

XMM-Newton CCF Release Note

XMM-CCF-REL-340

Correction to the RGS Effective Area

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1 CCF components

Name of CCF	VALDATE	List of Blocks changed	XSCS flag
RGS1.EFFAREACORR.0011	2000-01-01T00:00:00	AREACORR_1 AREACORR_2	NO NO
RGS2.EFFAREACORR.0011	2000-01-01T00:00:00	AREACORR_1 AREACORR_2	NO NO

2 Changes

During the last years, there has been increasing evidence for a systematic change with time in the ratio of fluxes derived from RGS1 and RGS2. Also, Kaastra et al. (2011) have shown the presence of “wiggles” in the effective area.

Two new extensions (`AREACORR_1` and `AREACORR_2`) have been added to the `EFFAREACOR` CCF to correct the RGS effective area for these effects. They apply to first and second order, respectively.

Similar to the other extensions in these CCFs, this correction is tabulated at several epochs, eight in this case.

3 Scientific Impact of this Update

The values included in these CCFs have been derived using the results of the work by Kaastra et al. (2015). These authors have used a large sample of observations of the bright blazars Mkn 421 and PKS 2155-304. Each spectrum was fitted to an absorbed broken power-law, and the residuals, in 0.05 Å wide bins, were fitted to the expression:

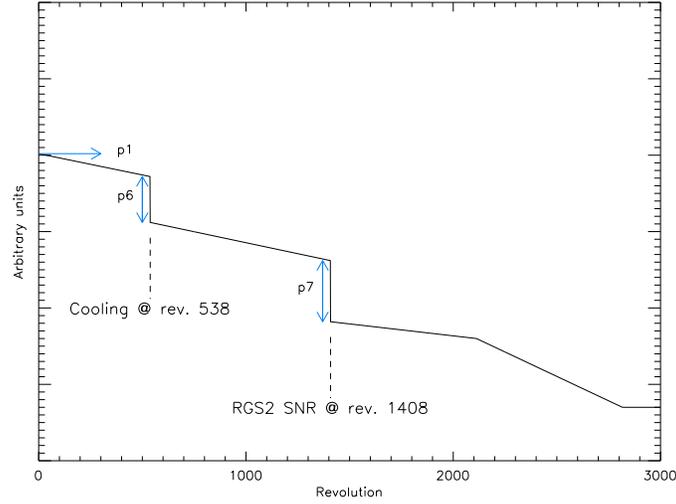
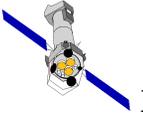


Figure 1: Scheme of the parametrisation used for the fit of the residuals.

$$t < 0.538 : f(\lambda, t) = p_1(\lambda) + (t/0.538) p_2(\lambda)$$

$$0.538 < t < 1.408 : f(\lambda, t) = p_1(\lambda) + p_2(\lambda) + p_6(\lambda) + ((t - 0.538)/0.870)/0.870 p_3(\lambda)$$

$$1.408 < t < 2.112 : f(\lambda, t) = p_1(\lambda) + p_2(\lambda) + p_3(\lambda) + p_6(\lambda) + p_7(\lambda) + ((t - 1.408)/0.704)/0.704 p_4(\lambda)$$

$$2.112 < t < 2.816 : f(\lambda, t) = p_1(\lambda) + p_2(\lambda) + p_3(\lambda) + p_4(\lambda) + p_6(\lambda) + p_7(\lambda) + ((t - 2.112)/0.704)/0.704 p_5(\lambda)$$

$$t > 2.816 : f(\lambda, t) = p_1(\lambda) + p_2(\lambda) + p_3(\lambda) + p_4(\lambda) + p_5(\lambda) + p_6(\lambda) + p_7(\lambda)$$

being t the time in units of 1000 revolutions. p_1 is the initial calibration mismatch; p_6 represents the potential discontinuity at the time of the instruments cooling (rev. 538), and p_7 at the time to the change of RGS2 to single node readout mode (rev. 1408, $p_7=0$ for RGS1).

The parameters p_1 to p_7 were fit to a spline in λ . In a few cases (near the Oxygen edge and near 31 Å), additional narrow gaussians were added to the spline.

The application of this correction to the effective area leads to an accuracy of the order of 1-2% for RGS1 and RGS2, respectively, over most of the wavelength band, as shown in Fig. 3. Also, there is a substantial improvement in the calibration of the second order.

4 Estimated Scientific Quality

Effective areas for the observation of PKS 0558-504 in revolution 1603 (obsid 0555170301) have been computed with and without this correction. First order spectra have been fit with XSPEC using an absorbed power law. The results of the fit are shown in Tables 1 and 2 and Figure 5.

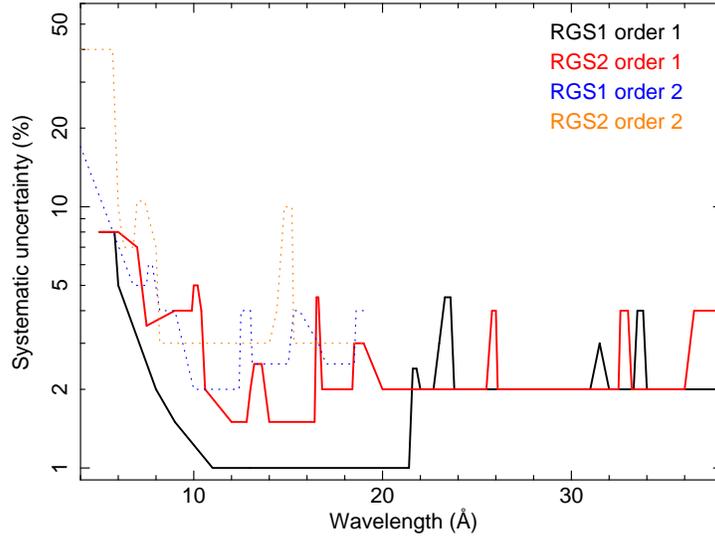
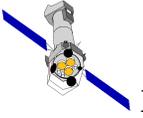


Figure 2: Estimated calibration uncertainty of the effective area after the application of this correction (Kaastra et al. 2015).

Table 1: Best fit parameters for a joint fit of RGS1 and RGS2 first order spectra

	without correction	with correction
N_H (10^{20})	3.11 ± 0.29	3.22 ± 0.29
slope	2.66 ± 0.03	2.66 ± 0.03
normalisation (10^{-3})	6.93 ± 0.07	7.18 ± 0.07
C/dof	5214/4981	5183/4981

Table 1 show the best fit parameters and their errors for a joint fit of RGS1 an RGS2, with and without this correction. They are similar, but there is a statistical improvement in the fit when applying the effective area correction, with C decreasing from 5214 to 5183 for 4981 degrees of freedom.

A substantial improvement is reached comparing independent fits to RGS1 and RGS2, as shown in Table 2. When applying the effective area correction, the discrepancies between both instruments decrease, from 14% to 9% in Hydrogen column density, and from 4% to 3% in normalisation. Also, the difference in the power law slope changes from -0.04 to 0.02.

5 Test procedures & results

The new CCFs have been fully tested in SASv16.

- The fits viewer fv has been used to inspect the new CCFs, their structure, validity dates and contents

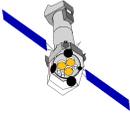


Table 2: Comparison of parameters for independent fits to RGS1 and RGS2 first order spectra

	without correction	with correction
ratio of N_{H}	1.14	0.91
difference in slope	-0.04	0.02
ratio of normalisations	1.04	0.97

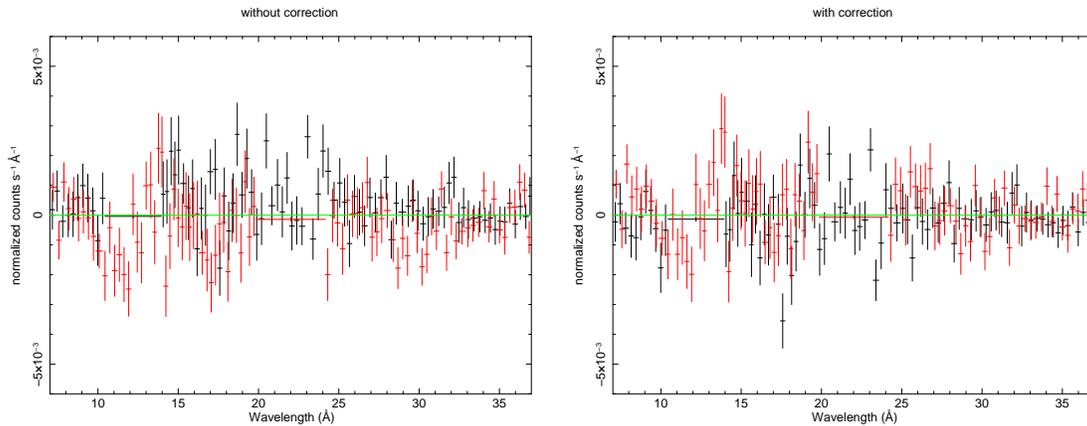


Figure 3: Residuals of the fit for the observation of PKS 0558-504 in rev. 1603.

- The SAS task cifbuild has been run to confirm that the right CCFs version is selected.

6 Expected Updates

This is the first implementation of this correction. More tests with different types of spectra need to be done, which may lead to improvements. The time evolution of the effective area should be closely monitored, and new records will be added (or the existing ones modified) to cope with potential changes.

7 References

- [1] “Multiwavelength campaign on Mrk 509. II. Analysis of high-quality Reflection Grating Spectrometer spectra”, J. Kaastra, C. de Vries, K. Steenbrugge et al., *A&A* 534, 37, 2011.
- [2] “Effective area calibration of the RGS”, J. Kaastra, C. de Vries, J.W. den Herder, SRON-RGS Internal Report, August 2015