A statistical study of shear motion of the footpoints in two-ribbon flares

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Overview

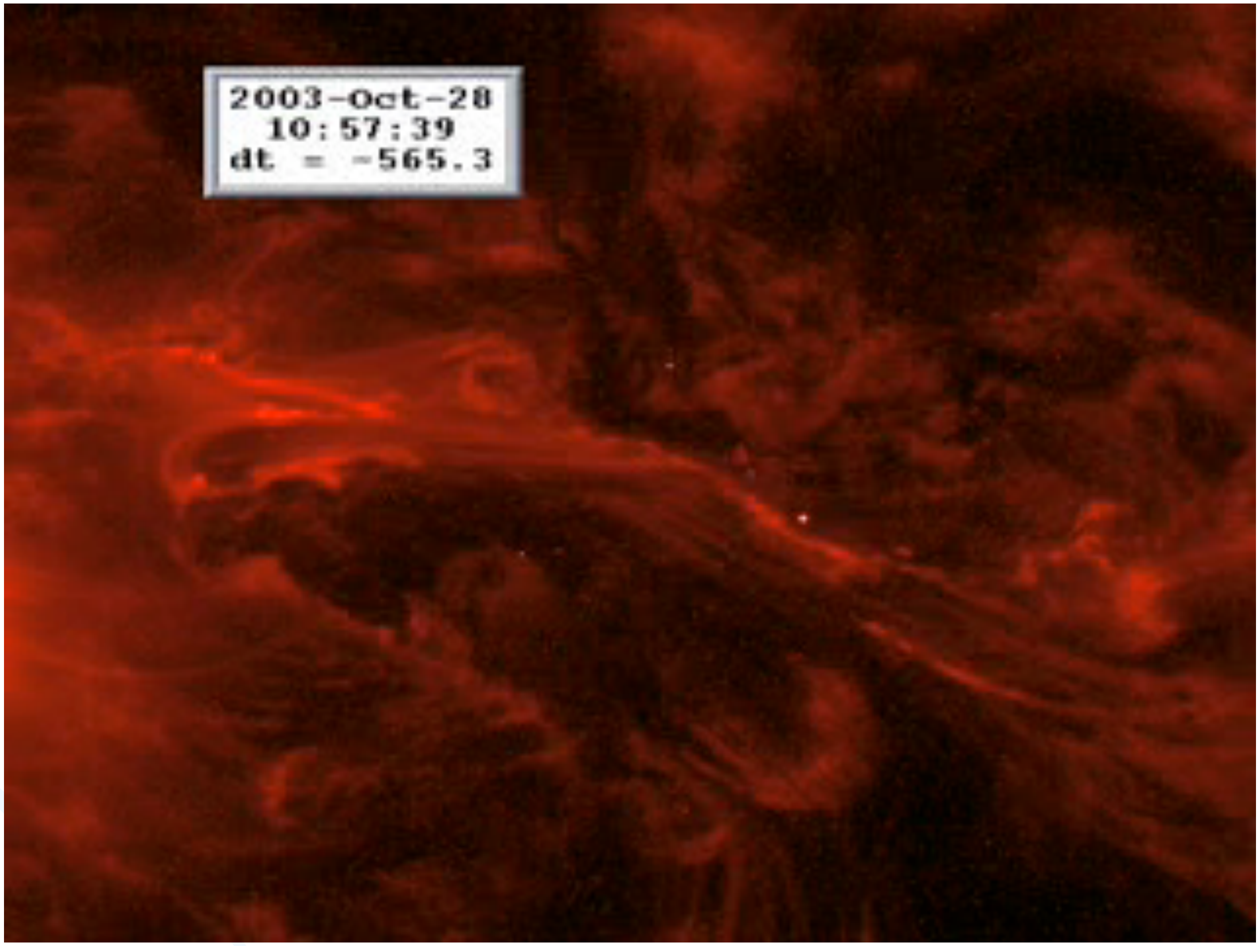
- **Introduction**

- **Detailed analysis of one event**
  - Observation I
  - Observation II
  - Interpretation

- **Statistical study**
  - Data Selection
  - Result I
  - Result II
  - Result III

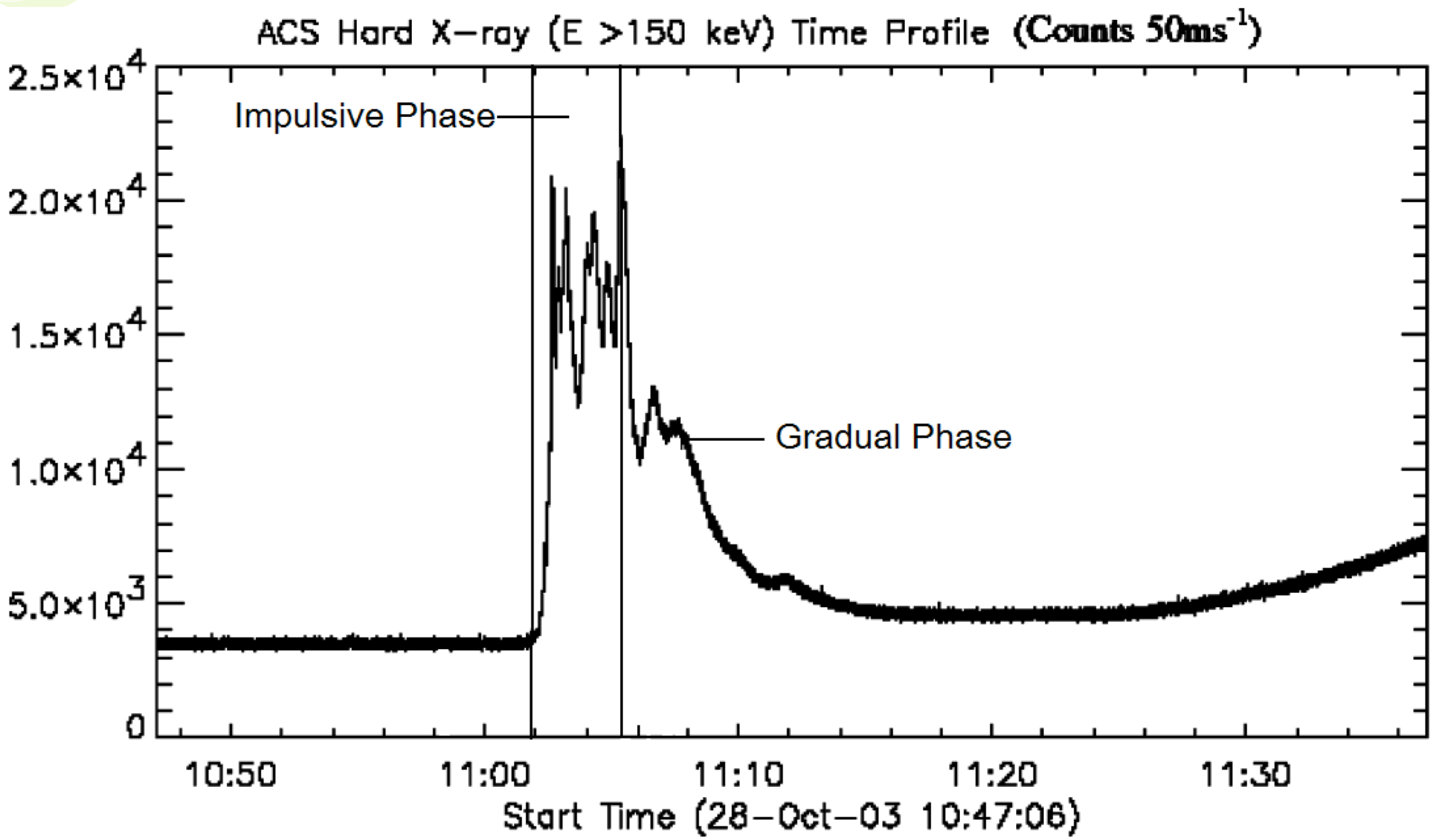
- **Conclusions**

❖ Shear Motion of Footpoints



Masuda, Kosugi, and Hudson (2001) reported **observations of the evolution of the HXR (*Yohkoh*/HXT) footpoints from a strong to weak sheared structure**, which was also found in Hα, EUV, and microwave observations (Su et al., 2006 and references therein).

❖ Impulsive Phase and Gradual Phase



In this work, we focus on two questions: ***Is the shear motion of the footpoints common?*** **Could the change from the impulsive to gradual phase be related to the magnetic shear change?**

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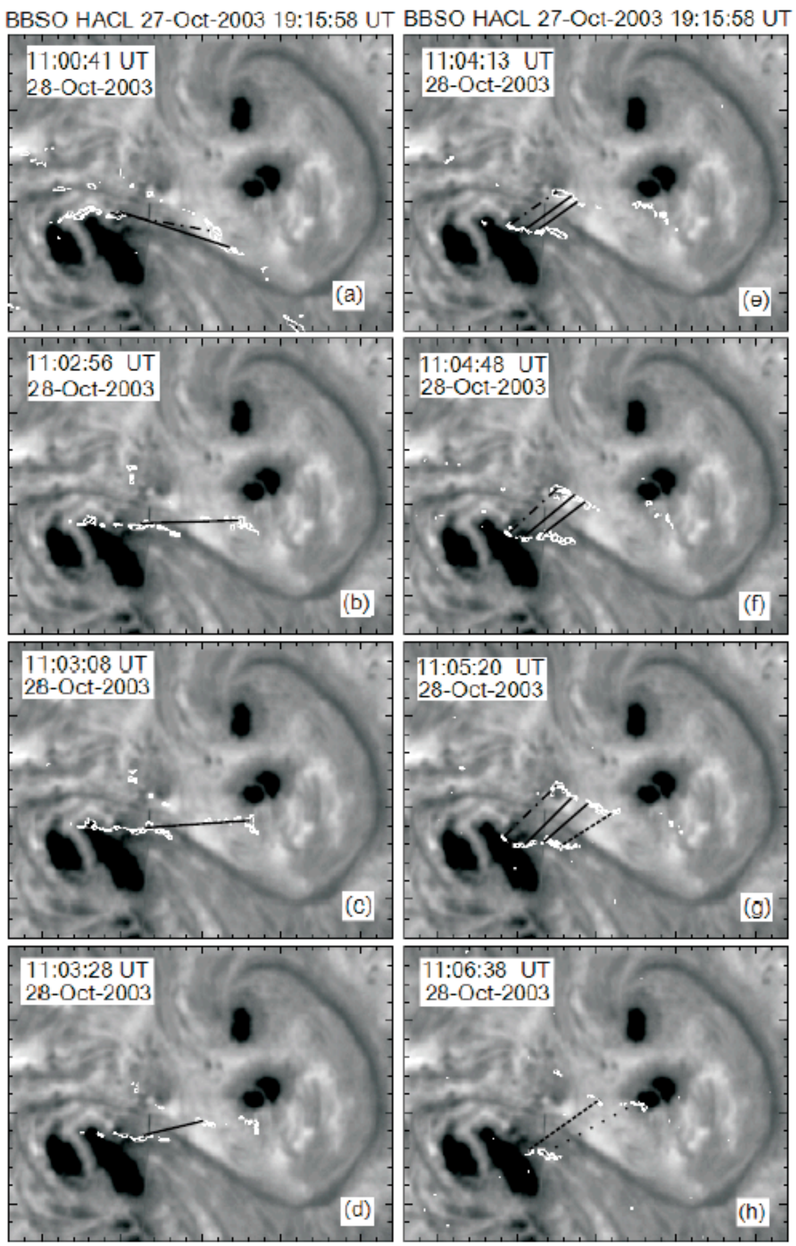
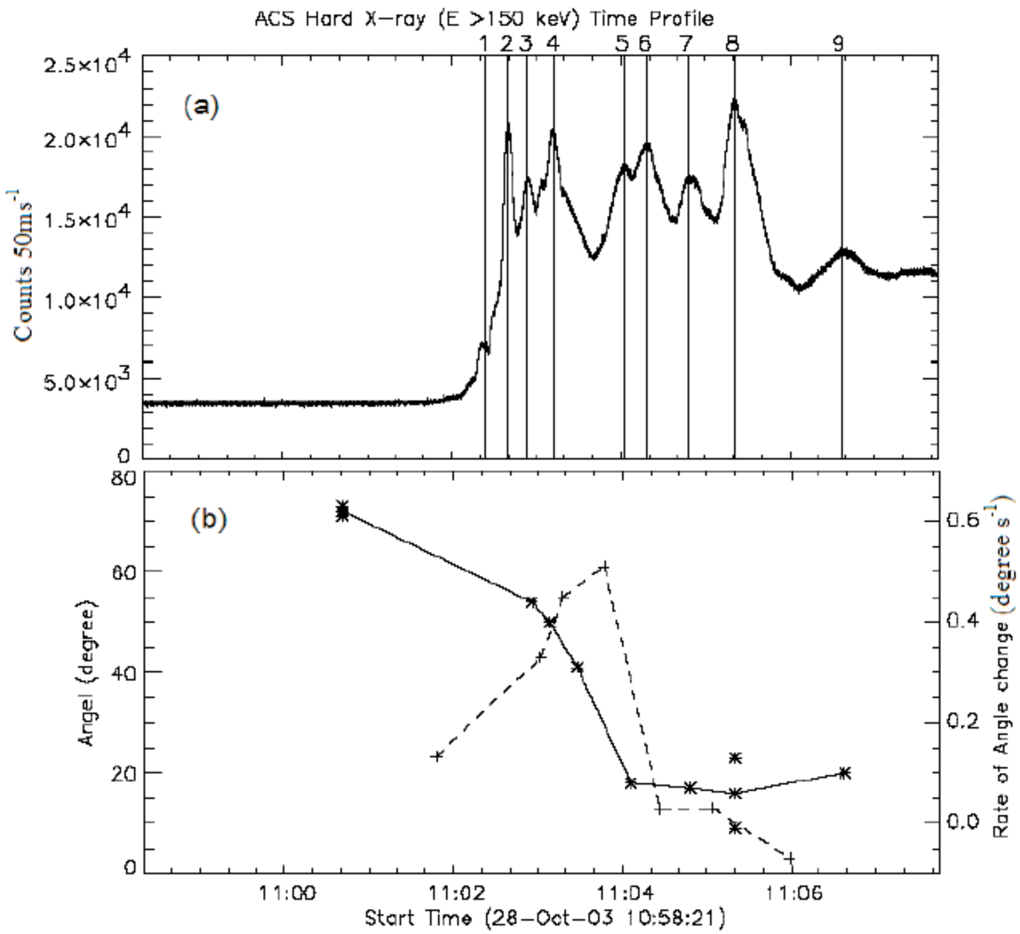
Observation I



TRACE/EUV contours at different times are overlaid on an earlier H α image from BBSO. The times of the EUV contours are marked on each image, and the black lines connecting to the EUV bright kernels represent the possible conjugate EUV footpoints (Fig. 1 shows an example about how to identify these conjugate footpints). Different kind of line refer to different group of brightening pairs. The field of view is 240''x160'' for each image.

- **The EUV brightening pairs start at a position close to the magnetic inversion line but widely separated along the inversion line (a), and change to straight across and far from the inversion line (d) gradually during the impulsive phase.**

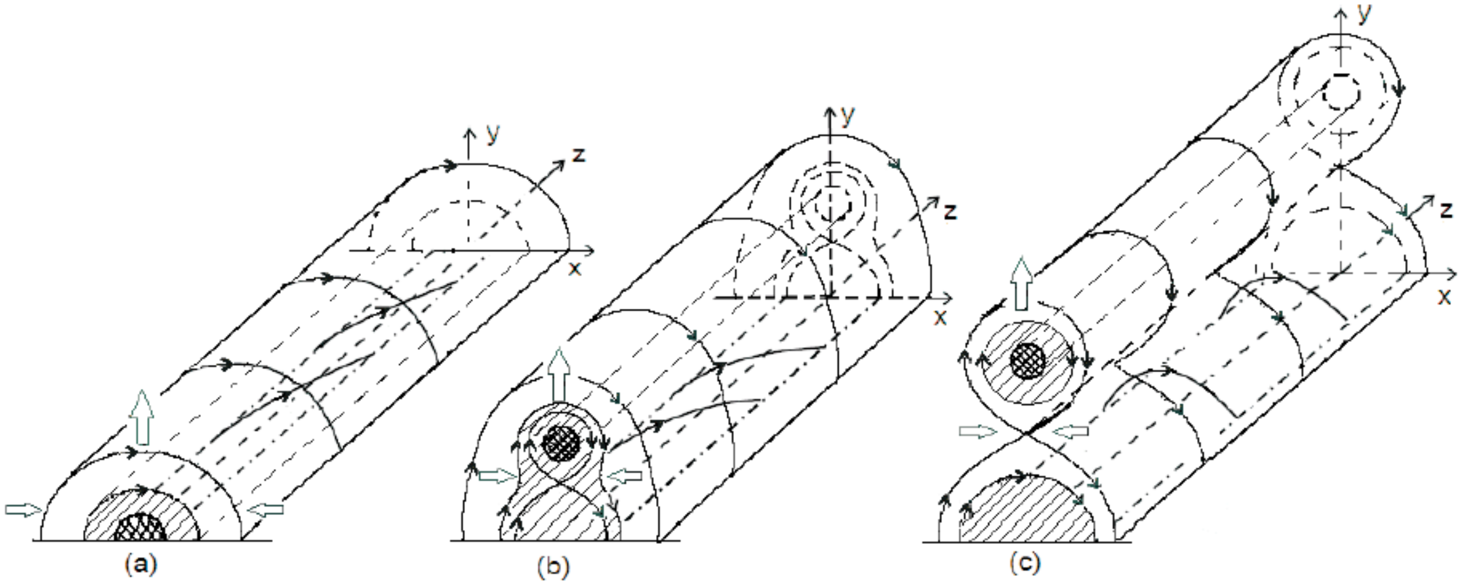
Observation II



HXR light curve and the temporal evolution of the shear angle and the change rate of this angle. (a) The ACS/HXR light curve of the solar flare on 2003 October 28. (b) The evolution of the shear angle (solid line with asterisk sign), and the evolution of the change rate of this angle (dashed line with plus sign).

- The shear change is very fast during the early impulsive phase, but stops in the middle of the impulsive phase (b).
- The change from impulsive to gradual phase may not correspond to the cessation of magnetic shear change in this event.

Interpretation



Cartoon of the evolution of the magnetic field in the standard model of solar flares.

This observed shear change can be understood by the cartoon we made corresponding to the standard model for solar flares (e.g., Moore et al. 1995, 2001).

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Data Selection

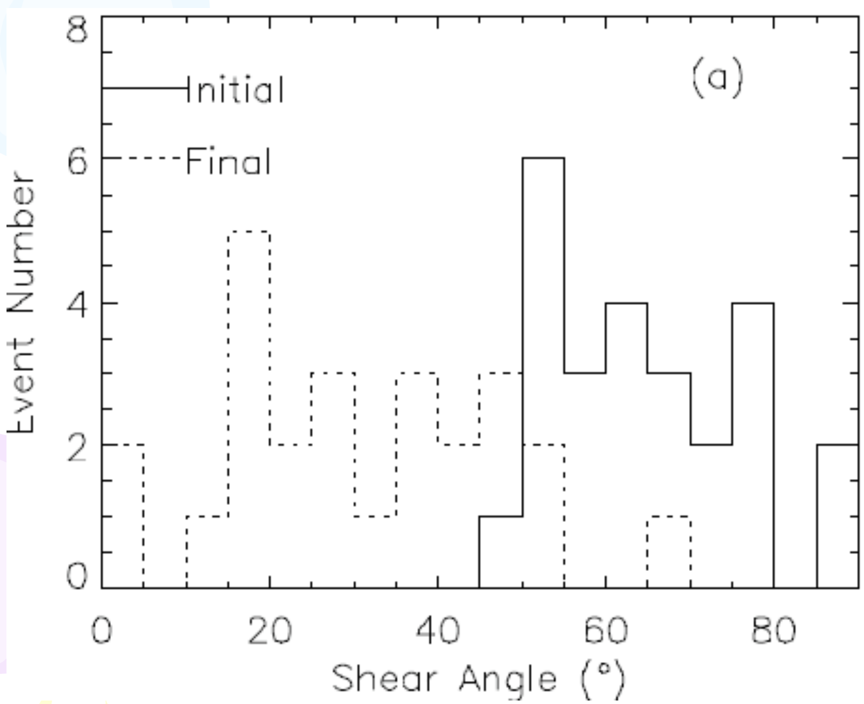
We have selected 50 well-observed two-ribbon solar flares listed in the TRACE Flare Catalog:

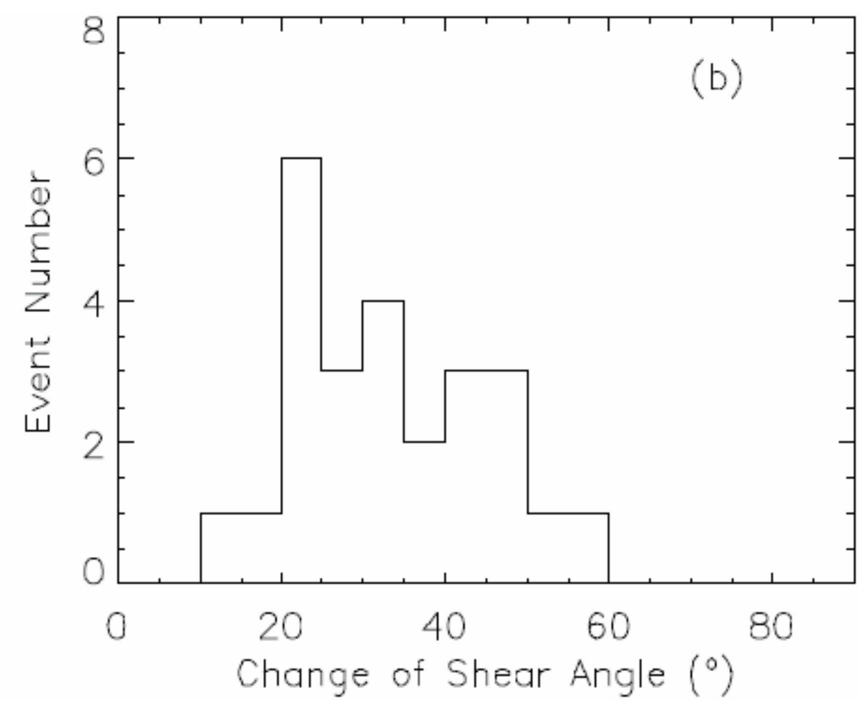
- **Type I flares** ----- flares which show shear change of footpoints.
- **Type II flares** ------flares which do not show shear change of footpoints.

Result I

The initial and final shear angles of Type I flares

In sum, 86% (43 out of 50) of the two-ribbon flares observed by TRACE belong to type I flares. The initial and final shear angles in most events are in the range from 50° – 80°and 15° – 55°.

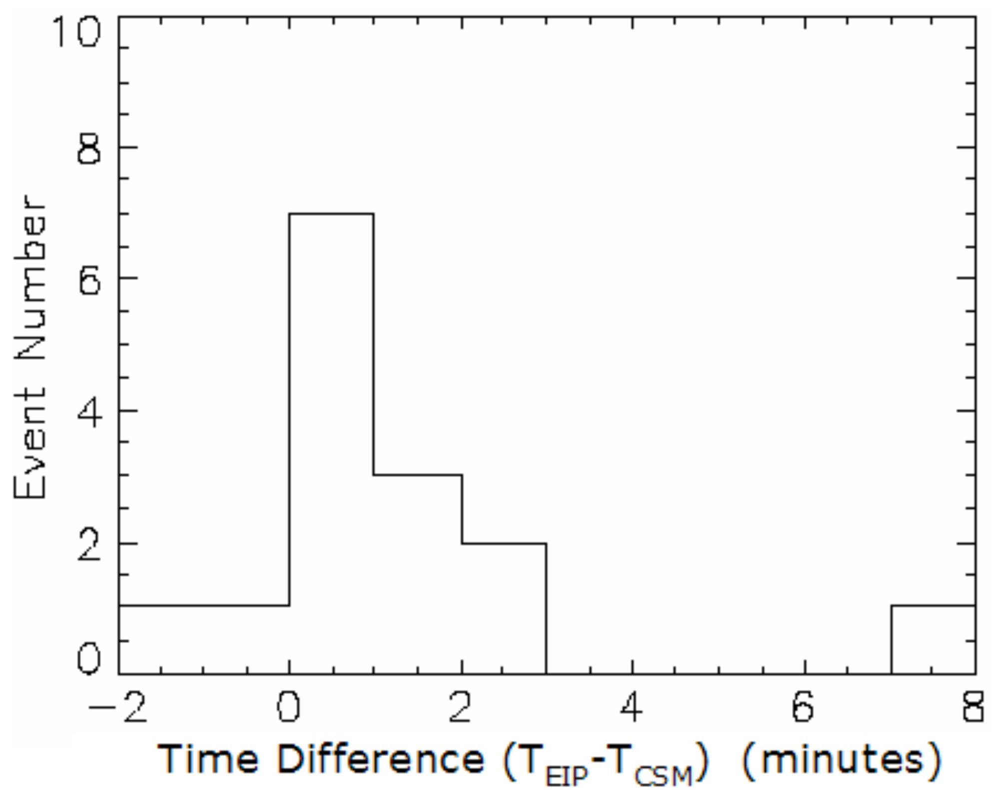




Result II

Time Difference (T_{EIP}- T_{CSM})

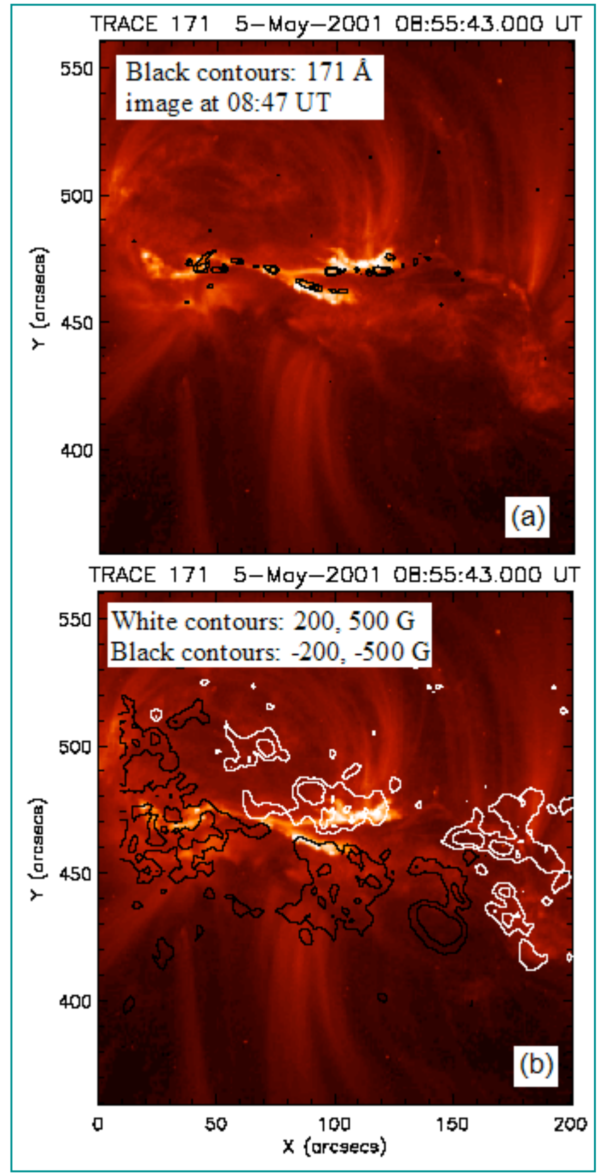
- **15 events with measured shear angle have corresponding HXR (*Yohkoh* or RHESSI) observations.**
- **In most events, the cessation of shear change is 0-2 minutes earlier than the end of the impulsive phase.**



Result III

Type II flares

- 7 out of the 50 flares
- no obvious ribbon separation
- no CMEs
- confined (compact or single loop) flares (Machado et al., 1988)?



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Conclusions

- ***The strong-to-weak shear motion of the footpoints is a common feature in two-ribbon flares,*** i.e., 86% (43 out of 50) of two-ribbon flares that we studied show this motion. The initial and final shear angles in most events are in the range from 50° – 80°and 15° – 55° .

- ***The cessation of magnetic shear change is 0-2 minutes earlier than the end of the impulsive phase in 10 out of the 15 events*** with measured shear angle and corresponding HXR observations.

- This observed shear change can be understood in terms of the standard model for solar flares (e.g., Moore et al. 1995, 2001, and references therein). In this model, ***the cessation of shear change of the footpoints during the early impulsive phase corresponds to the splitting of the sheared envelope of the highly sheared core field.***

- ***There is no obvious ribbon separation in those two-ribbon flares without measurable shear change.***

Thank You !