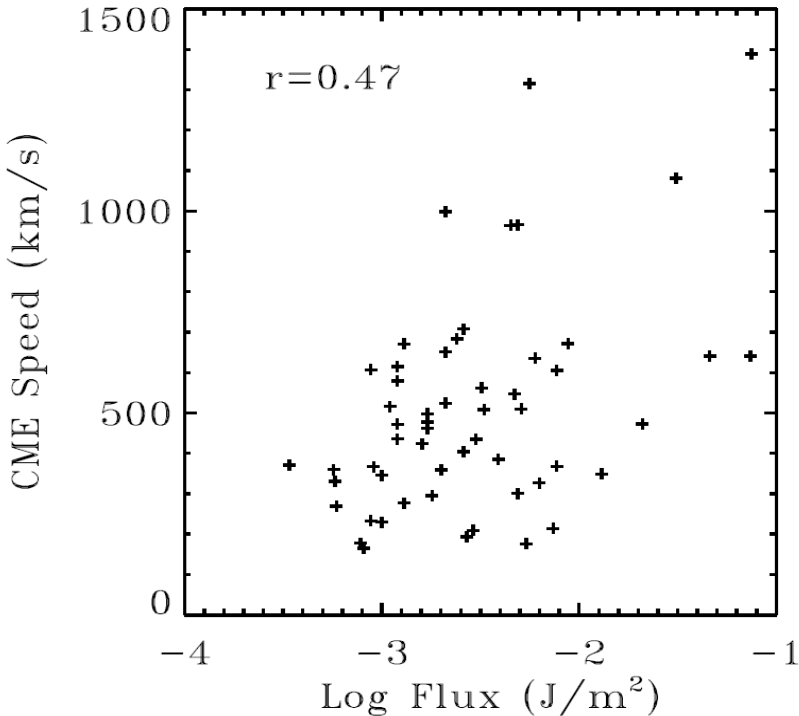# Two distinct types of CME-flare relationships based on SOHO and STEREO observations

Soojeong Jang, Yong-Jae Moon, Rok-Soon Kim, Sujin Kim, Jae-Ok Lee
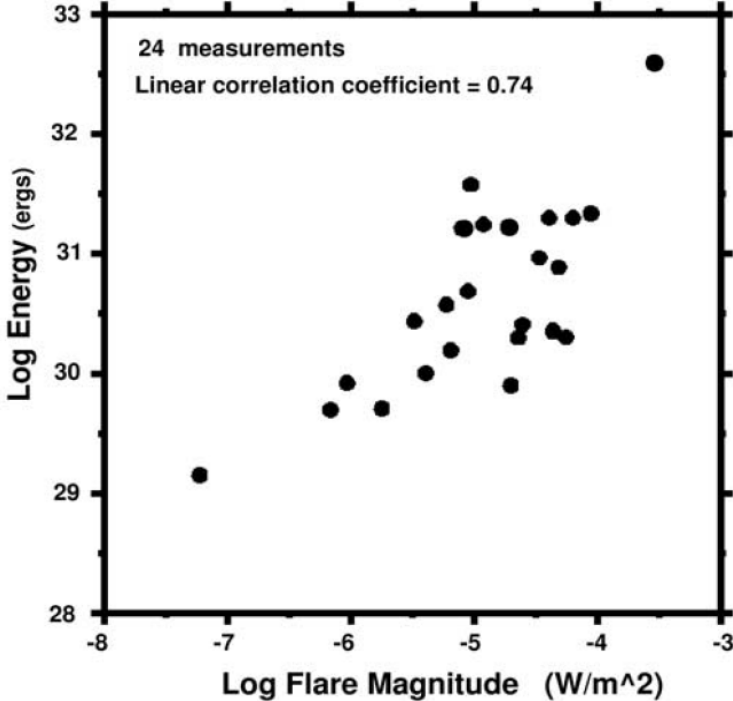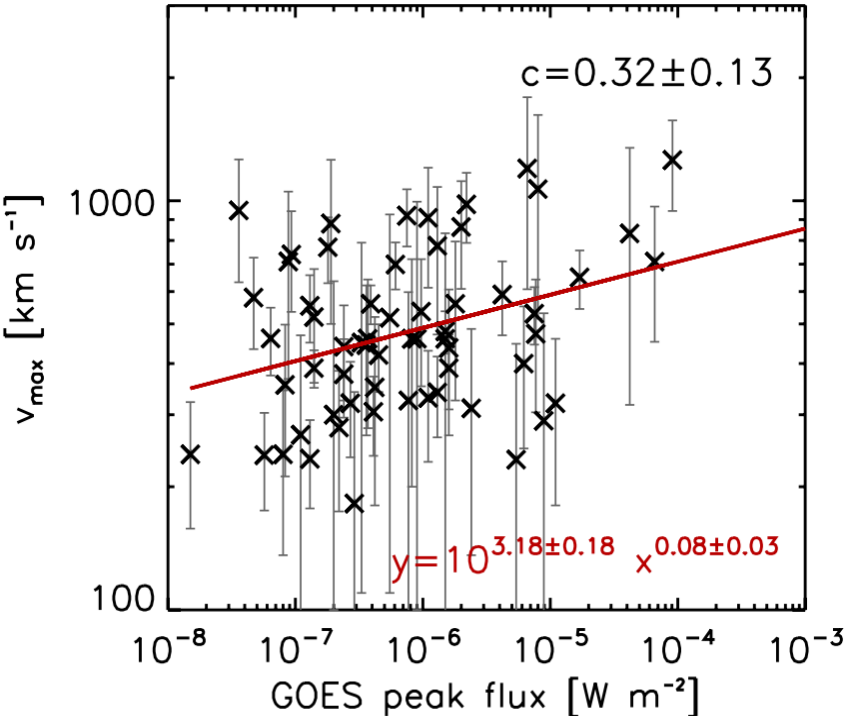
Kyung Hee University, KASI

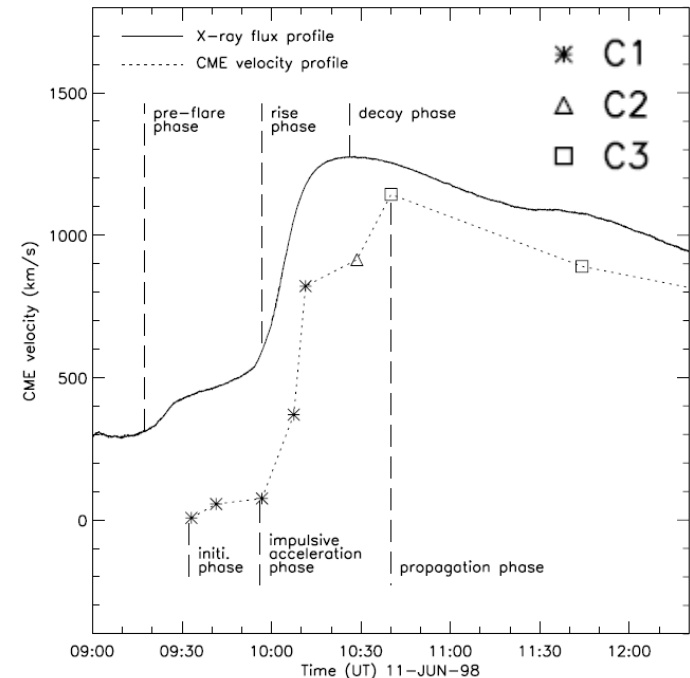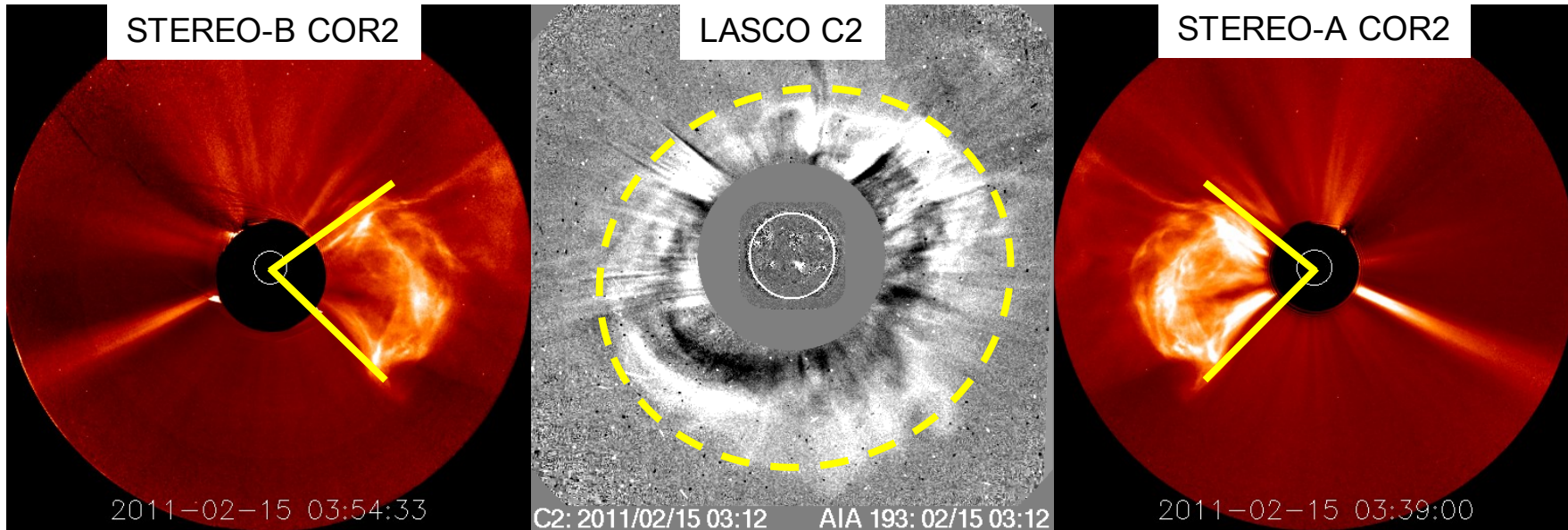# Previous study

Moon et al. (2002)

Burkepile et al. (2004)

Bein et al. (2012)

New attempts

1. We use the 3D CME parameters to reduce the projection effects of CME properties.

2. We use the data from STEREO COR1, which covers from 1.4 to 4 Rs, to investigate the propagation of CMEs in low corona.


Zhang et al. 2001

Data

- We choose 107 flare-associated CMEs among the 306 front-side halo events in the previous study (Jang et al. 2016) with the following criteria:

  (1) We pick flares which start within 2 hours of the CME first observing times in LASCO C2.

  (2) We try to find the change of the loop or filament eruption in AIA 193 and 304 Å near the flaring region in the same sector of CME occurrence during 2 hours time window. For the same event, we re-confirm the association using additional data set such as EUVI, COR1 and COR2 of STEREO A or B.

  (3) If there are several flares during the time window, we carefully inspect the evolution of SDO and coronagraph images and determine the corresponding flare, which all correspond to the largest flares.

  (4) Only flares observed within $\pm 70°$ longitude of solar central meridian as seen by SDO are included.

Data

- CME parameters
  - ✓ CME V_{2D} : SOHO LASCO CME catalog
  - ✓ CME V_{3D} : Stereoscopic CME analysis tool (StereoCAT) provided by NASA CCMC

- Flare parameters (fluence and duration) : NGDC flare list
  - ✓ 14 X-class flares, 44 M-class flares, 44 C-class flares, and 5 B-class flares.
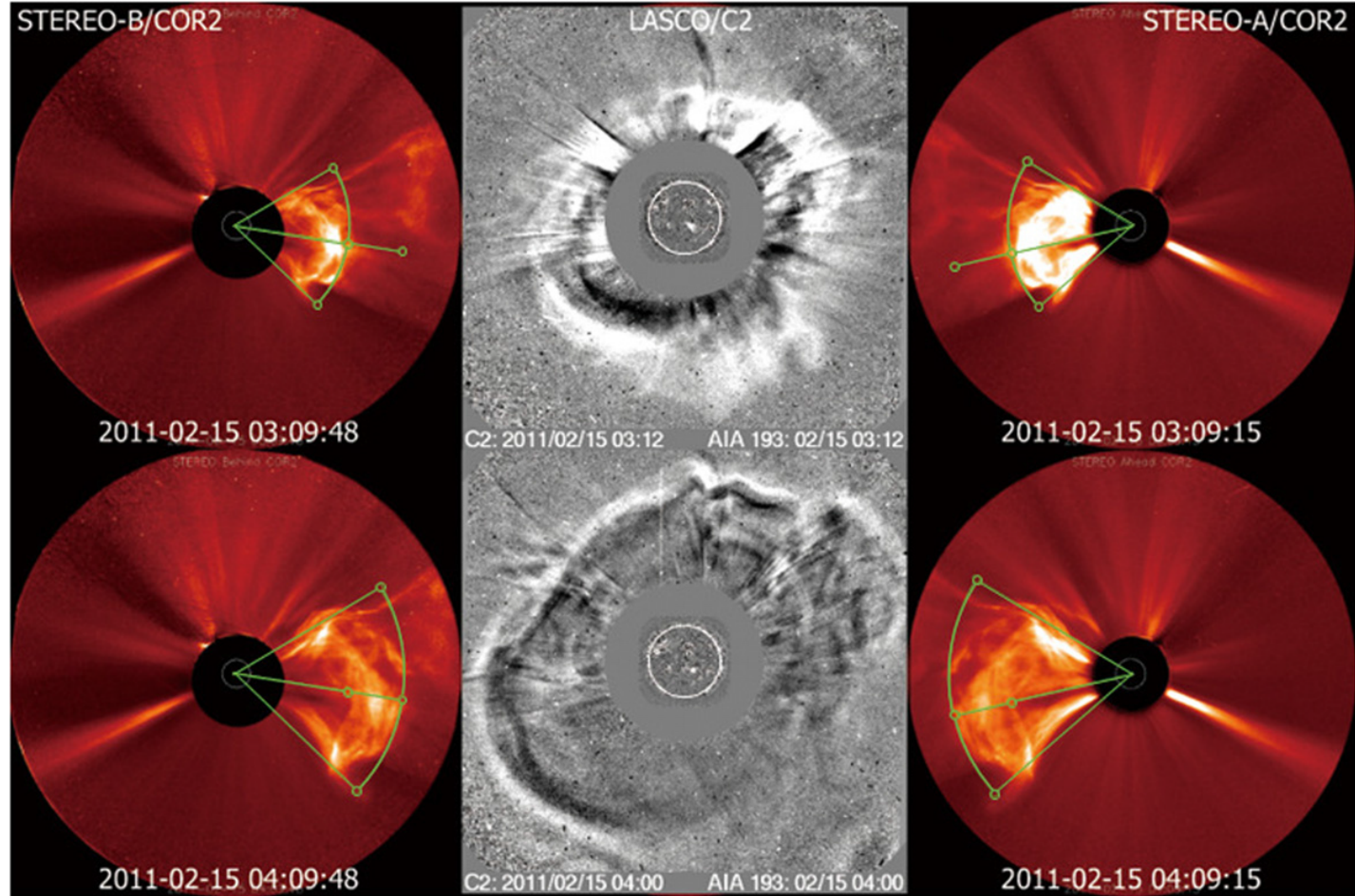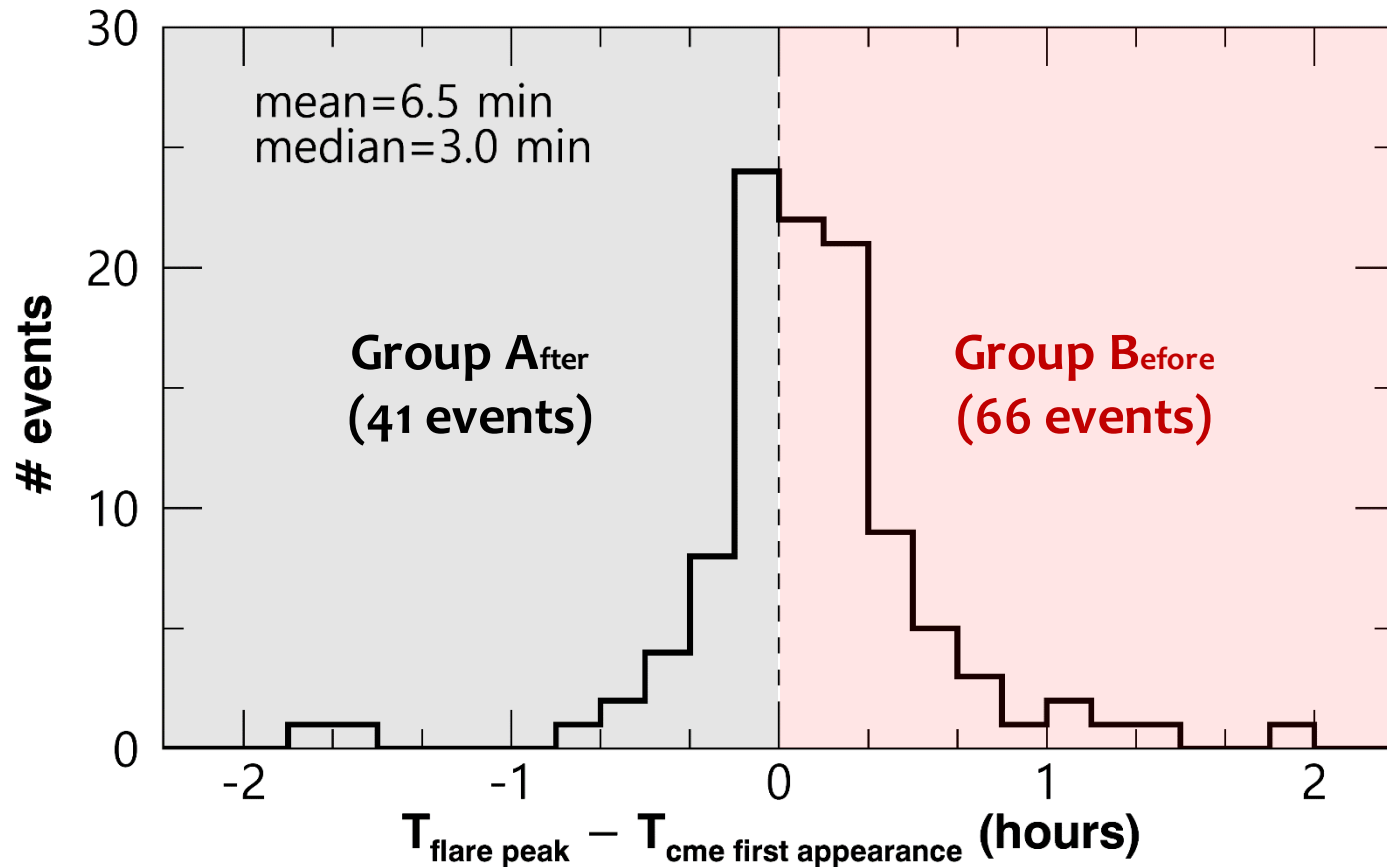
The separation angle between CME and flare

- The separation angle is defined as a difference between the measurement position angle of CME (MPA_{CME}) and the position angle of flare location (PA_{flare}).
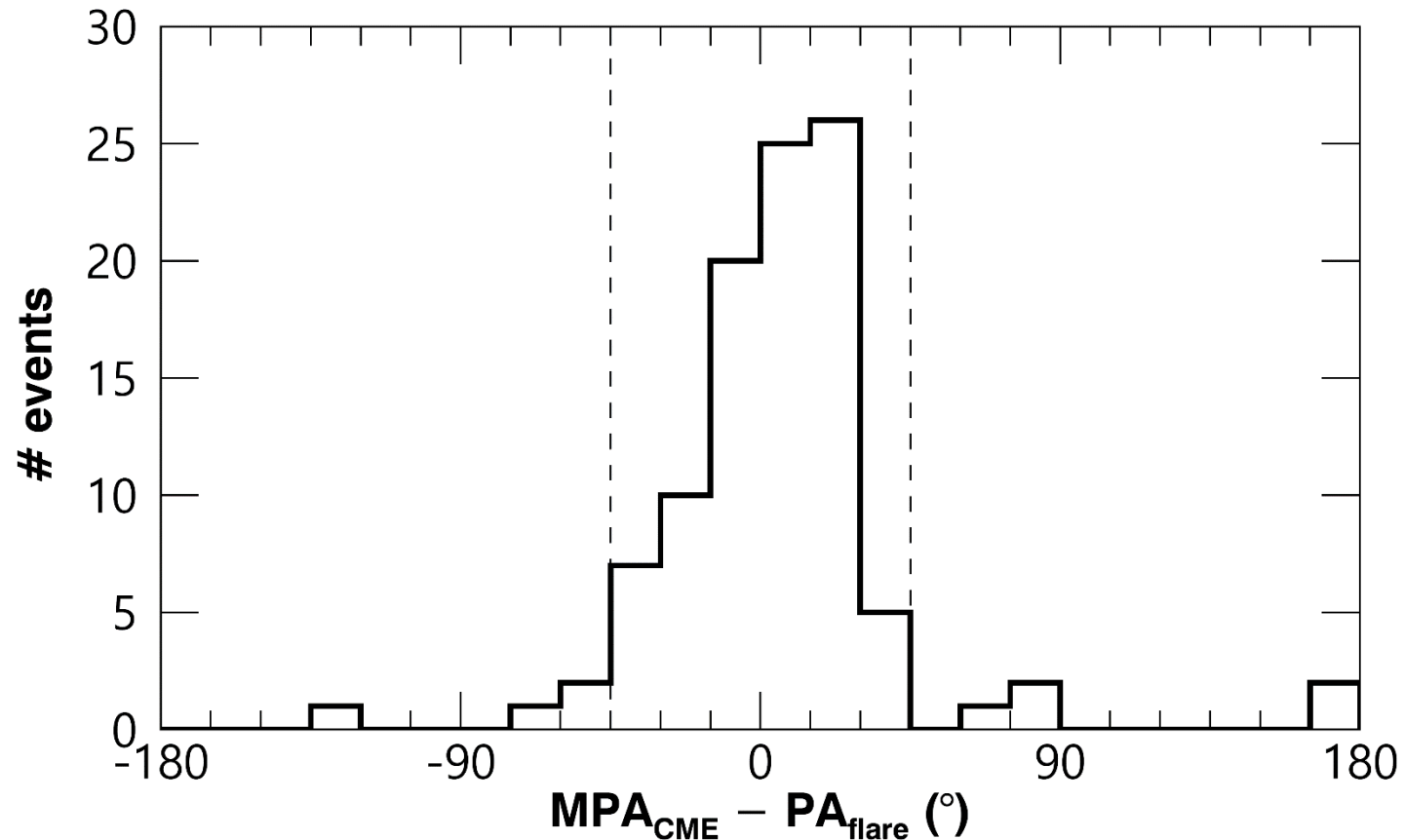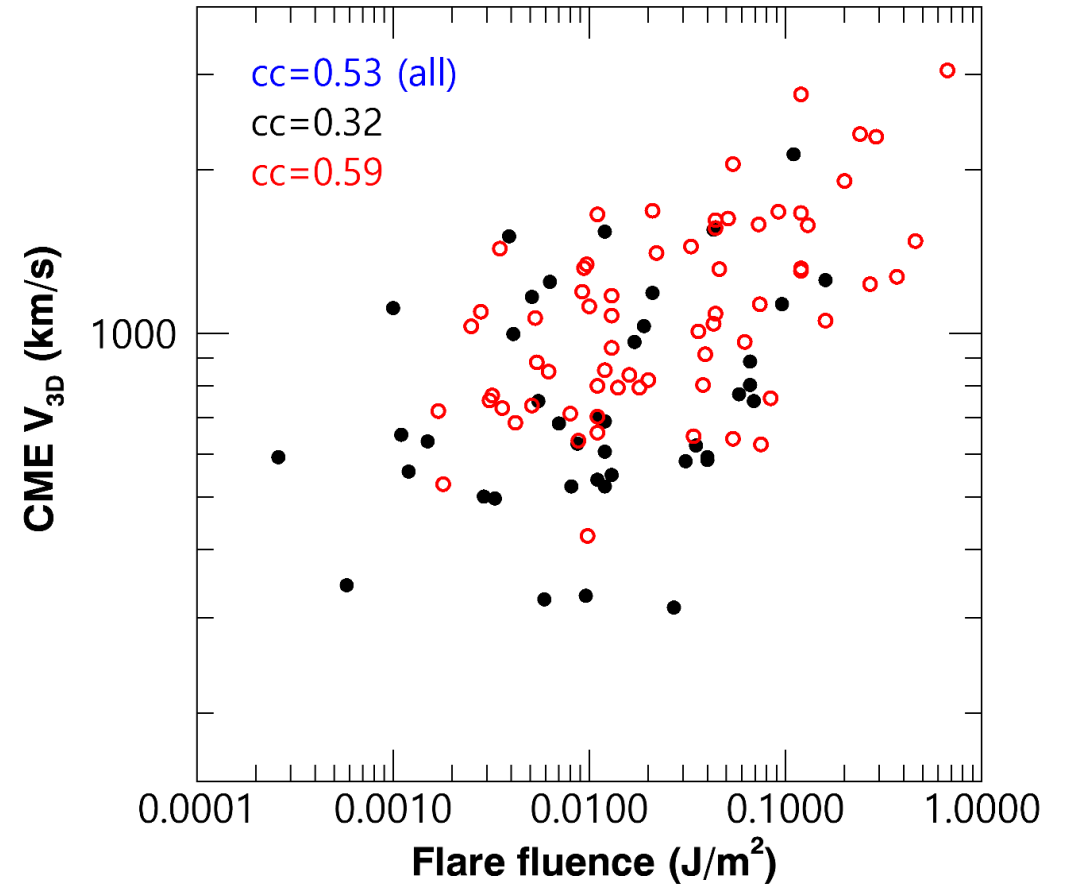
Observing time difference ΔT

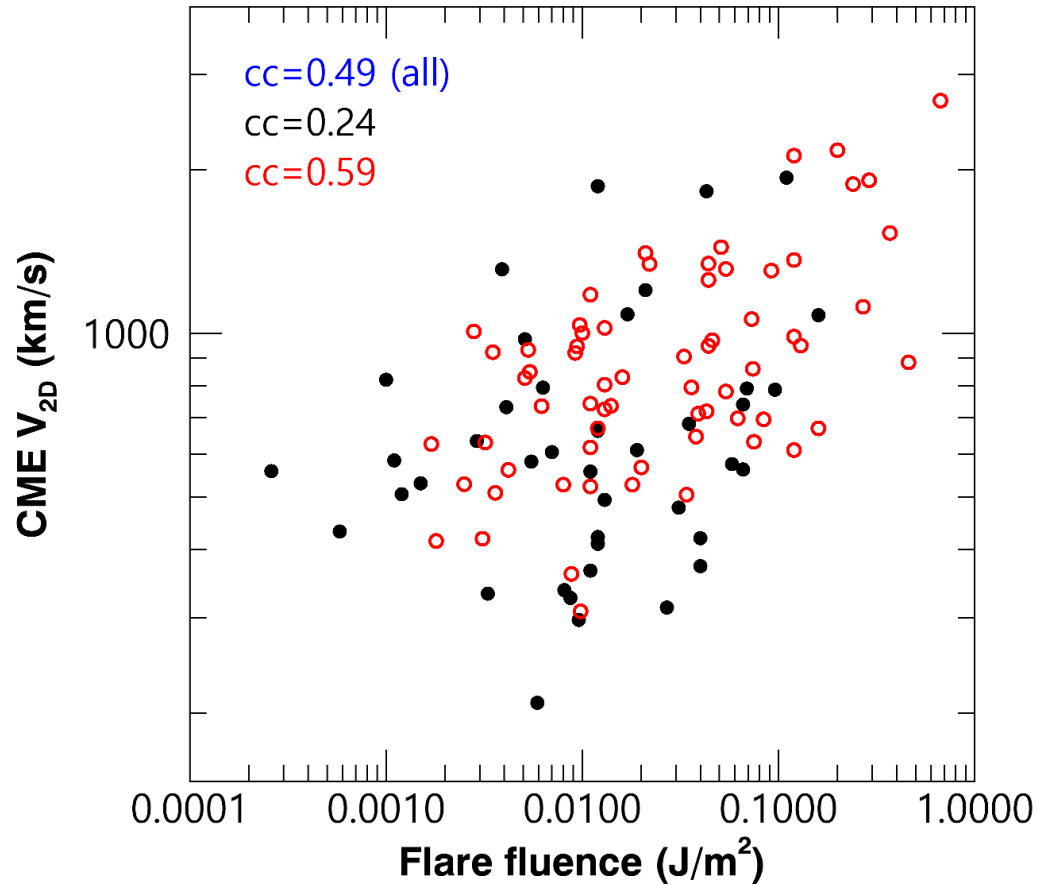- Observing time difference ΔT =
  T(flare peak) – T(CME first appearance at STEREO COR1 field-of-view; 1.4-4Rs)

✓**Group A** (ΔT<0; **41** events) means that CME first appears **after** the flare peak time.

✓**Group B** (ΔT≥0; **66** events) means that CME first appears **before** the flare peak time.

CME speed vs Flare fluence

The linear relationship between the 3D (and 2D) speed and the flare fluence for group B is much clearer than that for group A.

CME kinetic energy vs Flare fluence
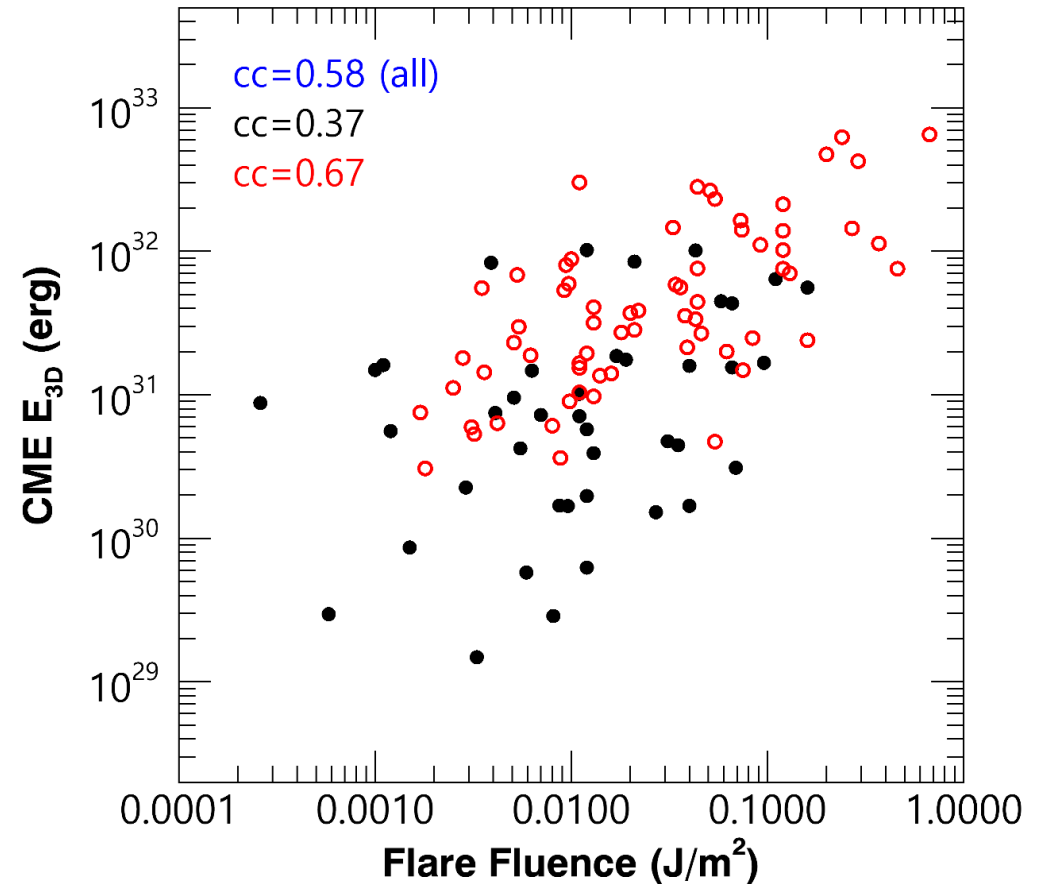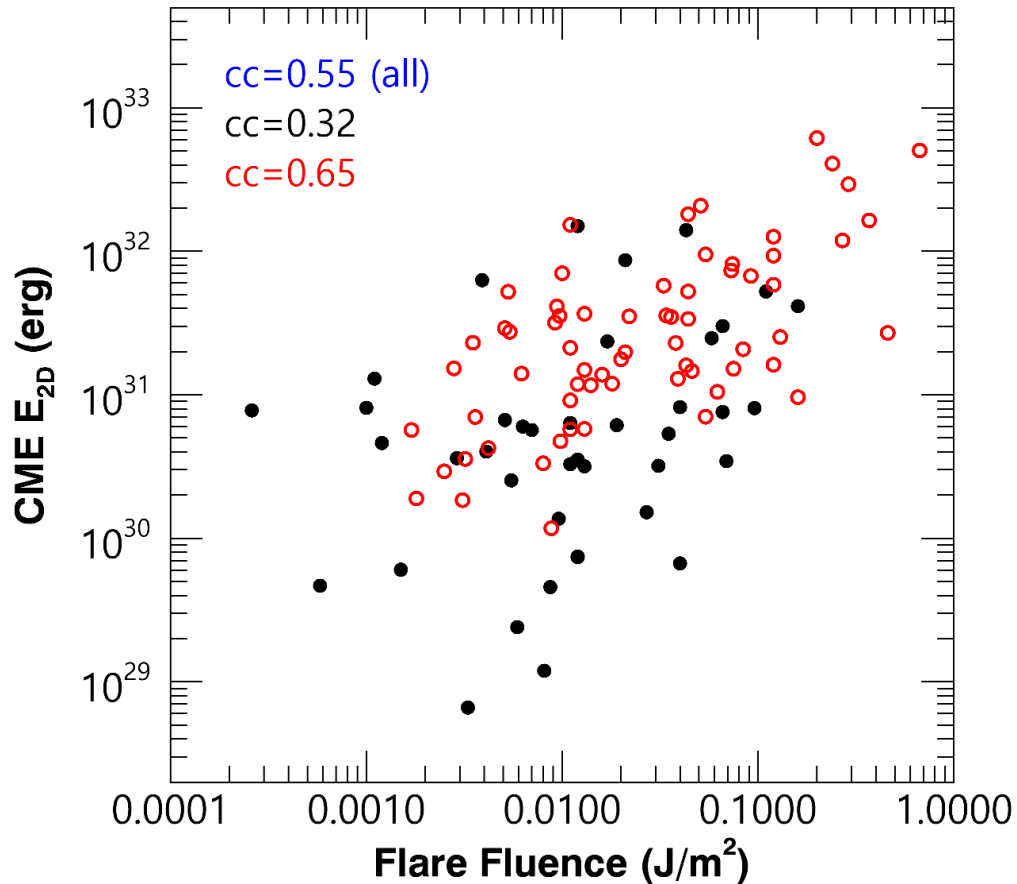
The correlation coefficient between 3D kinetic energy and flare fluence for group B is 0.67, which is much higher than that (0.39) for group A.

CME kinetic energy vs Flare duration
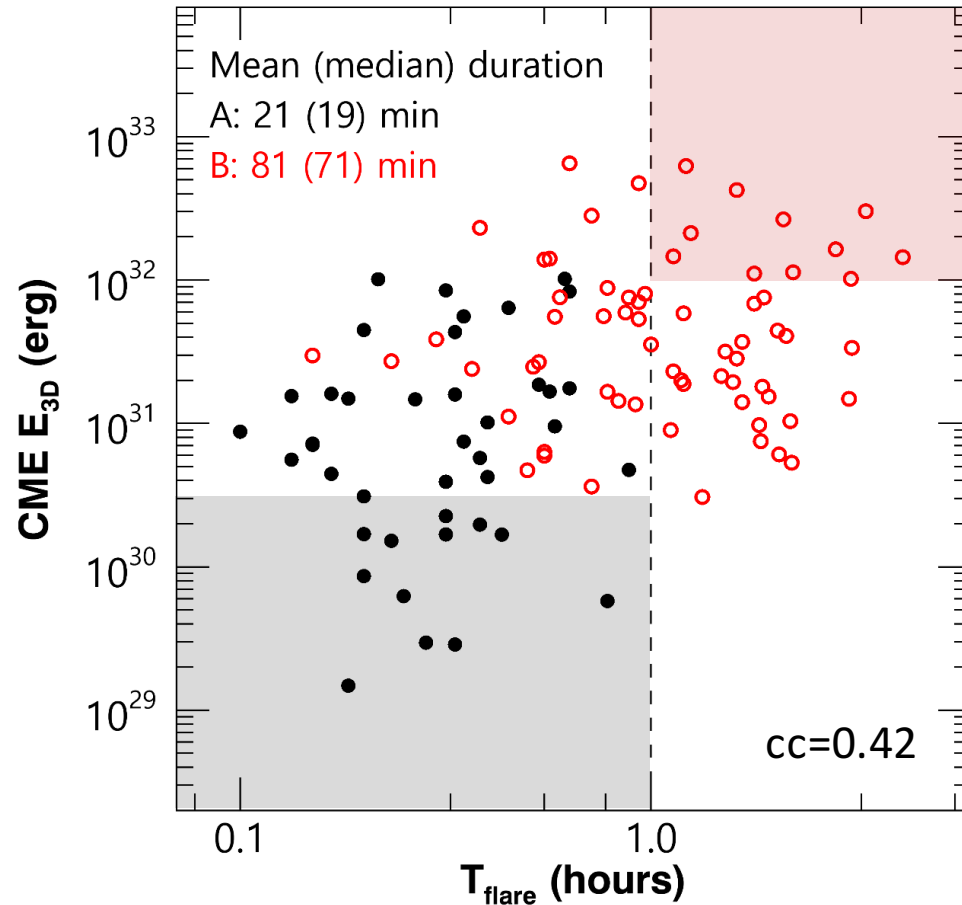
There are events for only group B with high 3D kinetic energy bigger than approximately 1×10^{32} erg and long duration flare longer than 1 hour.

H$_{vpeak}$ vs durations (using 31 STEREO limb CMEs)
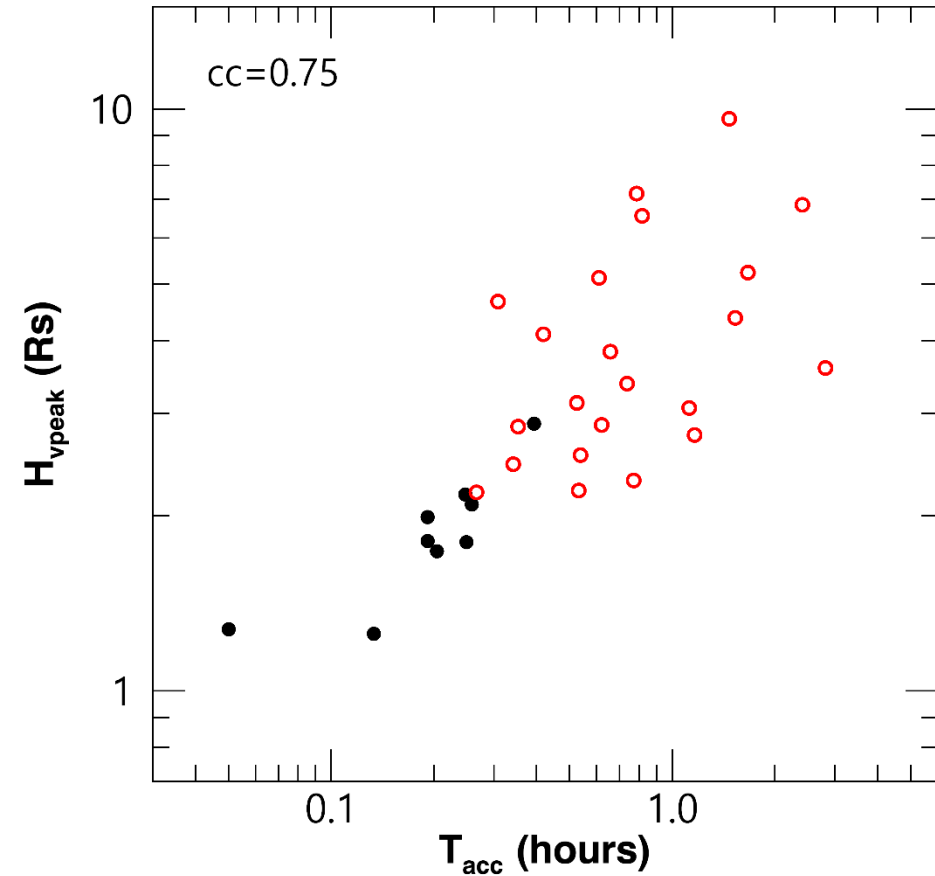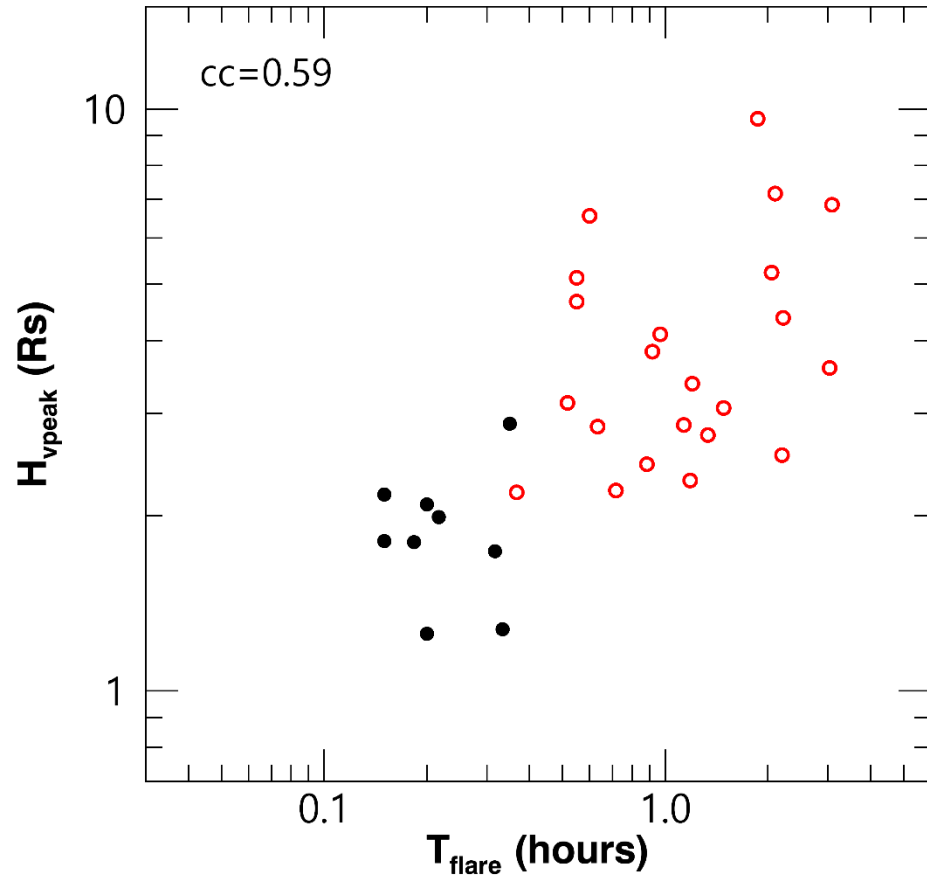
There is a general trend that H$_{vpeak}$ increases with T$_{flare}$ and T$_{acc}$ with correlation coefficients of 0.59 and 0.75.

Two representative events
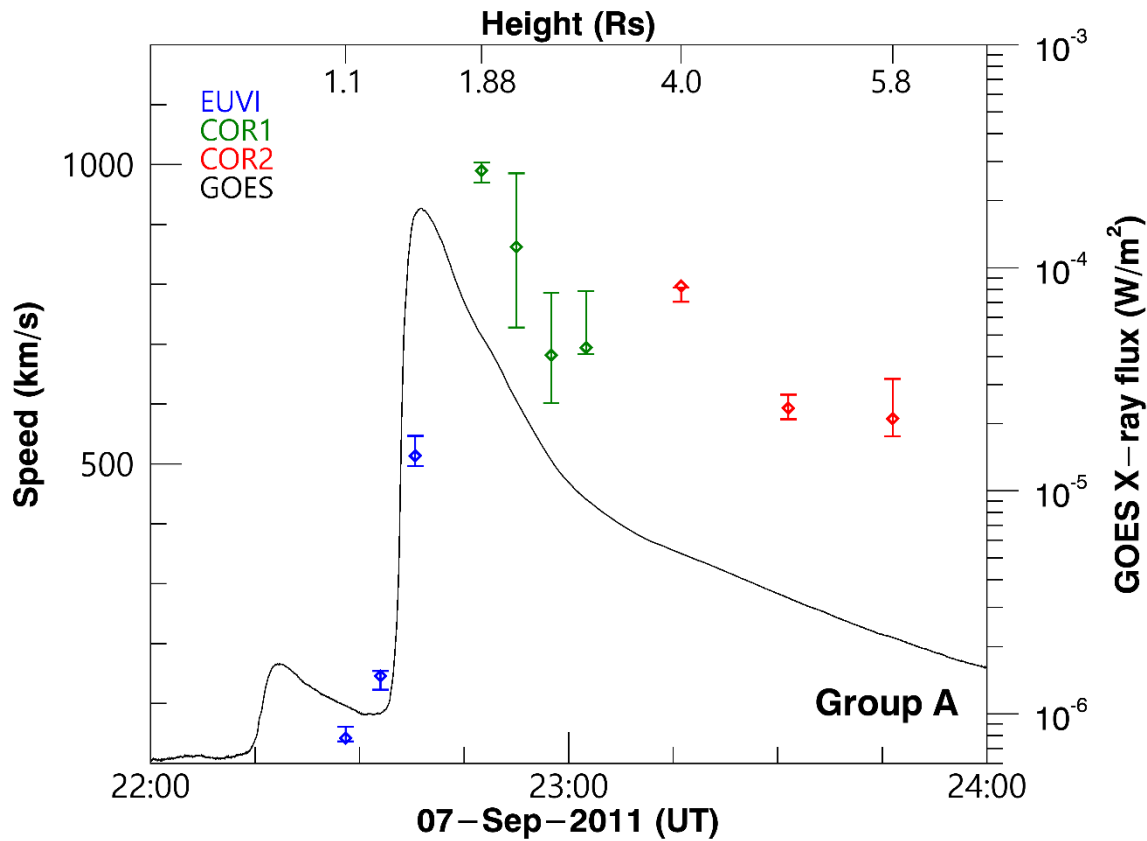
The temporal evolutions of CME speed and GOES X-ray flux profiles for group B are consistent with each other for a longer time than that for group A.

Summary and Conclusion

- We have found that there are much higher correlation coefficients between CME parameters (speed and kinetic energy) and flare fluence for group B than those of group A.
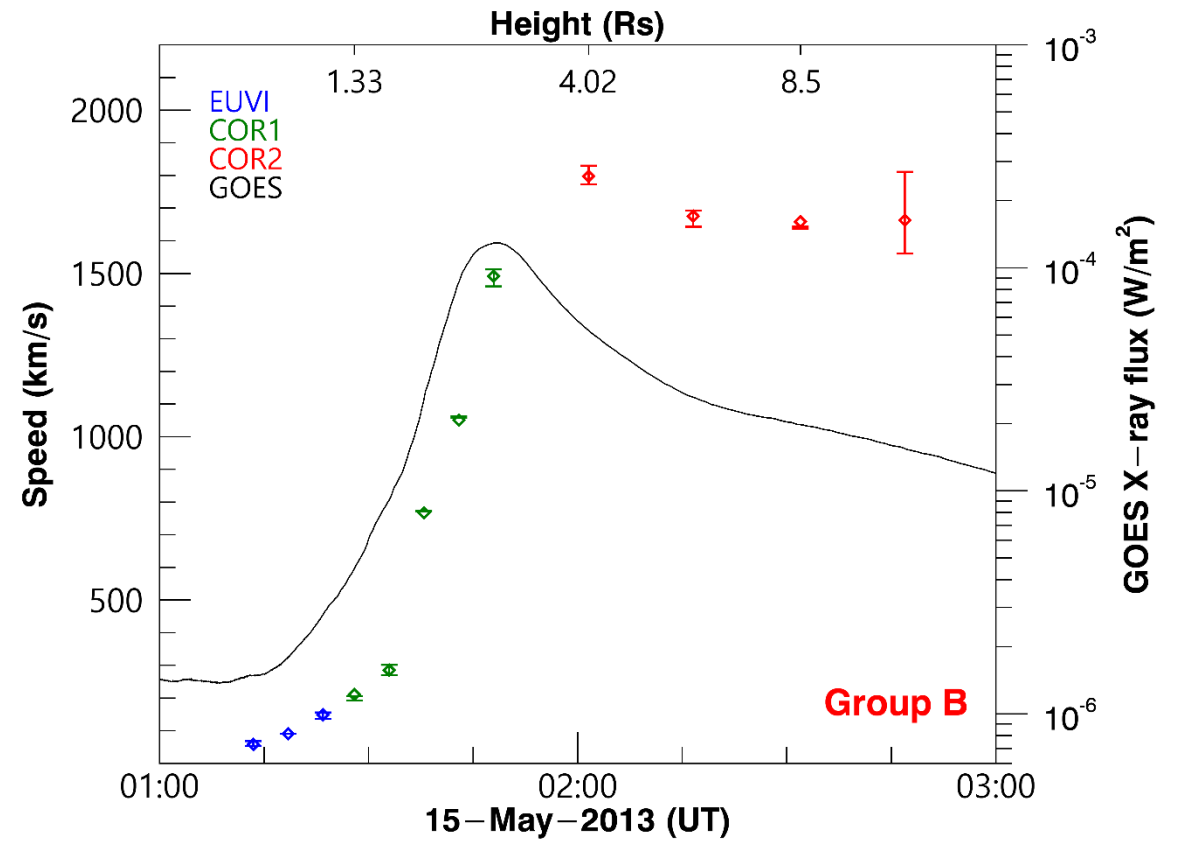
Parameters	All	Group A	Group B
CME 3D speed	1041 km/s	814 km/s	1182 km/s
CME 3D kinetic energy	6.41×10^{31} erg	1.96×10^{31} erg	9.17×10^{31} erg
CME height at peak speed (only 31 events)	3.47 Rs	1.85 Rs	4.05 Rs
Flare duration	58 mins	21 mins	81 mins
Flare rise time	30 mins	11 mins	41 mins

Summary and Conclusion

- The intimate relationship between flares and CMEs have been well observed and discussed by several studies (Zhang & Dere 2006; Maričič et al. 2007; Temmer et al. 2010), which insisted that there are the feedback relationship between CME initial acceleration and the flare energy release.

- It is very interesting to note that H_{vpeak} is well correlated with T_{flare} and T_{acc}. This could be explained by that magnetic reconnections for group B continuously occur for a longer time than those for group A. This fact implies that H_{vpeak} should be a proxy of the length of current sheet in CME evolution.

- These results show that the CMEs for group B are more closely related to flares than those for group A.

Thank you :D

	Peak flux						Fluence					
	All		Group A		Group B		All		Group A		Group B	
	cc	p-value	cc	p-value	cc	p-value	cc	p-value	cc	p-value	cc	p-value
V_{2D}	0.29	0.002	0.16	0.306	0.51	<0.001	0.49	<0.001	0.24	0.128	0.59	<0.001
V_{3D}	0.30	0.001	0.22	0.171	0.54	<0.001	0.53	<0.001	0.32	0.043	0.59	<0.001
E_{2D}	0.30	0.002	0.28	0.075	0.56	<0.001	0.55	<0.001	0.32	0.038	0.65	<0.001
E_{3D}	0.30	0.001	0.32	0.041	0.58	<0.001	0.58	<0.001	0.37	0.015	0.67	<0.001

The p-value means a probability to occur by chance when both quantities are randomly distributed.