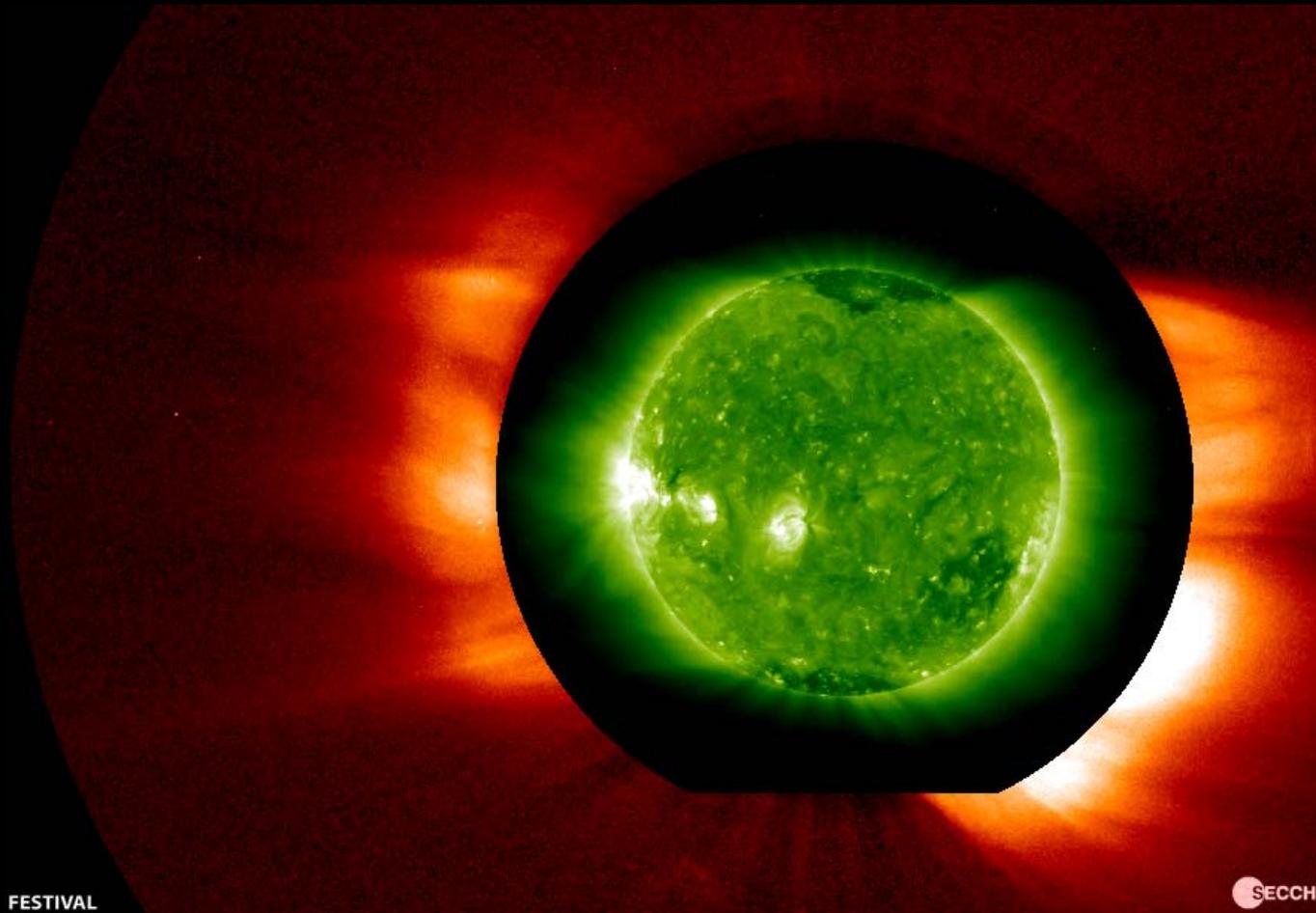


CMEs Associated With Impulsive Flares



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CME-Flare Relationship

Pre-SOHO results: The flare can precede or follow the associated CME (Harrison 1995), indicating that no causal relation may exist between the two phenomena.

SOHO results: The CME acceleration occurs during the impulsive phase of the associated flare (Jie Zhang et al. 2001), leading to a view that “CMEs and flares are two different manifestations of the same magnetic process in the corona.”

Are all CMEs and flares explained in this way? What about confined flares and CMEs with almost no increase in X-rays?

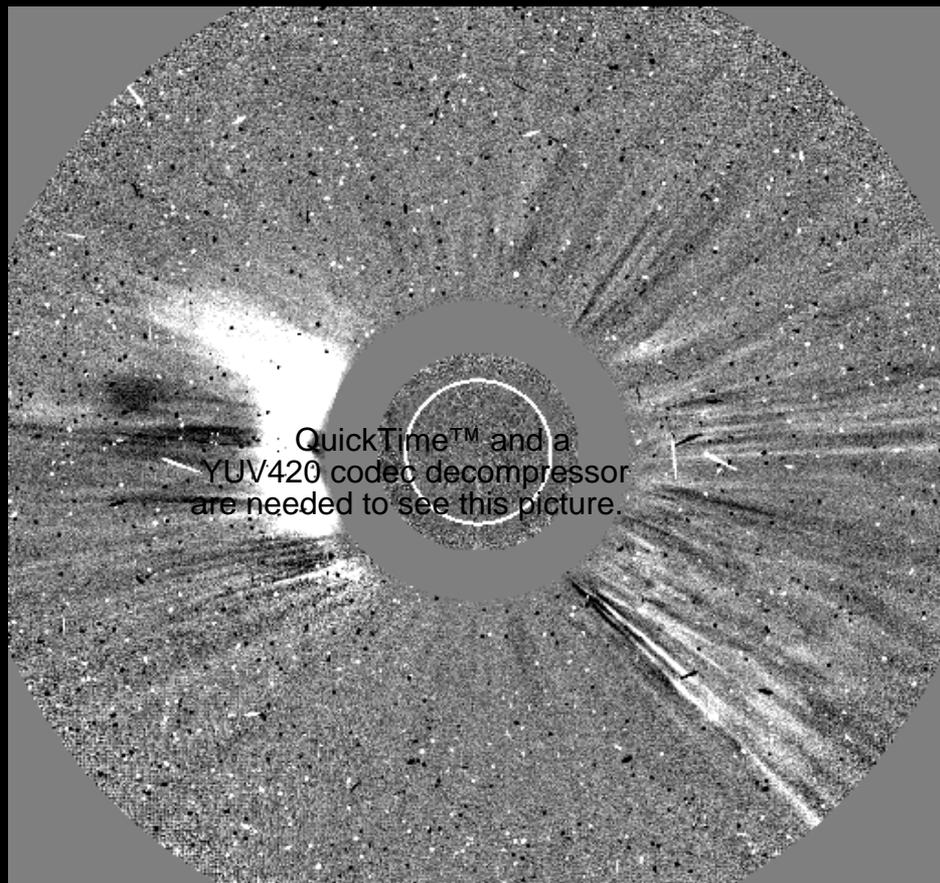
Solar Flares

Skylab observations (e.g., Pallavicini et al. 1977) led to the recognition that some flares are eruptive whereas others are confined.

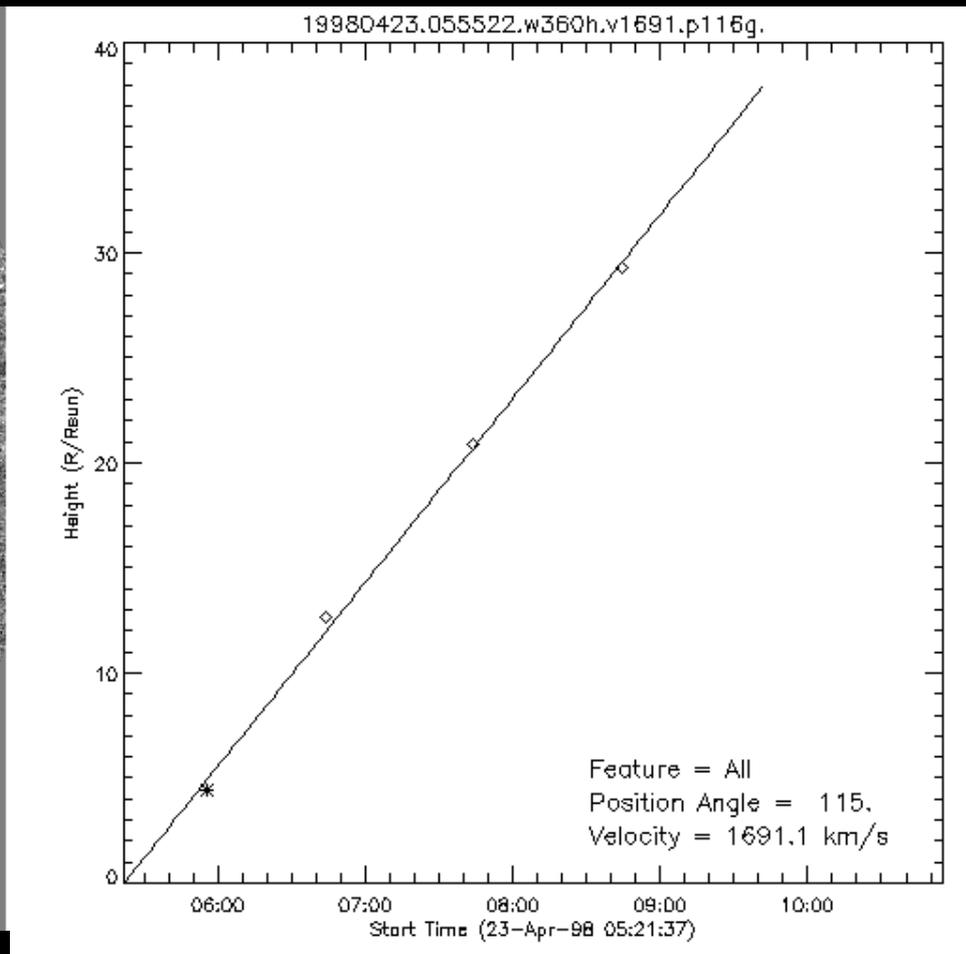
Long decay events (LDEs) are usually eruptive and many impulsive or short-duration are non-eruptive.

The CME initiation is relatively well understood for LDEs and two-ribbon flares, often associated with a filament eruption, but it may be challenging for impulsive flares (e.g., Cliver 1995).

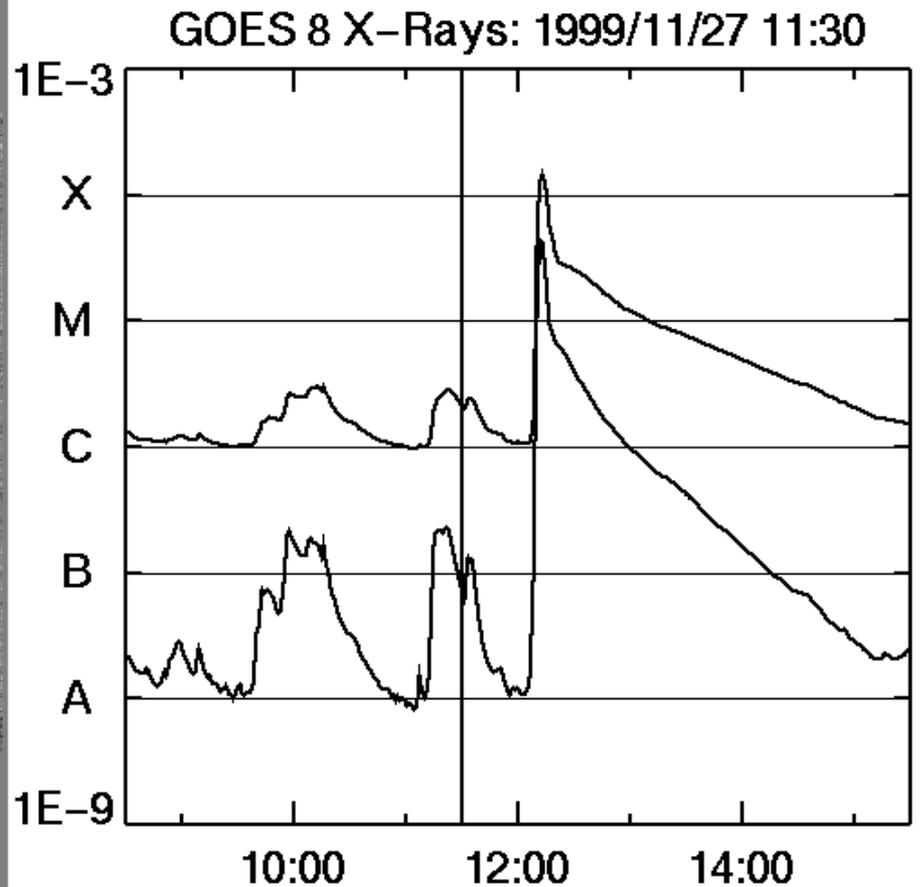
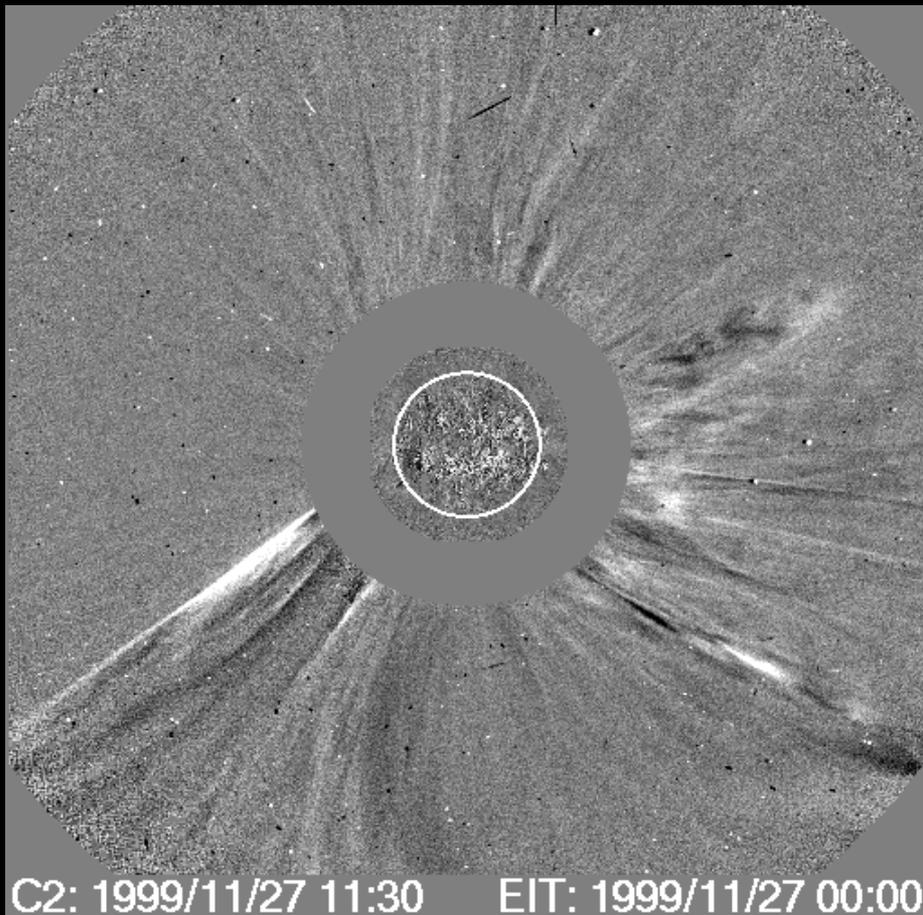
Flare-Associated Motions and CMEs (low coronal acceleration --> big CME)



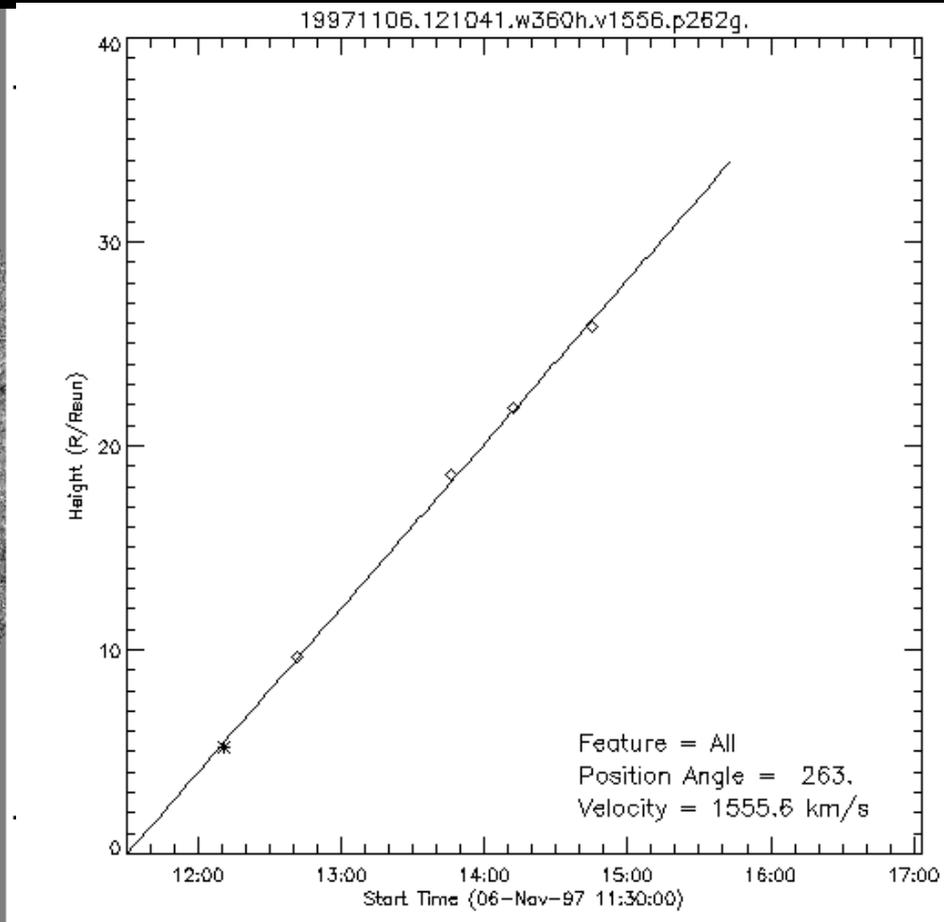
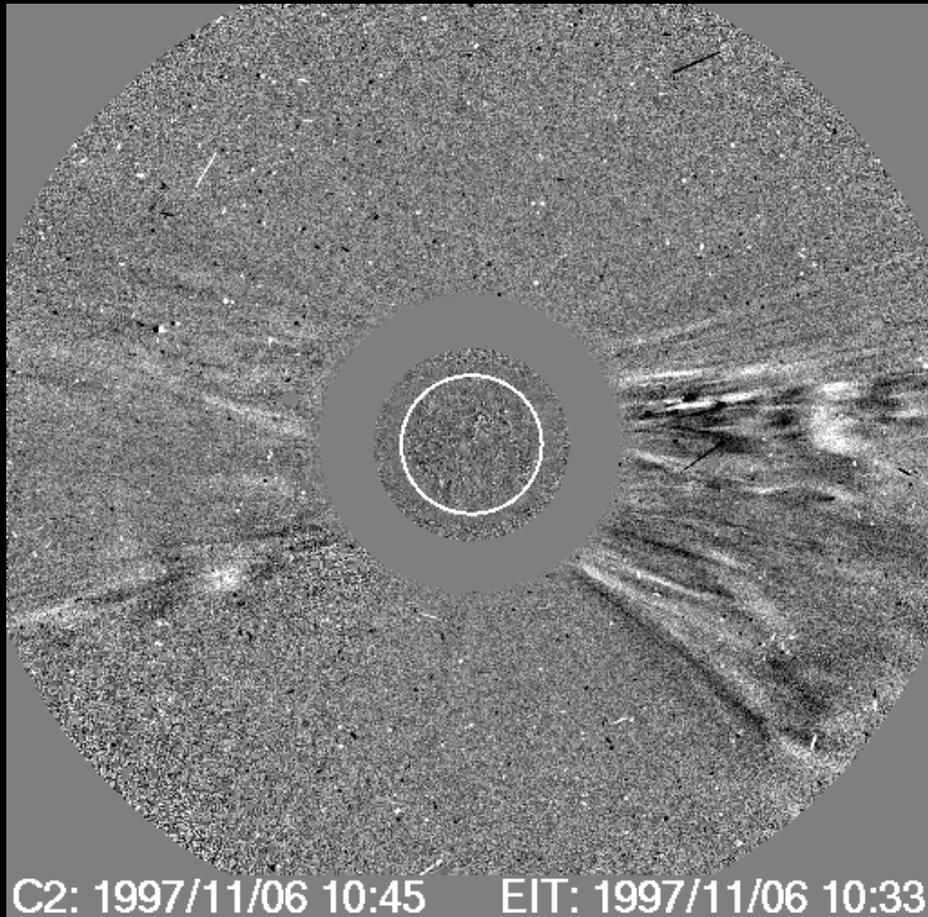
C2: 1998/04/23 05:27 EIT: 1998/04/23 05:20



Flare-Associated Motions and CMEs (confined ejection --> dubious CME)



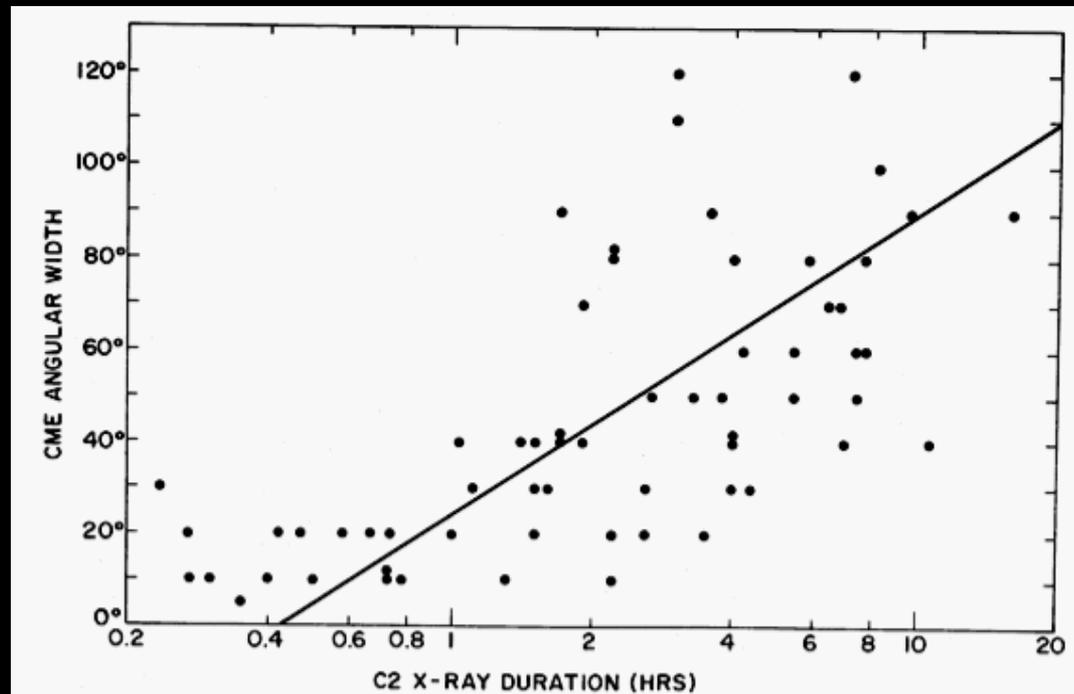
Flare-Associated Motions and CMEs (diffuse motion (wave?) --> big CME)



Impulsive Solar Flares vs CMEs

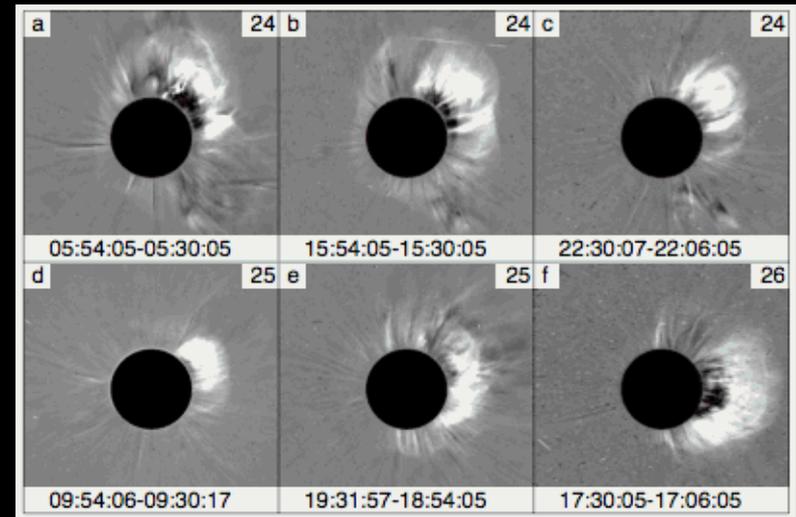
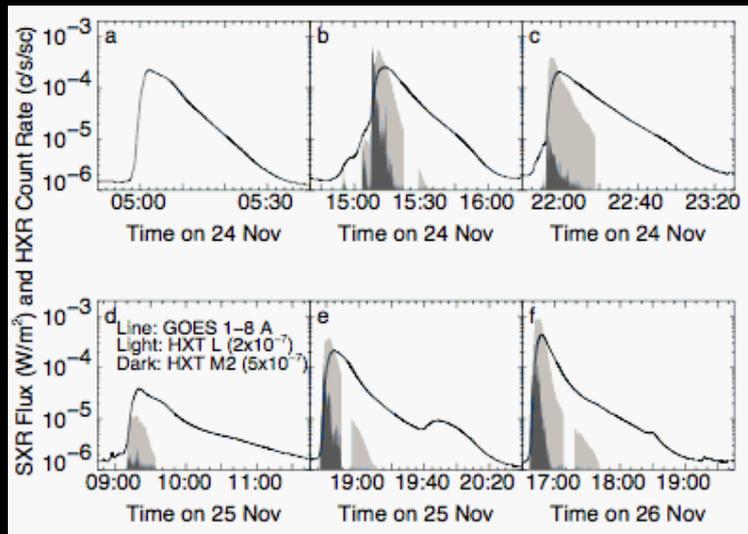
According to Kahler, Sheeley & Liggett (1989),

- Only ~20% of impulsive flares above M1 are associated with a CME.
- Impulsive flares with a CME are more energetic than those without.
- CMEs associated with an impulsive flare are narrower than those associated with a LDE.



Big CMEs and (Big) Impulsive Flares

Nitta & Hudson 2001



Flares in 2007-2008

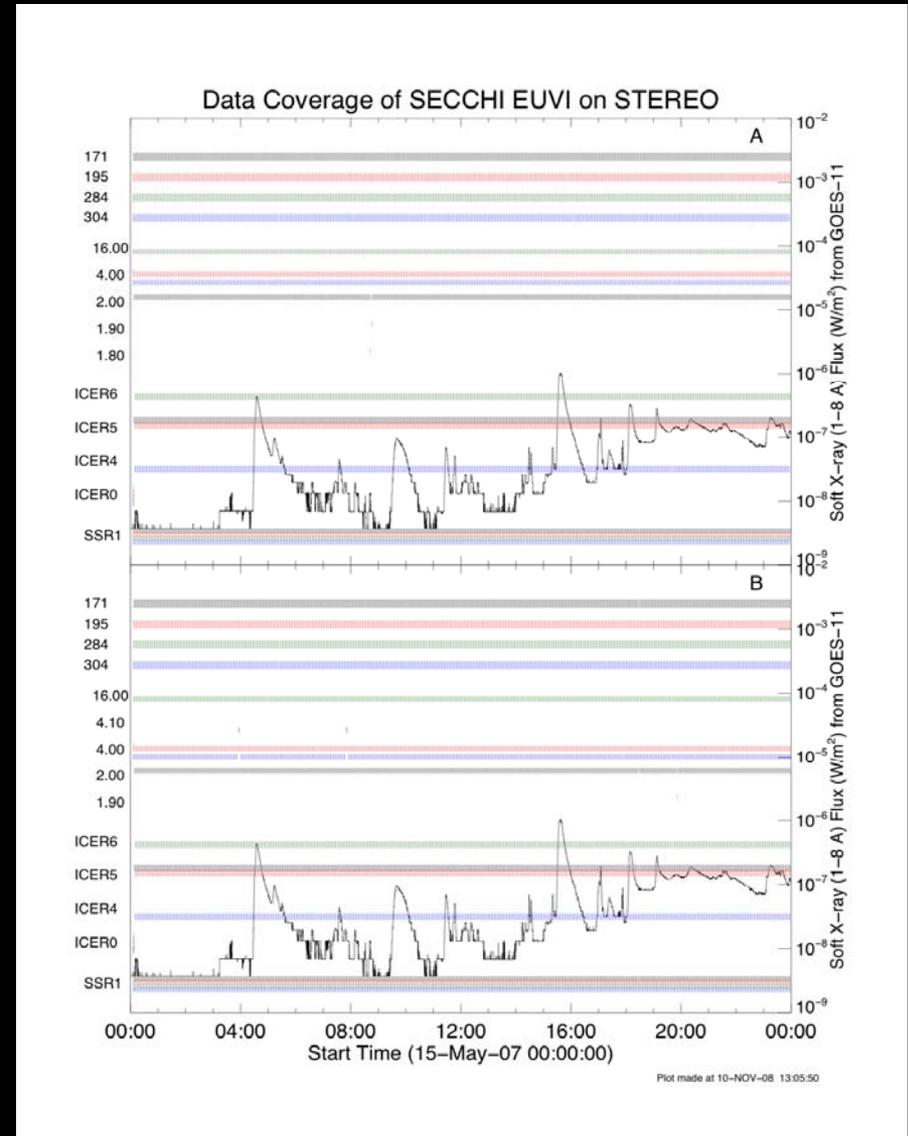
- No X-class flares
- 11 M-class flares - 10 of them were from AR 0960 in early June 2007
- 80 C-class flares
- > 650 B-class flares

Figure 1.10
Figure 1.11

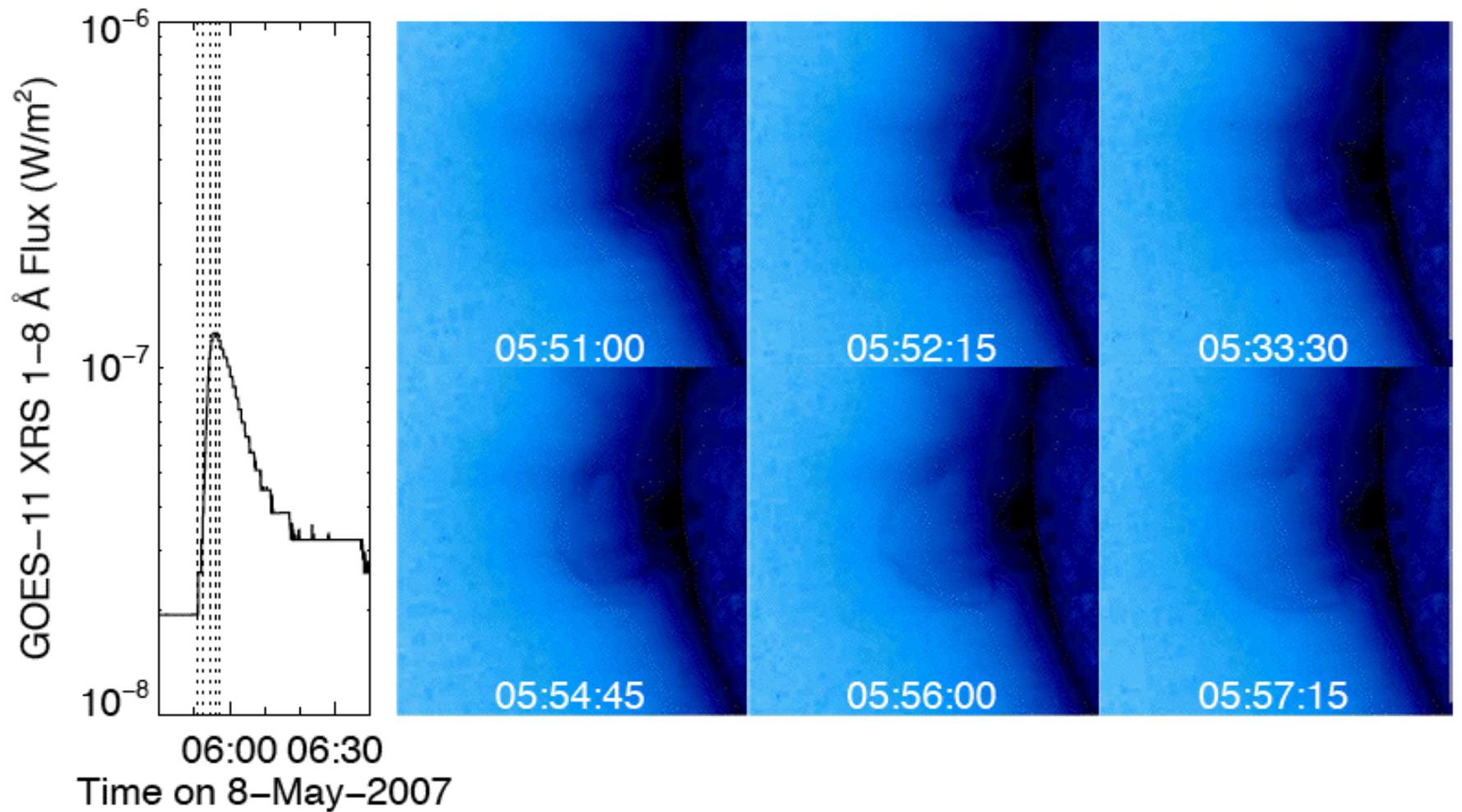
How many are Long Decay Events (LDEs)?
Various ways of defining flare end time.

Very Impulsive Flares

- Limit to impulsive flares with rise time < 10 min, duration < 40 min, using $t_{\text{end}}(1/2)$.
- Good data coverage.
- Not on a slow background.
- Separate from preceding or following flares by > 2 hours to make CME association less ambiguous.
- A total of 41 flares (A: 9, B: 23, C: 6, and M: 3)



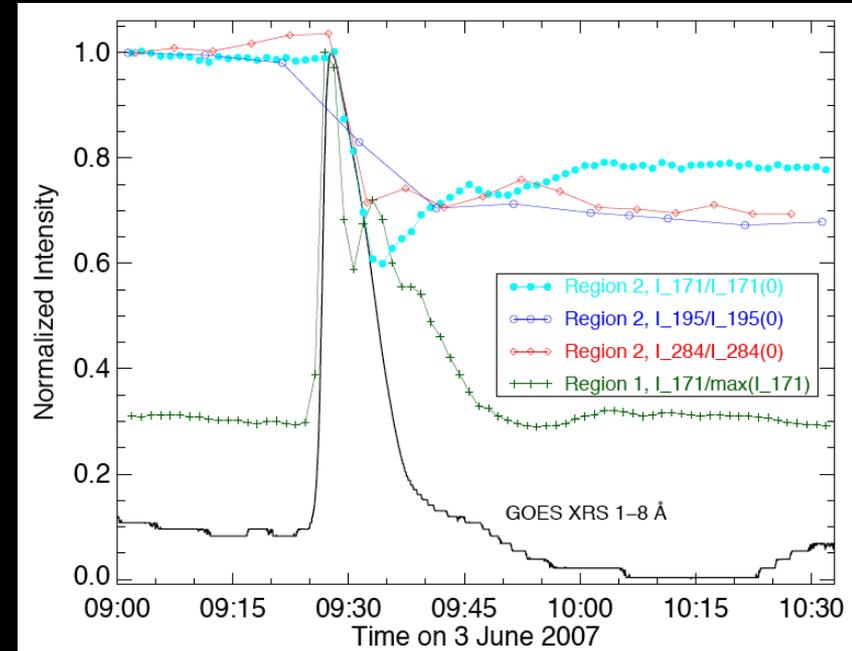
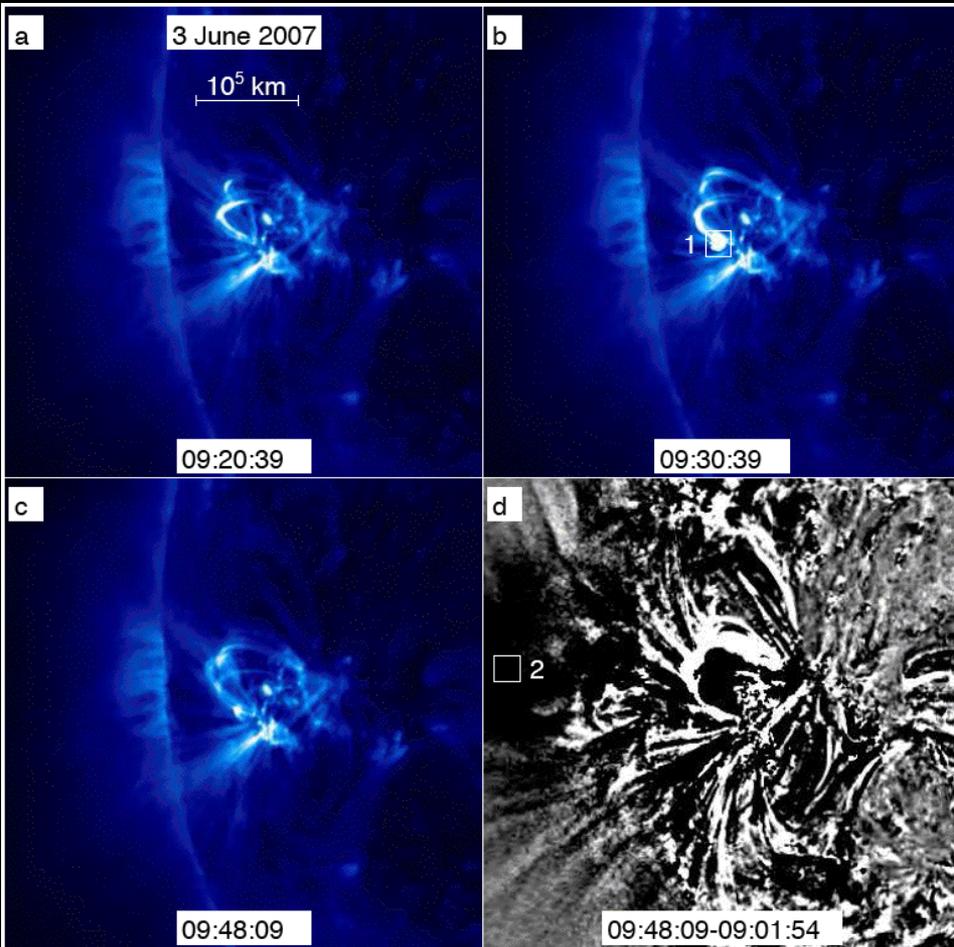
Eruptions



Dimming/Wave

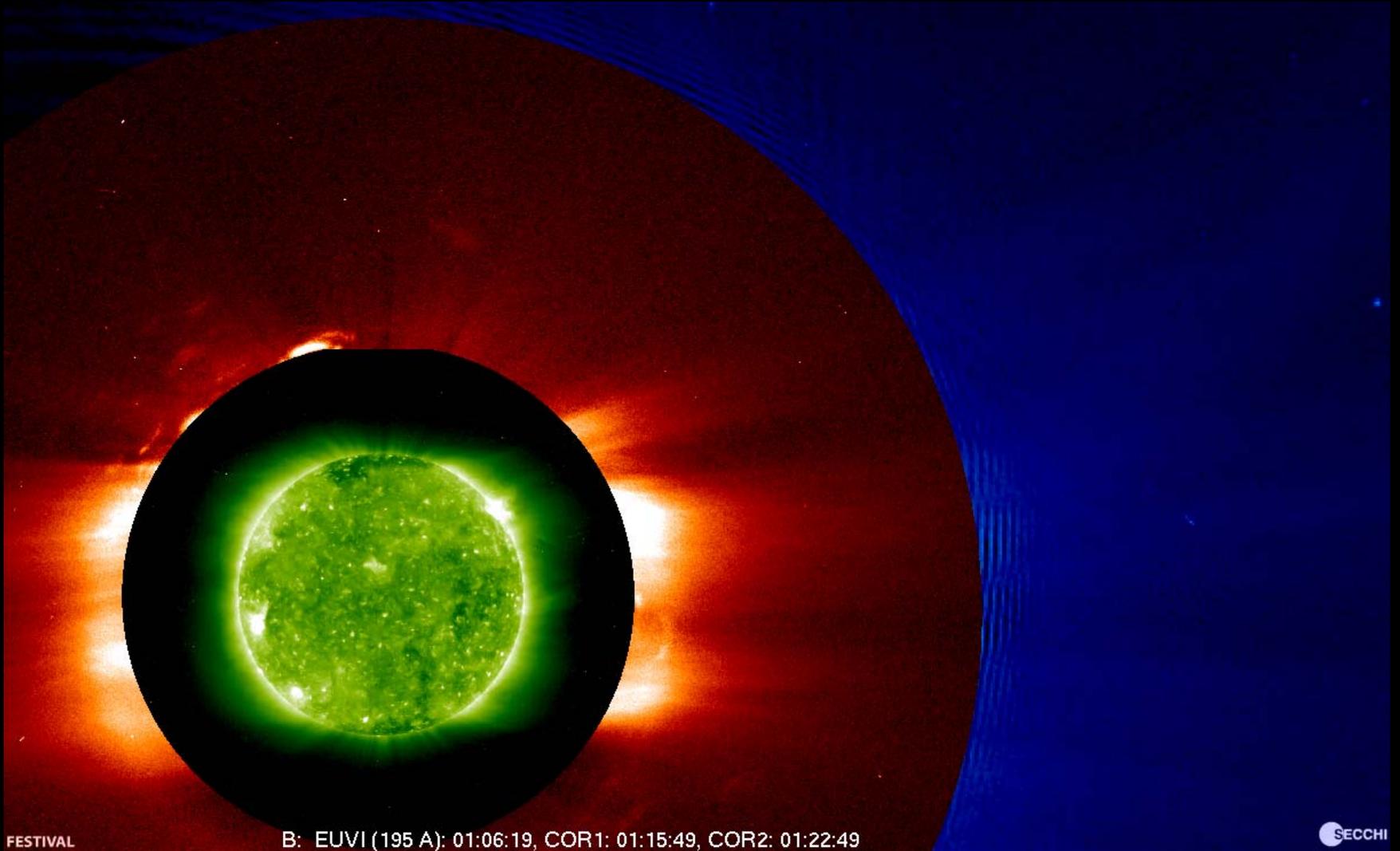
Difference movies

Dimming in Different Wavelengths



dimming starts at flare onset (cf. Zarro et al. 1999)

3-Nov-2008 Flare (C1.0)

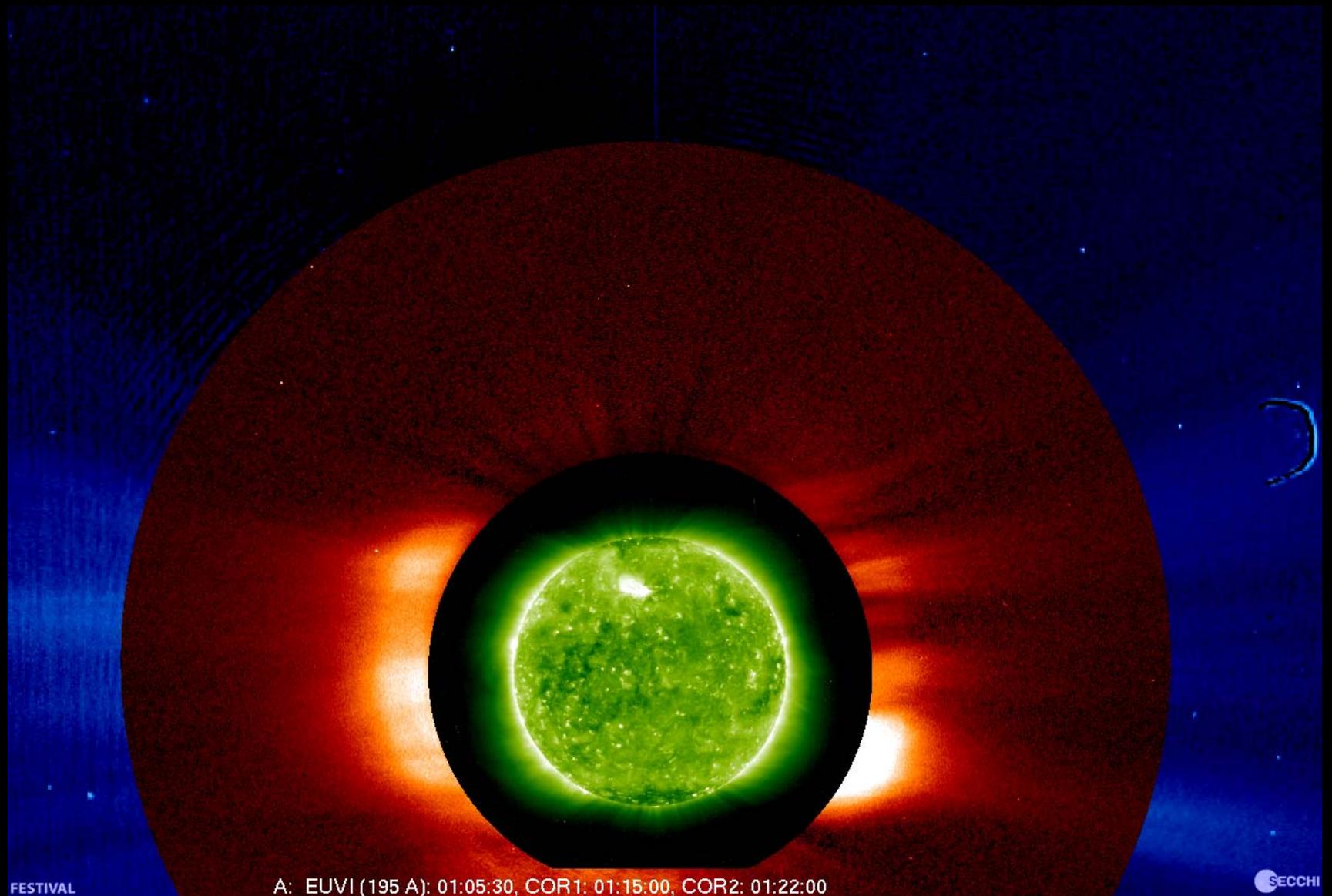


FESTIVAL

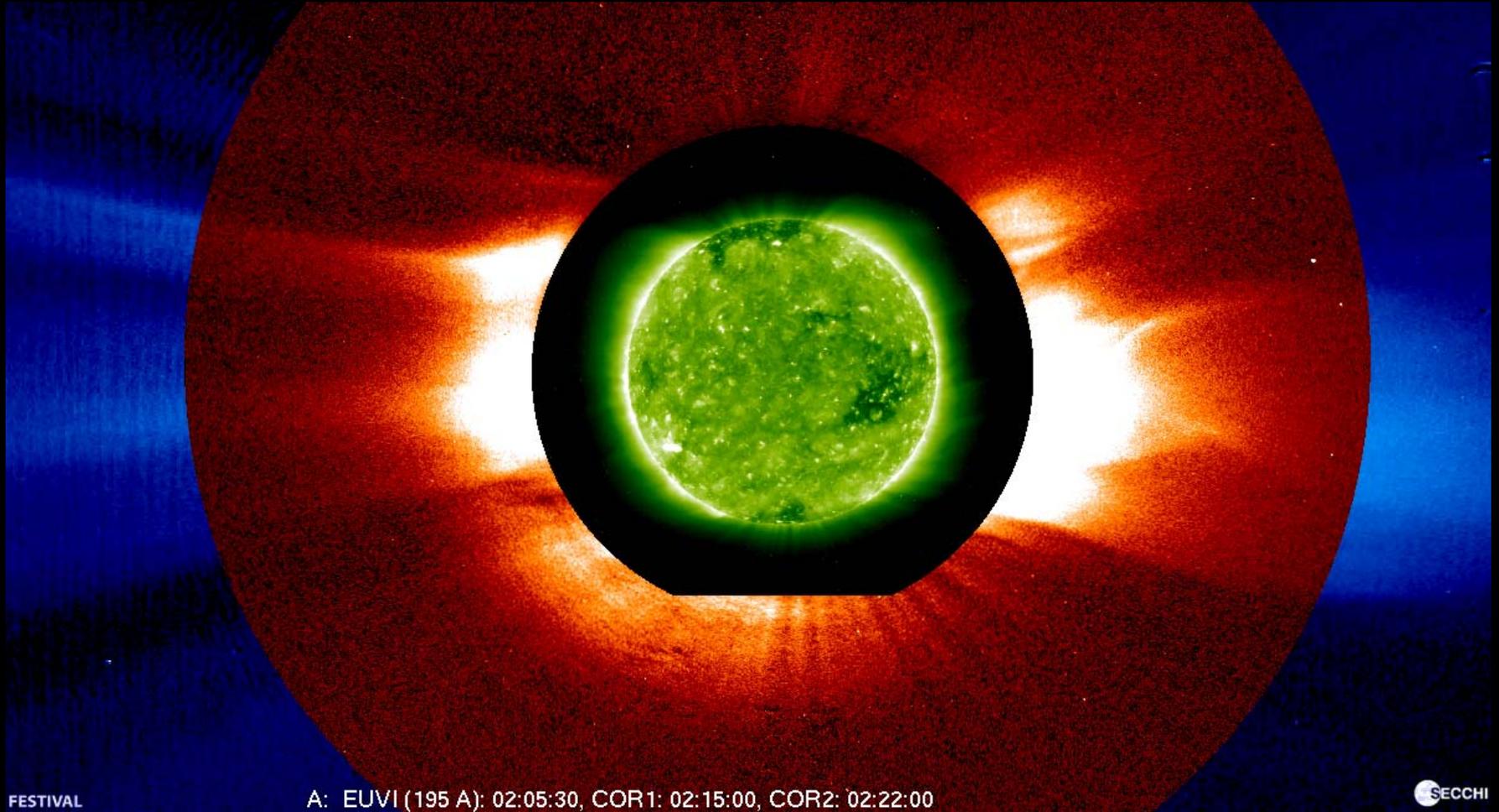
B: EUVI (195 A): 01:06:19, COR1: 01:15:49, COR2: 01:22:49

SECCHI

3-Nov-2008 Flare (C1.0)



3-Nov-2008 Flare (C1.0)



Properties of the 41 impulsive flares

Flare Class	Total	Eruptive Motions	Dimming	Waves	Outflow in COR1	Outflow in COR2 or LASCO
M	3	1	1	0	1	1
C	6	5	6	1	6	5
B	23	14	18	3	12	10
A	9	6	6	3	5	2
A-M	41	26	31	7	24	18

Summary

- The signatures often associated with CMEs (e.g. Hudson & Cliver 2001) are quite frequently observed in very short-duration impulsive flares.
- However, their association with real CMEs observed far out of the Sun (e.g., $> 5 R_s$) is low, perhaps these signatures not being reliable.
- Once we lift the restriction of the impulsive flares and include longer duration flares (but not quite LDEs), energetic CMEs are more often associated.

Science Questions

- What are the factors that make confined impulsive flares associated with CMEs? External field configurations more important than flare mechanisms?
- Are some of the narrow CMEs associated with impulsive flares just flows along pre-existing open field lines similar to jets?
- Can the same mechanism explain both full-blown CMEs associated with LDEs and narrow CMEs associated with impulsive flares?
- Does the flare process contribute to CME acceleration?
- What determines the distribution of energy going to eruption and flaring?
- What is the origin of some of coronal waves and metric type II burst?

Quest For CME Signatures From Minor Flares

- Does the flare duration mean much when the peak flux is below GOES C?
- Flare duration may sometimes be difficult to define.
- Since January 2007, there have been only 11 M-class flares, 10 of which occurred in June 2007.

- Here we search for coronal dimming and coronal waves using SECCHI EUVI data.
- Both running and base difference images are used.