XMM-Newton CCF Release Note

XMM-CCF-REL-281

Support to the X-ray Loading correction in EPIC-pn Fast Modes

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1 CCF components

Name of CCF	VALDATE	EVALDATE	Blocks changed	XSCS flag
EPN_REJECT_0006.CCF	2001-01-01	2020-01-01	XRL2PHA	NO

A systematic reanalysis of the offset maps taken prior to each EPIC-pn exposures in "Fast Modes" (Burst and Timing) unveiled that **X-ray Loading** (XRL; Smith 2005) affects them almost ubiquitously (Guainazzi et al. 2011). In a nutshell, XRL occurs when a source "contaminates" the dark current level measured through the offset maps. When this happens, the energy scale may be significantly distorted.

This discovery has potentially a major impact on the calibration of both modes. The spectra of a sizable fraction of the astrophysical sources used for the on-flight energy calibration of EPIC-pn Fast Modes may have been affected by XRL, *i.e.* by an uncalibrated distortion in their energy scale proportional to their count rate. This phenomenon offers a natural physical explanations to rate-dependent energy calibration effects such as the "Rate-Dependent CTI" (Guainazzi et al. 2009). Hence it stems the importance of a proper XRL correction prior to any calibration of the energy scale.

The CCF update described in this Release Note embeds the XRL correction. In general terms, one should expect that: $\Delta(PHA) \propto L$, where $\Delta(PHA)$ is the (in principle energy-independent) shift yielded by the XRL level L (expressed "ADU units"; for the EPIC-pn: 1 ADU = 5 eV). Existing calibration data based on a recent (September 2011) observation of the Crab Nebula are consistent with this assumption, at least for EPIC-pn Timing Mode. The SAS assumes for the time being a linear correction.

2 Changes

A new extension has been added to the EPN_REJECT CCF constituent: XRL2PHA. It contains the coefficients of the linear relation:

$$\Delta(PHA) = a + b \times L.$$

for the EPIC-pn Fast Modes. This change *does not affect* EPIC-pn imaging modes. In this version: a = 0 and b = 0 for both Burst and Timing Mode.

As of Version 12, these coefficients are used by the SAS task `epreject` to correct on an event-by-event basis the event PHA value for the XRL measured in the RAWX column where the event is detected. Readers are referred to the task description for a more detailed description of the XRL correction. The values in this CCF version ensure, however, that no correction is applied even if the task is run on an event list.

3 Scientific Impact of this Update

This CCF aims at ensuring that SASv12 supports the algorithm for the XRL correction. However, this correction cannot be delivered to the public yet, because its should be accompanied by other calibrations, whose content depends on a proper XRL correction. Nullifying the XRL correction for any value of L is obtained if a = 0 and b = 0, *i.e.* if the event PHA values remain untouched independently of the level of XRL measured.

4 Estimated Scientific Quality

The release of this CCF is a preliminary step to achieve the full recalibration of EPIC-pn Fast Modes. Readers are referred to Guainazzi et al. (2011) for a more detailed description of the basic scientific objectives of this exercise.

5 Test procedures and results

The content, formal integrity and compliance to FITS standards of the new CCF have been checked with `fverify` and `fv`.

We have applied `epreject` with `EPN_REJECT_0006.CCF` and the `EPN_TICLOSEDODI_*.CCF` (Smith et al., 2012) to the event list of one of the most recent Crab observations in EPIC-pn Timing Mode (Obs.#0611181101, offset map in THICK filter). Spectra extracted from event lists to which the XRL correction was not applied were indistinguishable from spectra extracted under the same conditions from event lists on which `epreject` was run, modulo a correction for offset shifts due to Minimum Ionising Particles (MIPs) during offset calculation, as expected. For further details on the SASv12 `epreject` validation results, including non-trivial cases of XRL correction under different assumptions, readers are referred to the SASv12 Scientific Validation Report (Gabriel et al., in preparation).

6 References

Guainazzi et al., 2009, XMM-CCF-REL-245 (available at:
http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0245-1-0.ps.gz)

Guainazzi et al., 2011, XMM-SOC-CAL-TN-0083 (available at:
http://xmm2.esac.esa.int/docs/documents/CAL-TN-0083.pdf)

Smith M., 2005, XMM-SOC-CAL-TN-0050 (available at:
http://xmm2.esac.esa.int/docs/documents/CAL-TN-0050-1-0.ps.gz)

Smith M. et al., 2012, XMM-CCF-REL-282 (available at:
http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0282-1-0.ps.gz)