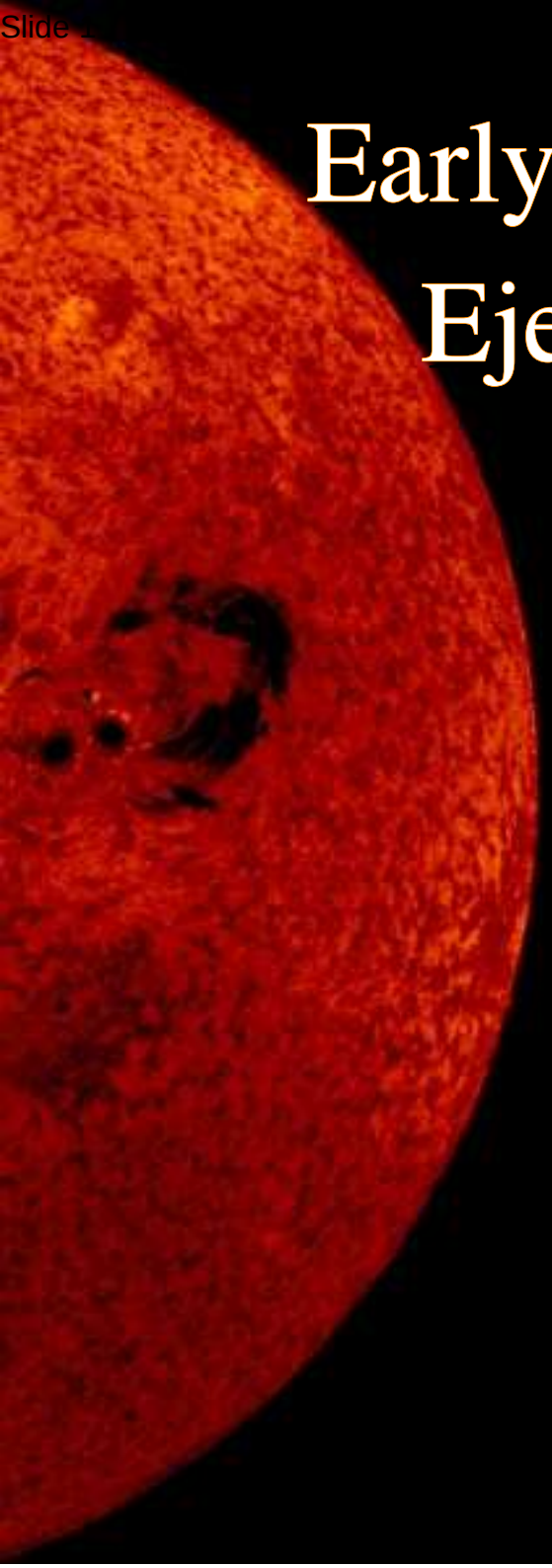

Early Diagnostics of Coronal Mass Ejections as a Potential Cause of Geomagnetic Activity

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Introduction

Solar active regions are often associated with powerful earth-directed magnetic eruptions that can significantly disturb earth's magnetosphere and cause severe geomagnetic storms.

We present a method to forecast the intensity of a geomagnetic storm 1-2 days in advance. The approach is based on the following:

i) dynamics of solar ejecta is believed to be determined by the Lorentz and pressure forces. Lorentz force is related to the amount of the magnetic flux confined in the erupted field

ii) the amount of the magnetic flux in the interplanetary ejecta, in particular the intensity of the negative Bz, are related to the size of a geomagnetic storms

Method

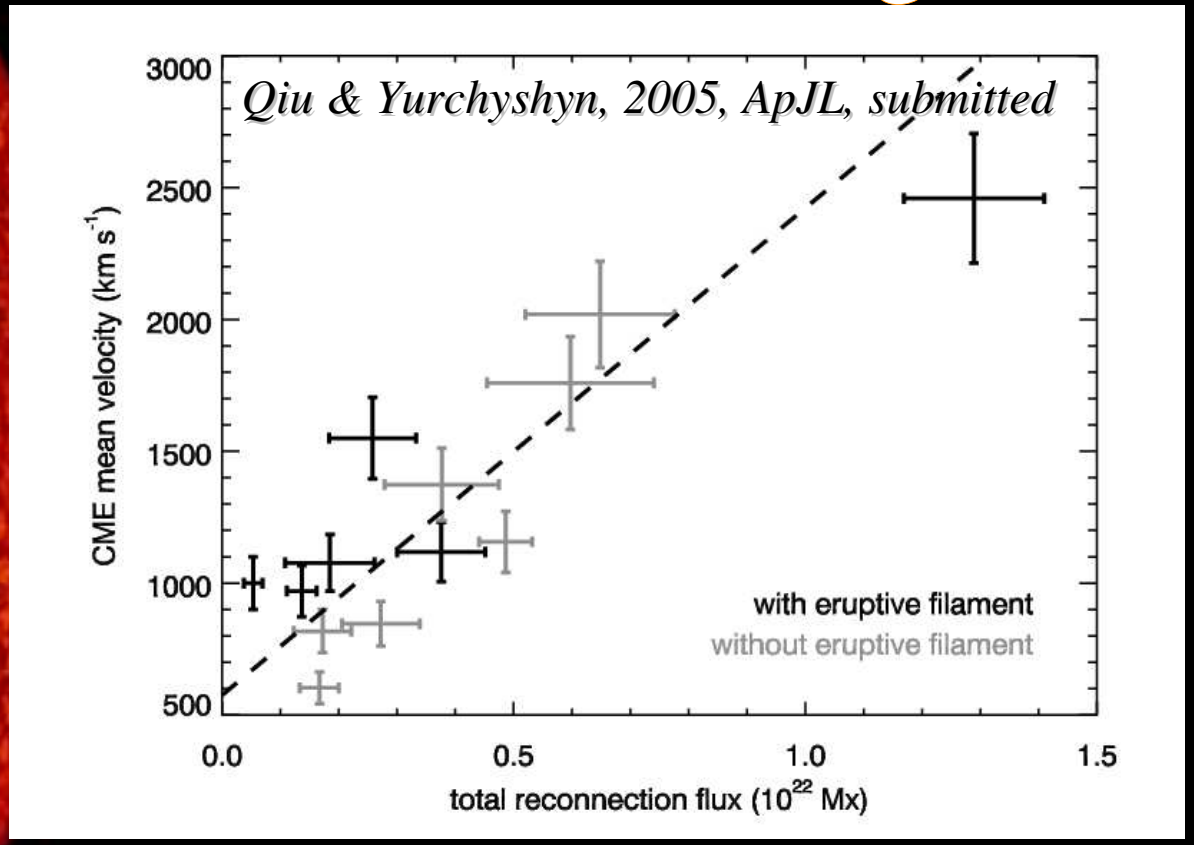
If the dynamics of solar ejecta is determined by the amount of the magnetic flux it contains, is it then possible to estimate this magnetic flux by analyzing solar data such as magnetograms, chromospheric, coronal and coronograph images?

To explore this question we studied:

i) the relationship between the amount of the magnetic flux that reconnected during an eruption and the speed of the associated coronal mass ejection (CME)

ii) the relationship between the magnitude of the interplanetary magnetic field observed at 1AU and the speed of the associated CMEs.

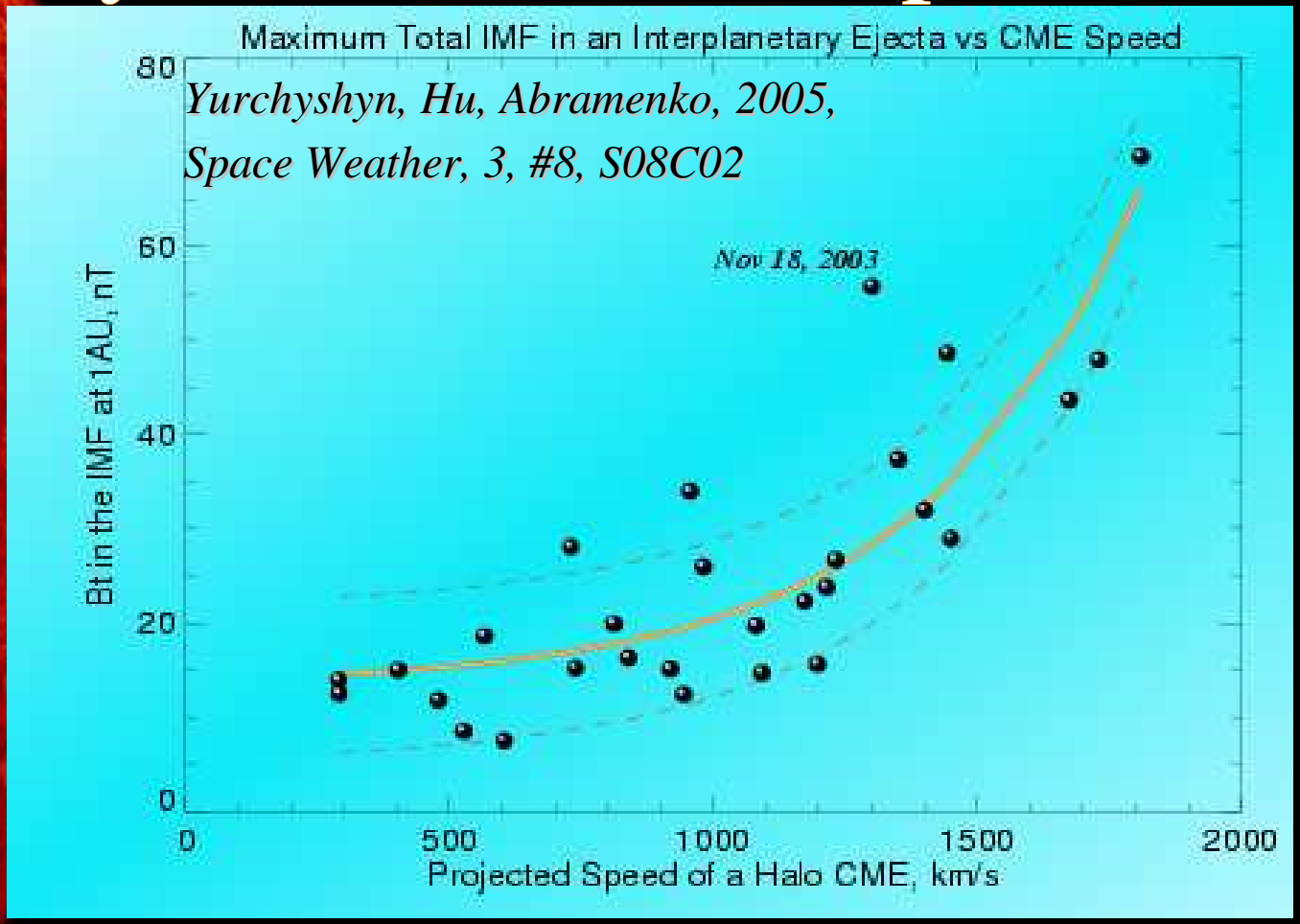
Speed of CMEs vs Magnetic Flux



The higher the total amount of the magnetic flux transferred to an erupting flux rope, the higher the speed of that eruption.

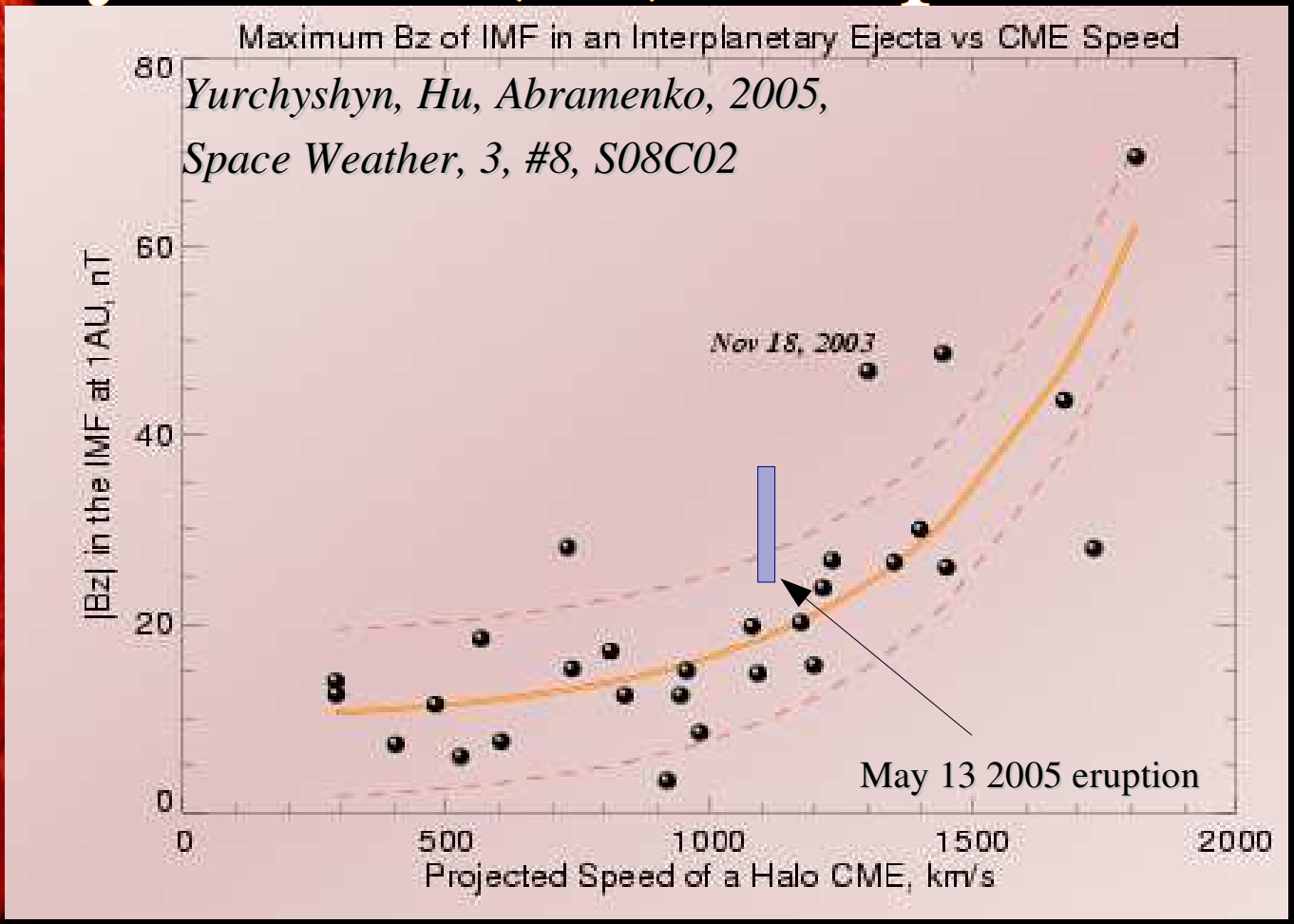
Dark and grey colors indicate events associated with erupting and non-erupting filaments. The guide line indicates the least-squared linear fit to the data points (total 13 events).

Intensity of IMF(Bt) vs Speed of CMEs



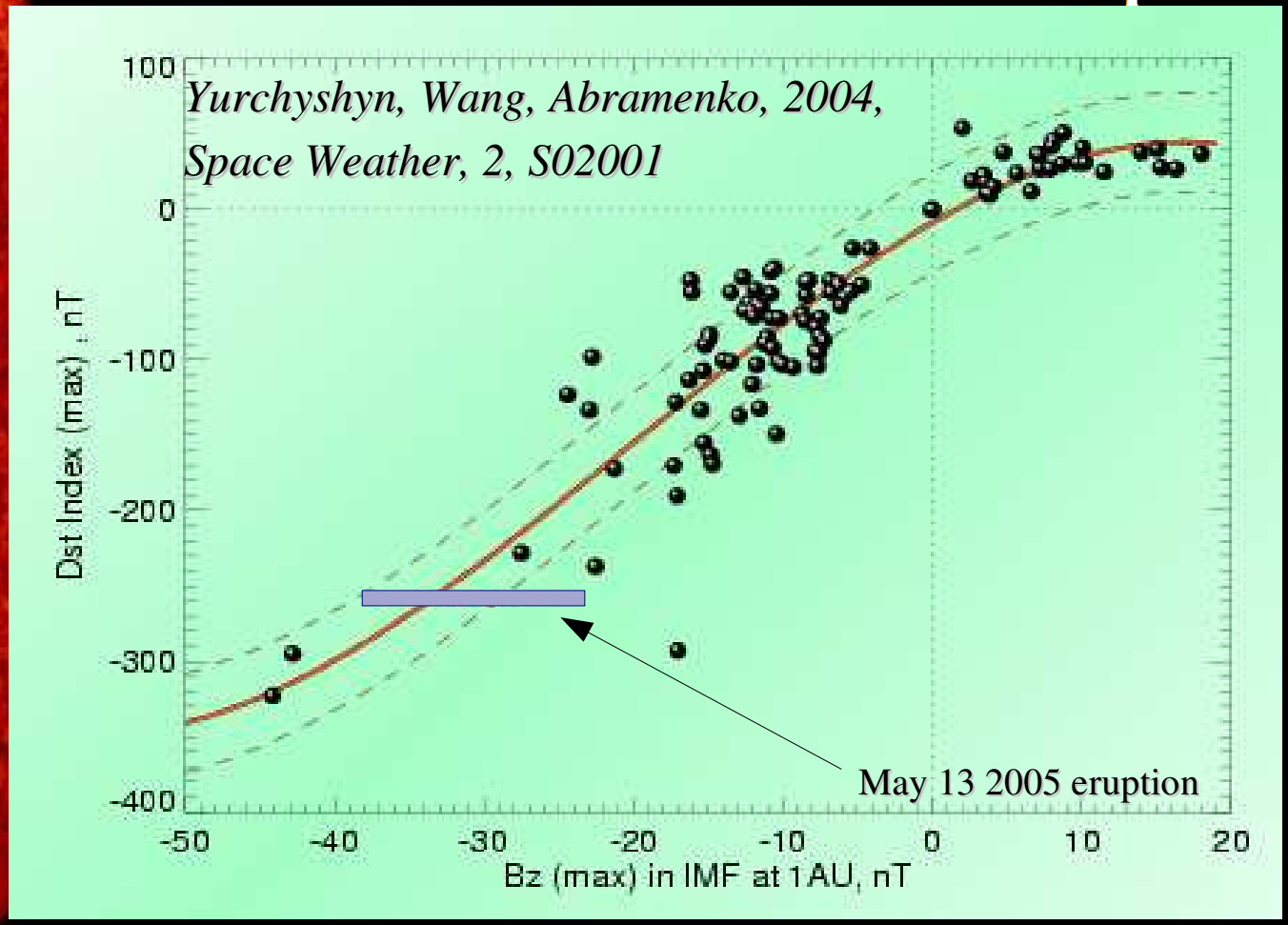
The intensity of the magnetic field (Bt) in interplanetary ejecta (ACE data) plotted vs the speed of the ejecta as determined from LASCO/C3 data.

Intensity of IMF(Bz) vs Speed of CMEs



Absolute intensity of the Bz component in interplanetary ejecta (ACE data) plotted vs the speed of the ejecta as determined from LASCO/C3 data.

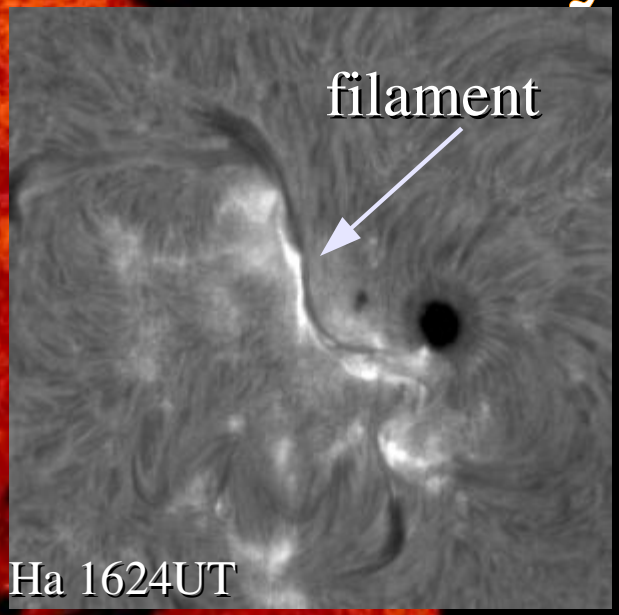
Size of the storm vs Bz component

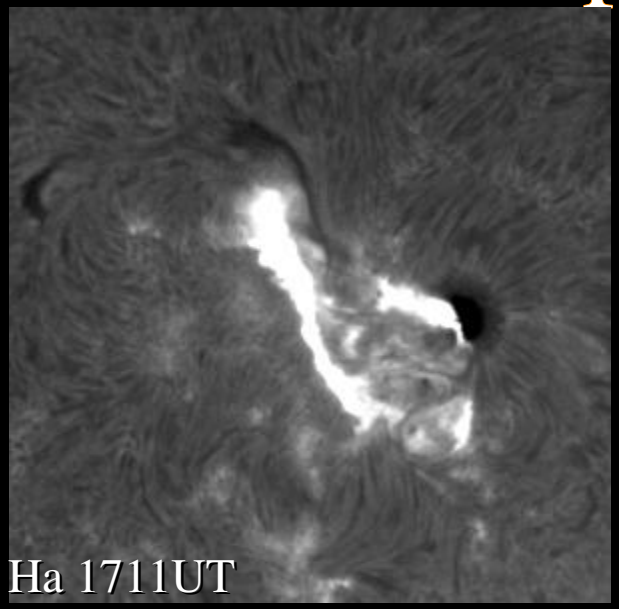


The Dst index plotted vs the magnitude of the Bz component.

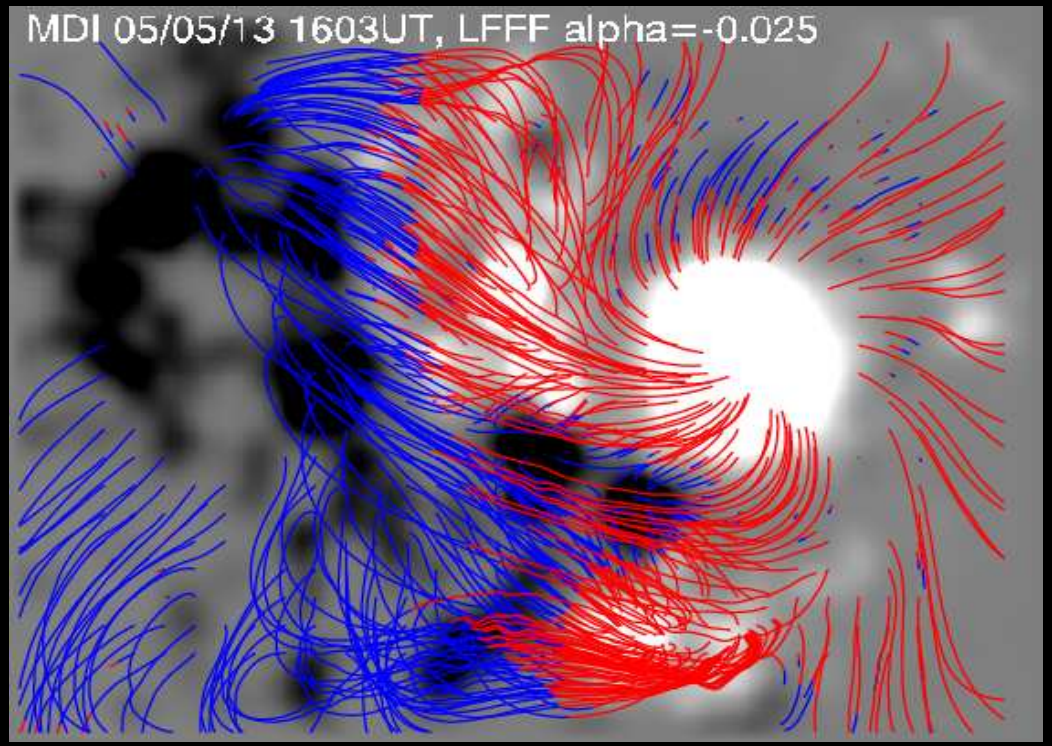
(see also Cane et al. 2000, GRL, 27; Wu & Lepping, 2002, JGR, 107)

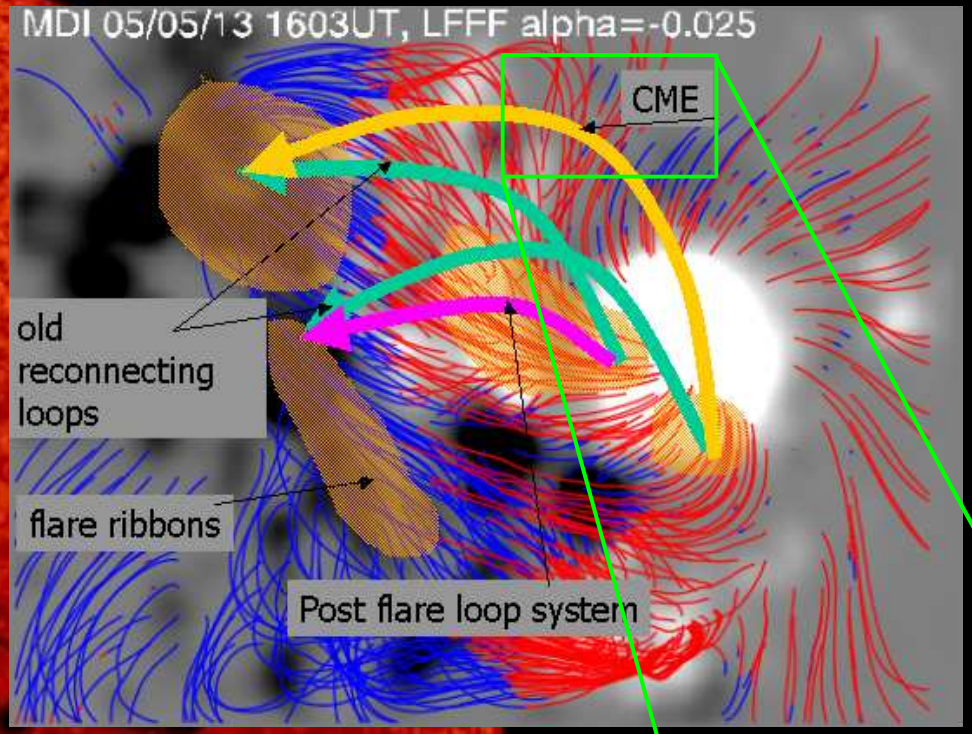
May 13 2005 Eruption

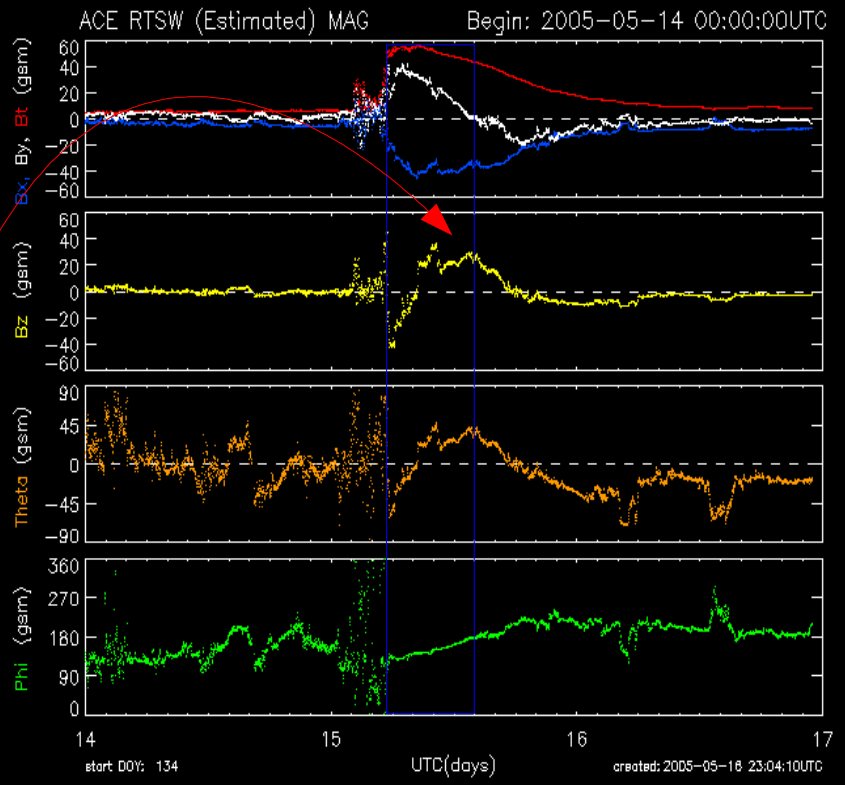




The eruption was associated with the major neutral line and a filament that did not erupt. This reverse "S" shaped filament and the post-flare loops both suggest that negative helicity (left handed twist) was dominant in this active region. LFFF field lines adequatelly represent both post-flare loops system and the general twist in the active region.

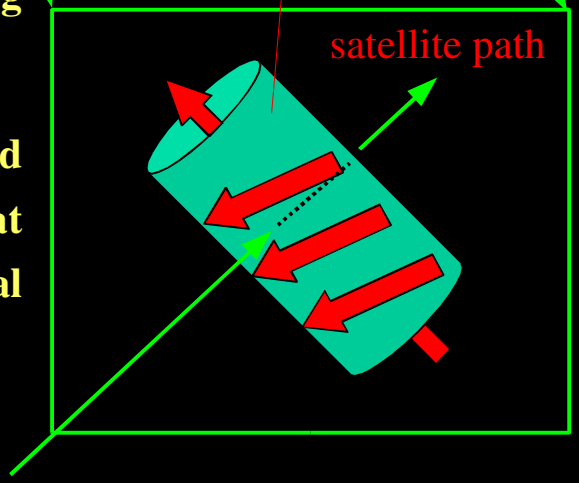




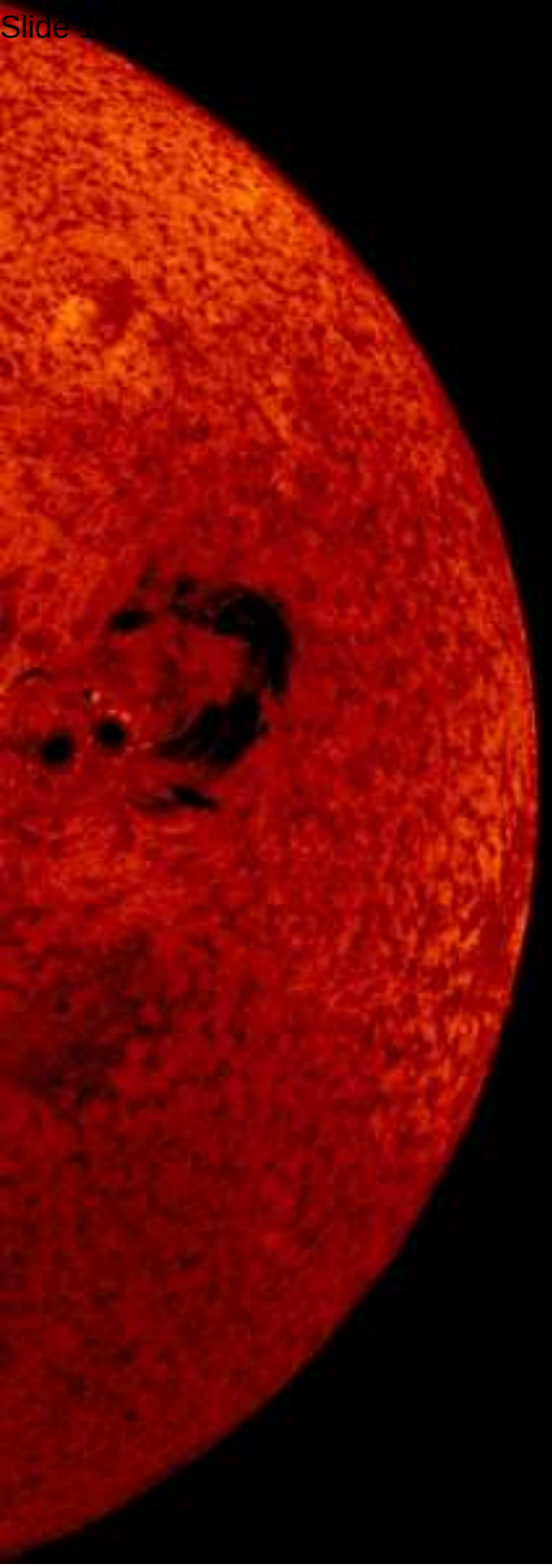


The erupted magnetic fields that became the CMEwere, most probably associated with the active region's large scale magnetic field, connecting two major magnetic structures.

If so, the flux rope in the ejecta should be left handed with the axial field at its edge being negative, while its axial field points eastward.



ACE data (above) shows that Bz component (second graph from the top) was rotating from southward (negative) to northward (positive), while the By (white curve, top graph)was eastwardly directed (positive).



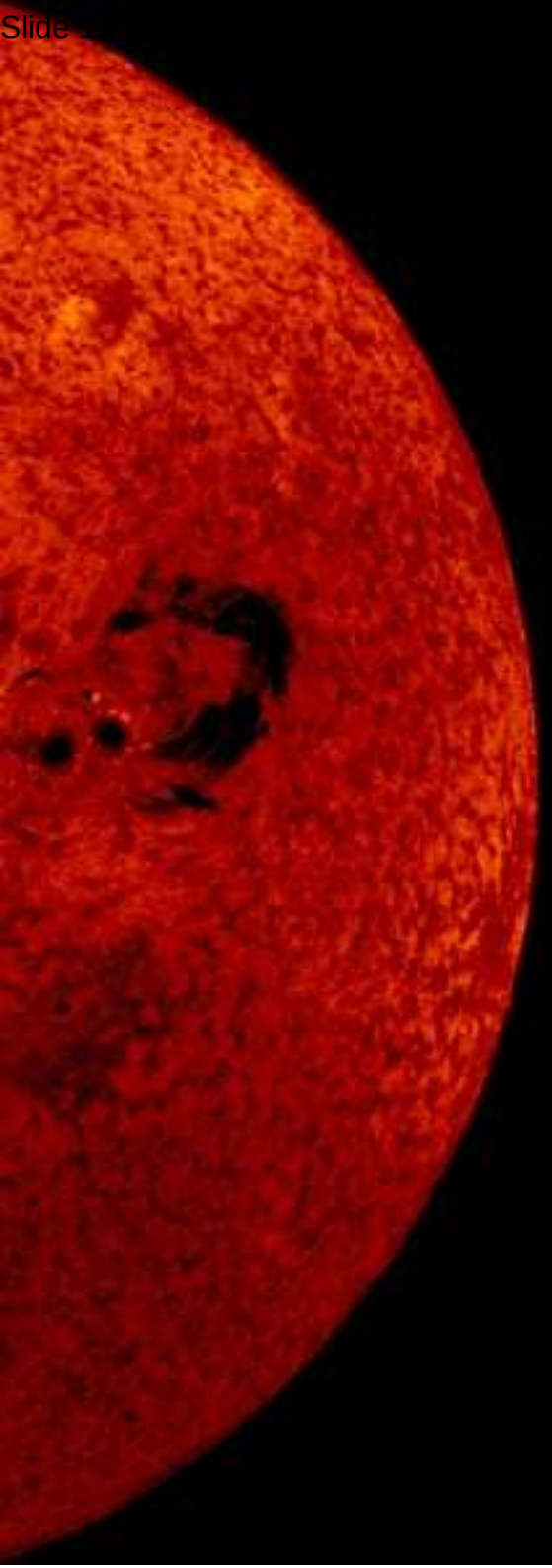
May 13 2005 Predictions

The two ribbon flare was associated with a fast CME. Because of gap in LASCO data, it was not possible to accurately measure the speed of the CME and therefore, it was estimated that this CME erupted with a speed about 1100 km/s.

*** Analysis of the solar data indicates that the leading edge of the interplanetary ejecta could have a strong negative southward Bz that will cause an intense geomagnetic storm.**

*** According to the Bz vs V(cme) plot the magnitude of the bz is estimated to be in the range -10 ... -25 nT (observed range: -20 ...-38nT)**

*** Interplanetary field of this magnitude is capable of causing a geomagnetic storm with the Dst index in the range -100 ... -250nT. The observed Dst index dropped during this storm down to -260nT.**



Conclusions

Analysis of the May 13 2005 event as well as other eruptions indicates that

1) the method presented here is capable of estimating the magnitude of the geomagnetic storm 1-2 days in advance

2) it can be used in near real time for Space Weather forecast

This method however, does not have a potential to predict:

1) the orientation of the flux rope, therefore the estimates should be considered as the upper limit

2) the arrival time and possibility that the CME will encounter the Earth