

# Ionospheric Footprints of Detached Magnetotail Interchange Heads

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November 21, 2022

## Abstract

As it was recently predicted, the kinetic ballooning/interchange instability (BICI) can provoke reconnection onsets that lead to detached azimuthally thin earthward intrusions (heads) of depleted plasma tubes when  $\beta_{eq} \gtrsim 100$ . Such detached BICI heads would be seen as localized earthward-propagating dipolarization fronts. Using Time History of Events and Macroscale Interactions during Substorms observations in the plasma sheet at XGSM  $\sim -11$  Re and conjugate All-Sky Imager and magnetometer networks observations on the ground, we show four examples when prominent dipolarization fronts with moderate earthward flows were observed amidst azimuthally drifting interchange heads and concurrently with the ionospheric current intensifications near Time History of Events and Macroscale Interactions during Substorms footprints and auroral bright spots originating from dimmer azimuthal beads/rays. These events support the idea that some of the BICI heads detach from the region with reversed radial gradient of  $B_z$ . The detached BICI heads propagate earthward-driving ionospheric pseudo-breakups.



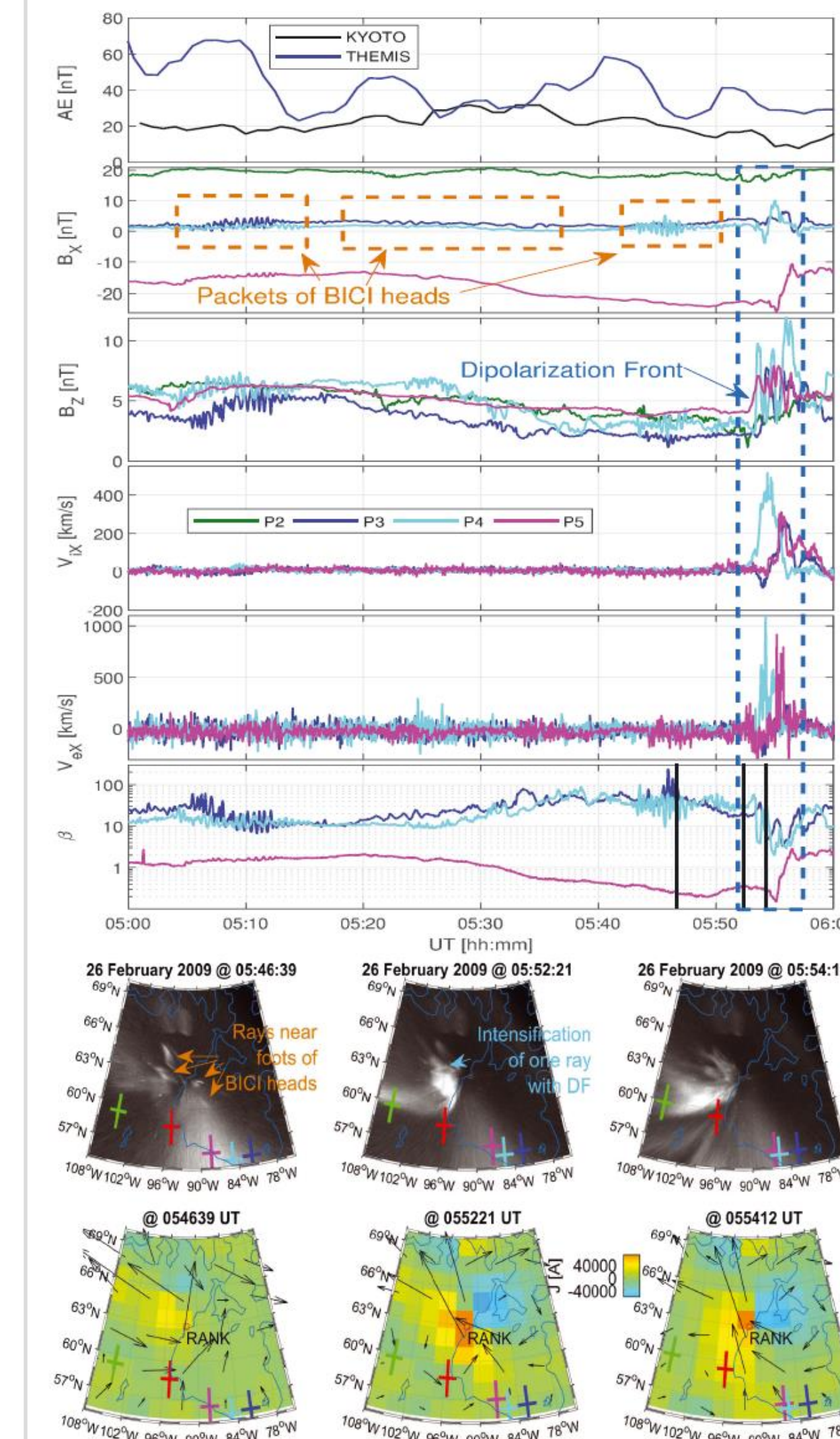
# SM11B-3285 - IONOSPHERIC FOOTPRINTS OF DETACHED MAGNETOTAIL INTERCHANGE HEADS

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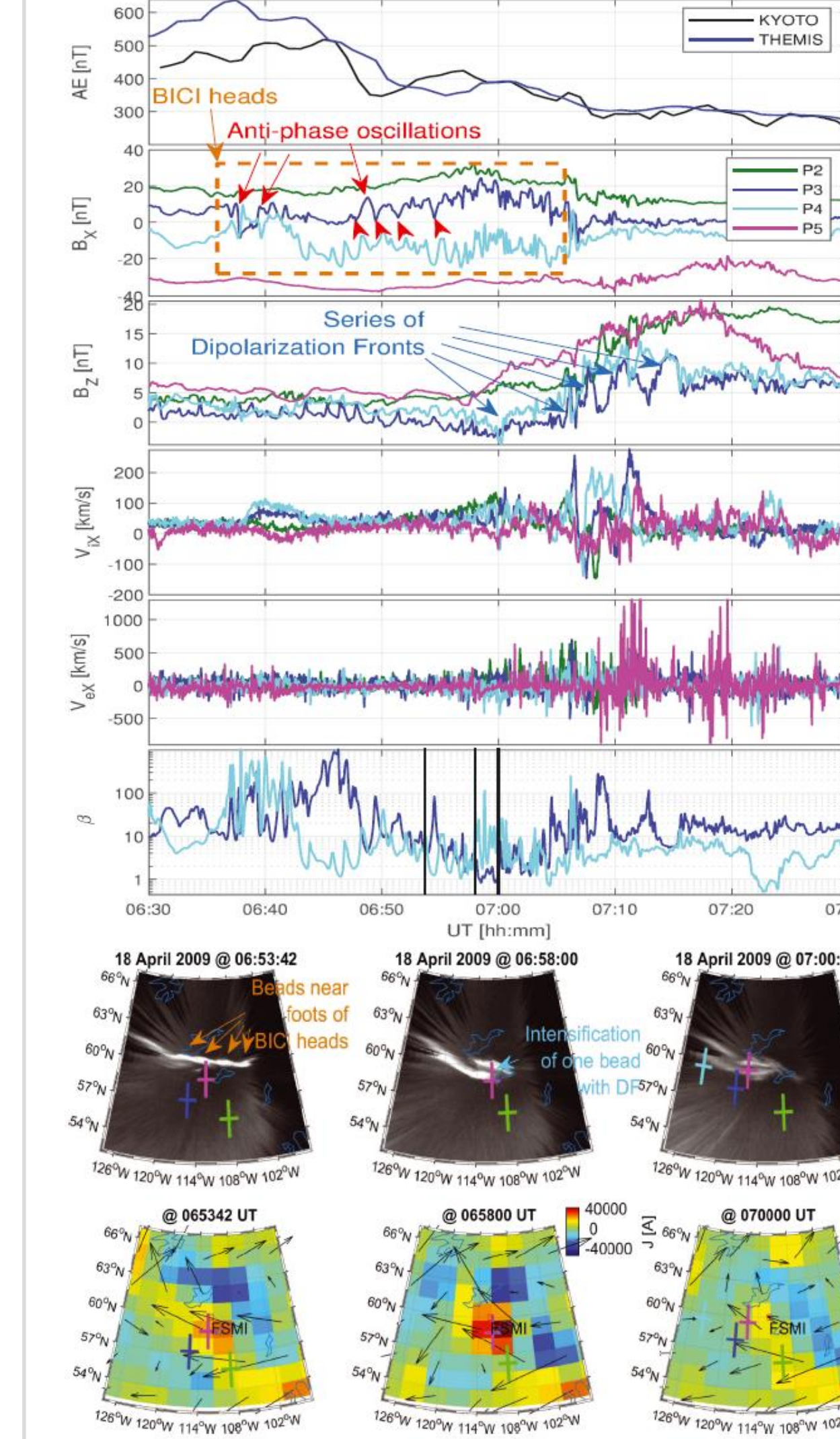
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## Localized DF amidst BICI heads 2



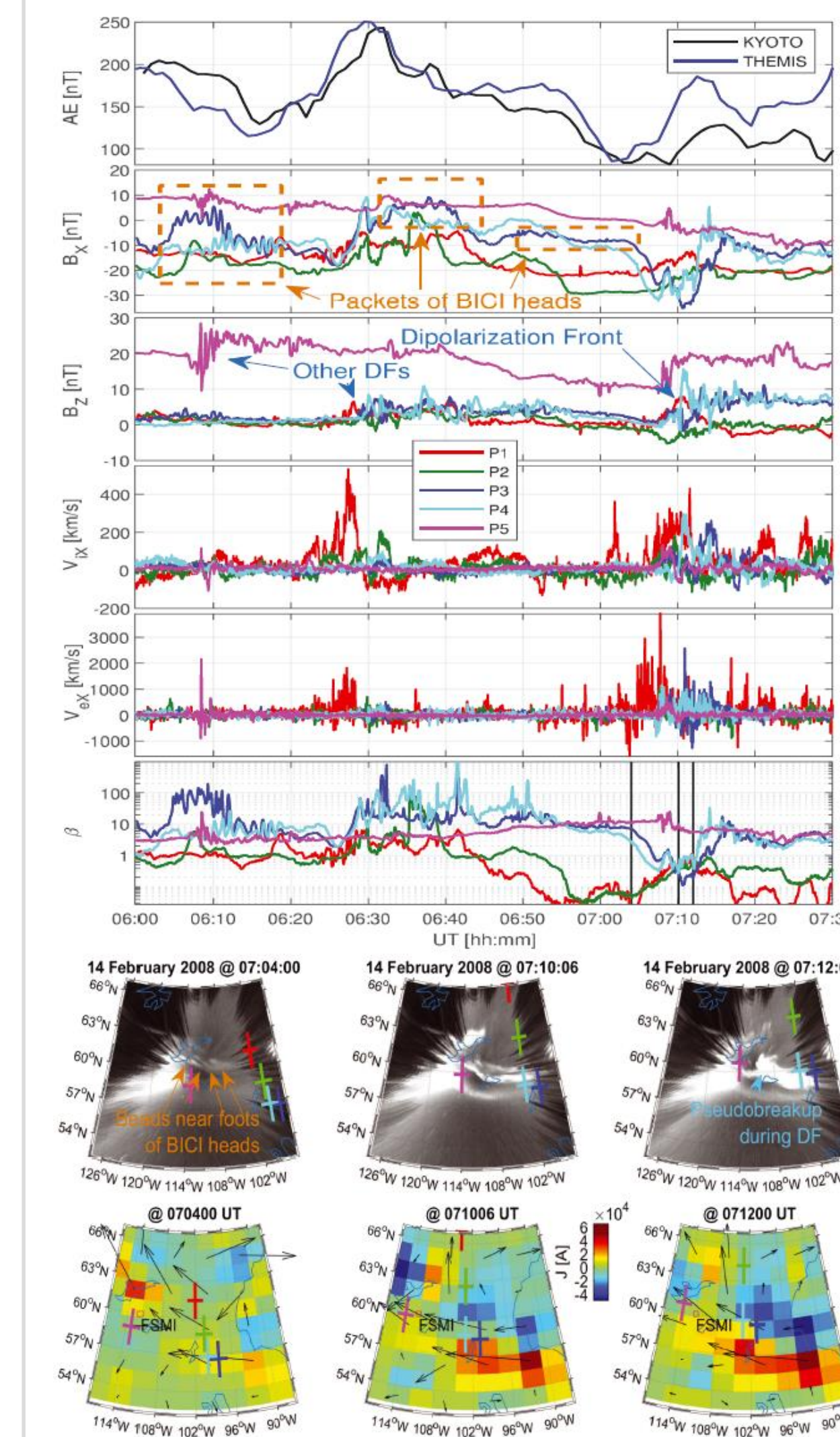
- ✓ One oscillation period in the wave train was about 25s
- ✓ Dawnward drift at ~1.2-1.7 times the ion thermal velocity (between 500 and 700 km/s).
- ✓ Typical azimuthal scale of a BICI head ~1.6Re (close to the event 1)
- ✓ Auroral rays near the foot of BICI heads
- ✓ Intensification of one ray with the dipolarization front
- ✓ Localized ionospheric current system associated with the intensification

## Series of dipolarization fronts



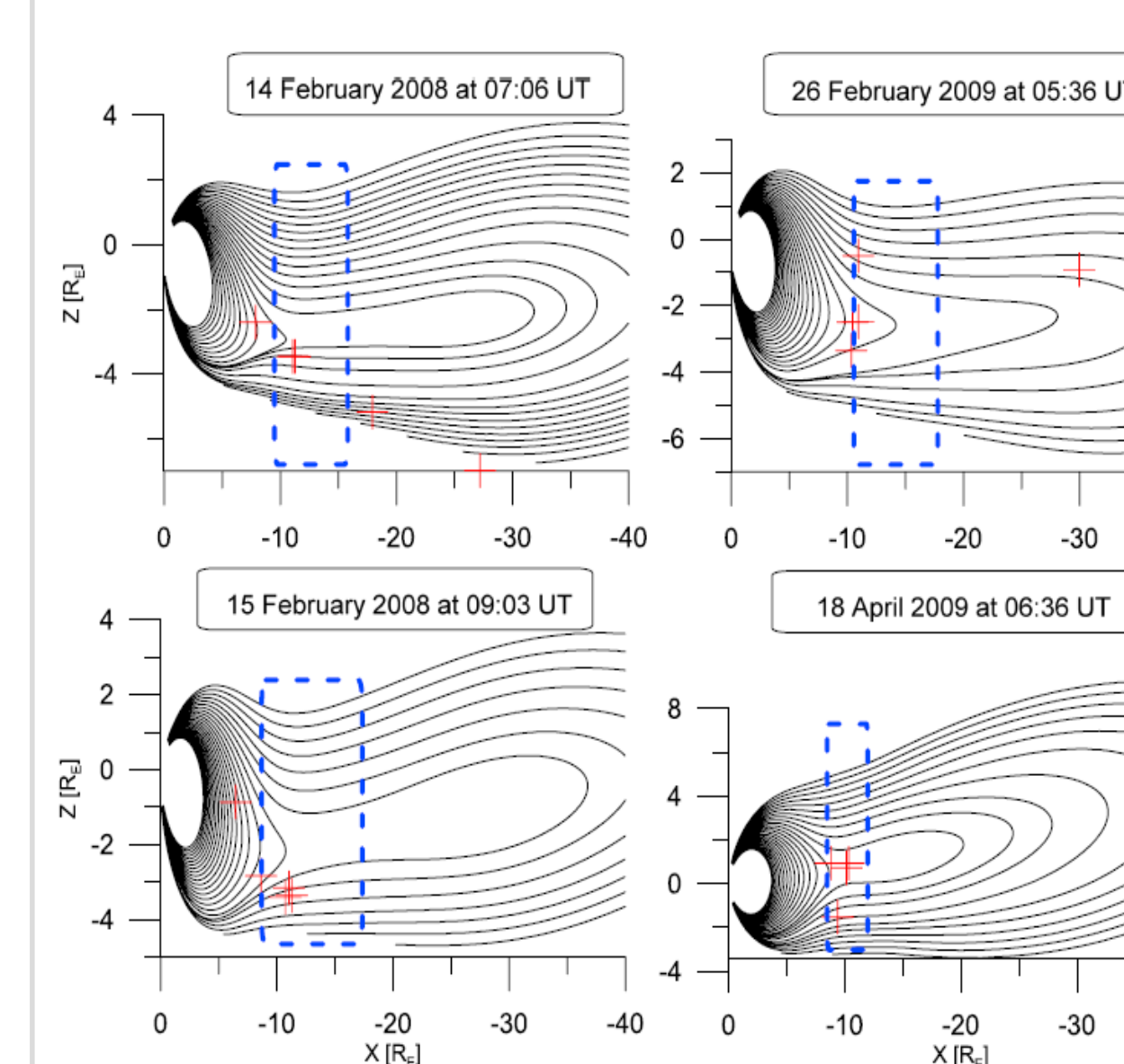
- ✓ One oscillation period in the wave train was about 100s
- ✓ Duskward drift at ~0.3 times the ion thermal velocity (about 600 km/s).
- ✓ Typical azimuthal scale of a BICI head ~1.5Re
- ✓ Sausage magnetic field oscillations were directly observed by P3 and P4 at different hemispheres
- ✓ Auroral beads near the foot of BICI heads
- ✓ Consecutive intensification of different beads with every new dipolarization front
- ✓ Localized ionospheric current systems associated with the intensifications

## Broader dipolarization front



- ✓ One oscillation period in the wave train was about 55 s
- ✓ Duskward drift at ~1.2 times the ion thermal velocity (about 600).
- ✓ Typical azimuthal scale of a BICI head ~3Re
- ✓ The plasma  $\beta$  was around 100 near the neutral plane (higher than in the two previous events)
- ✓ The DF was observed by three azimuthally separated probes (P3-P5)
- ✓ Auroral beads near the foot of BICI heads
- ✓ Broader intensification with the dipolarization front
- ✓ Broader ionospheric current system associated with the intensification

## Bz minimum appearance



- ✓ Magnetic field lines reconstructed using the AM-03 model in the noon meridian GSM plane reveal Bz minimum that is expected to drive BICI
- ✓ The Bz minimum is located in the transition region between the Earth's dipole field lines and the stretched field lines of the geomagnetic tail

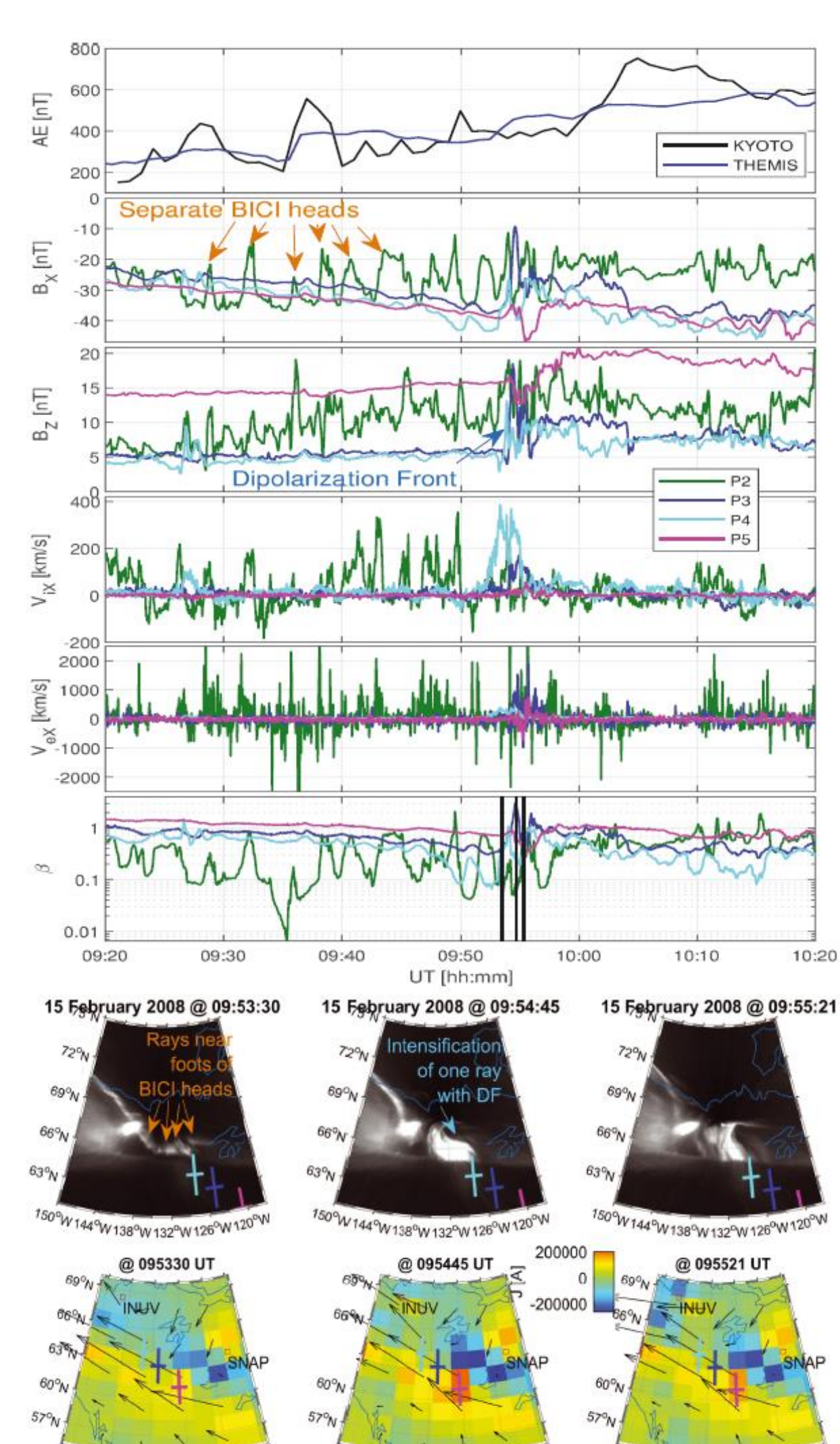
### Key Points:

- Azimuthally drifting interchange heads in the near-Earth plasma sheet may detach and propagate earthward.
- Detached interchange heads are seen as localized dipolarization fronts amidst azimuthally drifting interchange heads.
- The detachments cause ionospheric pseudo-breakups with local current system and auroral bright spots originating from azimuthal beads/rays.



The kinetic ballooning/interchange instability (BICI) can provoke reconnection onsets that lead to detached azimuthally thin earthward intrusions (heads) of depleted plasma tubes when  $\beta_{eq} \leq 100$ . Such detached BICI heads would be seen as localized earthward-propagating dipolarization fronts. Using Time History of Events and Macroscale Interactions during Substorms observations in the plasma sheet at XGSM  $\approx -11$  Re and conjugate All-Sky Imager and magnetometer networks observations on the ground, we show four examples when prominent dipolarization fronts with moderate earthward flows were observed amidst azimuthally drifting interchange heads and concurrently with the ionospheric current intensifications near Time History of Events and Macroscale Interactions during Substorms footprints and auroral bright spots originating from dimmer azimuthal beads/rays. These events support the idea that some of the BICI heads detach from the region with reversed radial gradient of  $B_z$ . The detached BICI heads propagate earthward-driving ionospheric pseudo-breakups.

## Localized dipolarization front amidst BICI heads 1



### BICI signatures include:

- ✓ Off-equator sausage oscillations
- ✓ Azimuthal propagation
- ✓  $n \sim (B_x)^{-1}$
- ✓  $E \sim V_{x, \text{ele}}$
- ✓  $\pi/2$  shift between  $n$ ,  $B$  and  $E, V_x$
- ✓ Dawnward drift at ~0.3 times the ion thermal velocity (about 200 km/s).
- ✓ Typical azimuthal scale of a BICI head ~2Re
- ✓ Auroral rays near the foot of BICI heads
- ✓ Intensification of one ray with the dipolarization front
- ✓ Localized ionospheric current system associated with the intensification