

XMM-Newton CCF Release Note

XMM-CCF-REL-418

Update of the RGS Time-dependent Rectification Correction (2025)

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1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
RGS1.EFFAREACORR_0017.CCF	2000-01-01T00:00:00	–	RECTIFICATION	NO
RGS2.EFFAREACORR_0017.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 obtained 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]. The time dependency of these factors was introduced in 2019 (see [3]). This correction is implemented into the extension RECTIFICATION of the EFFAREACORR CCF (see [2]), and it is applied by default in the processing of RGS data starting in SASv22.

The previous update of the rectification factors was done in 2023, and was based on observations of 3C 273 and PKS 2155-304 taken with EPIC-pn in Small Window Mode until June 2022 (see [5]). The present release extends the observational database until January 2025. In addition, a few datasets from early epochs have been added, and the algorithm has been refined (e.g. in the treatment of outliers). All EPIC-pn and RGS data have been processed with SASv22 using the Effective Area Correction described in [4].

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

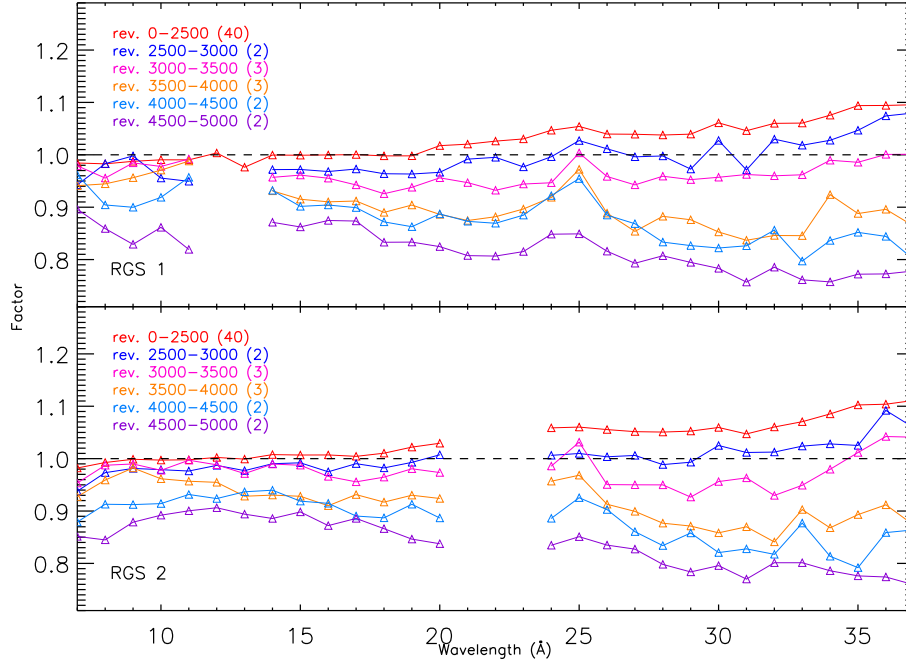
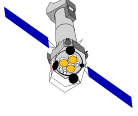


Figure 1: Uncorrected RGS to EPIC-pn flux ratios for the sample of observations of 3C 273 and PKS 2155-304. Different colours correspond to different ranges of revolutions, as shown in the legend of the plot. Numbers in brackets are the number of observations averaged for each period.

The procedure to derive the rectification files is the same as in the previous releases: these flux ratios have been parameterised 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 flux ratio in the period it is constant, the revolution where the change starts, and the rate of decrease since then, as shown in Fig. 2. This parametrisation is used to derive the values included in the CCF (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.

4 Estimated Scientific Quality

An example of the validity 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 4711 (August 2025), without applying the Rectification

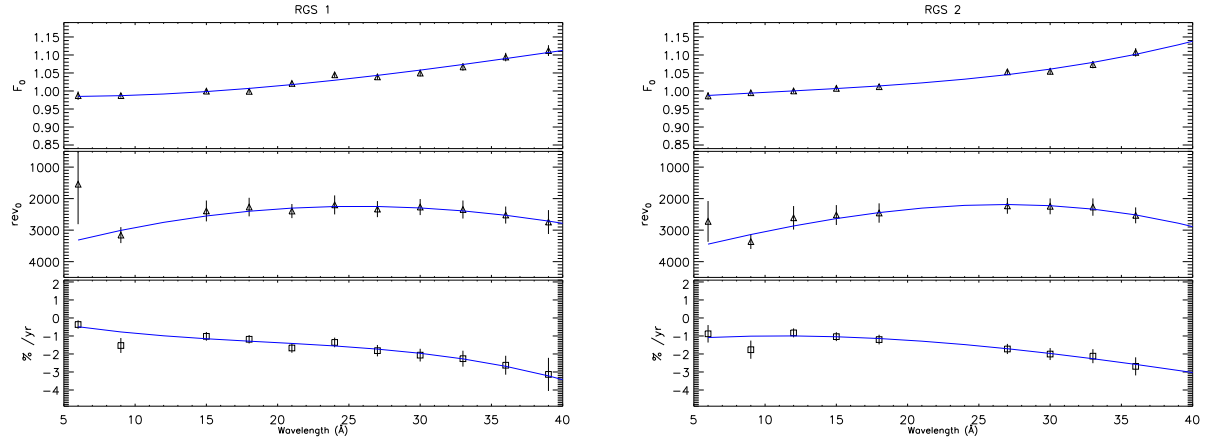
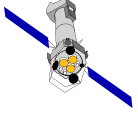


Figure 2: Parametrisation of the Rectification Factors. From top to bottom the three panels show the value of the RGS-to-pn flux ratio until the time the decrease started, the revolution where the flux ratio started to change, and the rate of decrease since that revolution, in percent/yr.

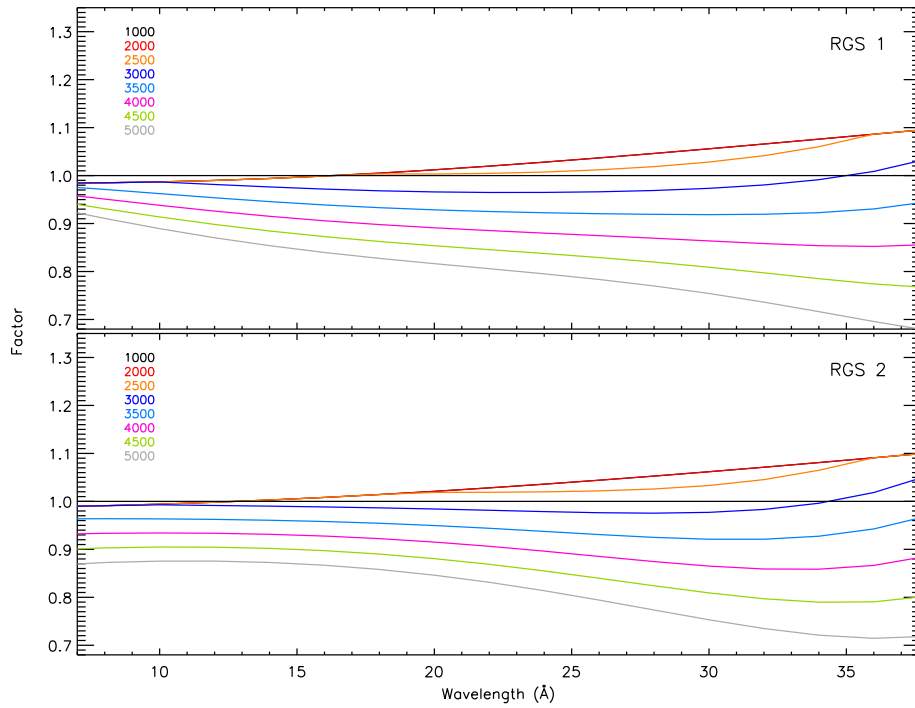


Figure 3: Rectifications Factors as implemented in the new CCF.

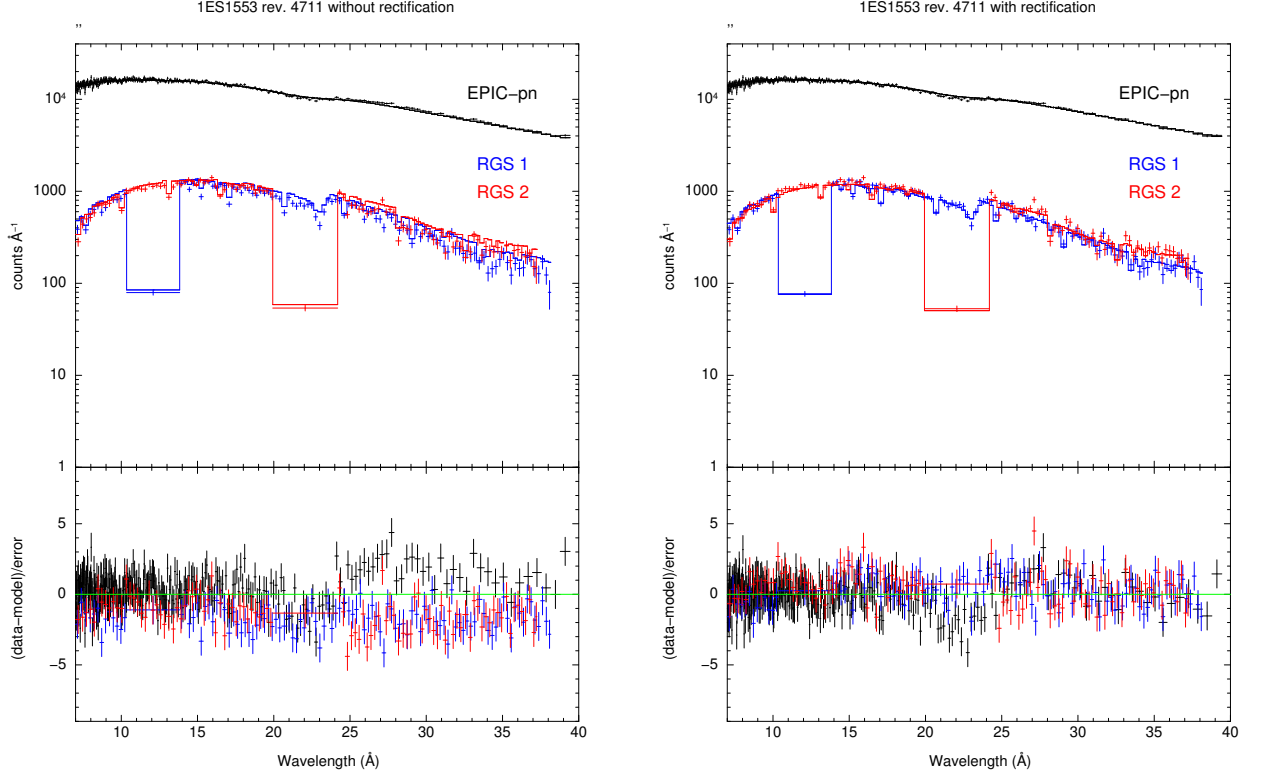
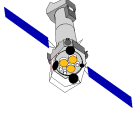


Figure 4: Joint fit to EPIC-pn and RGS data for an observation of the blazar 1ES 1553+513. Left: without correction, right: after application of the updated Rectification Factors.

correction. The right panel is similar, but after application of the correction. The improvement is clearly visible in the plots, with C-statistics decreasing from 6351 to 6059 (for 5518 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 better agreement with EPIC-pn, showing its applicability to cases with very different spectral shapes.

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 formally valid only for the comparison of RGS with EPIC-pn observations taken in Small Window mode.

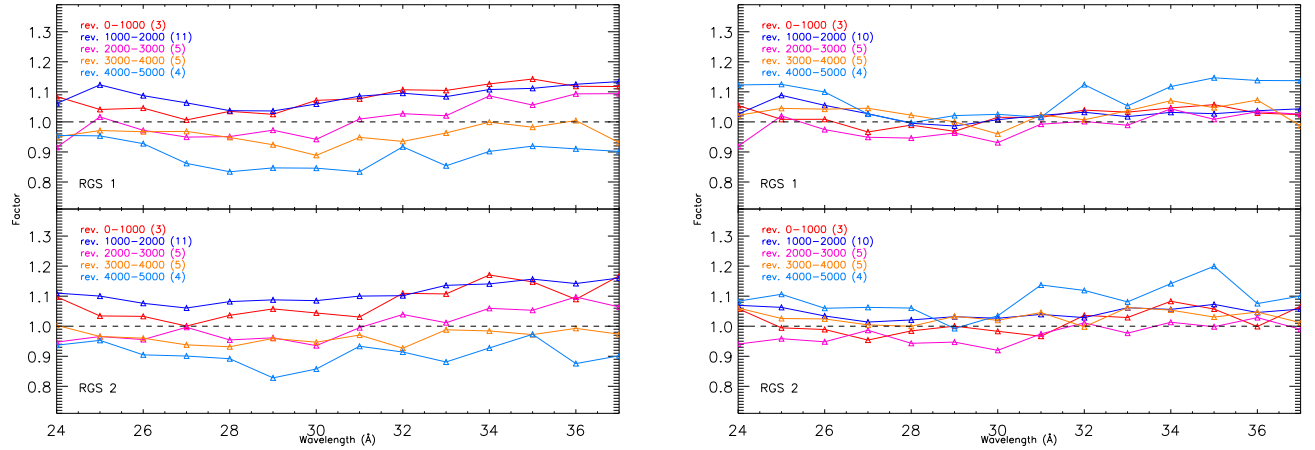
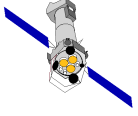


Figure 5: RGS/EPIC-pn flux ratios of the ISN RXJ 1856-3754 before (left) and after (right) application of the Rectification Correction. Different colours correspond to different ranges of revolutions, as shown in the legend of the plot. Numbers in brackets are the number of observations averaged for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

5 Expected Updates

Regular updates are important to characterise accurately the evolution of the correction, and to avoid extrapolations over a long time period.

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.

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.

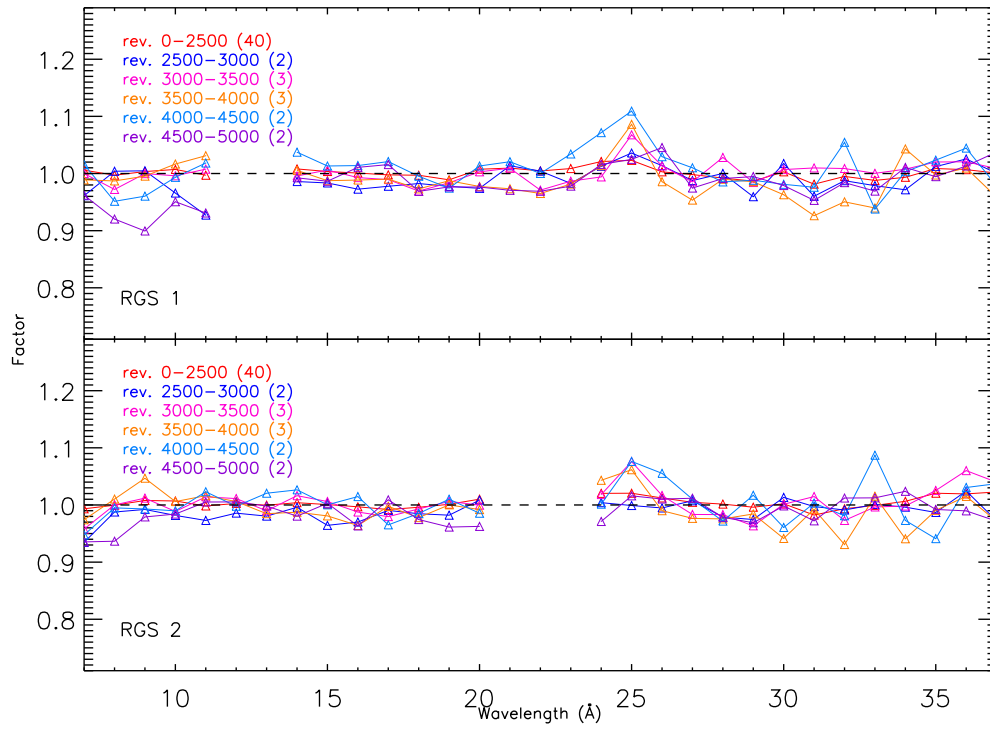
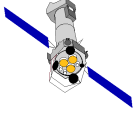
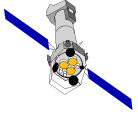


Figure 6: Flux ratios RGS/EPIC-pn for the observations of PKS 2155-304 and 3C 273 after application of the updated Rectification Correction (compare to Fig. 1).



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. “RGS Time-dependent Rectification Factors”, October 2019, XMM-CCF-TN-REL-372
- [4] González-Riestra, R. “Update of the correction to the RGS Effective Area”, April 2023, XMM-CCF-TN-REL-395
- [5] González-Riestra, R. “Update of the RGS Time-dependent Rectification Correction”, September 2023, XMM-CCF-TN-REL-401