Simultaneous Observations of a FTE on Jan. 4, 2005 with Cluster and TC1

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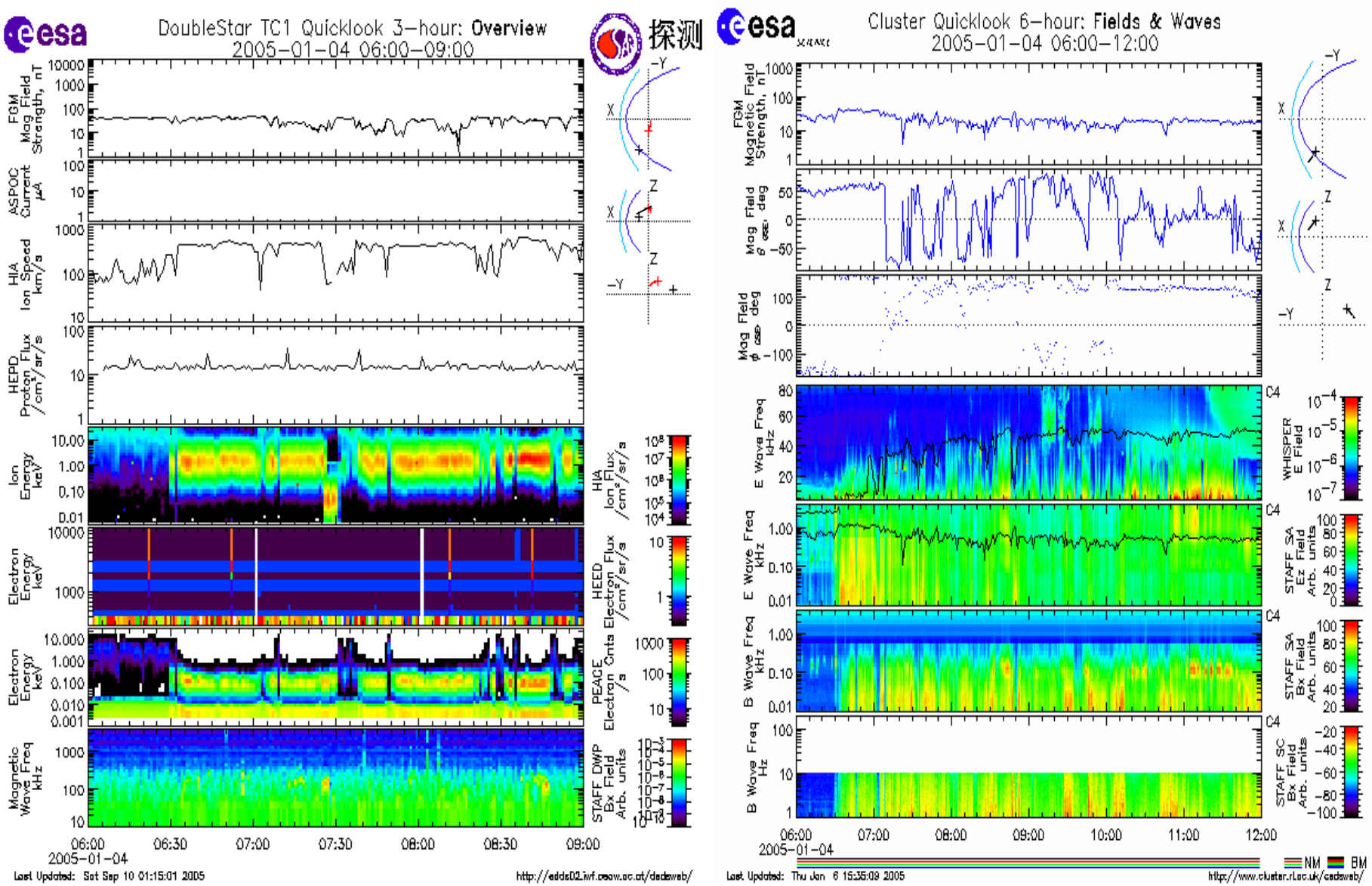
Chinese Double Star-Cluster Science Team

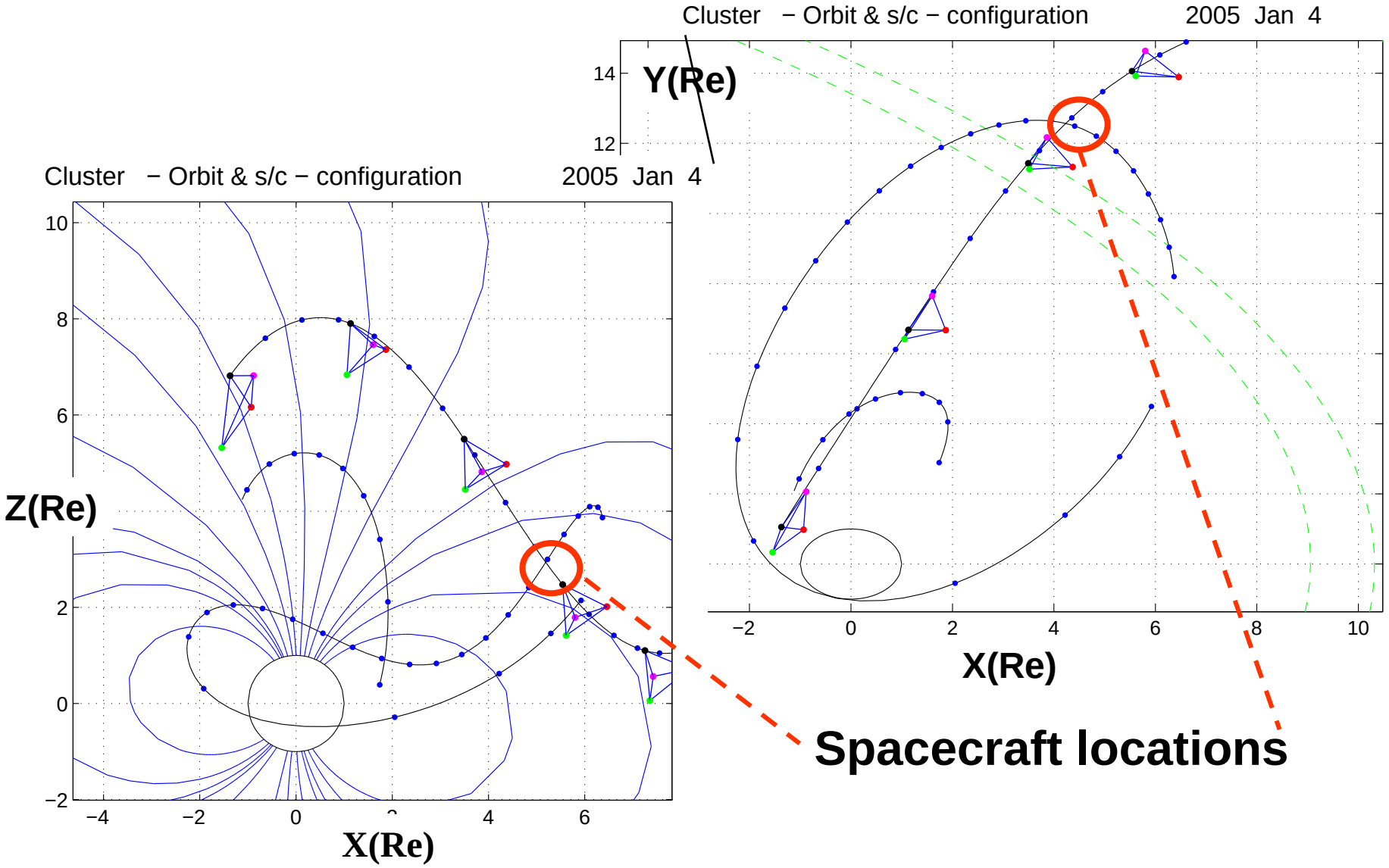
Outline

- Spacecraft Locations & Interplanetary Condition
- MP Crossing
- FTE signatures
- Event Analyses
- Summary

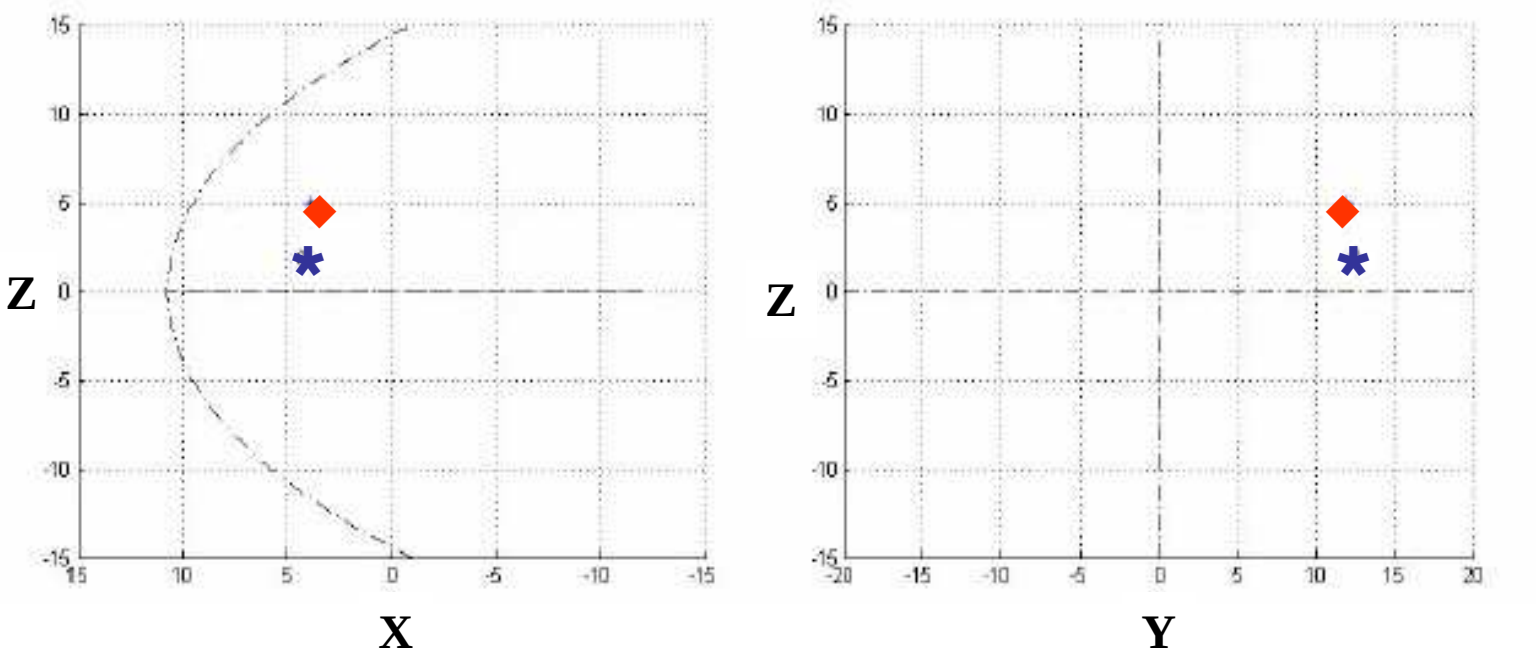


On Jan 4, 2005, TC-1 & Cluster were traversing, respectively, inbound and outbound across the duskside northern MP boundary.

Orbit of Cluster & TC1, TC2



Spacecraft Locations

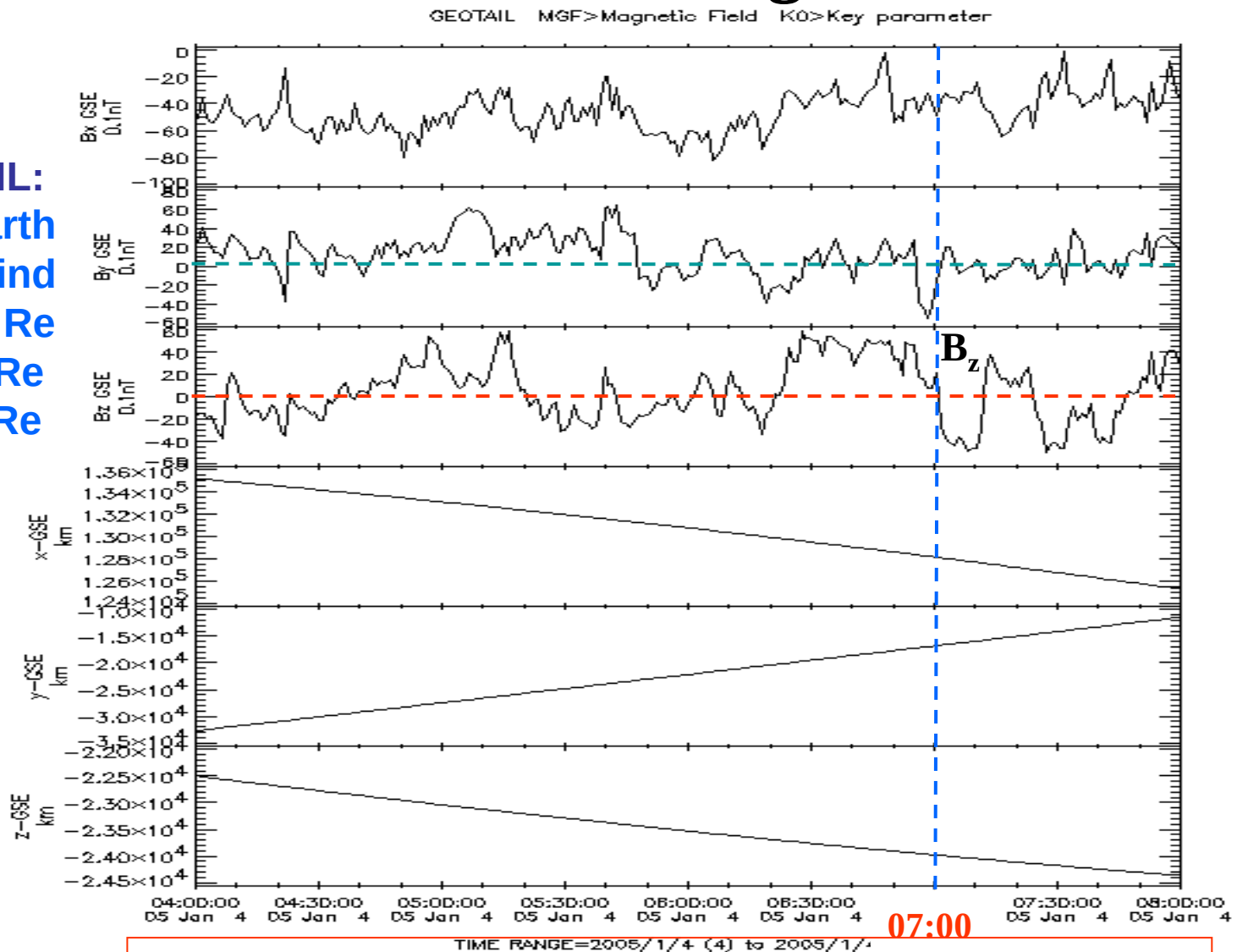


- C 4: (3.91, 12.03, 5.01) R_E (GSE)
- TC-1: (4.33, 12.50, 1.93) R_E (GSE)

$\Delta X \sim 0.42\ R_E$, $\Delta Y \sim 0.47\ R_E$, $\Delta Z \sim 3.08\ R_E$

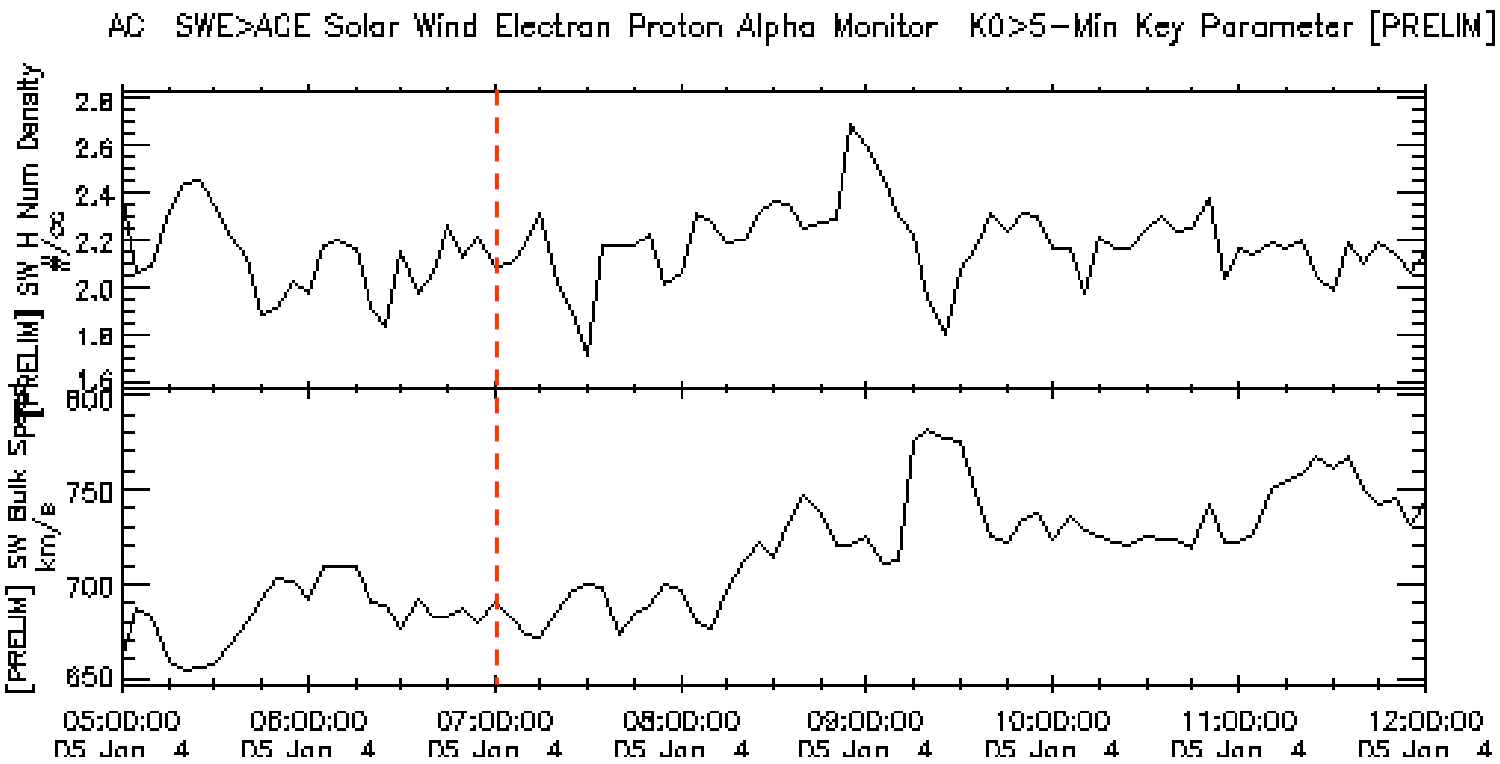
GEOTAIL Magnetic Field

GEOTAIL:
Near Earth
Solar wind
X~ 19.6 Re
Y~ 2.8 Re
Z~ 3.8 Re



~ 07:00 IMF B_z changed from Positive to negative

Solar Wind Condition

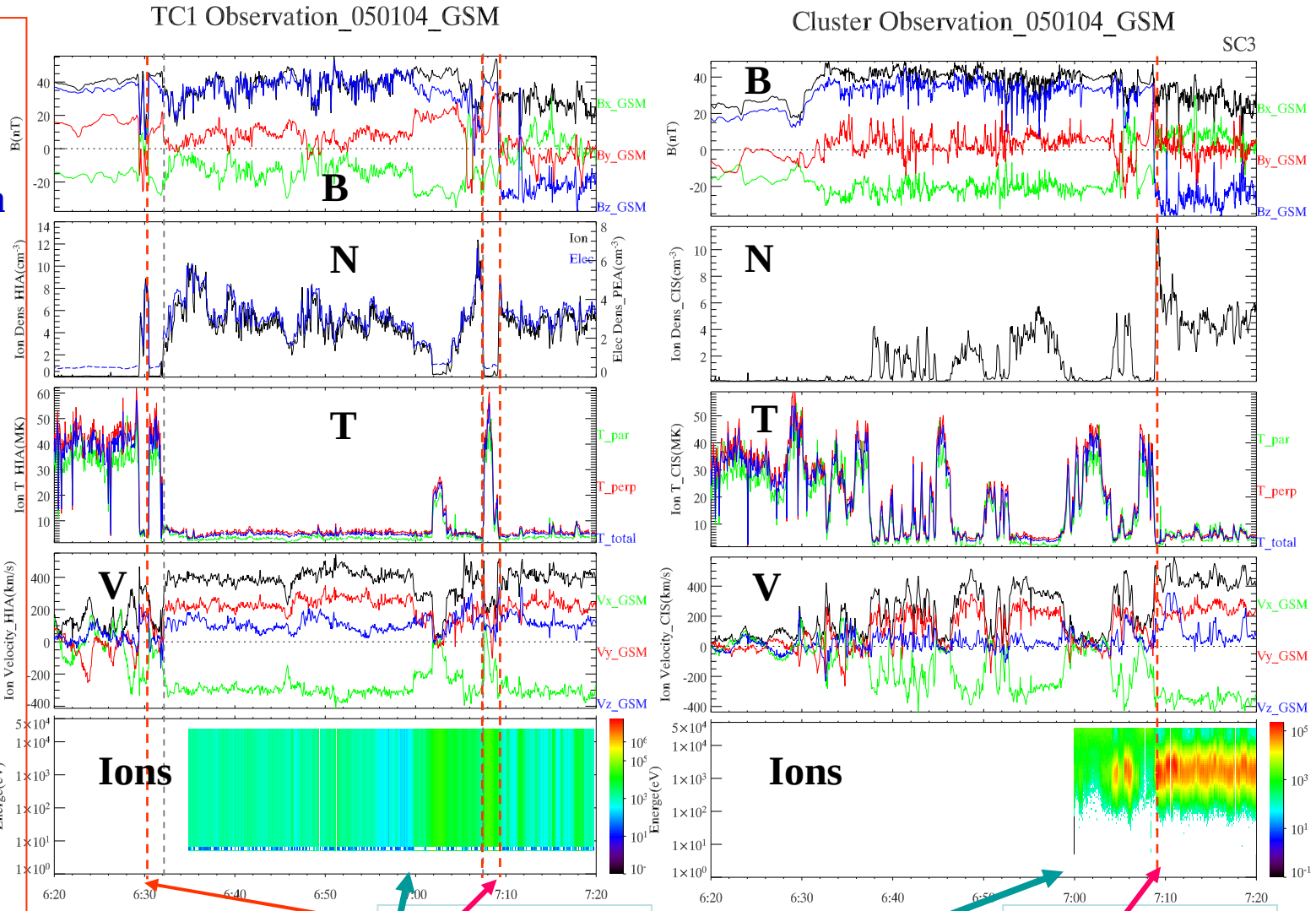


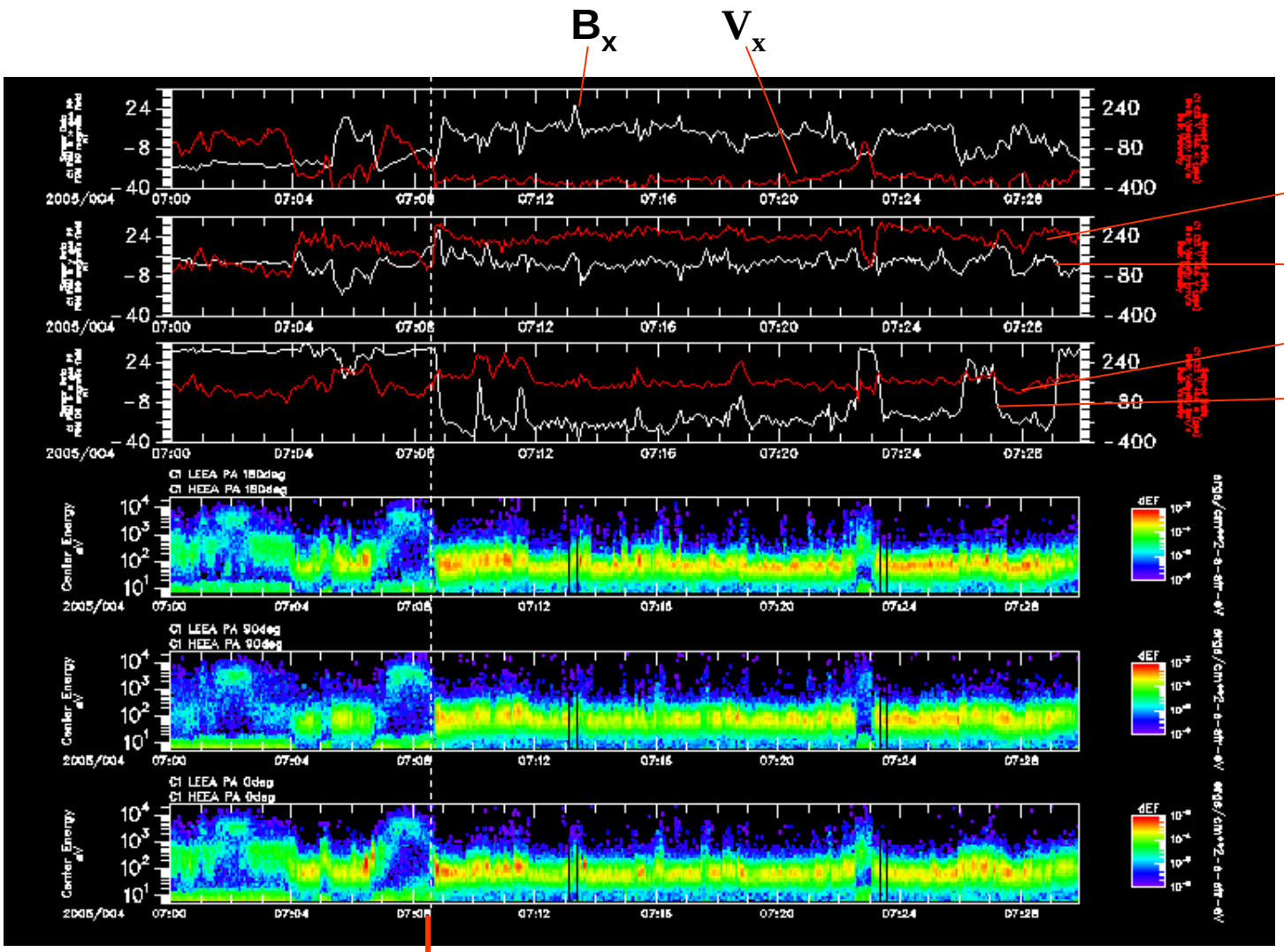
V_x ~ 685 km/3

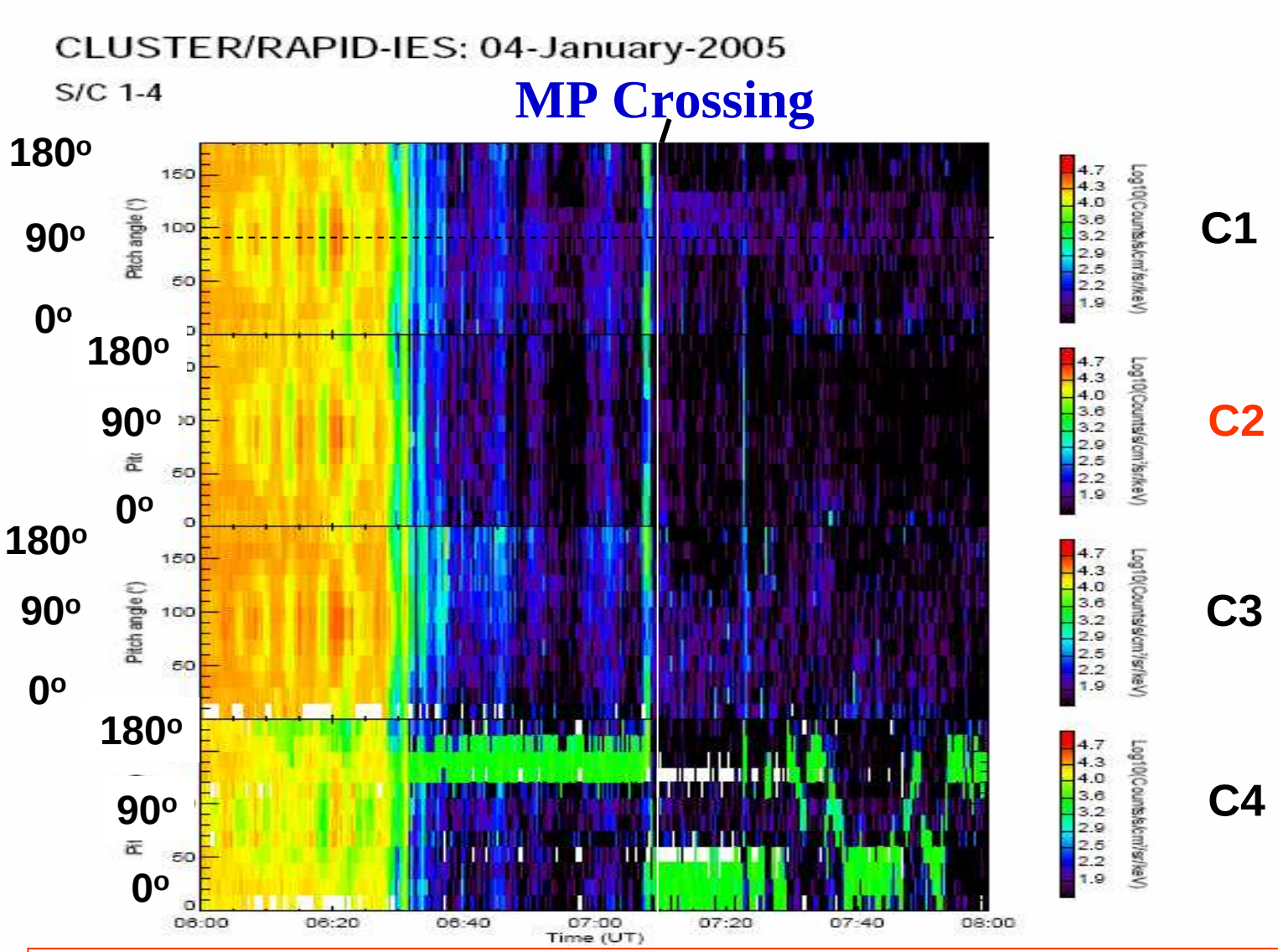
Magnetopause Crossing

From 06:30 to 07:10 UT TC1 and Cluster both Stayed in the MSP boundary region.

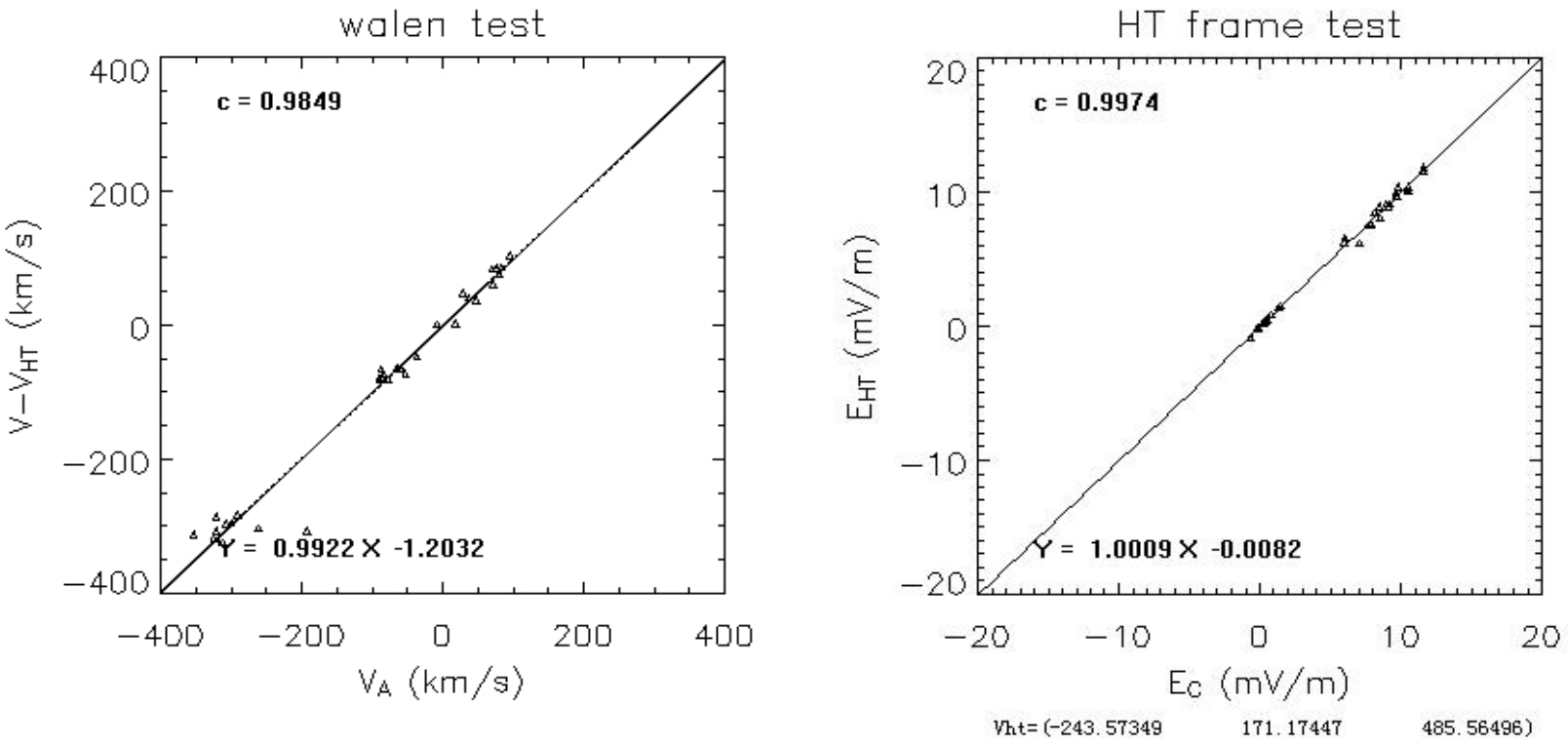
At ~07:10, MP moved inward, both TC1 & Cluster traversed across the MP into the MSH.




B_x
V_x
V_y
B_y
V_z
B_z
C1
Pitch angle spectrum of electrons from PEACE /C1
180°
90°
0°
MP crossing



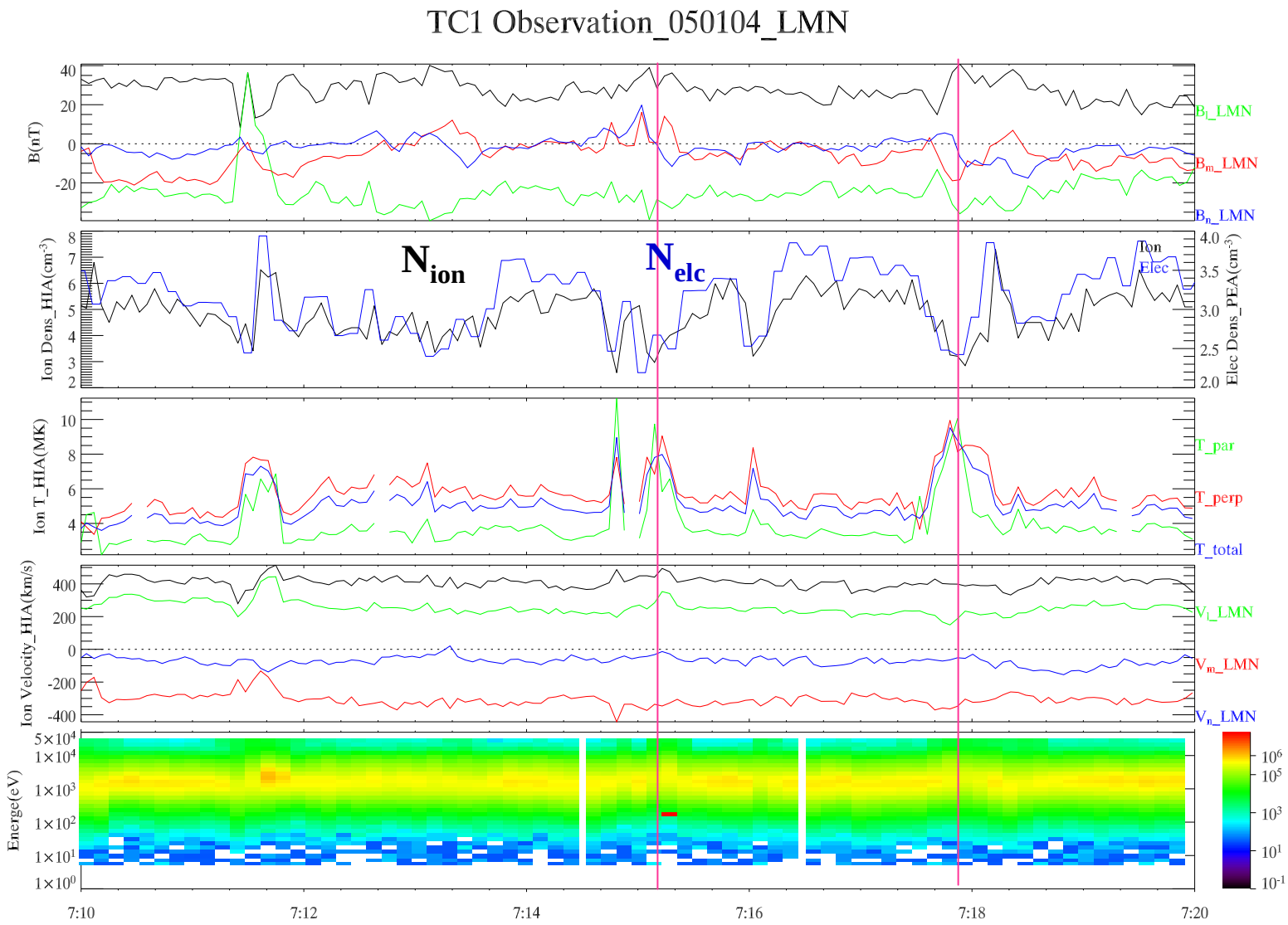
Just prior to the MP crossing, Cluster/RAPID saw a field-aligned bi-directional electrons in the MSP boundary layer.



TC1 071008-071048

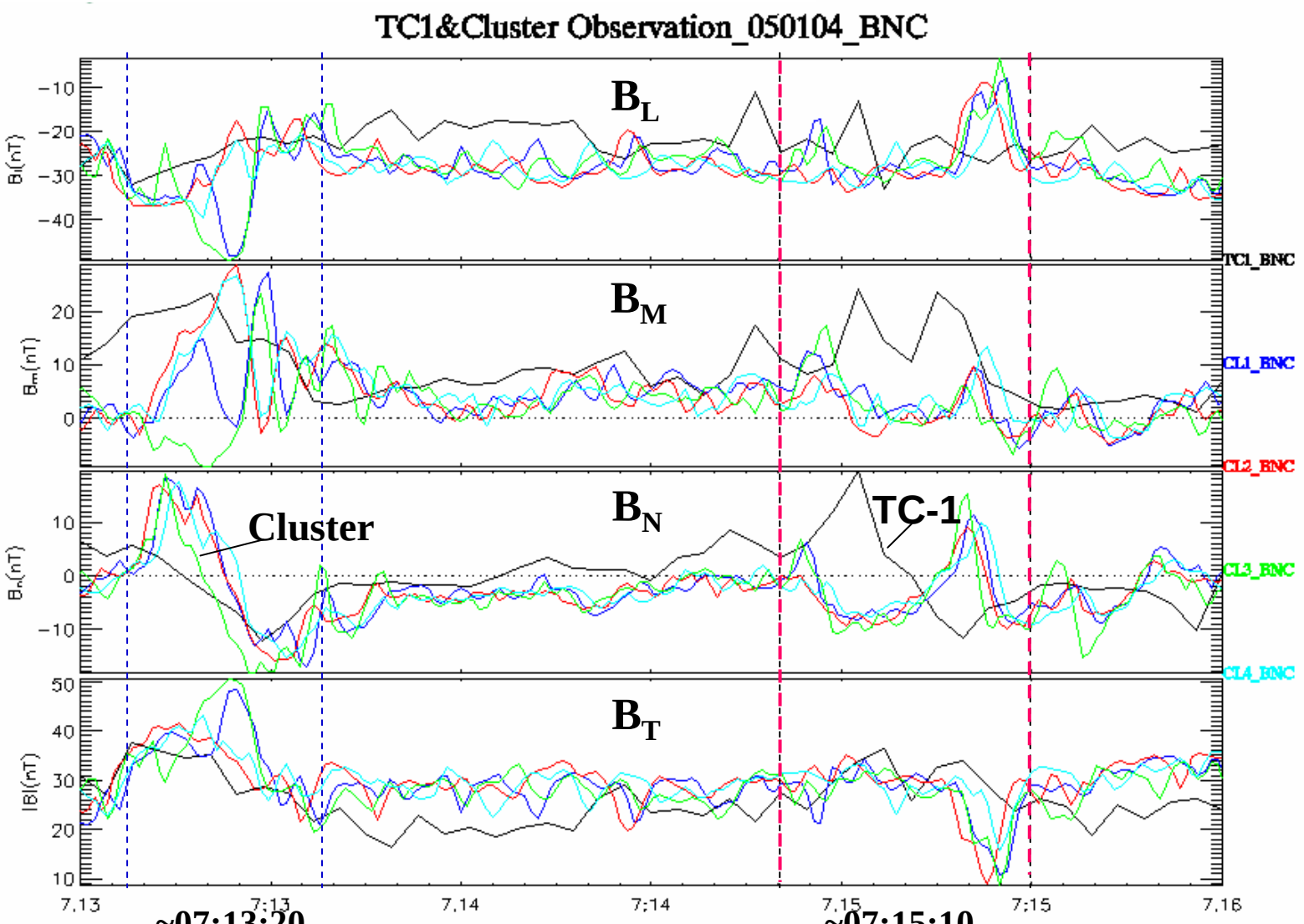
HT analysis indicates that the MP was an open boundary.

Cluster observed a few FTEs in the MSH after the MP crossing



TC-1 observed a couple of FTEs in the MSH after the MP crossing

— TC-1 — CS-1 — CS-2 — CS-3 — CS-4



~07:13:20

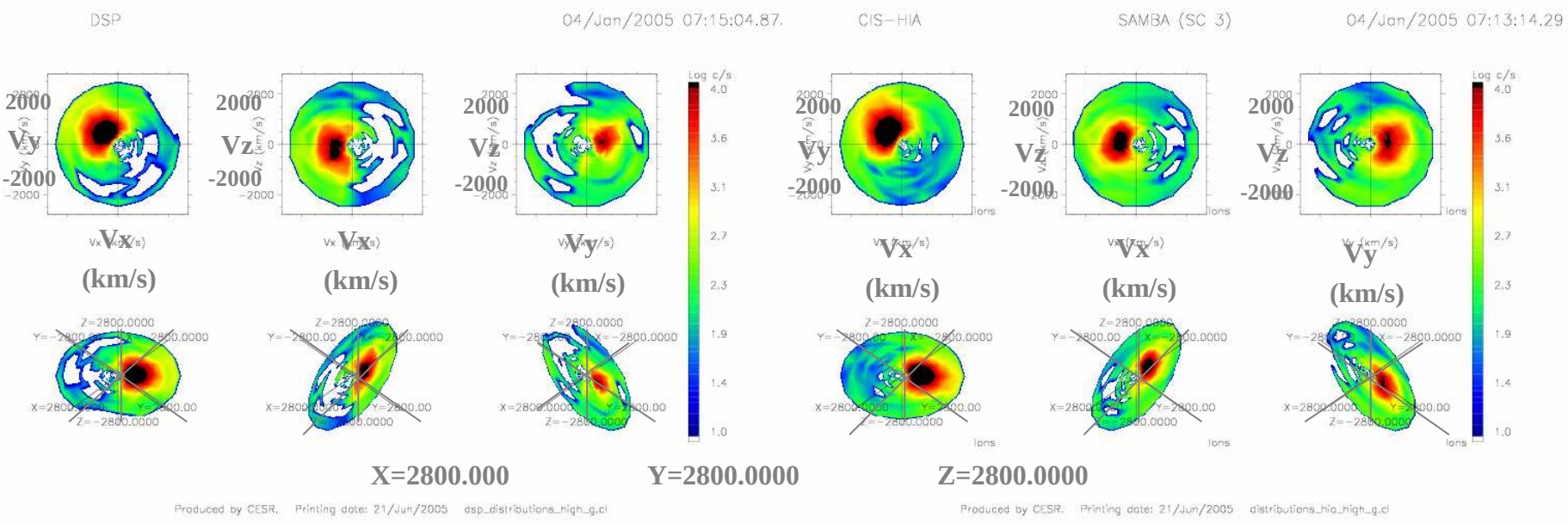
FTE-Cluster

~07:15:10

FTE-TC1

$\Delta T \approx 110$ s

3-D Distribution of Thermal Ions in FTE



TC-1/HIA at 07:15:05 CS3/HIA at 07:13:14

3-D distributions of thermal ions for both TC-1 and Cluster FTEs were very similar.

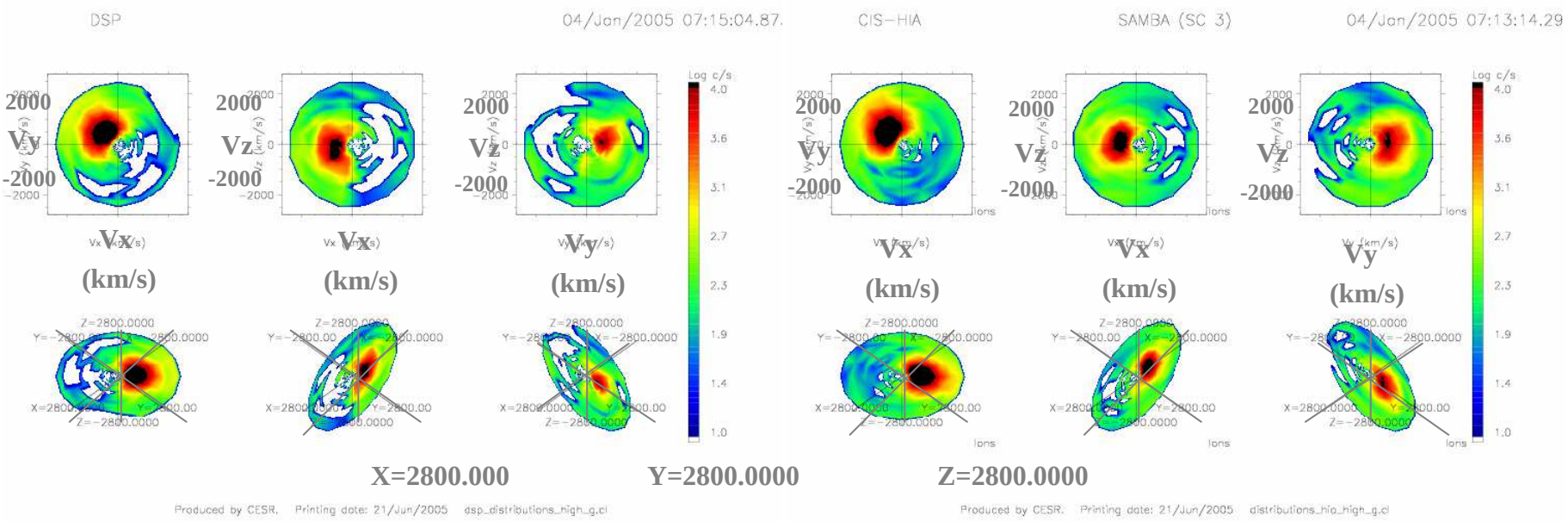
HT Velocities

TC1	-313.86, 269.94, 137.88 (km/s)
Cluster/SC1	-379.22, 270.50, 82.49 (km/s)
Cluster/SC3	-370.44, 274.22, 54.82 (km/s)
Cluster/SC4	-316.47, 237.22, 67.54 (km/s)

All HT velocities derived are similar

The larger components are V_x and V_y .

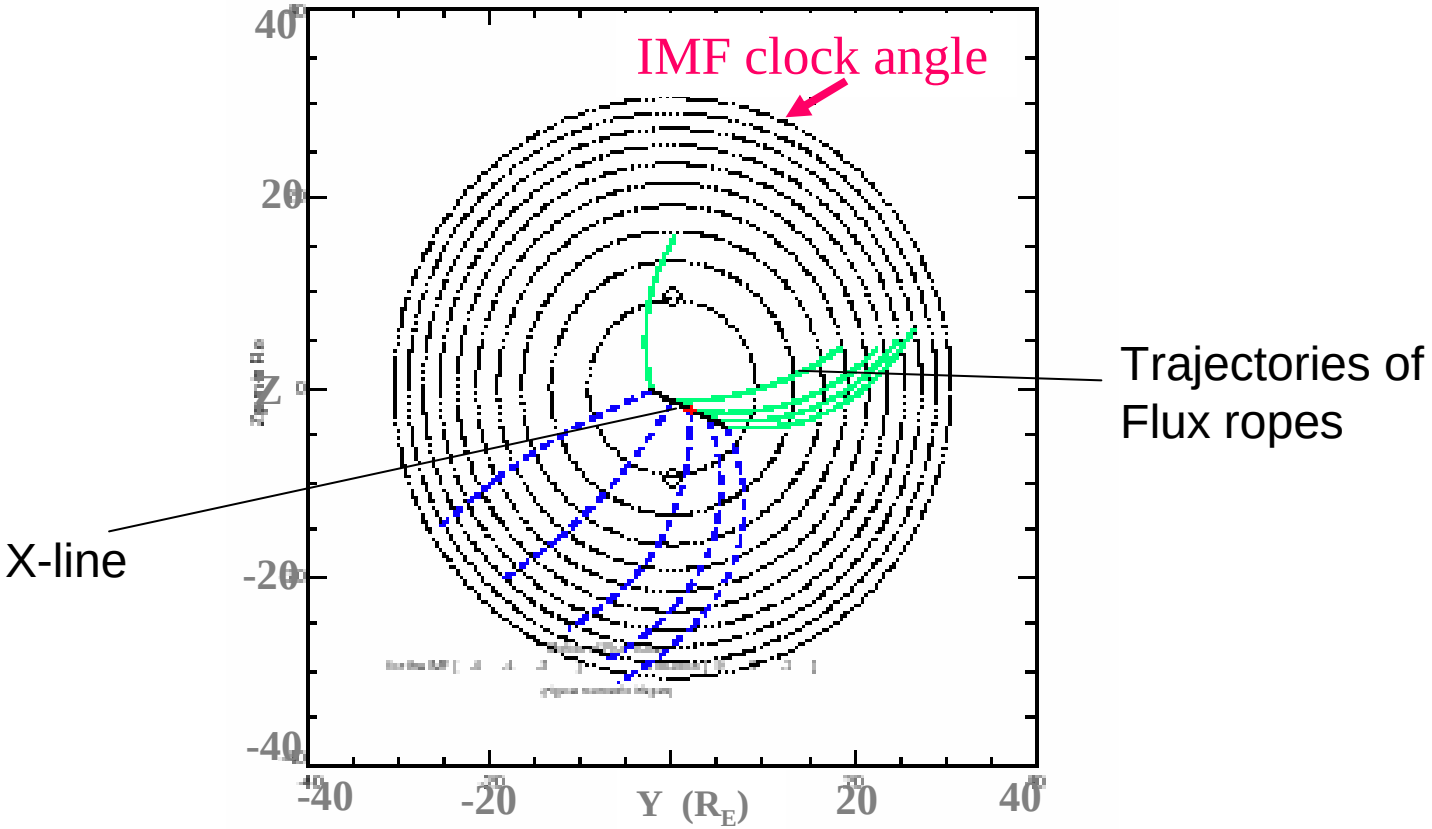
3-D Distribution of Thermal Ions in FTE



TC-1/HIA at 07:15:05 CS3/HIA at 07:13:14

The larger components are V_x and V_y.

Cowley-Owen-Cooling Model (Cooling et al., 2001) Calculation



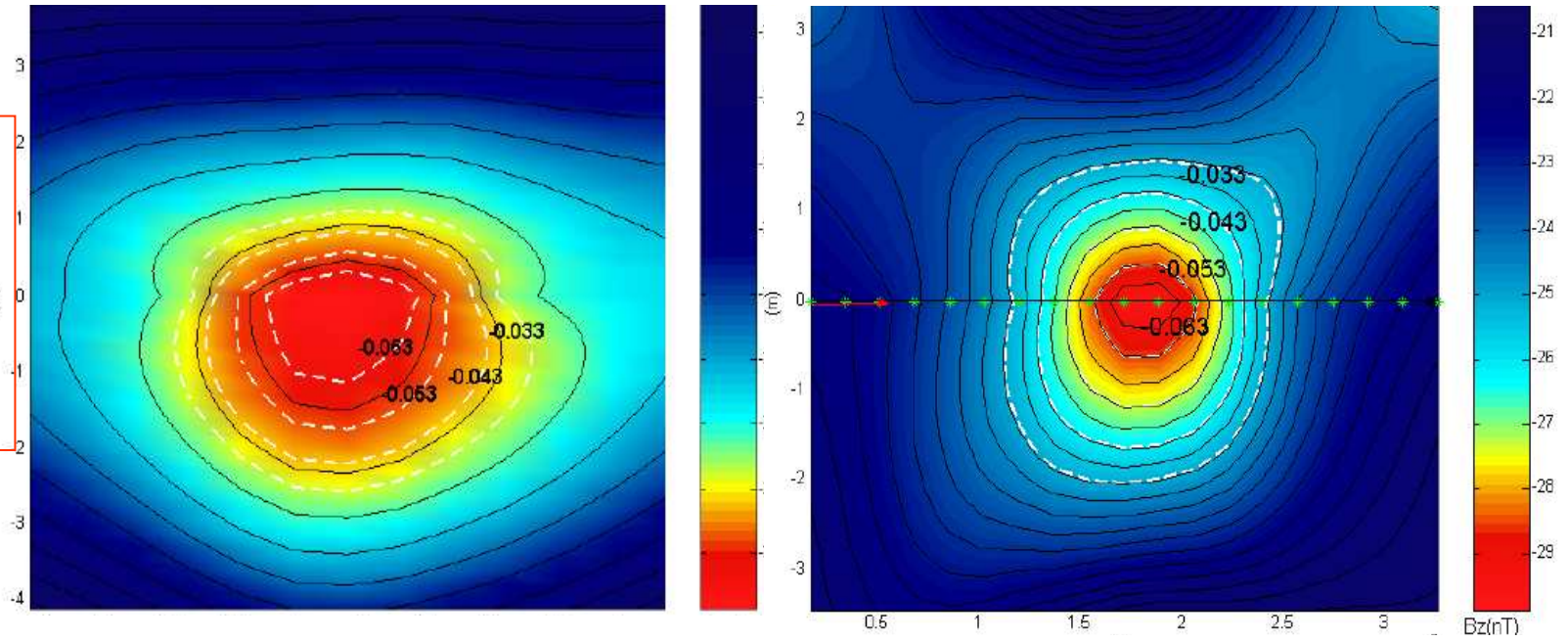
Derived HT velocity is consistent with model calculation that the FTEs were produced via time-dependent MR near the equator.

Reconstruction of Flux Ropes

(By Solving Grad-Shafranov equation (Sonnerup, 2004)

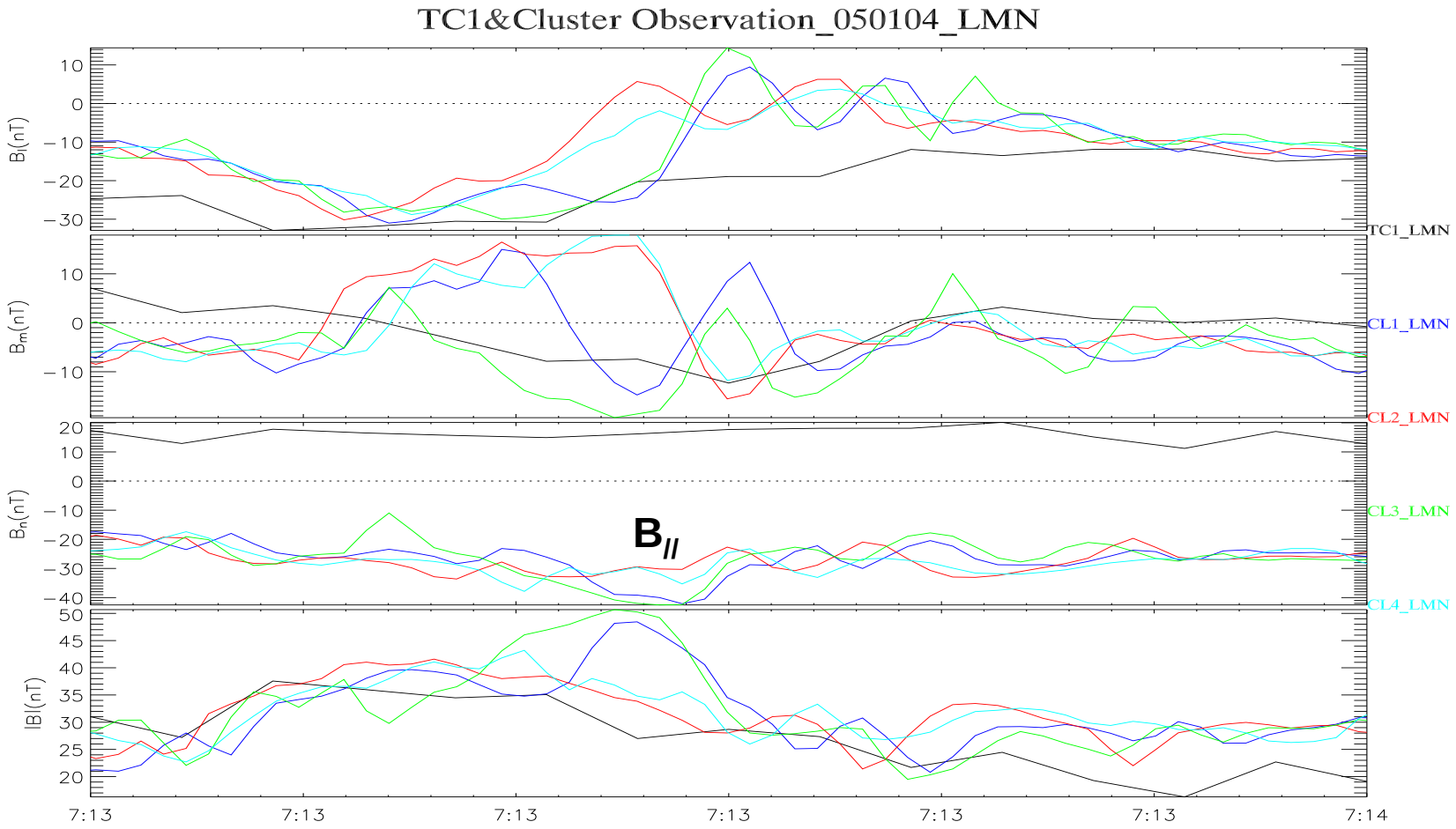
SC1 TC1

Strong axis-aligned core field



spacecraft \A	-0.05	-0.06	-0.07	-0.08
TC-1	1.541E+006	1.156E+006	8.916E+005	6.196E+005
SC1	1.276E+006	1.071E+006	8.869E+005	6.244E+005

Magnetic fluxes contained in two flux ropes are approximately equal



Both flux ropes had prominent axis-aligned magnetic field component.

Scale Size of the Cross-Section of Two Flux Ropes

$$L \sim |(V_{HT} \times e)| \times \Delta t$$

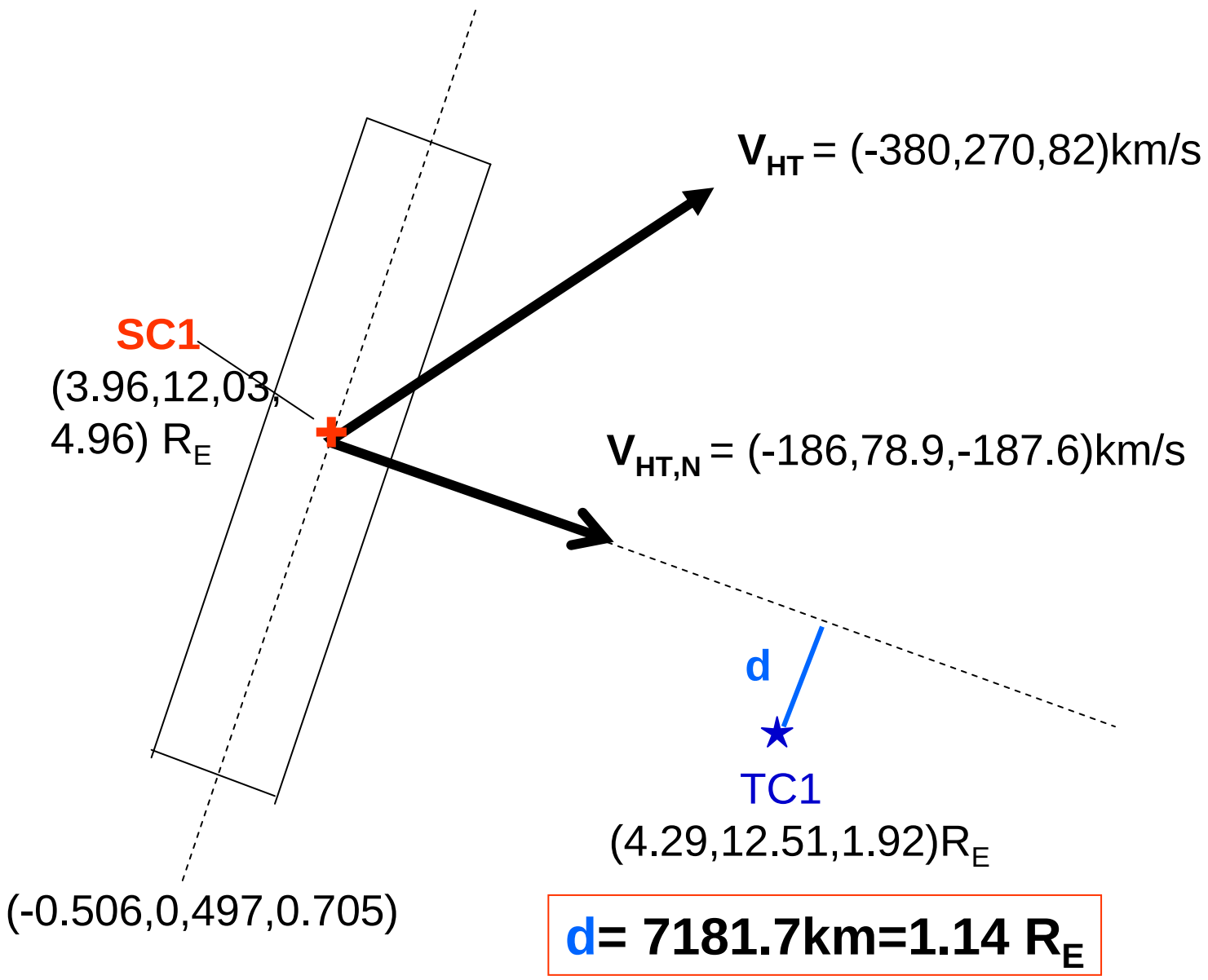
TC1	Cluster/SC1	Cluster/SC3	Cluster/SC4
2.10 R_E	2.28 R_E	2.27 R_E	1.94 R_E

The scale-sizes of the cross-section of TC-1 and Cluster flux rope are also similar.

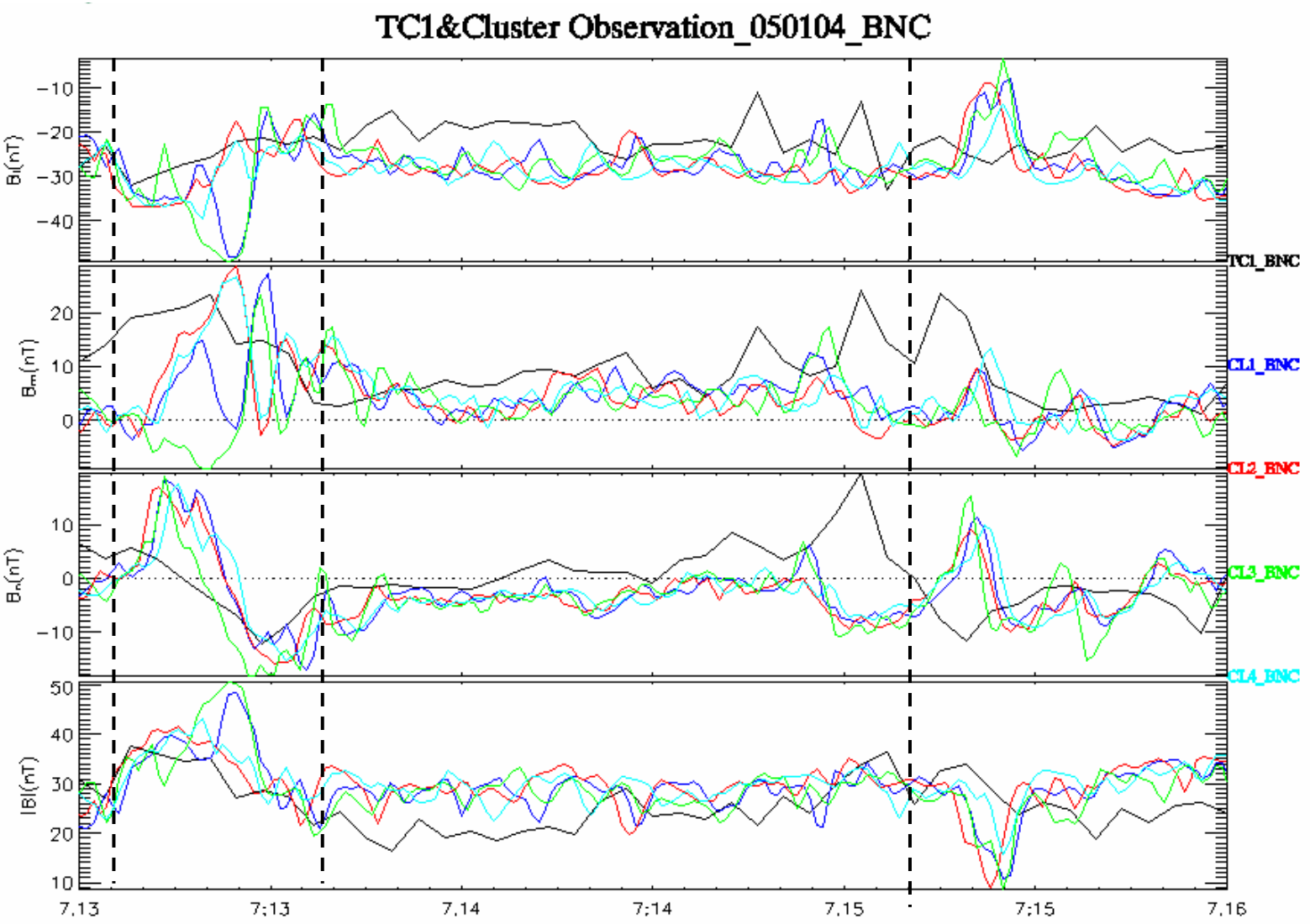
Orientation of Flux Rope

Methods	TC-1	Cluster
BMVA (a)	-0.4411, 0.0713, 0.8946	-0.5060, 0.4970, 0.7050
BMVA (b)	——	-0.2407, 0.4280, 0.8711
GS	-0.4040, 0.2190, 0.8880	-0.5450, 0.1710, 0.8210
Angel from IMF	73^o	50^o

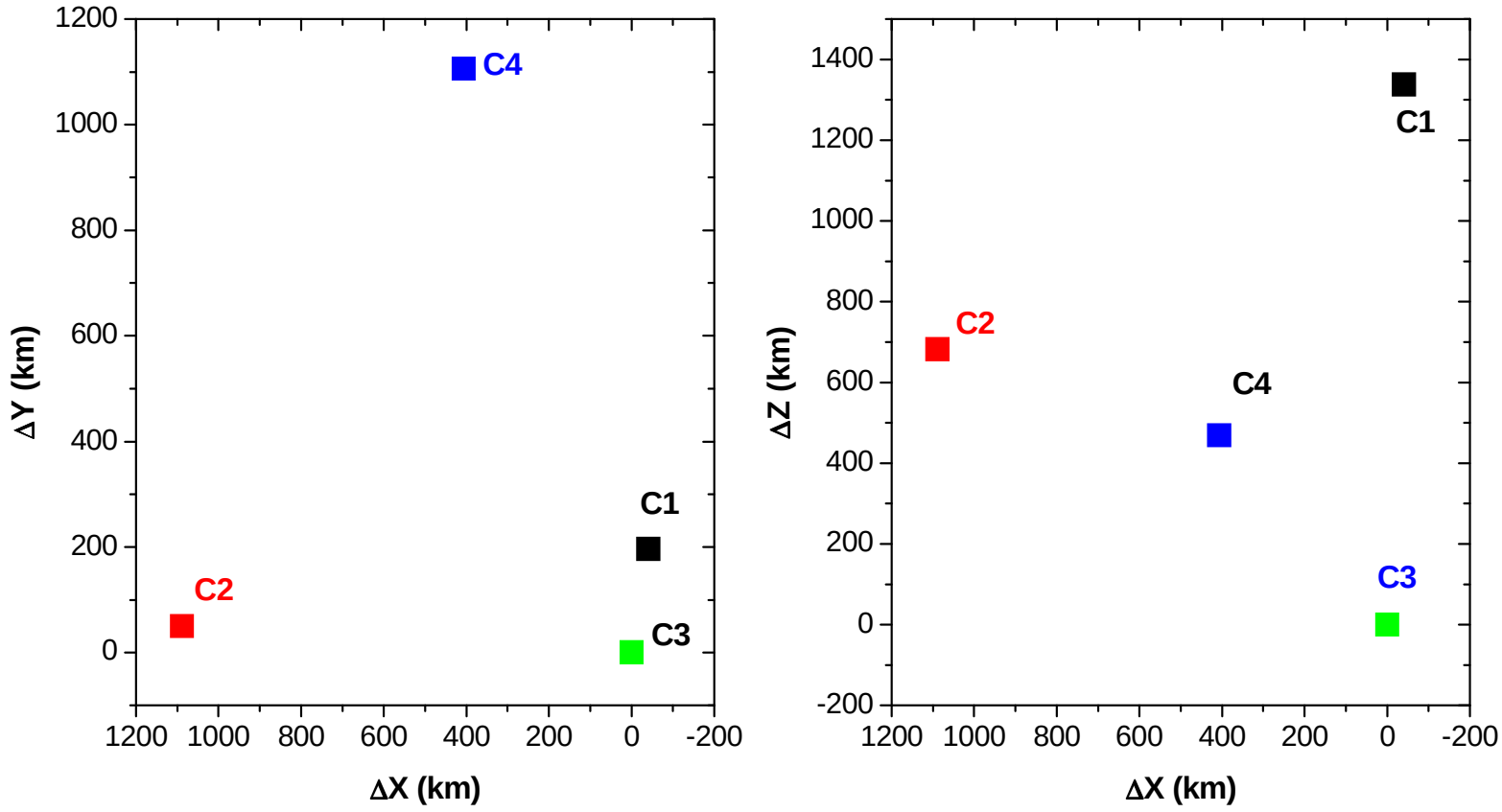
Flux rope orientation of two flux ropes were similar. The axis of flux rope observed by Cluster was somewhat closer to the ambient B field.


V_{HT} = (-380,270,82)km/s
SC1
(3.96,12,03, 4.96) R_E
$V_{HT,N}$ = (-186,78.9,-187.6)km/s
d
TC1
(4.29,12.51,1.92)R_E
(-0.506,0,497,0.705)
d= 7181.7km=1.14 R_E

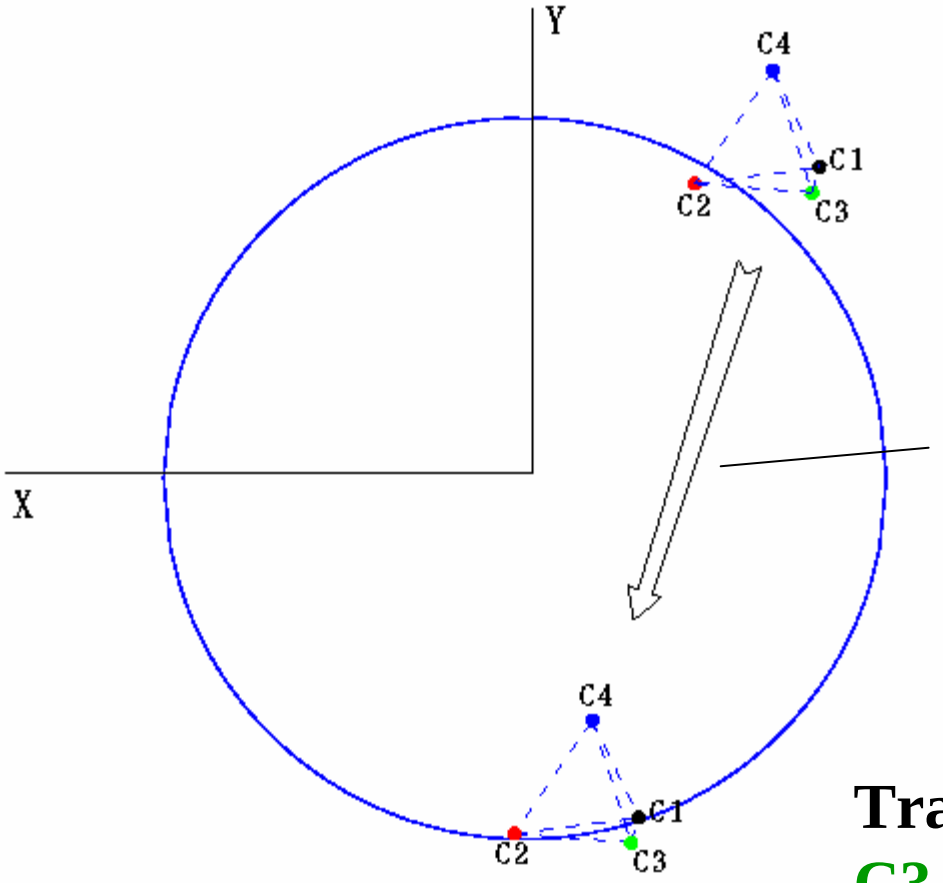
Leading edge: C2, C3, C1, C4 TC-1



Trailing : C3, C2, C1, C4 TC-1



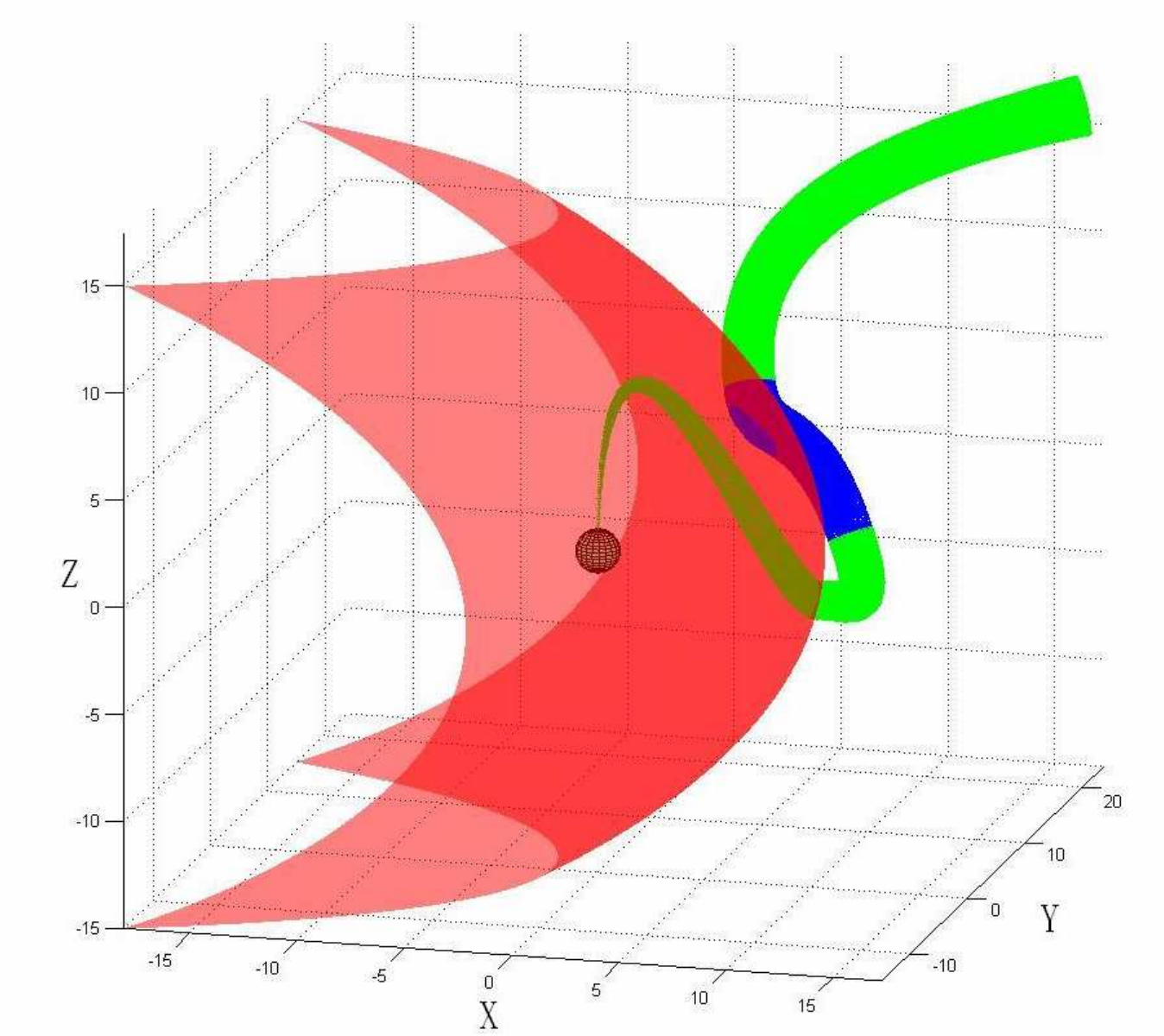
2005-01-05 07:10 UT



Leading edge:
C2, C3, C1, C4

$V_{HT,N}$

Trailing edge:
C3, C2, C1, C4


15
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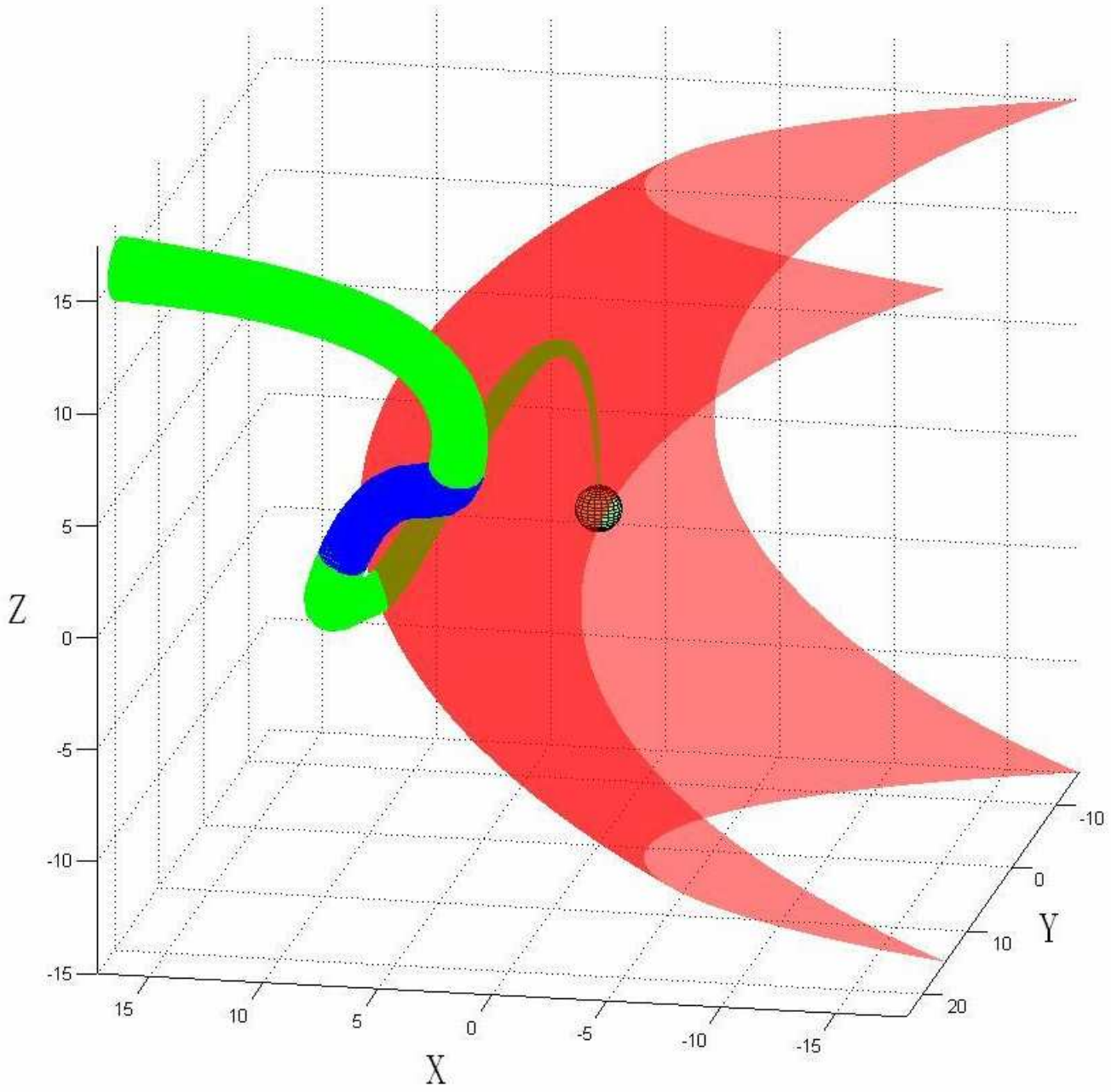
Z
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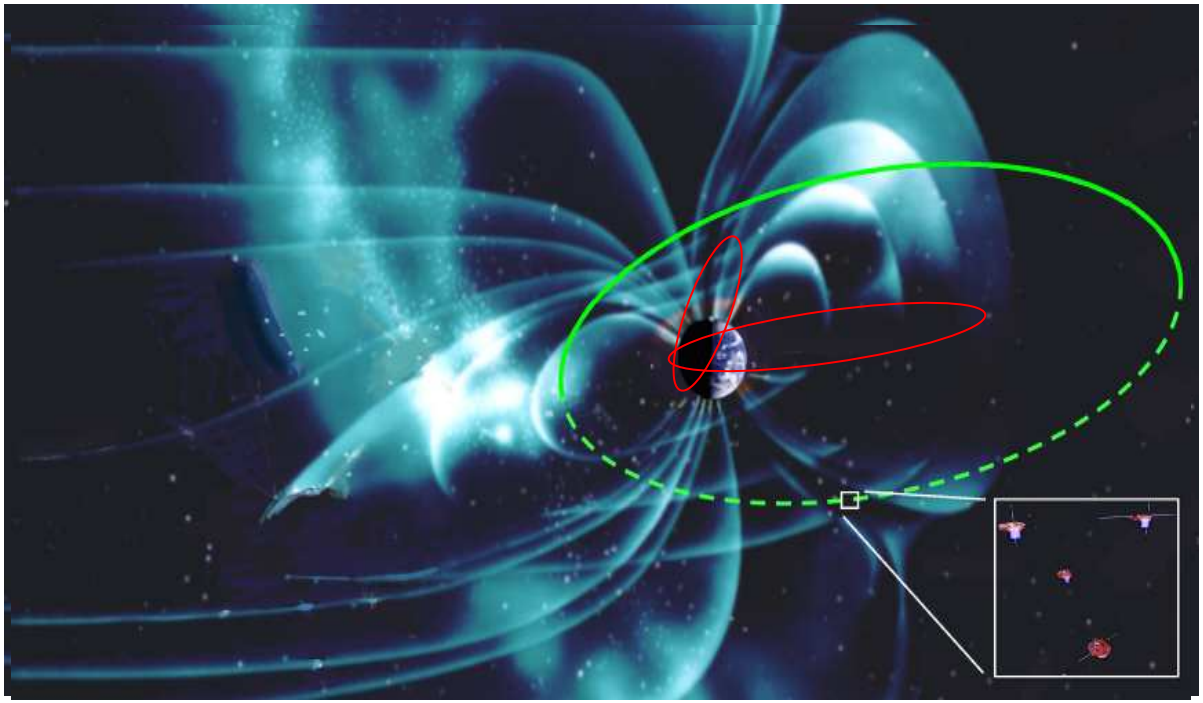
20

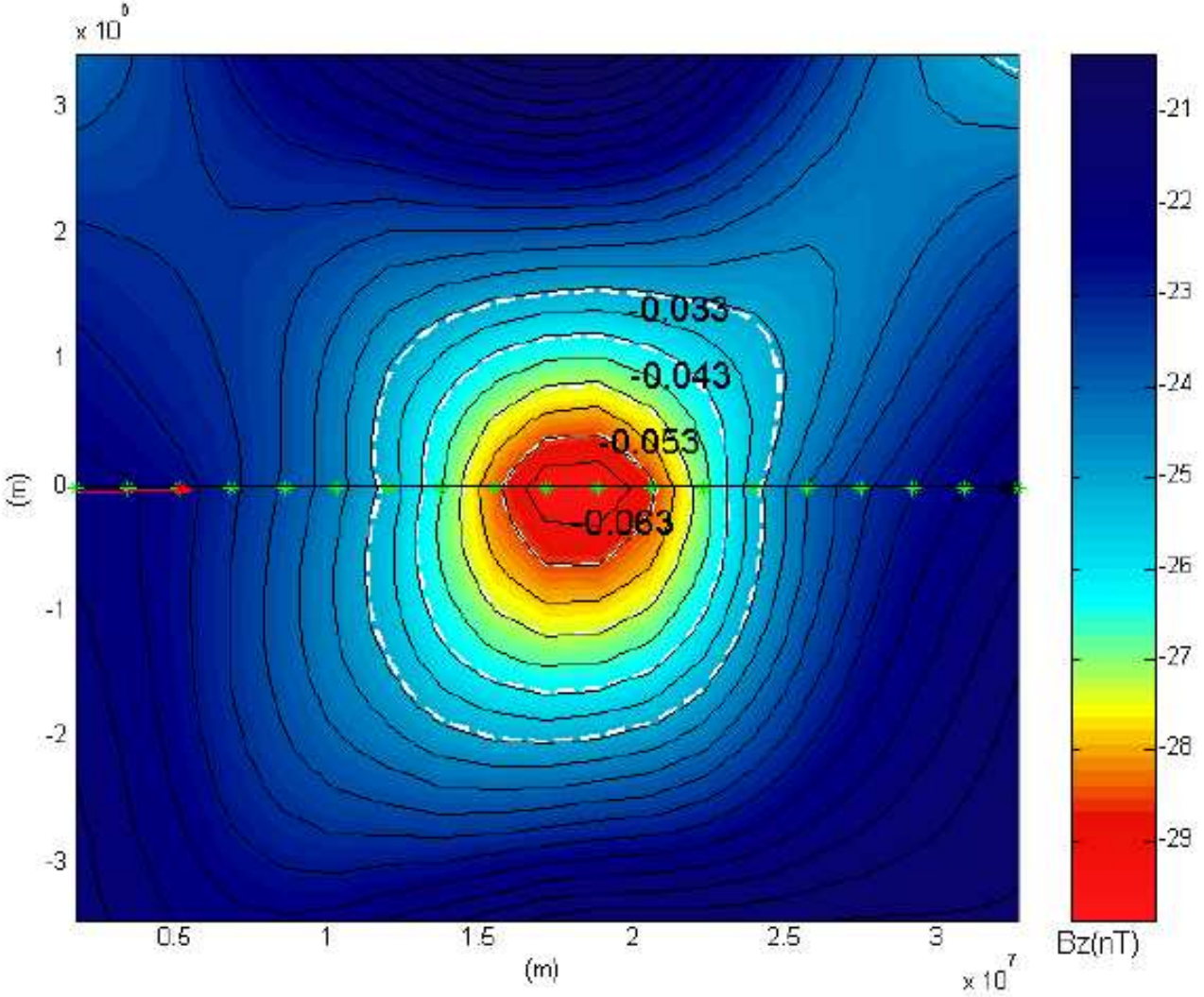
Summary

The coordinated measurements of Cluster and Double Star have given the possibility to study flux tube evolution along the magnetopause with five-point measurements: first giving accurate, quantitative estimate of the orientation, motion and characteristics of the open flux rope at Cluster and second relating this measurement to an adjacent location at TC-1. We can see the structures of FTEs at small scales within the Cluster tetrahedron, as well as the large-scale evolution with Cluster and Double Star. The 04 01 2005 event manifests a close conjunction FTE of Cluster and TC-1. More work is underway to expand on the context and controlling parameters of this event.

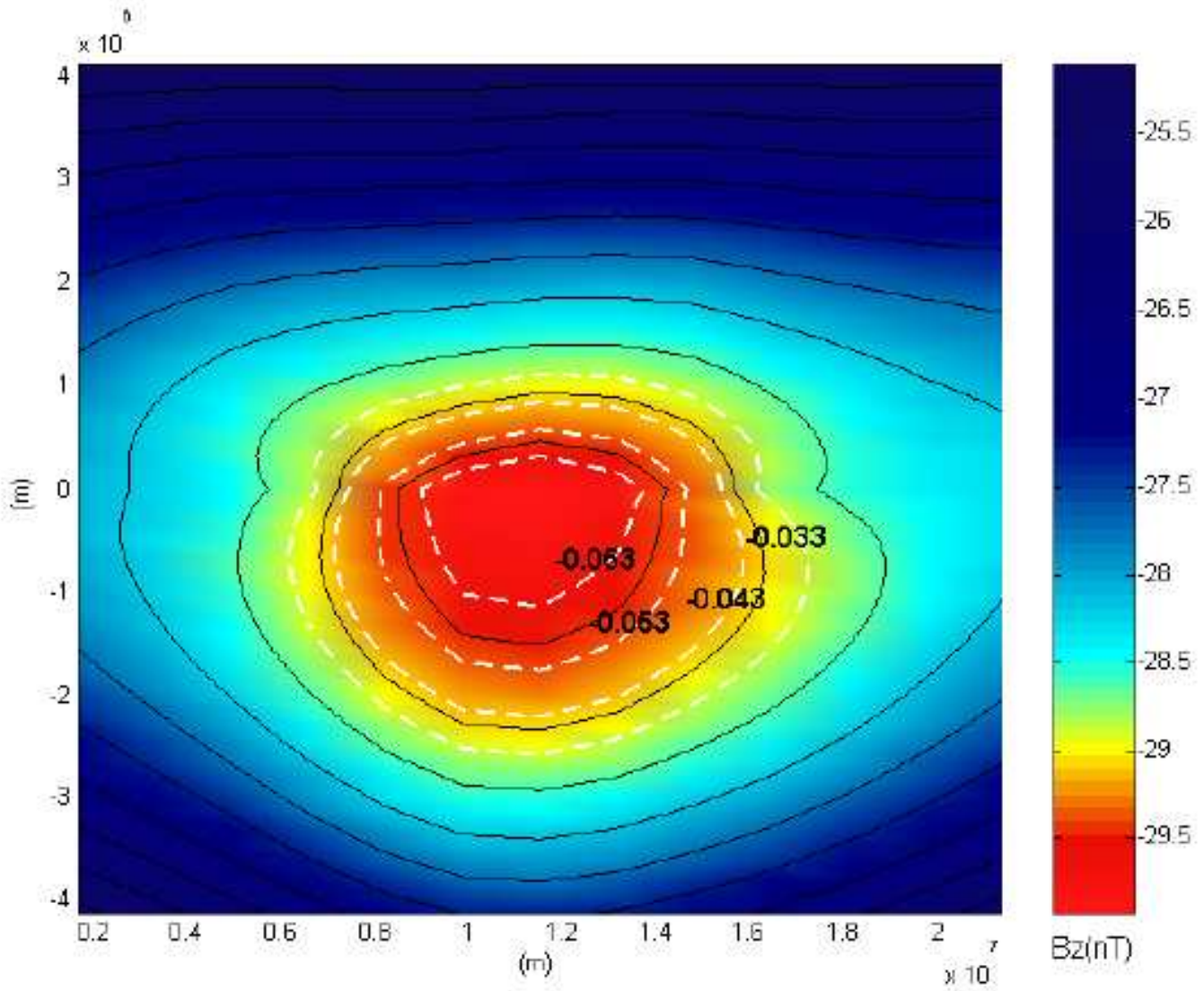
谢谢！

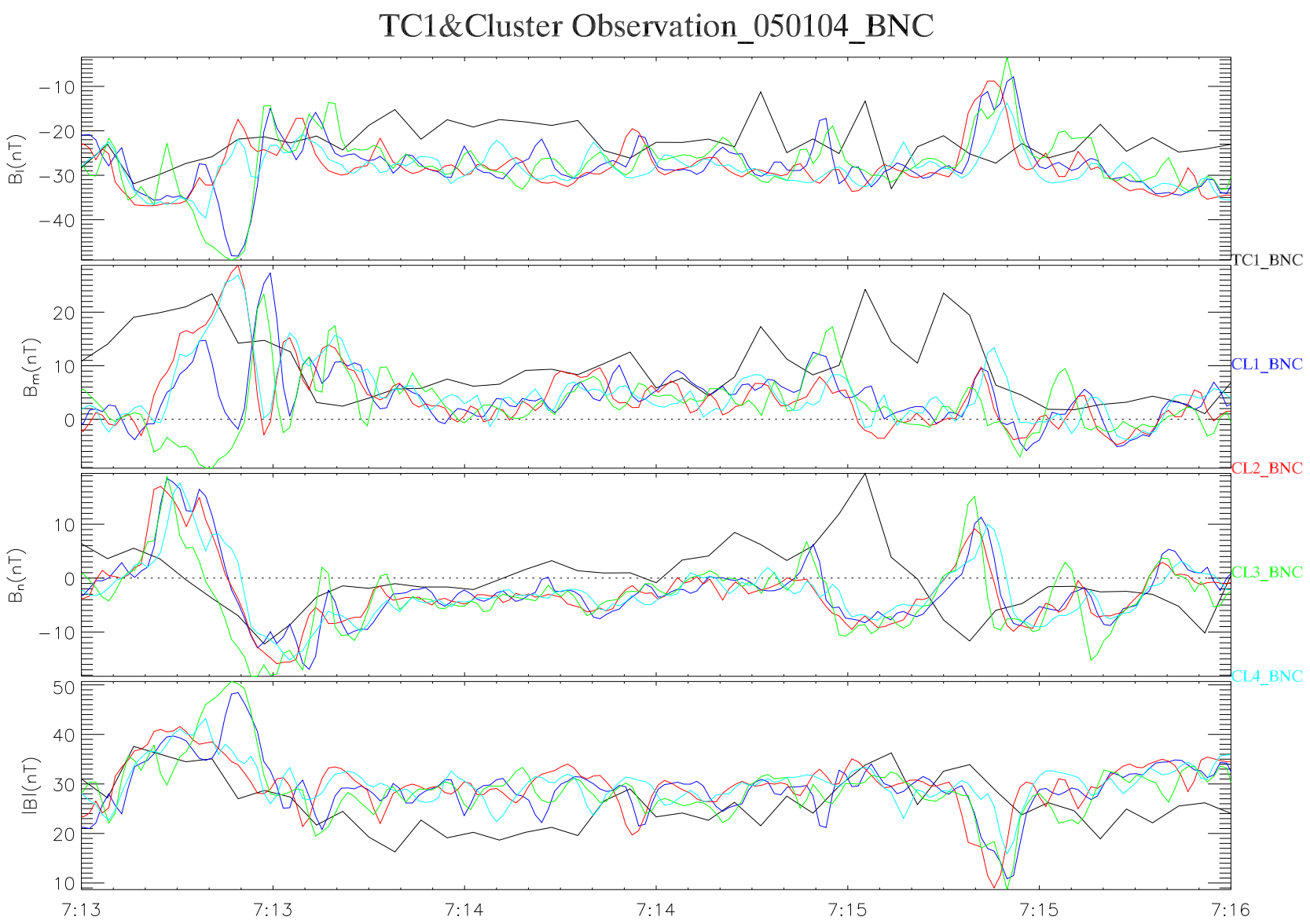


Result of GS (TC1)



Result of GS (Cluster)




TC1&Cluster Observation_050104_BNC
B_l(nT)
B_m(nT)
B_n(nT)
|B|(nT)
TC1_BNC
CL1_BNC
CL2_BNC
CL3_BNC
CL4_BNC
7:13
7:13
7:14
7:14
7:15
7:15
7:16