XMM-Newton CCF Release Note

XMM-CCF-REL-308

EPIC MOS Quantum Efficiency and redistribution

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1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
EMOS1_QUANTUMEF_0019.CCF	2000-01-01		QE_TOTAL	NO
EMOS2_QUANTUMEF_0019.CCF	2000-01-01		QE_TOTAL	NO
EMOSn_REDIST_0106.CCF	1999-12-10	2000-10-03	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0107.CCF	2000-10-03	2001-04-22	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0108.CCF	2001-04-22	2001-11-07	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0109.CCF	2001-11-07	2002-05-26	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0110.CCF	2002-05-26	2002-11-05	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0111.CCF	2002-11-05	2004-01-14	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0112.CCF	2004-01-14	2005-02-14	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0113.CCF	2005-02-14	2006-03-22	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0114.CCF	2006-03-22	2007-04-24	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0115.CCF	2007-04-24	2008-05-28	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0116.CCF	2008-05-28	2009-07-01	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0117.CCF	2009-07-01	2010-08-03	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0118.CCF	2010-08-03	2011-09-07	CCD_REDISTRIBUTION-n	NO
EMOSn_REDIST_0119.CCF	2011-09-07	2020-01-01	CCD_REDISTRIBUTION-n	NO

2 Changes

Joint spectral fits to EPIC spectra have revealed an increasing discrepancy between the EPIC-MOS and EPIC-pn cameras at low energies. This has partly been addressed by the introduction of an epoch-dependent contamination layer that reduces the effective area of the MOS cameras at low energies (Sembay & Saxton 2013). Here we present modifications to the MOS quantum efficiency (QE) and redistribution functions, compatible with the MOS contamination function, which further improve the agreement between the EPIC cameras at all epochs.

In this SRN the changes are:

- A reduction in the QE of 17.3%, below 280 eV, to the total QE of the two MOS cameras (Fig. 1).

The absolute QE of the MOS CCDs below 280 eV is not well constrained by ground measurements. An adjustment to the low energy QE of the MOS CCDs was previously made to improve the cross-calibration between MOS and the EPIC-pn and the RGS (Sembay 2007). The adjustment was in the form of an empirical function which contained a pseudo-carbon edge. Given the new contamination model we have removed this feature to give the shape of the *baseline* QE curve at low energies a more physically realistic shape.

- Epoch-dependent adjustments to the redistribution functions of both MOS cameras (Fig. 2)

The MOS redistribution is described by an empirical model whose parameters vary spatially across the CCD and evolve with time. The parameters of the model are derived by an iterative minimisation scheme which finds the parameter set which provides the best simultaneous fit to MOS data using spectral models of various astrophysical sources (designated as standard candle sources) and the onboard calibration source. The methodology is described in detail in Sembay, Saxton & Guainazzi (2011). A given RMF solution is dependent on the effective area and therefore for self-consistency has to be recalculated for every epoch given the change in the baseline QE described above and the evolutionary change in QE given by the contamination model.

The change in the shape of the redistribution function is relatively modest. Figure 2 shows a comparison of the redistribution function of MOS1 and MOS2 at 450 eV calculated for a late epoch on-axis source. The new RMF solutions show less redistribution (i.e. the secondary peak is lower and at a higher energy) compared with the previous solution. This is to be expected as the new solution is calculated assuming a relatively lower effective area at low energies.

3 Scientific Impact of this Update

These QE and redistribution changes, in conjunction with the introduction of a correction for the build up of a contaminant in the optical path, make a noticeable improvement to combined fits of the EPIC-pn and MOS cameras below the Oxygen edge.

In figure 3 we compare the performance with and without this change on the blazar PKS 2155-304. A spectral model of a power-law, with slope=2.74 and normalisation=0.0129, absorbed by a neutral hydrogen column of $N_H = 1.34 \times 10^{20}$, obtained from fitting the EPIC-pn spectrum, was applied to the MOS spectra from the same observation. Residuals from the SAS v13.0.2 and SAS v13.5 calibrations are shown as the black and red curves respectively. The χ^2 reduces from 1272/959 to 1240/959 for MOS1 and from 1874/959 to 1356/959 for MOS2 with the application of this calibration. The larger change in the fit statistic for MOS2 is predominantly due to the correction for the contamination layer which is more pronounced for MOS2.

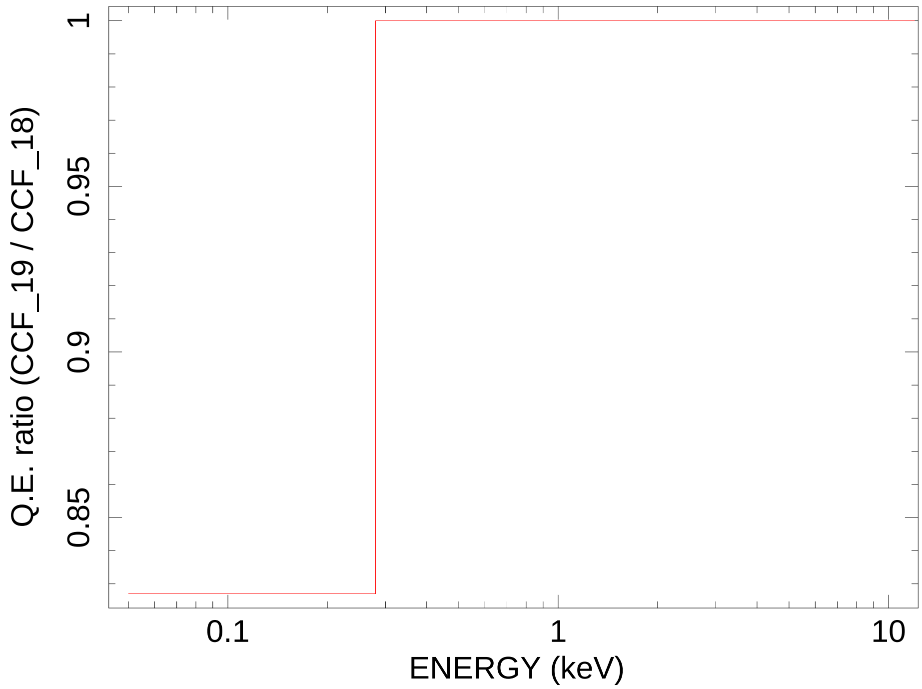

Figure 1: The change introduced in the total QE for the MOS-1 and MOS-2 cameras.

4 Estimated Scientific Quality

The combination of this QE and redistribution change, with the previous contamination change, results in an agreement between the EPIC-MOS and EPIC-pn cameras of $\sim 5\%$ at energies below 1 keV.

In figure 4 spectral parameters are presented, from the fit of a model of a black-body, absorbed by the Galactic column, to the individual EPIC and RGS spectra of the very soft source, RXJ 1856.5-3754.

5 Test procedures and results

A refit of all the sources in the calibration archive has been made using the new QE, new MOS contamination and MOS redistribution files. A general improvement in the agreement between cameras at low-energies may be observed for most sources at most epochs. For the ensemble of sources, the mean difference between the MOS and pn camera flux, in the 0.35-0.54 keV band, has reduced from 5% to 3% with this release.

References

Sembay 2007, CAL-SRN-0235
Sembay, Saxton & Guainazzi 2011, CAL-SRN-0272
Sembay & Saxton 2013, CAL-SRN-0305.

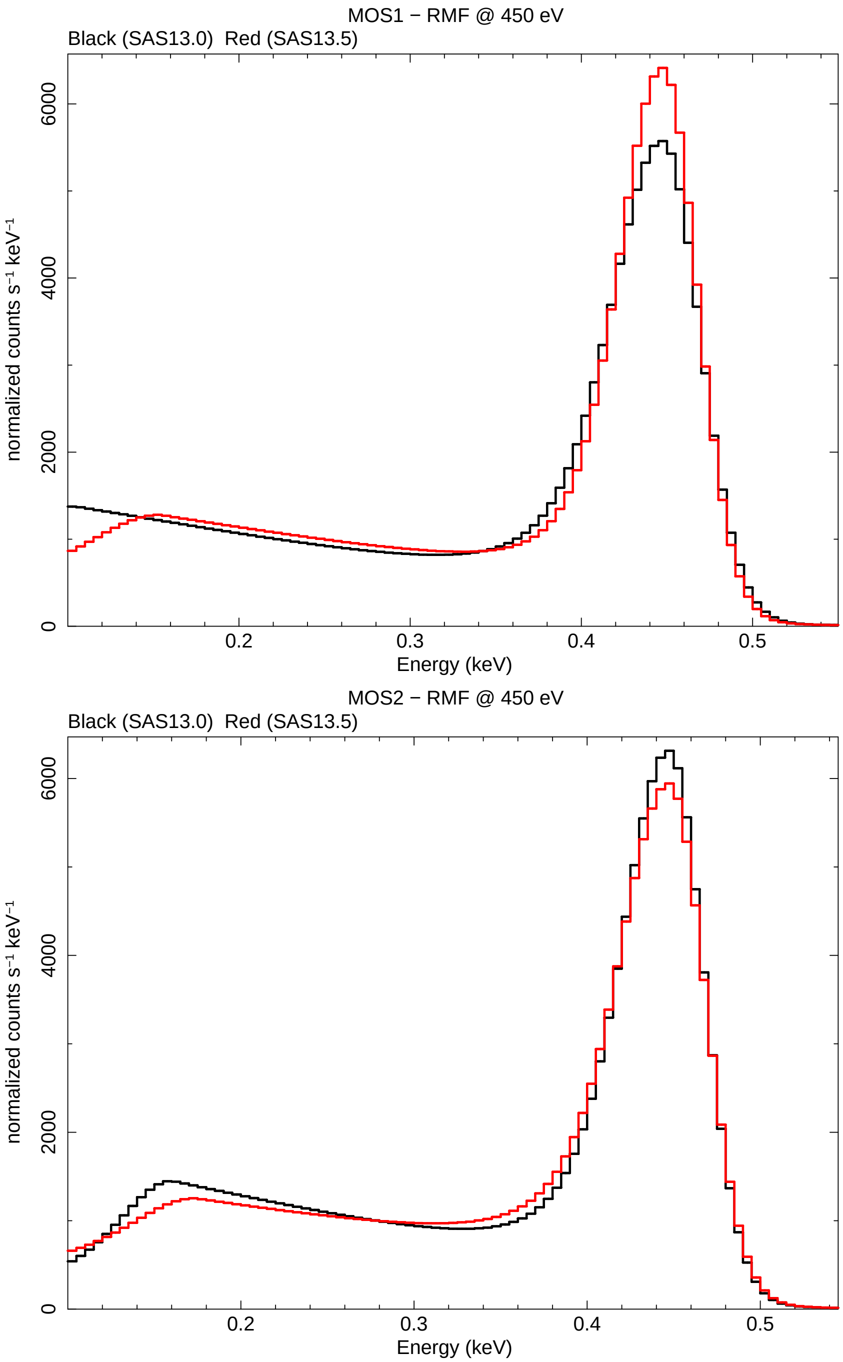

Figure 2: The 450 eV redistribution function at revolution 2363 for SAS v13.0 (black curve) and SAS v13.5 (red curve). MOS1 is shown in the upper plot and MOS2 in the lower.

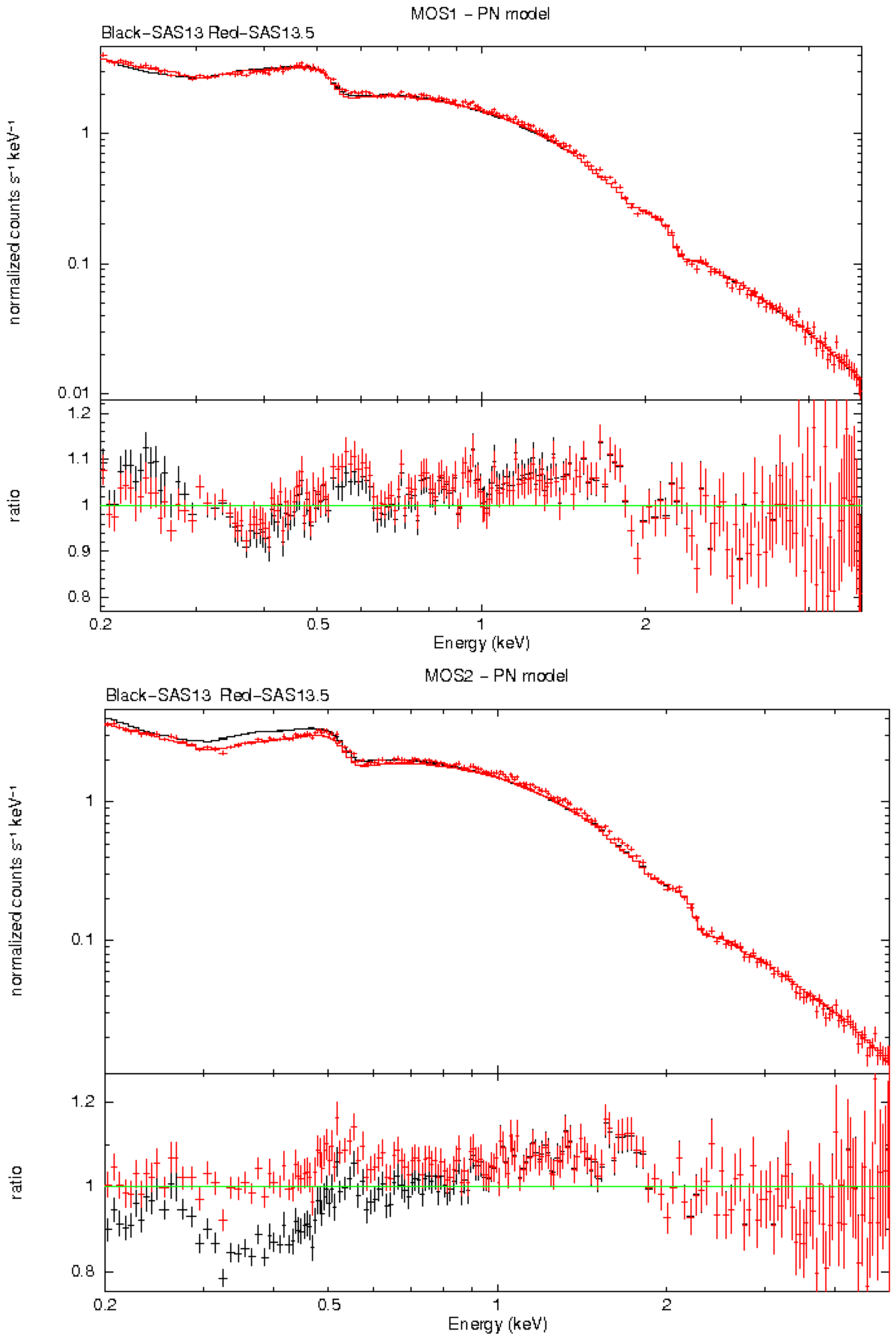

Figure 3: The result of applying an absorbed power-law model to the MOS, revolution 2449, OBSID=0411782101, observation of PKS 2155-304. Model parameters have been obtained by fitting the EPIC-pn data from the same observation. The black curve illustrates the existing situation (in SAS v13.0.2) where strong residuals can be seen below 0.5 keV. The red curve uses the new CCF elements described in this SRN plus the MOS contamination calibration (Sembay & Saxton 2013). MOS1 is shown in the upper plot and MOS2 in the lower. The change in MOS2 is much stronger.

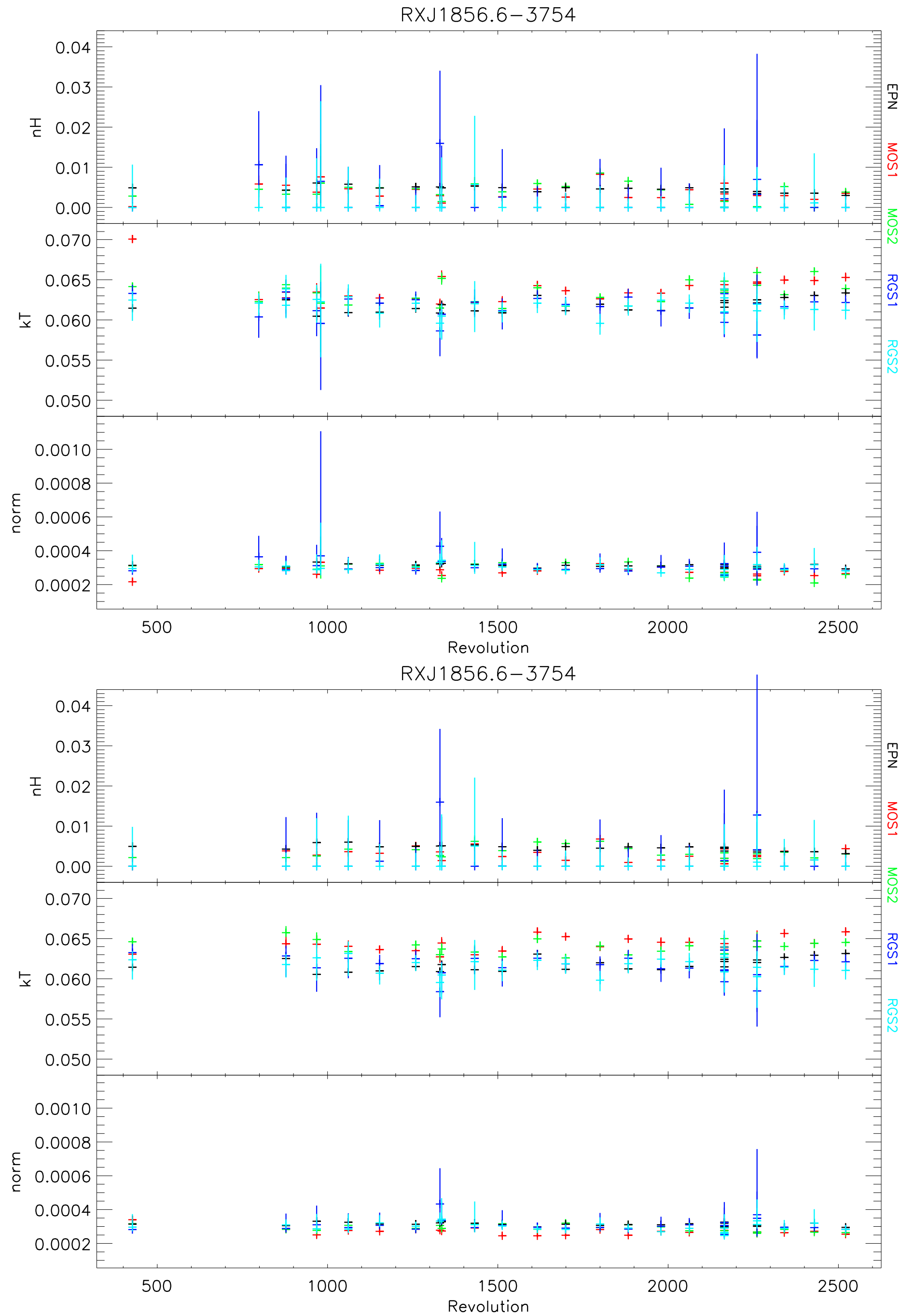

Figure 4: A comparison of spectral parameters returned by the fit of an absorbed black-body model to the EPIC and RGS spectra of RXJ 1856.5-3754 as a function of revolution number for SAS v13.0.2 (upper) and this calibration (lower).