RELATION BETWEEN ELECTROMAGNETIC WAVES AND ELECTRON HEATING INSIDE A FTE

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On May 20th, 2007, the 5 THEMIS spacecraft passed by a FTE, in the post-noon sector. Spacecraft configuration was interesting since the satellites bracketed the magnetopause current layer and FTE structure.

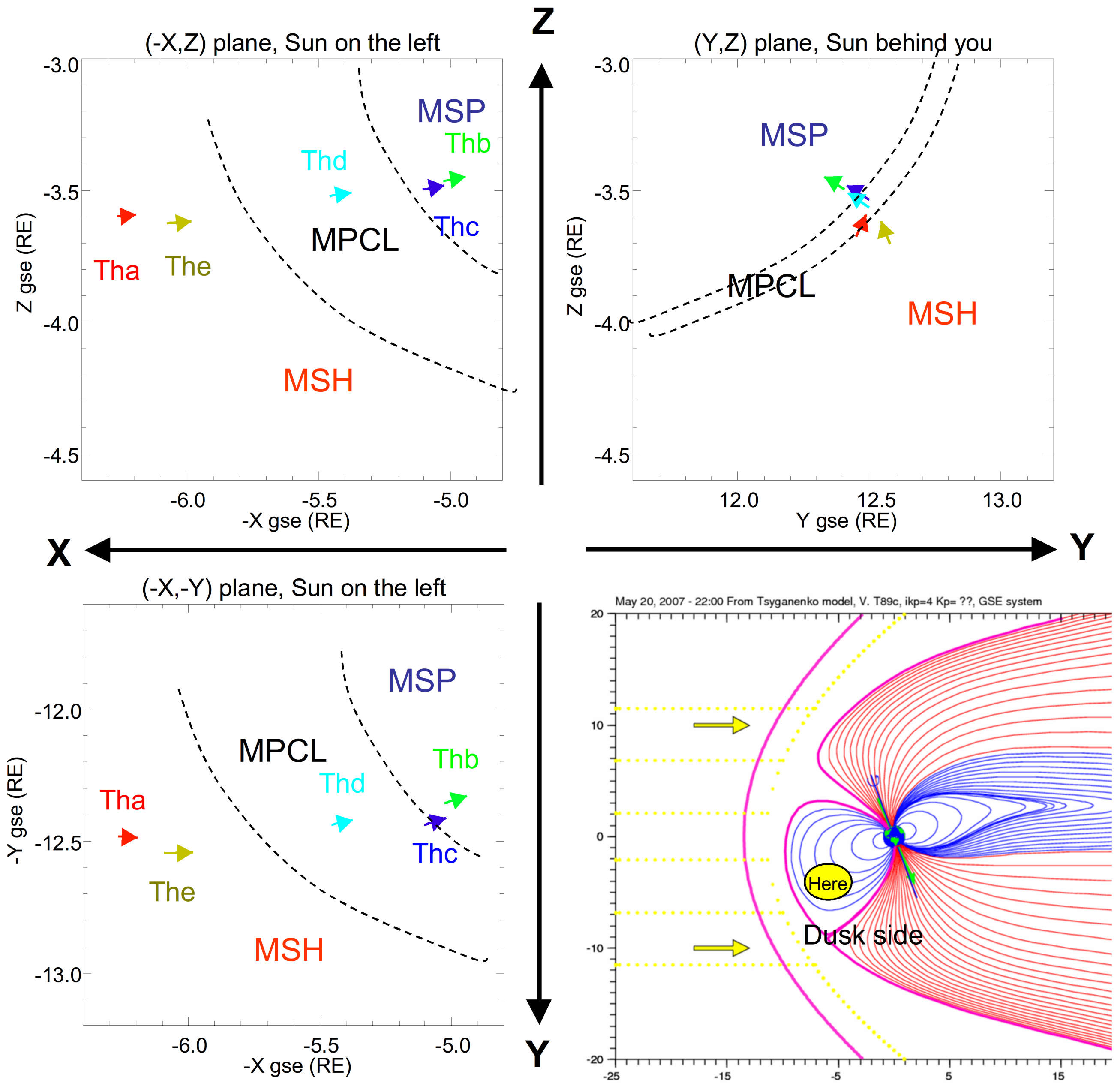
We take advantage of the configuration of the THEMIS constellation to study the possible role of waves at heating electrons.

THEMIS Positions - 2007-05-20 / 21:58:00.0 to 22:07:00.0

The 5 THEMIS spacecraft bracketed the FTE structure :

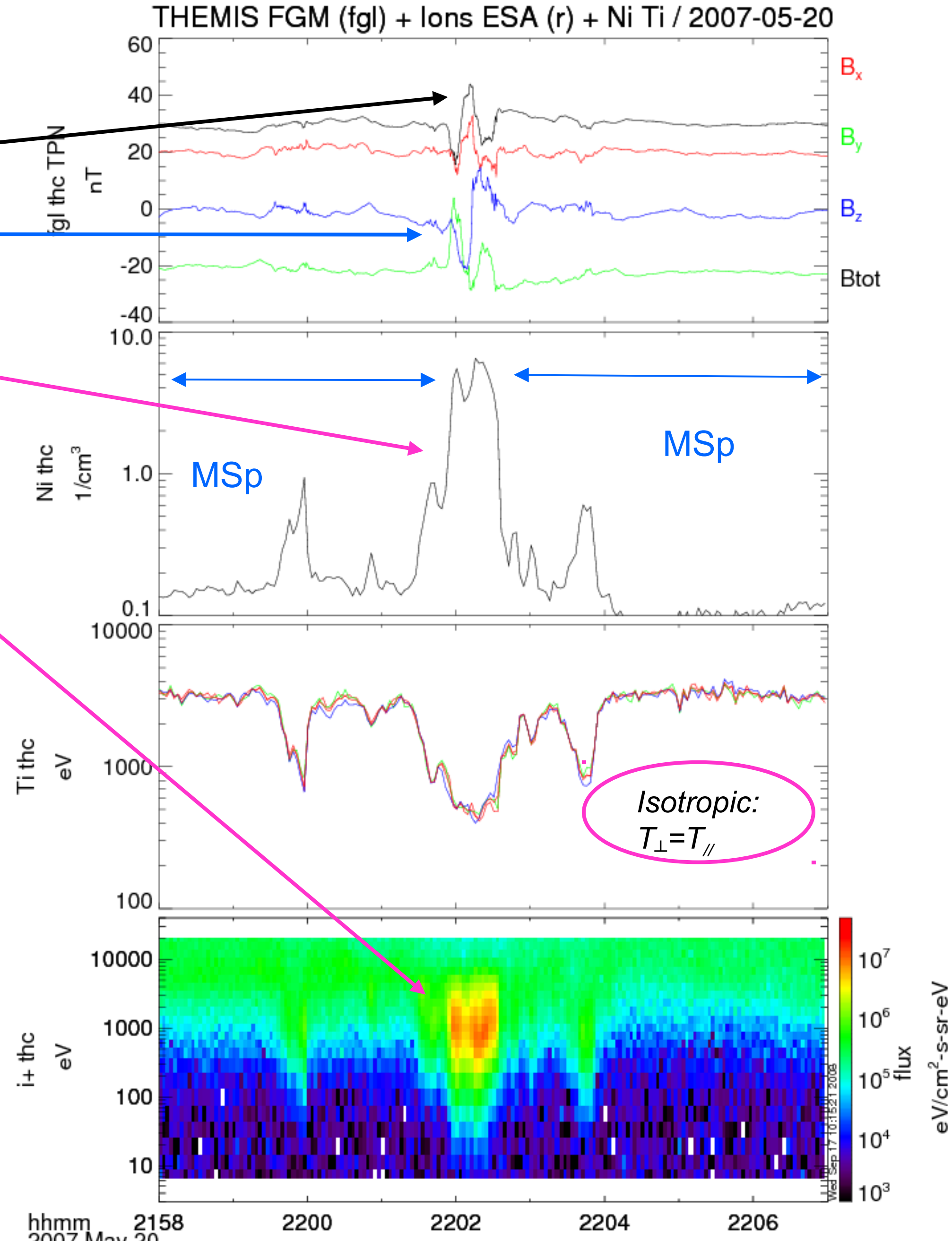
Thb, Thc on the **magnetospheric** side,
Tha, The on the **magnetosheath** side,
Thd inside the **magnetopause current layer.**

In the following, we show only Thc, Thd, & Tha



Thc (in the magnetosphere) observes a typical FTE signature, namely :

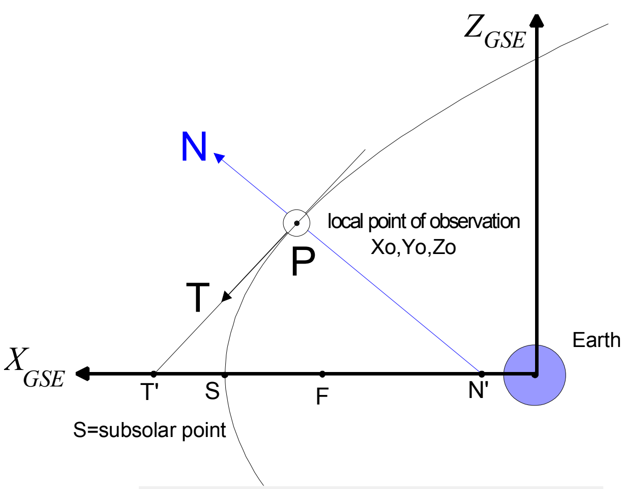
(i) a crater-like variation in the magnetic field strength,
(ii) a bipolar magnetic field signature normal to the nominal magnetopause (<Bz>=0),
(iii) enhanced densities,
(iv) enhanced ion intensities.



Why TPN system ?

- Normal component to the paraboloid
- well adapted to FTE's signatures
- Z Data often centered around zero
- generally close for the MVA system computed over a large time interval

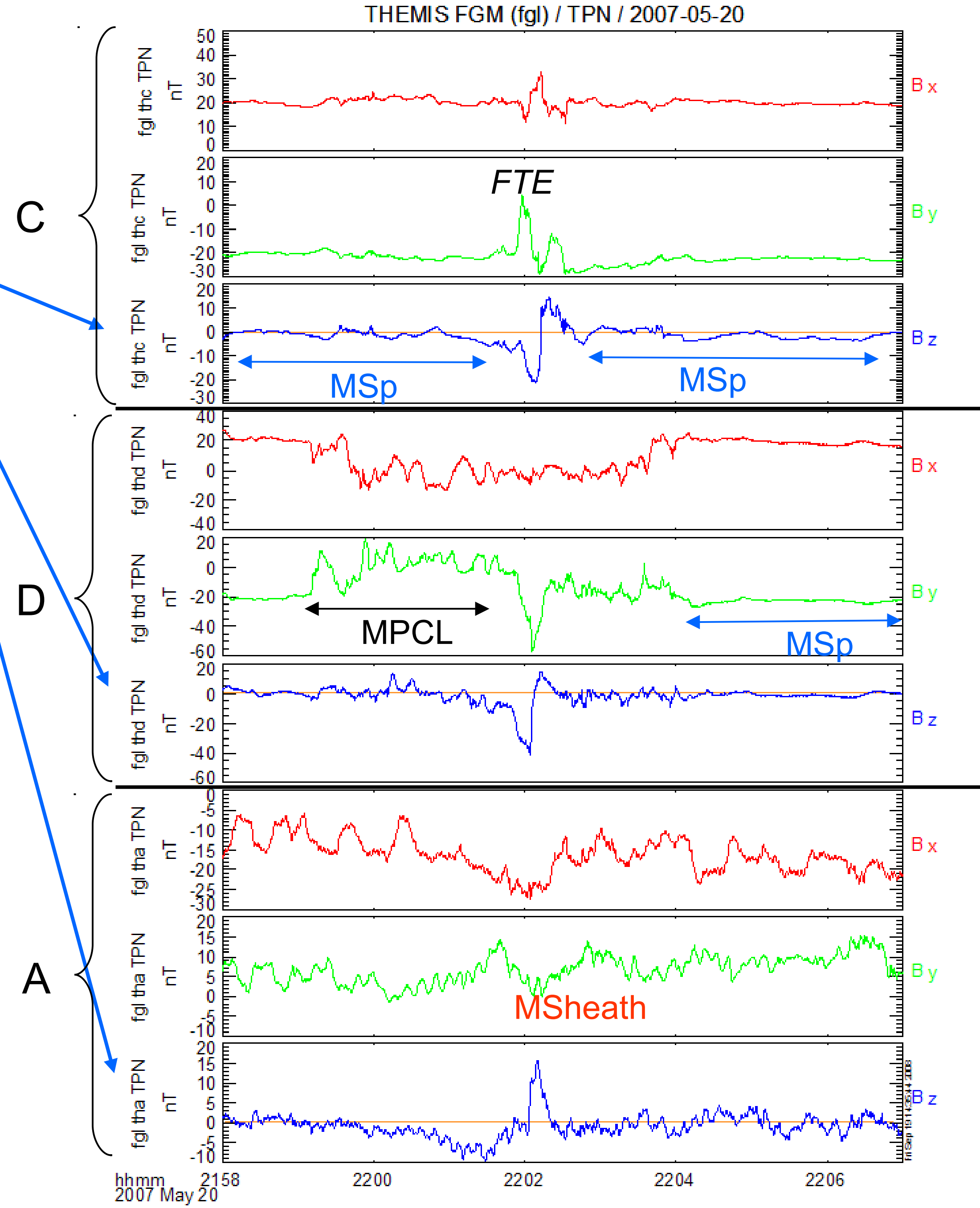
Definition of the local TPN system



The paraboloid is defined by its summit and the point of observation

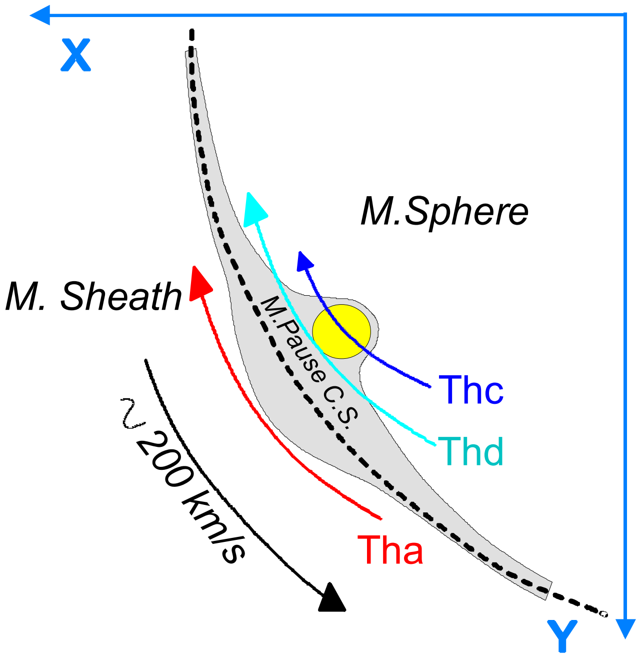
The TPN system is defined as:

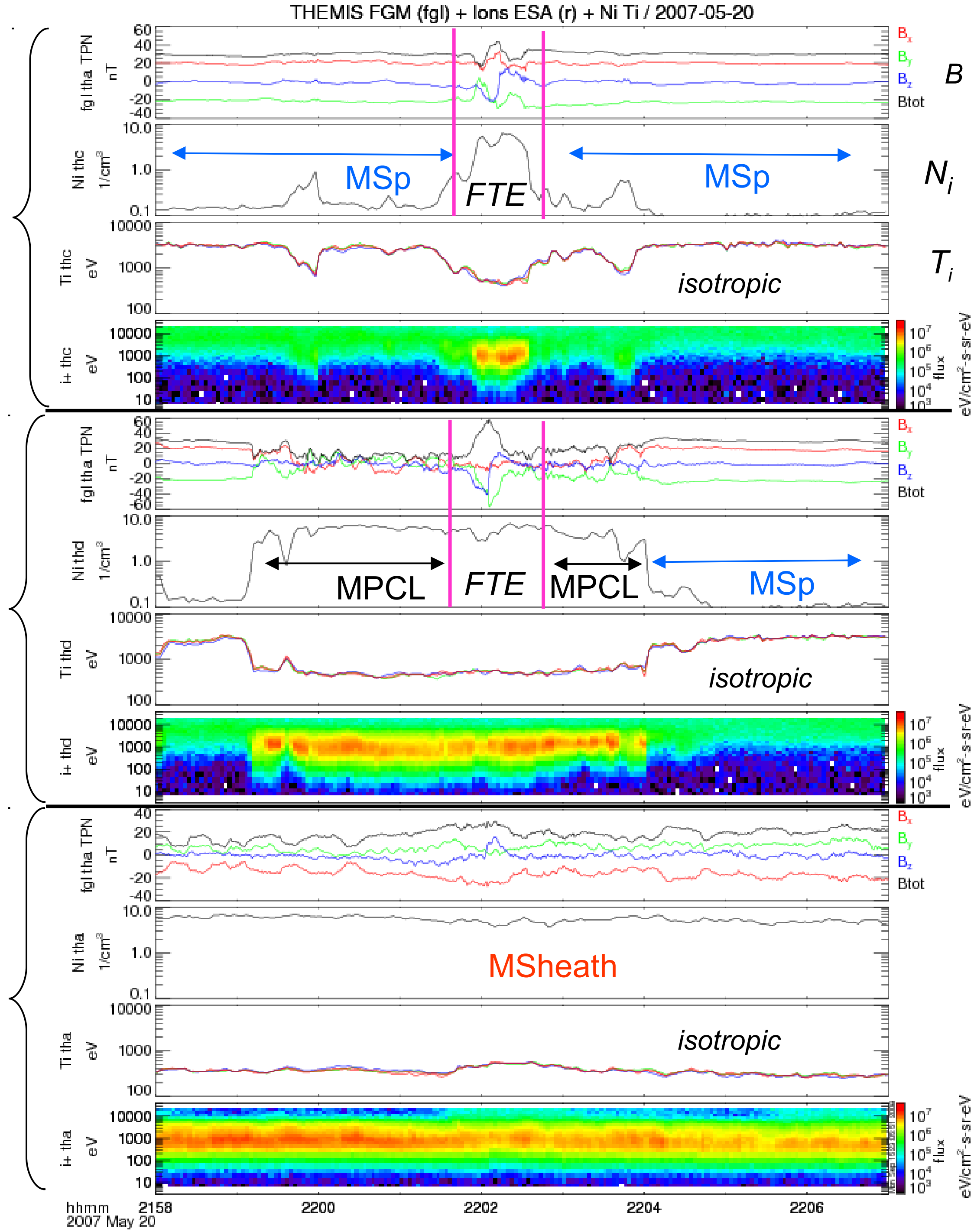
$\vec{T}$= local tangent toward the summit
$\vec{P}$= $\vec{N}$ X $\vec{T}$
$\vec{N}$= outward normal



Observations:

Thc crosses the FTE,
Thd passes nearby the FTE,and stays for a long time into the magnetopause current layer (MPCL),
Tha remains in the magnetosheath, but gets close to the MPCL.





Densities and ion velocities in the core region of the FTE and MCL are comparable to those in the magnetosheath

Deduction:

Magnetosheath ions penetrate in the current layer & the FTE, but ion temperature remains the same: (temp. Thd in CL=temp Tha in MSheath),

- no ion heating
- isotropic ion temperature ($T_{\perp} i = T_{//}$ i)

Observations:

While densities, ion velocities & temperature in the MPCL & FTE are comparable to the magnetosheath,

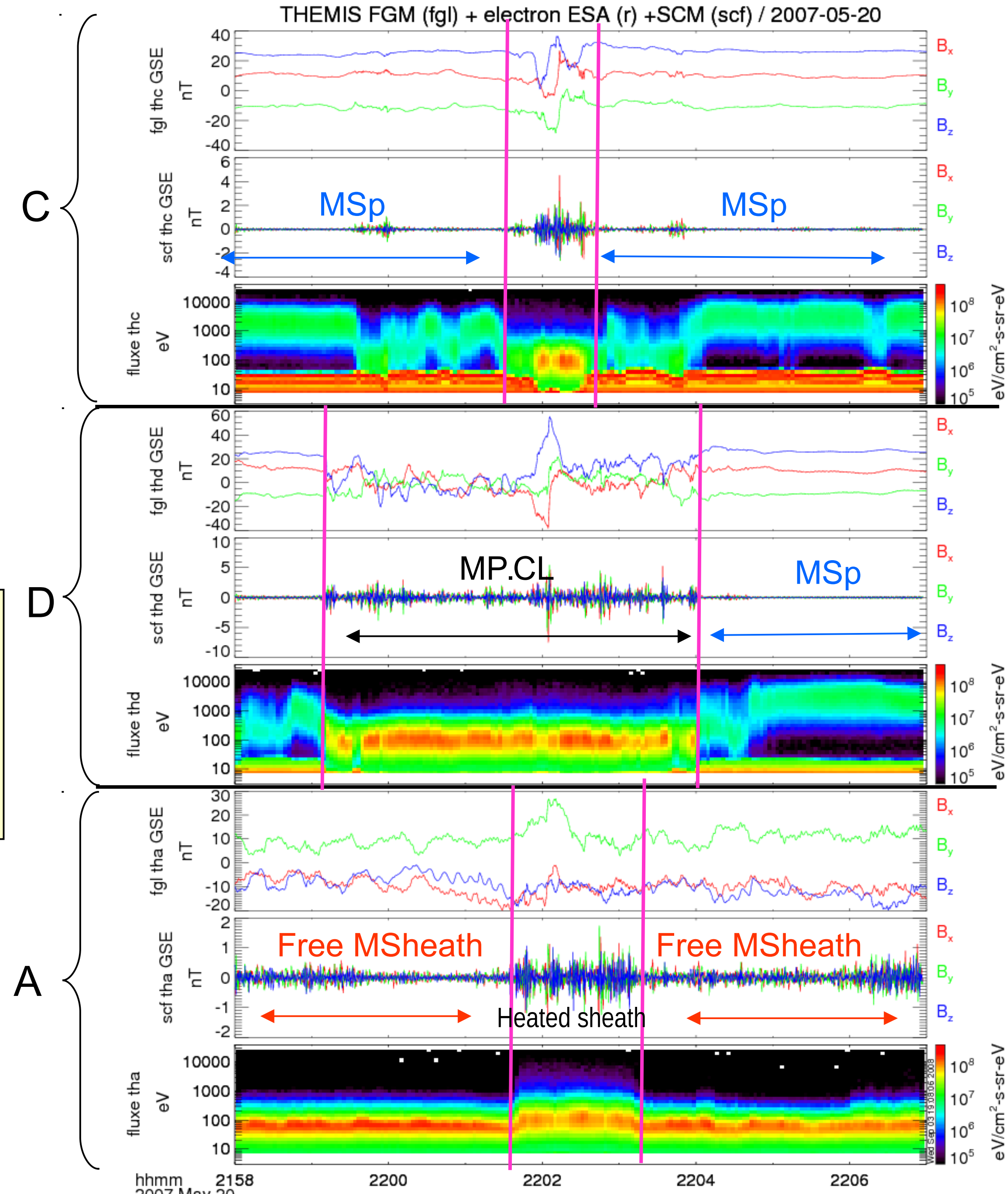
the electrons are apparently heated/accelerated well above magnetosheath values (A).

Te increases from the Sheath to the MP.CL & FTE

- Magnetosheath electrons are heated in MPCL & FTE and adjacent M.Sheath
- e^- heating coincides with enhanced magnetic components of ULF waves.

Question:

Do waves heat electrons ?



Characterization of the waves :

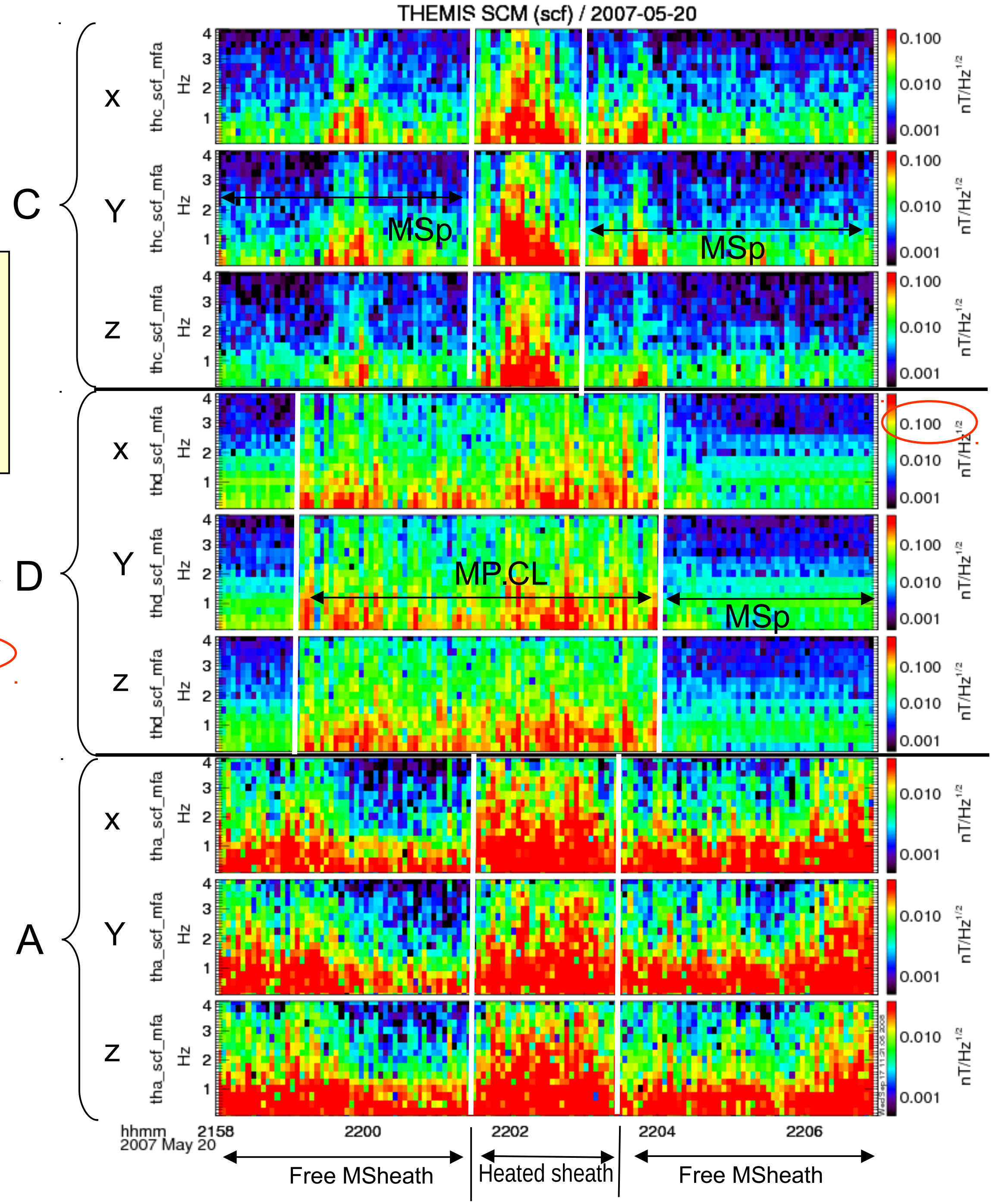
1) SCM

Observation:

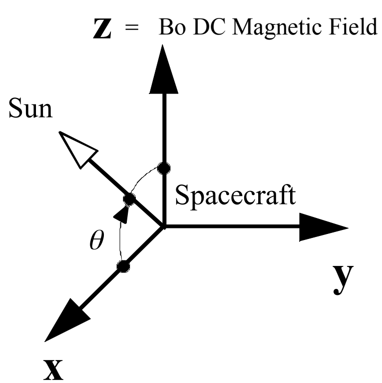
Waves are enhanced inside MPCL & FTE, but no clear polarization, even in MFA frame

Large Doppler shift expected

Largest intensities



MFA system:



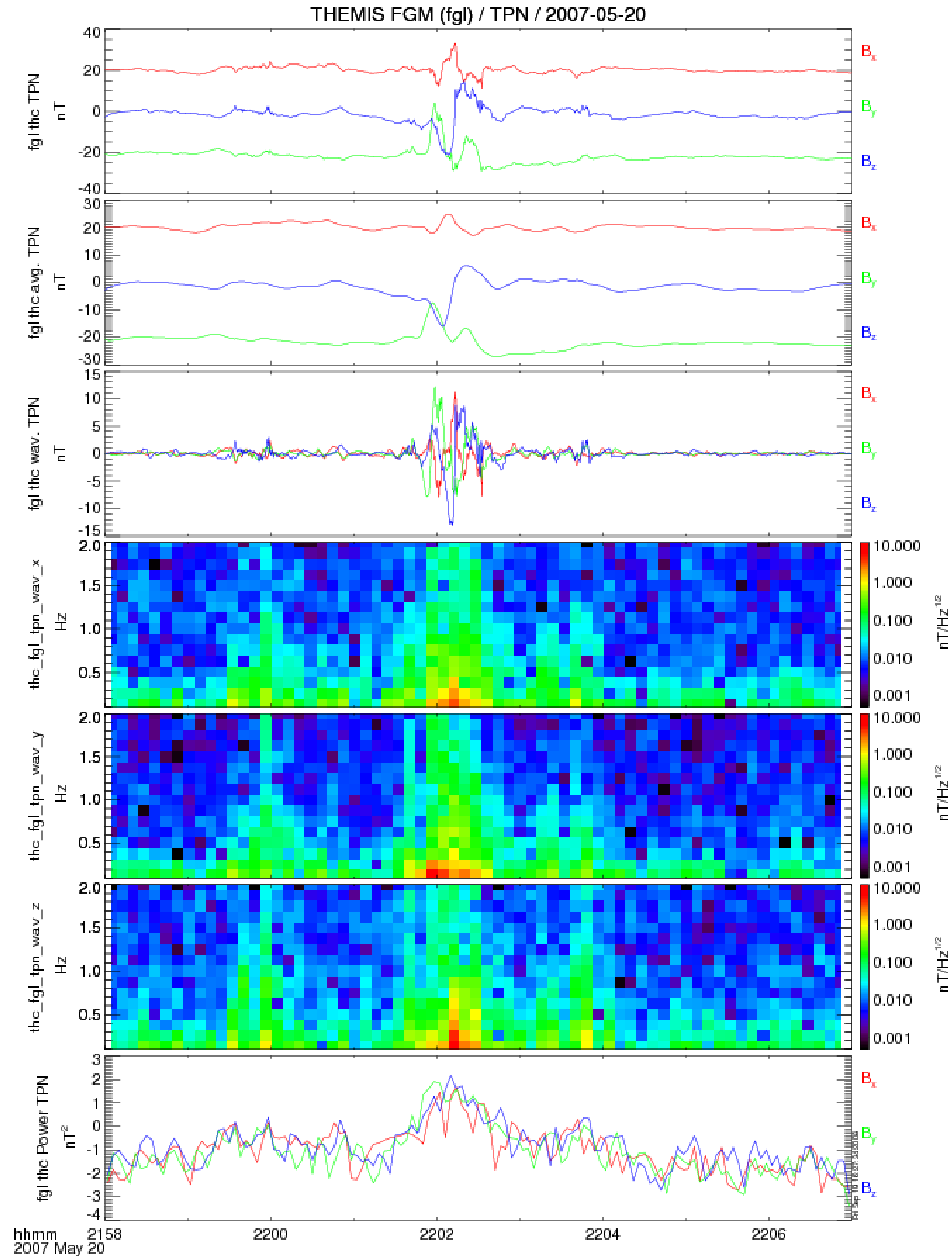
2) FGM

Check with FGM rather than SCM
(low frequencies ~ 1Hz)

FGM data in TPN

Smooth data ~ filtering < 0.1 Hz

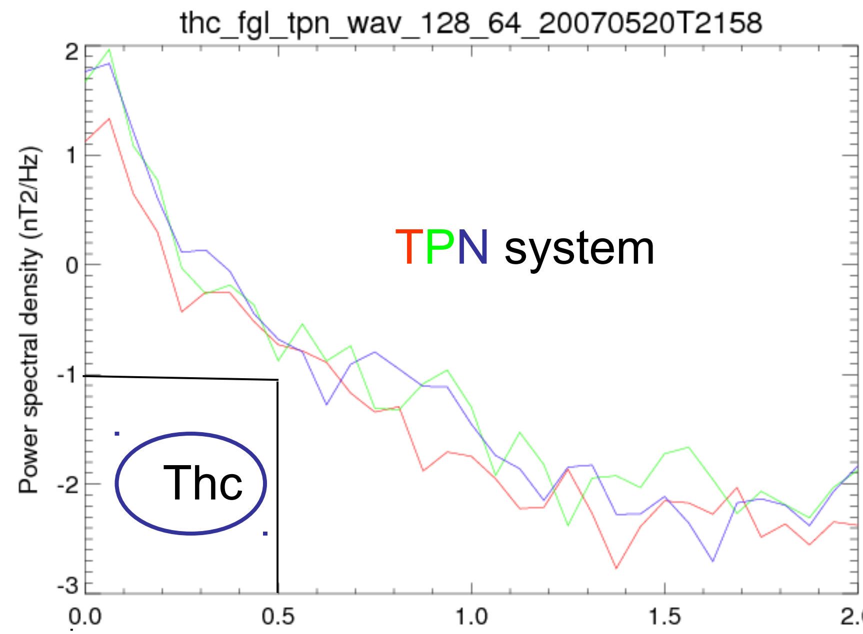
➨ subtract trend to obtain only the wave components

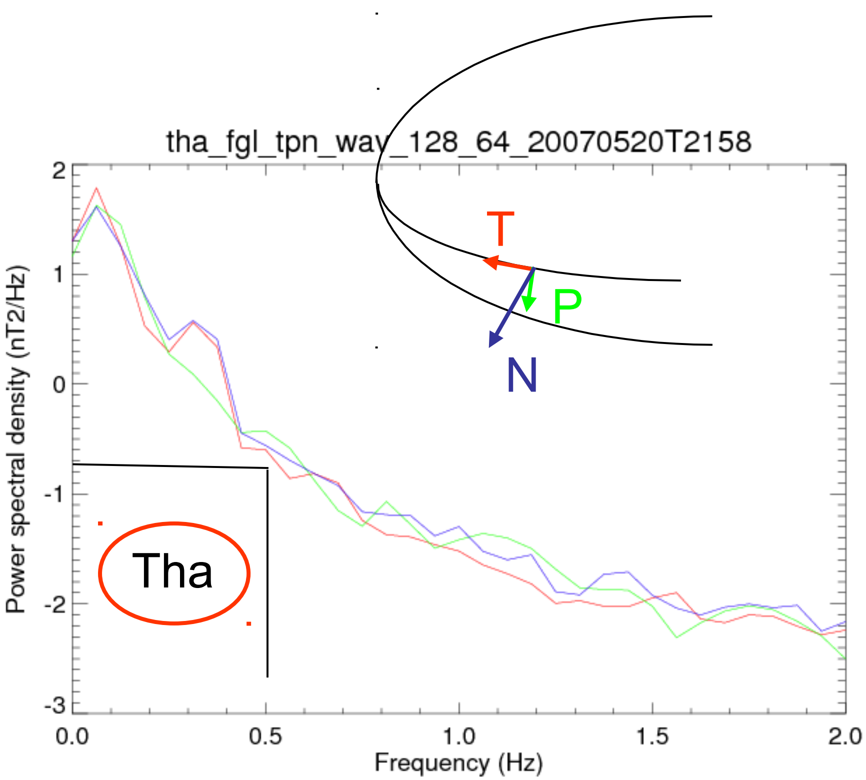


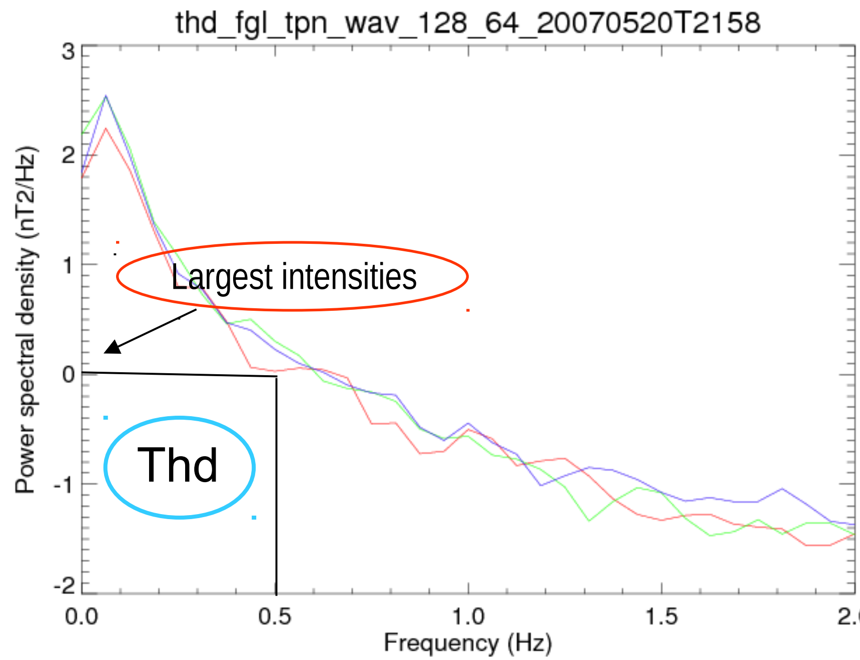
Relative spectrum intensities between S/C :

- **Thd** has the largest intensities
  (10 time more than Thc & Tha)

- Polarization a little bit more clear :
  T component (of TPN) seems to be the lowest
  So we expect an azimuthally propagation







Theorie:

What is the free energy source of the waves ?

- No thermal anisotropy of ions ;
- Shear Alfven waves do not interact with electrons $(\omega / k_{//} \approx V_A << V_e)$

$$\begin{cases} V_A \sim 10^5 \text{ m/s} \\ V_e \sim 4 \times 10^6 \text{ m/s (100eV)} \end{cases}$$

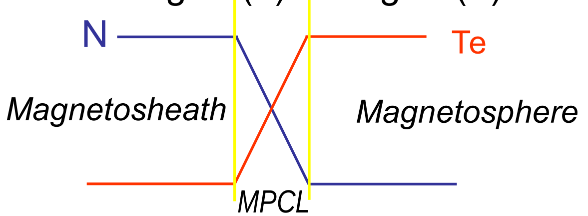
⇨ We suggest that the free energy source is the grad(B) drift of ions, associated with the magnetopause.

In this high β plasma ($\beta \approx 10$), drift waves are coupled to the magnetosonic mode (Hasegawa 1971).

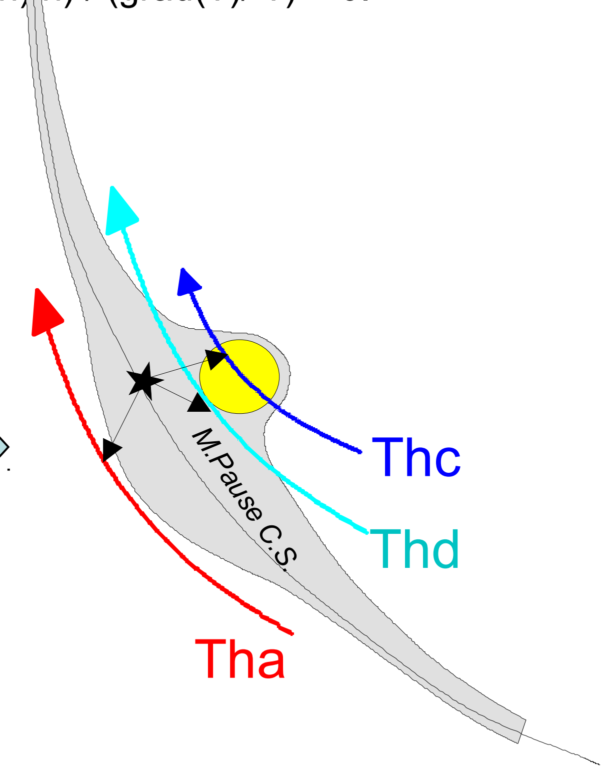
For a drift magnetosonic mode, $k_{//} << k_{\perp}$, then $\omega / k_{//}$ can be $\approx$ Ve.

Drift waves are easily destabilized (Mikhailovski, 1992), for η = (grad(n)/n) / (grad(T)/ T) < 0.

In the MPCL grad(n) and grad(T) have indeed opposite sign.



As waves are generated by gradients (B, N, T) in the current layer,
It is normal that Thd observe a maximum in wave intensity
As the waves propagate inward/outward, passing by Thc/Tha, it is also normal that their amplitudes decrease.



CONCLUSION

Observations suggest that electromagnetic waves interact with electrons, inside the MPCL and adjacent regions.

Spectra are difficult to interpret because they are probably affected by a large Doppler shift (but we observe a rather azimuthally propagation, which is consistent with drift waves).

We suggest that the observed waves are drift magnetosonic waves, destabilized by ions drifting in the magnetic field gradient of the magnetopause.

In this high β plasma, drift magnetosonic waves have large $\omega / k_{//}$ (~ V_e), then they can strongly interact with electrons, which can be heated via inverse Landau damping.