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Soft X-ray spectra of strong flares seen by Bragg flat crystal spectrometer Diogeness aboard Coronas-F

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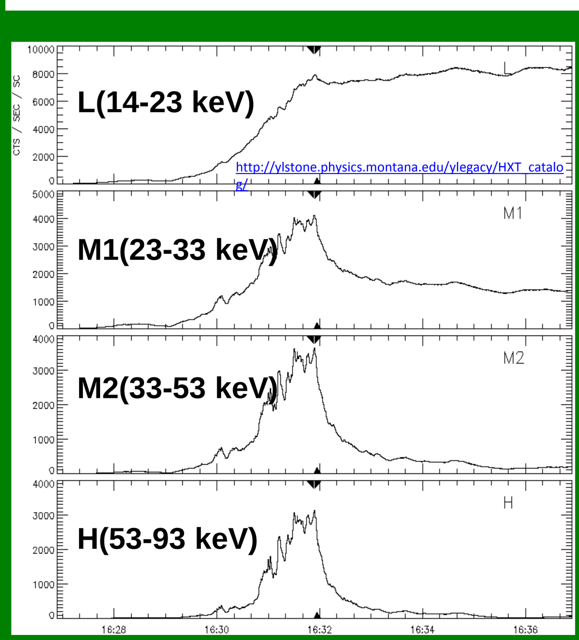
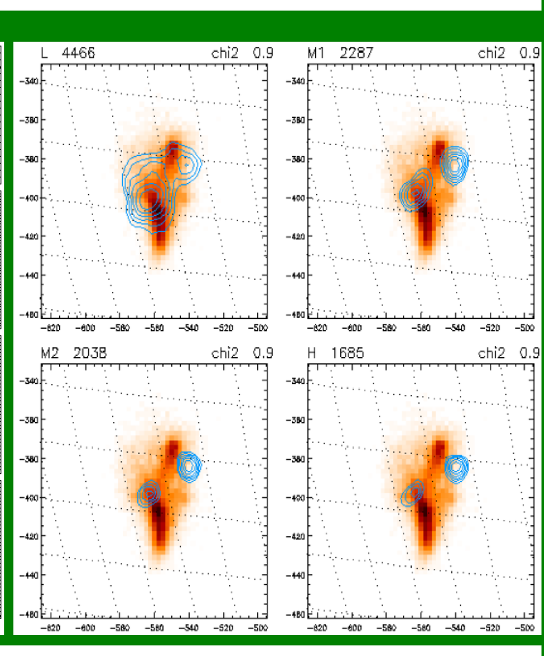
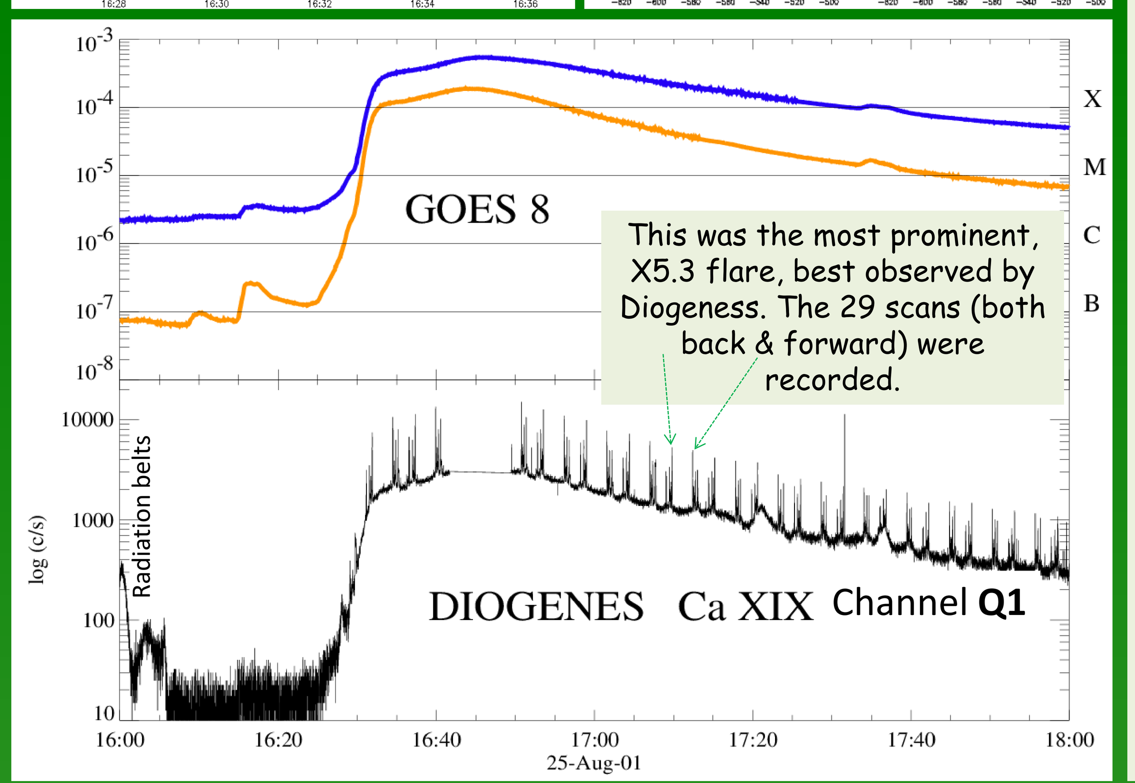
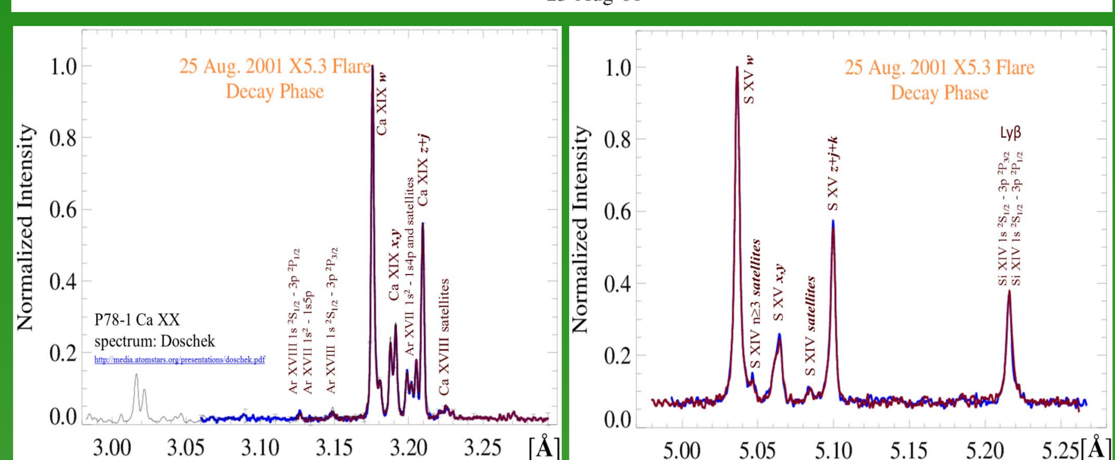
SOL2001-08-25T16:45

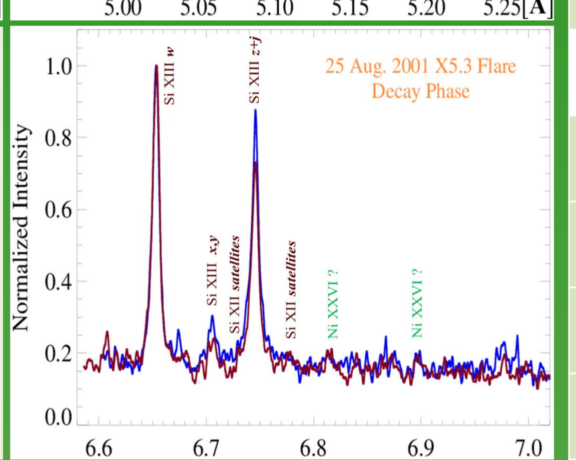


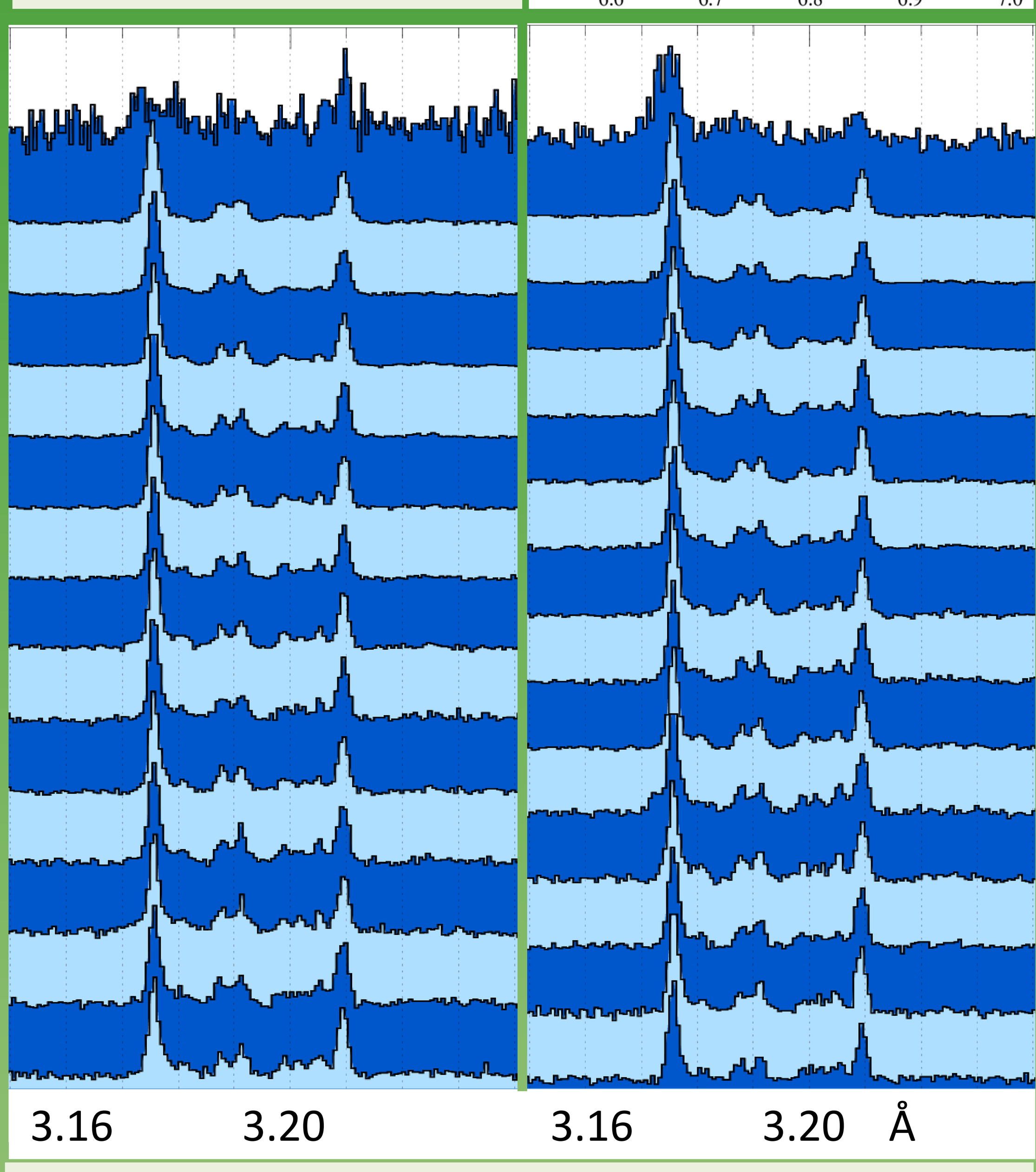






Three normalized, spectra averaged over the decay phase of the X5.3 flare on 25th August 2001. The spectrum for Ca XIX range was recorded using the Quartz 1 crystal while the spectra for S XV and Si XIII ranges were obtained using ADP and Beryl crystals respectively. Different colours (blue and claret) represent spectra recorded forward and backward in time. Identification of the most intense lines is provided.





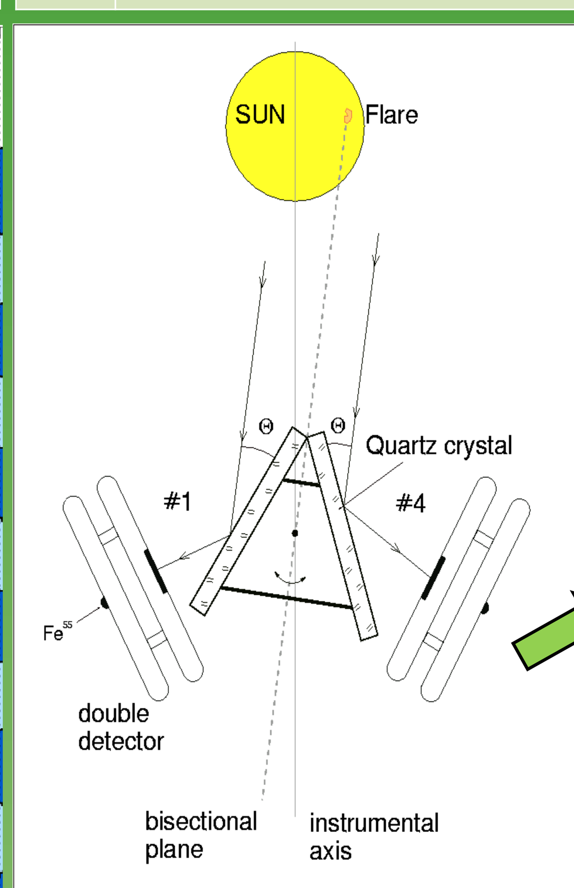
The stack of backward (left) and forward (right) scans for Quartz 2 channel. The time goes down from the top. Spectra are recorded approximately 2 minutes apart. It is seen that at the beginning the lines in the spectra are **wider** which is connected with the turbulent motions being the strongest during the impulsive energy release phase.

The instrument concept

Diogeness was an uncollimated Polish-design scanning Bragg flat crystal spectrometer observing the high-temperature plasma from the payload of **CORONAS-F** Russian satellite launched in 2001. This rocking spectrometer was equipped with four monocrystals used as dispersion elements for inciding X-rays. Two identical Quartz crystals are mounted on the common shaft in an unique, so-called dopplerometer configuration (see below). Such arrangement of the crystals' sense of dispersion (opposite each other) fixed at the precise angle 2Θ, allows for scanning the spectra in vicinity of Ca XIX resonance line (1s² -1s2p) at λ = 3.167 Å very close in time, but in the opposite wavelength direction. Such unique construction of the spectrometer permits for precise measurements of Doppler shifts of this X-ray line. The maxima of line scanned in opposite directions are to be measured closest in time for plasma being at rest. If the lines are Doppler shifted, they will be slightly wavelength displaced, and related time offset **Δt** of maxima recording is proportional to the radial component of plasma velocity.

Flares for which spectra were collected

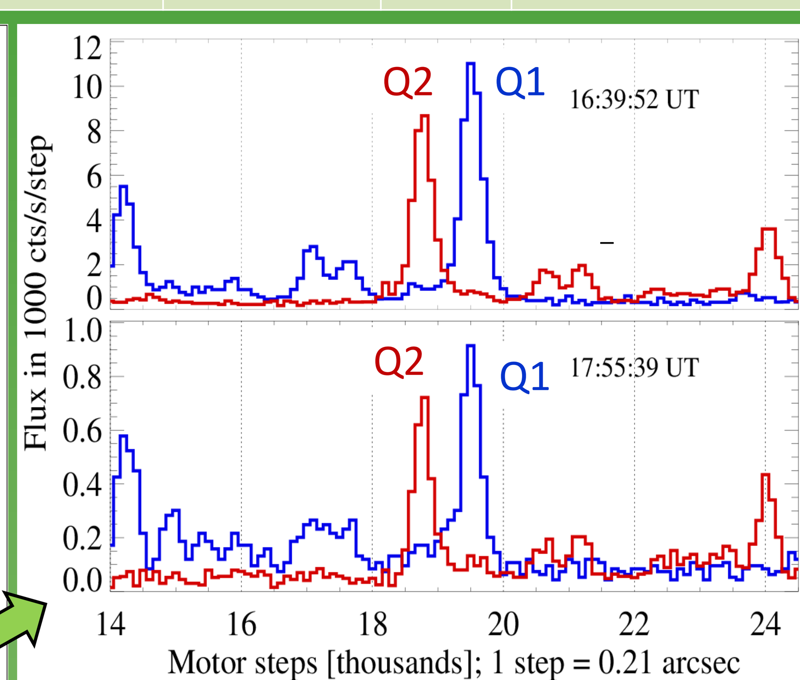
	Flare	GOES	Hα	Location
1	SOL2001-08-25T16:45	X5.3	3B	S17E34
2	SOL2001-08-30T17:57	M1.5	2N	S21W28
3	SOL2001-09-02T0602	M1.3	1F	S17W66
4	SOL2001-09-02T1348	M3.0	2N	S21W65
5	SOL2001-09-03T0158	C9.0	-	~E90S15
6	SOL2001-09-03T1716	M1.1	-	N10W06
7	SOL2001-09-03T1841	M2.5	-	~E90S28
8	SOL2001-09-16T0353	M5.6	2N	S29W54



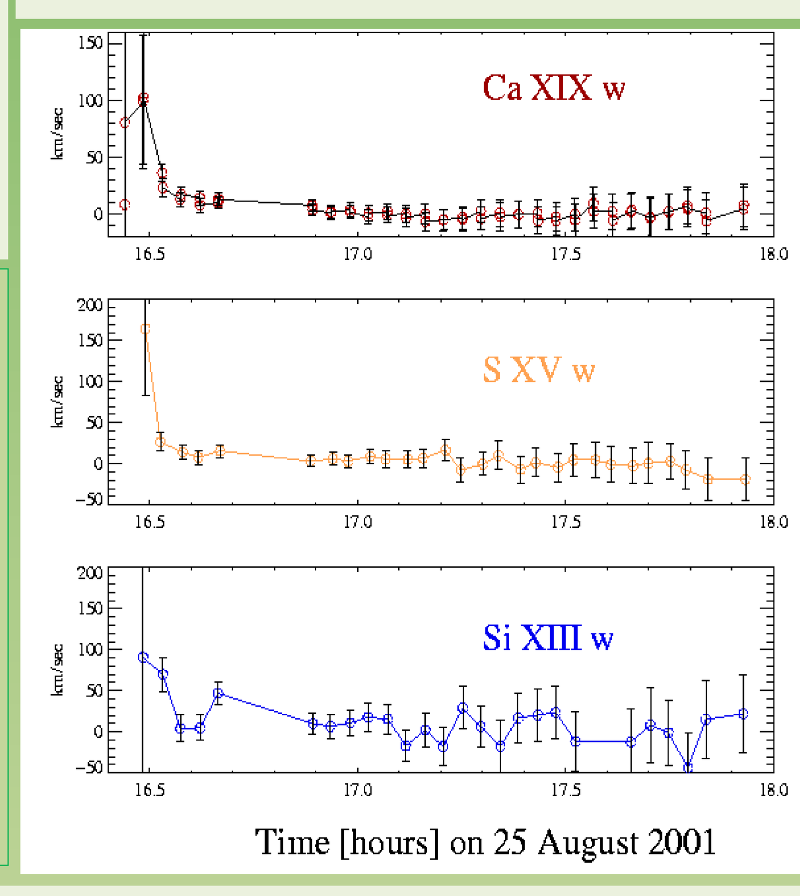
The scheme of dopplerometer section of **Diogeness**.
The bi-sector plane of the pair (Q1 and Q4) of identical Quartz mono-crystals (1011) points towards the X-ray source (flare). Crystals are fixed together mechanically at the exact angle of 2θ.
According to the Bragg condition:

$$\lambda = 2d \sin\theta$$

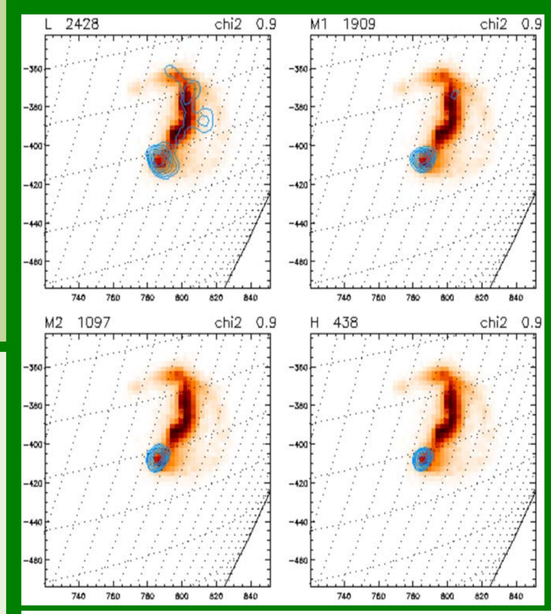
where λ is the wavelength, 2d is crystal spacing (2d=6.686 Å) and θ is the grazing angle, by rocking the double crystal section, spectra in the vicinity of Ca XIX resonance line are time recorded in the opposite wavelength sense.

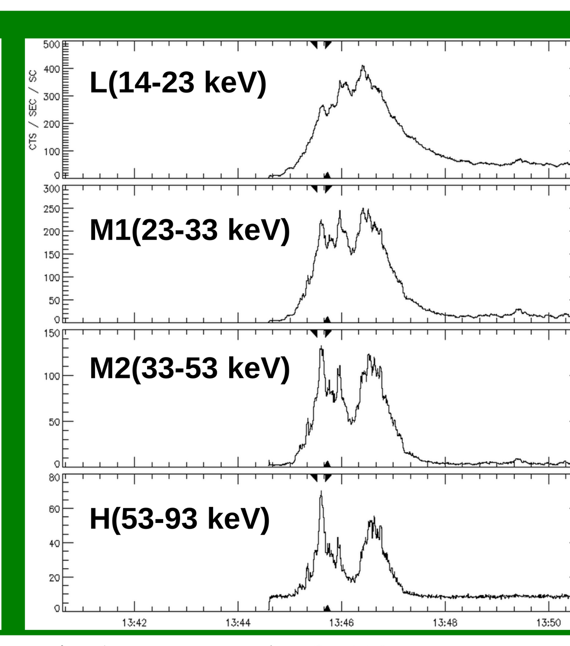


The two examples of spectral pairs measured nearly simultaneously in Channels Q1 and Q2 of Diogeness during the rise and decay of the flare on 25 August 2001.
On the horizontal axis the motor steps are plotted. The motor run evenly in time. The most prominent features are resonance lines of Ca XIX ion. The scanning in both channels were made in the opposite wavelength sense. A small difference of the „distance" between the resonance lines (central portion in the figure) are due to plasma radial velocity component. The evolution of values of radial velocities are shown below.

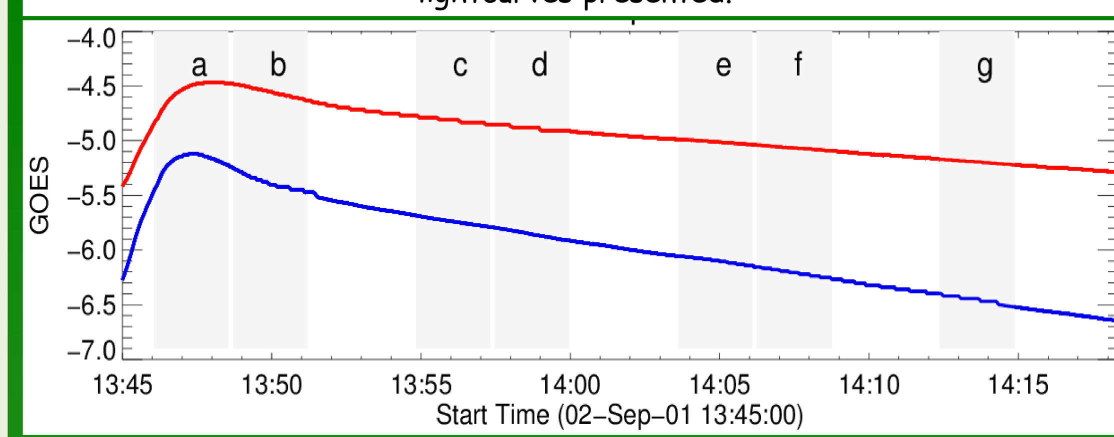


SOL2001-09-02T13:47

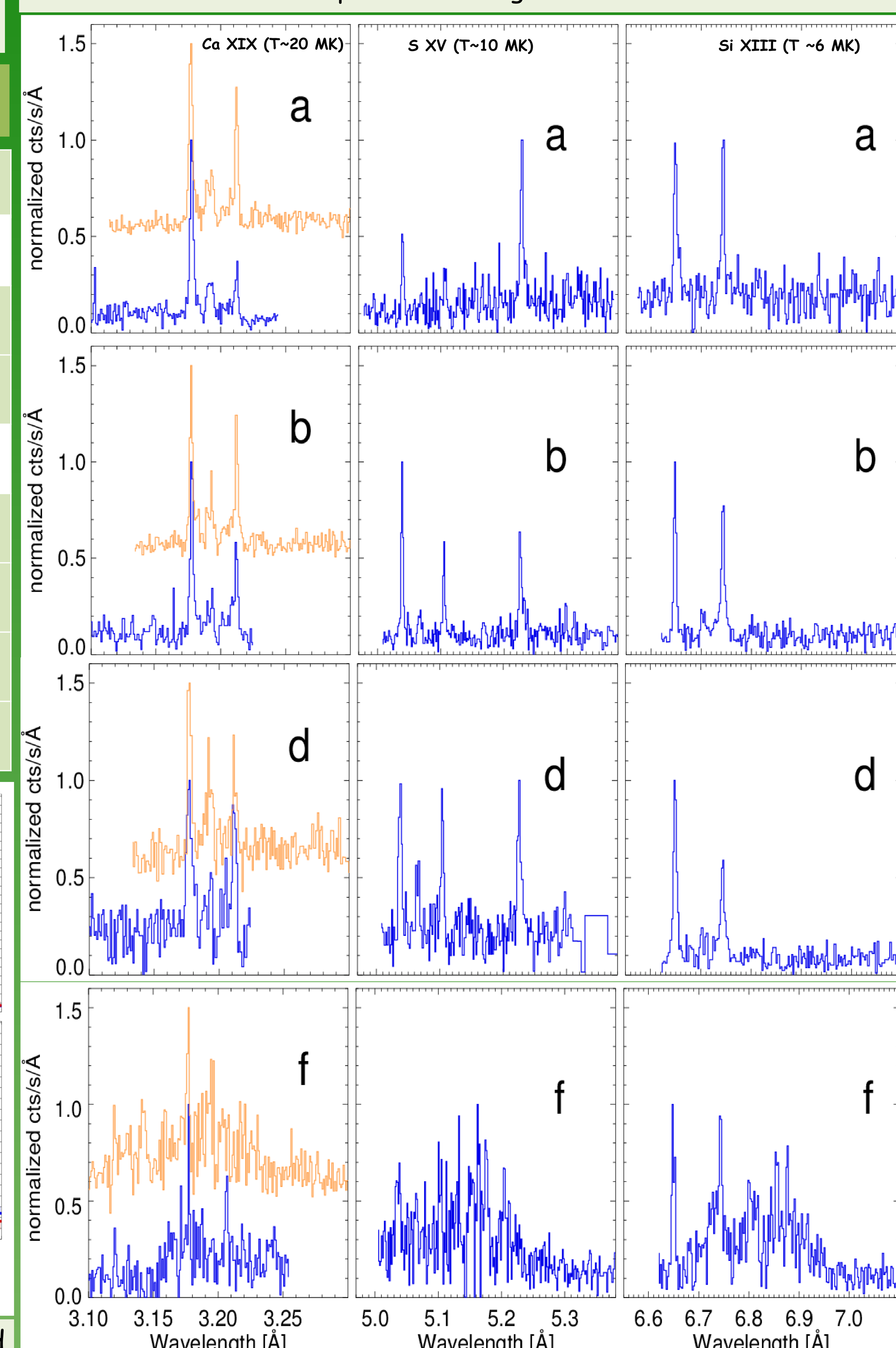




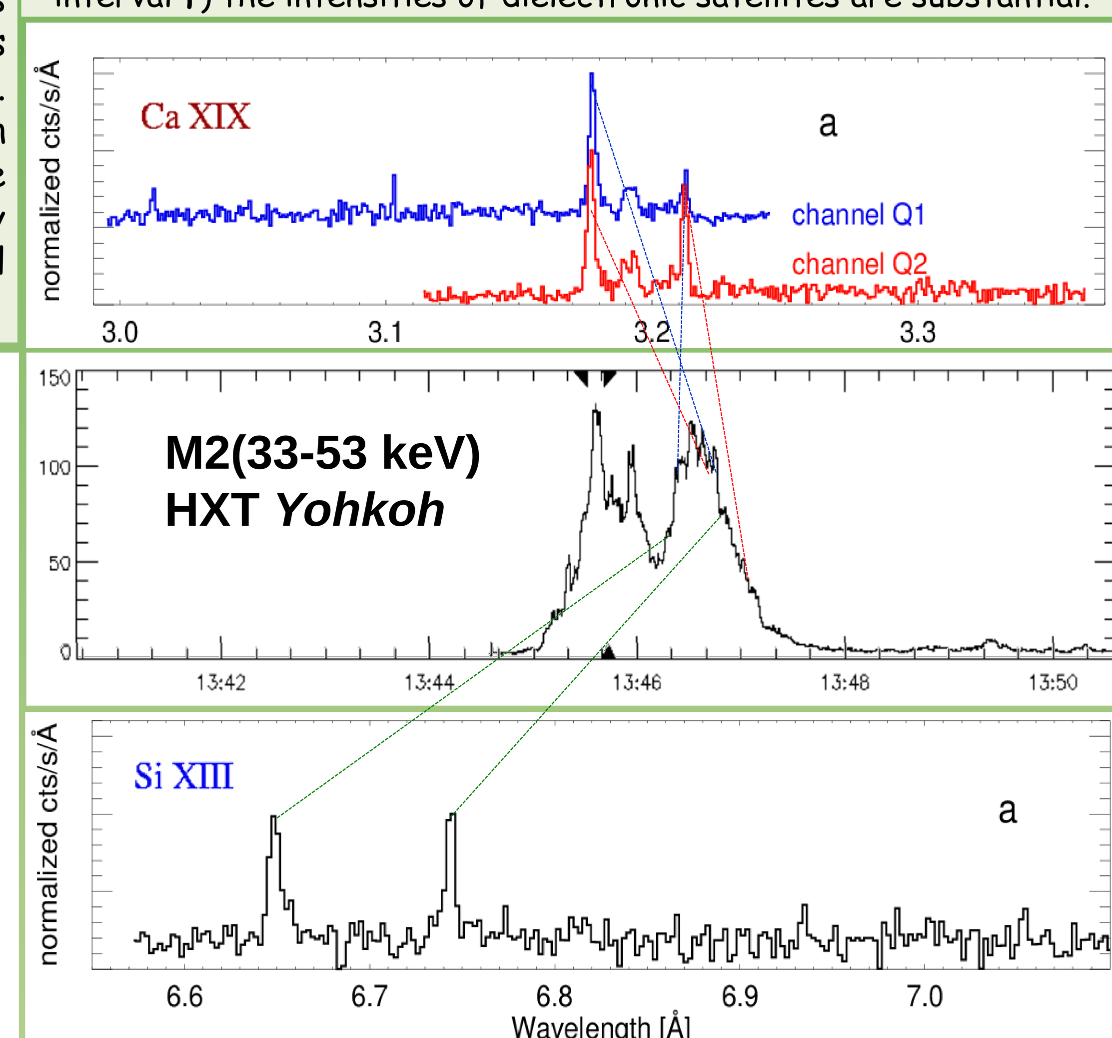
The contours for HXT Yohkoh channels drawn atop the Be119 SXT image during the first spike (13:45:32-13:45:40 UT), as indicated on the lightcurves presented.



The GOES lightcurves for the M3.0 class flare on 2nd September 2001 at 13:47 UT (maximum). The intervals (a-g) of Diogeness spectral observations are indicated as grey vertical strips. Each strip represents a single scan.



Level1 reduced spectra for the four selected intervals (**a**, **b**, **d**, **f**). Spectra obtained with two Quartz crystals (CaXIX triplet), ADP crystal (SXV triplet) and Be crystal (SiXIII triplet) around **3.18** Å, **5.04** Å and **6.65** Å are presented in the left, middle and the right column respectively. Note, that during the late decay phase (time interval **f**) the intensities of dielectronic satellites are substantial.



Composite picture showing relation of line registration time with peculiarities of the hard X-ray light curve as seen by HXT. Unfamiliar Si XIII triplet intensity ratios are observed for the first time.

Concluding remarks

The concept of soft X-ray dopplerometer has been successfully flight tested within the Diogeness spectrometer flown aboard CORONAS-F satellite. It has been proven that the use of this construction of Bragg spectrometer allows for precise determinations of X-ray line shifts due to line-of-sight velocity component. The results presented indicate that the Dopplerometer crystal configuration can be recommended for the future Bragg spectroscopy of solar and the other astrophysical sources (vide ChemiX aboard Interhelioprobe).
Examples of the spectral records and their initial analysis show that the data collected for eight observed flares will allow determination of the physical characteristics (temperature and emission measure) of hot plasma as well as studies of plasma velocities, especially during flare impulsive phases, based on the observed Ca XIX, S XV and Si XIII triplet lines.

We are happy to share our data for collaboration.

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