



# **Chromospheric Evaporation** *in an X1.0 Flare on 2014 March 29* **Observed with IRIS and EIS**

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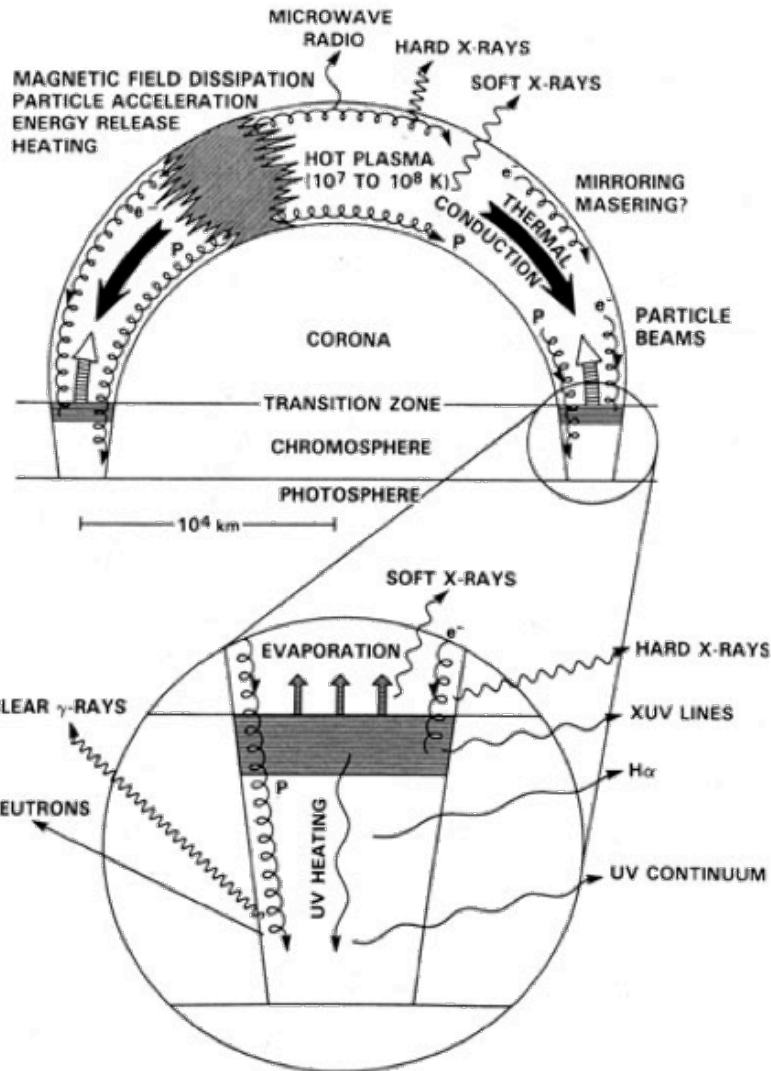


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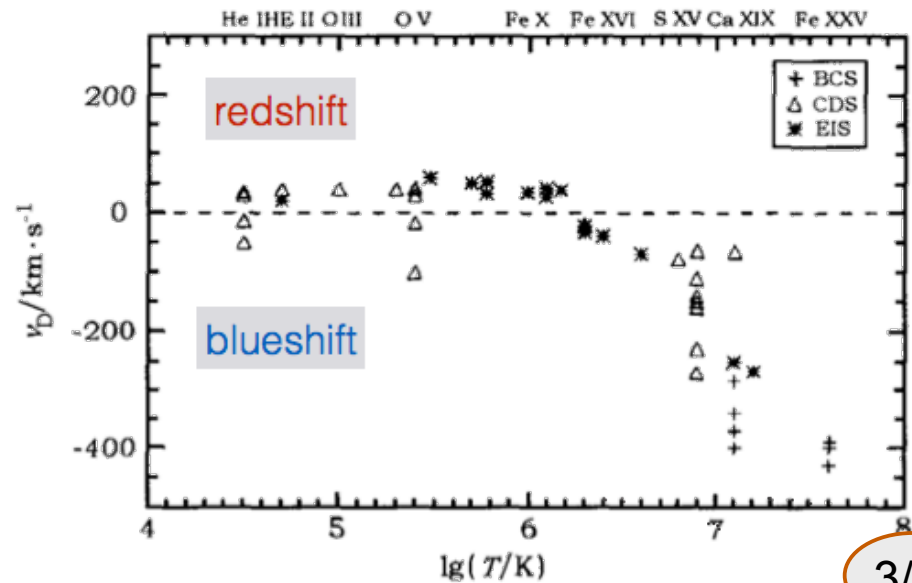
# Background

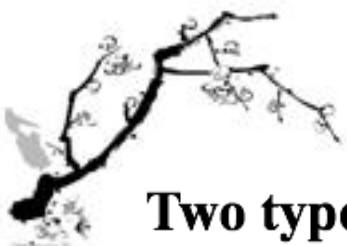


## Chromospheric evaporation

- **upward mass motions** in a flaring process due to thermal pressure  
(Feldman et al. 1980; Antonucci 1982)
- also some **downward motions** (condensation) conservation of momentum  
(Canfield et al. 1990; Fisher et al. 1985)

### in observations





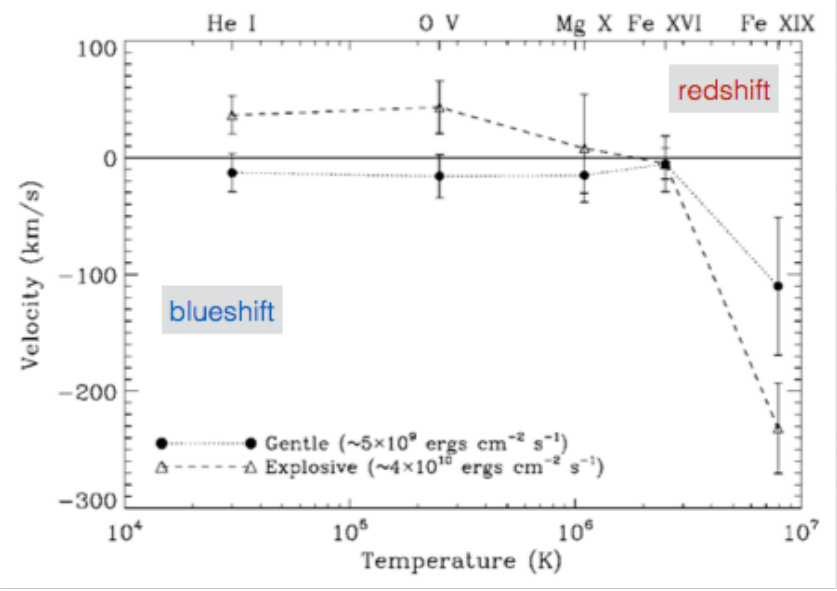
# Two types of evaporation

according to the observed Doppler velocity

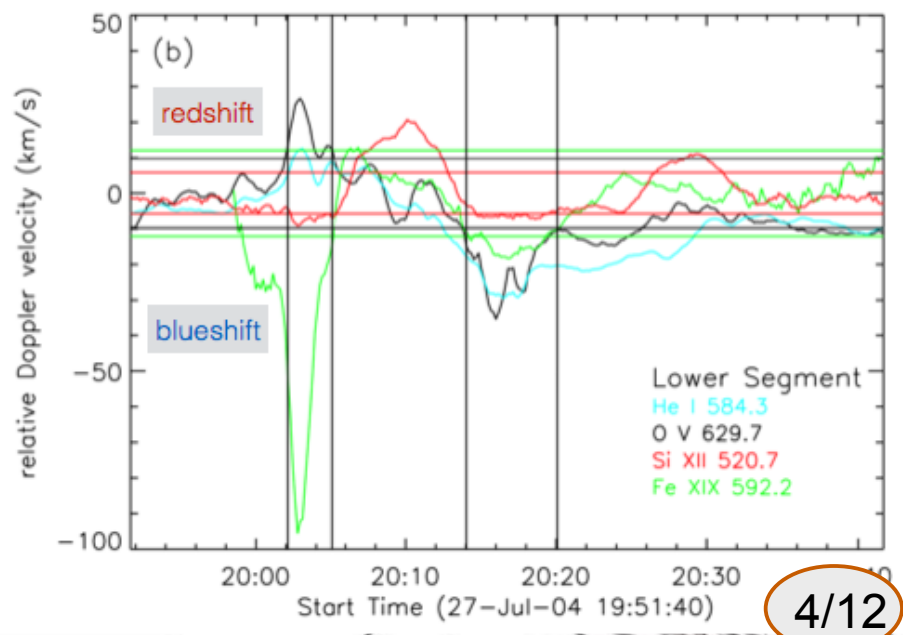
- explosive evaporation: blueshifts & redshifts  
(*Milligan et al. 2006a*)
- gentle evaporation: only blueshifts  
(*Milligan et al. 2006b*)

conversion from explosive to gentle  
chromospheric evaporation

explosive heating flux threshold  
 $\sim 10^{10} \text{ ergs cm}^{-2} \text{ s}^{-1}$  (*Fisher et al. 1985*)



(*Milligan et al. 2006a,b*)



(*Brosius 2009*)



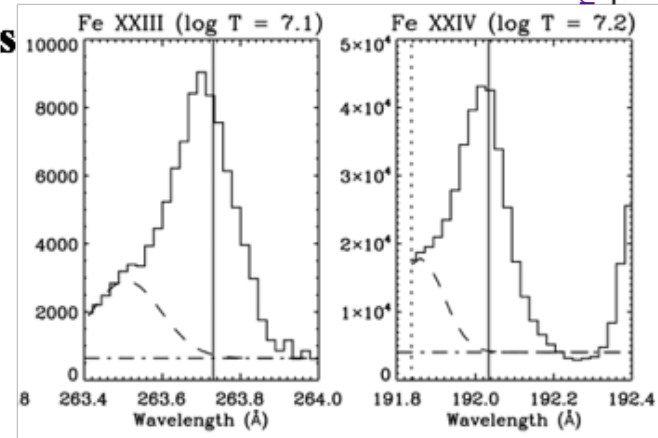
# Some problems (discrepancies between observations and models)

## dominant stationary component in high T ( $\geq 10$ MK) lines

(Ding et al. 1996; Milligan & Dennis 2009)

### explanations:

- (1) moving perpendicular to the line-of-sight (Falewicz 2009)
- (2) from the top of the flare loop (Doschek & Warren 2005)
- (3) multi-strand flare loop model (Brosius 2013)
- (4) instrument not sensitive (Doschek & Warren 2005)



(Milligan & Dennis 2009)

## high temperature downflows

reversal temperature from blueshift to redshift

$\leq 1$  MK (Kamio et al. 2005)

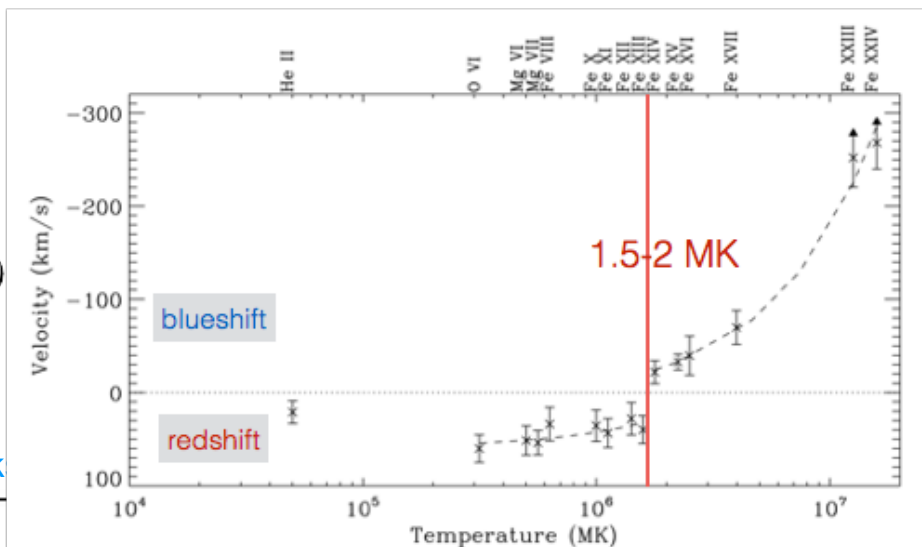
2 MK (Milligan 2008)

2.5-5 MK (Li & Ding 2011)

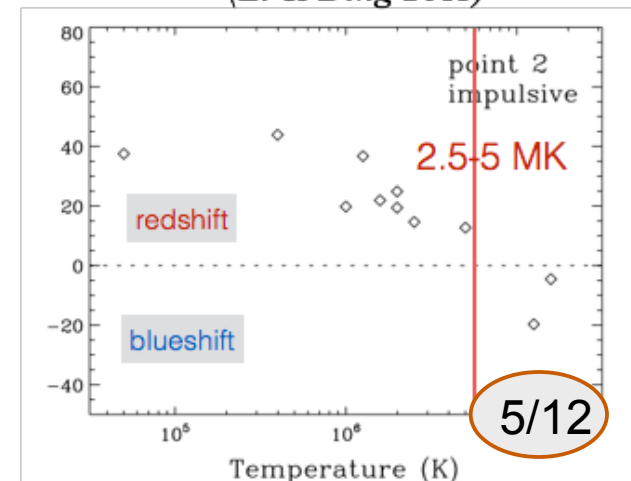
rather high energy deposition site??

(Milligan & Dennis 2009)

IRIS-4 Work



(Li & Ding 2011)





## Previous studies:

BCS/CDS/EIS (X-ray/EUV spectra)

→ chromospheric evaporation

## This present work:

**New IRIS UV spectra** (also with EIS)

→ mass motions in chromospheric evaporation  
in particular, unresolved problems

**IRIS**—Interface Region Imaging Spectrograph

---FUV (1332-1358 Å, 1389-1407 Å)

---NUV (2783-2834 Å)

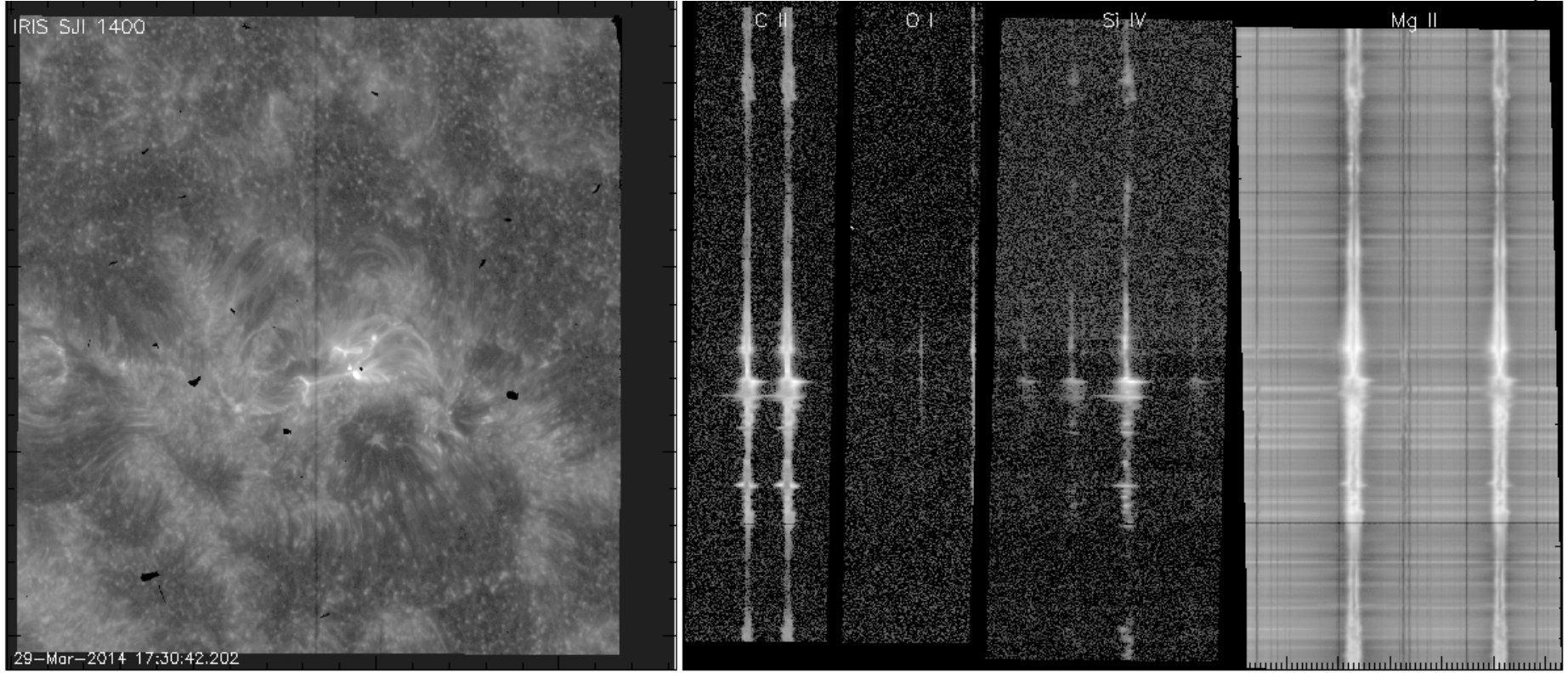
Slit-jaw image & spectra



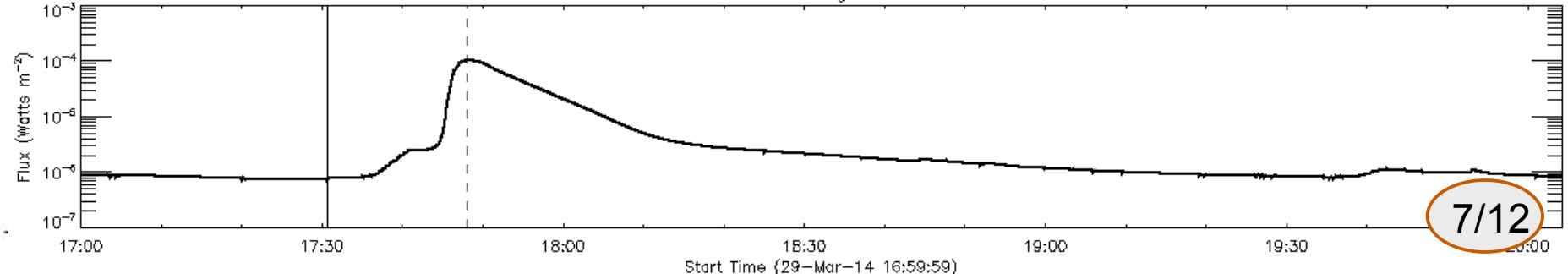
# Observations

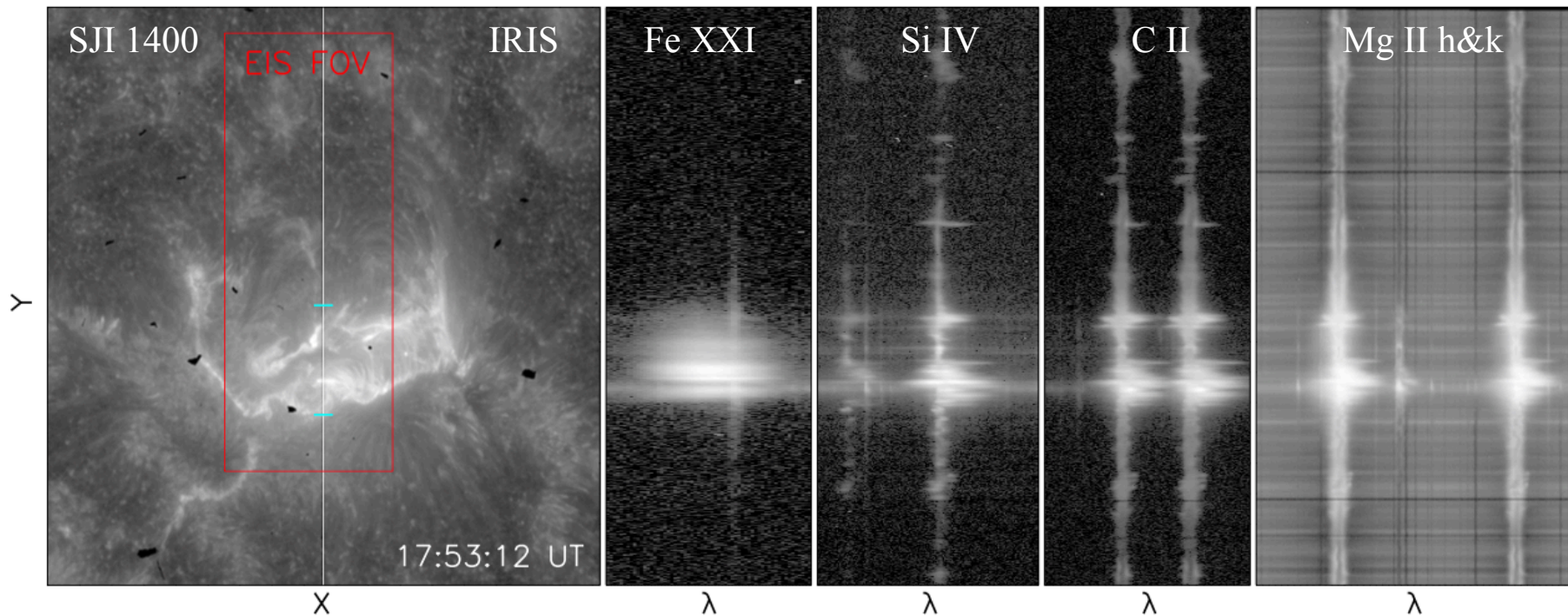
Boulder, CO

**X1.0 flare** on March 29, 2014 in AR 12017 (N10W32)

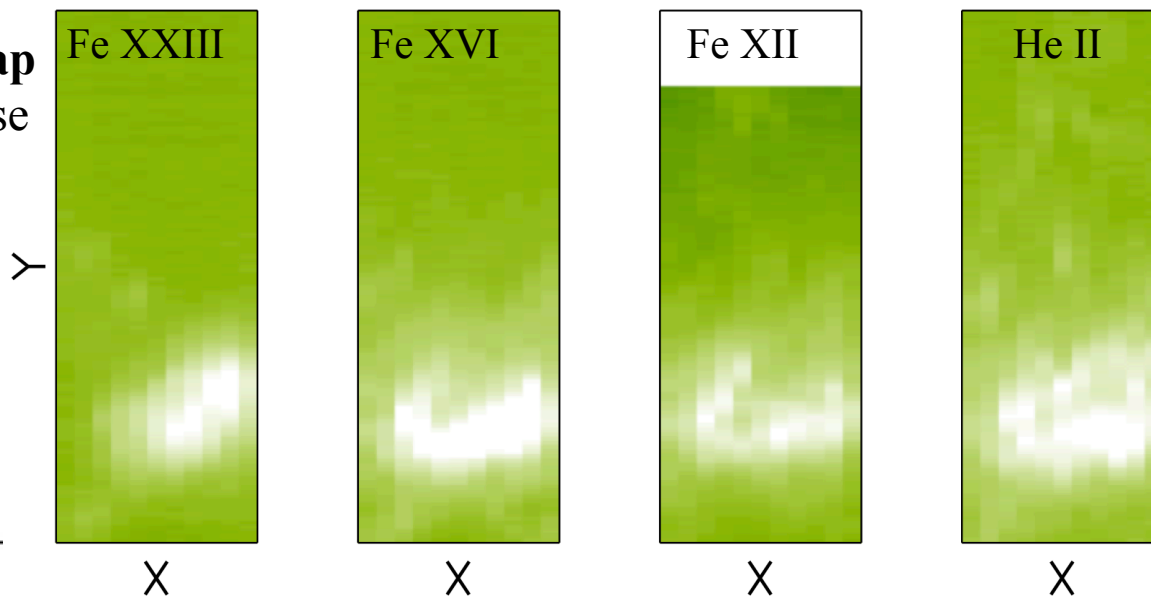


GOES 1-8 light curve





**EIS intensity map**  
in the decay phase





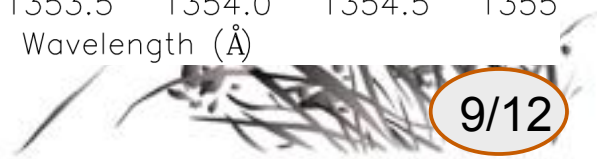
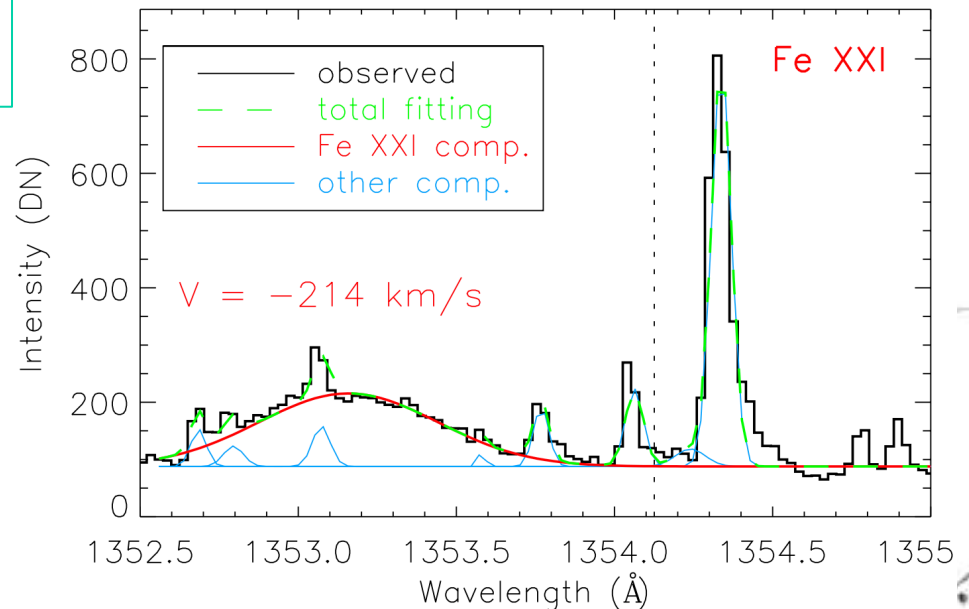
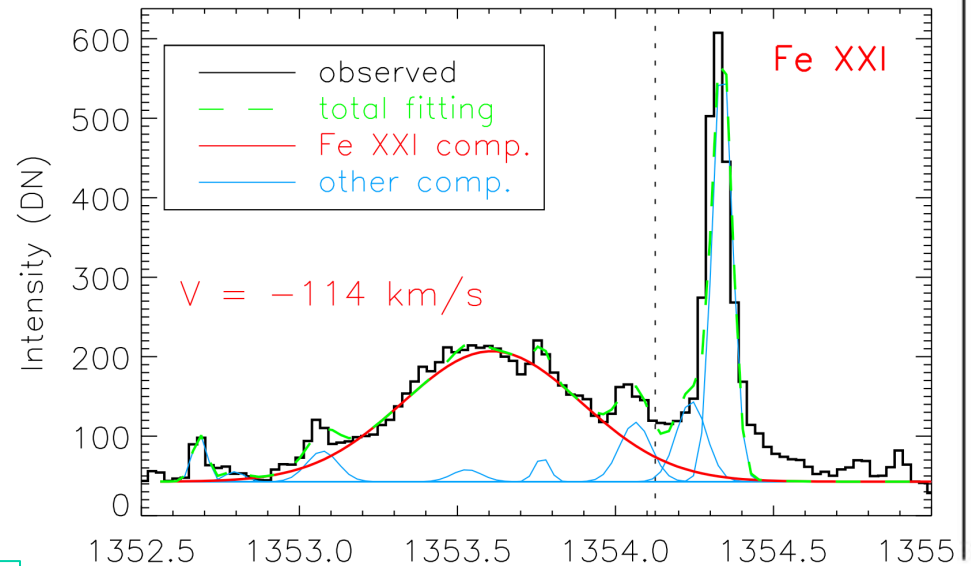


# Results

## Sample line profile of Fe XXI at the flare ribbon & Gaussian fitting curve

symmetry in the Fe XXI line profile  
entirely blueshifted at the ribbon

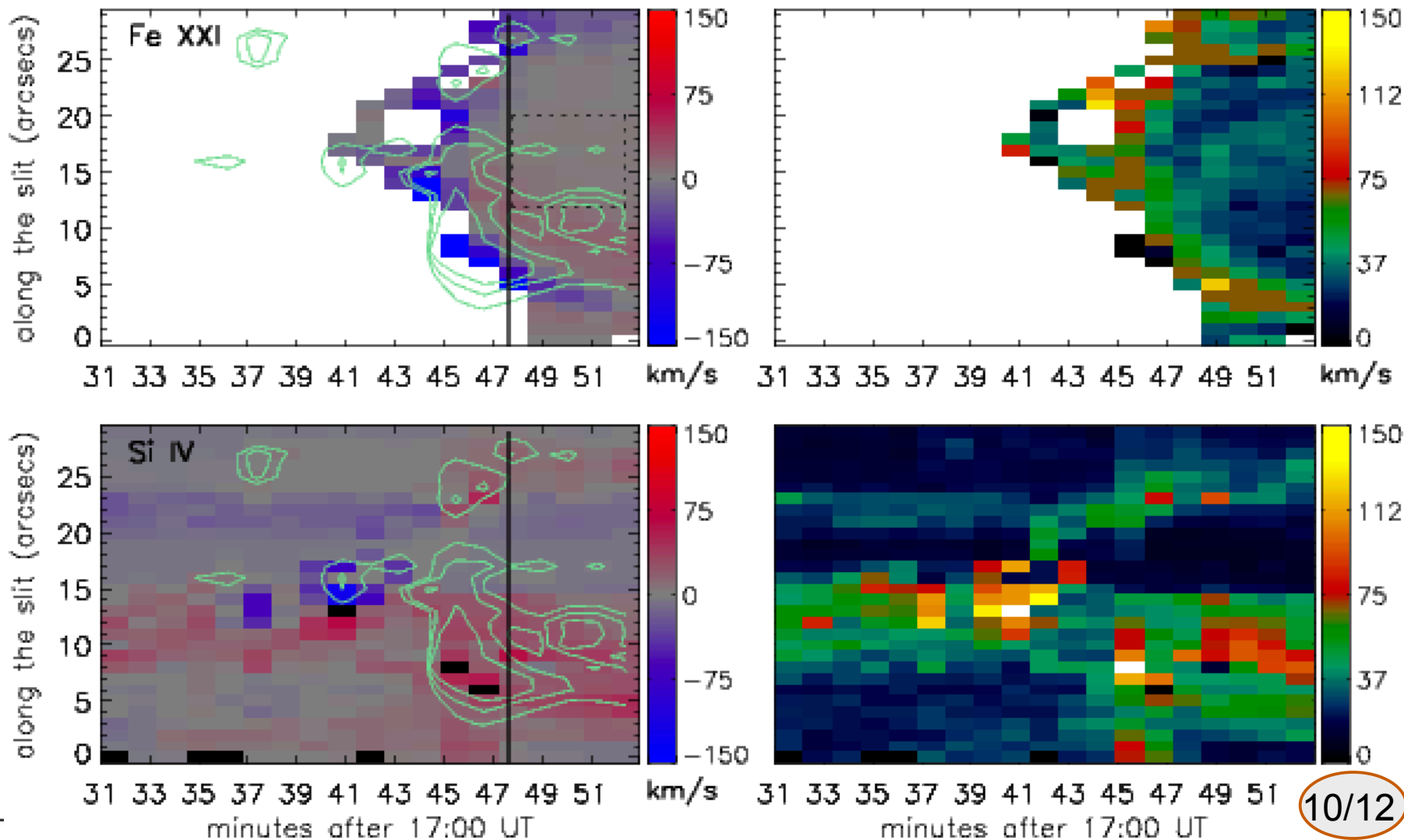
in agreement with  
theoretical predictions

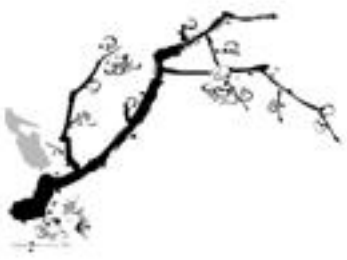


# Evolution of Doppler & non-thermal velocities along the slit in the Fe XXI ( $\sim 10$ MK) and Si IV ( $\sim 0.06$ MK) spectral lines

Boulder, CO

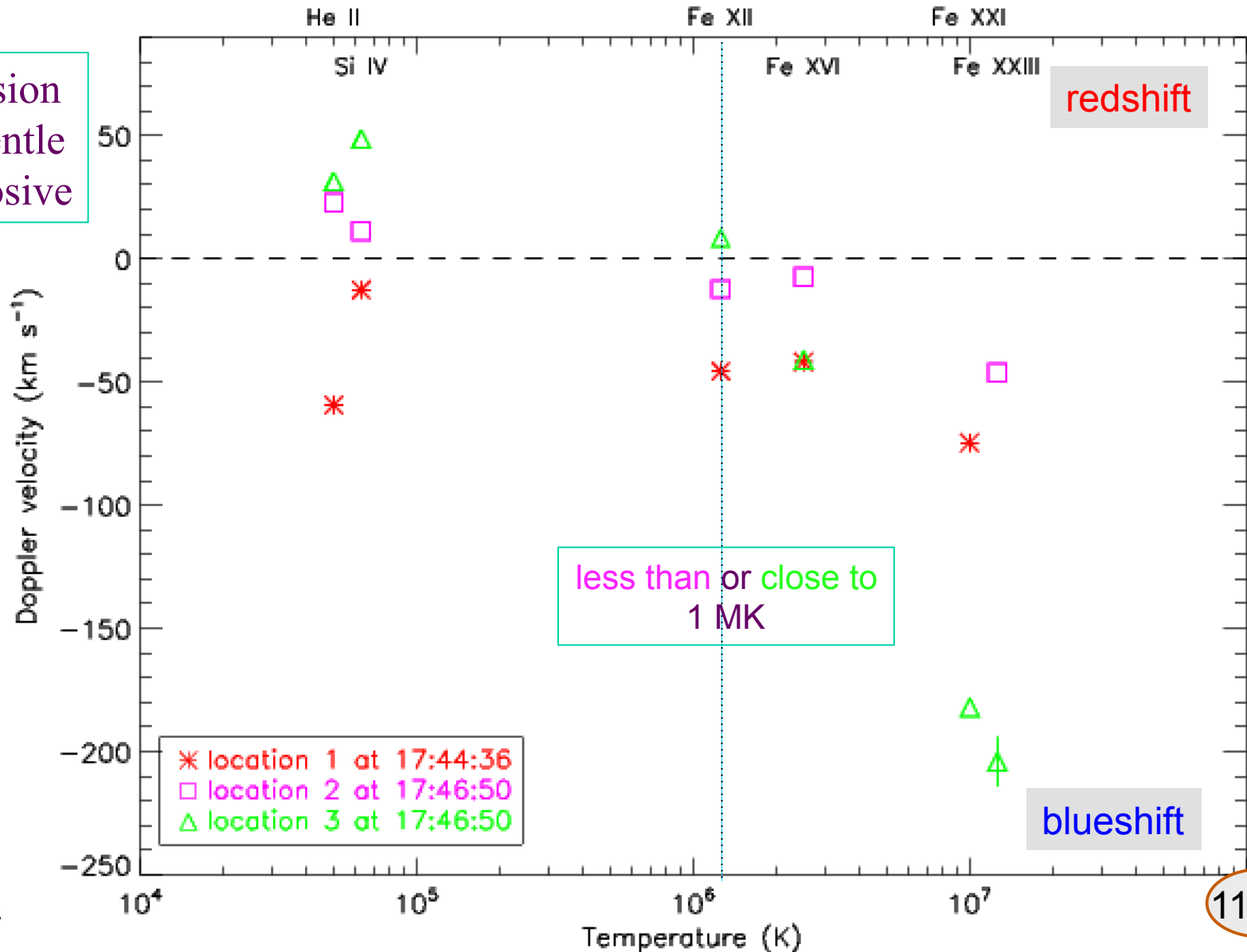
a pair of blueshift fronts co-spatial and coincident with separating ribbons





# Doppler velocity versus Temperature at three ribbon locations with different times

conversion  
from gentle  
to explosive





# Summary

*Using the high resolution observations from IRIS:*

- (1) we detect **dominant blueshifts** in the high temperature Fe XXI line, in agreement with theoretical predictions.
  - (2) We find **blueshifts co-spatial and coincident with separating ribbons**, suggesting that the reconnection/evaporation proceeds well into the decay phase of the flare.
- Different locations show different types of evaporation, and there is **a conversion** from gentle to explosive evaporation as the flare evolves.



Thanks for your attention!