# XMM-Newton CCF Release Note

XMM-CCF-REL-224

## Update of EPIC MOS CTI

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## 1 CCF components

| Name of CCF | VALDATE (start of val. period) | EVALDATE (end of validity period) | List of Blocks changed | CAL VERSION | XSCS flag |
|---|---|---|---|---|---|
| EMOS1_CTI_0030 | 1999-12-10T00:00:00 | 2000-07-15T12:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0031 | 2000-07-15T12:00:01 | 2000-11-09T12:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0032 | 2000-11-09T12:00:01 | 2001-04-18T00:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0033 | 2001-04-18T00:00:01 | 2001-08-18T00:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0034 | 2001-08-18T00:00:01 | 2001-09-26T22:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0035 | 2001-09-26T22:00:01 | 2001-11-25T12:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0036 | 2001-11-25T12:00:01 | 2002-05-16T05:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0037 | 2002-05-16T05:00:01 | 2002-11-07T05:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0038 | 2002-11-07T05:00:01 | 2003-11-09T18:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0039 | 2003-11-09T18:00:01 | 2005-01-21T18:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0040 | 2005-01-21T18:00:01 | 2005-07-24T01:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0041 | 2005-07-24T01:00:01 | 2005-10-19T19:00:00 | CTI_EXTENDED | | NO |
| EMOS1_CTI_0042 | 2005-10-19T19:00:01 | | CTI_EXTENDED | | NO |
| EMOS2_CTI_0031 | 1999-12-10T00:00:00 | 2000-07-15T12:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0032 | 2000-07-15T12:00:01 | 2000-11-09T12:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0033 | 2000-11-09T12:00:01 | 2001-04-18T00:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0034 | 2001-04-18T00:00:01 | 2001-08-18T00:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0035 | 2001-08-18T00:00:01 | 2001-09-26T22:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0036 | 2001-09-26T22:00:01 | 2001-11-25T12:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0037 | 2001-11-25T12:00:01 | 2002-05-16T05:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0038 | 2002-05-16T05:00:01 | 2002-11-07T05:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0039 | 2002-11-07T05:00:01 | 2003-11-09T18:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0040 | 2003-11-09T18:00:01 | 2005-01-21T18:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0041 | 2005-01-21T18:00:01 | 2005-07-24T01:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0042 | 2005-07-24T01:00:01 | 2005-10-19T19:00:00 | CTI_EXTENDED | | NO |
| EMOS2_CTI_0043 | 2005-10-19T19:00:01 | | CTI_EXTENDED | | NO |

## 2 Changes

A new set of CTI CCFs have been derived for the MOS taking into account the latest measured degradation rate of the parallel CTI. This new set of CCFs covers the same time periods as the previous CTI CCFs (MOS1 issue 17–29, MOS2 issue 17–30, see XMM-CCF-REL-124 and XMM-CCF-REL-221). The serial CTI is also updated, even though it remains nearly constant since cooling.

For previous CTI CCFs, we have provided the average CTI loss for an entire CCD. However, the charge loss in some areas of each CCD is different to the loss in other areas of the same CCD. Spectra taken from just a single column of a CCD could be shifted by up to 200 eV (in the most extreme case). This behaviour is caused by a single bad pixel (a charge 'trap') within a column. As the spectrum is read out of a column, events which pass through such a trap loose more charge than the average loss expected for each CCD. Evidence for this behaviour is shown in Fig. 1 (especially MOS2 CCD1 column 291), where the single Gaussian peak expected from the aluminium calibration line shows a double peak; one peak from unaffected events below a trap, and one peak from events that have lost a significant amount of charge to the trap, resulting in a spectral offset. We refer to regions within a column as 'column segments'. Note that the only change in the events affected by a trap is a spectral offset, and the remaining properties of the events remain valid.

The latest CTI CCFs contain a list of column segments and associated energy offsets. Each event within a given column segment is corrected by the addition of the energy offset. This correction is applied within the EMENERGY SAS task. The offsets have been calculated from combining all the CalClosed observations taken during a CCF period, in order to get the signal-to-noise required to analyse individual column segments in detail.

The CTI_COLUMN extension of the new CTI CCFs contains the following parameters:

1. CCD_ID: the CCD number (1-7)
2. NODE_ID: the CCD read–out direction
3. RAWX: column number (0–599)
4. RAWY_START: start position of a column segment within a column (0–599)
5. YLENGTH: length of the segment (1–600)
6. OFFSET: the offset of the segment in energy (ADU)

## 3 Scientific Impact of this Update

By applying the column offset correction, these new CCFs can improve the energy resolution for all observations at all epochs in two ways. First, the resolution is dependent on the spectral deviation of all the individual columns used to extract the spectrum, and this correction minimises that deviation. Secondly, the correction also leads to an increase in the number of counts at the line centroid.

The monitoring of the on-board calibration source reveals average FWHM improvements of about 4% at Al-K$\alpha$ and about 3% at Mn-K$\alpha$ energy. The average numbers of the calibration line FWHM for the post-cooling epochs (revolution > 533) are:

| Line | FWHM [eV] old CCFs | FWHM [eV] new CCFs |
|---|---|---|
| MOS1 Al (mean): | 80 | 76 |
| MOS1 Mn (mean): | 145 | 140 |
| MOS2 Al (mean): | 79 | 75 |
| MOS2 Mn (mean): | 142 | 137 |

The use of this set of CCFs also will improve the MOS energy scale for those observations performed in the latest epochs.

The new set of CTI CCFs are released together with a new set of ADUCONV CCFs (MOS1 issues 42-54, MOS2 issues 43-55, see XMM-CCF-REL-225), since using the new CTI CCFs with the old ADUCONV CCFs, or the old CTI CCFs with new ADUCONV CCFs, may give unexpected results!

## 4 Estimated Scientific Quality

This issue ensures that the MOS energy scale remains within 5 eV at 2keV, and 10 eV for most sources (not too bright), for all observations (see a more detailed discussion in XMM-CCF-REL-124).

It is recalled that since SASv5.4 the MOS parallel CTI is modelled with the simple formula of the CTI loss per transfer:

- $CTIY(E,t) = (A + B * t) * E^{\alpha}$

where A is a constant, B the degradation rate (slope), $\alpha$ a power index (all 3 parameters take different values for different CCDs and different time periods), E the event energy in ADUs and t the time since launch. Note that the serial CTI is also modelled with the same formula but is mostly constant since launch. Since SASv7.0, the energy correction uses an additional offset term:

- $E_{corr} = E + RAWY * CTIY + RAWX * CTIX - OFFSET(RAWX, RAWY)$

This algorithm allows an energy scaling of the CTI that fits very well the Mn and Al lines of the internal calibration source.

## 5 Test procedures & results

The new CTI CCFs have been tested with the SASv7.0. The results are presented in Fig. 2 to Fig. 9.

## 6 Expected Updates

None.

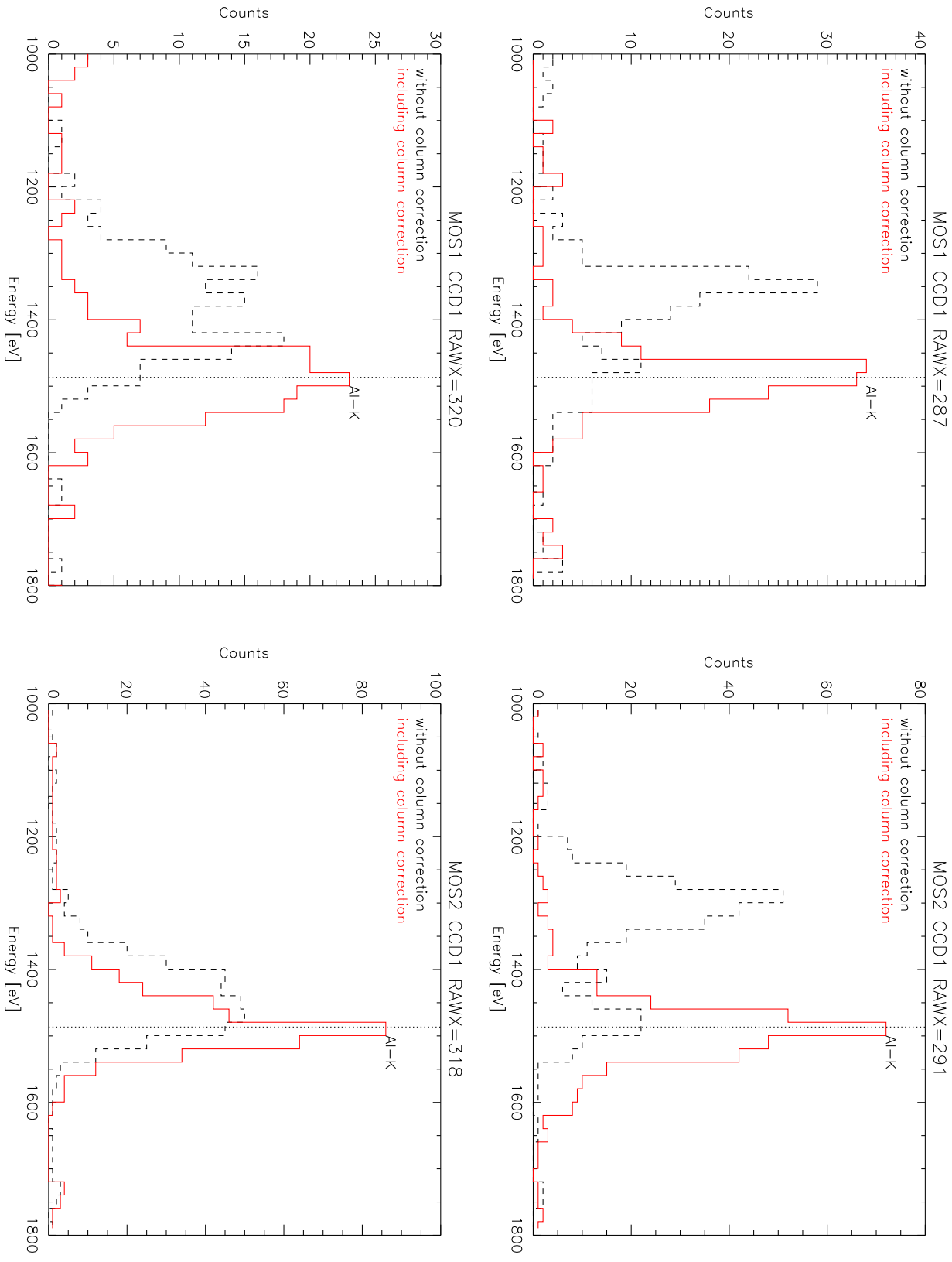


Figure 1: Examples of the column offset corrections for MOS1 (top) and MOS2 (bottom) using the 51 ksec calclosed observation 0160363001 (rev. 0981): The correction removes possible double peaks in the single column spectra (caused by the spectrum being offset by a trap mid-way down a column) and shifts the line to the correct energy. The different line fluxes are due to different strenghts of the MOS1 and MOS2 calibration sources.

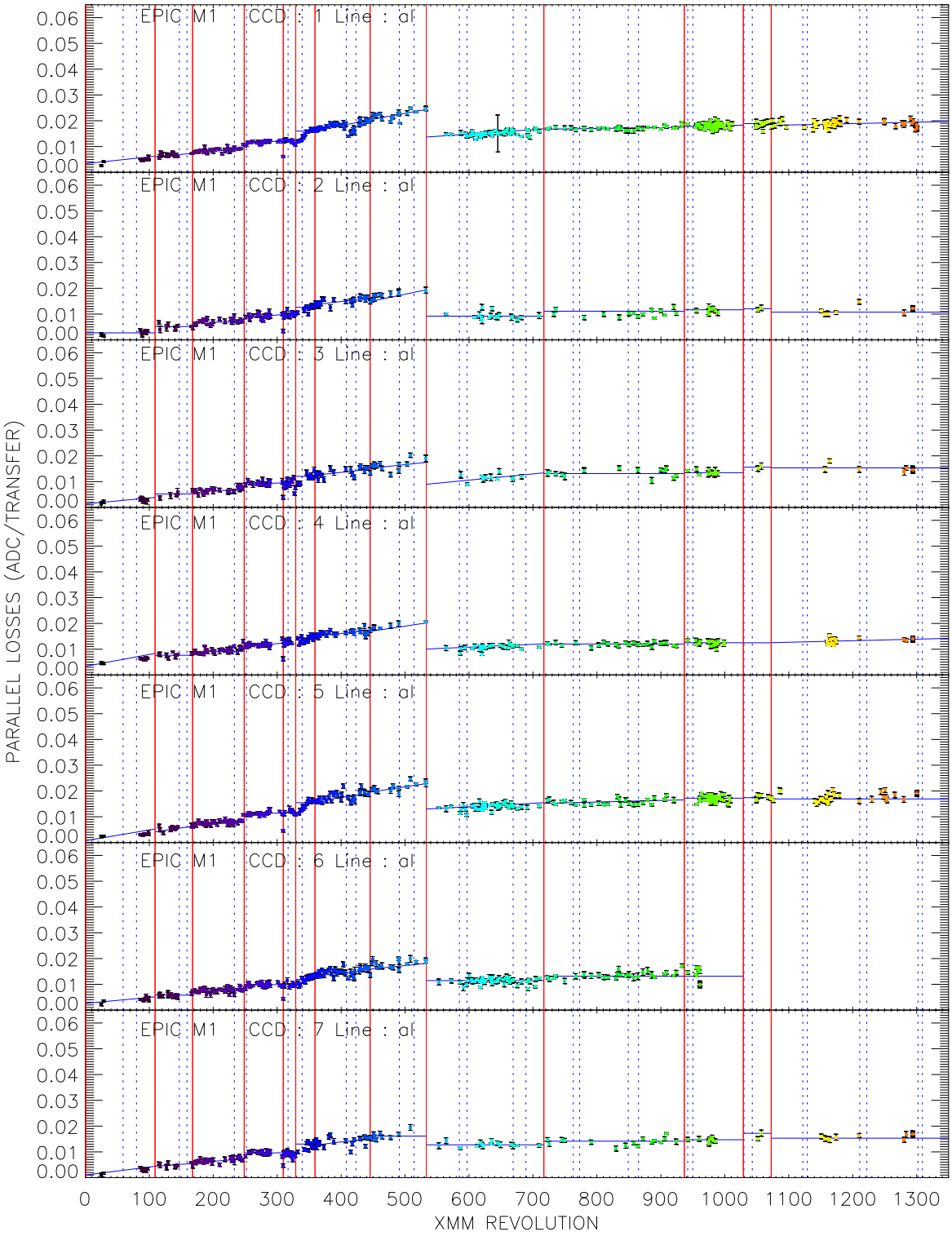


Figure 2: MOS1 parallel transfer losses since launch at 1.5 keV, the energy of the Al calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

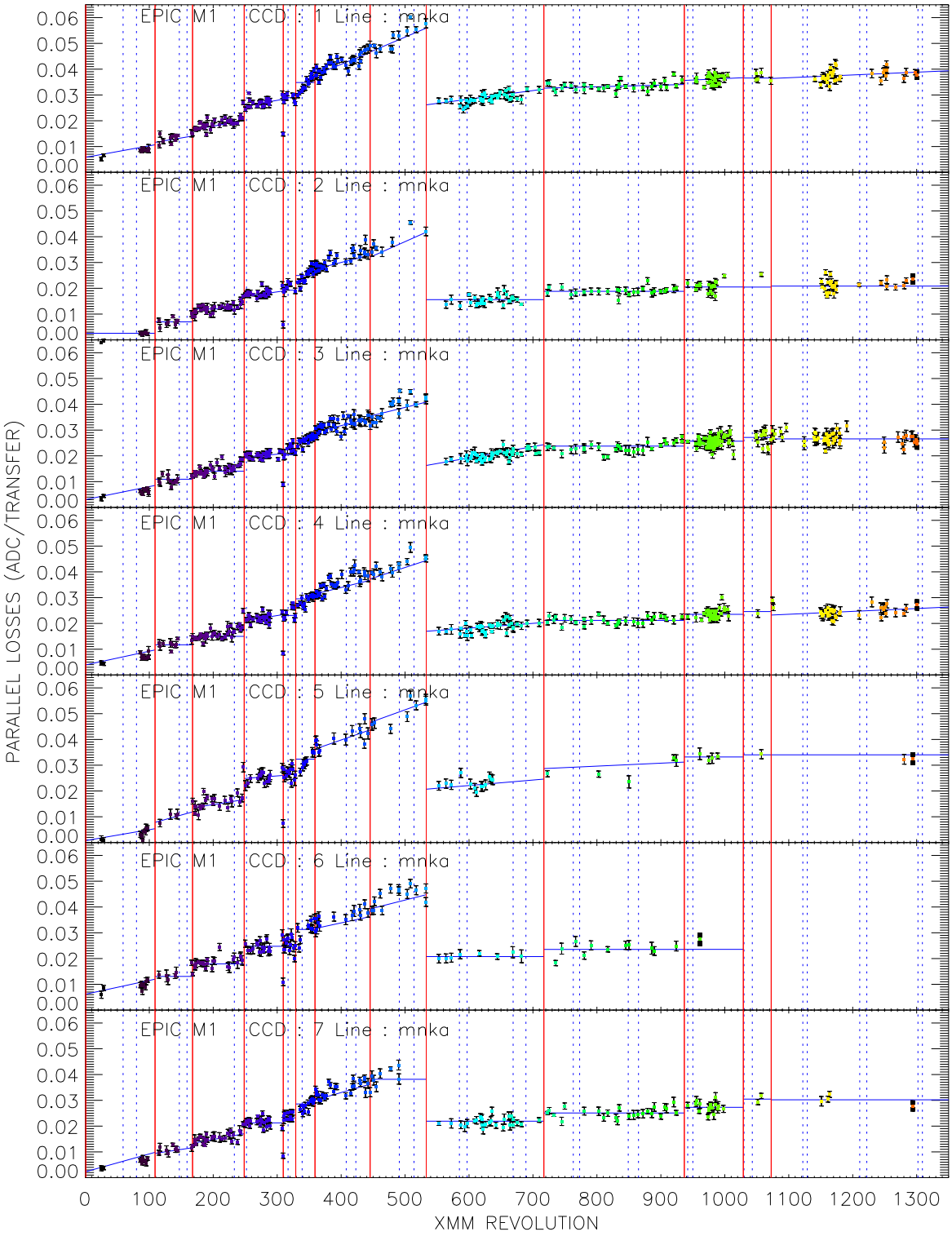


Figure 3: MOS1 parallel transfer losses since launch at 5.9 keV, the energy of the Mn K$\alpha$ calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

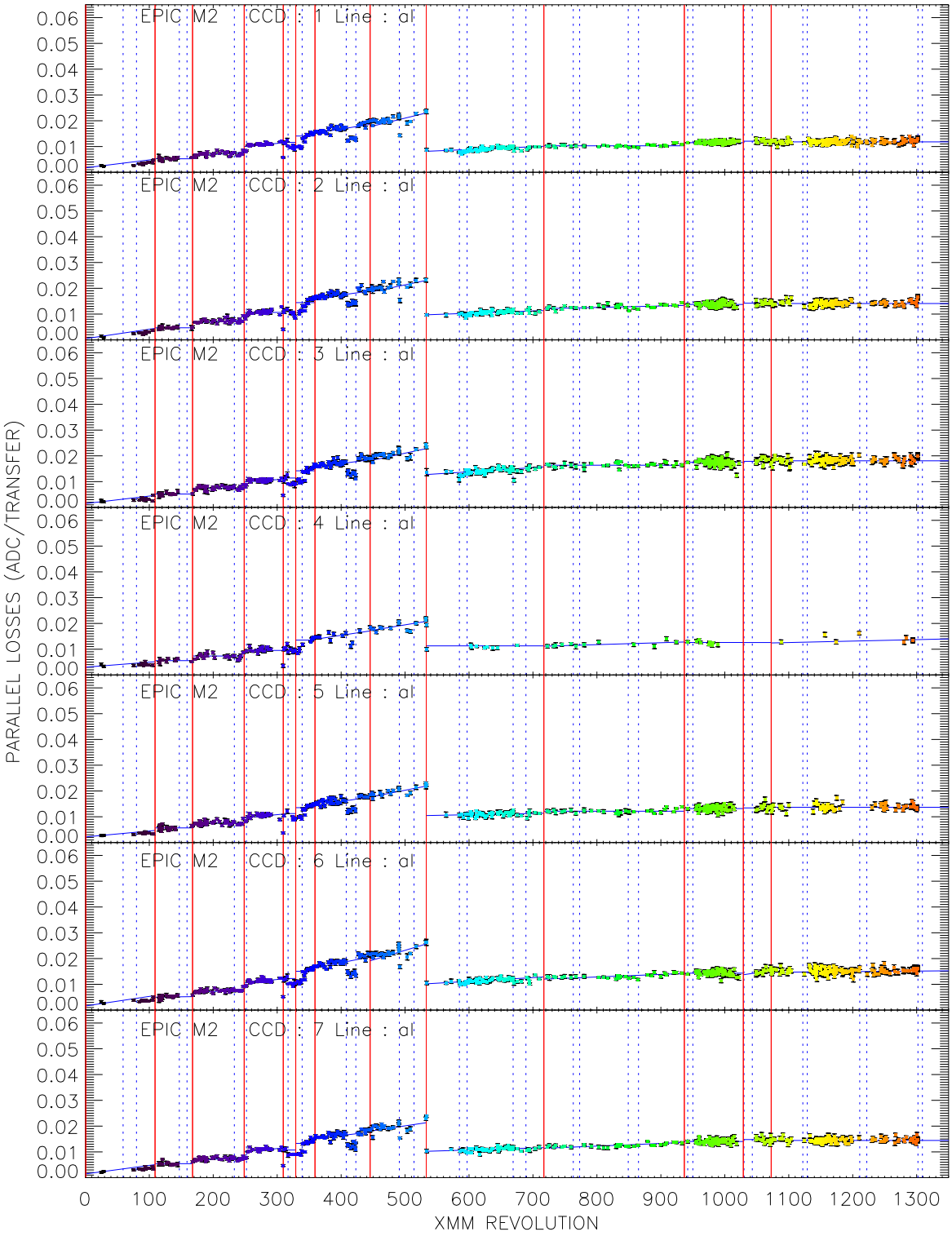


Figure 4: MOS2 parallel transfer losses since launch at 1.5 keV, the energy of the Al calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

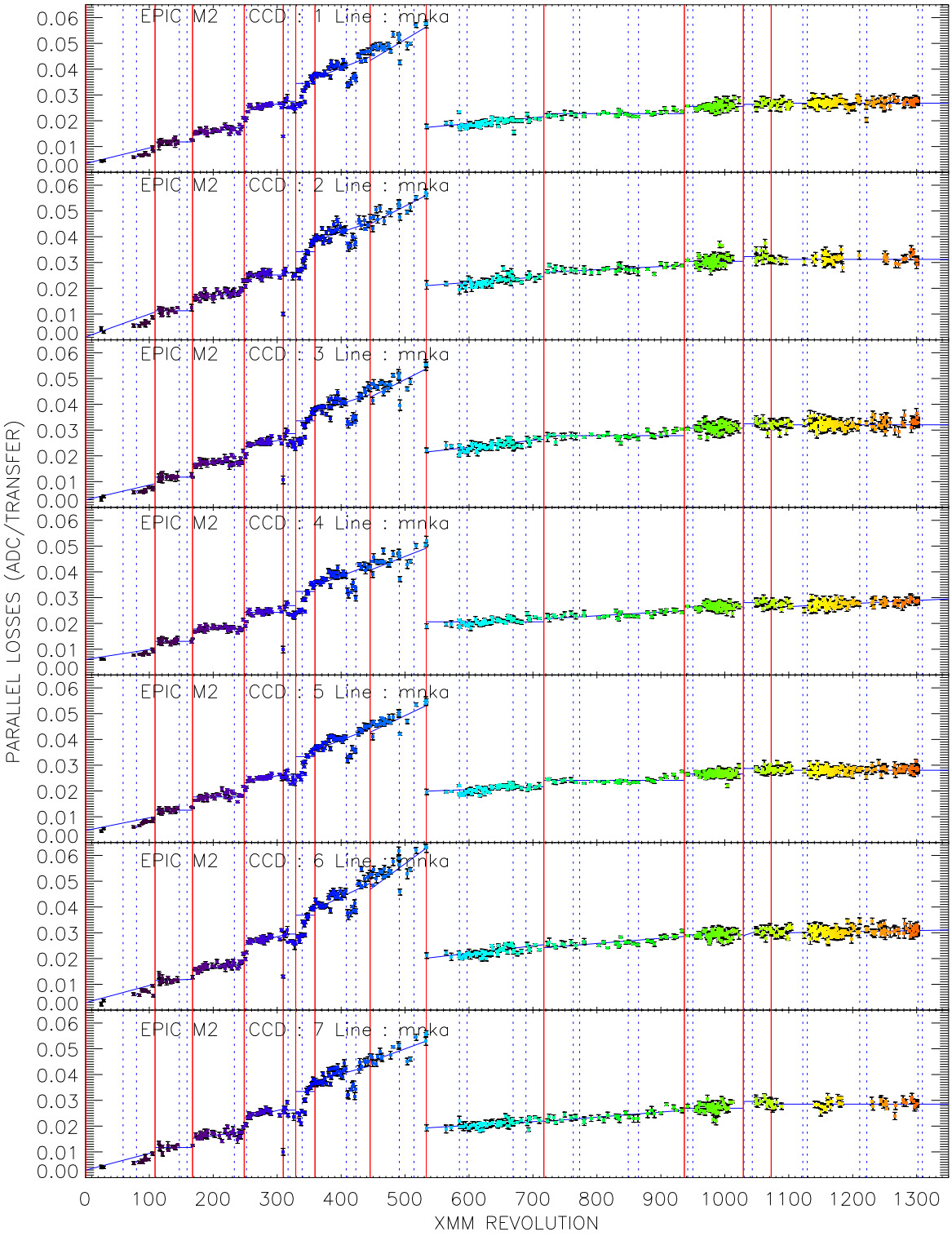


Figure 5: MOS2 parallel transfer losses since launch at 5.9 keV, the energy of the Mn K$\alpha$ calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

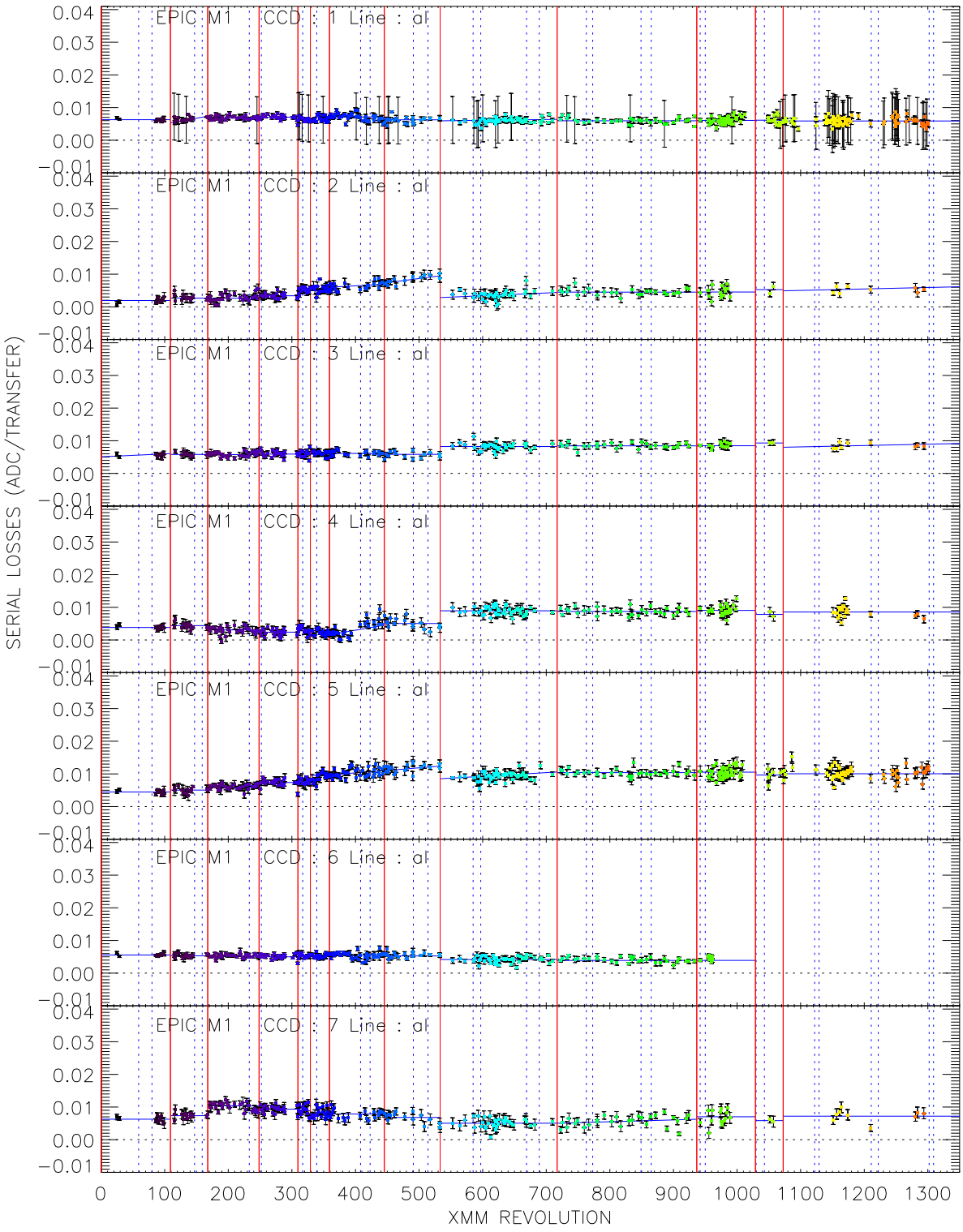


Figure 6: MOS1 serial transfer losses since launch at 1.5 keV, the energy of the Al calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

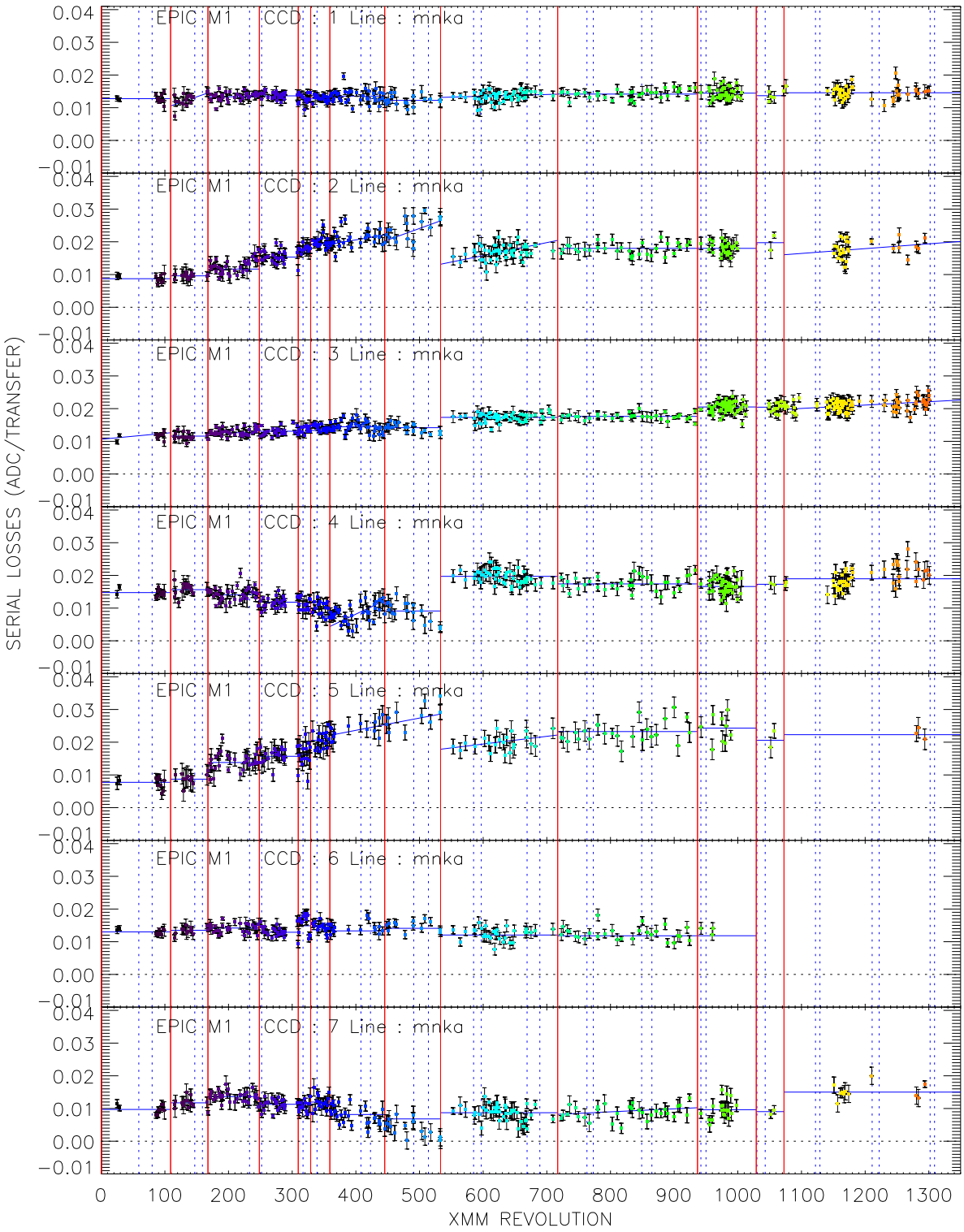


Figure 7: MOS1 serial transfer losses since launch at 5.9 keV, the energy of the Mn K$\alpha$ calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

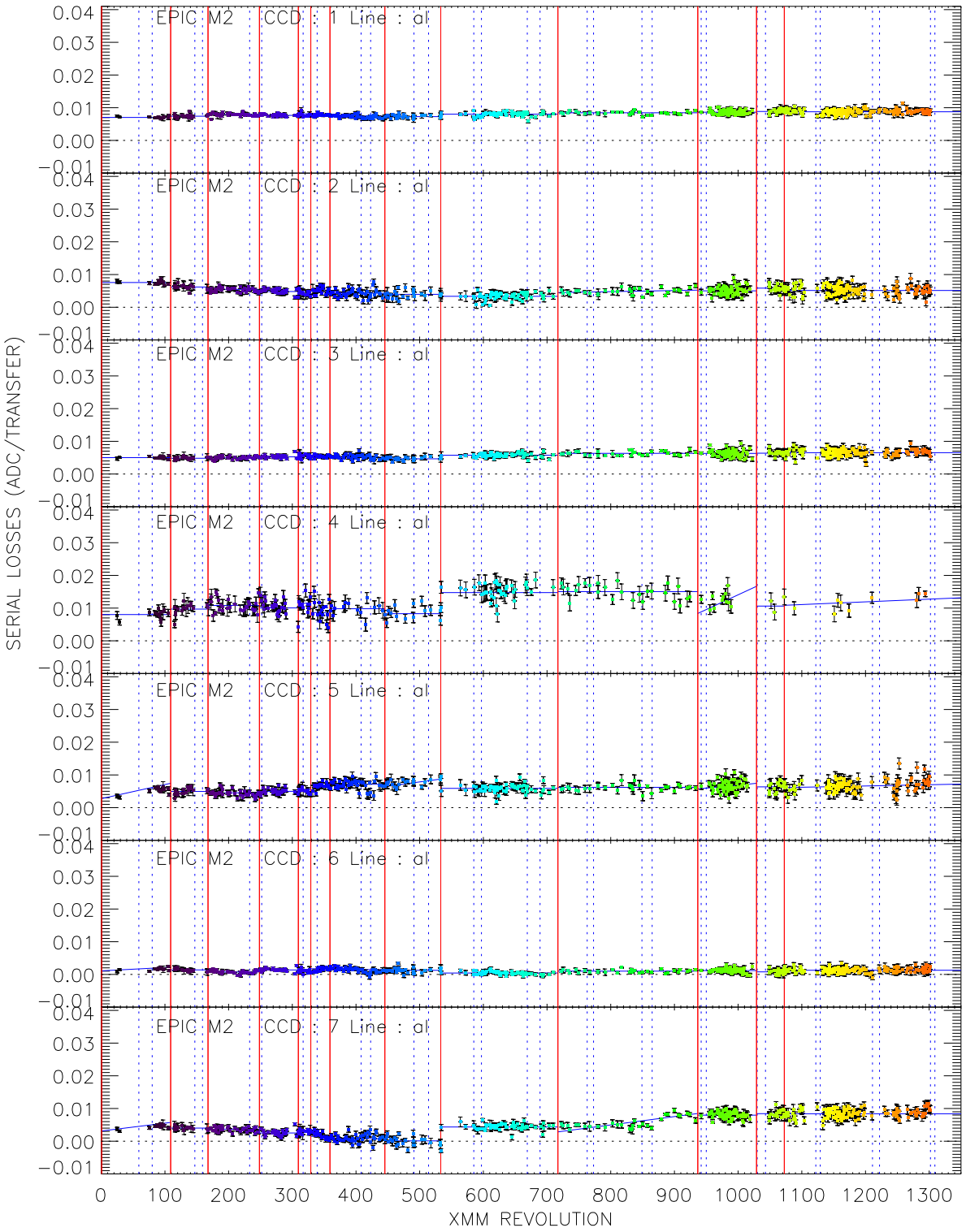


Figure 8: MOS2 serial transfer losses since launch at 1.5 keV, the energy of the Al calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.

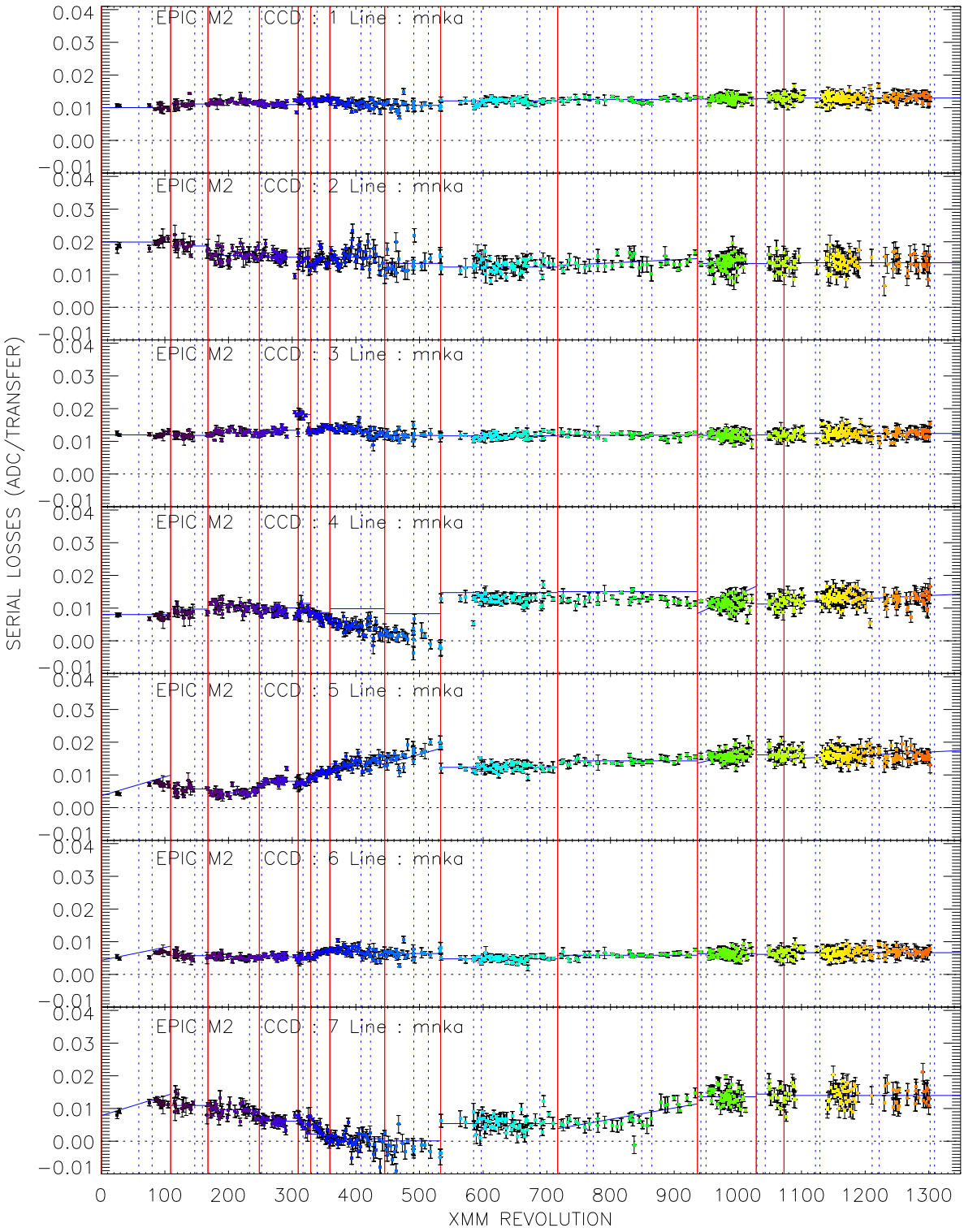


Figure 9: MOS2 serial transfer losses since launch at 5.9 keV, the energy of the Mn K$\alpha$ calibration line, for CCD1 to CCD7 (top to bottom), overlaid with the CTI models as parametrised in the new set of CCFs. The CCF epochs are indicated as solid vertical lines, the eclipse seasons as vertical dashed lines.