

Polar UVI Support of THEMIS Science: Pre- and Post-Launch

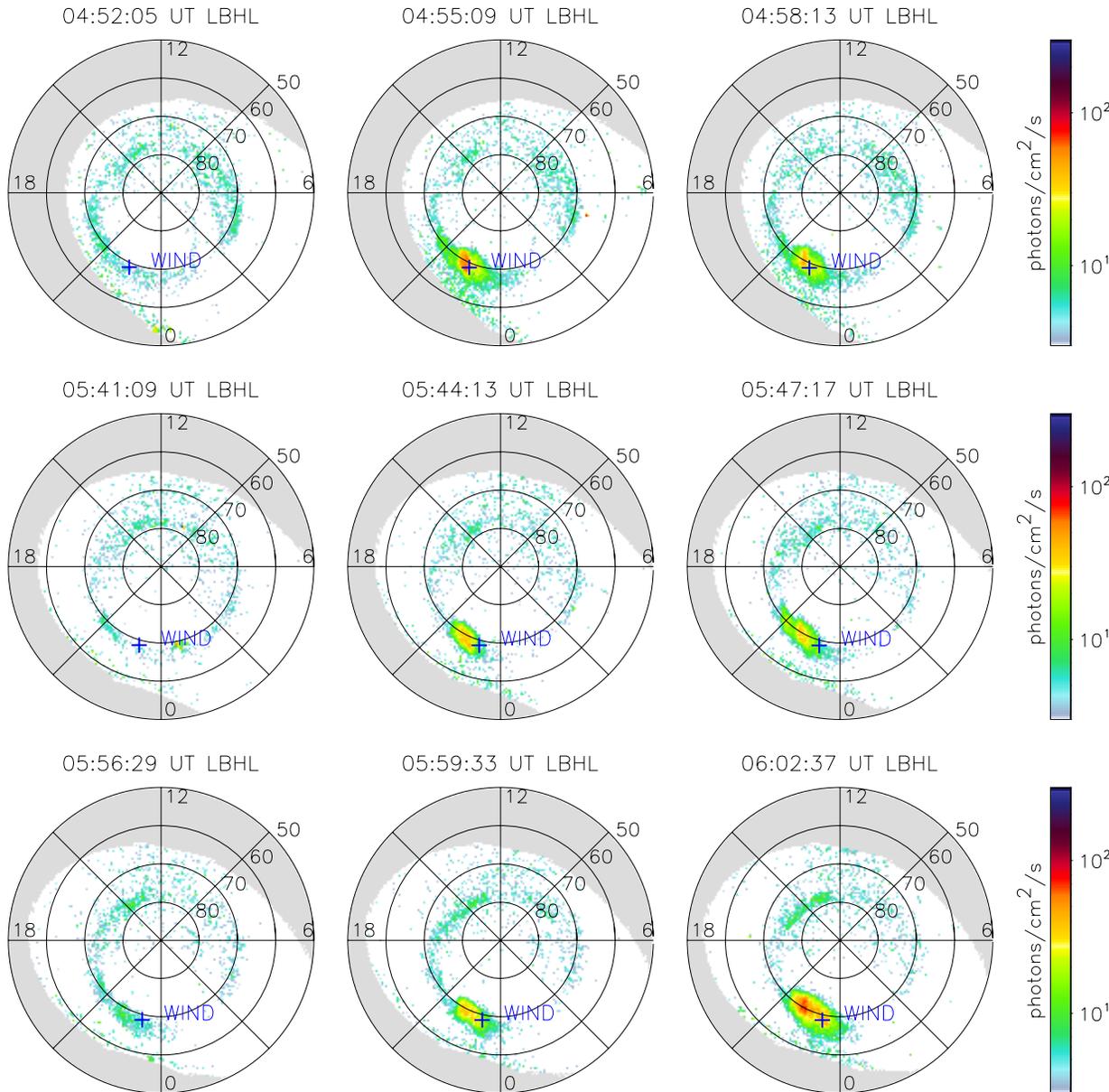
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Part 1: Pre-THEMIS Launch

- **Our goal:** Combine plasma sheet measurements with global auroral images to address the question: “Do substorm effects travel in \rightarrow out (current disruption) or out \rightarrow in (NENL)?”
 - Rather than use several spacecraft in a radial alignment, analyze several single-spacecraft events at different radial distances
 - Quasi-statistical – not instantaneous – picture (few events)
(Not a new idea: e.g., *Angelopoulos et al.* [1997]; *Fairfield et al.* [1999]; *Fillingim et al.* [2000; 2001; 2003]; *Baker et al.* [2002]; *Nakamura et al.* [2002]; and **many, many** others)
- **Our results:** Activity in the near-Earth plasma sheet ($X < -20 R_E$) is magnetically connected to intense auroral emission
- **Our conclusion:** Plasma sheet disturbances propagate tailward as intense auroral emission moves poleward \rightarrow **source $\sim 10 R_E$**

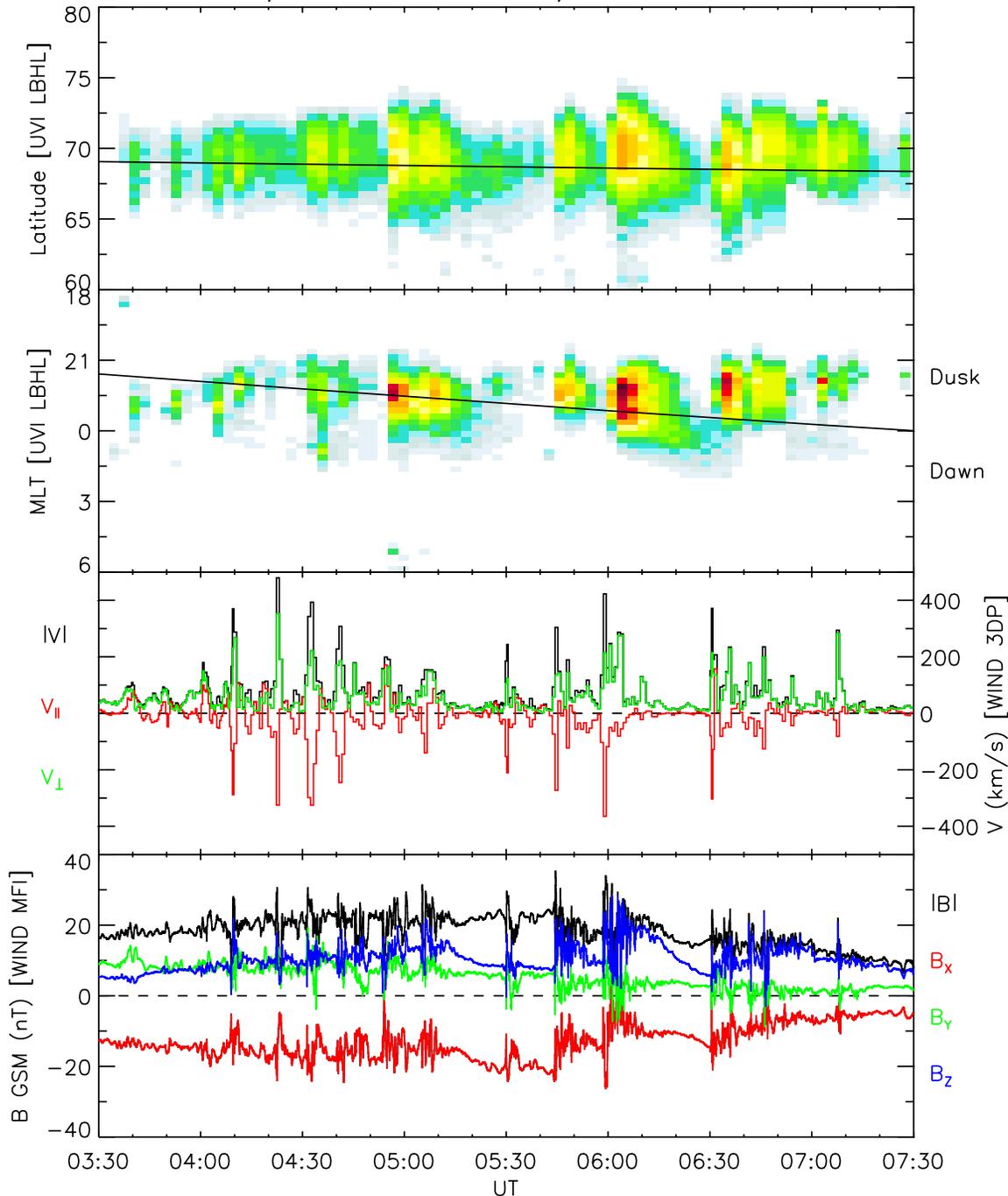
Example 1: 1997-07-26



Polar UVI observed a series of small scale, short lived auroral brightenings – pseudo-breakups and/or small substorms – also see *Fillingim et al.* [2000; 2001; 2003]

Wind located in the near-Earth plasma sheet at $X \sim -10 R_E$

Polar UVI/WIND: 1997-07-26/03:30:00 - 07:30:00



Top two panels:

Magnetic latitude and local time keograms; black line is Wind footprint

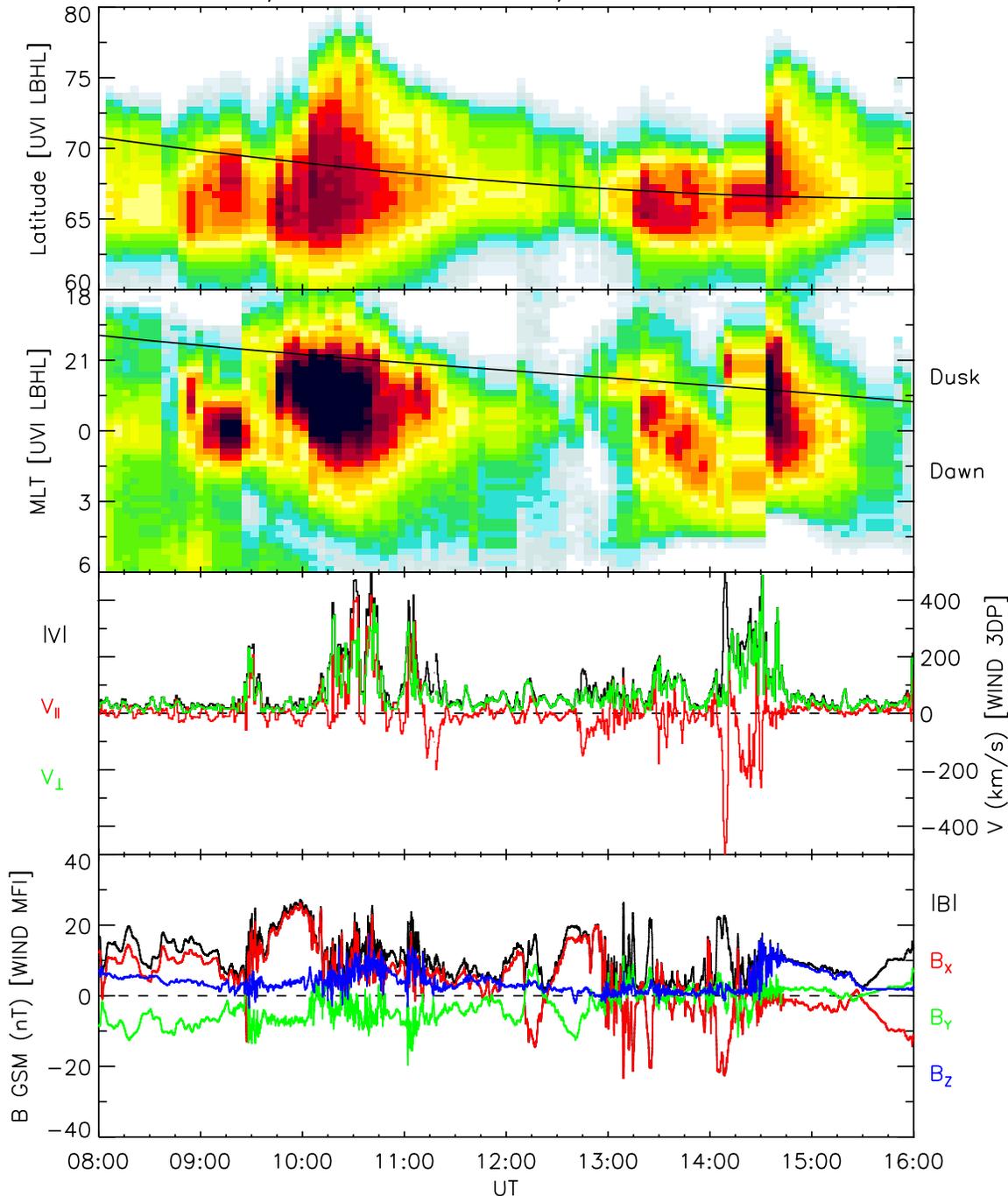
Bottom two panels:

Plasma sheet $\langle \mathbf{v} \rangle$ and \mathbf{B}

Excellent correlation between large $\langle \mathbf{v} \rangle$, ΔB , and the onset of auroral brightenings near Wind footprint

Plasma sheet activity and auroral brightenings **simultaneous** within resolution of instruments (~ 1 minute)

Polar UVI/WIND: 1996-03-27/08:00:00 - 16:00:00



Example 2: 1996-03-27

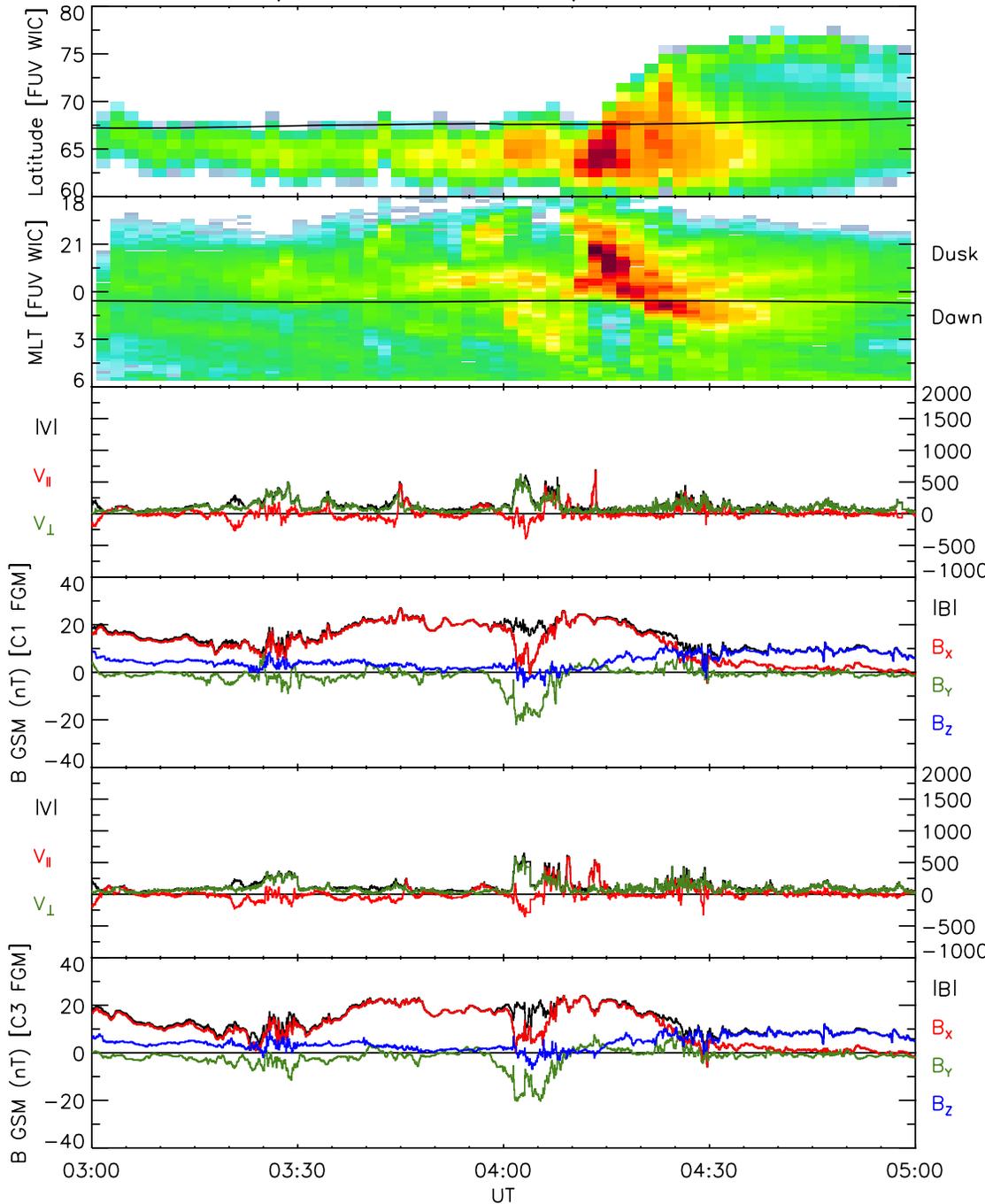
Polar UVI observed two major multi-intensification substorms – also see *Angelopoulos et al. [1997]; Fillingim et al. [2001; 2003]*

Wind at $X \sim -15 R_E$

Large $\langle \mathbf{v} \rangle$ only seen when region of intense aurora expands to encompass footprint **or** intensification occurs near footprint

Large amplitude, high frequency fluctuations of \mathbf{B} well correlated with $\langle \mathbf{v} \rangle$ ($\Delta \mathbf{B}$ also associated with current sheet and PSBL)

IMAGE FUV/Cluster: 2001-08-27/03:00:00 - 05:00:00



Example 3: 2001-08-27

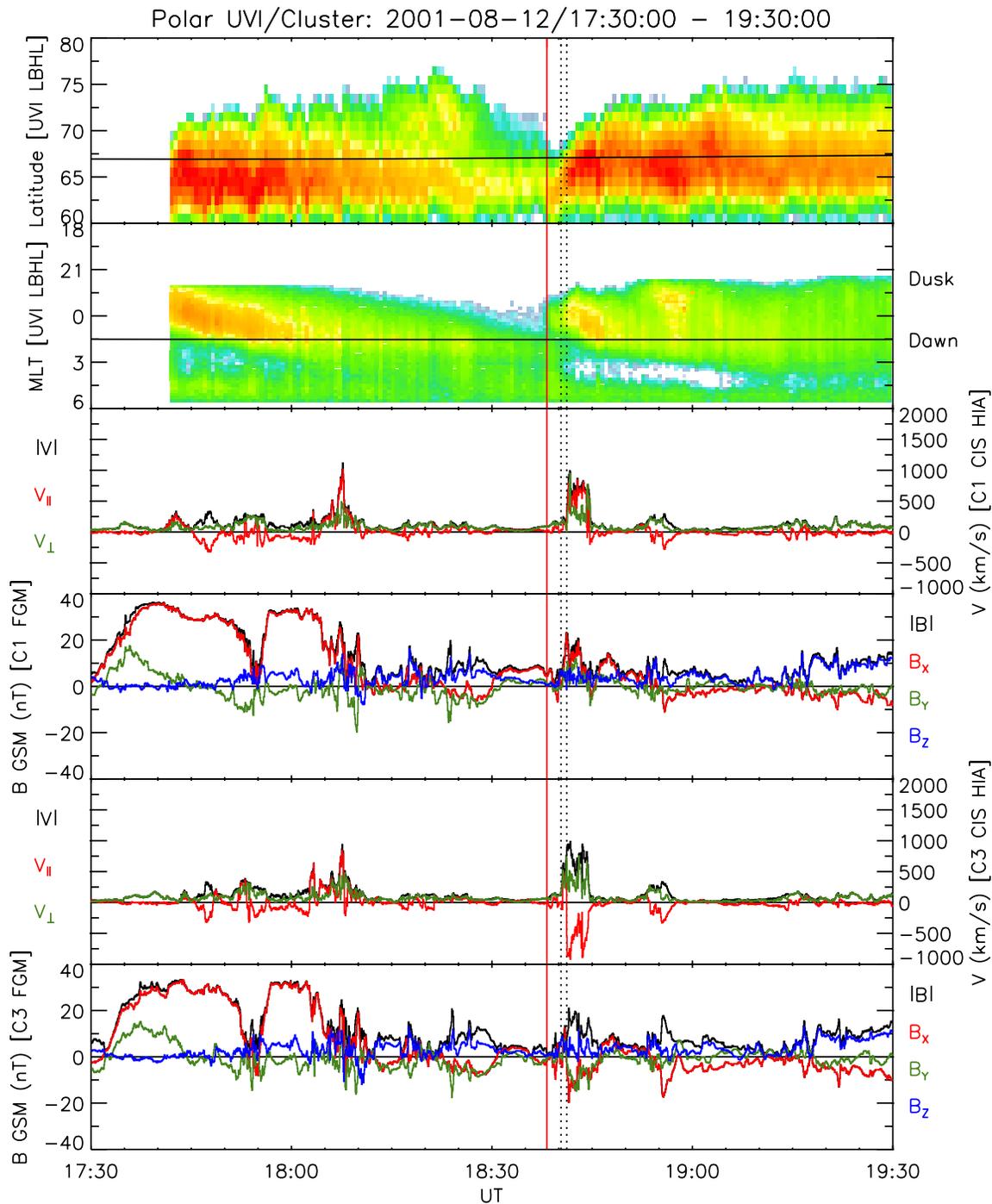
IMAGE FUV observed precursor activity followed by onset at 4:08 UT – also see *Baker et al.* [2002]

Cluster at $X \sim -18 R_E$

Large $\langle v \rangle$ seen by C1 and C3 when aurora brightens near footprint (3:25, 3:45, 4:01, 4:09, 4:14, 4:22 UT)

Different interpretation than *Baker et al.* [2002]: Reconnection occurs at 4:01 UT, 7 minutes **before** substorm expansion

However, at 4:01 UT, Cluster maps to aurora!



Example 4: 2001-08-12

Polar UVI observed onset at 18:38:30 UT \pm 18 sec (red line) – also see Nakamura *et al.* [2002]

Cluster at X $\sim -18 R_E$

From onset to 18:44 UT, aurora expands poleward at $\sim 1^\circ/\text{min}$ or $\sim 2 \text{ km/s}$

Emission reaches Cluster ~ 2 min after onset;

onset maps to $\sim 6 R_E$; from 6 to $18 R_E$ in 2 min $\rightarrow \sim 600 \text{ km/s}$ tailward

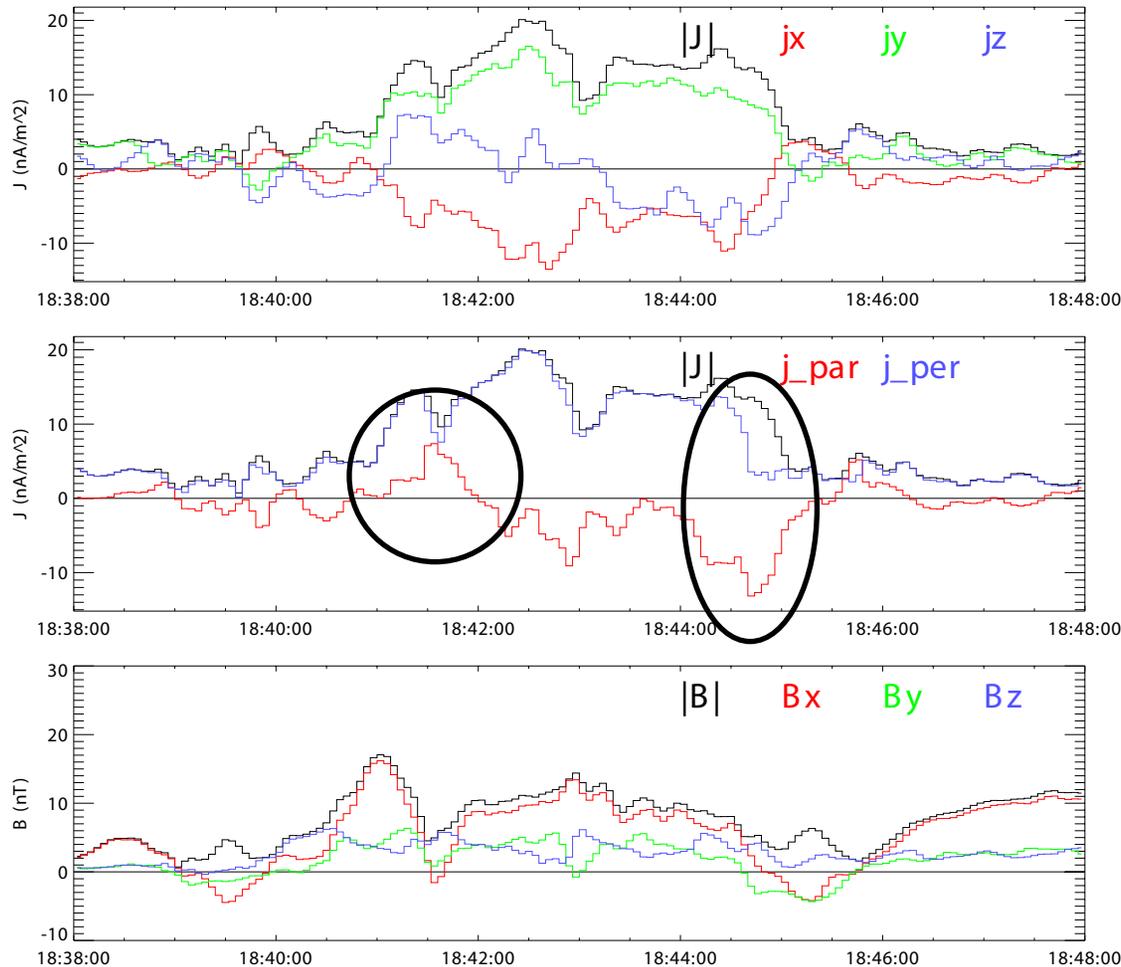
As auroral emission moves poleward, plasma sheet activity propagates tailward

Coupling through Field Aligned Currents

Field aligned currents can provide connectivity between plasma sheet and ionosphere

Determine currents using curlometer ($\mathbf{J} = \nabla \times \mathbf{B}$)
→ Significant FAC during large $\langle \mathbf{v} \rangle$ event (circled)

Plasma sheet-ionosphere travel time for thermal electrons ($\frac{1}{2} - 1$ keV) is ~ 10 seconds
→ “Simultaneous” within resolution of detectors



Summary and Conclusions

In the near-Earth plasma sheet ($X < \sim -20 R_E$), **plasma sheet activity** (large $\langle v \rangle$ and ΔB) is **magnetically connected** to **intense auroral emission** → FACs provide M-I connection

Plasma sheet activity propagates **tailward** as auroral emission moves **poleward** → this suggests a **near-Earth** ($\sim 10 R_E$) source

Caveat: Our interpretation relies on accuracy of magnetospheric model [*Tsyganenko, 1996*] → static model, dynamic conditions

Our results appear **inconsistent** with the NENL (out → in) model of substorm onset: mid-tail source ($\sim 25 R_E$), Earthward propagation

However, we cannot completely *exclude* a NENL interpretation ***if...***

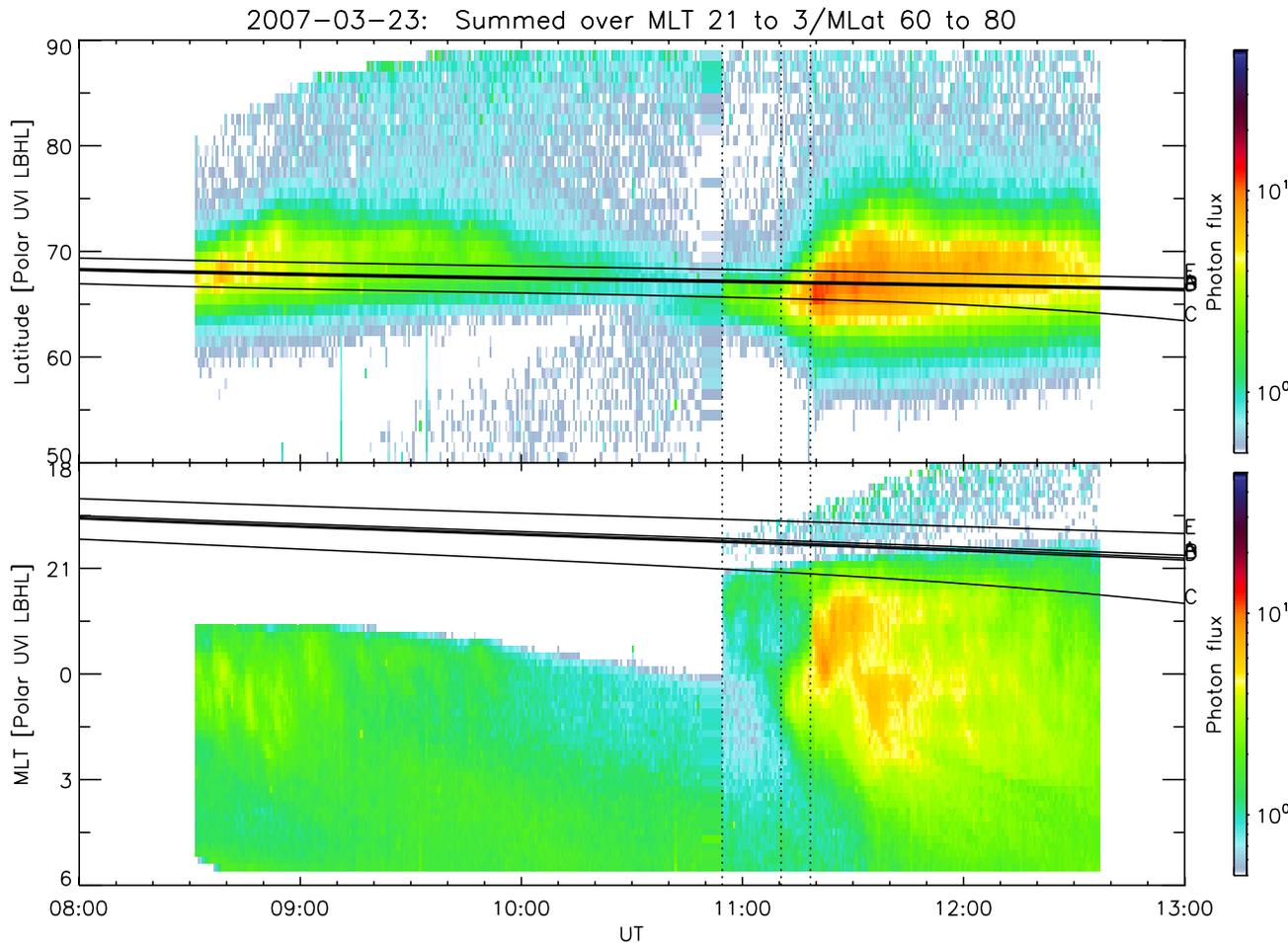
- There is no auroral signature of reconnection
 - Fast flows launched by reconnection are confined to a “thin” layer
 - There is no auroral signature of Earthward fast flows
- Extensive literature discussing auroral signatures of fast flows!

[*Henderson et al., 1998; Fairfield et al., 1999; Sergeev et al., 1999; Fillingim et al., 2000; Zesta et al., 2000; Nakamura et al., 2001; Ohtani, 2004; just to name a few*]

Part 2: Post-THEMIS Launch

- Polar currently supports THEMIS science by providing space-based observations of global aurora during THEMIS events
- These data are especially useful during times when THEMIS Ground Based Observatory (GBO) observations are limited; i.e.,
 - During northern hemisphere summer
 - During dayside events (see Example 3)
 - During inclement weather/full Moon
- Polar observations are conjugate to THEMIS GBO observations
→ further investigate conjugacy of substorm processes

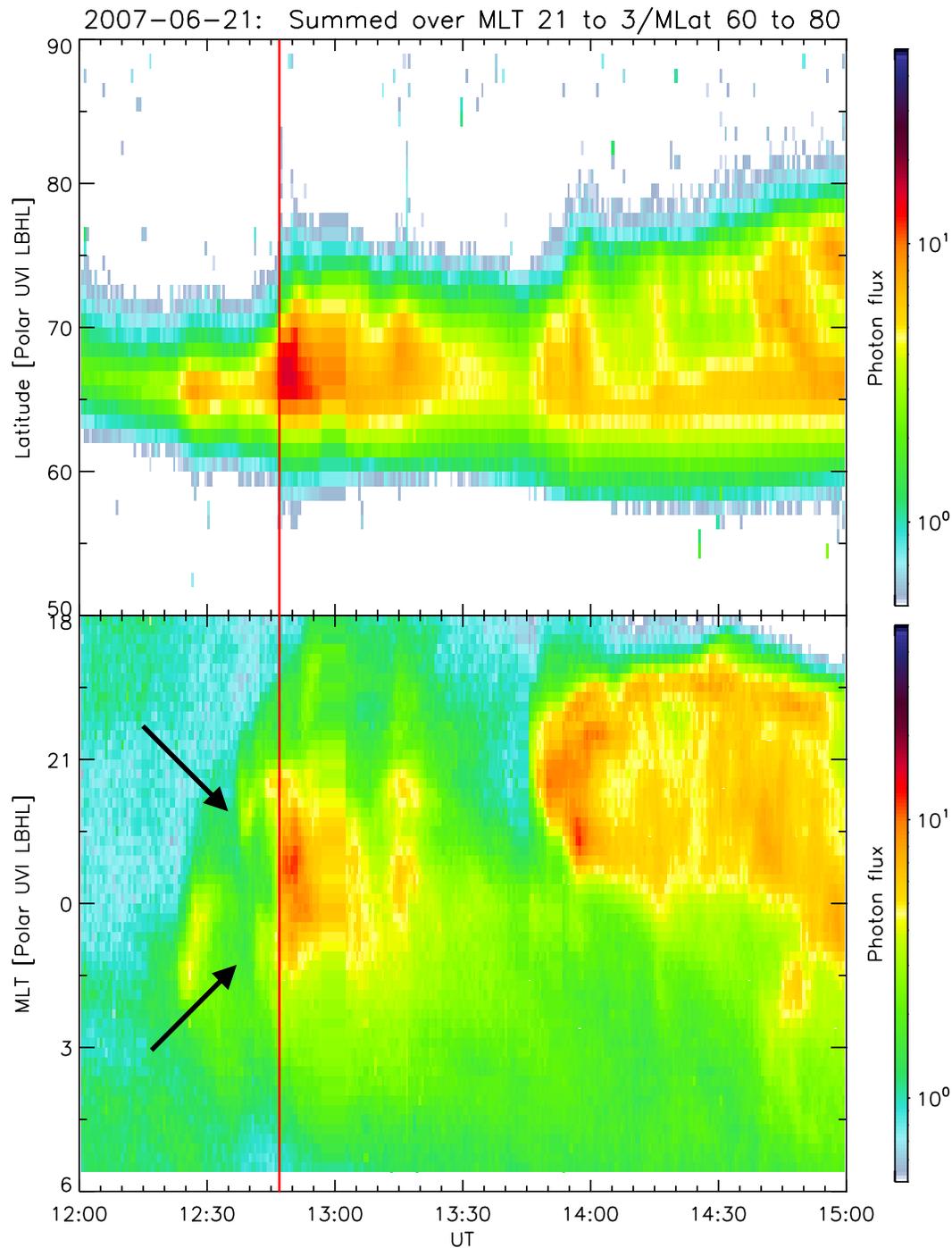
Example 1: 2007-03-23



Ground based magnetometers recorded substorm onset at ~11:18 UT

Polar UVI observed onset at 11:10 UT and intensification at 11:18 UT

Propagation of intensification
~ 1 hour MLT/min (or ~ 15°/min) westward
→ consistent with **THEMIS** timing

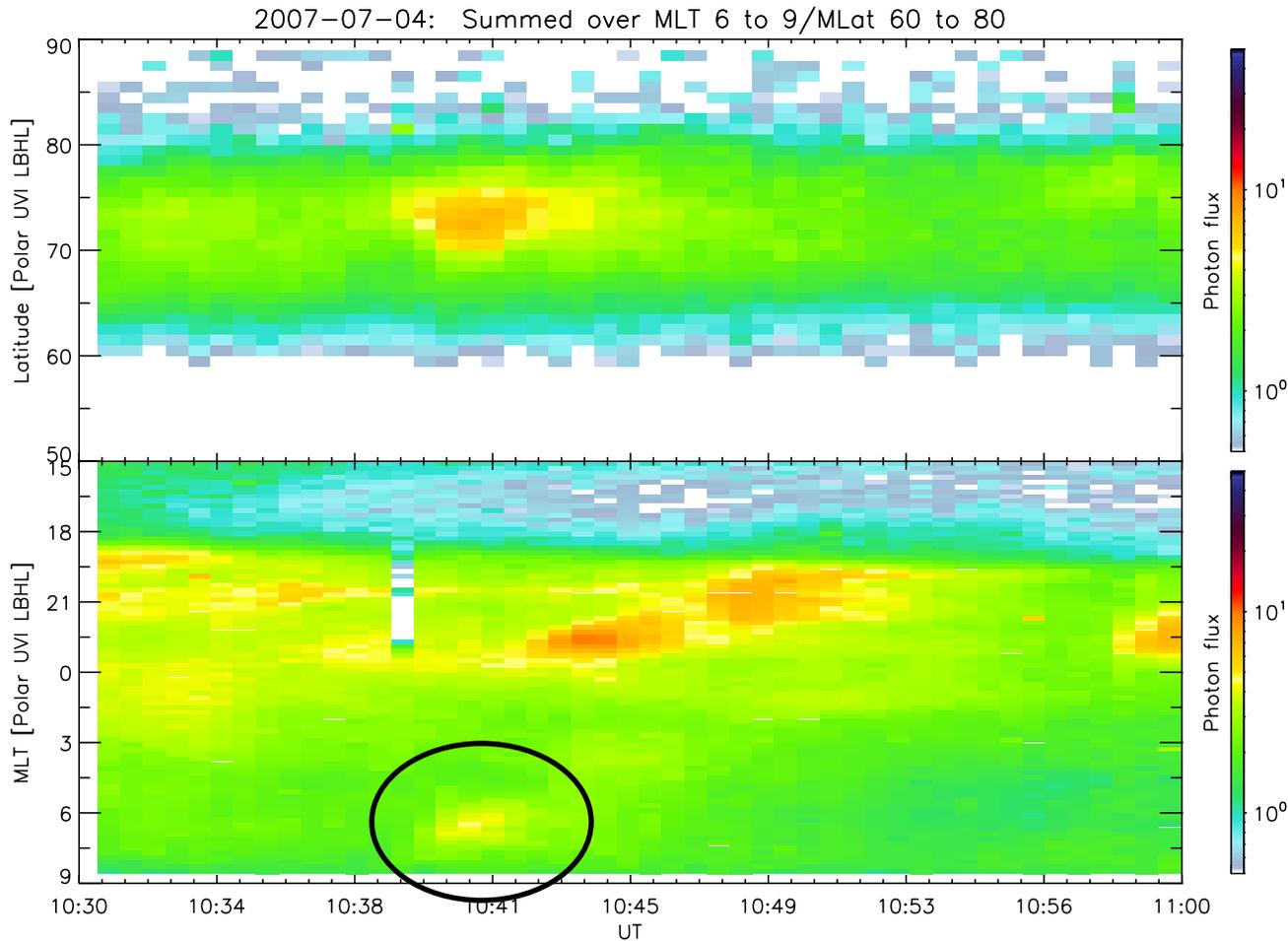


Example 2: 2007-06-21

THEMIS observed solar wind pressure pulse-induced magnetopause compression at ~ 12:46 UT

Polar UVI observed localized activity starting at 12:36 UT (pre-midnight) and 12:41 UT (post-midnight); pressure pulse-induced onset near midnight at 12:46 UT – at the same time or a few seconds *before* THEMIS observed magnetopause compression (it's OK – THEMIS was post-noon, pressure pulse hit pre-noon)

Example 3: 2007-07-04



THEMIS observed a hot flow anomaly (HFA) outside the magnetopause

Ground based magnetometers observed disturbance traveling downward from noon

Polar UVI observed emission in the pre-noon sector – auroral signature of HFA interacting with magnetosphere?

Summary & Future Opportunities

- Propagation speeds of auroral emission determined from Polar UVI images are consistent with propagation speeds of magnetospheric disturbance determined from timing between THEMIS spacecraft
 - Pressure pulse-induced onset nearly coincident with magnetopause compression (PP-induced vs. “normal” onsets)
 - Possible dayside auroral signature of HFA interacting with magnetosphere
- all warrant further study!
- Polar should remain operational through THEMIS tail phase (confirm or disprove interpretation presented in Part 1?)
 - Conjugate observations with GBOs
 - Unpredicted new opportunities...