

SCOSTEP-WDC Workshop. 2-7

29-Sep-2015

Flux Rope Structures of the Solar Wind Associated with Two Intense Geomagnetic Storms in 2015: The 17 March and the 22 June Storms

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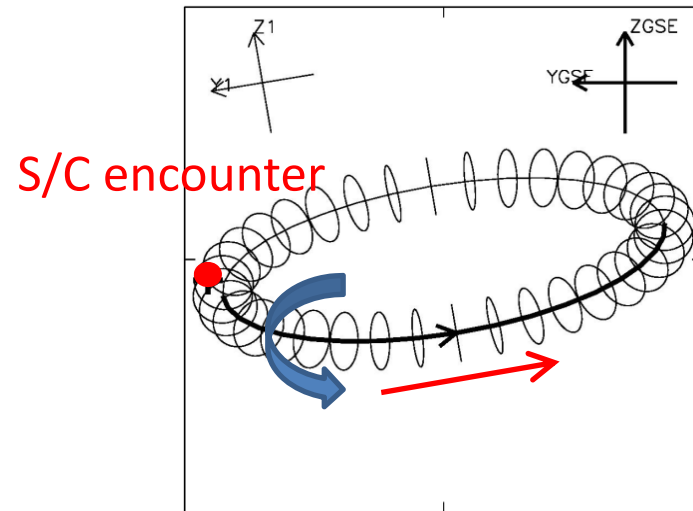
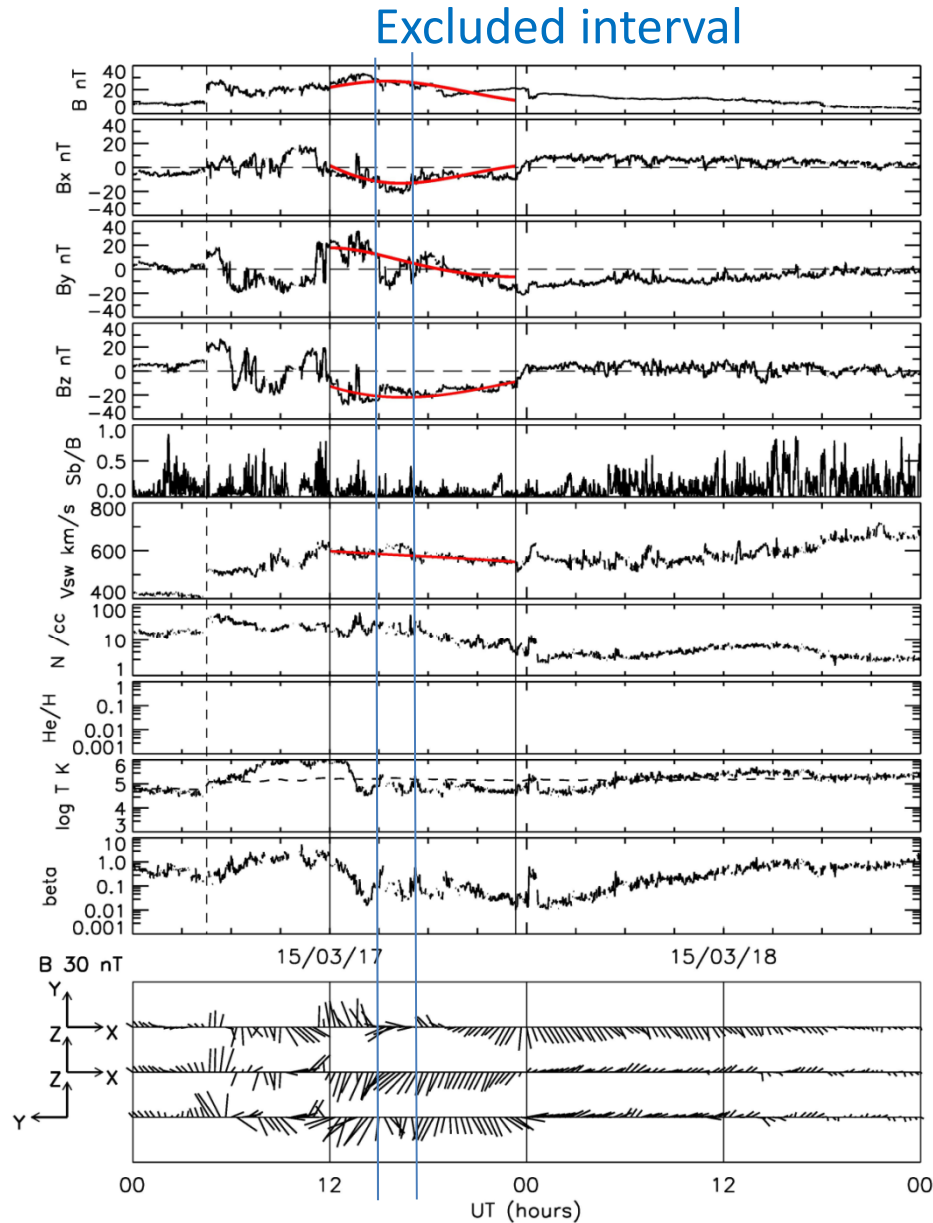
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⁴ National Observatory of Athens

Outline

1. March 17 storm: Flux rope and consistent solar source
2. June 22 storm: Flux rope and inconsistent solar source
3. September 22, 2014 Flux rope: Our experience of encounter with the same difficulty and the final settlement (Our present hope)
4. Examination of Dst development based on Burton et al. (1975) paper

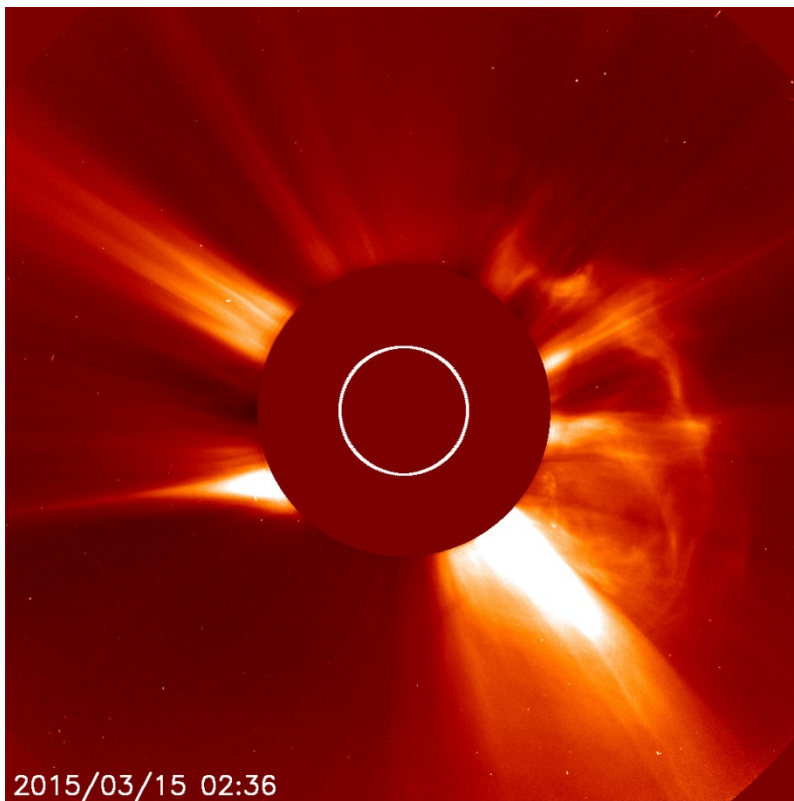
1. March 22 Flux rope (Best fit: RH torus)



This encounter is characterized by negative B_z all through the passage, causing the long-lasting negative B_z . (For near-apex encounter, B_z changes negative to positive, duration of B_s becoming much shorter.)

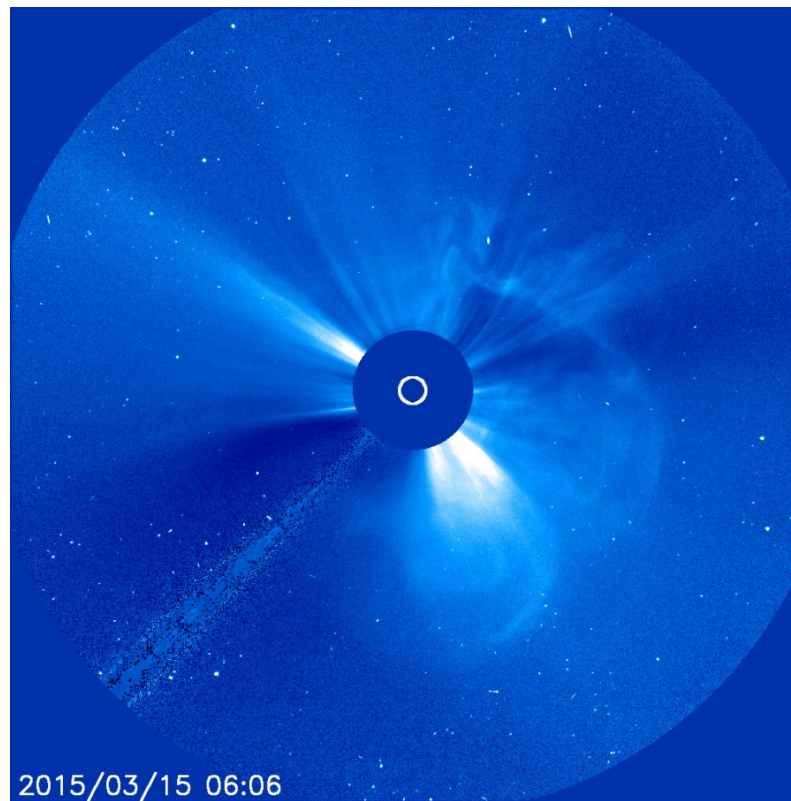
Associated CME

C2



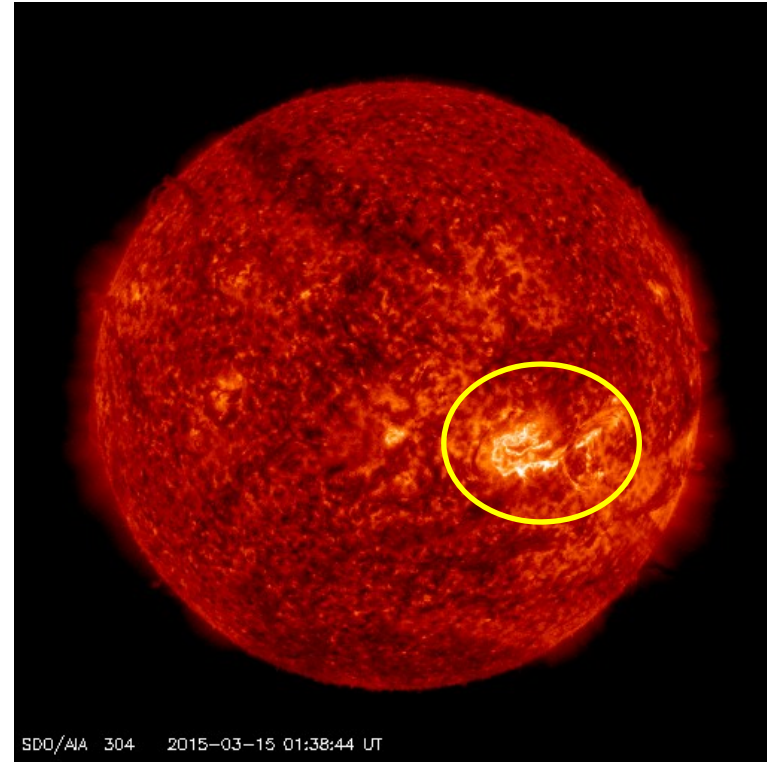
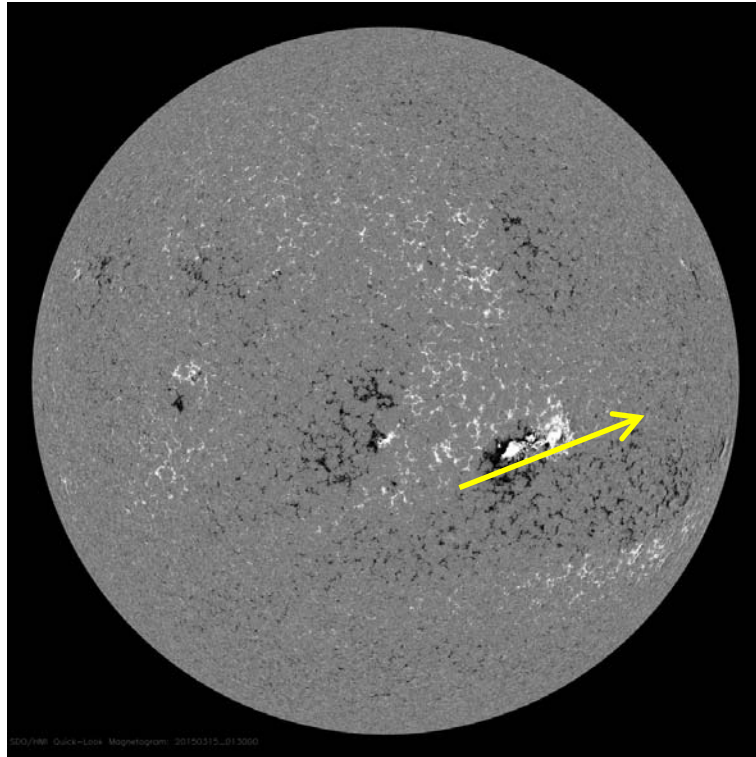
2015/03/15 02:36

C3



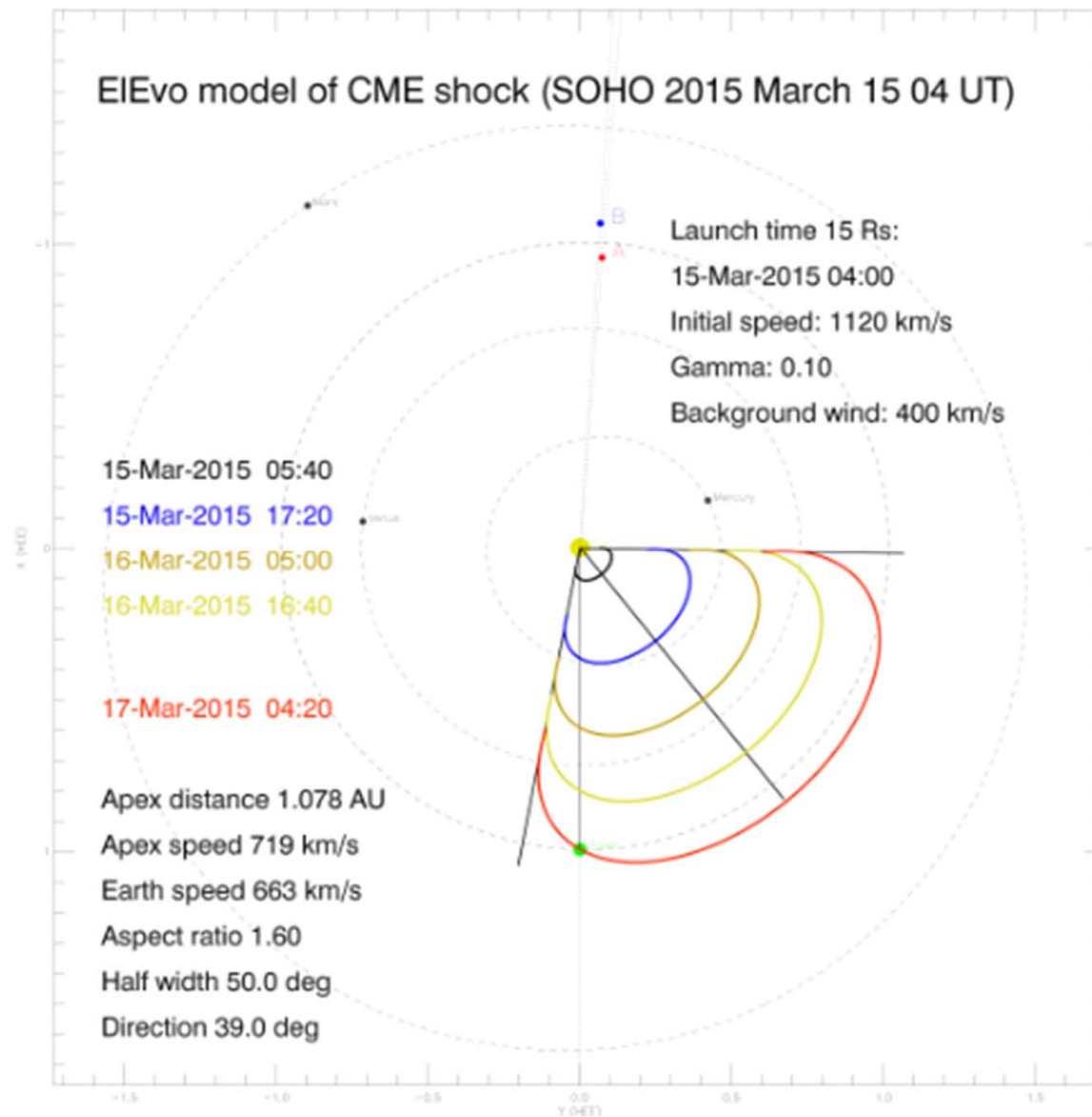
2015/03/15 0606

Solar source event: AR 12297
C9.1 flare at S22W25 Mar 15/01:15 UT (start)



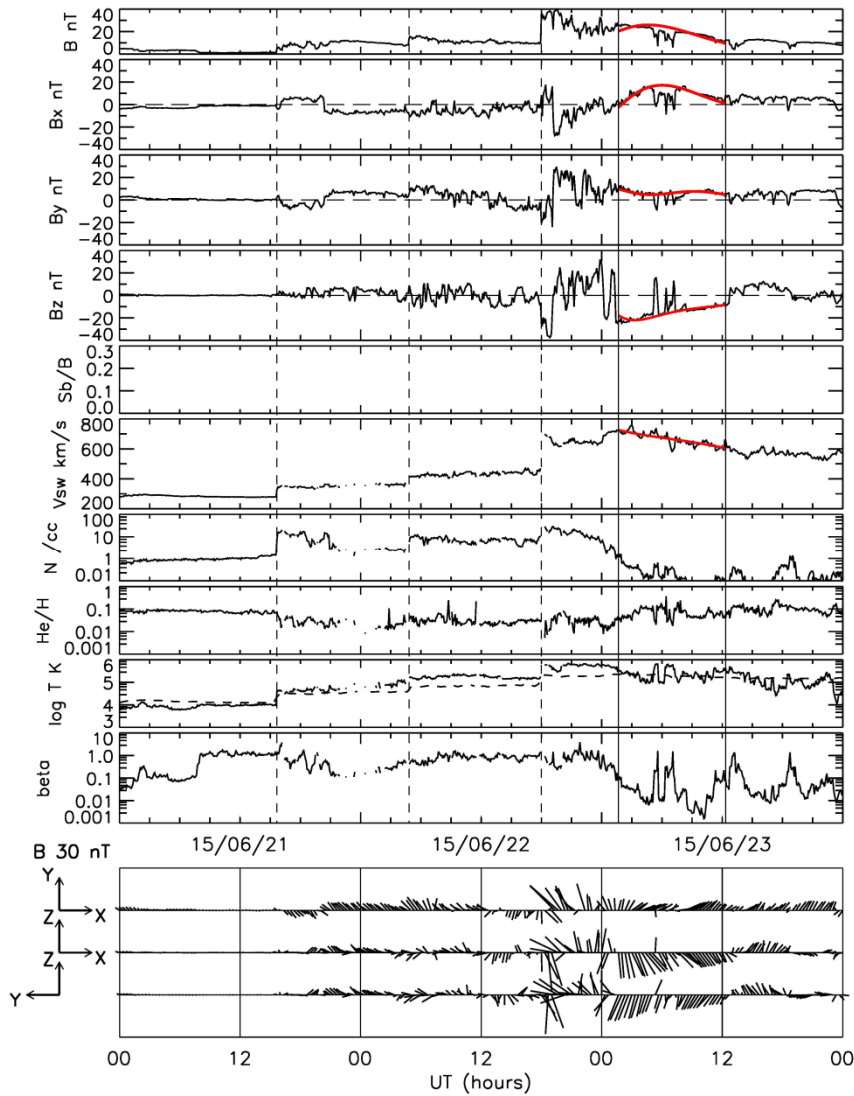
1. The neutral line tilt coincides with the flux rope tilt.
2. The source region is consistent with the S/C encounter at the eastern edge of the flux rope loop.

Flux rope result is consistent with shock model (Möstl)

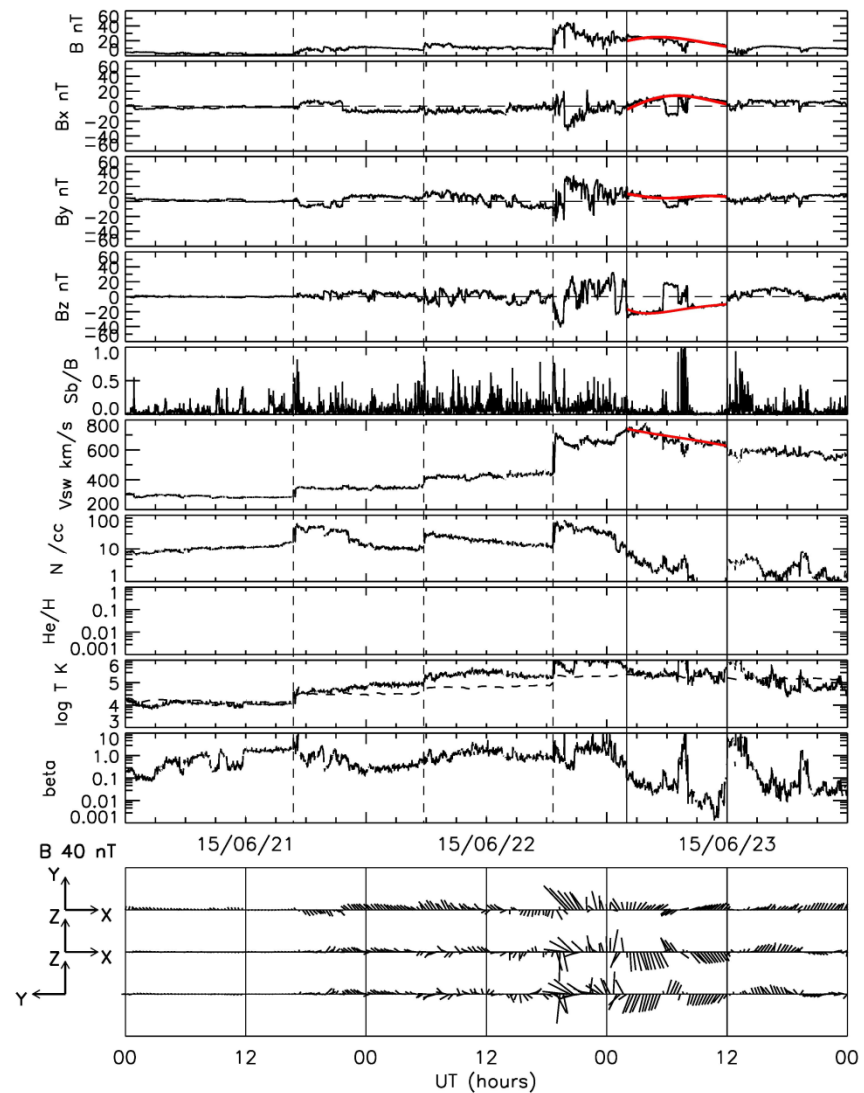


2. June 23 flux rope (torus fit)

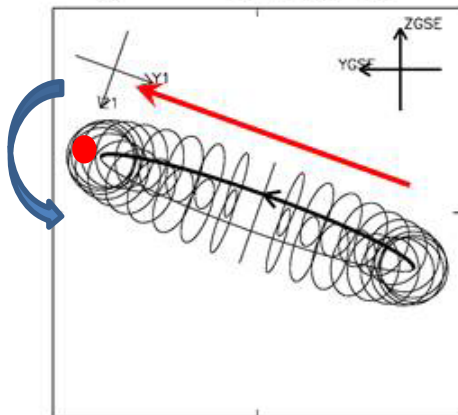
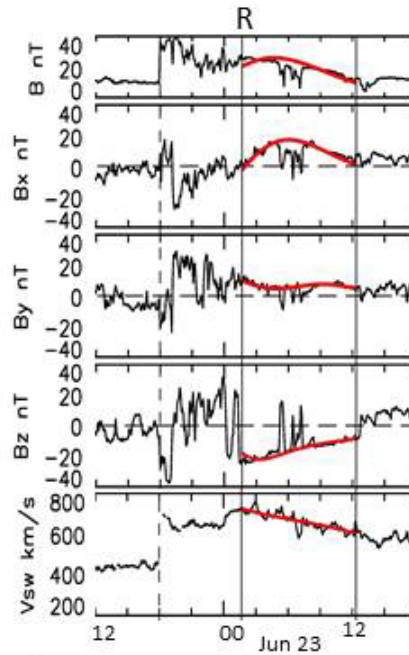
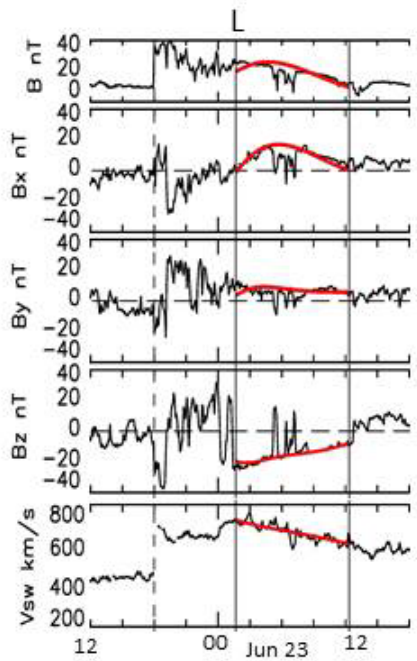
ACE Browse data



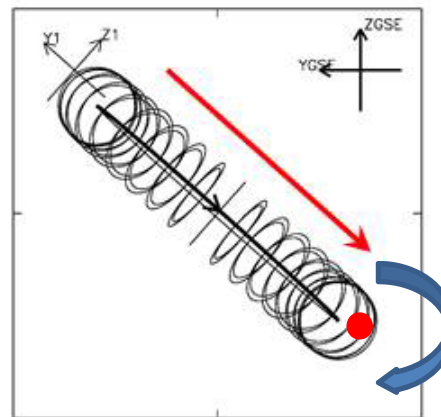
OMNI (WIND) data



Note that the field vector rotation in the Y-Z plane is SMALL.



$R = 0.157$, $r = 0.0318$
 $\text{Lat} = -69^\circ$, $\text{Lon} = 109^\circ$
 $\text{Erms} = 0.161$

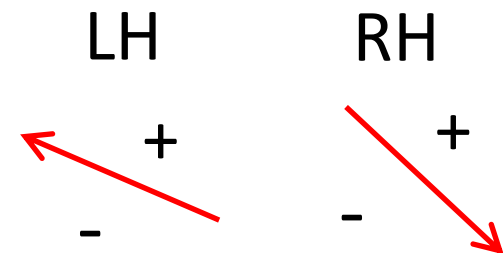


$R = 0.143$, $r = 0.0340$
 $\text{Lat} = 48^\circ$, $\text{Lon} = 272^\circ$
 $\text{Erms} = 0.132$

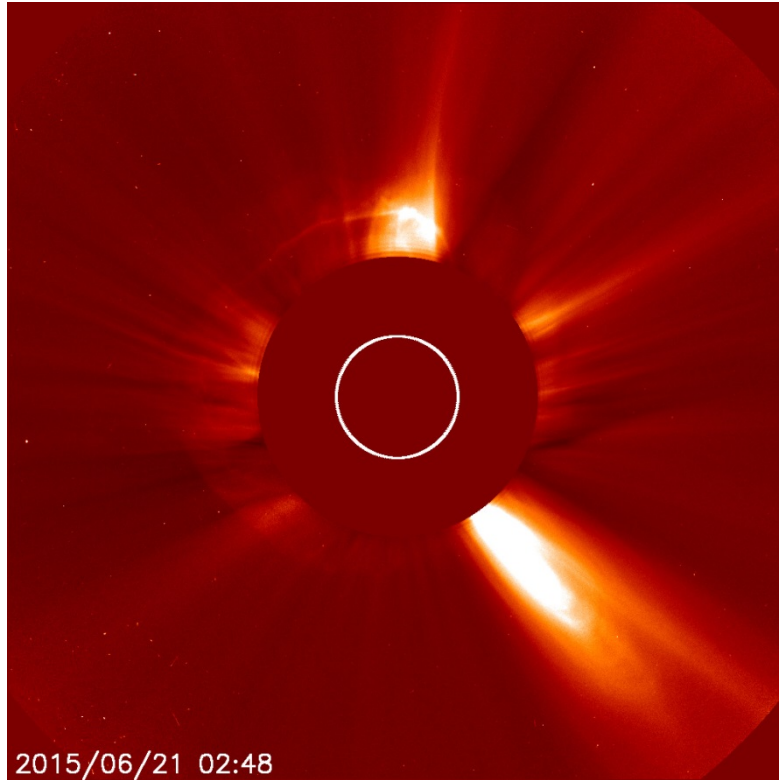
Either of RH & LH can explain the observed B fields.

Again (like March) S/C encounter yields negative Bz through passage.

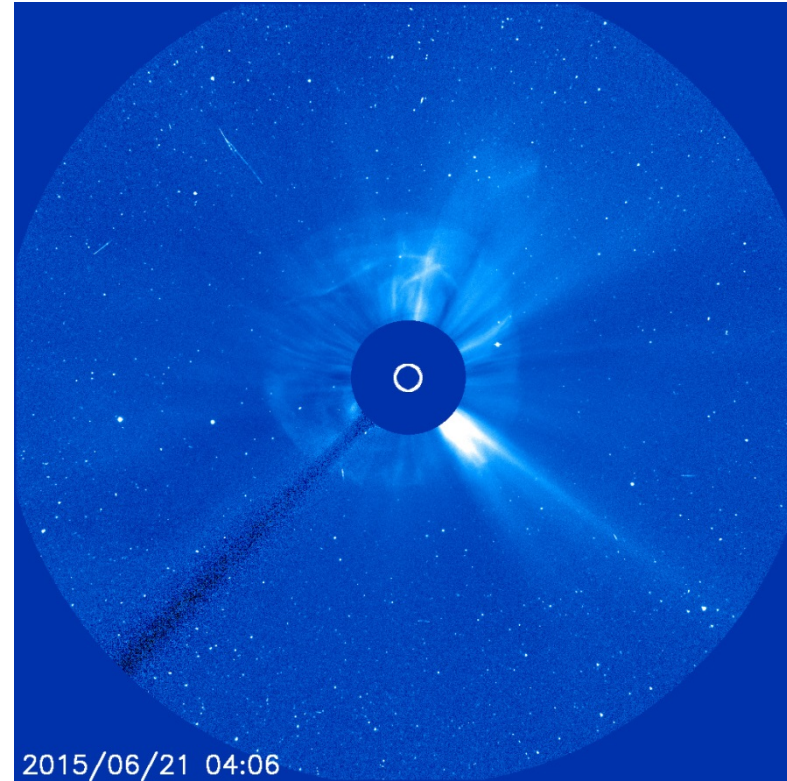
Required polarity:



A CME: Almost complete CIRCLE

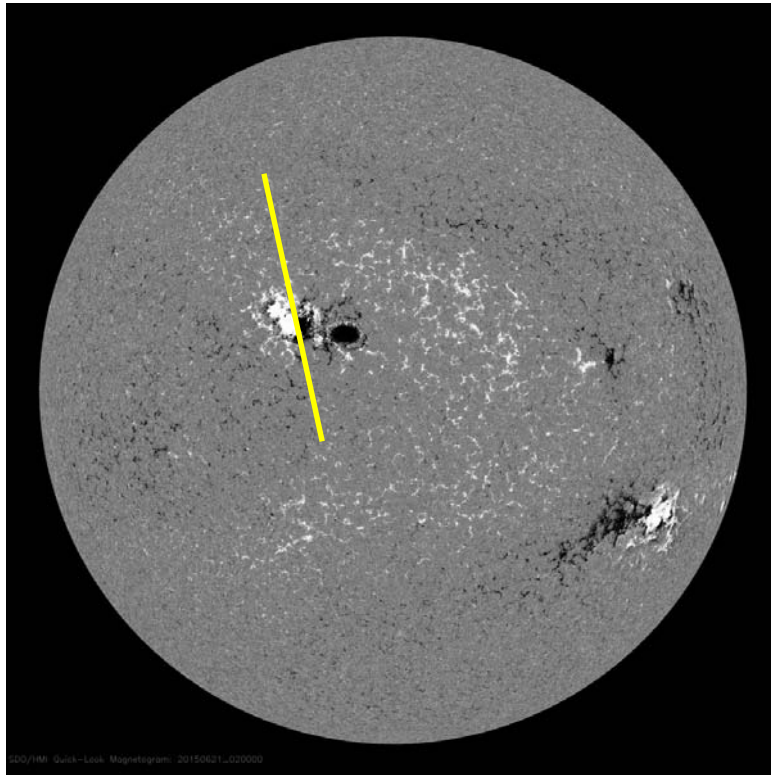


C2: June 21/02:48 UT

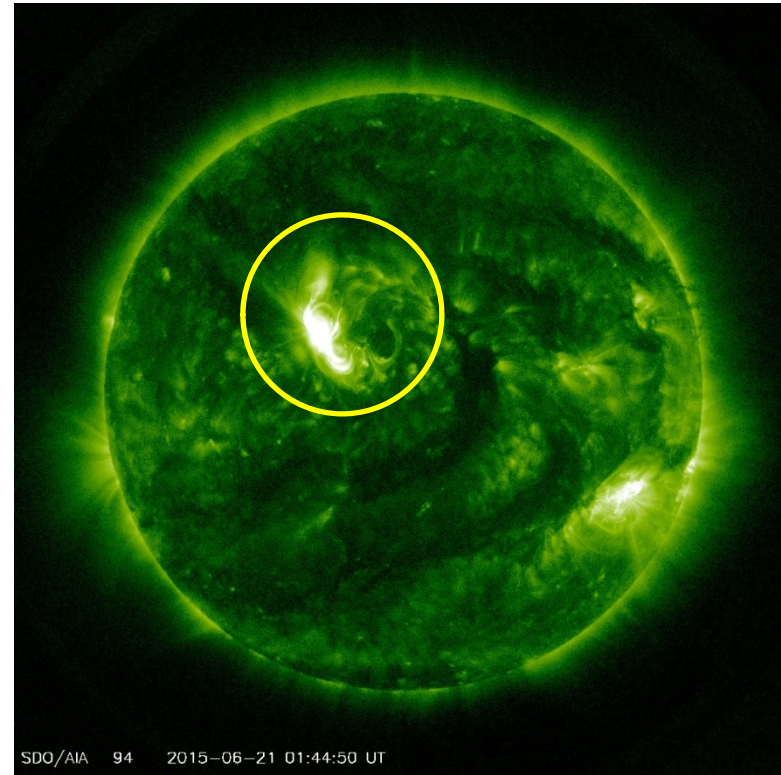


C3: June 21/04:05 UT

Solar source event (?) AR 12371
N12E13, M2.7 flare, 06/21/01:02 (start)



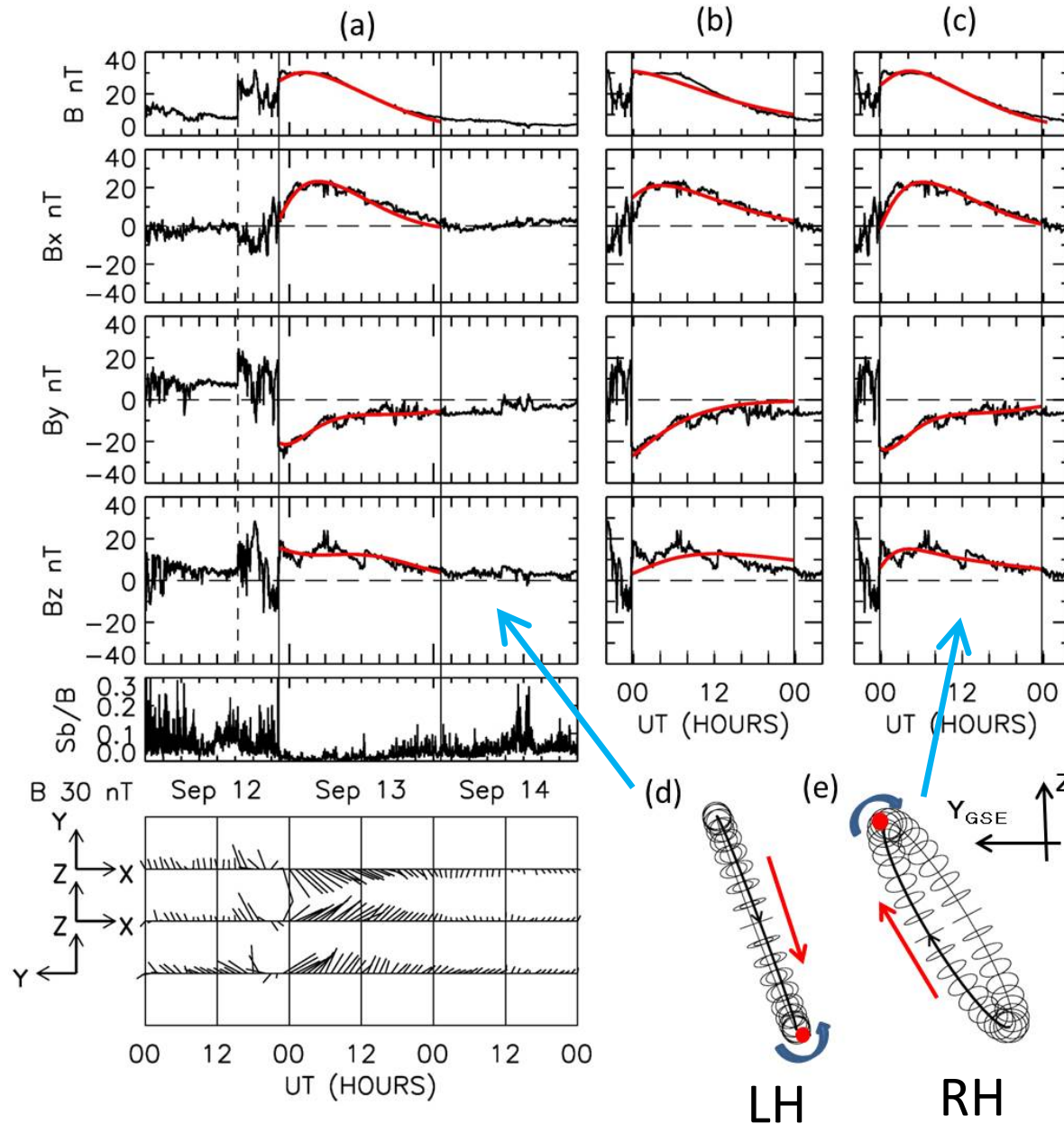
SDO/HMI 2015 June 21 02:00



SDO/AIA094 2015 June 21 01:44

The polarity change across the neutral line: **opposite** to that required from the flux rope!

3. Sep-12 2014 fluxrope (RH, LH both fit well, no rotation)



Encounter: edge
 LH: southern edge
 RH: northern edge
 $B_z > 0$ throughout
 the passage
 (If encounter near
 the apex, strong
 $B_z < 0$ observed)

The required
 polarity change

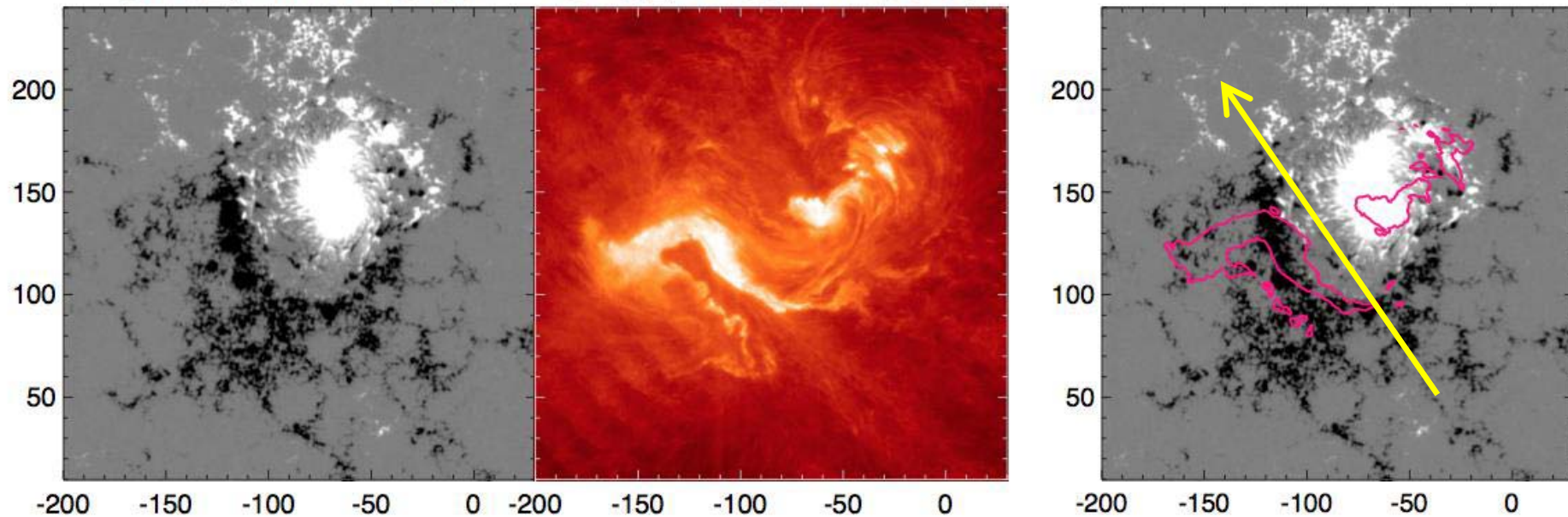


10 September, X1.6 flare,
AR 12158 (N11E05), start: 17:21 UT

The main neutral line (yellow arrow)

SDO_HMI 17:29:50

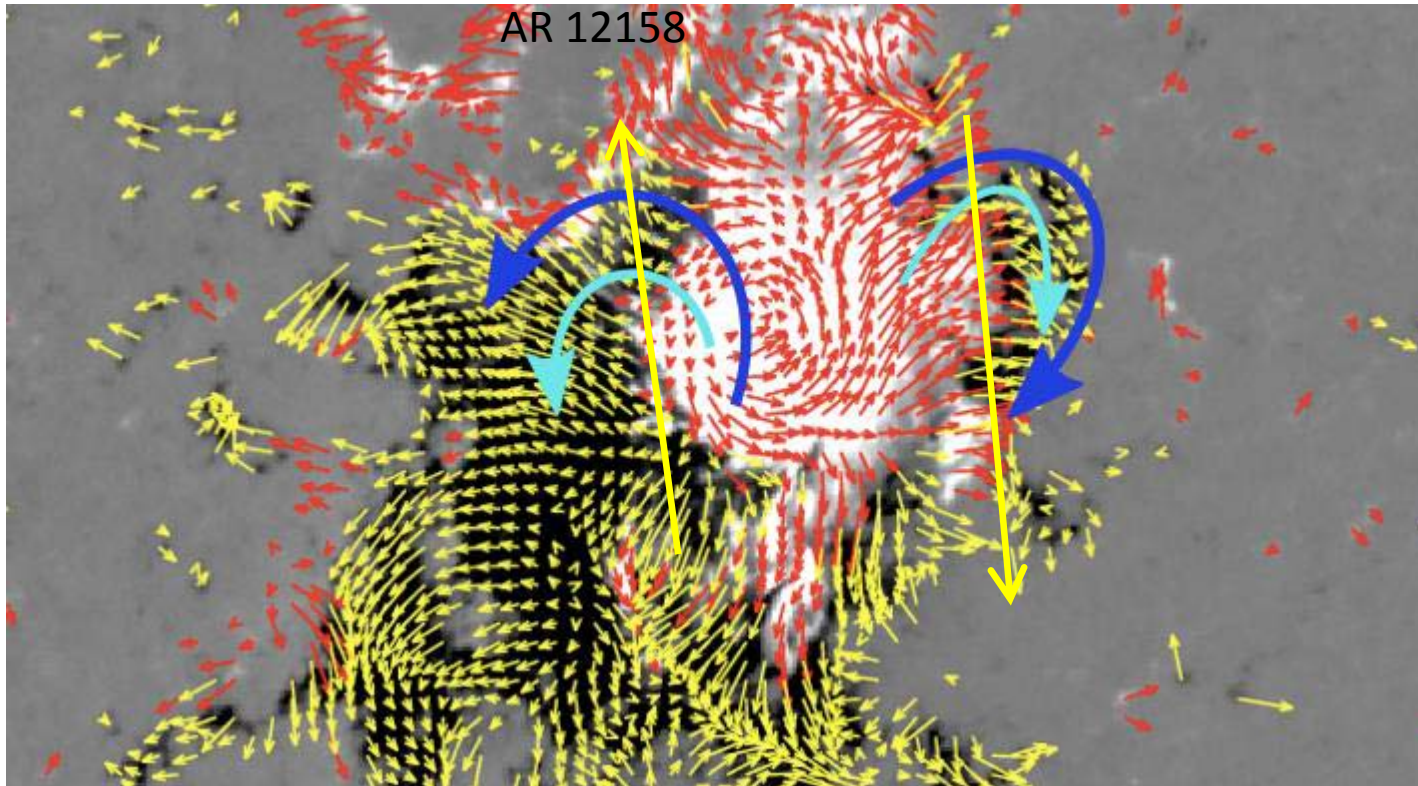
SDO_AIA304 17:30:09



If this WAS the source, the polarity change is **opposite to the required** one: same difficulty as for June storm.

However,

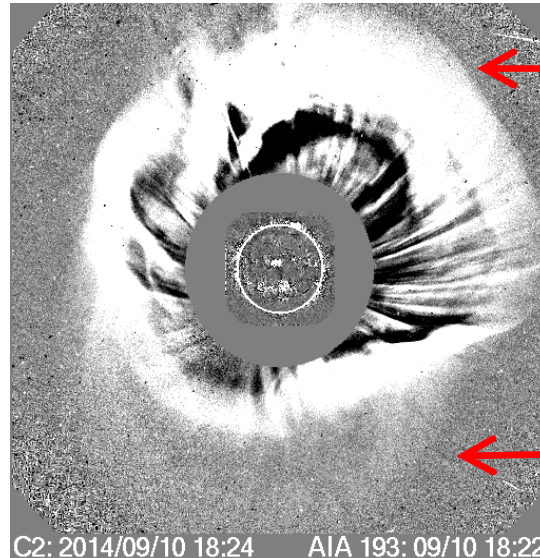
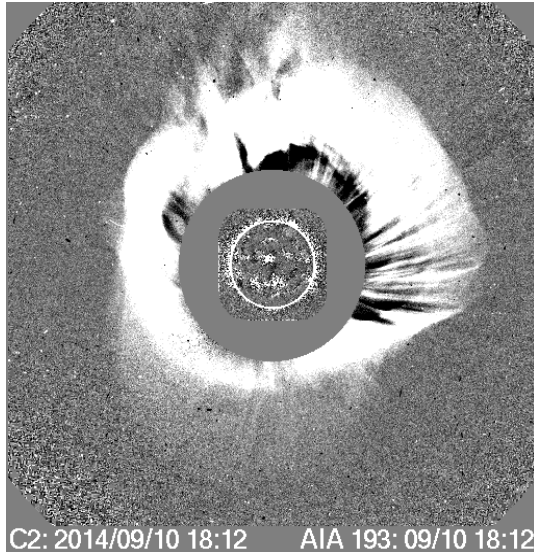
The FACT is “2 eruptions occurred SEPARATELY!”



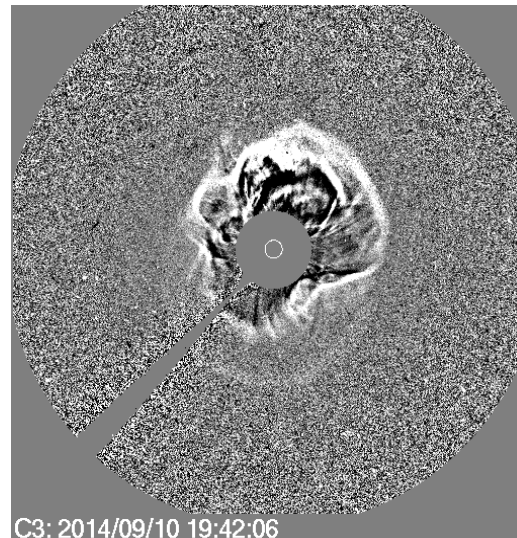
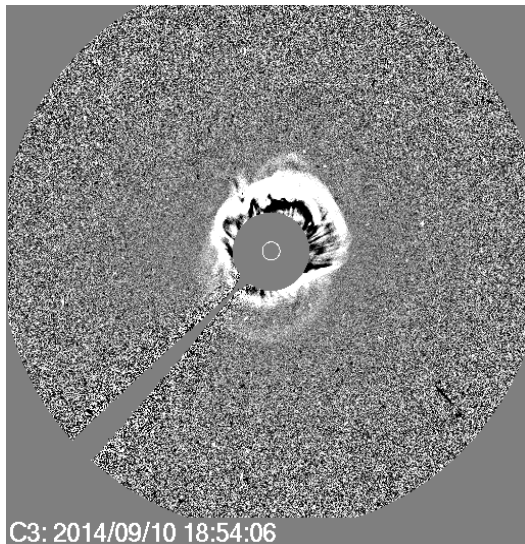
The western eruption gives the consistent features with the LH flux rope signatures.

→ **Difficulty settled!**

FACT: 2 eruptions and 2 CMEs (one to N, one to S)



CME1: from the western eruption, denser, moved toward the Earth



CME2: from the eastern eruption, lower density, may be a shock, moved to south

4. Dst development and solar wind conditions

Formula by Burton et al. (1975)

$$dDst^*/dt = Q(t) - Dst^*/\tau \quad (\text{injection \& exponential decay})$$

Q_{obs} : $Q(t)$ can be estimated from Dst^* (if τ is assumed)

$$Q_{obs} = dDst^*/dt + Dst^*/\tau$$

Q_{sw} : $Q(t)$ to be determined by the solar wind conditions

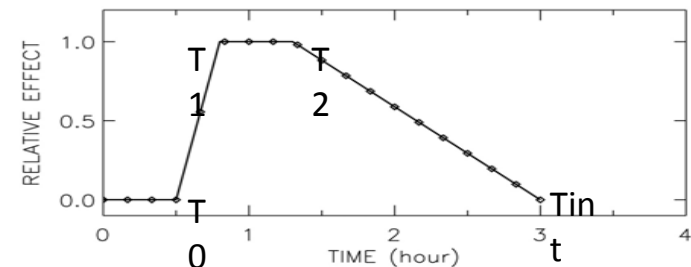
$$Q_{sw}(t) = a + b \int F(\tau) E y(t - \tau) d\tau$$

where $F(\tau)$ is a response function

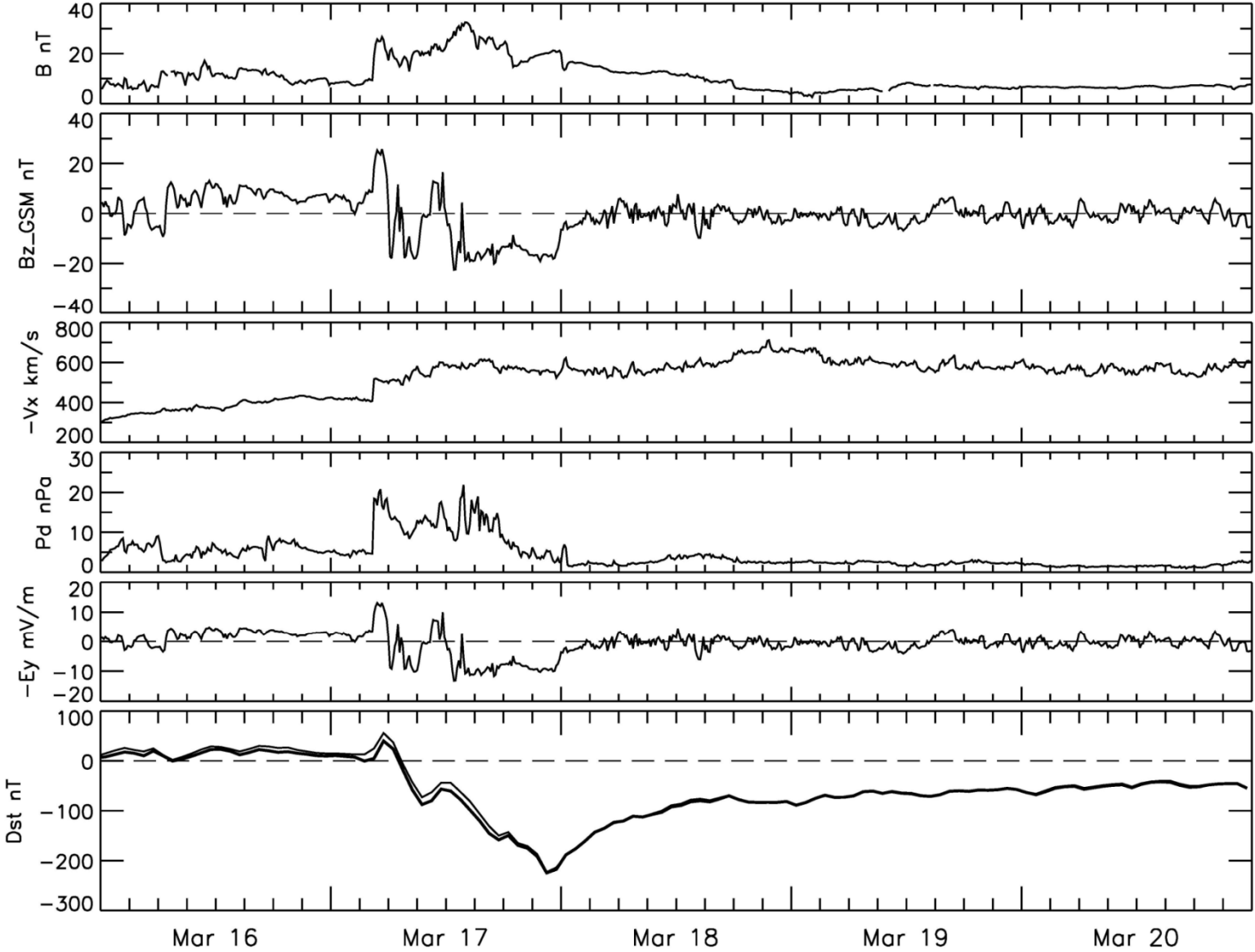
What is “2-step geomagnetic storm”?

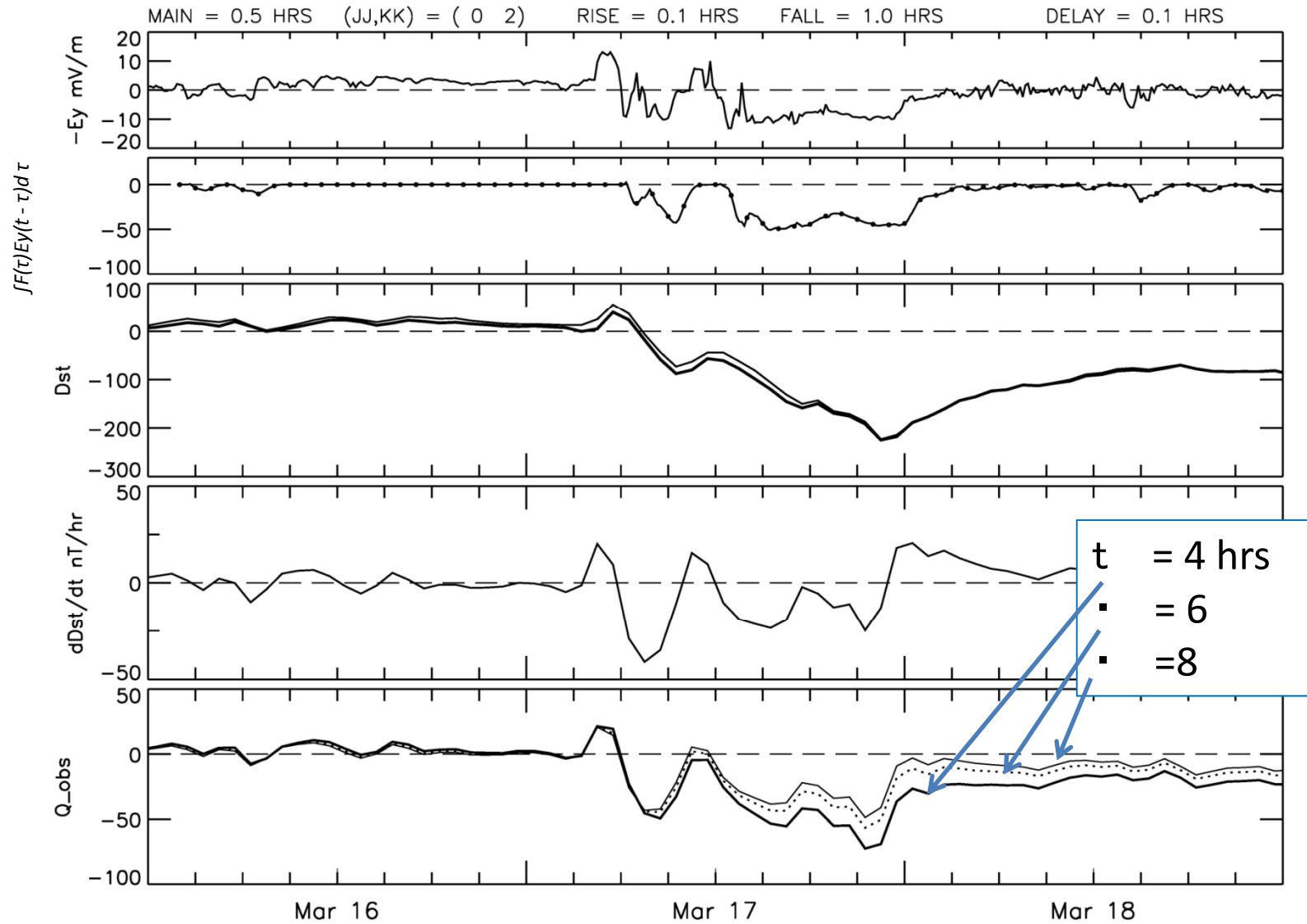
If the “2-step” should cause intense storms, b (and/or a) should be intensified in the second step.

→ Let’s take a look at data for March storm.



Solar wind conditions (B, Bz, Vx, Pd, Ey) and Dst/Dst*





No indication of enhancement of Q_{obs} in the second step is clear.
 Conclusion (tentative): The point is the duration (1st added to 2nd)

Summary

1. March 17 storm: Solar phenomena/solar wind features are consistent with each other.
2. June 22 storm: Flux rope is inconsistent with solar source. Needs more detailed examination of possible solar sources.
3. In both cases, the flux rope encounter was SPECIAL. $B_z < 0$ throughout the S/C passage.
4. September 22, 2014 Flux rope: A success story for the settlement of the difficulty in March event.
5. The most important reason for the development of Dst in the March 17 storm is the long duration of $B_z < 0$.
(The 2-step may not be very important.)

Thank you
for
your attention!