field structure and potentially the cross-shock potential, modifying the behavior of electrons.
- We investigate how shock ripples can modify reflected and accelerated electrons.

Example shock

- Quasi-perpendicular shock with intermittent changes in reflected electrons.
- Langmuir waves are also intermittent and colocated with high-energy electron fluxes.

Shock ripples



Highly variable electron fluxes antiparallel to B.

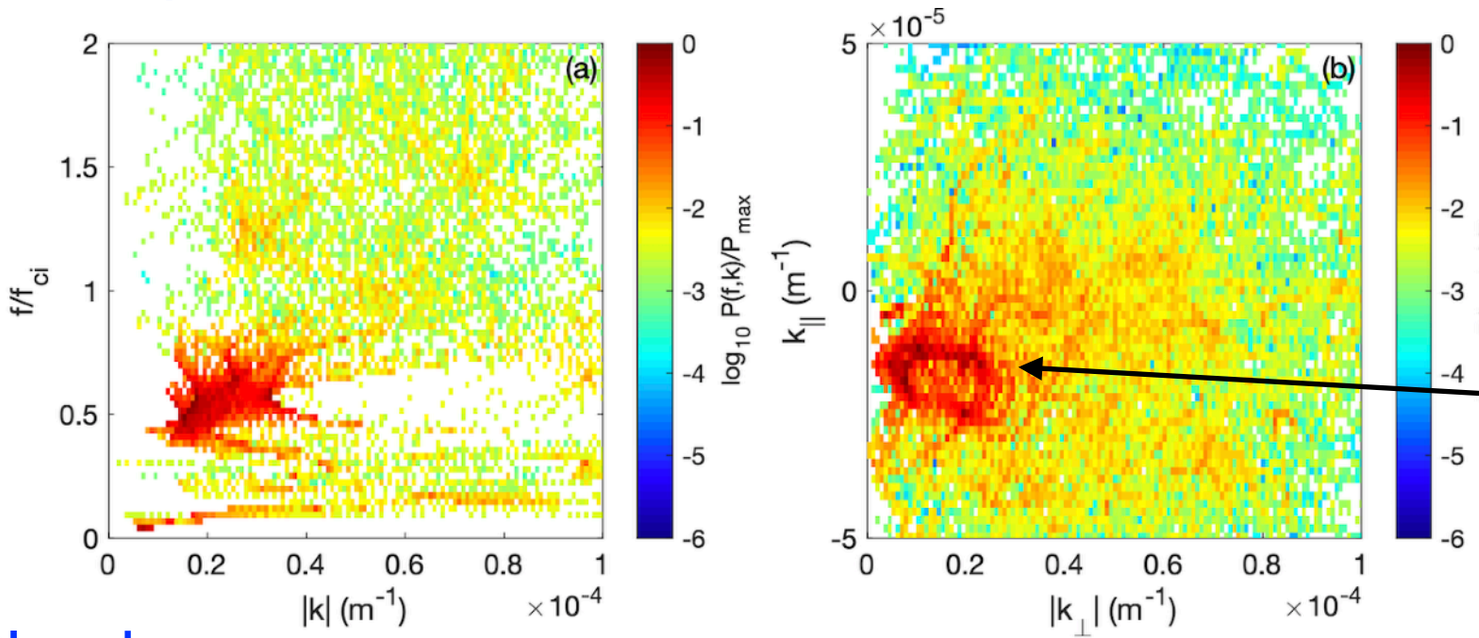
Langmuir waves seen at the same time as high energy electron fluxes.

$\theta_{Bn} = 85$
$M_A = 8$

Shock ripples properties

- Show ripples are oblique Alfvenic fluctuations. [cf. Johlander, 2018]

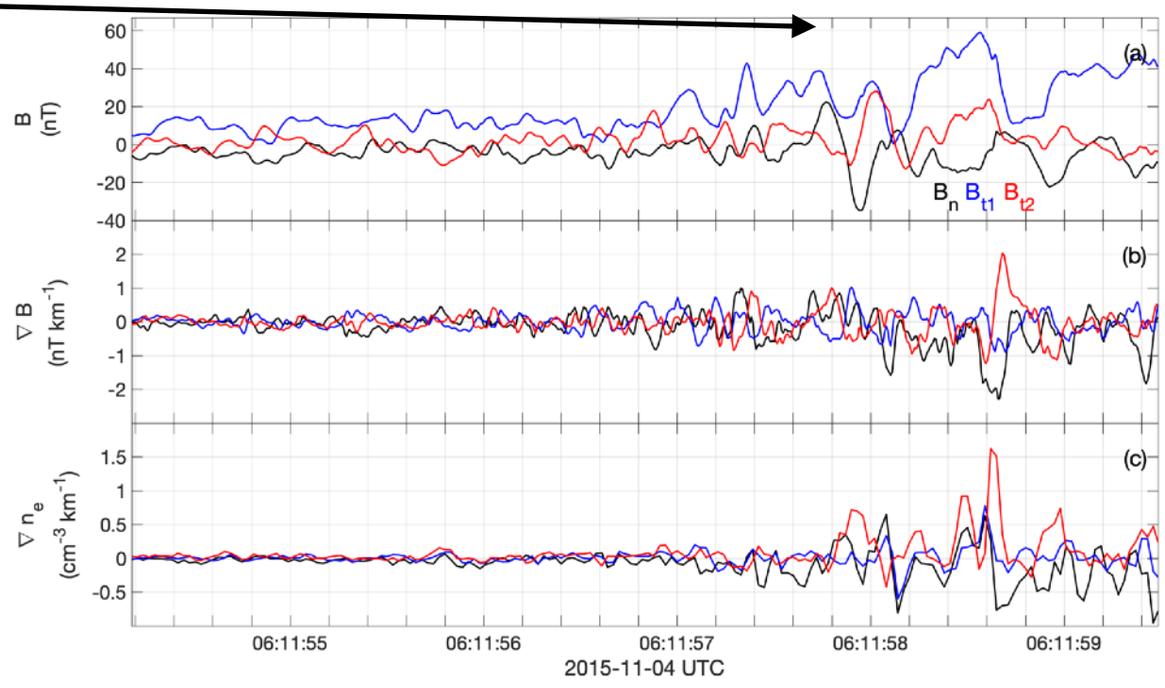
Dispersion relation obtained from four spacecraft observations.



Waves have frequency in the alfvenic frequency range.

Oblique wave power.

Shock ripples

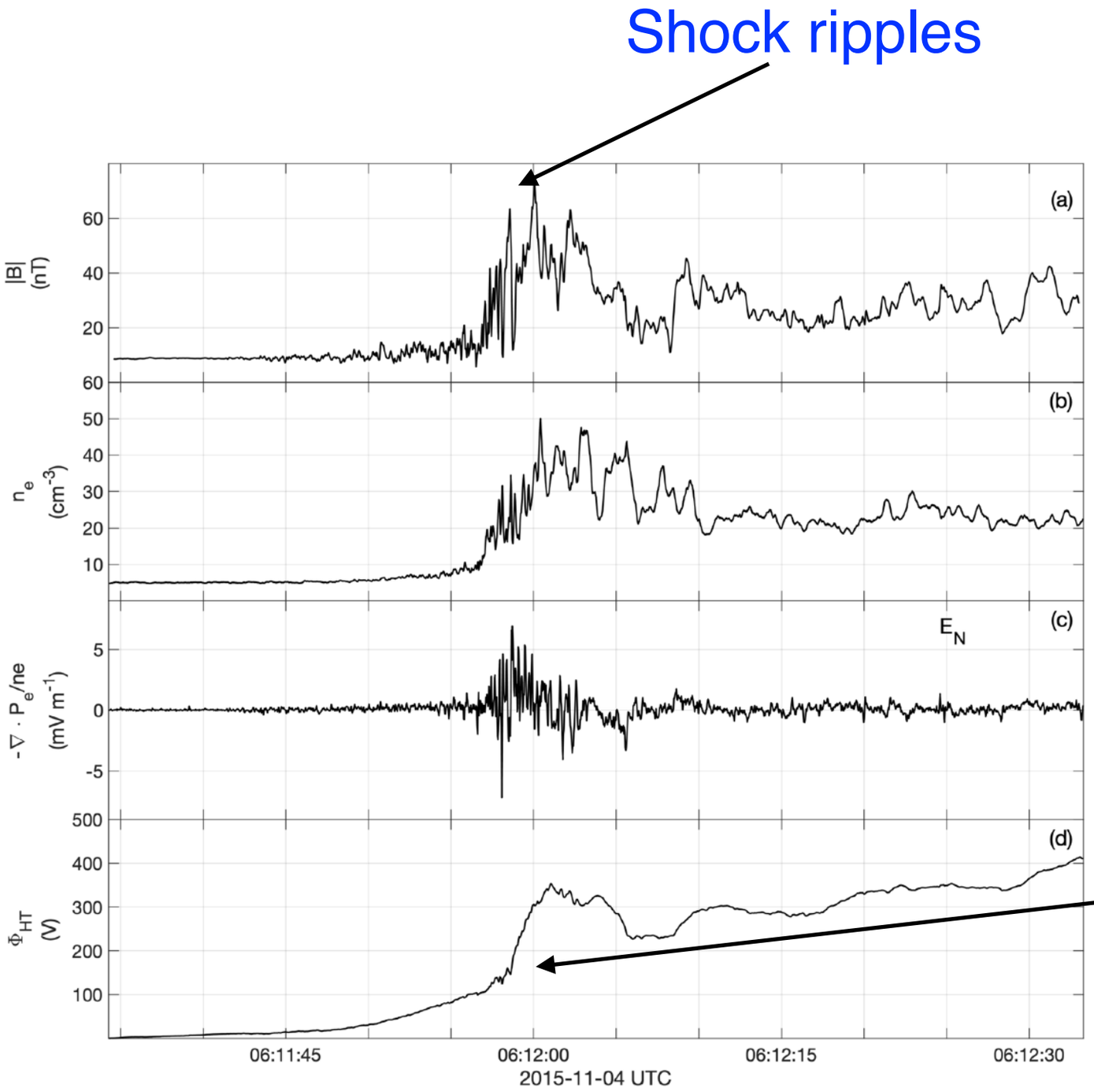


Gradients in B and n in directions normal and tangential to overall shock.

This suggests that local shock normal angles changes due to ripples.

Shock ripples

- Shock ripples do not significantly change cross-shock potential.



- Cross-shock potential (in the deHoffman-Teller frame) is calculated using:

$$\Phi_{HT} = \int \frac{\nabla \cdot P_e}{ne} dx$$

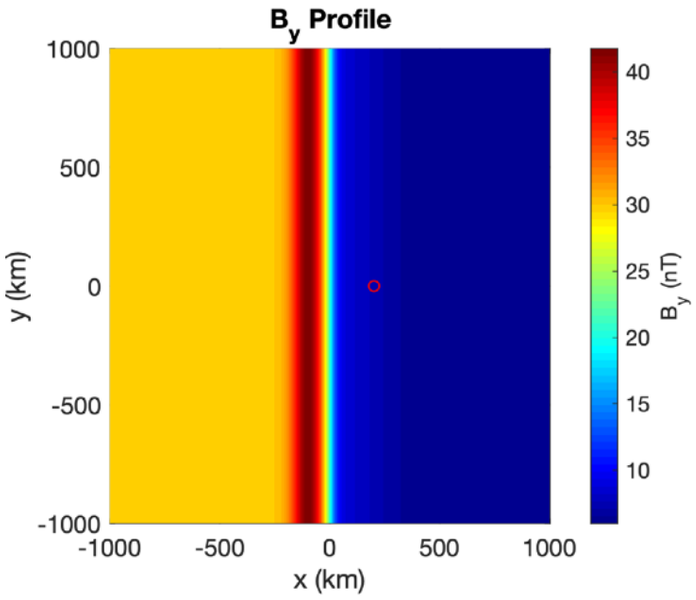
Contribution of shock ripples to cross-shock potential is very small.

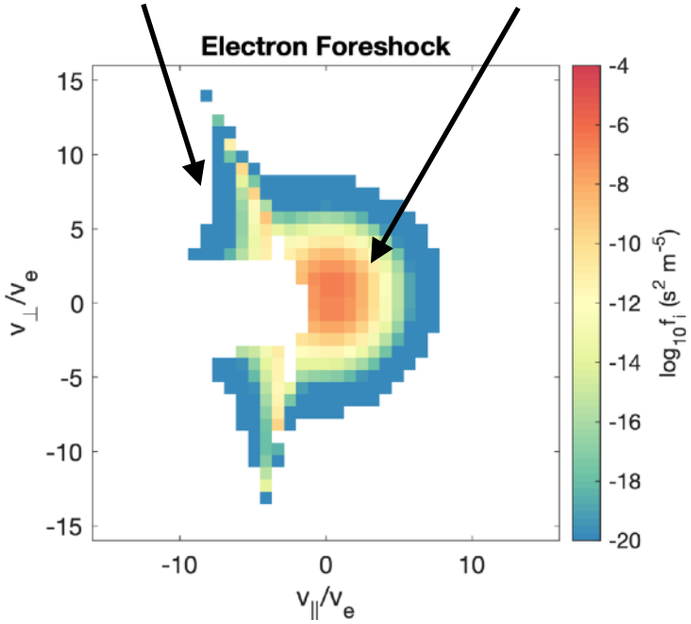
Model electron distributions

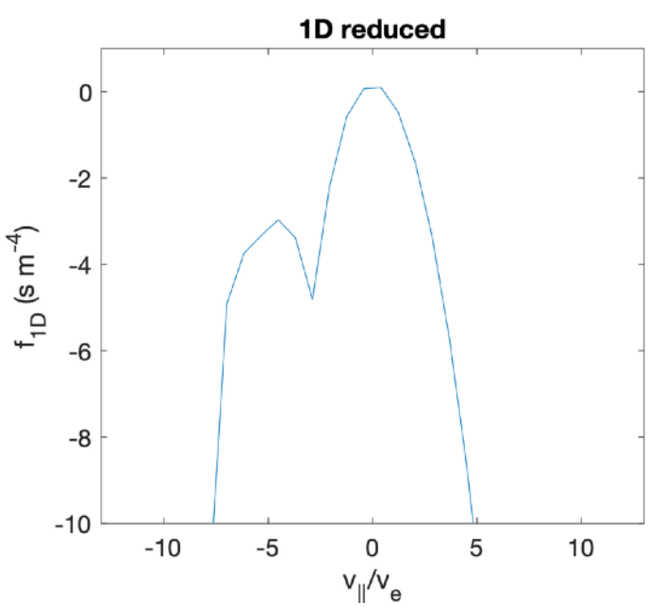
Reflected electrons

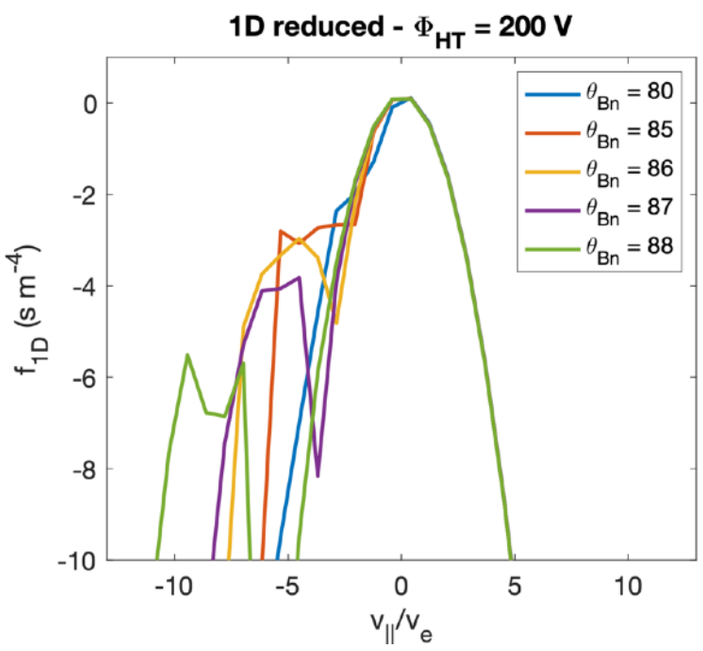
Solar wind electrons

Electron distribution in the electron foreshock.

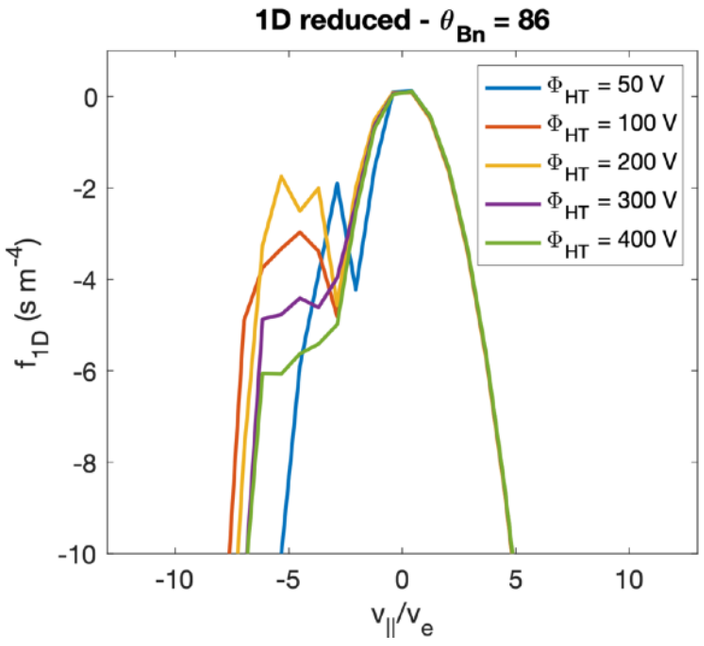








Faster, lower density beams develop as θ_{Bn} approaches 90.



Ripples modifying the local θ_{Bn} by a few degrees can change beam speed to determine whether Langmuir waves can grow (approx. threshold $v_b/v_e > 3$).

Conclusions

- Langmuir waves and accelerated electrons are often intermittent in the electron foreshock.
- Shock ripples can modify the local θ_{Bn}, affecting the electron beams speeds in the electron foreshock. This can result in intermittent bursts of Langmuir waves.