

STEREO Observations of Langmuir Waves and Ion Events in the Terrestrial Foreshock

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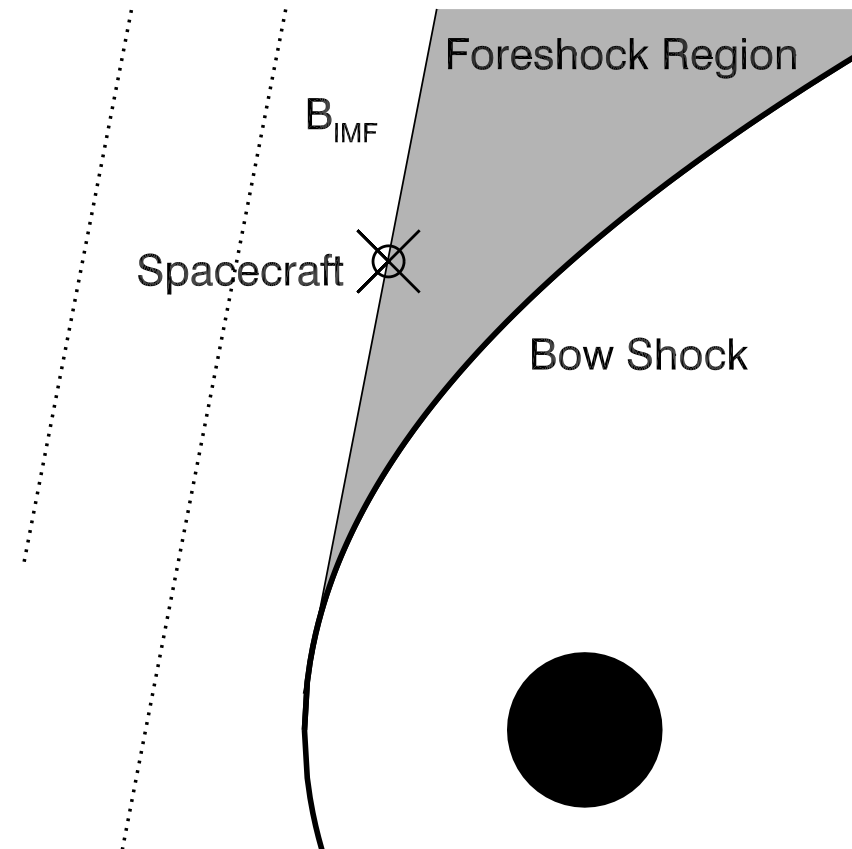
Electron Foreshock

Ion Foreshock

Conclusions and
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- The foreshock is the region upstream of Earth's bow shock that is magnetically connected to the shock.
- Particles in the interplanetary medium travel along field lines and can be mirrored by the bow shock.
- The reflected beams cause bump-on-tail velocity distributions and generate Langmuir wave emission.

(Filbert and Kellogg 1979 and many others)



Instruments

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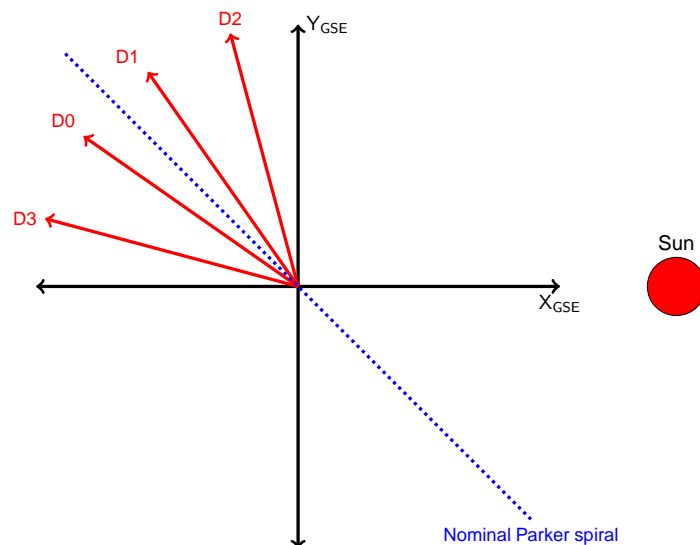
Electron Foreshock

Ion Foreshock

Conclusions and
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STE:

- 2-100keV
- Solid state detector
- Electrons, ions, neutrals
- 4 look directions, down-stream and upstream (STE-U is not working)



SWEA:

- 8-2000 eV
- Electrostatic detector
- Nearly 4π angular resolution

Late 2006: Petal Orbit

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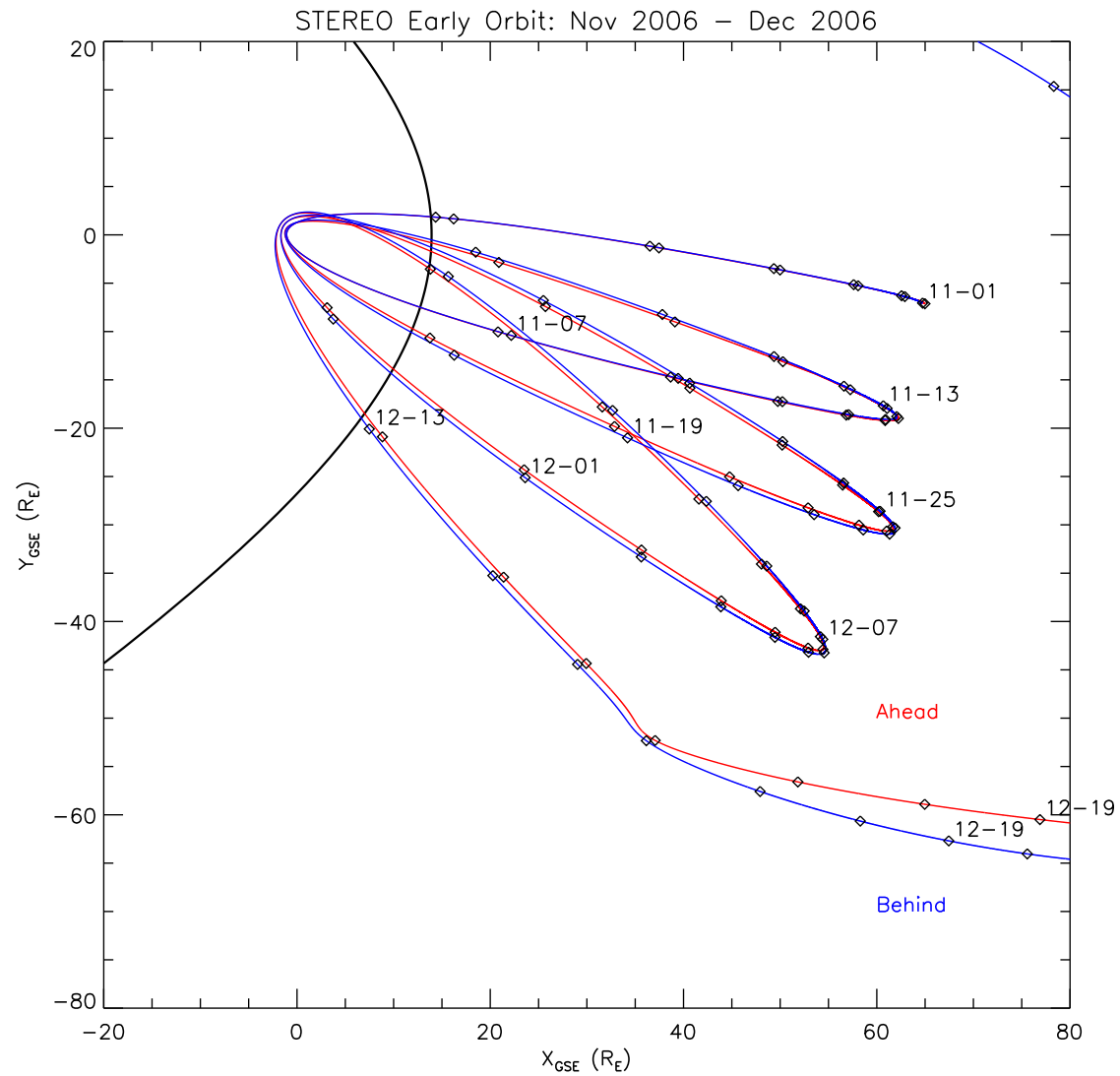
Late 2006: Petal Orbit

[Early 2007: STEREO/Ahead in the Foreshock](#)

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Early 2007: STEREO/Ahead in the Foreshock

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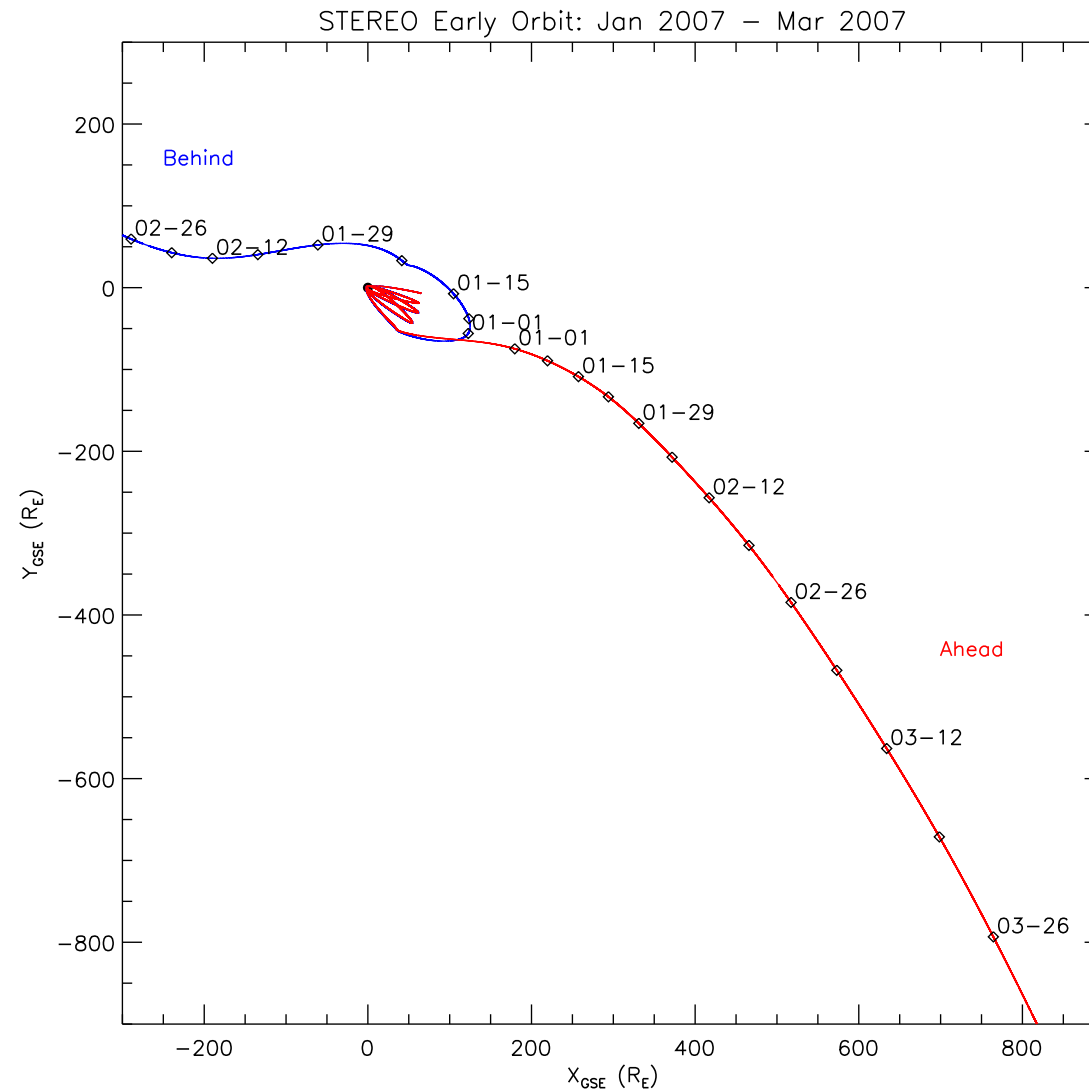
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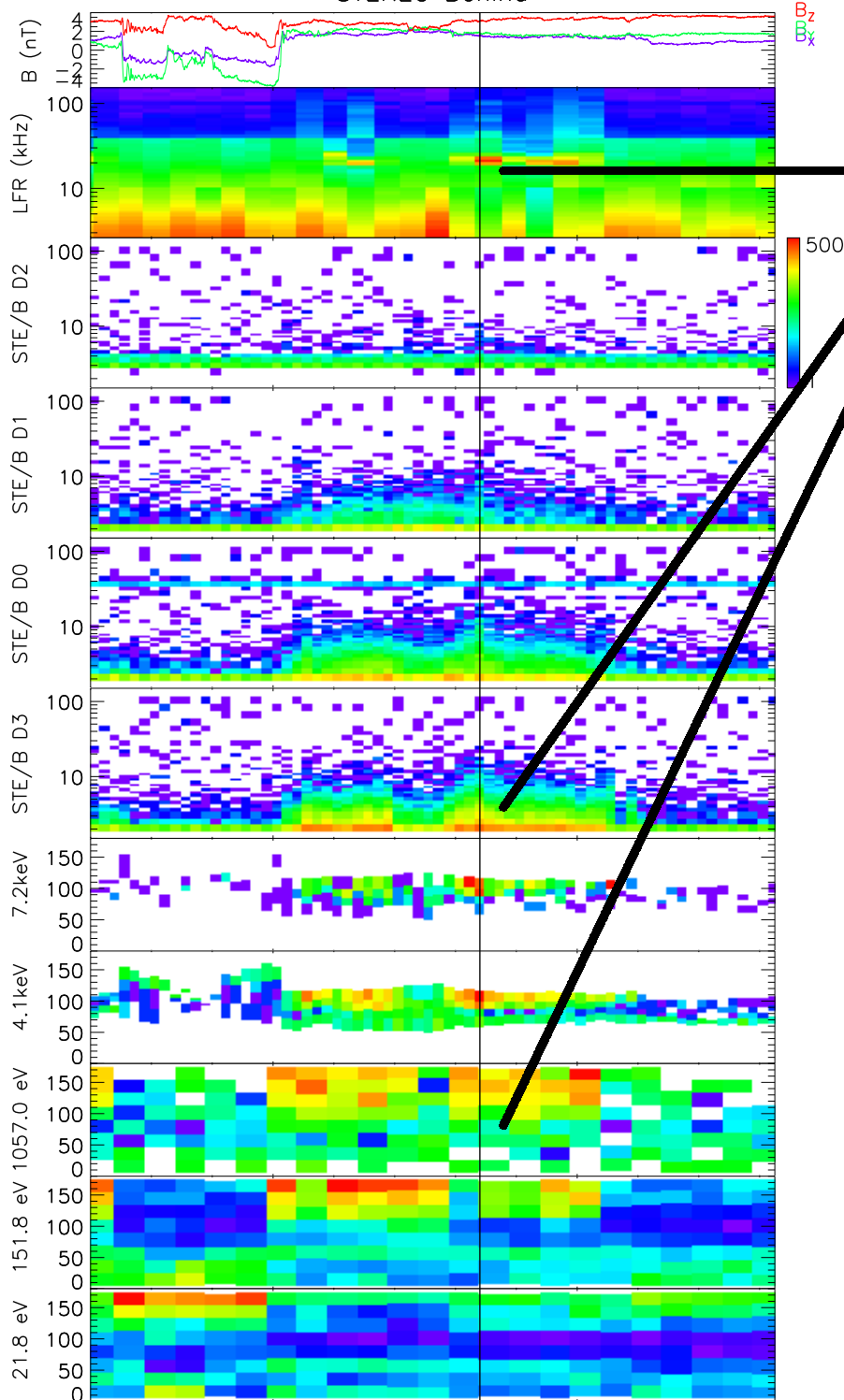
Electron Foreshock Event

Intense Langmuir waves at f_p accompanied by STE and SWEA electrons indicate foreshock electron beam.

Energy spectra for each STE look direction. Electron beam is visible in STE D0 and D3.

STE PADs

SWEA PADs



Electron spectra

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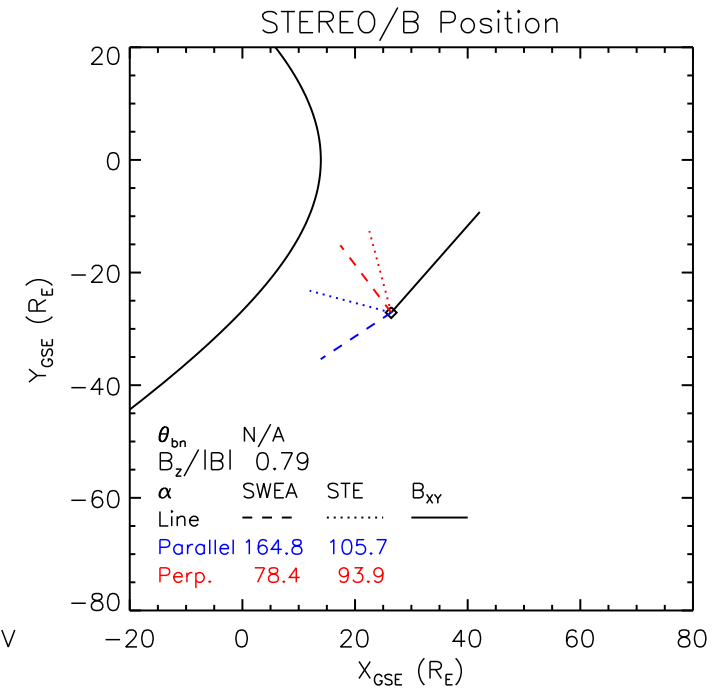
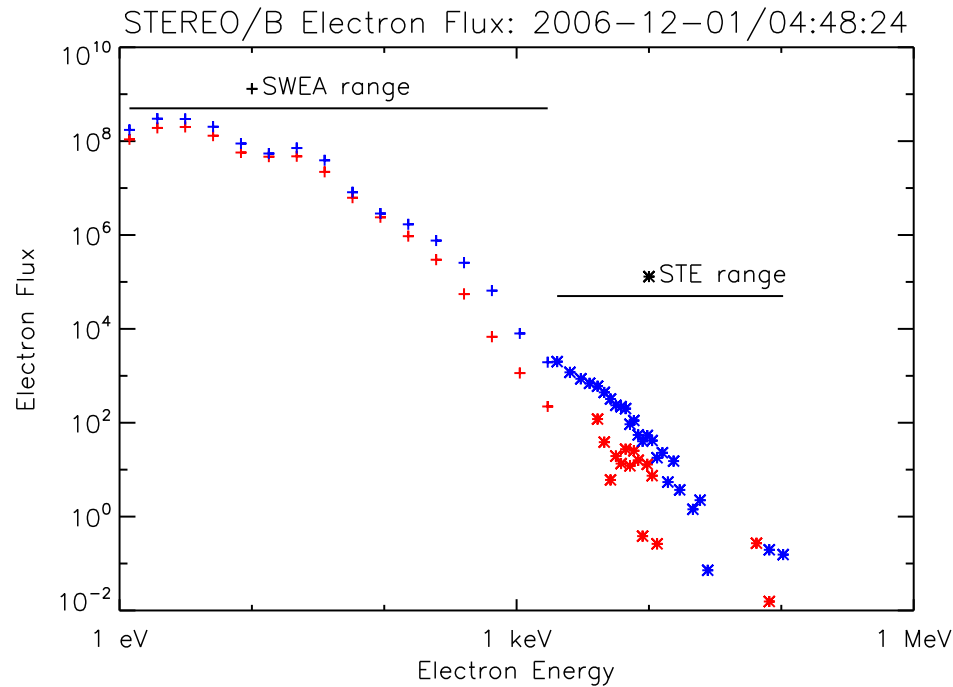
Electron Event

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- Blue = Parallel, Red = Perpendicular.
- Electron beam present in both SWEA and STE.
- Pitch angle coverage limited by fixed look directions of STE.

Distribution of electron events

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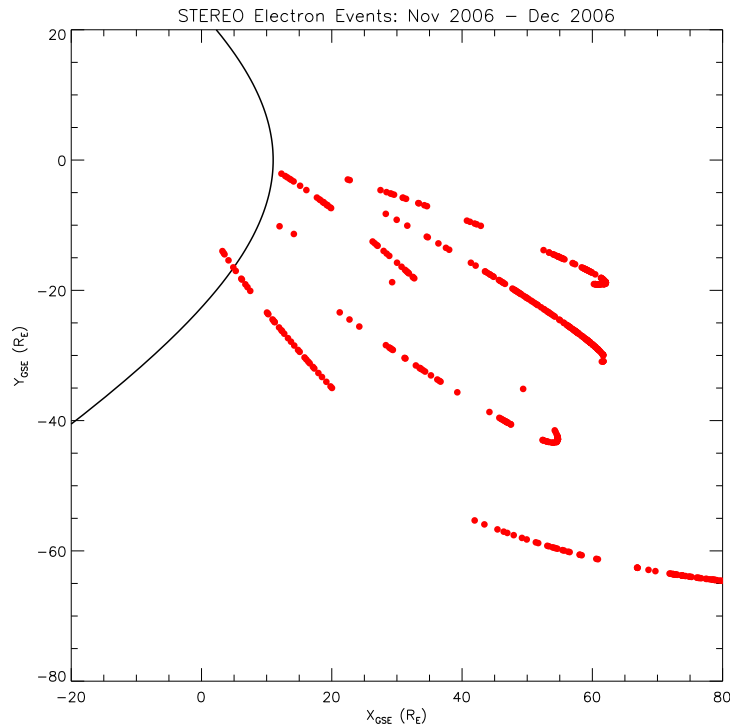
Electron Event

Electron spectra

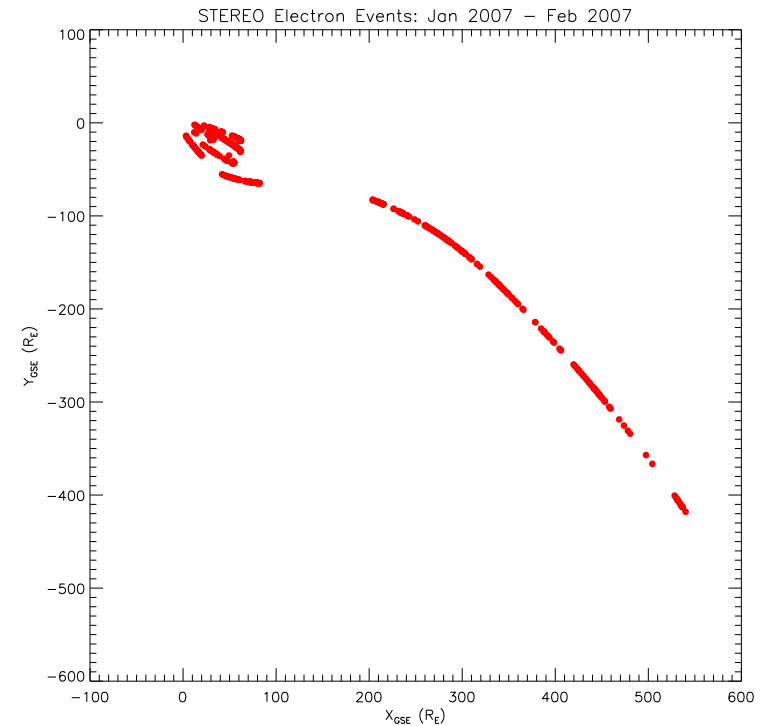
Distribution of electron events

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Hundreds of events, no immediately obvious organization by spacecraft position.



Electrons continue to be observed months into 2007. (The blank space is due to incomplete cataloguing, not a data gap or a dearth of events.)

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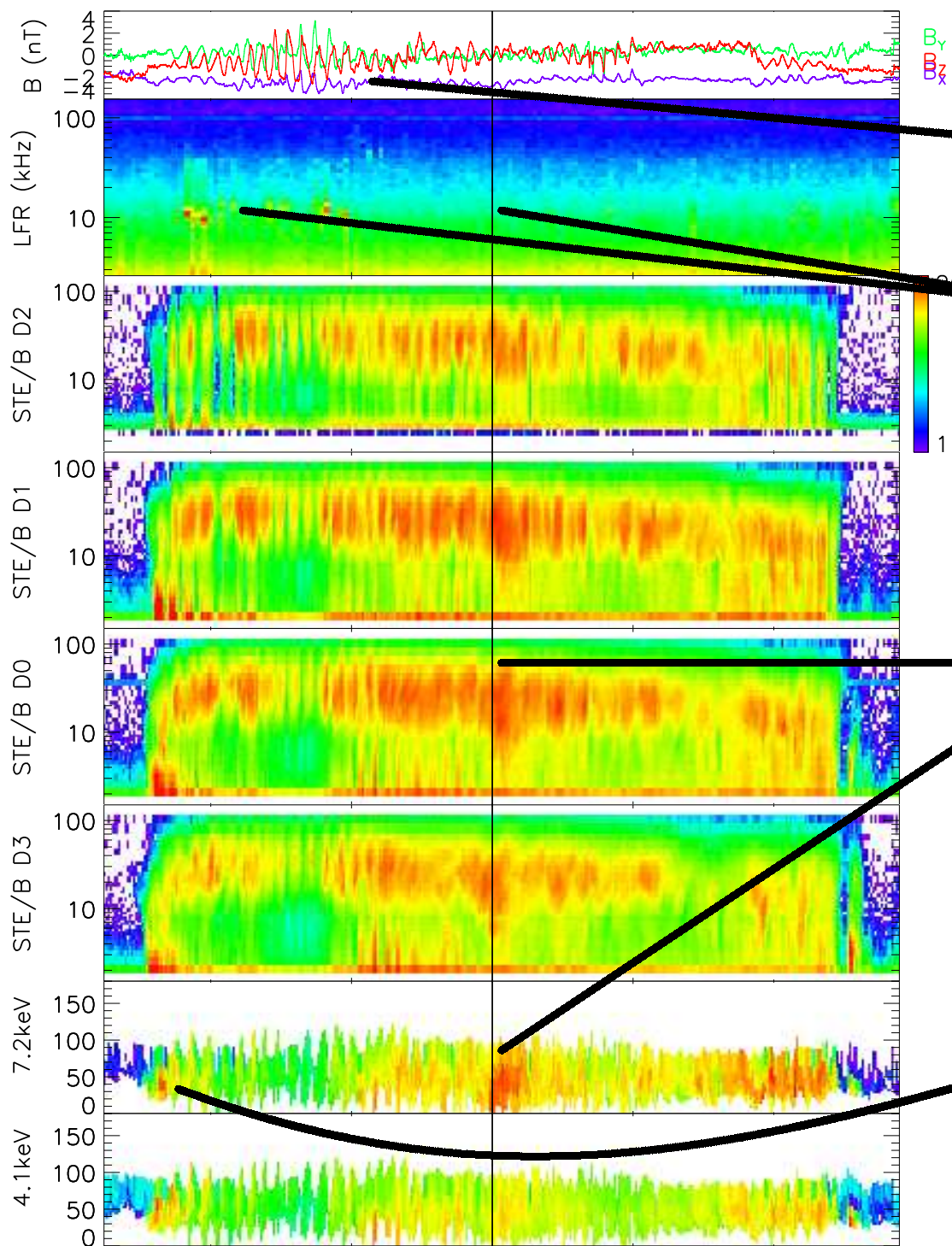
Foreshock event
with fine structure

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Ion Foreshock

STEREO Behind



Ions in the ULF Foreshock

Strong ULF fluctuations

Only intermittent Langmuir wave activity

Monoenergetic, mostly isotropic beam from around 10-80 keV suggests diffuse ions rather than electrons. Note anticorrelation between peak flux and peak wave activity.

Field aligned ion beam or electrons near beginning of event?

(Mazelle 2002 and others)

Ion spectra

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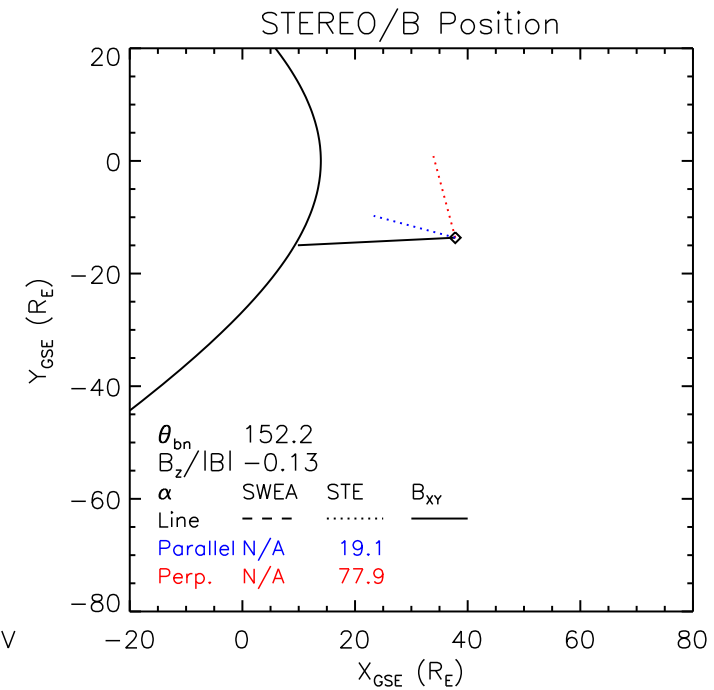
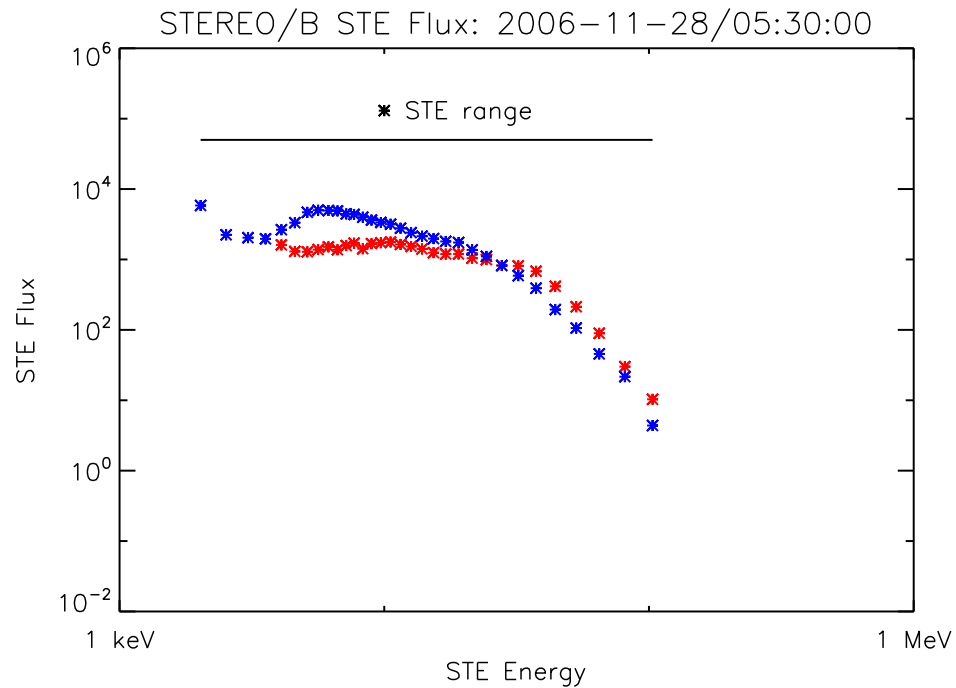
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Ion Foreshock Event with Fine Structure

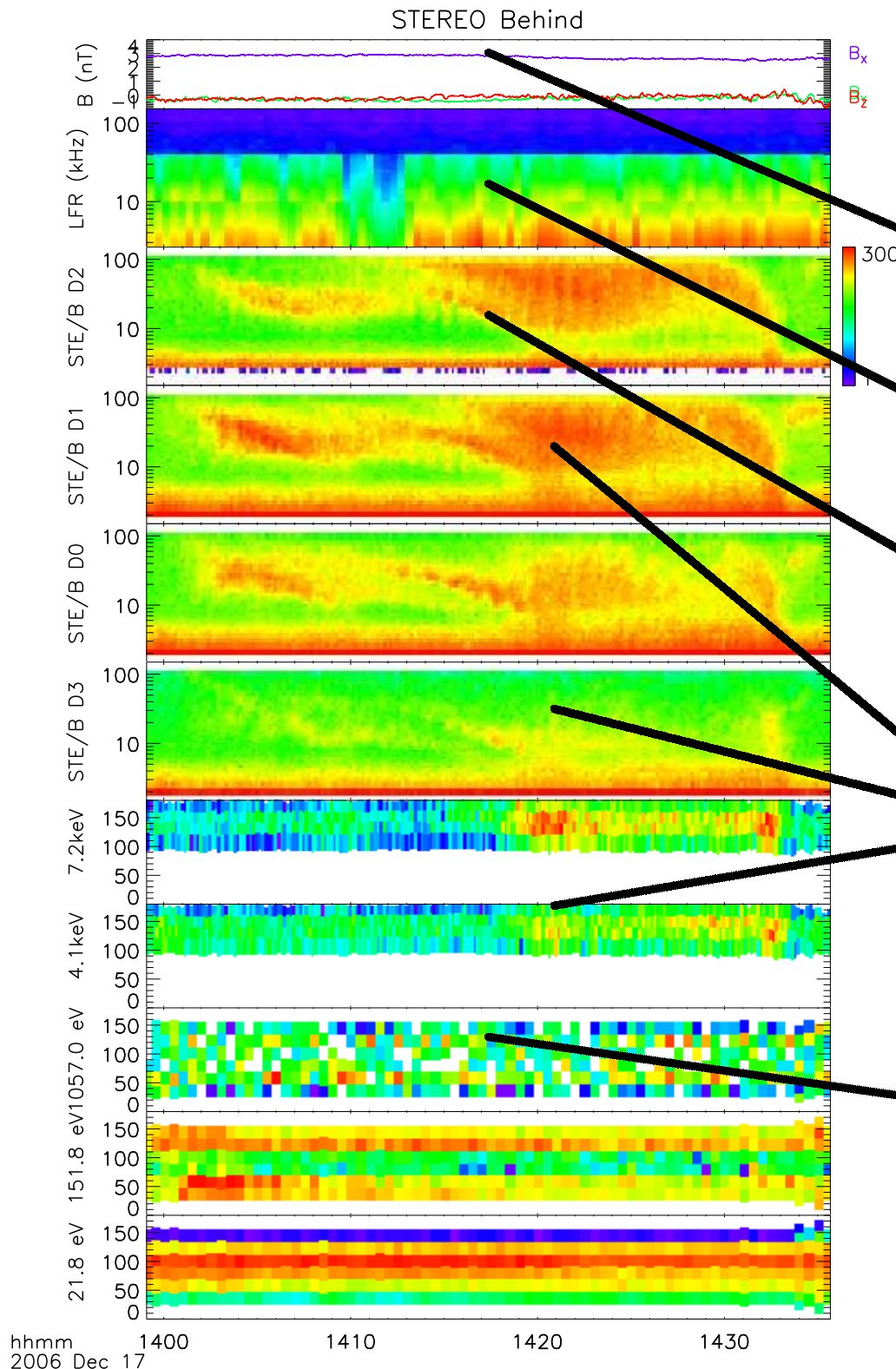
Magnetic field mostly dominated by B_x with B_y and B_z fluctuating around 0.

No plasma wave activity

Evolution of lower and upper energy cutoffs, at times upper limit of energies reaches ≥ 100 keV

Same general structure seen in all STE look directions, but there is some difference in intensity.

No evidence of electrons



Distribution of ion events

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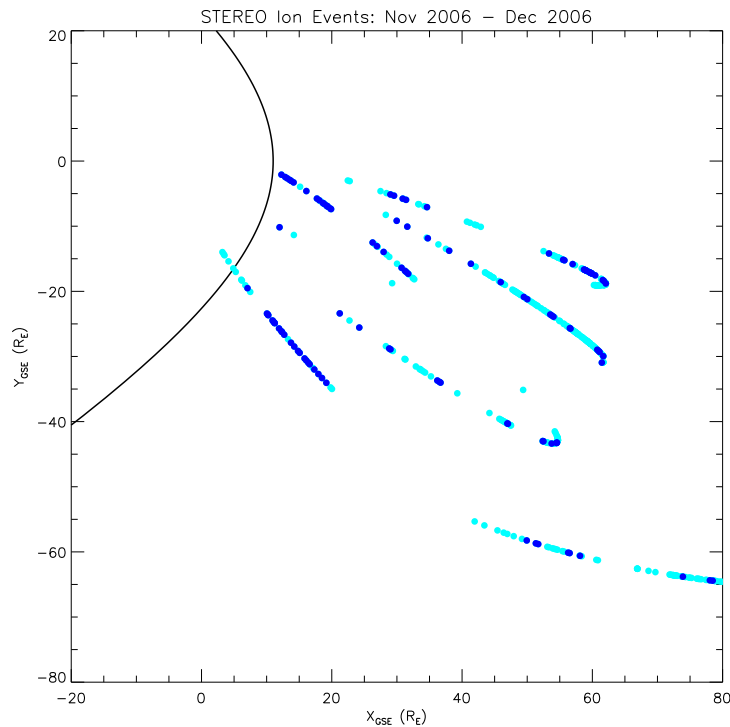
[Ion Foreshock](#)

[Ion spectra](#)

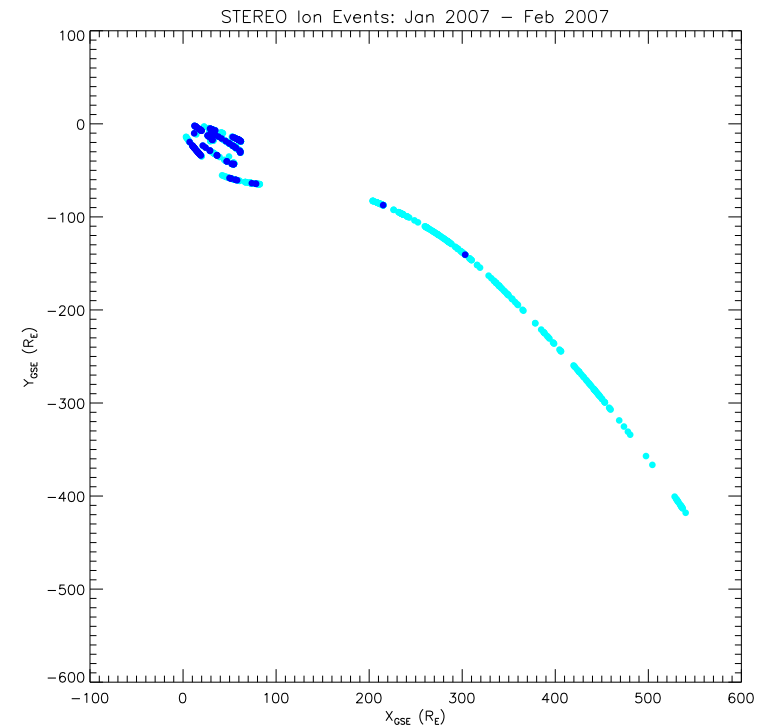
[Foreshock event with fine structure](#)

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Light blue dot is an ion event, dark blue dot is an ion event with associated ULF activity.



Ion events continue, but ULF events die out. Issue of distance versus depth.

Conclusions and Future Work

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- STE and SWEA see many examples of electrons and ions upstream of the foreshock. STEREO/A continues to observe upstream particles well into 2007.
- STE can measure the energy spectrum of foreshock electron beams with good sensitivity and energy resolution. However, it is limited by incomplete pitch angle coverage.
- STE also sees ion events, including ULF events. The strength and frequency of ULF events decreases as STEREO/A moves farther from the bow shock, but it is unclear whether this is due to distance or depth in the foreshock.
- Put observations in magnetic coordinates (organized by θ_{BN} and depth in foreshock) rather than GSE coordinates. A better bow shock model is necessary.
- Resolve ambiguous events and use current SWEA data.

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Thank you!