DYNAMIC PROPERTIES OF PROMINENCE ERUPTIONS

OBSERVED BY AIA AND LASCO

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OUTLINE

- Prominences
  - Eruption types
  - Environment
- Methods of measurements
- Velocity variations
  - AIA/SDO
  - LASCO/SOHO
  - Other factors impact
  - Related phenomena impact
- Conclusions & Future plans

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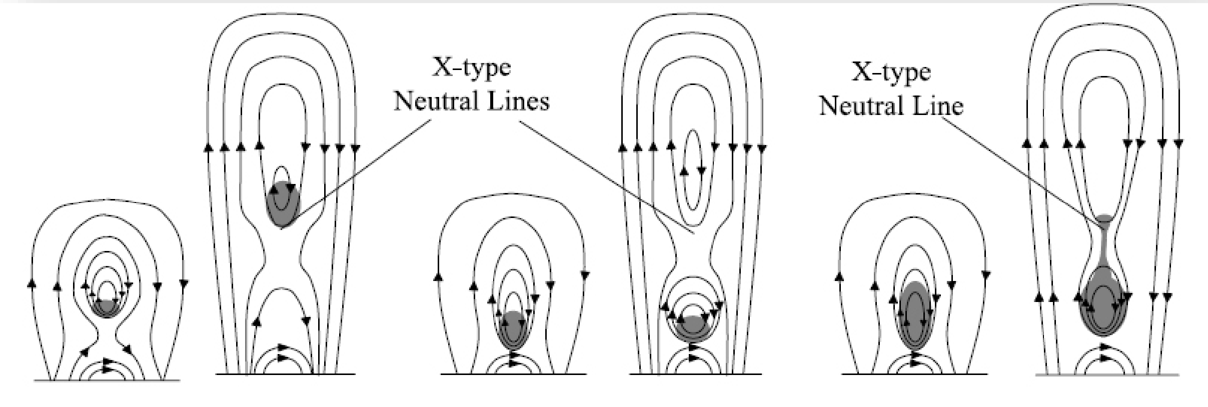
PROMINENCES
ERUPTION TYPES

*According to the filament mass and structure.

	Eruption types	Description
1	Full	At least 90% of filament mass and magnetic structure escapes the Sun
2	Partial	(a) Entire magnetic structure erupts with some or none of the filament mass (as a result of mass draining)
		(b) Partial eruption of the magnetic structure with some or none of the filament mass (as a result of mass draining and/or settling)
3	Confined	None of the filament mass nor the magnetic structure escapes the Sun

Full Confined Partial

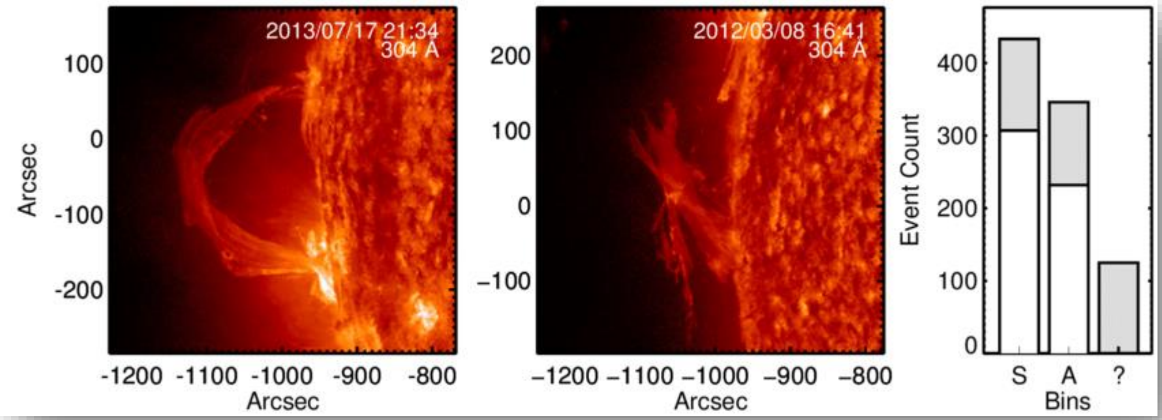


Gilbert, Alexander & Liu, 2007

**According to the behaviour of prominence body.

S – 48%
A – 38%
u – 14%

Symmetric Asymmetric

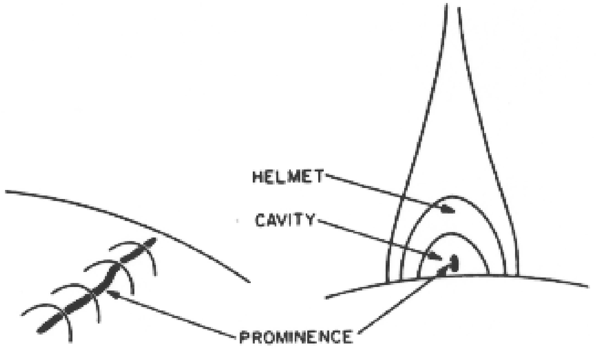


McCauley et al., 2015

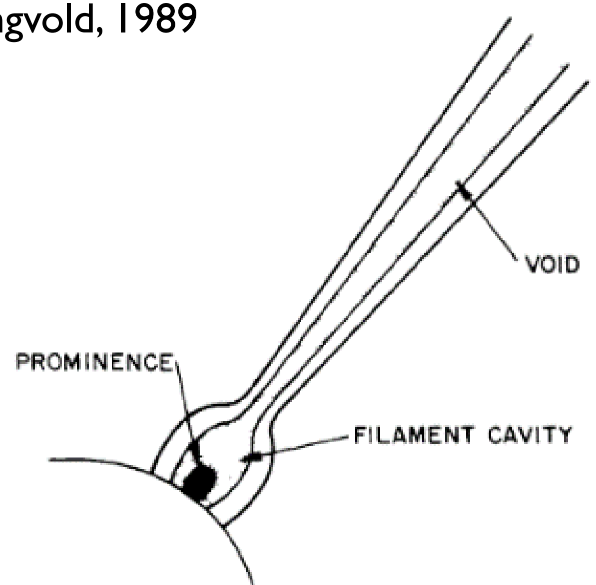
Gilbert, H.R., Alexander, D., Liu, R.: 2007, *Sol. Phys.* **245**, 287.
McCauley, P.I., Su, Y., Schanche, N., et al.: 2015, *Sol. Phys.* **290**, 6.

PROMINENCES
ENVIRONMENT

- Topology of prominence environment:
  - Helmet streamers:
    - Typical locations: $\Theta \gtrsim 50°$
    - Typical size: $d \sim 300\ 000\ km\ \&\ d < 1R_{\odot}$
  - Coronal cavities – darker and less denser inner part
  - Coronal voids – beam-like structures
    - Typical size: $d < 3R_{\odot}$
    - Typical lifetime: $t < 4h$



Engvold, 1989

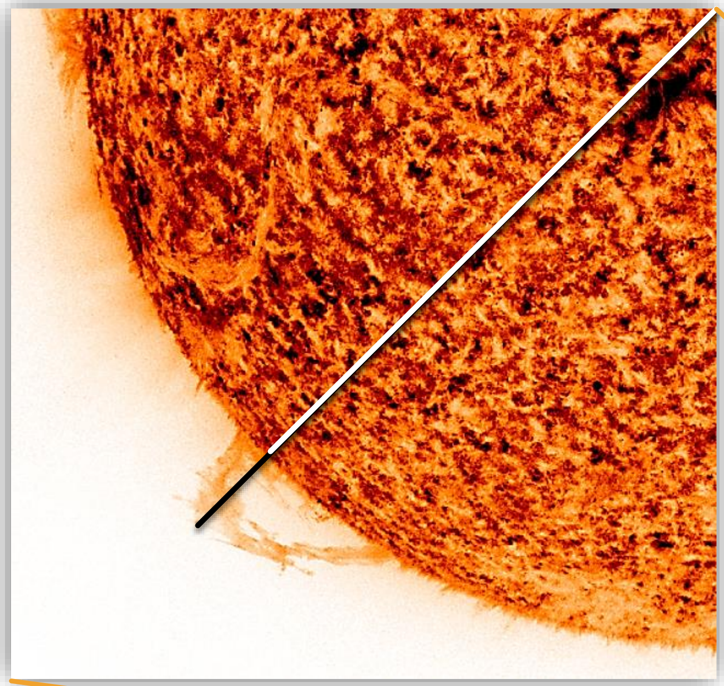


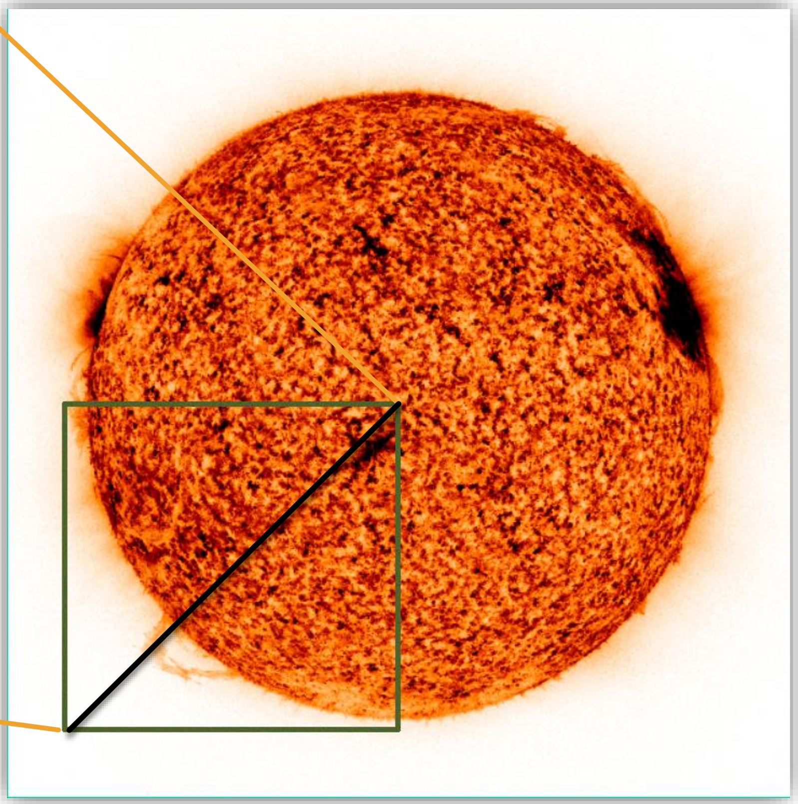
MacQueen et al., 1983

Engvold, O.: 1989, in E. R. Priest (ed.), *Dynamics and Structure of Quiescent Solar Prominences*, Kluwer Acad. Publ., 47.
MacQueen, R. M., Sime, D. G. and Picat, J.-P.: 1983, *Sol. Phys.* **83**, 103.

DATA PROCESSING

- AIA/SDO data
- IDL-based SolarSoftware procedure



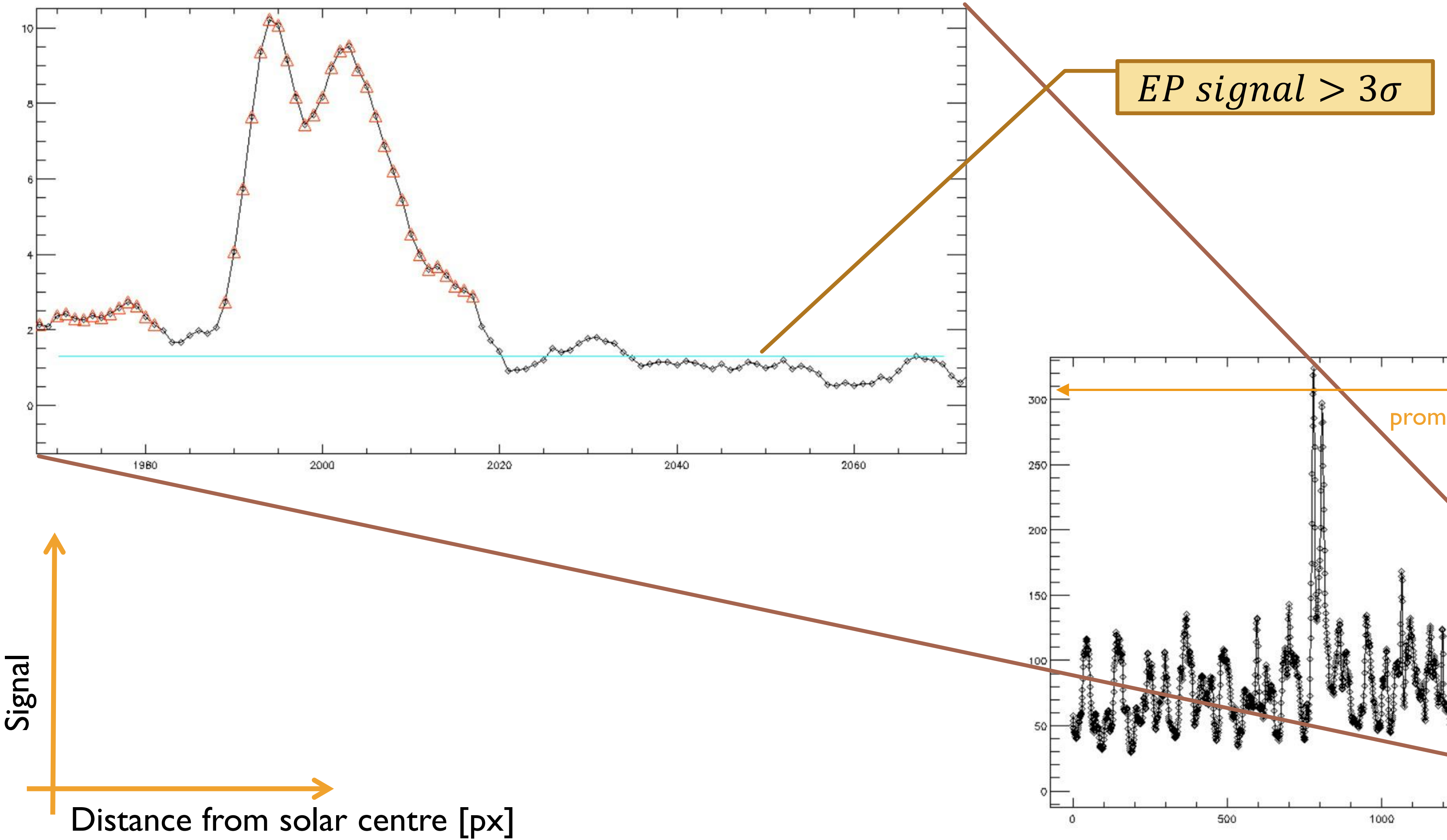


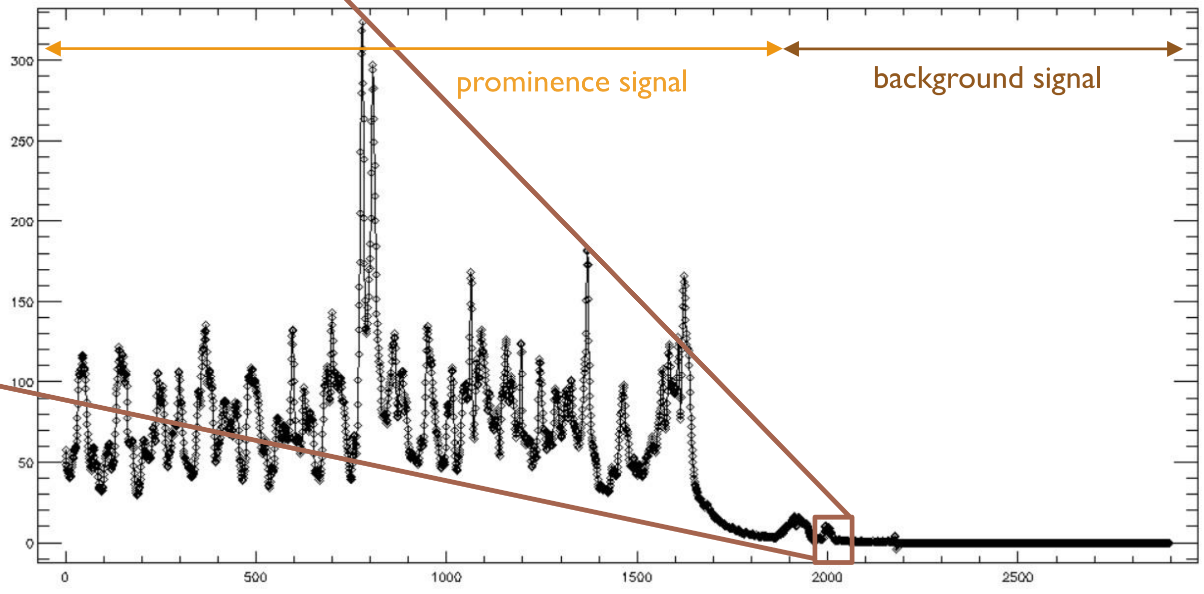
Distance between the top of the EP loop and solar centre
\- Solar radii

Height of the EP above solar limb

DATA PROCESSING

- Signal profile
- Universal definition of the boundaries of prominence body
- Measurement error

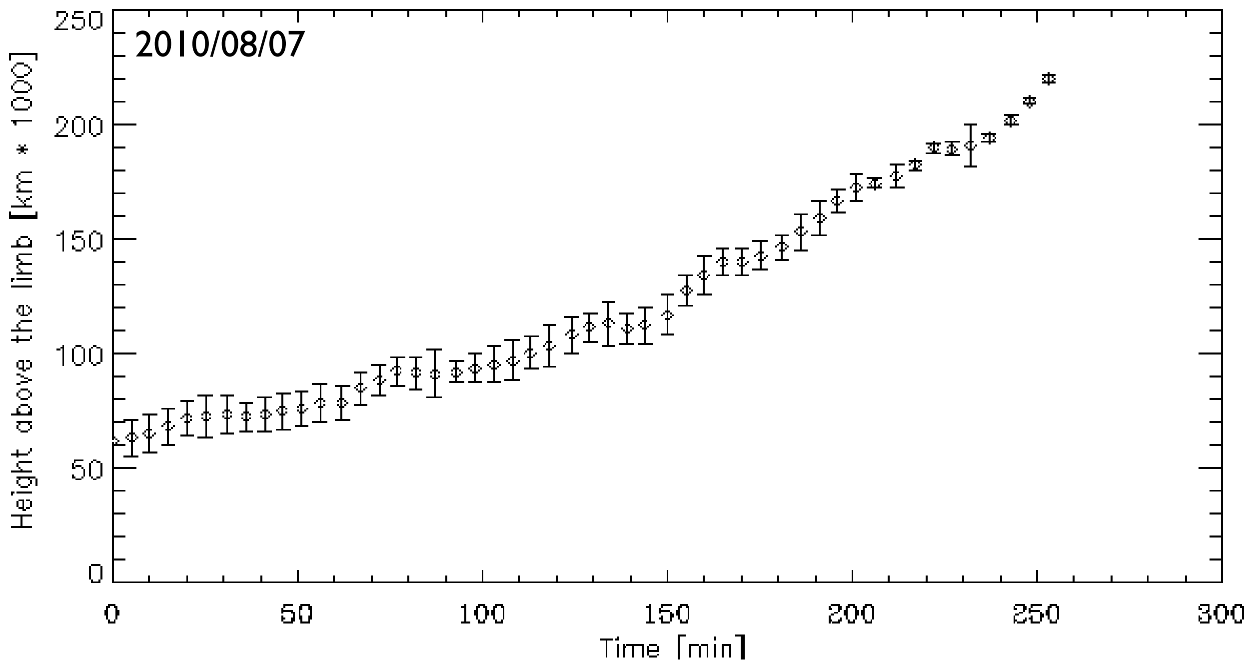


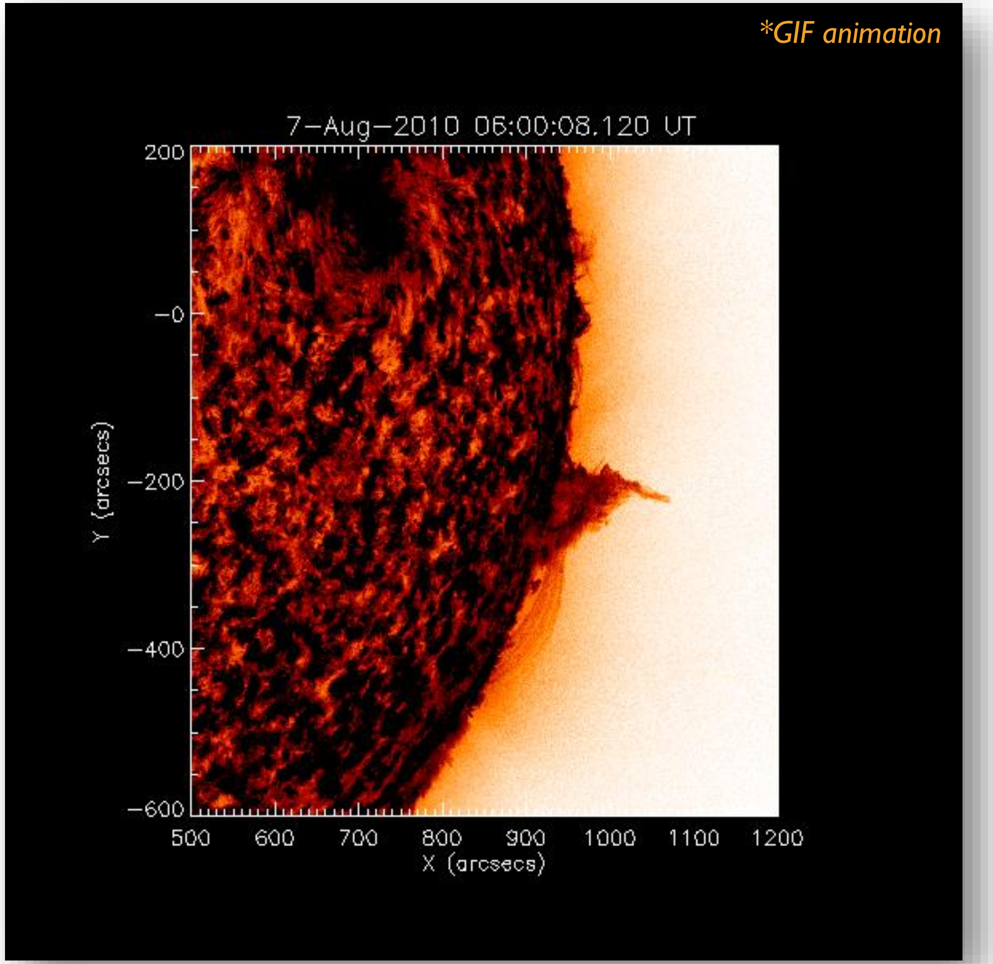


VELOCITY VARIATIONS

AIA/SDO

- Vertical fluctuations of EP plasma
- Observed in kinematic curves of EPs

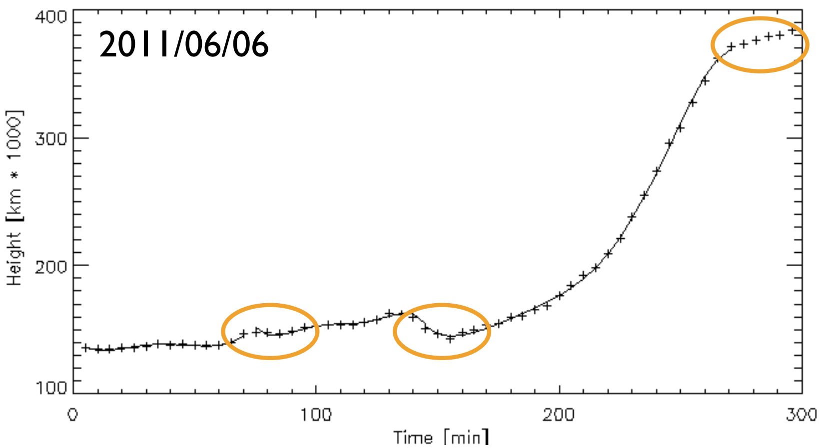


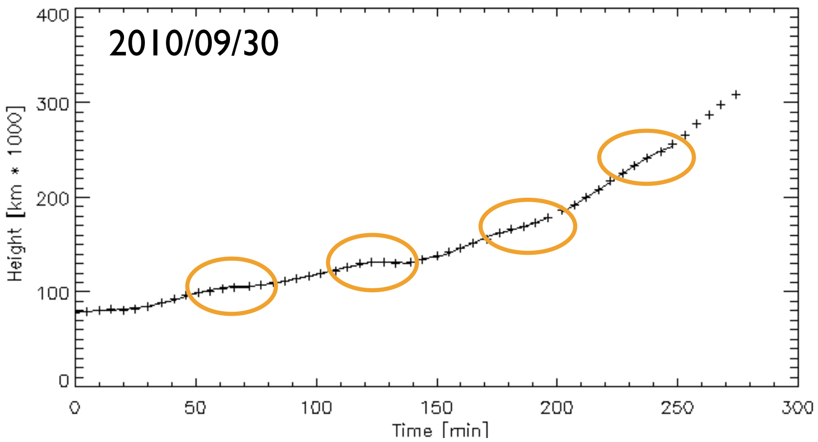


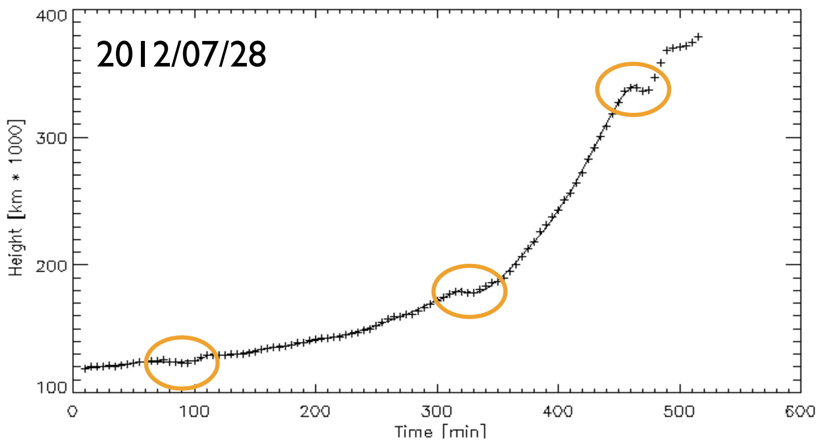
VELOCITY VARIATIONS

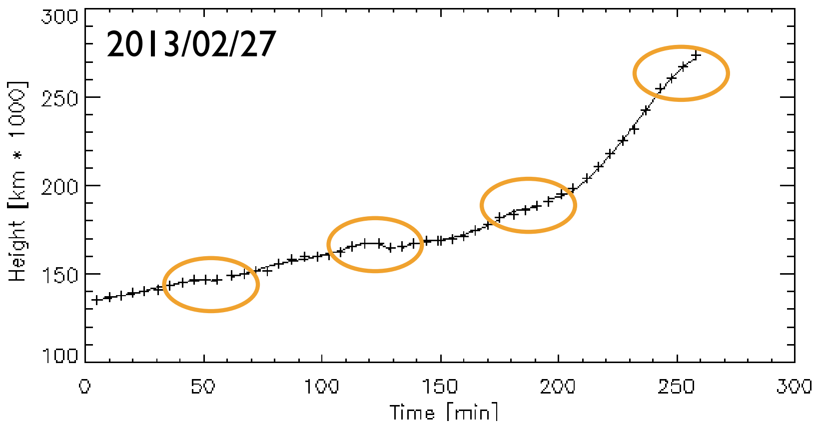
AIA/SDO

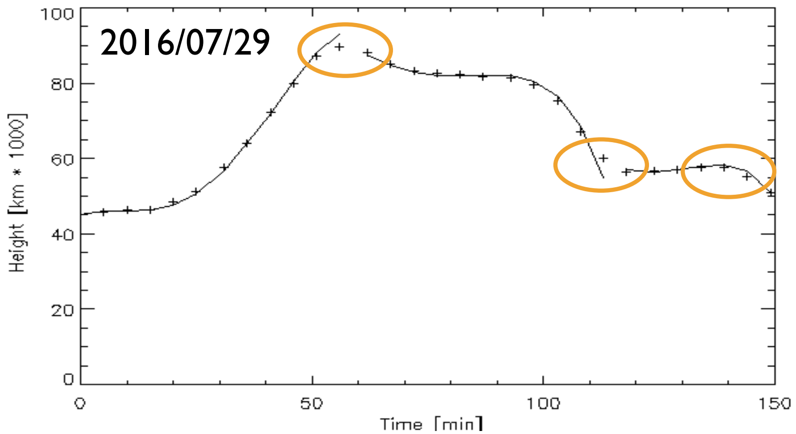
- List of >40 EPs







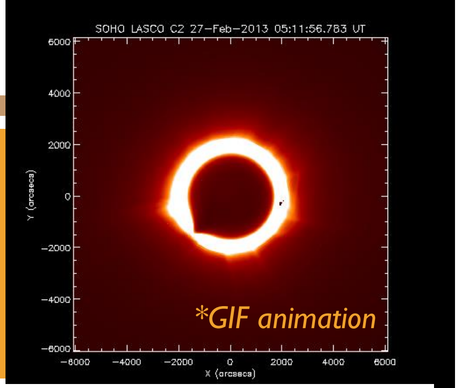




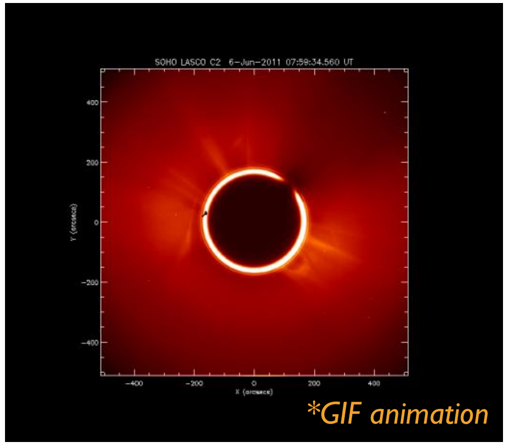
ЕП	I	II	III	IV	V
Eruption duration [h]	~5	~8	~11	~4.5	~2.5
Number of peaks	3	4	3	4	3
H_{max} [km*10^3]	~385	~310	~380	~275	~93

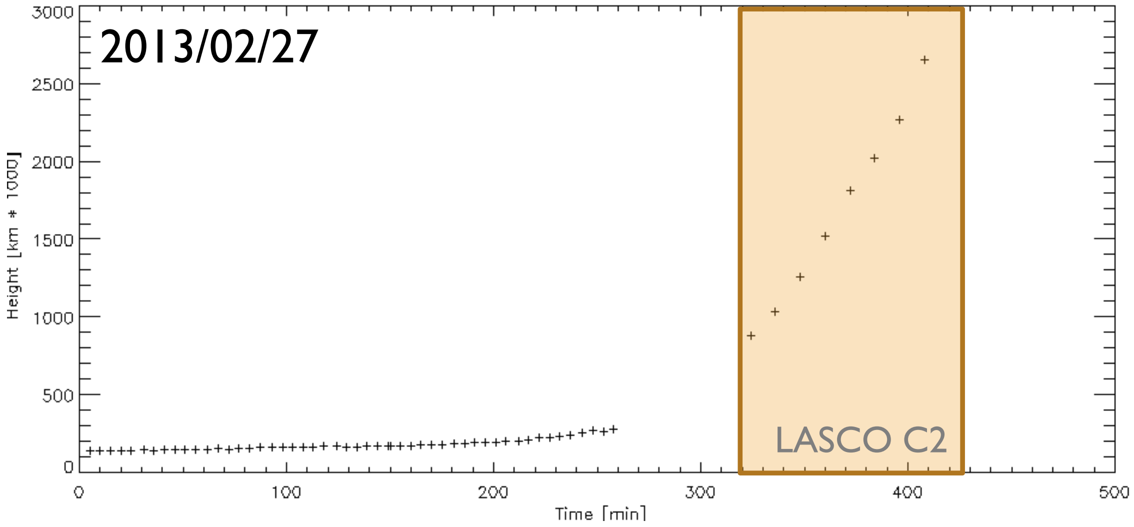
VELOCITY VARIATIONS

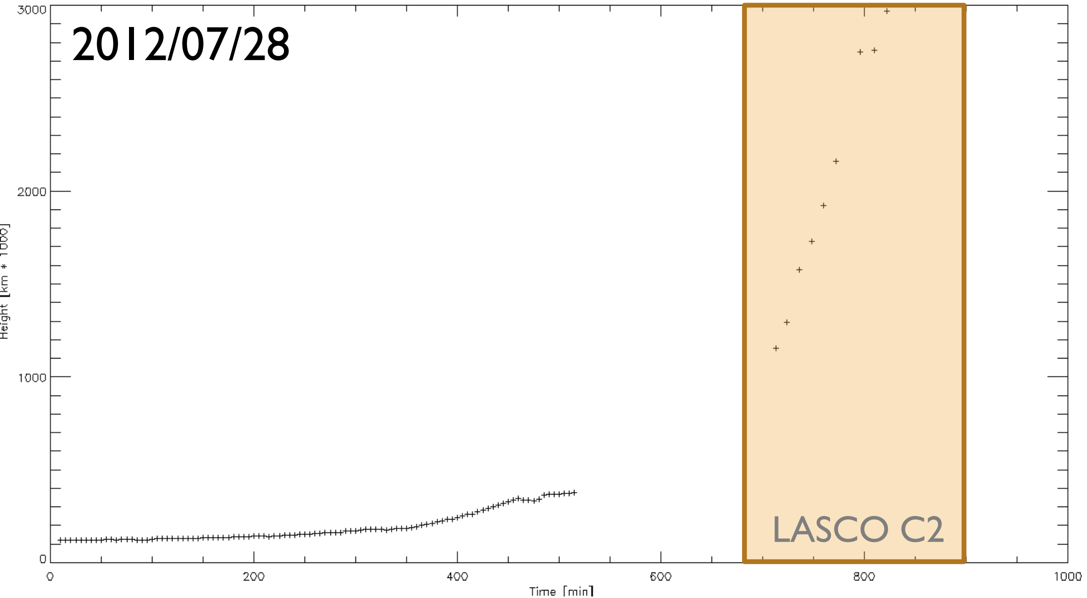
LASCO/SOHO

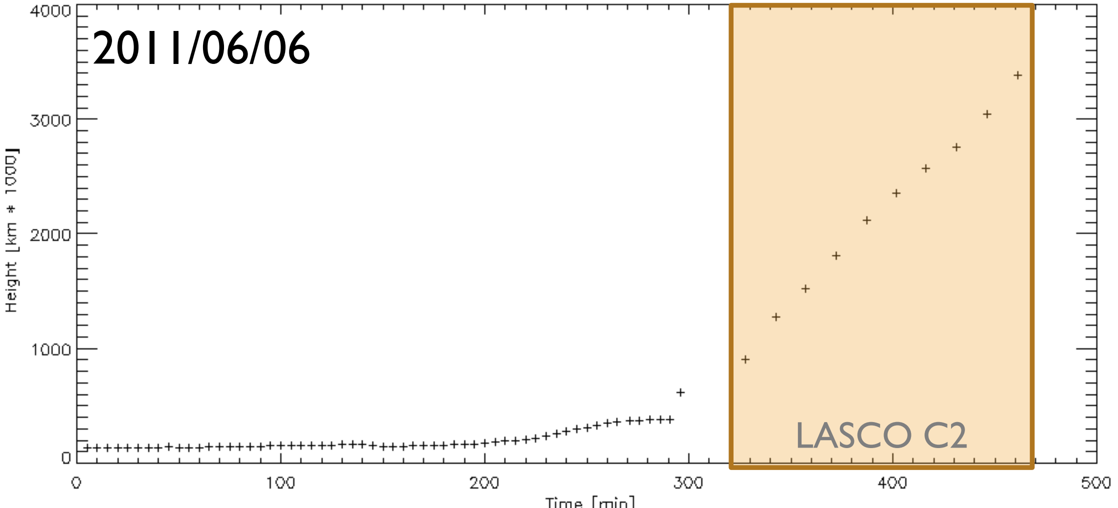


- No variations in LASCO FOV
- Higher cadence (~15 min)
- Higher altitudes



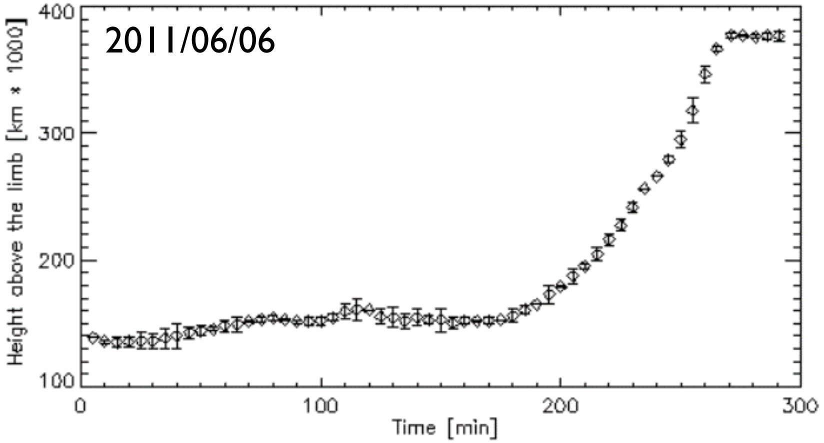


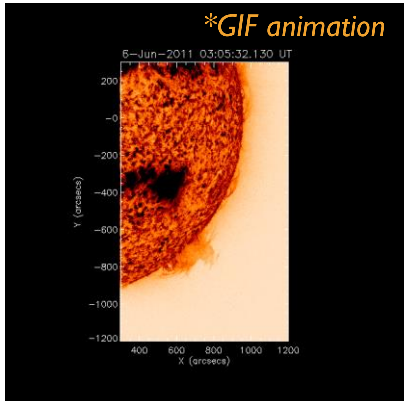


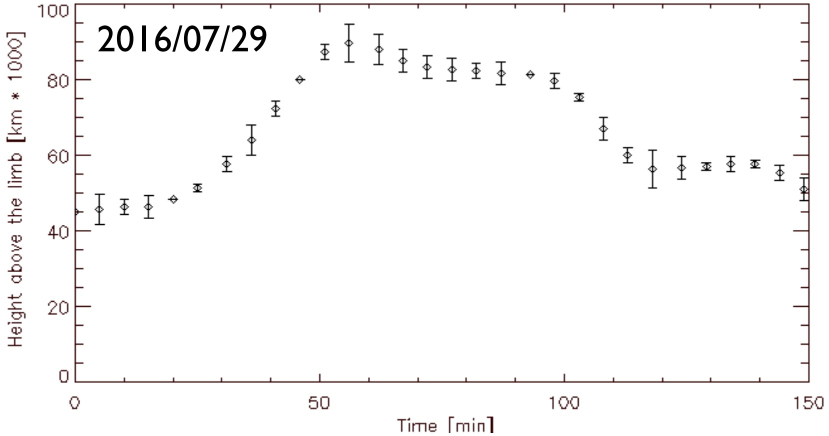


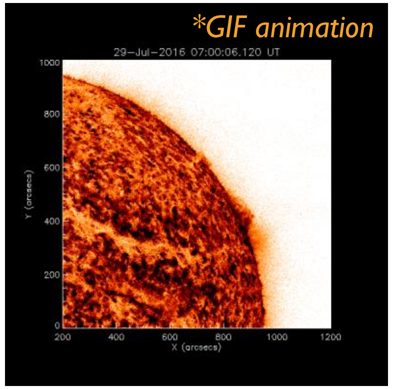
OTHER FACTORS IMPACT
ERUPTION TYPE

Symmetric

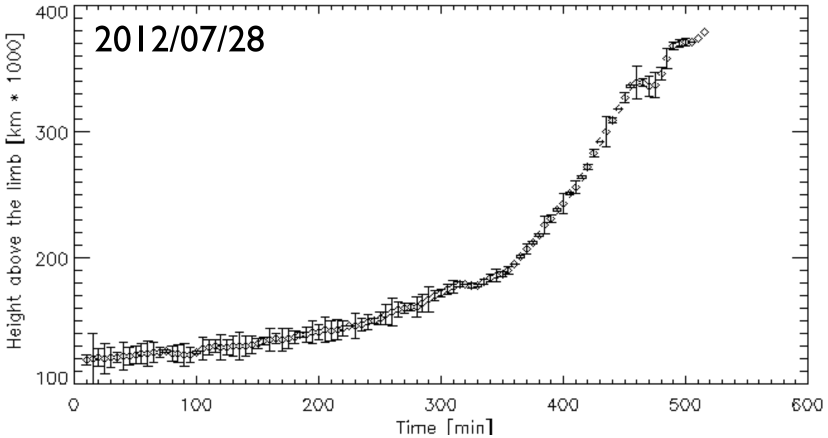


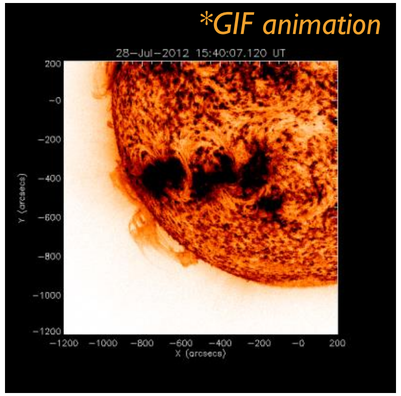


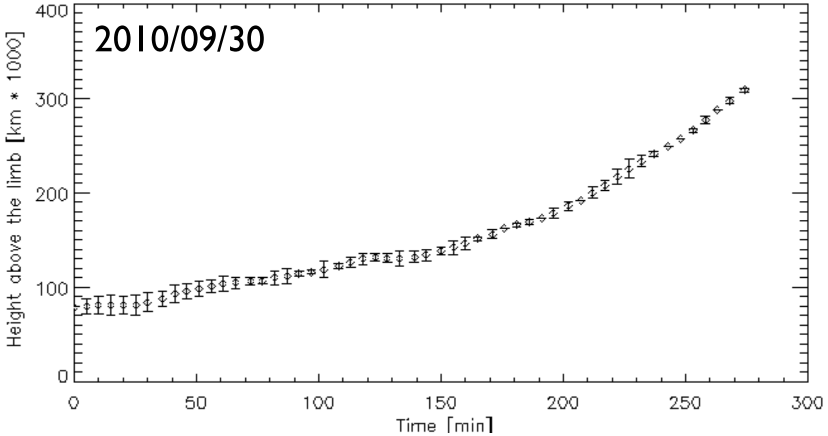


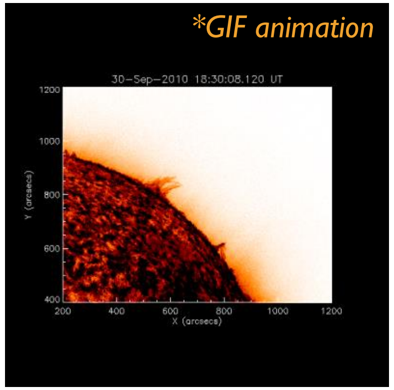


Asymmetric





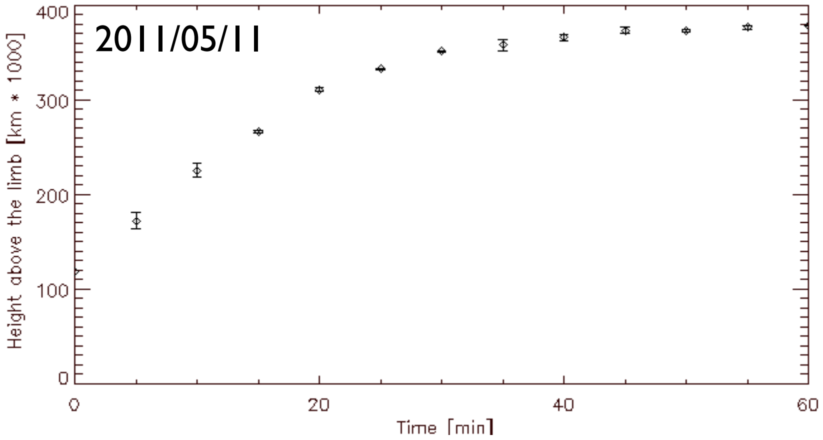


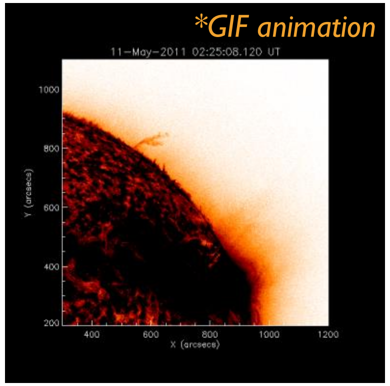


OTHER FACTORS IMPACT

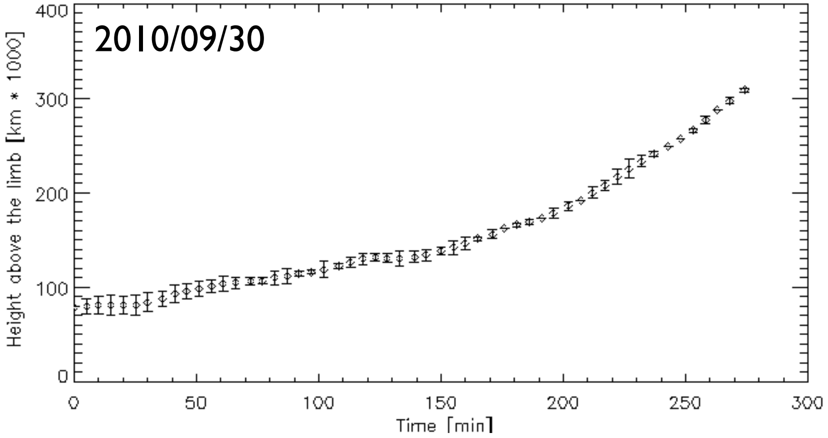
ERUPTION TYPE

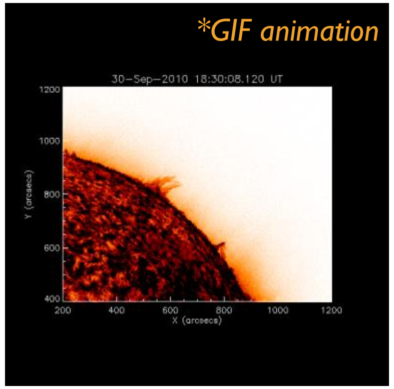
Full



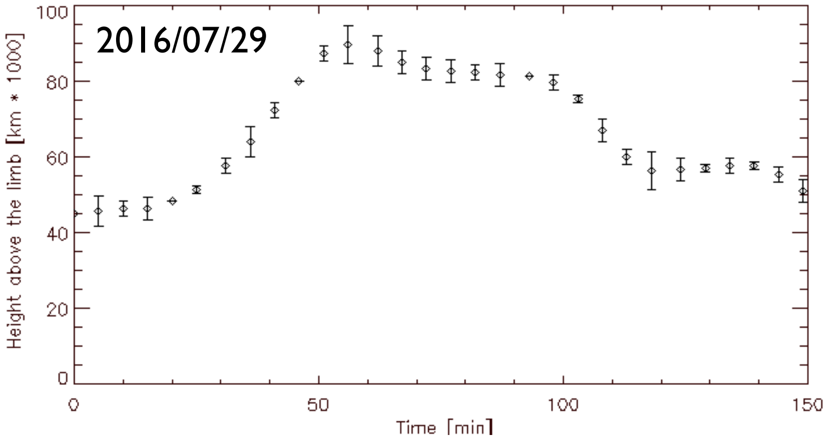


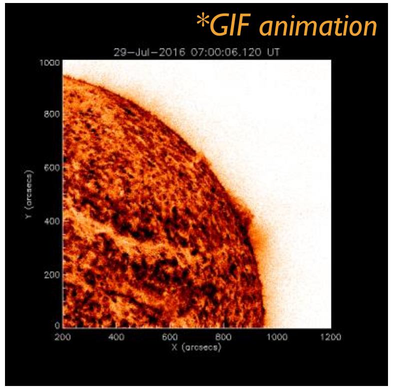
Partial





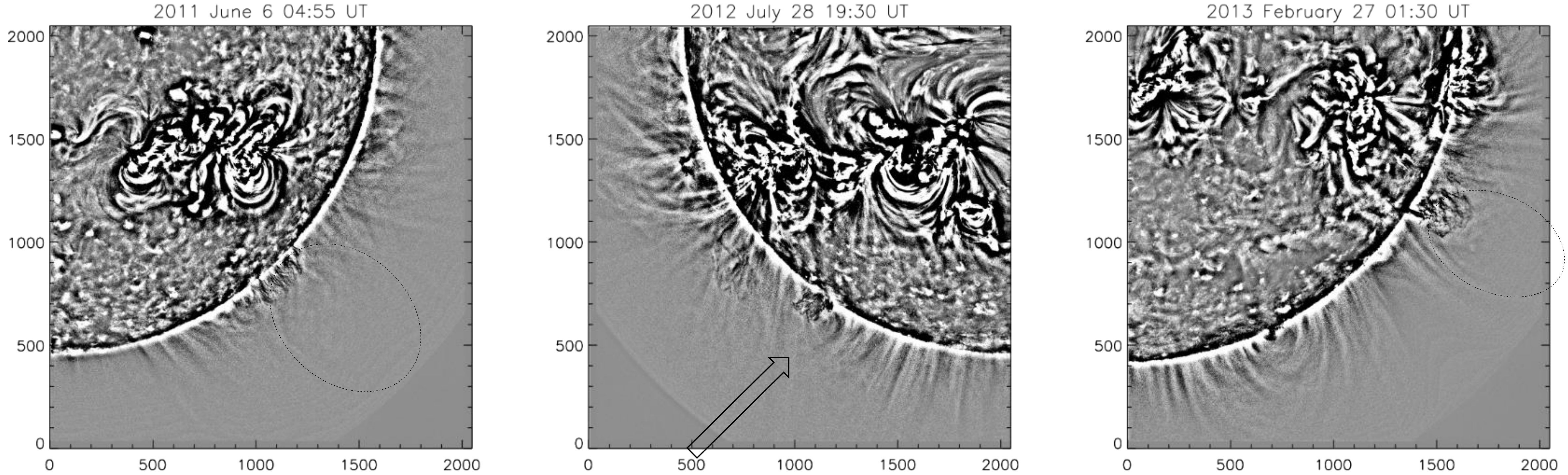
Confined





OTHER FACTORS IMPACT
ENVIRONMENT – CORONAL CAVITIES

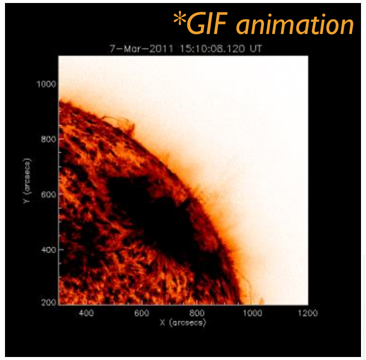
- 211 Å channel image differences from the moments between activation and eruptive phase
- 40% association rate between EPs and CCs (Gopalswamy, 2006) / line-of-sight effects - the cavity is occluded by foreground arcade emission (Gibson et al., 2010)

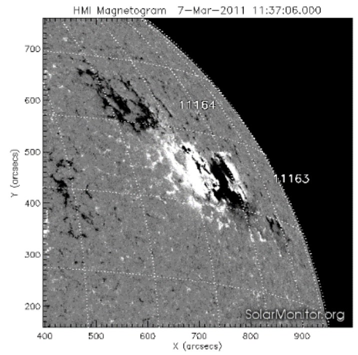


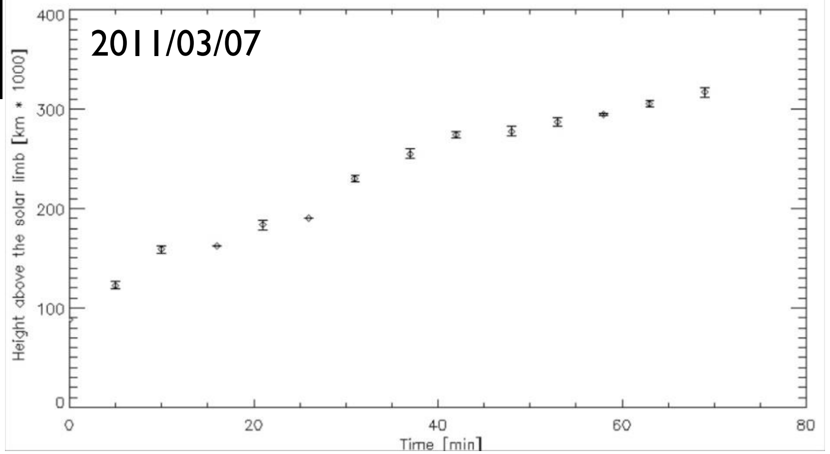
Gopalswamy, N., 2006. *JApA* **27**, 243.
Gibson, S.E., Kucera, T.A., Rastawicki, D., et al., 2010. *APJ (Acta Pathol. Jpn.)* **724** (2), 1133.

RELATED PHENOMENA IMPACT
ACTIVE REGIONS

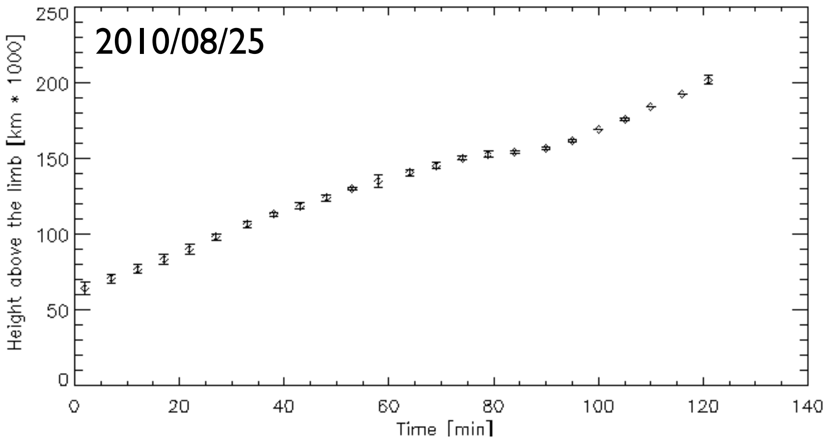
Inside AR

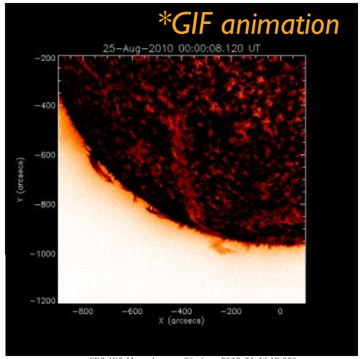


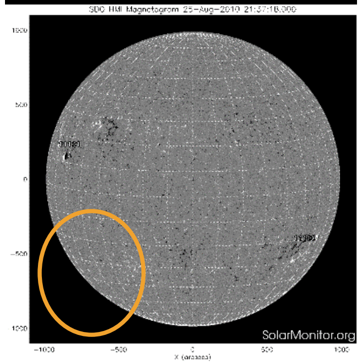




Outside AR







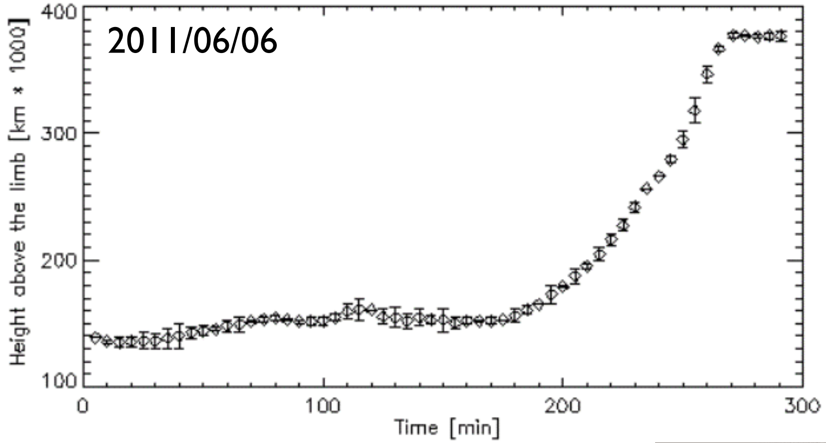
NOAA	Position	Hale class	Number of sunspots	Produced flares
11164	N24W60	βγδ/βγδ	25/28	2 x M-class 13 x C-class

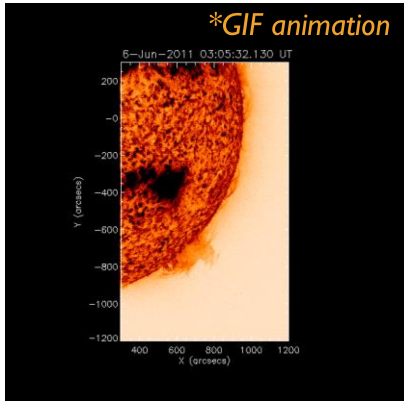
- *21 AR EPs*
- *19 EPs outside ARs*

RELATED PHENOMENA IMPACT

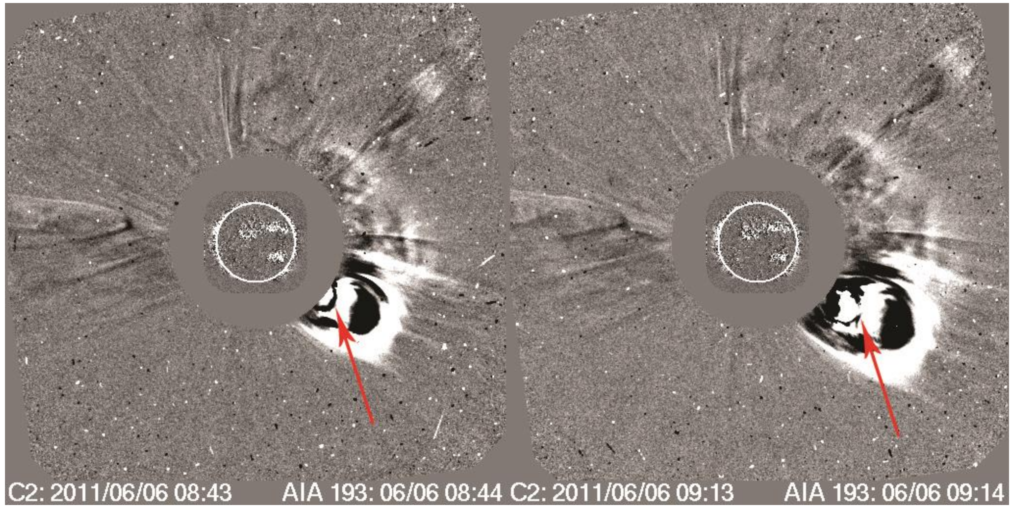
CMEs

Associated CME

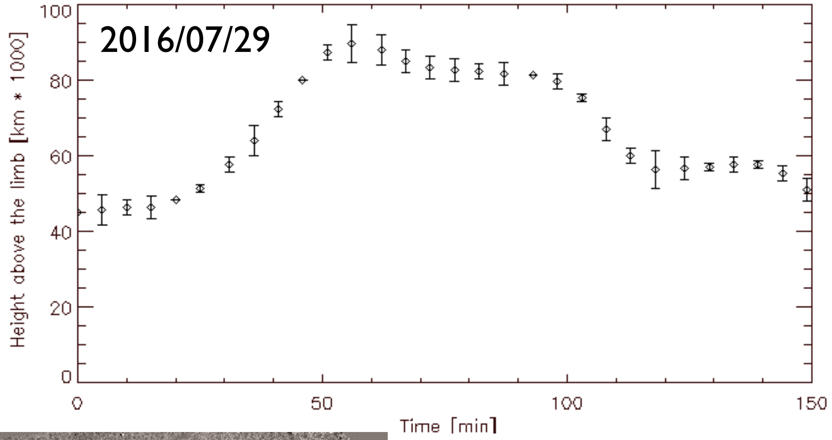


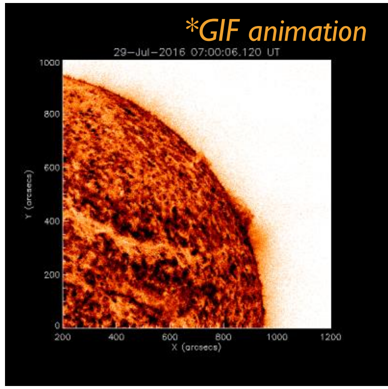


Onset [UT]	07:30
Central PA	241º
Angular width	72º
Linear speed	582 km s^{-1}



No associated CME

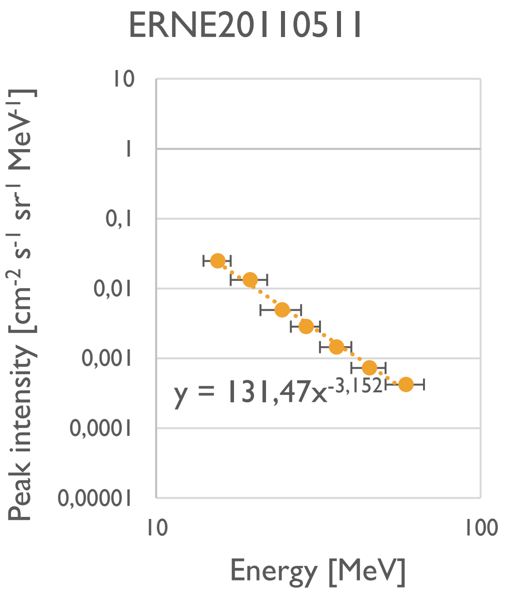


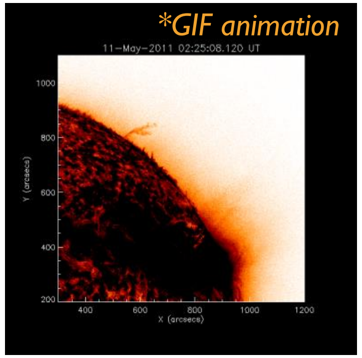


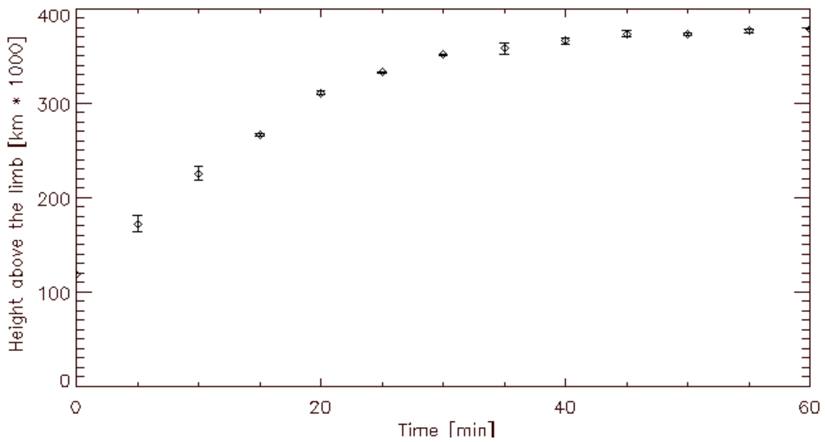
- *27 CME-related EPs*
- *13 EPs not associated with CME*

RELATED PHENOMENA IMPACT
SEP-PRODUCTIVITY

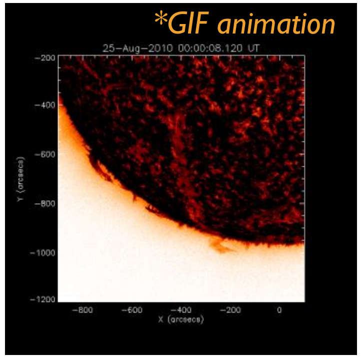
SEP-related EP

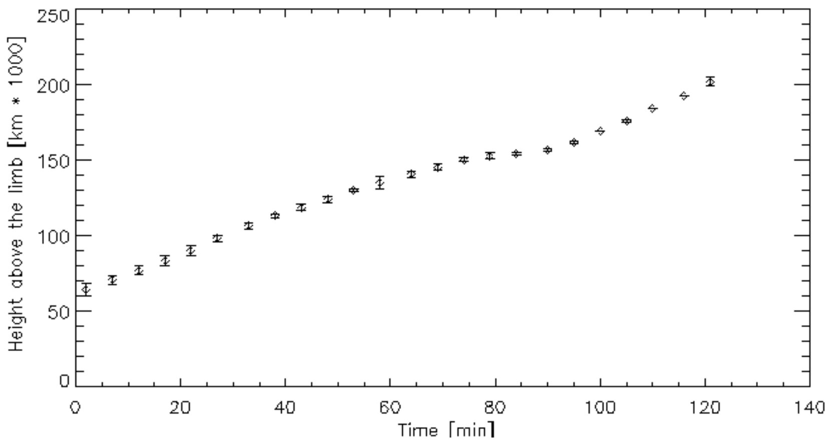






Not SEP-related EP



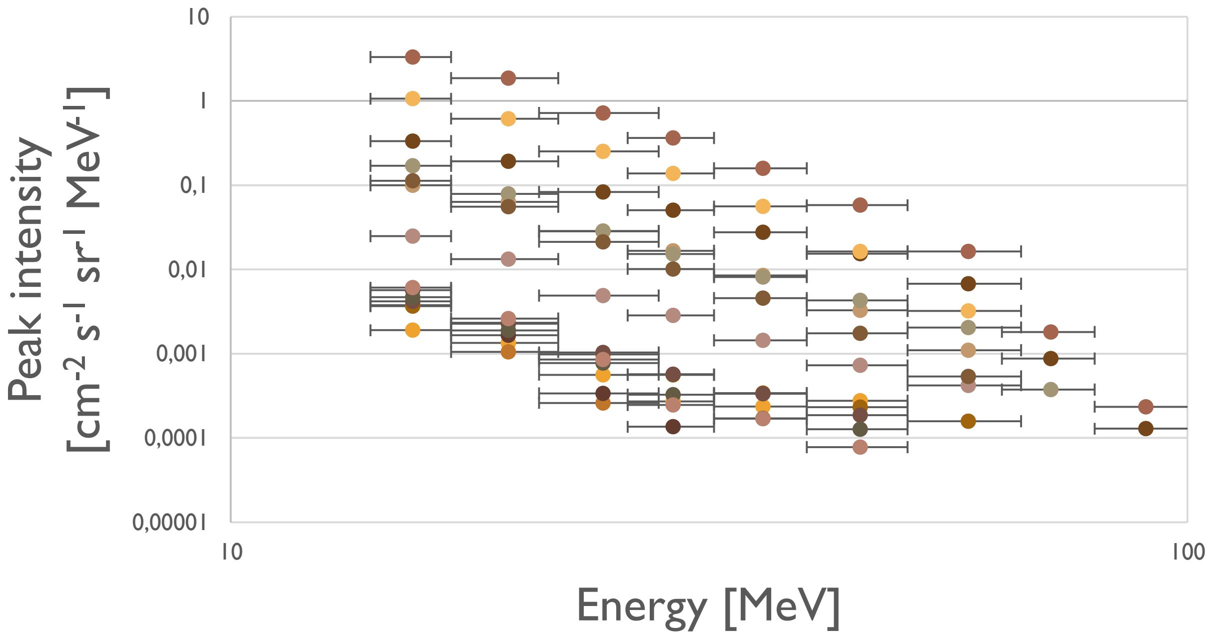


- *13 SEP-related EPs*
- *27 EPs not followed by SEP events*

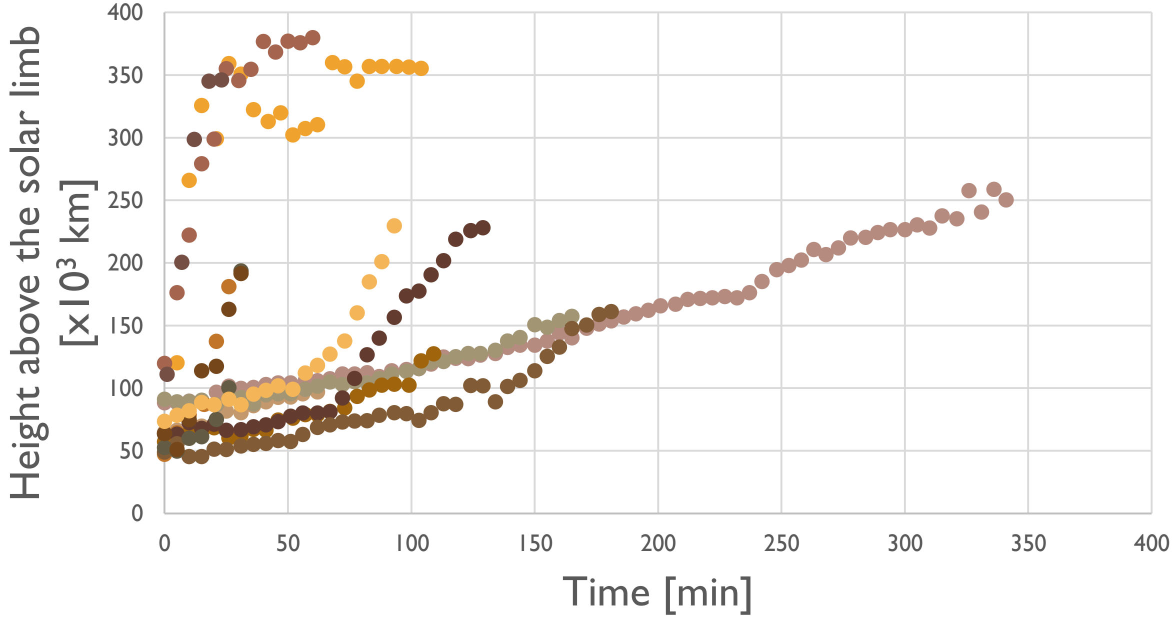
RELATED PHENOMENA IMPACT

SEP-PRODUCTIVITY

EP-related SEPs Energy Spectra



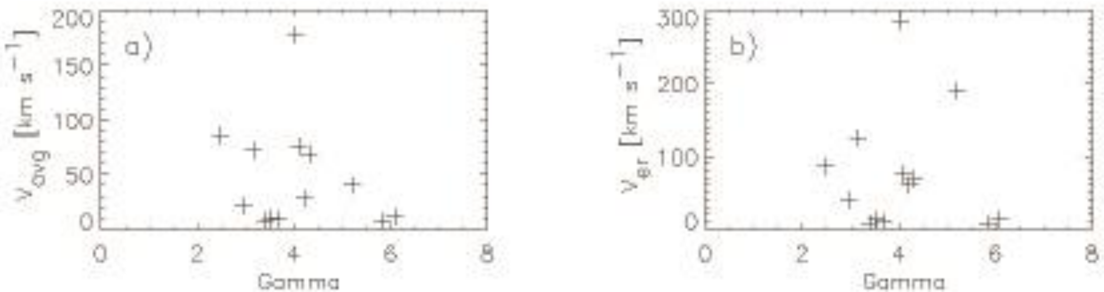
Height-time profile of SEP-related EPs



Power-law function fit

$$\frac{dN}{dE} = kE^{-\gamma}$$

Spectral index



CONCLUSIONS

- Velocity disturbances during prominence eruptions
- No influence from:
  - Eruption type (symmetric/assymetric)
  - Full/partial/confined eruption
  - Nearby active regions/coronal cavities
  - Solar cycle
- No influence on:
  - Associated CMEs
  - EP-related SEP events
- Specific behaviour from event to event

FUTURE DEVELOPMENT

- Modelling prominence environment
- Structure of prominence/coronal cavity system

Tsvetkov, Ts., Petrov, N.: 2018, Journal of Atmospheric and Solar-Terrestrial Physics **177**, p. 29–37

- This study is part of the Bulgarian-Russian project:

The origin of solar energetic particles: solar flares vs. coronal mass ejections

https:// http://newserver.stil.bas.bg/SEPorigin

SEPorigin

SEPorigin

THANK YOU!

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