

Halo CMEs in October – November 2003: predictions and reality

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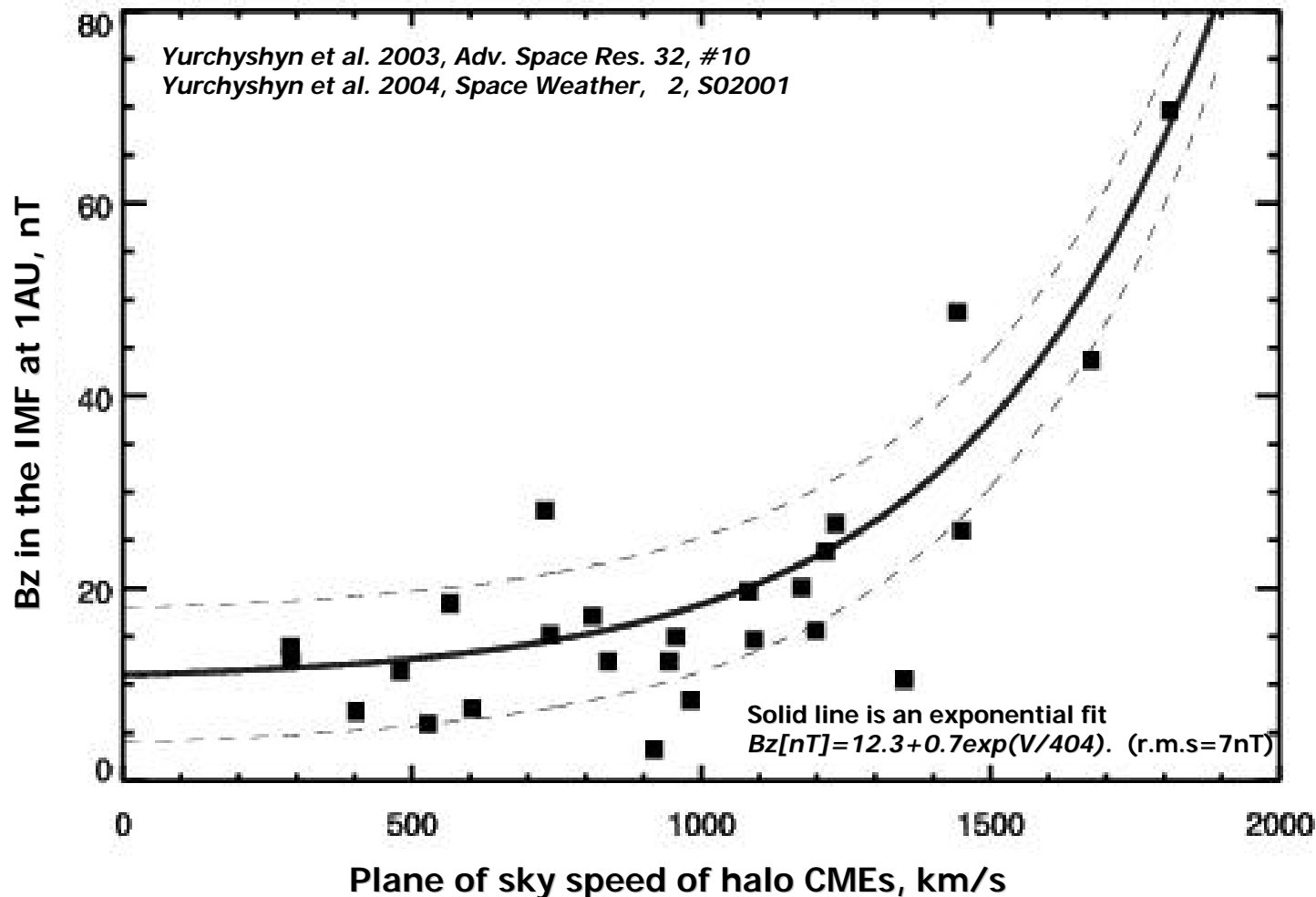
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We have found recently that the intensity of Bz in the IMF is correlated with the plane of sky speed of coronal mass ejections (CMEs)^{1,2}. In turn, the Bz in the IMF is correlated with the Dst index of geomagnetic activity^{2,3,4,5} (see figures below).

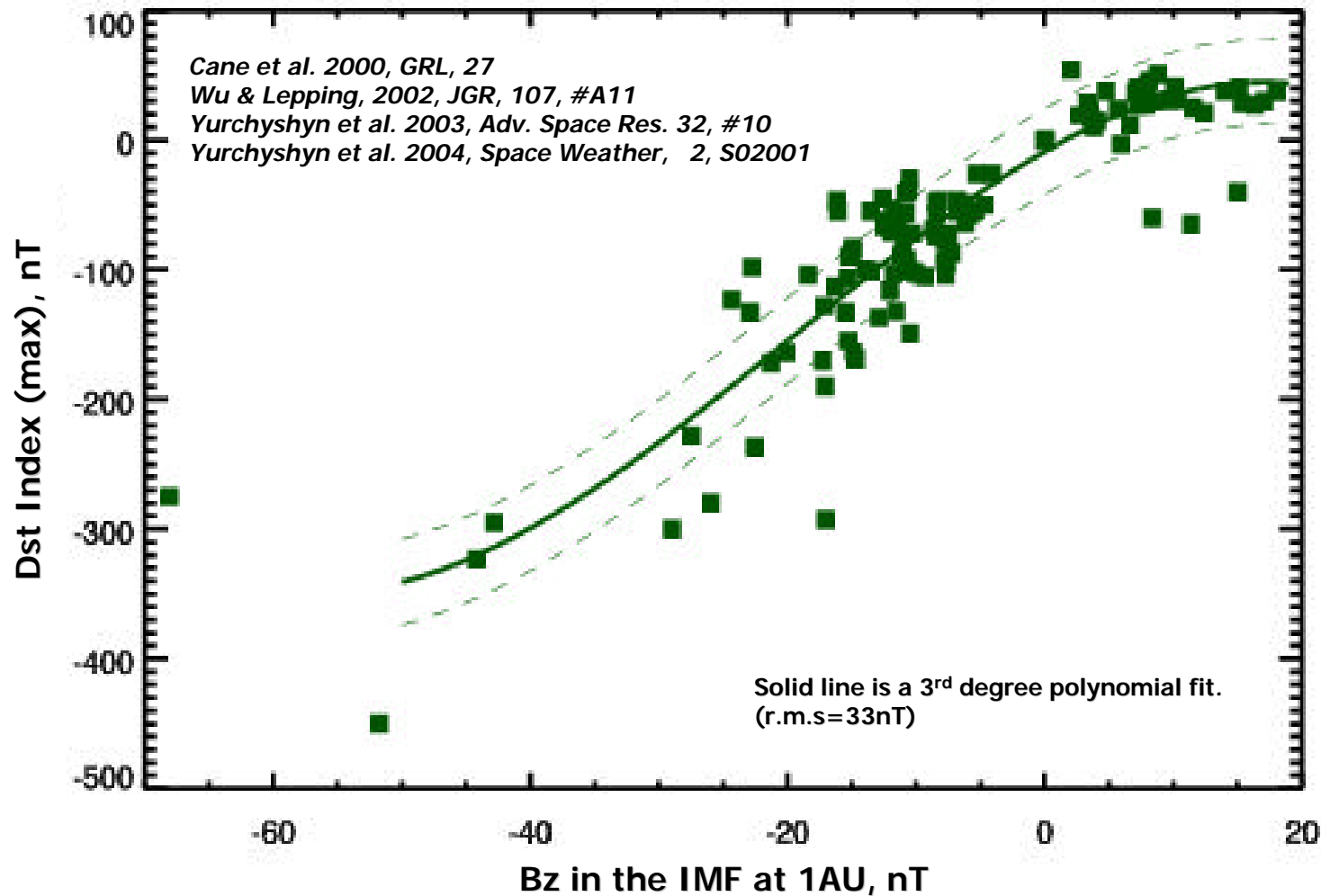
Here we present results of prediction of the Bz and the Dst index made for 3 halo CMEs erupted in October-November 2003 (Oct 28, Oct 29 and Nov 18; events I, II and III respectively).

The comparison between the predicted values of the Bz and the Dst index and the observed data shows that we were able to successfully predict the magnitude of the Bz and Dst index for for the October events I and II, while we have underestimated the magnitude of the Dst for the November event III.

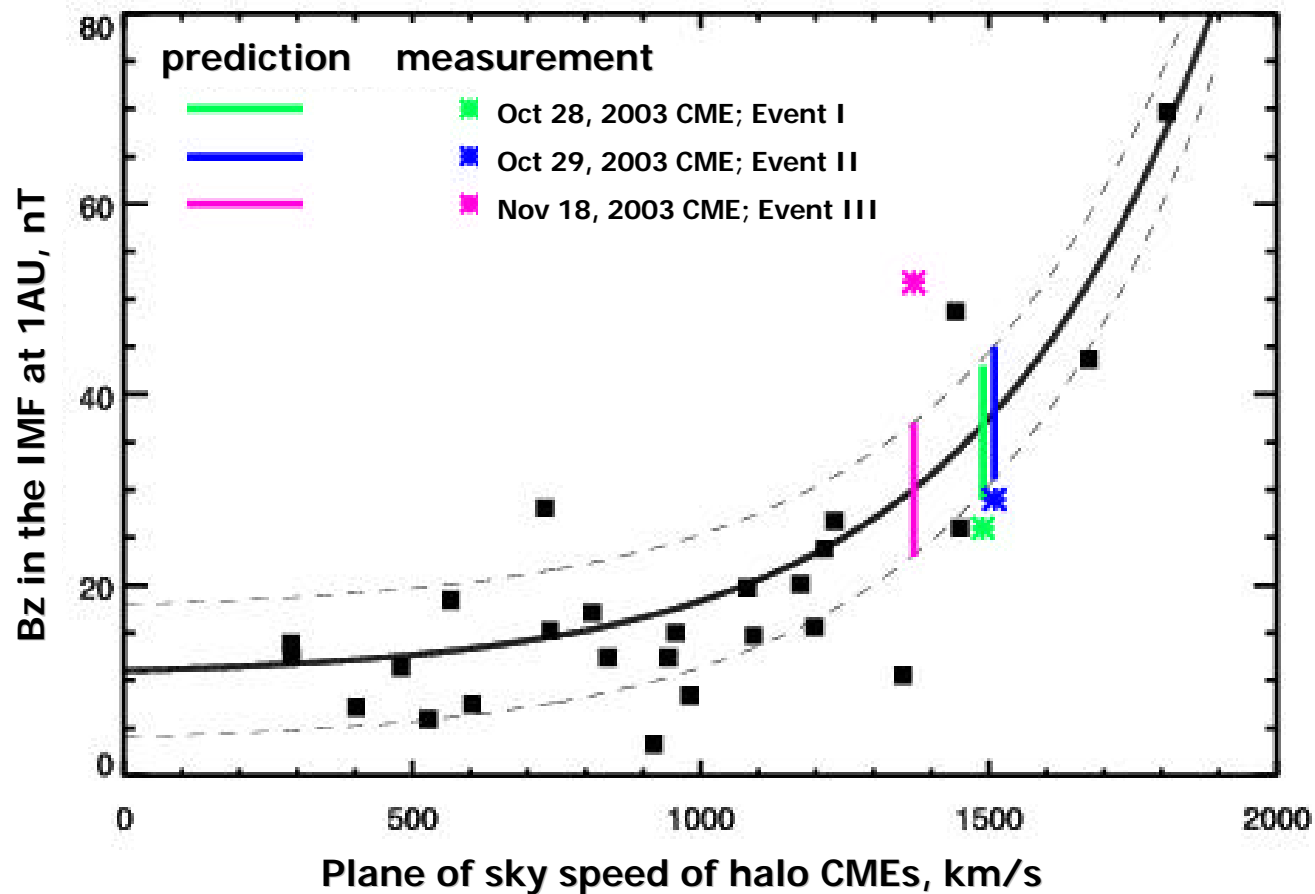
Prediction Scheme: I. relationship between the expansion speed of halo CMEs and the magnitude of Bz in IMF:



Prediction Scheme: II. relationship between the Bz in IMF and the Dst index of geomagnetic activity:



Results of the prediction of the magnitude of the B_z in the IMF from the plane of sky speed of 3 halo CMEs in October-November 2003



Event I:

The X17.2/4B flare started at 0951UT on Oct 28 2003 and it produced a halo CME. The solar data suggested that the axial field of the CME **may have a southward** component and the erupted field has **negative helicity**. The clock angle (measured clockwise from the east) of the post flare loops system, associated with this CME, was about **215 deg**. The plane of sky speed of the CME was about 1500km/s. Based on this speed we predicted

i) Bz in IMF to be **-30 ... -44 nT** and ii) changes in the Dst index: **-250 ... -320 nT**.

The shock arrived at 1 AU on Oct 29 at about 06:00UT, while the magnetic cloud arrived at about 1200UT. The magnetic cloud was **southwardly** oriented with the clock angle of about **266 degree** and it had **negative helicity** (see the event reconstruction figure) .

The Bz measured by the ACE satellite reached **-26 nT**, while the Dst index dropped by **-320 nT** and reached **-360 nT**.

Event II:

The X11 flare at 2037UT on Oct 29 2003 produced a second halo CME. The lack of the data did not allow us to reliably determine the possible orientation of the axial field and/or magnetic helicity. The plane of sky speed of the CME was, too, about 1500km/s. Based on this speed we predicted

i) Bz in IMF : **-30 ... -44 nT** and ii) Changes in the Dst index: **-250 ... -320 nT**

The shock arrived at 1 AU on Oct 30 at about 1530UT, while the corresponding magnetic cloud could not be confidently distinguished in the ACE data.

Nevertheless this, quite possibly, complex ejecta presented a strong southward Bz component of **-29 nT** and the Dst index dropped by about **-300 nT** from -100 to -400 nT.

Event III:

The M3.9/2N flare started at 0812UT on Nov 18 2003 and it produced another halo CME. The solar data suggested that the axial field of the CME **may have a southward** component and the erupted field had **positive helicity**. The clock angle (measured clockwise from the east) of the post flare loops system, associated with this CME, was about **10 deg**. The plane of sky speed of the CME was about 1400km/s. Based on this speed we predicted

i) Bz in IMF to be **-21 ... -35 nT** and ii) changes in the Dst index: **-190 ... -250 nT**.

The shock arrived at 1 AU on Nov 21 at about 0700UT, while the magnetic cloud arrived at about 1100UT. The magnetic cloud was **south-eastwardly** oriented with the clock angle of about **311 deg** and **positive helicity** (see the event reconstruction figure).

However, the magnitude of the Bz, measured by the ACE satellite, was about **-52 nT (!)**, while the Dst index dropped by **450 nT** from +20 nT to -430 nT.

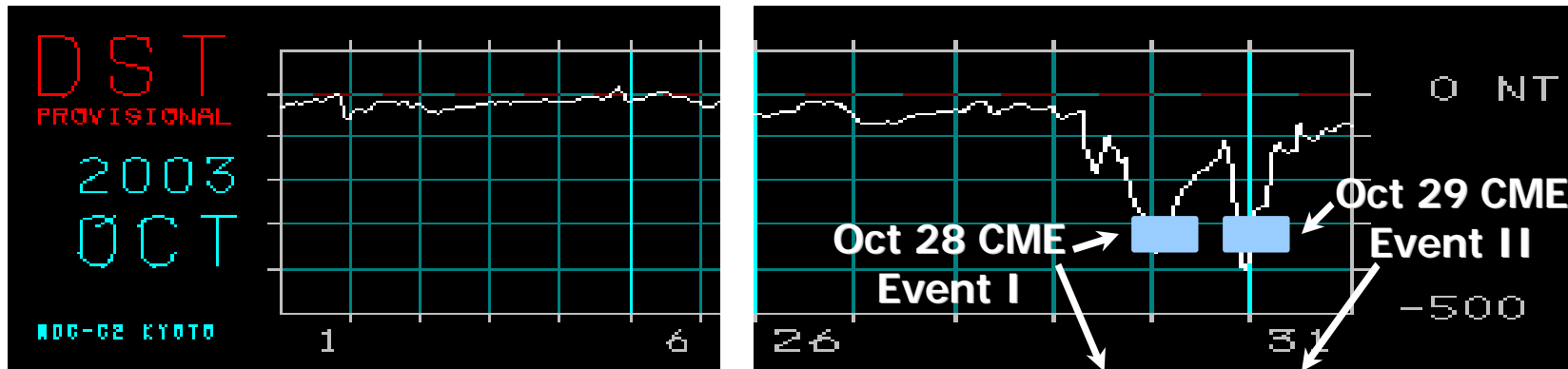
References:

1. Yurchyshyn, V., Wang, H., and Abramenko, V., 2003, *Adv. Space Res.*, 32, #10
2. Yurchyshyn, V., Wang, H., and Abramenko, V., 2004, *Space Weather*, 2, S02001
3. Cane, H.V., Richardson, I.G., and St. Cyr, O.C., 2000, *GRL*, 27
4. Wu, C.C., and Lepping, R.P., 2002, *JGR*, 107, #A11
5. Gonzalez, W.D., et al., 2004, *J. Atm. Sol-Terr. Phys.*, 66, 161

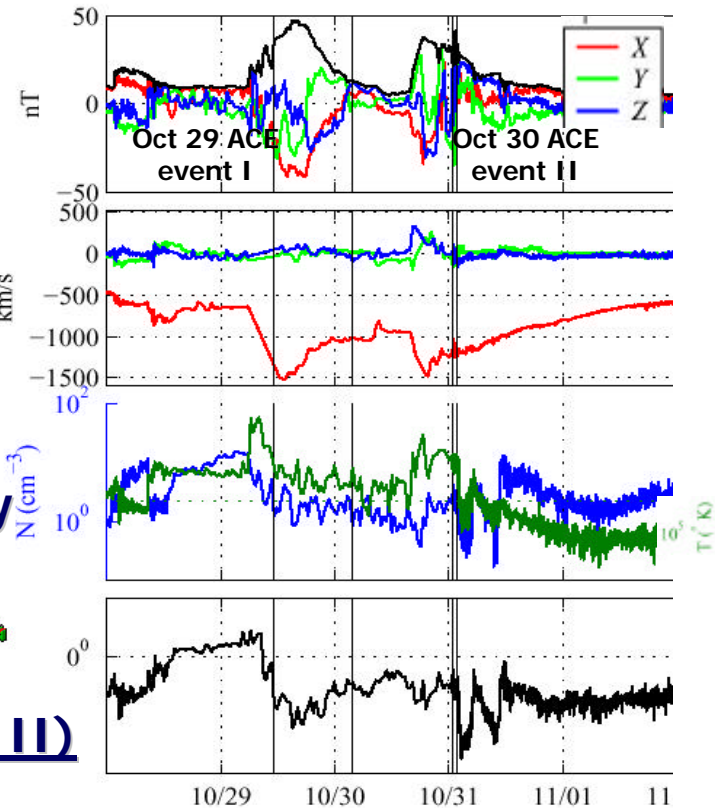
Acknowledgement: We thank the ACE MAG/SWEPAM instrument team and the ACE Science Center for providing the ACE data. In particular, we thank Ruth Skoug for providing the merged data set for the Oct 30 event. We acknowledge the use of geomagnetic data from the World Data Center for Geomagnetism in Kyoto. The CME catalog is generated, and maintained, by the Center for Solar Physics and Space Weather, The Catholic University of America in cooperation with the Naval Research Laboratory and NASA. SOHO is a project of international cooperation between ESA and NASA. We acknowledge the use of the data from the Global High Resolution Ha Network, operated by the Big Bear Solar Observatory, New Jersey Institute of Technology. The BBSO work was supported, in part, by NSF grants ATM-9903515, ATM-0205157, ATM-0076602 and NASA(NAG5-9682) grants; work at UCR was funded by NASA NNG04GF47G grant .

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

The Dst Index for October 2003



The two CMEs on Oct 28 and 29 had similar plane of sky speeds (~ 1500 km/s) and the predicted ranges of changes in the Dst index in both cases were the same -250 ... -320 nT (*blue boxes*).



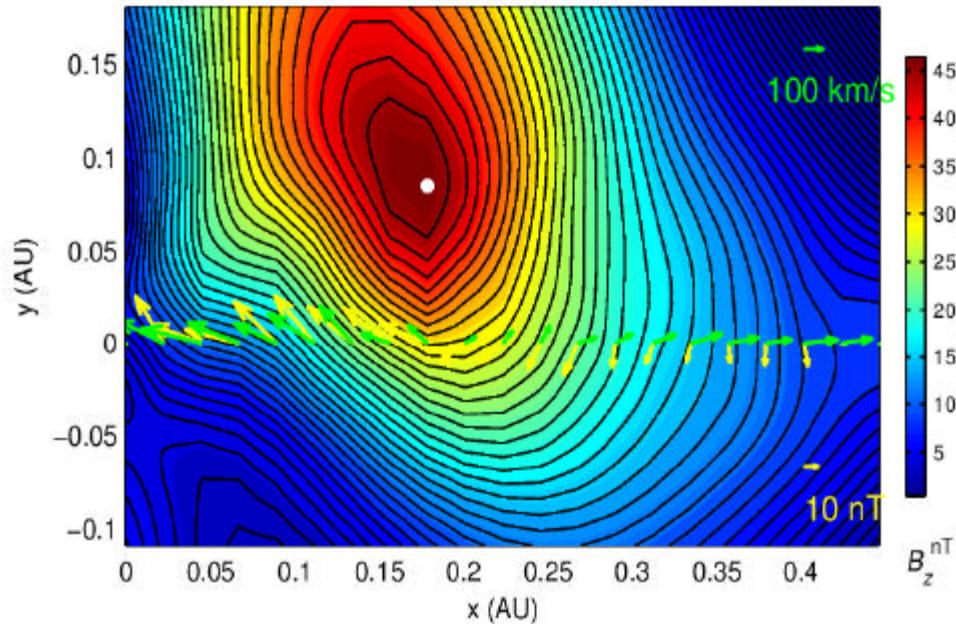
In reality, the Dst index decreased by

320nT due to the first CME (event I)

and by

300nT due to the second CME (event II)

Oct 29 ACE Event I Reconstruction



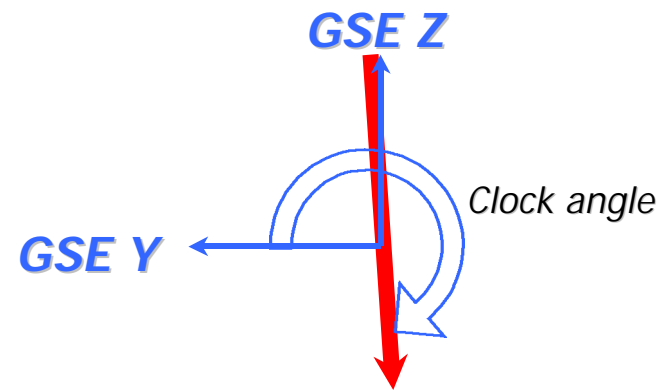
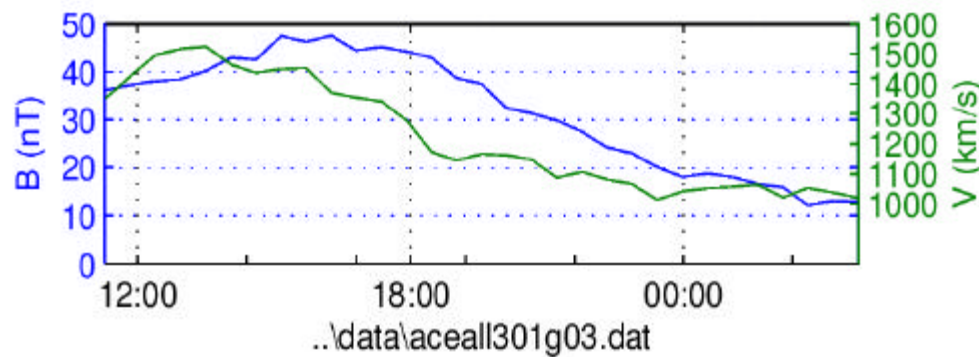
**Ejecta Time: 10/29 1117 UT
– 10/30 0349 UT**

Cone angle: 113 deg

**Clock angle: 266 deg
(clockwise from positive Y)**

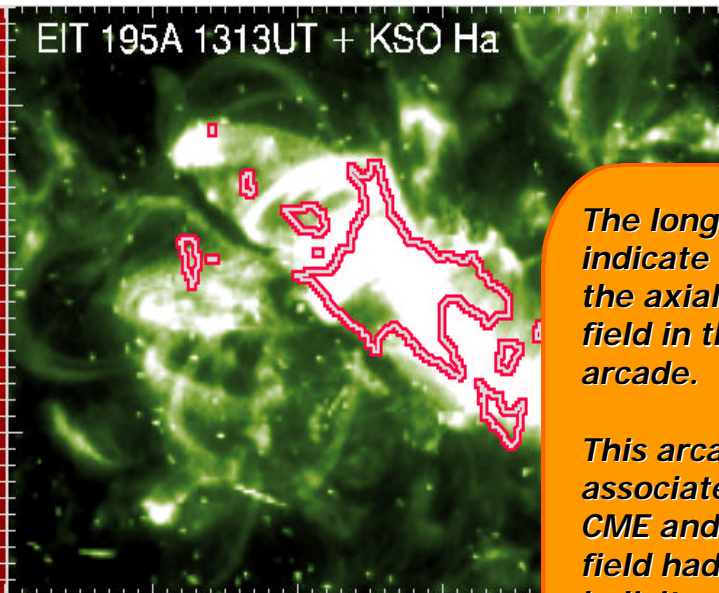
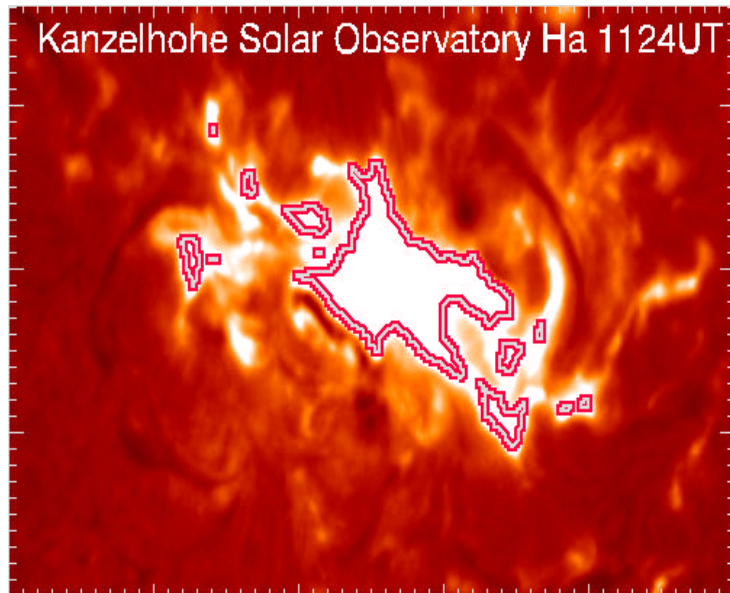
Axial Field: $B_{z0} = 45$ nT

Magnetic Helicity: Negative



Orientation of the Ejecta was 266 deg

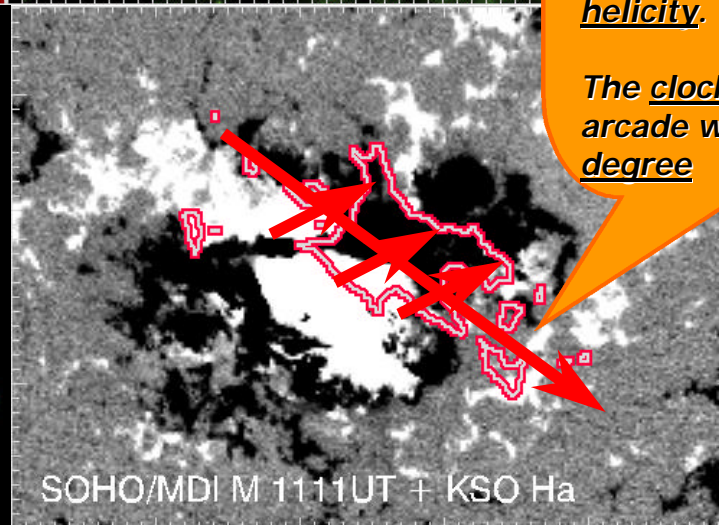
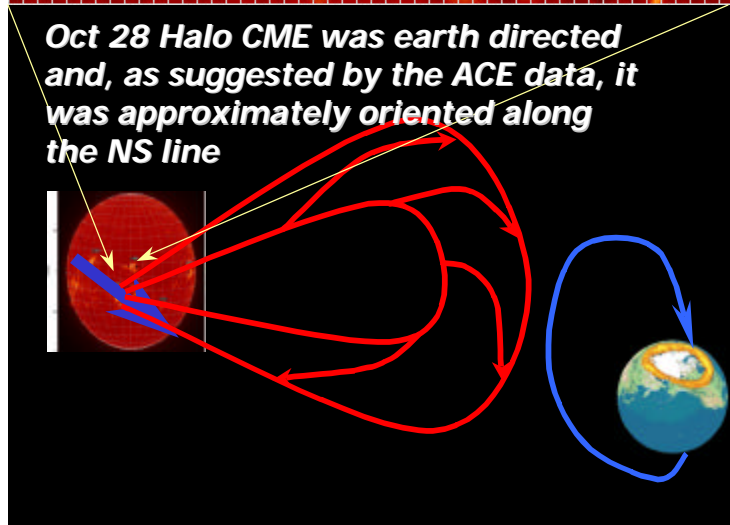
Event I: Oct 28 2003 X17.2/4B Flare



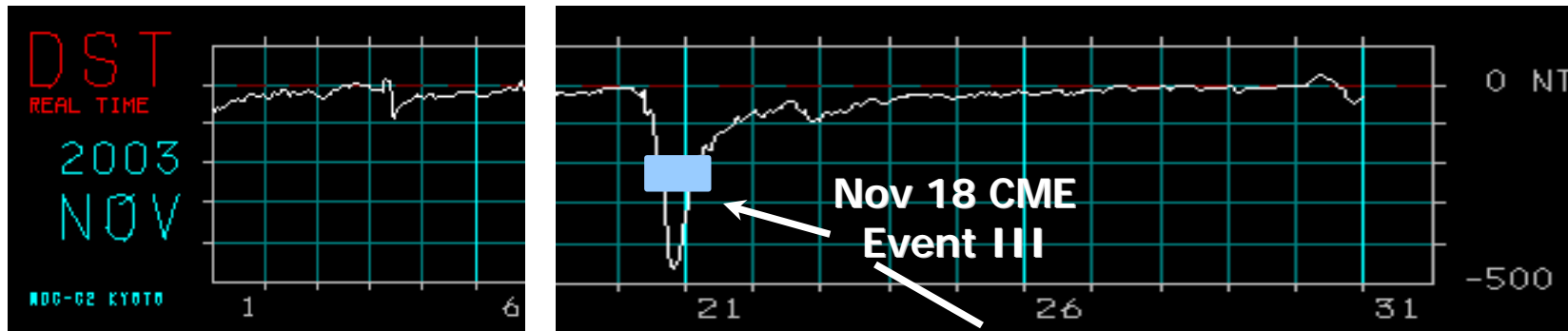
The long (short) arrows indicate the direction of the axial (azimuthal) field in the post flare arcade.

This arcade was associated with a halo CME and its magnetic field had negative helicity.

The clock angle of this arcade was about 215 degree

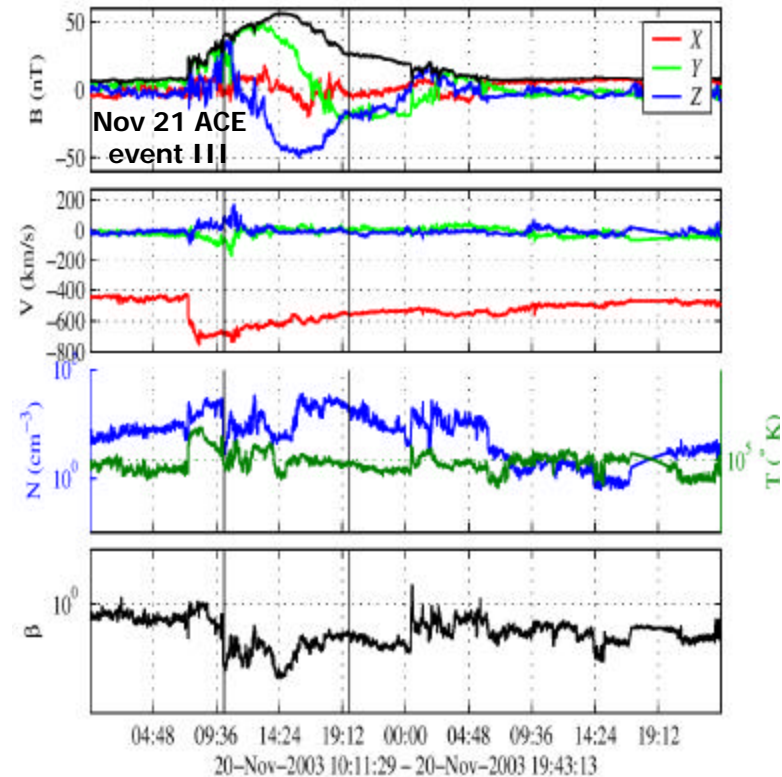


Dst Index for November 2003

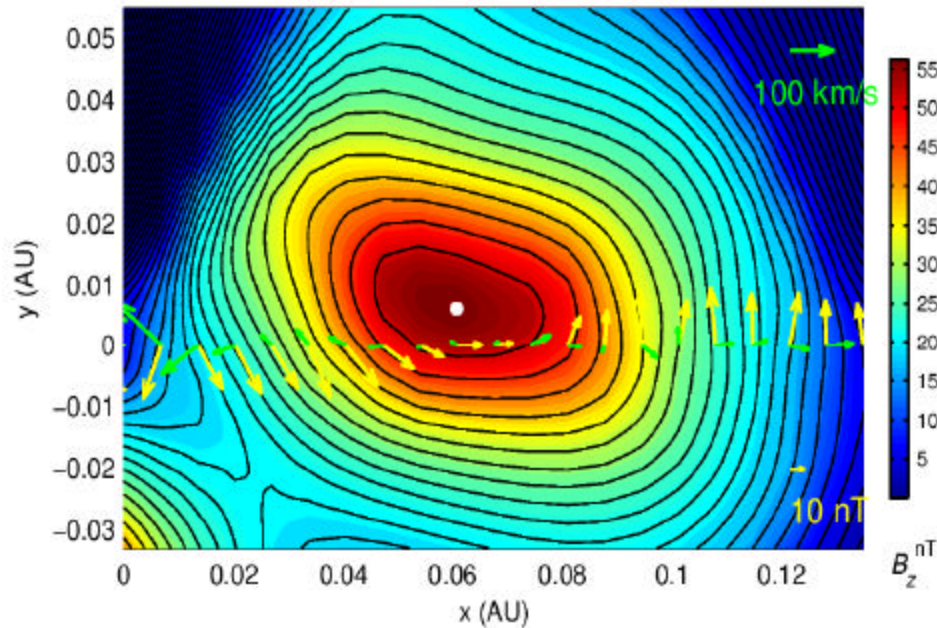


The CME on November 18 had the plane of sky speed of about 1400 km/s and the predicted range of changes in the Dst index was about $-190 \dots -250$ nT (*blue box*).

In reality, we have underestimated this event: the ejecta had an extremely large and *prolonged* southward B_z , which caused a 450 nT decrease of the Dst index.



Nov 21 ACE Event III Reconstruction



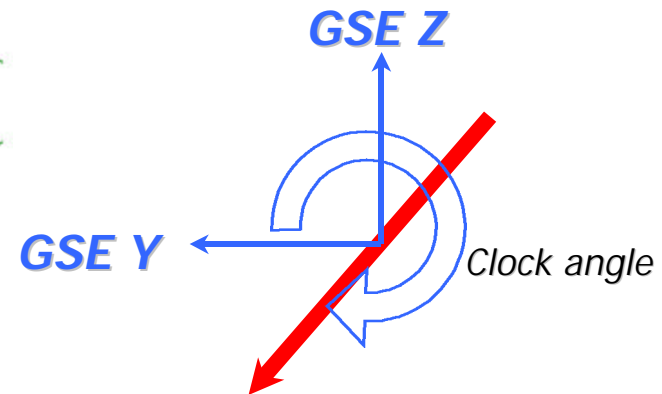
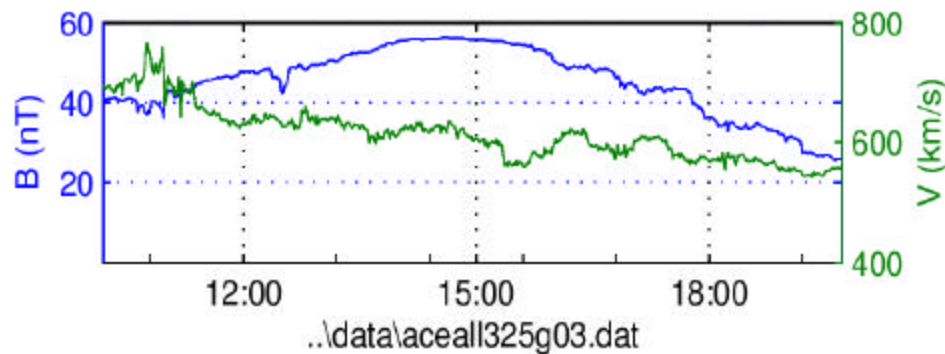
**Ejecta Time: 10/29 1117 UT
– 10/30 0349 UT**

Cone angle: 105 deg

**Clock angle: 311 deg
(clockwise from positive Y)**

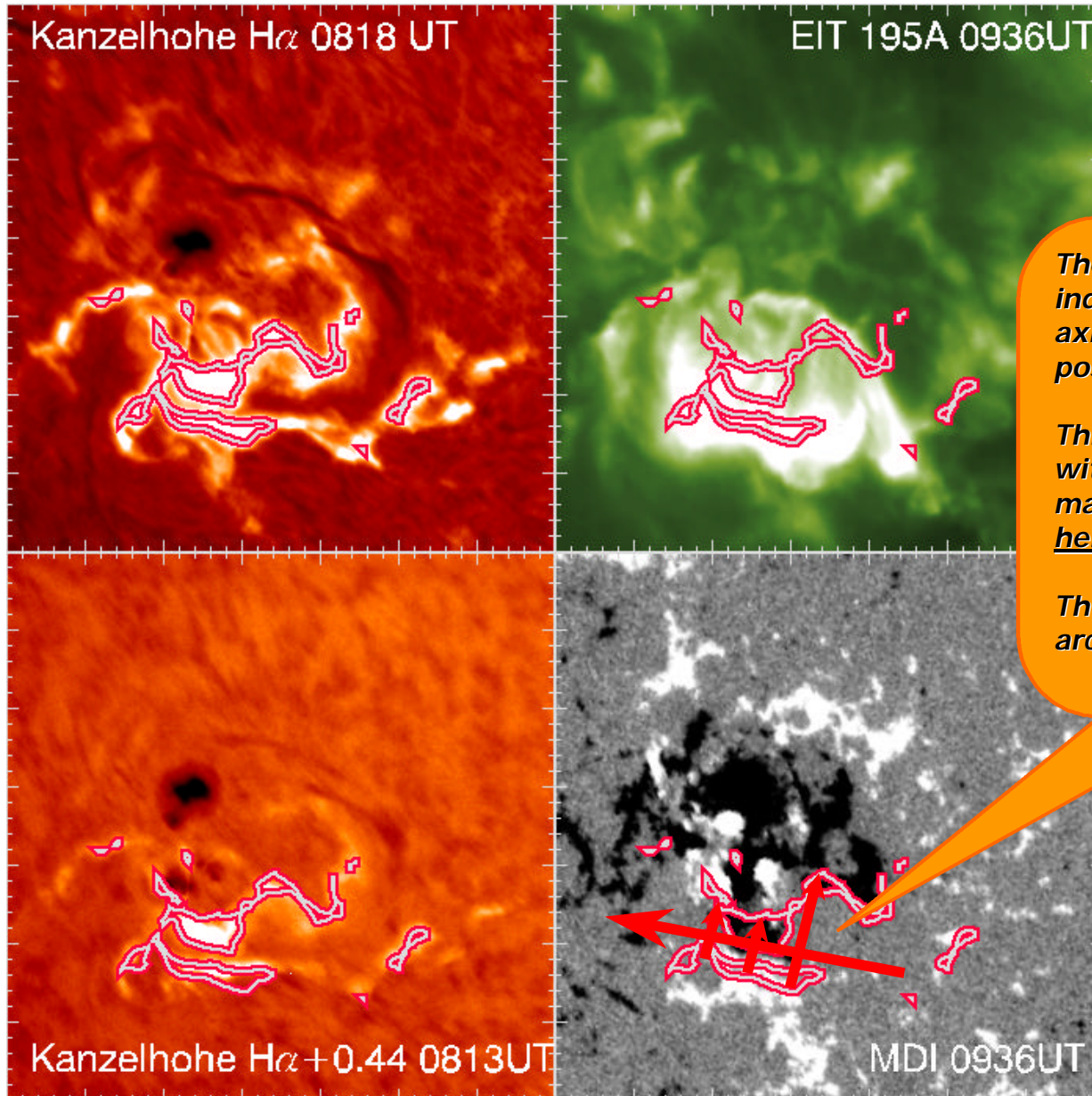
Axial Field: $B_{z0} = 57$ nT

Magnetic Helicity: Positive



Orientation of the Ejecta was 311 deg

Event III: Nov 18 2003 M3.9/2N Fla



The long (short) arrows indicate the direction of the axial (azimuthal) field in the post flare arcade.

This arcade was associated with a halo CME and its magnetic field had positive helicity.

The clock angle of this arcade was about 10 degree