XMM-Newton CCF Release Note

XMM-CCF-REL-297

Sun Angle correction to the RGS Wavelength scale

R. González-Riestra

April 17, 2013

1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
RGS1_SAACORR_0001.CCF	2000-01-01T00:00:00	–	SAACORR	NO
RGS2_SAACORR_0001.CCF	2000-01-01T00:00:00	–	SAACORR	NO

2 Introduction

Studies of RGS spectra of emission line sources have shown that line positions are systematically shifted with respect to laboratory wavelengths, and that the wavelength scales of both RGS are displaced by a few mÅ. These works have also established that wavelengths measured in RGS spectra are accurate to $\approx$ 7 mÅ in first order and to $\approx$ 5 mÅ in second order (Lorente et al. 2003). Along the last years, several studies have been carried out to clarify the origin of these systematic effects (see e.g. Coia and Pollock 2007).

González-Riestra (2008) found a strong correlation between the angular distance between the spacecraft pointing direction and the Sun, hereafter "Solar Angle"[1]. This correlation was confirmed independently by Kaastra et al. (2011) in their analysis of the RGS spectra of Mrk 509.

This dependence was parametrised as a linear relation, with different coefficients for each instrument and spectral order. Once the Variable Boresight was implemented in the reduction of the data of the RGS instruments the coefficients of this relation were re-derived (González-Riestra, 2012), resulting the values shown in Table 1.

The Sun Angle correction to the RGS wavelength scale has been implemented for the first time in SAS13.0, as a non-default processing option. In this first implementation, the same linear relation

[1] This angle is equivalent to the Fine Sun Sensor Pitch Angle + 90 degrees. Operational range is 70-110 degrees.

Table 1: RGS Wavelength shifts: Fits to Solar Angle

	a	b	Res
RGS1 o1	1.2±0.2	-0.52±0.02	0±5
RGS2 o1	6.1±0.2	-0.50±0.02	1±5
RGS1 o2	1.8±0.2	-0.29±0.02	0±3
RGS2 o2	2.7±0.2	-0.33±0.02	0±2

correction (in mÅ) = a + b × (SA - 90)
Res: residuals of the fit in mÅ, errors are standard deviations.

Table 2: RGS Wavelength shifts

Average shifts per spectrum (in mÅ)		
	SAS12	SAS13
RGS1 o1	2±6	1±5
RGS2 o1	8±6	1±5
RGS1 o2	2±3	1±3
RGS2 o2	3±4	1±3
order 1 - order 2		
RGS 1	1±4	0±4
RGS 2	4±4	-1±3
RGS 1 - RGS 2		
order 1	-5±2	1±3
order 2	-2±2	1±2
Shifts of individual lines (in mÅ)		
	SAS12	SAS13
RGS1 o1	2±7	1±6
RGS2 o1	7±7	1±6
RGS1 o2	1±5	1±5
RGS2 o2	3±4	0±6

is applied to first and second order data (but different for each instrument). The error introduced by this approximation has been estimated to be less than 2 mÅ for second order data taken at extreme values of Solar Angle.

3 Scientific Impact of this Update

After application of this correction, the scatter in the line shifts is reduced, and the wavelength scale of both spectrographs and orders is aligned. This is shown in Table 2 and Fig. 1, that compare the wavelength shifts of a sample of 60 spectra of the four wavelength calibrators (Capella, AB Dor, HR 1099 and Procyon) processed with SAS12 and with SAS13+Sun Angle correction.

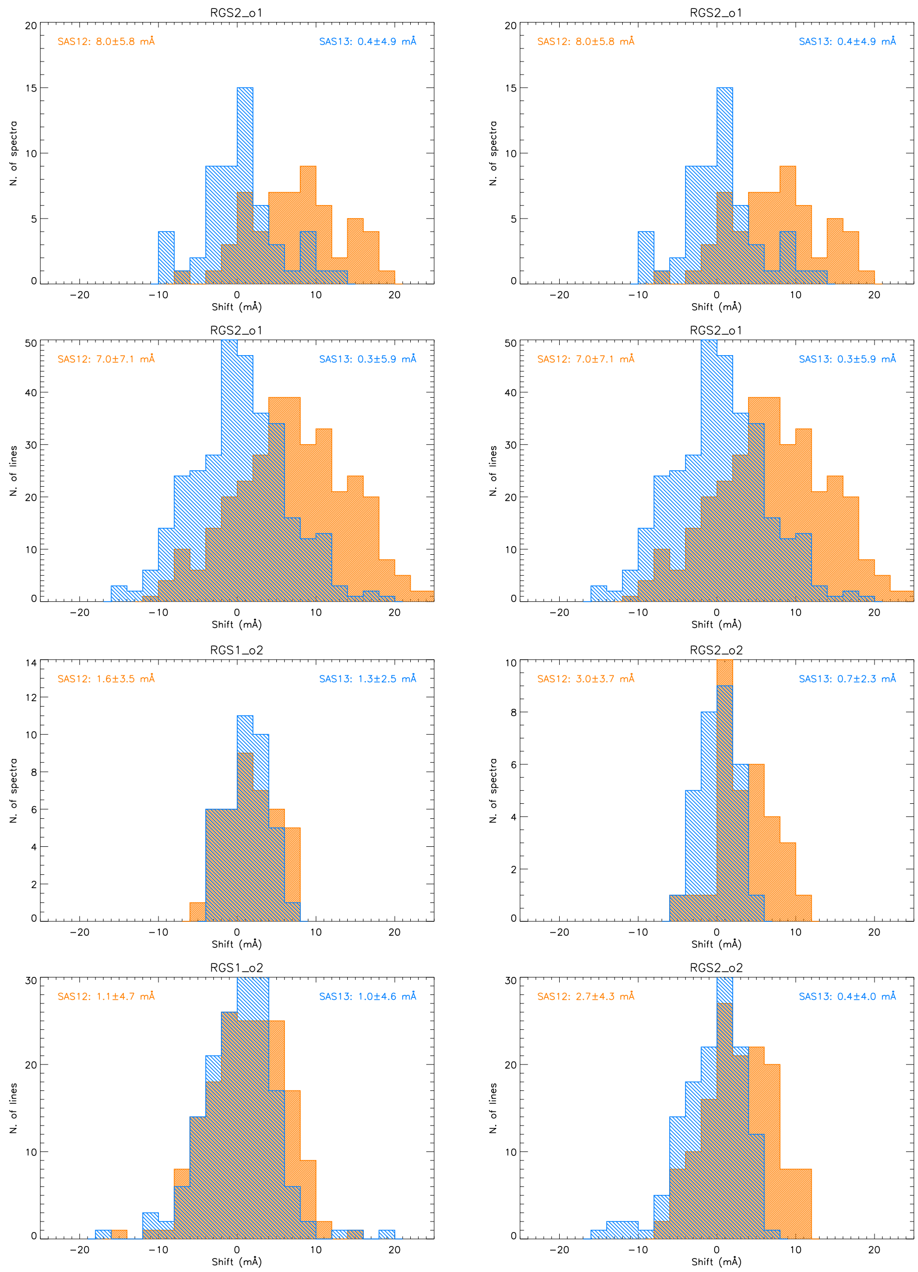

Figure 1: Comparison of the wavelength shifts in spectra processed with SAS12 and with SAS13 applying the Sun Angle correction

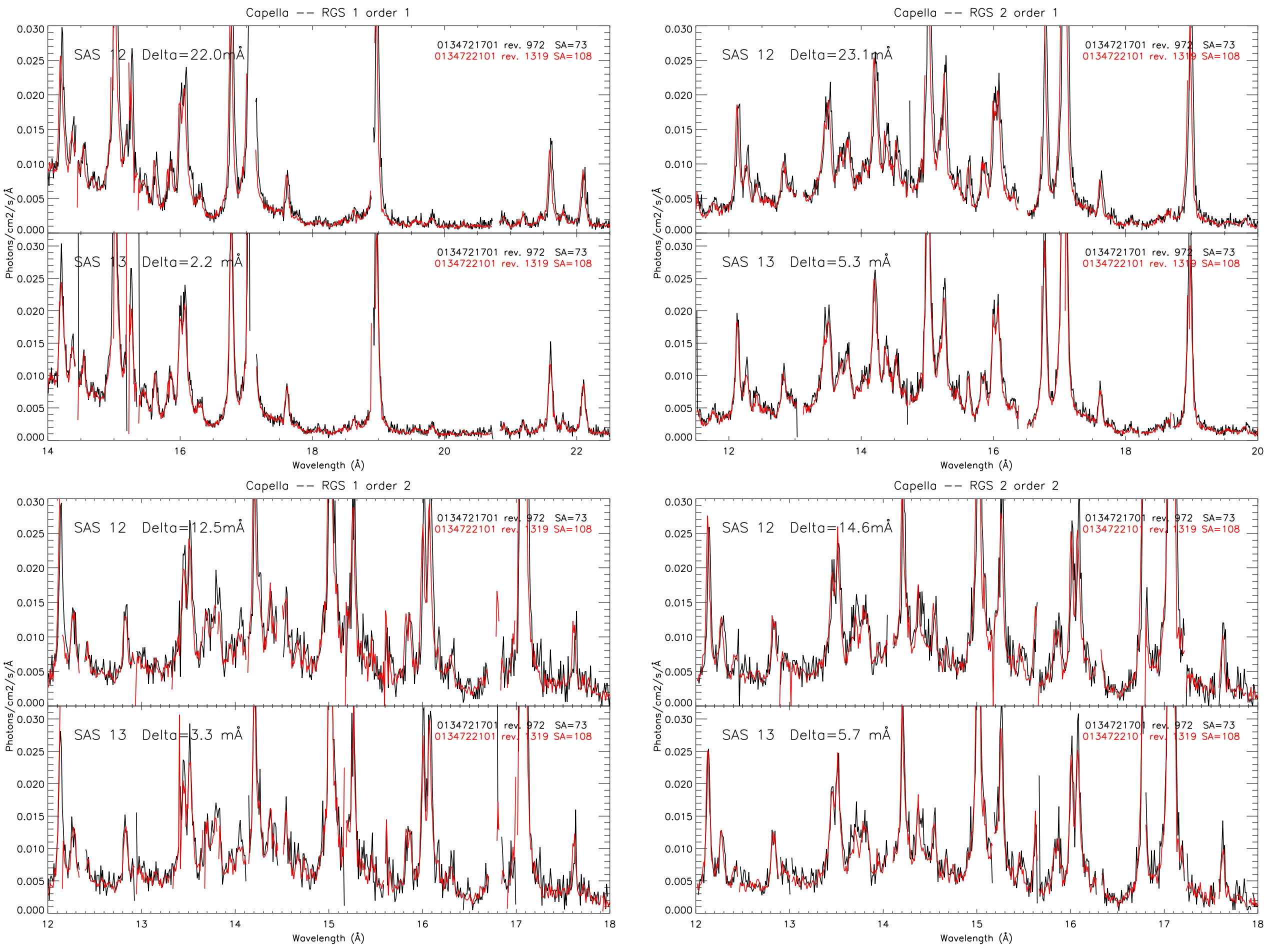

Figure 2: Spectra of Capella taken at Sun Angles 73 and 108, processed with SAS12 and with SAS13 applying the Sun Angle correction.

4 Estimated Scientific Quality

We have compared two observations of Capella taken at extreme Solar Angle values (108 and 73) processed with SAS12 and SAS13+Sun Angle correction. Spectra of both instruments and orders are shown in Fig. 2.

Shift between both spectra (in mÅ)

	SAS12	SAS13
RGS1 o1	22	2
RGS2 o1	23	5
RGS1 o2	12	3
RGS2 o2	15	6

As expected, the application of the Sun Angle correction improves substantially the agreement between the wavelengths measured in both datasets: from approx. 22 mÅ to approx. 3 mÅ for first order, and from 13 mÅ to 4 mÅ for second order. A small, intrinsic, shift due to orbital motion cannot be excluded.

5 Expected Updates

The relation betwwen line shifts and Solar Angle will be revised regularly, as new data of the wavelength calibrators become available. The coefficients will be updated as needed.

6 Test procedures

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

Coia, D. and Pollock, A., “A survey of lines in coronal sources for the RGS wavelength scale”, December 2007
SOC-CAL-TN-0079-1-0

González-Riestra,R., “Systematic Effects in the RGS Wavelength scale”, September 2008
SOC-CAL-TN-0082-1-0

González-Riestra, R., “The effect of the variable boresight on the RGS Wavelength scale”, June 2012
SOC-CAL-TN-0101-0-0

Kaastra, J. et al.,” Multiwavelength campaign on Mrk 509. II. Analysis of high-quality Reflection Grating Spectrometer spectra”, 2011
A&A 534, A37

Lorente, R. et al.,“The RGS Wavelength Scale”, July 2003
SOC-CAL-TN-0041-1-0