

# XMM-Newton CCF Release Note

XMM-CCF-REL-344

## EPIC filter-wheel closed data

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### 1 CCF components

Name of CCF	VALDATE	List of Blocks changed	Change in CAL HB
EMOS1_FWC_0001.CCF	2000-01-01	EVENTS, EXPTIME	YES
EMOS2_FWC_0001.CCF	2000-01-01	EVENTS, EXPTIME	YES
EPN_FWC_0001.CCF	2000-01-01	EVENTS, EXPTIME	YES

### 2 Change

The EPIC CCD cameras on board XMM-Newton are equipped with a filter wheel system and 6 different filter setups. One of these is a CLOSED filter. Exposures taken with the filter wheel in the CLOSED position are dominated by the instrumental background and can be used to model and subtract the internal instrumental background. This is composed of:

- Electronic readout noise (at lowest energies)
- High energy particles producing charge directly in CCD and Camex
- Particle induced X-rays (continuum and fluorescent lines), generated inside the camera
- Thermal CCD noise (negligible)

Filter Wheel Closed (FWC) event lists exist and are available through the SOC web pages for EPIC-pn and EPIC-MOS and for the different EPIC modes. This CCF contains only FWC event lists corresponding to EPIC-pn Full Frame (FF) Mode and EPIC-MOS Full Frame (FF) Mode. It is strongly recommended not to combine event lists from different submodes since line widths and pattern fractions are slightly different for each of the EPIC readout modes.

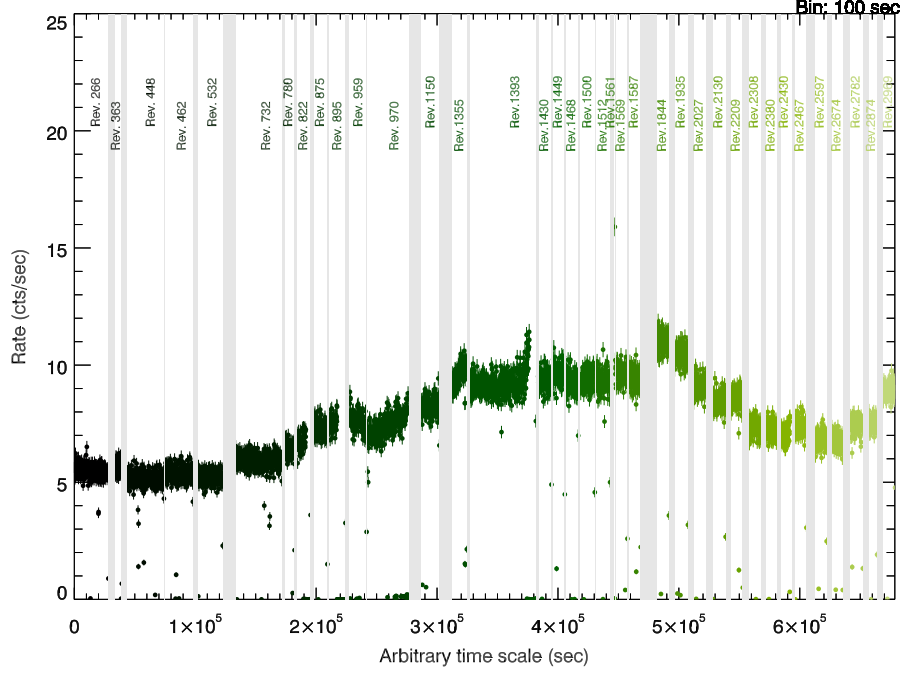


Figure 1: Sections of the EPIC-pn FF FWC events displayed in a 100s bin light curve. The figure represents the count rate, over the whole field of view and full energy range, extracted between revolutions 266 and 2969 (2001-05-22 to 2016-02-24).

An example of the EPIC-pn FF FWC CCF light curve, in bins of 100s, is shown in Fig. 1. The filter expression used to create this light curve was ( $\text{FLAG}==0 \ \&\& \ \text{PATTERN} \leq 4$ ) and it shows the evolution of the non-sky background from early in the mission until revolution 2969 (2016-02-24).

## 2.1 Generation

The individual events files from FWC observations were filtered for periods of strong background flaring before adding them to create the CCF files. Flares were filtered by checking deviations of the rate against 'quiescent' periods, defined as those where the rates are stable with time. Periods beyond the 3 sigma level with respect to this quiescent level are discarded (see Fig. 2).

The CCF contains an extension *EVENTS* with the following columns:

- TIME
- RAWX, RAWY - chip coordinate
- DETX, DETY - detector coordinate

- PI - event energy
- FLAG - event flag
- PATTERN - event pattern
- CCDNR - CCD number of event
- WEIGHT - weighting factor, related to off-axis angle
- REV - revolution number of observation containing the event

Most of these columns are copied directly from the original event file. The revolution number has been added to the CCF events list to help identify from which observation each event comes from. A weight column has been added for each event giving the inverse of the ratio of the effective area at the source position to that of the centre of the detector (i.e. the vignetting factor at the event energy). Weights have been computed using the SAS task *evigweight*.

A second table *EXPTIME* gives the FWC exposure time contained in the CCF for each revolution and each CCD. Columns are:

- REV - revolution number
- TSTART - the start time in MRT
- TSTOP - the end time in MRT
- CCDNR - CCD number
- EXPOSURE - the total exposure time for this revolution, ccd combination
- NFLAG - whether the CCD was noisy during this revolution

A column *NFLAG* is included to indicate whether the CCD was noisy during this revolution. This has currently just been set for the EPIC-MOS CCFs. In MOS there are low level ‘flickerings’ of a small number of pixels at an occurrence rate  $< 1\%$ . Two peripheral CCDs of the MOS cameras (CCD4 on MOS1, and CCD5 on MOS2) are frequently affected by a low-energy ( $E < 1$  keV) noise plateau (see [1]).

### 3 Scientific impact of this update

This CCF can be used by a SAS task to generate an event file containing the expected instrumental background or quiescent particle background (QPB) for a given observation and camera. It will do this by extracting the FWC data, for the given EPIC camera, from times closest to the observation date. The generated FWC event file may be used to provide EPIC science exposure images with the QPB subtracted and to provide a better background subtraction for spectra and time series.

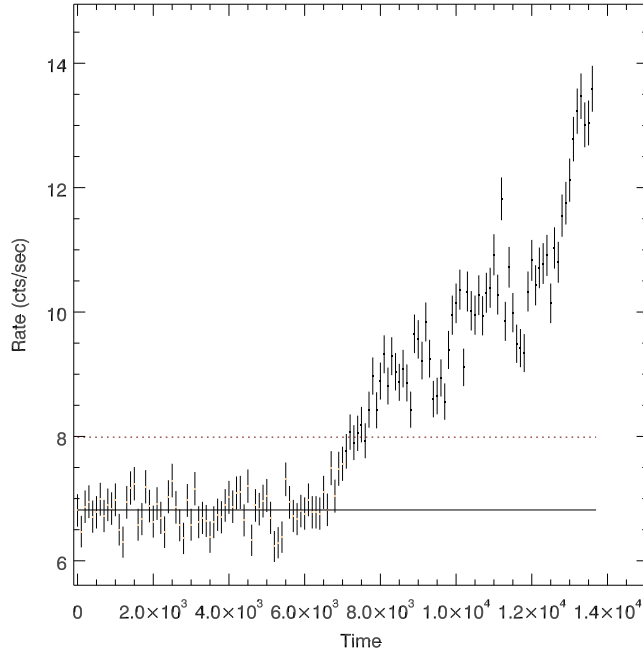


Figure 2: The light curve of an EPIC-pn FWC observation, extracted from the whole field of view. Quiescent data is present from 0 to  $\sim 6000$  seconds while data from  $\sim 7000$  seconds onwards falls outside the three-sigma range of the quiescent count rate and is discarded.

An example of the improvement which may be gained in image contrast by subtracting the QPB is shown for the supernova remnant, SN 1006, in Fig. 3.

The ability to estimate the QPB from the actual detector position of a source has some advantages in spectral background subtraction. For example, the EPIC-pn background is spatially dependent, especially at the Cu line ( $\sim 8$  keV) where fluorescent Cu radiation is present in the outer part of the detector but is absent from a hole occupying the detector centre. This tends to result in an over-subtraction of the background around 8 keV. If the corresponding QPB is subtracted from the source and background spectra this problem is much reduced (Fig. 4).

## 4 Estimated scientific quality

The quality of results which can be derived from the FWC data can be gauged by comparing with the data found in the out-of-FOV regions of science observations. In Fig 5 the spectra extracted from the FWC (pink) and SN 1006-1 science (grey) EPIC-pn, out-of-FOV events are compared. The FWC exposure spectrum has been extracted from the tailored exposure provided by new SAS task *evqpb* in conjunction with the draft CCF files. Ideally the spectra would be identical and the ratio equal to 1 across all energies (blue curve). However, the out-of-field data from the science exposure is contaminated

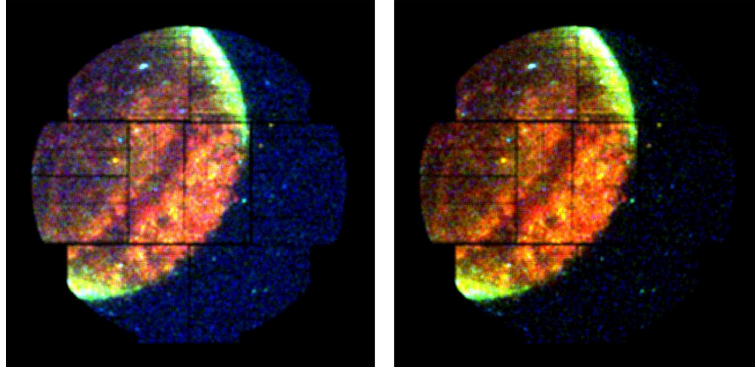


Figure 3: A MOS-2 image of SN 1006 from observation 0555630101 before (left) and after (right) correction for the QPB.

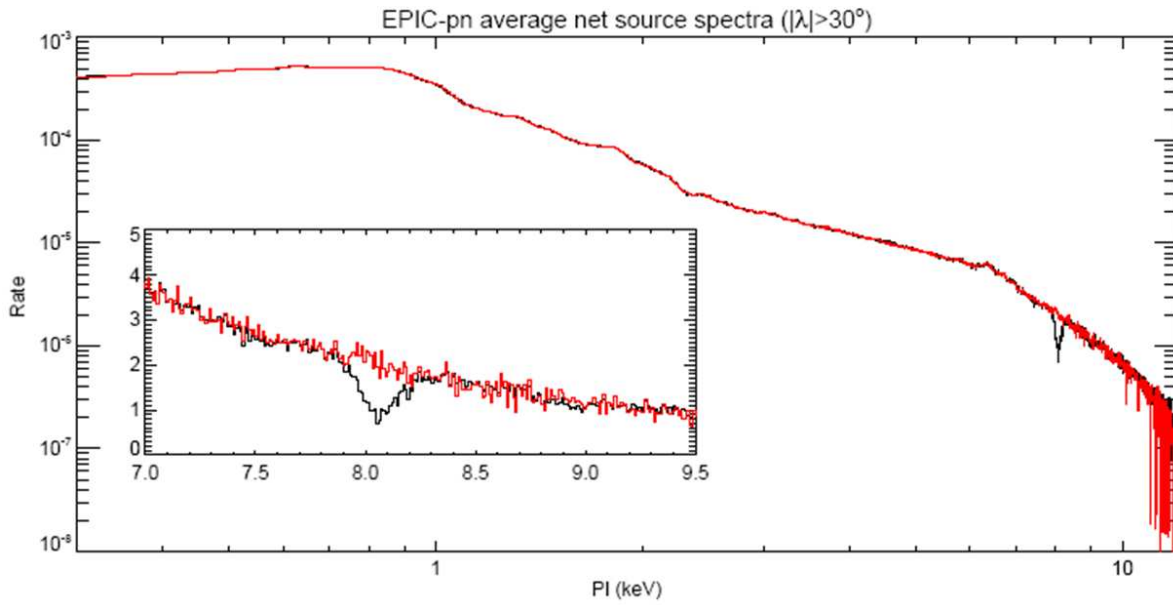


Figure 4: Average source spectrum, after background subtraction, from all sources found in EPIC-pn Full Frame exposures in XSA (black). After correction of both source and background spectra for internal background estimates from FWC data, the Cu line feature at 8 keV is greatly reduced (red).

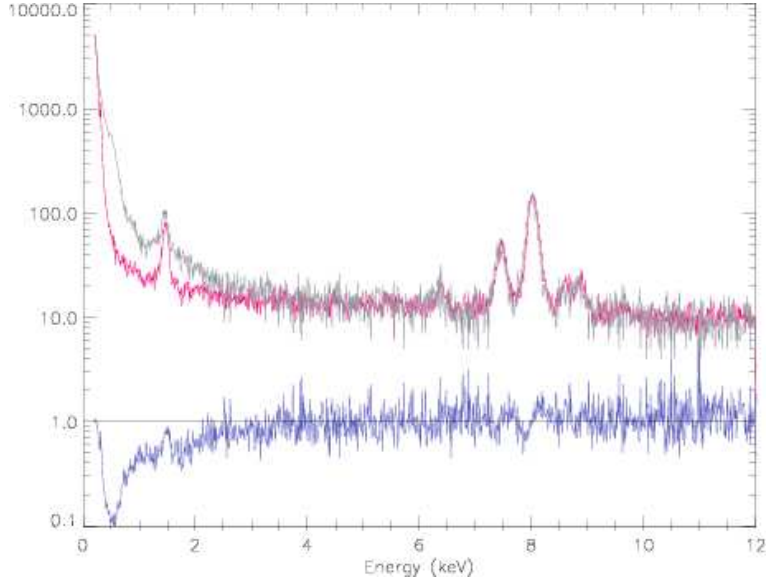


Figure 5: Comparison of the spectrum of events from the out-of-field-of-view, EPIC-pn, SN 1006-1 science exposure 0555630101 (grey) and the spectrum derived from the EPIC-pn FWC data for this observation and the same spatial region (pink). The blue curve gives the ratio FWC / observation.

by flux from the extended source SN 1006-1, hence at low energies the agreement is not as expected, but at higher energies where there is no contribution from SN 1006-1, the spectra agree to within 10%.

## 5 Test procedure and results

Tests were run as part of the SAS 16 validation campaign using the SAS task *evqpb* in conjunction with the draft CCF files. The tests ran successfully.

## 6 Future changes

There is one CCF available per EPIC instrument (EPIC-pn, EPIC-MOS1 and EPIC-MOS2) and only for FF mode. The CCF consists of the sum of all the corresponding individual EPIC observations FWC event files available in the XMM-Newton archive up to a given date. This repository of FWC observations is updated regularly and hence there will be regular releases of the CCF files.

## 7 References

[1][http://xmm-tools.cosmos.esa.int/external/xmm\\_user\\_support/documentation/uhb/epicdetbkgd.html](http://xmm-tools.cosmos.esa.int/external/xmm_user_support/documentation/uhb/epicdetbkgd.html)