# XMM-Newton CCF Release Note

XMM-CCF-REL-288

## 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_0026.CCF | 2000-01-01T00:00:00 | | LONG_TERM_CTI | | NO |

## 2 Changes

The parameters to correct the effects of pn long-term charge transfer inefficiency (CTI) have been modified to reflect the latest calibration data.

These parameters are contained in the T_COEFF vector column in the LONG_TERM_CTI extension. There are individual vectors per mode and CCD, with each vector containing the coefficients of a cubic polynomial in time.

The long-term CTI correction is based on an empirical modelling of the non-long-term CTI corrected line centroid trends, obtained from exposures illuminated by the on-board calibration source (CalClosed exposures). Full details of the method may be found in [1].

The method is illustrated in Fig. 1, which shows the Full Frame Mode Mn-$K_\alpha$ line centroids as determined without any long-term CTI correction, and the best fit model from which the values of the long-term CTI correction parameters are derived. In order to optimise the energy reconstruction for targeted sources, the data selected for CCD 4 are restricted to an area around the boresight (RAWY in the range [181..200]). For the other CCDs, data from the complete CCD are used, although low-illuminated areas are excluded to limit the relative contribution of out-of-time events.

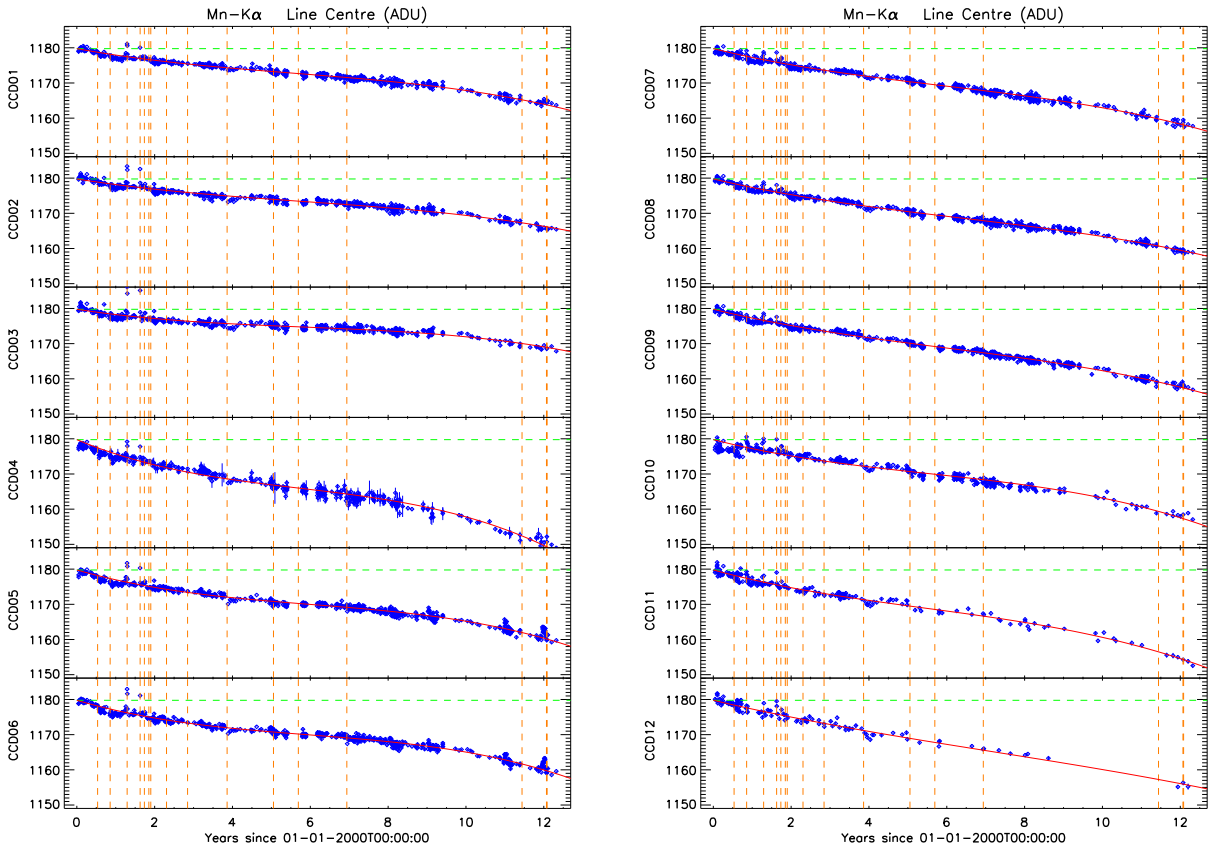


Figure 1: Mn-$K_\alpha$ line centroid energies (in ADU) as determined from Full Frame Mode CalClosed observations, without applying any long-term CTI correction. The horizontal green dashed line shows the theoretical line energy, the vertical dashed lines indicate the times of major solar coronal mass ejections. The best fit empirical model is overlaid in red; this is used to derive the parameter values of the long-term CTI correction. The data shown here were extracted from the well illuminated areas of the complete CCDs, except for CCD 4, where the data were extracted from a 20-row region around the boresight.

Similar modelling of Extended Full Frame Mode line centroids allows the determination of long-term CTI correction parameters for this mode.

Large Window, Small Window, Timing and Burst Modes are not designed for full-frame illumination, thus complicating the interpretation of CalClosed data. As an approximation, for these modes the Full Frame Mode parameter values are used.

## 3 Scientific Impact and Estimated Quality

The following plots show the reconstructed Mn-$K_\alpha$ line centroid energies from CalClosed data extracted from the complete CCD area, except for CCD 4 where the data are extracted from around the boresight. The results obtained with the new CCF, issue 0026, are compared with those of the most recent previous issue 0024.

The Full Frame Mode results are shown Fig. 2 (CCDs 1 - 6) and Fig. 3 (CCDs 7 - 12); data for the old and new CCFs are shown in the left and right panels respectively.

For several CCDs, the reconstructed Mn-K$_\alpha$ line energies obtained with the previous CCF issue show systematic deviations from the theoretical energy from the beginning of 2010 onwards. The deviations range from approximately $-3.5$ ADU to $+2.5$ ADU (equivalent to $-15$ eV to $+10$ eV; the conversion is: 1 ADU $= 5$ eV), depending on the CCD. In particular, the line reconstruction at the boresight location shows an under correction of up to 3 ADU.

Using the new CCF, the systematic deviations in recent observations have been greatly reduced. Over the course of the mission, the Mn-K$_\alpha$ reconstructed line energies are in general within $\pm 2.5$ ADU ($\pm 12.5$ eV) of the theoretical value. Somewhat larger deviations occur in distinct periods up to approximately 2001, and at times of increased solar activity. The standard deviation of the line centre distributions for CCDs 4, 10 and 12 is $\sim 1.1$ ADU, while for the other CCDs the values lie within the $0.5 - 0.8$ ADU range.

Similarly, the results for Extended Full Frame Mode are shown in Figs. 4 and 5. The results of the new CCF for Extended Full Frame Mode data are slightly better than those of Full Frame Mode data, showing a stability within $\pm 10$ eV of the theoretical energy at Mn-K$_\alpha$. The standard deviation of the line centre distribution lies within $0.4 - 0.8$ ADU for all CCDs except CCD 4, with a standard deviation of 1.1 ADU.

## 4 Expected Updates

The pn CTI will continue to develop in time. Model parameters will likely have to be adjusted to the results of new calibration observations.

## 5 Test Procedures and Results

Verification of functionality of EPN_CTI_0026.CCF with SAS 12: `calview`, `cifbuild`, `epproc`. Testing and validation described in Section 3.

## 6 References

[1] Smith, M.J.S., et al., 2010, XMM-SOC-CAL-SRN-0271

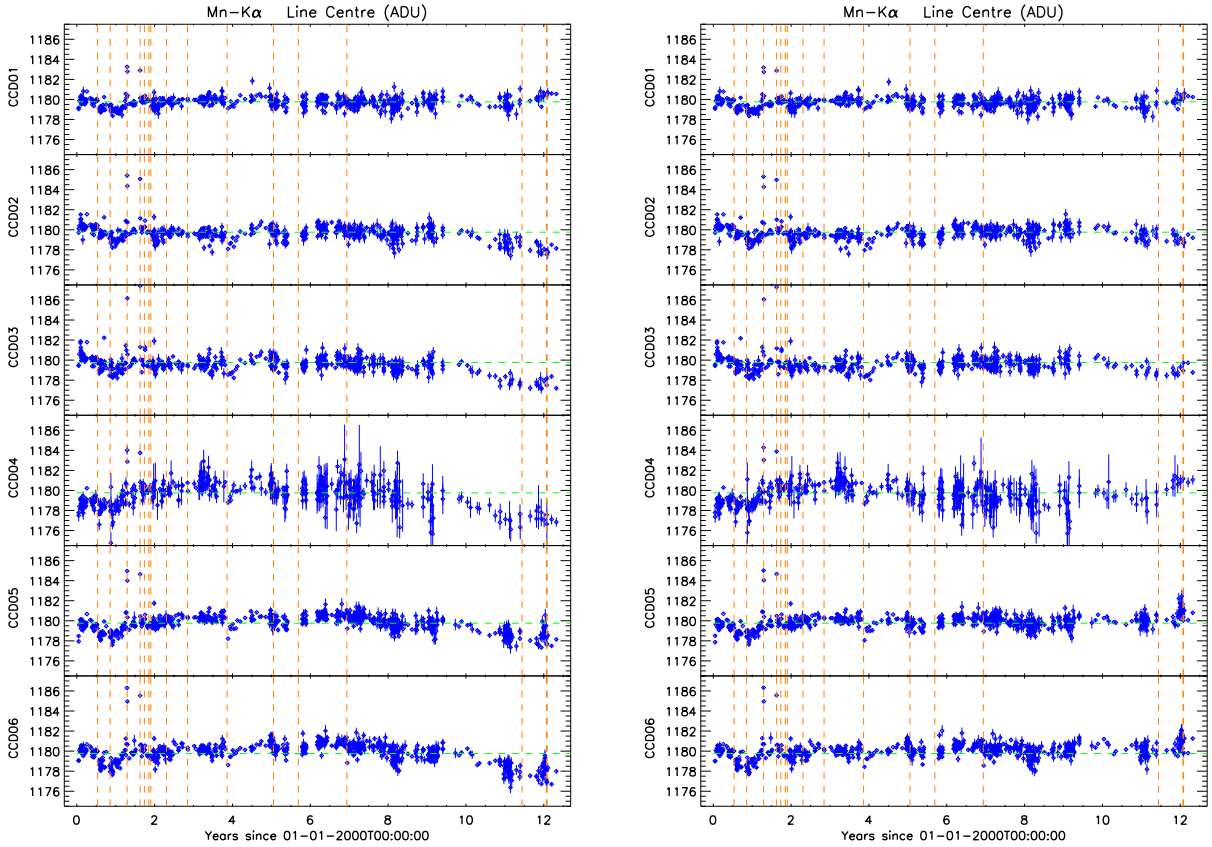


Figure 2: Full Frame Mode Mn-K$_\alpha$ line centroid energy reconstruction for CCDs 1 - 6. Results of the old and new CCFs are shown in the left and right panels respectively. The data were extracted from the well illuminated parts of the complete CCDs, except for CCD 4, where the data are obtained from around the boresight only. The green dashed line shows the theoretical energy. Vertical dashed lines indicate the times of major solar coronal mass ejections. Post revolution $\sim$ 1800 (October 2009), the old CCF results in Mn-K$_\alpha$ line centroid energies dropping systematically below the theoretical value by up to 20 eV.

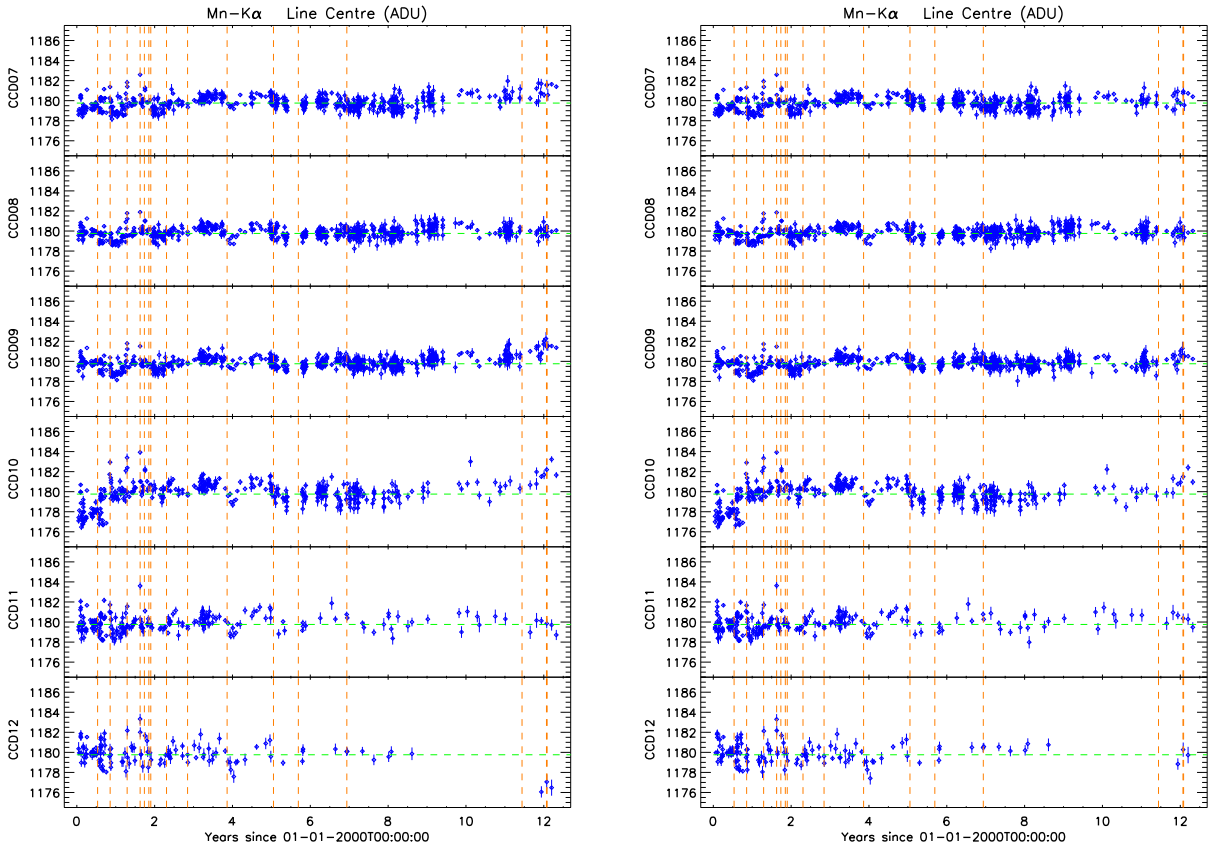


Figure 3: As Fig. 2, for CCDs 7 - 12. Results obtained with the old CCF are shown in the left panel, and with the new CCF in the right panel.

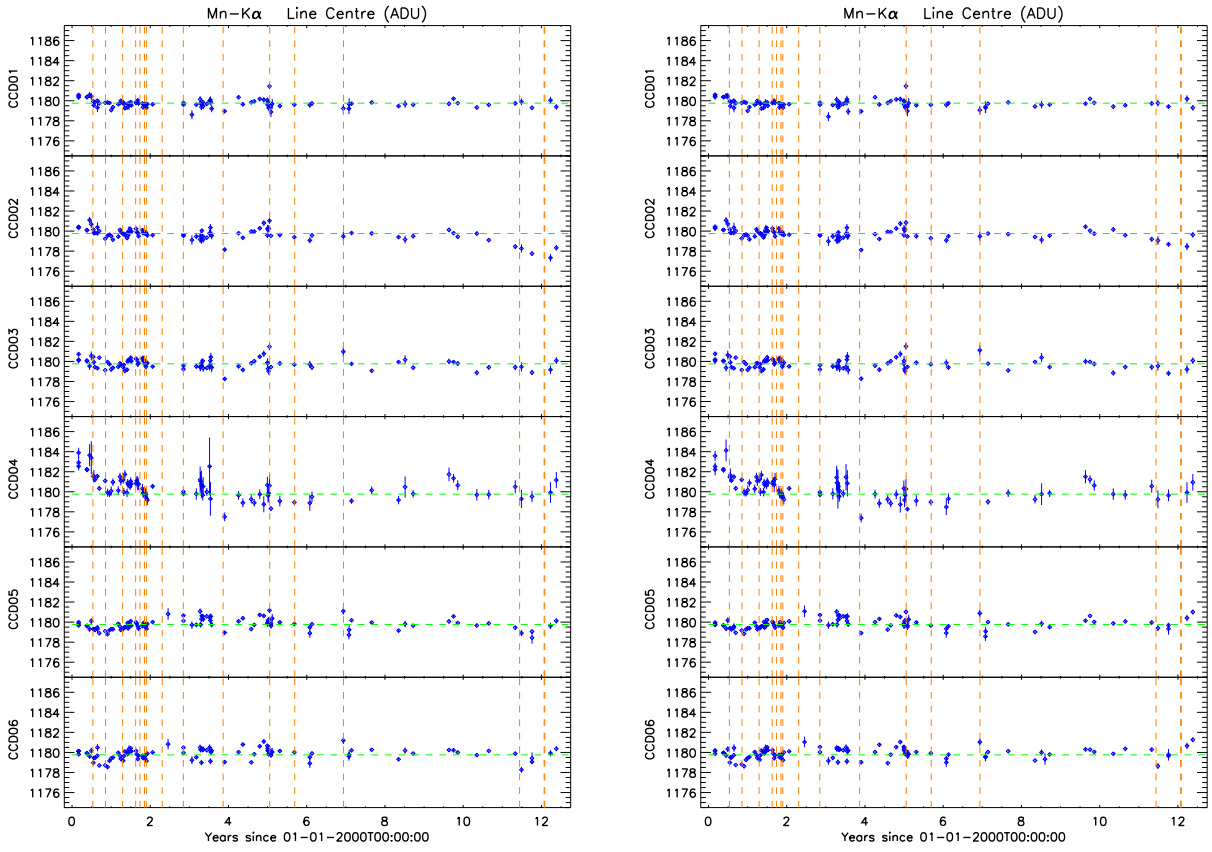


Figure 4: As Fig. 2, for Extended Full Frame Mode.

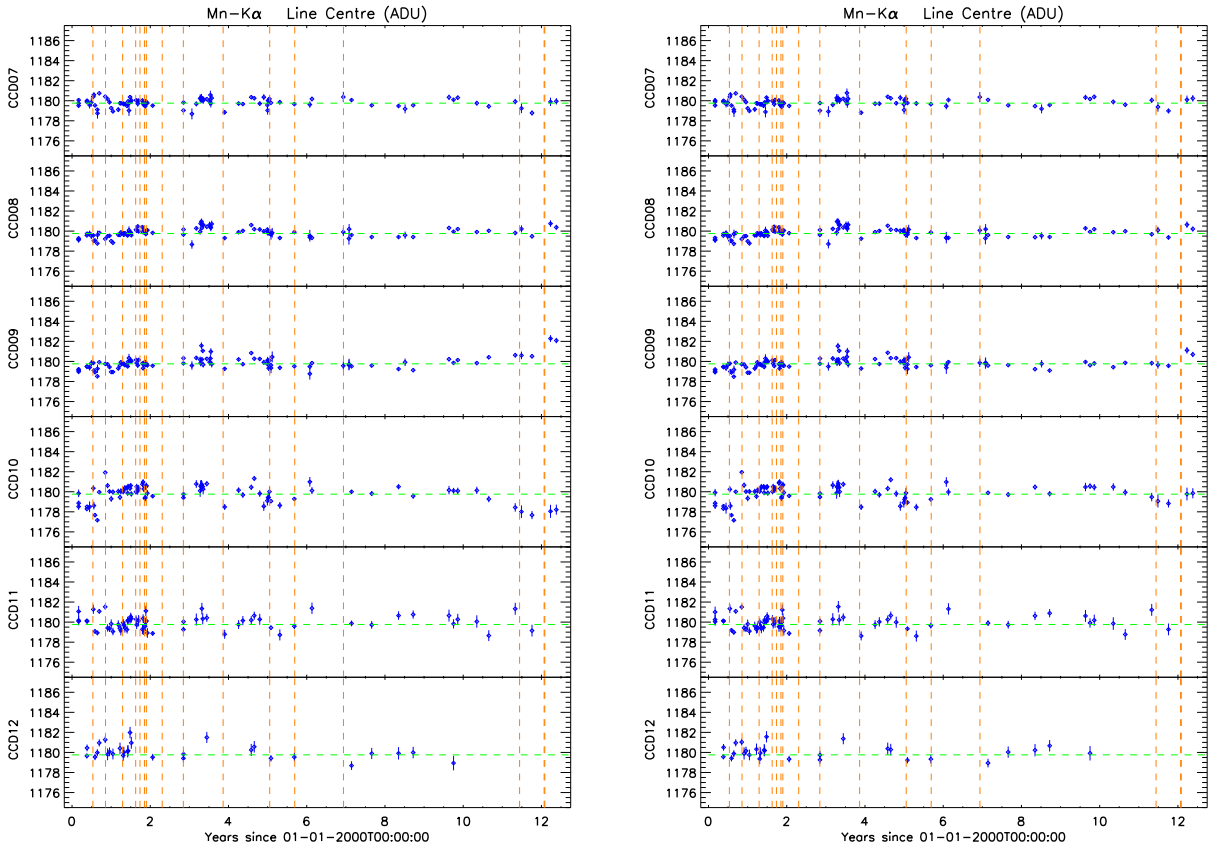


Figure 5: As Fig. 3, for Extended Full Frame Mode.