XMM-Newton CCF Release Note

XMM-CCF-REL-192

# EPIC MOS response

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## 1 CCF components

| Name of CCF | VALDATE | EVALDATE | Blocks changed | XSCS flag |
|---|---|---|---|---|
| EMOS1_REDIST_0057.CCF | 2001-11-25 | 2002-05-01 | CCD_REDISTRIBUTION-n | NO |
| EMOS1_REDIST_0058.CCF | 2002-05-01 | 2002-11-07 | CCD_REDISTRIBUTION-n | NO |
| EMOS1_REDIST_0059.CCF | 2002-11-07 | 2004-01-01 | CCD_REDISTRIBUTION-n | NO |
| EMOS1_REDIST_0060.CCF | 2004-01-01 | - | CCD_REDISTRIBUTION-n | NO |
| EMOS2_REDIST_0057.CCF | 2001-11-25 | 2002-05-01 | CCD_REDISTRIBUTION-n | NO |
| EMOS2_REDIST_0058.CCF | 2002-05-01 | 2002-11-07 | CCD_REDISTRIBUTION-n | NO |
| EMOS2_REDIST_0059.CCF | 2002-11-07 | 2004-01-01 | CCD_REDISTRIBUTION-n | NO |
| EMOS2_REDIST_0060.CCF | 2004-01-01 | - | CCD_REDISTRIBUTION-n | NO |

## 2 Changes

A small patch has developed at the boresight of each MOS camera where the spectral resolution of the detectors at low-energies ($< 0.8$ keV) is degraded [1]. This leads to the need to quantify the redistribution function (RF) of each camera in three different spatial regions.

- A core region centred on a point between the two boresights where EPIC-pn and RGS are prime.
- A wings region, consisting of an annulus about the core
- An outer region, consisting of the CCD-1 area which is outside the core and wings regions.

The redistribution function for the outer CCDs is unaffected by this change and has been set equal to that of the outer region of CCD-1.

Physically, it is believed that the incident X-rays, possibly in conjunction with soft protons, have damaged the CCDs in such a way that an increasingly large amount of charge is lost to the surface layer as the mission progresses. At the boresight, where the X-ray

Table 1: **Regions in RAW coordinates on CCD-1**

| Camera | Core | Wings | Outer |
|---|---|---|---|
| MOS-1 | Circle(312,293,14) | Annulus(312,293,14,36) | !Circle(312,293,36) |
| MOS-2 | Circle(301,302,14) | Annulus(301,302,14,36) | !Circle(301,302,36) |

doseage has been the highest, this damage has led to a broadening of the RF which is particularly noticeable at low energies and for later revolutions. This release covers revolution 360 and beyond when the effect is already important. The smaller effects seen prior to this revolution are in the process of being measured and a further release of CCFs is expected for earlier epochs.

The spatial regions (Tab. 1) have currently been set to be the same for all epochs which is something that will need to be reviewed as the mission progresses. It is expected that the affected regions will gradually expand as greater numbers of X-rays are accumulated. SAS software and the CCF structure have been designed to cope with changes to the number and definition of these regions.

An indication of the extent of the time dependence of the *core, wings* and *outer* RFs is show in Figure 1. Here, the reponse at 0.5 keV can clearly be seen to change more within the patch region.

The time span from 07/11/2002 has been divided into two periods in this release: until the end of 2003 and from 2004 onwards.

## 3 Scientific Impact of this Update

It has long been noted that spectral fits below 1 keV show discrepancies between the EPIC cameras with pn returning more flux than the MOS cameras, sometimes by up to 20% [2]. In addition there is strong evidence that the discrepancy increases with time. The identification of a time-dependent change in the MOS redistribution parameters for on-axis sources at low energies improves the agreement between the cameras considerably. The residual errors are now seen to be around 5–10% for most sources.

The 8 CCFs in this release have been tested extensively in the validation exercise undertaken for SAS 6.5 [3]. In general the results show an improvement in the agreement between the pn and MOS cameras for post-revolution-360 observations. As an example, in Figure 2 the residuals of a galactic absorption plus two power-law model fit to the pn, MOS-1 and MOS-2 spectra of a revolution 1023 observation of the Radio-Loud Quasar 3C273 are shown. There is a clear improvement in the agreement between the instruments below $\sim 0.5keV$. The reduced $\chi^2$ improves from 4551/2744 to 3831/2744 with the new redistribution function.

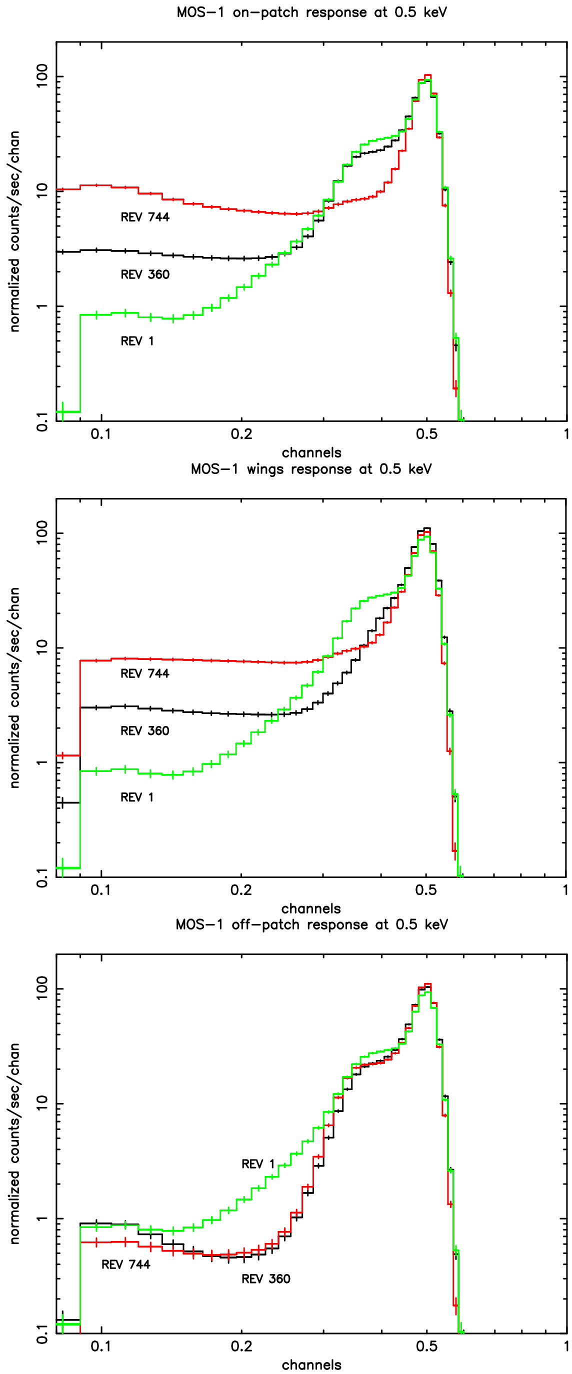


Figure 1: A comparison of the MOS-1 response function for three different epochs (revs 1, 360 and 744) at 0.5 keV. Top panel: core of the patch, Centre: wings of the patch, Bottom: outside the patch

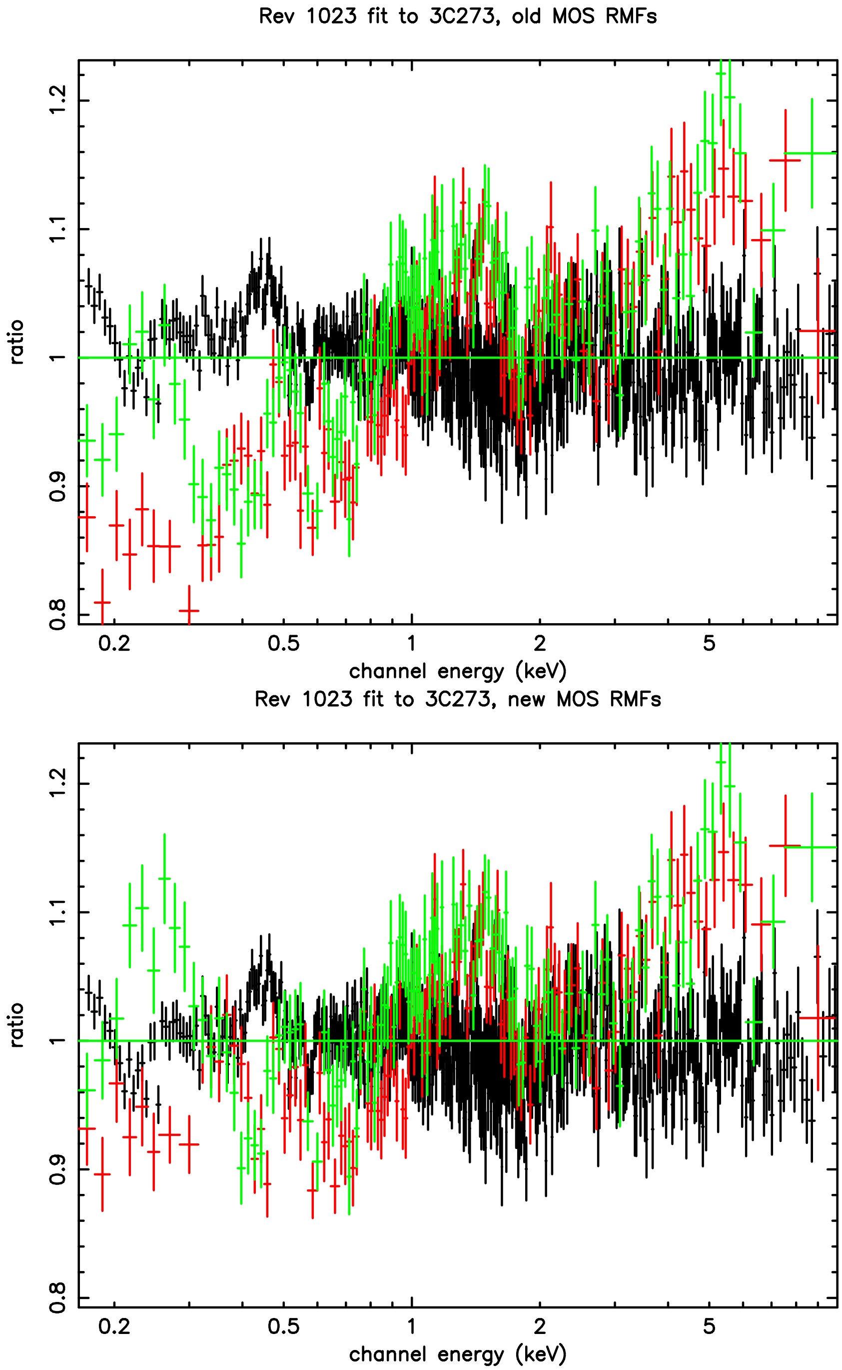


Figure 2: An absorbed two-power-law fit to a revolution 1023 observation of 3C273. The upper plot gives the residuals using RMFs generated by SAS 6.1 using the CCFS EMOS1_REDIST_0051.CCF and EMOS2_REDIST_0051.CCF. The lower plot shows the same fit but using responses generated by *rmfgen* using EMOS1_REDIST_0060.CCF and EMOS2_REDIST_0060.CCF.

## 4 Estimated Scientific Quality

This update improves the agreement between the EPIC cameras to ~5–10% at low energies for most sources (see [3] for a summary).

## 5 Expected Updates

Calibration is continuing for data prior to revolution 360. It is expected that CCFs for these epochs will be released in due course.

## 6 Test procedures and results

The new CCF files were used to produce redistribution matrices using rmfgen for on patch and off-patch regions and several different epochs. These were compared with canned matrices produced by the MOS instrument team and were seen to be nearly identical in all cases.

**References**

[1] Kirsch, M. et al, 2005, "SPIE 5898-29: Health and cleanliness of the XMM-Newton science payload since launch", XMM-SOC-CAL-TN-0062
[2] Altieri, B. et al., 2005, "Status of XMM-Newton instruments cross-calibration with SAS 6.1", XMM-SOC-CAL-TN-0052
[3] Guinazzi, M. et al., 2005, "XMM-Newton Science Analysis System (version 6.5) EPIC Science Validation Report", XMM-SOC-USR-TN-0009 issue 2.0.