LYRA Calibration Campaigns and Degradation Estimate - Update

IED 03 Dec 2010

Calibration campaign values were added from 22 Sep, 15 Oct, 04 Nov, and 24 Nov 2010, making it 27 data points which were manually selected. Now, additionally, the dark currents of heads 2 and 3 were estimated and subtracted. This document concentrates on heads 2 and 3, because this is an attempt to estimate the degradation of head 2, partially by comparing it to head 3.

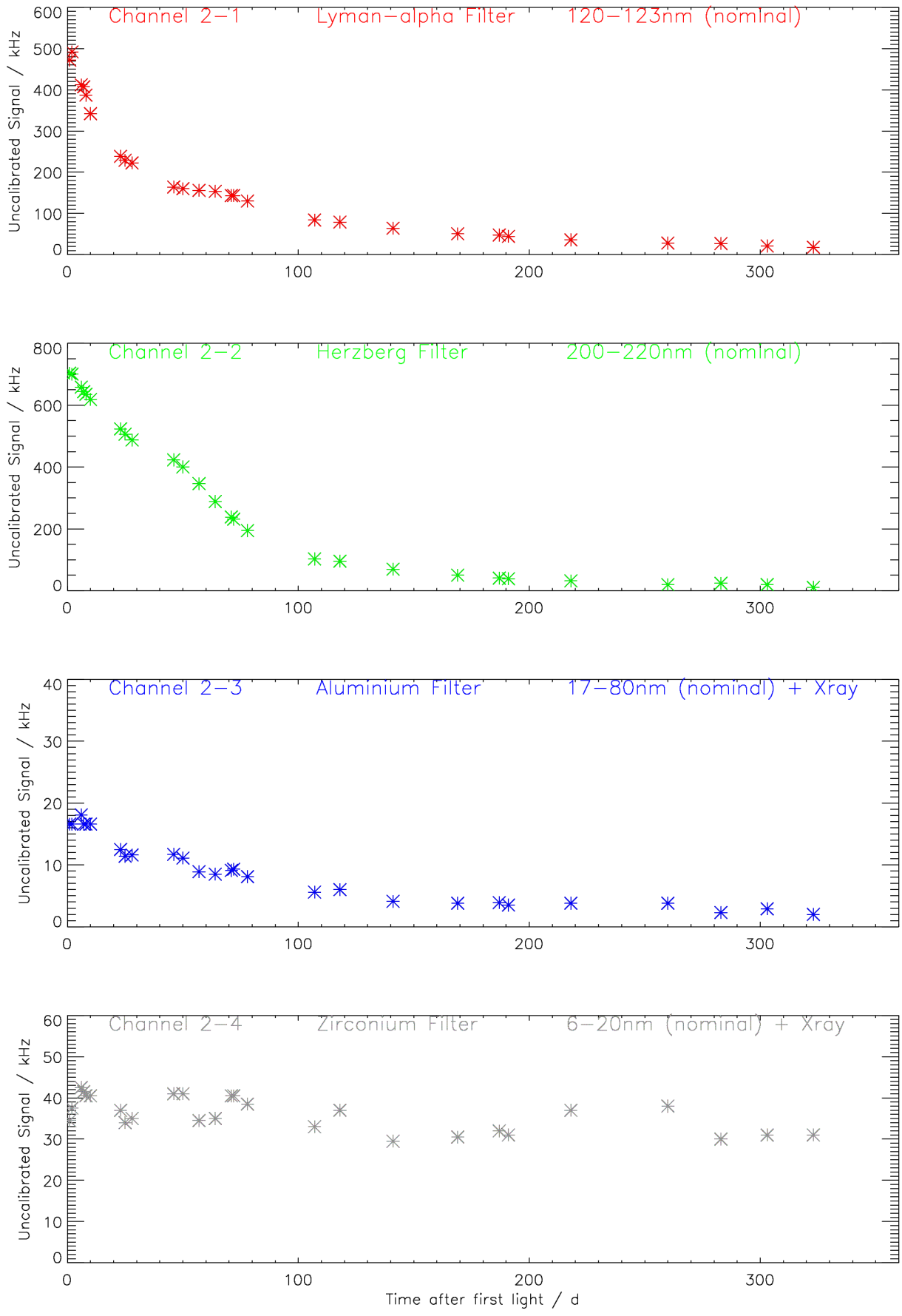
In the following images, first the development of heads 2 and 3 are shown vs. days after First Light, dark currents subtracted. Afterwards, channels 2-3 and 2-4 are divided by a normalized channel 3-4; the latter channel shows no apparent degradation but the same relative solar variation as all short-wavelength channels. As a result, channels 2-3 and 2-4 are smoothed, and their degradation can be fitted more easily.

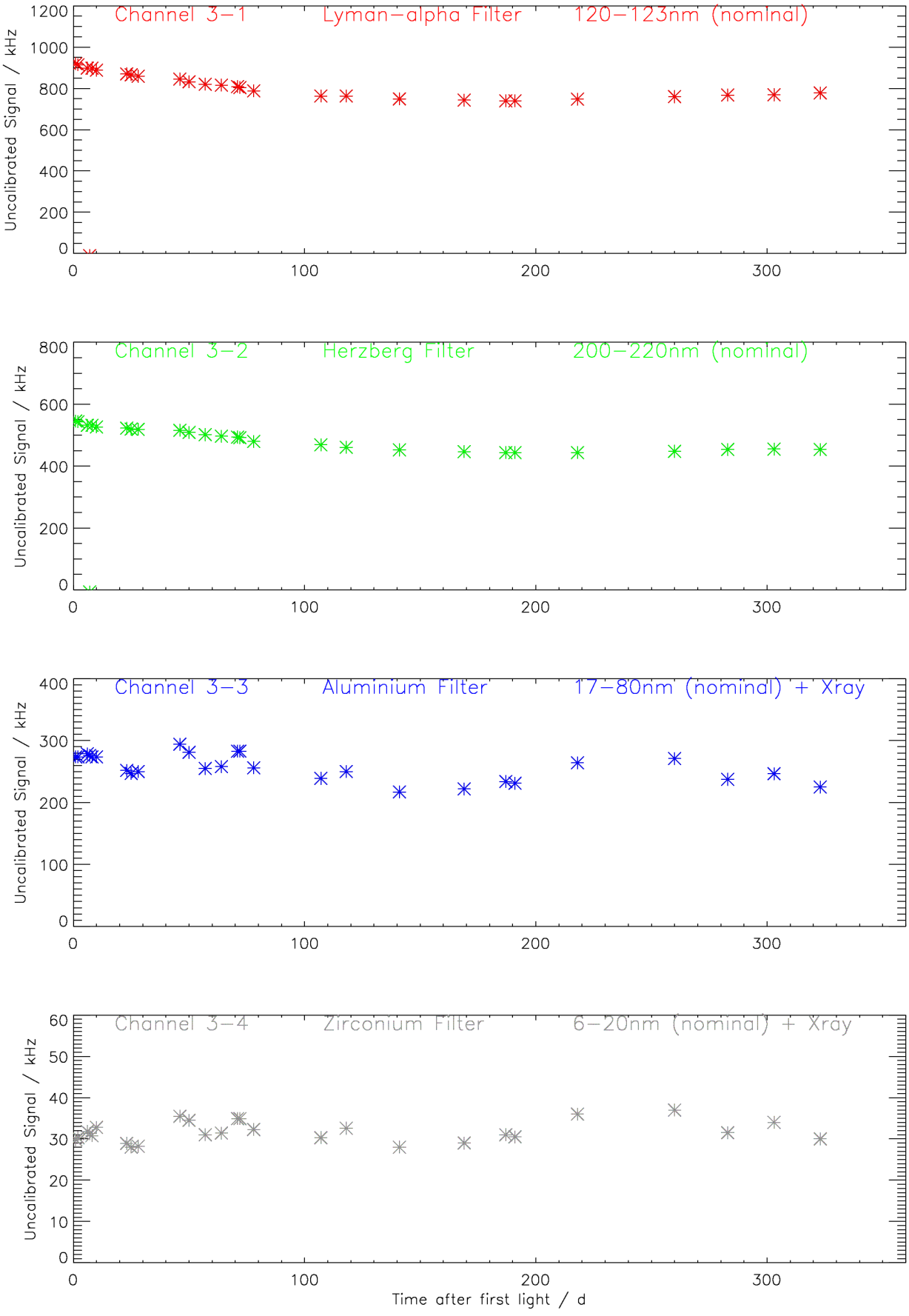
The next two images show the projection of the degradation for a shorter and a longer interval. This projection (dotted line) is based on fitting the last half year to a 1/time function; this appears to be quite a stable approach. For calibration purposes, it is currently planned to estimate the degradation as the difference between a channel's output at First Light and its fitted or projected curve, and then to add this difference to the measured signal.

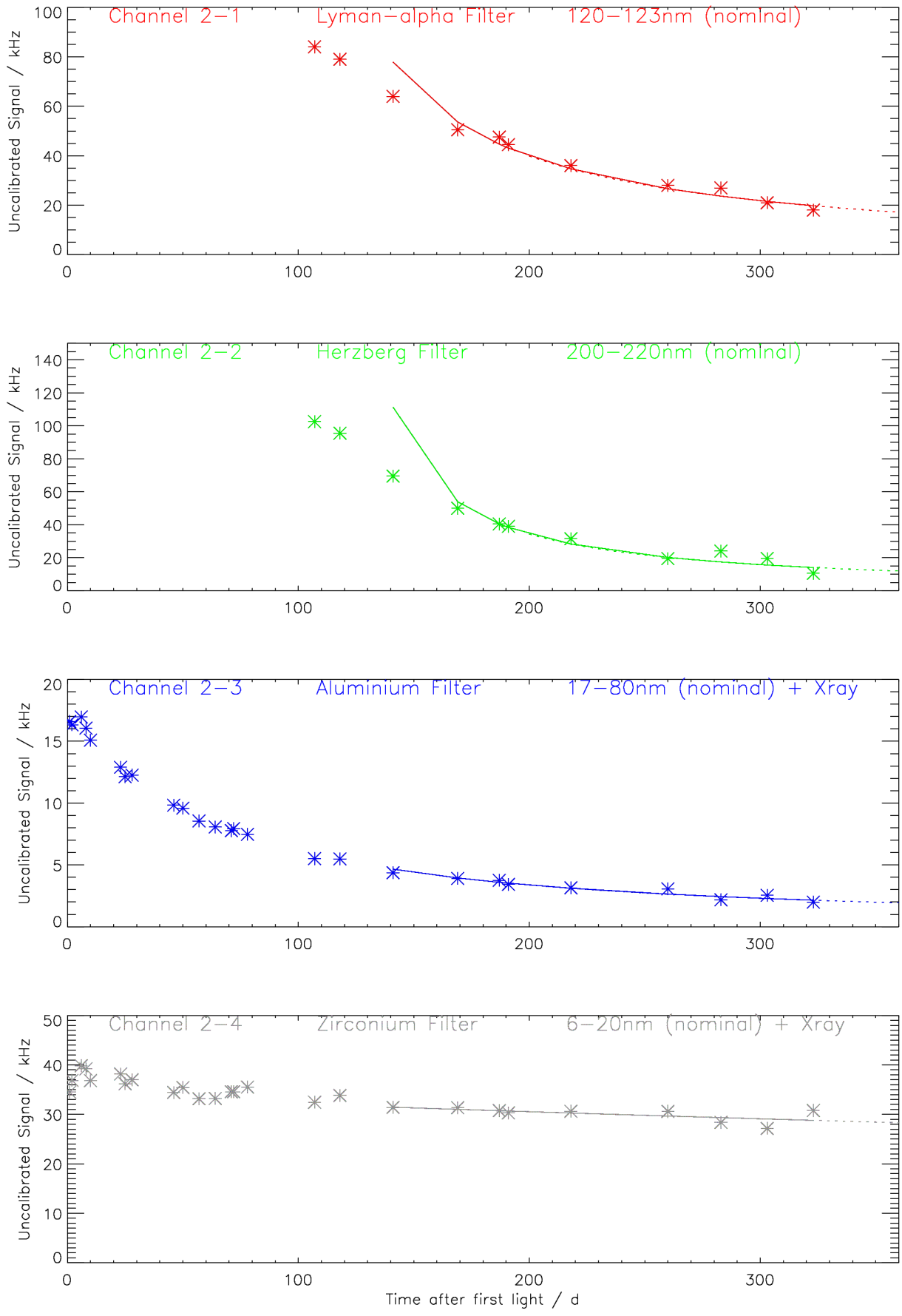
The images showing the development of heads 1, 2, and 3 within their first 40, 50, or 60 hours of open covers follow afterwards; there were more campaigns with head 3 lately, so this is the only one actually changed. (These images were formerly referred to as document IED__20100831_CalCampJanAug.pdf)

It may be interesting to note that channels 3-1 and 3-2 reversed their downward trend. Since it is hard to imagine that they are recovering from degradation, it can be assumed that channels 3-1 and 3-2 show solar variation, as the short-wavelength channels *-3 and *-4 do all the time.

The original version of this document (see my eMail of 31 Aug 2010) is attached at the bottom, for completeness.


Channel 2-1 Lyman-alpha Filter 120-123nm (nominal)
Channel 2-2 Herzberg Filter 200-220nm (nominal)
Channel 2-3 Aluminium Filter 17-80nm (nominal) + Xray
Channel 2-4 Zirconium Filter 6-20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time after first light / d


Channel 3-1
Lyman-alpha Filter
120-123nm (nominal)
Channel 3-2
Herzberg Filter
200-220nm (nominal)
Channel 3-3
Aluminium Filter
17-80nm (nominal) + Xray
Channel 3-4
Zirconium Filter
6-20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time after first light / d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Herzberg Filter
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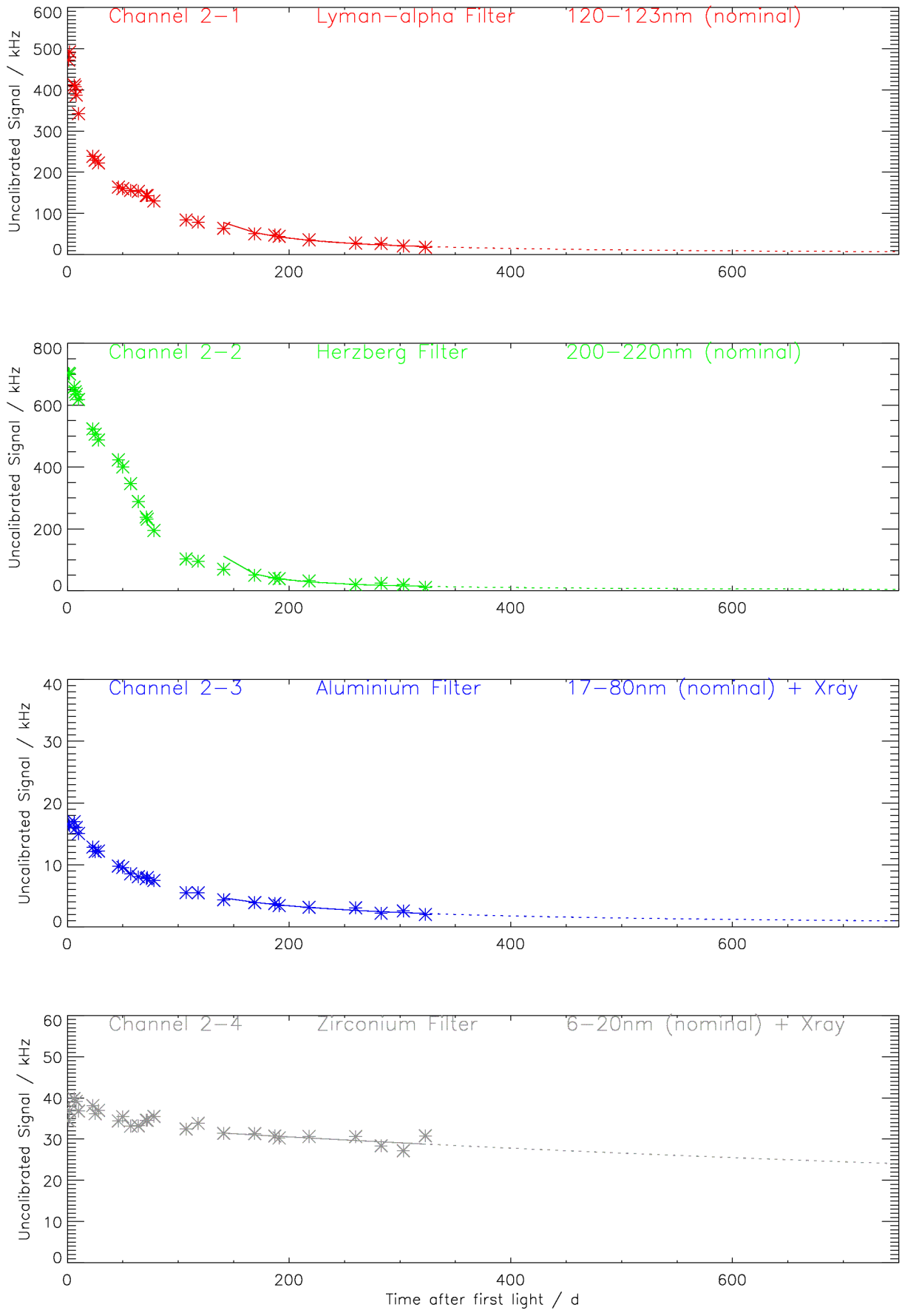
Aluminium Filter
17-80nm (nominal) + Xray
Channel 2-4
Zirconium Filter
6-20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time after first light / d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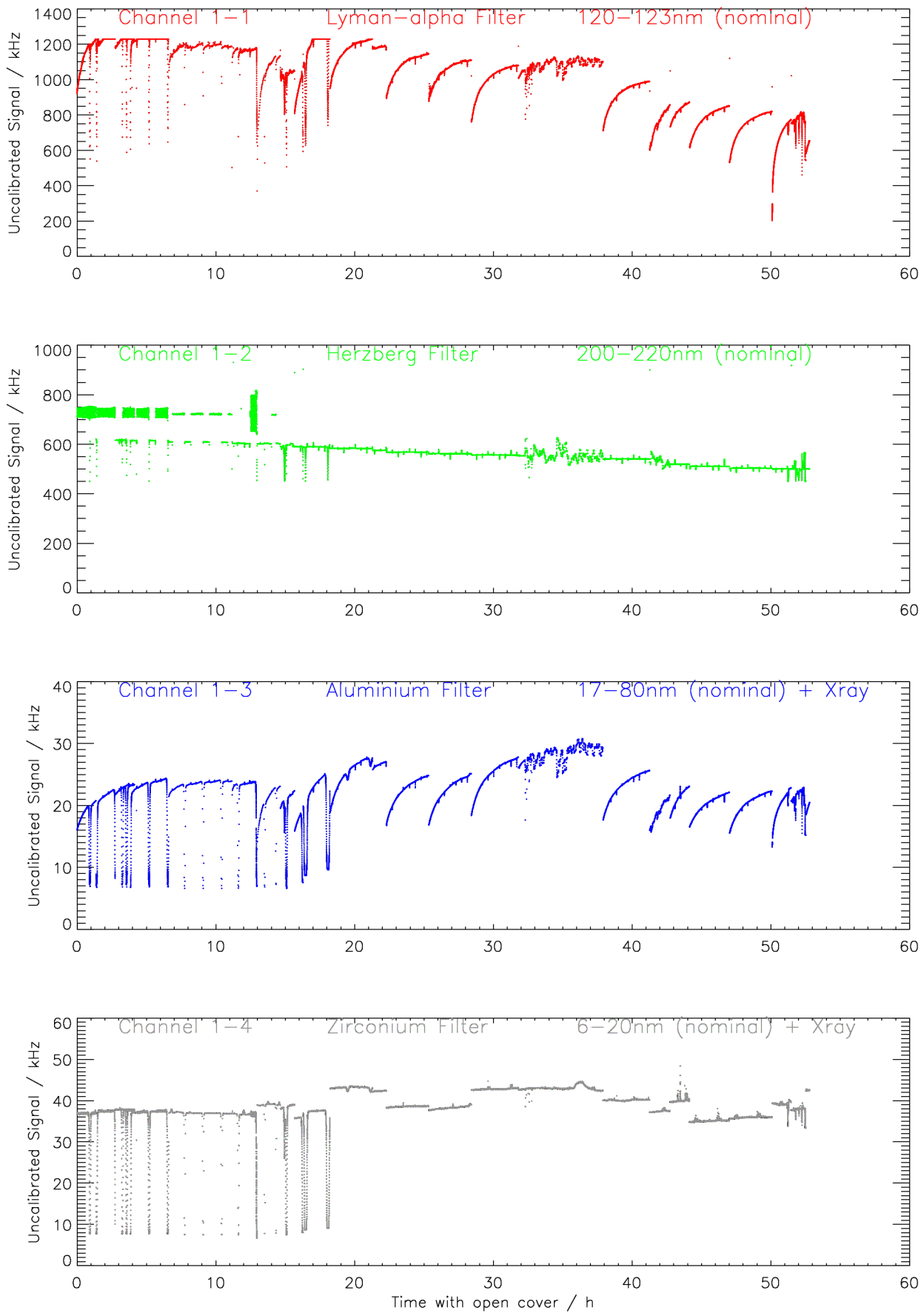
Zirconium Filter
6-20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time after first light / d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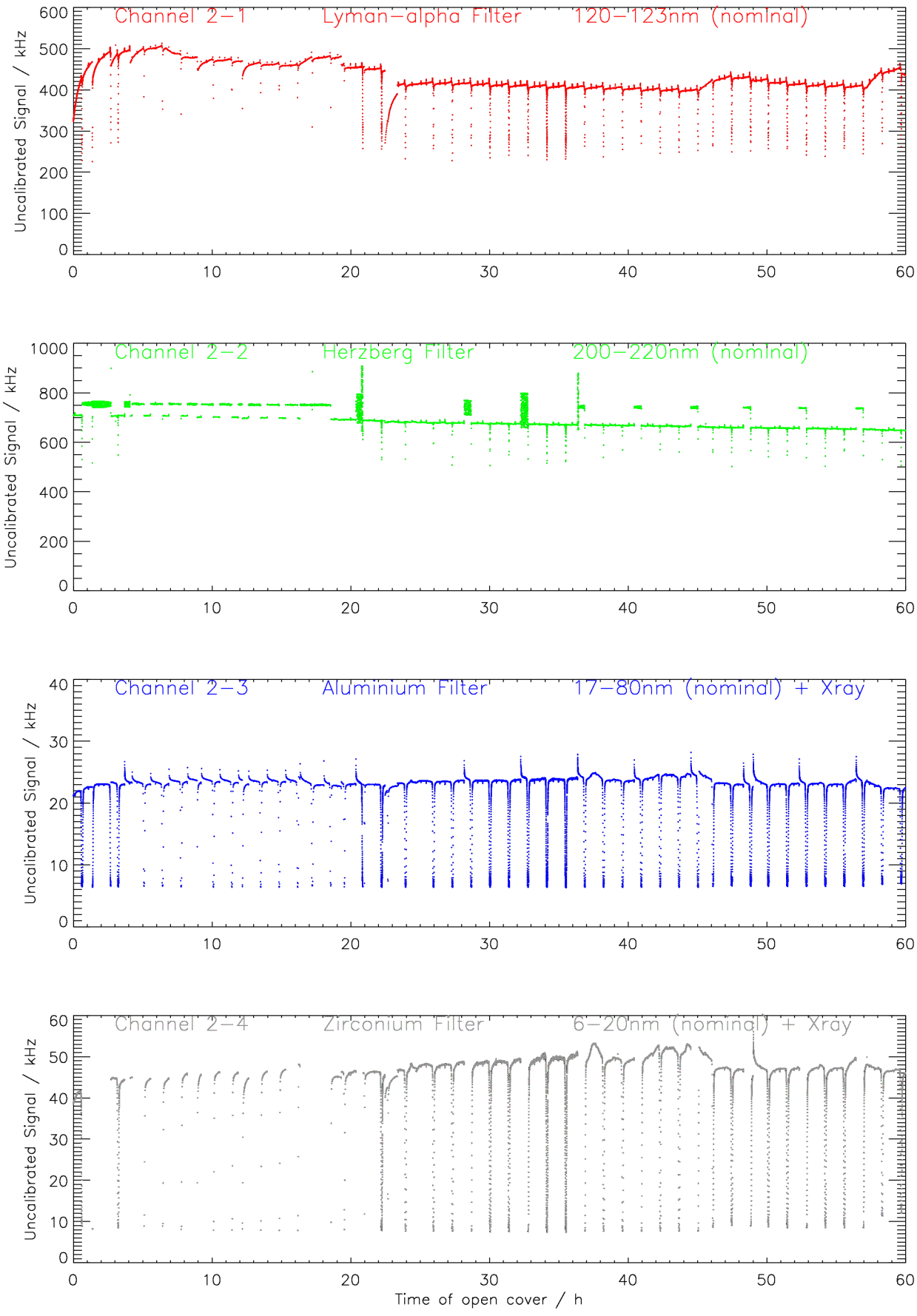
120-123nm (nominal)
Channel 1-2
Herzberg Filter
200-220nm (nominal)
Channel 1-3
Aluminium Filter
17-80nm (nominal) + Xray
Channel 1-4
Zirconium Filter
6-20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time with open cover / h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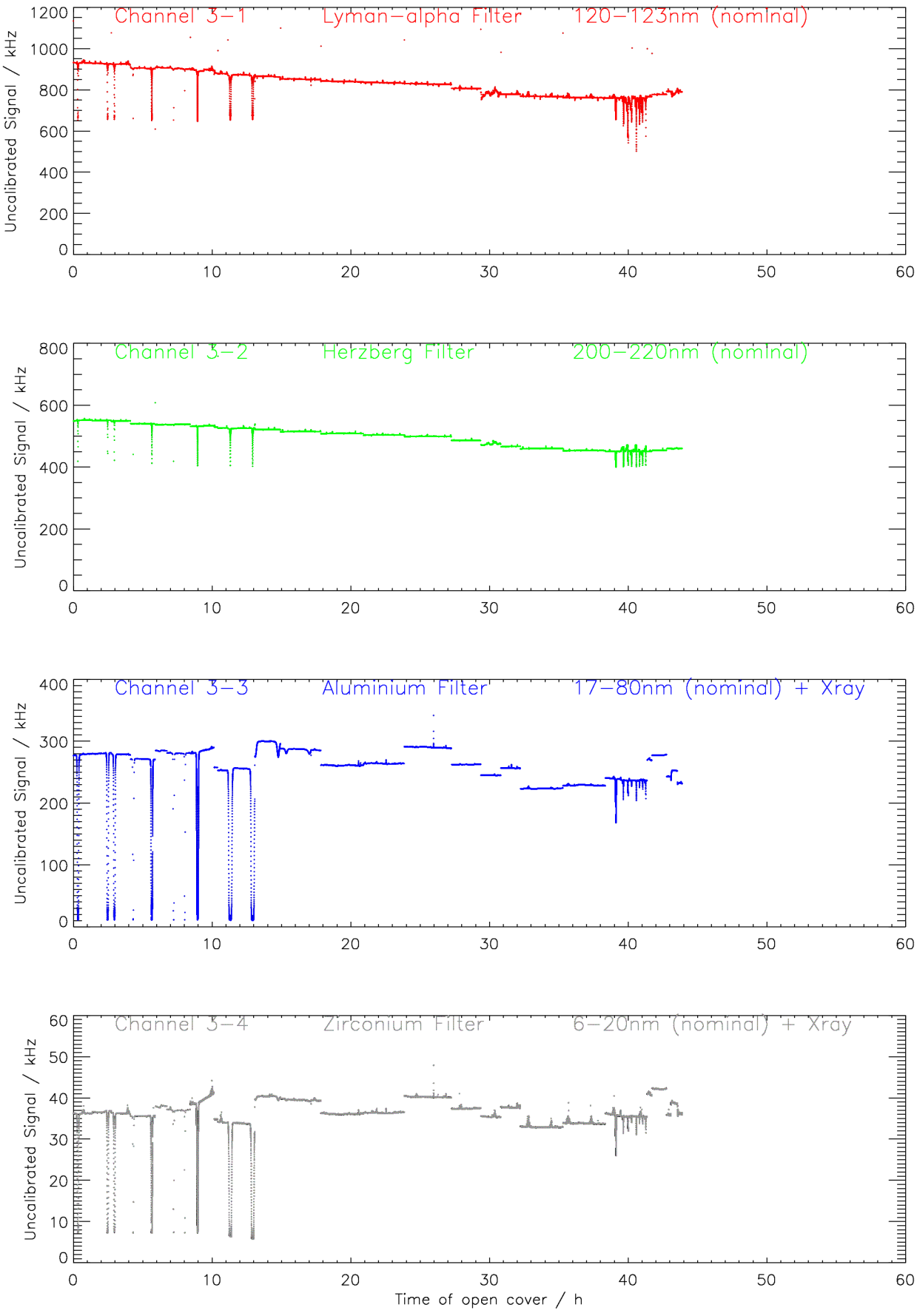
Channel 2-4
Zirconium Filter
6-20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time of open cover / h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Uncalibrated Signal / kHz
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Uncalibrated Signal / kHz
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Uncalibrated Signal / kHz
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Uncalibrated Signal / kHz
Time of open cover / h

LYRA Calibration Campaigns and Degradation Estimate

IED 31 Aug 2010

Values for LYRA heads 1, 2, and 3 were used from the following calibration campaigns: 06, 07, 11, 12, 13, 15, 28, 30 Jan, 02, 20, 24 Feb, 03, 10, 17, 18, 24 Mar, 22 Apr, 03, 26 May, 23 Jun, 11, 15 Jul, 11 Aug 2010, resulting in 23 data points, more or less simultaneously taken for all three heads.

In the document IED_20100831_CalCampJanAug.pdf, the development of the LYRA channels' output was shown vs. the first forty, fifty, or sixty hours of sunlight exposure (open covers). In this document, on the other hand, the output is shown vs. days after first light. In a narrow sense, this results in a functional relationship only for head 2 which was almost continuously open and exposed since 06 Jan 2010.

Channels 1-1 and 1-3 are problematic since they have a long (three, four hours) stabilization phase, and stabilization is usually not reached within the various calibration campaigns. In the following plots, the minimum (starting value) was used. The maximum (stabilization value) could have been used as well, but is was sometimes bounded by the VFC maximum. A better way would be to estimate the theoretical maximum value with a fitting function.

The first three figures below show the development for heads 1, 2, and 3. Typical values from the various calibration campaigns were selected by hand.

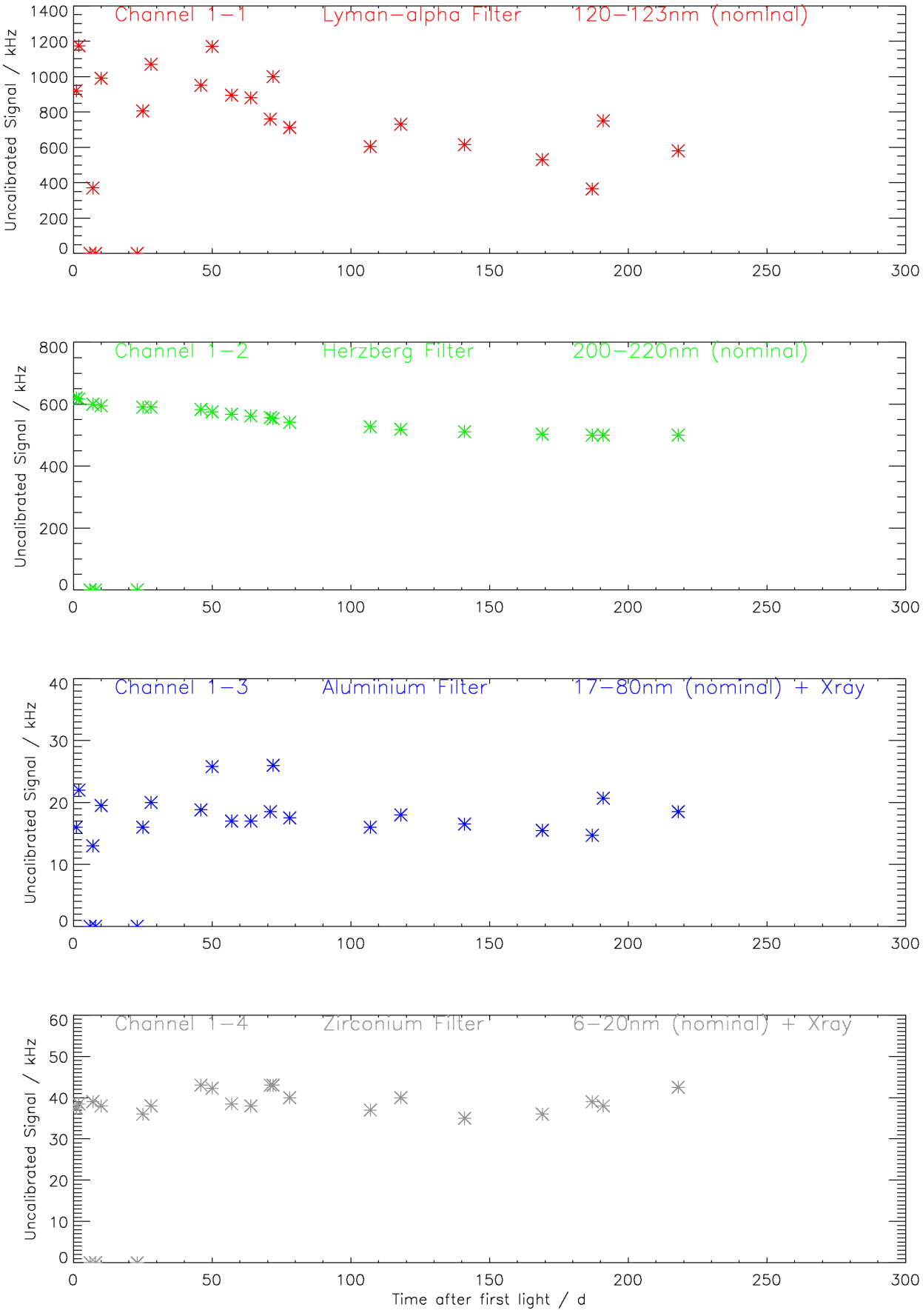
As has been mentioned before, the development of the long-wavelength channels *-1 (Lyman-alpha) and *-2 (Herzberg) is dominated by instrument degradation, while the development of the short-wavelength channels *-3 (Aluminium) and -4 (Zirconium) is dominated by solar variation. To remove the latter variations, channel 2-3 can, for example, be divided by channel 3-3 to result in an almost smooth line. The same holds for ch2-4/ch3-4 or ch2-4/ch1-4. Also, ch*-3 can be divided by ch*-4 to result in a smooth line (i.e. without solar variations). In the end, ch1-4 and ch3-4 appear to be straight; they show no decline in their first forty, fifty hours of exposure, and can thus be used as a reference.

According to Christoph Wehrli from PMOD/WRC, there is a physical reason for this: The degradation is caused by polymerization of outgassing molecules on the filter surface. The resulting layer absorbs longer wavelengths more than shorter wavelengths, thus ch*-4 is affected the least.

In the last two figures below, ch2-3 and ch2-4 are corrected by a normalized ch3-4.

The development, especially in ch2-1 and ch2-2, shows phases of different degradation velocity. After day 80, the degradation seems to have stabilized, though. Therefore, only the last eight data points, representing the calibration campaigns 24 Mar - 11 Aug 2010 (connected by straight lines) were used for a fit to estimate the future development (dotted line). The fit uses a function 1/(a+b*time). The result – as can be seen in the last figure - is that only ch2-3 reaches its dark current level within the next two years, approx. 410 days after first light (mid Feb 2011). Ch2-1 and ch2-2 stay slightly above their dark currents, ch2-4 does not even get close.

According to Tom Woods, the parameter estimates for calibration purposes of SORCE/SOLSTICE or TIMED/SEE are updated on a ~monthly basis, with weights varying according to the distance from the most recent observations. At first glance, this appears to be a viable solution also for LYRA.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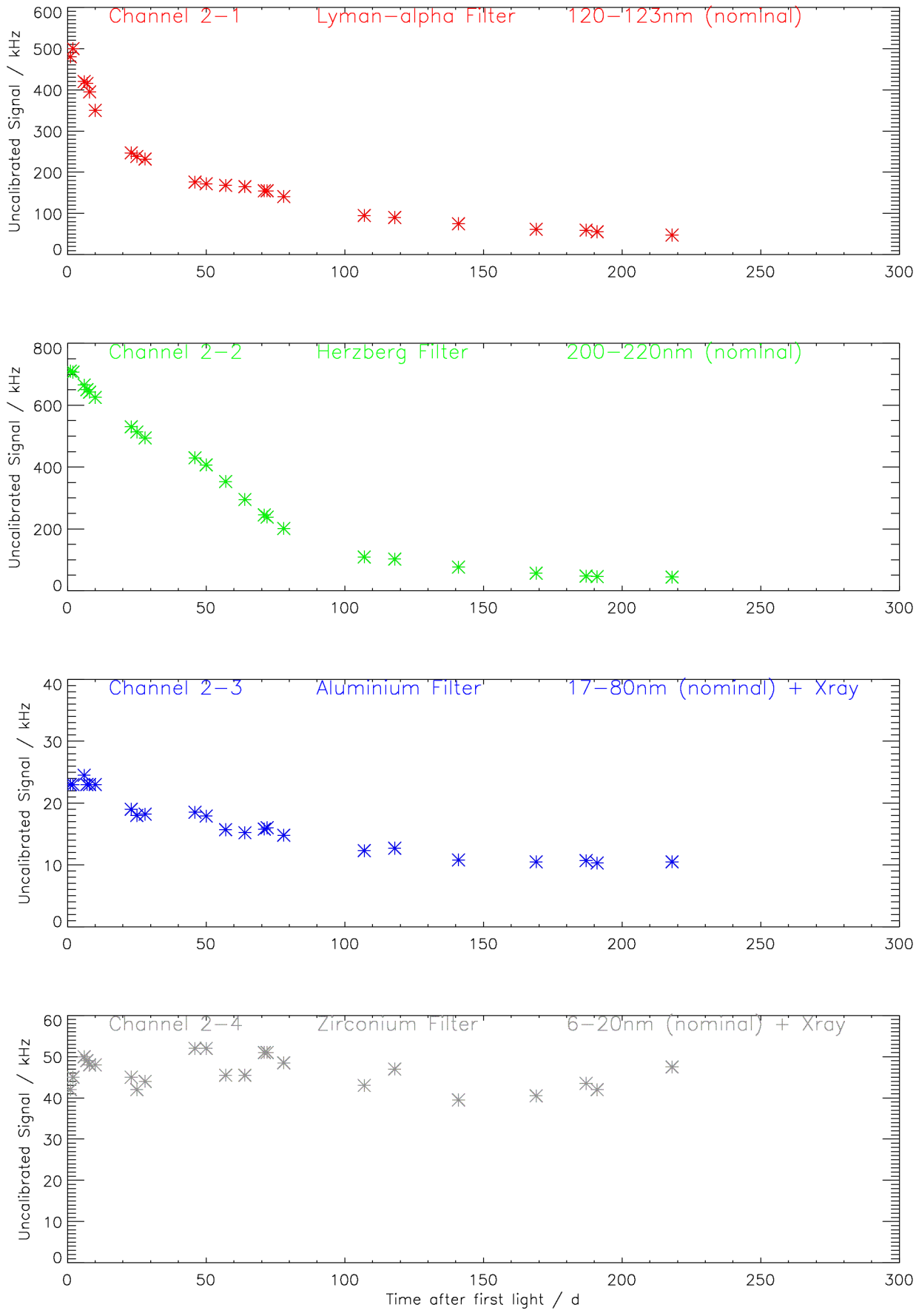
Channel 1–4 Zirconium Filter 6–20nm (nominal) + Xray
Uncalibrated Signal / kHz
Time after first light / d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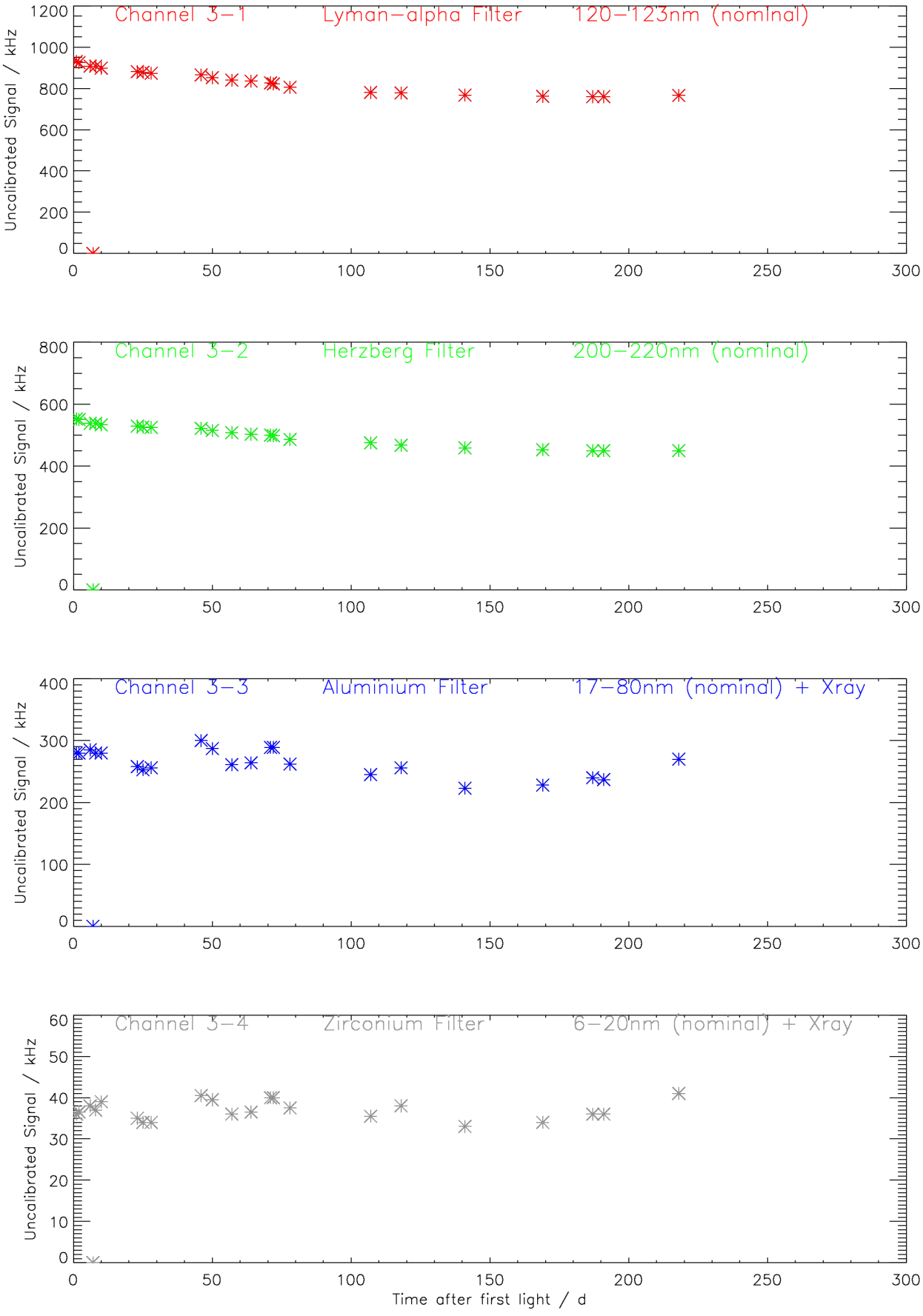
Time after first light / d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Zirconium Filter
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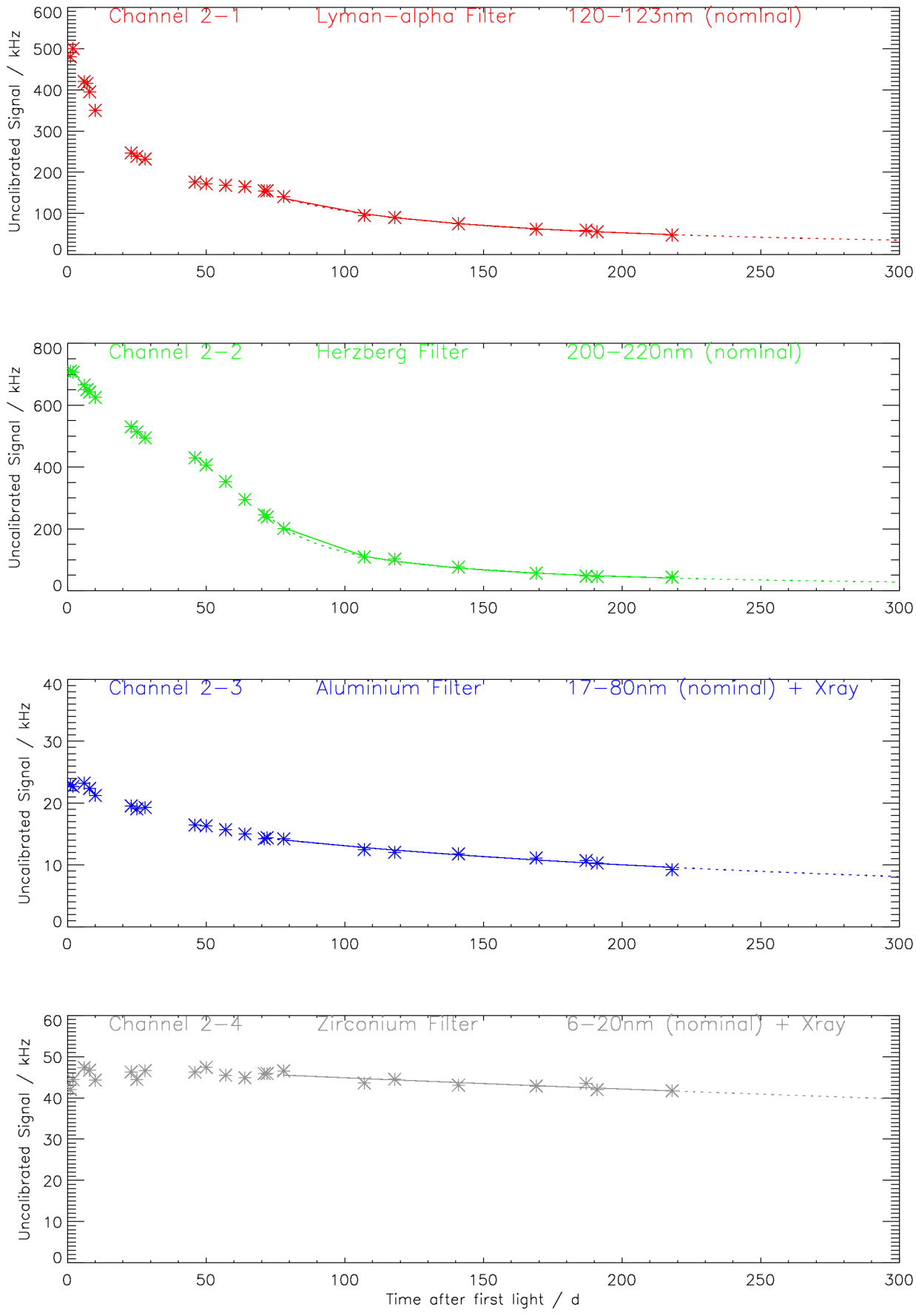
Uncalibrated Signal / kHz
Time after first light / d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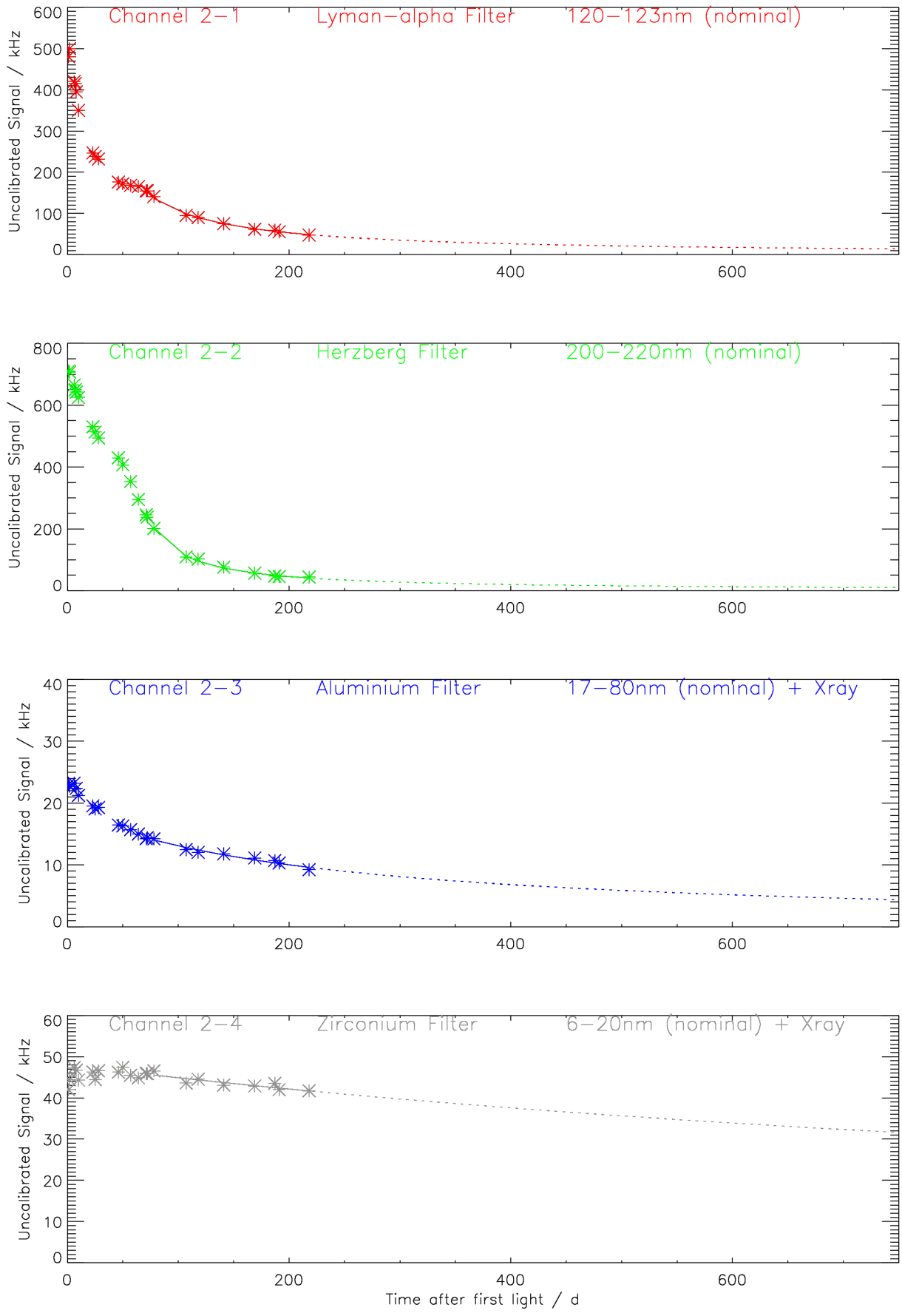
Time after first light / d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Uncalibrated Signal / kHz
Time after first light / d