PN Long-Term CTI

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Two topics related to the Long-Term CTI (LTCTI) correction:

- Energy reconstruction and background radiation level.
- Double events energy reconstruction.
Correction for the long-term CTI in the energy reconstruction:

Currently we use an **empirical correction** function:

Why not a function based on the measured long-term CTI, a “CTI-based LTCTI correction”: 
CTI-Based LTCTI correction @ Mn-Kα
Radiation Monitor rate at apogee:

(P. Rodriguez-Pascual)
CTI-Based LTCTI correction @ Mn-Kα (II)
In general, there is a known dependence of CTI on b/g (larger charge deposits reduce trap vacancies, leading to increased transfer efficiency).

However, the data here have been nominally corrected for CTI through the LTCTI modelling – why then the secular trend?

Perhaps the LTCTI model is inadequate…?

... incomplete explanation, as the deficiencies in the LTCTI model are unable fully to explain the measured deviations in reconstructed energies; see full analysis in technical note XMM-SOC-CAL-TN-0195.

E.g., strong evidence against a CTI origin is given by a comparison of the dynamic range of the secular trend along the read-out direction.
Comparison along read-out direction (I)

Close to read-out: ~ 30 shifts

Far from read-out: ~ 190 shifts
Comparison along read-out direction (II)

Close to read-out: ~ 30 shifts

Far from read-out: ~ 190 shifts

~ 60 - 80% difference in dynamic range

CTI could only account for up to ~ 16%
Proposed framework for correction in SAS 14

Empirical SAS correction function:

\[ E_{\text{corr}} = (a_1 + a_2 \cdot R) \cdot E + a_3 \cdot R \]  
(gain offset and/or slope)

with

\[ R(E,t) = (b_1 + b_2 \cdot \log(E) + b_3 \cdot \log^2(E)) \cdot \text{Rate}(t) \]

Add new extension **QUIESCENT_BG_GAIN** to **EPN_CTI_####.CCF** containing parameters \( a_1, a_2, a_3 \) and \( b_1, b_2, b_3 \).

\( \text{Rate}(t) \) derived from a suitable epoch-dependent parameterisation, possibly contained in a new set of CCFs **QUIESCENT_BG_####.CCF**.
Two topics related to the Long-Term CTI (LTCTI) correction:

- Energy reconstruction and background radiation level.
- Double events energy reconstruction.
Doubles vs singles event energies

$E_{\text{double}} - E_{\text{single}}$
Doubles overcorrection: offset and slope
The slope is probably in large part an artefact of the current implementation of the LTCTI correction:

- The current LTCTI correction function has no energy dependence.
- However, the measured LTCTI behaviour does differ significantly at Mn-K and Al-K.
- LTCTI parameters used are those derived for single events at Mn-Ka, where the correction works well.
- But at Al-Ka single event energies show an increasing overcorrection:

  As events are CTI-corrected before combining into higher patterns, one may expect both constituent parts of e.g. Mn-K doubles to be increasingly overcorrected, the extent of which determined by the energy dependence.
Simple MC simulation at Mn-Ka:

Define double events composed of constituent event energies:

\[ E_1 + E_2 = E_{\text{Mn}} \]

with:

\[ E_1 \] uniformly randomly sampled in \([20, E_{\text{Mn}} - 20]\).

At a given time \(t\), the LTCTI at energies \(E_1\) and \(E_2\) are derived through interpolation using the values measured at Al-K and Mn-K.

The constituent energies are corrected and added together to yield the energy of the double event.

This is compared to the energy obtained through the \(E\)-independent LTCTI correction.
The **LONG_TERM_CTI** extension of **EPN_CTI_####.CCF** already contains a table with the parameters describing the LTCTI measured at Mn-K:

$$\text{CTI}(E_{\text{Mn}}, t) = a_0 + a_1 * t + \cdots + a_4 * t^3$$

- Include tables with parameters describing LTCTI measured at Al-K, and possibly Cu-K, **CTI**(E$_{\text{Al}}$, t) and **CTI**(E$_{\text{Cu}}$, t).

- Determine the **CTI**(E, t) = $b_0 + b_1 * \log(E) + b_2 * \log^2(E)$
  where $b_0$, $b_1$ (and $b_2$) are derived through interpolation using **CTI**(E$_{\text{Mn}}$, t), **CTI**(E$_{\text{Al}}$, t) (and **CTI**(E$_{\text{Cu}}$, t) if available, e.g. non-zero).

- Pass the derived **CTI**(E, t) on to the existing LTCTI correction code (with added check that the final energy correction factor is $\geq 1$).