XMM-Newton Technical Note

XMM-CAL-TN-221

RGS Diagnostic Trend Analysis Report - 2018

C. Gabriel and R. Pérez

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1 Introduction

The purpose of this note is to report again this year on the evolution of several indicators derived from the RGS Diagnostic and Science data, with the aims of looking for eventual instrument degradation and necessary changes in the data corrections performed in the RGS scientific data reduction.

Running the RGS Diagnostic and Trend Analysis tools (see XMM-SOC-SW-TN-0012) we have collected and analysed data from the whole mission up to now. Evolution of instrument offsets ("system peak") and bad pixels / columns have been under study.

2 Results of RGS Diagnostic and Trend Analysis

The RGS Diagnostics Tools are running over all collected diagnostic data through the monitoring procedures. They are started every night, looking for new PMSFITS data arrival. If data corresponding to a new orbit are present, they get analysed, the reduced data stored and some of the results published in the internal RGS monitoring web page [1].

2.1 System Peak evolution

Figure 1 shows the evolution of the so-called System Peak corresponding to the C nodes of all working CCDs in RGS1 in the whole XMM-Newton history. They are obtained from the mean values of the pixel offset distributions per CCD and node, the offsets being the CCD signals measured by absence of any illumination. These values tend to be very stable and vary only by a few percent over very large time periods. A significant and very similar decrease can be observed however by all mean offset values after around revolution 2700 in the node C of this instrument, which in the last years seem to be a bit more stable (2), especially in the last ∼350 revolutions (3). A small but noticeable drop can also be seen around revolution 3250.

Node D continues showing a stable trend despite a slight increase of around 1% in the last 700 revolutions for all CCDs, and a factor 2 larger shown by CCD 1 , increasing to a ∼3% from rev ∼3000. (see figure 4). This deviation of CCD 1 from the almost absolutely parallel behaviour of all other CCDs, is also partially seen on the C side values, and can be attributed to the "hot spots" of CCD 1, discussed further below. There is no clear explanation however for the somewhat erratic behaviour of the RGS1 offsets on node C nor it can be related to any environmental event such as solar flares. No operational hiccup or instrument misbehavior (eg: focal plane temperature or analog electronic chain variations) can be linked to it either. With a large probability this is caused by the readout electronics used by all CCDs on that side, which explains the parallelism of the observed curves. Nevertheless, no impact in the quality of the RGS science products has been noticed.

RGS2 offsets show the expected stable trend, with no significant evolution, again with variations averaging within the 1% range compared to last CCF, as shown by Figs.6. We recall that there

[1] http://xmm.esac.esa.int/ xmmdoc/internal/int_cal_instr_supp/rgs/monitoring.php

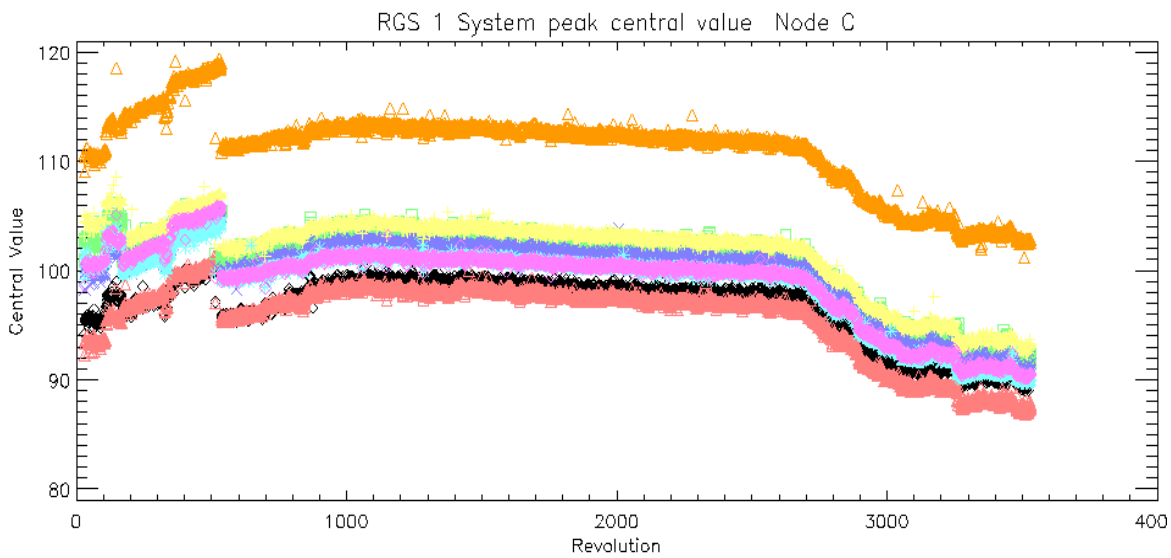

Figure 1: RGS1 - system peak evolution of node C data. Different colors represent the eight RGS1 working CCDs.

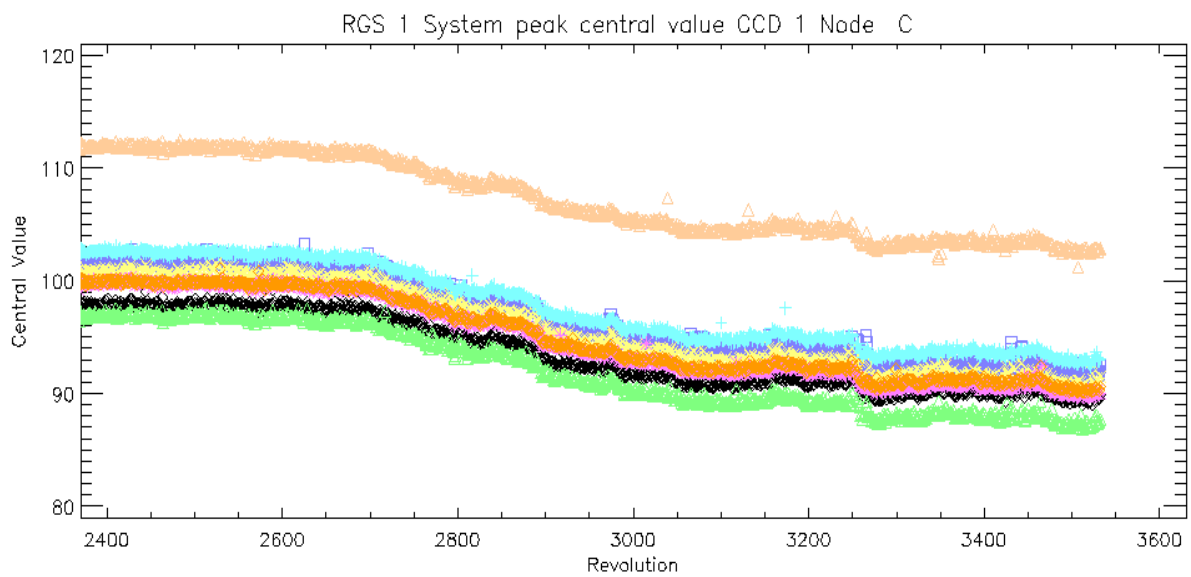

Figure 2: RGS1 - system peak evolution of node C data. Last 1000 revolutions.

is only one node, C, used for reading out the whole of the RGS2 detector since revolution 1408, therefore this side of the CCD has not been updated since then.

Apart from the RGS1 node C issue, it is evident in all distributions that the evolution of the offset values became substantially smoother after revolution 532. In that revolution, the operating temperatures of the RGS were reduced from -80 C to -113 C degrees. A especially remarkable fact is that, while every medium-large to large solar flare produced a sensible change in the offset

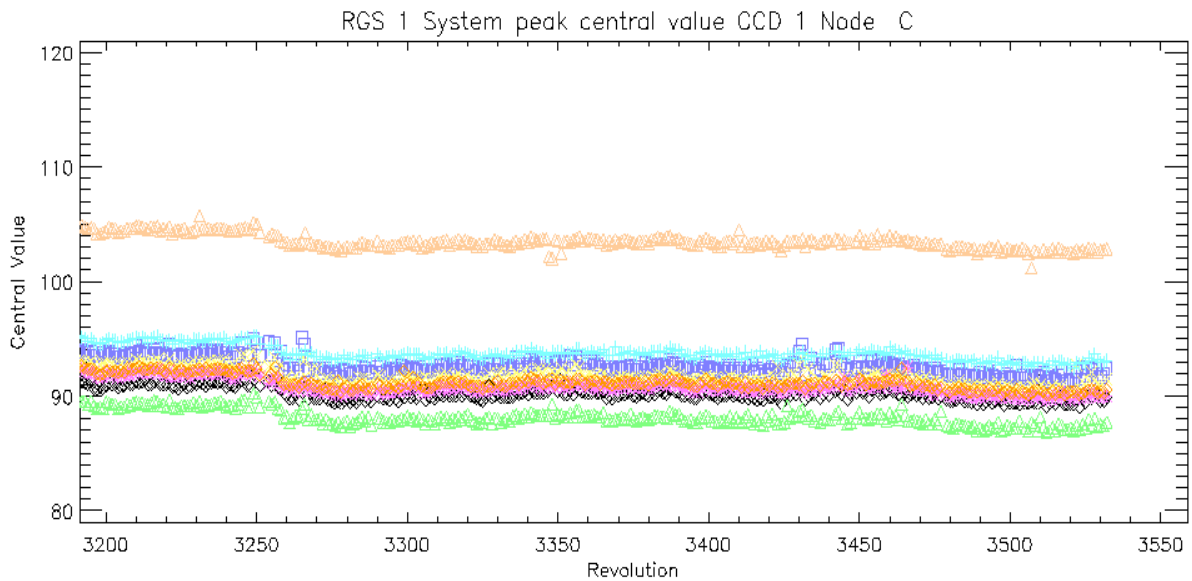

Figure 3: RGS1 - system peak evolution of node C data. Last 350 revolutions.

https://www.cosmos.esa.int/web/xmm-newton/calibration-documentation

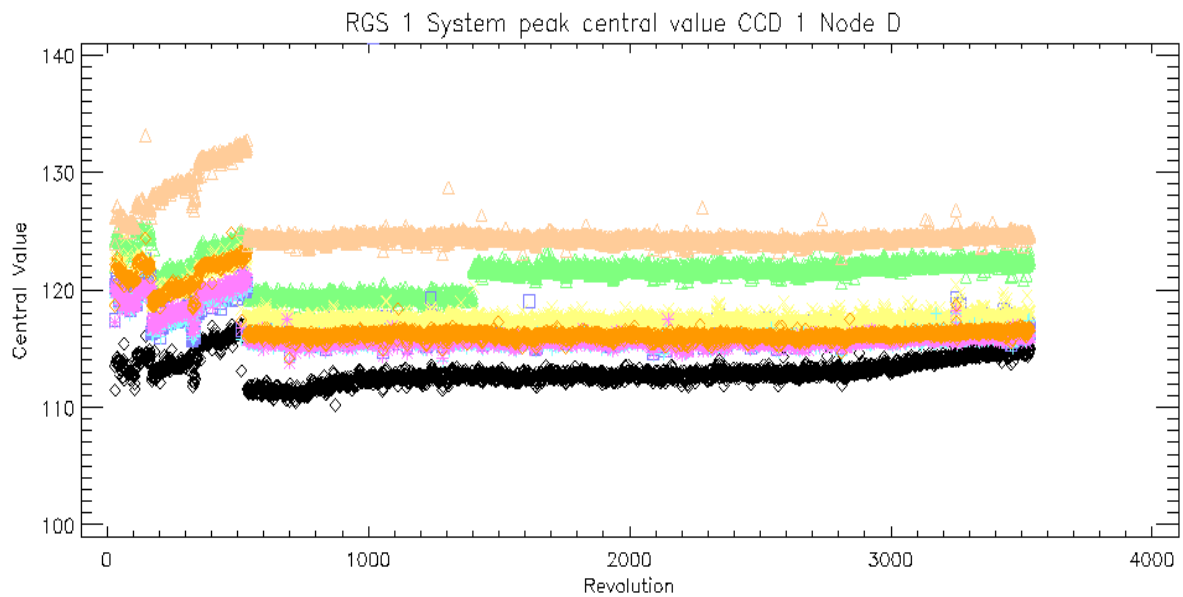

Figure 4: RGS1 - system peak evolution of node D data. Different colors represent the eight RGS1 working CCDs.

values during the first period, after cooling down the instruments these were fully insensitive to high radiation events, which continued to happen with approximately the same frequency within the same periods of the solar cycle.

The default way of subtracting the offsets from the RGS scientific data consists in using the RGS Offset files derived from the averages of diagnostic images taken during three consecutive revolutions.

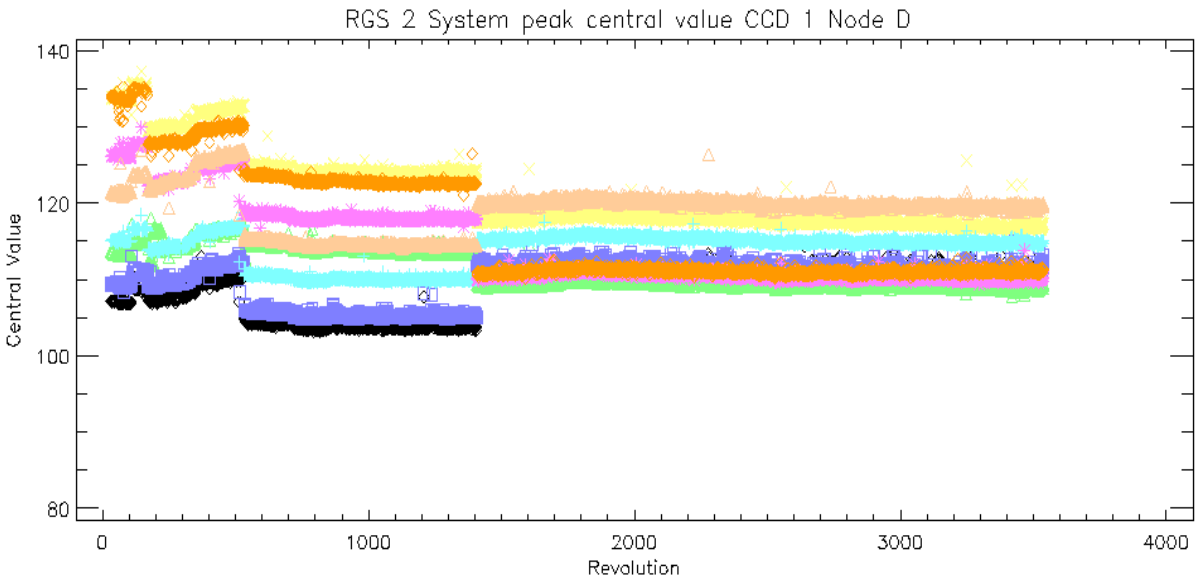

Figure 5: RGS2 - system peak evolution.

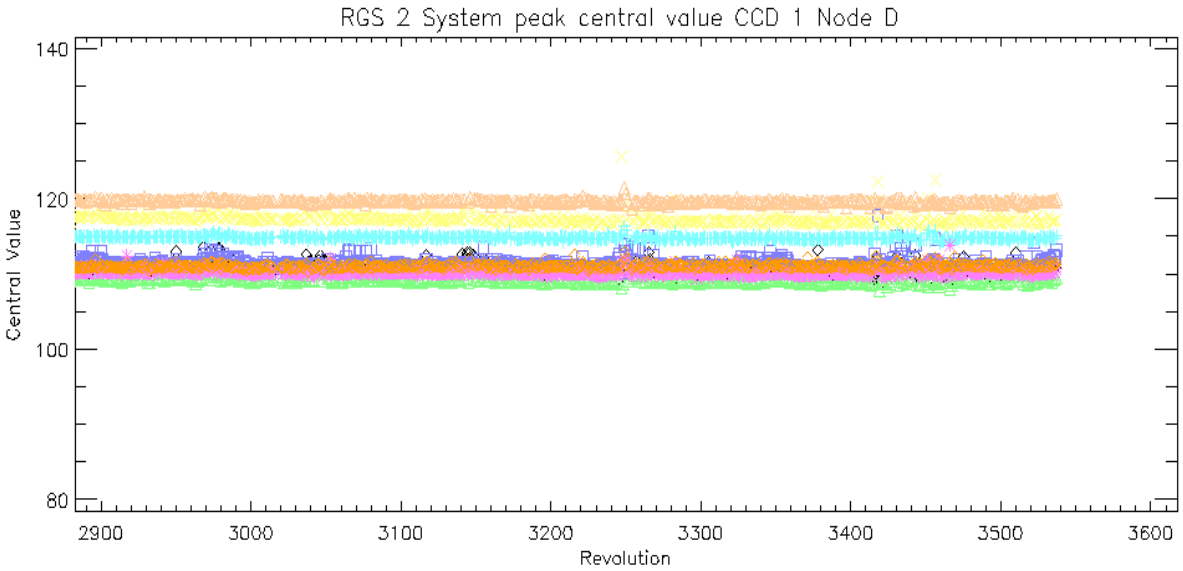

Figure 6: RGS2 - systehttps://www.cosmos.esa.int/web/xmm-newton/calibration-documentationm peak evolution in the last 600 revolutions.

This has the advantage of resolving the offsets per CCD pixel, and so to cover the variation of the offsets on a pixel by pixel basis. Nevertheless the possibility of subtracting a single offset value per CCD and node is also possible in the SAS (to be used for exceptional cases of lacking diagnostic derived offset files), with the corresponding values contained in the CCF RGS ADUCONV file.

2.2 Evolution of Hot Columns and Hot Pixels

We have analysed both diagnostic and science data for finding out the evolution of hot columns and pixels. The analysis methods have been discussed in former reports (see XMM-CCF-REL-226[2] and XMM-CCF-REL-370[3]). Actually the diagnostic data does not show any increase of hot columns in the last 10 years. There are 2 persistent hot columns, one in each RGS (RGS1-CCD1-D38 and RGS2-CCD9-C94), as well as the hot spots, whose variation has been reported in the same CCF release notes. With the last CCF release the formerly 'advisory' columns have been uploaded.The diagnostic bad pixel maps in Fig.7 show the 2018 collected data corresponding to RGS1 CCD1.

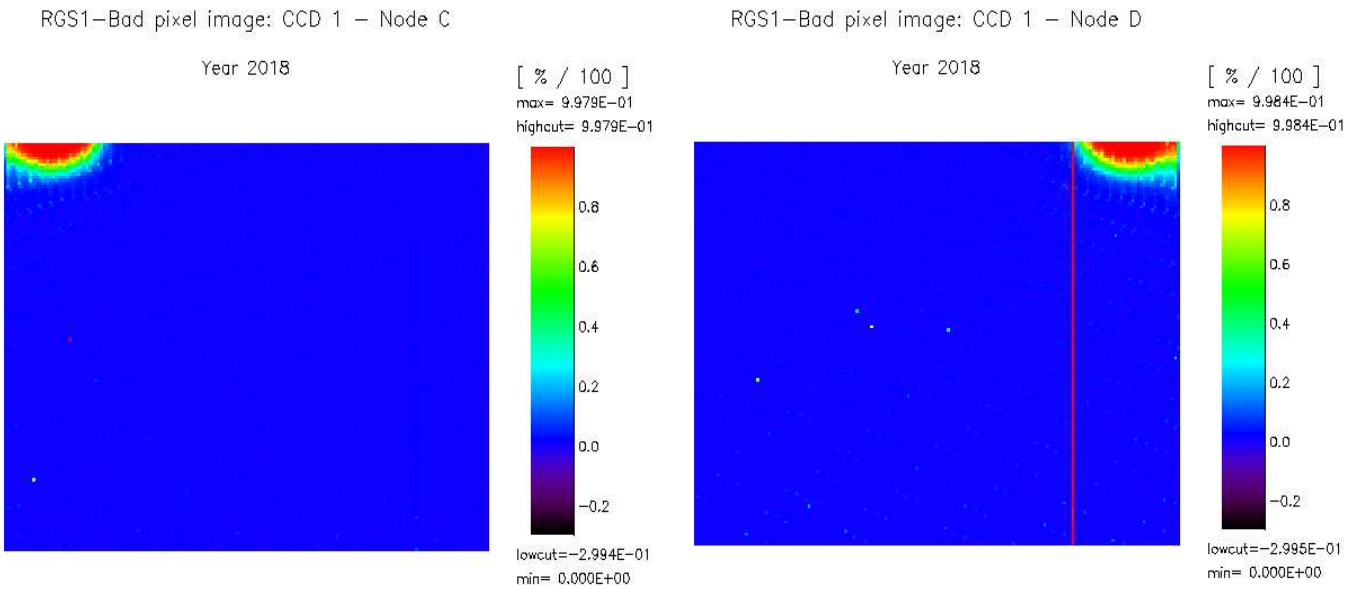

Figure 7: RGS1 - CCD1 C and D bad pixel maps showing the two"hot spots" and the only hot column found in RGS1 in the diagnostic data (column 38 on the D side) corresponding to the data taken in 2017.

The other permanent hot column detected in the diagnostic data (RGS1-CCD9-C94) is further detected as hot 100% of the time during 2018, as revealed in the corresponding bad pixel map (Fig.8).

The analysis of the science data is based on the SAS task `rgsbadpix`. We monitor yearly the number of columns and pixels found to be "hot" by the task, without using the otherwise default parameter *withadvisory=true*, which would be excluding the advisory hot columns and segments present in the valid BADPIX CCF file. In this way we can detect unstable segments and columns, which become hot in certain periods and irregularly. Seen on the long term there is a large level of stability in the number of hot stuff found. Plotting the number of columns found hot $B_c = N_c^{bad}/N_c^{total}$ in more than 25% ($B_c > 0.25$) of the observations analysed (Fig.9), we see clearly that the number of hot stuff is extremely stable for the RGS2 instrument since after the operational temperature has been reduced in 2002. The data corresponding to RGS1 is more variable, with a relative peak in 2009, an increase in 2012 and 2013 and a small reduction in 2014, followed by an

[2]http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0226-1-0.ps.gz
[3]http://xmm2.esac.esa.int/ xmmdoc/CoCo/CCB/DOC/Attachments/CAL-SRN-0370-1-0.pdf

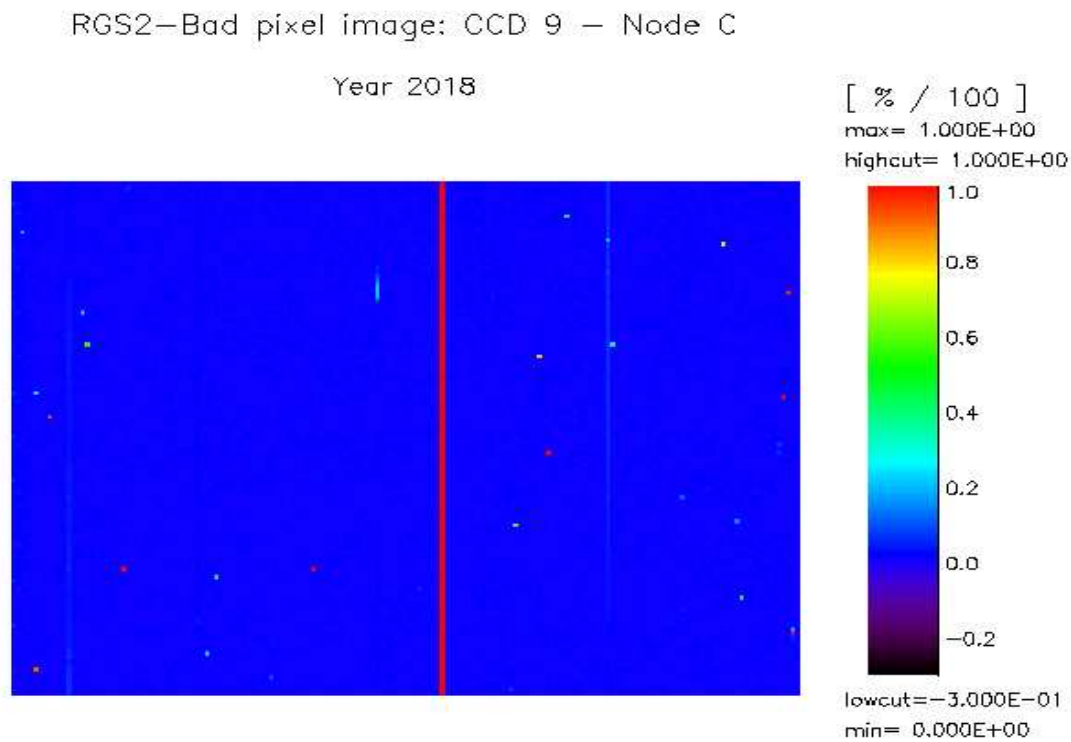

Figure 8: RGS2 - CCD9 C bad pixel maps showing the only hot column detected in the RGS2 Data.

increase in the last four years.

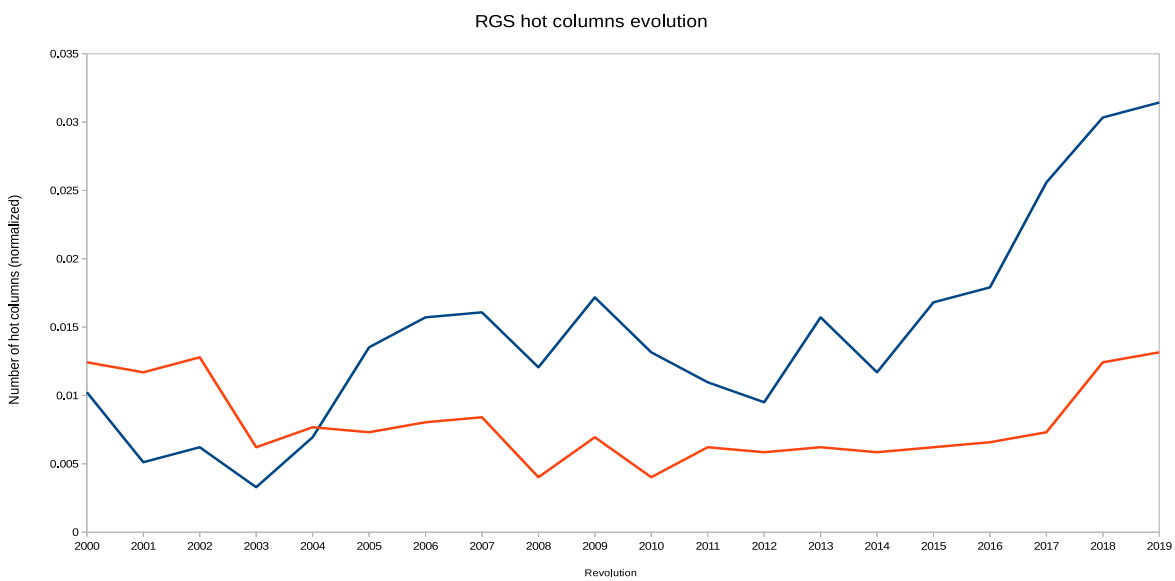

Figure 9: Hot columns found hot in more than 25% of the observations. The numbers are normalized to the total number of columns

It has already been reported in the former issue of this document (XMM-CAL-TN-0217) that the variation is mainly due to the number of columns found hot under the "hot spots" of RGS1

CCD1 on the C side and later on the D side. The bad pixel maps computed with the science data help to understand this: the two maps corresponding to 2016 and 2018 (Fig.10), show that the number of "hot columns" below the "hot spot" on the D side has dramatically increased, while on the C side only a few "hot columns" right from the mask are observed (Fig.11), of different intensity. For the C side a vertically larger masked region was uploaded in May 2016 (http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0334-1-0.pdf). Last year's report has already argued, however, for a larger mask in the vertical direction on the D side (extending it from 8 to 16 rows) as well as in the horizontal direction on both sides (by 8 columns) to avoid fake hot columns which started to appear on the sides of the masked regions. This has been confirmed by the data obtained along 2018. Due to operational constraints, the upload of this extension has taken place in March 2019. Please refer to XMM-CCF-REL-370[4] for further details,

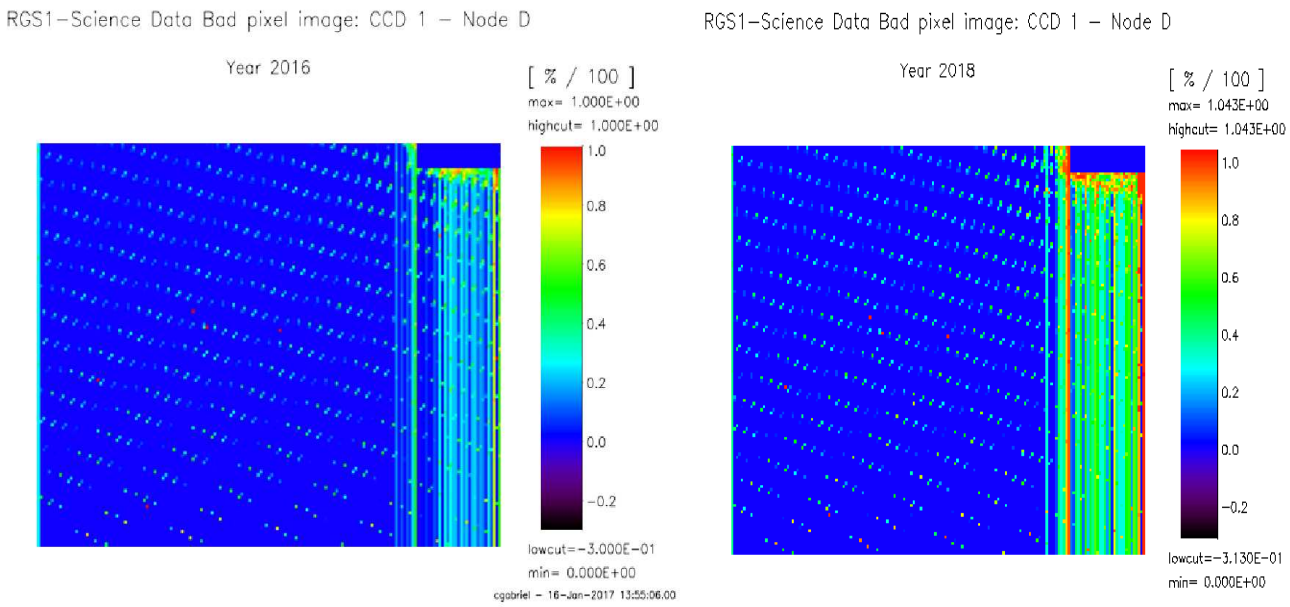

Figure 10: RGS1 - CCD1 D science bad pixel maps corresponding to data from 2016 (left) and 2018 (right).

No further changes can be observed in the data of 2017 with respect to the former years, which would justify changing the number of advisory hot columns.

[4]http://xmm2.esac.esa.int/ xmmdoc/CoCo/CCB/DOC/Attachments/CAL-SRN-0370-1-0.pdf

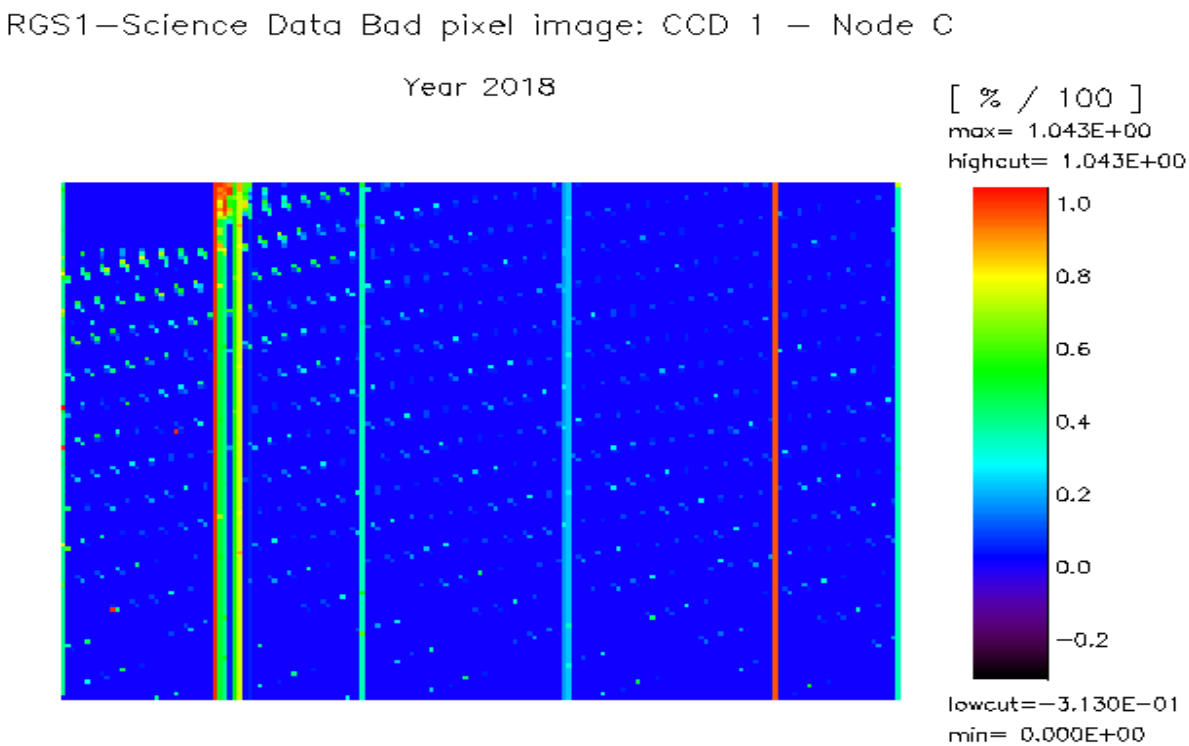

Figure 11: RGS1 - CCD1 - C science bad pixel map. The vertically extended uploaded mask has helped a lot against spurious “hot columns”, while on the right side there are still some.

2.3 Conclusions

After the analysis of the diagnostic data and hot stuff from the 2018, we conclude in following recommendations:

- It is not necessary to release a new RGS1_ADUCONV CCF, containing an update of the average offset values per CCD and node, since the evolution of the Offsets has stabilised and the differences between the numbers quoted in that file and the actual levels are less than 5%.
- The necessity of extended masking both for the C and D side of RGS1 CCD1 has been addressed by updating the hot stuff table on board. The new table is operational as of the 15th of March. 2019.
- Routine monitoring should continue, and a full analysis should be repeated at the end of 2019, to confirm the effectiveness of the last point, and to react to any changes which may occur.