CDAW 2010, San Diego

Flux-rope fitting results for MCs and non-MCs

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Purposes:

1. To discuss results of flux-rope identification in “non-MCs”
2. To supplement the pptx file uploaded to CDAW-ftp

CDAW2010 List : 62 events

MC-category : 27
EJ-category : 35
31 cases: Embedded flux-ropes are seen.
4 cases: no flux-rope signature are seen.
[(#4), #36, #43, #44]

Why this result was obtained?

(1) Definition modified: "Any magnetic structures that can be <u>well</u> described by flux rope models" are taken as flux ropes.

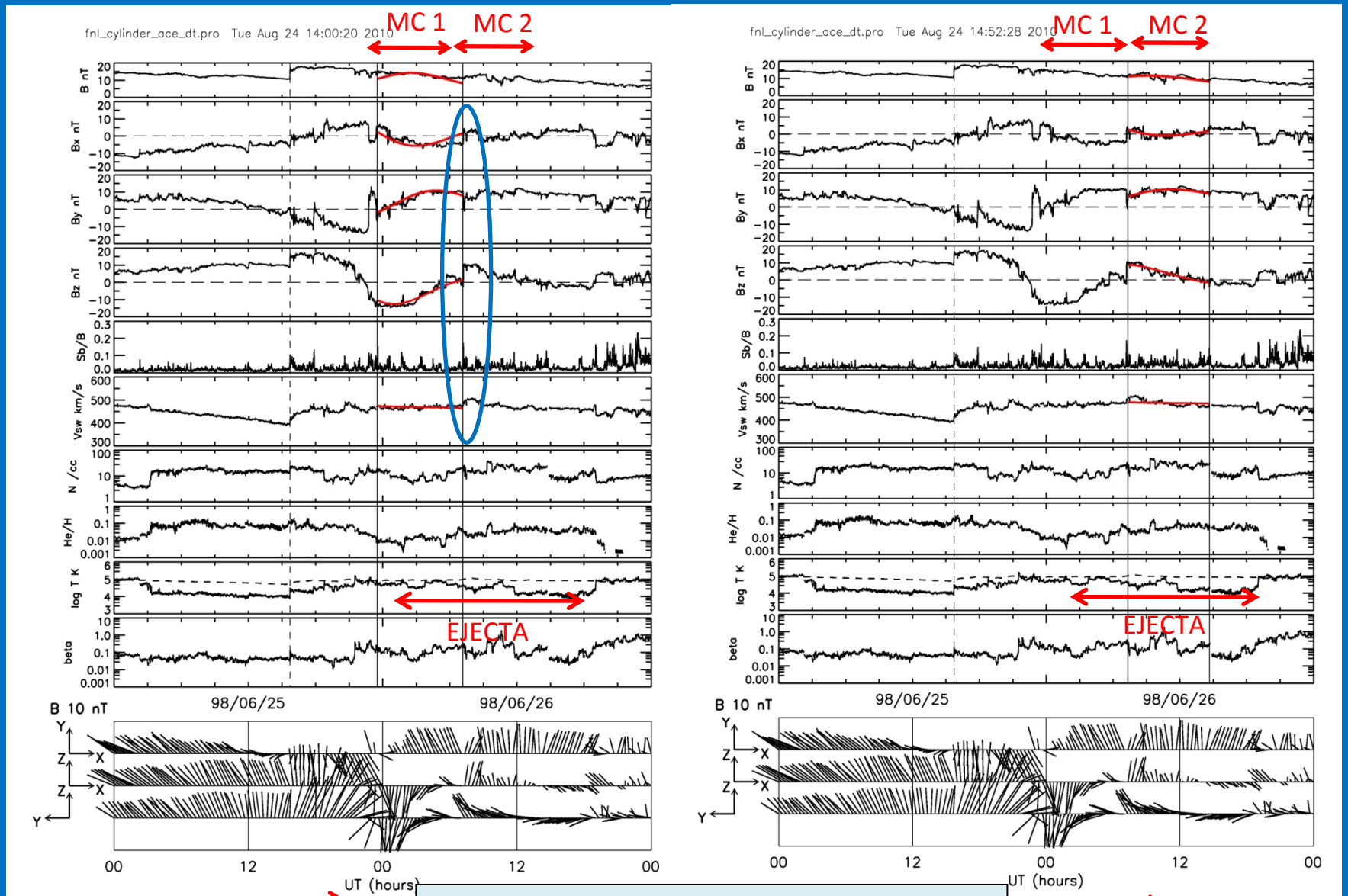
"How well" is "<u>well</u>"?

How reasonable the obtained parameters are?

→ The criteria should change the result, of course.

(2) Careful analysis and introduction of a torus model.

An example: Event #7 (Ejecta → 2 successive flux-ropes)



They could be taken as one flux-rope, if circled part be neglected.

Structure of “CDAW_yyyyevents.pptx” file

The purposes of files:

(1) To show evidence for flux-rope identification

(Further refined analysis is required for comparison between flux-ropes (MCs) and characteristics of eruption from the Sun.)

(2) To show how the flux rope characterisrics should be compared with solar magnetic fields, and other observed signatures in the future

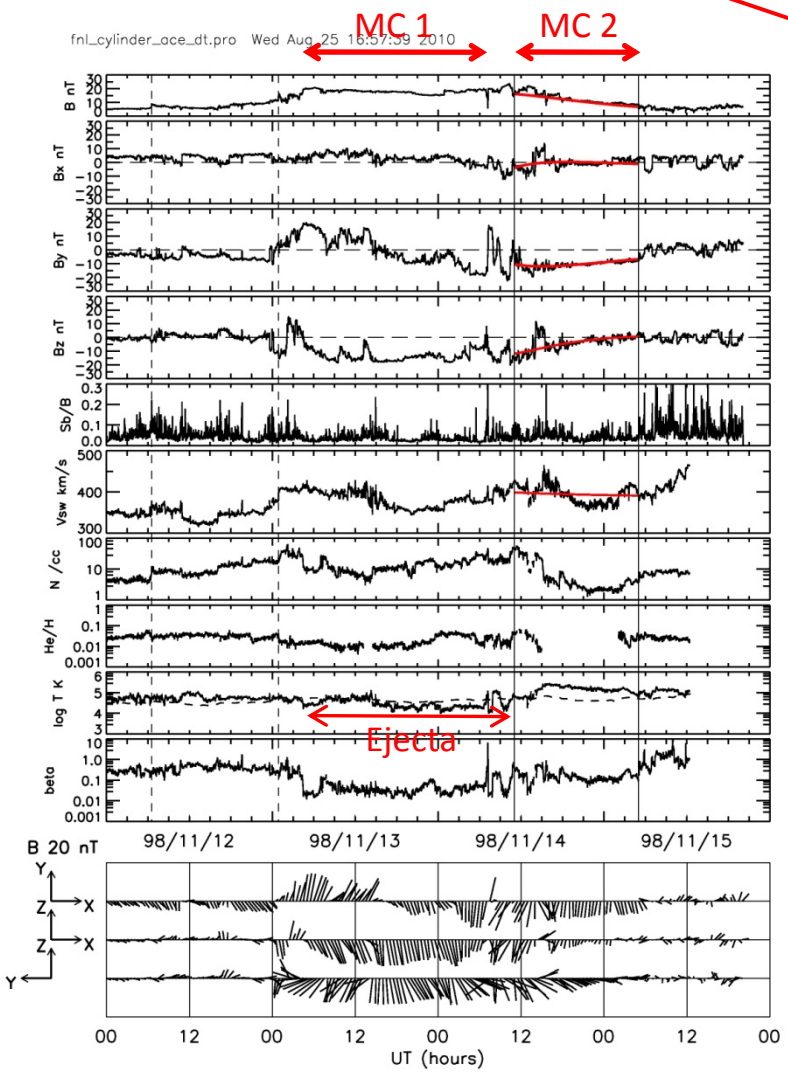
(At present, caution is needed, as stated above.)

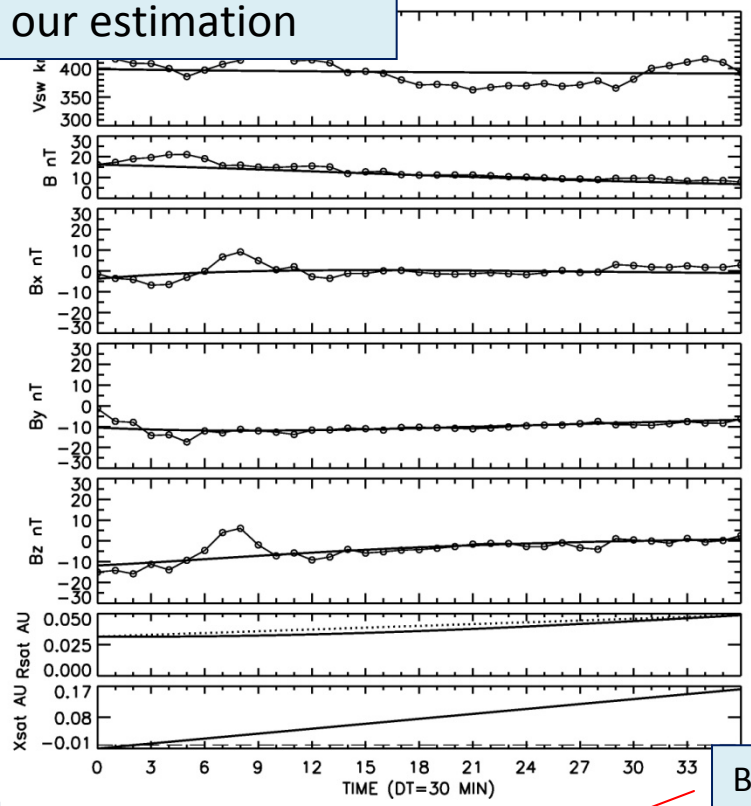
For each event, results from both cylinder- and torus-fitting are shown (when possible), with parameters obtained from fitting, and the orientation of magnetic polarity inversion line, and the chirality of sheared field in the source region which are inferred from the flux-rope geometry.

#9 EJ → 2 consecutive MCs: cylinder-fitting of MC (2)

Yellow title: EJ → MC

Classification in the LIST and our estimation





U_0
r_0
P
T

1998/11/14/11:00 – 1998/11/15/05:00 (DT=30 MIN)

Usw	= 396.230	B_axis	= 31.26
Ro	= 0.0315	LAT	= −9.294
p	= −0.9974	LONG	= 350.394
To	= 33.0	SGN	= 1

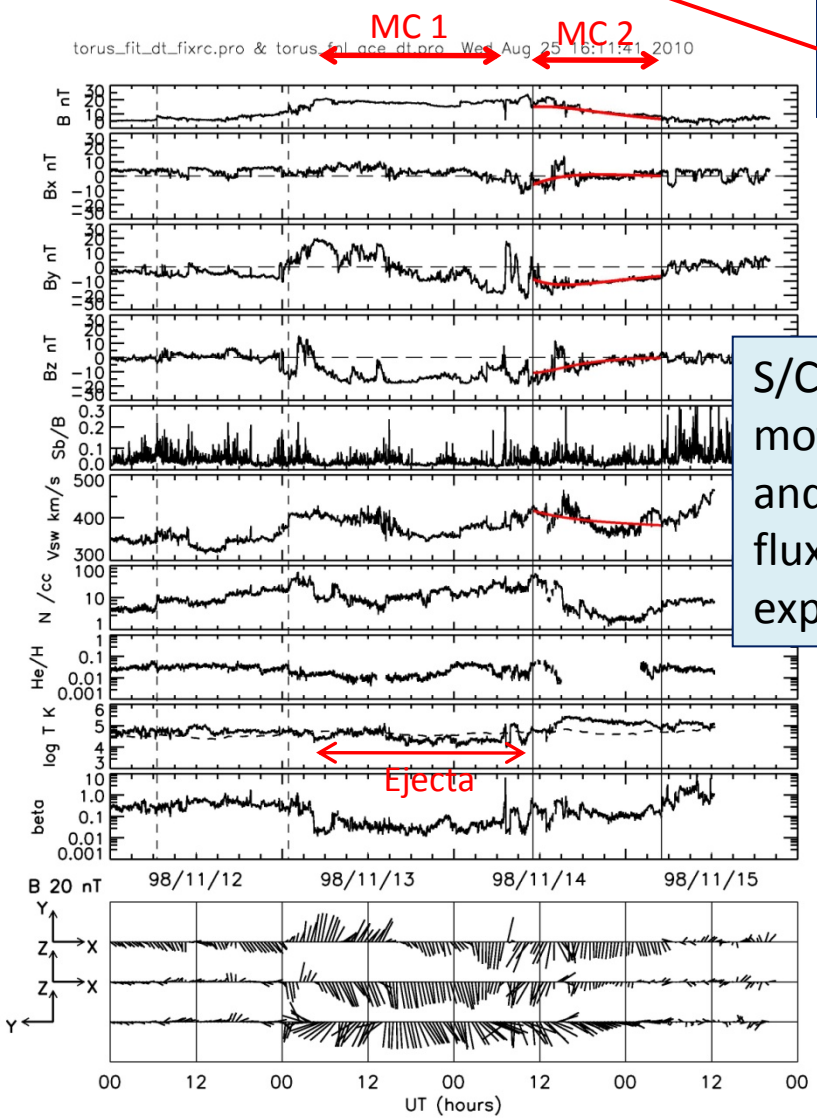
RMS(Vsw) = 19.27 RMS(Bvec) = 5.28
RMS_B/Bmax = 0.250

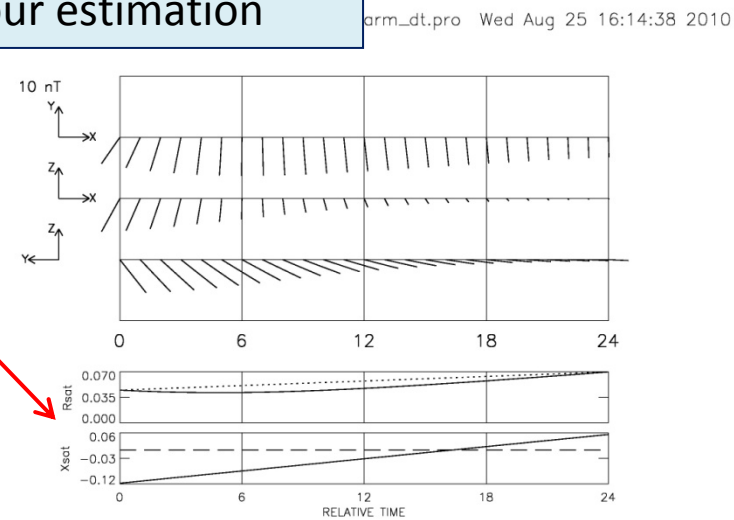
B_0
□$_0$
□
s
Erms

Small cone angle: torus model needed

#9 EJ → 2 consecutive MCs: torus-fitting of MC (2)

Classification in the LIST and our estimation



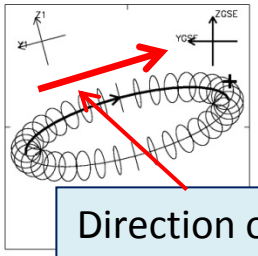


S/C motion and flux-rope expansion

U_{T0}
D_f
□n
□n
DRCT
s
R_{M0}
r_{m0}
T
pz
py

U_bulk = 400.8 km/s
decel rate = 0.279 km/s/hour
theta0 = 67.7
phi0 = 40.6
drct = 1
sgn = 1
B_axis = 33.2
R_curv = 0.320 AU
r_cyl = 0.0447 AU
t_xpnd = 32.1 hrs
I.P_x (GSE) = 1.2594
I.P_y (GSE) = −0.0740
I.P_z (rotated) = 1.1980
I.P_y (rotated) = −0.3955
Calculated Traverse Time = 18.0 hrs

axis_eqv: θ=−14.1 Φ=348.4
norm_in: θ= 42.4 Φ=254.3
norm_out: θ= 72.1 Φ=353.1
Min(R_sat/R_rope) = 0.3013

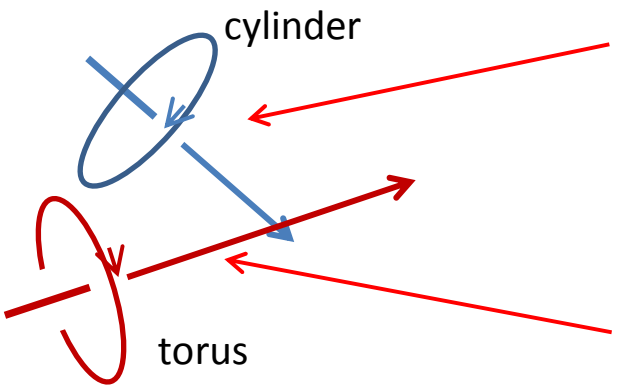


Direction of torus axis at the apex, projected on YZ-plane

Local direction of torus axis, (locally approximated by cylinder)

#9 EJ → 2 consecutive MCs: cylinder vs. torus for MC (2)

	cylinder	torus
R_0 (AU)	0.032	0.045
E_{rms}	0.250	0.312
Local θ	-9°	-14°
φ	350°	350°

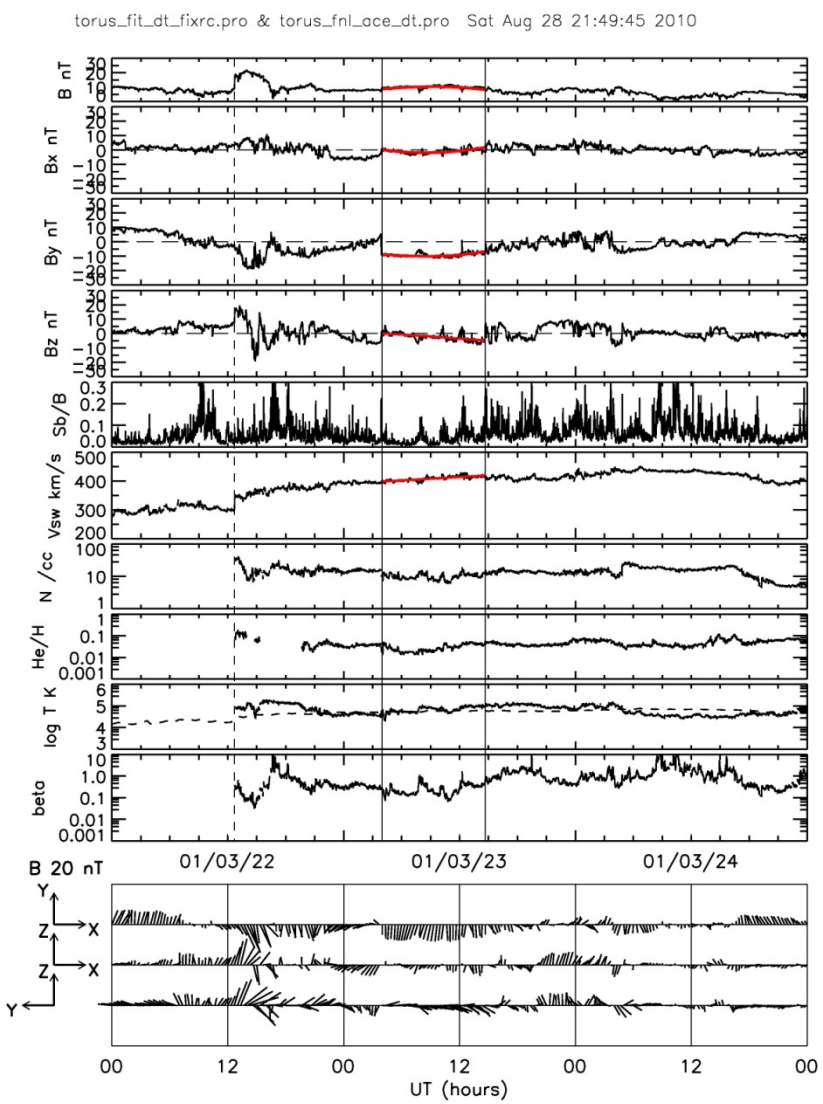


Axis direction of cylinder projected on Y-Z plane, together with handedness of magnetic chirality

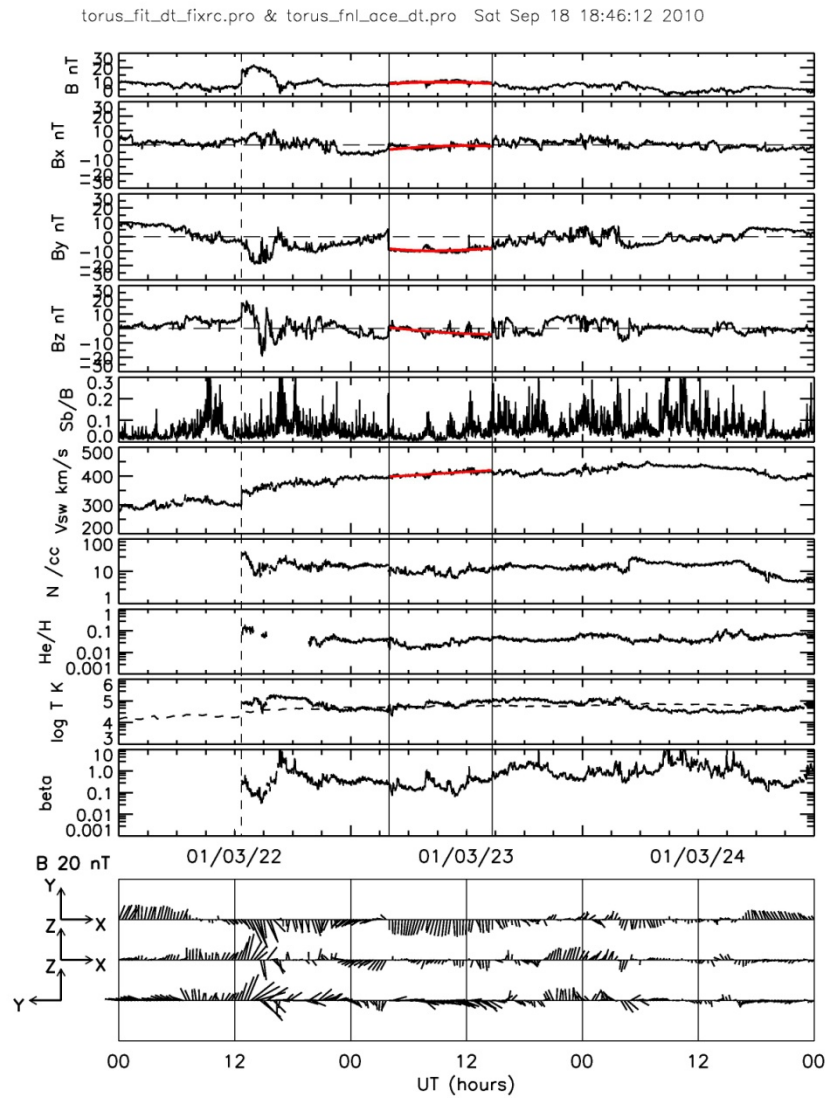
Axis direction of torus at apex, projected on Y-Z plane. together with handedness of magnetic chirality

Flux rope structure near the Sun, deduced from MC geometries obtained by fitting with cylinder and torus models. To be compared with sigmoid/post-eruption arcade.

A caution on torus-fitting: Uniqueness not guaranteed

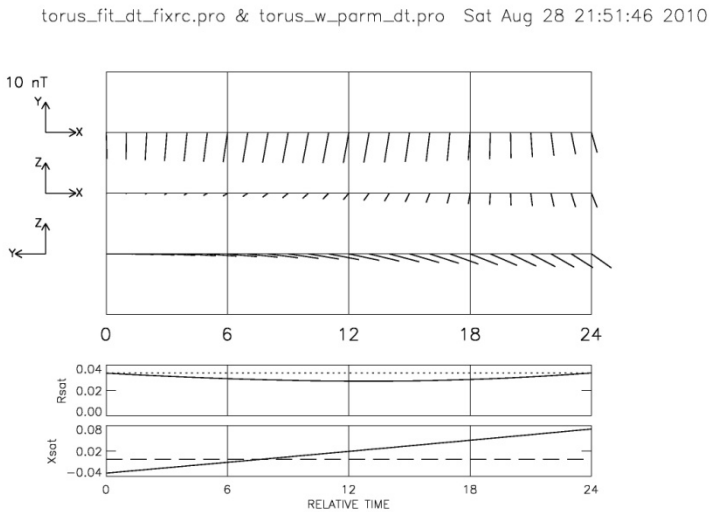


torus-fitting result A

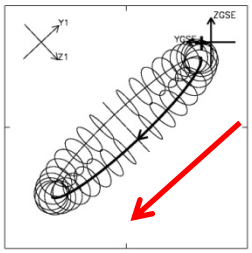


torus-fitting result B

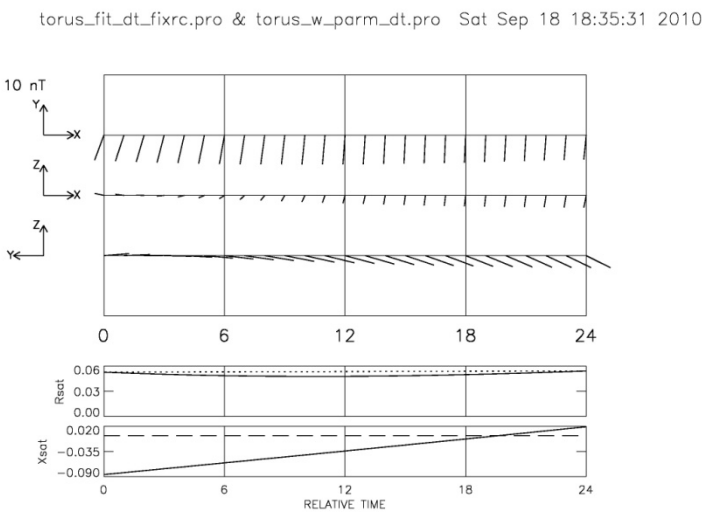
A caution on torus-fitting: Uniqueness not guaranteed



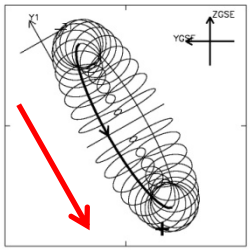
U_bulk = 398.2 km/s
decel rate = −2.016 km/s/hour
theta0 = −45.9
phi0 = 283.9
drct =−1
sgn =−1
B_axis = 18.9
R_curv = 0.206 AU
r_cyl = 0.0336 AU
T_xpnd = 2246.1 hrs
I.P_z (GSE) = 0.8503
I.P_y (GSE) =−0.0656
I.P_z (rotated) =−0.5746
I.P_y (rotated) = 0.6303
Calculated Traverse Time = 10.7 hrs



axis_eqv: Θ= −3.2 Φ=190.6
norm_in: Θ= 78.0 Φ=183.5
norm_out: Θ= 55.3 Φ=297.8
Min(R_sat/R_rope) = 0.8095



U_bulk = 396.7 km/s
decel rate = −2.308 km/s/hour
theta0 = 28.8
phi0 = 255.9
drct = 1
sgn =−1
B_axis = 22.0
R_curv = 0.206 AU
r_cyl = 0.0528 AU
T_xpnd = 389.0 hrs
I.P_z (GSE) =−0.8891
I.P_y (GSE) = 0.4046
I.P_z (rotated) =−0.7902
I.P_y (rotated) =−0.5742
Calculated Traverse Time = 10.7 hrs



axis_eqv: Θ= −2.3 Φ=344.6
norm_in: Θ=−76.6 Φ=178.3
norm_out: Θ=−62.2 Φ= 64.7
Min(R_sat/R_rope) = 0.8916

When S/C passes the structure skimming through the surface of a torus, contribution of axial field component can be negligibly small. (Only negative By in these 2 cases)

Concluding remarks

Flux-rope structures were found being embedded around the EJ regions, in 31 cases out of 35 EJs in the CDAW2010 List.

This fact supports the view that "All CMEs have flux rope structure, but sometimes they are not observed so because of geometry." (Existence of small number of "non-MC Ejecta" is acceptable, because we know cases where flux ropes largely deflect from radial direction.)

In not a few cases, 2 or more flux ropes are seen in one EJ region. It may have some connection with multi-eruption-like events.

In order to compare the MC (flux rope) geometries with solar data in the source regions, more careful analyses are required. (Such as: re-confirmation of MC-solar source association, selection of more appropriate model, MC boundaries, etc.)

Thank you very much for your attention!