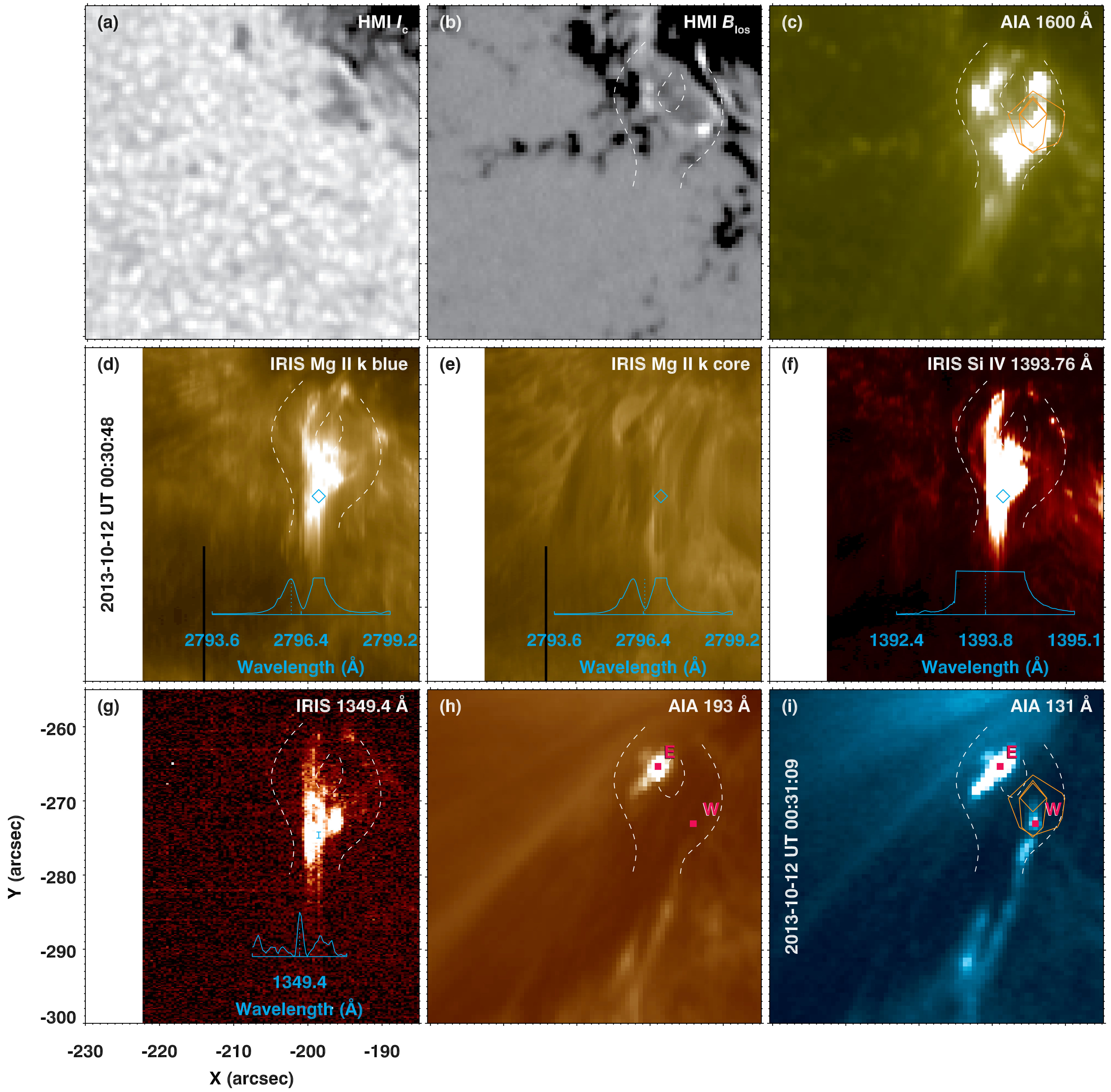
Hard X-ray emission from an unusual flare in the solar chromosphere



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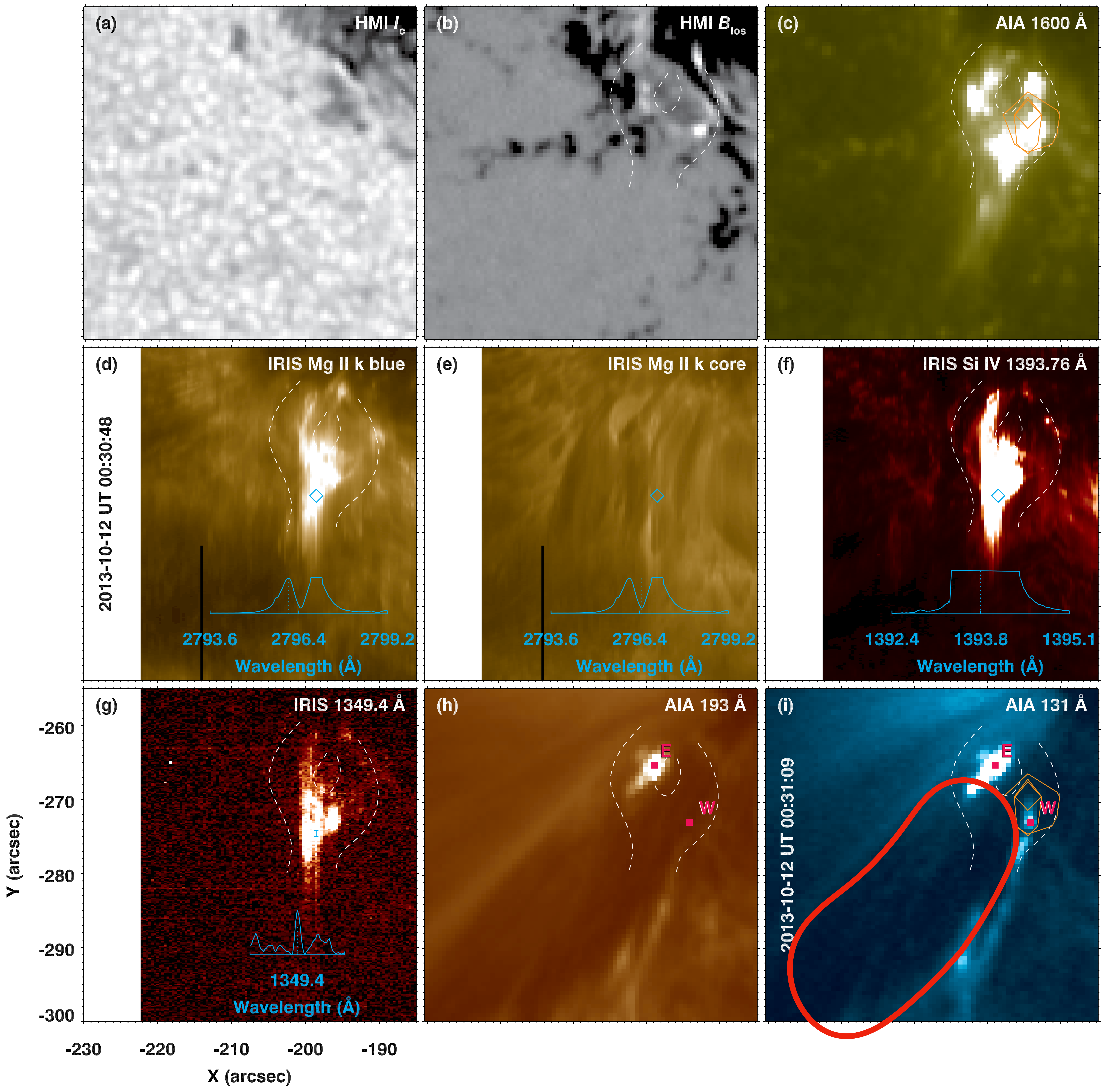
Unusual Chromospheric flare

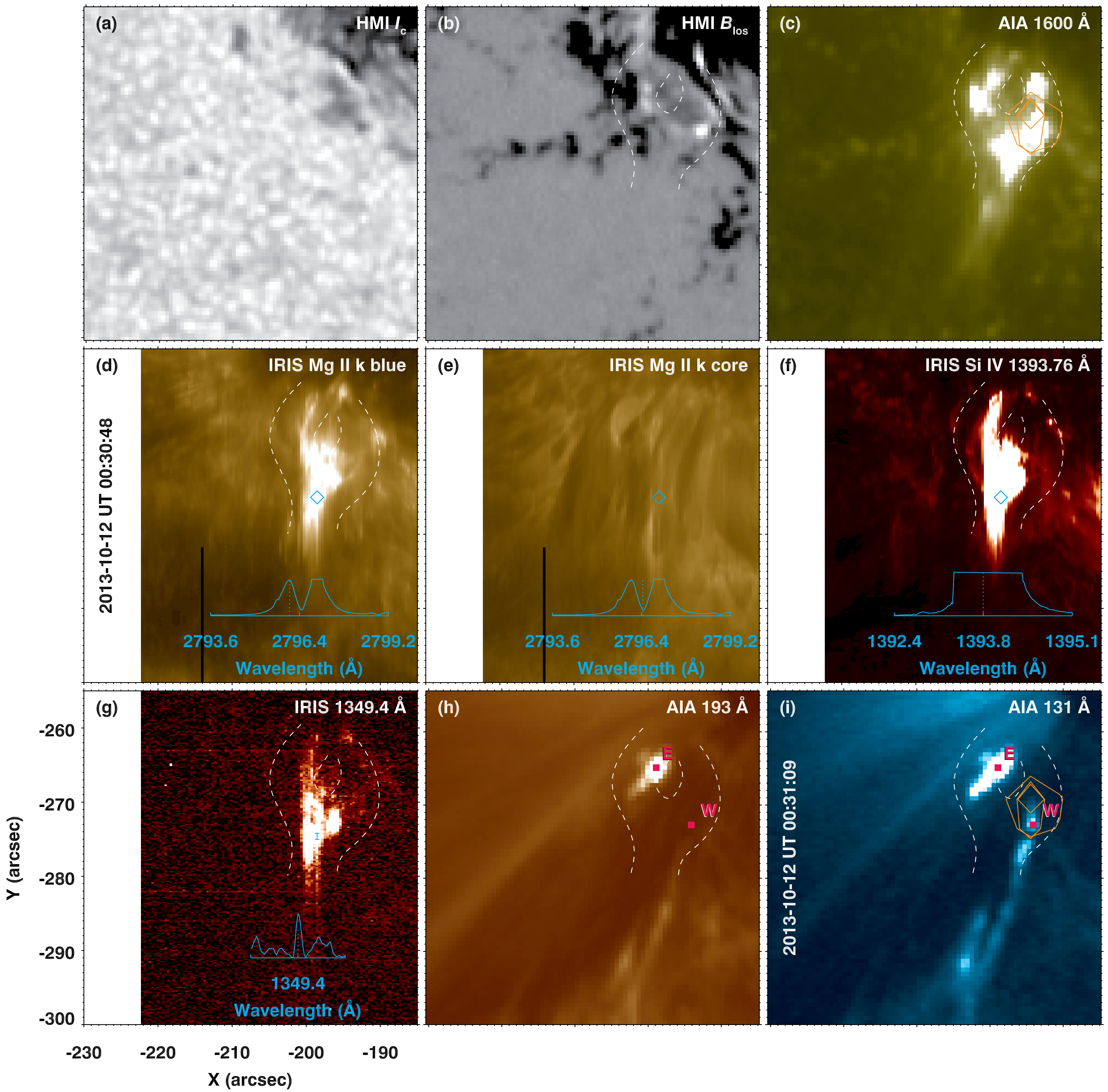


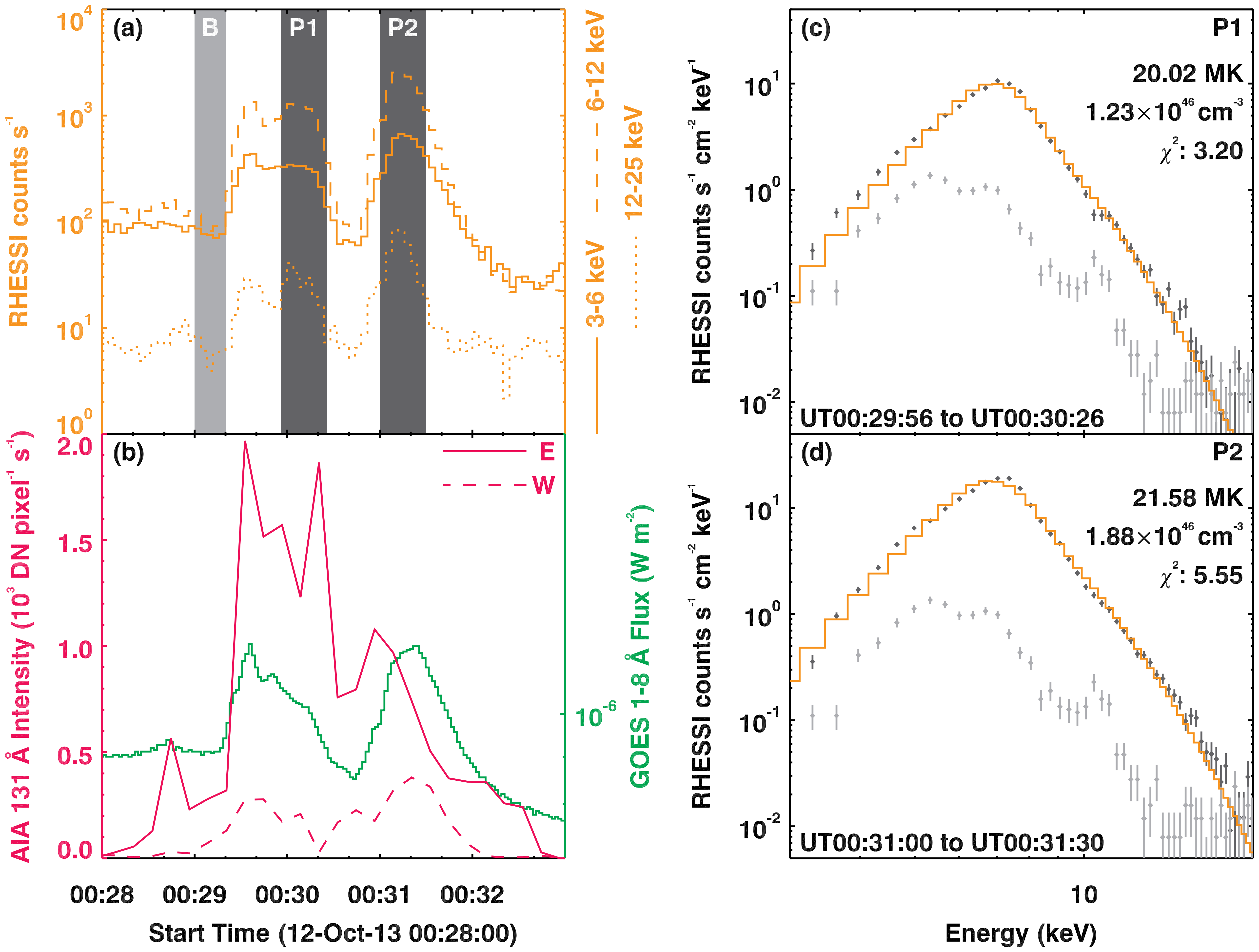
SDO/AIA 1600 Å UV filter recorded a compact brightening at the outer edge of sunspot on 2013-Oct-12 around UT 00:30

IRIS also detected that event – while the brightening is clearly seen in the wings of Mg II K line and Si IV lines, there was no signature of the event in the core of Mg II K. This suggests that the brightening is confined to heights below the chromospheric canopy

The AIA EUV filters recorded merely footpoint regions (E/W) of the brightening. The footpoint-W is seen only in the AIA 131 Å and 94 Å filter images while the footpoint-E is recorded by all filters. The bulk of the event is obscured by dark material (red outlined region).

Unusual Chromospheric flare



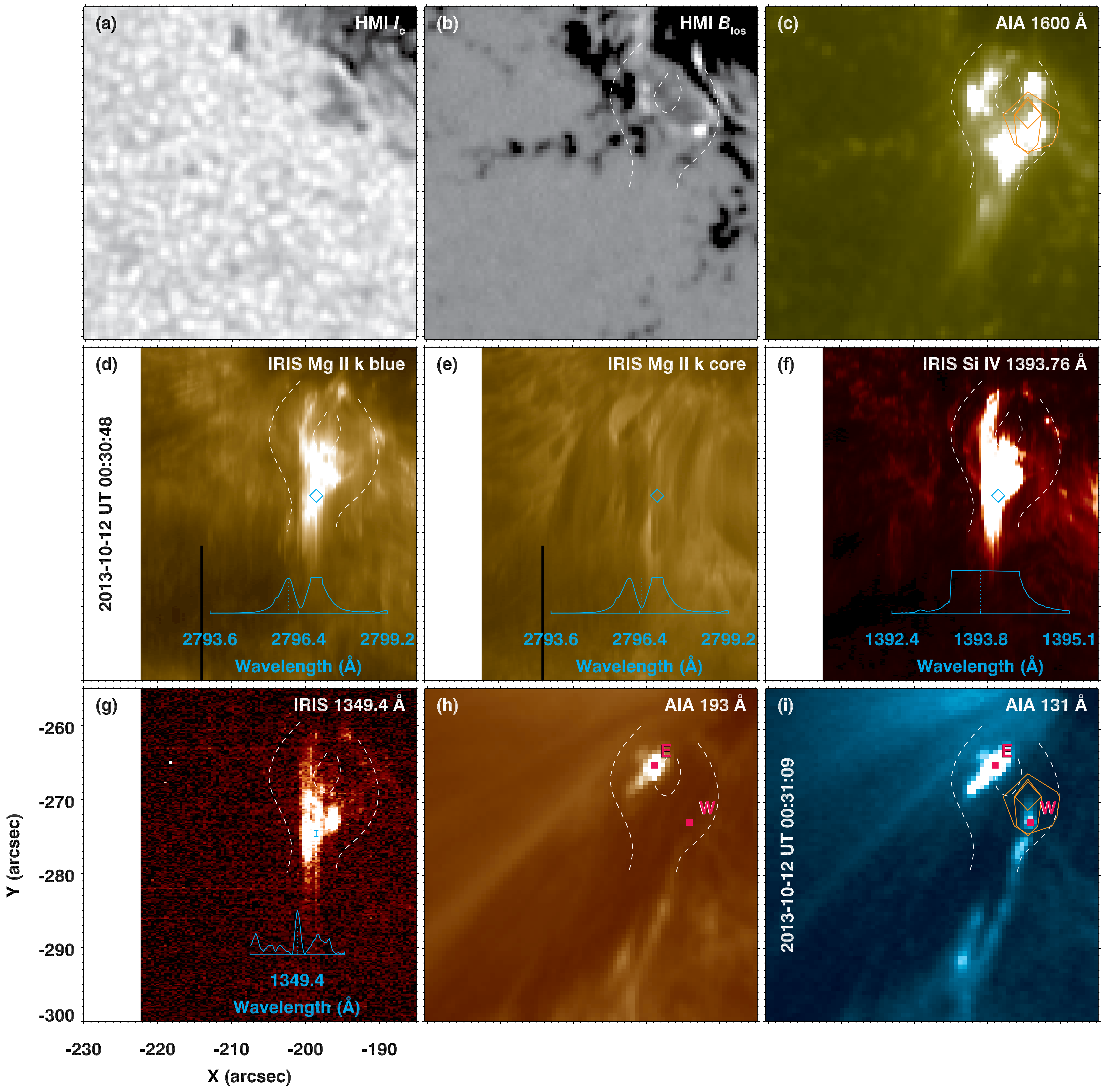


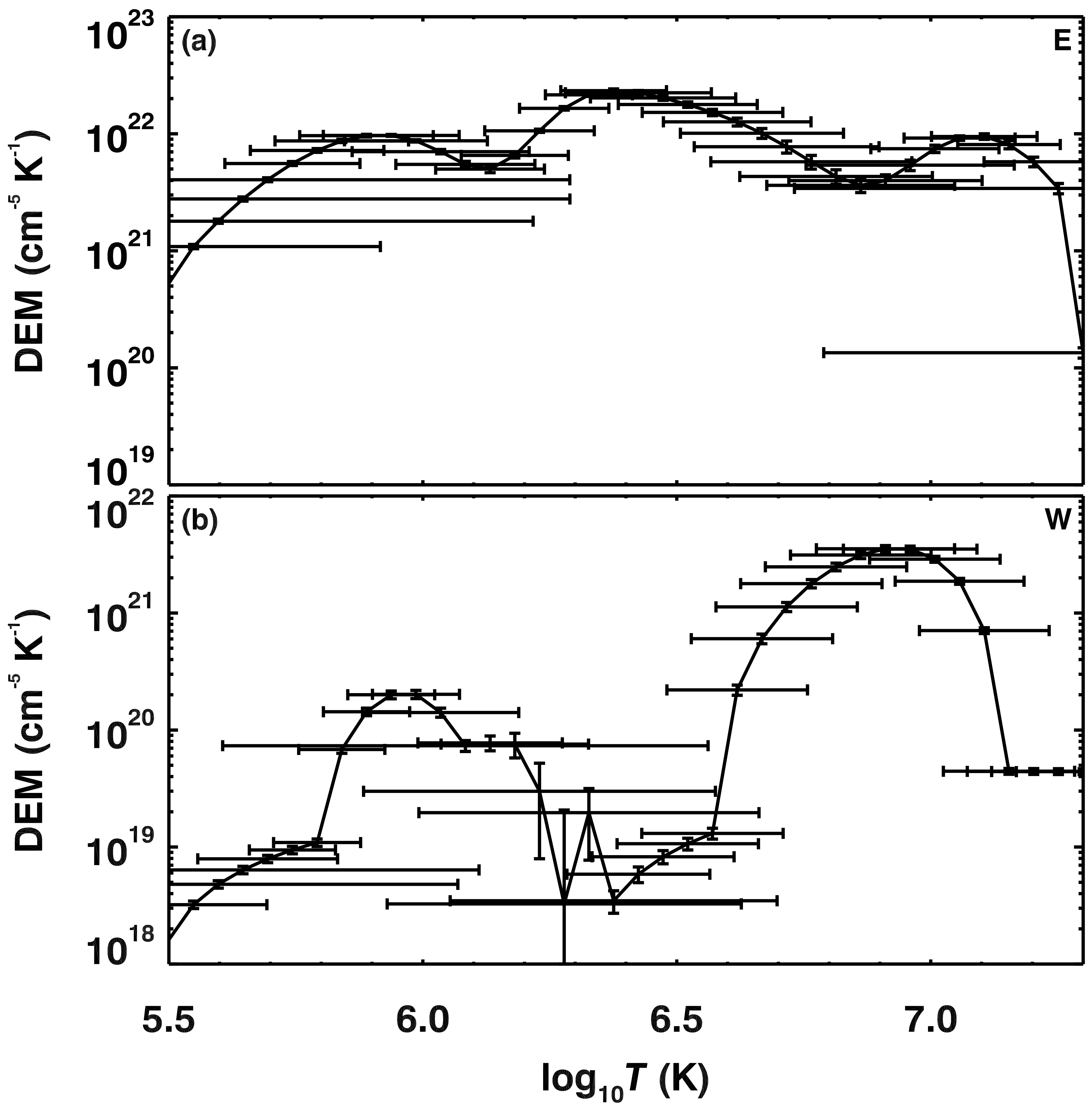
Hard- X-ray emission in excess of 10 keV is recoded by RHESSI over footpoint-W (contours). The event is a compact flare confined to the chromosphere.

Unusual Chromospheric flare

Spectral fits to RHESSI data reveal that footpoint-W is heated to over 20 MK in two episodes, each lasting 60 s.

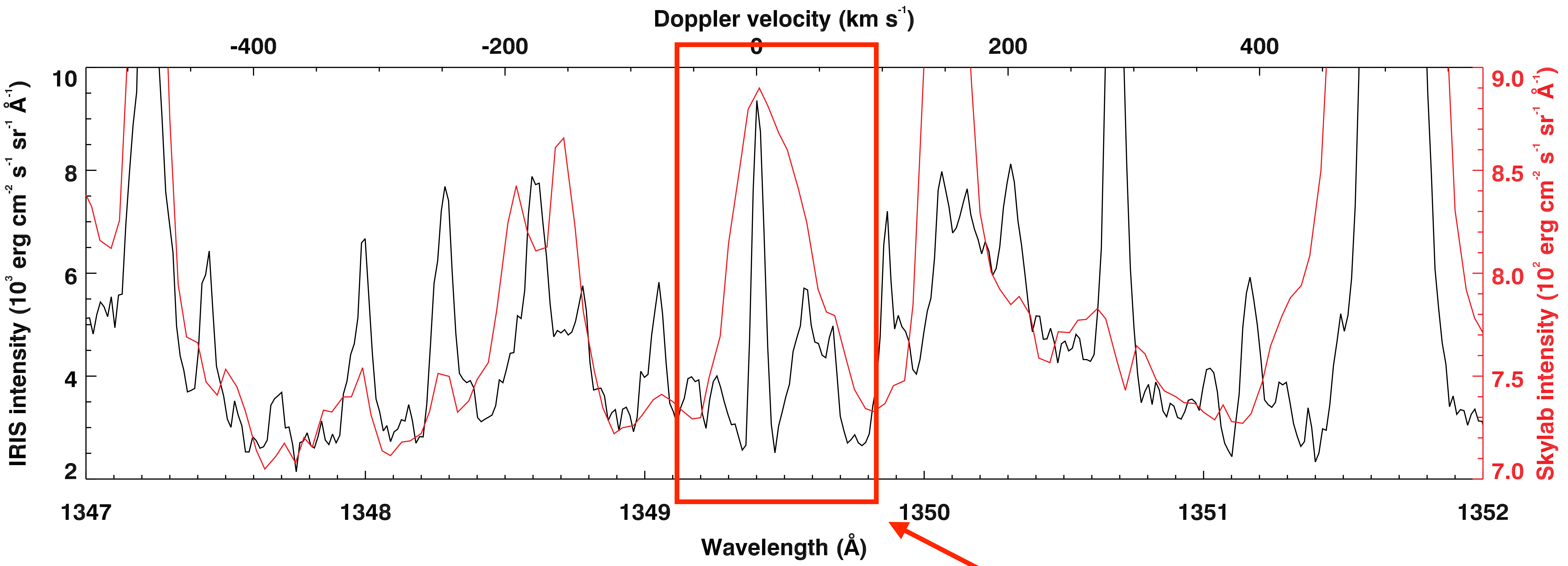
Unusual Chromospheric flare

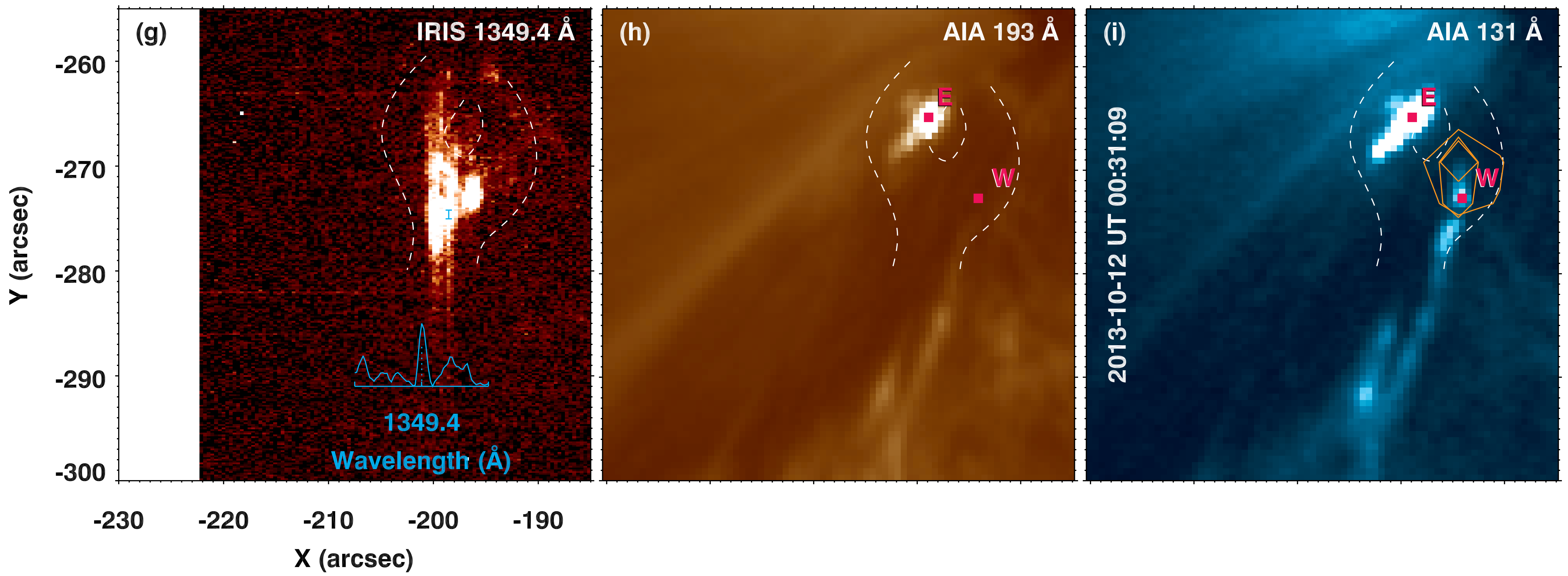




DEMs based on AIA/EUV emission from footpoints E and W do hint at the presence of high temperature plasma that could be responsible for RHESSI and GOES signals.

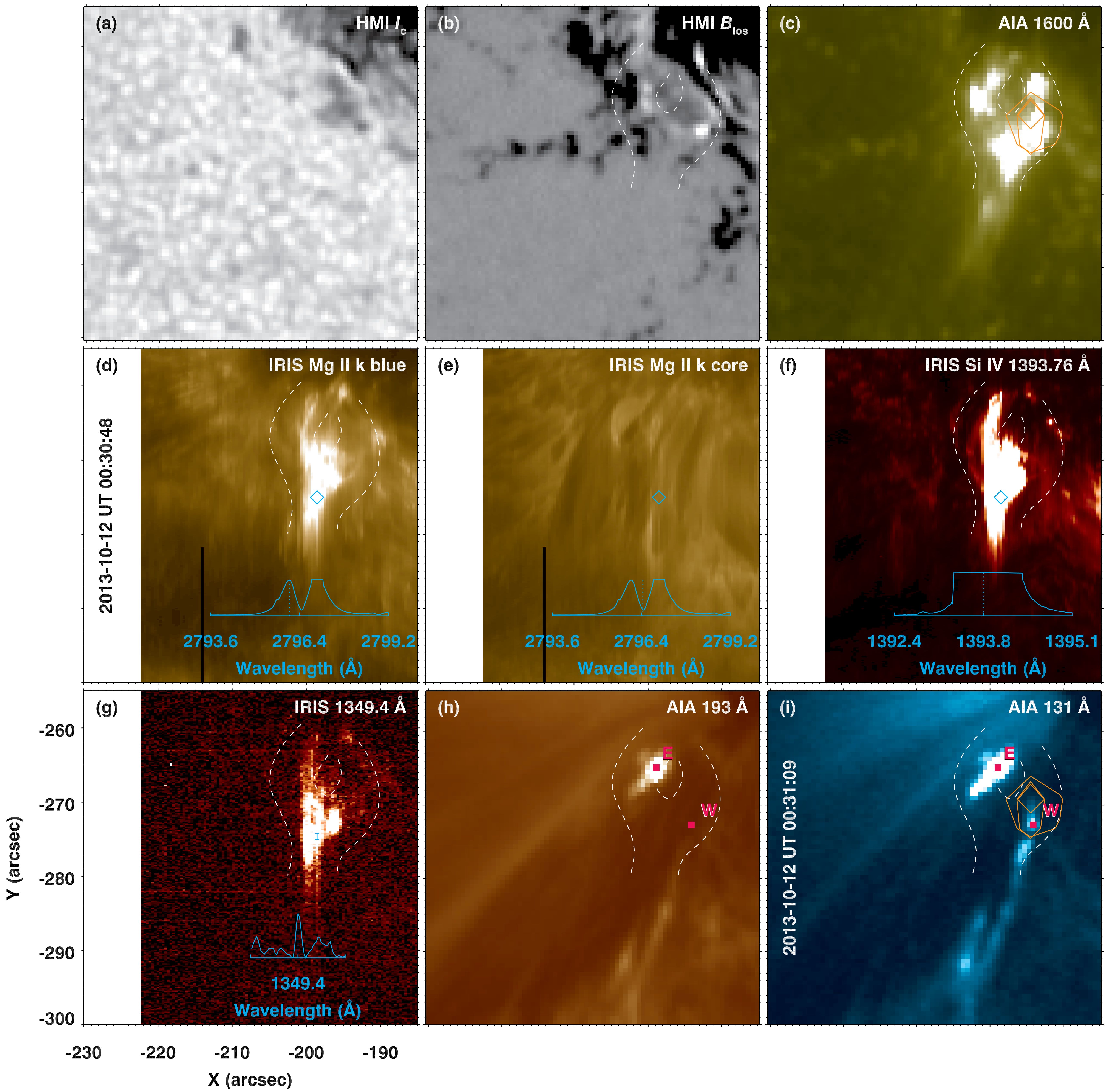
Unusual Chromospheric flare

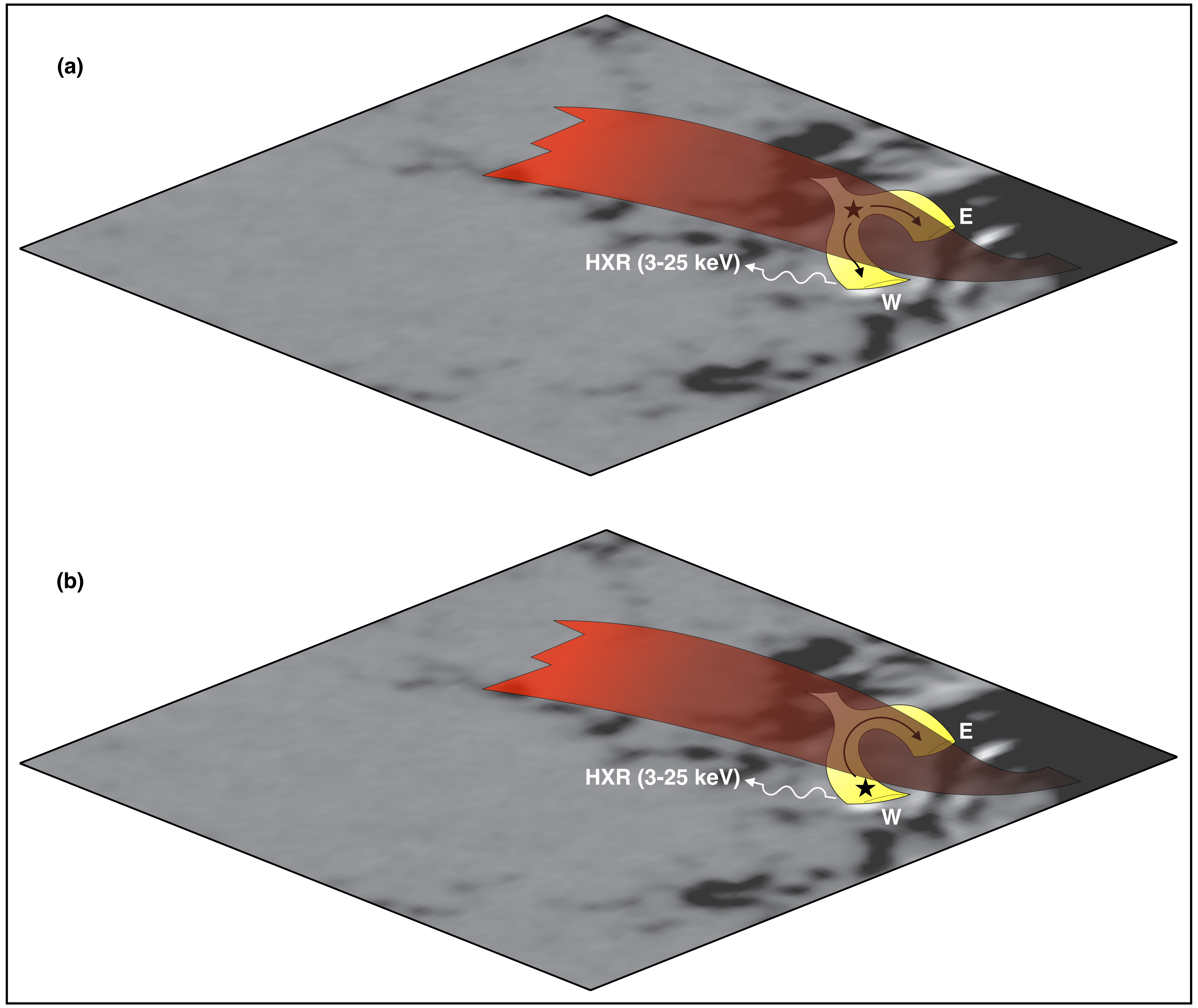




Intriguingly, there is no clear Fe XII (~1.6 MK) and Fe XXI (~10MK) signal detected by IRIS. There is indeed some line emission around the wavelengths nominal to the Fe XII emission (1394 Å; bottom left panel). But its thermal width is narrower than what is expected for Fe XII around 1.6 MK. This is further evident when that line emission was compared with Fe XII spectral line observed with Skylab (Simões et al. 2019, ApJ, 870, 114).

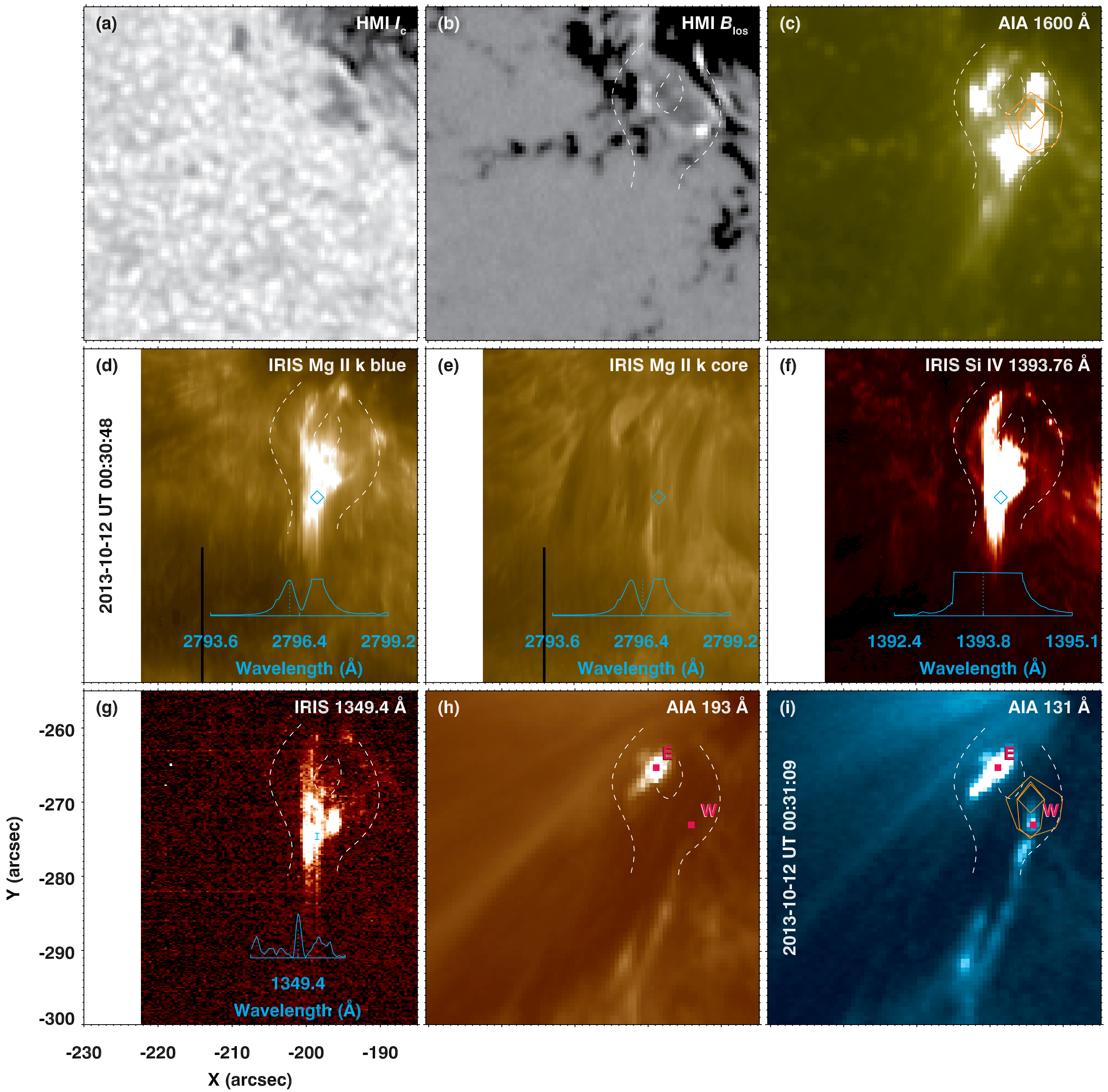
Unusual Chromospheric flare





Possible scenarios of the unusual chromospheric flare. In one scenario, magnetic energy released at the cusp-shaped loop-top (star in the top panel) is deposited at both footpoints. This deposited energy is the source of HXR emission at footpoint-W. In the second scenario, energy released directly at footpoint-W is responsible for HXR emission at that location (star in the bottom panel). Part of the energy is also transported from footpoint W to E.

Unusual Chromospheric flare



This unusual flare points to the possibility that magnetic energy release and deposition within the chromosphere could heat the plasma to flare temperatures.

Events similar to these in the lower atmosphere, but not necessarily obscured by the chromospheric canopy, could be common in flare productive active regions that exhibit complex magnetic field distribution at the surface.

Observations do suggest that similar events (but at lower energies) could be responsible for microflare/nanoflare loop heating in active regions (Chitta et al. 2018, A&A, 615, L9; Chitta et al. 2020, A&A, 644, A130).

Could such chromospheric flares explain at least some of the hard X-ray emission observed at the footpoints of major flares?

Chitta et al. (in prep.)

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