Connecting Magnetic Clouds to Solar Surface Features

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- Coronal mass ejecta (CMEs) are known to cause strongest geomagnetic storms
- Most of the strongest storms are associated with arrival of an organized magnetic structure – magnetic clouds (MC)
- If a MC has an intense southward component of the magnetic field, it will induce a strong storm. Can we predict it in advance?

CME orientations

- MC is thought to correspond globally to a curved flux rope as shown and can be related to various solar parameters such as magnetic field helicity, strength and direction

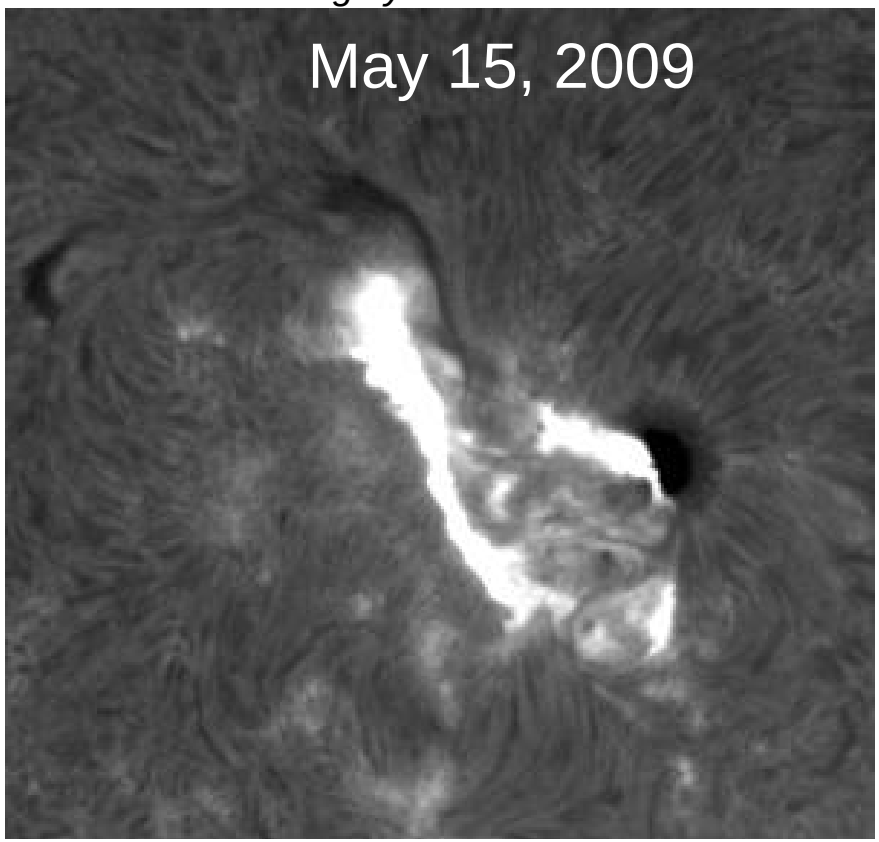
- According to various case and statistical studies many interplanetary ejecta maintain nearly the same orientation and twist as the source regions they are associated with

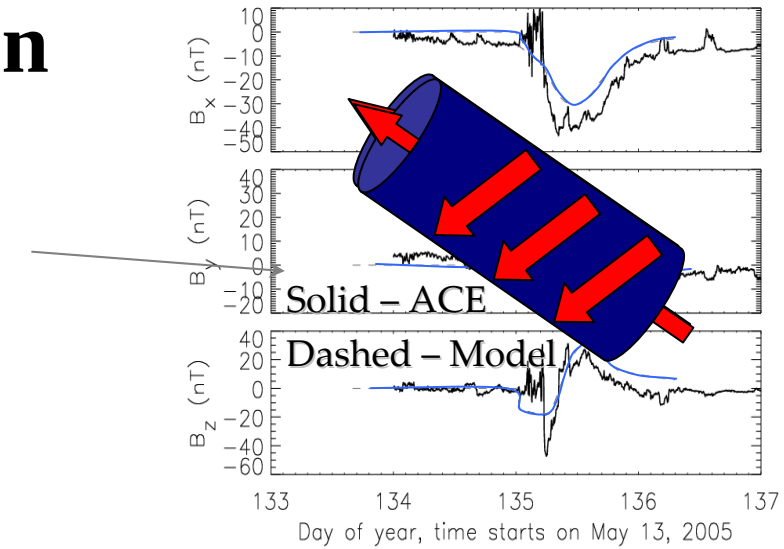
- Several statistical studies, however, produced inconclusive results. For example, Harra *et al.* concluded that the same active region may produce interplanetary ejecta with different magnetic orientations

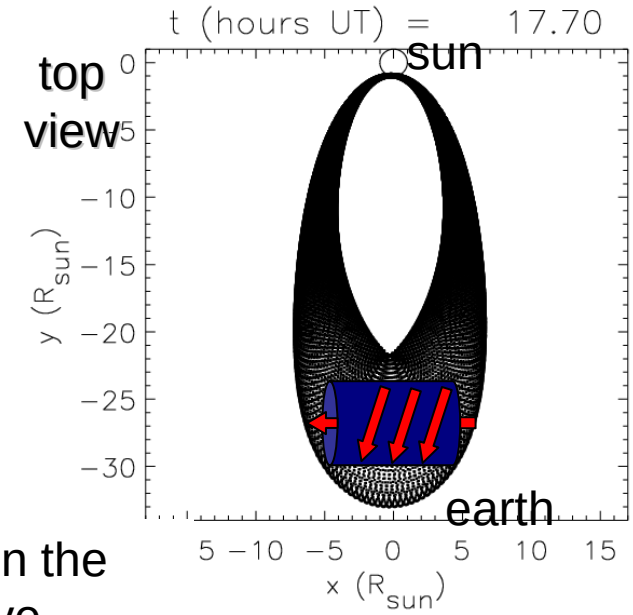
Magnetic Filed Orientation

Orientation of the simulated flux rope
View from the Earth (as in LASCO Images)

Fitting by Jonathan Krall



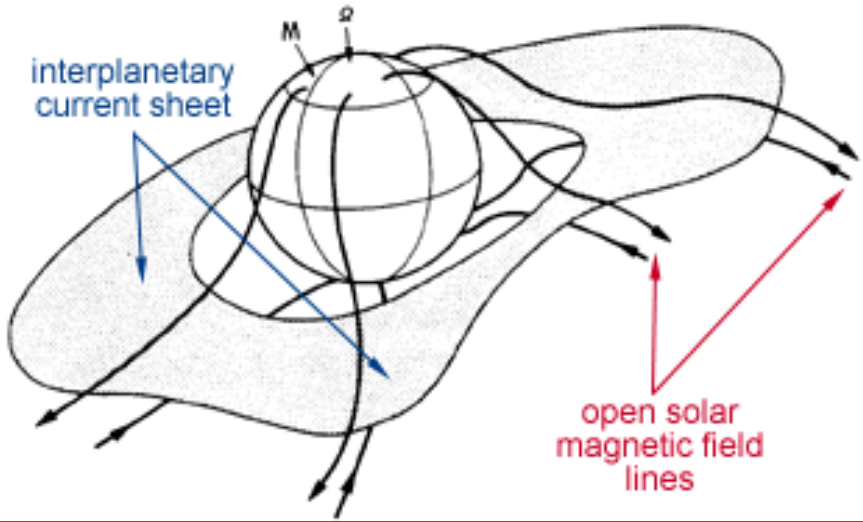




In this simple case there is an agreement between the orientation and twist of magnetic fields in the active region and in the interplanetary flux rope

CMEs & Heliospheric Current Sheet

- CMEs disrupt heliosphere (*Zhao & Hoeksema 1996*)
- Fast CMEs interact w/ upstream plasma, shock formation (*Gosling et al., 1994; Howard & Tappin 2006*)
- CMEs may "displace" and "push" the heliospheric magnetic fields (*Smith 2001*)
- Heliospheric current sheet considered to be a conduit for CMEs (*Crooker et al., 1993*)
- Does the heliosphere affects CMEs?



Comparison between Orientations of EIT Post Eruption Arcades (PEA), LASCO CMEs, WSO Coronal Neutral Lines and Magnetic Clouds

- Determined the clock angle of MCs from fitting routines (Grad-Shafranov by *Hu;* MC fitting by *Lepping et al. (2006), Lynch et al. (2005) an* EFR model fitting by *Krall & Yurchyshyn*

- Determined the axial and azimuthal fields in EIT PEAs

- Resolved the 180 ambiguity of LASCO CME fields based on the EIT PEA data

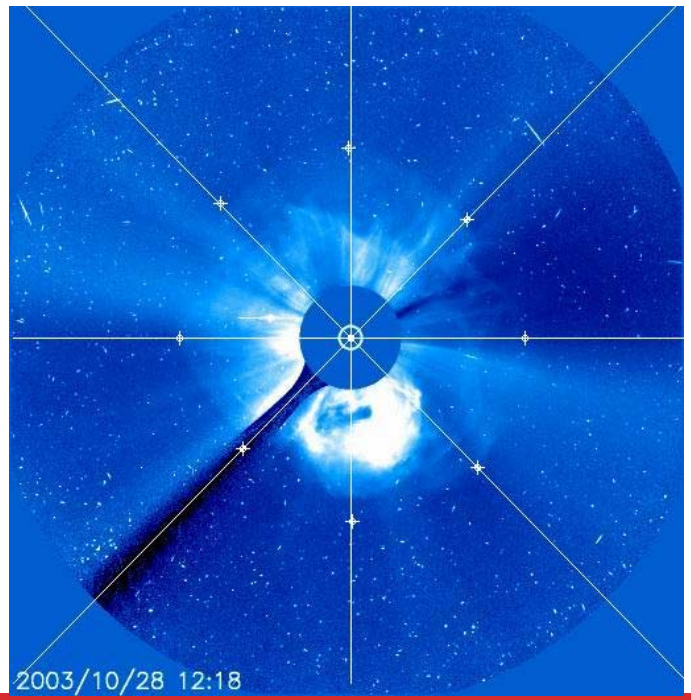
- Determined orientation of the WSO neutral line at the eruption site

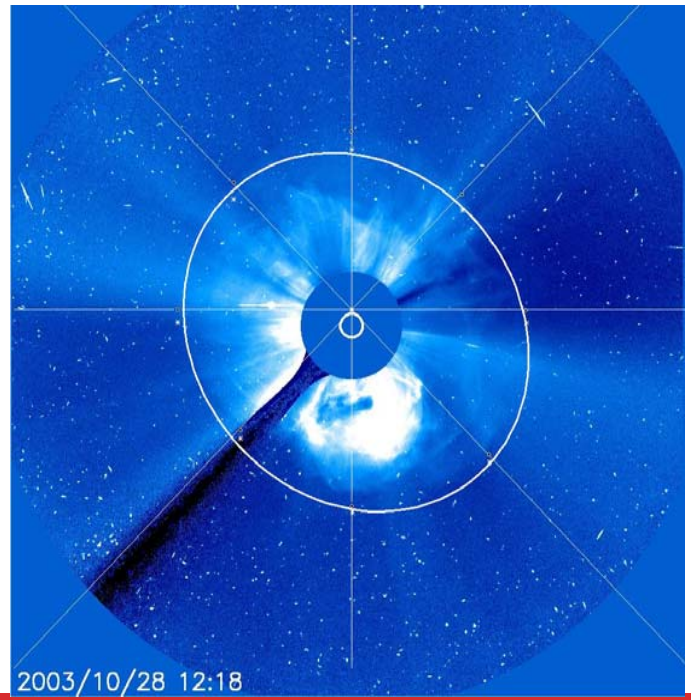
Orientation Halo CMEs

Halo CMEs exhibit various sizes and shapes. Many of them could be enveloped by an ellipse and fitted with a cone model (Zhao, Plunkett & Liu 2002, Xie Ofman & Lawrence 2004; Zhao 2005)

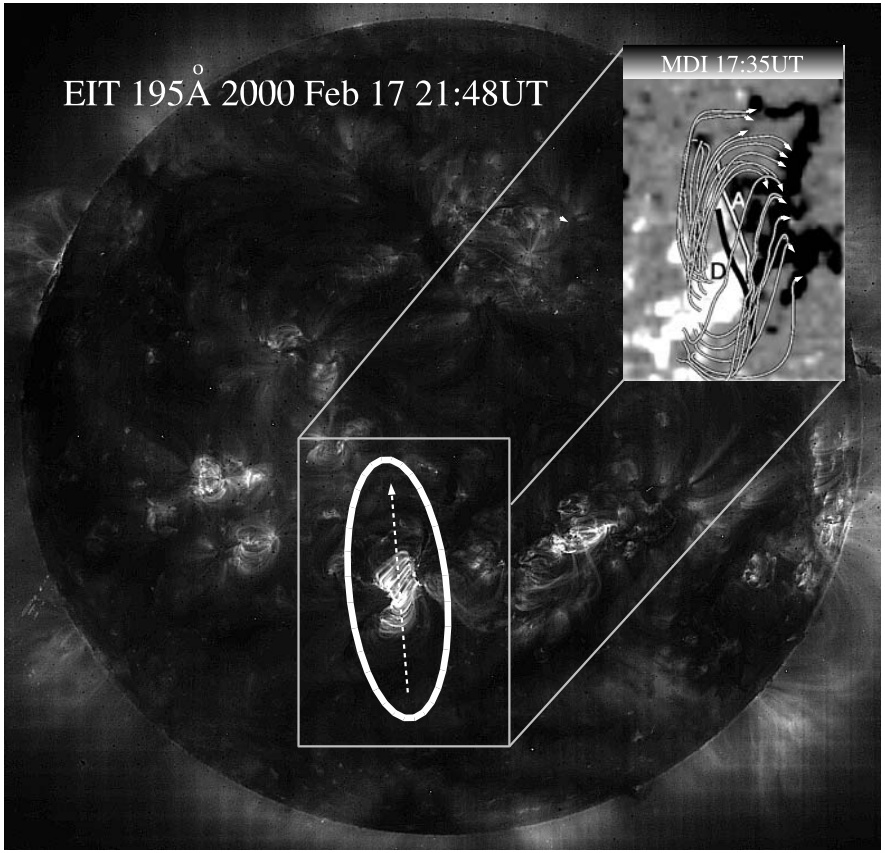
or

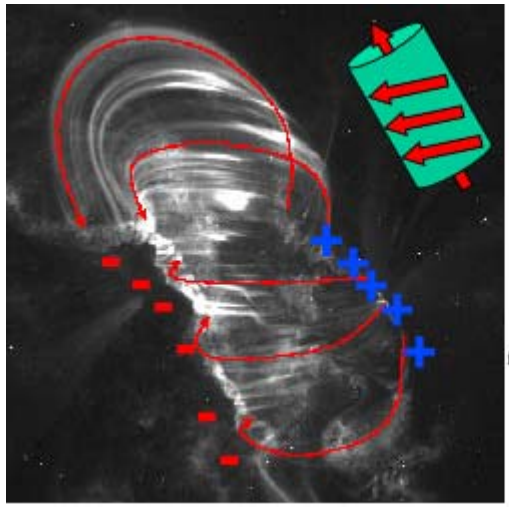
measured to determine the direction parameter (Moon et al., 2005; Kim et al. 2008)

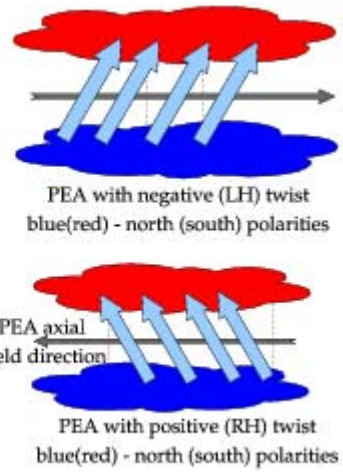




Orientation of Post Eruption Arcades

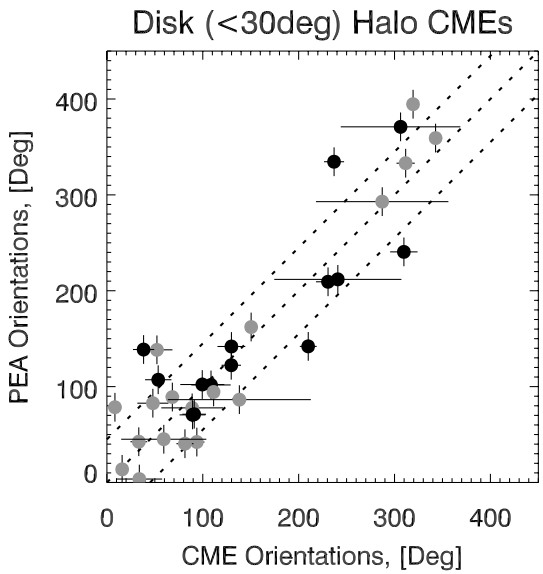


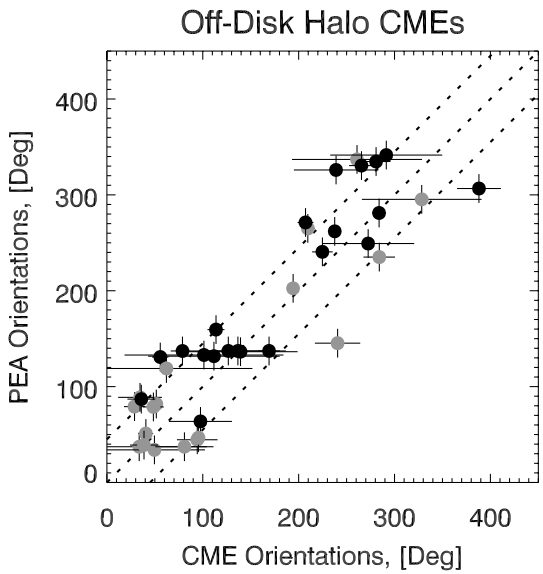


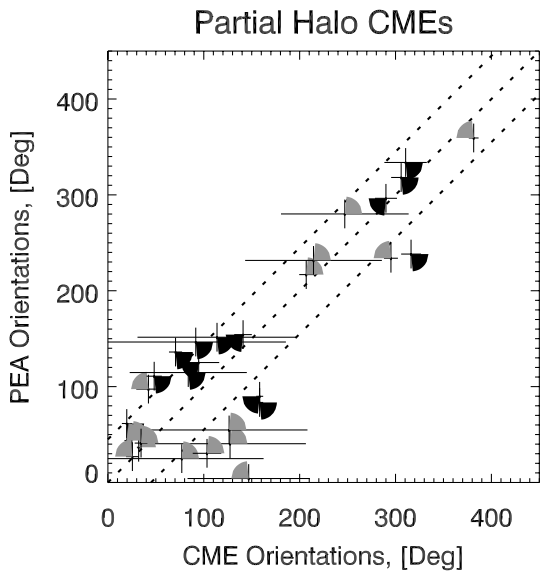


CME vs PEA Orientations (101 events)

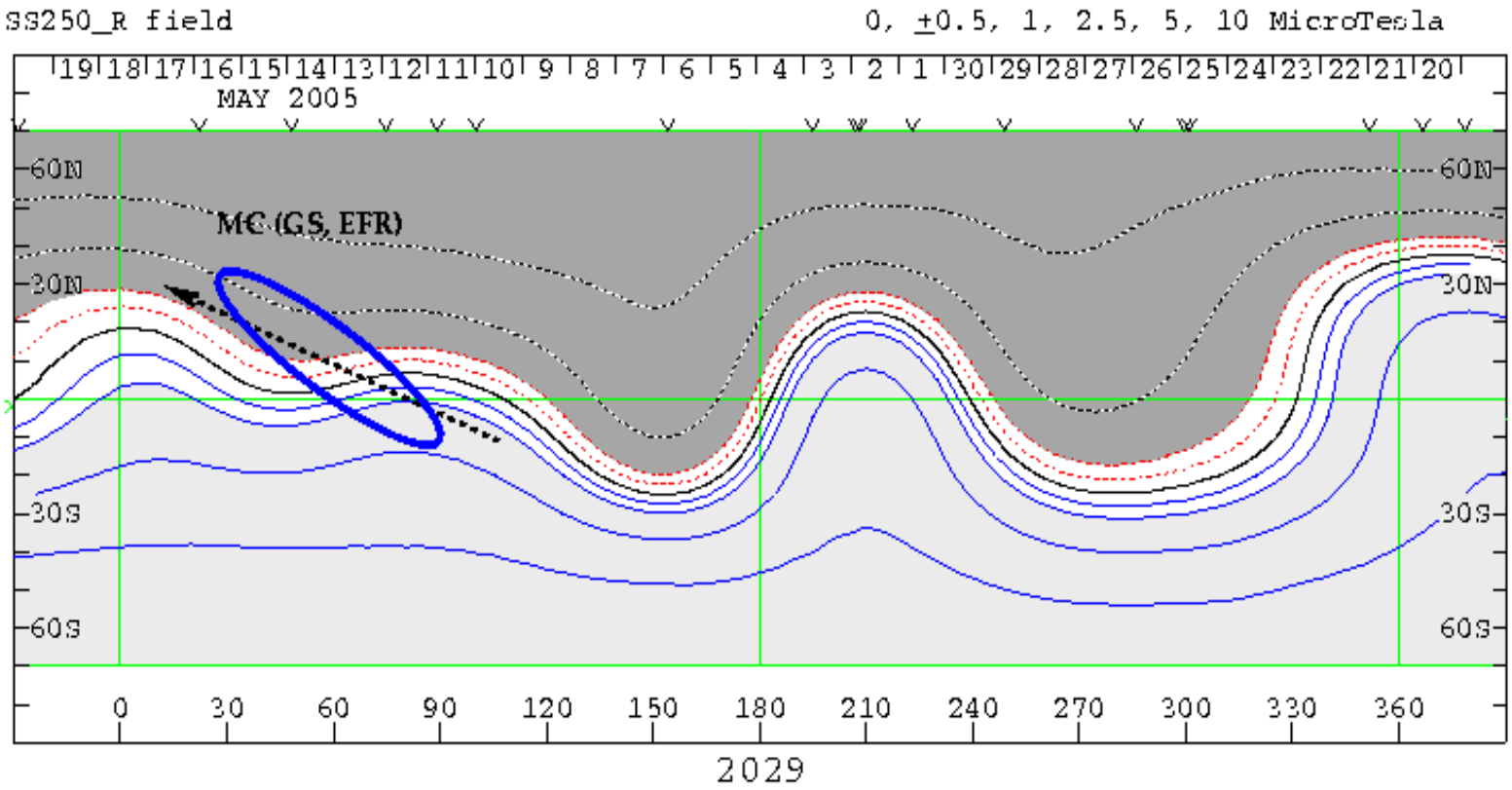
CME directional angles plotted versus those of PEAs. The panels show (from left to right) data points for disk halo CMEs that originated within a 30 deg circle centered at the disk center, off-disk halo CMEs and partial CMEs. Black (gray) symbols represent events launched from southern (northern) hemisphere. The partial halo events are plotted with pie segments, whose orientation indicates their solar location.



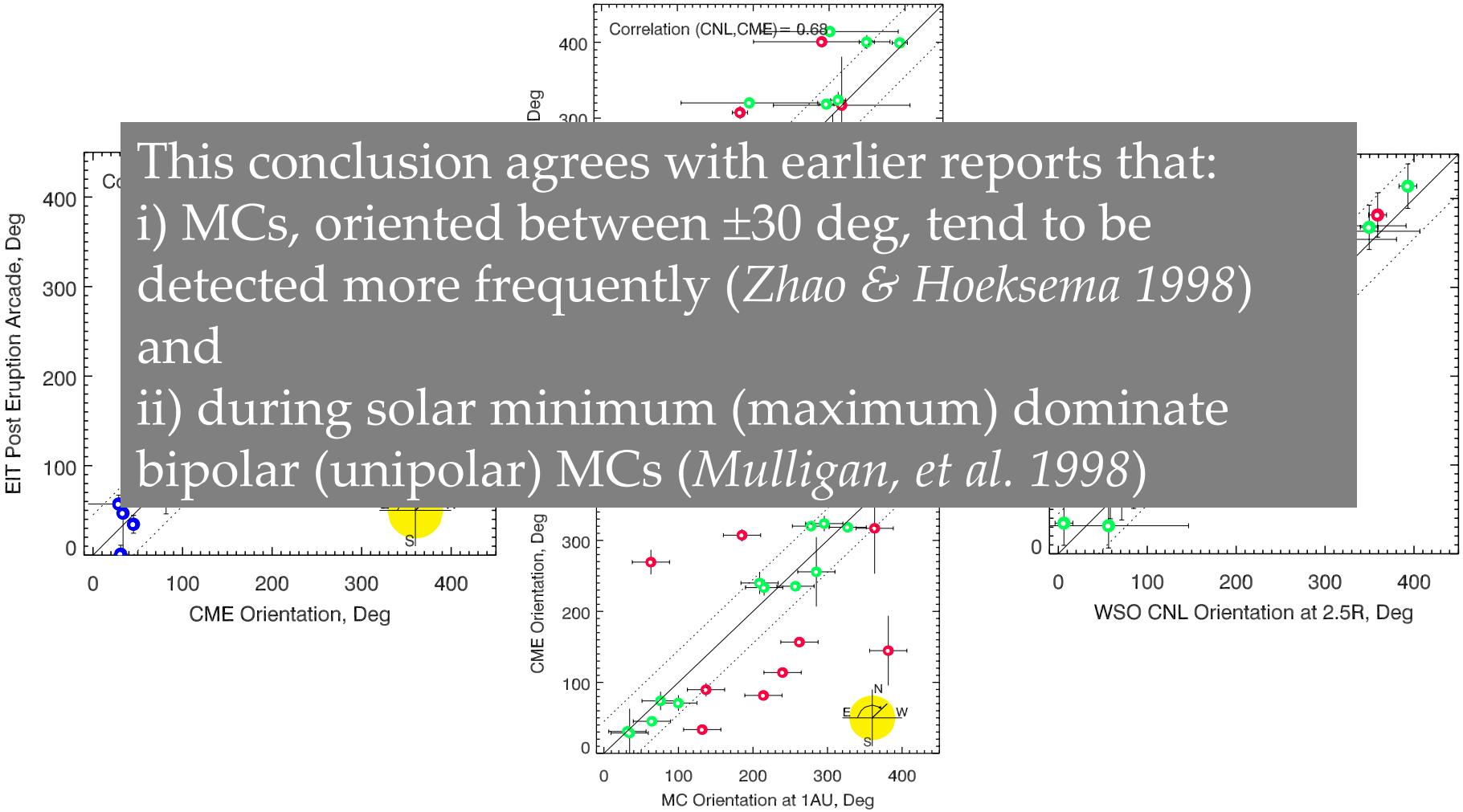




CMEs (and PEA) Orientations versus WSO Neutral Lines

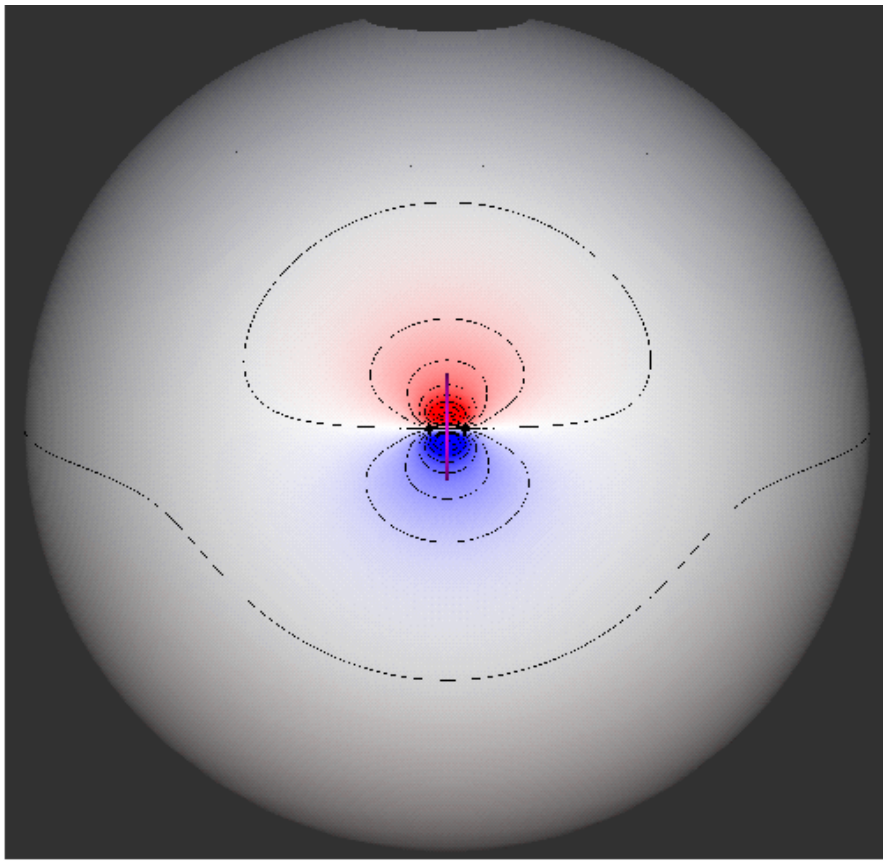


Green Events: EIT Arcade – CME – Current Sheet and MC are aligned;
Red Events: EIT arcade aligned with CME, they both are not aligned with CS and ICME rotates so that at the end MC is aligned with CS

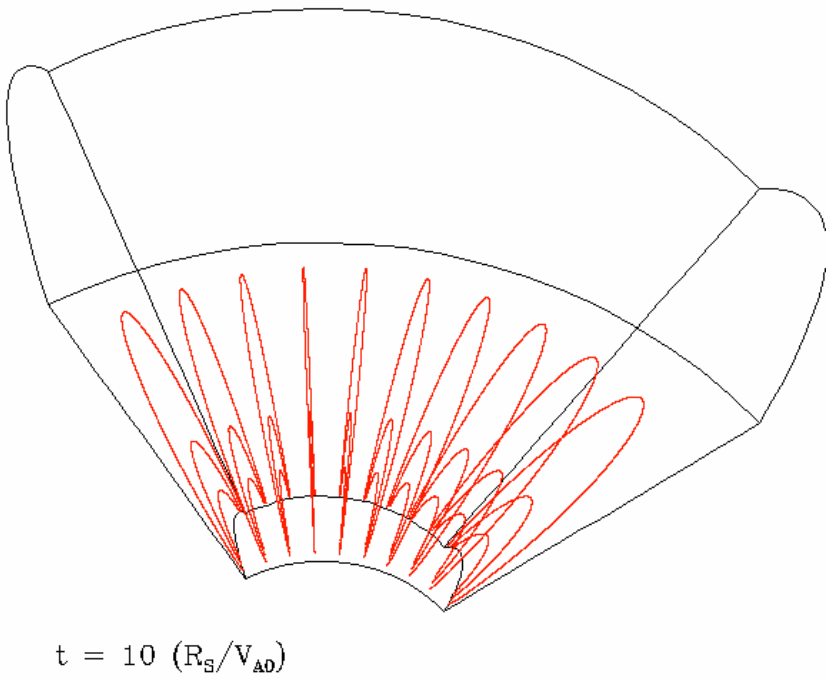


This conclusion agrees with earlier reports that:
i) MCs, oriented between ±30 deg, tend to be detected more frequently (*Zhao & Hoeksema 1998*) and
ii) during solar minimum (maximum) dominate bipolar (unipolar) MCs (*Mulligan, et al. 1998*)

Eruption Dynamics – Flux Rope Rotation

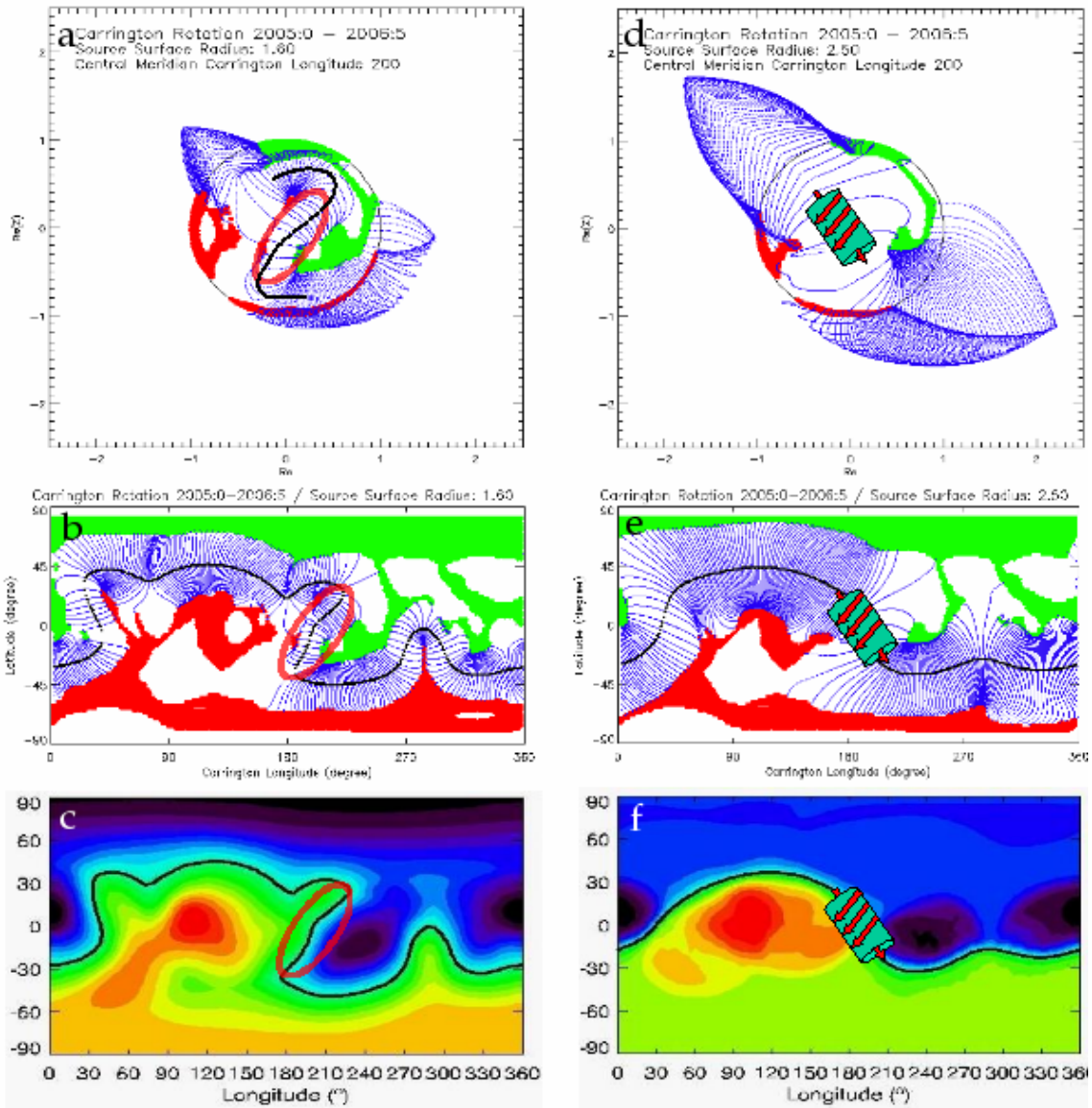


Lynch et al., 2008, 2009



Fan & Gibson 2008,
also work by Green et al.

Does HCS affect ICMEs?

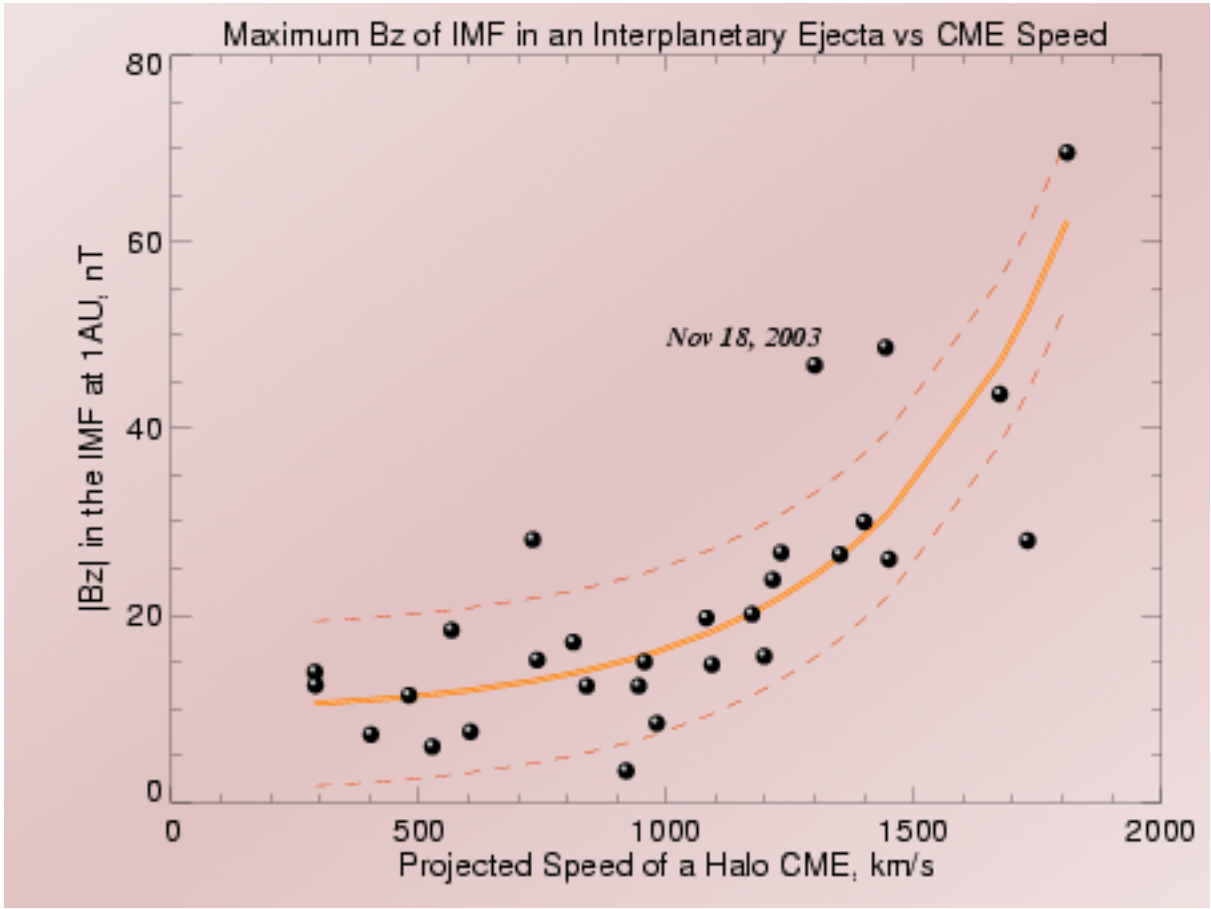


Coronal field maps for CR2006 with CCMC/PFSS (top and middle) and MAS models (bottom). Panels a, b and c show maps for source surface radius of 1.6 R⊙, d and e show maps at 2.5 radii, while panel f shows MAS map at 16.5 radii. The thick black contour is the coronal neutral line. The red oval represents the halo CME on Aug 14, 2003, which was aligned with the coronal neutral line at 1.6R⊙. Magnetic field has changed further outward from the solar surface so that the neutral line rotated by approx. 50 deg.

HMI data products for Space Weather

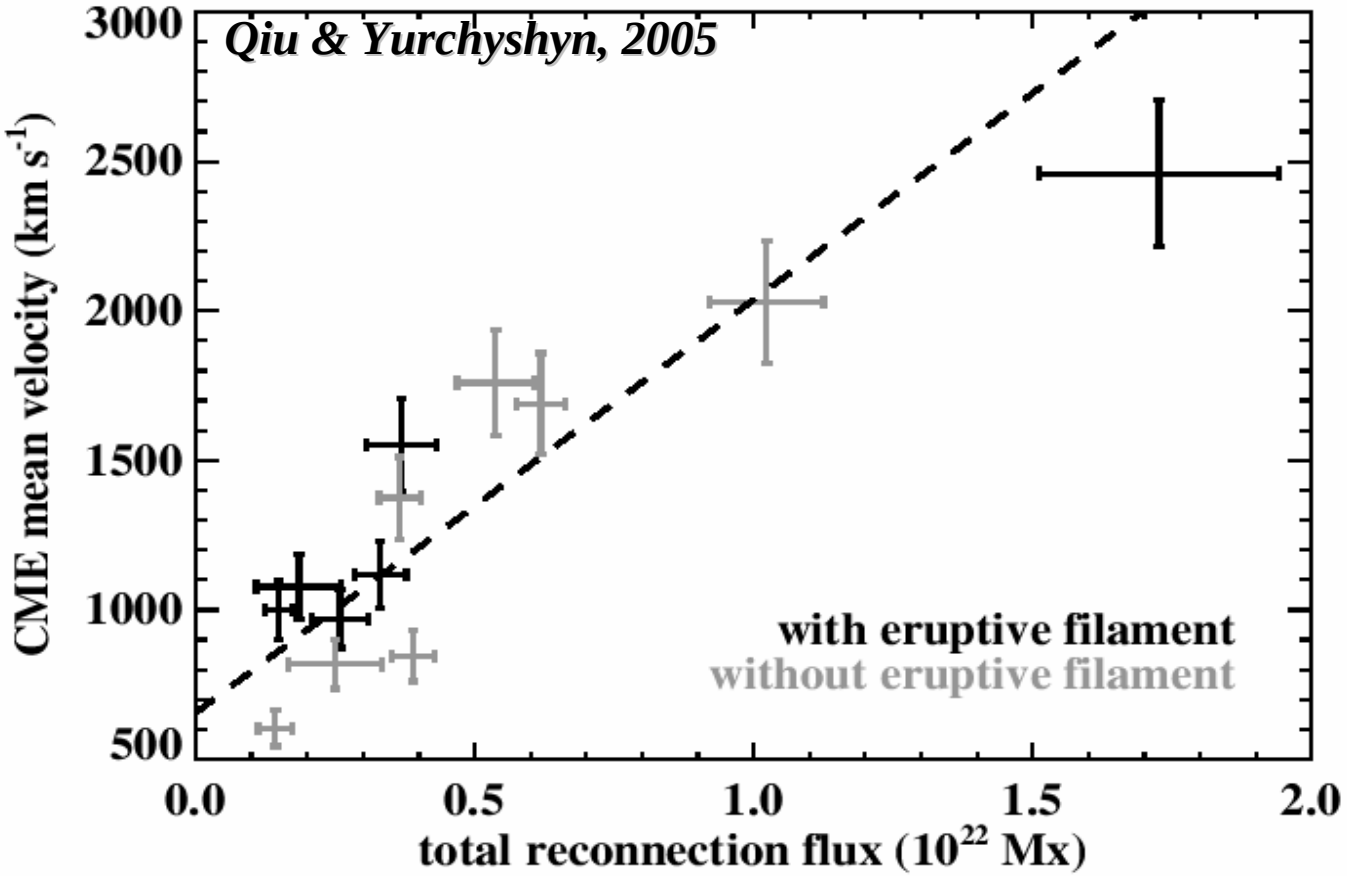
- Dominant twist (helicity) associated with the major neutral line in an eruptive active region – NLFFF needs to be run once a day at least for the active regions prone to eruption (using AR index?)
- HMI synoptic maps; PFSS models; local tilt of the coronal neutral line
- MHD models; local tilt of the neutral line at large solar radii; understanding the magnetic environment in which CME propagate, etc
- Very simple wish: HMI magnetic field contours plotted over EUV images (not entirely HMI data product; quick-look data?)

Correlation of the CME Speed and the Bz



The hourly ACE Bz in the IMF vs the LASCO projected CME's speeds

Speed of CMEs vs Reconnected Magnetic Flux



The higher the total amount of reconnected flux the higher the speed of that eruption.