XMM-Newton CCF Release Note

XMM-CCF-REL-355

Update of EPIC MOS gain

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February 6, 2018

1 CCF components

Name of CCF	VALDATE (start of val. period)	EVALDATE (end of validity period)	List of Blocks changed	CAL VERS.	XSCS flag
EMOS1_ADUCONV_0087	1999-12-10T00:00:00	2000-07-15T12:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0088	2000-07-15T12:00:01	2000-11-09T12:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0089	2000-11-09T12:00:01	2001-04-18T00:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0090	2001-04-18T00:00:01	2001-08-18T00:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0091	2001-08-18T00:00:01	2001-09-26T22:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0092	2001-09-26T22:00:01	2001-11-25T12:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0003	2001-11-25T12:00:01	2002-05-16T05:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0094	2002-05-16T05:00:01	2002-11-07T05:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0095	2002-11-07T05:00:01	2003-11-09T18:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0096	2003-11-09T18:00:01	2005-01-21T18:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0097	2005-01-21T18:00:01	2005-07-24T01:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0098	2005-07-24T01:00:01	2005-10-19T19:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0099	2005-10-19T19:00:01	2006-08-11T00:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0100	2006-08-11T00:00:01	2007-11-24T16:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0101	2007-11-24T16:00:01	2008-03-03T09:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0102	2008-03-03T09:00:01	2008-04-30T05:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0103	2008-04-30T05:00:01	2009-01-22T11:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0104	2009-01-22T11:00:01	2009-10-28T16:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0105	2009-10-28T16:00:01	2010-09-30T17:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0106	2010-09-30T17:00:01	2012-01-10T09:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0107	2012-01-10T09:00:01	2012-12-12T10:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0108	2012-12-12T10:00:01	2013-06-03T22:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0109	2013-06-03T22:00:01	2014-05-28T21:00:00	OFFSET_GAIN		NO
EMOS1_ADUCONV_0110	2014-05-28T21:00:01		OFFSET_GAIN		NO

Name of CCF	VALDATE (start of val. period)	EVALDATE (end of validity period)	List of Blocks changed	CAL VERS.	XSCS flag
EMOS2_ADUCONV_0088	1999-12-10T00:00:00	2000-07-15T12:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0089	2000-07-15T12:00:01	2000-11-09T12:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0090	2000-11-09T12:00:01	2001-04-18T00:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0091	2001-04-18T00:00:01	2001-08-18T00:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0092	2001-08-18T00:00:01	2001-09-26T22:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0093	2001-09-26T22:00:01	2001-11-25T12:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0094	2001-11-25T12:00:01	2002-05-16T05:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0095	2002-05-16T05:00:01	2002-11-07T05:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0096	2002-11-07T05:00:01	2003-11-09T18:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0097	2003-11-09T18:00:01	2005-01-21T18:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0098	2005-01-21T18:00:01	2005-07-24T01:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0099	2005-07-24T01:00:01	2005-10-19T19:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0100	2005-10-19T19:00:01	2006-04-15T08:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0101	2006-04-15T08:00:01	2006-10-09T20:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0102	2006-10-09T20:00:01	2007-08-02T23:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0103	2007-08-02T23:00:01	2008-01-15T13:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0104	2008-01-15T13:00:01	2008-07-26T23:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0105	2008-07-26T23:00:01	2009-07-05T01:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0106	2009-07-05T01:00:01	2009-11-09T16:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0107	2009-11-09T16:00:01	2010-05-14T02:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0108	2010-05-14T02:00:01	2010-12-23T11:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0109	2010-12-23T11:00:01	2011-09-10T17:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0110	2011-09-10T17:00:01	2012-03-02T05:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0111	2012-03-02T05:00:01	2012-12-12T10:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0112	2012-12-12T10:00:01	2013-06-03T22:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0113	2013-06-03T22:00:01	2014-05-28T21:00:00	OFFSET_GAIN		NO
EMOS2_ADUCONV_0114	2014-05-28T21:00:01		OFFSET_GAIN		NO

2 Changes

A new set of ADUCONV CCFs have been generated which include updated values for the gain parameters. This first 12 CCFS of this new set (MOS1 issue 87–98, MOS2 issue 88-99) covers the same time periods as previous ADUCONV CCFs (MOS1 issue 70–81, MOS2 issue 71–82, see XMM-CCF-REL-279). The following CCFs cover new defined epochs which address the variability of column offsets of the focal CCD. Therefore the epoch conformity between MOS1 and MOS2 CCFs is broken after 2006-04-15 (rev. 1163).

These new gain parameters have been tuned to suppress the residuals present in the energy scale using previous CCFs. The replacement CCFs, as with their previous versions, assume a linear relationship between the charge deposited inside a pixel and the energy of the detected X–ray:

$$E_{\mathrm{eV}} = \mathrm{gain} \times E_{\mathrm{charge}} + \mathrm{offset}$$

The new gain and offset values have been calculated from observations of the on-board calibration sources, which offer three spectral lines: Al Kα at 1486.57 eV (Suresh et al 2000, J. Phys. B. At. Mol. Opt. Phys. 33), Mn Kα at 5895.75 eV and Mn Kβ at 6489.97 eV (Holzer et al 1997, Phys. Rev. A, 56, 6). The derived gain and offset values used in each CCF are averaged values taken from the calibration observations made during the corresponding CCF time period. Starting at rev. 918, the MOS calclosed observations are performed during slews. For the analyses, several slew calclosed observations were combined to achieve reasonable statistics.

However, observations during eclipse seasons have been neglected, since the cooler EPIC MOS Analogue Electronics (EMAE) require a smaller gain correction. This effect is most notable in the calibration observations, since these were performed immediately after the end of the eclipses; by the time science observations commence, the EMAE has returned to its nominal temperature and so this temperature variation during eclipse has no impact on science observations.

Calculating the linear gain term, further spurious points that deviate from the mean value by more than 5 times the average error of the points are also rejected; such rejection is not required for the constant offset term.

3 Scientific Impact of this Update

For all CCDs and all time periods, the energy scale is now reconstructed to about 5 eV or better for the entire energy range. The improvement of this new gain on existing data is expected to be up to 15 eV at 6 keV at the most recent epoch, and less than 5 eV at 1.5 keV.

The new set of ADUCONV CCFs are released together with a new set of CTI CCFs (MOS1 issues 75-98, MOS2 issues 76-102, see XMM-CCF-REL-354), since the new CTI with old gains, and old CTI with new gains may give unexpected results!

4 Estimated Scientific Quality

The energy scale accuracy is better or about 5 eV over the whole energy range for i) not too bright sources and ii) outside of eclipse seasons (at the start of revolutions).

In the latter two cases, as explained in XMM-CCF-REL-124, the energy scale can be significantly over-corrected.

5 Test procedures & results

The new ADUCONV CCFs have been tested with SASv16.1. The results of the new CCFs are presented in Fig. 1 to Fig. 4.

6 Expected Updates

None.

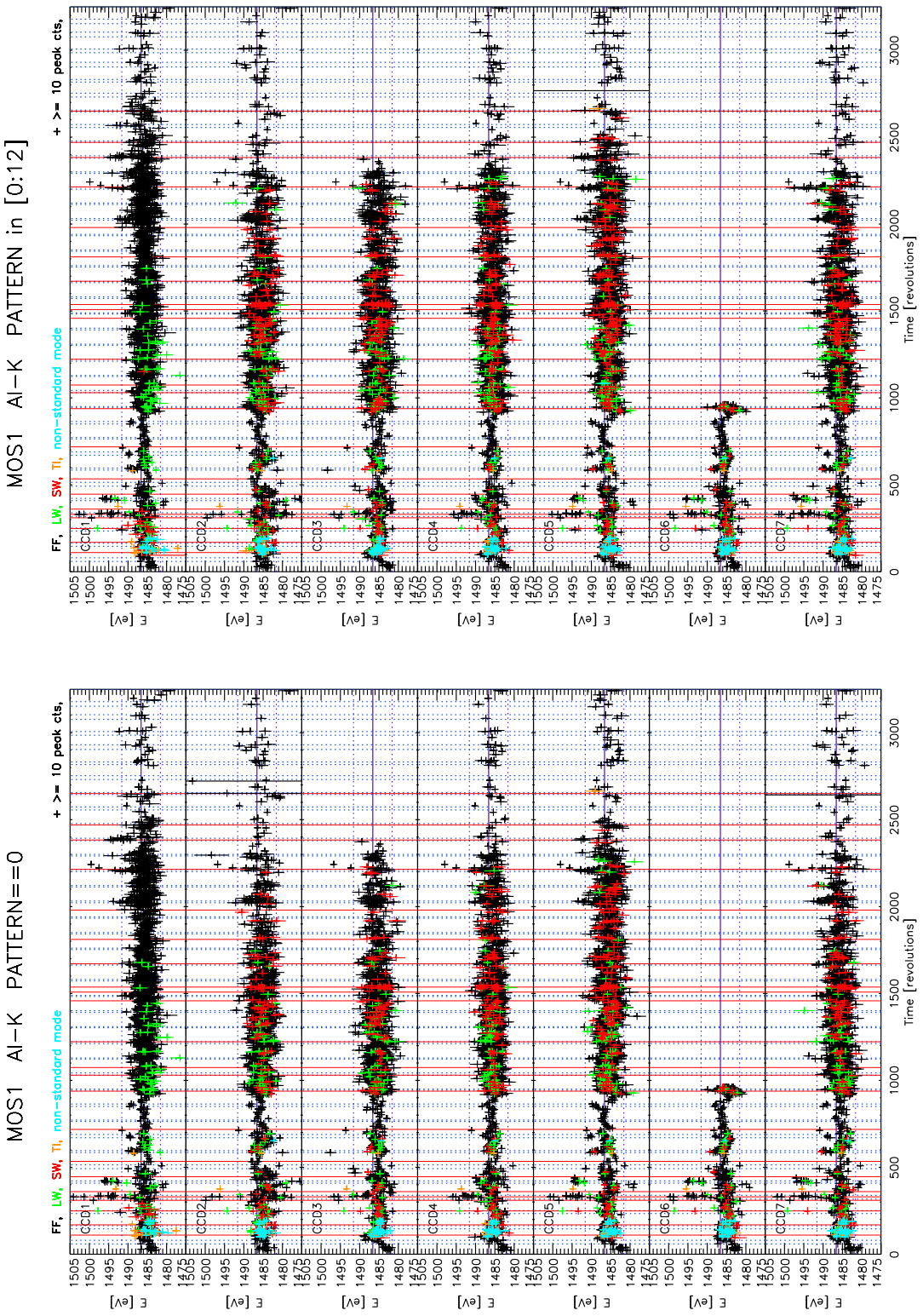

Figure 1: MOS1 Al K_α line energy scale using the new CTI+ADUCONV CCFs. Eclipse seasons are indicated by vertical blue lines, CCF epochs by red lines. The horizontal solid line represents the laboratory line energy, the dotted lines the ± 5 eV deviations.

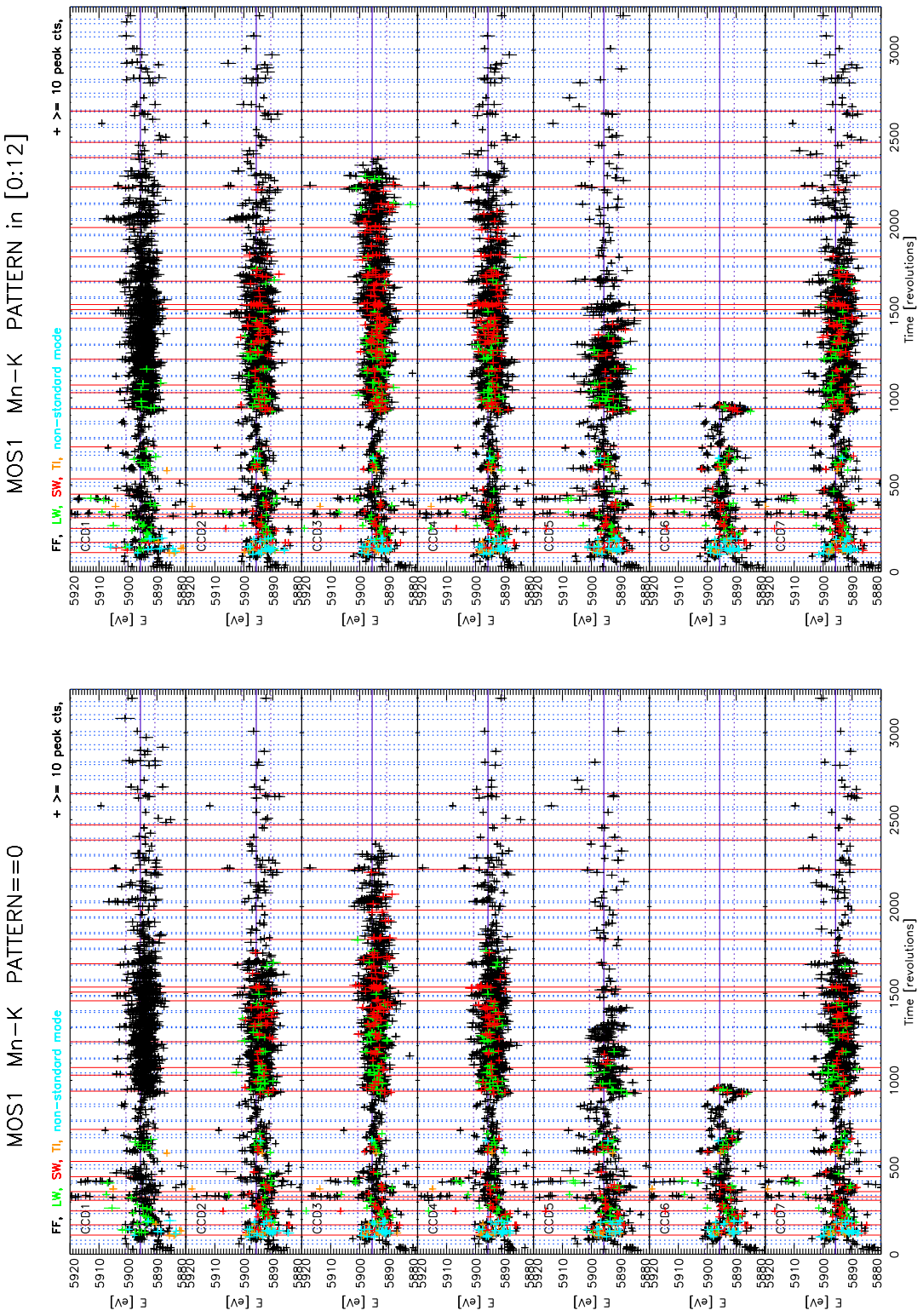

Figure 2: MOS1 Mn K_α line energy scale using the new CTI+ADUCONV CCFs. Eclipse seasons are indicated by vertical blue lines, CCF epochs by red lines. The horizontal solid line represents the laboratory line energy, the dotted lines the ± 5 eV deviations.

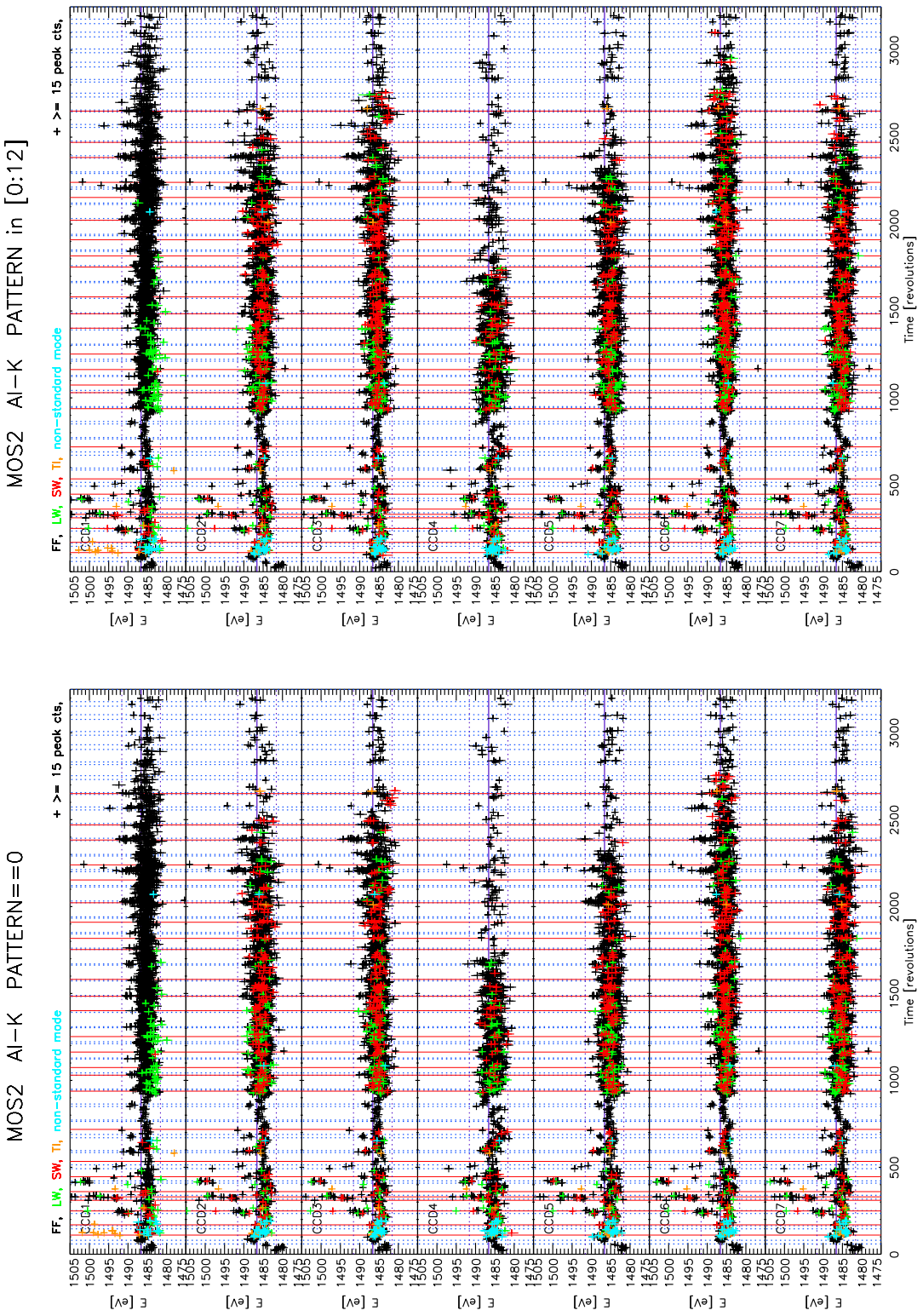

Figure 3: MOS2 Al K_α line energy scale using the new CTI+ADUCONV CCFs. Eclipse seasons are indicated by vertical blue lines, CCF epochs by red lines. The horizontal solid line represents the laboratory line energy, the dotted lines the ± 5 eV deviations.

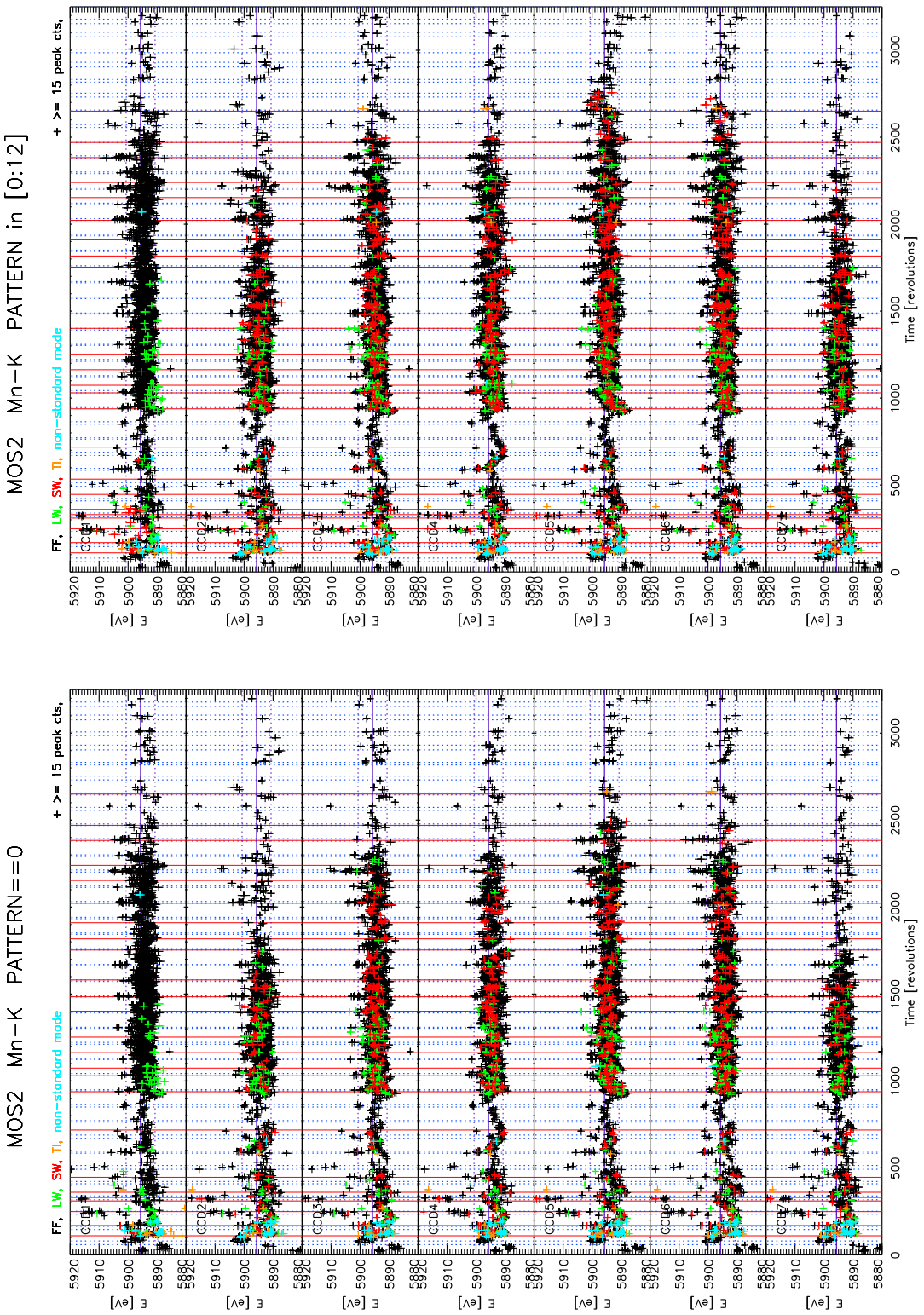

Figure 4: MOS2 Mn K$_\alpha$ line energy scale using the new CTI+ADUCONV CCFs. Eclipse seasons are indicated by vertical blue lines, CCF epochs by red lines. The horizontal solid line represents the laboratory line energy, the dotted lines the ±5 eV deviations.