XMM-Newton CCF Release Note

XMM-CCF-REL-223

EPIC-pn CTI and Gain updates

M. Kirsch with input from F. Haberl, K. Dennerl and M.J. Freyberg

August 13, 2007

1 CCF components

Name of CCF	VALDATE	List of Blocks changed
EPN_CTI_0016	2000-01-01T00:00:00	LONG_TERM_CTI
EPN_CTI_0016	2000-01-01T00:00:00	SW_PAR
EPN_CTI_0016	2000-01-01T00:00:00	LW_PAR
EPN_CTI_0016	2000-01-01T00:00:00	EFF_GAIN
EPN_CTI_0016	2000-01-01T00:00:00	TIMING_GAIN
EPN_CTI_0016	2000-01-01T00:00:00	QBOXTEMP_GAIN

2 Changes

2.1 Possibility of individual longterm CTI for each CCD and Mode

Motivation: CCDs 7-12 show evidence for different long-term behaviour: the Mn-K energy appears to drop slowly after about revolution 700 while it is more stable for CCDs 1-6. With the new CCF this effect could be corrected for in the future. Currently all values are still the same.

2.2 Timing mode special Gain refinement

EPIC-pn timing (TI) mode observations of Blazars show a systematic gain/CTI over-correction in the spectra around the instrumental O-edge. This leads to large χ^2 values due to the usually good statistics for sources observed in TI mode. The CCF contains an update of the TIMING_GAIN parameters adjusted to reduce the correction below ∼1 keV, while above 2 keV the correction remains at the old level. See Fig. 1 for a comparison of the old and new correction functions. The new parameters were derived using TI mode spectra of PKS2155-304 and Mkn 421.

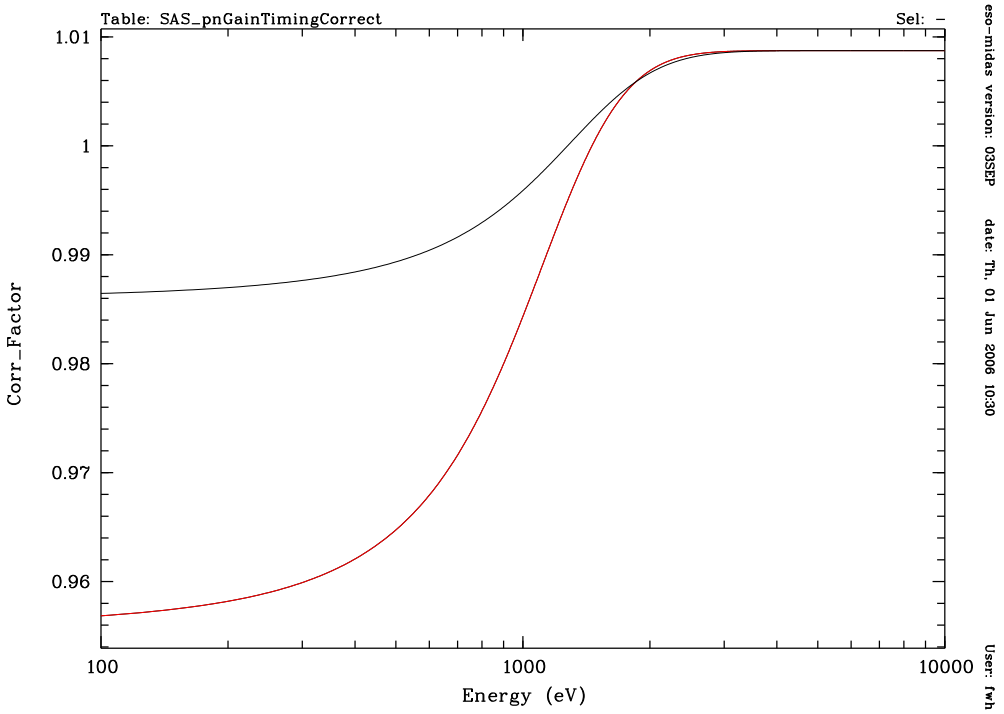

Figure 1: Comparison of old (black, as in the currently public EPN_CTI_0015.CCF) and new (red) gain/CTI correction function for EPIC-pn TI mode (the new parameters for the TIMING_GAIN extension of the CCF are: 1.0495, 0.99134, 900.0, 320.0).

2.3 SW mode CTI refinement

Spectral fits to SW mode spectra of BL Lac objects show residuals around the Si and Au edges. Gain fits reveal that these are caused by energy shifts of typically -10 eV with the spectral data points at lower energies than the model. Also spectral fits to the SNR 1E0102.2-7219 show a systematic difference in line energies between the SW and other read-out modes, however, at lower level (about -5 eV at Neon energies around 1 keV and no significant difference at Oxygen around 600 eV). This suggests an energy dependent CTI under-correction of the data. Therefore, the correction function for the SW mode fast-shift CTI correction (see Fig. 2) was adjusted.

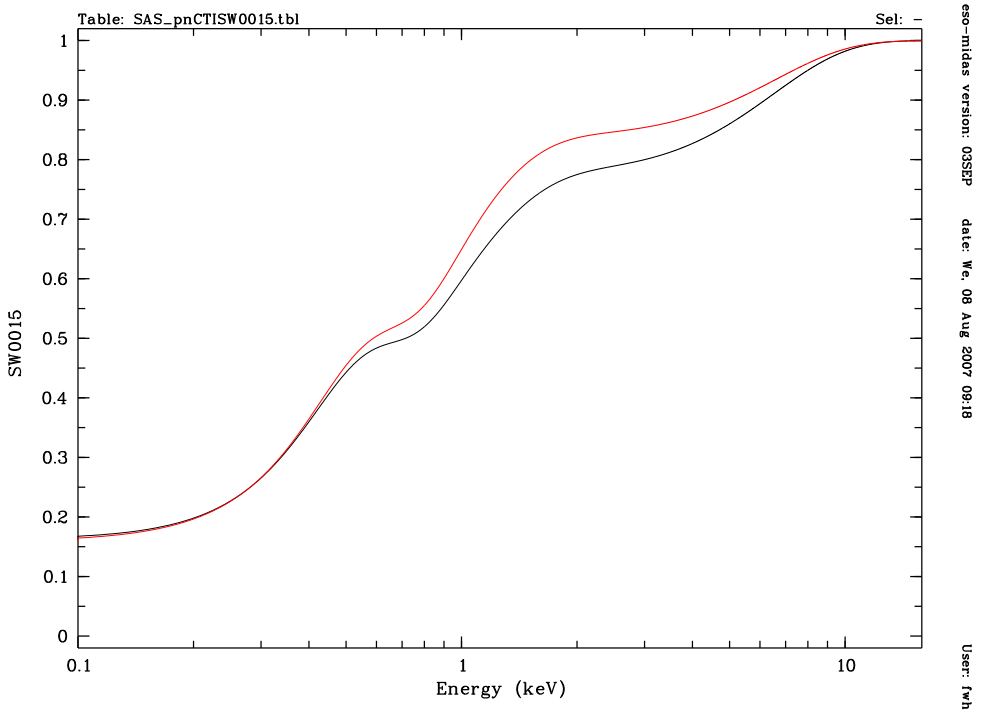

Figure 2: Correction function for the SW mode fast-shift CTI correction. The function using the parameters in the extension CTI-HIGH_ADD_PAR of EPN_CTI_0015.CCF is shown in black while the new function with the adjusted parameters (EPN_CTI_0016.CCF) is plotted in red.

2.4 LW mode CTI refinement

The large window mode CTI parameters, that adjust the FF CTI for the special read out in LW mode have been refined according to ground calibration measurement of the spare chain at PANTER in combination with measurements from a dedicated observation (NRCO-47) of N132D to determine the CTI during fast-shifts (i.e. during shift of the integration window to the quasi framestore area in the SW and LW modes). N132D had been placed once at about RAWY=135 in CCD 4 of EPIC-pn, i.e. in the nominal integration window, and then shifted by 100 pixels (RAWY=35), illuminating directly the framestore area. In the first case the total CTI is the sum of 100 fast shifts and 35 slow shifts (normal readout), in the second there are only the 35 slow shifts. The difference is then interpreted as the effect of 100 fast shifts. For details see Freyberg et al, EPIC Consortium Meeting 2005,Ringberg, MPE Report 288, pp.159-164.

Fig. 3 shows the new and the old adjustment factor that operates on the FF CTI as a function of energy and only concerns the fast shifts. The difference between the old and new factor is a small refinement only, however proving with a real measurement of separated fast and slow CTI the earlier approximated values.

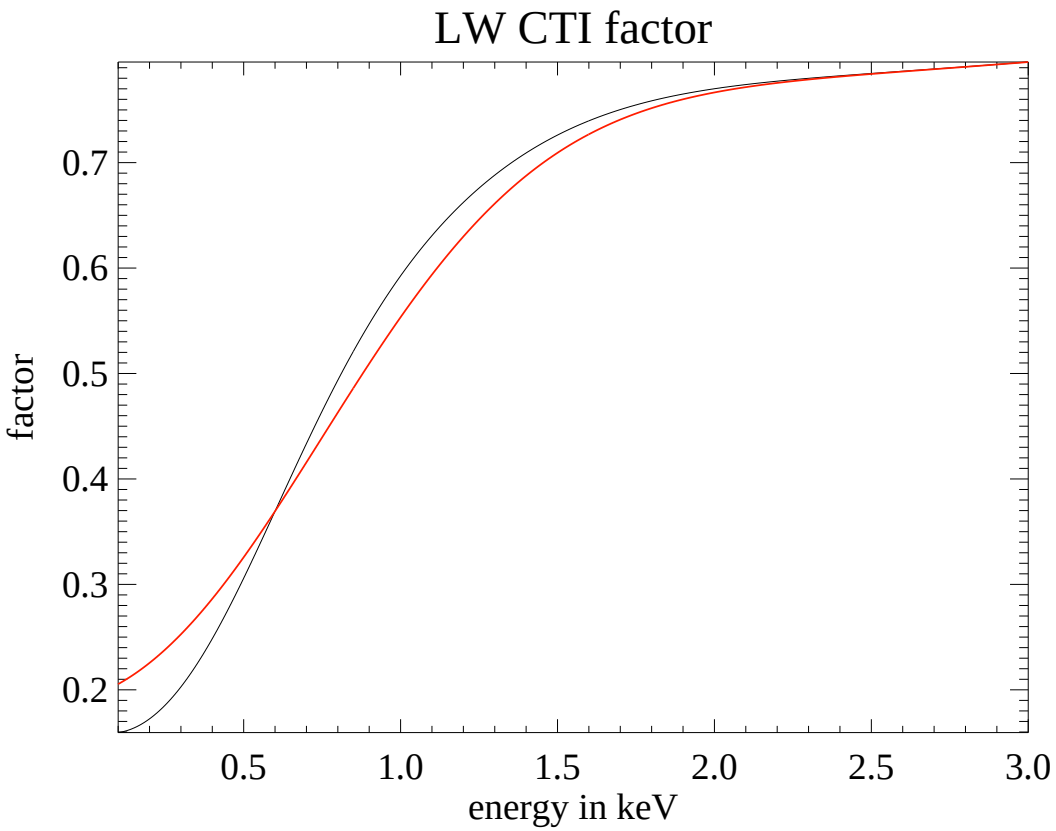

Figure 3: LW CTI correction factor. Black: old CCF 15, Red: new CCF 16. Note that above 2.5 keV the functions are identical.

2.5 CCD dependent eFF special gain values

The eFF mode gain tuning has been adjusted individually for each CCD by refining the from a line rich source derived correction function for each CCD using the on board calibration source. The plateaus of the function have been adjusted using for each CCD the energy ratios at Al and Mn for FF and eFF mode.

2.6 Temperature dependent gain correction

The peak gain of the pn camera is affected by the temperature of the quadrant box electronics. A higher/lower than nominal temperature leads to a higher/lower gain such that detected photons would be shifted to higher or lower energies. A clear correlation of the quadrant box temperatures and the peak position of the internal calibration source is shown in Fig. 4. The slope of the temperature dependent gain is 0.43 ADU/deg Celsius. Correction algorithms are available in the SAS, but not switched on as the default. The correction can be enabled running epproc with the parameter *withtempcorrection=Y*. Currently the correction is performed only for the FF mode (all CCDs with the same parameters). However the CCF and SAS code provide the possibility to treat the effect in the future mode and CCD dependent.

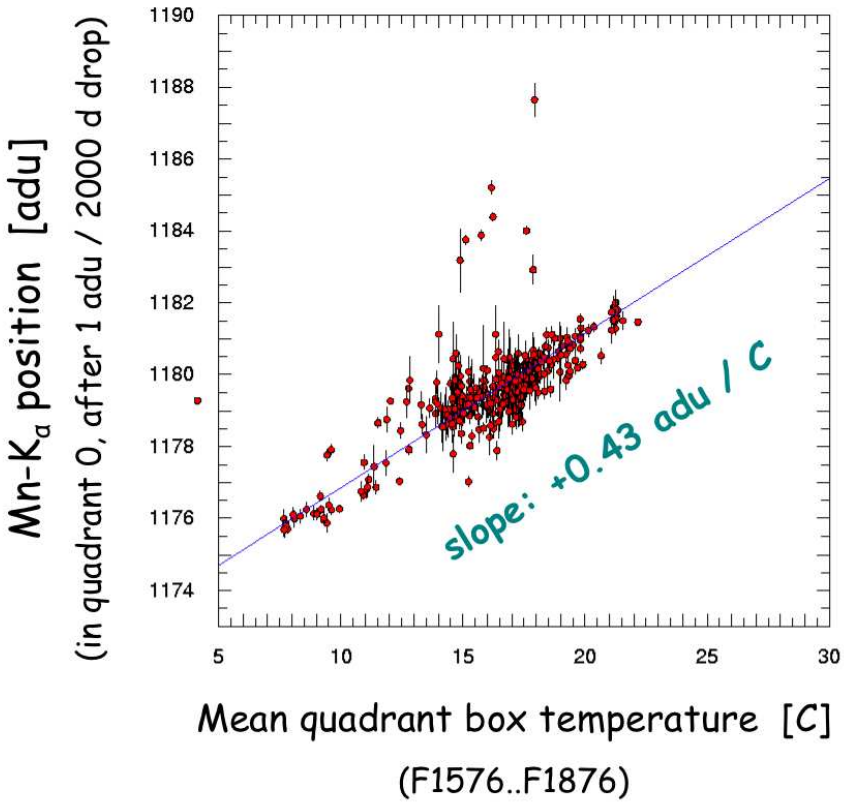

Figure 4: Line position of the internal calibration source as a function of mean quadrant box temperature.

3 Scientific Impact of this Update

Energy accuracy is further refined and brings Timing and SW mode in better agreement with the Full Frame mode. Overall improvement of consistency between CCDs will be reached when temperature and long term effects are switched on.

4 Estimated Scientific Quality

EPIC-pn energy accuracy will stay within 5-10 eV, now also for special cases where temperature excursions occur. Spectral fits for the fast timing mode and SW mode will improve regarding χ^2.

5 Test procedures & results

5.1 Possibility of individual longterm CTI for each CCD and Mode

Only functional tests have been performed.

5.2 Timing mode special Gain refinement

Fig. 5 compares the fit results for two spectra of PKS2155-304, for two cases: a) using SAS7.0.0 with public CCFs (in particular EPN_CTI_0015.CCF), b) event file created with the new TIMING_GAIN parameters.

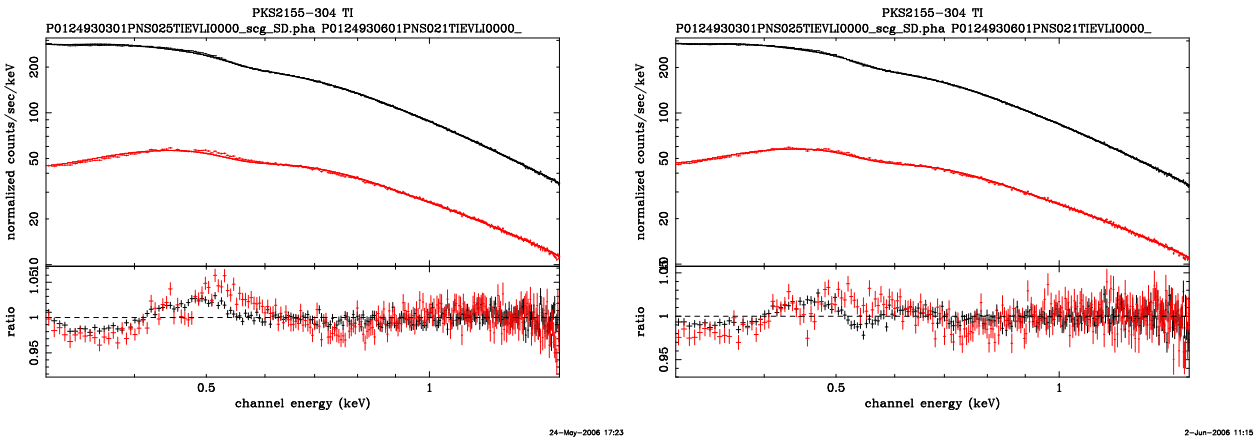

Figure 5: EPIC-pn TI mode spectra (single + double event patterns) of PKS2155-304 from satellite revolutions 362 (black) and 545 (red). Left: SAS7.0.0, $\chi^2 = 1791$ for 474 dof; right: new TIMING_GAIN parameters, $\chi^2 = 1116$ for 474 dof

To verify that the changes do not decrease the quality of spectral fits to sources with different spectral shapes, spectra of the neutron star RX J1856.5-3754 and the star Zeta Puppis were investigated. In both cases we do not see a significant deterioration of the fits.

5.3 SW mode CTI refinement

A comparison of the energy shifts obtained from PKS2155 spectra using old and new SW mode parameters is presented in Fig. 6. The average gain offset around the Au edge reduces from -9.6 eV to +0.4 eV.

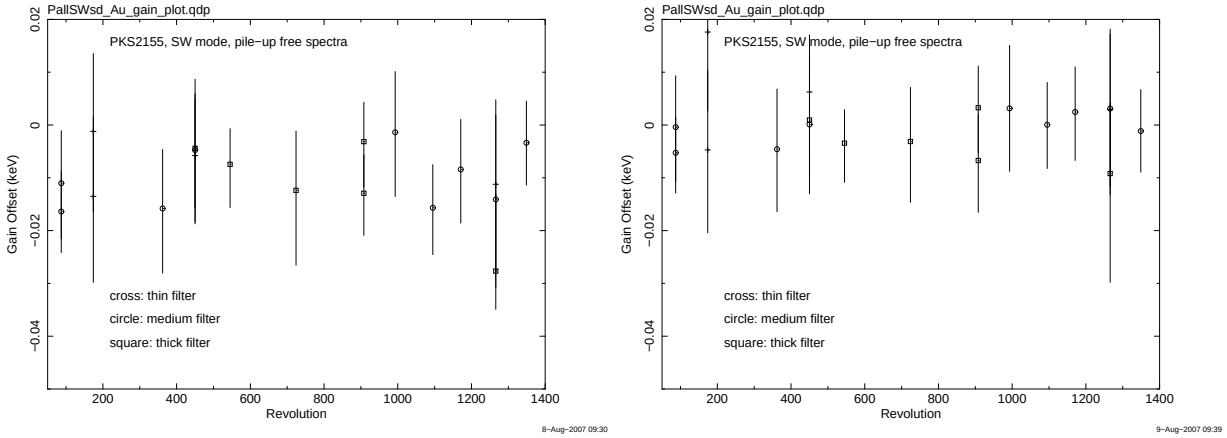

Figure 6: Energy shifts around the mirror Au edge determined from gain fits to the spectra of PKS2155 in the energy band 1.5-4.0 keV using a simple powerlaw with fixed absorption. Using the SW mode parameters from EPN_CTI_0015.CCF (left) shows a CTI under-correction of -9.6 eV (error weighted mean). Using the newly adjusted parameters from EPN_CTI_0016.CCF yields an improved CTI correction (right). The average gain offset around the Au edge reduces to +0.4 eV

5.4 LW mode CTI refinement

The new CTI correction has been tested on the SNR N132D and zeta Puppis. As expected from the smallish refinement of the fast shift CTI only no significant changes in the spectrum could be observed.

5.5 CCD dependent eFF special gain values

All available CALCLOSED data have been reprocessed with the EPN_CTI_0015.CCF and EPN_CTI_0016.CCF and Al and Mn line positions have been compared. Fig. 7 shows the line positions of Mn for all CCDs with EPN_CTI_0015.CCF and EPN_CTI_0016.CCF.

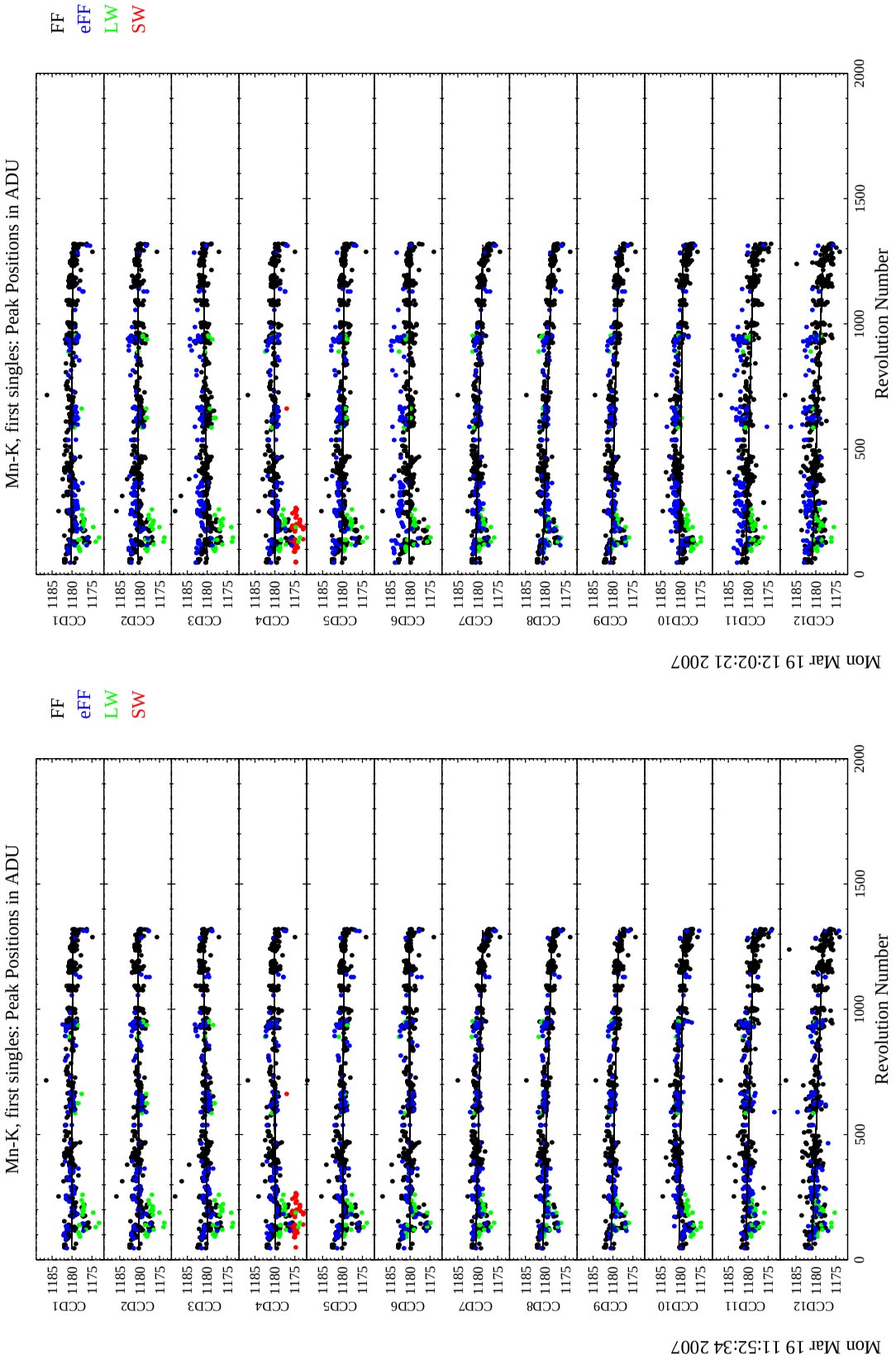

Figure 7: Line positions of the internal calibration source for all modes for Mn-K(alpha): Upper: EPN_CTI_0015.CCF and lower:EPN_CTI_0016.CCF. Note that the SW mode (red) and LW mode values of the absolute line position for CALCLOSED is not meaningful, but plotted in these monitoring plots for consistency and time evolution reasons.

5.6 Temperature dependent gain correction

The temperature dependent correction has been checked on all FF CALCLOSED data. Fig. 8 shows the Mn-K_α calibration line as a function of revolution for CCD4. With the correction for the temperature (red points) the scatter of the line position is much smaller than before.

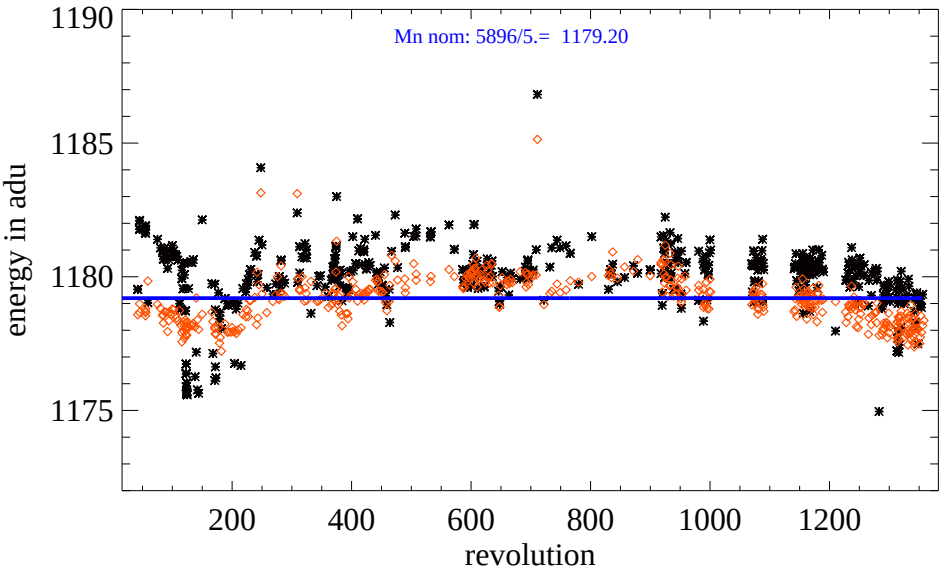

Figure 8: Line position of the internal calibration source as a function revolution. The red points are corrected for temperature effects of the quadrant box electronics. Note that still a small time dependent effect can be seen that will be corrected for soon with the capabilities described 2.1

6 Expected Updates

We expect to refine the individual longterm CTI for each CCD and Mode (2.1) before November 2007.