Prominence eruption as observed with the IRIS mission and ancillary instruments

Ping Zhang
Institut d'Astrophysique Spatiale

Eric Buchlin and Jean-Claude Vial

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Contributed Talk

4. Eruptions in the solar atmosphere

The derivation of mass flows in an erupting prominence from simultaneous observations with IRIS, AIA/SDO, EUVI/STEREO and K-COR

Ping Zhang[1], Éric Buchlin[2], Jean-Claude Vial[3]

[1] *Institut d'Astrophysique Spatiale*
[2] *Université Paris-Sud*

From simultaneous observations of an eruptive prominence performed with IRIS, AIA/SDO, EUVI/STEREO and the ground-based K-COR coronagraph, we focus on the determination of mass flows during the pre-eruptive and early phases of the eruption. As far as velocities are concerned, we combined an optical flow method on the AIA 304 and IRIS Mg II h&k observations in order to derive the POS velocities in the prominence and a Doppler technique on the IRIS Mg II h&k profiles to compute the LOS velocities. We used the STEREO observations to derive the 3D geometry of the prominence in order to define velocity vectors. As far as densities are concerned, we tried to characterize the Mg h and k profiles (time and space-dependent) and compare with the signatures of more than one hundred prominence models through NLTE radiative transfer computations (I.A.S. PROM7 code). We paid much attention to the exact incident radiation in various lines and continua. The model parameters include pressure, temperature, height, thickness, radial and turbulence velocities. As a first step, we focused on the k and h integrated intensities and selected the best (fitting) models. We were able to derive the total (hydrogen) density and consequently compute the mass flows. We also used the K-COR observations to derive the density later on in the process of eruption. Applying this method to more prominences observed by IRIS could help to reduce the large range of thermodynamic parameters in eruptive prominences and to improve their MHD modeling.

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Rationale

Prominence eruptions (PEs):

➢ triggering mechanism:

the thermal signatures (Fan 2012), the height of acceleration (McCauley et al. 2015) and flux emergence (Chatterjee & Fan 2013)

➢ the correlation between PEs and CMEs:

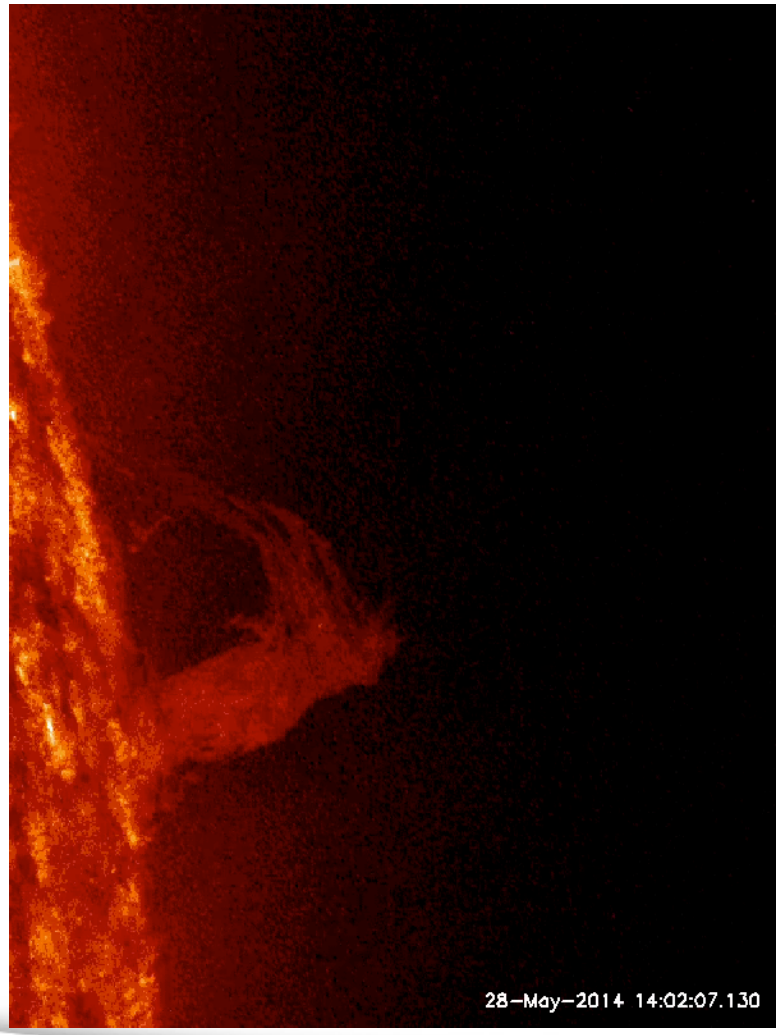
the mass exchanges between the chromosphere and the corona and the total mass maintained in the prominence (Liu et al. 2012)

Multiwavelength spectroimaging is necessary for these studies. We analyzed an eruptive prominence on May 28 2014 with IRIS imaging spectroscopy observations and observations from SDO, STEREO, SOHO and ground based observatories (such as K-COR from HAO observatory)

Observations

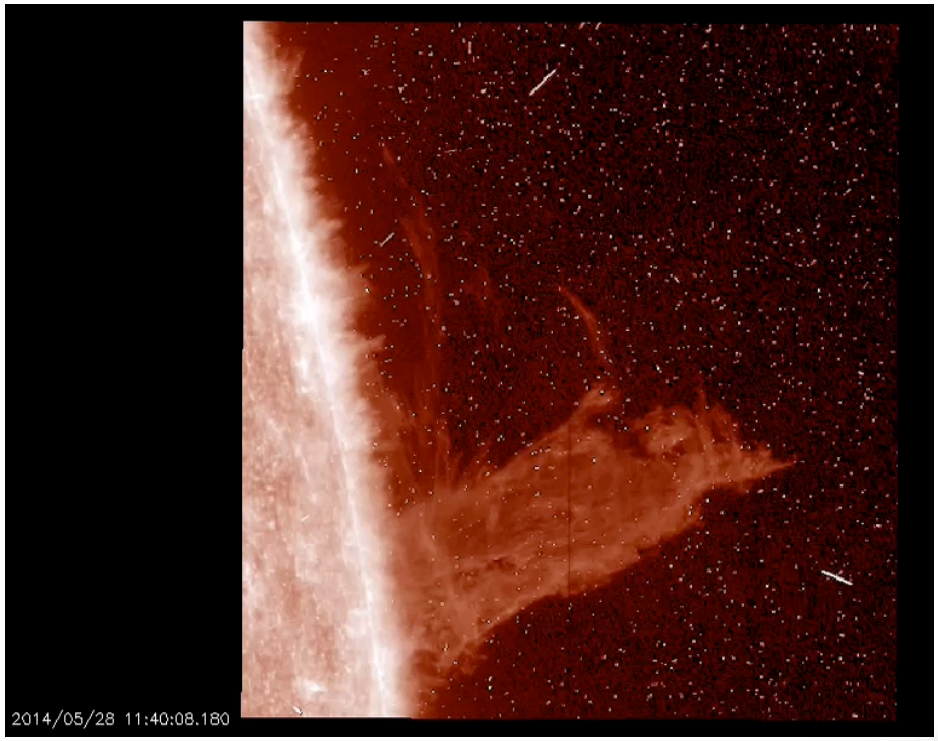
On 2014 May 28, a prominence eruption occurred near NW limb of the Sun

SDO/AIA 304Å observation



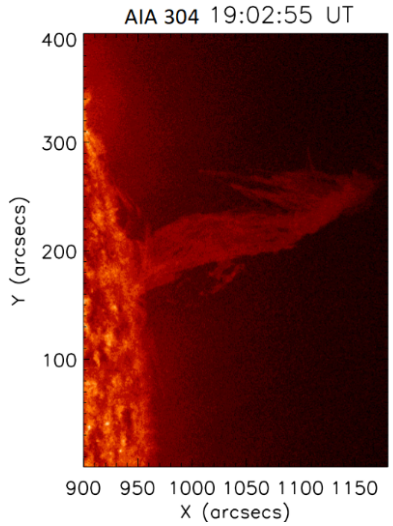
IRIS observation (11:24-16:01 UT)

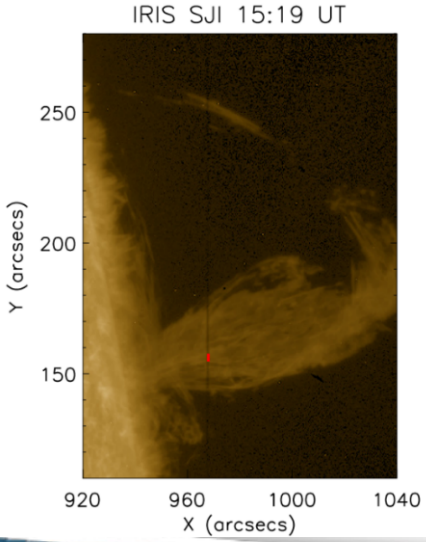
- Very large sparse 64-step rasters, 16.2s cadence, 230” x 175”
- Slit-jaw: 1330, 1400, and 2796 Å

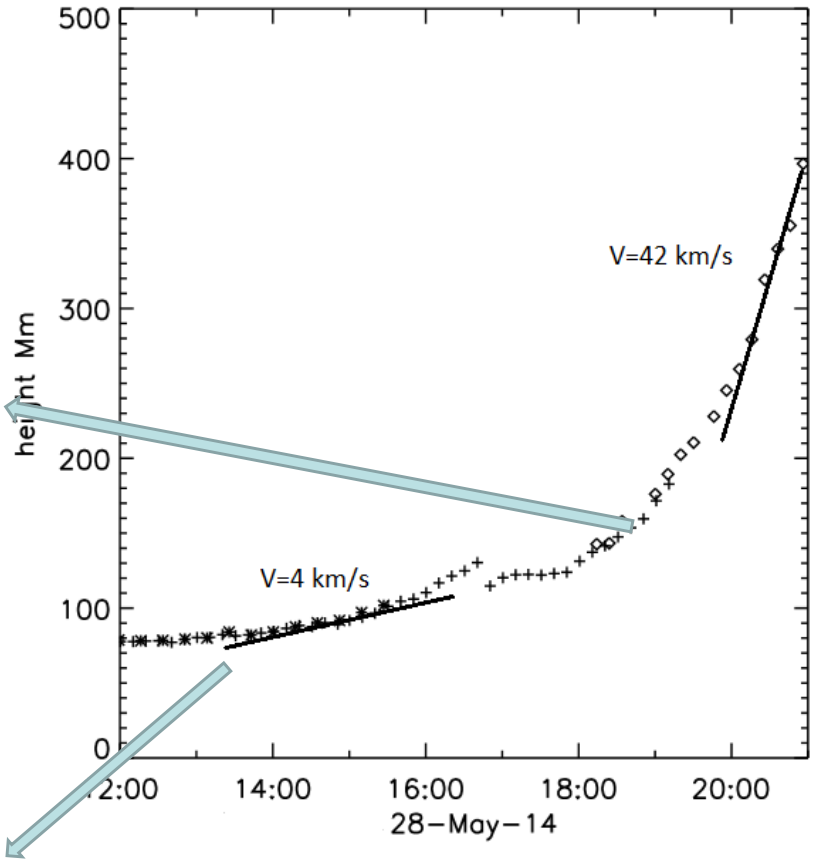


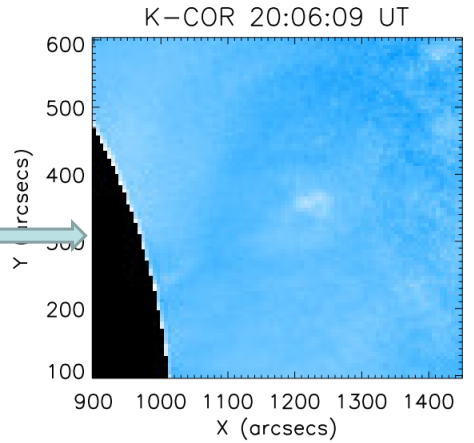
Height-time profile

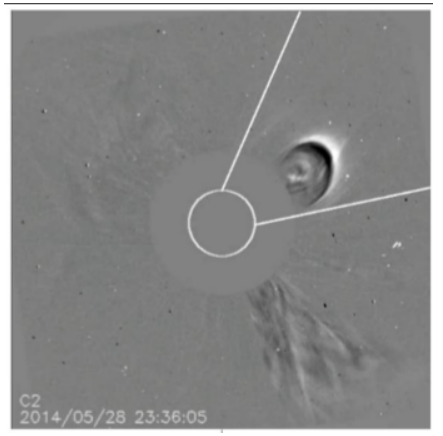
Top of the prominence tracking:
IRIS 12:00-15:26 UT, AIA 12:00-19:10 UT, K-COR 18:30-21:00 UT







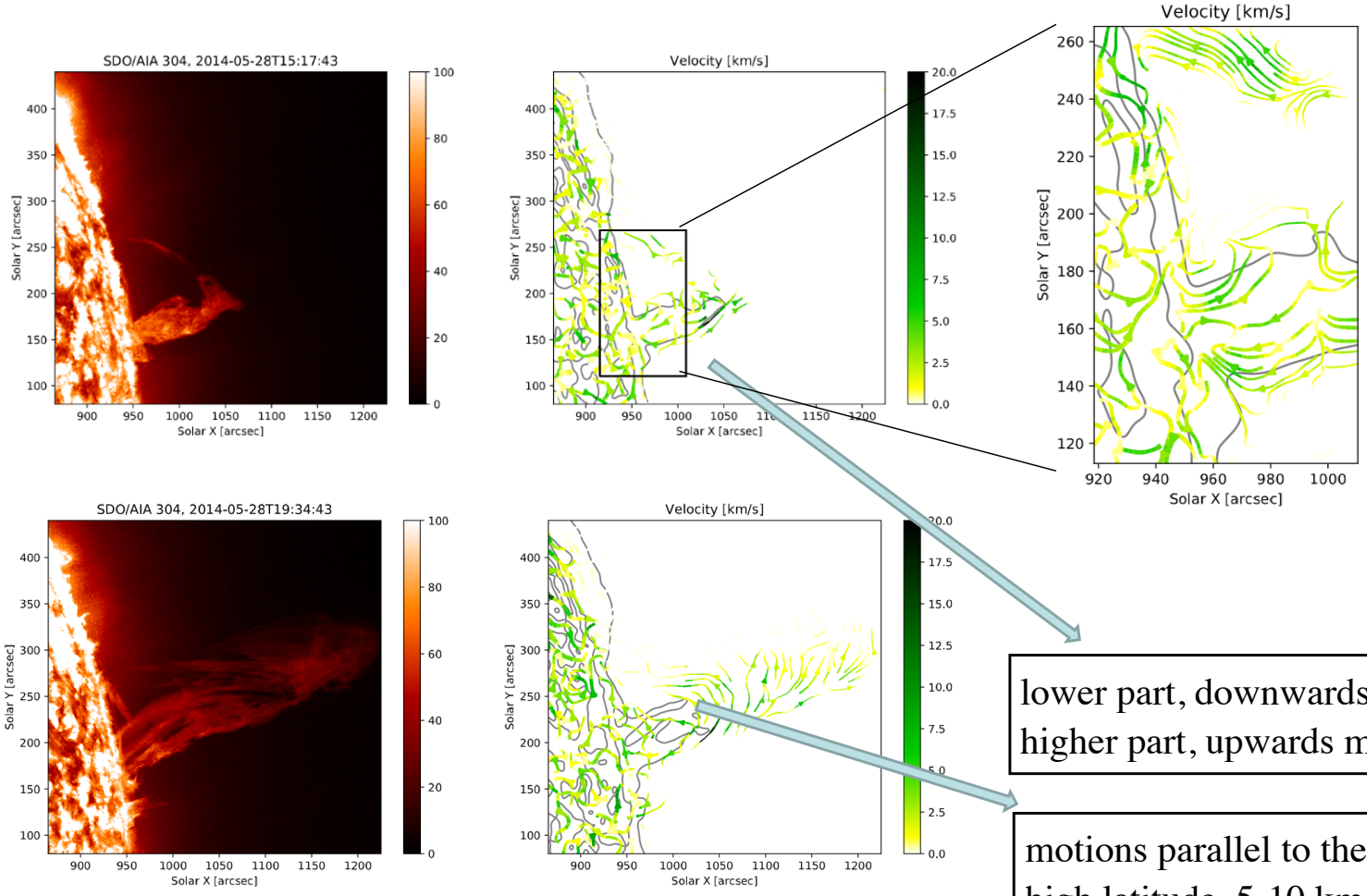




The front of a CME was observed by LASCO C2 at 21:36 UT, it reaches the maximum velocity of 332 km/s at 01:25 UT on May 29.

POS velocity

Velocities in the plane of sky (POS): optical flow algorithm (Farnebäck)



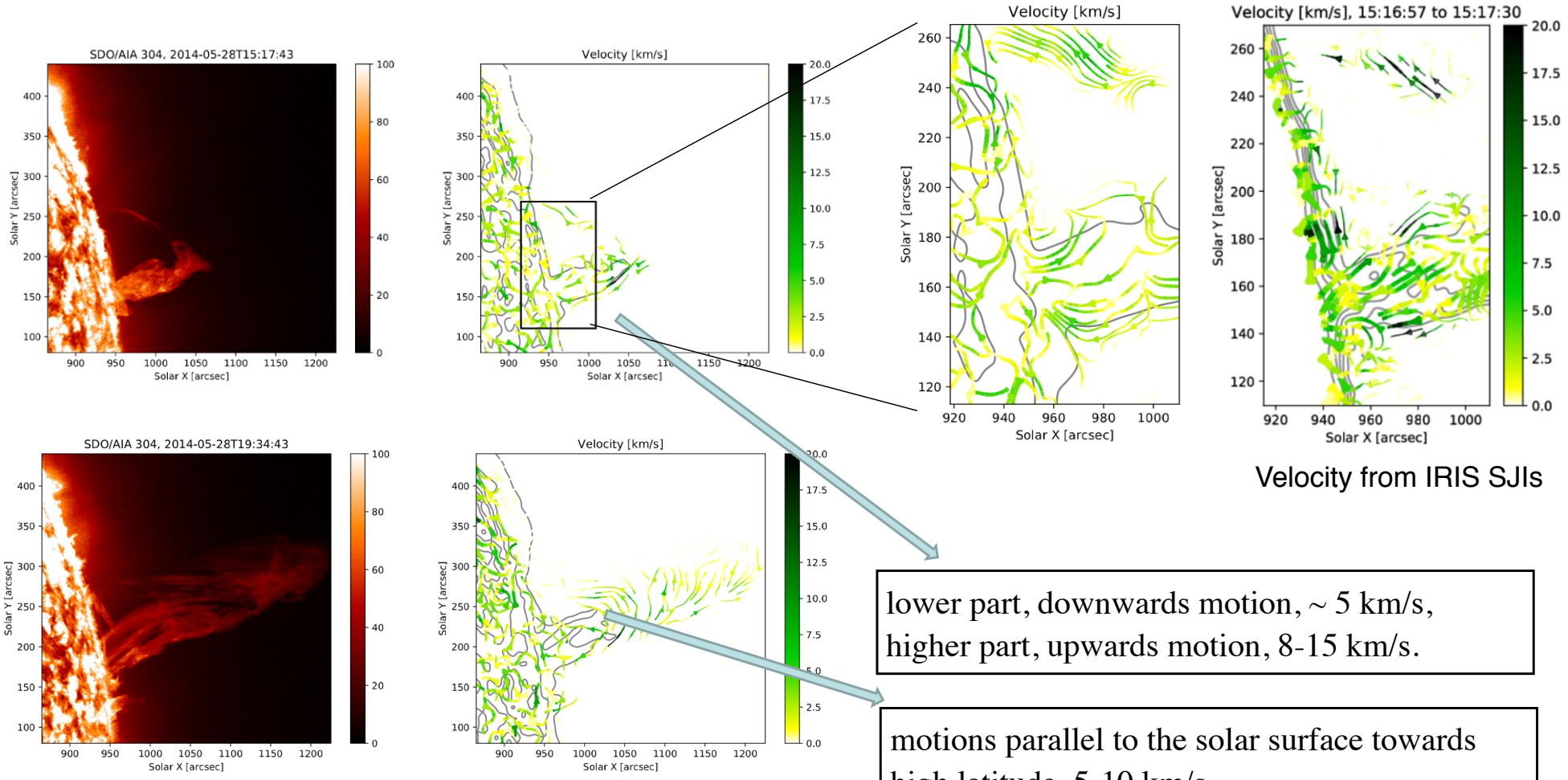
lower part, downwards motion, ~ 5 km/s,
higher part, upwards motion, 8-15 km/s.

motions parallel to the solar surface towards high latitude, 5-10 km/s

Velocity from AIA images

POS velocity

Velocities in the plane of sky (POS): optical flow algorithm (Farnebäck)



Velocity from IRIS SJIs

lower part, downwards motion, ~ 5 km/s,
higher part, upwards motion, 8-15 km/s.

motions parallel to the solar surface towards high latitude, 5-10 km/s

Velocity from AIA images

Spectral analysis

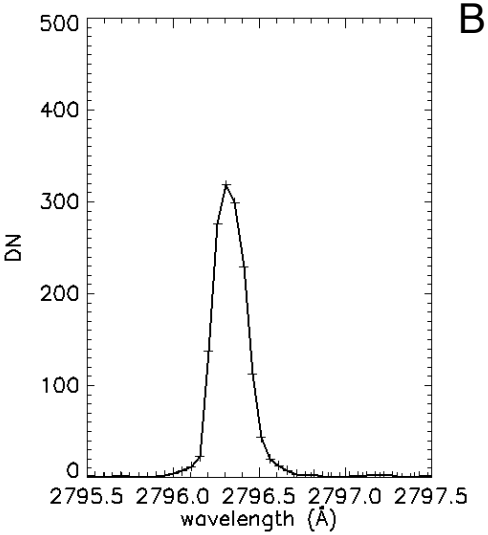
3 groups of profiles:

A) single-peaked profiles,

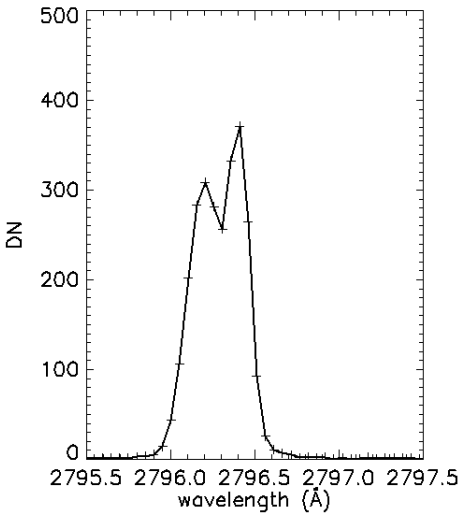
B) central reversed profiles,

C) complex profiles: have more than two peaks or have two peaks and the distance between the two peaks is larger than 0.5 Å.

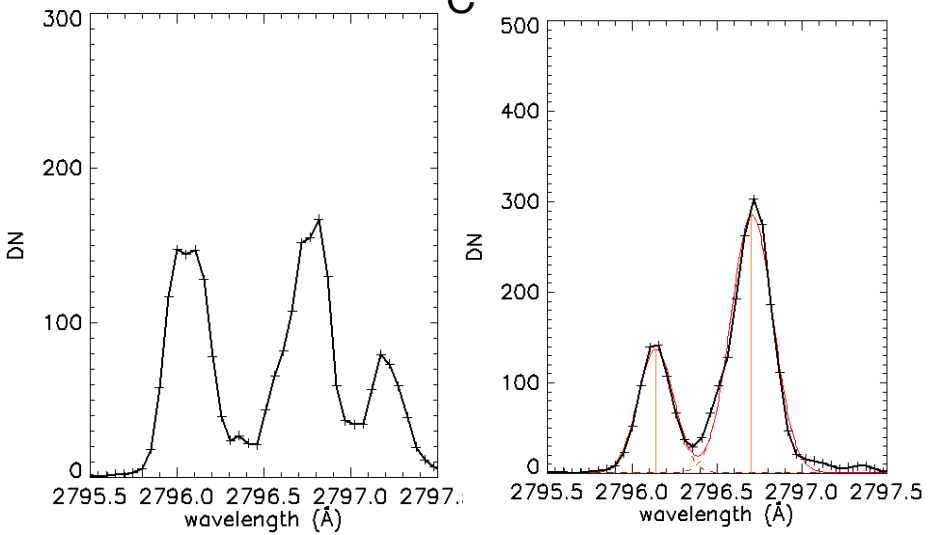
A

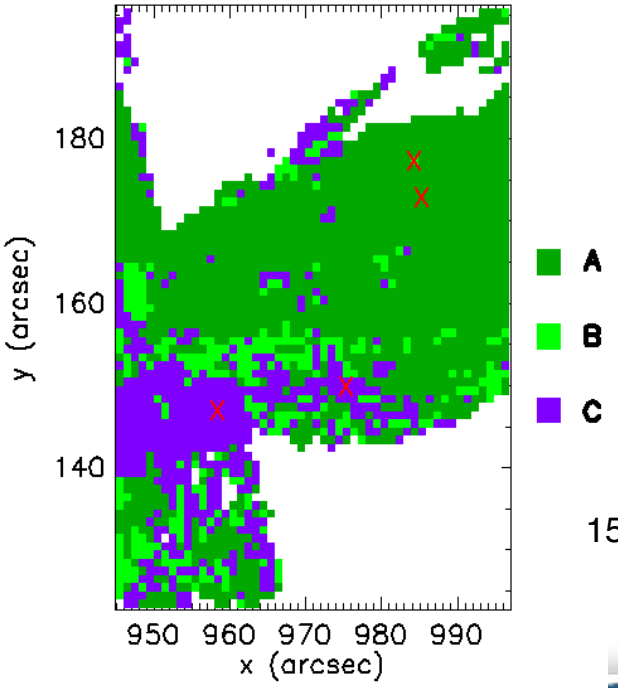


B



C

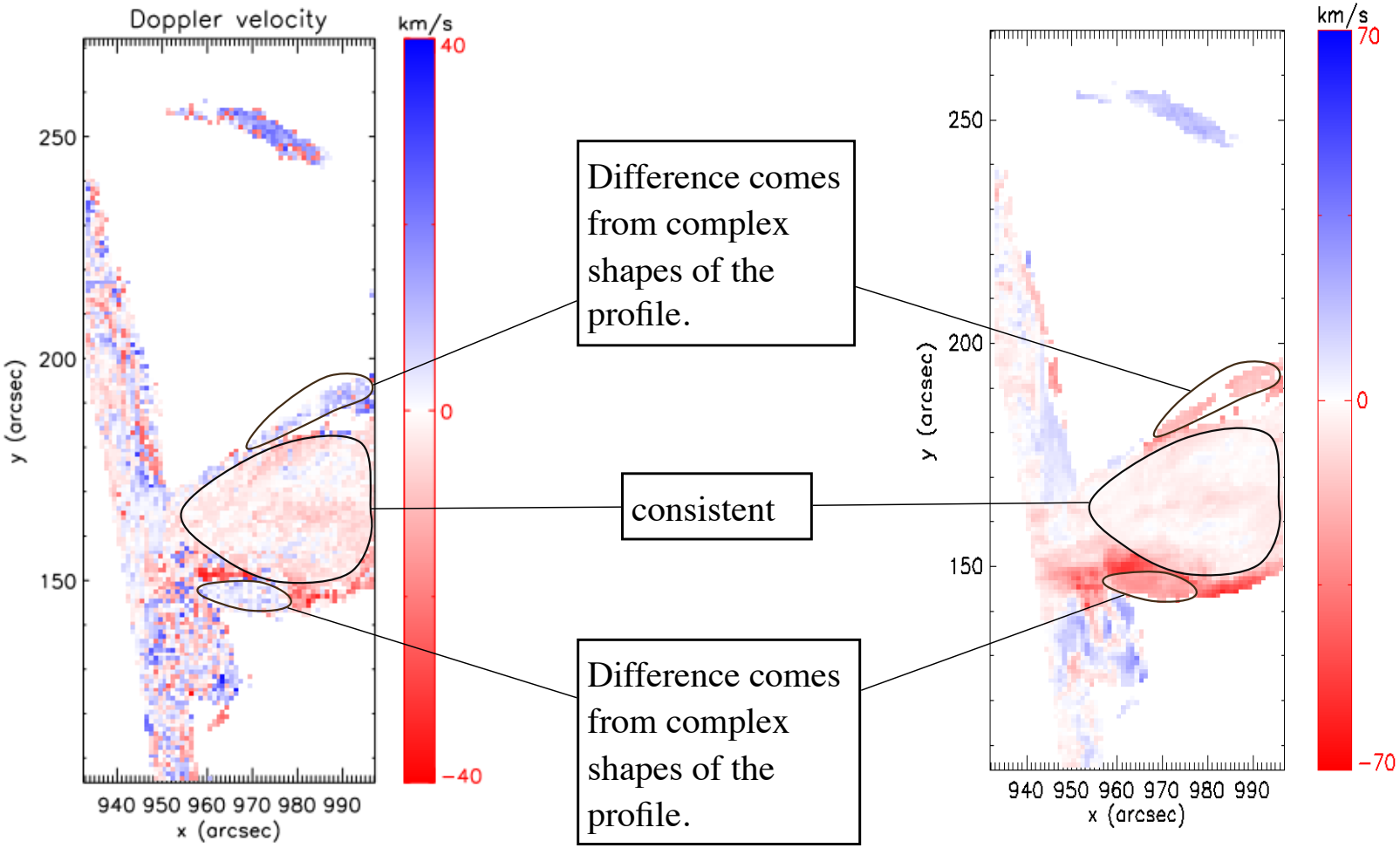




IRIS raster
15:10-15:27 UT

Doppler velocity

Reference wavelength: average over a large quiet region out of the West limb

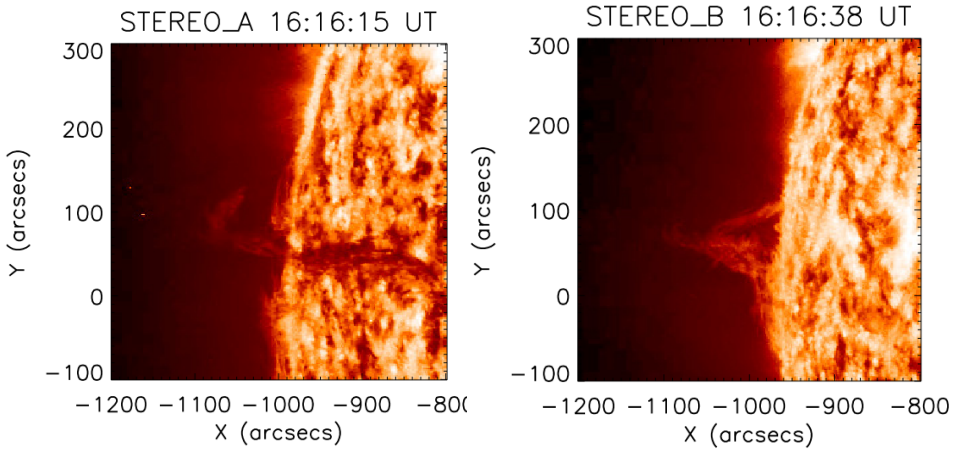


Extremum-finding algorithm
(Leenaarts et al.)

Gravity center

3D velocity

3D geometry

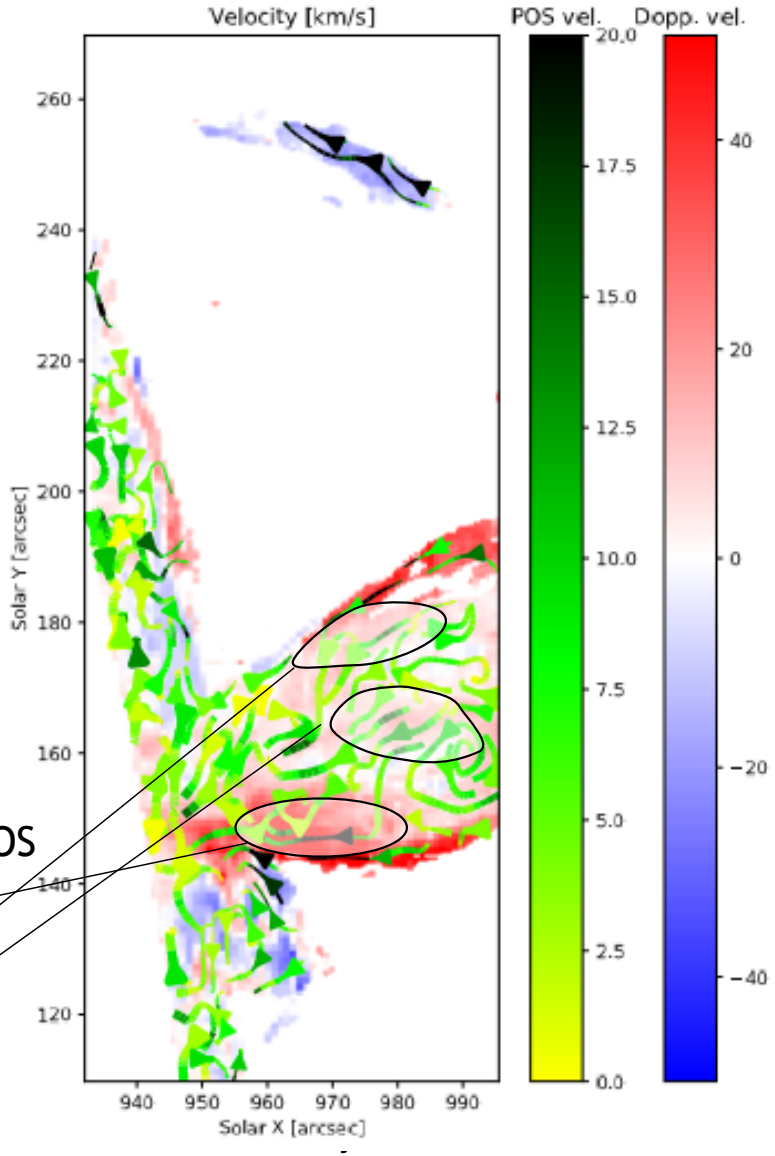


The EP is mainly located behind the POS

For the lower part, the inclination angle between the prominence axis and the solar horizontal plane < 40 ◦ at

Doppler red shift ⟷ downward motions in POS

The ratio of Doppler velocity to POS down flow velocity ~1 to 3



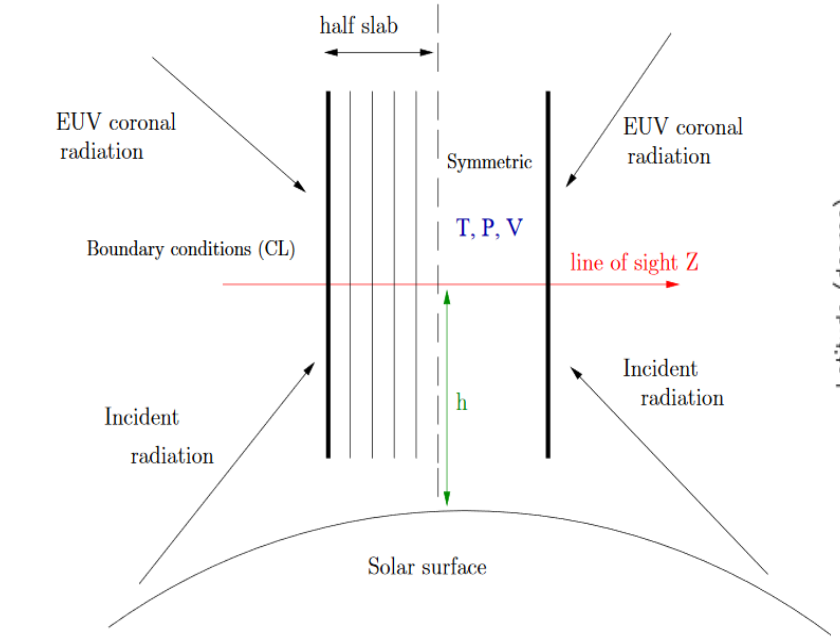
Plasma diagnostics

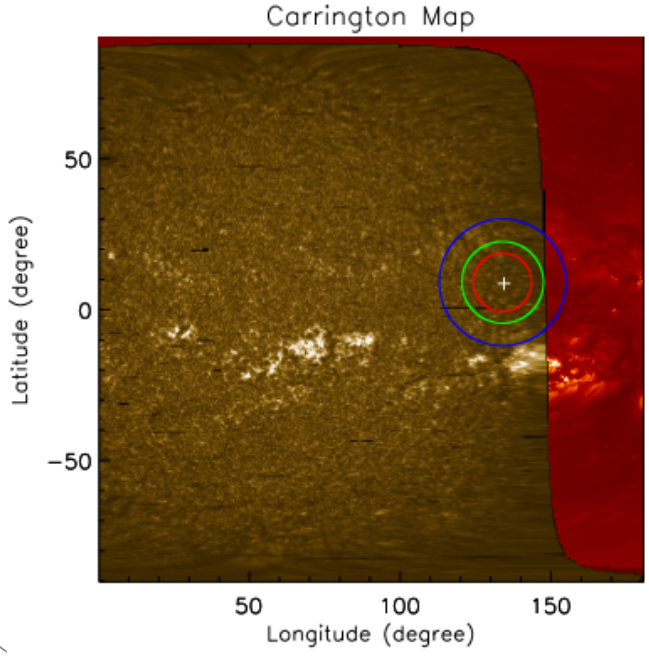
1D NLTE radiative transfer model: PROM7 (MEDOC)

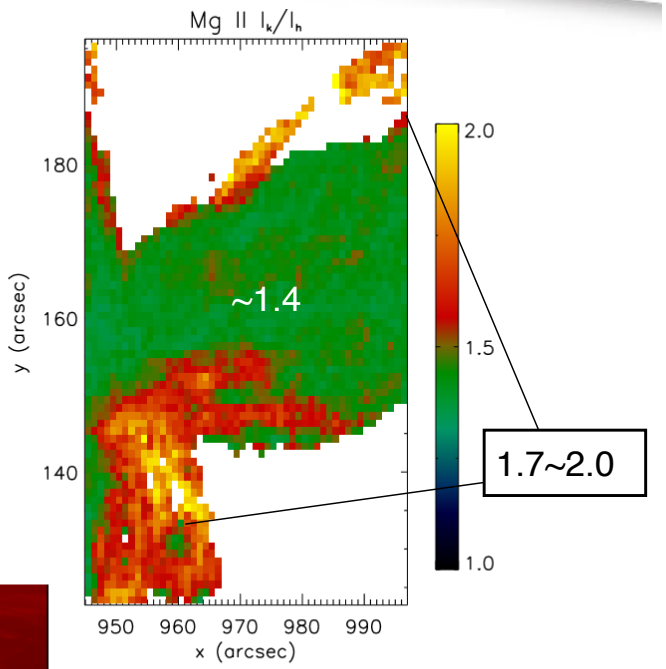
◆Consists of plane-parallel slabs standing vertically above solar surface.

◆It solves the equations of radiative transfer, statistical equilibrium, ionization and pressure equilibria

◆5 parameters: Temperature, Pressure, Thickness, Turbulence



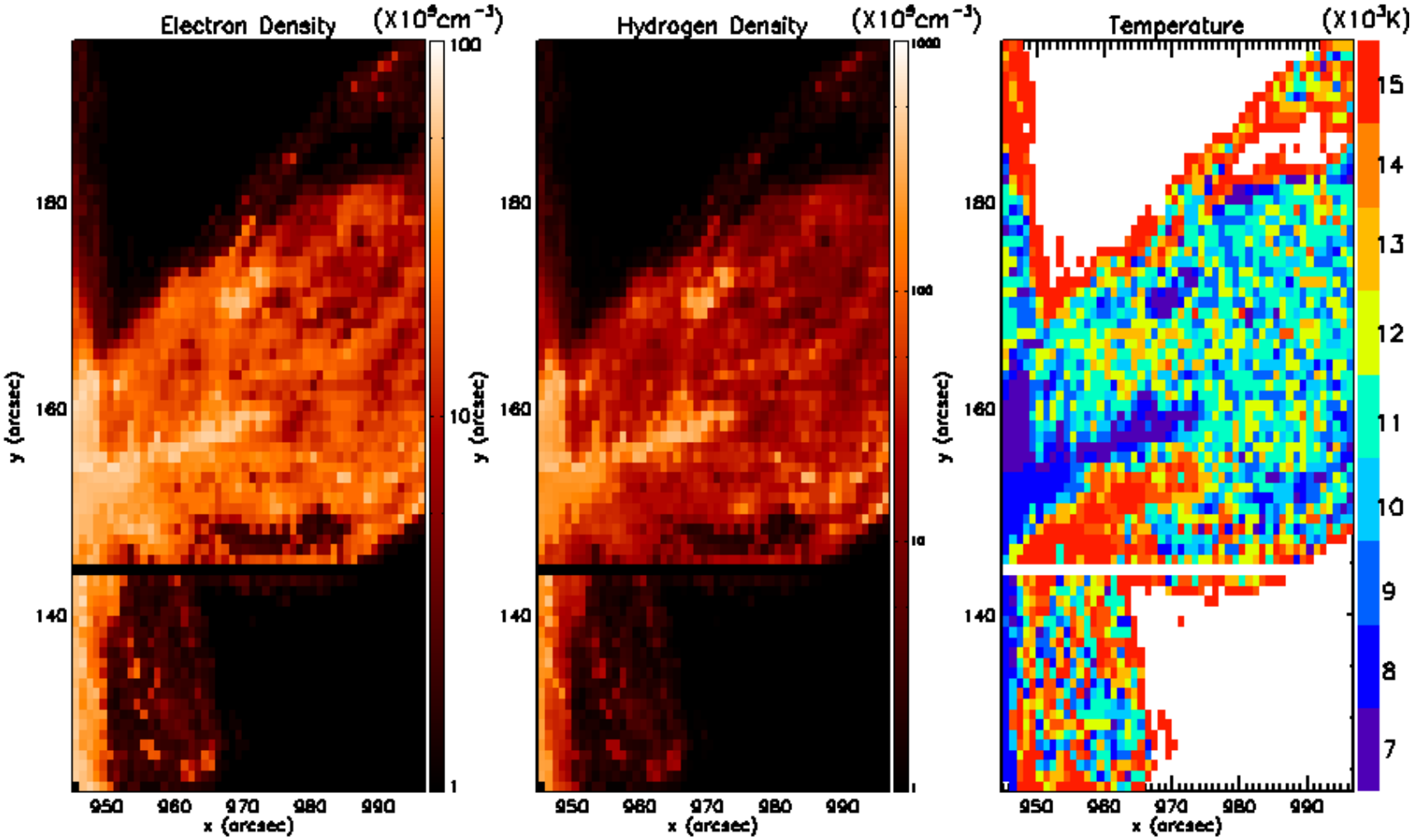




IRIS mosaic on May 27

Temperature (K)	Pressure (dyn/cm²)	thickness (km)	Turbulence Velocity (km/s)	Height (km)
5000-15000	0.002-0.5	1000	5	10000-50000

Plasma diagnostics

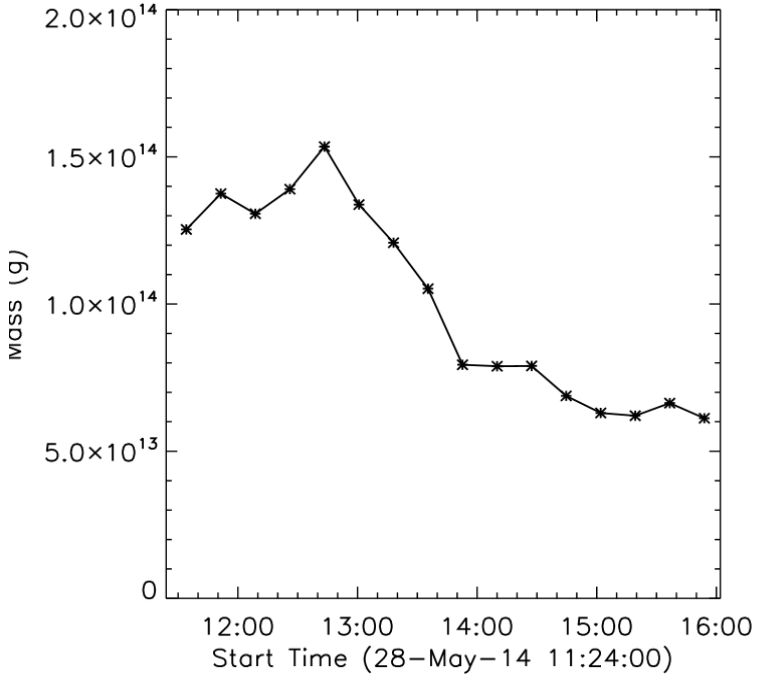


IRIS 15:10-15:27 UT

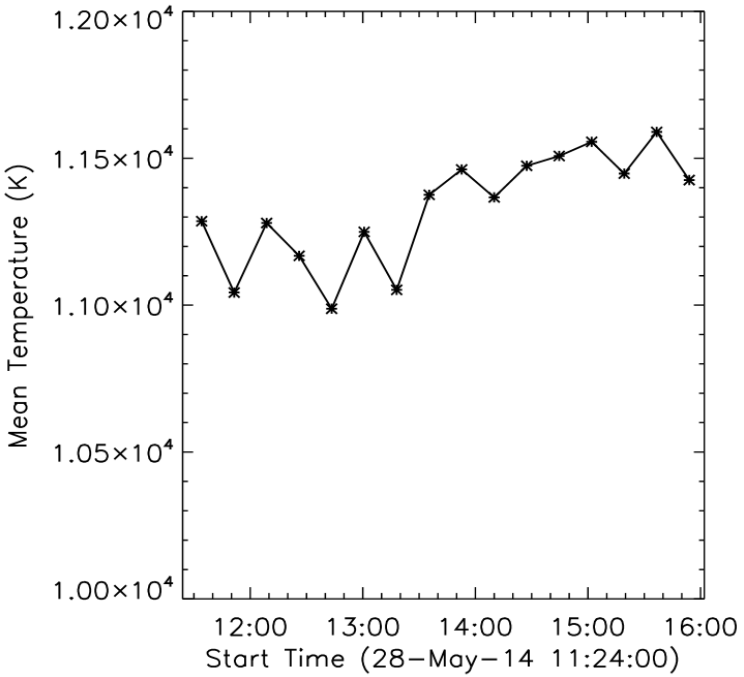
Electron densities: 1.3×10^{9} to 6.0×10^{10} cm^{-3} (7×10^{9} cm^{-3} from Si IV doublet and K-COR white light)

Hydrogen densities: 1.5×10^{9} to 2.4×10^{11} cm^{-3}

Mass flow and temperature in IRIS FOV



Total mass in IRIS FOV changes with time



Mean temperature in IRIS FOV changes with time

Mean POS velocity: downward, 1-4 km s^{-1}

Total mass drainage from the prominence in IRIS FOV adds up to 1.3×10^{13}g during the whole observation time of IRIS

Mean temperature changes from around 1.11×10^{4} K to around 1.15×10^{4} K.

Discussion and Conclusions

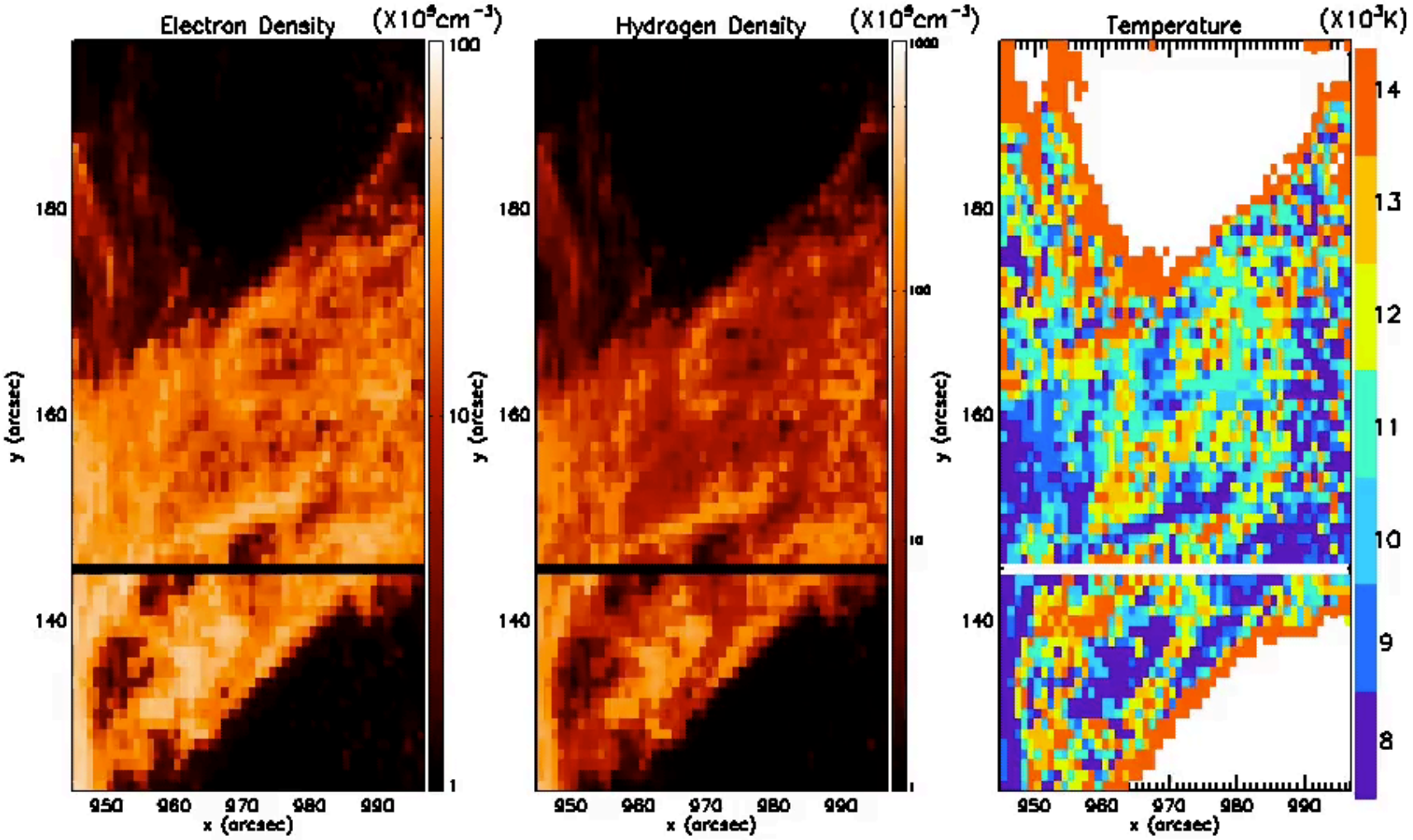
Characteristics of the activation phase of the eruption:

- Temperature (about 11 000 K) higher than in a quiescent prominence, and increase at the 'edges'
- Electron densities: 1.3×10^{9} to 6.0×10^{10} cm^{-3}, Hydrogen densities: 2.0×10^{9} to 2.4×10^{11} cm^{-3}, in the usual range
- Ionization degree (n_e/n_1): generally 0.3-4, and > 10 at edges
- Total mass: 1.5×10^{14} to 3.7×10^{14}g, in the range of observed values
- Evidence of motions returning to the Sun: threads in the top part

of the prominence and downward motions dominate in the lower part of the prominence

Thank you!

Plasma diagnostics



IRIS 11:24-16:01 UT

Plasma diagnostics