XMM-Newton CCF Release Note

XMM-CCF-REL-372

RGS Time-dependent Rectification Factors

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1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
RGS1_EFFAREACORR_0014.CCF	2000-01-01T00:00:00	–	RECTIFICATION	NO
RGS2_EFFAREACORR_0014.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. 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 was implemented into the extension RECTIFICATION of the EFFAREACORR CCF (see [2]).

These 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]).

Evidences for a systematic change in the ratio of RGS1 and RGS2 fluxes, and for a decrease in the (RGS) observed flux of the Isolated Neutron Star RX J1856-3754 led to a revision of the RGS effective area. The first result of that revision was the derivation of a time-dependent correction to bring both instruments in agreement ([4, 5]), implemented in further extensions of the EFFAREACORR CCF ([6, 7, 8]),

This work also led to a full re-assessment of the RGS to EPIC-pn rectification Factors, taking into account the above correction.

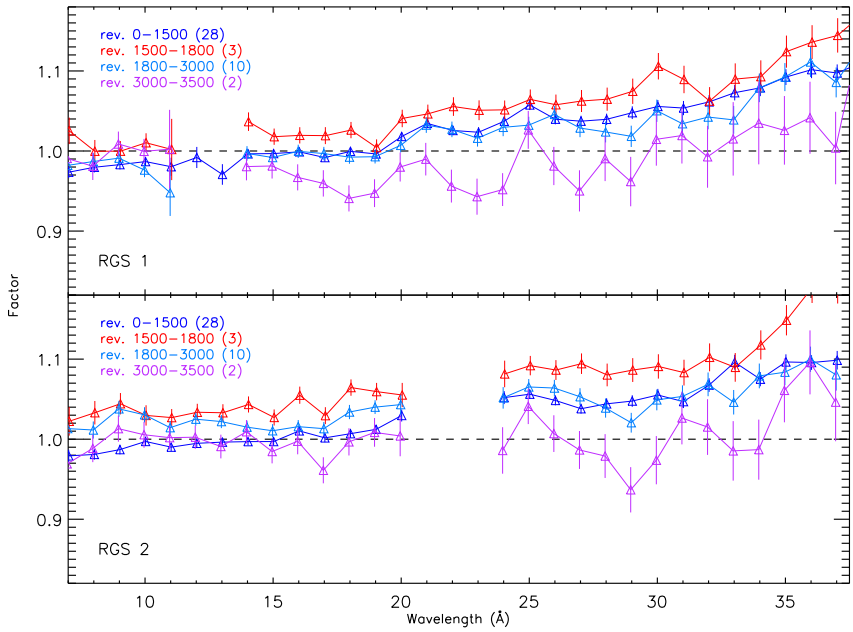

Figure 1: RGS/EPIC-pn flux ratios. Different colors correspond to different ranges of revolutions, as shown in the legend of the plot. Numbers in brackets are the number of observations averaged for each time period.

To this purpose, all the available observations of 3C 273 and PKS 2155-304, having EPIC-pn in Small Window Mode with the Thin or Medium filters, were processed using the `rgsproc` option `witheffectiveareacorrection=yes`. Then, the RGS spectra were compared to the EPIC-pn best-fit model, and flux ratios in bins of 1 Å where derived.

Results are shown in Fig. 1, where these flux ratios are plotted averaged over different ranges of revolutions. A time dependence is clearly visible, in particular longward the O edge. Ratios corresponding to observations taken before revolution 2700 (approximately mid 2014) show little difference, while there is a noticeable decrease after that date.

This change has been parametrised assuming that the flux ratio RGS/EPIC-pn has been constant until a given date and has started to decrease linearly afterwards. Then, for each bin, three parameters have been computed: the RGS/EPIC-pn flux ratio during the period it was constant, the revolution where the change started, and the rate of decrease since that revolution up to now. 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.

The updated Rectification Factors, as implemented in the CCF using the parametrisation described above, for some epochs are shown in Fig. 3.

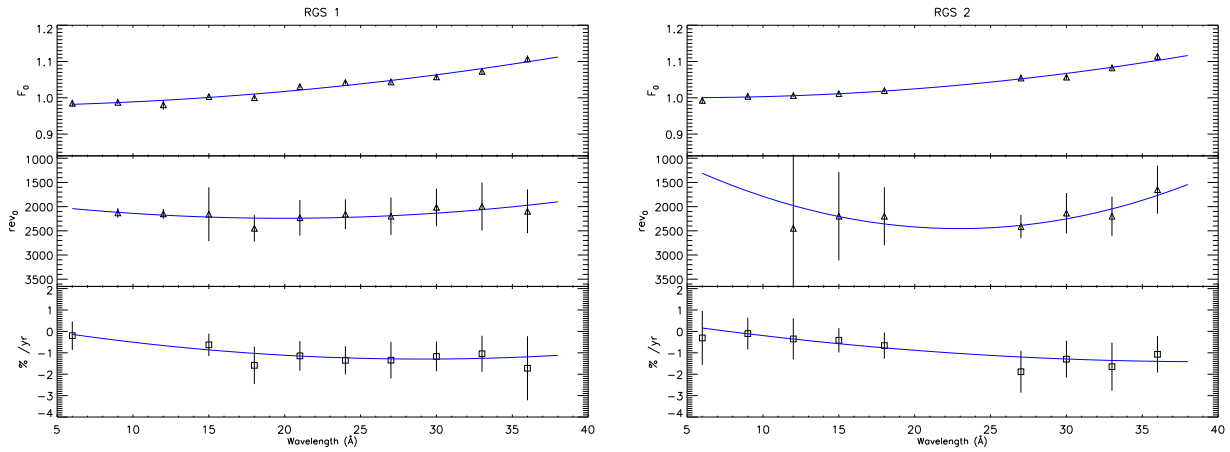

Figure 2: Parametrisation of the Rectification Factors. From top to bottom the three panels show the value of the flux ratio until the time the decrease started, the revolution where the ratio started to change, and the rate of decrease since that revolution, in percent/yr.

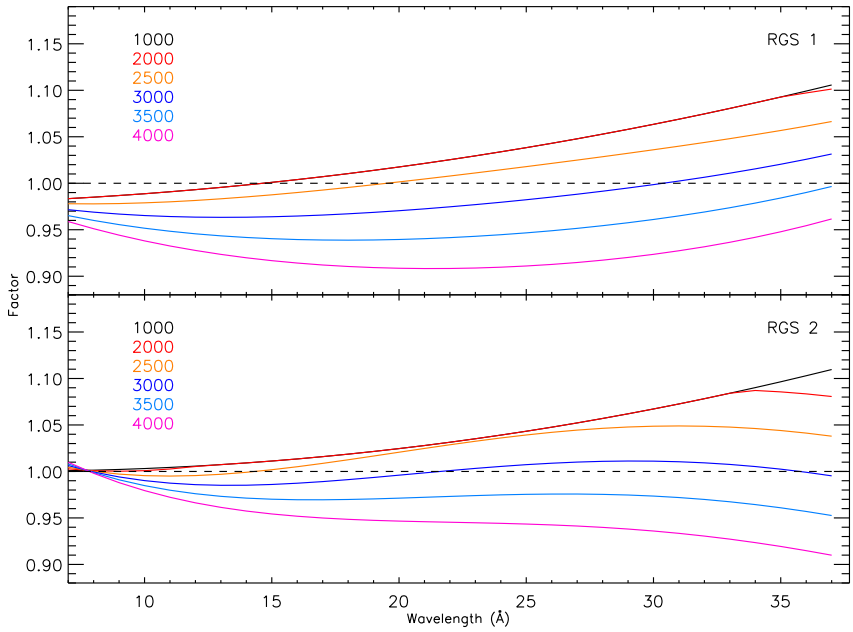

Figure 3: Updated Rectifications Factors for different revolutions, as implemented in the CCF.

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 an observation of the Blazar 1ES 1553+513, taken in revolution 3143 (see Fig. 4). Joint fits to the tree instruments are shown before (left) and after (right) application of the Rectification Factors. The improvement in the agreement between the three instruments is clearly visible, with C-statistics decreasing from 6371 to 5985 (for 5398 d.o.f.) after application of the correction.

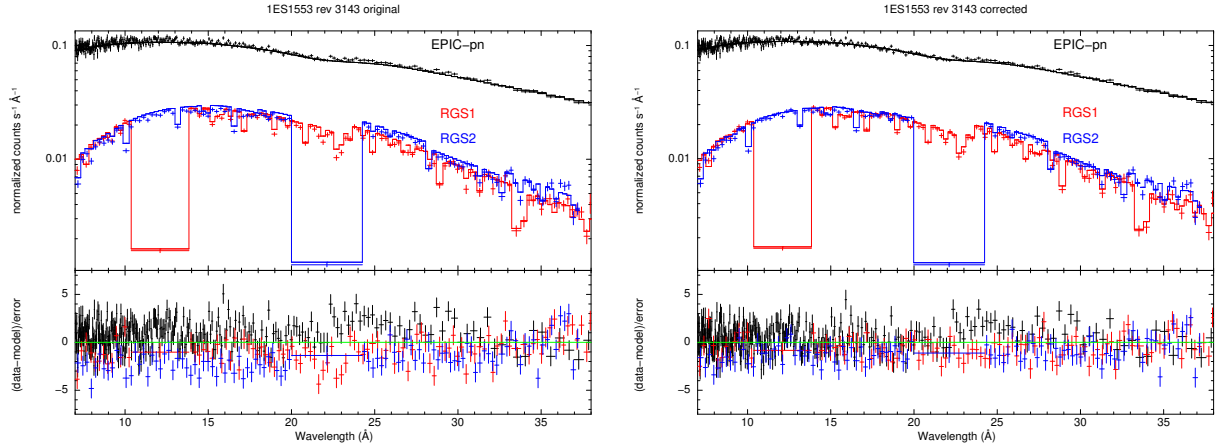

Figure 4: Joint fit to EPIC-pn and RGS data for an observation of the blazar 1ES 1553+513. Left: without correction, right: after application of the Effective Area correction and the updated Rectification Factors.

4 Estimated Scientific Quality

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 (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, with the Thin or Medium filters.

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 assess-

ment of their applicability after the changes.

6 Test procedures

Consistency check:

A consistency check has been done by applying the new Rectification Factors 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. 5.

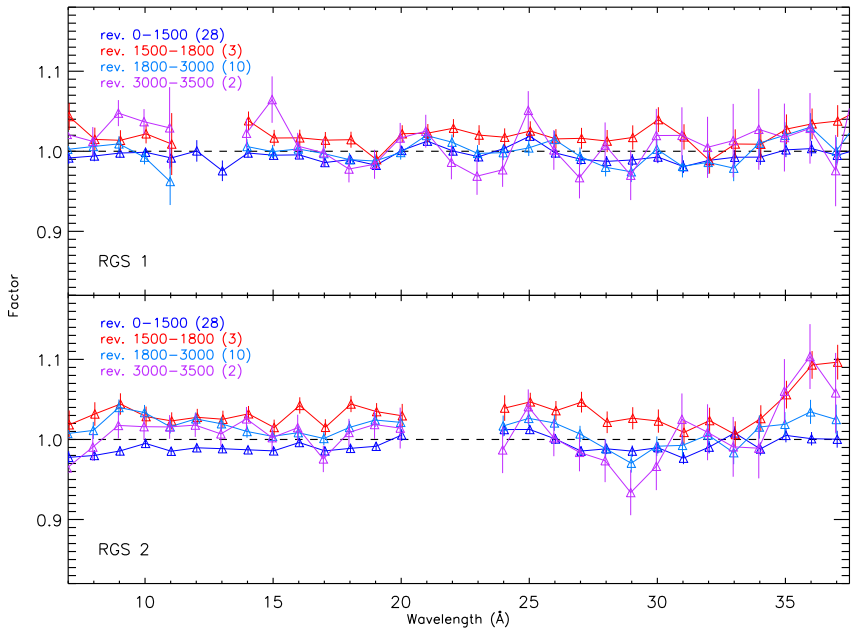

Figure 5: Flux ratios RGS/EPIC-pn of the observations of PKS 2155-304 and 3C 273 after application of the new Rectification Factors (compare to Fig. 1).

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] Kaastra, J. et al. "Effective area calibration of the RGS", August 2015, SRON Internal Report

[5] Kaastra, J. et al. "Effective area calibration of the RGS", April 2019 SRON Internal Report

[6] González-Riestra, R. "Correction to the RGS Effective Area", December 2016, XMM-CCF-TN-REL-340

[7] González-Riestra, R. "Extrapolation of the correction to the RGS Effective Area", June 2017, XMM-CCF-REL-349

[8] González-Riestra, R. "Update of the Correction to the RGS Effective Area", June 2019, XMM-CCF-TN-REL-371