XMM-Newton CCF Release Note

XMM-CCF-REL-328

Update of the RGS to EPIC-pn Rectification Factors

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1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
RGS1_EFFAREACORR_0010.CCF	2000-01-01T00:00:00	–	RECTIFICATION	NO
RGS2_EFFAREACORR_0010.CCF	2000-01-01T00:00:00	–	RECTIFICATION	NO

2 Introduction

The RGS to EPIC-pn rectification factors were first implemented in December 2010, with the purpose of evaluating, and eventually correcting, the systematic differences between the fluxes from the three instruments, in particular longward the O edge (i.e. at energies below 0.5 keV).

A detailed description of the method followed to derive these factors and a discussion of the results can be found in [1]. This correction was implemented into a new extension of the EFFAREACORR CCF as a step function, with different constant values shortward/longward 23.5 Å, except for the range between 6 and 7 Å in which a linear function was used (see [2]).

Since this correction was first derived, SAS has evolved, and several aspects of the calibration of the instruments have undergone modifications, among others, the EPIC-pn redistribution and PSF, the EPIC-pn and RGS CTI corrections and the RGS contamination model. In the meantime, it has also been found that the annular regions used for the extraction of the EPIC-pn spectra were not optimized for pile-up mitigation, and new regions have been implemented in the XCAL archive. All these changes made necessary to re-evaluate these factors to assess their applicability.

The sample used was the same as in [1], plus a few more data available since then, taken until April 2014 (XMM revolution 2634). Only EPIC-pn observations taken with the Thin and Medium filters were used, as it was found that observations taken with the Thick filter gave systematically discrepant results. The seven available observations of H1426+428 were finally not included due to their lower signal-to-noise ratio. The final sample was then composed of 42 observations, 17 of PKS 2155-304 and 25 of 3C 273, distributed in time over all the mission.

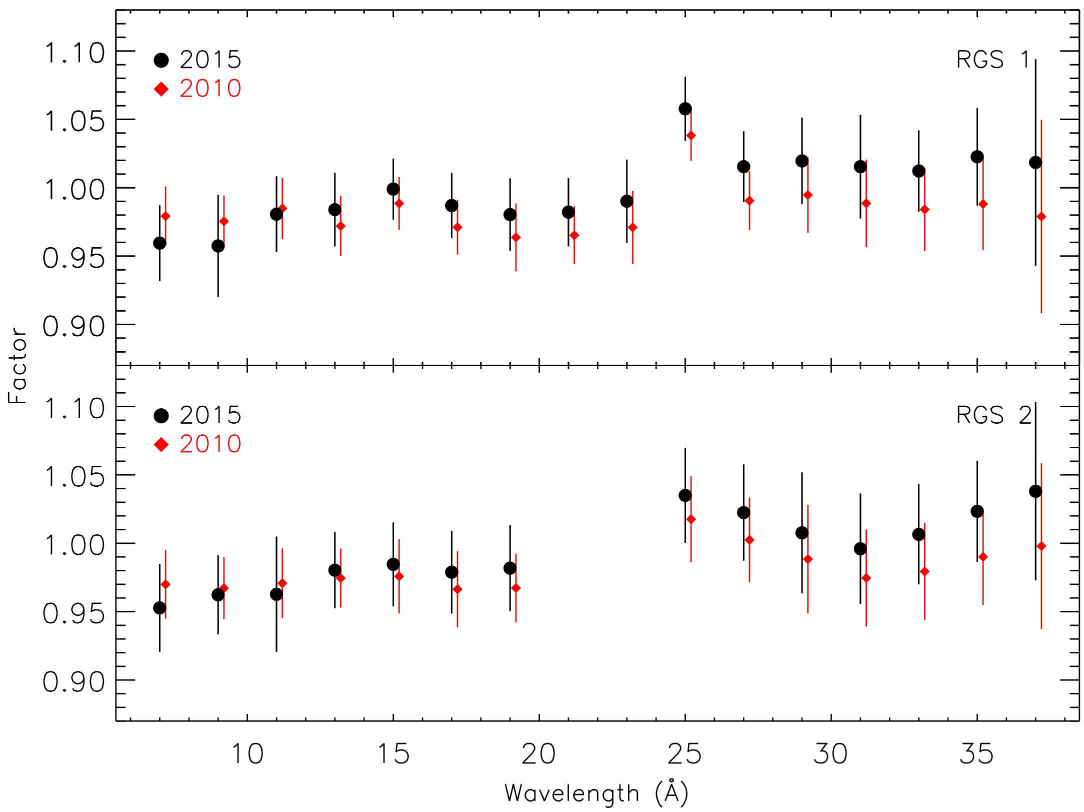

Figure 1: Comparison of the updated rectification factors with the previous ones. The two datasets have been slightly shifted for a better comparison. Error bars represent the rms of each point.

All the data were processed with SASv14.0 using the calibration files available in November 2014. The same GTIs were applied to EPIC-pn and RGS. EPIC-pn spectra were extracted with new optimised annular regions.

The procedure was slightly different from that used for the first derivation, but the results obtained with both methods are within a 0.5% (except for the point at 6 Å, see below). Spectra were binned to 25 cts/channel and then fitted in XSPEC, using Chi square statistics, to the models defined in the XCAL archive with a fixed Hydrogen column density. After a first fit, all parameters were frozen except for scale factors for the RGS spectra. Then fits were performed in 2 Å wide bands, and the rectification factor in that interval was defined as the ratio of RGS to EPIC-pn fluxes. Tests have shown that the use of 1 or 2 Å bins does not affect significantly the final results, therefore the latter was preferred to speed up the process.

Factors were derived with this procedure for every observation. Average rectification factors were derived separately for PKS 2155-304 and for 3C 273, and the final values were obtained as the mean of both, weighted by the number of spectra.

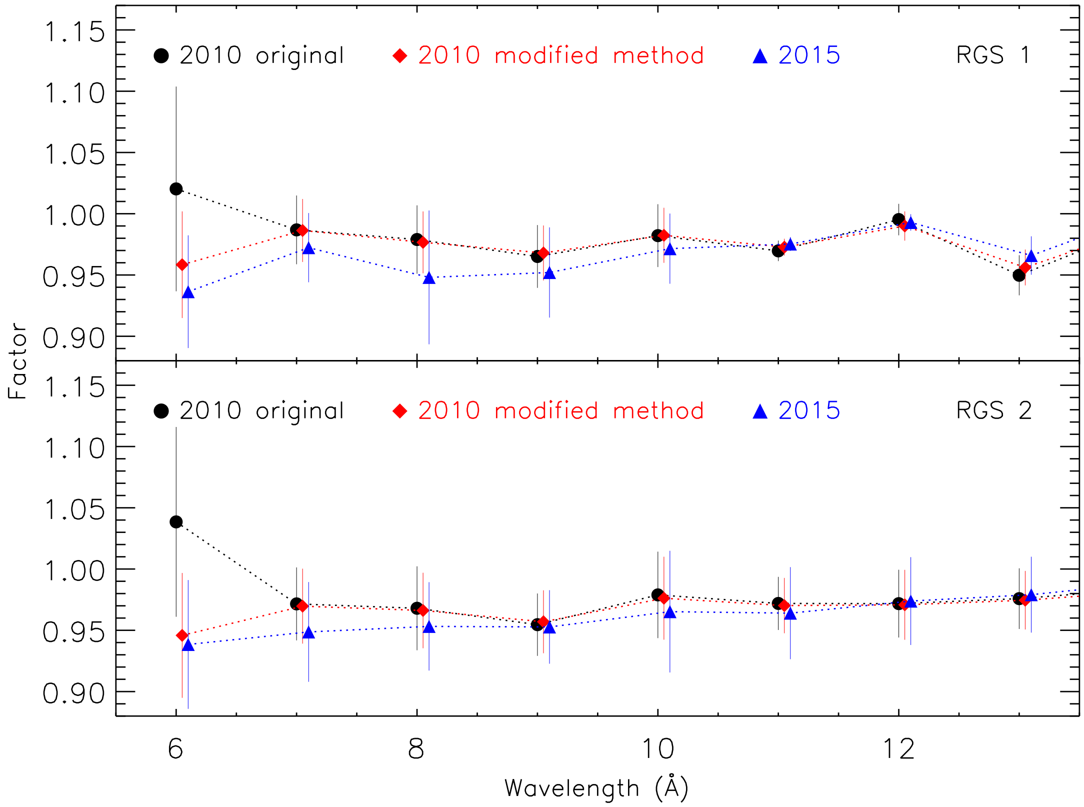

Figure 2: Detail of the rectification factors in 1 Å bins at the shortest wavelengths. The three set of data shown in the plot have been slightly displaced to show better the differences and similarities.

The updated rectification factors are shown in Fig. 1, where they are compared to the values derived in 2010. The new factors are, on average, 2% higher longward 12 Å and $\leq$ 1% at shorter wavelengths.

As mentioned above, in the 2010 derivation, the factors in the interval between 6 and 7 Å were represented as a linearly decreasing function, because the value at 6 Å was found in both RGS systematically higher than the contiguous points. However, this effect does not appear neither in the new derivation, nor when the new method is applied to the 2010 data (see Fig. 2). Therefore, we conclude that the large value was an artifact of the previous computations.

For implementation in the CCF, the new rectification factors have been approximated as:

Table 1: Parameters for CCF implementation

	a	b	c
RGS 1	0.96	1.45 10^{-3}	1.017
RGS 2	0.94	2.49 10^{-3}	1.016

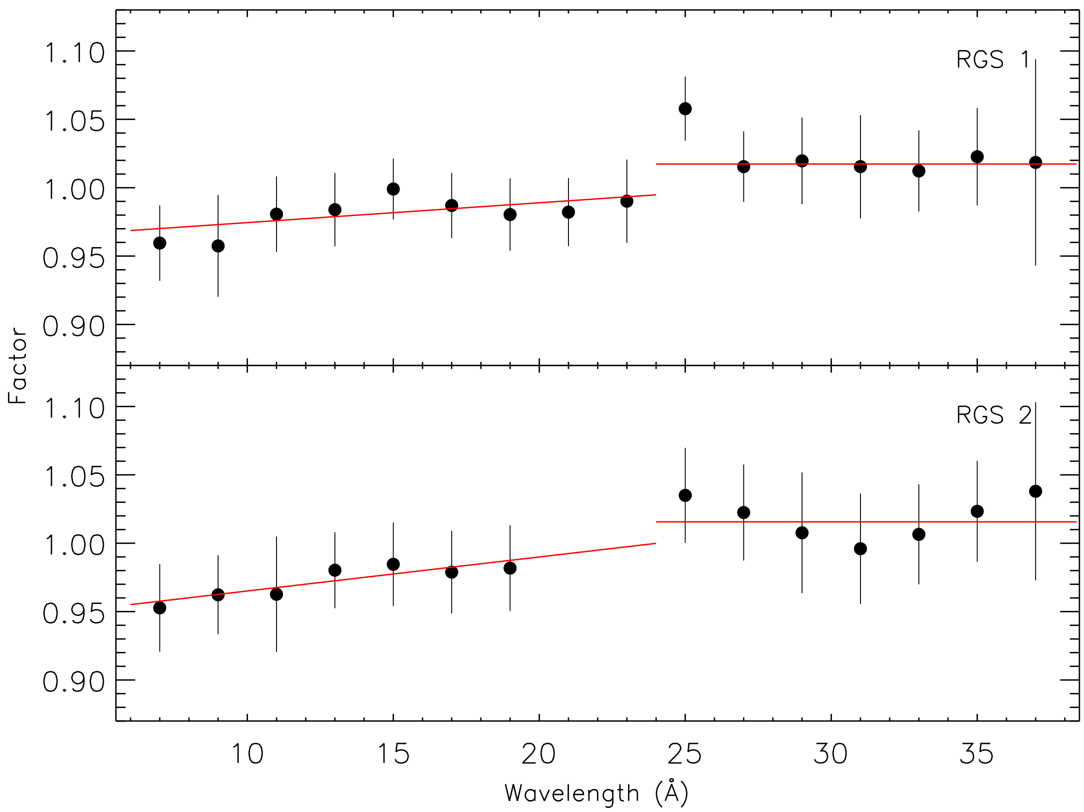

Figure 3: Parametrisation of the new factors. As described in the text, the rectification factors have been parametrised for implementation in the CCF as a linearly increasing function between 6 and 24 Å, and a constant value at longer wavelengths.

For $\lambda \leq 24$ Å: a + b * λ

For $\lambda > 24$ Å: c

with the parameters given in Table 1, see Fig. 3.

3 Scientific Impact of this Update

The application of these factors should correct the systematic differences found between the fluxes obtained from EPIC-pn and from the RGS.

The performance of this correction has been checked by applying it to six observations of H1426+428 that were excluded from the sample used in the computation of the factors. The resulting RGS to EPIC-pn flux ratios are shown in Fig. 4. There is a general improvement in the flux ratios, in the sense that the scatter of the points decreases by 1-2% (i.e. the flux ratios are 'flatter'). This can still be improved in the future by taking into account other potential effects such as e.g. time variability or dependency on the spectral shape.

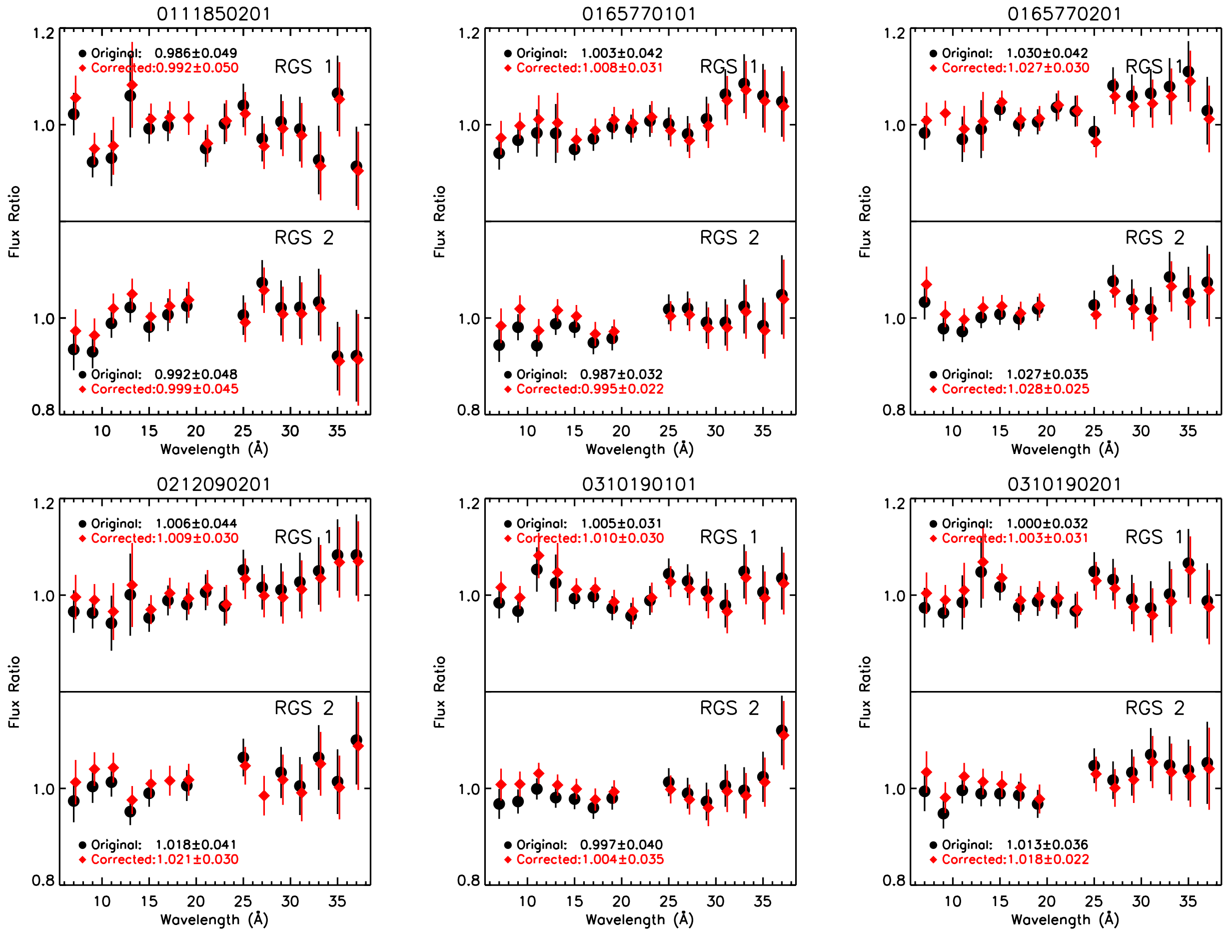

Figure 4: Result of the application of the new correction to six observations of H1426+428.

4 Estimated Scientific Quality

The following points must be taken into account when applying this correction:

- These factors are valid only for the comparison of RGS with EPIC-pn in Small Window mode, with the Thin or Medium filters.
- These factors are applicable only to data processed with SASv14.0, with the CCFs available in November 2014. Any change either in software or in calibration files would imply a re-evaluation of these factors. This would also be the case if the regions used in the extraction of the EPIC-pn spectra are found to be non-optimal for pile-up mitigation.
- There are indications of a steady flux decrease in RGS2 (Kaastra, private communication). This effect has not been taken into account in the determination of these factors.

5 Expected Updates

These factors have been derived for a particular combination of software and calibration files. Any modification of either of them would imply a re-evaluation of the factors or, at minimum, an assessment of their applicability after the changes, e.g., in case a correction is applied to the RGS2 effective area to take into account the observed time evolution.

6 Test procedures

Consistency check:

A consistency check has been done by processing the 42 observations of PKS2155-3014 and 3C273 with the effective area corrected with the new rectification factors. Then, RGS to EPIC-pn flux ratios have been computed and averaged, with the result shown in Fig. 5. The standard deviation of the points is 0.8% and 1.1% for RGS1 and RGS2, respectively.

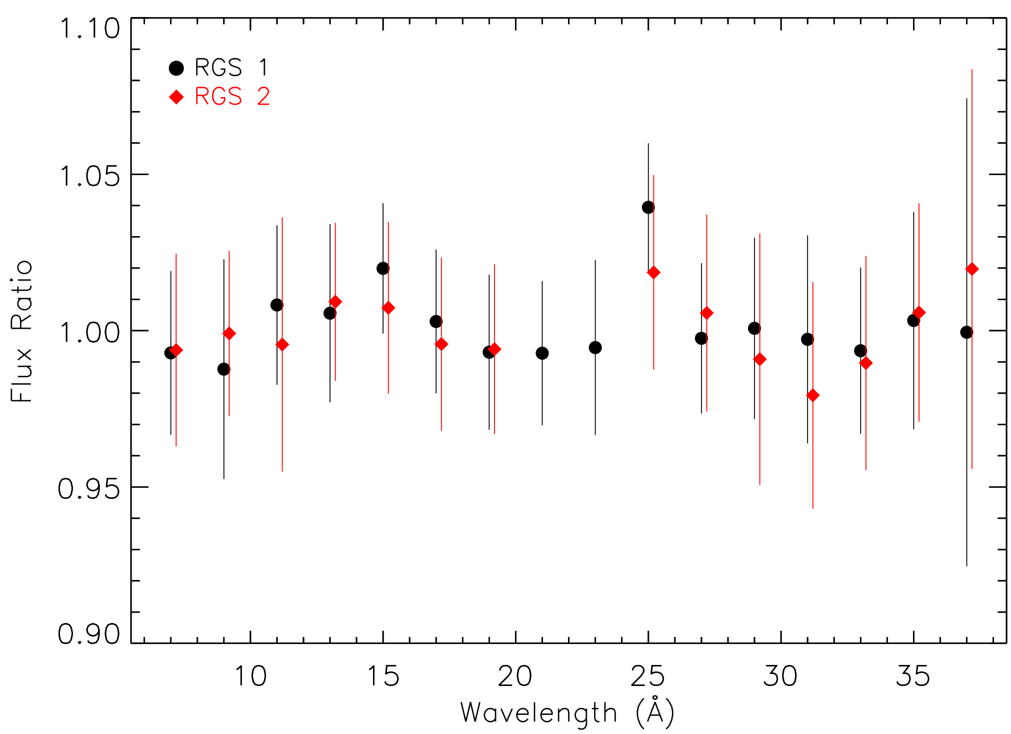

Figure 5: Average flux ratio RGS/EPIC-pn of the observations of PKS2155-3014 and 3C273 processed with the new rectification factors.

General checks:

- use `fv` (or another FITS viewer) for file inspection. It should contain six binary extensions.
- use the SAS task `cifbuild` to see if the CAL digests and creates correctly the calibration index file.

References

[1] Pollock, A. and González-Riestra, R., "An investigation into RGS-pn rectification", May 2010, XMM-SOC-CAL-TN-0089

[2] Pollock, A. and González-Riestra, R., "CCF implementation of RGS-pn rectification", December 2010, XMM-CCF-TN-REL-269