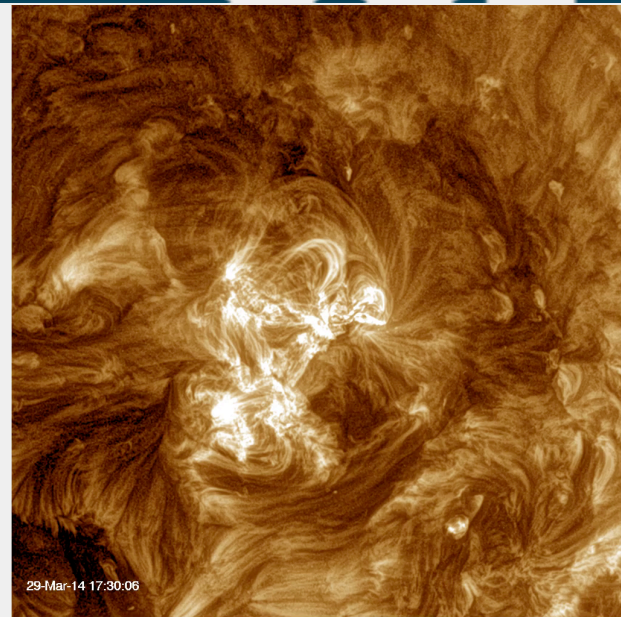


# Spectroscopic analysis of the pre-flare period leading up to the X-class flare on the 29<sup>th</sup> March 2014



Magnus M Woods<sup>1</sup>, Louise K Harra<sup>1</sup>, Sarah Matthews<sup>1</sup>  
Duncan H Mackay<sup>2</sup>

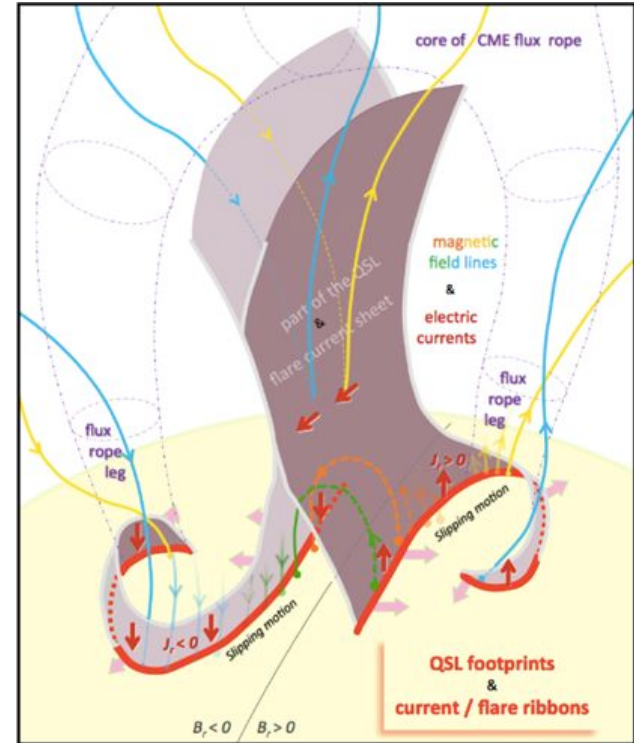
*magnus.woods.15@ucl.ac.uk*

*<sup>1</sup>UCL-Mullard Space Science Laboratory*

*<sup>2</sup>University of St. Andrews*

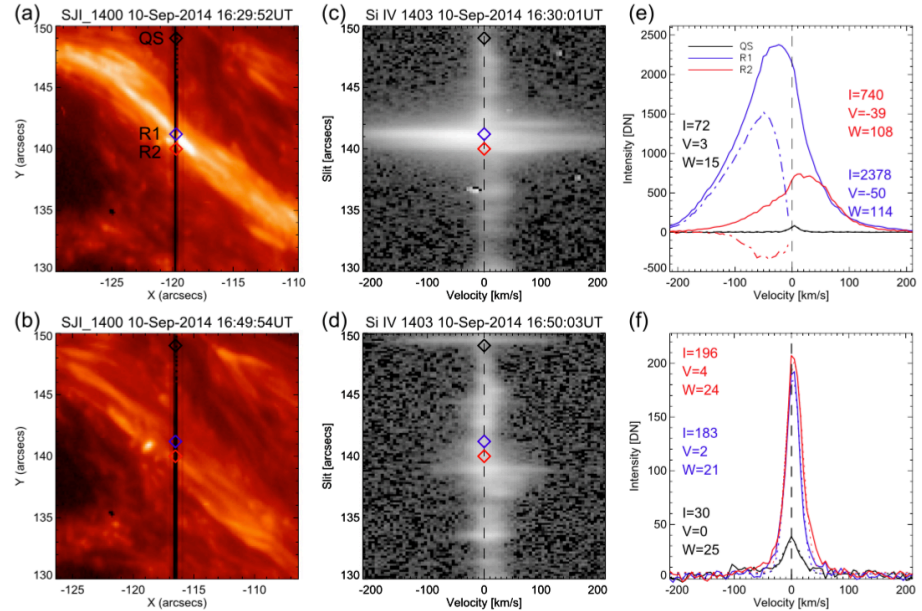
# Flares and their triggers

- Rapid releases of stored magnetic energy in the corona.
- Release thought to be the result of reconnection of field lines
- Possible trigger mechanisms could be; flux emergence (Heyvaerts et al. 1977); flux cancelation (Van Ballegooijen & Martens 1989); or sunspot rotation (Sundra Raman et al. 1998).



# Possible flare trigger indicators

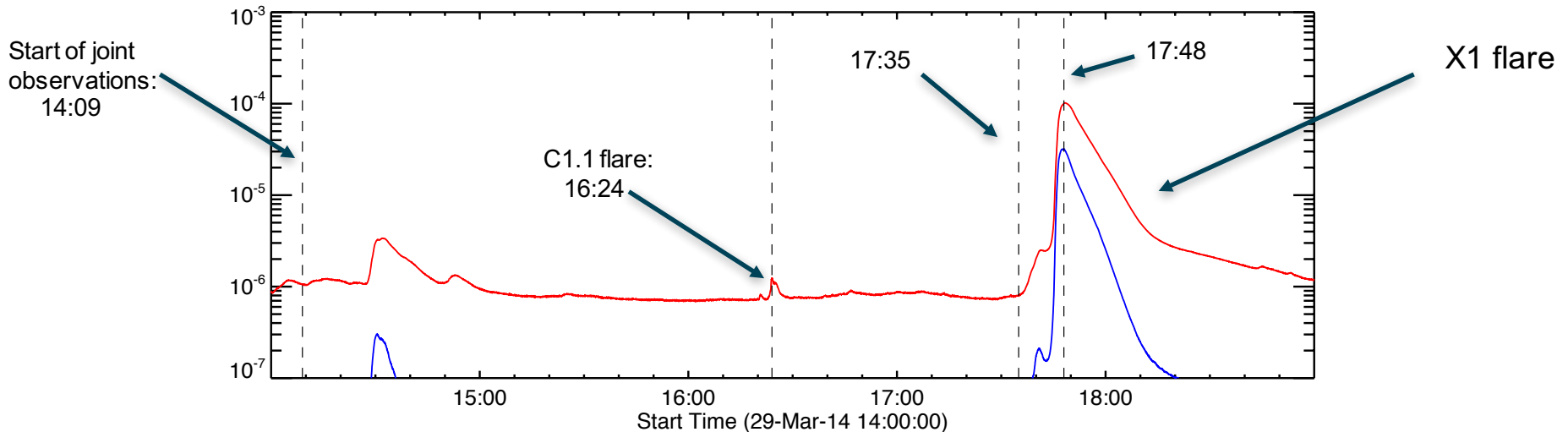
- Intensity enhancements;  
eg. Warren et al. (1999)
- Plasma flows;  
eg. Cheng et al. (2015)
- Non-thermal velocity enhancements;  
eg. Doschek (1980), Harra (2001, 2009)

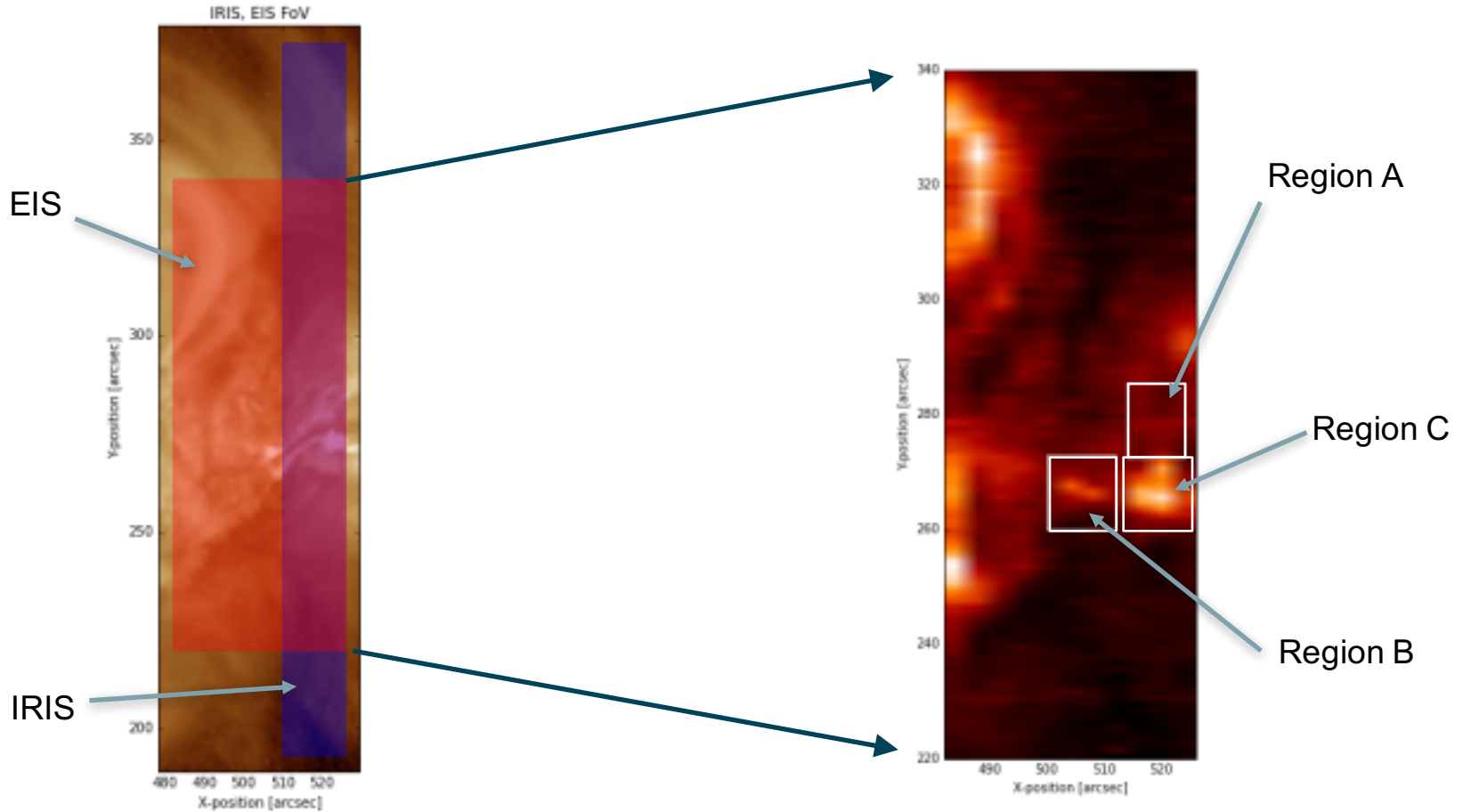


Cheng et al. (2015)

# 29 March 2014, X1 flare

- Possibly the best observed flare event, with both space and ground based observations in numerous wavelengths.
- Quality of available data makes it a source of intense study eg. Judge (2014), Kleint et al.(2015), Matthews et al. (2015), Aschwanden (2015) etc.





# Site of C-flare: Region A

Region A: Intensity vs Vnt

Fe XII 192 Å

Intensity

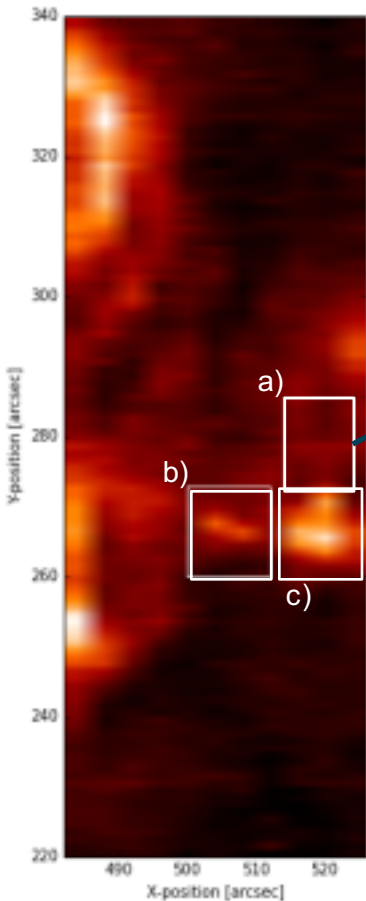
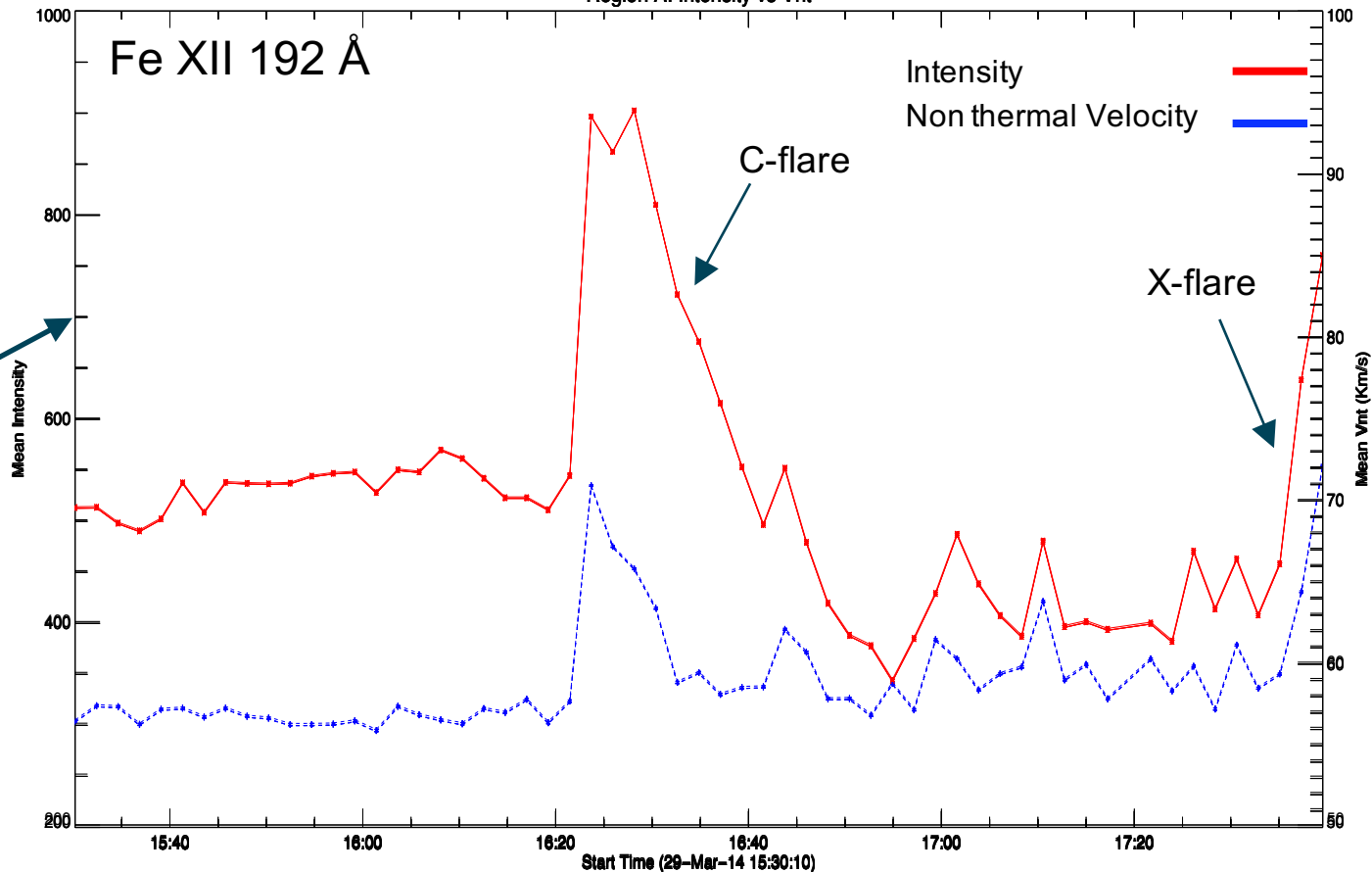
Non thermal Velocity

—

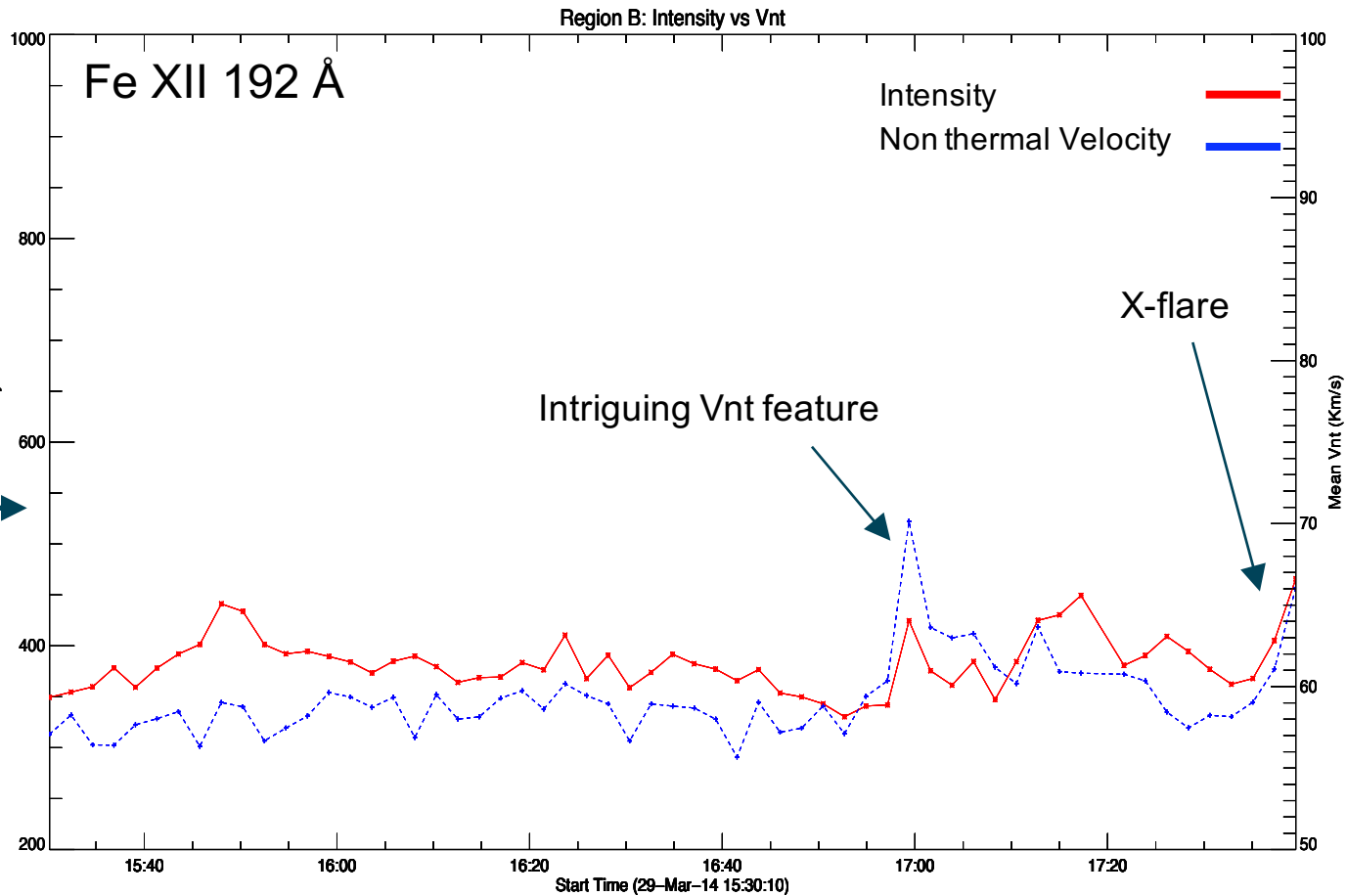
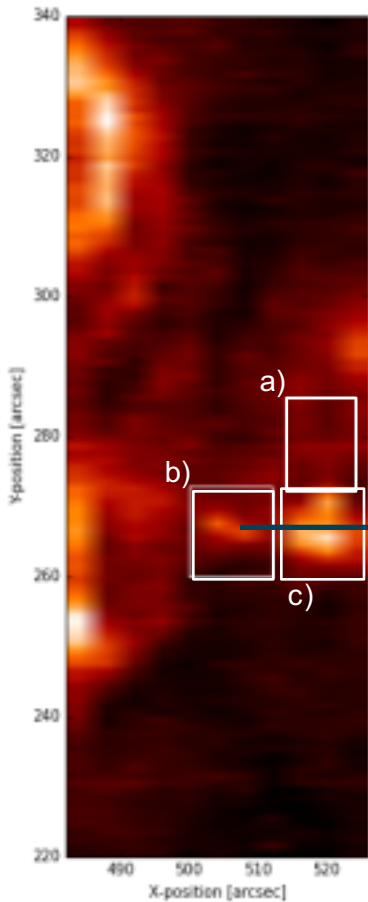
—

C-flare

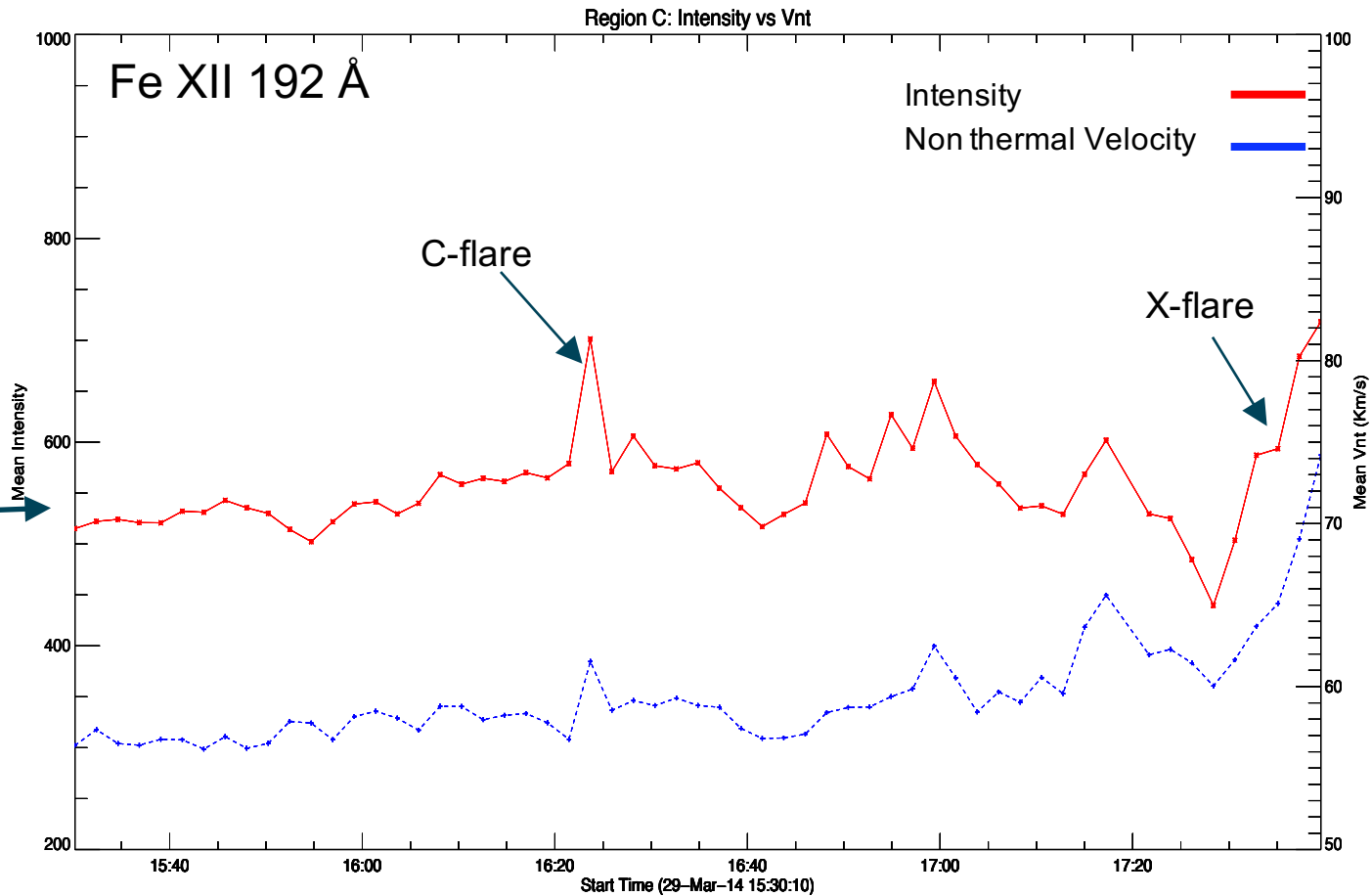
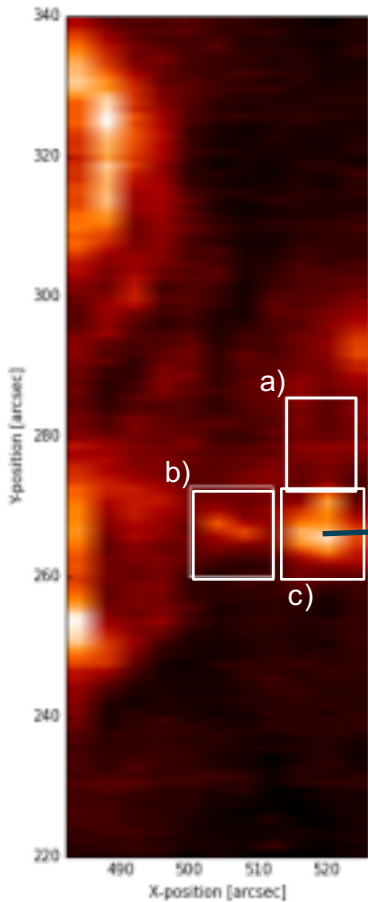
X-flare



# Site of preflare Vnt feature: Region B



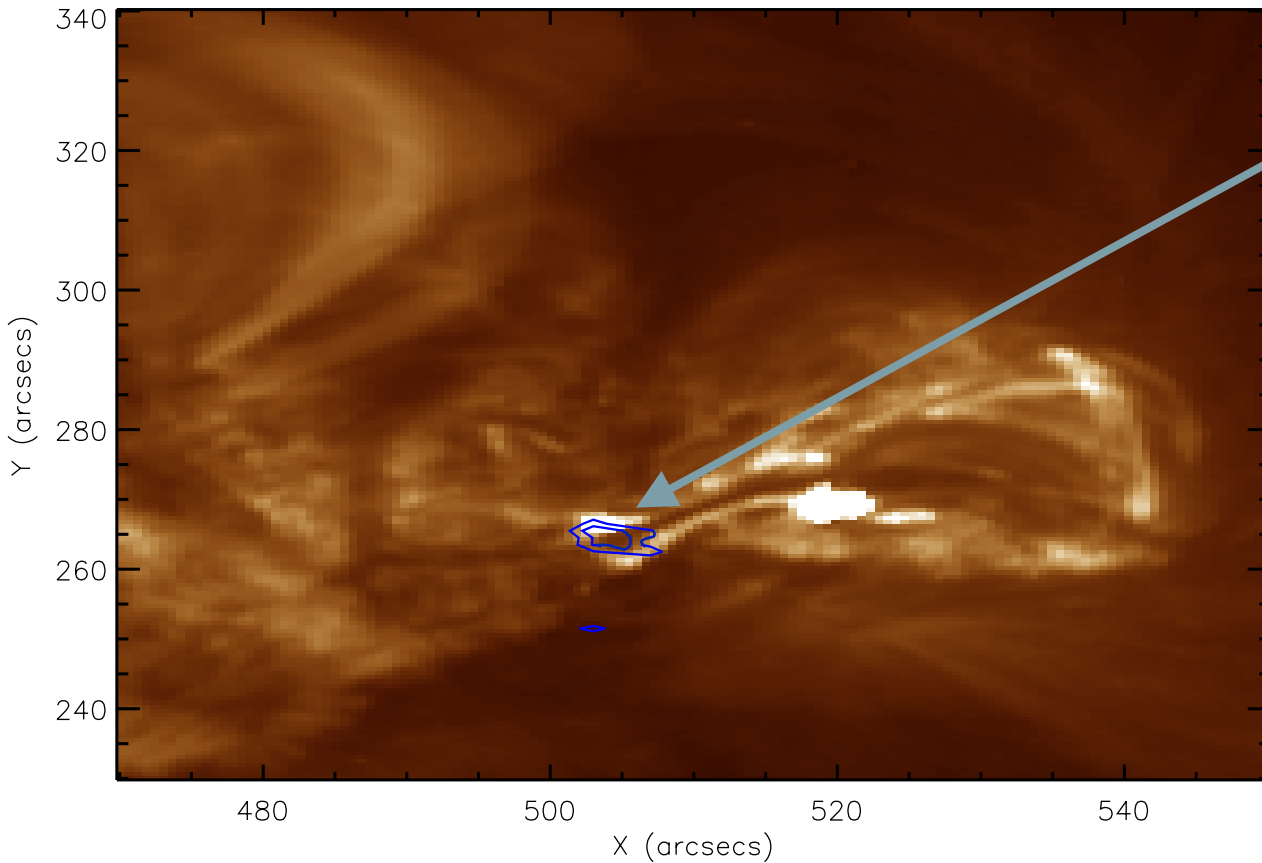
# Site of earliest response to X-flare: Region C





## Coronal Dynamics

29-Mar-2014 17:00:06.840

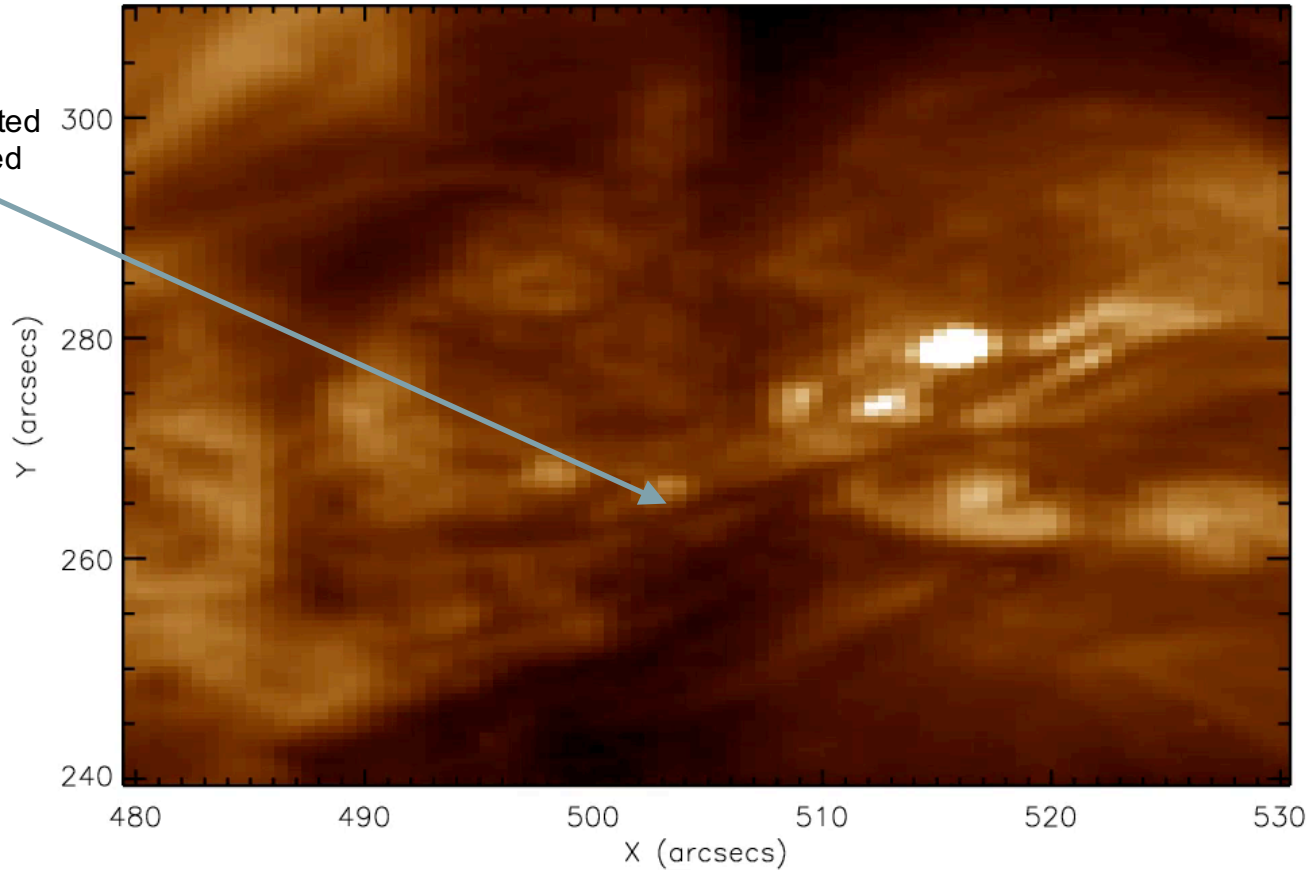


- The coronal Fe XII 192Å data show the Vnt feature to lie across the filament.
- This feature is also found to be blue shifted with velocities of  $\sim 20$  km/s

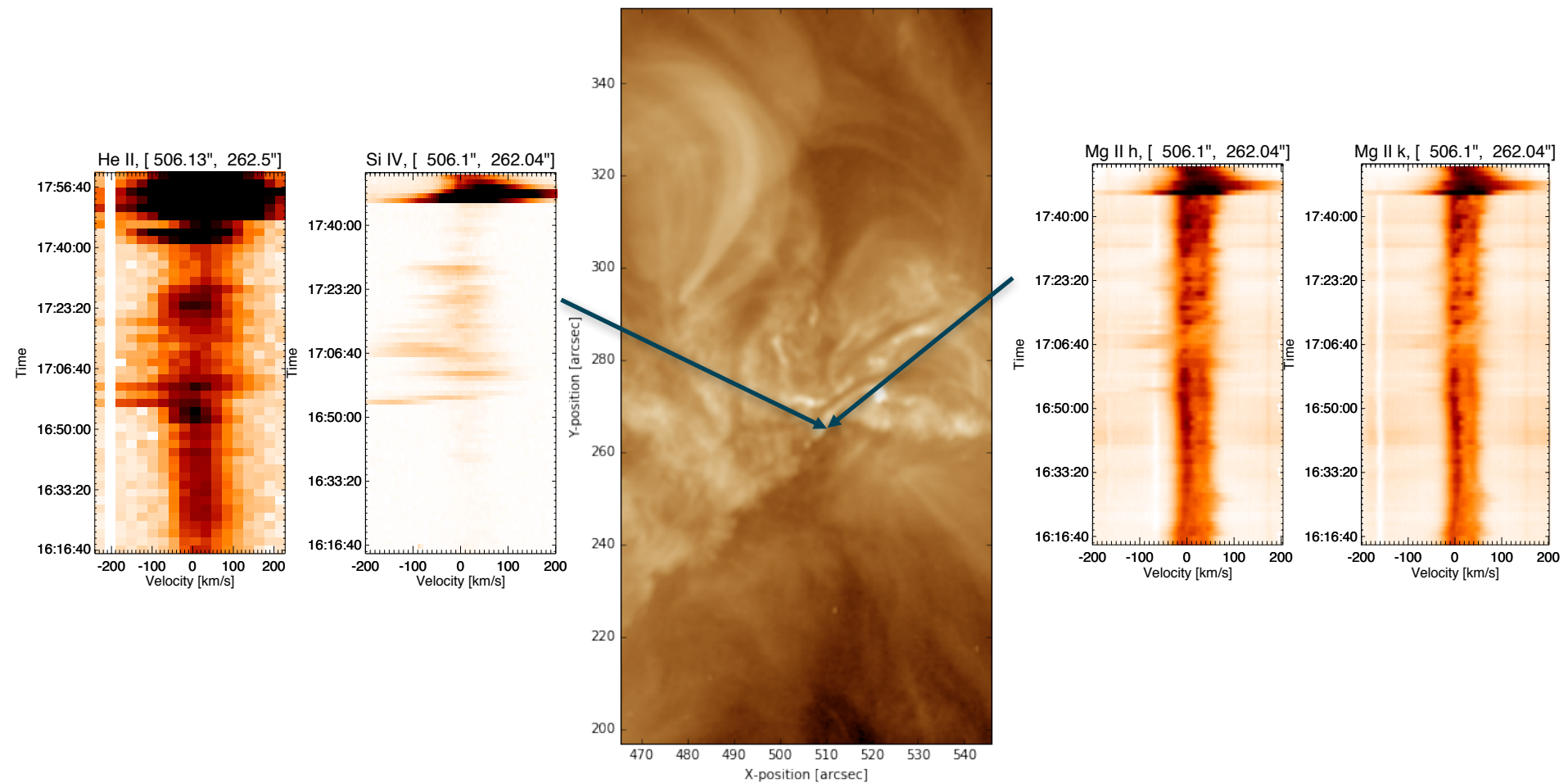
## Coronal Dynamics

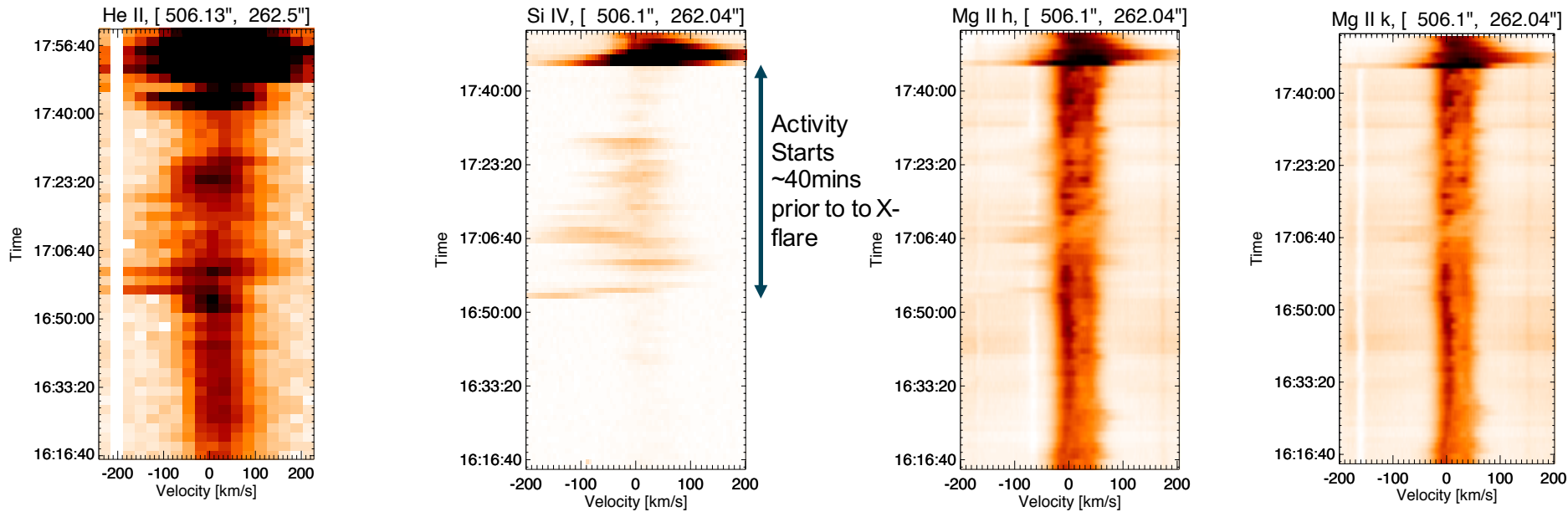
29-Mar-2014 16:40:30.840

Site of blue shifted  
feature observed  
by EIS.



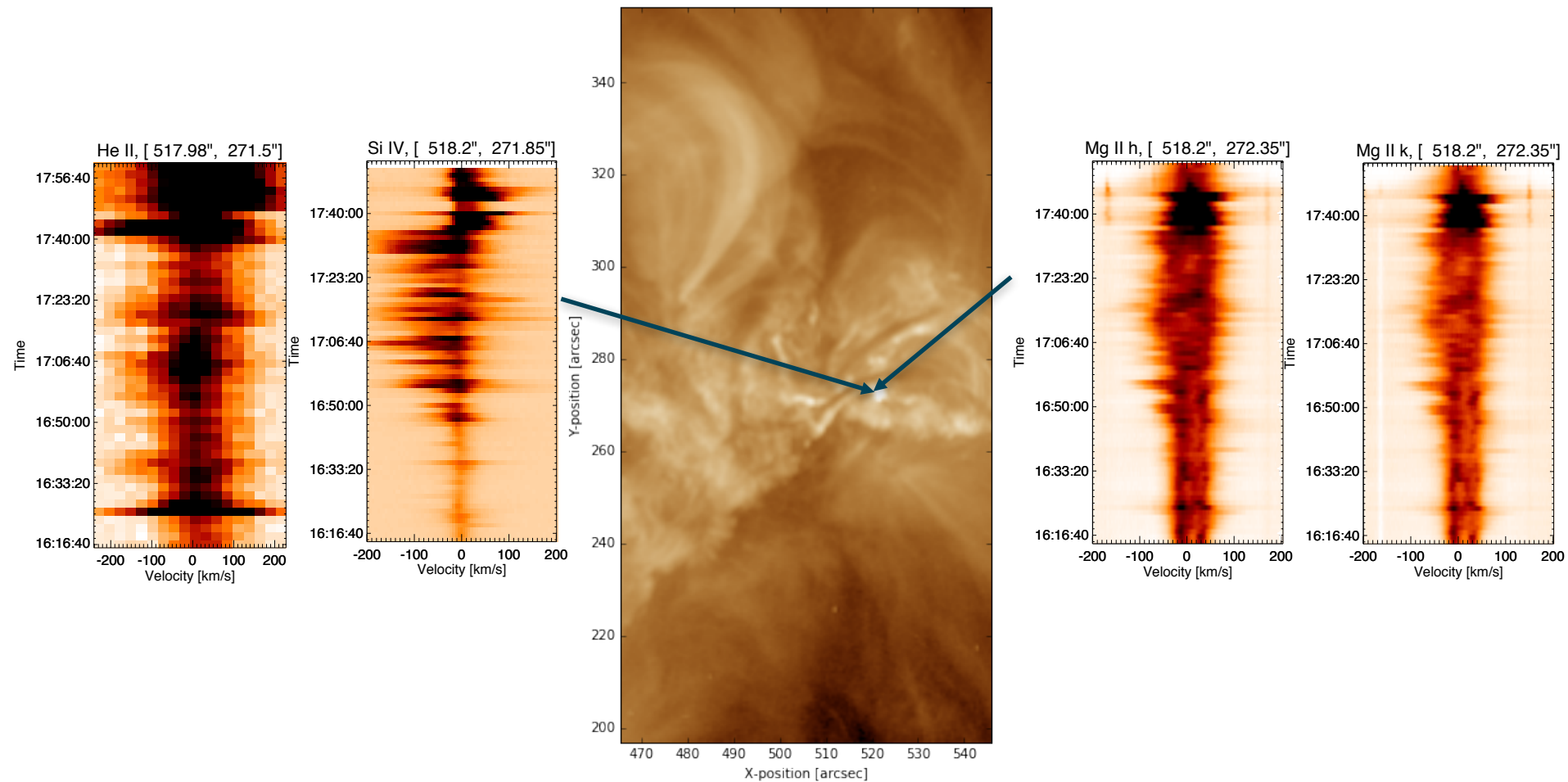
# Pre-flare response at site of early Vnt feature



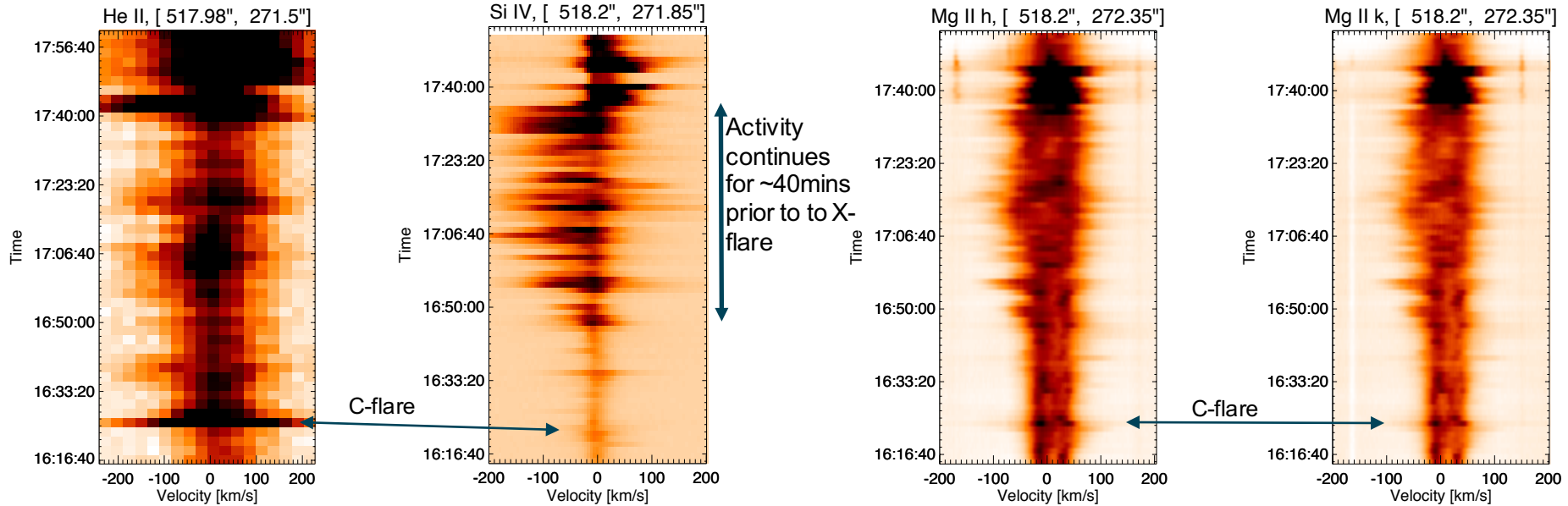


- EIS He II and IRIS Si IV observations show evidence of blue shifts within the area of the strongest coronal blueshift. Mg II spectra show asymmetries to shorter wavelengths at these times.
- These strong blueshifts in the lower atmosphere occur before and after peak Coronal blueshift, but reduce at Coronal peak time.
- These strong  $\sim 200$  km/s pre-flare blueshifts have also been observed in other active regions, Cheng et al. (2015)

# Preflare response in Region C

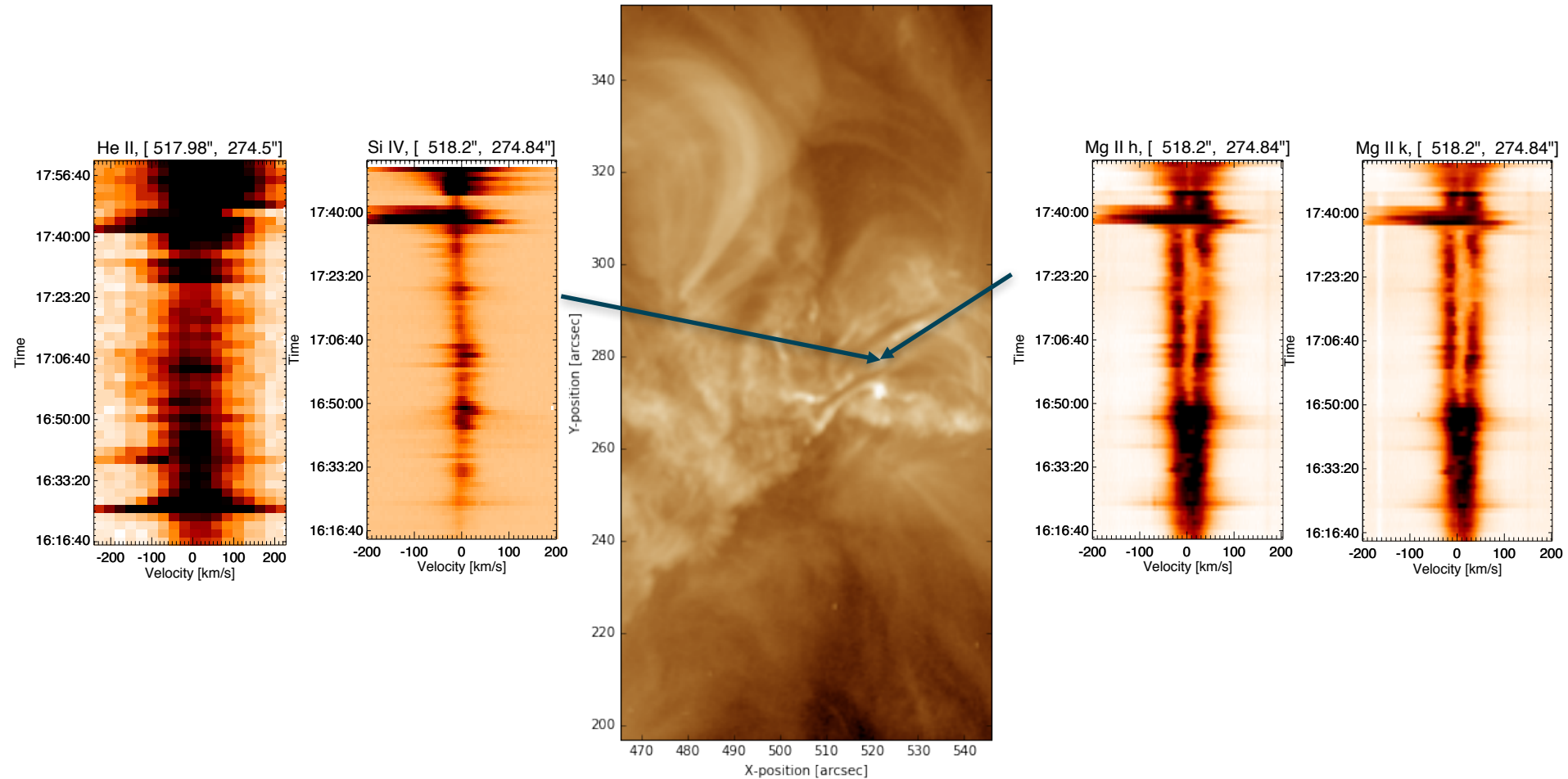


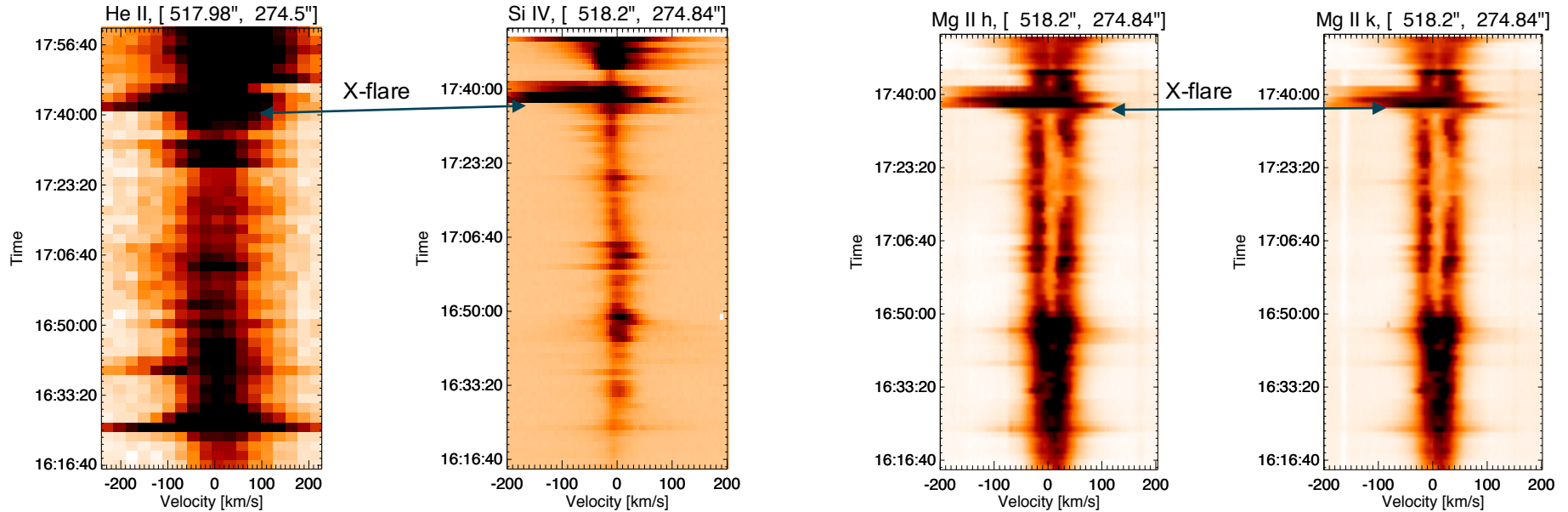
# Preflare response in Region C



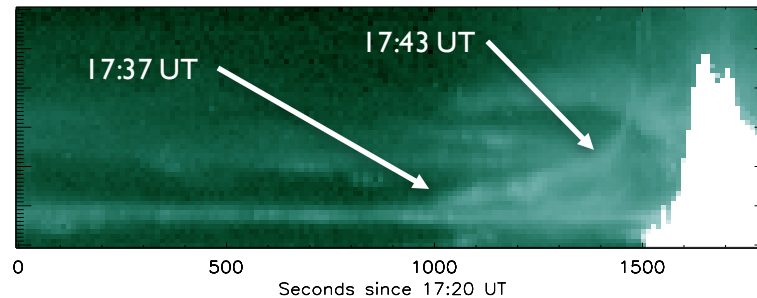
- Region C exhibits very different behavior to Region B.
- Intermittent blue shifts are seen from ~16:47 which continue until the onset of the flare at 17:35.
- Similar behavior is also observed in He II.
- Mg II observations show signs of asymmetries toward shorter wavelengths during the times when Si IV blueshifts are observed.

# Preflare response at site of C-flare





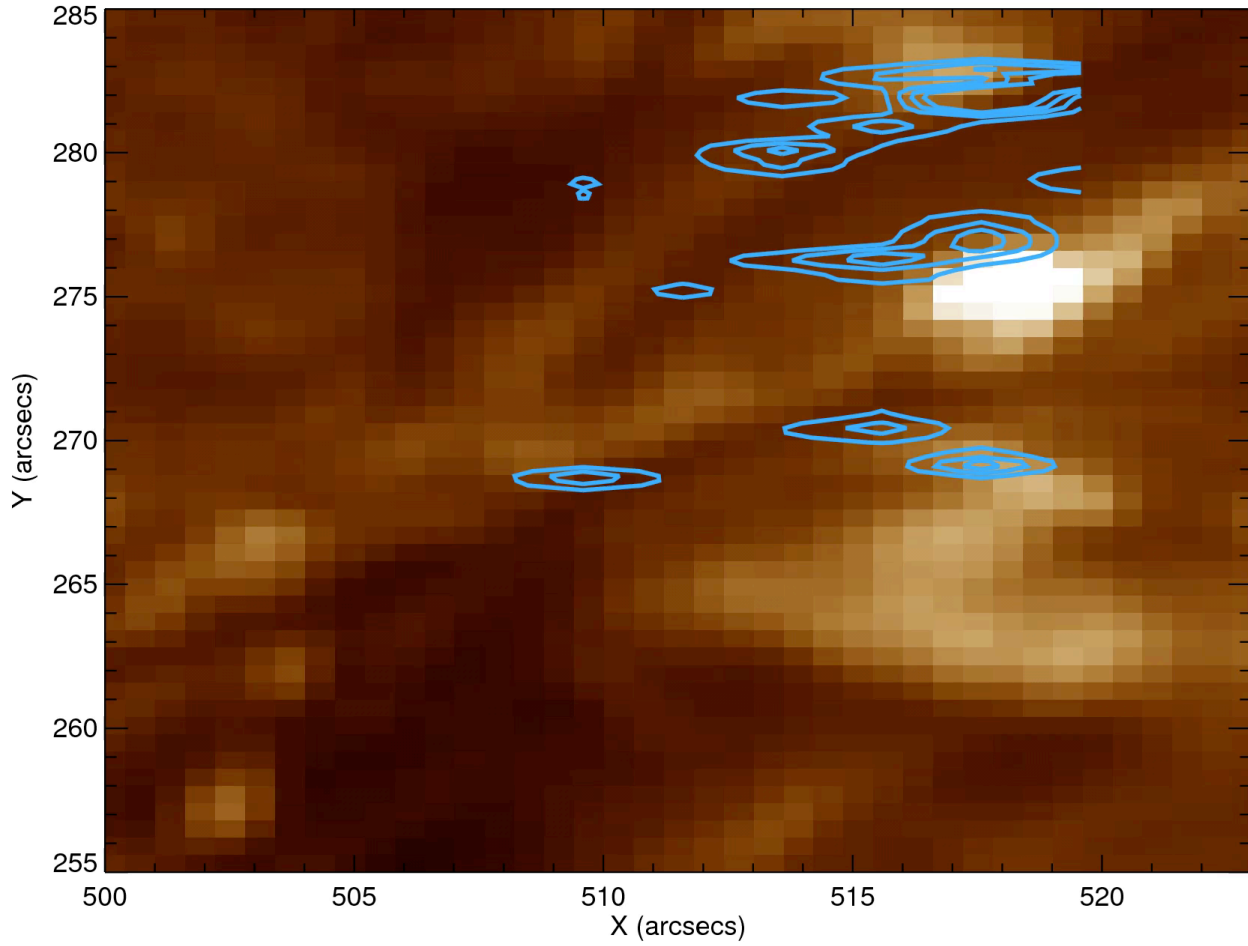
- Strong blueshifts between ~17:36 and 17:41 agree with analysis of SDO data which identifies the slow rise phase of the eruption.





# Location of preflare flows along the filament

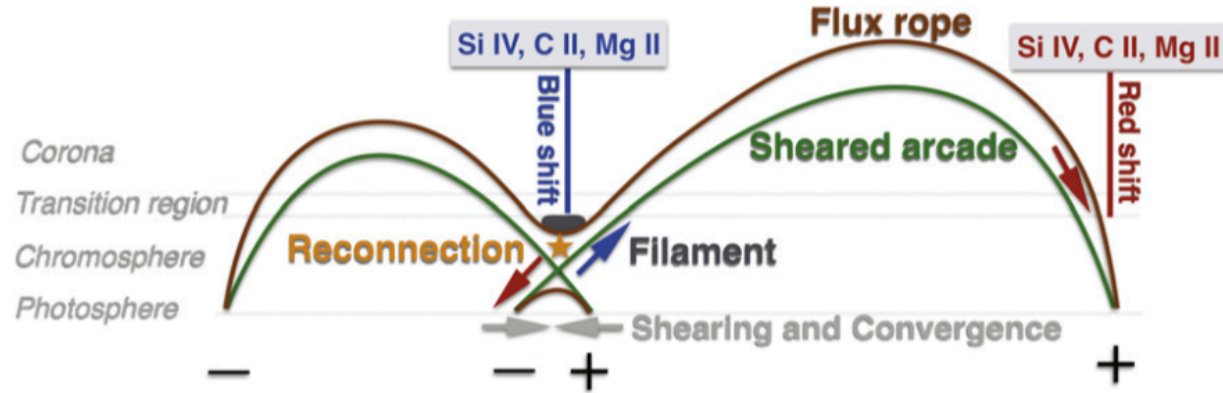
29-Mar-2014 16:51:30.840



SI IV -100km/s

# A possible interpretation?

- Cheng et al. (2015) observe -200km/s blueshifts in two separate active regions prior to flaring.

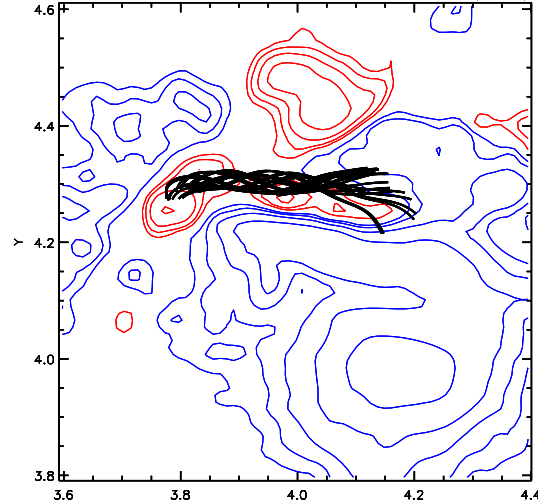


- Their interpretation is the formation of a magnetic flux rope, from two sheared arcades, with strong plasma flows being a result of reconnection.
- How does this fit with our observations?

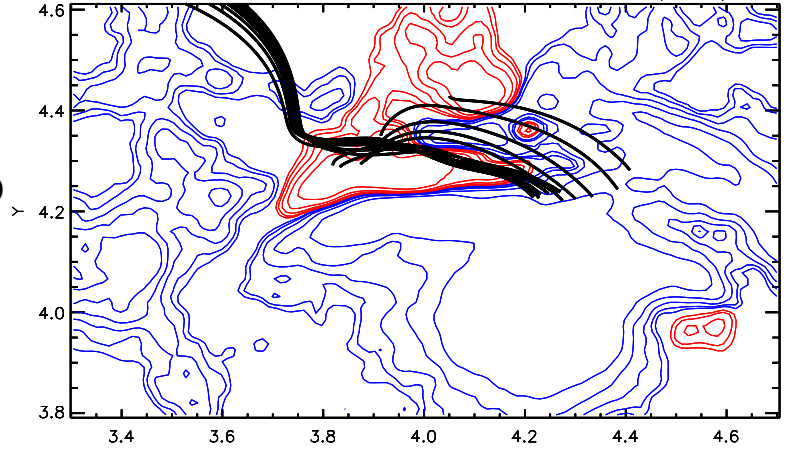
# Do we have a flux rope?

- **AIM:** Is there a flux rope, and how does it relate to the positions of our observational features?
- Initial runs of the model have produced a magnetic flux rope in the approximate position of the observed filament.
- Modeling also predicts the eruption of this flux rope.
- The presence of a flux rope in this region is also backed up by the work of Yang et al. (2016)

run3\_00078, Z= 0.00, V\_MAG\_XY, VM= 936.512, C\_MAG\_Z, CM= 1626.896, MOD (KZ= 0)



run3\_00084, Z= 0.00, V\_MAG\_XY, VM= 1156.568, C\_MAG\_Z, CM= 500.000, MOD (KZ= 0)



# Conclusions

- We have observed plasma dynamics in multiple layers of the atmosphere up to 40 minutes pre-flare.
- Up to 200km/s blueshifts have been observed in the transition region/upper chromosphere (Si IV/He II), blueshifts of tens of km/s are observed in the corona. Blue asymmetries are also observed in the lower atmosphere.
- Comparison of observations with non-potential magnetic field modeling by Duncan Mackay to determine location of possible magnetic flux rope has produced promising results, but there is further work to be done.