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QUANTIFYING CME EFFECTS ON PLASMA PARAMETERS AND ELEMENTAL ABUNDANCE RECOVERY DURING A FLARE EVENT WITH X-RAY SPECTROSCOPY

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A. OBJECTIVES

Soft X-ray spectroscopy can tell us about the evolution of plasma parameters and elemental abundances during a solar flare. Abundance recovery depends on the time plasma is trapped within the magnetic field.

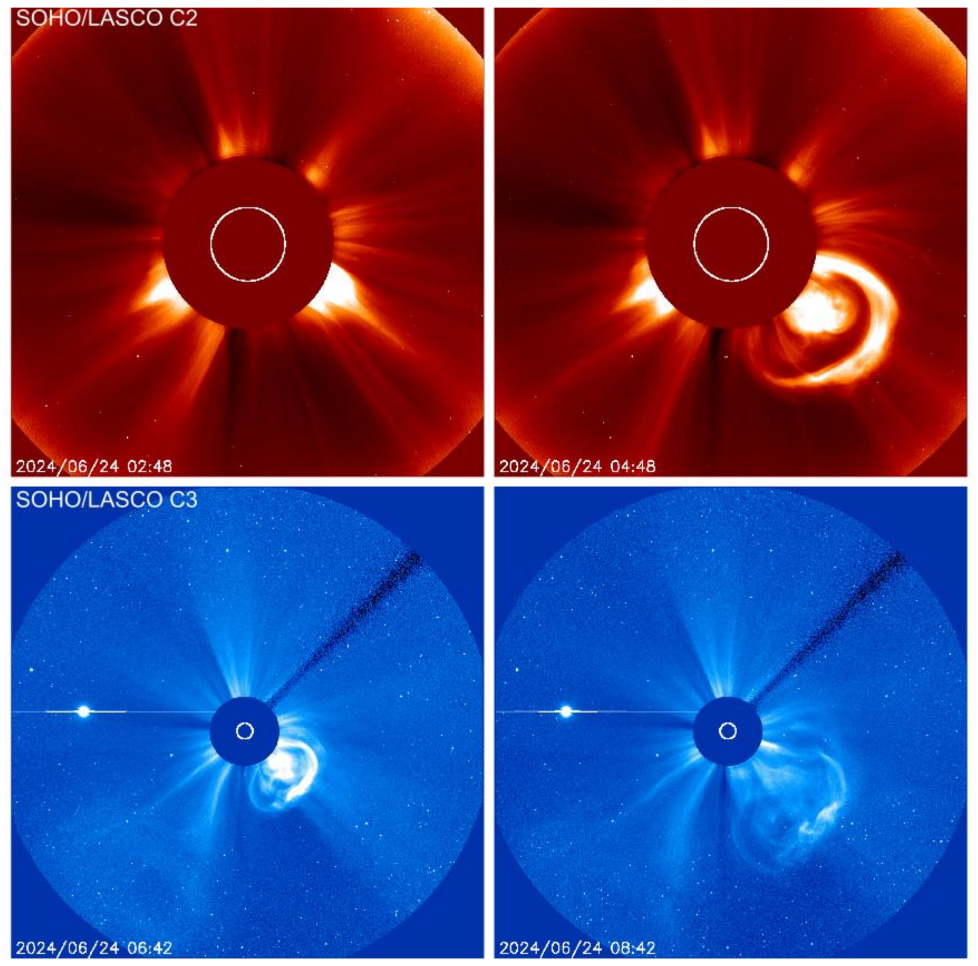
Flare-CME model: plasma flow continues along open field lines connected to the CME core after eruption → how does an associated CME affect flare signatures observable in soft X-rays?

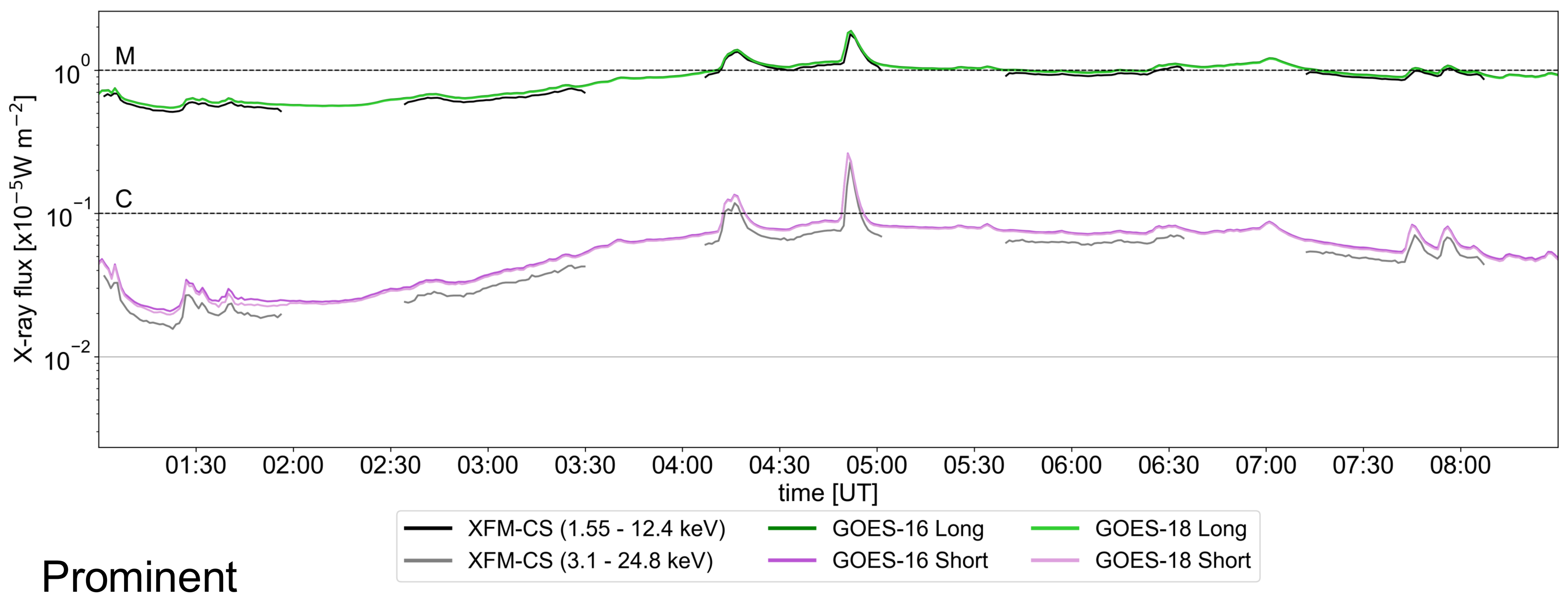
B. EVENT OVERVIEW

A CME was observed in white light 24 June 2024 from AR 13712 at S25W9.

CME onset time $t \leq$ 02:48 UT. Linear speed 640.0 km/s, direction 91/-40 (lon/lat HEEQ), half-width 44.0° [1].

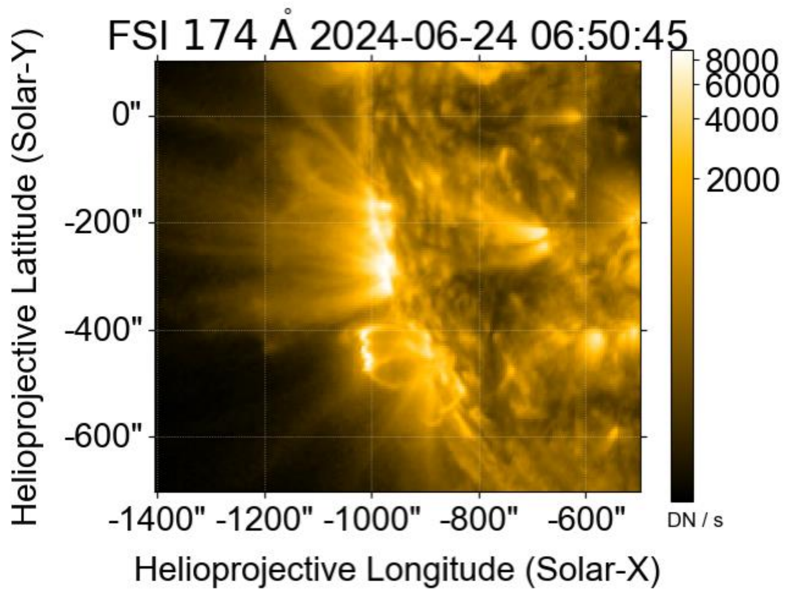
After CME onset, there was a gradual rise in X-ray flux. Two M-class flares and several local brightenings were observed from the same AR. Flux levels remained high, but other flares were not reported → what was the source of emission?

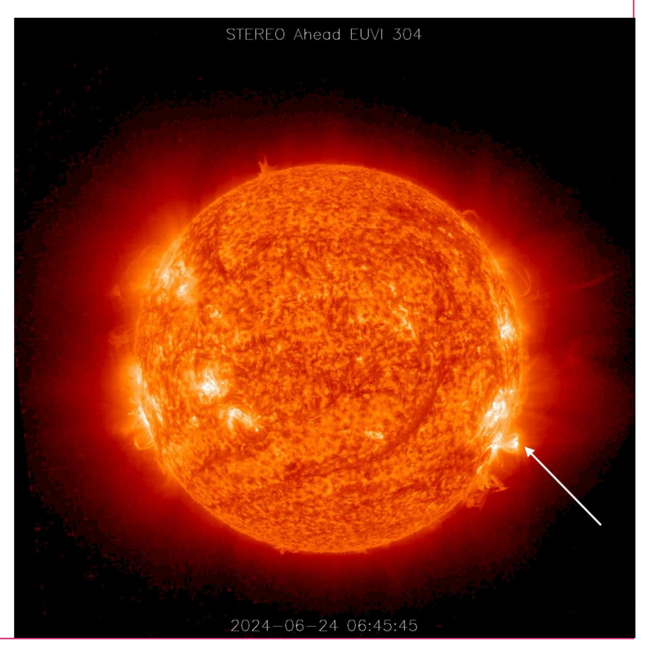




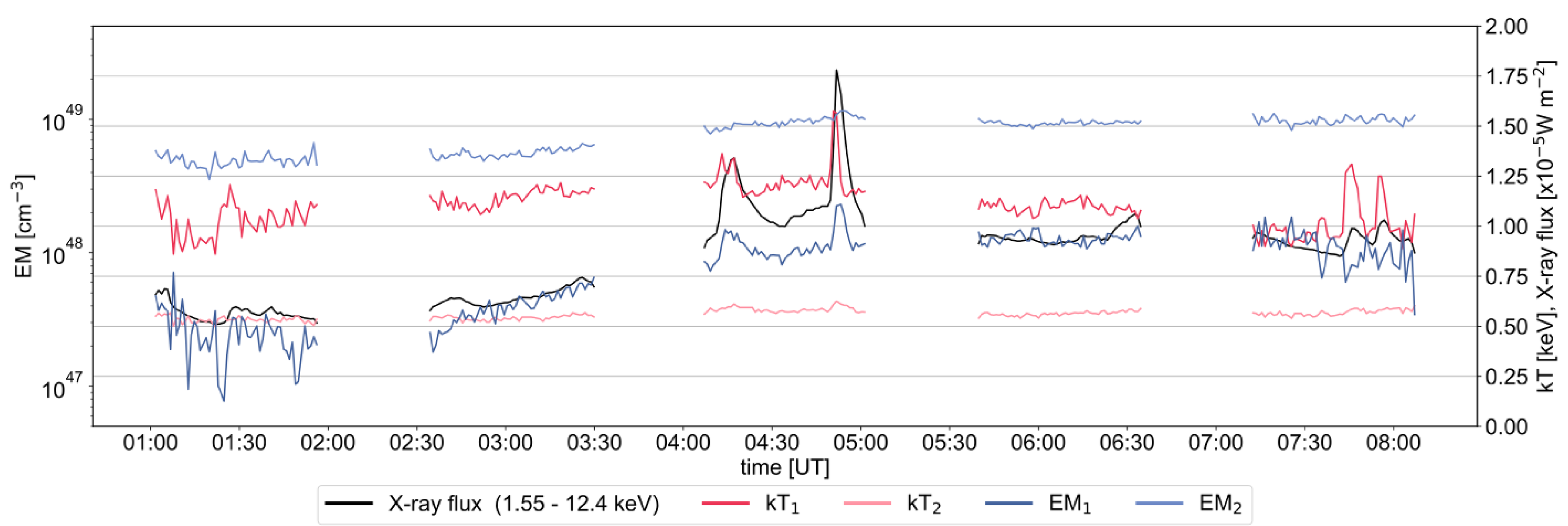
Prominent post-CME loops appeared in EUV.

Longevity and brightness imply that this was a significant emission source.





D1. RESULTS: PLASMA PARAMETERS



Evolution of plasma temperature (kT) and emission measure (EM) for the model components. Darker colors are used for the hotter component and lighter colors for the cooler component. EM is a proxy for particle density: $\int n_e n_H dV$.

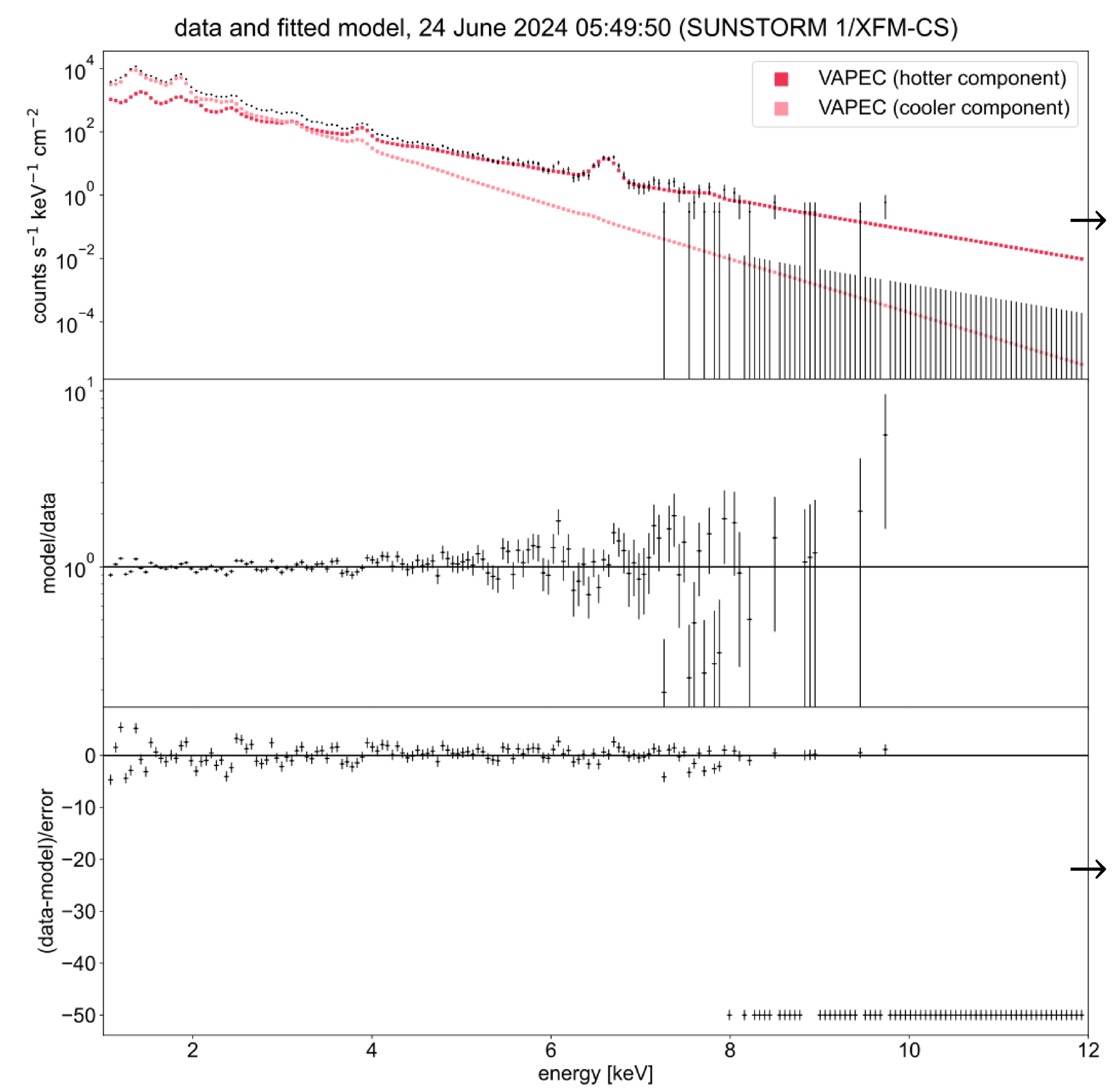
Temperature and emission measure increase after CME lift-off. Reconnection accelerates electrons that stream along magnetic field lines towards the footpoints. The chromosphere heats, and pressure gradients form SXR loops.

The heated plasma is conducted to the flare loop. Chromospheric evaporation is rapid and the temperature peaks.

Once the loops are filled with chromospheric plasma, pressure increases. Heating is slowed down, and emission measure peaks.

C. METHODS

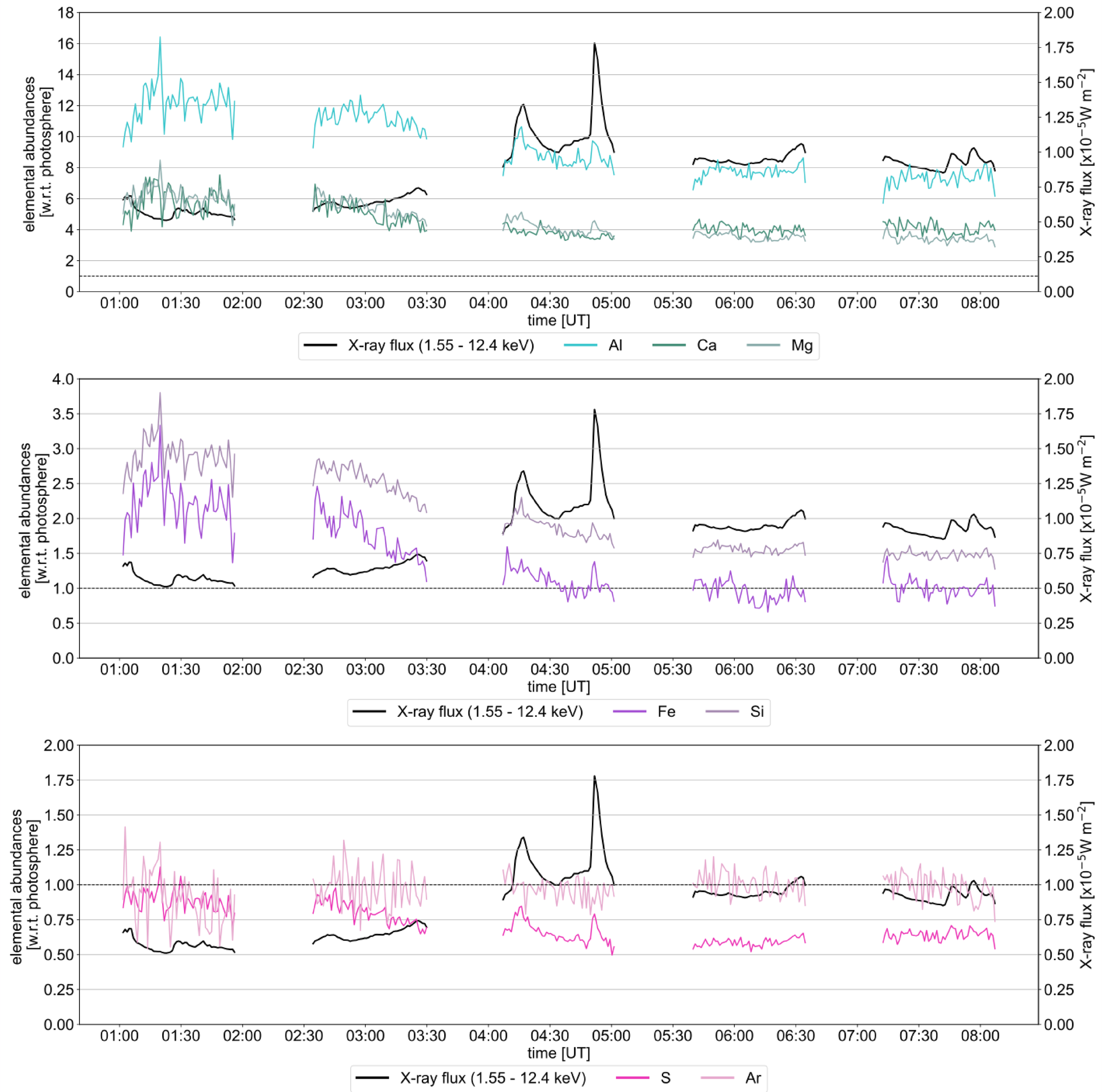
Spectral data from SUNSTORM 1/XFM-CS [2] was fitted with XSPEC [3] using a two-component VAPEC [4] thermal plasma model between 1-12 keV.



→ Cooler component fits low energies, hotter component fits higher energies.

→ Larger fit residuals are seen above 8 keV: Poisson noise and fluctuations of the electron background.

D2. RESULTS: ELEMENTAL ABUNDANCES



Evolution of abundances with respect to photospheric values for low FIP elements Al, Ca, Mg, Fe and Si (top and middle panels), mid-FIP element S and high-FIP element Ar (bottom panel).

FIP bias: abundances of low FIP (first ionization potential < 10 keV) elements are higher in the corona than the photosphere.

During a flare, fast plasma flow fills the X-ray loop with unfractionated material, and the FIP bias is depleted. Increased pressure causes the plasma to spend more time in the fractionation layer and abundances recover.

Abundances are 0.2 to 1.5 times higher before the eruption in comparison to the last fitted intervals. Abundance recovery is not observed for any of the elements within the fitted interval!

E. CONCLUSIONS

Field lines remain connected to the core of the expanding CME. Pressure build-up is slower, and plasma flows faster through the fractionation layer → abundance recovery is delayed.

CME significantly affects spectroscopic results. Hard X-ray imaging can be used to track evolution of the emission source.