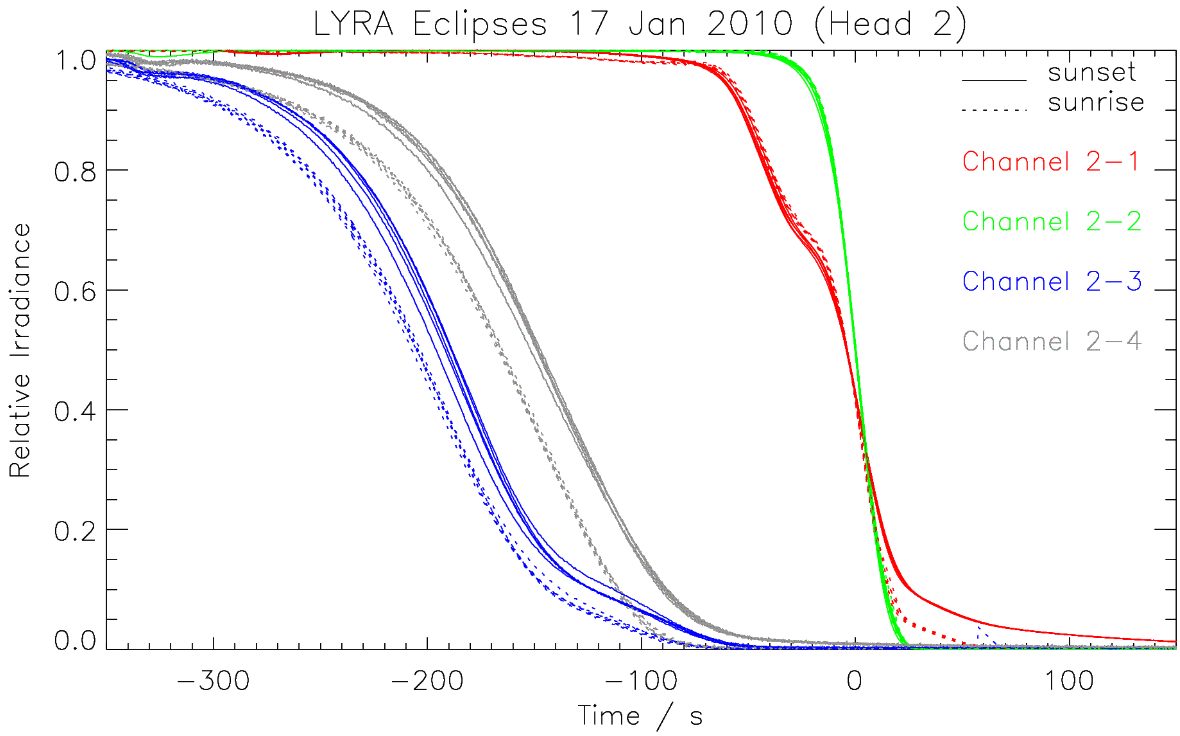
LYRA – the first three months

Data analysis during the commissioning phase

IED 26 Jan 2010

Contents of Part II.

Several eclipse profiles 17 Jan 2010



The 11 profiles – exploiting 6 eclipses on 17 Jan 2010 - were temporally synchronized by setting the 50% point of the Herzberg channel to 0. The sunrise profiles were reversed in time. The profiles are scaled by subtracting the minimum within the eclipse and dividing by the maximum within the interval 100 s before the sunset starts (or the sunrise ends).

The Herzberg channel (2-2) is symmetrical wrt sunrise and sunset, the Lyman-alpha channel (2-1) is almost symmetrical; the difference between sunset (slower; showing a "tail") and sunrise (faster; initial rise almost as for Herzberg continuum) is caused by the slow MSM detector dynamics. Interesting to note are the "ramps", especially well visible in channels 1 and 3 during sunrise, but also during sunset. The cause for these ramps and the cause for the temporal differences between sunset and sunrise in the lower-wavelength channels (2-3, 2-4) are not yet known.

Degradation

Channel 2-1, the Lyman-alpha channel of head 2, seems to deteriorate. It lost 33% (from 450 kHz to 300 kHz) within the ten days after 09 Jan 2010.

Channel 2-2, the Herzberg continuum channel of head 2, seems to degrade, too. It lost 16% (from 690 kHz to 580 kHz) within the last 10 days. See next two figures.

The "line" structures above 700 kHz are due to the noise after the ASIC reloads.

Please note that the solar irradiance (according to TIMED/SEE, 120-123 nm = Lyman alpha) was actually *increasing* between 09-15 Jan 2010.

In the beginning, we immediately noticed that the responses of channels 2-1 and 2-2 were higher than the LRM predicted. Maybe this was due to a recalibration of SORCE. Maybe the detectors are simply more sensitive than we expected.

So, maybe the load on the detectors is too high, and LYRA is wearing out. But it might as well be the filters or the detectors accumulating contamination. Bake-outs and tests with various LEDs will be performed to find out.

Channels 3 and 4, which are running at a fraction of the output of channels 1 and 2, appear to be stable.

Concerning LYRA's other heads: The last measurements with head 1 were on 12 Jan, the last measurements with head 3 were on 13 Jan 2010. Only head 2 was more or less running continuously.

First light was:
```
1-1  1200 kHz (saturating)
1-2   700 kHz (ASIC data fault)
2-1   470 kHz
2-2   700 kHz
3-1   900 kHz
3-2   550 kHz
```

Last available values are (Head1=12Jan, Head2=18Jan, Head3=13Jan):
```
1-1  1200 kHz (saturating)
1-2   600 kHz
2-1   300 kHz
2-2   580 kHz
3-1   900 kHz
3-2   550 kHz
```

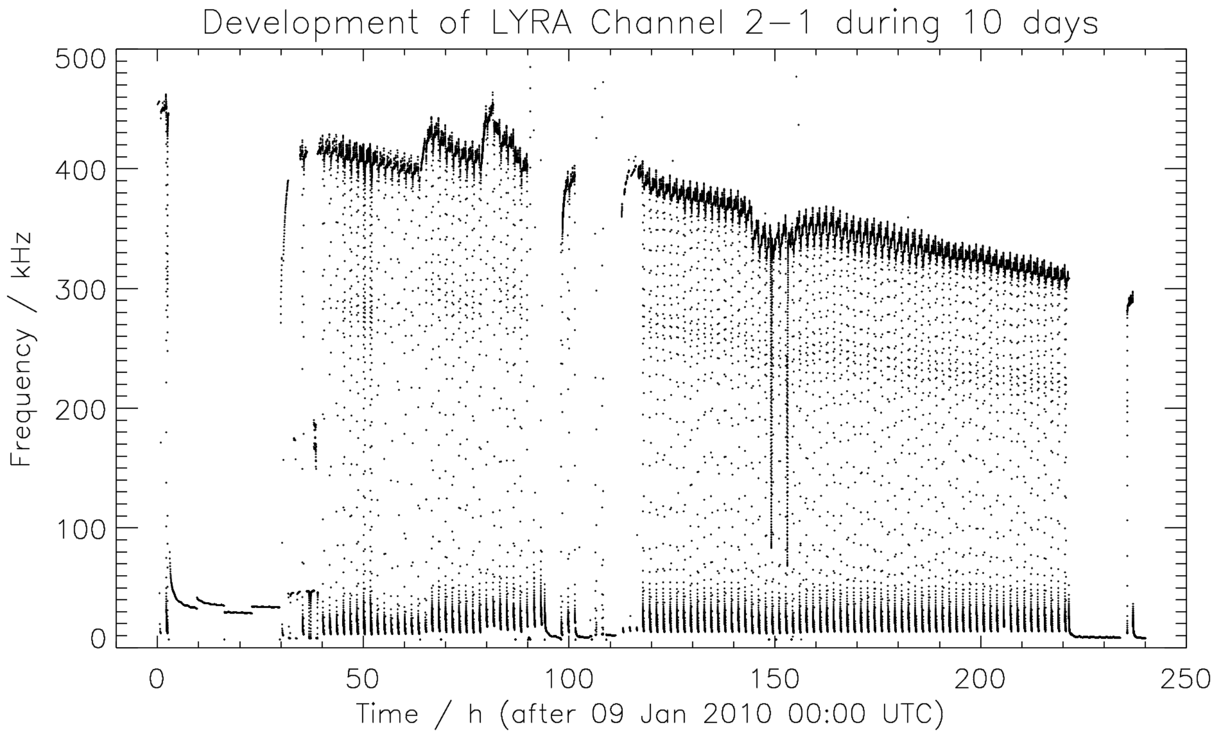
So, head 1 is hard to decide. Head 2 is degrading, Head 3 appears stable at first glance.

Anticipating the next logical question: Here are the VFC parameters, measured on 09 Jan (using 500 ms) and on 18 Jan (using 50 ms), the start and the end of the 10 days discussed here:

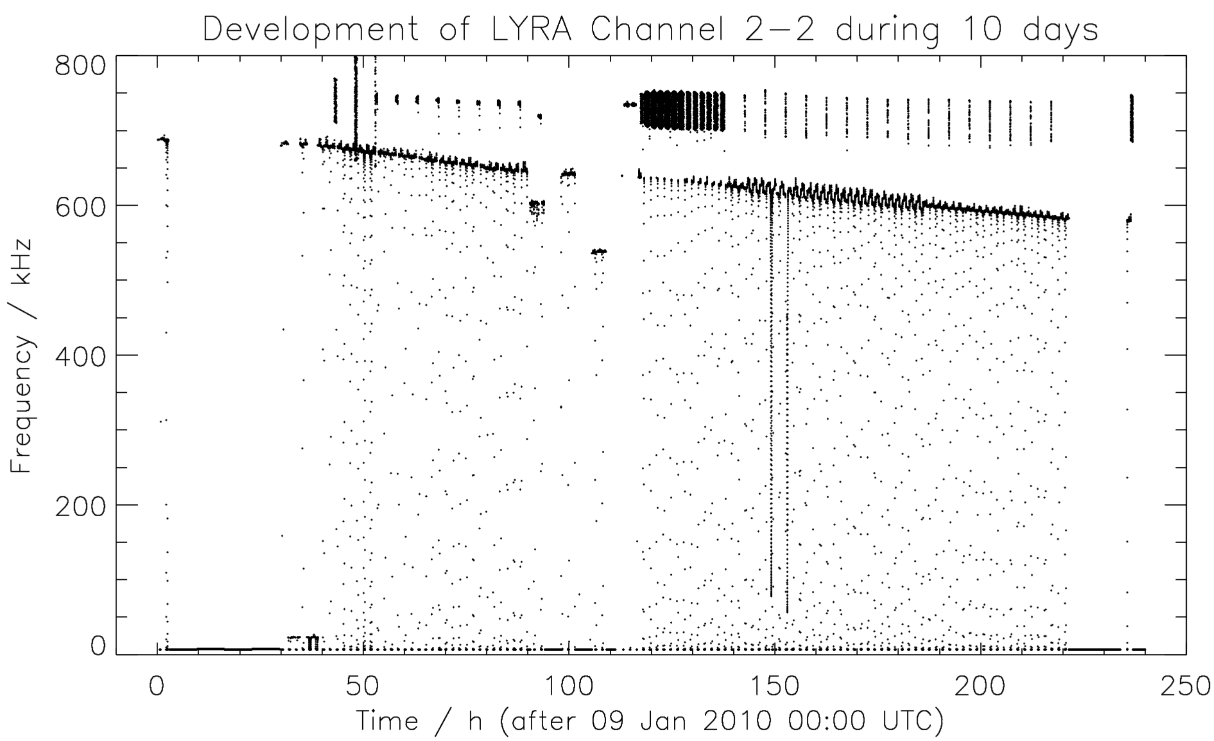
09 Jan 2010 (values in kHz):
```
0.0V;    6.8    6.6    6.6    6.7
2.5V:  608.7  609.2  608.8  608.9
5.0V: 1211.3 1212.5 1211.5 1211.5
```

18 Jan 2010:
```
0.0V:    6.7    6.6    6.6    6.7
2.5V:  608.6  609.1  608.7  608.8
5.0V: 1211.1 1212.2 1211.3 1211.3
```

These are basically the same values as in December 2009 and as in dSVT5. I do not see the VFC as the cause for degradation.



Development of LYRA Channel 2−1 during 10 days
Frequency / kHz
0
100
200
300
400
500
0
50
100
150
200
250
Time / h (after 09 Jan 2010 00:00 UTC)



Development of LYRA Channel 2−2 during 10 days
Frequency / kHz
0
200
400
600
800
0
50
100
150
200
250
Time / h (after 09 Jan 2010 00:00 UTC)

Dark currents on ground and in flight

Comparing

- the ground test at BESSY of March 2006,
- the dSVT5 of March 2009,
- the flight tests with closed doors of December 2009,
- the recent tests of January 2010 (see figure below).

Mar 2006

Head 1	9-11	6.6	6.8	7.4
Head 2	9-15	6-7	6-7	9-15
Head 3	12-20	6-7	5-7	6.0

Mar 2009

Head 1	10-11	6.6	6.7	6.8
Head 2	7.9	6.5	6.5	7.9
Head 3	8.1	6.5	6.5	6.5

Dec 2009

Head 1	7.2	6.6	6.6	7.0
Head 2	9.0	6.5	6.6	8.7
Head 3	11.0	6.4	6.3	6.0

Jan 2010

Head 1	9.0	6.6	6.8	7.2
Head 2	7.8*	6.5	6.4	7.7*
Head 3	9.7	6.5	6.4	6.2

(all values in kHz)
(*) = these channels went up to ~8.5 kHz when head 2 was switched on again between head 1 and head 3

The heads are used as follows:
19 Jan 2010, 00:00-17:34 **head 2** (with a gap between 13:41-15:20)
19 Jan 2010, 17:35-22:34 **head 1**
19 Jan 2010, 22:25-03:34 **head 2**
20 Jan 2010, 03:35-08:34 **head 3**

Some of the spikes in the next figure are not caused by ASIC reloads, but by radiation due to the South Atlantic Anomaly (SAA). One cannot simply say that Si detectors are sensitive to the SAA while diamond detectors are not; the situation is more complicated (cf. also "First dark current" figures above):

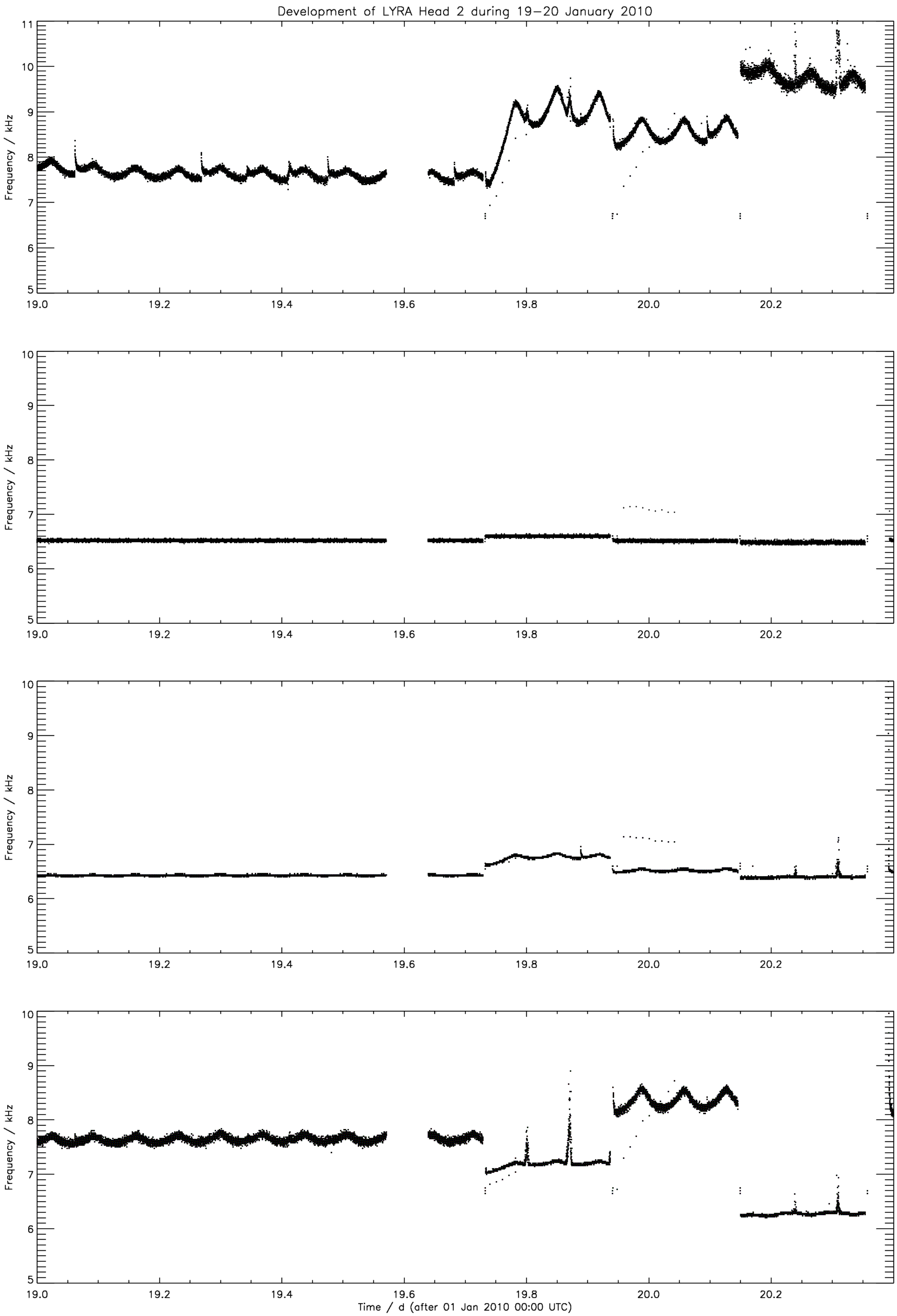
- all Si detectors are significantly sensitive to the SAA (e.g. Ch 1-4: delta = 0.8 kHz)
- some MSM diamond detectors are somewhat sensitive to the SAA, but just in the order of temperature changes (e.g. Ch 1-1: delta = 0.2 kHz)
- some MSM diamond detectors are not sensitive to SAA, e.g. Ch 1-3.
- all PIN diamond detectors are not sensitive to SAA, e.g. Ch 1-2.

One should be careful not to mix up the SAA noise with the ASIC reload noise.

The following are qualitative impressions about reactions

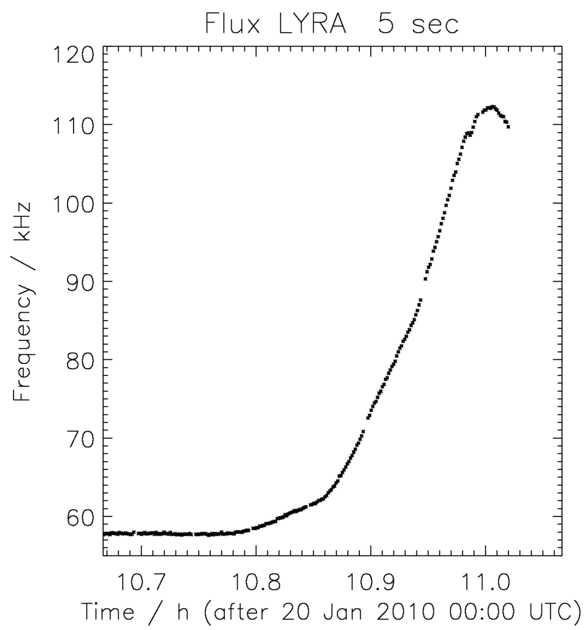
- to SAA,
- to temperature (cyclic change caused by orbit) ,
- and to noise in general (random noise, e.g. increased by pre-amplifiers):

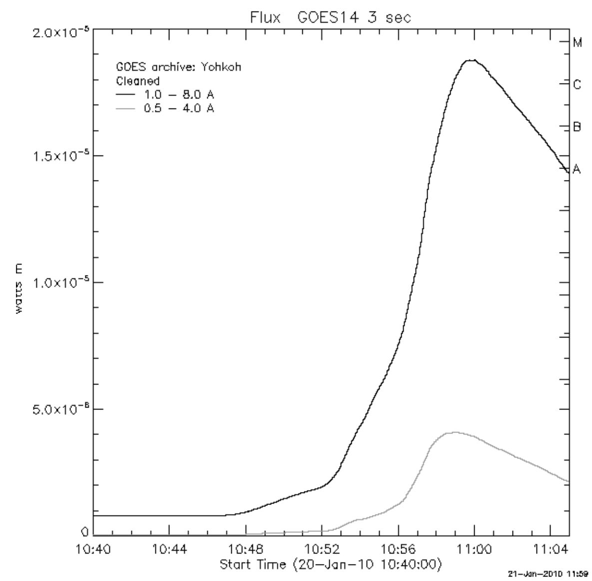
	SAA	temperature	noise
1-1 (MSM12) :	small	yes	low
1-2 (PIN10) :	no	no	low
1-3 (MSM11) :	no	small	low
1-4 (AXUV20D):	yes	small	low
2-1 (MSM21) :	small	yes	high
2-2 (PIN11) :	no	no	low
2-3 (MSM15) :	no	small	low
2-4 (MSM19) :	small	yes	high
3-1 (AXUV20A):	small	yes	very high
3-2 (PIN12) :	no	no	low
3-3 (AXUV20B):	yes	small	low
3-4 (AXUV20C):	yes	small	low



Development of LYRA Head 2 during 19–20 January 2010
Frequency / kHz
Time / d (after 01 Jan 2010 00:00 UTC)

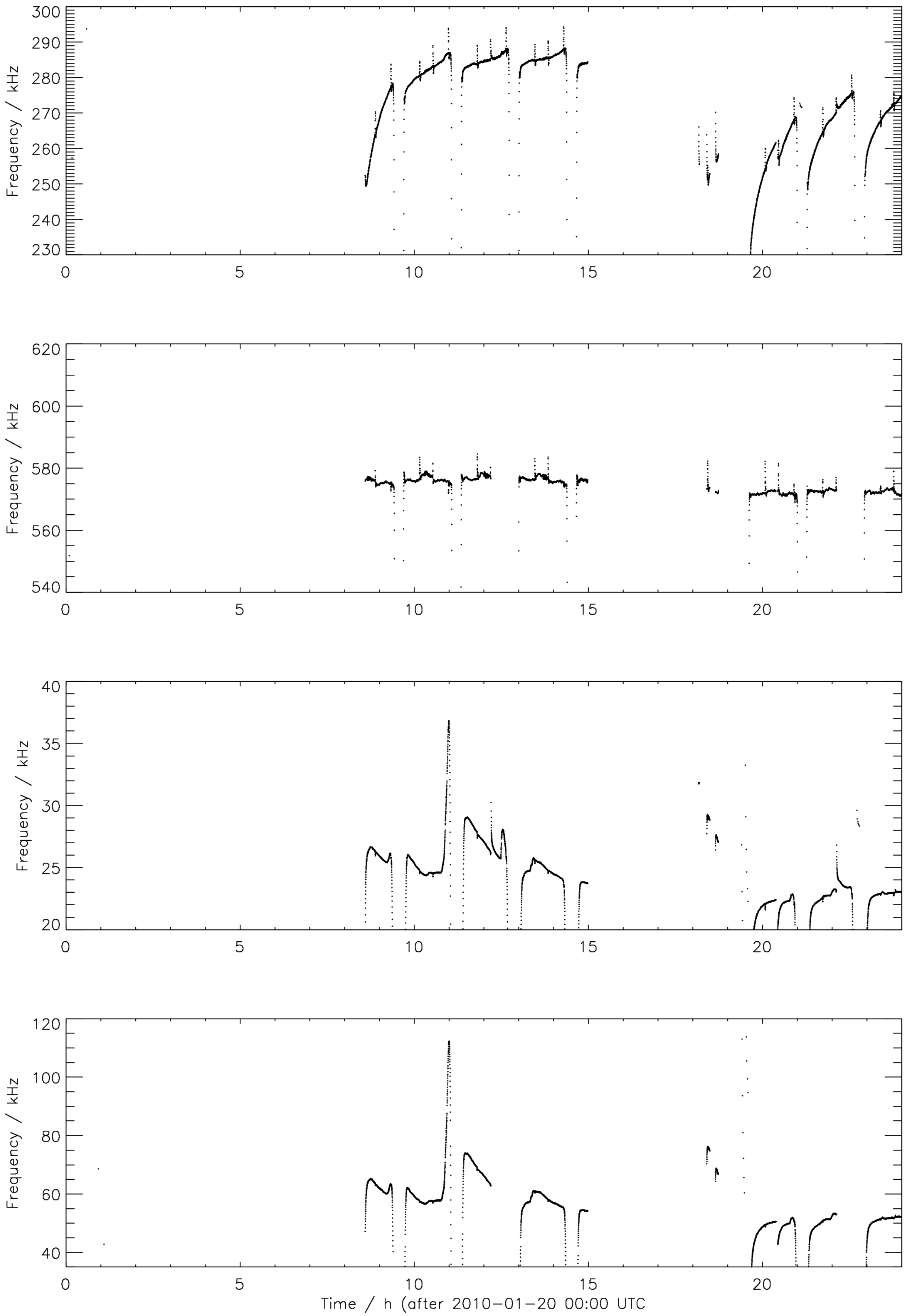
First M flare





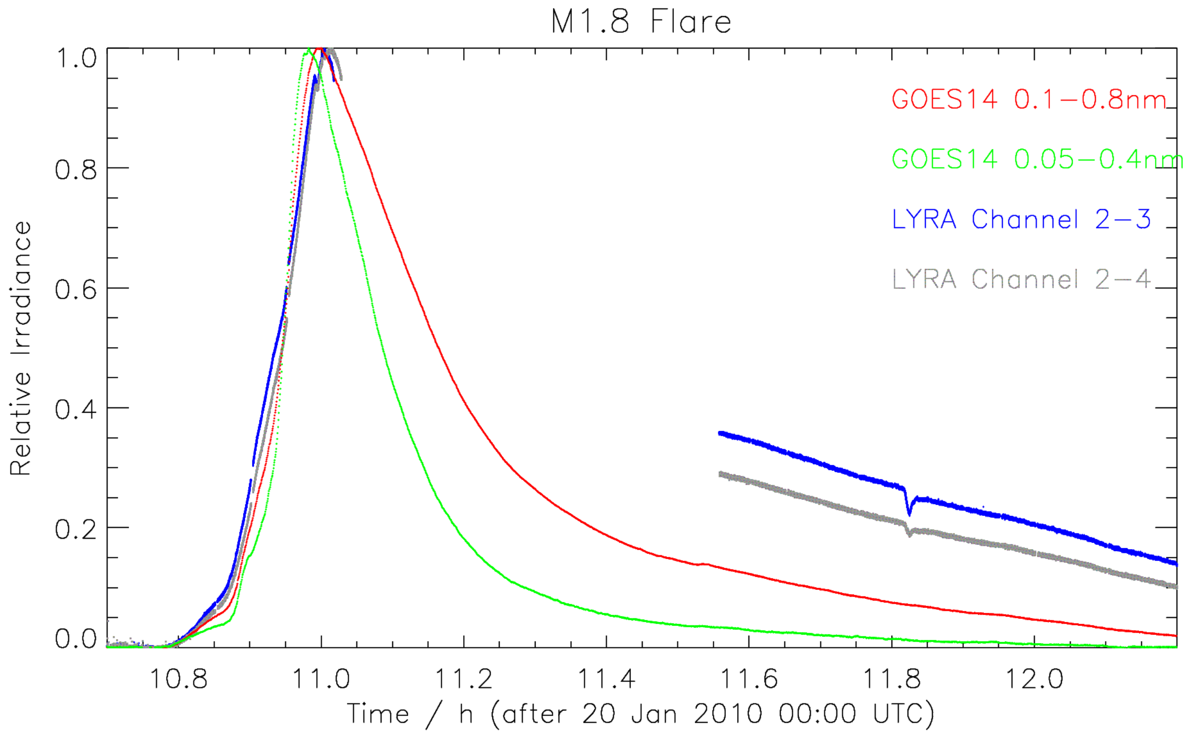
After observing several B and C flares in the days before, LYRA caught its first M flare (20 Jan 2010, 10:59 UTC, M1.8, according to GOES).

One can see it on channels 3 and 4 in the next figure. The figure above shows the GOES time series on the same temporal scale as the LYRA time series. Please note that this is an overview plot: it only takes 1% of LYRA data into account. Actually, LYRA integration time is 50 ms, so there are 100 additional points in between.

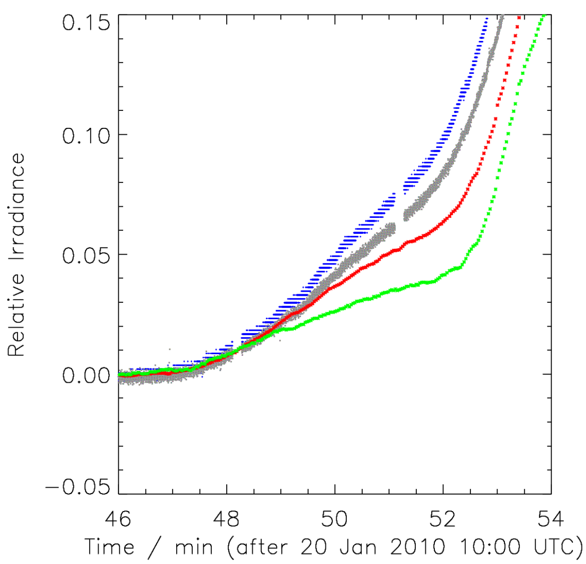


300
290
280
270
260
250
240
230
Frequency / kHz
620
600
580
560
540
Frequency / kHz
40
35
30
25
20
Frequency / kHz
120
100
80
60
40
Frequency / kHz
0
5
10
15
20
Time / h (after 2010-01-20 00:00 UTC

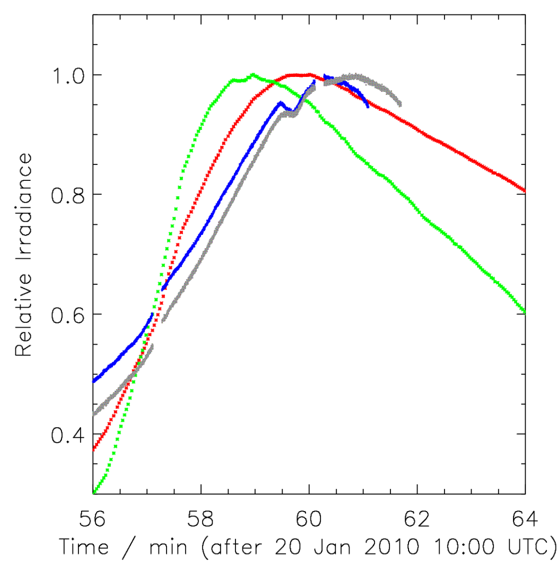
LYRA and GOES in one image:



The start of the flare:



The peak of the flare:

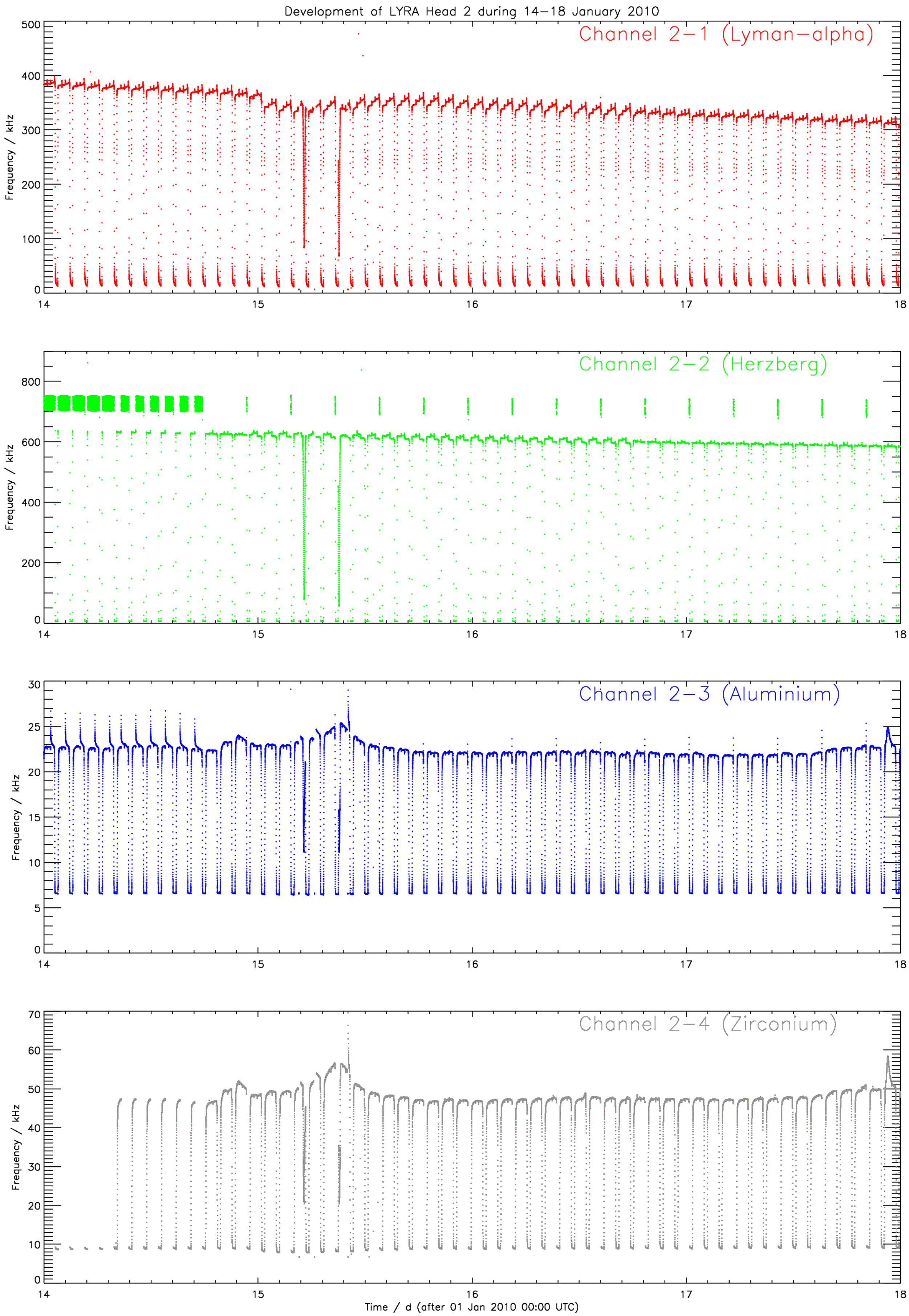


30 seconds were added to LYRA time after detecting a difference. As a result, LYRA onset exactly coincides with GOES onset, and both instruments show the same "ramp" during the first five minutes. So I think the time correction is valid. - In the PROBA2 Info Table, the attitude changes are given at (e.g.) 11:00:36 and 11:50:12 UTC. A closer look at the latter case - it is simpler to analyze, because there is no flare peak – shows that it actually *ends* at this time. I hope this is correct, otherwise the dips would happen too early. One dip takes approx. 70 seconds altogether, so probably the rotation also takes that long. If this is not the case, than these figures are not completely correct.

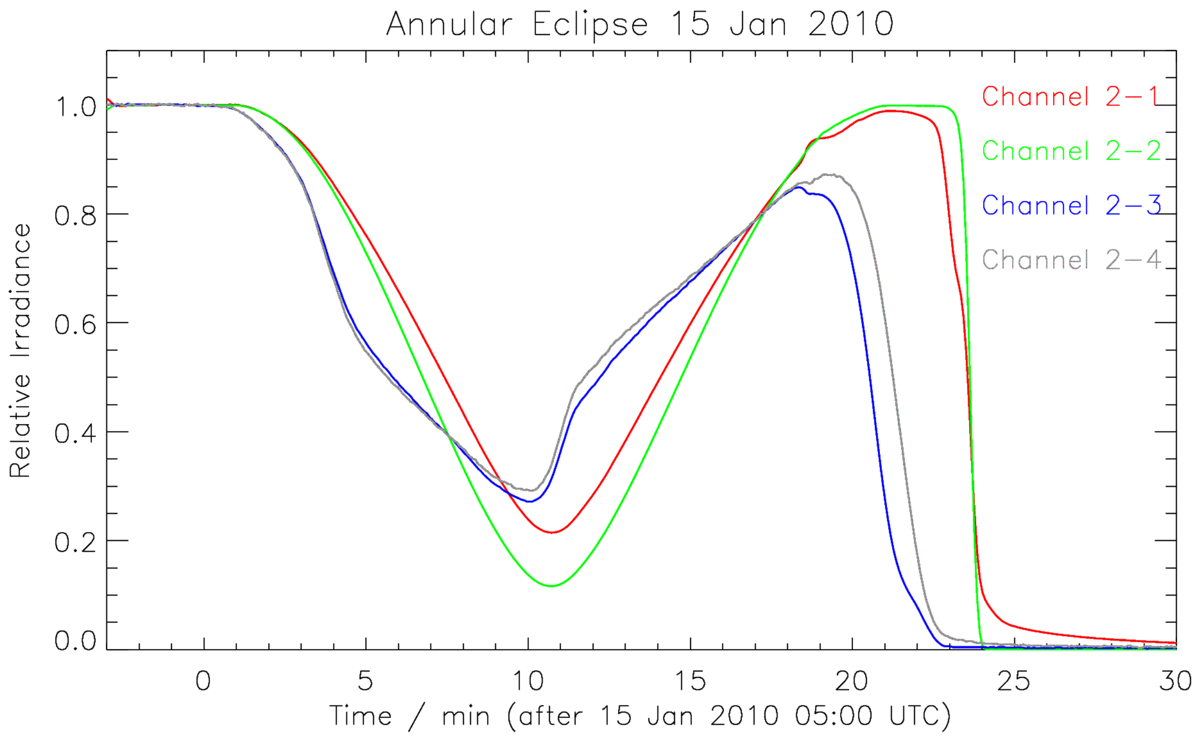
Overview 14-18 Jan 2010

The next figure shows:

- the steady decline of channels 2-1 and 2-2
- the apparent stability of channels 2-3 and 2-4
- 26 ASIC reloads, visible as dashes in channel 2-2, as spikes or sometimes only as dots in channel 2-3, and as one spike in channel 2-4 where some of the other faulty values are outside the plotting field
- 58 eclipses caused by the Earth's shadow (i.e. one in every 1 h 39 m)
- 4 spacecraft 90-degree rotations (attitude changes) per orbit
- 2 eclipses caused by the lunar shadow on 15 Jan 2010
- at least 5 flares, visible in channels 2-3 and 2-4:
  14 Jan 2010, 21:39 UTC, B8.1
  15 Jan 2010, 08:41 UTC, C1.3
  16 Jan 2010, 12:40 UTC, B3.9
  17 Jan 2010, 19:43 UTC, B4.2
  17 Jan 2010, 22:33 UTC, C2.1
- the output according to the LYRA radiometric model was estimated as:
  (Ch2-1) 259 kHz (Ch2-2) 581 kHz (Ch2-3) 19 kHz (Ch2-4) 42 kHz
  between 14-18 Jan 2010, i.e. after one week of linear degradation of channels 1 and 2, LYRA observed
  (Ch2-1) 350 kHz (Ch2-2) 600 kHz (Ch2-3) 22 kHz (Ch2-4) 48 kHz


Development of LYRA Head 2 during 14–18 January 2010
Channel 2–1 (Lyman–alpha)
Channel 2–2 (Herzberg)
Channel 2–3 (Aluminium)
Channel 2–4 (Zirconium)
Frequency / kHz
Time / d (after 01 Jan 2010 00:00 UTC)

Eclipses by moon and earth



This figure shows, first, the shadow of the moon crossing the sun, and then the regular eclipse by the shadow of the earth. It looks interesting because of the asymmetry in the short-wavelength channels 2-3 and 2-4. The reason could be the inhomogeneous distribution of EUV and X-ray radiation across the solar surface.

Again, 30 seconds were added to LYRA time, such that the end of the little bumps in the upper right corner correspond to the attitude change of 05:19:31 UTC.

The other eclipse around 09:00 UTC of the same day was not used here, because it was partially hidden by an earth eclipse.