XMM-Newton CCF Release Note

XMM-CCF-REL-336

EPIC-pn Long-Term CTI

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1 CCF Components

Name of CCF	VALDATE	EVALDATE	Blocks Changed	CAL Version	XSCS Flag
EPN_CTI_0047.CCF	2000-01-01T00:00:00		LONG_TERM_CTI LTC_TIMES	3.236.3	NO

2 Changes

The parameters which describe the long-term CTI (LTCTI) behaviour have been updated taking into account data until revolution 3013 (May 2016).

The EPIC-pn shows an expected steady increase in CTI over time. Event energies are corrected for this effect through an empirical modelling of the measured line centroid trends using data obtained from exposures illuminated by the on-board calibration source (*CalClosed* exposures). Details of the method may be found in Smith et al. (2010) and Smith et al. (2014).

As more data is collected the LTCTI description needs to be updated periodically. Especially as the model extrapolation starts to to deviate from the most recently analysed observations. This is the driver for this calibration update.

Novel in this release is the temporal description of the line centroid trends. Originally based on a polynomial function, now the implementation uses a look-up table (a functionality already introduced with SAS 15.0 but not used until this release). This allows greater flexibility in modelling the long term trends, especially allowing a better constraint on the extrapolation to the future. The look-up table values were determined from a sampling of the best fit polynomial function, with the

Mode	Pattern	$\overline{E_{measured} - E_{nominal}}$ (eV)	
		Al-K$_\alpha$	Mn-K$_{\alpha_2}$
		($E_{nominal}$ = 1.486 keV)	($E_{nominal}$ = 5.888 keV)
FF	singles	-3.3 <5.1> (-1.2 <3.8>)	-0.7 <5.0> ($+1.2$ <3.9>)
	doubles	-5.5 <5.9> (-2.4 <5.0>)	$+3.7$ <10.4> ($+9.3$ <6.0>)
EFF	singles	-0.9 <3.7> (-0.1 <3.4>)	$+1.1$ <5.0> (-0.1 <4.4>)
	doubles	-1.3 <6.2> ($+0.9$ <6.2>)	$+5.1$ <4.0> ($+5.9$ <3.5>)

Table 1: Summary of the EPIC-pn energy reconstruction accuracy at the boresight location for *CalClosed* observations taken over the course of the mission. Values shown are the mean and standard deviation (in eV) of the differences between measured line centroid and nominal energy. They are derived from all observations with exposure times $\geq$ 10 ks since launch; values between parentheses exclude observations taken before 2002.

sample times stored in the new LTC_TIMES extension. Extrapolated values were uncoupled from the polynomial and defined to follow a reasonably expected trend.

3   Scientific Impact and Estimated Quality

The changes essentially correct where the extrapolation of the most recent modelling (mid 2014) deviates from the data. In general, this affects observations taken since mid 2015. Off-axis data are most affected, with the old calibration yielding an overestimate of energies of up to 5 eV at 1.5 keV and 15 eV at 6.0 keV; the impact of the changes on data taken at the nominal aim point is not significant as the CCD 4 model extrapolation closely follows the recent measurements.

The results obtained with the new calibration for Full Frame Mode data are shown in Figs. 1 and 3, and for Extended Full Frame Mode data in Figs. 2 and 4.

A summary of the accuracy of the *CalClosed* energy reconstruction obtained with the new long-term CTI modelling is given in Table 1.

4   Test Procedures

Verification of functionality of EPN_CTI_0047.CCF with SAS 15.0: `calview`, `cifbuild`, `epproc`, `epchain`.

5   Expected Updates

As the PN LTCTI will continue to develop in time, model parameters will have to be periodically updated. Inclusion of an extra LTCTI calibration point based on the Cu-K$_\alpha$ fluorescent emission

line is under investigation.

6   References

Smith, M.J.S., et al., 2010, XMM-SOC-CAL-SRN-0271
   (`http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0271-1-0.ps.gz`)

Smith, M.J.S., et al., 2014, XMM-SOC-CAL-SRN-0323
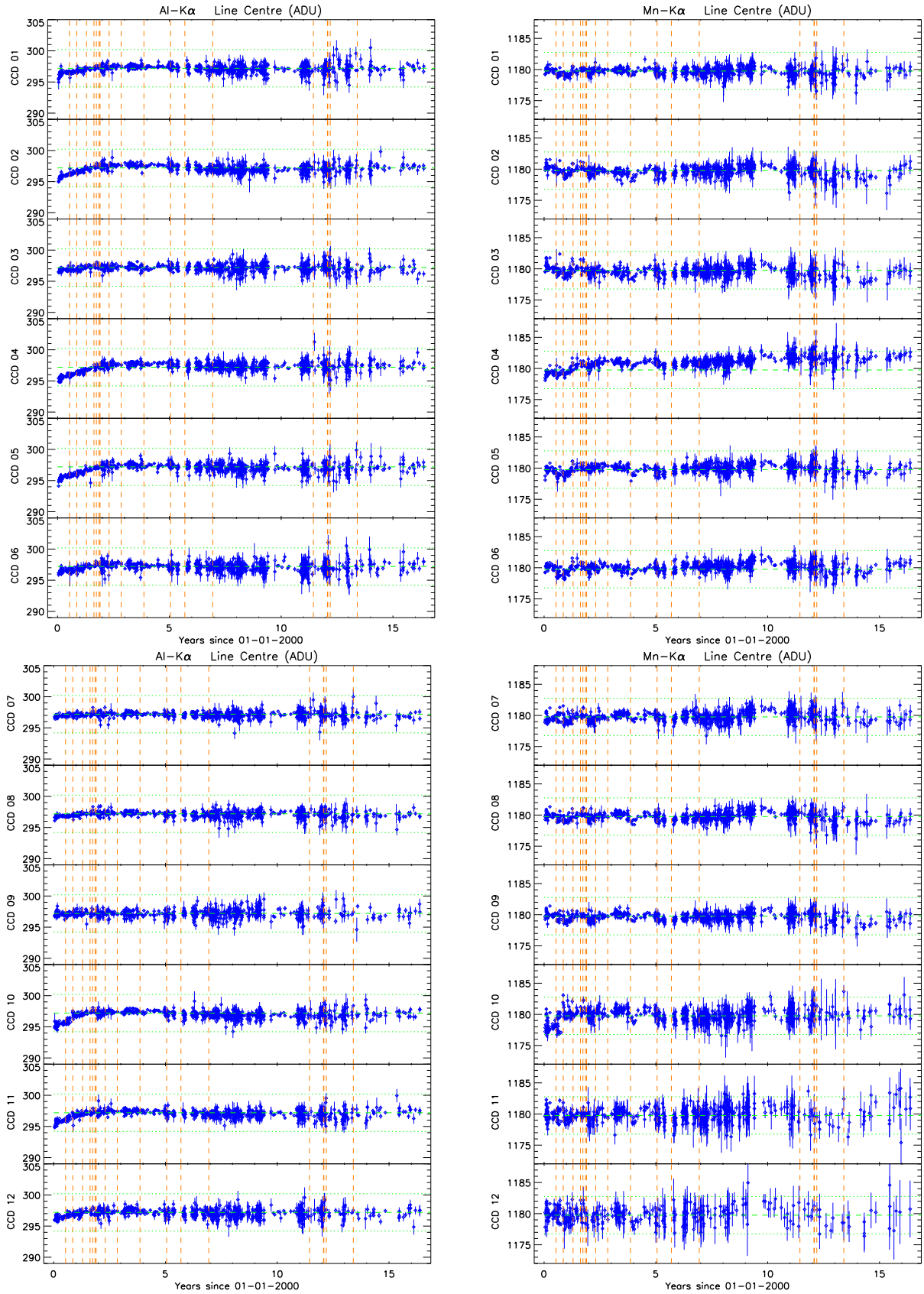   (`http://xmm2.esac.esa.int/docs/documents/CAL-SRN-0323-1-1.ps.gz`)

Figure 1: Al-K$_\alpha$ (left) and Mn-K$_\alpha$ (right) line centroid energies (in ADU) as determined from Full Frame mode *CalClosed* observations using the new long-term CTI calibration. The data shown here are based on first-single events extracted from the well illuminated areas of the complete CCDs. The horizontal green dashed line shows the nominal line energy, the vertical dashed lines indicate the times of major solar coronal mass ejections.
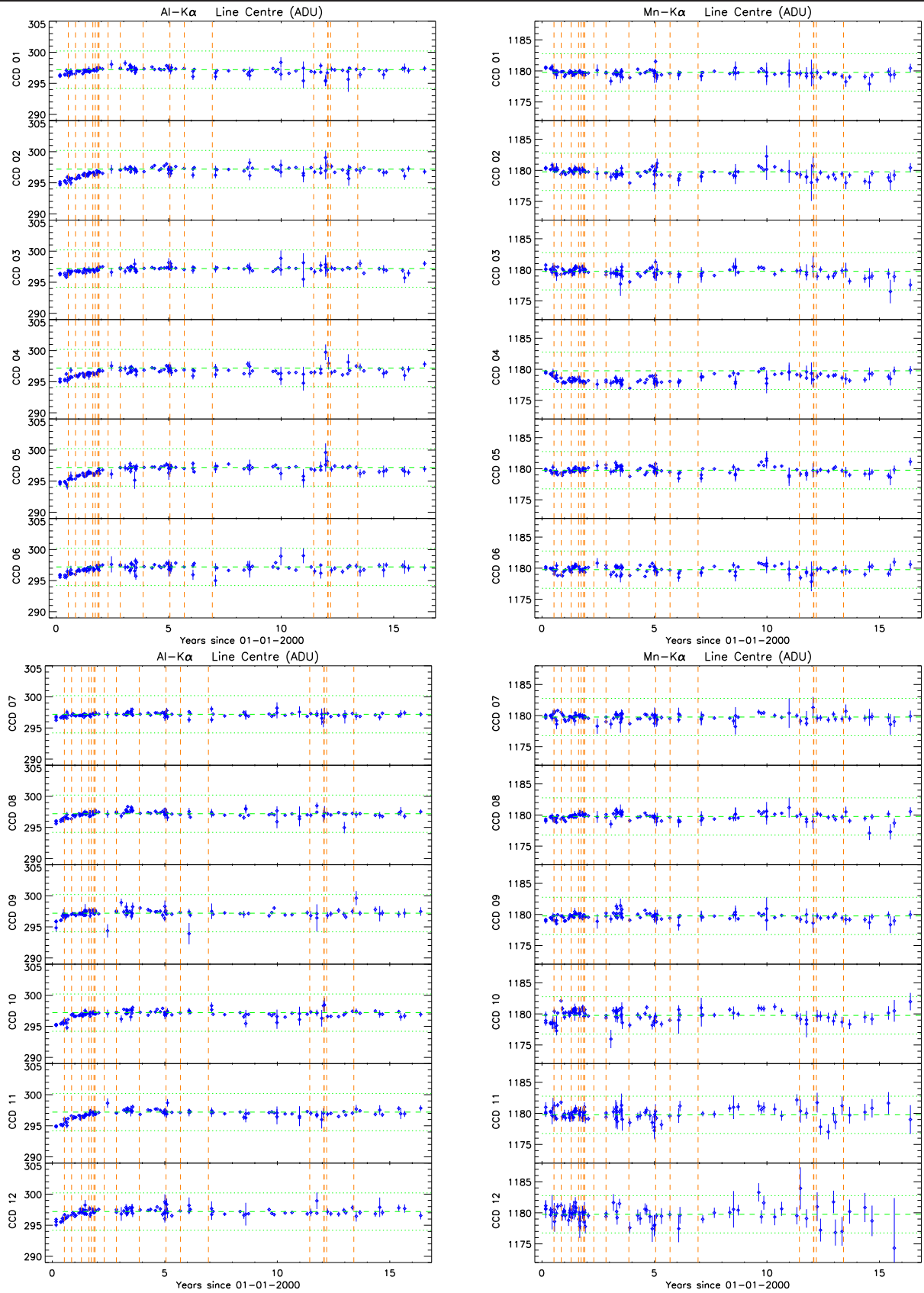
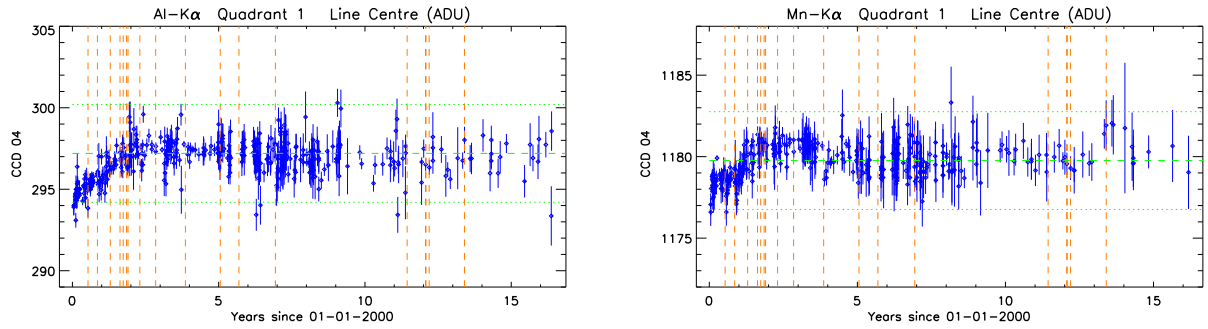Figure 2: As Fig 1, for Extended Full Frame mode.

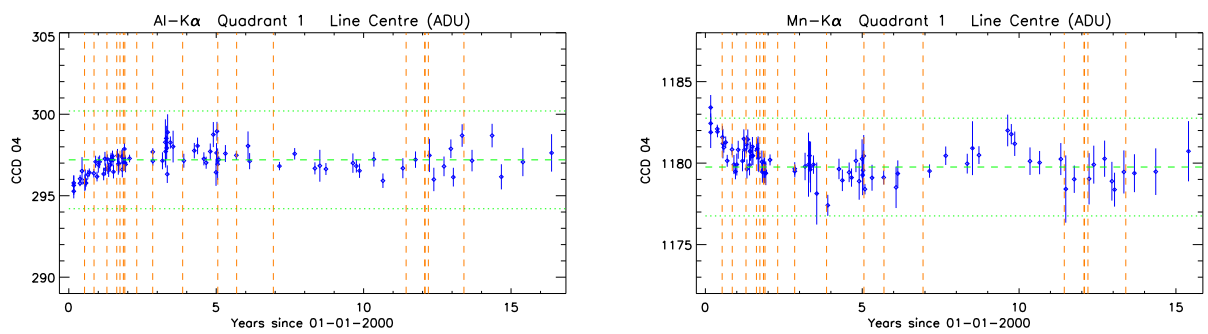Figure 3: As Fig 1, but for data taken from a 20-row region around the boresight.

Figure 4: As Fig 3, but for Extended Full Frame mode.