Double Star mission extension

- Rationale for extension
- Spacecraft and instrument status
- Ground segment and data system

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Mission extension: rationale

- To increase the number of conjunctions between Cluster and Double Star
- To measure small, medium and large scales simultaneously
- To measure size of large scale structures at the magnetopause/cusp
- To observe more rare events like reconnection and storms
- To acquire “stereo” ring current images with IMAGE

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1. To increase the number of conjunctions between Cluster and Double Star

- Conjunction: two spacecraft at the same time on the same field line
- **Prediction** from Jan. to Apr. 2004: 40 conjunctions with Cluster at +/- 2h from magnetopause and DSP TC-1 at +/- 1h
- **Observations**: 21 magnetopause crossings within 1 h and 4 within 15 min

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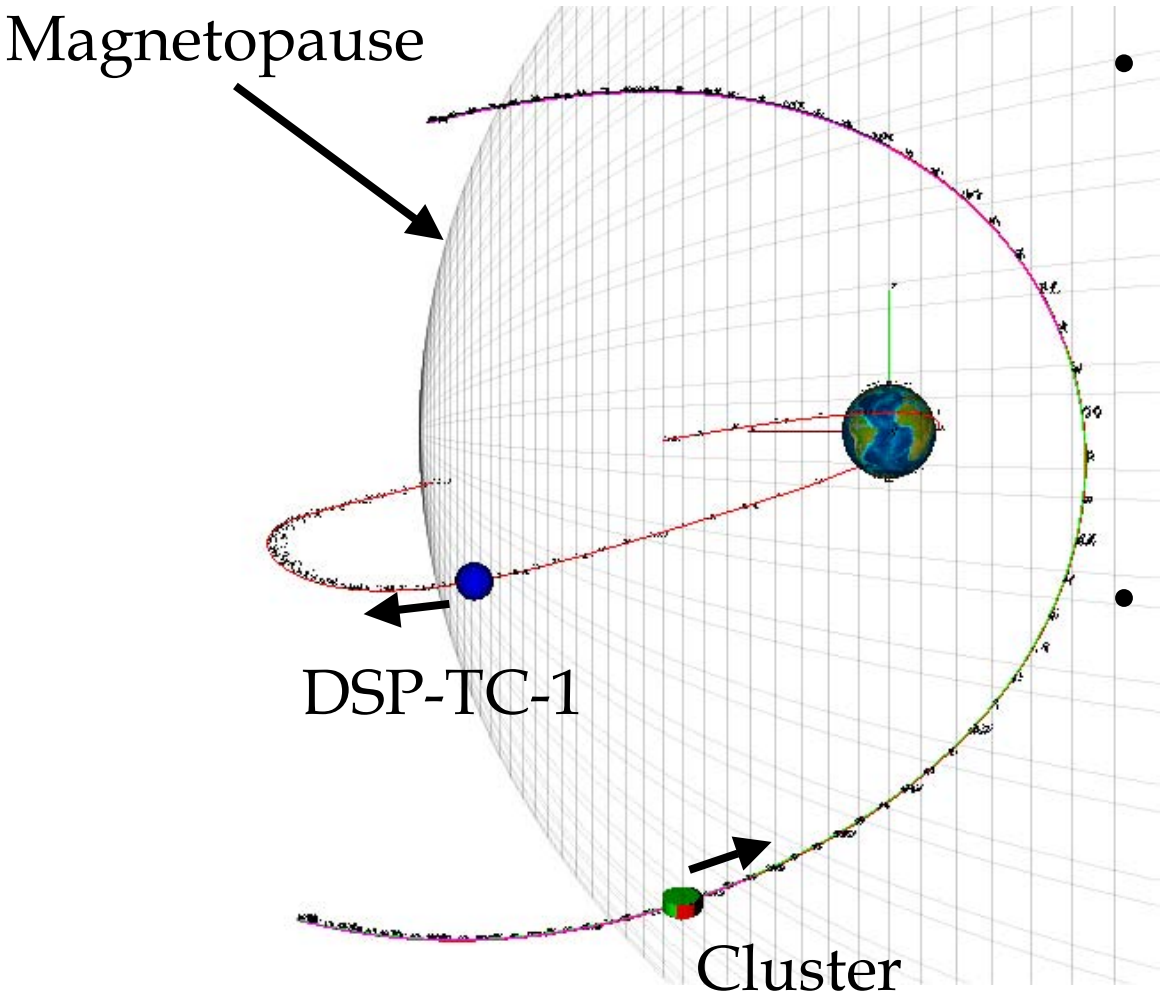
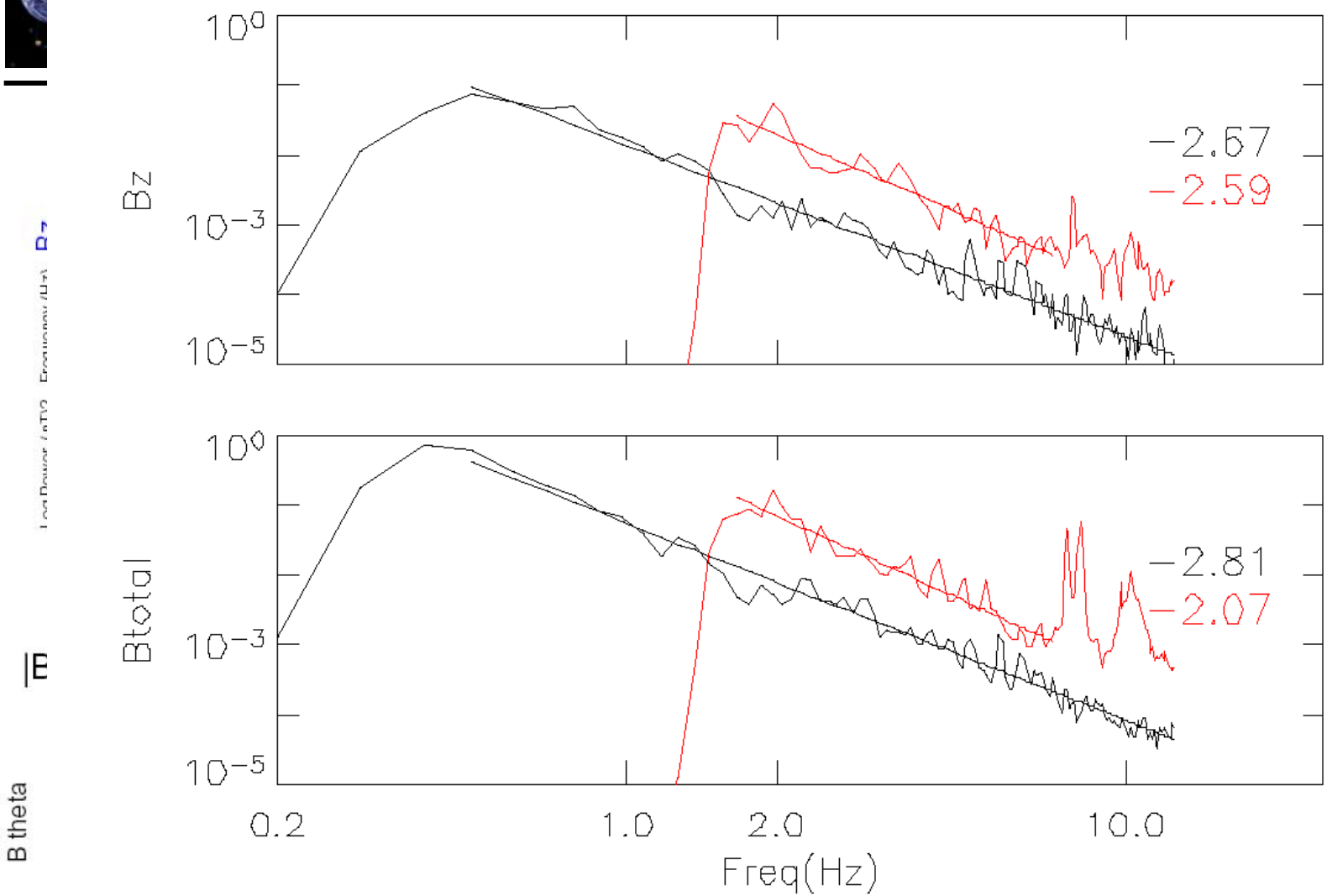


- Magnetopause crossing 22/02/2004:
  - DSP-TC1: 19:30 UT outward, subsolar
  - Cluster: 20:10 UT, inward, high lat.
- Delta t = 40 min

From Cornilleau et al., 2005

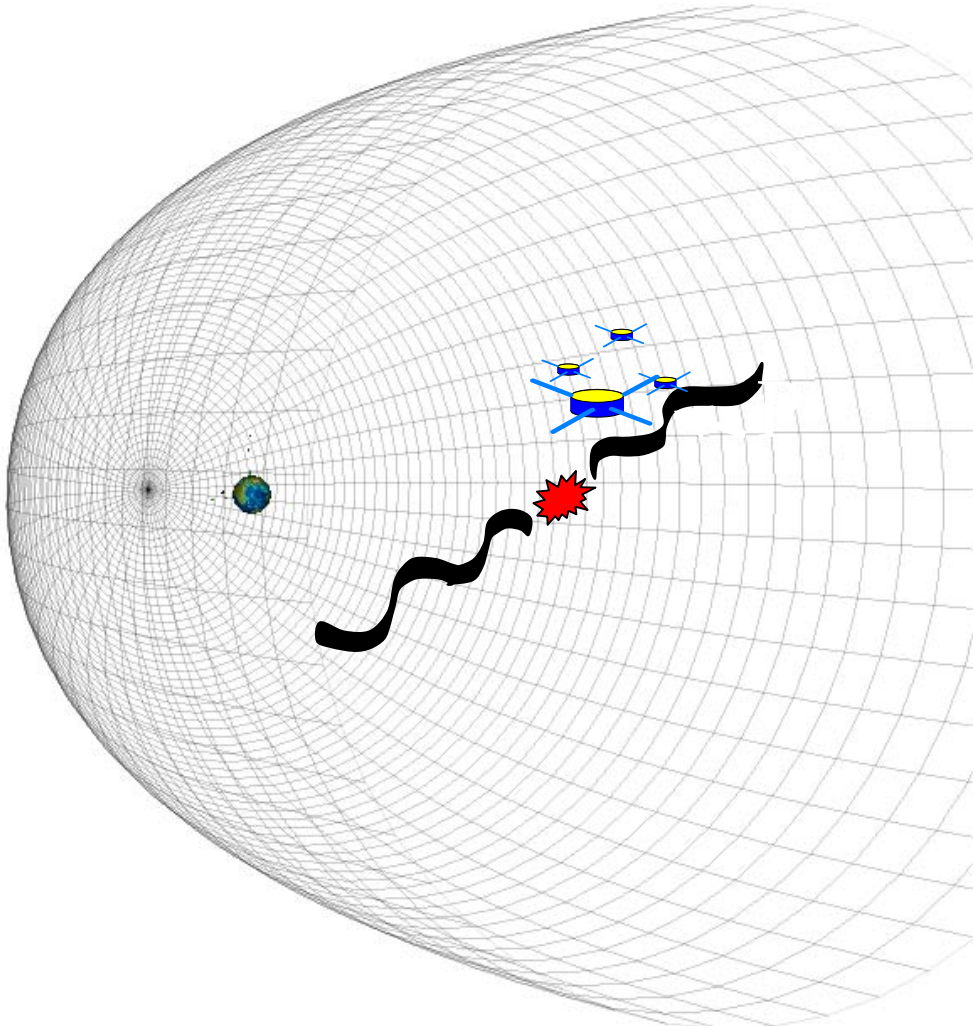


⇒10 times wave power at subsolar than high Latitude (reconnection more likely subsolar?)

=> Need more conjunctions with small delay

u et al., 2005

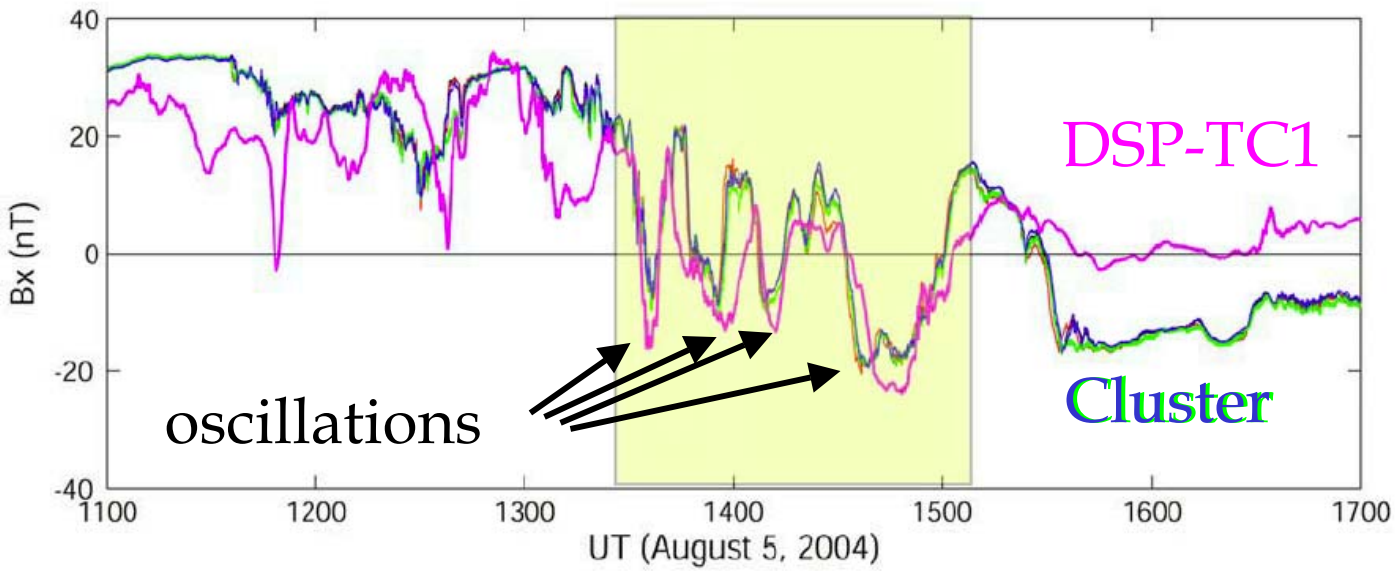
Surface waves in plasmasheet: Cluster



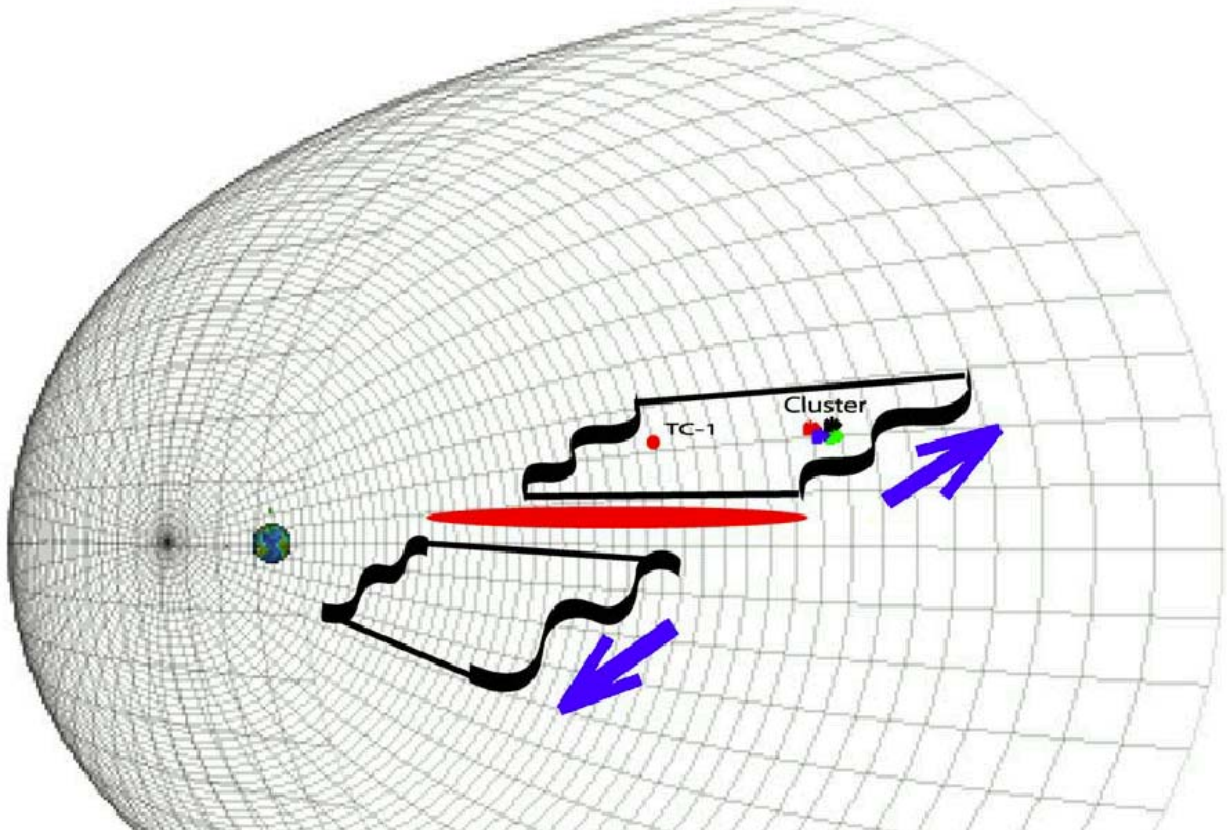
- Observed July-Nov 2001
- 58 crossings (19 on the dawnside, 39 on the duskside)
- Wave propagate outwards
- propagation speed
  - 57 km/s for 39 samples of quiet current sheets and
  - 145 km/s for the active sheets.

From Sergeev et al., 2004

Surface waves in plasma sheet Cluster-Double Star



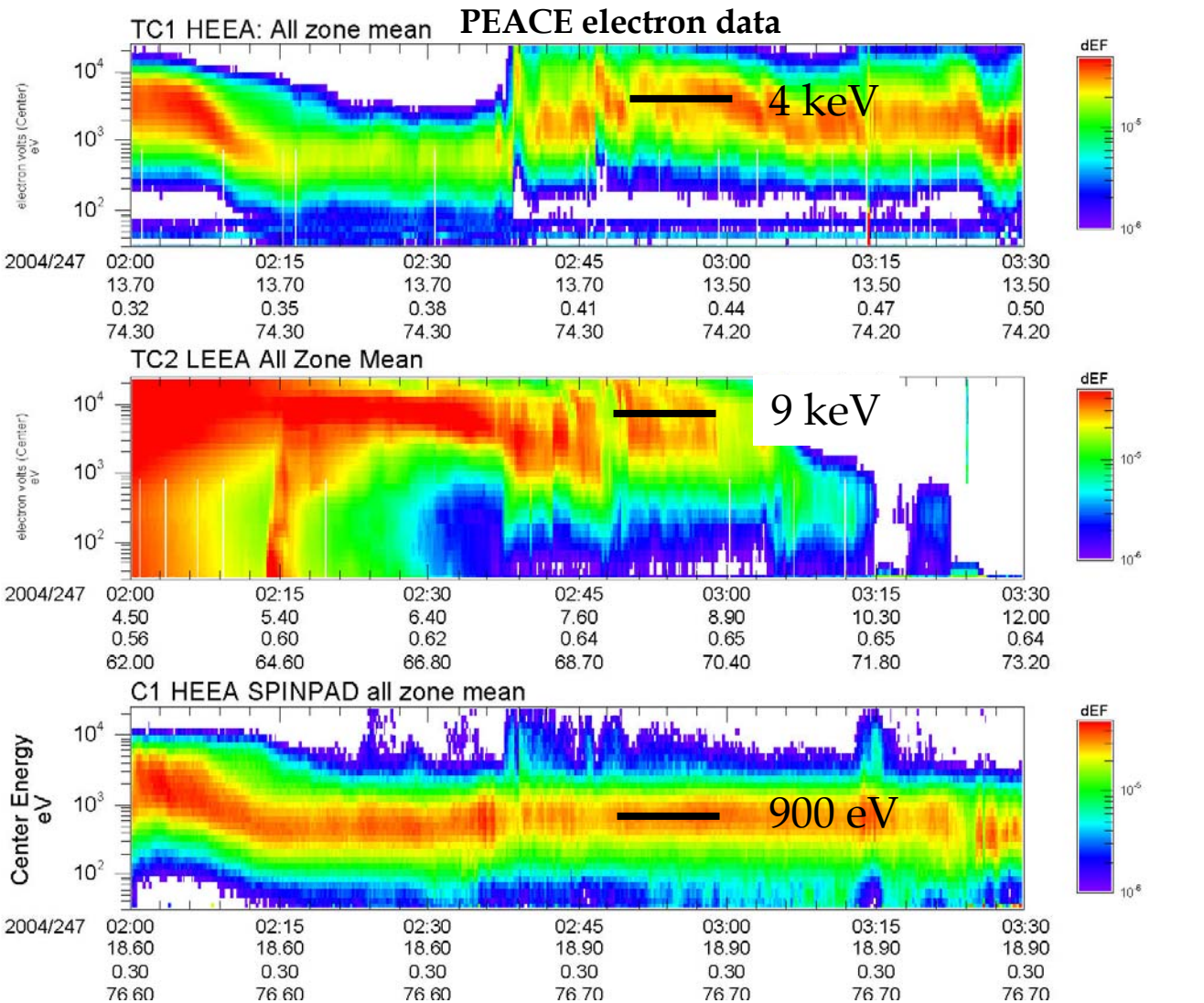
From Zhang et al., 2005



⇒Waves extend from 11 to 16 Re

⇒Need more conjunctions in tail to see If waves always extend up to 11 Re

From Zhang et al., 2005



=> Need more conjunction under different activity From Fazakerley et al., 2005

2. To measure simultaneously small, medium and large scale in tail

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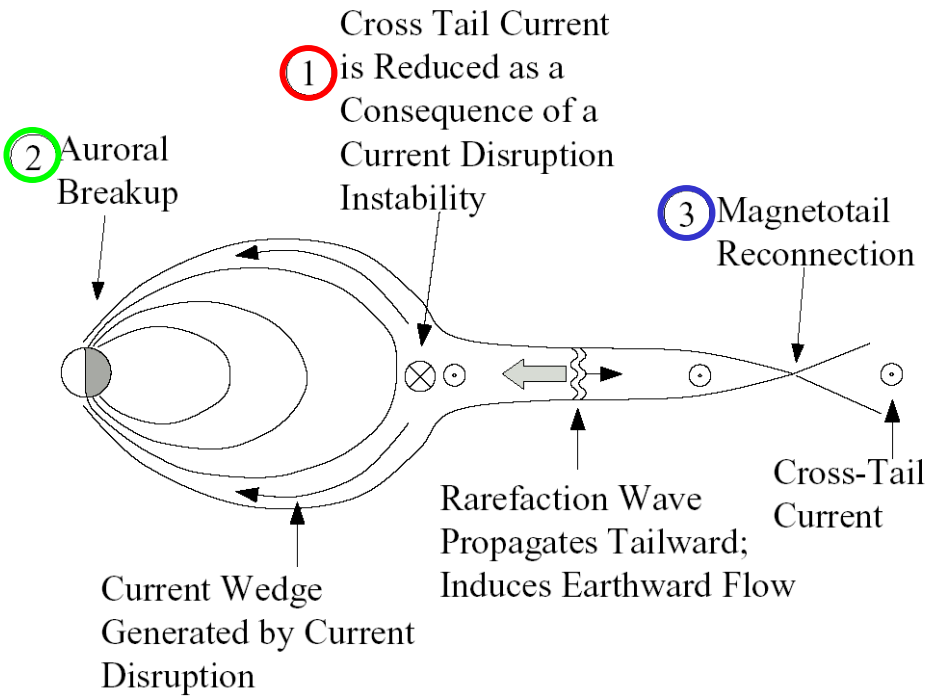
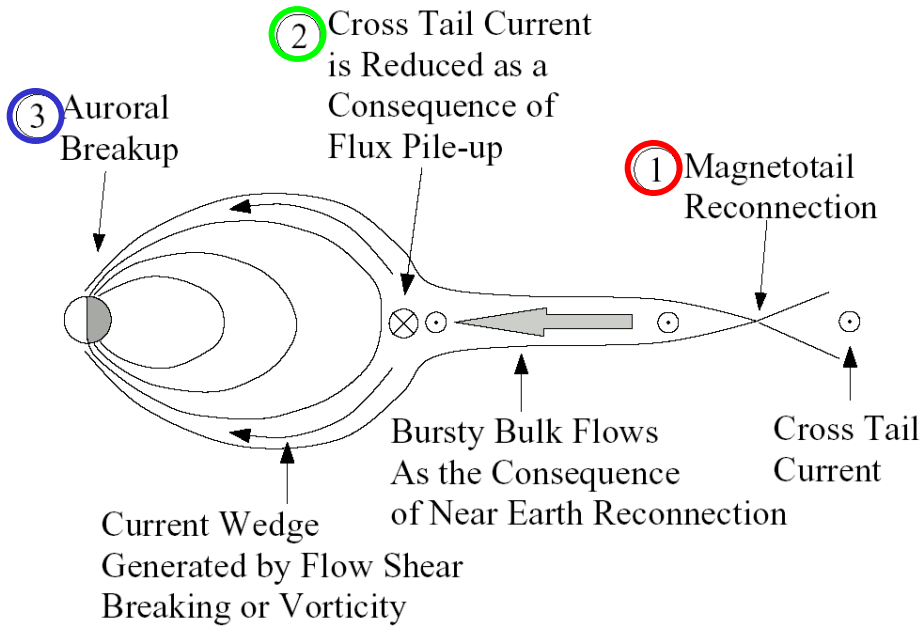
Two substorm models

Current disruption



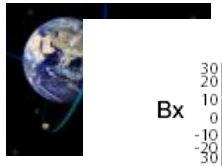
Reconnection

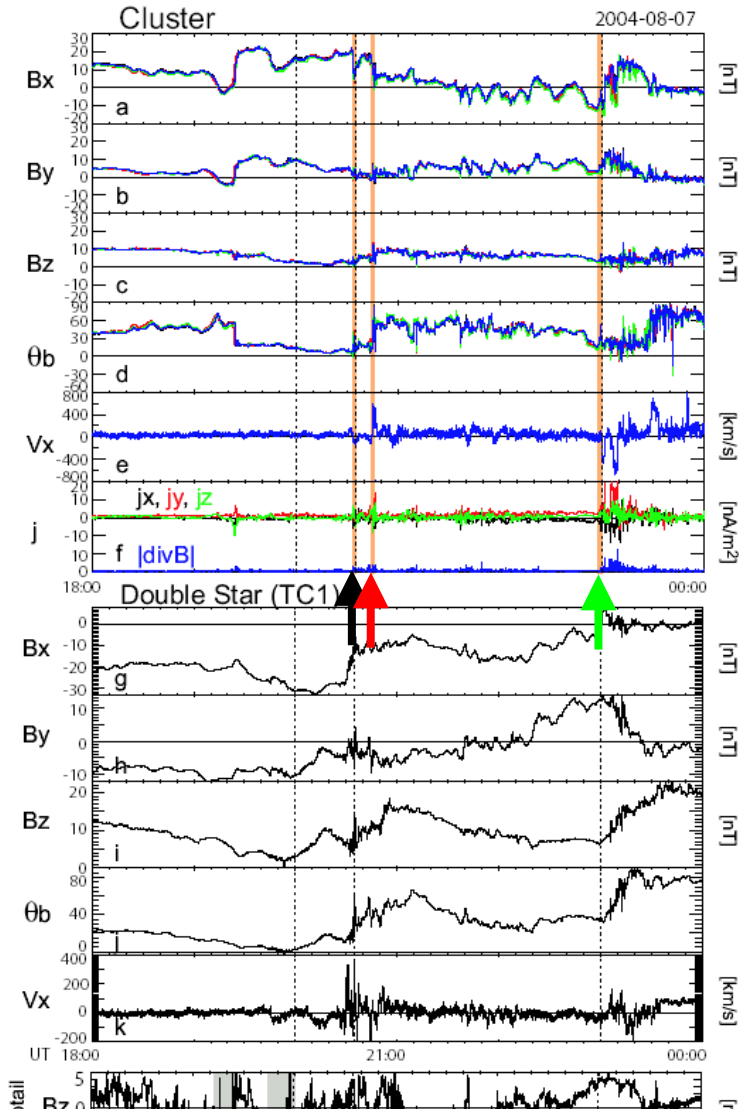


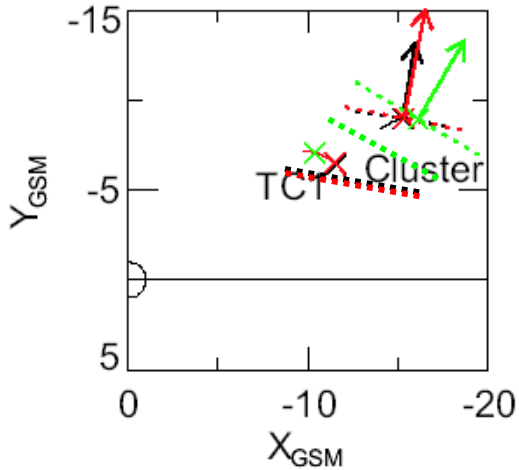
Current disruption

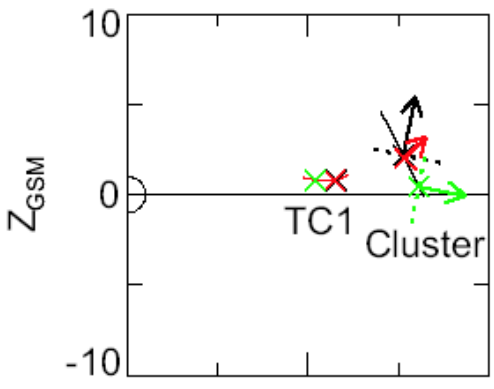
Near Earth neutral line

From Angelopoulos, 2001





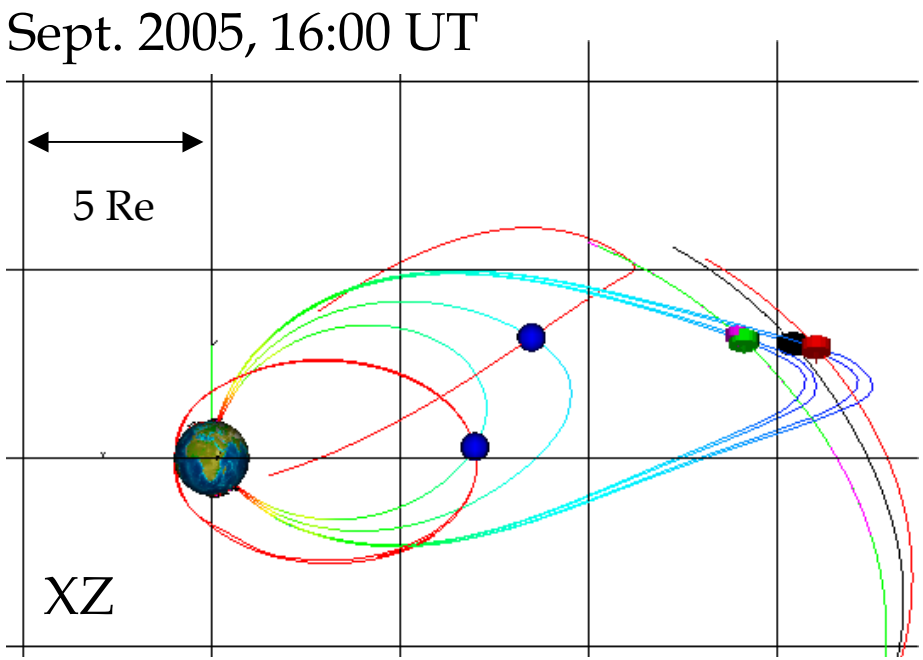




⇒Process at small and medium scales

⇒Need small, medium and large => extension

Extension tail: summer 2005



- Cluster: 14-16 Re, 1000-10000 km sep.
- DSP TC-1: 9 Re, apogee above equator
- DSP TC-2: apogee in tail, 7 Re

⇒Bursty bulk flow starting at Cluster and monitor breaking at DSP and disruption

=> Current disruption at DSP

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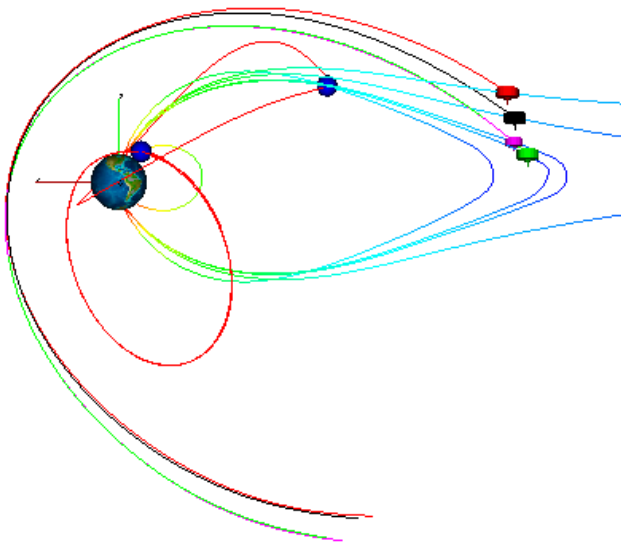
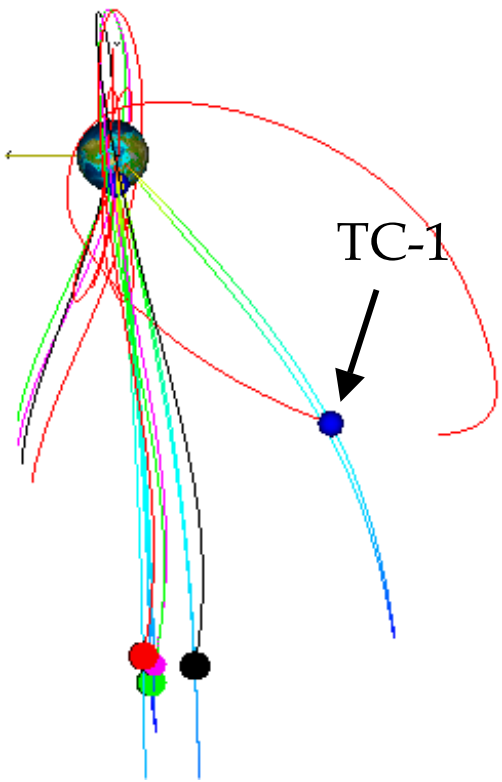
Extension: summer 2006

11 Sept 2006 00:00



XZ plane



XY plane

- Cluster: 14-16 Re, 1000-10000 km sep.
- DSP TC-1: 9 Re, gradual sep. in Y
- DSP TC-2: apogee in South hemisphere

=> Azimuth extent of current disruption

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3. To measure size of large scale structures at the magnetopause/cusp

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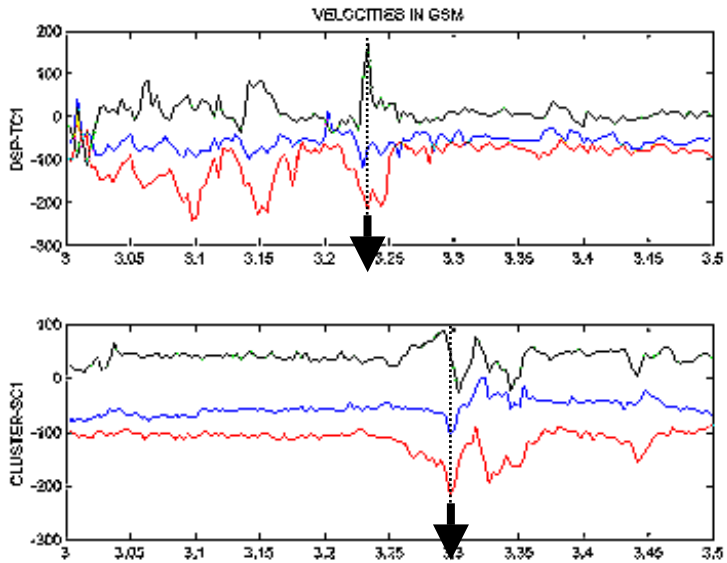
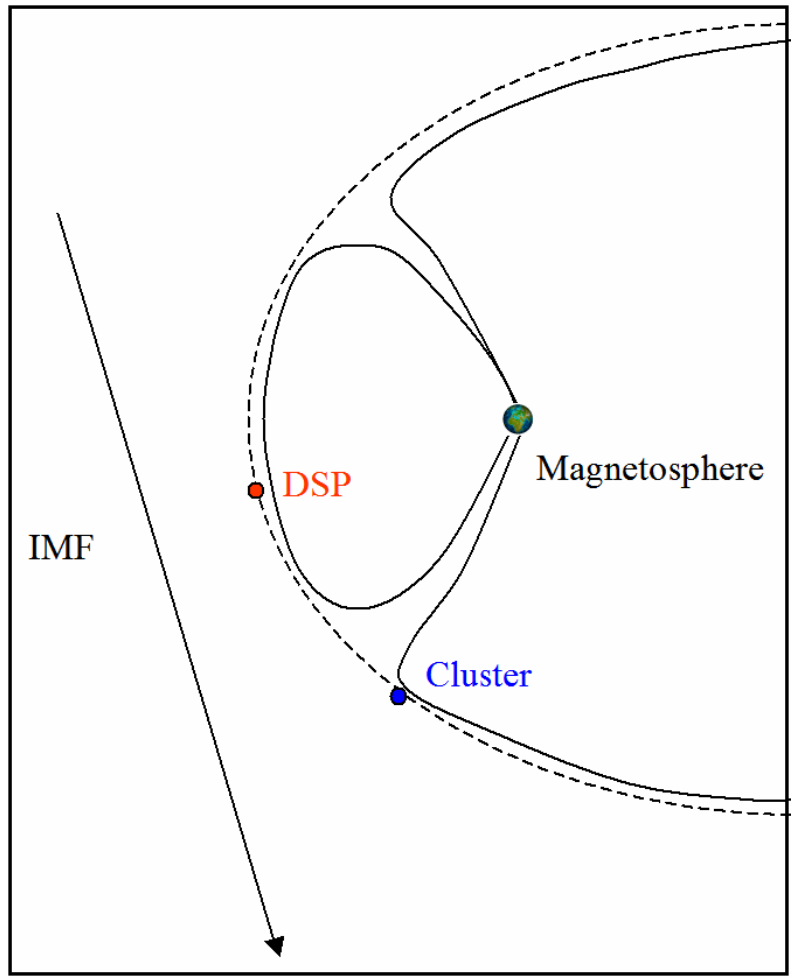
Double Star – Cluster: FTE evolution

DSP

Cluster





Strong flow of plasma observed first at Double Star and 5 min later at Cluster

⇒Reconnection starts at subsolar point

⇒FTEs size? 1 Re? X line extended azimuth?

From Pitout et al., 2005

Opposite FTEs

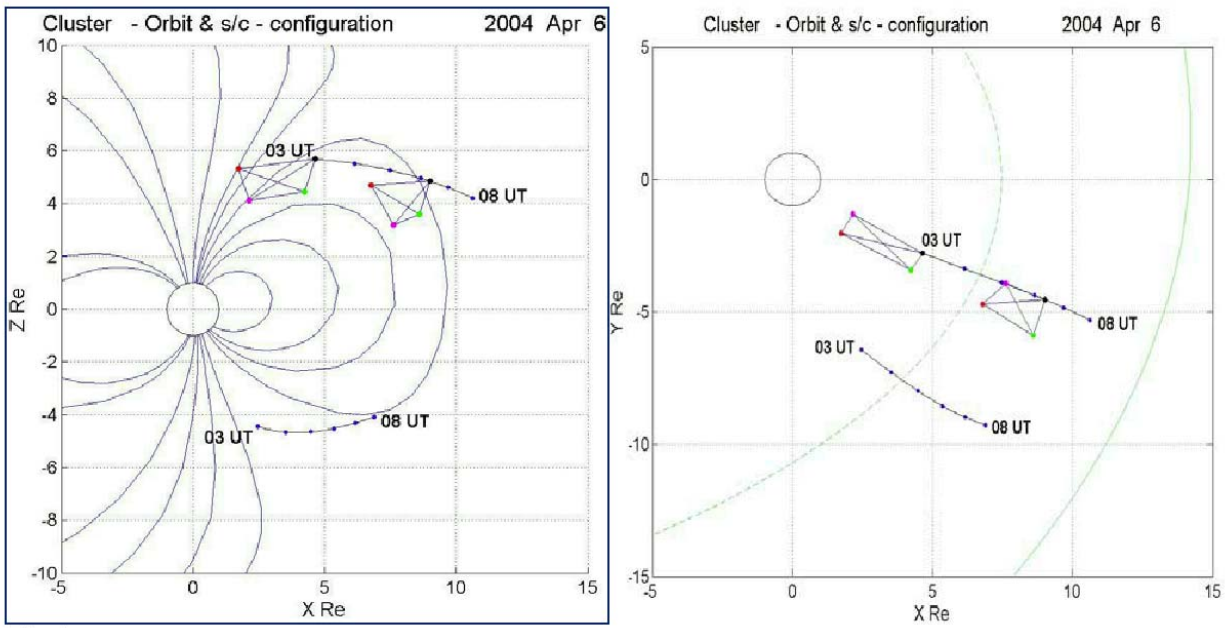


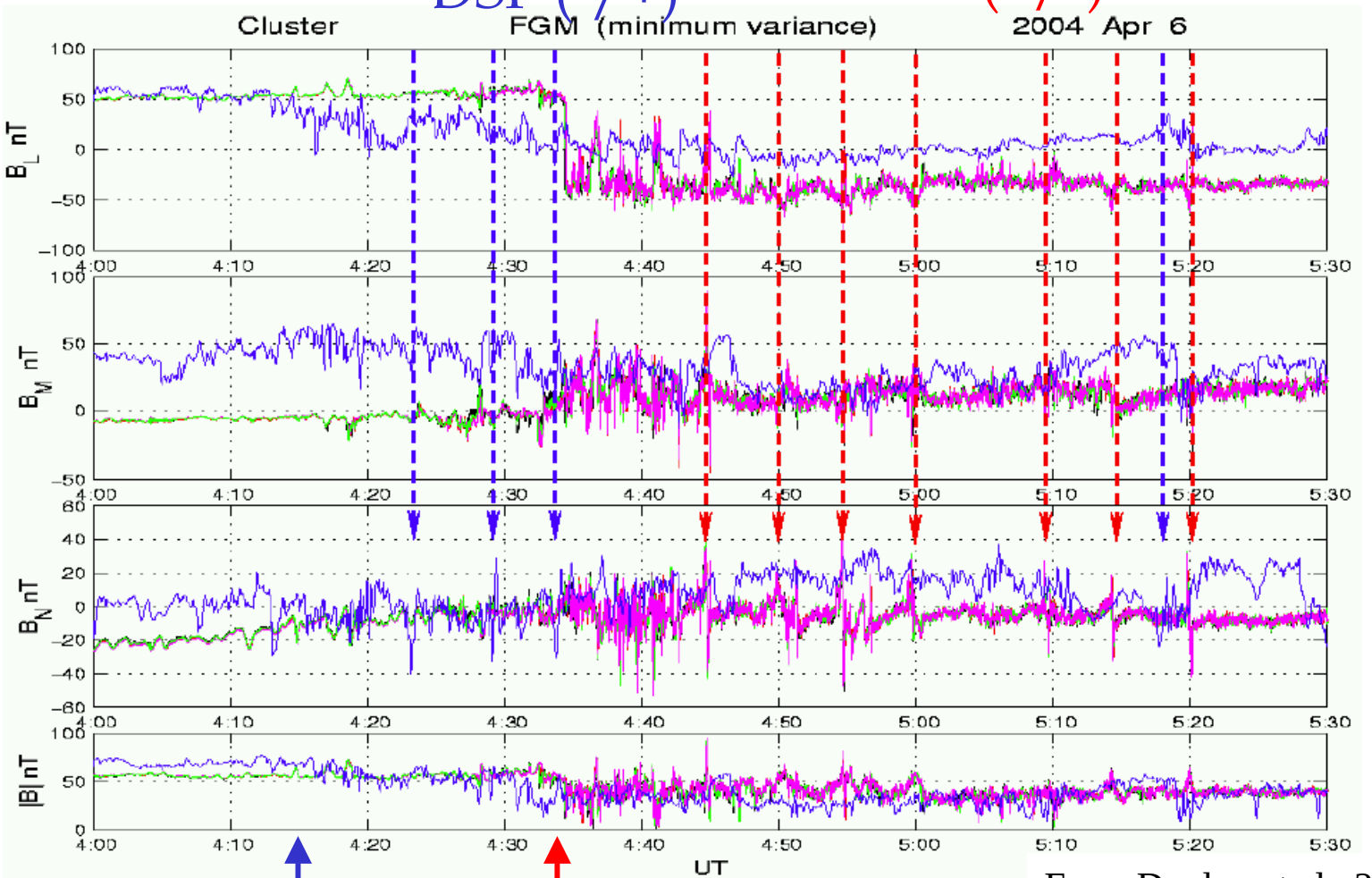
Fig 1

From Dunlop et al., 2005

Opposite FTEs

DSP (-/+)

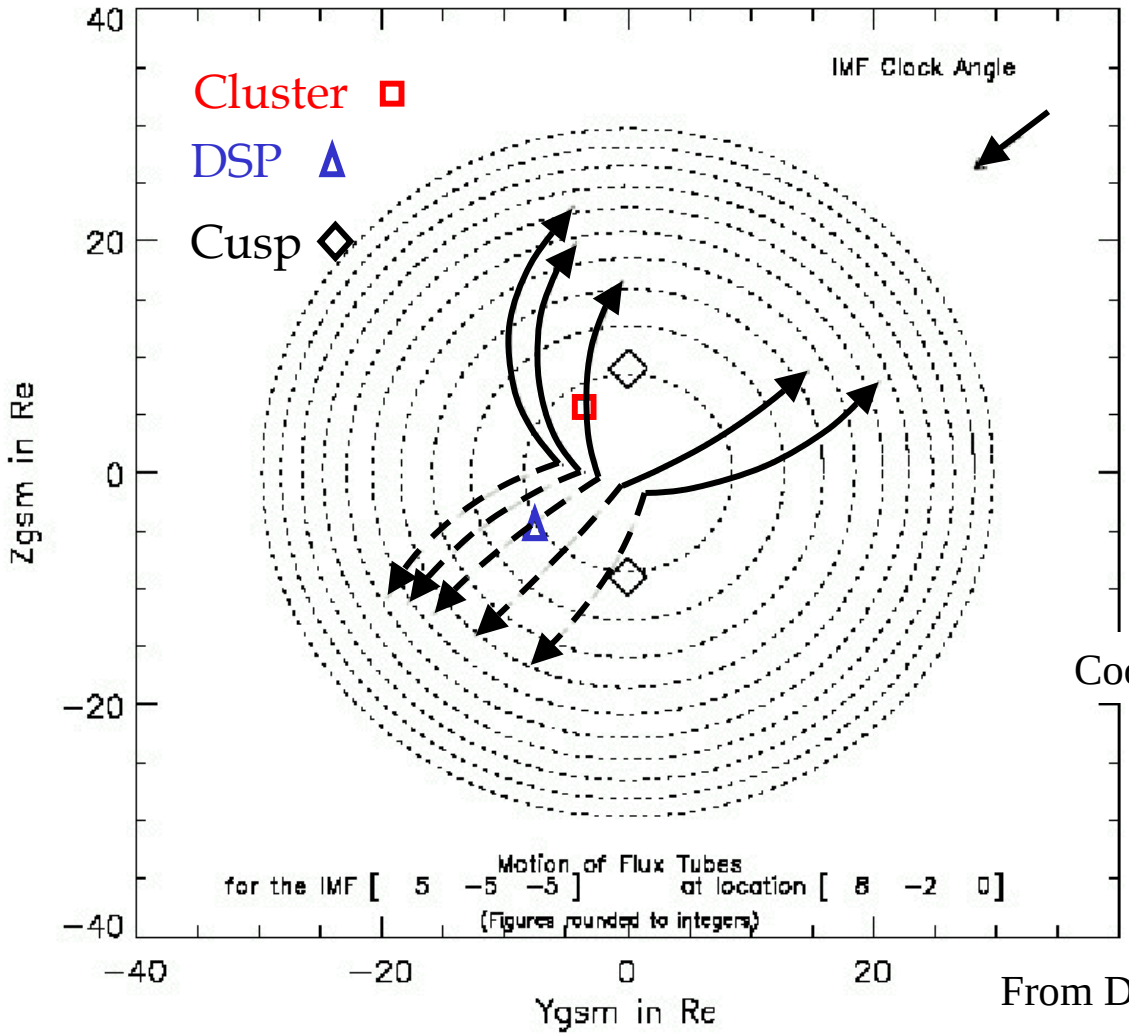
Cluster (+/-)



Mpause

From Dunlop et al., 2005

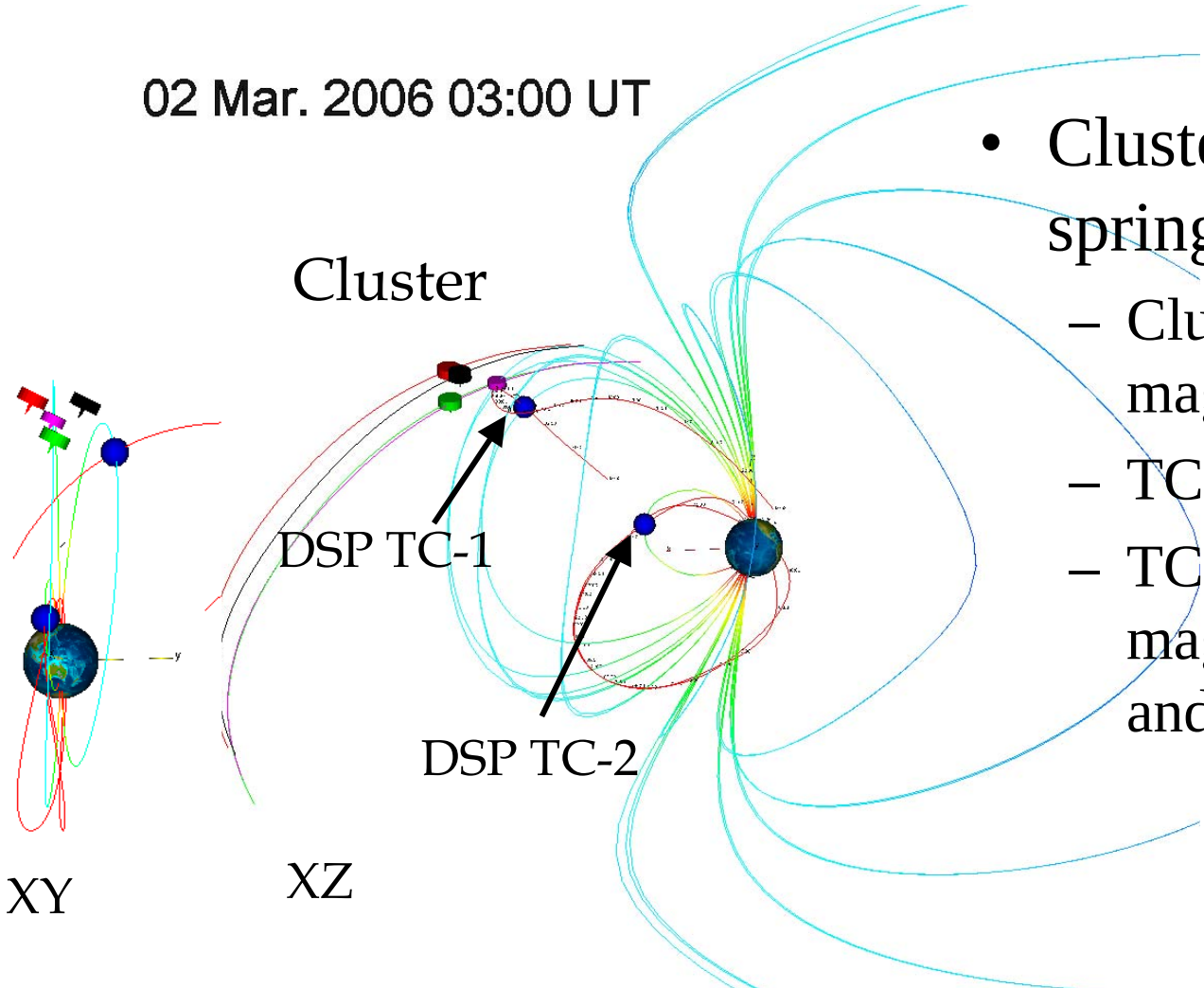
Opposite FTEs



Cooling's model

From Dunlop et al., 2005

Extended mission cusp: spring 2006



- Cluster and DSP spring 2006
  - Cluster 10000 km at magnetopause/cusp
  - TC-1 near the cusp
  - TC-2 inner magnetosphere dayside and Southern cusp

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4. To observe additional rare events like reconnection and geomagnetic storms

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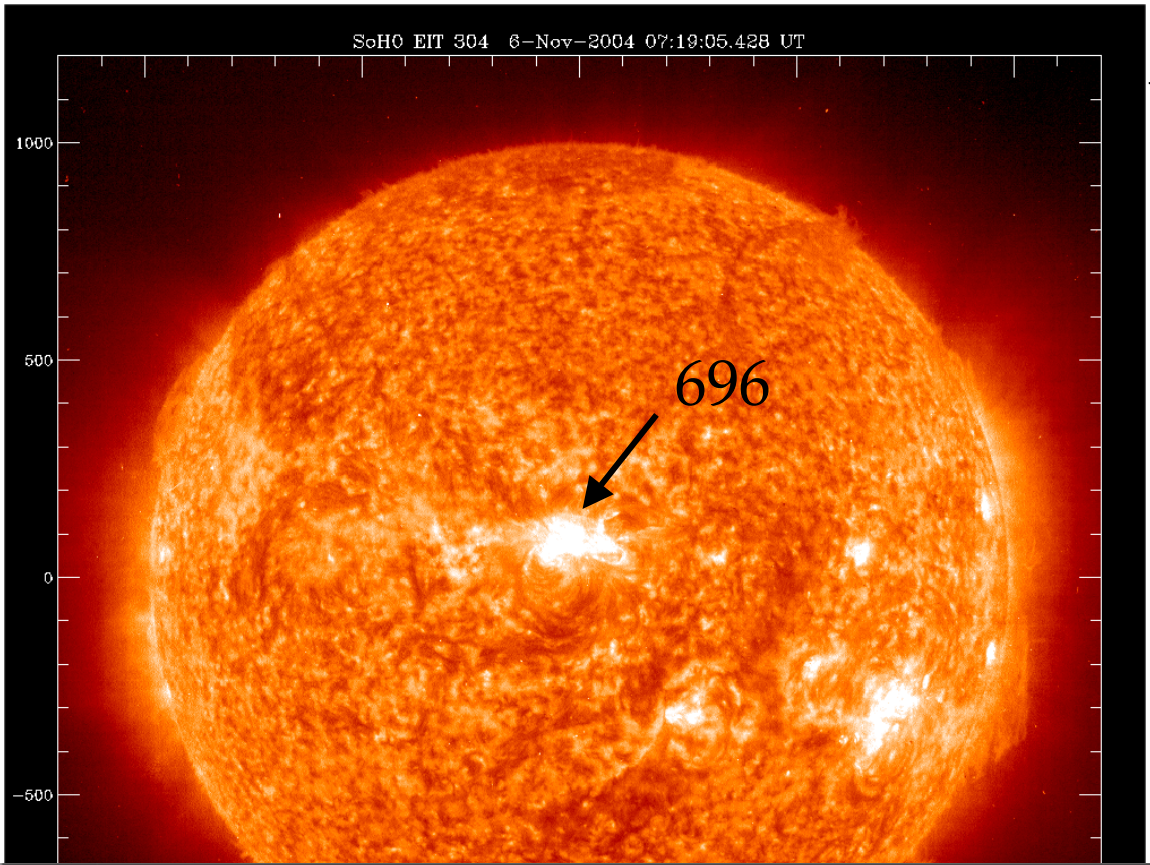
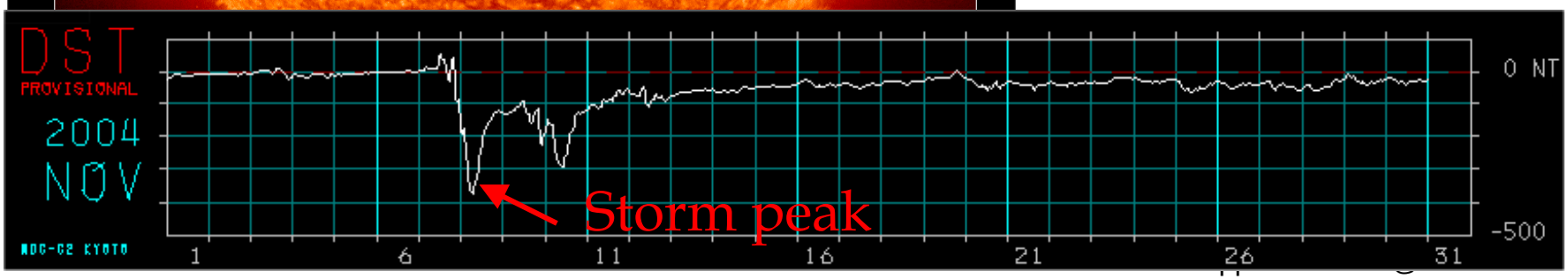
Double Star



Very large Solar storm, 3-13 Nov. 2004:

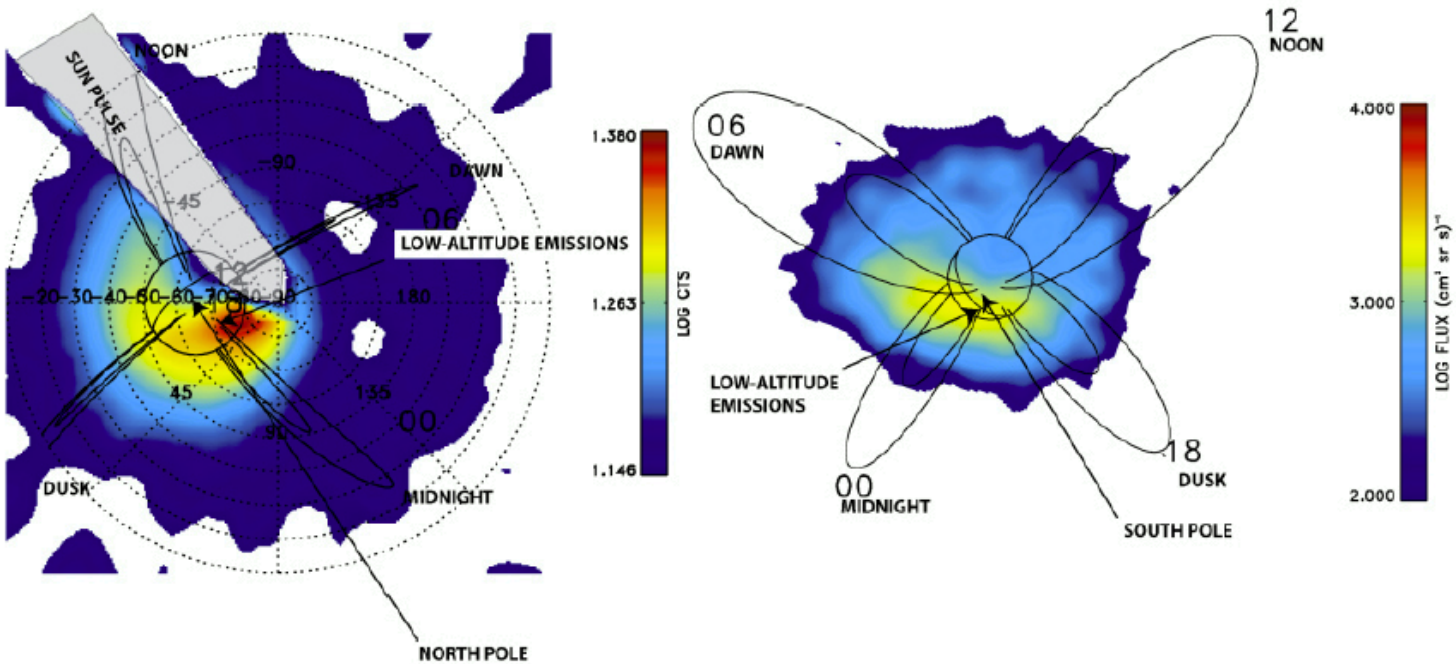
- Eleven M class and 2 X class flares
- 9 Earth directed CMEs
- DST index down to -383 nT



Energetic Neutral Atoms images

North hemisphere
Double Star

South hemisphere
IMAGE



=> Need more storms

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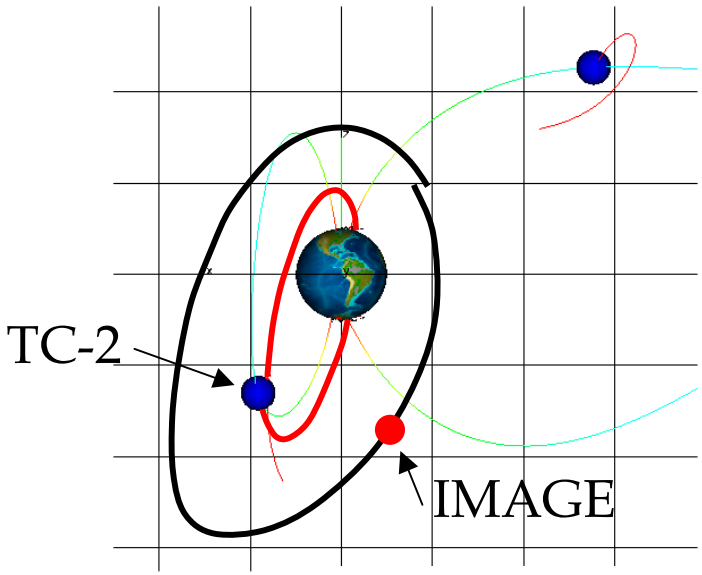
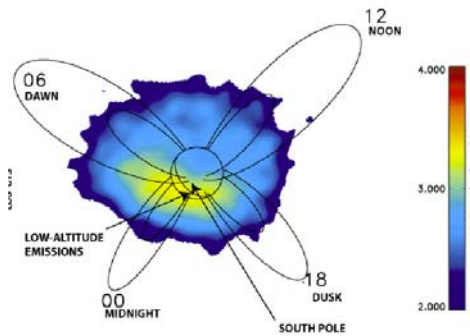
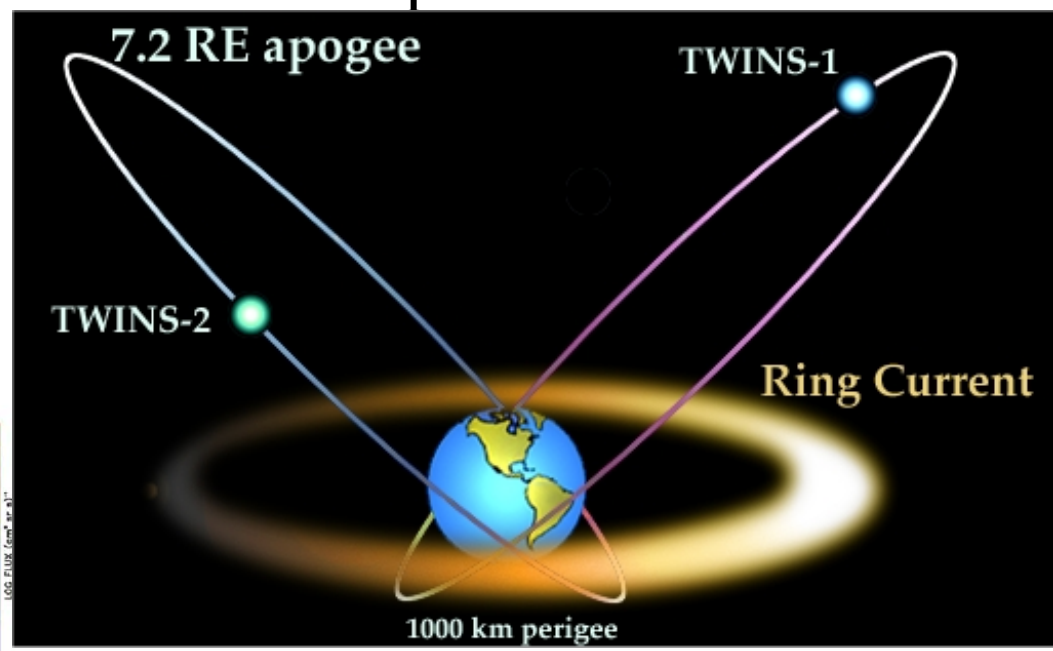
Extended mission : winter 2005

22 Dec 2005, 00 UT





- DSP TC-2 and IMAGE both in South hemisphere



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Double Star spacecraft status

- TC-1 and TC-2 are working nominally, apart from the attitude computer failure
- Operation and data analysis OK, since attitude derived from magnetometer data
- Evolution of attitude during extension:
  - TC-1: 9^{o} drift up to end 2006
  - TC-2: 30^{o} drift up to end July 2006

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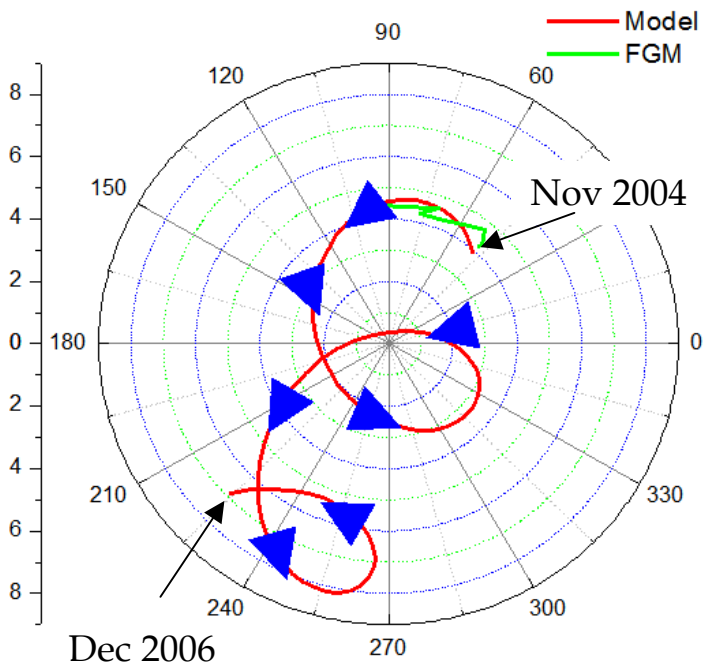
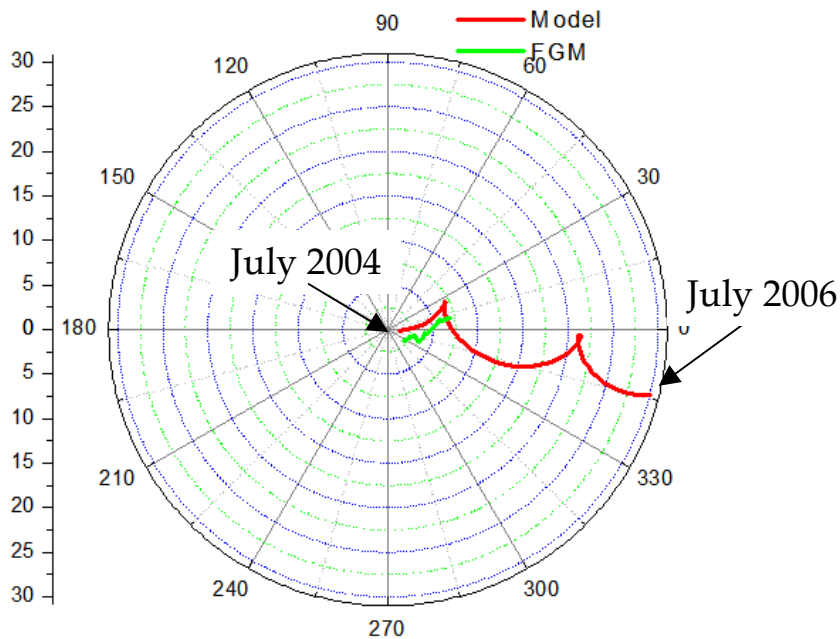
Spacecraft attitude evolution

TC-1



TC-2



Y. Shigeng, CAST, China

Instrument status

- FGM: OK (more work to calibrate TC-1 data)
- HIA: OK
- PEACE: OK (resets but regular switch on)
- ASPOC: OK
- STAFF/DWP: OK (interferences)
- NUADU: OK
- Chinese instruments: OK (calibrations)

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Ground segment and data system

- Vilspa II: 3.3 h of data dump per day (99% dumps OK)
- Shangai, Beijing: OK
- Data distribution system:
  - Quicklook (DSDSweb): OK, five days after acquisition
  - Summary and Prime parameters: TC-1 (up to Jan 2005), TC-2 (Sept 2004)

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Double Star

Year	**Cluster Separation** (Km)	TC-1-Cluster (km)	TC-2-Cluster (km)	Comment
2004 spring	250	~10 Re		Nominal mission
2004 summer	1000	~ 5 Re	~ 15 Re	Nominal mission
2005 spring	1300	~ 7 Re	~ 5 Re	Nominal mission
2005 summer	1000 and 10000	7-8 Re	8-9 Re	- TC-2 apogee tail - TC-1 apogee above equator
2006 spring	10000	1-2 Re	4-5 Re	- TC-2 South pole - TC-1 mid-latitude Magnetopause
2006 summer	10000	~ 6 Re	~ 15 Re	- TC-1 apogee back to equator separated in Y with Cluster - TC-2 South pole

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Conclusion

- Very good results (Double Star-Cluster) and will do new studies with other configurations and separations.
- Spacecraft, instruments and data system are ready for an extension:
  - TC-1: up to end 2006
  - TC-2 up to end July 2006

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Double Star

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