

XMM-Newton CCF Release Note

XMM-CCF-REL-401

Update of the RGS Time-dependent Rectification Correction

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1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
RGS1_EFFAREACORR_0016.CCF	2000-01-01T00:00:00	–	RECTIFICATION	NO
RGS2_EFFAREACORR_0016.CCF	2000-01-01T00:00:00	–	RECTIFICATION	NO

2 Changes

The RGS to EPIC-pn “Rectification Correction” was first implemented in December 2010, with the purpose of evaluating, and eventually correcting, the systematic differences between the fluxes from the three instruments. A detailed description of the method followed to derive these factors and a discussion of the first results can be found in [1]. This correction is implemented into the extension RECTIFICATION of the EFFAREACORR CCF (see [2]).

The rectification factors were updated in 2015 to take into account the changes both in calibration and in the SAS software, and the update of the parameters of the annular regions used to extract the EPIC-pn spectra used to derive this correction ([3]). A second update was done in 2019, introducing then the time dependency ([4]).

The present release extends the observations database until June 2022. The dataset consists of all the available observations of 3C 273 and PKS 2155-304 taken with EPIC-pn in Small Window Mode, including now those taken with the EPIC-pn Thick filter, that were not considered in the previous releases.

Data have been processed with the last update of the Effective Area Correction, as implemented in CCF#15 ([5]).

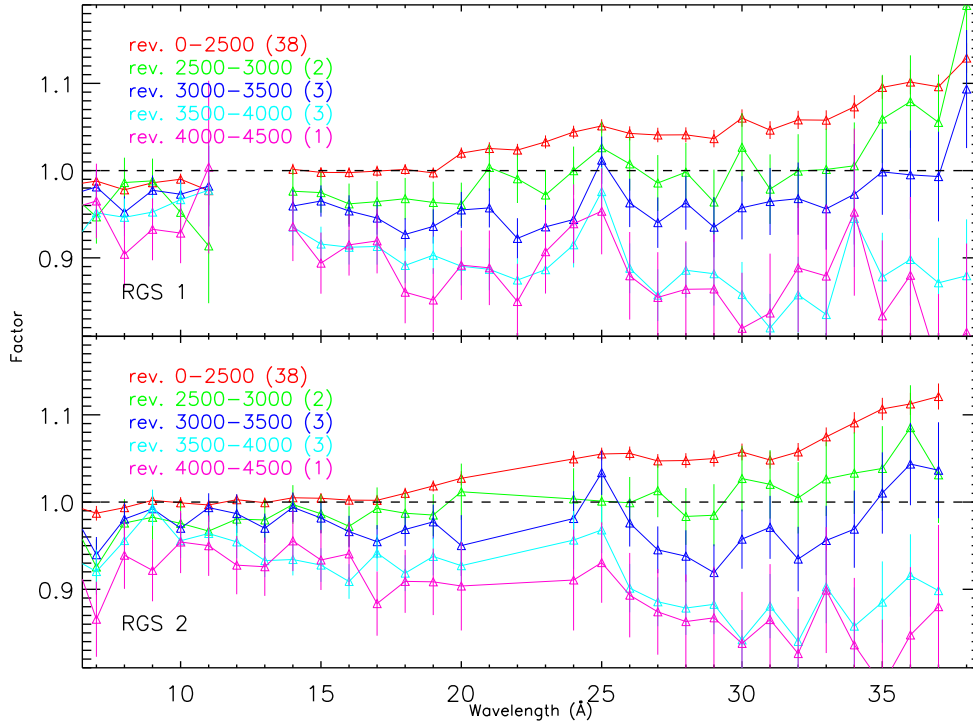
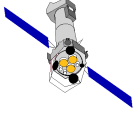


Figure 1: RGS to EPIC-pn flux ratios. Different colors correspond to different ranges of revolutions, as shown in the legend of the plot. Numbers in brackets are the number of observations averaged for each time period.

The RGS spectra are compared to the EPIC-pn best fit model, and flux ratios in bins of 1 \AA are derived. Results are shown in Fig. 1, where the RGS-to-EPIC-pn flux ratios are plotted averaged over different ranges of revolutions.

These ratios have been parametrised assuming that the ratio RGS/EPIC-pn is constant until a given date and starts to decrease linearly afterwards. Three parameters are computed for each wavelength bin: the ratio in the period it is constant, the revolution where the change starts, and the rate of decrease since then. The results are shown in Fig. 2, where the lines are second degree polynomials used to interpolate these parameters in wavelength for implementation in the CCF. This parametrisation is used to derive the values included in the CCF (see Fig. 3). Differences between the values represented in this figure and those in a similar figure in [4] are mostly due to the different set of observations used, though other factors (e.g. the updated Effective Area Correction) may also play a role. The same applies to the the data shown in Fig. 2.

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.

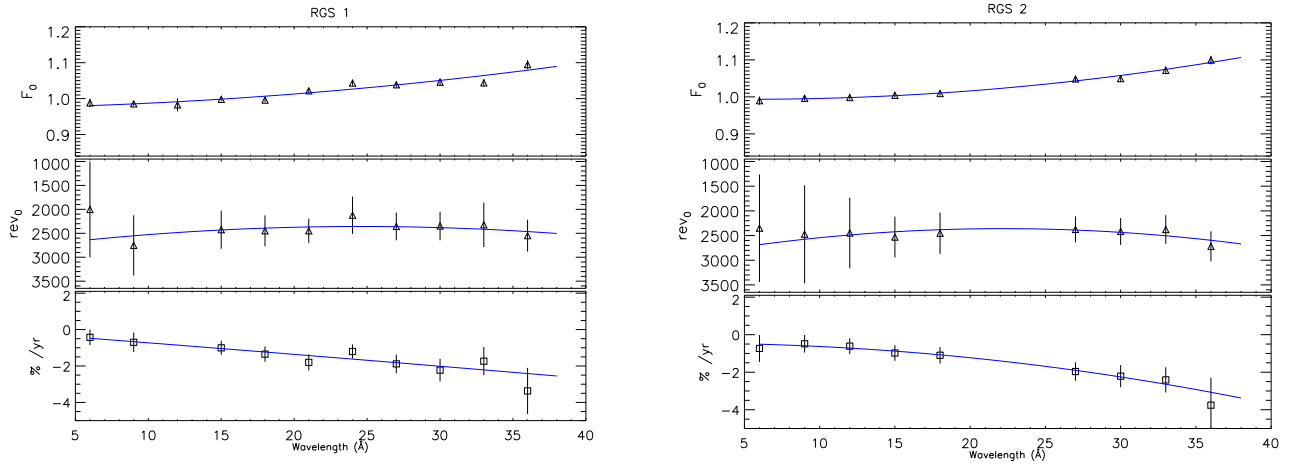
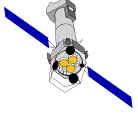


Figure 2: Parametrisation of the Rectification Factors. From top to bottom the three panels show the value of the flux ratio in the period it is constant, the revolution where the ratio starts to change, and the rate of decrease since that revolution, in percent/yr.

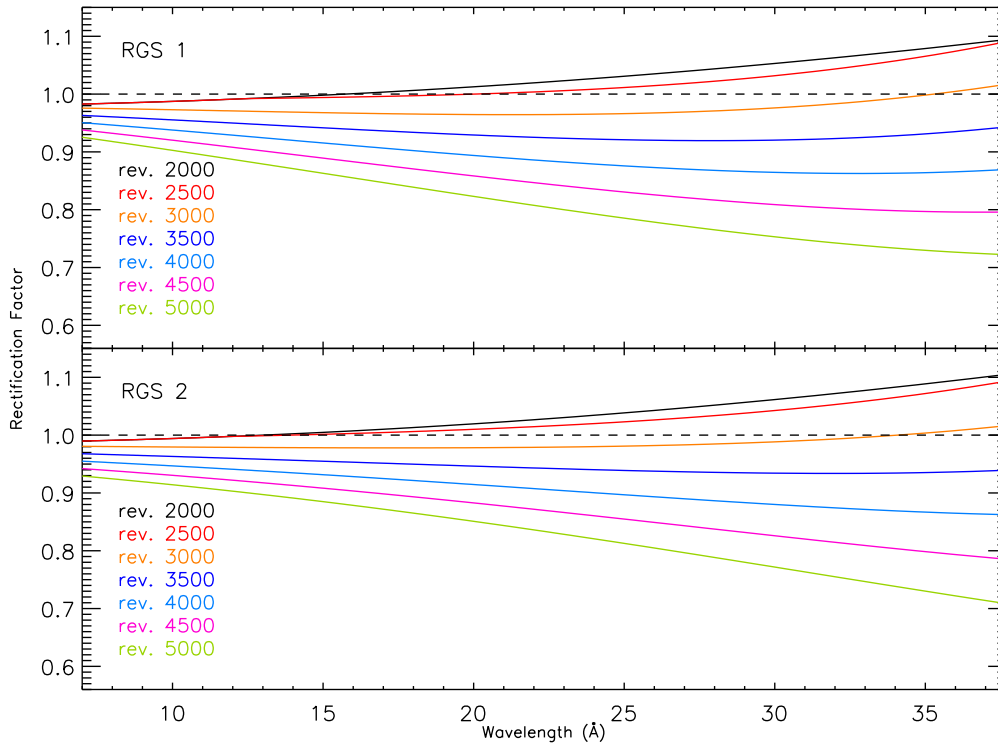


Figure 3: Rectifications Factors as implemented in the CCF.

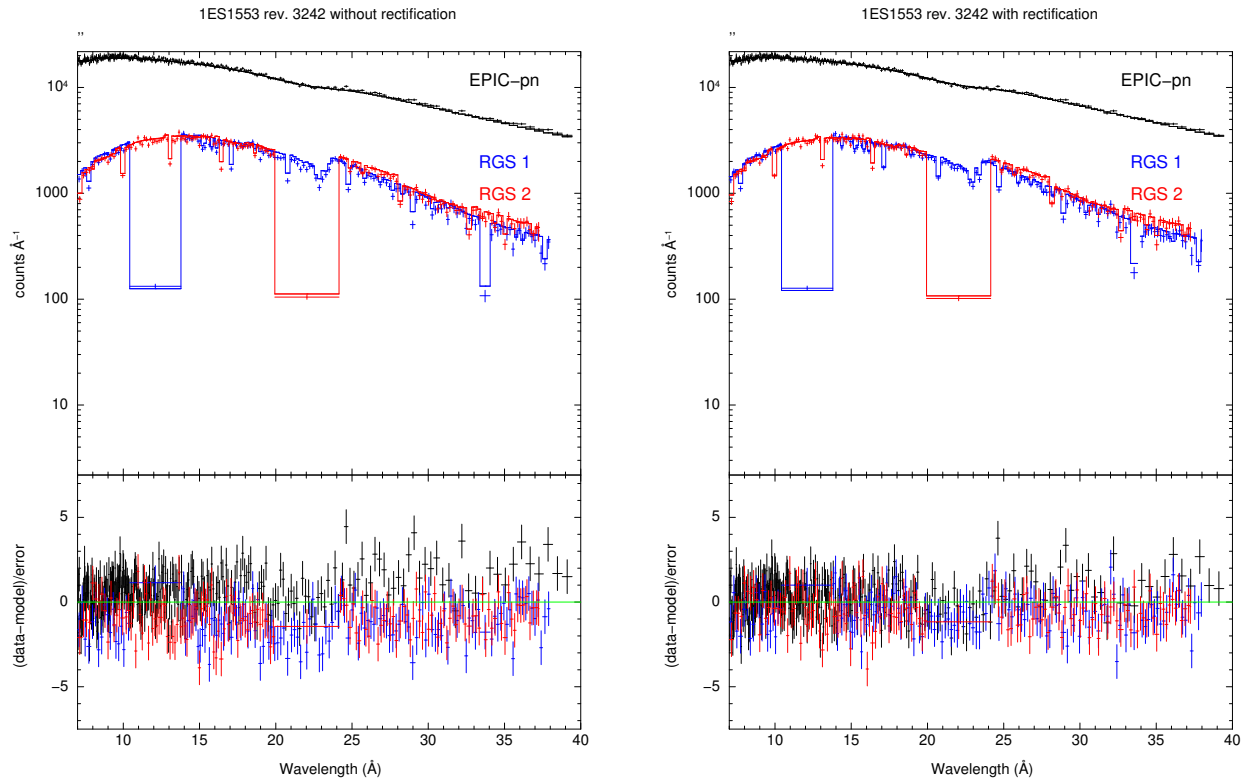
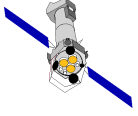
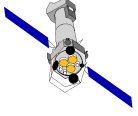


Figure 4: Joint fit to EPIC-pn and RGS data for an observation of the blazar 1ES 1553+513. Left: without correction, right: after application of the updated Rectification Factors.



4 Estimated Scientific Quality

An example of the performance of this correction can be seen in Fig. 4. The left panel shows the result of a joint fit to the three instrument (EPIC-pn, RGS 1 and RGS 2) for an observation of the Blazar 1ES 1553+513, taken in revolution 3242, without applying the Rectification correction. The right panel is similar, but after application of the correction. The improvement in the agreement between the three instruments is clearly visible, with C-statistics decreasing from 6052 to 5562 (for 5458 d.o.f.) after application of the correction.

The application of this correction to RGS data of the Isolated Neutron Star RXJ 1856-3754 (Fig. 5), also leads to a much better agreement with EPIC-pn, showing its applicability to cases with very different spectral shapes.

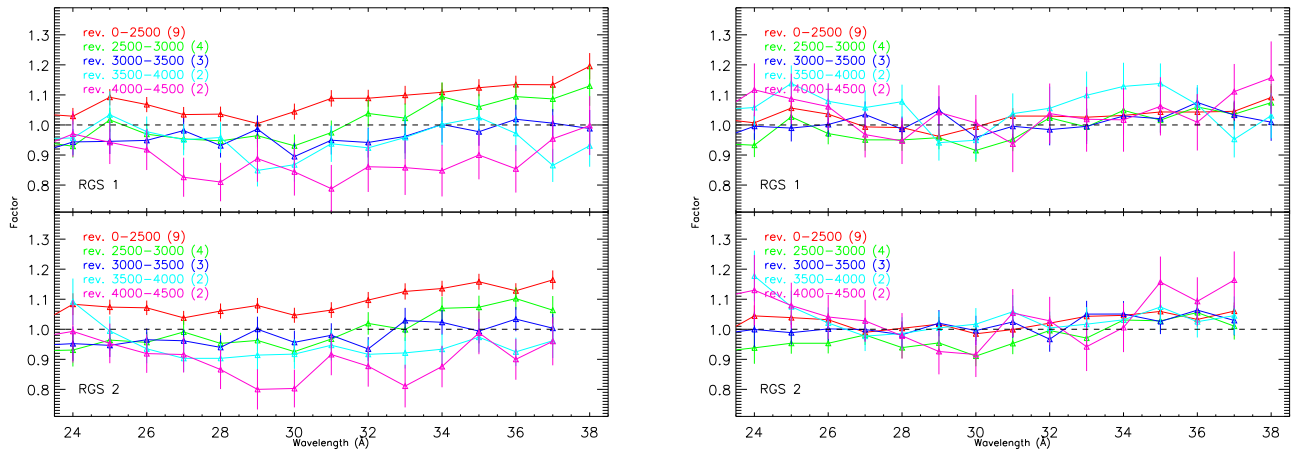


Figure 5: RGS/EPIC-pn flux ratios of the ISN RXJ 1856-3754 before (left) and after (right) application of the Rectification Correction. Different colors correspond to different ranges of revolutions, as shown in the legend of the plot. Numbers in brackets are the number of observations averaged for each time period.

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

- This correction is applicable only to RGS data corrected for Effective Area changes (default option `witheffectiveareacorrection=yes` in `rgsproc/rgsrmfgen`).
- These factors are valid only for the comparison of RGS with EPIC-pn observations taken in Small Window mode.

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.

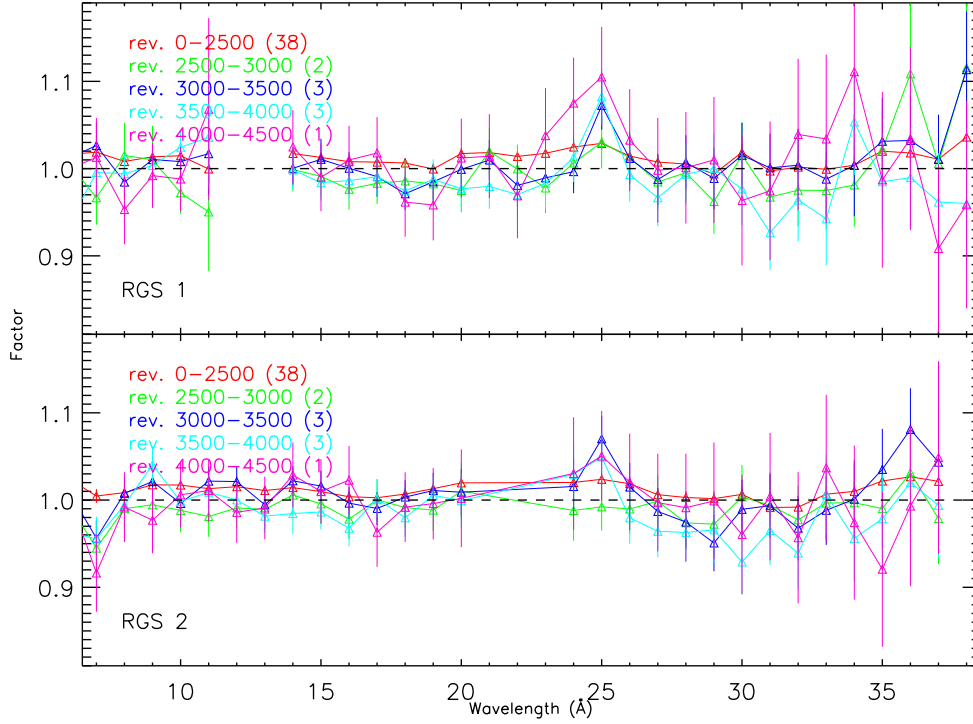
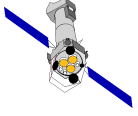


Figure 6: Flux ratios RGS/EPIC-pn of the observations of PKS 2155-304 and 3C 273 after application of the Rectification Correction (compare to Fig. 1).

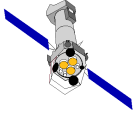
6 Test procedures

Consistency check:

A consistency check has been done by applying the updated Rectification Correction to the observations of PKS 2155-304 and 3C 273. Then, RGS to EPIC-pn flux ratios have been computed and averaged, with the result shown in Fig. 6.

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
- [3] González-Riestra, R. “Update of the RGS to EPIC-pn Rectification Factors”, July 2015, XMM-CCF-TN-REL-328
- [4] González-Riestra, R. “RGS Time-dependent Rectification Factors”, October 2019, XMM-CCF-TN-REL-372
- [5] González-Riestra, R. “Update of the correction to the RGS Effective Area”, April 2023, XMM-CCF-TN-REL-395