



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

**Ying Li (李瑛)**

**Collaborators: M. D. Ding, J. Qiu**

**Nanjing University, China**

October 15 2014



# Contents

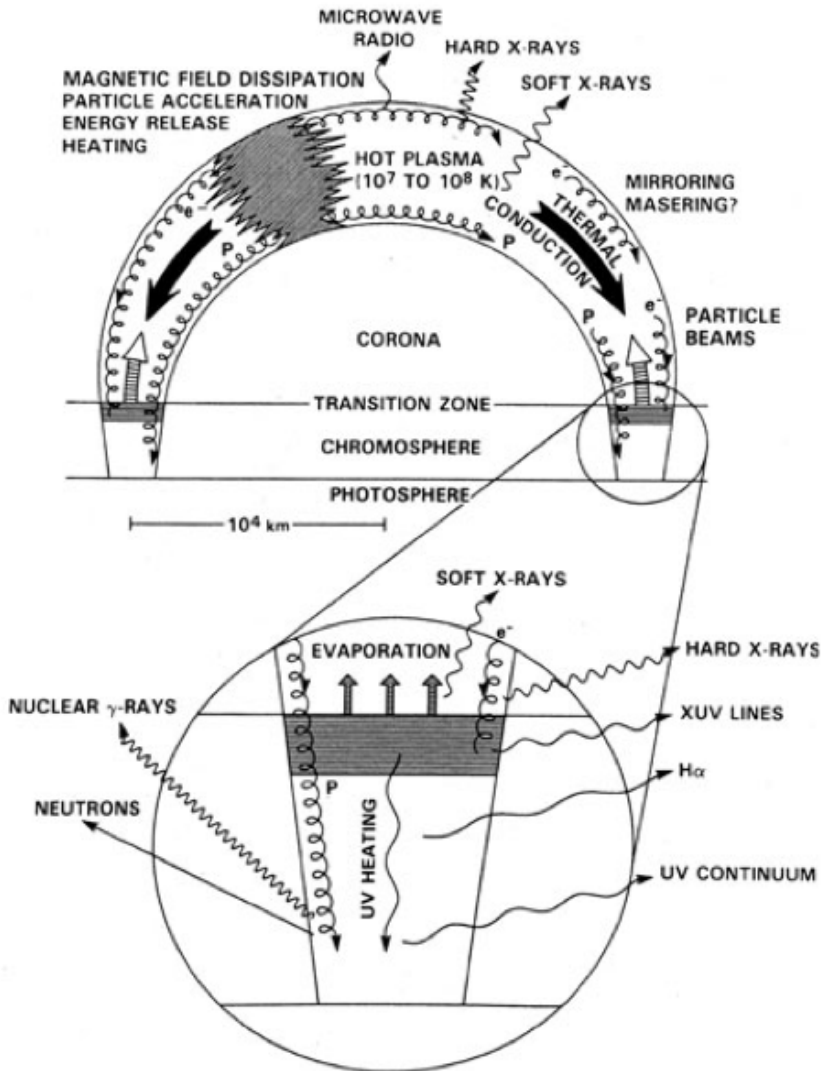
- Background
- Observations
- Results
- Summary



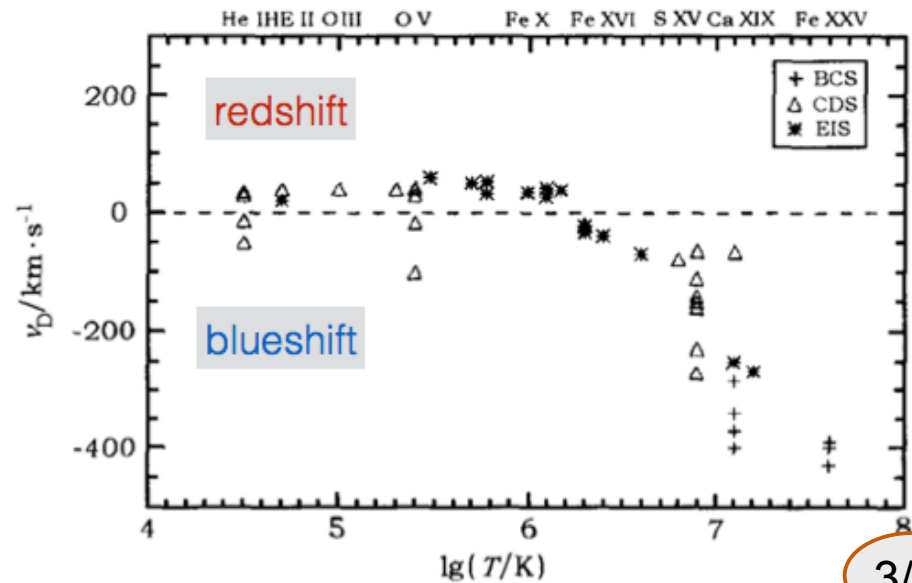
# Background

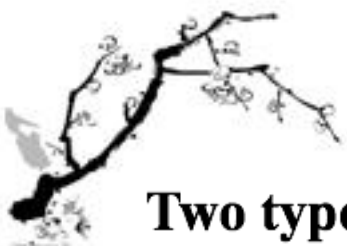
## Chromospheric evaporation

- **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

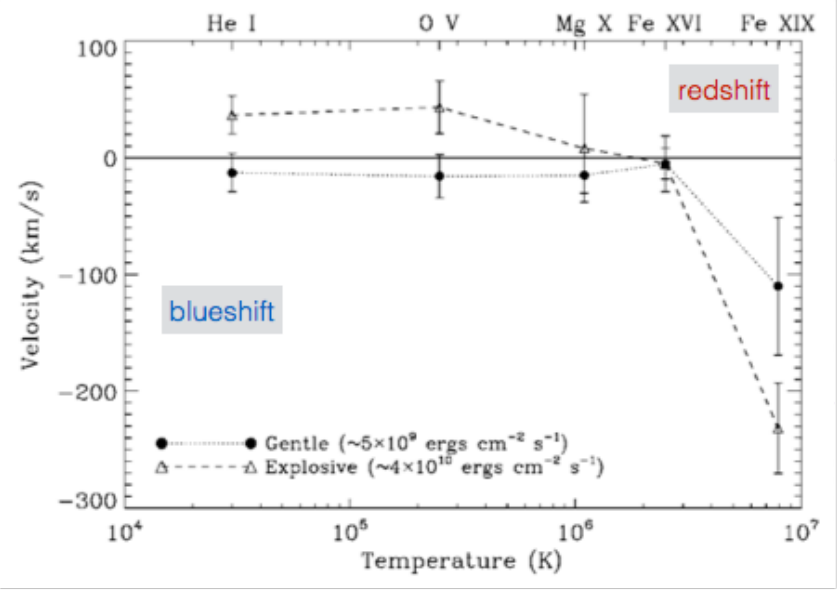




## Two types of evaporation

according to the observed Doppler velocity

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

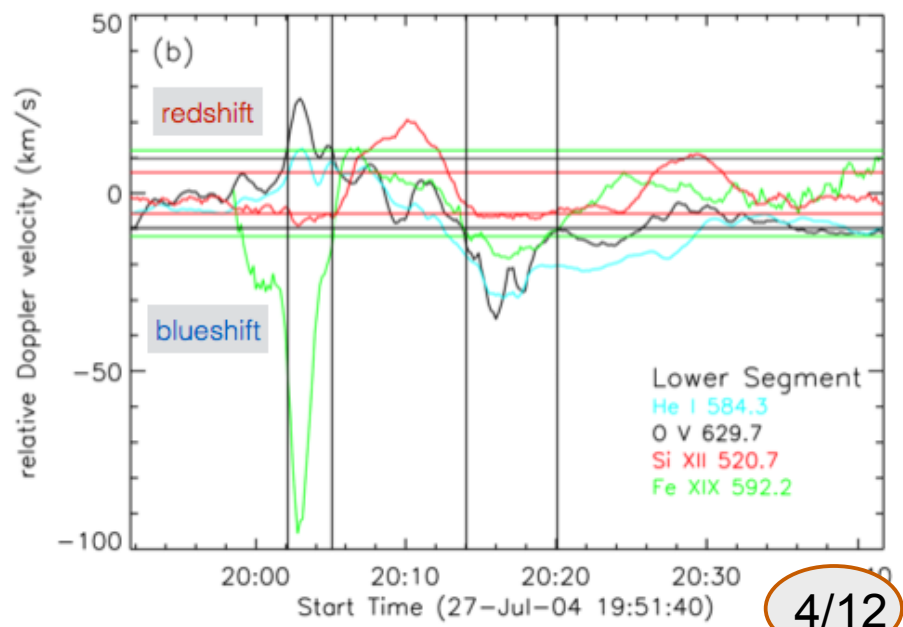


(Milligan et al. 2006a,b)

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)



(Brosius 2009)



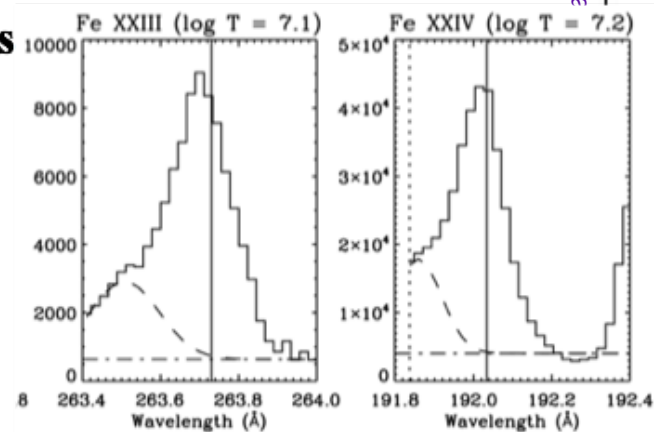
# Some problems (discrepancies between observations and models)

## 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) instrument not sensitive (Doschek & Warren 2005)
- (4) multi-strand flare loop model (Brosius 2013)



(Milligan & Dennis 2009)

## high temperature downflows

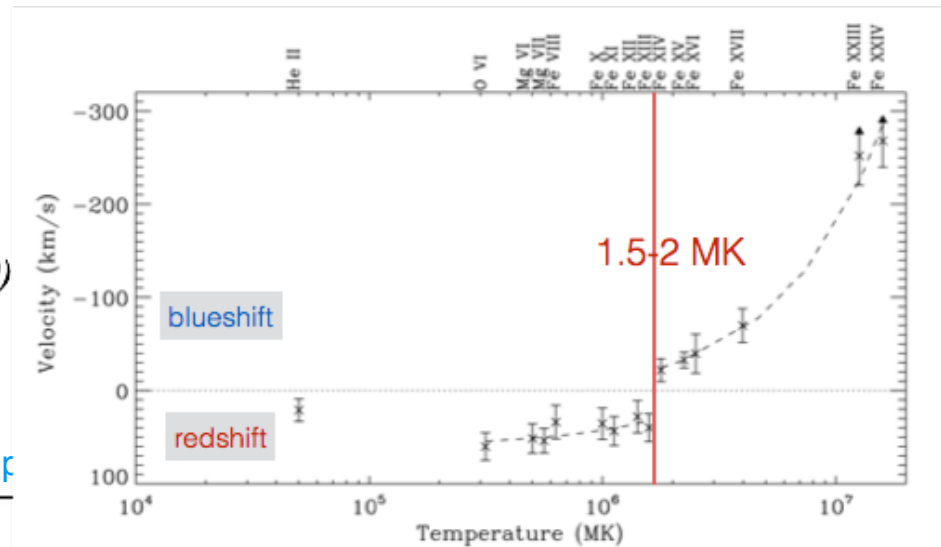
reversal temperature from blueshift to redshift

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

2 MK (Milligan 2008)

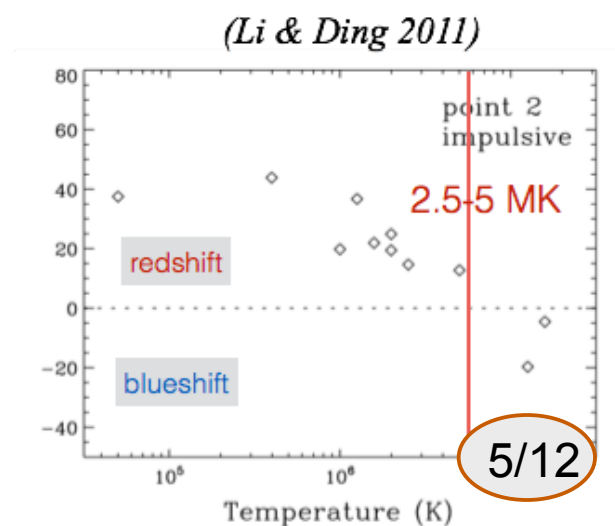
2.5-5 MK (Li & Ding 2011)

rather high energy deposition site??



(Milligan & Dennis 2009)

STP13 Symf



(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)

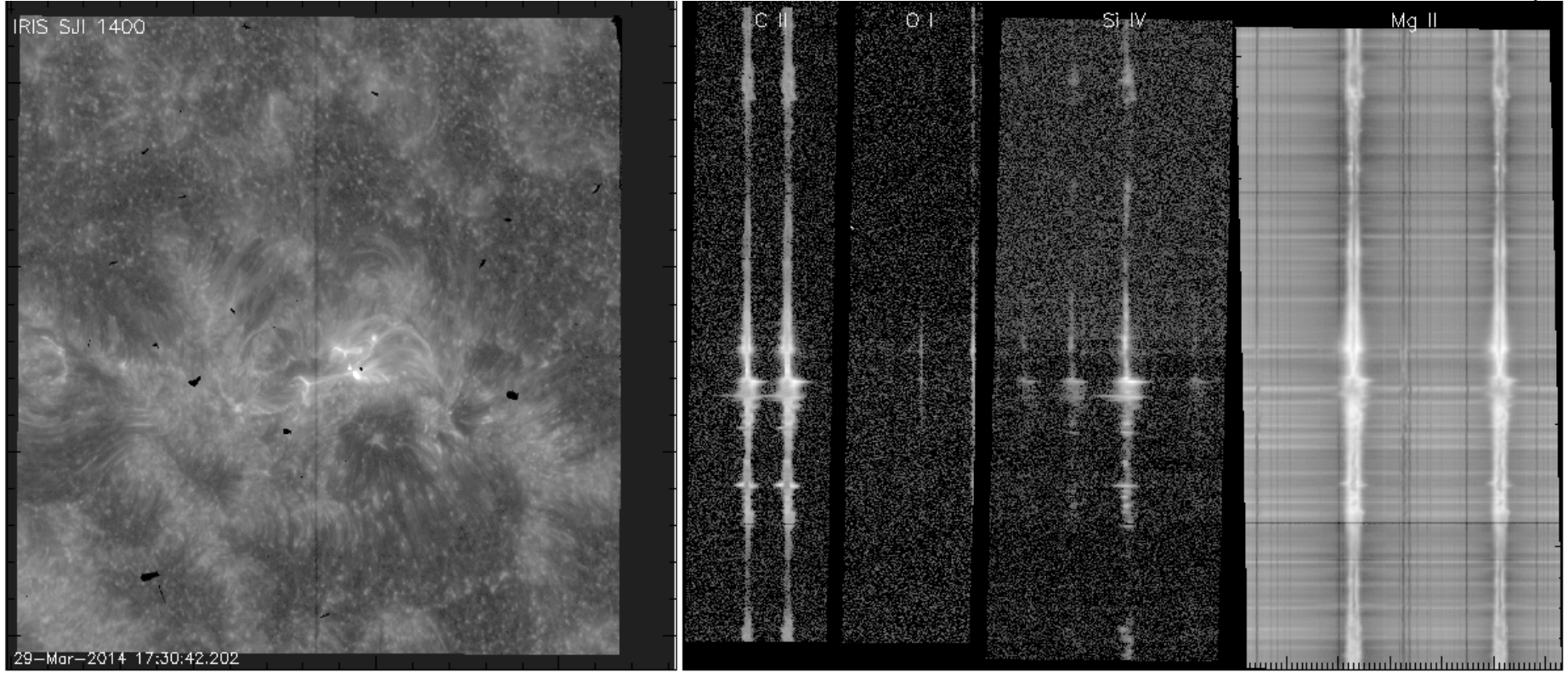
Slit-jaw image & spectra



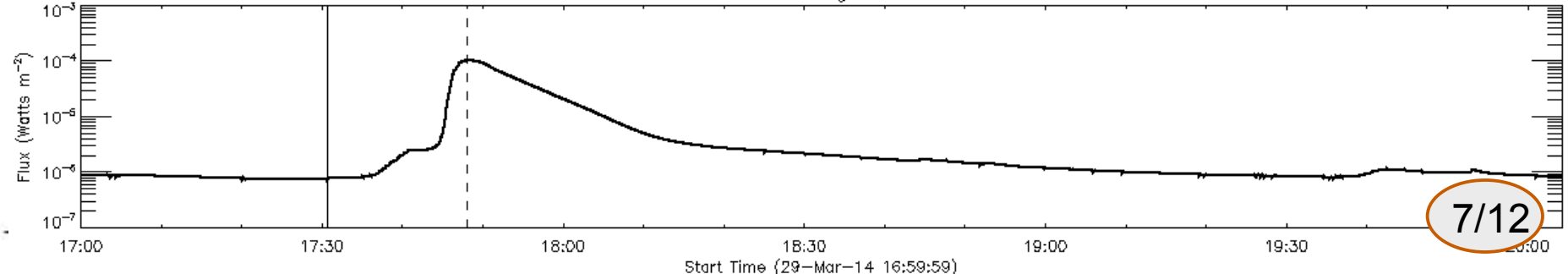


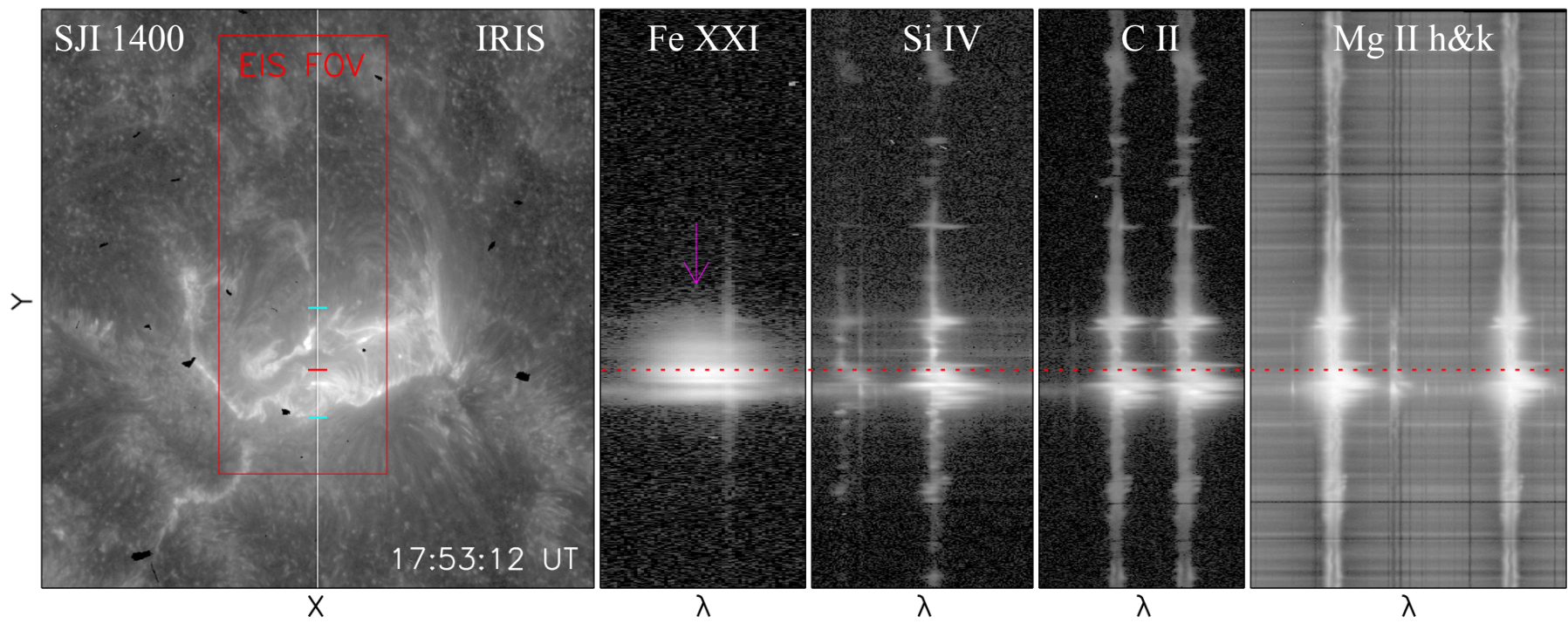
# Observations

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

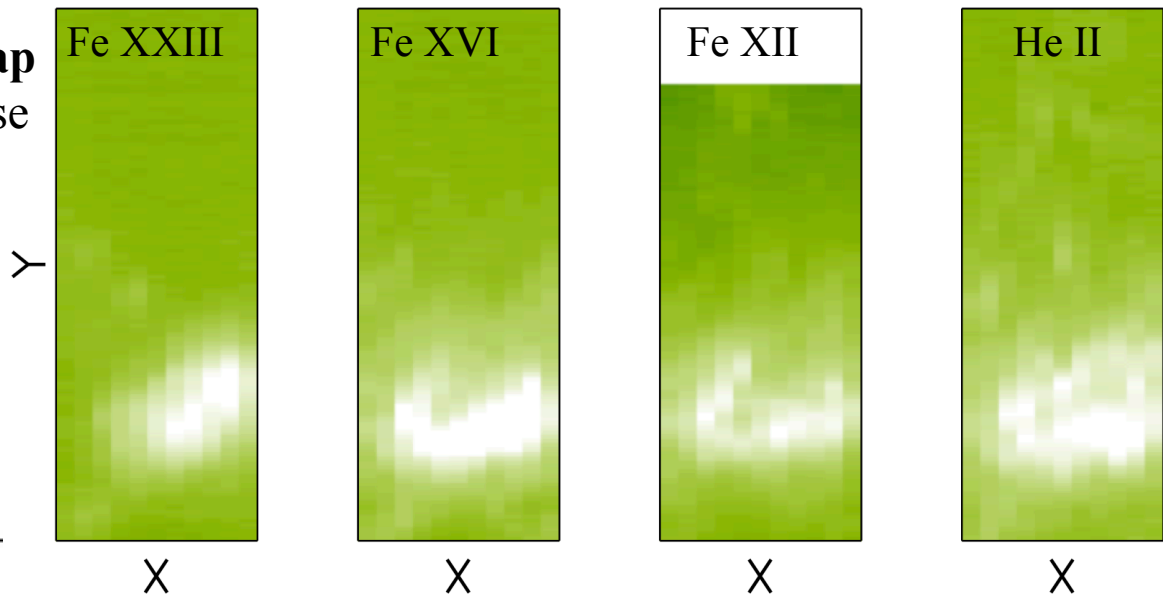


GOES 1-8 light curve

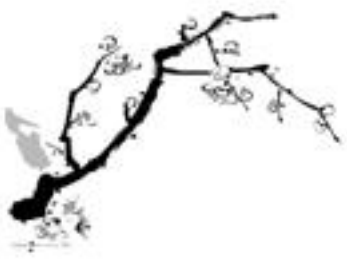




**EIS intensity map**  
in the decay phase

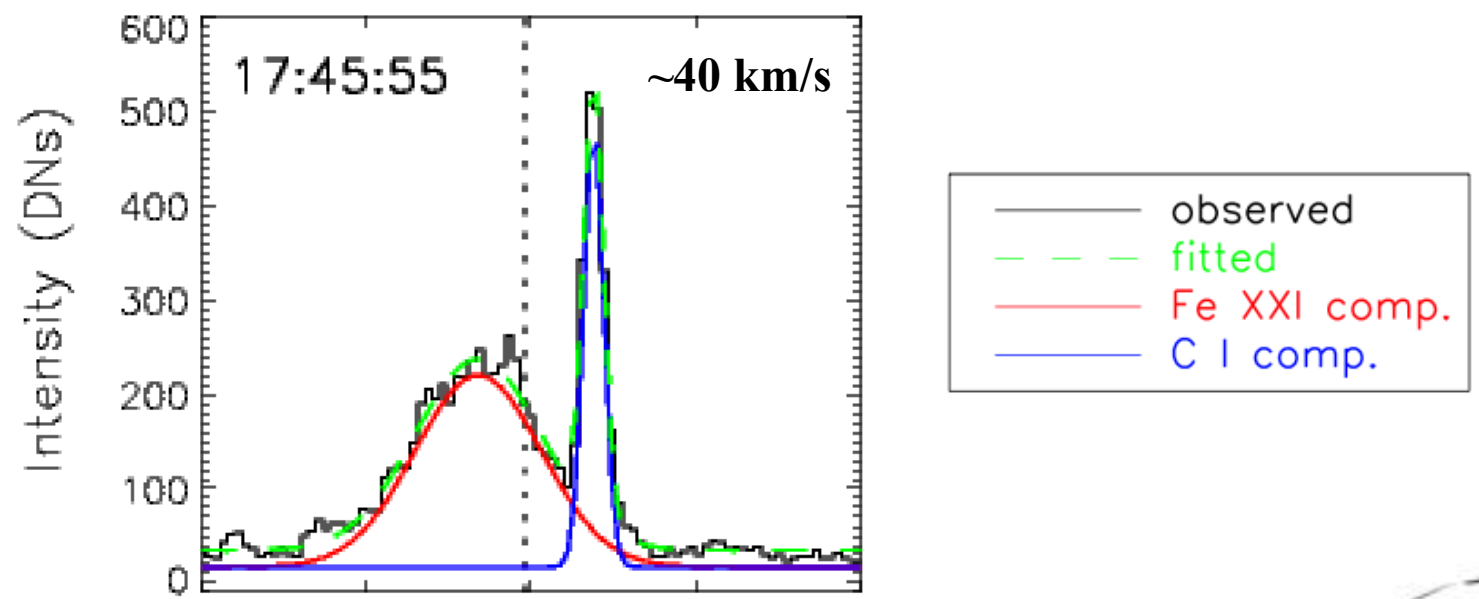






# Results

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



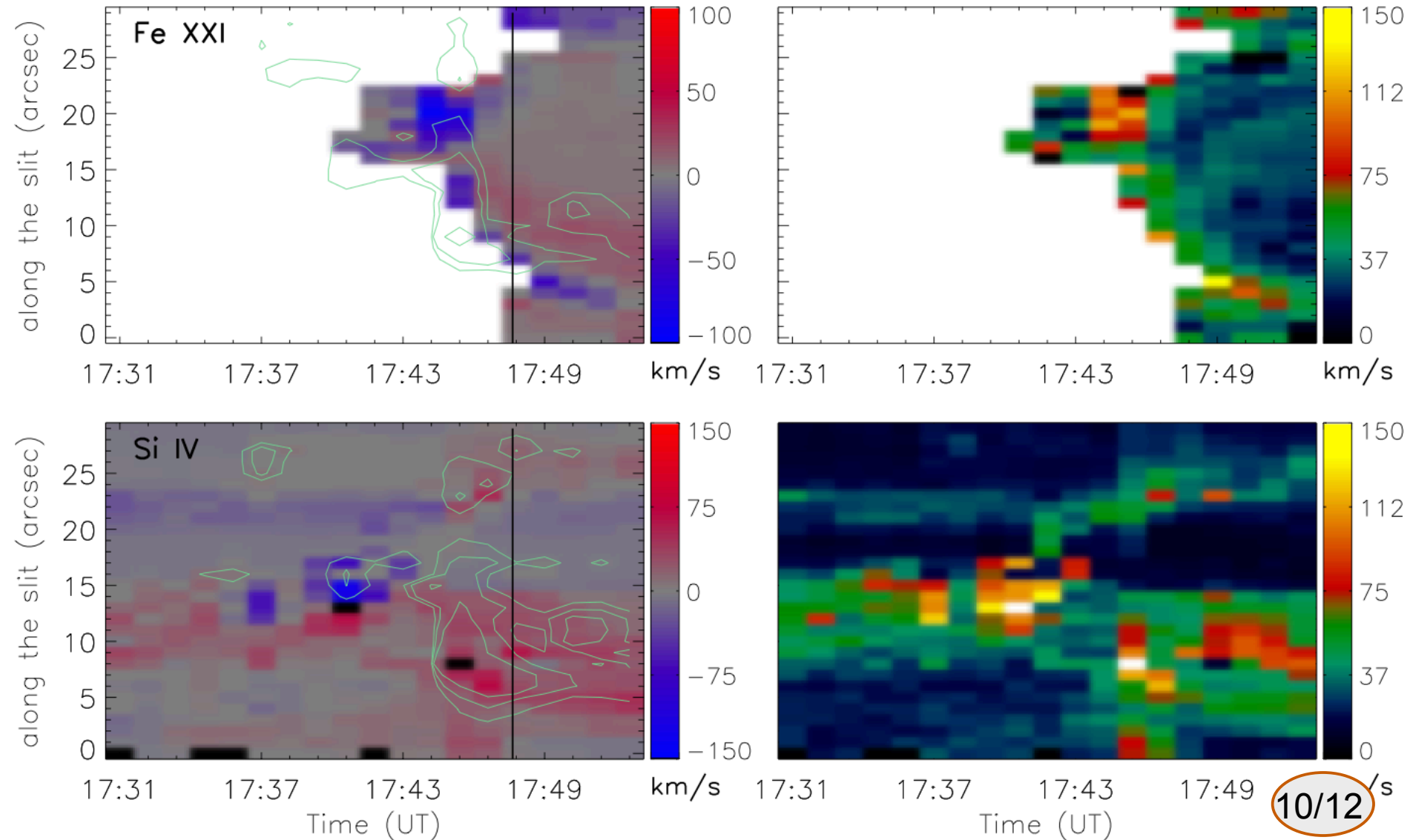
symmetry in the Fe XXI line profile  
entirely blueshifted at the ribbon

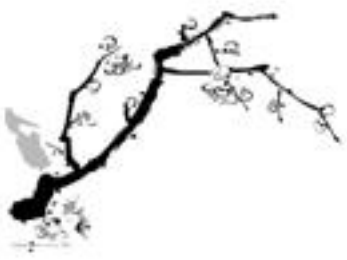




# Evolution of Doppler & non-thermal velocities along the slit in the Fe XXI ( $\sim 10$ MK) and Si IV ( $\sim 0.06$ MK) spectral lines

Xian China

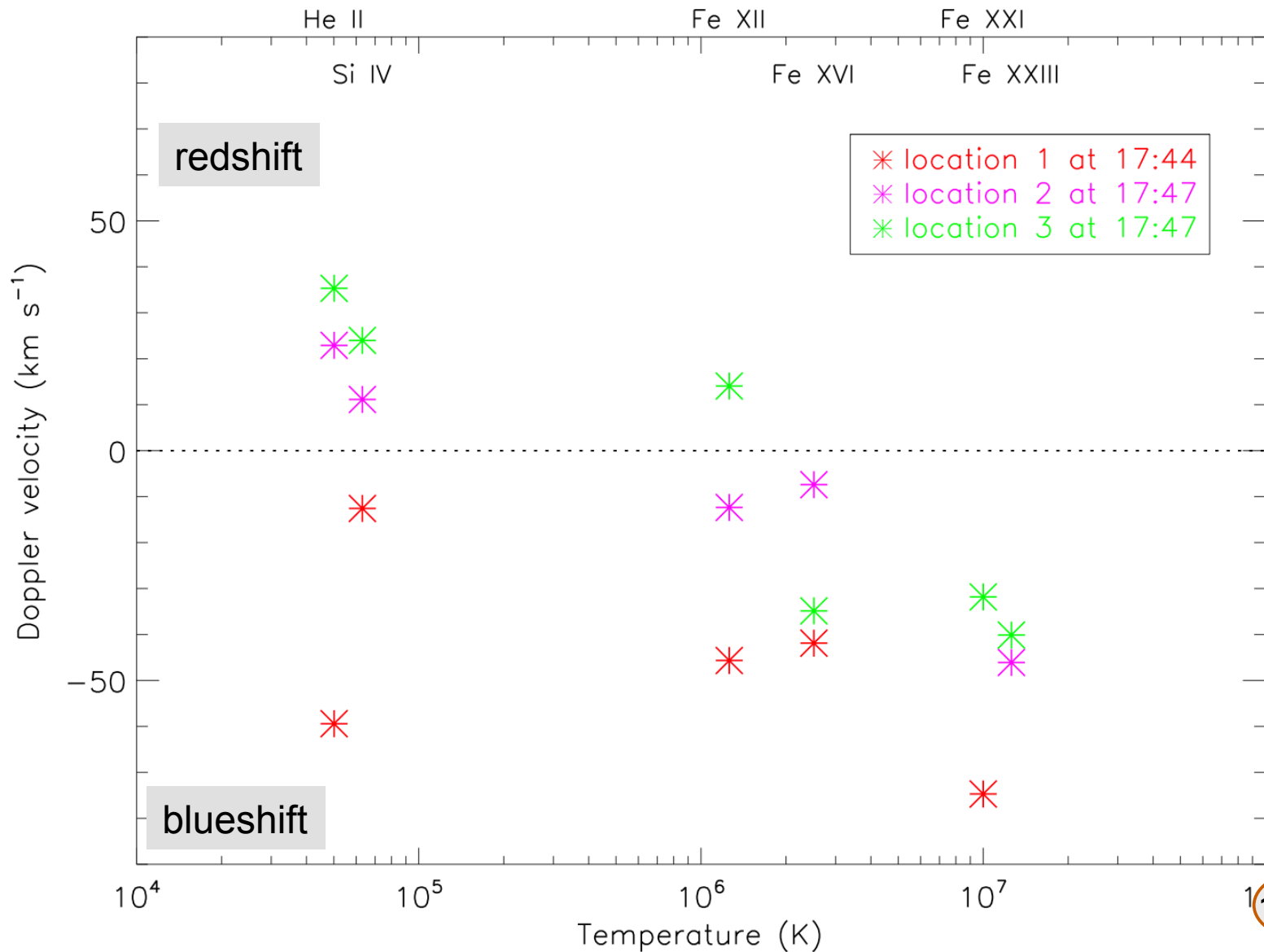




# Temperature dependence of Doppler velocity at several locations with different times

Xi'an China

October 2014



STP1

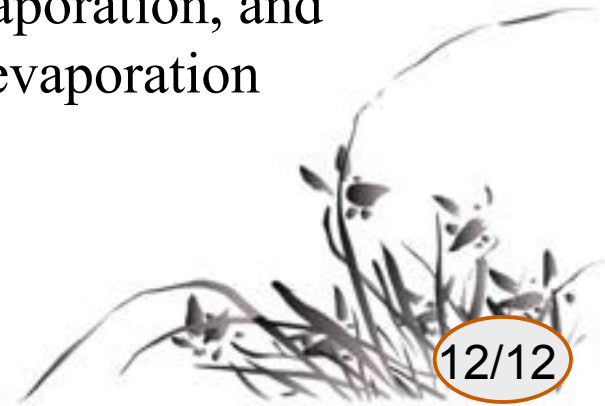




# Summary

*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!

