PN Long-Term CTI

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PN Long-Term CTI

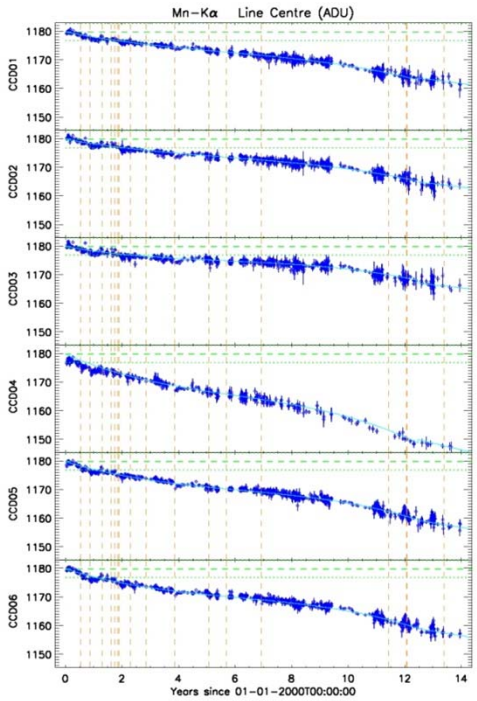
Two topics related to the Long-Term CTI (LTCTI) correction:

- Energy reconstruction and background radiation level.
- Double events energy reconstruction.

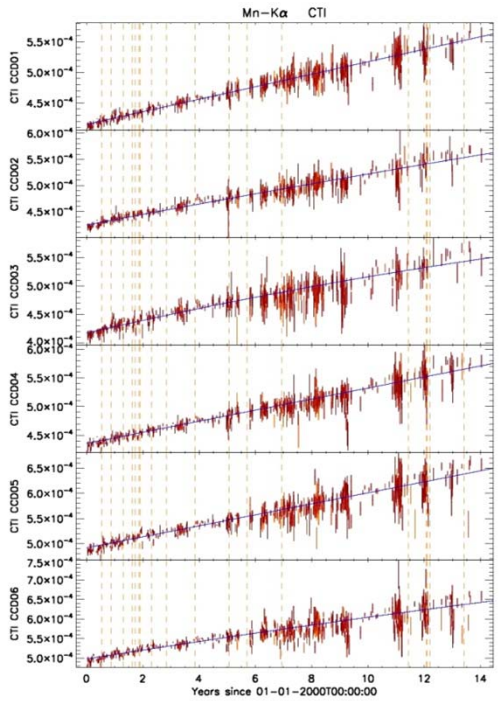
Long-Term CTI correction function

Correction for the long-term CTI in the energy reconstruction:

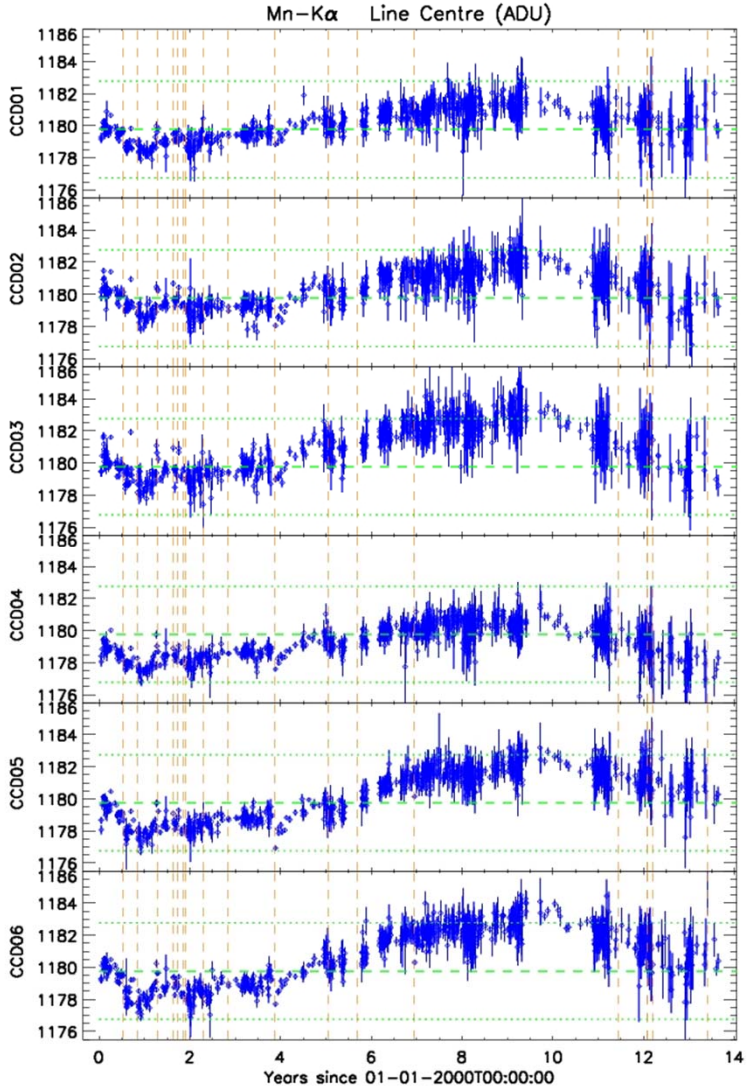
Currently we use an **empirical correction** function:

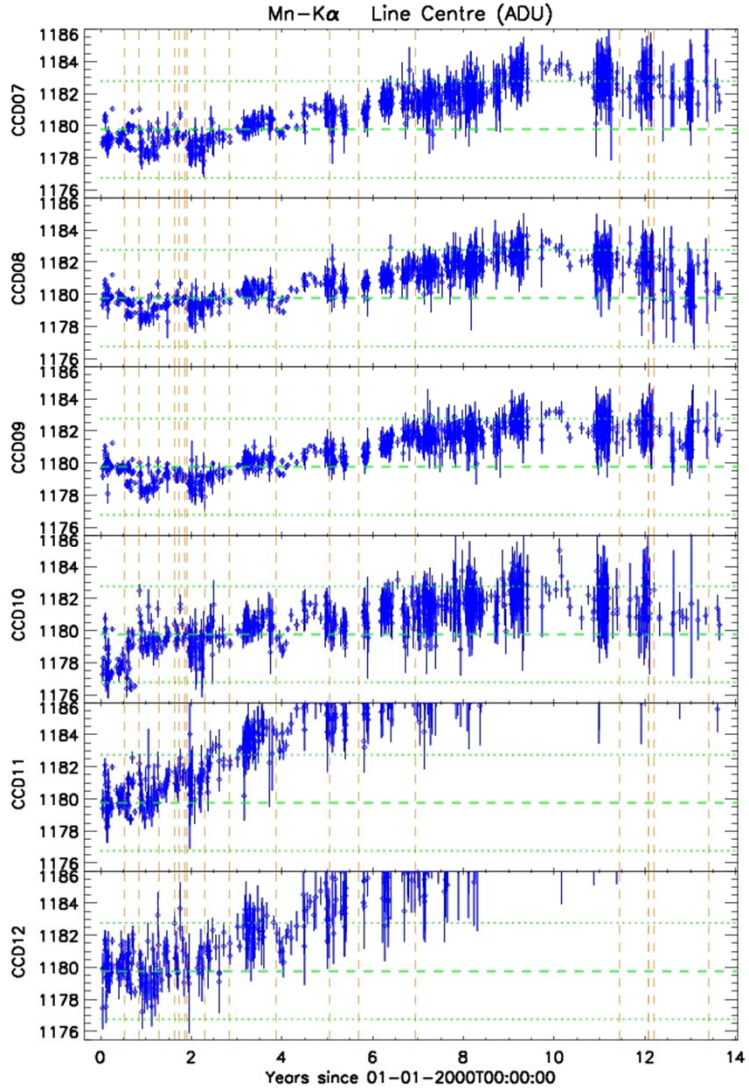


Why not a function based on the measured long-term CTI, a "**CTI-based LTCTI correction**":



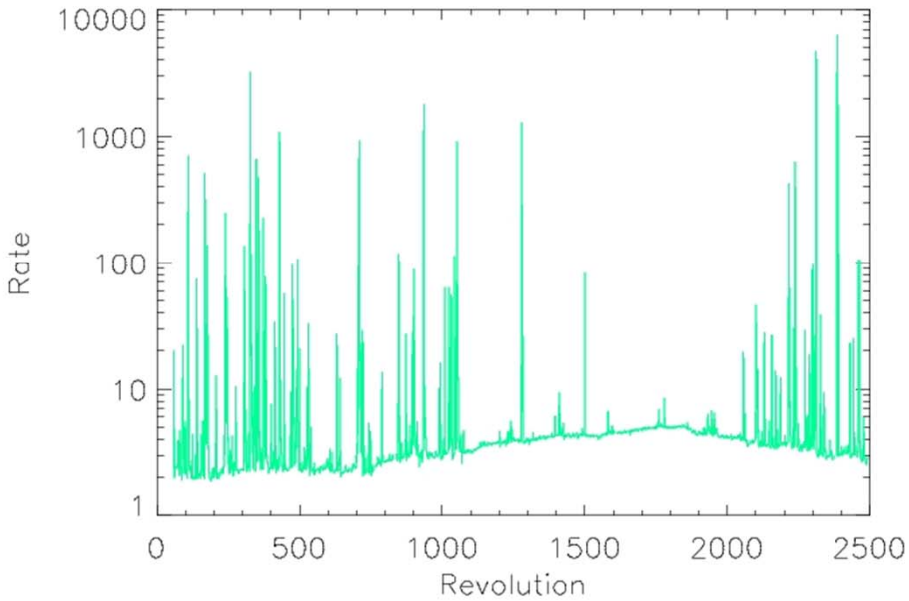
CTI-Based LTCTI correction @ Mn-Kα

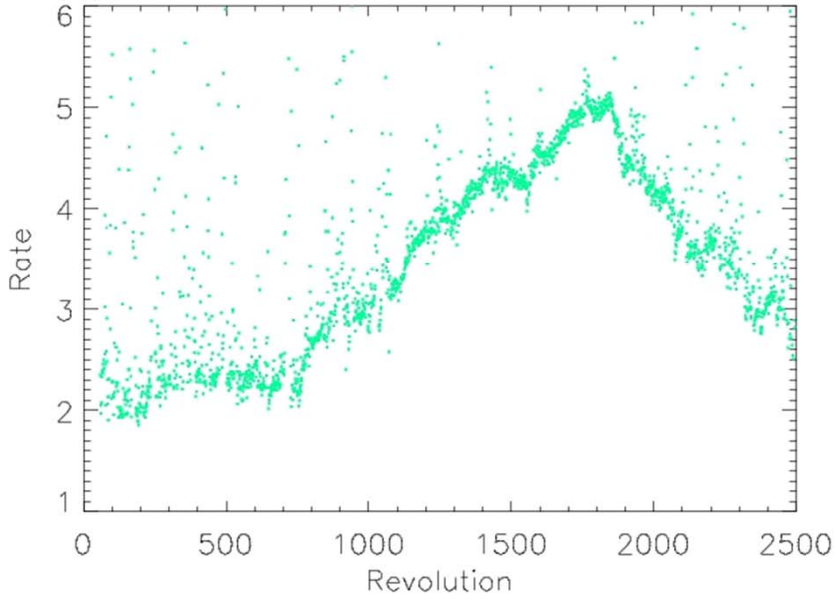




Quiescent background

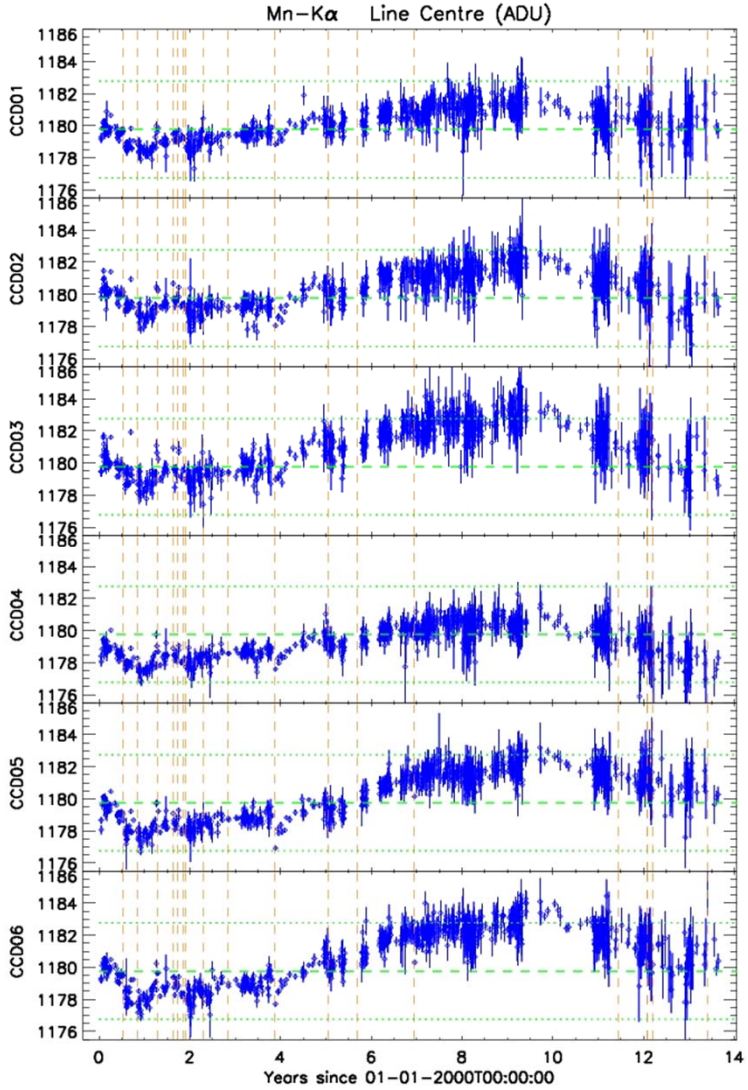
Radiation Monitor rate at apogee:

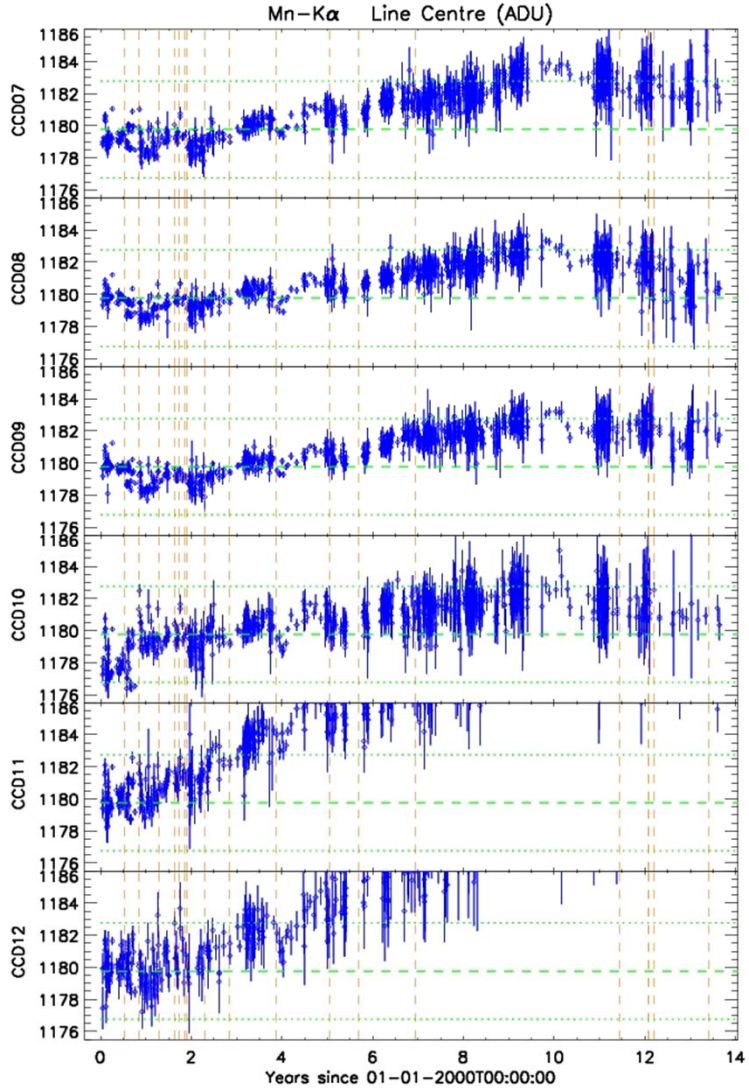




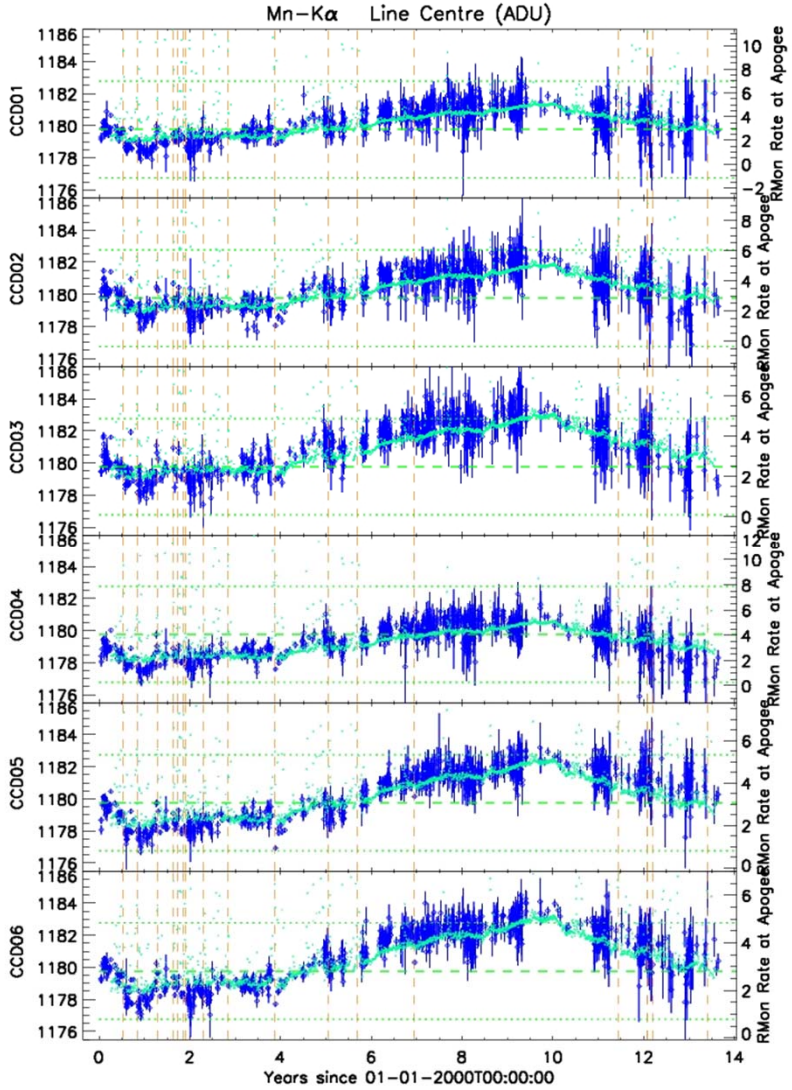
(P. Rodriguez-Pascual)

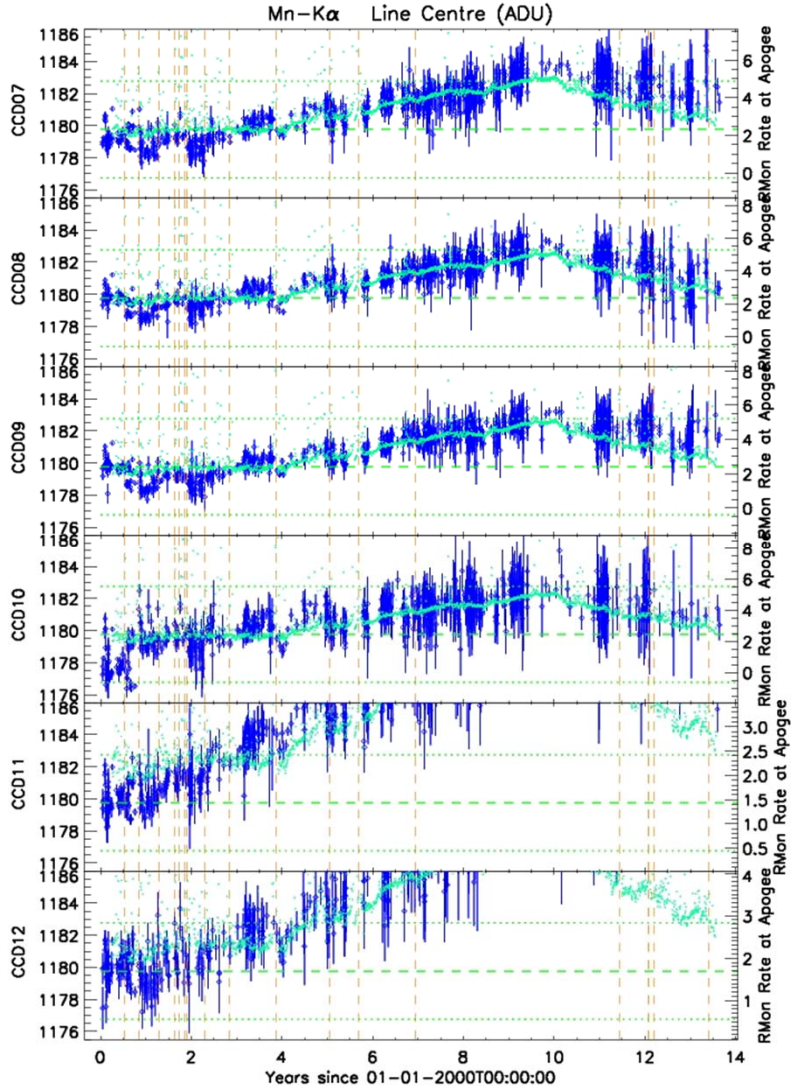
CTI-Based LTCTI correction @ Mn-Kα (II)



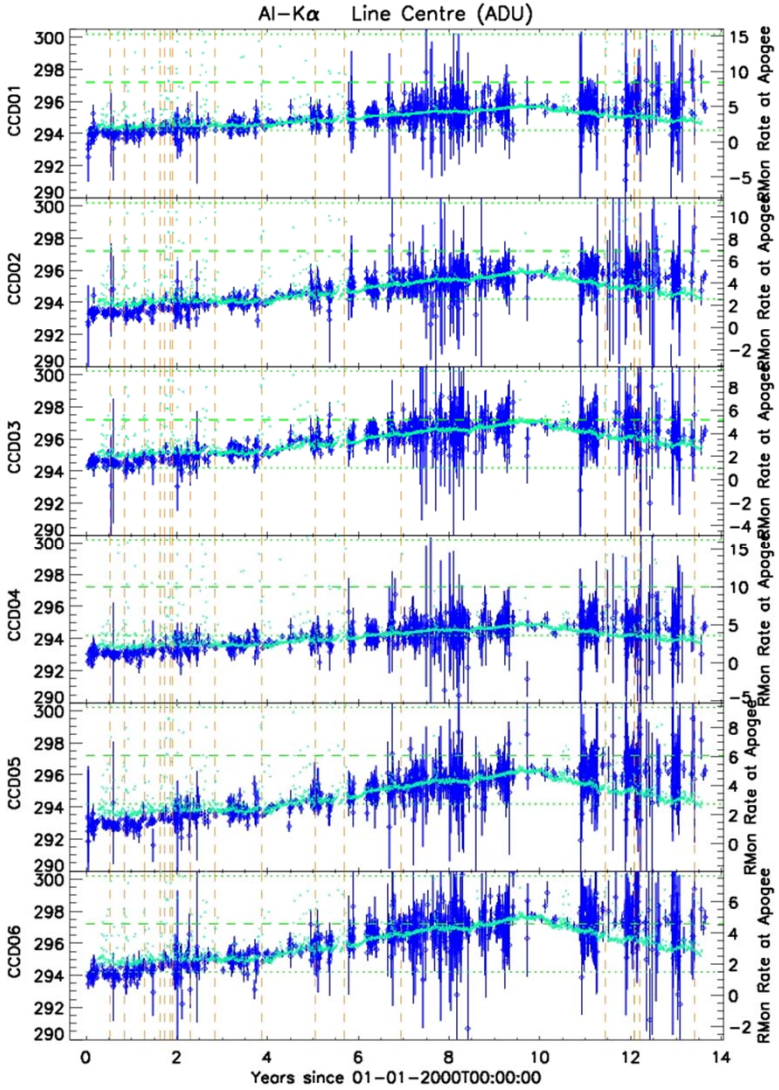


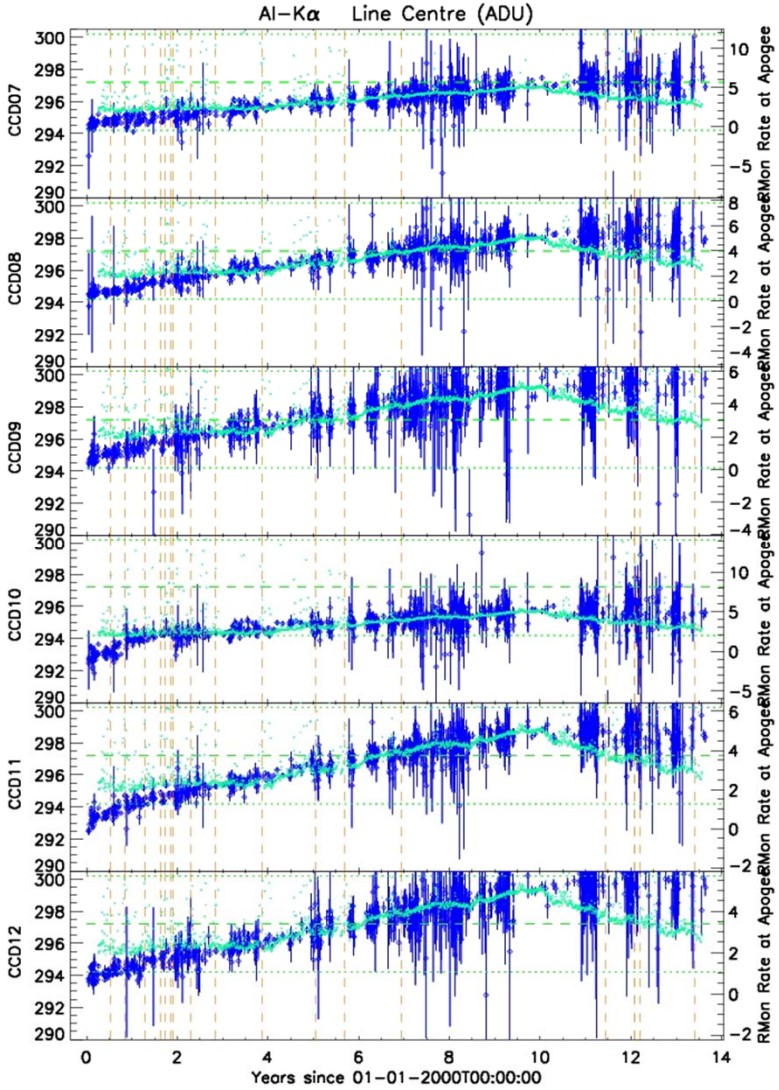
CTI-Based LTCTI correction @ Mn-Kα





CTI-Based LTCTI correction @ Al-Kα

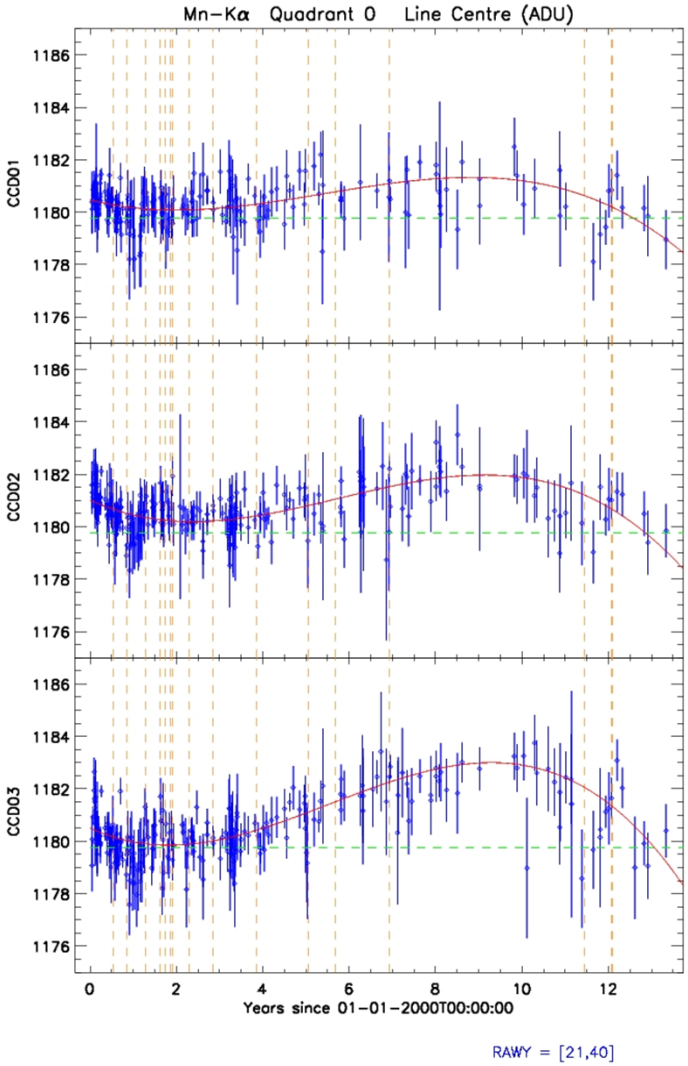




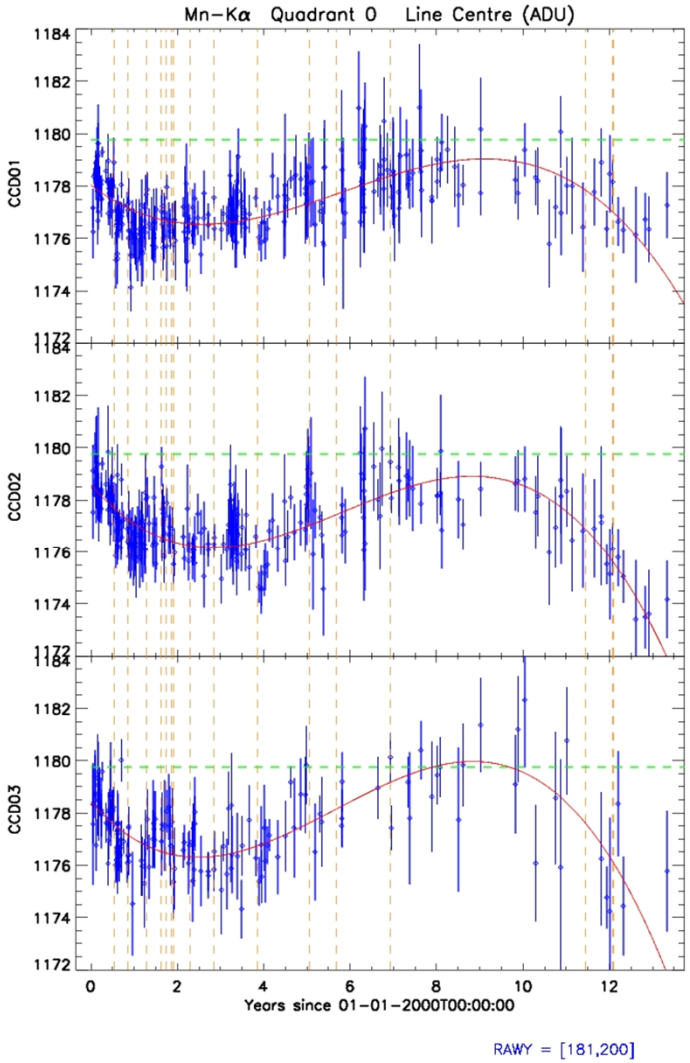
Can this be explained by CTI?

- 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)

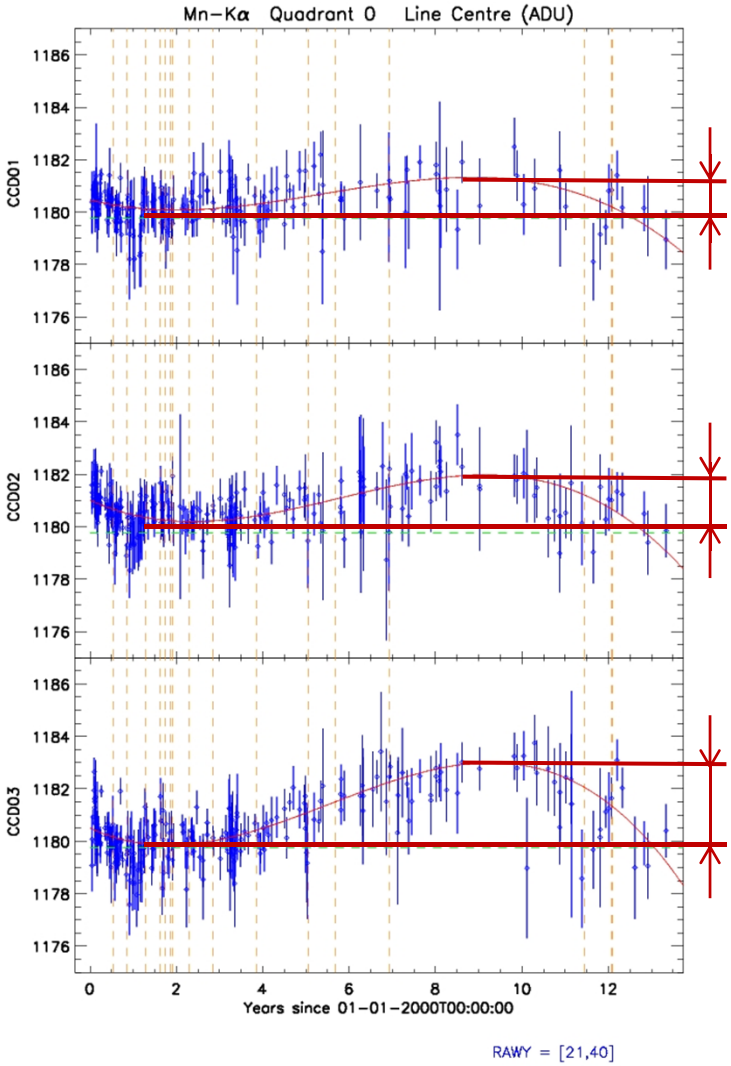


Close to read-out: ~ 30 shifts



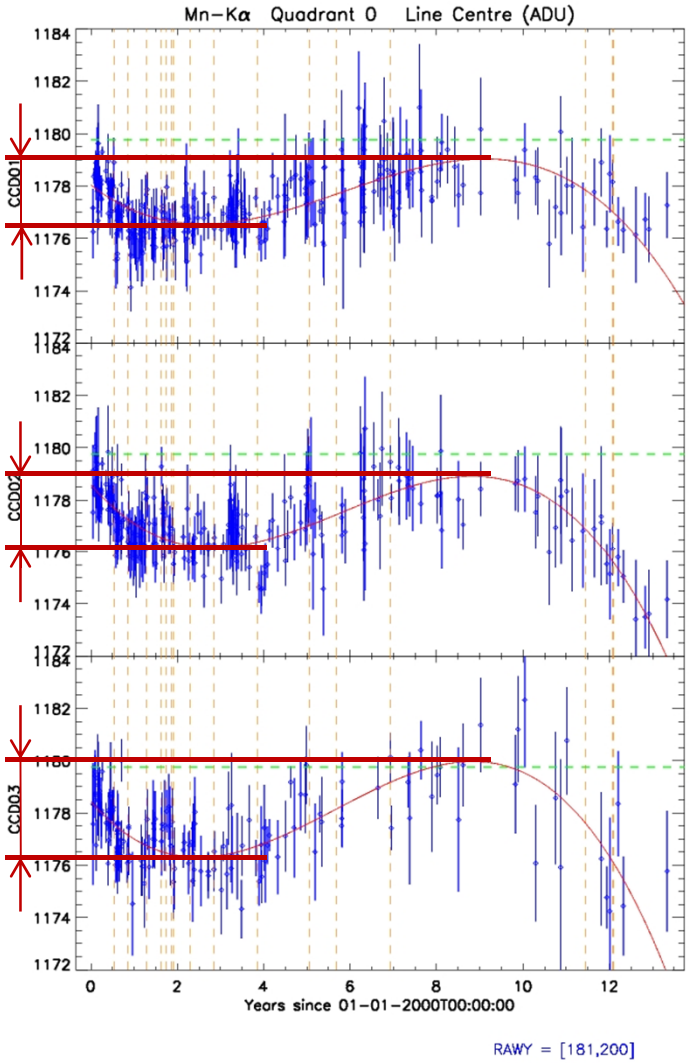
Far from read-out: ~ 190 shifts

Comparison along read-out direction (II)



~ 60 - 80% difference in dynamic range

CTI could only account for up to ~ 16%



Close to read-out: ~ 30 shifts

Far from read-out: ~ 190 shifts

Proposed framework for correction in SAS 14

Empirical SAS correction function:

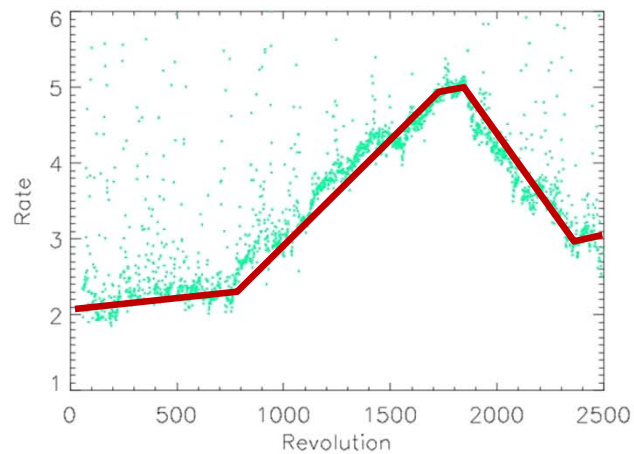
$E_{corr} = (a_1 + a_2 * R) * E + a_3 * R$ (gain offset and/or slope)

with

$R(E,t) = (b_1 + b_2 * \log(E) + b_3 * \log^2(E)) * Rate(t)$

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.

Rate(t) derived from a suitable epoch-dependent parameterisation, possibly contained in a new set of CCFs **QUIESCENT_BG_####.CCF**.



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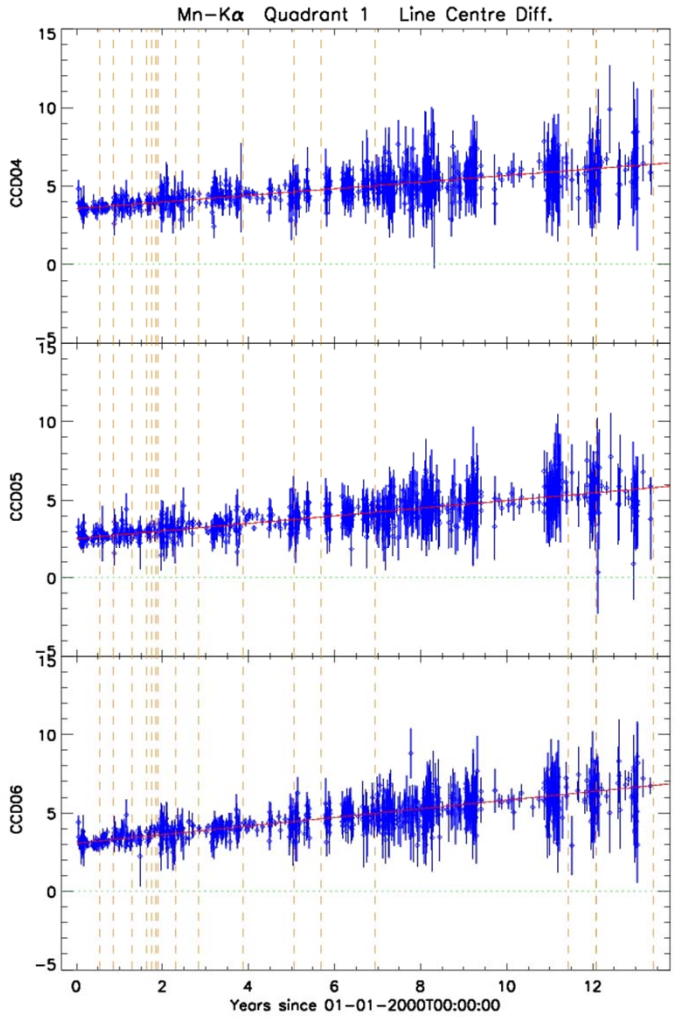
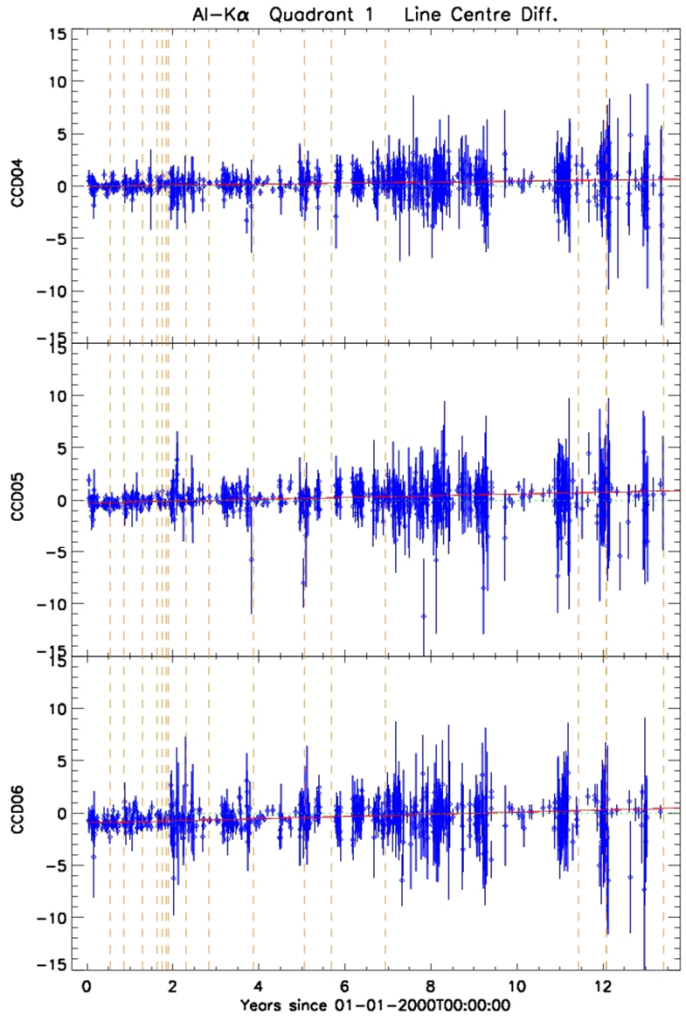
Two topics related to the Long-Term CTI (LTCTI) correction:

- Energy reconstruction and background radiation level.
- Double events energy reconstruction.

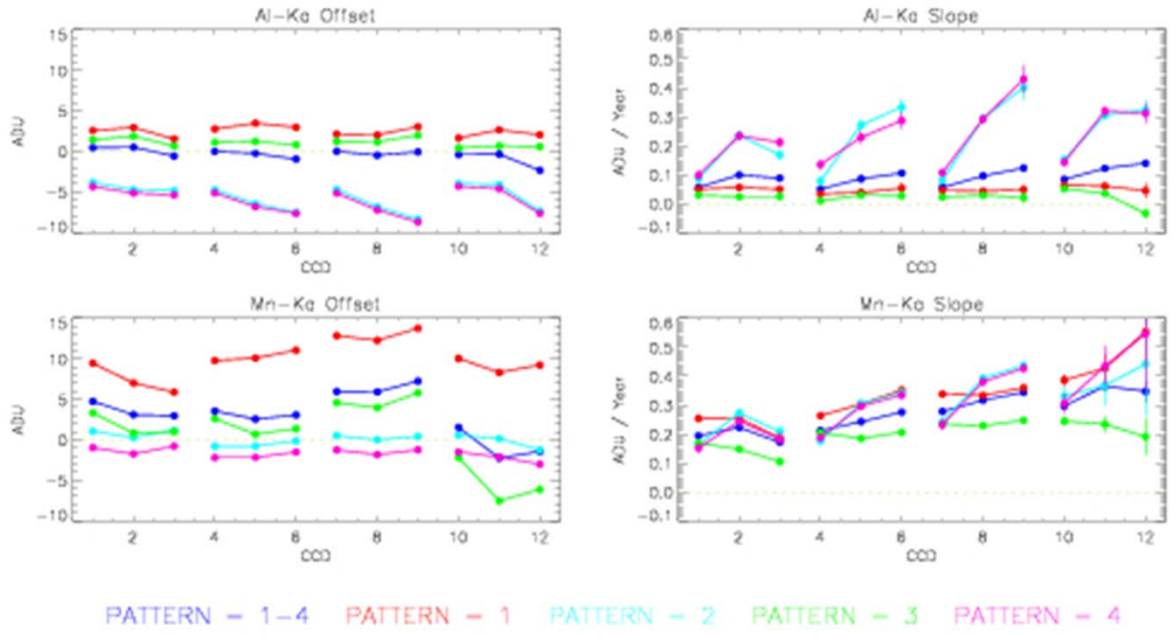
Doubles vs singles event energies





$E_{double} - E_{single}$

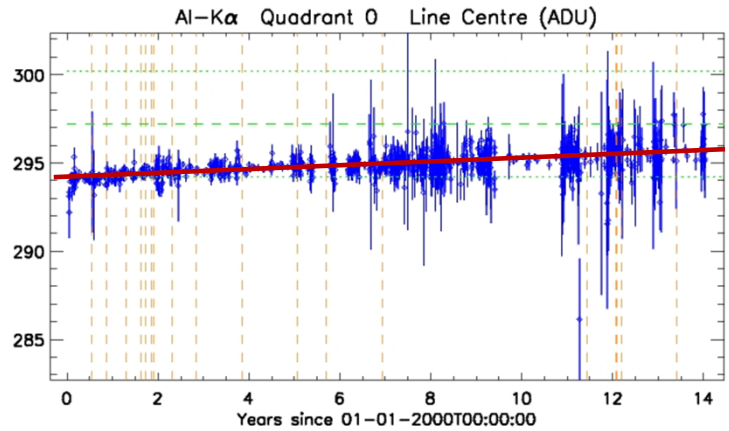
Doubles overcorrection: offset and slope



LTCTI model can explain slope

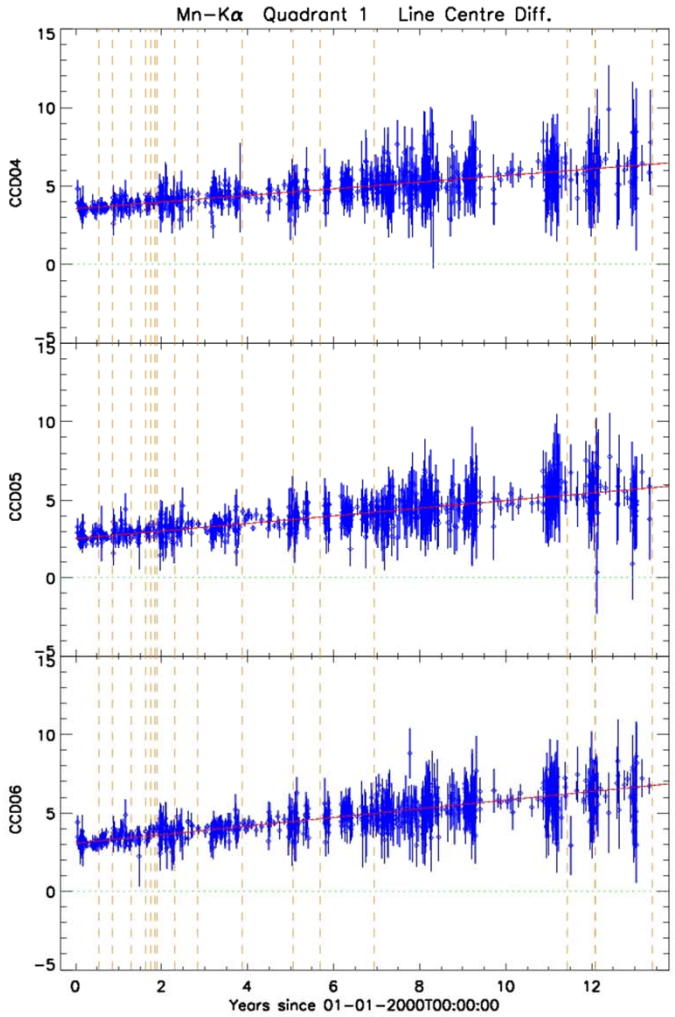
The slope is probably in large part an artefact of the current implementation of the LTCTI correction:

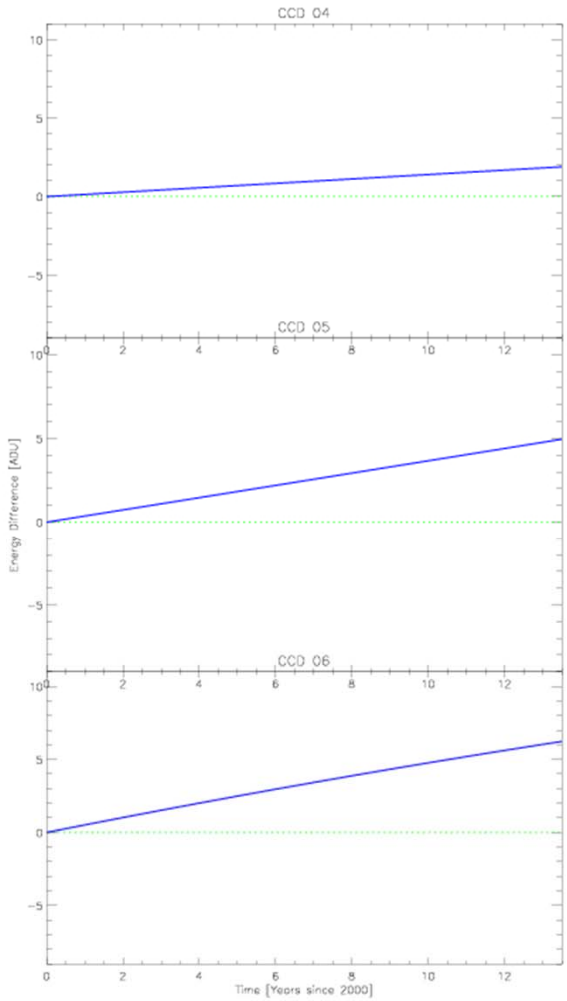
- The current LTCTI correction function has no energy dependence.
- However, the measured LTCTI behaviour does differ significantly at Mn-K and Al-K.
- LTCTI parameters used are those derived for single events at Mn-Ka, where the correction works well.
- But at Al-Ka single event energies show an increasing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

LTCTI model can explain slope





Simple MC simulation at Mn-Ka:

Define double events composed of constituent event energies:
$E_1 + E_2 = E_{Mn}$

with:

E_1 uniformly randomly sampled in $[20, E_{Mn}-20]$.

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.

Proposed framework for correction in SAS 14

The **LONG_TERM_CTI** extension of **EPN_CTI_####.CCF** already contains a table with the parameters describing the LTCTI measured at Mn-K:

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

- Include tables with parameters describing LTCTI measured at Al-K, and possibly Cu-K, $CTI(E_{Al},t)$ and $CTI(E_{Cu},t)$.

- 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 $CTI(E_{Mn},t)$, $CTI(E_{Al},t)$ (and $CTI(E_{Cu},t)$ 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 >= 1).