Evolution of dark currents in LYRA detectors - Update 2019

IED 18 Feb 2020 (updated 04 Jun 2020)

Please note the earlier reports:
(2016) http://solwww.oma.be/users/dammasch/IED_20160307_EvolotionDC.pdf
(2017) http://solwww.oma.be/users/dammasch/IED_20180119_DevelopmentDC2017Update.pdf
(2018) http://solwww.oma.be/users/dammasch/IED_20180817_DCUpdate.pdf

The current report uses data from calibration campaigns (with closed covers) performed in 2018 and 2019.

To further check the development of unit 2, some hours of data were used from 05 Feb 2020, when the cover of unit2 accidentally did not open again. These data were interesting, because they covered a range 52.6 - 53.6 degree C.

Normally, the campaign data sets cover a short time and thus a small temperature range. Therefore, the laboratory data sampled before the launch (except for channel 3-1), the data sampled at the begin of the mission, and the long time with closed covers (22 Mar 2018) were weighted heavier to estimate and extrapolate the development of the two parameters b and c.

Parameter b is always positive, and declining for all units. Parameter c is always negative; it is assumed constant (for simplicity, but actually slightly decreases) for unit 2, but it is increasing for units 1 and 3. By the interaction of these two parameters over the time of mission, the dark currents as a function of temperature become less steep for unit 2, but steeper for units 1 and 3.

The dark currents of the PIN detectors ("Herzberg" channel 2) have almost not changed at all.

For channels 1, 3, and 4, it appears that the dark-current development of unit 1 has practically come to a standstill, it is not changing any more; units 2 and 3 are still changing. Since most detectors changed faster at the begin of the mission, one could speculate that part of the historic development of the dark currents stems from space condition, part stems from exposure to the Sun.

Since (for unknown reasons) channels 3-3 and 3-4 show declining dark currents for higher temperature, they are treated slightly different: The pre-launch measurement DC=0 for 60C is not used for the parameter fit of channel 3-4; probably DC=0 holds already for 57C. For the calibration software, negative dark-current estimates for channels 3-3 and 3-4 are set to zero.

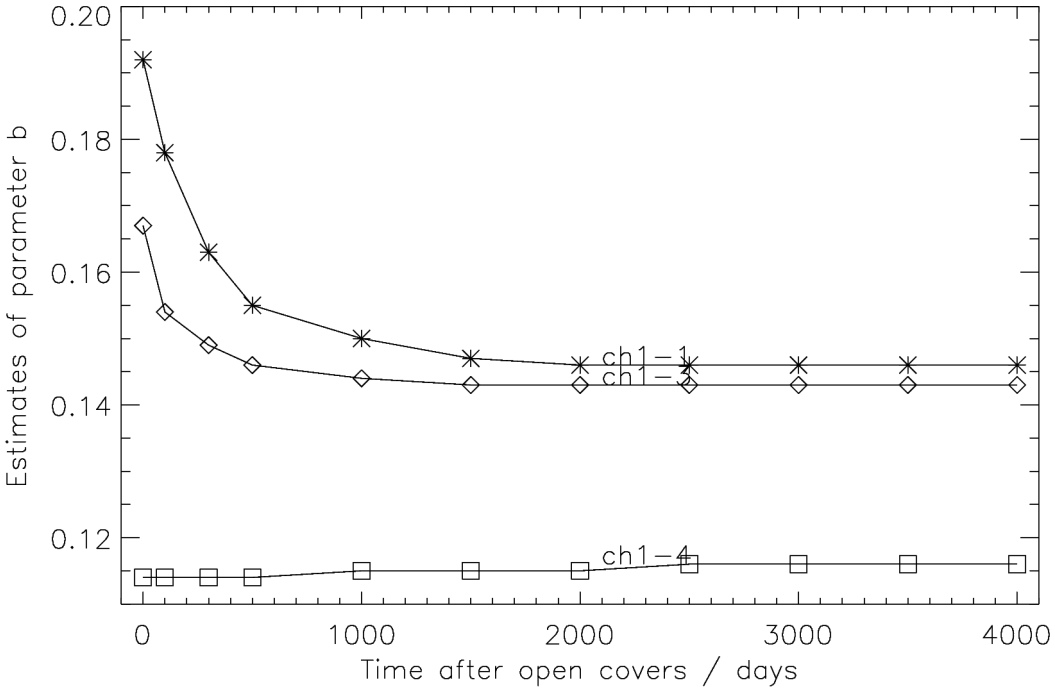
Instead of gray shades as in the last reports (dark = older, light = newer observations), this report uses colors (blue = older, red = newer observations), which hopefully makes the figures easier to understand. In order to check whether the estimate actually fits the observed data, an IDL animation is used which unfortunately cannot be reproduced in this PDF, but it shows that the errors are very small.

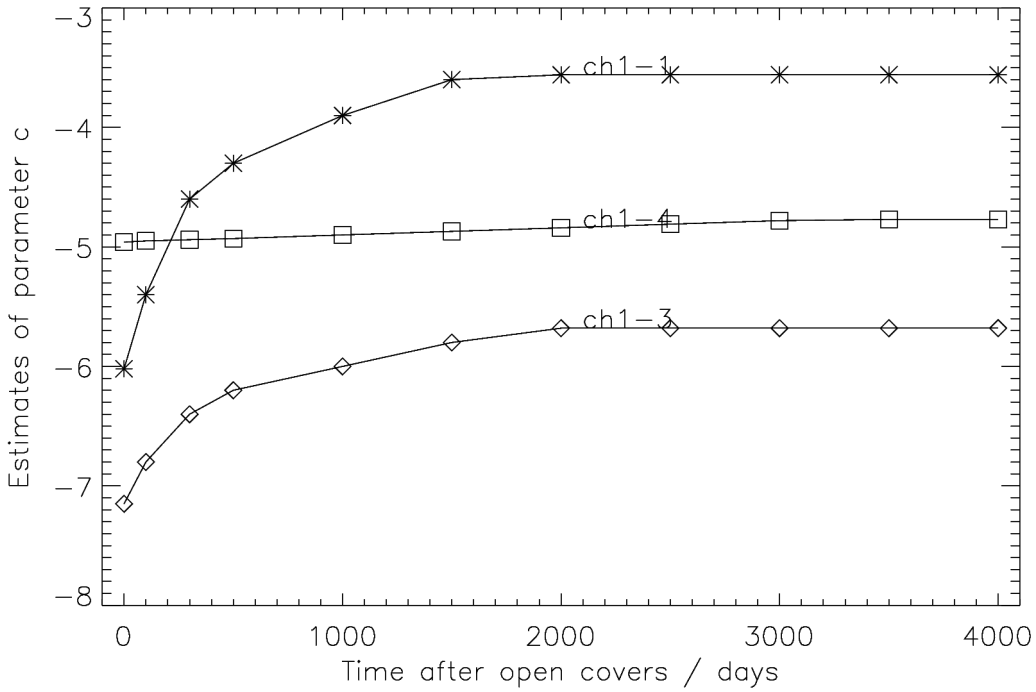
The following three figures show the development of the factors b and c, for all three units.

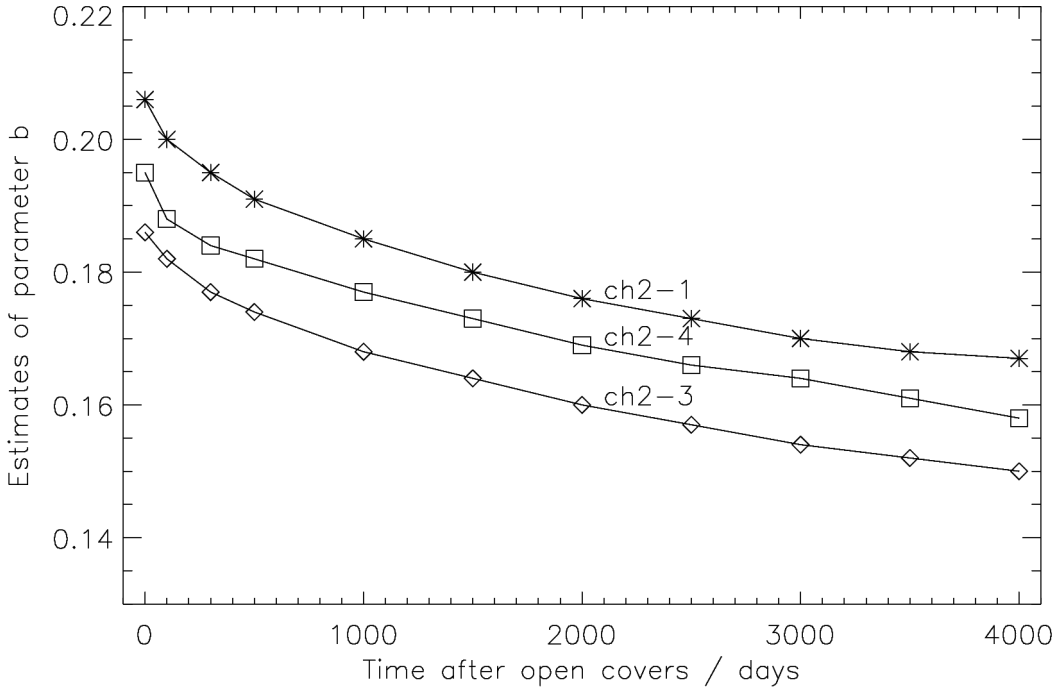
Below that, the nine figures show dark currents vs. temperature for channels 1, 3, and 4, for all three units.

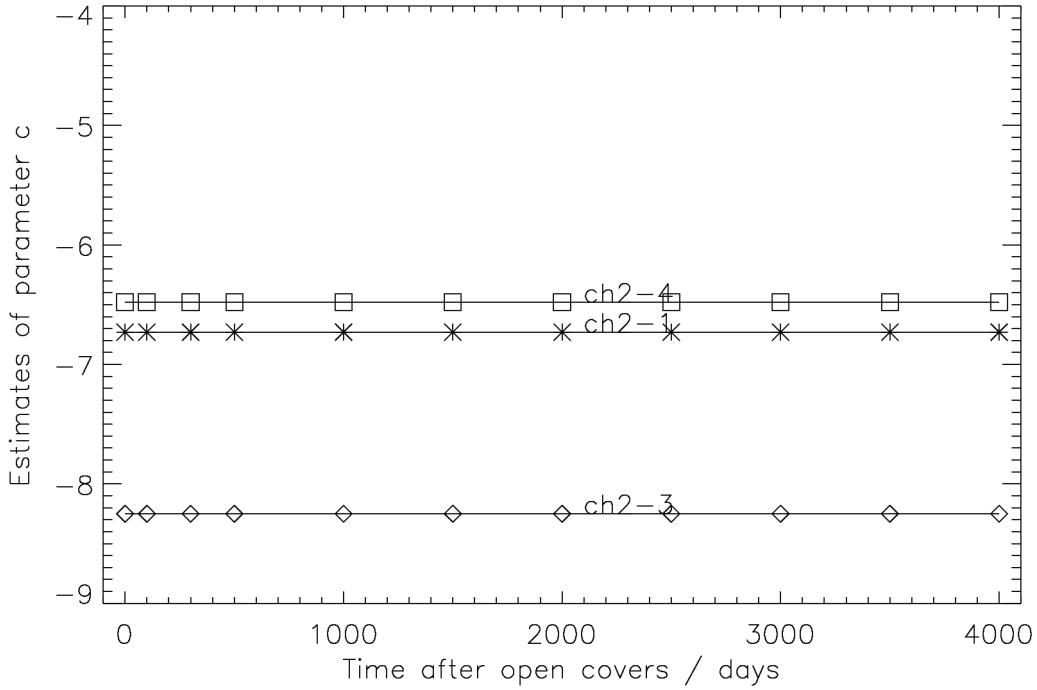
Update: To demonstrate that the dark-current subtraction really works well, one example is used from the middle of the last occultation season, the campaign of 15 Dec 2019. The results are shown for all four channels of unit 1 (temperature 40.1-43.8C), unit 2 (43.3-45.0C), and unit 3 (42.6-44.4C), in the last three figures below.

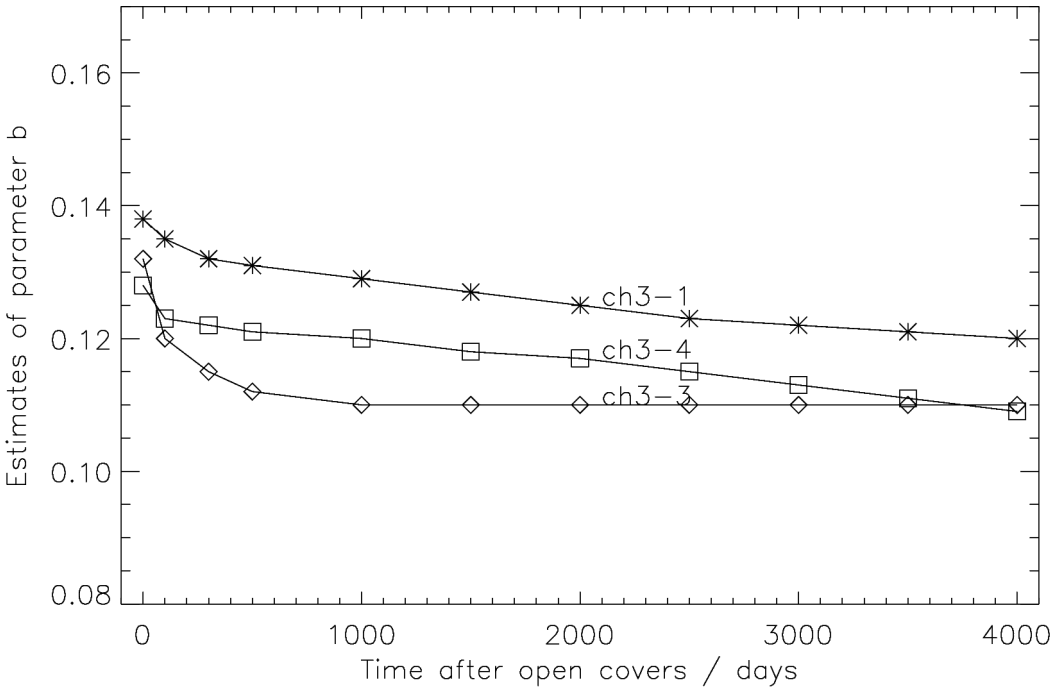
Each figure covers around two hours, including one full occultation. The raw data is shown by a straight line, the dark current is shown by a dotted line ("DC"), the corrected irradiance (dark current subtracted) is shown by a dashed line. The dashed line should touch zero level (shown by a red line) during the full occultation. This is basically always the case, QED.

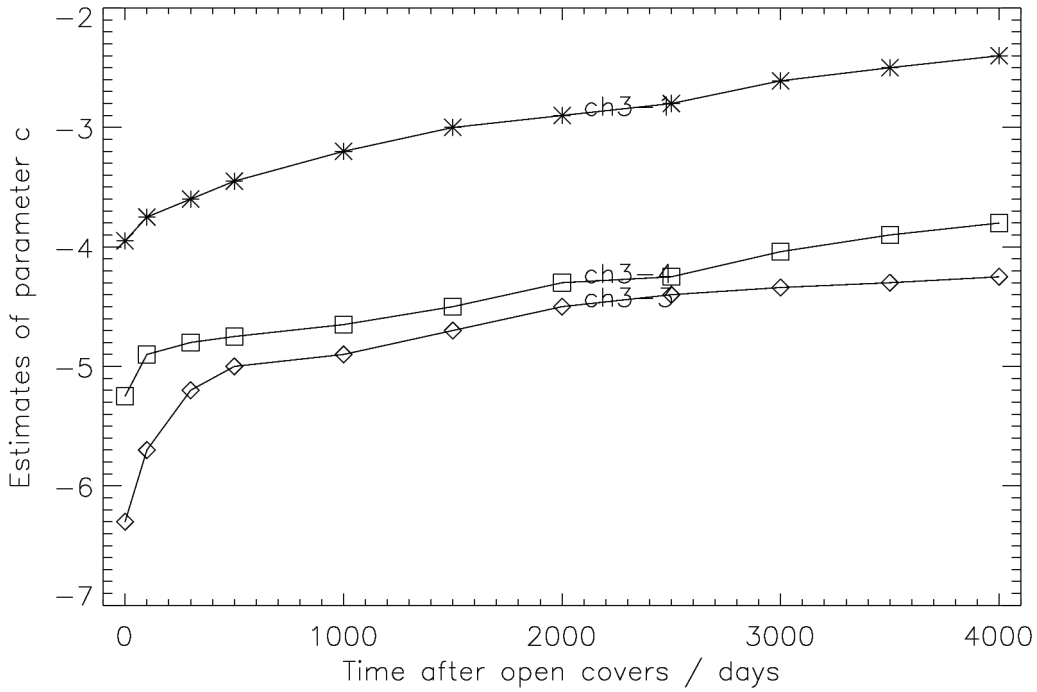

0.20
0.18
0.16
0.14
0.12
Estimates of parameter b
ch1−1
ch1−3
ch1−4
0
1000
2000
3000
4000
Time after open covers / days

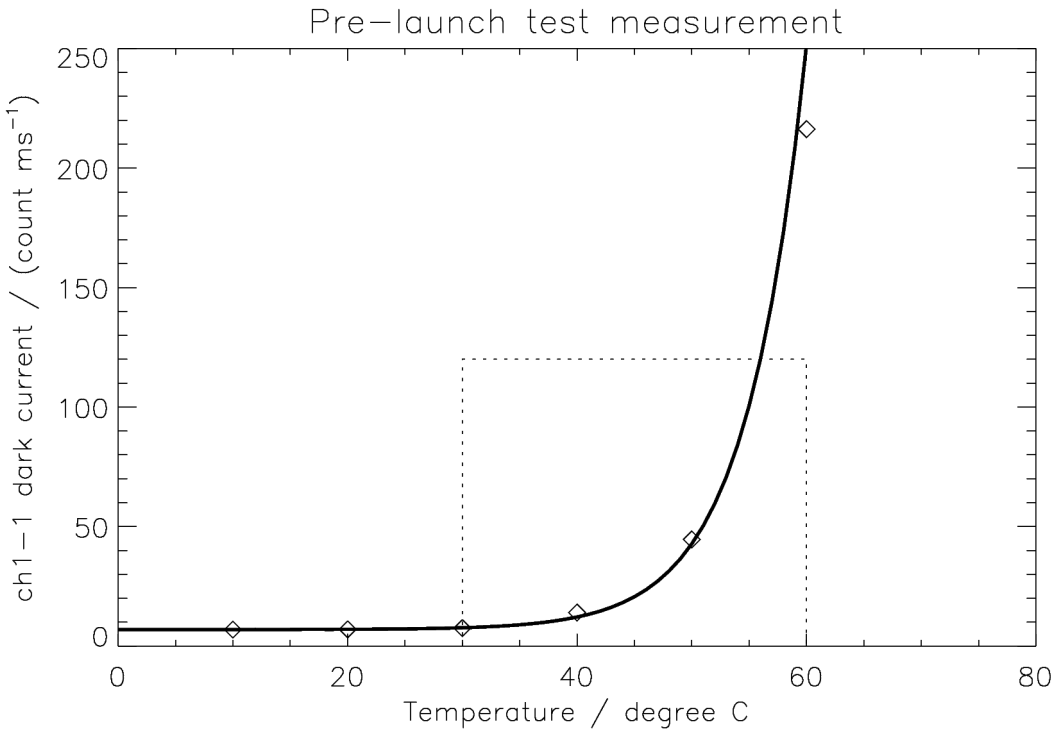

−3
−4
−5
−6
−7
−8
Estimates of parameter c
ch1−1
ch1−4
ch1−3
0
1000
2000
3000
4000
Time after open covers / days

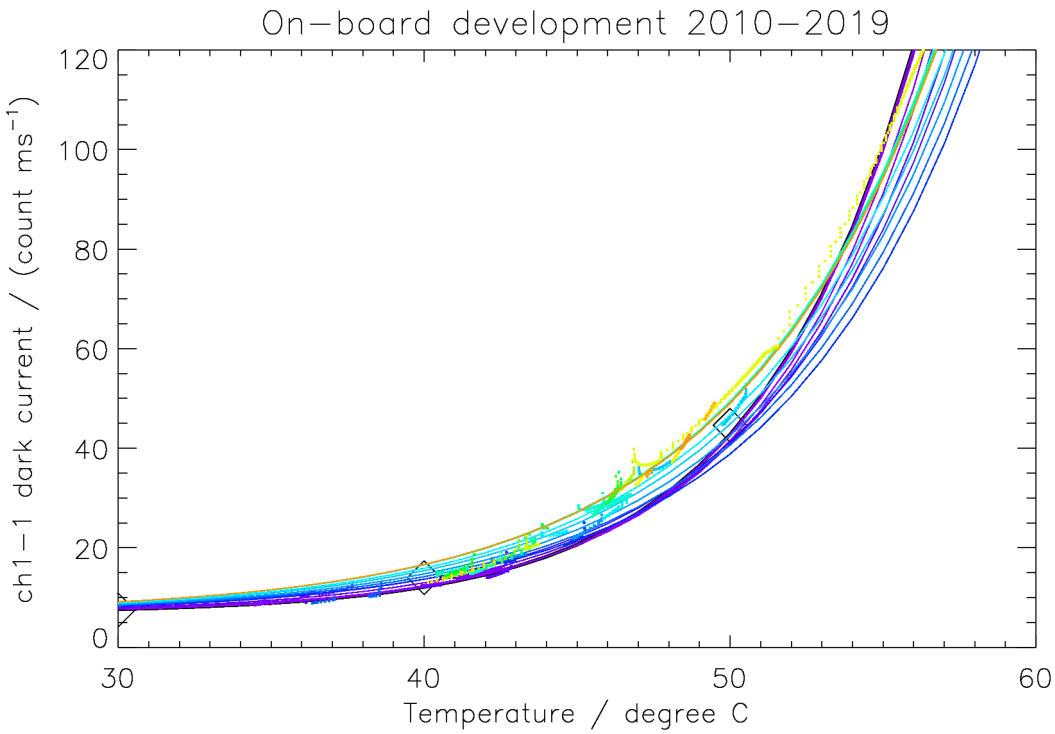

0.22
0.20
0.18
0.16
0.14
Estimates of parameter b
ch2−1
ch2−4
ch2−3
0
1000
2000
3000
4000
Time after open covers / days

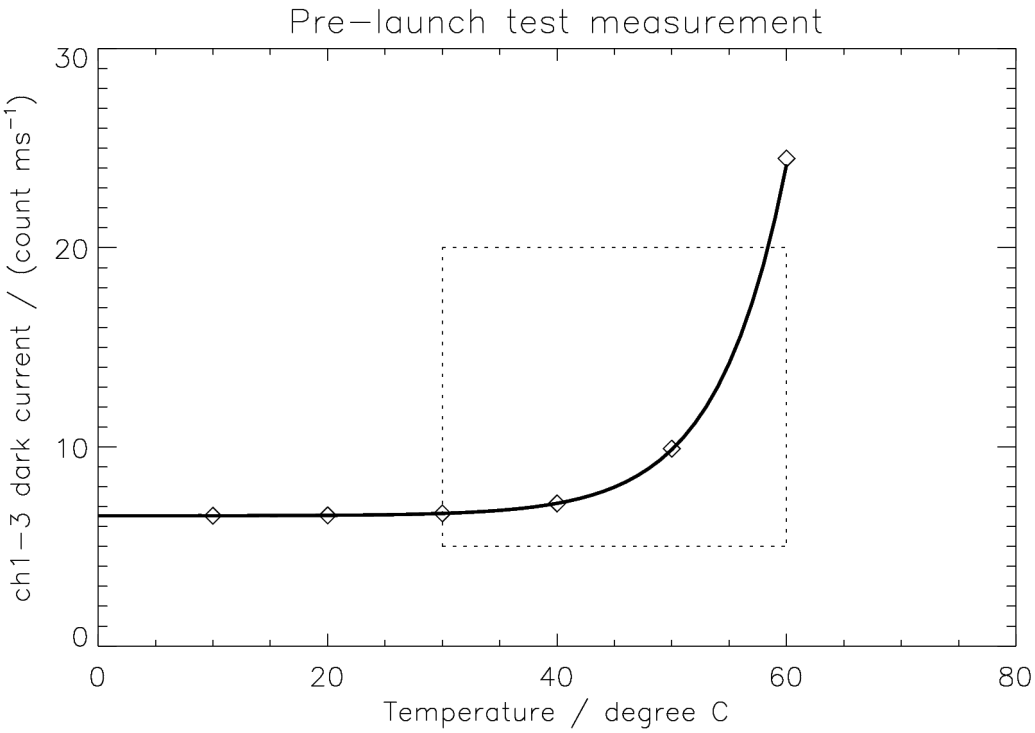

−4
−5
−6
−7
−8
−9
Estimates of parameter c
ch2−4
ch2−1
ch2−3
0
1000
2000
3000
4000
Time after open covers / days

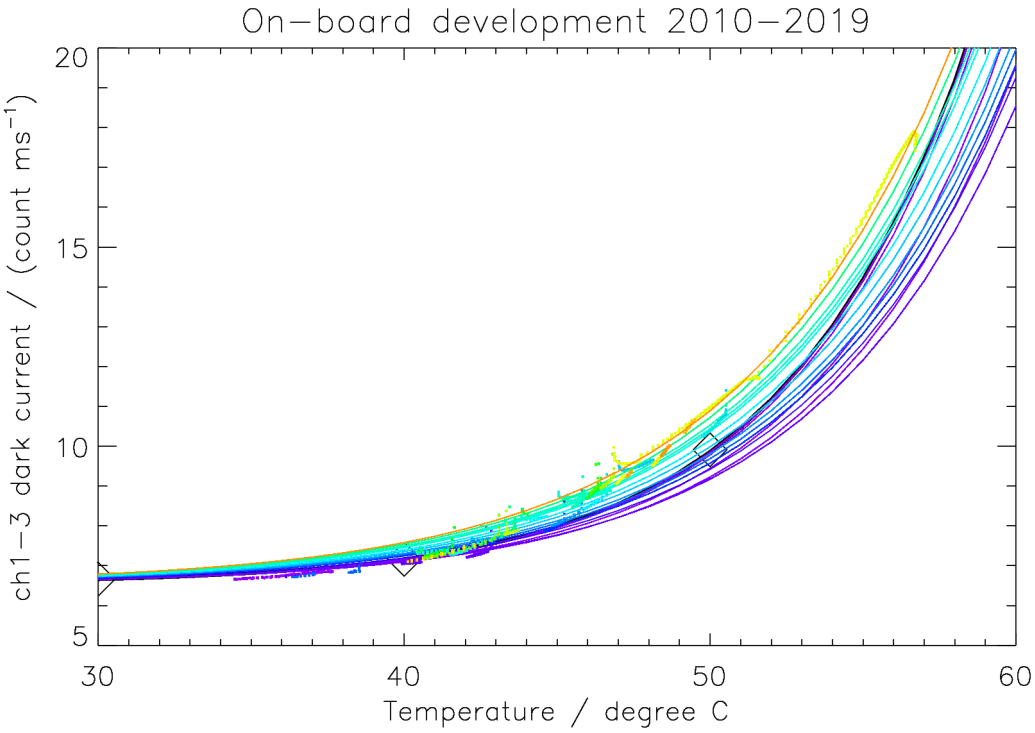

Estimates of parameter b
0.16
0.14
0.12
0.10
0.08
ch3−1
ch3−4
ch3−3
0
1000
2000
3000
4000
Time after open covers / days

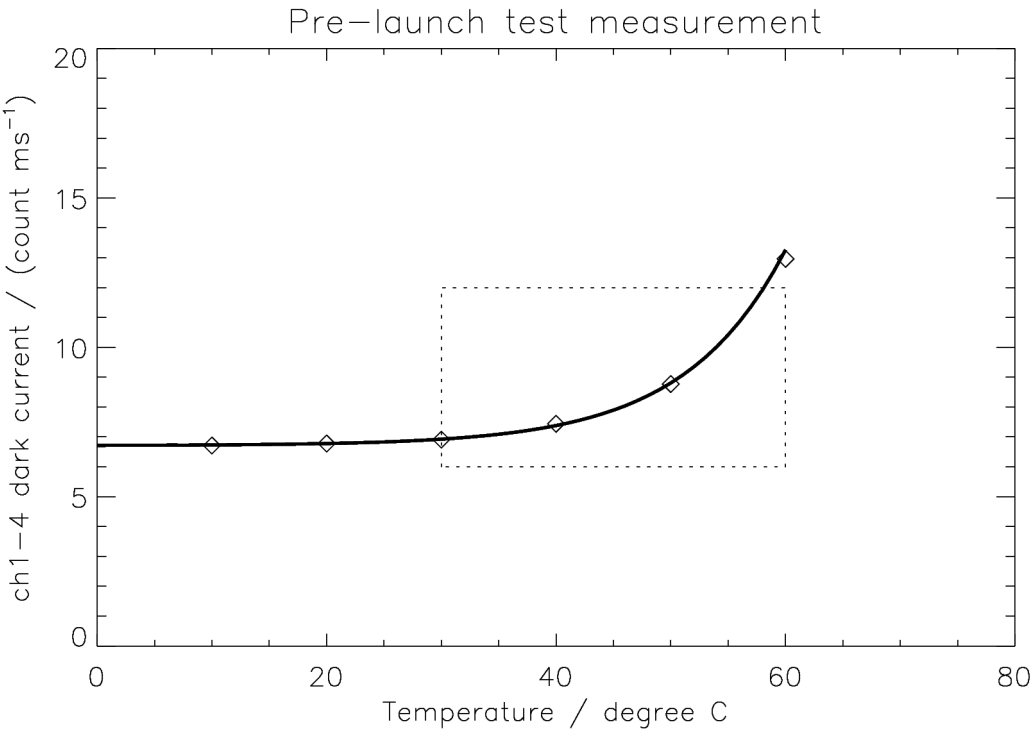

Estimates of parameter c
−2
−3
−4
−5
−6
−7
ch3−1
ch3−4
ch3−3
0
1000
2000
3000
4000
Time after open covers / days

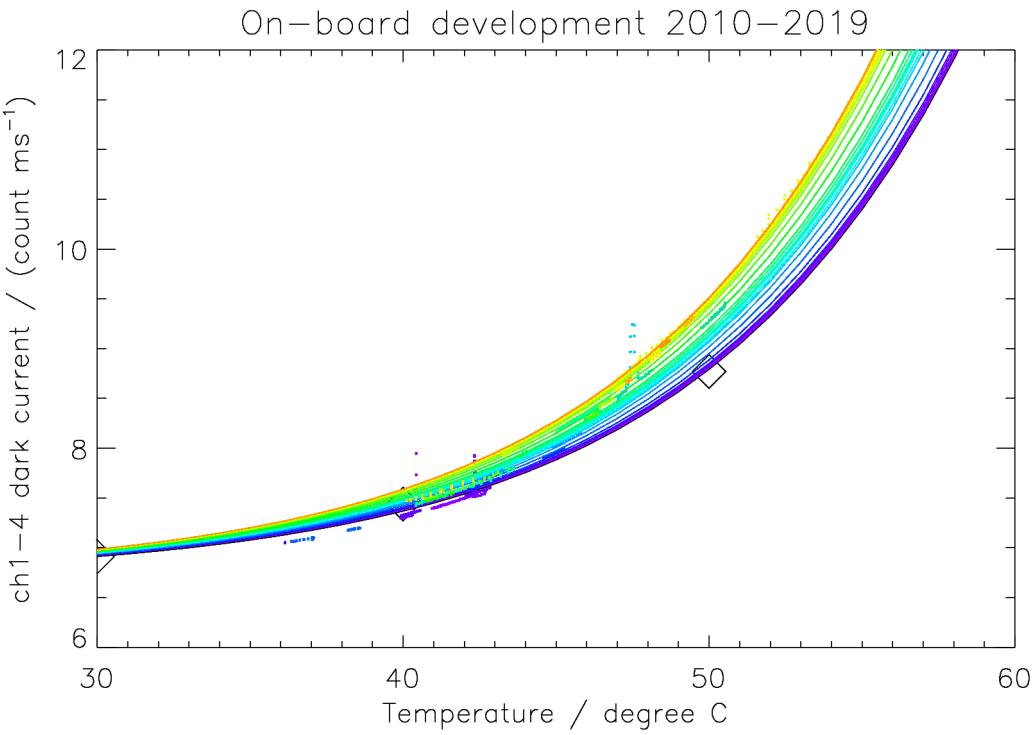

Pre−launch test measurement
ch1−1 dark current / (count ms^{-1})
250
200
150
100
50
0
0
20
40
60
80
Temperature / degree C

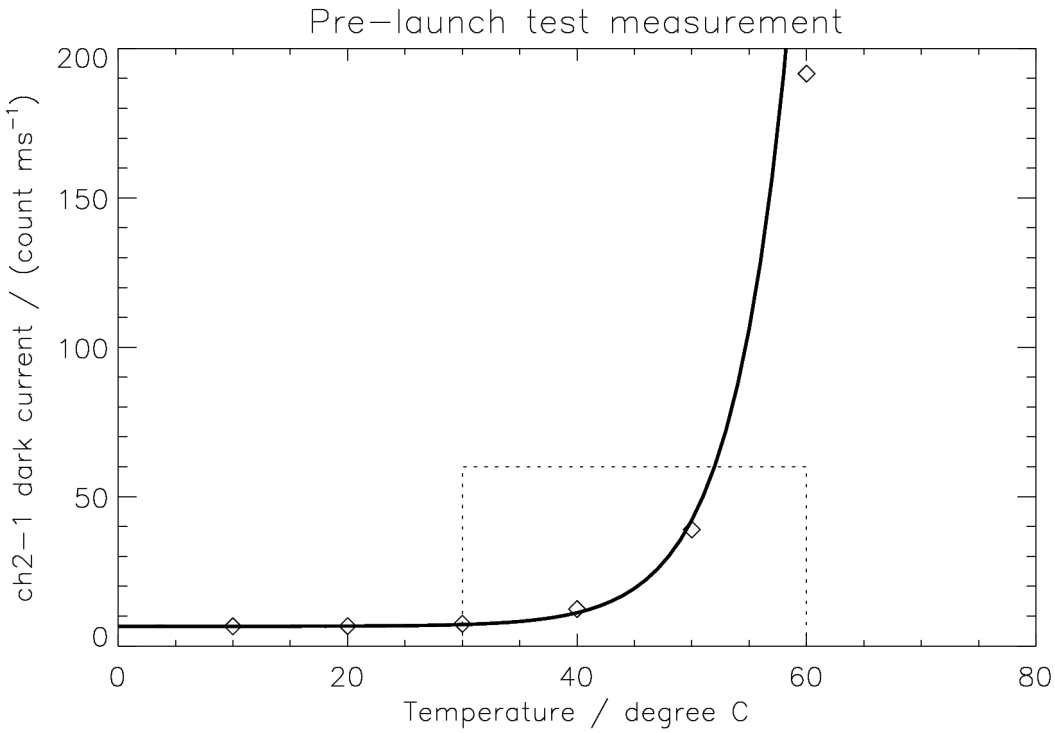

On−board development 2010−2019
ch1−1 dark current / (count ms^{-1})
120
100
80
60
40
20
0
30
40
50
60
Temperature / degree C

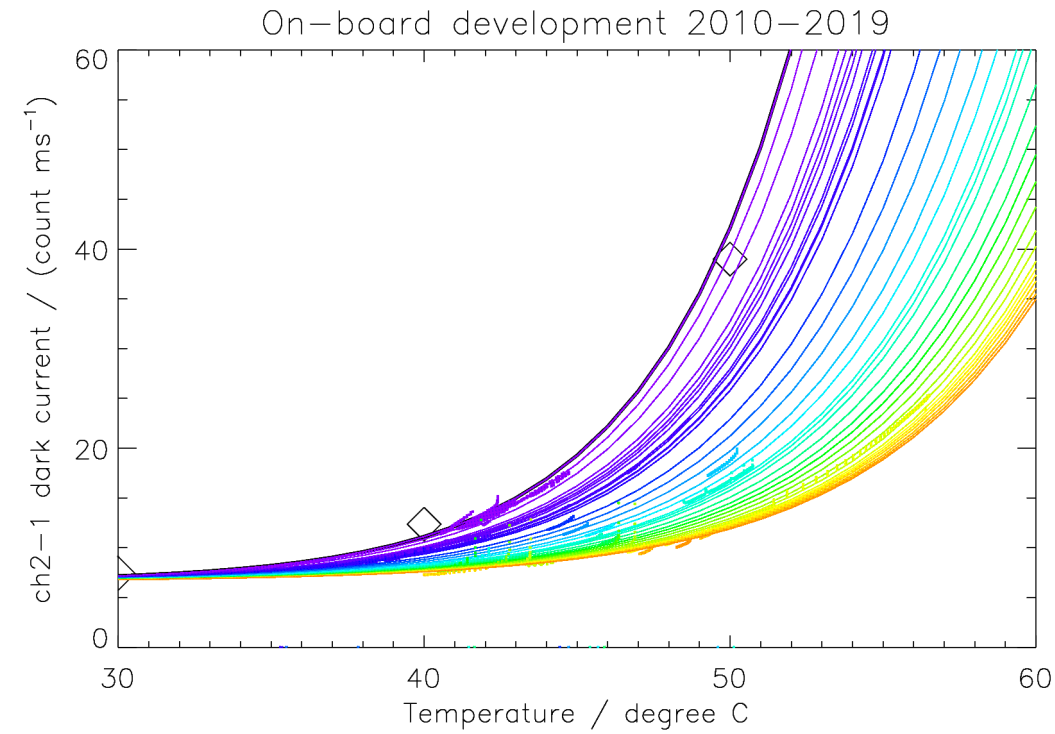

Pre−launch test measurement
ch1−3 dark current / (count ms^{-1})
Temperature / degree C
0
10
20
30
0
20
40
60
80

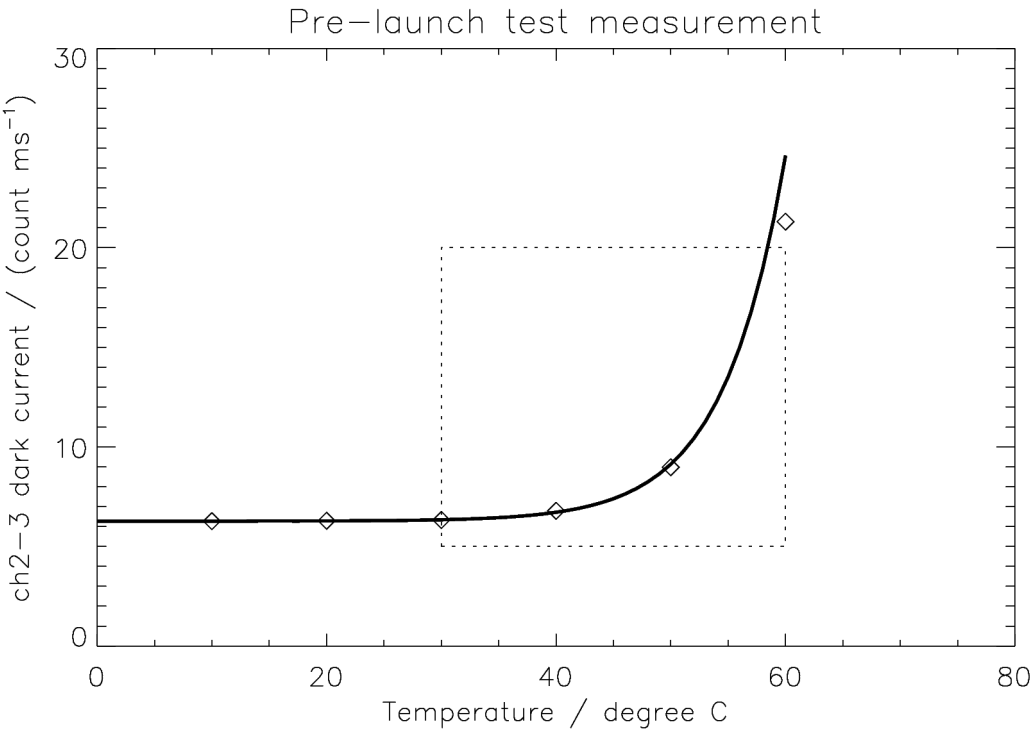

On−board development 2010−2019
ch1−3 dark current / (count ms^{-1})
Temperature / degree C
5
10
15
20
30
40
50
60

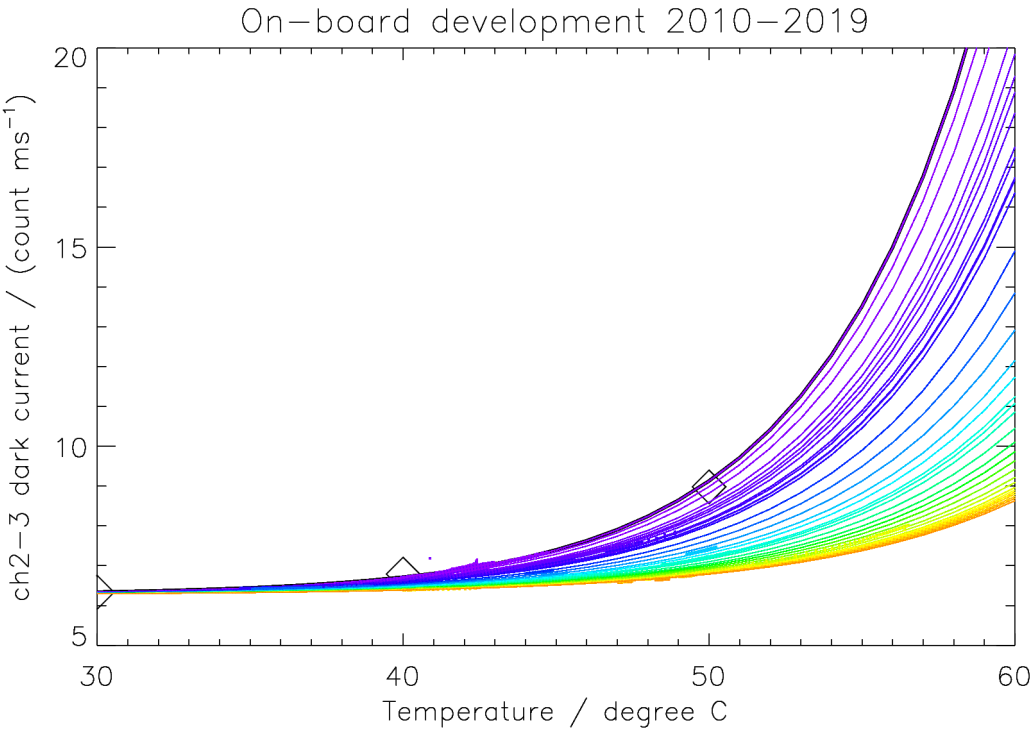

Pre−launch test measurement
ch1−4 dark current / (count ms^{-1})
Temperature / degree C
0
5
10
15
20
0
20
40
60
80

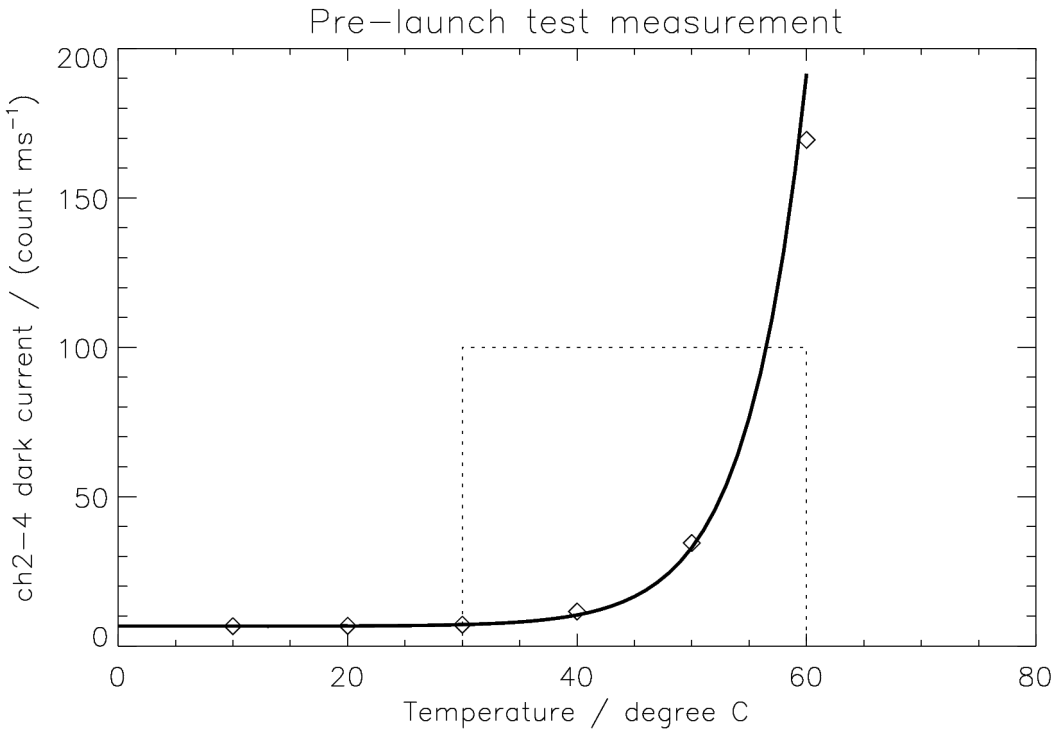

On−board development 2010−2019
ch1−4 dark current / (count ms^{-1})
Temperature / degree C
6
8
10
12
30
40
50
60

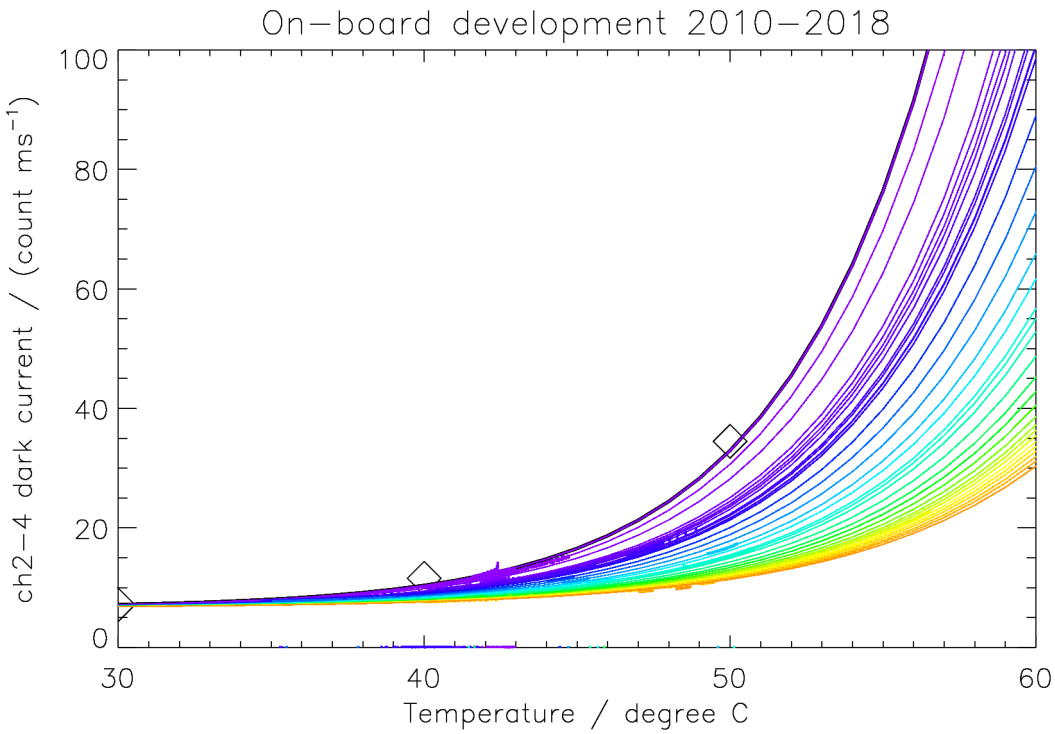

Pre−launch test measurement
ch2−1 dark current / (count ms^{-1})
200
150
100
50
0
0
20
40
60
80
Temperature / degree C

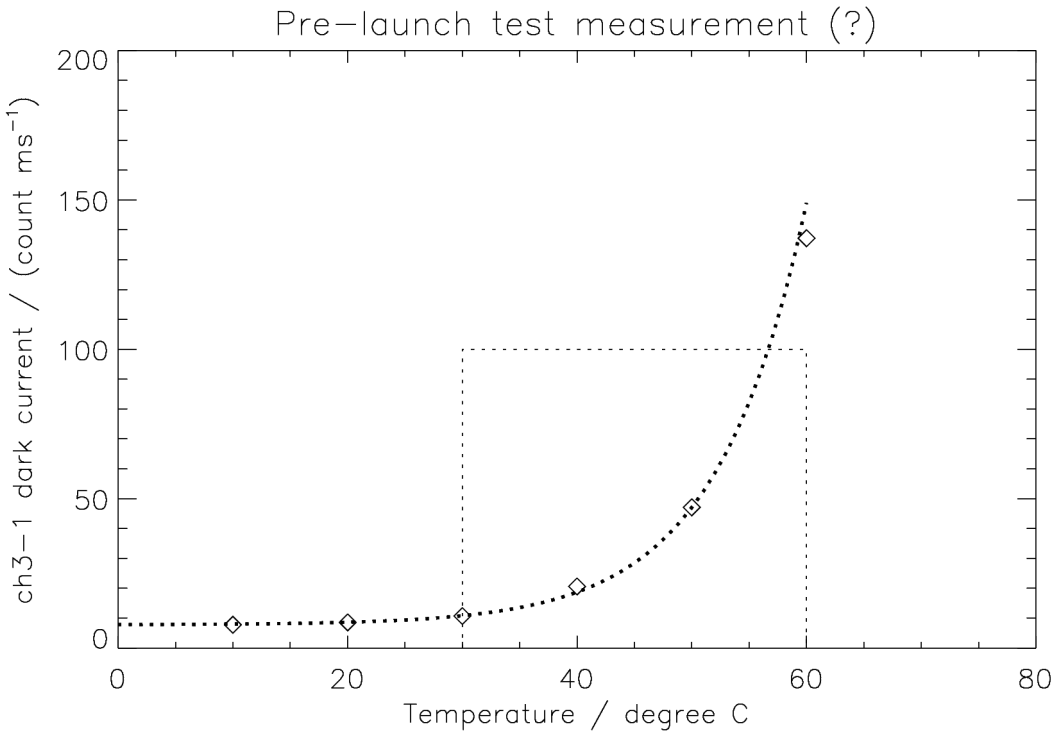

On−board development 2010−2019
ch2−1 dark current / (count ms^{-1})
60
40
20
0
30
40
50
60
Temperature / degree C

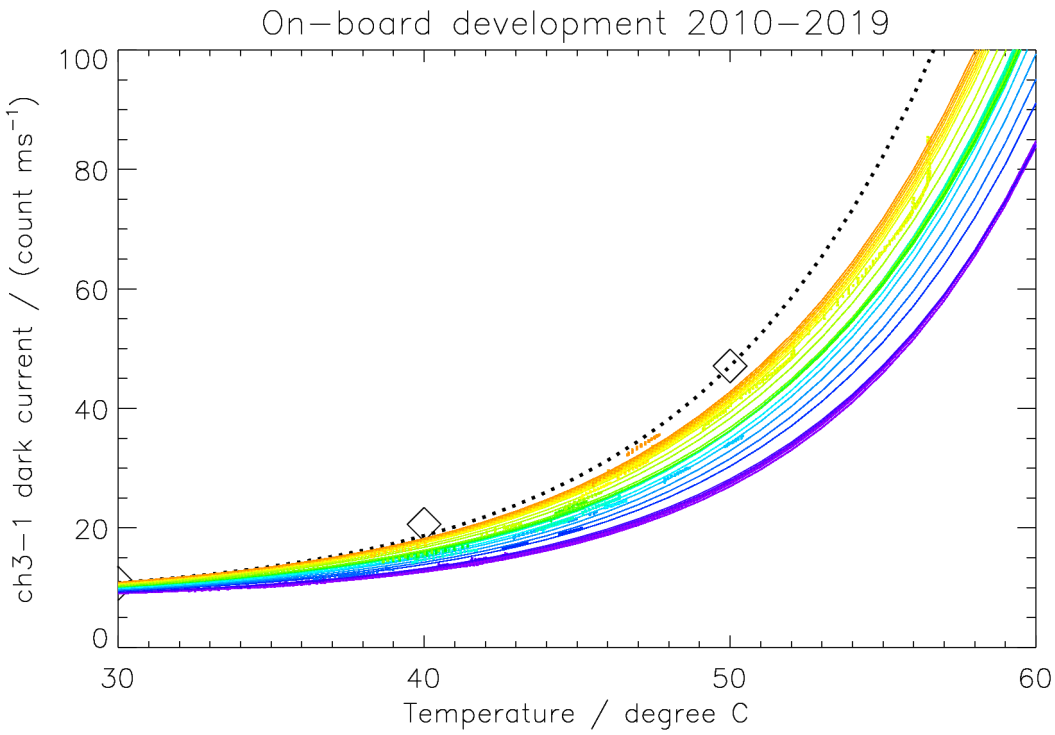

Pre−launch test measurement
ch2−3 dark current / (count ms^{-1})
Temperature / degree C
0
10
20
30
0
20
40
60
80

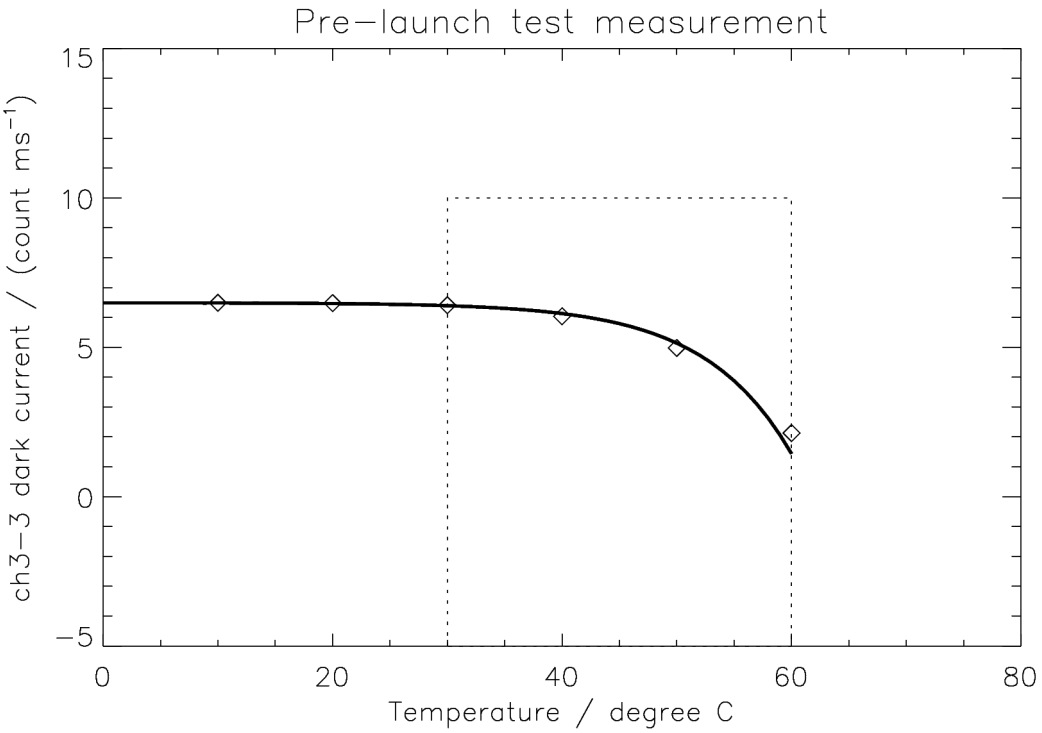

On−board development 2010−2019
ch2−3 dark current / (count ms^{-1})
Temperature / degree C
5
10
15
20
30
40
50
60

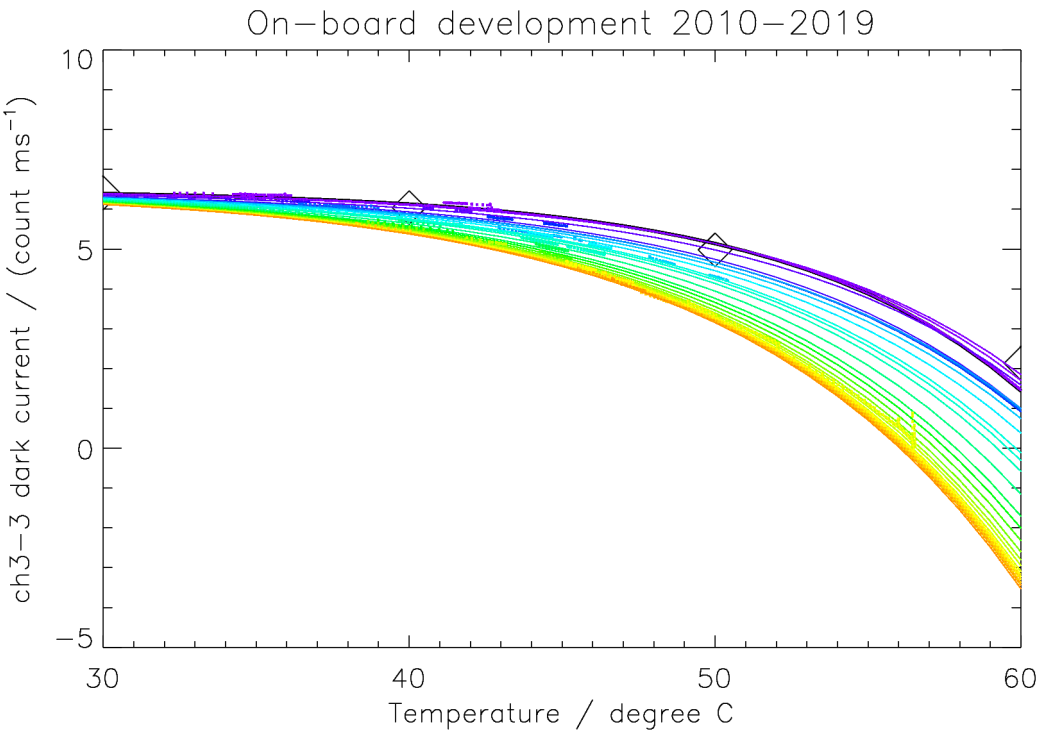

Pre−launch test measurement
ch2−4 dark current / (count ms^{-1})
200
150
100
50
0
0
20
40
60
80
Temperature / degree C

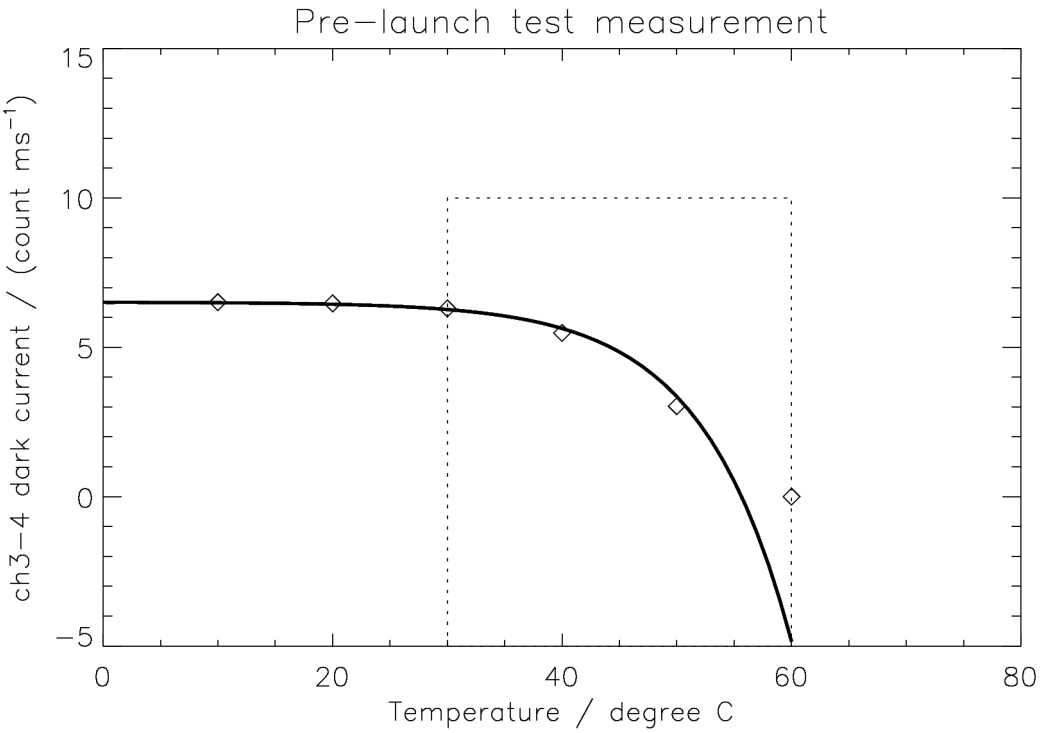

On−board development 2010−2018
ch2−4 dark current / (count ms^{-1})
100
80
60
40
20
0
30
40
50
60
Temperature / degree C

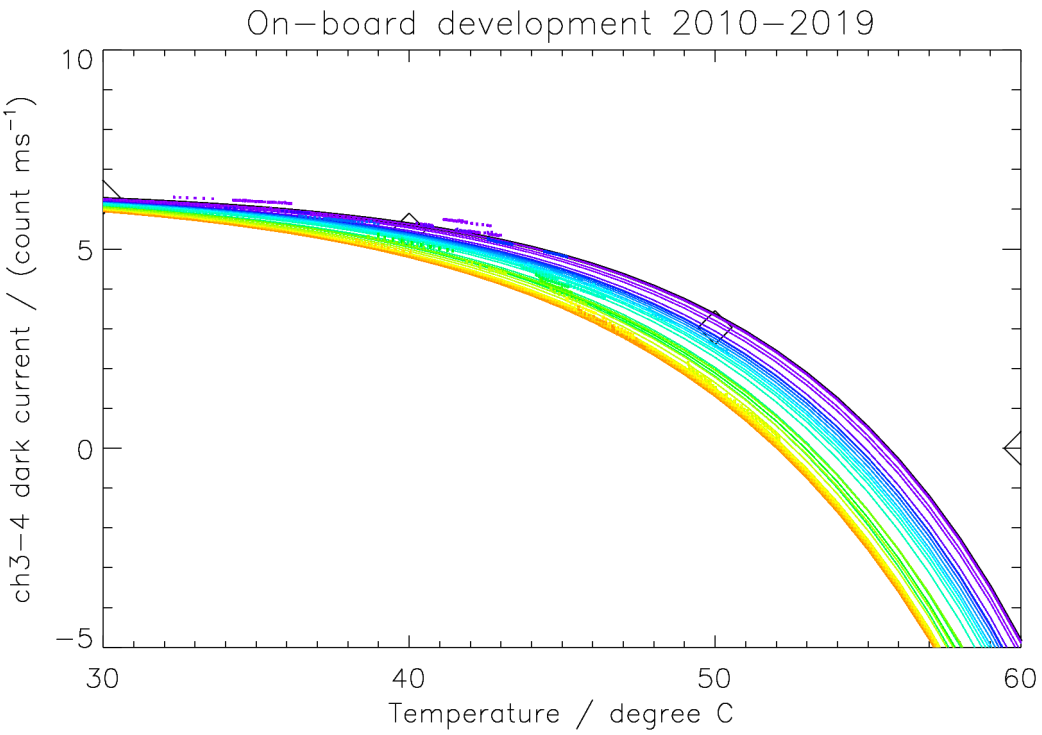

Pre−launch test measurement (?)
ch3−1 dark current / (count ms^{-1})
200
150
100
50
0
0
20
40
60
80
Temperature / degree C

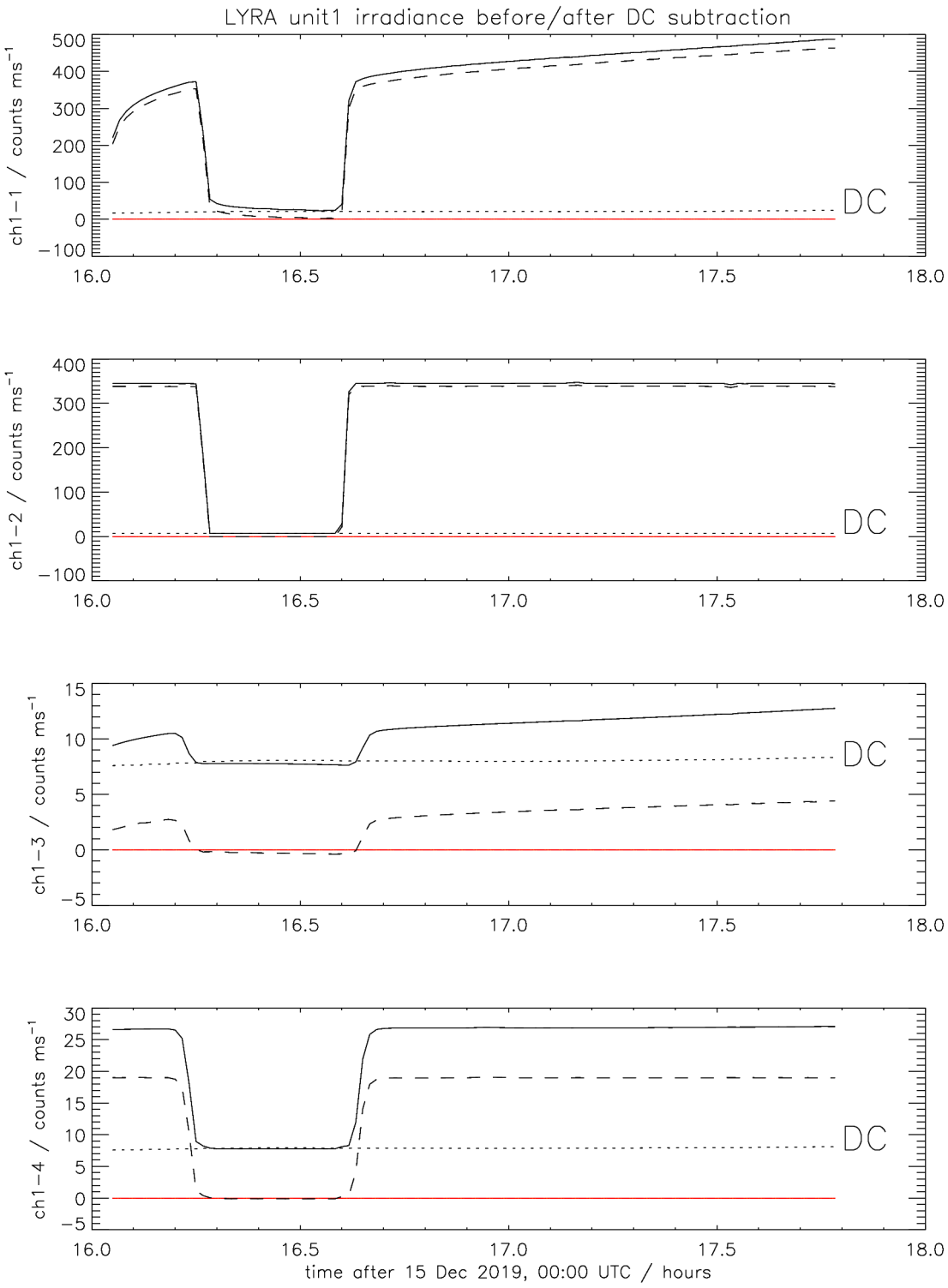

On−board development 2010−2019
ch3−1 dark current / (count ms^{-1})
100
80
60
40
20
0
30
40
50
60
Temperature / degree C

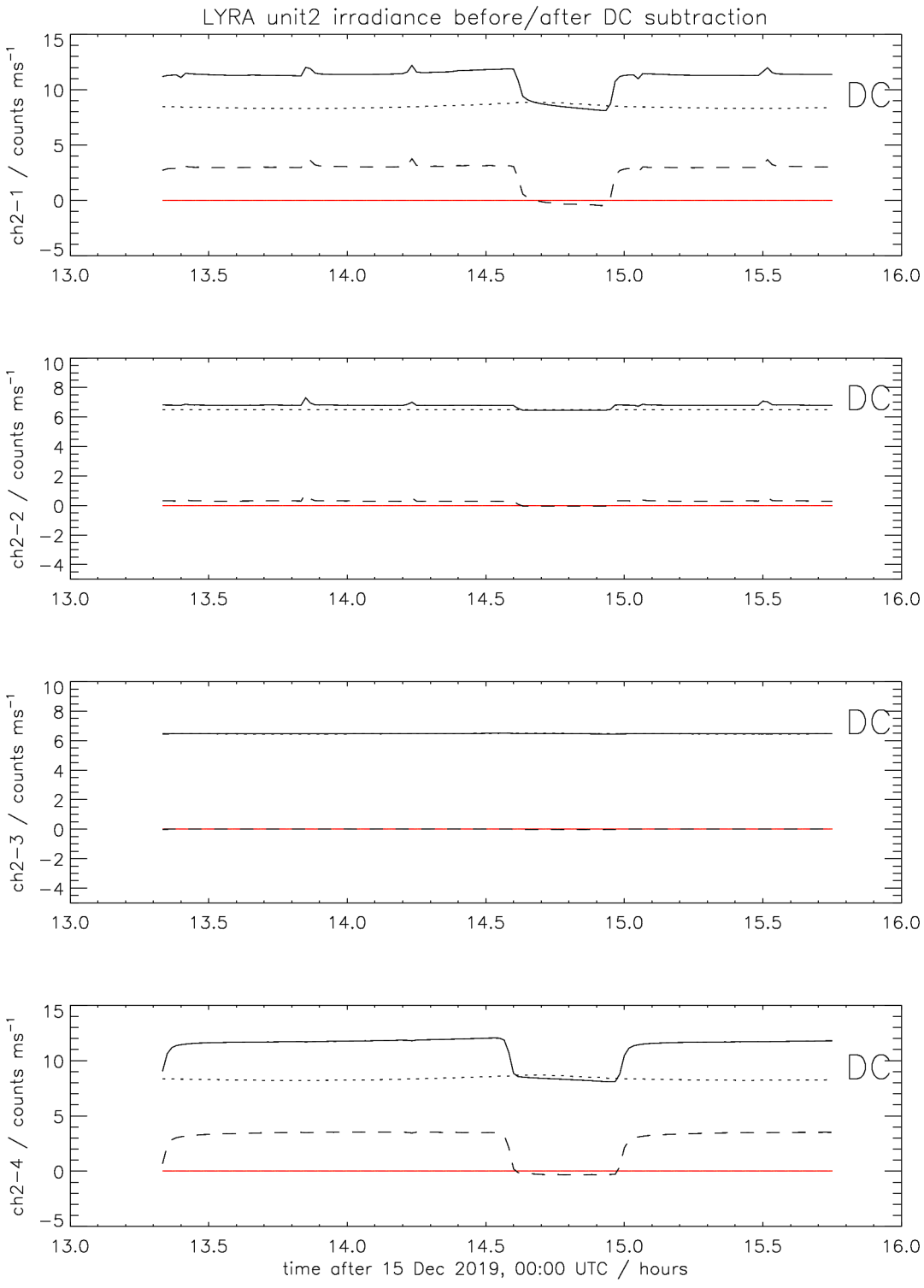

Pre−launch test measurement
ch3−3 dark current / (count ms^{-1})
15
10
5
0
−5
0
20
40
60
80
Temperature / degree C

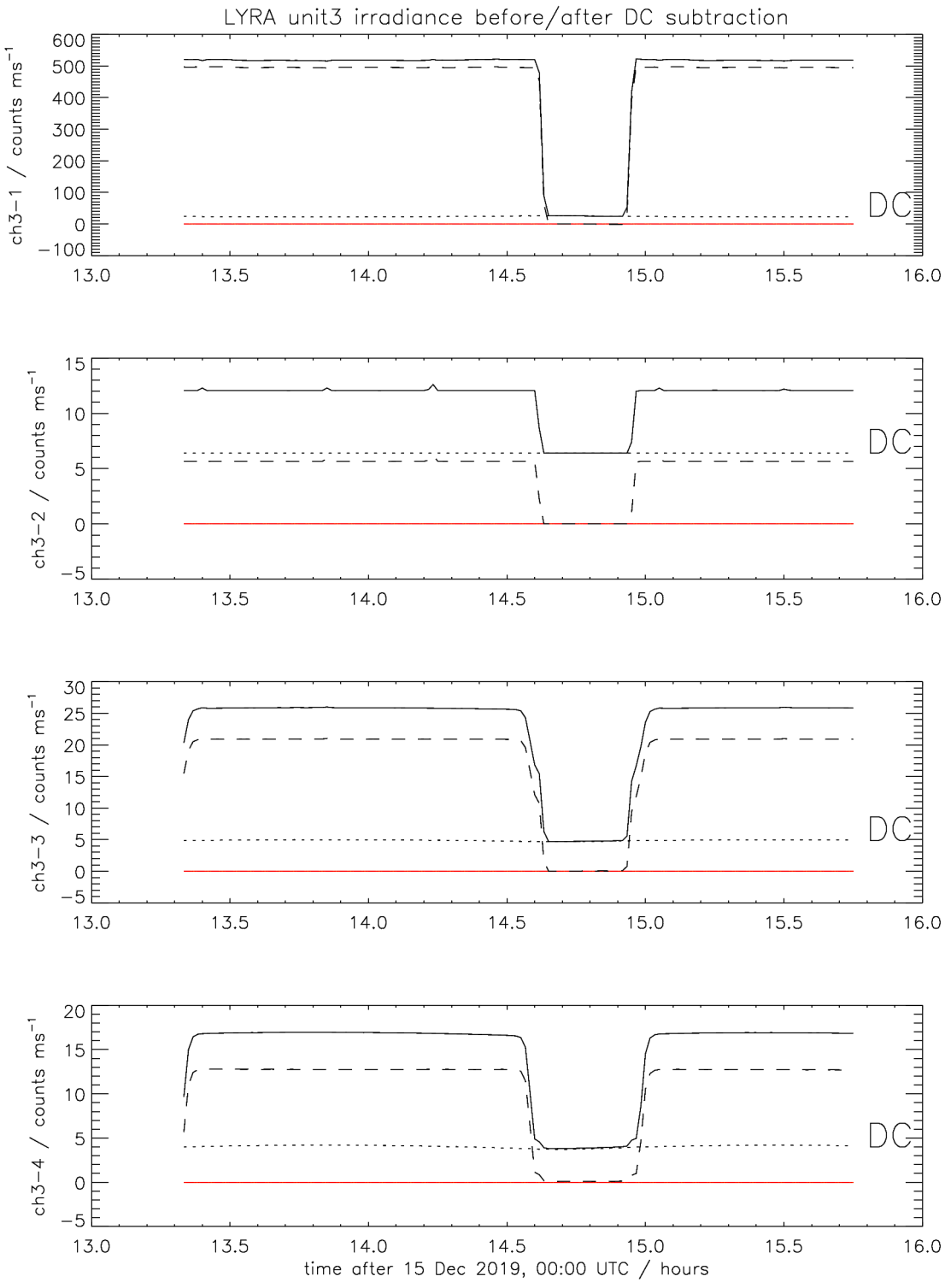

On−board development 2010−2019
ch3−3 dark current / (count ms^{-1})
10
5
0
−5
30
40
50
60
Temperature / degree C


Pre−launch test measurement
ch3−4 dark current / (count ms^{-1})
15
10
5
0
−5
0
20
40
60
80
Temperature / degree C


On−board development 2010−2019
ch3−4 dark current / (count ms^{-1})
10
5
0
−5
30
40
50
60
Temperature / degree C


LYRA unit1 irradiance before/after DC subtraction
ch1-1 / counts ms-1
ch1-2 / counts ms-1
ch1-3 / counts ms-1
ch1-4 / counts ms-1
DC
time after 15 Dec 2019, 00:00 UTC / hours


LYRA unit2 irradiance before/after DC subtraction
ch2−1 / counts ms−1
ch2−2 / counts ms−1
ch2−3 / counts ms−1
ch2−4 / counts ms−1
DC
13.0
13.5
14.0
14.5
15.0
15.5
16.0
time after 15 Dec 2019, 00:00 UTC / hours


LYRA unit3 irradiance before/after DC subtraction
ch3-1 / counts ms-1
ch3-2 / counts ms-1
ch3-3 / counts ms-1
ch3-4 / counts ms-1
DC
time after 15 Dec 2019, 00:00 UTC / hours