# Dayside Aurora as an Indicator of Asymmetric Solar Wind-Magnetosphere Energy Transfer

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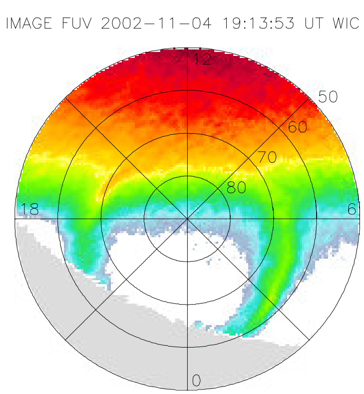
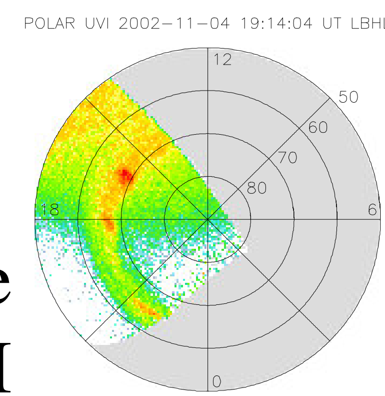



Northern Hemisphere
IMAGE WIC

Southern Hemisphere
Polar UVI



# Introduction (part 1)

- The dayside magnetosphere responds directly to incident interplanetary magnetic field (IMF) and solar wind energy

- Changes in the IMF and solar wind drive changes in magnetospheric and ionospheric convection

- Currents and (in the case of upward currents) aurora respond to these changes

  ⇒ Dayside aurora is a direct indicator of how the magnetosphere-ionosphere system responds to IMF and solar wind energy input

# Introduction (part 2)

- Focus on afternoon sector – 15 MLT bright spot
- Region of persistent auroral emission centered near 15 MLT and 75 degrees latitude [*Cogger et al.*, 1977; *Liou et al.*, 1997]
- Caused by low energy (< ~ 1 keV) electron precipitation [*McDiarmid et al.*; 1975, *Evans*, 1985; *Newell et al.*, 1996]
- Co-located with maximum in Region 1 upward field aligned current [*Iijima and Potemra*, 1987]
- Appearance and behavior influenced by solar wind and IMF [*Murphree et al.*, 1981; *Vo and Murphree*, 1995]
- Can be structured and dynamic (string of pearls configuration) [*Lui et al.*, 1987; *Potemra et al.*, 1990, *Rostoker et al.*, 1992]
- Varies with season: more likely in summer [*Liou et al.*, 2001]
  ⇒ **hemispheric differences**

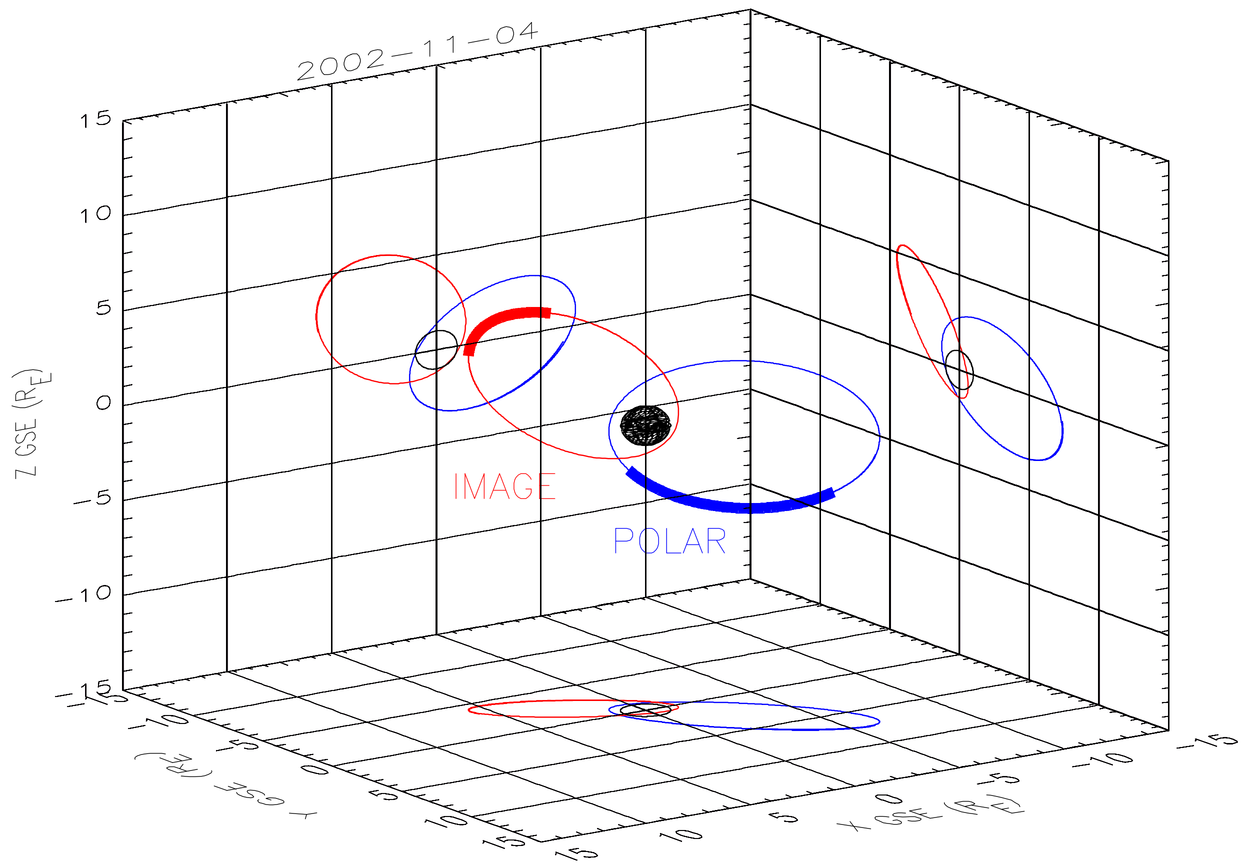
# Introduction (part 3)

- Previous conjugate observations limited to small scales (in situ point measurements or ground based instruments) in at least one hemisphere [*Dickinson et al.*, 1986; *Mende et al.*, 1990; *Burns et al.*, 1990, 1992; *Vo et al.*, 1995]

- *Fillingim et al.* [2005] presented the first simultaneous images of dayside aurora from two global auroral imagers in opposite hemispheres (IMAGE WIC in northern hemisphere and Polar UVI in south)
- Addressed the issue of conjugacy of the dayside aurora on a synoptic scale for the first time
- Related differences in aurora to solar wind and IMF conditions
- Continuation of the work of *Fillingim et al.* [2005]

# Spacecraft Orbits

| IMAGE | Polar |
|---|---|
| Launch: Mar. 25, 2000 | Feb. 24, 1996 |
| Apogee: 8 $R_E$ | 9 $R_E$ |
| Period: 14 hours | 18 hours |



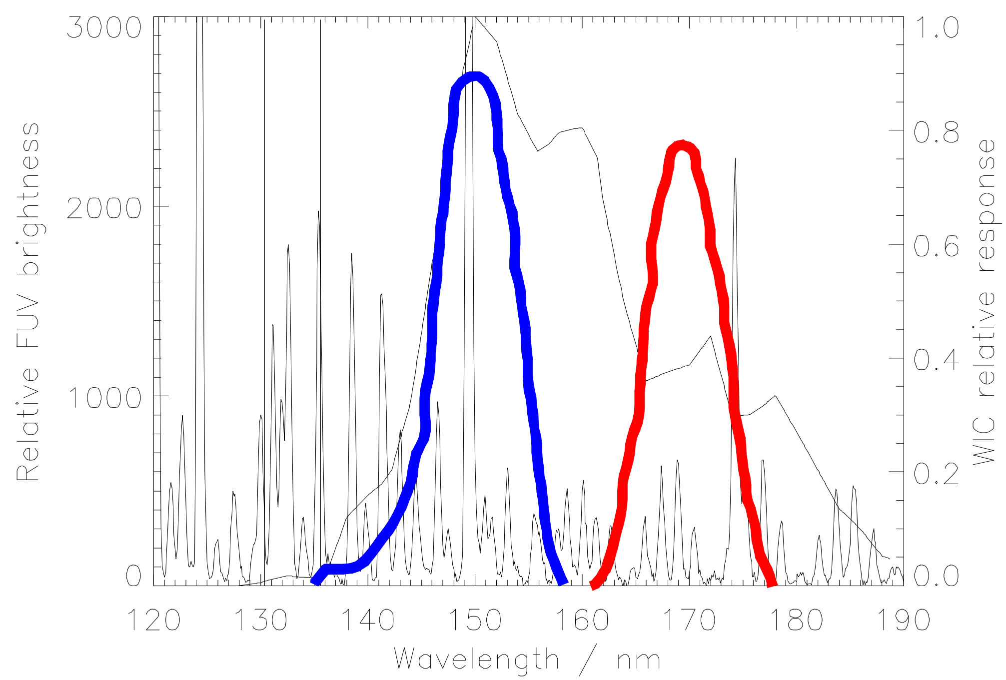
# Instrumentation

IMAGE Wideband Imaging Camera (WIC) &
Polar Ultraviolet Imager (UVI) LBHS & LBHL

Temporal resolution
WIC: 10 second integration every 2 minutes
UVI: 18 & 36 second integration, cyclic

Spatial resolution
WIC: ~ 50 km
UVI: ~ 30 km

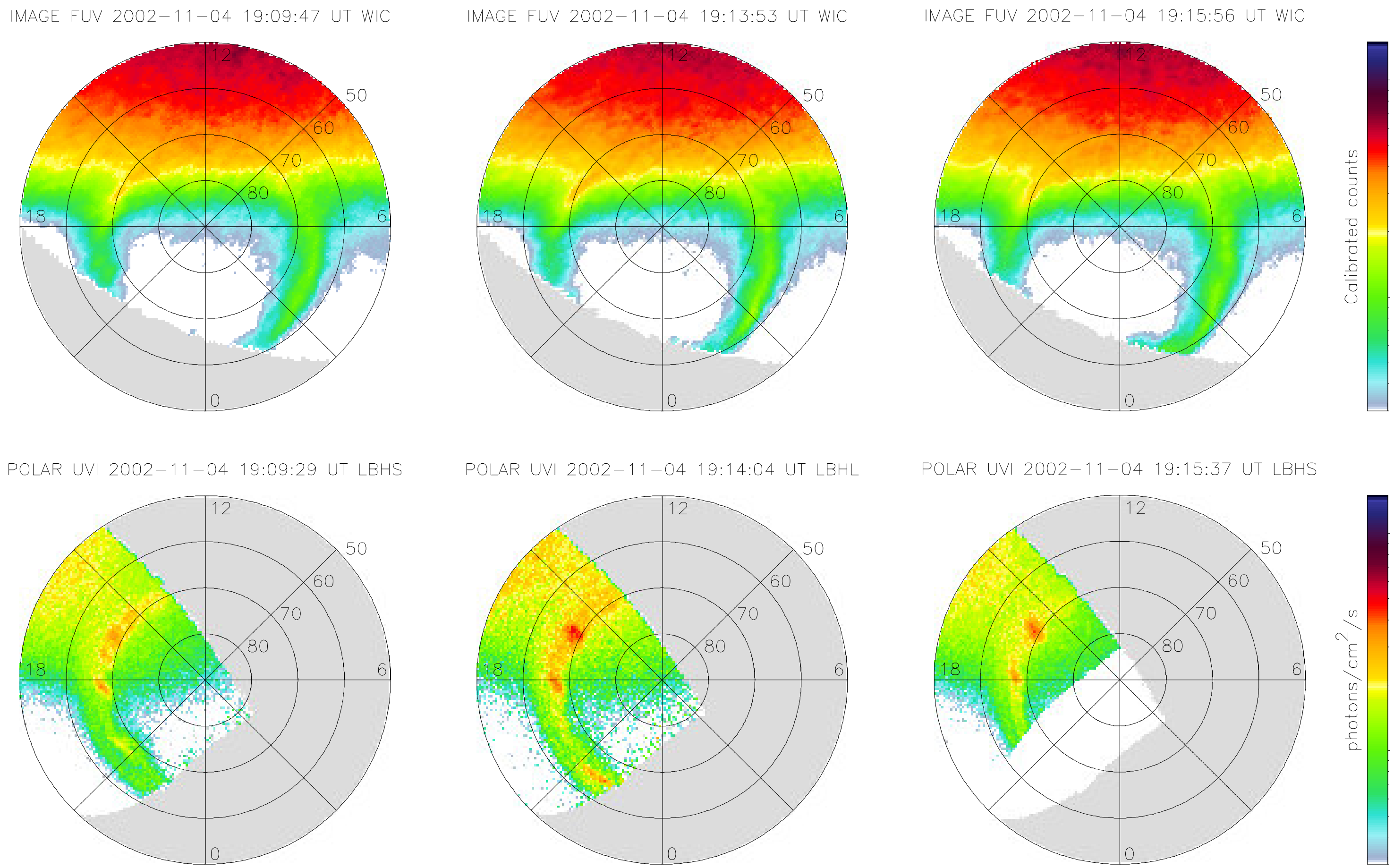
Spectral resolution
WIC: 140 to 190 nm –
LBHS: 140 to 160 nm –
LBHL: 160 to 180 nm –



# 4 November 2002

Northern Hemisphere

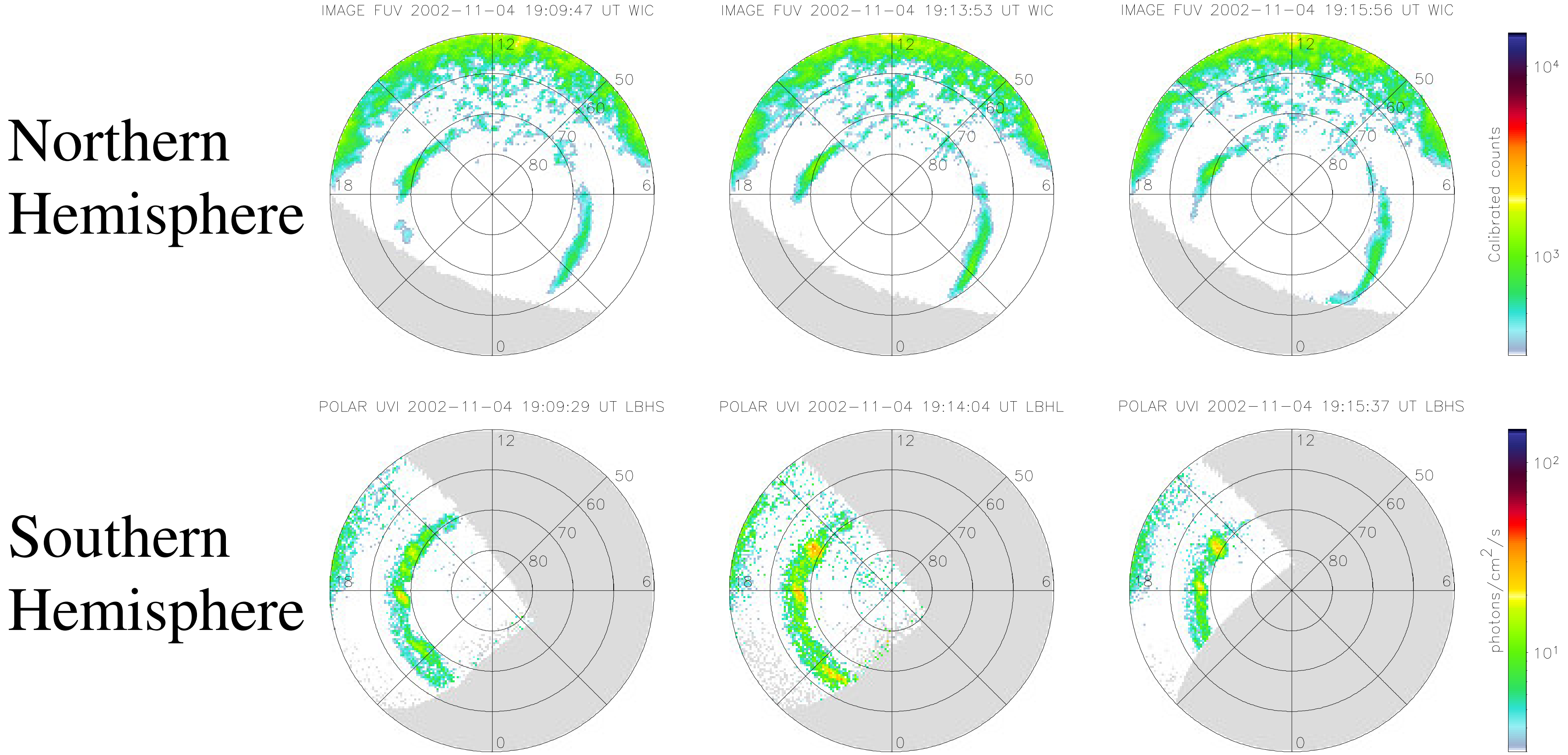
Southern Hemisphere




NH: enhanced, unstructured emission in afternoon

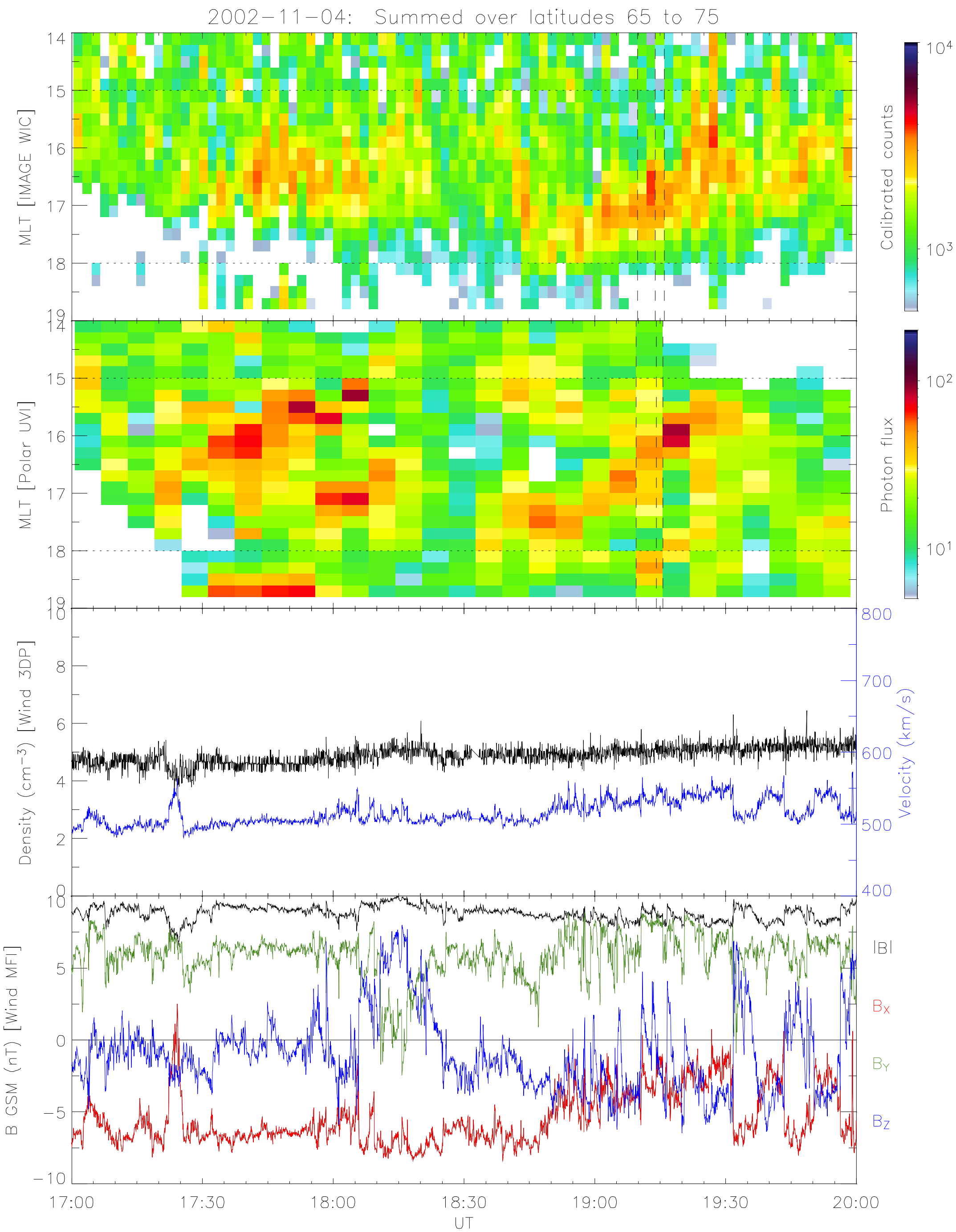
SH: multiple spots; number, location, and intensity change

# 4 November 2002




NH: enhanced, unstructured emission in afternoon

SH: multiple spots; number, location, and intensity change




NH: enhanced emission in afternoon; variable intensity and location; single region

SH: multiple regions of emission; vary in intensity and location; different regions behave differently

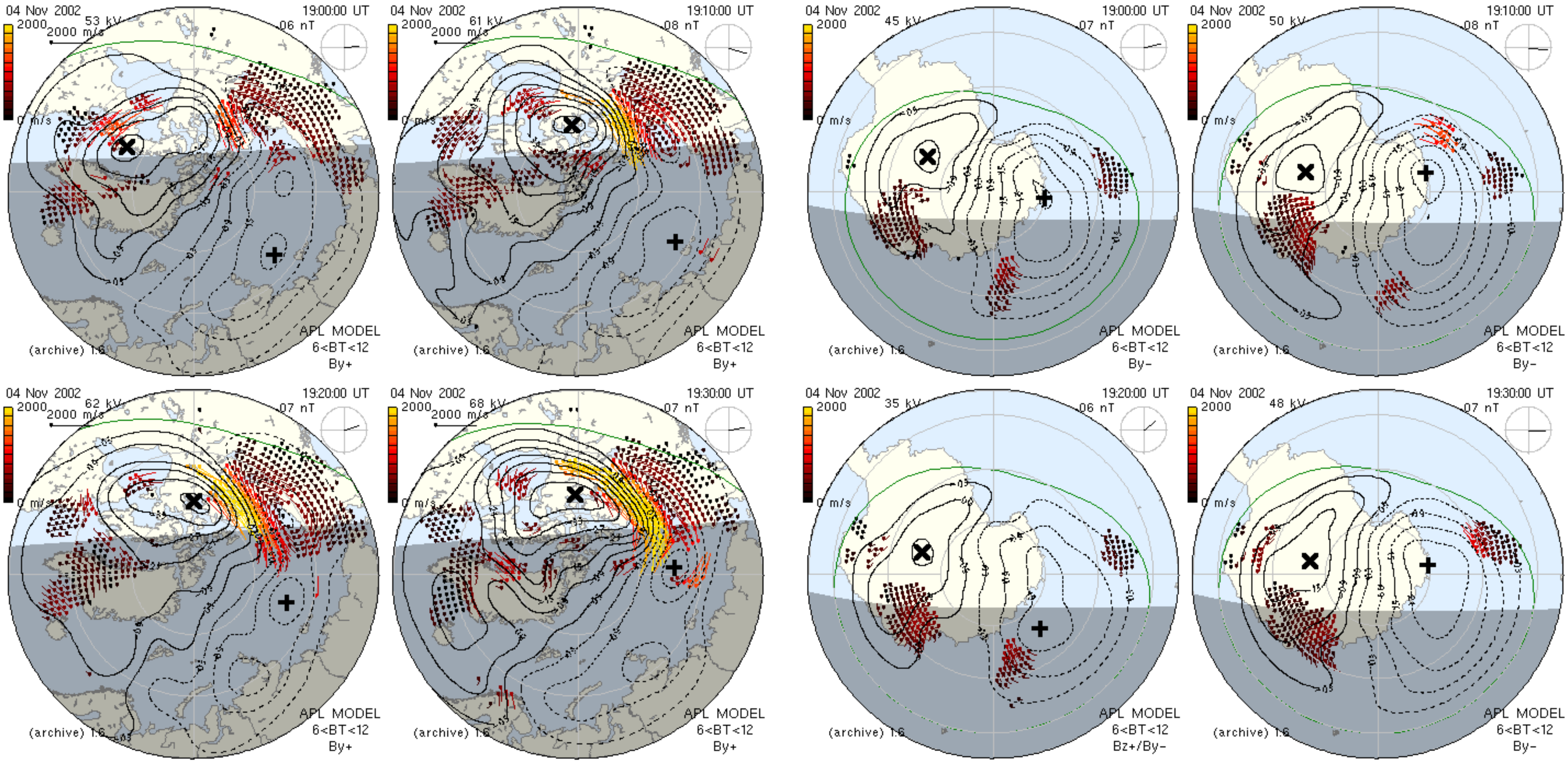
Steady solar wind density and velocity

IMF $B_X < 0$

$B_Y > 0$

$B_Z < 0$ (with some positive excursions)

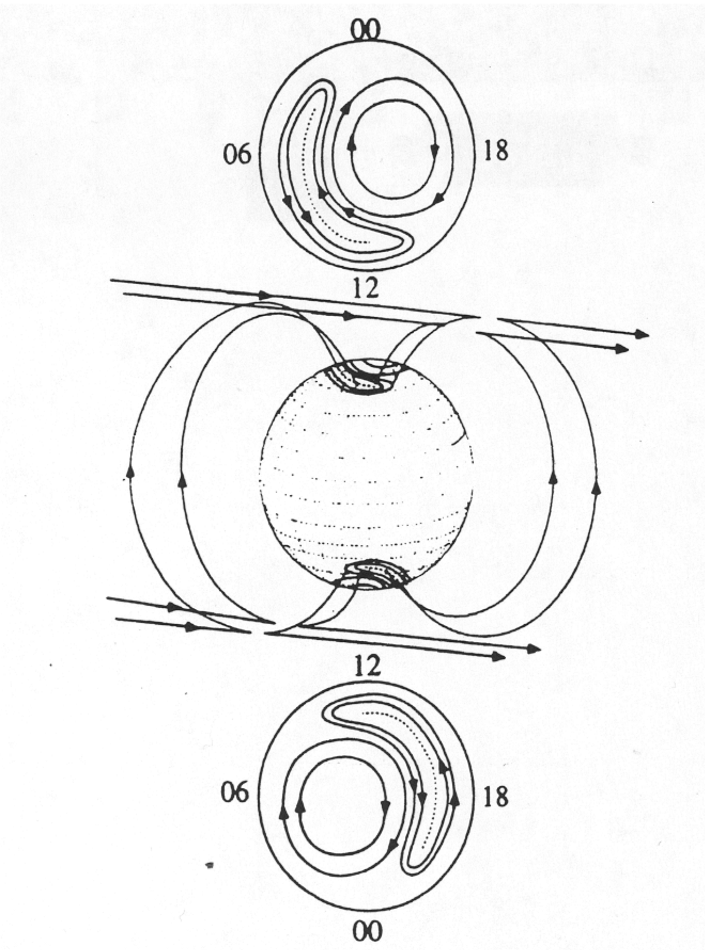
# SuperDARN Ionospheric Velocity Data




NH: large velocities pre-noon; moderate velocities in afternoon

SH: poor coverage; crescent shaped cell in afternoon, large v?

# Interpretation




(from *Clauer et al.*)

For $B_Z < 0$, strong $B_Y$

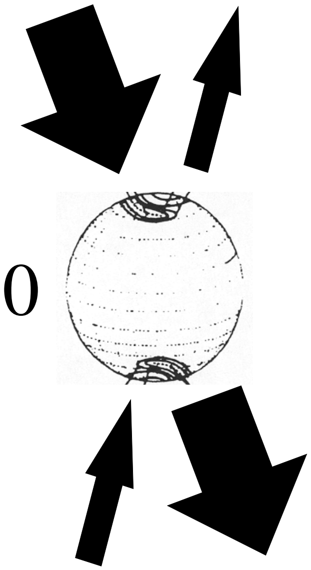
⇒ mirror image convection patterns

Strong flow shear, divergent $E_\perp$, $J_\perp$, strong $J_{//}$

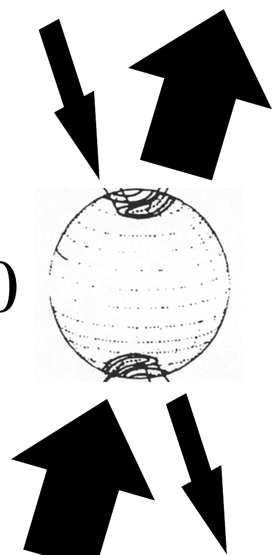
⇒ more discrete auroral structure (brighter?)

⇒ Hemispheric asymmetry

$B_Y > 0$



$B_Y < 0$

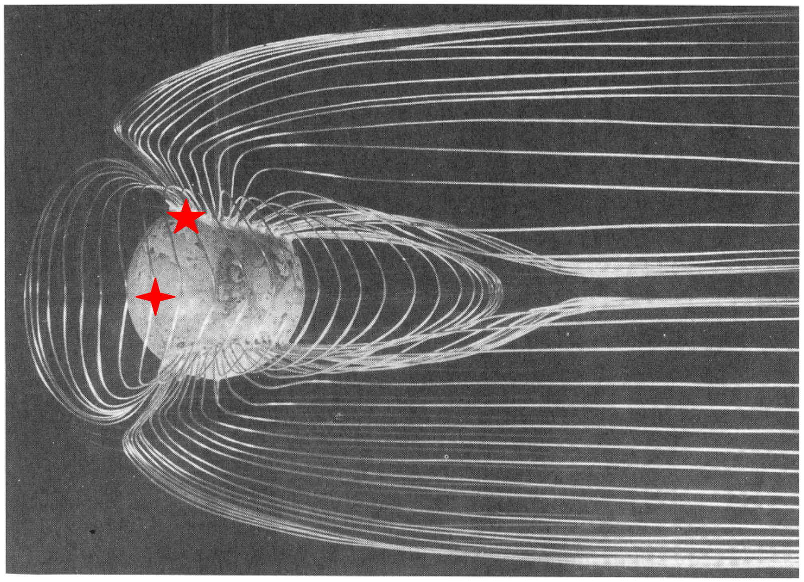


# Why Multiple Spots?

"String of pearls" configuration is consistent with being the result of a Kelvin-Helmholtz Instability (KHI) [*Lui et al.*, 1989; *Rostoker et al.*, 1992; *Wei and Lee*, 1993]

- KHI occurs at velocity shear; assumed to occur at equator ✦
- Multiple spots only in one hemisphere, not both as expected

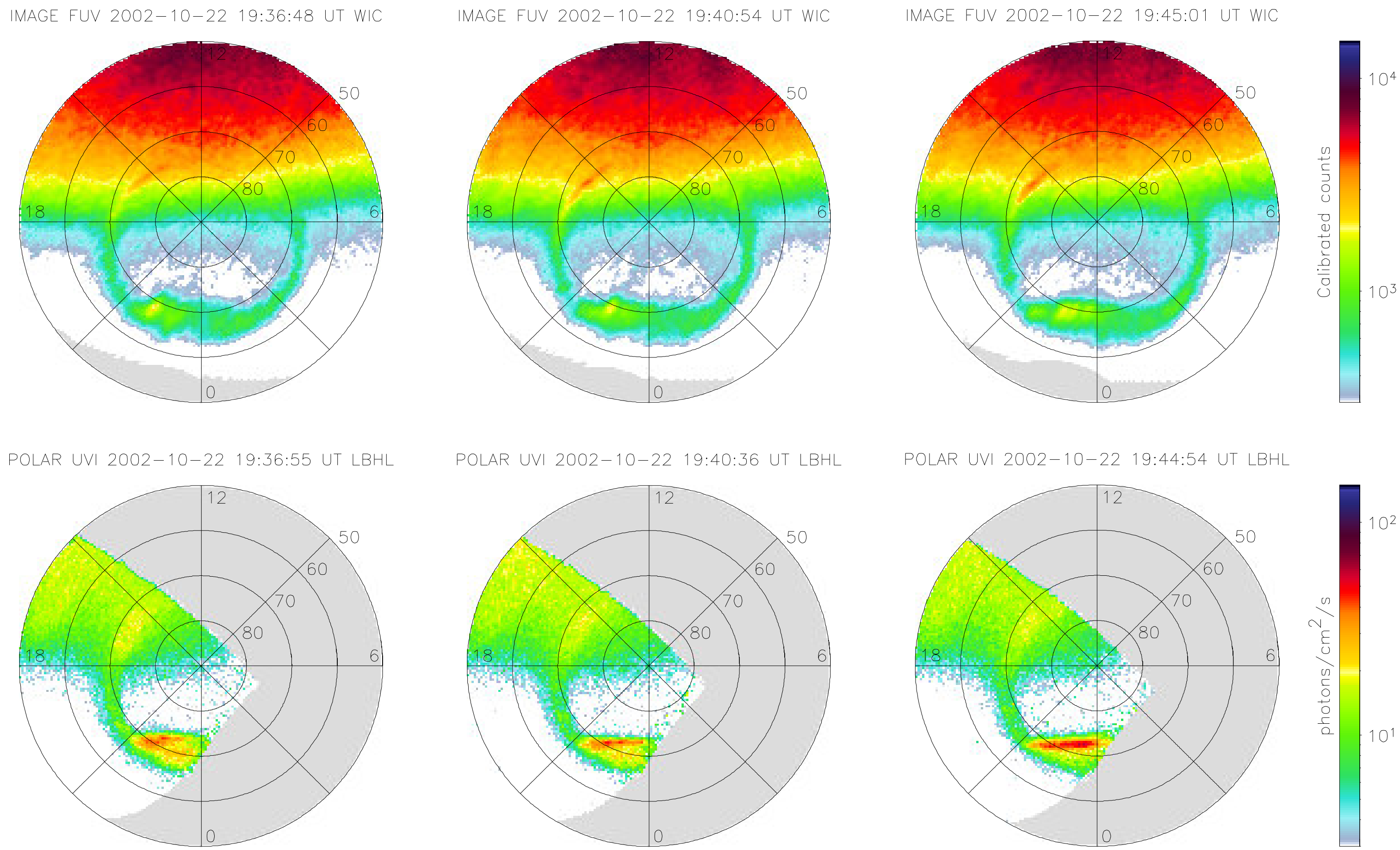
⇒ KHI occurs at high latitude near the ionosphere (in crescent cell)★ and depends on $|B_Y/B_Z|$ [cf. *Ridley and Clauer*, 1996]



# 22 October 2002

Northern Hemisphere

Southern Hemisphere



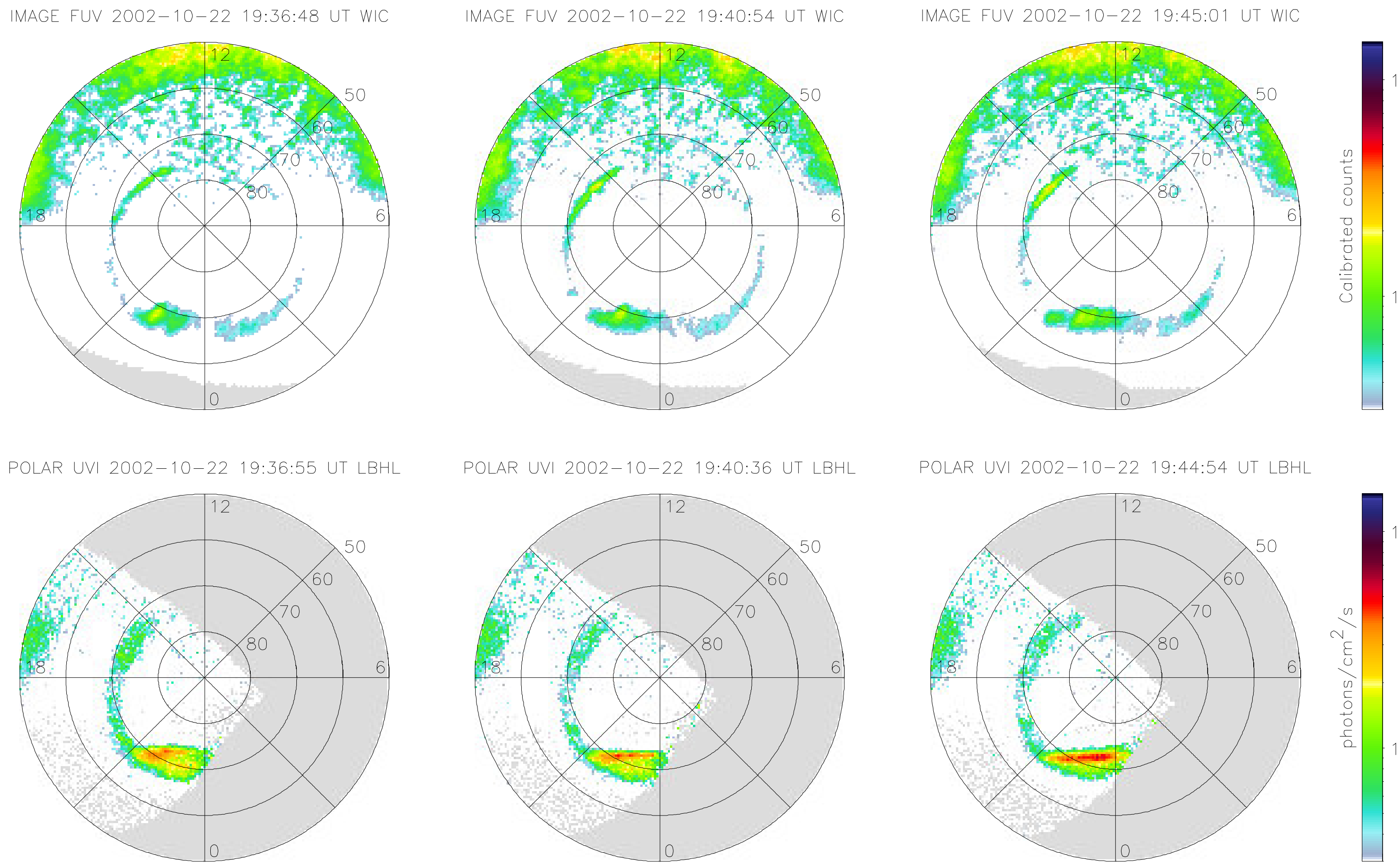

NH: latitudinally narrow emission, brightens near 19:40 UT

SH: broader, more diffuse emission; no noticeable change

# 22 October 2002

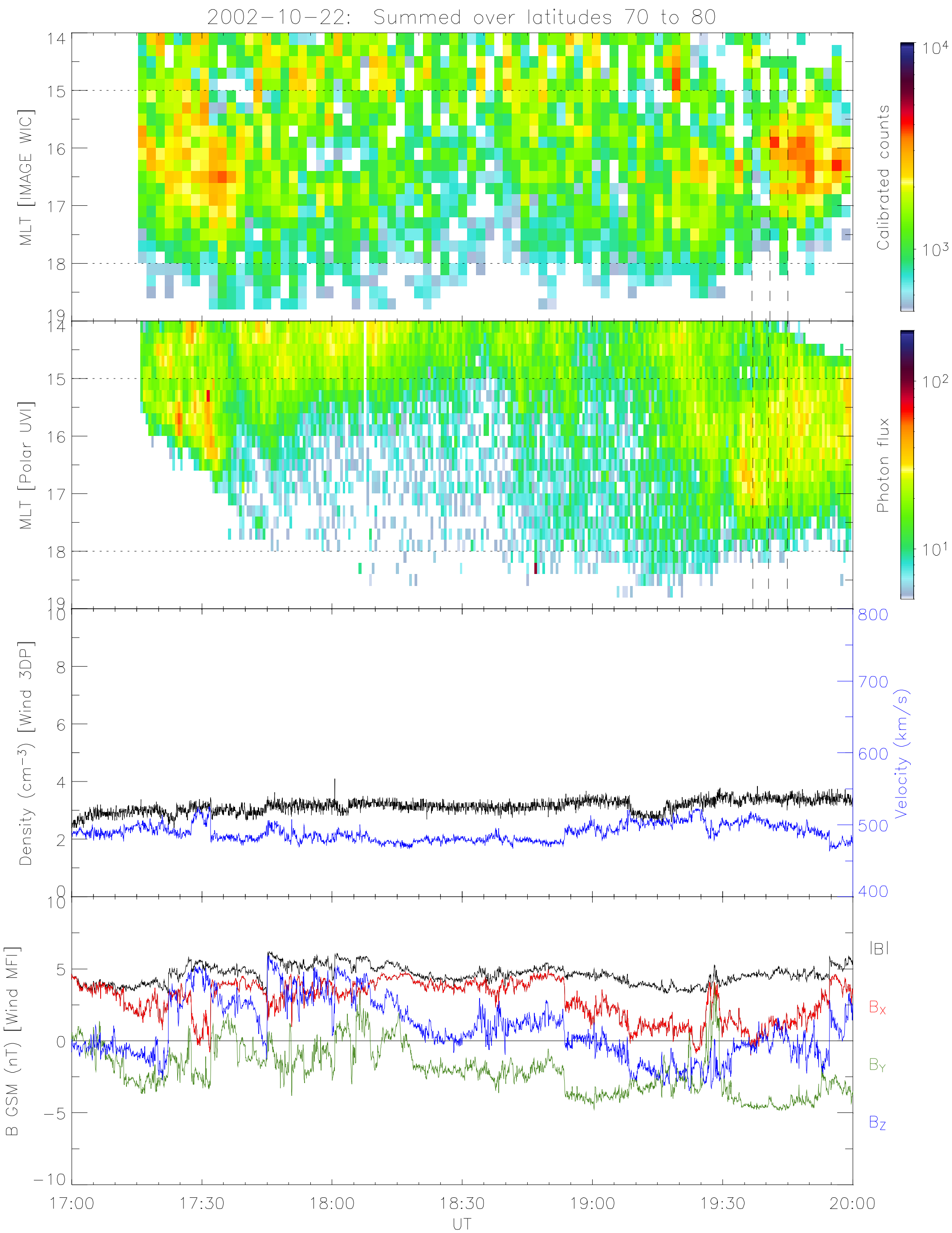
Northern Hemisphere

Southern Hemisphere




NH: latitudinally narrow emission, brightens near 19:40 UT

SH: broader, more diffuse emission; no noticeable change




# 22 October 2002

NH: very quiet from 17:45 to 19:15 UT; brightening near 19:40 UT; narrow MLT range (peaked)

SH: aurora brightens near 19:30 UT; diffuse in latitude and MLT

Steady solar wind density and velocity

IMF $B_X > 0$

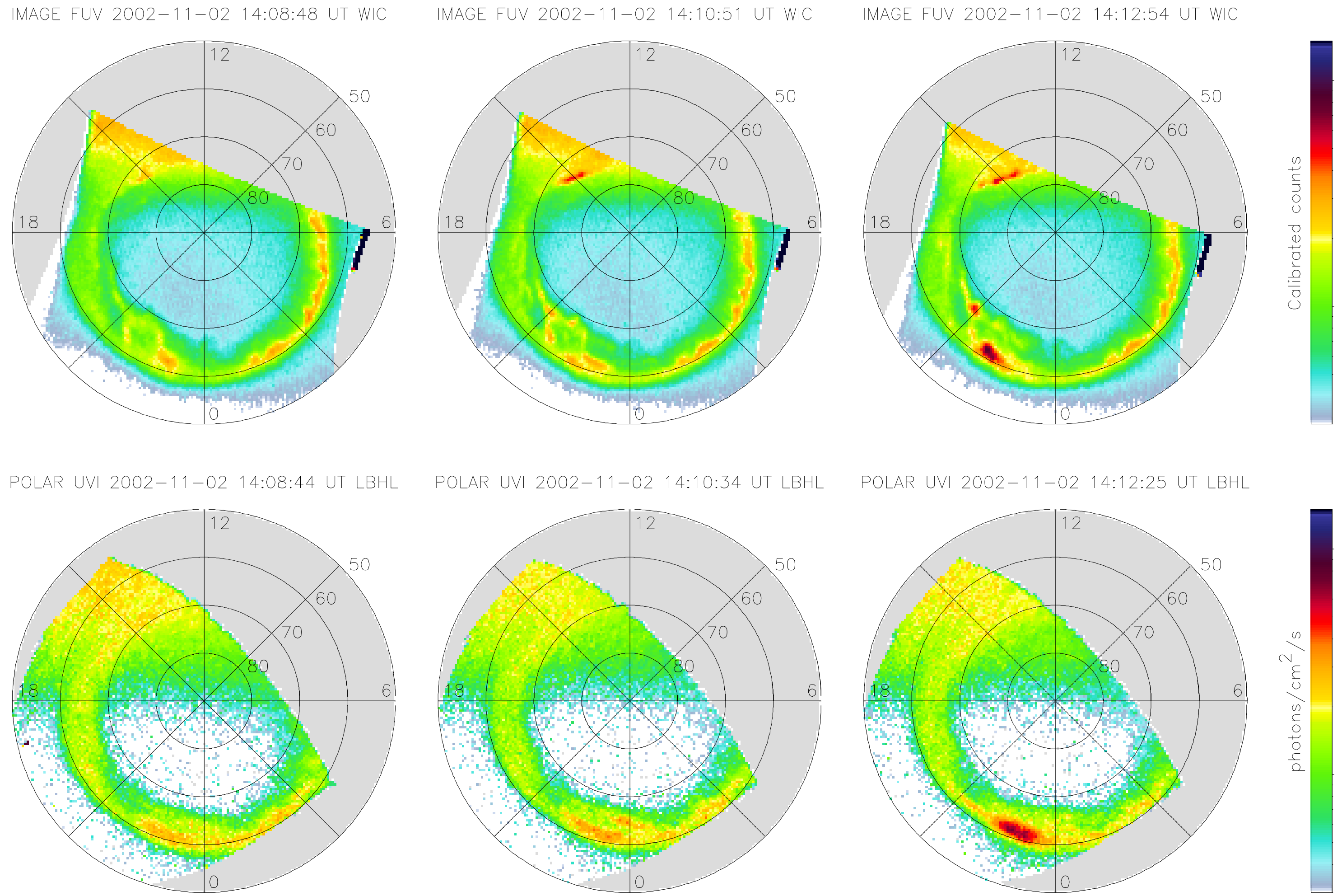
$B_Y < 0$

$B_Z < 0, > 0, <0$

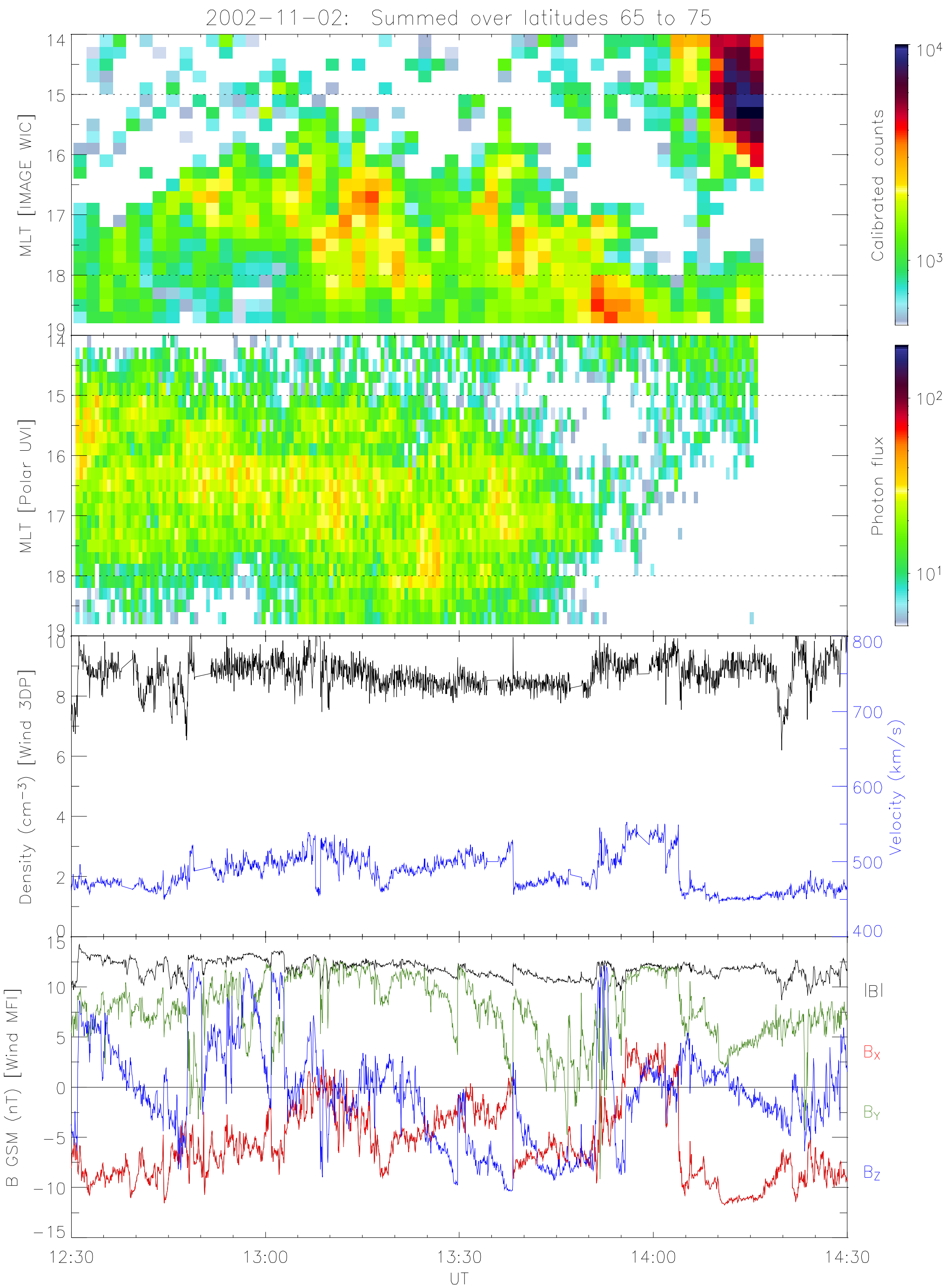
# 2 November 2002

Northern Hemisphere

Southern Hemisphere




NH: Sudden brightening at 14:10 UT; SH: No change



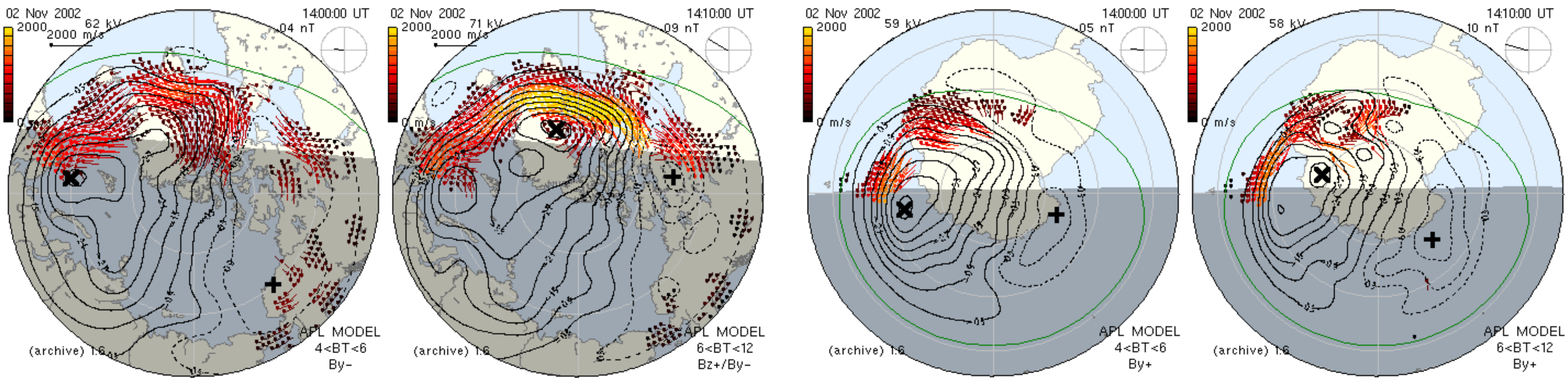

NH: Sudden brightening at 14:10 UT

SH: No change

> 30% drop in solar wind dynamic pressure (related to brightening?)

Large IMF |**B**|
(note change in scale)
Change from +Y dominated to −X dominated (radial) IMF
(related to brightening?)

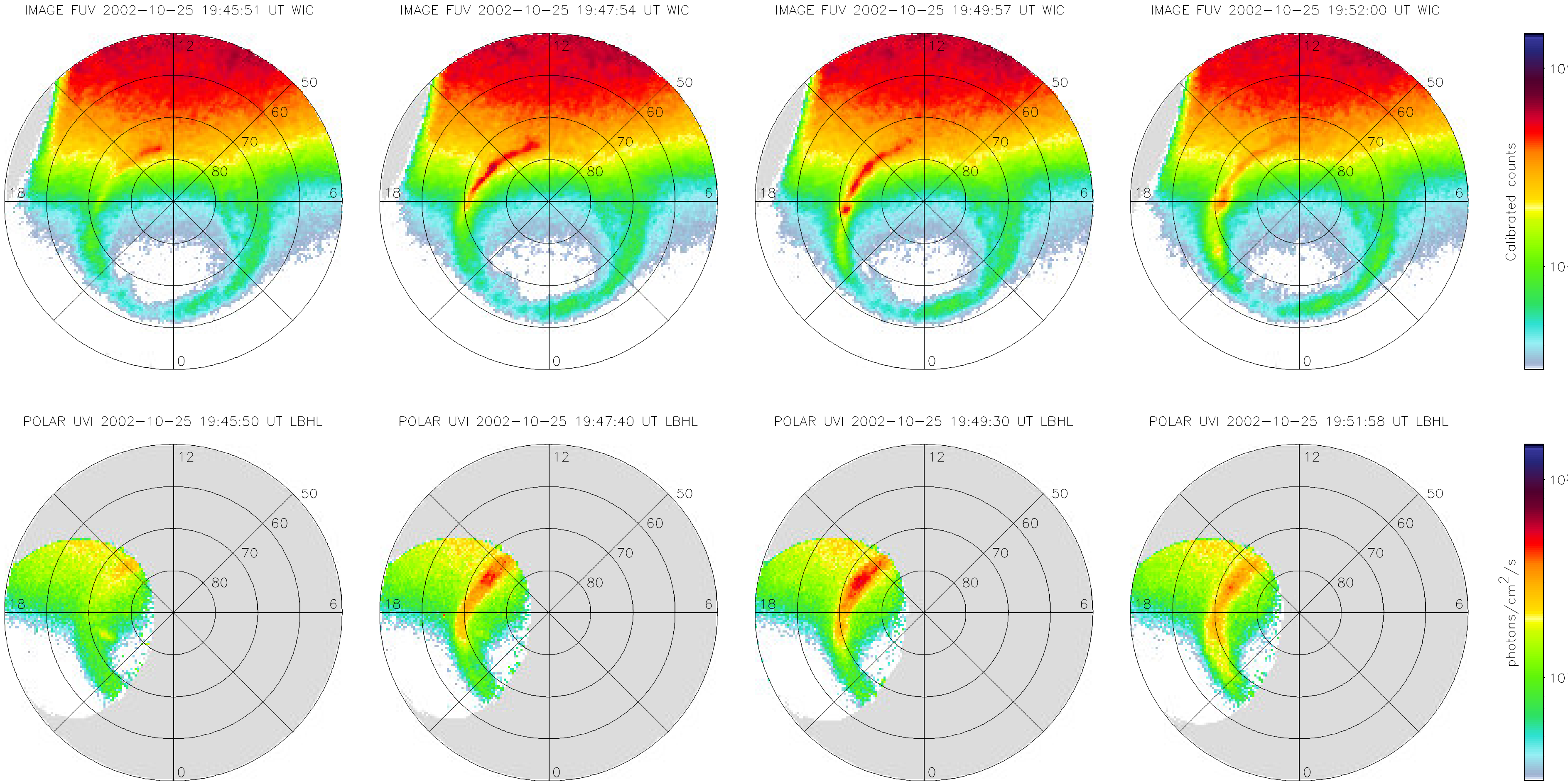
# SuperDARN Data



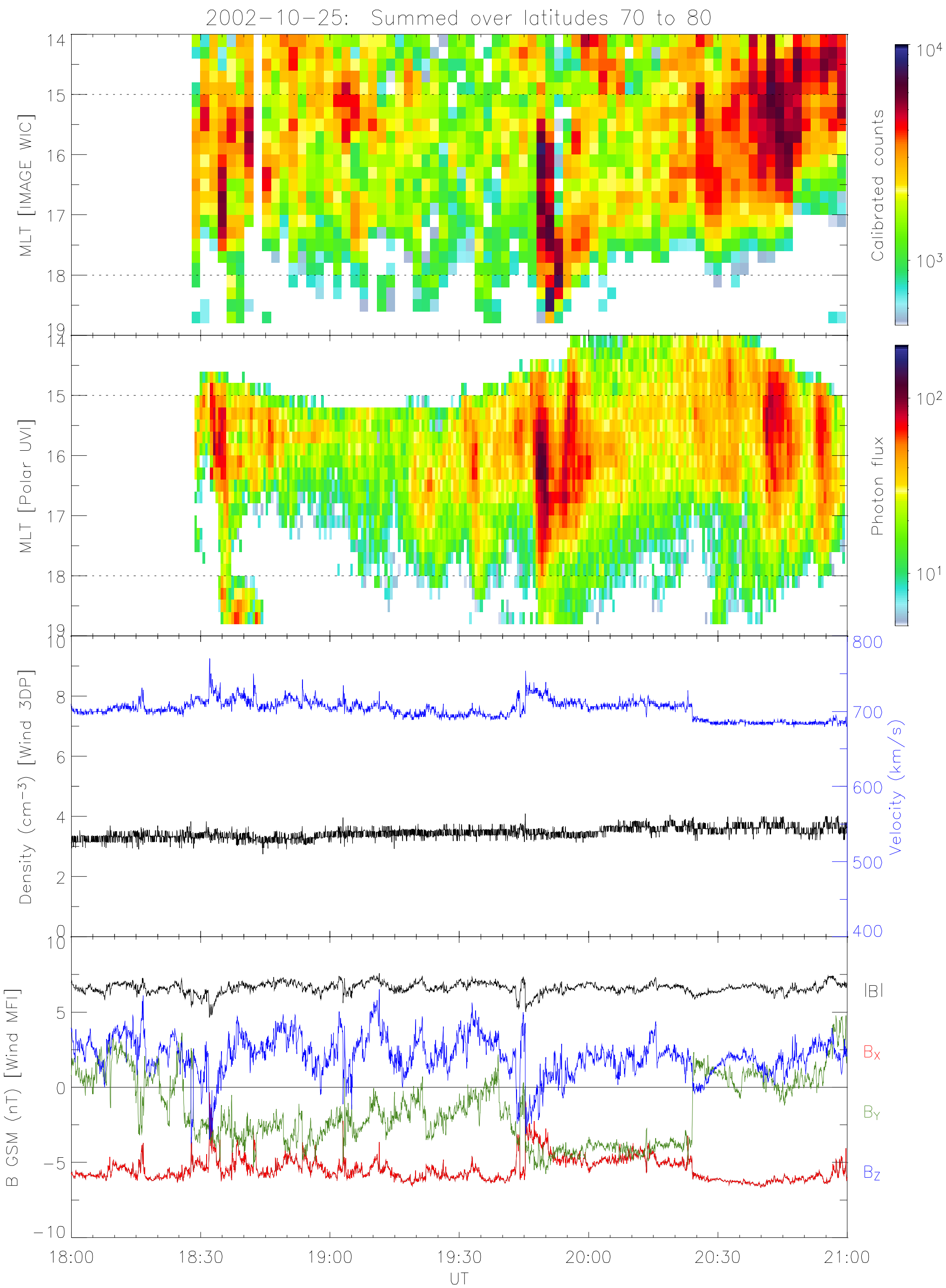

NH: Large increase in dayside velocities in eastward direction
Large increase in velocity shear ⇒ could increase FAC
Response to solar wind/IMF change?

SH: Good data coverage; no increase in dayside velocities
Complex change in convection pattern; stagnation point?
No auroral signature

# 25 October 2002




Simultaneous widespread brightening (< 15 MLT to 18 MLT) in both hemispheres at 19:47 UT (relatively conjugate)




Simultaneous widespread brightening at 19:47 UT in both hemispheres

Other brightenings and structure (and lots of it) non-conjugate

Solar wind density constant; velocity large with minor variations

IMF $B_X < 0$

$B_Y < 0$ (mostly)

$B_Z > 0$ w/fluctuations

# Summary

Prediction: For $B_Y > 0$, afternoon aurora more structured [brighter] in the southern hemisphere

For $B_Y < 0$, afternoon aurora more structured [brighter] in the northern hemisphere

2 November 2002:

Brightening in north aurora absent in south for $B_Y > 0$

$\Rightarrow$ Large decrease in dynamic pressure and IMF rotation

25 October 2002:

Sporadic brightenings in north and south for $B_Y < 0$

$\Rightarrow$ High solar wind velocity and large $B_Z$ fluctuations

Seeing short-lived response to changes in solar wind and IMF and not quasi-steady state conditions observed on 4 November 2002

**=>** M-I system responds asymmetrically to solar wind variability