12th European Solar Physics Meeting
8 - 12 September 2008
Freiburg, Germany

Electronic proceedings

For further information on the meeting,
for all abstracts of talks and posters
as well as other articles of these proceedings,
please visit the following web site:

http://espm.kis.uni-freiburg.de

edited by Hardi Peter
Kiepenheuer-Institut für Sonnenphysik
Freiburg, Germany
peter@kis.uni-freiburg.de

2.3-07

Relation between CME Acceleration Profile and Flare Energy Release derived from Combined STEREO and RHESSI Observations

Temmer, M.[1]*; Veronig, A.M.*[1]*; Vrsnak, B.*[2]
[1]*IGAM/Kanzelhöhe Observatory, Institute of Physics, UNI Graz;* [2]*Hvar Observatory, Faculty of Geodesy, University of Zagreb*

In the standard flare/CME picture magnetic reconnection occurs in a current sheet formed behind the CME, which may provide a feedback relationship between both phenomena. To study the relationship of the large-scale CME acceleration and the energy release in the associated flare we analyze three well observed events. The observations cover the early (low corona) evolution of the CMEs with the EUVI instruments aboard the twin STEREO spacecraft and the RHESSI hard X-ray emission of the associated flare. Since the flare hard X-rays are due to fast electrons, they provide the most direct indicator of the evolution of the flare energy release in the flare. The results are compared to case studies for halo-CMEs where a close synchronization between the CME acceleration and the flare energy release was found (Temmer et al., ApJ, 2008, 673, L95).

Relation between CME acceleration profile and flare energy release derived from combined STEREO and RHESSI observations

Temmer, M.[1], Veronig, A.[1], and Vršnak, B.[2]

[1] Kanzelhöhe Observatory/IGAM, Institute of Physics, University of Graz, Austria (manuela.temmer@uni-graz.at)
[2] Hvar Observatory, University of Zagreb, Croatia

www.uni-graz.at/~temmerma

Flare-CME relation, the standard picture

In the standard picture of the flare energy release an erupting filament or coronal mass ejection (CME) distorts the overlying coronal magnetic field, which stretches out to form a vertical current sheet where magnetic reconnection may set in and release vast amounts of energy (e.g. Forbes, 2000). Under this assumption, we expect a close relation between the dynamics of the CME and the energy release in the associated flare (cf. Zhang et al. 2001, 2004; Temmer et al. 2008; **Fig 1a+b**). With the observation of hard X-ray emissions (HXR) from accelerated electrons, RHESSI provides the most direct indication of the evolution of the energy release in a flare (Lin et al., 2002).

CME observations from GOES to STEREO

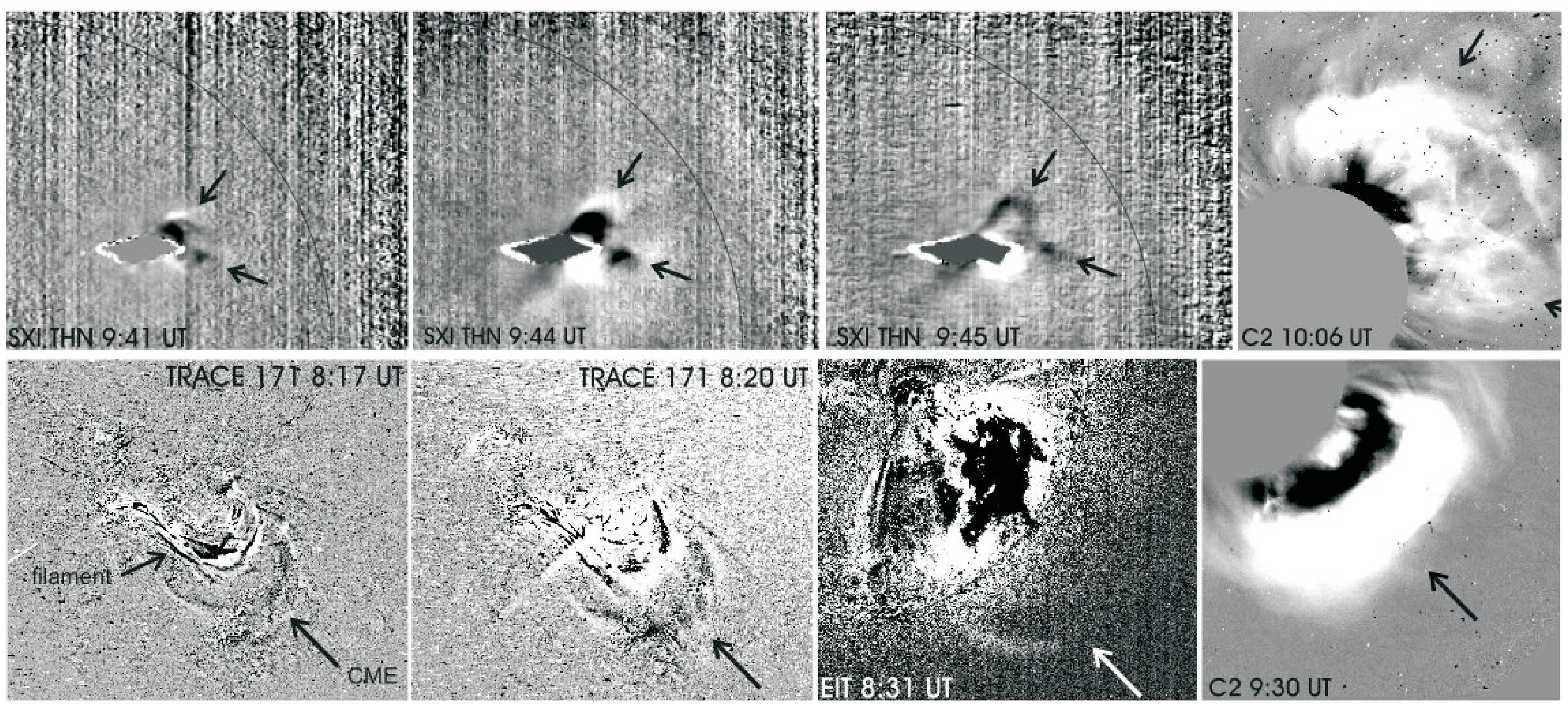


Figure 1a: Top: 2005 January 17 halo CME event. Sequence of three GOES/SXI run. ratio images and one LASCO C2 run. difference image. Bottom: 2006 July 6 halo CME event. Sequence of two TRACE 171Å, one EIT 195Å, and one LASCO C2 run. difference images.

With the new **STEREO** mission (Howard et al., 2008), high cadence observations in the EUV emission line of 171Å are available with a nominal cadence of 2.5 minutes; during times of observing campaigns even higher (~1 min). The SECCHI/EUVI instrument has a field of view (FoV) of 1.7 Rs which enables the detection of the early propagating phase of erupting CME structures (**Figs. 2a, 3a**). Together with observations from the COR1 (**Figs. 2a, 3a**) and COR2 instruments having FoVs of 1.4-3.0 and 2.0-15 Rs, respectively, we can derive a complete velocity/acceleration profile for the early propagation phase. Note the similarity between EUVI and COR1 observations.

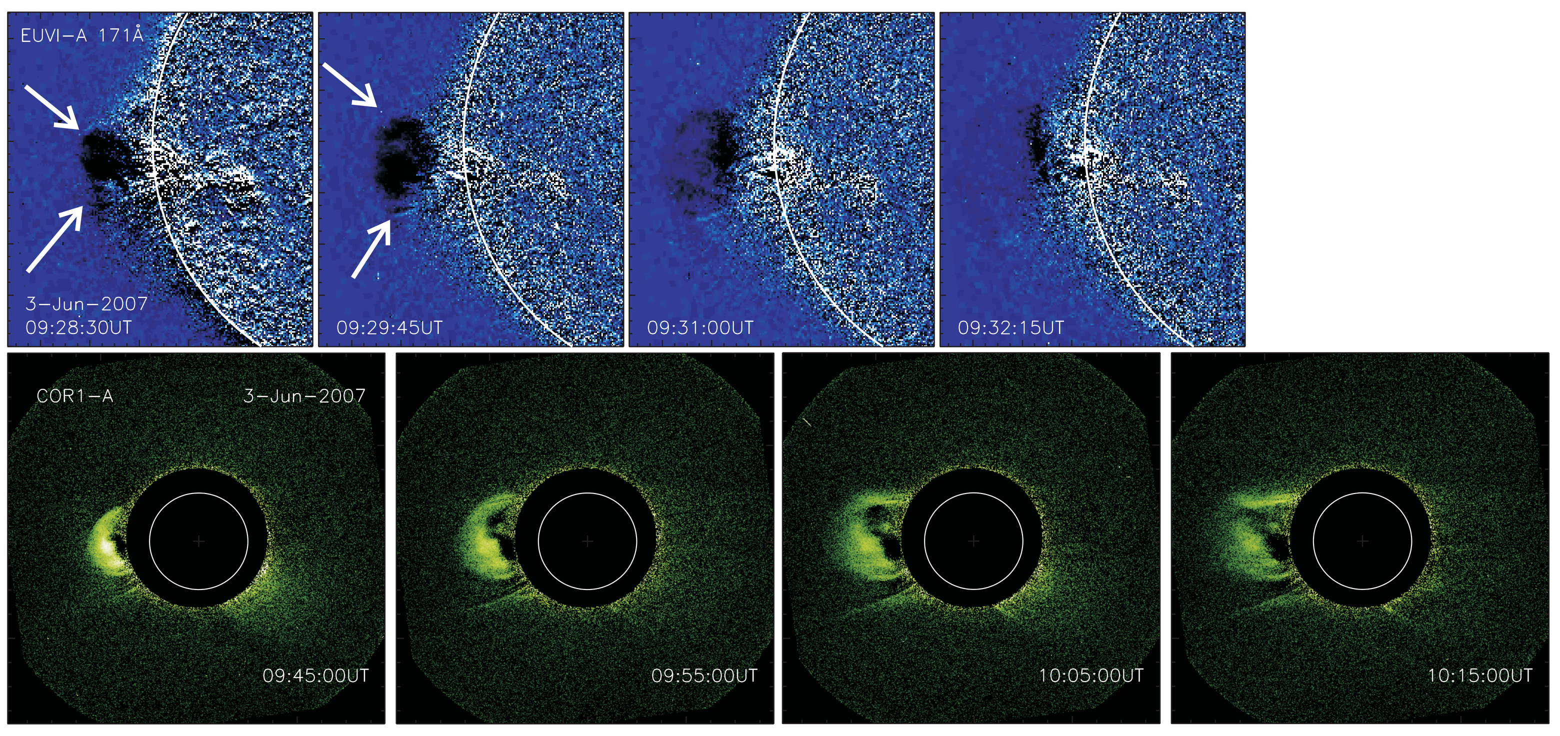


Figure 2a: 2007 June 3, C5.3 flare/CME event observed with STEREO-A. Top: sequence of EUVI 171Å running difference images. Bottom: sequence of COR1 images.

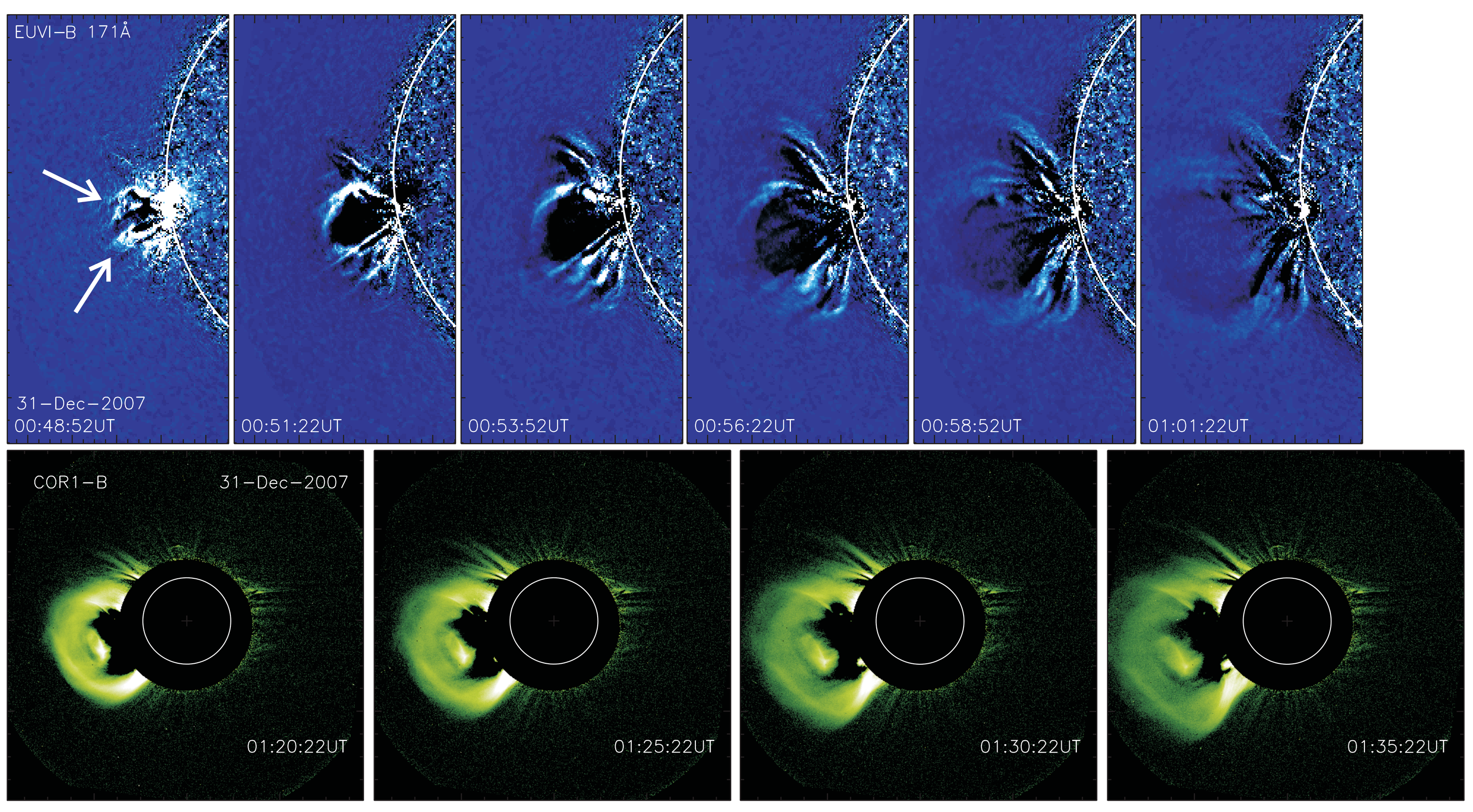


Figure 3a: 2007 December 31, C8.3 flare/CME event observed with STEREO-B. Top: sequence of EUVI 171Å running difference images. Bottom: sequence of

Standard flare/CME scenario?

In **Figs. 1b-3b** we show the distance-time profile d(t), velocity v(t), and acceleration a(t) of the measured CME fronts as they propagate away from the Sun. The bottom panels show for comparison also the RHESSI hard X-ray flux curves of the associated flare . The right panels zoom into the early acceleration phase of the ejecta as observed for **1b)** against the solar disk in GOES/SXI and TRACE images and for **2b)** and **3b)** above the limb in STEREO/EUVI 171Å images.

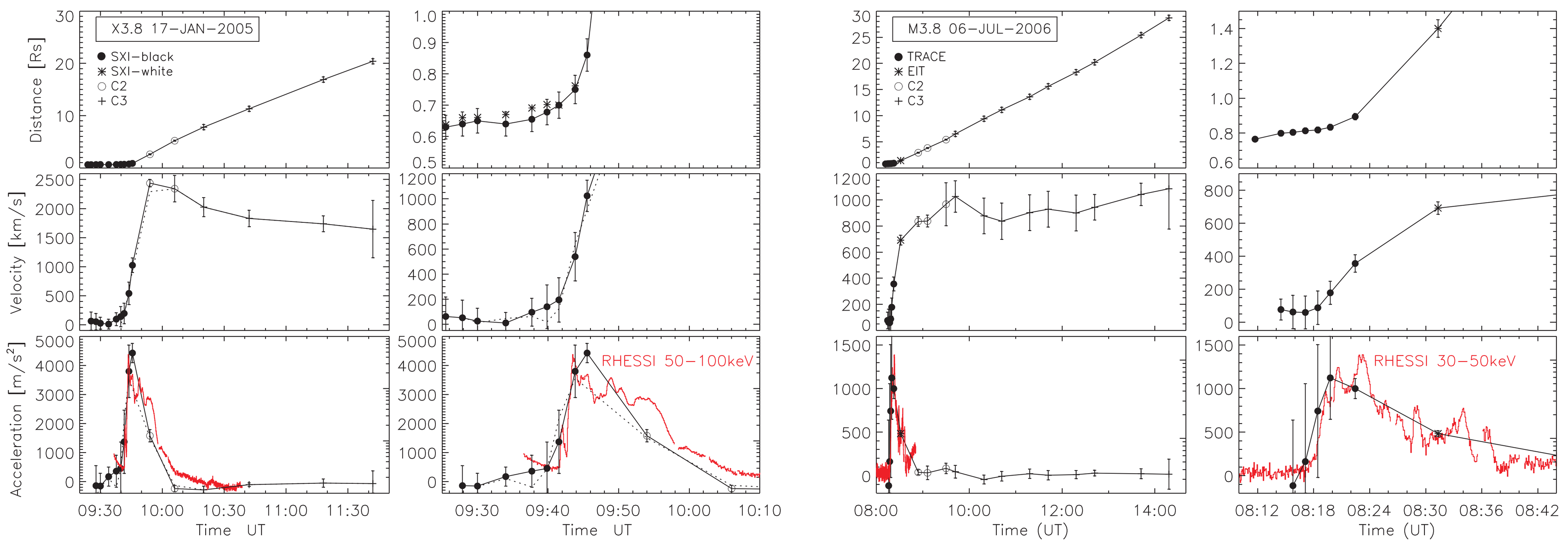
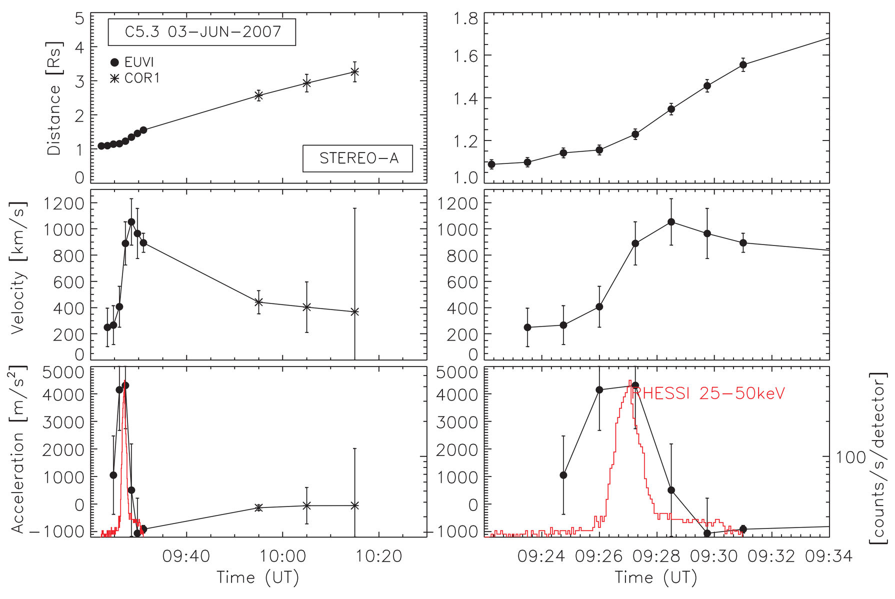


Figure 1b: Left: CME dynamics for the 2005 January 17 X3.8 flare/CME event. Right: CME dynamics for the 2006 July 6 M3.8 flare/CME event. The acceleration of the CMEs and the RHESSI HXR flux are closely synchronized within about 5 min. The peak acceleration of about 5 km/s² and 1.3 km/s² occurs at a plane-of-sky distance from the Sun center <1 Rs.

Figure 2b: CME dynamics for the 2007June 3 C5.3 flare/CME event. The acceleration of the CMEs and the RHESSI HXR flux are closely synchronized within about 5 min. The peak acceleration of ~4.5 km/s² occurs at a plane-of-sky distance from the Sun center below 1.3 Rs. This is consistent with the results for the halo CMEs (cf. **Fig. 1a+b**).



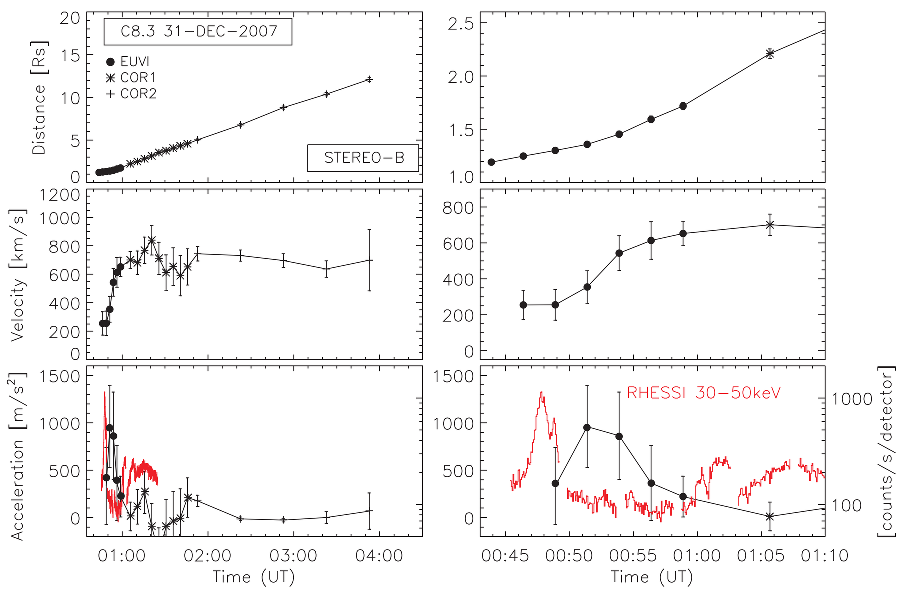
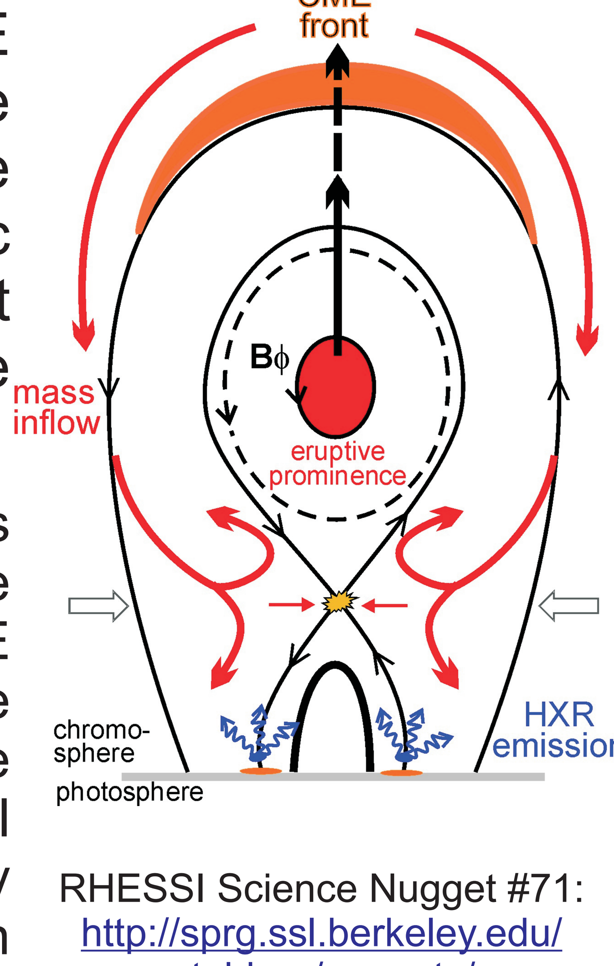


Figure 3b: CME dynamics for the 2007 December 31 C8.3 flare/CME event. It is clearly seen that the acceleration peak of the CME is delayed with respect to the RHESSI HXR flux by about 5 min. The time cadence of EUVI images for this event is better than 1.5 min. The peak acceleration of ~1 km/s² occurs at a plane-of-sky distance from the Sun center <1.5 Rs.

We find for 3 out of 4 events a close feedback relationship between the CME acceleration and the HXR energy release in the associated flare, which may be naturally established by magnetic reconnection occurring in a current sheet behind the CME as envisaged in the "standard" flare/CME picture.

On the one hand, magnetic reconnection adds poloidal flux (B_Φ) to the CME, sustaining the Lorentz force which drives the CME acceleration. On the other hand, the higher the acceleration of the CME, the larger the space that is evacuated per unit time in the coronal region behind. This has to be compensated by a stronger mass inflow into the reconnection region, which, in turn, causes stronger magnetic reconnection in the current sheet beneath, i.e., stronger flare energy release (see cartoon).



RHESSI Science Nugget #71: http://sprg.ssl.berkeley.edu/~tohban/nuggets/

Ref:
- Howard, Moses, Vourlidas et al. 2008, Space Science Reviews, **136**, 67
- Forbes 2000, JGR, **105**, 23153
- Lin et al., 2002, Solar Physics, **210**, 3
- Temmer et al. 2008, ApJ Letters, **673**, L95
- Zhang et al. 2001, ApJ, **559**, 452
- Zhang et al. 2004, ApJ, **604**, 420