GENERATION MECHANISMS OF QUASI-PARALLEL AND QUASI-CIRCULAR FLARE RIBBONS IN A CONFINED FLARE

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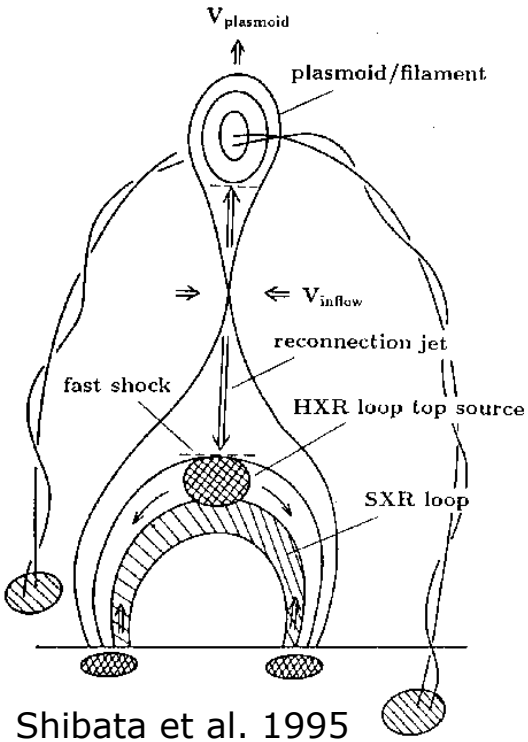
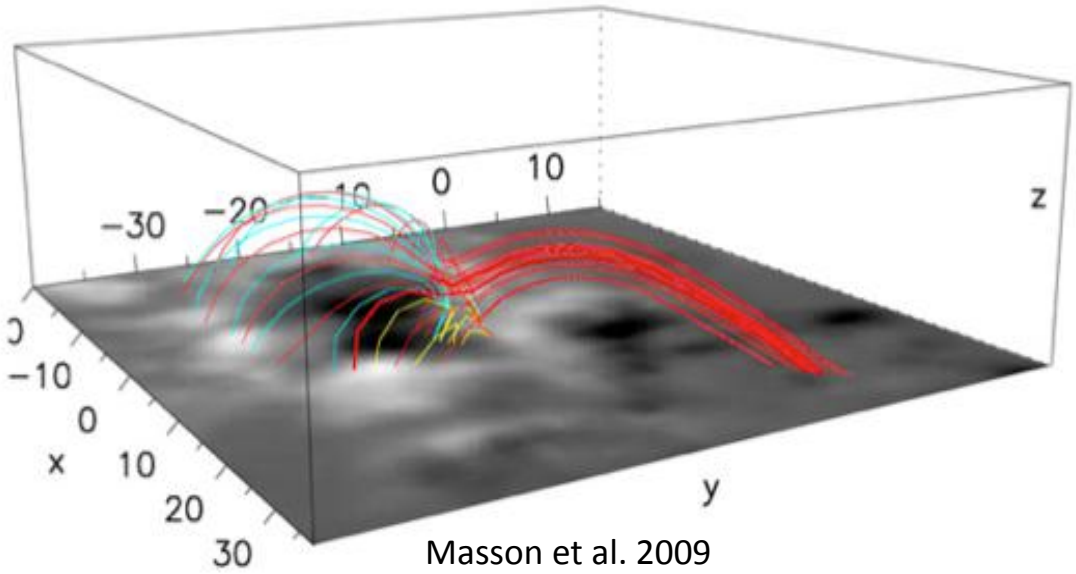
1. Introduction

- Ribbon formation: Electrons, accelerated to non-thermal energies in and around the reconnection region, spiral along the newly reconnected magnetic field toward the denser lower solar atmosphere, producing X-ray emission in the form of quasi-parallel ribbons.

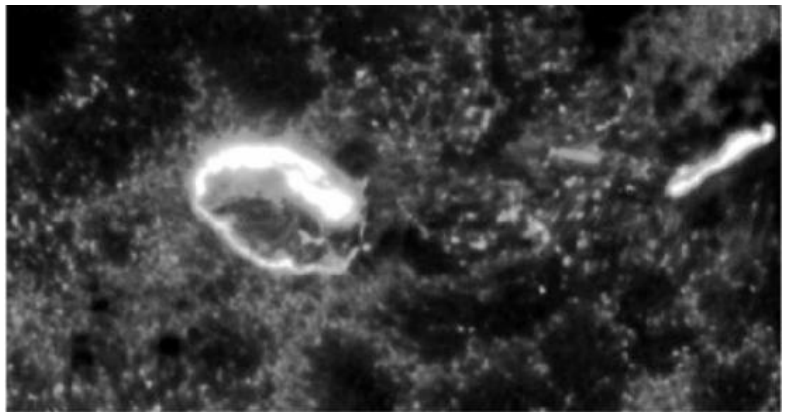


Shibata et al. 1995

- The fan-spine topology of a 3D null-point:



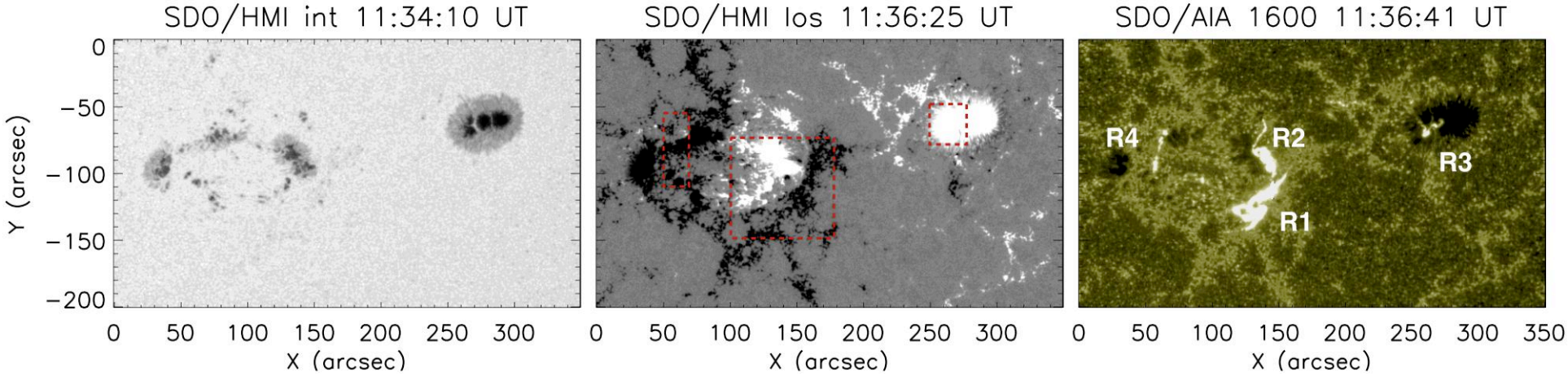
Masson et al. 2009



Shibata, K., Masuda, S., Shimojo, M., et al. 1995, ApJ, 451, L83
Masson, S., Pariat, E., Aulanier, G., & Schrijver, C. J. 2009, ApJ, 700, 599

2.1 Event Overview and (E)UV and X-ray flare morphology

Date: January 29th 2015
Heliographic position: S10°,W18°
Active Region: NOAA 12268



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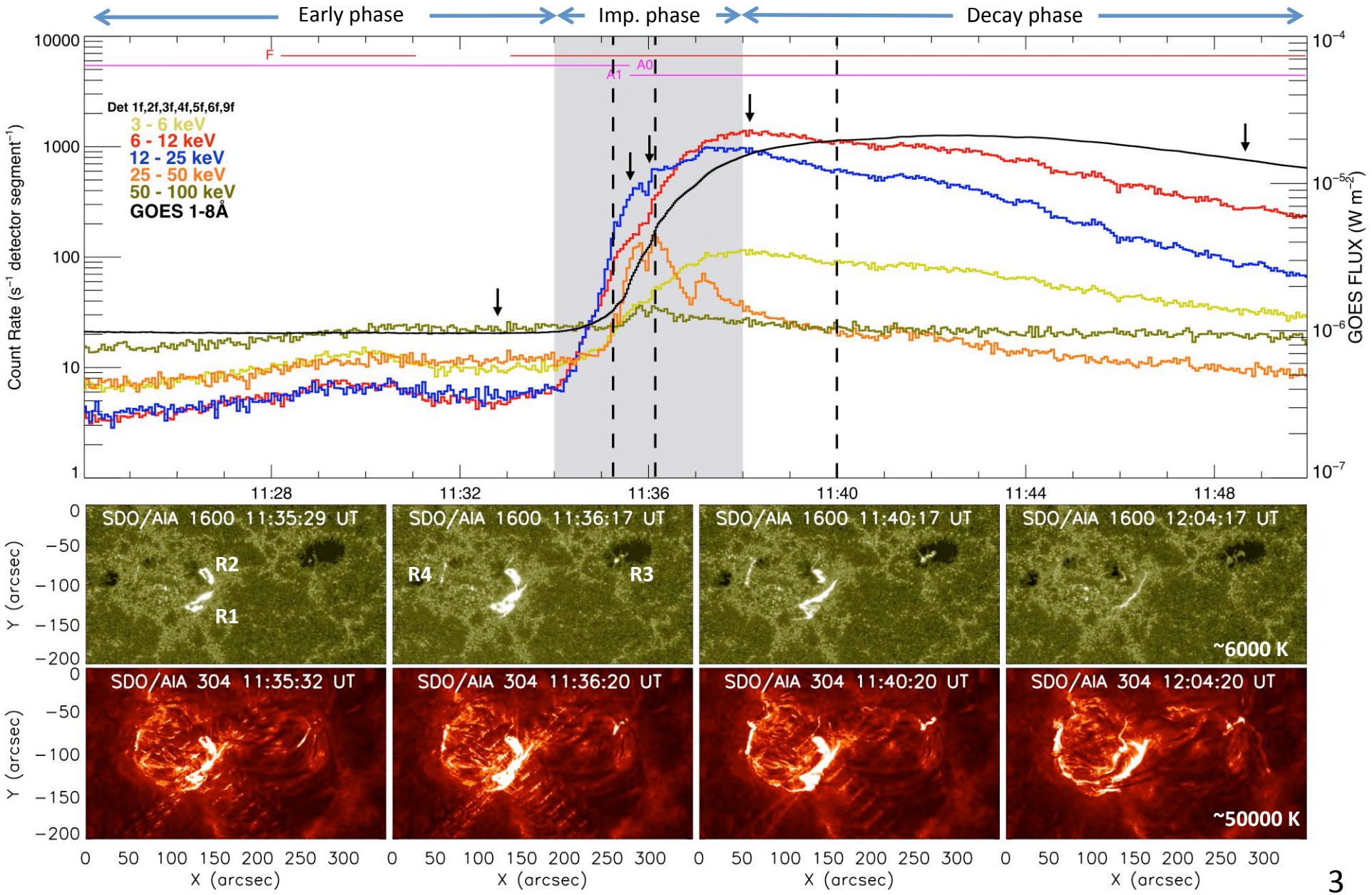

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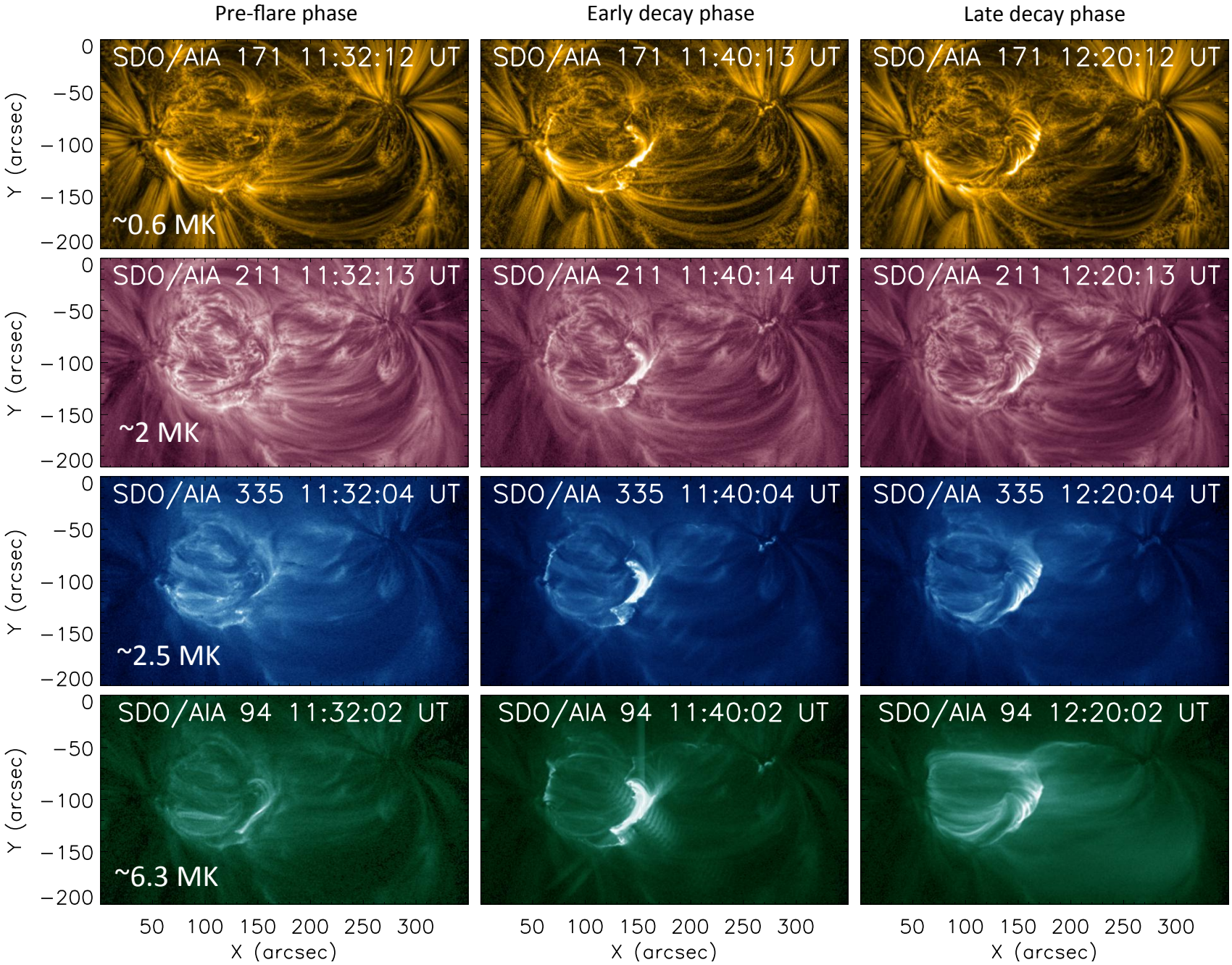
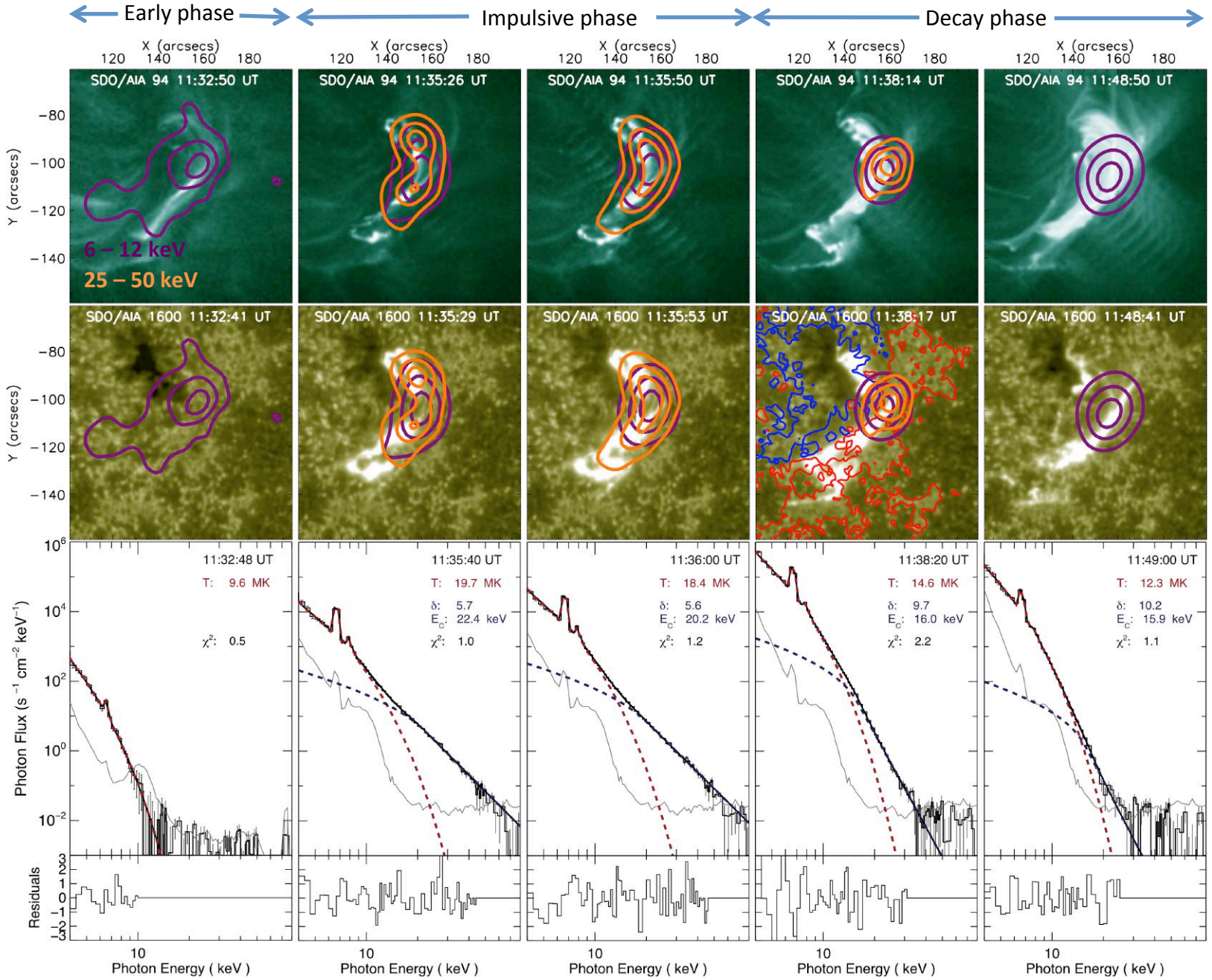


2.2 Spatial and temporal correspondence of UV and HXR emission



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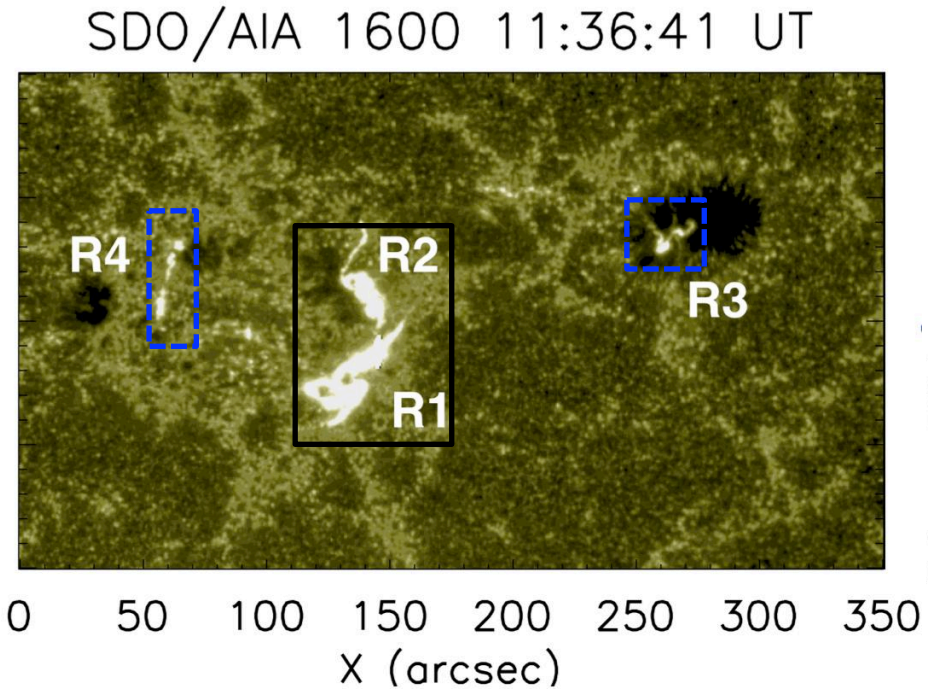
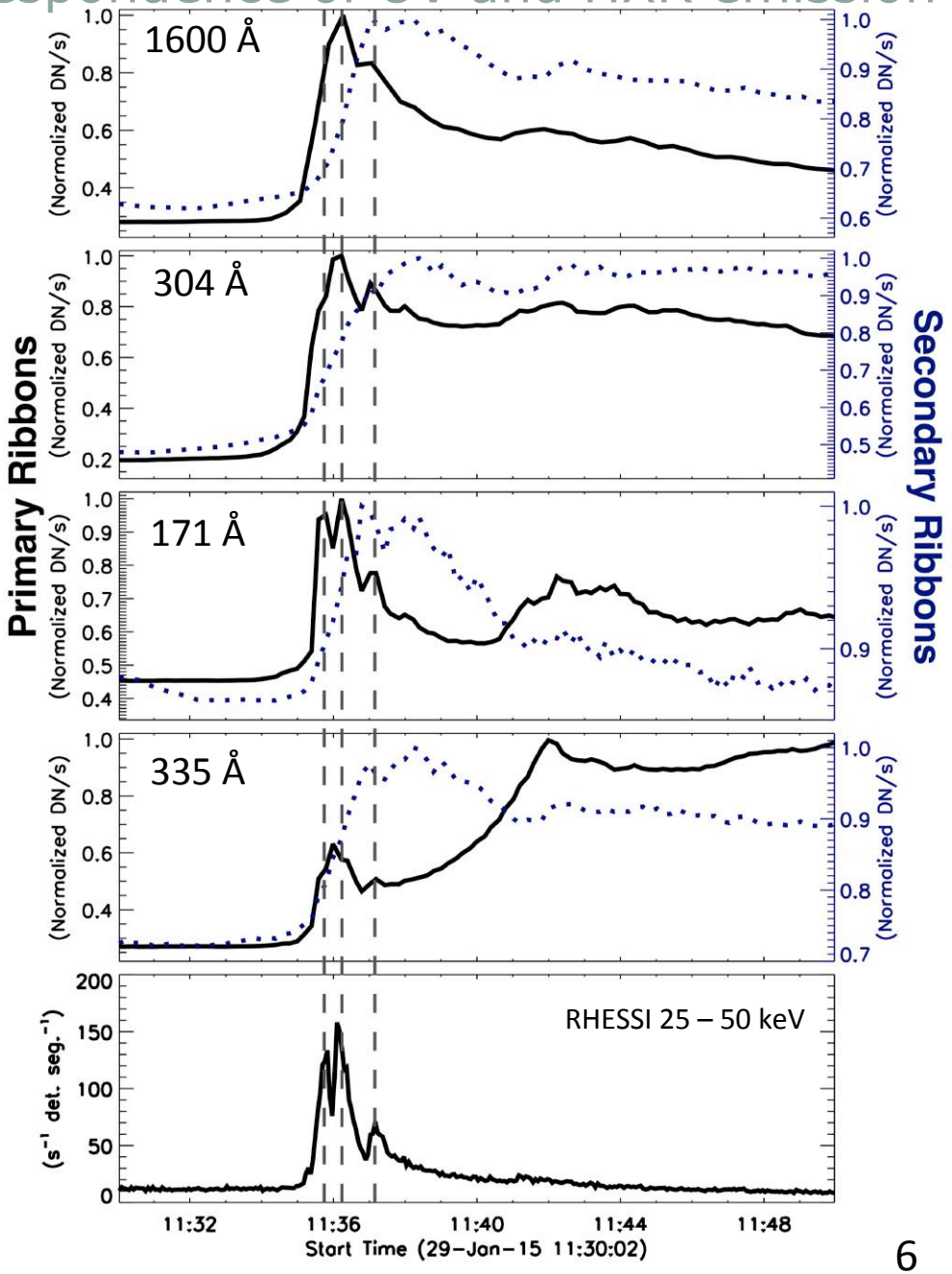
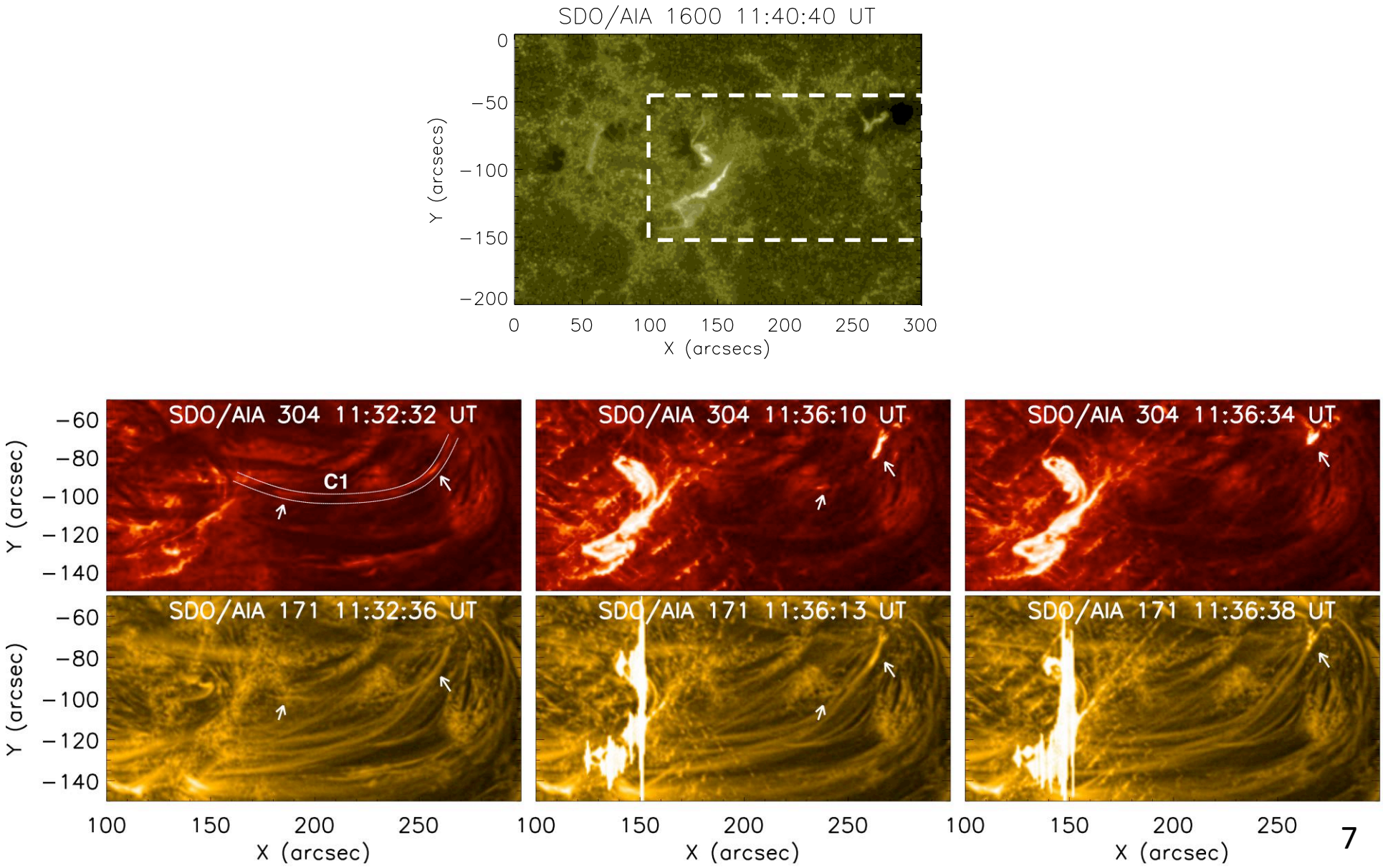




- The HXR peaks correlate with the peaks of the brightness for the primary ribbons for AIA 171 Å.
- The maximum brightness of secondary ribbons is registered at 11:38 UT.
- The peaks for the secondary ribbons have a longer decay time of about 5 minutes.

2.3 Possible causes of secondary (remote) flare ribbons



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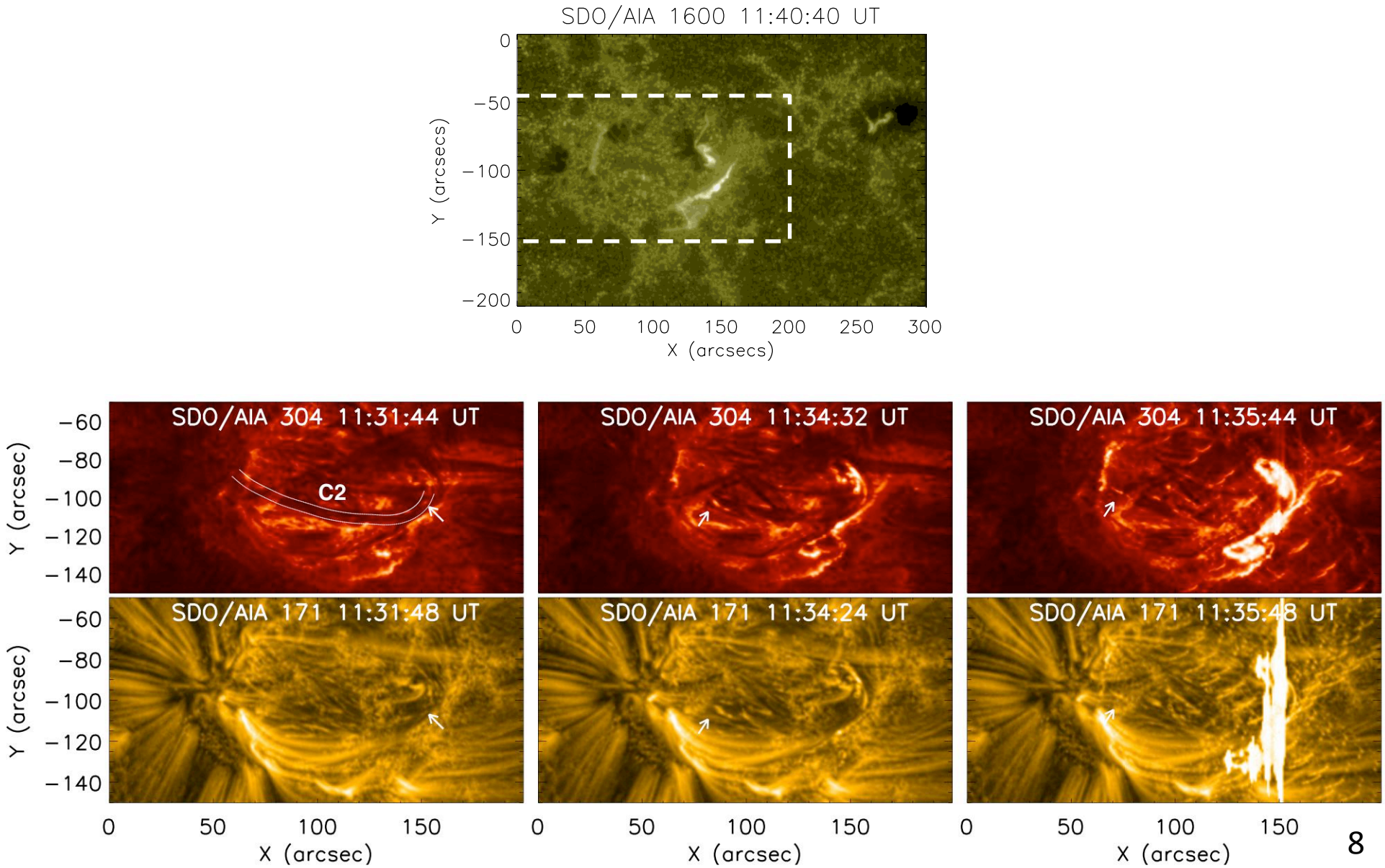

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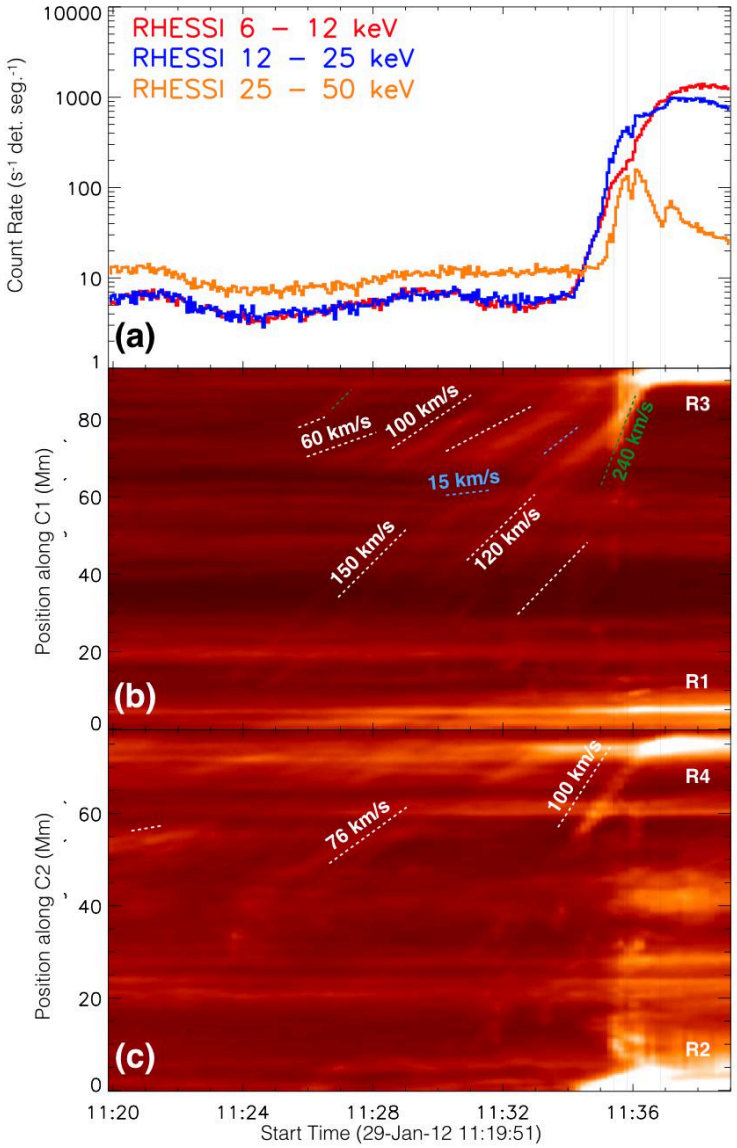
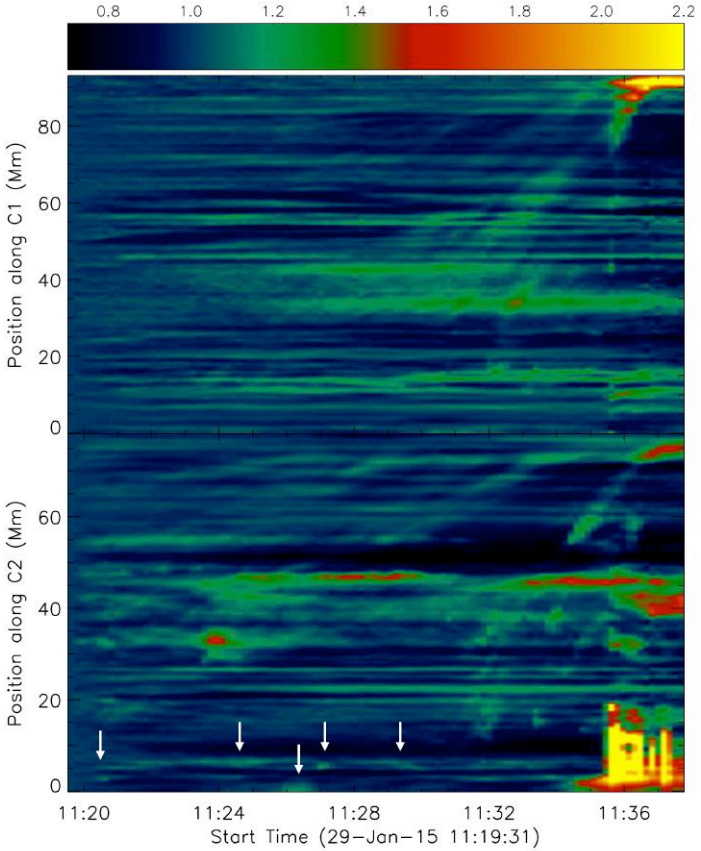


- Speeds: Below 630 km/s
- Acceleration
- Deceleration
- Amplitude increase of about 30-40%
- Amplitude increase at R3: >100%
- Amplitude increase at R4: 60 - 70%



2.3 Possible causes of secondary (remote) flare ribbons

	De Moortel et. al. (2002)	**Our study**
Observed in EUV channels	171, 195 (only 2 cases)	All
Speed (km/s)	25 - 165	< 630
Intensity increase	< 10 %	30 - 40 %
Downward motion	No	Yes
Acceleration	No	Yes
Deceleration	No	Yes

De Moortel, I., Hood, A.W., Ireland, J., Walsh, R.W., 2002b, Solar Phys.,209,89–108.

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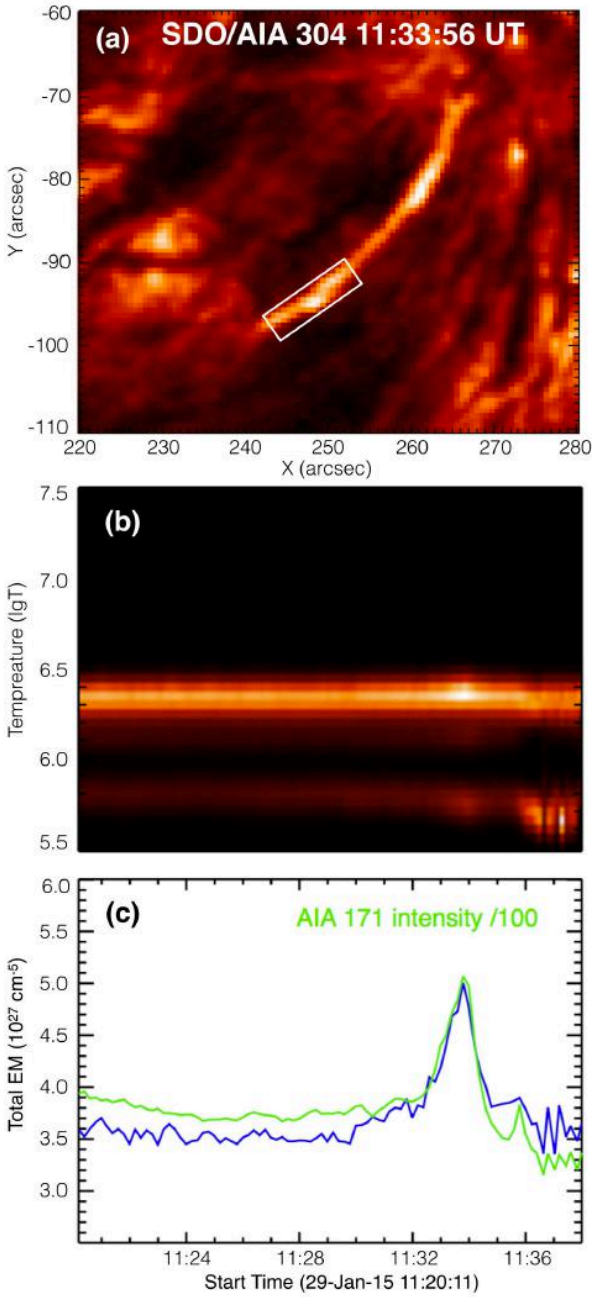


Size: 12'' (length) and 3.6'' (width and depth).

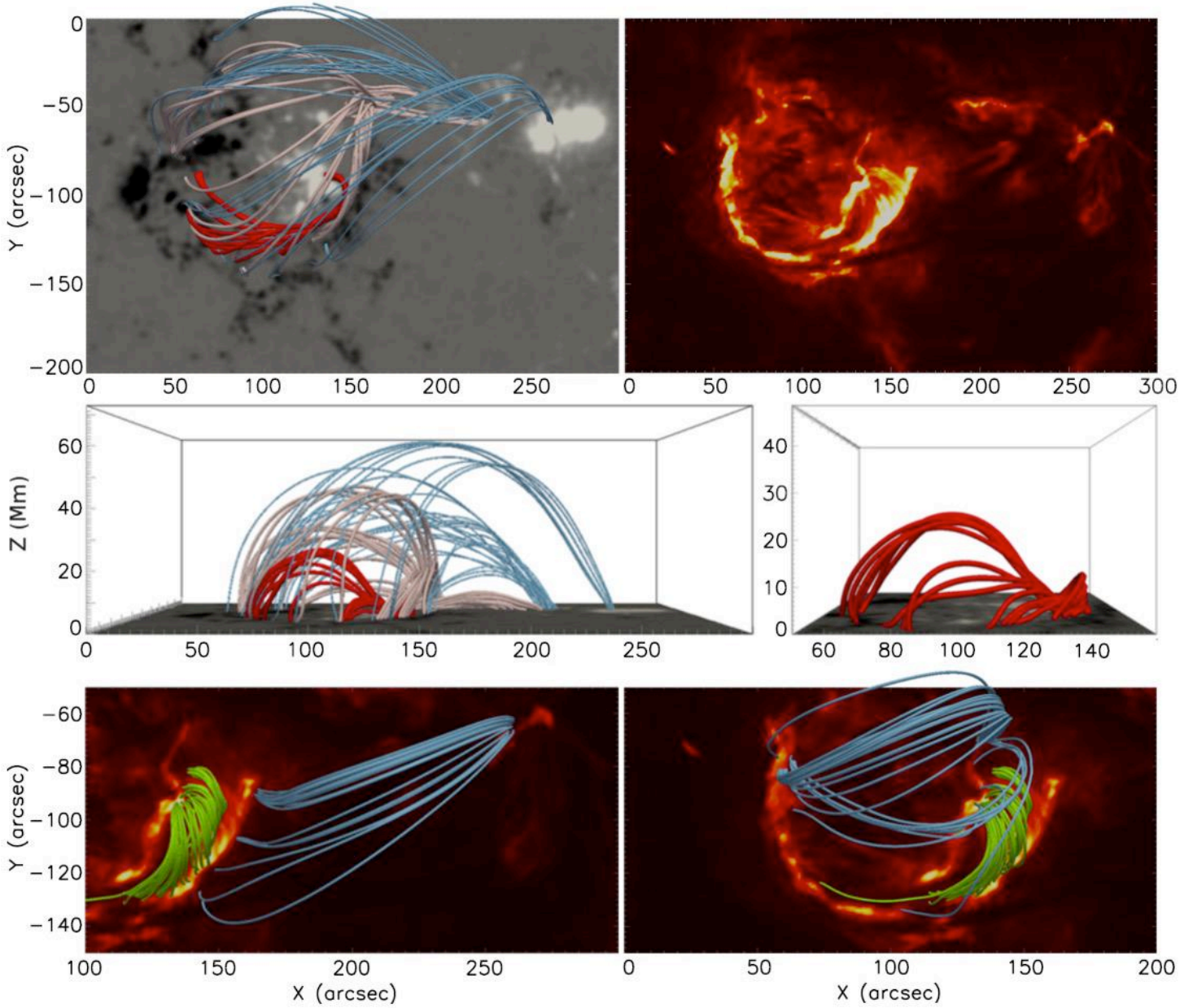
Plasma temperature: 3MK
EM increase: 1.5 x 10^{27} cm^{-5}

$$\frac{\rho_{structure}}{\rho_{background}} = \sqrt{\frac{EM_{peak}}{EM_{background}}} = 1.2$$

The peak thermal energy (Emslie et al. 2005) in R3: **10^{27}** erg.

Mass: 4.8 x 10^{8} kg
Speed: 630 km/s
Kinetic energy: **8 x 10^{26}** erg.

2.4 Non-linear force free coronal magnetic field model



3. Summary and conclusion

Primary Ribbons:
- Group of reconnected sheared arcades
- RHESSI thermal and non-thermal emission
- Strong time correlation between the (E)UV brightness and the 25-50 keV count rate.
- Direct magnetic connectivity between a null-point and the primary flare site

Secondary Ribbons:
- No X-ray sources were detected
- The maximum (E)UV emission of the SR occurs 1 min after the last 25 - 50 keV peak
- Multi-thermal plasma flows were observed to travel from the PR site to the SR sites.
- The kinetic energy for the fastest plasma flow closely matches peak thermal energy at R3
- No direct connectivity between the position of R3 and the location of the null point

Alternative scenario for the formation of the SR: the plasma flows generated during the pre-flare compressed the chromospheric material at the secondary flare sites, dissipating its kinetic energy and causing the SR.

Thank you for your attention!