XMM-Newton CCF Release Note

XMM-CCF-REL-109

EPIC MOS Energy Scale

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1 CCF components

Name of CCF	VALDATE	List of Blocks changed	CAL VERSION	XSCS flag
EMOS1_CTI_0006	2000-01-01T00:00:00	CTI_EXTENDED		NO
EMOS2_CTI_0006	2000-01-01T00:00:00	CTI_EXTENDED		NO

2 Changes

An improved MOS CTI (Charge Transfer Inefficiency) correction algorithm had been developped, that reconstructs the energy of every x-ray event to a better accuracy.

Charge transfer losses are measured, calibrated and monitored by using an internal calibration source. This has Mn K α and Mn K β lines of 5.89 keV and 6.4 keV, and a fluorescent Al line at 1.49 keV.

As can be seen in figure 1 (for MOS2 at the Mn line) a linear fit is good approximation of the parallel CTI degradation since launch, although solar flares (indicated with red dotted lines) tends to create discrete jumps in the CTI. The same behaviour is observed with the Al line parallel CTI and for MOS1.

On the other hand the serial CTI is relatively constant since launch, as the transfert area is shielded against (soft-protons) radiation. (up-to-date plots can always be found on the internal web at : http://xmm.vilspa.esa.es/ xmmdoc/MOS/mos_cti.html)

This new algorithm required a change of structure of CCF, with more column parameters added, and a change of the SAS *cal* task, which is called by the ALGOID = 1 in the CCF.

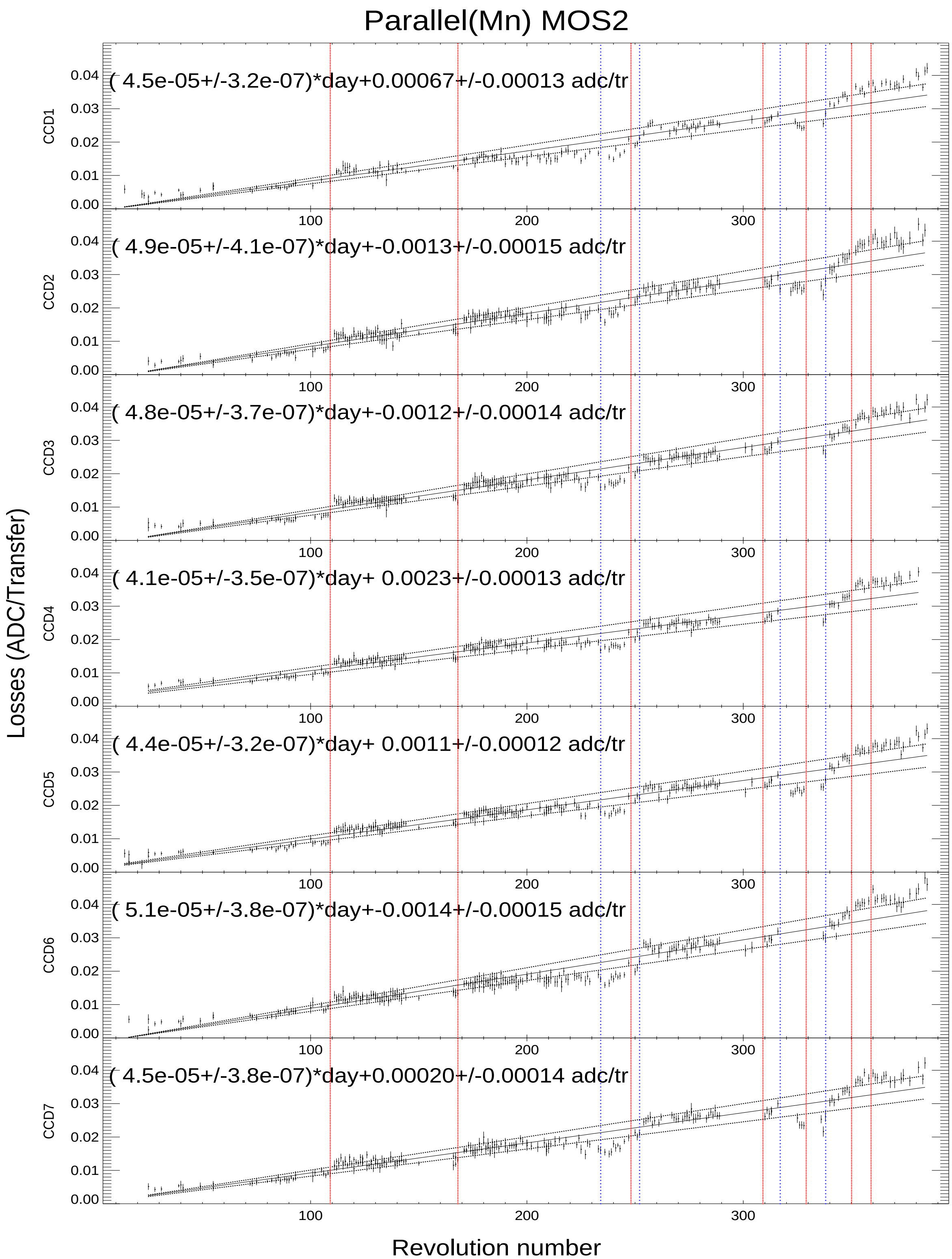

Figure 1: MOS2 transfer losses since launch at Mn energies

The CTI loss for an event in position (RAWX,RAWY) on the CCD is the sum of serial losses and parallel losses : $CTI = CTIX.RAWX + CTIY.RAWY$

The previous CTI was modelled in SAS v5.2 as :

- $CTIX_i = \delta T.rate_x + (a_{0Xi} + b_{0Xi}E)$ for the serial losses
- $CTIY_i = \delta T.rate_y E^{1/2} + (a_{0Yi} + b_{0Yi}E)$ for the parallel losses

for CCDi (i = 1 to 7), $where(a, b)_{0X,Yi}$ are the initial CTI pre-launch values from ground-based test, $\delta T = T - T_{launch}$, E is the PHA energy in ADUs and $rate_x$, $rate_y$ the serial and parallel degradation rates.

The new proposed CTI correction is :

- $CTIX_i = (a_{1Xi} + b_{1Xi}E)$
- $CTIY_i = \delta T.rate_{yi}.E^{\alpha i} + (a_{1Yi} + b_{1Yi}E)$

where $(a, b)_{1X,Yi}$ (CTI at launch) are extrapolated from in-flight measurements (see figure 1) and α_i is a CCD dependent power index.

6 parameters per CCD are now required to characterize the CTI: 4 for parallel losses and 2 for serial losses. The serial CTI as observed in flight is constant (although the new CCF structure allows for a time dependance) The time-dependant parallel CTI component has now a power law dependence of energy (α), CCD dependent, instead of the theoritical square root dependence as before. The power indexes varies from 0.55 to 0.7. The degradation rate has also been adjusted per CCD.

3 Scientific Impact of this Update

The under-correction of the old CTI correction (SAS 5.2) shifts the line position up to 30-40 eV at Mn energies by revolution 350, as can be seen in figure 2.

The new CTI correction with MOS CTI CCF version 6, recovers much of the energy losses and bring back the Mn and Al line position almost at the expected position.

4 Estimated Scientific Quality

The new CTI corection algorithm gives rather good results for MOS1, but still shows some under-correction for MOS2. The Mn line position (5899 eV) for CCD1 is about 4 eV too low for MOS1 but up to 10 eV too low for MOS2 at revolution 388 (see figure 3). This is believed to be due to the

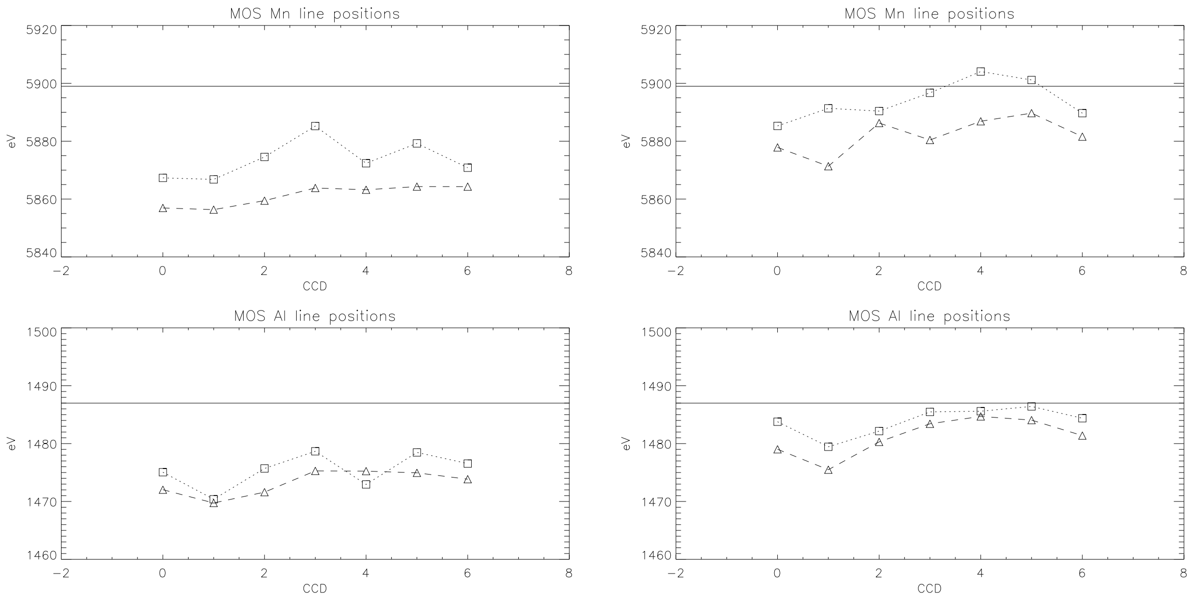

Figure 2: Mn and Al line positions with the old (left) and the new (right) SAS CTI correction at revolution 388 for CCDs 1 to 7

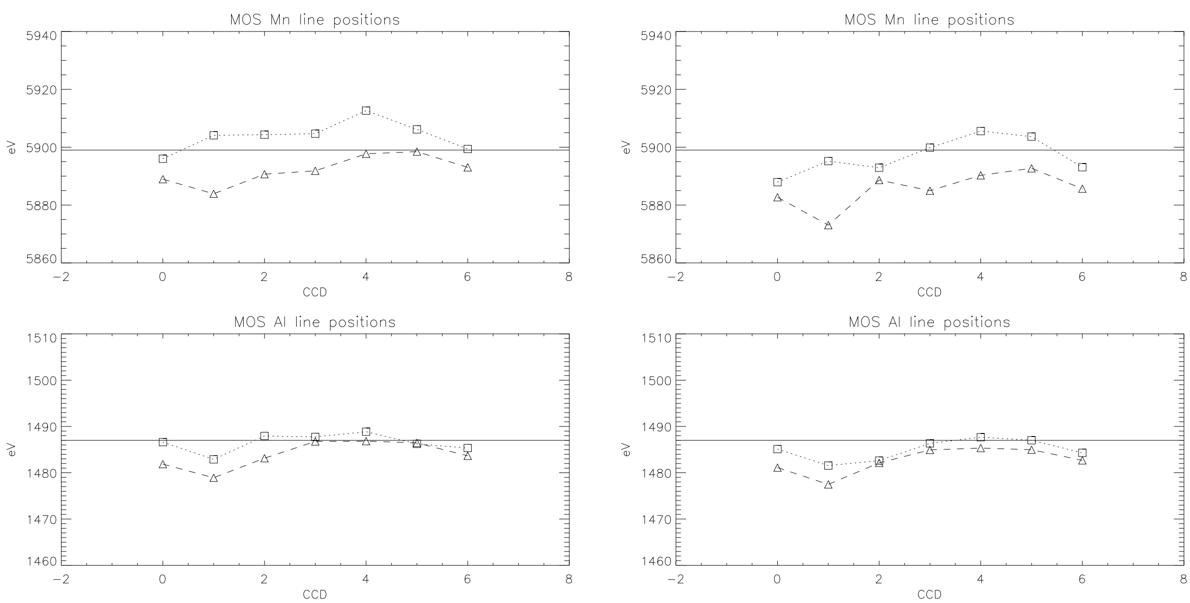

Figure 3: Mn and Al line positions with the new SAS CTI correction in revolution 316 and 355 for CCDs 1 to 7

fact that the calibration source flux is relatively large compared with most astronomical exposures, (especially for MOS2) and thus a systematic discrepancy due to a count-rate dependency (a high count rate tends to decrease the CTI as the charge traps are more filled on average)

The two Mn and Al lines do not provide good leverage either on energy-dependent CTI effects for low signal packet magnitudes and energies between 1.5 and 6keV. The serial CTI is also possibly too crudely modelled, some CCDs showing strange evolution or even CTI improvements !

However the line position accuracy with this new CTI correction in SAS 5.3, is believed to be better than 5 eV at 1-2 keV and better than 10 eV at 6 keV up, to revolution 350.

5 Test procedures & results

The new CTI correction has been tested with MOS CTI CCF version 6 and the SAS version 5.3 alpha that includes the new algorithm, called by the keyword ALGOID = 1 in the CCF FITS header. The results have be shown in the previous section.

6 Expected Updates

As the MOS CTI degradation evolves in the future, tuning of the CTI parameters (e.g. degradation rate) will be needed. There is a hint of an acceleration of the degradation rate after revolution 300 and therefore a tendency of under-correction.

The under-correction of the MOS2 CTI will have to be properly understood, corrected, and calibrated with emission lines of celestial targets (SNR).

This CTI correction also assumes a linear degradation with time, which might not be the case in the long term. A different slope might be observed when leaving the maximum of the solar flare.

An apparent temporary decrease of the CTI has been observed on internal calibration measurements acquired during the eclipse season when the EMAE temperature was lower than nominal at the start of revolution after the camera switch-off during perigee. Properly speaking it is a gain change, but that could be corrected by at the level of the CTI correction, when the effect be properly calibrated. However it is believed to have affected only few science observation, since they were not scheduled at the moment of stong temperature gradient, just after the switch-on. To give an order of magnitude, the observed effect is about 1 ADU (3.5 eV) per degree ($\delta E/\delta T = -3.5$)