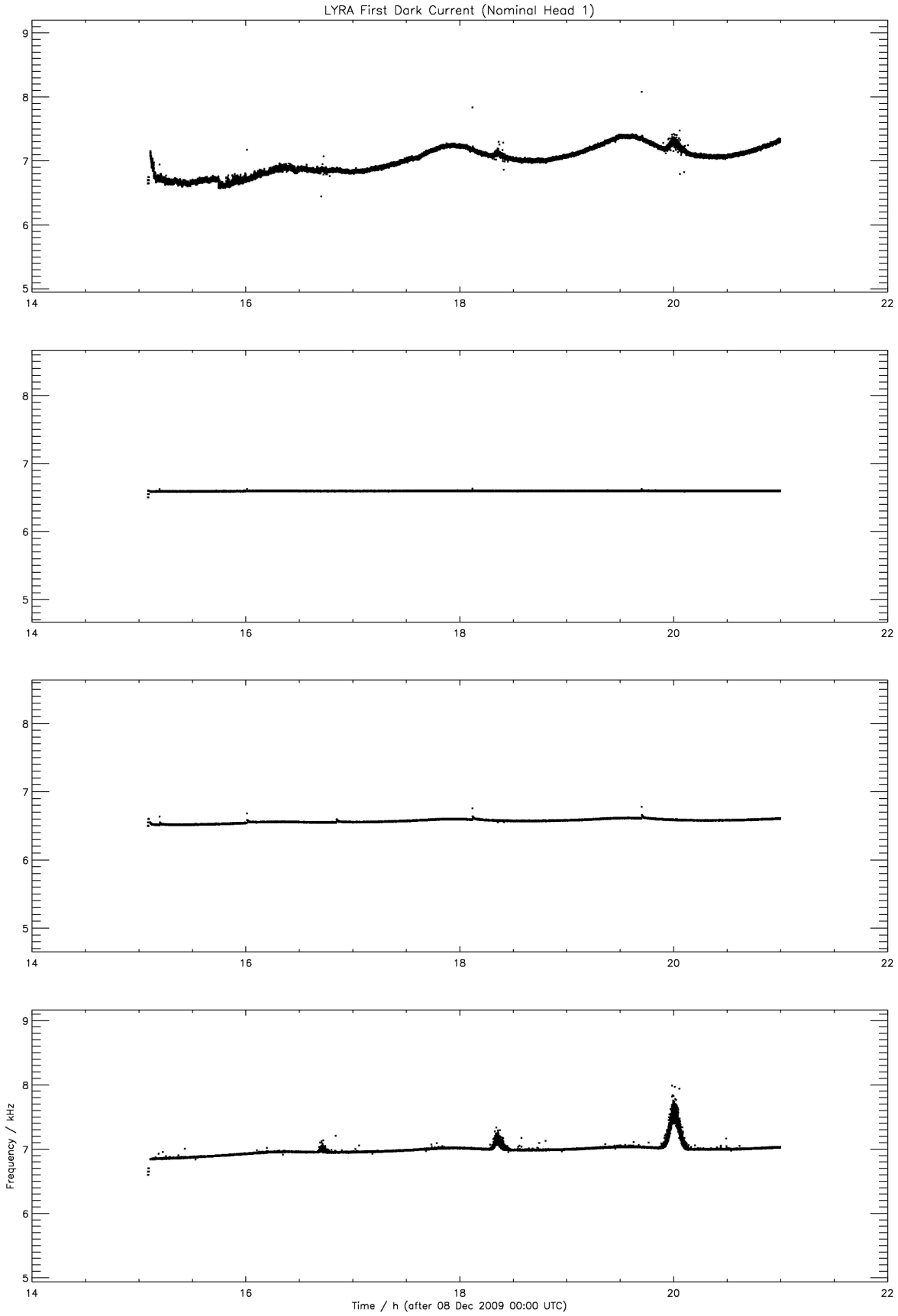
LYRA – the first three months

Data analysis during the commissioning phase

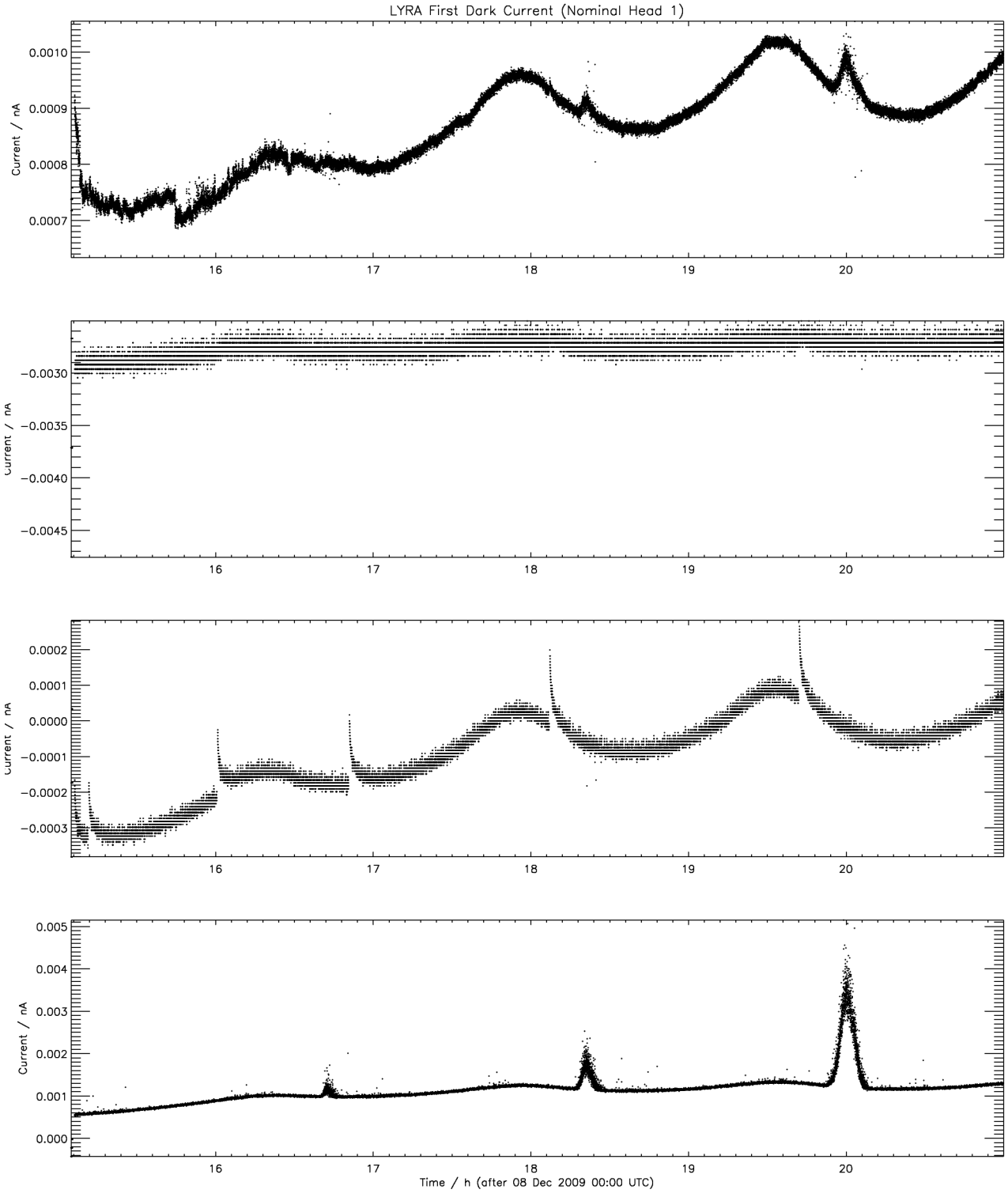
IED 26 Jan 2010

Contents of Part I.

First dark current



... the same in nA and full resolution (more information can be found below in “Dark currents on ground and in flight”):



Solar predictions for open doors

Science is about a possible falsification of a hypothesis, at least according to Karl Popper. So if one does not present a hypothesis, it cannot be falsified.

After having looked at some results from December, I assume the dark currents to be as follows (all values in kHz):

```
Unit 1: (ch1) 7.23   (ch2) 6.60   (ch3) 6.60   (ch4) 7.00
Unit 2:       8.97         6.50         6.55         8.68
Unit 3:      11.00         6.36         6.25         5.95
```

Channel 1-1, 1-4, 2-1, 2-4, 3-1 may have a tendency to increase, channel 3-4 to decrease; values are from the saturation phase.
Channel 2-1 seems to oscillate between 8.61 and 9.33
Channel 2-4 between 8.43 and 8.94
Channel 3-1 between 10.67 and 11.34

Likewise, I assume the VFC values as follows:

```
back-up 0.0V: (ch1) 6.63   (ch2) 6.51   (ch3) 6.55   (ch4) 6.60
        2.5V:     609.20       608.90       609.40       609.60
        5.0V:    1212.16      1211.55      1212.61      1212.85
nominal 0.0V:       6.76         6.61         6.62         6.73
        2.5V:     608.76       609.25       608.81       608.87
        5.0V:    1211.33      1212.49      1211.53      1211.53
```

From this, I assume the factor to convert frequencies to voltage, or rather differences thereof, to be (nominal unit):

```
               0.00415086   0.00414635   0.00414969   0.00415007
```

Looking at the values from TIMED/SEE and SORCE/SOLSTICE, I assume the present situation (05 Jan 2010) to be as follows (daily averages in W/m²):

```
Channel 1 (120-123nm) 0.0062 - 0.0063
Channel 2 (200-220nm) 0.460 - 0.463
Channel 3 (17-80nm)   ~0.00176
Channel 4 (6-20nm)    0.00063 - 0,00066
```

(TIMED/SEE values for channel 3 jump between 0.0010-0.0012 and 0.0017. I chose the latter value for consistency reasons.)

Channels 1, 3, and 4 are exactly at the lower limit of LYRA expected values, which is plausible since we are still close to solar minimum. Channel 2 is rather in the middle of the expected range. This is apparently due to a change in SORCE/SOLSTICE calibration (version 10), which occurred in September of 2009, i.e. after my last reports (June/July 2009). But this should not lead to wrong calibration values.

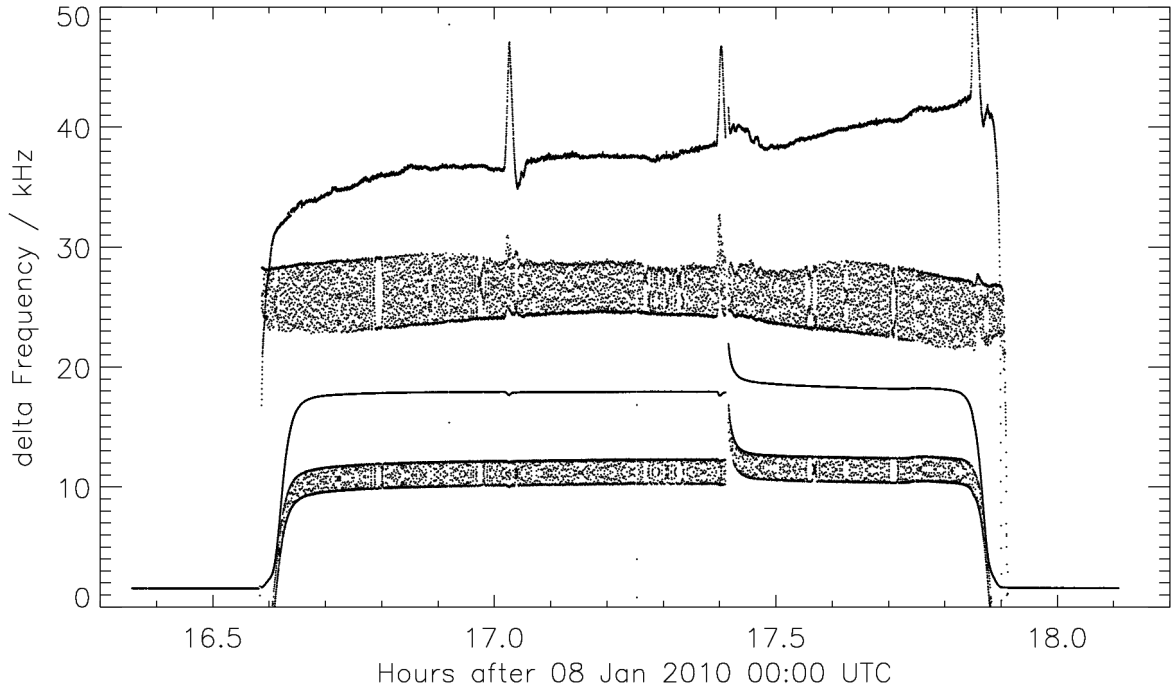
My predictions – one day before opening of the covers - are thus (all values in kHz):

```
Unit 1: (ch1) 698-702   (ch2) 548-553   (ch3) 19-21   (ch4) 29-31
Unit 2:       258-260         579-585         18-20         41-43
Unit 3:       685-689         469-473         231-233       28-30
```

In this case, "kHz" means that with Channel 1-1 and 1 second exposure time we will get 698 000 – 702 000 counts of which 7230 are dark currents.

One can easily see that the determination of the dark currents will be crucial: In the case of, e.g., channel 1-3, we will get 19000-21000 counts with 1 second exposure time, where 6600 counts, or one third, are from dark current.

Time Series 08 Jan 2010



This is LYRA head 2, channel 1,2,3,4 (top to bottom). It does not show the real levels (being approx. 500, 700, 20, and 160 kHz, resp.) but just the differences.

Citing from the table *PROBA2_Info_20100104.txt*, the following things are supposed to happen:

```
2010/ 1/ 8   16:33:27 INTO PENUMBRA
2010/ 1/ 8   16:33:59 INTO FULL SUN
2010/ 1/ 8   16:35:28 CHANGE ATTITUDE FROM  1 TO  4
2010/ 1/ 8   17: 2:32 CHANGE ATTITUDE FROM  4 TO  3
2010/ 1/ 8   17:25:12 CHANGE ATTITUDE FROM  3 TO  2
2010/ 1/ 8   17:52:13 CHANGE ATTITUDE FROM  2 TO  1
2010/ 1/ 8   17:56: 6 INTO PENUMBRA
2010/ 1/ 8   17:56:38 INTO UMBRA
```

So the time series begins and ends with an eclipse (completely visible here only in channel 3 - its dark current is actually around 6.5 kHz; the levels of the other channels are too high to display their dark currents in this plot).

The first attitude change (16:35) appears still to be hidden by the eclipse. The next three changes are clearly visible as peaks in channel 1 and 2; only two of the changes (17:02 and 17:25) are somewhat visible as little dips in channel 3 and 4.

The Sun appears later and vanishes earlier (simultaneously) for channel 3 and 4, which is plausible, since both observe the corona. Channel 1 and 2 appear earlier and vanish later (simultaneously) which is also plausible, since both observe the chromosphere. (But it may also be caused by the different absorption due to the Earth's atmosphere.)

Channel 1 shows a drift which was known before and expected.

In addition to that, channel 1 shows some irregularities which may come from the Sun; GOES observes a B flare around 17:30. (But later on, flares were only visible in channels 3 and 4, so it may as well be another cause.)

Something happens at 17:24. The data display the following:

```
.....
2010-01-08T17:24:38.450Z 5834050.450 5999 239659 374684 11446 84628 500
2010-01-08T17:24:38.950Z 5834050.950 6000 239611 376873 11447 84453 500
2010-01-08T17:24:39.450Z 5834051.450 6001 239574 375404 11448 83757 500
2010-01-08T17:24:46.916Z 5834058.916   46 251916 441090 16291 73825 500
2010-01-08T17:24:57.416Z 5834069.416   67 288249 405367 90433 154867 500
2010-01-08T17:24:57.916Z 5834069.916   68 240814 375581 13472 86178 500
2010-01-08T17:24:58.416Z 5834070.416   69 240762 374882 13433 86922 500
2010-01-08T17:24:58.916Z 5834070.916   70 240681 375070 13394 86875 500
2010-01-08T17:24:59.416Z 5834071.416   71 240612 376580 13359 86780 500
.....
```

Lines "46" and "67" can be considered faulty. Nevertheless, after the reset of the numbering, a peak and a gradual decline can be observed, especially in channel 3 and 4. It looks a bit too good to be true (in the sense of "natural" causes), so probably it is not a flare, but what was mentioned to be an "ASIC reload" and its unwanted consequences.

Finally, I think that the noise displayed in channel 2 and 4 (and the level of channel 4, which is too high by a factor of 4) is not natural but looks like a decoding error.

The first image (08 Jan 2010 ~17:00 UTC) was taken from folder 3320 (284_RED3). Integration time was 500 ms. There were VFC measurements at 17:15 and 18:04 (0.0V), 16:55 and 17:44 (2.5 V), 16:23, 16:35 and 17:24 (5.0V).

The next figure (see below) also shows data from 08 Jan 2010, but taken after the figure above. The time series starts around 18:06 UTC. The file is quite large, I stopped processing after about 1 hour IDL running time and thus got about half the file (from pass 3386); it represents approx. 267 000 lines of text. It is getting way too long for IDL to process the data like this.

Around the attitude change at 22:22 UTC

```
.....
2010/ 1/ 8   21:33:10 CHANGE ATTITUDE FROM  1 TO  4
2010/ 1/ 8   22: 0:15 CHANGE ATTITUDE FROM  4 TO  3
2010/ 1/ 8   22:22:54 CHANGE ATTITUDE FROM  3 TO  2
2010/ 1/ 8   22:49:55 CHANGE ATTITUDE FROM  2 TO  1
.....
```

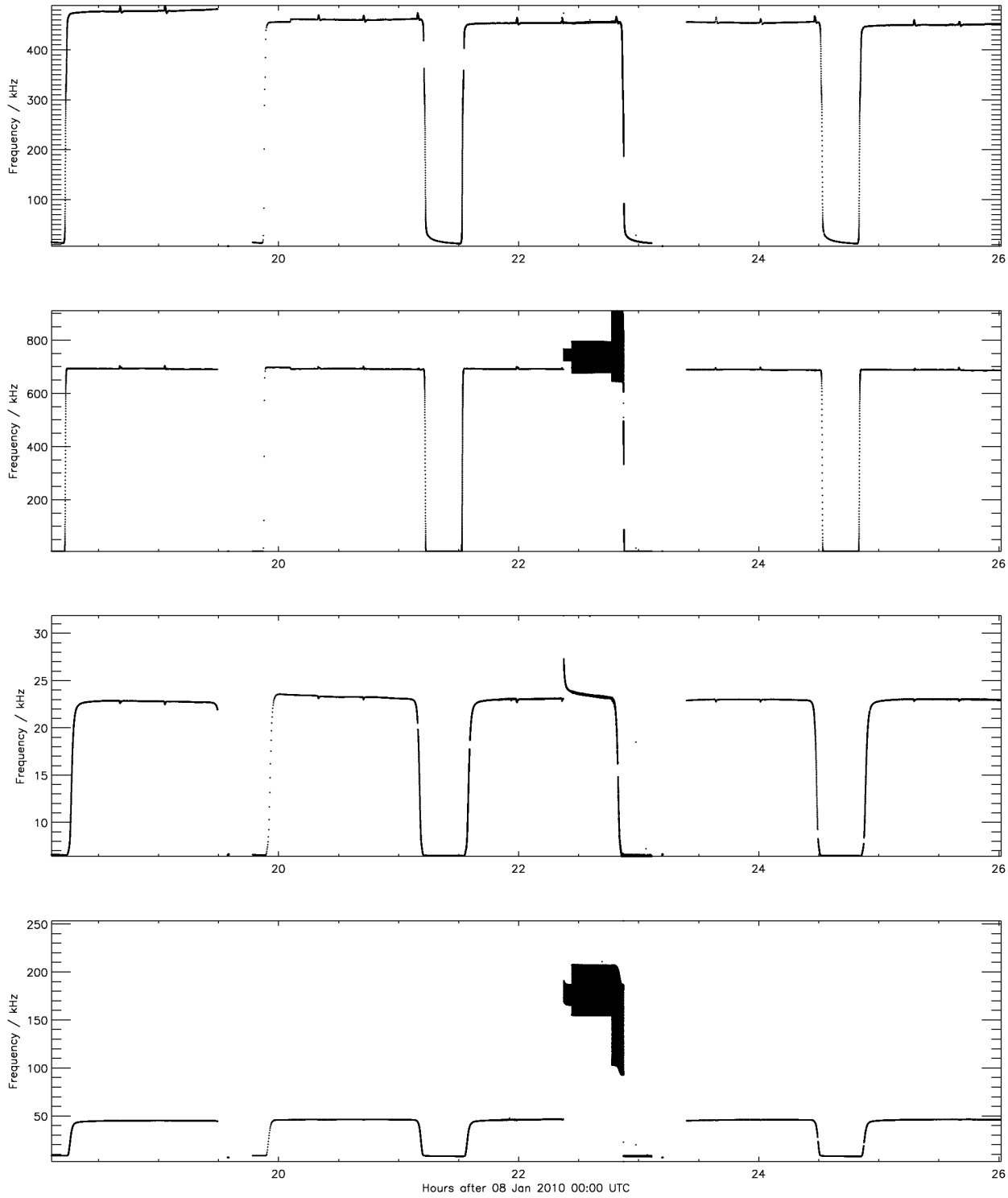
there is once again this strange peak which coincides with a restart in numbering:

```
.....
2010-01-08T22:22:20.227Z 5851912.227 60203 22650 34512 1154 2324 50 3
2010-01-08T22:22:20.277Z 5851912.277 60204 22644 34516 1154 2319 50 3
2010-01-08T22:22:27.391Z 5851919.391    64 23675 37703 1597 8642 50 3
2010-01-08T22:22:27.441Z 5851919.441    65 23664 38331 1593 8644 50 3
2010-01-08T22:22:37.491Z 5851929.491   266 34523 46206 19767 24596 50 3
2010-01-08T22:22:37.541Z 5851929.541   267 22787 36199 1364 9083 50 3
2010-01-08T22:22:37.591Z 5851929.591   268 22778 37820 1363 8490 50 3
.....
```

Obviously, lines number 64, 65, and 266 are faulty and have to be deleted. But it looks like the action that restarts the numbering also causes channel 2 and 4 to behave strangely. Within the next eclipse, this strange behaviour ends.

How to find the typical faulty lines to be thrown away after changes in integration time, VFC checks etc: My criterion is
`if (in_time gt (time(i)+1.1*in_intt/1000.)) then [delete]`

In other words: If the time that I currently read ("`in_time`", in seconds) is greater than the last line's time ("`time(i)`", in seconds) plus 110% of the current integration time ("`in_intt`", in milliseconds) then I delete this value in the end. I think, like this I get rid of most faulty values.


Frequency / kHz
100
200
300
400
20
22
24
26
Frequency / kHz
200
400
600
800
20
22
24
26
Frequency / kHz
10
15
20
25
30
20
22
24
26
Frequency / kHz
50
100
150
200
250
20
22
24
26
Hours after 08 Jan 2010 00:00 UTC

After a very brief look at the flatfields, it appears that the peaks in channel 2-1 during the attitude changes may indeed be due to the flatfield. In the following report

http://solwww.oma.be/users/dammasch/IED_20070320_LYRA_Detectors_GI06NI07upd.pdf

page 7 (Figure 2.2) shows that the flatfield of channel 2-1 is very asymmetric. On page 11 (Figure 3-2) the simulation of off-pointing shows a possible difference of 0.77% within the nominal S/C jitter which was given to be ± 5 arcmin (TBC). Now, actually, we even see approx 2% change in real channel 2-1 data. But if the pointing is not exactly to the center of the Sun, this may explain the rest. The concentric circles denote the levels: 100%, 95%, 90%, 85%. If the jitter is 3 arcmin during the attitude change, and if this happens somewhere in the area between 100% and 95%, this may very well lead to 2%.

With more symmetric flatfields, the jump can be expected to be smaller. And it is equally possible to hit either a more sensitive or a less sensitive part of the flatfield, so the attitude change may lead to peaks as well as dips. Indeed, channel 2-1 shows both: a big peak and a small dip.

First light

The next three fugures show LYRA “First Light” from 06 Jan 2010, for all three heads.

Some additional notes:

The drifts and the tails of the MSM detectors are just as expected, compare the following report

http://solwww.oma.be/users/dammasch/IED_20060920_LYRA_Signal.pdf

The PIN and the Si detectors are stable.

Only the Si detectors appear to be sensitive to the SAA (given that we are in fact over the SAA at 18:40 and 22:00 UTC on 06 Jan 2010); it leads to approx. 4 kHz of noise.

The observed eclipse profiles are already interesting at this stage: Note the differences in Lyman-alpha (bump in the middle) as opposed to Herzberg (apparently straight), and opposed to the short-wavelength channels 3 and 4 on the other side (wider).

In addition, there is an extra bump in the Si detectors in channels 3 and 4, at the very bottom of the eclipse. It coincides with the reaching of the bottom level of the long-wavelength channels. So maybe the Si detectors of channel 3 and 4 (1-4, 3-3, 3-4) are also sensitive to longer wavelengths (visible straylight, pinholes), while the MSM detectors (1-3, 2-3, 2-4) are not.

We missed a B flare around 19:30-20:00 (see Head 2: we were in an eclipse).

The problem of the noise in channels 2 and 4 is still to be solved.

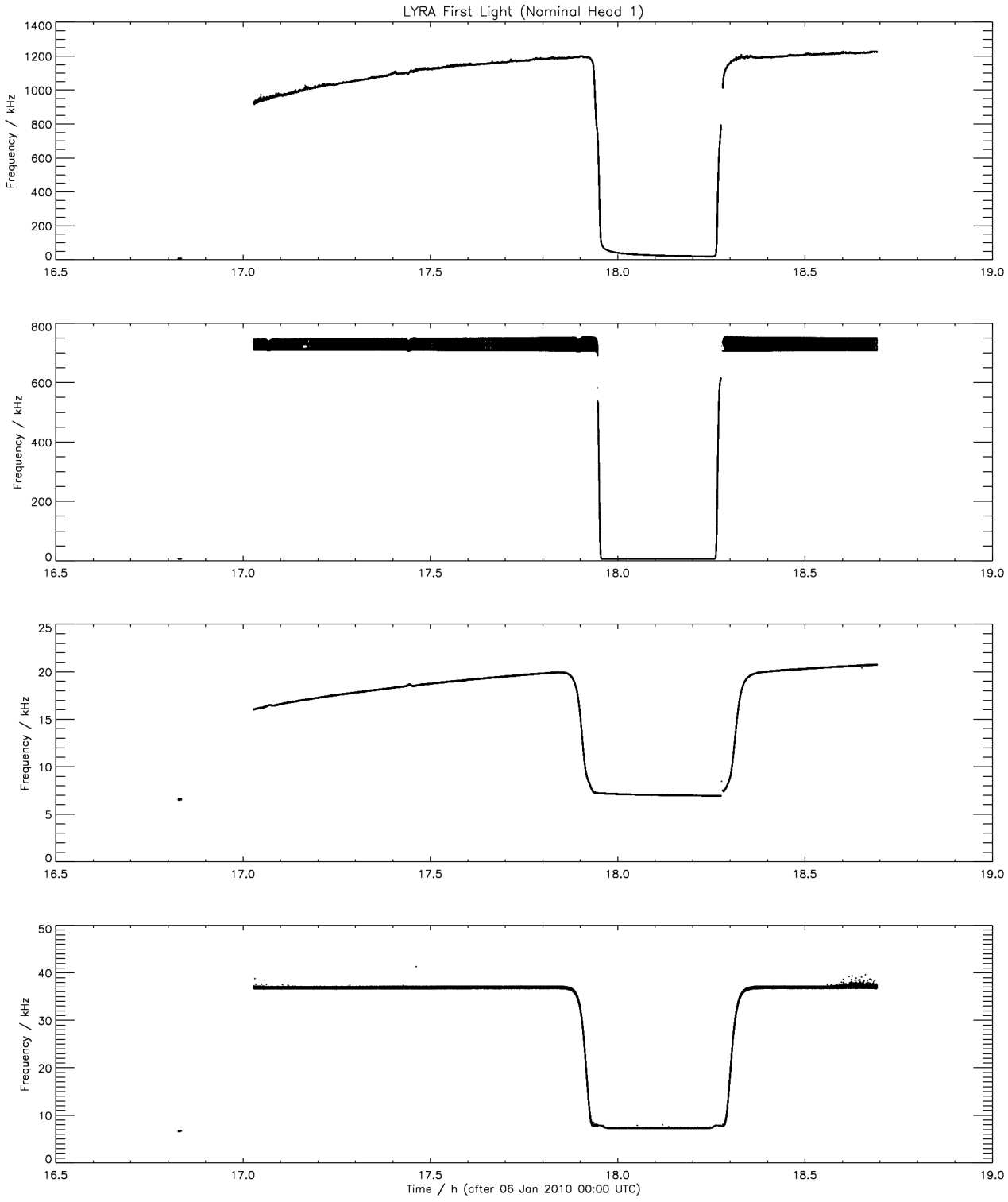
Other than heads 1 and 3 - where solar irradiance is shown as observed frequency in kHz - the image for **head 2** shows irradiance as estimated current in nA.

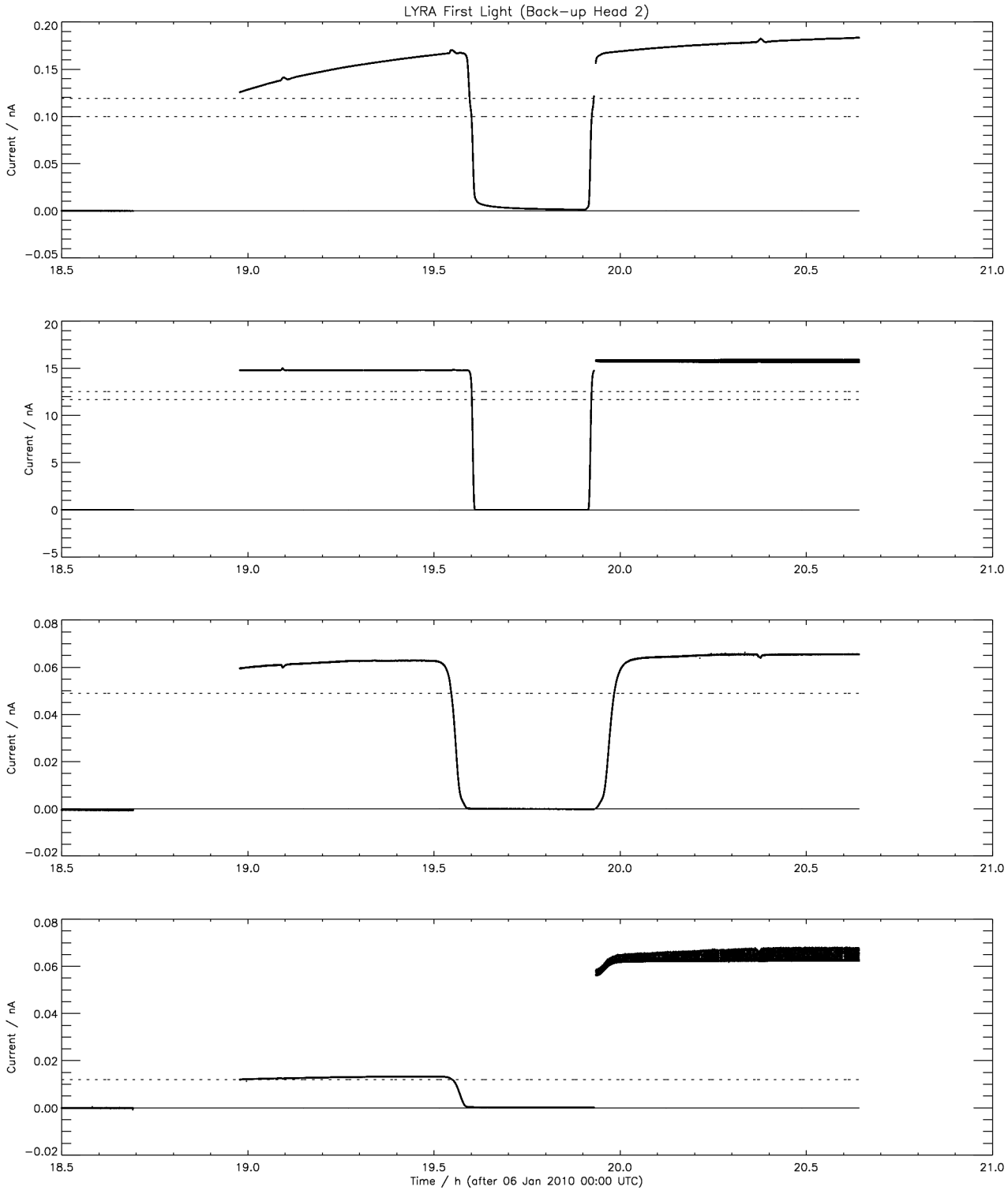
The assumptions are as stated above in “Solar Predictions” with respect to dark currents and VFC parameters. In addition, I assumed that the back-up VFC behaves like the nominal VFC (for head 2), which is not exactly the case, but almost.

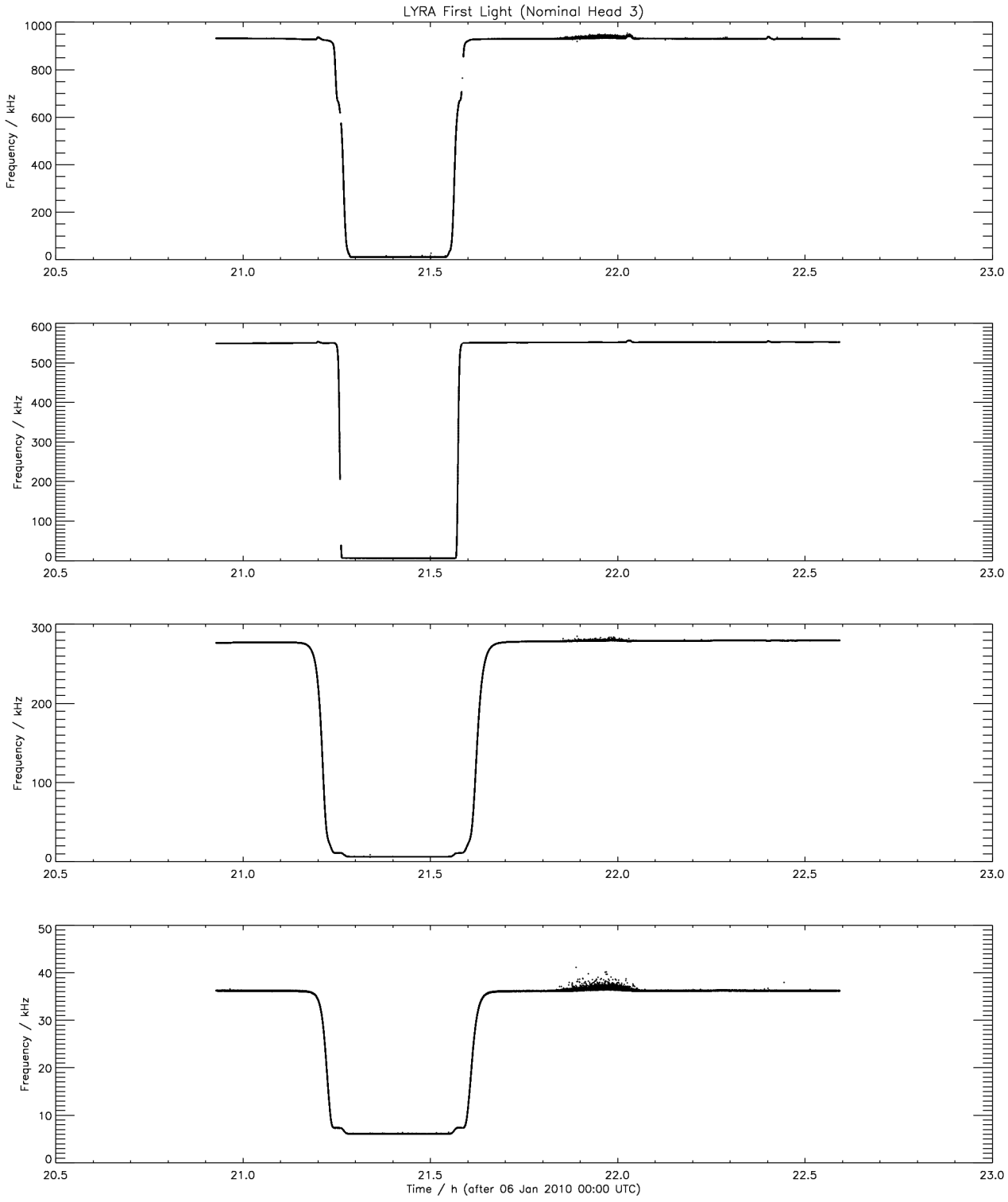
Also included is the zero level in some instances, to make sure that the dark currents were estimated correctly. The dotted lines denote the old LRM predictions; for channels 3 and 4 only the lower limits are shown, the upper limits (X-flare situations) are too high for a linear plot. The current situation is almost like the minimum spectrum taken on 29 Jun 2008.

One of the future steps will be to re-calculate the LRM with the 06 Jan 2010 spectra from TIMED/SEE and SORCE/SOLSTICE.

One source of error - apart from the unresolved "noise" problem - is the recalibration of SORCE/SOLSTICE (Version 10 of September 2009). Another possible source of error is the mysterious interval-building of the SORCE online tool: When asked for 200-220nm time series, it calculates 200.5-219.5nm. But the right side of this interval makes a huge difference, since the continuum rapidly increases. - Another possible error source could be the responsivity curves taken at BESSY: In case they were taken at the starting phase of the MSM detectors they could be too low later on.


LYRA First Light (Nominal Head 1)
Frequency / kHz
1400
1200
1000
800
600
400
200
0
16.5
17.0
17.5
18.0
18.5
19.0
Frequency / kHz
800
600
400
200
0
16.5
17.0
17.5
18.0
18.5
19.0
Frequency / kHz
25
20
15
10
5
0
16.5
17.0
17.5
18.0
18.5
19.0
Frequency / kHz
50
40
30
20
10
0
16.5
17.0
17.5
18.0
18.5
19.0
Time / h (after 06 Jan 2010 00:00 UTC)


LYRA First Light (Back-up Head 2)
Current / nA
0.20
0.15
0.10
0.05
0.00
−0.05
18.5
19.0
19.5
20.0
20.5
21.0
Current / nA
20
15
10
5
0
−5
Current / nA
0.08
0.06
0.04
0.02
0.00
−0.02
Current / nA
Time / h (after 06 Jan 2010 00:00 UTC)


LYRA First Light (Nominal Head 3)
Frequency / kHz
1000
800
600
400
200
0
20.5
21.0
21.5
22.0
22.5
23.0
Frequency / kHz
600
500
400
300
200
100
0
Frequency / kHz
300
200
100
0
Frequency / kHz
50
40
30
20
10
0
Time / h (after 06 Jan 2010 00:00 UTC)

C flare and spacecraft events 12 Jan 2010

The next figure shows one of LYRA's first flare observations, visible in the two short-wavelength channels. According to GOES14, it was a C1.1 flare, beginning 12:33 UTC, peaking 13:20, ending 13:34.

The plot is enhanced with some events, namely:
- the spacecraft rotations (marked as "+")
- the ASIC (there's only one, marked with a diamond)
- the VFC parameter checks (marked with little "*")

Results:

The VFC checks happen regularly every 10 minutes (0.0V, 5.0V, 2.5V,...). They have no apparent influence.

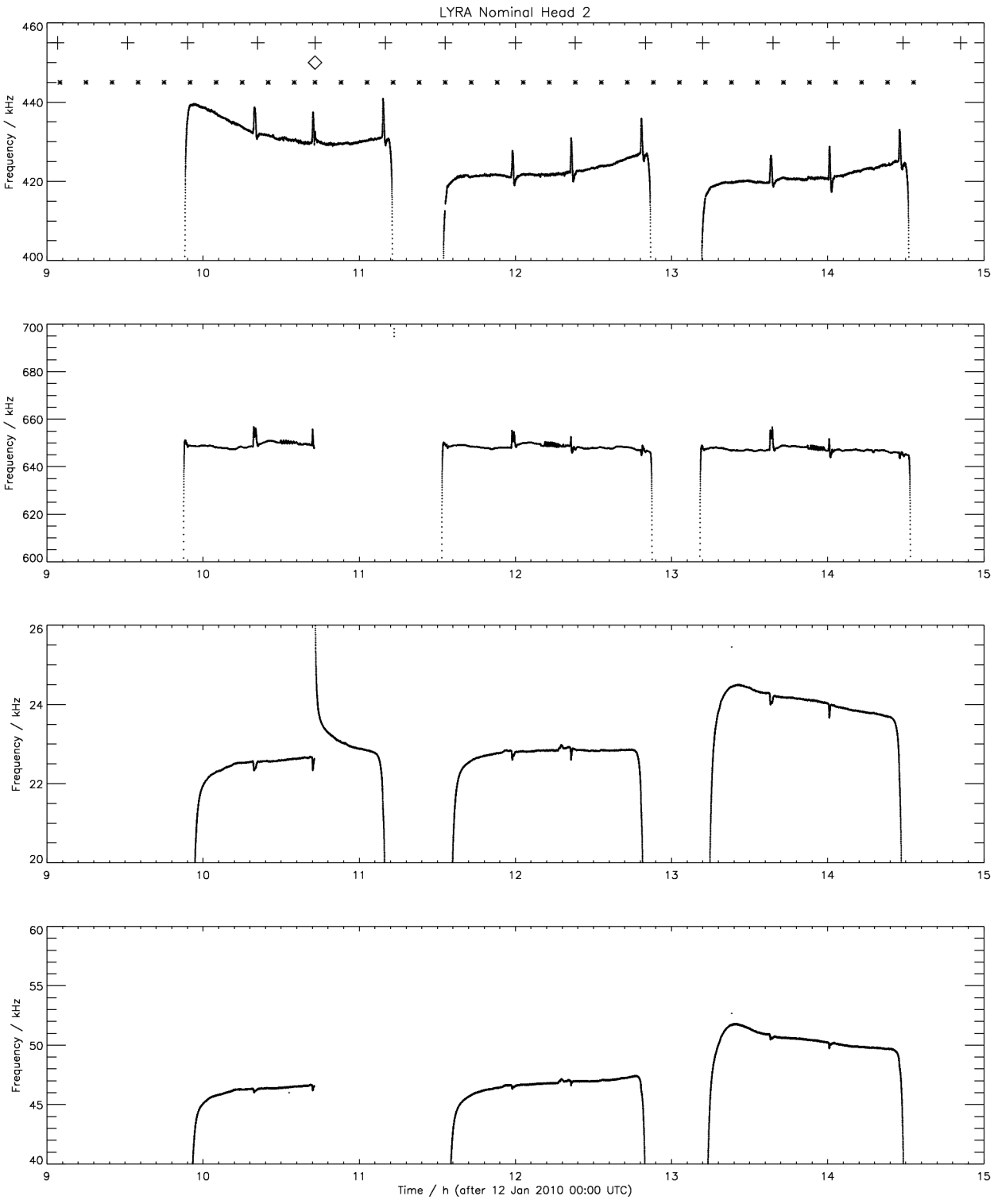
The ASIC - determined as the time where the counter is reset to zero - coincides with the peak in channel 3 and the start of data faults in channels 2 and 4. - Maybe the following could be of interest, too: The data faults end within the next eclipse, when the data values are dropping. In channel 1 and 3, data values drop continuously. In channels 2 and 4, they jump, see here (line 4 of 7):

```
2010-01-12T11:13:26.415Z 6157378.415 3704 131447 349018 3405 78534 500 3
2010-01-12T11:13:26.915Z 6157378.915 3705 130084 348234 3406 78517 500 3
2010-01-12T11:13:27.415Z 6157379.415 3706 128619 347444 3406 78527 500 3
2010-01-12T11:13:27.915Z 6157379.915 3707 127096 284410 3402 34003 500 3
2010-01-12T11:13:28.415Z 6157380.415 3708 125514 246085 3398 5360 500 3
2010-01-12T11:13:28.915Z 6157380.915 3709 123844 241307 3399 5356 500 3
2010-01-12T11:13:29.415Z 6157381.415 3710 122157 236327 3398 5355 500 3
```

The rotations as predicted almost coincide with the various peaks (channels 1 and 2) and dips (channels 3 and 4). As an example, the "change attitude from 4 to 3" is set at 10:20:51 UTC, the peaks and dips already happens around 10:19:40 (LYRA time).

The eclipses are cut off at the bottom to concentrate on the general irradiance.

While the variation in the level of channel 1 is probably due to attitude changes leading to light on different parts of the asymmetric detector, the changes in channels 3 and 4 are really due to the flare.


LYRA Nominal Head 2
Frequency / kHz
460
440
420
400
700
680
660
640
620
600
26
24
22
20
60
55
50
45
40
9
10
11
12
13
14
15
Time / h (after 12 Jan 2010 00:00 UTC)

First eclipse profiles

For the task of LYRA in the field of atmospheric modeling, it will be interesting to produce overplots of solar occultations in several variants. As a start, I chose the "sunsets" of the first three eclipses taken by heads 1, 2, and 3 (the first light data from 06 Jan 2010), see next three figures.

They were normalized between max and min and synchronized with the 50% point of the continuum irradiance (channel 2).

Some remarks:

```
red   = channel 1 (Lyman-alpha)
green = channel 2 (Herzberg)
blue  = channel 3 (Aluminium)
grey  = channel 4 (Zirconium)
```

Channel 1-2 initially shows the faulty noise; the gap in the data is probably caused by a switch-back to correct data.

The gaps in the curves of head 3 are caused by 10 seconds of VFC parameter check.

Channel 3 starts decreasing earlier than channel 4. Either the Sun is "bigger" as seen in channel 3 and thus commences its decrease further outwards, or channel 3 sees the Sun in a radiation which is absorbed earlier by the Earth's atmosphere than the radiation that channel 4 sees. Or the proportion of energetic (<20nm) photons going through Zr is larger than through Al, and those penetrate further in Earth's atmosphere.

Channel 3 has a bump leading it closer to channel 4 (at the bottom) which is independent from the detector type.

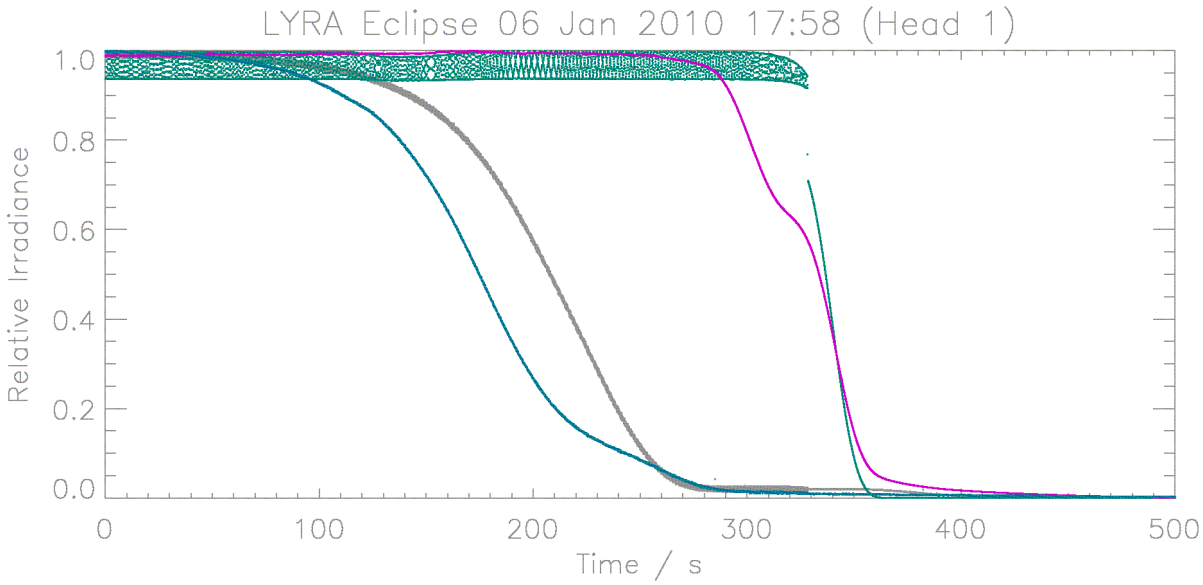
Channel 1 has a bump around the middle which is independent from the detector type. Again, this could be the Sun, "sticking out further" in the chromosphere than in the photosphere, or it could be the Earth's atmosphere absorbing Lyman-alpha radiation more than continuum radiation.

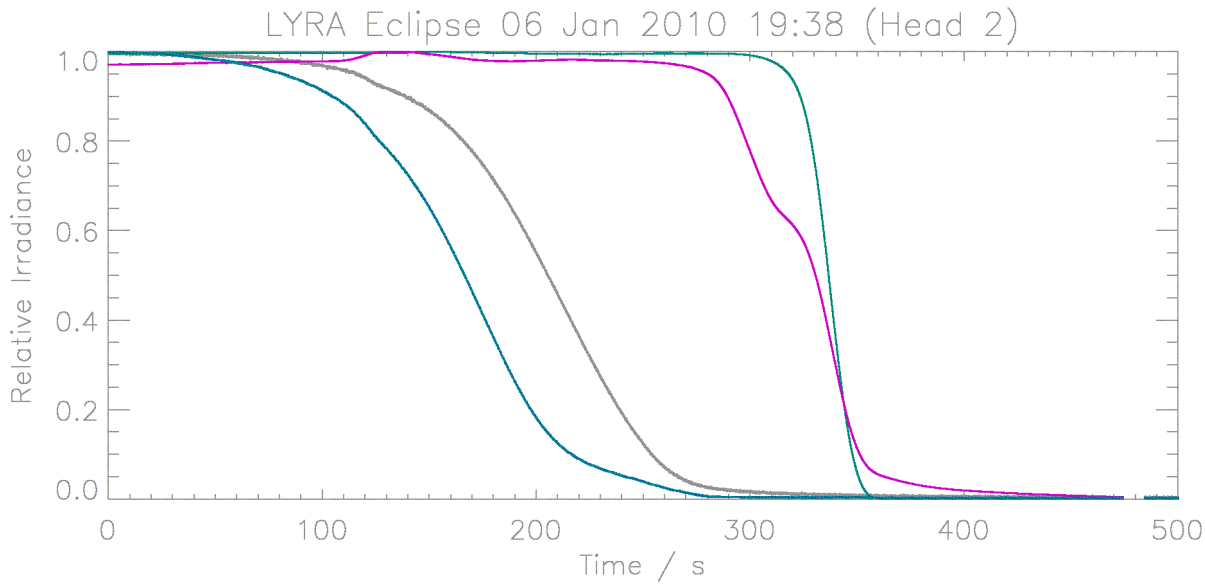
The MSM channels (1-1, 1-3, 2-1, 2-3, 2-4) show a tail at the bottom which is to be distinguished from the bumps. In other words, the bumps have different causes than the tails (detector responsivity vs. detector dynamics).

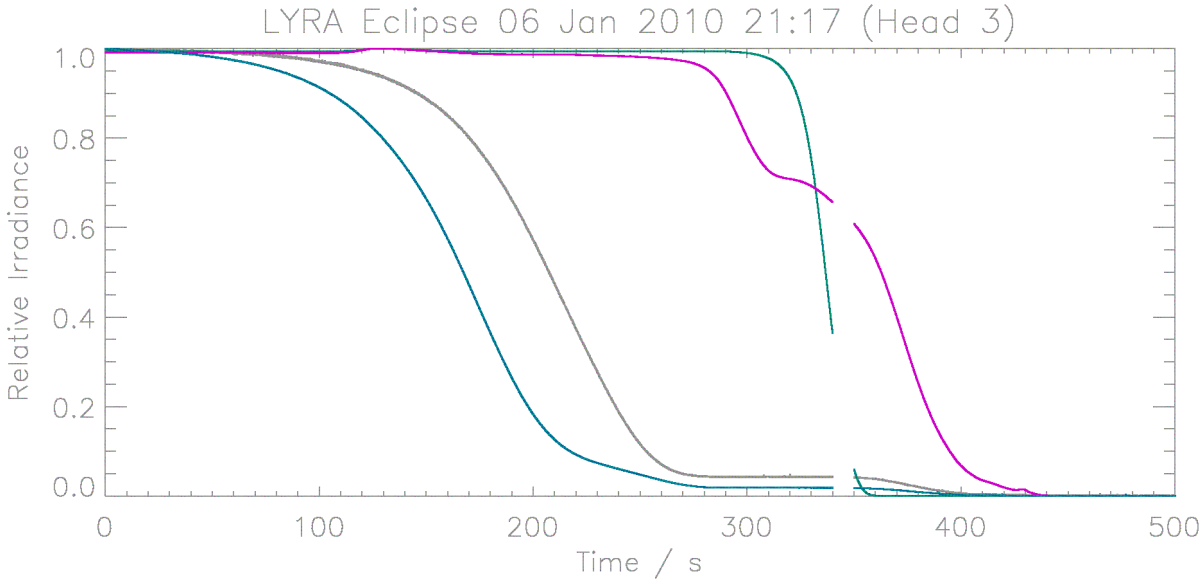
The PIN detectors have no bumps and no tails.

The Si detectors (1-4, 3-1, 3-3, 3-4) show bumps at the bottom which may point to responses to non-nominal signals (pinholes, straylight, long-wavelength influence?) Channel 3-1 shows this bump in the middle, as in heads 1 and 2, but it stretches out much stronger.

The little bumps visible in all Lyman-alpha channels before occultation (maximum level) are caused by the S/C attitude changes.


LYRA Eclipse 06 Jan 2010 17:58 (Head 1)
Relative Irradiance
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
Time / s


LYRA Eclipse 06 Jan 2010 19:38 (Head 2)
Relative Irradiance
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
Time / s


LYRA Eclipse 06 Jan 2010 21:17 (Head 3)
Relative Irradiance
1.0
0.8
0.6
0.4
0.2
0.0
0
100
200
300
400
500
Time / s

Three days of observation

The next figures show three days of almost continuous LYRA observations (14-16 Jan 2010) plus the corresponding GOES observations. It appears that LYRA is able to observe everything from B1.9 flares upwards.

The table at the end shows the flares that GOES observes; those flares that LYRA also observes are marked with a "+" in the rightmost column.

Please note that the plots are not all on the same scale from day to day.

To produce plots like these, I did the following:

- Select files from the P2SC-S2 LYRA data quicklook viewer; if they appear twice, I took the second one, but they appear to be identical anyway.

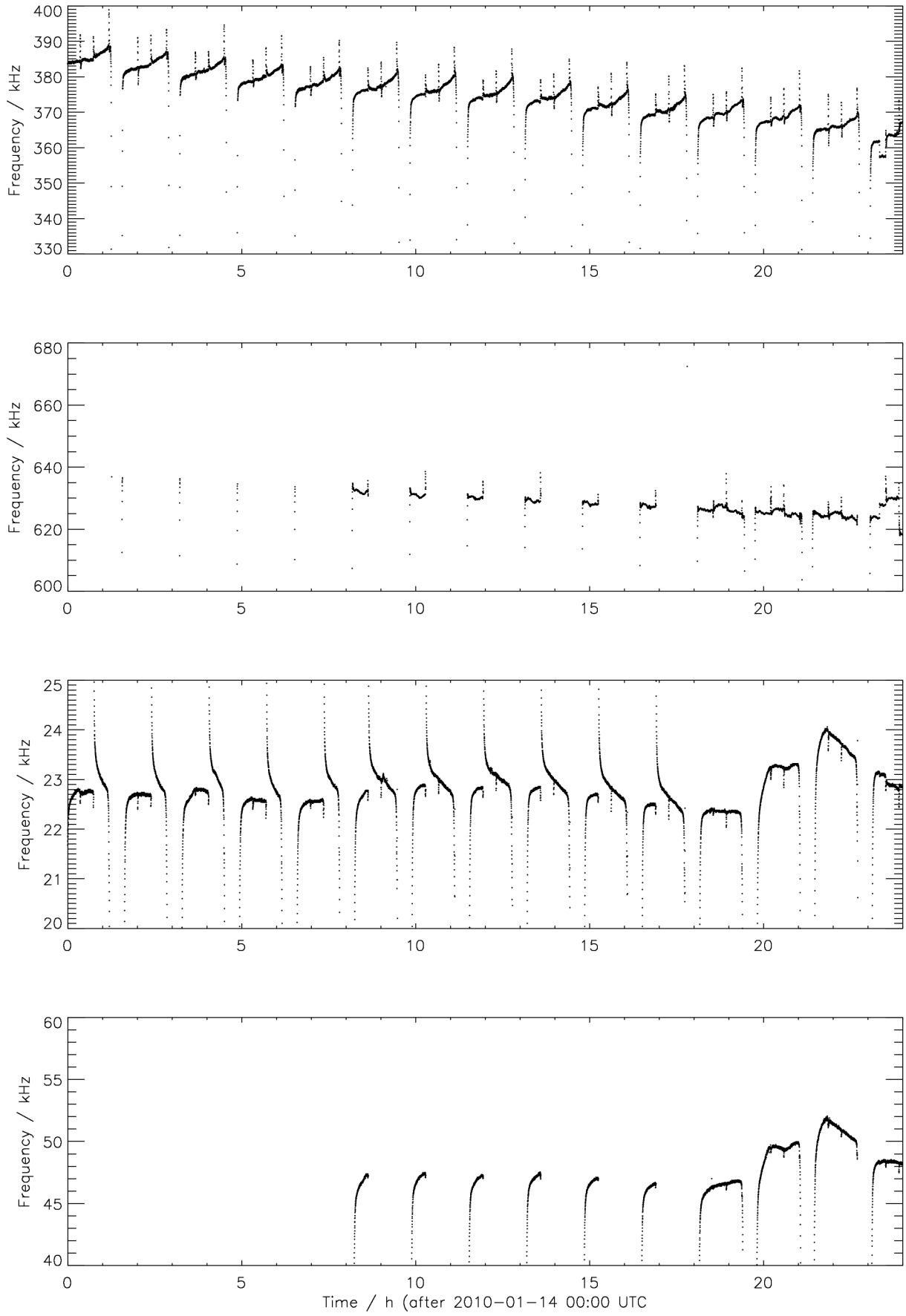
- Download the file to my PC and transfer it via sftp to noublipa.

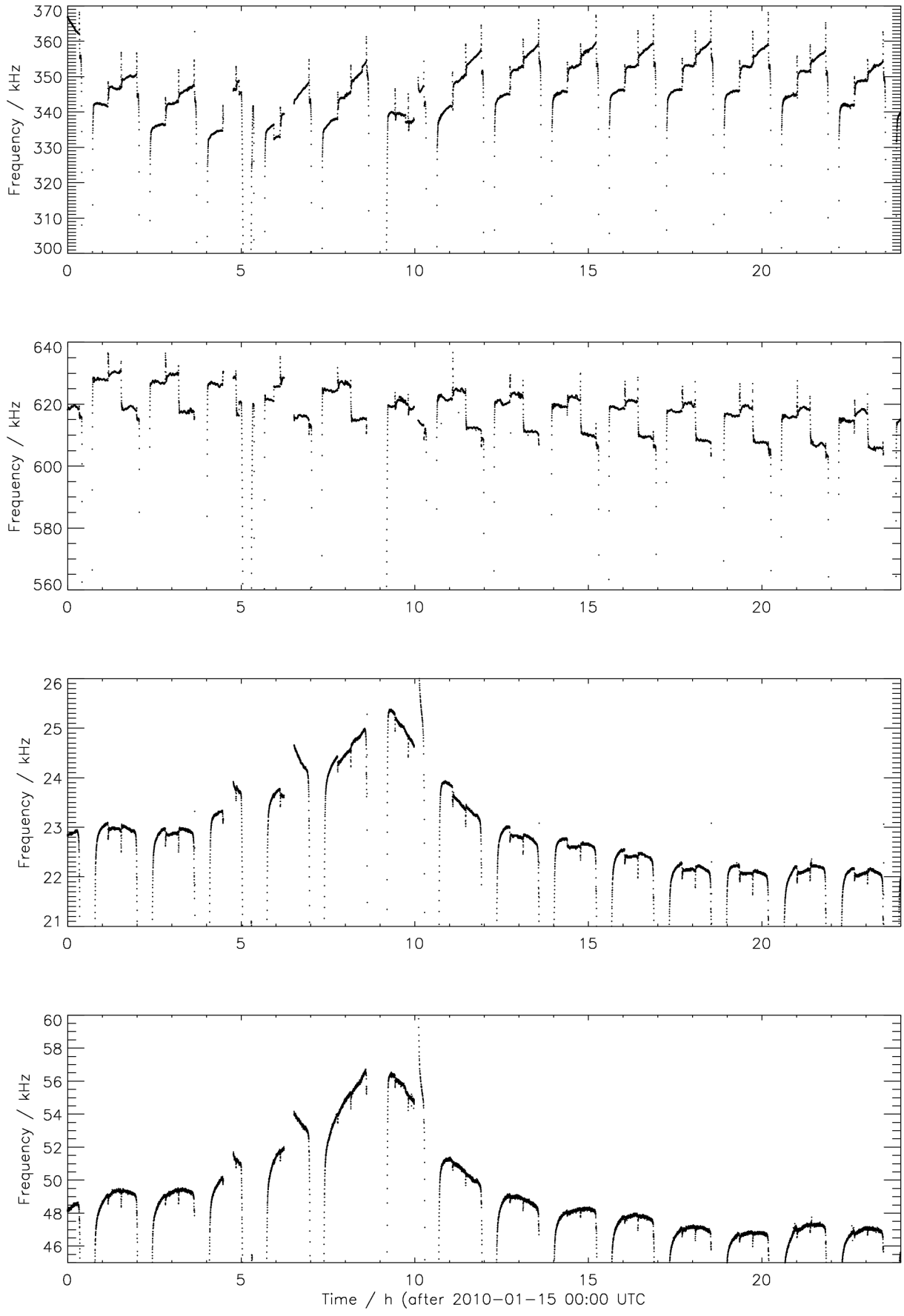
- Using something that I learned from Boris' visualization tool, I did *not* read the *complete* files which sometimes have 600000 lines or so, but only 1%, i.e. 1 out of 100 lines, and neglect the others. With 50 ms integration time, that gives a data entry every 5 seconds, and that appears sufficient for this overview purpose.

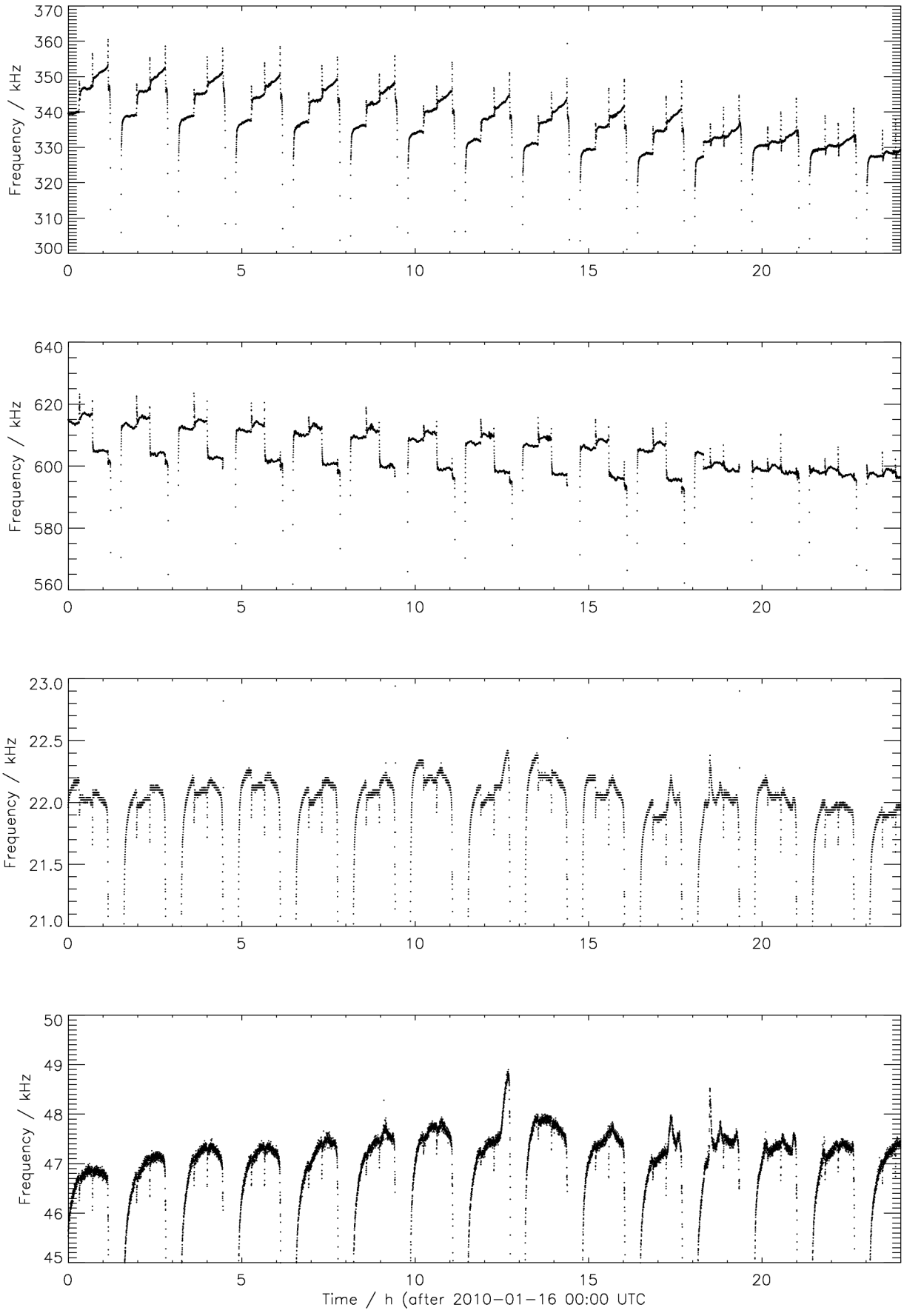
- You can see the results per file on the internet within my personal pages:
http://solwww.oma.be/users/dammasch/PreliminaryOverview.html
Please take a look at this list every once in a while. It is still growing. Until the automatic pipeline runs, I try to keep it up-to-date. So far, it is not publicly linked.

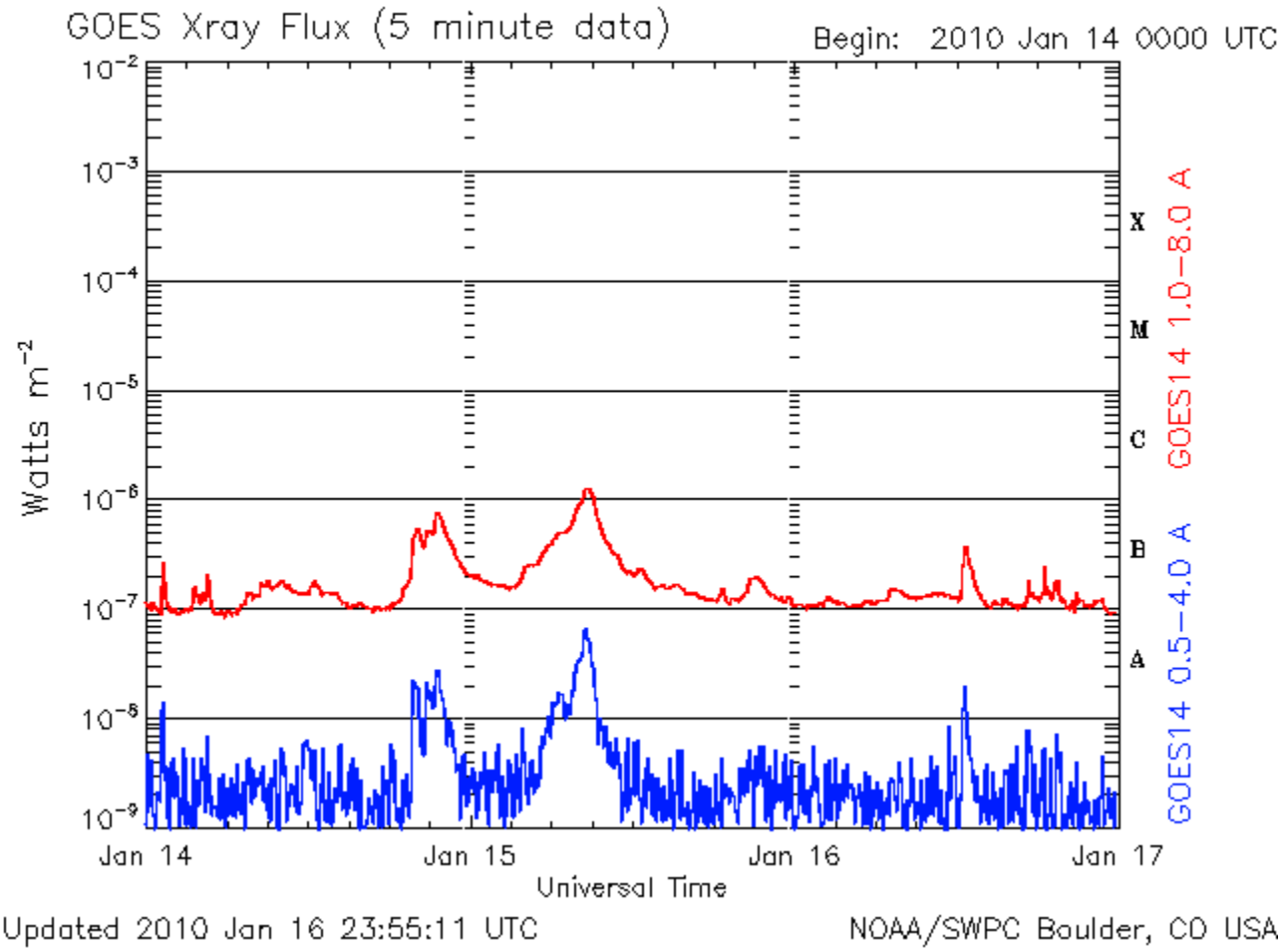
- I did not only produce these images but also restore files containing the processed 1% of the raw data. For every day (14, 15, 16 Jan 2010), I wrote software that collects the data from the relevant restore files. The end product is a daily overview which is also on the "Preview" page. These images were used in the attached PDF.

To a certain extent, we already got rid of the noise due to the ASIC reloads by commanding it to happen less often.


Frequency / kHz
400
390
380
370
360
350
340
330
0
5
10
15
20
Frequency / kHz
680
660
640
620
600
0
5
10
15
20
Frequency / kHz
25
24
23
22
21
20
0
5
10
15
20
Frequency / kHz
60
55
50
45
40
0
5
10
15
20
Time / h (after 2010-01-14 00:00 UTC


Frequency / kHz
370
360
350
340
330
320
310
300
0
5
10
15
20
Frequency / kHz
640
620
600
580
560
0
5
10
15
20
Frequency / kHz
26
25
24
23
22
21
0
5
10
15
20
Frequency / kHz
60
58
56
54
52
50
48
46
0
5
10
15
20
Time / h (after 2010-01-15 00:00 UTC


Frequency / kHz
370
360
350
340
330
320
310
300
0
5
10
15
20
Frequency / kHz
640
620
600
580
560
0
5
10
15
20
Frequency / kHz
23.0
22.5
22.0
21.5
21.0
0
5
10
15
20
Frequency / kHz
50
49
48
47
46
45
0
5
10
15
20
Time / h (after 2010-01-16 00:00 UTC



#Event	Begin	Max	End	Obs	Q	Type	Loc/Frq	Particulars		Reg#
2010-01-14										
5160	0115	0121	0126	G14	5	XRA	1-8A	B3.0	1.4E-04	1040 -
5170	0334	0339	0348	G14	5	XRA	1-8A	B1.8	1.4E-04	1040 -
5210	0428	0436	0447	G14	5	XRA	1-8A	B2.2	2.1E-04	1040 -
5280	1857	2139	2223	G14	5	XRA	1-8A	B8.1	5.7E-03	1040 +
2010-01-15										
5330	0722	0841	1022	G14	5	XRA	1-8A	C1.3	8.9E-03	1040 +
2010-01-16										
5360	1228	1240	1300	G14	5	XRA	1-8A	B3.9	6.1E-04	1040 +
5370	1716	1723	1726	G14	5	XRA	1-8A	B1.9	8.6E-05	1040 +
5380	1827	1830	1832	G14	5	XRA	1-8A	B3.5	5.5E-05	1040 +
5390	2052	2057	2100	G14	5	XRA	1-8A	B1.5	5.1E-05	1040 -