Investigating the polar ionosphere during the development of dayside cusp enhancements on 25 September 2000

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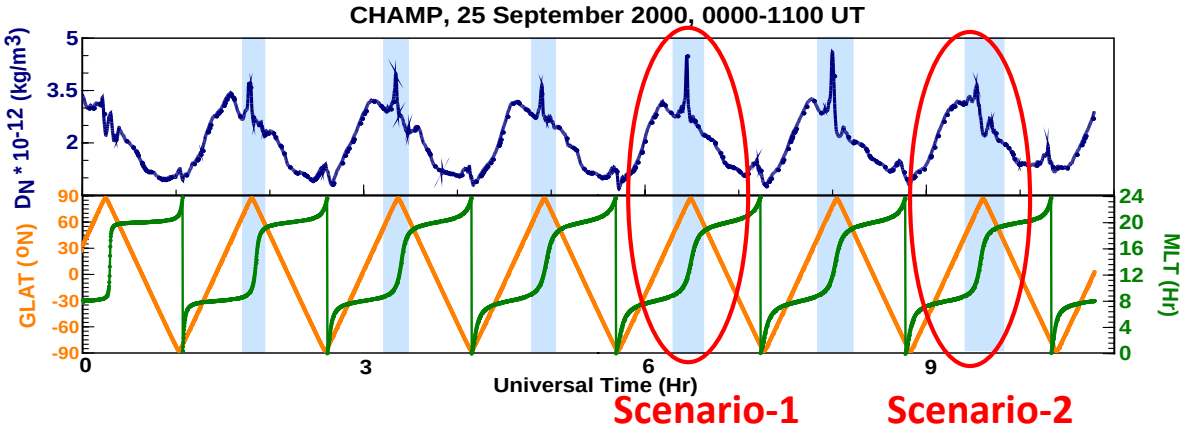
density spikes of the northern dayside cusp region [Lühr et al., 2004]



Motivation

It is not clear:

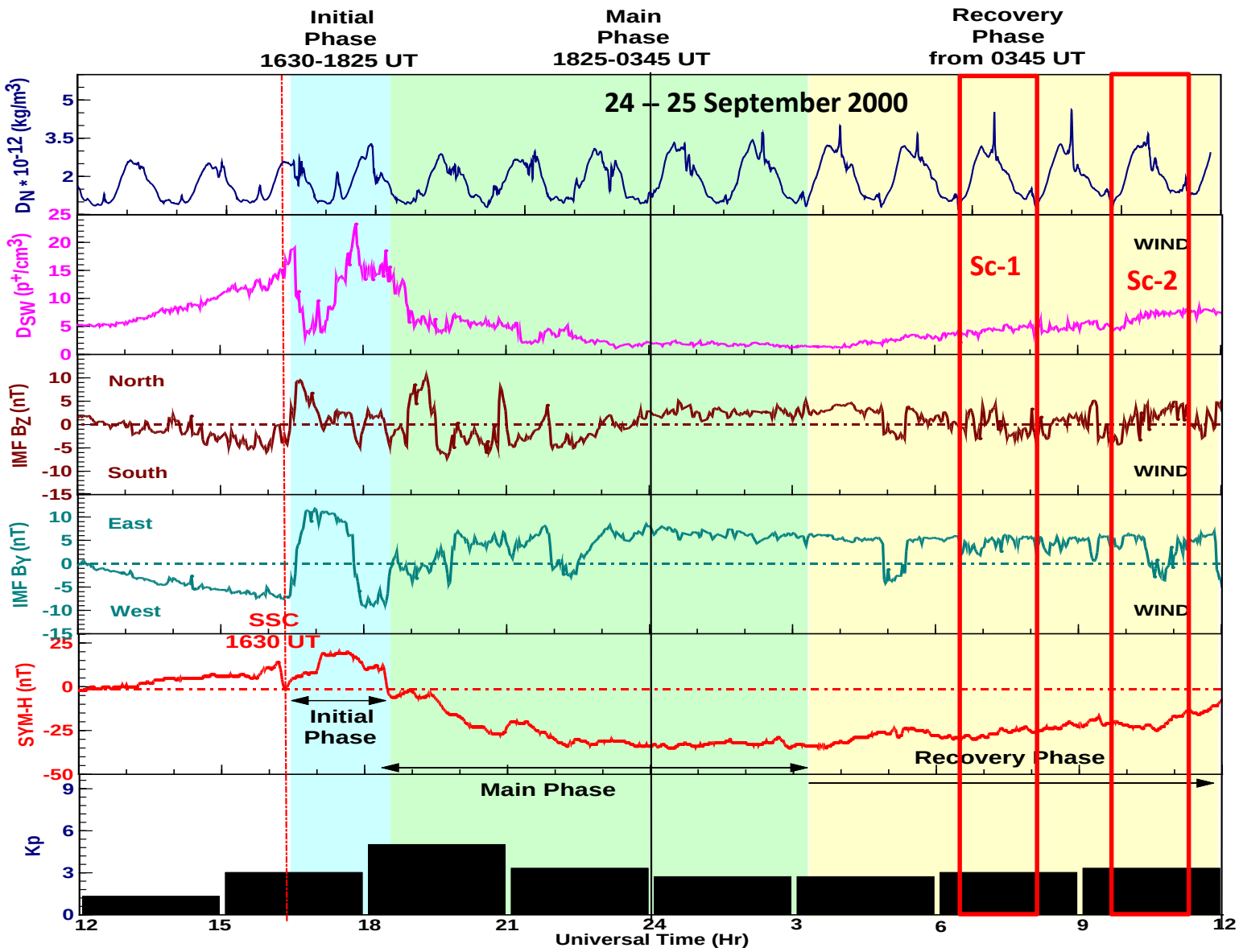
- how SW and IMF conditions varied during the development of dayside cusp enhancements (or density spikes) on 25 September 2000
  (only an average Kp of 3 is given for 25 September 2000 by Lühr et al. [2004])
- what sort of flow channels (FCs) were associated with the density spikes of 25 September 2000
  (only CHAMP fine-scale field aligned currents (FS-FACs~1-km size) and their averaged values are shown by Lühr et al. [2004])
- how the two key elements of upwelling, (1) FC and (2) upwelling over FC, were associated during the development of 25 September 2000 density spikes
  (20 December 1998 EISCAT Svalbard Radar (ESR) observations are shown by Carlson et al. [2012])

Aims

1) to investigate SW/IMF conditions and the state of the polar cap region on 24-25 September 2000 in the context of the Dungey [1961] convection cycle
2) to employ additional CHAMP wind data in order to observe flow channel signatures associated with the density spikes
3) to demonstrate with all CHAMP 25 September 2000 observations and with two scenarios that:
   - enhanced average FS-FACs were associated with flow channels (FCs)
   - enhanced average FS-FACs and FCs were commonly associated with the density spikes of 25 Sep. 2000

Results: SW and IMF conditions on 24-25 September 2000:

weak (SYM-H_{Min} ≈ -27 nT) geomagnetic storm



1) density pikes developed during the storm main phase and recovery phase

2) B_Z ≈ 0 on 25 September

3) B_Y > 0 on 25 September

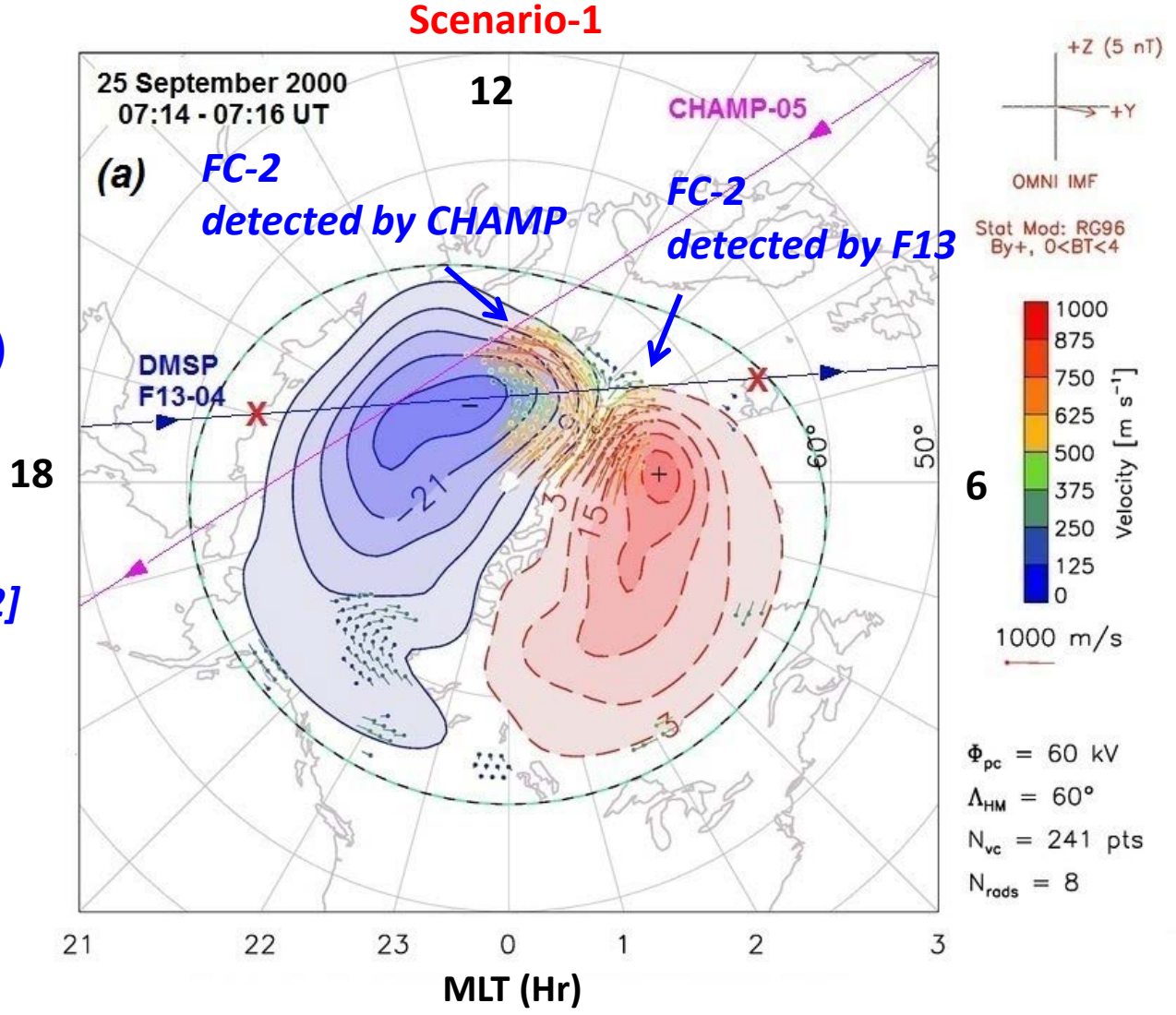
4) $|B_Y| > |B_Z|$ implies B_Y dominations and an asymmetic 2-cell convection pattern

Results: State of the polar cap region on 25 September 2000 during 0714-0716 UT: SuperDARN detected an asymmetric 2-cell convection pattern due to IMF B_Y domination and FC-2 type flow channels that are also tracked by CHAMP and DMSP F13

FC-2:

- **is located on old-open field lines in the polar cap (dayside MLT sector)**
- **occurs later on (t > 20 min) during dayside reconnection**

[Andalsvik et al., 2011, 2012]



Results: CHAMP wind (1136 MLT) and DMSP F13 drift (1053 MLT) measurements detect a FC-2 type flow channel underlying the midday density spike

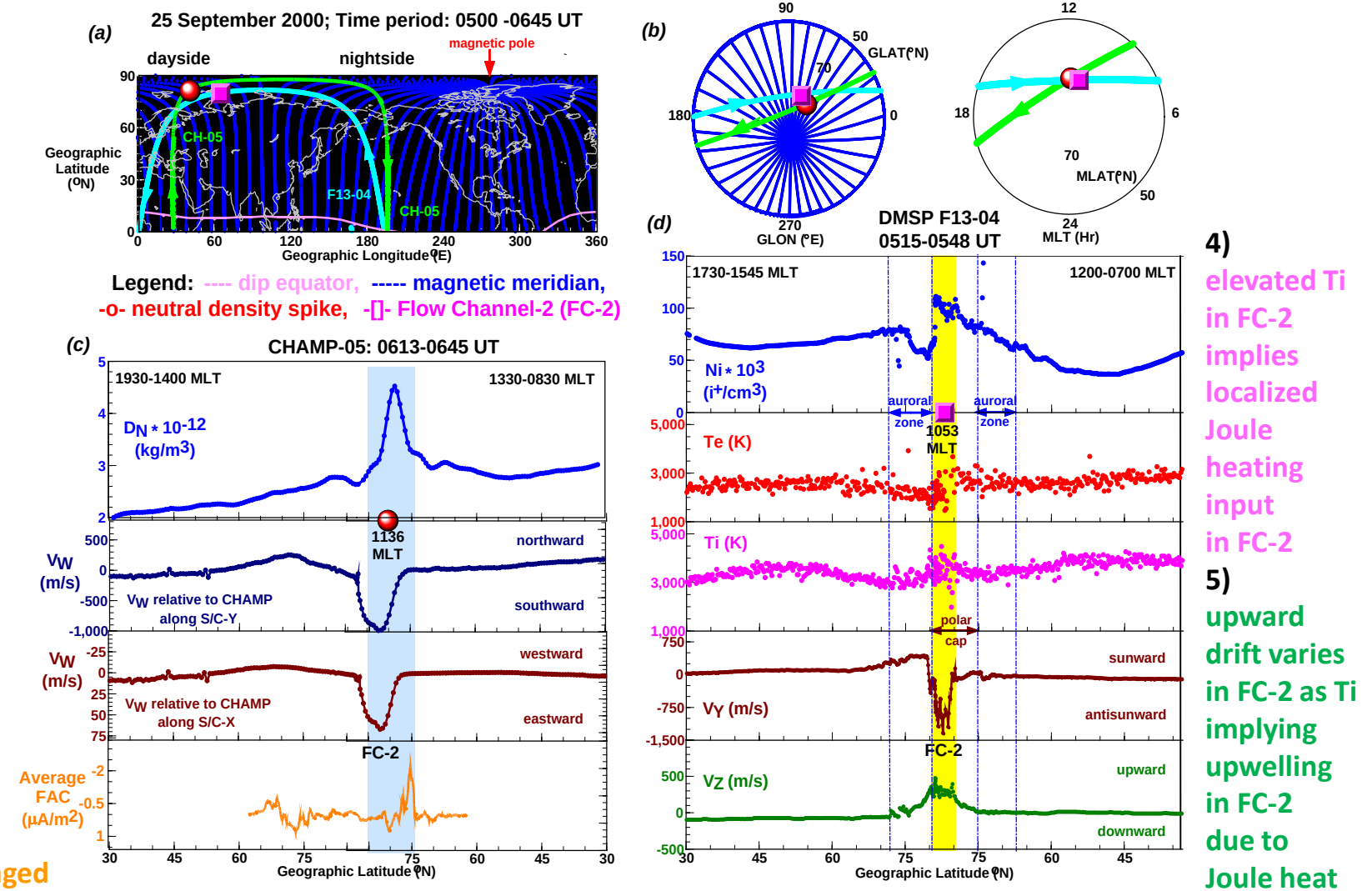
Scenario-1

1) FC-2 underlying the density spike

2) FC-2 signature in southward meridional winds (~1,000 m/s)

in eastward zonal winds (~60 m/s)

3) enhanced averaged FS-FACs in FC-2

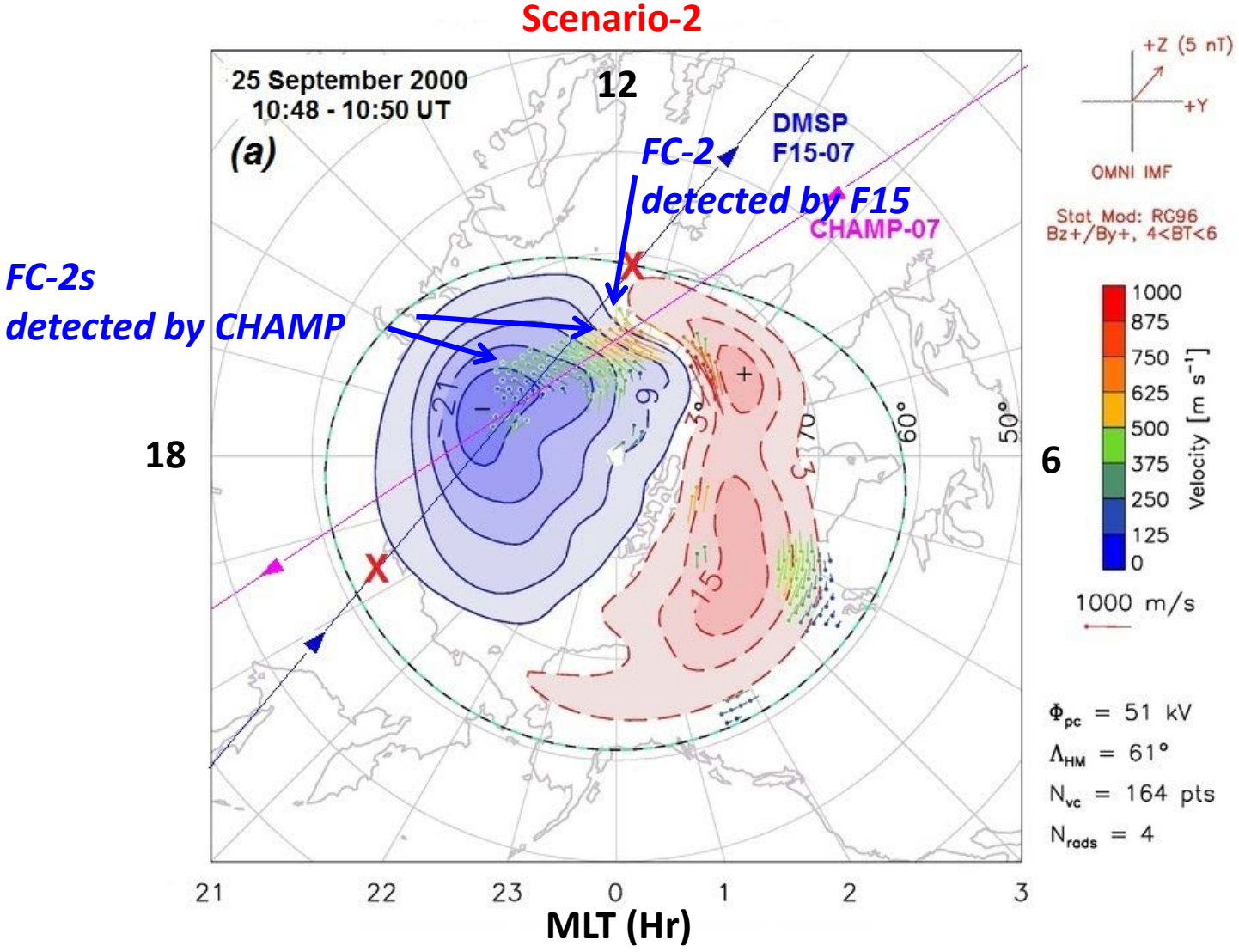


4) elevated Ti in FC-2 implies localized Joule heating input in FC-2

5) upward drift varies in FC-2 as Ti implying upwelling in FC-2 due to Joule heat

in FC-2: C1-C2 FACs connect via ionospheric Pedersen currents *[Sandholt and Farrugia, 2009]*

Results: State of the polar cap region on 25 September 2000 during 1048-1050 UT: SuperDARN detected an asymmetric 2-cell convection pattern due to IMF B_Y domination and FC-2 type flow channels that are also tracked by CHAMP and DMSP F15



Results: CHAMP wind measurements detect FC-2s underlying the midday (1134 MLT) and evening (1937 MLT) density spikes DMSP F15 drift measurements detect the midday (1145 MLT) FC-2

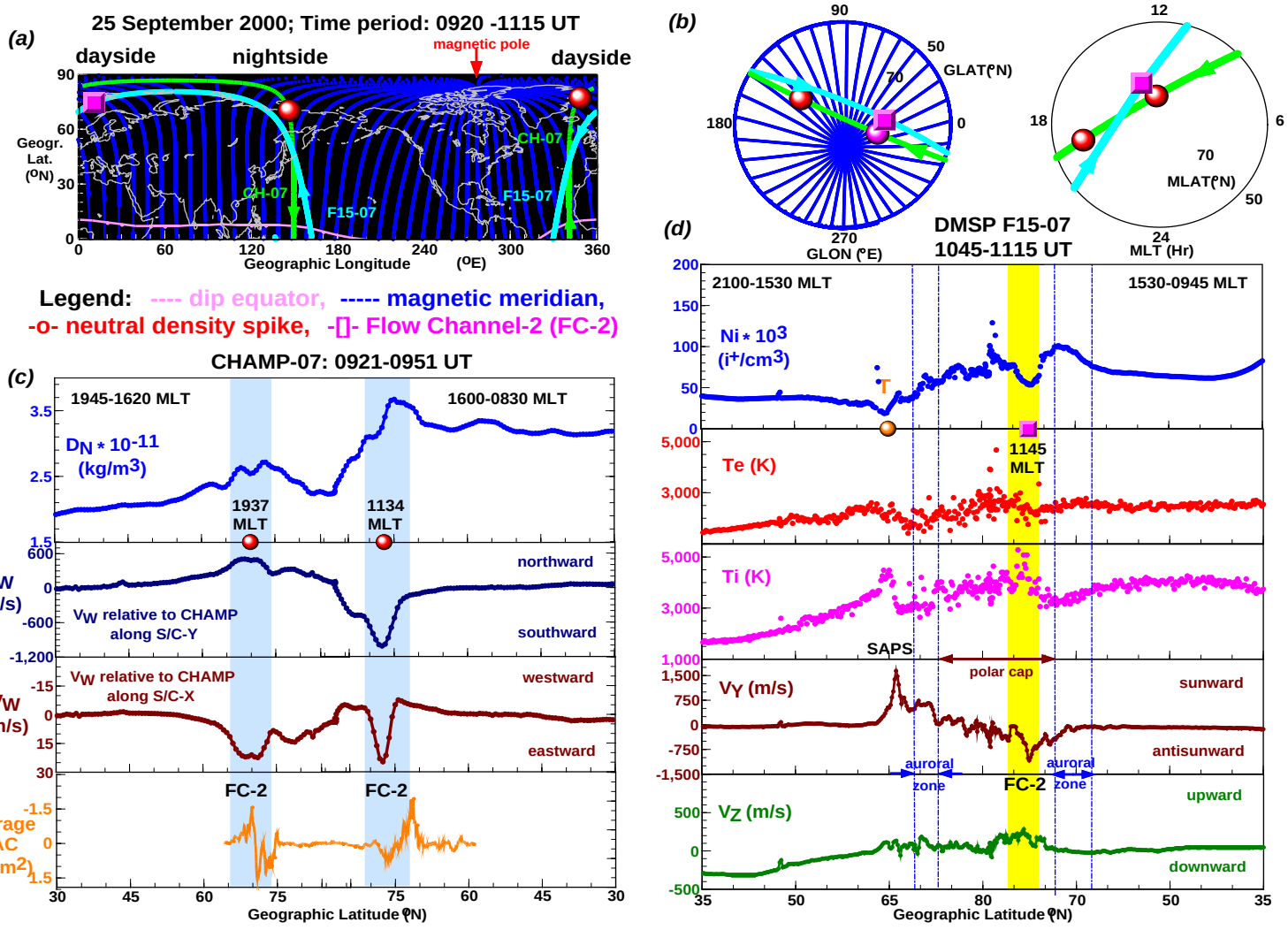
Scenario-2

1) each FC-2 underlying a density spike

2) each FC-2 signature in meridional winds

and in zonal winds

3) enhanced averaged FS-FACs in each FC-2

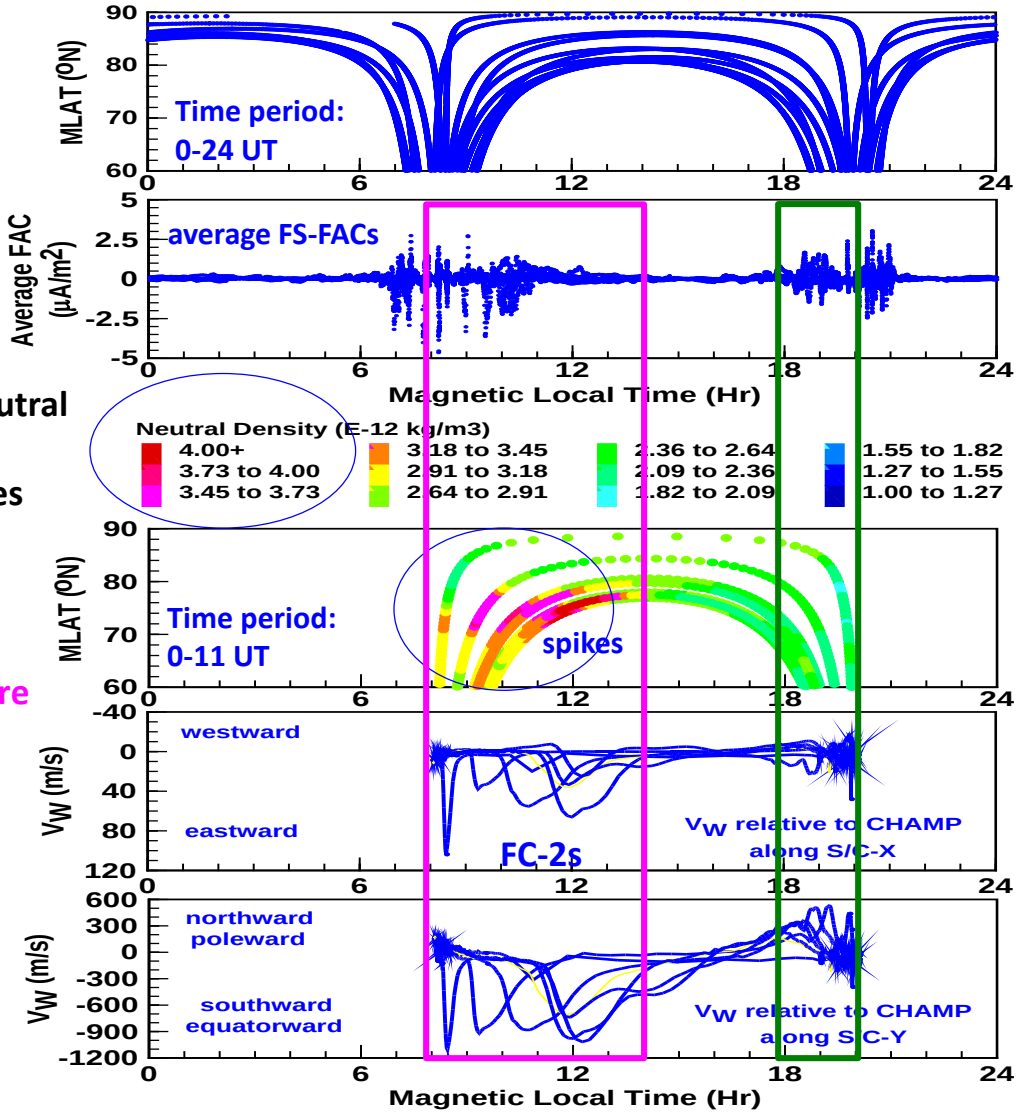


3) elevated Ti in FC-2 implies localized Joule heating input in FC-2

4) upward drift varies in FC-2 as Ti implying upwelling in FC-2 due to Joule heat

in FC-2: C1-C2 FACs connect via ionospheric Pedersen currents *[Sandholt and Farrugia, 2009]*

Results: Summary of CHAMP observations for 25 September 2000
CHAMP detected FS-FACs, FC-2 type flow channels, and density spikes



elevated neutral densities of density spikes

large (small) density spikes were associated with :
- intensive (weak) SS-FACs
- large (small) FC-2s
- strong (weak) equatorward (poleward) winds

in the daytime (evening) sector of 25 September 2000

CHAMP measured fine-scale field-aligned currents (FS-FACs~ 1 km) averaged over 16 sec

CHAMP measured air drag converted to neutral density

CHAMP measured zonal east/west winds relative to CHAMP (~8,000 m/s)

CHAMP measured meridional north/south winds relative to CHAMP (~8,000 m/s)

Conclusions

- The development of dayside cusp enhancements (or density spikes) detected by CHAMP on 25 September 2000 are specified as a storm-time phenomenon.
- The 8-15 MLT CHAMP wind observations demonstrate a strong connection between the eastward (or antisunward) flow channels underlying the daytime density spikes and the southward (or equatorward) winds.
- The 18-20 MLT CHAMP wind observations demonstrate a strong connection between the eastward (or antisunward) flow channels underlying the evening density spikes and the northward (or poleward) winds.
- By identifying these eastward (or antisunward) flow channels as FC-2s, the FACs connecting via ionospheric Pedersen currents in these FC-2s could be specified as cusp currents or C1-C2 FACs.
- Two key elements of upwelling associated with density spikes are verified with the simultaneous CHAMP observations of (1) FC and (2) upwelling over FC fueled by FS-FACs, and their associated cusp enhancements (or density spikes).

Flow Channel (FC) types of the two-cell Dungey convection cycle

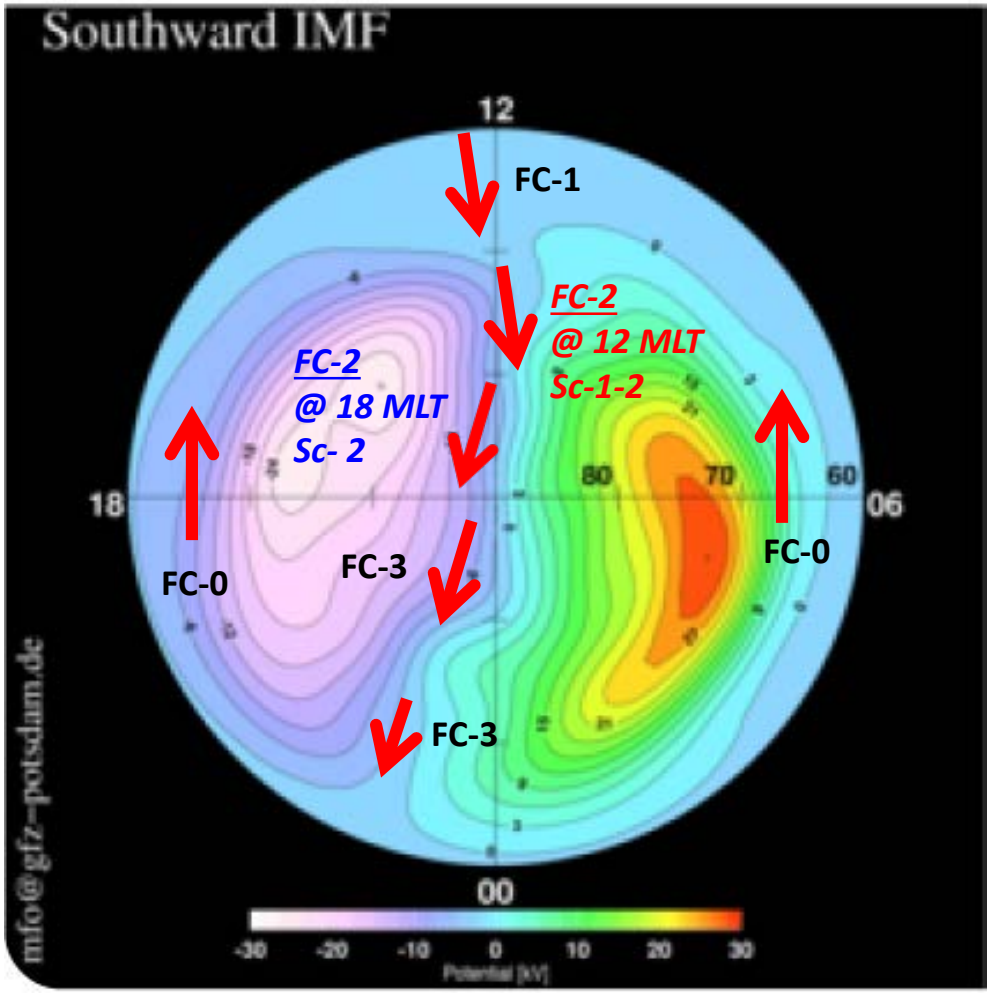
FC-1:
located on newly-open field lines
in the auroral zone (BPS open field line regime)
occurs within the first 10 min of dayside reconnection

FC-2: *(interest of this study)*
located on old-open field lines
in the polar cap (dayside MLT sector)
occurs later on (t > 20 min)
during dayside reconnection

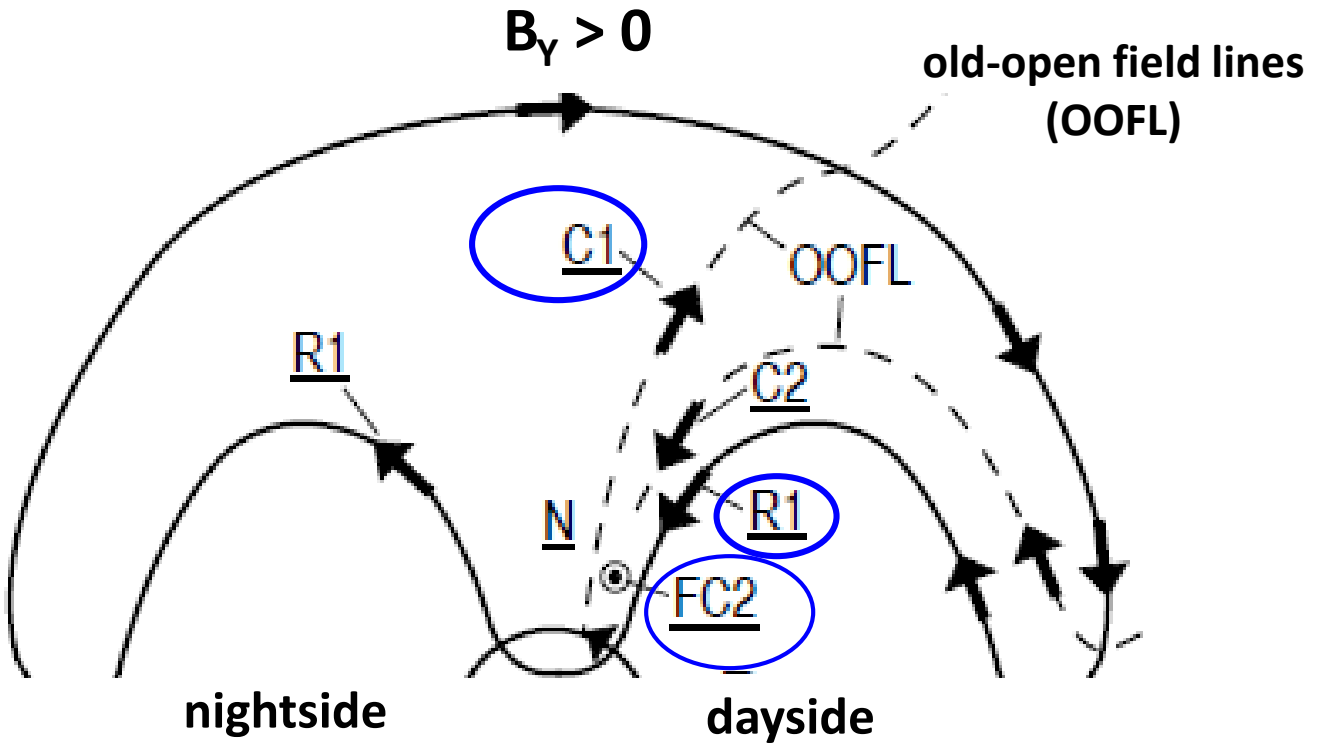
FC-3: located on old-open field lines
in the polar cap
(evening/nightside MLT sector) and
driven by magnetotail reconnection

FC-0:
located on closed field lines
in the auroral zone
(CPS closed field line regime)
represents return flows

[Andalsvik et al., 2011, 2012]



FC-2 type flow channel and associated field aligned currents (FACs) on the dayside



[Sandholt and Farrugia 2009]

FC-2 on the dayside:

Upward Cusp 1 (C1) FACs connect via ionospheric Pedersen currents with downward C2 FACs within FC-2.

New Findings

- A weak magnetic storm (SYM-H_{Min} ≈ -27 nT) had been unfolding on 25 September 2000 when some significant dayside reconnections occurred of which ionospheric signatures appeared as flow channels.

- CHAMP detected northern dayside cusp enhancements (or density spikes) during the storm main phase and recovery phase.

- CHAMP wind measurements detected the signature of FC-2 type flow channels in the southward (or equatorward) winds in the daytime sector (8-14 MLT) and in the northward (or poleward) winds in the evening sector (18-20 MLT).

- All CHAMP observations show simultaneously (1) the enhancement of average FS-FACs and (2) FC-2 type flow channels plus their associated density spikes demonstrating two key elements of upwelling with simultaneous CHAMP measurements.