Experiments towards FSI flare detector

D. Berghmans (ROB)

(collaboration with A. De Groof
& K. Bonte @ KULeuven)

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Goal

- Event detection in FSI: timing & location
- Flag towards HRI, other instruments and spacecraft
- We only need to detect the biggest splashes. Small & ambundant features will be observed in any dataset.
- Limited onboard resources

XRT flare detection

5.5.3.1 FLD Patrol Image

XRT takes full frame CCD images with 8 arcsec resolution (called FLD patrol images) at regular intervals. The intervals during the normal observation and during the flare observation can be set independently in the FLD Control Table. The baseline interval to take FLD patrol images is about 30 sec.

Each FLD patrol image is first divided into 16×16 blocks ("macro-pixels"). The Macro-pixel image is created by summing the intensity in each macro-pixel.

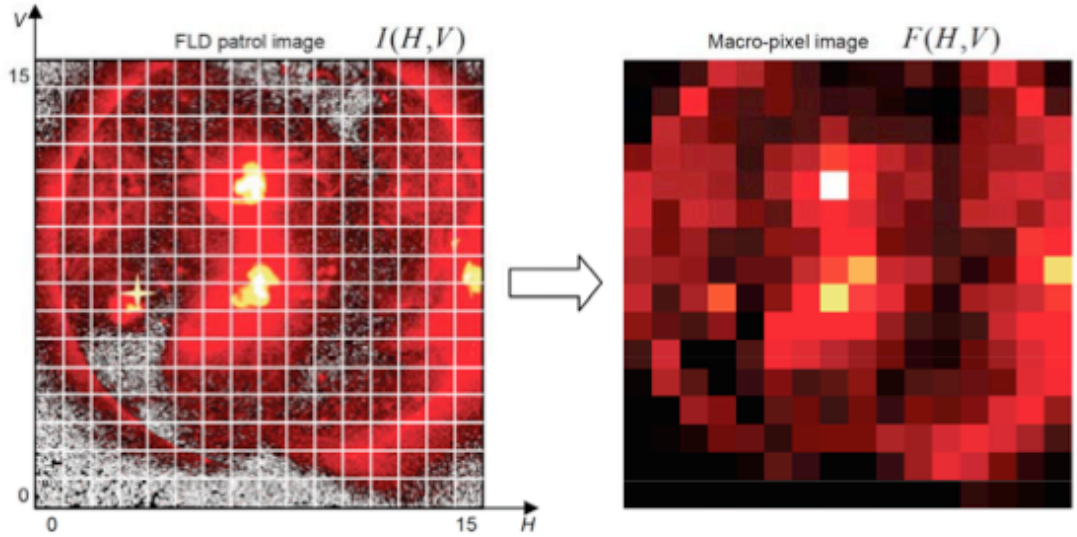


Figure 5.5-6: FLD Patrol Image and Macro-Pixel Image.

5.5.3.2 Detection of Flare

From a macro-pixel image, the MDP calculates the following parameter q^2 which indicates the increase of the X-ray intensity normalized by the photon noise;

$$q^2(H,V)=\begin{cases}\dfrac{\{F(H,V)-F_{\mathrm{avg}}^{(i-1)}(H,V)\}^2}{F_{\mathrm{avg}}^{(i-1)}(H,V)+g} & \cdots \quad F \geq F_{\mathrm{avg}}^{(i-1)} \\ 0 & \cdots \quad F < F_{\mathrm{avg}}^{(i-1)}\end{cases} \qquad \text{[Eq.-Q]}$$

where g is a control parameter to avoid the division by 0, and $F_{\mathrm{avg}}^{(i)}$ is the running-averaged patrol image calculated by

$$F_{\mathrm{avg}}^{(i)}(H,V)=\gamma\cdot F(H,V)+(1-\gamma)\cdot F_{\mathrm{avg}}^{(i-1)}(H,V)\,. \qquad \text{[Eq.-F]}$$

The parameter γ controls the effective duration of the running average. Figure 5.5-7 shows how q^2-maps and $F_{\mathrm{avg}}^{(i)}$-maps are generated from macro-pixel images F.

FSI flare detection

- No X-rays but 17nm bandpass
- Lower cadence
- CMOS detector
- Limited computing resources

SWAP flare detection

- 17nm bandpass
- 1 min cadence
- HAS CMOS detector 1024x1024
- *Assume limited computing resources*

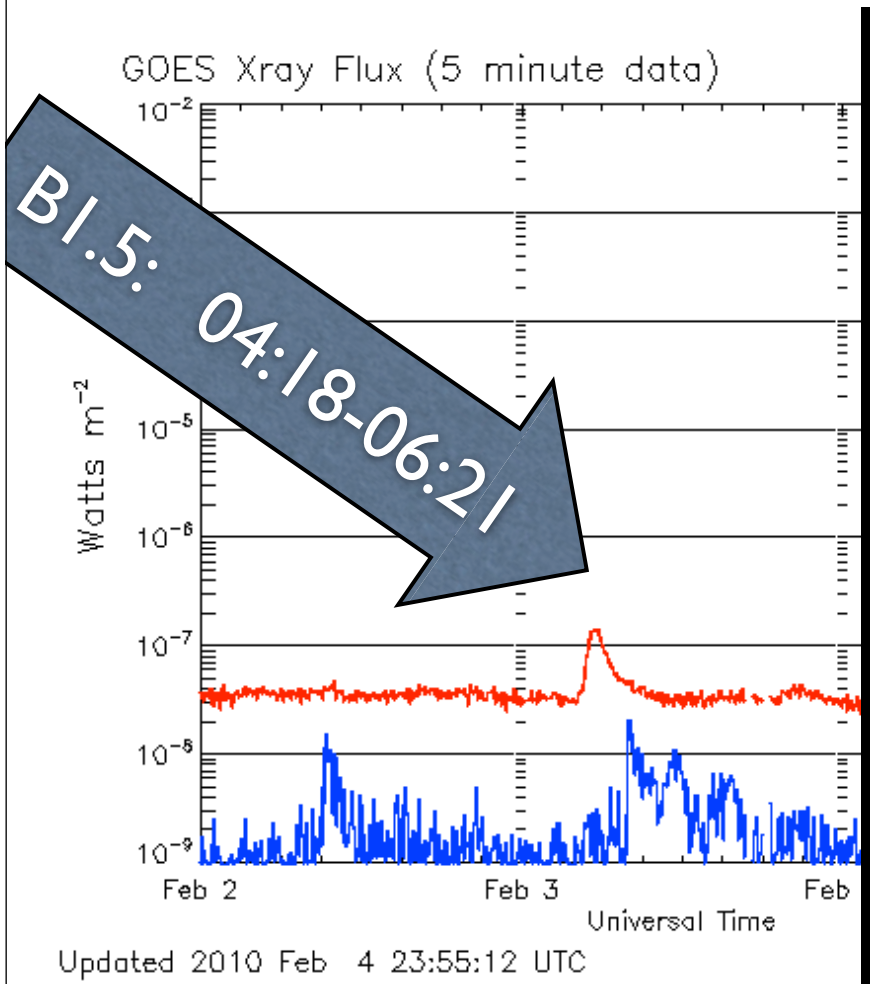
Flare 2010 statistics

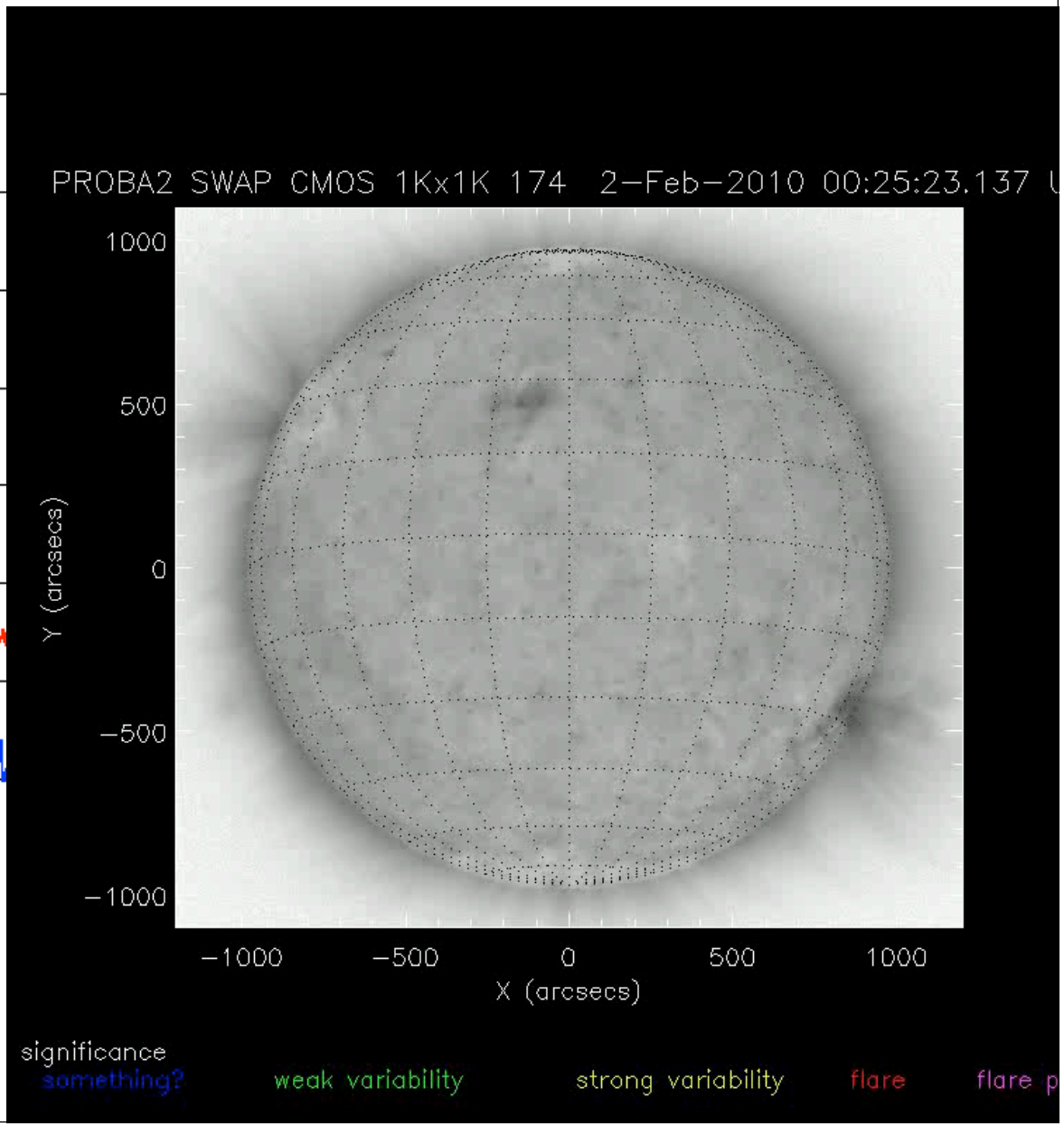
- No X-flare, 23 M-flares and 175 C-flares
- 75 flares > C2.0 that are well observed with SWAP

The top 10 largest events are:

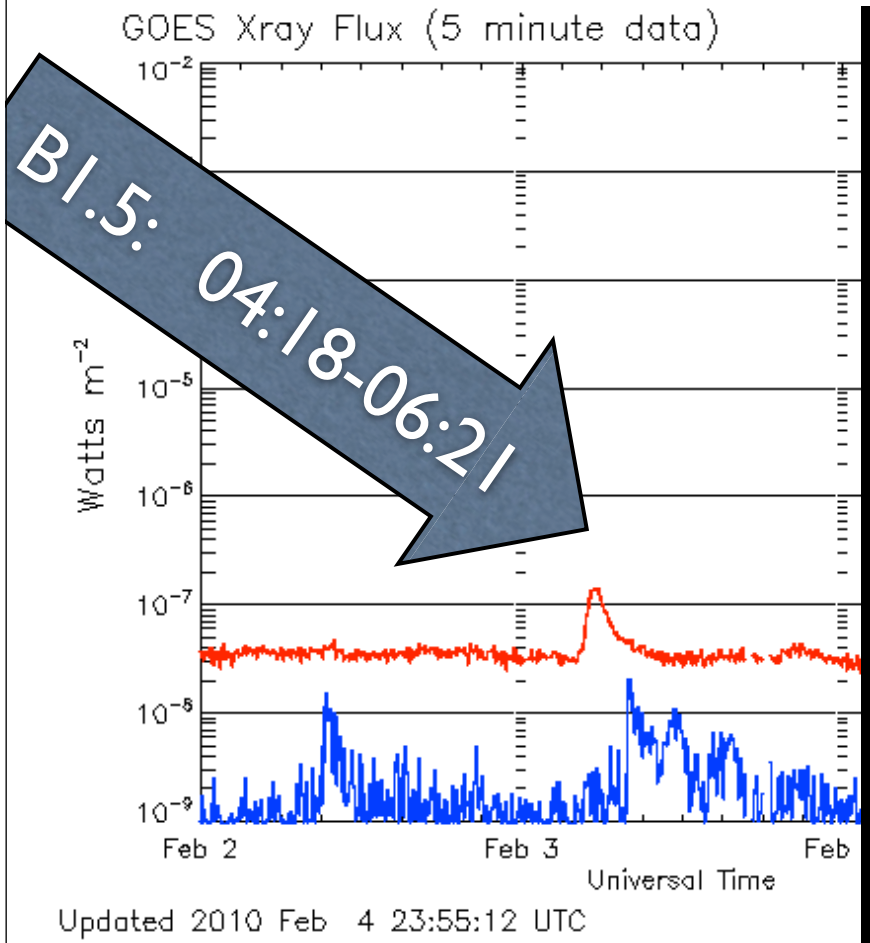
2010-02-12	M8.3	0	0
2010-02-07	M6.4	18	2
2010-11-06	M5.4	24	4
2010-02-08	M4.0	0	0
2010-01-20	M3.4	0	0
2010-10-16	M2.9	26	4
2010-02-06	M2.9	16	7
2010-01-19	M2.3	8	5
2010-06-12	M2.0	24	12
2010-02-08	M2.0	2	6

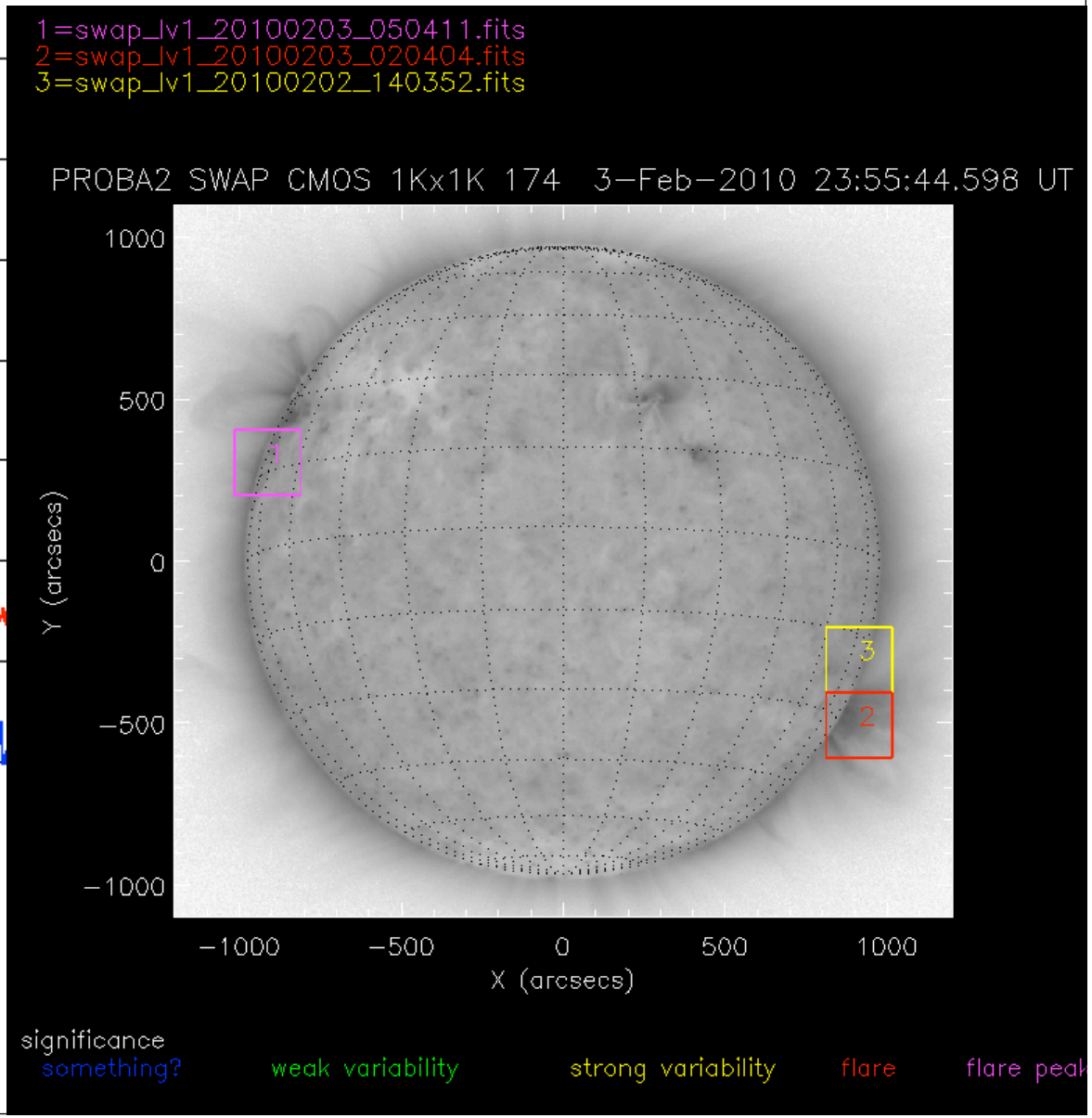
Feb 2-3 2010


GOES Xray Flux (5 minute data)
B1.5: 04:18-06:21
Watts m^{-2}
10^{-2}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
Feb 2
Feb 3
Feb
Universal Time
Updated 2010 Feb 4 23:55:12 UTC

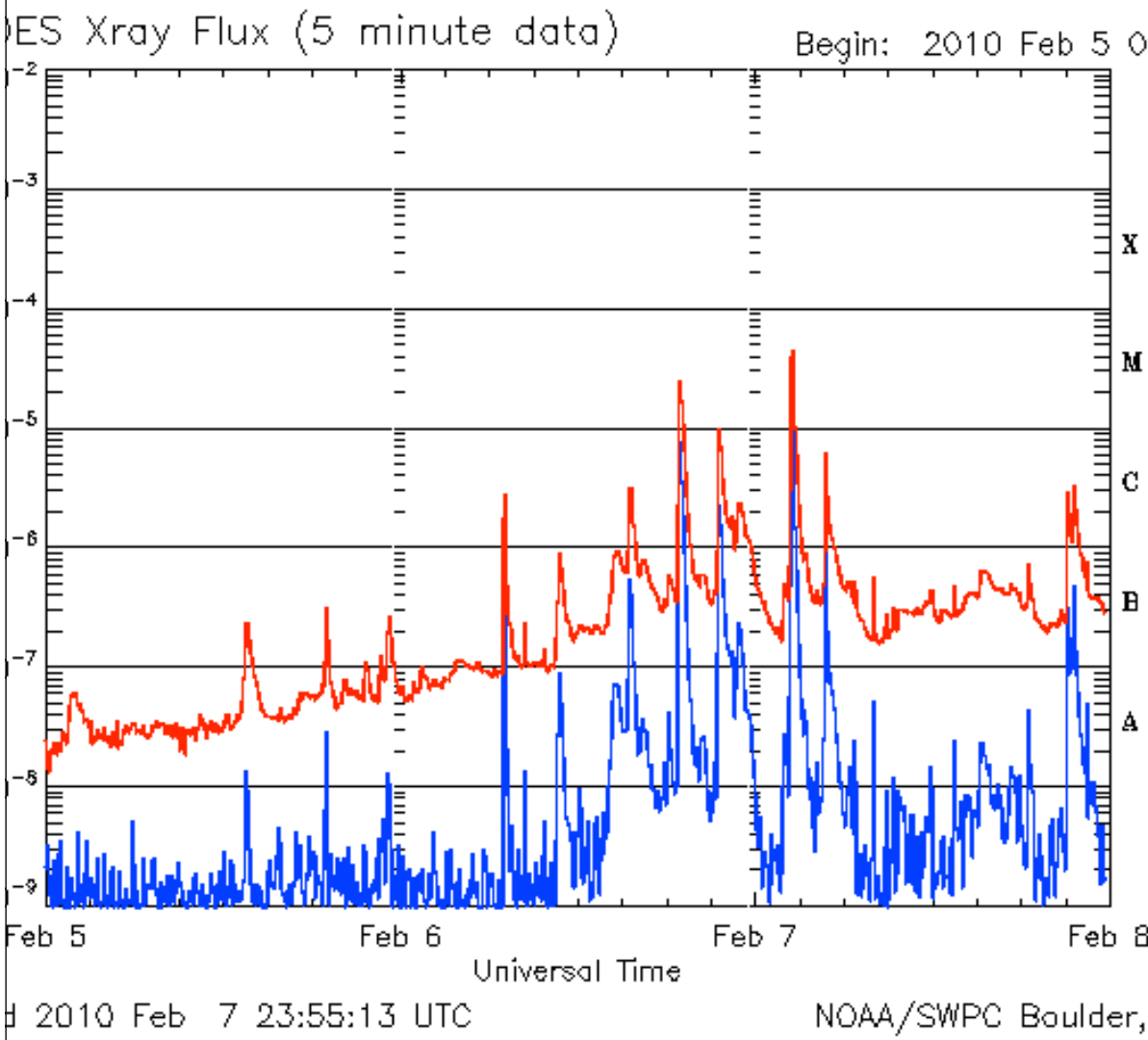

PROBA2 SWAP CMOS 1Kx1K 174 2-Feb-2010 00:25:23.137
1000
500
0
−500
−1000
Y (arcsecs)
−1000
−500
0
500
1000
X (arcsecs)
significance
something?
weak variability
strong variability
flare
flare p

Feb 2-3 2010


GOES Xray Flux (5 minute data)
B1.5: 04:18-06:21
Watts m^{-2}
10^{-2}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
Feb 2
Feb 3
Feb
Universal Time
Updated 2010 Feb 4 23:55:12 UTC

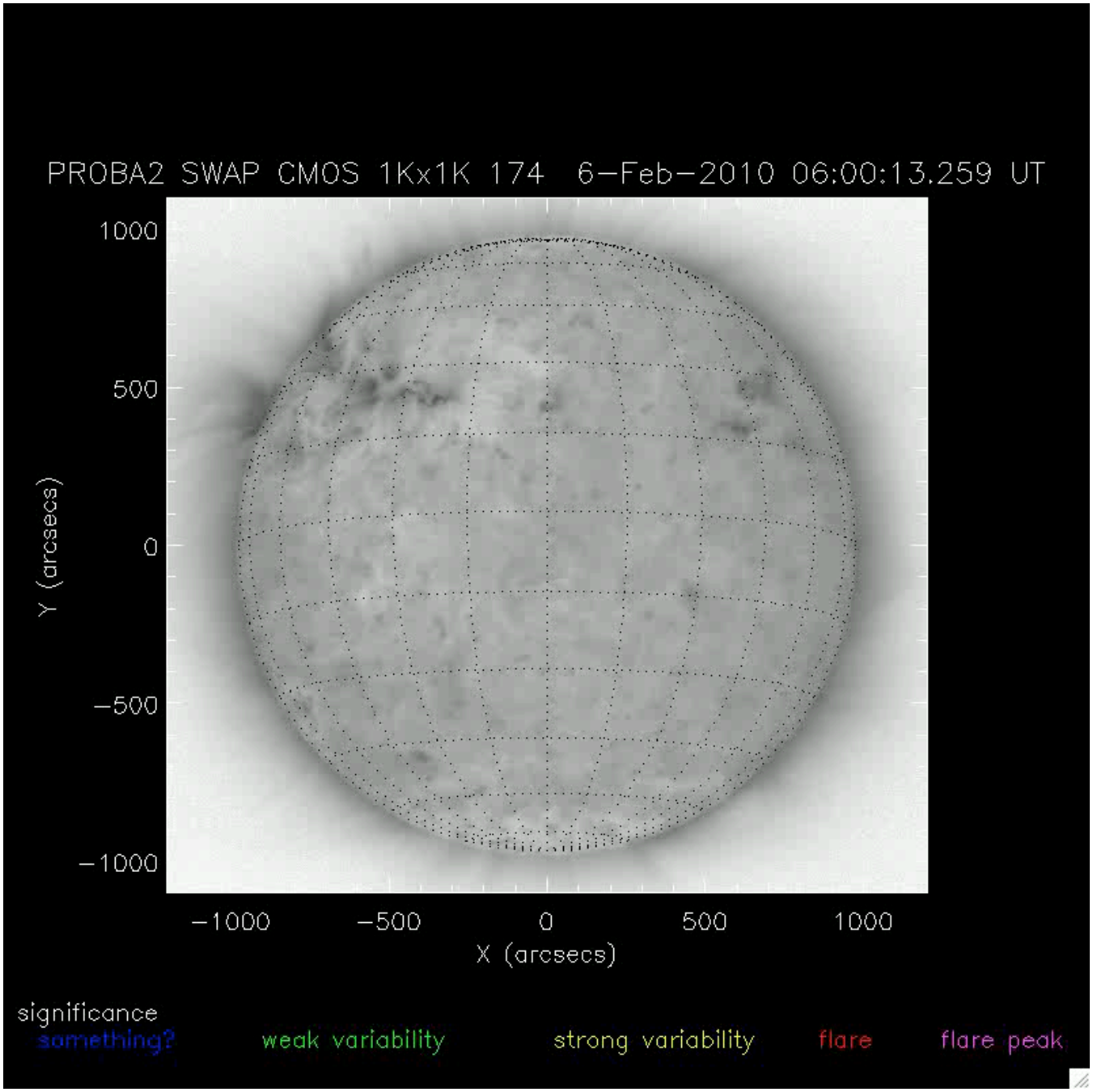

1=swap_lv1_20100203_050411.fits
2=swap_lv1_20100203_020404.fits
3=swap_lv1_20100202_140352.fits
PROBA2 SWAP CMOS 1Kx1K 174 3-Feb-2010 23:55:44.598 UT
1000
500
0
−500
−1000
Y (arcsecs)
−1000
−500
0
500
1000
X (arcsecs)
1
2
3
significance
something?
weak variability
strong variability
flare
flare peak

Feb 6-7 2010

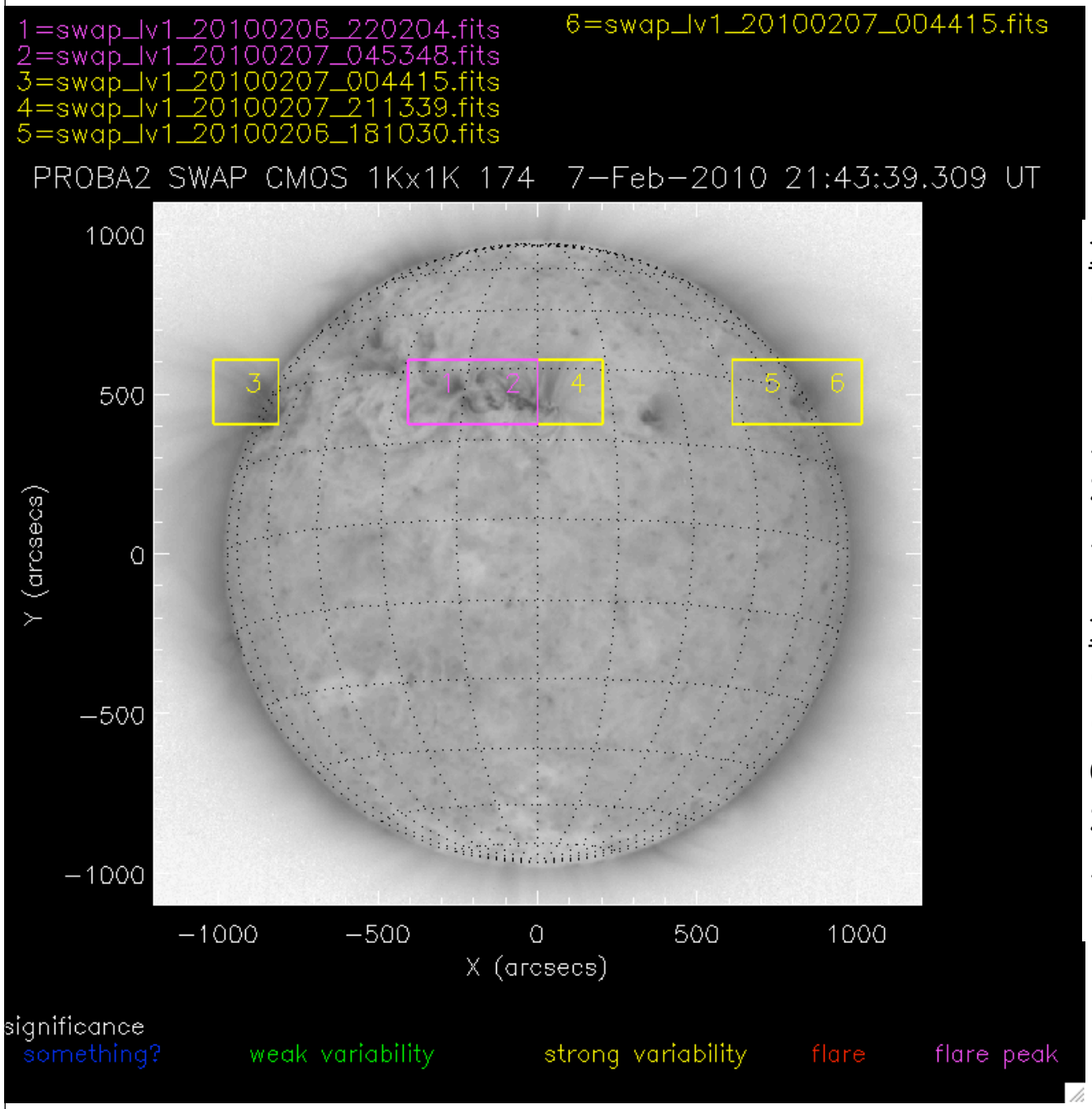


N21E17

Feb 6			
	0659	0709	C4.0
	1525	1549	C3.4
	1847	1909	M2.9
	2131	2142	M1.3
	2227	2233	C2.2
	2245	2319	C2.7
Feb 7			
	0220	0239	M6.4
	0325	0333	C1.1
	0442	0454	C9.9
	2109	2119	C4.2
	2131	2145	C4.2


PROBA2 SWAP CMOS 1Kx1K 174 6-Feb-2010 06:00:13.259 UT
1000
500
0
−500
−1000
Y (arcsecs)
−1000
−500
0
500
1000
X (arcsecs)
significance
something?
weak variability
strong variability
flare
flare peak

- images from feb 6 06:00 till 023:59, gaps7h-14h and around 16h, 20h



Feb 6

0659	0709	C4.0
1525	*1549*	*C3.4*
1847	**1909**	**M2.9**
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Feb 7

0220	0239	M6.4
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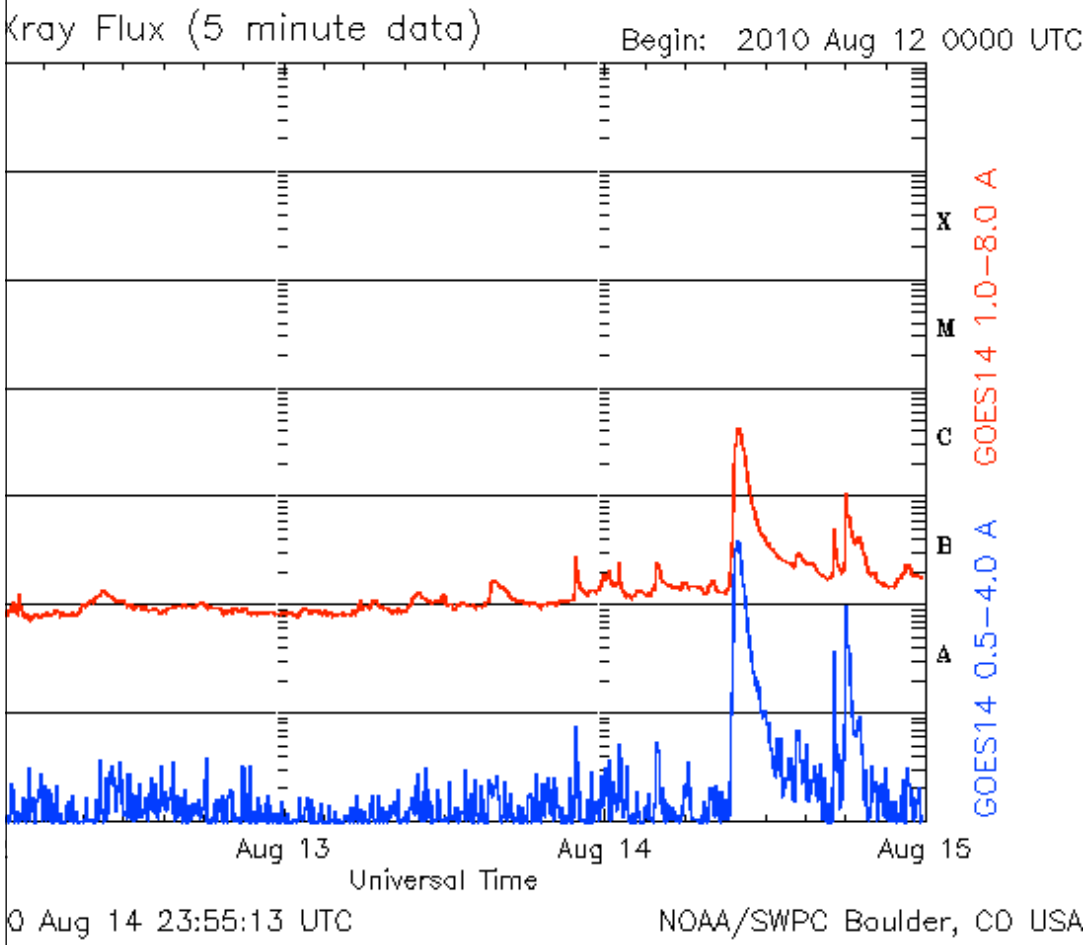
2131	2145	C4.2

- images from aug 13 all day
- images from aug 14 all day

Aug 13-14

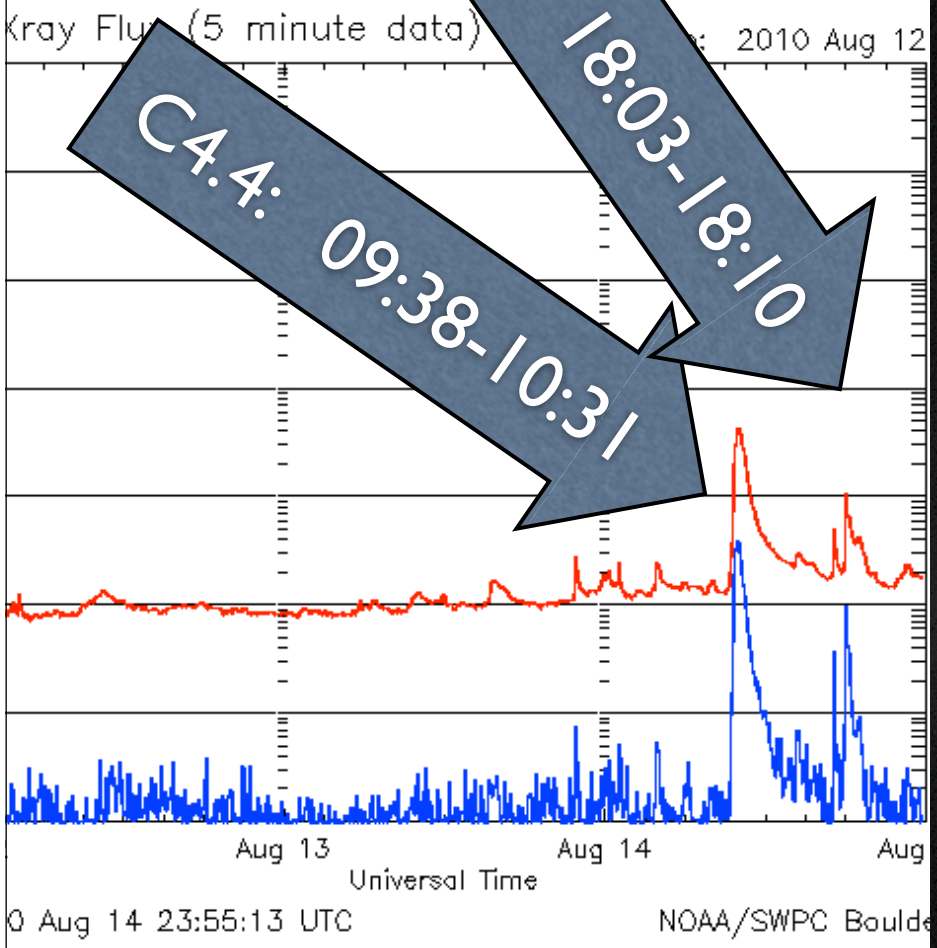


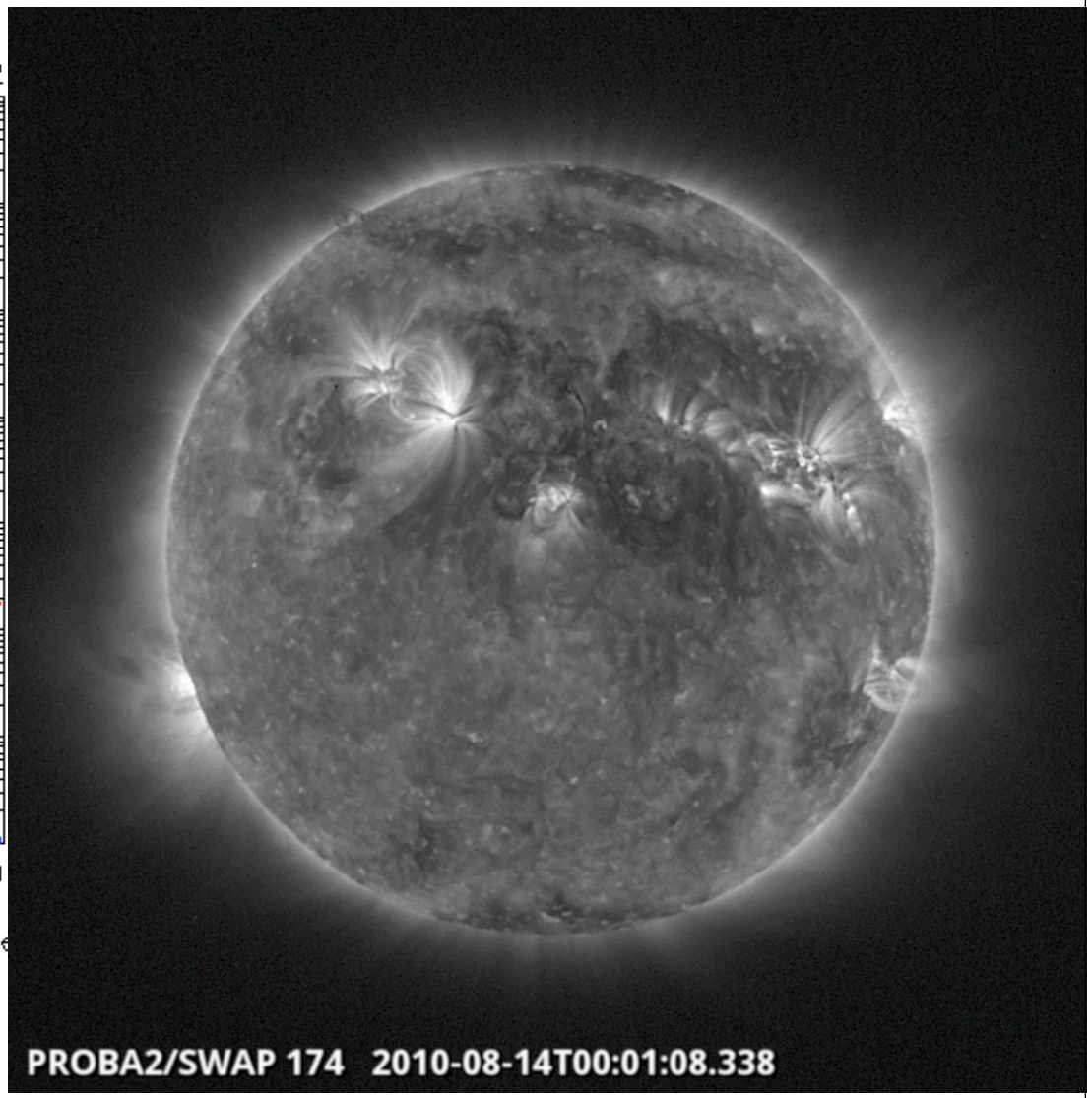
- images from aug 13 all day
- images from aug 14 all day

Aug 13-14 2010

C1.6: 18:03-18:10

C4.4: 09:38-10:31





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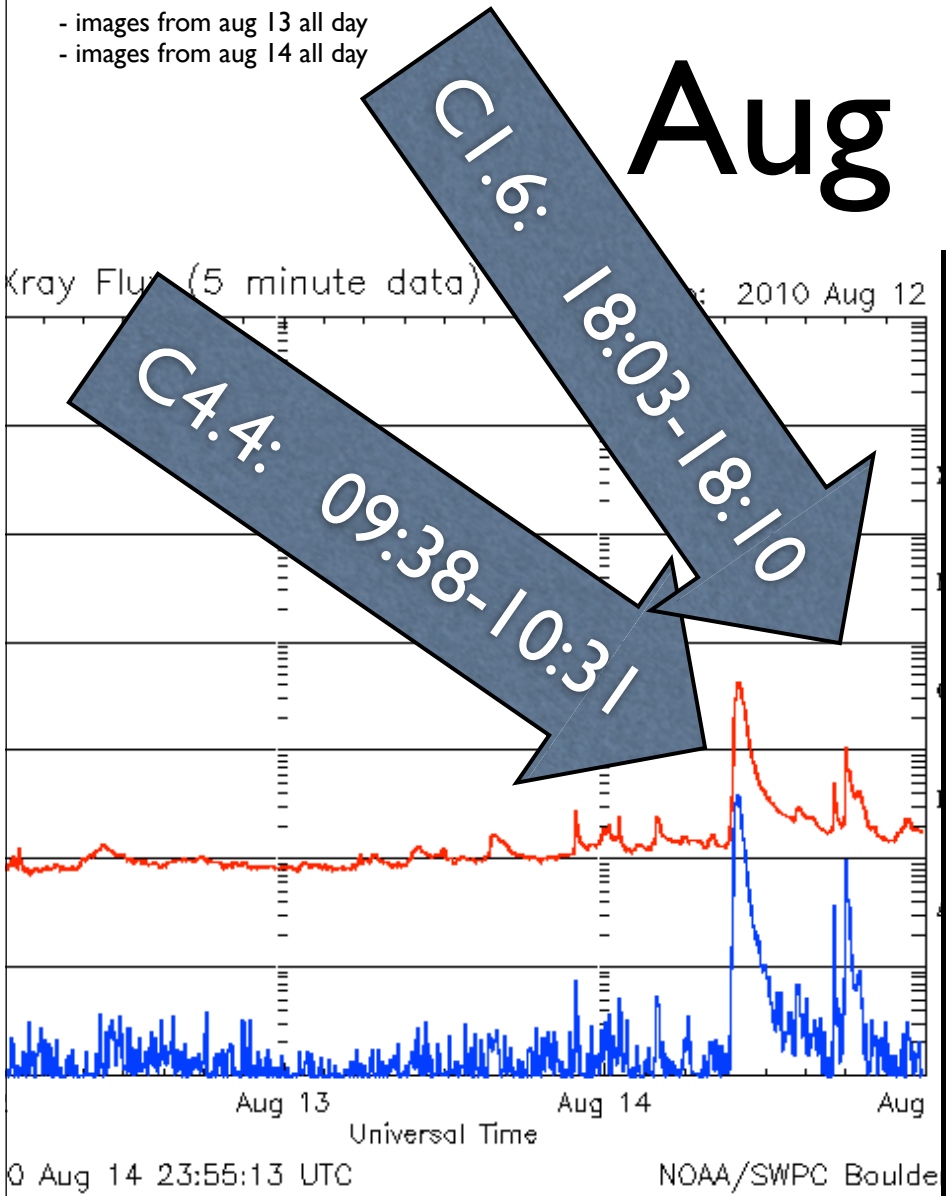
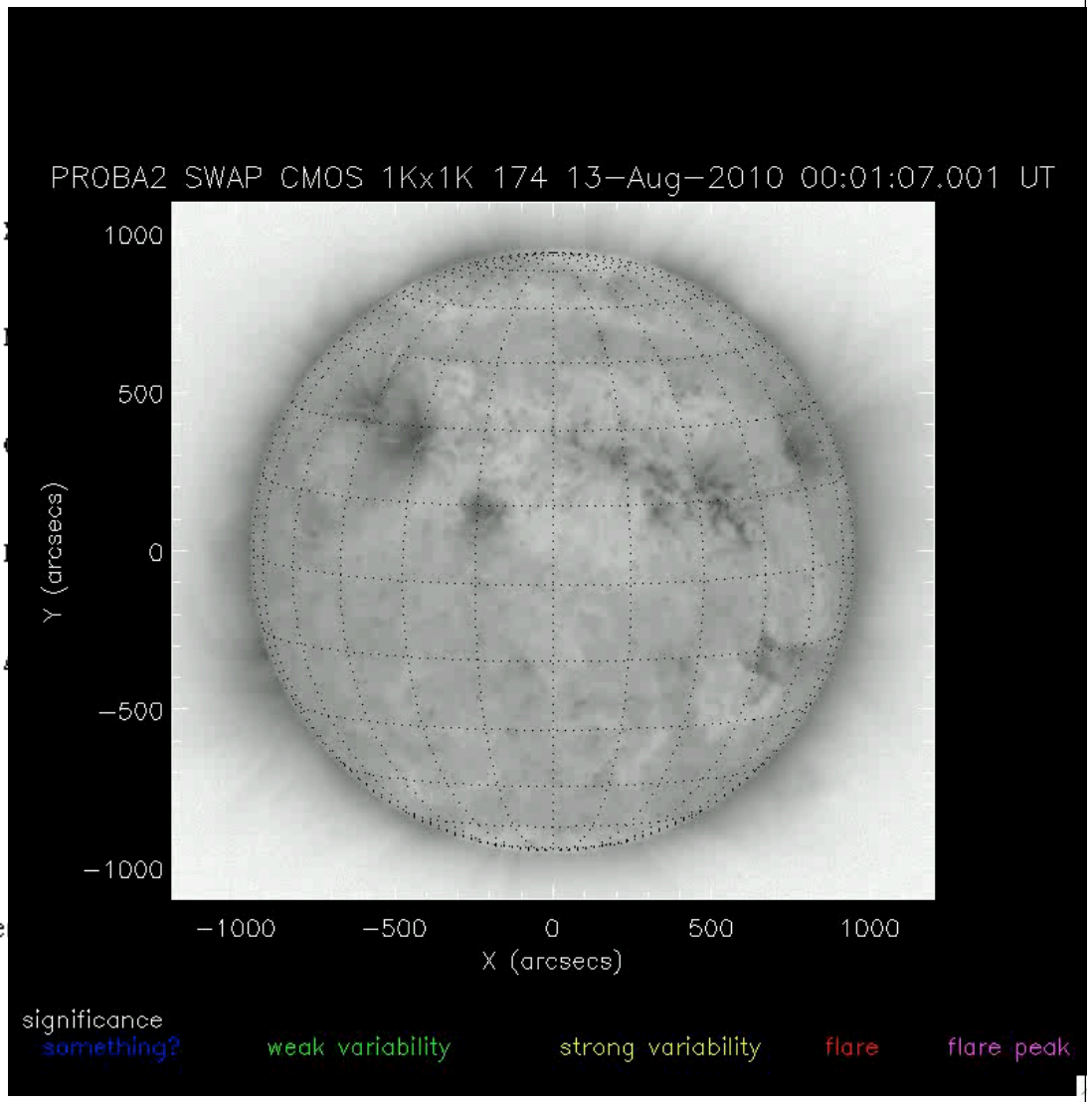
- images from aug 14 all day

Aug 13-14 2010





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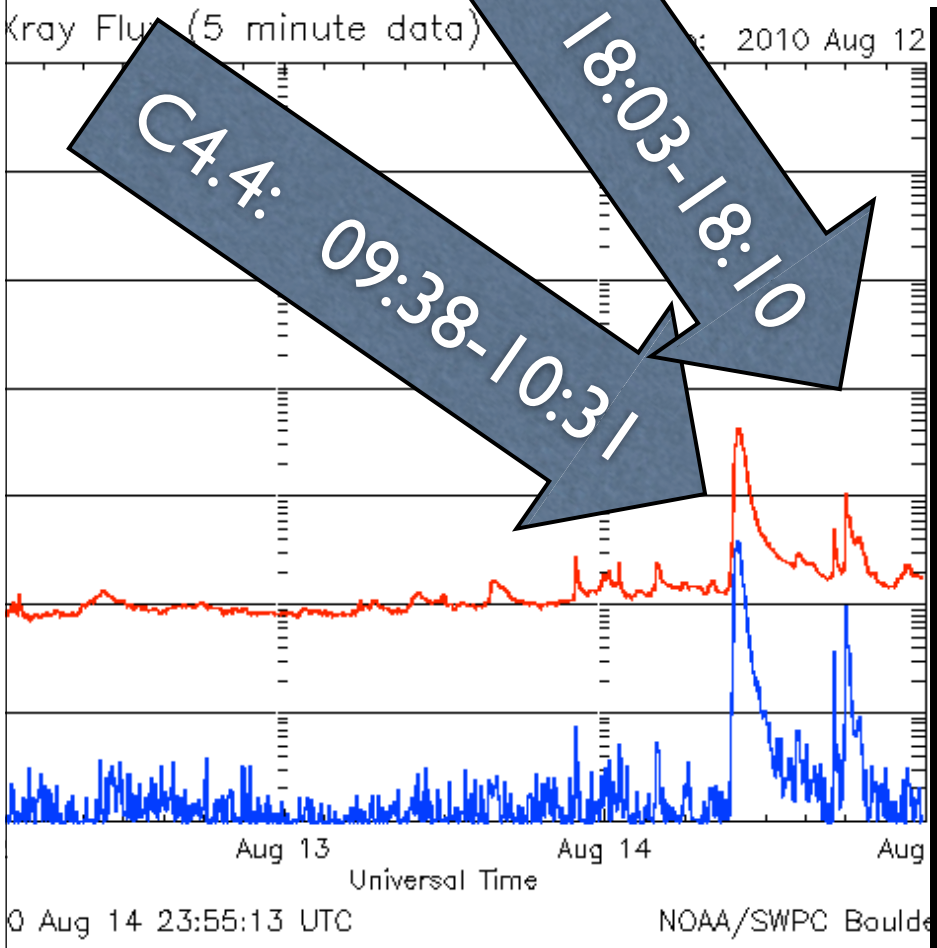

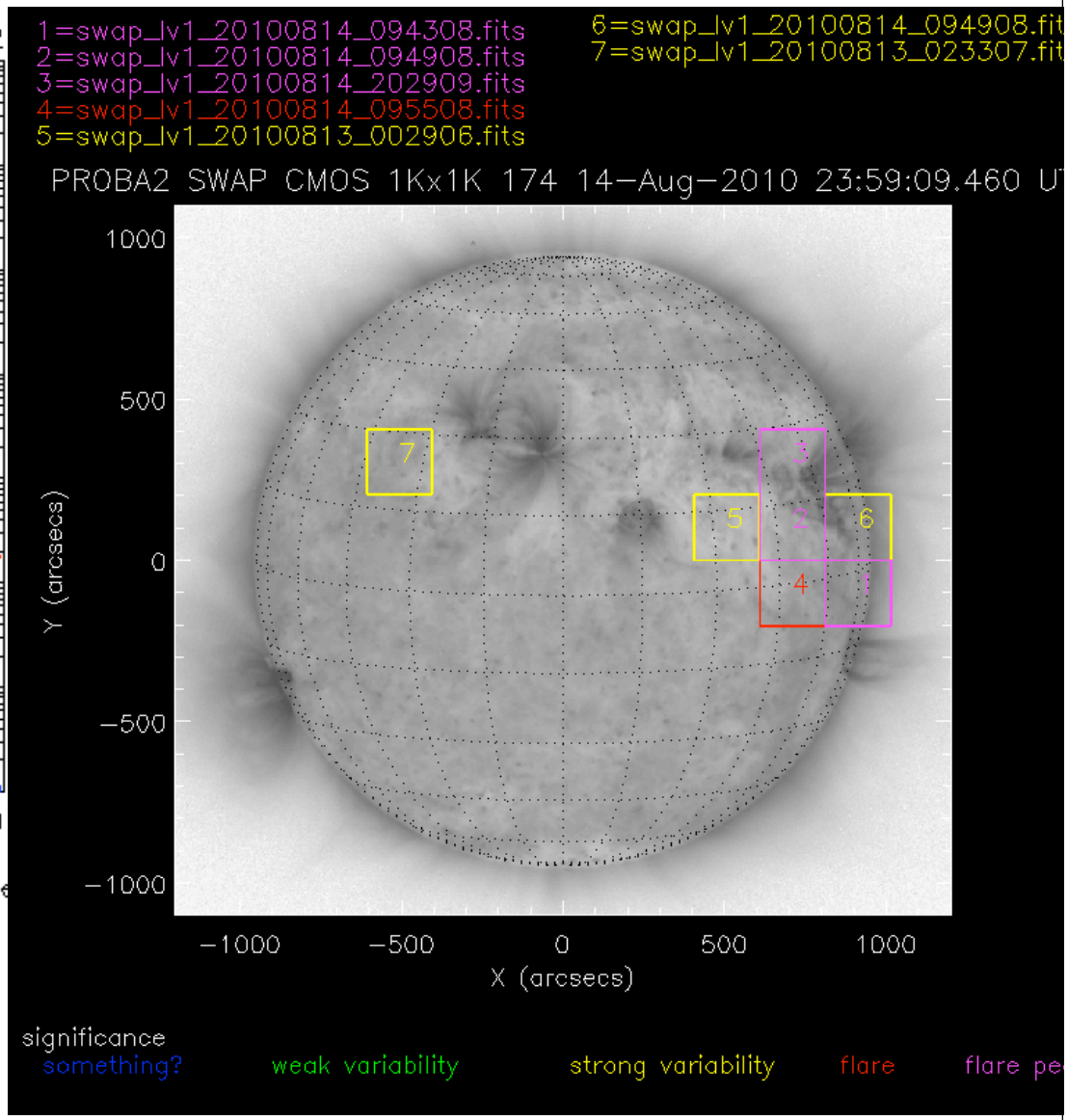

How does it work?

Preprocessing

- SWAP 'level one' images are used: dark current removed, sun-aligned
- only regular images are accepted (no off-pointing, calibration, weirdos, ...)
- underexposed images are refused (sum of images needed)
- blurred images are identified and refused
- images with cosmic rays are refused

How does it work?

Detection

- Each image is rebinned to 16x16 (double arr)
- From each 16x16 image we subtract a reference 16x 16 image of 12 +/- 1 min ago
- The result is thresholded.

Conclusion

- it seems to work, but more study needed
- the tool is not detecting "individual X-ray flares" but rather "dynamic EUV regions"
- detection is only first step, heuristics on what to do afterwards is missing:
  - which flare is best?
  - how much to store?

Requirements, first guess

- stable operations: all images need the same integration time, gain, etc (optional underexposure detector)
- stable imaging: same scene, no jitter (optional bluriness detector)
- cosmic ray identification & removal
- rebinning of images, storage of 12 min of 16x16 images