LYRA degradation status after ~ 3000 days

IED 23 Feb 2018

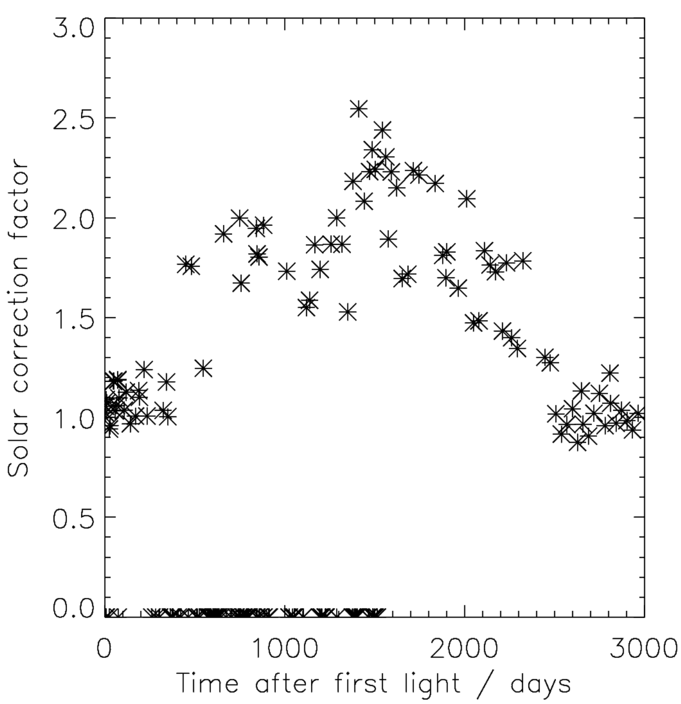
To calibrate LYRA irradiance values, the instrument's degradation has to be taken into account and corrected. Right from the beginning, it was observed that (a) degradation depended on the time of open cover, (b) the long-wavelength channels (Lyman-alpha and Herzberg) degraded fast and appeared almost independent of long-term solar activity changes, (c) the short-wavelength channels (Aluminium and Zirconium) degraded slower and were heavily dependent on solar activity. So the problem was to separate the degradation of the latter two channels from solar activity.

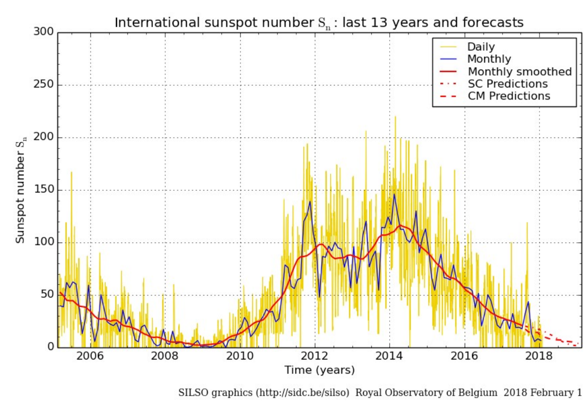
For the most time, it was simply assumed that the Zirconium channel of unit 1 (ch1-4) did not degrade. This was plausible, because unit 1 was only used as a backup unit for calibration purposes, and thus its cover was only opened for short periods, i.e. in the order of hours over most of the years, while unit 3 was opened for campaigns (days to weeks), and the nominal unit 2 was permanently open since Jan 2010. In addition, the Zirconium channel was observed to degrade the slowest of the four LYRA channels.

Therefore, the values of ch2-3, ch2-4, ch3-3, ch3-4 were divided by a correction factor in order to eliminate the influence of solar activity and estimate their degradation more realistically. This correction factor is calculated by the relation between the actual value of ch1-4 and its initial (first light) value, which was considered quiet Sun. This was the best that could be achieved for most of the time.

Now, after eight years of observation, the solar activity cycle is practically back to minimum values. Two developments can be seen now, exploiting 195 calibration campaigns Jan 2010 - Feb 2018: (1) There is an abrupt downward jump in ch1-4 due to a long flare campaign using unit 1 in September 2017. (2) There must have been a linear decrease in ch1-4 response - similar to ch2-4 and ch3-4, less but significant. The numbers suggest a linear degradation of 5 counts/ms over the eight years, and 3 counts/ms due to the campaign. This will be modeled from now on instead of assuming ch1-4 to be constant.

With this new assumption, the development of the solar-activity correction factor mentioned above closely follows the development of the sunspot number from 2010 to 2018, with its quasi-minimum period during the first 400 and last 500 days, and its double peak, see figures below. (Campaigns without participation of unit 1 lead to a factor = 0.0)





With these assumptions, the response status of LYRA is as follows.

For comparison, please see also an earlier report, here:
http://solwww.oma.be/users/dammasch/IED_20141006_LyraStatusAfter1500Days.pdf

Values are in counts/ms. Percentages tell what is left from the original signal at First Light. Solar variations in the short-wavelength channels 3 (Aluminium) and 4 (Zirconium) are corrected.

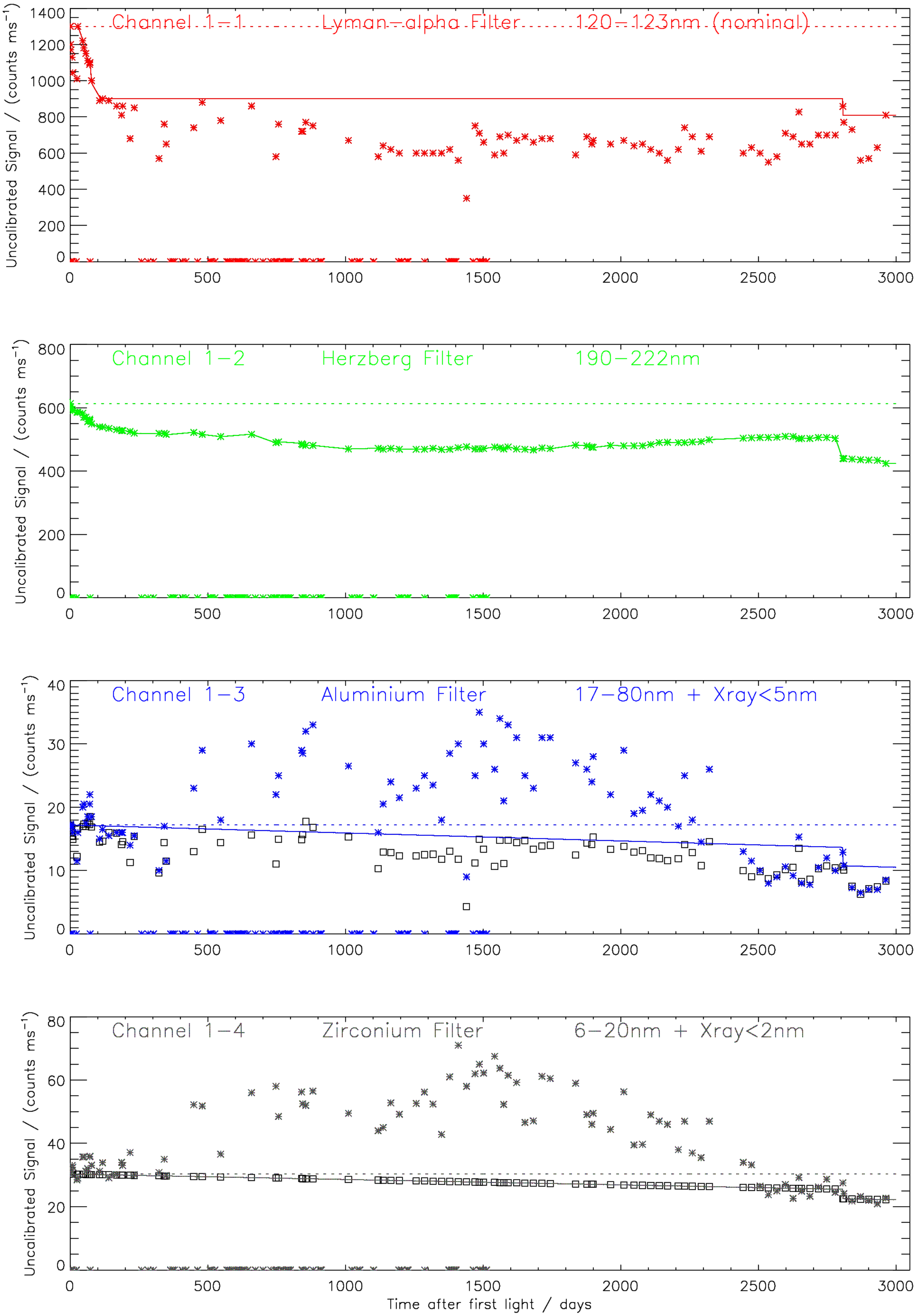
ch1-1	1300	->	810	62%
ch1-2	613.4	->	424	69%
ch1-3	17.2	->	10.4	60%
ch1-4	30.3	->	22.2	73%
ch2-1	492	->	(1.5)	<0.5%
ch2-2	703.5	->	(2.5)	<0.5%
ch2-3	16.6	->	0.2	1%
ch2-4	37.5	->	6.5	17%
ch3-1	920	->	535	58%
ch3-2	545.5	->	16	3%
ch3-3	273.6	->	31	11%
ch3-4	30.0	->	16.7	56%

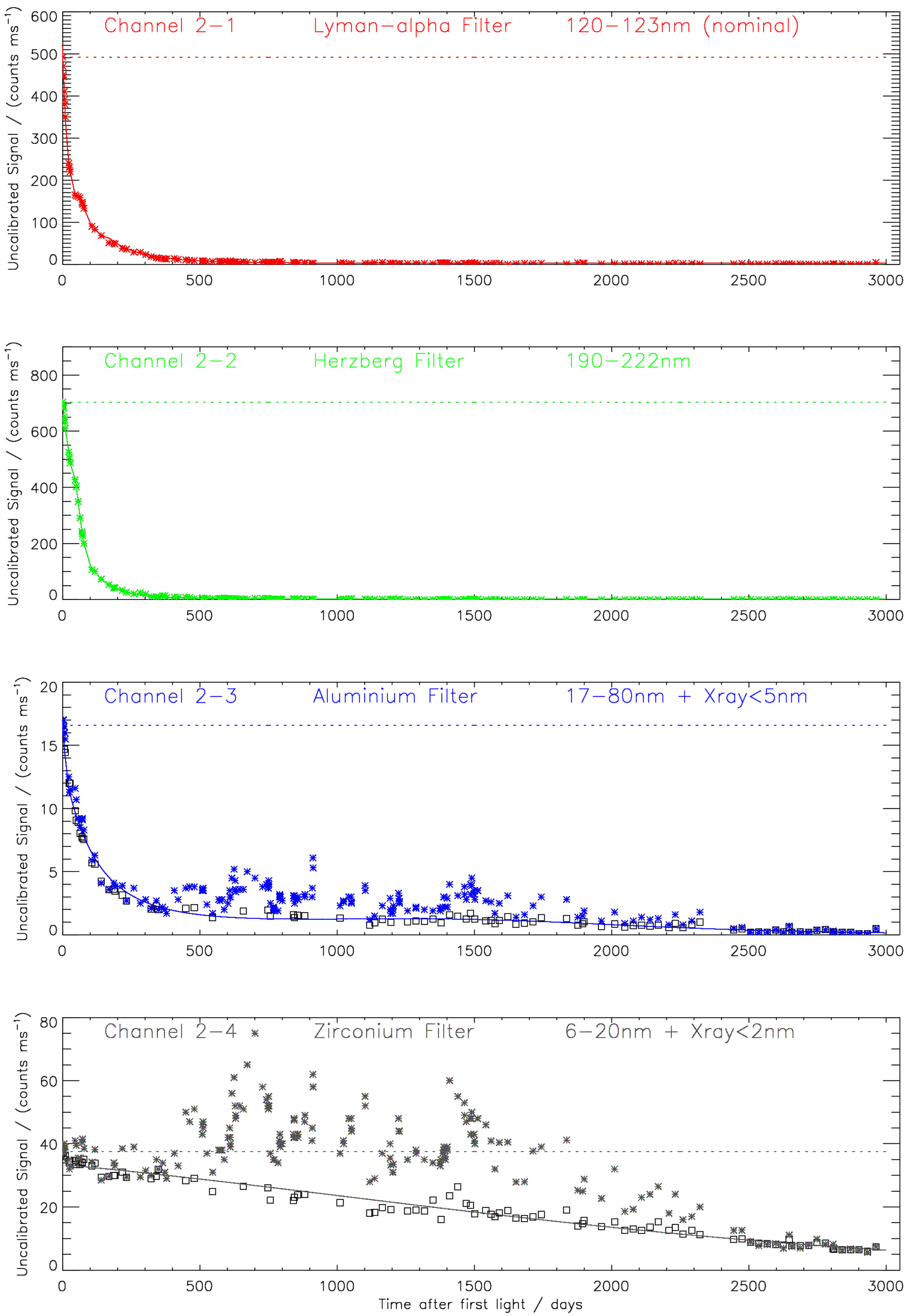
Some comments on the different channels follow. See also the figures on the next three pages; the dotted line represents the First Light level, the solid line is the fitted degradation estimate, asterisks represent raw measurements in counts/ms corrected only by dark currents and 1AU, squares in channels 3 and 4 represent these measurements also corrected by solar activity as described above.

ch1-1: The values of this channel are difficult to interpret, because this includes an MSM detector that takes several hours to reach its saturation, and normally the campaigns are shorter than that. Thus, one has to concentrate on the campaigns that have the longest duration. It is assumed that there was a fast decline directly after First Light (~ 100 days), then the channel remained stable until the long unit 1 flare campaign, where it fell from 900 to 810 counts/ms.
ch1-2: A rapid decline is observed directly after First Light (~ 200 days), then the channel remained relatively stable and even recovered somewhat. This is independent of solar activity which rather declined during the recovery. Due to the flare campaign, the level abruptly fell.
ch1-3: Like ch1-1, this MSM detector takes several hours to reach its saturation level, therefore only the longest campaigns should be taken into consideration. It is assumed that this channel shows a slow linear decline, plus an abrupt drop due to the flare campaign.
ch1-4: It is assumed that the current level should be identical to the level after First Light, since both these periods are practically solar minimum. Thus, a linear decline was assumed between these two periods, plus the observed drop due to the flare campaign.

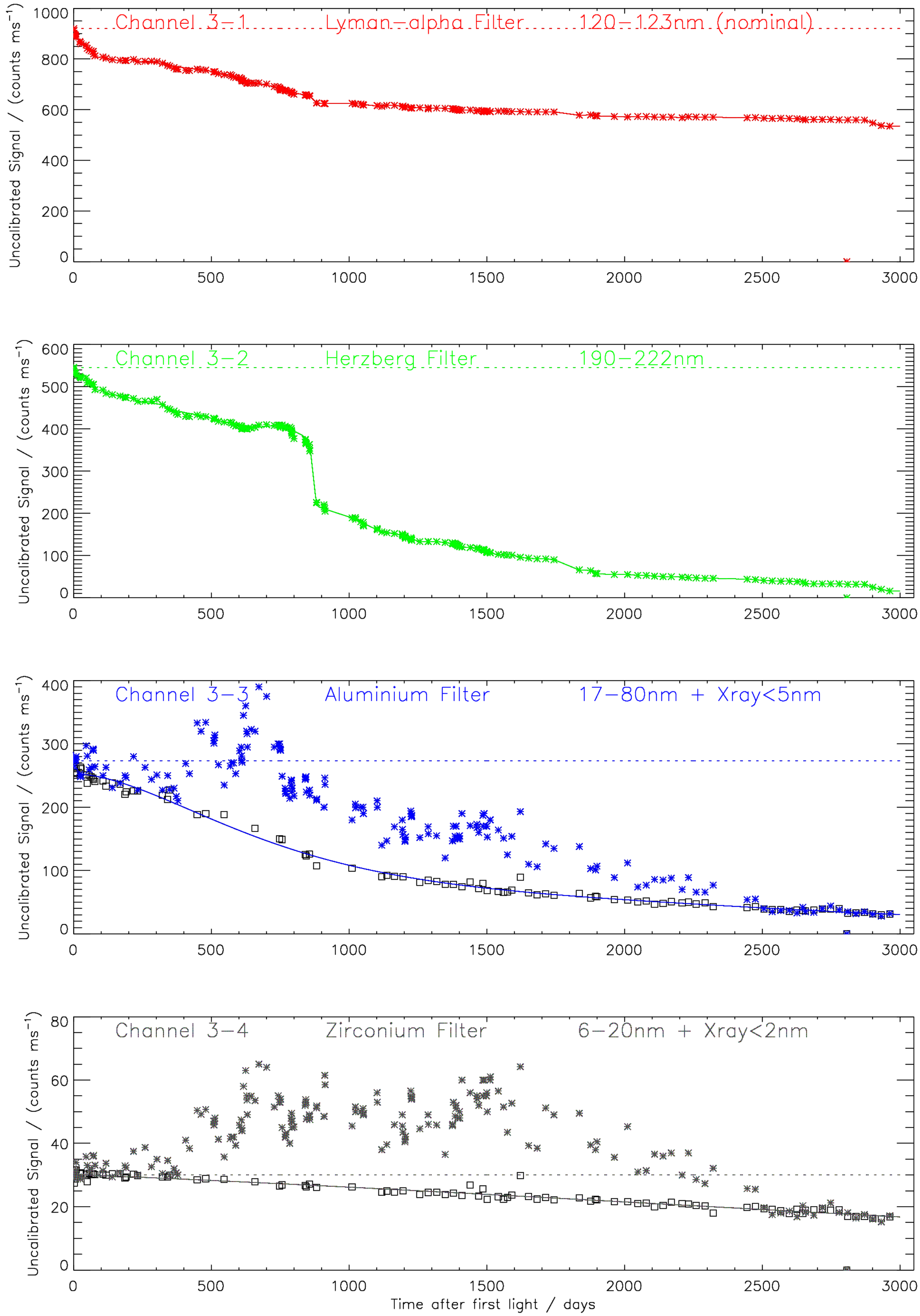
ch2-1: This channel declined fast within the first ~ 50 days, then slower, and has now been practically flat since day 500, but some measurements are still possible.
ch2-2: This channel declined fast within the first ~ 100 days, then slower, and has now been practically flat since day 500, but some measurements are still possible.
ch2-3: This channel declined relatively faster within the first ~ 500 days, and slower afterwards. Since day 2500 it is practically flat, but still at a significant level. Especially changes due to active regions and due to flares are still observable. due to less spectral degradation in SXR.
ch2-4: It is assumed that this channel dropped fast within the first ~ 50 days and declined linearly afterwards.

ch3-1: Fast decline during the first ~ 100 days, slower decline afterwards. Almost no further decline after ~ day 900, probably because all response that is left now comes from the infrared interval, which is not affected by degradation like the nominal interval.
ch3-2: Permanent steady decline, plus an abrupt drop due to a long period of open covers.
ch3-3: Faster decline in the beginning, slower afterwards, estimate fitted by a polynomial.
ch3-4: Faster decline in the beginning, slower afterwards, estimate fitted by a polynomial.


Channel 1–1
Lyman–alpha Filter
120–123nm (nominal)
Uncalibrated Signal / (counts ms⁻¹)
0
200
400
600
800
1000
1200
1400
0
500
1000
1500
2000
2500
3000
Channel 1–2
Herzberg Filter
190–222nm
Uncalibrated Signal / (counts ms⁻¹)
0
200
400
600
800
Channel 1–3
Aluminium Filter
17–80nm + Xray<5nm
Uncalibrated Signal / (counts ms⁻¹)
0
10
20
30
40
Channel 1–4
Zirconium Filter
6–20nm + Xray<2nm
Uncalibrated Signal / (counts ms⁻¹)
0
20
40
60
80
Time after first light / days



Channel 2−1
Lyman−alpha Filter
120−123nm (nominal)
Channel 2−2
Herzberg Filter
190−222nm
Channel 2−3
Aluminium Filter
17−80nm + Xray<5nm
Channel 2−4
Zirconium Filter
6−20nm + Xray<2nm
Uncalibrated Signal / (counts ms−1)
Time after first light / days



Channel 3−1 Lyman−alpha Filter 120−123nm (nominal)
Channel 3−2 Herzberg Filter 190−222nm
Channel 3−3 Aluminium Filter 17−80nm + Xray<5nm
Channel 3−4 Zirconium Filter 6−20nm + Xray<2nm
Uncalibrated Signal / (counts ms^{-1})
Time after first light / days
0
500
1000
1500
2000
2500
3000