

XMM-Newton Technical Note

XMM-CAL-TN-0209

RGS Diagnostic Trend Analysis Report - 2015-2016

C. Gabriel

January 23, 2017



1 Introduction

The purpose of this note is to report 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, while node D continues showing a stable trend despite a slight increase of around 1% in the last 300 revolutions, especially shown by CCD 1 (see figure 2). In average, the variation shown by the data from the C node in the last 500 revolutions has been around 8% in everyone of the 8 CCDs. There is no clear explanation for this issue 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. Probably this is caused by the readout electronics used by all CCDs on that side. Nevertheless, no impact in the quality of the RGS science products has been noticed.

A detailed look of the data corresponding to the last 4 years (3) shows the clear and parallel decrease of all offset values shortly before the end of 2015, continuing almost over the whole period reported here of the years 2015 and 2016. It has already been mentioned in the former hot stuff report from May 2005 and also in the CCF release notes addressing the new calibration file RGS1_ADUCONV_0027 (<http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0342-1-1.pdf>), containing updated mean offset values due to this decrease. If we zoom further into the last 100 revolutions (see Fig.4) we can conclude that the decrease seems to have stopped, or at least to become almost not noticeable anymore in the 3 months.

¹http://xmm.esac.esa.int/xmmdoc/internal/int_cal_instr_suppl/rgs/monitoring.php

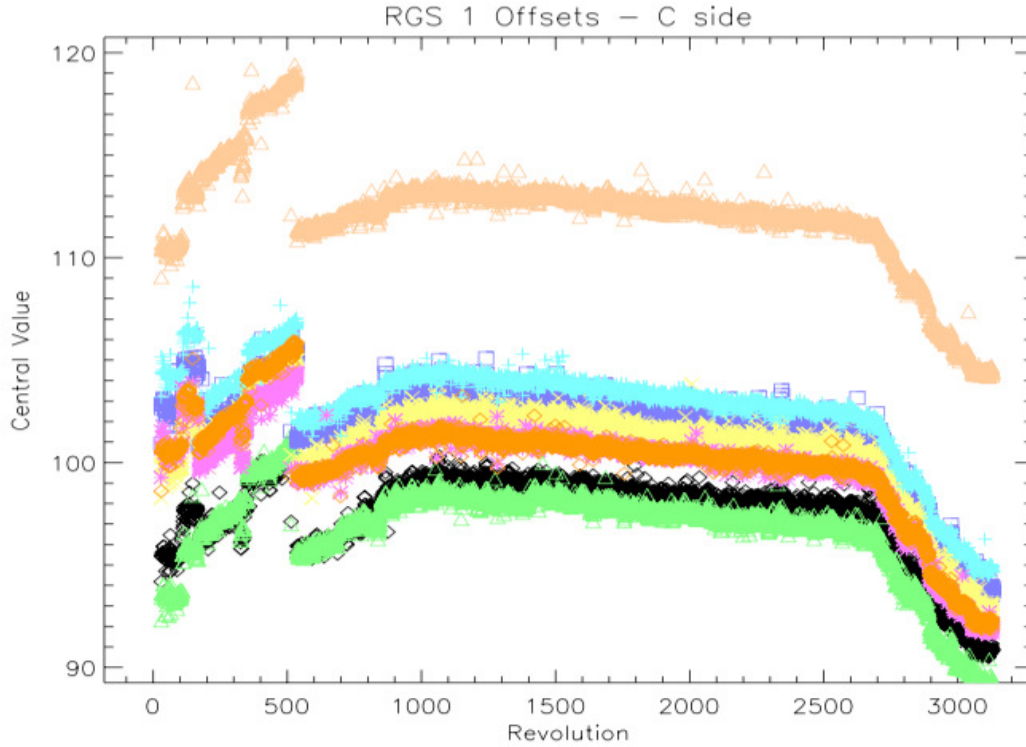


Figure 1: RGS1 - system peak evolution of node C data. Different colors represent the eight RGS1 working CCDs.

RGS2 offsets show the expected stable trend, with no significant evolution, again with variations averaging within the 3% range compared to last CCF, as shown by Figs.5. We recall that there 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 evolution 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 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. 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 ADU CONV file.

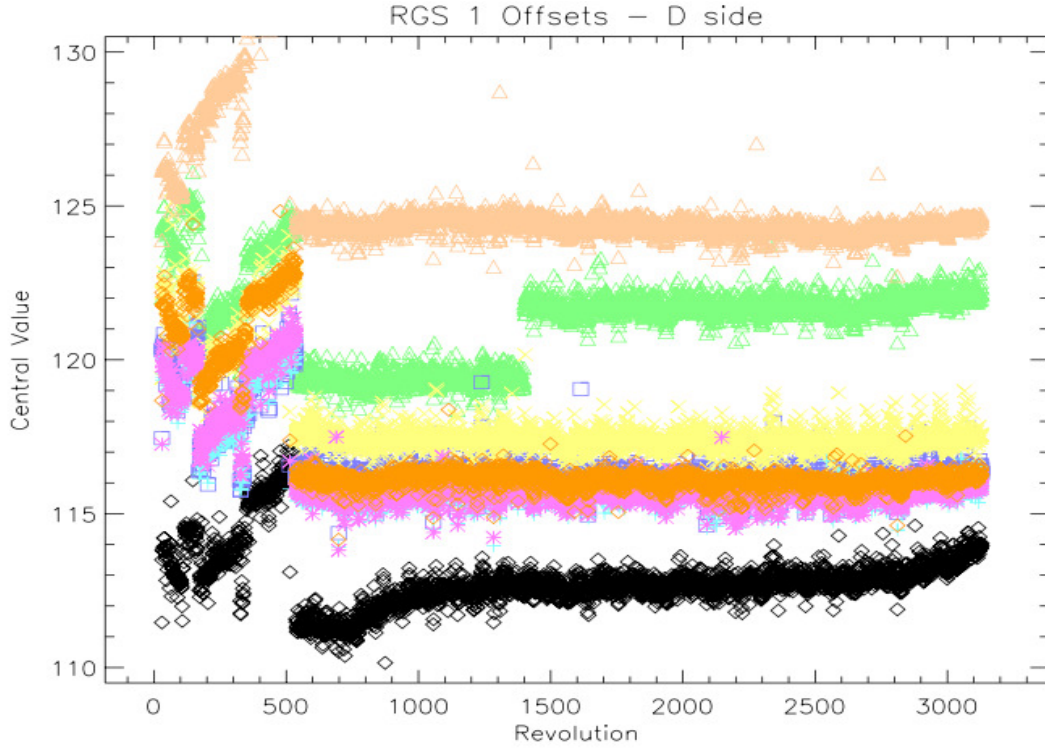


Figure 2: RGS1 - system peak evolution of node D data. Different colors represent the eight RGS1 working CCDs.

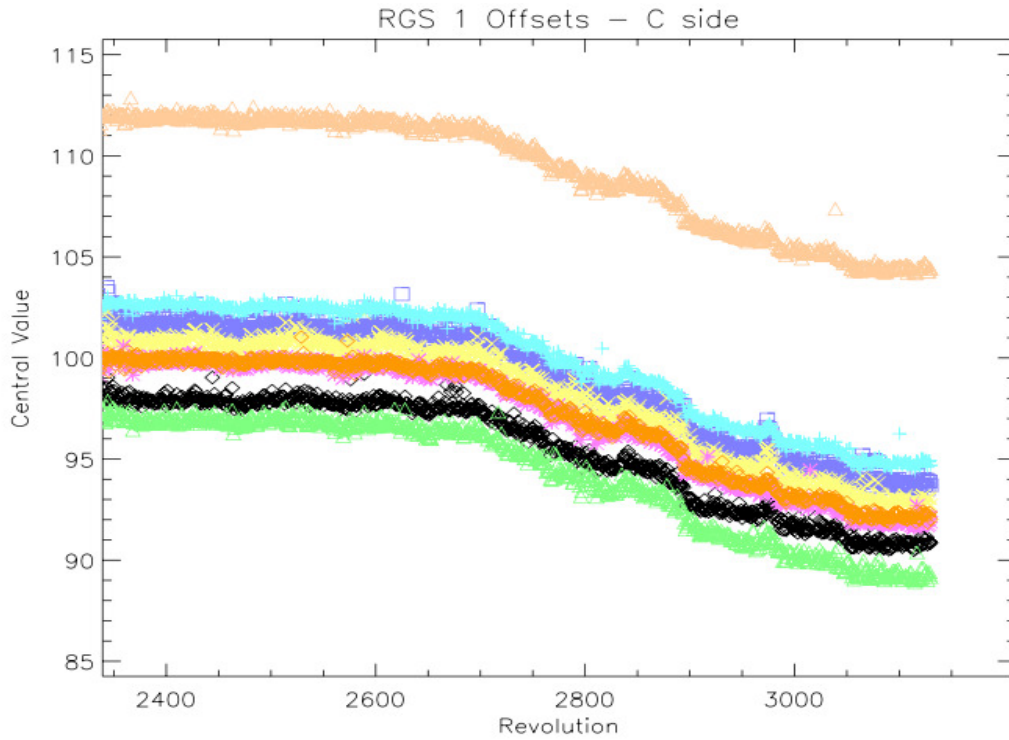


Figure 3: RGS1 - system peak evolution of node C data in the last 800 revolutions

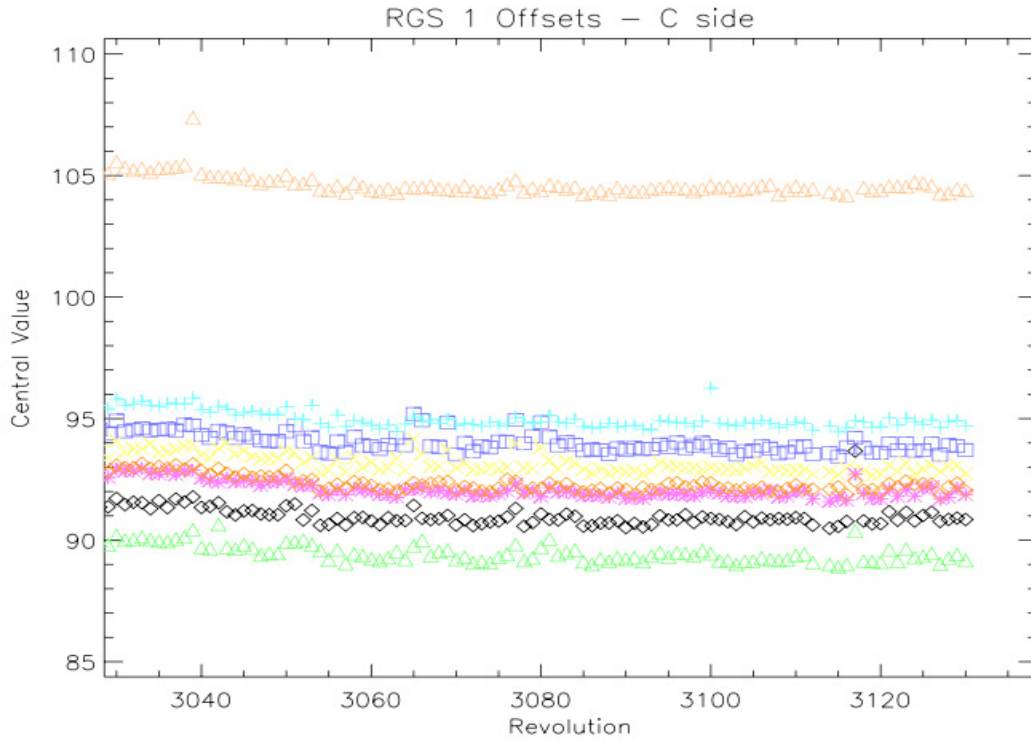


Figure 4: RGS1 - system peak evolution of node C data in the last 100 revolutions.

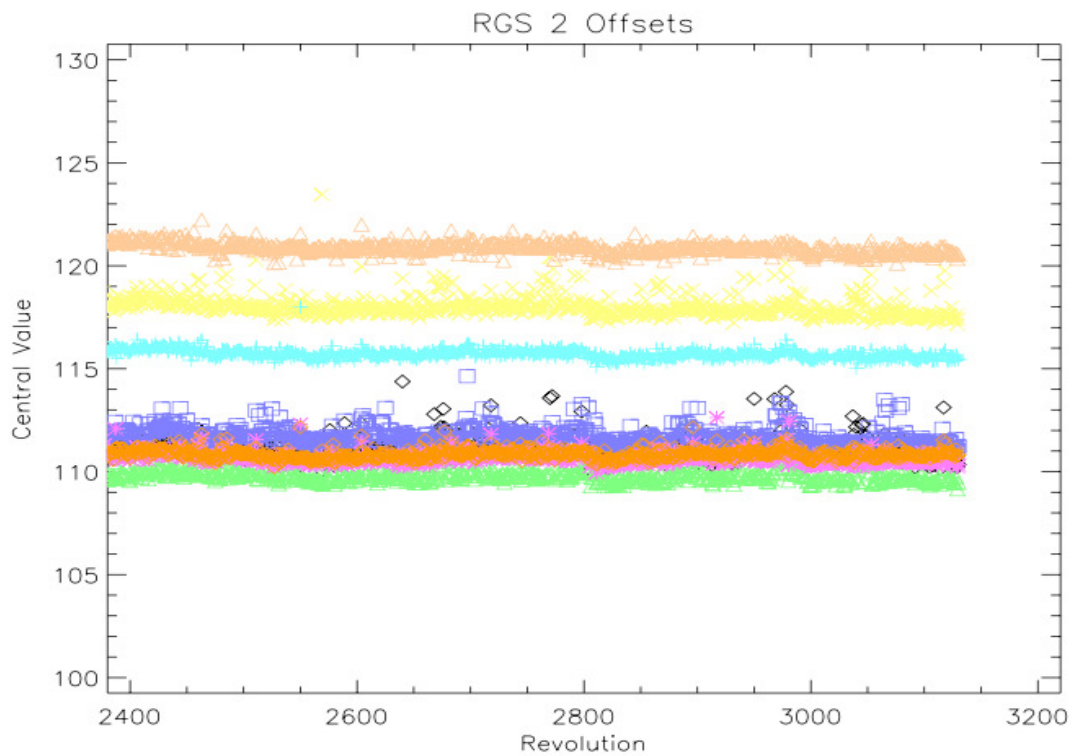


Figure 5: RGS2 - system peak evolution in the last 100 revolutions.

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-226²). Actually the diagnostic data does not show any increase of hot columns in the last 5 years. There are 2 persistent hot columns, one in each RGS (RGS1-CCD1-D38 and RGS2-CCD9-C94), as well as the hot spots, reported in the same CCF release note. The diagnostic bad pixel maps in Fig.6 show the 2016 collected data corresponding to RGS1 CCD1.

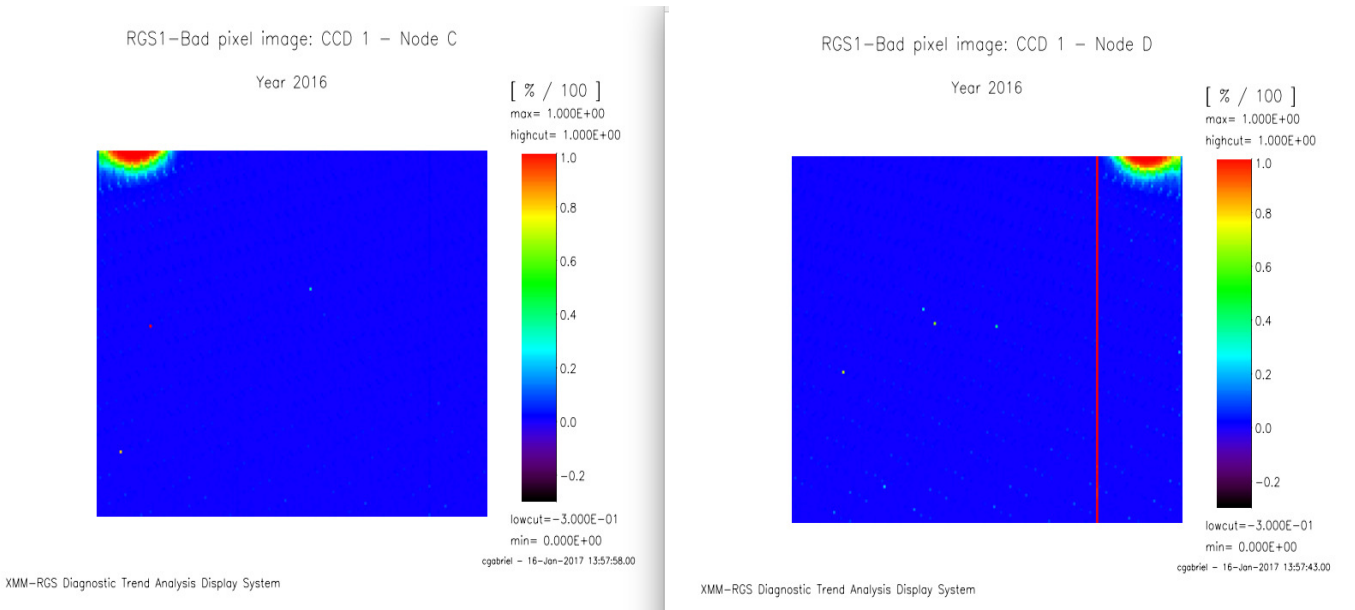


Figure 6: RGS1 - CCD1 C and D bad pixel maps showing the two “hot spots” and the only hot column found in RGS1 in the diagnostic data (column 38 on the D side) corresponding to the data taken in 2016.

The other permanent hot column detected in the diagnostic data (RGS1-CCD9-C94) is further detected as hot 100% of the time during 2016, as revealed in the corresponding bad pixel map (Fig.7).

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 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.8), 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 increase in the last two years.

²<http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0226-1-0.ps.gz>

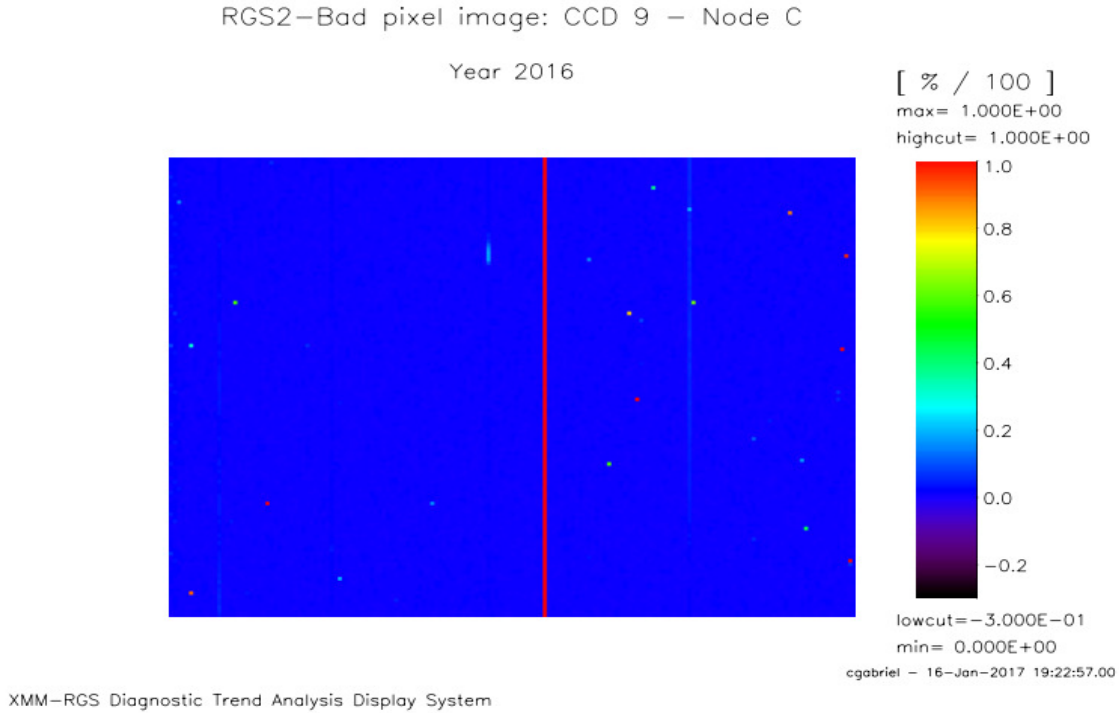


Figure 7: RGS2 - CCD9 C bad pixel maps showing the only hot column detected in the RGS2 Data.

A closer analysis reveals 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 the years 2015 and 2016 (Fig.9), show that the number of “hot columns” below the “hot spot” on the C side has dramatically decreased. Furthermore, if we restrict the map to the period mid May-December 2016 (see Fig.10), we see that after the upload of a larger masked region on the C side happened on 11 May 2016 (the corresponding CCF release note is <http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0334-1-0.pdf>) there are no visible hot columns anymore below the “hot spot”. There is however a column (#32) found hot almost all the time (96% in the whole year) which we can clearly attribute to the hot spot expanding to the side. This is calling for a larger mask in the horizontal direction to avoid the fake hot column.

The explanation of the further increase of the total RGS1 “hot stuff” in 2016 observed in Fig.8 despite this reduction on the C side is given by the evolution on the other side of the detector, the D side. A comparison between the corresponding maps in 2015 and 2016 (Fig.11) shows the rapidly increasing number of columns seen as ‘hot’ below the “hot spot” on that side, including a horizontal expansion. We have to conclude that here it is also now necessary to expand the masking region, both in the vertical direction doubling its size from 8 to 16, as done last year with the C side, as also in the horizontal direction, extending it by say 8 further rows, as it should be also done with the C side. It should be followed by the issue of a corresponding new CCF BADPIX file for RGS1.

No further changes can be observed in the data of 2015 and 2016 with respect to the former years, which would justify changing the number of advisory hot columns.

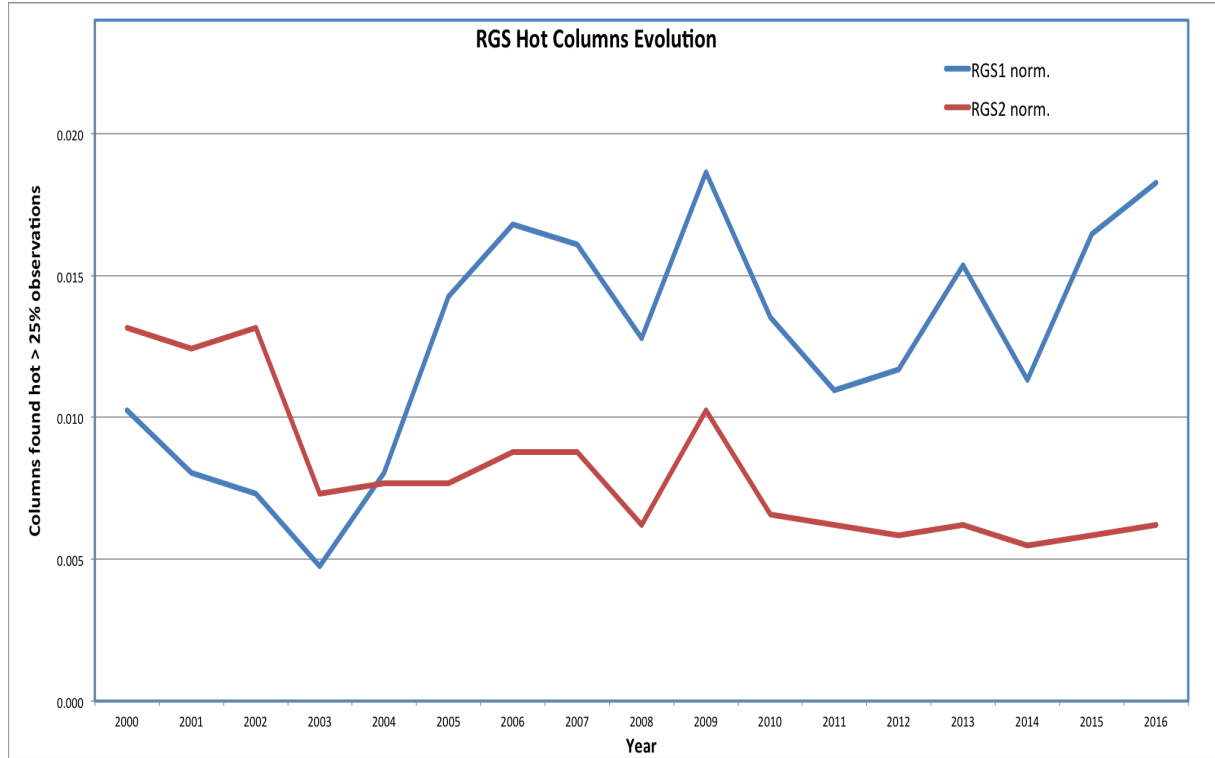


Figure 8: Hot columns found hot in more than 25% of the observations. The numbers are normalized to the total number of columns

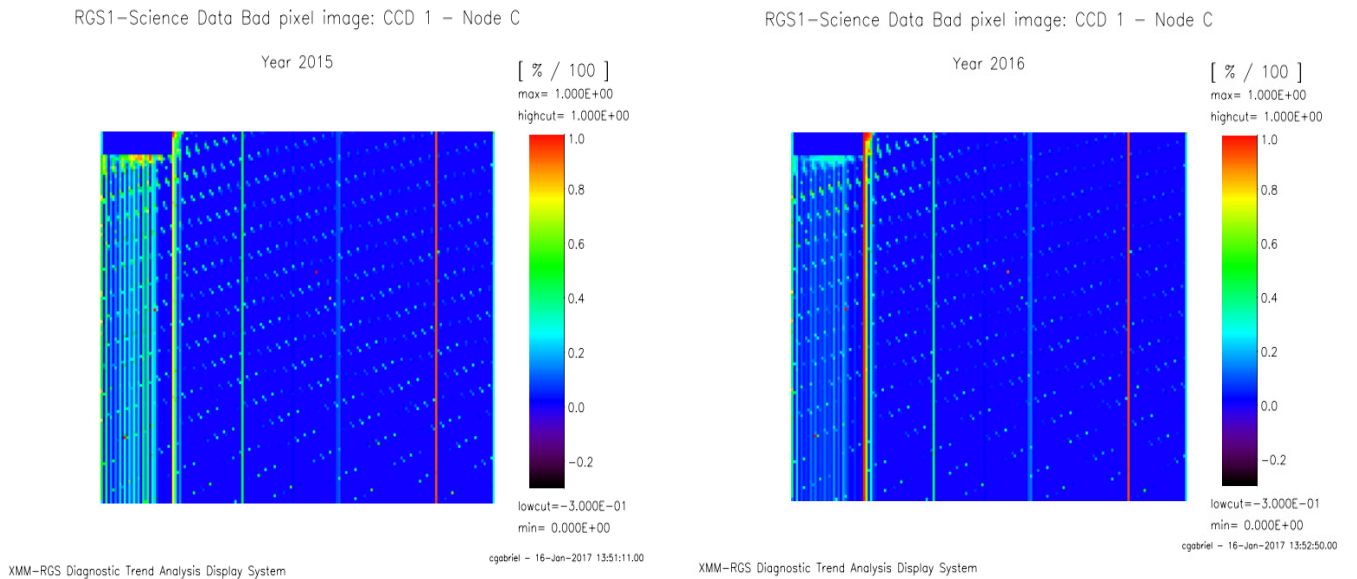
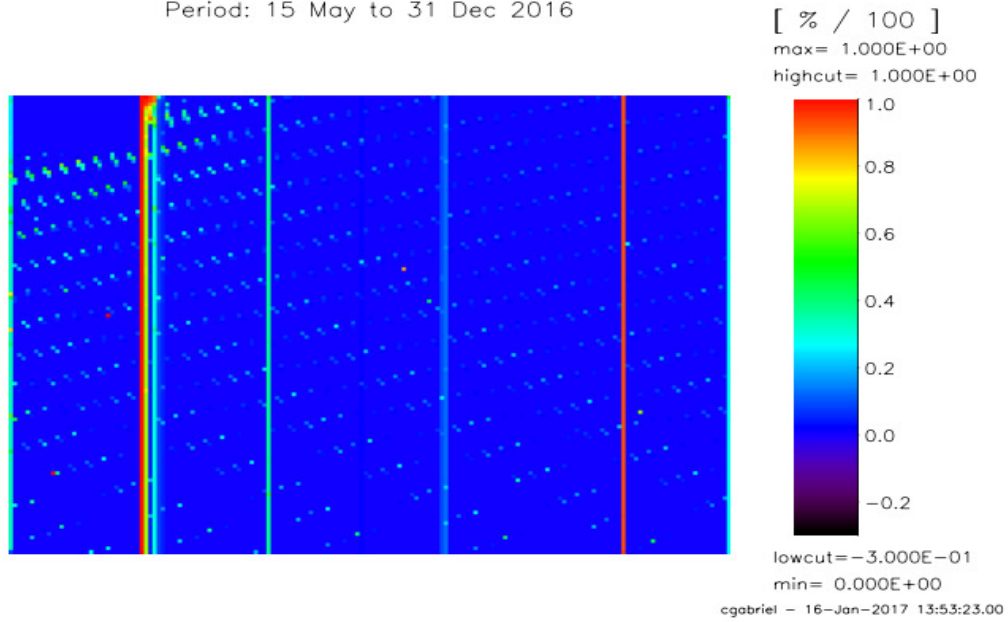


Figure 9: RGS1 - CCD1 C science bad pixel maps corresponding to data from 2015 on the left and 2016 on the right.



RGS1—Science Data Bad pixel image: CCD 1 — Node C

Period: 15 May to 31 Dec 2016

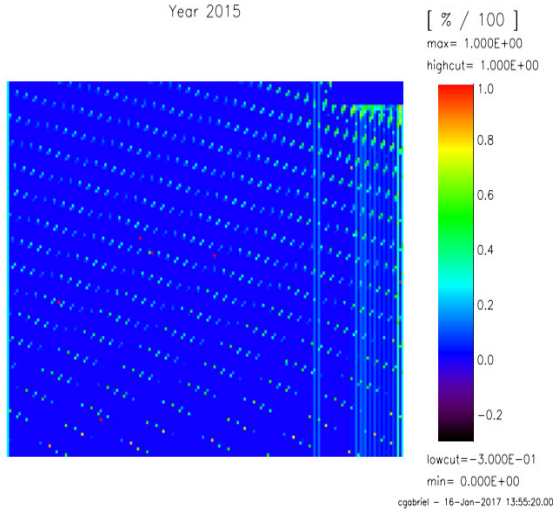


XMM—RGS Diagnostic Trend Analysis Display System

Figure 10: RGS1 - CCD1 C science bad pixel maps corresponding to data from mid May to December 2016.

RGS1—Science Data Bad pixel image: CCD 1 — Node D

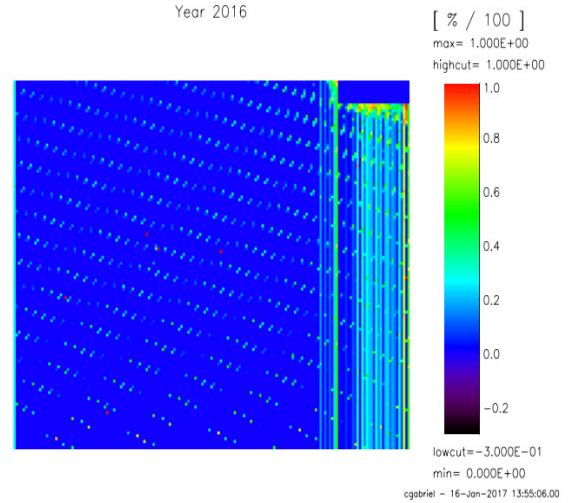
Year 2015



XMM—RGS Diagnostic Trend Analysis Display System

RGS1—Science Data Bad pixel image: CCD 1 — Node D

Year 2016



XMM—RGS Diagnostic Trend Analysis Display System

Figure 11: RGS1 - CCD1 D readout side science bad pixel maps corresponding to data from 2015 on the left and 2016 on the right.



2.3 Conclusions

After the analysis of the diagnostic data and hot stuff from the two years 2015 and 2016, we conclude in following recommendations:

- a new RGS1_ADU CONV CCF should be released, containing an update of the average offset values per CCD and node, with the stable values on the C side, as seen in the last year. They are in average around 4% below the values used for RGS1_ADU CONV_0027.CCF.
- extended masking both for the C and D side of RGS1 CCD1 should be uploaded, to cover completely the “hot spots”, which have grown up in the last years. On the C side only adding 8 columns to the right, since the horizontal extension has taken place already, on the D side both on the horizontal, extending it from 8 rows to 16, and to the left also by 8 columns.
- routine monitoring should continue, and a full analysis should be repeated at the end of 2017, to see how effective these measures have been.