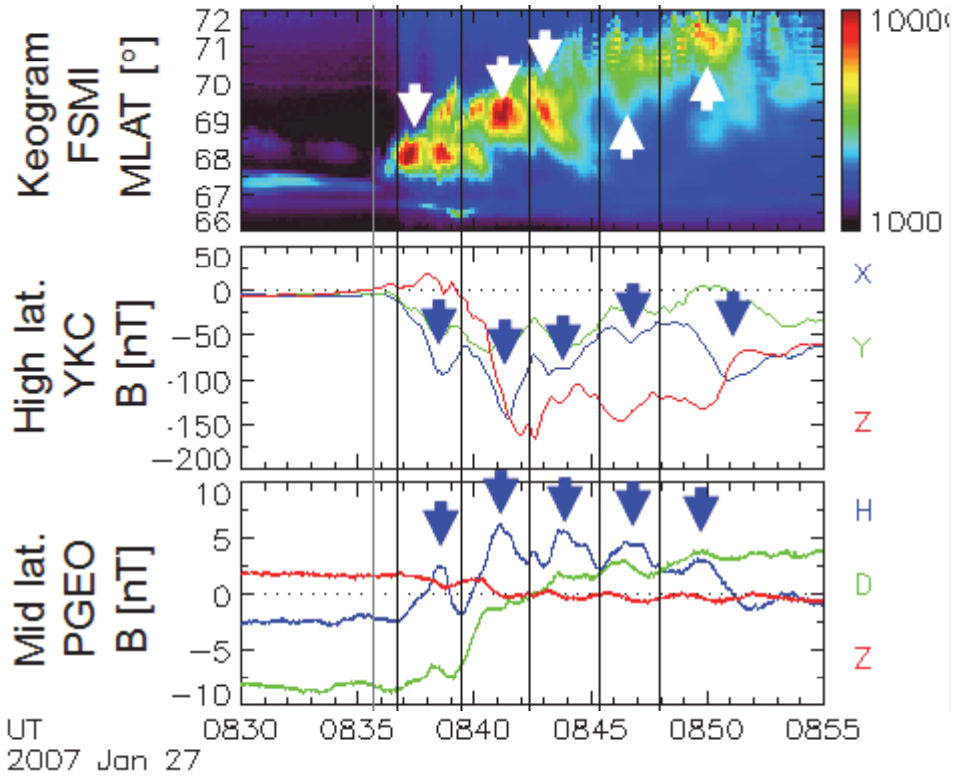
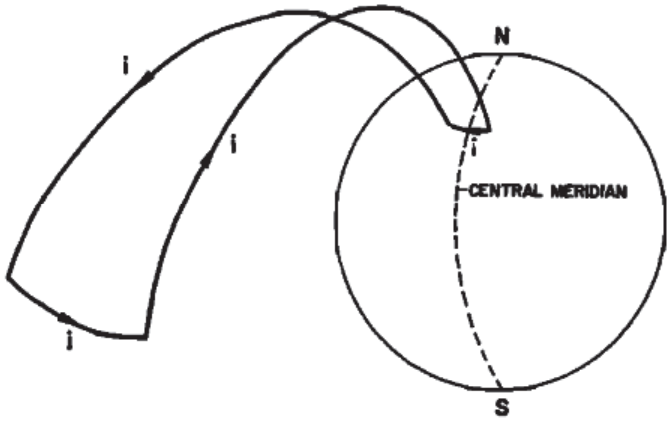
Auroral signature of ground Pi 2 pulsation

Toshi Nishimura (UCLA), Larry Lyons, Takashi Kikuchi, Eric Donovan, Vassilis Angelopoulos, Peter Chi and Tsutomu Nagatsuma

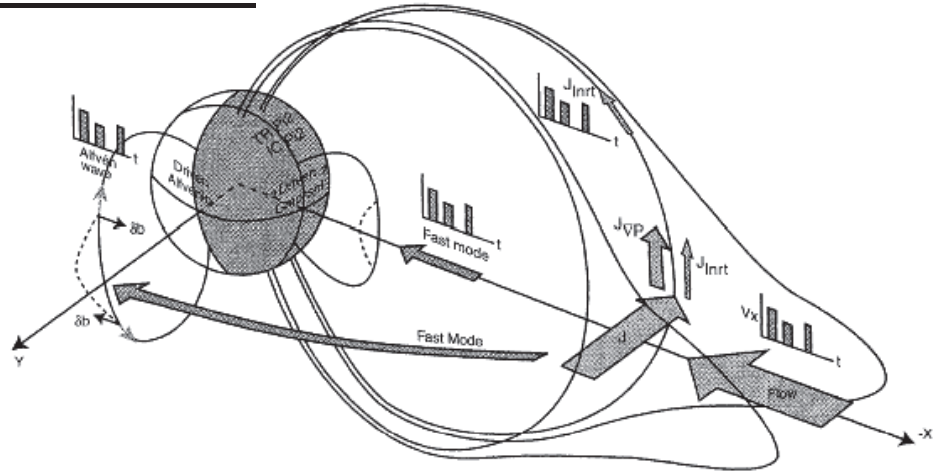


Long-standing discussion on Pi 2 pulsation

Driver in the plasma sheet

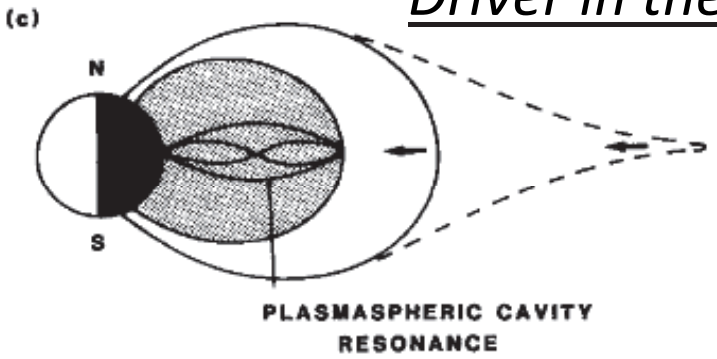


Current wedge oscillation [Samson and Rostoker, 1983: Lester et al., 1989]

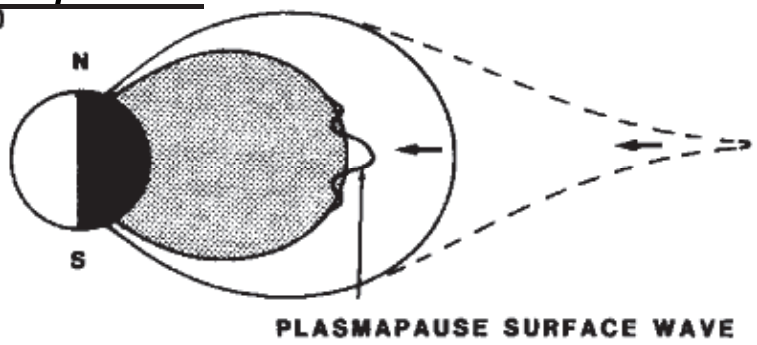


Directly driven by BBF
[Kepko et al., 2001; Frissell et al., 2011]

Driver in the plasmasphere

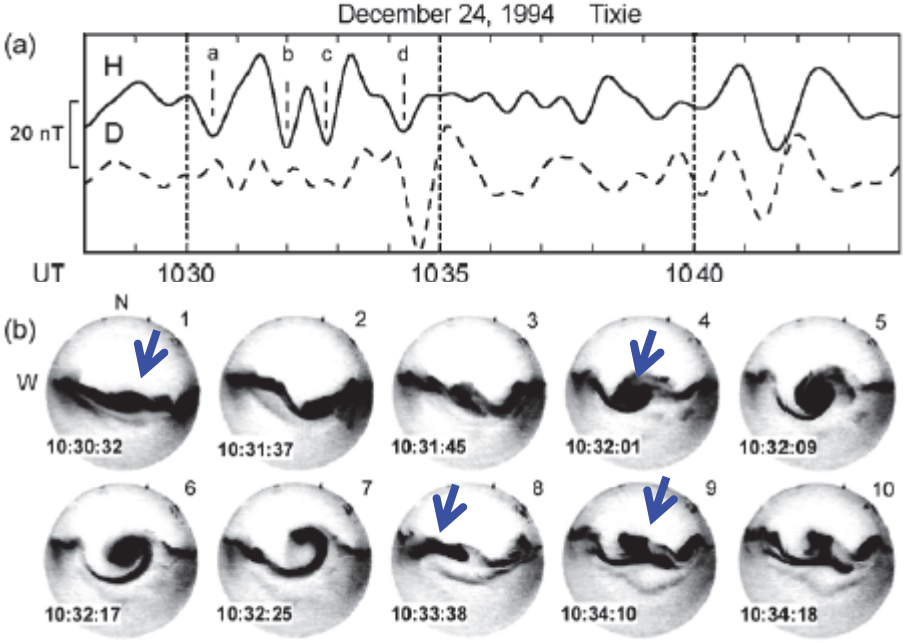


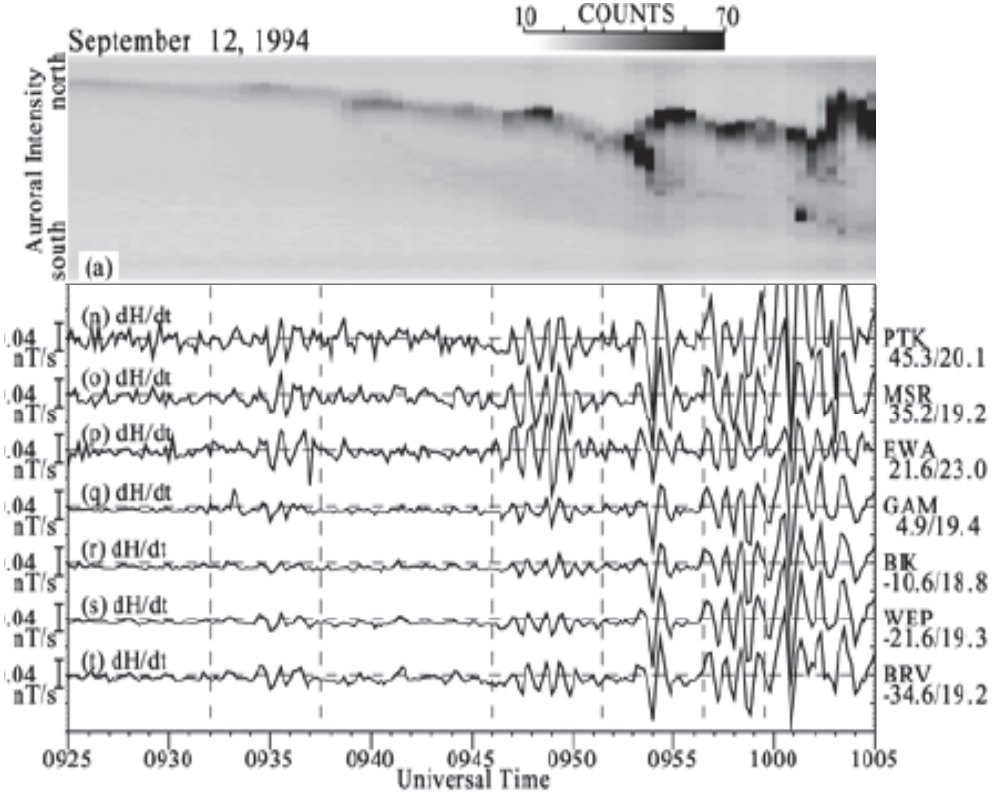
Cavity mode resonance
[Yeoman and Orr, 1989; Takahashi et al., 2003]



Plasmapause surface wave
[Lester and Orr, 1983]

Difficult to determine the source location → Aurora can highlight it.





Periodic vortex propagation correlates with Pi 2 [Solovyev et al., 2000].

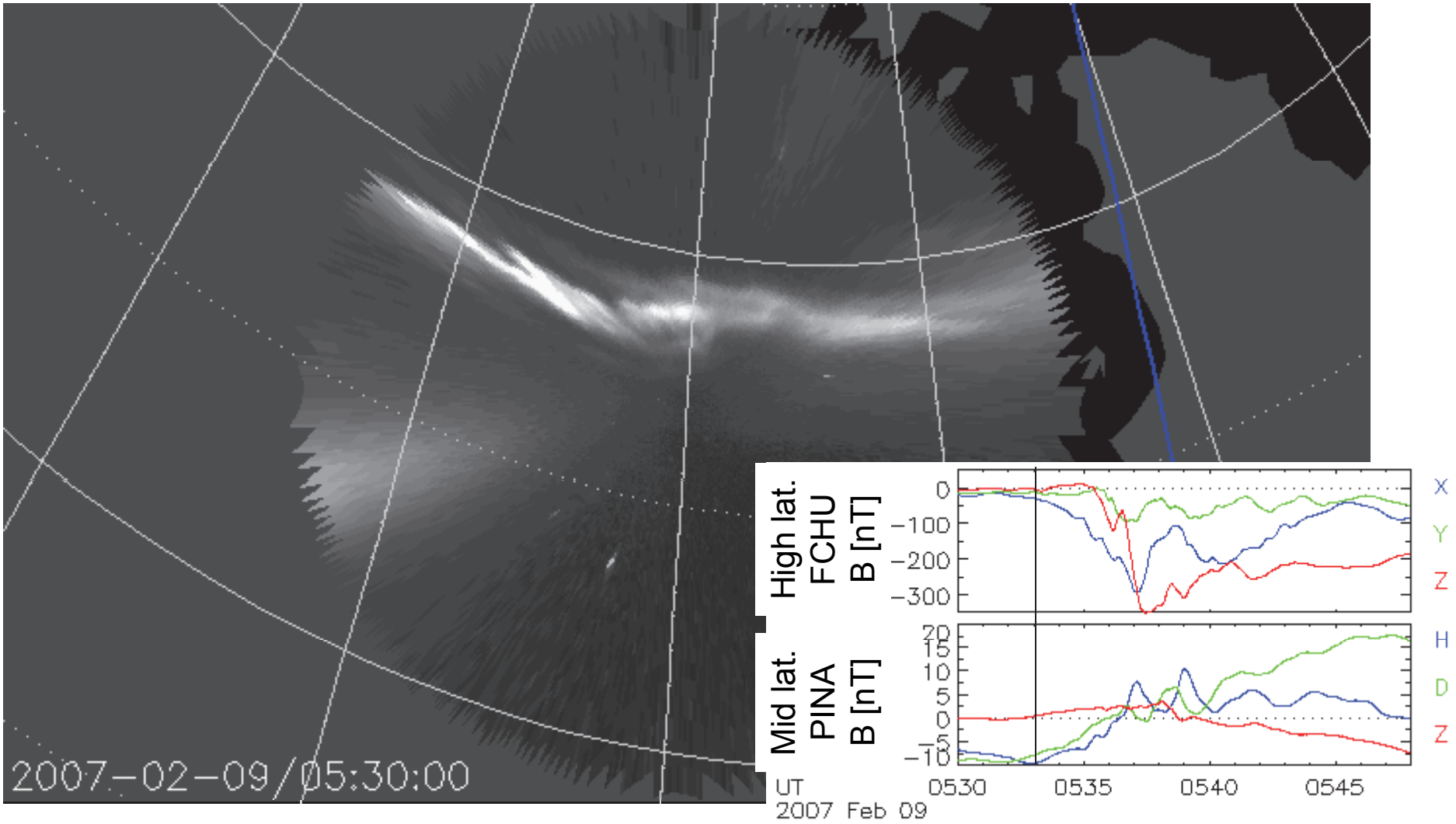
Auroral luminosity variations do not show oscillations in the Pi 2 frequency range [Shiokawa et al., 2002].

Different results. Due to limited coverage?

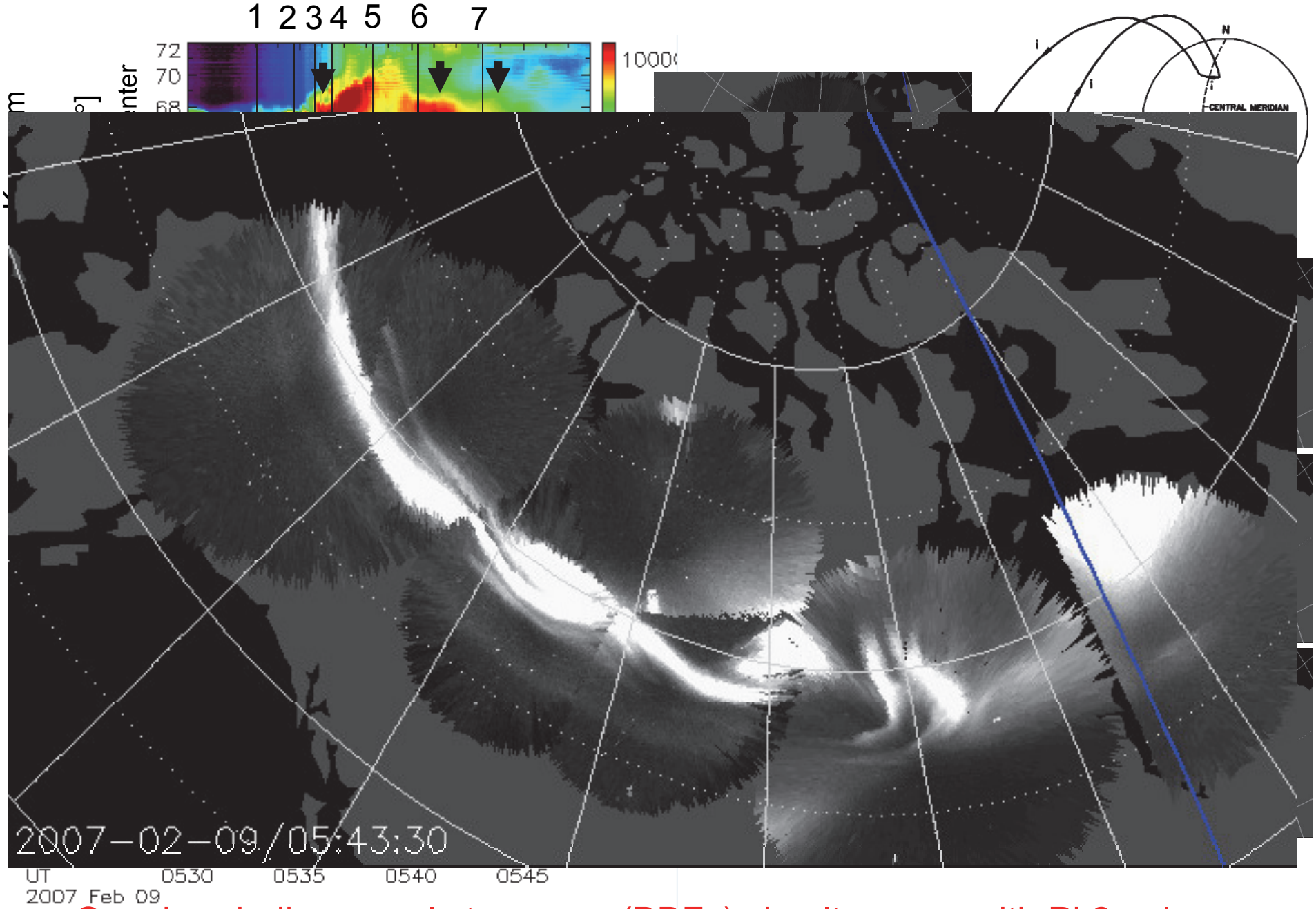
The present study takes advantage of the wide coverage of the THEMIS ASIs and ground magnetometer network, for determining if auroral signature of Pi 2 exists.

Auroral sequence

9 Feb 2007 substorm

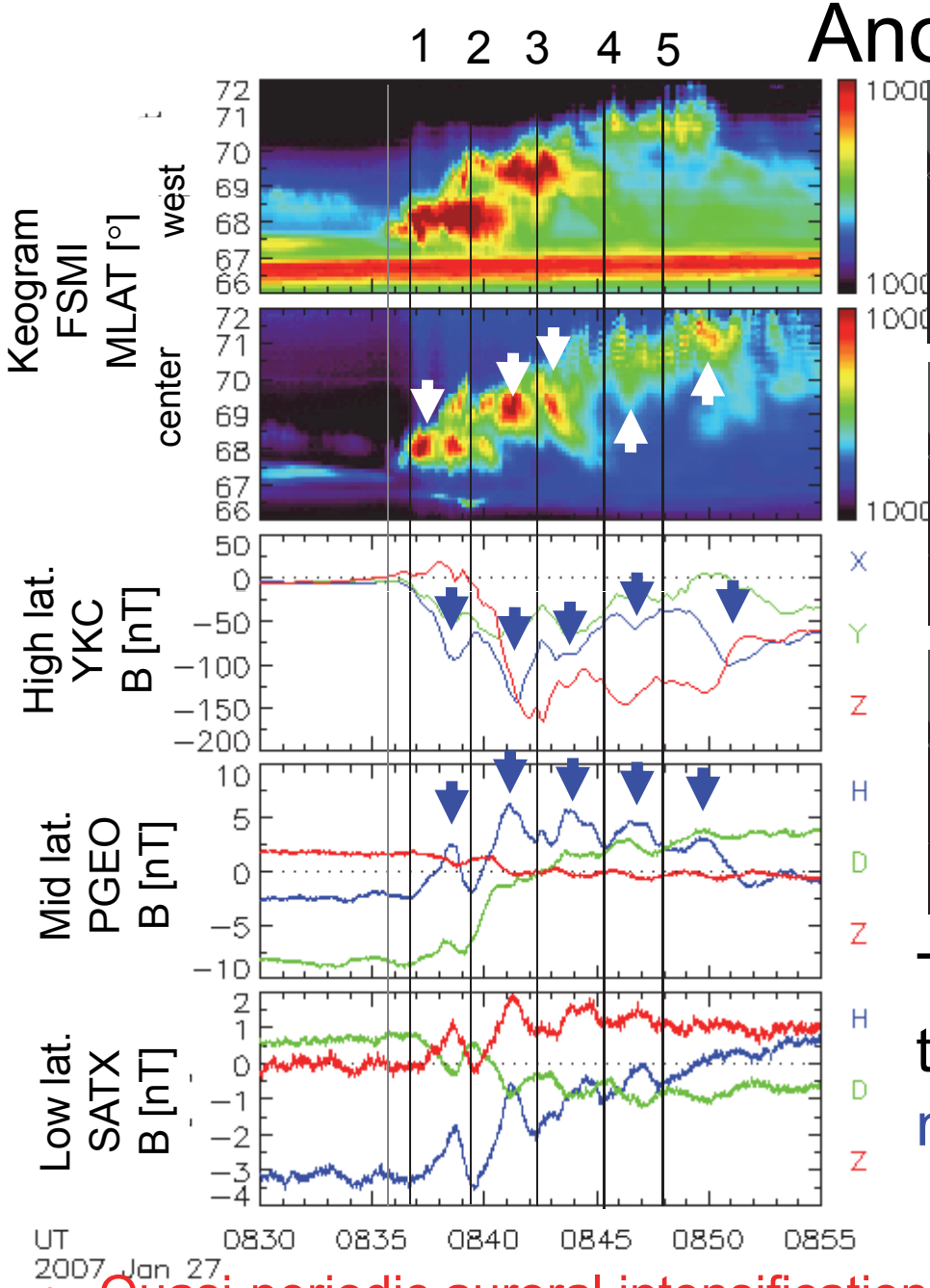


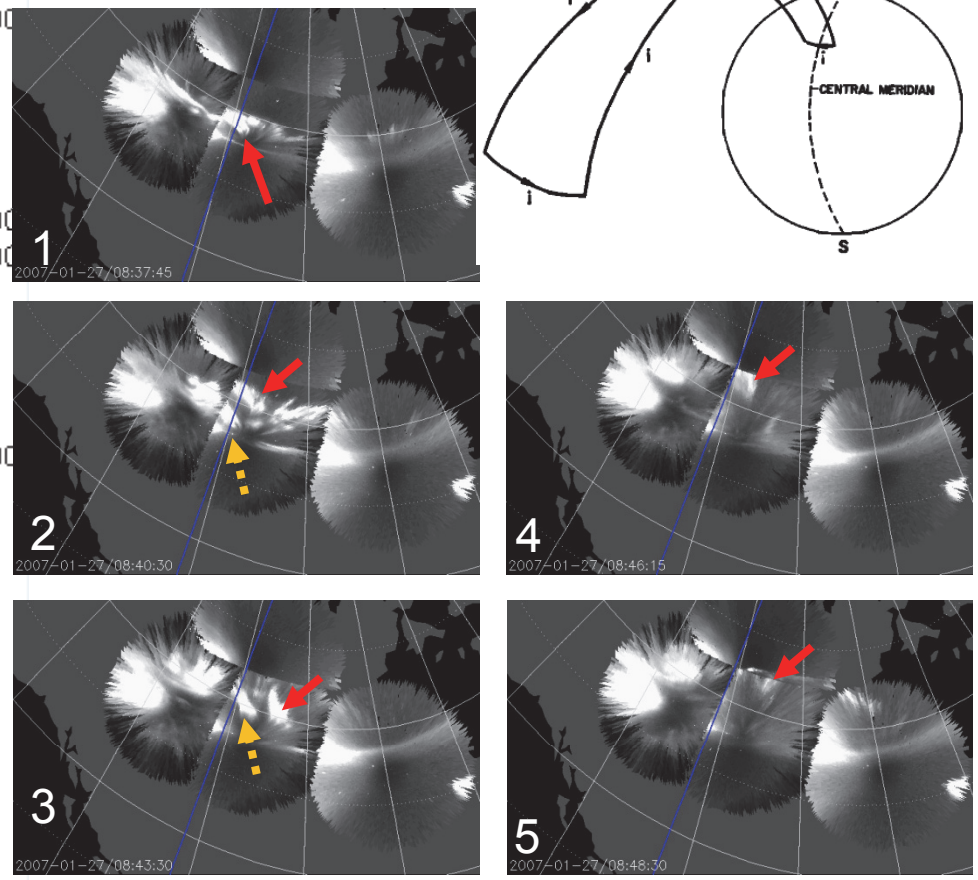
Quasi-periodic auroral intensifications (streamers) with a ~1-2 min recurrence period



- Quasi-periodic auroral streamers (BBFs) simultaneous with Pi 2 pulses
- Anti-correlating Pi 2 and negative bay oscillation

Another event

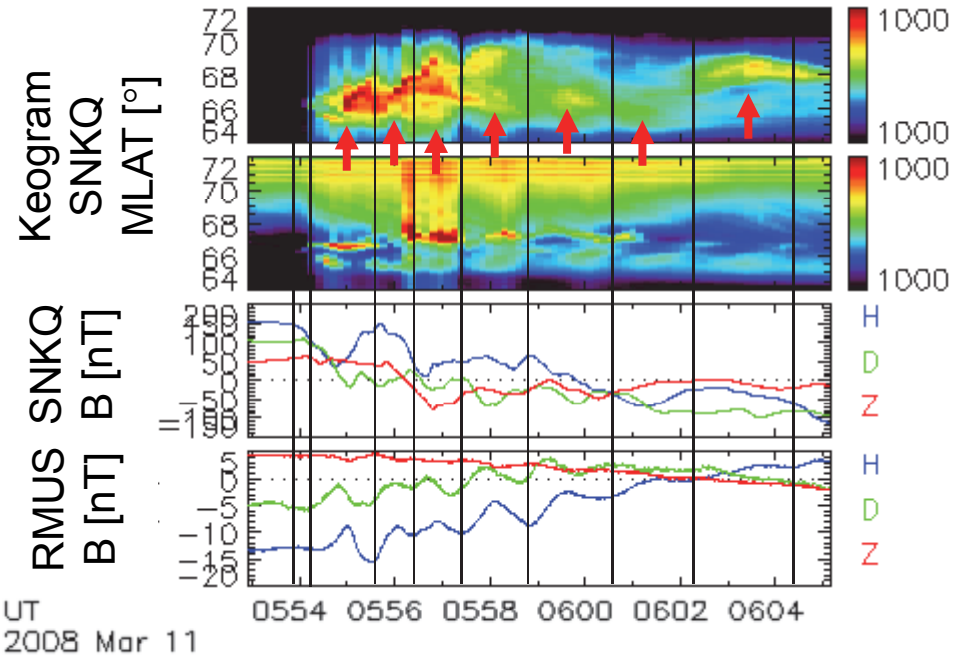


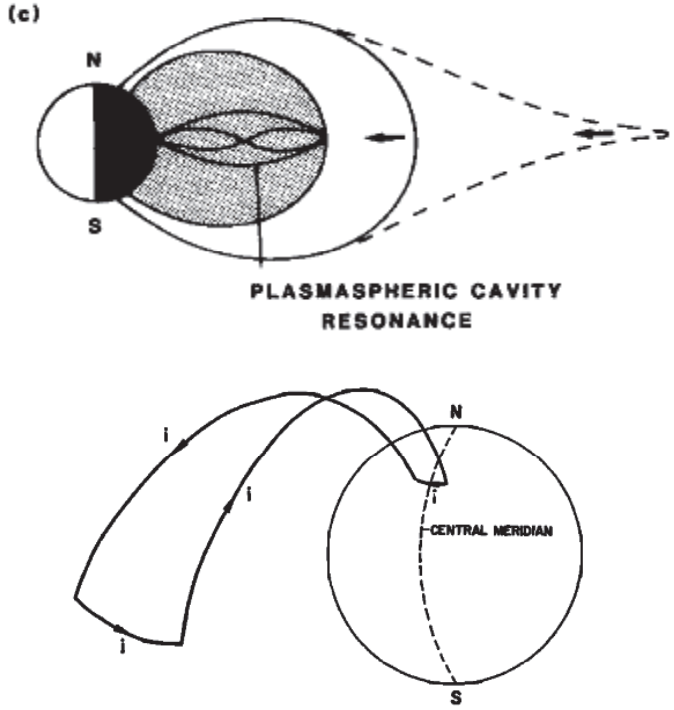


The streamers are seen in only the limited MLTs. Could be missed if the coverage is limited.

- Quasi-periodic auroral intensifications (streamers) simultaneous with Pi 2
- Anti-correlating positive and negative bays

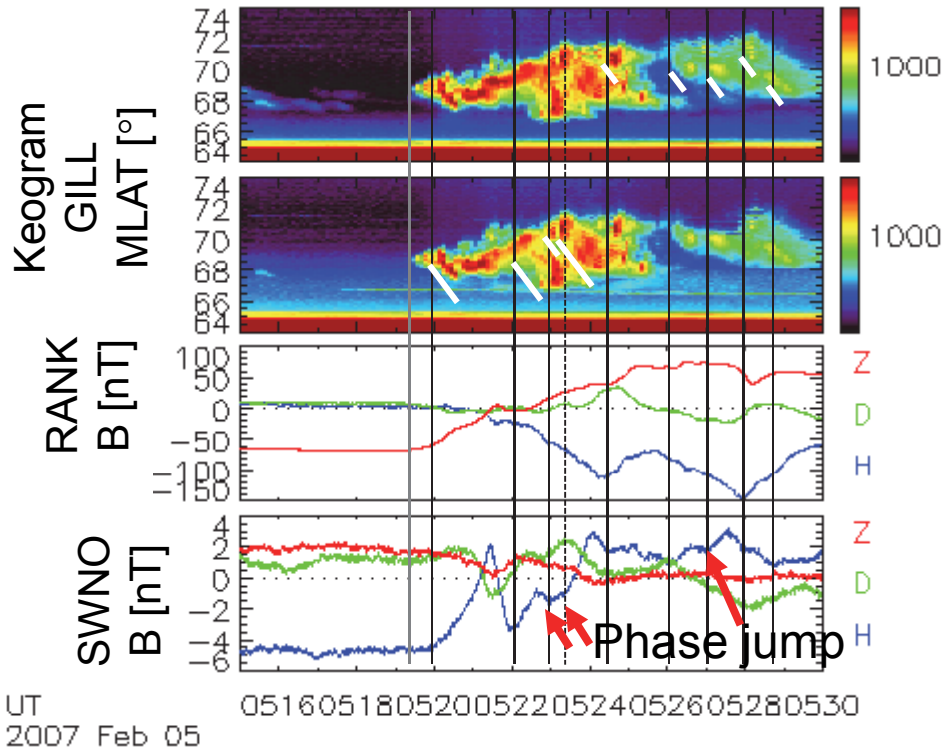
Period and phase changes in Pi 2

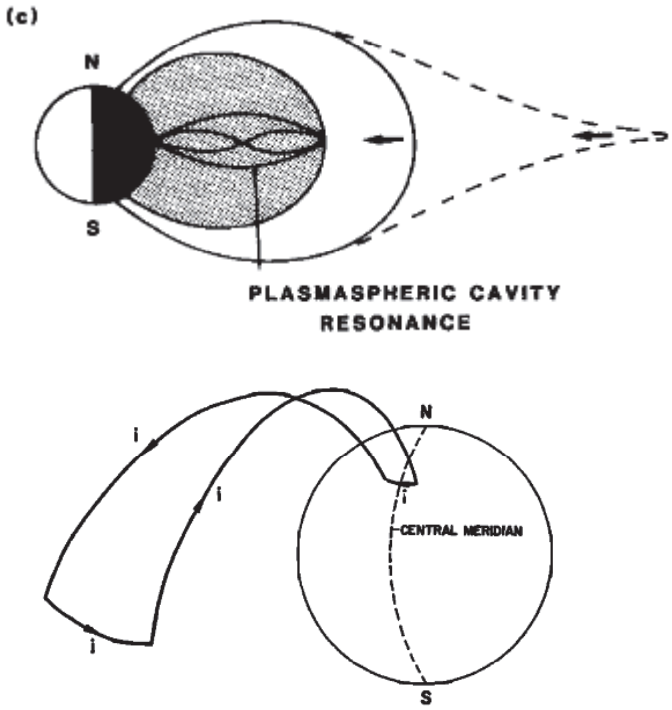




If the cavity mode is assumed, the Pi 2 period does not change or decrease in time because the plasmasphere shrinks due to particle injection and enhanced convection.

This event shows the Pi 2 period increasing in time. The plasmasphere is not expected to inflate twice as much in ~10 min.



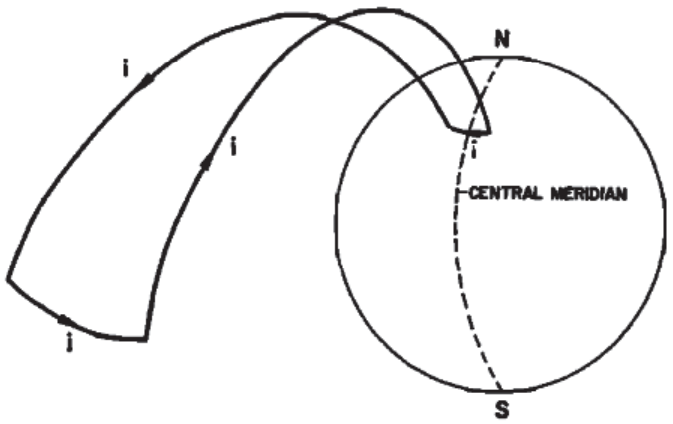


If the cavity mode is assumed, the magnetic field shows a coherent oscillation.

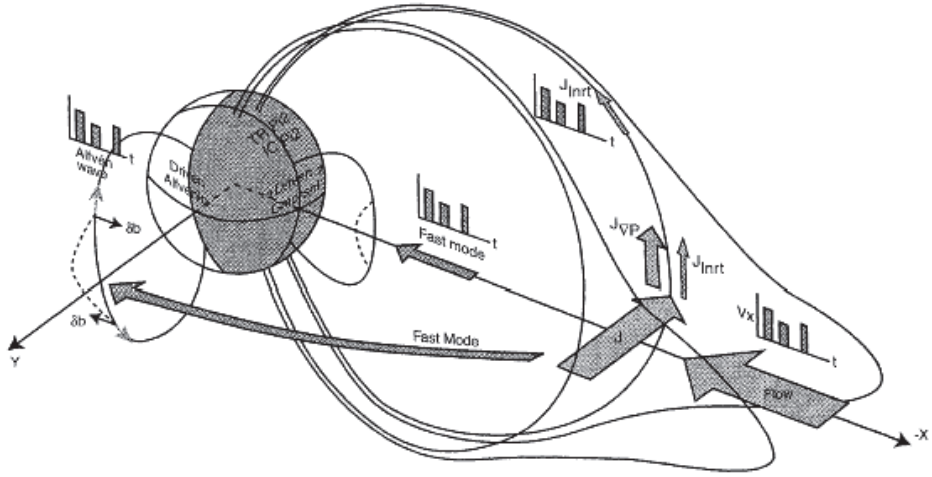
The phase of Pi 2 tends to change abruptly, suggesting non-resonant driver.

Auroral streamers correlate with such Pi2 phase changes.
→ Driven by reconnection

Summary



Current wedge oscillation [Samson and Rostoker, 1983: Lester et al., 1989]

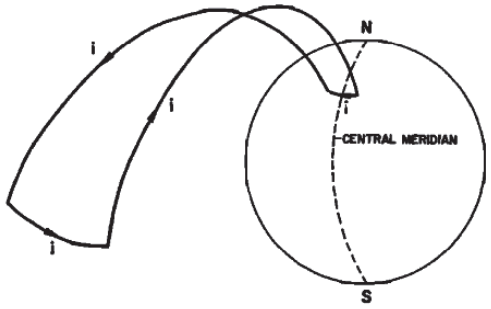


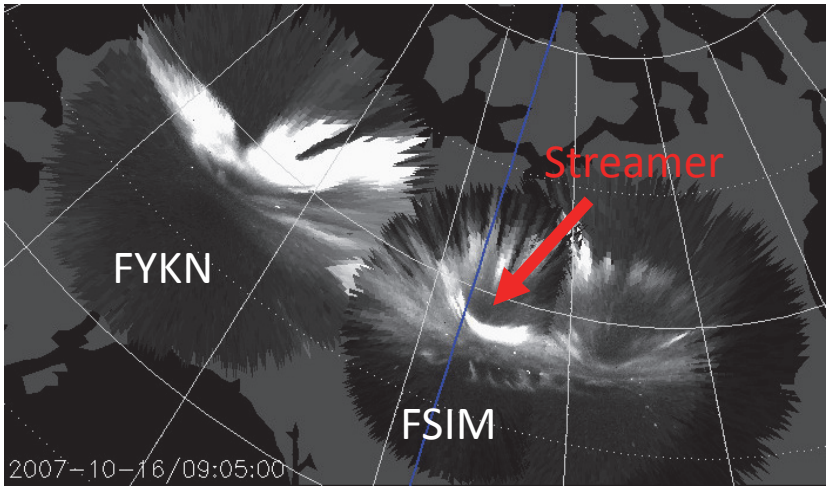
Directly driven by BBF [Kepko et al., 2001; Frissell et al., 2011]

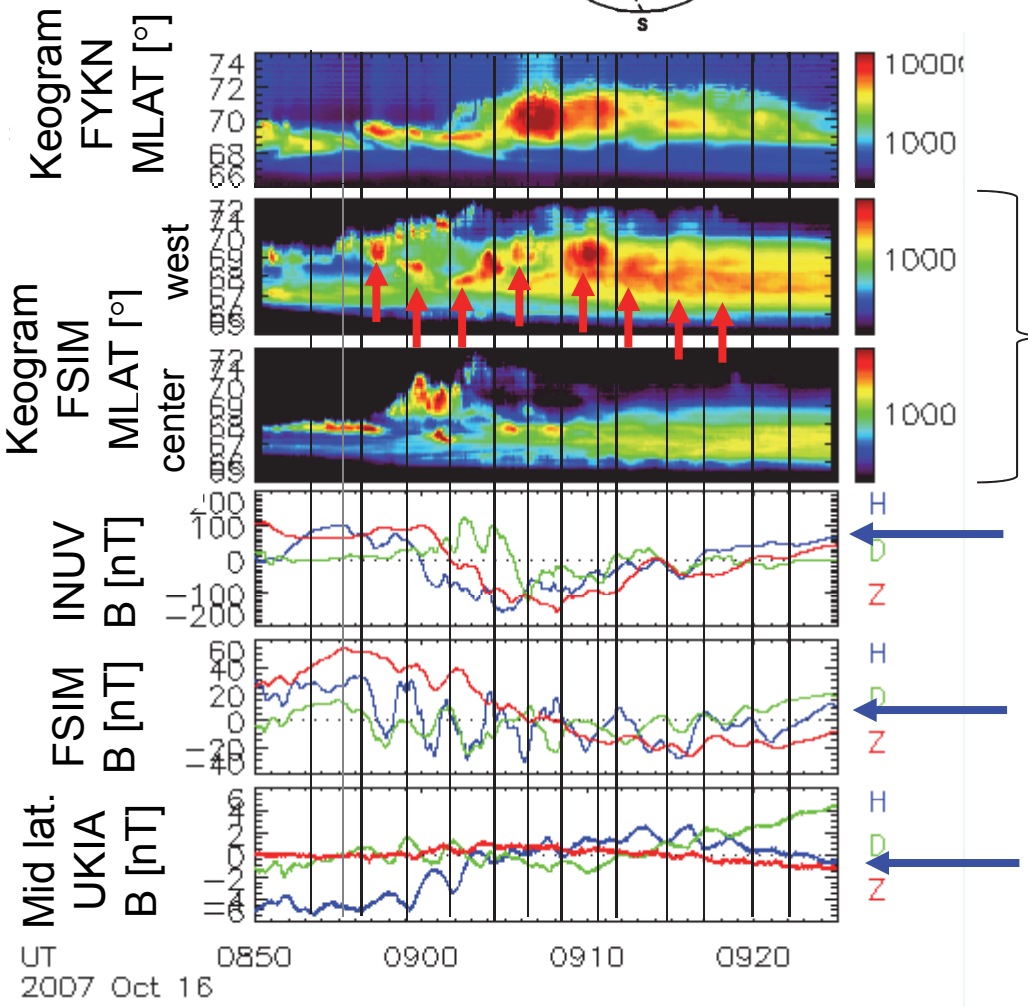
- Auroral signature of ground Pi 2 has been identified.
- Pi2 pulses are correlated with multiple auroral streamers, supporting the models of oscillation of current wedge driven by multiple BBFs in the plasma sheet.
- Plasma sheet activity (e.g., BBF rebounds [Panov et al., 2010] and impulsive activations [Runov et al., 2008]) could be the plasma sheet counterpart.
- Reconnection is likely to drive the Pi 2 current system.

BACKUP

One more example







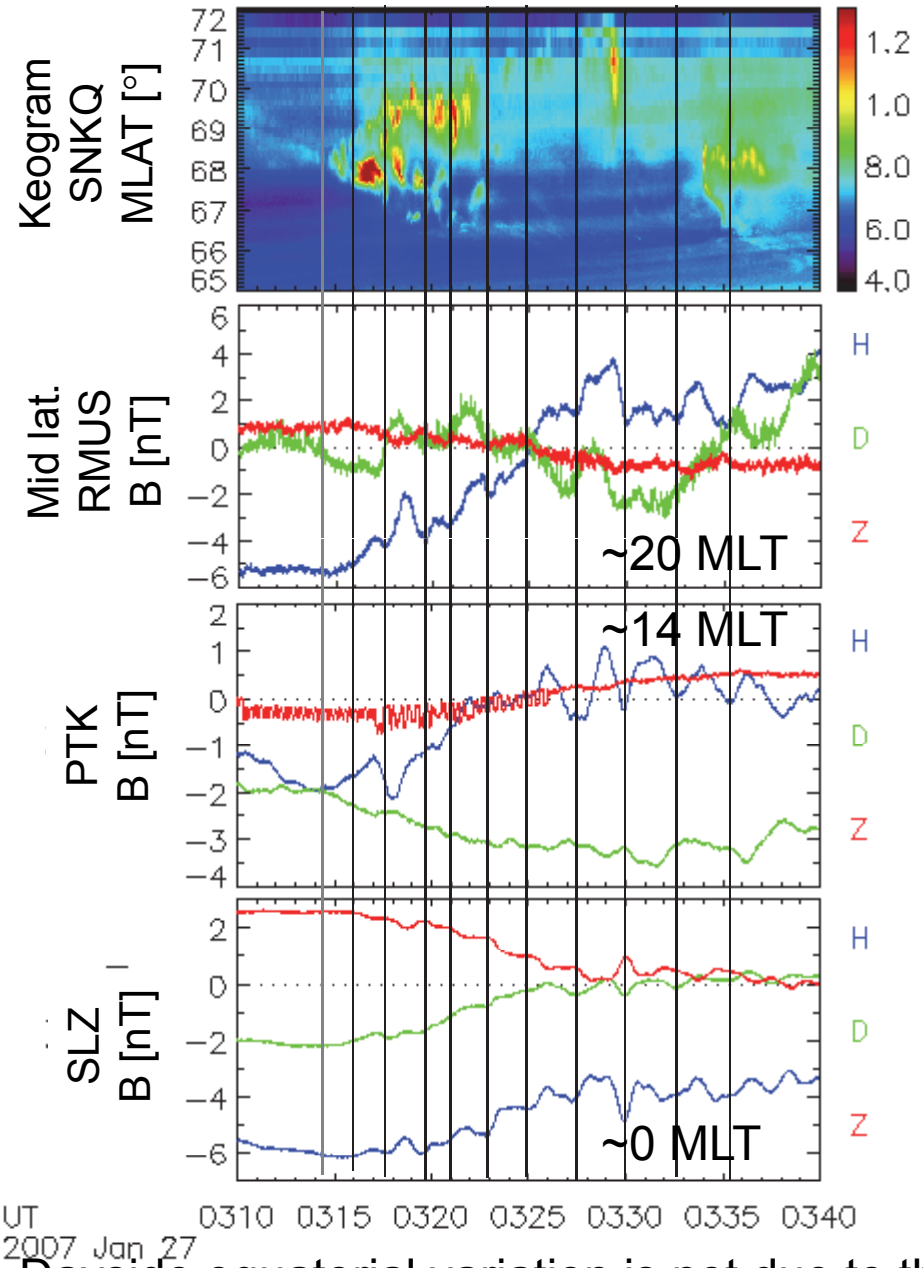
The periodic brightenings are seen in only the streamer meridians.
Could be missed if the coverage is limited.

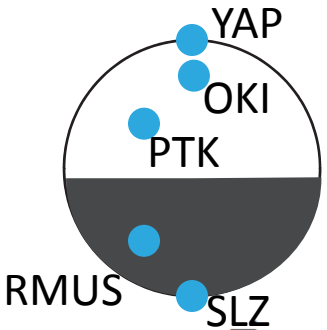
Less clear oscillation

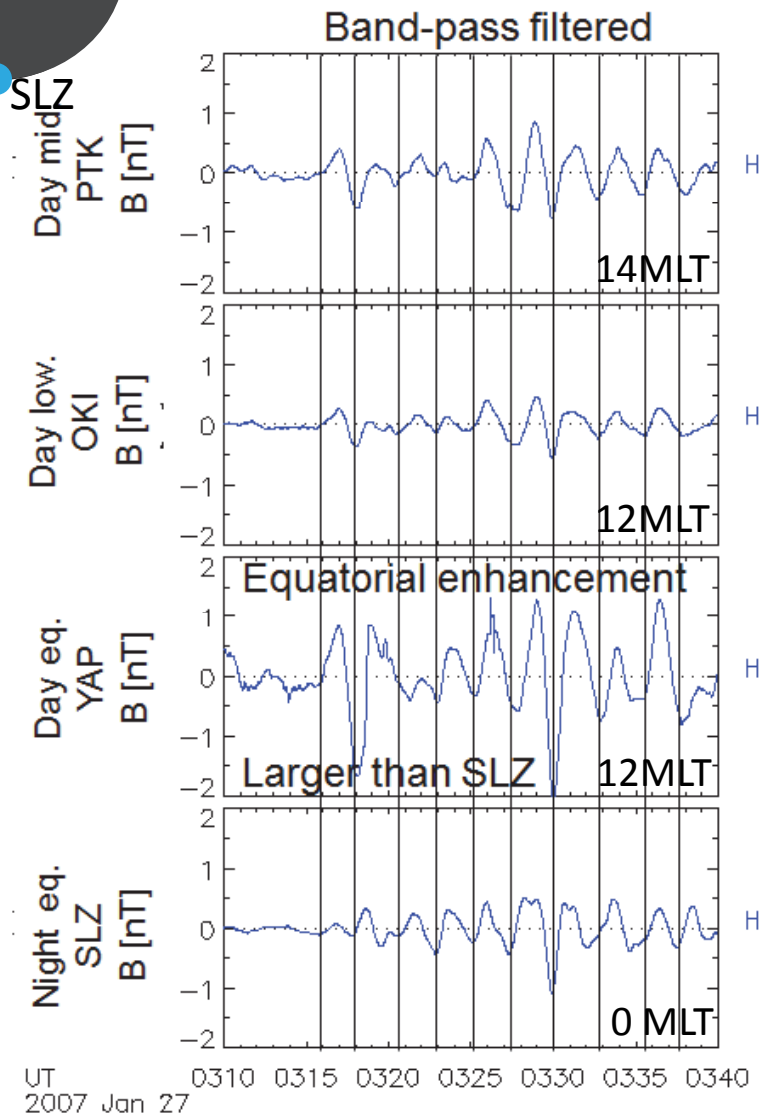
Auroral electrojet oscillation, anti-phase

Midlatitude Pi 2

Comparison to equatorial Pi 2

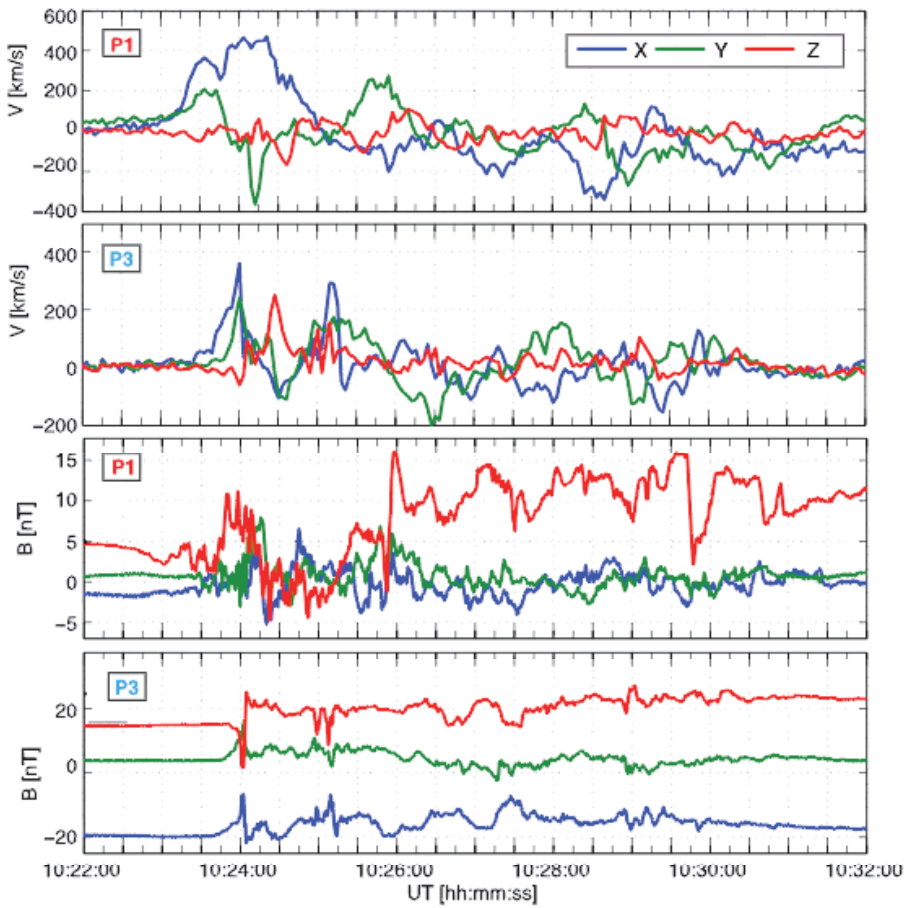




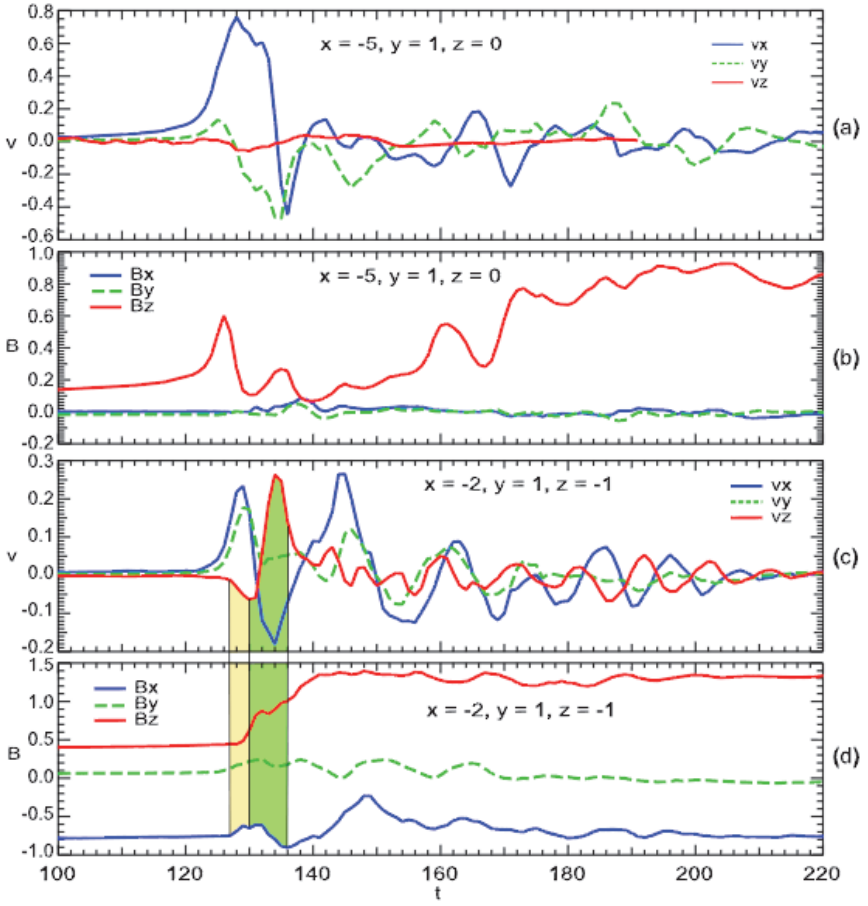


Dayside equatorial variation is not due to the cavity mode or FAC but to the prompt response of global ionospheric electric field.

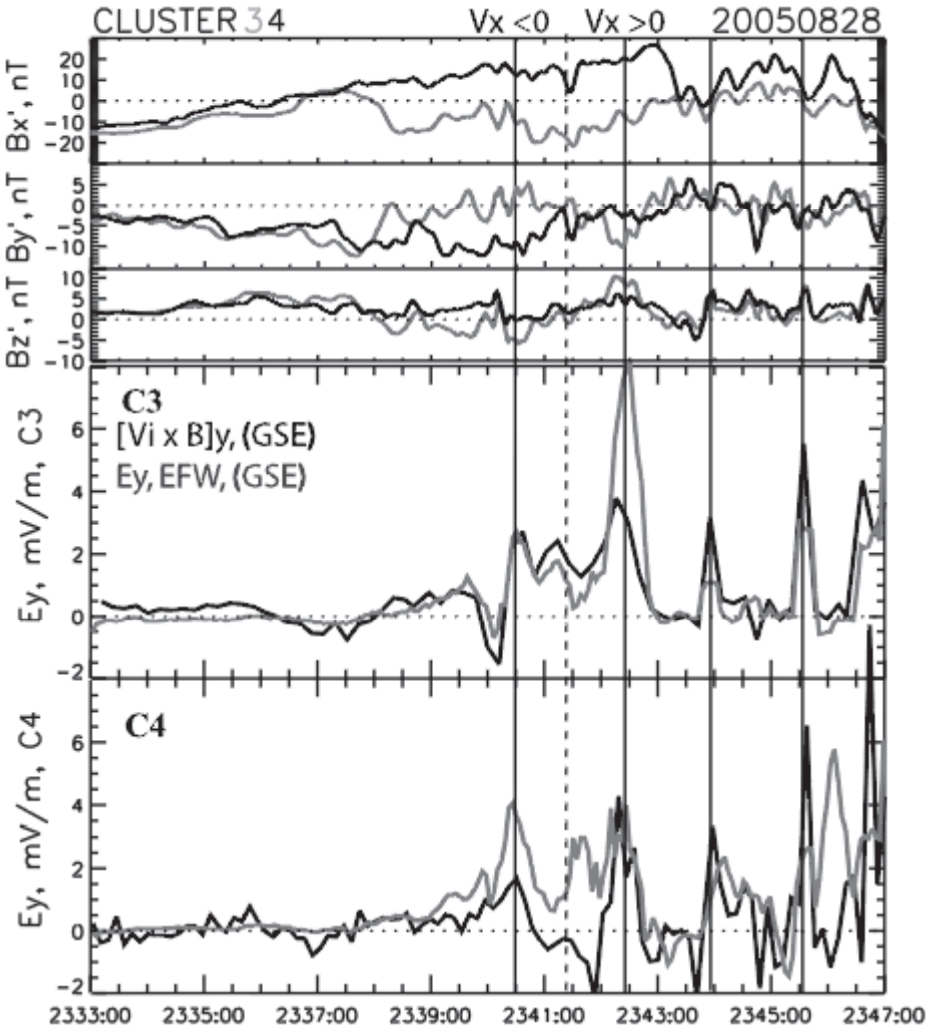
Bouncing BBF



[Panov et al., 2010]

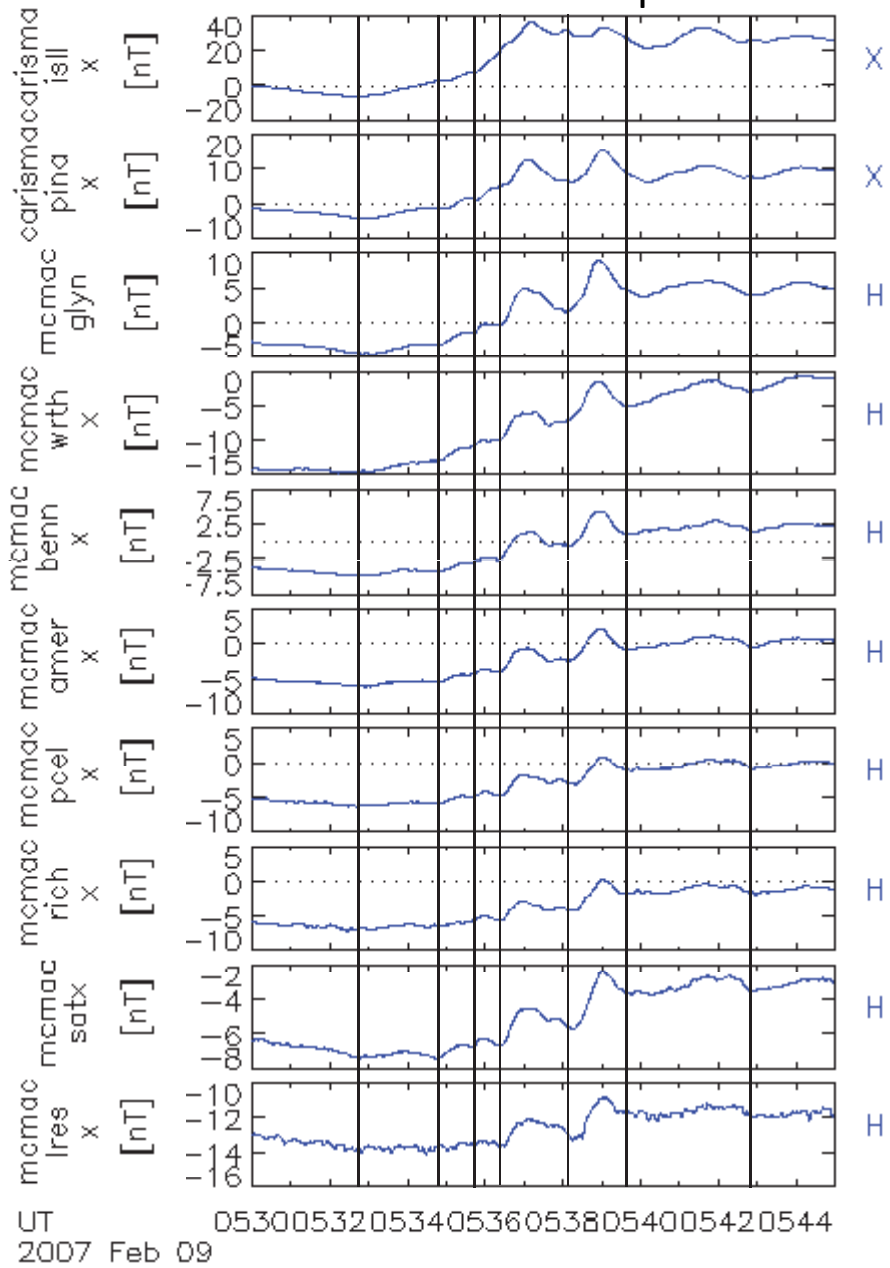


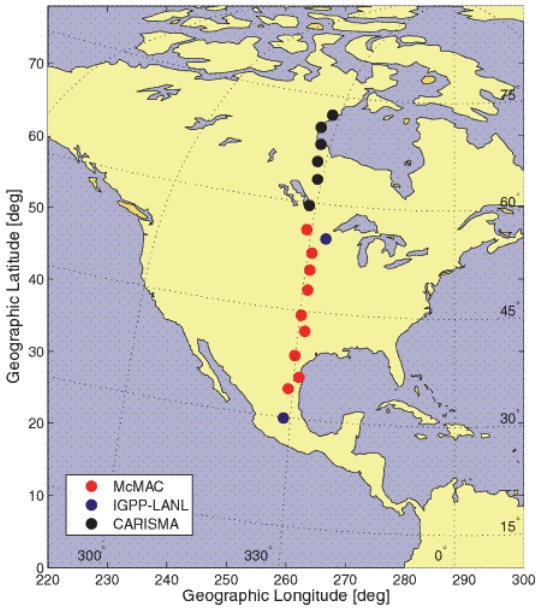
[Birn et al., 2011]



[Runov et al., 2008]

McMAC Latitudinal profile





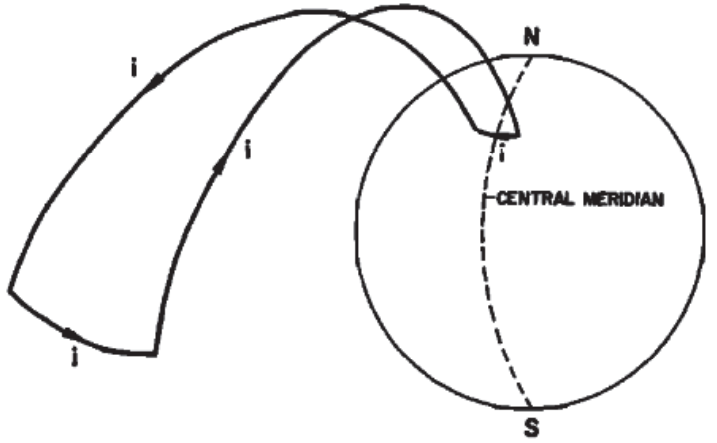
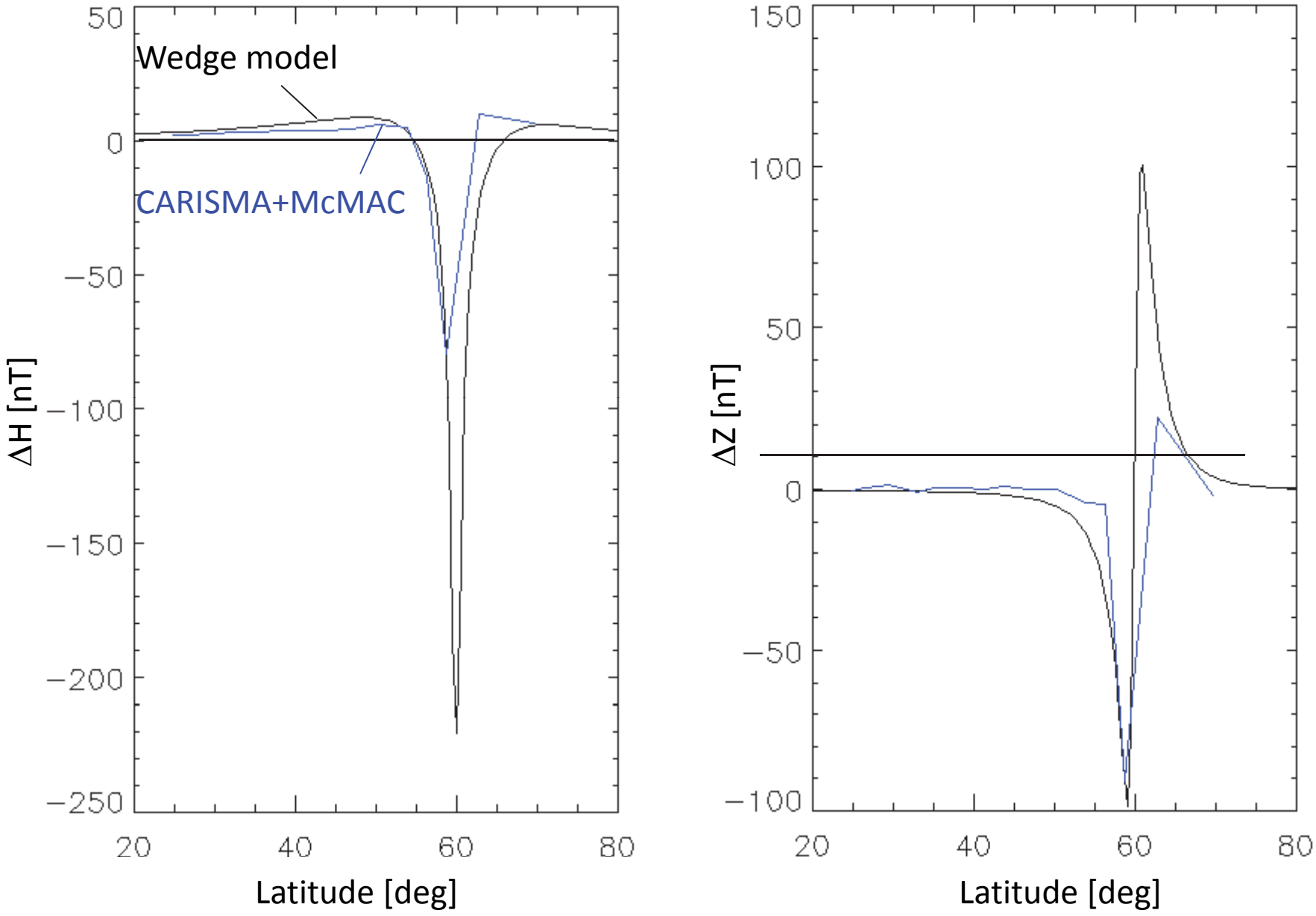


Fig. 1. Three-dimensional model current system proposed by *Bonnevier et al.* [1970].

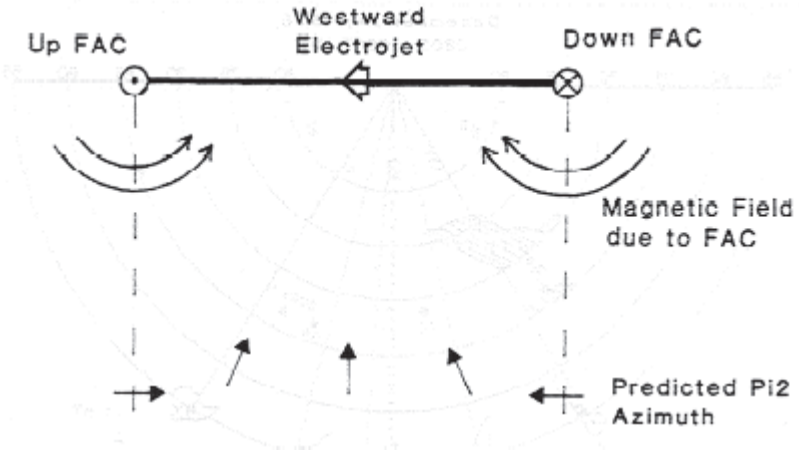
No significant phase lag or frequency change over latitudes.

Inconsistent with fast-mode propagation in the Tamao travel time idea.



The simple wedge current model can explain the latitudinal profile of the magnetic field.

What is the cause of ground Pi 2 pulsation?



Current wedge oscillation [Samson and Rostoker, 1983: Lester et al., 1989]

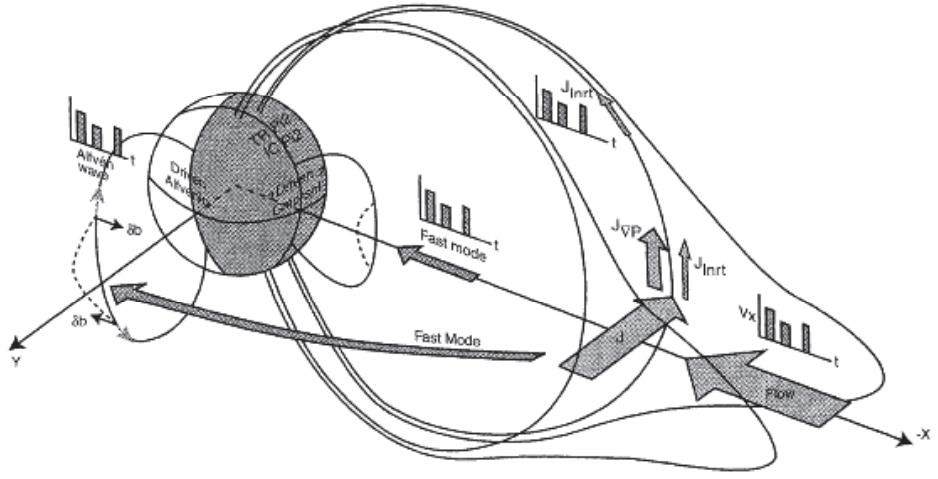
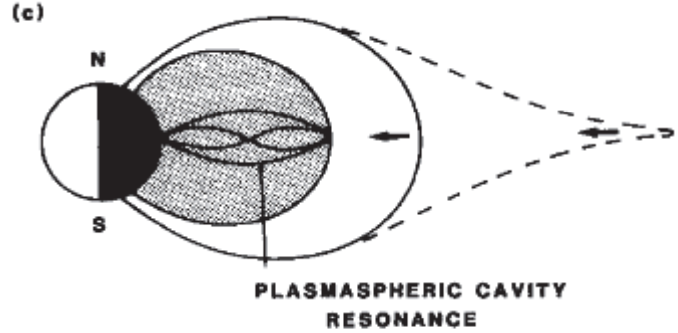
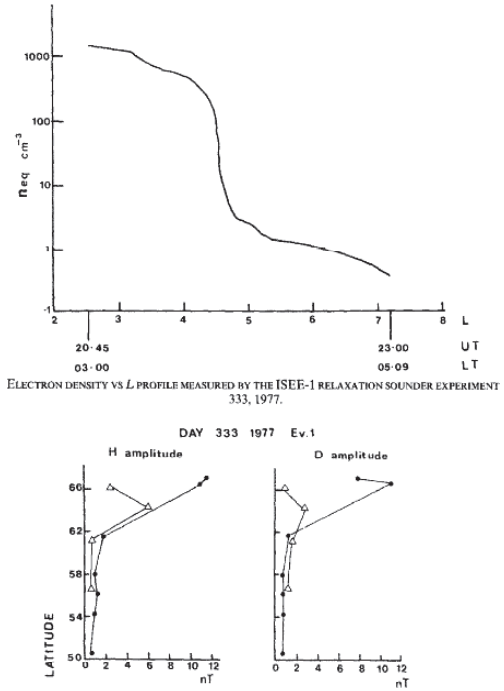


Figure 15. Summary of Pi2 generation (see text for details).

Directly driven by fast mode [Kepko et al., 2001]



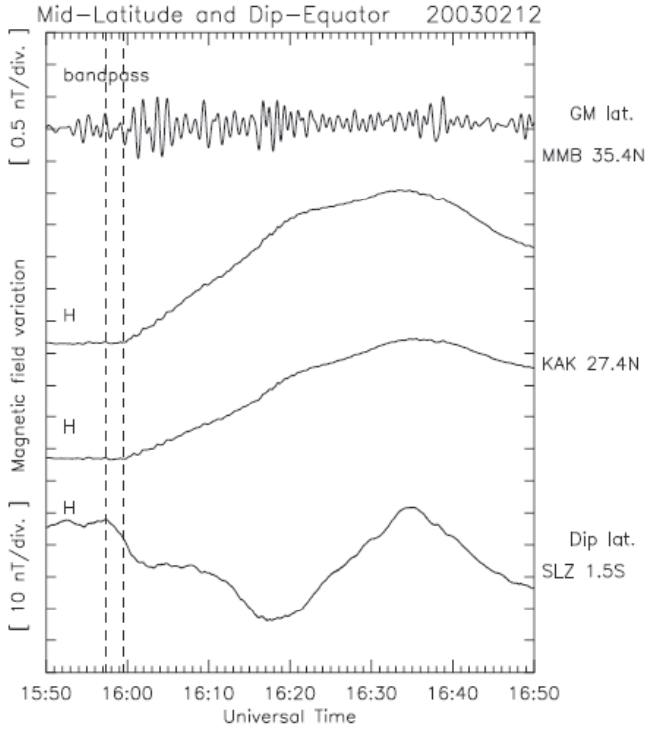
Cavity mode resonance [Yeoman and Orr, 1989]



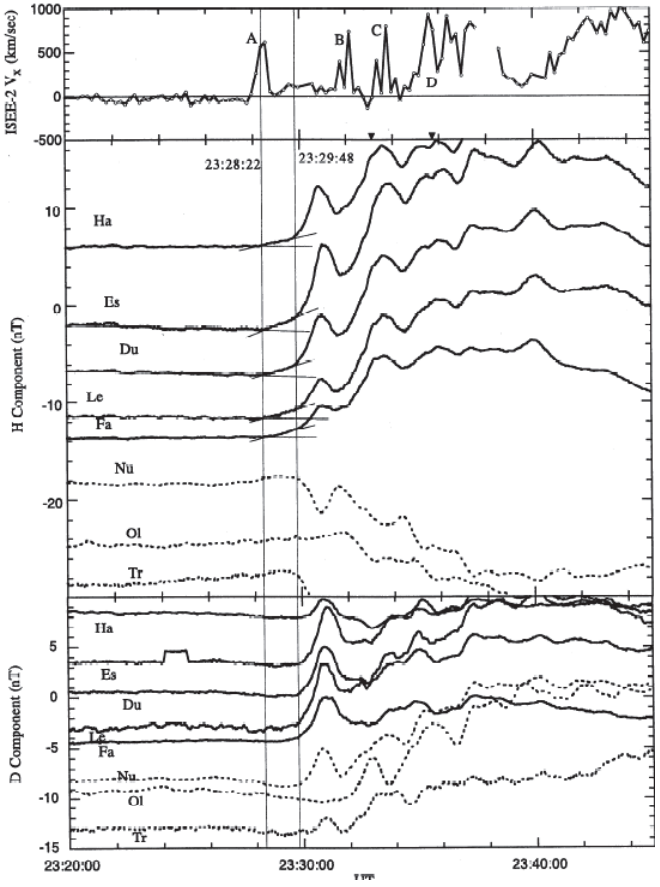
ELECTRON DENSITY VS *L* PROFILE MEASURED BY THE ISEE-1 RELAXATION SOUNDER EXPERIMENT 333, 1977.

Plasmapause surface wave [Lester and Orr, 1983]

Pi2—aurora—ground mag.

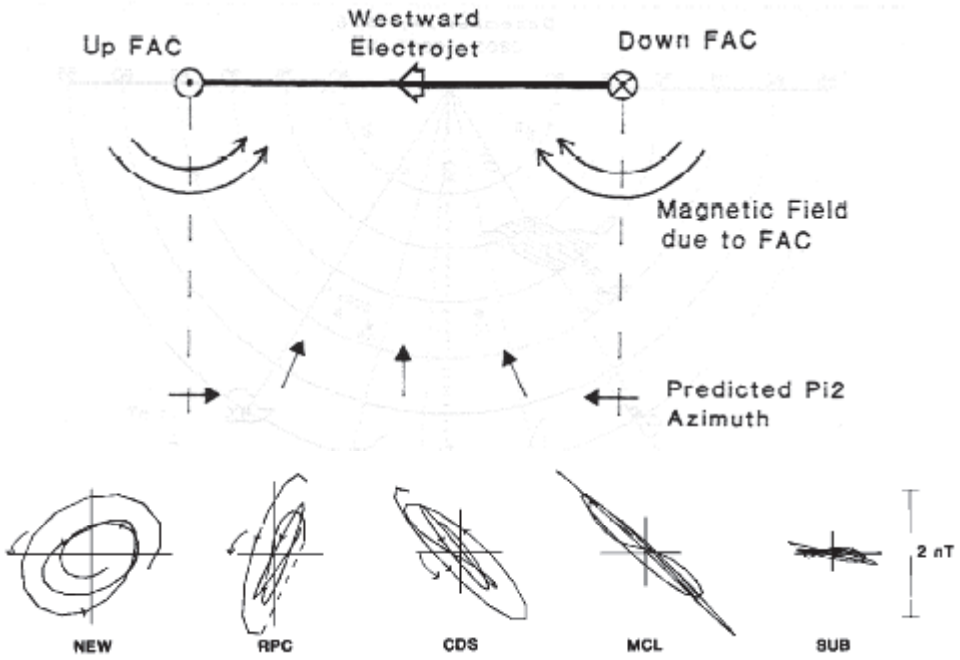


Time lag among Pi 2, positive bay and overshielding [Hashimoto et al., in press]



BBF oscillating in Pi 2 range [Kepko et al., 2002]

What is the current system leading to ground Pi 2?



Wedge type of polarization pattern [Lester et al., 1989]

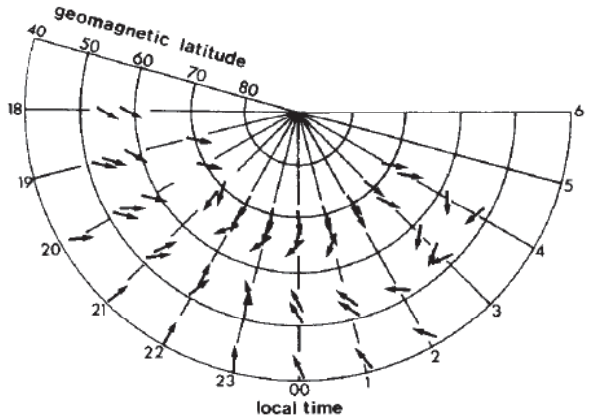
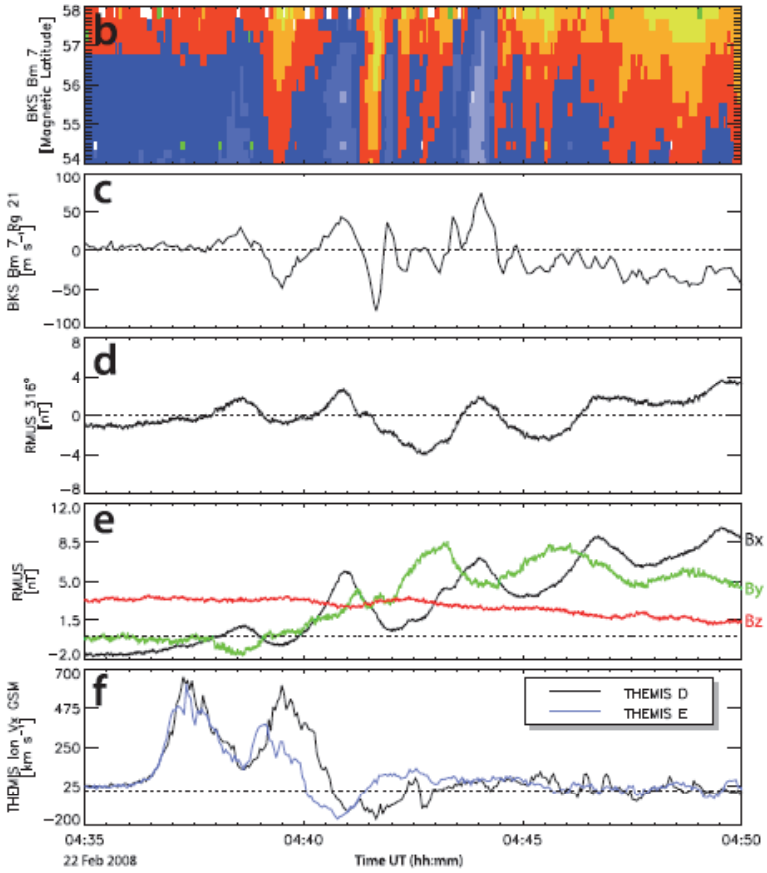
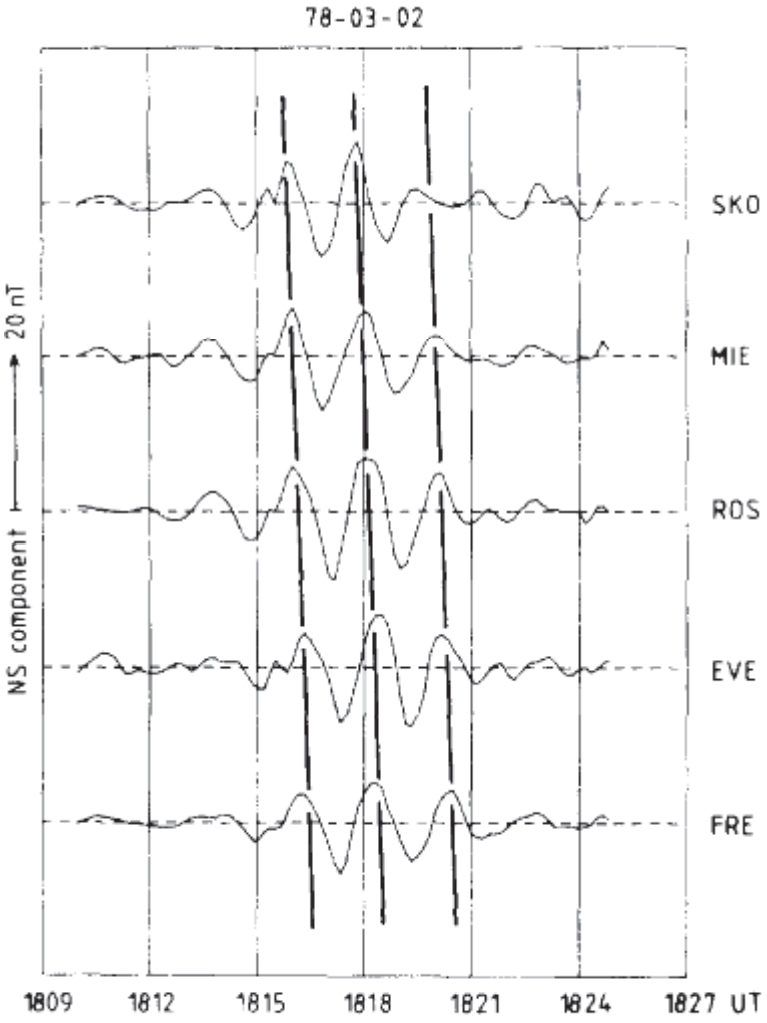


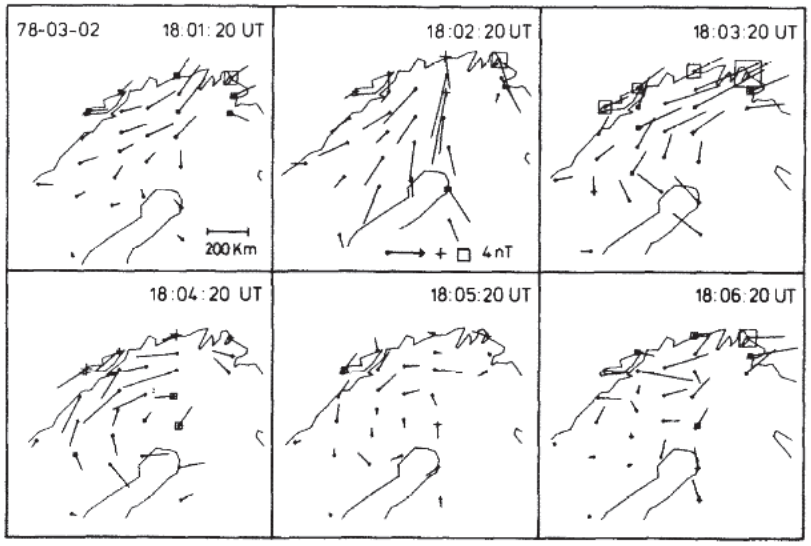
FIG. 2. THE DIRECTION OF POLARIZATION OF Pi 2 EVENTS (AFTER BJÖRNSSON *et al.*, 1971).



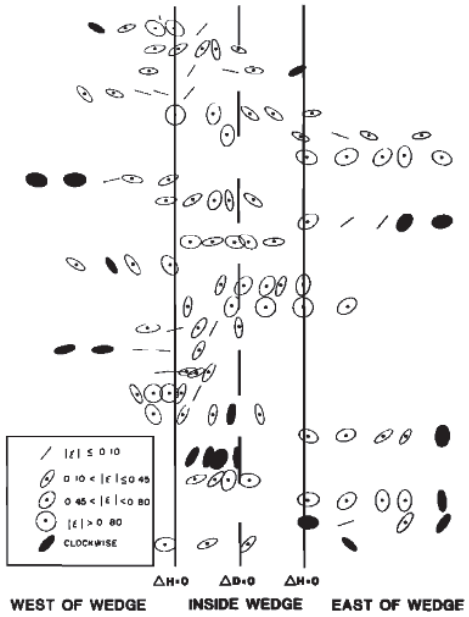
Flow by SuperDARN oscillating coherently with magnetic field [Frissell et al., 2011]



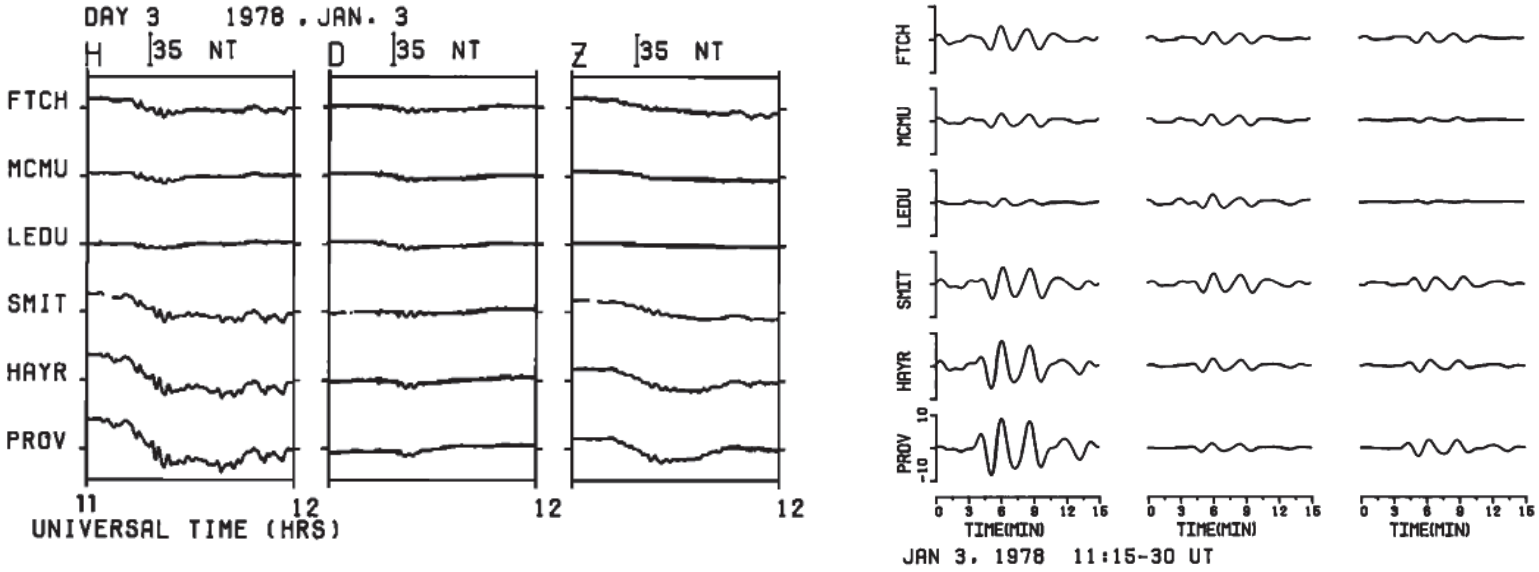
Westward phase propagation
[Lester et al., 1985]



The sense of polarization is predominantly clockwise at the northern stations and anticlockwise at the southern stations.

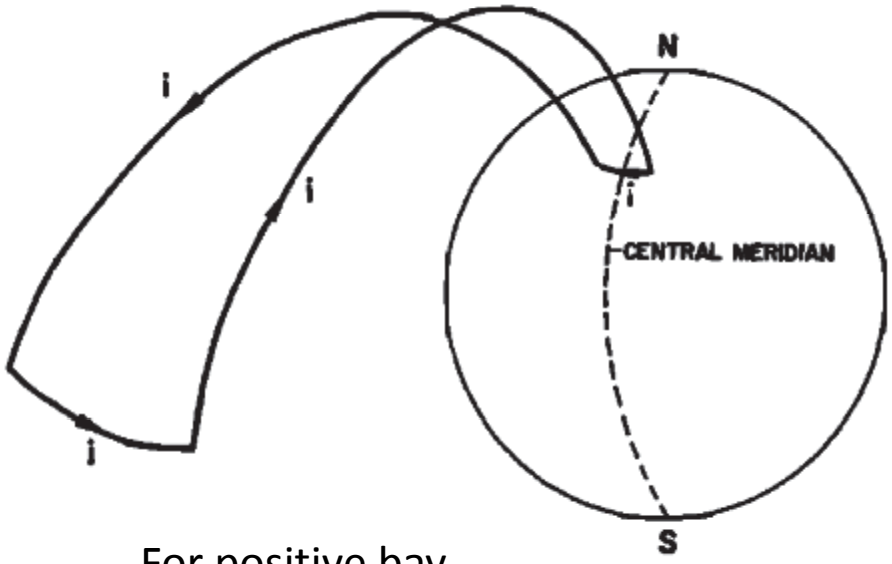


[Lester et al., 1984]



High latitude Pi 2 [Webster et al., 1989]

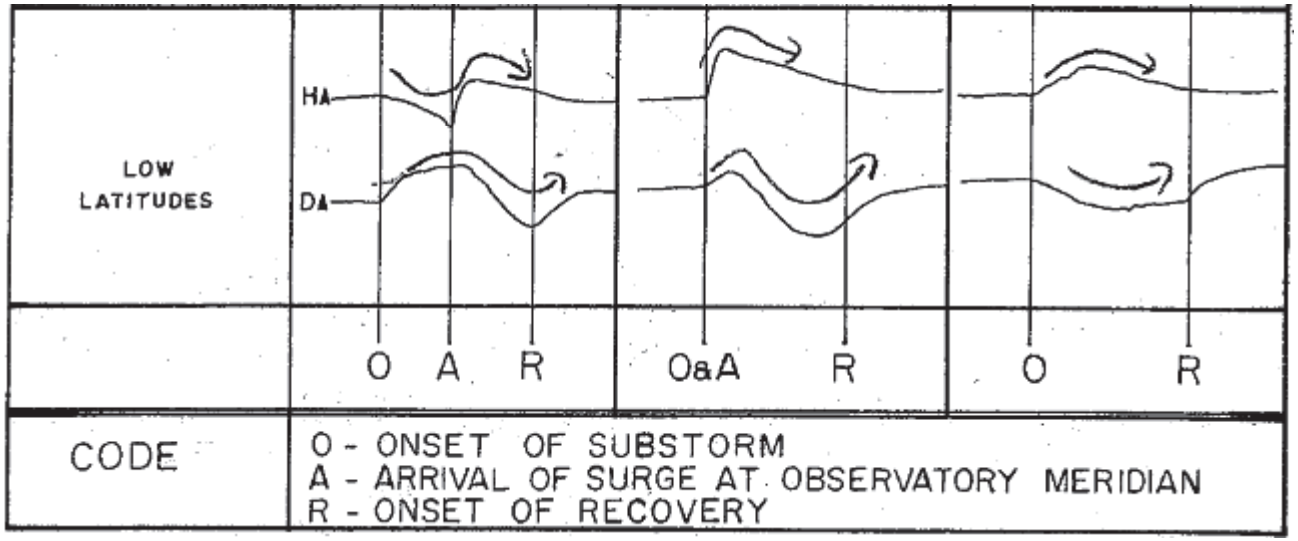
Comparison to the current wedge model

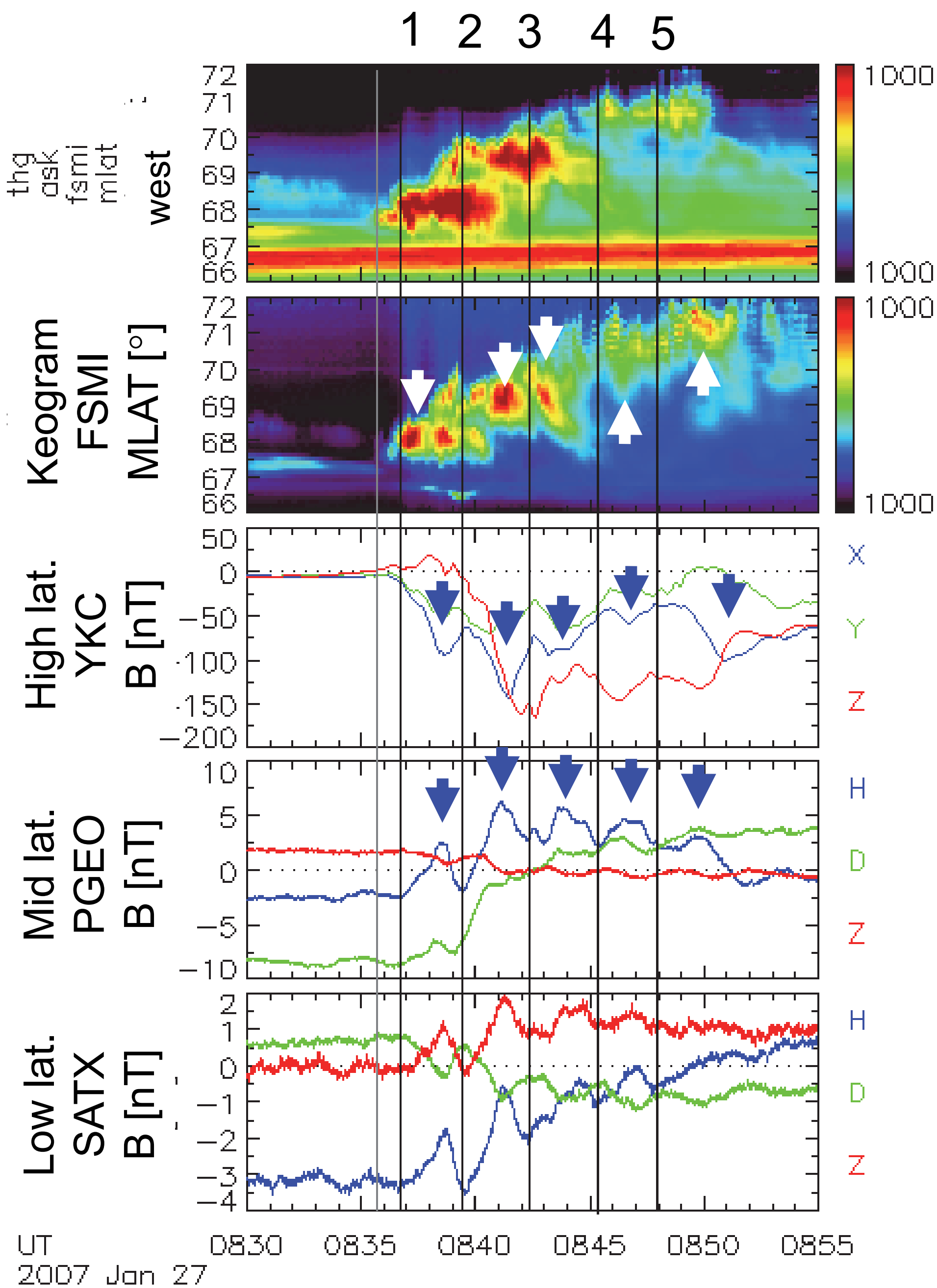


For positive bay

Fig. 1. Three-dimensional model current system proposed by *Bonnevier et al.* [1970].

Anti-correlation of the oscillation of the negative and positive bays suggests that the Pi 2 current system is connected to the auroral electrojet.





1 2 3 4 5
thg ask fsmi mlat west
Keogram FSMI MLAT [°]
High lat. YKC B [nT]
Mid lat. PGEO B [nT]
Low lat. SATX B [nT]
X
Y
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2007 Jan 27
0830 0835 0840 0845 0850 0855